



# CEOS Atmospheric Composition Constellation

## **Gap Analysis Study**

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## 1 Introduction

This study was commissioned by NASA, through SSAI, to support work on the CEOS Constellations programme.

A number of constellations were identified as study topics, including the Atmospheric Composition Constellation, which is the scope of this study. The term "constellation" is used in a broad sense and is not limited to the potential of a dedicated set of closely related observation satellites operated in constellation, but extends to the combination of measurement information from different platforms in a more general sense. The concept of the "constellation" is therefore a "virtual" one, which includes the potential of combining different measurement types from a variety of platforms.

## Study Objective

The objective of this study is, in the context of monitoring atmospheric composition, to:

- collect and distil information on observational requirements
- summarise the observational capabilities of current and planned satellite missions
- compare the requirements to the identified capabilities
- examine the capability and availability of observations and identify gaps in both

The relevant timescale is from the present, 2008, over the next decade and beyond. The planning horizon used by agencies varies but mission plans in some cases are drafted for the next 20 years. The analysis aims to be quantitative where practical though the amount of detailed information varies widely and a fully quantitative analysis is not possible.





## **Report Structure**

This study report is structured as follows:

#### Chapter 1

This introduction, outlining the scope and purpose of the study, and structure of the report.

#### Chapter 2

Product requirements for atmospheric composition applications are collated from inputs available from agencies. In many cases this is publically available information on the internet. Reference information is given for all inputs.

Requirements and observational capabilities are defined in terms of geophysical products derived directly from measurements, often referred to as level 2 data; in such context level 0 data corresponds to raw telemetry and level 1 as calibrated and geo-located measurement observations.

#### Chapter 3

Missions with instrumentation able to target atmospheric composition are collated. The timescales and capabilities of current and planned missions are summarised.

#### Chapter 4

Analysis of how the missions address the requirements and identification of gaps in measurement coverage and capability.

#### Chapter 5

A summary of the study and comment.





## 2 Assessment of Requirements

## 2.1 Requirement Inputs

The requirements collected fall into three broad groups covering US, European, and international agencies and programmes. The information has been drawn together in consultation with scientists and programme managers and discussed and enhanced at Atmospheric Composition Constellation (ACC) workshops in 2007 and 2008. Requirements are cast as basic geophysical products derived directly from satellite measurements and may be described as "level 2" requirements.

A list of documents and other material that were considered in producing the distilled set of requirements is provided in the following sections, with brief descriptions, drawing out relevance to atmospheric composition. References are provided.

#### US Programmes

For the US the primary relevant input is the NRC Decadal Survey published in 2007:

 NRC Decadal Survey 2007
 Committee on Earth Science and Applications from Space, 2007: National Imperatives for the Next Decade and Beyond, National Research Council, Washington DC. <u>http://www.nap.edu/catalog/11820.html</u>

This document focuses on Earth observation in the period 2005-2015 and directions beyond. It includes requirements and mission concepts for the period 2010-2020 for 7 themes:

- 1. Earth-science applications and societal needs.
- 2. Land-use change, ecosystem dynamics, and biodiversity.
- 3. Weather, including space weather and chemical weather.
- 4. Climate variability and change.
- 5. Water resources and the global hydrologic cycle.
- 6. Human health and security.
- 7. Solid-Earth hazards, resources, and dynamics.

The themes of relevance to atmospheric composition particularly are 3, 4 and 6, covering air pollution, climate and ozone; themes 2 and 5 include carbon budget and water vapour related requirements with atmospheric composition aspects.

The NASA Science Plan provides a context for its missions planned over the next decade with Earth Science as one of the science areas covered.

Science Plan for NASA's Science Mission Directorate 2007-2016
 <a href="http://nasascience.nasa.gov/about-us/science-strategy/Science">http://nasascience.nasa.gov/about-us/science-strategy/Science</a> Plan 07.pdf





#### **European Programmes**

European programmes come under the responsibility of two organisations, the European Space Agency, ESA, and the European Organisation for the Exploitation of Meteorological Satellites, EUMETSAT.

Information is available from study and programme development reports, and mission requirement documents.

#### European Space Agency (ESA)

• CAPACITY Final Report CAPACITY – 'Composition of the Atmosphere: Progress to Applications in the user CommuITY', Operational Atmospheric Chemistry Monitoring Missions, Final Report, ESA contract no. 17237/03/NL/GS, October 2005

#### • GMES Requirements

GMES Service Element PROMOTE U5 Core User Needs Dossier, Version 12, Paliouras, E. et al., 23 May 2006 Also see <u>http://www.gse-promote.org/</u>

 Sentinel 4 & 5 Mission Requirements Document GMES Sentinels 4 and 5 Mission Requirements Document (Initial Version) 2 April 2007, Issue 1, Revision 0 J. Langen, ESA

#### EUMETSAT

- MTG Mission Requirements
   MTG Mission Requirements Document
   EUM/MTG/SPE/06/0011, Issue : v2B, Date : 6 October 2006
   <u>http://www.eumetsat.int/Home/Main/What We Do/Satellites/Future Satellites/
   Meteosat Third Generation/SP 1124972380654?l=en

  </u>
- Post-EPS Atmospheric Chemistry Position Paper
   Position Paper on Post-EPS Atmospheric Chemistry Data User Requirements
   for Operational Atmospheric Chemistry Monitoring in the Post-EPS Time
   Frame beyond 2020, H. Kelder, KNMI, the Netherlands, B. Kerridge,
   Rutherford Appleton Laboratory, U.K., I. Isaksen, University of Oslo, Norway,
   B. Carli IFAC, CNR, Italy, N. Harris University of Cambridge, U.K., E.
   Hilsenrath University of Maryland, U.S.A
   6 March 2006, Issue 0 Draft H
- Post-EPS Mission Requirements Document Post-EPS Mission Requirements Document (Initial Version) 10 January 2007, Issue v1J Draft P. Schlüssel, P. Phillips, C. Accadia, R. Munro, S. Banfi, J. Wilson





The atmospheric composition monitoring requirements formulated in Europe have evolved from the international IGACO report, through the CAPACITY study, to the Post-EPS Atmospheric Chemistry position paper (EPS is the current EUMETSAT Polar System). There is some cross-over between and ESA and EUMETSAT approaches and there appears to be a level of convergence on both the requirements and the observational implementation. The requirements used in this study are those available in 2007 provided through the assistance of Dr. R. Munro at EUMETSAT and Dr. J. Langen at ESA.

#### **International Programmes**

In terms of international context, input is available from the Global Climate Observing System (GCOS) programme and the formal response by CEOS, as well as the IGACO report produced by the Integrated Global Observing Strategy (IGOS) partnership:

#### • GCOS Requirements

Systematic observation requirements for satellite-based products for climate Supplemental details to the satellite-based component of the implementation plan for the global observing system for climate in support of the UNFCCC, September 2006, (WMO/TD No.1338) http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf

#### • CEOS Response to GCOS

Satellite Observation of the Climate System The Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan (IP) http://www.ceos.org/pages/CEOSResponse 1010A.pdf

#### • IGACO Theme Report

The Changing Atmosphere, An Integrated Global Atmospheric Chemistry Observation Theme for the IGOS Partnership, Report of the Integrated Global Atmospheric Chemistry Observation Theme Team, September 2004, ESA SP-1282, September 2004, Report GAW No. 159 (WMO TD No. 1235) http://ioc.unesco.org/igospartners/Atmosphere.htm

#### GCOS is co-sponsored by the World Meteorological Organization, the

Intergovernmental Oceanographic Commission of UNESCO, the United Nations Environment Programme and the International Council for Science. Its remit is *"to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users"*. It has established requirements for climate and identifies so-called Essential Climate Variables (ECVs) for atmospheric, oceanic and terrestrial observations.

IGOS is an international partnership of many participants including CEOS and various groups of the WMO and UNESCO. The IGACO report was produced by a panel of scientists convened by WMO and ESA.



2-3



## 2.2 Distilled Requirements

This study follows an approach developed over the last decade or so, and taken forward in the CAPACITY study and the Post-EPS Atmospheric Chemistry position paper, by distinguishing 3 application areas that cover atmospheric composition monitoring, namely:

- 1. Ozone layer and surface UV monitoring and forecasting
- 2. Composition-climate interaction
- 3. Air quality monitoring and forecasting

All observational requirements are put into one of these general categories. They have been collected for identified atmospheric species and are shown in table form at the end of this chapter, in section 2.4, one for each product, with quantitative values for particular requirements where available. Typically, these cover any of the following: horizontal and vertical resolution, accuracy, sampling, coverage, stability. The source and driver for the requirements are also noted to ensure traceability. An identifier for the potential programme that is dealing with particular requirements is given and covers NASA, GMES and GCOS.

Measurement requirements generally vary with height and the following height domains are used and indicated in the tables:

Domain Name	Abbreviation	Typical Altitude
Troposphere	т	0 – 12 km
Planetary Boundary Layer	PBL	0–2 km
Free Troposphere	FT	2 – 12 km
Upper Troposphere	UT	8 – 12 km
Stratosphere	S	12 – 50 km
Lower Stratosphere	LS	12 – 25 km
Middle Stratosphere	MS	20 – 35 km
Upper Stratosphere	US	25 – 50 km
Mesosphere	М	50 – 80 km

 Table 2-1: Standard Altitude Domains

The altitude assignment should be taken as relaxed and varying with latitude, with typical mid-latitude values given in Table 2-1. Other terms used to define a combination of altitude range and vertical resolution are *Total*, *Tropospheric* and *Stratospheric Column* (abbreviated to *Tot*, *Trop and Strat Col* respectively) which indicates that a value related to the total amount of the target product in the given height range is required.





In producing the distilled tables some simplification and rationalisation has been attempted. The requirements are, by their nature, estimates so may be interpreted with some flexibility. For horizontal resolution, for example, the Post-EPS Atmospheric Chemistry position paper states that the requirement is only specified for one direction and that it is relaxed in other aspects, e.g. for a polar orbiting sounder the along-track sampling interval should satisfy the requirement but some relaxation could be accommodated across track.

One important simplification is that only minimum requirements, also referred to as "threshold" in some contexts, are taken, with the philosophy that this is the level at which measurement is considered useful. The origin of the requirement is indicated in the tables so that for any particular purpose the source documents should be referred to and considered.

There are a large number of different requirements for aerosol and cloud, ranging from detection of polar stratospheric clouds to identification of particle size in the troposphere. These varied requirements are all presented in a single table covering the "Aerosol & Cloud" product. The other products treated as a group are "Volatile Organic Compounds", VOCs, which in some source documents have generic requirements but include specific requirements for ethyne (acetylene,  $C_2H_2$ ) and ethane ( $C_2H_6$ ) in the Post-EPS position paper.

The requirements tables cover the following species and groups:

H <sub>2</sub> O	CO	NO <sub>2</sub>	CH <sub>2</sub> O
O <sub>3</sub>	$CO_2$	$N_2O_5$	PAN (Peroxyacetyl Nitrate)
$CH_4$	CIO	$SO_2$	VOCs (Volatile Organic Compounds)
HNO₃	BrO	HDO	Aerosol & Cloud
$N_2O$	HCI	$SF_6$	

Table 2-2: Requirement Products





## 2.3 Requirements Summary

The requirements tables in section 2.4 draw together the observational requirements as specified by particular agencies and programmes. They attempt to detail, in a quantitative manner where possible, the measurement variable and its attributes. Although self-explanatory, a summary and some general comments are given here.

Table 2-3 indicates the application area and programme for each product given in the requirements.

				Applic	ation A	rea			
	0	zone & L	JV	Comp	osition-C	limate	Ai	r Quality	/
Product				Pro	gramme	)			
	GMES	NASA	GCOS	GMES	NASA	GCOS	GMES	NASA	GCOS
H₂O		$\checkmark$		$\checkmark$	$\checkmark$	$\checkmark$	~	$\checkmark$	
O <sub>3</sub>	$\checkmark$	$\checkmark$		$\checkmark$		$\checkmark$	$\checkmark$	$\checkmark$	
CH <sub>4</sub>		$\checkmark$		$\checkmark$		$\checkmark$			
HNO₃	$\checkmark$	$\checkmark$		$\checkmark$			$\checkmark$		
N₂O		$\checkmark$		$\checkmark$		$\checkmark$			
CO		$\checkmark$		$\checkmark$			$\checkmark$	$\checkmark$	
CO <sub>2</sub>		$\checkmark$		$\checkmark$	$\checkmark$	$\checkmark$			
CIO	$\checkmark$	$\checkmark$							
BrO	$\checkmark$	$\checkmark$							
HCI	$\checkmark$	$\checkmark$							
NO <sub>2</sub>	$\checkmark$	$\checkmark$		$\checkmark$			$\checkmark$	$\checkmark$	
$N_2O_5$							$\checkmark$		
SO <sub>2</sub>							✓	$\checkmark$	
HDO		$\checkmark$		$\checkmark$					
SF <sub>6</sub>				$\checkmark$		$\checkmark$			
CH <sub>2</sub> O		$\checkmark$					$\checkmark$	$\checkmark$	
PAN							✓		
VOCs							$\checkmark$	$\checkmark$	
Aerosol & Cloud	✓	$\checkmark$		~	$\checkmark$	$\checkmark$	~	$\checkmark$	~

Table 2-3: Summary of Product Requirements by Application and Programme





#### **General Attributes and Features**

There is, overall, good consistency in the products required by programmes for particular requirement types. There are some notable differences however.

The Decadal Survey requirements are, in many cases, an order of magnitude more stringent than others, for both vertical and horizontal resolution. On the other hand accuracy is often not specified and sampling and revisit times are vague in some instances. Such features may be due to the fact that the Decadal Survey covers not only "monitoring" but also "research" interests. It may be for this reason that it also has more species requirements relating to ozone and UV monitoring than the GMES programme.

GCOS, by definition, only has climate requirements (except that the aerosol ECV also covers air quality). It is the only source to specify measurement stability requirements, though does not have these in all cases.

#### Requirements by Type

The requirement tables and the summary in Table 2-3 indicate that the largest number of products required is for the Ozone and UV application, with many requirements only coming out of the US Decadal Survey. In contrast, the GMES programme requires many composition-climate products, in conjunction with GCOS. For air quality almost all the products are drawn out both in the GMES and the Decadal Survey documents.

#### **Requirements by Product**

Water vapour, ozone, nitric acid, carbon monoxide, nitrogen dioxide (NO<sub>2</sub>), as well as cloud and aerosol measurements are required across the board for all three application areas. The first two of these products,  $H_2O$  and  $O_3$ , are required with high (~1%) to medium (~10%) accuracy and good resolution (~10-100 km horizontal, ~<1-5 km vertical) and throughout the troposphere and stratosphere. As mentioned previously, the aerosol and cloud requirements are varied and, although collated in a single table, there are a number of individual and different products included.

Dinitrogen pentoxide (N<sub>2</sub>O<sub>5</sub>), sulphur dioxide (SO<sub>2</sub>), peroxyacetyl nitrate (PAN) and volatile organics (VOCs) are only required in the context of air quality and pollution and so observations focus naturally in the troposphere and should generally include boundary layer sensitivity. In some cases high vertical resolution (e.g.1 km in the boundary layer) and frequent sampling or revisit times are specified ( $\leq$ 4 hours).

The halogen compounds CIO, BrO, HCI are only required for ozone and UV monitoring. Their involvement in ozone chemistry means that the measurements of relevance are in the stratosphere.  $SF_6$  only appears in the climate context, as a stratospheric tracer. Requirements on resolution, accuracy and revisit time are relatively modest for all these species.





Methane, nitrous oxide, carbon dioxide, deuterated water vapour (HDO), and formaldehyde ( $CH_2O$ ) are required for ozone/uv and composition climate and cover troposphere and stratosphere.

## 2.4 Requirements Tables

Tables summarising the requirements are shown in the following pages. The data have been drawn together from a variety of sources including the requirements of US, European, and multi-national programmes.

There is a table for each product outlining the measurement requirements for all 3 application areas. Quantitative data on requirements for measurement height domain, resolution, sampling or revisit time, accuracy, coverage and stability is presented where available. In general only the minimum threshold requirements, indicating the level at which measurement may be considered useful for the application is shown.





Opproaction     Layer & Surface UV     NASA     US Decadal     Health       Ozone Layer & Surface UV     NASA     US Decadal     Health       Monitoring and Forecasting     Survery     Badiation       Composition - Climate     GMES     Postion Paper     Dynamics       Interaction     Coordinate     GCOS     GCOS     GCOS     Satellite       GCOS     GCOS     GCOS     Satellite     ECV Water Val			(hm)	(km)	(km) (hre)	Accuraci	Coverand	Ctability
NASA US Decadal Survery GMES Post-EPS Position Paper GCOS GCOS Satellite Requirements			(IIIN)	(IIIII)	(em)		coverage	OldUIIIY
n - Climate GMES Post-EPS Position Paper GCOS GCOS Satellite Requirements		SM	5	en en			global	
n - Climate GMES Post-EPS Position Paper GCOS GCOS Satellite Requirements								
Position Paper GCOS GCOS Satellite Requirements		PBL	75	I	12	30%	global	
GCOS Satellite Requirements	mamics	FT	250	e	12	20%		
GCOS Satellite Requirements	Stratospheric H2O	rs	250	ი	12	30%		
GCOS Satellite Requirements		MS	500	4	168	30%		
GCOS Satellite Requirements		M+SU	500	9	168	30%		
GCOS Satellite Requirements		Total Column						
	ECV Water Vapour	PBL	50	0.1	ო	2%		0.3%
		FT	50	0	ო	2%		0.3%
		S	50	0	ი	2%		0.3%
		Total Column	50	2	e	1%		0.3%
NASA US Dec Survey Climate		Total Column					global	
		3 0					6	e 39
Air Quality GMES Post-EPS AQ Forecast &		PBL	20	r	4	10%	global & regional	
& Forecasting Position Paper		FT	50	4	4	20%		
NASA US Dec Survey Health		Total Column	10				regional & global	



H2O





03

					Horizontal Resolution	Vertical Interval / Resolution Revisit Time	Interval / Revisit Time			
Application	Programme Source	e Source	Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV	GMES	Post-EPS	Ozone and	UT	250	ю	72	20%	global	
Monitoring and Forecasting		Position Paper	UV Forecast;	LS	250	Ю	72	20%		
			Ozone Trend	MS	500	4	72	20%		
				M+SU	500	9	168	20%		
				Trop Col	75	I	72	20%		
				Total Column	75	;	72	3%		
	NASA	US Dec Survey Health		MS	5 2	e			global	
Composition - Climate	GMES	Post-EPS		PBL	75	P	72	50%	global	
Interaction			Dynamics	FT	250	5	72	30%		
				LS	250	ю	72	20%		
				MS	500	4	72	20%		
				M+SU	500	9	168	20%		
				Total Column	75	1	72	5%		
	GCOS	GCOS Satellite	ECV Ozone	FT	50	0.5	ო	10%	global	1%
		Requirements		MS	100	в	ო	5%		0.6%
Air Quality	GMES	Post-EPS	AQ Forecast &	PBL	20	Ð	4	30%	global & regional	
Monitoring & Forecasting		Position Paper	Concentration	FT	50	2	4	30%		
			Monitoring	Total Column	20	1	4	5%		
	NASA	Idal	Health	PBL	10		48		regional & global	
		Survery	Chemical Weather	Trop Col	5		1		regional >5000km	
			Ch Weather - Ozone	FT		N			global	



CH4										
Application	Programme Source	Source	Driver	Height Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Interval / Revisit Time (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Decadal Survery	Health	WS	5	c			global	
Composition - Climate Interaction	GMES	Post-EPS Position Paper	Emissions; Ozone-Climate	PBL FT LS MS Total Column	50 500 500 500	Inc ω 4 Ι	72 72 72 72	10% 20% 20%	global	
	GCOS	GCOS Satellite Requirements	ECV CO2, CH4 & GHGs	Total Column	250	ан.	3	1%		
Air Quality Monitoring & Forecasting	None applicable									
HNU3					Horizontal	Vertical	Interval /			
Application	Programme	Source	Driver	Height Domain	Resolution (km)	Resolution (km)	Revisit Time (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	GMES	Post-EPS Position Paper	Ozone Trend & Nitrogen Budget	LS MS Strat Col	250 500 250	44 (	72 72 72	50% 50% 50%	global	
	NASA	US Dec Survey	Health	MS	5	3			global	
Composition - Climate Interaction	GMES	Post-EPS Position Paper	Ozone-Climate; Nitrogen Budget	FT LS MS Total Column	250 250 500	1041	72 72 72	50% 20% 20%	global	



global & regional

50% 50%

4 4

1 1

50

PBL FT

Post-EPS AQ Forecast Position Paper Concentration

GMES

Air Quality Monitoring & Forecasting



1	
c	1
0	
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1.00	

					Horizontal Resolution	Vertical Interval	Interval / Revisit Time			
Application	Programme Source	Source	Driver	Height Domain	(km)	(km) (km) (hrs)	(hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Dec Survey Heal	th	MS	പ	ო			global	
				2017 2017						
Composition - Climate	GMES	Post-EPS	Ozone-Climate	SJ	250	ო	72	20%	global	
Interaction		Position Paper		MS	500	4	72	20%		
	GCOS	GCOS Sat Regs ECV	ECV CO2, CH4 & GHGs	s						
		241								
Air Quality Monitoring & Forecasting	None applicable									

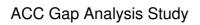
8

	h				Horizontal Resolution		Vertical Interval / Resolution Revisit Time			
Application	Programme Source		Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Dec Survey Health	Health	MS	5	e			global	
				1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 -						
Composition - Climate	GMES		Emissions;	PBL	75	3	72	20%	global	
Interaction		Position Paper	Ozone-Climate	FT	250	5	72	30%		
				Total Column	75	1	72	25%		
9 19	(A)			2 10						
Air Quality	GMES	Post-EPS	AQ Forecast &	PBL	20	I	4	30%		
Monitoring & Forecasting		Position Paper	Concentration	FT	50	S	4	30%		
			Monitoring; Emissions Total Column	Total Column	20	1	4	25%		
	NASA	US Decadal	Health	PBL	10	Ŧ	-		regional & global	
		Survery		Total Column	3	1	1			
			Land & Ecosystems	PBL	0.1	Ļ	24		regional & global	
			Chemical Weather	FT	5	5			regional >5000km	
			Ch Weather - Ozone FT	FT	1	5	£			0





Annlication	Programme Source	Source	Driver	Heidht Domain	Horizontal Resolution /km)	Vertical Resolution (km)	Vertical Interval / Resolution Revisit Time (km) (hrs)	Accuracy	Coverade	Stability
Including		course	LIVE		(IIII)	/mm/	(611)	Uccut acy	Coverage	oradinity
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Decadal Survery	Health	WS	ъ	e			global	
Composition - Climato	CMEC	Doct EDC	Dadiation		EU	ġ	10	E0/	Icholo	
Composition - Cimitate	GIVIES	aner	Dynamics	L L	250	1 10	54	2%	giunai	
			Stratospheric H2O	S	250		168	5%		
				MS	500	4	168	10%		
				US	500	9	168	10%		
				Total Column	50	1	12	1%		
	GCOS	GCOS Satellite	ECV CO2, CH4 & GHGs	Total Column	250	t.	ო	1%		0.3%
	NASA	US Dec Survey	Land/Ecosystems	Total Column	0.1		24		global	
Air Quality Monitoring & Forecasting	None applicable									
CIO										
					Horizontal Resolution	Vertical Resolution P	Interval / Revisit Time			
Application	Programme Source		Driver	Height Domain	(km)		(hrs)	Accuracy	Coverage	Stability
Orana Lauar & Curfaca UV	CMEC		0.0000	0	DED		02	EO0/	Indala	
Monitoring and Forecasting	GINEO	aper	Halogen Trend	MS Strat Col	500 250	14	72	50% 50%	gional	
	NASA	US Dec Survey	Health	MS	5	e			global	
		L 1								
Composition - Climate Interaction	None applicable									
include in the second	a subsection of the section of the s									





None applicable

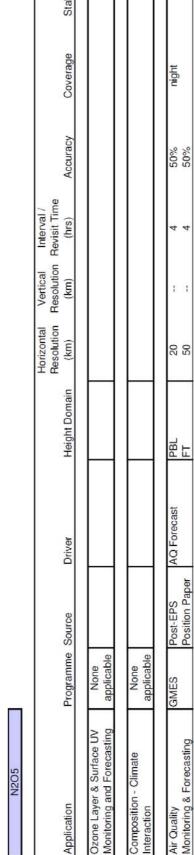
Air Quality Monitoring & Forecasting

e UV sting					Horizontal	Vertical	Interval /			
GN NA	Programme S	Source	Driver	Height Domain	Resolution (km)	E	Revisit Time (hrs)	Accuracy	Coverage	Stability
NA		Post-FPS	Ozona &	S	250	γ	62	50%	dohal	
NA		aper	Halogen Trend	MS Strat Col	500	4	72	50% 50%	3005	
		US Dec Survey	Health	MS	5	e	Ĩ	200	global	
Composition - Climate No Interaction appli	None applicable									
Air Quality No Monitoring & Forecasting appli	None applicable									
HCI										
					Horizontal Resolution	Vertical Resolution	Interval / Revisit Time			
Application Progra	Programme Source		Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability
		- F								
Ozone Layer & Surtace UV GMES Monitoring and Forecasting		Post-EPS Position Paper	Ozone & Halogen Trend	MS	250 500	44	72	50% 50%	global	
				Strat Col	250	I	72	20%		
NASA		US Dec Survey	Health	MS	5	e			global	
on - Climate	None									
	Incapie									
Air Quality No	None									





NO2										
Application	Programme Source	Source	Driver	H <del>e</del> ight Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Vertical Interval / Resolution Revisit Time (km) (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	GMES	Post-EPS Position Paper	Ozone Trend & Nitrogen Budget	LS MS US Strat Col	250 500 250	4401	72 72 72	30% 30% 20%	global	
	NASA	US Dec Survey	Health	MS	20	З	į	2	global	
Composition - Climate Interaction	GMES	Post-EPS Position Paper	Emissions; Ozone-Climate	PBL FT Total column	75 250 75	сэ г	72 72 72	50% 50% 2.6e15 cm-2		
Air Quality Monitoring & Forecasting	GMES NASA	Post-EPS Position Paper US Decadal Surverv	AQ Forecast & PBL Concentration FT Monitoring; Emissions Total Column Health Total Column	PBL FT s Total Column PBL Total Column	20 20 10	– .	444-;	30% 50% 2.6e15 cm-2	regional & global	
			Chemical Weather Ch Weather - Ozone	Trop Col Total Column	ı ک	: :	- :	Ϊą.	regional >5000km global	
N2O5										
Application	Programme Source	Source	Driver	Height Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Interval / Revisit Time (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	None applicable									



2-15





SO2										
Application	Programme Source	Source	Driver	Height Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Horizontal Vertical Interval / Resolution Resolution Revisit Time (km) (hrs)	Accuracy	Coverage	Stability
										7
Ozone Layer & Surface UV Monitoring and Forecasting	None applicable									
Composition - Climate	None									
Interaction	applicable									
	142									
Air Quality	GMES	Post-EPS	AQ Forecast	PBL	20	1	4	30%		7
Monitoring & Forecasting		Position Paper		FT	50	;	4	50%		
				Total Column	20	;	4	2.6e15 cm-2		
	NASA	US Decadal	Health	PBL	10	÷	÷		regional & global	
		Survery		Total Column	3		3		С 19	
			Chemical Weather	FT	5	£	1		regional >5000km	
			Ch Weather - Ozone	FT	3	3	a		007cs	
UDH										
001	_									
					Horizontal	Vertical	Interval /			
	1				Resolution	Hesolution	Resolution Revisit lime			
Application	Programme Source	Source	Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability



function of the second s			100000	1	2				
Monitoring & Forecasting		Position Paper		FT	50	;	4	50%	
				Total Column	20	;	4	2.6e15 cm-2	
	NASA	US Decadal	Health	PBL	10	-	÷		regional & globs
		Survery		Total Column	1	1	3		R) NJ
			Chemical Weather	FT	5	e.	1		regional >5000kr
			Ch Weather - Ozone	FT	4	а	1		11 TO
HDO									
					Horizontal Resolution	Vertical Resolution	Vertical Interval / Resolution Revisit Time		
Application	Programme	Source	Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Dec Survey Health		SM	5	3			global
Composition - Climate	GMES	Post-EPS	Stratospheric	rs	250	ю	168	20%	global
Interaction		Position Paper	H2O	MS	500	4	168	20%	
		2		NS	500	9	168	20%	





None applicable

Air Quality Monitoring & Forecasting

SF6										
Application	Programme Source	Source	Driver	Height Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Interval / Revisit Time (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	None applicable									
Composition - Climate Interaction	GMES	Post-EPS Position Paper	Ozone-Climate	LS NS US	250 500	c 4 σ	168 168 168	20% 20% 20%	global	
	GCOS	GCOS Sat Reqs	GCOS Sat Reqs ECV CO2, CH4 & GHGs	IGs						
Air Quality Monitoring & Forecasting	None applicable									
CH2O										
					Horizontal	Vertical	Interval /			
Application	Programme Source	Source	Driver	Height Domain	Resolution (km)	Resolution (km)	Revisit Time (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	NASA	US Decadal Survery	Health	SM	5	Э			global	
Composition - Climate Interaction	None applicable									
Air Quality Monitoring & Forecasting	GMES	Post-EPS Position Paper	AQ Forecast; VOC Emissions	PBL FT Taulother	50 20	1 1	44,	30% 50%		

					Decolution	Declution Declution Devicit Time	Douisit Timo			
-	Programme Source		Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stabili
/er & Surface UV NASA	NASA	adal	Health	SM	5	с			global	
and Forecasting		Survery								
on - Climate	None									
	applicable									
10	GMES	Post-EPS	AQ Forecast;	PBL	20	Ę	4	30%		
& Forecasting		Position Paper	VOC Emissions	FT	50	1	4	50%		
				Total Column	20	;	4	2.6e15 cm-2		
	NASA	US Decadal	Health	PBL	10	-	-	L	regional & global	
		Survery		Total Column	ī					
			Chemical Weather	FT	9	:	1	re	regional >5000km	
			Ch Weather - Ozone FT	FT	1	;	;			
				and						





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Application	Programme Source	Source	Driver	Height Domain	Horizontal Resolution (km)	Vertical Resolution (km)	Horizontal Vertical Interval / Resolution Resolution Revisit Time (km) (hm) (hrs)	Accuracy	Coverage	Stability
Ozone Layer & Surface UV Monitoring and Forecasting	None applicable									
Composition - Climate	None									
Interaction	applicable									
Air Quality	GMES	Post-EPS	AQ Forecast	PBL	20	÷	4	50%		
Monitoring & Forecasting		Position Paper	6	FT	50	a.	4	50%		

OCs
ž

					Horizontal Resolution F	Vertical Resolution	Vertical Interval / Resolution Revisit Time			
Application	Programme Source	Source	Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability
		11.1 T		100 A						3 3
Ozone Layer & Surface UV	None									
Monitoring and Forecasting	applicable									
Composition - Climate	None									
Interaction	applicable									
Air Quality	GMES	Post-EPS	VOC Emissions	PBL	20	;	4	50%		
Monitoring & Forecasting		Position Paper		FT	50	ß	4	50%		
R.	NASA	US Decadal	Health	PBL	10	÷	÷		regional & global	
		Surverv		Total Column	;	;	;			





					Horizontal Resolution	Vertical Resolution	Interval / Bevisit Time			
Application	Programme Source	e Source	Driver	Height Domain	(km)	(km)	(hrs)	Accuracy	Coverage	Stability
M martin Contraction	ONEO	Doot FDC	Co Trans 0 Chamber	0	DED		02	0.05	alabal	
Monitoring and Forecasting	GINIEO	Position Paper	(Strat OD)	MS MS	200	1 4	72	0.05	gional	
2		3	UV Forecast & Trend (UV OD)	Total Column	50	ł	72	0.10		
			O3 Trend & Chemistry (PSCs)	LS	250	4	72	0.10		
	NASA	US Dec Survey	Health (Particles)	Total Column	5	3			global	- (
	8 35	2			6.8				2014	
Composition - Climate	GMES		Radiation;	PBL	20	1	24	0.05	global	
Interaction		aper	Emissions;	FT	50	;	24	0.05		
			Ozone-Climate	rs	250	1	72	0.05		
			(Aerosol OD)	MS	500	I	72	0.05		
				Total Column	50	:	24	0.05		
			Radiation;	PBL	20	1	24	0.02		
			Ozone-Climate	FT	50	I	24	0.02		
			(Absorption OD)	Total Column	50		24	0.02		
			Radiation (Aer Phase Fn)	PBL	20	I		0.1 (asymmetry)		
				FT	50	•	24	0.10		
			Radiation (Cirrus OD)	UT	100	1	24	50%		· · · · · · · ·
			Radiation (Cirrus Phase Fn)	UT	100	10	24	0.17		
	GCOS	GCOS Satellite	ECV Aerosol (Aer OD)	Total Column	F	1	24	0.01		0.005/decade
		Requirements	ECV Aerosol (Albedo)	Total Column	ł	1	24	0.02		0.015/decade
	NASA	US Dec Survey	Climate (Aerosol & Cloud)	Total Column	1	ŝ	72	ĩ	global	
	2									1
Air Quality	GMES	Post-EPS	AQ Forecast & Monitoring	PBL	20	U.	4	0.2245	global & regional	
Monitoring & Forecasting		Position Paper	Emissions; Aviation	FT	50	ı	4	0.05		
			(Aerosol OD)	S	250	ო	4	0.05		
				Total Column	20	ł.	4	0.05		
			AQ Forecast & Monitoring	PBL	20		4	10%		
			Determination of PM val	Ŀ	50	I	4	10%		
			(Aerosol Type)	Total Column	20		4	10%		
	GCOS	GCOS Sat Req	ECV Aerosol	Trop Col	100	2				I
	NASA	US Decadal	Health (Aerosol Type)	Total Column	10	橋	4		global & regional	
		Survery	Tropospheric Weather	FT	:	0.2	ī	a)	global	
			Ch Weather (OD, Type)	FT	20	0.15	ä	1	global & regional	



Aerosol & Cloud





## 3 Current & Planned Missions

Missions targeting atmospheric composition have been in orbit over the last four decades. A number of missions are active currently and many under development. In this chapter current and planned missions, with instrumentation directly relevant to atmospheric composition, are collated.

A useful resource, covering Earth Observation missions and instruments in general, and including atmospheric composition, is

"The Earth Observation Handbook, Climate Change Special Edition 2008", <u>http://www.eohandbook.com/</u>, prepared for CEOS by ESA.

This provides information on missions including launch date and lifetime, instrument complement and programme status.

## 3.1 Missions with AC Instruments

Earth observation missions are planned and run by a number of organisations. A search for information, publically available on the internet, was carried out to determine, as best as possible, the current operations and the future plans of each agency. Basic data on missions and their atmospheric composition instruments, including orbit and time frame have been collected. Links to the source information and other relevant detail have been included where deemed appropriate.

## 3.1.1 NASA

The US programme of satellite missions is extensive and a link listing current NASA missions may be found at <u>http://www.nasa.gov/missions/current/index.html</u>. This includes links to most missions, including those relevant to observations for atmospheric composition; it also includes references to the operational NOAA missions. A similar (but not identical) list may be found at the GSFC site <a href="http://www.nasa.gov/centers/goddard/missions/index.html">http://www.nasa.gov/centers/goddard/missions/current/index.html</a>. This includes links to most missions, including those relevant to observations for atmospheric composition; it also includes references to the operational NOAA missions. A similar (but not identical) list may be found at the GSFC site <a href="http://www.nasa.gov/centers/goddard/missions/index.html">http://www.nasa.gov/centers/goddard/missions/current/index.html</a>.

The current NASA missions of relevance are Terra, <u>http://terra.nasa.gov/</u>, Aqua <u>http://aqua.nasa.gov/index.php</u>, Aura <u>http://aura.gsfc.nasa.gov/</u> and CALIPSO <u>http://www.nasa.gov/mission\_pages/calipso/main/index.html</u>. Future missions in the near timeframe include Glory, <u>http://glory.gsfc.nasa.gov/</u> and OCO, <u>http://oco.jpl.nasa.gov/</u>, due for launch by 2009.

These missions all form part of the "Afternoon Constellation", sometimes called the A-Train.

Longer timescale developments are currently following the recommendations of the NRC Decadal Survey, <u>http://www.nap.edu/catalog.php?record\_id=11820</u>. These





missions appear to be in early development at the current time. The missions with instruments targeting composition are ASCENDS, ACE, GEO-CAPE and GACM.

## 3.1.2 NOAA

NOAA is the agency responsible for operational observations in the US. General information on its programme of mission may be found at <u>http://www.nesdis.noaa.gov/satellites.html</u>.

The agency runs geostationary and polar orbiting missions under its GOES and POES programmes outlined at <u>http://noaasis.noaa.gov/NOAASIS/ml/genlsatl.html</u>.

In terms of atmospheric composition only the POES programme is of relevance directly, <u>http://goespoes.gsfc.nasa.gov/poes/index.html</u>.

Starting with NOAA-18, the POES platforms and the European MetOp series of EUMETSAT are operated in coordination, to provide low Earth orbit data with good temporal frequency, primarily for meteorological applications.

Details for the future of the POES programme, called NPOESS, are uncertain. The NPOESS Preparatory Project (NPP) is under way, <u>http://jointmission.gsfc.nasa.gov/;</u> the following missions are still under development at this time, <u>http://www.ipo.noaa.gov/</u>.

## 3.1.3 ESA

General information on European Space Agency (ESA) missions can be found at <u>http://earth.esa.int/missions/</u>.

Current missions directly relevant to atmospheric composition are ERS-2 (<u>http://earth.esa.int/ers/</u>), including the GOME-1 and ATSR-2 instruments, and Envisat (<u>http://envisat.esa.int/</u>), with MIPAS, SCIAMACHY, GOMOS and AATSR.

Planned programmes include the GMES Sentinel missions being carried forward with the European Union and EUMETSAT. Details for the GMES programme can be found at <u>http://www.esa.int/esaLP/LPgmes.html</u>. The full details of payloads are still under development at the present time but in terms of atmospheric compositions the most relevant missions are Sentinels 4 and 5, designed to target composition form GEO and LEO orbits, and Sentinel 3 which follows the ATSR instrument heritage and is therefore likely to have some cloud and aerosol capabilities of relevance.

ESA's other major Earth Observation initiative is the Earth Explorer programme. Missions now selected and under full development are listed at <u>http://www.esa.int/esaEO/SEM9JP2VQUD index 0 m.html</u>. The only mission targeting aspects of composition is EarthCARE, developed in conjunction with JAXA and targeting clouds and aerosols. The next round of future Earth Explorer missions





is still in the selection process and described at http://www.esa.int/esaLP/ESADQ0UHN6D LPfuturemis 0.html. There are currently 3 candidate missions with composition measurement potential, PREMIER, A-SCOPE and TRAQ.

## 3.1.4 EUMETSAT

EUMETSAT is the European organisation responsible for procuring and operation of operational satellites. The home page is http://www.eumetsat.int/.

A practical list of its current and planned satellite mission is given at http://www.eumetsat.int/Home/Main/What We Do/Satellites/index.htm?l=en.

The programmes relevant to atmospheric composition are the EUMETSAT Polar System (EPS) with its MetOp series of satellites. http://www.eumetsat.int/Home/Main/What We Do/Satellites/EUMETSAT Polar Syst em/index.htm?l=en and the Meteosat programme with the MSG (Meteosat Second Generation) series. http://www.eumetsat.int/Home/Main/What We Do/Satellites/Meteosat Second Gen eration/index.htm?l=en.

Technical details for these missions are also available at http://www.esa.int/esaLP/LPmetop.html and http://www.esa.int/SPECIALS/MSG/index.html

As mentioned in the NOAA programme section, POES and MetOp are operated in coordination.

## 3.1.5 Other Agencies

A number of other national programmes are relevant in the context of atmospheric composition measurement.

## 3.1.5.1 Sweden

The Swedish National Space Board is leading the Odin satellite project (http://www.snsb.se/eng odin intro.shtml and http://odin.ssc.se/). Future developments are currently part of the ESA PREMIER mission.

## 3.1.5.2 Canada

Canada's space agency, CSA, launched SCISAT in 2003 which include the ACE occultation instrument, http://www.space.gc.ca/asc/eng/satellites/scisat/default.asp. It is developing the SWIFT instrument which targets and ozone emission line but is focussed on determination of stratospheric winds, http://www.swift.yorku.ca/index.html.





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## 3.1.5.3 France

The French CNES agency currently has its PARASOL mission, <u>http://smsc.cnes.fr/PARASOL/</u>.

## 3.1.5.4 Japan

The Japanese Space Agency, JAXA, <u>http://www.jaxa.jp/index\_e.html</u>, is a major partner in ESA's EarthCARE mission and is developing the GOSAT and GCOM-C missions, both relevant to atmospheric composition.

GOSAT http://www.jaxa.jp/projects/sat/gosat/index e.html,

http://www.gosat.nies.go.jp/eng/proposal/proposal.htm,

GCOM-C

http://www.jaxa.jp/projects/sat/gcom/index e.html.

## 3.1.5.5 China

The China Meteorological Administration, CMA, <u>http://www.cma.gov.cn/english/</u>, operates the Meteorological Satellite Program of China and covers both polar orbiting and geostationary series with its "Feng-Yun" satellites (abbreviated as FY). The polar orbiting missions are odd numbered e.g. FY-1, FY-3, and the geostationary platforms are designated with even numbers, FY-2 and upwards.





## 3.2 Mission Summaries

Information on the missions outlined in the previous section is collated at the end of this section in Table 3-2, for current missions, and Table 3-3 (a), for those planned.

Parameters listed include mission name, operating agency, orbit type and relevant position/equator-crossing time, lifetime (including planned extensions), and instrument name and type for AC instruments.

Orbits are distinguished as either low-Earth (LEO) or geostationary (GEO) and additional information provided as appropriate, e.g. equator crossing times for sun-synchronous (SS) LEO orbits, longitude for GEO orbits.

Instrument types have been classed into 9 basic groupings, with 5 nadir (or nearnadir) and 4 limb types. Solar occultation measurements, although measuring in limb geometry, are handled separately to "standard" limb instruments because of the different type of geographical coverage that they provide. They are listed in Table  $3-1.^1$ 

Instrument Type	Abbreviation
Nadir	
Infrared	IR
UV-Visible and/or Near-Infrared	UVN
Lidar	Lidar
Multi-Angle Polarimeter	MAP
Imager	Imager
Limb	
Infrared	IR
Millimetre/Sub-Millimetre	MM
UV-Visible and/or Near-Infrared	UVN
Solar Occultation	Occultation

Table 3-1: Instrument Types and Abbreviations

<sup>&</sup>lt;sup>1</sup> Cross-references to instrument types assigned in the WMO study *"Gap Analysis",* by B. Bizzarri, WMO, 2<sup>nd</sup> Workshop on the Re-Design and Optimisation of the Space-Based GOS, Geneva, Switzerland, 21-22 June 2007, OPT2/Doc. 5 (11.VI.2007) are listed in Appendix A of this report.





### **Current AC Mission Summary**

Mission	Agency	Orbit		Lifetime		AC Instr	uments
Name(s)		Type / Eq Crossing	Mission Start	Nominal End	Extended End	Name	Туре
		Equipositing	Start	Ellu	Eliu		
Existing Missio	ons						
Aqua	NASA	LEO SS 13:30	2002	2007	2011	AIRS MODIS	IR nadir Imager
Terra	NASA	LEO SS 10:30	2000	2005	2011	MOPITT MODIS	IR nadir Imager
Aura	NASA	LEO SS 13:45	2004	2009	2013	MLS OMI TES HIRDLS	MW limb UVN nadir IR nadir IR limb
CALIPSO	NASA	LEO SS 13:30	2006	2009		CALIOP	Aerosol-lidar
ERS-2	ESA	LEO SS 10:30	1995	1998	2010	GOME-1 ATSR-2	UVN nadir Imager
ENVISAT	ESA	LEO SS 10:00	2002	2007	2010	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager
NOAA-15	NOAA	LEO SS 09:30	1998	2000	2008	AVHRR-3	Imager
NOAA-16	NOAA	LEO SS 13:30	2001	2003	2008	AVHRR-3 SBUV-2	lmager UVN nadir
NOAA-17	NOAA	LEO SS 09:30	2002	2004	2008	AVHRR-3 SBUV-2	lmager UVN nadir
NOAA-18	NOAA	LEO SS 13:30	2005	2008	2011	AVHRR-3 SBUV-2	lmager UVN nadir
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	2007	2011		GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	2002	2011		SEVIRI	Imager
MSG-2 Meteosat-9	EUMETSAT	GEO 0 lon	2005	2014		SEVIRI	Imager
Odin	SNSB	LEO SS 06:00	2001	2003	2009	SMR OSIRIS	MW limb UVN nadir
SCISAT	CSA	LEO	2003	2005	2009	ACE	Occultation
PARASOL	CNES	LEO SS 13:30	2004	2006	2007	Polder	MAP
FY-3A	СМА	LEO SS 10:10	2008	2011		VIRR TOU/SBUS	lmager UVN nadir

Table 3-2: Current Missions relevant to Atmospheric Composition



## Planned AC Mission Summary

Mission	Agency	Orbit		Lifetime		AC Instruments			
Name(s)		Type / Eq Crossing	Mission Start	Nominal End	Extended End	Name	Туре		
Planned Missio	ns								
Glory	NASA	LEO SS 13:30	2009	2012		APS	MAP		
осо	NASA	LEO SS 13:20	2009	2011		NIR Spectrometer	CO2 NIR nadir		
ASCENDS	NASA	LEO SS	2013	2016		Lidar	CO2-lidar		
GEO-CAPE	NASA	GEO 280 Ion	2016	2019		UVN Spectrometer IR Spectrometer	UVN nadir IR nadir		
ACE	NASA	LEO SS ~13:30	2013	2016		Lidar Polarimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir		
GACM	NASA	LEO SS	2017	2020		UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MW limb		
Sentinel-3 [A-C]	ESA	LEO SS ~10:00	2012	2026		SLSTR OCLI	lmager Imager		
Sentinel-4 [A-B]	ESA	GEO 0 lon	2017	2032		IR Spectrometer UVN Spectrometer	IR nadir UVN nadir		
Sentinel-5 prec	ESA	LEO SS ~10:00	2014	2020		IR Spectrometer UVN Spectrometer	IR limb UVN nadir		
Sentinel-5	ESA	LEO SS ~10:00	2020	2027		UVN Spectrometer	UVN nadir		
EarthCARE	ESA-JAXA	LEO SS 10:30	2013	2016		ATLID MSI	Aerosol-lidar Imager		
A-SCOPE	ESA	LEO	2015	2018		Lidar	CO2-lidar		
PREMIER	ESA-SSC	LEO SS 10:30	2015	2018		IMIPAS STEAM-R	IR limb MW limb		
TRAQ	ESA	LEO not SS	2015	2018		UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP		

 Table 3-3 (a): Planned Missions relevant to Atmospheric Composition





Mission	Agency	Orbit		Lifetime	AC Instruments			
Name(s)		Type / Eq Crossing	MissionNominalExtendedStartEndEnd			Name	Туре	
Planned Missi	ons							
NOAA-N'	NOAA	LEO SS 13:30	2009	2015		AVHRR-3 SBUV-2	lmager UVN nadir	
NPP	NOAA	LEO SS 10:30	2010	2014		OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LEO SS 13:30	2013	2017		OMPS VIIRS	UVN nadir IR nadir	
NPOESS-2	NOAA	LEO SS 13:30	2018	2022		OMPS VIIRS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	2011	2016		GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	2015	2020		GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ion	2011	2017		SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 lon	2013	2019		SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	2011	2016		SWIFT	O3 IR limb	
GOSAT	JAXA	LEO SS 13:00	2008	2013		TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	2013	2018		SGLI	UVN nadir	
FY-3 [B-G]	СМА	LEO SS	2009	2018		VIRR TOU/SBUS	lmager UVN nadir	
FY-4 O/ [A-E]	CMA	GEO	2013	2024		MCSI	Imager	

#### NOTES

Instrument names are placeholders and may be subject to modification
 Future programmes are subject to development and change

Table 3-3 (b): Planned Missions relevant to Atmospheric Composition





## 3.3 Measurement Capabilities by Type

Information on atmospheric composition instrumentation has been collated and classed in types. In order to reference mission measurements to requirements the capabilities of each type of instrument and measurement technique have been identified.

The contribution of measurement techniques have been specified using the terms: significant, partial, and none. These terms are defined as:

significant	meets a significant number of the requirement characteristics
partial	makes measurements of target and may meet some or none of the characteristics (still likely to be useful in an integrated sense e.g. with use of modelling, assimilation)
none	makes no useful measurements

Tables have been generated for each of the 3 application areas and all products, as specified under "Distilled Requirements" in section 2.2. The tables are shown below.

#### Application : Ozone Layer

Products	Measurement Technique									
	Nadir				Limb			Occultation		
	IR	UVN	Lidar	MAP	Imager	IR	MM	UVN		
H2O O3										
CH₄										
HNO3 N2O										
CO CO2										
CIO BrO										
HCI NO2										
HDO										
CH <sub>2</sub> O Aerosol/Cloud										
		1			I I			1		
Contribution :			none	pa	rtial	signific	ant			

Table 3-4: Contribution of Measurement Types to Ozone Layer Requirements



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Application : Composition-Climate

Products	Measurement Technique										
	Nadir Limb									C	Occultation
	IR	UVN	Lidar	MAP	Imager		IR	MM	UVN		
H2O											
O3											
CH₄											
HNO₃											
N2O											
co											
CO <sub>2</sub>											
NO <sub>2</sub>											
HDO											
SF <sub>6</sub>											
Aerosol/Cloud											
	•				•						•
									1		
Contribution :	Contribution :		none	none partial			signific				

#### Table 3-5: Contribution of Measurement Types to Composition-Climate Requirements

Application : Air Quality

Products	Measurement Technique									
	Nadir				Limb		Occultation			
	IR	UVN	Lidar	MAP	Imager	IR	MM	UVN		
H₂O										
O3										
HNO <sub>3</sub>										
CO										
NO <sub>2</sub>										
N2O5										
SO <sub>2</sub>										
CH <sub>2</sub> O										
PAN										
VOCs										
Aerosol/Cloud										
<u>-</u>	•	•				•	•		<u> </u>	
								-		
Contribution :			none	ра	rtial	signific	ant			

Table 3-6: Contribution of Measurement Types to Air Quality Requirements





The classification applied to the contribution of measurement type to requirements is inevitably subjective and, in this case, also rather general in that it is intended to represent "typical" performances. As technologies evolve the contribution level is likely to change and these classifications will require re-evaluation.





# 4 Gap Analysis

#### 4.1 Approach

In comparing the application requirements with current and planned measurements to produce a "gap analysis" a number of aspects come into consideration.

Specifically, for a single instrument, the following questions arise:

- 1) How do measurements address application requirements on an individual basis such as atmospheric profiles or columns?
- 2) What geographical and temporal coverage are the measurements able to provide?

For example, limb-sounding typically provides good vertical resolution but is limited in its achievable horizontal resolution, whilst nadir sounding can access fine horizontal scales but are generally limited in distinguishing vertical structure unless an active sensor (e.g. radar, lidar) can be employed.

Low-Earth orbit (LEO) based instruments are able to provide good global coverage but have revisit times of several days. Geostationary missions on the other hand are designed to provide a high sampling interval, but cannot provide global coverage with a single platform. Solar occultation instruments, flown on LEO platforms, produce sparsely spaced data but may provide useful information where good accuracy and high sensitivity are required and geographical coverage is not a driver.

Other considerations include the number of missions to provide coverage and redundancy, the mission timescales both launch and duration.

The following analysis considers the application areas in turn and each of the measurement products individually. As a first step, the quality of the measurements from single instruments is examined and any general gaps in potential data availability highlighted. Then, sampling and revisit times required are considered and contrasted with the number of useful sensors which might be available and how this varies with time.

Tables have been produced for all cases where some useful measurements are expected. They are shown towards the end of the chapter in section 4.5 and use the same indicators and shading as used in the assignments of capabilities by measurement type i.e. the terms **significant**, **partial** and **none**, colour-coded appropriately.

The analysis covers each "Application Area" in turn, dealing with all the products for each area as indicated in Table 2-3 (chapter 2), which shows product requirements by application and programme.





## 4.2 Ozone Layer and Surface UV Monitoring and Forecasting

## $H_2O$

- Many measurements providing partial contributions, with instruments meeting either vertical or horizontal resolution requirements
- No strong sampling or revisit time requirements
- Good overlap of current and planned missions
- No gaps up to ~2020

#### **O**3

- Many measurements, with limb MW and IR covering requirements most effectively; nadir instrumentation also provides useful input
- No strong sampling or revisit time requirements
- Reasonably good overlap of current and planned missions
- No gaps up to ~2020

#### CH<sub>4</sub>

- Requirements are minor and are partially satisfied by IR-limb and occultation measurements
- Little redundancy currently and none in planned missions
- Potential gaps in ~2014 and ~2019

### HNO<sub>3</sub>

- Requirements covered by limb IR and MW instrumentation, with occultation sensors also providing relevant input
- Currently there is adequate coverage, but a potential gap ~2014 and low redundancy after ~2020

## $N_2O$

- Requirements are minor and are partially satisfied by IR and MW limb, as well as occultation sensors
- Little redundancy in period ~2013-14 and ~2019 onwards

## CO

- Requirements are minor and are partially satisfied many instrument types including limb and nadir sensors and all major wavelength ranges
- Good overlap between current and planned missions and significant redundancy
- No gaps up to at least 2020





### 

- Requirements are minor and are met by future lidar and NIR sensors. Many instrument types partially meet requirements including limb, nadir and occultation sensors at all major wavelength ranges
- Good overlap between current and planned missions and significant redundancy.
- No gaps up to ~2020

#### CIO

- MW limb sounding measurements are able to meet the requirements which have no major sampling or revisit time aspects.
- There is a low level of redundancy with reliance on single missions in parts of the timescale to 2020
- Potential gap in ~2014

#### BrO

- Requirements are only partially met by MW limb sounding techniques
- There is a low level of redundancy with reliance on single missions in parts of the timescale to 2020
- Potential gap in ~2014

#### HCI

- MW limb sounding measurements are able to meet the requirements which have no major sampling or revisit time aspects.
- There is a low level of redundancy with reliance on single missions in parts of the timescale to 2020
- Potential gap in ~2014

#### NO<sub>2</sub>

- Only IR limb measurements provide a significant contribution towards the requirements. UVN and occultation instrumentation provide partial contributions
- Few IR limb sensors exist in the mission plans and there is little redundancy as well as a measurement gap in year 2014
- There are multiple UVN nadir sensors providing good redundancy for their contributions

### HDO

- The requirements are minor and well met by IR nadir instrumentation which has good redundancy with no gaps apparent to 2020
- Limb MW and IR sensors are also able to provide partial contributions





## 

• The requirements are minor but only partially met by available instrumentation with UVN nadir and IR and MW limb providing good coverage up to 2020

### Aerosol & Cloud

- The requirements are well met by imager data and measurements from dedicated lidar and MAP (polarimeter) instruments. Other instrumentation is able to make partial contributions.
- Good redundancy throughout time frame to 2022
- No gaps evident

## 4.3 Composition-Climate Interaction

## $H_2O$

- Many measurements available, with IR and MW limb making significant contributions and a number of techniques, including nadir sensors and occultation measurements, contributing partially
- There are some important revisit time requirements, including 12 and 3 hrs, which are impossible to meet without multiple missions if global coverage is required
- Multiple mission coverage for current missions, thinning slightly in 2012-2015, then more missions again in the period 2015-20
- Sampling too sparse throughout to meet most stringent revisit time requirements

## **O**<sub>3</sub>

- MW and IR limb measurements contribute significantly, nadir measurements and occultation partially meet requirements
- GCOS requires a revisit time of 3 hrs, which is impossible without multiple missions for global coverage
- Multiple coverage for current and planned mission to 2020, however if revisit times are to be met and night time measurements are required there are significant gaps in orbit coverage

### CH<sub>4</sub>

- IR limb observations contribute significantly to the requirements, with occultation making a partial contribution
- GCOS requires a revisit time of 3 hrs, for column measurements, which is impossible without multiple missions for global coverage
- Few missions, likely gaps in ~2014 and ~2019, little redundancy and sampling too sparse throughout to meet most stringent revisit time requirements







### HNO<sub>3</sub>

- Requirements covered by limb IR and MW instrumentation, with occultation sensors also providing relevant input
- Mission coverage generally sufficient, however a potential gap in ~2014

### N<sub>2</sub>O

- Requirements are well covered by limb IR and MW instrumentation, with occultation also contributing
- A gap is indicated in ~2014 and there is little or no redundancy

#### CO

- Requirements are well covered with nadir IR and UVN, as well as MW limb sensors.
- Good mission coverage with redundancy and no apparent gaps to beyond 2020

## $CO_2$

- Requirements only partially met by the available instrumentation which consists of a number of UVN nadir instruments and the planned deployment of lidar and specialised NIR instruments
- GCOS requires a revisit time of 3 hrs, for column measurements, which is impossible without multiple missions for global coverage
- There is good mission coverage though a 3 hr revisit time is not evident in a consistent manner, day and night

#### NO<sub>2</sub>

- Requirements significantly addressed by UVN nadir sensors, with IR limb making a partial contribution
- Good mission coverage and redundancy to beyond 2020 •

### HDO

- Requirements covered by limb IR and MW instrumentation, with occultation sensors also providing relevant input
- Mission coverage generally sufficient, however a potential gap in ~2014

## SF<sub>6</sub>

- IR limb observations contribute significantly to the requirements, with occultation making a partial contribution
- Few missions and little or no redundancy, a likely gap in ~2014







## Aerosol & Cloud

- The requirements are varied in terms of specific product type and some aspects can only be derived from dedicated instruments such as MAP (polarimeter) and lidar
- Broadly, the requirements are well met by imager data and measurements from dedicated lidar and MAP instruments
- Good redundancy throughout time frame to 2022
- No gaps evident

### 4.4 Air Quality Monitoring and Forecasting

### $H_2O$

- Many measurements available, but only nadir IR sensors providing a significant contribution, with a number of techniques contributing partially including UVN-nadir, IR and MW limb
- Temporal sampling of 4 hours is a driving requirement for GMES requiring multiple missions
- Multiple mission coverage currently, thinning slightly in 2012-2015, then more missions again in the period 2015-20
- Sampling provided is marginal for requirements

#### **O**<sub>3</sub>

- UVN nadir measurements provide a significant contribution to the requirements, with several other techniques contributing including IR limb and nadir, MW limb, and occultation
- Temporal sampling of 4 hours is a driving requirement for GMES requiring multiple missions
- There is good multiple mission coverage but sampling provided marginal and inadequate if day and night coverage is required

### HNO<sub>3</sub>

- Requirements are partially covered by IR limb and occultation sensors
- Temporal sampling of 4 hours is a driving requirement for GMES requiring multiple missions
- Mission coverage does not cover sampling requirements and is particularly sparse in the period ~2012-14 with little or no redundancy





### СО

- IR and UVN nadir measurements are able to significantly contribute to the requirements, with MW limb making a partial contribution
- GMES has a 4 hour sampling requirement but even more stringent is a Decadal Survey requirement of ~1 hour, though with only relevant regional coverage required
- There is good multiple mission coverage up to ~2020 but sampling provided may be marginal if day and night coverage is required

#### NO<sub>2</sub>

- UVN nadir measurements are able to significantly contribute to the requirements, with IR limb making a partial contribution
- GMES has a 4 hour sampling requirement; the Decadal Survey has a more stringent requirement of ~1 hour, though only for relevant regional areas
- There is good multiple mission coverage up to ~2020 but sampling provided may be marginal and inadequate if day and night coverage is required

## $N_2O_5$

- IR limb is the sole measurement technique to make a contribution to requirements and addresses these only partially
- There is a 4 hour sampling requirement from GMES which would require multiple missions to achieve global coverage
- There are few current or planned missions to cover this, providing little or no redundancy and no scope for achieving the sampling requirements

## SO<sub>2</sub>

- UVN nadir measurements are able to significantly contribute to the requirements
- GMES has a 4 hour sampling requirement but even more stringent is a Decadal Survey requirement of ~1 hour, though with only relevant regional coverage required
- There is good multiple mission coverage up to ~2020 but sampling provided would be insufficient if day and night coverage is required

## CH<sub>2</sub>O

- IR limb, UVN nadir and occultation sensors all make partial contributions to the requirements
- GMES has a 4 hour sampling requirement, the Decadal Survey has a requirement of ~1 hour, though with only relevant regional coverage required
- There is good multiple mission coverage up to ~2020 but sampling provided may be marginal and inadequate if day and night coverage is required







#### PAN

- IR limb is the sole measurement technique to make a contribution to requirements and addresses these only partially
- There is a 4 hour sampling requirement from GMES which would require multiple missions to achieve global coverage
- There are few current or planned missions to cover this, providing little or no redundancy and no scope for achieving the sampling requirements

### VOCs

- IR and UVN nadir measurements are able to significantly contribute to the requirements, with IR limb making a partial contribution
- GMES has a 4 hour sampling requirement; the Decadal Survey has a requirement of ~1 hour over limited regional coverage
- There is good multiple mission coverage up to ~2020 and good sampling provided though it would not meet the most stringent requirement if day and night coverage is required globally

## Aerosol & Cloud

- The requirements are varied in terms of specific product type and some aspects can only be derived from dedicated instruments such as MAP and lidar
- Broadly, the requirements are well met by imager data and measurements from dedicated lidar and MAP (polarimeter) instruments, with a number of other sensors contributing
- There is a 4 hour sampling requirement from GMES which would require multiple missions to achieve global coverage
- Good redundancy throughout time frame to 2022
- No gaps evident





### 4.5 Analysis Tables

Tables follow for each application area:

- 1. Ozone layer and surface UV monitoring and forecasting
- 2. Composition-climate interaction
- 3. Air quality monitoring and forecasting

They are intended to summarise the contributions of instruments and missions and how they fit into the timescale of the next two decades or so.





# 4.5.1 Ozone Layer and Surface UV Monitoring and Forecasting







Applie         Applie<	Species					
	cation					none
Approv         Old         Approv         Other         Approv         Other         Approv         Not         Stort         Stort <th< th=""><th></th><th>10000000</th><th>10000</th><th>10.202 (J</th><th>10.00 000 00.000 00.000</th><th></th></th<>		10000000	10000	10.202 (J	10.00 000 00.000 00.000	
The late	uu	Agency	Orbit		nstruments	Timeline
MISA         LEO         AIRS           MISA         LEO         MODIS           MISA         LEO         MODIS           MISA         LEO         MODIS           MISA         LEO         MODIS           MISA         SS 10:30         MODIS           MISA         SS 10:30         MODIS           MISA         LEO         MISA           SS 13:30         CALIDP         MISA           ESA         LEO         ATSR-2           NASA         LEO         ATSR-2           NASA         SS 10:30         ATSR-2           NOAA         SS 10:30         ATHRR-3	(8)		Type / CEq		Type	2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
MASA         LEO         MODIT           NASA         LEO         MODIS           NASA         SS 10:30         MODIS           NASA         LEO         MILIS           NASA         LEO         MILIS           NASA         LEO         MILIS           BSA         LEO         MILIS           PIRDLS         SS 13:30         CALIDP           ESA         LEO         ATSR-2           NOAA         SS 10:300         ATSR-2           NOAA         SS 10:300         ATSR-2           NOAA         SS 10:300         ATSR-2           NOAA         SS 10:300         ATSR-2           NOAA         SS 0:300         ATHR-3           SS 0:300         SUV-2         SUV-2           NOAA         SS 0:300         SUV-2           SS 0:300         SUV-3         SUV-3           SS 0:300         SS 0:300         SUV-3 <td></td> <td>NASA</td> <td>LEO SS 13:30</td> <td>AIRS MODIS</td> <td>IR nadir Imager</td> <td></td>		NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
MASA         LEO         MLS           NASA         LEO         MLS           SS 13,45         SS 13,45         CMII           ESA         LEO         COME-1           NCAA         LEO         ATTSR-           NCAA         LEO         ATTSR-           NCAA         LEO         ATTSR-           NCAA         LEO         ATTSR-           NCAA         SS 03-30         ATTSR-           NCAA         SS 03-30         SBUV-2           NCAA         SS 03-30         SBUV-2           NCAA         SS 03-30         SBUV-2           EUMETSAT         LEO         SBUV-2           SUSS         SUV-3         SBUV-2           CAA         SS 03-30         SBUV-2           SUSS         Obm         SBUV-2           CUMETSAT         CEO         SEV/161           SUSS         SS 05:00         COME-2           SUSS         SS 05:00         COME-2           SUSS		NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
MASA         LEO         CALIOP           ESA         LEO         ATSR-2           ESA         SS 10:30         ATSR-2           ESA         SS 10:30         ATSR-2           ESA         LEO         ANTRR-2           ESA         SS 10:30         ATSR-2           MOAA         LEO         AVHRR-3           NOAA         SS 13:30         SBUV-2           NOAA         LEO         AVHRR-3           NOAA         SS 13:30         SBUV-2           SS 13:30         SBUV-2         SBUV-2           NOA         SS 13:30         SBUV-2           SS 13:30         SBUV-2		NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MW Itmb UVN nadir IR nadir IR Itmb	
ESA         LEO         COME-1           ESA         LEO         ATSR-2           ESA         SS 10:00         ATSR-2           SS 10:00         ATSR-2         SS 10:00           MPAS         SS 10:00         ATSR-2           NCMA         LEO         AVHRR-3           NCMA         SS 09:30         SBUV-2           NCMA         LEO         SBUV-2           NCMA         LEO         AVHRR-3           BLWETSAT         LEO         SBUV-2           ST 13:30         SBUV-2         SUVR-2           ST 13:30         SUVR-2         SUR-2           ST 13:50         SEVR-2         SUR-2           ST 13:50         SUR-2         SUR-2           ST 10:10         TOU-1 <td< td=""><td>0S</td><td>NASA</td><td>LEO SS 13:30</td><td>CALIOP</td><td>Aerosol-lidar</td><td></td></td<>	0S	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
EA         LEO         SCIAMACHY SS 1000         SCIAMACHY AT SR AGNOS           NCMA         SS 1000         MIRTS ANHR 3         MIRTS ACMAS           NCMA         LEO         AVHRR 3           NCMA         SS 03-30         SUV 2           LUMETSAT         LEO         AVHRR 3           LUMETSAT         GEO         SEVIRI           LUMETSAT         GEO         SEVIRI           ST 33         O.bm         SEVIRI           CMA         ST 33         O.bm           ST 33         O.bm         SEVIRI           CMA         ST 33         O.bm           ST 33         O.bm         CMAR 3           CMA         ST 33         O.bm           ST 34         O.bm         CAGE           CMAR 3         ST 34         CAGE           ST 34         O.bm         CAGE           CMA         ST 34         CAGE           CMA		ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
NCMA         LEO         AVHRR.3           NCMA         LEO         SS 09300         AVHRR.3           NCMA         LEO         SS 11330         SBUV.2           NCMA         LEO         SBUV.2         SURR.3           NCMA         LEO         SBUV.2         SBUV.2           NCMA         LEO         SBUV.2         SBUV.2           NCMETSAT         LEO         SBUV.2         SBUV.2           EUMETSAT         LEO         SBUV.2         SBUV.2           EUMETSAT         LEO         SBUV.2         SBUV.2           STISJG         SBUV.2         SBUV.2         SBUV.2           EUMETSAT         LEO         SEVIRI         SEVIRI           STISJG         Obm         SEVIRI         SEVIRI           CMA         STISJG         SEVIRI         SEVIRI           STISJG         Obm         STISJG         SURI           CMA         LEO         SMR         SCIAR         STIRS           CMA         STISJG         PUMAR         STIRS         STIRS	AT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occuttation Imager	
NCMA         LEO         AVHRR3           NCMA         LEO         SS 13:30         SBUV-2           NCMA         SE 69:30         SBUV-2         SBUV-2           NCMA         LEO         SBUV-2         SBUV-2           NCMA         LEO         SBUV-2         SBUV-2           NCMA         LEO         SBUV-2         SBUV-2           EUMETSAT         LEO         SBUV-2         MVHRR-3           EUMETSAT         GEO         SEVIFI         SEVIEI           EUMETSAT         GEO         SEVIFI         SEVIEI           SNSB         LEO         SEVIEI         COMR           SNSB         SS 13:30         CSHRIS         SS 13:30           CMA         LEO         SS 13:30         CSHRIS           CMA         LEO         POMAR         CMAR           CMA         SS 10:10         TOURSBUS         CMAR	ŧ	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NCMA         LEO         AVHRP.3           NCMA         LEO         AVHRP.3           NCMA         LEO         AVHRP.3           NCMA         LEO         AVHRP.3           BUV.2         S13:30         SBUV.2           BUMETSAT         LEO         SBUV.2           EUMETSAT         LEO         COME.2           BUMETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           SNUSB         LEO         SEVIRI           SNUSB         SS 06:00         CORFIS           CAME         LEO         AVER           CMA         LEO         MAR.3           CMA         SS 10:10         TOWISBUS	4	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NCMA         LEO SS 13:30         AWHRP.3 SU/V.2           EUMETSAT         LEO SS 09:30         GU/K.2 AWHRP.3           EUMETSAT         CGO SS 09:30         GO/K.2 AWHRP.3           EUMETSAT         CGO SS 09:00         SE VIRI           SNSB         LEO Obm         SE VIRI           SNSB         LEO Obm         SIRIS           CAS         LEO A/CE         CMR           CMA         LEO POMM         MAR           CMA         LEO VIRB         PUMM	12	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT LEO GOME-2 SS 09:30 AVAIRA-3 ELUMETSAT GEO SEVIRI UMETSAT GEO SEVIRI 0 ban Seviri 0 ban Seviri 0 ban SPIS CSA LEO SMAR CMA LEO POMAr CMA ST 10:10 TOUSBUS	18	NOAA	LEO SS 13:30	AVHRR.3 SBUV-2	Imager UVN nadir	
EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI 0 Ion SNSB LEO SMR SS 05:00 OSIRIS CAA LEO AJCE CMA LEO Polder CMA SS 10:10 TOUISBUS	40	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
EUMETSAT GEO SEVIAI SVSB LEO SMA SS 06:00 CSIAIS CSA LEO AGE CNES LEO POMar CMA LEO VIAR SS 10:10 TOURSUS	sat-B	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
SVSB LEO SMR SS 05:00 CSFIRS SS 05:00 CSFIRS CSA LEO POMer OL CNES LEO POMer CMA LEO VIER SS 10:10 TOURSUS	sat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
C CSA LEO ACE OL CNES LEO Polder SS 13:30 CMA LEO VIER SS 10:10 TOUISBUS		SNSB	LEO SS 06:00	SMR OSIRIS	MWV limb UVN radir	
OL CNES LEO Polder SS 13:30 Polder CMA LEO VIER SS 10:10 TOU'SBUS	F	CSA	LEO	ACE	Occultation	
CAMA LEO VIER SS 10:10 TOU/SBUS	SOL	CNES	LEO SS 13:30	Polder	MAP	
		CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-1: H<sub>2</sub>O Measurements from Current Missions for Ozone Layer Requirements





H2O

Species



Mission Mission AsCENDS asCENDS asCENDS ascintrate ASCENDS accurate accurat	Agency Nasa Nasa Nasa Nasa Nasa Nasa Nasa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa	Othit         Othit           1, type / left Co         0           1, type / left Co         55 (1320)           15 (14) Co         0           16 (14) Co         0           17 (14) Co         1           16 (14) Co         1           17 (14) Co         1           16 (14) Co         1           17 (14) Co         1           18 (14) Co         1           19 (14) Co         1	AC Instruments           APS         Amm           APS         MMP           APS         MMP           NIR Spectrometer         CO2181           Uddre         CO2181           UMN Spectrometer         UMN spectrometer           PUNN Spectrometer         UMN spectrometer           UNN Spectrometer         UMN spectrometer           PUNN Spectrometer         UMN spectrometer           UNN Spectrometer         UMN spectrometer           Rissertometer         UMN spectrometer           Rissertometer         UMN spectrometer           Rissertometer         UMN spectrometer           UNN Spectrometer         UMN spectrometer           Rissertometer         UMN spectrometer           Rissertometer         UMN spectrometer           Mill         UNN spectrometer           UNN spectrometer         UMN spectrometer           UNN spectrometer         UMN spectrometer           Mill         MM           STEAULAR         MMI           Mill         MMI           Mill         MMI           MILLID         MMI           MILLID         MMI           MILLID         MMI           MILLID <th>Type Type MAP MAP Type CO2 NR nodir MAP CO2 NR nodir NA nodir NA nodir NN NN nodir NN NN nodir NN NN NN</th> <th>Controlion:  Tende Tende</th>	Type Type MAP MAP Type CO2 NR nodir MAP CO2 NR nodir NA nodir NA nodir NN NN nodir NN NN nodir NN NN	Controlion:  Tende
Meteocat-10 MSG-4 Meteocat-11			SEVIRI	Imager	
Chinook	CSA		SWIFT	C8 IR limb	
GOSAT GCOM-C	ЛАХА		TANSO-FTS TANSO-CAI SGLI	IR nadir İmager UVN nadir	
FY-3 (B-G) FY-4 O/ (A-E)		LEO SS GEO	VIRR TOU/SBUS MCSI	Imager UNN nadir Imager	
		J		P	

Table 4-2: H<sub>2</sub>O Measurements from Planned Missions for Ozone Layer Requirements





Mathematical stateMathematical stateMathematical stateMathematical stateMathematical stateMathematical state $1 \times 1 \times$	Species Application	03 Ozone Layer				Contribution : none partial significant	
Motion         Other         Contrasted         Image $1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -$							
Turket         Turket<		Agency	Orbit	AC I	Instruments	Timeline	
			Type / Eq		Type		
MASN         LEO         AIRS           NASN         LEO         MODIS           NASN         SS 10.30         MODIS           NASN         LEO         MCH           NASN         SS 13.46         MLS           NASN         SS 13.46         MLS           NASN         SS 13.46         MLS           NASN         SS 13.46         MLS           NASN         SS 13.46         CALIOP           SS 13.30         CALIOP         SS 13.45           SS 13.30         CAMASN         SS 13.30           EBA         LEO         CAMASN           NDAA         SS 09.30         MHR.3           NDAA         LEO         AVHR.3           NDAA         SS 09.30         SUV-3           NDAA         SS 09.30         AVHR.3           NDAA         LEO         AVHR.3           NDAA         SS 09.30         SUV-3           SS 13.50         COME-1         SUV-3           SS 09.30         SUV-4         SUV-3           SS 09.30         SUV-4         SUV-3           SS 13.51         OA         SUV-3           SNS         SS 09.30         SUV-4						2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024	2026
MSA         LEO         MOPITI MOSA         LEO         MOPITI FIES           MSA         LEO         MODIS         MISA           MSA         LEO         MISA         FIEOS           MSA         LEO         MISA         FIEOS           MSA         LEO         CUIDP         MISA           MSA         LEO         CUIDP         MISA           MSA         SS 1330         CUIDP         MISA           MSA         SS 1030         ATSR2         MISA           MDAA         LEO         AVHRR3         MISAS           MDAA         LEO         MISAS         MISAS           MISAS         SS 1330         GOMS         MISAS           MISAS         SS 1330		NASA	LEO SS 13/30	AIRS MODIS	IR nadir Imager		
MSA         LEO         M.S.           MSA         LEO         M.S.           MSA         LEO         M.S.           MSA         LEO         COME.1           EBA         SS 13:30         COME.1           EBA         SS 10:30         ATSR.           EBA         LEO         COME.1           EBA         SS 10:30         ATSR.           NCMA         LEO         ATSR.           NCMA         LEO         ATSR.           NCMA         SS 0:300         ATSR.           NCMA         SS 0:300         ATSR.           NCMA         SS 0:300         SUV.2.           SS 0:300         SUV.2.         SUV.2.           SS 0:300         SUV.2.         SUV.2.           SS 0:300         SUV.2.         SUV.2.           SS 0:300         SUV.2.         SUV.3.           SS 0:300         SUV.2.         SUV.1.           SS 0:300         SUV.1.         SUV.1.		NASA	LEO SS 10:30	MOPITT	IR nadir Imager		
MSA         LEO         CULOP           ESA         LEO         GOME-1           ESA         SS 10:30         ATSR2           ESA         SS 10:30         ATSR2           ESA         SS 10:30         ATSR2           ESA         LEO         GOME-1           ESA         SS 10:30         ATSR2           ROMA         LEO         MPRR3           NOMA         LEO         AVHRR3           NOMA         LEO         AVHRR3           NOMA         SS 09:30         SBUV-2           NOMA         LEO         AVHRR3           NOMA         SS 09:30         SBUV-2           NOMA         SS 09:30         SBUV-2           NOMA         SS 09:30         SBUV-2           NOMA         SS 09:30         SBUV-2           NOMETSAT         GEO         SBUV-2           SNSB         EUMETSAT         GEO           SNSB         SS 05:30         SBUV-2           SNSB         SS 05:30         SUPHR9           SNSB         SS 05:30         SUPHR9           CM         GEO         SS 05:30           SNSB         SS 05:30         SUPHR9		NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MVV limb UVN nadir IR radir IR limb		
ESA         LEO         COME I SS 10:00         ATSR:2           ESA         LEO         ATSR:2         ATSR:2           NOAA         SS 10:00         ATSR:2         ATSR:2           NOAA         LEO         AVHRR:3         ATSR:2           NOAA         LEO         AVHRR:3         ANTSR:3           NOAA         SS 10:30         AWHR:3         ANHRR:3           NOAA         SS 10:30         AWHRR:3         ANHRR:3           NOAA         LEO         AVHRR:3         ANHRR:3           NOAA         SS 10:30         SBUY:2         ANHRR:3           NOAA         LEO         AVHRR:3         SBUY:2           NCAA         SS 10:30         SBUY:2         SBUY:2           NCAA         LEO         AVHRR:3         SBUY:2           NCAA         SS 10:30         SBUY:2         SBUY:2           NCAA         LEO         AVHRR:3         SBUY:2           EUMETSAT         GEO         SE VIEI         SS 10:30           SNSB         LEO         SS 10:30         SS 10:30           SNSB         SS 10:30         SS 10:30         SS 10:30           SNSB         SS 10:30         SSI 10:30         SS 10:30<	8	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar		
EA         LEO         SSUAMACHY SS 1000           NCMA         SS 1000         MIRAR ATAR AGNSS           NCMA         LEO         AWHRA3           NCMA         LEO         AWHRA3           NCMA         SS 09309         AWHRA3           NCMA         LEO         AWHRA3           NCMA         LEO         AWHRA3           NCMA         LEO         AWHRA3           NCMA         LEO         AWHRA3           BUW2         SBUV2         SBUV2           NCMA         LEO         AWHRA3           BUW2         SS 13309         SBUV2           BUWETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           CMA         SS 10300         CSHRA3           CMA         SS 10300         CSHRA3           CMA         COMEZ         SUMHRA3           BUMETSAT         GEO         SEVIRI           BUMETSAT         GEO         SEVIRI           CMA         SS 10300         CSHRA3           CMA         MURA3         SEVIRI		ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager		
NCMA         LEO         AVHRR.3           NCMA         LEO         SS 09300         AVHRR.3           NCMA         LEO         SE 11300         SEUV.2           NCMA         LEO         SE 017-2         SE 017-2           NCMA         LEO         SE 017-2         SE 017-2           NCMETSAT         LEO         AVHRR.3         SE 017-2           EUMETSAT         LEO         AVHRR.3         SE 017-2           ST 03-00         SE 017-2         SE 018-0         SE 018-0           ST 03-00         SE 018-0         SE 018-0         SE 018-0           SNSB         LEO         SE 018-0         SE 018-0           CMA         LEO         SE 018-0         CMAR           CMA         ST 03-10         TOUSBUS         SE 103-10	AT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Irrager Occultation Irrager		
NCMA         LEO         AVHRR-3           NCMA         LEO         AVHRR-3           NCMA         LEO         SEUV-2           NCMA         LEO         AVHRR-3           NCMA         LEO         AVHRR-3           NCMA         LEO         AVHRR-3           NCMA         LEO         AVHRR-3           EUMETSAT         LEO         AVHRR-3           EUMETSAT         GEO         SEVIRI           EUMETSAT         GEO         SEVIRI           SNSB         LEO         SEVIRI           SNSB         SS 10:010         SIRIS           SNSB         SS 10:010         SIRIS           CMA         LEO         AVHR-3           CMA         LEO         SIRIS           CMA         SS 10:10         TOUSBUS	5	NOAA	LEO SS 09:30	AVHRR-3	Imager		
NCMA         LEO         AVHRPR.3           NCMA         LEO         SS 09:30         SBUV.2           NCMA         LEO         SS 13:30         SHVRP.3           RUMETSAT         LEO         SBUV.2         SBUV.2           EUMETSAT         LEO         SBUV.2         SBUV.2           EUMETSAT         COME.2         SBUV.2         SBUV.2           EUMETSAT         CEO         SEVIRI         LEO           SNSB         LEO         SMRS         CSIRIS           CMES         LEO         CSIRIS         CSIRIS           CMES         SS 13:30         PMBR         CUMBR           CMA         LEO         VIRB         MAR	5	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	1	
NOJA         LEO         AVHRR-3           EUMETSAT         LEO         SEUV-2           EUMETSAT         LEO         GOME-2           EUMETSAT         CGO         SEVIFI           EUMETSAT         GEO         SEVIFI           EUMETSAT         GEO         SEVIFI           EUMETSAT         GEO         SEVIFI           BUNC         0.0m         SEVIFI           CAS         LEO         SMR           CSA         LEO         SMR           CMS         SS 13:00         OSIRIS           CMA         LEO         MR           CMA         LEO         MR	2	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir		
EUMETSAT LEO COMEZ SS 0930 MARAR3 EUMETSAT GEO SE VIRI EUMETSAT GEO SE VIRI 0 bin 0	18	NOAA	LEO SS 13:30	AVHRR.3 SBUV-2	Imager UVN nadir		
EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI BEUMETSAT GEO SEVIRI 0 ion SNSB LEO SMR CSA LEO SMR CSA LEO MAR SS 13:30 Polaior CMA LEO VIRP SS 10:10 TOU/SBUS	<b>A</b> 0	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər		
<ul> <li>EUMETSAT GEO SEVIAI</li> <li>Obia</li> <li>SNSB LEO SMR</li> <li>SNSB S0500 CSIRIS</li> <li>CSA LEO ACE</li> <li>CMA LEO Polor</li> <li>CMA LEO TOU/SBUS</li> </ul>	at-B	EUMETSAT	GEO 0 Ion	SEVIRI	Imager		
SVSB LEC SMR SS 96300 CSIRIS CSA LEO ACE SS 13300 Polder SS 13300 TOU/SBUS SS 10:10 TOU/SBUS	at-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager		
CSA LEO ACE CNES LEO Polder SS 13:30 Polder CMA LEO WRR SS 10:10 TOU/SBUS		SNSB	LEO SS 06:00	SMR OSIRIS	MWV limb UVN radir		
CNES LEO Polder SS 13:30 MBR CAM LEO VIRP SS 10:10 TOUISBUS		CSA	LEO	ACE	Occultation		
LEO VIER SS 10:10 TOU/SBUS	ы	CNES	LEO SS 13:30	Polder	MAP		
		CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir		

Table 4-3:  $O_3$  Measurements from Current Missions for Ozone Layer Requirements



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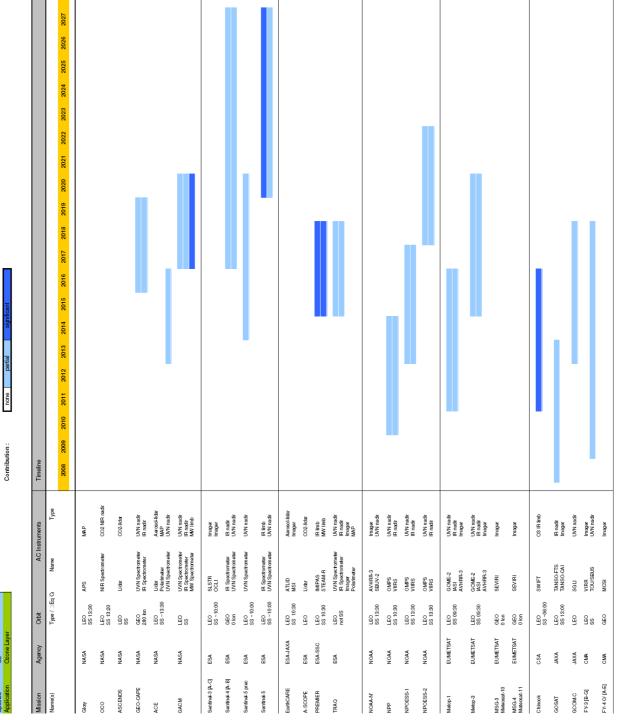


Table 4-4: O<sub>3</sub> Measurements from Planned Missions for Ozone Layer Requirements



monioe



Mitter         Appril         Activation	Species Application	CH4 Ozone Layer	L.			Contribution : none partial significant
Territicity	Mission	Agency	Orbit	AC In	struments	Timeline
MISA         LEO         AIRS           MISA         LEO         MODIS           MISA         LEO         MISI           MISA         LEO         MISI           MISA         LEO         MISA           MISA         LEO         ALISA           MISA         SS 1330         ALISA           MISA         SS 1330         ALISA           MISA         SS 1330         ALISA           MISA         SS 1030         ALISA           MISA         SS 1030         ALISA           MISA         SS 1030         ALISA           MIABA         SS 1030         ALISA           MISA         SS 1030         ALISA           MISA         SS 1030         ALISA           MISA         SS 1030         ALISA           MIABA         SS 1030         ALISA           MIABA         SS 1030         ALISA           MISA <td< th=""><th>Name(s)</th><th></th><th>Type / GEq</th><th></th><th>Type</th><th>2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026</th></td<>	Name(s)		Type / GEq		Type	2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
MASA         LEO         MODIT           NASA         LEO         MODIS           NASA         ES 1345         MISS           NASA         LEO         MISS           NASA         LEO         MISS           NASA         LEO         MISS           NASA         LEO         ALTSR- SS 1330         MISR- ATSR- SS 1030           ESA         LEO         AVHRR- SS 1030         ATSR- ATSR- SS 1030           NOAA         LEO         AVHRR-3           NOAA         SS 1030         ATSR- SBUV-2           NOAA         LEO         AVHRR-3           NOAA         SS 1030         ATSR- SBUV-2           NOAA         SS 1030         AVHR-3           NOA         SS 1030         AVHR-3           NOA         SS 1030         AVHR-3           NOA         SS 1030         AVHR-3           SS 10310         SBUV-2         SS           NOA         SS 10310         SS	Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
MASA         LEO SS 13.445         MLS FES TES S 13.445         LEO CRUICP FES FES FES FES FES FES FES FES FES FES	Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
MASA         LEO         CALIOP           ESA         LEO         GOME-1           ESA         SS 10:300         ATSR.2           ESA         SS 10:300         ATSR.2           ESA         LEO         GOME-1           ESA         SS 10:300         ATSR.2           NCMA         LEO         MPRR.3           NCMA         LEO         AVHRR.3           NCMA         LEO         AVHRR.3           NCMA         LEO         AVHRR.3           NCMA         SS 13:30         SBUV.2           NCMA         SS 13:30         SBUV.2           NCMA         SS 09:30         SBUV.2           NCMA         SS 09:30         SBUV.2           NCMA         SS 09:30         SBUV.2           NCMA         SS 09:30         SBUV.2           NCMETSAT         GEO         SEVIRI           Obin         Obin         SS 09:30           SINSB         SS 09:30         SEVIRI           SINSB         SS 09:30         SEVIRI           SINSG         SS 09:30         SEVIRI           SINSB         SS 09:30         SEVIRI           SINSG         SS 09:30         SEVIR	Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MW Ilmb UVN nadir IR nadir R limb	
ESA         LEO         COME: 1           ESA         SS 10:30         ATSR: 2           ESA         SS 10:30         ATSR: 2           RIPASAMCHY         SS 10:30         MFRASACASS           NCMA         LEO         ATSR: 2           NCMA         SS 10:30         ATSR: 2           NCMA         SS 09:30         AVHRR: 3           NCMA         SS 13:30         AWHR: 3           NCMA         SS 09:30         AWHR: 3           NCMA         SS 13:30         BUV: 2           NCMA         SS 09:30         BUV: 2           BUMETSAT         LEO         SS 09:30           BUMETSAT         Obin         SS 09:30           SNSB         SS 09:30         SS 09:30           CME<	CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
EA         LEO         SSLAMACHY AT SR SO 000           NCMA         SS 10,00         AM SR AT SR ACMOS           NCMA         LEO         AW HR R3           UL         SS 13.30         SBUY 2           UL         LEO         AW HR R3           EUMETSAT         LEO         AW HR R3           EUMETSAT         OLA         SE VIRI           OLA         OLA         SE VIRI           OLA         OLA         SE VIRI           OLA         OLA         SE VIRI           OLA         CEO         SE VIRI           OLA         OLA         SE VIRI           OLA         OLA         SE VIRI           OLA         OLA         SE VIRI           OLA         CEO         SE VIRI           OLA         SE VIRI         OLA <t< td=""><td>ERS-2</td><td>ESA</td><td>LEO SS 10:30</td><td>GOME-1 ATSR-2</td><td>UVN nadir Imager</td><td></td></t<>	ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
NCMA         LEO         AVHRR3           NCMA         SS 0930         AVHRR3           NCMA         LEO         SB UV-2           NCMA         LEO         AVHRR3           NCMA         LEO         BUV-2           NCMA         SS 1330         SBUV-2           NCMA         LEO         AVHRR3           EUMETSAT         LEO         AVHRR3           EUMETSAT         LEO         COME2           SS 0530         SBUV-2         AVHRR3           EUMETSAT         LEO         COME2           SNSB         GEO         SE VIRI           Obin         Obin         SS 0530           CMETSAT         GEO         SC VIRI           Obin         Obin         SS 0530           CMETSAT         GEO         SC VIRI           Obin         Obin         SS 0530           CMES         SS 05500         COME3	ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS ANTSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
NCMA         LEO         AWHRR3           NCMA         LEO         SS 13:30         SBUy:2           NCMA         LEO         SBUy:2         SBUy:2           NCMA         LEO         AWHRR3         SBUy:2           NCMA         LEO         SBUy:2         SBUy:2           NCMA         LEO         AWHRR3         SBUy:2           EUMETSAT         LEO         GOME.2         SEUN:2           EUMETSAT         GEO         SEVIRI         AWHRR3           EUMETSAT         GEO         SEVIRI         COME.2           SNSB         LEO         SGINS         SCINS           SNSB         SS 65:00         CSIRIS         COME.2           CMA         LEO         MAR         COME.2           CMA         SS 10:10         COME.2         CMA	NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NCMA         LEO S 06:300         AWHRP3 S 04:2; S 04:20           NCJAA         LEO S 04:20         AWHRP3 S 04:20           EUMETSAT         LEO S 04:20         AWHRP3 S 04:20           EUMETSAT         COME-2 S 04:10         AWHRP3 AWHRP3 AWHRP3           EUMETSAT         COME-2 S 04:10         AWHRP3 AWHRP3           EUMETSAT         COME-2 S 04:10         AWHRP3 AWHRP3           SV55         COME-2 BURT         AWHRP3 AWHRP3           EUMETSAT         COME-2 BURT         AWHRP3 AWHRP3           COME-2 BURT         S 04:10         AMHRP3           CMA         LEO S 10:10         MAR           CMA         LEO S 10:10         MAR	NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NCMA         LEO SS 13:30         AWHRR3 SBUr2           EUMETSAT         LEO         GOME-2 SS 09:30         AWHRR3           EUMETSAT         LEO         GOME-2 AWHRR3         AWHRR3           EUMETSAT         GEO         SE VIRI         AWHRR3           SNSB         LEO         SE VIRI         AWHRR3           SNSB         LEO         SS 05:00         SS 05:00           CSA         LEO         AGE         POMOR           CMA         LEO         VIRR         NURR           CMA         LEO         VIRR         NURR	NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT LEO GOME-2 SS 0930 MSI EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI 0 bin SNSB LEO SMR SS 0500 OSIRIS CSA LEO AGE CMS SS 13:30 Pobler CMA LEO VIRP CMA SS 10:10 TOU/SBUS	NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI BUMETSAT GEO SEVIRI SNSB GEO SEVIRI CSA LEO AGE CHES SS 13:30 CMES SS 13:3	Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR.3	UVN nadir IR nadir Irnager	
EUMETSAT GEO SEVIRI 0.6m Seviral SNSB LEO SMA CSA LEO ACE CMES LEO Polder CME SS 13:30 Polder CMA LEO VIRP CMA SS 10:10 TOU/SBUS	MSG-1 Meteosat-8	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
SNSB LEO SMA SS 06:00 CSIAIS C CSA LEO ACE CL CKES LEO Polder CMA LEO VIAR SS 10:10 TOUISBUS	MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
r CSA LEO ACE OL CNES LEO Polder SS 13:20 Polder CMA LEO VIPP SS 10:10 TOUISBUS	Odin	8NS8	LEO SS 06:00	SMR OSIRIS	MWY limb UVN radir	
OL CNES LEO Polder SS 13:30 CAM LEO VIAR SS 10:10 TOUISBUS SS 10:10 TOUISBUS	SCISAT	CSA	LEO	ACE	Occultation	
CMA LEO VIRP SS 10:10 TOU/SBUS	PARASOL	CNES	LEO SS 13:30	Polder	MAP	
	FY-3A	CMA	LE0 SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-5:  $CH_4$  Measurements from Current Missions for Ozone Layer Requirements



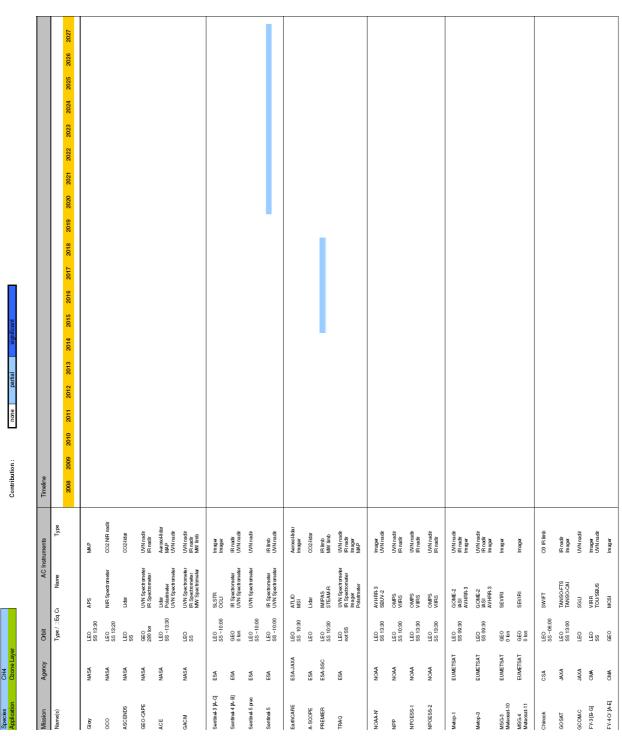
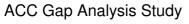


Table 4-6: CH<sub>4</sub> Measurements from Planned Missions for Ozone Layer Requirements









		2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timeline	2008 2009 2010 2011 2012 2013 2014 2015 2016 2																	
	AC Instruments	e Type	IR nadir Imagər	IR nadir Imager	MVV Ilmb UVN nadir IR nadir IR limb	Aerosol-lidar	UVN radir Imager	UVN nadir R limb Innager Occultation Imager	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Irnagər	Imager	Imager	MWV Ilmb UVN readir	Occultation	MAP	Imager UVN nadir
		C Name	AIRS MODIS	MOPITT	MLS OMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AA TSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR.3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
J	Orbit	Type /Eq C	LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LEO SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
Species HNO3 Application Ozone Layer	Agency		NASA	NASA	NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	8NS8	CSA	CNES	CMA
Species Application	Mission	Name(s)	Aqua	Тегга	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-B	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-7:  $\ensuremath{\mathsf{HNO}_3}$  Measurements from Current Missions for Ozone Layer Requirements





Agency Orbit Type / JEq Ci	Nar	AC Instruments Type	Timeline 2008 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
E0 S 13:30		MAP	
LEO SS 13:20 LEO SS	NIR Spectrometer Lidar	CO2 NIR nadir CO2-lidar	
80 km	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
E0 S ~13:30		Aerosol-lidar MAP UVN nadir	
SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
LEO SS ~10:00	SLSTR	lmager Imager	
0 lon	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
LE0 SS ~10:00	UVN Spectrometer	UVN nadir	
E0 S ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
0	Lidar	CO2-lidar	
E0 5 10:30	IMIPAS STEAM-R		
e0 of SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
E0 S 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
E0 S 10:30	OMPS	UVN nadir IR nadir	
E0 S 13:30	OMPS	UVN nadir IR nadir	
LE0 SS 13:30	OMPS	UVN nadir IR nadir	
LE0 SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
GEO 0 lon	SEVIRI	Imager	
lon 6	SEVIRI	Imager	
EO SS ~06:00	SWIFT	C8 IR limb	
LE0 SS 13:00	TANSO-FTS TANSO-CAL	IR nadir Imager	
ЕО		UVN nadir	
SS EO		Imager UVN nadir	
	MCSI	Imager	

Table 4-8: HNO<sub>3</sub> Measurements from Planned Missions for Ozone Layer Requirements



C C C C

**United** 



Species Application	N2O Ozone Layer	H.			Contribution : none partial significant
Mission	Agency	Orbit	AC In	AC Instruments	Timelre
Name(s)		Type / GEq C	C Name	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13/30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MW limb UVN nadir IR nadir R limb	
CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-15	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Irnager	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	BSNS	LEO SS 06:00	SMR OSIRIS	MWY limb UVN radir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-9: N<sub>2</sub>O Measurements from Current Missions for Ozone Layer Requirements





Species Application	N2O Ozone Layer				Contribution : none partial significant
Mission	Agency	Orbit		AC Instruments	Tineine
Name(s)		Type / ⊐Eq Ci	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2023 2023 2024 2025 2026 2027
0 Generation	NASA	9	SOV	144 D	
form		SS 13:30	0		
000	NASA	LE0 SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS SS	Lidar	CO2-lidar	
GEO-CAPE	NASA	GE0 280 lon	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	Aerosol-Ildar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
Sentine <del>l</del> 3 [A-C]	ESA	LEO SS ~10:00	SLSTR OCLI	Imager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentin <del>el</del> 5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LE0 SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LEO SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	C3 IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
FY3[B-G]	CMA	SS 0	VIRR TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-10: N<sub>2</sub>O Measurements from Planned Missions for Ozone Layer Requirements





R radit Imager UN mains H radit R radit Aerosol. Iddar Aerosol. Iddar Aerosol. Iddar Aerosol. Iddar R radit UN nadit R radit R	oc latite natific	of mainter modifier modifier det modifier not mation modifier modi	oc natification and and and and and and and an	of inter- in	de heith heith heith heith heith heith heithich	dd helfer he	de nelifie	de nelifie	the first sector of the fi
mager Marine Marine Rado Rado Aecosolidar Aecosolidar Aecosolidar Rado UVN nadir IR Ma Rado Irager Irager Irager	mager UNN main UNN main Ri madi Ri madi Aerceol-Idar Aerceol-Idar NuN radir Rush Ri ma Rush Rush Rush Rush Rush Rush Rush Rush	mager UN main In nad R mad Acrosol-lidar Acrosol-lidar Acrosol-lidar R mager Innager Innager Innager Innager Innager UN madir UN madir Innager UN madir	mager UNN namér FE nadér FE nadér FE nadér Aerosol Iddar Aerosol Iddar Inager Inager Inager Inager Inager Inager UNN nadir Inager UNN nadir Inager UNN nadir UNN nadir UNN nadir UNN nadir UNN nadir	Imager Internet R Inde R Inde R Inde Aeroso-Iddar Aeroso-Iddar Aeroso-Iddar R Inde R I	mager UNN naid Aerceol-Iddar Aerceol-Iddar VNN readir IR imb IR imb IR imb IR imb IR imb Irager Irager Irager Irager IVN readir Irager IVN readir Irager IVN readir IVN readir I	mager WN main UNN main Ri mad Recoolidar Aerosolidar Aerosolidar Ri ma Pager Ri ma UNN radir Imager UNN radir UNN radir UNN radir Imager UNN radir Imager UNN radir Imager	mager In addr R madr R madr R madr R mager In ager In ager In ager In ager In ager In ager In ager In ager In addr In ager In ager	mager Inder Render Render Render Render NN rudir Pager Prager Inder Prager UNN rudir Prage	mager Inder Acrosol-Idatr Acrosol-Idatr Acrosol-Idatr Acrosol-Idatr Rimager Innager Innager UVN nadir Innager UVN nadir Innager INN nadir Innager UVN nadir INN NADIR
U/M radie Imager U/M nudie R Imager Cecultation Imager Imager	U/N radie Imager U/N radie R limb R limb Cecultation Imager Imager U/N radie	U/N radie Imager U/N radie Rimager Croatinsfon Imager U/N nadie Imager U/N nadie Imager U/N nadie	U/N radir Imagar U/N radir Rimagar Coontindon Imagar Imagar U/N nadir Imagar U/N nadir U/N nadir U/N nadir U/N nadir U/N nadir	U/N radie Imager U/N radie Rimger Rimger Erager Imager U/N radie Imager U/N radie Imager U/N radie	U/N radie hasar U/N radie Rimager Rimager Eragger Imager U/N radie Imager U/N radie Imager U/N radie Rimager U/N radie Rimager Imager Imager Rimager Imager	U/N radie U/N radie U/N radie R limager Cocaditation Imager U/N radie U/N radie U/N radie U/N radie U/N radie U/N radie Imager U/N radie U/N radie	UVN radie UVN radie UVN radie Rinnger Cechnision Imager UVN radie Imager UVN radie Imager UVN radie Imager Imager Imager Imager IVN radie Imager UVN radie Imager Imager UVN radie Imager Imager UVN radie Imager Imager UVN radie Imager Imager Imager Imager Imager Imager Imager IVN radie Imager IVN radie IVN radie IVN radie Imager IVN radie Imager IVN radie Imager IVN radie IVN radie IVN radie Imager IVN radie IVN radie IVN radie Imager IVN radie IVN radi	UVN radie Imager UVN radie Rinnger Cecutation Imager UVN radie Imager UVN radie Imager UVN radie Imager Imager Imager Imager Coultation Coultation	UNN radie hunder Rilmager UNN nadie Rilmager UNN nadie Imager UNN nadie Imager UNN nadie Rinader Rinader Rinader Rinader Rinader MW finadie MW finadie MW finadie MW finadie MM MM
UVN nodir Ri limb Imager Decuttation Imager Imager	UNN nodif Ri mager Cocontration Imager Imager Imager	UN1 node Ri imde Rosentation Imager Imager UN1 nader Imager UVN nader	UN1 nodif Ri major De cutation Imagor Innagor UN1 nadir Innagor UNN nadir Innagor UNN nadir	UN1 node Rimager Cocumation Imager Imager UN1 noder UNN noder UNN noder UNN noder	UNN node Rimager De calination Imager Inager Inager UNN nadir Imager UNN nadir Imager UNN nadir Imager Imag	UNN node Rimbe Roader Coordination Imager UNN node UNN node UNN node Roader Imager Ima	UNTradit Rimbe traget Condition Imager UNTradit Imager UNTradit Rinder Imager I	UNTradit Rima Proger Coontration Imager UNTradit Innager UNTradit Rinader Imager Imager Imager Imager Innager Cooltholon Cooltholon	UNTradit Rimbe Rocalination Imager Imager UNTradit Imager
truger	krager krager UVN radir	Irrager Irrager UVN radir IUM radir	krager krager UVN radir UVN radir Rnager NY radir	Irrager Irrager UrVi radir Irrager UrVi radir UrVi radir	Irrager Irrager UVN nadir IUNN nadir Irrager UVN nadir Irrager Irrager Irrager	Irrager Irrager UVN nadir IVN nadir Irrager UVN nadir Irrager Irrager Irrager Irrager	Irrager Irrager UNN nadir IUNN nadir IUNN nadir Innager Innager Innager Innager Innager Innager Innager Innager Innager Innager Innager Innager INN nadir	Irrager Irrager UN nadir IUN nadir IUN nadir Inager Irrager Irrager Irrager Irrager Irrager Irrager Irrager Irrager Occutation	Imager Invager Universit Imager Universit Imager Im
	lmager UVN nacir	Imager UVN madir Imager UVN madir	Imager UN Inadir IUN Inadir UN Inadir Imager UN Inadir	UM nadir UM nadir Imager UM nadir UM nadir UM nadir	UN nadir UN nadir Imger UN nadir UN nadir R nadir R nadir Imger Imger	UM radir UM radir UM radir UM nadir UM nadir R nadir R nadir R nadir R nadir R nadir Hrager	UM radir Ium adir UM radir UM radir UM radir Radir Imager Imager Imager MW Imb	UM radir Ium radir Ium radir UM nadir Ium nadir Radir Imager Imager Imager Imager CVM nadir Radir Imager Imager CVM nadir Radir Imager CVM nadir Radir Imager CVM nadir Radir Imager CVM nadir Radir Imager CVM nadir Radir Imager CVM nadir Radir Imager CVM nadir Radir Imager Imager CVM nadir Radir Imager	UM hadir Ium adir Ium adir UM hadir Ium adir Rador Rador Imager Imager Imager MM imb UM hadir Imager

Table 4-11: CO Measurements from Current Missions for Ozone Layer Requirements



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Species	CO Ozone Layer				Contribution : none partial significant
Mission	Agency	Orbit		AC Instruments	Tmelne
Name(s)		Type / ⊐Eq 0	Si Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glay	NASA	LEO SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS		LEO SS	Lidar	CO2-lider	
GEO-CAPE		GEO 280 km	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir	
GACM	NASA	SS EO	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MV limb	
Sentinet-3 [A-C]	ESA	LEO SS~10:00	SLSTR OCLI	Imager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentin <del>d.</del> 5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAQ	ESA	LE0 not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LEO SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LE0 SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	C3 IR limb	
GOSAT	AXA	LEO SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU VIID	UVN nadir	
- 7:4 [b; 7		SS	VIRR TOU/SBUS	Imager UNN nadir	
FY-40/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-12: CO Measurements from Planned Missions for Ozone Layer Requirements





			2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timetine		2008 2009 2010 2011 2012 2013 2014 2015 2016 2017								1	1								
	AC Instruments	Type		IR nadir Imager	IR nadir Imager	MVV limb UVN nadir IR nadir R limb	Aerosol-lidar	UVN nadir Imager	UVN nadir IR limb Inager Occutation Imager	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imagər	Imager	Imager	MW limb UVN nadir	Occultation	MAP	Imager UVN nadir
	AC II	C Name		AIRS MODIS	MOPITT	MLS OMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMA CHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
er	Orbit	Type / GEq C		LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LE0 SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LE0 SS 10:10
CO2 Ozone Lay	Agency			NASA	NASA	NASA	NASA	ESA	ESA	NDAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	SNSB	CSA	CNES	CMA
Species CO2 Application Ozone Layer	Mission	Name(s)		Aqua	Terra	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY-3A

Table 4-13: CO $_2$  Measurements from Current Missions for Ozone Layer Requirements





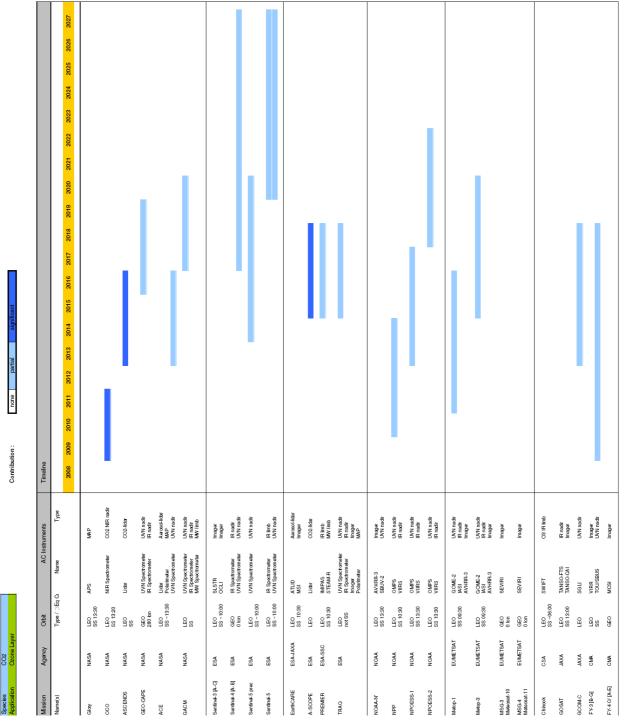


Table 4-14: CO<sub>2</sub> Measurements from Planned Missions for Ozone Layer Requirements





Agency         Oth           Agency         Oth           Type/_Eq.C         Name           MASH         EE0         AFRS           MASH         EE0         AFRS           MASH         EE0         MOSI           MASH         EE0         MOSI           MASH         EE0         MOSI           MASH         EE0         MOSI           MASH         EE0         MASH           SS 13:34         MOSI         SS 13:30           MASH         EE0         CAUOP           ESA         SS 10:30         ATRS           MASH         ES0         COME:           MASH         EE0         SS 10:30           MASH         SS 10:30         ATRS           MASH         EE0         SUMAGHY           ESA         SS 10:30         ATRS           MASH         SS 10:30         ATRS           MASH         SS 10:30         ATRS           MASH         SS 10:30         ATRS           MASH         SS 10:30         ATRS           MARSH         SS 10:30         ATRS           MARSH         SS 10:30         ATRS <td< th=""><th>Species Application</th><th>CID Ozone Layer</th><th></th><th></th><th></th><th>Contribution : none partial significant</th></td<>	Species Application	CID Ozone Layer				Contribution : none partial significant
Type/List         Type/List         Type         Type/List         Type         Type/List         Type         Type/List         Type	Mission	Agency	Orbit			Timelne
Weik         Effort         Meria         Meria </th <th>Name(s)</th> <th></th> <th>Type / GEq</th> <th></th> <th>Type</th> <th></th>	Name(s)		Type / GEq		Type	
MASA         LEO         AIRS           NASA         LEO         MODIS           NASA         LEO         MODIS           NASA         LEO         MODIS           NASA         LEO         MUS           NASA         LEO         ALIOP           SS 13345         CALIOP         SS 1345           SS 13200         ASTSR 2         CALIOP           SS 13200         ANHRH 3         MARAS           NOAA         LEO         AVHRH 3           NOAA         SS 1330         SUV2 2           NOAA         SS 1330         SUV3 2           NOAA         SS 1330         SUV3 2           NOAA         SS 1330         SUV3 2           NOAA         SS 1330         SUV4 2           NOA <td></td> <td></td> <td></td> <td></td> <td></td> <td>2009 2010 2011 2012 2013 2014 2015 2016 2017</td>						2009 2010 2011 2012 2013 2014 2015 2016 2017
MSA         LEO         MOOFIT           MSA         LEO         MOOFIS           MSA         LEO         MILS           MSA         LEO         ATSR2           MSA         ST 10:20         ATSR2           MSA         ST 10:20         ATSR3           MERIS         ST 10:20         ATSR3           MCMA         LEO         AVHRR3           MCMA         ST 13:30         SUV:2           SUB         SU		NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
MASA         LEO SS 13,445         MLS CMI SS 13,445         LEO CMICS           MASA         LEO SS 13,455         COME-1 FES         COME-1 FES           ESA         LEO SS 10,500         MTSA MPASS         COME-1 FES           MATSA         SS 10,500         MTAR-3 MPASS         MASS           NCMA         LEO SC 000SS         AVHRR-3 MPASS         MARSA           NCMA         LEO SS 03,500         AVHRR-3 MPASS         MATSA           NCMA         LEO SS 03,500         AVHRR-3 MPASS         SUV-2 SUV-2 MVHRR-3           NCMA         LEO SB 04,20         AVHRR-3 SUV-2 SUV-2 SUV-2         SUV-2 SUV-2 MVHRR-3           EUMETSAT         LEO SB 04,2         SUV-2 SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SB 04,2         SUV-2 SUV-2         SUV-2 SUV-2           MATSAT         LEO SB 04,2         SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SB 04,2         SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SB 04,2         SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SUV-2 SUV-2         SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SUV-2 SUV-2         SUV-2 SUV-2         SUV-2 SUV-2           SV 35 05,00         SUV-2 SUV-2		NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
MSA         LEO         CULOP           ESA         LEO         ATSR2           ESA         SS 10:30         ATSR2           ESA         LEO         GOME-1           ESA         SS 10:30         ATSR2           ESA         LEO         GOME-1           NOAA         LEO         AVHRR3           BUV-2         BUV-2         BUV-2           NOAA         LEO         SBUV-2           BUV-2         SUV-3         SBUV-2           COME-1         LEO         SBUV-2           SY 1330         SBUV-2         SUV-2           SY 1320         SBUV-2         SUV-2           SY 1320         SBUV-2         SUV-2           SY 1320         SBUV-2         SUV-2           SY 1320         SUV-2         SUV-2           SY 1320         SUV-2         SUV-2           SY 1320         SUV-2         SUV-2           SY 1320         SUV-2         SUV-2           SY		NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MV limb UVN nadir IR nadir R limb	
ESA     LEO     COME: 1       ESA     LEO     ATSR-2       ESA     SS 10:00     ATSR-2       SS 10:00     ATSR-2     SAMACHY       NCMA     LEO     ANTRR-3       BUV-2     SS 09:30     SBUV-2       NCM     LEO     ANTRR-3       BUMETSAT     LEO     SEVIRI       BUMETSAT     GEO     SEVIRI       BUMETSAT     GEO     SEVIRI       SNSB     SS 09:30     GSMF-3       SNSB     SS 13:30     GNF-3       SNSB     SS 13:30     GNF-3 <td>0</td> <td>NASA</td> <td>LEO SS 13:30</td> <td>CALIOP</td> <td>Aerosol-lidar</td> <td></td>	0	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
EA         LEO         SCAMACHY SS 1000           NOAA         SS 1000         MIRAS ATAR CORSS           NOAA         LEO         AVHRR 3           NOAA         SS 0330         SBUY-2           NOAA         SS 0330         SBUY-2           LEO         AVHRR 3         SBUY-2           UNETSAT         LEO         AVHRR 3           EUMETSAT         LEO         SCHR 3           SNSB         UNAR 3         SS 0430           COME 2         SCHR 3         SCHR 3           EUMETSAT         LEO         SCHR 3           Obn         Obn         SS 0430           SNSB         SS 06:00         SS 0418           CMETSAT         GEO         SCHR 3           SNSB         SS 06:00         OSIRS           CSA         LEO         SHR 3           CMETSAT         LEO         SHR 3		ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
LEC AVHRR.3 SS 0930 AVHRR.3 SE 1330 SBUV.2 LEC AVHRR.3 SBUV.2 SS 0930 SBUV.2 SS 1330 SBUV.2 SS 1330 SBUV.2 SPUR.3 SBUV.2	ENVISAT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Inager Occuttation Imager	
NCMA         LEO         AWHRR3           NCMA         LEO         SS 13:30         SBUV:2           NCMA         SS 09:30         SBUV:2         SBUV:2           NCMA         LEO         SB 09:30         SBUV:2           NCMA         LEO         SB 09:30         SBUV:2           EUMETSAT         LEO         SG 06:30         SBUV:2           EUMETSAT         CEO         SS 09:30         SBUV:2           EUMETSAT         CEO         SEVIRI         SS 09:30           EUMETSAT         GEO         SEVIRI         SS 09:30           SNSB         UNEN         GEO         SEVIRI           SNSB         SS 06:50         CSIRIS         CSIRIS           CNES         LEO         AME         AME           CNES         SS 05:50         CSIRIS         SS 05:50	E2	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOMA         LEO SS 06:300         AWHRR3 SBUY:2           NOMA         LEO SS 13:30         AWHRR3 SBUY:2           NOMA         LEO SBUY:2         AWHRR3 SBUY:2           EUMETSAT         LEO O bin         AWHRR3 AWHRR3           EUMETSAT         GEO O bin         SEUV:2           SYSB         SS 09:30         AWHRR3           SYSB         O bin         AWHRR3           SYSB         O bin         AWHRR3           SYSB         O bin         AWHRR3           SYSB         O bin         AWHRR3           SYSB         CAE         CAE           SYSB         LEO         SMR           CMES         LEO         AMER	ø	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NDAA LEO AWHRR3 SS 13:30 SBUY-2 SUMETSAT LEO GOME-2 EUMETSAT CAEO SEVIRI EUMETSAT GEO SEVIRI 0 ban SS 05.00 CSIRIS CSA LEO AGE CSA LEO AGE CNES LEO POMor	2	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT LEO GOME-2 S 99,300 MSI EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI 0 ban SEVIRI 0 ban CSIRIS CSA LEO AGE CNES LEO POMAr	80	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT GEO SEVIRI BUMETSAT GEO SEVIRI 0 km 8 km 8 km 8 km 8 km 8 km 8 km 8 km 8		EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
EUMETSAT GEO SEVIRI 0.6m SAR SNSB LEO SAR CSA LEO AGE CMES LEO Polder S1330 Polder	11.8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
SNSB LEC SMR SS 96:00 CSFIS CSA LEO ACE LEO Polder SS 13:30	6-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
CSA LEO ACE L CNES LEO Polder SS 13:30		SNSB	LEO SS 06:00	SMR OSIRIS	MW limb UVN radir	
CNES LEO Polder SS 13:30		CSA	LEO	ACE	Occutation	
	z	CNES	LEO SS 13:30	Polder	MAP	
LEO VIER SS 10:10 TOU/SBUS		CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-15: CIO Measurements from Current Missions for Ozone Layer Requirements





Species Application	CID Ozone Layer				Contribution : none partial significant
Mission	Agency	Orbit		AC Instruments	Tmelne
Name(s)		Type / ⊐Eq /	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Gloy	NASA	LEO	APS	MAP	
000	NASA	SS 13:30 LEO	NIR Spectrometer	CO2 NIB radir	
		SS 13:20			
ASCENDS	NASA	SS SS	Lidar	CO2-lider	
GEO-CAPE	NASA	GE0 280 km	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir	
GACM	NASA	SS O	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
Sentinel-3 [A-C]	ESA	LEO SS ~10:00	SLSTR OCLI	Imager Imager	
Sentine-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LE0 SS ~10:00	UVN Spectrometer	UVN nadir	
Sentin <del>el</del> 5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lictar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LE0 SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA		UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NPP	NOAA	LE0 SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT		SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	C3 IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAI	IR nadir İmager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
FY-3[B-G]	CMA	SS SS	VIRR TOU/SBUS	Imager UNN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-16: CIO Measurements from Planned Missions for Ozone Layer Requirements





Application					
	Agency	Orbit	AC II	AC Instruments	Timetree
		Type / GEq C	C Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
	NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MVV Ilimb UVN nadir IR nadir IR limb	
	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
	NOAA	LEO SS 09:30	AVHRR-3	Imager	
	NOAA	LEO SS 13:30	AV HRR-3 SBUV-2	Imager UVN nadir	
	NOAA	LE 0 SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
	SNSB	LEO SS 06:00	SMR OSIRIS	MWV limb UVN nadir	
	CSA	LEO	ACE	Occultation	
	CNES	LEO SS 13:30	Polder	MAP	
	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager ID/N made	

Table 4-17: BrO Measurements from Current Missions for Ozone Layer Requirements





Species Application	BrO Ozone Layer				Contribution : none partial significant
Mission	Agency	Orbit	AC Ins	AC Instruments	Indite
Name(s)	formers	Tune / TEd Ci	Na	Tvne	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glay	NASA	LEO SS 13:30	APS	MAP	
000	NASA	LE0 SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	LE0 SS	Lidar	CO2-lidar	
GEO-CAPE	NASA		UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA		Lidar Polatimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM Itmb	
Sentinel-3 [A-C]	ESA	LEO SS ~ 10:00	SLSTR	Imager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LE0 SS ~10:00	UVN Spectrometer	UVN nadir	
Sentin <del>d.</del> 5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UNN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC		IMIPAS STEAM-R	IR limb MW limb	
TRAQ	ESA		UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LE0 SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRP-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 bn	SEVIRI	Imager	
MSG-4 Meteocat-11	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	CG IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAL	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
FY-3[B-G]	CIMB	SS 0	VIHH TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-18: BrO Measurements from Planned Missions for Ozone Layer Requirements



a a la a



	ACI	AC Instruments	Timeline
100	Type /Eq C Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
	LEO AIRS SS 13:30 MODIS	IR nadir Imager	
0	SS 10:30 MODIS	IR nadir Imager	
	LEO MLS SS 13:45 CMI TES HIRDLS	MVV Ilmb UVN nadir IR nadir IR limb	
0	LEO CALIOP SS 13:30	Aerosol-lidar	
8	LEO GOME-1 SS 10:30 ATSR-2	UVN nadir Imagər	
LEO SS 10:00	a SciaMachy Mipas Aatsr Gomos Meris	UVN nadir IR limb Inager Occuttation Imager	
LEO SS 09:30	AVHRR-3	Imager	
LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
LEO SS 13:30	AVHRR-3 0 SBUV-2	Imager UVN nadir	
LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir İmagər	
GEO 0 lon	SEVIRI	Imager	
GEO 0 Ion	SEVIRI	Imager	
LEO SS 06:00	sMR OSIRIS	MW limb UVN radir	
LEO	ACE	Occultation	
3	LEO Polder SS 13:30	MAP	
LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-19: HCI Measurements from Current Missions for Ozone Layer Requirements



모

Species



Million         Apply         Otal         Apply         Apply <t< th=""><th>hone partial significant</th></t<>	hone partial significant
Type: JEI,0         Number         Type: JEI,0         Number         Type: JEI,0         Number         State         Number         Numb	
MASA         LED         ATS           NASA         E.0         NIT Speatromester           NASA         E.0         Uat           NASA         E.0         Uat           NASA         E.0         Uat           NASA         E.0         Uat           NASA         E.0         UNVSpeatromester           E.0         E.0         UNVSpeatromester <t< th=""><th>2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027</th></t<>	2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
NKM         EPD         INT Spectrometry           MSA         EV         Uor           ESA         EV         Uor           ESA         EV         Uor           ESA         EV         Uor           MA         EV         Uor           ESA         EV         Uor           ESA         EV         Uor           ESA         EV         Uor           MOMA         EV         Uor           ESA         EV         Uor      <	
MKA         ED         Lide           MSA         EEO         UN Spettminist           ESA         EEO         UN Spettminist           UNA         EEO         UN Spettminist           ESA         EEO         UN Spettminist           ESA         EEO         UN Spettminist           ESA         EEO         UN Spettminist	
MISA         EEC         MitSame           MSA         ELC         Intersectioned           MSA         ELC         Untersectioned           ESA         ESC         Untersectioned           ESA         ECO         Untersectioned	
MSA         ECO         Dutransponse           MSA         SE -1:30         Untraspectonese           MSA         SE -1:00         Untraspectonese           ESA         SE -0:00         SUN Spectonese           ESA         GEO         UN Spectonese           ESA         GEO         UN Spectonese           ESA         GEO         UN Spectonese           ESA         ESO         UN Spectonese           NOAA         ESO         UN Spectonese           ESA         ESO         UN Spectonese           NOAA         ESO         UN Spectonese           NOA         ESO         UN Spectonese           NOA         ESO         UN Spectonese           ESA         ESO         UN Spectonese	
MKA         EED         OWN Spectromer Misspectromer Misspectromer Misspectromer Misspectromer ESA         EED         Display ESA ESA         ELD ESA         Misspectromer Risplay ESA           ESA         EEO         UNI Spectromer Misspectromer Misspectromer ESA         UNI Spectromer Misspectromer Mis	
ESA         ED         SUTA           ESA         ED         UNISpectrometer           EA         ED         UNISpectrometer           EA         ED         UNISpectrometer           EA         ED         UNISpectrometer           EA         ED         UNISpectrometer           NOAA         ED         UNISpectrometer           EA         ED         UNISpectrometer           NOAA         ED         UNISpectrometer           EA         ED         UNISpectrometer           NOAA         ED         UNISpectrometer           EA         ED         UNISpectre           <	
EA         EE0         R Superimuter           EA         E0         UN Systemater           EA         E0         MEIS           EA         E0         MEIS           EA         E0         MEIS           EA         E0         MEIS           MOA         E0         MEIS           NOA         E0         MEIS           MOA         E0         MEIS           MOA         E0         MEIS           E0         MEIS         SUNS           E0         SUNS         SUNS <td></td>	
E         EAA         LEC         UNTSpectrometr           EVALAX         LEC         UNTSpectrometr           ESA-JAXA         LEC         UNTSpectrometr           EVALAX         ST 1320         UNTSpectrometr           NOUA         LEC         ONES           NOUA         ST 1320         UNTSpectrometr           NOUA         ST 1320         UNTSpectrometr           NOUA         ST 1320         UNTSpectrometr           NOUA         ST 1320         UNTSpectrometr           UNCA         ST 1320         UNTSpectr	
ED         IR Spectromater           SS-10:00         IN Spectromater           SS 10:30         ATLD           SS 10:30         MPAS           EEO         Lidit           EEO         IMPAS           SS 10:30         RIMPAS           SS 10:30         RIMPAS           SS 10:30         RIMPAS           EEO         NVS Spectromater           Postmater         Postmater           EEO         NVS Spectromater           Postmater         Postmater           EEO         NVS Spectromater           Postmater         Postmater           St 13:00	
E64.4X4         LEO         ATUD           ESA         1020         MSI           ESA         53         1030         MSI           ESA         55         1030         MSI           ESA         55         1030         MSI           ESA         55         1030         MIPAS           EA         LEO         MIPAS         55           NOAA         LEO         WYBRP3           NOAA         S1330         880V-2           NOAA         S1330         0085           NOAA         S1330         0089V-2           NOAA         S1330         0085           E0METSAT         LEO         0085           EUMETSAT         DEO         AVHER-3           EUMETSAT         LEO         0085           EUMETSAT         LEO         0085           EUMETSAT         DEO         SURSA           EUMETSAT         DEO         SURSA           EUMETSAT	
ESA         LEO         LIdar           ESASSC         LEO         Indars           ESASSC         LEO         NINSACTIONAL           REA         LEO         NINSACTIONAL           REA         LEO         NINSACTIONAL           NOAA         LEO         NINSA           NOAA         SE 1030         NINSA           SE 1030         NINSA         NINSA           LEO         NINSA         NINSA           LUMETSAT         CEO         SEVIEL           CSA         SEVIEL         SEVIEL           LEO         SEVIEL         SEVIEL           LEO         SEVIEL         SEVIEL           JAVA         SEVIEL         SEVIEL           LEO         SEVIEL         SEVIEL	
ESA-SSC         LEO         IMPAS           ESA         LEO         IVN Spectrometric pagementer pagementer pagementer           FLAN         LEO         VVN Spectrometric pagementer           NOAA         EO         VVN Spectrometric pagementer           NOAA         EO         VVN Spectrometric pagementer           NOAA         EO         ONES           NOAA         EO         ONES           NOAA         LEO         ONES           NOAA         LEO         ONES           NOAA         SS 13:30         ONES           NOAA         LEO         ONES           NOAA         SS 13:00         ONES           EUMETSAT         LEO         ONES           SS 03:00         MAHRB3         VHRB3           EUMETSAT         LEO         COME 2           SS 03:01         GEOR         SVHRB3           EUMETSAT         DEO         SS 0450           SS 03:02         GEORE2         SVHRB3           EUMETSAT         DEO         SS 0450           SS 03:03         GEORE2         SS 0466           MAHRB3         COME 2         SS 0466           MAHRB3         COME 2         SS 0466     <	
LEO NIV Sucrementar Putamentar LEO NIVARS SS 1330 SB 1000 NIPS SS 1330 SB 1000 NIPS SS 1330 NIPS LEO NIPS SS 1330 NIPS LEO NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 NIPS SS 1330 SB 1000 LEO SE NIPS SS 1330 NIPS SS 1300 NIPS SS 1300 NIPS SS 1300 NIPS SS 1300 NIPS SS 1300 NIPS SS 1300 NIPS SS	
NOAA         EEO         AVHRR3           NOAA         EEO         AVHRR3           NOAA         EEO         MAS           NOAA         SS 10.20         MAS           NOAA         SS 10.20         MAS           NOAA         EEO         MAS           NOAA         EEO         MAS           NOAA         EEO         MAS           NOAA         EEO         MAS           EUMETSAT         LEO         MAS           EUMETSAT         LEO         MAS           EUMETSAT         GEO         MAS           EUMETSAT         LEO         SOME           MAN         OS         SOME	
EEO         ONPRS           SE 10.300         ONPRS           LED         ONPRS           SE 13.30         MARP           SE 00.30         MARP           SE 00.30         GOME 2           GEO         SEVIRI           OFM         SEVIRI	
LED         ONRES           SS 13.30         UIRS           LED         ONRES           SS 13.30         UIRS           SS 13.30         UIRS           SS 13.30         UIRS           SS 03.30         NHR2           LED         COME-2           SS 03.30         MHR2           SS 04.30         AMHR2           SS 04.30         AMHR2           GED         SC VIR           Obio         SC VIR           Obio         SC VIR           SS 0450         AMHR2           LED         SC VIR           OK         SC VIR           OK         SC VIR           OK         SC VIR           OK         SC VIR           CED         SC VIR	
LEO         OHROS           Si (320         VINS           ELEO         VINS           Si 0030         AGME2           ELEO         ACME2           Si 0030         AGME2           ELEO         ACME2           Si 0030         AGME2           Si 0040         AGME2	
EUMETSAT LEO GOME-2 Soggo ANHRP3 EUMETSAT LEO ANHRP3 EUMETSAT LEO ACHR-2 SS0420 ACHR-3 ANHR93 EUMETSAT DEO EVIRI DIA DEO SEVIRI DIA DEO ANFT ANA LEO ANTACAN ANA LEO AU	
EUMETSAT LEC Storage KSIMER Storage KSIMER AWHER AWHER EUMETSAT OEO ESVIRI OR CSA DEO ENTR DIG CSA DEO ENTR ANA LEO ANTROCAL JANA LEO AGU	
EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI 06m SEVIRI 06m SEVIRI 06m SEVIRI 06m SEVIRI 10m SEVIRI 06m SEVIRI 10m	
EUMETSAT GEO SEVIRI Oran SE-06.00 SWIFT CSA EEO SWIFT MAXA EEO TANSOETS JAXA EEO TANSOETS JAXA EEO SOLI CMA EEO SOLI	
LEO SWIFT 55-06300 TANSOFTS EEO TANSOFAI LEO VIRR LEO VIRR SS TOURDR	
LEO TANSO-FTS SS 13300 TANSO-CAI LEO SG L LEO VIRENS SS TOURENS	
LEO SGU LEO VIRR es Truiseuis	
LEO VIRR SS TOUVEDIS	
000000000000000000000000000000000000000	

Table 4-20: HCI Measurements from Planned Missions for Ozone Layer Requirements





			2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : partial significant	Timeline		2008 2009 2010 2011 2012 2013 2014 2015 2015 2017								1	1								
	AC Instruments	Type		IR nadir Imager	IR nadir Imager	MN limb UVN nadir IR radir IR limb	Aerosol-lidar	UVN nadir Imager	UVN nadir IR limb Inager Occuttation Imager	Imager	Imager UVN nadir	lmager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imagər	Imager	Imager	MWV limb UVN rvadir	Occultation	MAP	Imager UVN nadir
_	AC	C Name		AIRS MODIS	MOPITT	MLS CMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
er	Orbit	Type / GEq C		LEO SS 13:30	LEO SS 10:30	LEO SS 13:45	LEO SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
Species NO2 Application Ozone Laver	Agency			NASA	NASA	NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	8NS8	CSA	CNES	CMA
Species Application	Mission	Name(s)		Aqua	Тегга	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-21: NO $_2$  Measurements from Current Missions for Ozone Layer Requirements





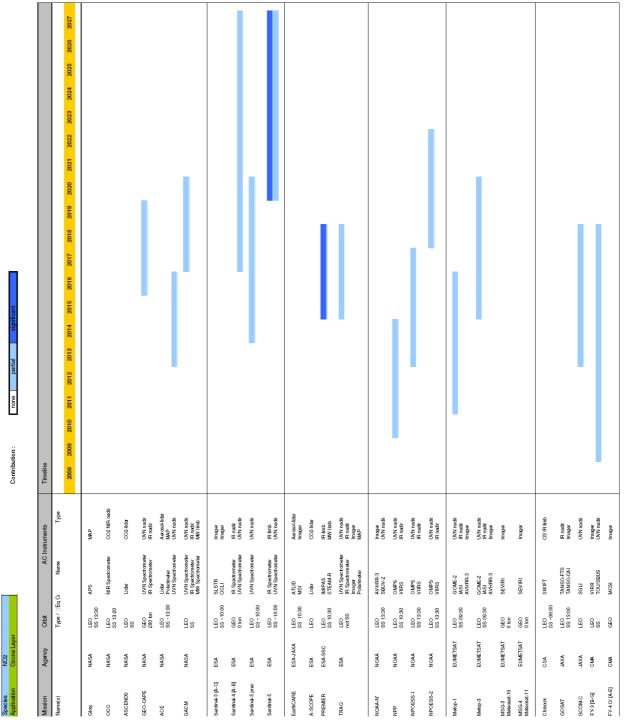


Table 4-22: NO<sub>2</sub> Measurements from Planned Missions for Ozone Layer Requirements





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Table 4-23: HDO Measurements from Current Missions for Ozone Layer Requirements







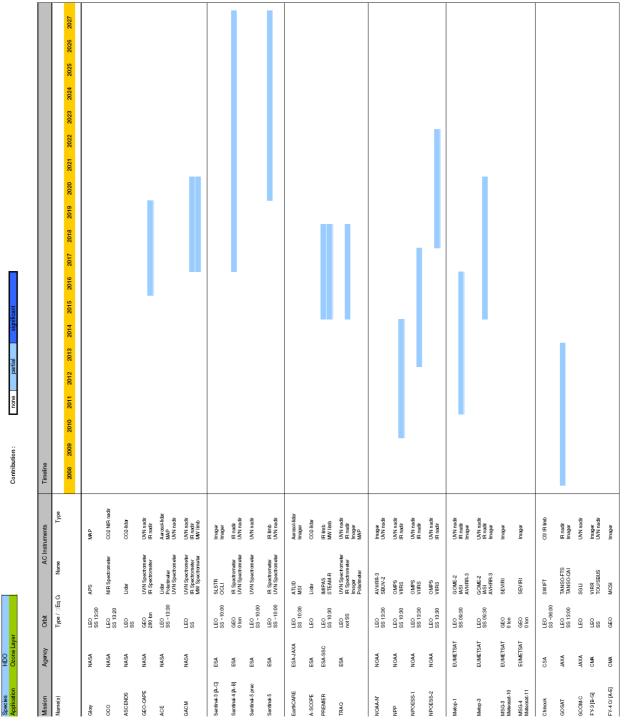


Table 4-24: HDO Measurements from Planned Missions for Ozone Layer Requirements





Species	Species CH2O Application Ozone Layer				Contribution : none partial significant
			1		
Mission	Agency	Orbit	AC Instr	AC Instruments	Timelre
Name(s)		Type /Eq C	C Name	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MODIT	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MV limb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Innager Occultation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	SNSB	LEO SS 06:00	SMR OSIPIS	MW limb UVN radir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-25: CH<sub>2</sub>O Measurements from Current Missions for Ozone Layer Requirements





Species Application	CH2O Ozone Layer				Contribution : none partial significant
Mindon	Annani	the second	V los	the concerts	Taoloo
MISSIOL	Agency		:		There
Name(s)		n yaqı	Name A	el fi	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glay	NASA	LE0 SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS IEO	Lider	CO2-lider	
GEO-CAPE	NASA	GEO 280 bn	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	AerosoHildar MAP UVN nadir	
GACM	NASA	SS IEO	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MV Iimb	
Sentinel-3 [A-C]	ESA	LEO SS ~10:00	SLSTR	lmager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentinel-5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lictar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC		IMIPAS STEAM-R	IR limb MW limb	
TRAO	ESA	not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NPP	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	SMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS VIIRS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 km	SEVIRI	Imager	
MSG-4 Meteccat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	C3 IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
FY:3[B-G]	CMA	SS SS	VIRR TOU/SBUS	Imager UVN nadir	
FY-40/[A-E]	CMA	GEO	MCSI	Imager	

Table 4-26: CH<sub>2</sub>O Measurements from Planned Missions for Ozone Layer Requirements





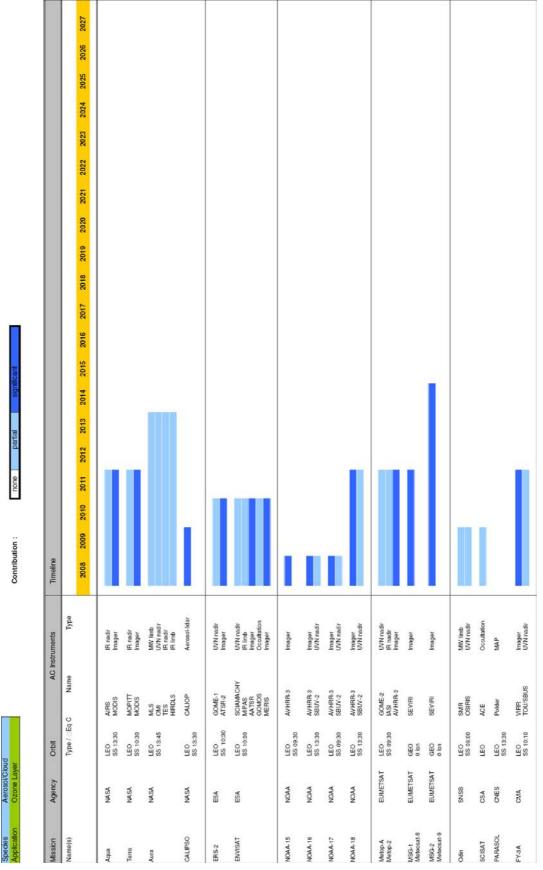


 Table 4-27: Aerosol & Cloud Measurements from Current Missions for Ozone Layer

 Requirements



Aerosol/Cloud

Species



Mission	Agency	Orbit	AC Inst	AC Instruments	Truefre
		Type / □Eq Ci	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2025 2027
- Contraction of the second se	NACA	0	A DC	C WY	
(mp	LOCK	SS 13:30		140	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	LE0 SS	Lictar	CO2-lider	
GEO-CAPE	NASA	GEO 280 bn	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	Aerosol-lider MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MN limb	
Sentinet-3 [A-C]	ESA	LEO SS ~ 10:00	SLSTR	Imager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentinet-5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aerceol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	LE0 not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN -	NOAA	LEO SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	C3 IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
FY3[BG]	CIMA	SS SS	VIRR TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

 Table 4-28: Aerosol & Cloud Measurements from Planned Missions for Ozone Layer

 Requirements





## 4.5.2 Composition-Climate Interaction





Species Application	H2O Composition-Climate	Climate			Contribution : none partial significant
Mission	Agency	Orbit	AC Inst	AC Instruments	Timetre
Name(s)		Type /Eq C	Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MVV IImb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
ERS.2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Innager Occuttation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	1
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	lmager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	BSNSB	LEO SS 06:00	SMR OSIRIS	MW limb UVN radir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-29: H<sub>2</sub>O Measurements from Current Missions for Composition-Climate Requirements





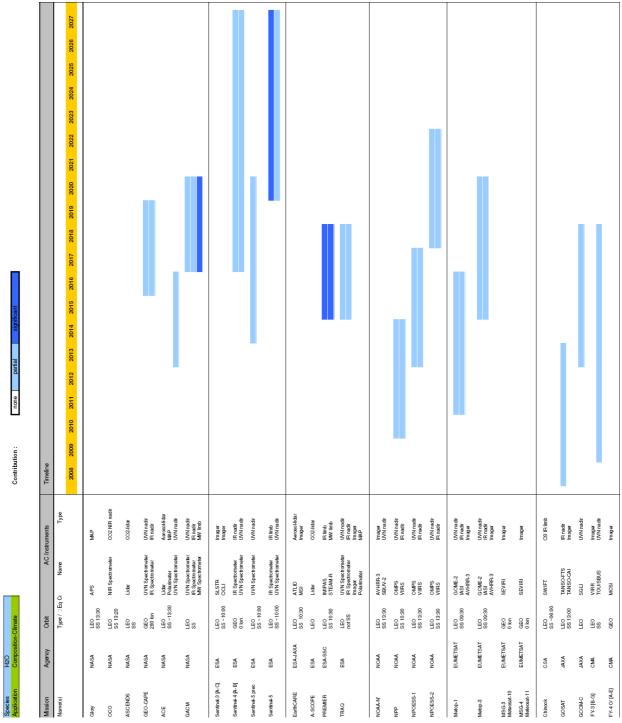


Table 4-30: H<sub>2</sub>O Measurements from Planned Missions for Composition-Climate Requirements





AC Instruments Timeline Pe Type 2008 2010 2011 2012 2013 2014 Finador Fi	Timeline         Timeline           Type         2008         2010         2011         2013           Start         2008         2009         2013         2013           Italic         Italic         Italic         Italic         Italic           Italic         Italic         Italic         Italic         Italic         Italic           Italic <td< th=""><th>Timeline Type B Car Car Car Car Car Car Car Car</th><th>Theire         Theire           Theire         2008         2004         2012         2013           State         2008         2004         2014         2013           State         State         State         State         State           State         State         State         State         State</th><th>Theire Type type that</th><th>Theire Type Theire all all all all all all all al</th><th>Their Participant of the state</th></td<>	Timeline Type B Car Car Car Car Car Car Car Car	Theire         Theire           Theire         2008         2004         2012         2013           State         2008         2004         2014         2013           State         State         State         State         State	Theire Type type that	Theire Type Theire all all all all all all all al	Their Participant of the state
A macurena and the second seco	A macurena and the second seco	An macure and a solution and a soluticati a solution and a solution and a solution and a solutio	Non-matures     Image       Productions     2008     2009     2011     2012     2013       Reade     Reade     2008     2009     2011     2012     2013       Reade     Masser     Masser     2009     2010     2011     2012     2013       Reade     Winnade     Masser     Masser     Ender     Ender     Ender     Ender       Masser     UNNade     Masser     Ender     Ender     Ender     Ender       Masser     UNNade     Ender     Ender     Ender     Ender       Masser     UNNade     Ender     Ender     Ender       Masser     Ender     Ender     Ender     Ender       Masser     Ender     Ender     Ender     Ender       Masser     Ender     Ender     Ender     <	A manufacture of the second se	Non-metron     Image       Image     Type       Image     2008       Image     2011	Non-metricina     Image       Particip     2003     2010     2011     2012     2013       Reading     Reading     2003     2010     2011     2012     2013       Reading     Reading     Montaling     Reading     2010     2011     2012     2013       Reading     Reading     Montaling     Reading     2010     2011     2012     2013       Reading     Montaling     Reading     Reading     Reading     Reading     Reading     Reading       Acrossitiat     Montaling     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading       Reading     Reading     Reading     Reading     Reading     Reading     Reading       Re
2008 2019 2011 2012 2013 Read: Read: Read: MV Imb WW Imb	2008 2019 2011 2012 2013 Read: Read	2008 2019 2011 2012 2013 Read: Read	2008 2010 2011 2012 2013 2014 2014 2014 2014 2014 2014 2014 2014	2008 2010 2011 2012 2013 2014 2014 2014 2014 2014 2014 2014 2014	2008         2004         2014         2015         2014         2015 <th< th=""><th>2008         2004         2014         2015         2014         2015         2014         2015         2016         2015         <th< th=""></th<></th></th<>	2008         2004         2014         2015         2014         2015         2014         2015         2016         2015 <th< th=""></th<>
AFRS Fradit MODIT Fradit MODIT Fradit MODIT Fradit MUS MW Imb MVN modit Fradit Fradit HIRUS Fradit Fradit HIRUS COLOP Acrosolidat COLOP Acrosolidat Acrosolidat ArrSR Common MISS Configur		Caller altra registration in Indept Strated Tables altra altra altra				
			nerva politikan in telefo bitanat taun yatu narah shekar untukan kata kata kata			
	993 101 1991. R. (1993) 2014 (1997) 1994 - 540 (1999)		10130164 A 104401564 10 4843 101001 2020 126638 202 100			
2. (1993) - 2014, 1993 (1994) - 1993			<ol> <li>New Technell'Access VC (44-03 VPDO) 2000 (2000)</li> </ol>		A. 1945 TELEASTANA AT ARC 4400 (1999) 2000 USADE- 201 (199 2004 40)	
					145 - 4940 - 49506 (2454 - 156 - 156) (246 - 156)	
			ANNUL PARTS			2020 1099 1099 10996 4220 3090
			10.60			

Table 4-31: O<sub>3</sub> Measurements from Current Missions for Composition-Climate Requirements





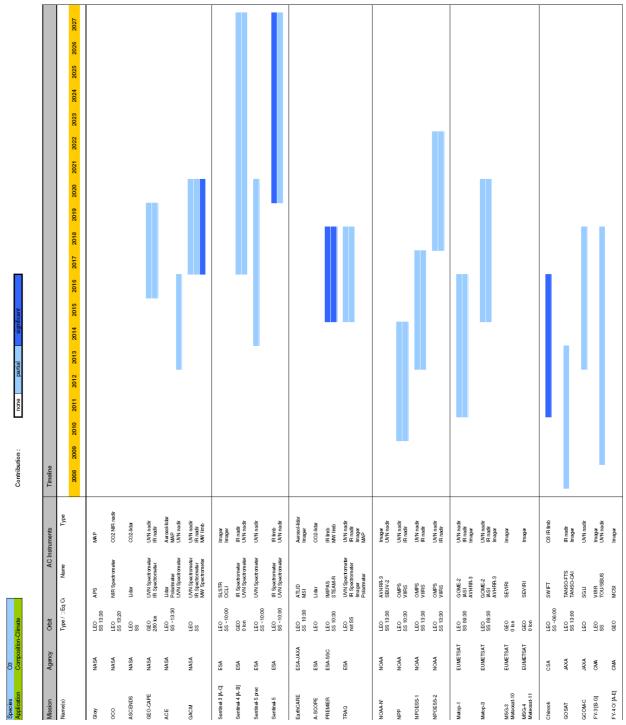


Table 4-32: O<sub>3</sub> Measurements from Planned Missions for Composition-Climate Requirements





Species Application	Composition-Climate	Climate			Contribution : none partial significant
Mission	Agency	Orbit	AC Inst	AC Instruments	Timelre
Name(s)		Type / Gq C	c Name	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MV Iimb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
ERS 2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AA 15R GOMOS MERIS	UVN nadir IR limb Imager Occuttation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-15	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR.3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	BSNSB	LEO SS 06:00	SMR OSIRIS	MW limb UVN radir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY.3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

 Table 4-33: CH4 Measurements from Current Missions for Composition-Climate Requirements





Species Application	CH4 Composition-	Climate			Contribution : none partial significant
Mission	Agency	Orbit		AC Instruments	Timeline
Name(s)		Type / □Eq.	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glory		LEO SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS		SS SS	Lidar	CO2-lidar	
GEO-CAPE		GEO 280 bn	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE		LEO SS ~13:30		Aerosol-lictar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
Sentinet-3 [A-C]	ESA	LEO SS ~10:00	SLSTR OCLI	Imager Imager	
Sentinet 4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentine <del>l</del> 5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRP-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteccat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	O3 IR limb	
GOSAT	JAXA	LEO SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGL	UVN nadir	
FY-3[B-G]	GMA	SS	VIRR TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-34: CH<sub>4</sub> Measurements from Planned Missions for Composition-Climate Requirements





HartoAdvisoryColorAdvisoryColorAdvisoryInsurancemain $ $	Species Application	HNO3 Composition-Climate	Climate			Contribution : none partial significant
The liet of the lie	Mission	Agency	Orbit	AC Ins	struments	Timeline
MASA         LEO         ARSA           MASA         LEO         MODIS           MASA         LEO         MULA           ESA         LEO         ALTAR           RESA         SS 1330         ATSR2           MASA         LEO         ALMAR           RESA         SS 1030         ATSR2           MODA         SS 1030         ATSR2           MODA         SS 1030         ATSR2           MODA         SS 0330         ATSR2           MODA         SS 0330         ATSR2           MODA         SS 0330         ATTSR2           MODA         SS 0330         ATTSR3           MODA	Name(s)		Type /Eq		Type	2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
MASN         LEO         MODIT           NASN         LEO         MODIS           NASN         SS 10:30         MODIS           NASN         SS 13:30         MODIS           NASN         LEO         MILE           NASN         LEO         MILE           NASN         LEO         ATSR-2           ESA         LEO         ATSR-2           ESA         SS 10:30         ATSR-2           NDAA         LEO         AVHRR-3           NDAA         LEO         AVHRR-3           NDAA         SS 09:30         AVHR-3           NDAA         LEO         AVHRR-3           NDAA         SS 09:30         AVHR-3           NDAA         SS 09:30         AVHR-3           NDAA         SS 09:30         AVHR-3           NDAA         SS 09:30         AVHR-3           NDAA         LEO         AVHR-3           NDAA         SS 09:30         AVHR-3           NDAA         SS 09:30         AVHR-3           NDAA         SS 09:30         AVHR-3           SS 19:30         SUV-2         SUV-2           NDAA         SS 09:30         SUV-2	enby	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
MASA         LEO         MLS           NASA         LEO         MLS           SS 13.445         TEM         LEO           NASA         LEO         CAUDP           ESA         SS 13.30         CAUDP           ESA         SS 10.30         ATSR-2           ESA         LEO         CAUDP           NCMA         SS 10.30         MTSR           NCMA         SS 10.30         MTSR           NCMA         SS 09.30         ATYRRA           NCMA         SS 10.30         MTRR3           NCMA         SS 09.30         SUV-2           NCMA         SS 09.30         SUV-2           NCMA         SS 19.30         SUV-2           NCMA         SS 09.30         SUV-2           NCMA         SS 09.30         SUV-2           NCMA         SS 09.30         SUV-2           SS 19.30         COME-2         SUV-2           SS 19.30         SUV-2         SUV-2           SS 19.30         SUV-2         SUV-2           SS 09.30         SUV-2         SUV-2           SS 09.30         SUV-2         SUV-2           SS 09.30         SUV-2         SUV-2 </td <td>erra</td> <td>NASA</td> <td>LEO SS 10:30</td> <td>MOPITT MODIS</td> <td>IR nadir Imager</td> <td></td>	erra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
MASA         LEO         CALUOP           ESA         LEO         ATSR-2           ESA         SS 10:300         ATSR-2           ESA         SS 10:300         ATSR-2           ESA         SS 10:300         ATSR-2           ESA         SS 10:300         ATSR-2           NOAA         LEO         AVHRR-3           NOAA         SS 09:30         AVHRR-3           NOAA         SS 09:30         AVHRR-3           NOAA         SS 09:30         AVHRR-3           NOAA         SS 09:30         SBUV-2           NCAA         SS 09:30         SBUV-2           NCAA         SS 09:30         SBUV-2           SS 19:30         SBUV-2         SUVRR-3           EUMETSAT         GEO         SE VIRI           SS 09:30         COME-2	ura	NASA	LEO SS 13:45	MLS CMI TES HIRDLS	MWV IImb UVN nadir IR nadir IR limb	
ESA         LEO         COME: 1           ESA         SS 10:30         ATSR: 2           ESA         SS 10:30         ATSR: 2           RS 10:30         MFRASACHY         MFRASACHY           NCMA         LEO         MFRAS           NCMA         SS 10:30         ATSR: 2           NCMA         SS 10:30         AWRR: 3           NCMA         SS 10:30         AWRR: 3           NCMA         LEO         AWRR: 3           NCMA         SS 10:30         AWRR: 3           EUMETSAT         GEO         SE VIRI           SNSB         SS 10:50         SGNR: 5           SNSB         SS 10:50         SGNR: 5           CSA         LEO         SIRI<	ALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
EA         LEO         SSIOMMACHY SSIODD           NCMA         SSIODD         AMTARA	RS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN radir Imager	
NCMA         LEO         AVHRR.3           NCMA         LEO         SS 09:30           NCMA         SS 13:30         SBUY.2           NCMA         LEO         AVHRR.3           NCMA         SS 13:30         SBUY.2           NCMA         SS 09:30         SBUY.2           NCMA         SS 09:30         SBUY.2           NCM         SS 09:30         SBUY.2           BUMETSAT         LEO         AVHRR.3           EUMETSAT         LEO         AVHRR.3           BUMETSAT         LEO         AVHRR.3           BUMETSAT         GEO         SE VIRI           BUMETSAT         Obin         AVHRR.3           COMETSAT         GEO         SE VIRI           BUMETSAT         Obin         AVHRR.3           COMETSAT         Obin         AVHRR.3           COMETSAT         Obin         AVHRR.3           COMETSAT         Obin         AVHRR.3           COMETSAT         Obin         Obin           COMETSAT         Obin         Obin           COMETSAT         Obin         Obin           COMETSAT         Obin         Obin           COMETSA         COMBUS	AVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AA TSR GOMOS MERIS	UVN nadir IR limb Imager Occuttation Imager	
NCMA         LEO         AWHRR3           NCMA         LEO         SSI 13:30         SBUY:2           NCMA         LEO         SBUY:2         SBUY:2           NCMA         LEO         AWHRR3         SBUY:2           NCMA         LEO         AWHRR3         SBUY:2           NCMA         LEO         AWHRR3         SBUY:2           BUMETSAT         LEO         AWHRR3         SBUY:2           BUMETSAT         CEO         SEVIRI         AWHRR3           BUMETSAT         GEO         SEVIRI         AWHRR3           BUMETSAT         GEO         SEVIRI         COME           BUMETSAT         GEO         SEVIRI         COME           BUMETSAT         Obin         SSI 10:0         SSI 10:0           BUMETSAT         GEO         SSI 10:0         SSI 10:0           BUMETSAT         SSI 10:0         SSI 10:0         SSI 10:0 <td>JOAA-15</td> <td>NOAA</td> <td>LEO SS 09:30</td> <td>AVHRR-3</td> <td>Imager</td> <td></td>	JOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NCMA         LEO         AWHRP3           NCMA         LEO         SI 05:30         SBUY:2           NCMA         LEO         SBUY:2         SBUY:2           NCMA         LEO         SBUY:2         SBUY:2           NCMA         LEO         SBUY:2         SBUY:2           BUMETSAT         LEO         SBUY:2         SBUY:2           EUMETSAT         LEO         SEVIRI         SEVIRI           SNSB         LEO         SEVIRI         SSIRS           CMES         SS 05:00         SEVIRI         SSIRS           SNSB         LEO         AGE         CSIRIS           CMES         SS 05:00         SMRS         CSIRIS           CMES         SS 05:00         SMRS         SSIRS           SNSB         COUSDIS         SS 05:00         COUSDIS           CMES         SS 05:00         COUSDIS         SSIRS           CMES         SS 05:00         COUSDIS         COUSDIS	10MA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOUA         LEO SS 13:30         AWHRR-3 BUV-2           EUMETSAT         LEO         GOME-2 SS 09:30         AWHRR-3 AUR           EUMETSAT         LEO         GOME-2 AUR         AWHRR-3 AUR           EUMETSAT         GEO         SE VIRI           BUMETSAT         GEO         SE VIRI           BUMETSAT         GEO         SE VIRI           BUMETSAT         GEO         SE VIRI           CAS         LEO         SMR           CMA         LEO         MAR           CMA         LEO         MAR           CMA         LEO         MAR           CMA         ST 10:10         TOUSBUS	VOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT LEO GOME2 SS 09:30 MISI SS 09:30 MISI AWHRR3 EUMETSAT GEO SEVIRI 0.0m SEVIRI 0.0m SS 05:00 OSIAIS CSA LEO SMR CMS LEO OSIAIS CSA LEO OSIAIS CMS LEO OSIAIS CSA LEO NAR CMS SS 10:10 TOUSBUS	10A.18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT GEO SEVIRI 0.0m EUMETSAT GEO SEVIRI 0.0m 3NSB LEO SEVIRI 0.0m CSA LEO AGE CMES SS 13:30 CMES SS 13:30 CMA LEO VIPP BUGS	Aetop-A Aetop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Inagər	
EUMETSAT GEO SEVIRI 0.0m 0.0m SARR SNSB LEO SARR CSA LEO AGE CMA LEO MAR CMA LEO MAR CMA SS 10:10 TOUISBUS	ASG-1 Aeteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
SNSB LEO SMR SS 06.00 CSIRIS CSA LEO ACE CNES LEO Polder CMA LEO VIPP CMA SS 10:10 TOU/SBUS	ASG-2 Aeteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
CSA LEO ACE CNES LEO Polder SS 13.30 Polder CMA LEO VIPP SS 10:10 TOU/SBUS	Ddin	SNSB	LEO SS 06:00	SMR OSIRIS	MW limb UVN nadir	
DL CNES LEO Polder SS 13:30 CAA LEO VIRR SS 10:10 TOUISBUS	CISAT	CSA	LEO	ACE	Occultation	
LEO VIRR SS 10:10 TOU/SBUS	ARASOL	CNES	LEO SS 13:30	Polder	MAP	
	Y3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-35:HNO<sub>3</sub> Measurements from Current Missions for Composition-Climate Requirements



EON B



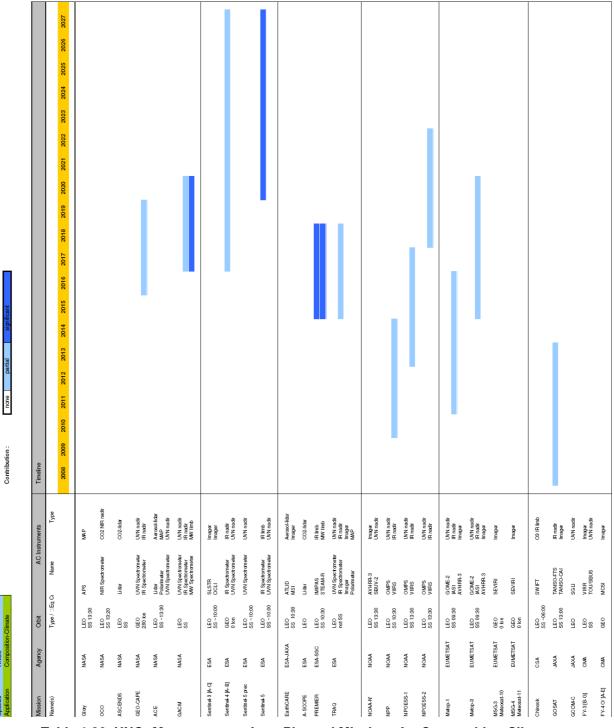


 
 Table 4-36: HNO<sub>3</sub> Measurements from Planned Missions for Composition-Climate Requirements





Species Application	N20 Composition-Climate	Climate			Contribution : none partial significant
Mission	Agency	Orbit	AC Inst	AC Instruments	Timeline
Name(s)		Type / GEq C	Name	Type	2008 2099 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MVV Ilmb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
ERS.2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occuttation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	SNSB	LEO SS 06:00	SMR OSIRIS	MW limb UVN nadir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	
				•	

Table 4-37:N<sub>2</sub>O Measurements from Current Missions for Composition-Climate Requirements







Species Application	N2O Composition	-Climate			Contribution: none partial significant
Mission	Agency	Orbit		AC Instruments	Tineline
Name(s)		Type / ⊒Eq Ci	Nar	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Gloy	NASA	LEO SS 13:30	APS	MAP	
000	NASA	LE0 SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS SS	Lidar	CO2-lider	
GEO-CAPE	NASA	GEO 280 Ion	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polatimeter UVN Spectrometer	Aerceol-lictar MAP UVN na dir	
GACM	NASA	SS LEO	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MW limb	
Sentinel-3 [A-C]	ESA	LE0 SS ~10:00	SLSTR OCLI	lmager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00		UVN nadir	
Sentine <del>l</del> 5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aercsol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	not SS	UVN Spectrometer IR Spectrometer Imager Polatimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NPP	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	SMIC	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	OS IR limb	
GOSAT	JAXA	LE0 SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGU	UVN nadir	
140	HMD	SS	TOU/SBUS	UNN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-38: N<sub>2</sub>O Measurements from Planned Missions for Composition-Climate Requirements





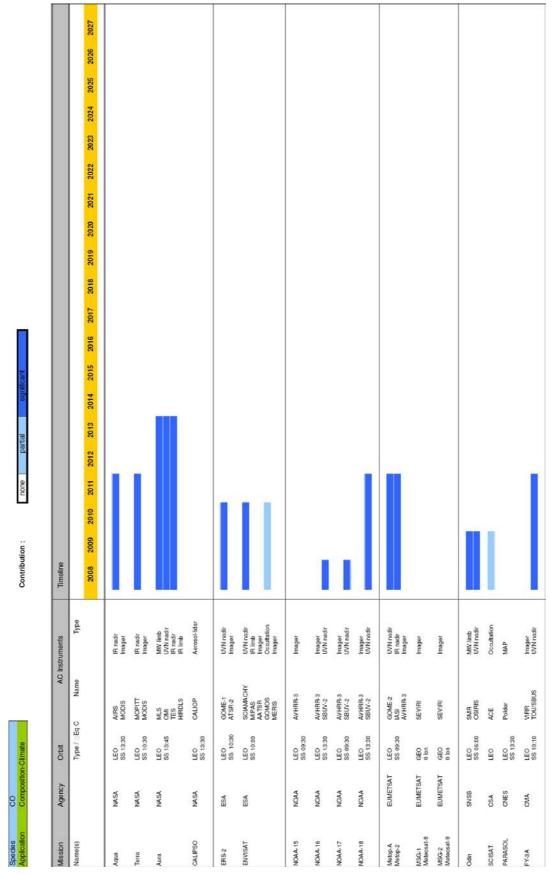


Table 4-39: CO Measurements from Current Missions for Composition-Climate Requirements





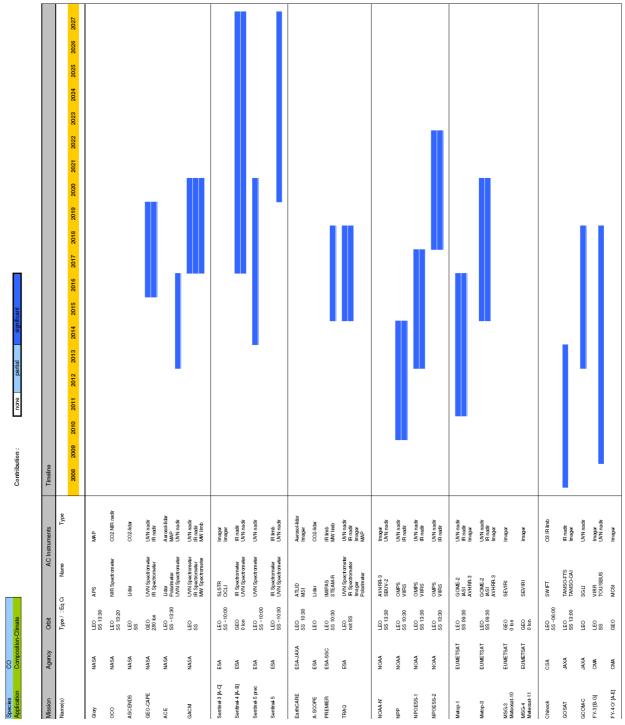


Table 4-40: CO Measurements from Planned Missions for Composition-Climate Requirements





Matter         Approv         Ori         Approv         Ori         Approv         Ori         Approv	Species Application	CO2 Composition-Climate	Cimate			Contribution : none partial significant
Induction          Induction         Induction <t< th=""><th>hoi</th><th>Agency</th><th>Orbit</th><th>AC Ins</th><th>struments</th><th>Tmelite</th></t<>	hoi	Agency	Orbit	AC Ins	struments	Tmelite
MASA         LEO         AIRS           MASA         LEO         MODIS           MASA         LEO         MURIS           FESA         SS 13:30         CUUP           ESA         SS 10:30         ATSR-2           MASA         SS 10:30         ATSR-2           NOAA         SS 10:30         ATSR-2           NOAA         LEO         AVHRR-3           NOAA         SS 09:30         BUV-2           NOAA         LEO         AVHRR-3           NOAA         LEO         AVHRR-3           NOAA         LEO         AVHRR-3           NOAA         LEO         AVHRR-3           SI 13:0         SUV-2         SUV-2           NOAA         LEO         AVHRR-3           SI 13:1         Ob         SUVR-2           SI 13:1 <t< th=""><th>Name(s)</th><th></th><th>Type / ©Eq (</th><th></th><th>Type</th><th>2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026</th></t<>	Name(s)		Type / ©Eq (		Type	2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
MASA         LEO         MODIT           NASA         LEO         MODIS           NASA         SS 10.30         MODIS           NASA         ES 13.45         RES           NASA         LEO         OMI           ESA         SS 13.30         CALIOP           ESA         LEO         CALIOP           ESA         SS 10.30         ATSR-2           NOAA         SS 10.30         ATSR-2           NOAA         SS 10.30         ATSR-2           NOAA         SS 10.30         ANTRR-2           NOAA         SS 10.30         ANTRR-3           SS 10.31         GONE2         SUVR-2           SS 10.31         GONE2	Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
MASA         LEO         MLS           NASA         LEO         MLS           SS 13.445         TEM         ES           NASA         LEO         CAUDP           ESA         SS 13.30         CAUDP           ESA         SS 10.00         MTSA           NCMA         SS 10.00         MTSA           NCMA         SS 10.00         MTSA           NCMA         SS 03.00         MTSA           NCMA         SS 03.00         MTSA           NCMA         SS 03.00         SGUV-2           SS 13.00         SGUV-2         SGUV-2           SS 03.00         SGUV-2 <t< td=""><td>Terra</td><td>NASA</td><td>LEO SS 10:30</td><td>MOPITT MODIS</td><td>IR nadir Imager</td><td></td></t<>	Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
MASA         LEO         CULOP           ESA         LEO         GOME-1           ESA         SS 10:300         ATSR.2           ESA         LEO         GOME-1           ESA         LEO         ATSR.2           ESA         LEO         ATSR.2           NOAA         LEO         ATSR.2           NOAA         LEO         ATSR.2           NOAA         LEO         ANHR.3           BUV.2         SUV.2         SUV.2           NDAA         LEO         ANHR.3           SI 13.00         SUV.2         SUV.2           BUV.2         SUV.2         SUV.2           SI 13.00         SUV.2         SUV.3           SI 13.00         SUV.3         SUV.3           SI 13.00         SUV.3         SUV.3           SI 13.00         SUV.3         SUV.3           SI 13.00         SUV.3         SUV.3           SI 13.00 <td></td> <td>NASA</td> <td>LE0 SS 13:45</td> <td>MLS OMI TES HIRDLS</td> <td>MW limb UVN nadir IR nadir IR limb</td> <td></td>		NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MW limb UVN nadir IR nadir IR limb	
ESA         LEO         COME: 1           ESA         SS 10:30         ATSR: 2           ESA         SS 10:30         ATSR: 2           ESA         SS 10:30         MPASAMCHY           MOAA         EFO         MPASA           NOAA         EFO         ATSR: 2           NOAA         EFO         AWHRP.3           NOAA         EFO         AWHRP.3           NOAA         EFO         AWHRP.3           NOAA         EFO         AWHRP.3           NOAA         SS 13:30         SBUY: 2           NOAA         SS 09:30         SBUY: 2           NOAA         SS 09:30         SBUY: 2           NOAA         SS 09:30         SBUY: 2           NCAA         SS 09:30         SBUY: 2           NCAA         SS 09:30         SBUY: 2           EUMETSAT         LEO         SCME.2           SNSB         ELO         SS 018           SNSB         SS 05:30         SCMF.2           SNSB         SS 05:30         SCMF.2           SNSB         CACE         SS 055           CME         SS 05:30         SCMF.2           SNSB         SS 05:30         SCMF.2<	CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
EA         LEO         SSIAMACHY MATSR SSIODB         SSIAMACHY ATSR ATSR ATSR ATSR AMATSR AMATSR AMATSR AMATSR AMATSR AWHRR3           NCMA         LEO         AWHRR3           BUWETSAT         LEO         AWHRR3           EUMETSAT         CEO         AWHRR3           EUMETSAT         GEO         SEVIRI           SNSB         LEO         AGE           SNSB         SSI03-3         SUV-2           CMA         SSI03-3         SUV-2           CMA         SSI03-3         SUV-2           CMA         SSI03-3         SUV-2           SSI03-3         SUV-2         SUV-2           CMA         SSI03-3         SUV-2           SSI03-3         SUV-2         SUV-2           CMA         SSI03-3         SUV-2           SSI03-3         SUV-3         SUV-3           CMA         SSI03-3         SUV-3           CMA         SSI03-10         SUV-3	ERS.2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
NCMA         LEO         AVHRR.3           NCMA         SE 0930         AVHRR.3           NCMA         SE 15:03         SBUV.2           NCMA         LEO         SBUV.2           NCMA         SE 0330         SBUV.2           NCMA         SE 0330         SBUV.2           NCMA         LEO         SUMRR.3           EUMETSAT         LEO         SOMR.2           EUMETSAT         LEO         GOME.2           SINS         GEO         SE VIRI           EUMETSAT         GEO         SE VIRI           Obin         Obin         SINS           EUMETSAT         GEO         SE VIRI           Obin         SS 05:00         COME.2           SNSB         LEO         MURINA.3           CMES         SS 05:00         COME.2           SNSB         SS 05:00         COME.3           CMES         SS 05:00         COME.3           CMES         SS 05:00         COME.3           CMES         SS 05:00         COME.3           SS 05:01         COME.3         COME.3	ENVISAT	ESA		SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
NCMA         LEO         AWHRR3           NCMA         LEO         SS 13:30         SBU/2           NCMA         LEO         SBU/2         SBU/2           NCMA         LEO         AWHRR3         SBU/2           NCMA         LEO         SBU/2         SBU/2           NCMA         LEO         AWHRR3         SBU/2           BUMETSAT         LEO         SBU/2         SBU/2           EUMETSAT         CGO         SGWE2         AWHRR3           EUMETSAT         CGO         SEVIFI         SS 05:00           SNSB         LEO         SEVIFI         CSA           SNSS         CMS         SS 05:00         CSIRIS           CMS         SS 05:00         CSIRIS         SS 05:00           SNSS         SS 05:00         CSIRIS         COME           SNSS         SS 05:00         CSIRIS         COME           CMS         SS 05:00         CSIRIS         COME           CMA         SS 05:00         CONRES         COME           SS 05:00         CONRES         SS 05:00         COME           SS 05:00         COME         COME         COME           SS 05:00         COME	NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NCMA         LEO SS 06:300         AWHRP.3 SB 10/2           NCMA         LEO SS 05:300         SB 10/2           NCMA         LEO SS 05:300         AWHRP.3 SB 10/2           EUMETSAT         LEO NA         AWHRP.3 AWHRP.3           EUMETSAT         GEO NA         SS 06/2           EUMETSAT         GEO NA         SS 06/1           EUMETSAT         GEO NA         SS 06/1           EUMETSAT         GEO NA         SS 06/1           CASA         LEO SS 06/1         AGE           CMES         SS 10:10         MAR           CMA         LEO SS 10:10         MAR	16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NCAA         LEO SS 13:30         AWHRP.3 SBUY.2           EUMETSAT         LEO SS 09:30         GOME.2 MARR.3           EUMETSAT         LEO 0.0m         GOME.2 MARR.3           EUMETSAT         GEO 0.0m         SE VIRI           SNSB         ELO         SE VIRI           SNSB         LEO         SCIRIS           CSA         LEO         MARR           CMS         SS 05:00         CSIRIS           CMA         LEO         MAR           CMA         LEO         VIRR           CMA         SS 10:10         TUUSBUS	NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT LEO GOME-2 SS 09:30 MAIRRa3 EUMETSAT GEO SEVIRI 0 bin 0 bin SEVIRI 0 bin 0	NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
EUMETSAT GEO SEVIRI EUMETSAT GEO SEVIRI BUNETSAT GEO SEVIRI SNSB LEO SAR CSA LEO AGE CNA LEO POMOR CNA LEO VIRR SS 10:10 TOU'SBUS	Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
EUMETSAT GEO SEVIRI 0.6m SS 05.00 OSIRIS CAES LEO ACE CAES LEO ACE CAES SS 13.30 Pobler CMA LEO VIRP CMA SS 10:10 TOU/SBUS	MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
SNSB LEO SMR SS 06:00 CSIFIS CSA LEO ACE CMES LEO Polder CMA LEO VIFIR SS 10:10 TOURBUS	MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
CSA LEO ACE CNES LEO Polder SS 13:30 Polder CMA LEO VIER SS 10:10 TOUISBUS		SNSB	LEO SS 06:00	SMR OSIRIS	MWV IImb UVN nadir	
DL CNES LEO Polder SS 13:30 Polder CMA LEO VIER SS 10:10 TOUISBUS	F	CSA	LEO	ACE	Occultation	
CMA LEO VIER SS 10-10 TOU/SBUS	SOL	CNES	LEO SS 13:30	Polder	MAP	
		CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-41: CO<sub>2</sub> Measurements from Current Missions for Composition-Climate Requirements





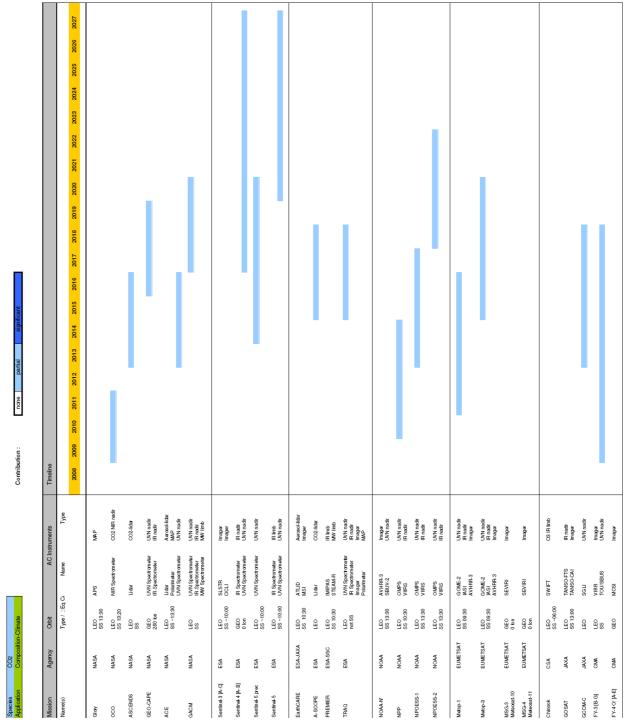


Table 4-42: CO<sub>2</sub> Measurements from Planned Missions for Composition-Climate Requirements





Species Application	NO2 Composition-Climate	Climate			Contribution : significant significant
Mission	Agency	Orbit	AC Ins	AC Instruments	Timeline
Name(s)		Type /Eq C	Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MW limb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AA TSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIHI	Imager	
Odin	BSNSB	LEO SS 06:00	SMR OSIRIS	MVV limb UVN radir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-43: NO<sub>2</sub> Measurements from Current Missions for Composition-Climate Requirements







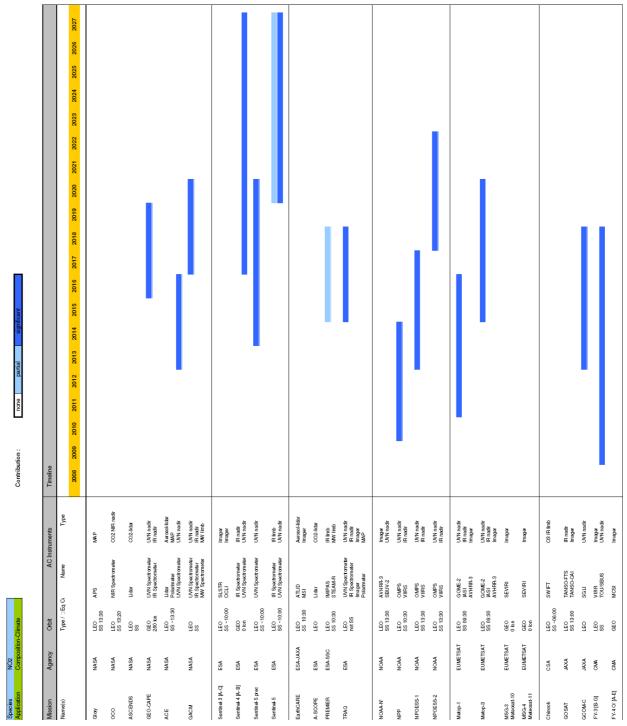


Table 4-44: NO<sub>2</sub> Measurements from Planned Missions for Composition-Climate Requirements





Species Application	HDO Composition-Climate	Climate			Contribution : none partial significant
Mission	Agency	Orbit	AC Inst	AC Instruments	Timeline
Name(s)		Type /Eq C	Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MNV IImb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN radir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occultation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	SNSB	LEO SS 06:00	SMR OSIRIS	MWY limb UVN redir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-45: HDO Measurements from Current Missions for Composition-Climate Requirements







Species Application	HDO Composition-	Climate			Contribution : none partial significant
Madan	A second s	Chi.		tan management	Tardes
MISSIOF	Ageiry		ł		ITTERIN
(s) Linear				8	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Gloty	NASA	LE0 SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS SS	Lidar	CO2-lidar	
GEO-CAPE	NASA	GEO 280 bn	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LEO SS ~13:30	Lidar Polatimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MN limb	
Sentinet-3 [A-C]	ESA	LEO SS ~10:00	SLSTR OCLI	Imager Imager	
Sentinel-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrometer	UVN nadir	
Sentinel 5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	LEO not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NPP	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS VIIRS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteccat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	O3 IR limb	
GOSAT	AXA	LEO SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	E EO	SGU	UVN nadir	
173	CIMH	SS	TOU/SBUS	UNN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-46: HDO Measurements from Planned Missions for Composition-Climate Requirements





Species Application	SF6 Composition-Climate	Climate			Contribution : none partial significant
Mission	Agency	Orbit	AC Instr	AC Instruments	Timelre
Name(s)		Type /Eq C	Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT MODIS	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS CMI TES HIRDLS	MV limb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LE0 SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMACHY MIPAS AATSR GOMOS MERIS	UVN nadir IR limb Imager Occuttation Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR.3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imagər	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	SNSB	LEO SS 06:00	SMR OSIRIS	MW IImb UVN nadir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-47: SF<sub>6</sub> Measurements from Current Missions for Composition-Climate Requirements







Species Application	SF6 Composition-	Climate			Contribution : none partial significant
Mission	Agency	Orbit		AC Instruments	Timeline
Name(s)		Type / ⊐Eq.	G Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glory		LEO SS 13:30	APS	МАР	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS		SS SS	Lidar	CO2-lidar	
GEO-CAPE		GEO 280 bn	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE		LEO SS ~13:30		Aerosol-lictar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
Sentinel-3 [A-C]	ESA	LEO SS ~10:00	SLSTR OCLI	Imager Imager	
Sentinet 4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrameter	UVN nadir	
Sentinel-5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAG	ESA	not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRP-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteccat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	O3 IR limb	
GOSAT	JAXA	LEO SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	LEO	SGL	UVN nadir	
FY-3[B-G]	CIMA	SS	VIRR TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA	GEO	MCSI	Imager	

Table 4-48: SF $_6$  Measurements from Planned Missions for Composition-Climate Requirements





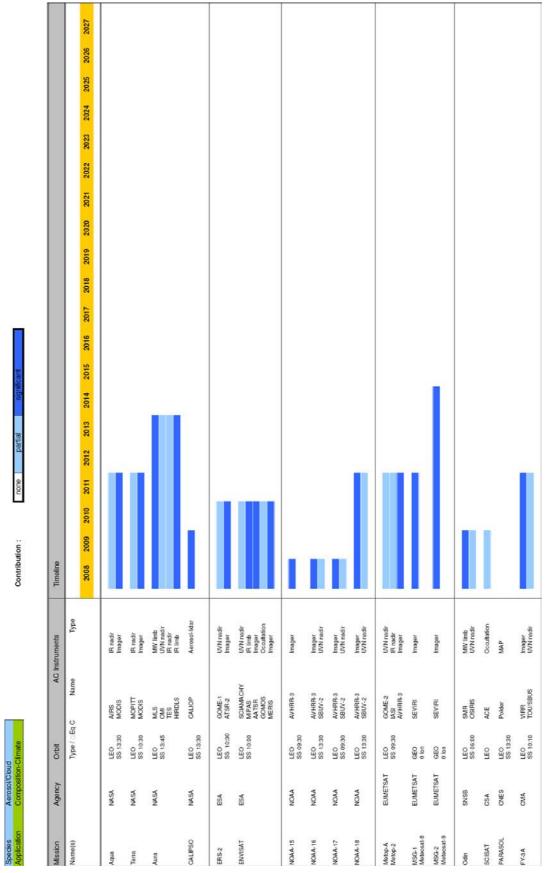


 Table 4-49: Aerosol & Cloud Measurements from Current Missions for Composition-Climate

 Requirements





Contribution: none partial significant	Tmeine		2009 2010 2011 2012 2013 2014 2019 2014 2019 2014 2018 2018 2020 2021 2022 2023 2024 2029																											
0		Type		MAP	CO2 NIR nadir	CO2-lidar	UVN nadir IR nadir	Aerosol-lidar MAP UVN nadir	UVN nadir IR nadir MM limb	Imager Imager	IR nadir UVN nadir	UVN nadir	IR limb UVN nadir	Aerosol-lidar Imager	CO2-lidar	IR limb MW limb	UVN nadir IR nadir Imager MAP	Imager UVN nadir	UVN nadir IR nadir	UVN nadir IR nadir	UVN nadir IR nadir	UVN nadir IR nadir Imager	UVN nadir IR nadir Imager	Imager	Imager	O3 IR limb	IR nadir Imager	UVN nadir	Imager UVN nadir	-
	AC Instruments	a Name		APS	NIR Spectrometer	Lidar	UVN Spectrometer IR Spectrometer			SLSTR	IR Spectrometer UVN Spectrometer		IR Spectrometer UVN Spectrometer	ATLID MSI	Lidar	IMIPAS STEAM-R	ometer	AVHRR-3 SBUV-2	OMPS VIIRS	OMPS VIIRS	OMPS	GOME-2 IASI AVHRR-3			SEVIRI	SWIFT	TANSO-FTS TANSO-CAI		SUS	
d Climate	Orbit	Type / □Eq Ci			LEO SS 13:20				SS		GEO 0 Ion		LEO SS ~10:00				LEO not SS				LEO SS 13:30	SS 09:30	LEO SS 09:30		GEO 0 lon		LEO SS 13:00			
Aerosol/Cloud Composition-C	Agency			NASA	NASA	NASA	NASA	NASA	NASA	ESA	ESA	ESA	ESA	ESA-JAXA	ESA	ESA-SSC	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	EUMETSAT	CSA	AXA	JAXA	CMA	
Species Application	Mission	Name(s)		Glay	000	ASCENDS	GEO-CAPE	ACE	GACM	Sentinel-3 [A-C]	Sentinel-4 [A-B]	Sentinel-5 prec	Sentinel 5	EarthCARE	A-SCOPE	PREMIER	TRAQ	NOAA-N'	NPP	NPOESS-1	NP0ESS-2	Metop-1	Metop-3	MSG-3 Meteosat-10	MSG-4 Meteosat-11	Chinook	GOSAT	GCOM-C	FY-3[B-G]	

 Table 4-50: Aerosol & Cloud Measurements from Planned Missions for Composition-Climate

 Requirements





## 4.5.3 Air Quality Monitoring and Forecasting







		2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timeline	2008 2009 2010 2011 2012 2013 2014 2015 2016								I	1								
	AC Instruments	Name Type	IR nadir Imager	IR nadir Imager	MVV limb UVN nadir IR nadir IR limb	Aerosol-lidar	UVN radir Imager	Y UVN radir IR limb Inager Occutation Imager	Imager	Imager UVN nadir	lmager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imagər	hinager	Imager	MVV limb UVN readir	Occultation	MAP	Imager UVN nadir
			AIRS MODIS	MOPITT	MLS CMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
	Orbit	Type /  □Eq C	LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LE0 SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LE0 SS 10:10
H2O Air Ouality	Agency		NASA	NASA	NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	8SNS8	CSA	CNES	CMA
Species Application	Mission	Name(s)	Aqua	Terra	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-47: H<sub>2</sub>O Measurements from Current Missions for Air Quality Requirements





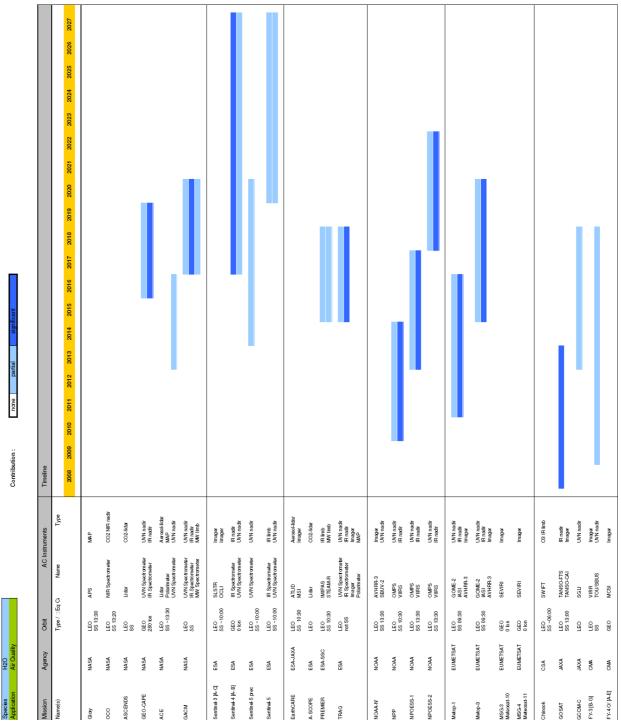


Table 4-48: H<sub>2</sub>O Measurements from Planned Missions for Air Quality Requirements





AC Instruments     Timeline       Image: Instruction I	Circlestical     Titletical       Titletical     Titletical       Type     2008     2010     2013       Finadic     Rinadic     2010     2013     2013       Finadic     Finadic     2014     2013     2013       Finadic     Finadic     Finadic     2014     2013       Minidic     Minidic     Finadic     2014     2013       Minidic     Minidic     Finadic     2014     2013       Minidic     Minidic     Finadic     2014     2014       Minidic     Minidic     Finadic     2014     2014       Minidic     Finadic     Finadic     Finadic     2014       Minidic     Finadic     Finadic     Finadic     2014       Minidic     Finadic     Finadic     Finadic     Finadic       Minidic     Finadic     Finadic     Finadic     Finadic       Minidic     Finadic     Finadic     Finadic     Finadic<	Circlestion     Timeline       Timeline     Timeline       Type     2008     2010     2013       Finadis     Finadis     2008     2010     2013       Finadis     Finadis     Finadis     Finadis     Finadis       Finadis     Finadis     Finadis     Finadis     Finadis       Montalis     Finadis     Finadis     Finadis     Finadis       Vinnadis     Finadis     Finadis     Finadis     Finadis       Finadis     <
AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Mare         Mare         2010         2011         2012           Mare         Mare         Mare         2008         2010         2011         2012           Mare         Mare <td< th=""><th>AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Mare         Mare         2008         2009         2014         2012           Mare         Mare         Mare         Mare         2008         2009         2014         2012           Mare         Mare         Mare         Mare         2008         2010         2011         2012           Mare         Mare         Mare         Mare         2008         2010         2011         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare         <td< th=""><th>AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2010         2011         2012           Mare         Type         Reade         2008         2009         2010         2011         2012           Mare         Mare         Withink         Reade         2008         2009         2011         2012           Mare         Mare         Mare         Mare         Mare         2008         2009         2011         2012           Mare         <t< th=""></t<></th></td<></th></td<>	AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Type         2008         2009         2011         2012           Mare         Mare         Mare         2008         2009         2014         2012           Mare         Mare         Mare         Mare         2008         2009         2014         2012           Mare         Mare         Mare         Mare         2008         2010         2011         2012           Mare         Mare         Mare         Mare         2008         2010         2011         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare         Mare         2010         2014         2012           Mare         Mare         Mare <td< th=""><th>AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2010         2011         2012           Mare         Type         Reade         2008         2009         2010         2011         2012           Mare         Mare         Withink         Reade         2008         2009         2011         2012           Mare         Mare         Mare         Mare         Mare         2008         2009         2011         2012           Mare         <t< th=""></t<></th></td<>	AC Instruments         Timeline           Name         Type         2008         2010         2011         2012           Mare         Type         2008         2009         2010         2011         2012           Mare         Type         Reade         2008         2009         2010         2011         2012           Mare         Mare         Withink         Reade         2008         2009         2011         2012           Mare         Mare         Mare         Mare         Mare         2008         2009         2011         2012           Mare         Mare <t< th=""></t<>
C     Number     Type       AIRS     Ready MOSIT	C     Nume     Type       AFS     Reads     2008     2010     2011     2012     2013       AFS     Reads     Reads     Non     2011     2012     2013       AFS     Reads     Non     Non     2011     2012     2013       AFS     Non     Non     Non     Non     2011     2012     2013       AFS     Non     Non     Non     Non     Non     Non       AFS     Non     Non     Non     Non     Non       Arresh     Non     Non     Non     Non       Arresh     Non     Non     Non     Non       Arresh     Non     Non       Ar	C     Number     Type       MS     Reade     2008     2010     211     2012     2013       MS     Reade     Reade     2008     2000     2010     2011     2012       MS     Reade     Maine     Reade     2008     2000     2010     2011     2012       MS     Reade     Maine     Reade     Maine     Reade     2008     2000     2010     2011     2012       MS     Maine     Reade     Maine     Reade     Reade     2008     2000     2011     2012       MS     Maine     Reade     Maine     Reade     Reade     Reade     Reade       MHR3     Reade     MMR3     Reade     MMR3     Reade     Reade       MMR3     Reade     MMR3     Reade     Reade     Reade       MMR3     Reade     MMR3     Reade     Reade       MMR3     Reade     Read     Reade     Reade
AIRS MODIS MUS MLS MLS MLS CALIOP CALIOP CALIOP CALIOP CALIOP ATSR-2 CALIOP CALIOP CALIOP CALIOP ATSR-2 CALIOP ATSR-2 CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP SIGNAS CALIOP CALIOP CALIOP CALIOP SIGNAS CALIOP CALIOP CALIOP SIGNAS CALIOP CALIOP CALIOP SIGNAS CALIOP SIGNAS CALIOP SIGNAS CALIOP CALIOP SIGNAS SIGNAS CALIOP SIGNAS CALIOP SIGNAS CALIOP SIGNAS CALIOP SIGNAS SIGNAS CALIOP SIGNAS SIGNAS CALIOP SIGNAS SIGNAS CALIOP SIGNAS SIGNAS SIGNAS SIGNAS CALIOP SIGNAS SIG	AIRS MODIS MODIS MLS MLS MLS MLS CALIOP CALIOP CALIOP CALIOP ATSR2 CALIOP CALIOP CALIOP ATSR2 CALIOP ATSR2 CALIOP CALIOP ATSR2 CALIOP SECURI SECURI CALIOP CALIOP CALIOP CALIOP CALIOP SECURI CALIOP CALIOP CALIOP SECURI CALIOP CALIOP CALIOP SECURI CALIOP CALIOP SECURI CALIOP CALIOP CALIOP SECURI CALIOP CALIOP SECURI CALIOP CALIOP CALIOP SECURI CALIOP CALIOP SECURI CALIOP SECURI CALIOP CALIOP SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI CALIOP SECURI SECURI SECURI CALIOP SECURI SECURI CALIOP SECURI S	AIRS MODIS MODIS MUS MUS MUS MUS MUS ANIAR2 CALIOP OR ANIAR2 ANIAR2 ANIAR3 ANIA
MODIS MUS MUS CALIOP CALIOP CALIOP CALIOP CALIOP ANTSR-2 CALIOP ANTSR-2 AVHER-3 AVHER-3 AVHER-3 SBUV-2 SBUV	MODIS MUS MUS CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP CALIOP ANTSR-2 ANTSR-2 ANTSR-2 ANTRR-3 SANTSR-2 AVHRR-3 SBUV-2 SB	MOPITT MACOIS MACOIS MACOIS MACOINS CAUIOP CAUIOP CAUIOP CAUNCHY MITRAS AVHER-3 SUV-2 AVHER-3 SUV-2 AVHER-3 SUV-2
	MLS TES TES CALLOP CALLOP CALLOP CAME-1 ATTSR CAME-1 ATTSR CAME-1 ATTSR CAME-1 ATTSR CAME-1 ATTSR CAME-1 ATTSR CAME-1 SUV-2 SU	MLS TES TES CALLOP CALLOP CALLOP CALLOP CALLOP ATSR2 MERS AVHRR3 AVHRR3 AVHRR3 AVHRR3 SBUV2 SBU2 SBU2 SBU2 SBU2 SBU2 SBU2 SBU2 SBU
CALIOP GCME-1 ATSR-2 ATSR-2 SIZMACHY MIPAS CAMSS AVHRR-3 SBUV-2 SBUV-2 AVHRR-3 SBUV-2	CALIOP GCOME-1 ATSR-2 ATSR-2 SAMACHY MIPAS GOMOS MERIS SBUV-2 AVHRR-3 SBUV-2 SB	CALIOP COME:1 COME:1 AURAS AURAS AURAS AURAS AURAS AURAS SBUV:2 AURAS SBUV:2 AURAS SBUV:2 AURAS SBUV:2 AURAS SBUV:2 COME 2 AURAS SBUV:2 SBUS COME 2 AURAS AU
GOME-1 ATSR-2 MIPAS ANTSR ANTSR ANTSR ANTSR ANTRP 8 AVHRP,3 SBUV-2 SBUV-	GOME-1 ATSR-2 MIPAS ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR ANTSR SEVIRI SEVIRI SEVIRI SEVIRI SMR SMR ACSIMS	GOME-1 ATSR-2 SICAMACHY MIPARA AVHRR3 AVHRR3 BUV-2 AVHRR-3 BUV-2 BUV-2 BUV-2 BUV-2 SUV-2 COME-2 AVHRR-3 SUV-2 SUV-2 SUV-2 SUV-2 COME-2 AVHRR-3 SUV-2 SUV-2 SUV-2 COME-2 AVHRR-3 SUV-2 SUV-
SCIAMACHY MPAS ANTER ANTER ANTER ANTER SEUV-2 SEUV-2 SEUVE ANTER SEUV-2 SEURI SEURI SEVIRI SEVIRI SEVIRI SEVIRI SEVIRI	SCIAMACHY MTPAS ANTRA ANTRA ANTRA ANTRA SEUV-2 SEUV-2 SEUV-2 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-1 SEUV-1 SEUV-1 SEUV-1 SEUV-1 SEUV-1 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV-1 SEUV-2 SEUV	SCIAMACHY MATSR ANTRA ANTRA MATSR MATSR MATSR MATRA SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SBUV-2 SMTR SEVIRI S
AVHRR-3 AVHRR-3 SQUV-2 AVHRR-3 SQUV-2 SQUR-2 SQUR-2 SQUR-2 SQUR-3	AVHRR-3 AVHRR-3 SSUV-2 AVHRR-3 SBUV-2 SBUV-2 SBUV-2 SSVIRI SEVIRI SEVIRI SEVIRI SSMR SCIRIS SAR	AVHRR-3 AVHRR-3 SBUY-2 AVHRR-3 BBUY-2 SBUY-2 SBUY-2 AVHRR-3 SBUY-2 AVHRR-3 SBUY-2 SURI SEVIRI SEVIRI SEVIRI SCIPIS SURI CSIPIS
AVHRR-3 SBUV-2 AVHRR-3 SBUV-2 AVHRR-3 SBUV-2 SBUV-2 GCOME-2 LIVS SBUR-2 SEVIRI SEVIRI SEVIRI SBUR SBUR	LEO AVHRR-3 Ss 13:30 SUV-2 ELEO AVHRR-3 Ss 09:30 SUV-2 LEO AVHRR-3 Ss 09:30 AVHRR-3 Ss 09:30 AVHRR-3 AVHRR-3 AVHRR-3 AVHRR-3 AVHRR-3 AVHRR-3 AVHRR-3 AVHRR-3 Ss 06:00 SEV RI 0 bm SEV RI 0 bm SEV RI 1 EO SS 05:00 CSIRIS	LEO AWHRR 3 SS 1330 SUV 2 LEO AWHRR 3 SS 0930 SUV 2 LEO SUV 2 SS 1330 SUV 2 SS 0930 AWHRR 3 SS 0930 AWHRR 3 CEO GOME 2 MARR 3 CEO SUIRI 0 bin SEVIRI 0 bin SEVIRI 0 bin SEVIRI 1 EO SMR 2 SS 0650 SMR 2 LEO AGE LEO Polder LEO Polder LEO Polder
LEO AWHRR3 SS 09:30 BUV-2 LEO AWHRR3 SS 13:30 BUV-2 LEO GOME 2 SBUV-2 SUV-2 SBUV-2 SBUV-2 SUV-3 MV-3 MV-3 MV-3 MV-3 MV-3 MV-3 MV-3 M	LEO AWHRR3 SS 09:30 BUV-2 LEO AWHRR3 SS 03:30 BUV-2 LEO AWHRR3 SBUV-2 SUV-2 SUV-2 SBUV-2 SUV-2 MHRR3 GMMR SS 05:00 SSV191 O bu O bu O bu O bu O bu O bu O bu O bu	LEO AWHRR3 SS 0930 AWHRR3 LEO AWHRR3 SS 0930 AWHRR3 SS 0930 AWHRR3 GEO SEVIRI 0 bm AKS GEO SEVIRI 0 bm CSIRIS LEO SMR LEO AGE LEO AGE
LEO AWHRR.3 Ss 13:30 SEUV-2 ELEO GOME-2 Ss 99:30 MAR.3 GEO SEVIRI 0 bm SEVIRI 0 bm SEVIRI 1 bm Seviri	LEO AWHRR-3 Ss 13:30 SeUV-2 ELEO GOME-2 Ss 99:30 AVR MARR-3 ANRR-3 GEO SEVIRI 0 bm SEVIRI 0 bm CSIPIS LEO SMR ELEO CSIPIS	LEC AWHRR-3 SS 13:30 SUV-2 SS 03:30 SUV-2 LEC GOME-2 SS 05:30 KHRR-3 GEC SEVIRI GEC SEVIRI 0 bin 0 bin 0 bin 1 EC SIRIS LEC Polder LEC Polder SS 13:30
LEO GOME-2 SS 99-30 MASI MARR 3 GEO SEVIRI 0 bm SEVIRI 0 bm SEVIRI LEO SMR SS 06:00 CSIRIS	LEO GOME-2 SS 99-30 MAHR-3 MHR-3 GEO SEVIRI 0 bm SEVIRI GEO SEVIRI LEO SMR ELEO CGIPIS	LEO GOME-2 SS 99-30 MAHRA AWHRA GEO SEVIRI 0 bin SEVIRI 0 bin SVIRI LEO SMR ELEO SMR LEO AGE LEO POMer LEO POMer SS 13:30
SEVIRI SEVIRI SMR CSIRIS	SEVIRI SEVIRI SMR OSINIS ACE	SEVIRI SEVIRI SMR OSIRIS ACE Polder
SEVIRI SMR OSIRIS	SEVIRI SMR CSIRIS ACE	SEVIRI SAVR OSIRIS ACE Polder
SMR OSIRIS	SMR OSIRIS ACE	SMR OSIRIS ACE Polder
	ACE	ACE Polder

Table 4-49:  $O_3$  Measurements from Current Missions for Air Quality Requirements





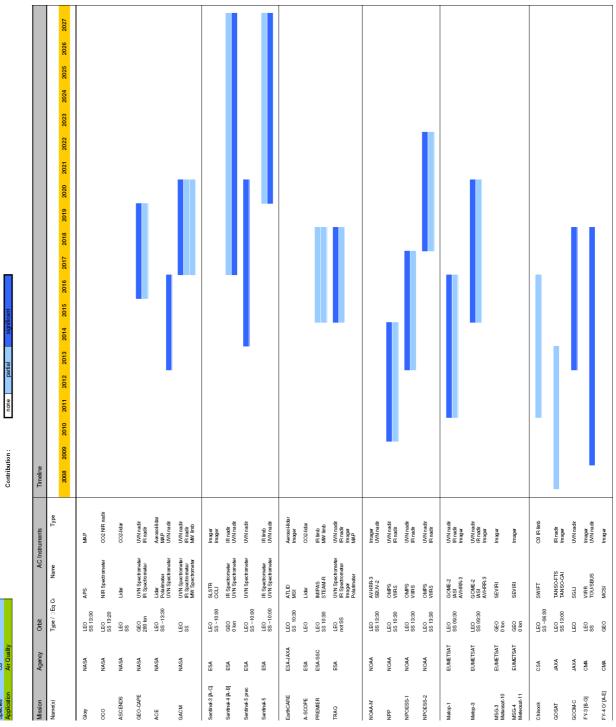


Table 4-50: O<sub>3</sub> Measurements from Planned Missions for Air Quality Requirements





			2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timeline		2008 2009 2010 2011 2012 2013 2014 2015 2016 2017																	
	AC Instruments	Type		IR nadir Imager	IR nadir Imager	MVV limb UVN nadir IR radir IR limb	Aerosol-lidar	UVN nadir Imager	UVN nadir IR limb Irager Occultation Imager	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imager	Imager	Imager	MWY limb UVN radir	Occultation	MAP	Imager UVN nadir
_	AC	c Name		AIRS MODIS	MOPITT	MLS CMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AA TSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU'SBUS
	Orbit	Type / GEq C		LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LEO SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 lon	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
Species HNO3 Application Air Quality	Agency			NASA	NASA	NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	SNSB	CSA	CNES	CMA
Species Application	Mission	Name(s)		Aqua	Terra	Aura	CALIPSO	ERS.2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-51:  $\ensuremath{\mathsf{HNO}_3}$  Measurements from Current Missions for Air Quality Requirements





Species Application	HNO3 Air Quality		_		Contribution : none partial aigniticant
Mission	Agency	Orbit		AC Instruments	Timeline
Name(s)		Type / ⊐Eq	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glory	NASA	LE0 SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	LEO SS	Lidar	CO2-lidar	
GEO-CAPE	NASA	GEO 280 km	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	Aerosol-lidar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MV limb	
Sentinet-3 [A-C]	ESA		SLSTR OCLI	lmager Imager	
Sentinel-4 [A-B]	ESA		IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA			UVN nadir	
Sentine <del>l</del> 5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA	LEO SS 10:30	ATLID MSI	Aerceol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC		IMIPAS STEAM-R	IR limb MW limb	
TRAQ	ESA	LEO not SS	UVN Spectrometer IR Spectrometer Imager Polatimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LE0 SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA	LEO SS 10:30	OMPS VIIRS	UVN nadir IR nadir	
NPOESS-1	NOAA	LE0 SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LE0 SS 13:30	OMPS VIIRS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA		SWIFT	O3 IR limb	
GOSAT	JAXA	8	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA		SGL	UVN nadir	
FY-3[B-G]	CMA	SS	VIRR TOU/SBUS	Imager UVN nadir	
FY-4 0/ [A-E]	CMA		MCSI	Imager	

Table 4-52: HNO<sub>3</sub> Measurements from Planned Missions for Air Quality Requirements





		5 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																		
Contribution : agrilloant	Timeline	2008 2009 2010 2011 2012 2013 2014 2015									1									
	AC Instruments	ne Type	IR nadir	Imager IR nadir	Imager	MNV limb UVN nadir IR nadir IR limb	Aerosol-lidar	UVN radir Imager	UVN nadir R limb Innager Occultation Innager	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imagər	Imager	Imager	MWY timb UVN redir	Occultation	MAP	Imager UVN nadir
		q C Name	AIRS	MODIS	SIGOM	MLS OMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMA CHY MIPAS AA TSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
	Orbit	Type /Eq C	LEO	SS 13:30 LEO	SS 10:30	LEO SS 13:45	LE0 SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
CO Air Quality	Agency		NASA	NASA		NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	SNSB	CSA	CNES	CMA
Species Application	Mission	Name(s)	Aqua	Terra		Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat 8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-53: CO Measurements from Current Missions for Air Quality Requirements



pecies



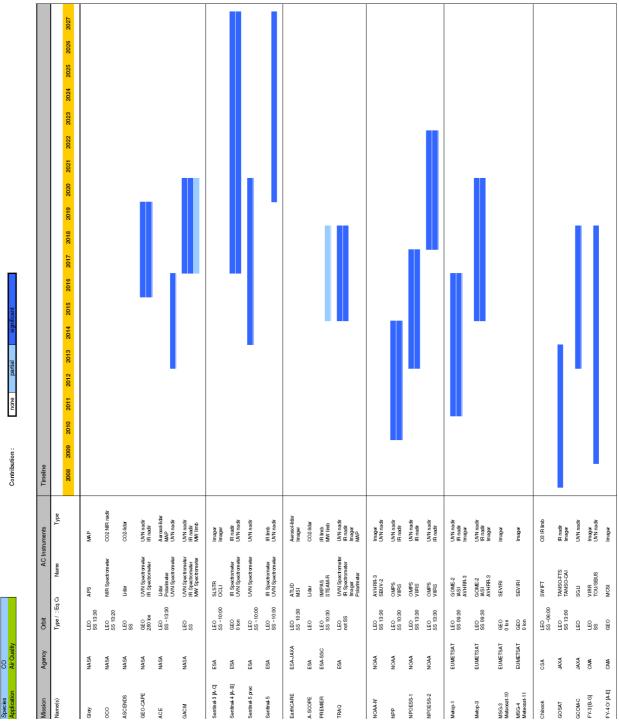


Table 4-54: CO Measurements from Planned Missions for Air Quality Requirements





partial significant			2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution :	Timeline		2008 2009 2010 2011 2012								I	I								
	AC Instruments	Name Type		IR nadir Imager	IR radir Imager	MNV limb UVN nadir IR nadir IR limb	Aerosol-lidar	UVN radir Imager	HY UVN nadir R limb Insger Occuttation Imager	Imager	Imager UVN nadir	knager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Irnagər	Imager	Imager	MMV limb UVN nadir	Occultation	MAP	Imager UVN nadir
				AIRS MODIS	MOPITT	MLS OMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	TOUSBUS
	Orbit	Type / CEq C		LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LEO SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 lon	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
NO2 Air Quality	Agency			NASA	NASA	NASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	8SNS	CSA	CNES	CMA
Species Application	Mission	Name(s)		Aqua	Terra	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-55:  $\mathrm{NO}_{\mathrm{2}}$  Measurements from Current Missions for Air Quality Requirements



8



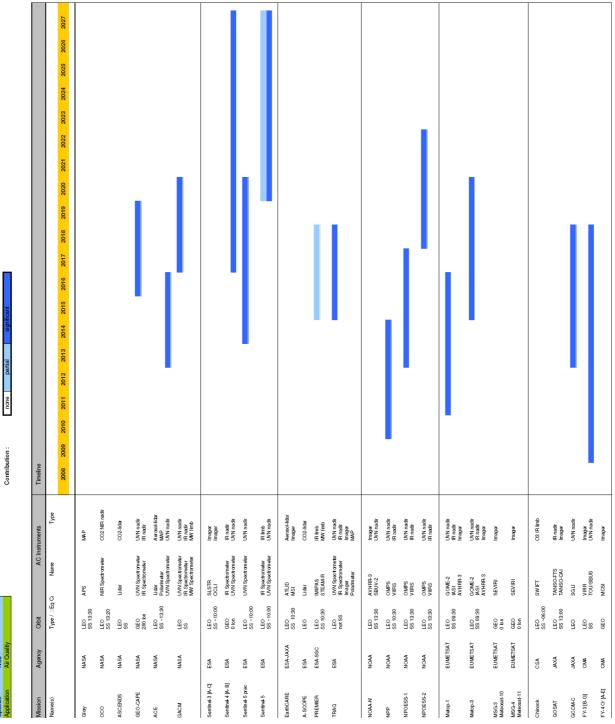


Table 4-56: NO<sub>2</sub> Measurements from Planned Missions for Air Quality Requirements





Species Application	N2O5 Air Quality		_		Contribution : none partial spritcant
Mission	Agency	Orbit	AC II	AC Instruments	Timeline
Name(s)		Type / GEq C	C Name	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR nadir Imager	
Terra	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
Aura	NASA	LE0 SS 13:45	MLS OMI TES HIRDLS	MV limb UVN nadir IR radir IR limb	
CALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AA TSR GOMOS MERIS	UVN nadir R limb Imager Occuthtion Imager	
NOAA-15	NOAA	LEO SS 09:30	AVHRR-3	Imager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 lon	SEVIRI	Imager	
MSG-2 Metaosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	8NS8	LEO SS 06:00	SMR OSIRIS	MNV limb UVN nadir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY.3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-57:  $N_2O_5$  Measurements from Current Missions for Air Quality Requirements





NPOR



Table 4-58:  $N_2O_5$  Measurements from Planned Missions for Air Quality Requirements





Imiliario       2008       2014       2015       2014       2014       2015       2014	2012 2013 2014 2015 2013 2014 2015 2015 2015 2015 2015 2015 2015 2015	2013         2014         2015         2014 <th< th=""><th>2013         2014         2015         2014         <th< th=""></th<></th></th<>	2013         2014         2015         2014 <th< th=""></th<>
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UVI rudir Imager IR III van de Rinder Rinder Imager IVI rudir Imager UVI rudir Imager UVI rudir Imager UVI rudir Imager IVI rudir IVI rud	ndir h di h di	notic to the to	notic termination
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56	ee Imb	er Imb rodir Mation	er Imb Tradir Lation
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Table 4-59: SO $_{\rm 2}$  Measurements from Current Missions for Air Quality Requirements







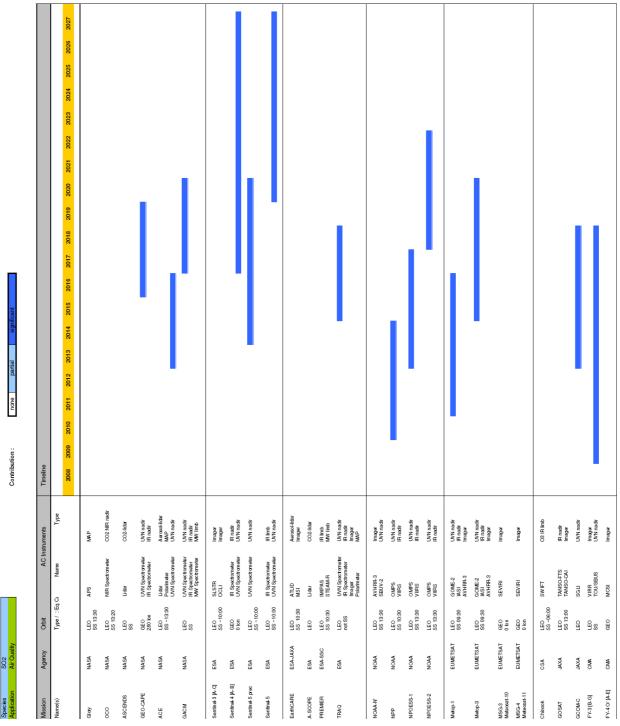


Table 4-60: SO<sub>2</sub> Measurements from Planned Missions for Air Quality Requirements





			2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timeline		2008 2009 2010 2011 2012 2013 2014 2015 2016								1	1								
	AC Instruments	e Type		IR nadir Imager	IR nadir Imager	MVV IImb UVN nadir IR nadir IR limb	Aerosol-lidar	UVN radir Imager	UVN nadir IR limb Imager Occuthation	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Irnagər	Imager	Imager	MMV limb UVN radir	Occultation	MAP	Imager UVN nadir
	'	C Name		AIRS MODIS	MOPITT MODIS	MLS CMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
	Orbit	Type / GEq C		LEO SS 13:30	LEO SS 10:30	LE0 SS 13:45	LEO SS 13:30	LEO SS 10:30	LEO SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
CH20 Air Quality	Agency			NASA	NASA	NASA	NASA	ESA	ESA	NCAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	BSNS	CSA	CNES	CMA
Species Application	Mission	Name(s)		Aqua	Terra	Aura	CALIPSO	ERS-2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-A Metop-2	MSG-1 Meteosat-8	MSG-2 Metecsat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-61: CH<sub>2</sub>O Measurements from Current Missions for Air Quality Requirements





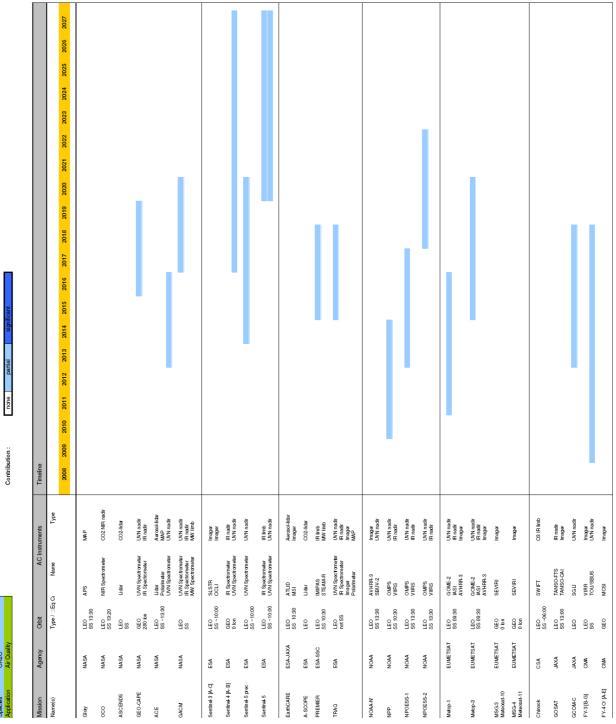


Table 4-62: CH<sub>2</sub>O Measurements from Planned Missions for Air Quality Requirements





Species Application	Species PAN Application Air Quality				Contribution : none partial significant
Mission	Agency	Orbit	AC Ir	AC Instruments	Timeline
Name(s)		Type /  GEq C	C Name	Type	
					2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Aqua	NASA	LEO SS 13:30	AIRS MODIS	IR radir Imager	
Terra	NASA	LEO SS 10:30	MOPITT	IR nadir Imager	
Aura	NASA	LEO SS 13:45	MLS OMI TES HIRDLS	MV limb UVN nadir IR nadir IR limb	
CALIPSO	NASA	LEO SS 13:30	CALIOP	Aerosol-lidar	
ERS-2	ESA	LEO SS 10:30	GOME-1 ATSR-2	UVN nadir Imager	
ENVISAT	ESA	LEO SS 10:00	SCIAMA CHY MIPAS AA TSR GOMOS MERIS	UVN radir IR limb Imager Occultation Imager	
NOAA-15	NOAA	LED SS 09:30	AVHRR-3	knager	
NOAA-16	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-17	NOAA	LEO SS 09:30	AVHRR-3 SBUV-2	Imager UVN nadir	
NOAA-18	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
Metop-A Metop-2	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Itnagər	
MSG-1 Meteosat-8	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
MSG-2 Meteosat-9	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Odin	8SNS	LEO SS 06:00	SMR OSIRIS	MW Ilmb UVN nadir	
SCISAT	CSA	LEO	ACE	Occultation	
PARASOL	CNES	LEO SS 13:30	Polder	MAP	
FY-3A	CMA	LEO SS 10:10	VIRR TOU/SBUS	Imager UVN nadir	

Table 4-63: PAN Measurements from Current Missions for Air Quality Requirements







Species Application	PAN Air Quality				Contribution : note partial significant
Mission	Agency	Orbit		AC Instruments	Trinelne
Name(s)		Type / ⊐Eq Ci	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glory	NASA	LEO SS 13-90	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS SS	Lidar	CO2-lidar	
GEO-CAPE	NASA	_	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA		Lidar Polatimeter UVN Spectrometer	Aercool-lidar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM limb	
Sentinet-3 [A-C]	ESA		SLSTR	lmager Imager	
Sentinel-4 [A-B]	ESA		IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA		UVN Spectrometer	UVN nadir	
Sentinel-5	ESA	LEO SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESA-JAXA		ATLID MSI	Aercsol-lidar Imager	
A-SCOPE	ESA		Lidar	CO2-lidar	
PREMIER	ESA-SSC		IMIPAS STEAM-R	IR limb MW limb	
TRAQ	ESA	LEO	UVN Spectrometer IR Spectrometer Imager Polatimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA		AVHRR-3 SBUV-2	Imager UVN nadir	
ddN	NOAA		OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA		SMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LEO SS 13:30	OMPS VIIRS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRP-3	UVN nadir IR nadir Imager	
MSG-3 Meteosat-10	EUMETSAT		SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA		SWIFT	OS IR limb	
GOSAT	JAXA	8	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C	JAXA	E EO	SGU	UVN nadir	
11-12	HMD		VINH TOU/SBUS	UVN nadir	
FY-4 0/ [A-E]	CMA		MCSI	Imager	

Table 4-64: PAN Measurements from Planned Missions for Air Quality Requirements





			2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027																	
Contribution : none partial significant	Timeline		2008 2009 2010 2011 2012 2013 2014 2015 20								I	I								
	AC Instruments	Name Type		IR nadir Imager	IR nadir Imager	MMV IImb UVN nadir IR nadir IR Iimb	Aerosol-lidar	UVN nadir Imager	Y UVN nadir R limb Inager Docultation	Imager	Imager UVN nadir	Imager UVN nadir	Imager UVN nadir	UVN nadir IR nadir Imagər	Imager	Imager	MW limb UVN radir	Occultation	MAP	Imager UVN nadir
				AIRS MODIS	MOPITT	MLS OMI TES HIRDLS	CALIOP	GOME-1 ATSR-2	SCIAMACHY MIPAS AATSR GOMOS MERIS	AVHRR-3	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	AVHRR-3 SBUV-2	GOME-2 IASI AVHRR-3	SEVIRI	SEVIRI	SMR OSIRIS	ACE	Polder	VIRR TOU/SBUS
	Orbit	Type / CEq C		LE0 SS 13:30	LEO SS 10:30	LE0 SS 13:45	LE0 SS 13:30	LEO SS 10:30	SS 10:00	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	LEO SS 13:30	LEO SS 09:30	GEO 0 Ion	GEO 0 Ion	LEO SS 06:00	LEO	LEO SS 13:30	LEO SS 10:10
VOCs Air Quality	Agency			NASA	NASA	VASA	NASA	ESA	ESA	NOAA	NOAA	NOAA	NOAA	EUMETSAT	EUMETSAT	EUMETSAT	SNSB	CSA	CNES	CMA
Species Application	Mission	Name(s)		Aqua	Terra	Aura	CALIPSO	ERS.2	ENVISAT	NOAA-15	NOAA-16	NOAA-17	NOAA-18	Metop-2 Metop-2	MSG-1 Meteosat-8	MSG-2 Meteosat-9	Odin	SCISAT	PARASOL	FY3A

Table 4-65: VOC Measurements from Current Missions for Air Quality Requirements





VOCS

pecies



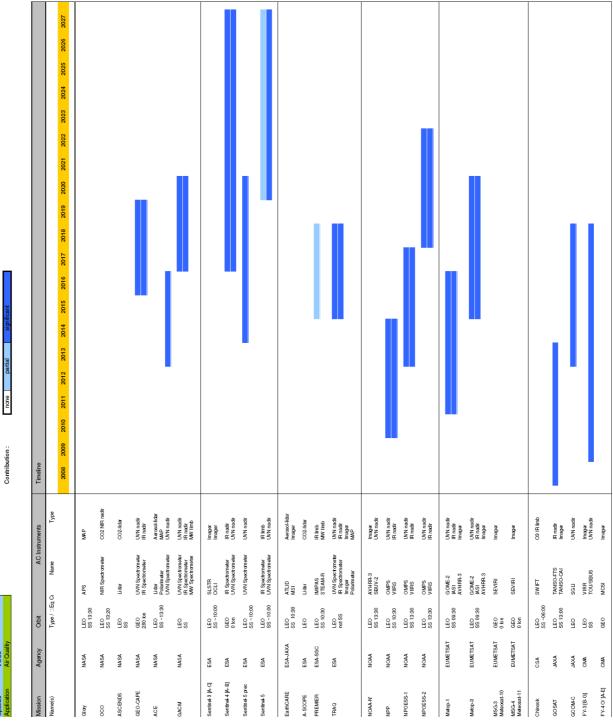


Table 4-66: VOC Measurements from Planned Missions for Air Quality Requirements





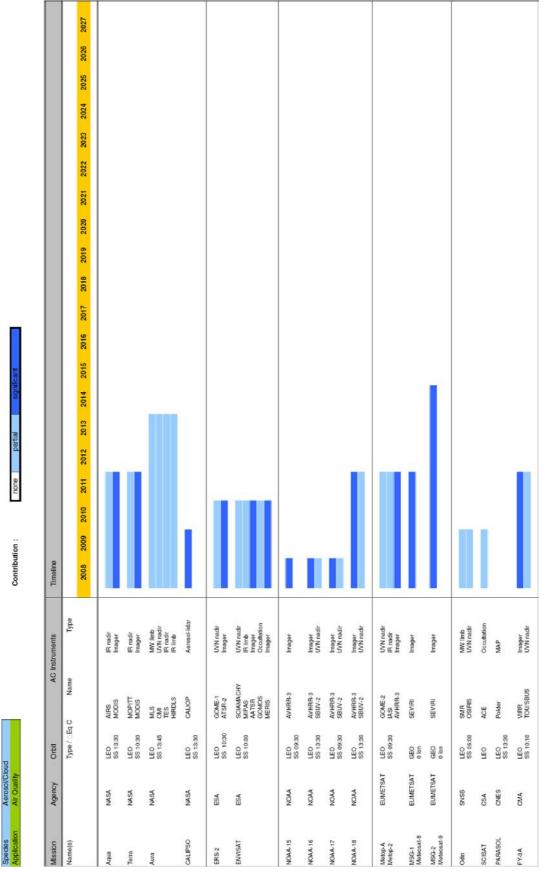


Table 4-67: Aerosol & Cloud Measurements from Current Missions for Air Quality Requirements



Aerosol/Cloud

Species



		O.F.			111
Mission	Agency	Orbit		AC Instruments	Imelne
Name(s)		Type / ⊐Eq Ci	Ci Name	Type	2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
Glory	NASA	LEO SS 13:30	APS	MAP	
000	NASA	LEO SS 13:20	NIR Spectrometer	CO2 NIR nadir	
ASCENDS	NASA	SS IEO	Lidar	CO2-lidar	
GEO-CAPE	NASA	GEO 280 km	UVN Spectrometer IR Spectrometer	UVN nadir IR nadir	
ACE	NASA	LE0 SS ~13:30	Lidar Polarimeter UVN Spectrometer	A erosol-lidar MAP UVN nadir	
GACM	NASA	SS SS	UVN Spectrometer IR Spectrometer MW Spectrometer	UVN nadir IR nadir MM Iimb	
Sentinel-3 [A-C]	ESA	LEO SS ~10:00	SLSTR	lmager Imager	
Sentinet-4 [A-B]	ESA	GEO 0 Ion	IR Spectrometer UVN Spectrometer	IR nadir UVN nadir	
Sentinel-5 prec	ESA	LEO SS ~10:00	UVN Spectrameter	UVN nadir	
Sentine <del>l</del> 5	ESA	LE0 SS ~10:00	IR Spectrometer UVN Spectrometer	IR limb UVN nadir	
EarthCARE	ESAJAXA	LEO SS 10:30	ATLID MSI	Aerosol-lidar Imager	
A-SCOPE	ESA	LEO	Lidar	CO2-lidar	
PREMIER	ESA-SSC	LEO SS 10:30	IMIPAS STEAM-R	IR limb MW limb	
TRAQ	ESA	LEO not SS	UVN Spectrometer IR Spectrometer Imager Polarimeter	UVN nadir IR nadir Imager MAP	
NOAA-N'	NOAA	LEO SS 13:30	AVHRR-3 SBUV-2	Imager UVN nadir	
ЧРР	NOAA	LEO SS 10:30	OMPS	UVN nadir IR nadir	
NPOESS-1	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
NPOESS-2	NOAA	LEO SS 13:30	OMPS	UVN nadir IR nadir	
Metop-1	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir Imager	
Metop-3	EUMETSAT	LEO SS 09:30	GOME-2 IASI AVHRR-3	UVN nadir IR nadir İmager	
MSG-3 Meteosat-10	EUMETSAT	GEO 0 Ibn	SEVIRI	Imager	
MSG-4 Meteosat-11	EUMETSAT	GEO 0 Ion	SEVIRI	Imager	
Chinook	CSA	LEO SS ~06:00	SWIFT	O3 IR limb	
GOSAT	JAXA	LEO SS 13:00	TANSO-FTS TANSO-CAI	IR nadir Imager	
GCOM-C FY-3[B-G]	JAXA CMA	LEO LEO	SGLI VIRR	UVN nadir Imager	
FY-4 0/ [A-E]	CMA	SS	TOU/SBUS MCSI	UVN nadir Imager	
	-	) and	200	* P	

 Table 4-68: Aerosol & Cloud Measurements from Planned Missions for Air Quality

 Requirements





# 5 Summary & Comment

## 5.1 Summary of Report

### Requirements

Requirements for atmospheric composition measurements have been drawn together from a variety of sources including information from US, European, multinational and national programmes. The emphasis is on atmospheric monitoring over the next decade and beyond, though it should be noted that the US Decadal Survey requirements include more detailed research aspects also.

A list of required products and relevant application areas has been identified and collected, and detailed, quantitative data on requirements for measurement height domain, resolution, sampling or revisit time, accuracy, coverage and stability presented where available.

### Missions

Information on current and planned missions by national and international agencies and organisations has been collected and atmospheric composition capability identified. Mission parameters have been collated and instruments classified into measurement type groups.

The capabilities of measurement types in terms of addressing the products and applications have been assigned so that, in conjunction with the information on missions, an analysis of how the missions address the requirements can be made.

## Analysis

An analysis to compare application requirements with the capabilities of current and planned missions has been carried out. It is an attempt to bring together information on requirements and missions. The interpretation of this information is made in a general sense, however, and a number of implicit assumptions are made, including the capability of generic instrument types and the nature of the requirements.

The analysis indicates the potential of the current and planned suite of missions to address the identified applications in the time frame from 2008 to ~2025. It is assumed that data delivery and compatibility issues are overcome. Mission failure and associated redundancies are treated without detailed examination of mission risks.





# 5.2 Comment

The work carried out in this study is intended to serve as a guide and reference and include a collection of useful information. For any specific application, a more detailed examination of requirements and the capabilities of available and planned measurements would need to be made.

A number of questions and issues naturally arise:

- Can all the data be brought together?
- Is the data compatible?
- Is timely delivery of data an issue (e.g. for forecasting applications), how feasible is it?
- Are there operational issues for current missions? (e.g. product quality, lifetime)
- What is the probability of instrument or mission failure?
- How should redundancy be handled?

Planned missions have a number of uncertainties associated with them such as:

- What is their selection status?
- What is the probability of launch date shift or delay?
- Are there orbit options?

The development of missions is a continually evolving process and even the measurement requirements are likely to change as atmospheric science progresses. Work updating the work presented here in some context seems likely to be appropriate in the future.

### Acknowledgement

The author would like to thank Dr Ernest Hilsenrath and Dr Brian Killough for their numerous inputs, constructive comments and helpful discussions during the course of this study.







# A Instrument Types in this Study and the WMO Study

In this study, instrument types have been classed into 9 basic groupings, with 5 nadir (or near-nadir) and 4 limb types and solar occultation.

These and associated types used in the WMO Study,

*"Gap Analysis"*, B. Bizzarri, WMO , 2<sup>nd</sup> Workshop on the Re-Design and Optimisation of the Space-Based GOS, Geneva, Switzerland, 21-22 June 2007, OPT2/Doc. 5 (11.VI.2007)

are indicated in Table A-1.

Instrument Type	Abbreviation	WMO "Gap Analysis" Associated Types
Nadir		
Infrared	IR	<ul> <li>3. IR temperature/humidity sounding from LEO</li> <li>4. IR temperature/humidity sounding from GEO</li> <li>23. Cross-nadir IR spectrometry from LEO</li> <li>24. Cross-nadir IR spectrometry from GEO</li> </ul>
UV-Visible and/or Near-Infrared	UVN	21. Cross-nadir short-wave spectrometry from LEO 22. Cross-nadir short-wave spectrometry from GEO
Lidar	Lidar	20. Lidar-based missions
Multi-Angle Polarimeter	MAP	
Imager	Imager	1. Multipurpose VIS/IR imagery from LEO 2. Multipurpose VIS/IR imagery from GEO
Limb		
Infrared	IR	26. Limb-sounding IR spectrometry
Millimetre/Sub-Millimetre	MM	27. Limb-sounding Sub-millimetre wave spectrometry
UV-Visible and/or Near-Infrared	UVN	25. Limb-sounding short-wave spectrometry
Solar Occultation	Occultation	

#### **Table A-1: Instrument Types and Abbreviations**

The WMO report is extensive, covering 29 instrument types. As indicated in the table, it includes composition measurements, but focuses on meteorology and also includes surface and radiation budget instruments. Although wide in scope it does not cover instrument performance or application areas in detail. It nevertheless provides a useful reference for some instrument types relevant to atmospheric composition and so is referenced here.

