The Ozone-cci project

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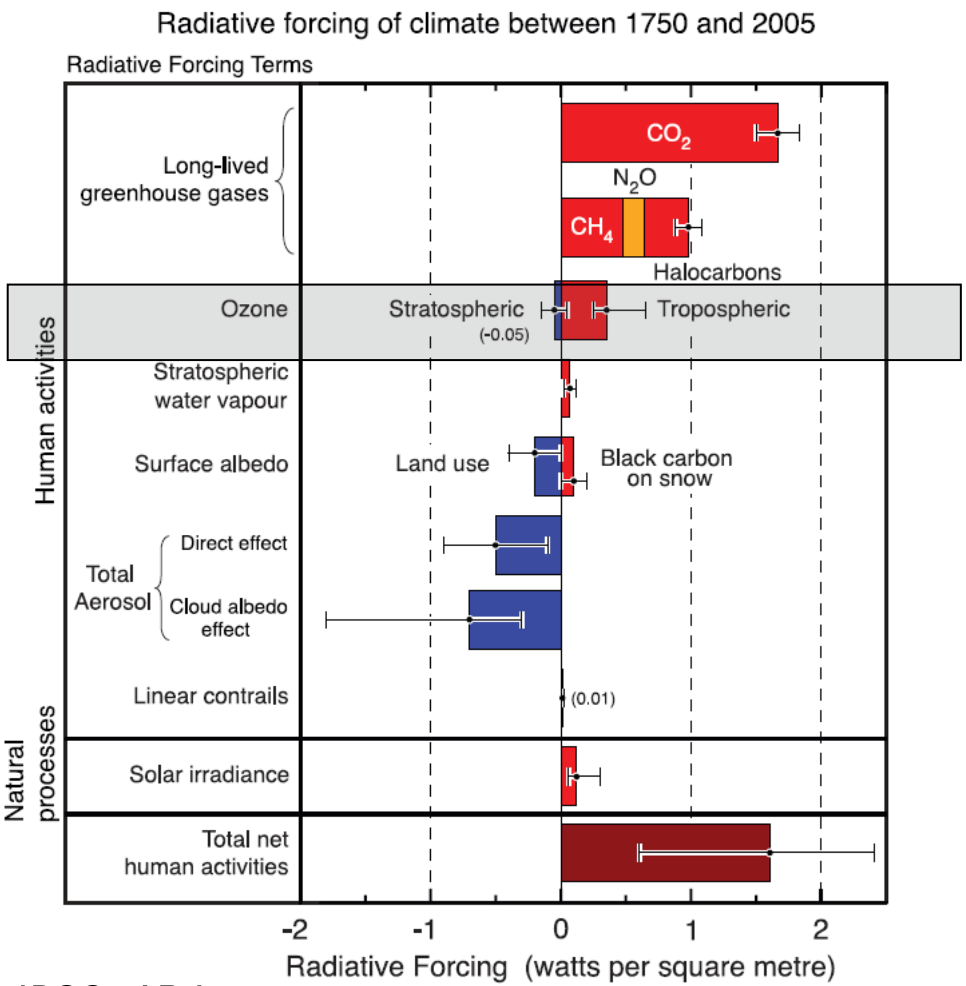
Background: climate impact of ozone changes

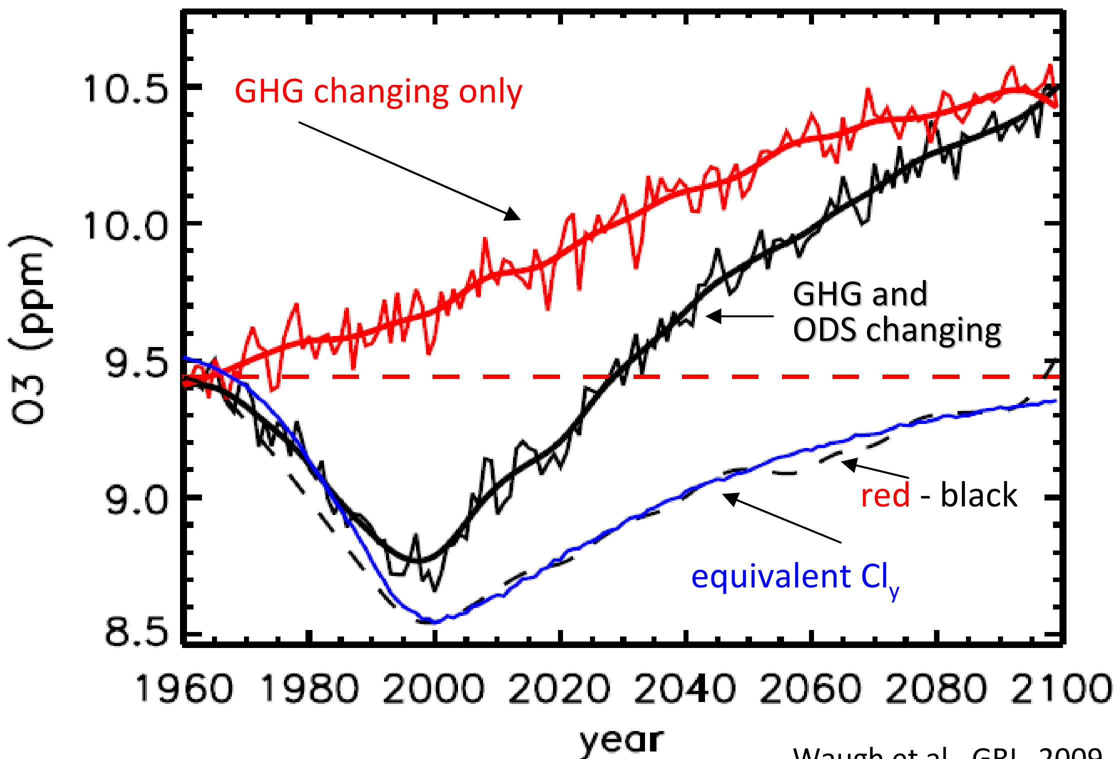


IPCC, AR4

- Ozone impact climate both directly and indirectly through its chemical interactions with other gases.
- Tropospheric ozone provides the 3rd largest positive radiative forcing.
- Forcing opposite in stratosphere and troposphere. Future evolution of stratospheric ozone strongly linked to climate change.
- Main uncertainties on RF related to vertical distribution of ozone changes. Uncertainties are largest at tropopause where radiative forcing by ozone is maximum.
- Upper stratospheric ozone is key for early detection of ozone recovery.

Expected ozone « super » recovery

Ozone at 5 hPa within 20° of the equator



Waugh et al., GRL, 2009

"A particularly important region for detecting ozone recovery, and eventually *super-recovery* is the upper stratosphere. This region is less variable than the lower stratosphere and ozone there is dominated by photochemical processes."

IGACO-O3 Implementation Plan 2008-2011

Ozone_cci

Aims:

- **Develop, produce and validate** long-term series of high quality global observations of atmospheric ozone derived from multiple satellite instruments.
- **Evaluate the impact** of the resulting improved Ozone ECV data products in a climate perspective
- Explore **system specifications** for ozone ECV production

GCOS requirements: the starting point

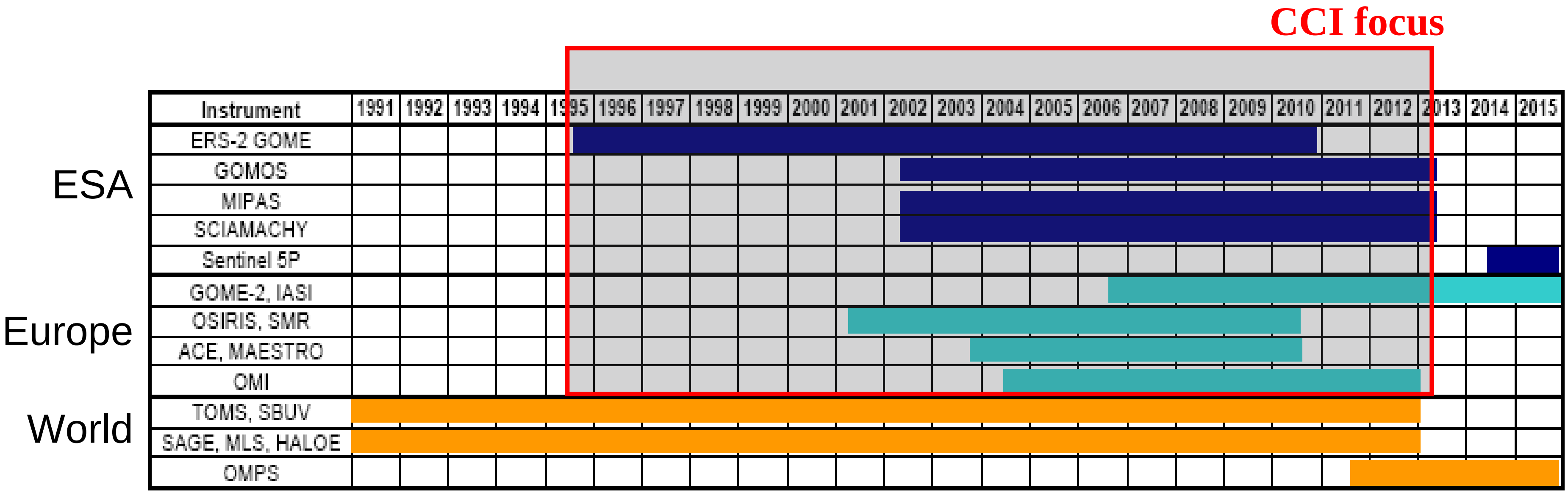
GCOS Requirement		Current Status
• Accuracy:	10% trop - 5% strat	20% trop, - 5% strat
• Spatial resolution:	5-50 km trop – 50-100 km strat	>20 km
• Vertical resolution:	0.5 km trop – 3km strat	5 km trop, 1-5km strat
• Temporal resolution:	3-hourly	Daily
• Stability:	1-0.6%	1% total column, >3% profiles

?

Critical review of GCOS requirements for ozone ECV products:

- **Accuracy, resolution, stability**
- What can be achieved using **current sensors** ?
- Which improvement can be expected from planned **future sensors** ?
- Can we refine the requirements from a **specialised climate user community** perspective, according to science and assessment goals, and altitude region (e.g. UT/LS) ?
- Is there a need to revise/refine the GCOS requirements for ozone ?

Satellite instruments and data sets



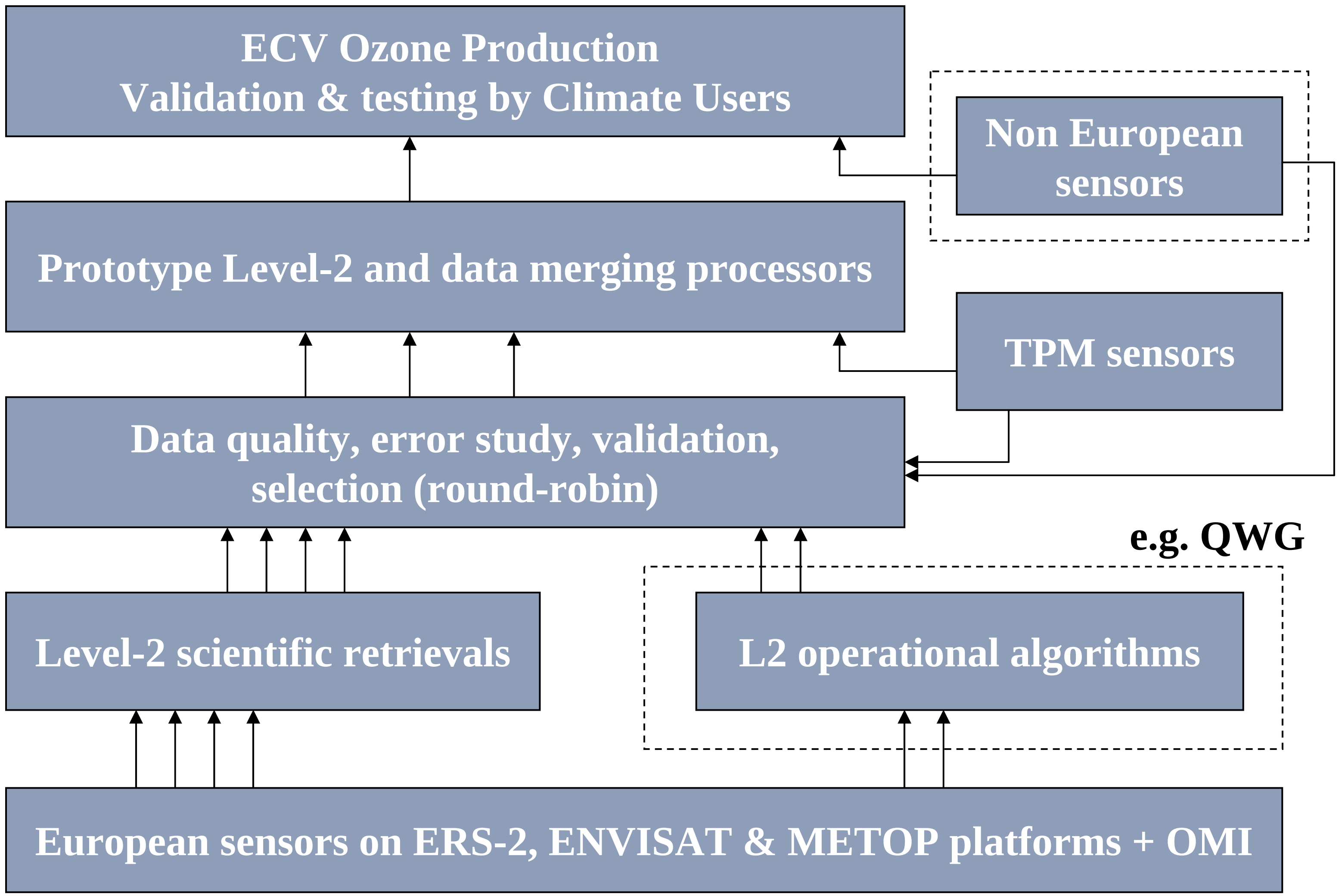
- Ozone ECV products to be developed:
  - **Total ozone** from all ESA UV-Vis nadir sensors
  - **Ozone profiles** from all European **UV-Vis nadir** sensors
  - **Ozone profiles** from ENVISAT & TPM **limb & occultation** sensors

- CCI focuses on ESA and TPM (European) sensors
- Non-european sensors are used for validation and quality assessment

The consortium

Institutions	Role
Belgian Institute for Space Aeronomy (BIRA-IASB) German Aerospace Center (DLR)	**Total ozone algo., Val., Modeling, Syst. Eng.**
Royal Netherlands Meteorological Institute (KNMI) Rutherford Appleton Laboratory (RAL)	**Nadir ozone profiles, Modeling, Syst. Eng**
University of Bremen (IUP) Karlsruhe Institute of Technology (KIT) Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS) Finnish Meteorological Institute (FMI)	**ENVISAT limb/occ. profiles**
Aristotle University of Thessaloniki (AUTH) University of Athens (NKUA) Royal Meteorological Institute of Belgium (KMI-IRM) Federal Office of Meteorology and Climatology MeteoSwiss	**Validation**
University of Cambridge (UCAM)	**Climate modeling**

Logical workflow



Nadir UV retrievals (EOST 1-2)

Nadir UV radiances
GOME, SCIAMACHY & GOME-2
Improvements through vicarious calibrations

Total columns

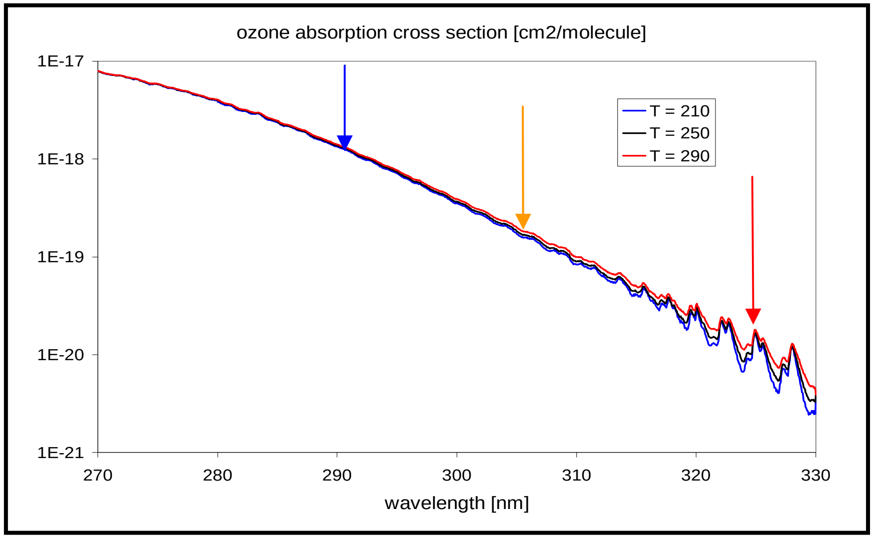
L2 algorithm improvements for GOME, SCIA & GOME-2

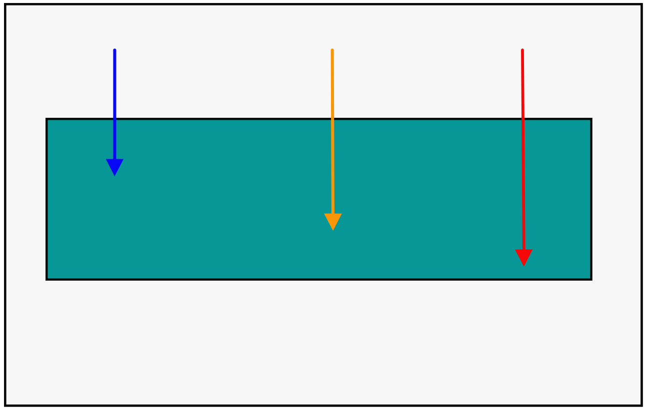
Baseline: GDP-5 direct-fitting type algorithm

Nadir profiles

Merged RAL and KNMI OPERA/OMI algorithms (all ESA sensors + OMI)

Optimised for all altitude incl. Trop.





Limb/occultation sesnors (EOST 3)

- Links established with ENVISAT Quality Working Groups
- Major focus on the characterization of individual data sets (sampling, geographical coverage, horizontal and vertical resolution) and on the error budget

SCIAMACHY → IUP scientific algorithm (full altitude coverage)

GOMOS → operational product (IPF v. 5 or 6)

MIPAS

- Selection among 4 competing algorithms (round-robin exercise)
- Full involvement of MIPAS SQWG through consultancy mechanism

Error analysis

- Random and systematic errors, accuracy & precision
- Error budget
- Validation (and geophysical validation of error bars)
- Time evolution of errors
- Quality flagging
- Representation of averaging kernels („climatology“, LUT)

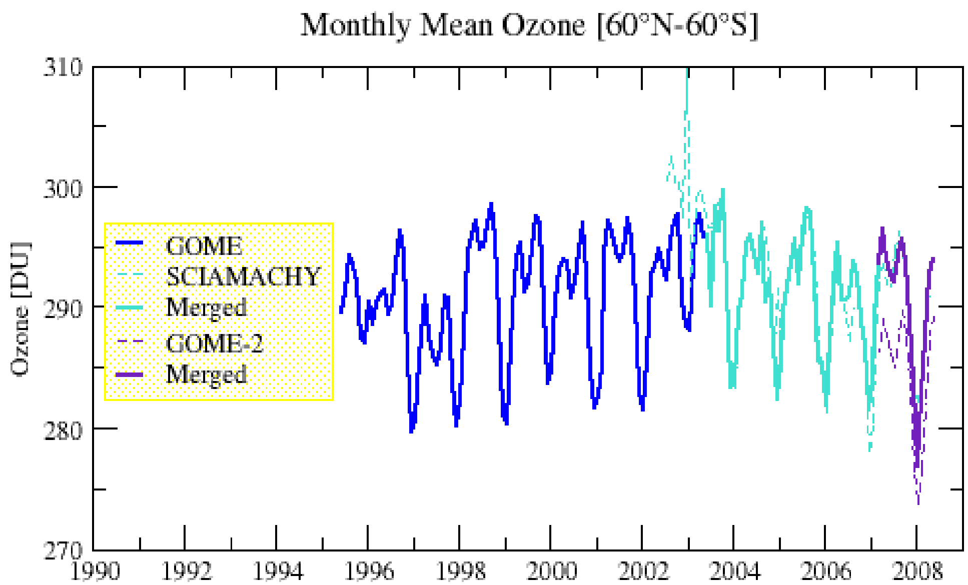
- Feedback to QWG & EUMETSAT regarding the operational processing

Data merging

The issue:

How to combine measurements from sensors having different sampling, resolution and bias ?

➔ Merging techniques

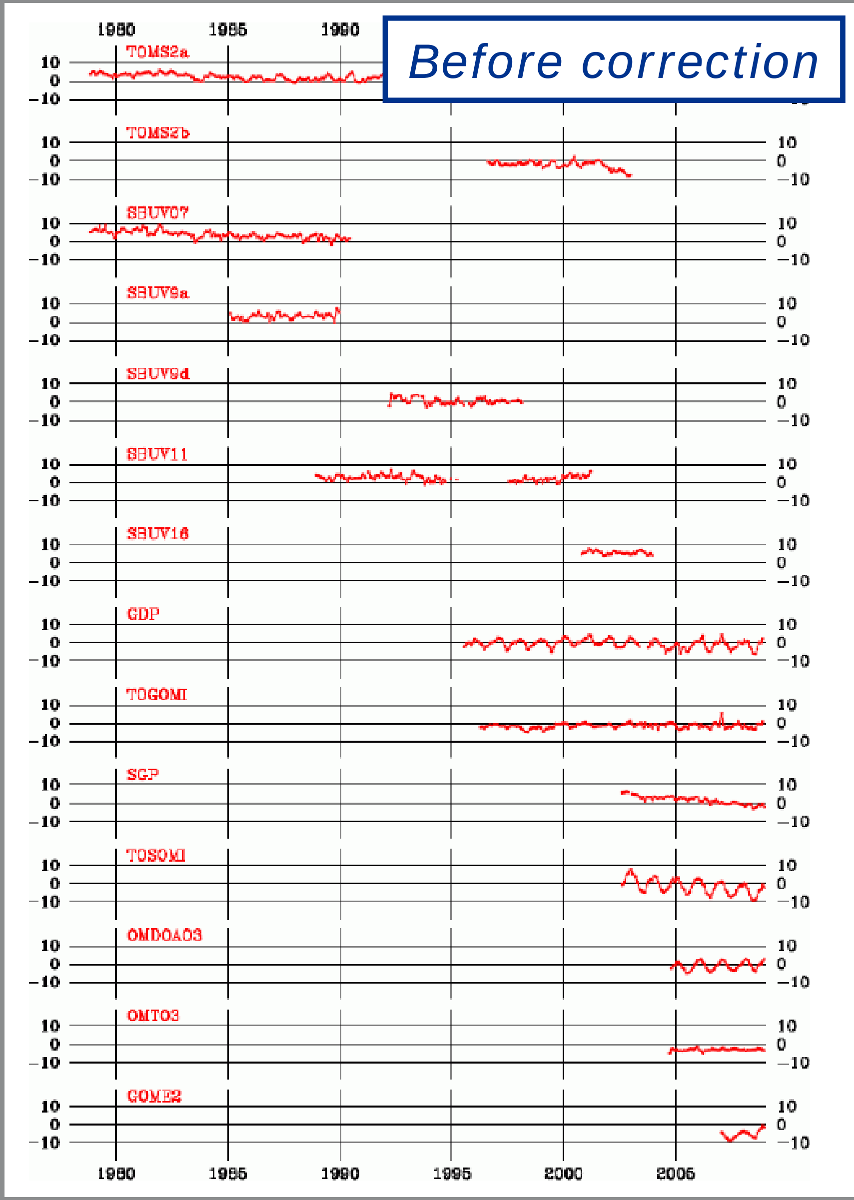


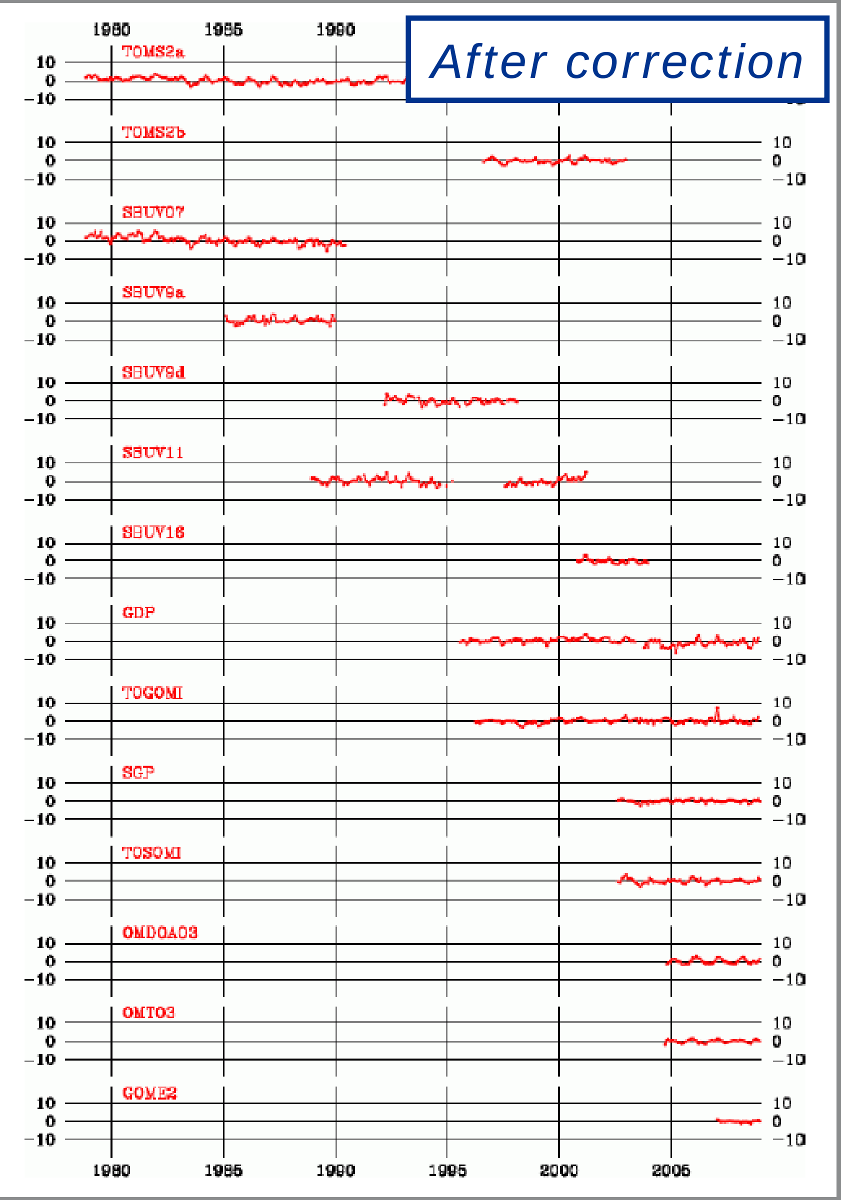
Ozone_cci approach

1) Reduce bias through <u>homogenization of retrieval algorithms</u>
2) Characterize data sets (full error budget, averaging kernels, bias, etc)
3) Derive correction factors based on reference agreed by scientific consensus
   → various possible approaches to be reviewed for each ozone product
4) Merge corrected data <u>using error estimates and averaging kernels</u>

Example of approach: Multi-Sensor Reanalysis of Total Ozone (MSR)

EO data corrected using multi-parameter (SZA, VZA, T°, time, offset) fit to ground-based reference





van der A et al., ACPD, 2010

Case of limb/occultation sensors

- Merging of ENVISAT & TPM limb & occultation sensors is by far the most challenging
- Not attempted so far
- Key issues to be addressed
    - How to use errors from individual data sets in the merging and propagating these errors in the final merged product?
    - Different merging strategies are needed according to different requirements from data assimilation, CCMval, and trend assessments
- One expected key output of the Ozone_cci project

Validation

VALT includes independent world-leading experts on ground network ozone measurements, having access to relevant data bases and critical knowledge of quality and maintenance of correlative data sets.

+ Link to ongoing ESA-sponsored cal/val activities

Table I: Ground-based data sets

Sensor	**Data product type**	**Source of the data**
Brewer UV spectrophotometer	Level 2, column	WOUDC, NDACC
Dobson UV spectrophotometer	Level 2, column	WOUDC, NDACC
DOAS UV-vis spectrometer	Level 2, column	NDACC
Baloon-borne ozonesonde	Level 2, profile	WOUDC, NDACC, SHADOZ
Lidar	Level 2, profile	NDACC
Microwave radiometer	Level 2, profile	NDACC

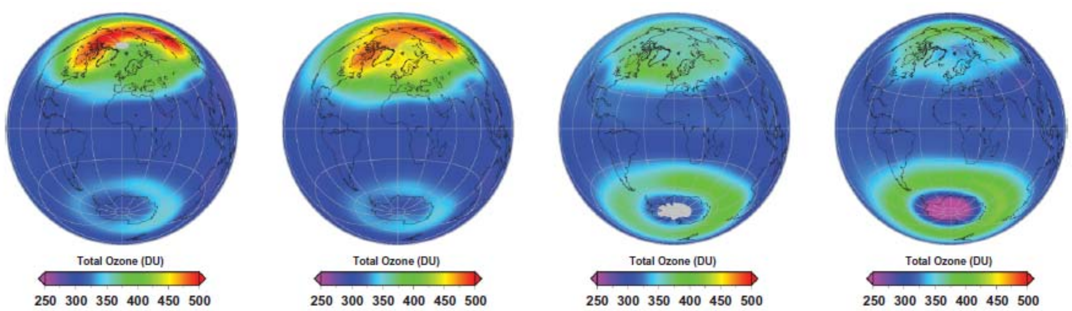
The basic procedure is to collect data from central data archives:

- World Ozone and Ultraviolet Data Centre (WOUDC, http://www.woudc.org)
- Network for the Detection of Atmospheric Composition Change (NDACC, http://www.ndacc.org)

Southern Hemisphere Additional Ozonesondes (http://croc.gsfc.nasa.gov/shadoz)

Link to climate modelling community and IPCC

- The project's Climate Research Group (CRG) involves three key partners providing a strong link to GCM community, which implies link to IPCC community as well.
- CRG specialized in climate research including strat-trop responses and feedbacks
- Strong involvement in SPARC CCMVal activity
- Participation as lead and/or co-authors in WMO/UNEP Assessment of Ozone Depletion and IPCC reports
- Involvement in IO_3C (several members of Ozone-cci)



Summary

- **Ozone-cci will result in:**
  - A major consolidation of European ozone data sets (column and profiles), through level 2 algorithmic improvements, consistent data merging, full data characterization and error budget
  - Production of the first merged limb/occ. data set based on ENVISAT and TPM missions
  - Independent validation against agreed common standards
  - Major advance in precisely quantifying status against GCOS requirements for ozone
  - Documented data sets freely available to the international scientific community

Need for international cooperation

- Exchange of expertise with non-European scientists; on level 2 retrieval algorithms, on ancillary data sets, on data characterization and error analysis, on data merging approaches, etc
- Interaction with international community on specification of user requirements for climate-relevant ozone data products; which climate products, which formats, which metadata, etc
- Consultation on use of non-ESA data sets for validation purposes
- Combine efforts on creation of joint (merged) ozone data products, feeding in appropriate error values, averaging kernels, etc