Japanese AQ missions and activities

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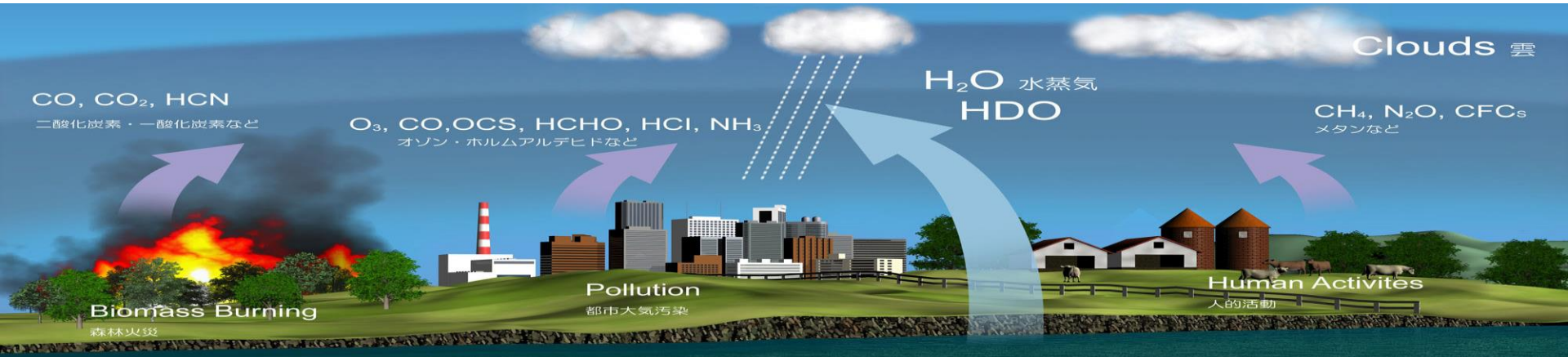
Dec 2009	GMAP-Asia Passed JAXA mission Definition Review
Jan 2011	APOLLO air pollution mission Selected as top 2 candidate for ISS large class mission by JAXA Earth observation commission
Dec 2013	uvSCOPE Selected as top 2 candidate for ISS middle class mission by JAXA Earth observation commission

Current:

1. Data analysis system for synergy analysis using HIMAARI-8 satellite with several other satellite datasets

2. micro-satellite for NO2 hot spot with 1x1 horisontal resolution.



Motivation

PM2.5 prediction 12:00 JST 10 Oct 2016

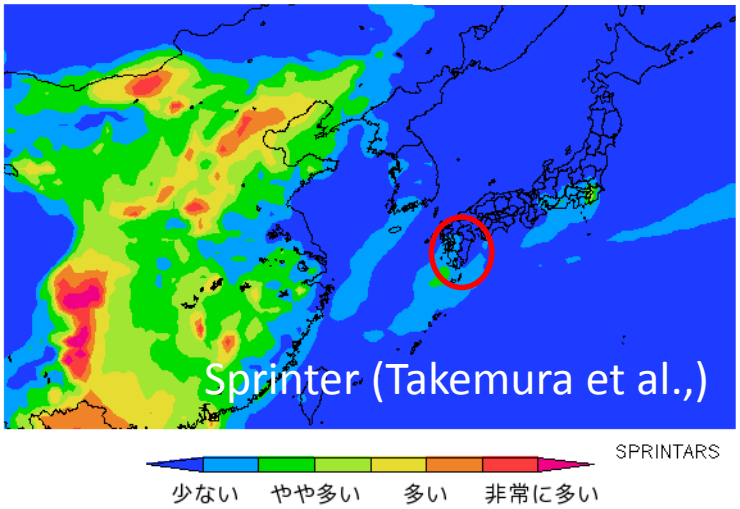
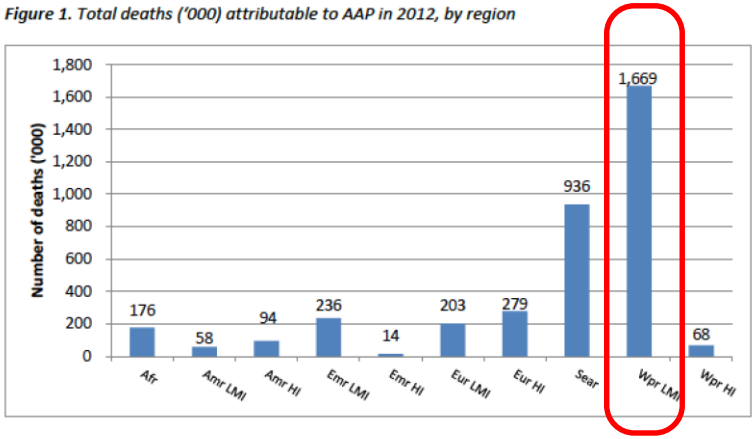


Figure 1. Total deaths ('000) attributable to AAP in 2012, by region



AAP: Ambient air pollution; Amr: America, Afr: Africa; Emr: Eastern Mediterranean, Sear: South-East Asia, Wpr: Western Pacific; LMI: Low- and middle-income; HI: High-income.

In Kyusu iland, more than 70% of pollution come from outside of Japan.

WHO report (2014): Globally, 3.7 million deaths were attributable to ambient air pollution (AAP) in 2012. The Western Pacific and South East Asian regions bear most of the burden with 1.67 million and 936'000 deaths, respectively. About 236'000 deaths occur in the Eastern Mediterranean region, 200'000 in Europe, 176'000 in Africa, and 58'000 in the Americas. The remaining deaths occur in high-income countries of Europe (280'000), Americas (94'000), Western Pacific (67'000), and Eastern Mediterranean (14'000).

Serious damage: How about to provide a prediction of detail health index for Fukuoka-city in 1km level?

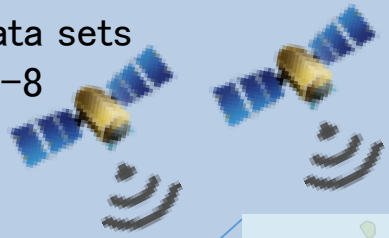
Project
A Pollution prediction system in Fukuoka, Kyushu, Japan

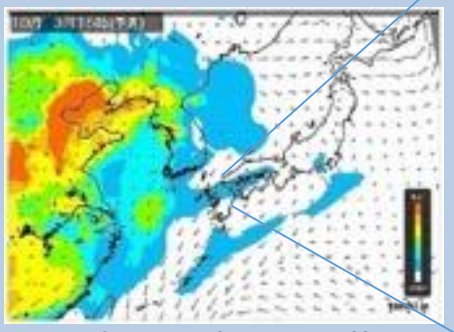
In Kyusu iland, more than 70% of pollution come from outside of Japan.

There are many ground-based observation base for pollution species.

Project
A Pollution prediction system in Fukuoka, Kyushu, Japan

Satellite data sets
HIMAWARI-8
GEMS
Etc…





Transboundary pollutant

Final Target

Surface/ remte sensing measurements
+ Soramame
+ Sky-net
+ DOAS
+ Lidar
+ JAMSTEC data
+ NIES data

Model: Stretch NICAM-Chem[Goto et al., 2015] **responsibility Takeshi Kuroda**

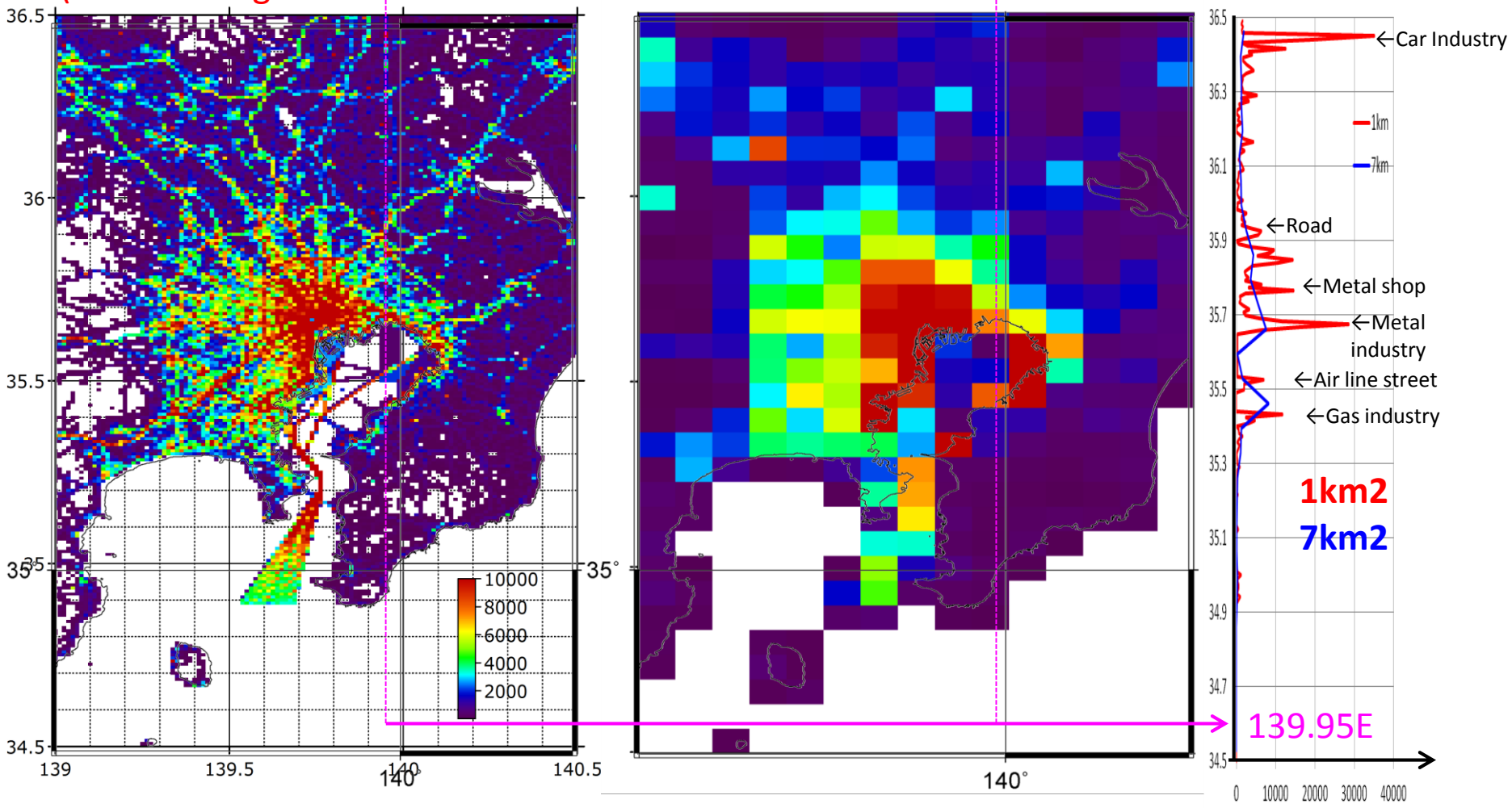
O_3 in boundary layer, $PM_{2.5}$ NO_2 for 1h x 1km2

Fukuoka Distribution of Air Quality Health Index ： AQHI

$$AQHI = \left(\frac{1000}{10.4}\right) \times [(e^{0.000537 \times O_3} - 1) + (e^{0.000487 \times PM_{2.5}} - 1) + (e^{0.000871 \times NO_2} - 1)]$$

1km x 1km
(APOLLO Target)

7km x 7km
Other satellite observations



NOx emission data by Kannari et al.,EAGrid2000, JCAP

Responsibility T. O. Sato

Joint data processing system for ozone, aerosol, NO_2

Joint satellite data processing system

~~SMILES~~ parallel processing system

+

New satellite data processing system for Himawari8 and GEMS

NICT testbed data center

Other Satellite data

OMI, GOSAT (TIR), TES, MLS, etc

In-situ data, ground-based remote sensing data + IOT data

Basic prediction system with horizontal resolution 5km

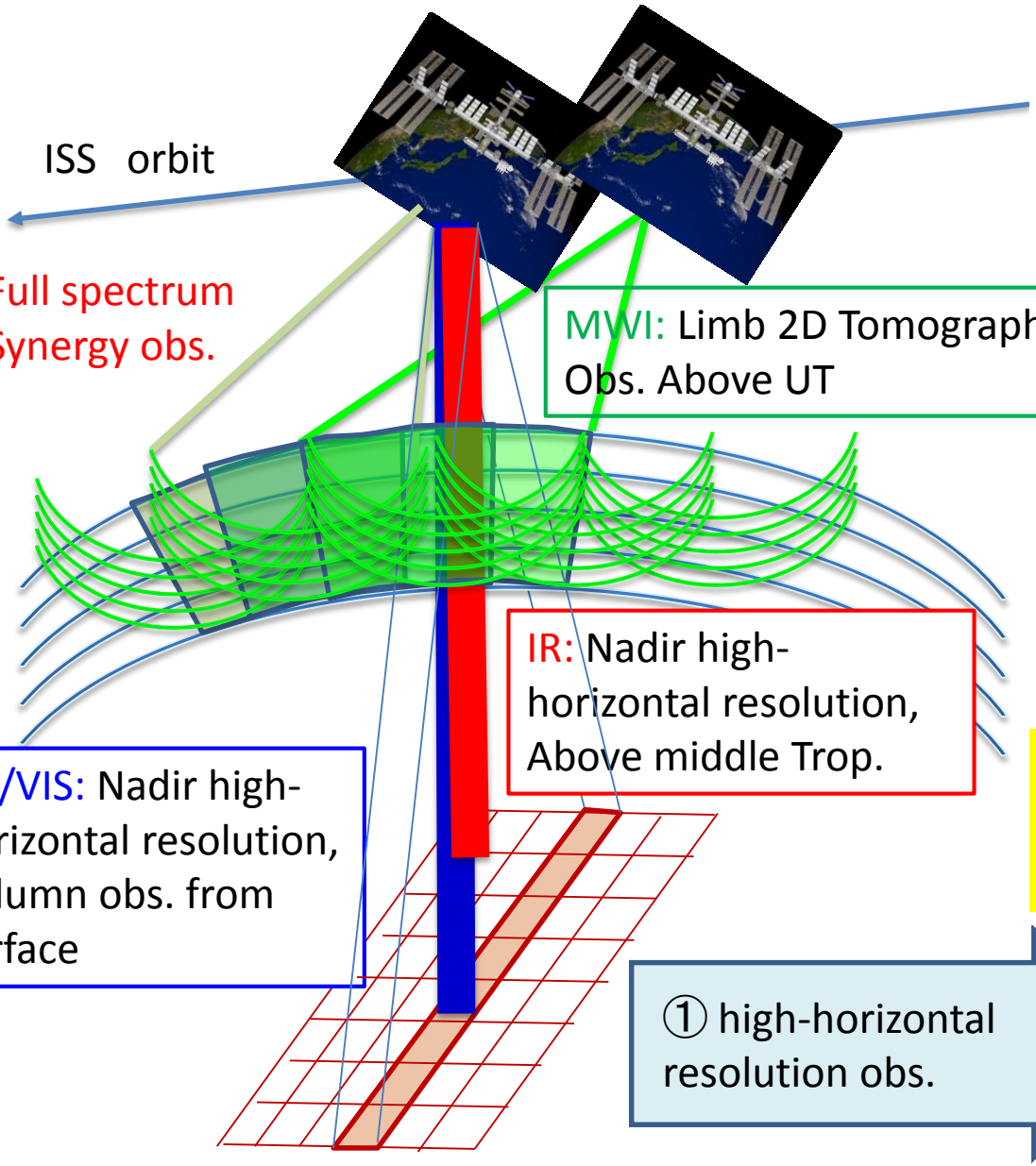
Better precision/accuracy

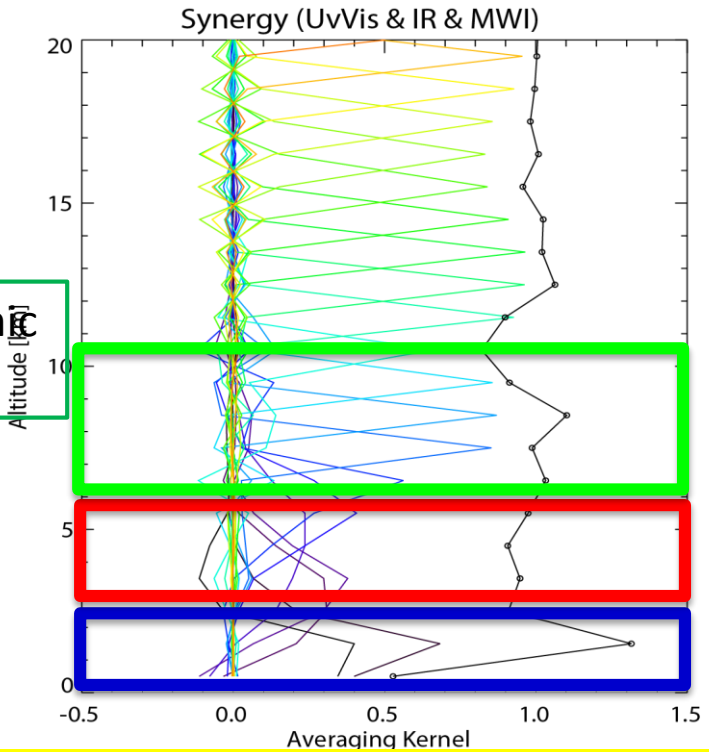
Toward 1km resolution

Model assimilation (T. Kuroda)

Air Quality Health Index ： AQHI (T.O.Sato)

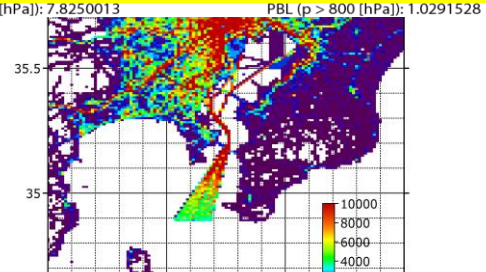
synergy observation



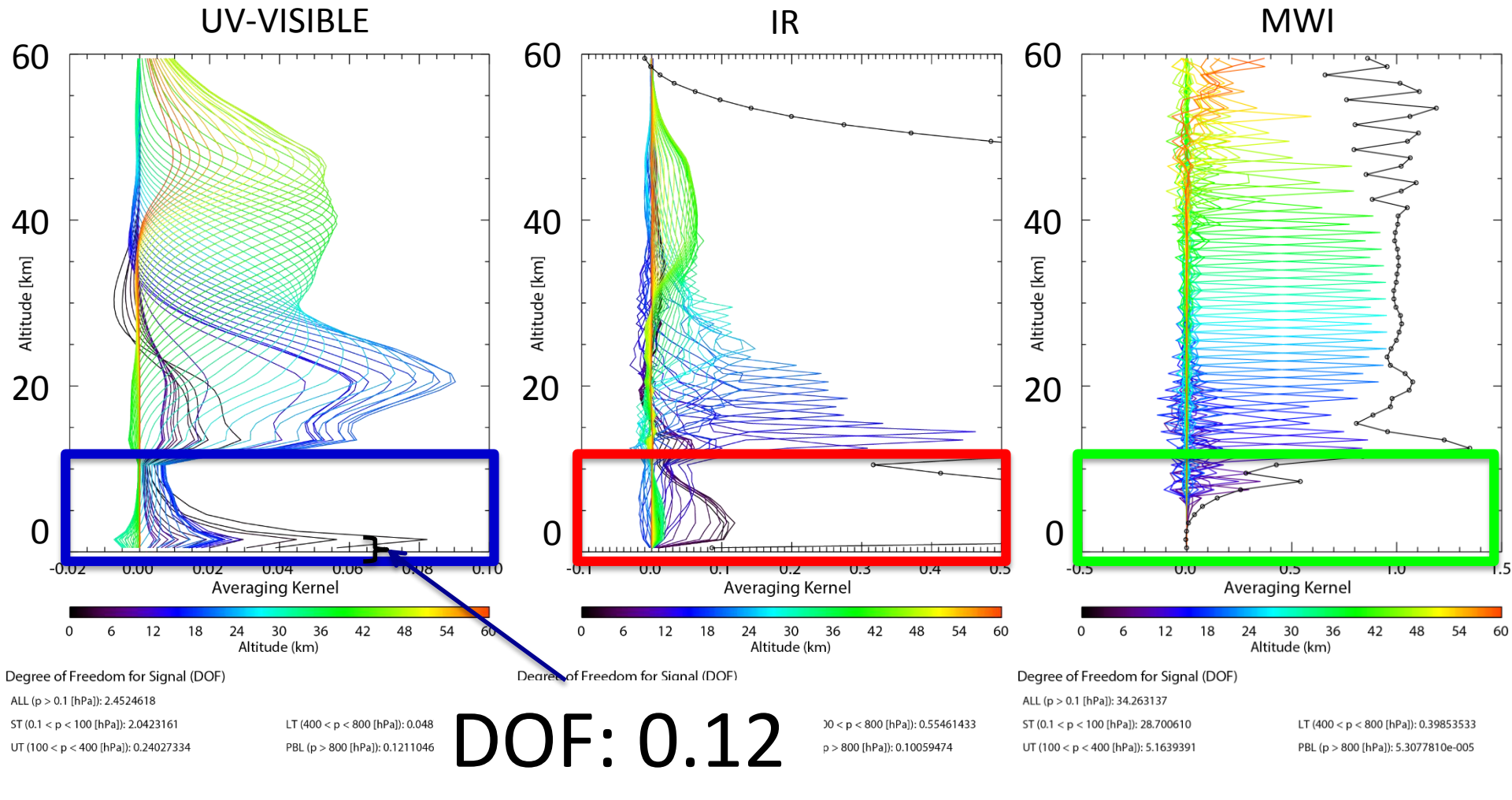


②Vertical profile of tropospheric ozone: MWI/IR/UV/Vis Synergy retrieval

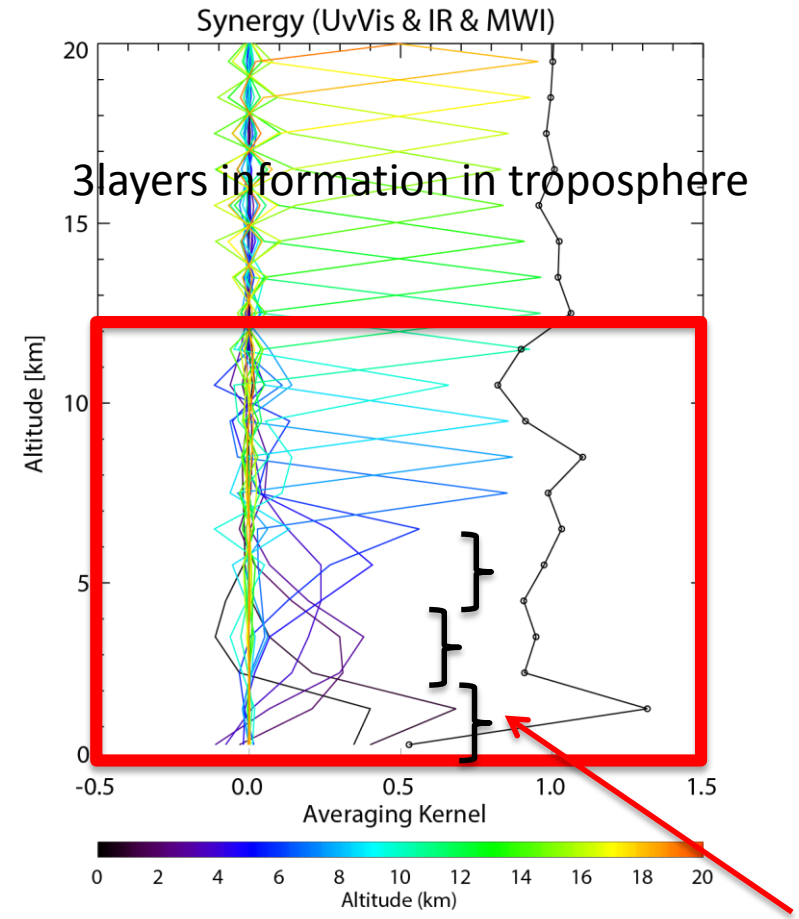
① high-horizontal resolution obs.

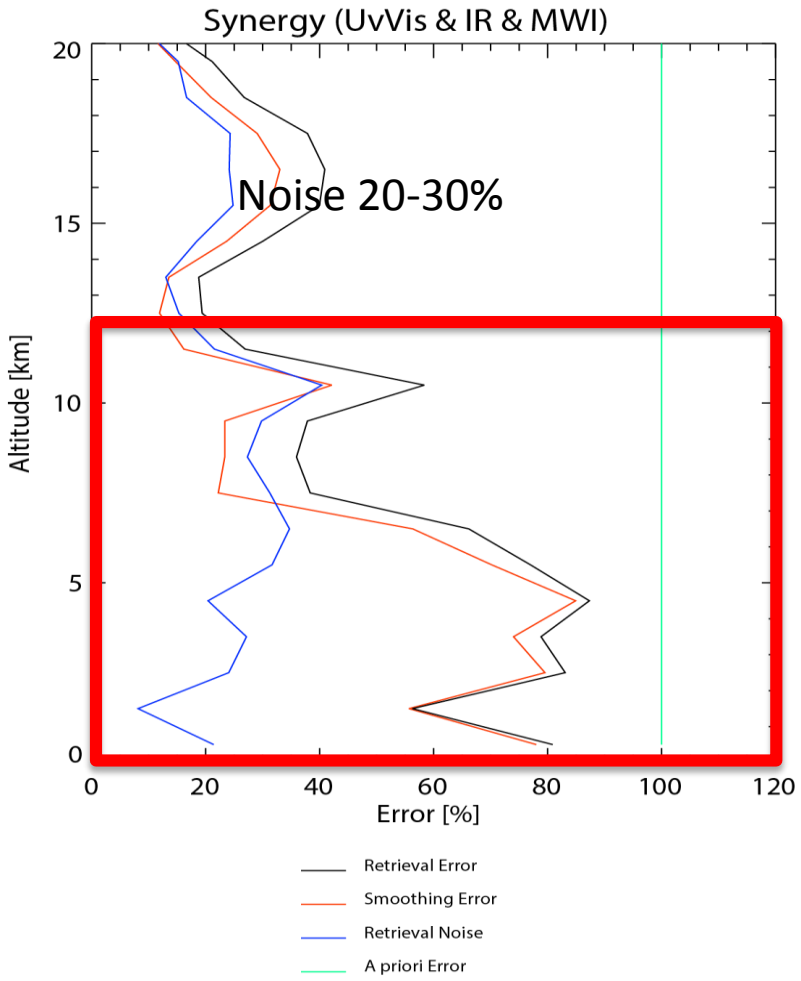


O3 Averaging Kernel



O3 Averaging Kernel





DOF: 1.03

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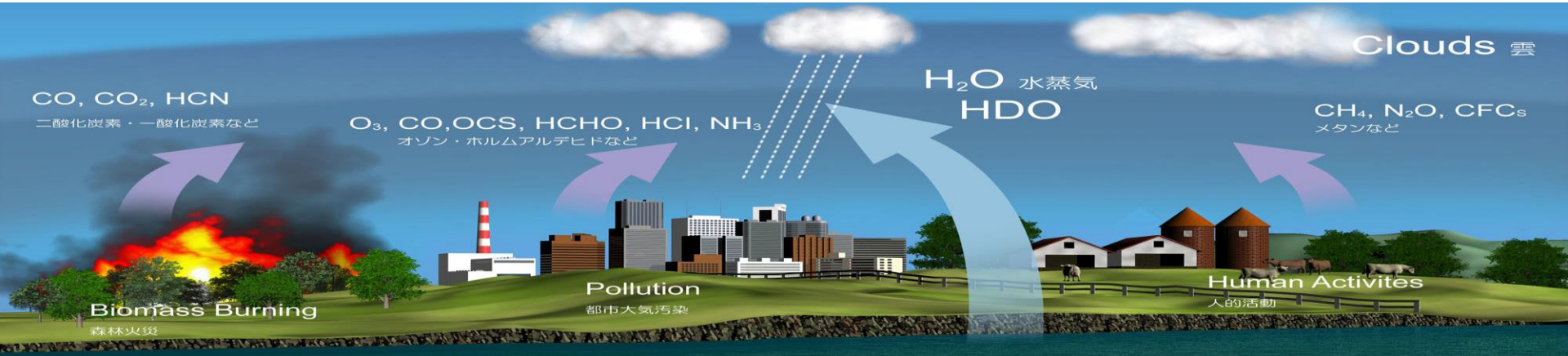


Collaboration with University of Bremen

Mission concept: A microsatellite with high horizontal resolution

In this study, we present a feasibility study for observation precisions of NO_2

→Synthetic spectra are calculated using SCIATRAN (RTM) with two geometries.

→Slant column densities (SCDs) are derived by DOAS method and converted to vertical column densities (VCDs).

Scientific requirement

Products	**Standard: NO_2,O_4**
Detection limit (**NO_2 column density**) [molecules/cm^2]	**3.0×10^{15}** (5%) (about 0.6ppb in boundary layer)
(ex) Tropospheric NO_2 column amount [molecules/cm^2]	6.0×10^{16} (Boundary layer 4.7×10^{16})
IFOV	1 km x 1km (2 km x 2 km)
Vertical resolution	Tropospheric column
Swath width	approx. 200 km

今後のきぼう曝露部ミッションの募集区分と募集分野

募集区分は大きく3つ。それぞれ以下の分野のミッションを募集。

①大型ミッション： 船外ポート利用／船外打上

「こうのとり（HTV）」などの船外貨物として打ち上げる必要のある、概ね1m^{3}以上の大型の船外利用ミッション

＜募集分野＞

- 地球観測（例：地球科学、観測センサ、データ処理技術）
- 宇宙科学（例：科学観測、惑星科学、工学・技術実証）
- 技術開発（例：ロボティクス、エネルギー伝送）

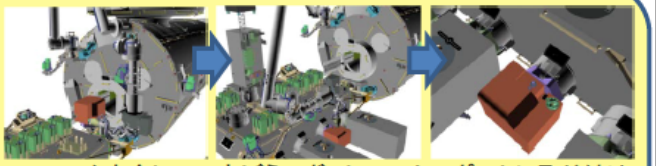
船外貨物として打上げ、そのまま船外ポートへ取り付けて利用

例：MAXI（X線観測）： 寸法0.8m×1.0m×1.85m、重量約500kg

②中型ミッション： 船外ポート利用／船内打上

船内貨物として打ち上げ、きぼう船内からエアロックを使って船外に出し、ロボットアームで船外ポートに取り付ける利用ミッション

＜募集分野＞ 同上（地球観測、宇宙科学、技術開発）



エアロックを介して船外へ移動

きぼうロボットアームの子アームで取付

ポートに取り付けて運用

中型ミッション： 寸法37×80×48[cm]程度、重量約80kg以下

③小型ミッション： 簡易船外利用／船内打上

船内貨物で打ち上げ、きぼう船内からエアロックで船外に出し、エアロックに取り付けたまま、またはロボットアームで把持したまま、もしくは船外のハンドレール等に取り付けて利用するミッション

＜募集分野＞

地球観測、宇宙科学、技術開発、物質・物理科学、生命科学、宇宙医学

実験装置 エアロック

エアロック取付形態

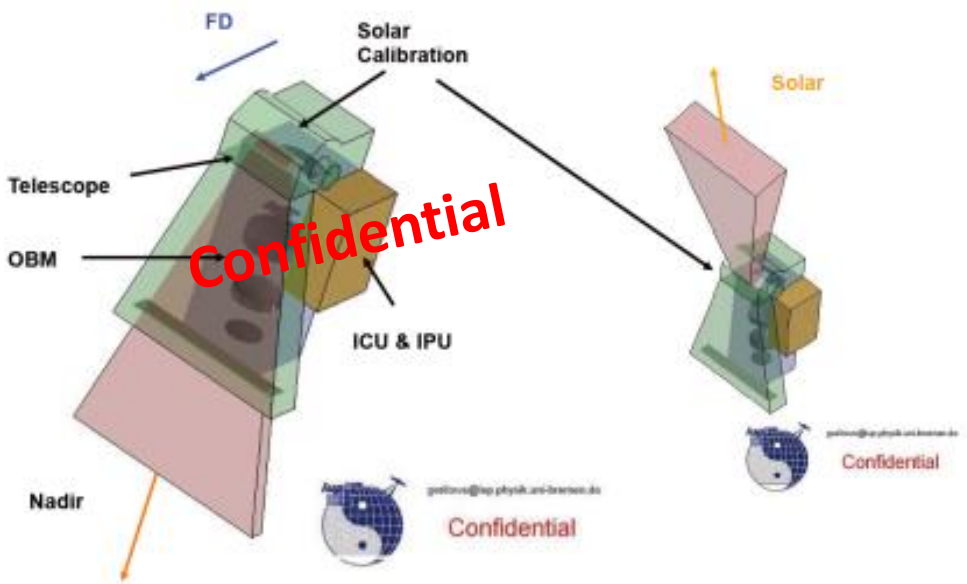
ロボットアーム把持形態

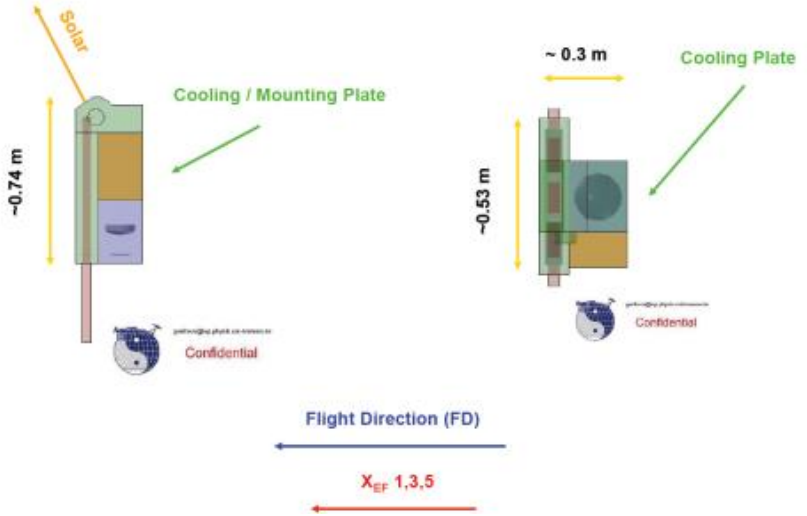
ハンドレール 実験サンプル

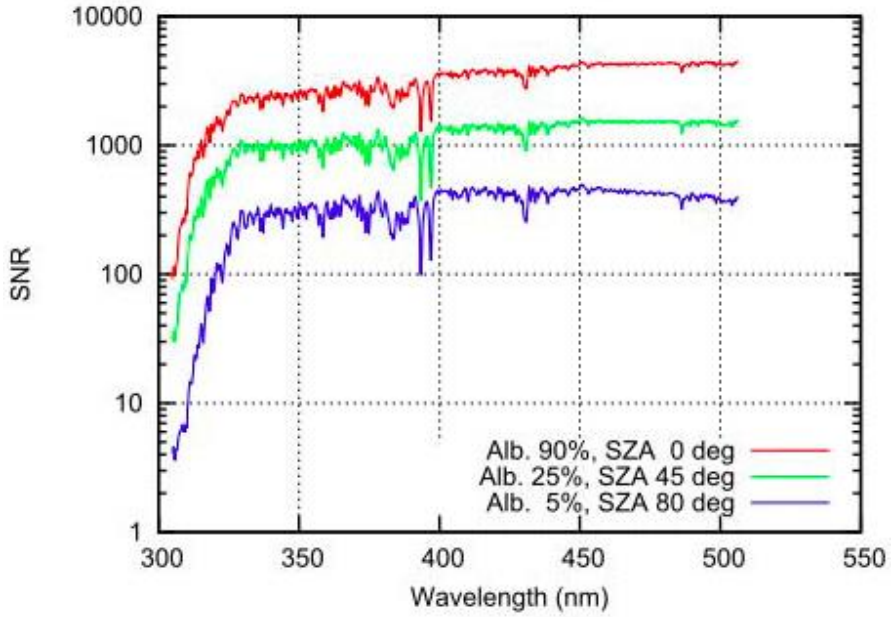
ハンドレール取付型材料曝露実験

小型ミッションの例

UV/VIS Sensor







Expected S/N ratio

Parameter setup in this study

Setup of each parameter

Parameters	The number of parameters	Elements of parameters
Wavelength range	2	Reference : 425 -450 (conventional region) 460-490
Area	2	Seoul (as polluted area) Hokkaido (as clean area)
Season	1	Winter(Jan.)
Altitude of satellite	1	300 km
Spectral resolution (FWHM)	1	0.4 nm
Sampling step	1	0.1 nm
Detector size	1	0.064 mm
Aperture size	1	0.74 cm
Read noise	1	10
IFOV	2	1 x 1 km^2 2 x 2 km^2

Input profile data - Area selection

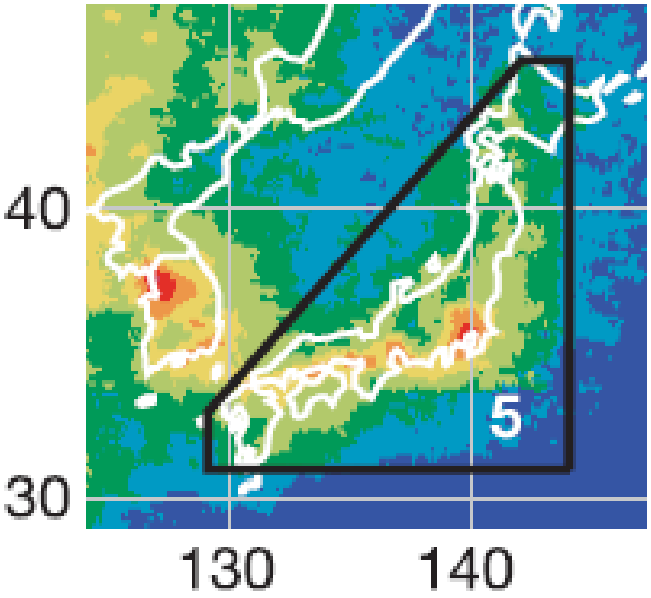
Area

- **Seoul (37.3 N, 127.0 E)**

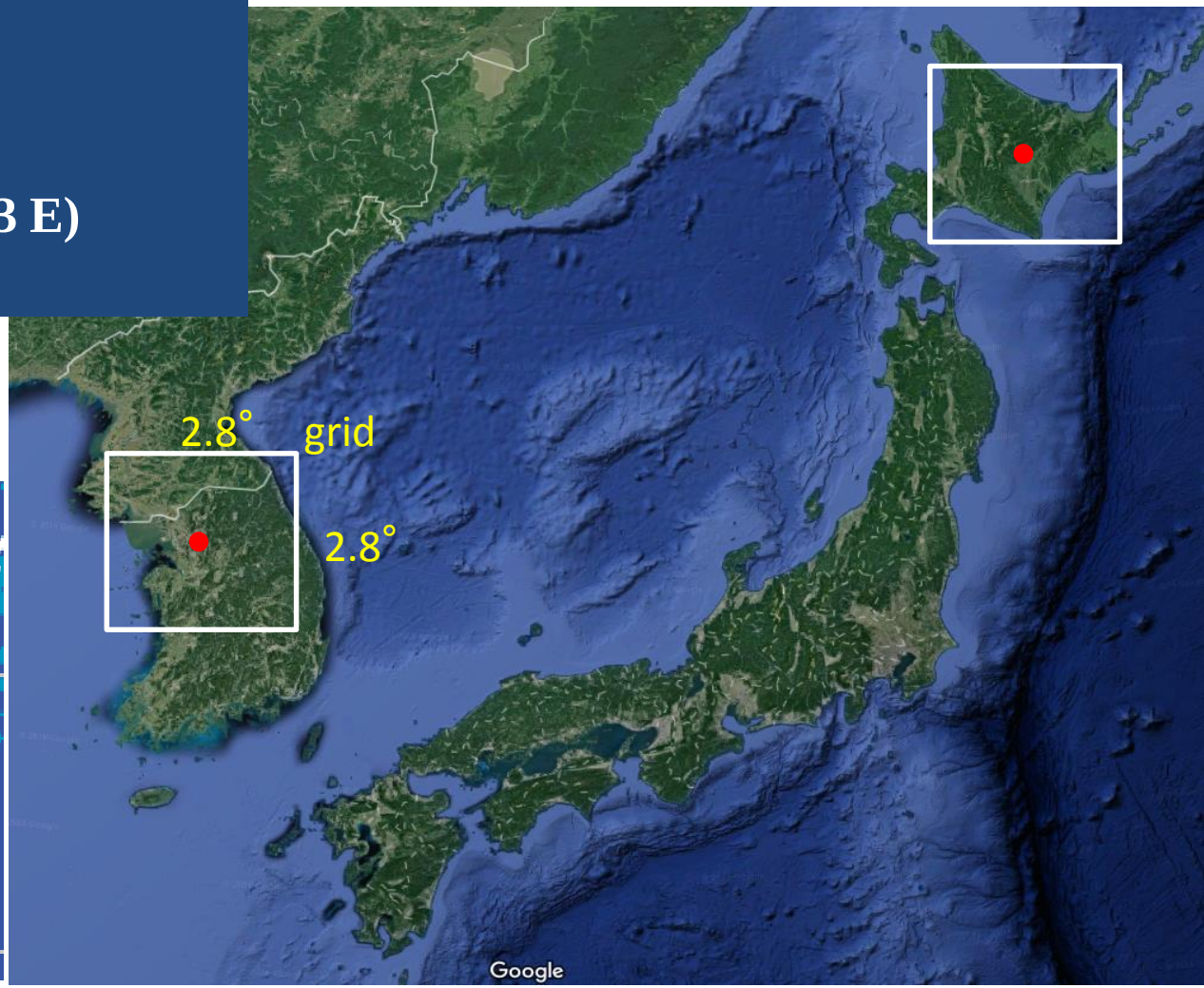
→ as polluted region

- **Hokkaido (43.3 N, 143.3 E)**

→ as clean region



Andreas et al., (2005) *nature*



Google earth

Results – Expected SNRs for each IFOV case

SNRs expected in each wavelength and spatial resolution

Wavelength [nm]	Spatial resolution [km^2]	Expected SNR (Electronics)	Expected SNR (Shot)	Dark current SNR	Expected SNR (all)
480 (460 - 490)	**1x1**	1642	691	2806	**621**
	2x2	9287	1954	11222	**1885**
450 (425 - 450)	**1x1**	1411	620	2518	**554**
	2x2	7983	1753	10073	**1688**

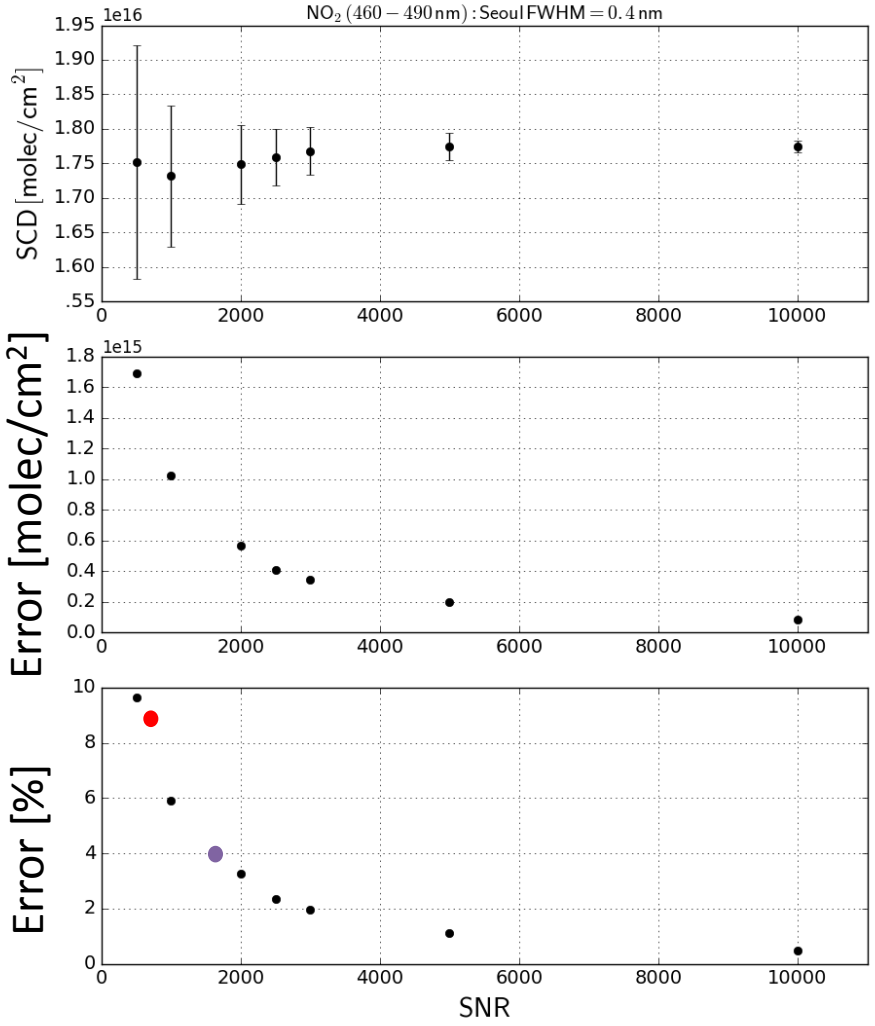
・We assumed that the detector was Si-CMOS 2D array sensor and the optical efficiency and quantum efficiency was 0.43.

・In both cases of wavelength, expected SNRs of 2 x 2 km^2 were about three times larger than them of 1 x 1 km^2.

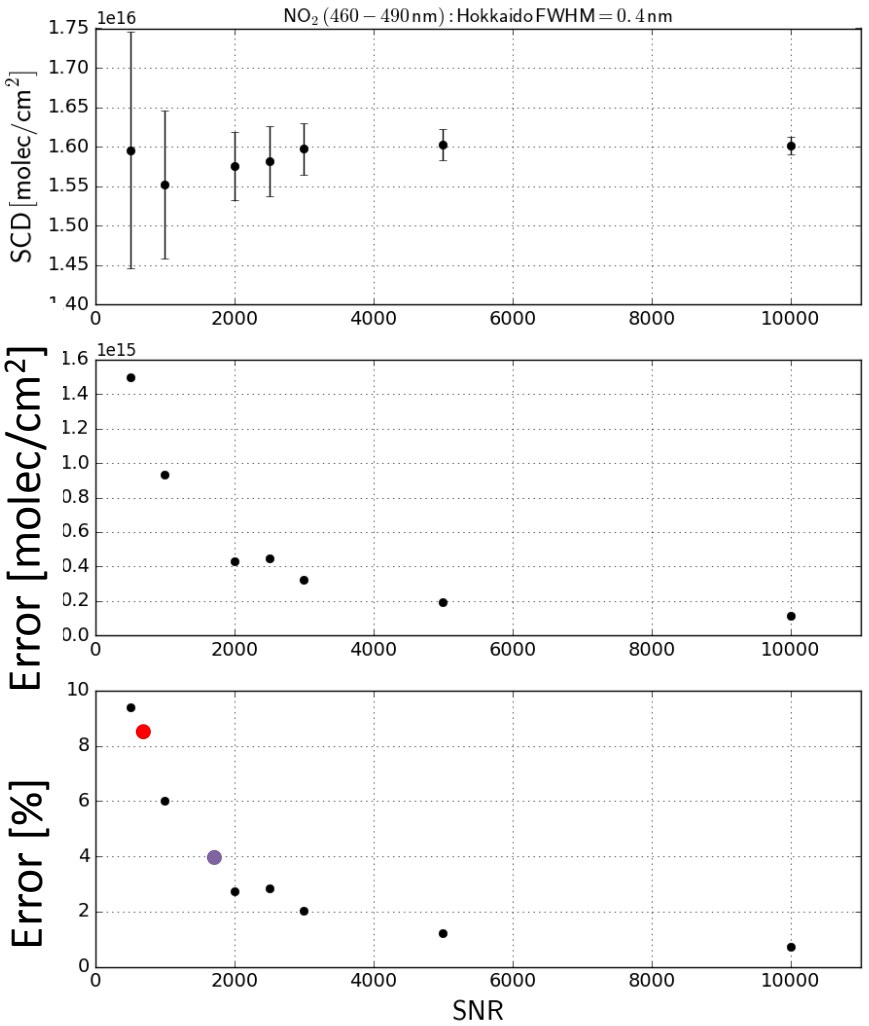
Results and discussion

Winter (Jan.), Alt. of satellite = 300 km, FWHM = 0.4, 460-490 nm, Δλ =0.1 nm

Left : Seoul



Right : Hokkaido



1x1 km^2 → SNR=621 @ 480 nm (red), 2x2 km^2 → SNR=1885 @ 480 nm (purple)

Upper figure : SCD (total = tropo. + strato.), Middle figure : Error [molec/cm^2], Lower figure : Error [%]

Results and discussion

Winter (Jan.), Alt. of satellite = 300 km, FWHM = 0.4, 425-450 nm, Δλ =0.1 nm

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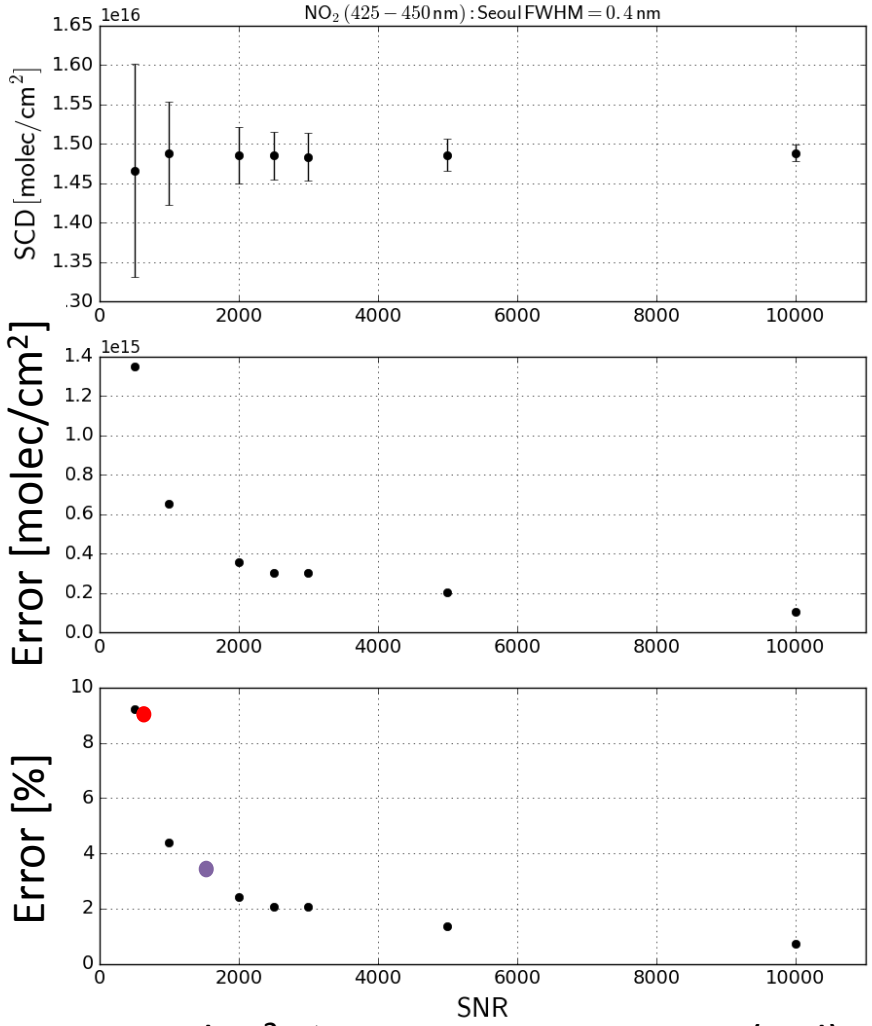

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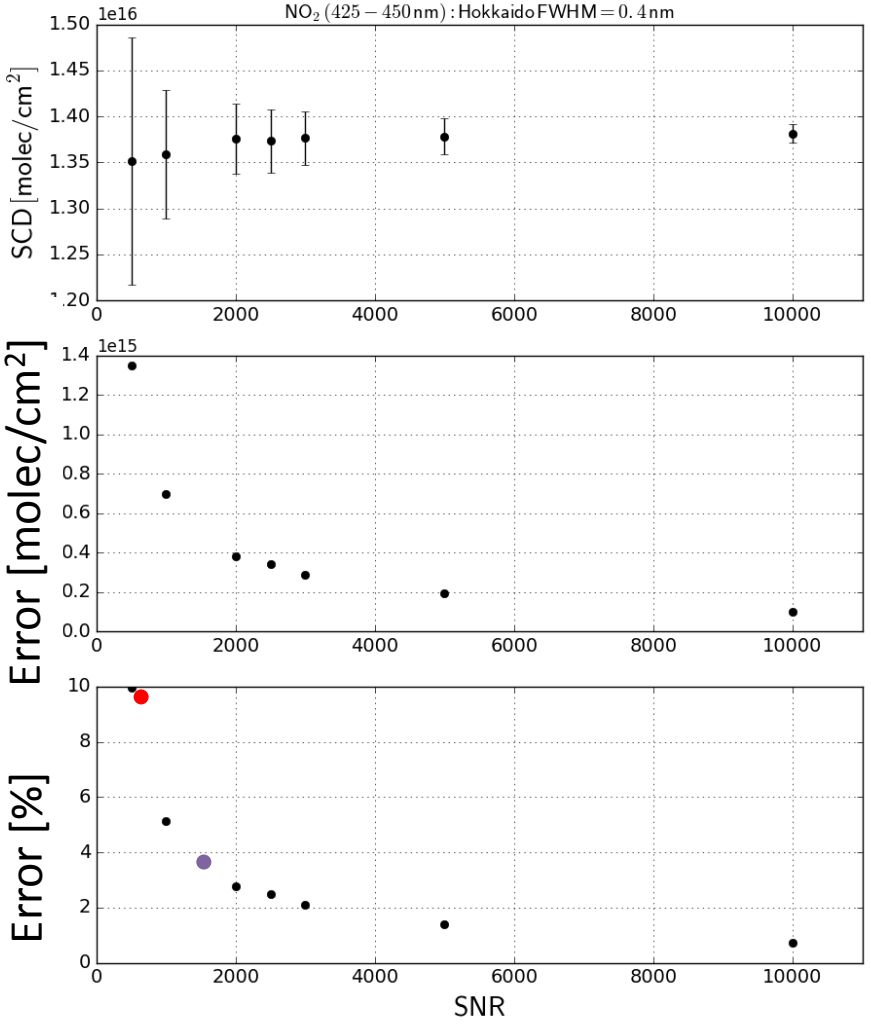


1x1 km^2 → SNR=554 @ 450 nm (red), 2x2 km^2 → SNR=1688 @ 450 nm (purple)

Upper figure : SCD (total = tropo. + strato.), Middle figure : Error [molec/cm^2], Lower figure : Error [%]

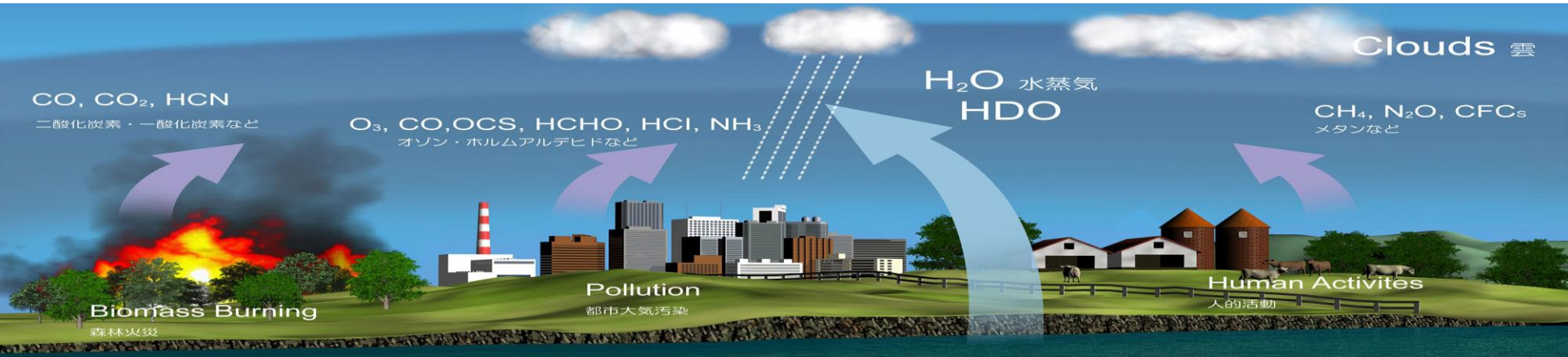
Current:

1. Data analysis system for synergy analysis using HIMAARI-8 satellite with several other satellite datasets

2. micro-satellite for NO2 hot spot with 1x1 horizontal resolution.

- Scientific requirement of NO2 observation is about 5%
- Spatial resolution of 1x1 km^2 provided SNR about 500 and the measurement precision to be 9% in this simulation.
- Spatial resolution of 2x2 km^2 provided SNR about 1700, and a measurement precision was about 4%.

- further lower orbit
- change the detectors
- more broader frequency resolution



Current satellite horizontal resolution is about 7-25km, which is not enough to estimate the inventory from the “large stationary emission source”, such as transport sector (car, ship), agriculture region, industrial region, and city.

ISS altitude will give higher horizontal resolution than any of past/future missions

Current 7-25 km → APOLLO 1-2 km

Air quality sensors

GOME2
OMI
SCIAMACHY
Korean GEMS
TROPOMI
Sentinel4/5
TES
IASI
CrIS
TRAQ

APOLLO

Horizontal resolution

10000km 1000km 100km 10km 1km

Hemispheric Pollution

Intercontinental Pollution Transport

Regional pollution

Mega-city

Cities

Area for
-Agriculture
-Residential
-Business

APOLLO with 1-2 km horizontal resolution →

Origin

Plants, Forest fire, volcano, pipe/funnel/ship /transportation