Development of NO_2 and SO_2 algorithm for GEMS

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October 8-10, 2012

Hotel Seokyo, Seoul, Korea

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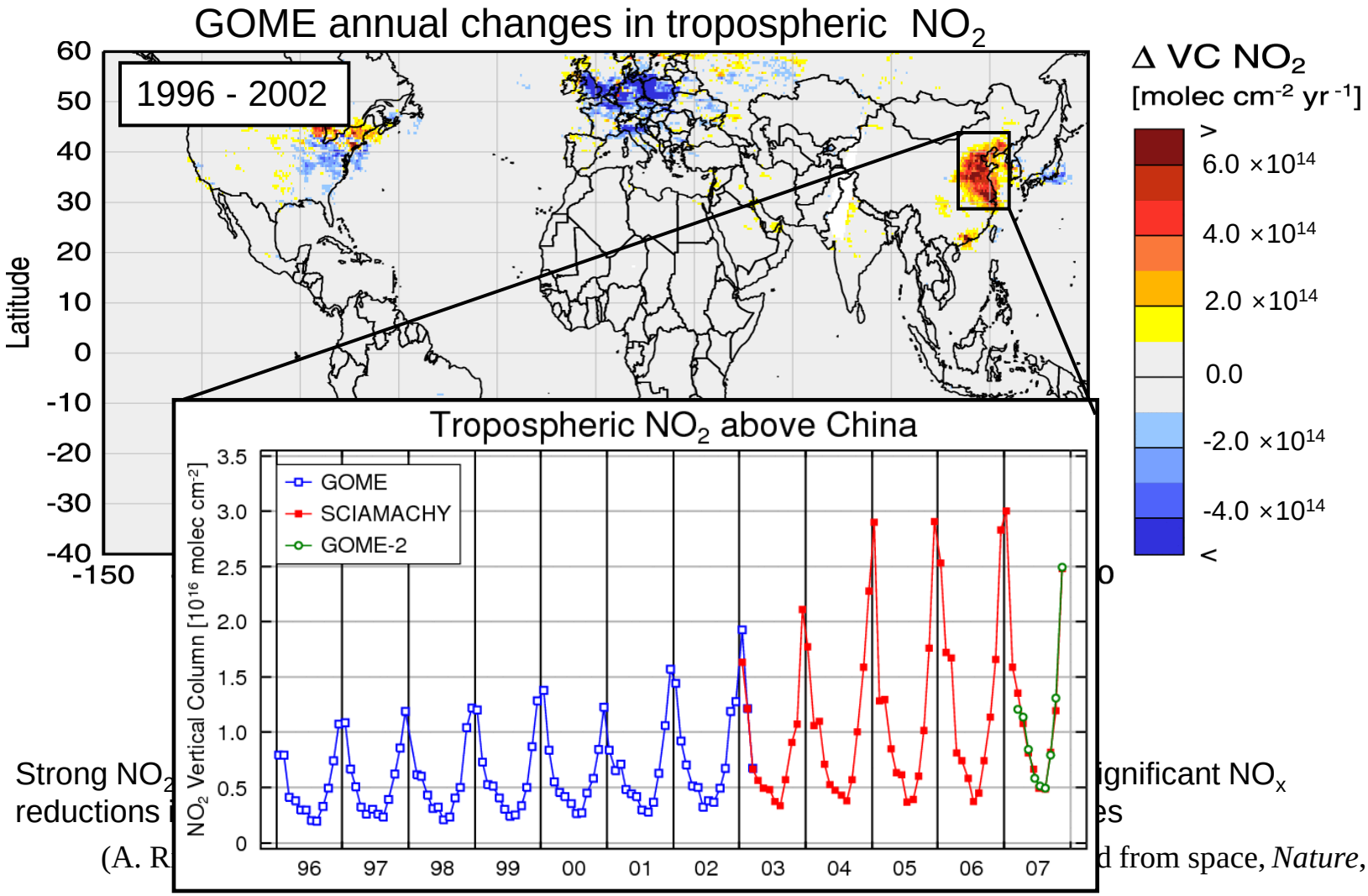
Tasks

- Develop algorithms for NO_2 and SO_2 retrieval for GEMS
- Determine science requirements for SO_2 retrieval for GEMS (Measured Range, Accuracy, SNR, and Spectral Resolution)

Tropospheric NO_2 columns

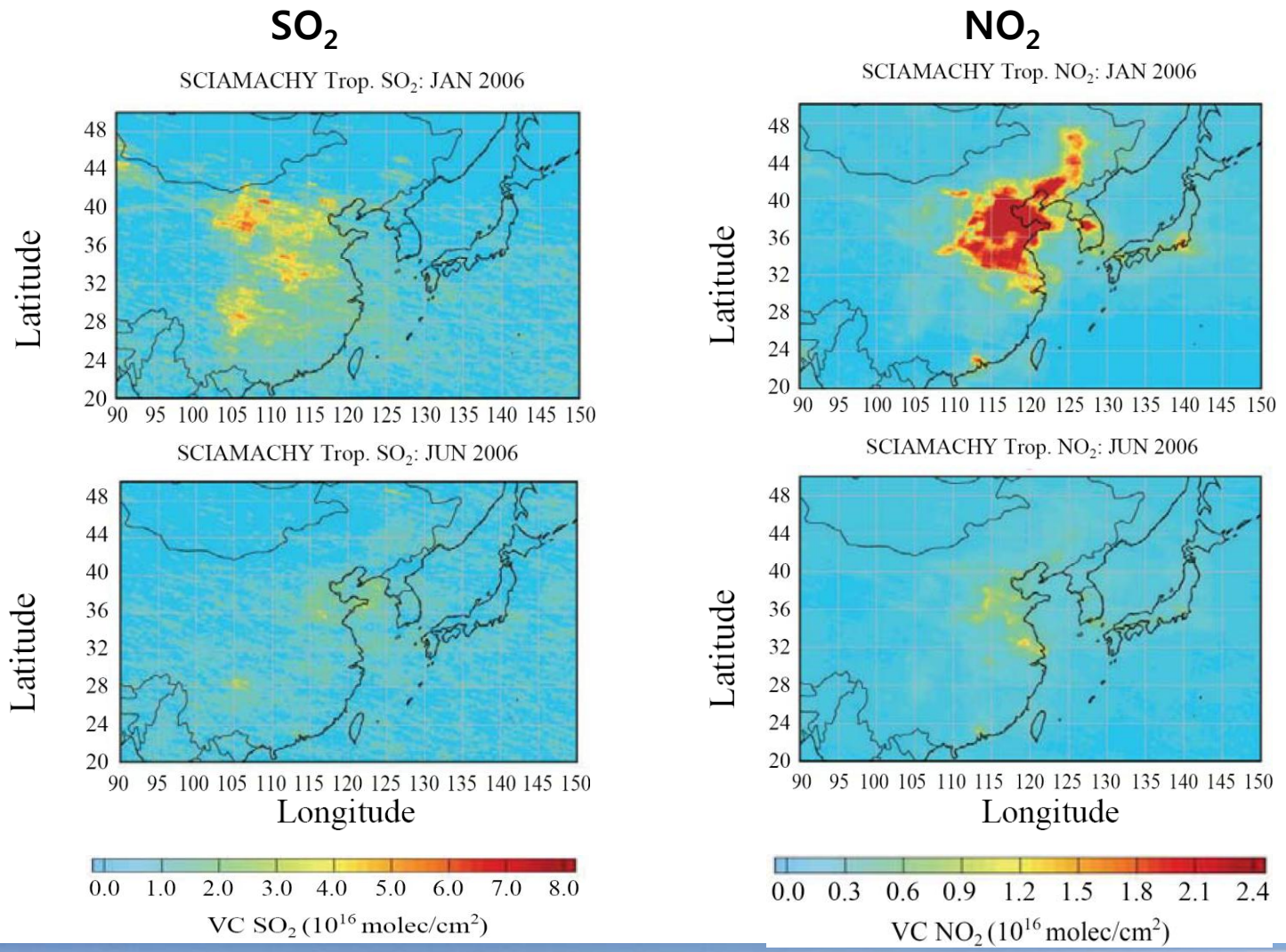


- Strong NO_2
- reductions i ignificant NO_x es

(A. R d from space, *Nature*, 2005)

Example

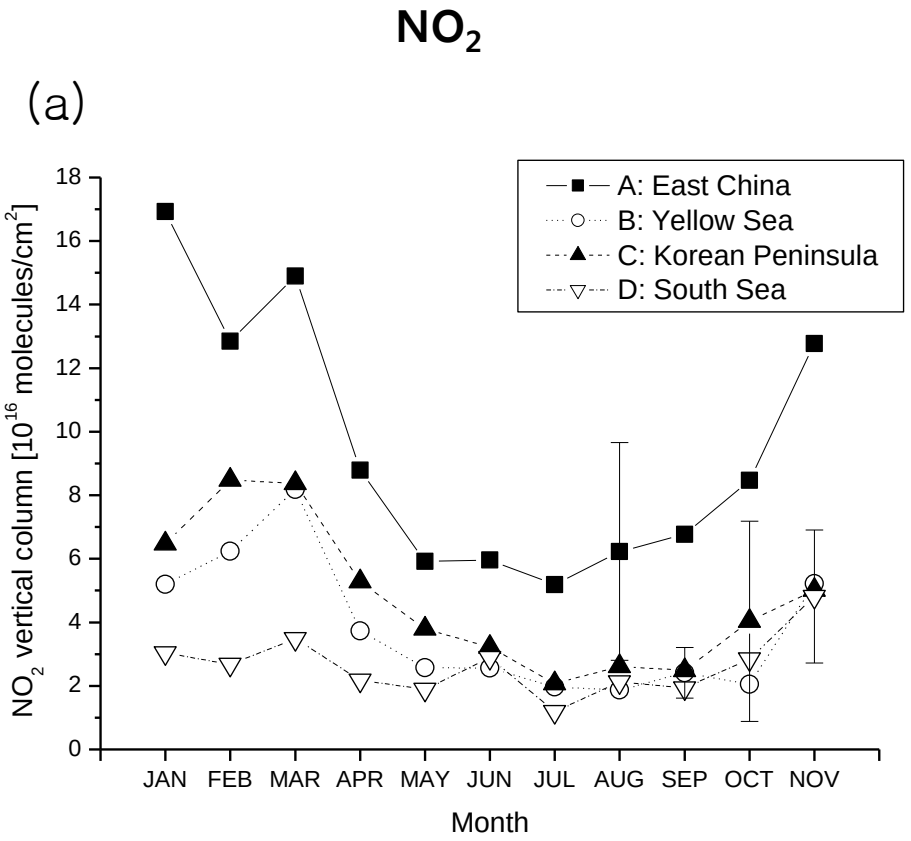
Monthly NO_2 and SO_2 VCD over East Asia in 2006

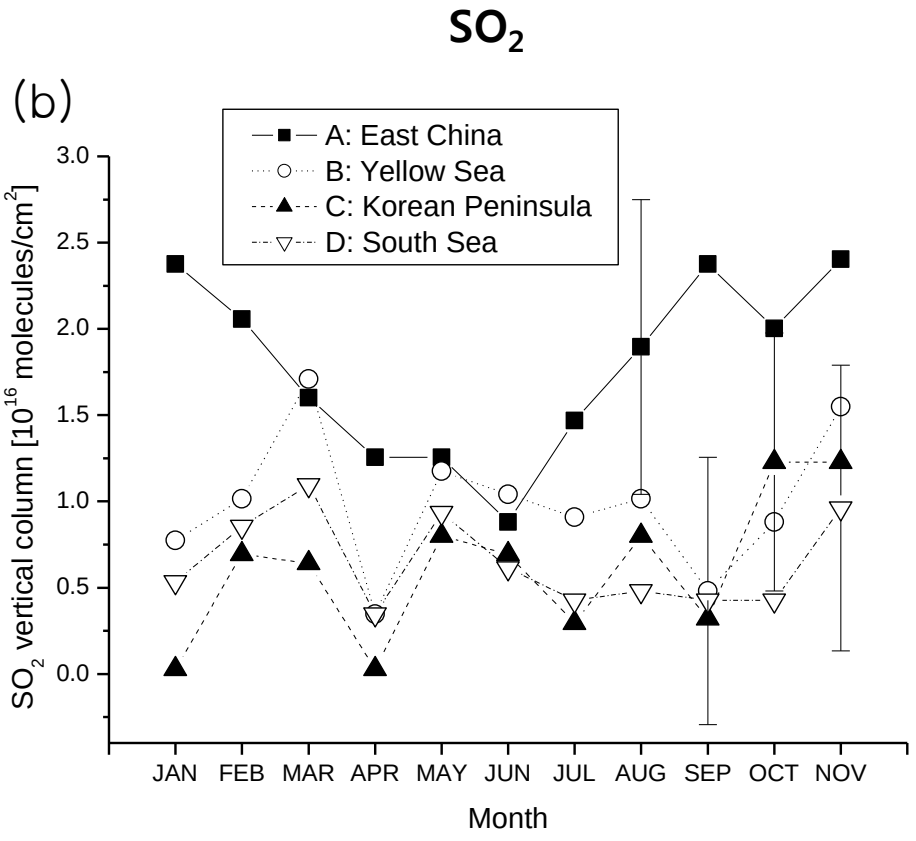


(Lee et al., KOSAE 2008)

Example

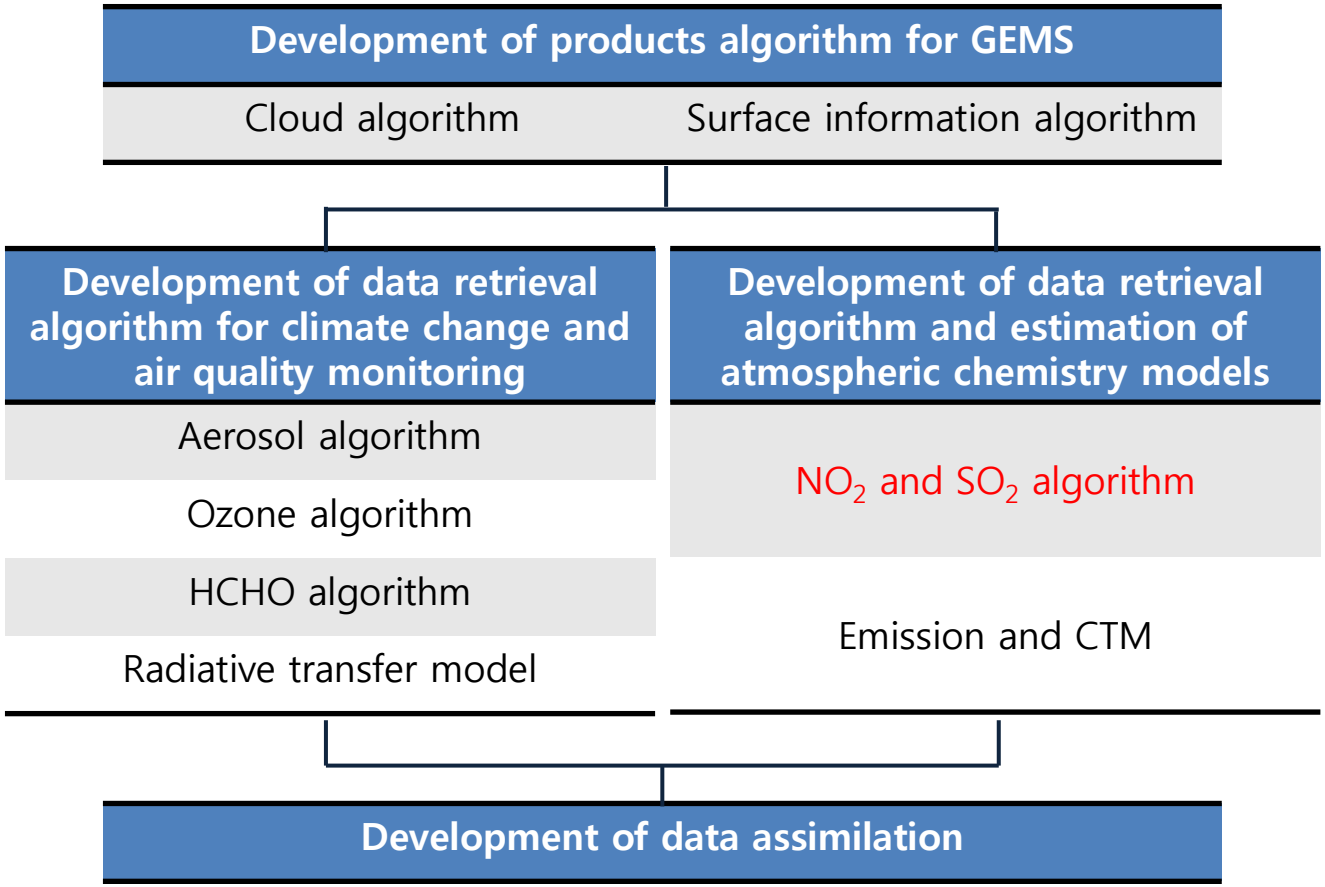
VCD Variation over East Asia (SCHIAMACHY Satellite Data)





(Lee et al., KOSAE 2008)

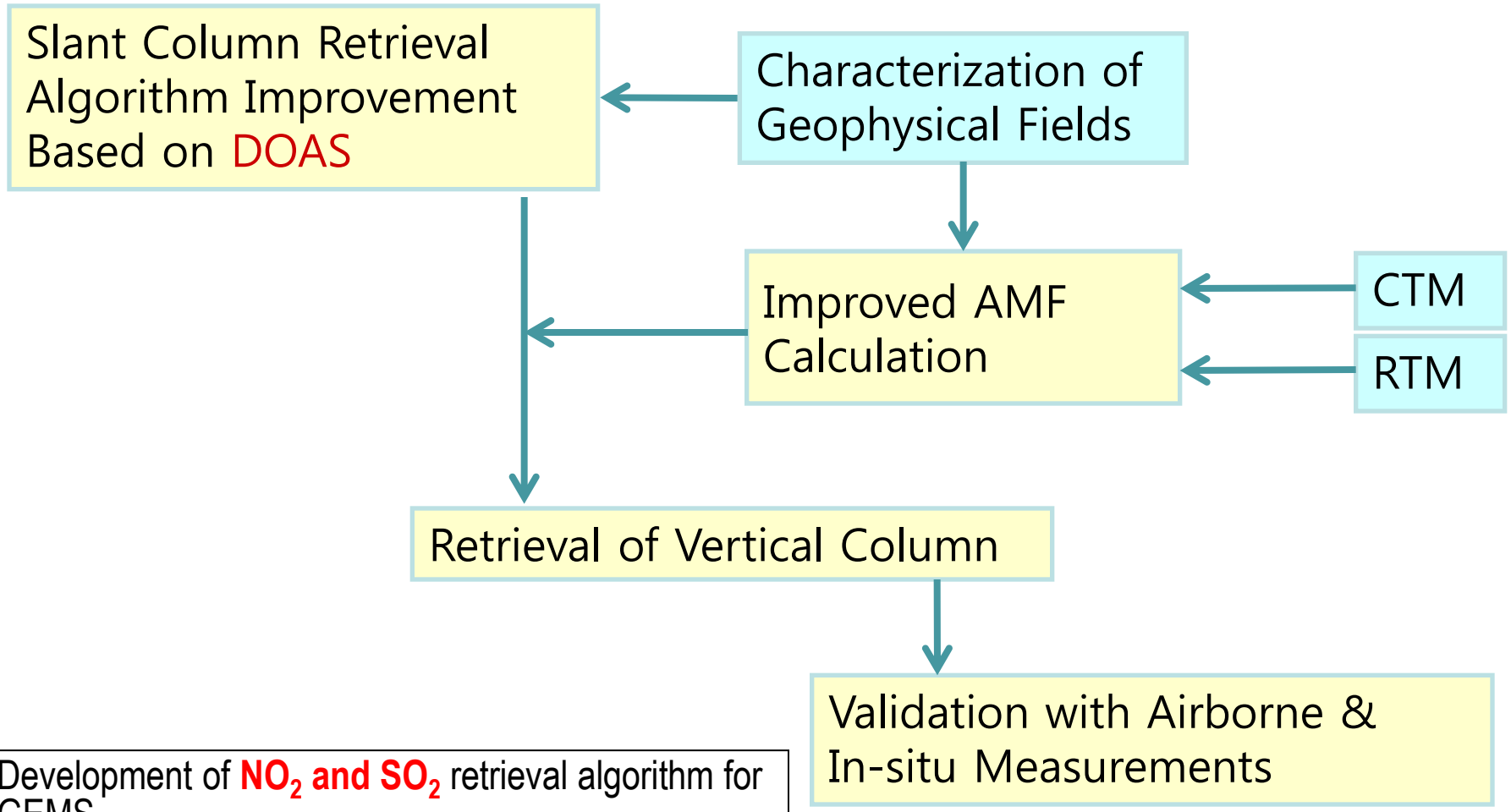
Research groups



Research goals

- **Development of NO_2 and SO_2 retrieval algorithm for GEMS**
  - ▶ Design of proto-type algorithm (NO_2 and SO_2)
  - ▶ Development of proto-type algorithm and evaluation/modification
  - ▶ Development of integration-type algorithm and modification

Design of proto-type algorithm (NO_2 and SO_2)

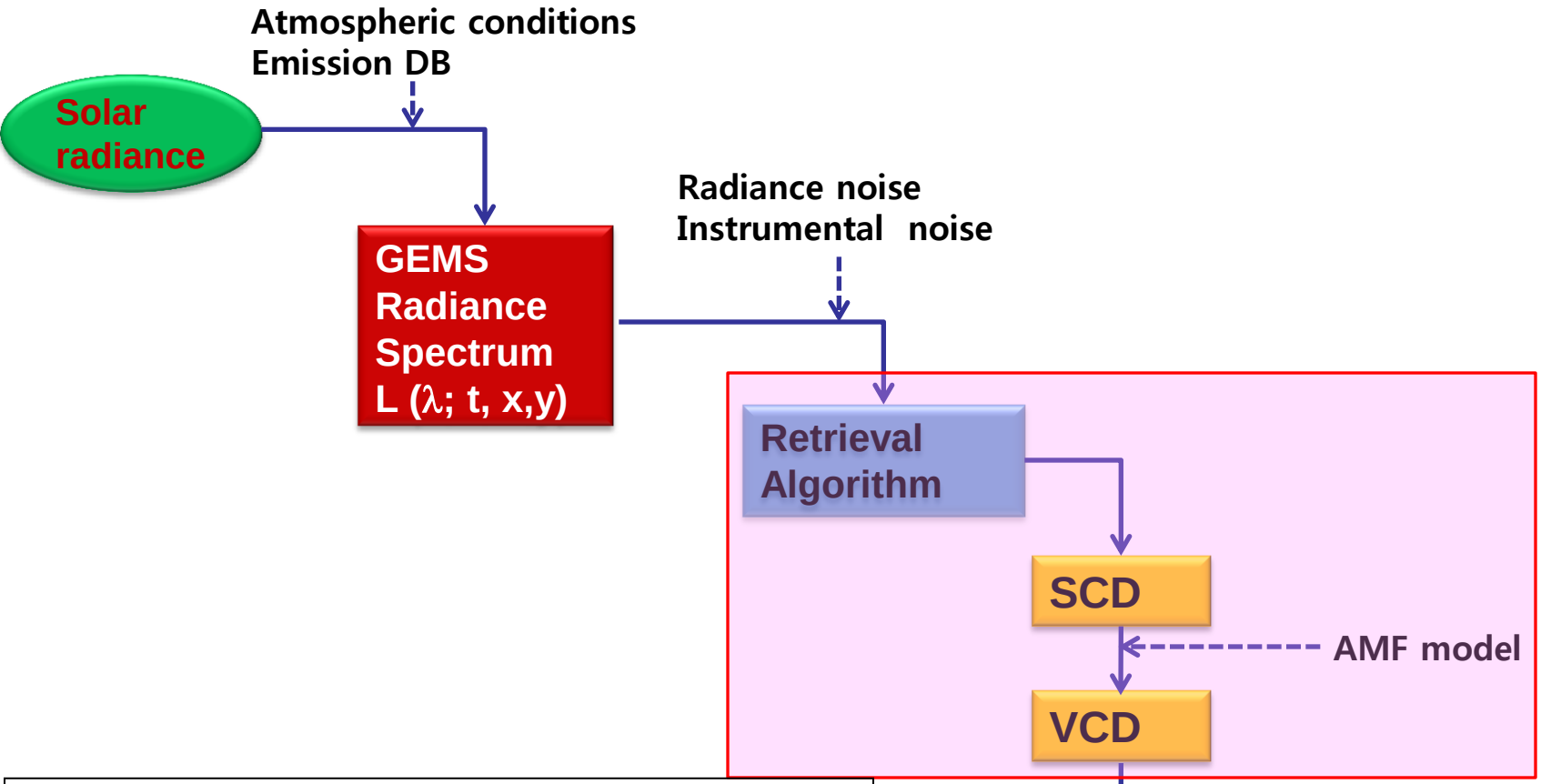


Development of **NO_2 and SO_2** retrieval algorithm for GEMS

➢ Design of proto-type algorithm (NO_2 and SO_2)

DOAS: Differential Optical Absorption Spectroscopy
AMF: Air Mass Factor;
CTM: Chemical Transport Model
RTM: Radiative Transfer Model

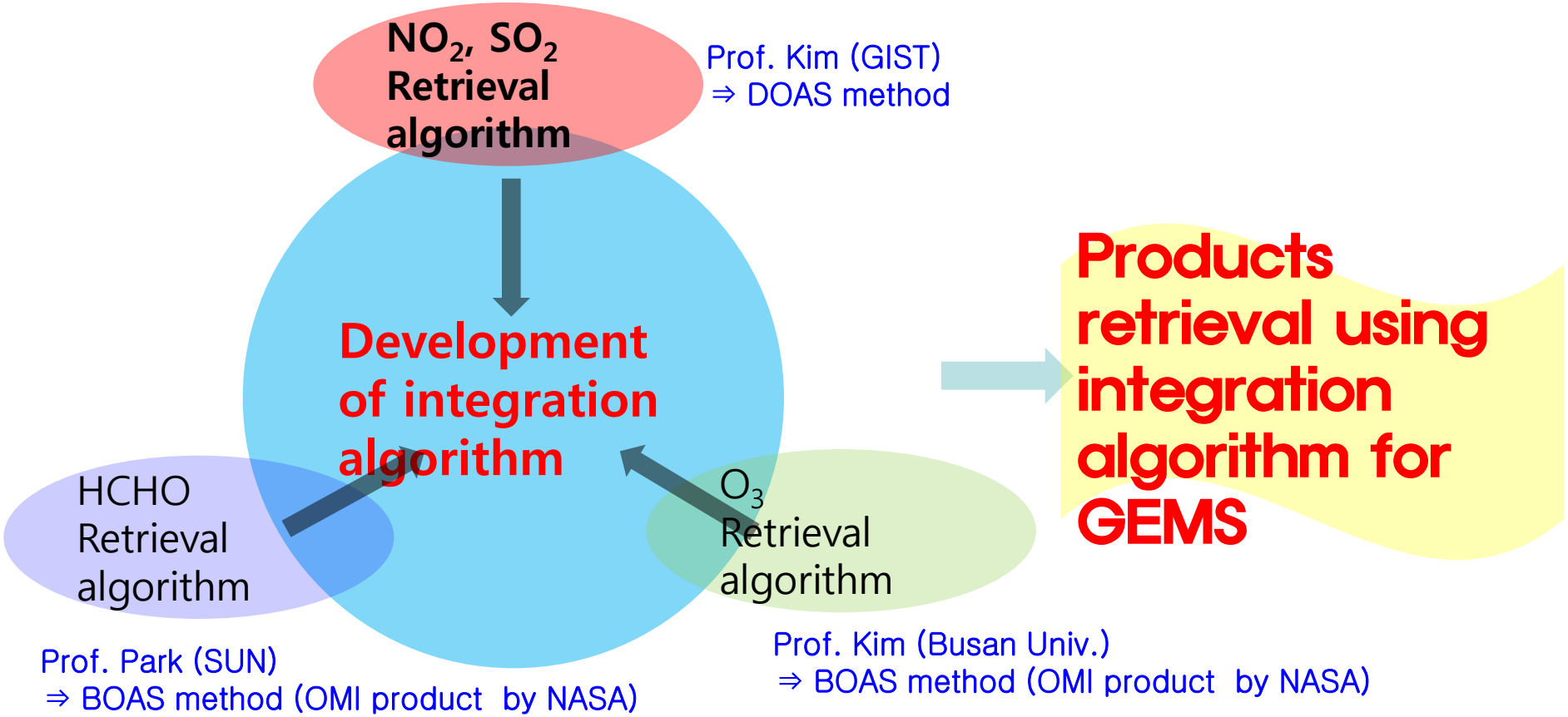
Development of proto-type algorithm and evaluation/modification



Development of NO_2 and SO_2 retrieval algorithm for GEMS

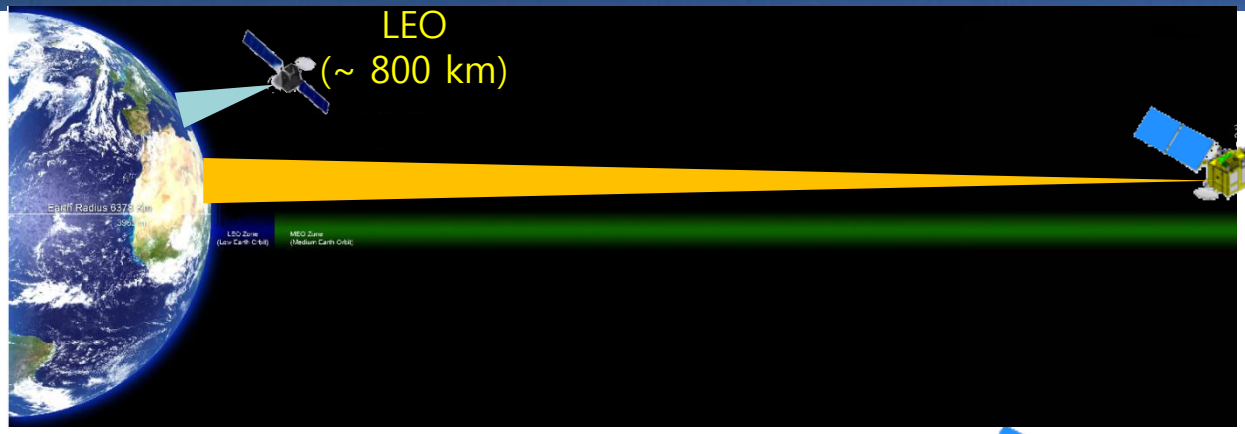
➢ Development of proto-type algorithm and evaluation/modification

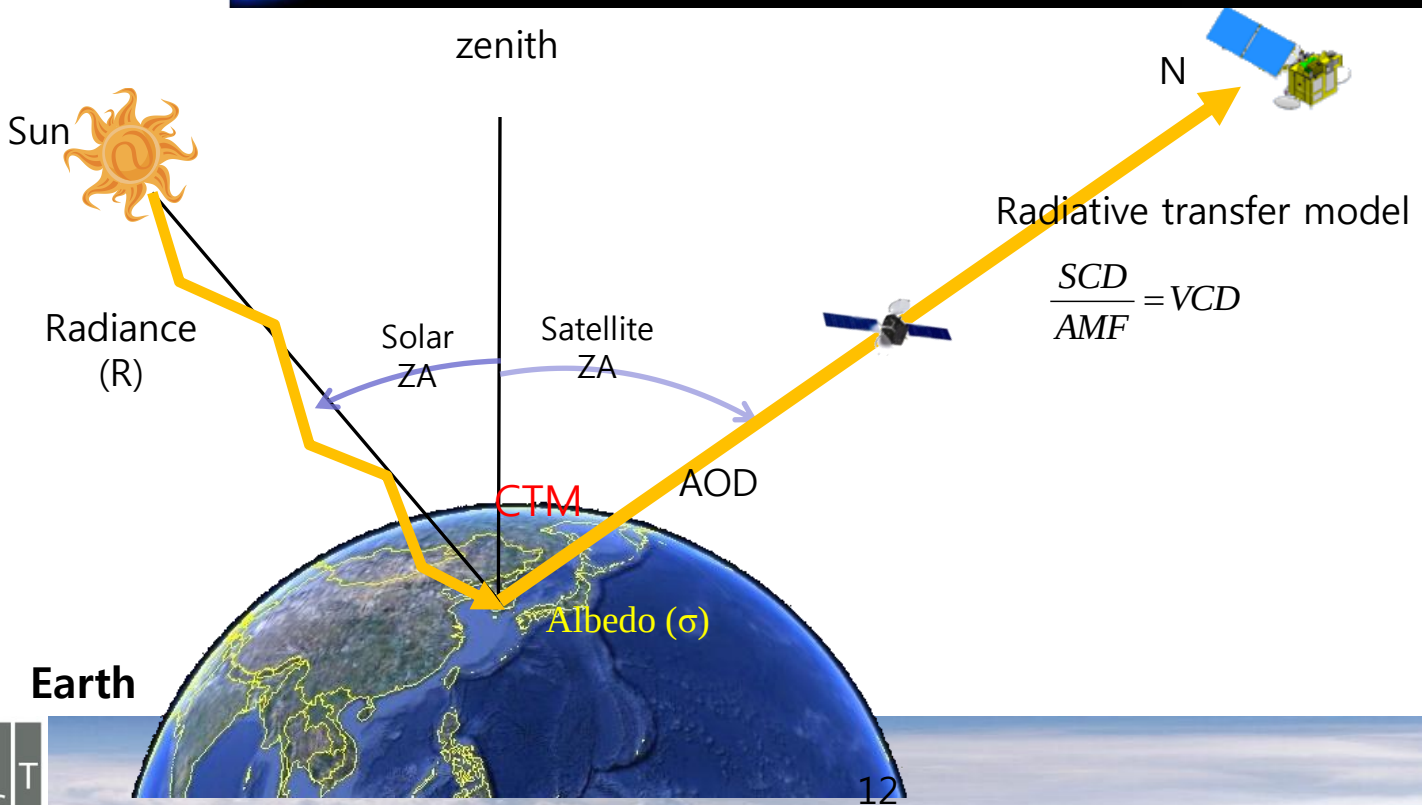
Development of integration-type algorithm and modification



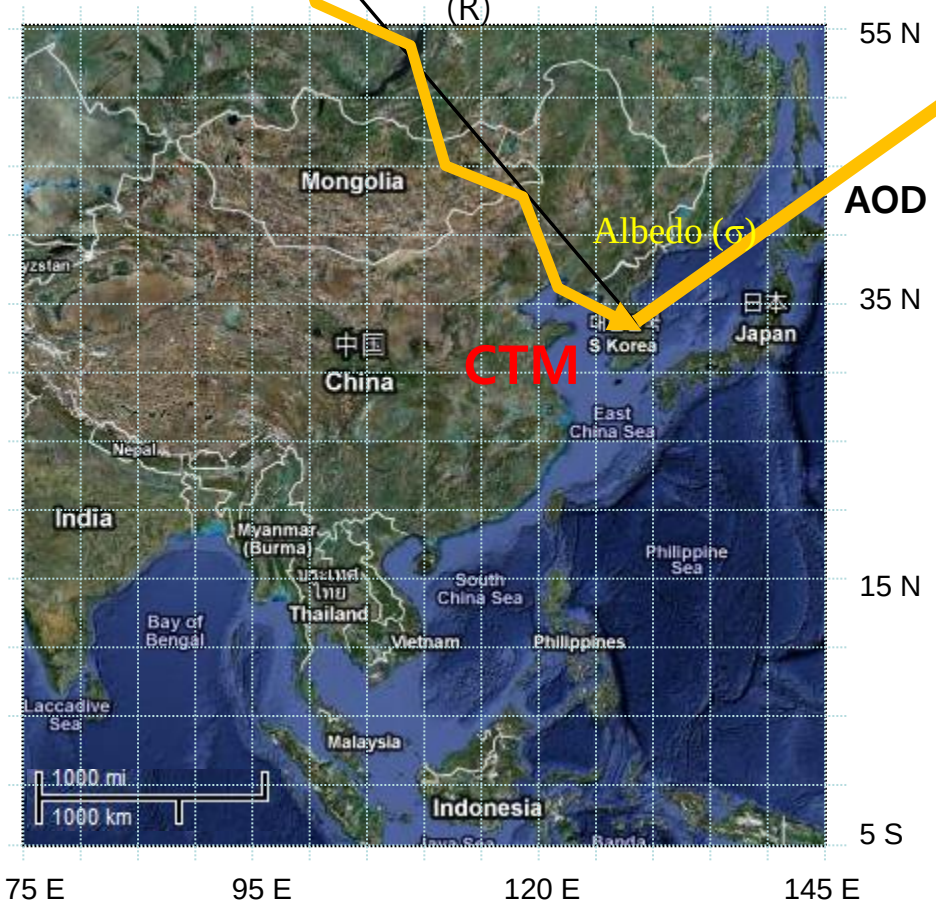
- ❖ **DOAS (Differential Optical Absorption Spectroscopy) Fitting**
- ❖ **BOAS (Basic Optical Absorption Spectroscopy) Fitting**

Overview of simulation method





SNR simulation for GEMS coverage area



$$\frac{SCD}{AMF} = VCD$$

Signal electron # =
$(R \cdot A \cdot \Omega \cdot \Delta\lambda \cdot \eta \cdot t \cdot \tau)/hc$

R: Radiance (W m^{-2} sr^{-1} μm^{-1})
A: aperture area (m^2)
Ω: solid angle (sr)
η: quantum yield
t: integration time (s)
τ: optical efficiency
h: Planck's constant (J s)
c: speed of light (m s^{-1})
σ: surface albedo
N: noise

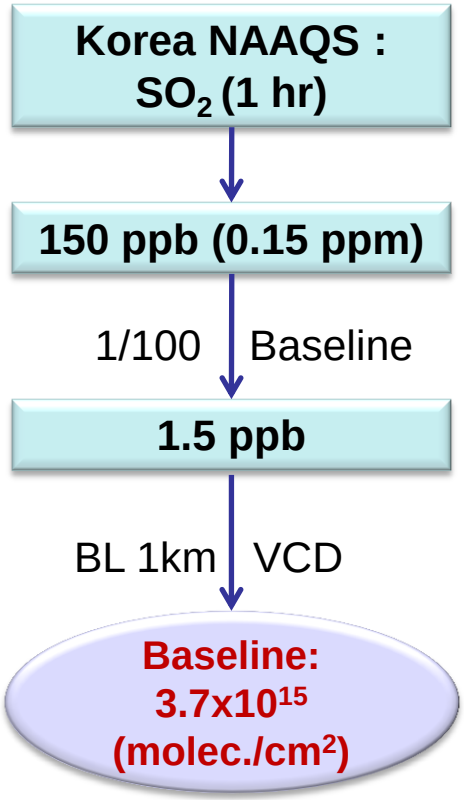
SNR Requirements

Wavelengths (nm)	SNR	Related gas	Uncertainty (cm^{-2})	SZA (deg)	Remark
315-325	1500* 720	SO_2	1.0×10^{16} 3.3×10^{16}	60	YJK, KC
327-356	1394* 1500* 720	HCHO	1.0×10^{16} 1.0×10^{16} 2.1×10^{16}	50 70	KC YJK, KC
423-451	2049* 1500	NO_2	1.0×10^{15} 1.5×10^{15}	70	YJK, KC
433-465	1931*	CHOCHO	4.0×10^{14}	50	KC

* May consider spatial coadding to increase the SNR.

Cf. Kelly Chance (2011), Y.J. Kim

Baseline levels of SO_2 column densities

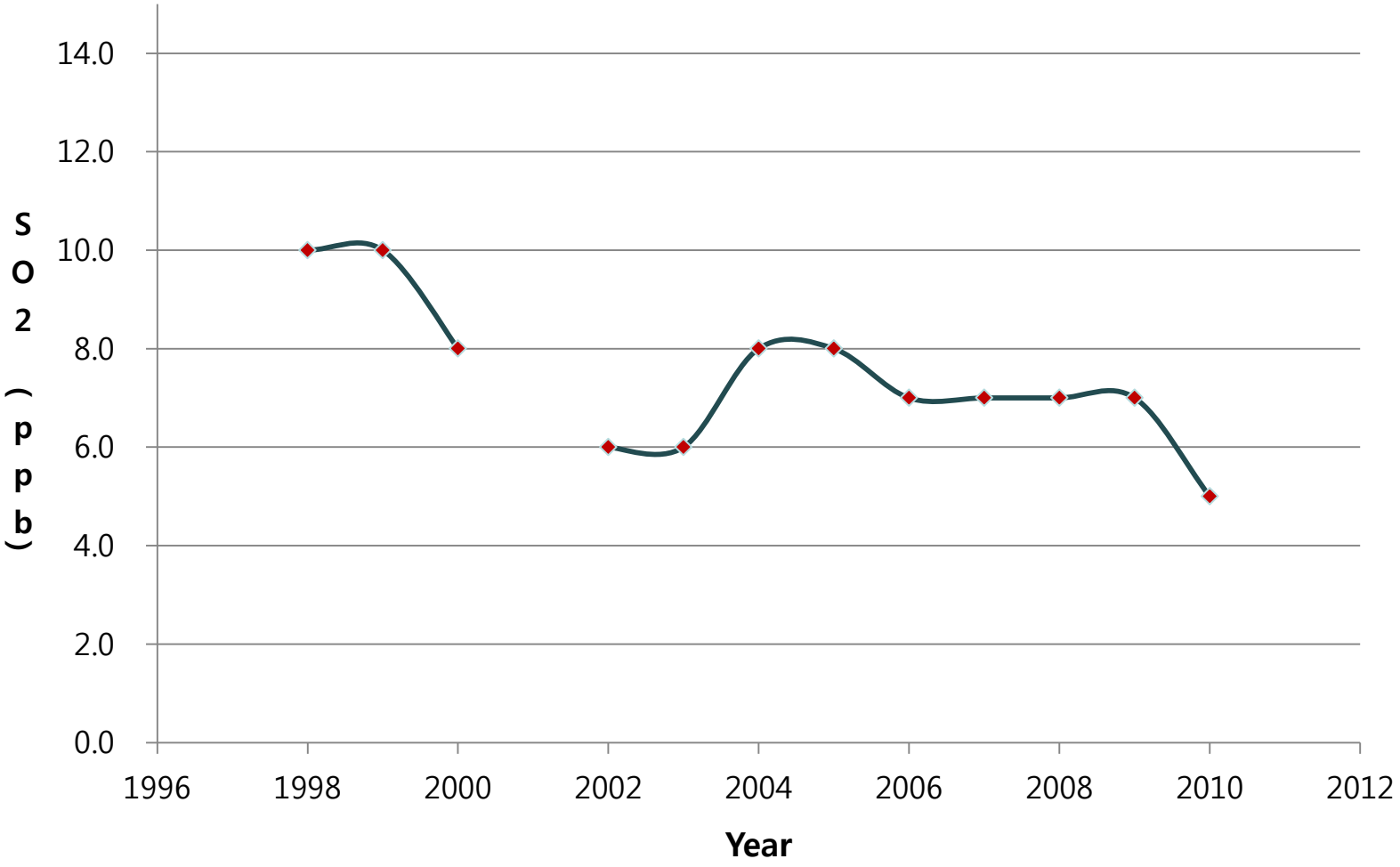


Atmosphere environmental standard (SO_2)

			winter(PBL, 1km)
Product	Standard	ug/m^3	VCD (molec./cm^2)
SO_2	Annual average 0.02ppm below	52.4	4.9E+16
	24 hr average 0.05ppm below	131.0	1.2E+17
	1 hr average 0.15ppm below	392.9	3.7E+17

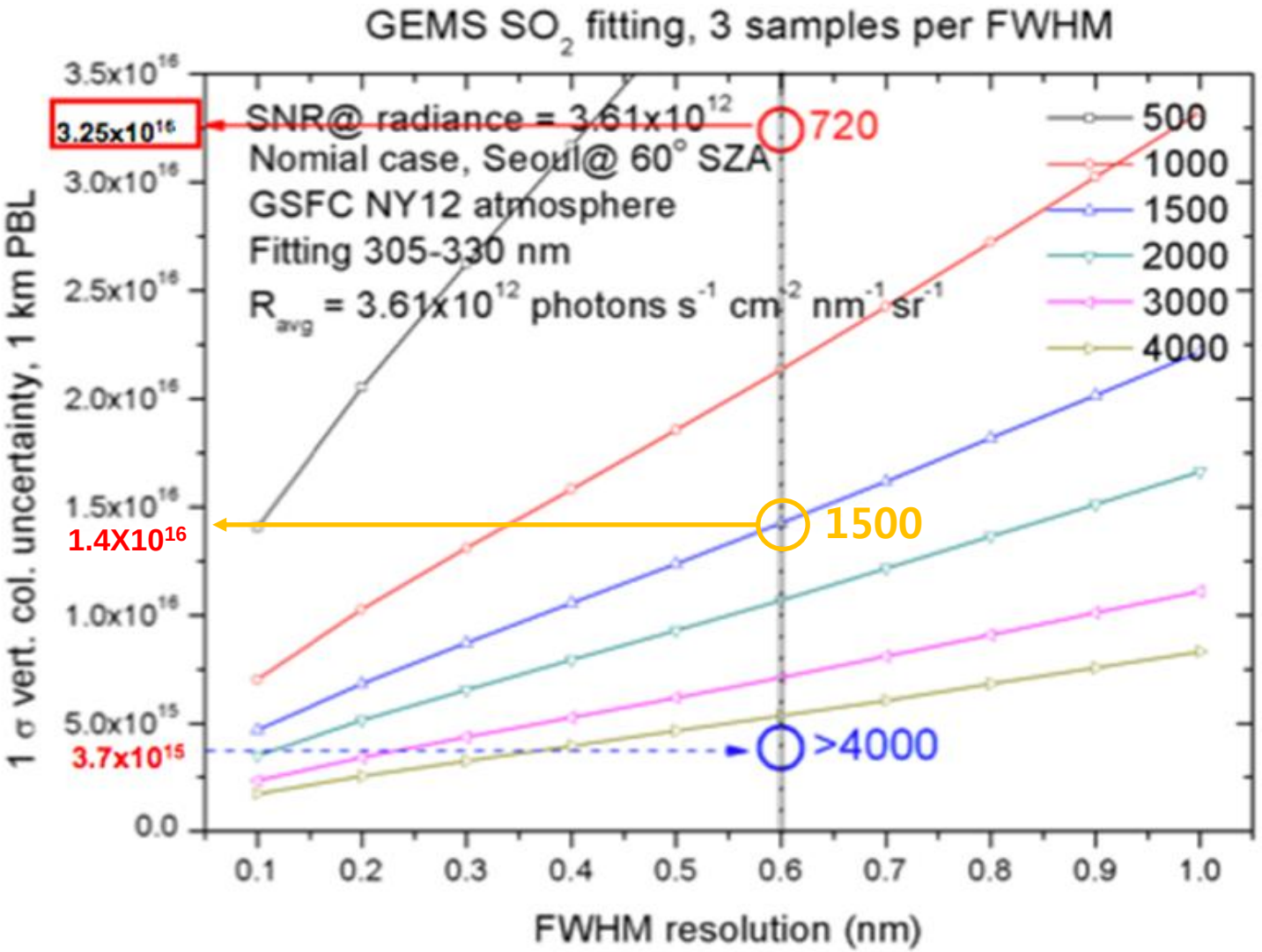
ppm ⇒	ug/m3	(P M /8.314 T)xppm
ug/m3 ⇒	VCD(molecules/cm2)	(ug/m3)x PBL(m)x1/M xAvogardo constant

Yearly average SO_2 in Seoul



(Annual report of air quality in Korea 2010)

Old simulation

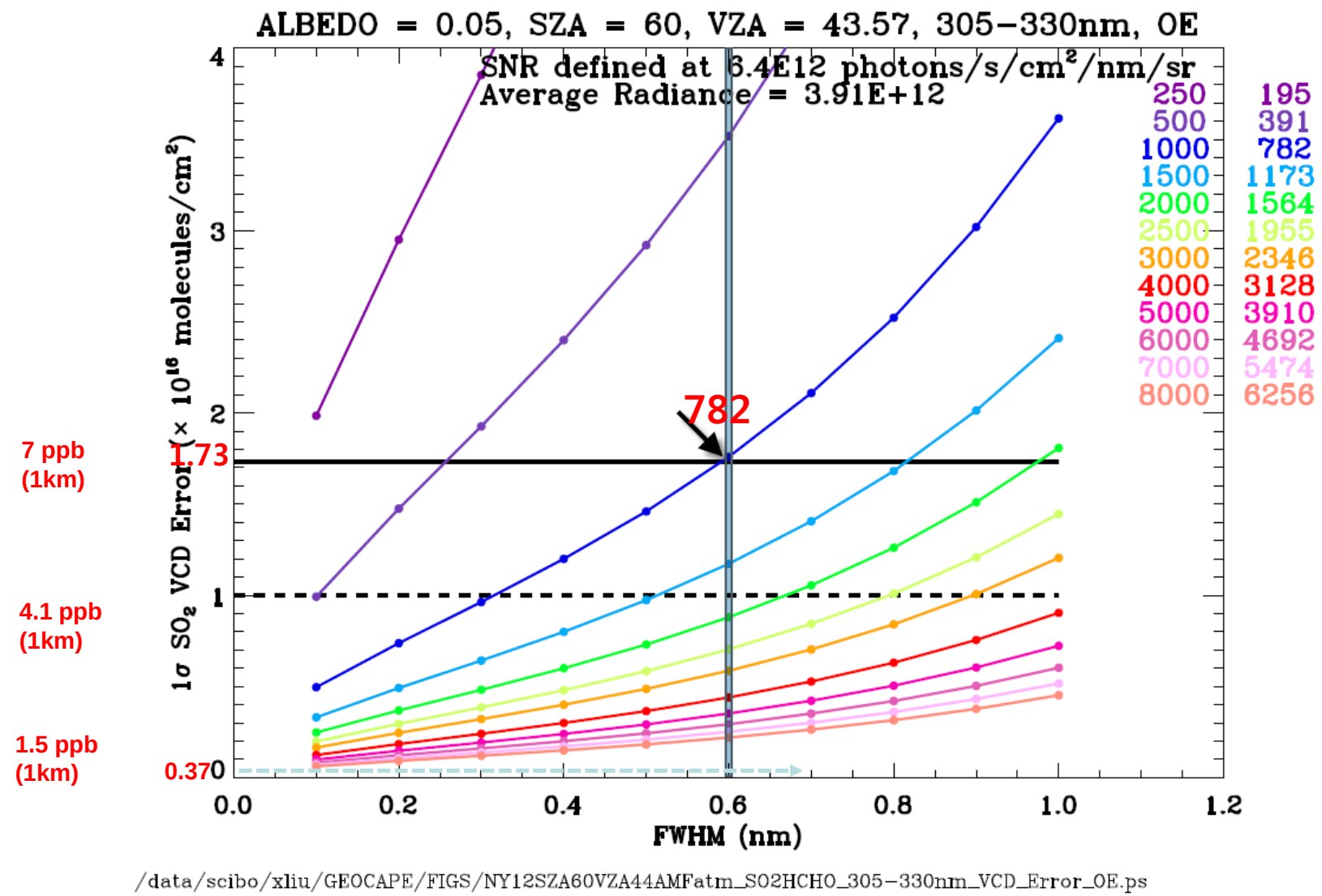


13.2 ppb (1 km)

5.7 ppb (1 km)

1.5 ppb (1 km)

New simulation



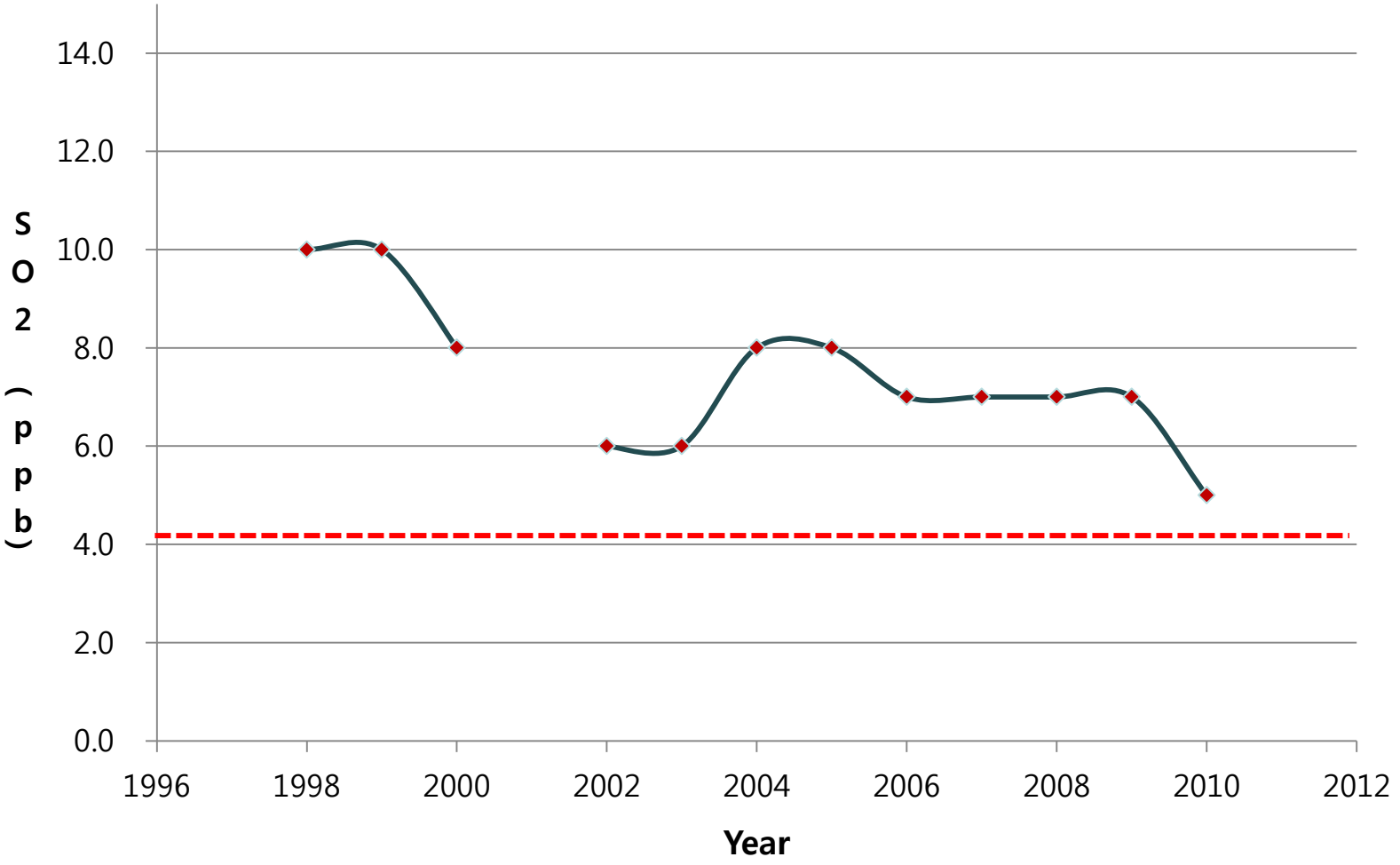
Results

	SO_2 (720@320 nm)	
	Old simulation	**New simulation**
Spectrum resolution	0.6 nm	0.6 nm
R_{avg}	3.61×10^{12} photons s^{-1} cm^{-2} nm^{-1} sr^{-1}	3.91×10^{12} photons s^{-1} cm^{-2} nm^{-1} sr^{-1}
SZA	60	60
Fitting window	305-330 nm	305-330 nm
1 σ VCD uncertainty	3.25×10^{16} →720 (13.2 ppb@ 1km)	1.73×10^{16} →782 (7.0 ppb@ 1km)
Baseline (3.75×10^{15})	>4000 (1.5 ppb@ 1km)	3910 (1.5 ppb@ 1km)

Results

Old simulation		New simulation		
SNR	Uncertainty	SNR	Uncertainty	ppb (Winter 1 Km PBL)
720	3.25E+16	782	1.73E+16	13.2
1500	1.40E+16	1750	1.00E+16	4.1
>4000	3.70E+15	>3910	3.70E+15	1.5

Yearly average SO_2 in Seoul



(Annual report of air quality in Korea 2010)

Summary and Future works

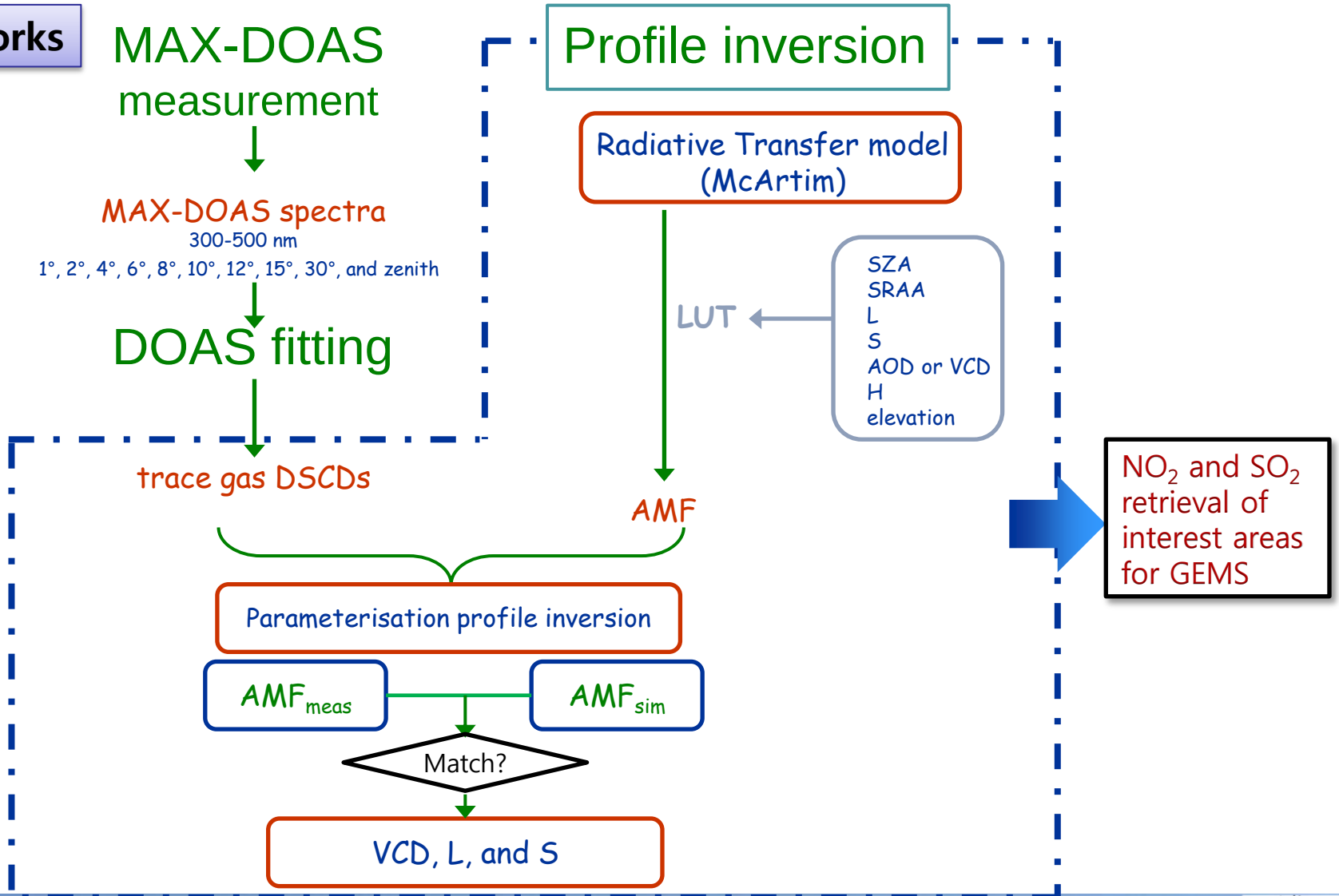
Summary

- **SNR simulation for GEMS observations has been performed for SO_2 retrieval.**
- **Resolution ($\Delta\lambda$ =0.6 nm),**
  - SO_2 Geo CAPE (1.0×10^{16} molec./cm^2)⇒ ≫ SNR 1750 (~4.1 ppb at surface level)

NO_2 (2.5×10^{15} molec./cm^2) ⇒ > SNR ~900 (423-451 nm)
SO_2 (1.0×10^{16} molec./cm^2) ⇒ > SNR ~1750 (315-325 nm)

Summary and Future works

Future works



Thanks for your attention!

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