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Planned GEO Mission in Korea for Air Quality Measurements : GEMS(Geostationary Environmental Monitoring Spectrometer)

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Asia – important region in Global AQ

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Both Anthropogenic and Natural Sources throughout the year

Anthropogenic	Geogenic	Biomass burning	Biogenic
			
Pollution	Asian dust	wild fires	sink change
Industry Transportation Mega Cities	Land use change Desertification Population(>60%) – Social benefit	Drought	Deforestation

Monsoon

Typhoon

Tsunami

Tibetan Plateau

COMS

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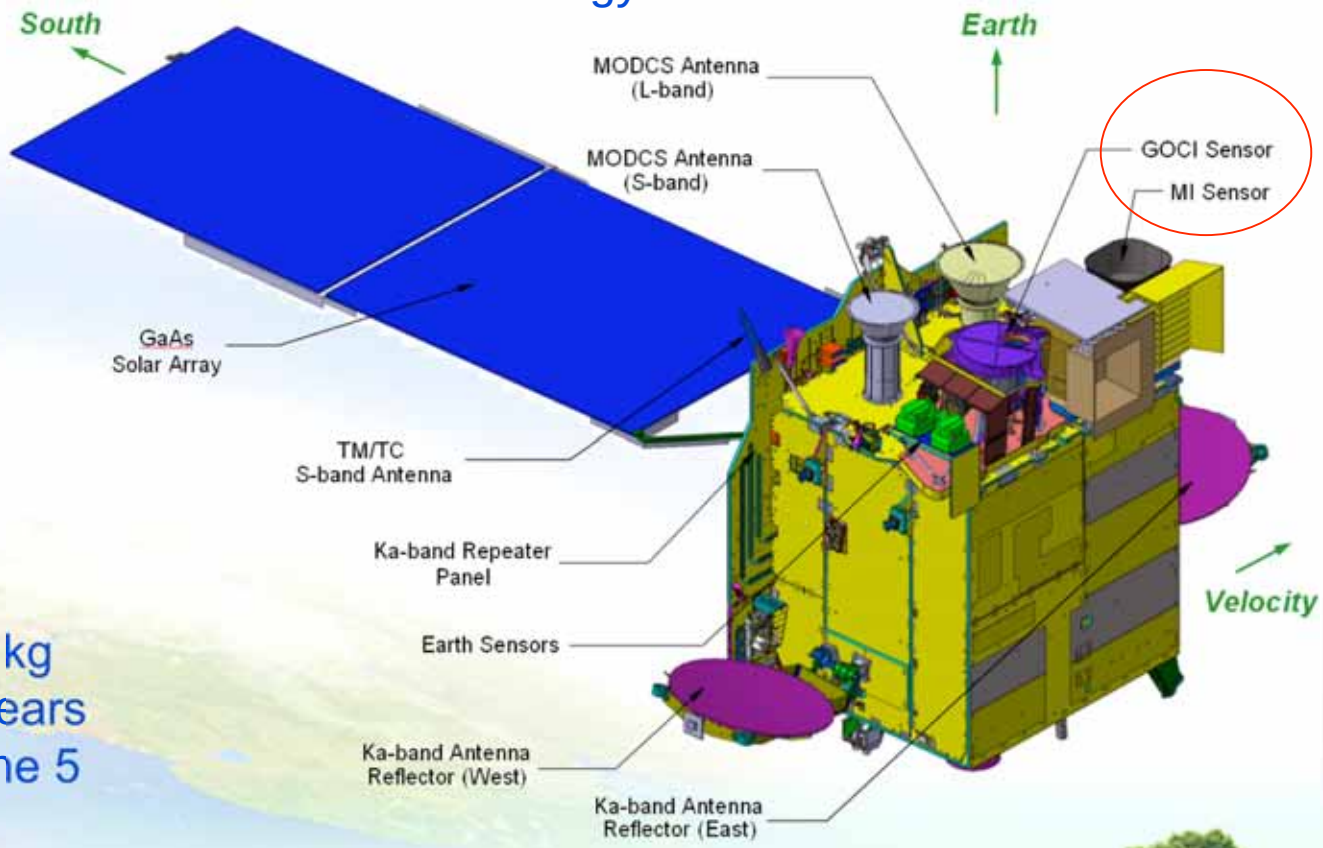
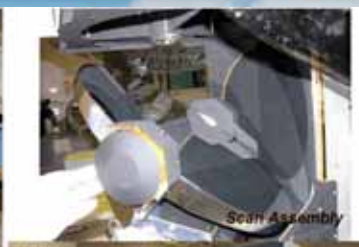
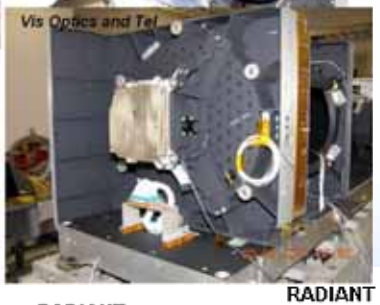
- Mission:
  - Communication
  - Ocean Color
  - Meteorology

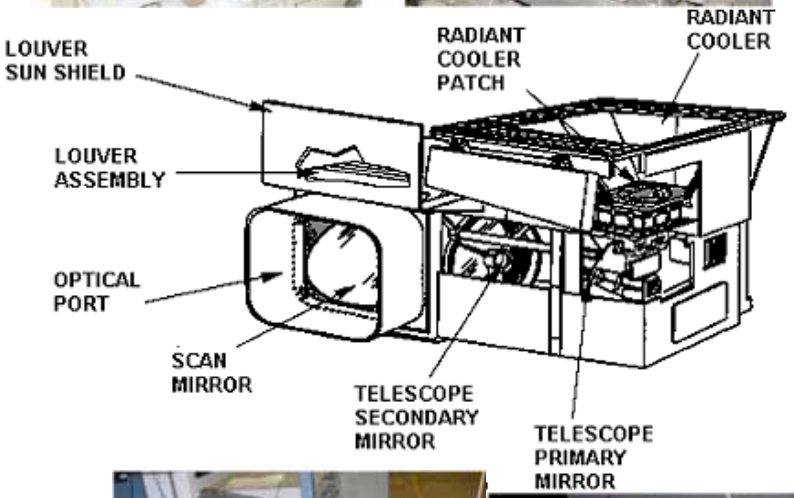


- Launch: Nov., 2009
- Orbit: GEO (128.2°E)
- SI: KARI + Astrium
- Mass at launch <2497 kg
- Operational life : 7.7 years
- Launch vehicle : Ariane 5

Meteorological Imager(MI)







	MI
Mass	144.6 Kg
Volume	130x90x80 cm^3
Spectral Band (μm)	0.63(0.55-0.75) 3.91(3.8-4.0) 6.7(6.5-7.0) 10.7(10.2-11.2) 12.0(11.5-12.5)
Spatial Resolution	1 km (VIS) 4 km (IR)
Coverage	Global
SNR	~
Temporal Resolution	30 min.
Products	Cloud, snow cover, CSR, OLR, AMV, SST, LST, TPW, Fog, CTT, CTP, rain rate, AOD

GEO Ocean Color Imager(GOCI)

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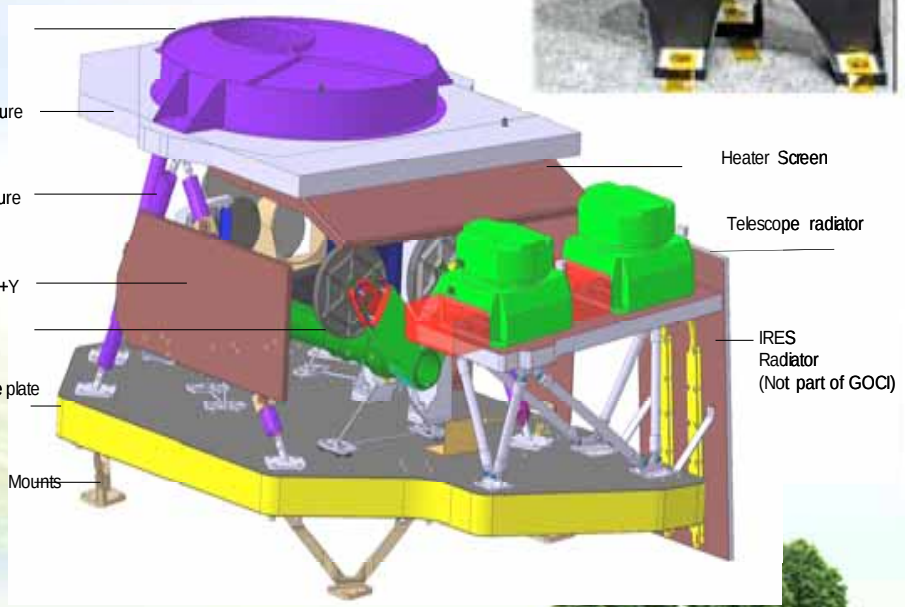
	GOCI
Mass	**83.3 Kg**
Spectral Band	**412, 443, 490, 555, 660, 680, 745, 865 nm (8)**
Spectral Resolution	**20 nm (B1~B5, B7)** **10 nm (B6)** **40 nm (B8)**
Spatial Resolution	**500 m x 500 m**
Coverage	**East Asia near Korea**
SNR	**~1000**
Temporal Resolution	**1 hour (8/day)**
Products	**Yellow substance turbidity** **Chlorophyl** **suspended sediment** **Vegetation** **AOD, aerosol size, type**



MP-GEO SAT Development Plan

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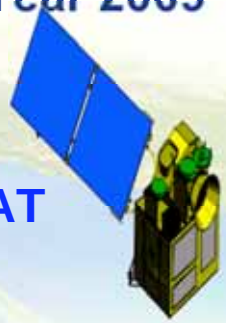
- **The continuity of COMS missions**
  - **COMS program : Launch at 2009, the predicted end of mission at 2016**
  - **For the continuous mission of meteorological and ocean monitoring, the next satellite should be launched no later than 2016.**

COMS

Development → Launch → Operation → End of Mission

Year 2009 — Year 2016



MP-GEO SAT

Development → Launch → Operation

Year 2010 — Year 2016 — Year 2025

Feasibility Study of MP-GEO Mission

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Feasibility study:

- Finished feasibility study of Geostationary Environment (AQ) Monitoring Mission
  - P.I. : Jhoon Kim (Yonsei University), Jun. – Sep., 2008, ME
  - Recommended measurements of SO_2, NO_2, O_3 and aerosol using UV/Visible spectrometer from Geostationary Orbit
  - As an option, recommended measurements of CO, CO_2 and CH_4 using IR FTS from GEO

- Finished feasibility studies of meteorological and ocean color monitoring mission

- Finished feasibility study of next Geostationary Mission
  - P.I. : Y.K. Chang (Korea Aviation University), Aug. 2008 – Feb. 2009, MEST
  - Recommended Atmospheric Environmental Monitoring Mission, together with Meteorological and Ocean Color Monitoring

Mission of Next GEO Satellite

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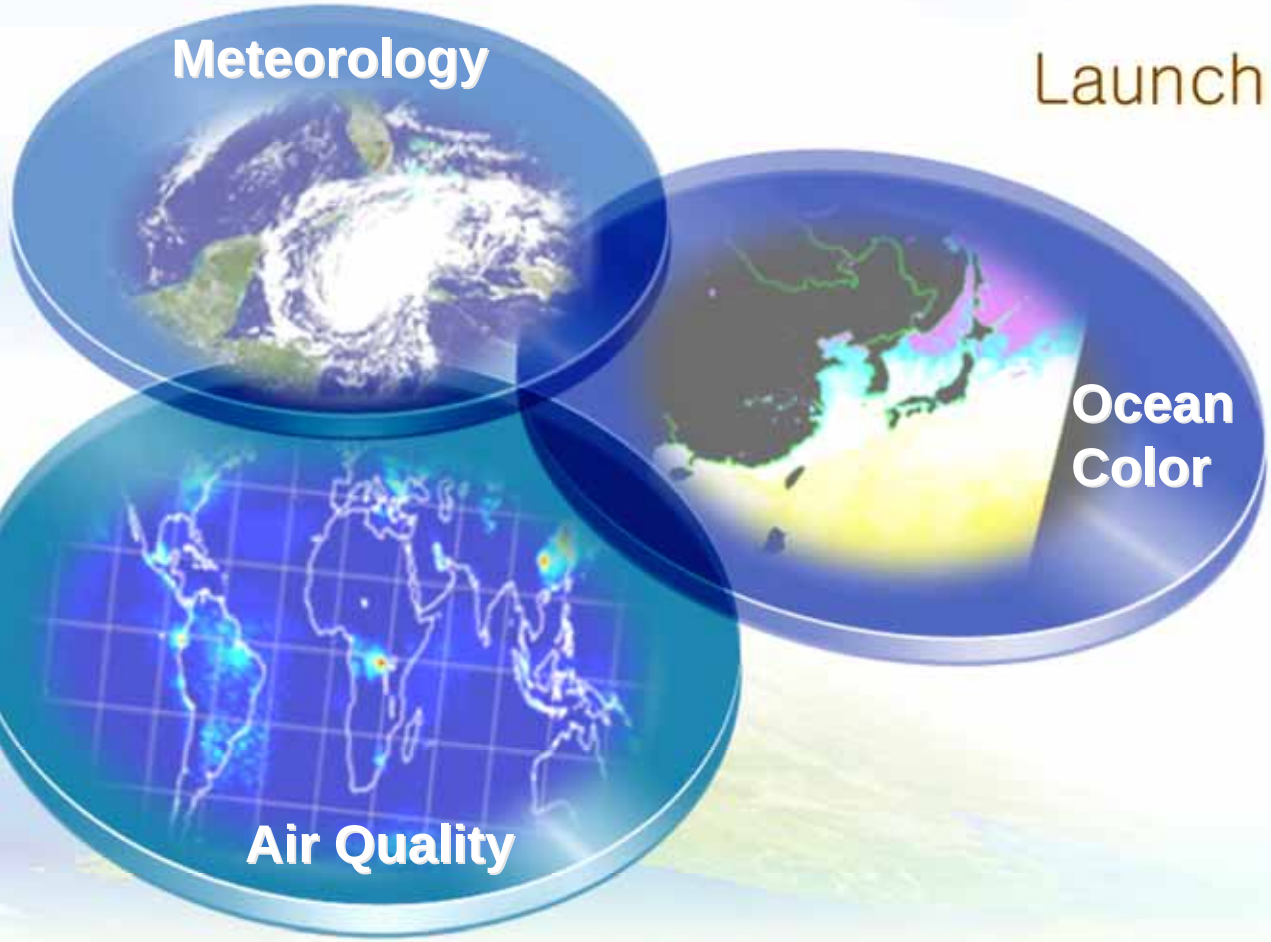
MP-GEO SAT after COMS



Launch in 2016

Environmental Mission Objectives

Air-quality:

- To provide global measurements with sufficient temporal resolution together with Meteorological mission
  - Globalization of tropospheric pollution
- To assess and forecast air quality
  - Monitoring, Validating CTM, improving accuracy
  - Emission Inventory from hourly measurements of concentration from space
- To monitor regional transport events
  - Transboundary pollution, Asian dust
- To understand long-term effect of aerosols in climate change
  - Aerosols and their precursors for long term

Social Benefit:

- Reducing economic loss by improving prediction of climate change
- Reducing medical costs and death rates through early warning of pollution events

Environmental Mission

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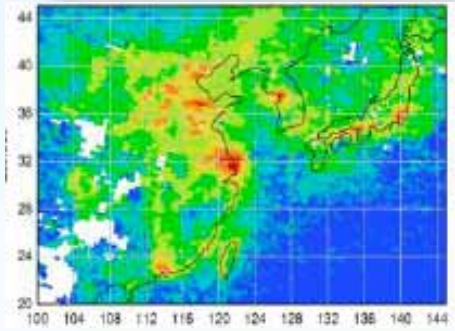
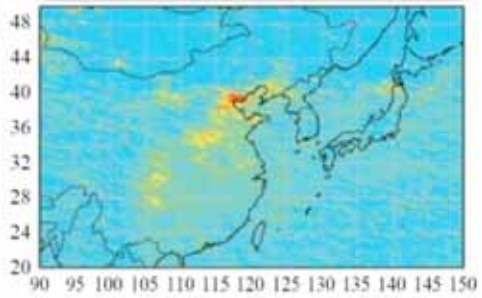
To monitor atmospheric environment and climate change

Monitoring NO_2, SO_2, O_3 , HCHO, Aerosol in East Asia – Emission/Distribution

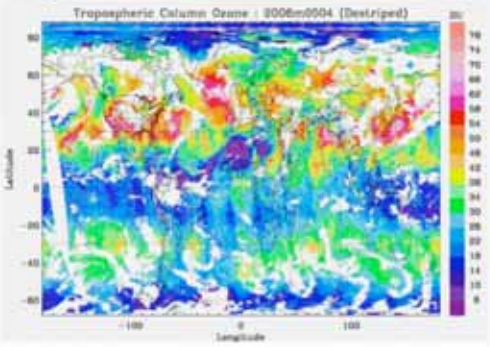
NO_2



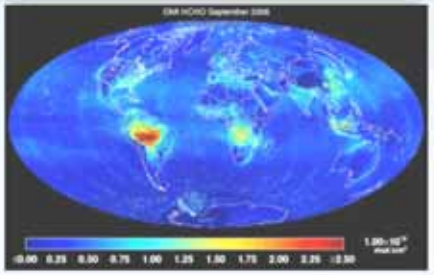
SO_2



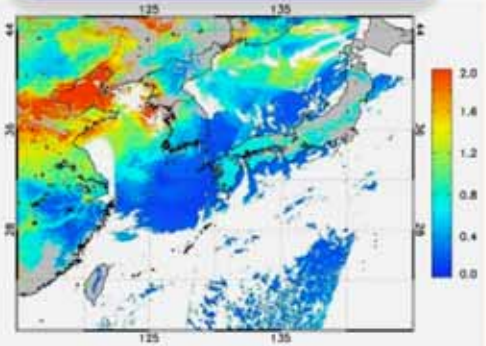
O_3



HCHO



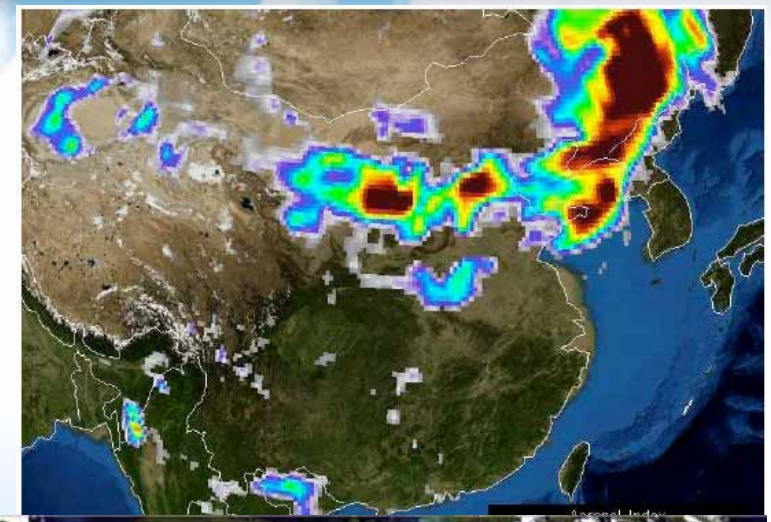
Aerosol



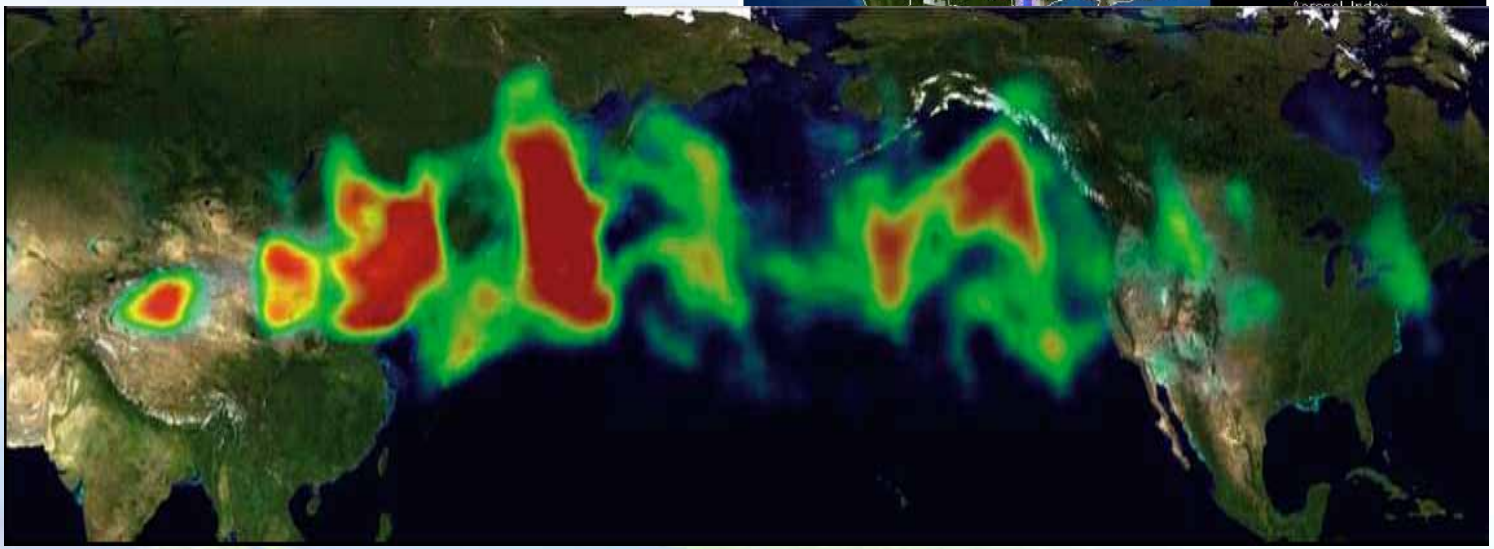
from Bhartia, Richter from OMI and SCIAMACHY

Dust detection over source region

- Aerosol Index,
  March 10, 2006



Asian Dust



Transport of Mongolian dust to N. America in April 2001.
This image was made by compositing several days of TOMS data.

(P. K. Bhartia)

Aerosols over clouds

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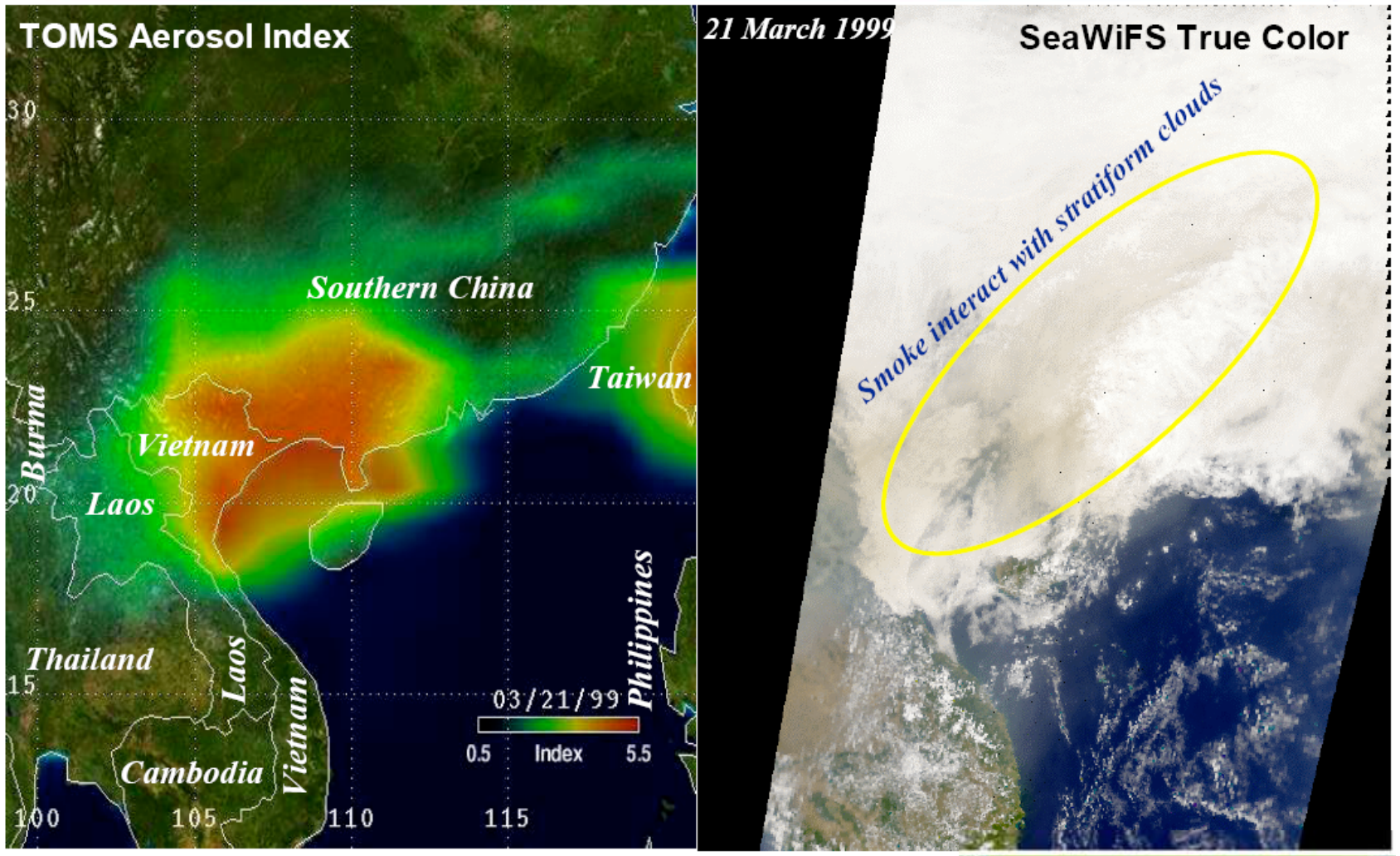
Smoke over clouds



(Bhartia)

NO_2 from SCIAMACHY and OMI

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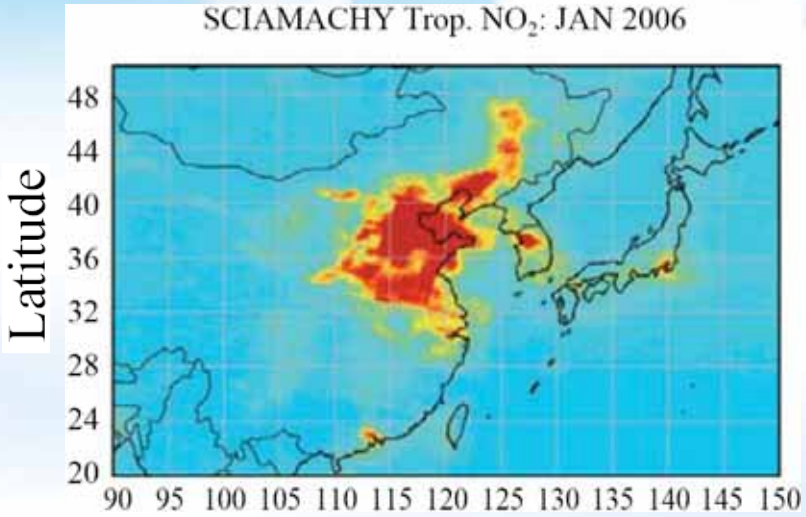
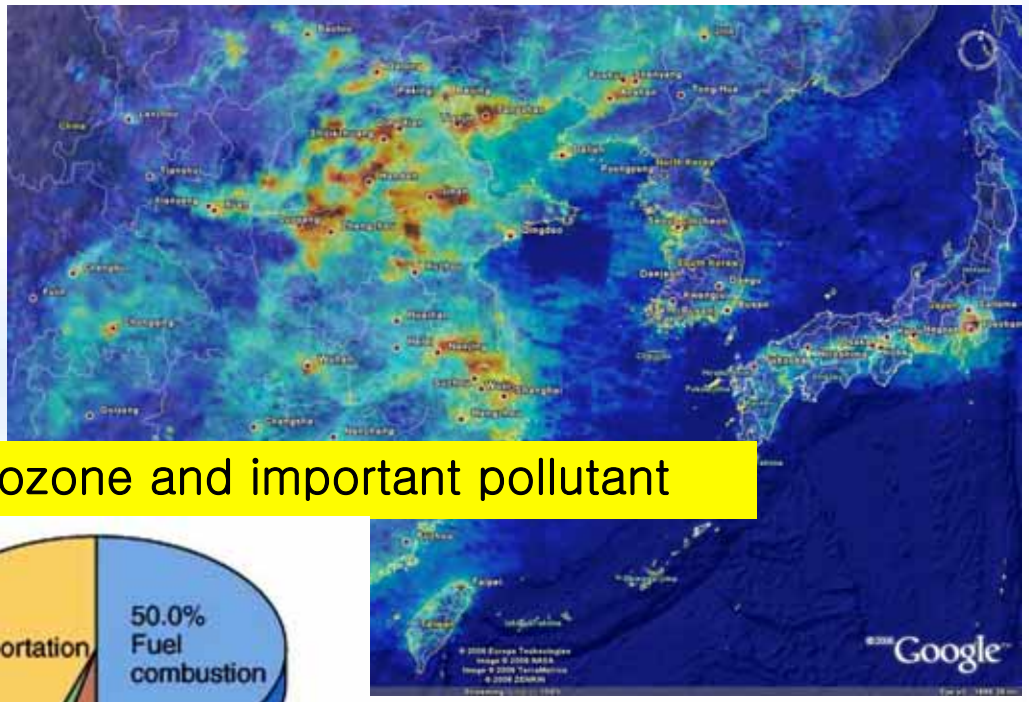
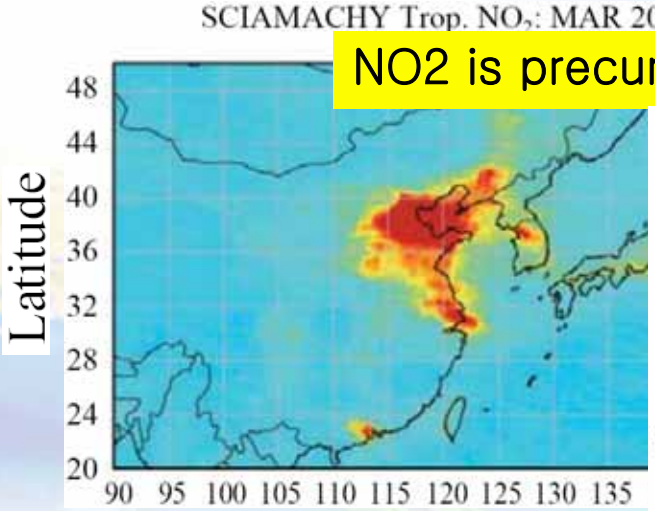
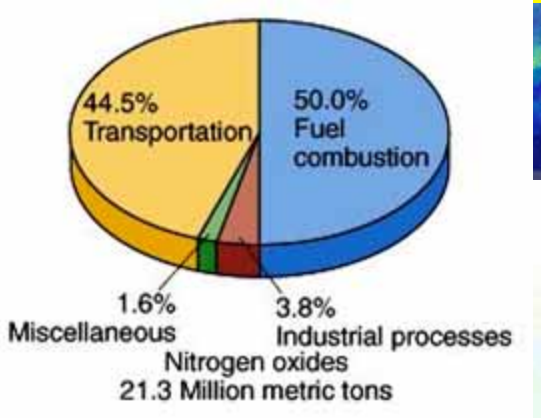
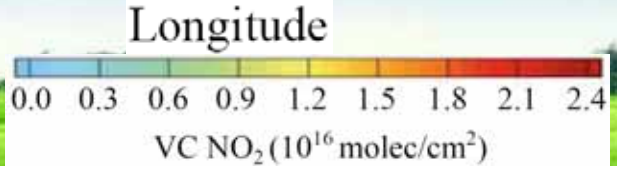






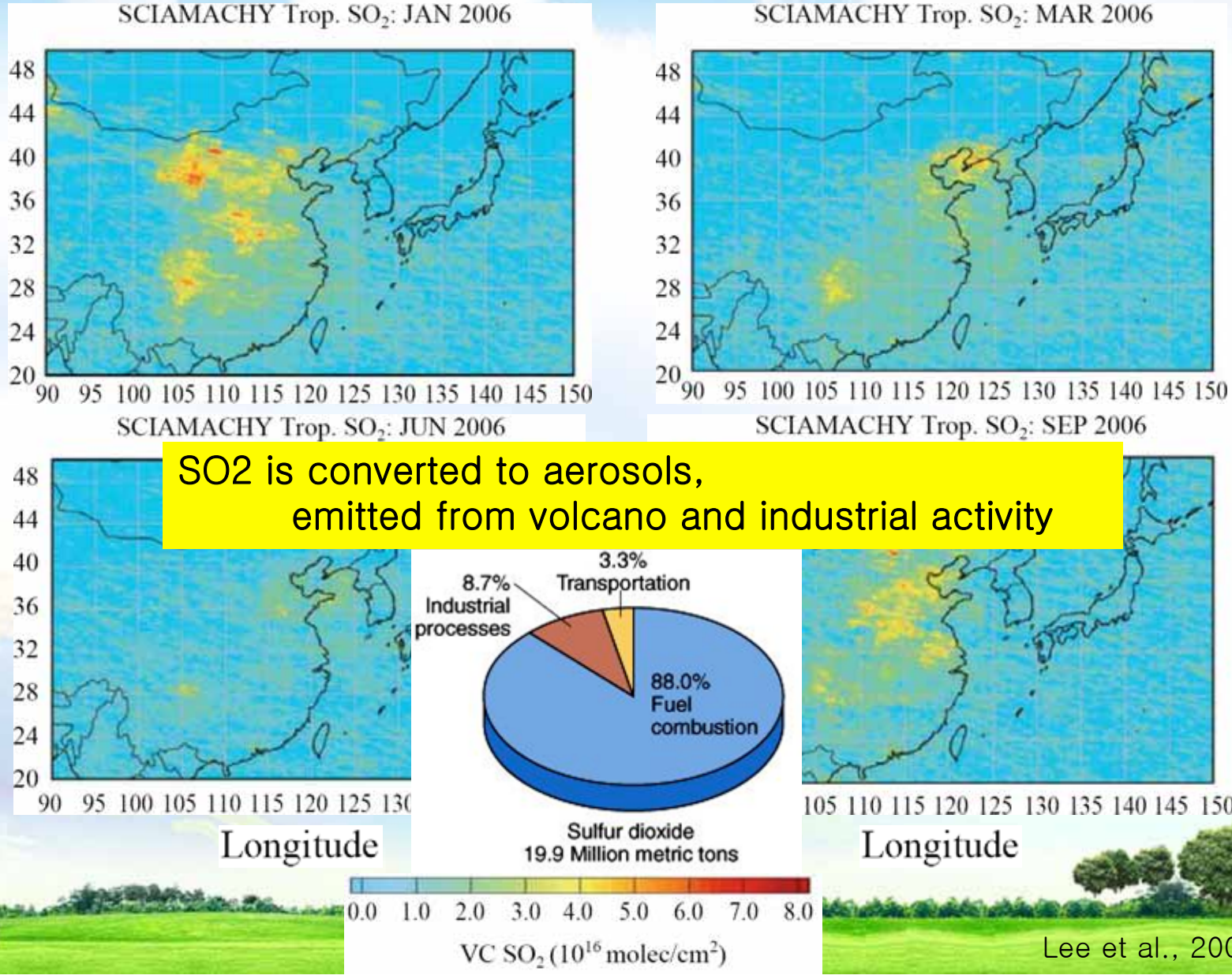
NO2 is precursor to ozone and important pollutant





Lee et al., 2008; Bhartia, 200

SO_2 from SCIAMACHY



Lee et al., 2008

SPACE-BASED MEASUREMENTS OF HCHO COLUMNS OFFER CONSTRAINTS ON VOC EMISSIONS

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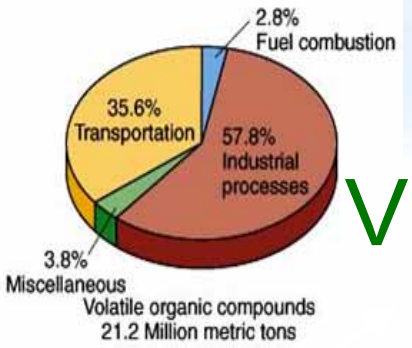
VOCs are important as
- precursors of tropospheric ozone
- precursors of organic aerosols
- sinks of OH



VOC

Oxidation (OH, O_3, NO_3)

several steps

τ_{VOCs} ~ an hour

340 nm

HCHO

hν (λ < 345 nm), OH

τ_{HCHO} ~ a few hours

Biogenic ~80

Anthropogenic ~40

Biomass burning ~12 Tg yr^{-1}

Emissions from Bottom-up inventories for East and South Asia [Fu et al., 2007]

Constraining Emission rate from satellite measurements with modelling

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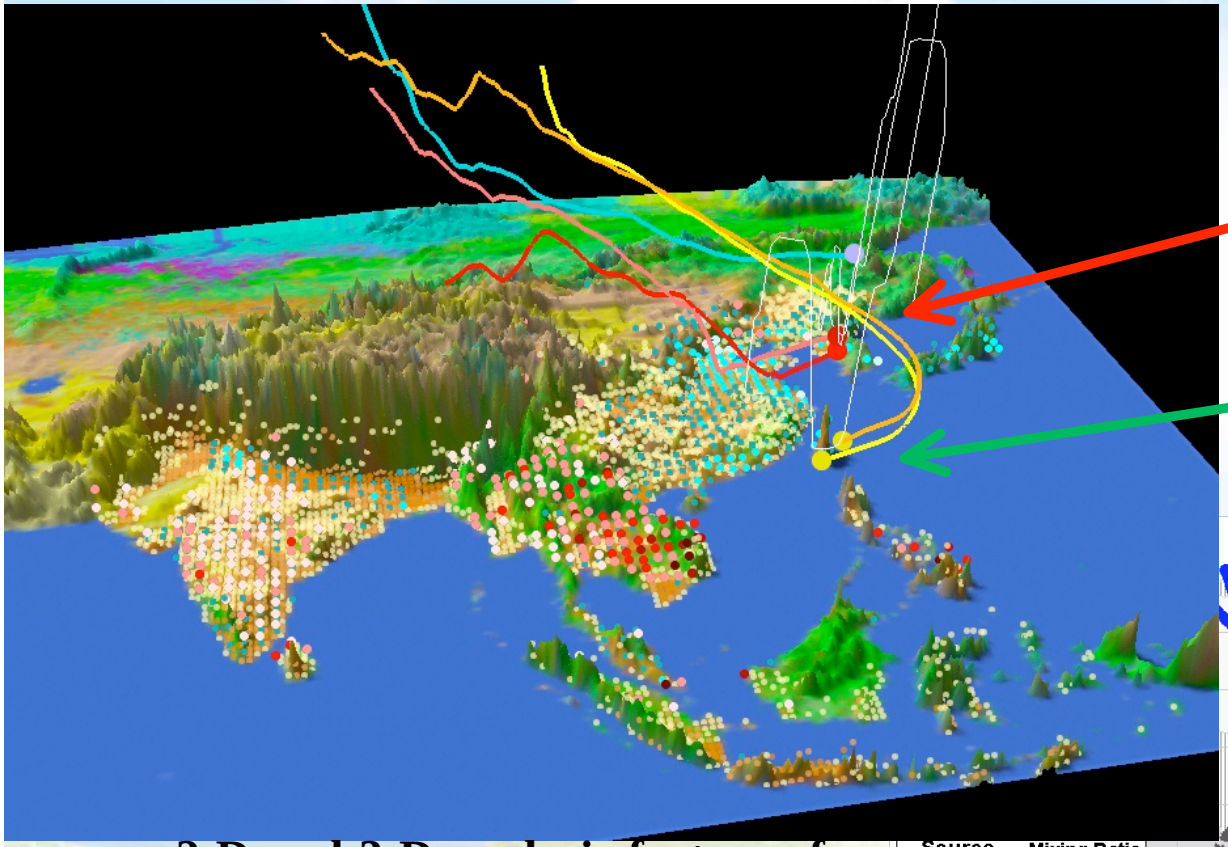
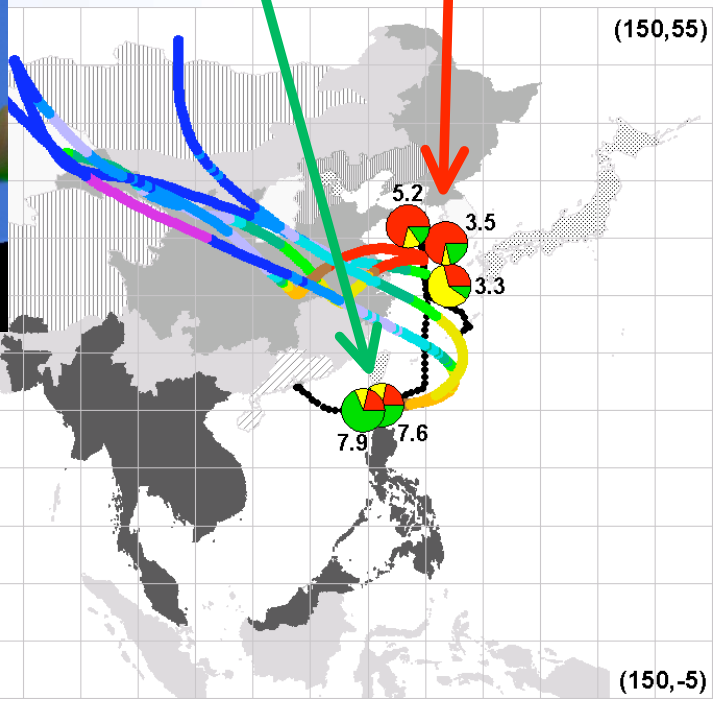
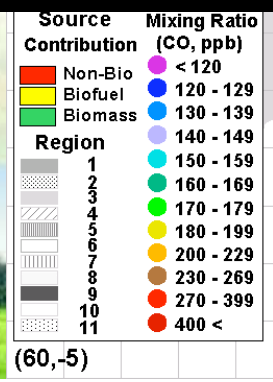


Anthropogenic e mission (fossil fu el and biomass)

Biomass bu rning



- 2-D and 3-D analysis features for DC8 flight9 (March 10th)
- Large uncertainty in emission rat es (factor of 2~5 in regional, +50% in global scale for BC, Ramanathan and Carmichael, 2008)



Environmental Payload onboard MP-GEO

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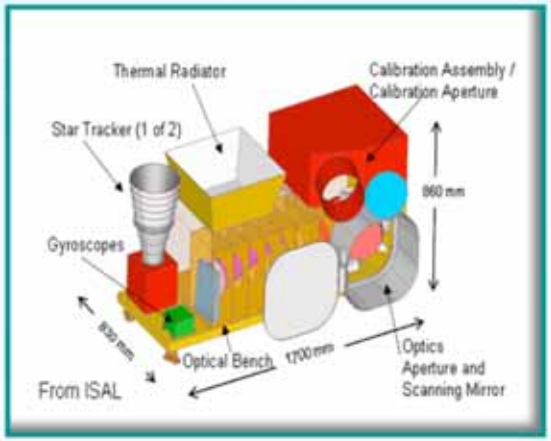
GEMS(Geostationary Environment Monitoring Spectrometer)

Scanning UV/VIS Spectrometer (SUVS)



- Heritage from OMI
- Completed technical feasibility thru NASA IIP

Spectral Range		300-500 nm (Resolution: 0.8 nm)
Spatial Resolution		5 km(N-S)×15 km(E-W)
Vertical Resolution		3~6km
Global Coverage		30 min to 1 hour
SNR		1500:1 at 430nm
Specifica-tion	Power	<100 Watts
	Weight	< 50 Kg
	Volume	0.5 x0.5x0.25 m3

(Bhartia, 2009)

Ocean Color Imager (GOCI-2)

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Spectral Bands Requirements

- 13 Bands (GOCI : 8 Bands) – can be changed later

– Phytoplankton type verification, Nighttime Observation, Enhanced Atmospheric Correction Accuracy

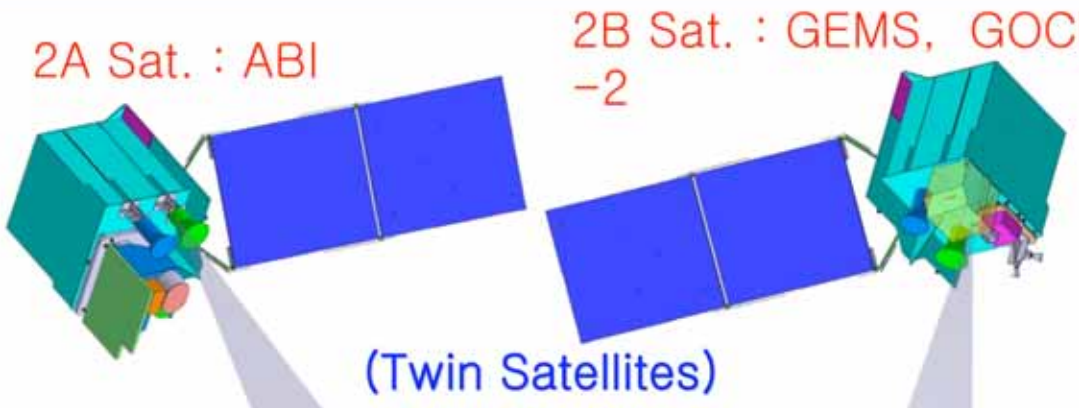
Radiance : W/m²/um/sr

Band	Heritage	Band Center	Band width	Nominal Radiance	Maximum Ocean Radiance	Saturation Radiance	Maximum Cloud Radiance	NEdL	SNR	Primary use
1	GOCI-B1	412nm	20nm	100.0	150.0	152.0	601.6	0.100	1000	Yellow substance and turbidity
2	GOCI-B2	443nm	20nm	92.5	145.8	148.0	679.1	0.085	1090	Chlorophyll absorption maximum
3	GOCI-B3	490nm	20nm	72.2	115.5	116.0	682.1	0.067	1170	Chlorophyll and other pigments
4	(KGOCI)	520nm	20nm							Red Tide
5	GOCI-B4	555nm	20nm	55.3	85.2	87.0	649.7	0.056	1070	Turbidity, suspended sediment
6	(KGOCI)	625nm	20nm							SS & Red Tide
7	GOCI-B5	660nm	10nm	32.0	58.3	61.0	589.0	0.032	1010	Baseline of fluorescence signal, Chlorophyll, suspended sediment
8	GOCI-B6	685nm	10nm	27.1	46.2	47.0	549.3	0.031	870	Atmospheric correction and fluorescence signal
9	GOCI-B7	745nm	20nm	17.7	33.0	33.0	429.8	0.020	860	Atmospheric correction and baseline of fluorescence signal
10	(KGOCI)	765nm	20nm							Aerosol Properties, Atmospheric Properties
11	GOCI-B8	865nm	40nm	12.0	23.4	24.0	343.8	0.016	750	Aerosol optical thickness, vegetation, water vapor reference over the ocean
12		905nm	40nm							Atmospheric Properties, Cloud Properties
13		650nm	500nm	6.5E-6						Night Band (Night time fishing boat activities)

(Ahn, Yu Hwan)

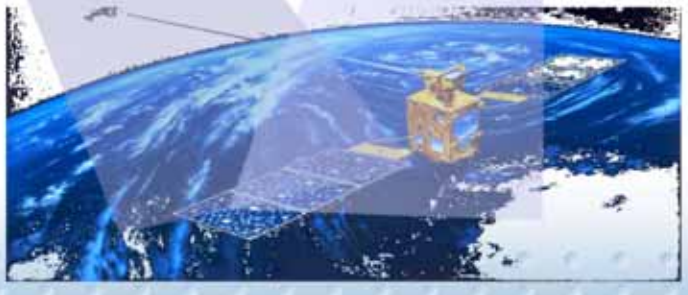
Master Schedule of MP-GEO SAT

MP-GEO SAT Configuration



- **GEMS and GOCI-2 now have more volume and mass budget**
  - **Can increase capability in spatial resolution or spectral coverage**

- **Mission : Air Pollution Monitoring**
  Meteorological observation
  Ocean Color monitoring
- **Mass : Dry mass 1280.9 kg**
  Launch mass 2640 kg
- **Power : In-orbit 1500 W, Transfer orbit 1100 W**
- **Mission Life : 10 years**



Satellite Orbit Options

	LEO	GEO
Altitude	< 1000 km	> 36000 km
Time Resolution	Several to 24 hrs	Up to minutes
Spatial coverage	Global	60S- 60N (lat.), ~120˚ in longitude
Viewing Options	Nadir, Limb, Occultation	Nadir only
Techniques	Multispectral, multi-angle, polarization, stereo-viewing	Multi-spectral only

Global Environmental Monitoring

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Constellation of GEO Mission to study Air Quality

GEO-CAPE
(America)

EPA

NASA

MP-GEO
(Asia Pacific)

KARI

ME

esa

GMES
(Europe)

Constellation synergy
- Improving spatial and temporal coverage
- Monitoring globalized pollutants
- sharing data and science
- supporting QA and CAL/VAL of instruments

Status of MP-GEO SAT

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- **Global Environmental Satellite Program Office**
  - To be established in June, 2009 by ME
  - First phase funding started for requirements of science and instrument, algorithm development strategy, and evaluation of social benefit
  - Research Center established at Yonsei University, in March, 2009
- **Collaboration discussed at Korea(MEST)-U.S.A.(NASA) Bilateral Meeting**
  - Delegation from NASA on April 21-22, 2009, at KARI, Daejon, Korea
  - "Satellites and instruments of mutual benefit" for innovative observations of the global integrated Earth system, including:

    - geostationary satellite: air quality and ocean color observation
  - Recommended to establish joint KARI-NASA working group (WG)
  - NASA offers to host inaugural meeting of WG in United States
- **Currently under Preliminary Investigation of Financial Budget**
  - Mar. – Jul., 2009; Ministry of Strategy and Finance

Summary

- **Suggest constellation of GEO AQ monitoring mission in global scale with collaboration in :**
  - defining requirements of science and instruments
  - data processing and sciences
  - quality assurance of similar instruments including calibration and validation
  - cross participation of researchers

- **Flight opportunities in GEO over Asian region :**
  - KARI provide spacecraft with launch service
  - KARI and ME are responsible for the GEMS payload,
  - and/or NASA/ESA provide support for the payload
  - including science, consulting, quality assurance
  - (participating in reviews), and possibly contributing subsystem

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THANK YOU

Collaboration among Asia, Europe and U.S.

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