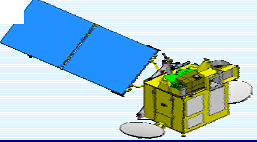
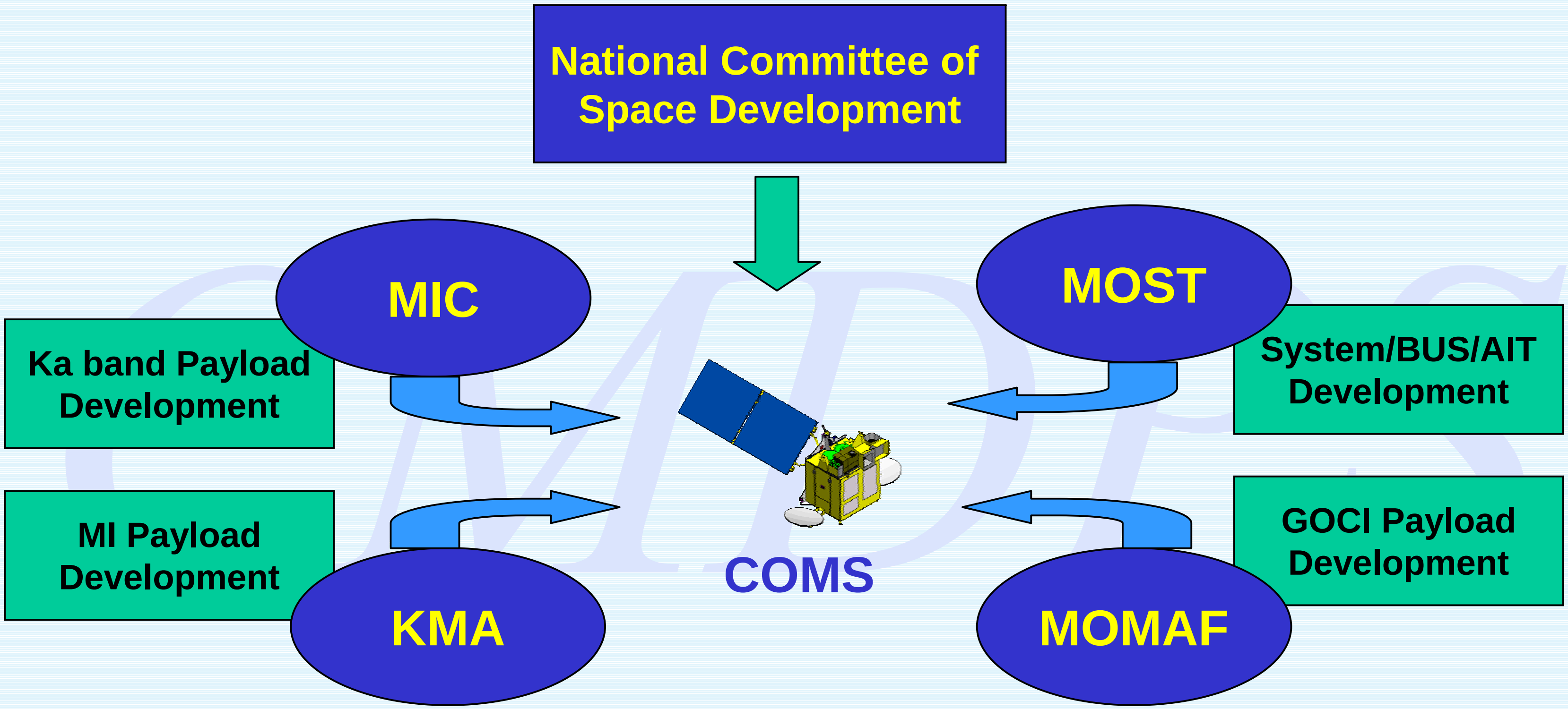


Introduction to the COMS Program and Development of COMS Meteorological Data Processing System

Hyo-Sang Chung/KMA

2005. 07. 12

Governmental Support for COMS



- MOST : Ministry of Science and Technology
- MIC : Ministry of Information and Communication
- MOMAF : Ministry of Maritime Affairs and Fisheries
- KMA : Korea Meteorological Administration

Mission Objectives of COMS

Satellite Communication Mission

- In-orbit verification of developed communication technologies
- Experiment of wide-band multi-media communication service

Ocean Monitoring Mission

- Monitoring of marine environments around the Korean peninsula
- Production of fishery information (Chlorophyll, etc.)
- Monitoring of long-term/short-term change of marine ecosystem

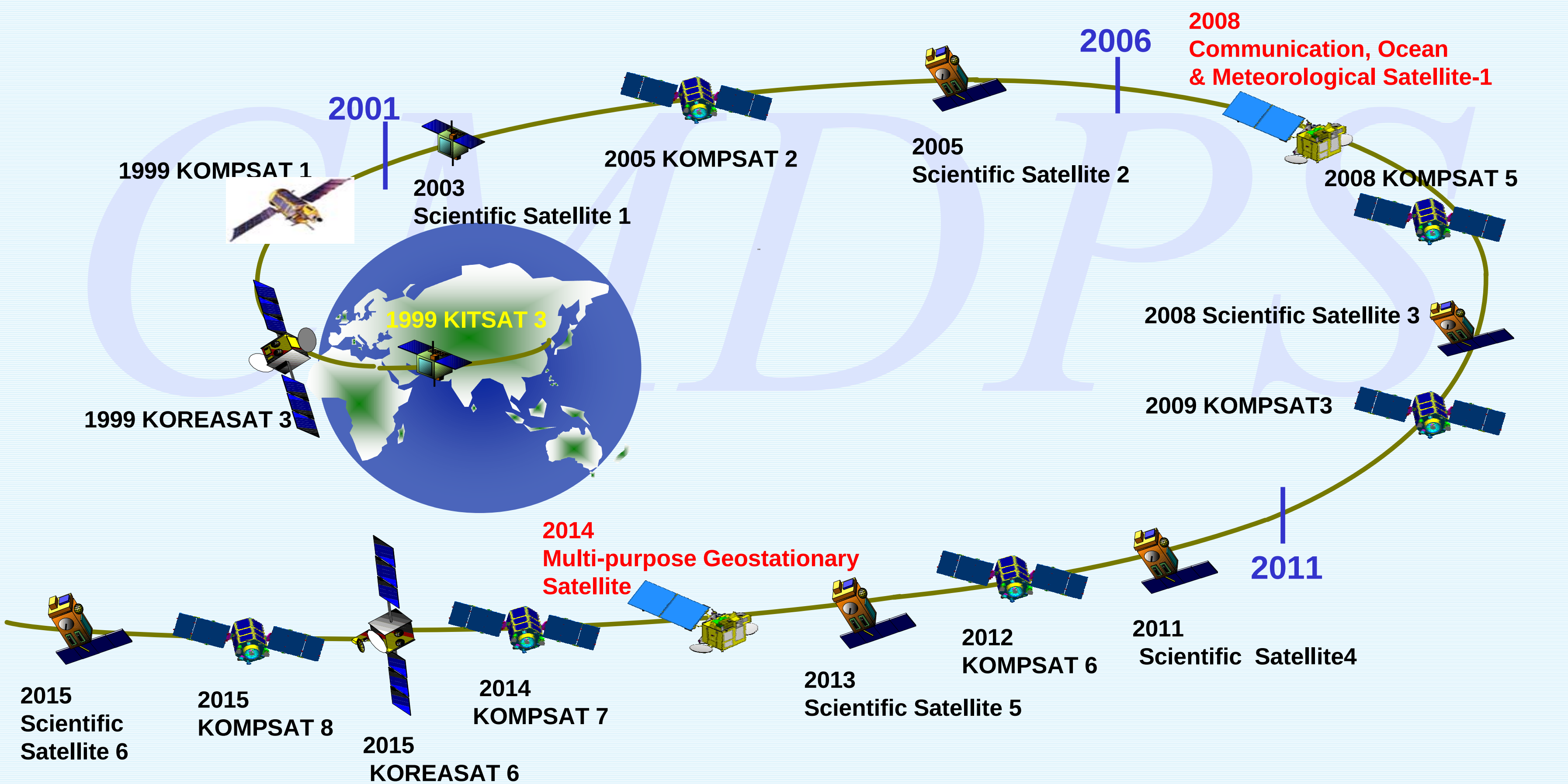
Weather Monitoring Mission

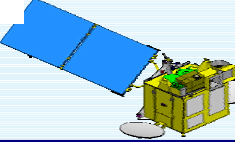
- Continuous monitoring of imagery and extracting of meteorological products with high-resolution and multi-spectral imager
- Early detection of special weather such as storm, flood, yellow sand
- Monitoring of long-term change of sea surface temperature and cloud

COMS in Space Dev.

❑ COMS Program

➢The only geostationary satellite program in the "National Plans for Long Term Plan for Space Development of South Korea ('05.02)"





Milestones for the COMS Program

Timeline (years 1995–2009):

- Data Service
- Launch (2009)
- Pre Ship Review
- Mission Readiness Review
- Critical Design Review
- Preliminary Design Review
- System Design Review
- 2003.9 COMS Project Kick-off
- 2002.4 Preliminary work for COMS
- 2001.4 Feasibility study for COMS
- 2000.12 National Plan for Long-term Space Development
- 2000.8 Meteorological Satellite Forum
- 2000.3 "Project for Centennial Meteorological Events"
- 1997.11 "Research on the Korean Meteorological Satellite"
- 1995.8 STEPI "Meteorological Sensors for Satellite" (Science & Technology Policy Institute)

Year
2009
2008
2007
2006
2005
2004
2003
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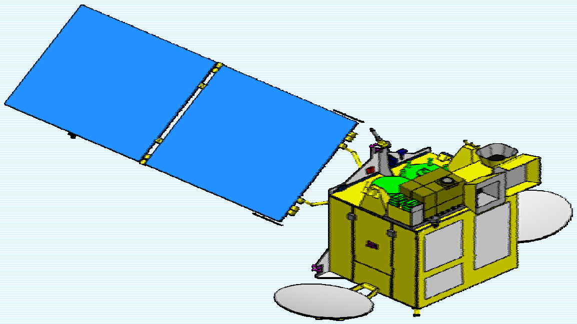
1995



COMS Mission-1

✓ Requirement of Ka-band Payload(TBC)

Frequency (Ka-band)	**Uplink : 29.6 ~ 30.0GHz Downlink : 19.6 ~ 20.3GHz**
Minimum EIRP edge of coverage	**58dBW**
G/T	**13dB/°K**
Bandwidth	**400MHz(100MHz/channel)**
Beamwidth	**0.6degree/each beam**
Coverage	**Refer to right figure**

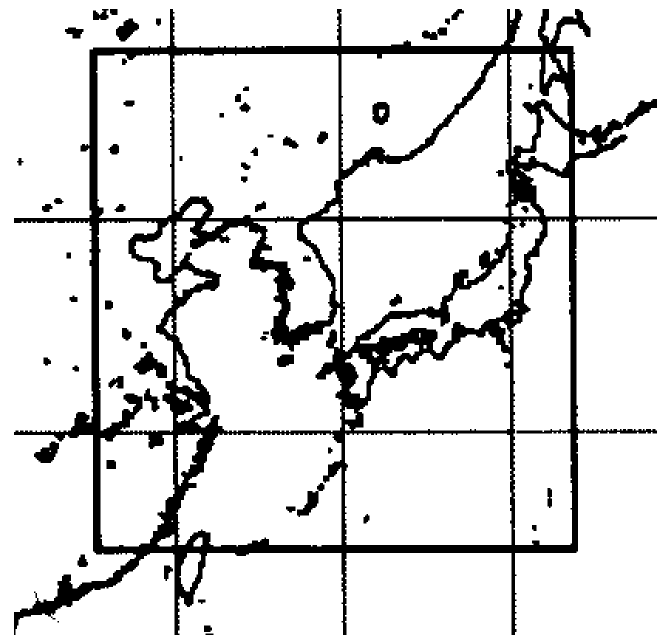
✓ Ka-band Service Coverage

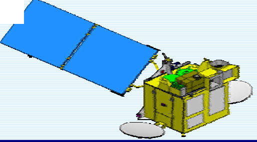
COMS Mission-2

Requirement of Ocean Sensor(TBC)

Item	Requirements					
Spatial Resolution	500m X 500m					
Coverage	2,500km X 2,500km					
No. of Band	8 fixed band					
Band Center & Band Width & Nominal Rad.& Max Rad. & NEdL & SNR (Sensitivity of sensor)	Band Center [nm]	Band Width [nm]	Nom. Rad [Wm^{-2} $um^{-1}sr^{-1}$]	Max. Rad. [Wm^{-2} $um^{1}sr^{-1}$]	NEdL	SNR
	412	20	100	150.0	0.100	1000
	443	20	92.5	145.8	0.085	1090
	490	20	72.2	115.5	0.067	1170
	555	20	55.3	85.2	0.056	1070
	625	20	32.0	58.3	0.032	1010
	670	20	27.1	46.2	0.031	870
	765	40	17.7	33.0	0.020	860
	865	40	12.0	23.4	0.016	750
MTF	≥ 0.3 at Nyquist frequency					
Dynamic Range	≥ 11bit					
Sensor Calibration	- Calibration type : Solar Calibration - Accuracy of Radiometric Calibration : ≤ 3%					
Number of observation	- Total : 8 times · 10:00 ~ 17:00 : 6 times, · 22:00, 02:00 : 2 times					

- Ocean Sensor Coverage



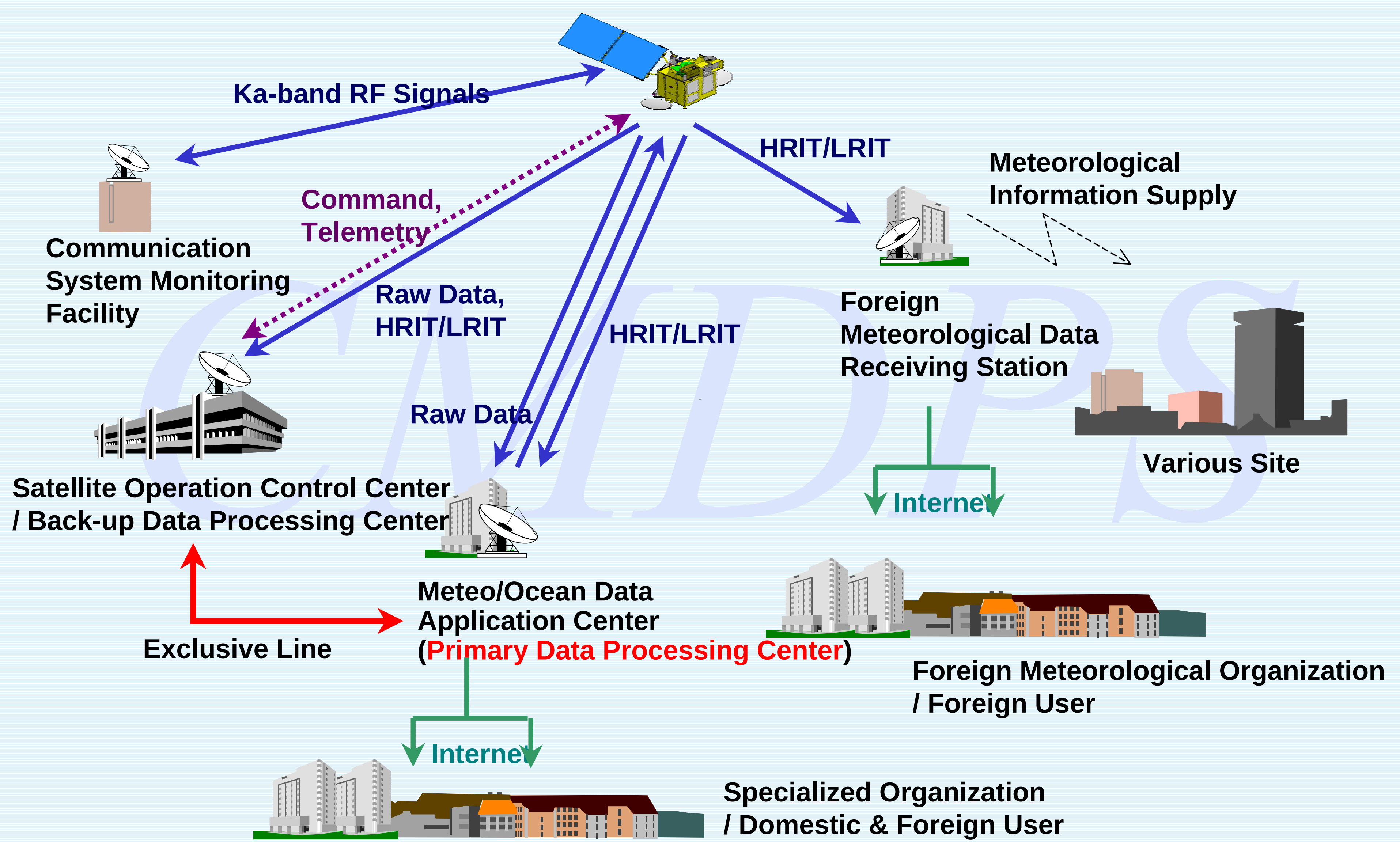


COMS Mission-3

- Meteorology
  - ✓Continuous monitoring of weather events with multi-channel Imager
  - ✓Early detection of sever weather such as tropical cyclones, heavy rainfall, dust out break, etc.
  - ✓Long term data acquisition for climate study
- Channels

Channel	Spectral band( )	Application
VIS	0.675	Daytime cloud imagery Detection of special event (yellow dust, fire, haze, etc.), Atmospheric motion vector
SWIR	3.75	Nighttime fog/stratus, Fire detection, Surface temperature
WV	6.75	Upper atmospheric water vapor, Upper atmospheric motion vector
WIN1	10.8	Standard IR split window channel (cloud, Sea surface temperature, Yellow sand detection)
WIN2	12.0	Standard IR split window channel (cloud, Sea surface temperature, Yellow sand detection)

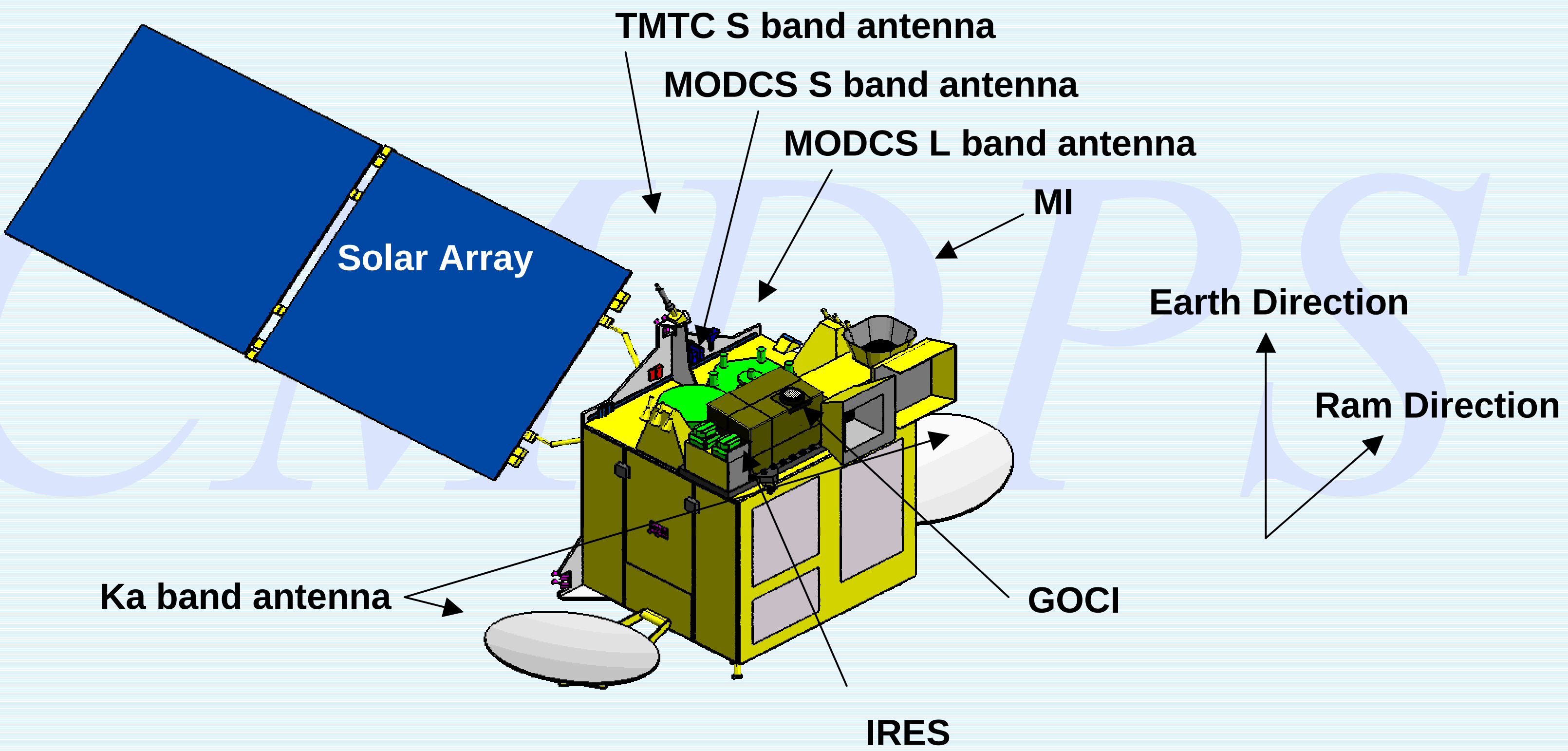
COMS System Architecture



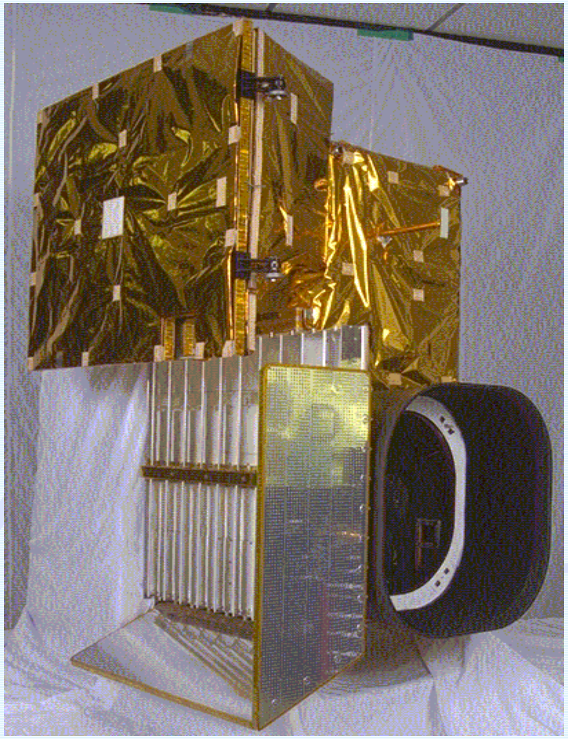
Major Milestones for COMS Develop.

- **Contract with EADS Astrium as a prime contractor: April 2005**
- **Kickoff Meeting at Astrium: 18-19 May 2005**
- **System Requirement Review: 13-14 June 2005**
- **System Design Review: 8-9 August 2005**
- **Preliminary Design Review: End of November 2005**
- **Critical Design Review: March 2007**
- **Launch: End of 2008**

COMS Satellite Overall Configuration

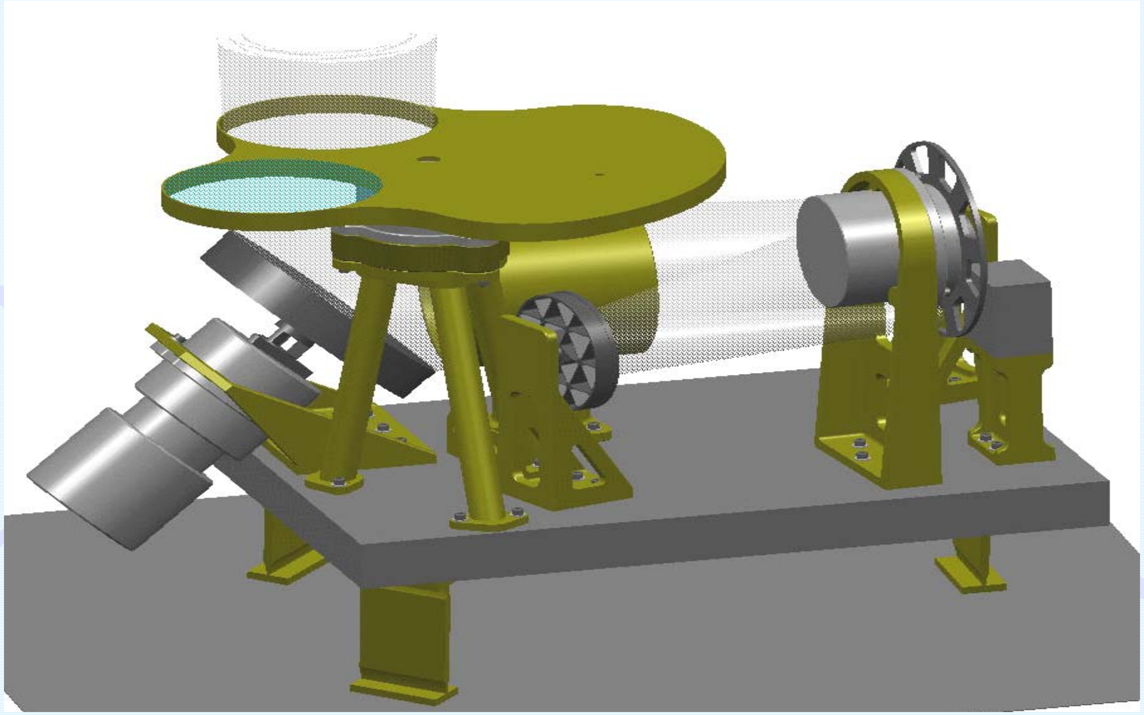


Meteorological Imager(MI)



5 channel MI will be provided from ITT

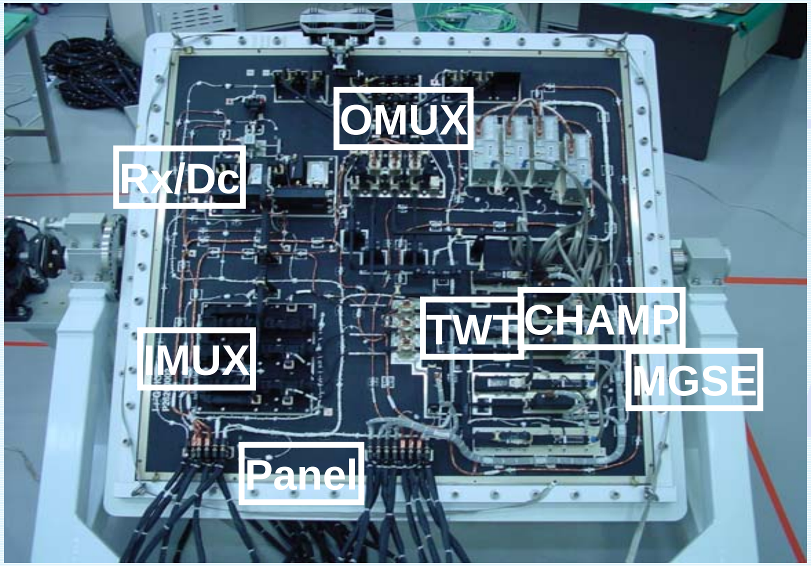
Geostationary Ocean Color Imager(GOCI)



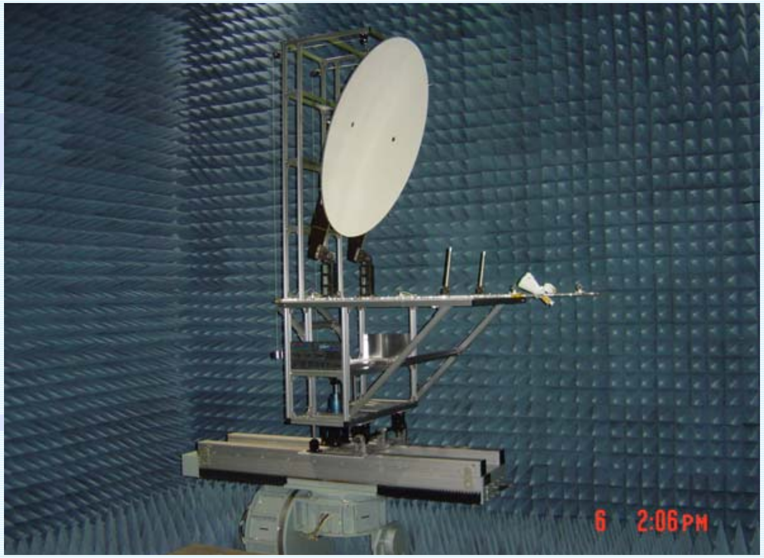
GOCI will be the first Geostationary Ocean Color Imager

and will be manufactured by EADS Astrium

Ka band Communication Payload

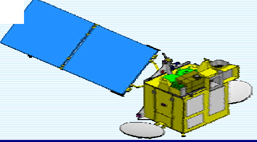


Ka band Transponder



Ka Band Antenna

Communication payload is under development by ETRI(Korea)



System Requirements (1)

Satellite Lifetime

- **Operational Life > 7 years from the end of IOT period**
- **Design Life > 10 years**

Spacecraft Stabilization

- **3-axis Stabilized Spacecraft for monitoring any regions at any time**

Reliability

- **> 0.75 for Meteorological and Ocean Monitoring Mission at End of Life**
- **> 0.85 for Communication Payload based on 12 years Design Life**

Launch Vehicle Compatibility

- **Compatible with Ariane, Delta, Atlas, Proton, H-IIA, Sea-Launch, etc.**
- **Compatible with the Launch vehicle Mission Profiles and Sequences**

System Requirements (2)

Orbital Location

- Geosynchronous Orbit at 116.2E or 128.2E
- Location will be finalized after the approval from ITU

Stationkeeping Accuracy

- ± 0.05 ° in longitude and latitude of the nominal orbit location

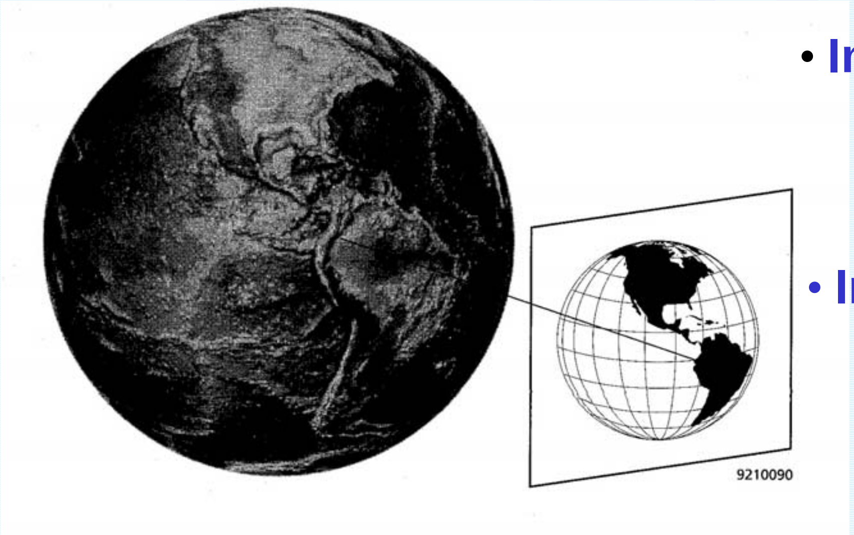
Image Navigation and Registration (Imager)

- Image Navigation Error within an Image < 56 μrad (2km)
- Image Registration
  : Within-frame Registration < 42 μrad (1.5km)
  : 15min Frame-to-Frame Registration < 28 μrad (1km)
  : 90min Frame-to-Frame Registration < 42 μrad (1.5km)
  : 24hours Frame-to-Frame Registration < 112 μrad (4km)
- Band-to-Band Co-registration
  : Visible/IR < 50 μrad , IR/IR < 28 μrad

System Requirements (3)

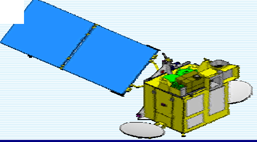
Image Navigation and Registration (Ocean Color Imager)

- **Image Navigation Error within an Image < 28 μrad (1km)**
- **Image Registration**
  : Within-frame Registration < 28 μrad (1km)
  : Frame-to-Frame Registration < 28 μrad (1km)
- **Band-to-Band Co-registration**
  : Visible/Visible < 7μrad



- **Image Navigation**
  : determining the location of any pixel within an Image in terms of Earth longitude and latitude

- **Image Registration**
  : keeping any pixel within an Image pointed to its nominal Earth location within specified accuracy



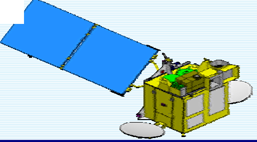
System Requirements (4)

Mode of Operation

- **Stationkeeping Mode**
  - **: Stationkeeping Frequency shall be determined for the minimal Impact to the Payload Operation**
  - **: Stationkeeping Maneuver and INR Performance Recovery < 60min.**
- **Housekeeping Mode**
  - **: 2 times per day with a Maximum Duration of 10 min.**
- **Safe-Hold Mode**
  - **: Ensure the Safety of the Satellite under an anomalous condition**
  - **: Via Ground Command or By the On-board Computer**
- **End-of-Life Mode**
  - **: Move the Spacecraft to 150km above the GEO. Orbit at End of Life**

Transfer Orbit Operation

- **Arrive at the Target Orbit within 30days after Separation from Launch Veh.**
- **6 months IOT to verify the Performance of the Spacecraft and Payloads**



System Requirements (5)

Simultaneous Operation of Multiple Payloads

- MI, GOCI and Comm. Payloads shall be Operable Simultaneously
- Not Induce any Interference or Performance Degradation

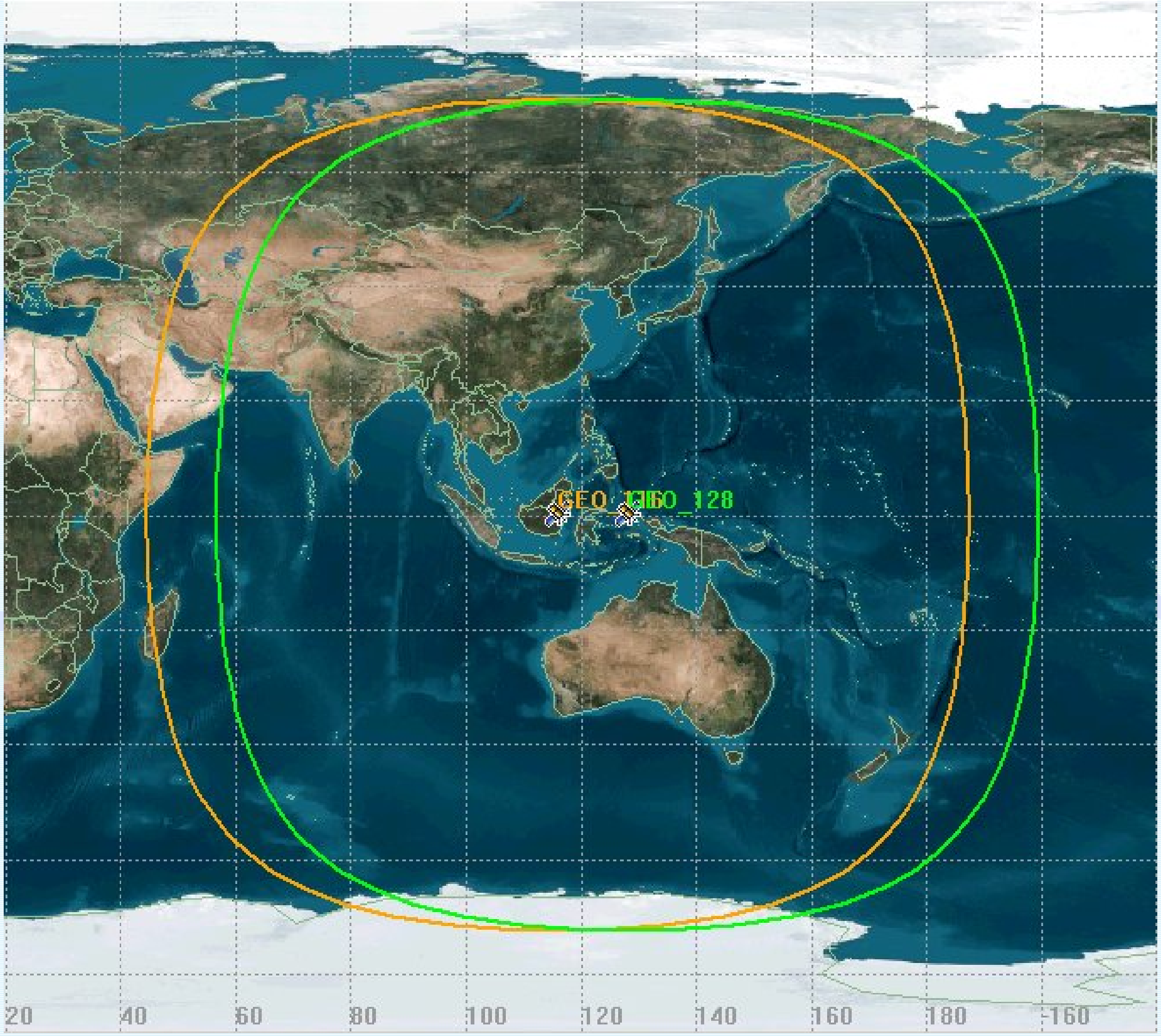
Processed Meteorological Data

- Data Format : HRIT(High Rate Information Transmission), LRIT
- Delivery Timeliness : within 15min. after the End of Image Acquisition

Space-to-Ground Interface

- Polarization
  : Telemetry & Command (CP), Raw and Processed Data (LP)
- Modulation
  : Telemetry & Command – PCM/BPSK/PM
  : Raw Data – PCM/QPSK
  : Processed Data – PCM/BPSK
- Bit Error Rate (BER)
  : Telemetry & Command – 10^{-6}, Raw and Processed Data – 10^{-8}

Processed Data Distribution Coverage



COMS Frequency Registration

ITU Registration Orbit : 116.2 °E, 128.2°E

ITU Registration Frequency Band

- **For Ocean and Meteorological Service and Satellite Operation**
  : 1,670 ~ 1,710 MHz(L-Band): Sensor Data & Processed Data Downlink
  : 2,025 ~ 2,110 MHz(S-Band): Processed Data & Command Uplink
  : 2,200 ~ 2,290 MHz(S-Band): Telemetry Downlink

- **For Communication Service**
  : 27.5 ~ 30.8 GHz: Ka-Band Uplink
  : 18.3 ~ 20.7 GHz: Ka-Band Downlink

Case Analyses

- July 31,1998 Shoonchun 187mm/day

  Mt. Jiri's Heavy rainfall

- July 15, 2001 Seoul 273.4mm/day

  Seoul/Kyungki Prov.

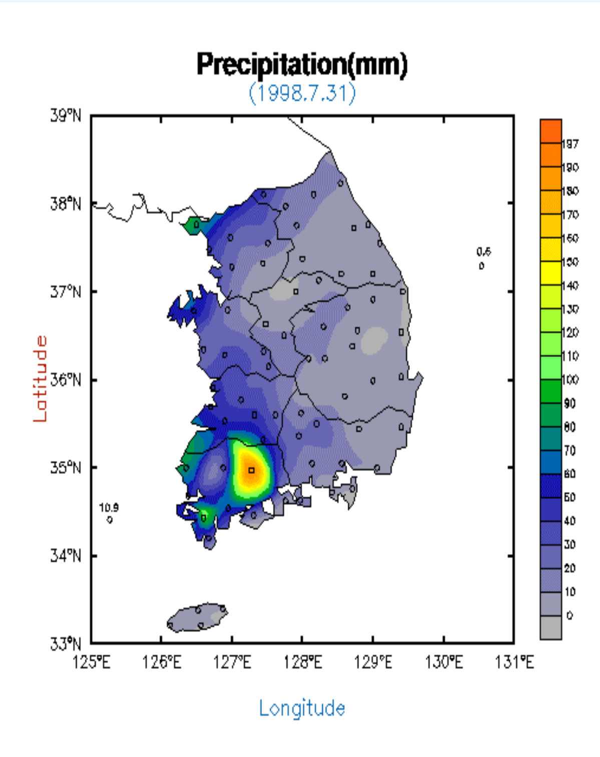
  Heavy Rainfall

- Aug. 31, 2002 Kangnung 870.5mm/day

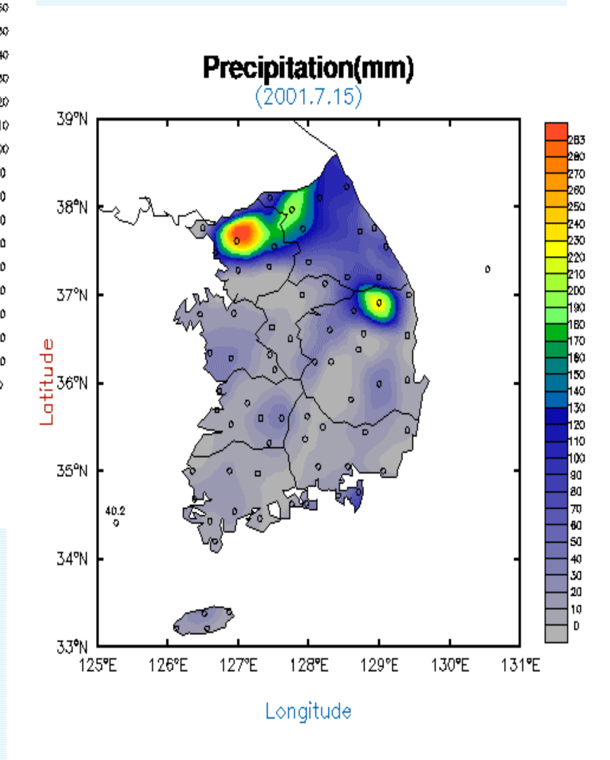
  TY Rusa's Heavy Rainfall

The Distributions of Daily Rainfall

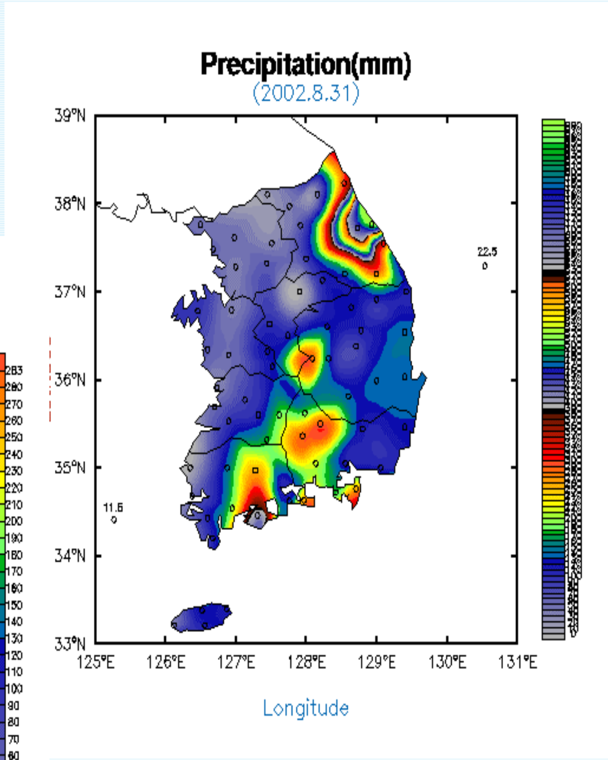
Mt. Jiri Heavy Rainfall



Seoul/Kuingki Prov

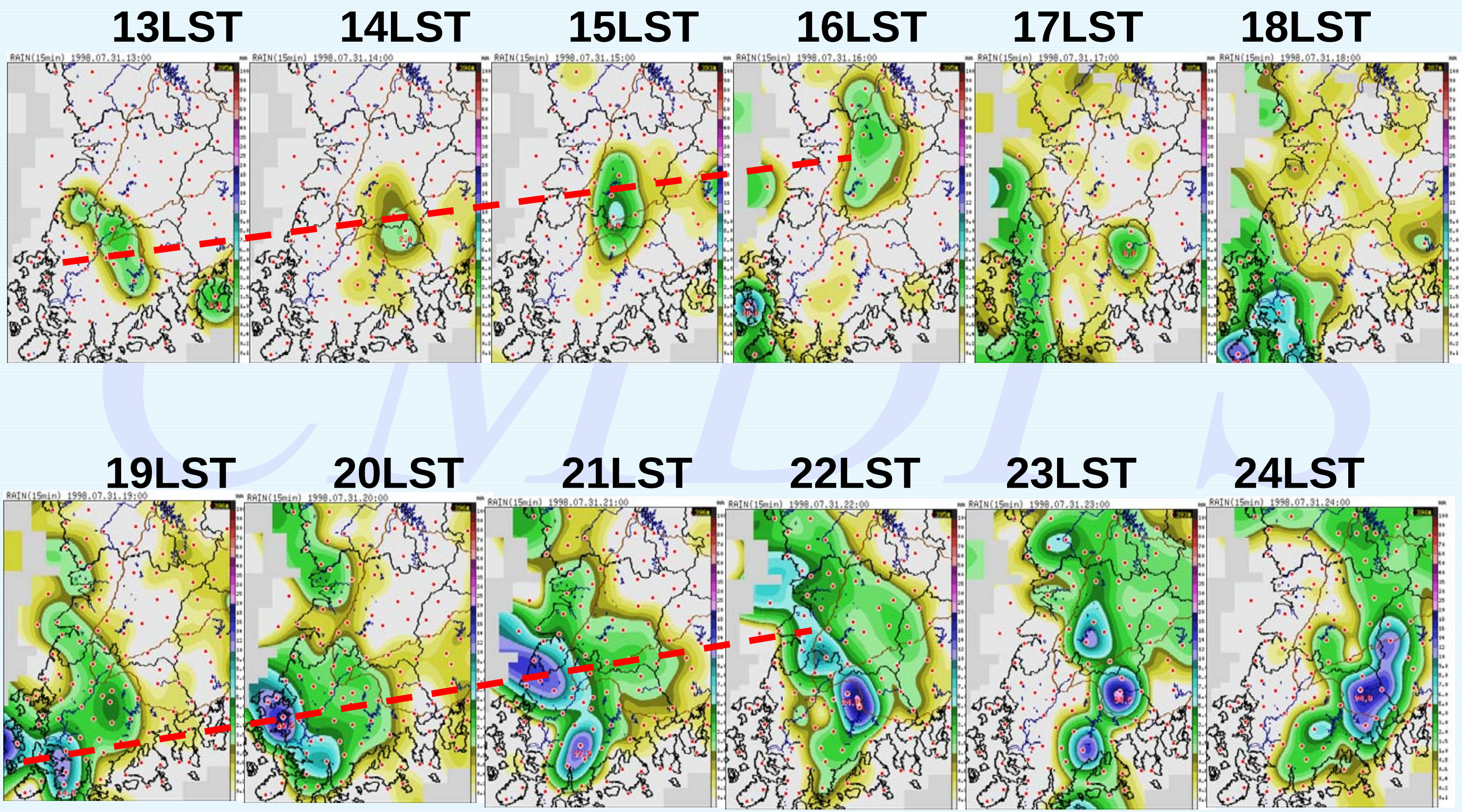


TY Rusa Heavy Rainfall



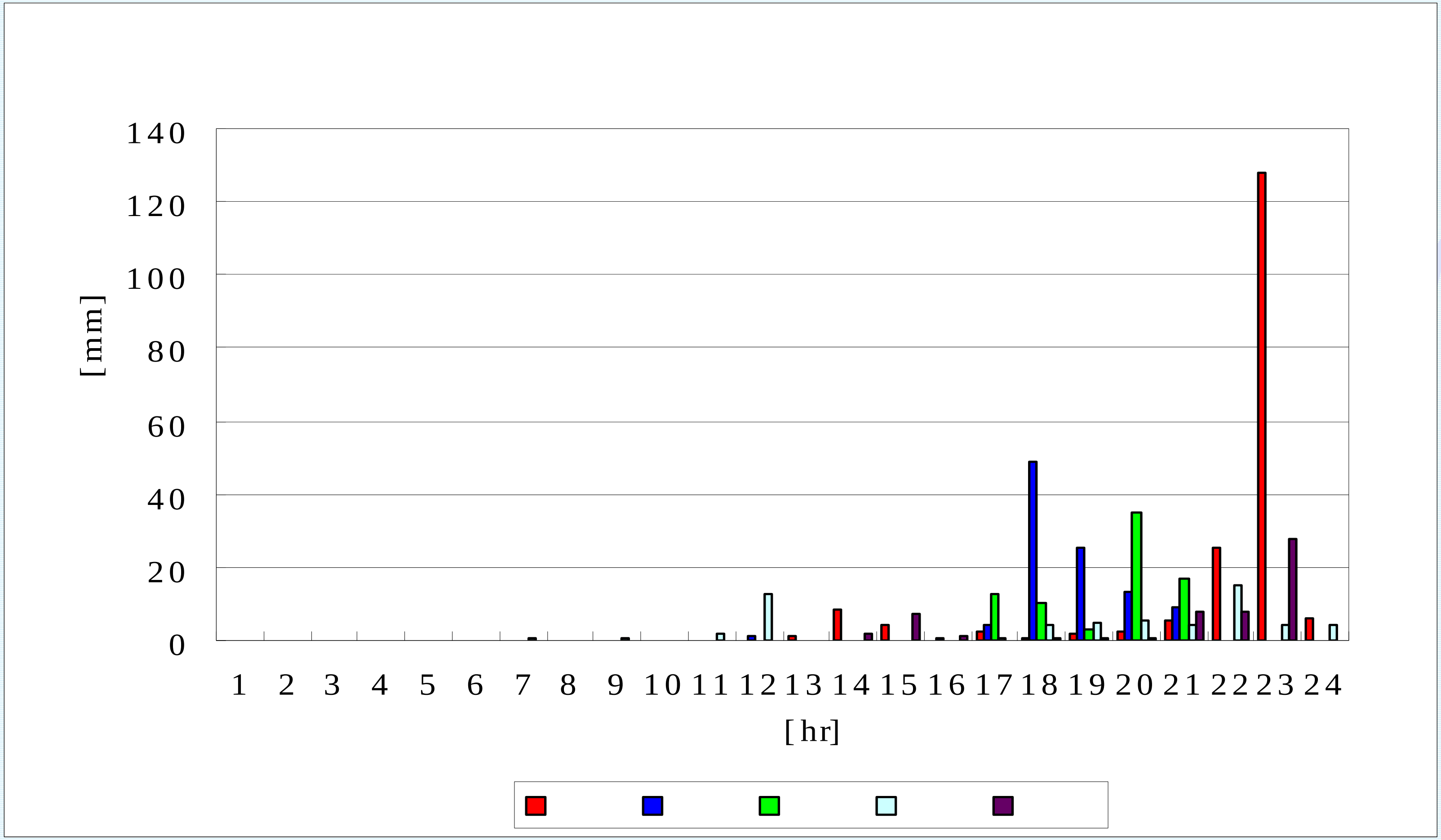
Distribution of Hourly Rainfall

- Mt. Jiri Heavy Rainfall



Hourly Rainfall Intensity

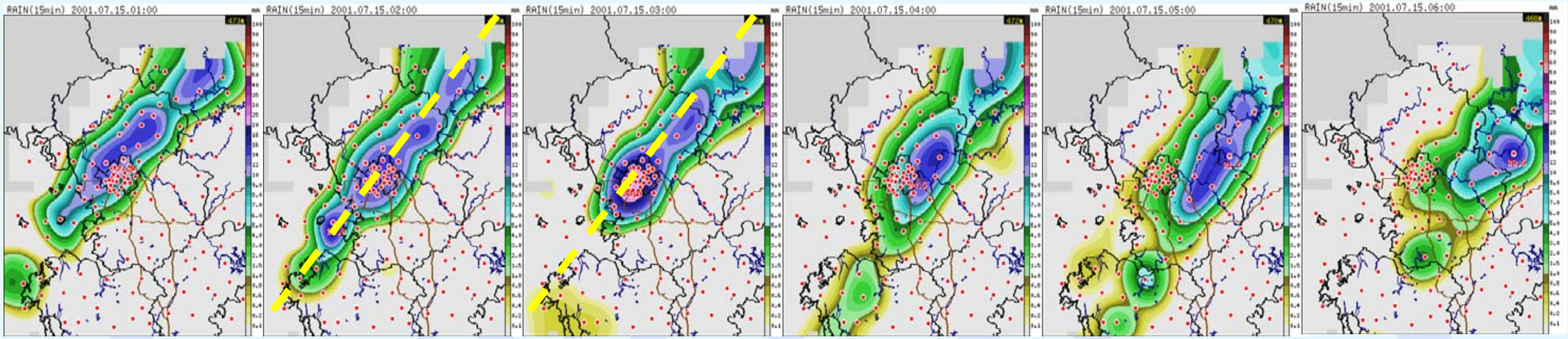
- Mt. Jiri's Heavy rainfall



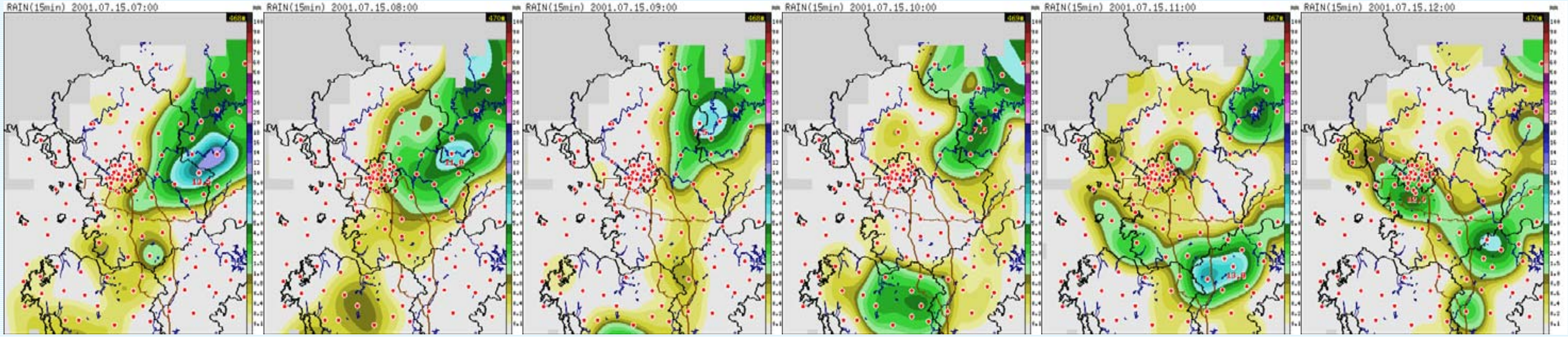
Distribution of Hourly Rainfall

- Seoul/Kyungki Prov. Heavy Rainfall

01LST 02LST 03LST 04LST 05LST 06LST



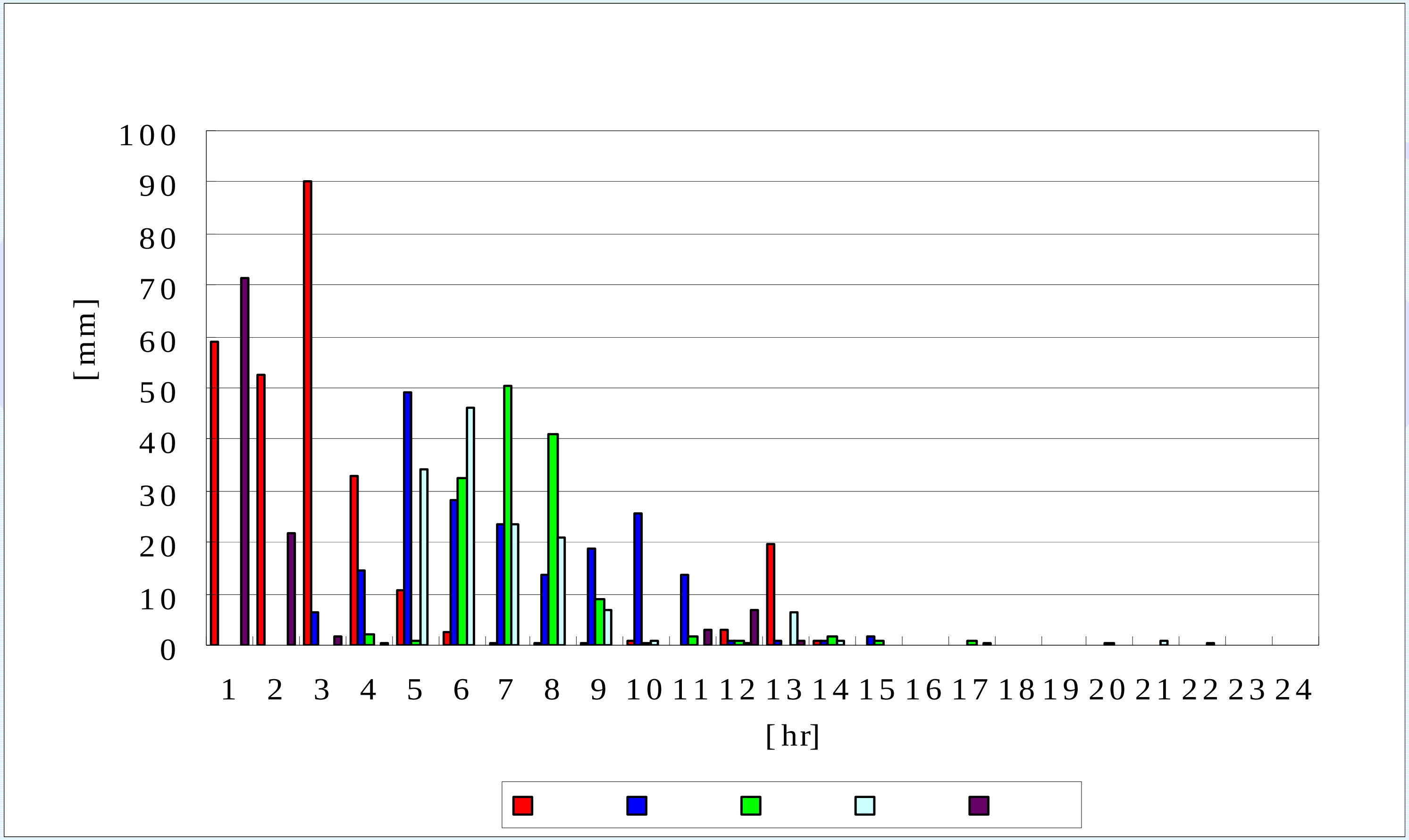
07LST 08LST 09LST 10LST 11LST 12LST



Hourly Rainfall Intensity

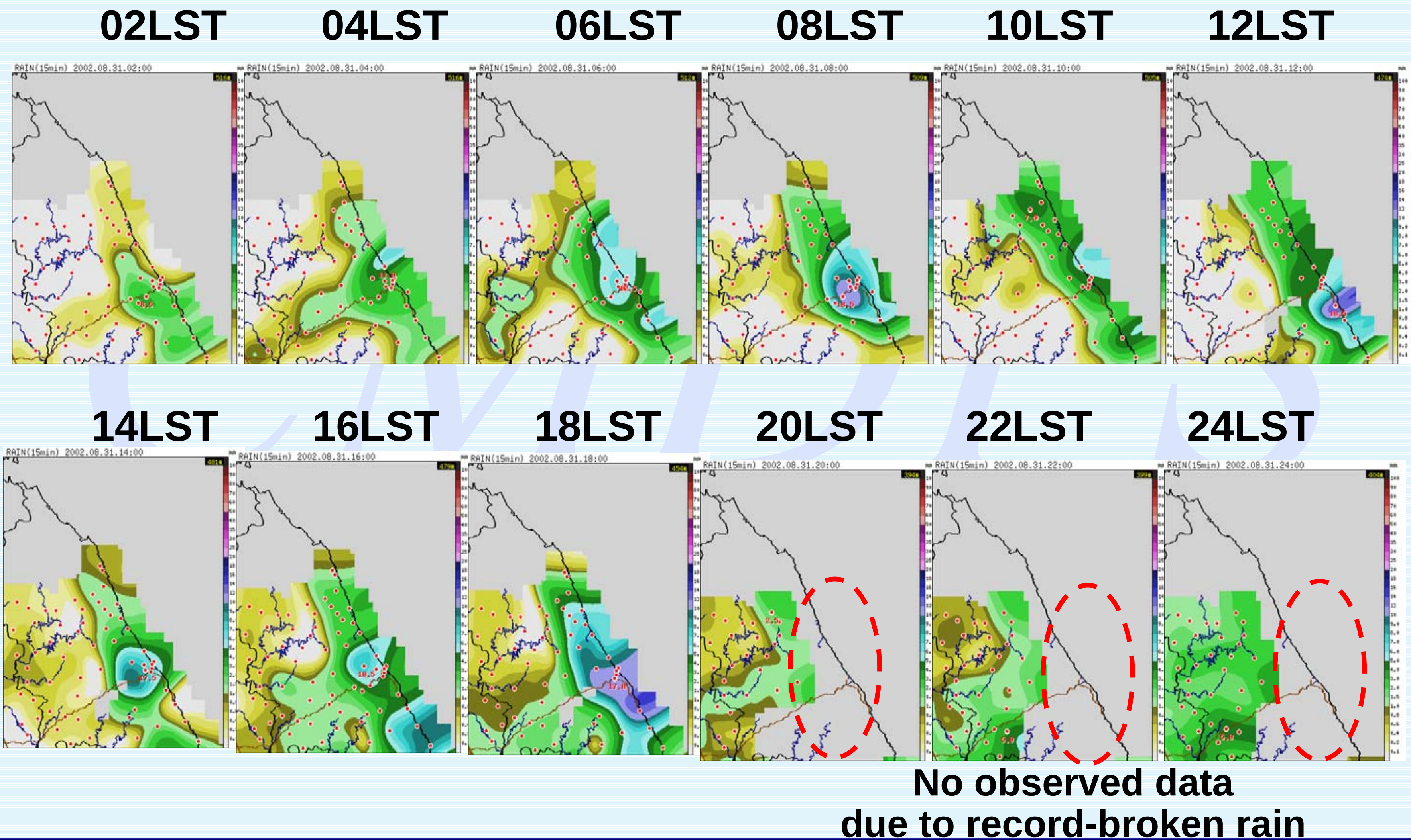
- Seoul/Kyungki Prov

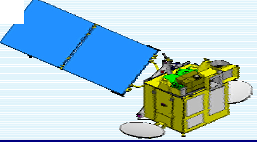
*** Top 5 daily Rainfall : Seoul, Choonyang(*), Hongcheon, Yangpyeong, Incheon**



Distribution of Hourly Rainfall

- TY Rusa Heavy Rainfall

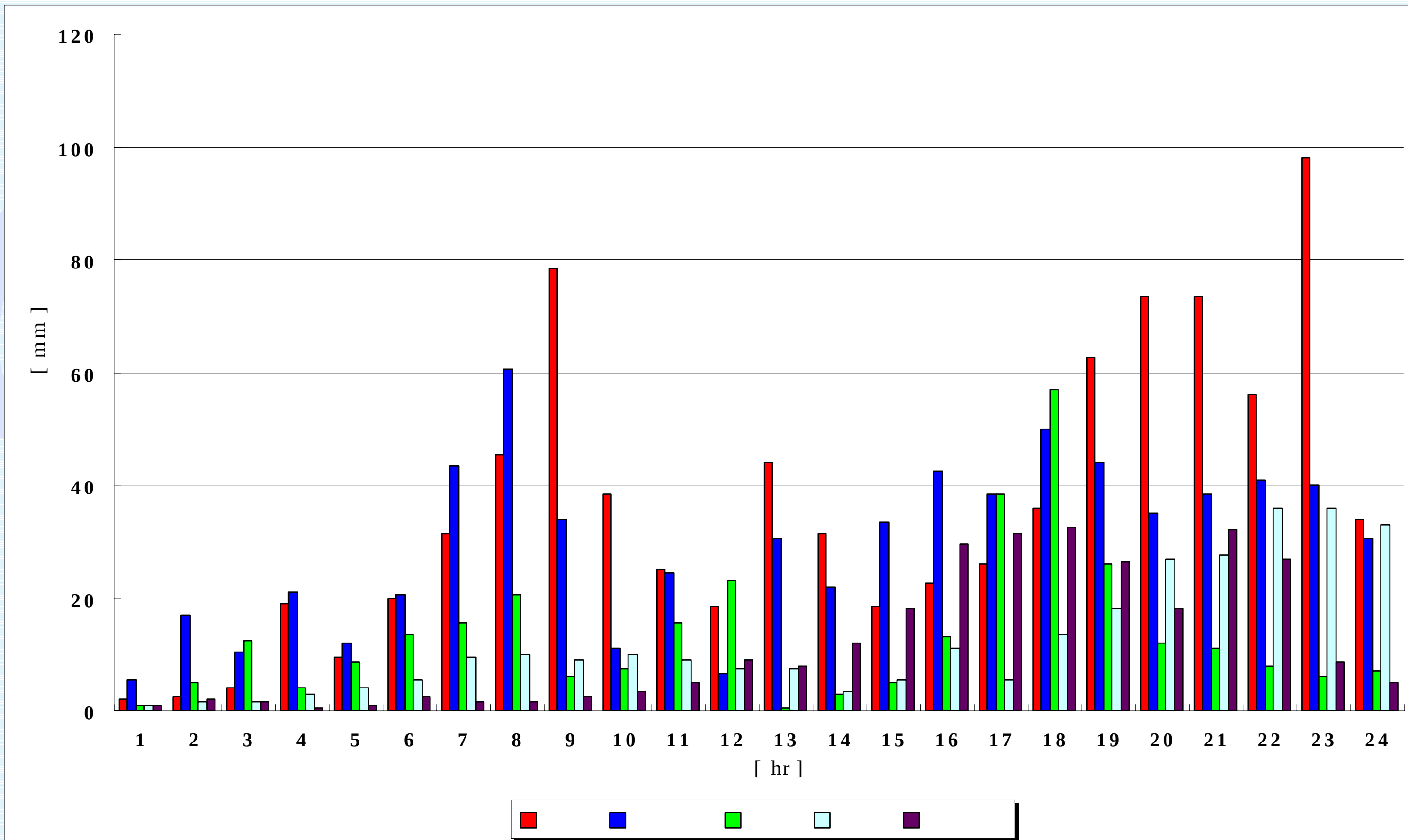




Hourly Rainfall Intensity

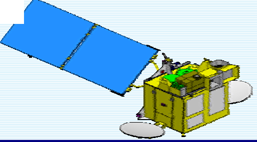
- TY Rusa Heavy Rainfall

*** Top 5 daily rainfall : Gangneung, Daekwanryoung, Donghae, Sokcho, Chupungryoung**

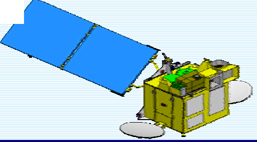


Summary

- Meteorological Effects:
  - Early detecting and continuous monitoring the high impact weathers
  - Improvement of NWP model using satellite data
  - Early detection of aerosol, such as Asian dust, and monitoring of its transport, etc.
  - Long term extraction of climate variation information
- Oceanographical Effects:
  - Reducing the property damages of fishermen
  - preventing the ocean resources from damaging
- Communicational Effect:
  - In-orbit test of developed communication payload



II. The Outline of CMDPS

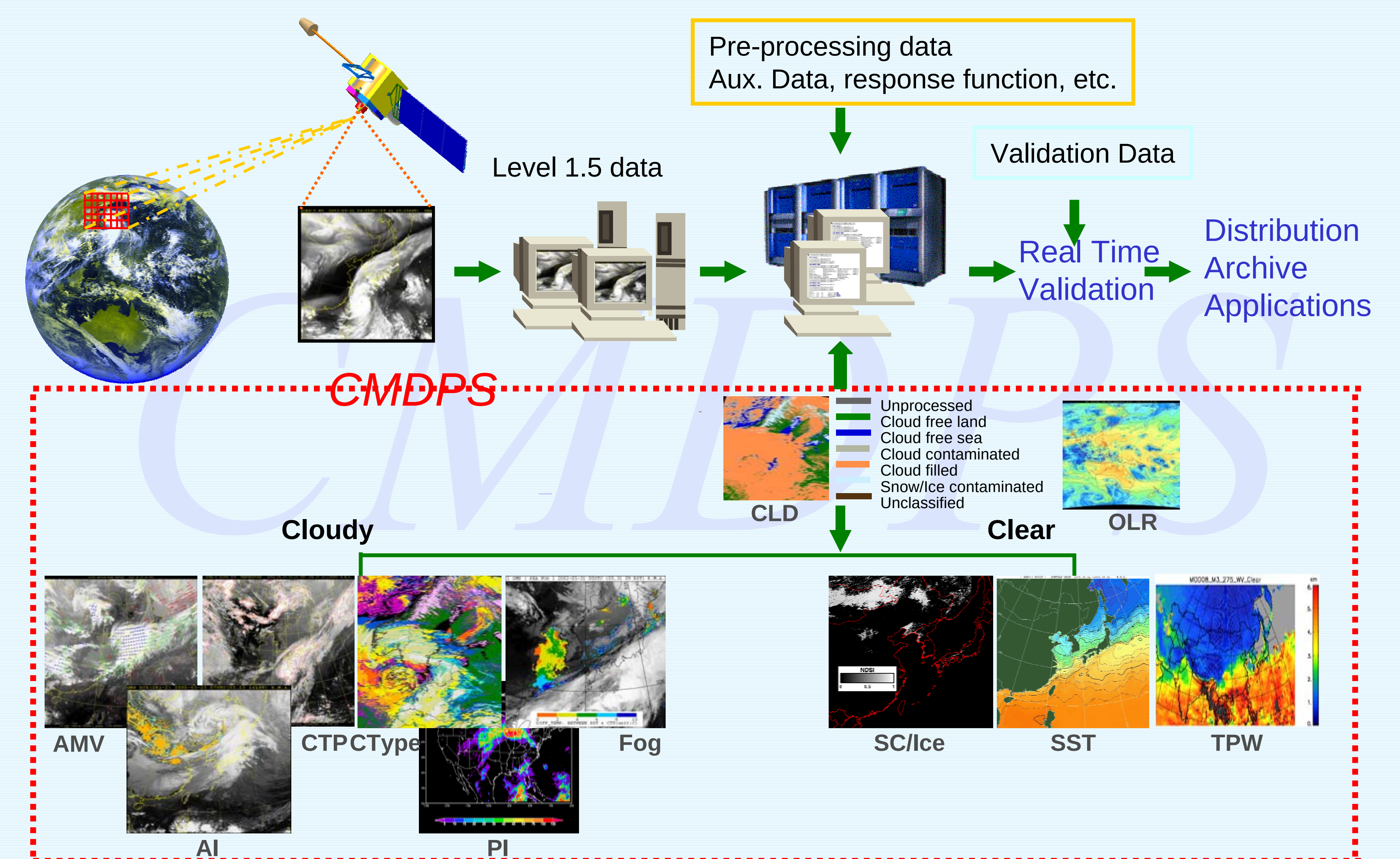


What is CMDPS ?

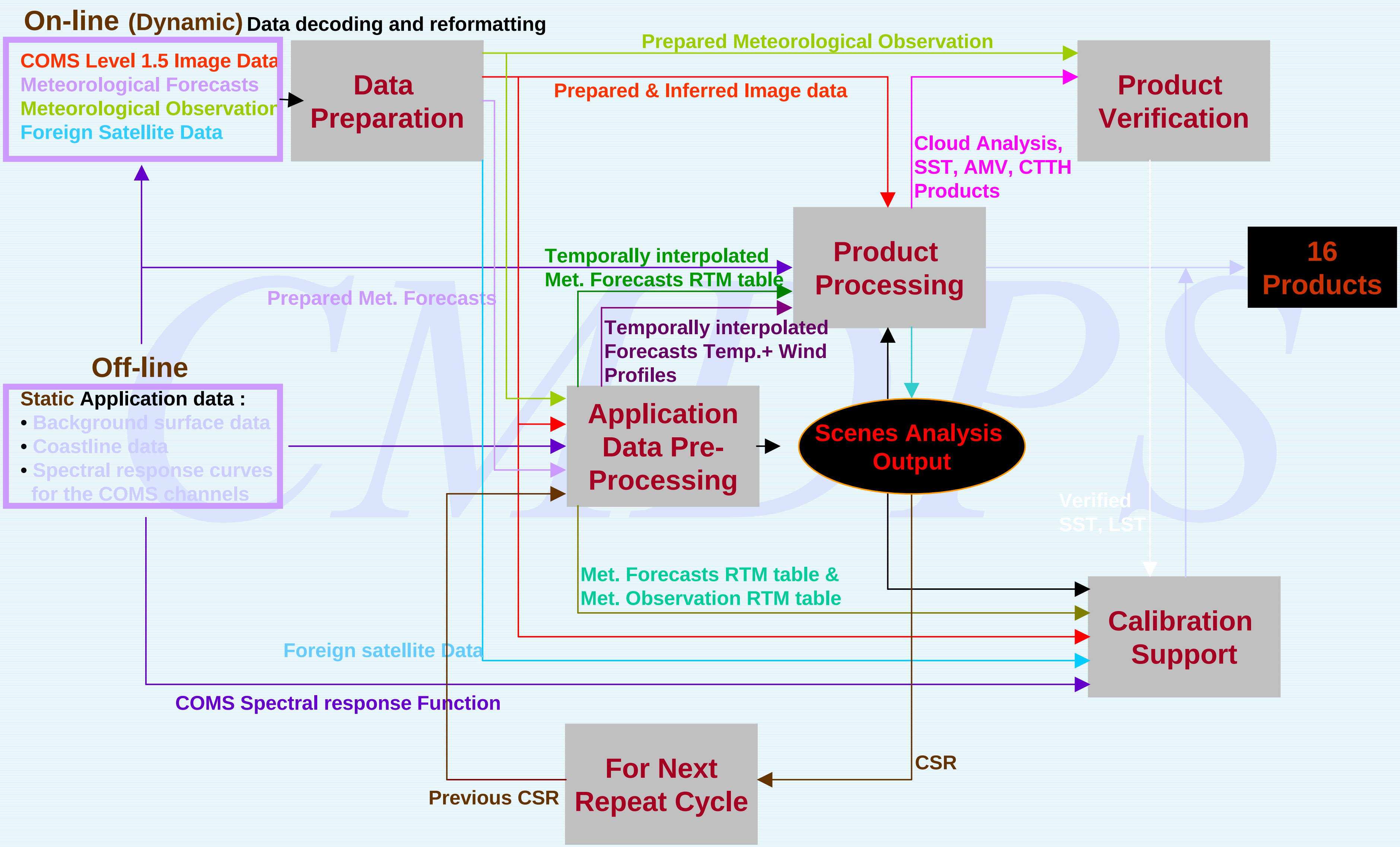
- COMS Meteorological Data Processing System (CMDPS)

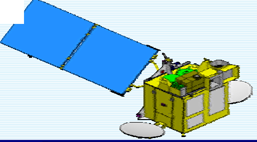
  - System to produce geophysical parameters from the satellite measured raw radiance data.
  - The system includes;
    - ✓ algorithms for each baseline products
    - ✓ various auxiliary data such as the surface emissivity, etc.
    - ✓ radiative transfer model
    - ✓ calibration monitoring scheme and algorithm
    - ✓ interfaces for between algorithms, and between CMDPS and OS
    - ✓ validation procedures.

CMDPS Data Flow



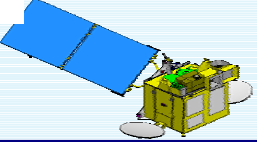
The Outline of CMDPS





Baseline products

Group	Product	Spatial Resolution	Temporal Resolution	Accuracy (Thres.)	Remarks
Cloud Detection	CLD	1x1 pixel	=obs		METRI
	CSR	~ 100km	=obs		METRI
AMV	AMV	~ 50km	3 hr.	9 m/s	METRI
Surface Information	SST	1x1 pixel	hourly	1.2 K	SNU
	LST	1x1 pixel	hourly	2 K	Kongju NU
	Sea Ice/SC	1x1 pixel	daily		METRI
	Insolation	1x1 pixel	hourly	10 %	Pukyoung NU
Water vapor Information	UTH	~ 50km	=obs	20 %	Kyoungpook NU
	TPW	~ 50km	=obs	20 %	Kyoungpook NU
Cloud Information	CLA	3x3 pixel	=obs		SNU
	CTT/CTH	1x1 pixel or 3x3 pixel	=obs	3 K 1 km	SNU
	Fog	1x1 pixel	=obs		EWU
	PI	1x1 pixel	=obs	20 % bias	Kangnung NU
	OLR	~ 10km	hourly	10 %	SNU
Aerosol Information	AI	1x1 pixel	=obs		Pusan NU
	AOD	10x10 pixel	=obs	35 %	YSU

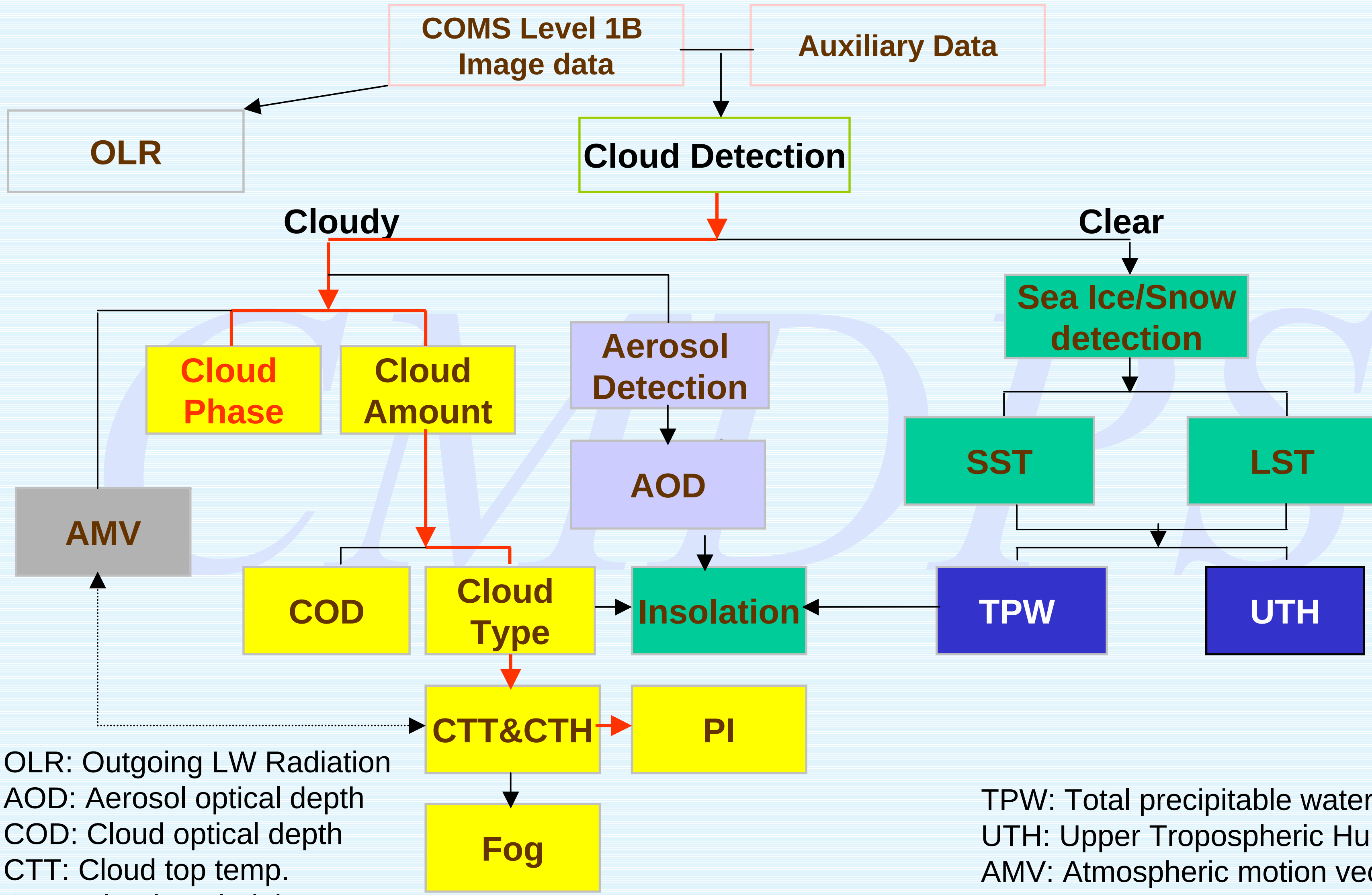


Baseline products

Name	New?	Issues	Remarks
CLD/CLR	No	Accuracy Improvement	Probability Info., Use of NWP products, SFC[1]
LST	Yes	New with enough acc.	SFC is mandatory for enough accuracy,
SST	No	Accuracy Improvement	Different algorithms for spatial and temporal scale
Insolation	Yes	New regression coeffs.	Better reference ground data and CLD information
Snow/Ice	Yes	Important in LSM	Combining with SSM/I, AVHRR, and MODIS
AMV	No	Accuracy Improvement	Height assignment using IR1/WV, IR1/IR2
TPW	Yes	NWP application	Regression with better database
UTH	Yes	NWP application	Regression and Physical approach
CLD Info.	No	Accuracy Improvement	Use of NWP products, better understanding of Chs.
CLD Cls.	No	Accuracy Improvement	Use of NWP products with better RTM
CLD Phs.	Yes	Important for nowcasting	Better understanding of Chs.
Fog	No	Accuracy Improvement	Better threshold values for different conditions
OLR	Yes	Expect better accuracy	Better calibration with improved aux. data
PI	No	Accuracy Improvement	Use Microwave data and precise topography
AI	No	Accuracy Improvement	Better threshold and SFC information
AOD	Yes	Became important info.	Accurate LUT and SFC information

[1] SFC includes the surface information acquired by both off-line and on-line

Baseline products



OLR: Outgoing LW Radiation
AOD: Aerosol optical depth
COD: Cloud optical depth
CTT: Cloud top temp.
CTH: Cloud top height

TPW: Total precipitable water
UTH: Upper Tropospheric Humidity
AMV: Atmospheric motion vector
PI: Precipitation index

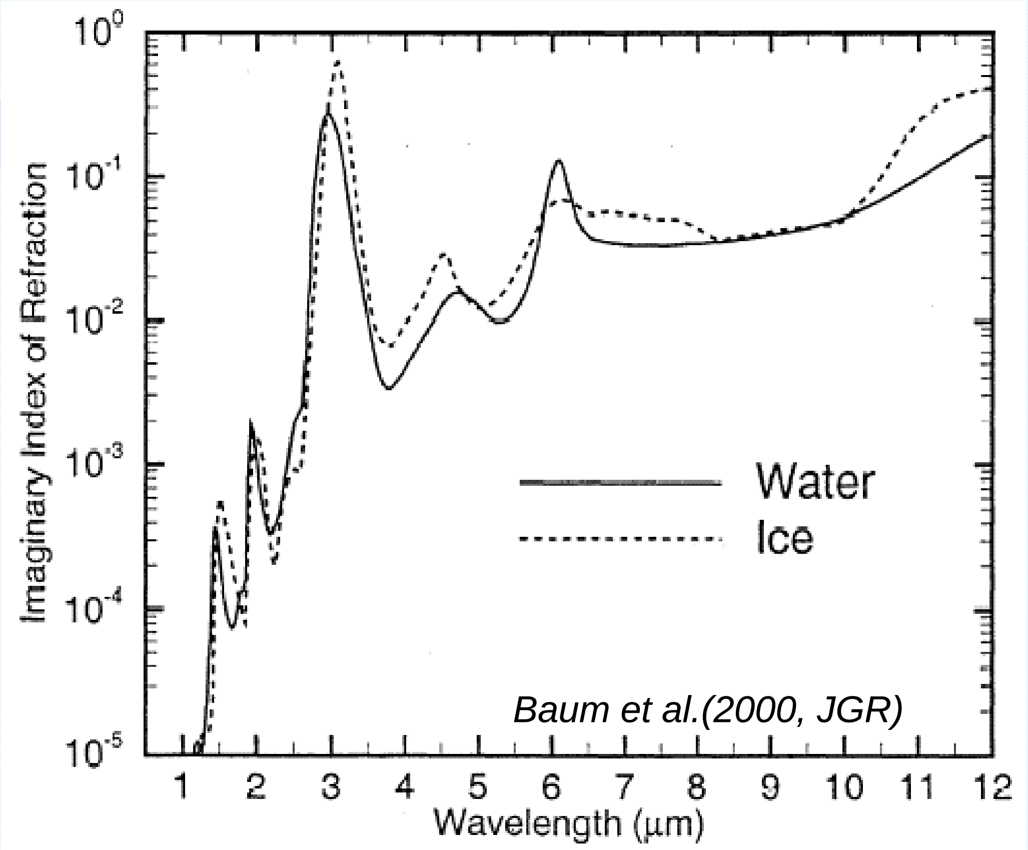
Cloud Phase-I

❑ Key issues

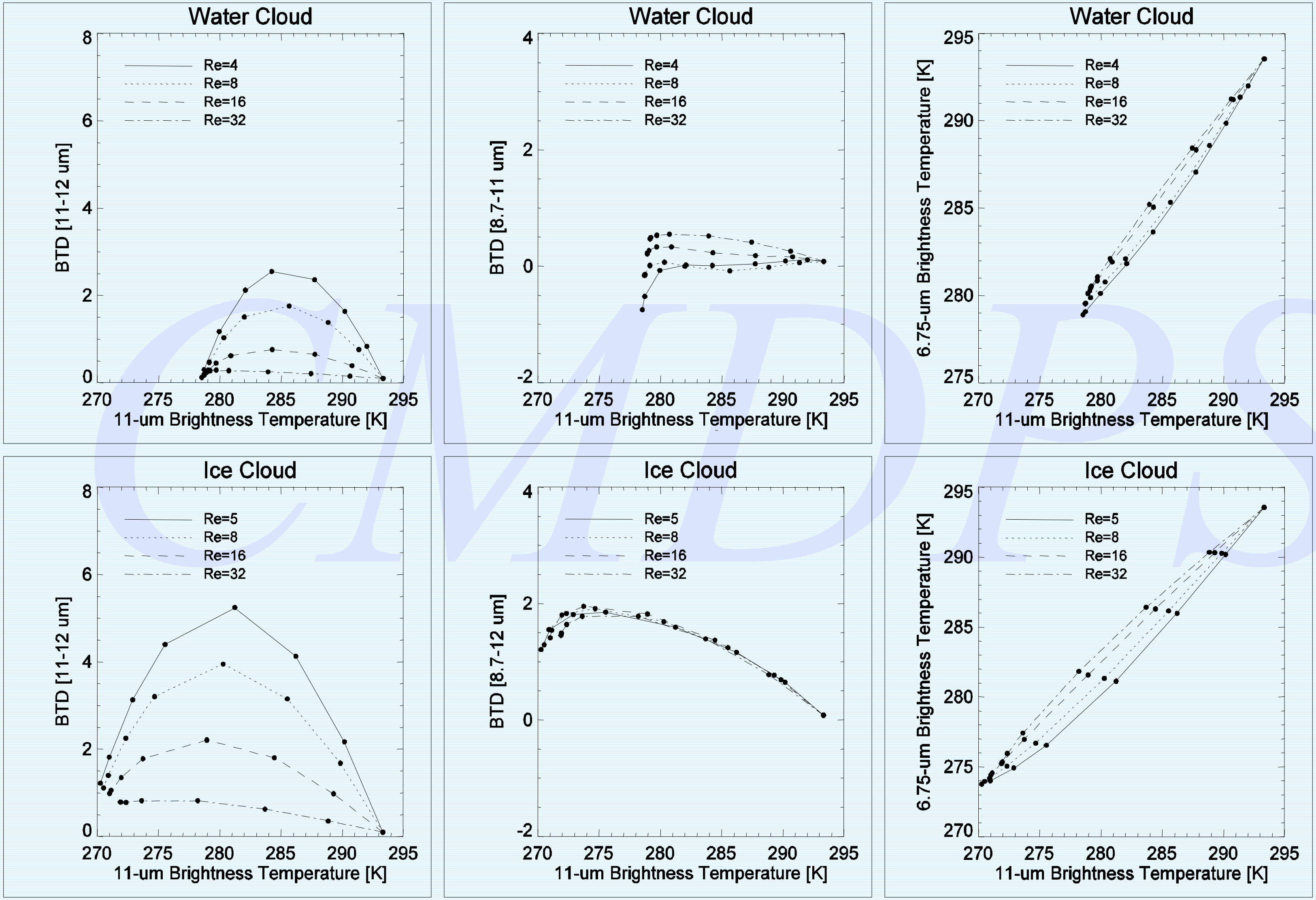
- ➢ Is WV channel useful for cloud phase
- ➢ How accurate for multi-layer cloud ?

❑ Approaches

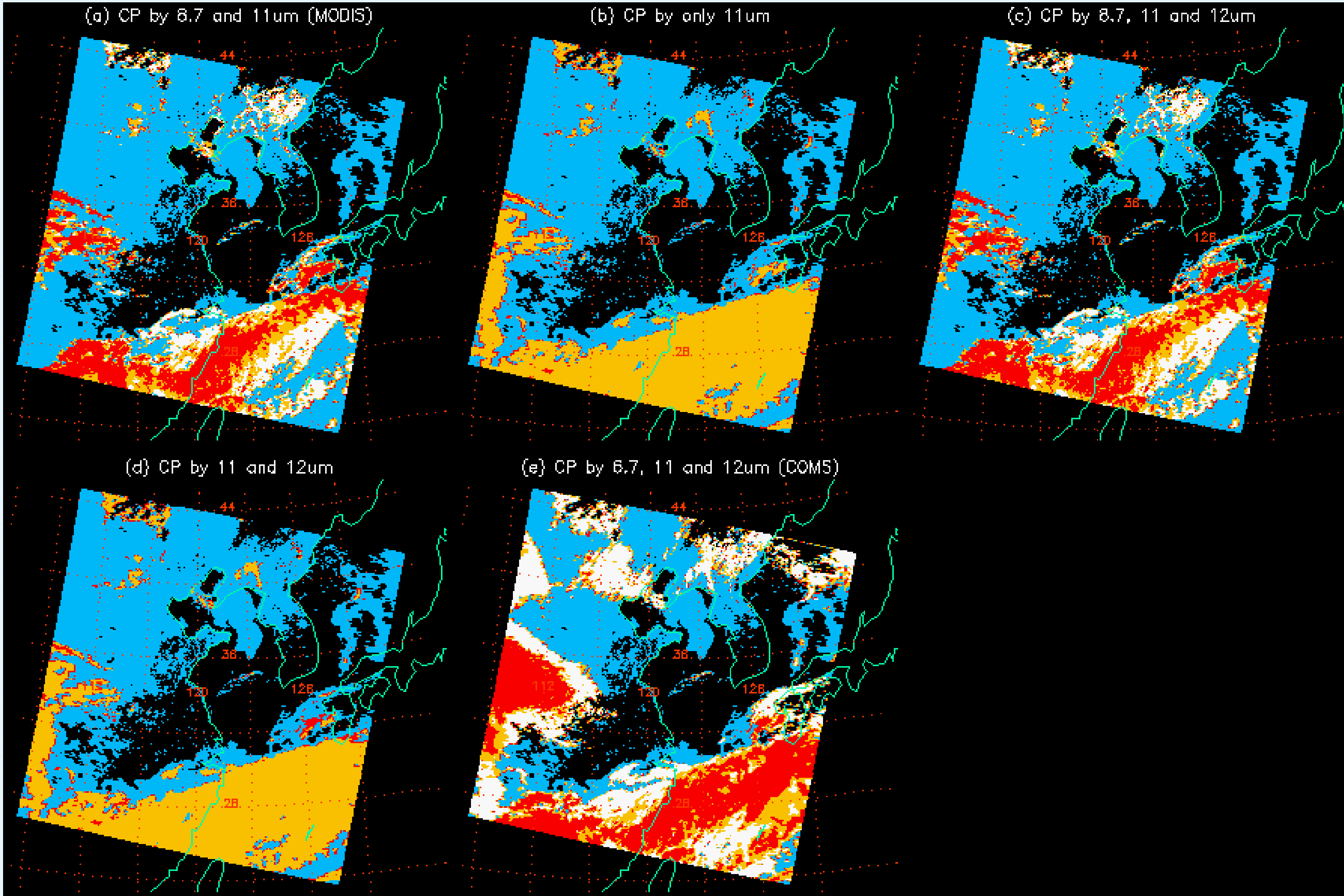
- ➢ Simulation
  - ✓ 8.7 vs. 6.3
- ➢ Application to MODIS data
  - ✓ comparison

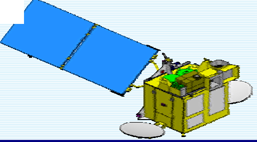


Cloud Phase-II



Cloud Phase-III





Aerosol Optical Depth-I

Cloud Removal

COMS Vis. Channel TOA Reflectance (α'_p)

COMS Vis. Channel TOA Reflectance (α_p)

LOOK UP TABLE METHOD
$\alpha'_s = F(\theta_0, \varphi_0, \theta_s, \alpha_p)$
$\tau_b = 0.0$ … in 6S

RTM (6S)
$\tau_a = F(\theta_0, \varphi_0, \theta_s, \alpha_p, \alpha_s)$

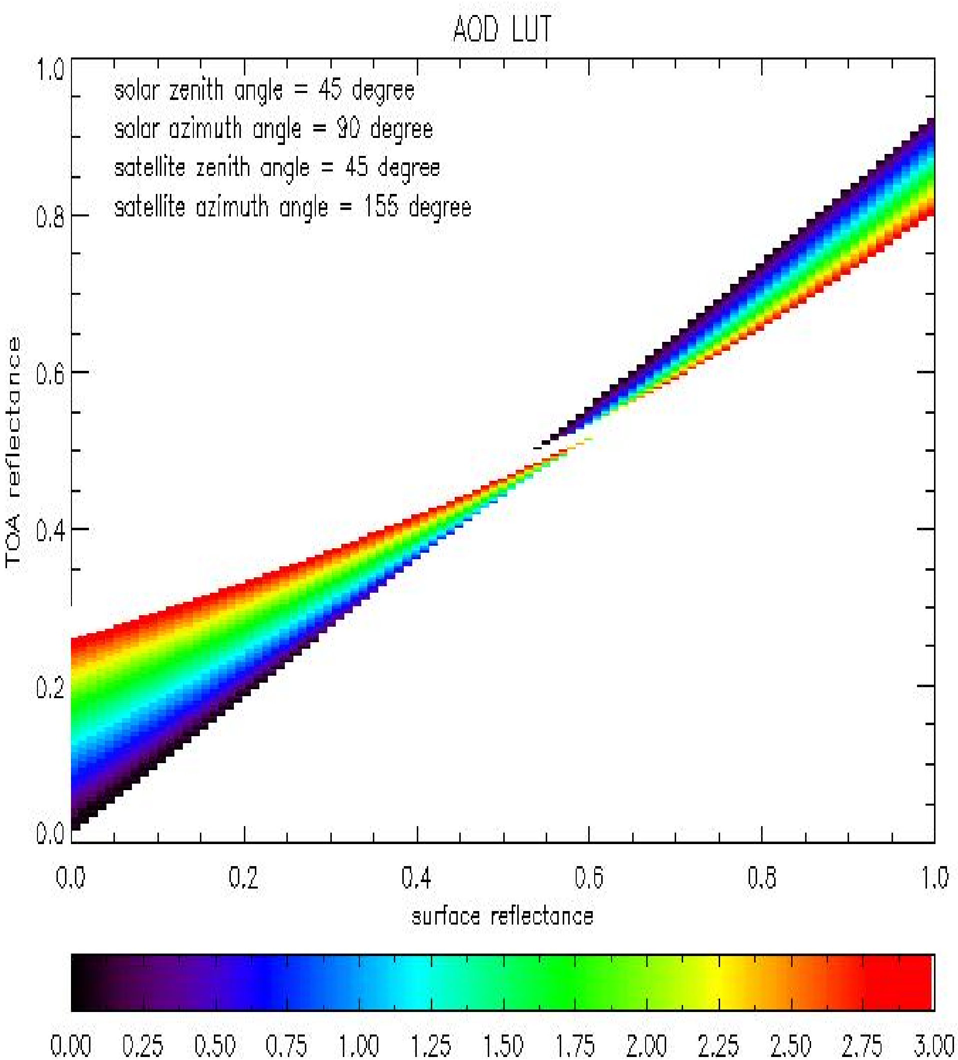
Look Up Table
$\theta_0 = 0\text{-}70^o, 5^o$
$\varphi_0 = 0\text{-}180^o, 10^o$
$\theta_s = 0\text{-}70^o, 5^o$
$\tau_a = 0\text{-}3, 0.1$
$\alpha_s = 0\text{-}1, 0.1$

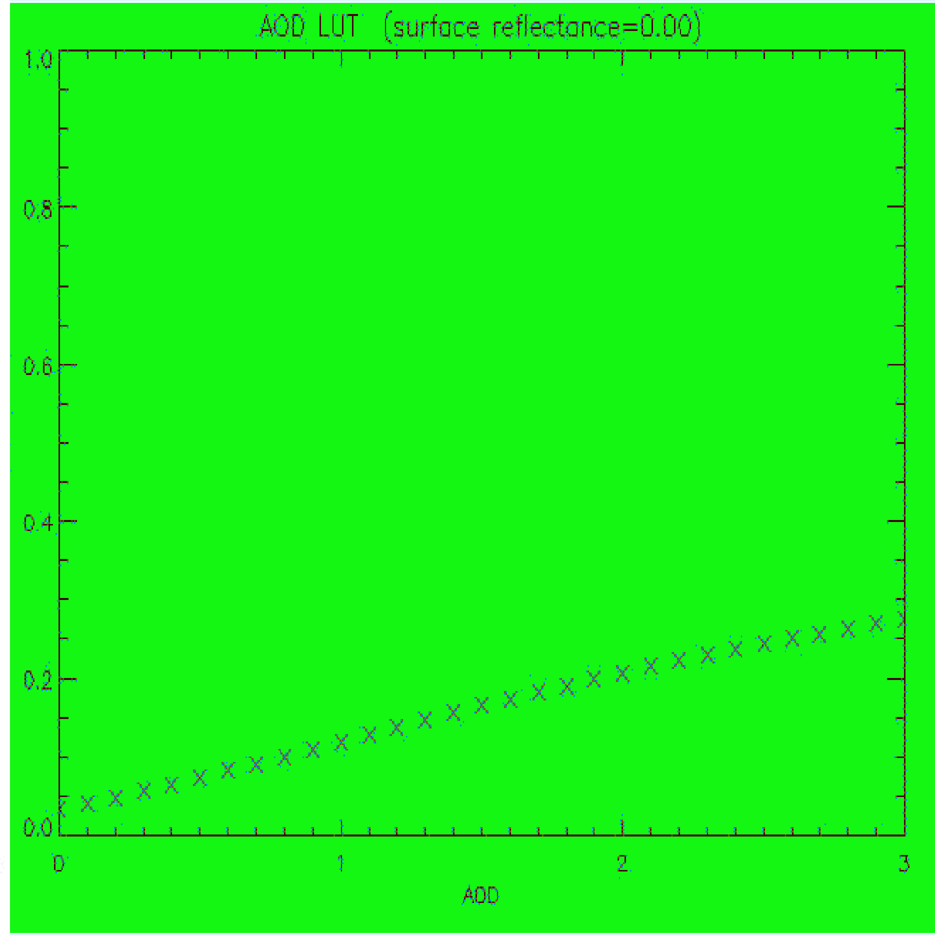
GOES-9 Vis. Channel Surface Reflectance (α'_s)

α_s (1 month 2nd min. reflectance)

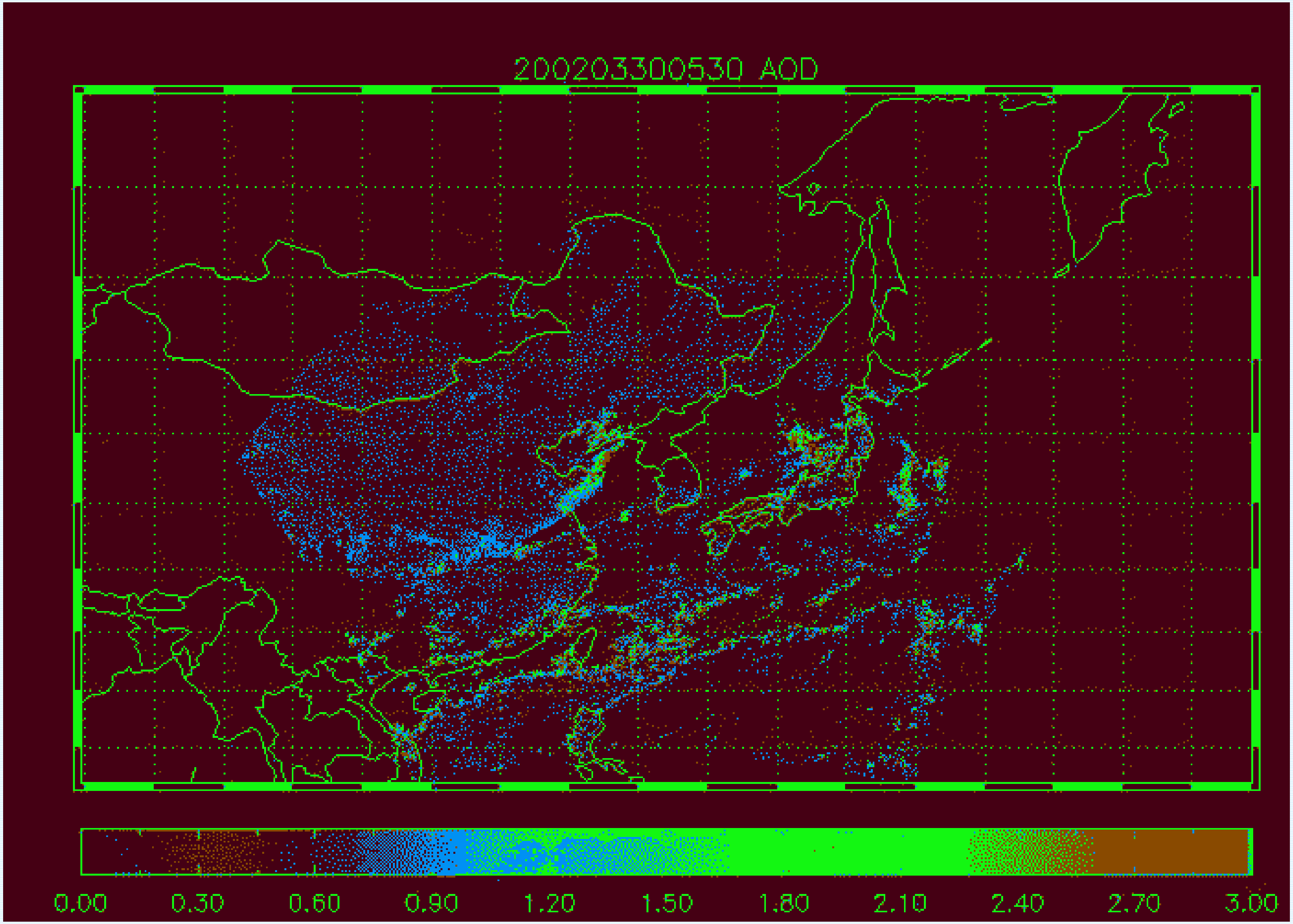
AOD(τ_a)

Aerosol Optical Depth-II

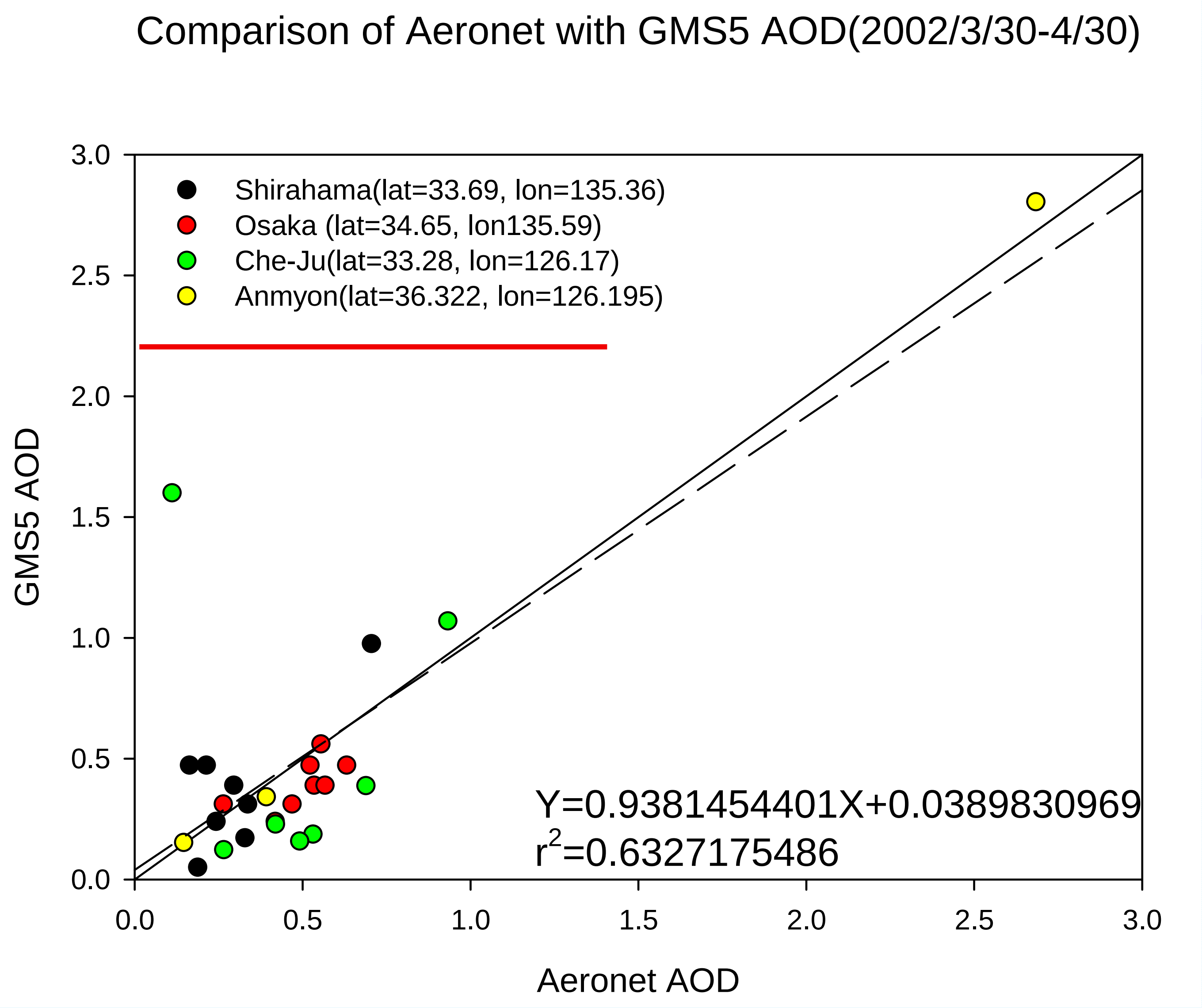




Aerosol Optical Depth-IV



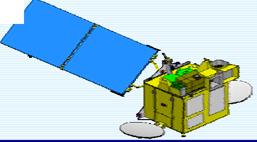
Aerosol Optical Depth-V



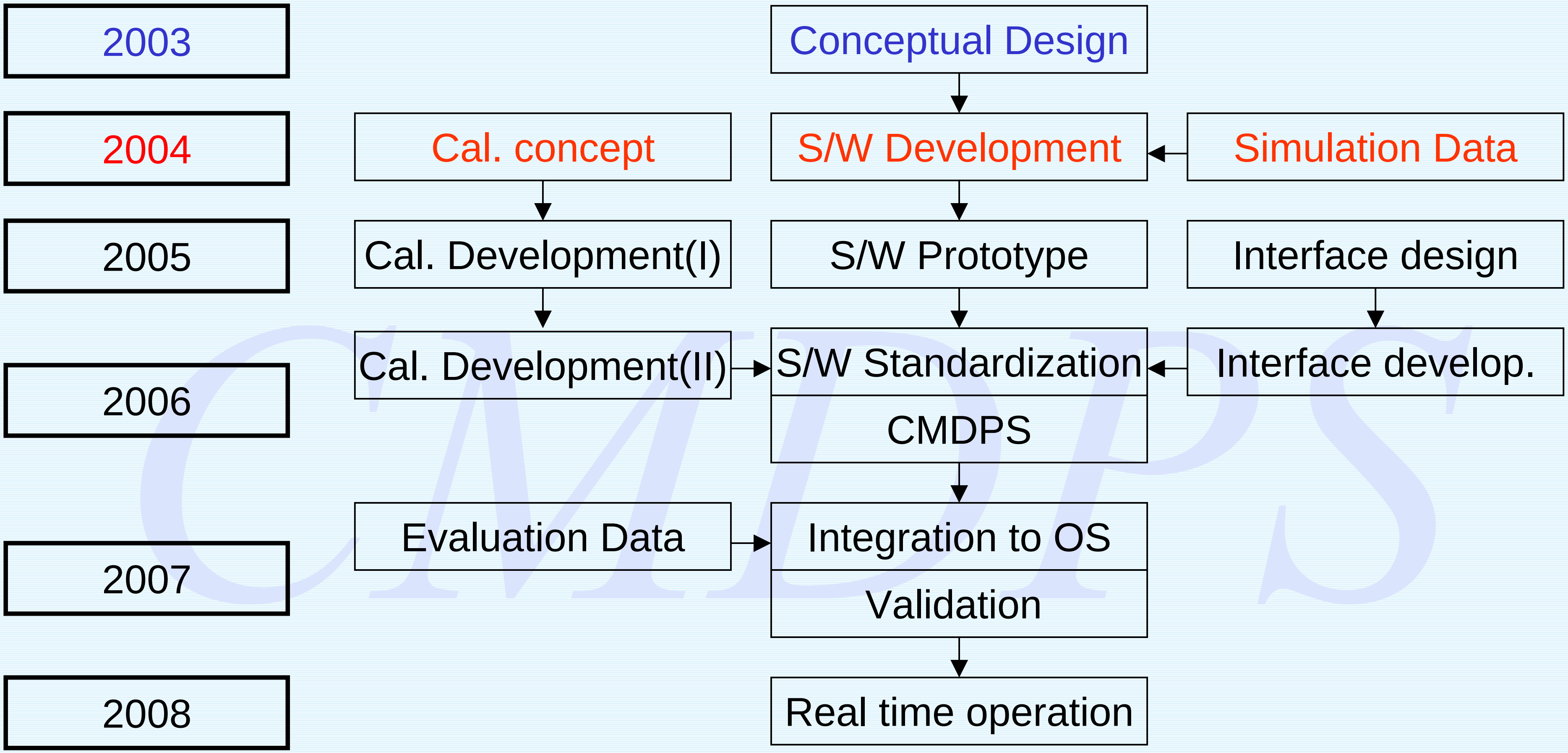
Aerosol Optical Depth-VI

Sources of uncertainty(Knapp et al., 2002)

	Source
Atmospheric	aerosol optical properties (e.g., sphericity, w_o, n(r), refractive index)
	location of the aerosol layer
	Rayleigh optical depth
	gaseous absorption
Surface	reflectance uncertainty
	bidirectional reflectance contamination
Instrument	calibration
	noise
Radiative transfer model	plane-parallel approximation
	multiple scattering



Future Plans



- Other major Task
  - Development of validation strategy for the raw and derived products
  - Preparation for the user service