Data processing (3)
Cloud and Aerosol Imager (CAI)

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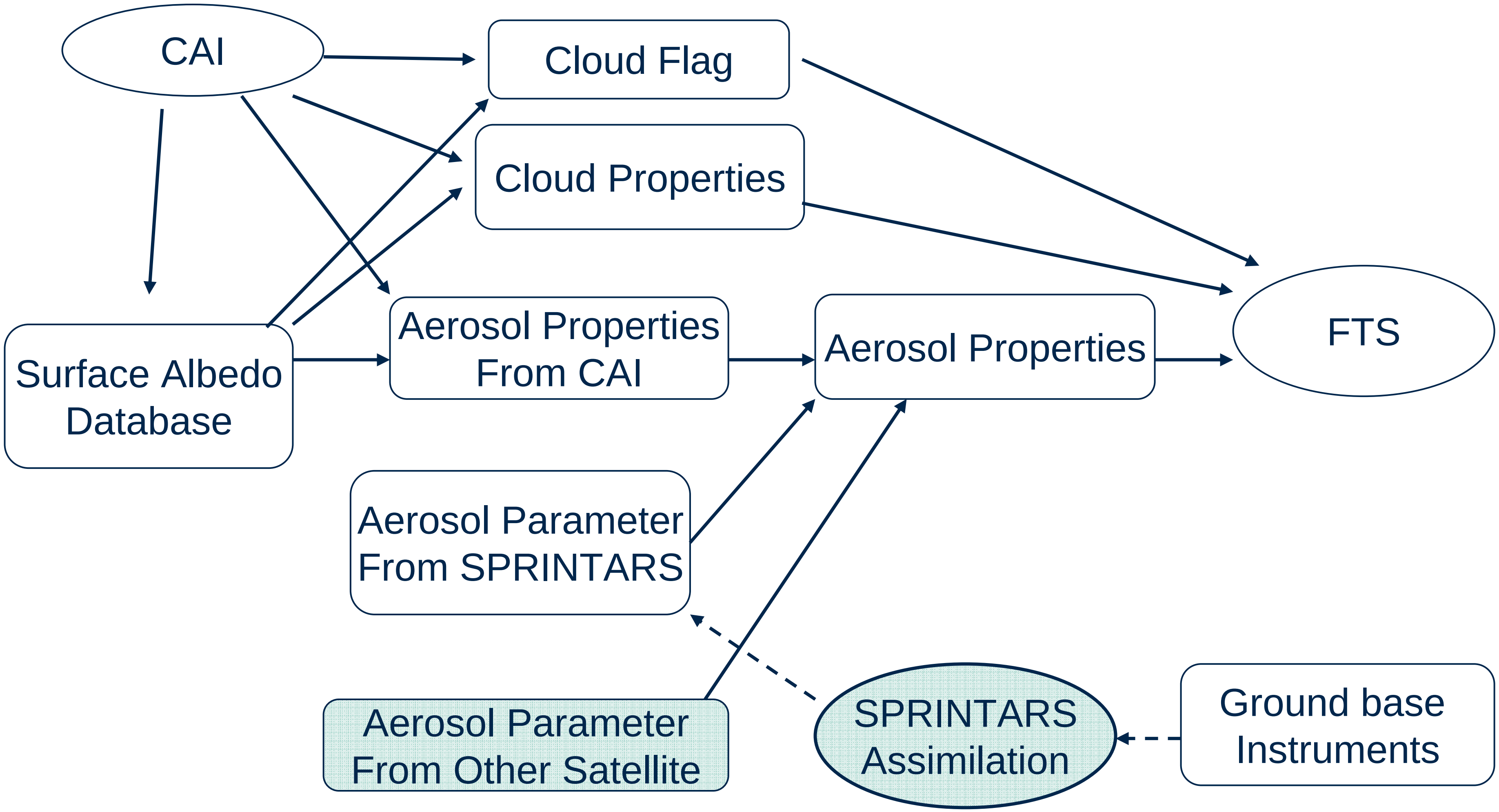
Cloud Aerosol Imager (CAI)

- **Objective**
  - Correct the effects of clouds and aerosols on the spectral radiation measurements obtained by GOSAT TANSO-FTS
- **CAI Atmosphere Products**
  - Cloud Flag
  - Cloud Properties (Optical Thickness, Cloud Particle Radius)
  - Aerosol Properties (Optical Thickness, Single Scattering Albedo, Phase Function, Soot Ratio)
- **SPRINTARS (Spectral Radiation-Transport Model for Aerosol Species)**
  - Aerosol Properties on Sun glint region

CAI Atmosphere Products

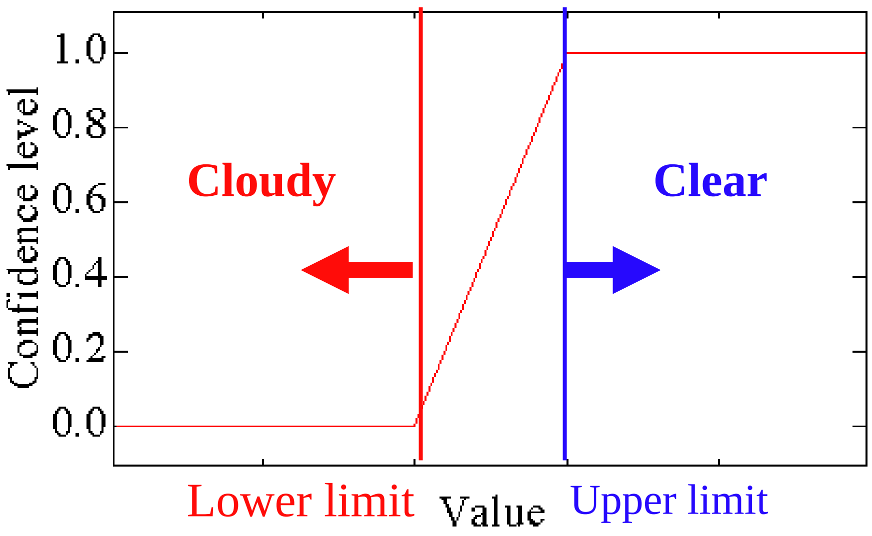


Cloud Flag

- **Objective**
  - **Distinct clear sky condition for FTS observation**
- **Products**
  - **Clear Confidence Level**
- **CAI bands in use**
  - **Band 2 (0.67μm)**
  - **Band 3 (0.87μm)**
  - **Band 4 (1.6μm)**

Clear Confidence Level

Cloud detection schemes	Scene Type
Reflectance at 0.66μm: R(0.66μm)	Land
Reflectance at 0.87μm: R(0.87μm)	Ocean
Reflectance Ratio: R(0.66μm)/R(0.87μm)	Thick Cloud
NDVI	Forest, Ocean
Reflectance Ratio: R(0.87μm)/R(1.64μm)	Desert
NDSI	Snow

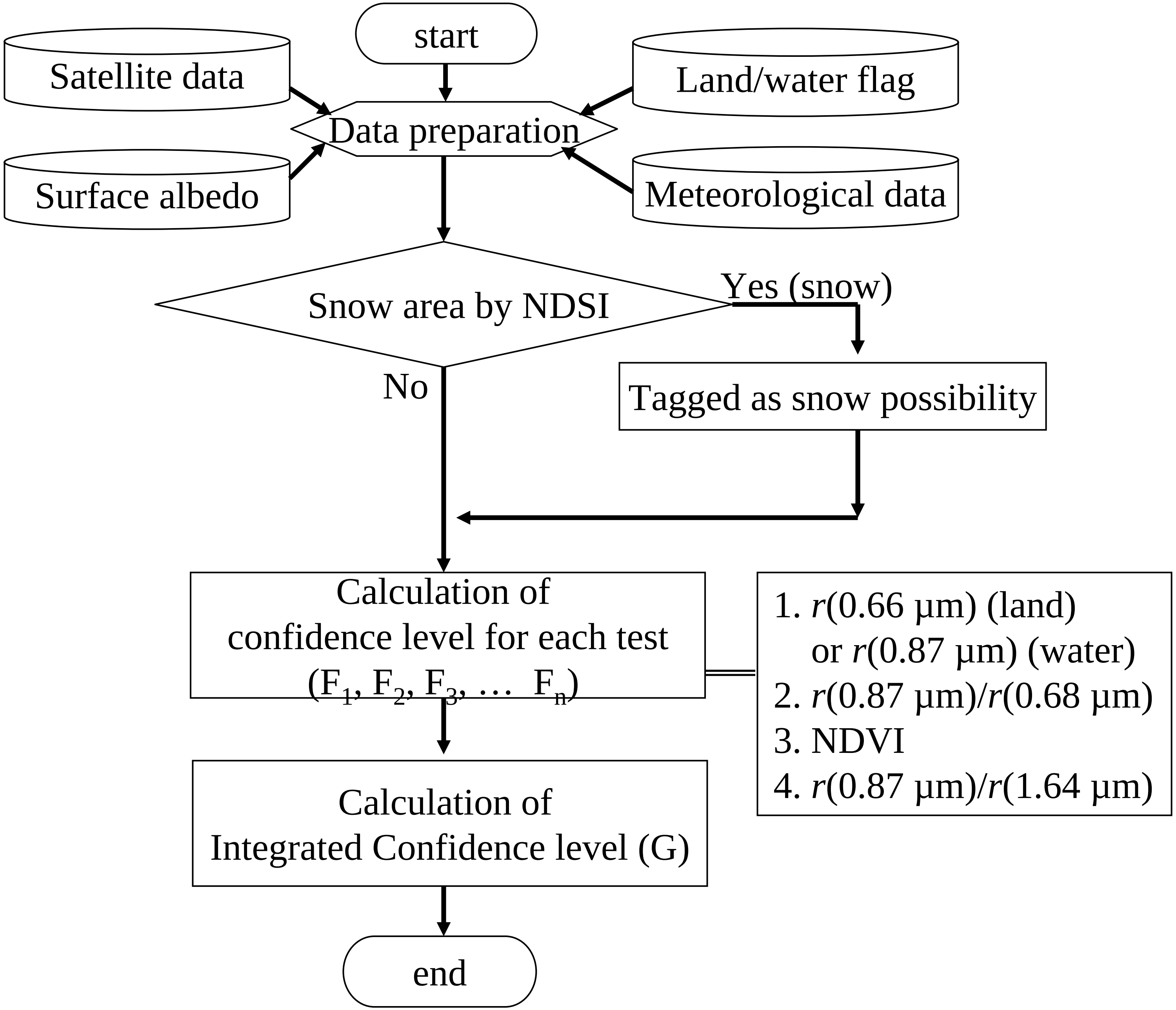


$$NDVI = \frac{R(0.87\mu m) - R(0.66\mu m)}{R(0.87\mu m) + R(0.66\mu m)}$$

$$NDSI = \frac{R(0.66\mu m) - R(1.64\mu m)}{R(0.66\mu m) + R(1.64\mu m)}$$

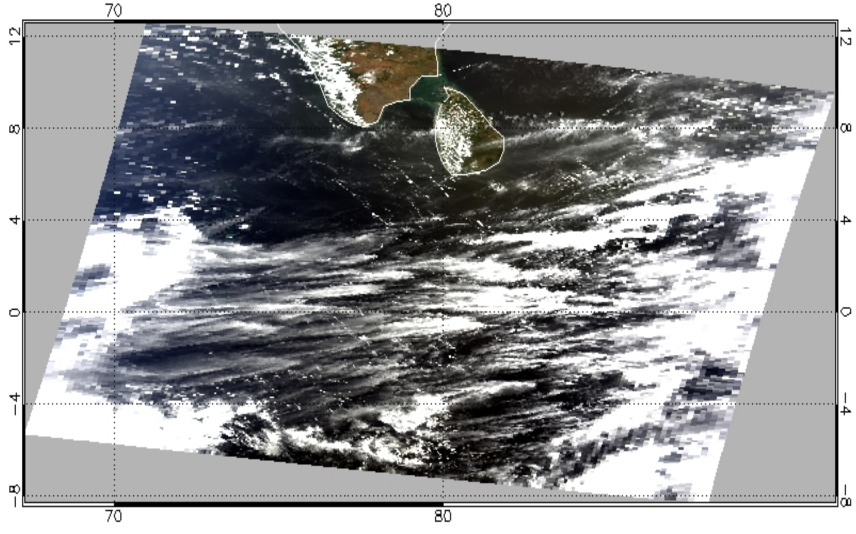
$$G = 1 - \sqrt{(1-F_1)\cdot(1-F_2)\cdot(1-F_3)\cdots(1-F_n)}$$

Algorithm flow chart of Cloud Flag

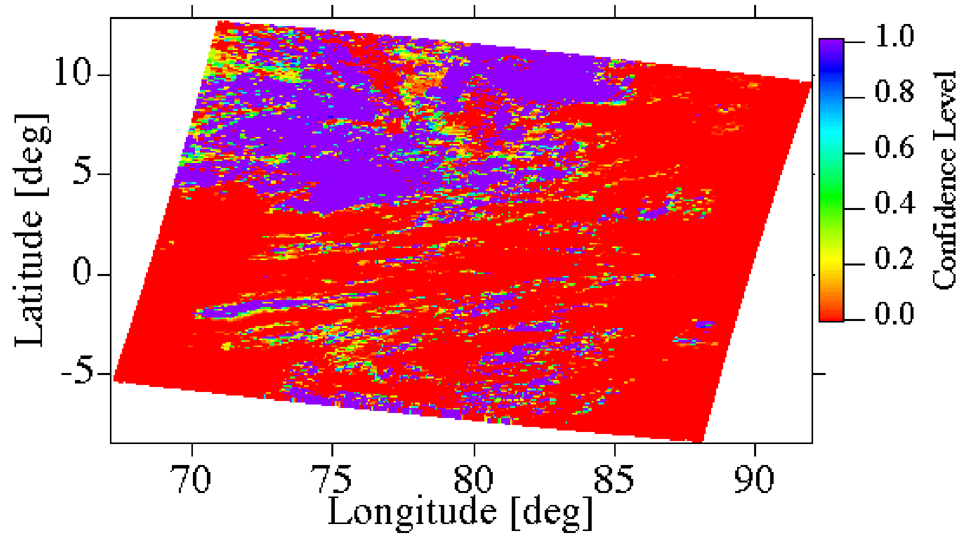


A case study over Ocean with MODIS

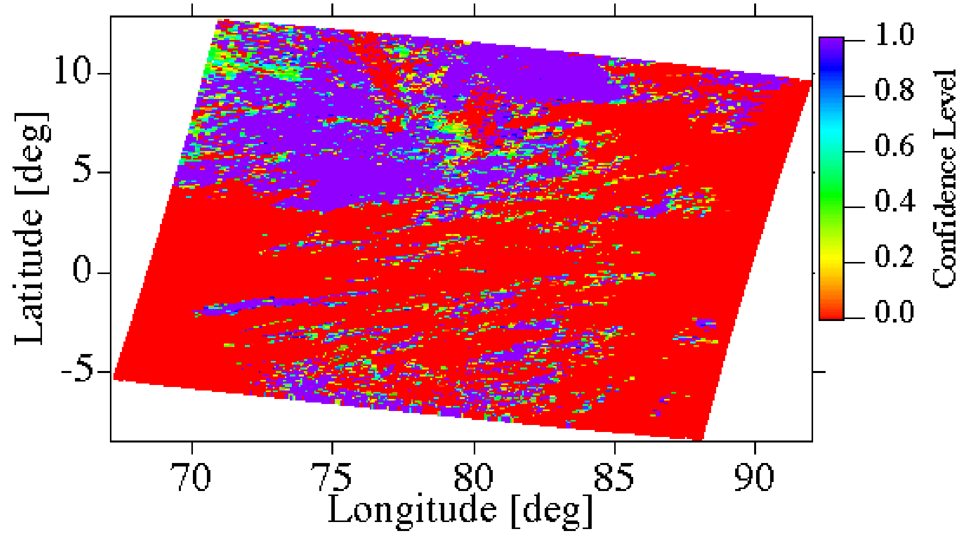
2006.07.18 0510



RGB



Confidence level by CAI



Confidence level by MODIS

Algorithm for retrieving cloud properties from CAI

- **Objective**
  - Estimate contamination of cloud effects in the FTS-measured signals.
- **Products**
  - Cloud Optical Thickness
  - Cloud Effective Particle Radius
- **CAI bands in use**
  - Band2 0.67µm
  - Band4 1.6µm

Formulation

$$L(\tau_c, r_e; \theta, \theta_0, \phi) = L_{obs}(\tau_c, r_e; \theta, \theta_0, \phi)$$

Observed calibrated radiance

$$-t(\tau_c, r_e; \theta)\frac{A_g}{1 - r(\tau_c, r_e)A_g} t(\tau_c, r_e; \theta_0)\frac{\cos\theta_0 F_0}{\pi}$$

Surface Reflection correction

Where,

$$t(\tau_c, r_e; \theta_0) = \frac{1}{\pi}\int_0^{2\pi}\int_0^1 T(\tau_c, r_e; \theta, \theta_0, \phi)\cos\theta d\theta d\phi + e^{-\tau/\cos\theta_0}$$

$$r(\tau_c, r_e; \theta_0) = \frac{1}{\pi}\int_0^{2\pi}\int_0^1 R(\tau_c, r_e; \theta', \theta_0, \phi)\cos\theta' d\theta' d\phi$$

$$\bar{r}(\tau_c, r_e) = 2\int_0^1 r(\tau_c, r_e; \theta)\cos\theta d\theta$$

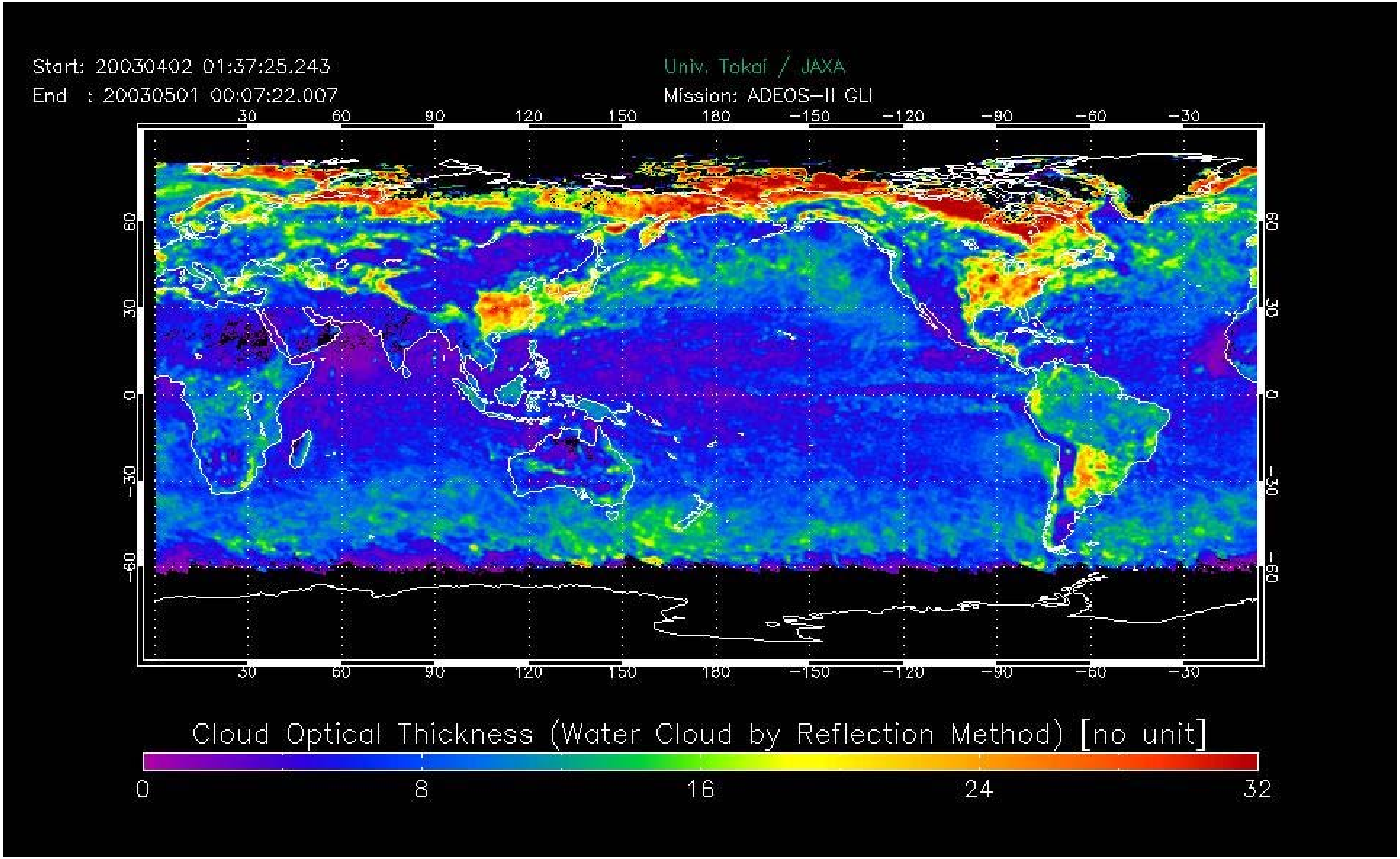
$F_0 : solar\_irradiance$
$\theta_0 : solar\_zenith\_angle$
$\theta : satellite\_zenith\_angle$
$\phi : relative\_azimuth\_angle$
$R : reflectance\_of\_atmospheric\_layer$
$T : transmittance\_of\_atmospheric\_layer$

$$(\tau_c, r_e) = F^{-1}(L_{vis}, L_{swir})$$

Band2 Band4

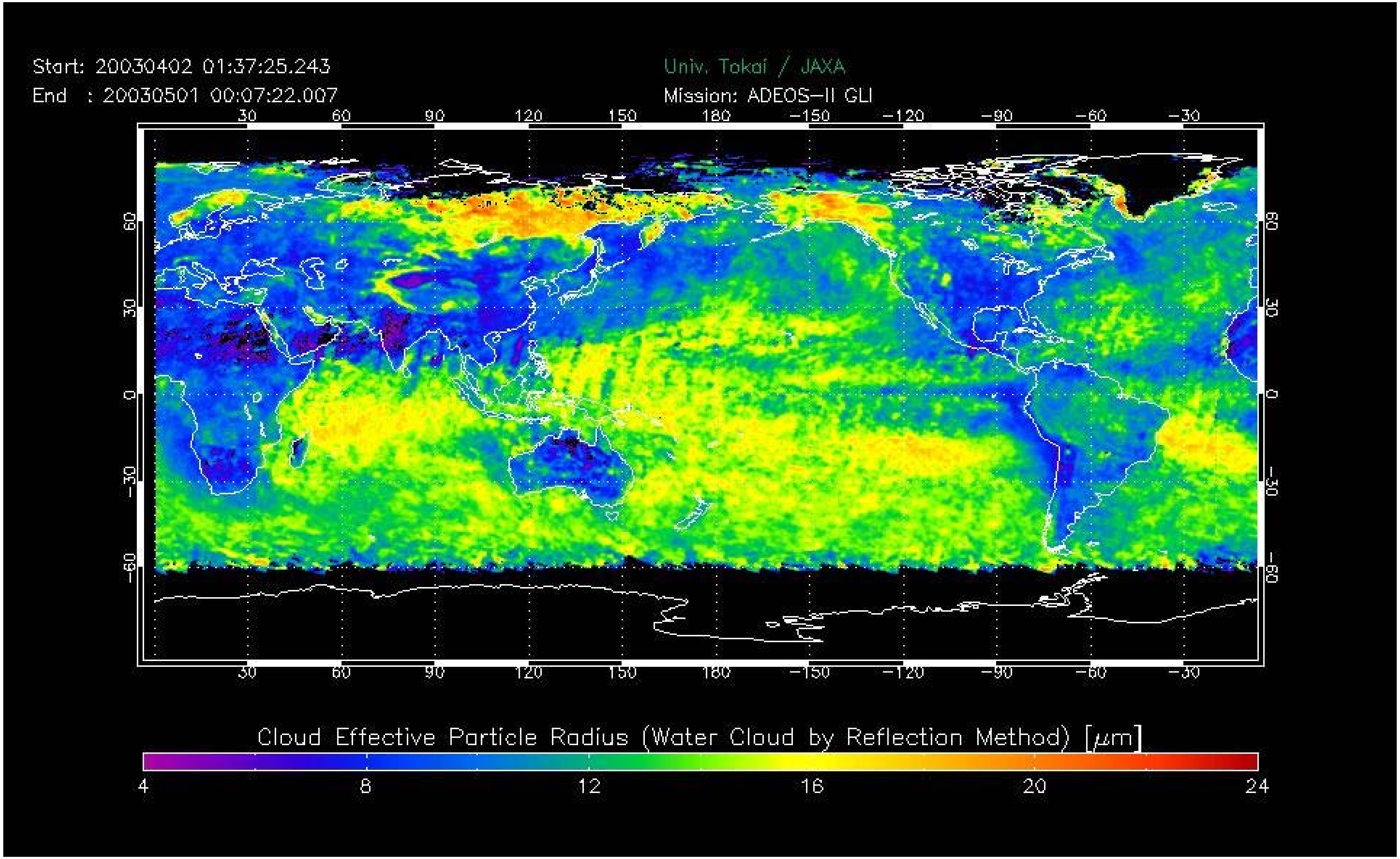
Solving by iteration with LUT of L, t, r, $\bar{r}$, and A_g

Cloud Optical Thickness from GLI



Data source: ADEOS-II GLI, Data period: 2003 April, Algorithm: Capcom ver102

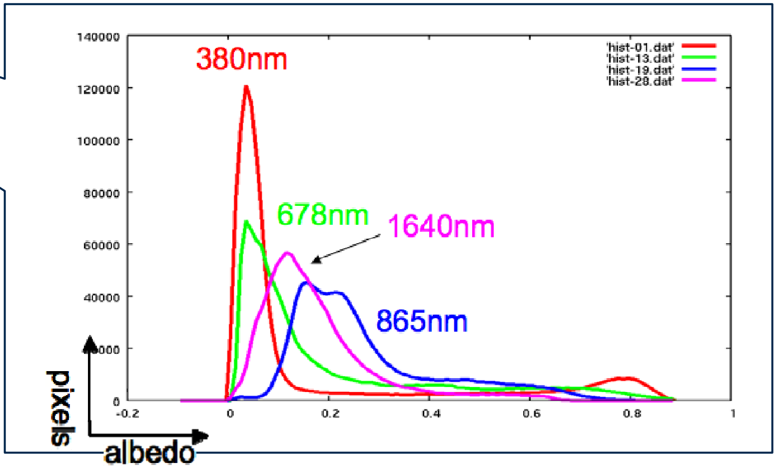
Cloud Effective Particle Radius from GLI



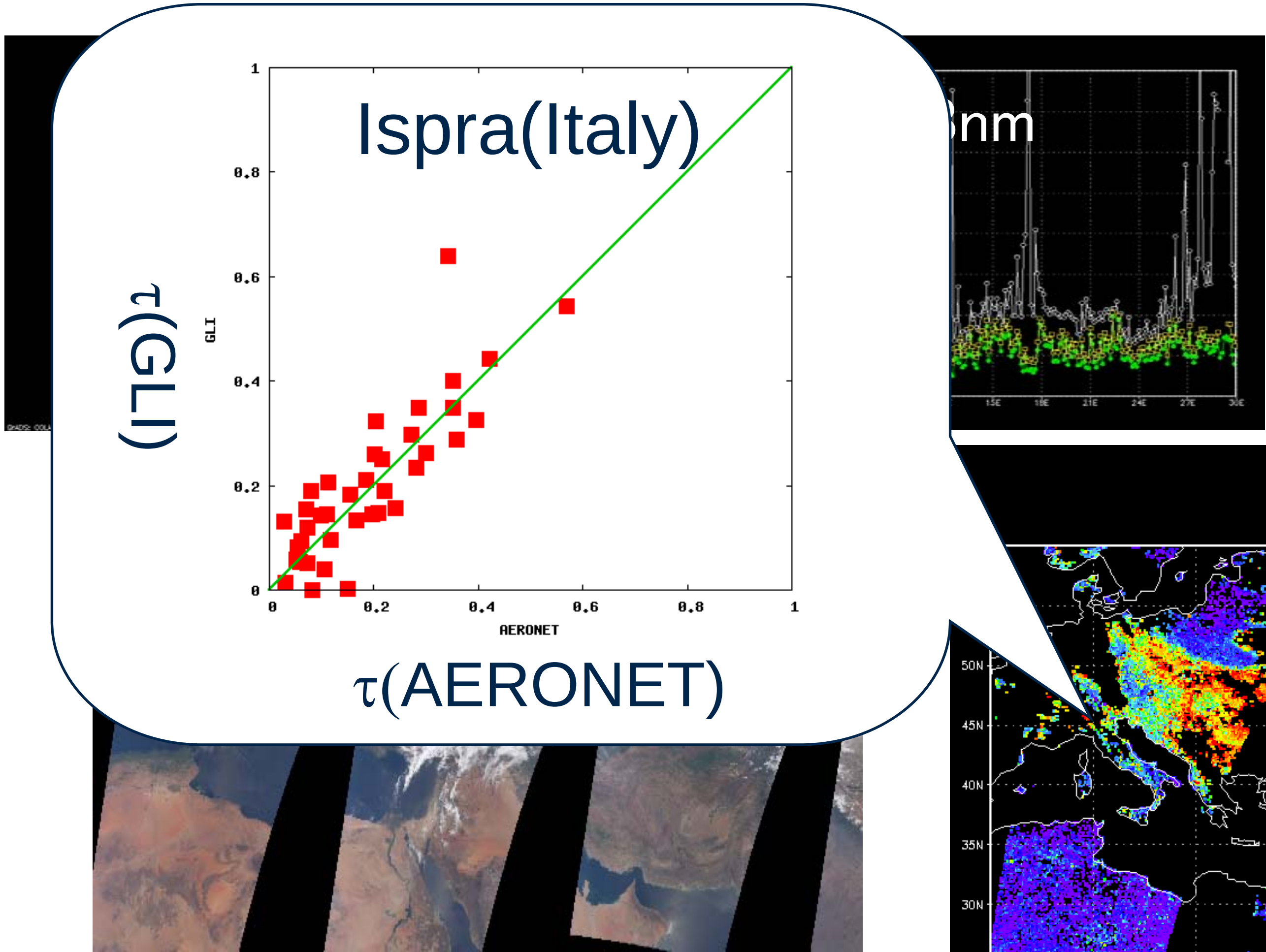
Data source: ADEOS-II GLI, Data period: 2003 April, Algorithm: Capcom ver102

Aerosol Properties

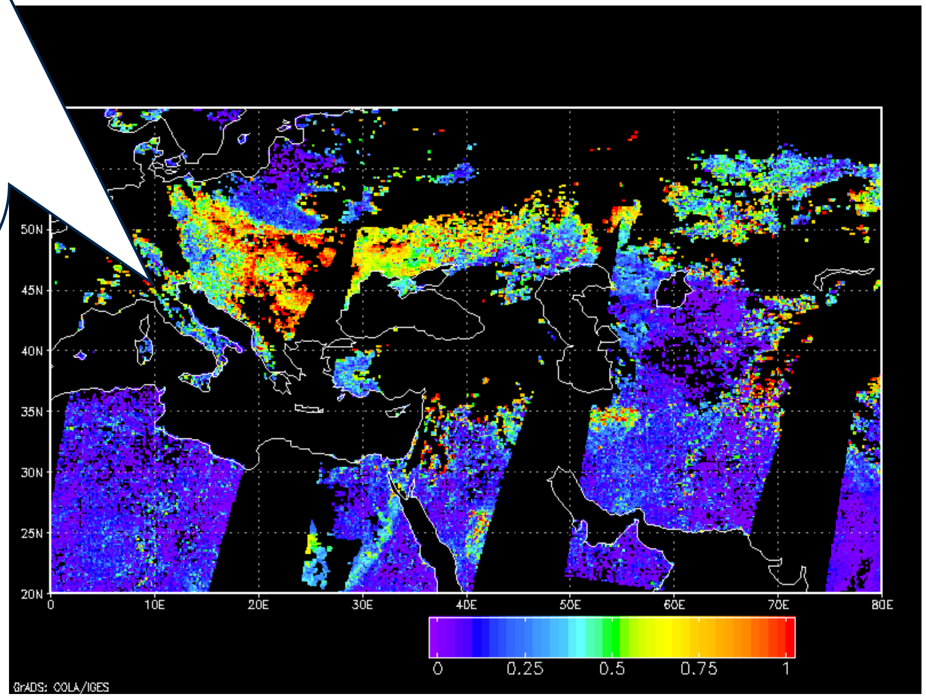
- **Objective**
  - **Correct for the effects of aerosols on spectral measurements of FTS**
- **Products**
  - **Optical thickness, single scattering albedo and phase function of each aerosol type**
- **Band character**
  - **band1(=0.38μm) is good for land aerosol retrieval**
- **GLI's heritage**
  - **drawing on its experience**



GLI result 1 (one day)



RGB True color

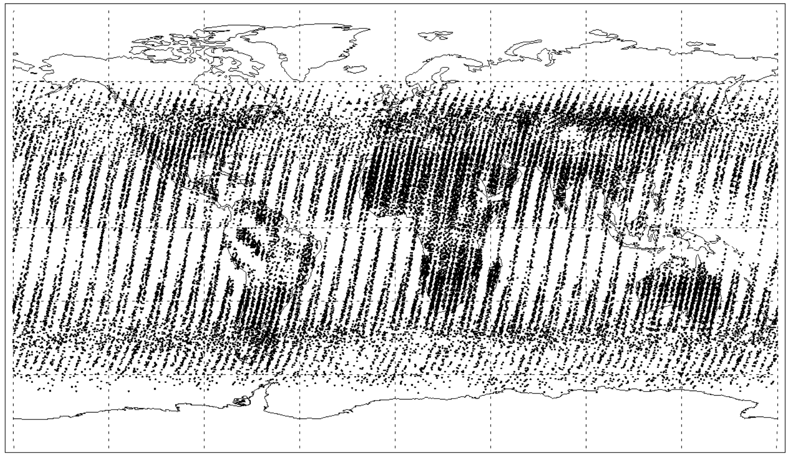


τ (550nm)

Apr. 25, 2003
Europe, North Africa, West Asia

LETKF-SPRINTARS
Aerosol Ensemble Assimilation

1) **FTS requires Aerosol optical thickness, even in sun-glint area**
2) **Use model calculations to fill in aerosol optical thickness for sun-glint area**
3) **Standard SPRINTARS model suffers from outdated emission inventories**
4) **Assimilation of CAI aerosol optical thickness observations leads to improved model prediction**



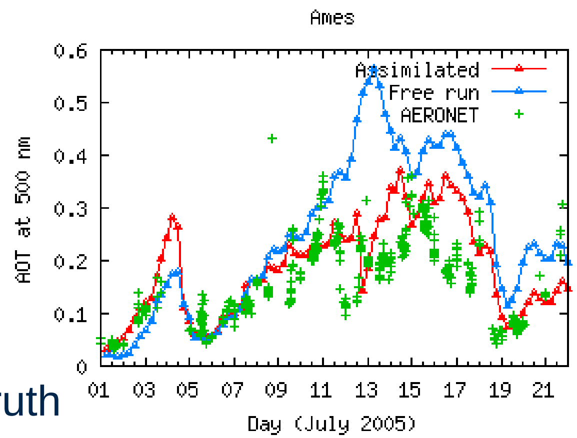
SPRINTARS: global aerosol model
LETKF: Local Ensemble Transform Kalman Filter
CAI: GOSAT Cloud Aerosol Imager

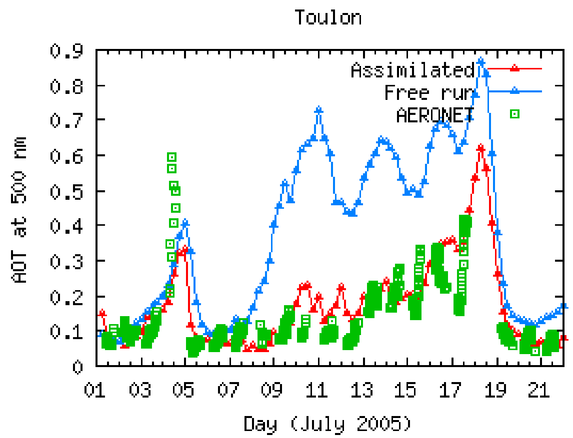
LETKF is applied to SPRINTARS by comparing model prediction to observations every 3 hours and adjusting the aerosol loads accordingly.

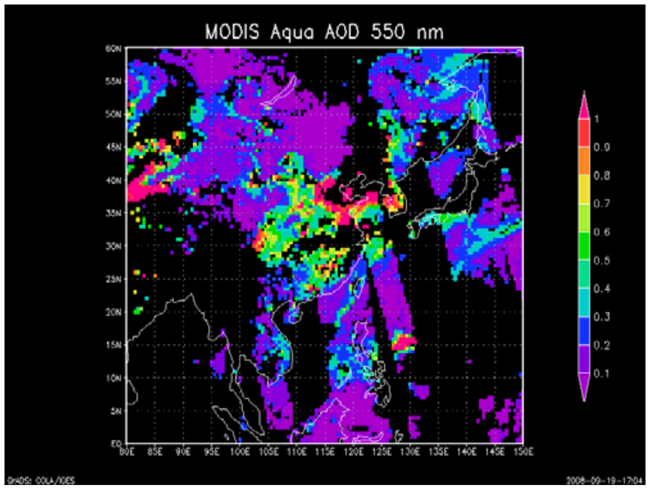
Experiment 1
Real QA lvl 2.0 AERONET Aerosol Optical Thickness

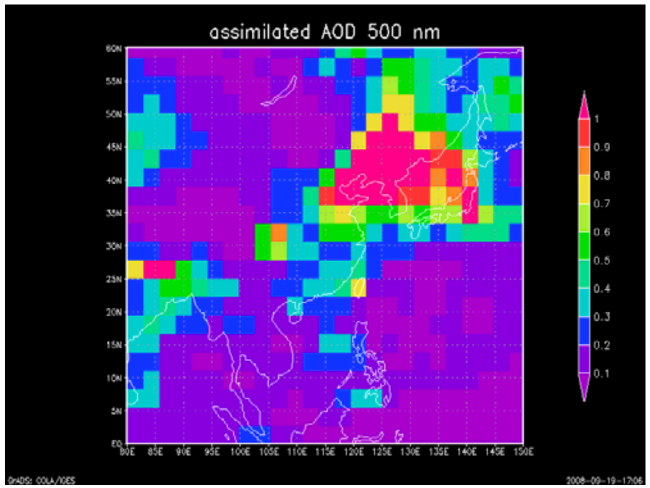
SPRINTARS assimilated real AERONET 675 nm Aerosol Optical Thickness. Results were validated with independent AERONET sites & MODIS.

1) Real test
2) Hard to define reference truth







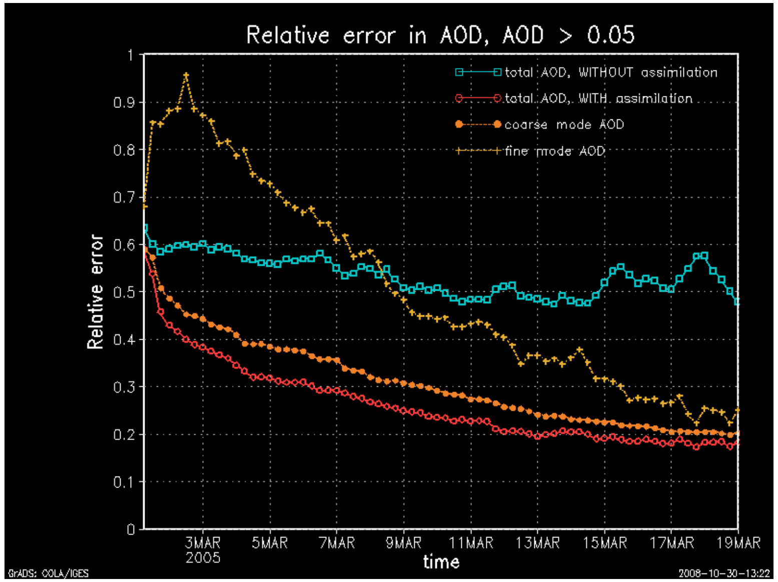


July 14, SE Asia

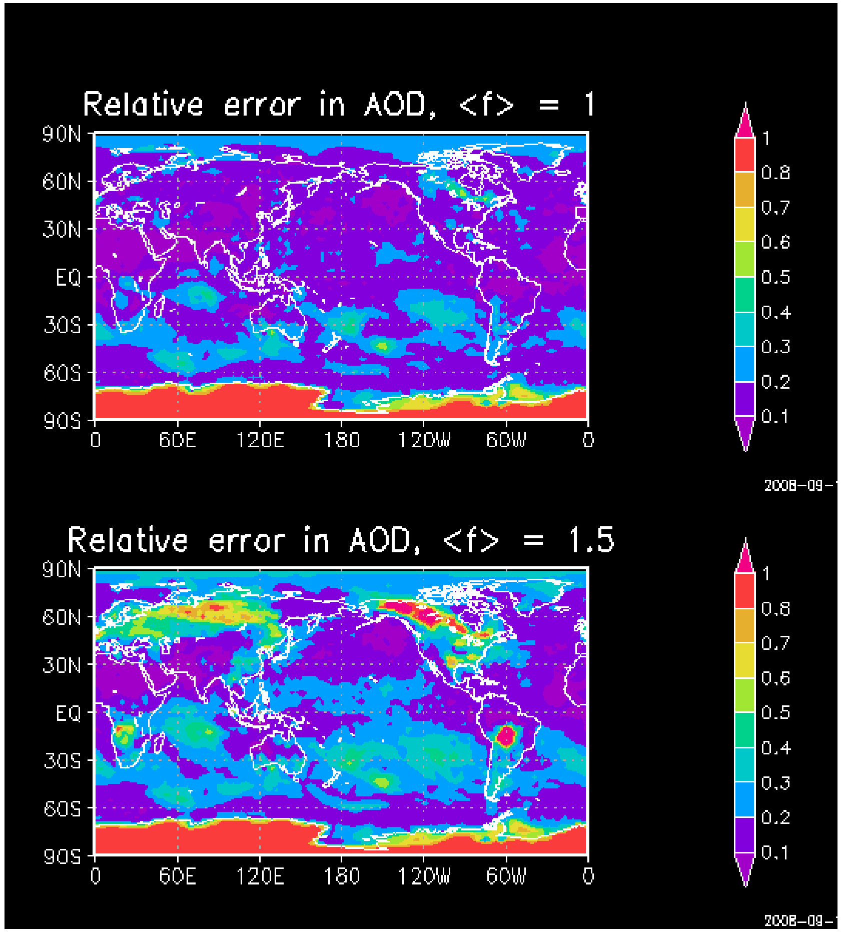
Experiment 2a & b
Simulated GOSAT Aerosol Optical Thickness

Here SPRINTARS assimilated simulated GOSAT CAI aerosol optical thickness at 675 nm. Results were easily validated with the known truth (assumed a-priori).

1) Perfect model experiment
2) Well-defined reference truth



Experiment with sulfate, carbon and sea-salt ensembles. Error is global average.



Experiment with sulfate & carbon ensembles. Error is 2-week average.