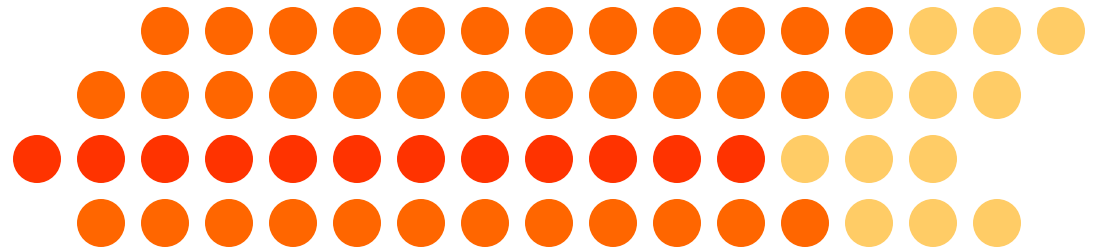# Overview - MRI/JMA
Asian Dust Simulation, Prediction, and Verification

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Contents

- Operational Dust Forecast of JMA

- MRI/JMA Data Assimilation Study
  - Ensemble Kalman Filter with Global Model
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- Future Work (EarthCARE, GCOM-C, etc)

Operational Dust Forecast of JMA

- Asian Dust

  (also known as "yellow sand" or "KOSA")

  – Seasonal phenomenon sporadically affecting East Asian countries during the springtime

  – Causes health and aviation problems

  – Originates in the deserts of Mongolia and China

JMA Dust Information (updated every 6hrs)

Operational Dust Forecast Model of JMA

- Current Status
 - Based on a global aerosol model (MASINGAR)
  - Aerosol observations are not assimilated to the forecast model AT ALL!
  - Only wind field (U & V), snow-cover rate, and SST analyses are assimilated.
  - Only dust aerosol is analyzed and forecasted; sulfate, sea-salt, carbonaceous aerosols are not included.
  - SYNOP (WMO weather report) is used to verify the performance of dust prediction.

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Global Aerosol Model (MASINGAR)

- The Model of Aerosol Species in the Global Atmosphere (MASINGAR) was developed by MRI/JMA.

- MASINGAR simulates dust (partitioned into 10-size bins), sea-salt, and sulfate aerosols.

- The meteorological field is assimilated with the JMA reanalysis (6-hourly).

- JMA is using the MASINGAR to operationally forecast Asian dust.
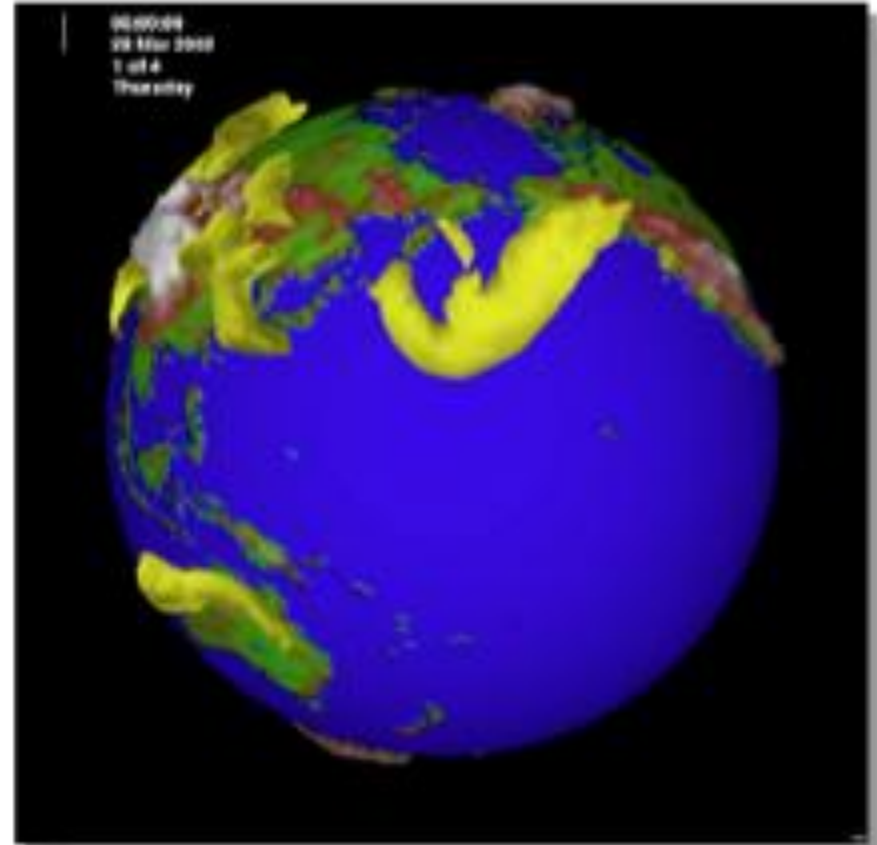
A snapshot of MASINGAR's dust simulation

MRI/JMA Data Assimilation Study

4-Dimensional Ensemble Kalman Filter

|	**4D-Var**	**4D-EnKF**
Background error statistics	Flow-dependent	Flow-dependent
Program code	Complicated	**Simple**
Adjoint matrix	Necessary	**Unnecessary**
Observation operator	Requires tangent linear & adjoint operators	**Requires only a forward transform operator**
Asynchronous observations	Handles at each observational time	Handles at each observational time
Analysis error covariance	Not provided	**Explicitly provided**

Available lidar data for EnKF assimilation

Ground-based lidar network (NIES AD-Net):
NIES Japan is operating more than 20 lidar stations in East Asia.
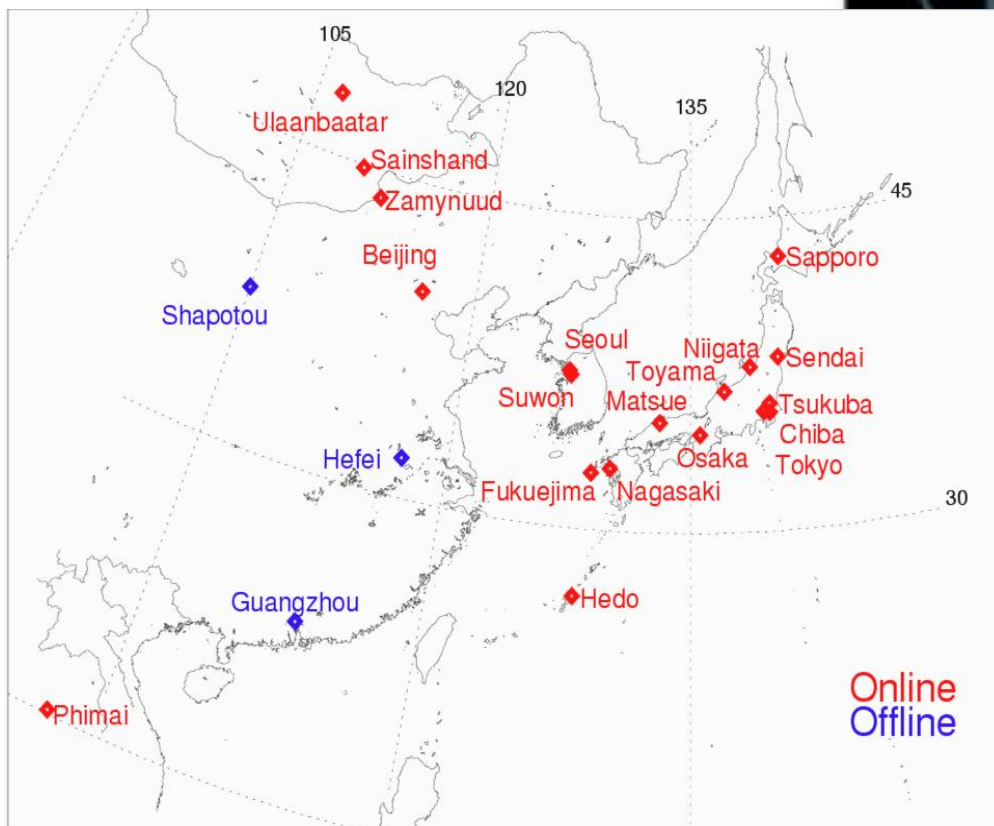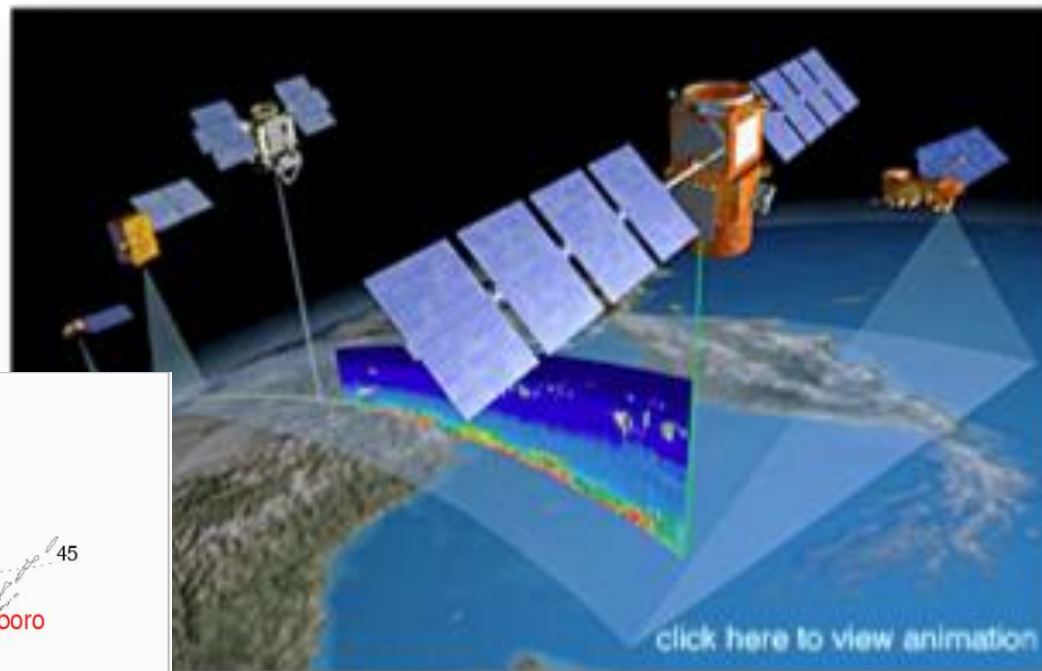
Satellite Lidar observation (CALIPSO/CALIOP):
The CALIPSO orbit has an about 1000 km longitudinal interval per day at mid-latitudes.

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Model Verification with independent lidar data

532nm extinction coefficients for non-spherical particles (≈ dust aerosol).

 The X-axis shows date in May 2007.

(**a**) Independent ground-based lidar observation;
(**b**) free model-run result without assimilation;
(**c**) data assimilation result with only CALIPSO observation.

10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} [m^{-1}]
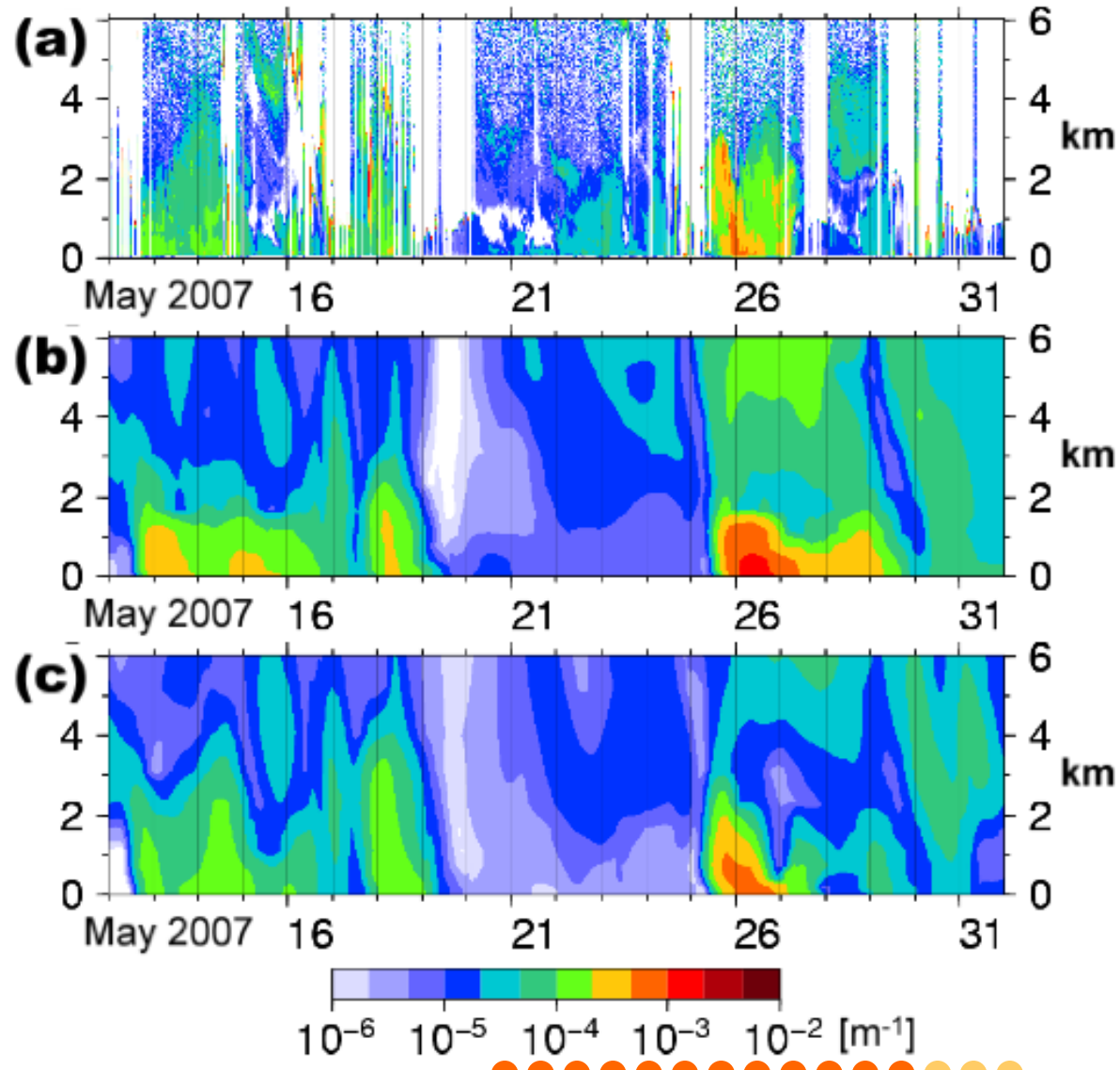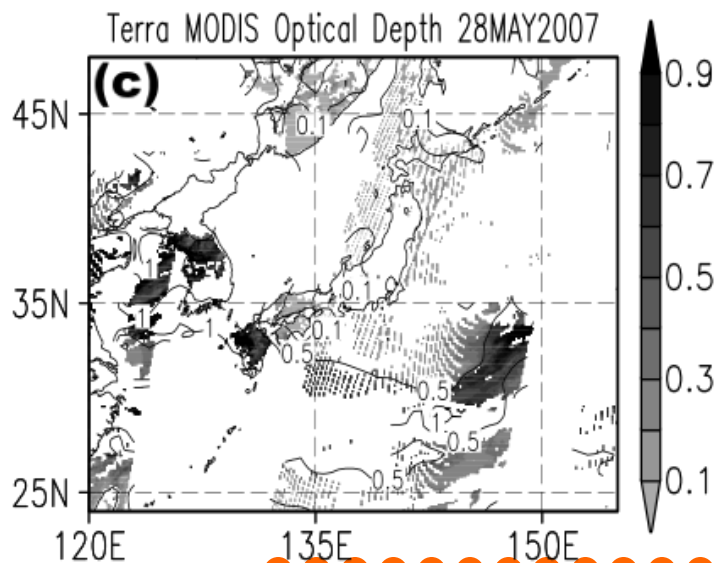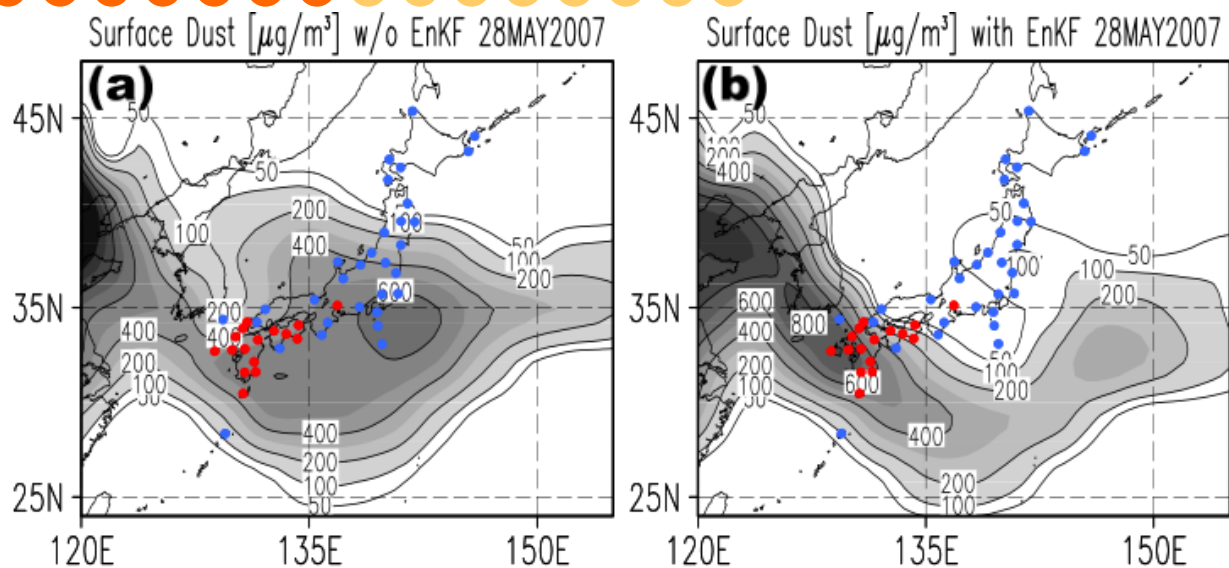
Model Verification with weather reports

Contours and gray shades are surface dust concentrations.

(a) Free model-run result without assimilation.
(b) CALIPSO data assimilation result.

Red and blue circles are weather stations. The Red ones observed aeolian dust on the day. Blue ones did not observe any dust events.

(c) MODIS optical Thickness on 28May07.

Surface Dust [μg/m³] w/o EnKF 28MAY2007

Surface Dust [μg/m³] with EnKF 28MAY2007

Terra MODIS Optical Depth 28MAY2007

Threat Score estimated by SYNOP

Model Verification with weather report

SYNOP:

WMO weather report (dust exists or not)

Model Result:

(CALIPSO-Assimilated) with a threshold $100 \mu gm^{-3}$

(4) Convert to the 1.25° × 1.25° grid resolution **[Fig. d]** same as the SYNOP conversion, using an arbitrary threshold.

(4) Compare these two gridded results **(b)** and **(d)**, and calculate threat scores.

(3) Model or forecast results of surface dust concentration on the same time **[Fig. c]**.

(1) For the grids that **observed** (or (2) Convert this SYNOP information to 1.25° × 1.25° grid resolution. **[Fig. b]** say 1 if it occurred SYNOP (WMO's surface synoptic observations) data in Japan, South Korea, North Korea, and Taiwan. **[Fig. a]**

Model Verification with weather report

- Calculation of *Threat Score*
  - *Threat score* is defined as:

    $$TS = C / (F + O + C)$$

    where F is the area "dust-forecasted (missed)", O is the area "dust-observed (missed)", and C is the "correct" area where the dust forecast for a given threshold overlaps with the dust-observed area.
  - Threat Score is generally used to qualify weather prediction performance for rare phenomena.
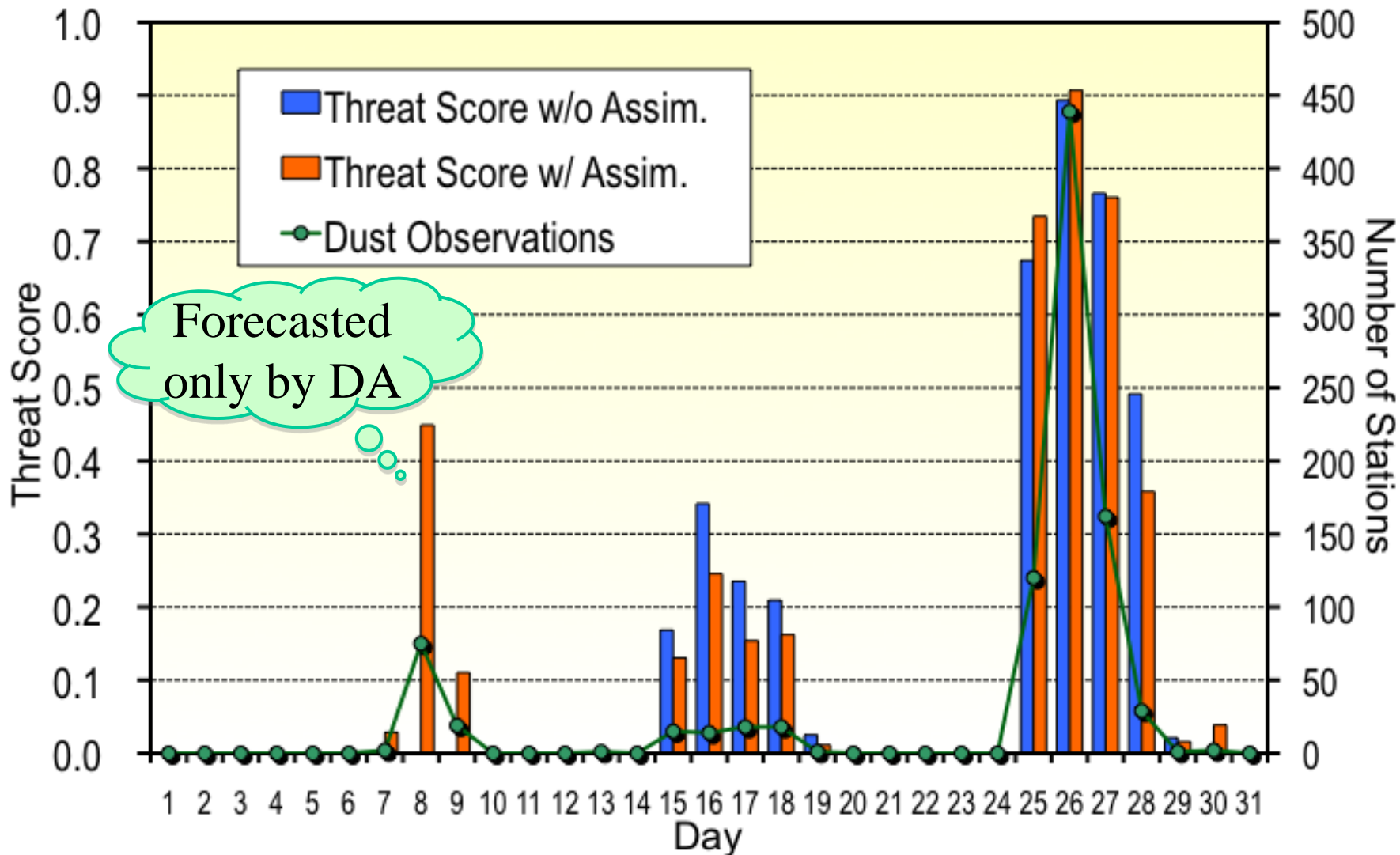   - The score ranges between 0 [worst] and 1 [perfect].

Model Verification with weather report
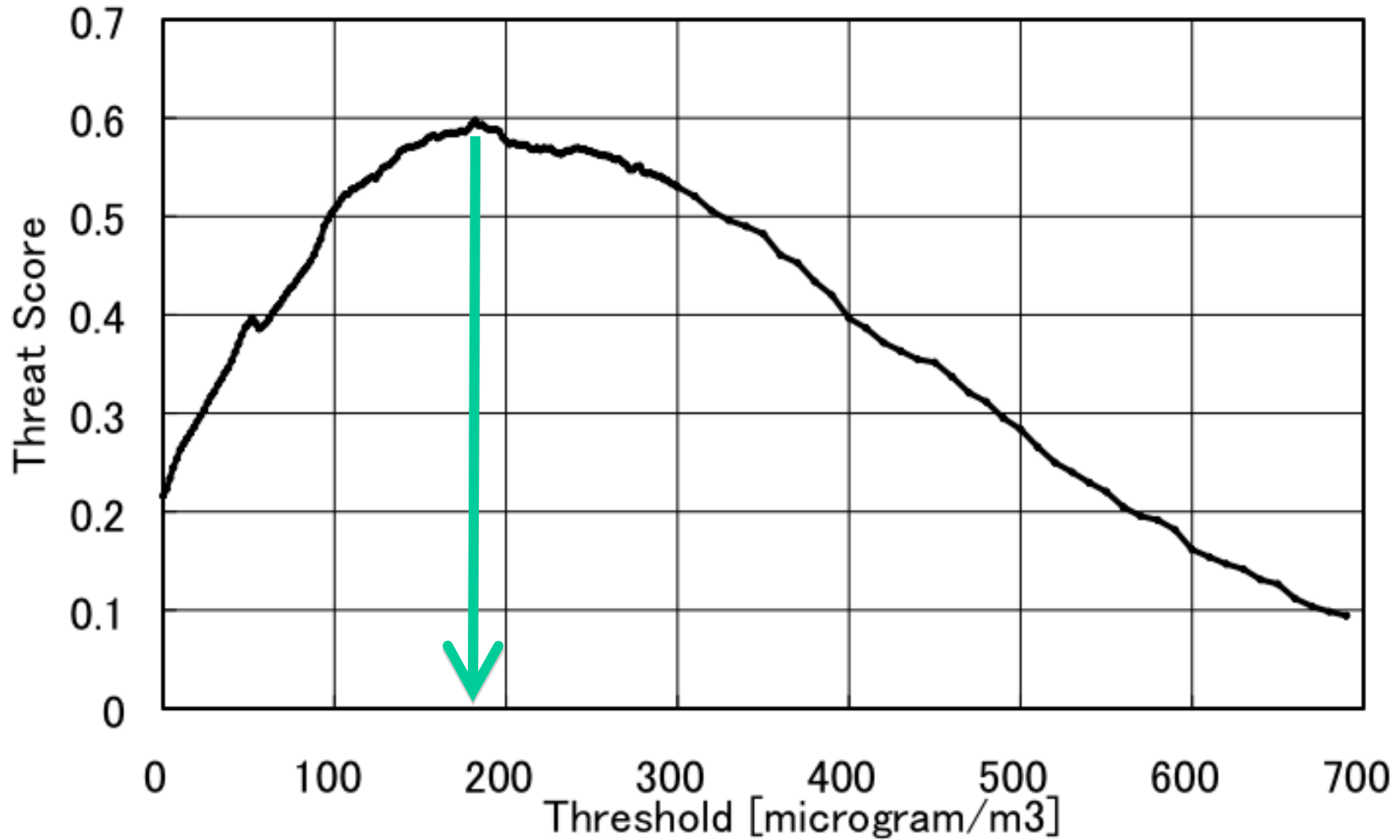
Monthly mean of threat score in May 2007 (1-day forecast)

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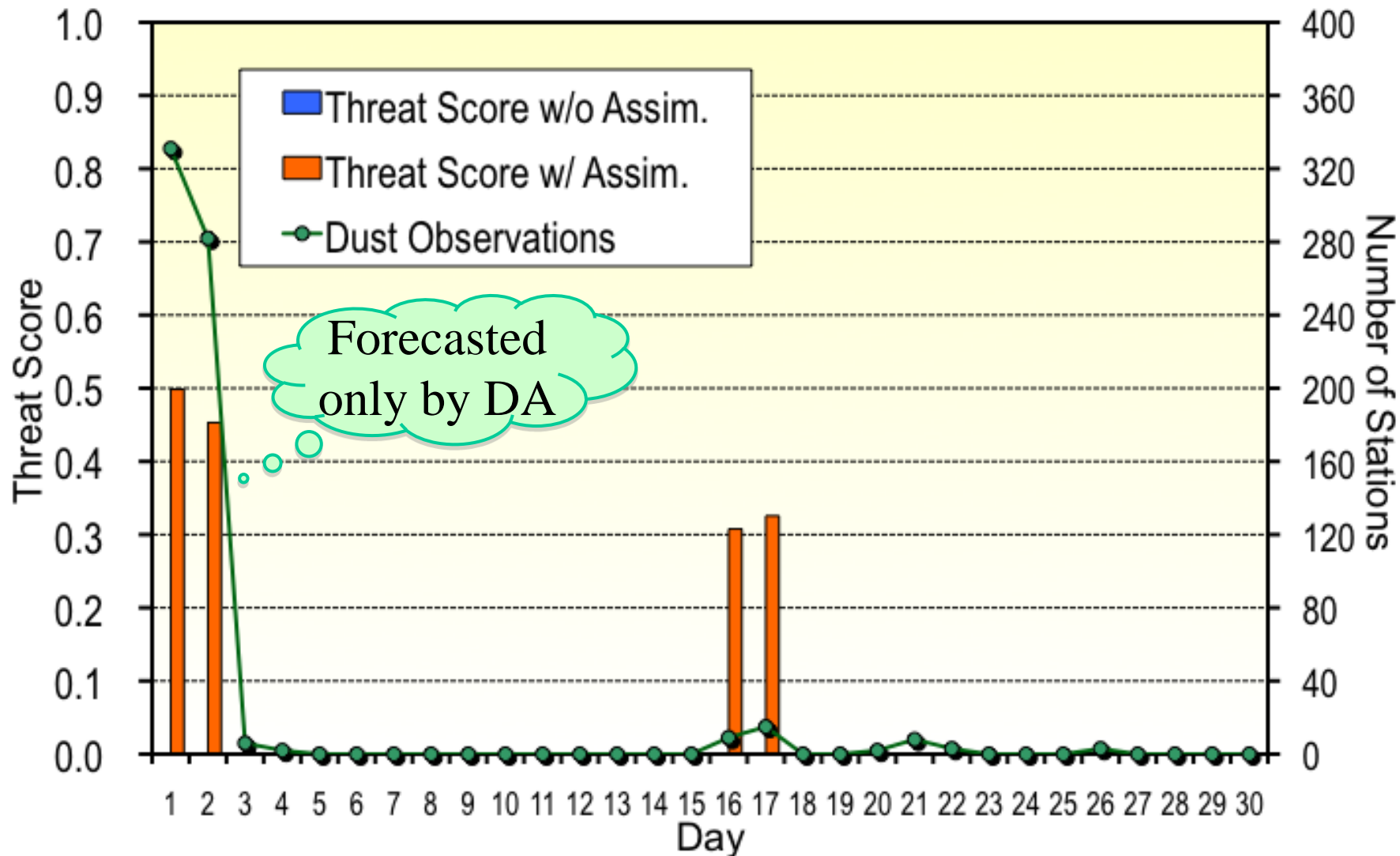# Model Verification with weather report

1-day forecast score in May 2007

Model Verification with weather report

1-day forecast score in April 2007

Future Work

- *To be operational*
  - EnKF data assimilation system for aerosol prediction is going to be operational in 2012 by JMA.

- *Use other satellites launched by JAXA*
  - **GOSAT/TANSO-CAI** (in operation, but their aerosol product not yet open)
  - **EarthCARE** (to be launched in 2013)
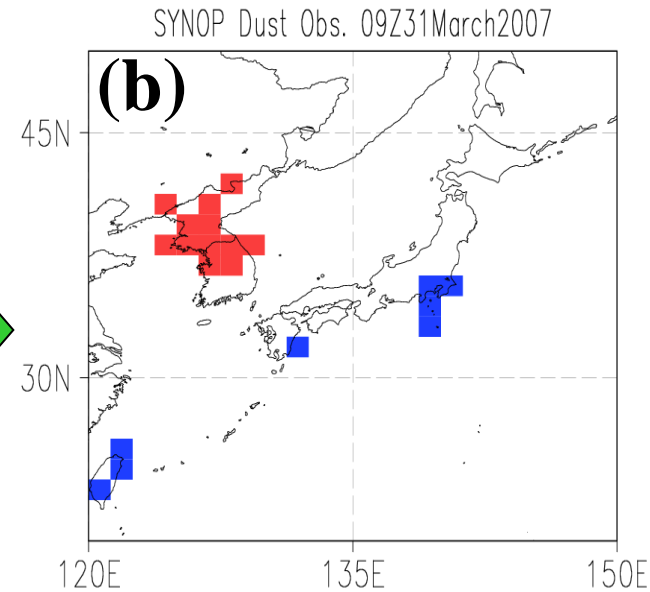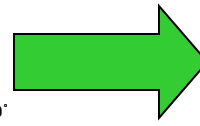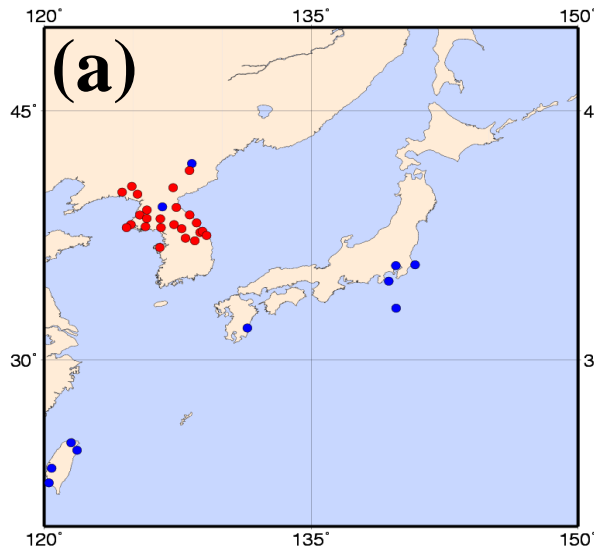 - **GCOM-C** (to be launched in 2014)

Thank you for your attention.
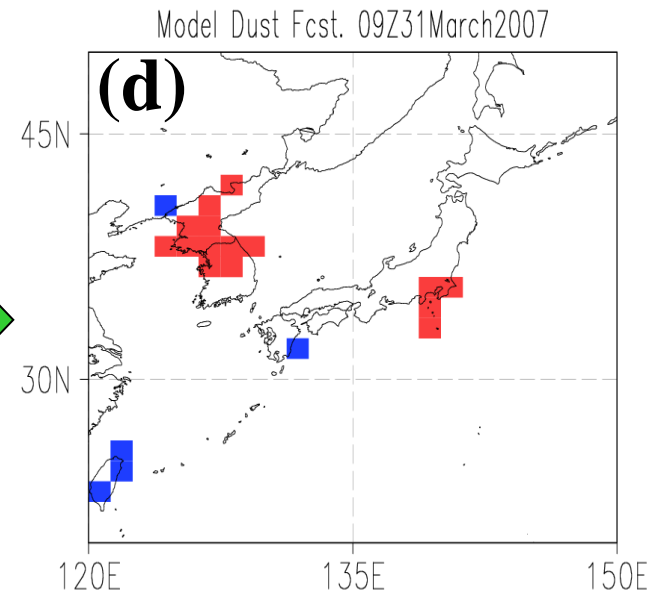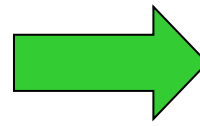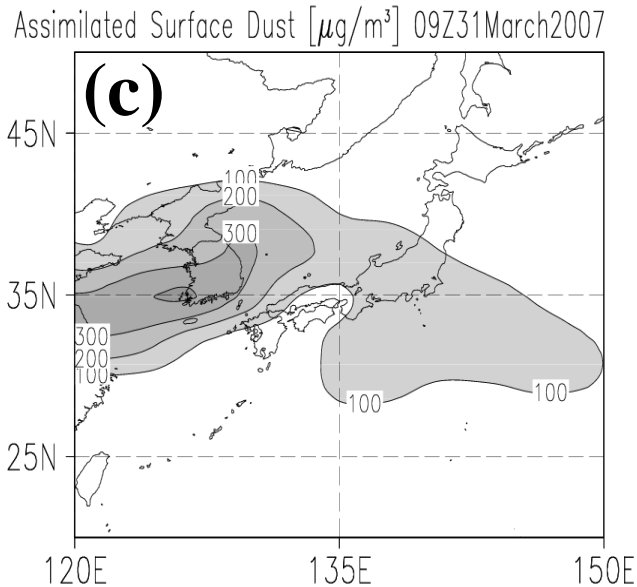
Model Verification with weather report

SYNOP:

WMO weather report (dust exists or not)

(a)

(b) SYNOP Dust Obs. 09Z31March2007

Model Result:

(CALIPSO-Assimilated) with a threshold 100μgm^{-3}

(c) Assimilated Surface Dust [μg/m³] 09Z31March2007

(d) Model Dust Fcst. 09Z31March2007

Model Verification with weather report

(1) Extract all the stations that observed (or surely does not observe) dust events, from every 3-hour SYNOP (WMO surface synoptic observations) data in Japan, South Korea, North Korea, and Taiwan. **[Fig. a]**

(2) Convert this SYNOP information to 1.25° × 1.25° grid resolution. **[Fig. b]**

(3) Model or forecast results of surface dust concentration on the same time **[Fig. c]** are converted to the 1.25° × 1.25° grid resolution **[Fig. d]** same as the SYNOP conversion, using an arbitrary threshold.

(4) Compare the results of (2) and (3), calculating threat scores.