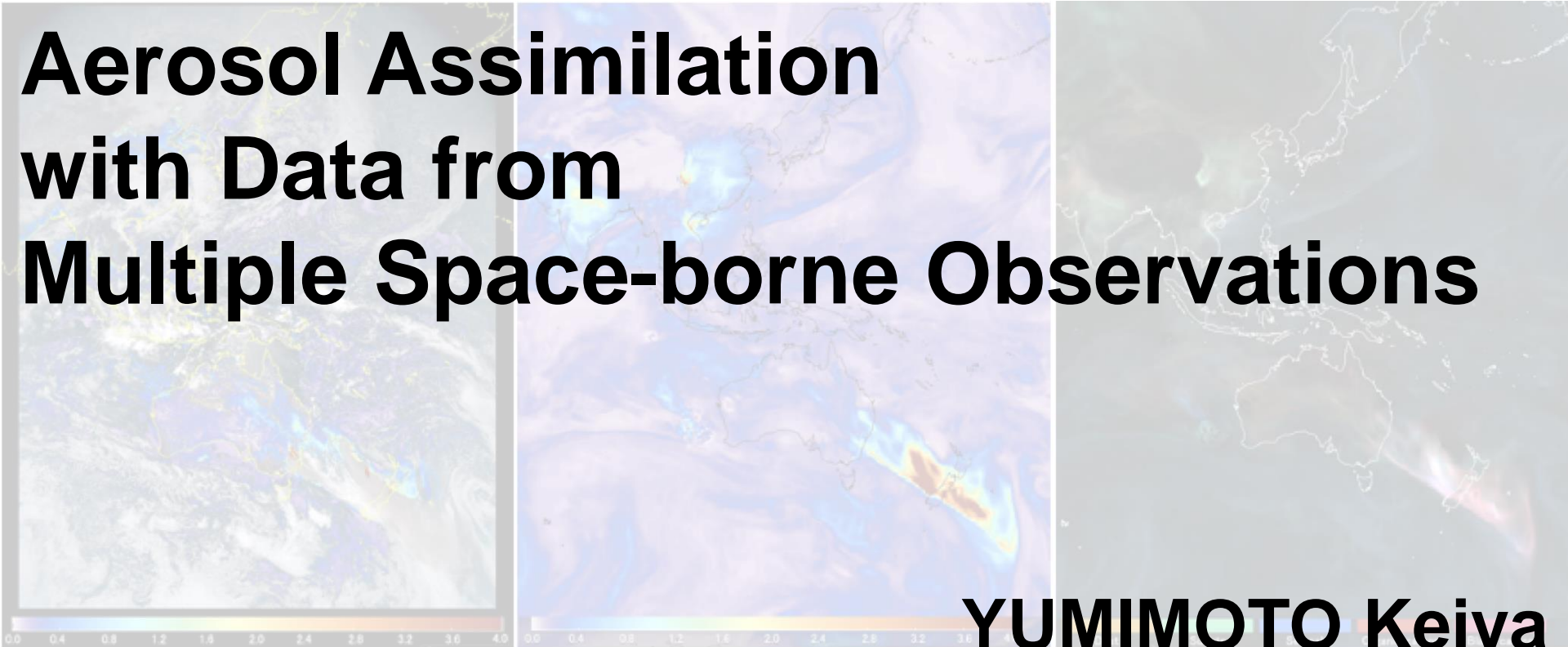# Aerosol Assimilation with Data from Multiple Space-borne Observations

YUMIMOTO Keiya

Research Institute for Applied Mechanics (RIAM), Kyushu University

TANAKA Taichu Y., MAKI Takashi

MRI, JMA

MURAKAMI Hiroshi, TANADA Kazuhisa

EORC, JAXA

YOSHIDA Mayumi, KIKUSHIMA Mirai

RESTEC
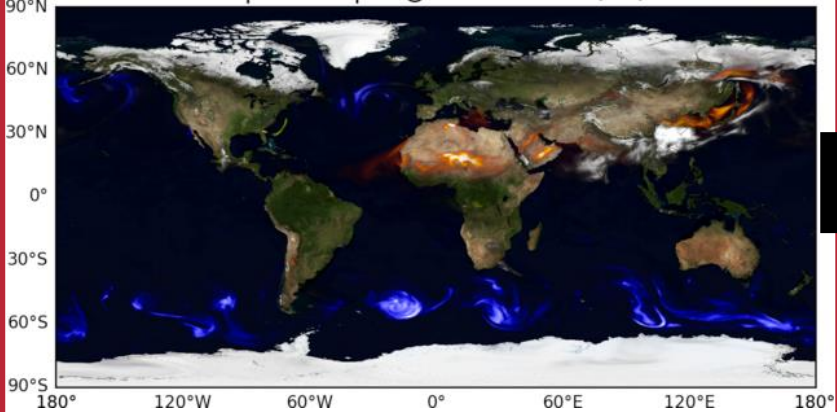
NAGAO Takashi

AORI, Tokyo Univ.

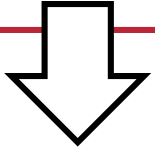# Aerosol assimilation/forecasting system in Japan

[Pilot system]
(Dust, sea salt, BC, OC, sulfate)

Aerosol Optical Depth @550nm : 2017/05/07 00:00

New version of model and DA method
New observation data for DA

[Operational system]
(Asian dust only)
Asian aeolian dust prediction by JMA

Analyzed surface concentration for 09:00 JST, 7 May 2017

Surface concentration

High

Low

(http://www.jma.go.jp/en/kosa)

[Development and Research use]

[JAXA Himawari monitor]
Monitoring and data archive

[ICAP* *International Cooperative for Aerosol Prediction* **]**
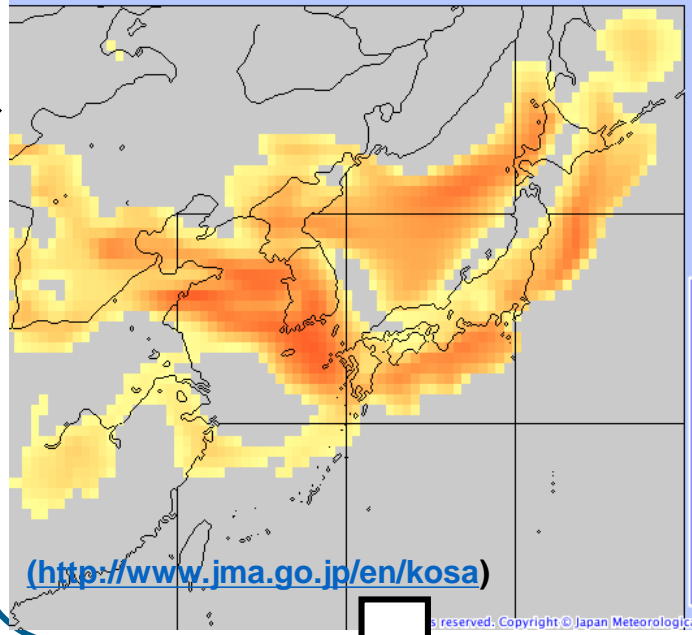Monitoring and inter-comparison

[JRAero]
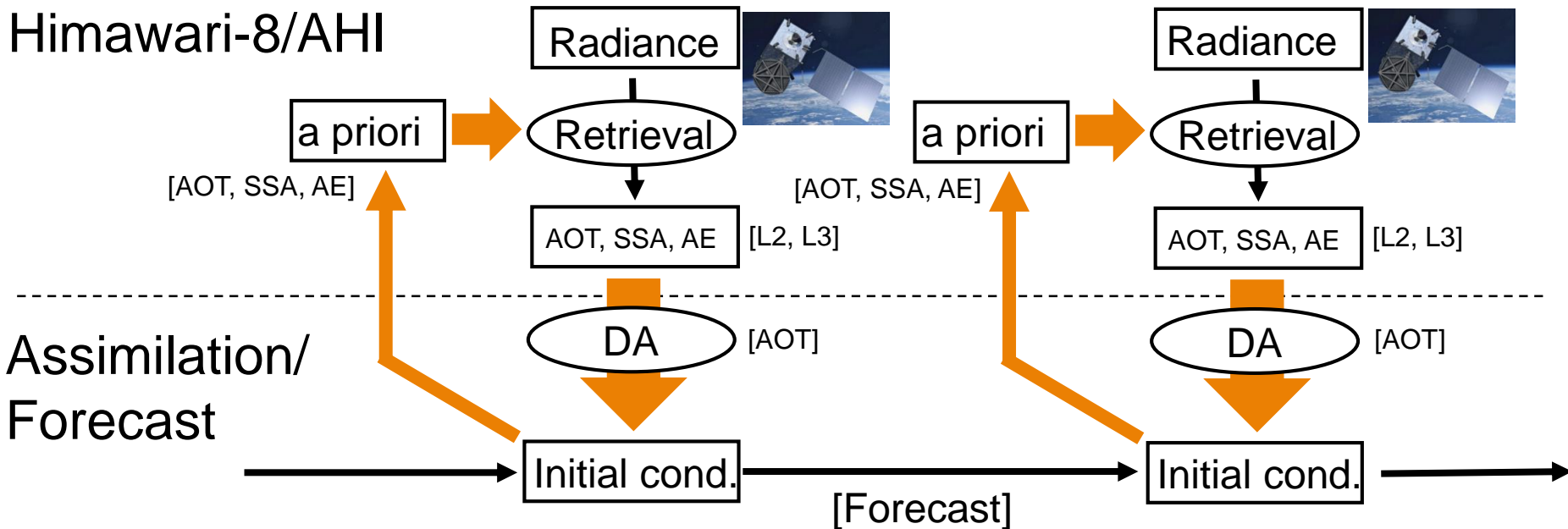Japanese Reanalysis for Aerosol

[Public use]

[Aeolian dust advisory]
[WMO SDS-WAS Asian Node]

The prediction results are also provided for private weather services and local government via the Japan Meteorological Business Support Center (JMBSC) in GRIB2 format.

Retrieval – DA – Forecast cycle system

Himawari-8/AHI

Radiance

a priori	→	Retrieval

[AOT, SSA, AE]

AOT, SSA, AE	[L2, L3]

Radiance

a priori	→	Retrieval

[AOT, SSA, AE]

AOT, SSA, AE	[L2, L3]

Assimilation/ Forecast

DA [AOT]

DA [AOT]

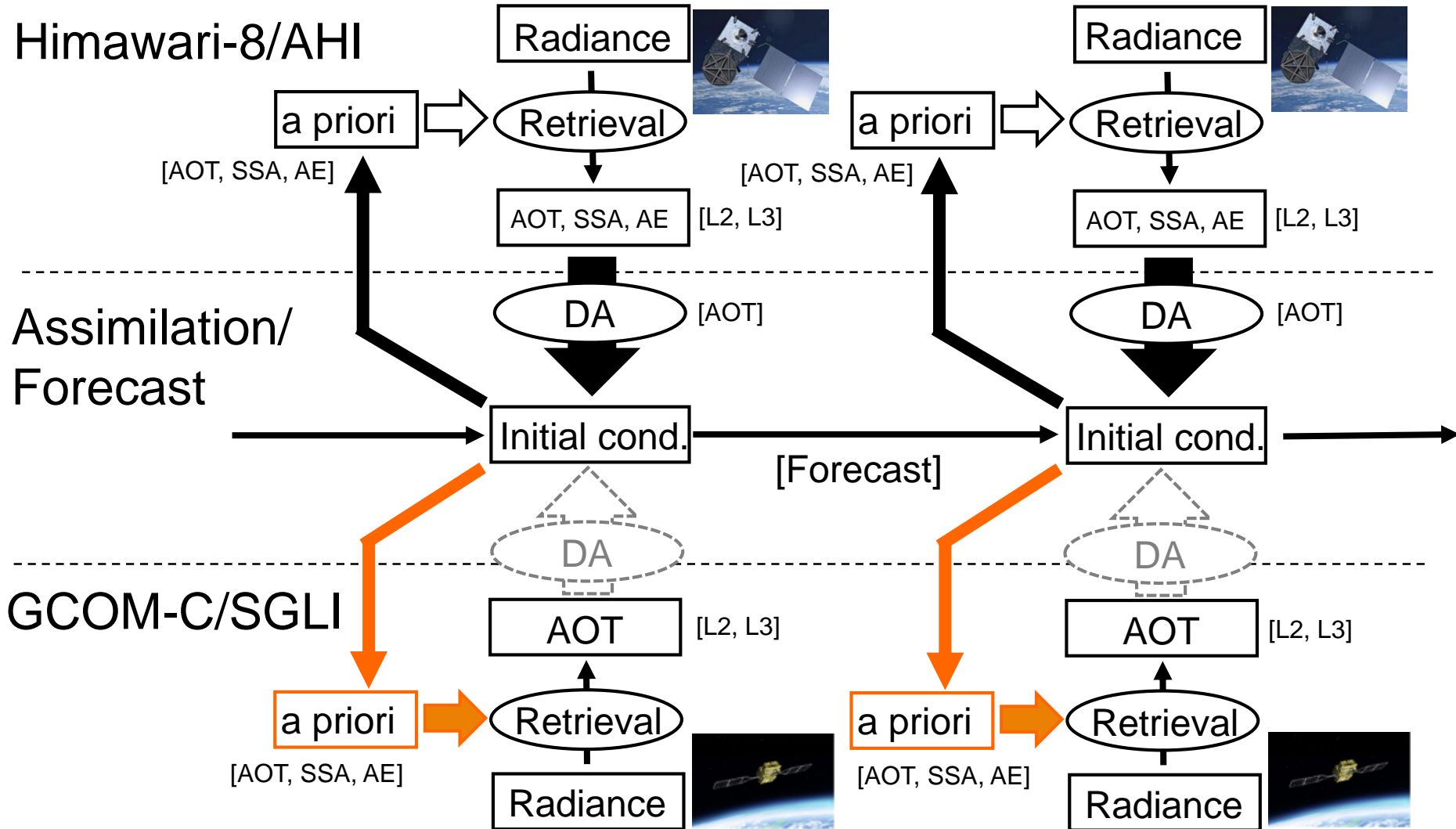| Initial cond.	→	Initial cond.

[Forecast]

Retrieval – Data Assimilation – Forecast cycle system is in operation.

Retrieved AOTs are injected to the forecast through data assimilation

Forecasted AOTs are fed backed to the AHI retrieval as a priori

- ・ Retrieval can use realistic a priori AOT instead of climate (constant) AOT value.
- ・ Observed information can be propagated to future retrieval through DA/FC.
→ Better accuracy in both retrieval and forecast.

Retrieval – DA – Forecast cycle system

Himawari-8/AHI

Radiance

a priori → Retrieval
[AOT, SSA, AE]

AOT, SSA, AE [L2, L3]

Assimilation/ Forecast

DA [AOT]

Initial cond.

[Forecast]

DA

GCOM-C/SGLI

AOT [L2, L3]

a priori → Retrieval
[AOT, SSA, AE]

Radiance

Radiance

a priori → Retrieval
[AOT, SSA, AE]

AOT, SSA, AE [L2, L3]

DA [AOT]

Initial cond.

DA

AOT [L2, L3]

a priori → Retrieval
[AOT, SSA, AE]

Radiance

Now, forecasted AOTs are used to SGLI retrieval as a priori!

But, SGLI AOTs are NOT used to data assimilation, yet.

Three development directions

- Assimilation with **MULTIPLE** space-borne Imagers
  - Horizontal coverage
  - Himawari/AHI (GEO) + GCOM-C/SGLI (LEO)

  ← To include SGLI into the cycle.
  ← To obtain wider data coverage and reduce uncertainty.

- Assimilation with **MULTIPLE** space-borne platforms (+ **Lidar**)
  - Vertical profile
  - Himawari/AHI (Imager) + CALIOP/CALIPSO (Lidar)

  ← To include vertical profile (the imagers cannot provide) into DA.

- Assimilation with **MULTIPLE** variables
  - Aerosol Optical Characteristics
  - AOT + Single Scattering Albedo (AAOD)

Vertical profile

Horizontal coverage

Aerosol characteristics
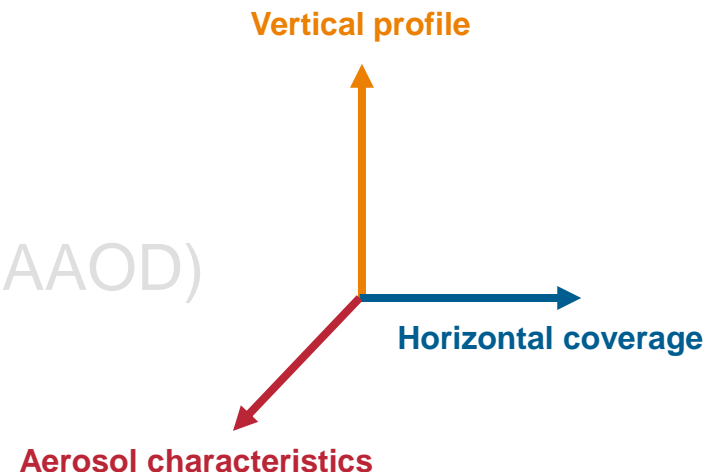
Assimilation with **MULTIPLE** Imagers

Integrate AOTs from GEO and LEO into one composite → DA
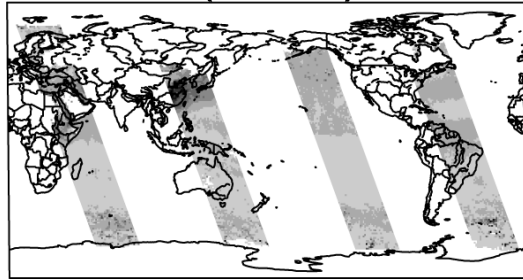
H08/AHI
(GEO)
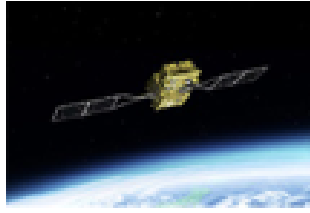
GCOM-C/SGLI
(LEO)

Composite product

+

→
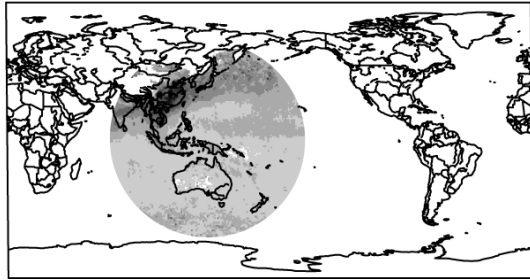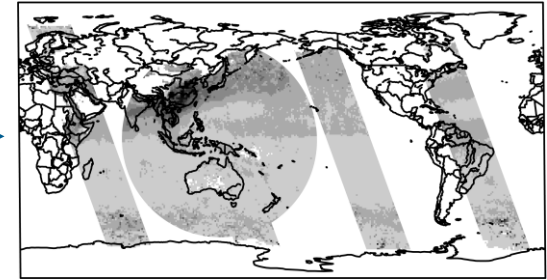
- Increase data coverage (especially on land areas)
- Reduce observation error

- Make QA/QC in the composite process
- The composite product is useful to not only data assimilation but also aerosol research and monitoring
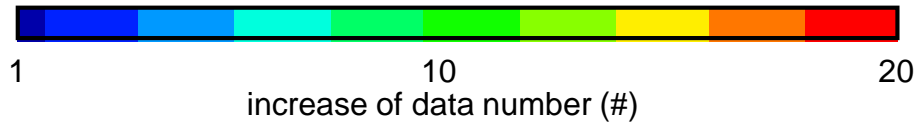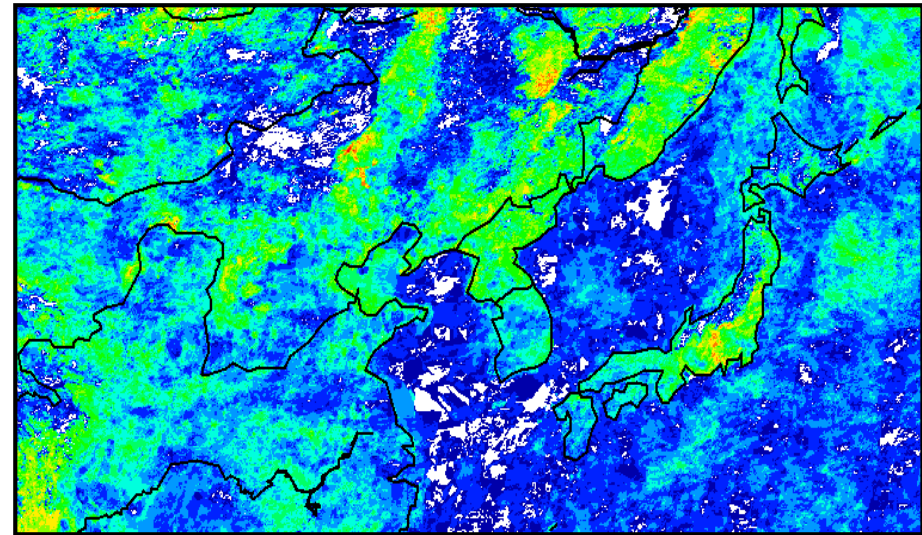
Assimilation with **MULTIPLE** Imagers

Monthly number of AOT data count in AHI (left) and its increase in Composite (right) (March 2022)

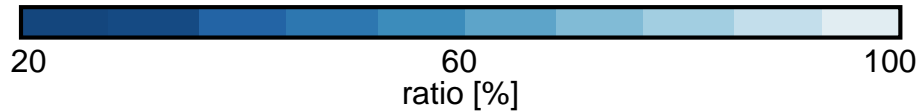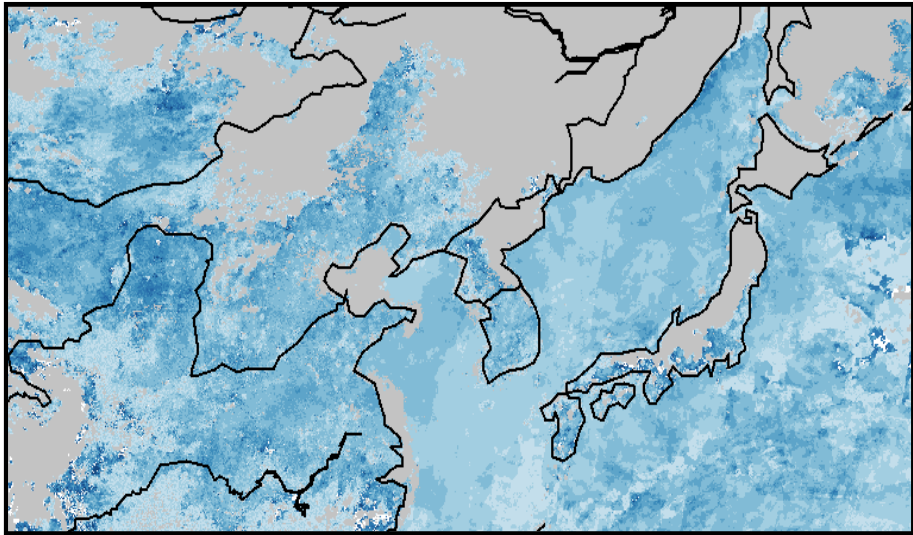Monthly data count (AHI)
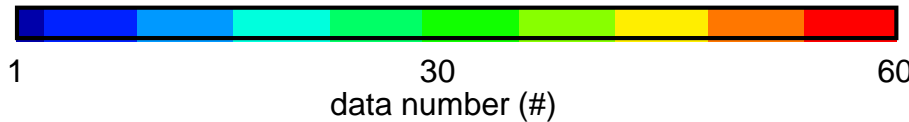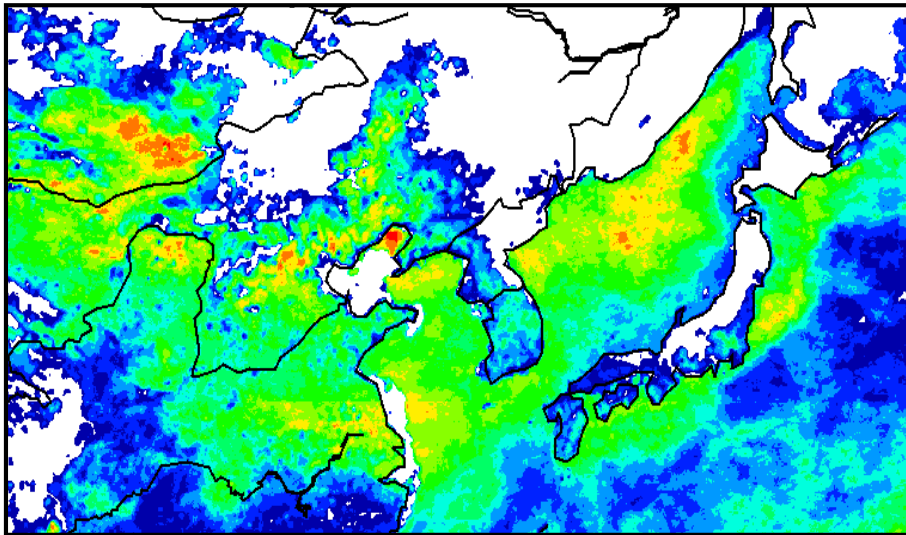
Increase in Composite

- More observation data on land area.
- SGLI covers an area where AHI has no observation.

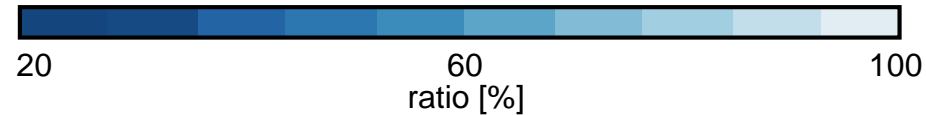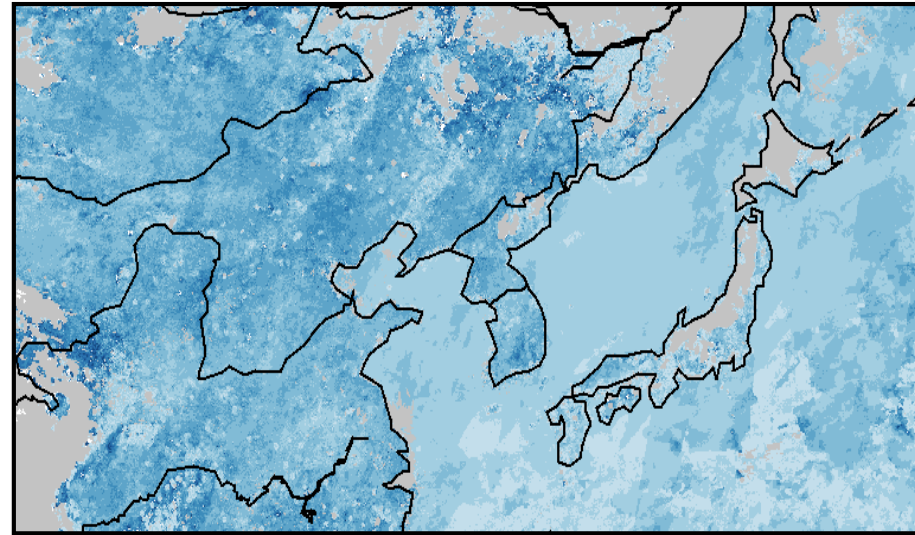# Assimilation with **MULTIPLE** Imagers

Monthly average of rate of uncertainty of Composite AOT to AHI AOT

$$\frac{\varepsilon_{Composite}}{\varepsilon_{AHI}}$$
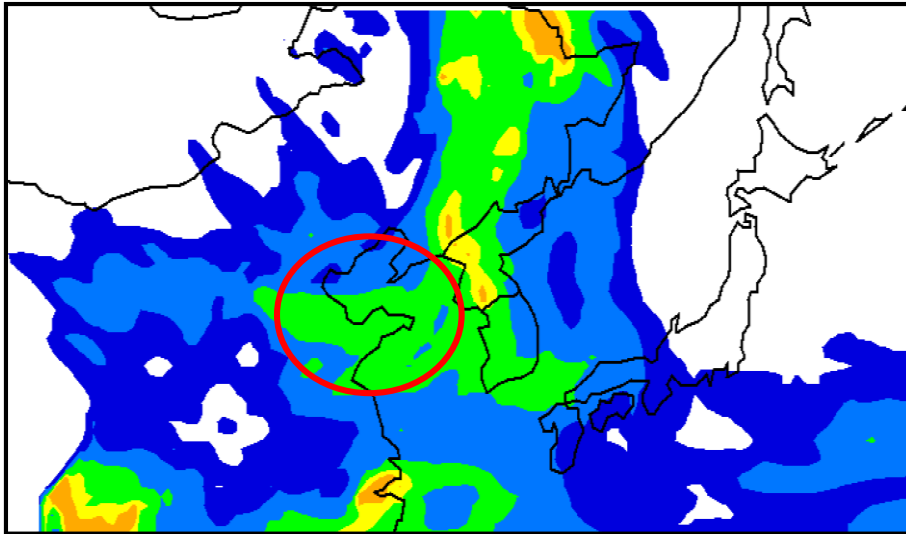
March 2022

April 2022

20   60   100
ratio [%]

20   60   100
ratio [%]

- Composite reduced uncertainties across the entire area.
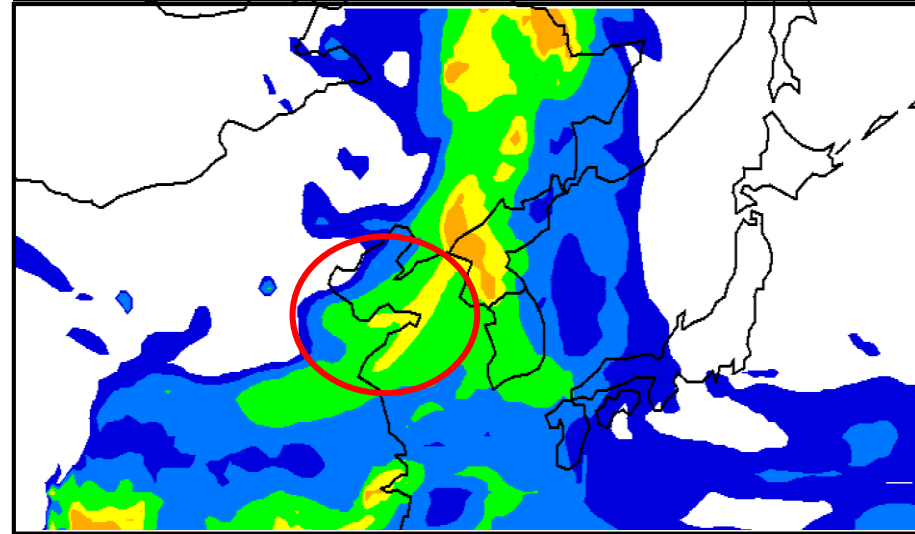- Tends to reduce uncertainties more on land area.

Assimilation with **MULTIPLE** Imagers

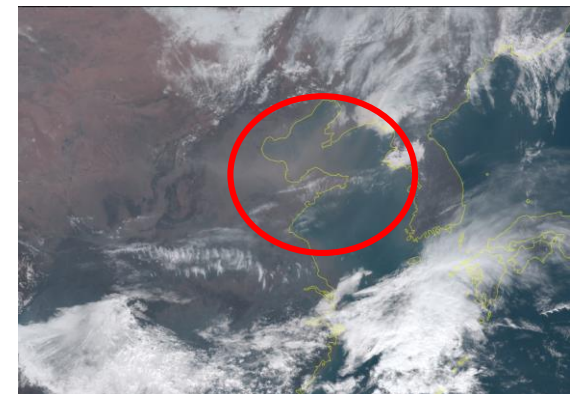Assimilation experiment for Asian dust storm in March 2022

AHI only
(20220304 03UTC)

Composite (AHI+SGLI)
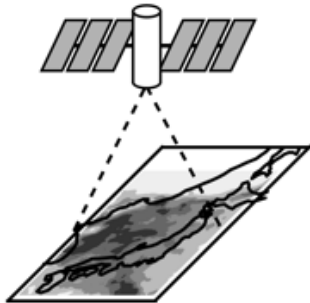(20220304 06UTC)

AOT

Himawari-8 RGB

- Further refinement of uncertainty estimation
- Perform long-term assimilation/forecasting experiment and evaluate impact on satellite retrievals
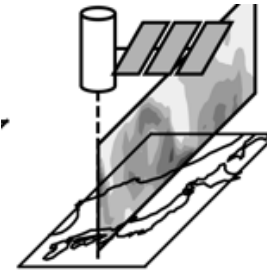
Assimilation with **MULTIPLE** platforms

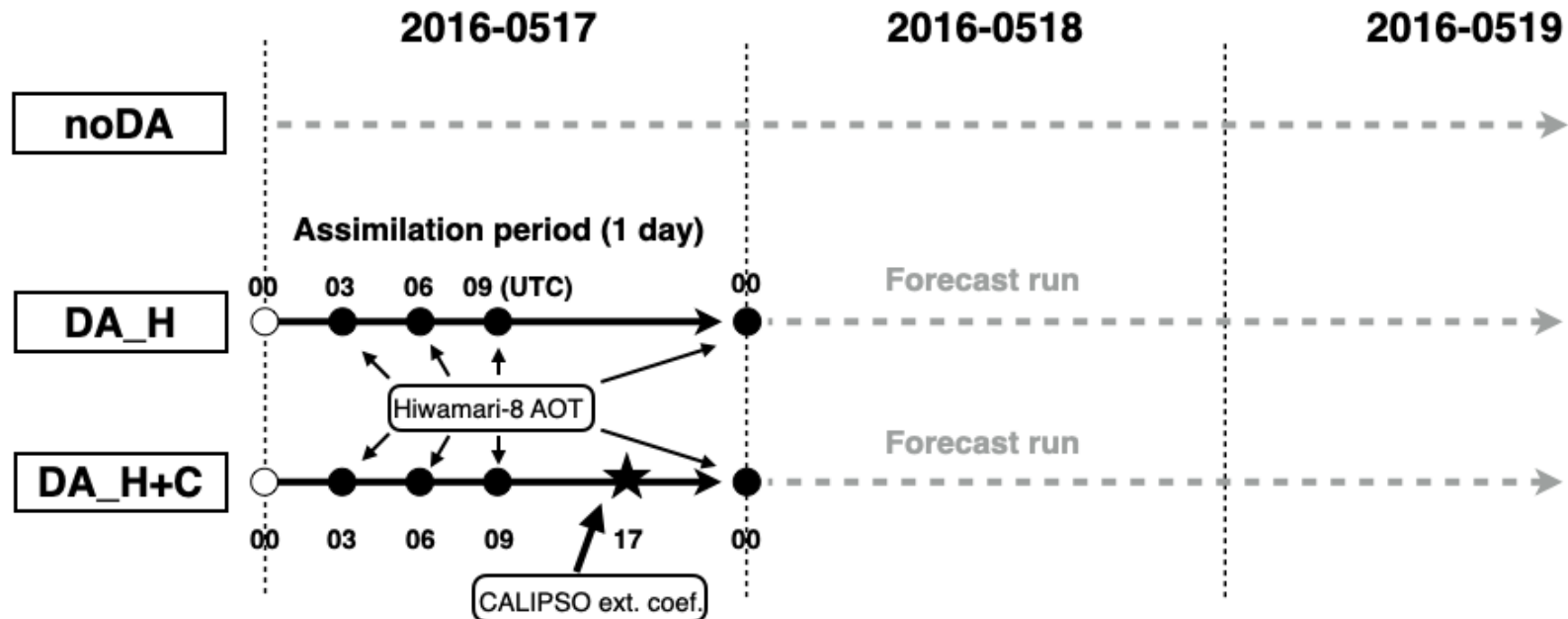Imager data does not include vertical information

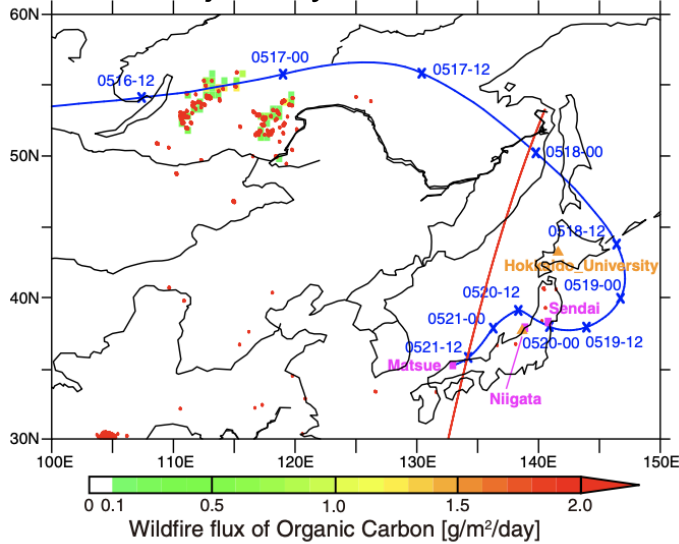H08/AHI (Imager)   CALIOP/CALIPSO (Lidar)

+

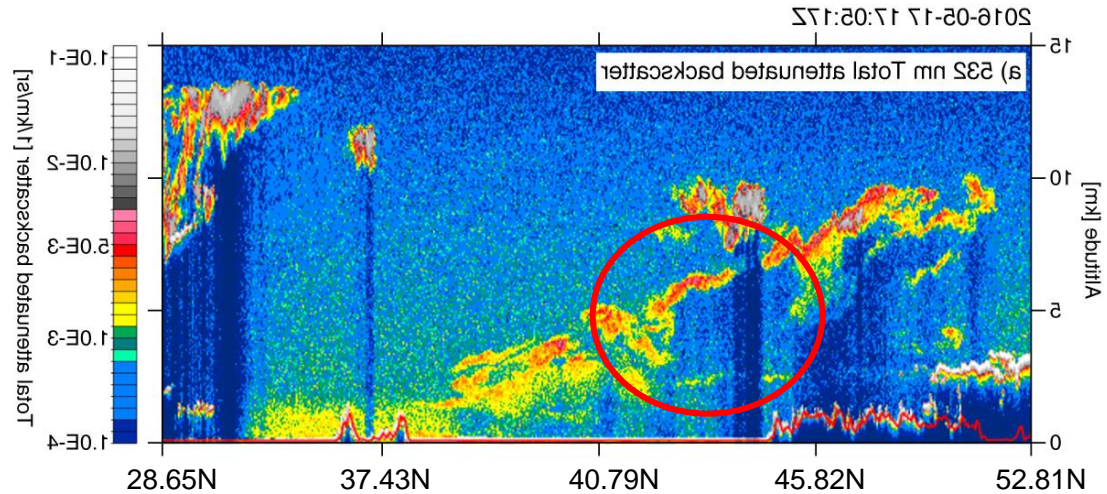Siberian wildfire smoke case in 2016

- Imager AOT and Lidar Extinction often "conflict" each other.
- Daytime Lidar data is "noisier" compared with nighttime.

Assimilation with **MULTIPLE** platforms

Trajectory of smoke

Wildfire flux of Organic Carbon [g/m²/day]

CALIPSO total attenuated backscatter

a) 532 nm Total attenuated backscatter

2016-05-17 17:05:172

Extinction coef. (DA_H, AHI only)
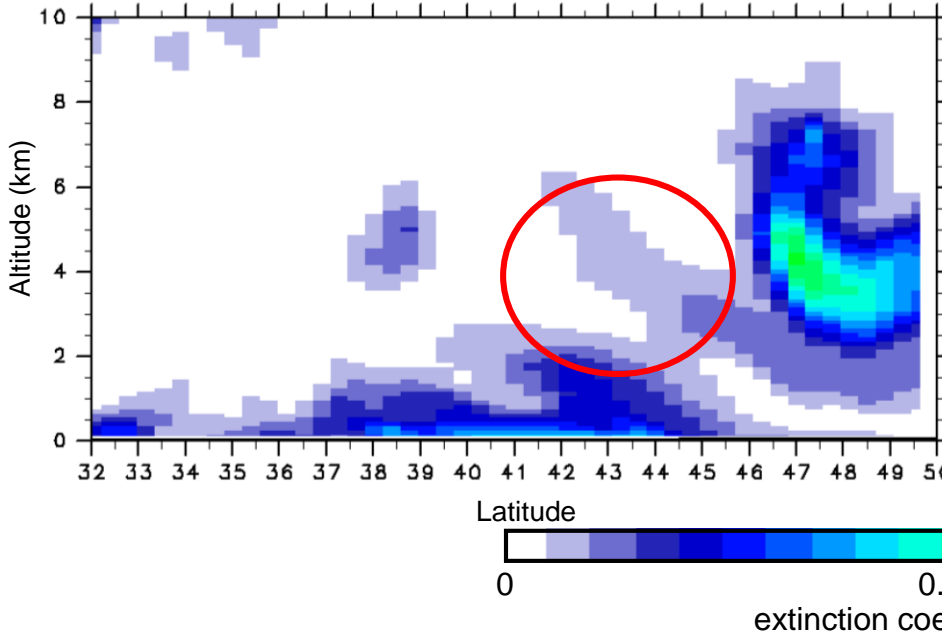
Extinction coef. (DA_H+C, AHI + CALIPSO)

extinction coefficient [1/km]
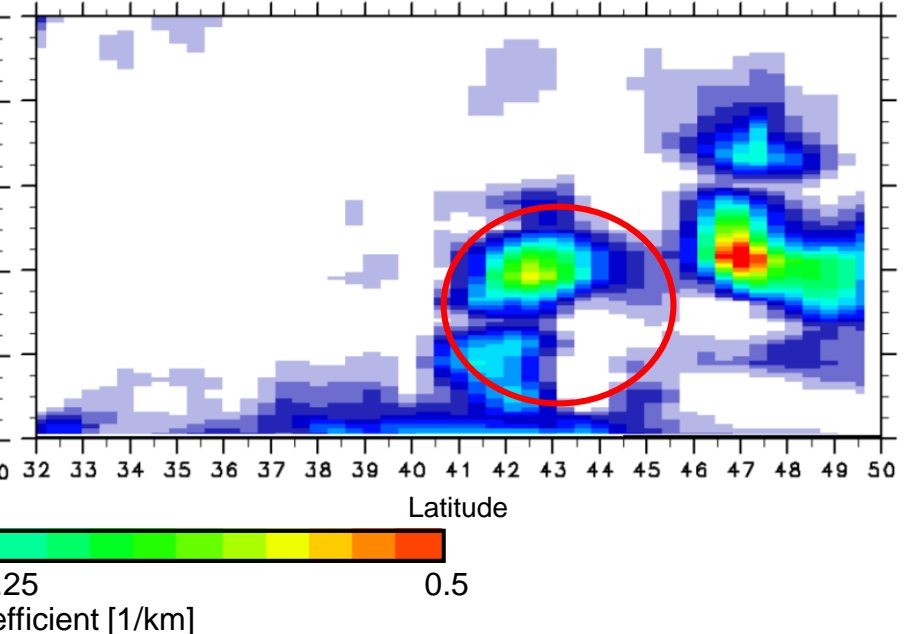
Assimilation with **MULTIPLE** platforms

AOD distribution before and after CALIPSO DA

a) before CALIPSO DA   b) after CALIPSO DA   c) incremenrt

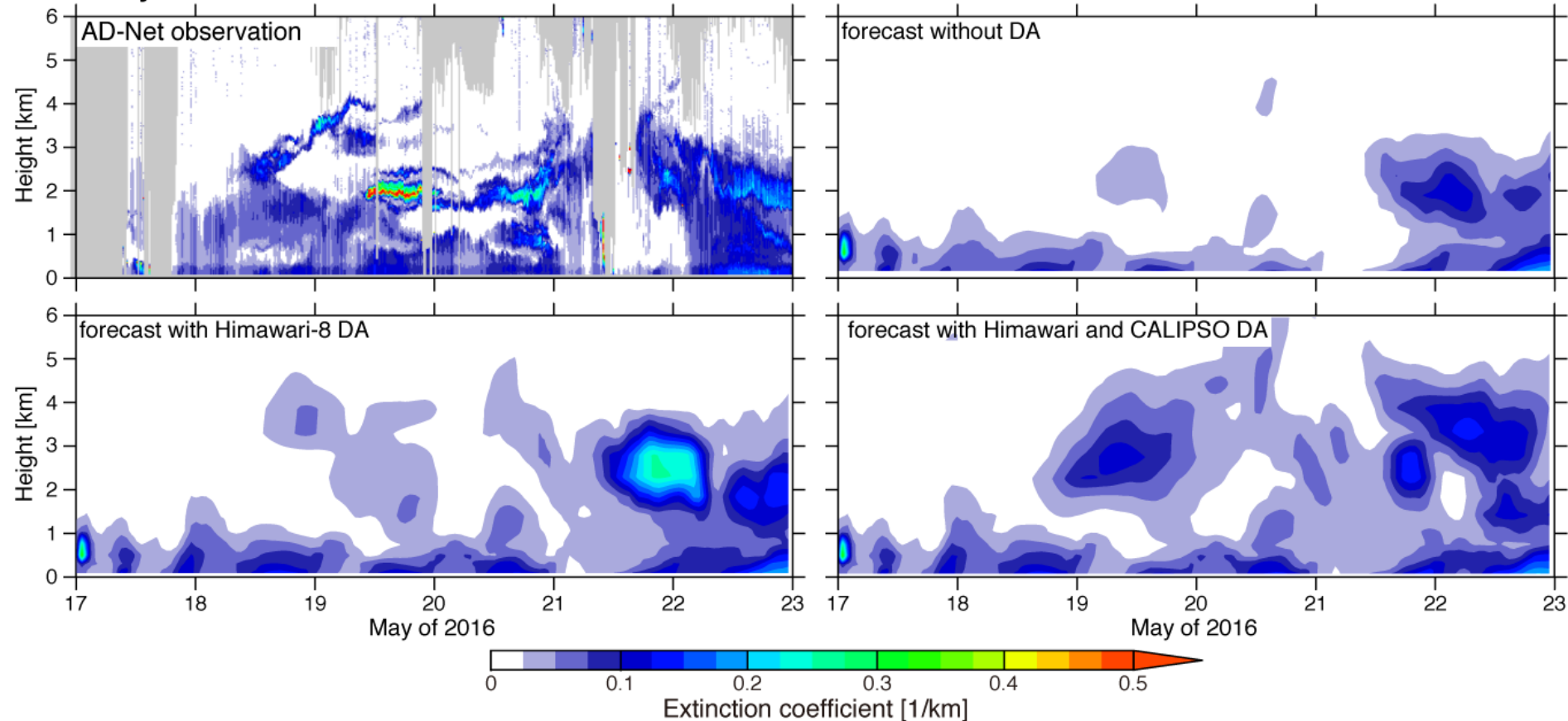Aerosol optical thickness (AOT)

Difference of AOT
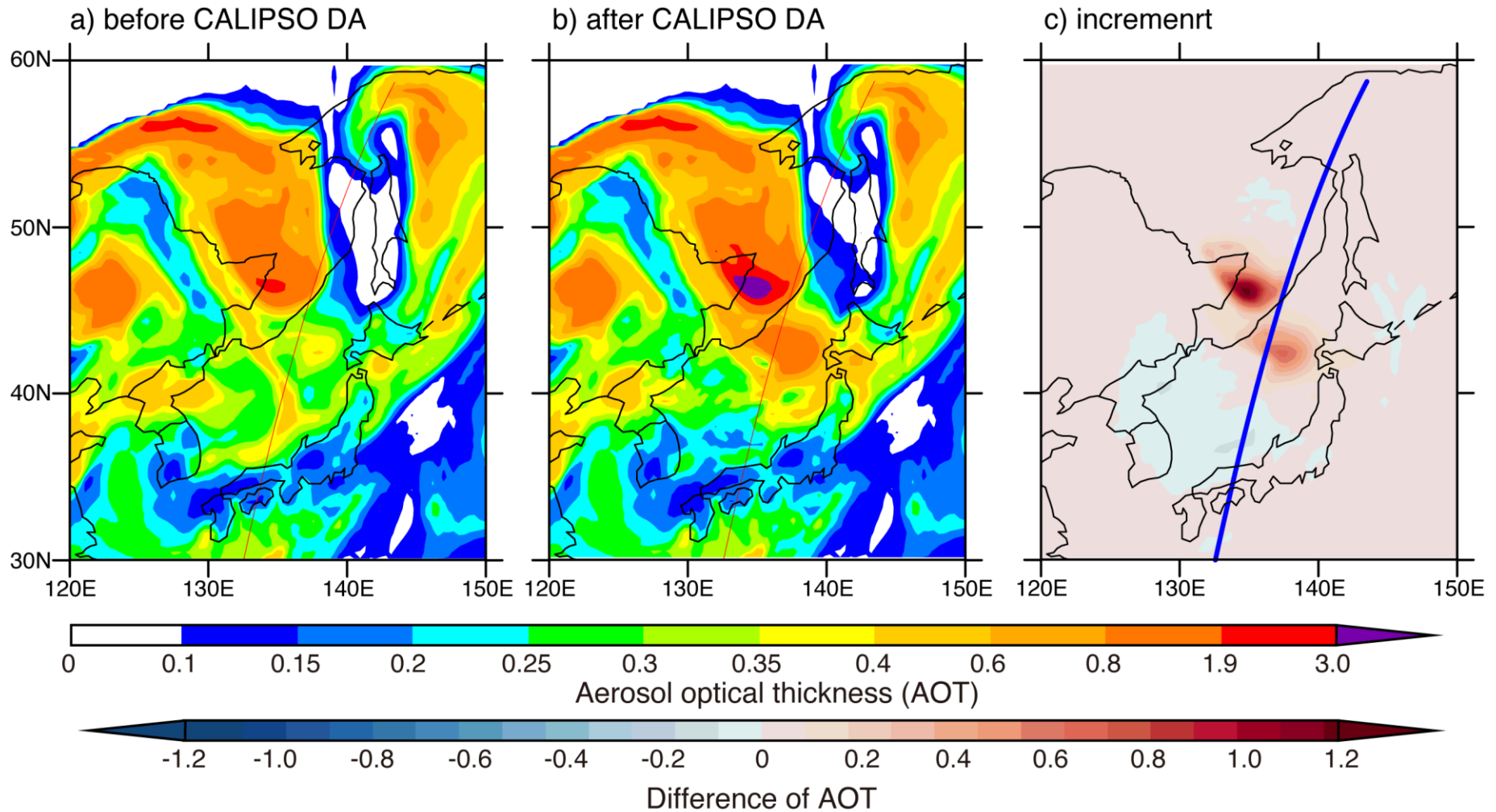
CALIPSO data impact not only vertical profile but also horizontal distribution through DA

Assimilation with **MULTIPLE** platforms

Comparison with ground-based Lidar (AD-Net)

- CALIPSO assimilation has been successful in modifying the vertical profile of the smoke and predicting its passing over Tokyo.
- The model vertical resolution is too course to simulate the fine structure of the smoke observed by ground-based lidar.

Summary

The JMA, MRI, JAXA and Kyushu Univ. cooperate in the development and operation of **the retrieval – assimilation – forecast cycling system**.

The Aerosol assimilation system is development in three direction.

- Assimilation with multiple imager (AHI(GEO) + SGLI(LEO))

  Addition of SGLI data increased AOT coverage especially over land areas and reduced uncertainty.

- Assimilation with both Imager (AHI) and Lidar (CALIOP/CALIPSO)

  Assimilation of CALIOP data has been successful in modifying the vertical profile and predicting that wildfire smoke pass over Tokyo.

Future plan

- Long-term experiments (AHI + SGLI) are performed to estimate the impact of SGLI data on both aerosol forecast and retrieval toward operational use.