Model Parameter Estimation Using Ensemble Data Assimilation: – A Case with the NICAM and GSMaP –

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Goals

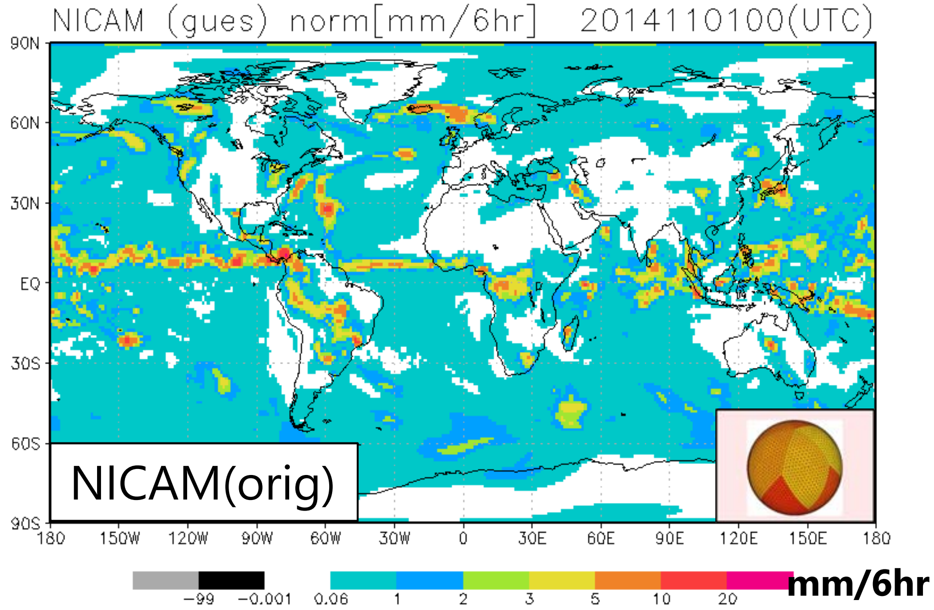
- To improve NWP using satellite-derived precipitation following *Lien et al. (2013, 2016a,b)*
- To produce a new precipitation product through data assimilation

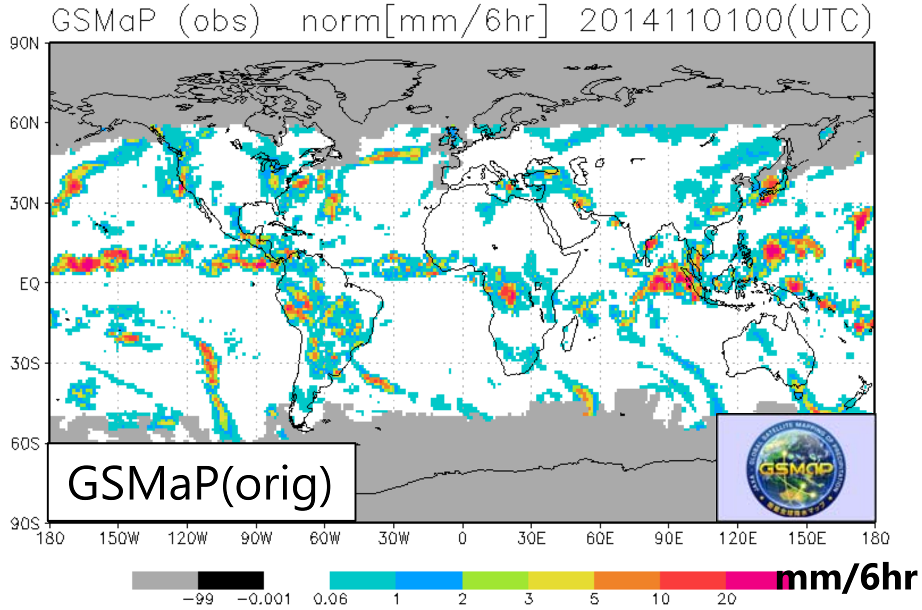
- **STEP1: State Estimation**
- STEP2: Parameter Estimation

Experimental Setting

- **Numerical Model**
  - NICAM (Satoh and Tomita 2004, Satoh et al. 2008, 2014)
    - GL6 (approx. 110 km resolution)
- **Observations**
  - CTRL: PREPBUFR: only upper sounding data (ADPUPA)
  - TEST: + GSMaP_Gauge (Ushio et al. 2009)
    - **with Gaussian transformation**
- **Data assimilation**
  - LETKF (Hunt et al. 2007)
  - NICAM-LETKF (Terasaki et al. 2015) with 36 members
    - 3D-LETKF
    - Localization: 400 km for horizontal & 0.4 log(p) for vertical
    - Relaxation to prior perturbation (Zhang et al. 2004; α = 0.7)

Gaussian Transformation





Gaussian Transformation

$$F^{G}(\tilde{y}) = F(y) \quad \Leftrightarrow \quad \underline{\tilde{y} = F^{G^{-1}}\left[F(y)\right]} \quad \Leftrightarrow \quad \underline{y = F^{-1}\left[F^{G}(\tilde{y})\right]}$$

Forward transform (mm/6hr→sigma) Inverse transform (sigma→mm/6hr)

y : original variable (mm/6hr)

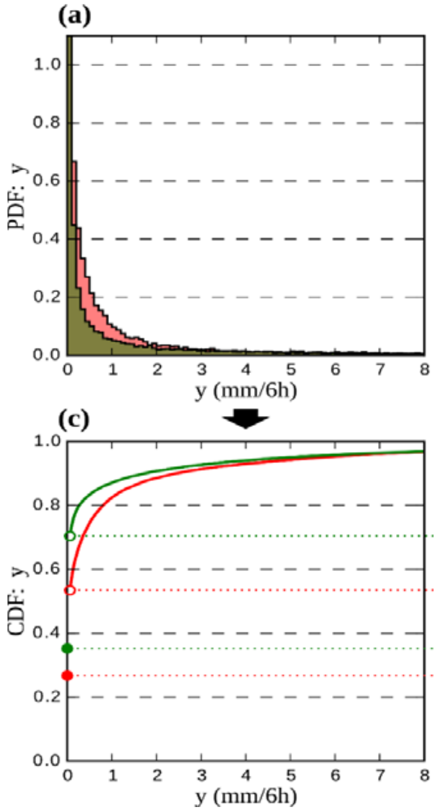
$\tilde{y}$: Transformed variable (sigma)

$F()$: CDF of original variable

$F^{G}()$: CDF of Gaussian distribution

PDF

CDF



Original variable

—: **Model**
—: **Obs.**

Step 0: Obtain PDF & CDF

Lien et al. (2013, 2016)

Gaussian Transformation

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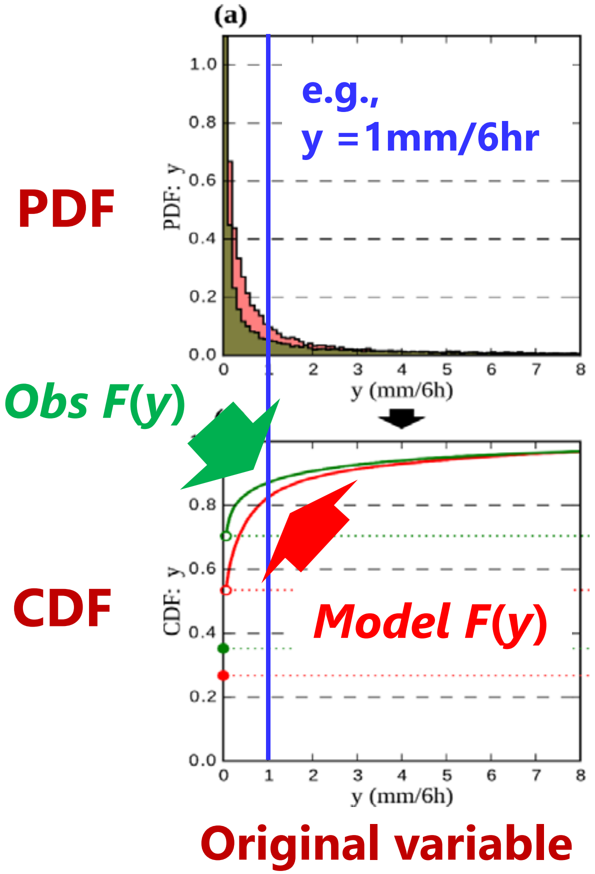

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Step 1: Compute $F(y)$

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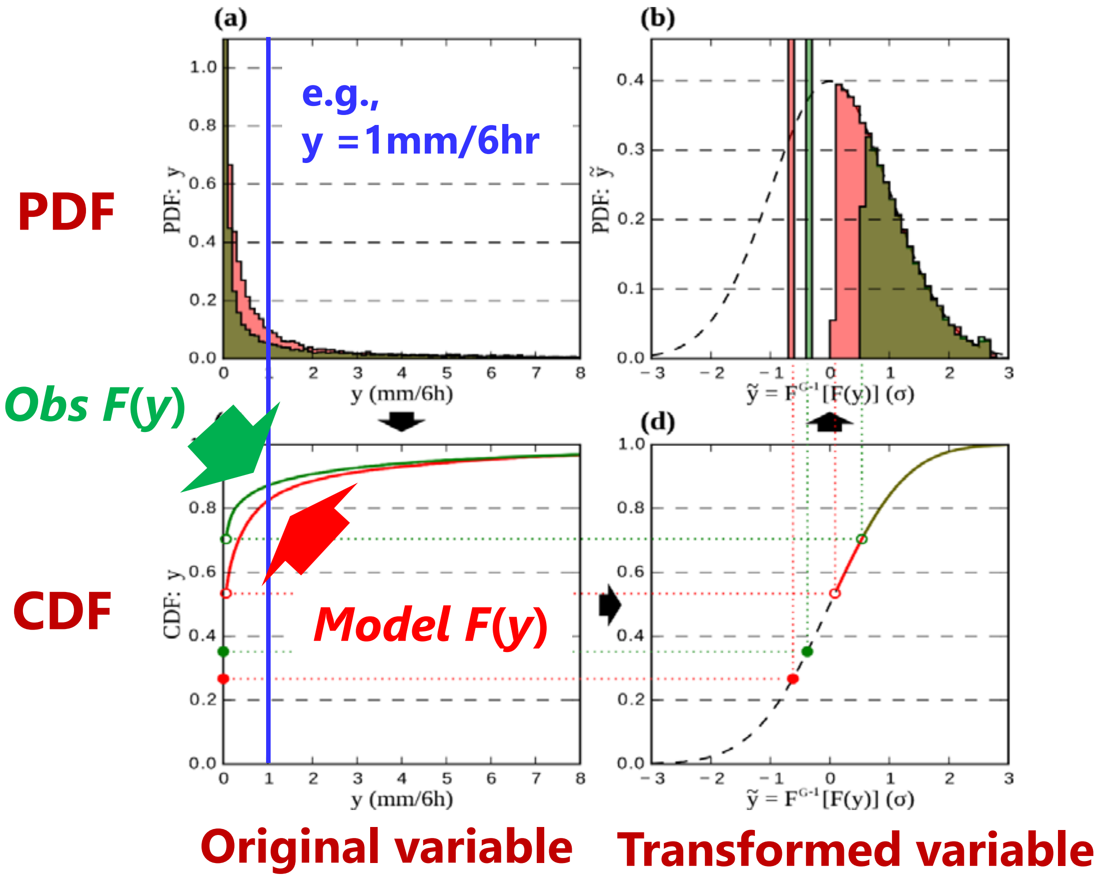

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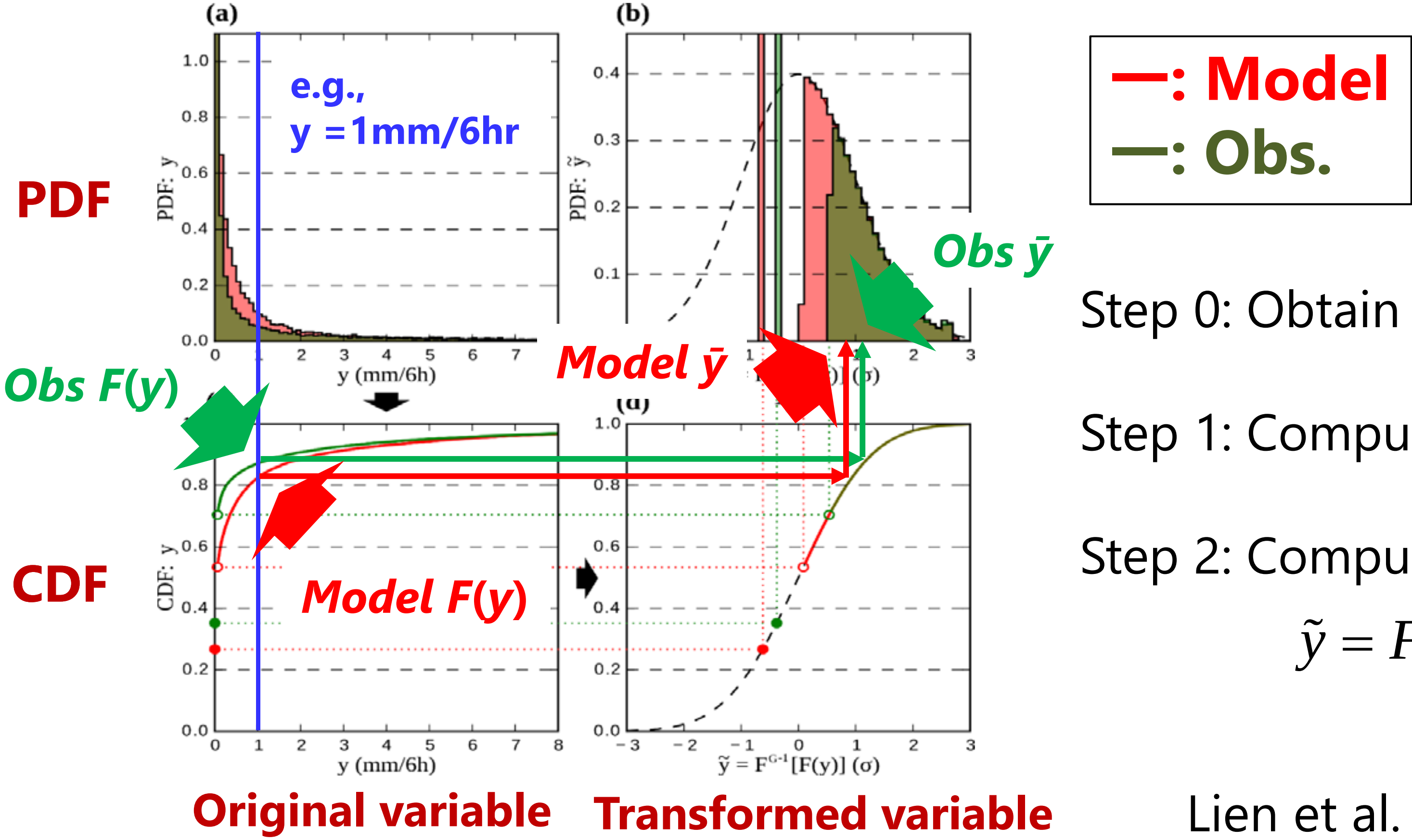

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Step 1: Compute $F(y)$

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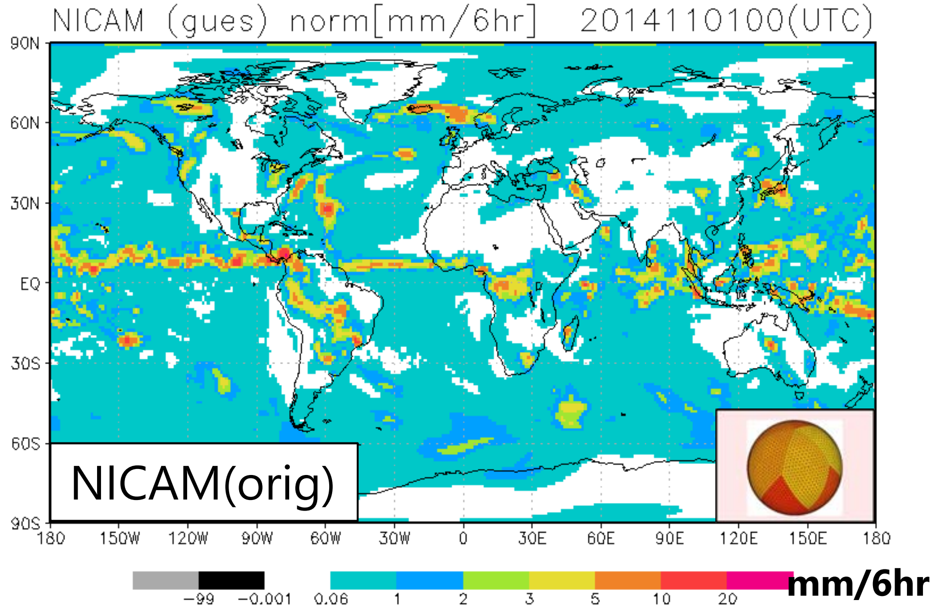
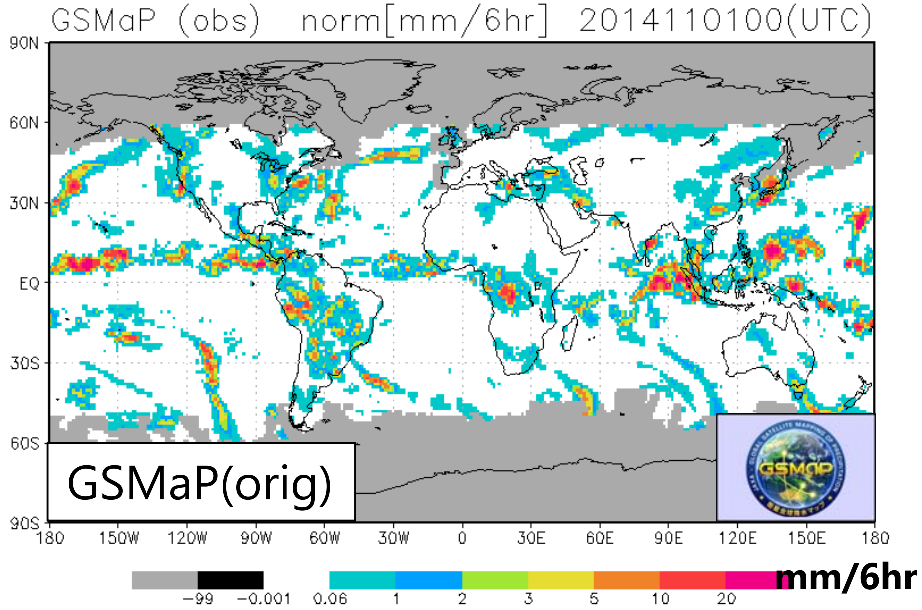
Gaussian Transformation





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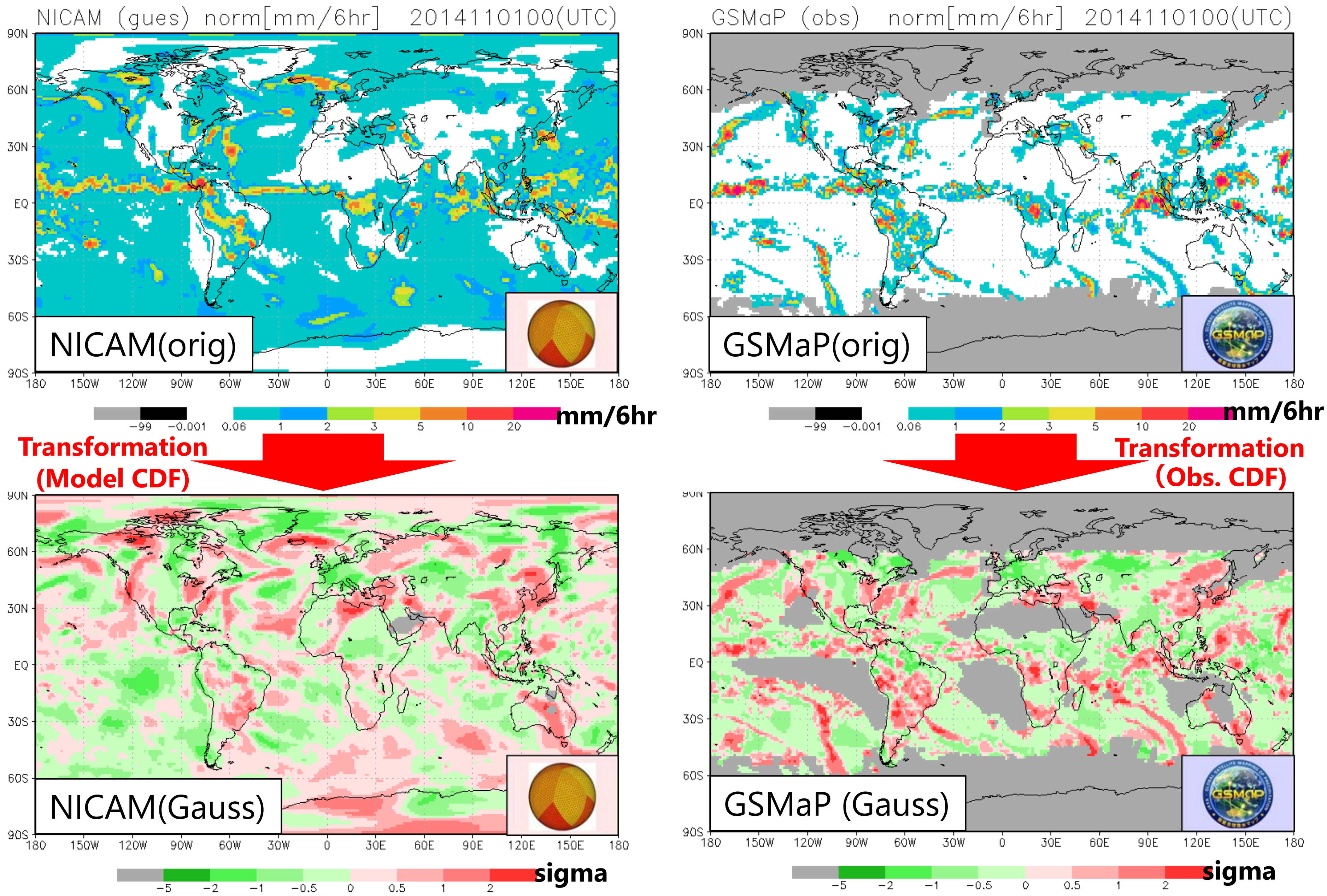
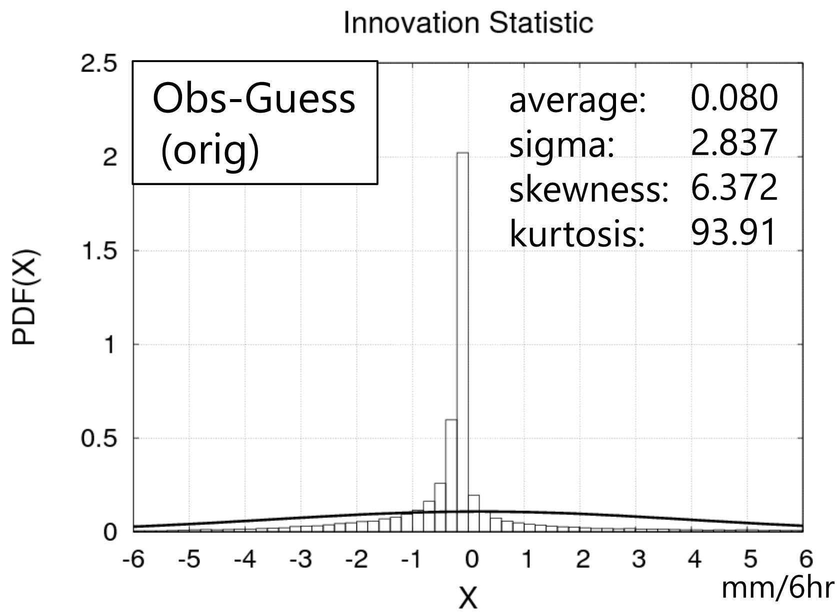


w/wo Gaussian Transformation

wo Gaussian-Transformation



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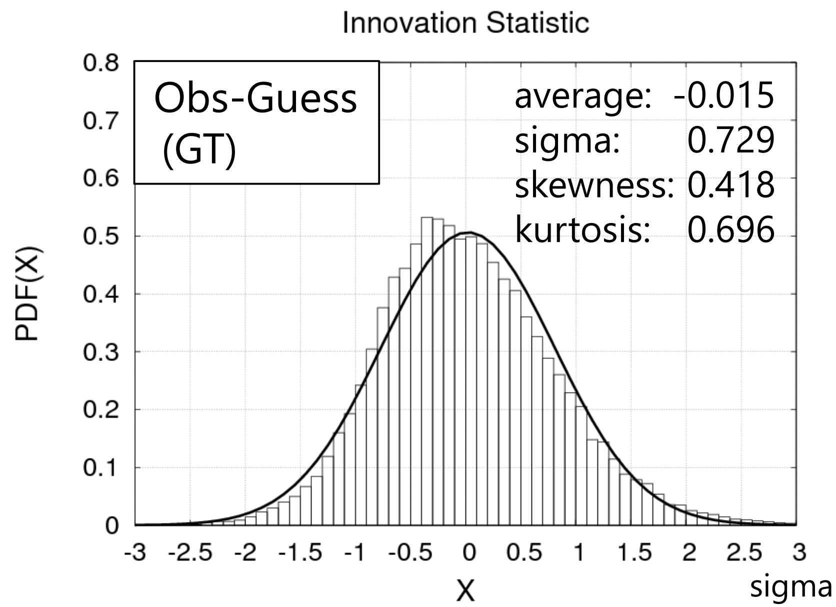

More Gaussian

Sampling period : 2014110100 - 2014110118

Inverse Transformation

$$F^{G}(\tilde{y}) = F(y) \quad \Leftrightarrow \quad \underline{\tilde{y} = F^{G^{-1}}\left[F(y)\right]} \quad \Leftrightarrow \quad \underline{y = F^{-1}\left[F^{G}(\tilde{y})\right]}$$

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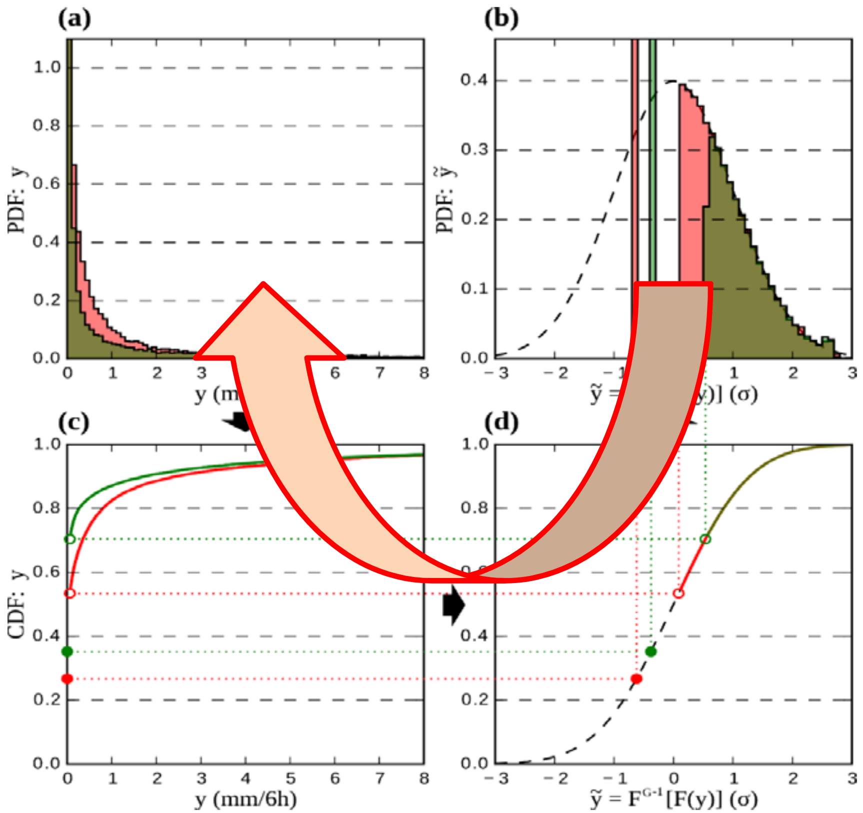

Original variable **Transformed variable**

—: Model
—: Obs.

Step 0: Obtain PDF & CDF

Step 1: Compute $F(y)$

Step 2: Compute

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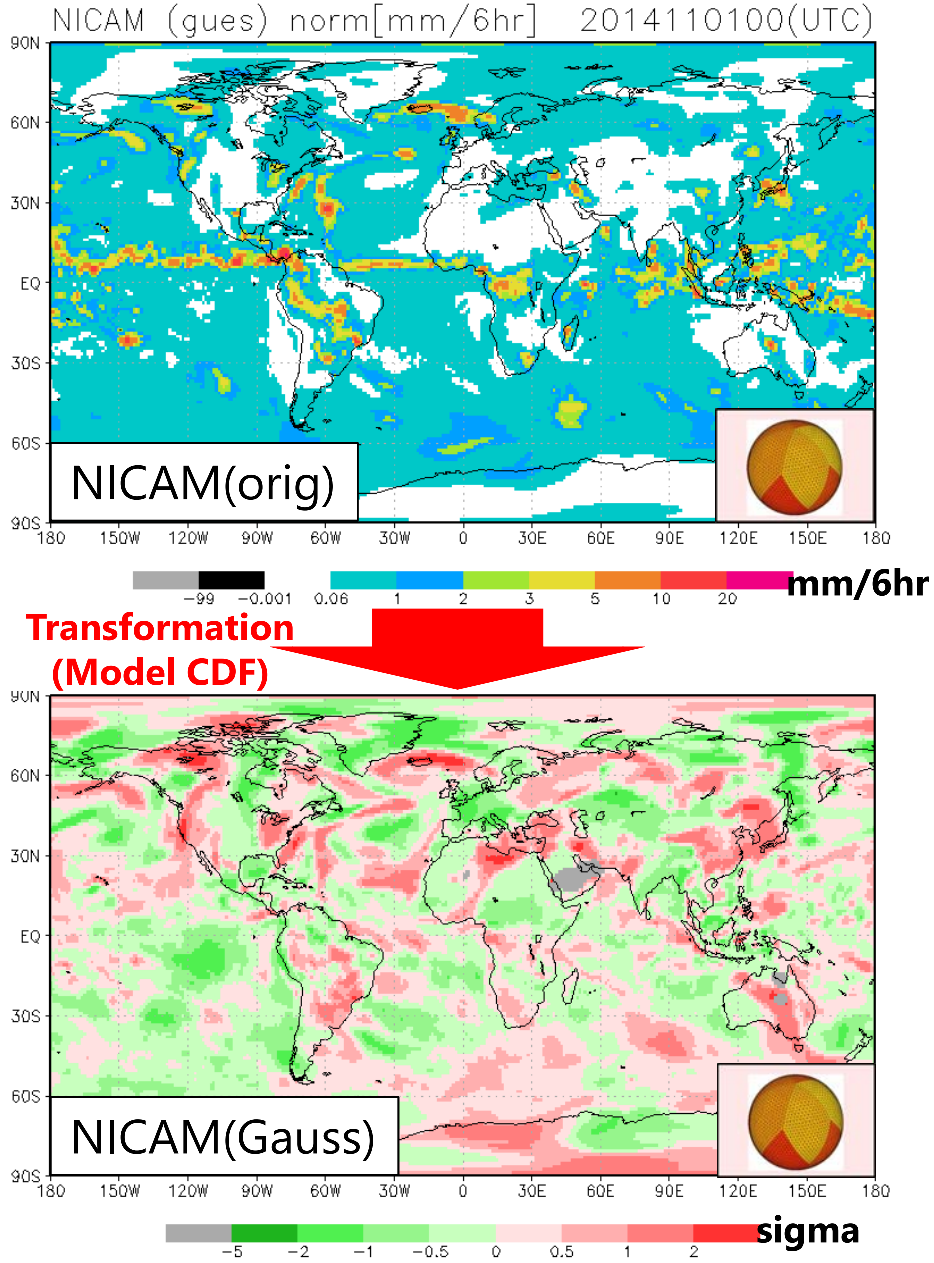
Lien et al. (2013, 2016)

Forward/Inverse Transformations



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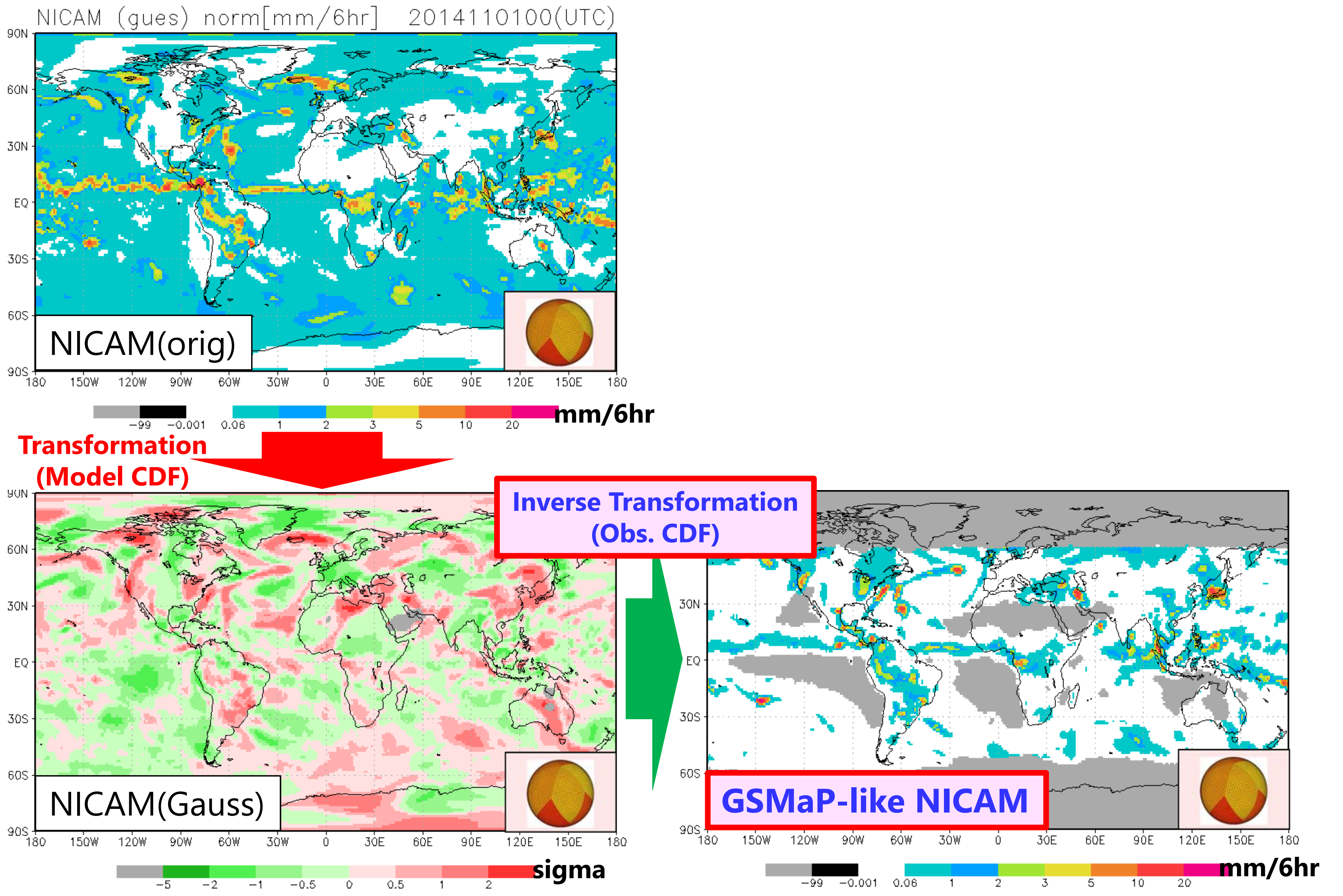

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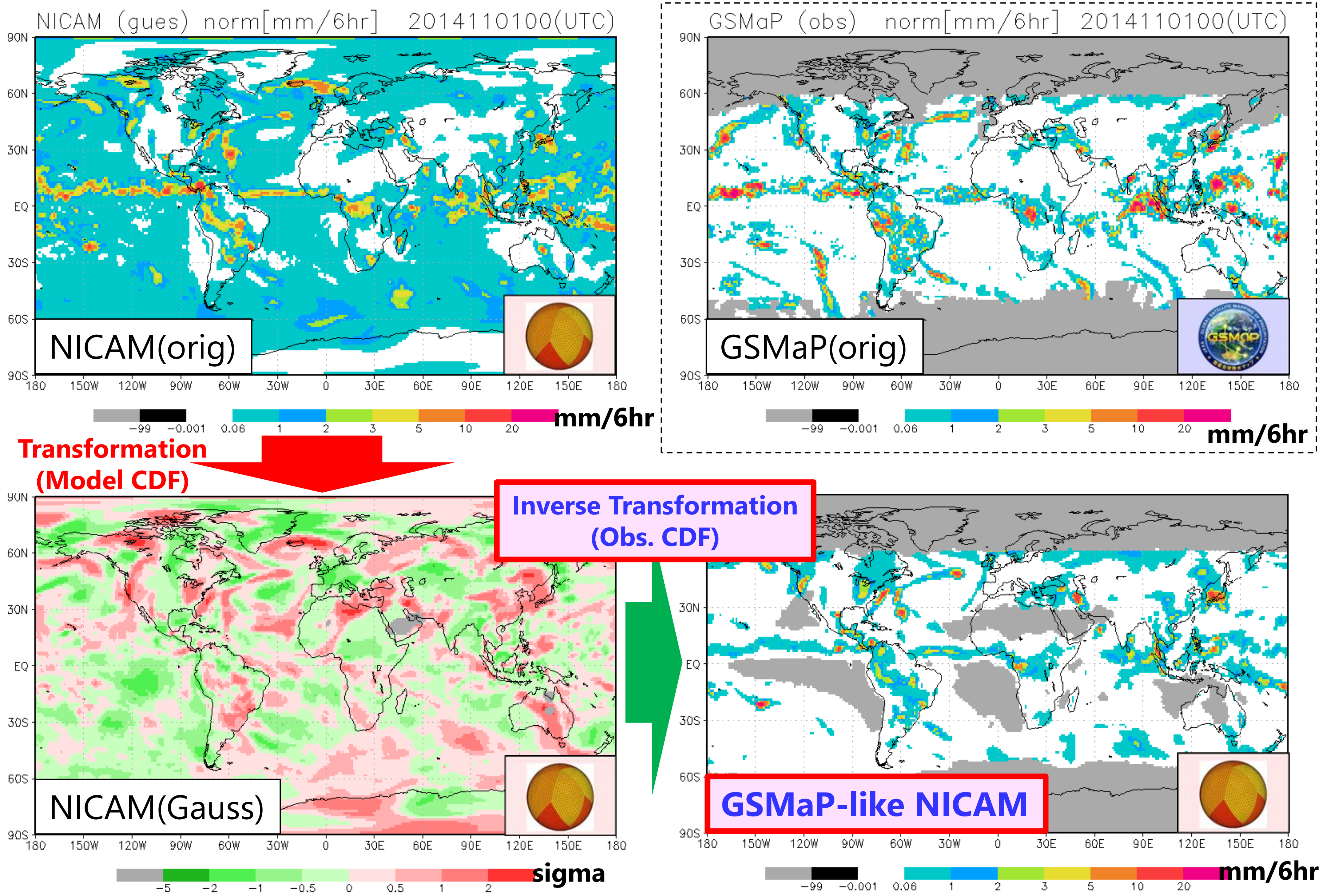
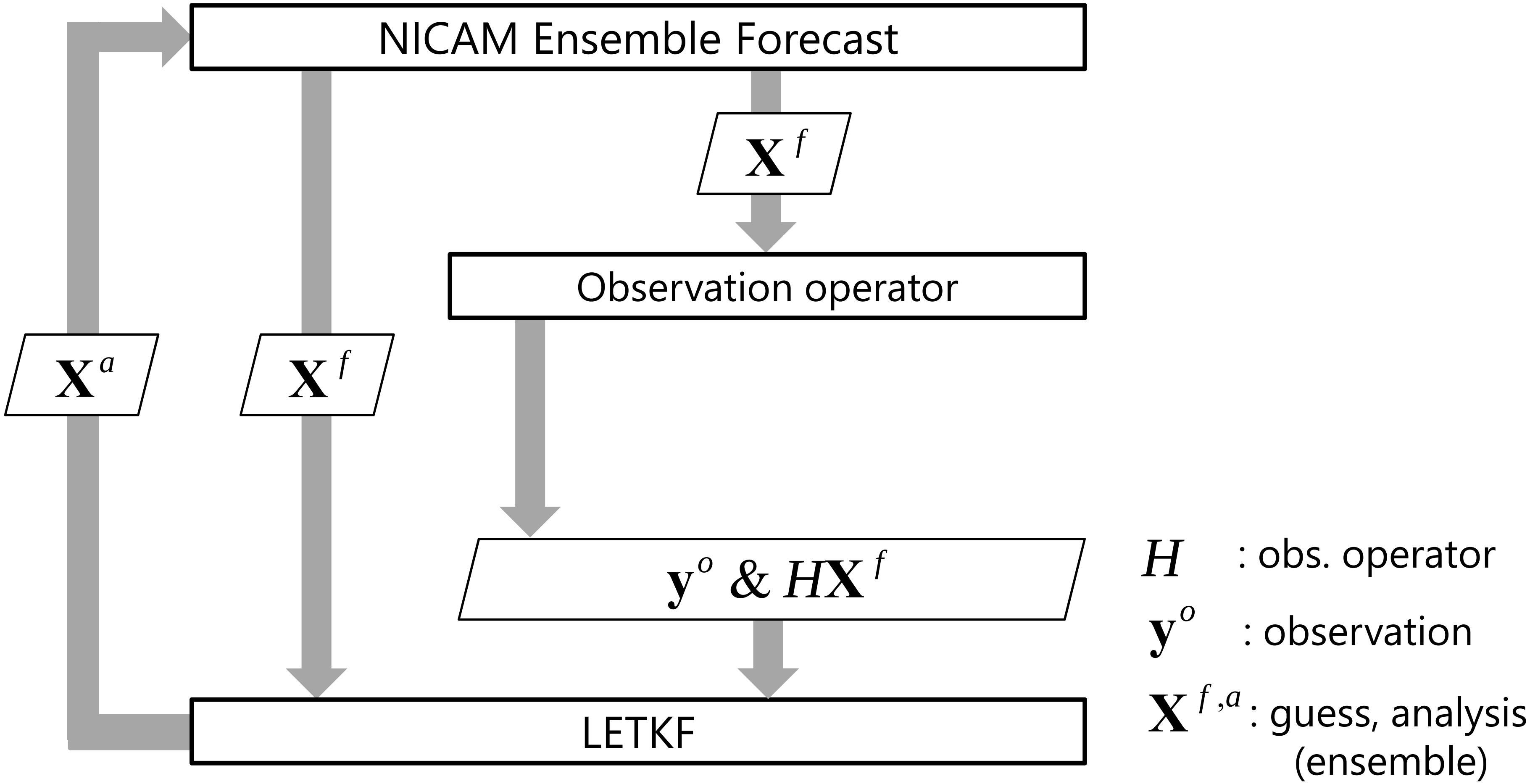


Assimilation of GSMaP by NICAM-LETKF



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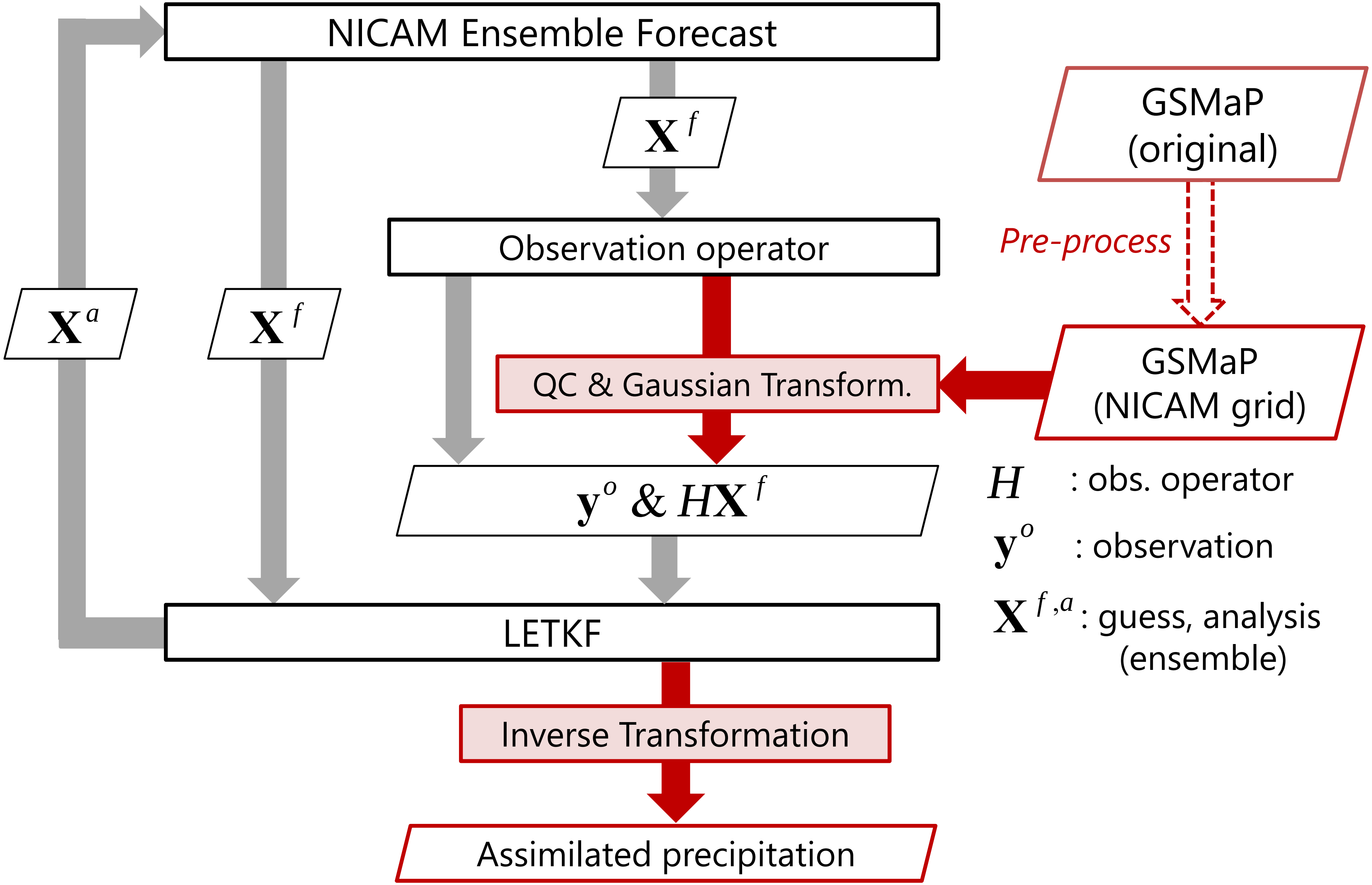
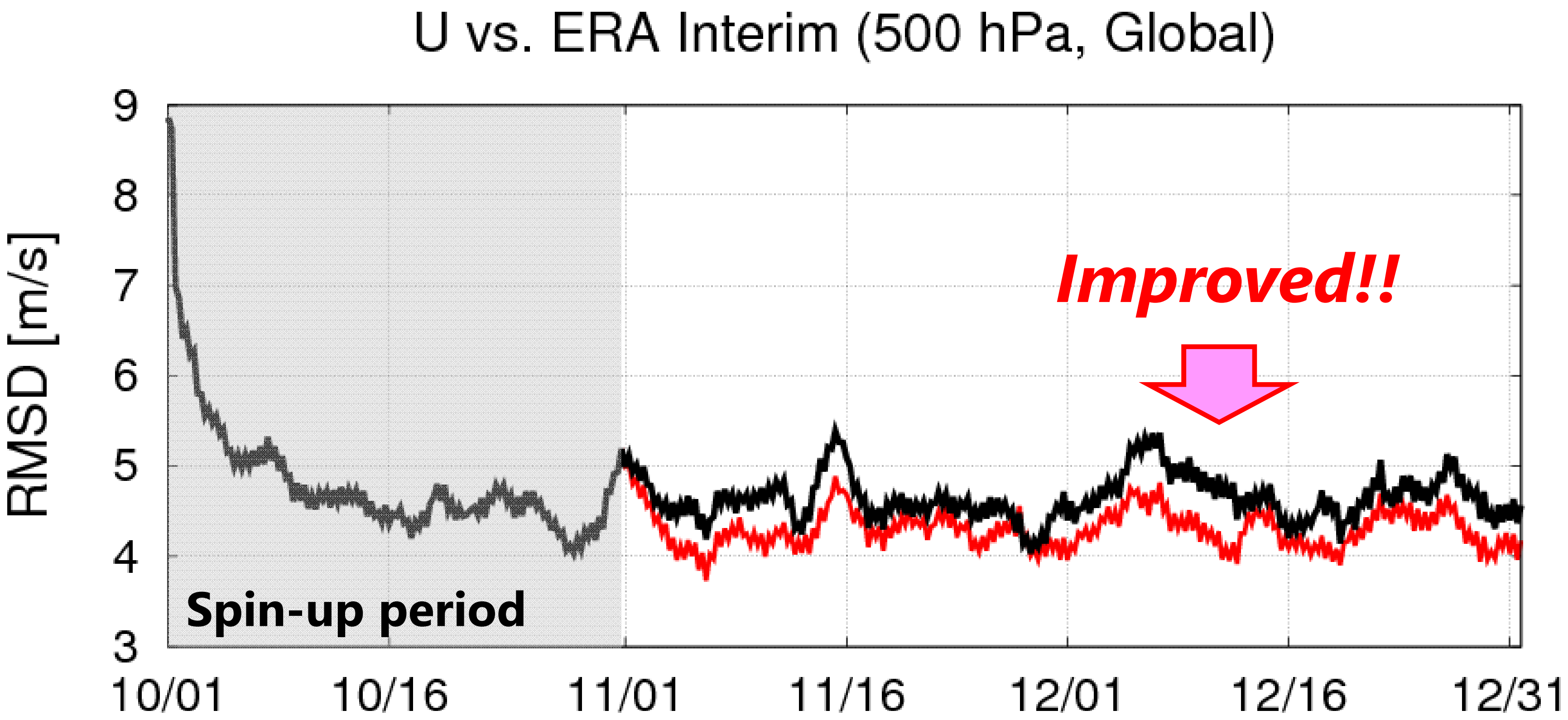


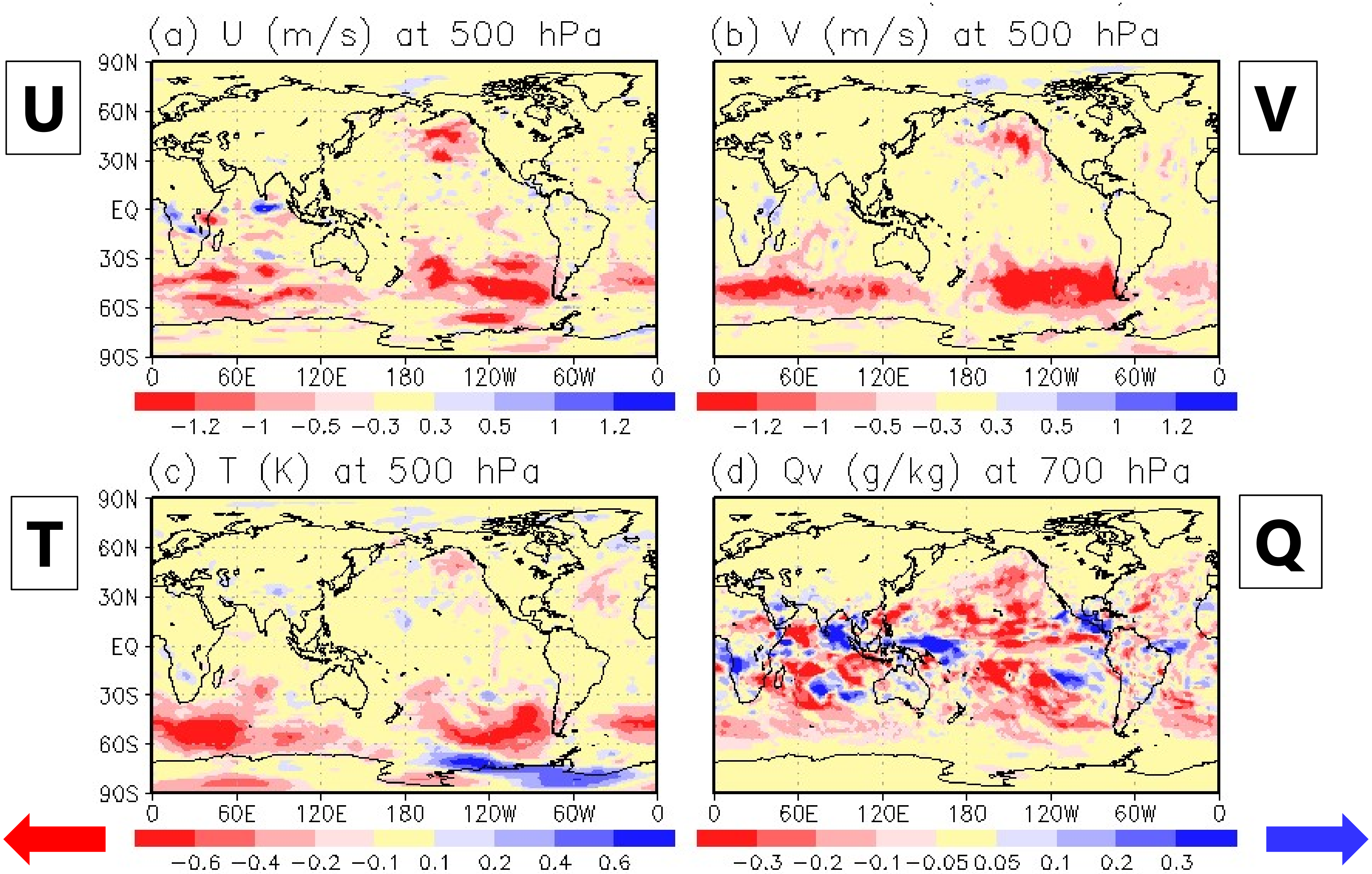
RMSDs relative to ERA Interim (in 2014)



—: CTRL: Radiosondes ONLY

—: TEST: Radiosondes + GSMaP/Gauge (every 5x5 grids)

MADs relative to ERA Interim (in 2014)

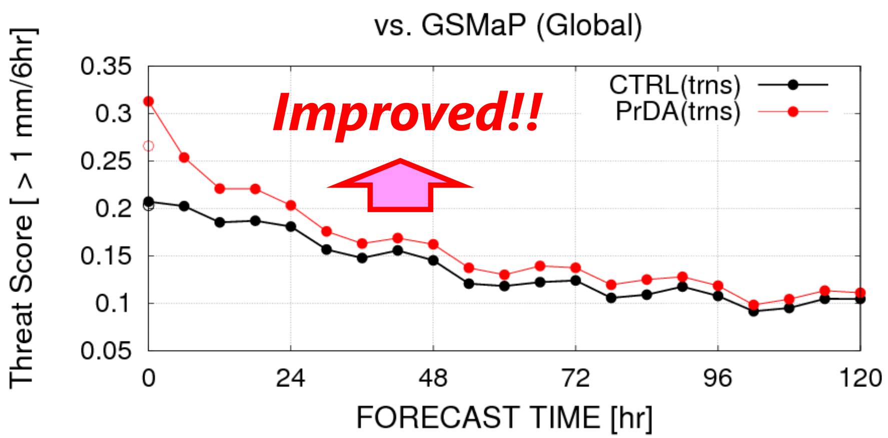


Improved by GSMaP DA

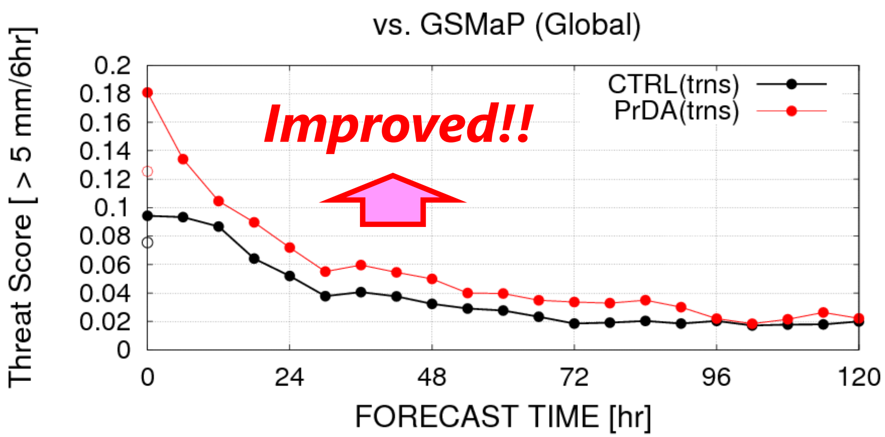
Degraded by GSMaP DA

RMSDs: 120 hr Forecasts vs. GSMaP/Gauge

Threat Score (≥ 1 mm/6hr)



Threat Score (≥ 5 mm/6hr)



—: Radiosondes ONLY

—: Radiosondes + GSMaP/Gauge

Precipitation forecasts are improved !!!

Average over 8 ensemble forecasts from different initial dates

Outline

- STEP1: State Estimation
- **STEP2: Parameter Estimation**

Summary

- Assimilating GSMaP precipitation with NICAM-LETKF
  - State estimation
    - Gaussian Transformation works well
    - Analyses and forecasts are improved
  - Parameter estimation
    - Precipitation forecasts are improved
    - Dry bias in the lower troposphere is improved

Kotsuki S., Miyoshi T., Terasaki K., Lien G.Y. and Kalnay E.:
Assimilating the Global Satellite Mapping of Precipitation Data with the Nonhydrostatic Icosahedral Atmospheric Model NICAM. JGR-Atmosphere (in revision)