Climatologically augmented local ensemble transform Kalman filter for estimating global precipitation from gauge observations

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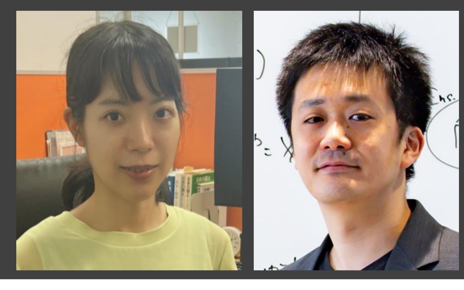


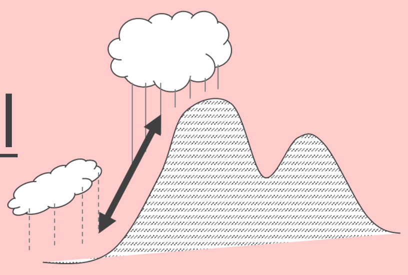
Summary

- This study proposes a method to estimate the global precipitation field with the use of the Local Ensemble Transform Kalman Filter (LETKF).
- We constructed a hybrid background error covariance (flow-dependent/climatological).
- Our estimates outperformed the estimates based on Optimal Interpolation (OI).

Introduction

Aim: To improve the method to estimate the historical global precipitation fields from rain gauge observations

- Background error covariance based on numerical weather predictions
  →Able to consider the mechanical relationship between 2 grids



- Hybrid approach
  - □ Flow-dependent
  - □ Climatological

Data assimilation ← Rain gauge observations

↓ Global precipitation fields

Method and Experiments

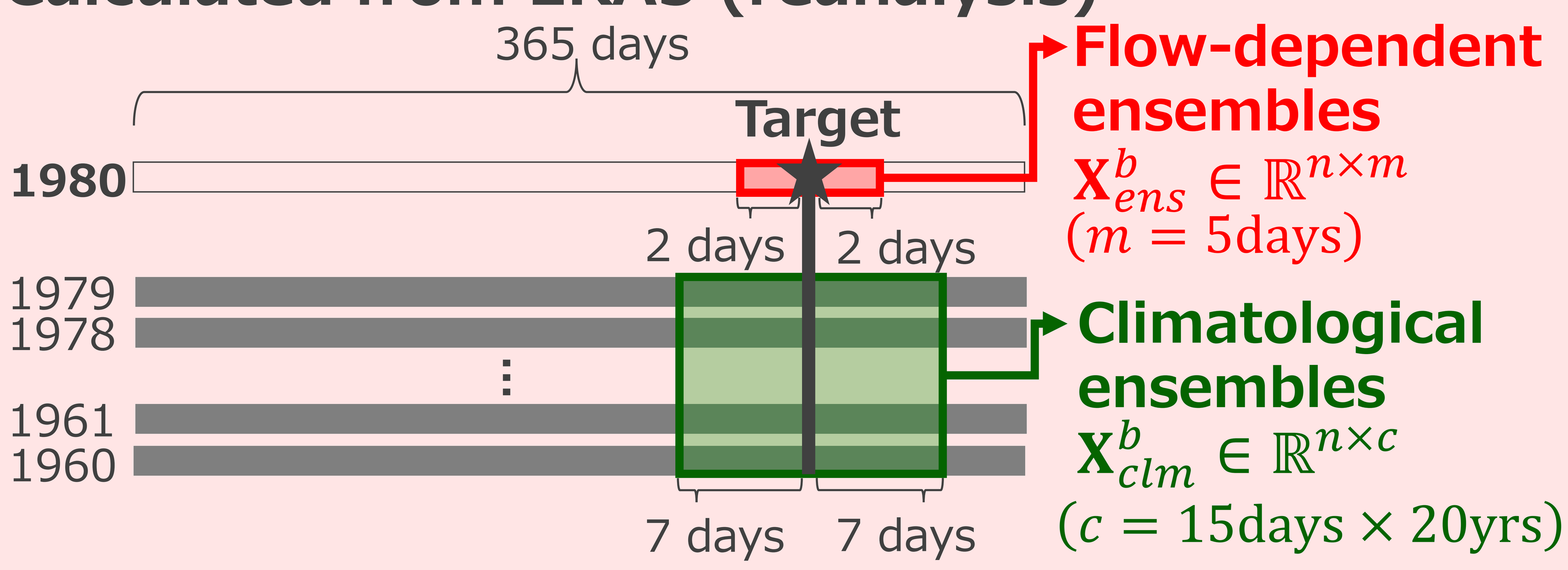
Estimation using the LETKF

$$\mathbf{x}_t^a = \mathbf{x}_t^b + \mathbf{K}_t\,(\mathbf{y}_t^o - H_t(\mathbf{x}_t^b))$$

Estimates ($\mathbf{x}_t^a$)

Daily gauge observations from Climate Prediction Center (CPC) ($\mathbf{y}_t^o$)

Calculated from ERA5 (reanalysis)



- Hybrid background error covariance

$$\mathbf{P}^b = \alpha\mathbf{P}_{ens}^b + (1-\alpha)\mathbf{P}_{clm}^b \Leftrightarrow \mathbf{Z}^b = \left[\frac{\sqrt{\alpha}\delta\mathbf{X}_{ens}^b}{\sqrt{m-1}}, \frac{\sqrt{1-\alpha}\delta\mathbf{X}_{clm}^b}{\sqrt{c-1}}\right]$$

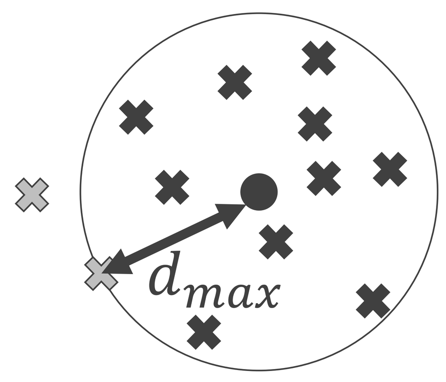
- Background $\bar{\mathbf{x}}_{clm}^b \in \mathbb{R}^n$

Experimental settings

- Observation error covariance
  - □ error variance $= \begin{cases}\log(2) & (obs \le 1.0\text{ mm})^* \\ \log(obs+1) & (obs > 1.0\text{ mm})\end{cases}$

  *Determined by preliminary experiment
- Localization
  - □ Observation Number Limit
    - $d_{max} \le 1{,}000$ km**
    - Num. of the obs. $\le 10^{**}$

    **Determined by sensitivity analysis

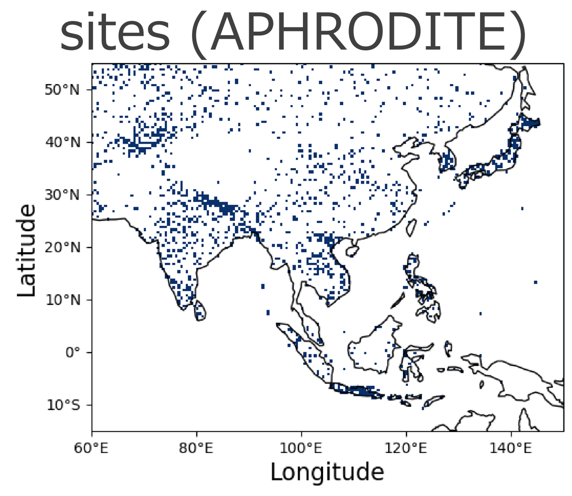


- Hybrid parameter $\alpha = 0.0, 0.1, 0.2, 0.3$

Validation

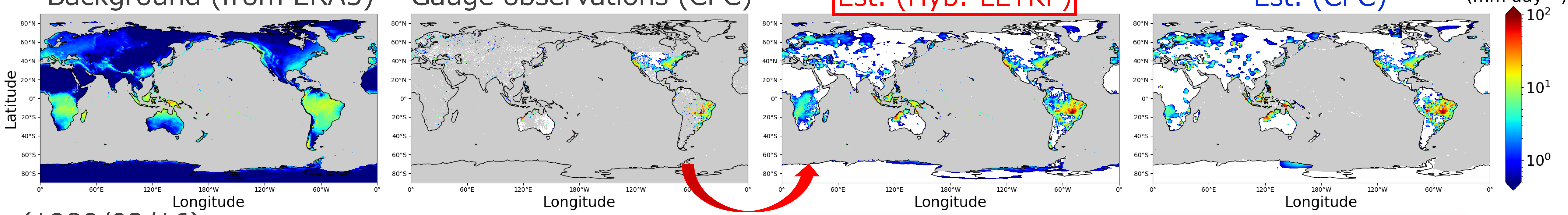
- Against independent daily rain gauge observations (APHRODITE)
  - □ Kendall's Rank correlation coefficient τ_b
- Against Global Precipitation Climatology Centre (GPCC) monthly precipitation

Independent rain gauge sites (APHRODITE)



Results

Example of a daily precipitation field ($\alpha = 0.1$)

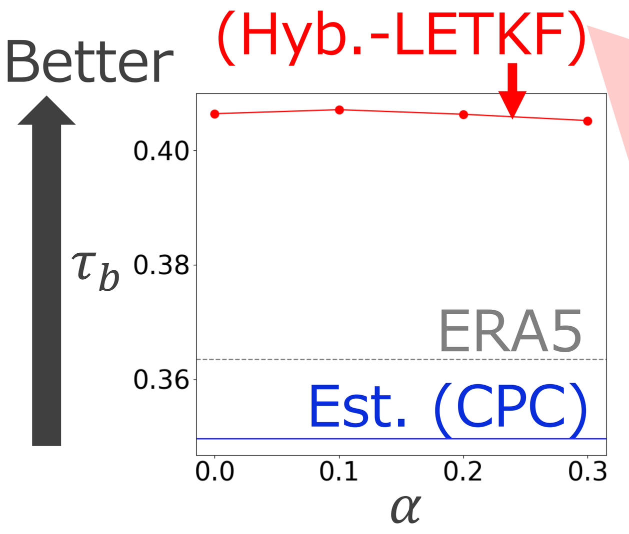


(1980/02/16) White: Pr< 0.5 mm day^{-1}

Successfully estimated by the hybrid-LETKF

Validation

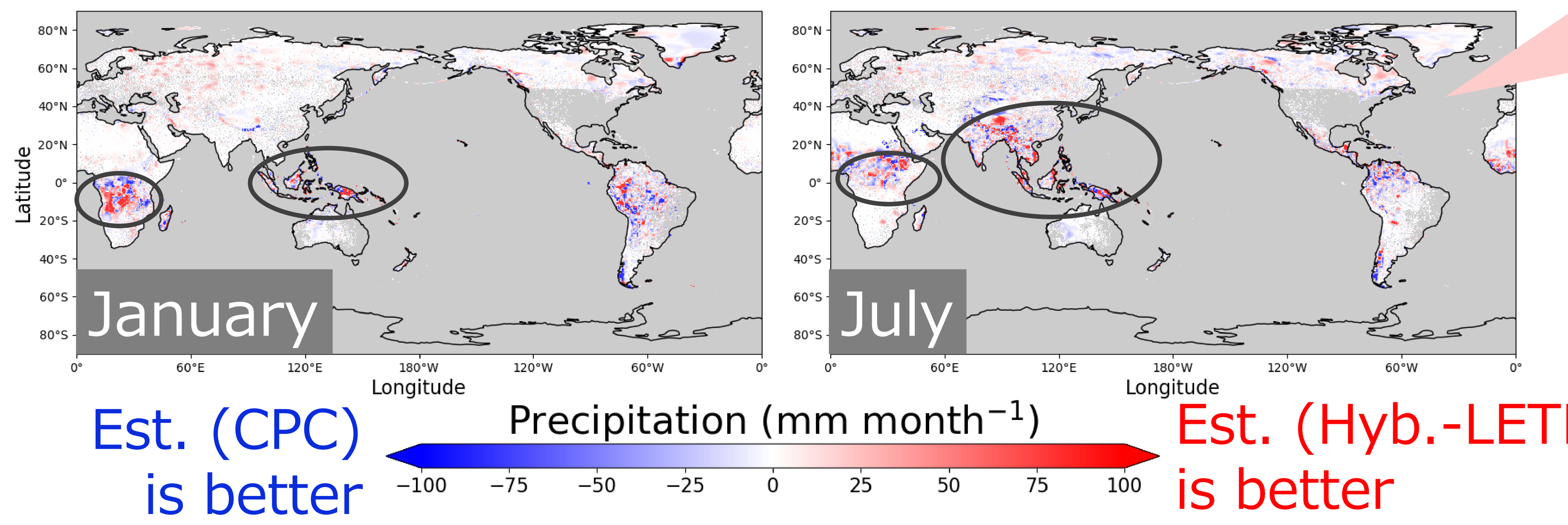
- Against APHRODITE



Better than existing products!
(The value of α is not influential.)

- Against GPCC ($\alpha = 0.1$)

Abs(GPCC-Est.(CPC)) − Abs(GPCC-Est.(Hyb.-LETKF))



Est. (CPC) is better

Est. (Hyb.-LETKF) is better

Est. (Hyb.-LETKF) is especially better in gauge-sparse regions

RMSE	(mm mon^{-1})
Est. (CPC)	43.21
Est. (Hyb.-LETKF)	40.93

Improved!