Assimilation of AMSU-A radiance observations within KIAPS-LETKF system

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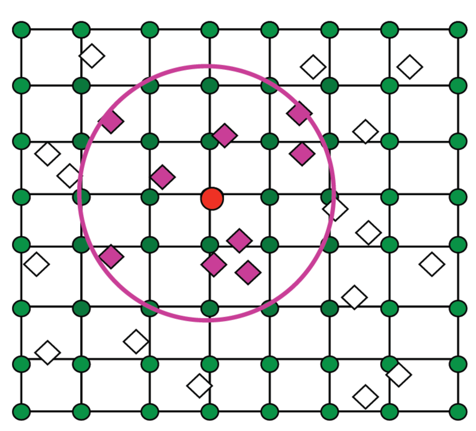
Korea Institute of Atmospheric Prediction Systems (KIAPS) has successfully implemented Local Ensemble Transform Kalman Filter (LETKF) data assimilation system to NCAR CAM-Spectral Element model. This model has the same grid structure on the cubed sphere as KIAPS-Global Model now developing without any singularity, and has a strong advantage on the flexibility and scalability in the future high performance computing environment. The KIAPS-LETKF system has also adopted most advanced data assimilation techniques such as an adaptive multiplicative inflation, an estimation of ensemble forecast sensitivity to observations (EFSO). With those promising tools in the KIAPS-LETKF system, we plan to assimilate conventional data as well as various remote sensing data such as AMSU-A, IASI, GPS RO, which an observation preprocessing team at KIAPS has processed. In this study, we will present our assimilation strategy of AMSU-A radiance data and show preliminary results.

LETKF (Hunt et al. 2007)

- Perform a separate analysis at each model grid point, using only obs. from a surrounding local region.
- Each local analysis is independent and can be done in parallel.



$$\overline{\mathbf{x}}^b = \frac{1}{k}\sum_{i=1}^{k}\mathbf{x}^{b(i)} \qquad \mathbf{X}^b = \left[\cdots \quad \mathbf{x}^{b(i)} - \overline{\mathbf{x}}^b \quad \cdots\right]$$

$$\mathbf{y}^{b(i)} = H\left(\mathbf{x}^{b(i)}\right)$$

$$\overline{\mathbf{y}}^b = \frac{1}{k}\sum_{i=1}^{k}\mathbf{y}^{b(i)} \qquad \mathbf{Y}^b = \left[\cdots \quad H\left(\mathbf{x}^{b(i)}\right) - \overline{\mathbf{y}}^b \quad \cdots\right]$$

$$\overline{\mathbf{x}}^a = \overline{\mathbf{x}}^b + \mathbf{X}^b\overline{\mathbf{w}}^a \qquad \overline{\mathbf{w}}^a = \tilde{\mathbf{P}}^a\left(\mathbf{Y}^b\right)^T\mathbf{R}^{-1}\left(\mathbf{y}^o - \overline{\mathbf{y}}^b\right) \qquad \tilde{\mathbf{P}}^a = \left[(k-1)\mathbf{I}/\rho + \left(\mathbf{Y}^b\right)^T\mathbf{R}^{-1}\mathbf{Y}^b\right]^{-1}$$

$$\mathbf{X}^a = \mathbf{X}^b\mathbf{W}^a \qquad \mathbf{W}^a = \left[(k-1)\tilde{\mathbf{P}}^a\right]^{\frac{1}{2}}$$

Two Main Issues for Radiance Obs.

Vertical Localization ~ Non-local nature of radiance obs.

The use of localization is essential for ensemble DA systems, due to the sampling error.
Due to the non-local nature of radiance obs., we need to

a) Specify the **vertical location** for radiance obs.
b) Determine the **shape** of vertical localization function

Bias Correction (BC)

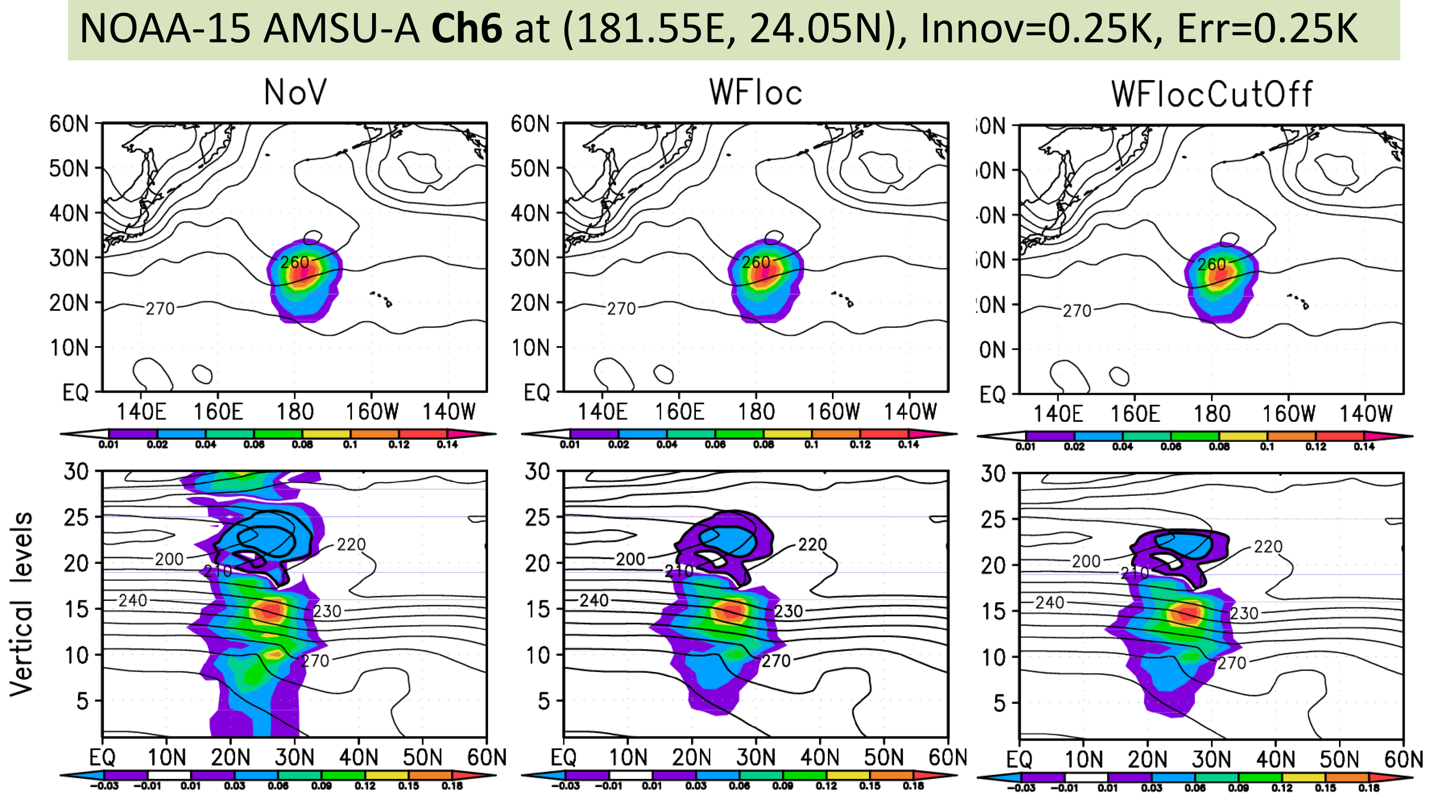
BC techniques play a critical role for direct use of radiance obs.
BC for scan/air-mass bias can be done by off-line statistical *and/or* on-line dynamical method.
In ensemble DA framework, statistical BC can be done with ensemble mean fields, while dynamical BC can also be done (Fertig 2009, Miyoshi et al. 2010, Aravequia et al. 2011)

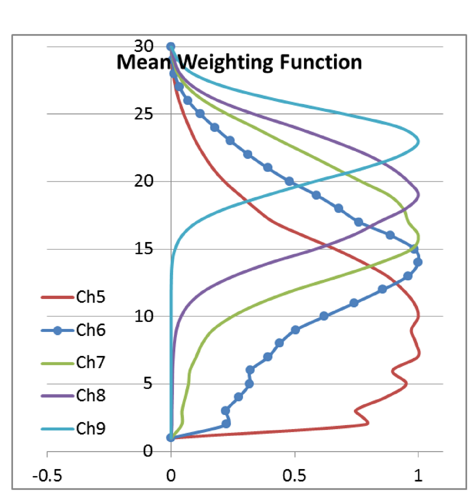
Vertical Localization Strategies for Radiance Obs.

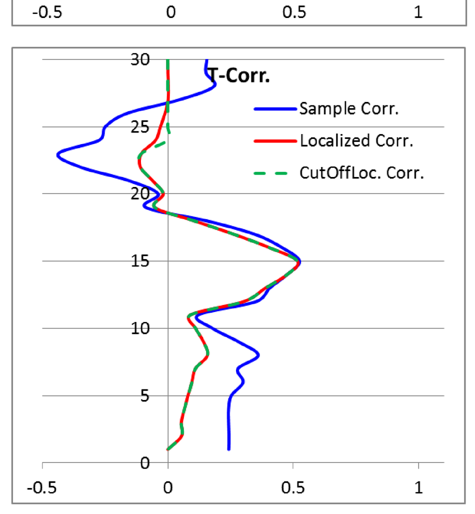
- Many pioneers: Houtekamer et al. (2005), Fertig et al. (2007), Miyoshi and Sato (2007)
- The keyword is … **Weighting Function (WF)** !
  : Vertical difference of the transmittance from RTTOV
  : Place the radiance observation at the peak level of **WF**
  : Use **WF** itself as a vertical localization function with normalization
    ~ for all levels or levels with significant weight

Single Obs. Test

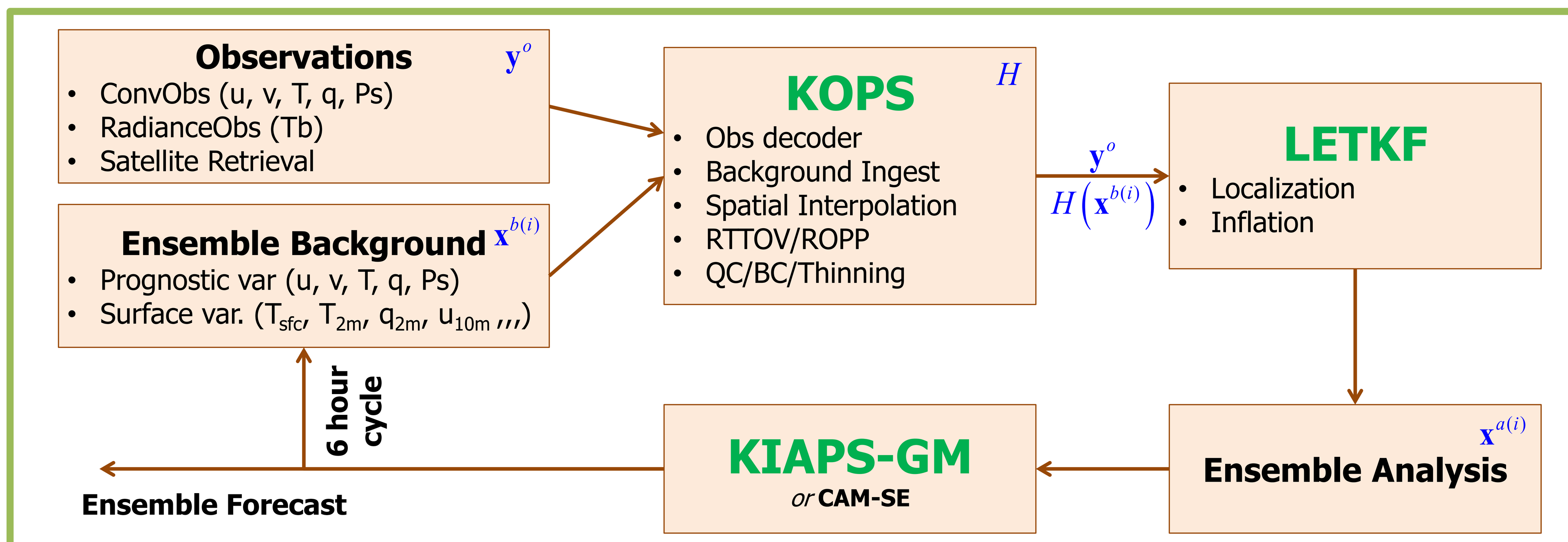
NOAA-15 AMSU-A **Ch6** at (181.55E, 24.05N), Innov=0.25K, Err=0.25K





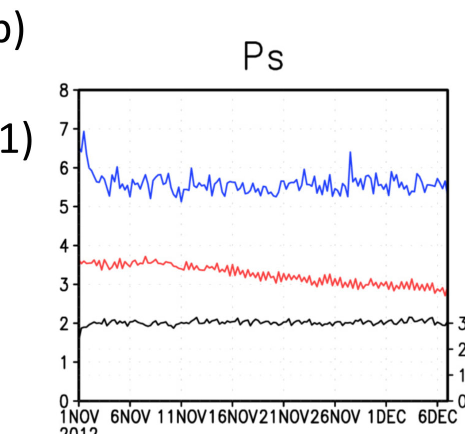


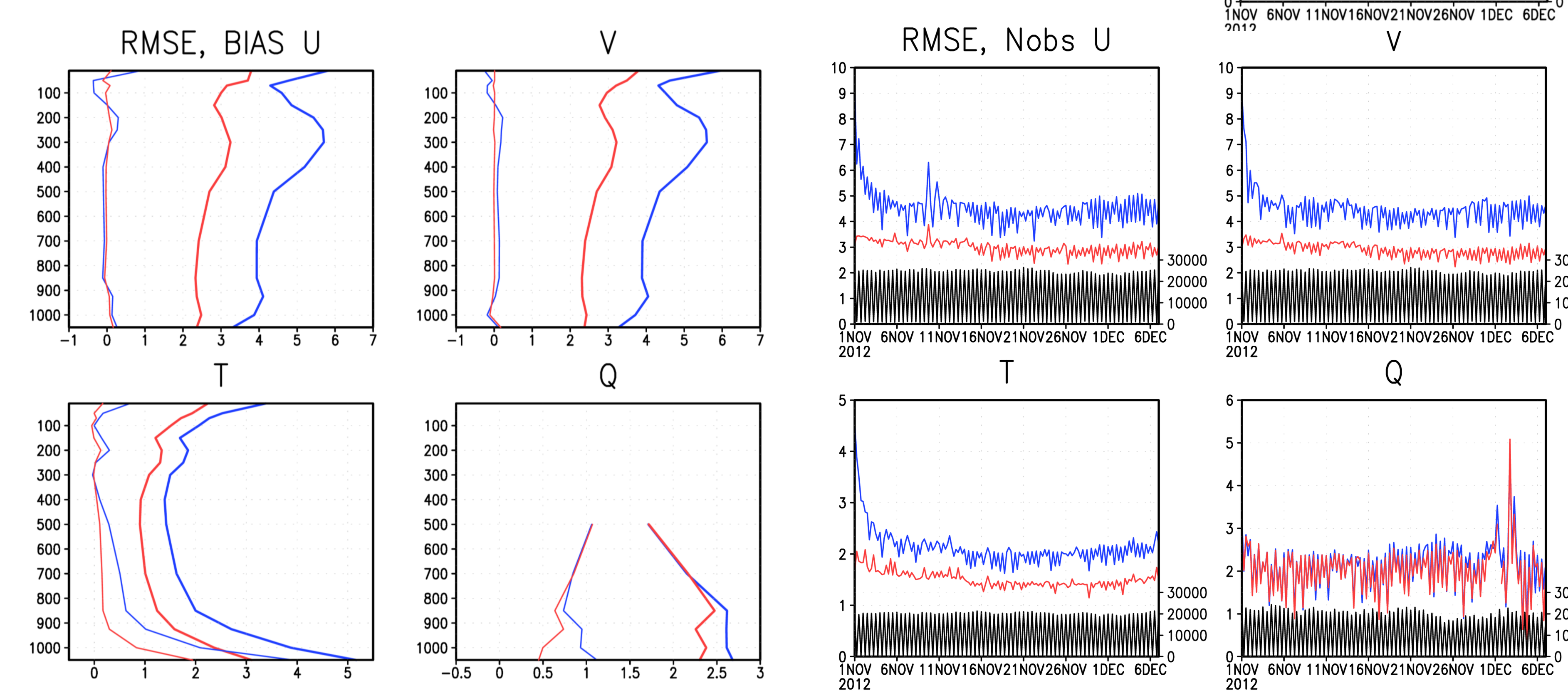
KIAPS-LETKF with KOPS



Preliminary KIAPS-LETKF Result with Real obs.

- NCAR CESM with CAM-SE atmospheric dynamic core
  : Same grid structure with KIAPS-Global Model
  : NE16NP4 (~ ***2.5*** degree) resolution with ***30*** vertical levels (~ 3 hPa top)
- Based on the OSSE configurations of Kang and Park (2013)
  : **64** Ensemble members, Adaptive multiplicative inflation (Miyoshi 2011)
- Assimilate the surface pressure observation and radiosonde observation from NCEP prepbufr data.
  : Height-difference within 100 m for Ps, q-analysis only for lower-levels
- 1 November ~ 7 December 2012



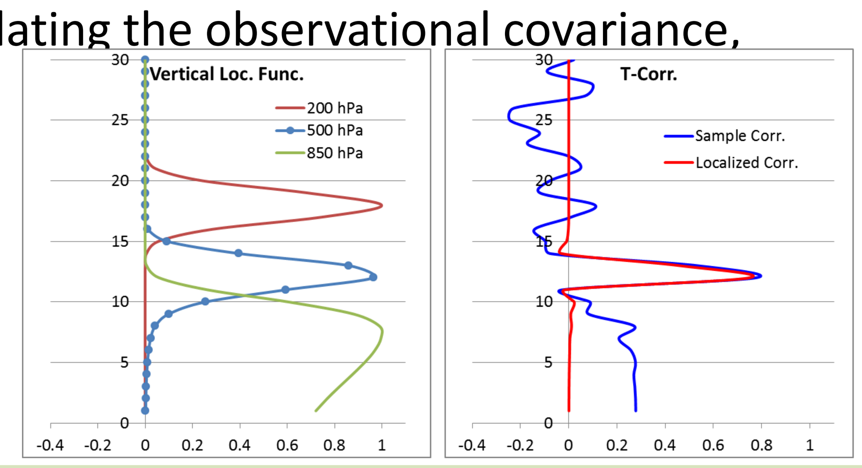


LETKF Localization Strategies for ConvObs.

The impact of observation is reduced by inflating the observational covariance, based on the distance.

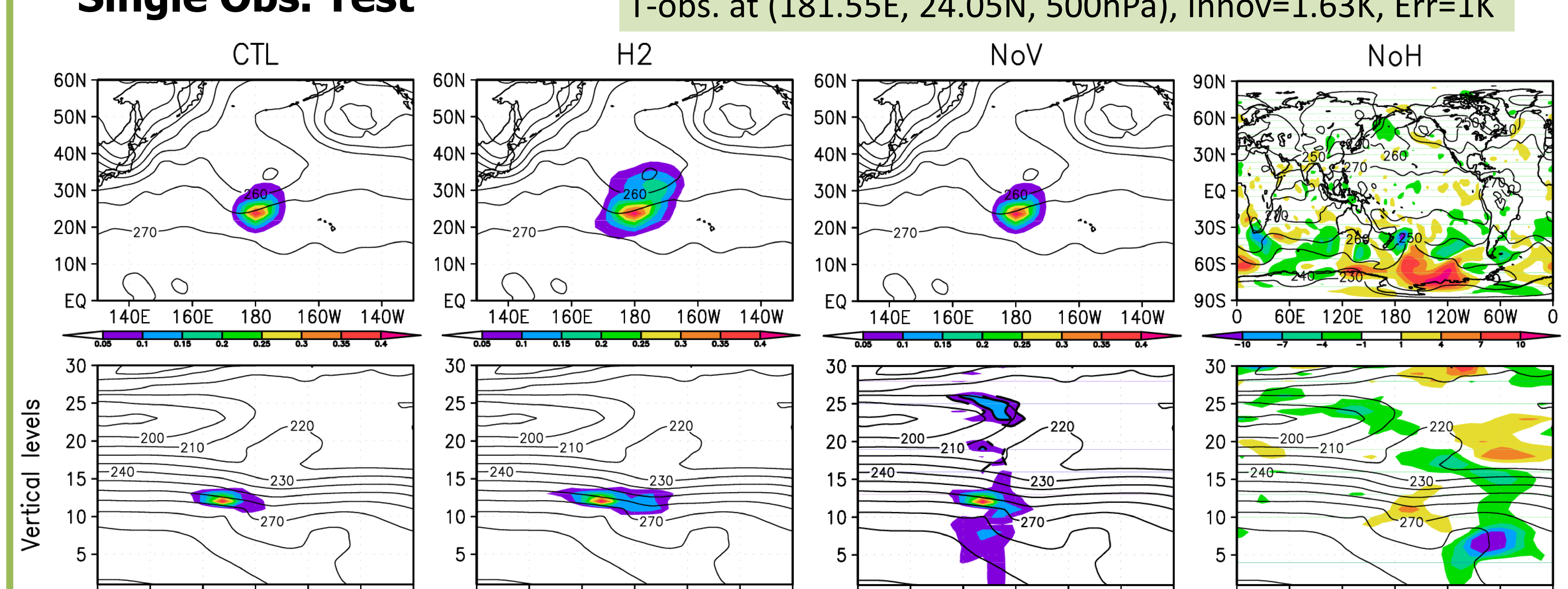
- 500 km for horizontal localization
- 0.2 ln(p) for vertical localization

$$\tilde{\mathbf{R}}^{-1} = \mathbf{R}^{-1} \times \exp\left[-\frac{1}{2}\left(\frac{dist_H^2}{\sigma_H^2} + \frac{dist_V^2}{\sigma_V^2}\right)\right]$$



Single Obs. Test

T-obs. at (181.55E, 24.05N, 500hPa), Innov=1.63K, Err=1K



Summary

- KIAPS-LETKF system is working well for real conventional observations.
- In a suite of single observation experiment, localization strategies for both (*local*) conventional obs. and (*non-local*) radiance obs. are evaluated.
- Working on the interface between **KOPS** and **KIAPS-LETKF** systems
- Bias correction, high-resolution configuration in the near future

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