Impact of the mid-loop for satellite radiance on a hybrid data assimilation skill

Ji-Hyun Ha[1,2], Hyo-Jong Song[1,3]*, and Hyoung-Wook Chun[1]

[1]Korea Institute of Atmospheric Prediction Systems

[2]Korean Meteorological Administration

[3]Myongji University

*Correspondence to hjsong@mju.ac.kr

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- 4D Ensemble Variational Assimilation
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Korean Integrated Model by KIAPS

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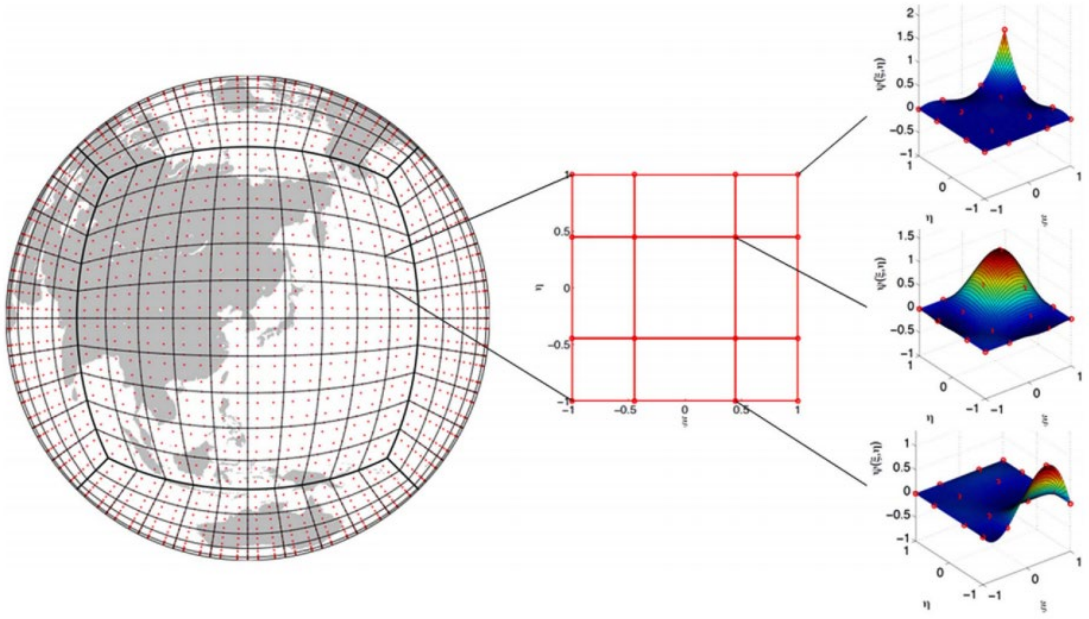
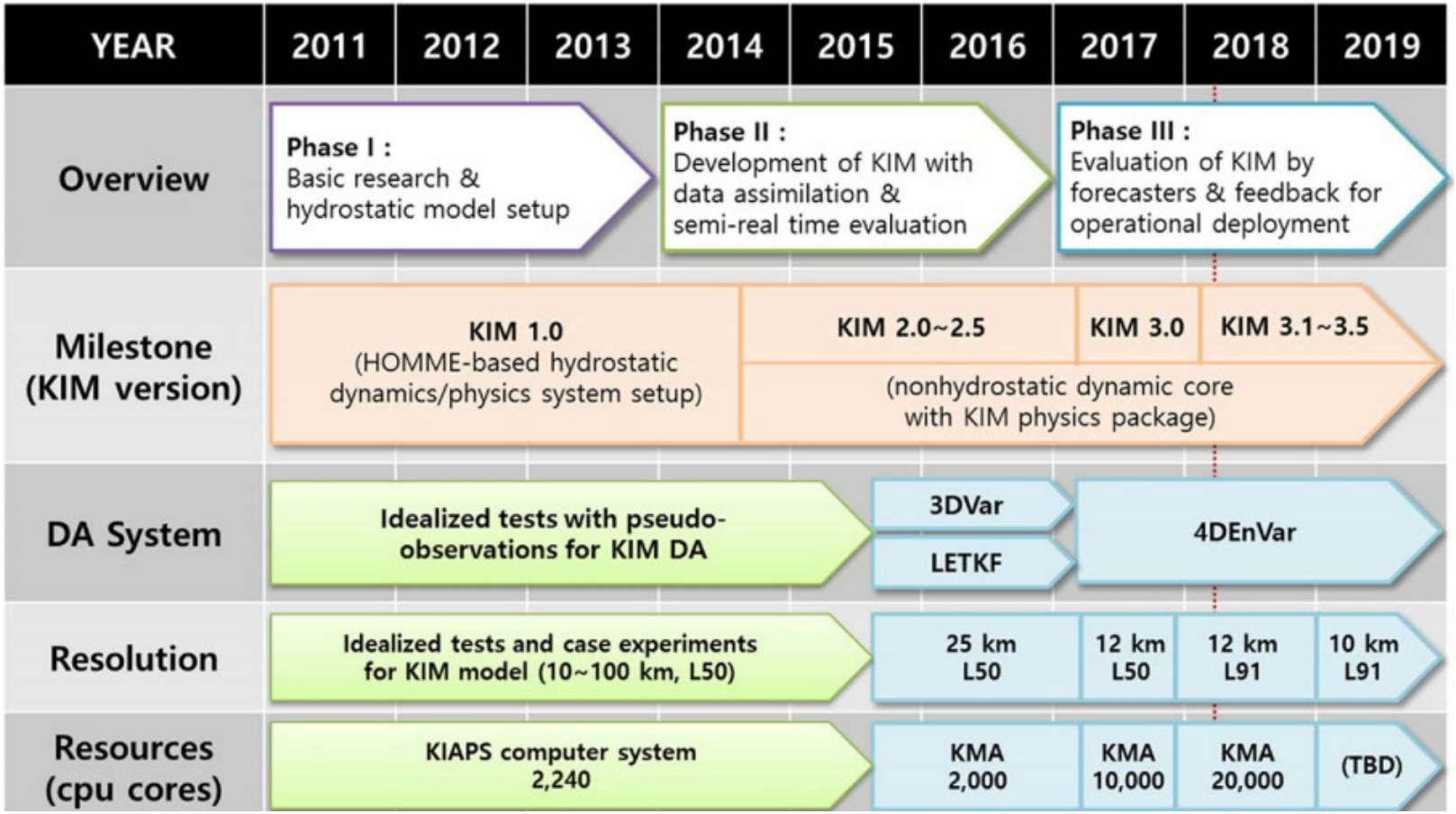
The Korean Integrated Model (KIM) System for Global Weather Forecasting

Song-You Hong, Young Cheol Kwon, Tae-Hun Kim, Jung-Eun Esther Kim, Suk-Jin Choi, In-Hyuk Kwon, Junghan Kim, Eun-Hee Lee, Rae-Seol Park, and Dong-Il Kim

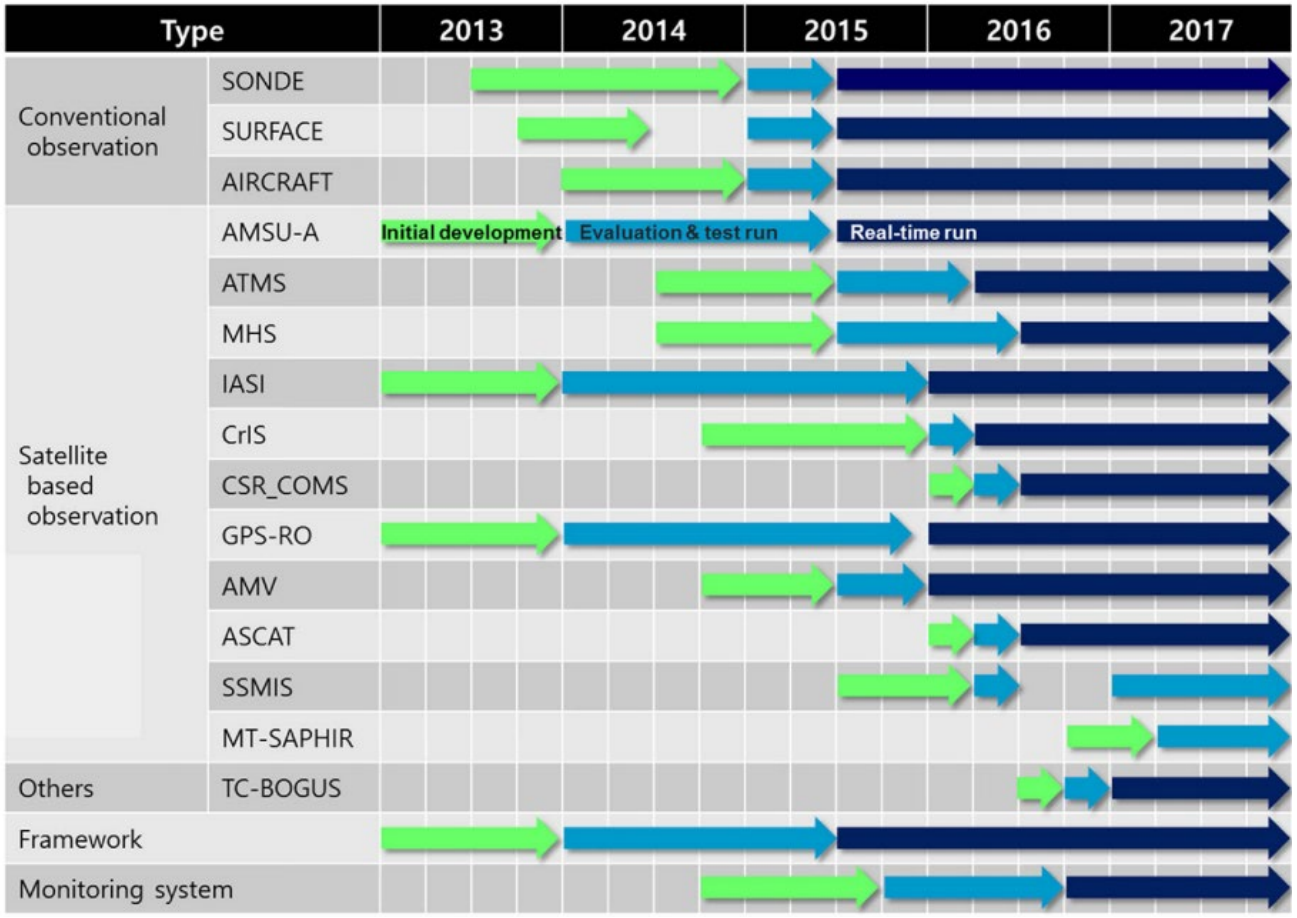
Korea Institute of Atmospheric Prediction Systems (KIAPS), Seoul, Korea



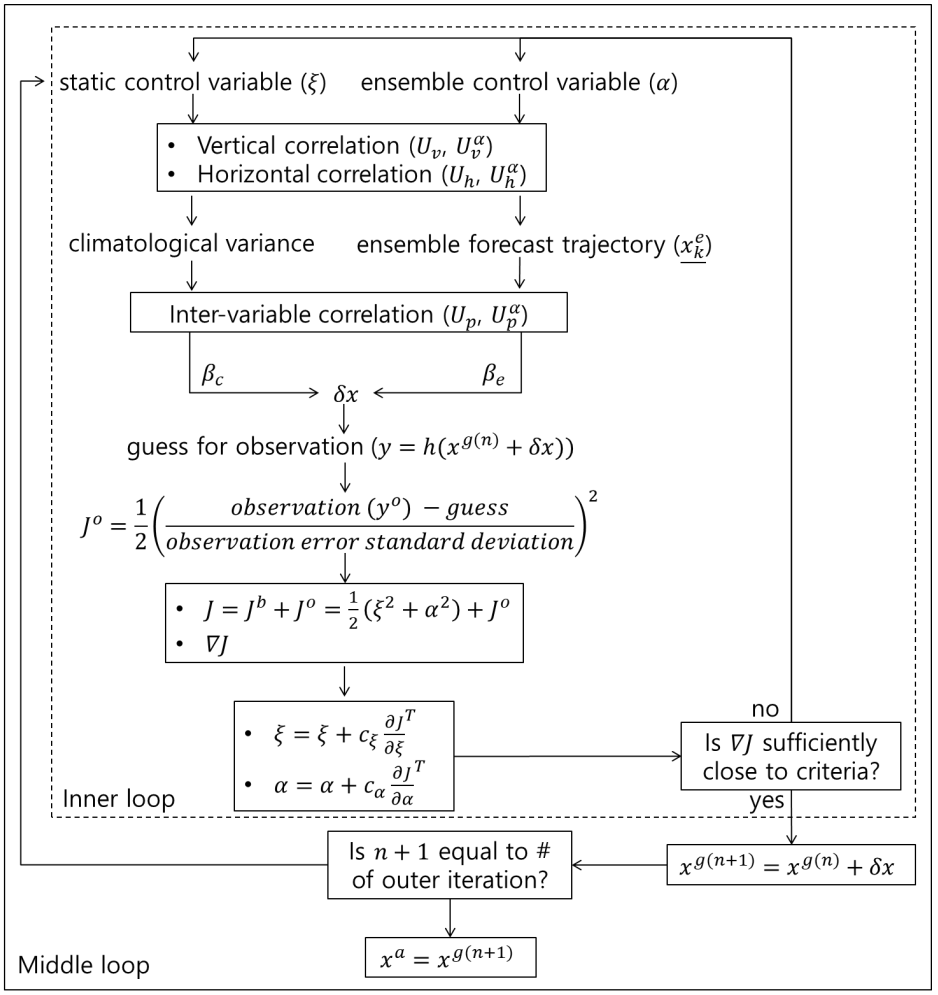
Korean Integrated Model by KIAPS



Korean Integrated Model by KIAPS



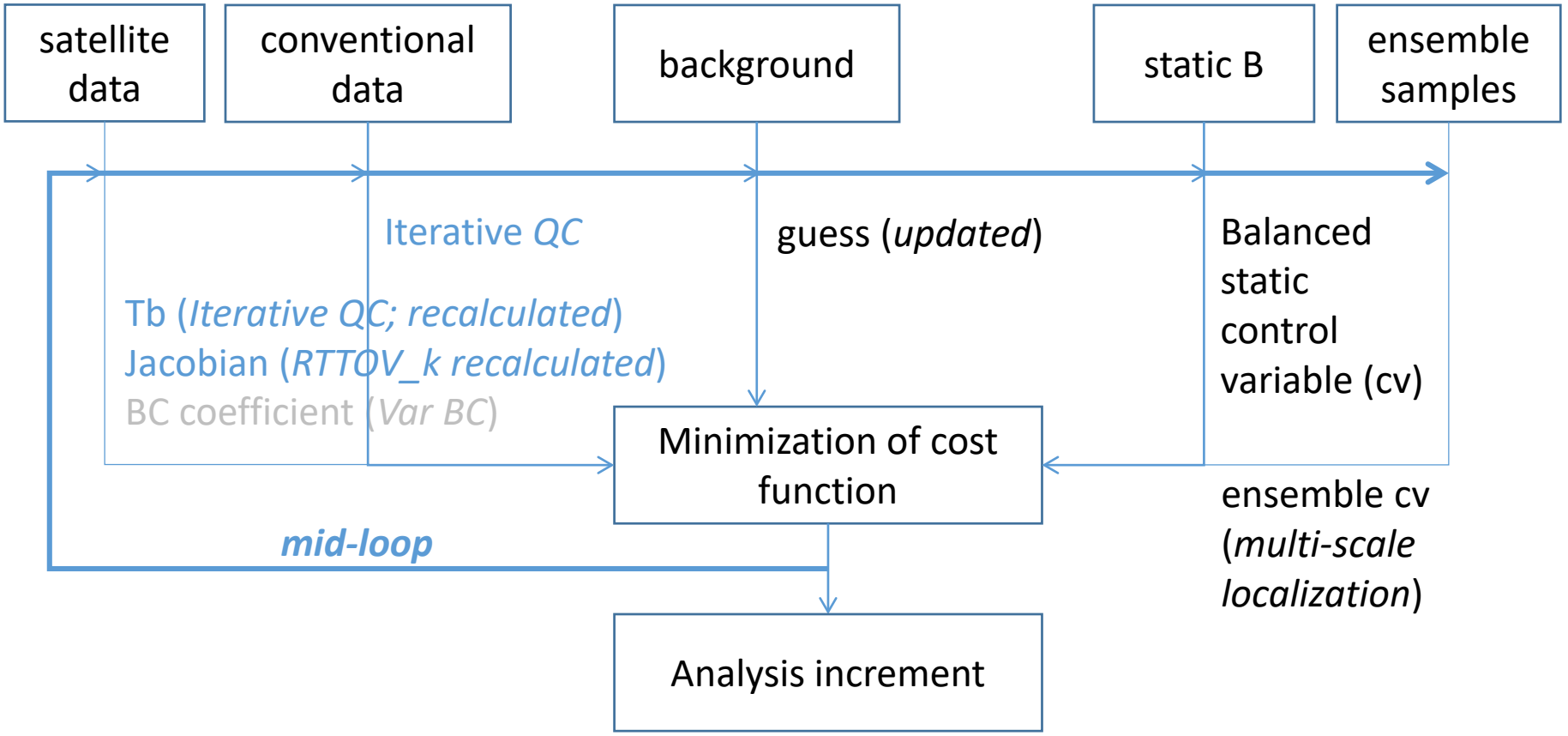
4D Ensemble Variational Assimilation - HybDA



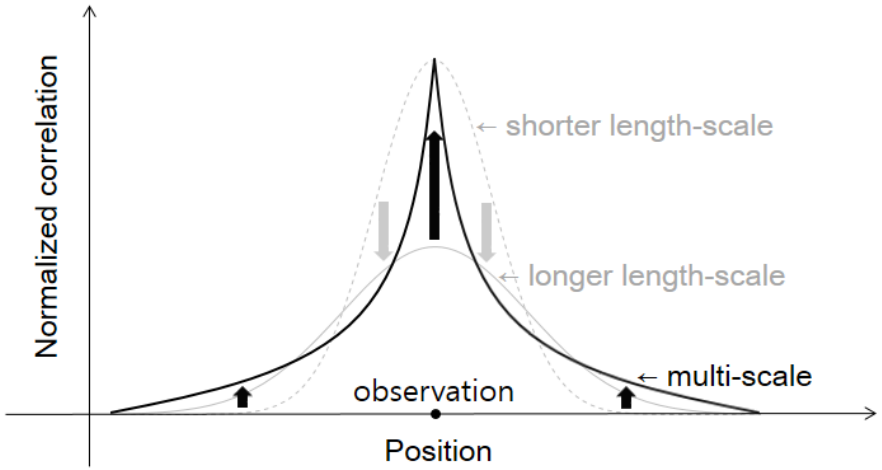
- Every mid-loop, brightness temperature and Jacobian of RTTOV are re-calculated without re-running of the NWP model.

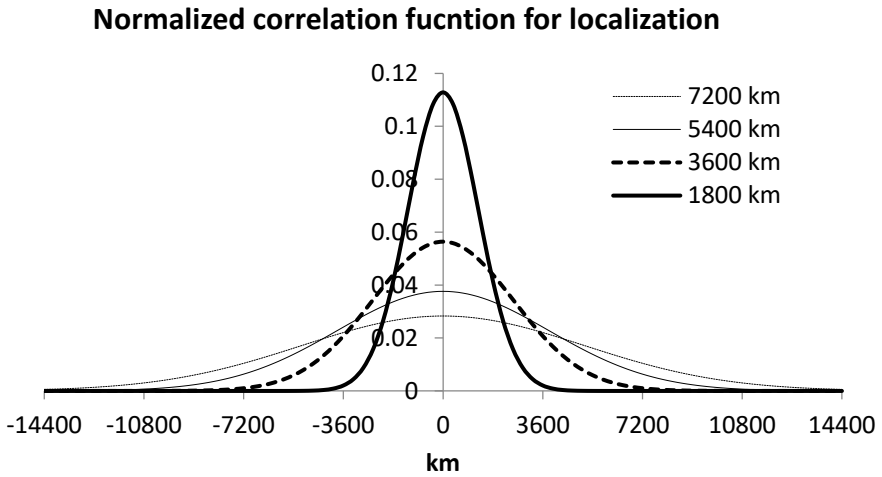
Song, H. J., Ha, J. H., Kwon, I. H., Kim, J., & Kwun, J. (2018). Multi-resolution hybrid data assimilation core on a cubed-sphere grid (HybDA). *Asia-Pacific Journal of Atmospheric Sciences*, *54*(1), 337-350.

Procedures in HybDA



Multi-resolution minimization

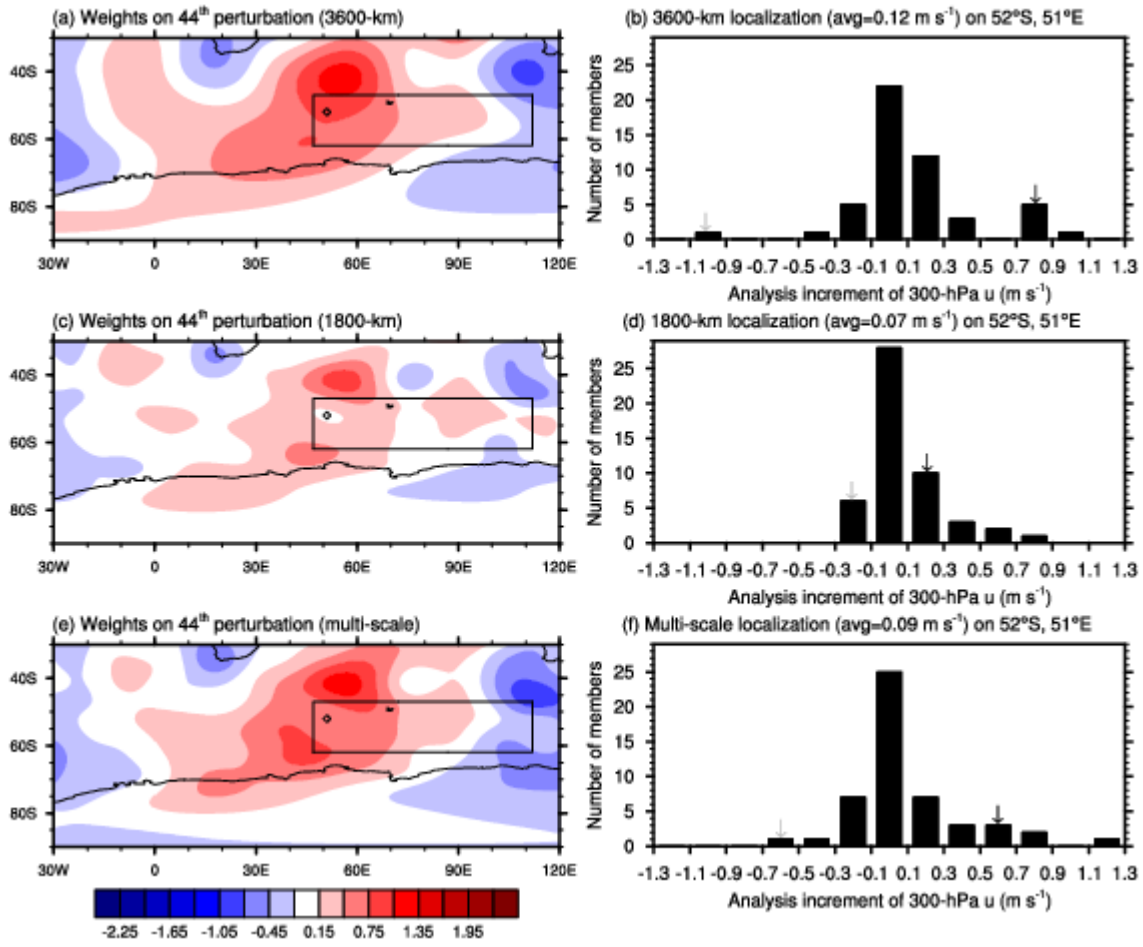




- Resolution of minimization also increases from 3600 km to 900 km in the way of 1/2*localization scale.

Song, H.-J. Existence of multiple scales in uncertainty of numerical weather prediction. *Sci Rep* **9,** 15672 (2019) doi:10.1038/s41598-019-52157-x

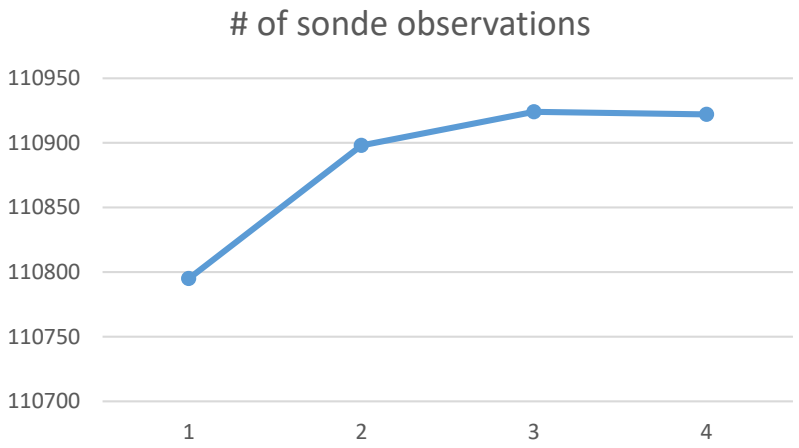
Impact of multi-scale localization

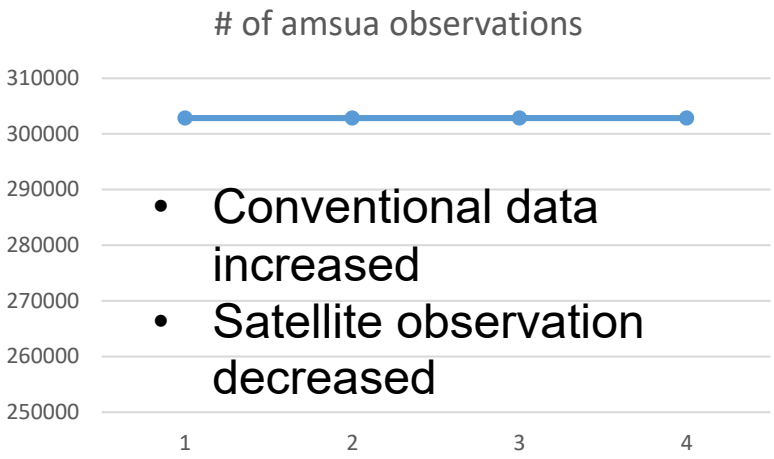


- **single experiment: fine resolution**
- **multi-scale experiment: large scale increment added**

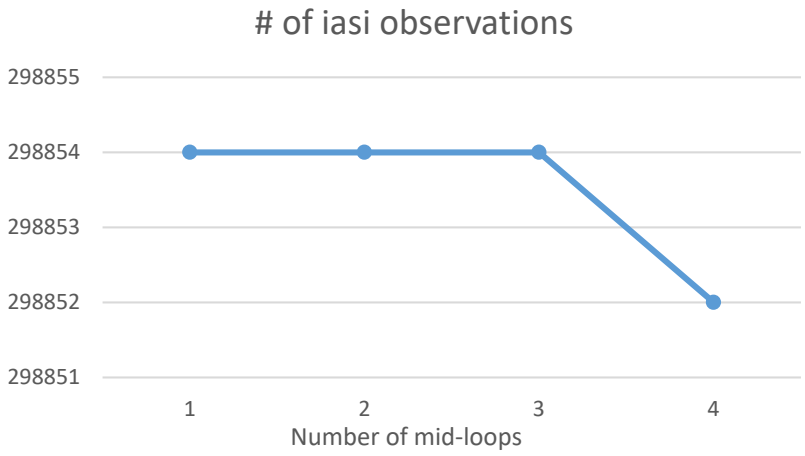
Song, H.-J. Existence of multiple scales in uncertainty of numerical weather prediction. *Sci Rep* **9,** 15672 (2019) doi:10.1038/s41598-019-52157-x

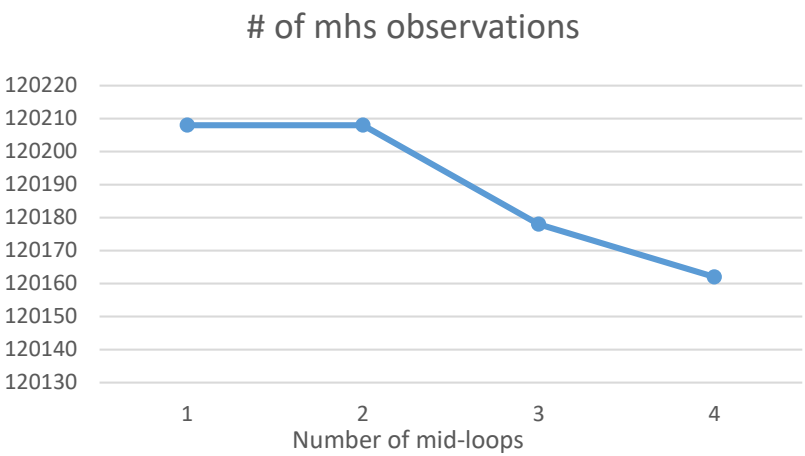
Iterative Quality Control (iQC)





- Conventional data increased
- Satellite observation decreased





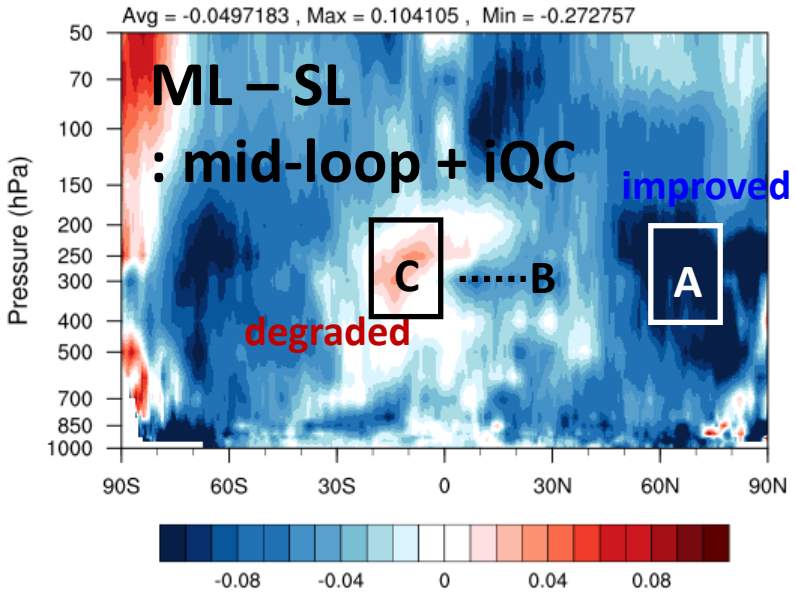
Experimental setting

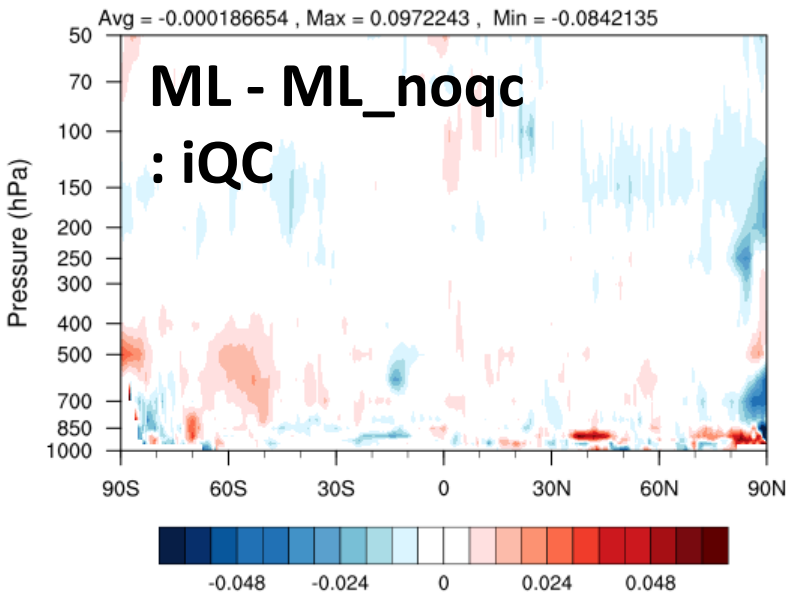
Experiment name	Configuration
SL	Single loop (no mid-loop) with final resolution
ML_noqc	4 times mid-loop, multiple resolutions of minimization each mid-loop, RTTOV and ROPP recalculated (mixed feature)
ML	The same as mid-loop_noqc with iterative QC

- Experimental period: 1 – 12 July 2018 (spin-up: 22-30 June 2018)
- NWP Model: Korean Integrated Model Version 3.3b
- Data assimilation scheme: Hybrid-4D Ensemble Variational Assimilation (HybDA)

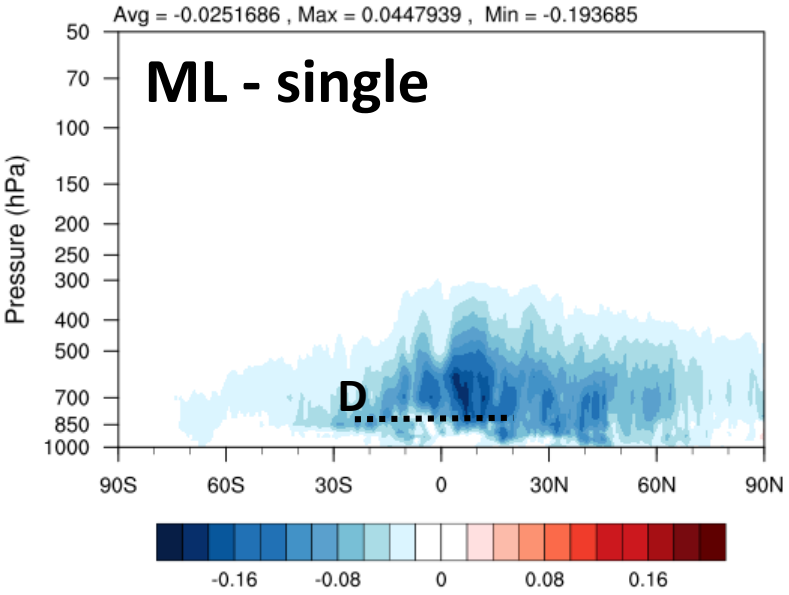
- ML_noqc – SL → impact of mid-loop
- ML – ML_noqc → impact of iterative QC
- ML – SL → impact of mid-loop + iterative QC

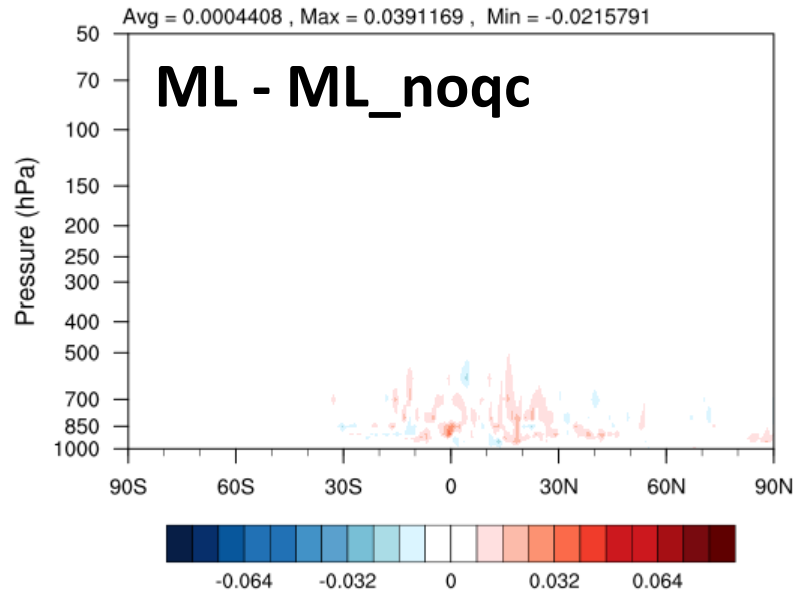
- **RMSE (against IFS analysis) of 6h forecast: Temperature**



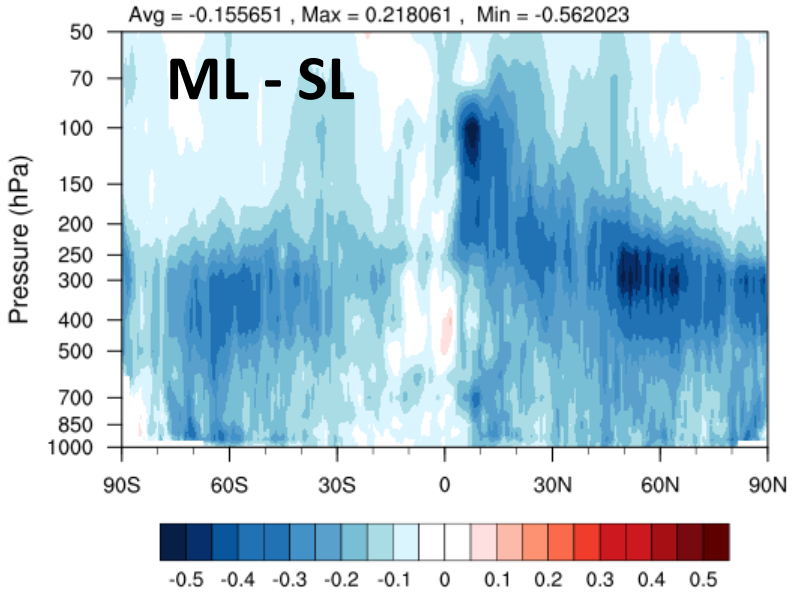


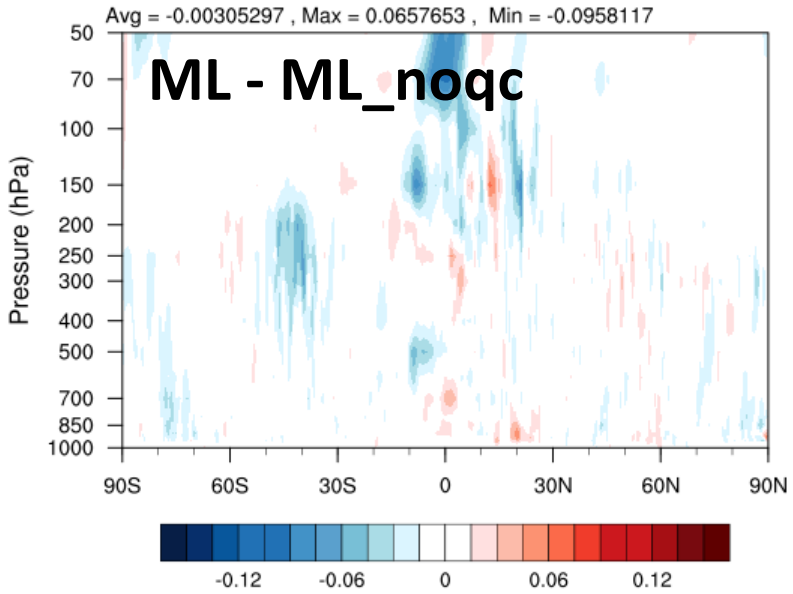
- **RMSE (against IFS analysis) of 6h forecast: Specific humidity**



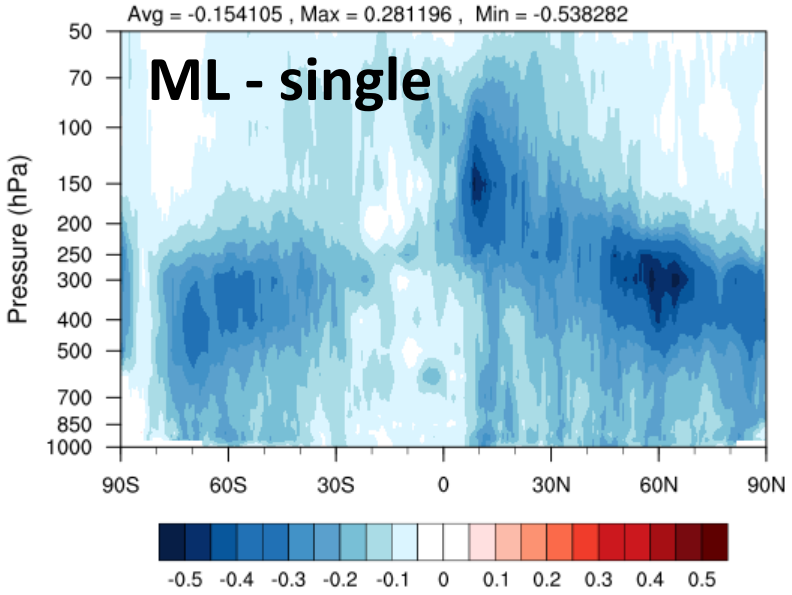


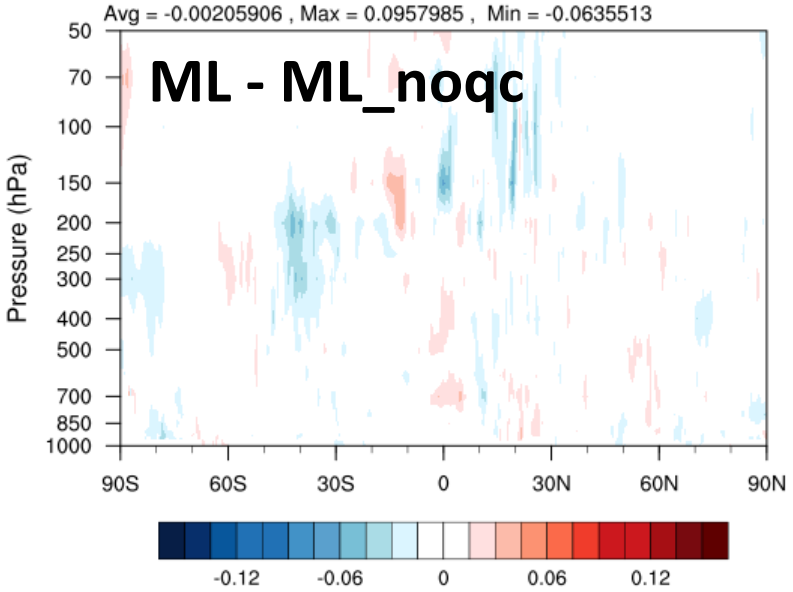
- **RMSE (against IFS analysis) of 6h forecast: Zonal wind**





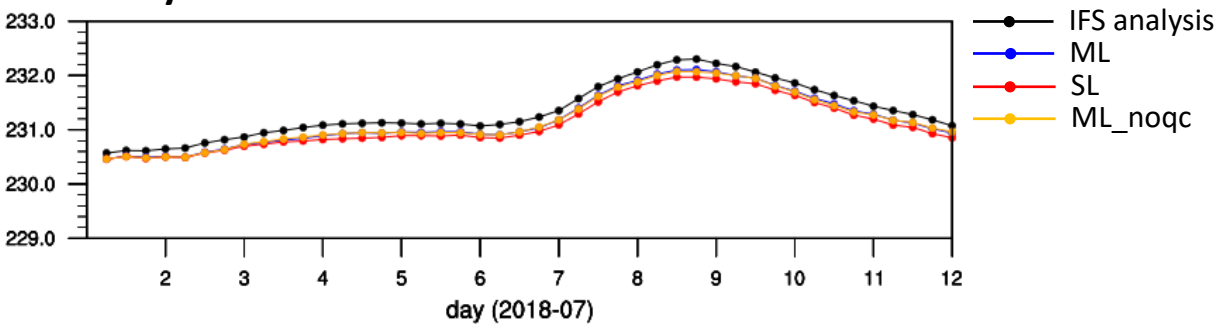
- **RMSE (against IFS analysis) of 6h forecast: Meridional wind**



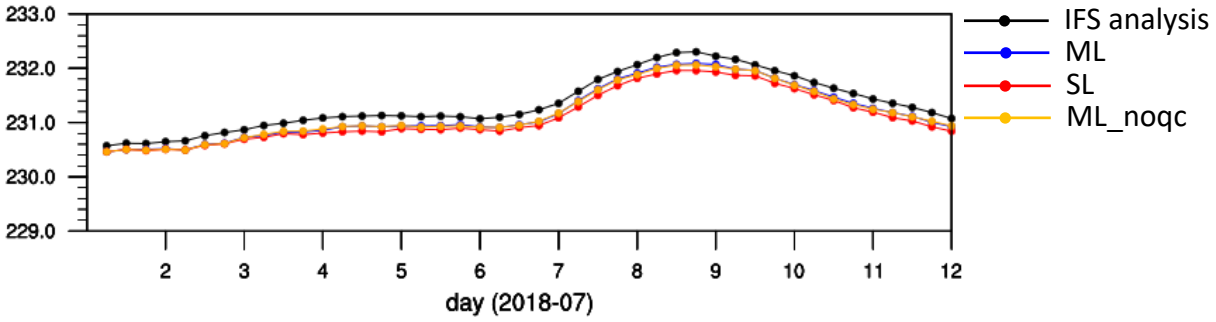


- Region A (60N~80N, 200~400 hPa; improved) averaged

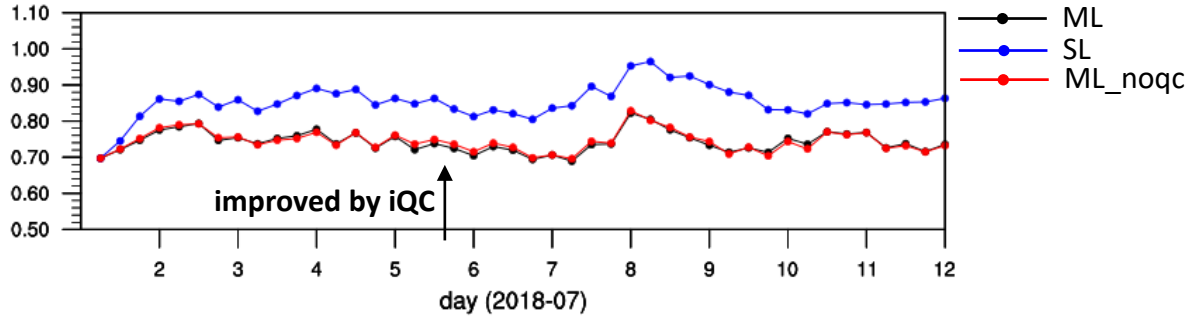
Analysis



6h forecast



6h forecast Temperature RMSE against IFS analysis



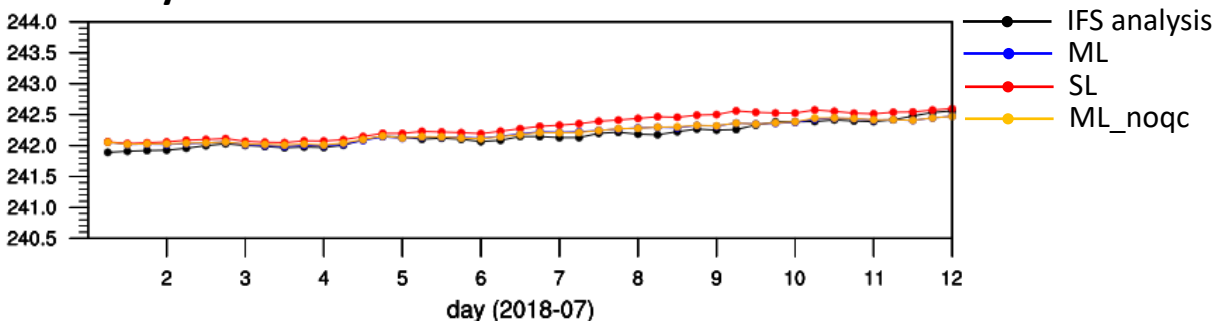
Cold bias corrected by increasing increment in mid-loop and iQC, compared to single

Similar even in 6h forecast

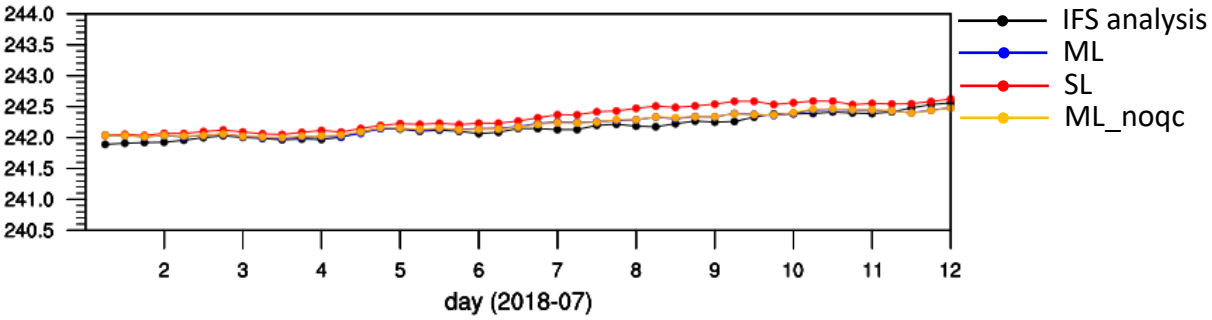
Against IFS analysis, the RMSE decreased in a consistent way by application of mid-loop and iQC

- Region B (0~20N, 300 hPa; improved) averaged

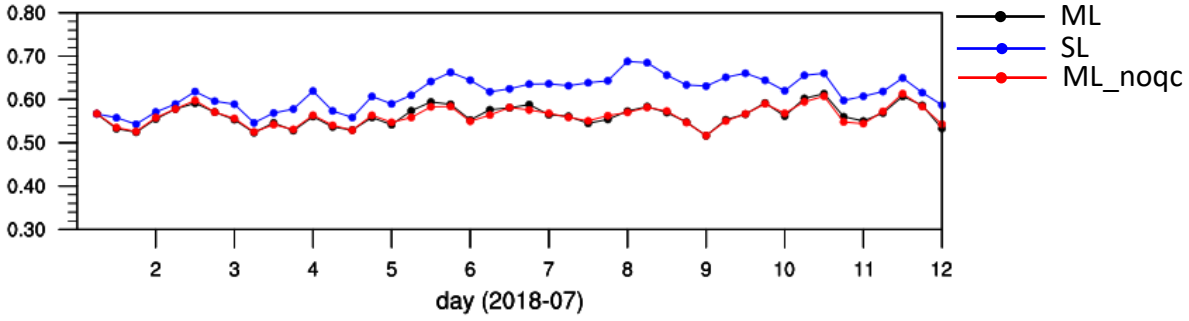
Analysis



6h forecast



6h forecast Temperature RMSE against IFS analysis



Warm bias corrected by decreasing increment in mid-loop, compared to single

↓

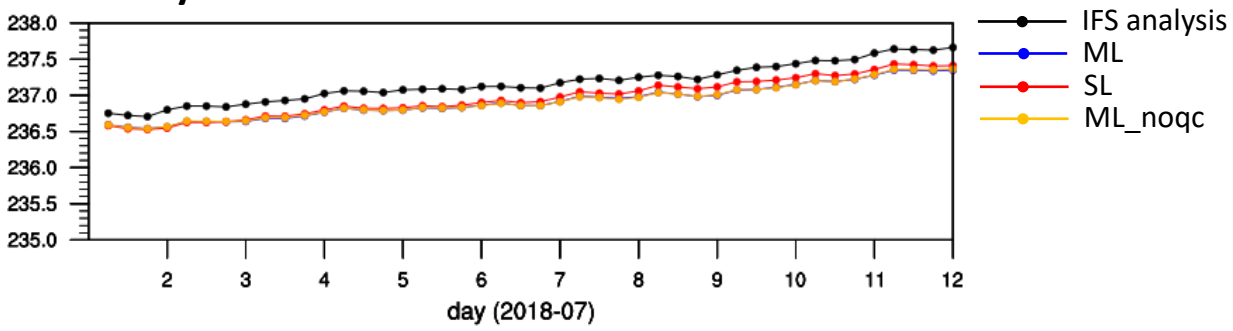
Similar even in 6h forecast

↓

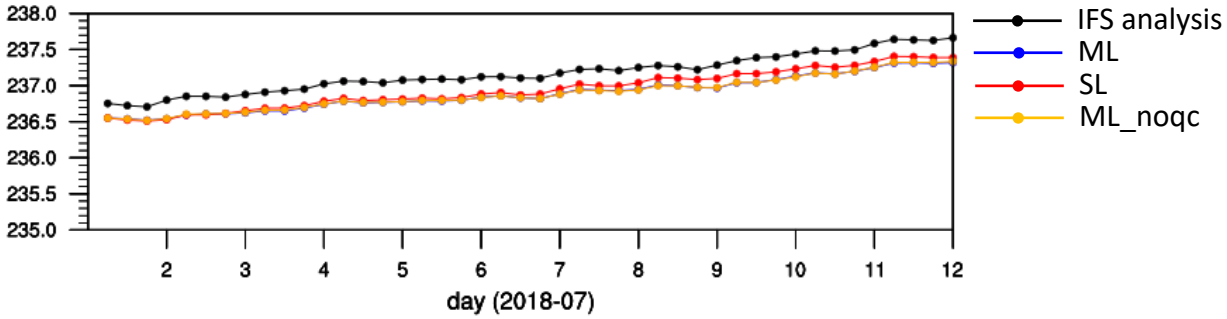
Against IFS analysis, the RMSE decreased consistently by application of mid-loop

- Region C (20S ~ 0, 200~400 hPa; degraded) averaged

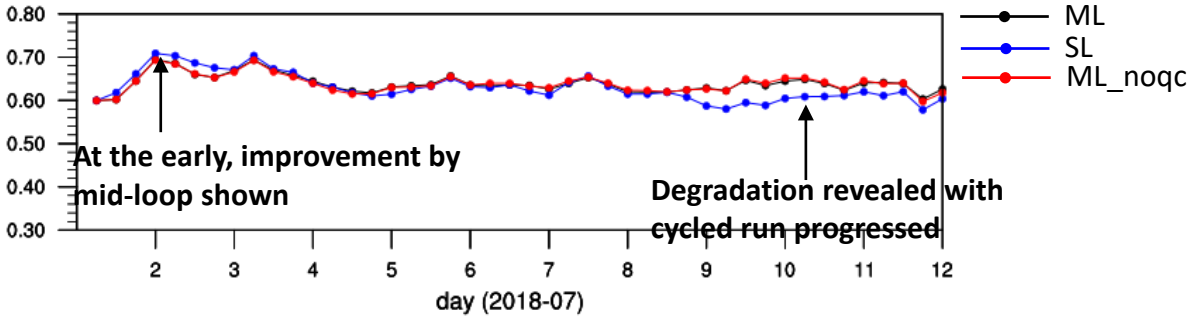
Analysis



6h forecast



6h forecast Temperature RMSE against IFS analysis



Cold bias worsened in mid-loop experiment

↓

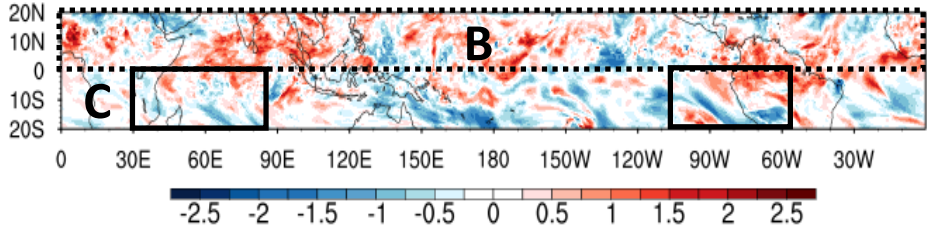
Similar way in 6h forecast

↓

Degraded by application of mid-loop as the cycled run is progressed

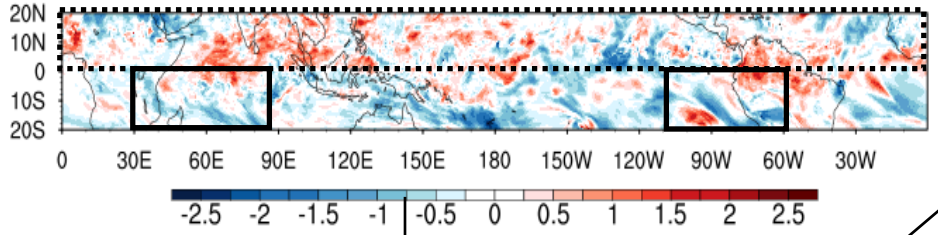
T Background error @ 300 hPa
(2018.07.10.00 UTC)

SL



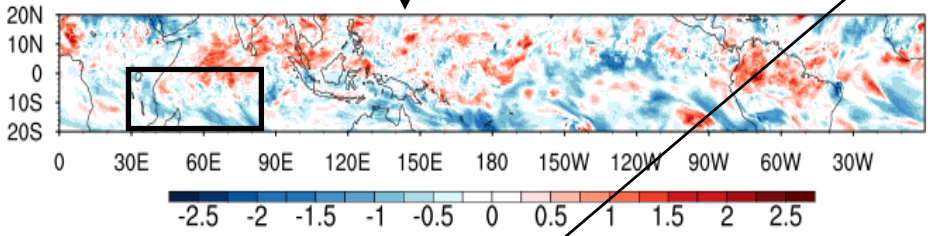
- **0~20N T warm bias decreased**
- **negative bias in Indian Ocean and southern Pacific**

ML_noqc



- **negative bias decreased**

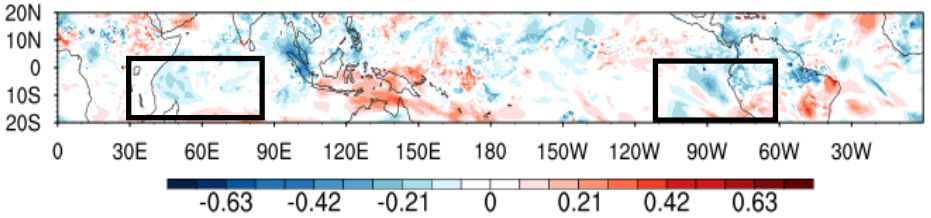
ML



Multi-scale approach may make larger-scale analysis increment feature making the situation worse

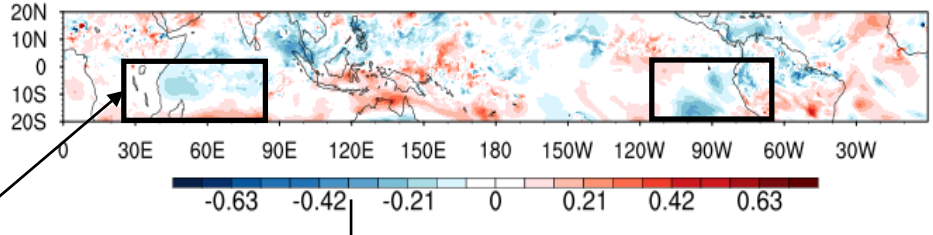
T Analysis increment @ 300 hPa
(2018.07.10.00 UTC)

SL



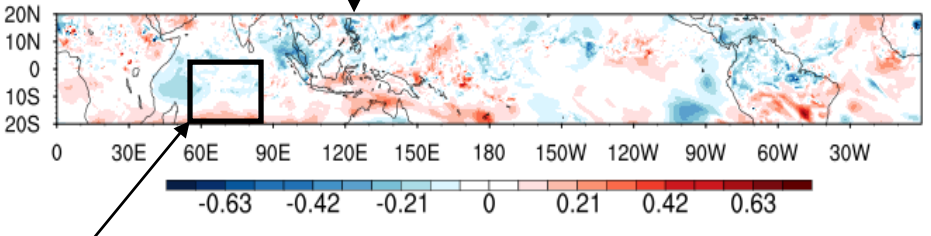
- **colder temperature increment in NH**

ML_noqc



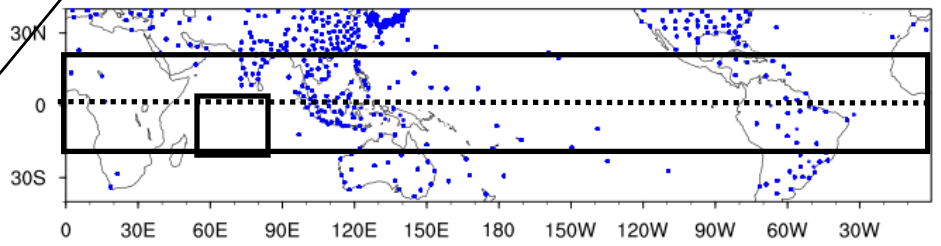
- **warmer temperature increment**

ML



Decreased satellite observation may yield less colder temperature increment (by iQC)

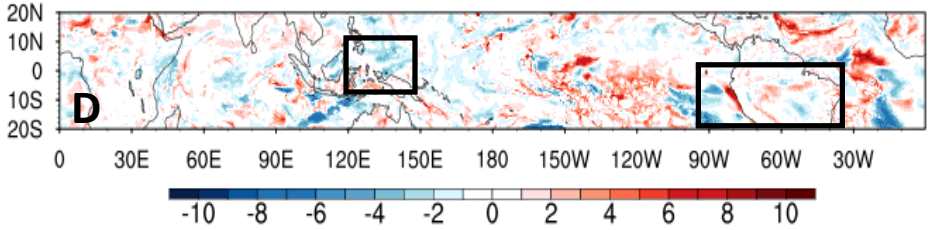
Positions of radiosondes



Q Background error @ 850 hPa
(2018.07.10.00 UTC)

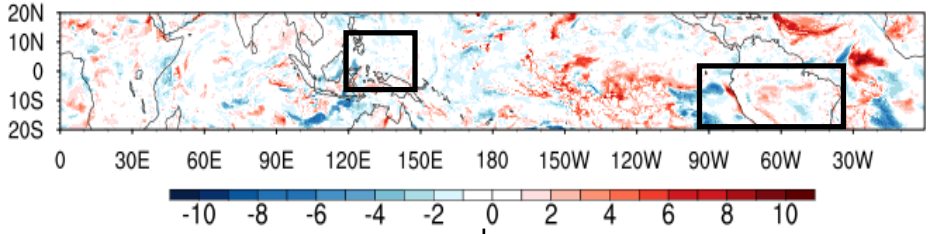
Q Analysis increment @ 850 hPa
(2018.07.10.00 UTC)

SL



moisture error decreased in the Pacific

ML_noqc



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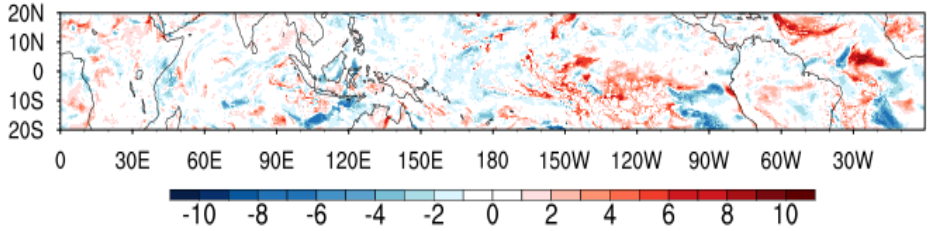

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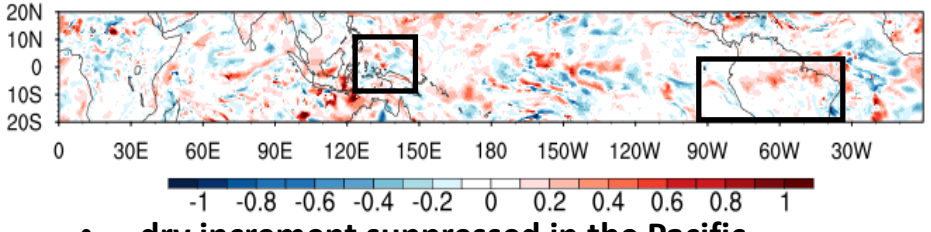
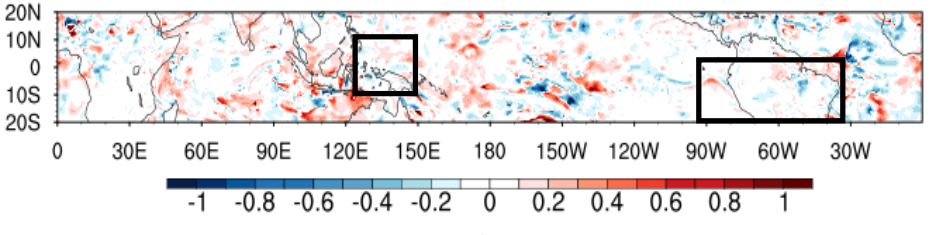


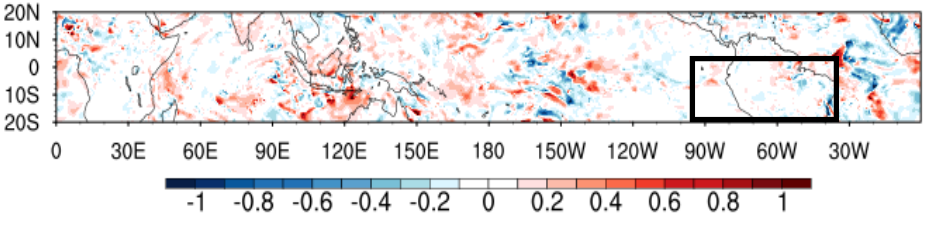
- **dry increment suppressed in the Pacific**
- **humid increment suppressed in the Southern America (by RTTOV recalculation)**

ML_noqc



more suppressed in the Southern America (iQC)

ML



Remarks

- Although mid-loop works well, it tends to make the temperature increment colder in southern tropical upper-troposphere, which is probably related to larger-scale increment included in the multi-scale approach.
- For the moisture analysis, it robustly works by suppressing suspicious dry and humid increments, which comes probably from RTTOV recalculation, with the additional aid of the iterative QC.
- These features need to be re-investigated with isolating the effects of RTTOV recalculation de-coupled from multi-scale impact.

Thank you for your attention!