

Estimation and Correction of the GFS systematic errors

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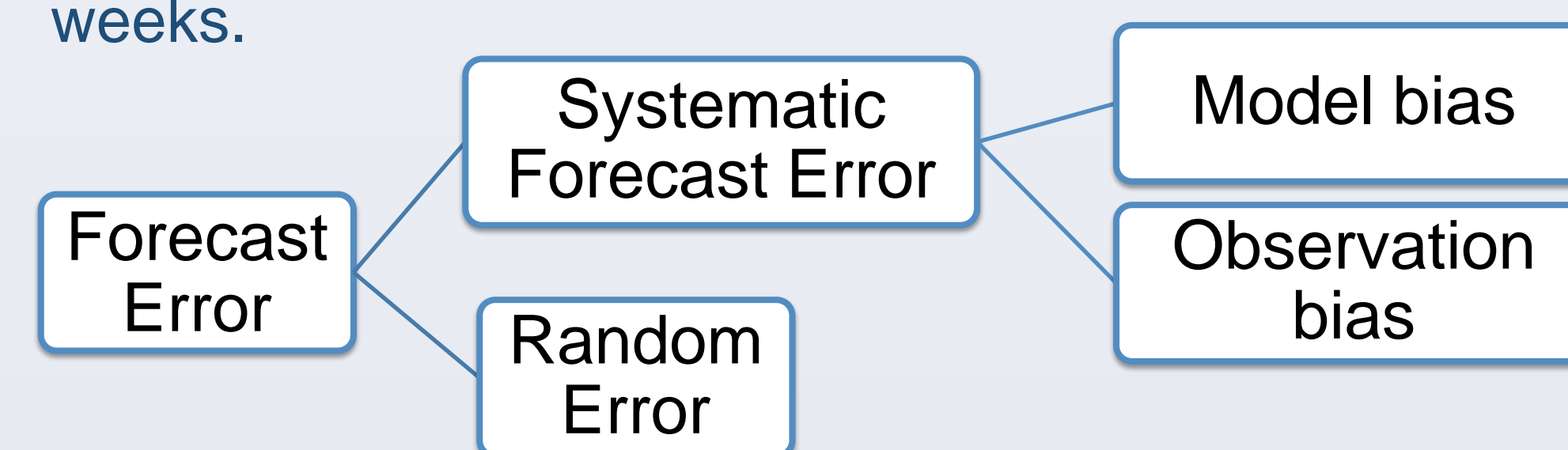
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INTRODUCTION

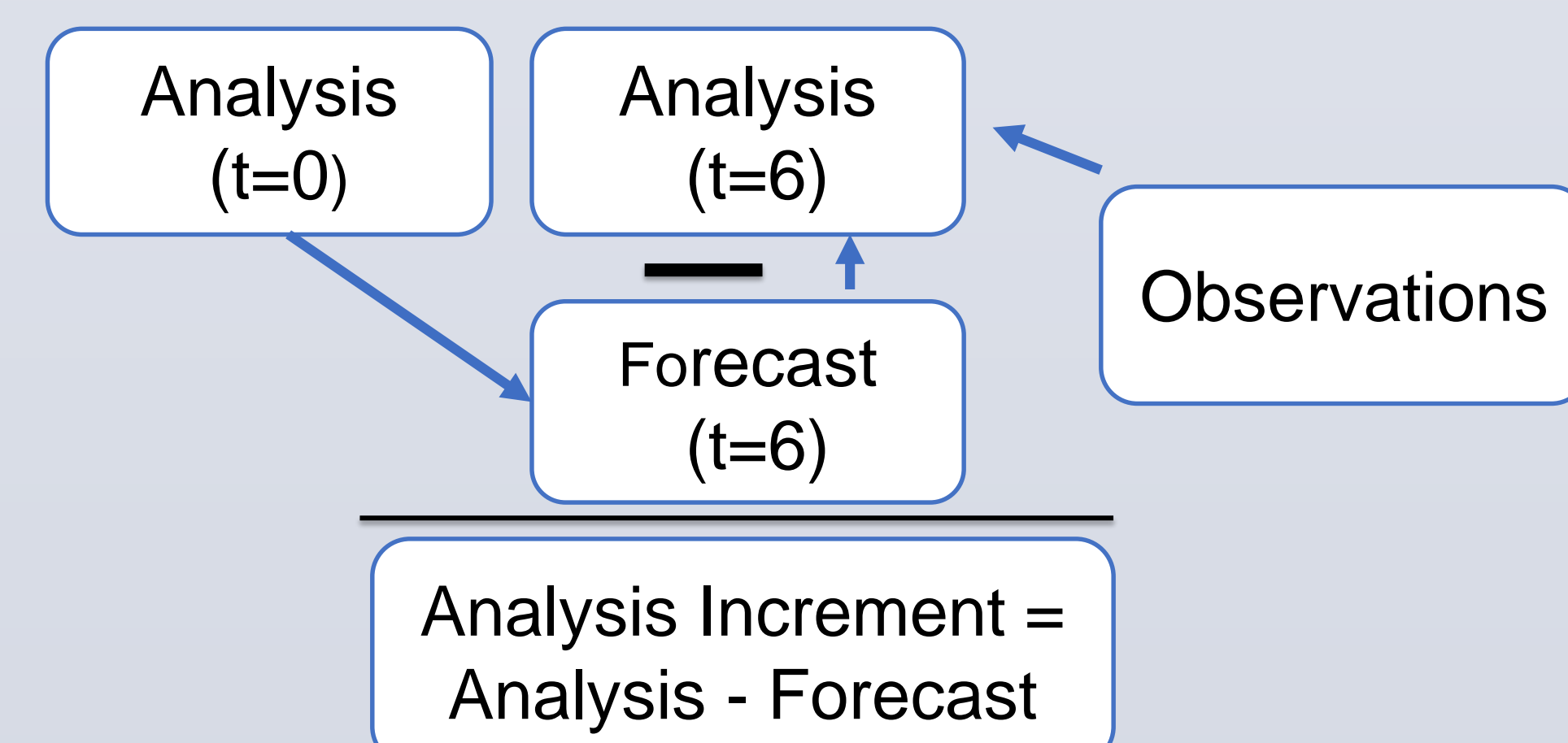
- ❑ The performance of numerical weather prediction models is limited by model errors.
- ❑ Systematic forecast errors form a significant portion of the total forecast error in weather prediction models like the Global Forecast System (GFS).
- ❑ They are the result of model bias and the impact of observation biases in the model initial conditions, that then grow nonlinearly as the model is integrated in time, until the systematic errors saturate at about two weeks.



- ❑ The goal of this paper is to estimate the initial model biases, and their spatial structure, for 2012-2016, as a first step towards correcting them within the model as in Danforth, Kalnay and Miyoshi 2007 (DKM07).

ANALYSIS INCREMENTS AS AN ESTIMATE OF MODEL BIAS

- ❑ The difference between the state analysis and background, gives six hour Analysis Increments (AI).
- ❑ Model biases are estimated from the time average of the 6-hr AIs, which are the corrections that the observations make on the 6-hr forecasts.



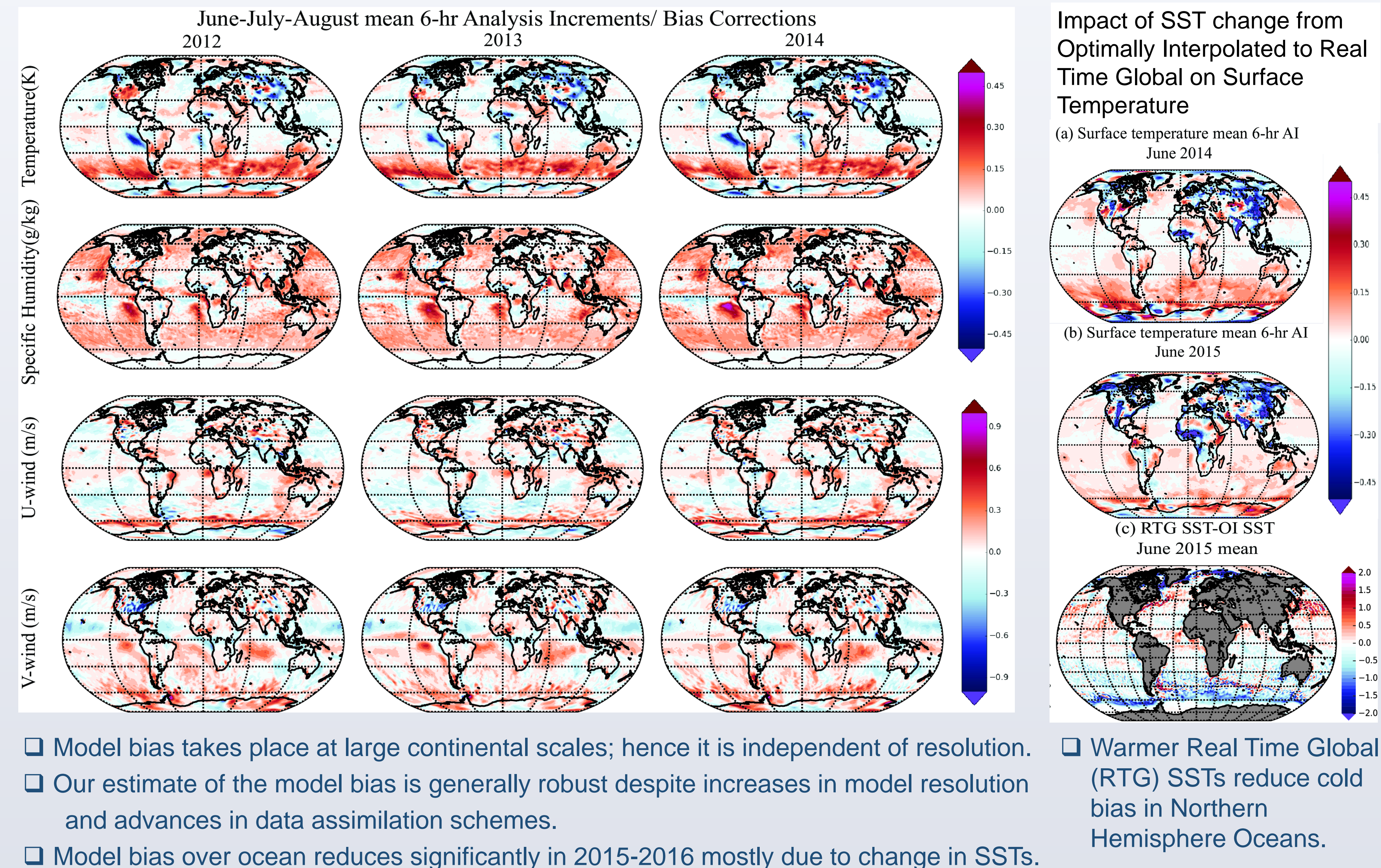
Advantages of 6-hr Analysis Increments

- ❑ The 6 hour forecast is short enough that the systematic errors grow approximately linearly.
- ❑ Analysis, unlike observations, is present on the model grid and available at desired time, which avoids introducing interpolation errors.
- ❑ These time average corrections can be applied directly on the model ("online model correction").

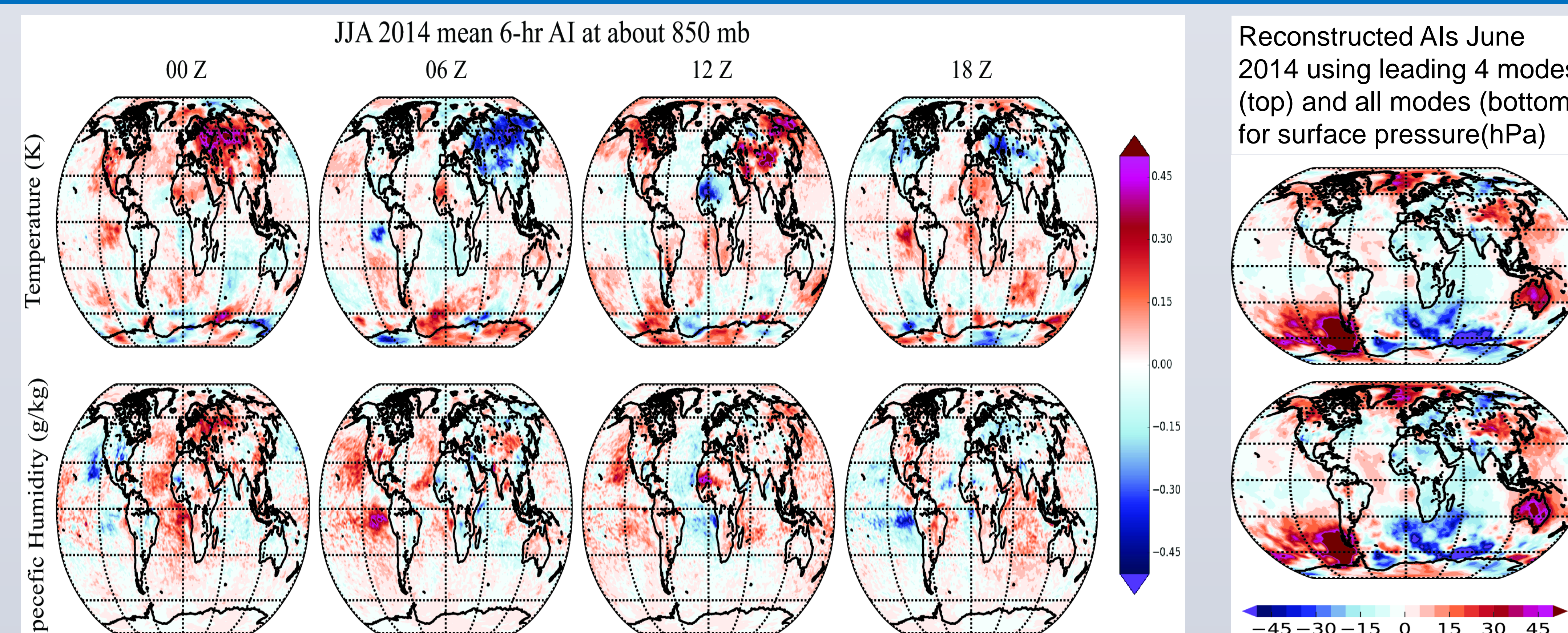
Disadvantage of 6-hr Analysis Increments

- ❑ If the observations are biased, however, this bias will also be included in the AIs.

SEASONALLY AVERAGED BIAS CORRECTIONS



DIURNAL CYCLE BIAS CORRECTIONS



SUMMARY

- ❑ The average of 6 hourly Analysis Increments (AIs) provide the best estimate of model bias before the errors start to grow non-linearly.
- ❑ GFS has significant seasonally averaged and periodic errors which take place at large continental scales.
- ❑ Model bias are mostly robust despite changes in model and data assimilation schemes.
- ❑ Periodic errors which are dominated by diurnal and semi-diurnal cycle errors can be corrected within the model using the low dimensional approach used by DKM07 that needs only the leading EOFs.
- ❑ Our estimate of model bias may also contain observation bias. For example, correcting the prescribed SSTs in 2015 and 2016 reduced the AI.

ONLINE CORRECTION METHOD

- ❑ Online Correction method corrects the model bias empirically during the model integration.
- ❑ This method reduces the non linear error growth of model bias while providing continuously corrected forecasts at all lead times .
- ❑ Online correction should also reduce random errors (Danforth and Kalnay, 2008).
- ❑ Our estimate of model bias can be conveniently used to correct the model online by adding the bias correction term in the model tendency equations.

$$\frac{\partial X}{\partial t} = M(X) + \frac{\langle AI \rangle}{6hr}$$

KEY REFERENCES

- ❑ Danforth, C. M., E. Kalnay, and T. Miyoshi, 2007: Estimating and correcting global weather model error, Monthly Weather Review, 135, 281–299.
- ❑ Danforth, C.M., and E. Kalnay, 2008: Impact of online empirical model correction on nonlinear error growth, Geophysical Research Letters, 35, L24805, doi: 10.1029/2008GL036239.

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