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Radiance Biases over Land and Ocean

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International Surface Working Group

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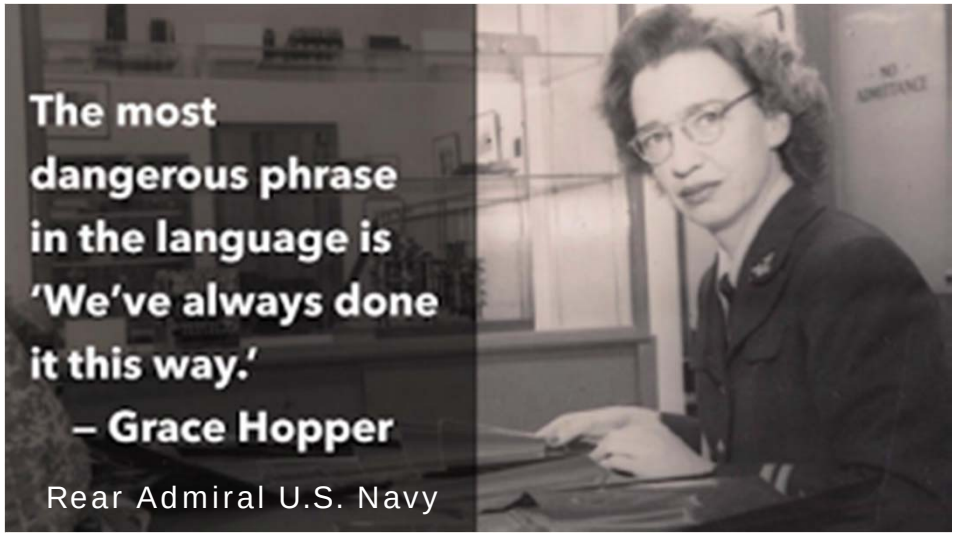
Outline

Forecast Model Bias Interaction with Radiance Bias Correction

- Does radiance bias correction reinforce forecast model bias?
- If so, can we design a radiance bias correction scheme that does not?

How do the bias corrections differ over land and ocean

- Retrievals (soil moisture)
  - CDF matching of soil moisture retrievals (Hauser et al. 2006)
- Brightness Temperatures (radiances)
  - A multi-angular bias correction approach based on a CDF-matching
  - Variational techniques



De Lannoy, G.J.M., Houser, P.R., Pauwels, V.R.N., Verhoest, N.E.C. (2006). State and bias estimation for soil moisture profiles by an ensemble Kalman filter: effect of assimilation depth and frequency. Water Resources Research, 43(6), W06401, doi:10.1029/2006WR005100.
Reichle, R., R. Koster, P. Liu, S. Mahanama, E. Njoku, and M. Owe, 2006. Comparison and assimilation of global soil moisture retrievals from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) and the Scanning Multichannel Microwave Radiometer (SMMR). JGR (112), D09108, doi:10.1029/2006JD008033.

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Bias Correction for Radiances

- Radiance Bias Correction
  - Eyre (1992) “A bias correction scheme for simulated TOVS brightness temperature” ECMWF Tech Memo 186.
  - Harris and Kelly (2001), “A satellite radiance-bias correction scheme for data assimilation.” Q.J.R. Meteorol. Soc., 127: 1453–1468.
  - Auligne, McNally and Dee (2007). “Adaptive bias correction for satellite data in a numerical weather prediction system.” Q.J.R. Meteorol. Soc., 133: 631–642.
- Radiance assimilation needed bias correction
  - Inconsistencies between families of sensors brought into alignment
  - Physical reasons for scan asymmetries can be handled with bias correction
- Variational (inline adaptive) corrections
  - Most centers update every assimilation cycle for atmospheric bias correction

“systematic errors in the brightness temperature simulated from forecast model profiles … unless these biases are corrected … it is difficult to use measured radiances to positive effect in NWP” – Eyre 1993

Residual variance after bias correction is a sum of errors variance in:

- Measurements
- Radiative transfer calculation
- Forecast model

Predictor selection (there have been many tried) for Atmosphere:

- Air mass
- Zenith angle
- Radiative transfer model (gamma)
- Lapse rate

Land:

- microwave roughness (h), vegetation opacity (τ), and scattering albedo (ω) by vegetation class

Regional models (separate coefficients for each watch?)

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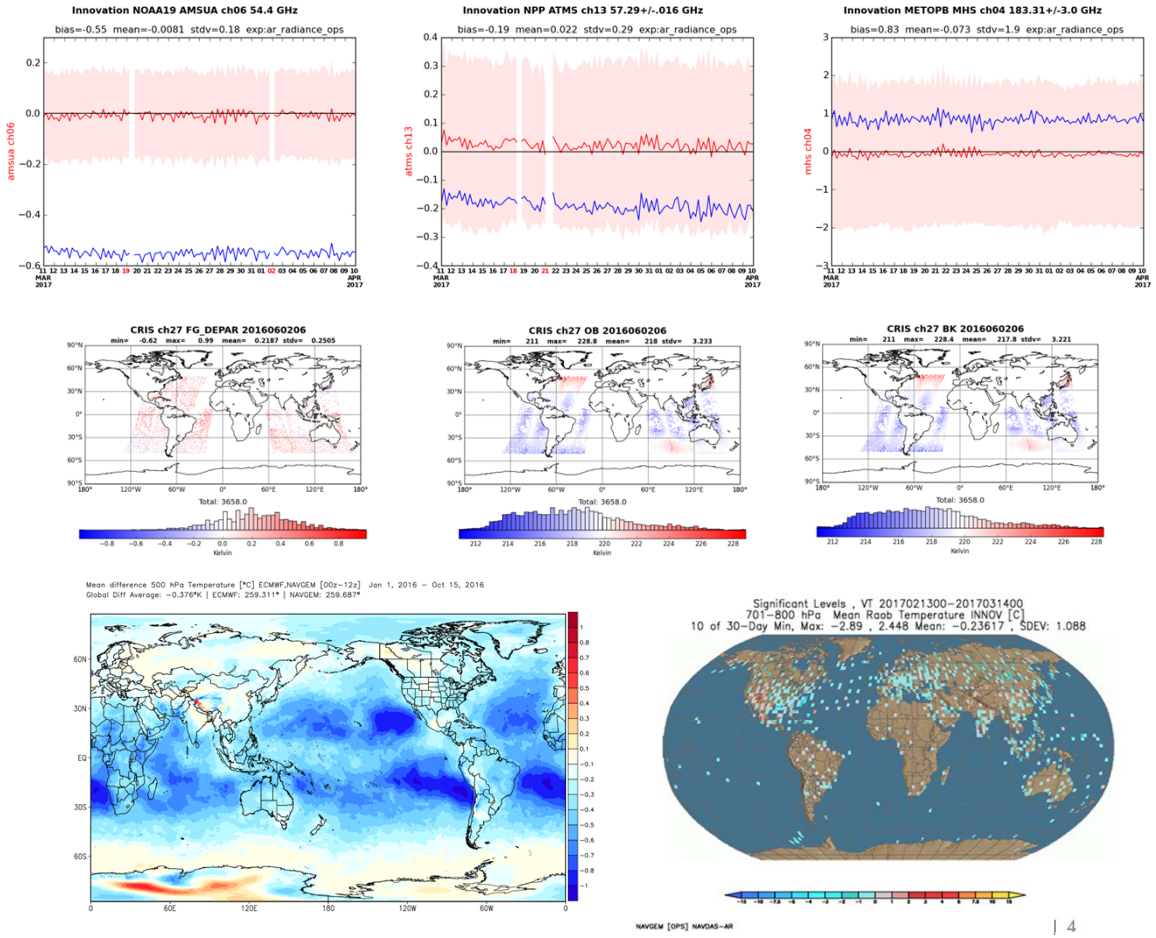
Bias Correction in Practice

- Global bias correction
  - Produces low standard deviation
  - Maps of residual show persistent bias with magnitudes much larger than global standard deviation

Should we correct for these spatially, or are these signal pointing to model bias?

- Is the Bias Correction Reinforcing Model Tendencies?
  - Model may have a tendency towards developing certain biases
  - How to diagnose these and communicate

- Can we remove some of these biases reinforced by radiance bias correction?
  - Create parallel update cycle every tau and run without radiances
    - Use this background to produce bias coefficients



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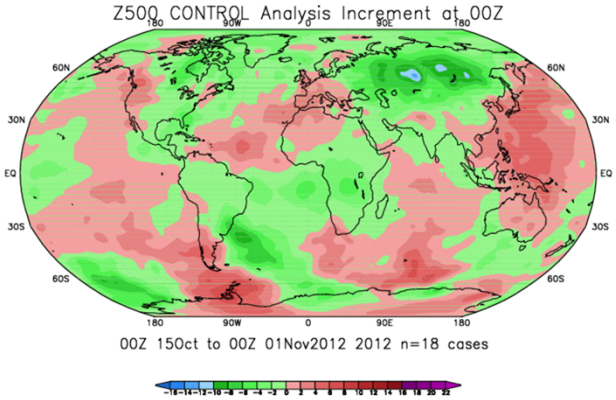
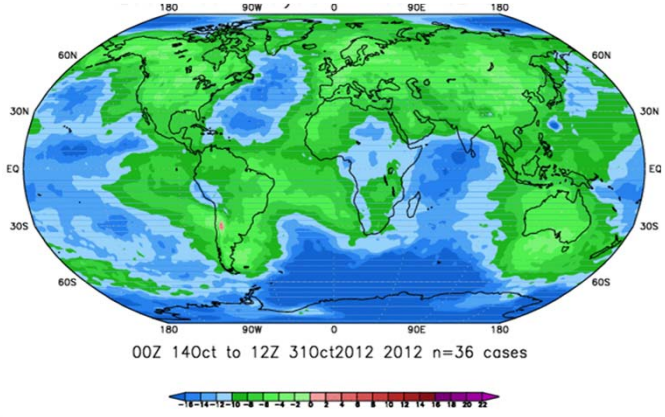
Bias Analysis through Increments

- Typically bias correction adjusts quickly
  - Spinup from zero bias correction typically stabilizes after 5 days
- Evolution of bias corrections
  - Model tendencies may change seasonal timescales
  - Allow adaptation to these changes
- How to best separate components of bias
  - Radiative transfer biases will likely have different characteristics than systematic NWP model biases
- Pitfalls of autonomous systems
  - Drifts over time:
    - Sensor degradation
    - Buildup of NWP bias (moisture in stratosphere, incorrect Ozone, …)

500 hPa Analysis Increment



500 hPa Analysis Increment (using ECMWF psuedo-obs)



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Model Bias in Land Parameters

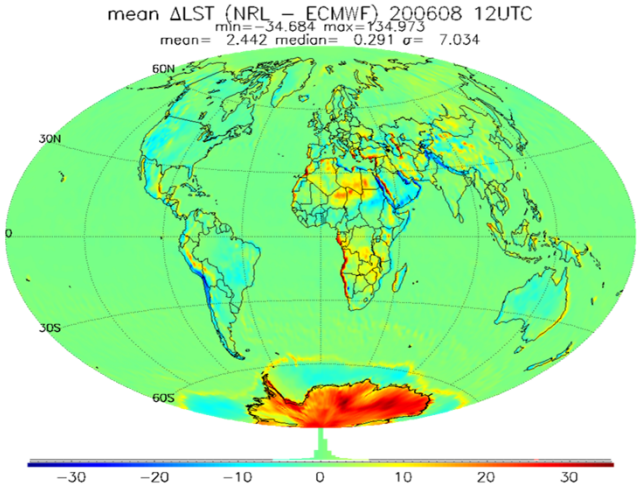
- Model bias in land parameters
  - Can be poorly defined in many regions
  - Dynamic range is critical
    - For LST in particular NWP models tend to under-predict the dynamic range

- Evolution of bias corrections
  - Model tendencies change seasonal timescales
  - Allow adaptation to these changes

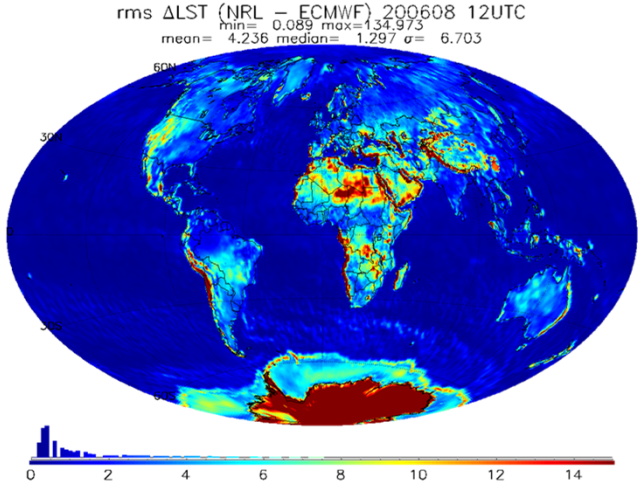
- How to best identify components of bias
  - Radiative transfer biases driven by different NWP models can help to separate components
  - Similarly different RT models can be used to identify differences due to internal parameters

- Pitfalls of autonomous systems
  - On a global scale, neither the satellite nor the model soil moisture are more consistent with the available in situ observations, implying that presently there is no agreed climatology of global soil moisture [Reichle et al.,2004].

Mean LST difference



RMS LST difference



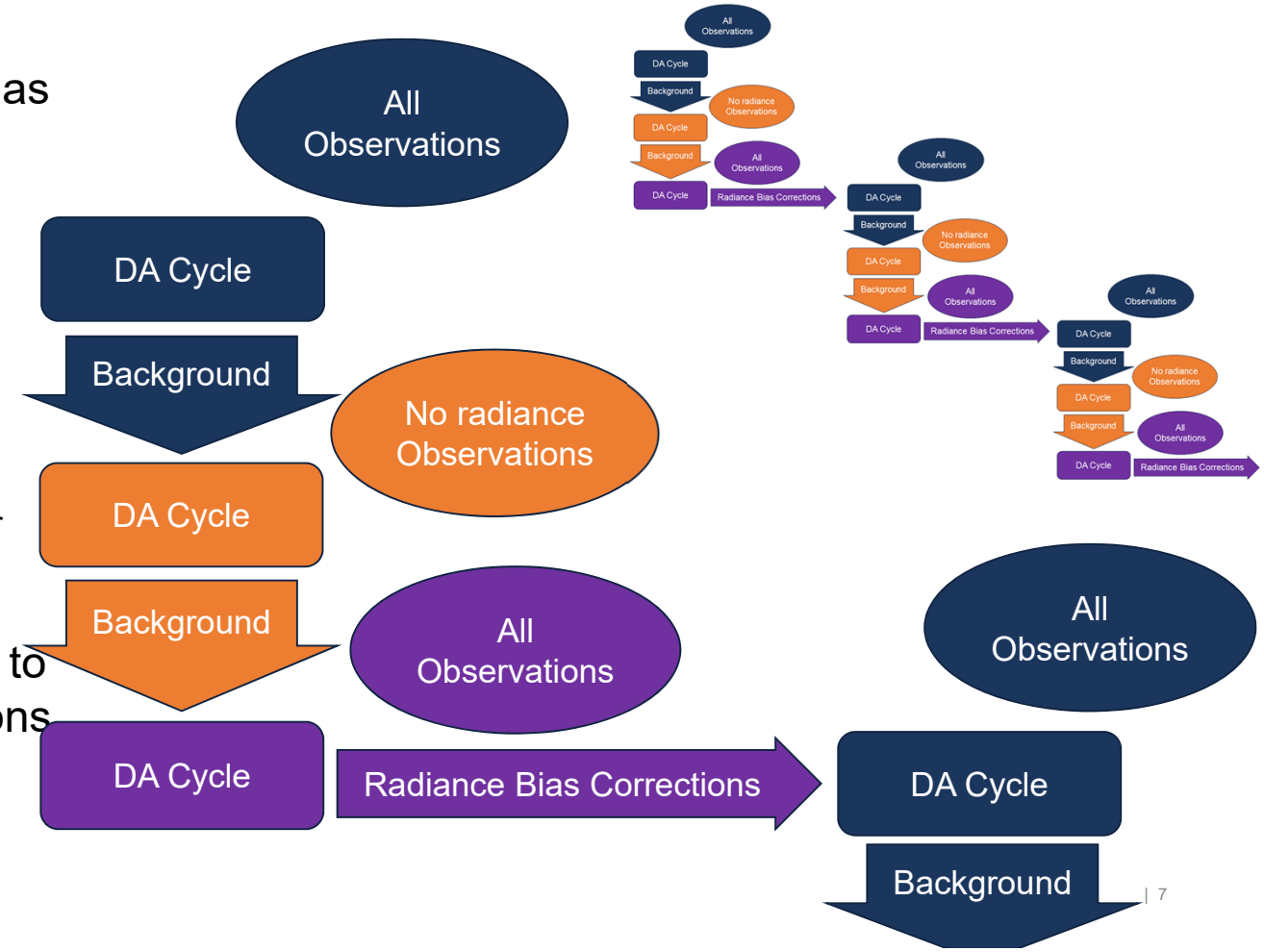
Bias Correction feedback with Model Bias

- Attempt to reduce radiance bias corrections contribution from model bias

- Assume non-radiance observations are un-biased
  - Trying to draw model to “truth”

- Background from “no-radiance” DA cycle will have smaller mode bias
  - Use this to produce bias corrections for radiances

- Not practical but a proof-of-concept to determine changes in bias corrections and model bias relative to other models and observations



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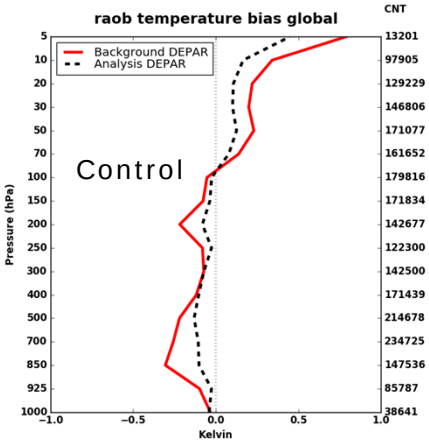
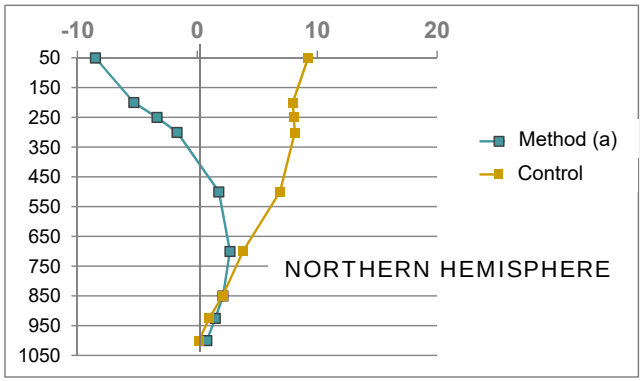
Bias Correction

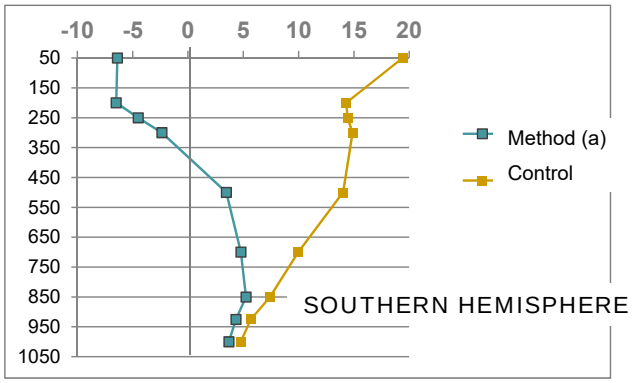
NAVGEM fit to Radiosonde
18Dec2015



- Prototype shows a dramatic shift in behavior of system.
- Proves that bias-drift can be altered incrementally in the cycling DA
- Long window DA; observation weighting; and DA control vector can all be examined

NAVGEM – ECMWF
HEIGHT (m) ANALYSIS
00UTC 18Dec 2015





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Summary

- Be somewhat sceptical, and remember the assumptions made by the system
  - Things work well but a lot depends on very gross assumptions
  - Re-examinations are worthwhile, often the simplest approach can apply more broadly
- Bias corrections are required for radiances to get beneficial impact in NWP
  - Do the bias corrections reinforce the NWP model bias?
  - Can a background using non-bias corrected observation be used to reduce model bias component in radiance bias corrections?
  - How can the resulting residuals be used to better inform and diagnose NWP model bias or radiative transfer model bias?
- What procedures can interchange between Land and Atmosphere Assimilation Techniques
  - How can we stop bias corrections from reinforce the NWP model bias?
  - Can a background using non-bias corrected observation be used to reduce model bias component in radiance bias corrections?
  - Long time series of satellite and in-situ observations used to remove long-term bias