Absolute Data in Climate Reanalysis

Stephen Leroy (Harvard)
Mark Rodwell, Marco Matricardi, Peter Bauer (ECMWF)

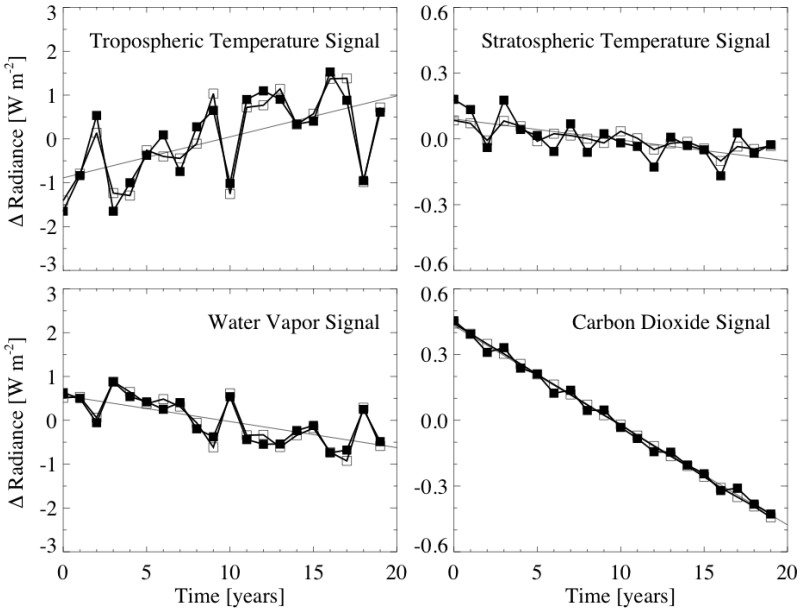
International Radio Occultation Working Group

March 28, 2012

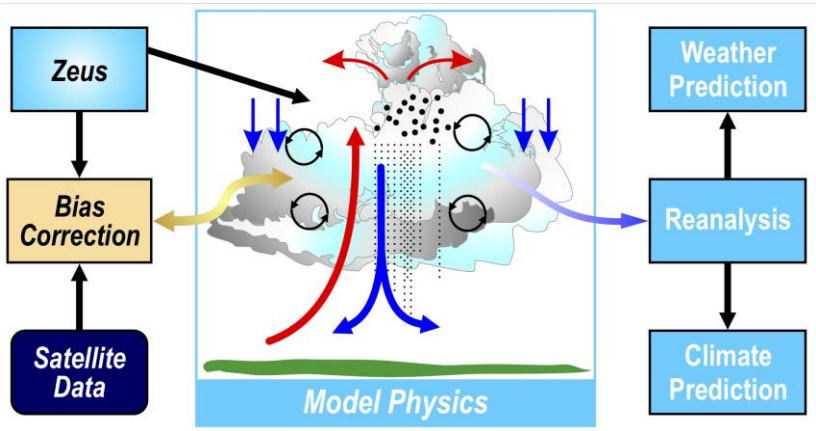
Outline

- Motivation
  - Improve reanalysis, NWP, and the climate model
- Perturbed physics
  - Distinguishing between radiation and physics
  - Impacts on climate
- Preliminary conclusion

Motivation

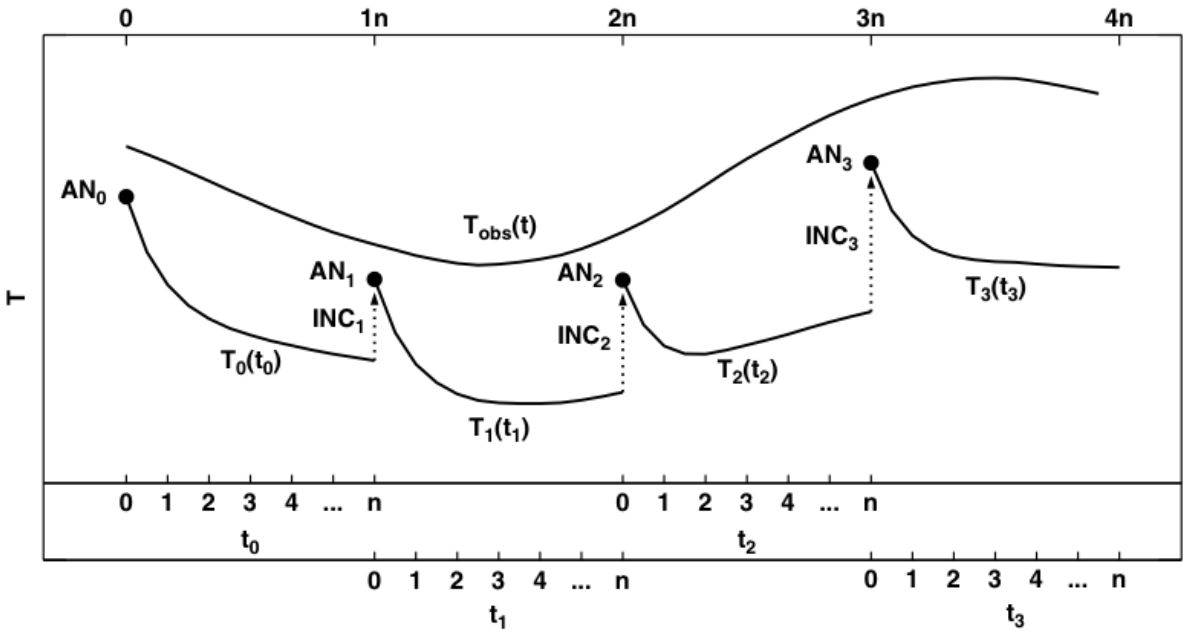


Leroy et al., *J. Climate* (2008b)



Zeus (2012)

Rodwell & Palmer (2007)

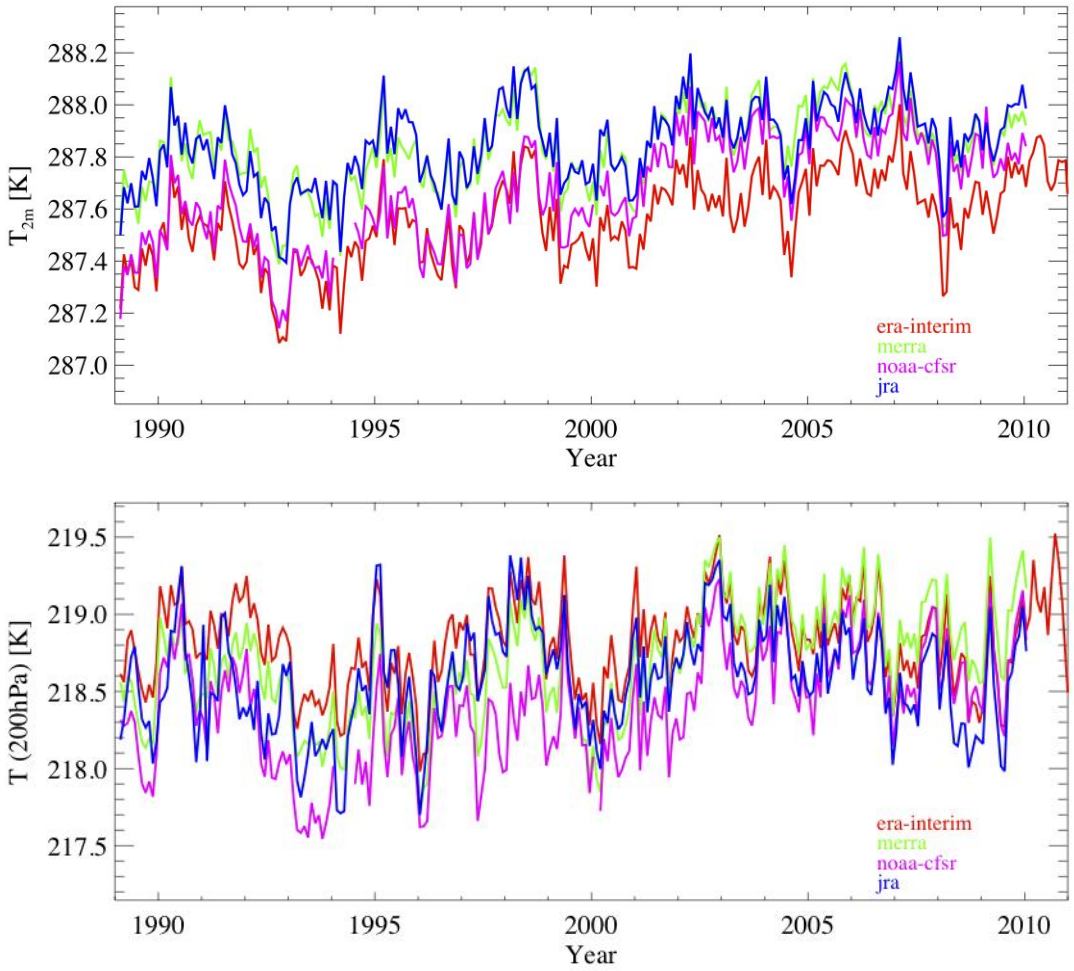


Rodwell, M.J., and T.N. Palmer, 2007: Using numerical weather prediction to assess climate models. *Q. J. R. Meteorol. Soc.*, **133**, 129–146.

Reanalysis

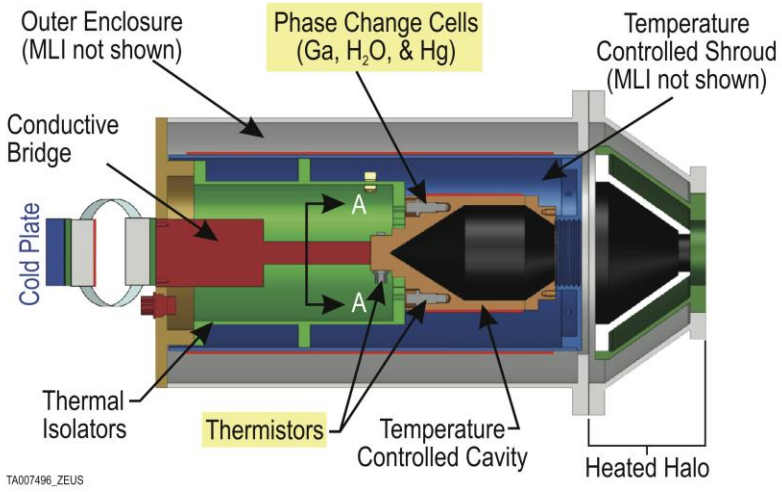
- Homogenization: Using the same system (physics and errors) throughout
- Bias correction: Remove biases from the data.
  - Biases are determined by fingerprints: scan angle, squared scan angle, lapse rate/air mass, etc. (Dee and Uppala 2009)
  - Without anchors, the system will drift. Current anchors are bias-adjusted radiosonde temperature, aircraft temperature, radio occultation, SSU channel 3/AMSU-A channel 14 (Kobayashi et al. 2009, Dee et al. 2011)

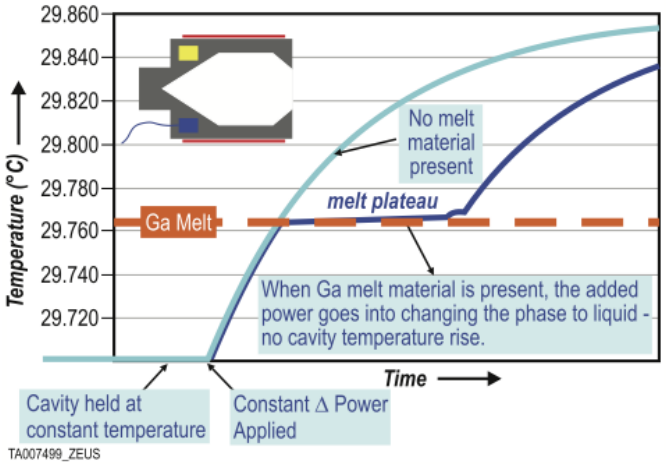
Is there a problem?



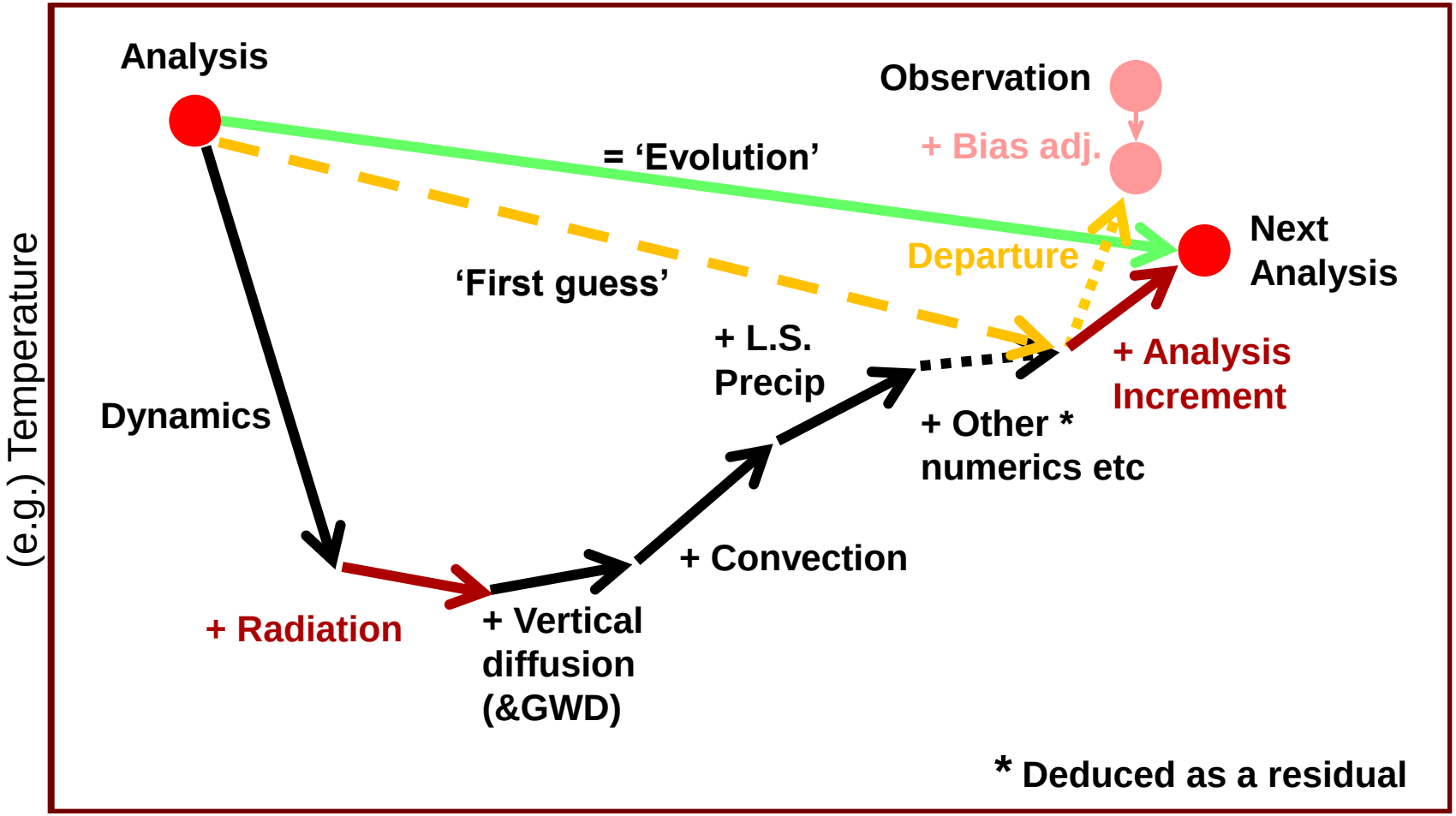
Climate benchmark data

- Help disentangle physics errors from instrumental bias by removing bias. Possibly improve
  - numerical weather prediction
  - climate prediction
  - reanalysis, present and past(!)
- Can the different uncertainties be distinguished from one another? Radiative transfer from convection physics?
- RO and radiosondes already assimilated without bias correction. What about spectral radiances?



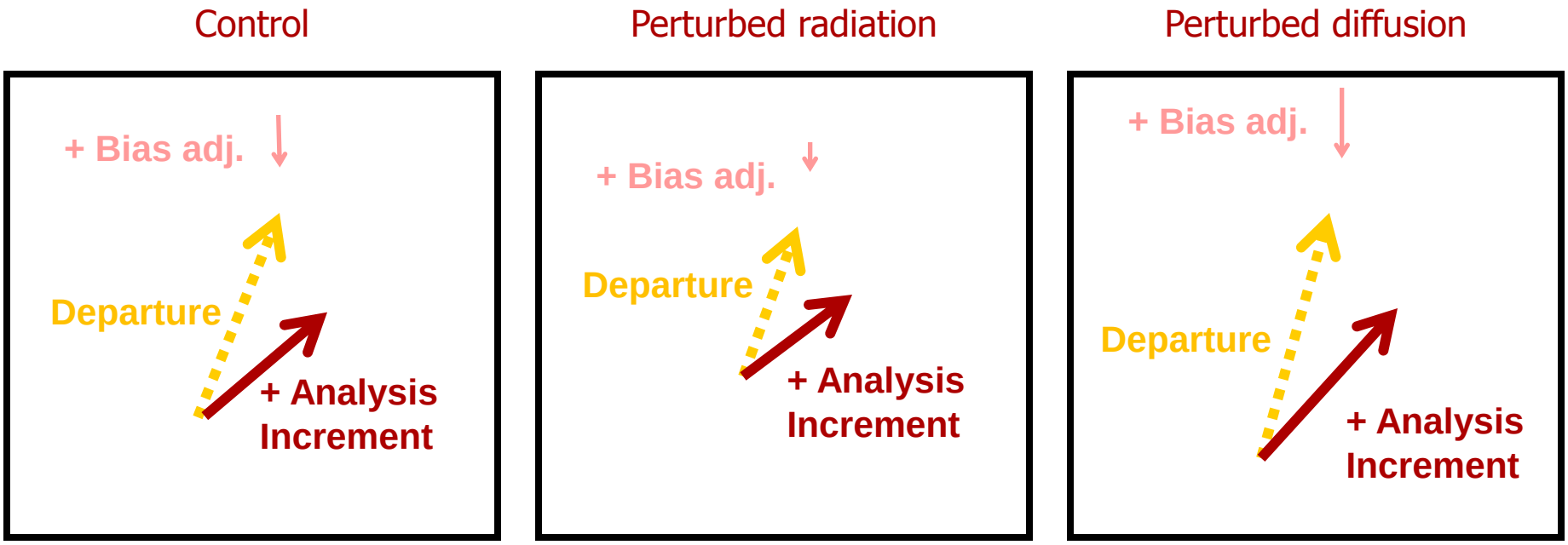


Fingerprinting 4DVAR diagnostics



Fingerprinting 4DVAR diagnostics (2)

- Account for inadequate modeling of bias correction: bias correction
- Account for relative weighting of data types: increments and departures

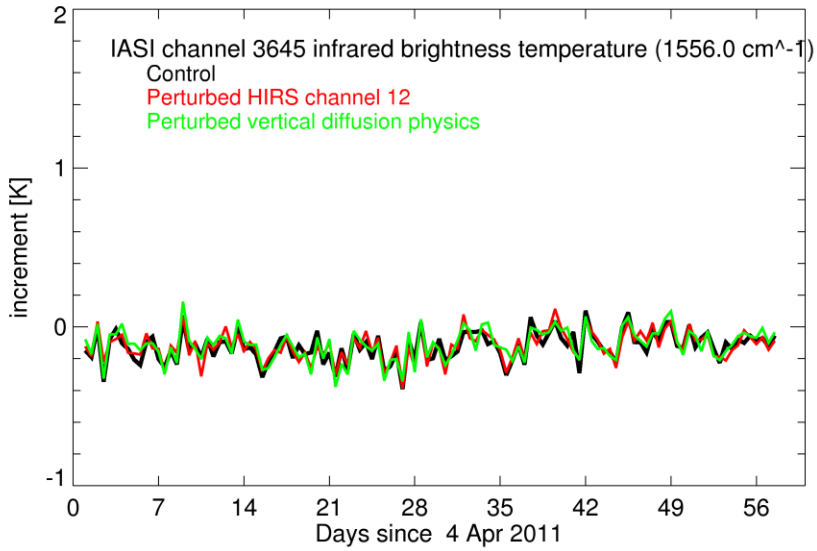


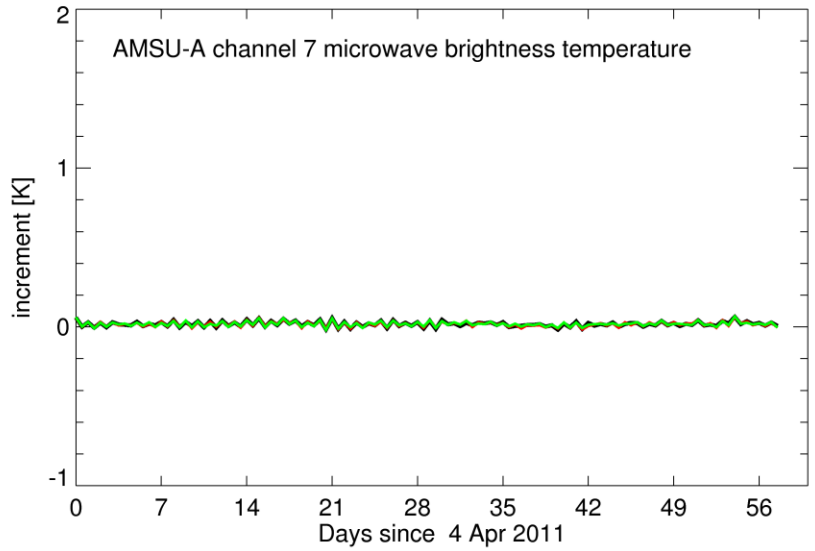
* With apologies to Aparicio (2009), Cucurull (2010), Healy (2011)

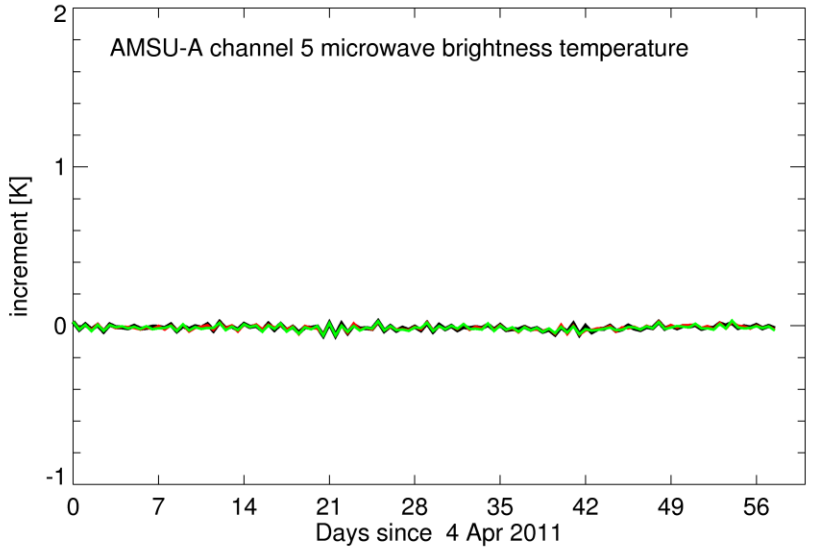
Numerical experiment

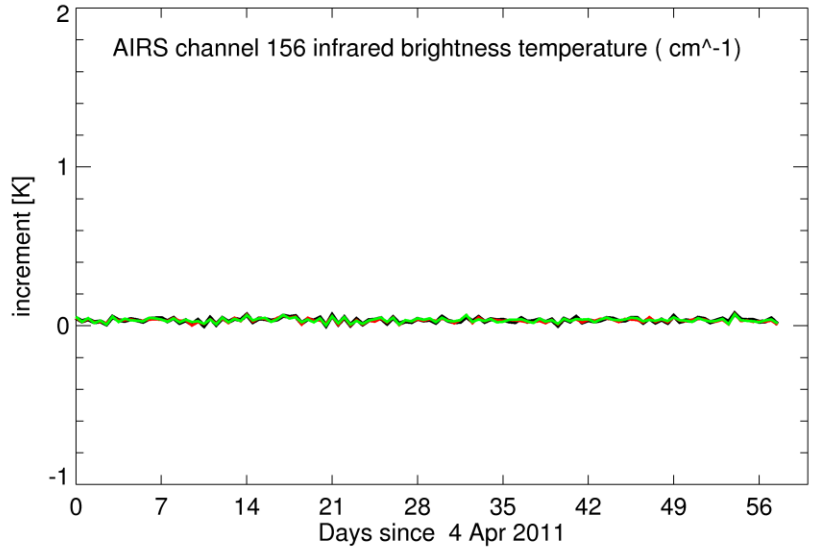
- Investigate upper tropospheric (specific) humidity
- Four runs, 4 April – 31 May 2011, 37r2 T511, 91 levels, 15min
  - Control
  - Perturb HIRS channel 12 radiative transfer (q @ 300 hPa)
  - Perturb AIRS channel 1783 & IASI channel 3645 radiative transfer (q @ 350 hPa)
  - Perturb vertical diffusion
- Monitor multiple data types
  - Conventional in situ data: radiosondes T, q, u, v; aircraft T, u, v;
  - Satellite water vapor: AIRS and IASI humidity channels (1556 cm^{-1}), AMSU-B channel 3, HIRS channel 12
  - Other satellite data: AMSU-A, HIRS channel 11, scatterometer winds, atmospheric motion winds, radio occultation bending angles, SSM/I channel 14
- Mistakes
  - AIRS and IASI passively assimilated
  - Bias correction remained dynamic for prospective benchmark data types

Evolution of tropical diagnostics

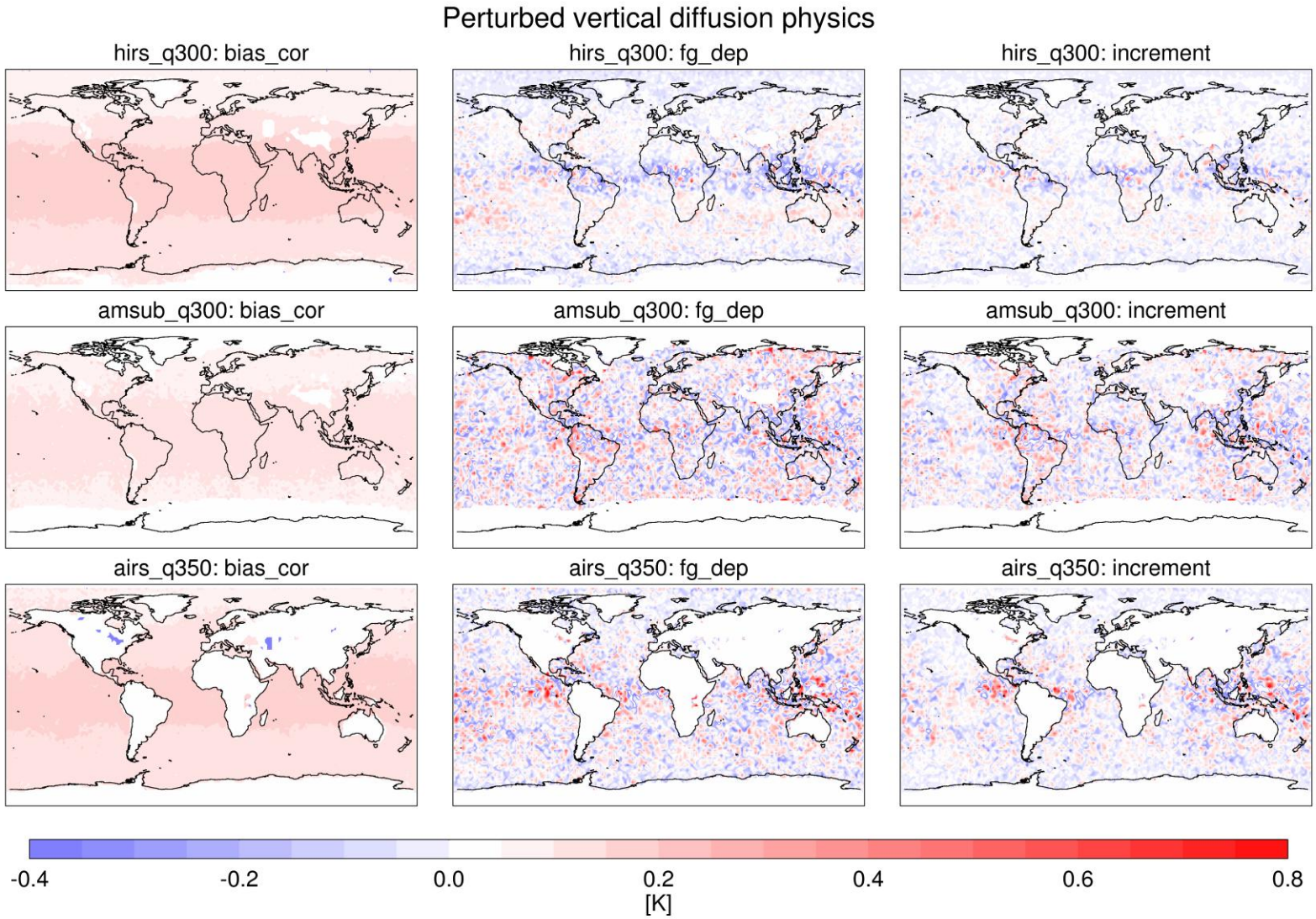




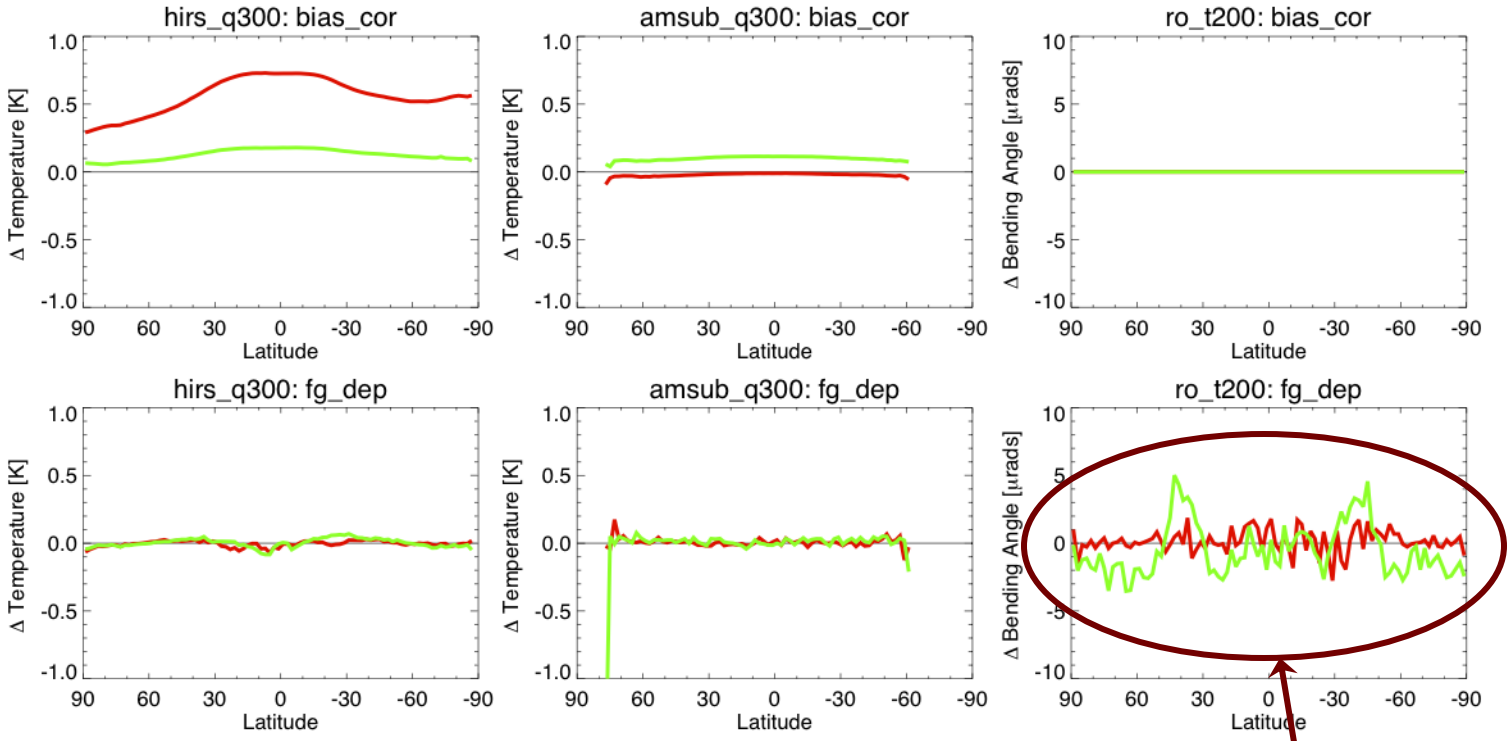




Spatial fingerprints



Zonal average fingerprints

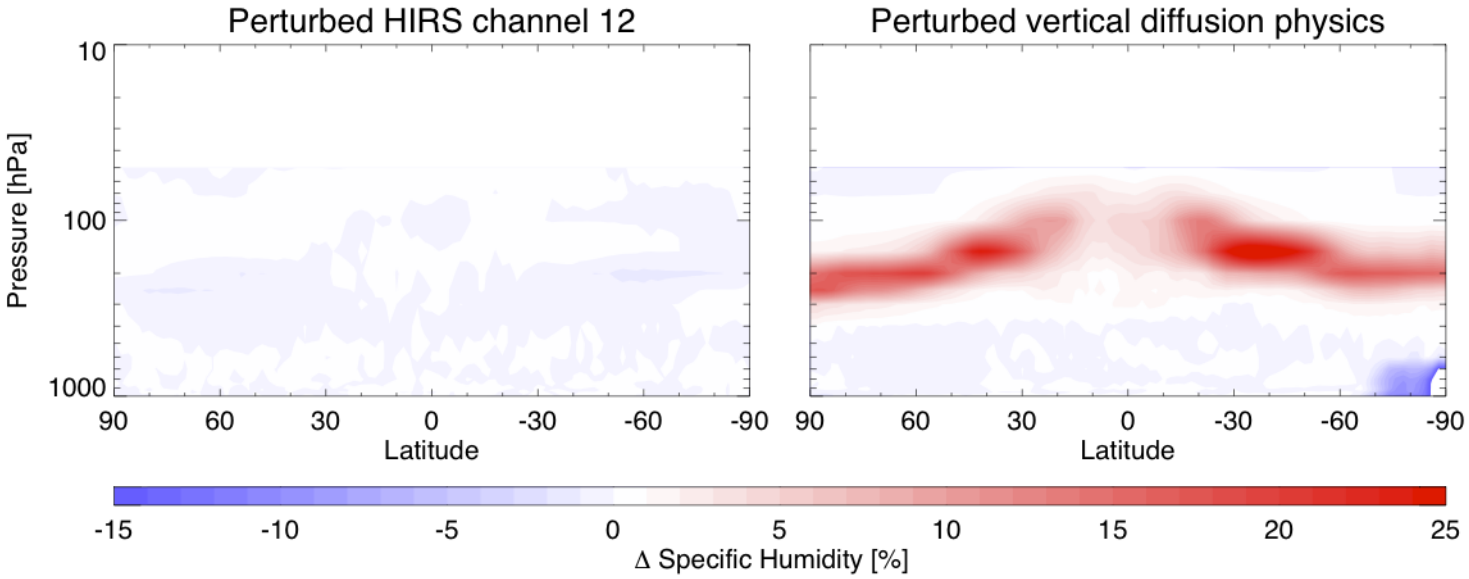


Perturbed HIRS channel 12

Perturbed vertical diffusion physics

~0.03%

Change to mean state humidity



Summary

- Vertical diffusion perturbation is mistaken as bias in ECMWF variational bias correction (of radiance data types)
- Necessary to have redundancy in anchoring state variables

- Better simulate effect of anchor data types by fixing bias correction to that determined by the control
- Additional perturbations:
  - AMSU-B radiative transfer
  - Convection physics (detrainment, rain re-evaporation)

End

Bias-correction performance

Dee and Uppala 2009