Stratospheric Temperature Trends from AIRS and GPS RO

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Sounder Science Team Meeting, Greenbelt, Maryland
October 2, 2018

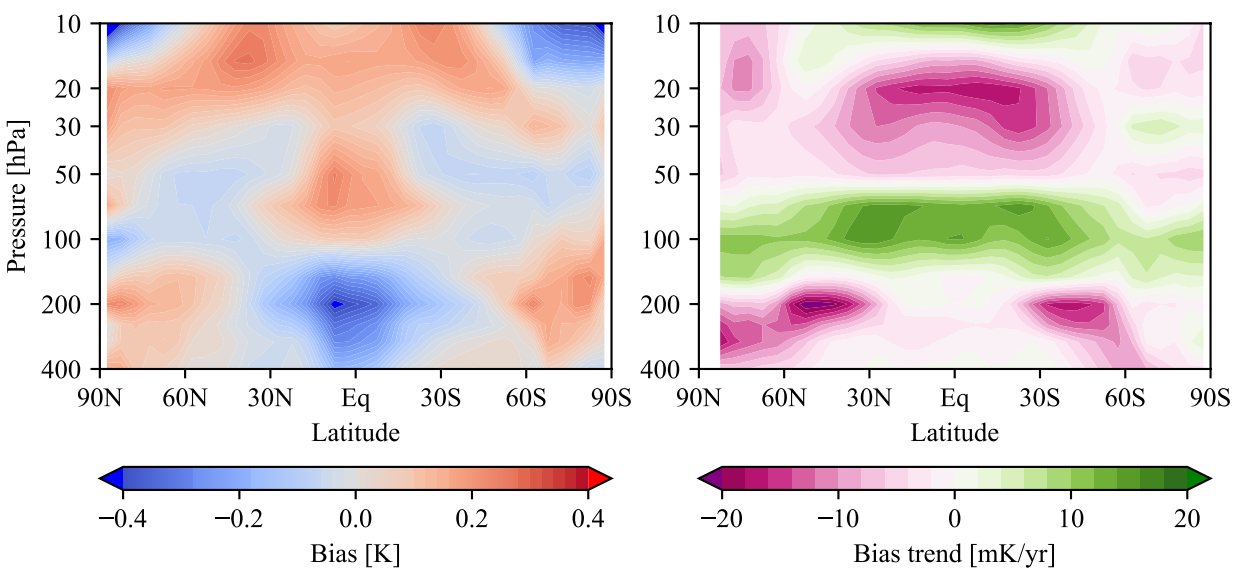
Background

- Multiple data types sensitive to the same atmospheric variables should yield same trends and anomalies.
  - Both are highly accurate…and ”stable”.
  - Bias in a retrieval system is acceptable; a time-dependent bias is not.
- Time-dependent biases can be identified by a comparison of trends in anomalies in two different data types.
  - Biases have structures that can be fingerprinted.
  - GPS RO and AIRS stratospheric temperature are good starting candidates for comparison.

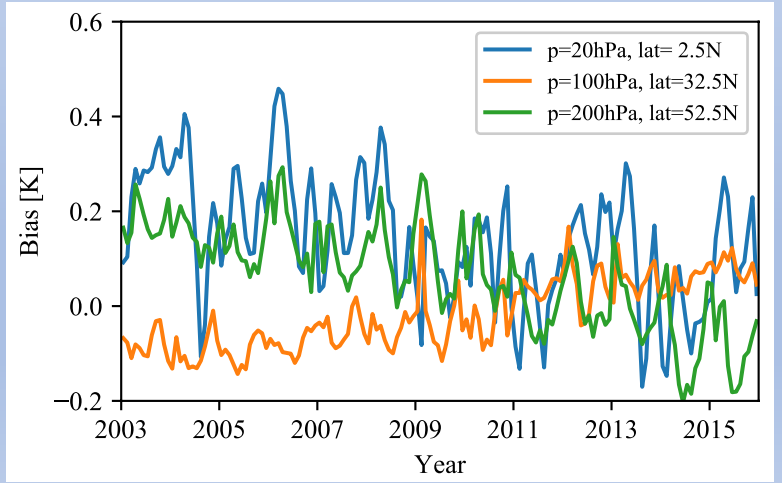
Data

- Atmospheric Infrared Sounder (AIRS)
  - Thermal IR, near-IR, 2378 channels, ascending node at 13:30
  - Temperature retrievals, 1 km resolution in troposphere, 2 km in stratosphere
  - Data since June, 2002, to present
  - Version 6, infrared-only products, combined infrared and microwave products
- GPS Radio Occultation, JPL
  - CHAMP mission, ~140 soundings daily, SNR ~550, rapidly precessing orbit, June 2001 through September 2008.
  - COSMIC mission, 6 satellites, ~2400 soundings daily, SNR ~700, separated 30° in ascending node, June 2006 to the present
  - Bayesian interpolation to generate level 3
- Common Processing Period: 2003–2014.

Intra-comparison: AIRS

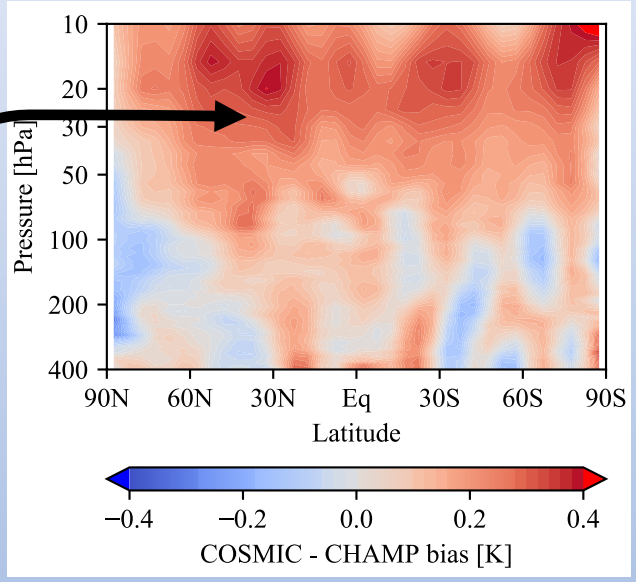


AIRS (IR+MW) – AIRS (IR)



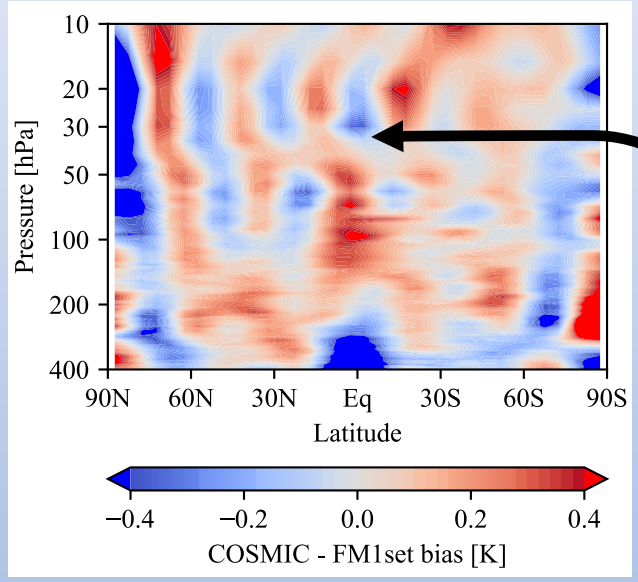
Intra-comparisons: GPS RO

27 months overlap, CHAMP and COSMIC



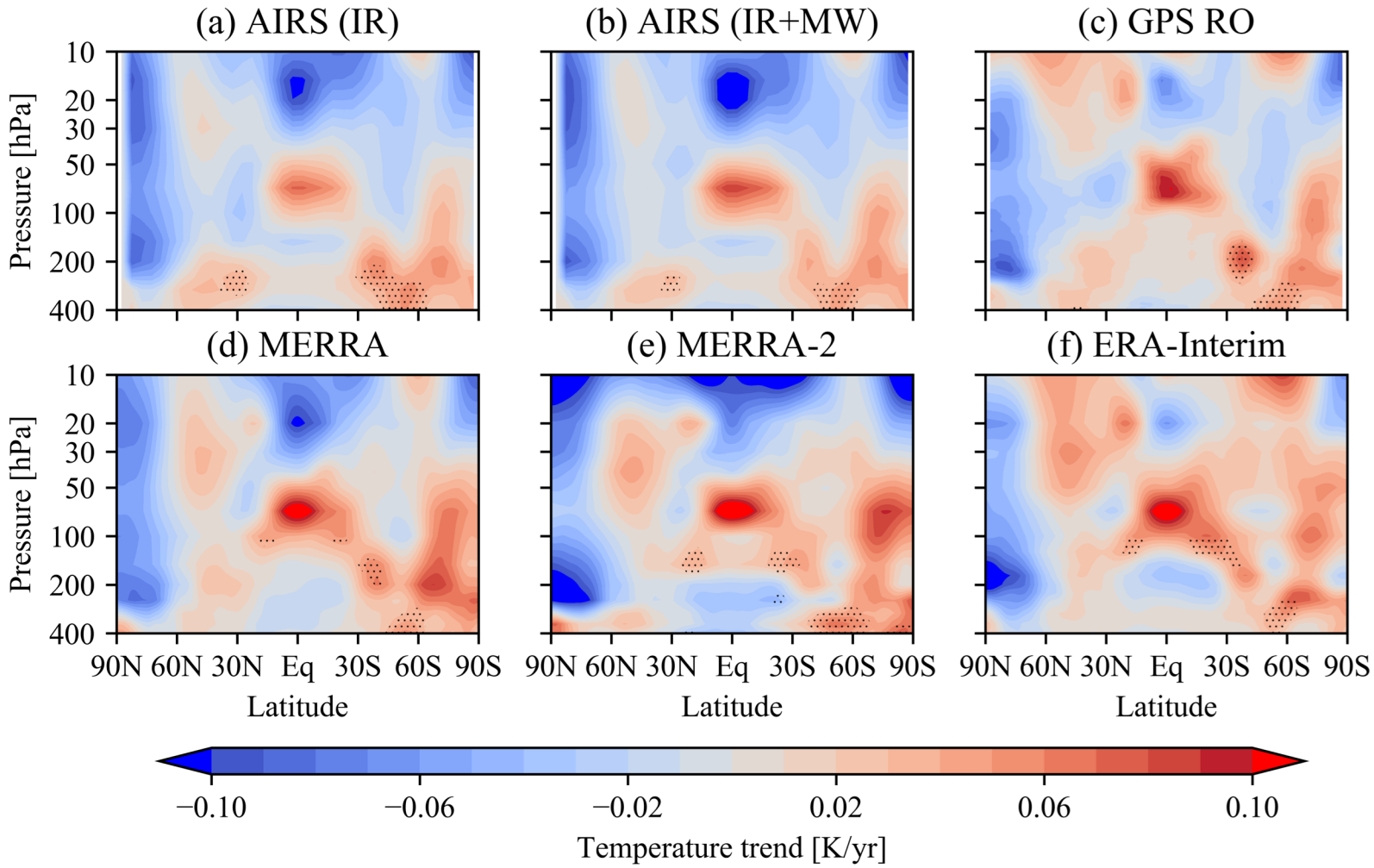
Different SNR, different upper boundary for Abel transform…

COSMIC – FM1, 1 month

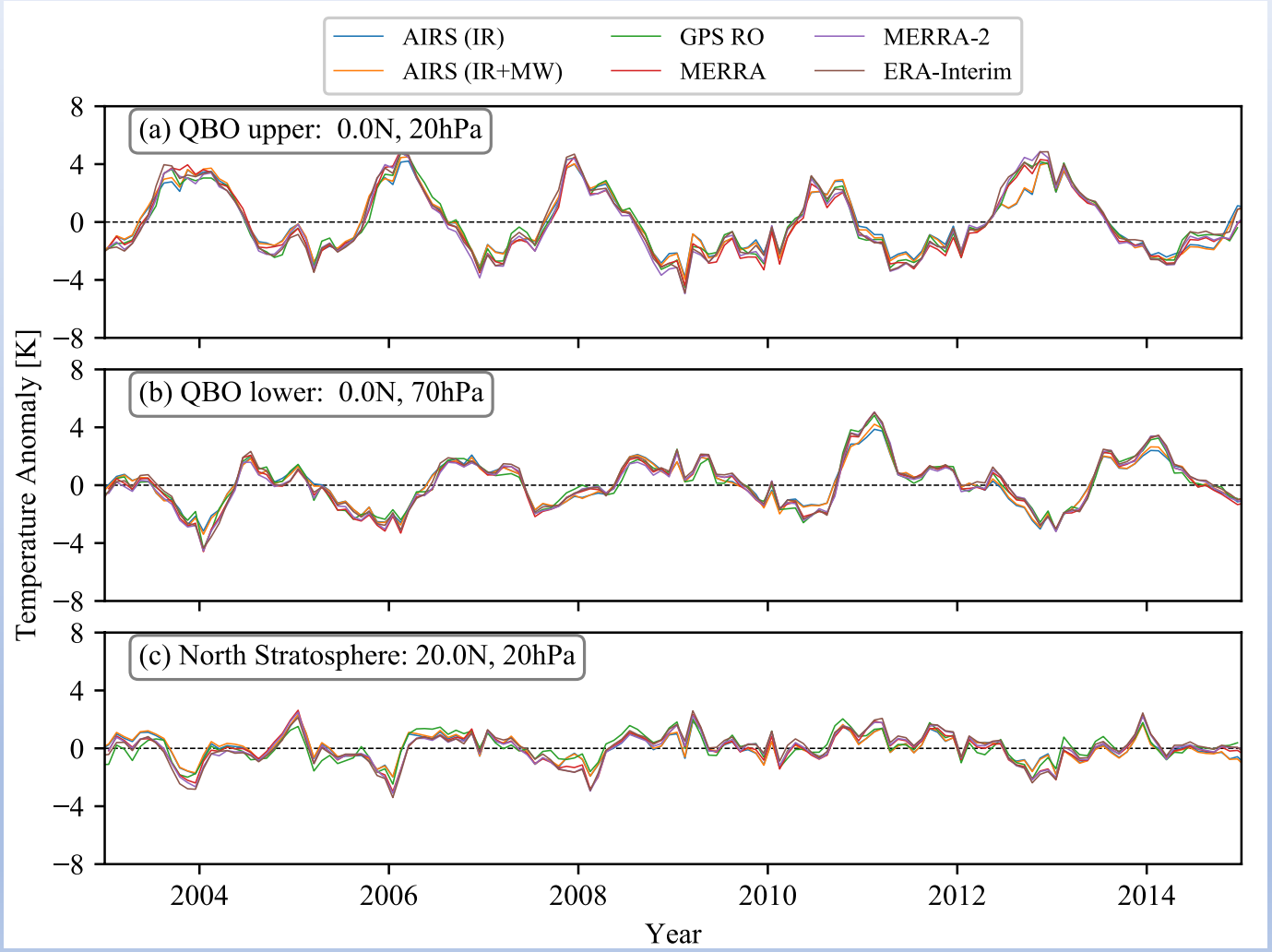


Sampling error for Bayesian mapping…

Trends

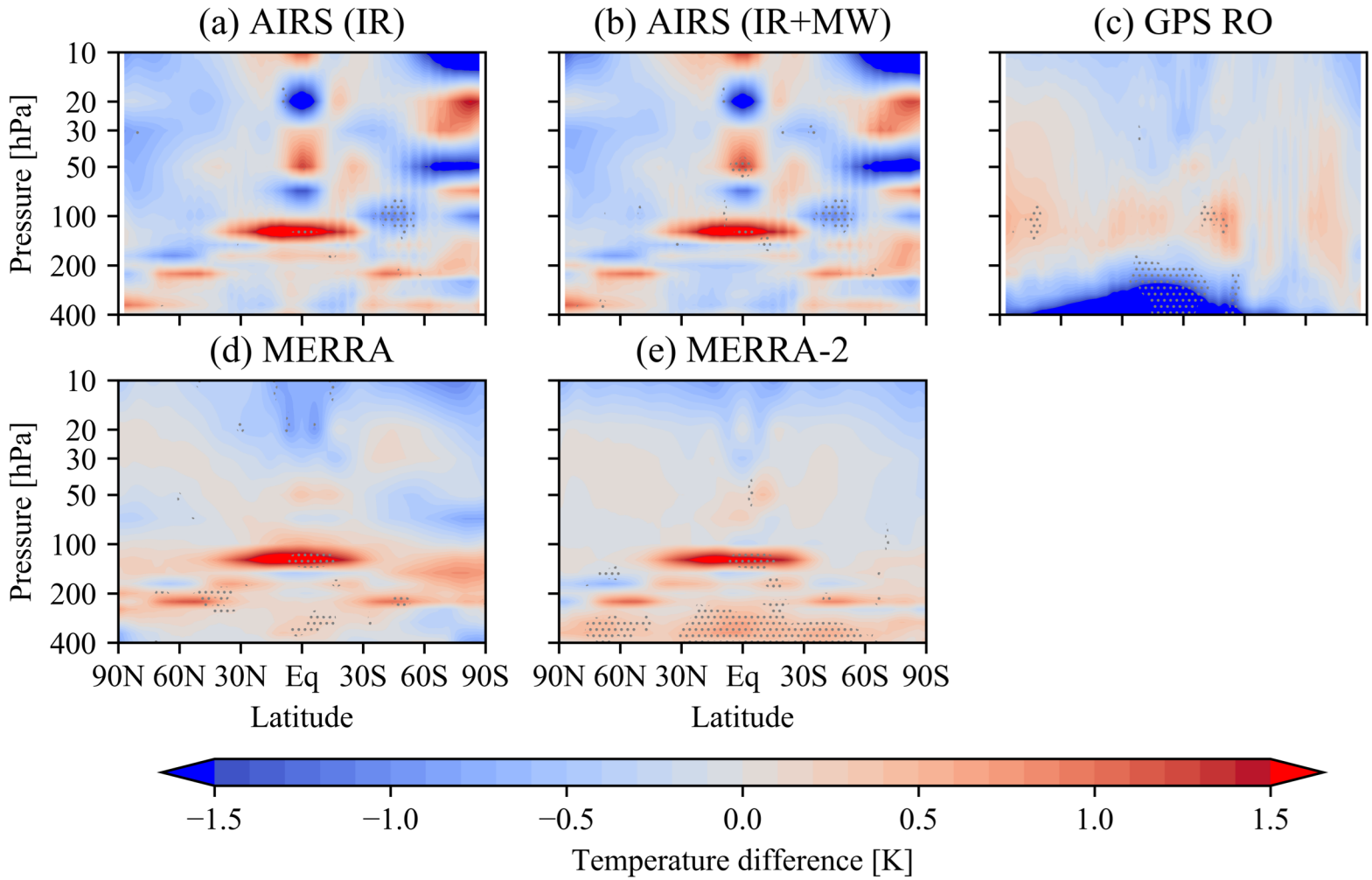

(a) AIRS (IR)
(b) AIRS (IR+MW)
(c) GPS RO
(d) MERRA
(e) MERRA-2
(f) ERA-Interim
Pressure [hPa]
10
20
30
50
100
200
400
90N 60N 30N Eq 30S 60S 90S
Latitude
−0.10
−0.06
−0.02
0.02
0.06
0.10
Temperature trend [K/yr]

Time-series: QBO

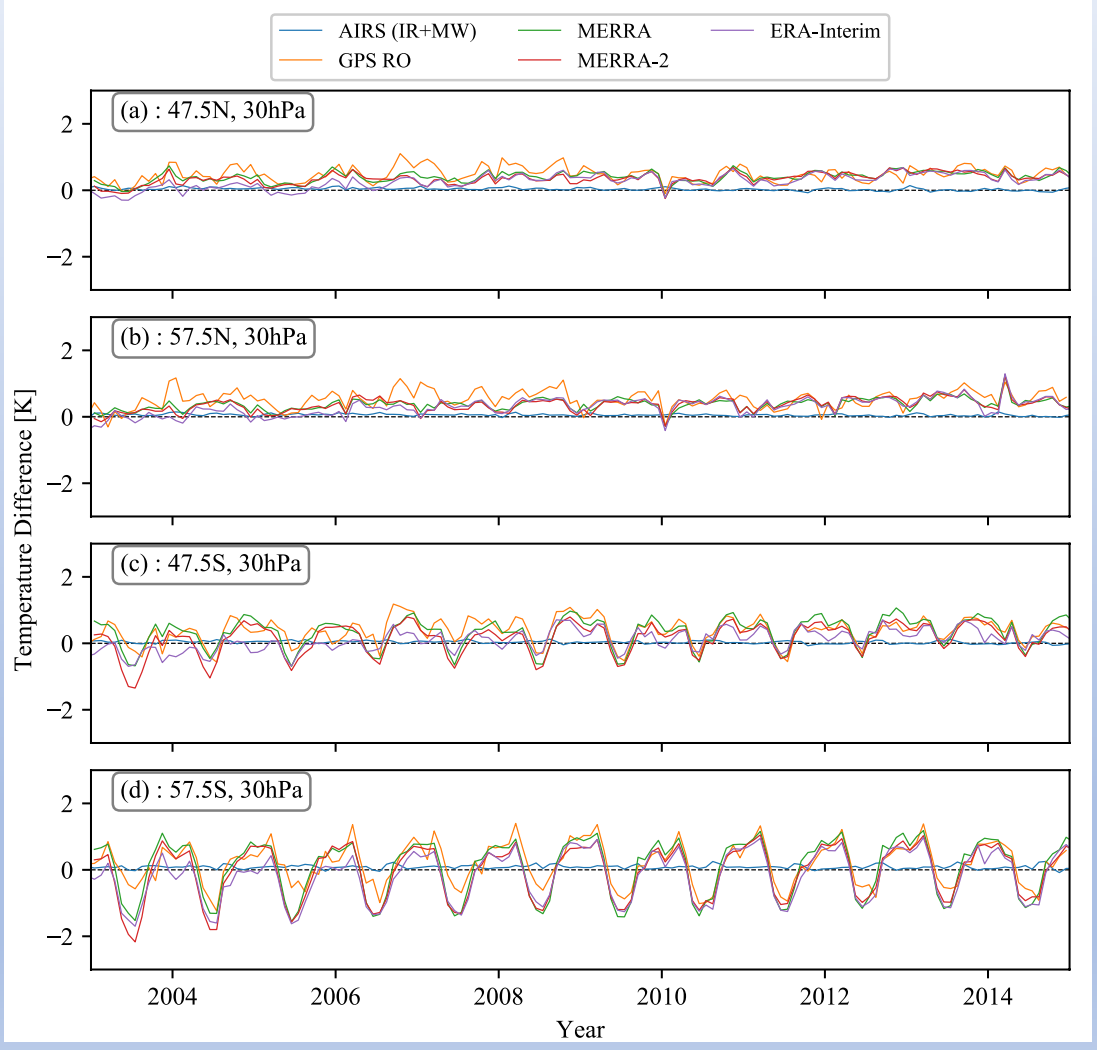


QBO upper,
QBO lower

AIRS QBO Error



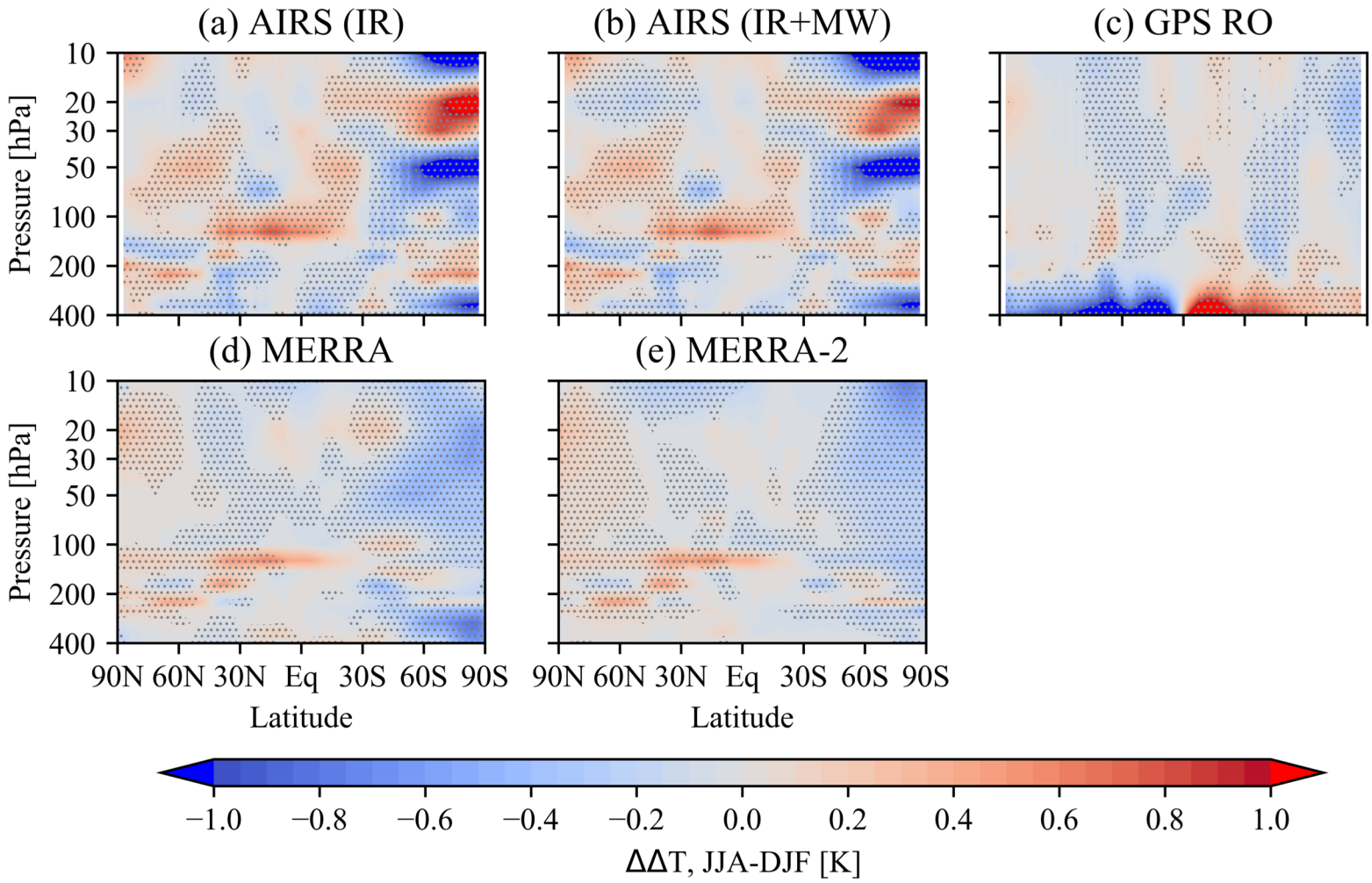
Time-series: Stratosphere Differences



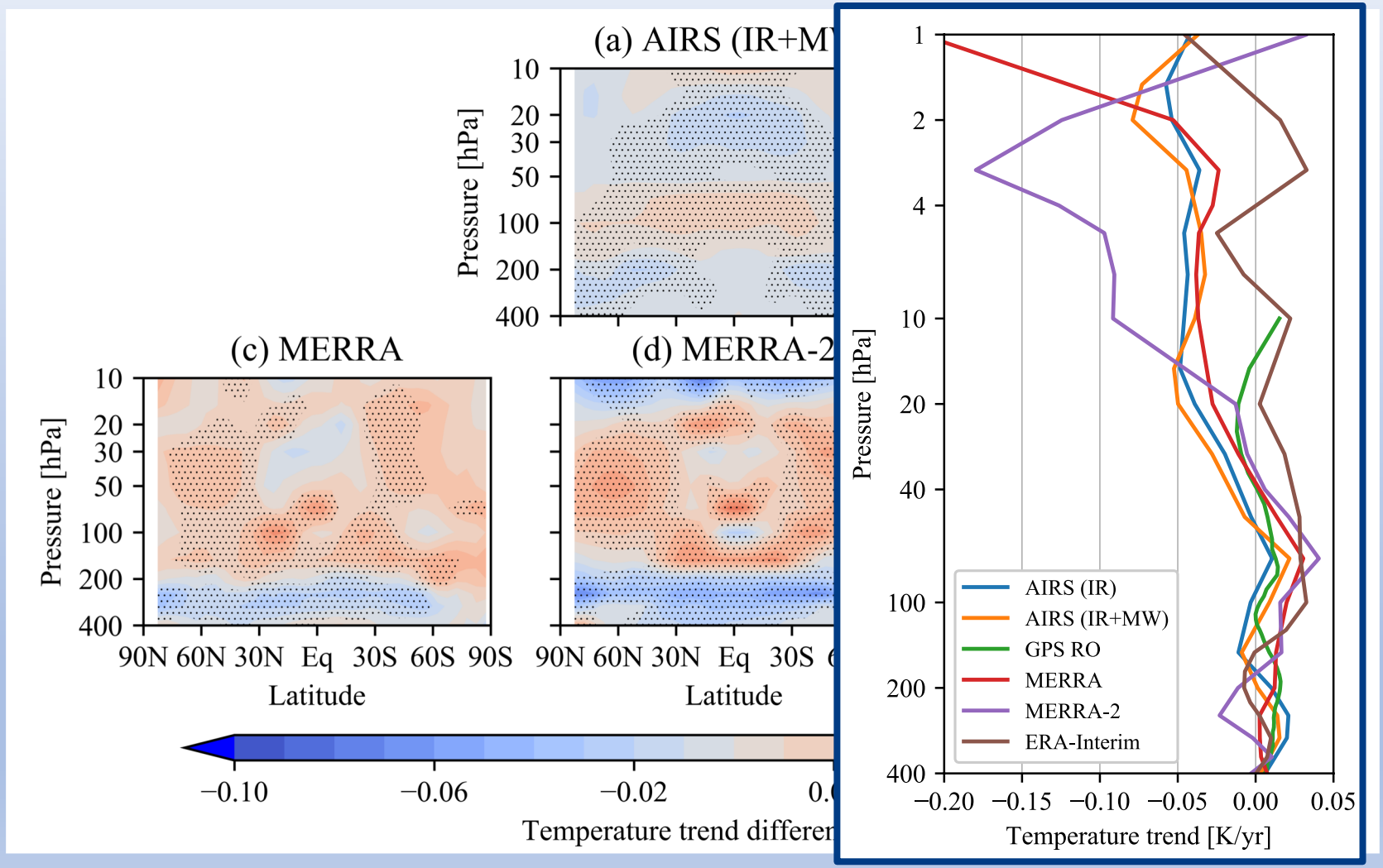
Northern stratosphere

Southern stratosphere

Seasonal Cycle Differences



Stratosphere Trends Differences



Conclusions

- Infrared-only AIRS retrieval introduces a trend bias compared to AIRS combined infrared and microwave retrieval of approximately 0.2 K/decade. The combined retrieval is preferable, but slightly.
- AIRS retrievals contain null-space error of ~3 K in realizations of QBO and annu
  - The respons unknown.
  - Theoretical ngwave feedbacks.
- GPS RO seasonal cycle error in upper troposphere points to flaws in humidity prior.
- Broad disagreement in stratospheric trends of 2 K/decade.
  - AIRS and MERRA most realistic, but even they disagree on trends in the Brewer-Dobson circulation.
  - GPS RO and ERA-Interim show no cooling at all; GPS RO probably overly influenced by ECMWF initialization of hydrostatic integral.

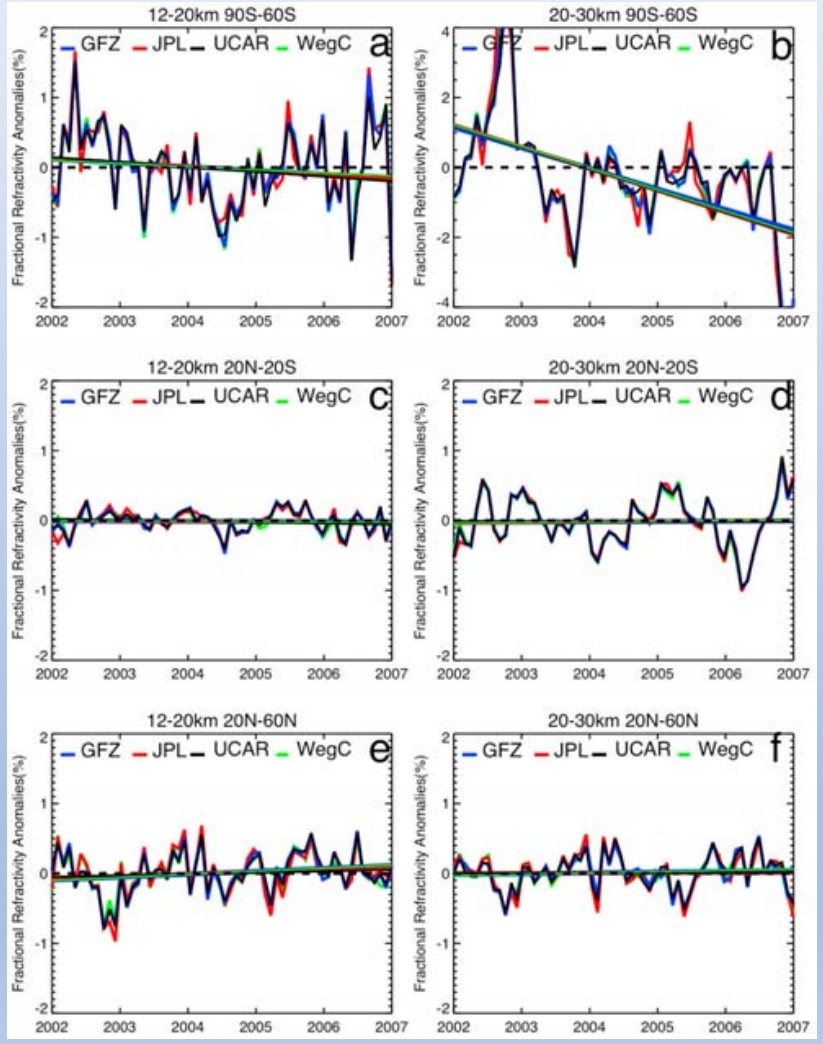
This work was supported by the NASA Atmospheric Radiation Program grant NNX15AC29G and NASA obs4MIPs NNH16ZDA001N-NDOA.

Recommendations

- AIRS and infrared generally:
  - Explore cause of drift between retrievals including microwave and those without over the lifetime of AIRS.
  - Discover and fix causes of null space error over the equator and in the Antarctic stratosphere.
- GPS RO:
  - Implement an algorithm that corrects for ionospheric residual.
  - Implement an algorithm that reduces sensitivity to initialization of Abel and hydrostatic integrals.

In review at *J. Geophys. Res.*

Independent retrievals

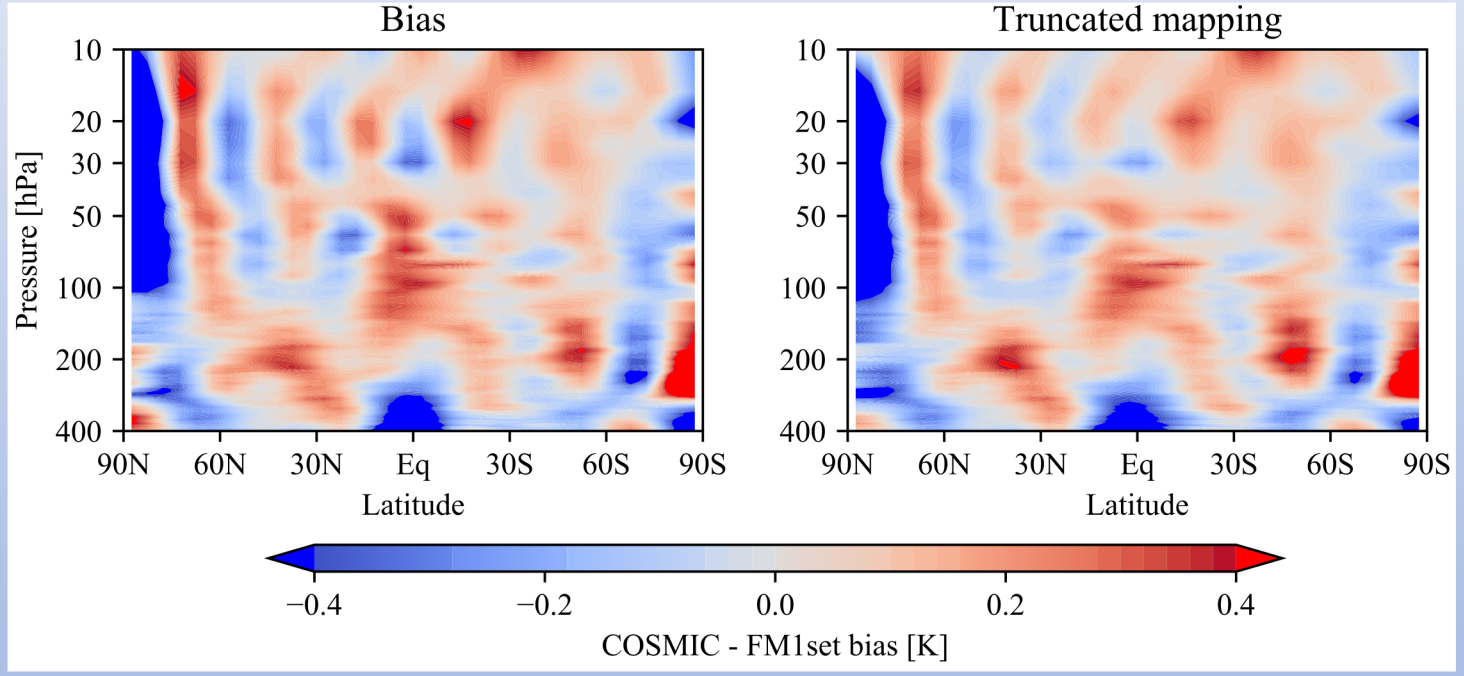


GPS RO (CHAMP) refractivity from four different retrieval centers

(Ho et al., JGR, 2009)

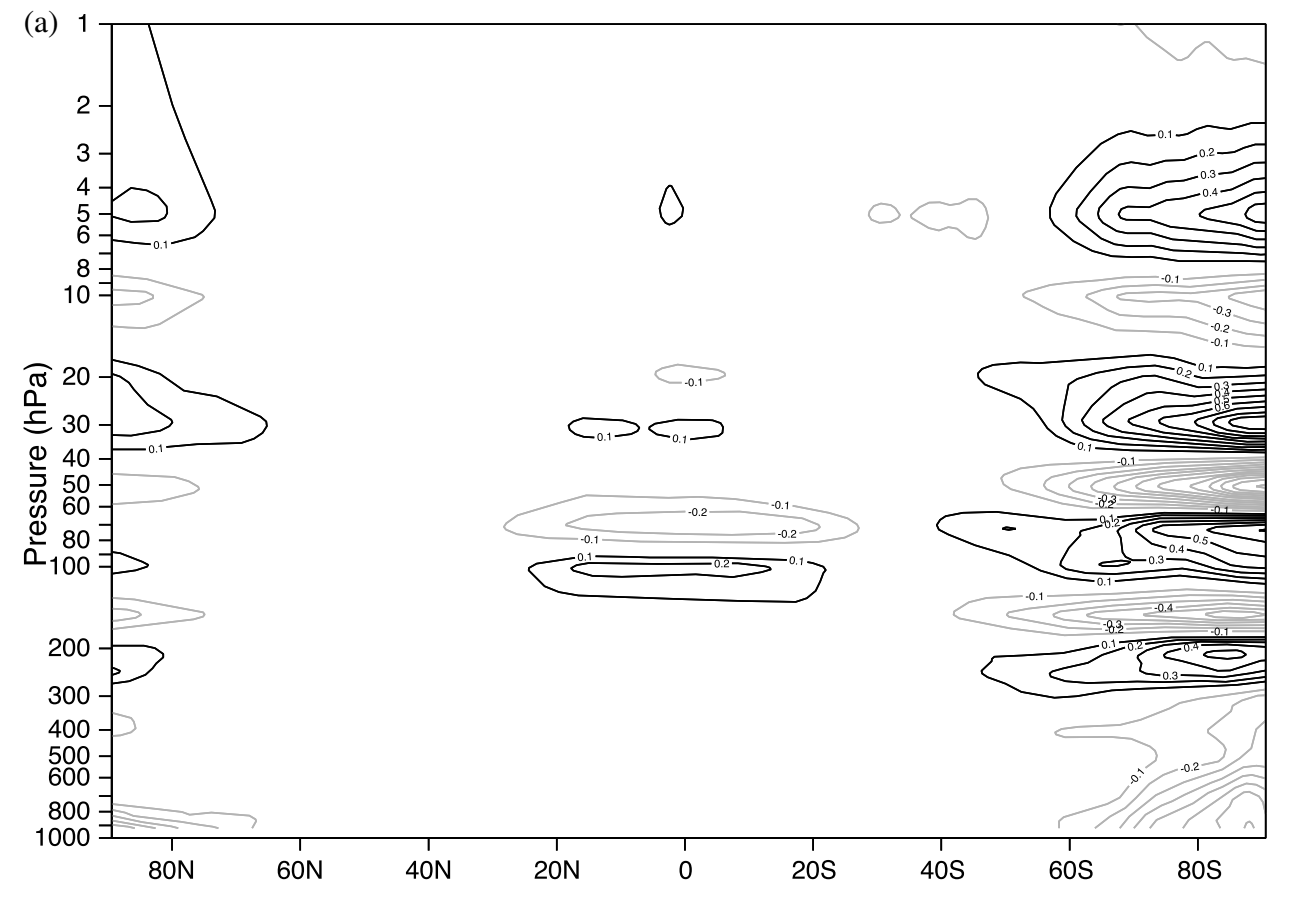
Truncate COSMIC data

$$\chi^2 = \beta\left(d - M(w)\right)^2 + \alpha w^2$$



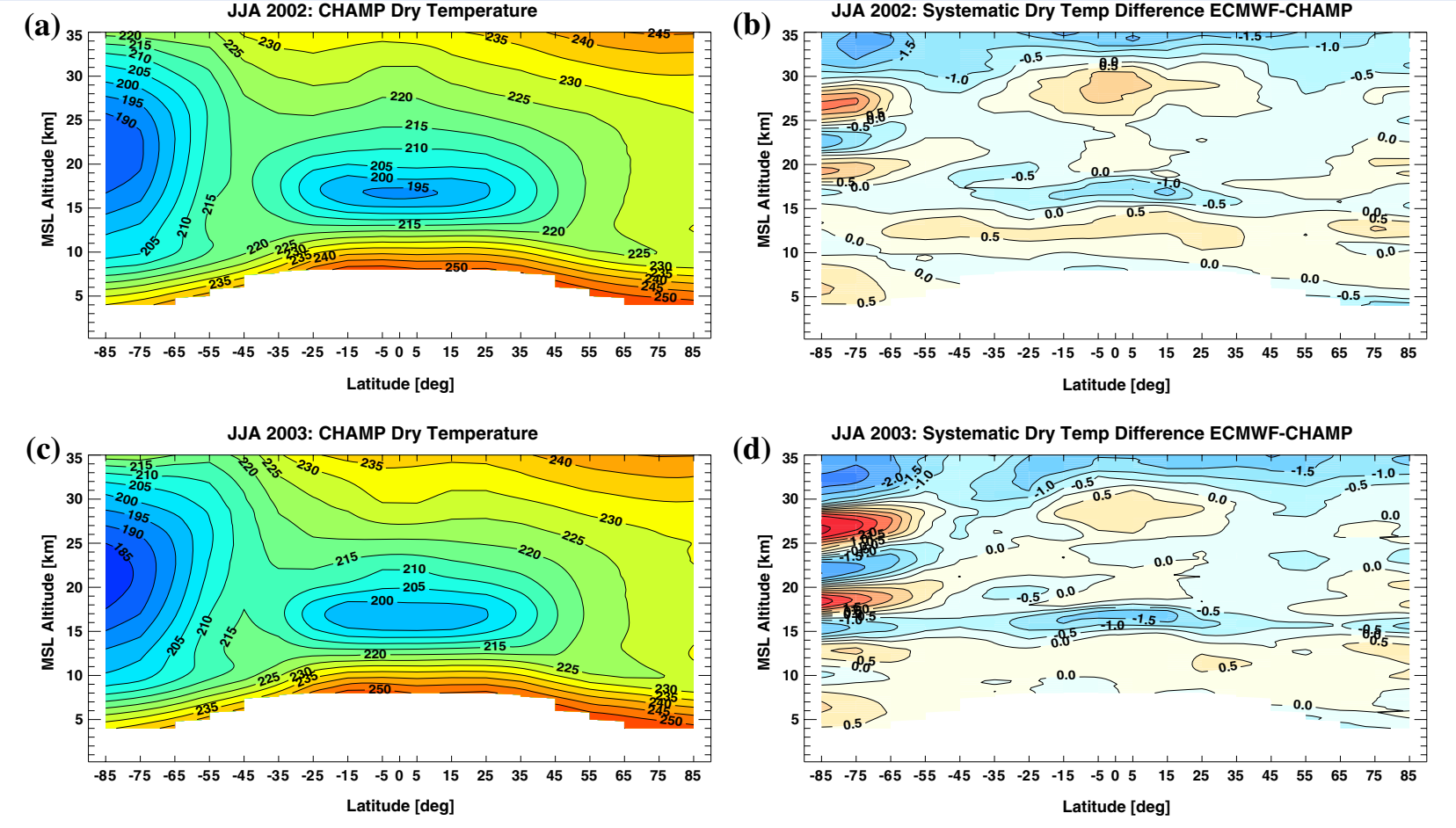
Sampling error for Bayesian mapping!

Null-space Error



Healy and Thepault., QJRMS, **132**, 605–623, 2006.

Null-space Error (2)



Foelsche et al., Climate Dynamics, **31**, 49–65, 2008.