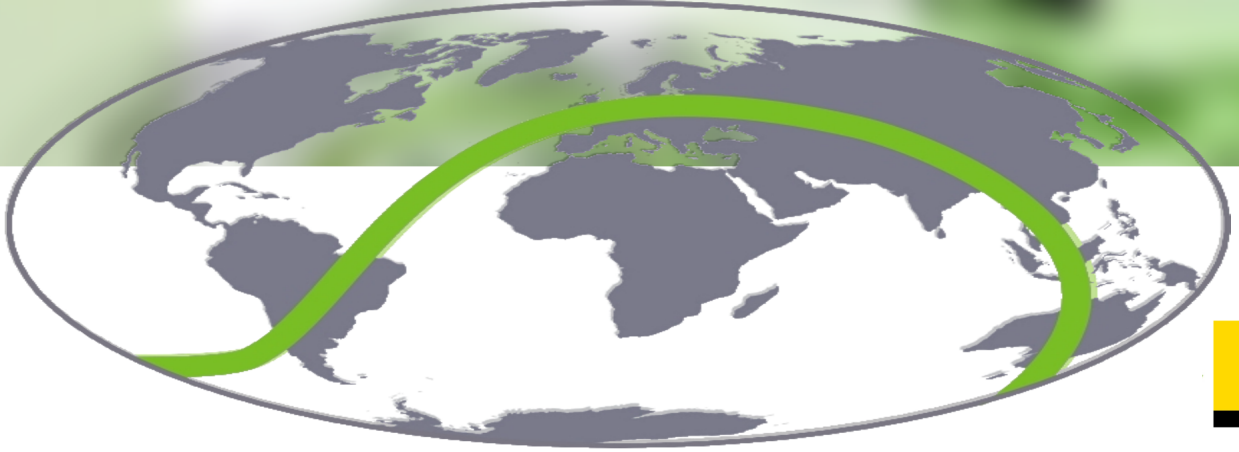

wege entstehen, indem wir sie gehen
paths emerge in that we walk them

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Atmospheric Remote Sensing and Climate System Research Group
ARSCliSys

Atmospheric Climate Change Detection With Radio Occultation Data

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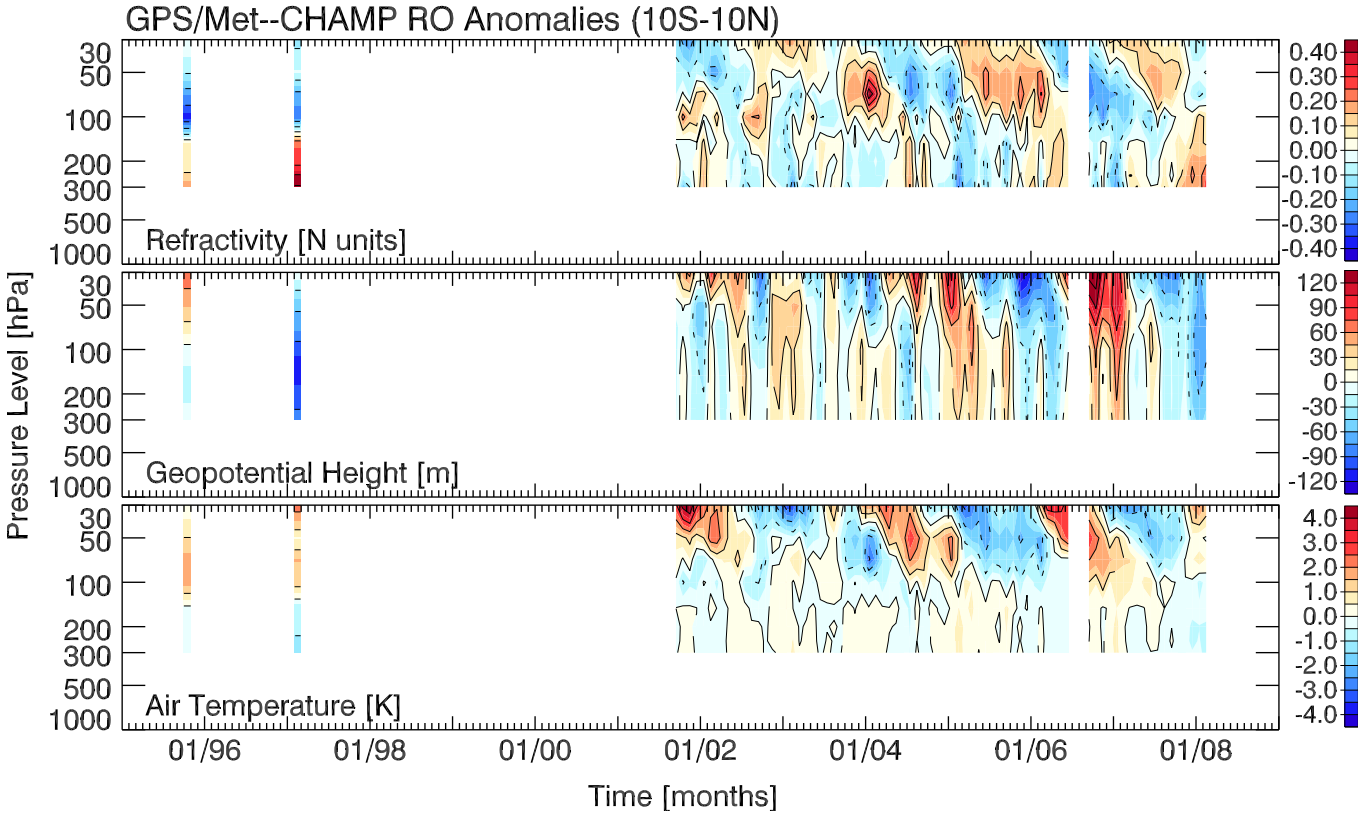
OPAC-4 / Graz / September 08, 2010

Can we see a climate change signal consistent with Global Climate Model (GCM) simulations in the available Radio Occultation (RO) record?

- climate change detection time estimates by Leroy et al. (2006) and Ringer & Healy (2008): 6–16 years of data
- use optimal fingerprinting method
- same method implemented for RO climatologies of different zonal mean horizontal resolutions

RO Data for Detection Study



- monthly mean **GPS/Met** (10/1995, 02/1997) and **CHAMP** (09/2001–02/2008, without 07-08/2006) data
- 8 pressure levels from 300 hPa to 30 hPa
- zonal mean bands between 50°N and 50°S (3 resolutions)
- refractivity , geopotent. height, temp. trend patterns

Optimal Trend Detection: Ordinary Least Square Fingerprinting

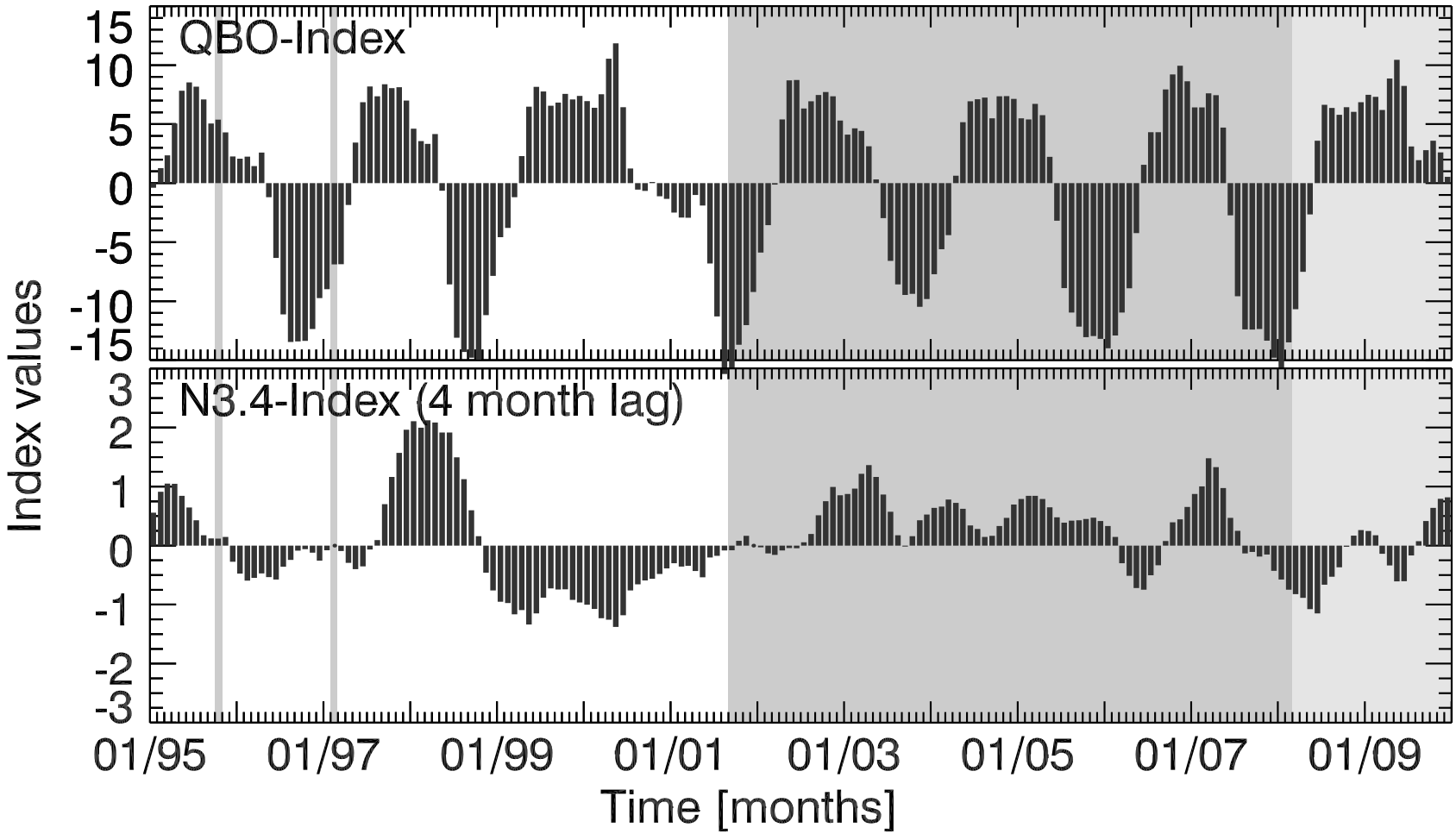
$$\mathbf{y}_{\mathrm{RO}} = \mathbf{X}_{\mathrm{fGCM}}\,\beta + \epsilon_{\mathrm{PICTRL}}$$

- monthly mean **GPS/Met** and **CHAMP** data
  - 5 zonal mean bands (focus of trend detection)
  - 10° zonal mean bands
  - zonal mean profile btw 50°N and 50°S
- 3 representative GCMs from IPCC AR4 (20th cent., A2 and B1)
  - CCSM3/NCEP-NCAR: 12 A2/B1 simulations
  - ECHAM5/MPI-M: 6 A2/B1 simulations
  - HadCM3/UK Met Office: 2 A2/B1 simulations
- estimate scaling factors $\hat{\beta}$ via

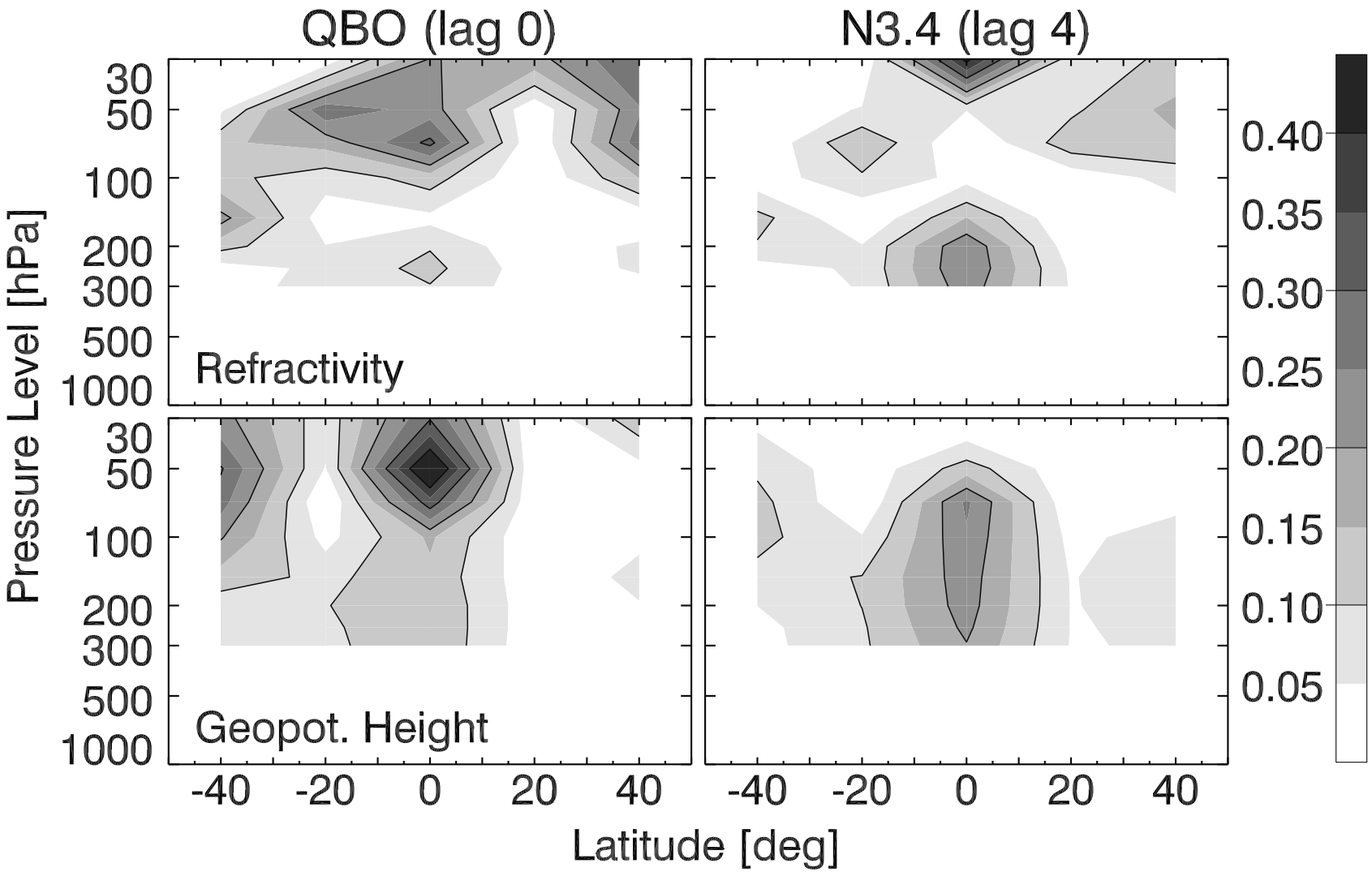
$$\hat{\beta} = \left(\mathbf{X}^{\mathsf{T}}\,\mathbf{C}^{-1}\,\mathbf{X}\right)^{-1}\,\mathbf{X}^{\mathsf{T}}\,\mathbf{C}^{-1}\,\mathbf{y}$$

- PICTRL simulations of GCMs to estimate nat. variability (**C**)

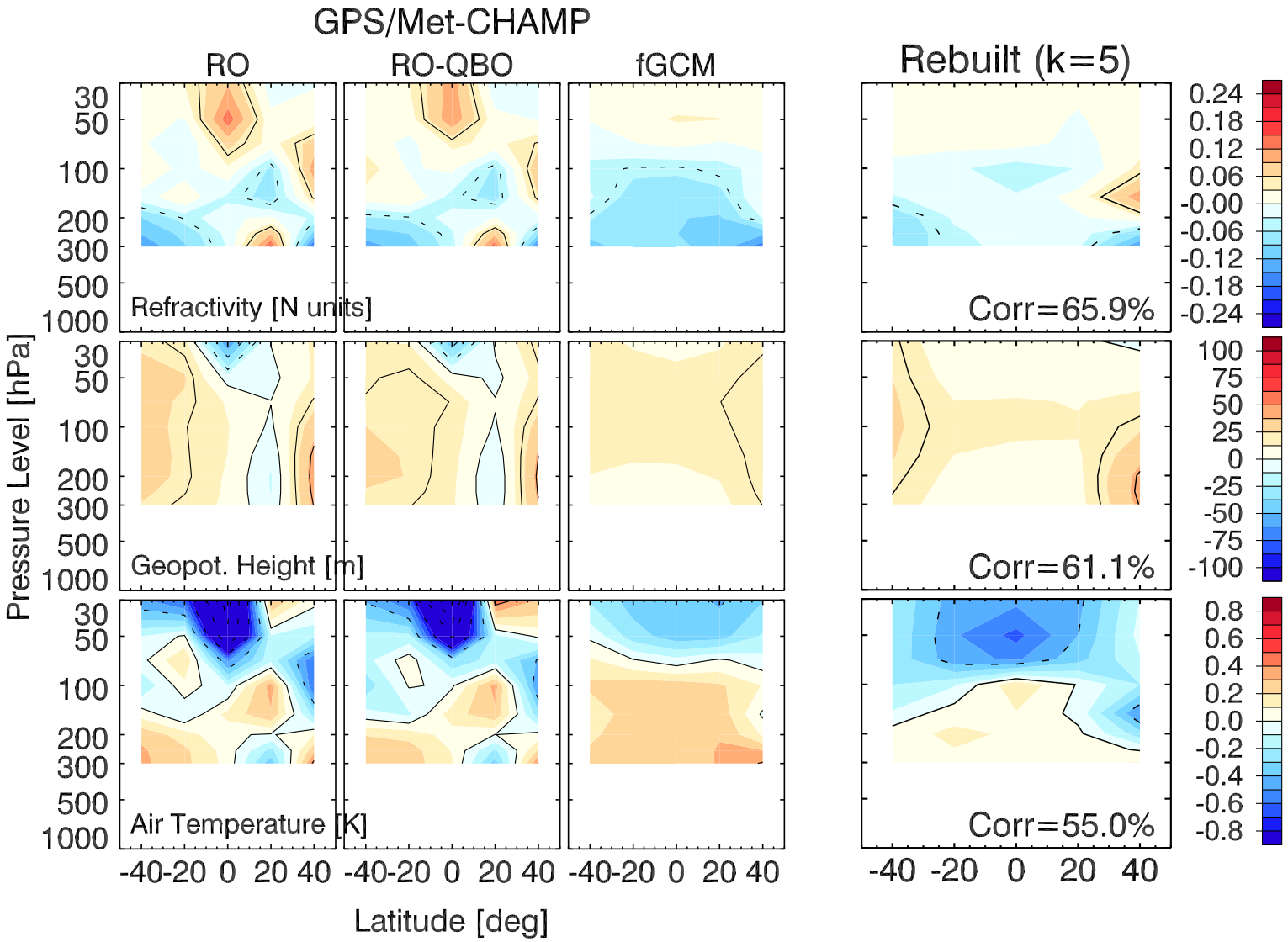
QBO and El Niño During the Study Period



Explained Variance (R^2) of QBO and El Niño in RO Data

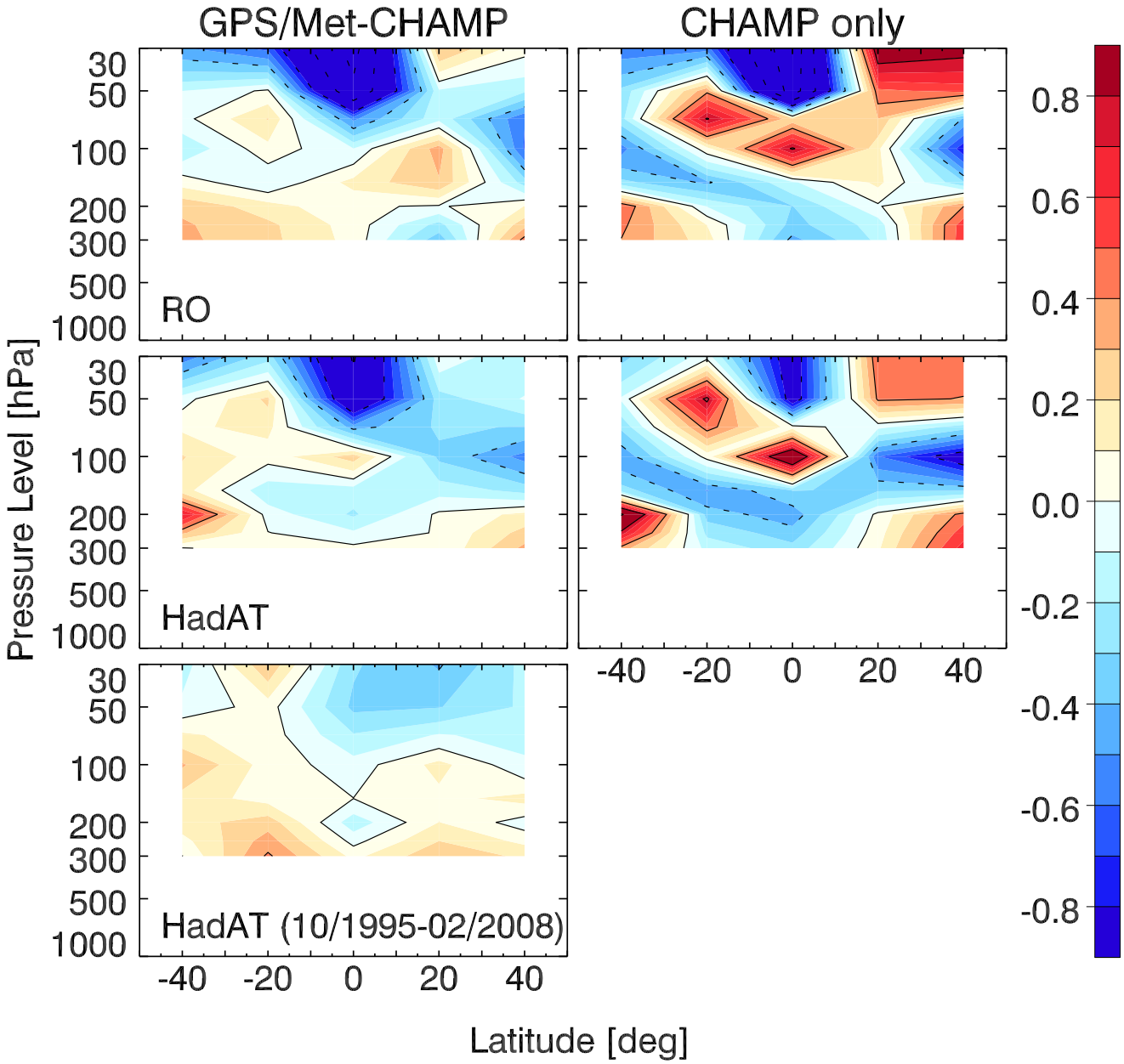


RO and fGCM Trend Patterns *with/without QBO*



Influence of Lacking Data on Trends?

Temperature



Distribution of Measurements for Radiosondes and RO

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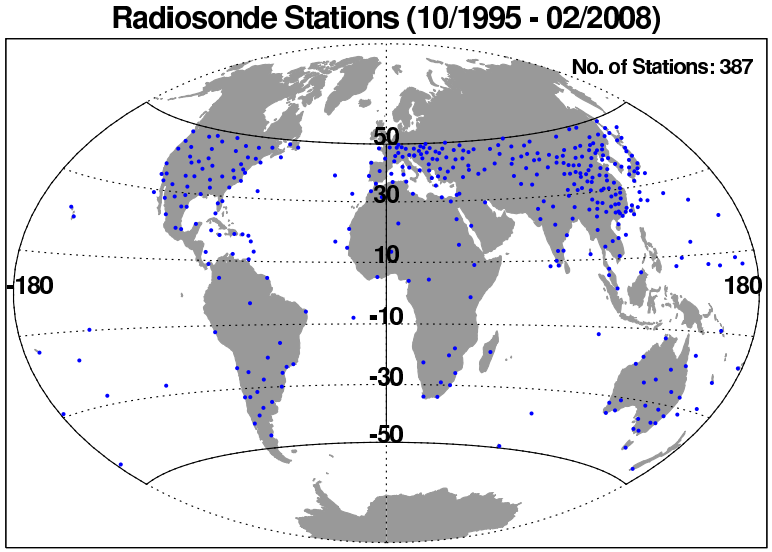
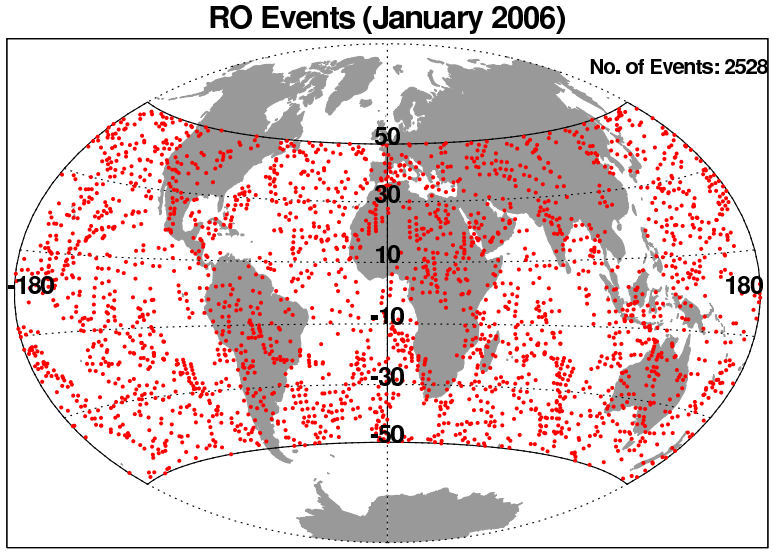
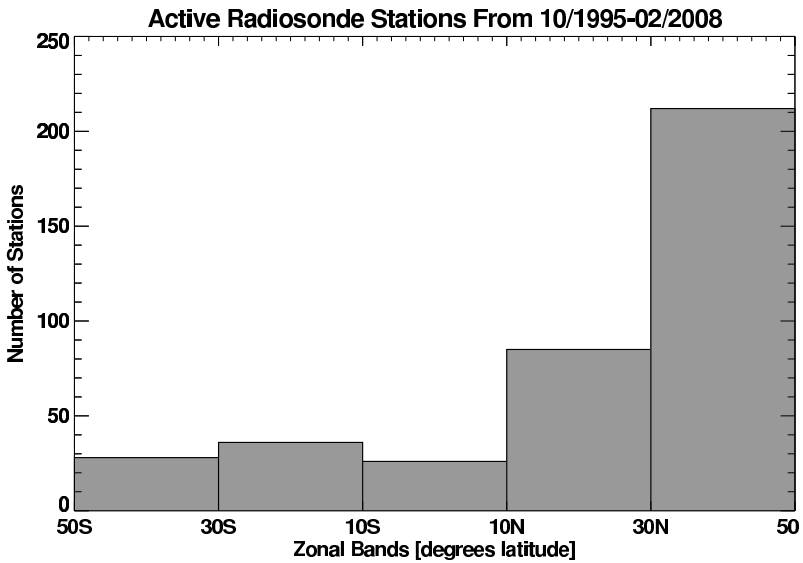
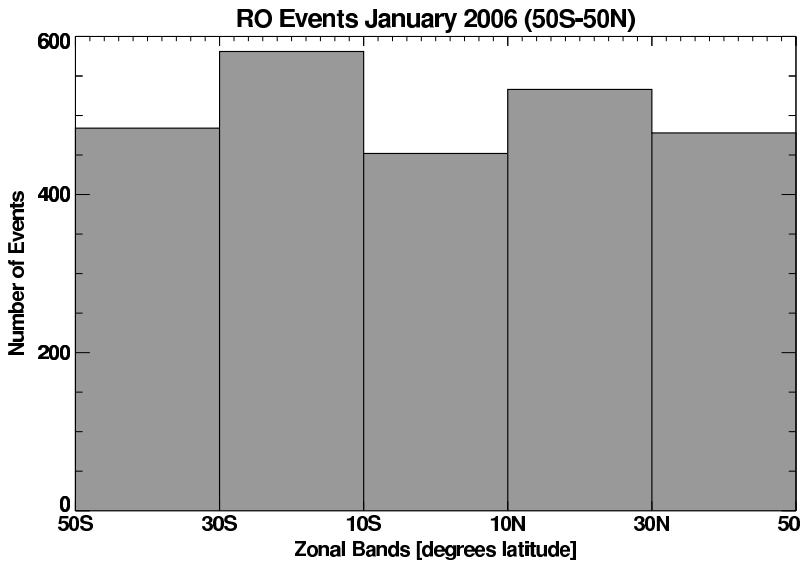
UNI GRAZ



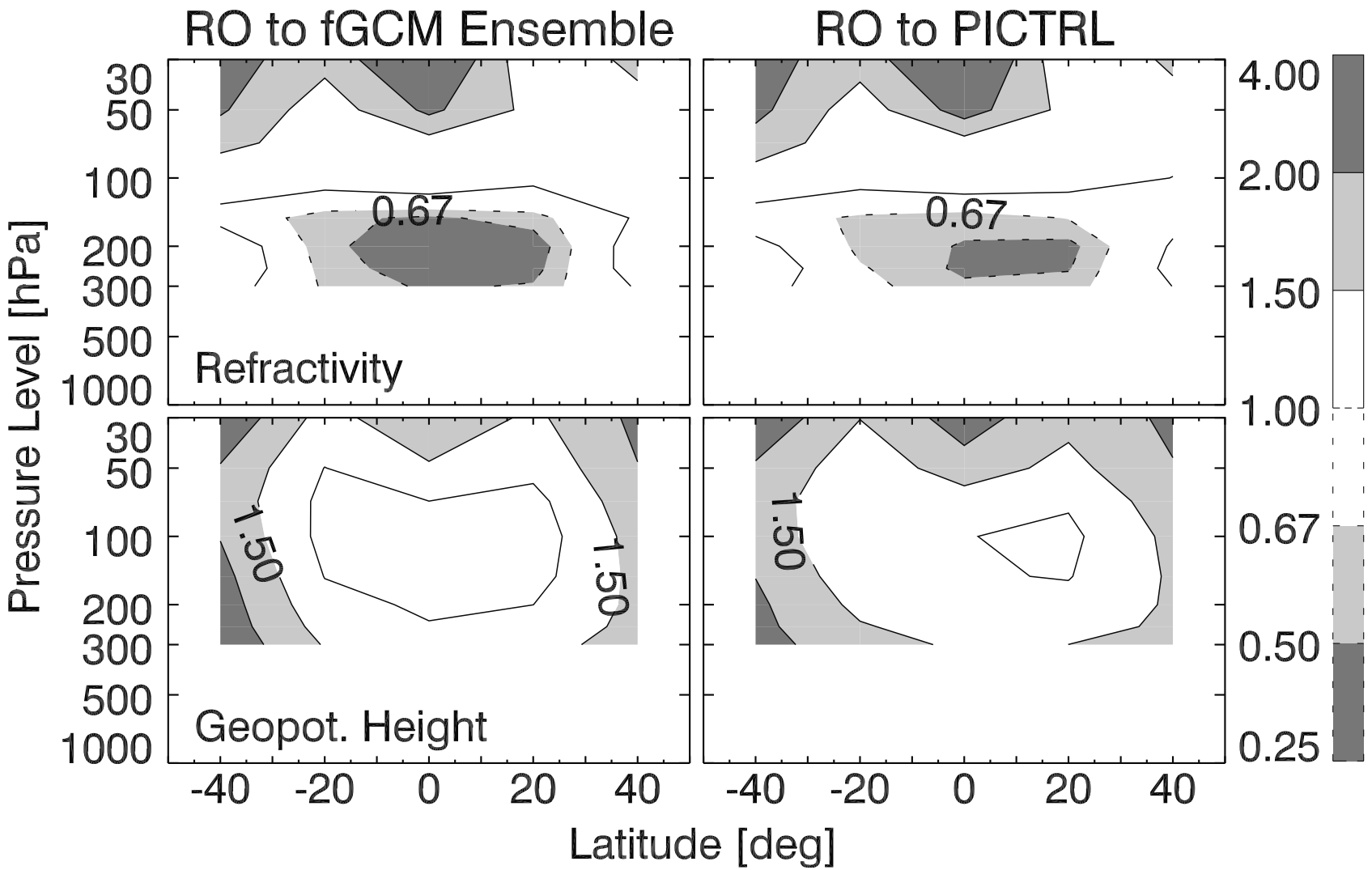






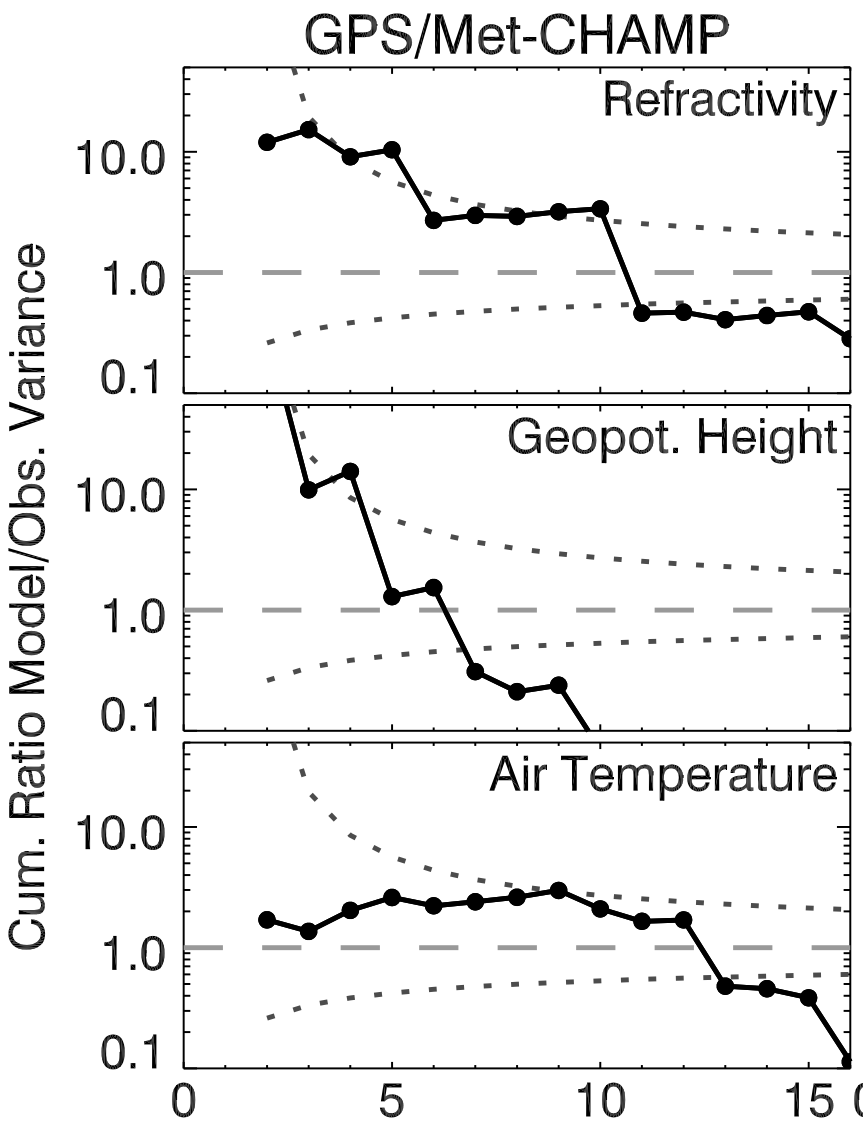
Comparison of RO and GCM Variability

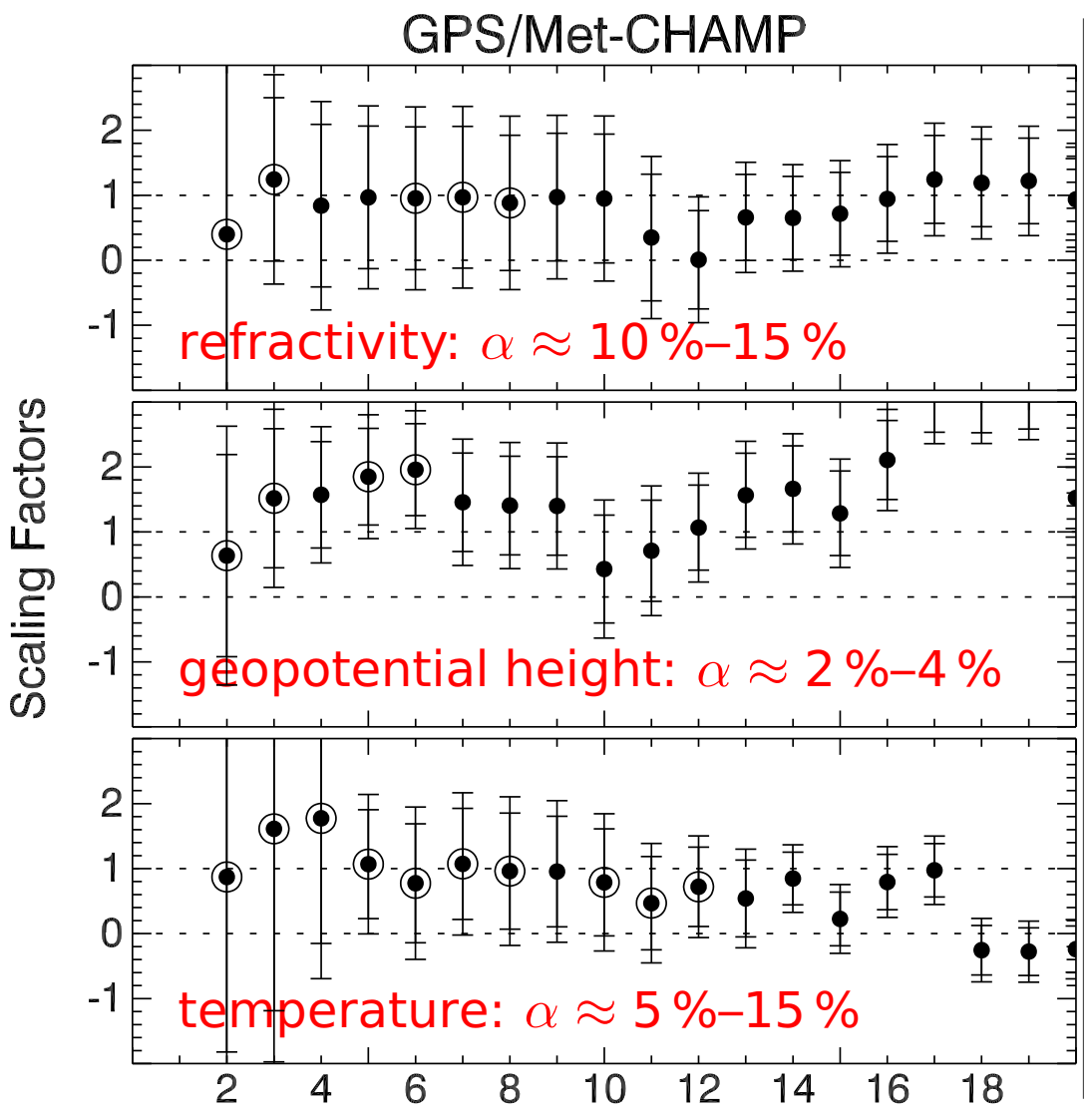
standard deviation ratios



GCMs show higher UT and lower LS variability than RO

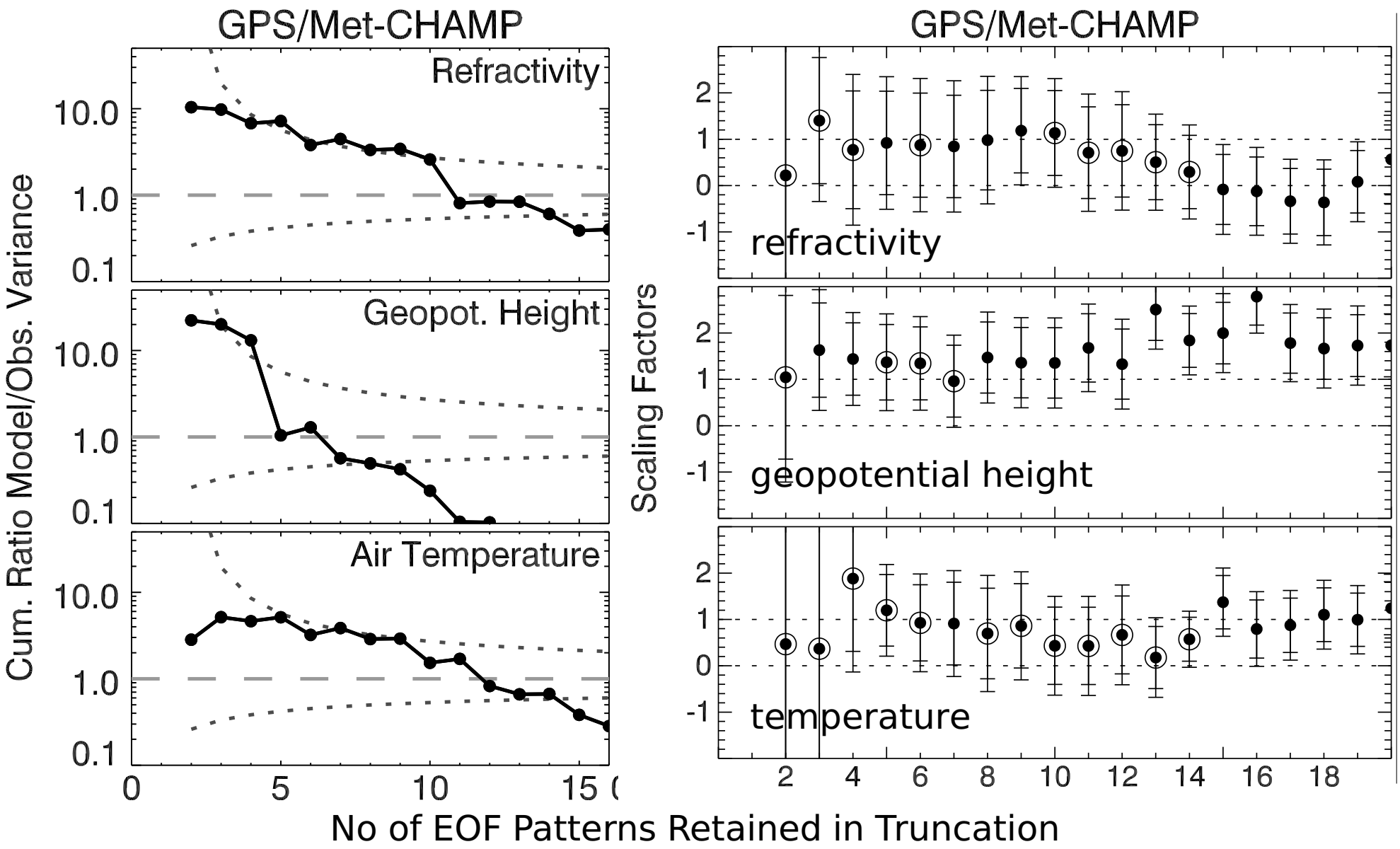
Residual Consistency Test and Uncertainty in Scaling Factors



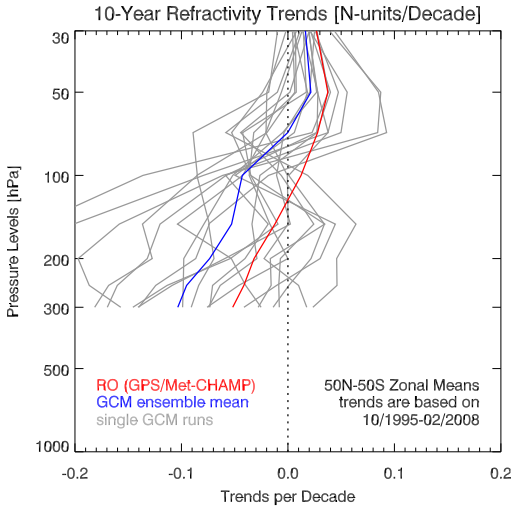


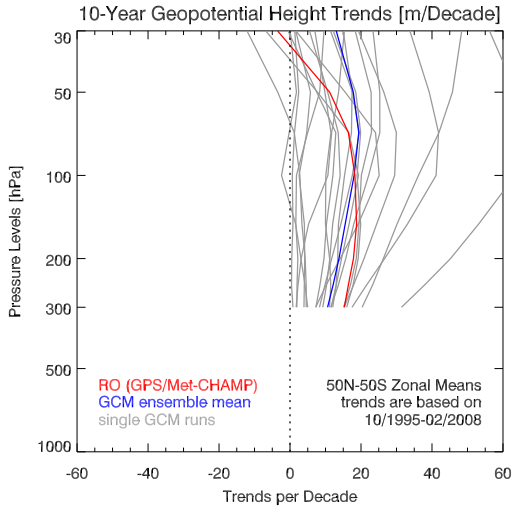
No of EOF Patterns Retained in Truncation

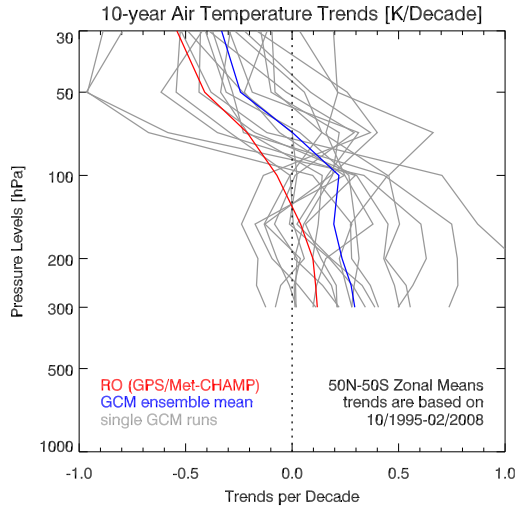
Results of 10° Latitudinal Resolution

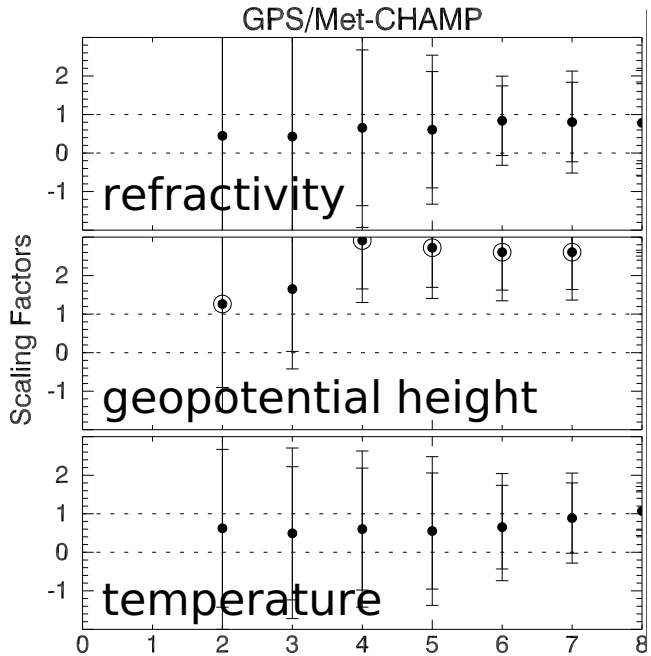


Results of Single Profile (50°S–50°N) Approach









- GCM trends of refractivity and temperature much stronger in UT, weaker in LS
- geopotential height trend similar
- only detection for geopotential height trends

Summary

- investigate usability of RO for climate change science
- test whether the 1995–2008 RO refractivity, geopotential height, and temperature trend patterns are consistent with GCM projections
- trend signal for CHAMP period (2001–2008) still masked by natural variability
- for 1995–2008 period, consistency of RO trend patterns with GCMs is given on
  - 90 % confidence level for temperature
  - slightly lower for refractivity
  - 95 % confidence level for geopotential height (robust results only if only large-scale aspects of pattern are resolved)
- consistency of single mean profiles only given for geopotential height