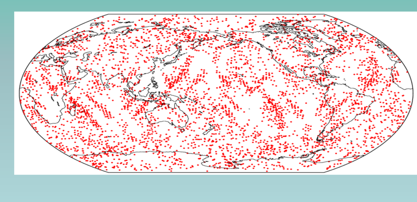
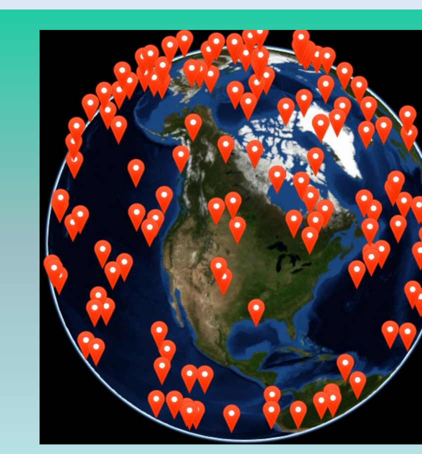


Construction of Temperature Climate Data Records using Multiple RO Missions



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Introduction: key uncertainties identified in IPCC AR5

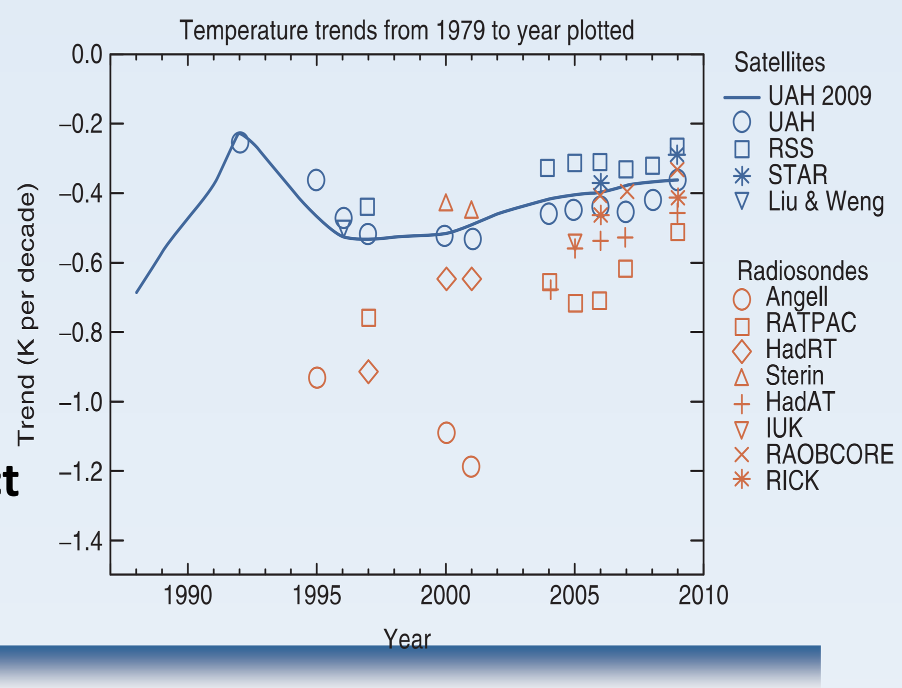
Monitoring and detecting the vertical structure of atmospheric temperature trends are key elements in the climate change problem, Current long-term variations of atmospheric vertical thermal distributions are mainly constructed from passive satellite microwave and infrared sounders. However, due to lack of on- board stable calibration references, the inter-satellite biases are still large when they are overlapped. The IPCC AR5 identified that:

- "There is only medium to low confidence in the rate of change of tropospheric warming and its vertical structure
- ... and low confidence in the rate and vertical structure of the stratospheric cooling"

We need measurements with high precision, high accuracy, long term stability, reasonably good temporal and spatial coverage as climate benchmark observations. Can we use RO temperature to construct climate records ?

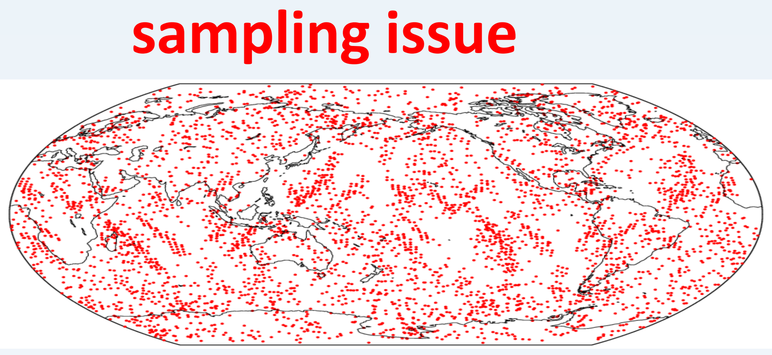
due to inversion procedures (Ho et al., 2009, 2011 JGR)

Dian J. Seidel et al., Stratospheric temperature trends: our evolving understanding, *WIREs: Clim Change* 2010.

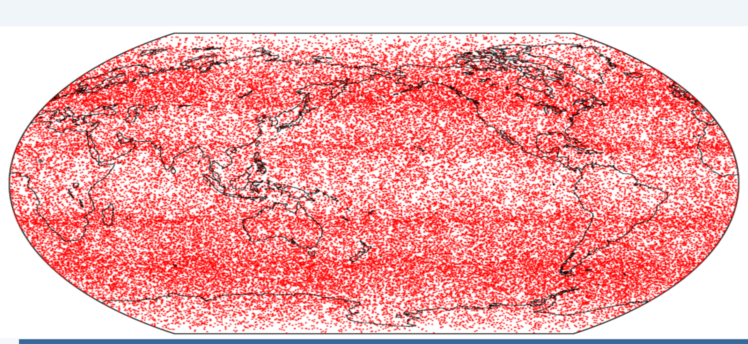


Challenges

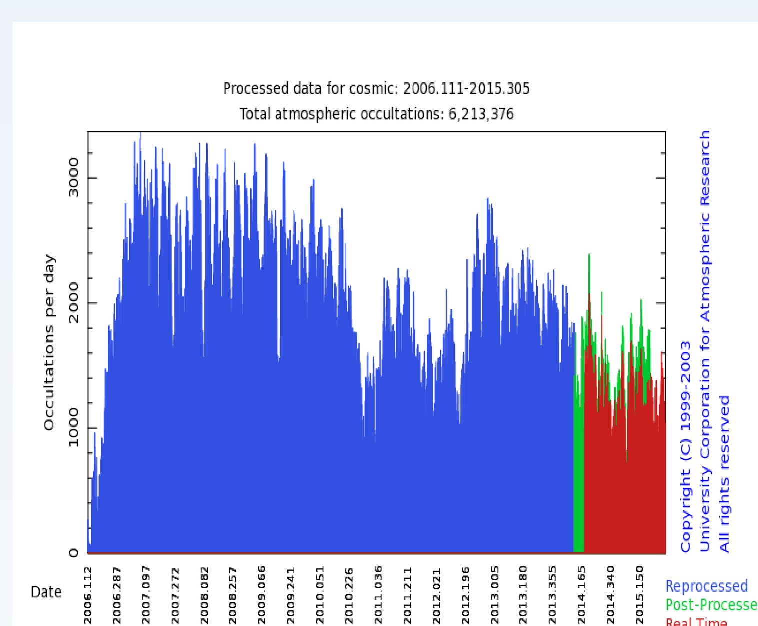
1) **Sampling issue (see occultation number plot below for CHAMP and COSMIC)**
2) **Uncertainty of reanalysis data (see Figure 1)**
3) **Structure Uncertainty of temperature climate data record due to sampling issue**



Distribution of CHAMP in June 2007



Distribution of COSMIC in June 2007



Approaches

Quantifying structure uncertainty of sampling errors using NCEP, MERRA, and ERA-Interim

MMC (monthly mean climatology) generated by dry temperature profiles from multiple RO missions in the UTLS (from 8km to 30 km altitude). Zonal bins of 5 degree latitudinal width were defined at Mean Sea Level (MSL) altitude grid with vertical resolution of 200 meters.

$MSE(i,j,k)=MMC_{int}(i,j,k)-MMC_{grd}(i,j,k)$

MSE: sampling error of the MMC estimated from reanalysis

MMC_{int}: reanalysis temperature interpolated to the times and locations of each RO profiles

MMC_{grd}: original reanalysis temperature

i,j,k: altitude, zonal bin, month

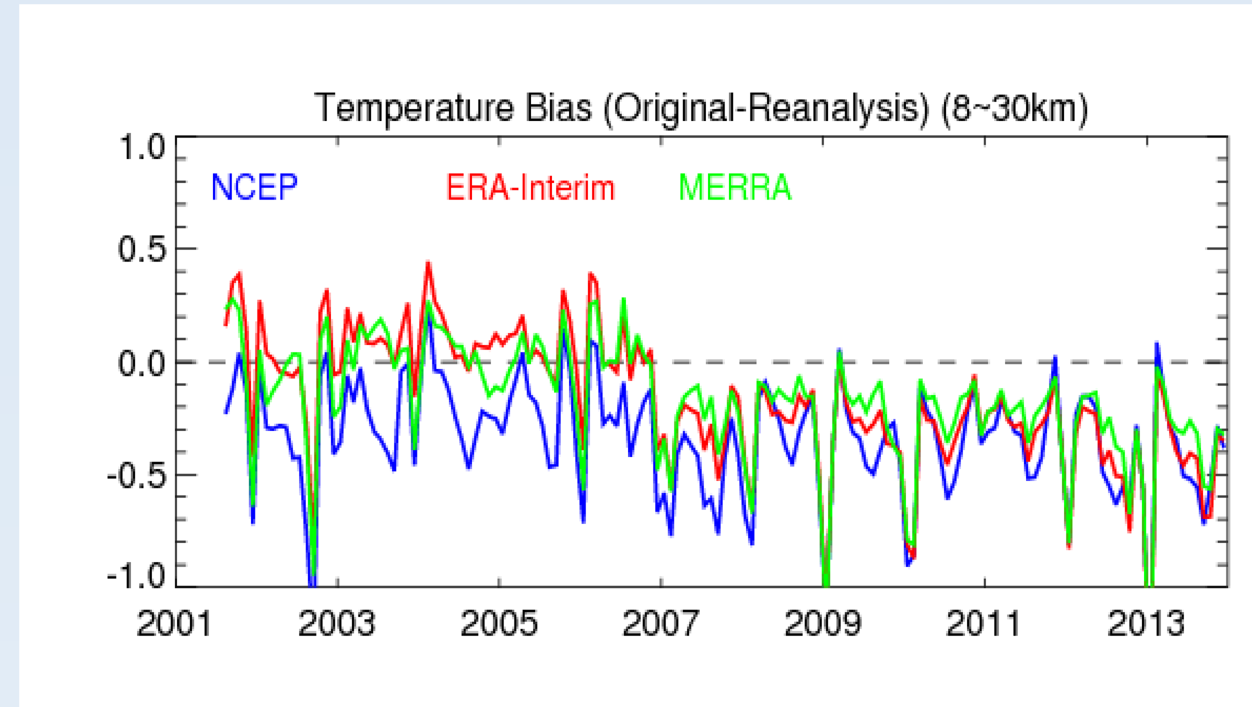
$MMC^{new}(i,j,k)=MMC_{RO}(i,j,k)-MSE(i,j,k)$

The mean temperature anomalies and trend from different reanalysis are almost identical (Figure 4 and 5).

Conclusions and Future Work

a. **The structural uncertainties for RO MMC sampling errors estimated by NCEP, MERRA, and ERA-Interim are within +/- 0.3K**
b. **The structural uncertainties for COSMIC MMC – GRAS MMC are within +/- 0.5K**
c. **Construction of RO only climate records T, W, B, N**
d. **Consistent re-processed data from all available missions**

Results



RO temperature MMC – Reanalysis MMC: this is to demonstrate the Temperature Difference among reanalysis

Fig. 1: RO temperature MMC – Reanalysis MMC

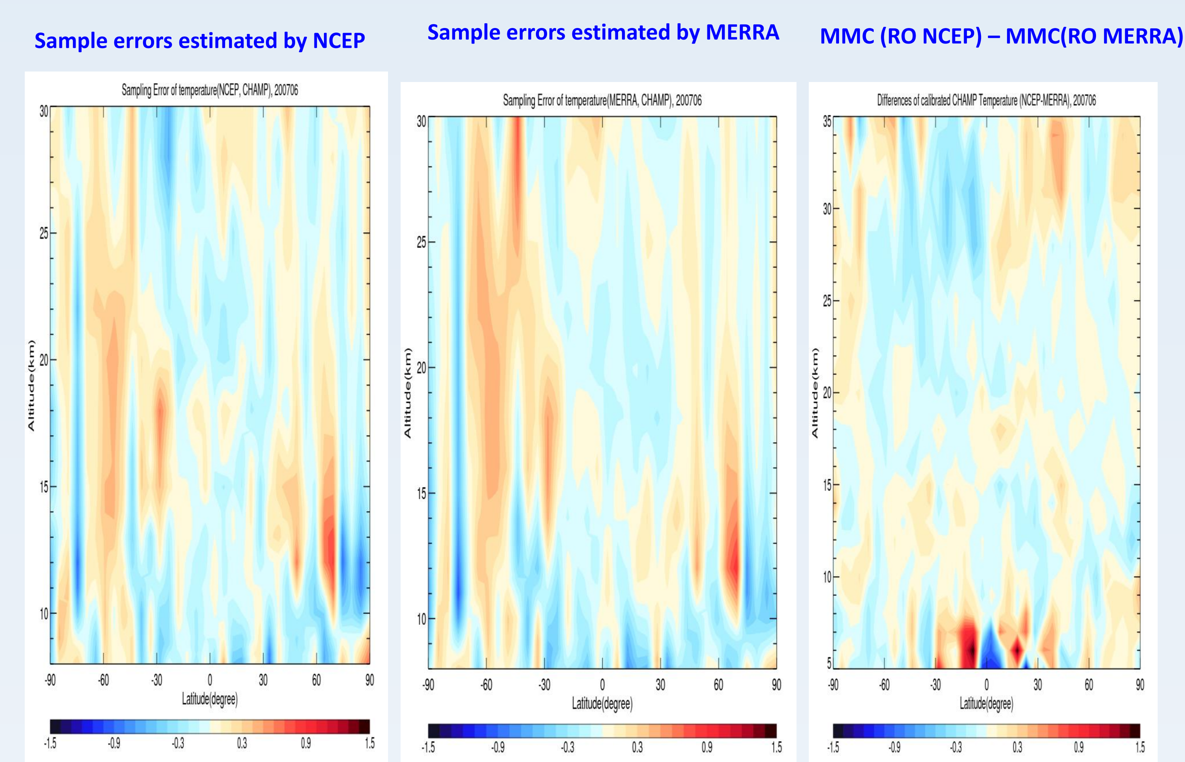
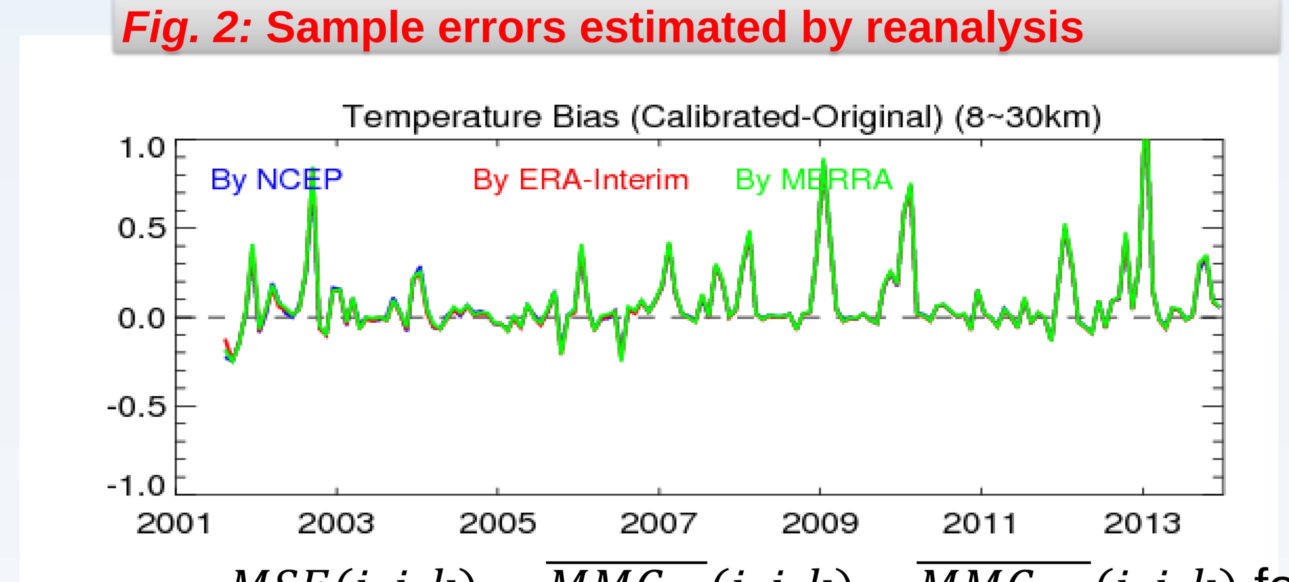


Fig. 2: Sample errors estimated by reanalysis

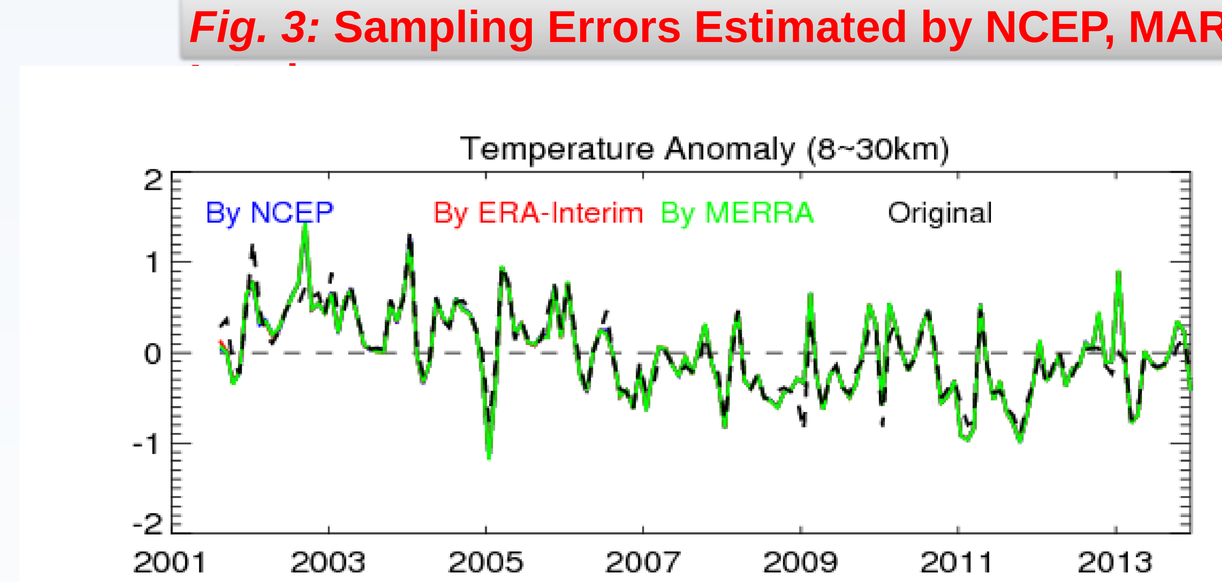
MMC (RO NCEP) is the MMC for NCEP at all RO locations ($\overline{MMC_{int}}(i,j,k)$ for NCEP) . MMC (RO MERRA) is the MMC for MERRA at all RO locations ($\overline{MMC_{int}}(i,j,k)$ for MERRA).



Sampling Errors Estimated by NCEP, MARRA, and ERA-Interim

$MSE(i,j,k) = \overline{MMC_{int}}(i,j,k) - \overline{MMC_{grd}}(i,j,k)$ for NCEP, MERRA and ERA-interim

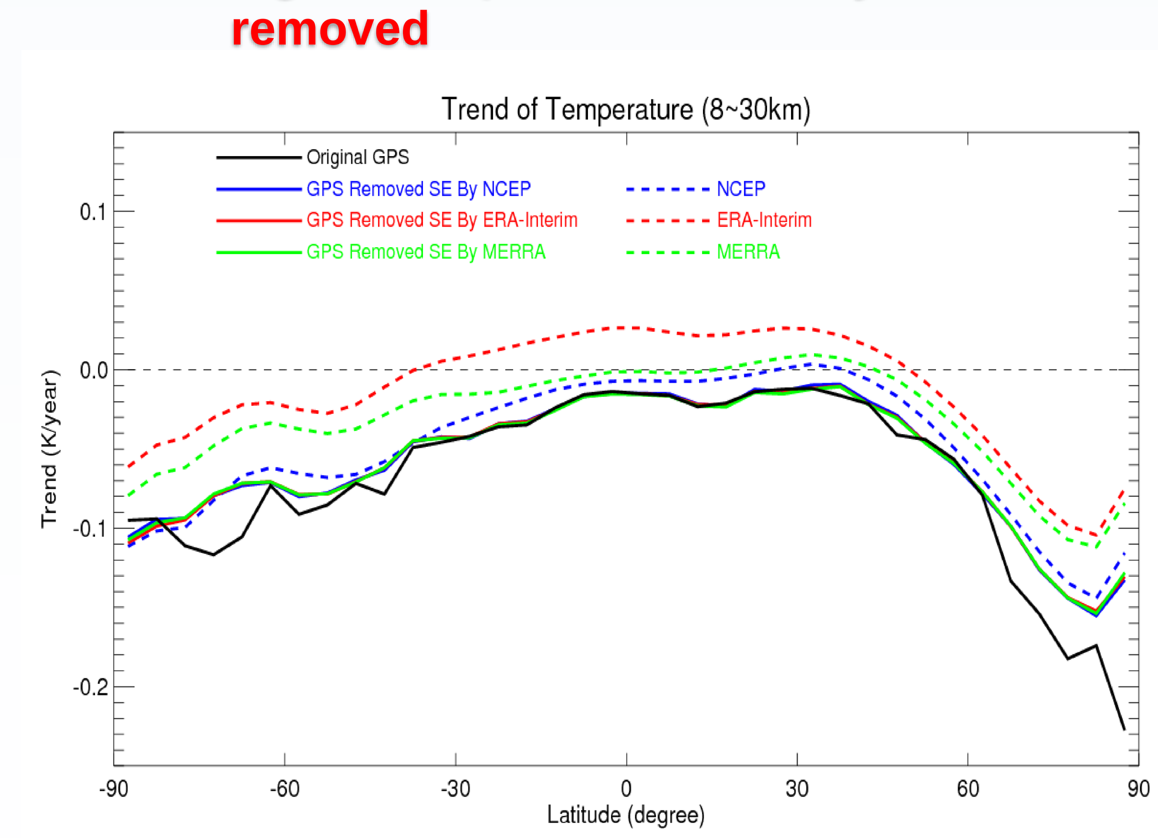
Fig. 3: Sampling Errors Estimated by NCEP, MARRA, and ERA-



Temperature anomaly after seasonal variation is removed

$MMC^{NEW}(i,j,k)$ For NCEP, ERA-interim, and MERRA after removing seasonal variation

Fig. 4: Temperature anomaly after seasonal variation is removed



RO MMC temperature trend for RO, MMC new after removing NCEP, ERA-interim, and MERRA sampling errors.

Fig. 5: Trend of RO temperature MMC from 2001 to 2013

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