Impacts of COSMIC GPS Observations on a Climate Reanalysis

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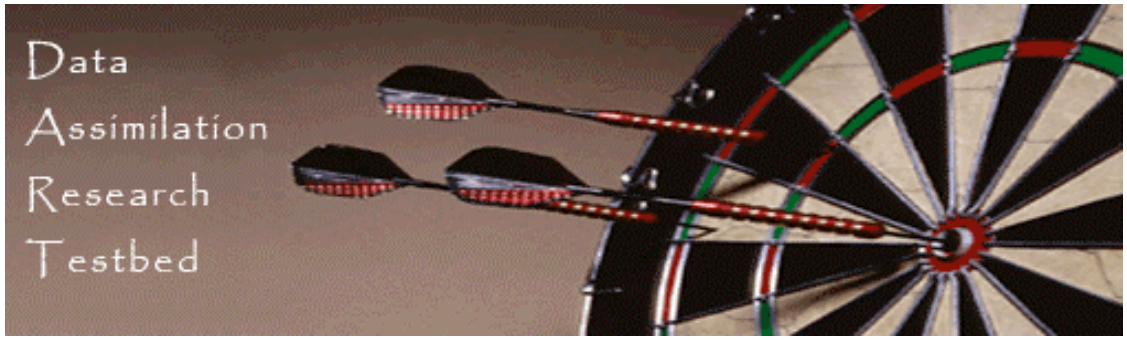

NCAR Data Assimilation Research Section,
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NCAR

Overview

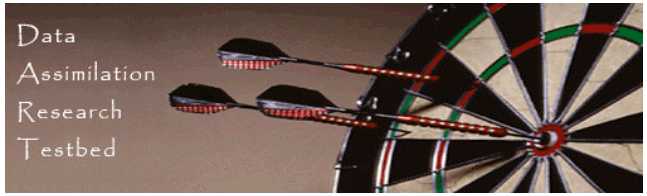
- Reanalysis from Sep. 2006 to Aug. 2007
- NCAR's Community Atmosphere Model
- DART ensemble Kalman filter facility
- Three cases:
  - **NoGPS**: Radiosonde and ACARS Temperature and Winds, Satellite drift winds
  - **Local_GPS**: Add COSMIC GPS using local refractivity
  - **NonLocal_GPS**: Add COSMIC GPS using nonlocal refractivity

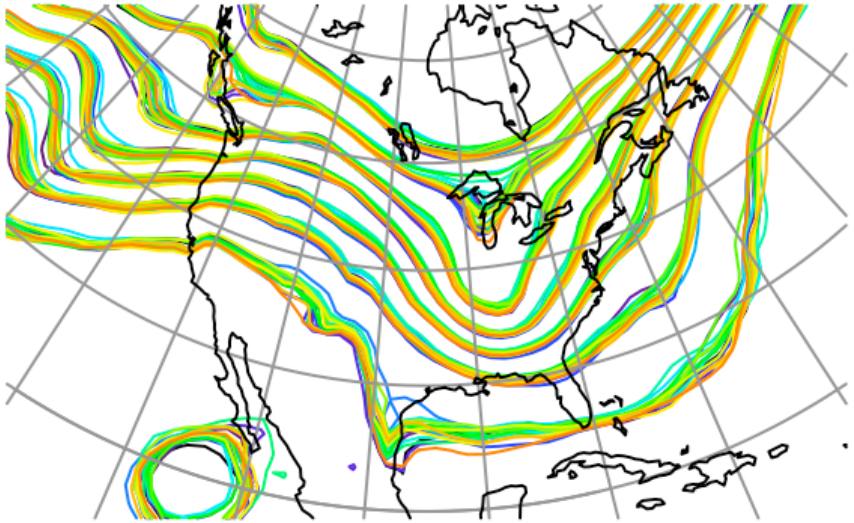
Community Atmospheric Model (CAM)

Atmospheric component of NCAR's Community Climate System Model

- Version 3.5:
  - Finite Volume dynamical core 1.9 x 2.6 degrees
  - Same core previously used by NASA/GMAO and NOAA/GFDL
- Physics include:
  - Zhang-McFarlane convection;
  - Neale-Richter convective momentum transport;
  - Observed SST/Sea ice.
- Preliminary Version of next IPCC climate model.

Data Assimilation Research Testbed (DART)



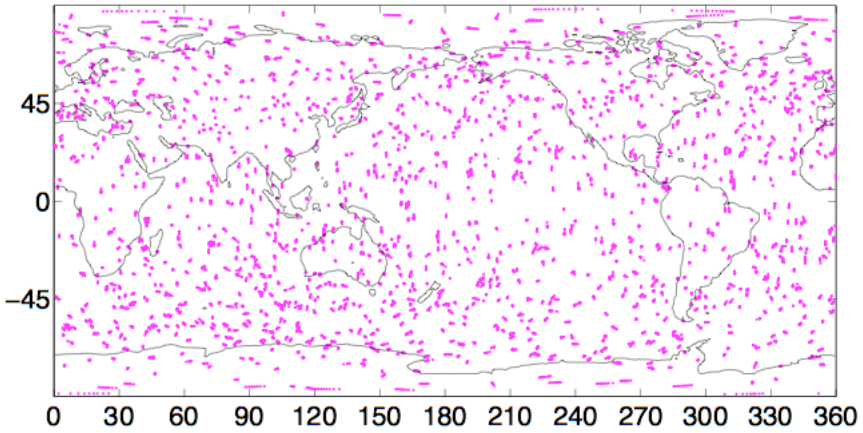


- Deterministic ensemble square root filter (EAKF)
- 80 ensemble members
- 6-hour cycling with +/- 3-hour observation window
- Adaptive spatially-varying inflation with damping
- 0.2 radian localization of observation impact
- 3.0 standard deviation outlier rejection
- Results competitive with NCEP operational

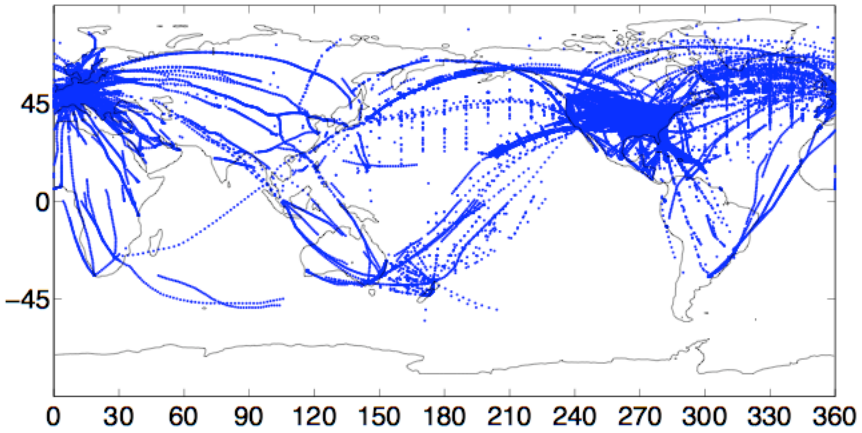
Observations

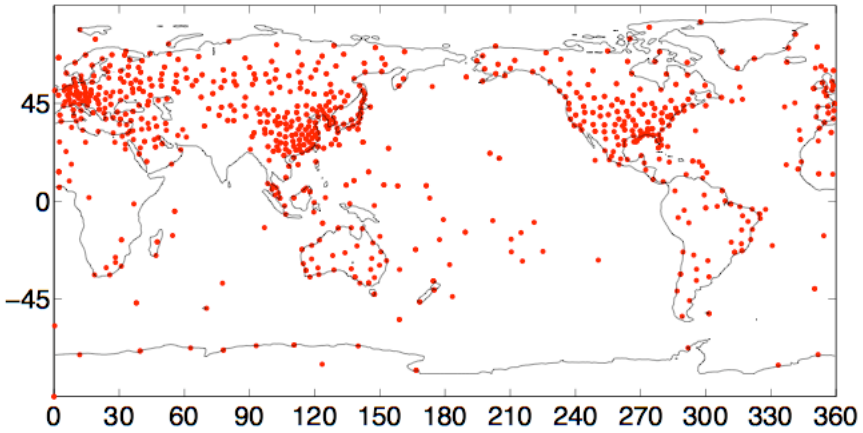
1 December 2006

GPS

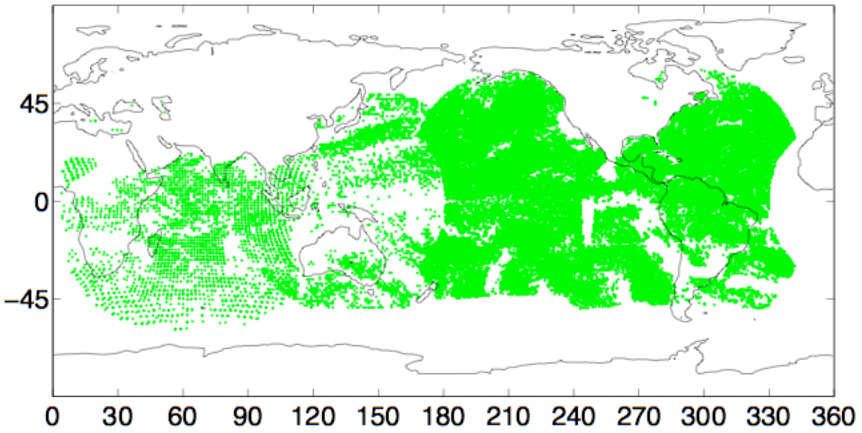


ACARS and Aircraft





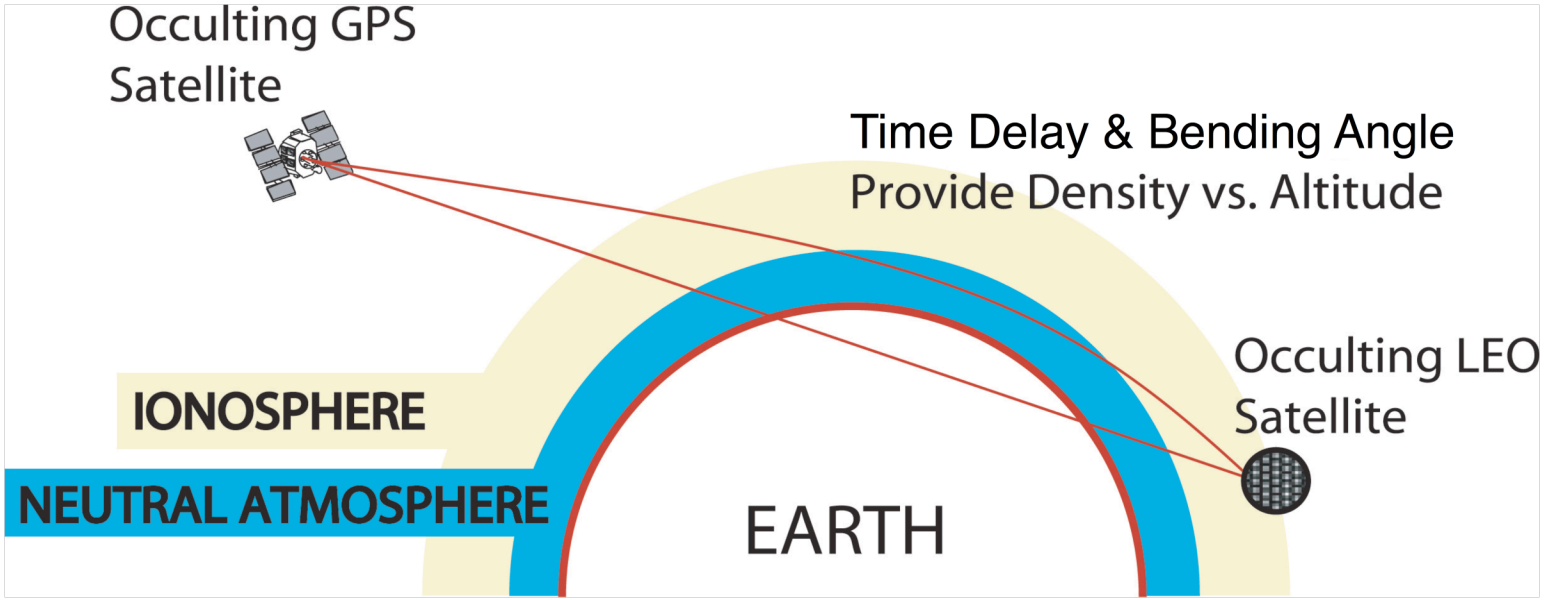
Radiosondes



Sat Winds

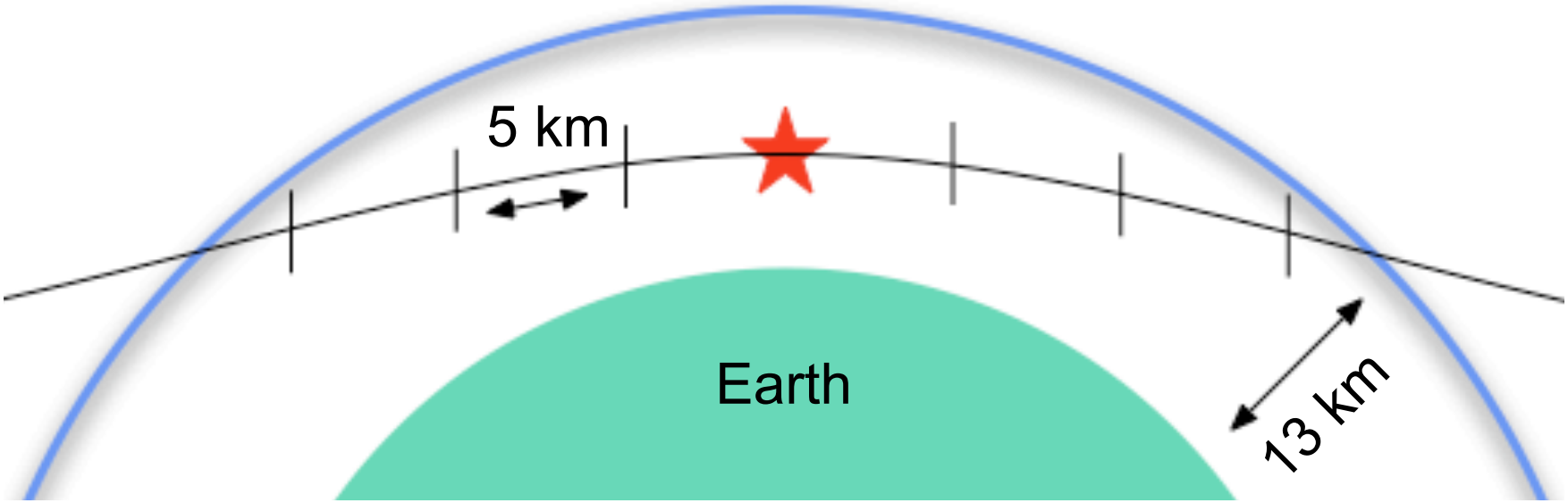
GPS occultation forward operators

- **Local refractivity**:
  - Interpolate model pressure, temperature and moisture to tangent point
  - Use refractivity from COSMIC DAAC
  - Max of 15 tangent points below 13 km per profile



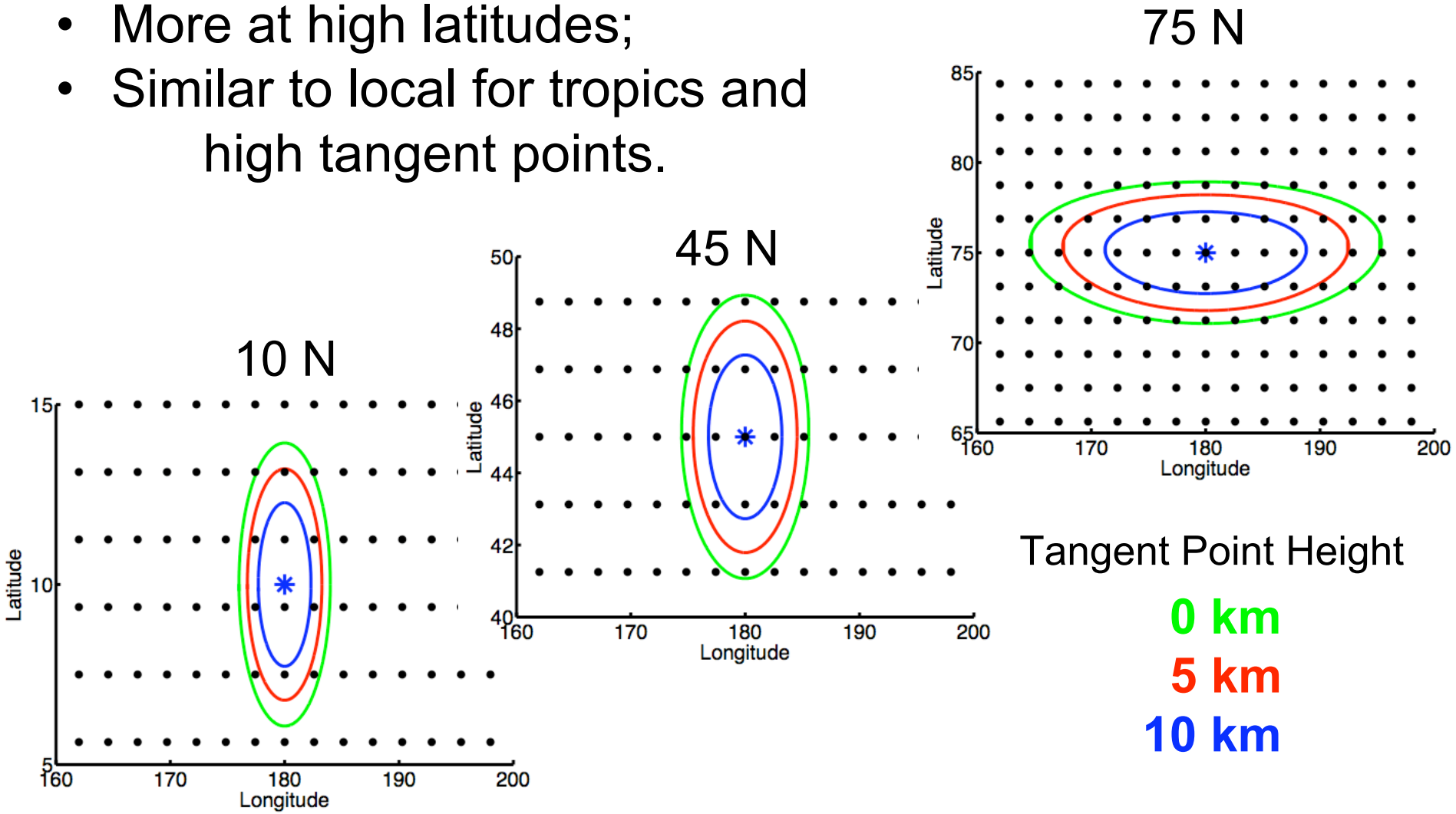
GPS occultation forward operators

- **Local**: uses tangent point only
- **Nonlocal**: uses every 5km along raypath
  (Sokolovskiy et al., MWR 133, 2200-2212)

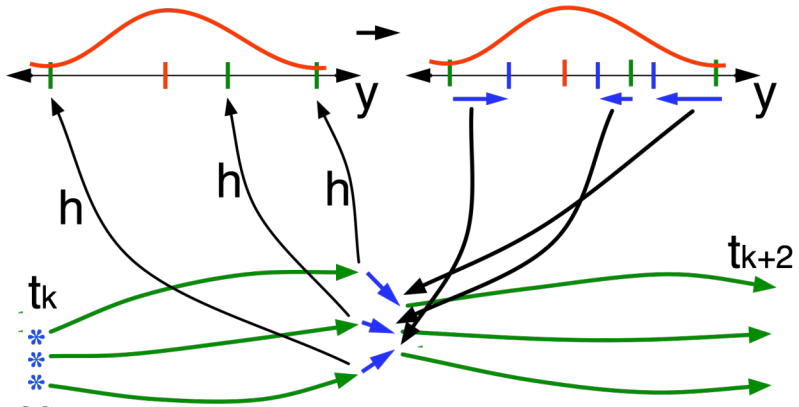


GPS occultation forward operators

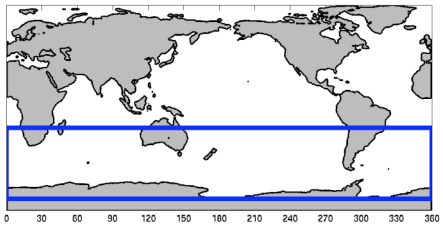
- **CAM grid points impacting Non-local refractivity**:
- More for low tangent points;
- More at high latitudes;
- Similar to local for tropics and high tangent points.

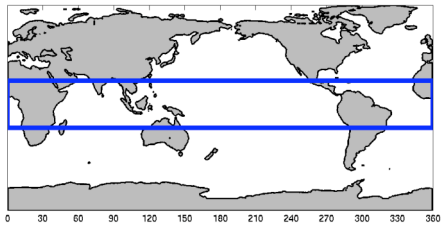


Metrics



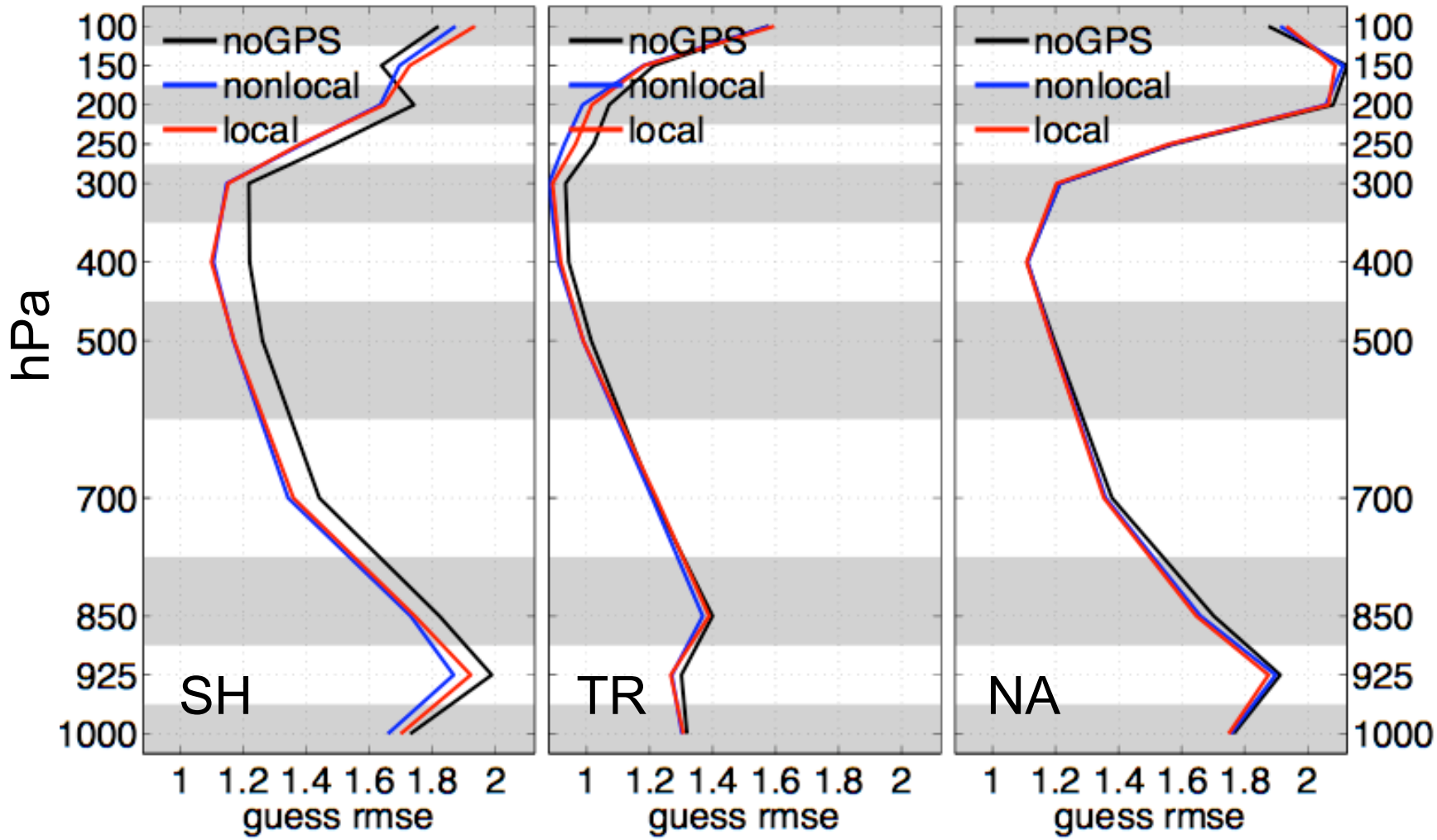
- 6-hour forecast RMS difference from radiosonde observations
  - Averaged over vertical slabs
  - Averaged over horizontal regions
  - Averaged over calendar months
- 6-hour forecast Bias (mean error)
- 6-hour forecast ensemble spread (standard deviation)





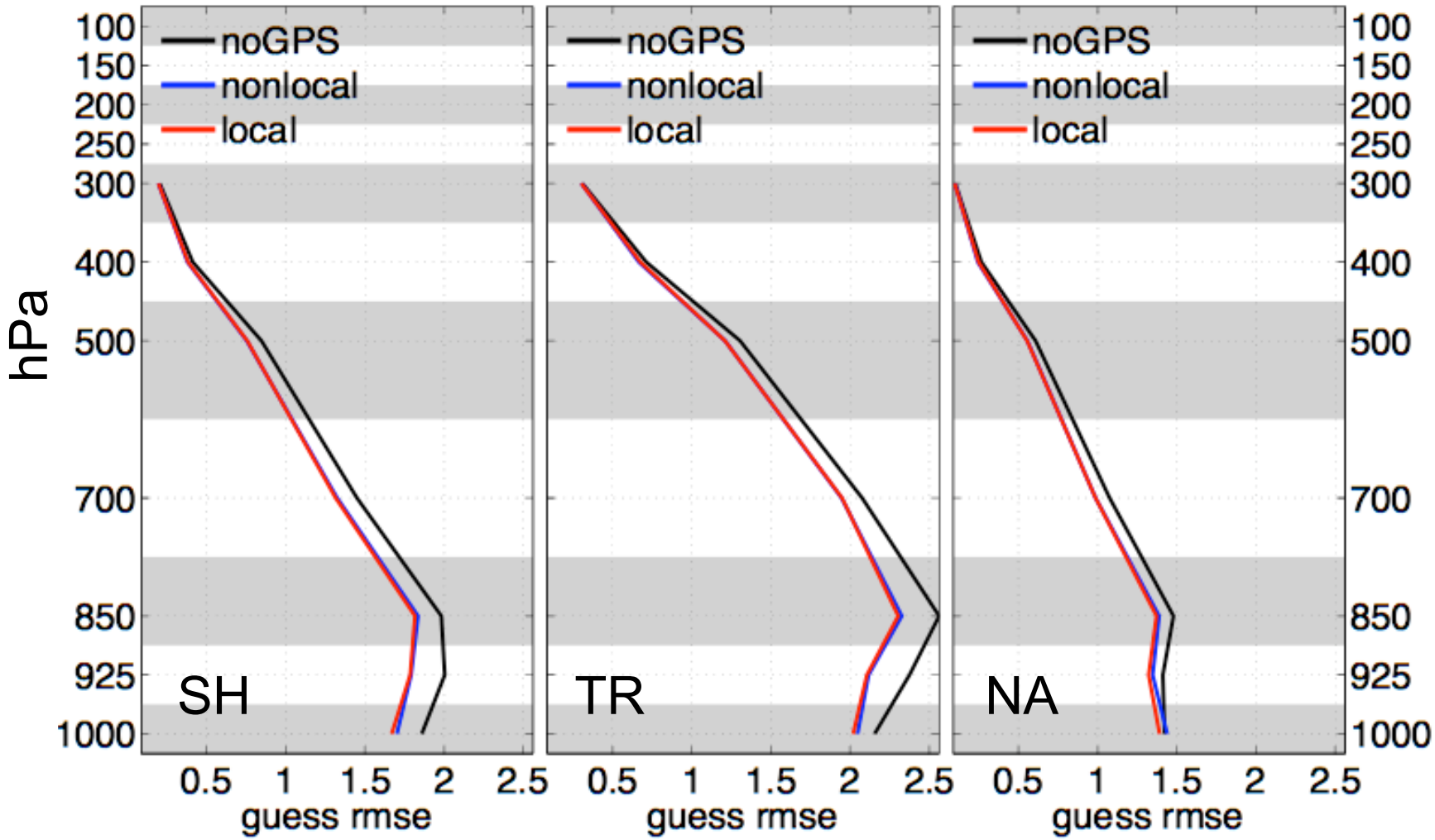
6-hour forecast RMS difference from Radiosonde Temperature

December 2006



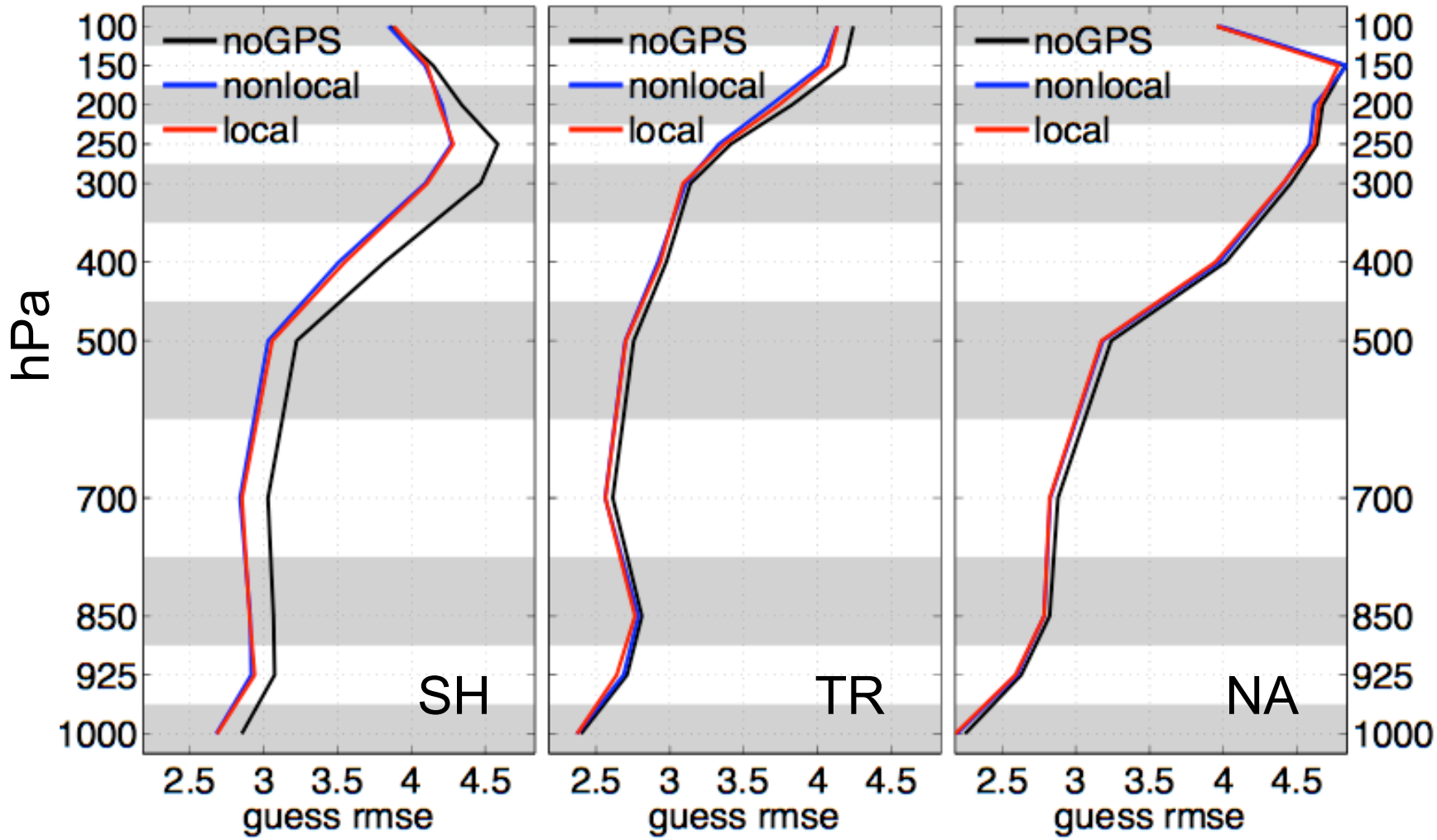
6-hour forecast RMS difference from Radiosonde Specific Humidity

December 2006



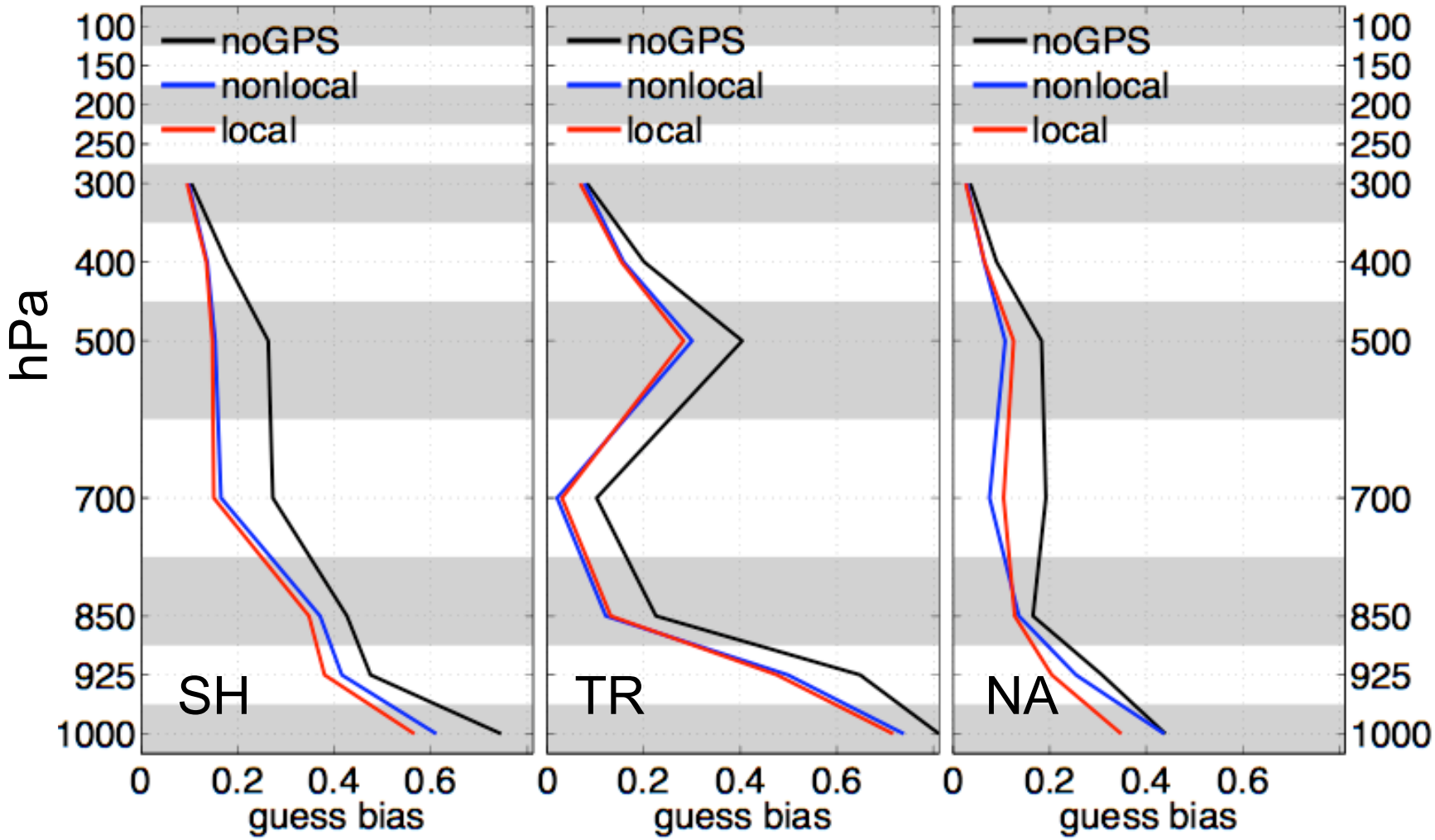
6-hour forecast RMS difference from
Radiosonde U Wind Component

December 2006

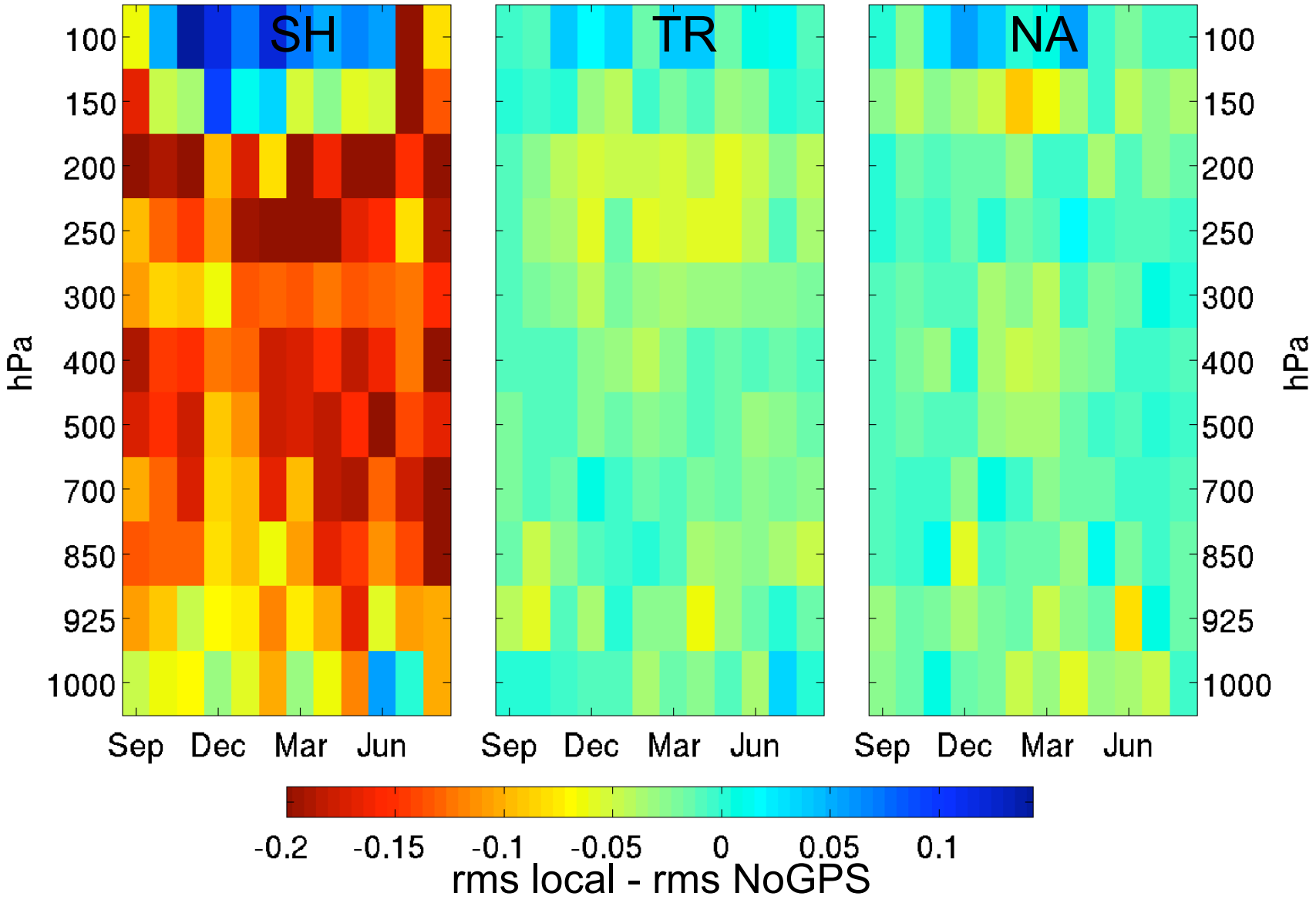


6-hour forecast Bias from Radiosonde Specific Humidity (Q)

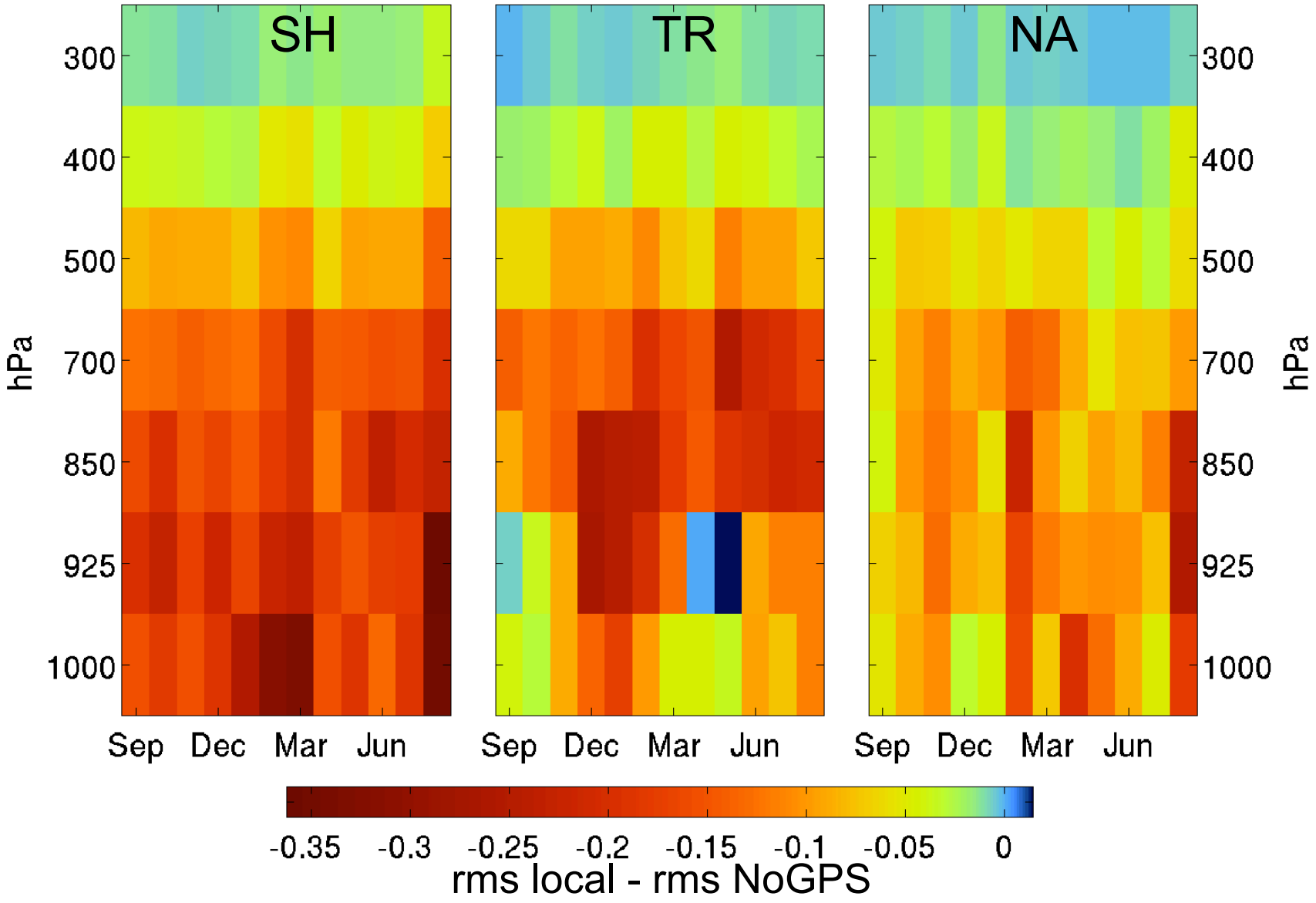
December 2006



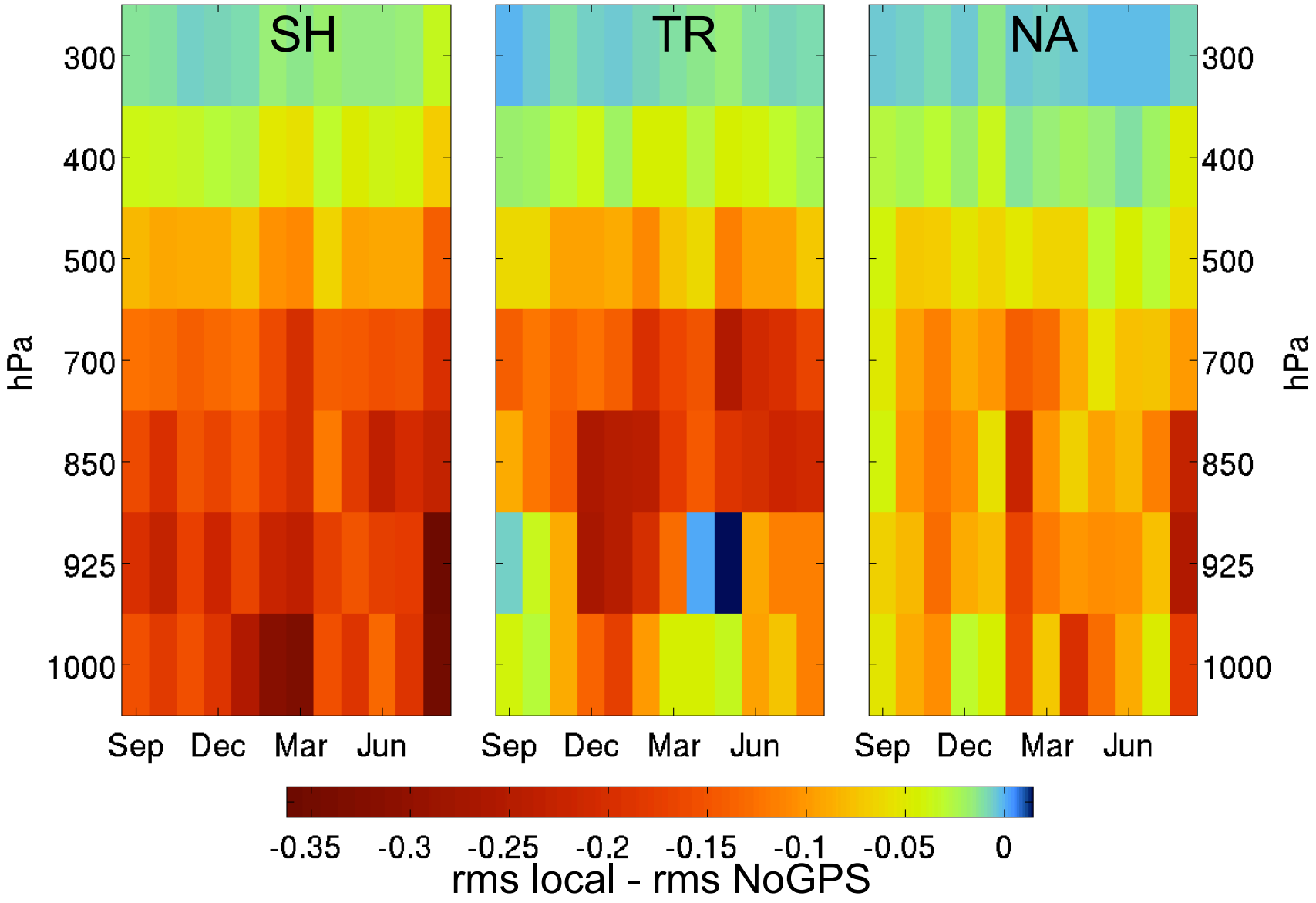
(LocalGPS - NoGPS) T RMS differences



(LocalGPS - NoGPS) Q RMS differences

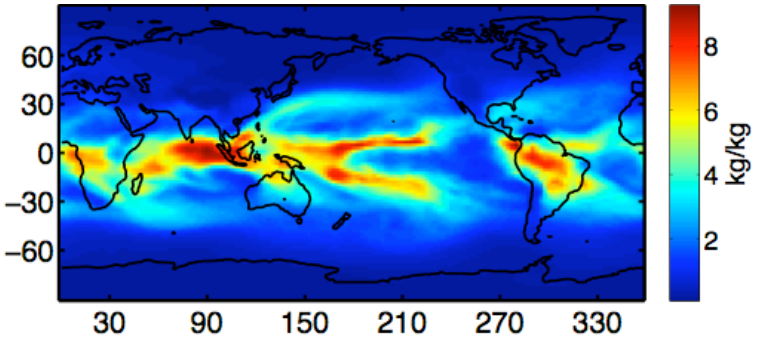


(LocalGPS - NoGPS) Q RMS differences

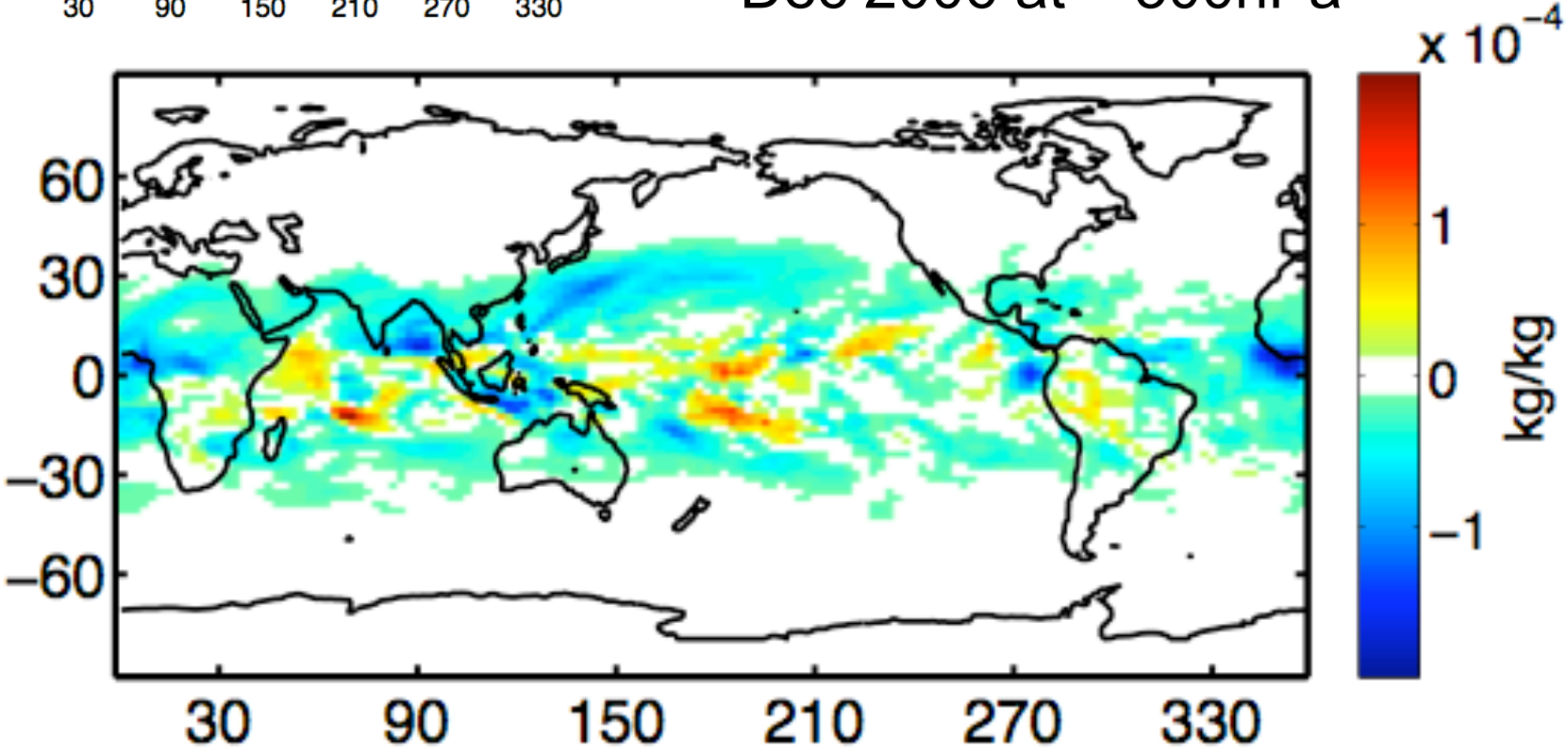


(LocalGPS - NoGPS) CAM Q

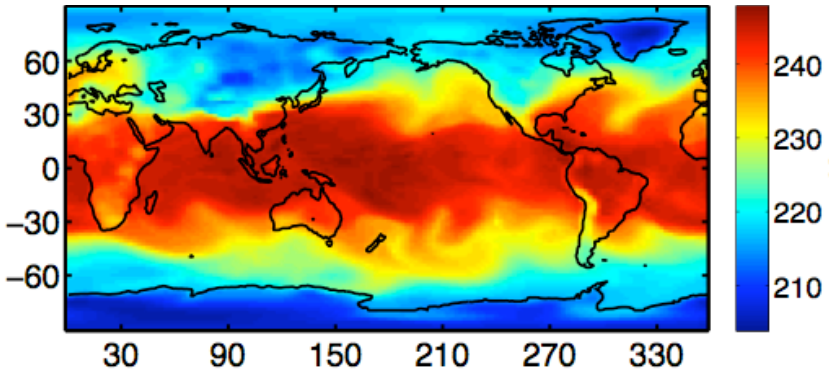
NoGPS monthly mean



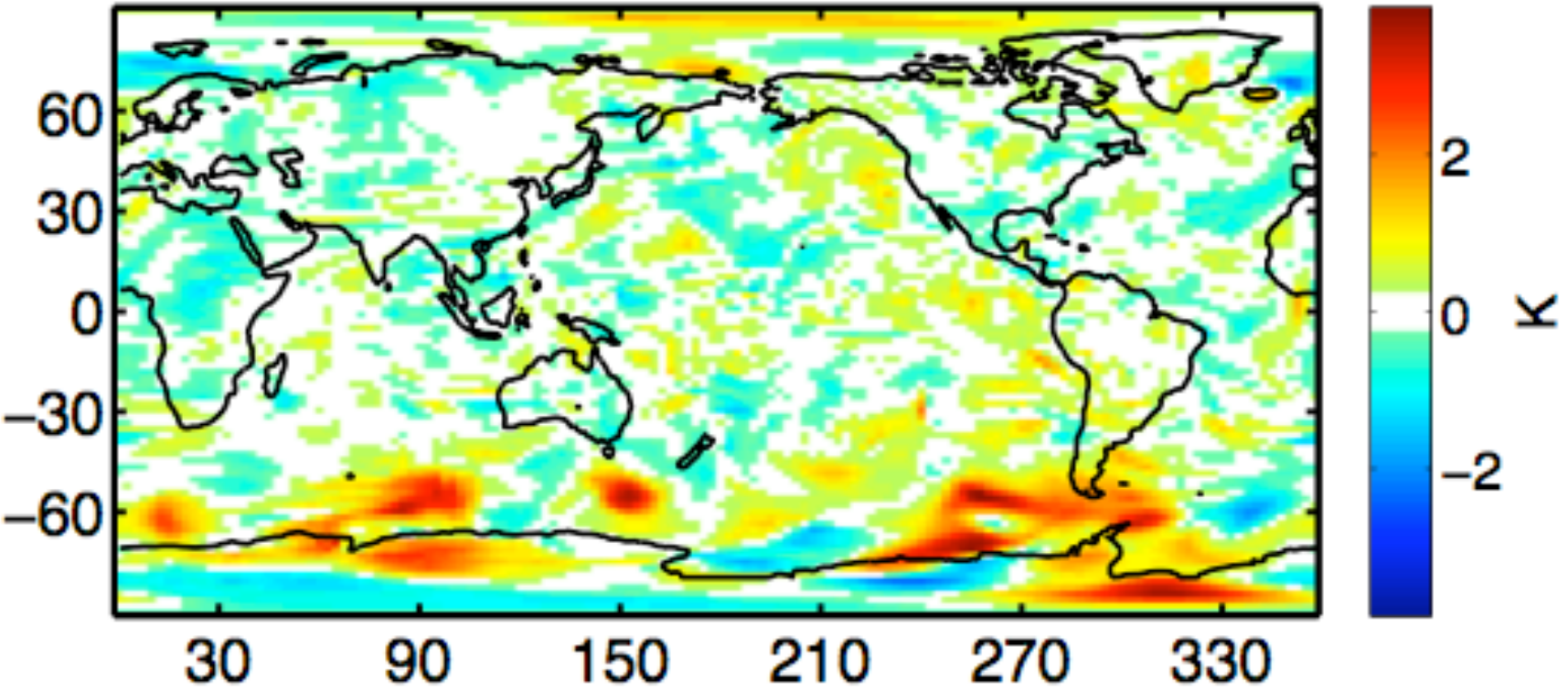
Difference of Monthly Average of Ensemble Means for Dec 2006 at ~ 300hPa



(LocalGPS - NoGPS) CAM Temperature



Difference of Daily Average of Ensemble Means for Dec 1, 2006 at ~ 300hPa



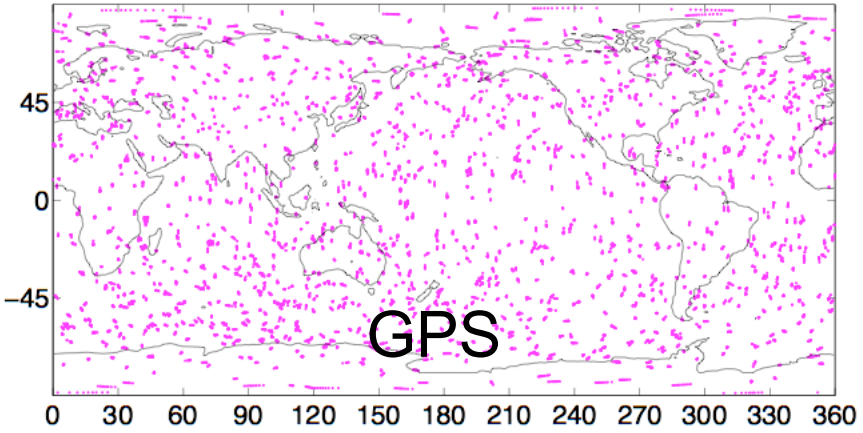
Compare to AIRS Retrievals

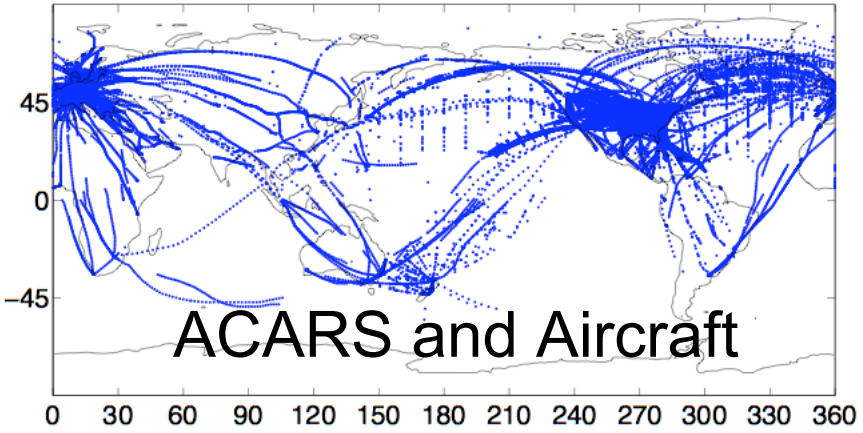
- Add two additional cases:
  - **AIRS**: Radiosonde and ACARS Temperature and Winds, Satellite drift winds plus AIRS temperature and moisture retrievals
  - **GPS+AIRS**: Add COSMIC GPS using local refractivity
- AIRS retrievals are Level 2 (AIRX2RET) data:

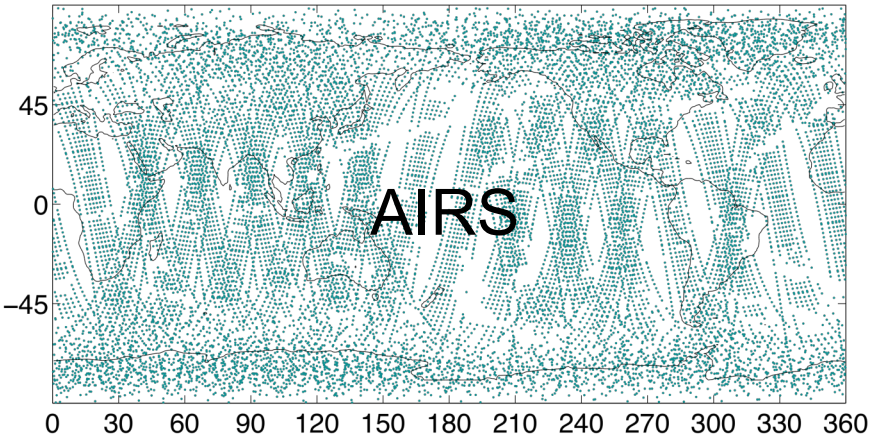
  All temperatures and moistures below 150hPa;

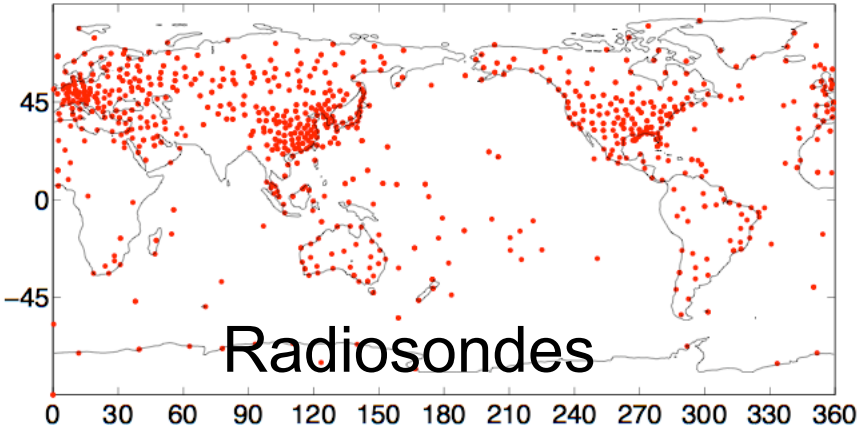
  Approximately 50km horizontal spacing.

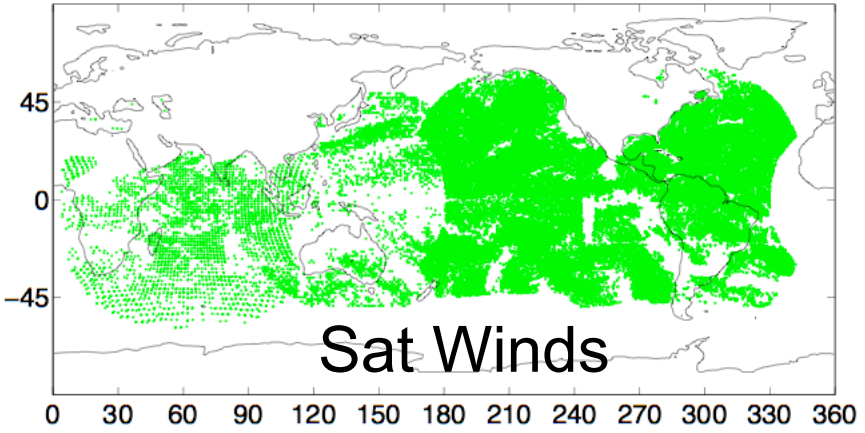
Observations 1 December 2006





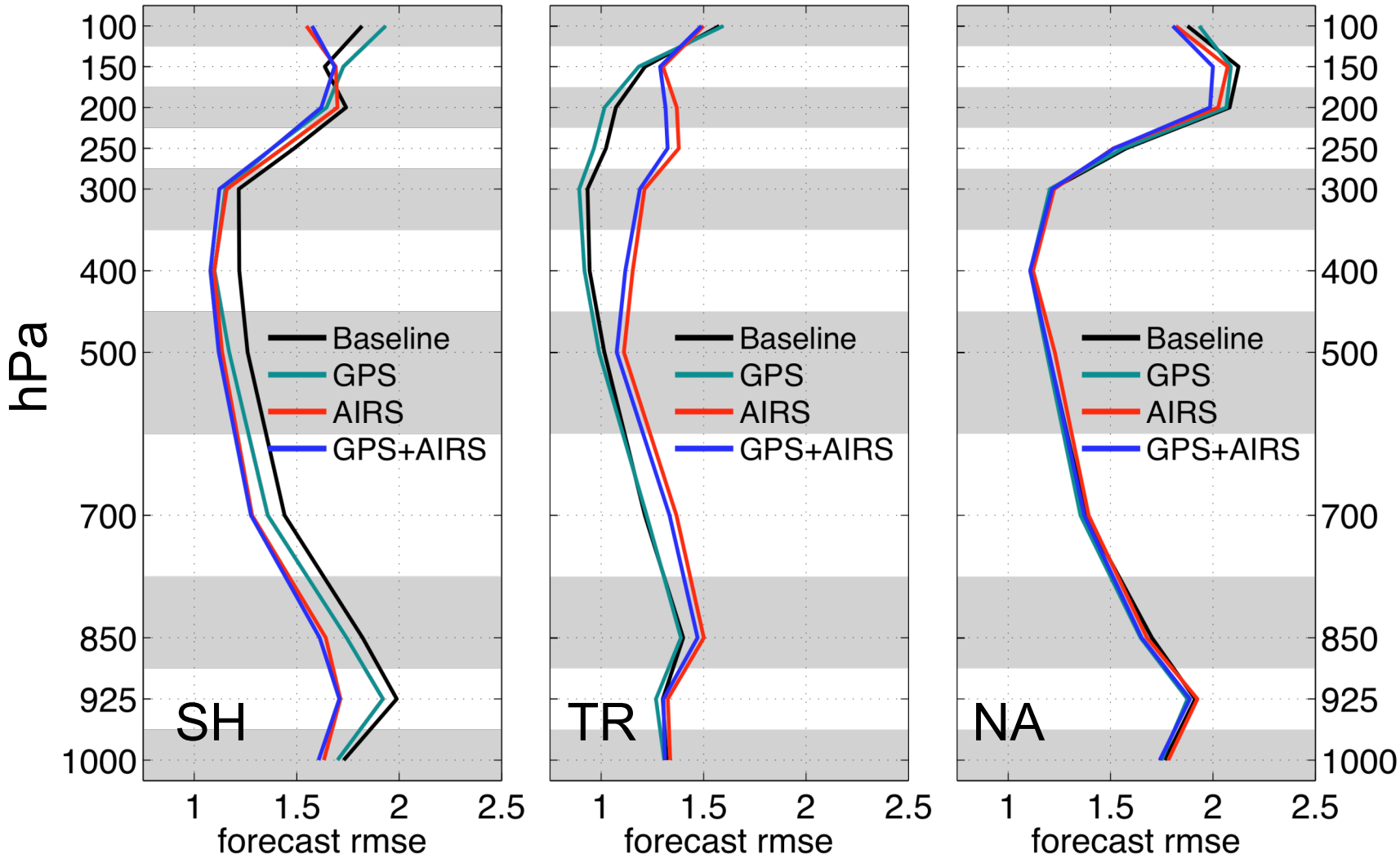






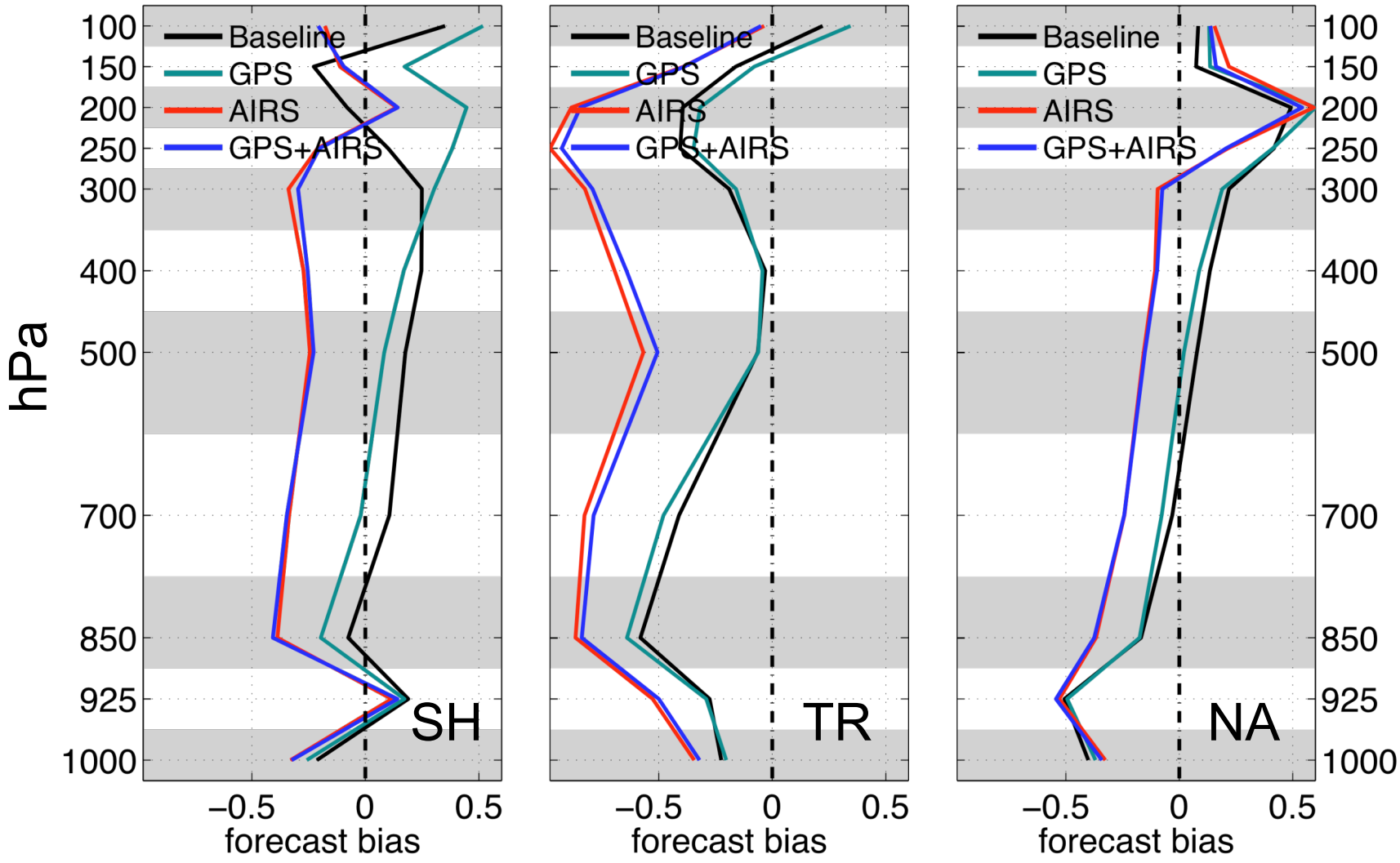
6-hour forecast RMS difference from Radiosonde Temperature

December 2006



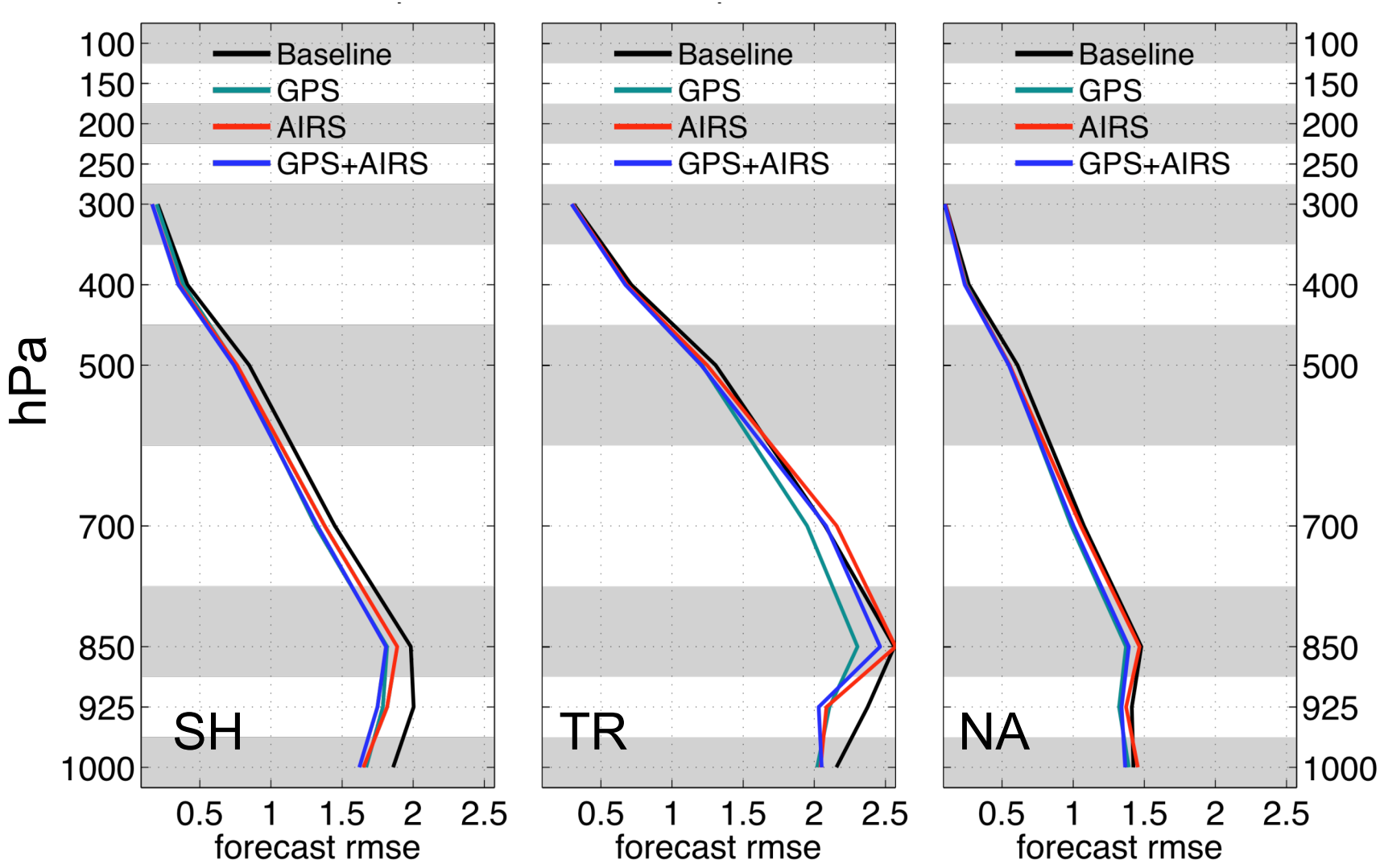
6-hour forecast Bias (forecast-obs)
Radiosonde Temperature

December 2006

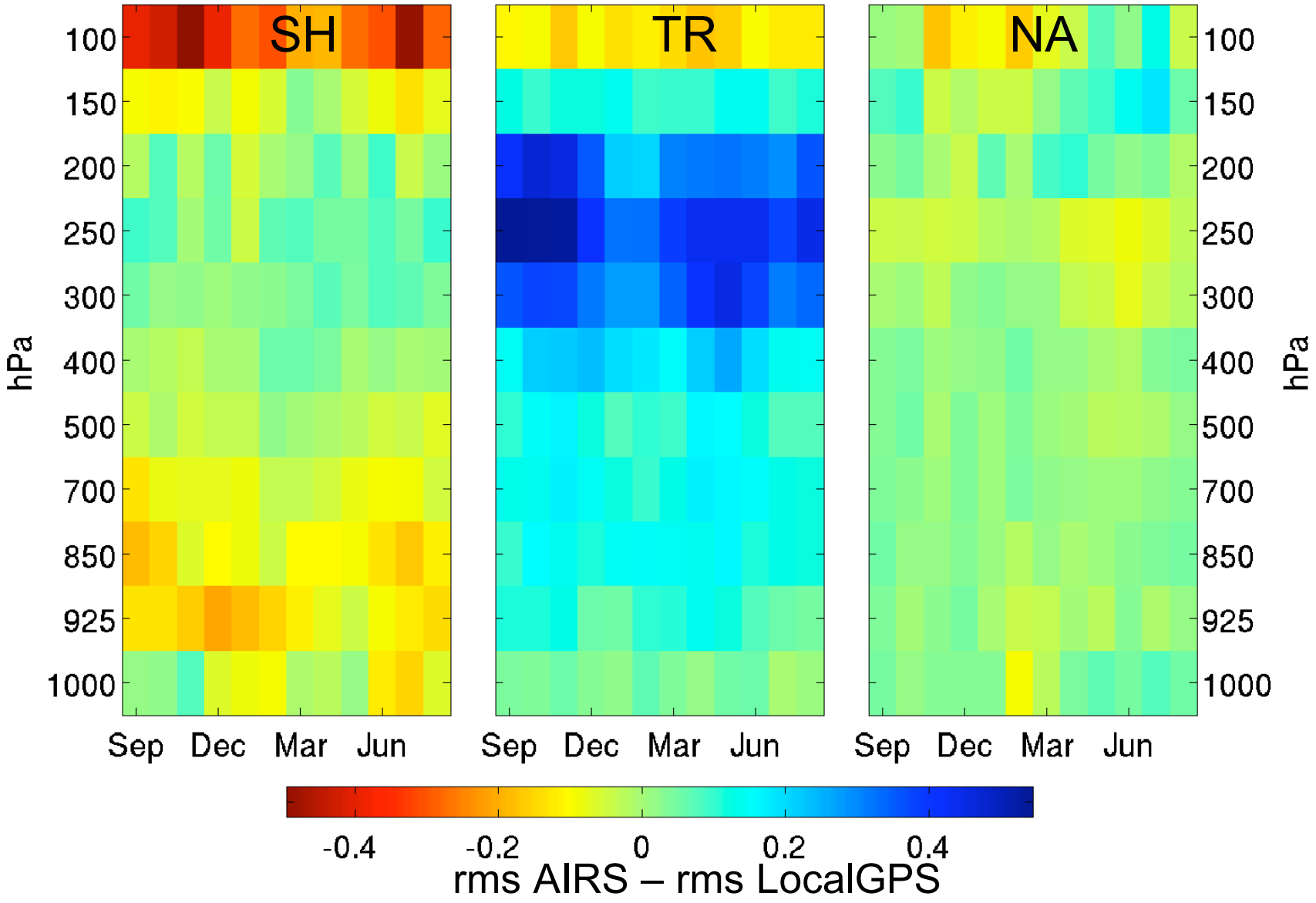


6-hour forecast RMS difference from Radiosonde Specific Humidity

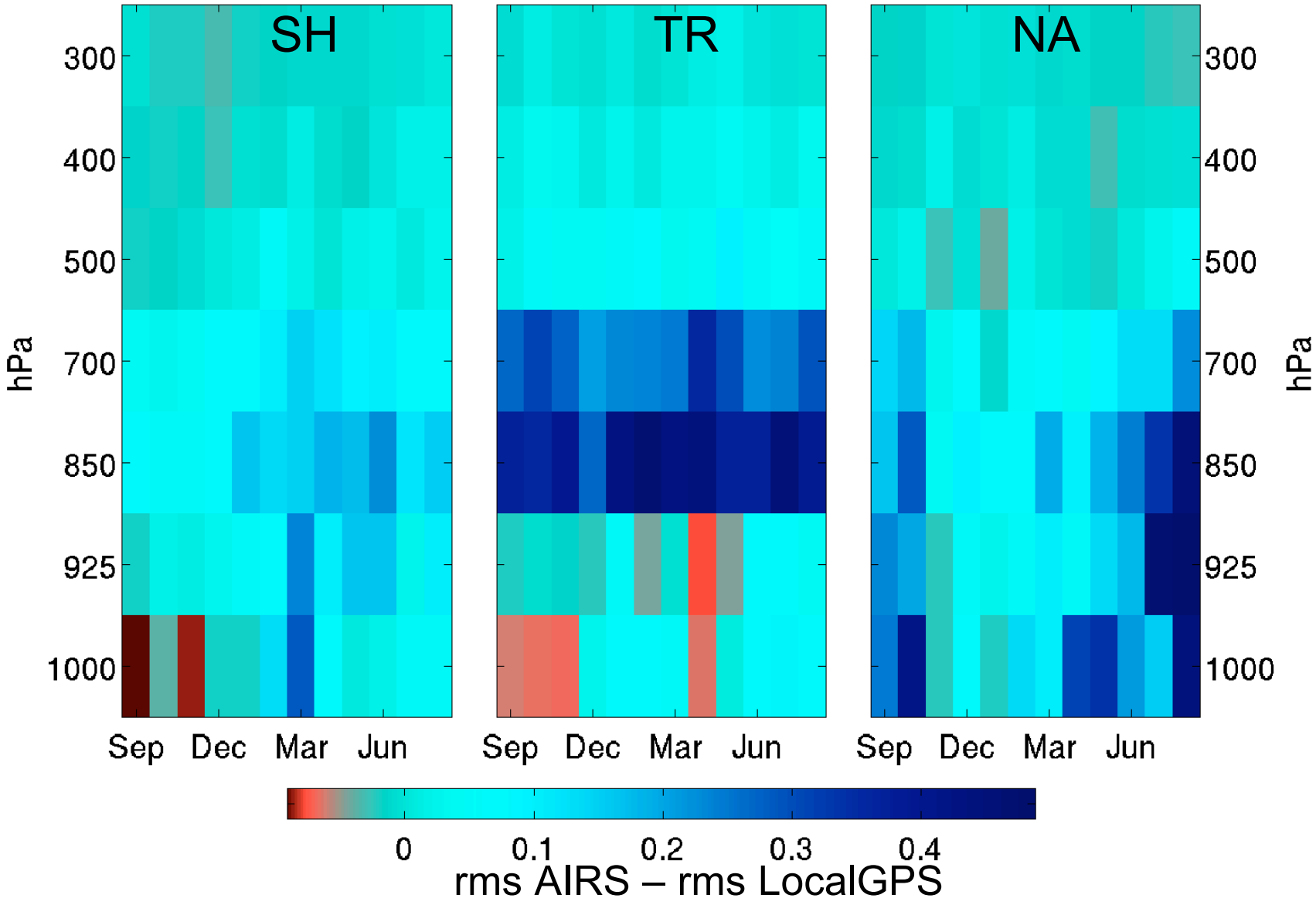
December 2006



(AIRS - LocalGPS) T RMS differences



(AIRS - LocalGPS) Q RMS differences



Conclusions

- GPS has significant information, especially about moisture;
- Most important where other observations are sparse;
- Ensemble assimilation can do full multivariate improvement;
- AIRS retrievals have more information, different bias;
- Nonlocal refractivity has little impact with this grid;
- Must carefully consider planning of future obs systems.