Applications Of WRF's Variational Data Assimilation System (WRF-Var) in AMPS

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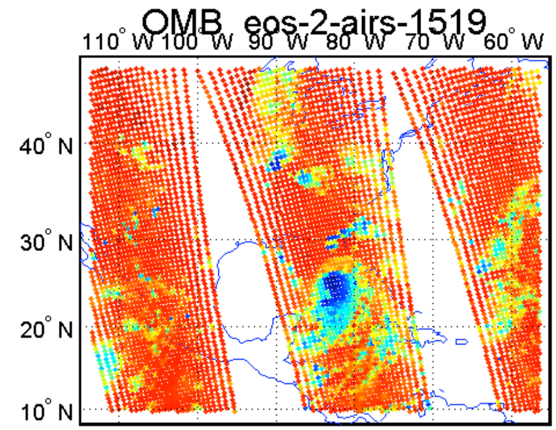
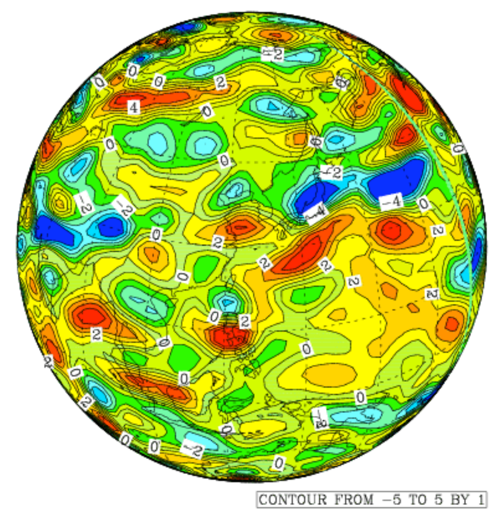
WRF-Var Data Assimilation Overview

- **Techniques:** 3D-Var, 4D-Var (regional), Hybrid Variational/Ensemble DA.
- **Software Engineering:** WRF framework.
- **Multiple Models:** Runs with WRF, MM5, KMA global model, etc.
- **Support:** MMM Division, NCAR.
- **Applications:** Regional/global, Research/Operational, Deterministic/Ensemble,

AIRS and Katrina



Korean T213/426 Global

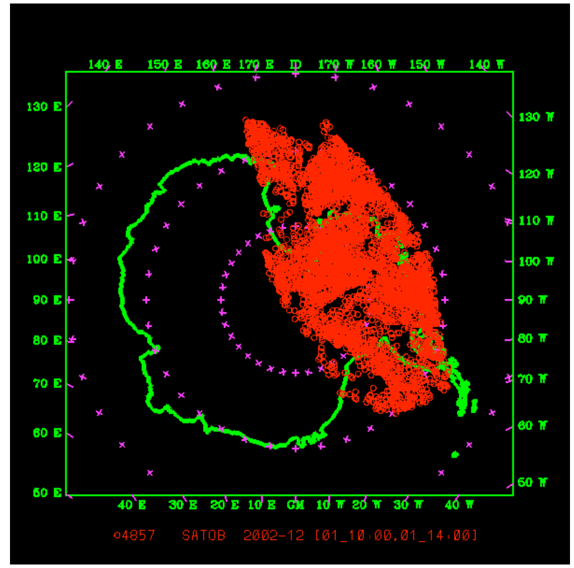


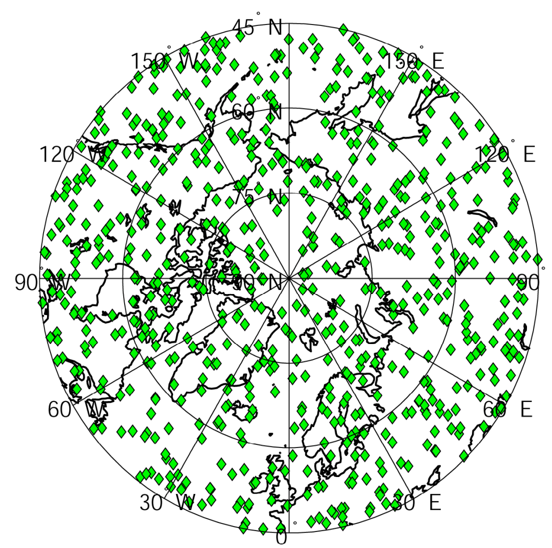
WRF-Var Observations

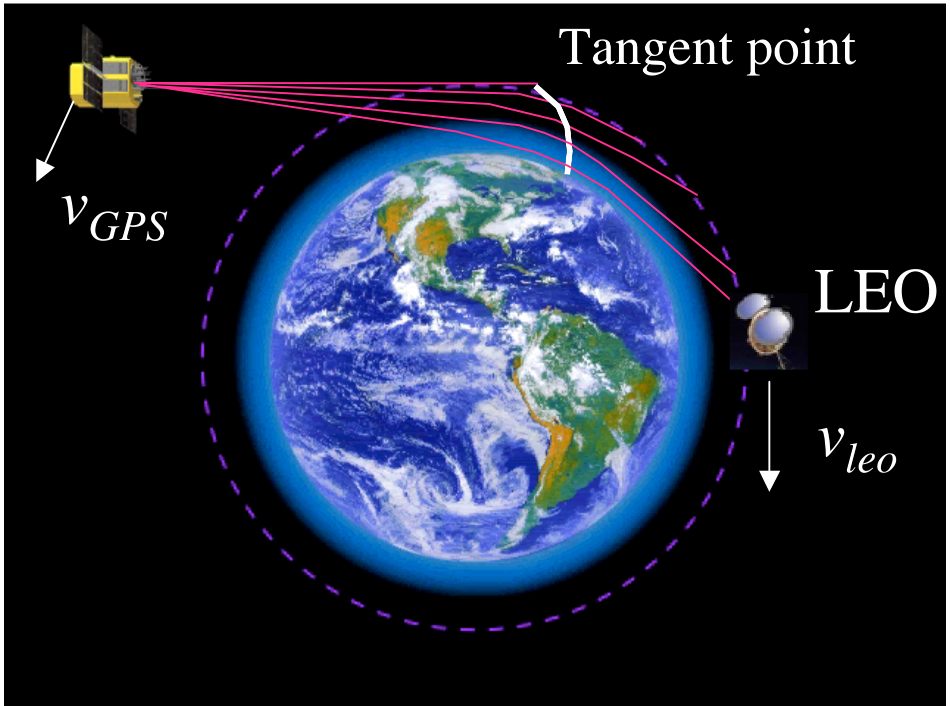
- Conventional:
  - Surface (SYNOP, METAR, SHIP, BUOY).
  - Upper air (TEMP, PIBAL, AIREP, ACARS).

- Remotely sensed retrievals:
  - Atmospheric Motion Vectors (geo/polar).
  - Ground-based GPS Total Precipitable Water.
  - SSM/I oceanic surface wind speed and TPW.
  - Scatterometer oceanic surface winds.
  - Wind Profiler.
  - Radar.
  - Satellite temperature/humidities.
  - GPS refractivity (e.g. COSMIC).

- Radiances:
  - SSM/I brightness temperatures.
  - Direct radiance assimilation (RTTOVS, CRTM).



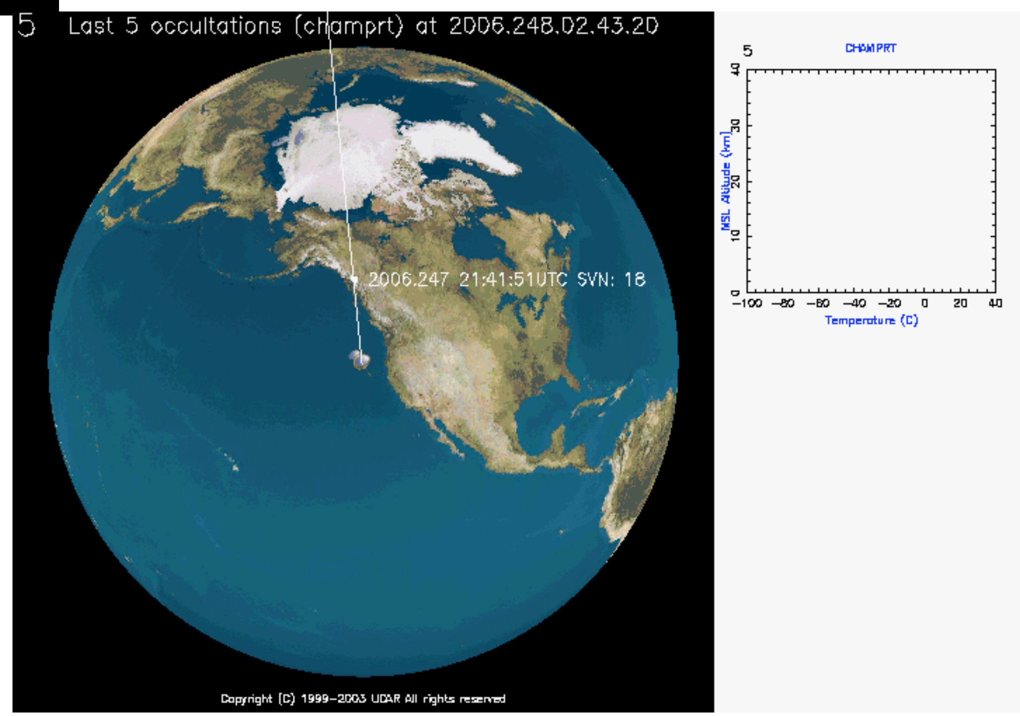




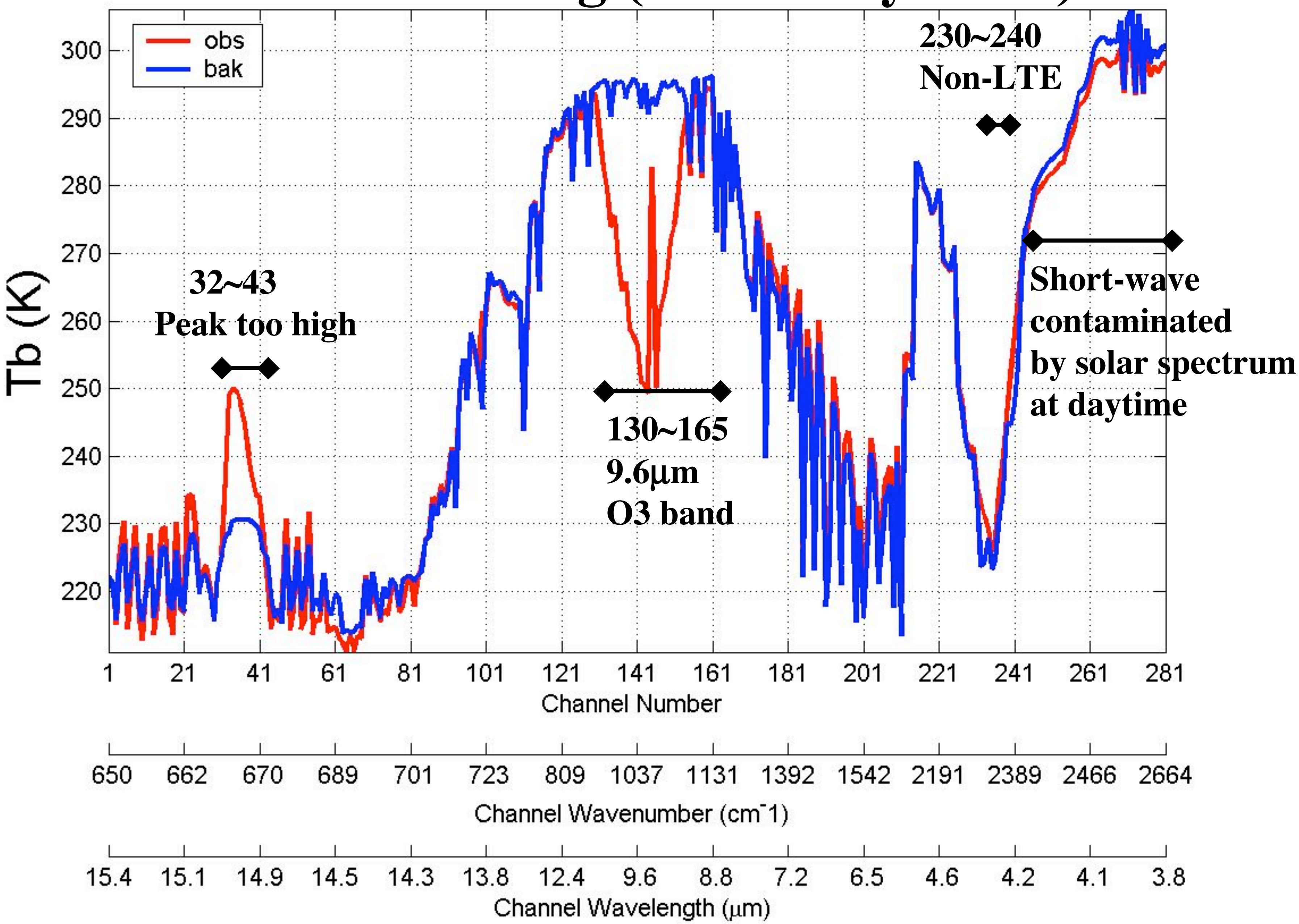
Courtesy: Bill Kuo

The LEO tracks the GPS phase while the signal is occulted to determine the Doppler shift

The velocity of GPS relative to LEO must be estimated to **~0.2 mm/sec** (velocity of GPS is ~3 km/sec and velocity of LEO is ~7 km/sec) to determine precise temperature profiles

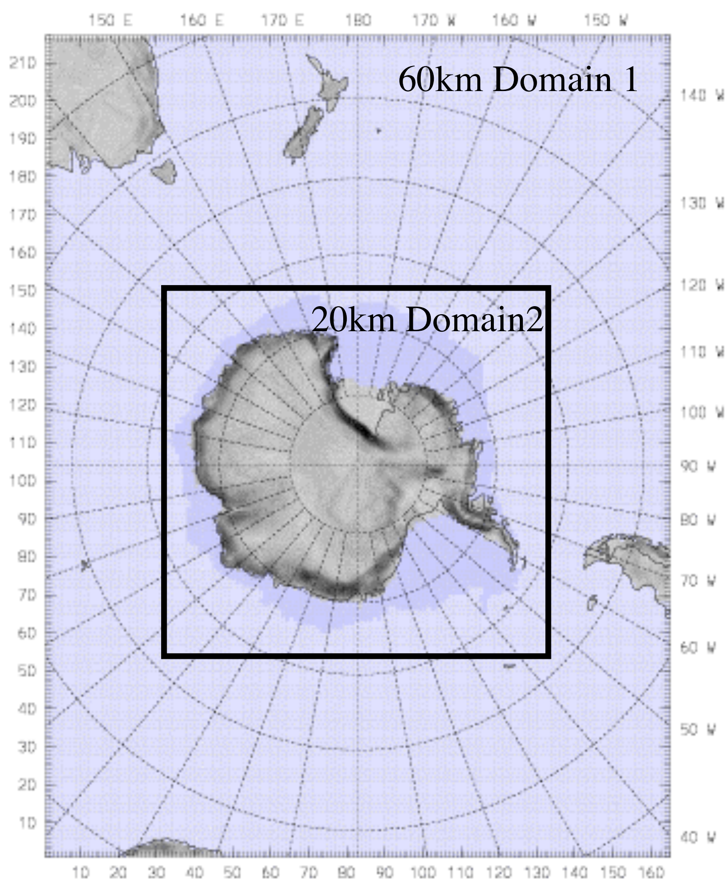


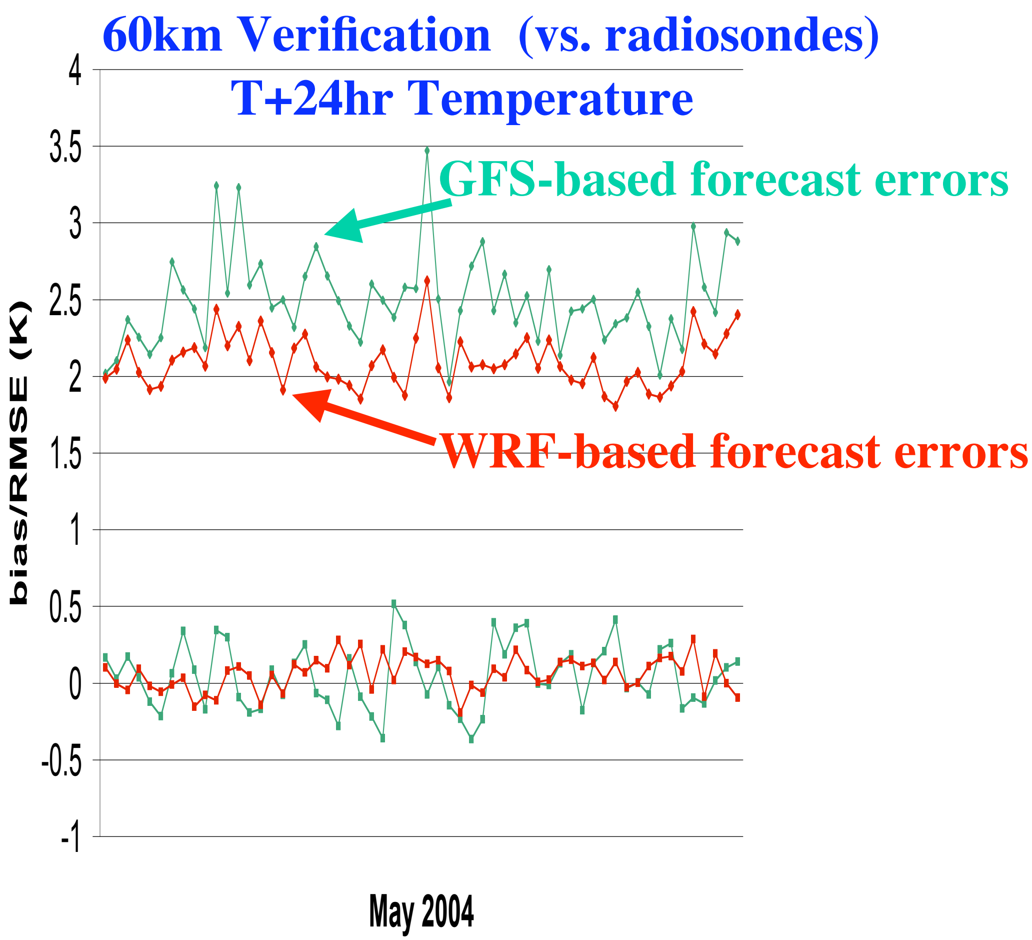
AIRS Monitoring (Clear-Sky Pixel)



AMPS Application Of WRF-Var

- WRF-Var is the operational data assimilation system for AMPS (MM5/WRF).
- Current Research Areas: Polar error covariances, full-cycling, COSMIC.

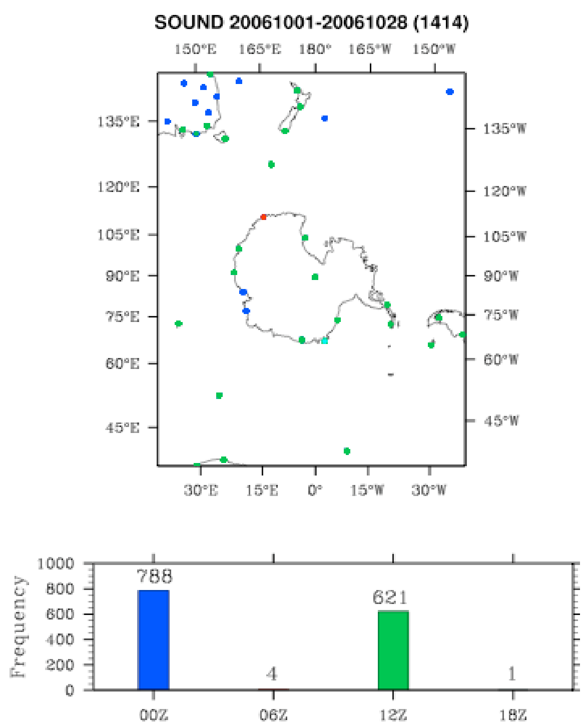




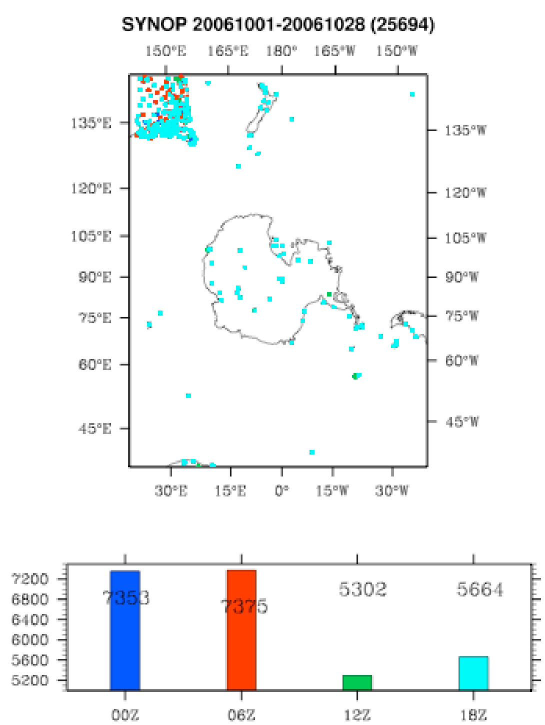
October 2006 Antarctic Testbed

- Initial benchmark studies use real-time AMPS 60km configuration.
- 1 - 31st October 2006 test period. 6 hourly full-cycling.
- Forecast verification against observations (south of 60S) and analyses.
- All available AMPS real-time observations + COSMIC.

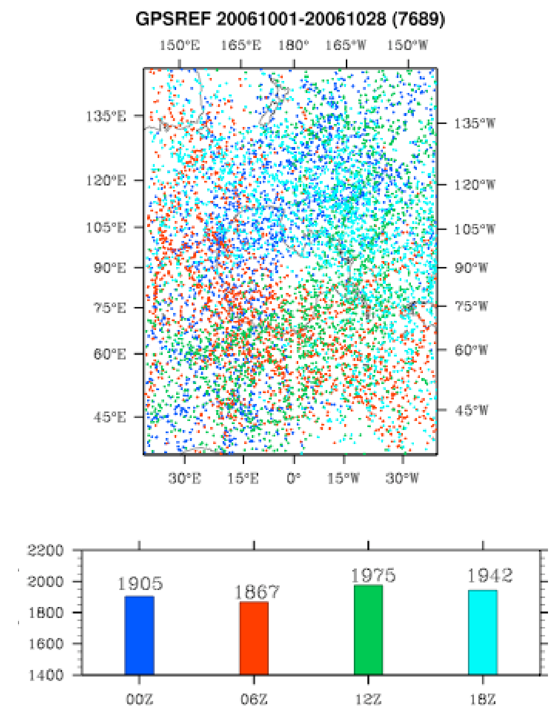
Sonde



Synop

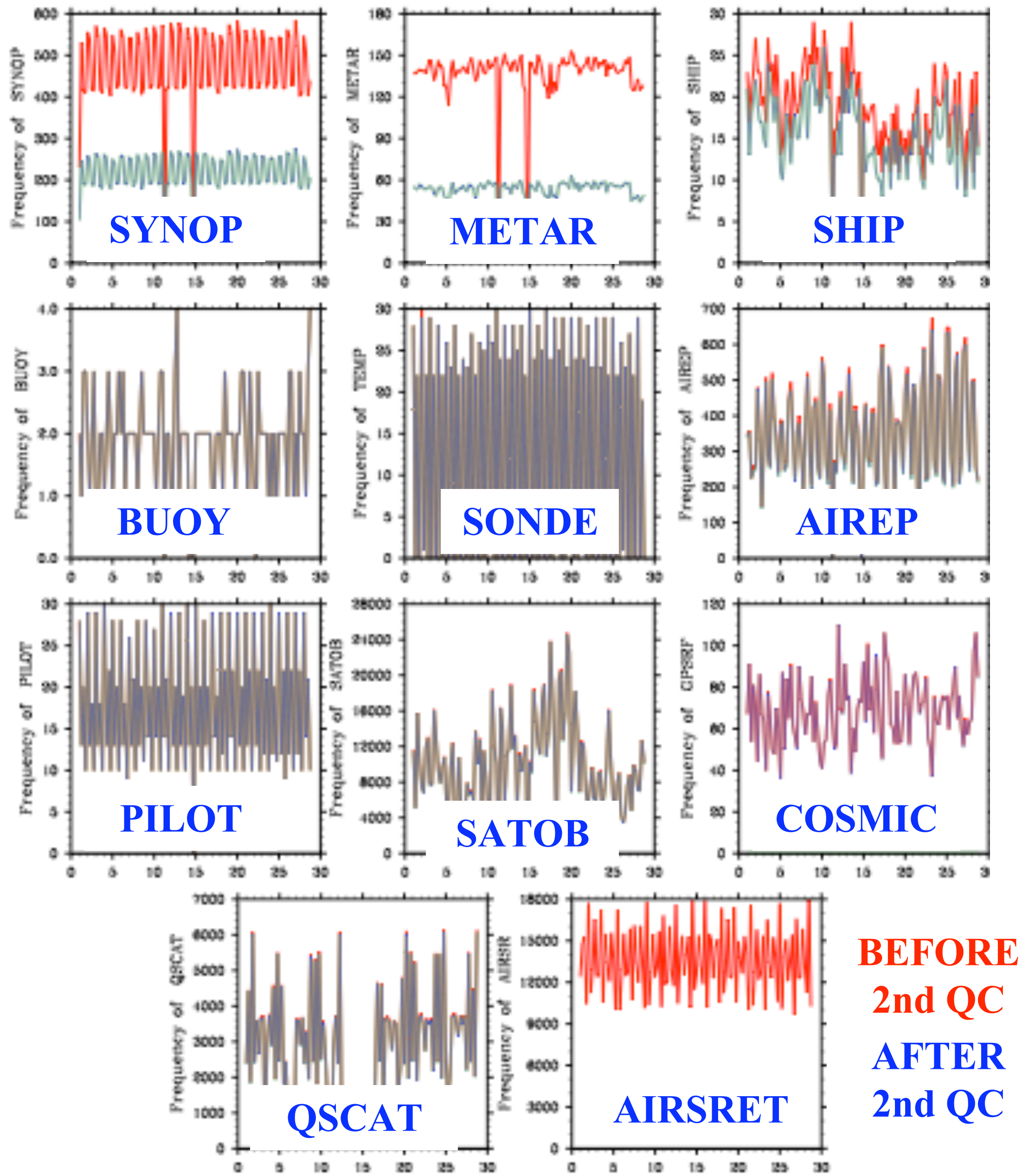


COSMIC



Impact Of WRF-Var Quality Control (QC)

- 1st (gross) QC performed by observation preprocessor.
- 2nd (difference between ob and forecast) QC performed in WRF-Var.
- Main impact of 2nd QC is on surface observations.
- Rejection rates will reduce with higher resolution, higher-order interpolation.



October 2006 Forecast Error Profile (verif vs. sondes)

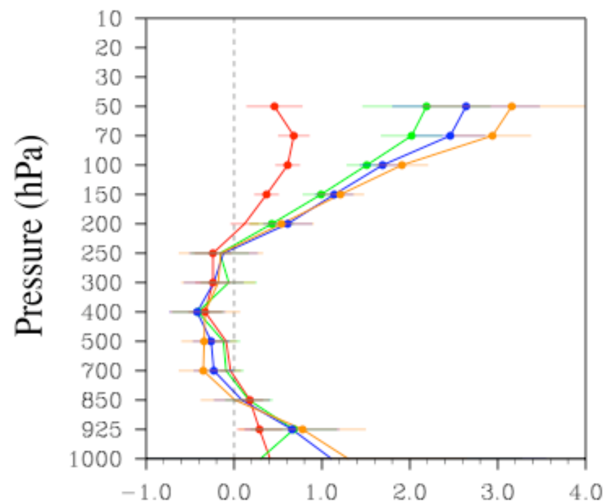
Forecast Range:

T+00

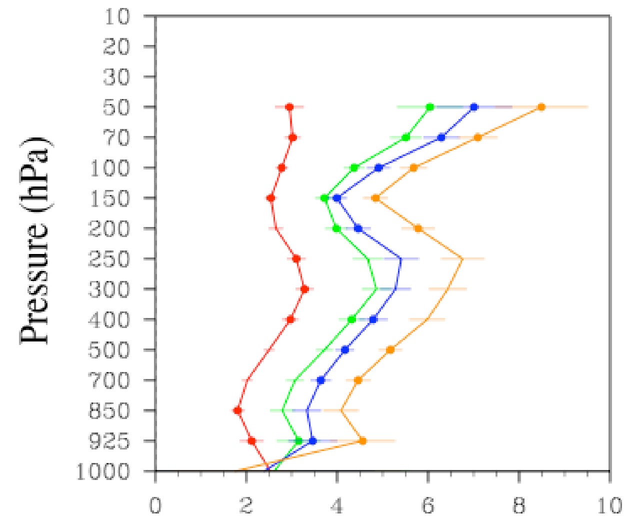
T+12

T+24

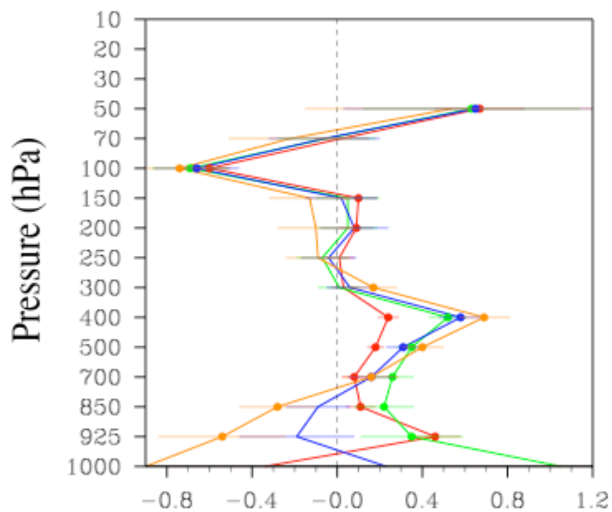
T+36



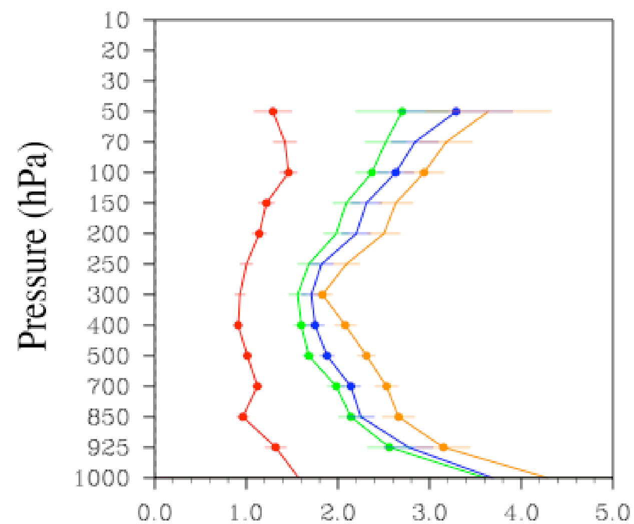
U Bias (m/s)



U RMSE (m/s)



T Bias (degK)



T RMSE (degK)

Time Series Of 70hPa Forecast Error (verif vs. sondes)

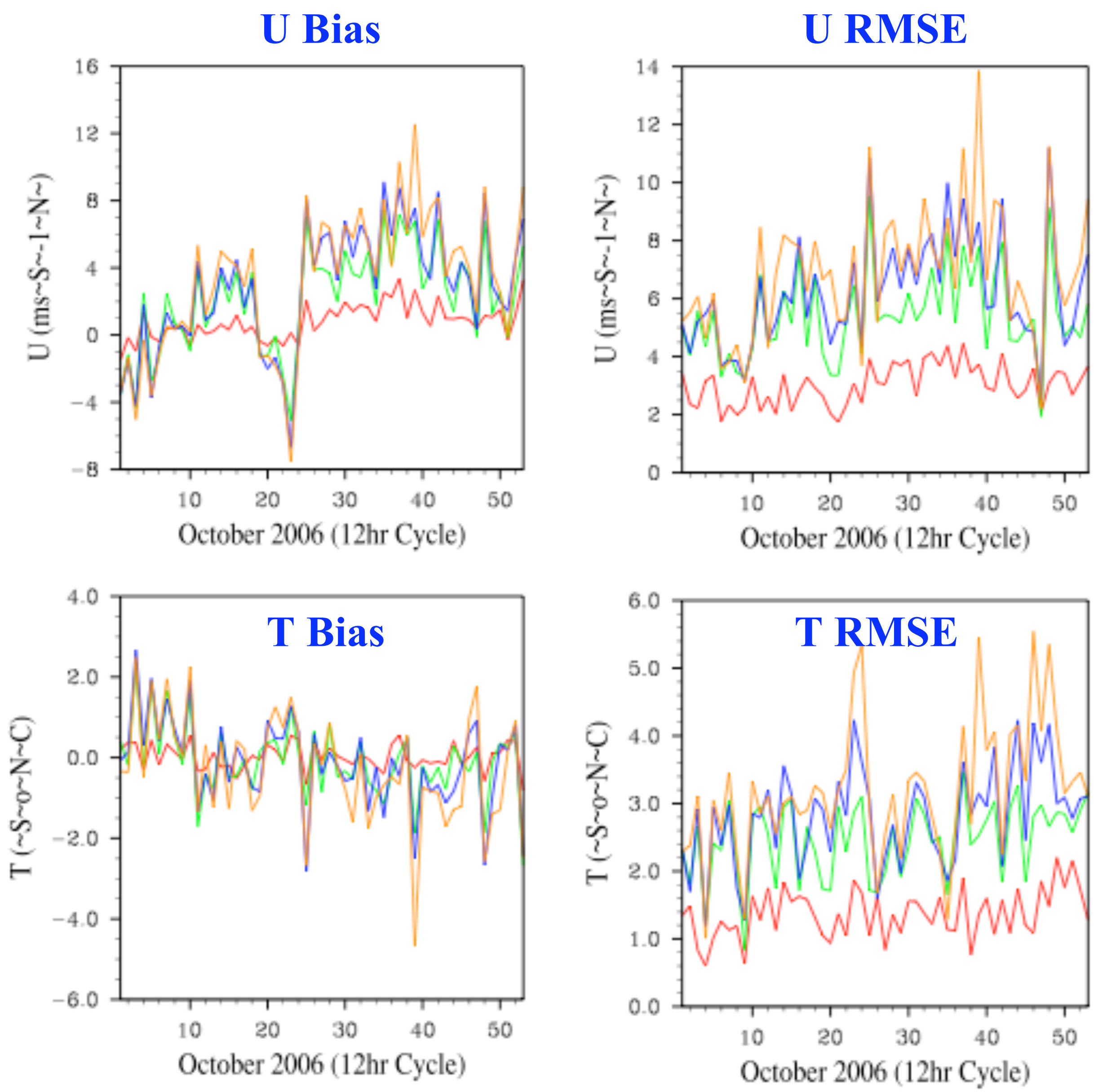
Forecast Range:

T+00

T+12

T+24

T+36



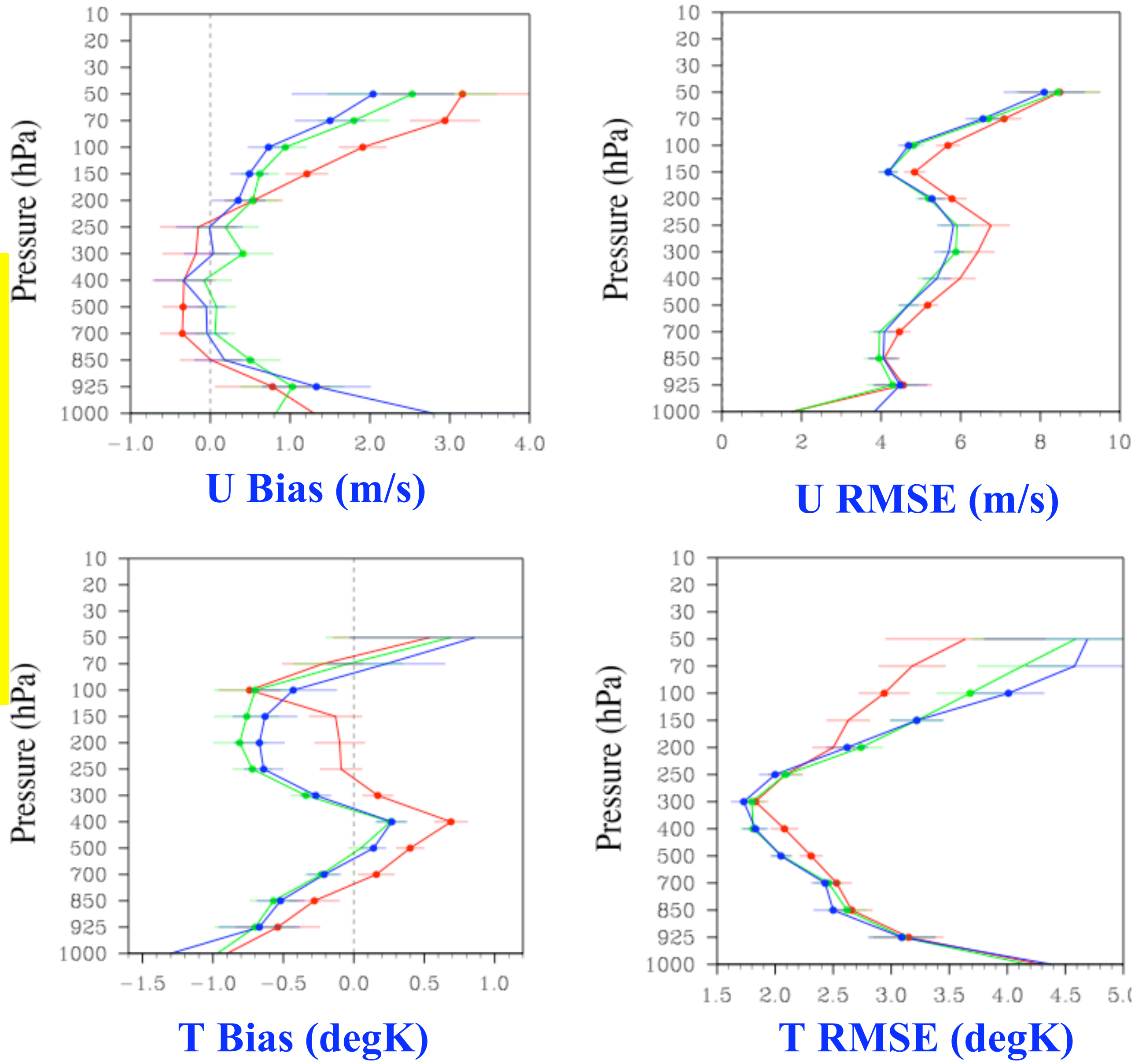
Impact Of COSMIC (36hr Forecast Verification Against Sondes)

Experiments:

1. Conventional Obs Only

2. Conventional + COSMIC

3. Conv. + COSMIC + Tuned BE



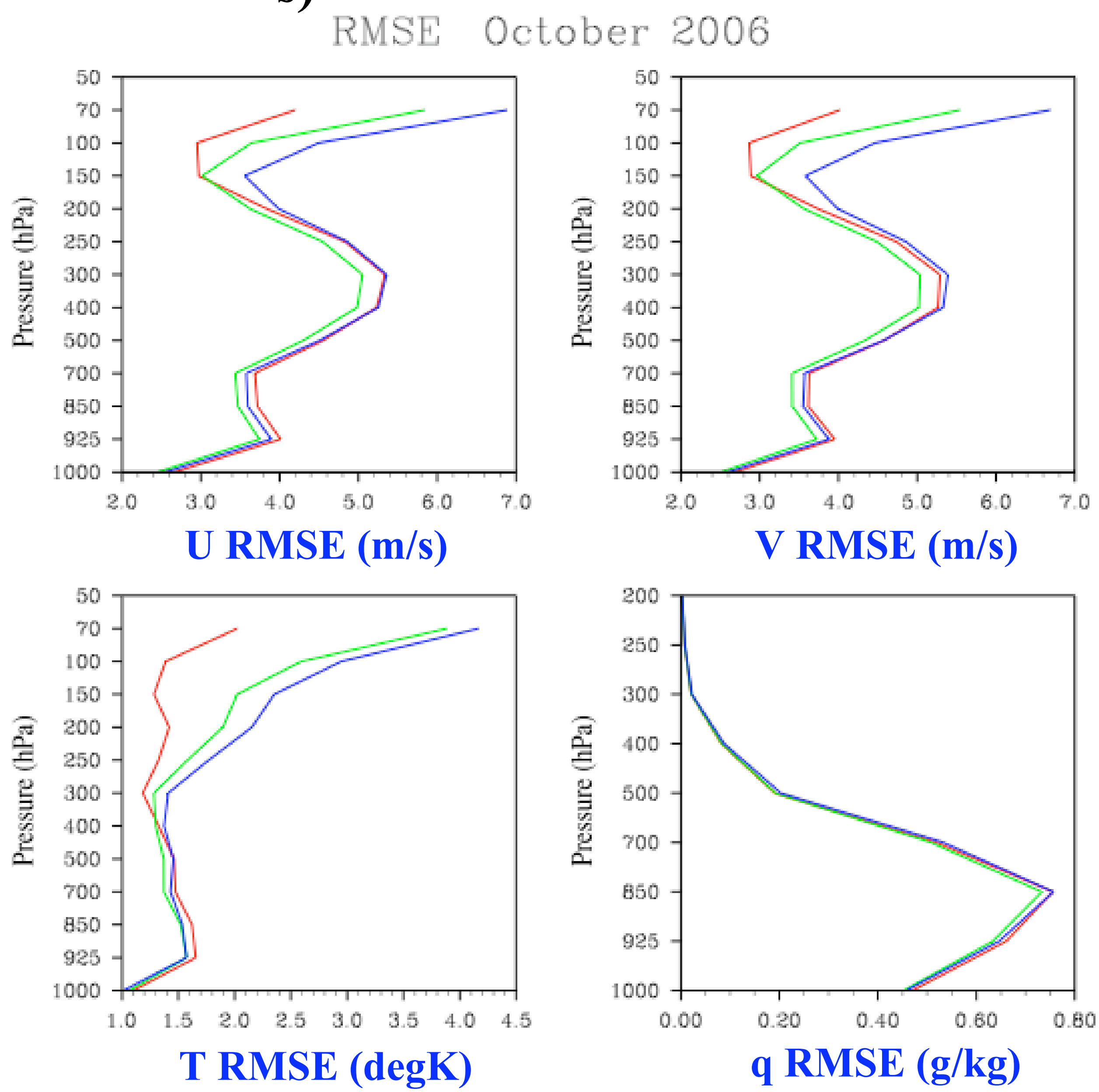
Impact Of COSMIC (36hr Forecast Verification Against Analyses)

Experiments:

1. Conventional Obs Only

2. Conventional + COSMIC

3. Conv. + COSMIC + New BE



Conclusions

- AMPS testing of WRF-Var focusing on impact of satellite data.
- Majority of AMPS DA effort is in observation QC/bias-correction, testing and tuning.
- QC has drastic effect on number of surface observations assimilated.
- COSMIC improves AMPS surface pressure, wind and tropospheric temperature forecasts.
- COSMIC degrades polar stratospheric temperature forecasts.
- Verification against obs and analyses gives **qualitatively** similar results.

Future Work

- Stratospheric noise in AMPS/WRF forecasts:
  - Model top (50hPA) too low.
  - Top boundary condition not optimal?
  - Lack of ozone in WRF?

- Diagnose and correct negative impact of COSMIC in stratosphere:
  - Tune COSMIC observation errors.
  - More rigorous QC (e.g. limit COSMIC data to below 300hPa).

- Test/tune AMSU, AIRS, SSM/IS radiances in AMPS.

- Increase horizontal (20km) and vertical (L51, 1-10hPa) resolution.

- Test advanced DA techniques (4D-Var and EnKF) in AMPS.