Assimilation of AIRS Version 6 Data in AMPS

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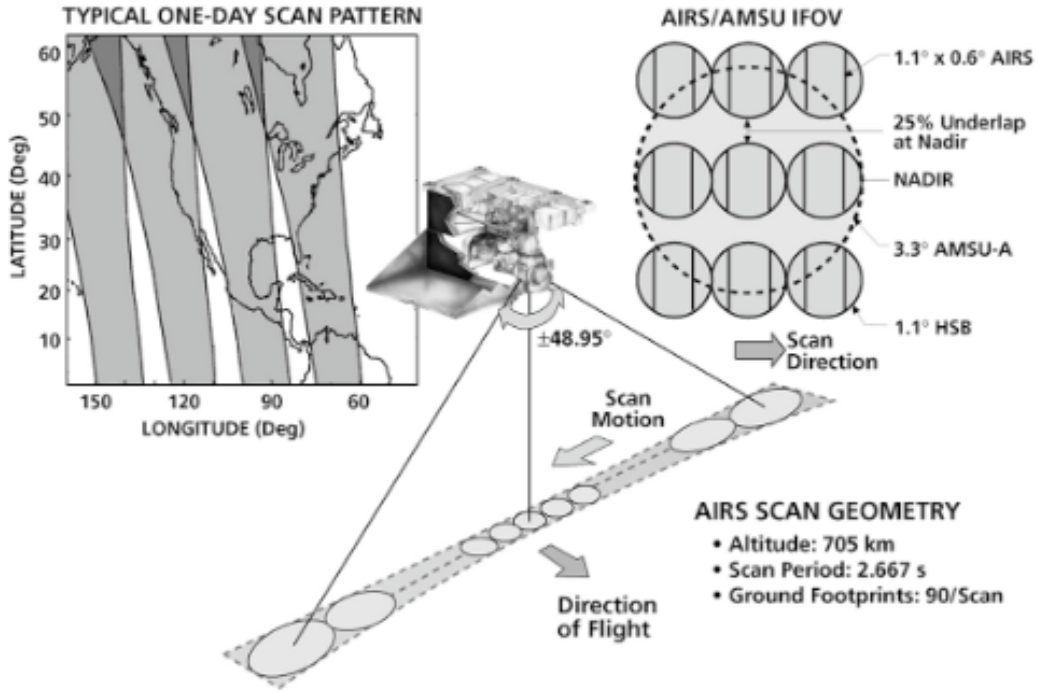
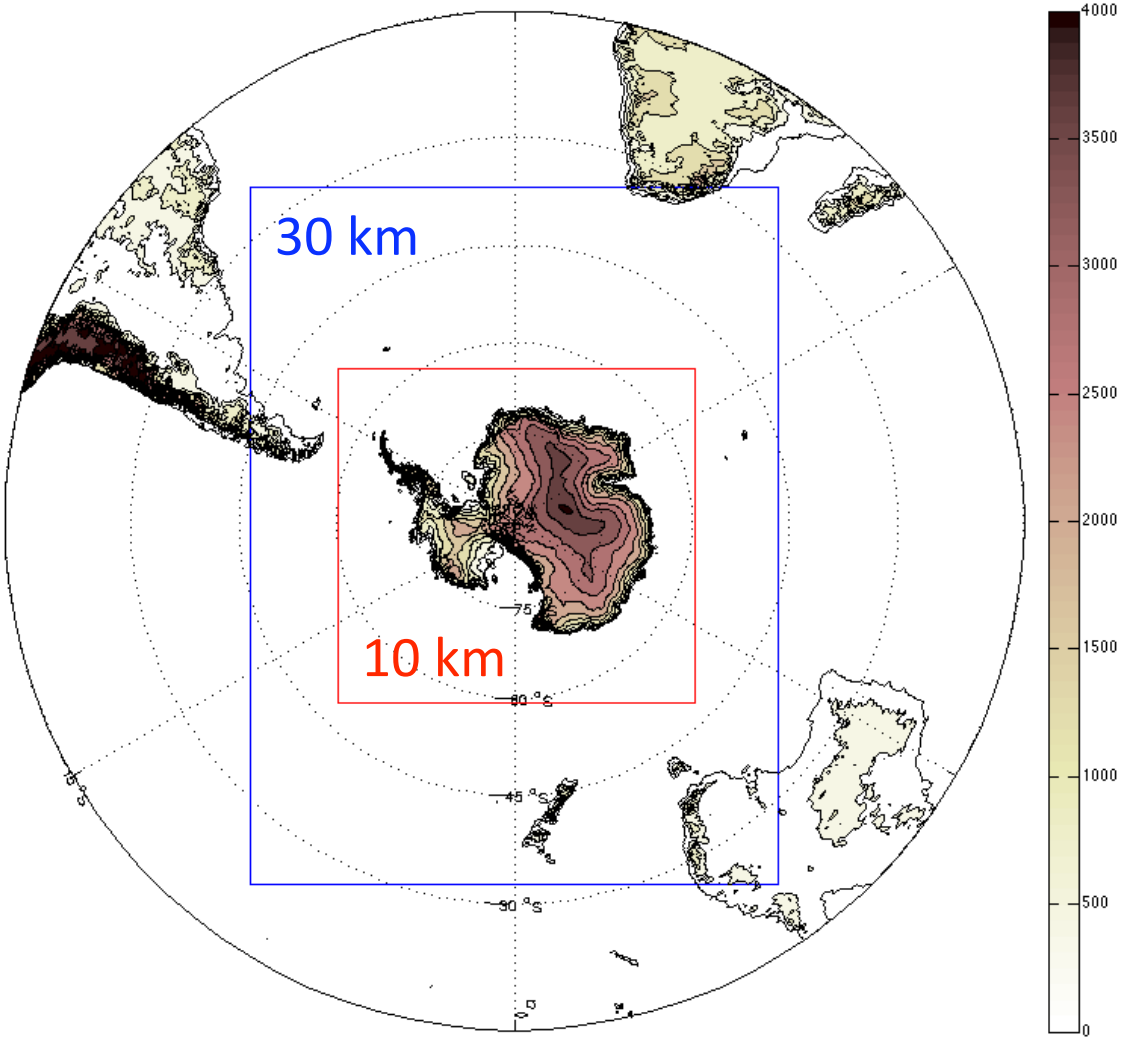
AIRS— Atmospheric Infrared Sounder

- **Background**
  - Instrument on Aqua satellite: Measures radiances
  - Datasets produced: Radiances and retrievals of temperature and moisture
  - Resolution: ~13.5 km
  - Accuracy:
    - 1K Temperature
    - 15% RH



- **AIRS Version 6**
  - AIRS Version 6 (V6) introduced 2013
  - Previous AMPS testing of AIRS Version 5 data: Mixed results
  - AIRS V6 differences from V5
    - Approach for calculating first guess for retrieval changed
      - V5: Linear regression
      - V6: Neural networks
    - Lower rejection rate (QC=2) on retrievals (1% v. 17%)
    - V6 has a QC flag for each variable/level

AMPS Domains for Tests: 30 km & 10 km



Terrain height (m)

AIRS Experiments

- **Periods**

  Winter: July–August 2014

  Summer: November 2014–January 2015

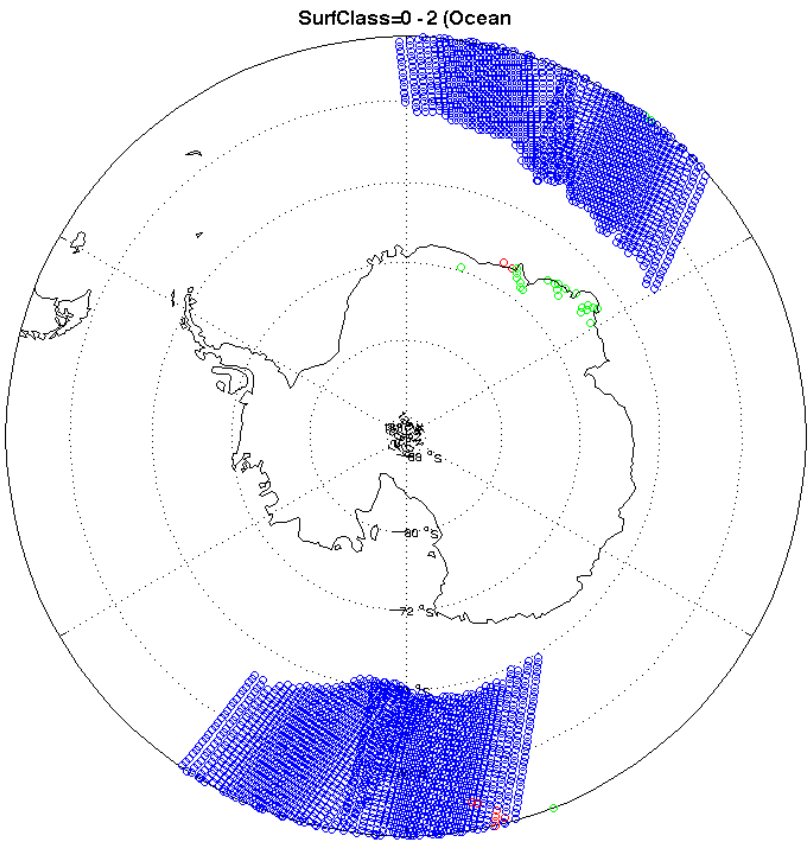
- **Data Assimilation**

  – WRFDA 3DVAR used

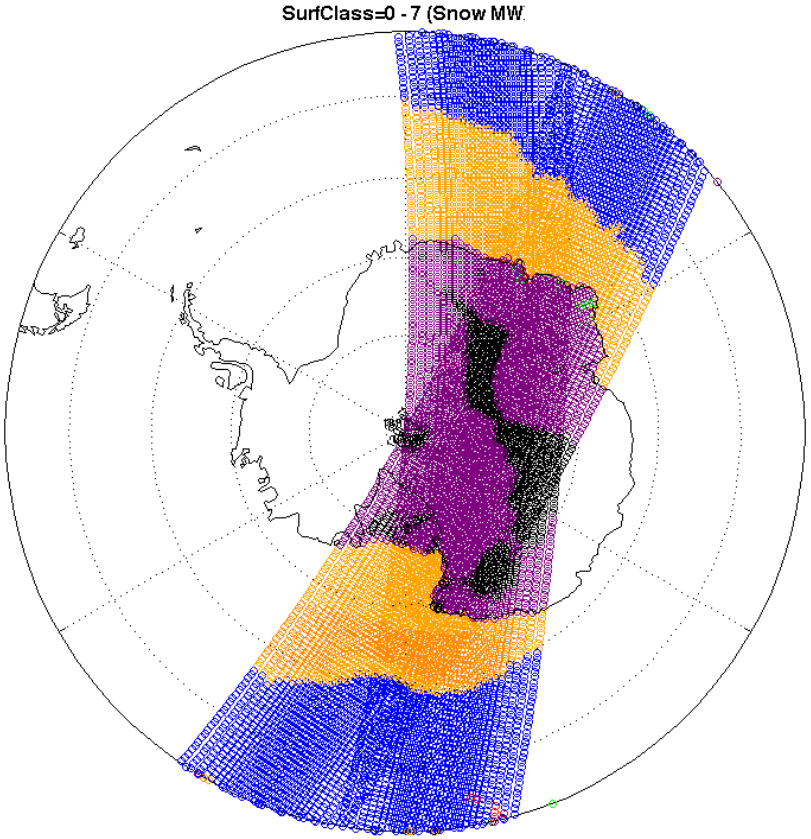
  – AIRS V6 retrievals of temperature and moisture

  – Standard AMPS observations in all forecasts and experiments:
  AWS, SYNOP, METAR, radiosonde, ship, buoy, aircraft, satellite AMVs, GPSRO, AMSU-A

AIRS Coverage & Surfaces



Ocean surfaces



All surfaces

1200 UTC 18 July 2014

AIRS Winter Experiment

– **Forecast Period:** July–August 2014

– **Experiments:** (i) Different quality control (QC) levels used

(ii) Different underlying surfaces used: All sfcs v. Ocean

– **AIRS QC groups used:** (a) Good + Best quality: QC= 1, 0

(b) Best quality: QC= 0

Experiment 01: No AIRS

Experiment 02: AIRS All QC / All surfaces

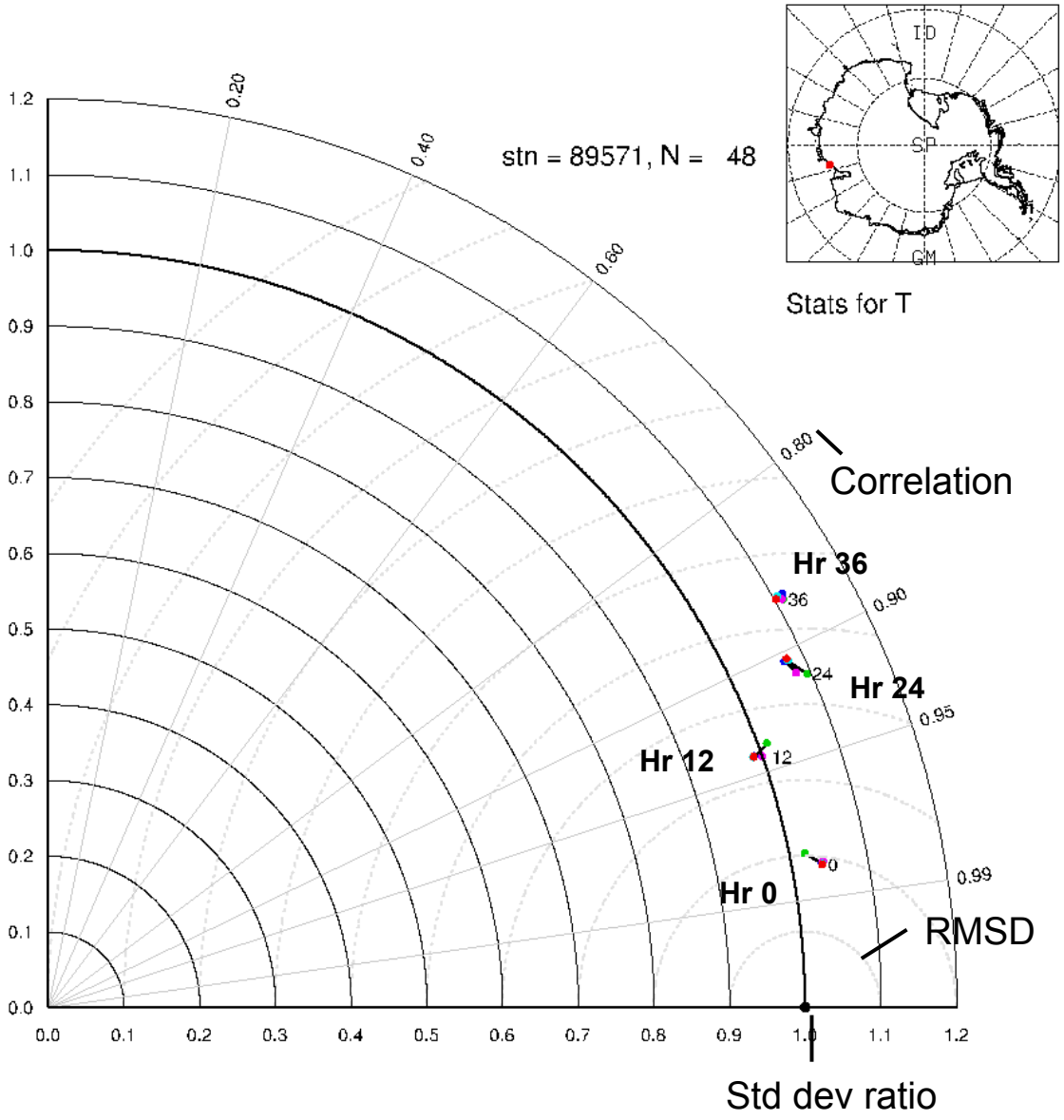
Experiment 03: AIRS All QC / Ocean only

Experiment 04: AIRS Best QC / All surfaces

Experiment 05: AIRS Best QC / Ocean only

– **Statistical Analyses:** T and RH (reflecting T and RH assimilated)

AIRS Winter Experiment— Surface Temperature



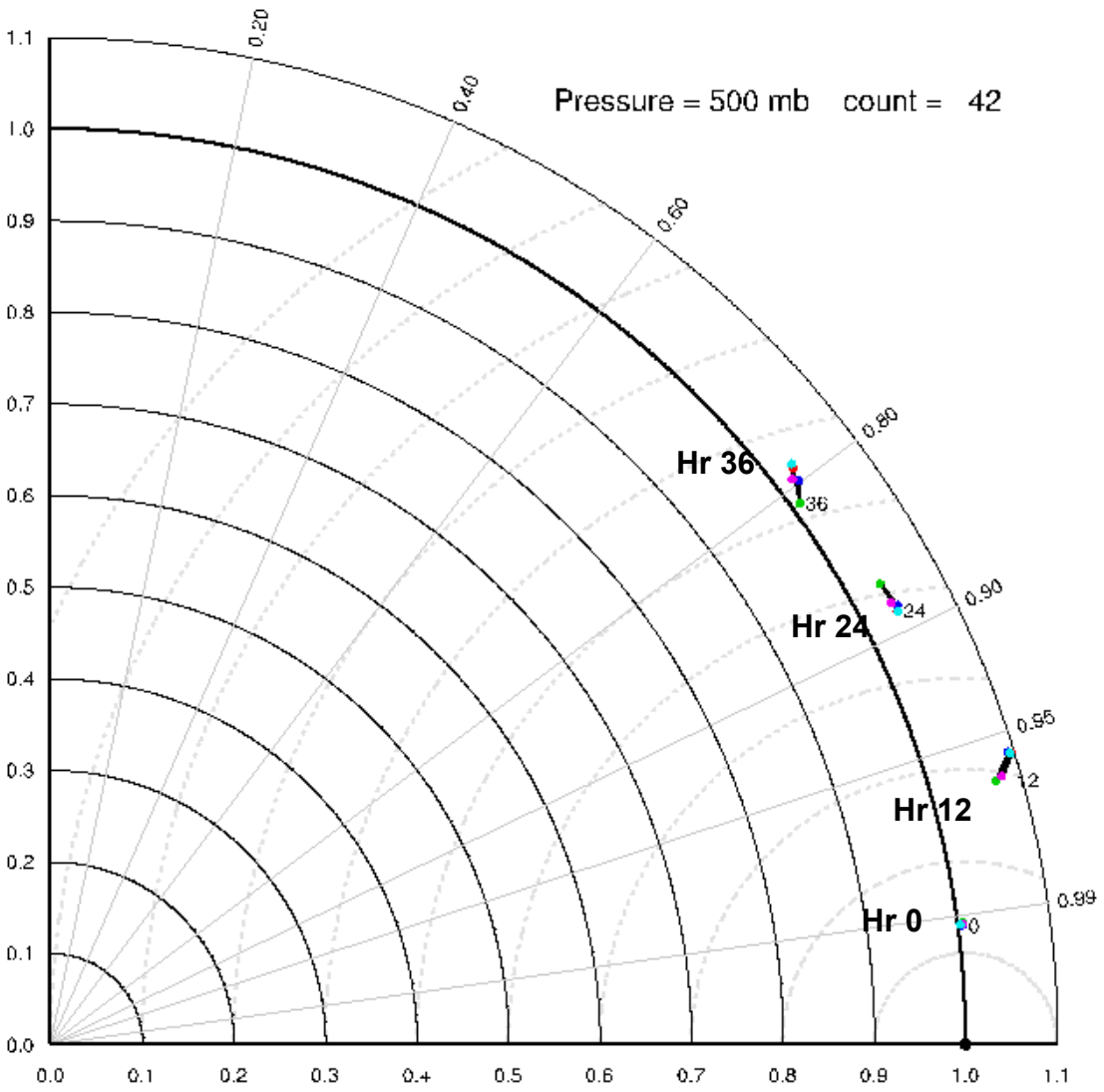
Taylor diagram: Davis

Surface T

Expt 01 No AIRS
Expt 02 All QC, All surfaces
Expt 03 All QC, Ocean
Expt 04 Best QC, All surfaces
Expt 05 Best QC, Ocean

Verification times:
Hr 0
Hr 12
Hr 24
Hr 36

AIRS Winter Experiment— 500 mb Temperature



Casey

500 mb T

Expt 01 No AIRS
Expt 02 All QC, All surfaces
Expt 03 All QC, Ocean
Expt 04 Best QC, All surfaces
Expt 05 Best QC, Ocean

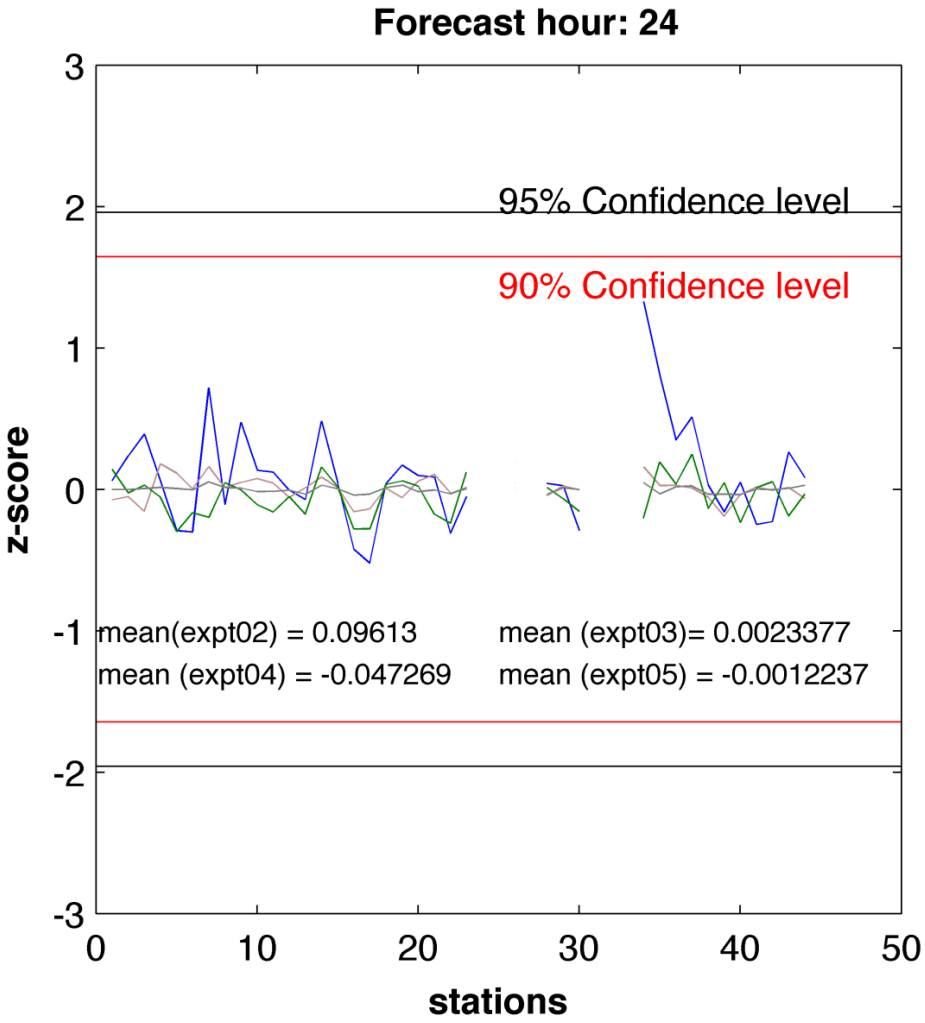
Verification times:
Hr 0
Hr 12
Hr 24
Hr 36

500 mb RH results similar:
No clearly better expt

-

AIRS Winter Experiment— Surface T

Significance Testing of Correlation Coefficient Differences



Confidence intervals for difference of correlation coeffs of surface T

AIRS experiments v. Expt 1 (control)

Sfc T (all sfc stations)
Hr 24

Expt 02
Expt 03
Expt 04
Expt 05

– Differences not statistically significant

AIRS Winter Experiment

- No real signal seen, but no forecast degradation from AIRS

- No degradation from using:

  (1) All QC levels

  (2) All underlying surfaces

  → **No negative impact from including all data**

- GFS first-guess influence on results

  → **Further Testing**

  (a) Analyze other forecast parameters & different season

  (b) Examine cycling

AIRS Summer Experiment

- Period: 28 November 2014 – 5 January 2015
- Tests: Variation of first-guess fields
  - Expt. 1: GFS first guess (AIRS / No AIRS)
  - Expt. 2: WRF cycling (AIRS / No AIRS)
  - Expt. 3: GFS first guess v. WRF cycling (AIRS)
- Experiments: **"No AIRS"** = Standard obs only

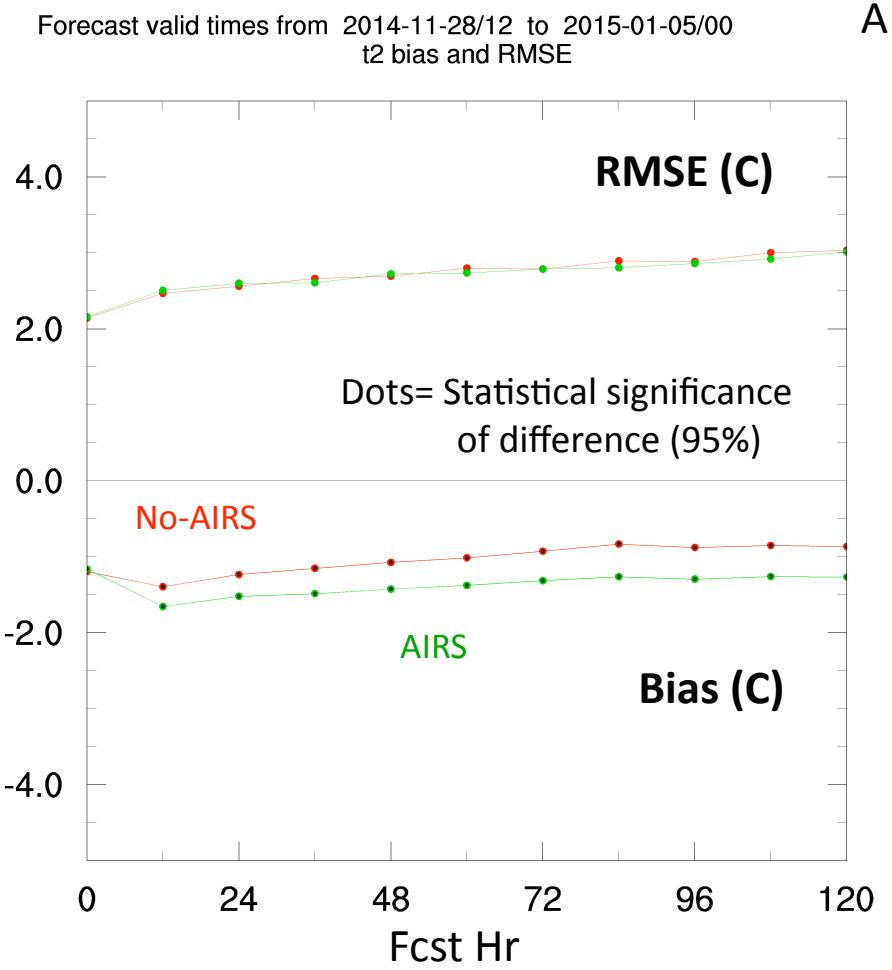
  "AIRS" = Standard obs + AIRS

  (all QC levels and surfaces)
- Analyses: T, U, V, Height, Wind speed

Expt 1: AIRS v. No AIRS

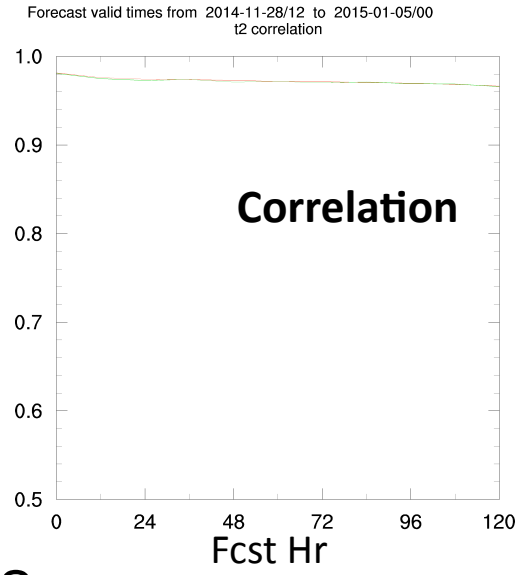
First guess: GFS

Temperature— Surface (Avg.)



No AIRS

AIRS



– T bias, AIRS

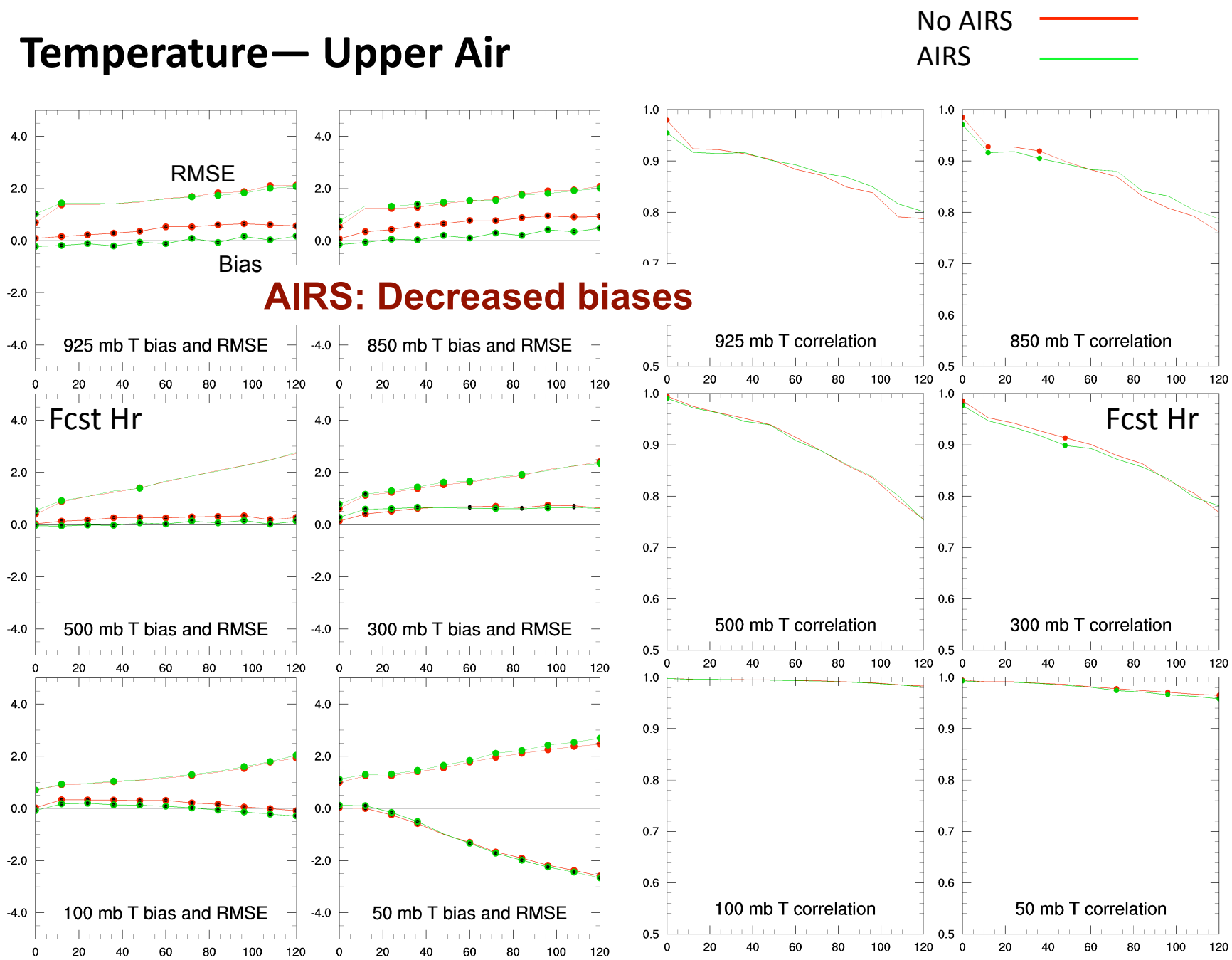
- Increased cold bias for avg

  NB: Bias varies with region

- Continental margin: Increased
- East Antarctic plateau: Decreased bias

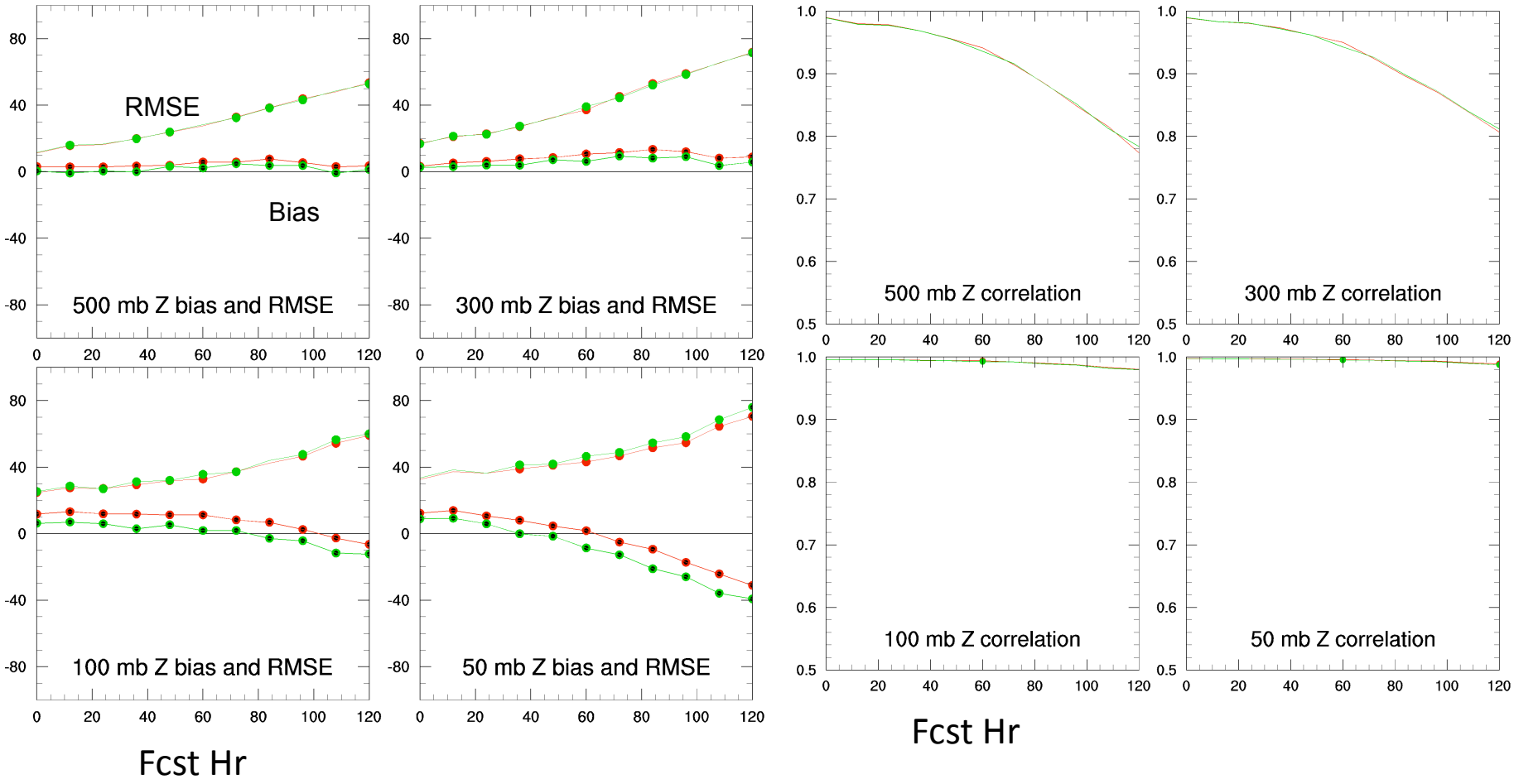
– T RMSE: No practical difference

Temperature— Upper Air

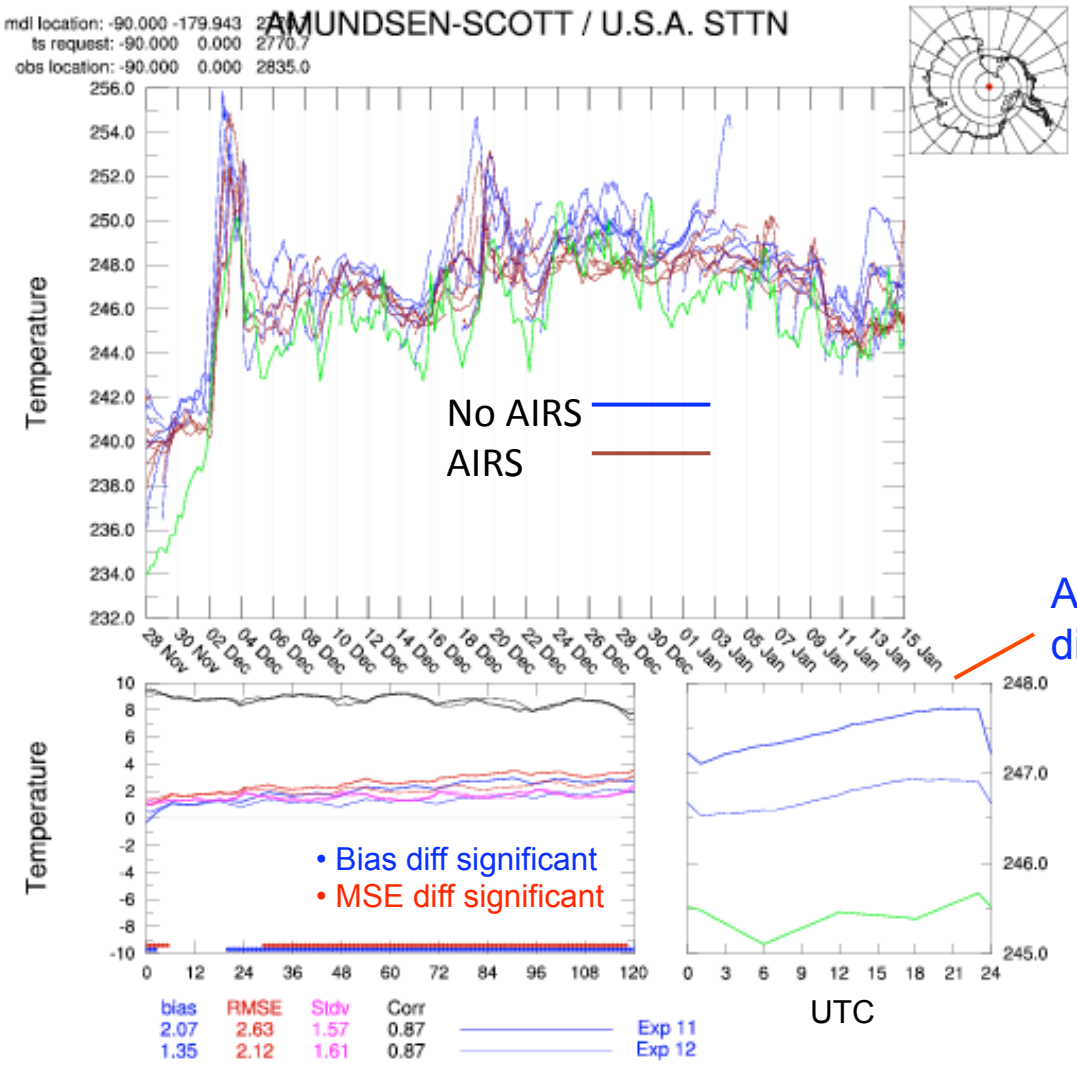


Height

– AIRS: Overall bias improvement



South Pole



AIRS: Decreased bias

Decreased RMSE

Bias: AIRS = 1.4 C

No Airs = 2.1 C

RMSE: AIRS = 2.1 C

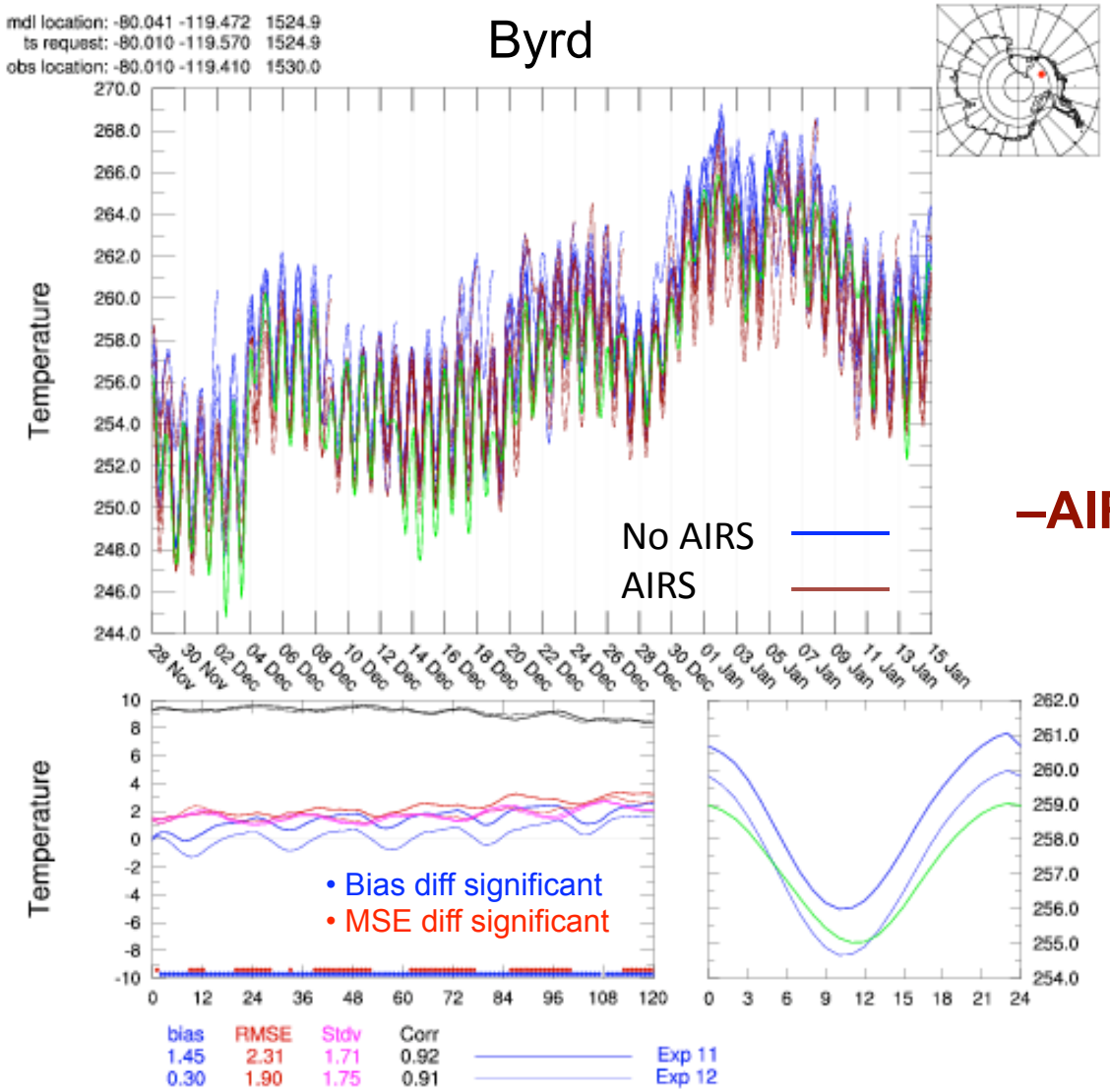
No AIRS = 2.6 C

Avg over diurnal cycle

No AIRS

AIRS

West Antarctica



–AIRS: Decreased warm bias

Decreased RMSE

No AIRS

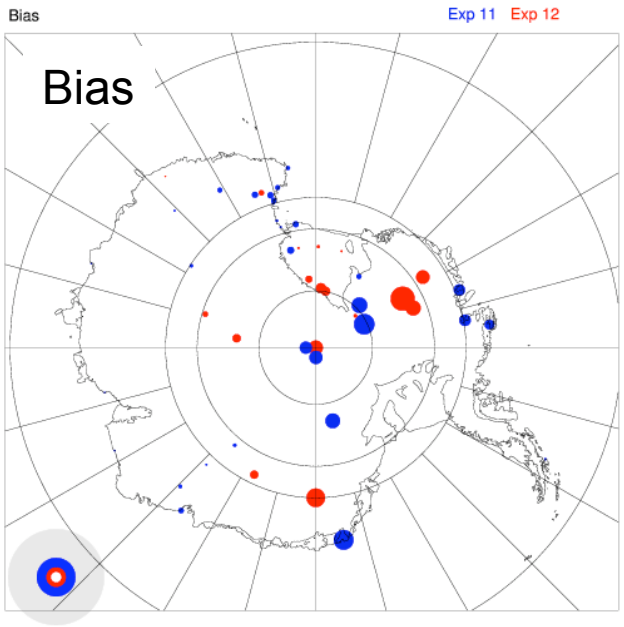
AIRS

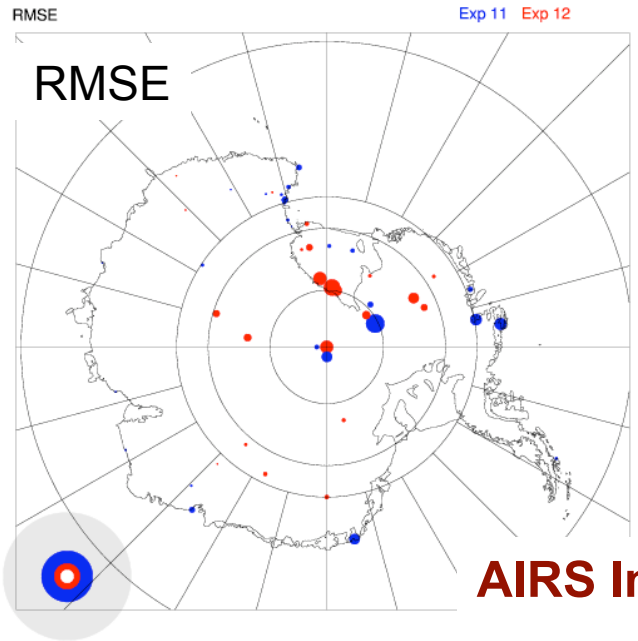
T Bias: AIRS = 0.3 C

No Airs = 1.5 C

T RMSE: AIRS = 1.9 C

No AIRS= 2.3 C

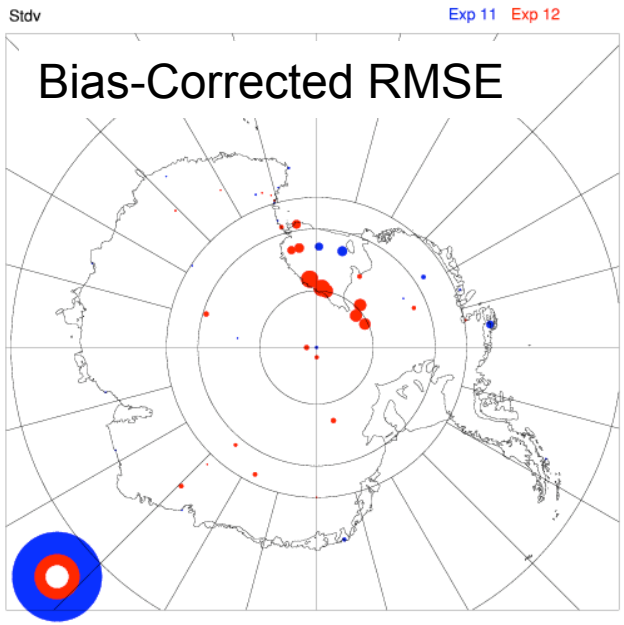


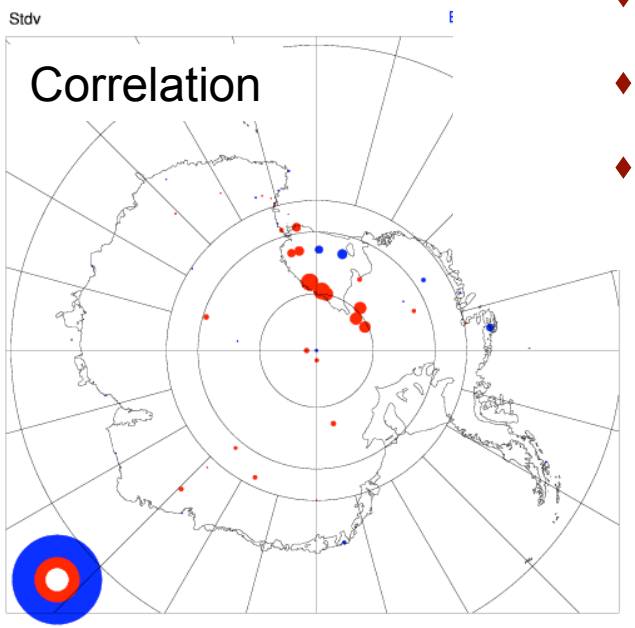


Surface T

No AIRS

AIRS





AIRS Improvements

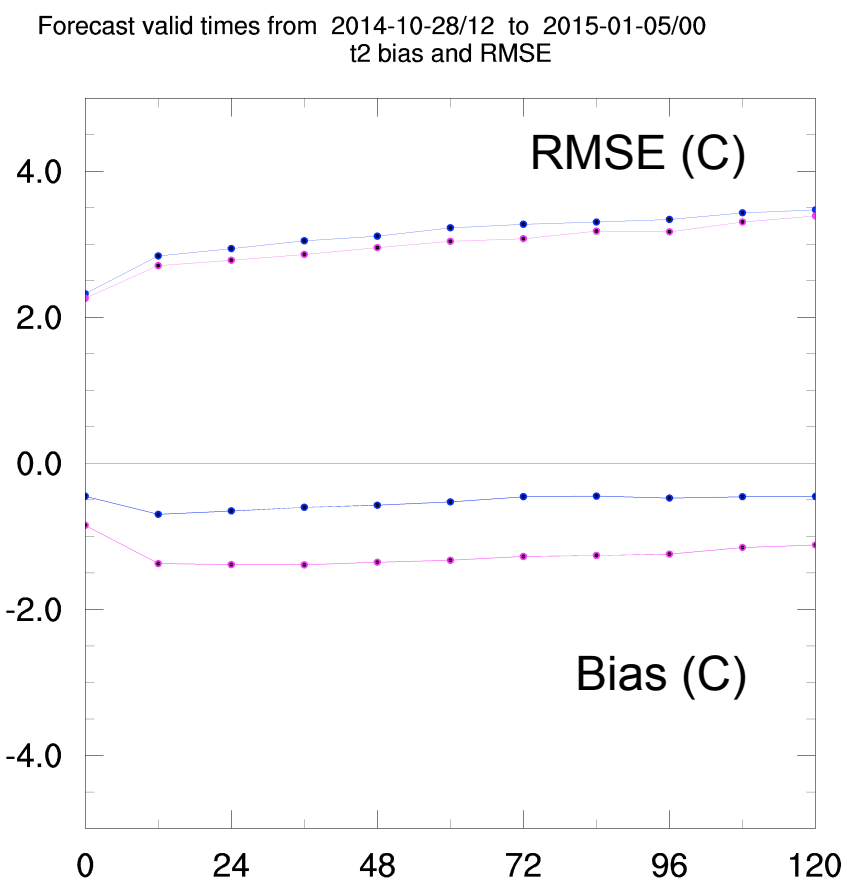
- **RMSE**
- **Correlation**
- **Bias-corrected RMSE**

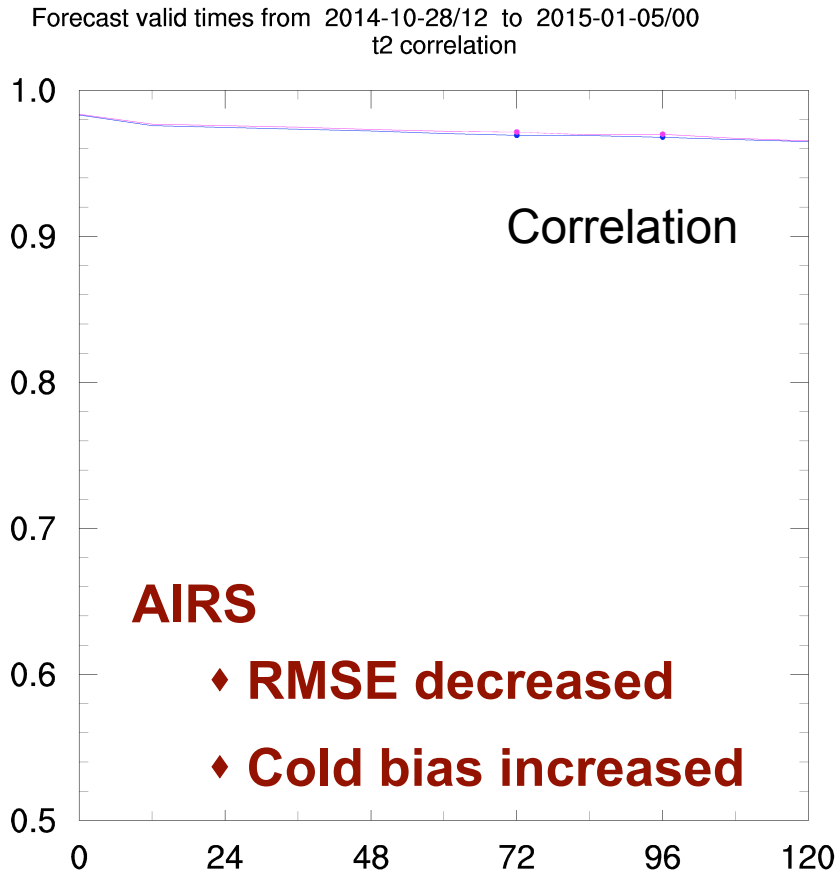
Expt 2: Cycling AIRS v. Cycling No AIRS

First guess: WRF

Temperature— Surface (avg'd)

No AIRS
AIRS

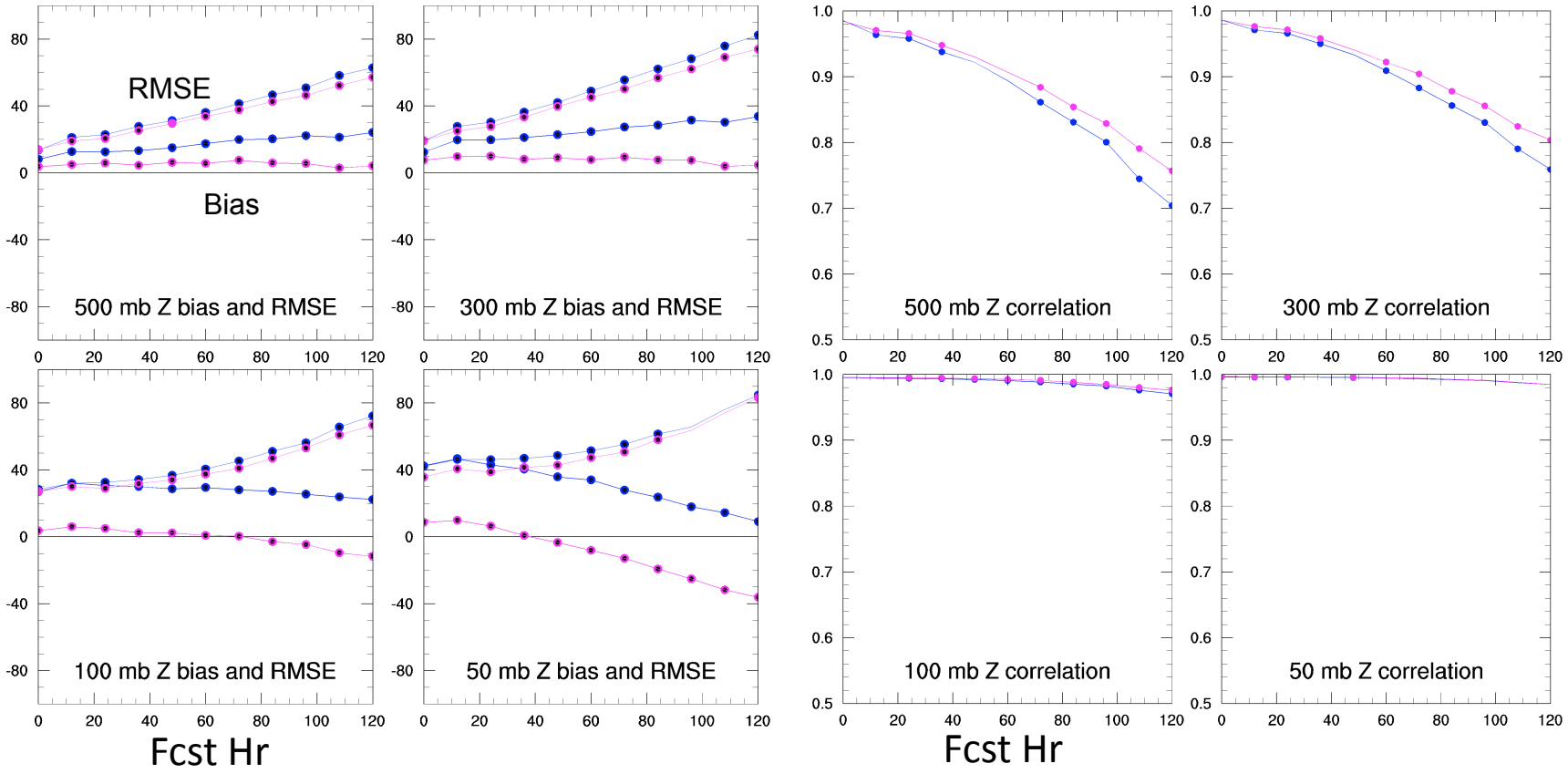




AIRS

- **RMSE decreased**
- **Cold bias increased**

Heights



AIRS

- **RMSE decreased**
- **Bias decreased**

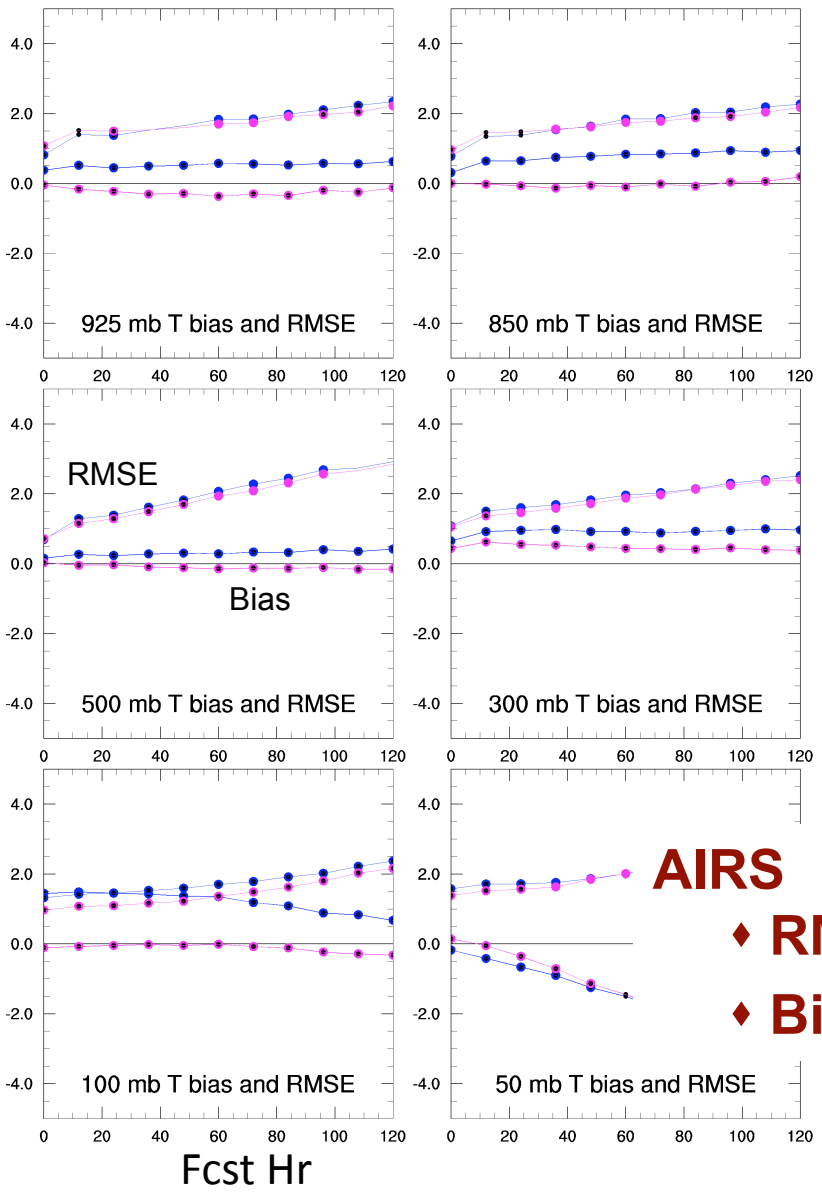
AIRS: Correlation increased

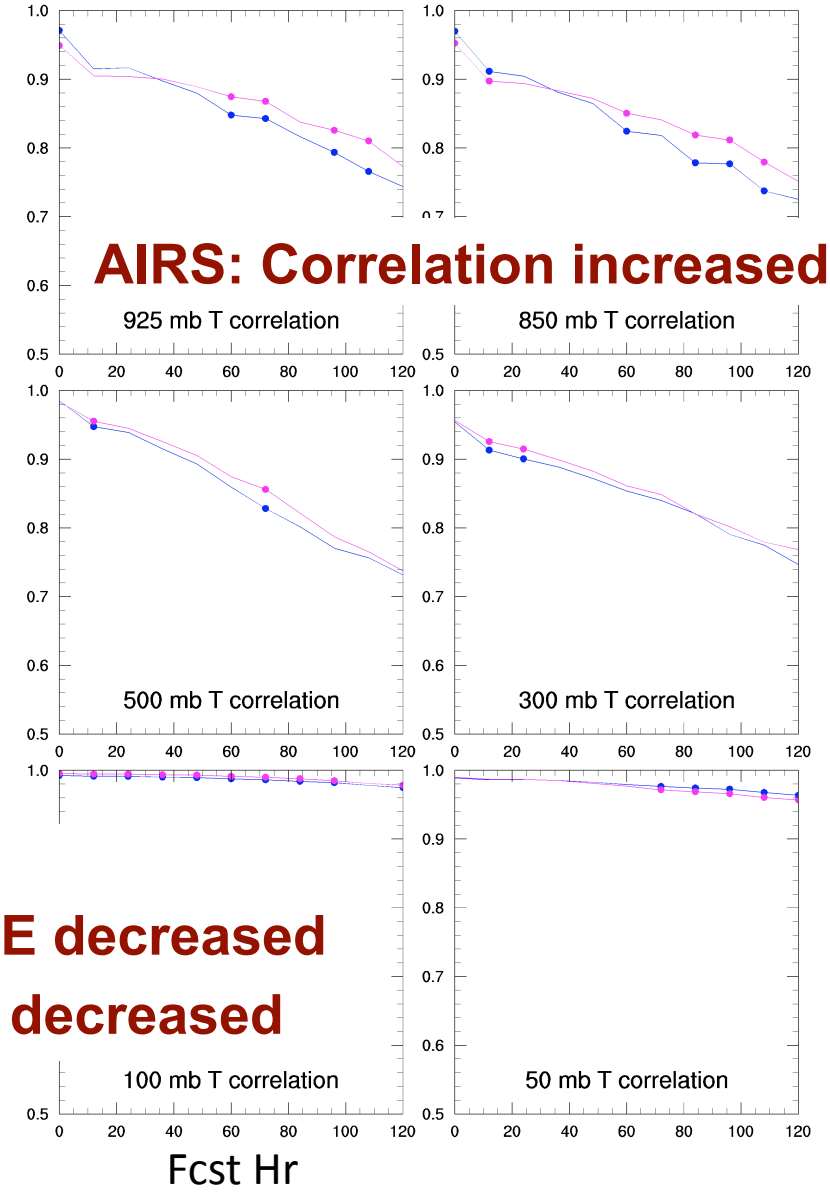
No AIRS

AIRS

Temperature— Upper-air

No AIRS
AIRS





AIRS: Correlation increased

AIRS

- **RMSE decreased**
- **Bias decreased**

Summary

- **AIRS Version 6 (V6) Data Testing: Temperature and Moisture Retrievals**
- **Results**

(a) Winter:

- ♦ No consistent impact / No degradation
- ♦ All sfcs and QC levels usable

(b) Summer: Cold Start AIRS

- ♦ Sfc T: (i) Bias impact varies with region

  (ii) RMSE, bias-corrected RMSE, and correlations better overall
- ♦ Upper-air T, Heights: Biases reduced

→ Overall improvement in cold-start mode w/AIRS

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Summary (cont'd)

- **Results**

  (c) Summer: Cycling AIRS v. No AIRS

  - Sfc T: Averaged RMSE improved, but bias colder
  - Upper-air T: RMSE & bias reduced
  - Heights: Bias, RMSE, correlations improved
  - Winds: Improved

  → **Cycling experiment supports AIRS**

⇒ ***AIRS V6 implemented in AMPS data assimilation: Feb 2015***

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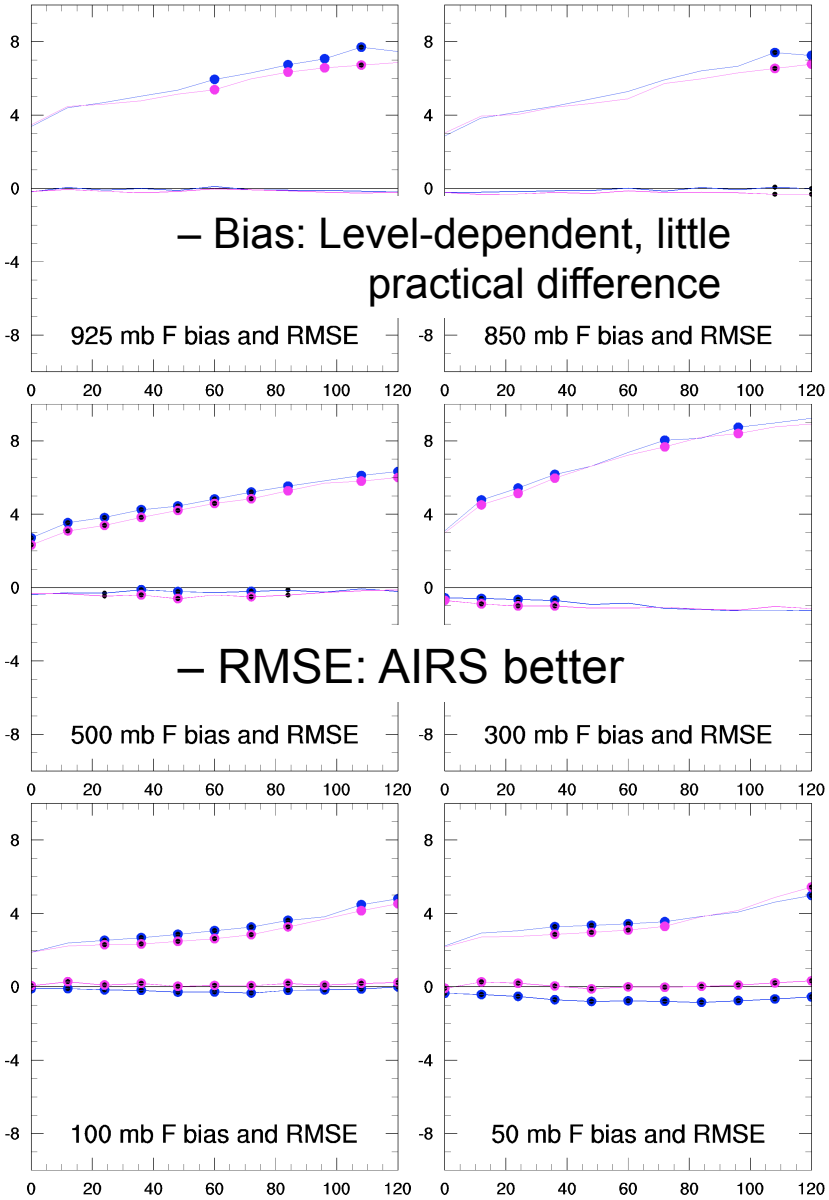
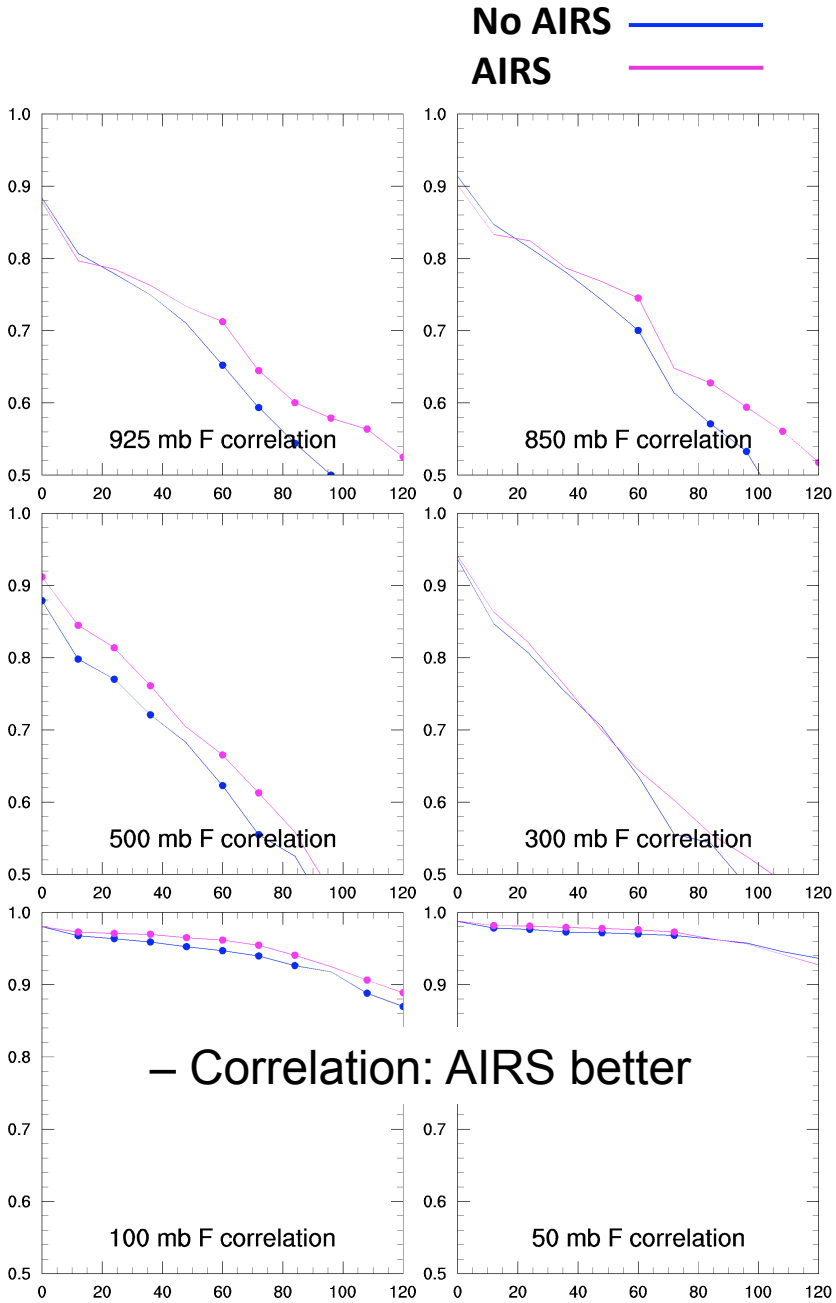
Wind Speed— Upper-air



– Bias: Level-dependent, little practical difference

– RMSE: AIRS better



– Correlation: AIRS better

Full-cycled DA with AIRS vs. Cold-started DA without AIRS

- Since AIRS generally improves scores, and cycling with AIRS is a notable improvement over cycling without AIRS, an obvious question is "How does cycling with AIRS compare to our current RT strategy of no-cycling, without AIRS?"

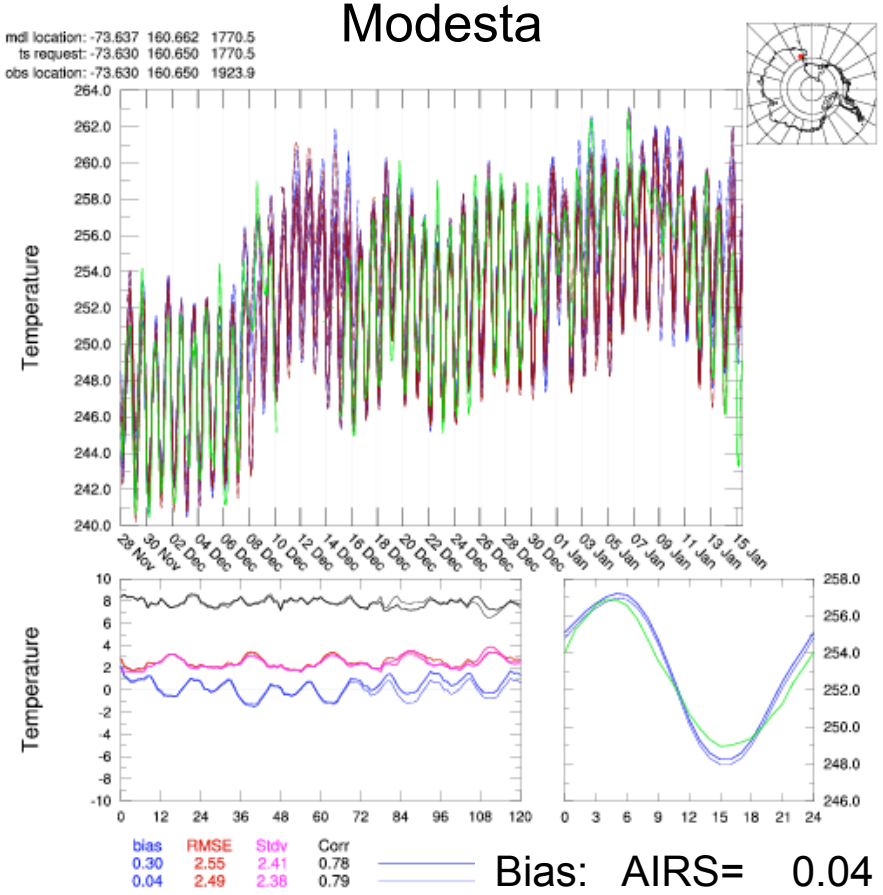
  With the addition of AIRS, are we justified in moving to a full cycling DA strategy?

  - Temperature scores
    - Surface: AIRS Cycled DA shows greater bias; other scores not substantially different
    - The bias at pressure-levels is improved in the AIRS Cycled DA runs, but RMSE and correlation scores are generally worse.
  - Height scores
    - Correlation and RMSE are generally worse in the AIRS Cycled DA runs. Results for BIAS are somewhat mixed, depending on level and forecast lead time.
  - Wind scores
    - Correlation and RMSE generally worse with the AIRS cycled DA runs; not a major difference in bias.
- Conclusion: We are not yet justified in moving to a fully-cycled DA strategy for our RT AMPS forecasts.

  It is promising, though. The fact that the biases are generally under control (at least at pressure levels) suggests that the model isn't drifting off into an unreal climate.

Eastern Ross Sea/Victoria Land

Modesta



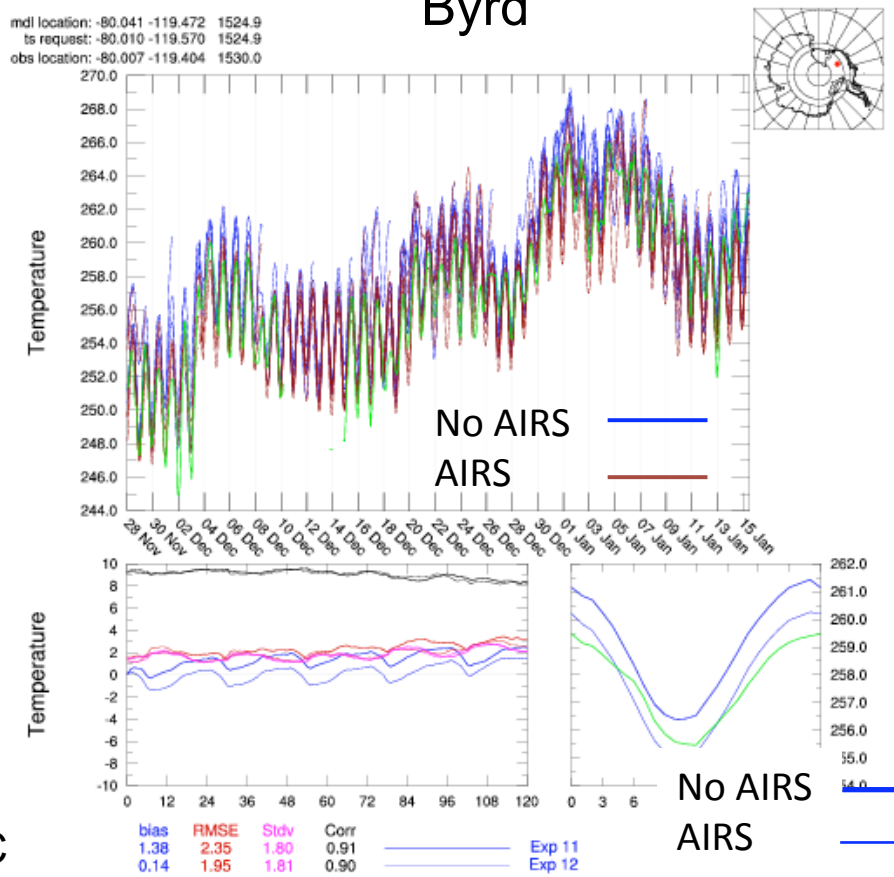
Bias: AIRS= 0.04 C
No Airs= 0.3 C

RMSE: AIRS= 2.5 C
No AIRS= 2.6 C

AIRS
– Decreased warm bias

West Antarctica

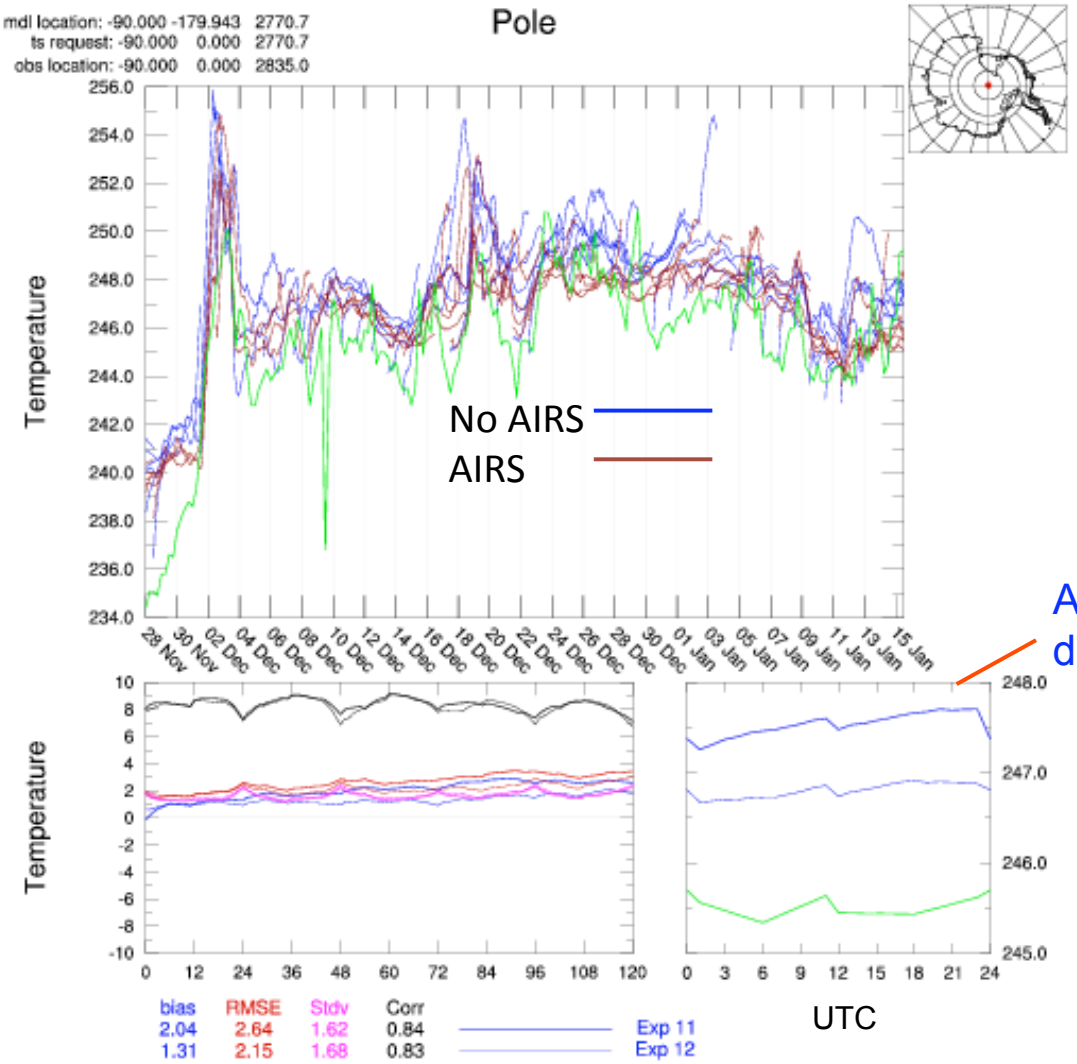
Byrd



Bias: AIRS= 0.1 C RMSE: AIRS= 2.0 C
No Airs= 1.4 C No AIRS= 2.4 C

AIRS: Decreased warm bias & RMSE

South Pole



AIRS: Decreased bias

Decreased RMSE

Bias: AIRS = 1.3 C

No Airs = 2.0 C

RMSE: AIRS = 2.2 C

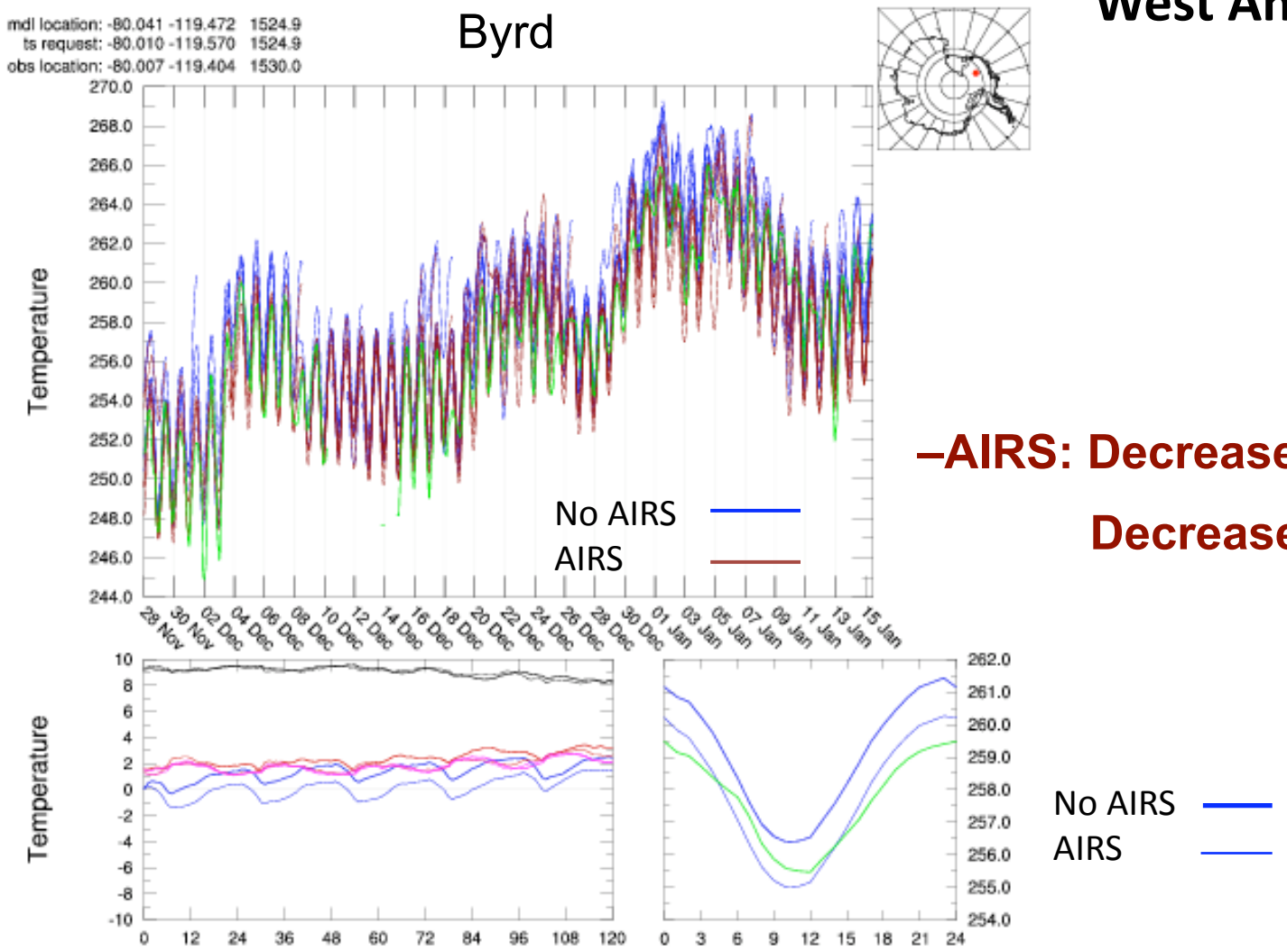
No AIRS = 2.6 C

Avg over diurnal cycle

No AIRS

AIRS

West Antarctica



–AIRS: Decreased warm bias

Decreased RMSE

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