AIRS Data Assimilation at SPoRT

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AIRS Science Team Meeting

Greenbelt, MD October 10, 2007

transitioning unique NASA data and research technologies to the NWS

Motivation: Use of AIRS measurements within a data assimilation system can potentially provide better atmospheric representation—particularly over data void regions—and improve short-term weather forecasts

◆ SPoRT AIRS Assimilation focuses on short-term regional forecasts—compliments work at JCSDA

◆ Profile Assimilation (B. Zavodsky) ⬅

• Motivation and review of previous case study work

• Design of experiment for month-long statistics

• Results from month-long statistics
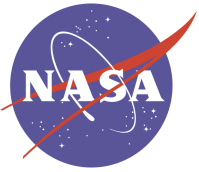
◆ Direct Radiance Assimilation (W. McCarty)

• Channel selection and assimilation cycle

• Results of case study

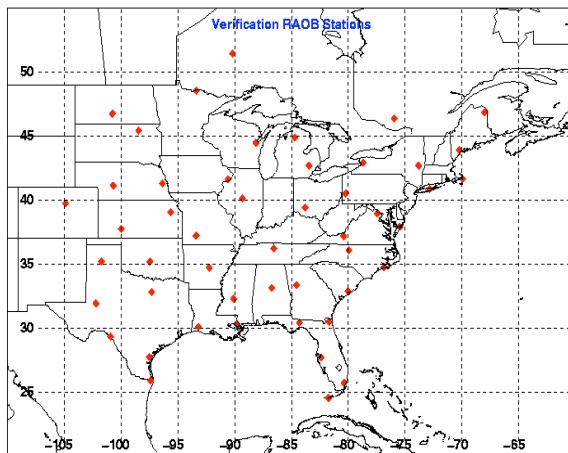◆ SPoRT AIRS DA work presented Sept. 24 and 25 at EUMETSAT/AMS Satellite Conference in Amsterdam, The Netherlands
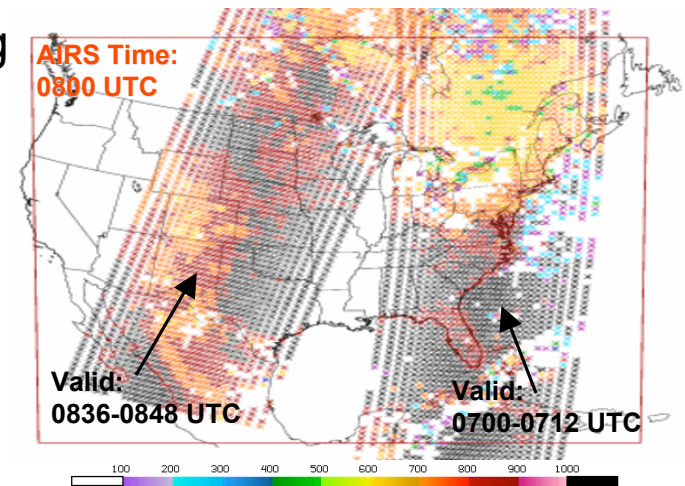
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♦ **Assimilation of AIRS profiles may benefit regional centers that are influenced by data sparse areas but are not equipped to handle radiance assimilation**

- Melbourne and Miami NWS WFOs

♦ **Previous work at SPoRT has focused on Nov. 20-22, 2005 case study**

- Found that AIRS profiles have positive impact on analyses by shifting large-scale model first-guess towards rawinsonde observations

- AIRS-updated initial conditions showed positive impact in temperature, mixing ratio, and 6-hr cumulative precipitation at most forecast times

♦ **More days needed to be run to find new case studies and to obtain a more robust set of cumulative statistics of forecast impact**

- 33 days of model runs from 17 January to 22 February 2007 were run (missing initial conditions for 3-5 February and 11 February)

- These results are shown herein

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Experiment Design

♦ L2 Version 5 <u>temperature and moisture</u> profiles assimilated over <u>land and water</u> with quality control using P_{Best} value in each profile

   • Eastern and central CONUS swathes combined into one swath; assimilation time is mean of the two overpasses

   • Only night time overpasses used

♦ 12-km WRF initialized at 0000 UTC on each forecast date using 40-km ETA/NAM; ADAS to assimilate profiles

AIRS Time: 0800 UTC

Valid: 0836-0848 UTC

Valid: 0700-0712 UTC

100 200 300 400 500 600 700 800 900 1000

Verification RAOB Stations

♦ Results of the 33 days of model runs are validated using sensible weather parameters compared to observations

   • Temperature and mixing ratio verified with 50 radiosondes east of 105°W

   • 6-hr cumulative precipitation verified with NCEP Stage IV data east of 105°W mapped to WRF grid
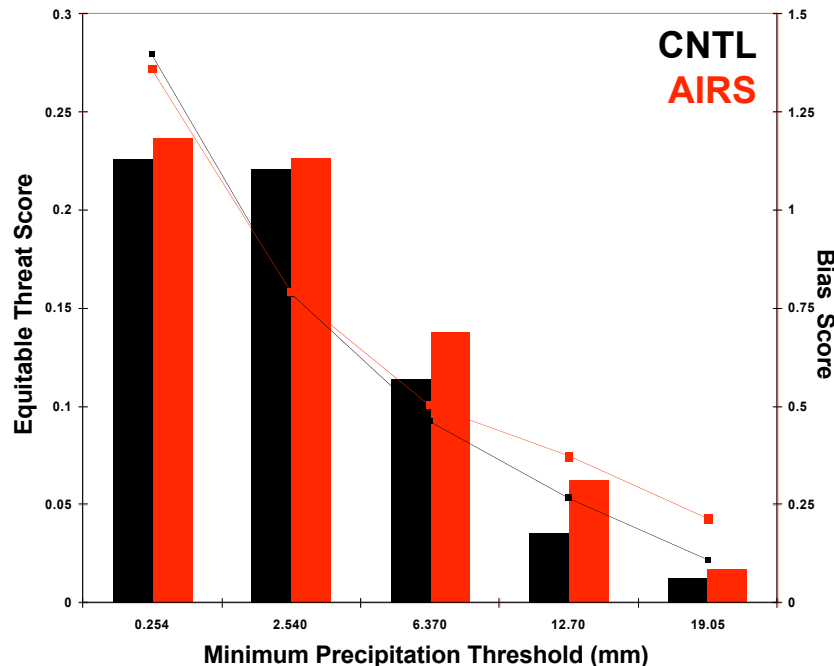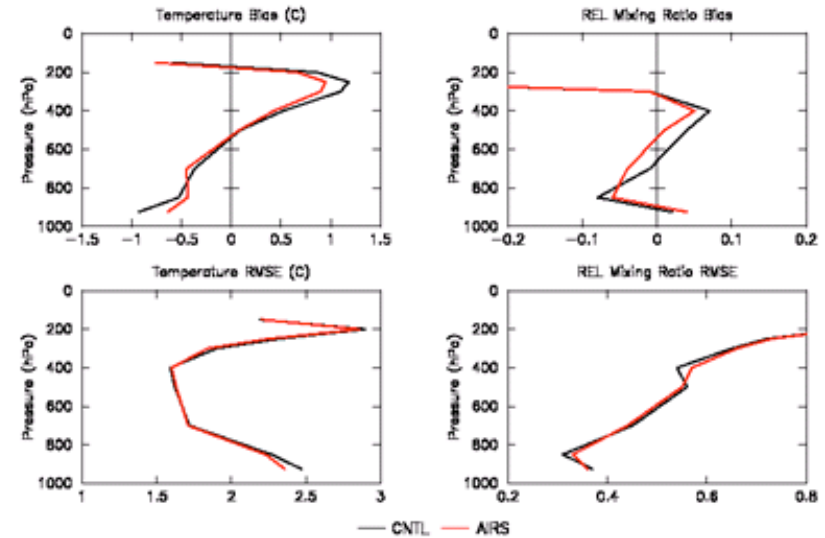
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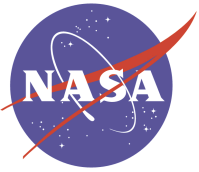
♦ AIRS reduces temperature bias at most levels by ≈0.3°C in lower and upper levels

♦ AIRS changes low and mid-level moisture by as much as 5% at some levels

♦ Temperature and moisture adjustments made without large increases to RMS error

♦ 6-hr cumulative precipitation improves with inclusion of AIRS profiles

• Larger ETS (bars) for AIRS runs indicates improvement in predicted precipitation location and amount

• Bias scores (lines) closer to 1.0 for AIRS suggest improvement in coverage of precipitation features
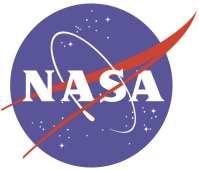
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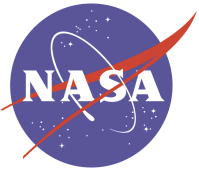
◆ In the NCEP Global Data Assimilation System (GDAS), AIRS has already been shown to have a significant impact in both northern and southern hemisphere global forecasts (Le Marshall et al. 2006)

◆ Previous work focused on preparation of AIRS radiances for data assimilation

  • CO_2 Sorting Technique can detect clouds and determine uncontaminated channels in hyperspectral data to increase the number of usable channels over a masking approach

◆ The proper use and assessment of these measurements within a regional system—such as the North American Model (NAM) Data Assimilation System (NDAS)—has yet to be fully assessed

  • Considerations of the proper utilization of AIRS data within the pseudo-operational NDAS environment and a preliminary look at their impact are investigated herein

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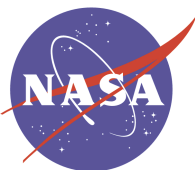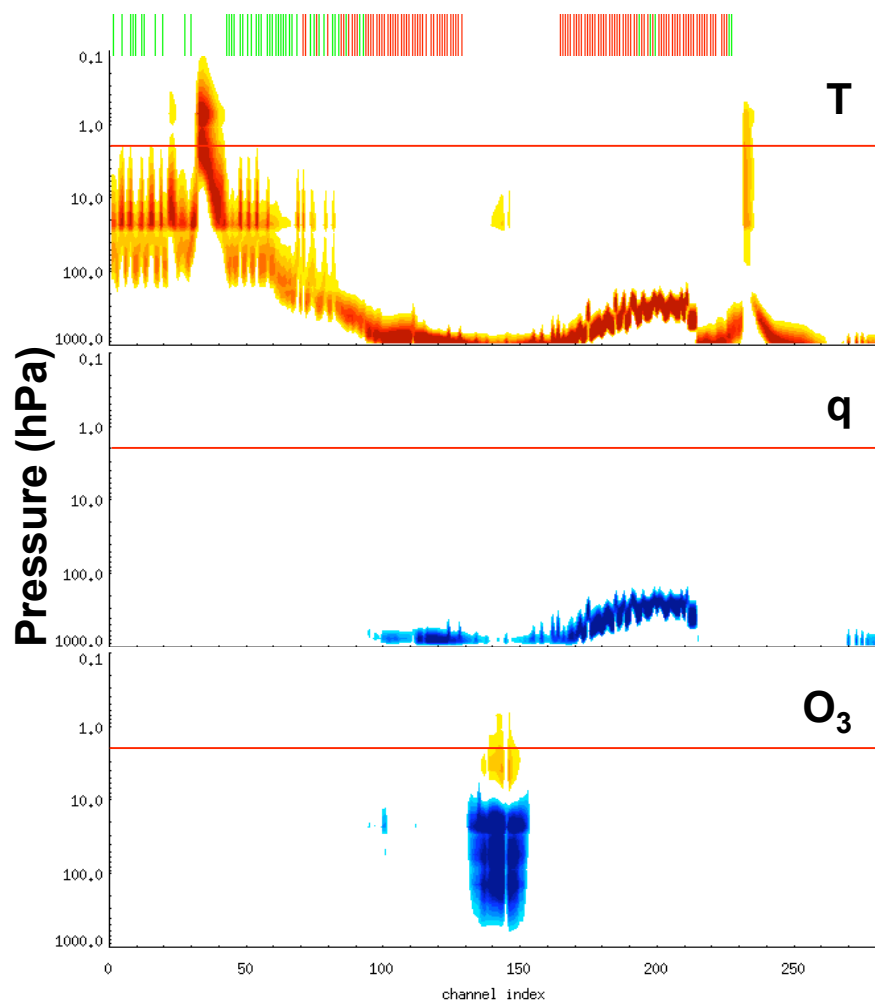
♦ Operationally, NCEP GFS uses 151 channels of the 281 channel subset

♦ Limitations to using a regional model:

  • lower P_{top} (2 hPa; red line)

  • O_3 not used in regional model

♦ No shortwave (< 5 μm) channels are used

♦ Plots show profile normalized Jacobians of each constituent: $\dfrac{dT_b}{dq_i} * 0.1q_i$

♦ Green hashes denote 151 GDAS channels

♦ Red hashes denote 103 regional channels

♦ No additional channels in regional subset that are not used in global analysis
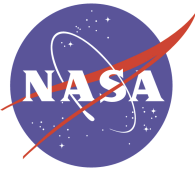
Assimilation Cycle
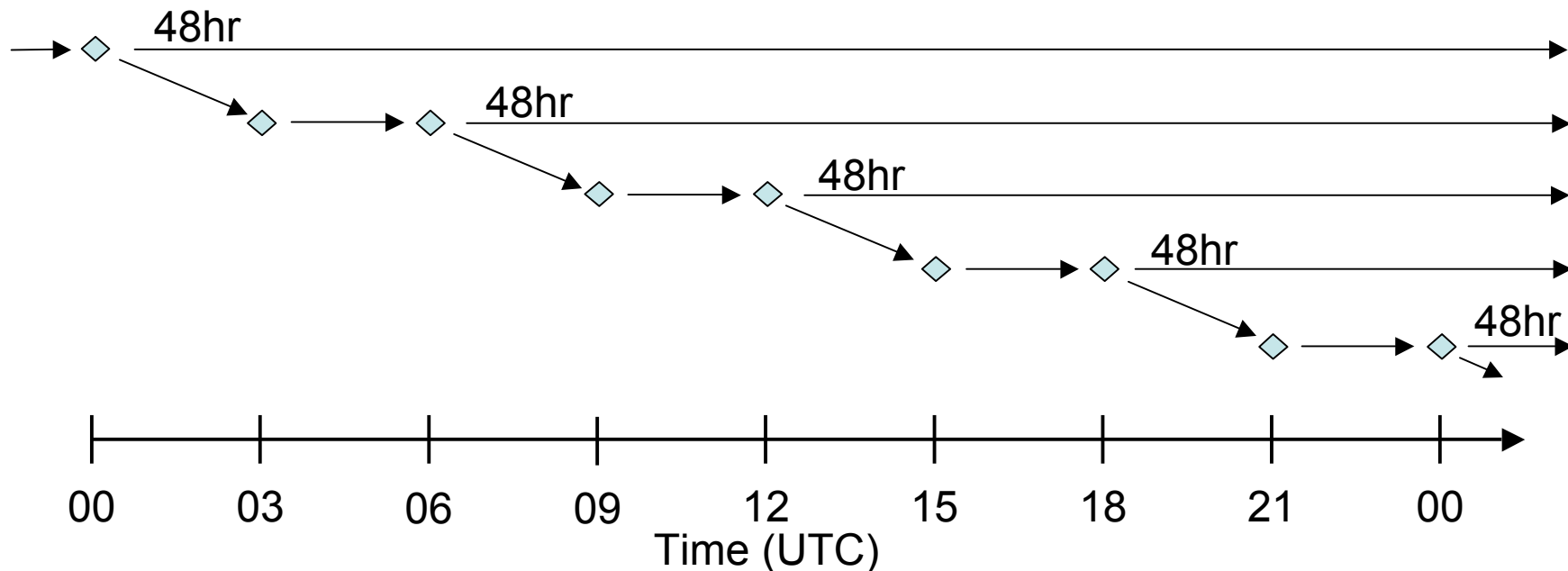
♦ All NCEP operational observations are assimilated every 3 hours (± 1.5 hrs) for the NOAIRS runs; AIRS radiances are the only difference between NOAIRS and AIRS runs

♦ A two-week spin-up period to propagate the impact of the AIRS measurements through the analysis and allow bias corrections to stabilize

♦ Gridpoint Statistical Interpolation (GSI) and the Weather Research and Forecasting Nonhydrostatic Mesoscale Model (WRF-NMM) used as analysis and model systems

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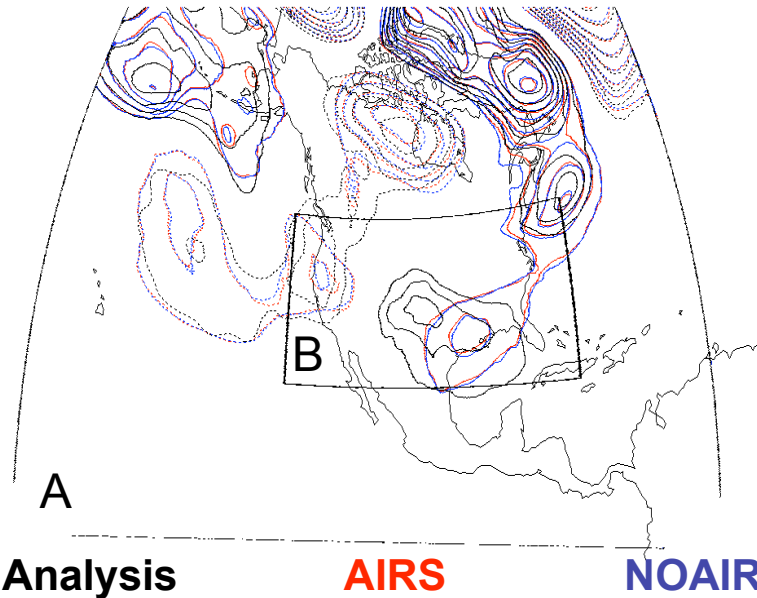
♦ 48-hr forecast valid at 0000 UTC on 11 April 2007

♦ 500 hPa height anomalies for control (NOAIRS; blue) and control+AIRS (AIRS; red); corresponding NDAS analysis in black
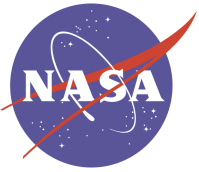
♦ Solid contours correspond to troughs; dashed cont

Height Anomaly

Analysis   **AIRS**   **NOAIRS**

♦ A: model domain (dashed lines)

♦ B: subdomain characterisized by conventional obs in analysis (solid lines)

♦ Both height anomaly correlation (R) and standard deviation (σ) show significant improvement throughout the troposphere
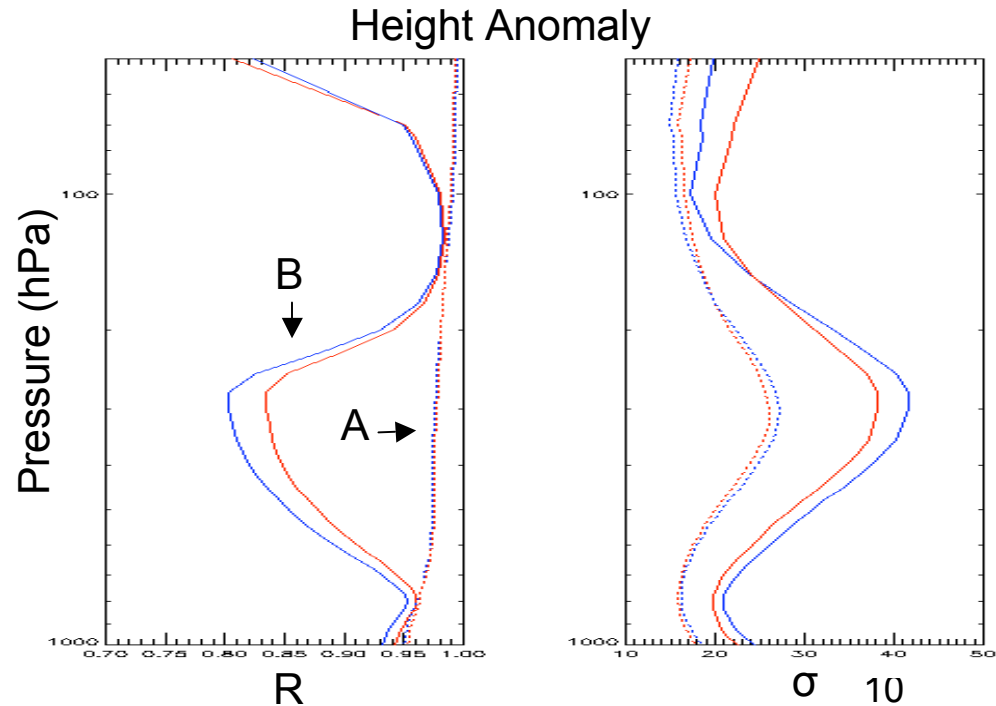
Pressure (hPa)

R   σ   10

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♦ Profile Assimilation Conclusions/Future Work

- For 33 days of model runs in late Jan./early Feb.

  ▪ <u>Biases are reduced</u> in temperature and mixing ratio at most levels

  ▪ <u>6-hr cumulative precipitation</u> coverage and <u>forecast accuracy improve</u>

- Further analysis of individual days from case study to determine where AIRS provides most added value; migrate to 3DVAR

♦ Direct Radiance Assimilation Conclusions/Future Work

- Limitations in use of AIRS radiances in regional NDAS reduced the number of usable channels by 17% relative to the 281 subset but still retained 37% of the channels overall

- An initial case study shows statistically significant forecast improvement throughout the entire model domain due to the assimilation of AIRS data

- Further investigate determination of cloud contamination using CO_2 sorting technique; further investigate use of AIRS radiances over a longer set of studies

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Questions?

Suggestions?

Comments?

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