ASSIMILATION OF ATMOSPHERIC INFRARED SOUNDER (AIRS) DATA IN A REGIONAL MODEL

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1. INTRODUCTION

- This research describes a procedure for assimilating AIRS profile data to a high-resolution analysis scheme.
- Results will focus on AIRS quality control issues, optimal assimilation strategies, and the impact of the AIRS data on subsequent numerical forecasts.

2. AIRS DATA

- The AIRS Science team standard Level 2 Version 4 data consist of T and q profiles retrieved at 12 levels topped at 100 hPa with a 50 km spatial resolution at nadir.
- Quality assessment flags provide the validation status and processing history of each retrieval.

Table 1. Description of the quality indicators for Version 4 AIRS profiles.

Quality Indicator	Description	Total %	Color in Fig. 2
Full (highest quality)	complete MW and IR	16.3	Black
SFC Failed	fails QC for emissivity	29.2	Blue
SFC+BOT Failed	fails QC below 3 km	13.5	Green
SFC+BOT+MID Failed	fails QC below 200 hPa	19.5	Orange
SFC+BOT+MID+TOP Failed	MW only retrieval	13.0	Yellow
All Failed	No retrieval	8.4	Red

3. ANALYSIS SCHEME

- Using the Bratseth method, which updates a background field using observations:

$$\phi_x(k+1) = \phi_x(k) + \sum_{i=1}^{n_{obs}} \alpha_{xi} \left[\phi^{obs} - \phi_i(k) \right]$$

- Weighting factor, α_{xi}, is a function of the distance of the observations from each grid point and the ratio of the observation and background error variances.

4. EXPERIMENT DESIGN

4.1 *Case Study – 14-17 January 2004* (Fig. 1 and 2)

- The area of interest is the eastern Pacific and western North America.
- A weak ridge provides relatively cloud-free conditions over the eastern Pacific allowing for the assimilation of many high quality AIRS soundings.
- This event presents an opportunity to examine the impact of AIRS soundings on the low-pressure system in the central Pacific.

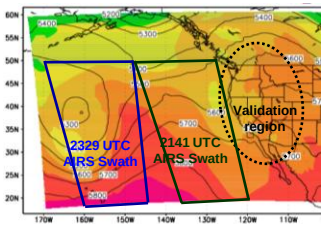


Fig. 1. 500 hPa height and temperature at 00 UTC 15 January 2004. The boxes indicate the location of the AIRS data, and the oval indicates the validation region.

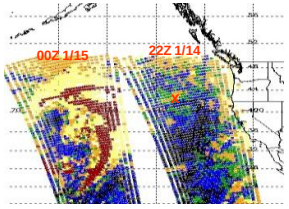


Fig. 2. Location of AIRS data used in ADAS. The color of each indicator is described in Table 1. X marks the location of sounding profiles in Fig. 3.

4.2 *Forecast Model Configuration – WRF (Weather Research and Forecasting System)*

- 360X200 horizontal grid with 30 km spacing.
- 37 sigma levels topped at 100 hPa with finest resolution near the boundary layer.

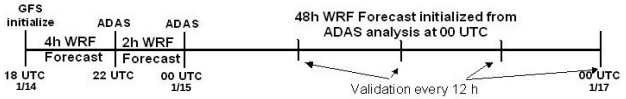
Microphysics: Ferrier (New Eta) — PBL Scheme: YSU
Longwave Radiation: RRTM — Convective Scheme: Kain-Fritsch
Shortwave Radiation: Dudhia — Soil Scheme: Noah

4.3 *Analysis Configuration – ADAS (ARPS Data Assimilation System)*

- Same horizontal grid as WRF.
- 43 sigma levels separated by an average of 500 m with emphasis near top and bottom.

4.4 *Assimilation Procedure*

- Using NCEP 1° GFS grids to initialize the model and update LBC every 6 hours.
- Beginning at 18 UTC 1/14 with a 4-h WRF forecast.
- Using the forecast as the first guess and assimilating 22 UTC AIRS profile data.
- Using ADAS analysis and BC to produce a 2-h WRF forecast.
- Assimilating 00 UTC 1/15 AIRS data.
- Running a 48-h forecast with no further data assimilation.



4.4 *Numerical Experiments*

- 5 Forecast experiments were conducted:
  - CNTL: MADIS data only (no AIRS)
  - FULL: MADIS + Full-retrieval AIRS
  - FLSF: FULL+ SFC-failed AIRS
  - SFBT: FLSF + SFC/BOT-failed AIRS
  - NULL: SFC/BOT-failed AIRS set to missing value below 700 hPa.

5. PRELIMINARY RESULTS

5.1 *Impact of AIRS on Initial Analysis* (Fig. 3)

- Sounding becomes cooler and drier at most levels with additional AIRS data.
- As expected, removal of lower quality data from the SFBT case in lower troposphere (NULL) results in a sounding that resembles the FLSF below 700 hPa and the SFBT above 600 hPa.

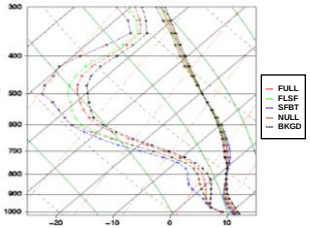


Fig. 3. Sounding profiles for various AIRS assimilation at 22 UTC 14 January 2004 (marked X in Fig. 2).

5.2 *Impact of AIRS data on forecast* (Figs. 4 and 5)

- AIRS impacts on temperature: 2ºC - significant differences.
- Thermal gradient weakened along 500 hPa front.

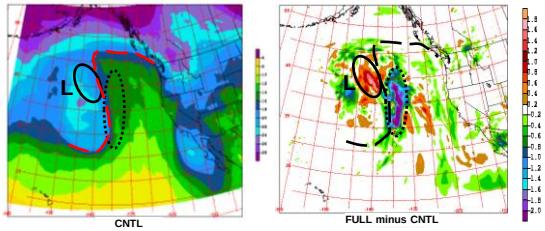


Fig. 4. 24-hour forecast for 500 hPa temperature valid at 00 UTC 16 January 2004.

- AIRS impacts on moisture: 2 g/kg.
- Less intense frontal boundary - consistent with 500 hPa temp analysis.

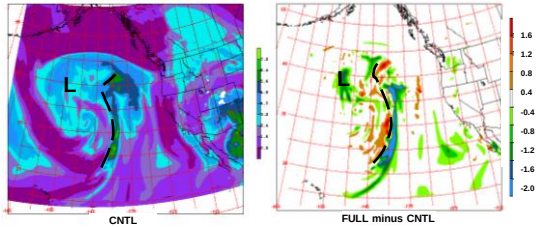


Fig. 5. 24-h forecast for 700 hPa mixing ratio valid at 00 UTC 16 January 2004.

5.3 *Verification Statistics* (Figs. 6 and 7)

- Using AIRS data improves forecast of T and q at all times and most levels.
- Forecast improves with addition of AIRS profiles (full and surface-failed, red and green lines).
- Low level forecast degradation with bottom-failed retrieval (blue) can be negated by excluding the values below 700 hPa (null case, dashed brown) to preserve upper level improvement.

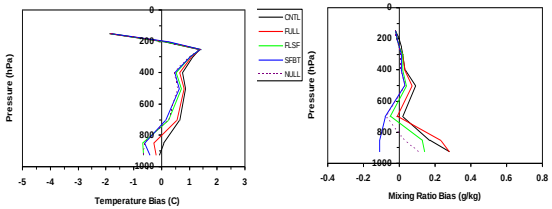


Fig. 6. 24-h forecast bias valid at 00 UTC 16 January 2004.

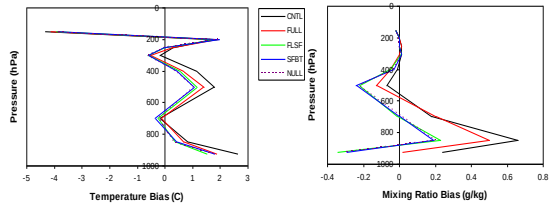


Fig. 7. 48-h forecast bias valid at 00 UTC 17 January 2004.

Acknowledgements

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