JP6.21 SENSITIVITY OF SHORT-TERM WEATHER FORECASTS TO ASSIMILATED AIRS DATA: IMPLICATIONS FOR NPOESS APPLICATIONS

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Background

- The SPoRT Center at Marshall Space Flight Center in Huntsville, AL works to improve weather forecasts using unique NASA satellite observations and research capabilities.
- NASA is using state-of-the-art assimilation techniques for improving atmospheric model initial conditions through use of the Atmospheric Infrared Sounder (AIRS).
- Use of AIRS radiances is the most sophisticated method but requires large computational resources; techniques to assimilate profiles are still in their infancy but smaller centers with limited computational resources can still benefit from the data.
- Studies of AIRS radiances (*e.g.* LeMarshall *et al.* 2005, Garand *et al.* 2006) and profiles (*e.g.* Reale *et al.* 2008) have shown promising results for assimilation of AIRS observations on the global scale.
- SPoRT has shown positive impact on short-term forecasts at the regional scale using both AIRS radiances (McCarty *et al.* 2009 in review) and profiles (Chou *et al.* 2009 (JP6.11)).
- Because AIRS is a heritage instrument to CrIS, lessons learned from AIRS can aid in product development for CrIS, and the data can be used in a similar manner.

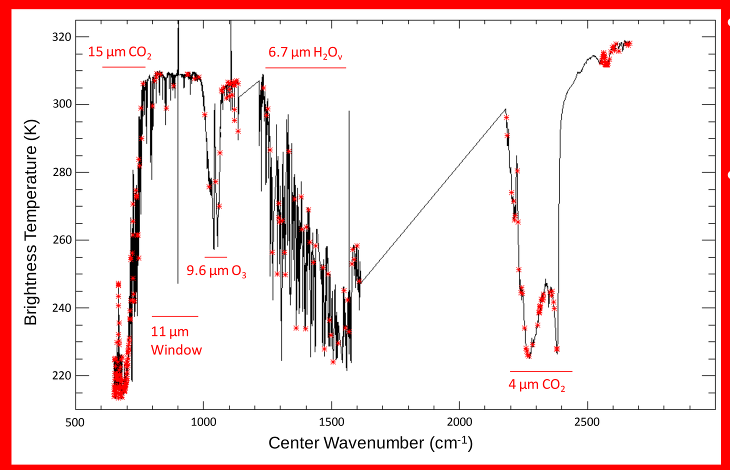
AIRS Radiance Assimilation

Analysis System

- The data assimilation scheme used in this study is the Gridpoint Statistical Interpolation (GSI, Wu et al. 2002) 3D-Var scheme used operationally at NOAA/NCEP, NASA/GSFC, and NOAA/ESRL/GSD
- The system minimizes the cost function

$$2J(\delta x) = \delta x^T B^{-1} \delta x + (H(x_b) + H\delta x - y)^T R^{-1} (H(x_b) + H\delta x - y)$$

to achieve an analysis increment, δx, which is determined as the combination of the observations, y, and the background state, x_b, weighted by their error covariance matrices, R and B, respectively
- Background error covariances are determined using the methodology of Wu 2005
- Radiance studies at SPoRT emulated the operational North American Mesoscale (NAM) Model, which is run at 12 km and utilizes the Weather Research and Forecasting Nonhydrostatic Mesoscale Model (WRF-NMM, Janjic et al. 2001) dynamic core, at NOAA/NCEP
- All conventional and remotely sensed measurements assimilated operationally during the period of study were utilized
- The assimilation cycle is performed at every three hours, using a 1.5 hour cutoff for data
- The experimental variable in the studies is solely the AIRS radiances. Launched in 2002, onboard the NASA Aqua EOS satellite, AIRS measures 2378 individual bands (in black) from 3.7 – 15.4 µm, with a 15 km spatial footprint. The major absorption continua are denoted by the red lines



- 281 bands denoted by the red stars at every footprint are delivered to NCEP for assimilation purposes.
- Radiative transfer calculations necessary for the assimilation of radiances (via the forward, H, and linearized, **H**, operators) are performed using the Community Radiative Transfer Model (Weng et al. 2005)

AIRS Channel Selection

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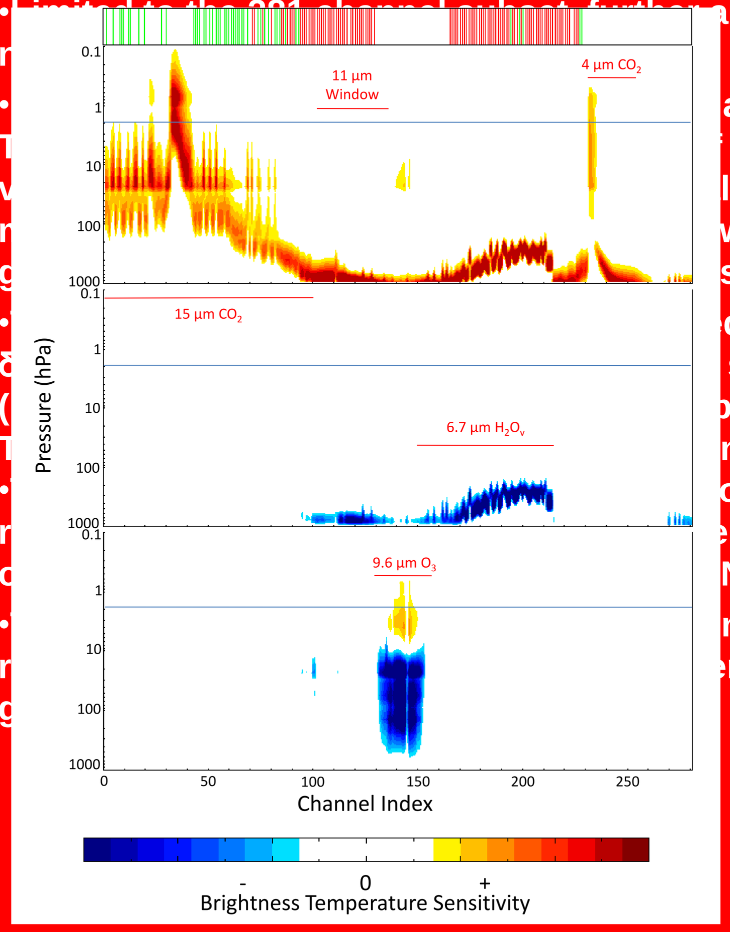
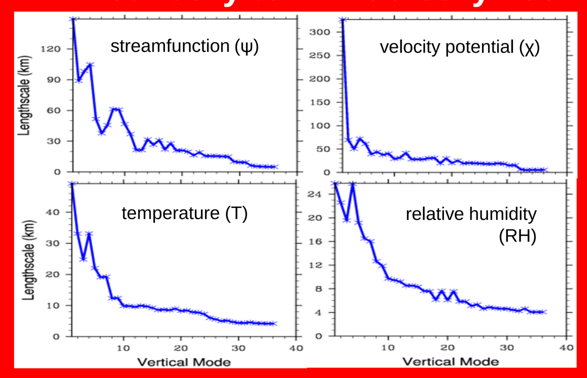
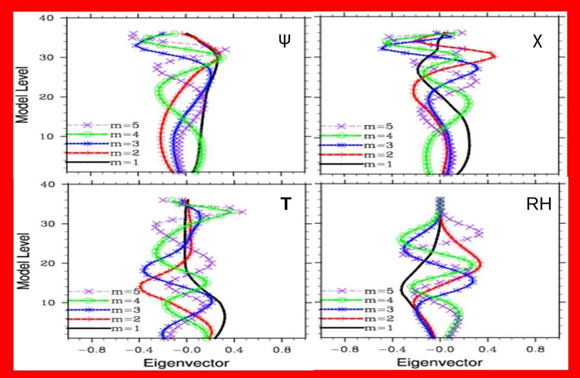


AIRS Profile Assimilation

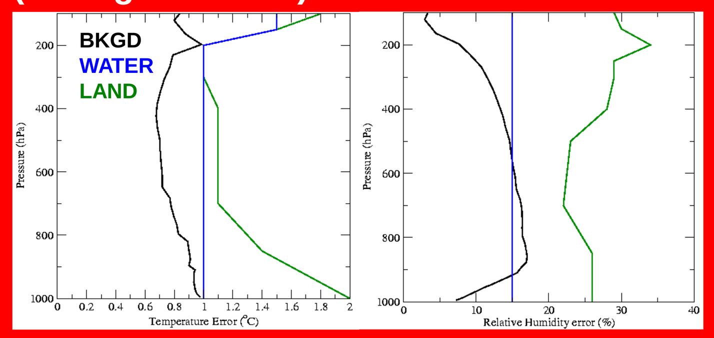
Analysis System

- The data assimilation scheme used in this study is the Weather Research and Forecasting 3D-Var (WRF-Var, Barker et al. 2004)
- Background error covariances are determined using the NMC method (Parrish and Derber 1992) which takes differences between 12 and 24-h control forecasts to describe model error. Background error covariances were created using the "gen_be" program in WRF-Var with forecasts from 17 January to 22 February 2007





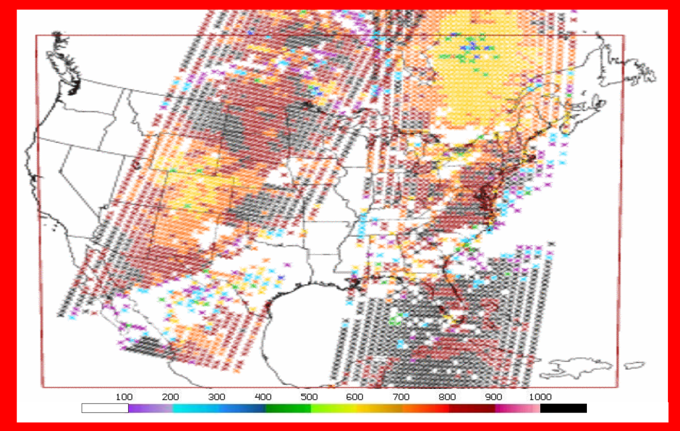
- Length scale (above left) and eigenvectors (above right) control horizontal and vertical spread of observations, respectively. Ratio of observation and background errors determines weighting on interpolations (see figure below)



- Only diagonal terms in the observation error matrix are used, but error estimates can be used to fill off-diagonal terms
- Profile studies at SPoRT have thus far amounted to sensitivity studies to determine the impact of AIRS observations on WRF forecasts. Comparisons between forecasts have been made to radiosondes and NCEP Stage IV data (see Poster JP6.11 in this session)

AIRS Profile Use

- SPoRT assimilates AIRS level-2 standard temperature *and* moisture retrievals (14 reported levels between 1000 and 50 hPa)—supplemental product contains too many correlated levels
- Profiles are obtained from University of Wisconsin direct broadcast site
- Ability to assimilate data above cloud top is important to increasing yields in regions of interesting weather; thus, each profile contains a quality indicator (QI) which denotes the maximum pressure level above which quality data have been measured (variable P_{best})



- These QIs are used in preprocessing AIRS profiles for WRF-Var by only including partial soundings where indicated by the QIs
- AIRS profiles are used over land *and* water with separate observation errors
  - Land: From Tobin et al. (2006)
    - Emissivity issues make land soundings less accurate
    - Validation for SGP—similar environment as SPoRT domain
  - Water: Use AIRS instrument specs (1K in 1 km layer for T; 15% in 2-km layer for RH)
    - Better soundings than land
    - Verified against TWP sites—different than SPoRT domain

Recommendations for CrIS data for use in Data Assimilation

- It will be necessary to provide near real-time access to radiances and sounding products to the community (*e.g. via* the NPOESS Data Exploitation (NDE) project, direct broadcast facilities, *etc.*). These sites will need to maintain the most recent versions of the supporting science algorithms.
- Validation of CrIS soundings with dedicated radiosondes and level-by-level retrieval error estimates are necessary for assigning appropriate observation errors.
- Inclusion of methodology for determining and using uncontaminated channel radiances and corresponding above-cloud levels in profiles is necessary to maximize performance impact within data assimilation systems.