Atmospheric Soundings of Temperature, Moisture and Ozone from AIRS

M.D. Goldberg, W. Wolf, L. Zhou, M. Divakarla, C.D. Barnet, L. McMillin,

NOAA/NESDIS/ORA
Oct 31, 2003

Presented at ITSC-13
Risk Reduction Benefits

- Early demonstration of operational processing of high spectral resolution infrared sounder data prior to CrIS, IASI and GOES-R
- Validation of retrieval performance
- Early opportunity for forecast centers to learn how to assimilate advanced IR data
- Demonstration of positive impact for NWP
- WE HAVE A LOT MORE TO LEARN!!!
AIRS Retrievals

- Microwave-only retrieval of sfc emissivity, sfc temperature, sfc type and profiles of temperature, water vapor and cloud liquid water.

- AIRS retrieval of cloud amount and height, cloud cleared radiances, sfc emissivity, sfc temperature, and profiles of temperature, water vapor and ozone.

- AIRS has two retrieval steps – very fast eigenvector regression followed by a physical retrieval algorithm.
• Spectrally and Spatially Thinned Radiances
• Principal Component Scores (Spatially Thinned)
• Reconstructed radiances (Spatially/Spectrally Thinned)
• Cloud-Cleared radiances (Spatially/Spectrally Thinned)
• Cloud-Cleared PCS (Spatially Thinned)
• Super channel radiances
What have we learned?

- AIRS instrument is extremely stable and accurate
- Only 5% of the globe is clear at a 14 km fov
- Impact on NWP is currently small (remember 5%)
- Cloud-clearing increases yield to 60%
- Retrievals from cloud-cleared radiances are significantly more accurate than AMSU-only.
- Retrievals from cloud-contaminated radiances are also significantly more accurate than AMSU-only.
Trace Eigenvalue: real 577096, simulation 774893

Brightness Temp. Space

LOG

Sqrt Eigenvalue (btemp)

real data -- June 14 2002
simulated data June 14 2002

eigenvector #
Regression prediction of ECMWF Temperature

July 20

Pressure (mb)

RMS (K)

Temperature RMS Error (K)
Regression prediction of ECWMF moisture

(note no AMSU channel due to incorrect s/w)

- blue: AIRS 85 pc + AMSU + hsb
- red: AMSU + hsb
- green: AMSU

Pressure (mb)

rms/mean (percent)
Regression prediction of ECWMF ozone

Note no AMSU channel due to incorrect s/w.

- AIRS 85 pc + AMSU + HSB
- AMSU + HSB
How sensitive is the regression solution to clouds?

- Regression should be able to reduce the impact of partial clouds in AIRS fov because of the high spectral resolution of AIRS.

- Each channel has a different sensitivity due to clouds.

- Generated coefficients for all cases where the predicted AIRS from AMSU difference test is less than 2 K (~50%)
Cloud-Cleared Radiiances
Are there benefits to use cloud-cleared data???
0N, 140E (white= sim., green= cc, yellow = raw rad.)
5 days of screened collocated ECMWF and CC PCS are used for generating the regression coefficients.

Example of Training Pop. for a given day

- Screen model data by requiring agreement between observed AIRS and model calculated AIRS

- Selected 12 channels
  - 702.7  706.1  711  712.7  715.9  724.8
  - 746.0  759.5  7965.4
  - 1468.83  1542.35  1547.88

- All channels < 2 K
- Coefficient generated used 5 days of data
Ocean – screened (sdv 0.32 cm, mean 2.53 cm, 12.6%)
Ocean – all (sdv 0.42 cm, mean 2.63 cm, 16%)
Temperature Bias and RMS (Land and Sea Samples) With Cloud Test

Bias and RMS (Deg. K), NSAMP=8238

Collocated Radiosondes

Pressure (mB)

10 100 1000

-1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5

AIRS-F258+AQ:AMSU (192 P) N-16(ATOVS) AIRS- F258+AQ:AMSU(192 P) N-16(ATOVS)
Water Vapor Error (Land and Sea Samples) With Cloud Test

% Error, NSAMP = 8238

COLLOCATED RADIOSONDES

Pressure (mB)

Air- F258+AQ:AMSU(192 P)  N-16(ATOV5)
Are there benefits to use reconstructed data???

Example of reconstructed brightness temperatures for 2616 cm⁻¹
Spectrum from 892 to 902 wavenumber

Green is reconstructed, white is original, yellow is calculated from model
Summary – Encourage!!!

- Reconstructed radiances
- Cloud-cleared radiances
- Cloud-contaminated radiances
- Geophysical Retrievals
Plans for IASI and CrIS

- Our AIRS processing system will be adapted for IASI and CrIS.

- Similar geophysical and radiances products will be available.

- We are also actively conducting research to produce trace gas products (CO, CO2, CH4) from AIRS, IASI and CrIS.
Backup
Mean diff = -.03, std = .29
Mean totw = 1.44
Radiance Reconstruction Scores Predominantly < 1

- Reconstruction scores > 1 are over hot ground, however because the nonlinearity of Planck function, these are region which has the best brightness temperature reconstructions.
Emissivity from Simulation

IR emis (1020cm⁻¹), JPL Sim. Data Dec 15 2000

iremis, truth
IR Emissivity Results

Mean emissivity spectra as a function of cloud-cleared radiances for 4 different surface types:

- Ocean = average between 50 S- 50 N
- Snow = 90S-80S
- Desert = 0- 30E, 25-29N
- Grass = 90W-80W, 30N-40N