# CURRENT RESULTS FROM AIRS/AMSU/HSB

**Presented at ITSC XIII**

**October 31, 2003**

**Joel Susskind, Robert Atlas, Chris Barnet, John Blaisdell, Lena Iredell, Fricky Keita**

**NASA GSFC Laboratory for Atmospheres**

# THE AIRS/AMSU/HSB SUITE

AIRS/AMSU/HSB launched on EOS Aqua May 4, 2002

AIRS is a multi-detector array grating spectrometer

2378 channels between 650 $cm^{-1}$ and 2760 $cm^{-1}$

Channel spacing $\approx \nu / 2400$ (0.25 $cm^{-1}$ - 1.1 $cm^{-1}$)

Resolving power $\nu / \Delta\nu \approx 1200$ (0.5 $cm^{-1}$ - 2.2 $cm^{-1}$)

Footprint 13 km at nadir

3 x 3 array within AMSU A footprint - collocated with HSB

One sounding produced per AMSU A footprint

HSB failed on February 5, 2003

# OBJECTIVES OF AIRS/AMSU/HSB

**Provide data to improve operational weather forecasting**

Required global accuracy in up to 80% cloud cover:

1 K RMS error in 1 km layer mean tropospheric temperature

20% RMS error in tropospheric 1 km layer precipitable water

**Provide long-term global coverage of surface and atmospheric parameters**

Monitor climate variability and trends

Study processes affecting climate change

# AIRS/AMSU PRODUCTS

Primary

- Atmospheric profiles
  - Temperature - surface air to 0.1 mb
  - Water vapor - surface air to 100 mb
  - Ozone - eight layers, surface to 1 mb
- Surface Parameters
  - Skin temperature
  - IR spectral emissivity
  - MW spectral emissivity
- Clear column radiances $\hat{R}_i$ - used to produce the solutions
- Cloud parameters - one product every AIRS FOV
  - Cloud top pressure - 2 cloud levels
  - 2 effective cloud fractions $\alpha\varepsilon$ (fraction times 11 $\mu$m emissivity)
  - OLR, clear sky OLR

Research

- CO and $CH_4$ profile, $CO_2$ total burden

# OVERVIEW OF AIRS TEAM RETRIEVAL METHODOLOGY

Start with initial guess that agrees with microwave radiances

Derive IR clear column radiances, $\hat{R}_i^0$, valid for 3x3 array of AIRS FOV's

$\hat{R}_i$ is estimate of radiance channel i would see if no clouds were present

Obtain AIRS regression guess consistent with $\hat{R}_i^0$ (1504 channels)

Derive $\hat{R}_i^1$ consistent with regression state - $\hat{R}_i^1$ is more accurate than $\hat{R}_i^0$

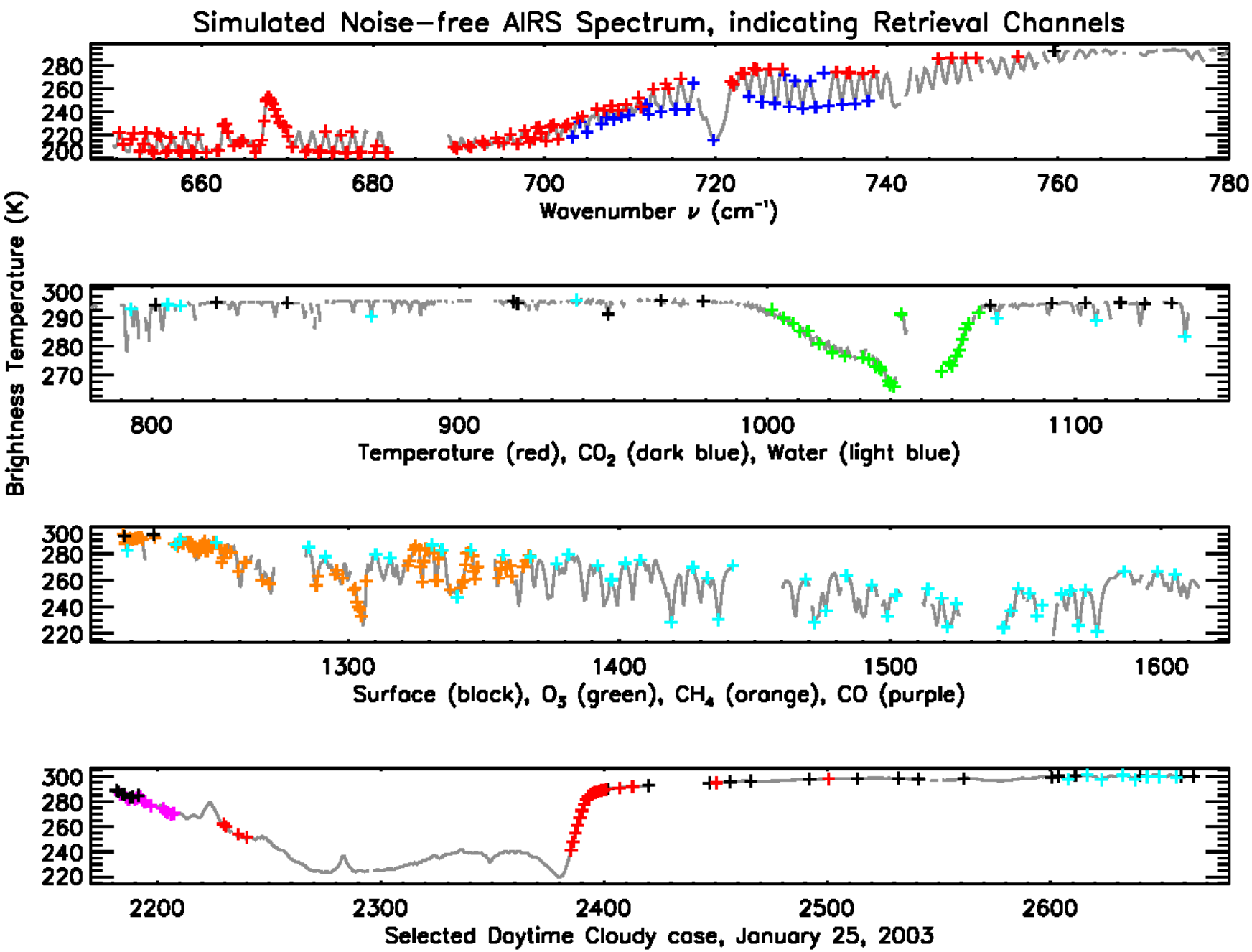
Derive all surface and atmospheric parameters using $\hat{R}_i$ (415 channels)

Derive cloud parameters consistent with solution and observed $R_i$

Apply Quality Control

Reject solution if retrieved cloud fraction > 80% or other tests fail

Redetermine cloud parameters using initial guess and $R_i$ if retrieval is rejected


Simulated Noise−free AIRS Spectrum, indicating Retrieval Channels
Brightness Temperature (K)
280
260
240
220
200
660
680
700
720
740
760
780
Wavenumber ν (cm⁻¹)
300
290
280
270
800
900
1000
1100
Temperature (red), CO2 (dark blue), Water (light blue)
300
280
260
240
220
1300
1400
1500
1600
Surface (black), O3 (green), CH4 (orange), CO (purple)
300
280
260
240
220
2200
2300
2400
2500
2600
Selected Daytime Cloudy case, January 25, 2003

# AIRS DATA SETS

**JPL Version 3.0.8**

Used operationally by Goddard DAAC to produce AIRS Level 2 Products since August 2003.

**JPL Version 3.1.9**

Improved version used by JPL and Mitch Goldberg (NOAA)

**GSFC Version 3.1.8**

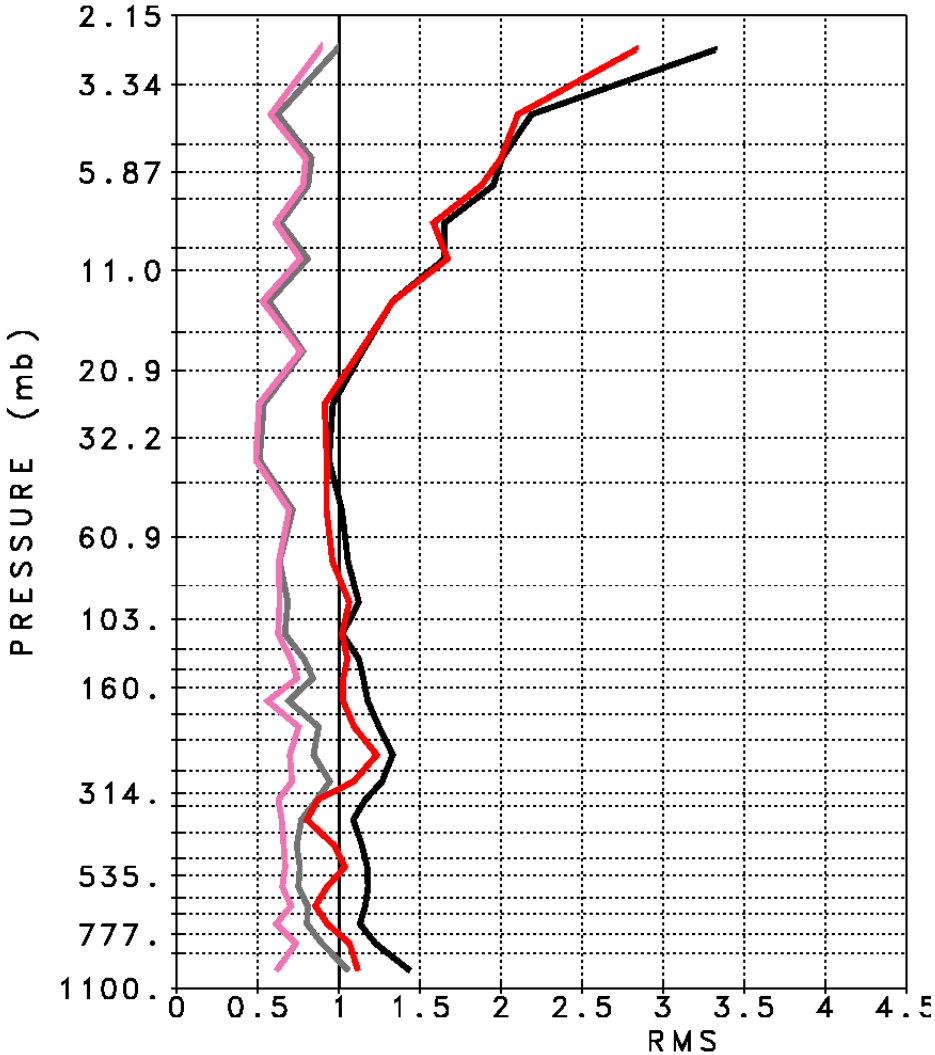
Slightly different from JPL version 3.1.9

Used to analyze AIRS focus day September 6, 2002 and all of January 2003

January 2003 data used in forecast impact test

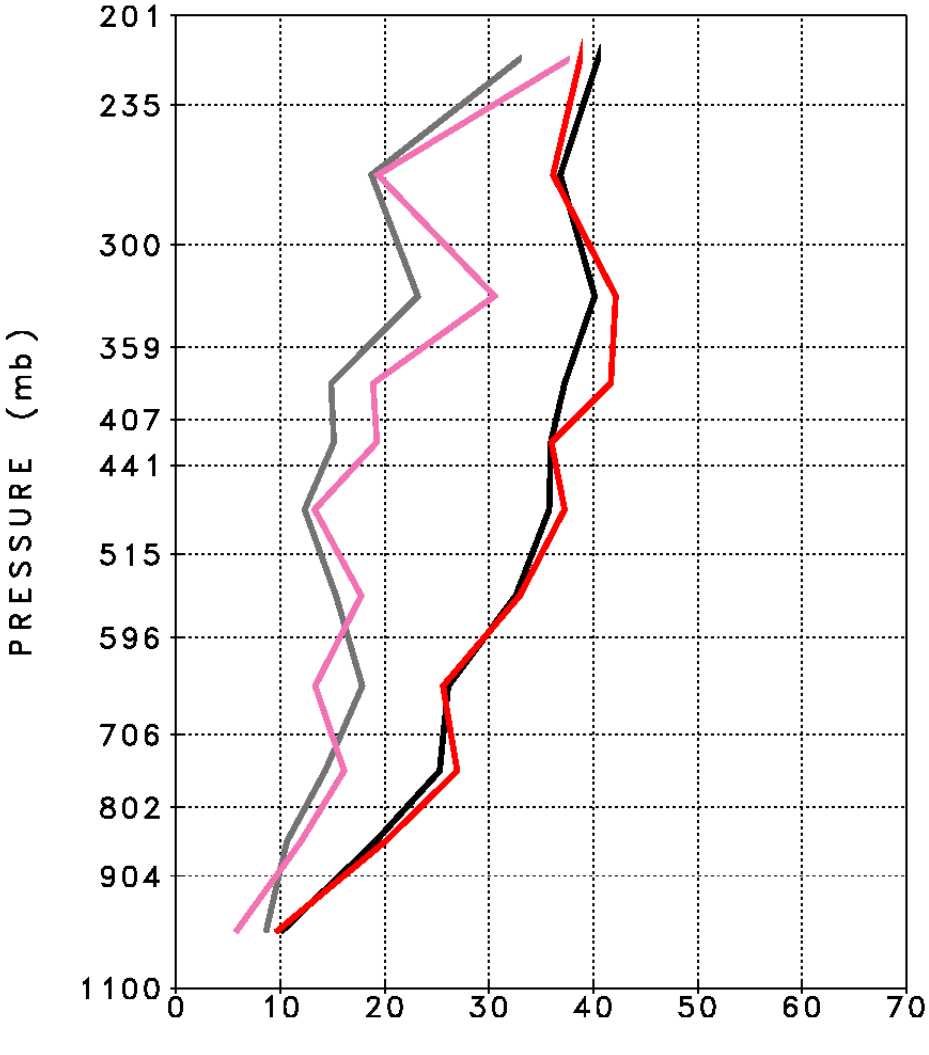
Monthly mean values were compared to ECMWF

LAYER MEAN RMS TEMPERATURE (°C)
DIFFERENCES FROM "TRUTH"

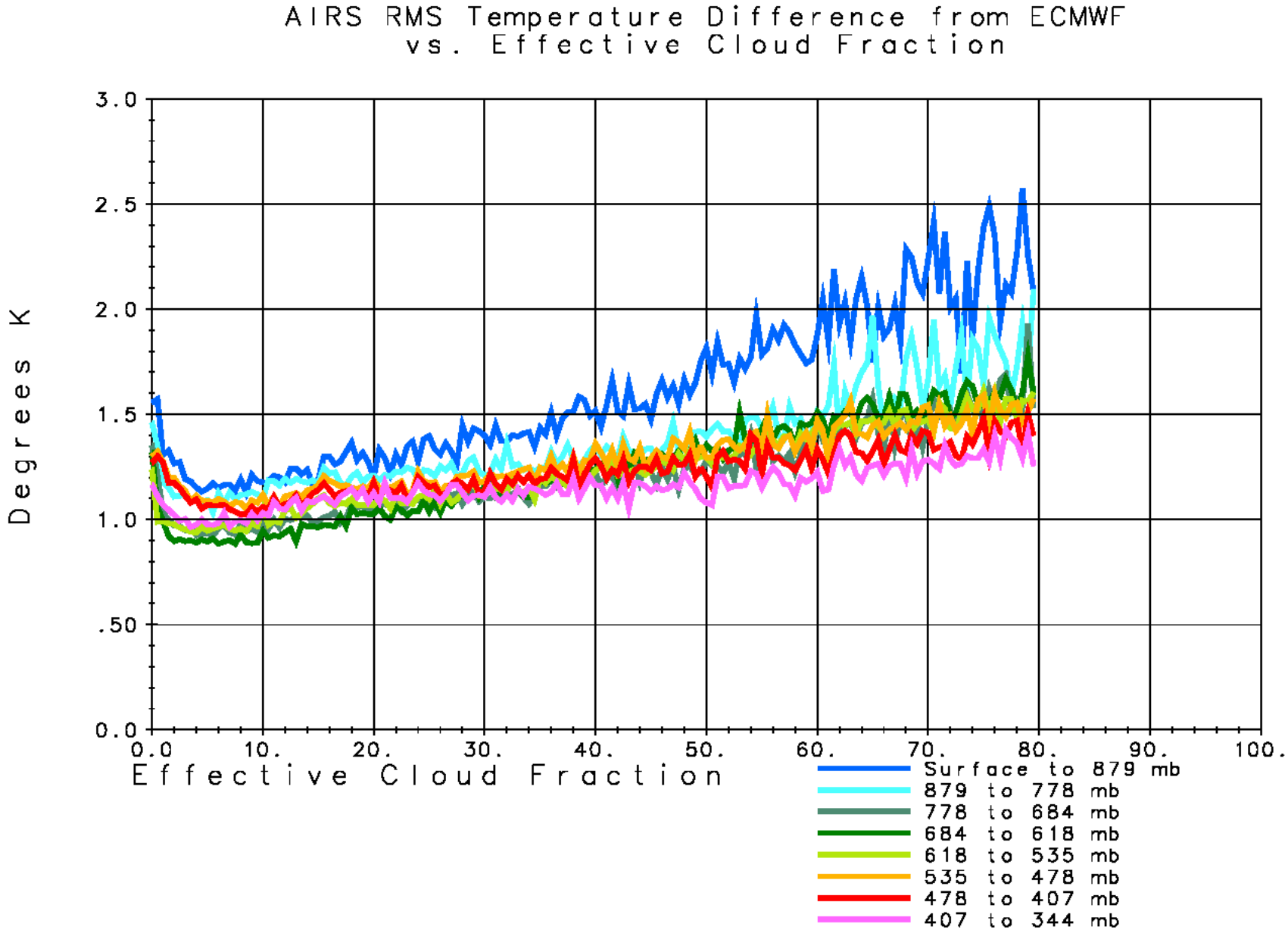


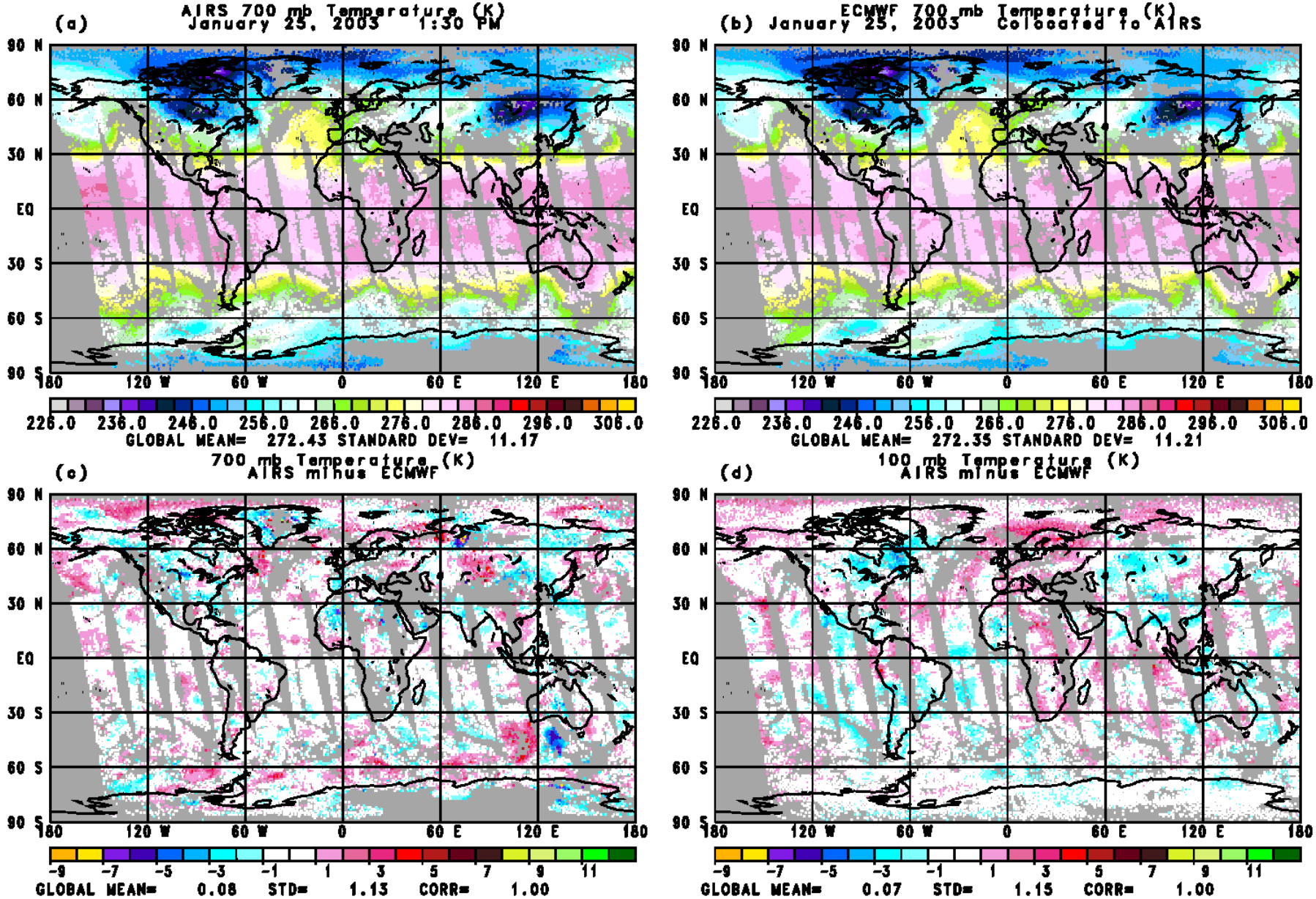

All Accepted Cases (Simulated) 63.9%
Clear Cases (Simulated) 6.0%
All Accepted Cases (Observed) 66.7%
Clear Cases (Observed) 8.7%

1 Km LAYER PRECIPITABLE WATER
PERCENT DIFERENCES FROM "TRUTH"




All Accepted Cases (Simulated) 63.9%
Clear Cases (Simulated) 6.0%
All Accepted Cases (Observed) 66.7%
Clear Cases (Observed) 8.7%


AIRS RMS Temperature Difference from ECMWF
vs. Effective Cloud Fraction
Degrees K
3.0
2.5
2.0
1.5
1.0
.50
0.0
0.0
10.
20.
30.
40.
50.
60.
70.
80.
90.
100.
Effective Cloud Fraction
Surface to 879 mb
879 to 778 mb
778 to 684 mb
684 to 618 mb
618 to 535 mb
535 to 478 mb
478 to 407 mb
407 to 344 mb


(a)
AIRS 700 mb Temperature (K)
January 25, 2003 1:30 PM
(b) January 25, 2003
ECMWF 700 mb Temperature (K)
Collocated to AIRS
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180
120 W
60 W
0
60 E
120 E
180
226.0 236.0 246.0 256.0 266.0 276.0 286.0 296.0 306.0
GLOBAL MEAN= 272.43 STANDARD DEV= 11.17
GLOBAL MEAN= 272.35 STANDARD DEV= 11.21
(c)
700 mb Temperature (K)
AIRS minus ECMWF
(d)
100 mb Temperature (K)
AIRS minus ECMWF
-9 -7 -5 -3 -1 1 3 5 7 9 11
GLOBAL MEAN= 0.08 STD= 1.13 CORR= 1.00
GLOBAL MEAN= 0.07 STD= 1.15 CORR= 1.00

# AIRS EXPERIMENTS WITH FVSSI

**Global data assimilation system used:**

fvSSI: fvGCM - Resolution: 1x1.25  SSI (NCEP) analysis-T62

**Period of assimilation:**

1 January - 31 January, 2003

**Experiments**:

**Control**: All Conventional Data + ATOVS Radiance (NOAA-14, 15, 16) + CTW + SSM/I TPW+ SSM/I Wind Speed + QuikScat + SBUV Ozone

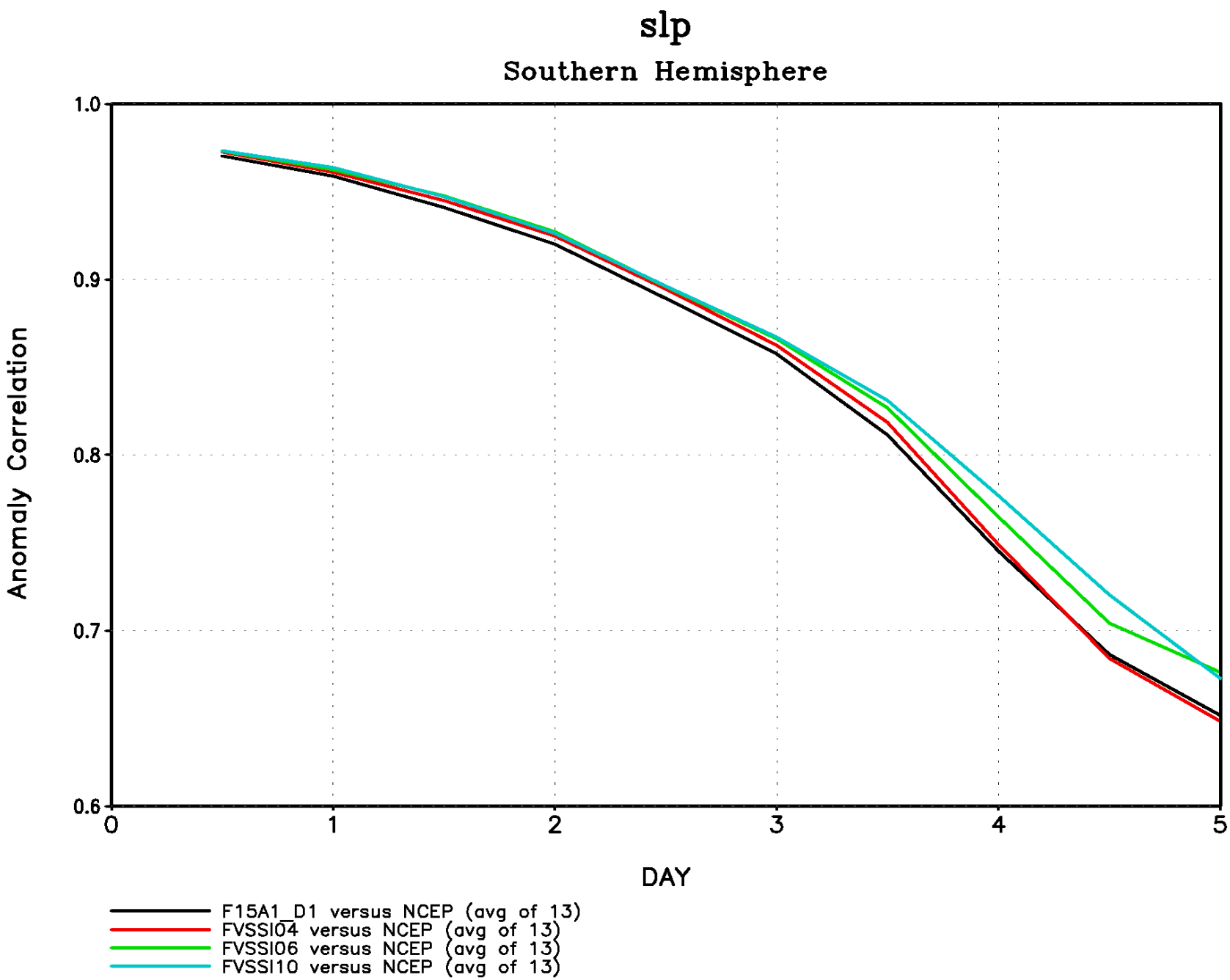
**Control + AIRS Retrieved Temperature Profiles** (Clear $\alpha\varepsilon < 0.02$ /Ocean / -40 - + 40 deg)

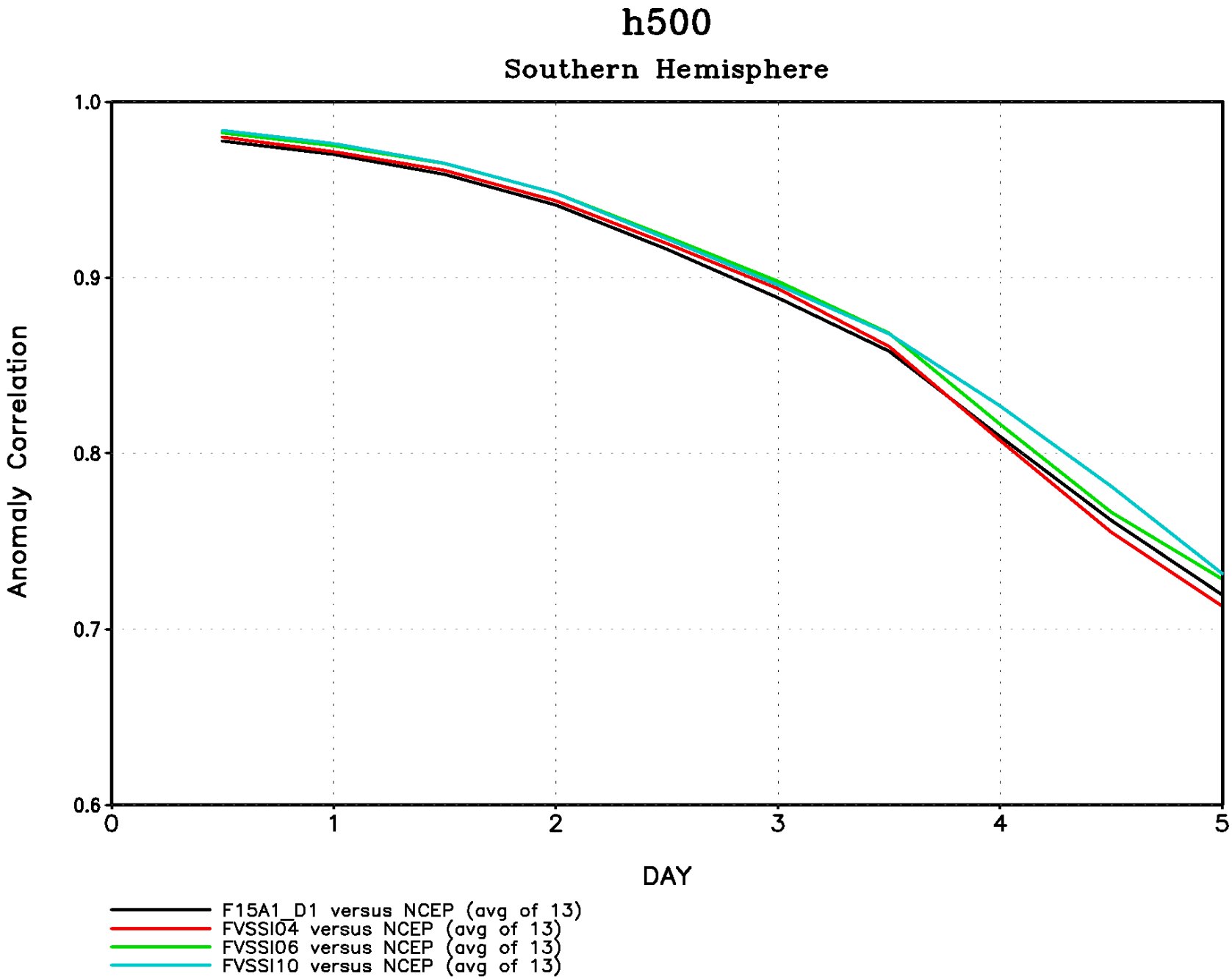
**Control + AIRS Retrieved Temperature Profiles** (Clear $\alpha\varepsilon < 0.02$ /Ocean/Global)

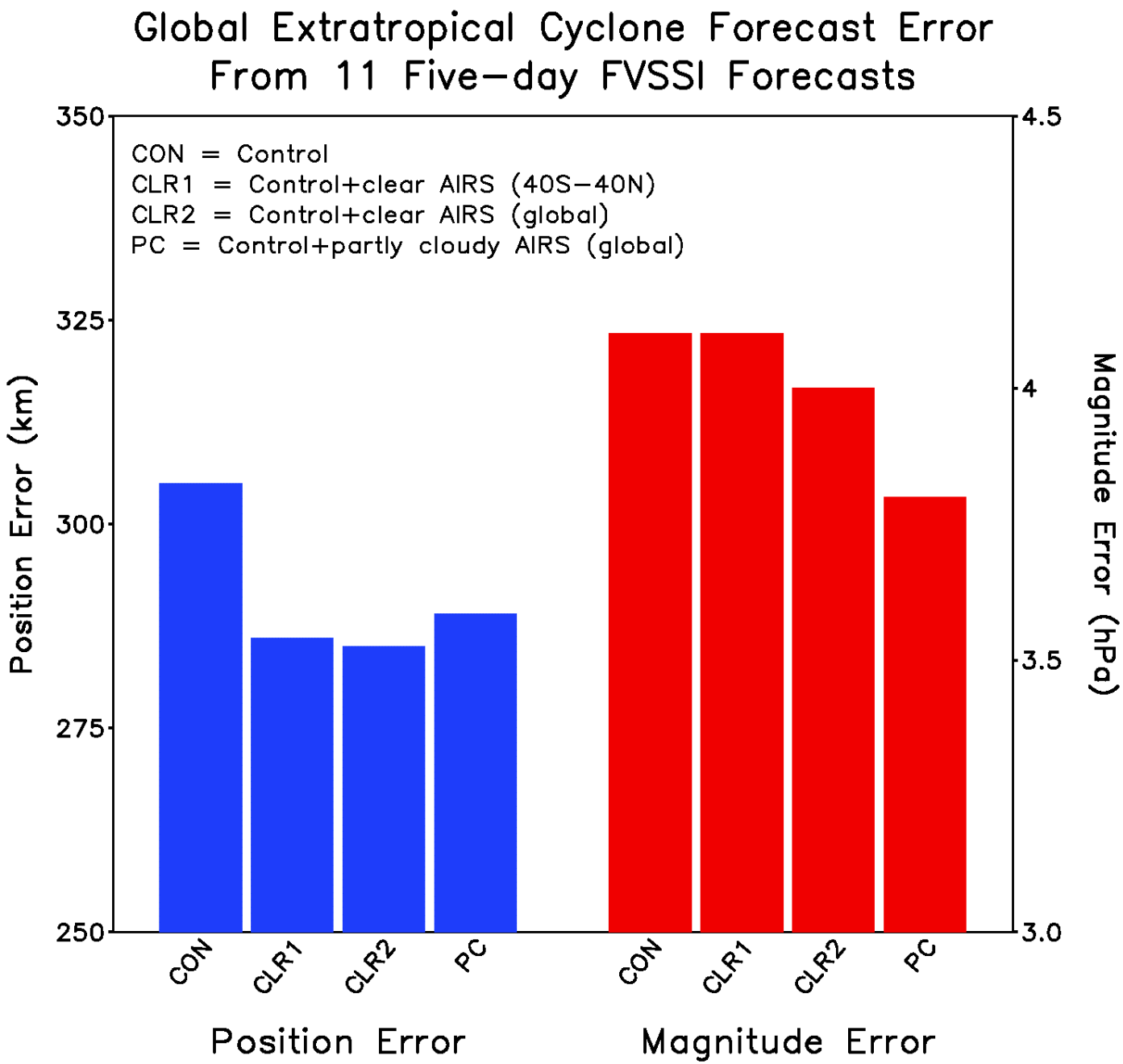
**Control + AIRS Retrieved Temperature Profiles** (Clear +Partly Cloudy $\alpha\varepsilon < 0.4$ /Ocean/Global)

**Forecasts**:

13 forecasts run every two days beginning on 6 January,  2003

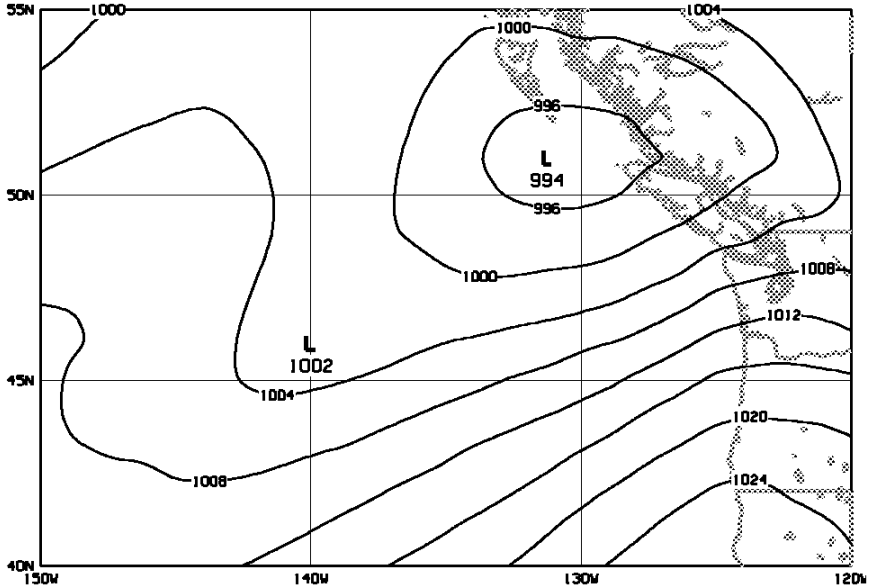

slp
Southern Hemisphere
Anomaly Correlation
1.0
0.9
0.8
0.7
0.6
0
1
2
3
4
5
DAY
F15A1_D1 versus NCEP (avg of 13)
FVSSI04 versus NCEP (avg of 13)
FVSSI06 versus NCEP (avg of 13)
FVSSI10 versus NCEP (avg of 13)


h500
Southern Hemisphere
Anomaly Correlation
1.0
0.9
0.8
0.7
0.6
0
1
2
3
4
5
DAY
F15A1_D1 versus NCEP (avg of 13)
FVSSI04 versus NCEP (avg of 13)
FVSSI06 versus NCEP (avg of 13)
FVSSI10 versus NCEP (avg of 13)

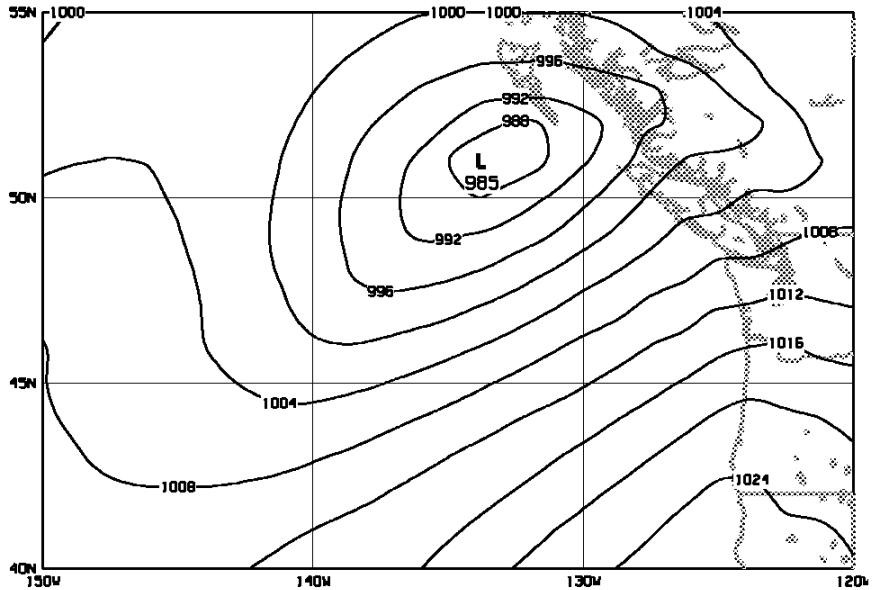

Global Extratropical Cyclone Forecast Error
From 11 Five-day FVSSI Forecasts
CON = Control
CLR1 = Control+clear AIRS (40S-40N)
CLR2 = Control+clear AIRS (global)
PC = Control+partly cloudy AIRS (global)
Position Error (km)
Magnitude Error (hPa)
350
325
300
275
250
4.5
4
3.5
3.0
CON
CLR1
CLR2
PC
CON
CLR1
CLR2
PC
Position Error
Magnitude Error

# Impact of AIRS on 72hr Forecast of Sea Level Pressure

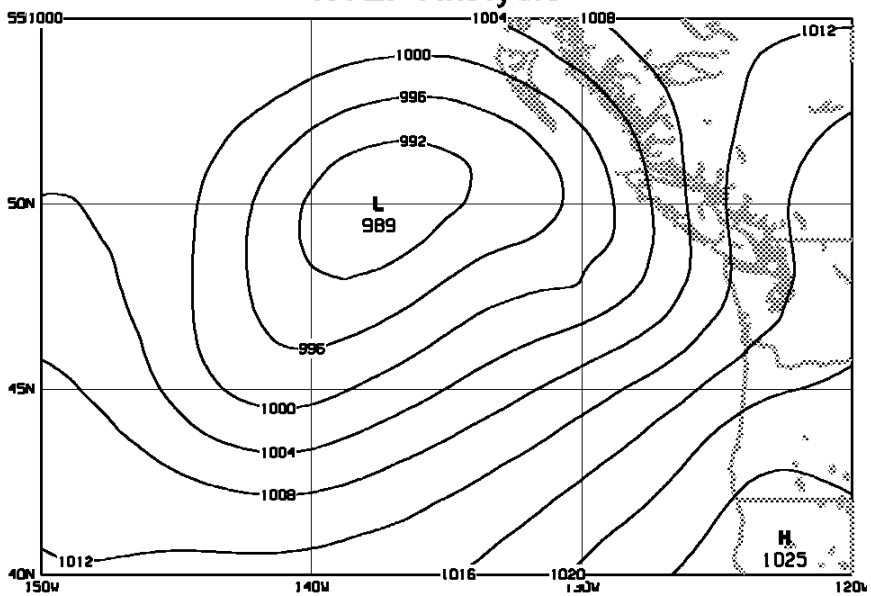
## Control Forecast




## AIRS Forecast




## NCEP Analysis




January 31, 2003 00Z

# SUMMARY

Global AIRS temperature profiles, in up to 80% cloud cover, approach required accuracy

Results degrade only slowly with increasing cloud cover

Assimilation experiments using AIRS temperature retrievals over ocean show:

- 8 hour improvement in 5-day Southern Hemisphere extratropics forecast skill
- Global improvement in 5-day forecast of cyclone position and intensity
- Addition of retrievals in partially cloudy conditions further improves forecasts

International TOVS Study Conference, 13th, TOVS-13, Sainte Adele, Quebec, Canada, 29 October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.