

Preliminary Results for Retrievals Using GFS Forecast as First Guess

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Joel Susskind and John Blaisdell

Sounder Research Team, GSFC

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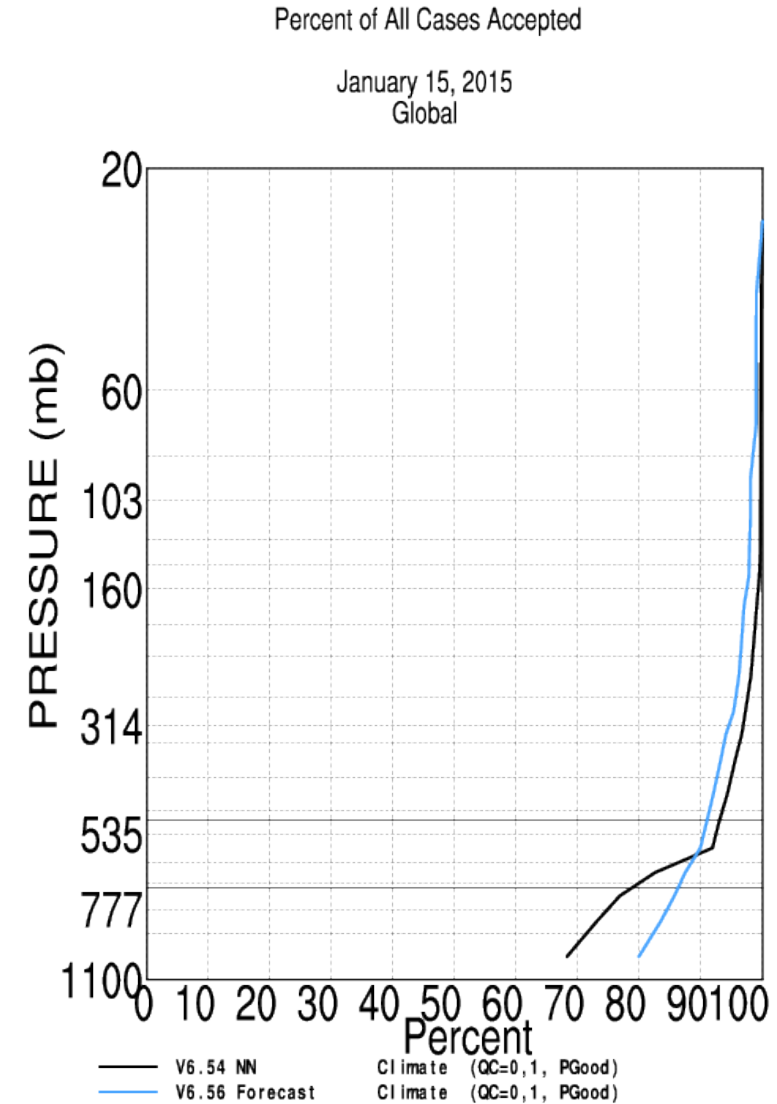
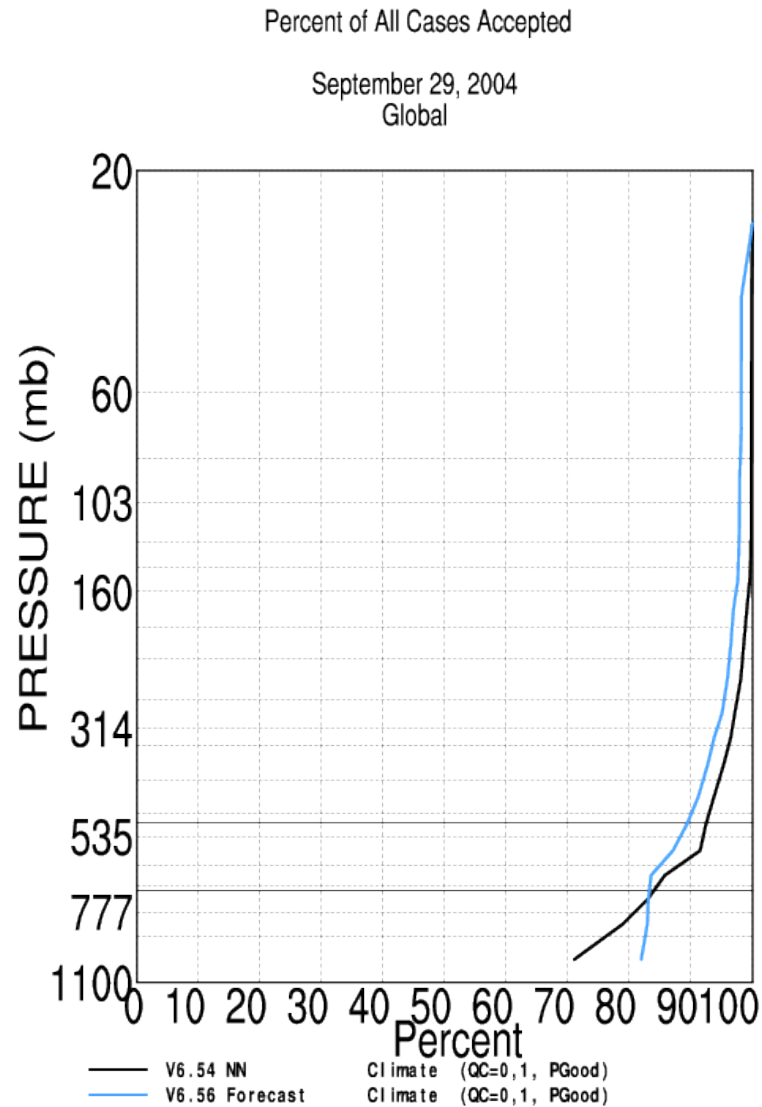


Experiments Run

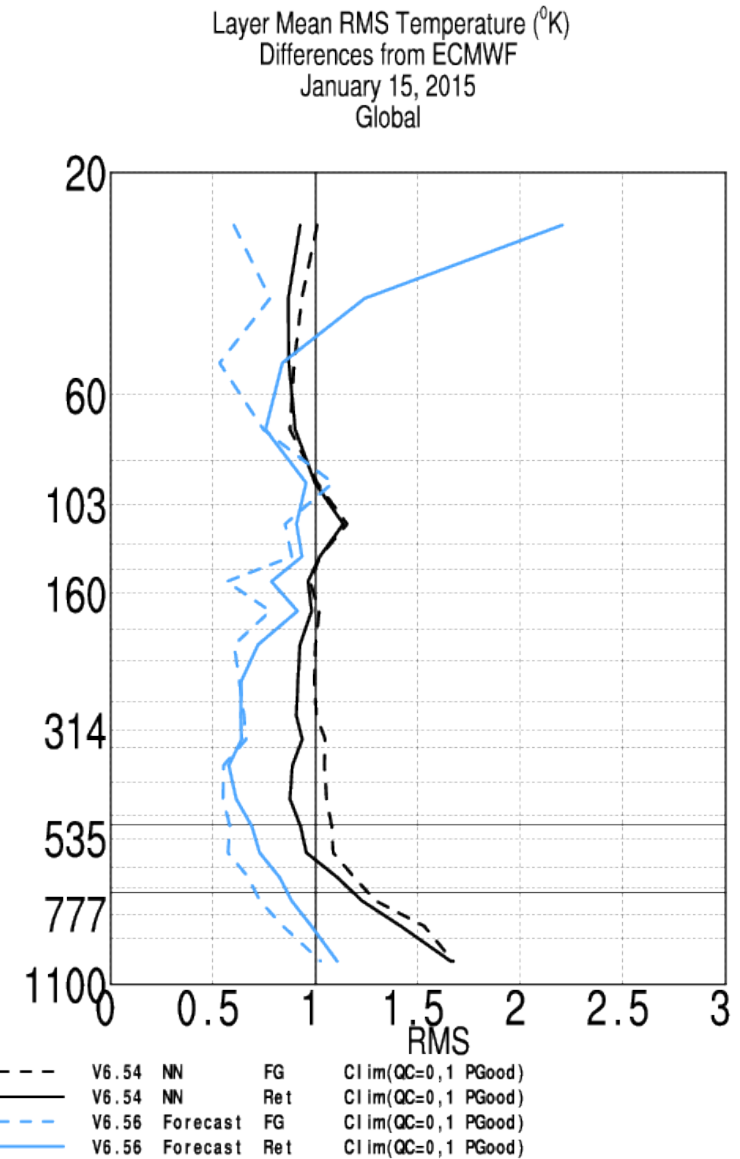
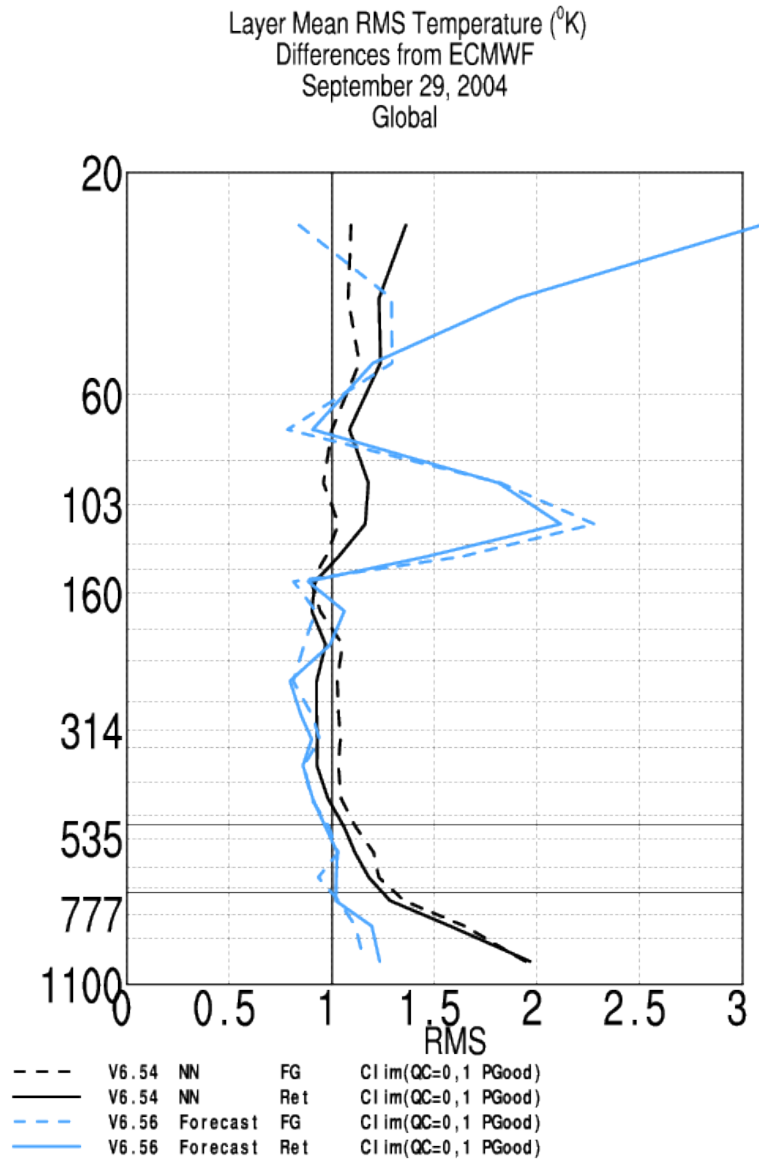
- Four days of retrievals in different years were performed using both a Neural Network first guess and also using the GFS forecast temperature profile, water vapor profile, and surface temperature as the first guess
- Yield and temperature and water profile plots for days early and late in the AIRS mission follow
- Yield is higher near the surface for forecast based retrievals
- Statistical comparisons show that forecast based retrieval temperature RMS differences from ECMWF are smaller than those of the Neural Net based system. AIRS retrievals improve over the Neural Net but degrade the forecast
- Statistical comparisons with ECMWF show that the bias structure of the forecast guess retrievals varies with time during the AIRS mission much more than those of the Neural Network based retrievals for both temperature and water vapor profiles



Yield of Temperature and Water Vapor Retrievals



Temperature Profile RMS Differences from ECMWF

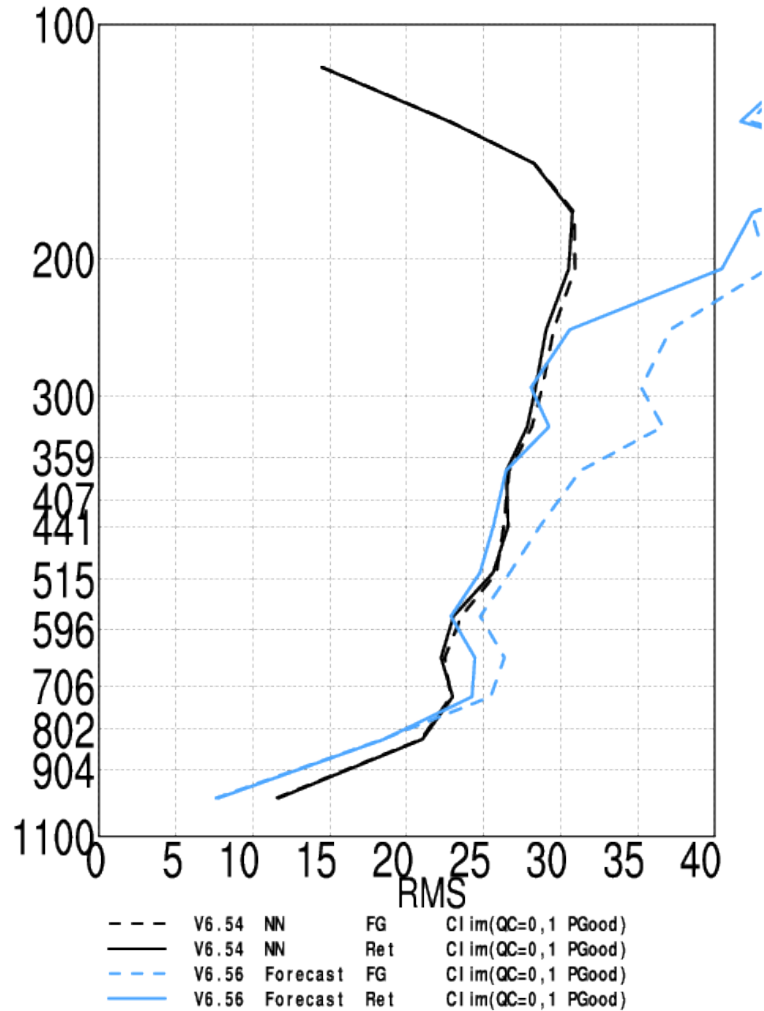


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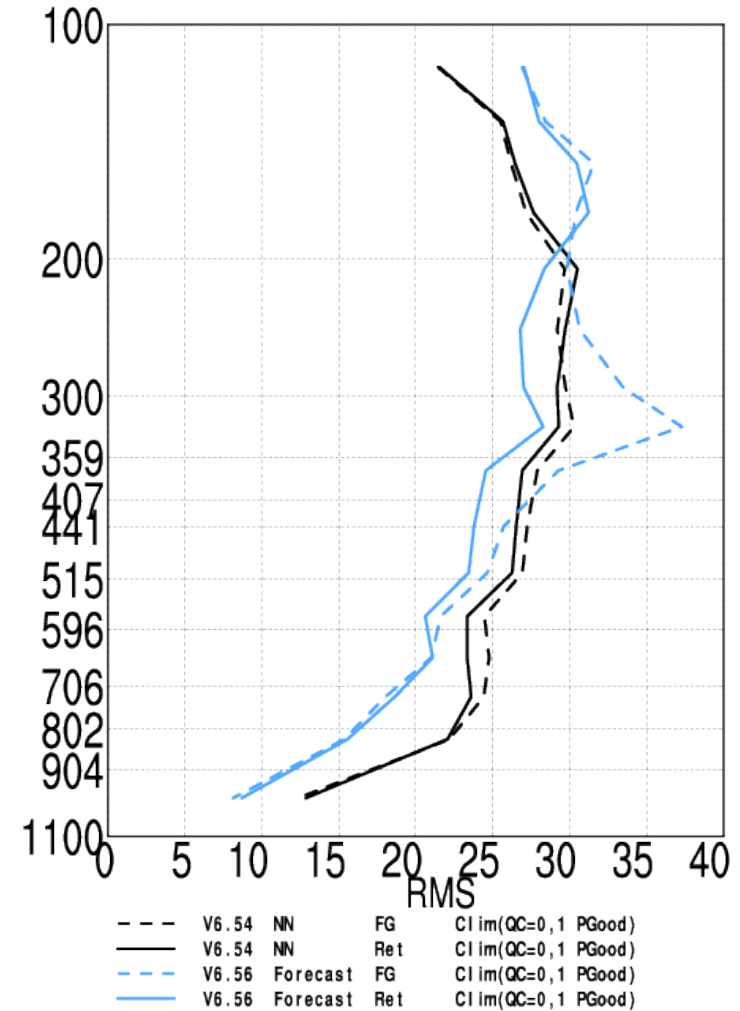


Water Profile RMS % Difference from ECMWF

1 Km Layer Precipitable Water RMS
% Differences from ECMWF
September 29, 2004
Global



1 Km Layer Precipitable Water RMS
% Differences from ECMWF
January 15, 2015
Global

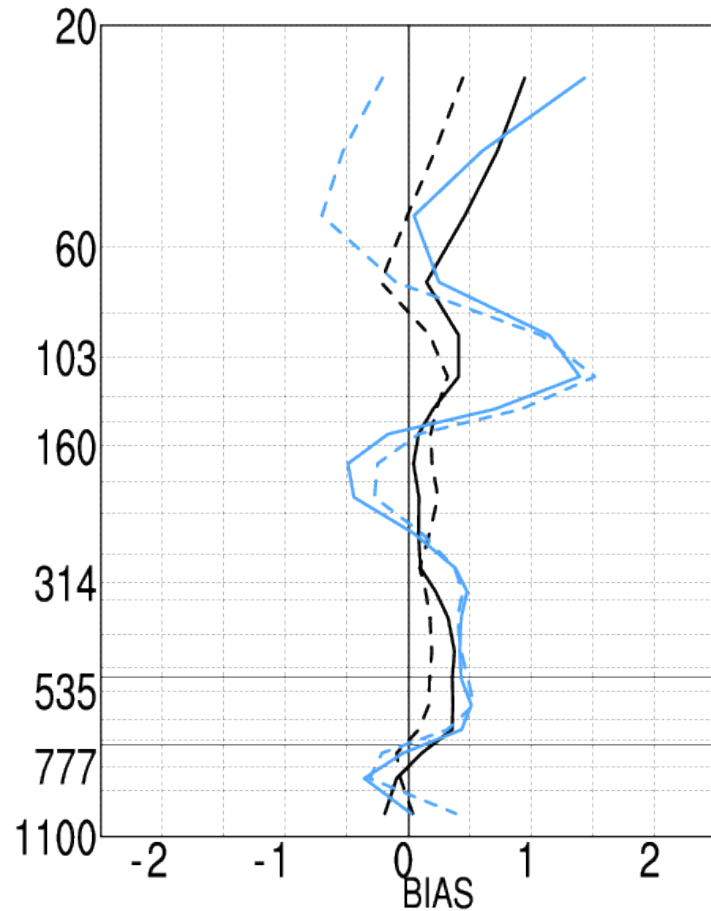


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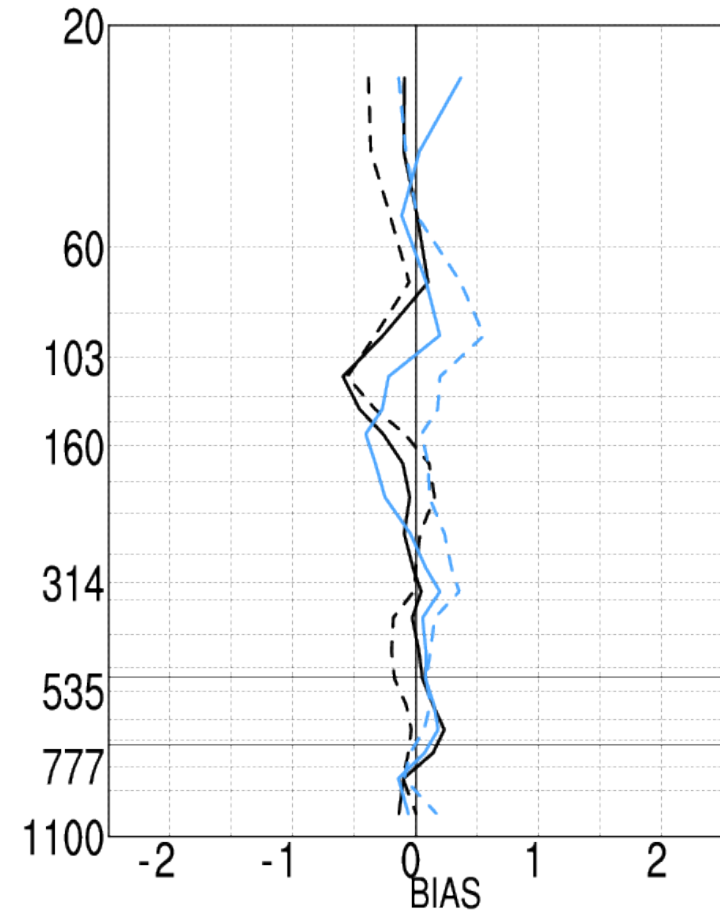
Temperature Profile Bias from ECMWF

Layer Mean Bias Temperature ($^{\circ}\text{K}$)
Differences from ECMWF
September 29, 2004
Global



-- --	V6.54	NN	FG	Clim(QC=0,1 PGood)
— —	V6.54	NN	Ret	Clim(QC=0,1 PGood)
-- --	V6.56	Forecast	FG	Clim(QC=0,1 PGood)
— —	V6.56	Forecast	Ret	Clim(QC=0,1 PGood)

Layer Mean Bias Temperature ($^{\circ}\text{K}$)
Differences from ECMWF
January 15, 2015
Global



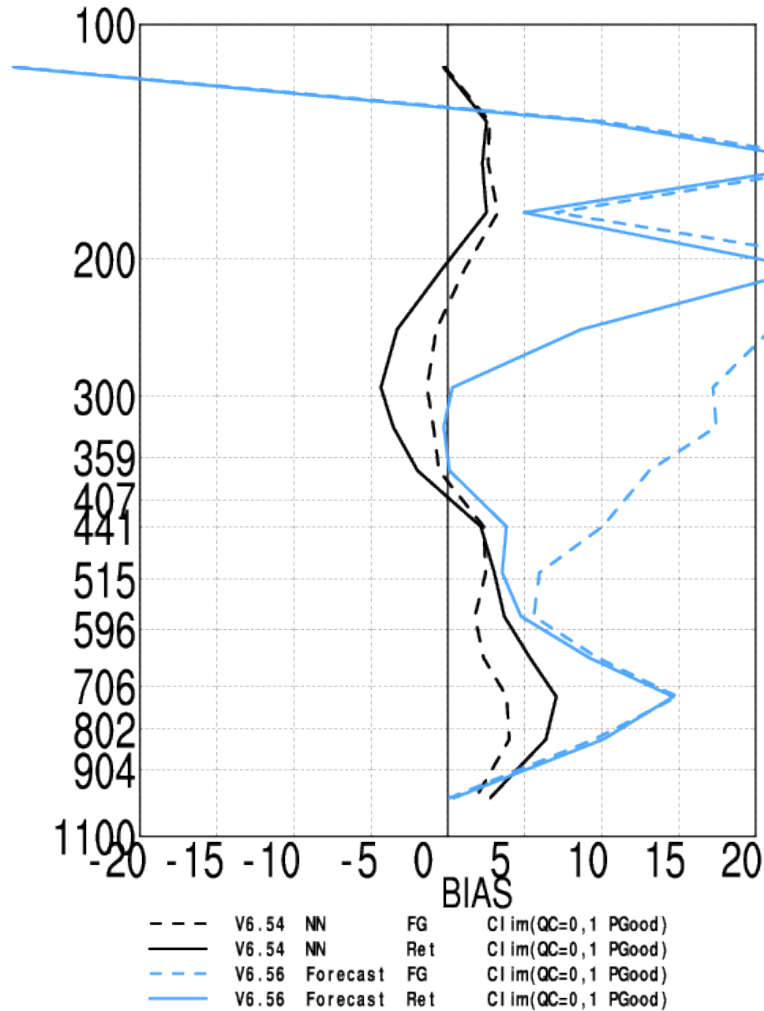
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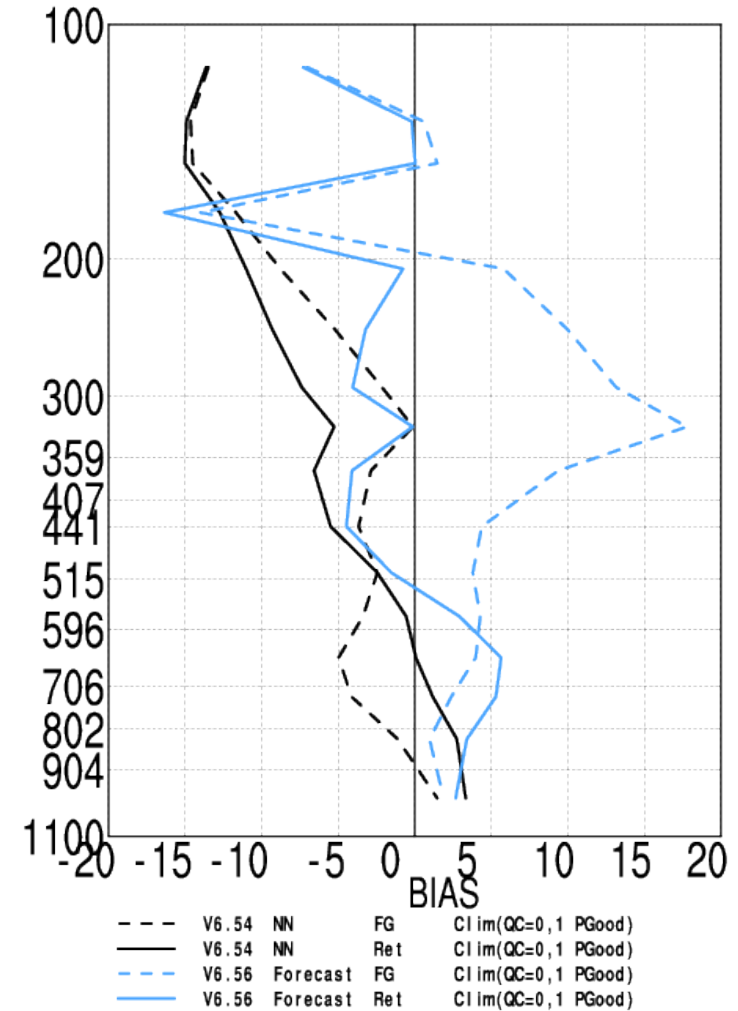


Water Vapor Profile % Bias from ECMWF

1 Km Layer Precipitable Water BIAS
% Differences from ECMWF
September 29, 2004
Global



1 Km Layer Precipitable Water BIAS
% Differences from ECMWF
January 15, 2015
Global



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Concerns

- The previous plots show that neural net based retrieval biases are relatively stable in time, whereas the forecast based bias structure is very different in 2004 and 2015. This type of result can lead to spurious trends in retrieved products that will be both misleading and incorrect
- This might be a result of bias characteristics of a model/analysis system changing over time as different types of input data are added or eliminated. This will introduce discontinuities in the bias structure of the first guess, and consequently of the retrievals, over time.



A More General Climate Related Concern

- **Experience using Neural Net Initial Guess**

- Version 6 results depend on training details, but depend only on AIRS observations
- AIRS Version 6 products have proven to be very useful to study climate phenomena related to trends, anomaly time series, and El Niño correlations, and also to cross validate analogous products using totally independent sources

- **Concerns using a Model/Analysis Initial Guess**

- AIRS may not be contributing much additional information to that of the guess
- AIRS retrievals using an analysis-based guess will not generate products that are totally independent of other data sources
- Climate related findings will depend on which model or analysis is used



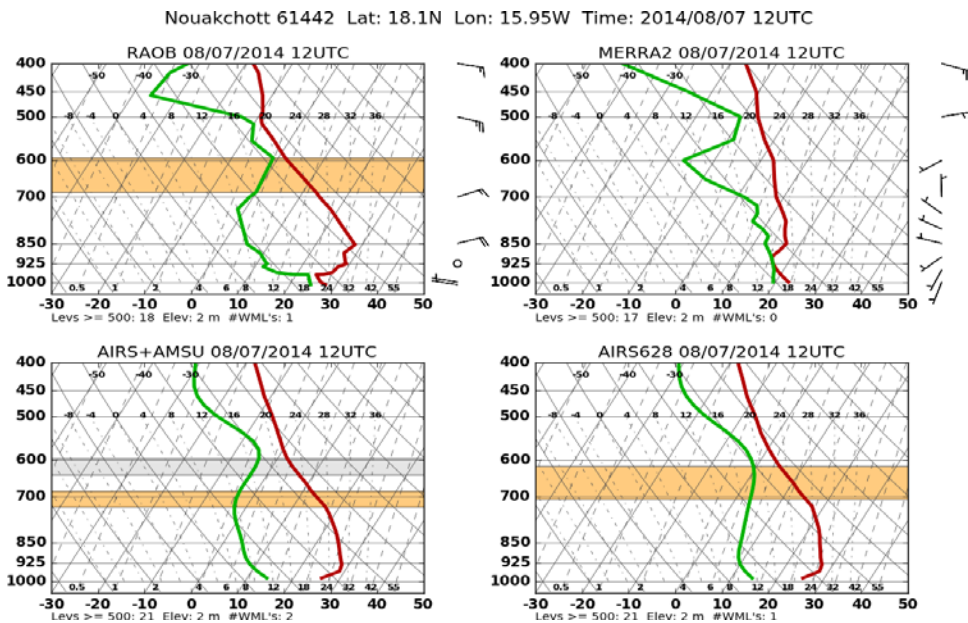
Importance of Having Independent Data Sets to Study Climate Processes

- Susskind research emphasizes comparing and validating AIRS multiyear data sets with other independent data sets
- J. Susskind, G. Schmidt, J. Lee, and L. Iredell, 2018, “Recent Global Warming as Confirmed by AIRS,” submitted to GRL
 - This paper shows that 15 years of AIRS Version-6 monthly mean surface skin temperature data sets on a 1x1 degree spatial grid are consistent with, and better than, those using only in-situ observations. This paper would not be meaningful if AIRS retrievals used in-situ surface skin temperature measurements.
- J. Susskind, J. Lee, L. Iredell, and N. Loeb, 2018, “Diurnal Differences Between AIRS and CERES OLR Climatologies and OLR Anomaly Time Series,” submitted to JGR
 - This paper shows that AIRS Version 6 multi-year OLR climatologies and anomaly time series are highly consistent, on a 1x1 degree spatial grid, with those of the totally independent CERES EBAF Edition 4 data set. This paper validates each OLR data set and also explains interannual variability of OLR on this spatial scale in terms of variability of AIRS retrieved products that depend only on AIRS observations.



Importance of Generating AIRS Products Which Are Independent of an Analysis - I

Analysis of the lower to mid-troposphere: **The Saharan Air Layer** (Mohr)

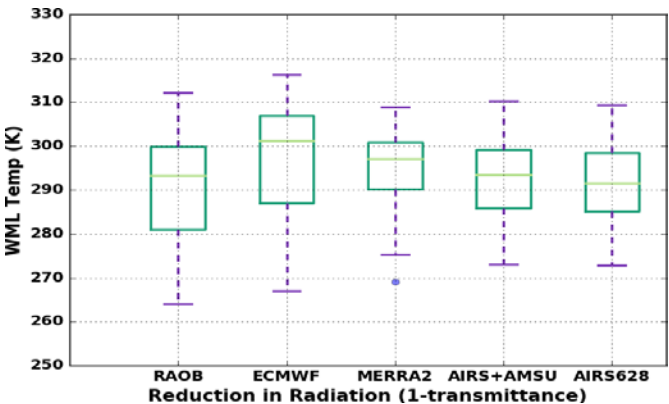


The intense surface heating and strong, dry convection occurring over hot deserts create **well-mixed layers (WML)** of warm, dry, and dusty air of nearly constant water vapor mixing ratio. A WML created by/sourced from the Sahara Desert is called the *Saharan Air Layer*.

Using a WML detection algorithm (Nicholls and Mohr 2018) on model and AIRS products (V6.0 and 6.28) vs. radiosonde data from a network of 52 synoptic stations across North and West Africa, WMLs in model products had greater biases in temperature (too warm) and humidity (too much) in analyzed WMLs.

The AIRS products more frequently captured the general structure of the 950-500 hPa profile than the model products (e.g., Nouakchott, Mauritania 8/7/14)

WML-mean potential temperature at 12Z, 2003-2014.



Operational GCMs are still incapable of representing the complex scale interactions (cloud to mesoscale to synoptic scale) responsible for the lower to mid-tropospheric structure in northern Africa (e.g., Garcia-Carreras et al. 2013; Redl et al. 2016; Hannak et al. 2017) with the most significant differences among models occurring below 600 hPa where the majority of convection takes place (e.g., Roberts et al. 2015; Vergados et al. 2018).

A product class from a NN-based retrieval is less likely to produce daily structure and climatological statistics biased by model physics.



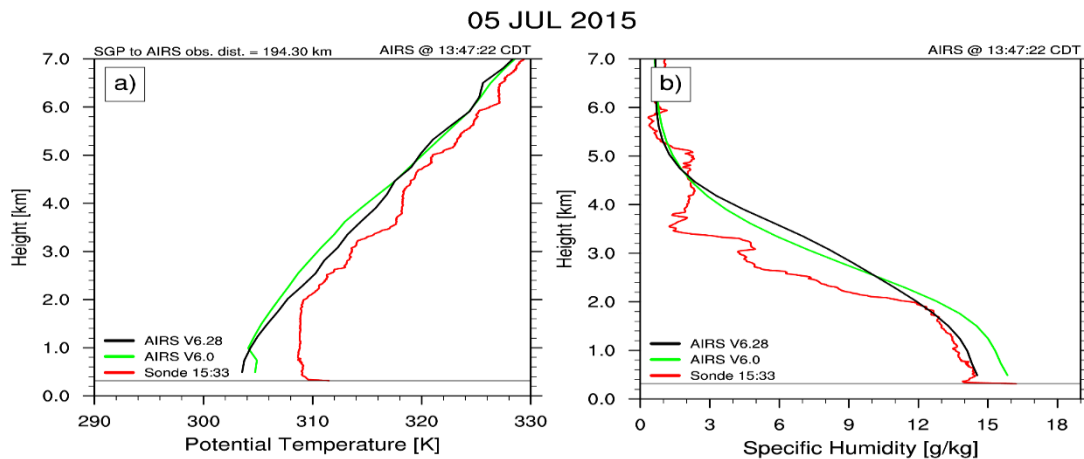
Importance of Generating AIRS Products Which Are Independent of an Analysis II

Boundary Layer (Santanello)

- Per the 2017 DS, there is an established and growing need for **routine PBL measurements** (i.e. thermodynamic profiles) for a range of applications:

- Hydrology & Ecology
- Clouds & Convection
- Aerosol, Pollution & Chemistry
- Land-Atmosphere Interactions & Coupling
- PBL turbulence & LES Model Development

**Weather &
Climate
Prediction and
Support of
Extremes**



- Independent observations of PBL thermodynamics are necessary for the above applications and model evaluation, development, and assimilation.

- AIRS-based PBL profile retrievals are inherently challenged by limited vertical resolution in lower troposphere.

- NN-based first guess for profile retrieval at least retains independent, observed radiance information from the PBL.
- Model-based first guess produces PBL thermodynamics and vertical structure as a function of model layers and physics (biased).

- Assessment of hyperspectral IR for PBL retrieval and the potential impact of spatial/temporal advancements in IR sounding in response to the DS should not be performed with strong model dependencies.



Improvements Since Version 6

SRT AIRS Version 6.54 NN has significant improvements since Version 6 which should make AIRS multi-year climate data sets even better

- Version 6.54 NN corrects a spurious Version 6 diurnal total precipitable water difference. This feature should be corrected in a new data set as soon as possible
- Version 6.54 NN AIRS-Only products over ice and snow are much improved over Version 6 AIRS-Only. This will make the multiyear skin temperature data set even better
- Version 6.54 NN AIRS-Only total ozone now matches that of OMPS very well where the data is in common, including observations in the ozone hole. AIRS generates ozone products in polar winter, and can depict the onset of the ozone hole earlier in August than observable by UV instruments



Different Data Sets for Different Purposes

- The Sounder Continuity Product is designed for continuity across instruments
 - Starts with AIRS/AMSU and transitions to CrIS/ATMS
 - NUCAPS/CLIMCAPS is such a product with a large scientific user community
- Version 6.54 NN AIRS-Only has a different purpose
 - Will allow for a 20+ year model-independent AIRS data set to study climate processes
 - Makes all the AIRS data available to the scientific community
 - Currently ready for testing and optimization on an extended data set

Recommendation

- AIRS Version 7 should be a finalized form of AIRS Version 6.54 NN AIRS-Only
 - Version 7 could go into production in the near future following testing
 - It would be a separate data set from CLIMCAPS, serving a different user community

