The NOAA/NESDIS/STAR Long Term Strategy of Environmental Data Records from Hyper Spectral Sounders: a cross-comparison among the AIRS, IASI and CrIS processing systems

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Abstract

Building on a 30-year relationship, NOAA and EUMETSAT maintain a long-term cooperative agreement, ensuring continued space-based weather forecast and climate monitoring. NOAA and EUMETSAT operate a joint polar satellite system, where EUMETSAT's Metop satellites fly in the mid-morning orbit and US satellites fly in the afternoon orbit. Scope of this talk is a cross-comparison among the AIRS/AMSU, IASI/AMSU/MHS and CrIS/ATMS retrieval data records using the NOAA/NESDIS/STAR hyper spectral retrieval algorithm.

1. Introduction

Since February 2013, NOAA/NESDIS/OSPO has been running three hyper spectral sounding product processing systems: 1) the Atmospheric InfraRed Sounder/Advanced Microwave Sounding Unit (AIRS/AMSU) retrieval product processing system, which has been running in near-real time since 2002; 2) the Infrared Atmospheric Sounder Interferometer/ Advanced Microwave Sounding Unit/Microwave Humidity Sounder (IASI/AMSU/MHS) NOAA unique cloud-cleared radiances and trace gas product processing system, which has been running operationally since 2008; and 3) the NOAA Unique Cross-track Infrared Sounder/ Advanced Technology Microwave Sounder (CrIS/ATMS) processing system (NUCAPS), which has become operational in the Fall of 2013. The long term strategy of NOAA/NESDIS will also involve the operational processing of the future JPSS and MetOp II and III missions, spanning a total period of ~30 years of hyper spectral remote sounding data processing.

The NOAA/NESDIS/STAR processing system is a modular architecture that was specifically designed to be compatible with multiple instruments: the same retrieval algorithm and the same underlying spectroscopy are currently used to process AIRS, IASI and CrIS data (Figure 1). This property is of fundamental importance in guaranteeing homogeneity across the multi-platform integrated dataset of retrieved Environmental Data Records. The CrIS instrument was launched in October 2011 and will ensure the continuity of the afternoon orbit sounding for the next decade in replacement of the AIRS instrument. The ongoing overlapping period between AIRS and CrIS will guarantee the inter-calibration between the three instruments. The combined sounding geometry of these three hyper spectral instruments (AIRS and CrIS have a 1:30pm

equator crossing time; IASI has a 9:30 am equator crossing time) and the employment of the same retrieval methodology will provide an unprecedented uniform and long-term integrated database of six global atmospheric measurements per day.

Scope of this talk is a cross-comparison among the AIRS/AMSU, IASI/AMSU/MHS and CrIS/ATMS retrieval data records using the NOAA/NESDIS/STAR hyper spectral retrieval algorithm. The full suite of retrieval products include: 1) temperature, 2) water vapor, 3) cloud cleared radiances, 4) cloud parameters, 5) trace gases (O3, CO, CH4, CO2, N2O, HNO3, SO2).For the scope of this paper, we will perform a test case study of temperature, water vapor and carbon monoxide retrievals.

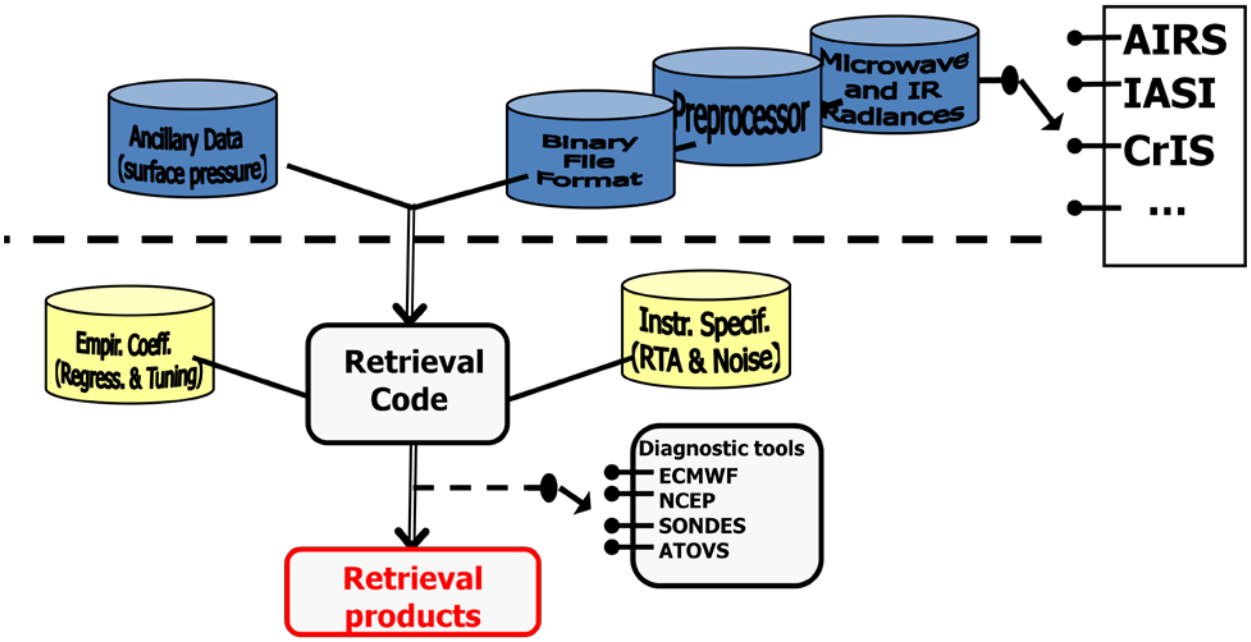

Figure 1. Modular retrieval architecture of the NOAA Operational Hyper Spectral Retrieval Algorithm

2. Temperature and Water Vapor Retrieval Comparisons

Figure 2 and 3 show a comparison of a global retrieval map of temperature and water vapor from January 2013 from the IASI (upper right), CrIS (bottom left) and AIRS (bottom right) systems. The top left panel indicate the limited yield of a clear sky only retrieval (~5%) compared to a cloud-clearing base algorithm whose acceptance yield generally corresponds to 70% daily.

Figure 4 is a global ocean night RMS retrieval statistics for temperature (left) and water vapor (right). Red curve is NUCAPS, blue is the NASA operational AIRS version 6 and cyan is the NOAA AIRS system. Dashed lines show first guess results.
Red vertical bars indicate the JPSS project mission requirements. After only one year in orbit, not only NUCAPS temperature and water vapor RMS statistical performance fully meets specifications but is also comparable to AIRS v6 and NOAA AIRS (10 year maturity product).

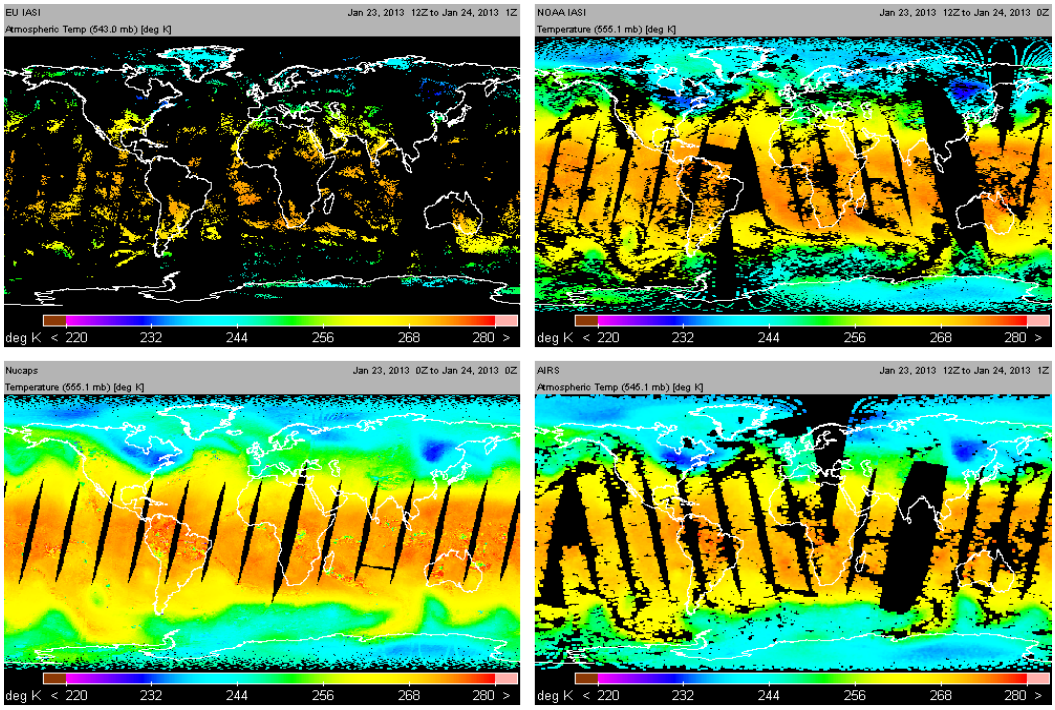

Figure 2. Global Temperature retrieval map from January 22, 2013 from IASI (top right), CrIS (bottom left) and AIRS (bottom right) using the cloud clearing module. Top left is a IASI clear sky only retrieval ensemble.

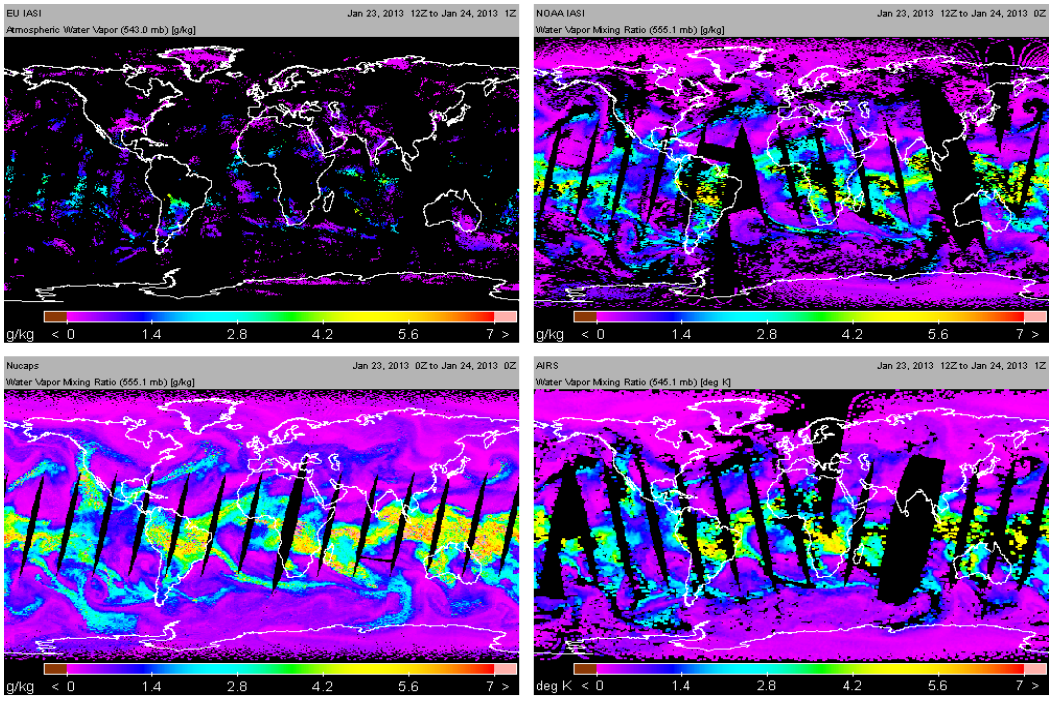

Figure 3. Same as in figure 2 but for water vapor at 500mb.

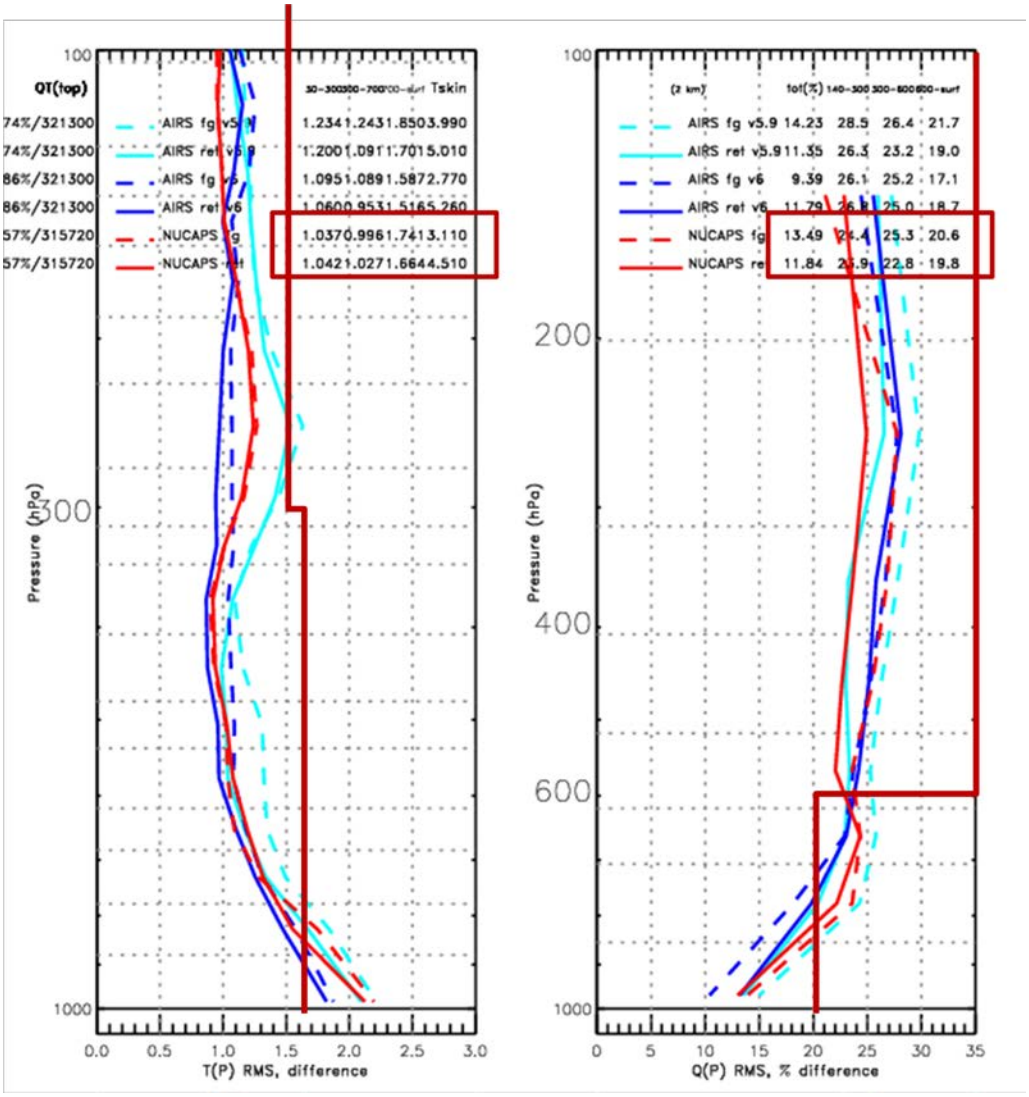

Figure 4. global ocean night RMS retrieval statistics for temperature (left) and water vapor (right). Red curve is NUCAPS, blue is the NASA operational AIRS version 6 and cyan is the NOAA AIRS system. Dashed lines show first guess results.

Figure 5 is a map of conventional radiosonde collocations to the AQUA, NPP and MetOp A satellites falling within a temporal and spatial range of 6-hr and 100-km respectively. In these collocations all AIRS, IASI and NUCAPS passed their own quality controls such that the sample used in the validation of Figure 6 and 7 is common to all three systems. “13859” denotes the number of total collocations (including the ones with “rejected” satellites or windows beyond 3 hr and 100 km), “605” means the number of collocations meeting the criteria and are used for the validation, and “175” the number of raob stations that contribute to 605 collocations. Solid line s indicate BIAS statistics, dash lines indicate RMS statistics. For both temperature (Figure 6) and water vapor (Figure 7), the three systems, AIRS (green curves), IASI (brown curves) and NUCAPS (blue curves), show comparable results consistently to what has been shown in Figure 4. This result proves the global stability of the three systems also under a land-dominated and independent validation data set as the one illustrated in Figure 5.

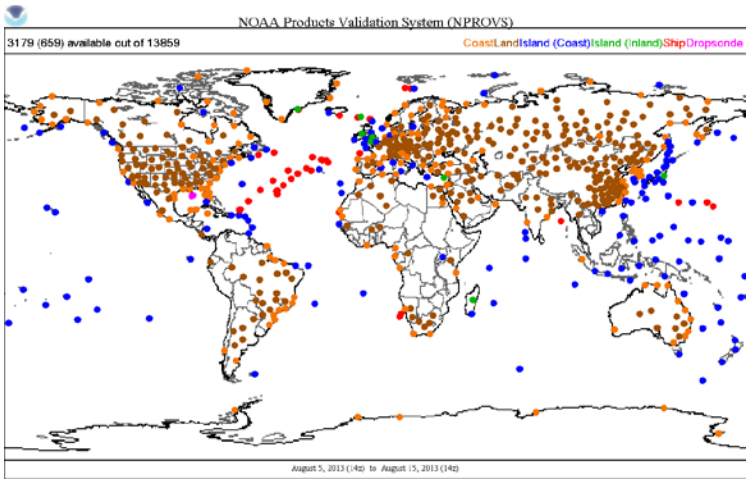

Figure 5 Map of conventional radiosondes collocated to IASI, AIRS and NUCAPS retrievals from August 5 to 15 2013. See text for details.

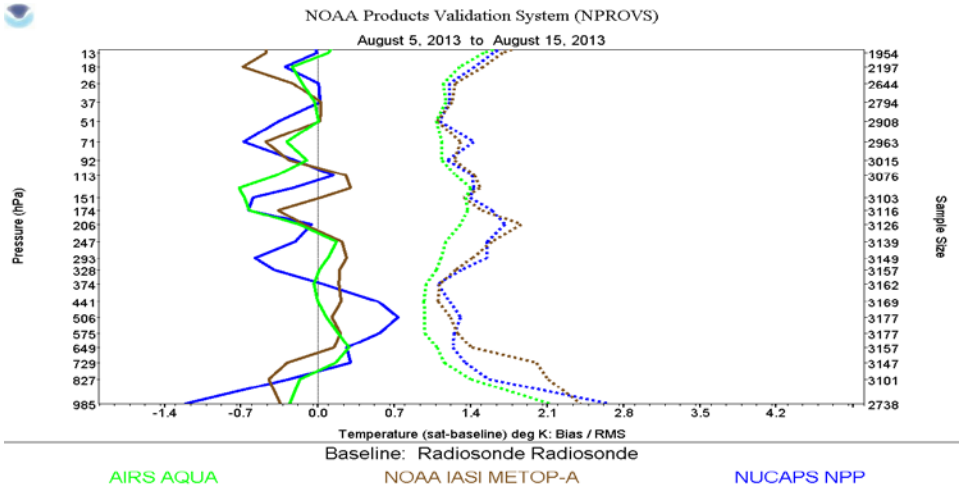

Figure 6 Temperature BIAS (Solid) and RMS (dashed) results. See text for details.

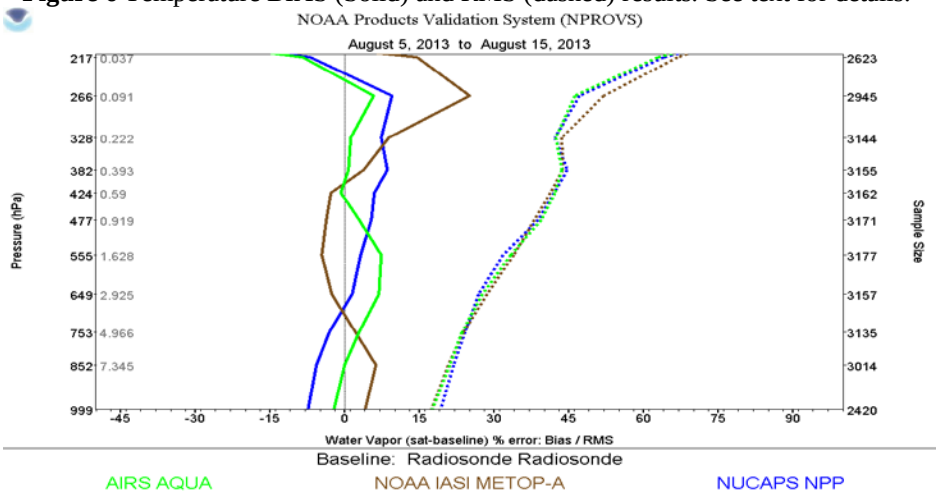

Figure 7 Water Vapor BIAS (Solid) and RMS (dashed) results. See text for details.

3. Conlcusions

After only one year in orbit, the NOAA Unique CrIS/ATMS Product System (NUCAPS) temperature and water vapor statistical performance is comparable to IASI and AIRS (11 and 7 year respectively maturity product). For both temperature and water vapor, AIRS, IASI and NUCAPS, show comparable results over different geophysical regimes and using independent validation data sets. This result proves the global stability of the NOAA Operational Hyper Spectral Retrieval Algorithm when operated across the three platforms.

Current studies involve the improvement of first guess, radiance bias correction, surface emissivity and cloud clearing to be applied consistently across multiple platforms. Ongoing dedicated cal/val field campaigns will be key to fully assess algorithm retrieval performance.