Intercomparisons between SSMI-POES-derived, *in situ*, and model-based Specific Humidity

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ABSTRACT

The upper ocean is of particular interest as the zone of oceanic and atmospheric energy exchanges. The transfer of latent and sensible heat at the air/sea interface has consequences for several key upper ocean features. In the initial planning for NPOESS, a net heat flux product was proposed with potential for application to numerical ocean prediction of near-surface processes. In anticipation of this development, the Naval Research Laboratory at Stennis Space Center, MS, implemented a near-real-time automated processing and quality control system for selected ocean surface parameters derived from remote sensing. The initial atmospheric parameter selected for development was specific humidity derived from the DMSP SSM/I and POES AMSU sensors, based on a recent set of specific humidity algorithms of Jackson, et al. (2006). The single-instrument algorithms were implemented for daily data feeds obtained from the NOAA Comprehensive Large Array-data Stewardship System (CLASS). The derived specific humidity values are processed through an automated data quality control routine that assigns a probability of error to each observation based on climatological or model-based background fields and variability. A 42-month dataset of match-ups with real-time in situ measurements was developed using ship and buoy observations obtained from the NOAA National Centers for Environmental Prediction. The match-ups were used to assess the bias and error characteristics of the remote sensing-derived specific humidity, in comparison with global atmospheric model fields.

Match-Up Criteria/ Algorithms Used

- The *in situ* observations were matched to microwave satellite observations using a time window of ± 3 hours
- The distances were limited down to 0.5°
- Surface pressure and the dew point temperature were used to calculate first the vapor pressure and then the Qa values for the *in situ* observations and the NOGAPS data
  - $V_p = 6.1078^{(7.5Td/(237.7+Td))}$
  - $Qa = 0.6228V_p/[P-(1-0.6228)V_p]$
- Microwave single-instrument satellite algorithms used were from Jackson, Wick, and Bates (2006)
  - $SSM/I\ Qa = -12.8597 + 0.35341Tb_{22V} - 0.21166Tb_{37V} - 0.05988Tb_{37H}$
  - $AMSU\ Qa = -34.6310 + 1.13815\ Tb_{52.8} + 0.22051Tb_{23.8} - 0.51428Tb_{50.3} - 0.66044Tb_{53.6}$

References

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3. Mo, T., 1999. "AMSU-A Antenna Pattern Corrections", IEEE Trans Geoscience and Remote Sensing, **37**, 103-112
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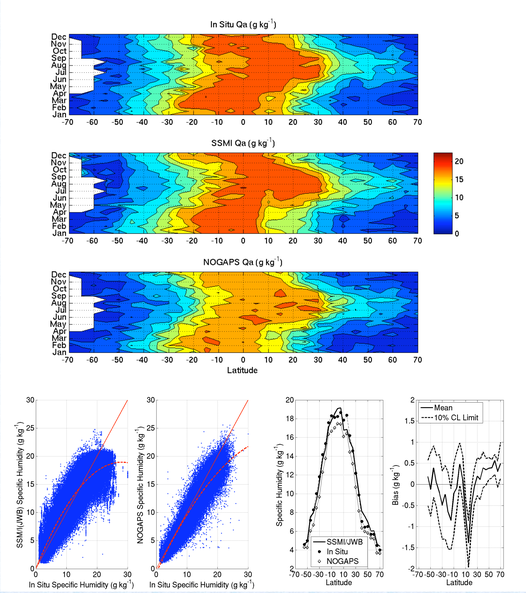
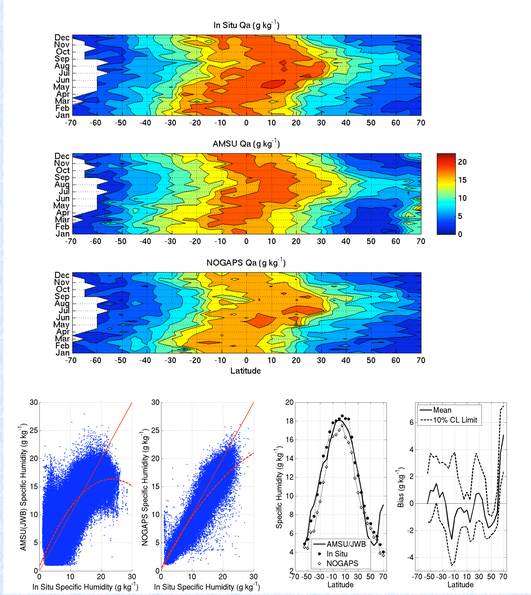


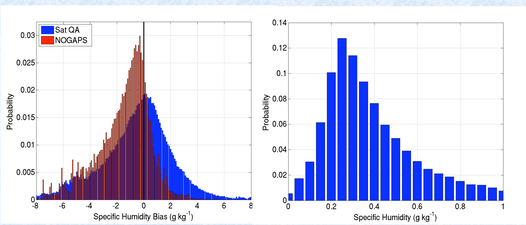


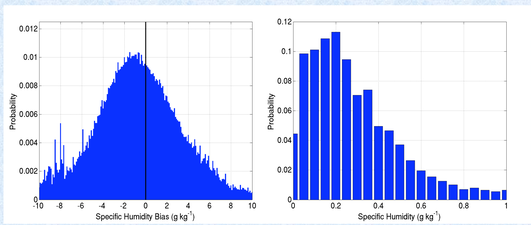
SSM/I and NOGAPS Distribution/Scatter of Observations

- SSMI-Qa and *in situ* values track well
- Some systematic low bias for NOGAPS-based Qa noted
- With the exception of a region from ~10°N to 20°N and latitudes greater than ~45°N, the SSM/I Qa values were not statistically different from the *in situ* values at the 90% confidence limit
- The entire data set was resampled to randomly select no more than 500 observations for Qa values between 1 to 30 g kg^{-1}, using 1 g kg^{-1} bins
- Second order regression curves were added to show the tendencies for both the SSM/I and NOGAPS data
- The regression curve for the SSM/I Qa data set suggested that for specific humidity below 15 g kg^{-1}, there was a wet bias in the JWB algorithm and above 15 g kg^{-1}, there was a dry bias
- Saturation of Tb channels at high Qa values is suspected

AMSU and NOGAPS Distribution/Scatter of Observations

- Similar dry bias noted at high Qa values that was found in the SSM/I Qa values
- 90% confidence limits much larger than the SSM/I Qa confidence limits
- Only at high northern latitudes is the AMSU Qa statistically different than the *in situ* observations at a 90% confidence limit





SSM/I and NOGAPS Global Bias and Sampling Uncertainty

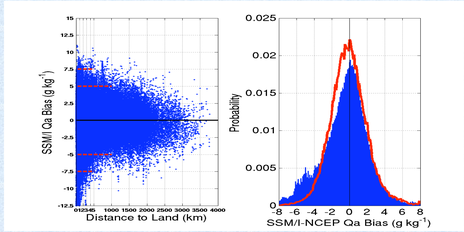
- A match-up distance of 0.25 degrees and a time differential of ten minutes was used to estimate the most probable value for the standard deviation
- The mode of σ between highly spatially and temporally correlated observations was 0.25 g kg^{-1}
- Cumulatively, 68% of the variability was at 0.42, with 90% of the observations having a variability of 0.82, and 99% of the observations having a variability of 1.94 g kg^{-1} or less
- The natural variability for the SSM/I data was characterized as 1.0 g kg^{-1}

	All Data	> 500 km
σ	3.1 g kg^{-1}	2.1 g kg^{-1}
μ	-0.82 g kg^{-1}	-0.11 g kg^{-1}
Mode	0.050 g kg^{-1}	0.050 g kg^{-1}

AMSU Global Bias and Sampling Uncertainty

- Most probable value for the standard deviation between spatially and temporally highly correlated observations is 0.2 g kg^{-1} (compare with SSM/I 0.25 g kg^{-1})
- AMSU Qa has a higher RMS error than SSM/I Qa

σ	4.2 g kg^{-1}
μ	-0.72 g kg^{-1}
Mode	-0.85 g kg^{-1}



Distance to Land Impacts on SSM/I Qa Bias

- Data was processed to be over water, but without regard to land
- Strong trend indicated that proximity to and increased the scatter the bias
- Noticeable out to 500 km as indicated by the dashed lines at ±7.5 g kg^{-1}

	All Data	> 500 km
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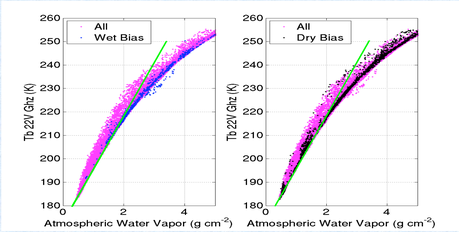
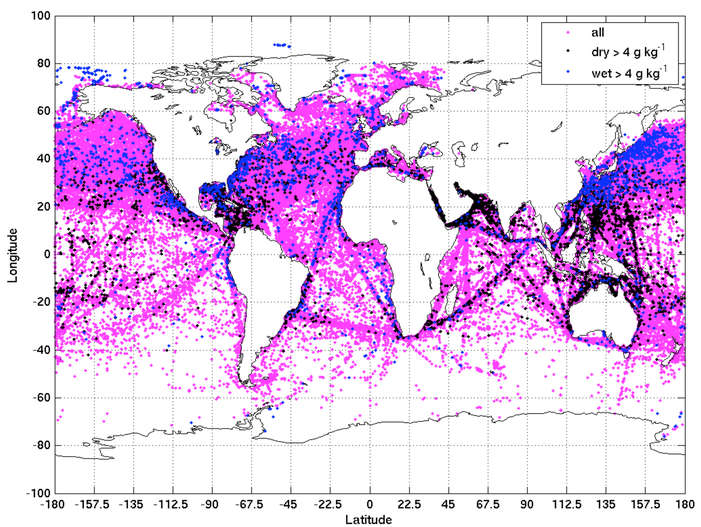


Dry Bias in SSM/I Values

- In the region between 10°N and 20°N, the SSM/I has a statistically significant dry bias
- Likely related to saturation of the 22 GHz channel, identified in Schlüssel and Emery (1990) in retrievals of atmospheric water vapor(w)
- The black/blue dots represent observations with a bias greater than 3.0 g kg^{-1}. The green lines were added for visual reference only
- Noticeable fall-off in the Tb_{22V} values in response to an increasing w



Distribution of Observations
January 2004-June 2007

Conclusions and Future Plans

- Both SSM/I and AMSU single sensor Qa have a dry bias at high values
- SSM/I sensor performance/algorithm has lower RMSE than the AMSU sensor/algorithm
- SSM/I Qa need to be carefully quality controlled near land
- The impact of using a blended SSM/I and NOGAPS Qa product for ocean model forcing will be evaluated using regional implementations of the Navy Coastal Ocean Model

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