Retrieval of Total Precipitable Water and Cloud Liquid Water Path from Jason-2 AMR Observations

Fuzhong Weng[1] , Wei Yu[1,2] , Ninghai Sun[1,3]

[1]NOAA/NESDIS/STAR, [2]Dell Inc. for NOAA, [3] IMSG Inc. for NOAA

1. Introduction

The operational AMSU water vapor and cloud algorithms combined with a linear mapping technique were used to retrieve total precipitable water and cloud liquid water from Jason-2 AMR's measurements for global unfrozen ocean environment under the Simultaneous Nadir Overpasses (SNO) condition. The linear mapped AMR algorithm is evaluated by comparing retrieved TPW and CLW with same quantities retrieved by AMSU-A and retrieved by CNES.

.

2. Objectives

- Create Jason-2 AMR TPW and CLW products.
- Provide a new tool to retrieval TPW and CLW for other microwave instruments with similar frequencies for satellite meteorology applications and climate study.

3. Linear Mapping between AMSU and AMR in SNO condition

- Dataset: entire Earth between 66.15 S to 66.15 N that is about global 95% unfrozen ocean environment.
- Inter-satellite calibration of AMSU-A and AMR radiometers using the SNO method.
- Linear mapping technique

○ For 2008 data: *Yamr = 1.0002Xamsu-a* (both at 23.8 GHz),

Yamr=0.9778Xamsu-a(AMR 34.0 GHz AMSU 31.4 GHz).

○For 2009 data: *Yamr = 0.9991Xamsu-a* (both at 23.8GHz)

Yamr = 1.0246Xamsu-a (AMR 34.0 GHz AMSU 31.4 GHz).

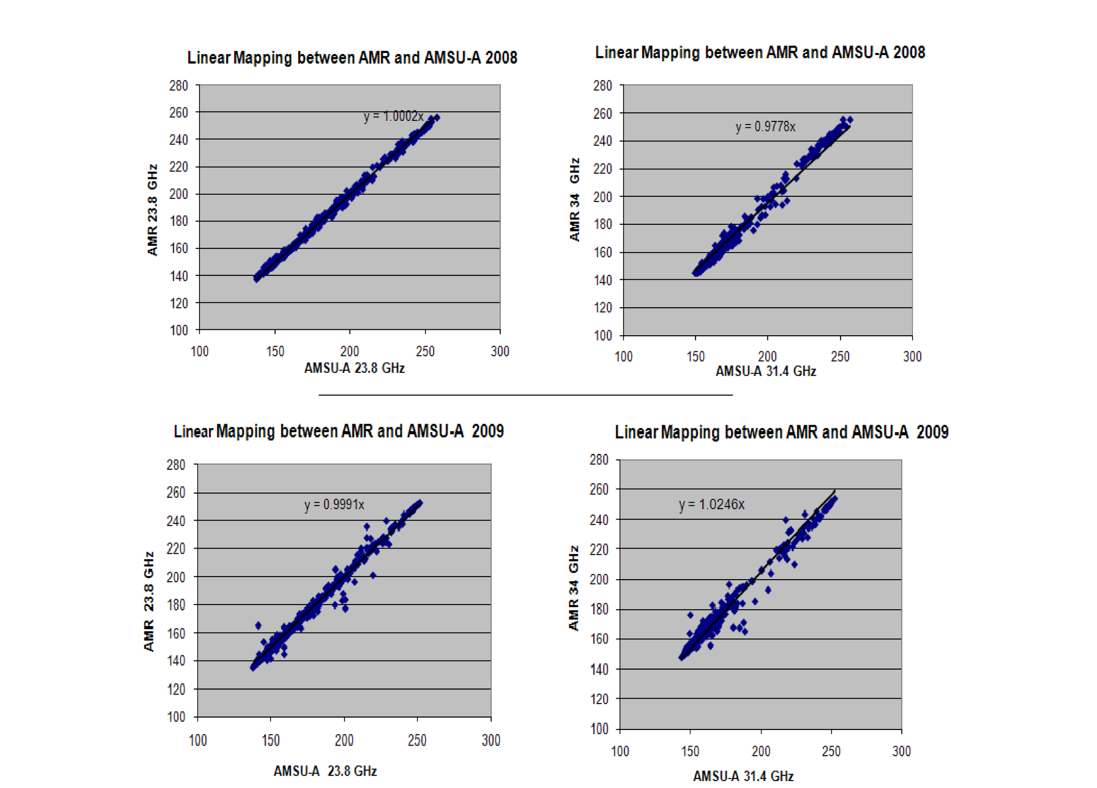

Figure 1 Linear Mapping between AMR and AMSU-A for 2008 and 2009

4. AMR Water Vapor and Cloud Liquid Water Retrievals

- AMSU-A Water Vapor and Cloud Algorithms

$$L = a_0\mu\,[\ln(T_s - TB_{31}) - a_1 \ln(T_s - TB_{23}) - a_2]$$

$$V = b_0\mu[\ln(T_s - TB_{31}) - b_1 \ln(T_s - TB_{23}) - b_2]$$

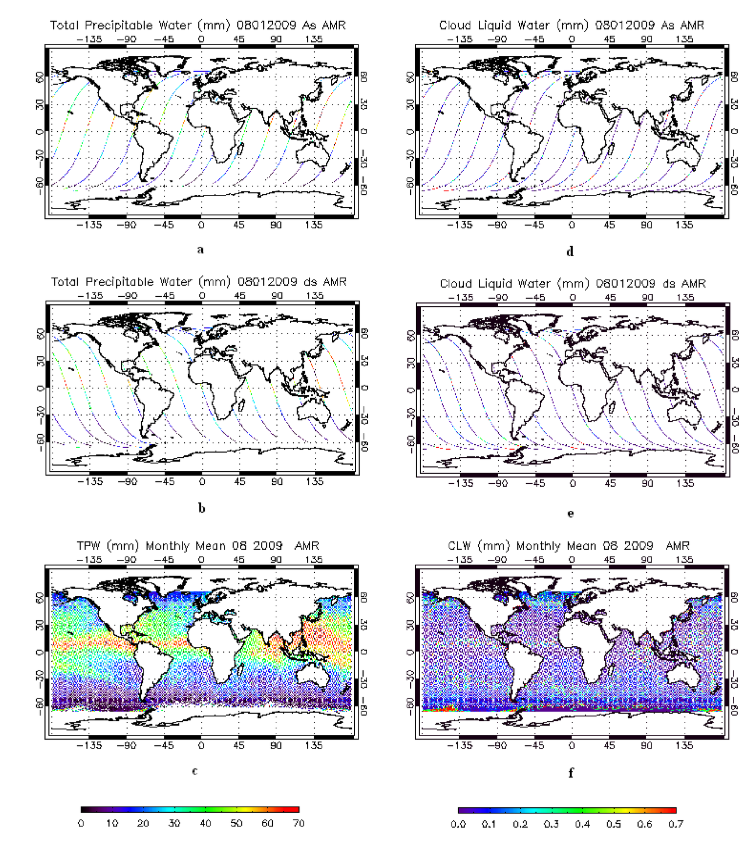

Figure 2 Daily and Monthly Mean Total Precipitable Water (mm) and Cloud Liquid Water (mm)

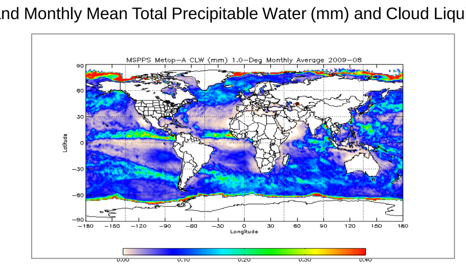

Figure 2a Metop-A CLW Monthly Average 200908

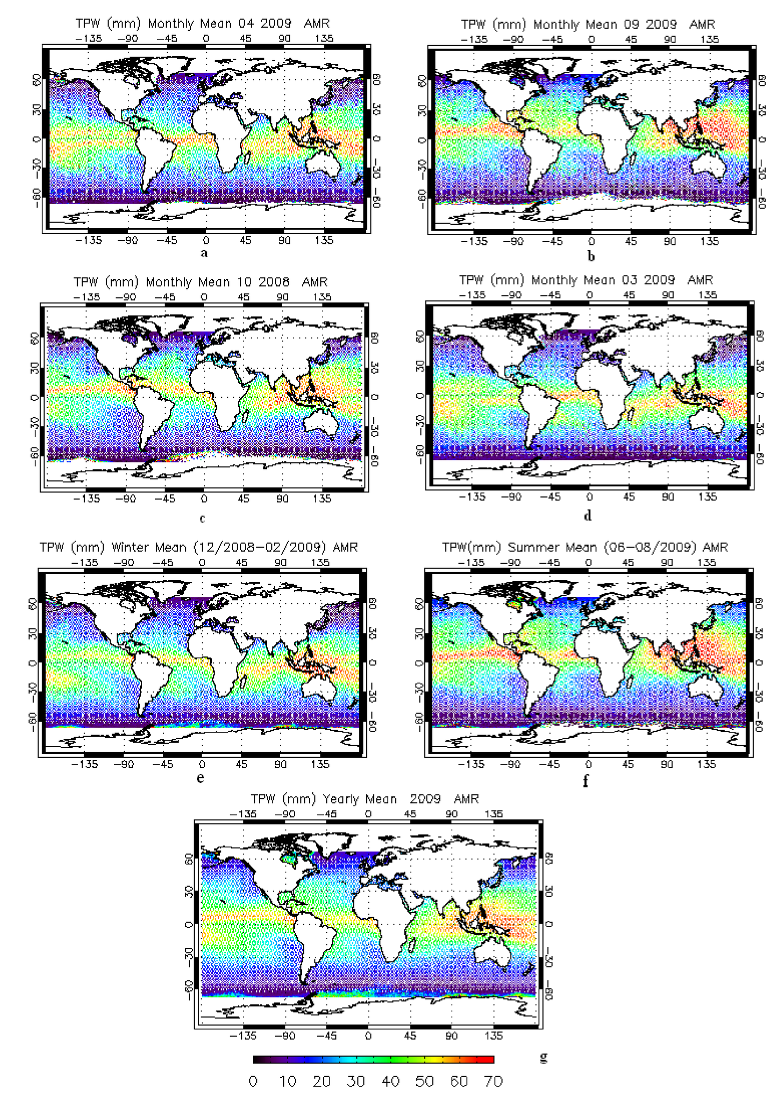

Figure 3 Monthly Seasonal and Yearly Mean Total Precipitable Water (TPW mm)

- Total Precipitable Water and Cloud Liquid Water Retrievals

AMR brightness temperatures based on mapping relations with correspondent auxiliary GDAS sea surface winds and sea surface temperature data were substituted into AMSU water vapor and cloud retrieval algorithm equations to get daily, monthly and yearly AMR total precipitable water and cloud liquid water.

5. Preliminary Results and AMR Linear Mapping Algorithm Performance

- Large TPW values near tropical region and small values near pole regions which reflect more water vapor with high evaporation, more clouds and precipitations in low latitudes and less water vapor with low evaporation, less clouds and precipitations in high latitudes.
- Large TPW values in red move northward slowly while its intensities get slightly stronger from April to September then move gradually southward with their intensities becoming weaker from October to March.
- More water vapor with high evaporation, more clouds and precipitation in summer than those in winter. There are more TPW in Hudson Bay in summer than in winter. The reddish and brighter areas along 66^o S are most likely caused by sea ice in those areas.
- Red color in CLW maps show large amount of cloud water and more convective clouds in those areas and blue and green show low to moderate amount cloud water or less cloud droplets in the columns from surface to top of the atmosphere in those areas. There are more CLW over Storm Tracks (North Atlantic, North Pacific), InterTropical Convergence Zone (ITCZ) and South Pacific Convergence Zone (SPCZ) and more sea ices showing in red and brighter along 66^o S which are consistent with CLW and sea ice pattern retrieved from AMSU-A. However, The CLW pattern in the monthly maps are not as obvious as those of TPW and not as clear as CLW pattern of AMSU-A as: 1) clouds are naturally spottier and not continuous in the atmosphere and in many places of the world there are no clouds with CLW values at zeros; 2) there are still gaps in the monthly averaged map due to Jason-2 satellite passing over the same point on the Earth's surface (to within one kilometer) every ten days.

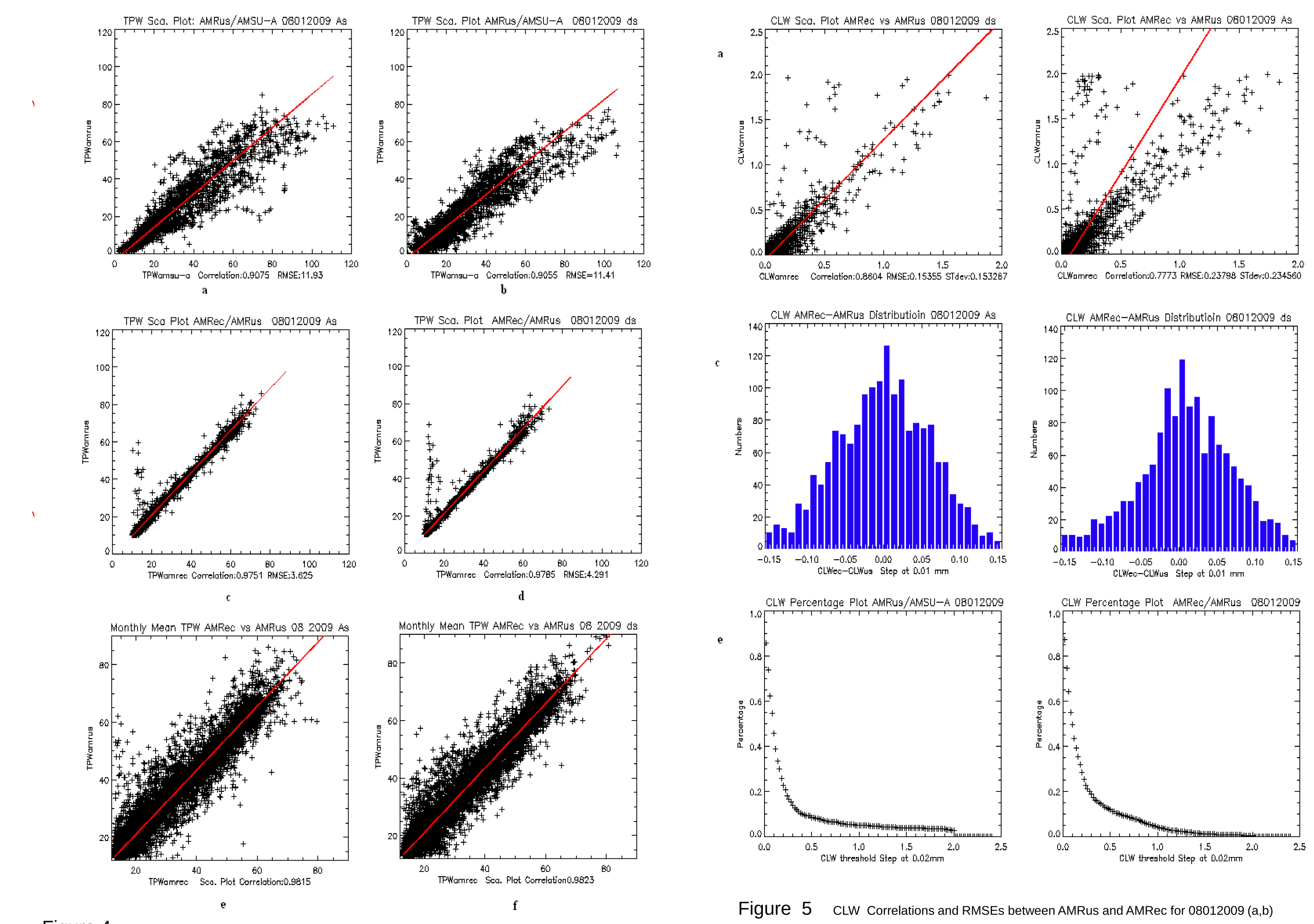

Figure 4 Daily TPW Correlations and RMSEs for 08012009: AMRus vs AMSU-A (a,b); AMRus vs AMRec (c,d) Monthly TPW Correlation between AMRus and AMRec for 08 2009 (e,f)

Figure 5 CLW Correlations and RMSEs between AMRus and AMRec for 08012009 (a,b) AMRec-AMRus CLW distribution for 08012009 (c,d) CLW percentage between AMRus and AMSU-A(e) and between AMRec and AMRus(f)

- TPW values are about 100 times those of CLW which demonstrates that water content in the column of atmosphere from surface to top is in the order of one hundred times larger in vapor form than in liquid form.
- The TPW correlations between our retrievals and those retrieved by CNES and between our retrievals and AMSU-A's retrieval are very good (0.91 to 0.98). The CLW correlation between our retrieval and CNES retrieval is good (0.78 to 0.86) and the CLW correlation between our retrieval to AMSU-A retrieval is scattered.
- The histogram indicates that a rough approximation of the CLWec subtracting CLWus number distribution is near the normal distribution with large numbers located around the center of the distributions.
- The CLW is also evaluated qualitatively by plotting cloud cover comparison between our linear mapping retrieval to AMSU-A retrievals and our linear mapping retrievals to CNES retrievals [Figure 5 e, f]. The X-axes is the cloud existence threshold from 0 to maximum CLW here at 2.5 mm. The Y-axes is the percentage of points where both retrievals are higher than the threshold with respect to all retrieved points.

6. Conclusion

The combination of the operational AMSU-A water vapor and cloud algorithms with a linear mapping technique under SNO condition is a simple but very efficient and practical retrieval method which can be easily adapted for use in other microwave instruments onboard satellites with similar frequencies in the application of CLW and TPW retrievals for weather and climate study and application**.**

References

•Cao, C., P. Ciren, M. Goldberg, F. Weng, 2005, Inter-satellite calibration of HIRS from 1980 to 2003 using the simultaneous nadir overpass (SNO) method for improved consistency and quality of climate data, resented at the ITSC14, Beijing, May 2005

•Grody, N., J. Zhao, R. Ferraro, F. Weng and R. Boers, 2001:Determination of precipitable water and cloud liquid water over oceans from the NOAA 15 advanced microwave sounding unit. *J. Geophys.Res.*, **106 D3**, 2943–2953

•Weng, F., L. Zhao, R. Ferraro, G. Poe, X. Li, and N. Grody, 2003: Advanced Microwave Sounding Unit Cloud and Precipitation Algorithms. *Radio Sci.*, **38**, 8,086-8,096.

•Weng, F., N. C. Grody and R. R. Ferraro and A. Basist and D. Forsyth, 1997: Cloud liquid water climatology derived from the Special Sensor Microwave Imager. *J. Climate*, **10**, 1086-1098

Acknowledgement

We thank Drs. C. Cao and R. Chen for providing us online access to AMR TPW and CLW data. The views, opinions, and findings contained in this report are those of the authors and should not be construed as an official NOAA or U.S. Government position, policy, or decision.

AMS 2011 #565

91th AMS Annual Meeting, Seattle, WA, 23-27 January 2011.

Correspondence: wei.yu@noaa.gov, Tel: 301-763-8211 x122, Fax: 301-763-8572