New Gridded Product for the Total Columnar Atmospheric Water Vapor over Ocean Surface Constructed from Microwave Radiometer Satellite Data

Analyzing and understanding the spatial and temporal patterns of water vapor are thus crucial for global climate change. In this study, multisource remote sensing water vapor observation data from SSMIS, WindSat, AMSR-E, ASMR2, and HY-2A microwave radiometers are used to develop an extended daily water vapor multisource remote sensing fusion product based on the OI algorithm. The merged daily available product features a high spatial resolution of 0.25° from 2003-2018.

1. Materials

1.1 Satellite Remote Sensing Data

Sensors	Resolution	Data time used	Spatial coverage
AMSR-E	Daily/25 km	2003.1-2011.10	Global ocean
AMSR2	Daily/25 km	2012.7-2018.12	Global ocean
WindSat	Daily/25 km	2003.1-2018.12	Global ocean
SSMIS	Daily/25 km	2003.1-2018.12	Global ocean
HY-2A RM	Swath/97 km	2011.10-2015.12	Global ocean

To control the water vapor quality, outliers beyond the range of 0 to 70 mm were eliminated based on the GCOM-W1 "SHIZUKU" Data Users Handbook. Using the HY-2A RM L2 swath data product, we developed a 0.25° grid data product based on the drop-in-the-box algorithm.

1.2 Radiosonde Data

Data from more than 1000 global radiosonde stations provided by the National Centers for Environmental Information (NCEI) and from 90 stations located in the oceanic region were collected. All atmospheric profile data measured from 2003 to 2018 were extracted, and then the atmospheric water vapor was calculated. The validity of the calculation results was then checked (radiosonde data with the highest measurement heights less than 10000 m were eliminated, and outliers from 0 to 70 mm were excluded).

2. Water Vapor Remote Sensing Product Fusion Algorithm

The OI algorithm is used for the production of water vapor fusion products. The OI algorithm minimizes the analytical variance of the solution as long as the background, observations, and analytical fields are deemed unbiased estimates. It is widely used in the production of data products, such as sea surface temperature and wind fields. According to the OI algorithm, the final value on the fused product grid point k, i.e., the water vapor content fusion value Ak, is calculated as follows

$$A_k = B_k + \sum_{i=1}^{N} (O_i - B_i) W_{ki}$$

3. Remote Sensing Fusion Product

The OI algorithm is applied to merge atmospheric water vapor results retrieved from HY-2A, SSMIS, WindSat, AMSR-E, and ASMR2 microwave radiometers. As a result, a total of 16 years of global daily oceanic atmospheric water vapor remote sensing fusion product data from 2003 to 2018 were generated with a resolution of 0.25° ×0.25° . As shown in Figure 1, the missing areas of each single satellite data can complement each other well and the fusion data can largely fill the gaps of each single satellite data and generate the water vapor product over the global ocean surface. The daily coverage in 2018 fluctuated between 80% and 84%.

The generated global oceanic atmospheric water vapor fusion data were compared with the corresponding radiosonde data with a 0.25° spatial window and a 1 day temporal window. The Bias, MAD, RMSE were calculated.

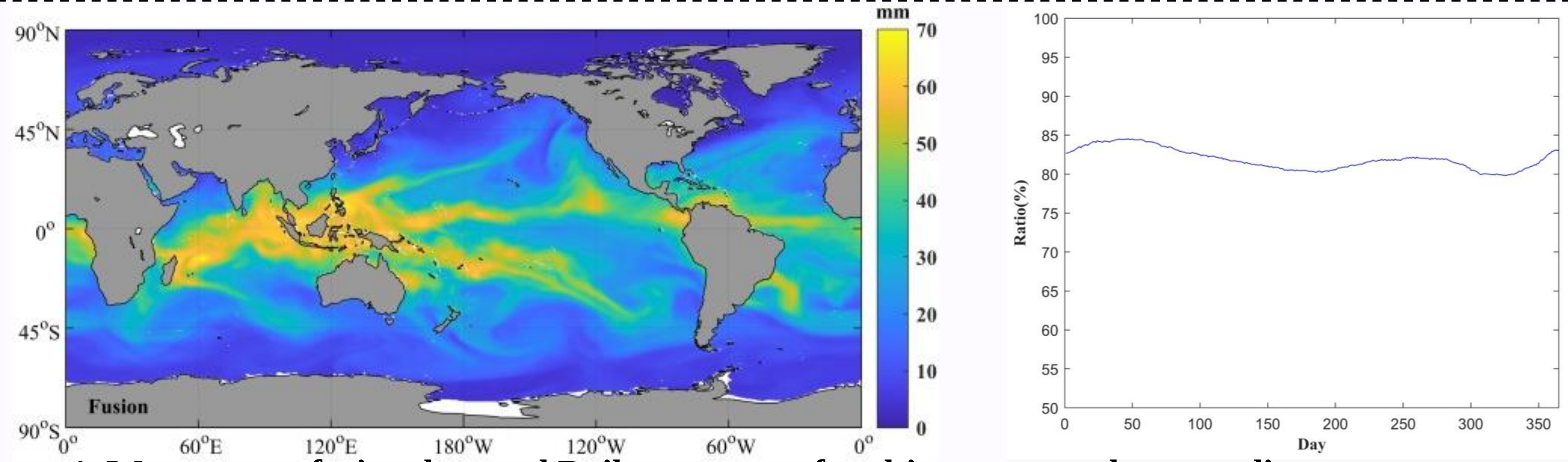

Figure 1. Water vapor fusion data and Daily coverage of multisource spaceborne radiometer water vapor data of 2018.

Year	Data Matches	Bias（mm）	MAD（mm）	Std （ mm	RMSE（mm）
2003	2365	0.50	2.07	2.79	2.84
2004	2961	0.52	1.94	2.60	2.65
2005	2916	0.87	2.04	2.66	2.80
2006	2771	0.99	2.52	3.17	3.33
2007	2616	0.36	2.24	3.02	3.04
2008	2847	0.48	2.04	2.78	2.83
2009	3036	0.66	1.80	2.43	2.53
2010	3490	0.43	1.53	2.11	2.15
2011	3098	0.41	1.84	2.67	2.70
2012	3014	0.24	1.56	2.15	2.16
2013	2969	0.30	1.72	2.42	2.44
2014	2998	0.57	1.87	2.52	2.59
2015	2870	0.37	1.96	2.70	2.73
2016	2755	0.30	1.85	2.60	2.62
2017	2520	0.54	1.78	2.51	2.57
2018	1965	0.66	1.65	2.27	2.36

The results show that the MAD and Std of this fusion product and the RSS product are 0.72 mm and 0.98 mm, respectively. Over most global oceans, the Std is mainly less than 1 mm. The largest Std between the two SST products appears in the middle and low-latitude areas (especially coastal areas), and the maximum occurs in equatorial South America. Thus, it can be concluded that the new gridded product coincides with the RSS product over most global oceans except for some coastal areas. A possible reason for the large Std in these areas is contamination from land and precipitation.

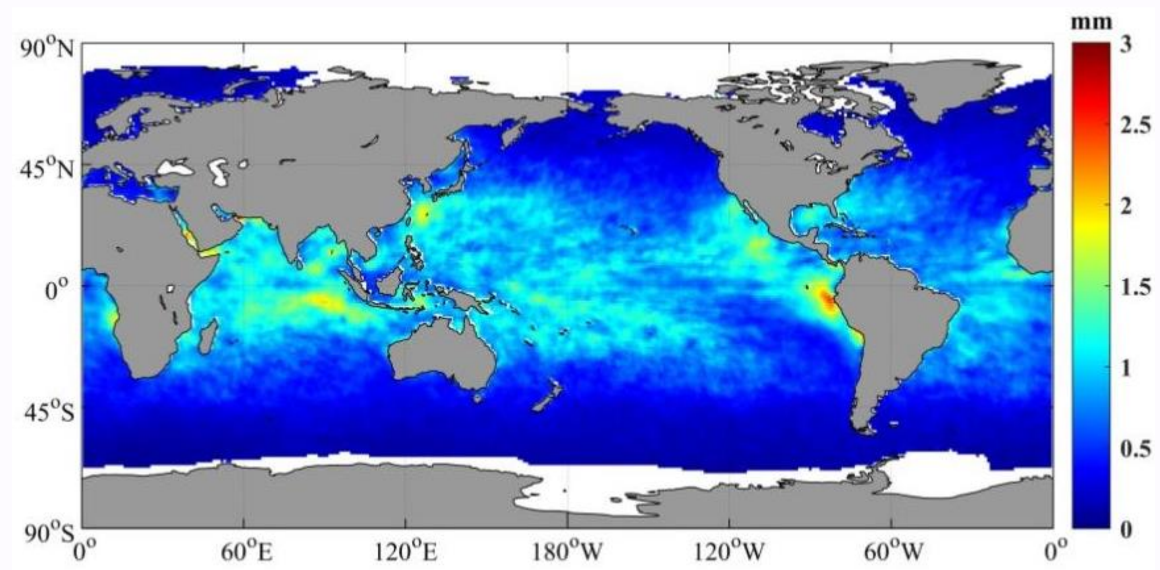

Figure 2. Global distributions of the monthly Std between the fusion and RSS product during 2016-2018.

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