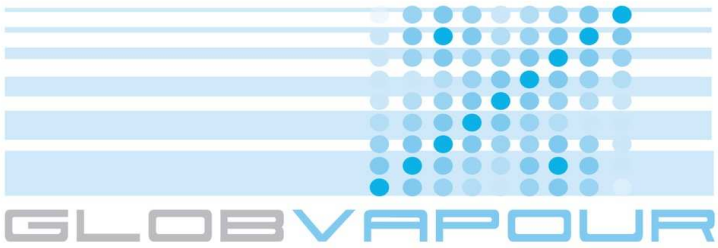
DUE GLOBVAPOUR

Product Validation Report
Merged IASI + SEVIRI



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1 Introduction

1.1 Purpose

This document constitutes the Product Validation Report for the GlobVapour merged IASI+SEVIRI products, describing the validation and intercomparison of these products for the monthly means of the prototype months January, June, August and December 2008. The report is currently limited to August 2008 only.

1.2 Definitions, acronyms and abbreviations

AIRS	Atmospheric Infrared Sounder
ARM	Atmospheric Radiation Measurement
ATOVS	Advanced TIROS Operational Vertical Sounder
CDO	Climate Data Operator
CM-SAF	EUMETSAT Satellite Application Facility on Climate Monitoring
GUAN	GCOS Upper Air Network
IAPP	International ATOVS Processing Package
IASI	Infrared Atmospheric Sounding Interferometer
IR	Infrared
MODIS	Moderate-Resolution Imaging Spectroradiometer
MWR	Microwave Radiometer
NIR	Near-Infrared
SEVIRI	Spinning Enhanced Visible and Infrared Imager
TCWV	Total Column Water Vapour
TPW	Total Precipitable Water

1.3 Applicable Documents

[AD-1] DUE GLOBVAPOUR Requirements Baseline Document (RBD), issue 1, revision 0, dated 16 April 2010.

[AD-2] DUE GLOBVAPOUR Technical Specification Document (TSD), issue 1, revision 0, dated 16 April 2010.

[AD-3] DUE GLOBVAPOUR Product Validation Plan (PVP), issue 1, revision 0, dated 20 July 2010.

[AD-4] DUE GLOBVAPOUR Validation Data Document (VDD), issue 1, revision 0, dated 20 July 2010.

1.4 Reference Documents

[RD-1] DUE GLOBVAPOUR Algorithm Theoretical Baseline Document (ATBD) for merged IASI+SEVIRI, issue 1, revision 0, dated 17 September 2010.

1.5 Structure of the document

Section 2 gives a concise overview of the GlobVapour merged IASI+SEVIRI products generated for the prototype months. In section 3 the methods, tools and data used for the validation and intercomparison are referenced. The results of the validation and intercomparison are presented in section 4, with a discussion of the observed figures at the end of the section. Conclusions are made in section 5.

2 Product Description

Technical specifications of the merged IASI+SEVIRI products are given in [AD-2]. The validated monthly mean product for August 2008 is shown in Figure 1 to Figure 3.

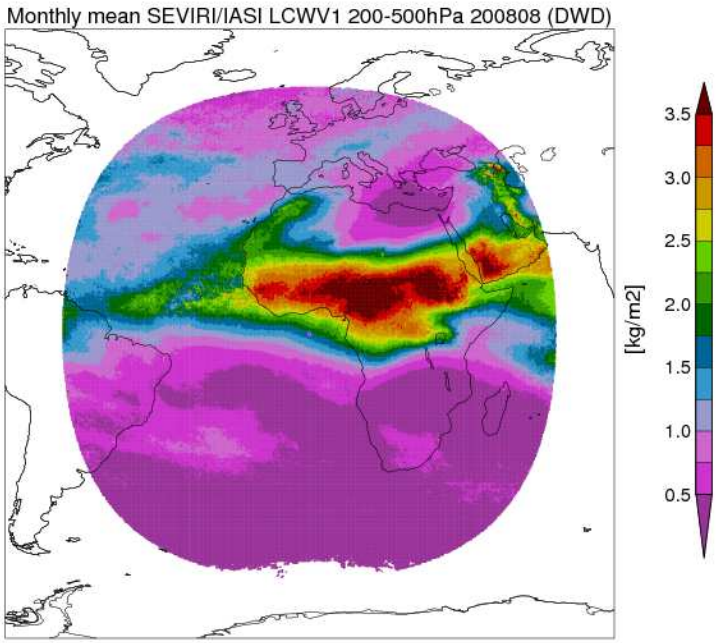

Figure 1: Merged IASI+SEVIRI monthly mean WV in layer 200-500 hPa for August 2008.

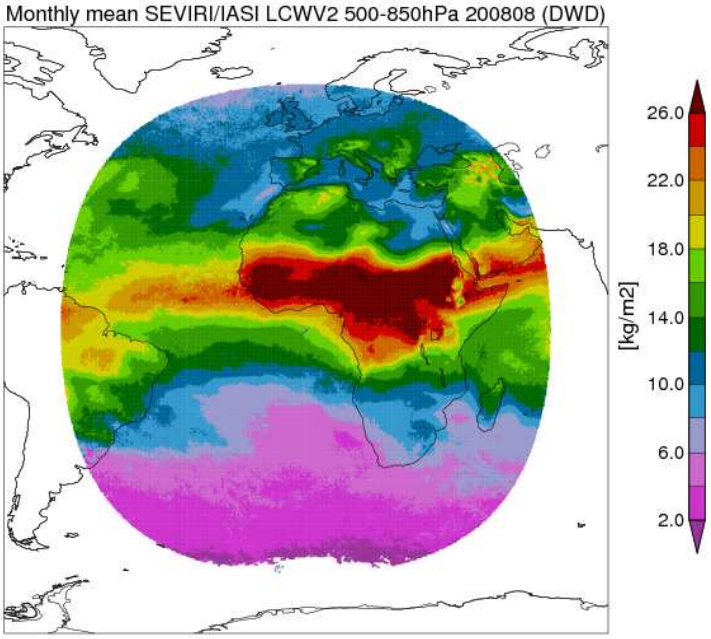

Figure 2: Merged IASI+SEVIRI monthly mean WV in layer 500-850 hPa for August 2008.

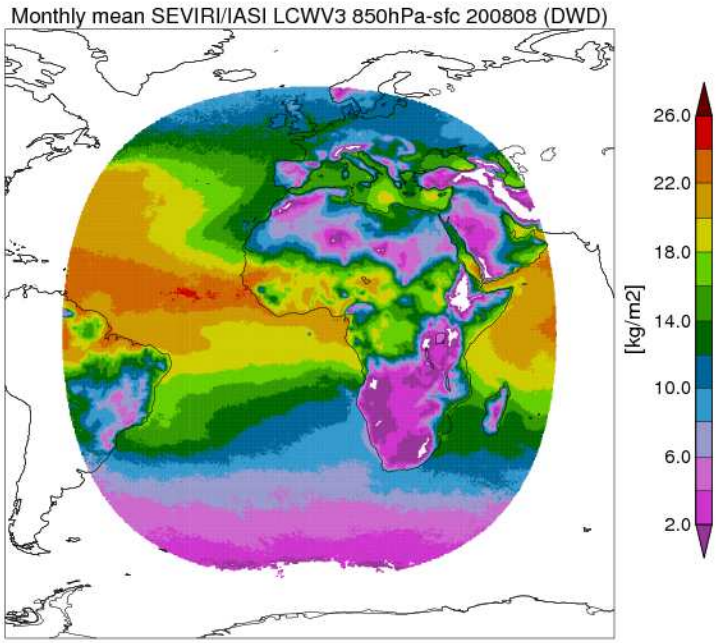

Figure 3: Merged IASI+SEVIRI monthly mean WV in layer 850 hPa -surface for August 2008.

3 Validation Method & Data

The methods & tools used for the validation and intercomparison of the combined IASI+SEVIRI products are described in the GlobVapour Product Validation Plan (PVP) [AD-3]. Further details to the specific techniques used for the processing, sampling and comparison of the Level 3 data, are described in the individual subsections of section 4. The ground based and satellite based data used for the validation and intercomparison are described in the Validation Data Document (VDD) [AD-4].

The validation and intercomparison has been performed for the monthly means of the prototype months, in such a way that positive and negative bias values imply respectively higher and lower humidity of IASI+SEVIRI data.

4 Validation Results

4.1 Ground based data

GUAN stations

The figures 4-9 show the validation results of the GlobVapour combined IASI+SEVIRI prototype products against the Radiosonde data from the GUAN network.

In these figures, the bias is shown as a scaled circle at the station location, where blue and red represent respectively positive and negative values. In the scatter plots the different colours refer to the dominating surface type for each grid box of IASI and SEVIRI.

The number of collocated stations ('numb') is indicated in the scatter plots. A threshold of 15 observations per station location per month has been applied to both the GUAN and combined IASI + SEVIRI data (values below this threshold have not been considered).

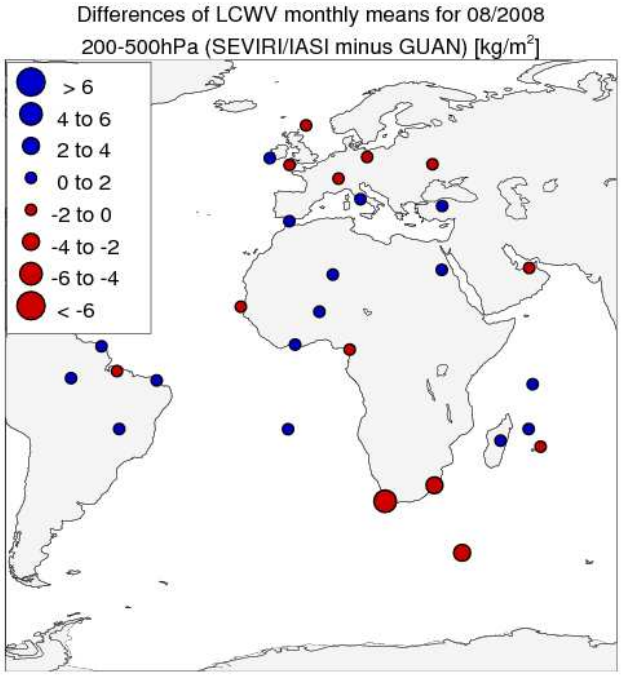

Figure 4: Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 200-500 hPa global distribution for August 2008.

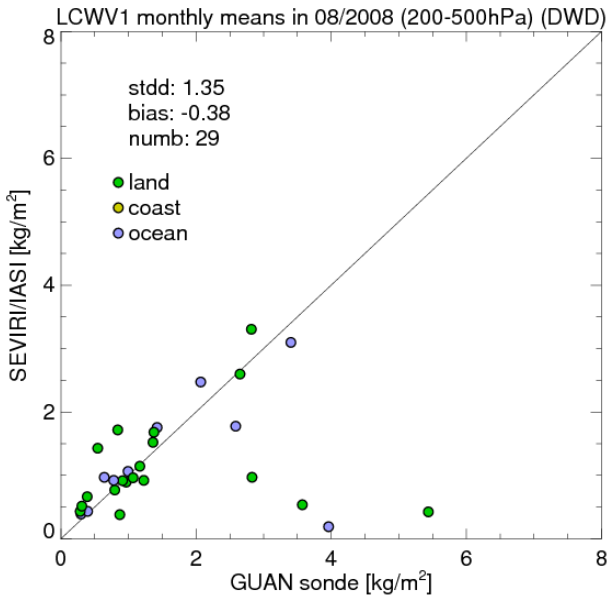

Figure 5: **Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 200-500 hPa scatter plot for August 2008.**

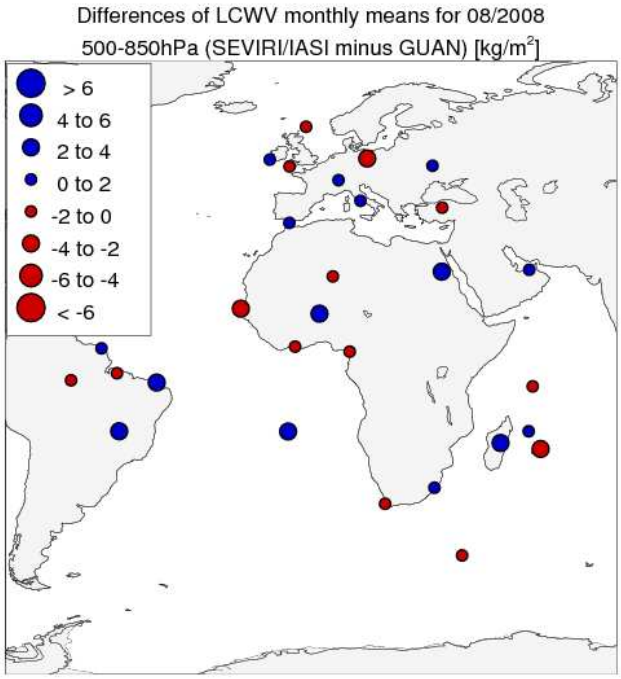

Figure 6: **Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 500-850 hPa global distribution for August 2008.**

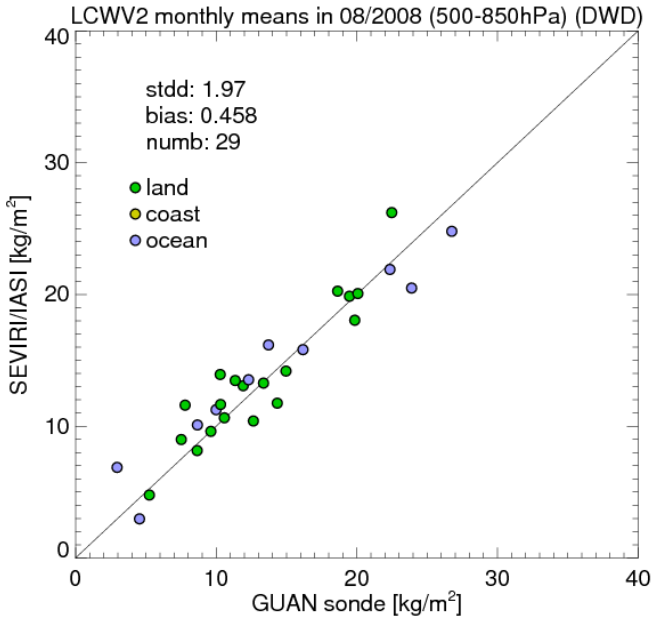

Figure 7: **Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 500-850 hPa scatter plot for August 2008.**

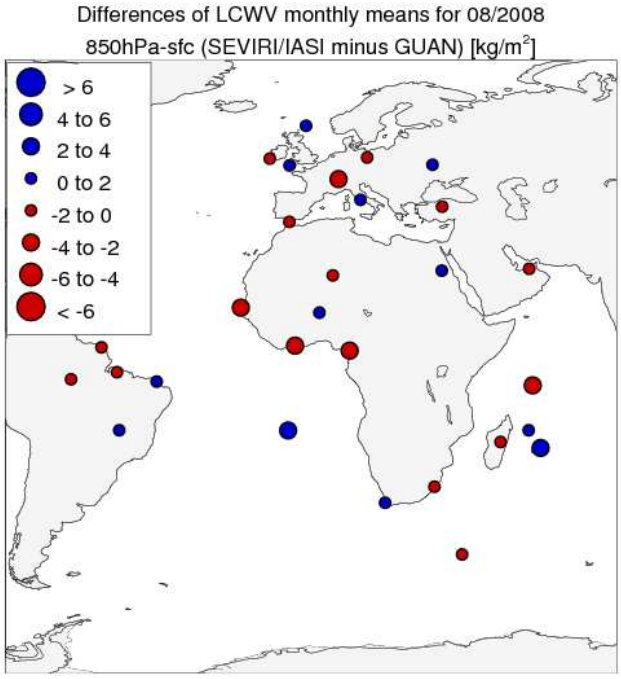

Figure 8: **Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 850 hPa - surface global distribution for August 2008.**

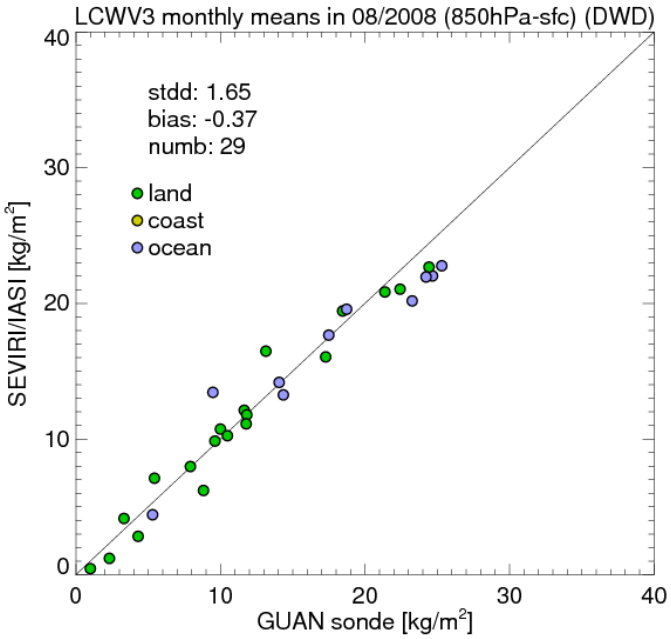

Figure 9: Merged IASI+SEVIRI versus GUAN radiosonde monthly mean WV in layer 850 hPa - surface scatter plot for August 2008.

4.2 Satellite based data

The statistics of the monthly means for the prototype month of August 2008, shown in tables per month, include the following for the IASI+SEVIRI product, the satellite product (AIRS layered IR) and the pixel-based difference: Minimum, maximum and mean value, standard deviation, root mean square error, the mean value of the number of observations per grid box ('N_obs') for the full month, and the number of valid grids in percent. N_obs is not yet available in the preliminary IASI+SEVIRI products.

AIRS

For the intercomparison with AIRS data, AIRS L2 swath based products have been processed to L3 daily and monthly means onto a 0.5 squared degree grid [AD-3]. AIRS data are described in [AD-4] and references therein. Water vapour AIRS data consist of a total column water vapour field and a 14-layer field with mixing ratio profiles. The latter has been used for the comparison with the combined IASI + SEVIRI, by conversion of mixing ratio to water vapour and integration of the available layers to the three IASI+SEVIRI compatible layers (surf-850, 850-500, 500-200 hPa). The L2 pressure field has been used for integration of the AIRS layers.

Only data where the quality flag was set to 'Highest Quality' or 'Good Quality' has been used for the processing (data with the third and lowest flag value 'Do Not Use' has been discriminated).

The availability of the downloaded AIRS L2 data (nominally 240 files per day) was 99.94% for the prototype month August 2008.

Table 4-1 to Table 4-3 below present the statistics of the monthly means for August 2008, for the three layers, differentiated to surface type (ocean/sea, coast, land). A generic distance of 150 km to the nearest land mass has been used for identification of the coastal area. A threshold of 10 observations per grid box has been applied (values below this threshold have not been considered). For the difference calculation, the AIRS product has been pixel-wise subtracted from the GlobVapour merged IASI+MERIS product, which was down-sampled to adapt spatial resolutions. All products have been normalised to the latitude dependent area of each grid box. The figures are given for the collocated subset of valid grids.

An AIRS WV contents plot of layer 3 (surface to 850 hPa), together with a difference plot to the combined IASI+SEVIRI product of layer 3, are shown in Figure 10 and Figure 11, respectively.

Table 4-1: Intercomparison results for IASI+SEVIRI versus AIRS for layer 1 (500-200 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.02	3.49	0.70	0.55	-	**-0.02**	**0.17**	11
AIRS	0.05	3.56	0.72	0.62	27			
Coast								
IASI+SEVIRI	0.04	3.74	1.00	0.78	-	**+0.07**	**0.20**	2
AIRS	0.05	3.66	0.93	0.75	29			
Land								
IASI+SEVIRI	0.25	9.32	1.46	1.07	-	**+0.18**	**0.29**	6
AIRS	0.16	3.92	1.28	1.02	29			
All								
IASI+SEVIRI	0.02	9.32	0.97	0.85	-	**+0.05**	**0.22**	19
AIRS	0.05	3.92	0.92	0.82	28			

Table 4-2: Intercomparison results for IASI+SEVIRI versus AIRS for layer 2 (850-500 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.41	25.15	8.77	5.90	-	**+0.43**	**1.29**	11
AIRS	0.68	26.02	8.35	6.08	27			
Coast								
IASI+SEVIRI	0.79	29.19	11.82	6.18	-	**+0.67**	**1.58**	2
AIRS	0.83	26.84	11.14	5.90	29			
Land								
IASI+SEVIRI	2.74	29.94	15.77	6.83	-	**+1.27**	**2.40**	6
AIRS	3.35	29.10	14.50	6.09	29			
All								
IASI+SEVIRI	0.41	29.94	11.30	6.99	-	**+0.72**	**1.74**	19
AIRS	0.68	29.10	10.58	6.66	28			

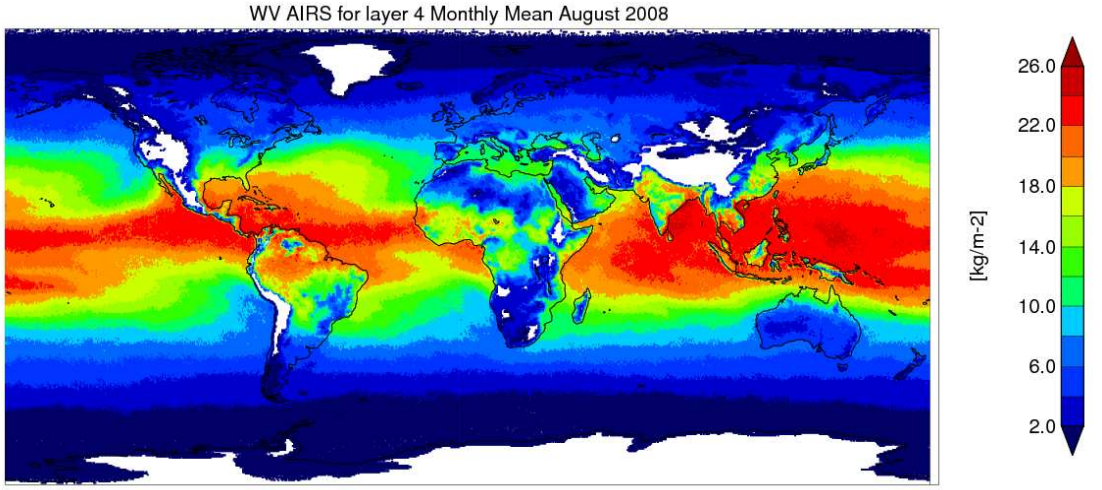

Figure 10: AIRS monthly mean WV global distribution in layer 3 (sfc-850 hPa) (AIRS layer 4) for August 2008.

Table 4-3: Intercomparison results for IASI+SEVIRI versus AIRS for layer 3 (sfc-850 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.49	24.91	11.83	6.57	-	**+0.48**	**0.94**	11
AIRS	0.73	23.86	11.35	6.45	27			
Coast								
IASI+SEVIRI	0.22	24.07	12.17	5.55	-	**+0.25**	**1.35**	2
AIRS	0.83	23.60	11.92	5.31	29			
Land								
IASI+SEVIRI	0.17	23.54	9.42	5.46	-	**+0.40**	**1.67**	6
AIRS	0.48	23.01	9.03	4.93	29			
All								
IASI+SEVIRI	0.17	24.91	11.15	6.25	-	**+0.43**	**1.27**	19
AIRS	0.48	23.86	10.72	6.01	28			

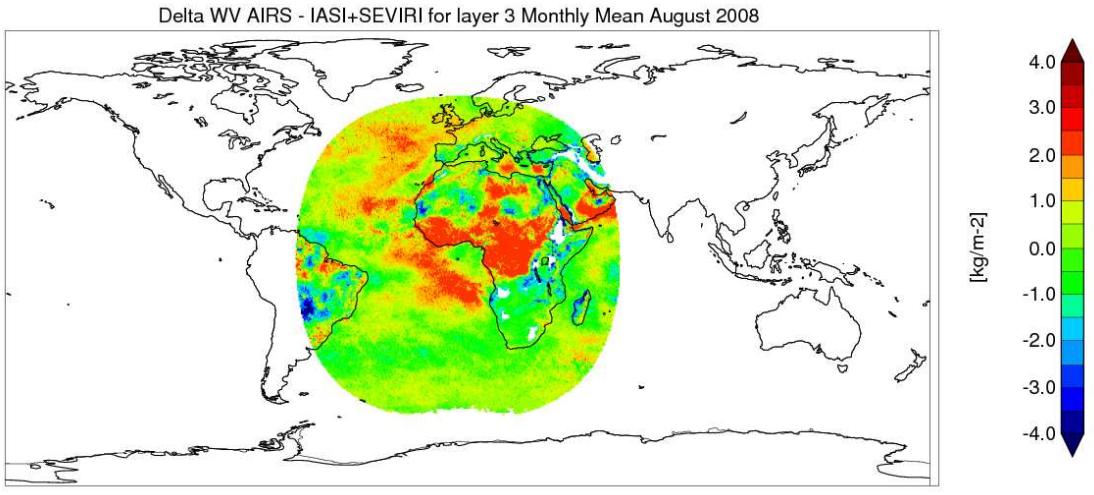

Figure 11: IASI+SEVIRI versus AIRS monthly mean WV global distribution in layer 3 (sfc-850 hPa) for August 2008.

Note that the (relative) number of valid grid boxes in above tables refers to the full 0.5 squared degrees AIRS grid with (720x360) boxes, whereas the actually filled area for IASI+SEVIRI is much smaller (i.e. (520x520) boxes on a 0.25 squared degrees grid, corresponding to (260x260) boxes when subsampled to the full 0.5 squared degrees grid) as can be seen in Figure 11.

ATOVS

For the intercomparison with ATOVS data, the CM SAF L3 products on a global (386 x 162) grid [AD-4], which is a cylindrical equal area projection with dimensions near to a 1 squared degree (360x180) grid, have been remapped and re-sampled to a 0.5 squared degree (720x360) grid using the Climate Data Operator (CDO) tool with a nearest-neighbour interpolation function. ATOVS data are described in [AD-4] and references therein. Water vapour ATOVS data consist of a Total Column field, as well as water vapour integrated over 5 different layers. The latter has been used for comparison to the merged IASI+SEVIRI, by combining ATOVS layer 1 (300-200 hPa) and 2 (500-300 hPa), 3 (700-500 hPa) and 4 (850-700 hPa), and 5 (sfc-850 hPa) separately.

The CM SAF ATOVS products have no quality flags or masks to be considered. The products have been generated with a quality assessment scheme applied to the IAPP algorithm with the following thresholds: no superadiabaticity, mixing ratio up to 55 g/kg, temperature between 180 and 340 K, TPW up to 90 kg/m^2, surface pressure up to 1050 hPa [RD-2].

Table 4-4 to Table 4-6 present the statistics of the monthly means for the prototype month of August 2008, differentiated to surface type (ocean/sea, coast, land). A generic distance of 150 km to the nearest land mass has been used for identification of the coastal area. A threshold of a minimum of observations per grid box has not been applied. For the difference calculation, the ATOVS product has been pixel-wise subtracted from the GlobVapour merged IASI+SEVIRI product, which was down-sampled to adapt spatial resolution. All products have been normalised to the latitude dependent area of each grid box. The figures are given for the collocated subset of valid grids.

An ATOVS WV contents plot of layer 3 (surface to 850 hPa), together with a difference plot to the combined IASI+SEVIRI product of layer 3, are shown in Figure 12 and Figure 13, respectively.

Table 4-4: Intercomparison results for IASI+SEVIRI versus ATOVS for layer 1 (500-200 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.00	3.21	0.69	0.55	-	**-0.14**	**0.27**	11
ATOVS	0.08	4.01	0.83	0.65	65			
Coast								
IASI+SEVIRI	0.03	4,72	1.00	0.78	-	**-0.10**	**0.26**	2
ATOVS	0.11	4.28	1.10	0.84	60			
Land								
IASI+SEVIRI	0.25	8.05	1.45	1.07	-	**-0.16**	**0.33**	6
ATOVS	0.14	4.56	1.61	1.15	45			
All								
IASI+SEVIRI	0.00	8.05	0.97	0.84	-	**-0.14**	**0.29**	20
ATOVS	0.08	4.56	1.10	0.93	58			

Table 4-5: Intercomparison results for IASI+SEVIRI versus ATOVS for layer 2 (850-500 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.00	27.12	8.73	5.90	-	**-0.75**	**1.12**	11
ATOVS	1.04	28.15	9.48	6.17	65			
Coast								
IASI+SEVIRI	0.72	29.21	11.78	6.19	-	**-0.80**	**1.56**	2
ATOVS	1.37	31.57	12.59	6.54	60			
Land								
IASI+SEVIRI	2.30	30.48	15.74	6.86	-	**-1.19**	**1.98**	6
ATOVS	4.04	33.96	16.93	7.07	45			
All								
IASI+SEVIRI	0.00	30.48	11.26	7.00	-	**-0.90**	**1.59**	20
ATOVS	1.04	33.96	12.15	7.32	58			

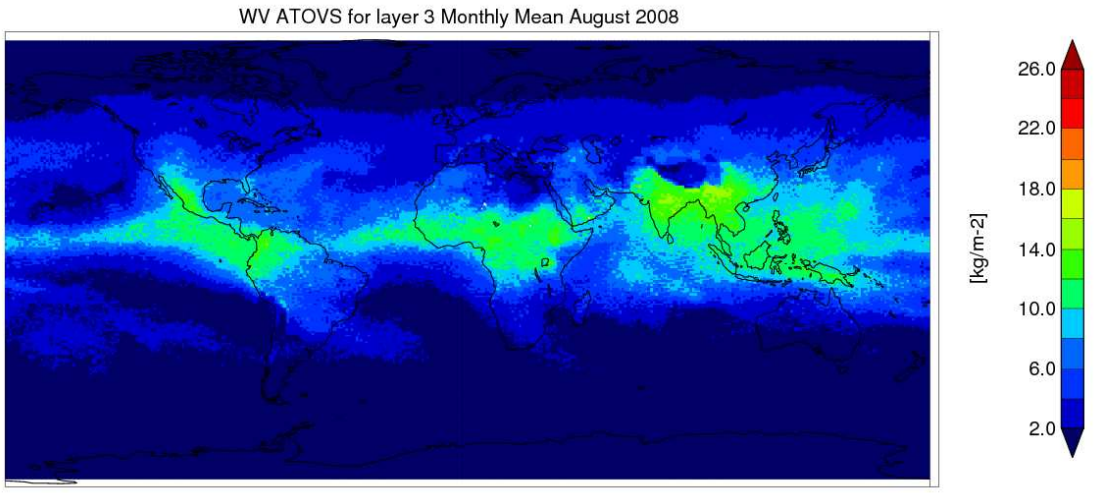

Figure 12: ATOVS monthly mean WV global distribution in layer 3 (sfc-850 hPa) for August 2008.

Table 4-6: Intercomparison results for IASI+SEVIRI versus ATOVS for layer 3 (sfc-850 hPa), August 2008 monthly mean.

	Min (kg/m^2)	Max (kg/m^2)	Mean (kg/m^2)	Std Dev (kg/m^2)	Mean N_obs	Bias (kg/m^2)	RMSE (kg/m^2)	Valid grids (%)
Sea/Ocean								
IASI+SEVIRI	0.00	24.90	11.79	6.60	-	**-0.80**	**1.04**	11
ATOVS	0.99	23.88	12.59	6.64	65			
Coast								
IASI+SEVIRI	0.03	24.60	12.15	5.58	-	**-0.78**	**1.62**	2
ATOVS	0.17	24.78	12.93	5.81	60			
Land								
IASI+SEVIRI	0.01	23.57	9.27	5.56	-	**-1.54**	**2.33**	6
ATOVS	0.05	25.74	10.81	6.30	45			
All								
IASI+SEVIRI	0.00	24,90	11.07	6.30	-	**-1.02**	**1.60**	19
ATOVS	0.05	25.74	12.09	6.51	58			

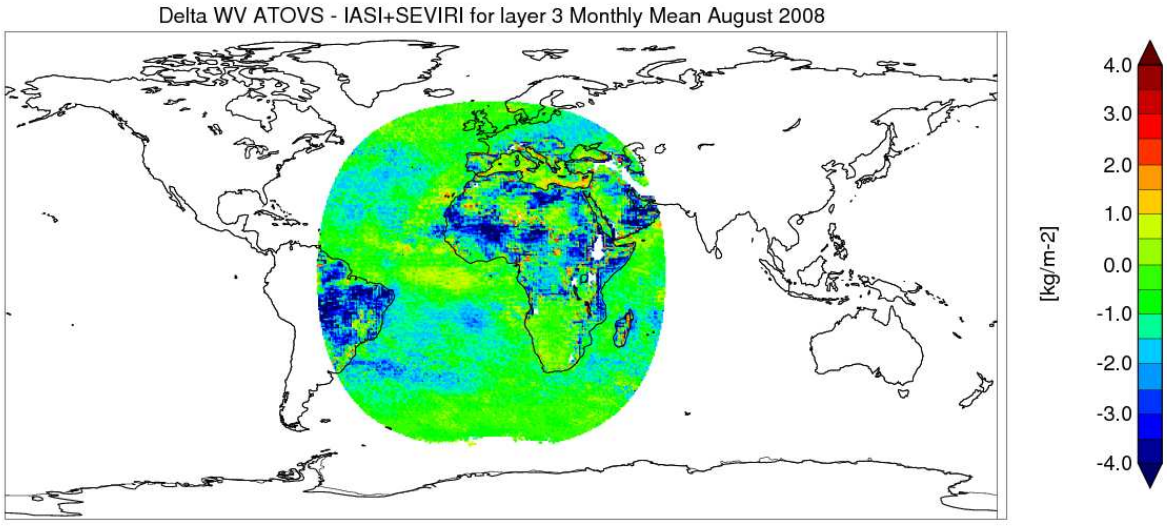

Figure 13: Merged IASI+SEVIRI versus ATOVS monthly mean WV layer 3 (sfc-850 hPa) for August 2008.

Note that the (relative) number of valid grid boxes in above tables refers to the full 0.5 squared degrees grid with (720x360) boxes, whereas the actually filled area for IASI+SEVIRI is much smaller (i.e. (520x520) boxes on a 0.25 squared degrees grid, corresponding to (260x260) boxes when subsampled to the full 0.5 squared degrees grid) as can be seen in Figure 13.

4.3 Discussion

All intercomparisons are based on collocated subsets of valid values on a latitude-corrected rectangular grid. It is recalled that the validation and intercomparison has been performed in such a way that positive and negative bias values imply respectively larger and smaller IASI+SEVIRI data.

The comparison against GUAN radiosondes showed good quality for layers 2 and 3 but low quality for the top-most layer.

The comparison against AIRS and ATOVS observations exhibited good quality, in particular in terms of RMSE. The top-most layer (500-200 hPa) matches very well with IASI+SEVIRI with very low bias and RMSE values, as to be expected considering the very low water vapour values. However also the mid and bottom layers are within limits for both AIRS and ATOVS. Strikingly the bias has opposite sign for AIRS (positive) and ATOVS (negative) for all layers. Averaged over all surface types, the biases for the mid-layer (850-500 hPa) and bottom layer (surface-850 hPa) are nearly the same, for both AIRS (+0.7 to +0.4 kg/m^2) and ATOVS (-0.9 to -1.0 kg/m^2). The same applies to the RMSE (all below 1.7 kg/m^2). In general the highest bias and RMSE are found over land surface.

5 Conclusions

This report presents extensive validation efforts by utilizing a large variety of “reference” observations. Among the considered data are GUAN radiosonde as well as AIRS and ATOVS water vapour products.

No unique picture of the quality of the merged IASI+SEVIRI product can be found. The technical specifications on bias (0.2-0.8 kg/m^2) are only met for the top-most layer AIRS and ATOVS case and for layer 3 ATOVS, whereas in all other cases the values are not far off. The sign of the bias is positive for AIRS and negative for ATOVS. The technical specifications of RMS (0.8-3.0 kg/m^2) are clearly met in all cases.

Note that the “reference” data also exhibit differences among another (see e.g. [RD-3, 7]), partly exceeding technical specifications of the GlobVapour products.

The presented results clearly underline the need for a sound assessment of at least the quality of satellite products. Also, the identification of true reference observations is an open issue. The GlobVapour project plans to support the GEWEX Radiation Panel in its efforts to start addressing these challenging issues in an international context.