



Cross-comparison of cloud liquid water path values derived from observations by two space-borne and one ground-based instrument in Northern Europe

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RPG-HATPRO microwave radiometer at the St.Petersburg University observational site





MW

radiation

cloud

liquid

water

path

(LWP)

<u>SEVIRI</u>

<u>AVHRR</u>

(Spinning Enhanced Visible and InfraRed Imager)



- Geostationary orbit
- Line by line scanning
- 12 channels (0.6 13.4 µm)
- Temporal resolution 15 min
- Spatial resolution about 7km (over Northern Europe)

(Advanced Very High Resolution Radiometer)



- Polar orbit
- Cross-track scanning
- 6 channels (0.58 12.50 µm)
- Temporal resolution 1 day
- Spatial resolution 1 km

Reflected solar radiation → cloud properties



The location of 441 SEVIRI measurement pixels (a) and 3721 AVHRR measurement pixels (b) selected for analysis in the large terrain. The position of the HATPRO radiometer is marked by the red cross.



The location and numbers of 9 SEVIRI (black squares) and 12 AVHRR (blue circles) measurement pixels closest to the position of the HATPRO radiometer (marked by the red cross). The small terrain is shown.

Synchronisation of data



The HATPRO data flow presented in the form of running average values with different averaging intervals (colour lines, see the legend).

The SEVIRI and the AVHRR instantaneous measurements are shown as green and red dots. The 2.5 hour interval of observations on 2 July 2014 is displayed in panel "a".

The 18 minute interval containing collocated SEVIRI and AVHRR measurements is magnified and is shown in panel "b".

The colour crosses designate the averaged HATPRO measurements which are selected for comparison with the satellite data.

Seasonal periods for comparison of the measurements of LWP

Designation of a period	Time intervals	Number of days	Total number of days	
WH	1 May – 30 November 2013	23	63	
(Warm and Humid)	1 May – 30 November 2014	40		116
CD	1 December 2012 – 30 April 2013	28	53	
(Cold and Dry)	1 December 2013 – 30 April 2014	25		

Characteristics of the data agreement

Compared data sets	Correlation coeff.	<i>bias</i> , kg m⁻²	<i>RMS diff.*</i> , kg m ⁻²		
WH					
SEVIRI - HAT ₆₀	0.66 ± 0.07	-0.003	0.031 (0.031)		
AVHRR - HAT ₆₀	0.92 ± 0.02	0.013	0.036 (0.034)		
CD					
SEVIRI - HAT ₆₀	0.69 ± 0.07	0.002	0.044 (0.044)		
AVHRR - HAT ₆₀	$\textbf{0.84} \pm \textbf{0.04}$	0.016	0.059 (0.057)		

* bias corrected RMS is in brackets





Black dots in combination with the right y axis indicate the month of measurements.

Colour dots are connected by lines only for demonstrative purpose.



The maps of the mean LWP values (AVHRR and SEVIRI measurements, colour scale, kg m⁻²)



The LWP variability estimate:

$$V_e = \sum_{i \neq j} \left| HAT_i - HAT_j \right|$$

$$\begin{split} V_{e} &= \left| HAT_{5} - HAT_{10} \right| + \\ \left| HAT_{5} - HAT_{20} \right| + \\ \left| HAT_{5} - HAT_{60} \right| + \\ \left| HAT_{10} - HAT_{20} \right| + \\ \left| HAT_{10} - HAT_{60} \right| + \\ \left| HAT_{20} - HAT_{60} \right| \end{split}$$

The absolute difference *D* between the ground-based and the satellite measurements of LWP as a function of the value of LWP variability estimate $V_{\rm e}$. The data refer to the WH season.



Main conclusions

- The LWP measurements by both satellite instruments SEVIRI and AVHRR agree well with the ground based observations by the microwave radiometer RPG-HATPRO during all seasons.
- The AVHRR results have some preference if the correlations with ground-based measurements are compared but the SEVIRI observations have the smaller bias.
- The AVHRR LWP data of the version considered in the present study may have problems in winter over ice-covered water surfaces.

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Current research: the detection of the LWP land-sea gradients by means of ground-based microwave measurements



The viewing geometry in the vertical plane. Position of the radiometer is marked by the red cross. Colour lines represent the lines of sight for different elevation angles (see the legend). Blue boxes designate the atmospheric layer 0.3-5.5 km over water areas (see text).