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

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cloud liquid water path (LWP)
SEVIRI
(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)

AVHRR
(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 small terrain is shown.

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.
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 (Warm and Humid)    | 1 May – 30 November 2013                     | 23             | 63                   |
|                        | 1 May – 30 November 2014                     | 40             | 116                  |
| CD (Cold and Dry)      | 1 December 2012 – 30 April 2013              | 28             | 53                   |
|                        | 1 December 2013 – 30 April 2014              | 25             |                      |

### Characteristics of the data agreement

| Compared data sets | Correlation coeff. | bias, kg m\(^{-2}\) | RMS diff.*, 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\(_{60}\) | 0.84 ± 0.04         | 0.016                | 0.059 (0.057)            |

* bias corrected RMS is in brackets
The LWP values obtained by HATPRO (HAT60, blue dots), SEVIRI (green dots) and AVHRR (red dots) as a function of day sequence number for the WH and CD seasons (a and b correspondingly).

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\(^{-2}\))

**CD season**

**WH season**

Abnormal LWP land-sea gradient

The location of HATPRO radiometer is marked by the red cross.
The LWP variability estimate:

\[ V_e = \sum_{i \neq j} |HAT_i - HAT_j| \]

The absolute difference \( D \) between the ground-based and the satellite measurements of LWP as a function of the value of LWP variability estimate \( V_e \). 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 location of the RPG-HATPRO radiometer and the viewing direction in the angular scanning mode. The black straight line is the distance scale.

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).