Cloud liquid water content measurements from the high mountains to the equator using ground-based microwave radiometers

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Objectives

Cloud liquid water is a prognostic variable in atmospheric models providing an immediate connection between radiation and dynamics. However, cloud microphysical parametrizations are still insufficient leading to large discrepancies even in mean cloud liquid water contents of different models (van Meijgaard and Crewell, 2005). One of the reasons is the scarcity of observations for model evaluation and improvement. Passive microwave remote sensing is by far the most direct, accurate and cost efficient technique to estimate the cloud liquid water path (LWP).

Recently, ground-based microwave radiometers have become less expensive and highly automated allowing continuous observations of LWP at certain sites all around the world. This permits new ways for developing cloud climatologies with different objectives. The validation of satellite images or the parameterization of radiation in atmospheric models represent research fields which require accurate informations on clouds.

Method – LWP Retrieval

To obtain liquid water path from the measured brightness temperatures statistical retrieval algorithms were developed for three different locations individually, on the basis of large sets of atmospheric profiles observed by radiosondes. The algorithms for the LWP have a theoretical accuracy of about 20 gm^{-2}. Continuous LWP measurements were carried out with a resolution of about 1 second and thus provide excellent information on the cloud variability over the measurement site.

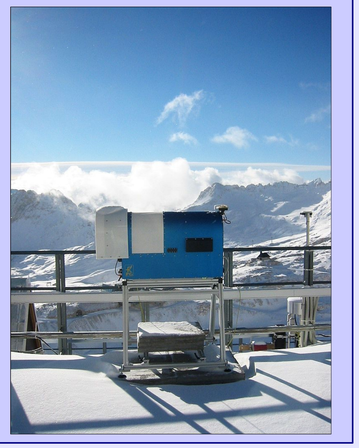
Data sets

The data for this study include three climatologically different sites:

Observations from the high mountain station Schneefernerhaus (2650 m MSL) in the German Alps between 4 November and 13 December 2005.

Results from the LAUNCH campaign at Lindenberg/Falkenberg, Germany where measurements were taken between 8 September and 1 November 2005. This site is situated 60 km south-east of Berlin and is characterized by a rather continental climate.

Tropical measurements in Darwin, Australia as part of the Tropical Warm Pool International Cloud Experiment (TWP-ICE). Data is available from this site between 19 January and 14 February 2006 which is during the Monsoon season in Northern Australia.



HATPRO on Schneefernerhaus in December 2005

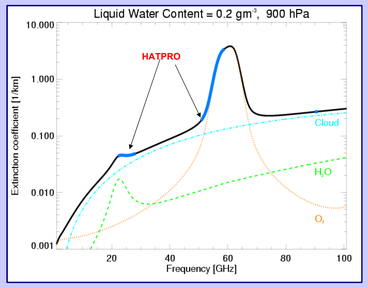
References

Meijgaard, E. van, and S. Crewell, 2005: Comparison of model predicted liquid water path with ground-based measurements during CLIWA-NET, *Atmos Res*., 75(3), 201 – 226.

Rose, T., S. Crewell, U. Löhnert and C. Simmer, 2005: A network suitable microwave radiometer for operational monitoring of the cloudy atmosphere. A*tmos. Res.,*, 75(3), 183-200, 2005.

HATPRO microwave radiometer (Rose et al. 2005)

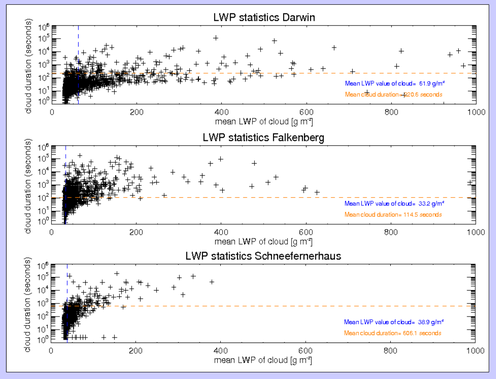
Continuous measurements of thermal emission by atmospheric components (water vapour, oxygen, cloud water) at 14 frequencies (see below) expressed as brightness temperatures.
Automatic observation during all weather conditions due to hydrophobic radome coating and high power dew blower.



Auxilliary measurements of environmental temperature, pressure and humidity; rain detection and GPS clock.
High accuracy in brightness temperatures is achieved by a combination of absolute and relative calibrations involving liquid nitrogen, noise diode standards and sky tipping.

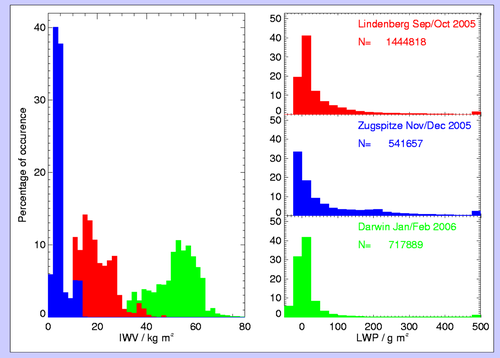
Statistical properties of clouds

The present study wants to highlight three different cloud climatology based on microwave radiometer measurements. As a cloud threshold, a LWP value of 30 g m^{-2} was chosen. From a large number of observations, some statistical properties of clouds could be derived. The mean cloud cover of the European measurements of 25-30 % represents typical dry conditions for autumn months in central Europe.



The three plots to the left show the lifetime of one single cloud above the measurement site as a function of the mean LWP content of this cloud. The table to the lower left contains some more statistical informations on the clouds.
On the lower right LWP histograms of the three stations are compared. Also shown are the histograms of the Integrated Water Vapor (IWV) which can also be retrieved from HATPRO measurements.

		Darwin	Falkenberg	Schneefernerhaus
Number of all HATPRO measurements used	N=	1082820	3346800	1659040
Number of all measurements (LWP > 30 g m-2)	N=	99633	1098590	411268
percent cloudy cases	in %	9,2	32,8	24,8
mean LWP of cloudy measurement	gm^{-2}	201,389	113,715	157,581
Number of cloud events	N=	2787	16719	2032
Mean duration of cloud event (in seconds)	sec	220,568	114,508	606,112
mean LWP of cloud event	gm^{-2}	61,9	33,2	38,9



EGU General Assembly 2006, Vienna, 3 – 7 April 2006