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Parameterization of atmospheric water vapor and cloud liquid water distribution using microwave radiometer profiler

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Water vapor is the most important carrier of energy in the atmosphere and is also the most important greenhouse gas. Its spatial and temporal distribution impacts weather and climate through a variety of processes, such as exchange of latent heat, radiative cooling and heating, cloud formation and precipitation. Clouds as a result of the condensation process also modify the radiative energy balance. A good parameterization of atmospheric water vapor and cloud liquid water distribution are thus important for modeling studies

A dataset gathered over 369 days in various midlatitude sites with a microwave radiometric profiler is used to analyze the statistical distribution of tropospheric water vapor content (WVC) and liquid water content (LWC). The microwave profiler is automated, providing atmospheric sounding up to 10 km height in clear and cloudy conditions. It observes passively brightness temperature at twelve frequencies in a region of the microwave absorption spectrum. Atmospheric profiles are derived from brightness temperature, infrared, and surface meteorological observations using a neural network based on historical local radiosondes and forward radiative transfer modeling.

The WVC distribution inside intervals of temperature is analyzed in clear and cloudy conditions. WVC is found to be well fitted by a Weibull distribution. The two Weibull parameters, the scale (λ) and shape (k), are temperature (T) dependent. k is almost constant, around 2.6, for clear conditions. For cloudy conditions, at $T < -10^{\circ}C$, k is close to 2.6. For $T > -10^{\circ}C$, k displays a maximum in such a way that skewness, which is positive in most conditions, reverses at negative in a temperature region approximately centered around 0°C, i.e. at a level where the occurrence of cumulus clouds is high. Analytical λ(T) and k(T) relations are proposed. The statistical distribution of liquid water content is also studied. It is found to be well fitted by lognormal distribution. To assess how the results presented in the present paper are biased by the retrieval uncertainty, we compute the RMS error on the retrievals, by adding to each retrieved profile a Gaussian noise with zero mean and a standard deviation equal to the RMS error for each layer.

The vertically integrated WV (IWV) is found to follow a Weibull distribution. Using the 15 years ECMWF (European Centre for Medium-range Weather Forecast) reanalysis meteorological database ERA 15, the Weibull parameters k and λ for the IWV distribution were calculated over the western European area, where the radiometric data were collected. The fields of k and λ values are rather homogeneous showing the validity of the assumption that this area can be considered as a single climatological entity for WVC distribution. Averaged values over the area are k = 2.5 and λ = 1.9 which compare very well with radiometric values, those are k = 2.8 and λ = 1.9. This agreement can be seen as supporting the validity of the IWV radiometric measurements. The vertically integrated LW (ILW) is found to be lognormaly distributed and agrees well when compared to ILW distribution obtained from EAR15.