Evaluating cloud liquid water in NWP and climate models using measurements from the BALTEX Cloud Liquid Water Network: CLIWA-NET

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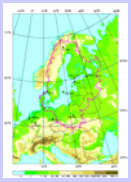
▶ Introduction

The EU-project **CLIWA-NET** (2000-2003) focused on observations of cloud liquid water and its vertical structure, and the evaluation and improvement of model parameterizations. For that purpose:

- the prototype of a European Cloud Observation Network (ECON) consisting of ground-based stations and satellite observations was setup
- three measurement campaigns took place namely two CLIWA-NET Network (**CNN**) campaigns covering North Central Europe and the BALTEX BRIDGE Campaign (**BBC**) covering the Netherlands
  - **CNN1**: August-September 2000
  - **CNN2**: April-May 2001
  - **BBC**: August-September 2001
- short-term forecasts of four European NWP and climate models (ECMWF, RACMO, RCA and LM) were thoroughly evaluated with the observations
- a "low cost" microwave radiometer optimized for operational networks was designed



▶ Model Setup

Global modeling

- ECMWF: spatial resolution : eff. 55 km
  60 vertical layers, Δt = 30min

Regional models

- KNMI/RACMO: spatial resolution: 18 km
  24 vertical layers, Δt = 2min
- Rossby Center/RCA-HIRLAM:
  spatial resolution: 18 km
  24/40/60 vertical layers, Δt = 7min 30s

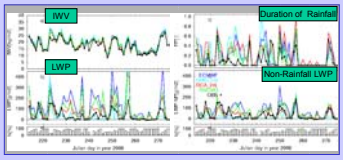
Short-term forecasts from +12 to +36 h

Non-hydrostatic model

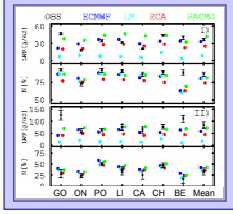
- Lokal-Modell (LM) of Deutscher Wetterdienst
  spatial resolution 7 km
  35 vertical layers, Δt =40s

▶ Evaluation: LWP

Time series of observed liquid water path (LWP) have been compared to model forecasts for every station. Daily mean values show a good agreement in integrated water vapor (IWV) while significant differences in LWP occur. After filtering of rain events three models predict LWP in the right order of magnitude.



Mean LWP for every station for CNN2. The error bars in the observations represent the variation which occurs due to temporal aggregation (10 to 60 min).



I.) non-precipitating periods
II.) non-precipitating water clouds

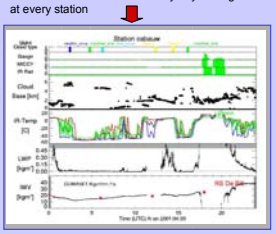
- models have little geographical variation in LWP
- models tend to overpredict precipitation for CNN2 (not CNN1) underestimation for the very rainy BBC period
- occurrence of water clouds is slightly overpredicted (stronger in CNN1)
- overcast periods are strongly underestimated (not shown)

The CLIWA-NET project was funded by the European Commision's RTD programme on Energy, Environment and Sustainable Development within the research area „Better exploitation of existing data and adaption of existing observing systems" under EVK2CT-1999-00007 from March 1, 2000 for the duration of three years. Web site: **http://www.knmi.nl/samenw/cliwa-net/**

▶ Observations: LWP

Within the ground-based network **microwave radiometers** were chosen as key instruments since this technique is by far the most direct and accurate method to determine the **liquid water path** (LWP). Additionally, most stations were equipped with lidar ceilometers measurering the cloud base height and infrared radiometers which can observe the cloud base temperature.

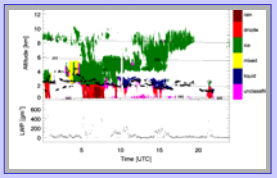
Continuous time series for every day were gathered at every station



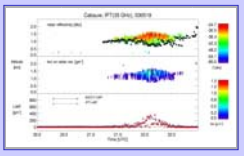
Precise knowledge of rain events turned out to be critical for the validation of observations. Due to rainfall, microwave radiometer measurements are meaningless as long as the water on the instrument has not completely evaporated. **Rain detection**, preferably with in-situ instruments, was used to filter out all MRAD measurements synchronous with rain events. Based on theses experiences the **low-cost radiometer** (see above) includes a rain sensor which controls a shutter system protecting the antenna in case of precipitation.

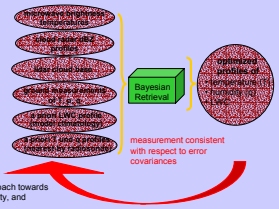
▶ Observations: LWC

The synergy of different sensores, e.g. cloud radar, lidar and microwave radiometer together with information of close-by radiosoundings can be exploited to classify the vertical distribution of clouds.



In case of single layer water clouds the **Integrated Profiling Technique (IPT)** can be applied to simultaneously retrieve profiles of temperature, humidity and liquid water content (LWC) in a physically consistent way.





Löhnert, U., S. Crewell, C. Simmer, 2004: An integrated approach towards retrieving physically consistent profiles of temperature, humidity, and cloud liquid water, *J. Appl. Met.*, in press

▶ Evaluation: LWC

The **IPT** was applied over the full two month period of the BBC campaign corresponding to about 7.3 percent of the total time. The model predicted vertical structure of temperature, humidity and cloud liquid water has been evaluated on the basis of the IPT retrievals at Cabauw. The IPT model predictions are confined to time slots for which profile information was successfully retrieved from the measurements. Model predicted profiles are furthermore restricted to cases without (model) precipitation reaching the surface.

Significant differences are found between the various model predictions both in **total LWC-amounts as in the altitude where the LWC is largest on average.** The LWC amounts precicted by RCA and RACMO are in the same order of magnitude as observed. The ECMWF model puts the level with largest LWC much too high; in contrast the LM predicts the level of the maximum below 1000 m and its profile exhibits much smaller amounts of LWC than is observed.

The RCA model shows low level cloud water not evident in the observations nor in the other models