1. Introduction

The accurate knowledge of the atmospheric state, i.e., temperature, humidity, cloud liquid water content and cloud ice profiles is needed for a number of applications - the calculation of radiative flux profiles being a particularly demanding one. In order to study cloud-radiation interactions, the atmospheric state has been derived for a nine month period of the Atmospheric Radiation Measurement (ARM) programs mobile facility (AMF) in the Black Forest, Germany (Fig. 1), using the Integrated Profiling Technique (IPT) and the Cloudnet retrieval algorithms. The derived profiles are subsequently used as input data for radiative transfer calculations to estimate the cloud radiative effect and forcing.

Measurements

The AMF was deployed in the Black Forest, Germany (N48°32', E08°24'), from April 1 to December 31, 2007. Together with data from the multispectral microwave radiometers of the University of Cologne, a set of long-term continuous measurements is available to apply the Baseline Instruments and Data for IPT:

- Cloud Radar: AMF W-Band (95 GHz) Cloud Radar
- Microwave Radiometer: 
  - HATPRO (Humidity And Temperature PROFiler): 2 bands (22.3-33.4 GHz, 51-58 GHz), 7 channels in each, availability of elevation and azimuth scans
  - DPR (Dual Polarization Radiometer): 3 channels (90 GHz, two orthogonal polarisations at 150 GHz)
- Radiosondes → a priori profiles of temperature, T, humidity, q, and LWC

3. Retrieval of atmospheric profiles

(A) Integrated Profiling Technique

- MVR Tbs
- Radar reflectivity Z
- a priori information of T, q, LWC

optimal estimation with forward model

continuous atmospheric profiles of T, q, and LWC and error estimates

The IPT [1] is used to derive physically consistent profiles. Meteosat-8 provides the position of the ARM site and cloud detection to derive cloud coverage. The ARM Cloudnet data can be downloaded from the ARM data server. The IPT derived uncertainty is used for re, water, and LWP uncertainties.

3. Cloud statistics for AMF site April-Dec 2007

- Water clouds
  - Mixed clouds
  - Ice clouds


- Water clouds
- Mixed clouds
- Ice clouds

5. Frequency distribution of IWC-LWC with respect to re and lq. The red line indicates the mean LWC profile of all cloudy profiles. Note that the values of the mean profile have been multiplied by 10 to fit to the x-axis.

6. Sensitivity tests

- Integrated Profiling Technique has been applied to AMF data set resulting in 88,110 profiles of temperature, humidity and liquid water content, including 33,168 cloudy scenes.
- Cloudnet data reveal a cloud freq. of 71.6% with 11.3% single-layer water clouds (no cloud above). Median thickness of lowest water cloud is 343 m and median MWR LWP 54 gm⁻².
- Calculated SW fluxes overestimate downwelling radiation and exhibit a considerable scatter compared to observations. Possible reasons: assumption of horizontal homogeneous conditions, misclassification of profile bins, uncertainties in derived cloud properties.
- Next step: Profiles need to be thoroughly checked and uncertainties in fluxes and heating rates due to uncertainties in the cloud properties need to be characterized for the whole period.

7. Summary and outlook

- Integrated Profiling Technique has been applied to AMF data set resulting in 88,110 profiles of temperature, humidity and liquid water content, including 33,168 cloudy scenes.
- Cloudnet data reveal a cloud freq. of 71.6% with 11.3% single-layer water clouds (no cloud above). Median thickness of lowest water cloud is 343 m and median MWR LWP 54 gm⁻².
- Calculated SW fluxes overestimate downwelling radiation and exhibit a considerable scatter compared to observations. Possible reasons: assumption of horizontal homogeneous conditions, misclassification of profile bins, uncertainties in derived cloud properties.
- Next step: Profiles need to be thoroughly checked and uncertainties in fluxes and heating rates due to uncertainties in the cloud properties need to be characterized for the whole period.

Acknowledgments:

- The authors would like to acknowledge the support from the Atmospheric Radiation Measurement (ARM) Program sponsored by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, Environmental Sciences Division. We acknowledge the Cloudnet project (European Union contract EVK2-2000-00611) for providing the Cloudnet data. The ARM Cloudnet data are available to the public from the ARM data server.

References: