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Report of the Final Cloudnet Symposium.

March 2006

REPORT OF THE FINAL CLOUDNET SYMPOSIIUM.

1. INTRODUCTION

The final Cloudnet workshop was held on 12 Oct 2005 at Beeskow near the Lindenberg Observatory in Germany. 50 scientists attended from 5 European countries with one visitor from the USA. A total of 19 presentations were made and can be found on the web site at www.cloud-net.org . Below in section 2, is the timetable and the titles of the presentations, followed by a short overview of the basic findings of each of the talks in Section 3. Finally in Section 4 is a summary of the discussion session.

2. PROGRAMME OF THE FINAL SYMPOSIUM – 12 OCT 2005

'Development of a European Network of stations for observing cloud profiles'
Hotel Schwan, Beeskow, Germany

0900	Introduction and Overview of the CloudNET	Anthony Illingworth
0920	CLOUD OBSERVING STATIONS	
	Instrumentation at the three original sites	Charles Wrench.
	Radar and lidar calibration	Ewan O'Connor.
0940	RETRIEVAL ALGORTHMS	
	Target categorisation	Robin Hogan
	Radar/lidar synergy to retrieve liquid water content.	HWJ Russchenberg
	Liquid Water Path from radiometer and lidar	Anthony Illingworth
	Liquid water content and drizzle in stratocumulus	Ewan O'Connor
1040 – 1100	coffee	
	Ice water content from reflectivity and temperature.	Robin Hogan
	Retrieving ice cloud properties from Doppler observations	Alain Protat
	Overview of radar-lidar techniques for ice cloud retrievals.	David Donovan
	Lidar techniques to retrieve cloud properties.	Martial Haeffelin
	Retrieving turbulence parameters from cloud radar.	Anthony Illingworth
1215-1315	Lunch	
1315	COMPARISON OF OBSERVATIONS WITH OPERATIONAL MODELS.	
	Evaluation statistics of cloud cover and water content.	Robin Hogan
	Liquid water content of cloud.	Ewan O'Connor
	Frequency of occurrence and cloud fraction.	Martial Haeffelin
	Microphysical and radiative cloud properties.	Alain Protat.
	Testing a new ice parameterisation scheme.	G-J van Zadelhoff
	Cloud fraction and ice water content in various weather regimes	Malcolm Brooks
	Use of regimes for diagnosis of climate model performance.	Damian Wilson
1515 -1540	Coffee.	
1540	A modellers perspective:	
	ECMWF Adrian Tomkins; UK Met Office Damian Wilson	
	Meteo-France Jean-Marcel Piriou (via Anthony Illingworth)	
	SMHI Ulrika Willen; DWD Axel Seifert	
1610	GENERAL DISCUSSION AND FUTURE PROSPECTS.	
1630	Recommended Specification of a Cloud Observing Stations + Discussion.	Anthony Illingworth
1700	Close.	

3. SUMMARY OF THE PRESENTATIONS.

3.1 Introduction and Overview of the CloudNET - Anthony Illingworth (UofR).
Summary of the sites involved, the models to be evaluated and the general approach with an overview of some of the key results.

CLOUD OBSERVING STATIONS

3.2 Instrumentation at the three original sites – Charles Wrench (RAL)
Descriptionof the instruments at the three original Cloudnet sites at Chilbolton (UK), SIRTA (F) and Cabauw (NL) together with the more recent sites at Lindenberg (D) and the USA ARM sites which have recently become associated with the Cloudnet project.

3.3 Radar and lidar calibration – Ewan O'Connor (UofR)
Description of two new techniques developed during Cloudnet for the absolute calibration of the radar reflectivity factor Z for cloud radars and the backscatter coefficient for ceilometers.

RETRIEVAL ALGORITHMS

3.4 Target categorisation -Robin Hogan (UofR)
Overview of the first stage of the analysis in which the observations 'pixels' at a resolution of 60 m in the vertical and 30 seconds in time are identified as ice and liquid water cloud, aerosols, insects, drizzle, precipitation etc. Once this is done, the pixels are mapped across to the grid of each model and the cloud fraction computed, and the appropriate algorithm invoked to compute liquid and ice water content.

3.5 Radar/lidar synergy to retrieve liquid water content – H W J Russchenberg (TUDelft).
A discussionof retreiving liquid water content in clouds using the radar return and the lidar return, which by its rapid attenuation at cloud base gives an indication of the cloud droplet concentration at cloud base – this can then be combined with the radar reflectivity to compute a liquid water content. The reuslts are compared with the liquid water path derived from the dual frequency radiomters. .

3.6 Liquid Water Path from radiometer and lidar – Anthony Illingworth (UofR).
A description of the technique for deriving accuarate liquid water paths from the dual frequency radiometers, which constrains the retrieval to give zero liquid water path when the lidar indicates no liquid cloud is present. This avoids the retrieval of cloud water when none is observed and also the physically impossible retrieval of negative cloud water.

3.7 Liquid water content and drizzle in stratocumulus **-** Ewan O'Connor (UofR).
An overview of the means of using radar and lidar profiles to define cloud top and cloud base which when combined with the liquid water path from the radiometer provides a liquid water content profile. Use of the Doppler parameters enables the size spectrum of the drizzle drops to be derived.

3.8 Ice water content from reflectivity and temperature – Robin Hogan (UofR).
Description of one of the standard Cloudnet algorithms for deriving ice water content from the radar refelctivity (which has been corrected for attenuation) in combination with the model temperature at that height to derive an ice water content.

3.9 Retrieving ice cloud properties from Doppler observations - Alain Protat (IPSL).
Radon - An alternative means of deriving ice water content, in this case using the radar reflectivity together with the observed Doppler velocity. Careful analysis is needed because the oberved Doppler is the sum of the ice particle terminal velocity and any up and down draughts in the cloud.

3.10 Overview of radar-lidar techniques for ice cloud retrievals - David Donovan (KNMI).
When the ice cloud can be penetrated by both the lidar and the radar then, once the lidar has been corrected for attenuation, the ratio of the radar and lidar returns is related to ice particle size. If size is

combined with the absolute value of the radar reflectivity an accurate value of ice water content can be derived. However , low clouds frequently obscure the lidar view of ice clouds. This accurate method is only able to sample about 15% of ice clouds, but is useful for evaluating the two radar only methods above.

3.11 Lidar techniques to retrieve cloud properties. – Martial Haeffelin (IPSL) .
A sensitive lidar at SIRTA is able to make direct observations of the optical depth of ice clouds by measuring the change in the molecular backscatter. By comparing the optical depth of the ice clouds with their radar reflectivity it is possible to compute the radar sensitivity needed to detect the high ice clouds which have a significant optical depth.

3.12 Retrieving turbulence parameters from cloud radar – Anthony Illingworth (UofR).
Analysis of the fluctuations in the mean Doppler velocity each second over a period of 30 seconds can be used to work out the rate of dissipation of kinetic energy due to turbulence.

COMPARISON OF OBSERVATIONS WITH OPERATIONAL MODELS.

3.13 Overview of radar-lidar techniques for ice cloud retrievals – David Donovan (KNMI).
Statistics of the ice water content and ice particles size for the 15% of ice clouds which can be detected from the ground are presented.

3.14 Evaluation statistics of cloud cover and water content – Robin Hogan (UofR).
Systematic comparisons of the ice water content and fractional cloud cover observed at the various cloudnet sites are made with the model representation. The performance and skill scores of the model are computed.

3.15 Liquid water content of cloud - Ewan O'Connor. (UofR).
As for the previous talks but the liquid water content is derived from the liquid water path observed by the dual frequency radiometer and then distributed between the ceilometer derived cloud-base and the cloud-top detected by the radar. Values are compared with those in the model, and the model performance is quantified.

3.16 Frequency of occurrence and cloud fraction. – Martial Haeffelin (IPSL) .
Sensitive lidar obsefrvations are used to quantify the occurrence of high altitude cirrus clouds which are not normally detected by the radar.

3.17 Microphysical and radiative cloud properties. – Alain Protat (IPSL).
The RADON method (3.9) in addition to estimating ice water content also provides information on ice particle size, density, and optical depth. Implications for their microphysical and radiative properties are explored.

3.18 Testing a new ice parameterisation scheme. – G-J van Zadelhof (KNMI).
Most models have a simple relationship between ice particle size and the temperature. The radar/lidar technique (3.10) suggests that ice particle size is better related to the distance from cloud top. A new paramterisation scheme is tested in which particle size depends upon the normalised distance from cloud top.

3.19 Cloud fraction and ice water content in various weather regimes – Damian Wilson (MetOffice).
The comparisons of modelled and observed cloud fraction and ice water content are carried out in terms of weather regime. The different weather regimes are defined by whether there is ascent at 300 and 700 mb, and the stability of the boundary layer.

4. SUMMARY OF THE DISCUSSION.

A modellers perspective:

Adrian Tompkins of ECMWF stressed the advantage of the Cloudnet data in that it provided almost instantaneous feedback when new model versions were released. This contrasted with most field campaigns, which take several years to anlayse, by which time several new generations of updates to the mdoel scheme have occured.
Damain Wilson of the Met Office reported that the effect of changing adjustable parameters in the cloud scheme was being tested off line so that they could be chosen to give model representation closer to the reality as revealed by the Cloudnet observations. These improved parameters would be used in the next release.
Jean-Marcel Piriou of Meteo France (via Anthony Illingworth) stressed how useful the Cloudnet observations had been in demonstrating the improved clouds for new releases of the model in 2003; this was in contrast with the traditional analysis using synoptic observations which gave a contradictory verdict.

Algorithm Discussion.

Comparisons reveal that the difference between the two ice water content retrievals (see 3.8 and 3.9) was generally small, and compared with the errors in the models was not significant. Accordingly it was not vital which one was used at this stage. It was also agreed that the liquid water content retrieval being used, while not perfect, was superior to any other proposed technique.

Recommended Specification for a cloud observing station.

Discussion centred on radar sensitivity and sampling problems. One difficulty identified was that if the radar observations were absent during period of rainfall because of unknown attenuation by the wet radome, then this mean that some of the higher periods of ice water content were not being observed. Means of sub-sampling the model were proposed. It was agreed that an ideal solution would be to have a radar system which operated during rainfall. The use of conventional X-band radars in vertically pointing mode appeared to be able to have the sensitivity to see the thin ice clouds, and also have the advantages that it was not affected significatnly by attenuation due to percipiation, cloud water or atmospheric gases. This advantage would make model comparisons much easier and improve data quality because frequently there was some uncertainty over the accuracy of the radar attenuation corrections.