SECTION 2: EXECUTIVE PUBLISHABLE SUMMARY, RELATED TO REPORTING PERIOD (12 MONTHS)

Contract n°	EVK2 – 2000 – 00065	Reporting period:	1 APRIL 2002 – 31 MARCH 2003 (YEAR 2)
Title	DEVELOPMENT OF A EUROPEAN NETWORK OF STATIONS FOR OBSERVING CLOUD PROFILES		

Objectives:

In this the second year of CLOUDNET the primary objectives are as follows:

- To test algorithms to derive cloud characteristics from existing data sets.
- To operate the three cloud stations, to quality control and archive the data.
- To develop algorithms for retrieving macroscopic cloud properties, and liquid ice and mixed phase cloud properties from radar and lidar observations and consider the technological implications of implementing such algorithms.
- To compare the macroscopic cloud properties, and liquid ice and mixed phase cloud properties inferred from radar and lidar observations with the values held in four European operational forecasting models.

Scientific achievements:

1. *Independent evaluation of a new radar/lidar retrieval of ice particle size and water content using blind tests.*
   Retrieval of ice cloud properties from lidar has always been very difficult because the lidar beam is attenuated to an unknown degree by the cloud itself. We have evaluated a new technique which uses the radar return as first guess for the attenuation and then requires a stable solution on the far side of the cloud, and found that the new retrieval method is very stable and accurate.

2. *One year's climatology of ice particle size as a function of ice water content and temperature.*
   We have used the new retrieval technique in 1) to analyse one year's radar and lidar data to produce a climatology of the ice water content and ice particle size as a function of temperature for use in forecast model parameterisation schemes.

3. *New algorithms for deriving liquid water content drizzle size spectra and attenuation within stratocumulus liquid water cloud.*
   Liquid water content and drizzle sizes have been derived from radar and lidar returns; these variables are used in operational forecast models to represent such clouds.

4. *Use of combined reflectivity and Doppler velocity to classify ice particles.*
   Remote observations of radar reflectivity and vertical velocity have been used to infer ice particle type. In-situ aircraft data have validated the radar inferences.

5. *Development of a calibration technique for 94GHz cloud radar.*
   Observational are only useful if the radar is calibrated. We have developed a new technique which uses the known constant return from rain at 94GHz for calibration.

6. *Characterise the lifetime and decay of a 94GHz cloud radar EIKA.*
   The 94GHZ EIKA amplifier is a crucial component of all cloud radars. We have characterised the lifetime and decay of an early amplifier. We are now monitoring the performance of a more advanced design of EIKA which appears to be superior.

7. *Demonstration of the ability to make unattended long time series of radar and lidar data.*
   Such equipment has been with weekly attention for a period of a year at two of the sites.

8. *Development of a lidar self-calibration technique.*
   Lidar observations are only useful if the lidar is calibrated. This technique uses the known integrated back scatter from water clouds to calibrate the lidar return.

9. *Theoretical demonstration of the retrieval of liquid water droplet size from a lidar with a double field of view.*
   Lidar multiple scattering increases as drop size increases. Theoretical studies suggest that drop size can

be derived from the returns from a lidar with two fields of view.

10. *Identification of specular reflection from ice crystals.*
The enhanced mirror like lidar return from pristine crystals can be identified by the anomalously high integrated lidar backscatter.

11. *Retrieval of particle size spectra from Doppler spectral width.*
It is shown that the Doppler width due to the different terminal velocities of the falling raindrops can be used to constrain the width of the raindrop size spectrum.

12. *Comparison of fractional cloud cover, observed ice water content and missed phase clouds with their representation in operational models.*
Clouds are represented in forecast models by their fractional cloud cover and ice water content; our observations provide the first evaluation of this model representation.

13. *Derivation of probability density functions (pdf) of water content and cloud inhomogeneities.*
It has been proposed that the model representation of the fraction of clouds within a grid box should be expressed in terms the pdf of the total water content; we provide the first analytic expressions for this pdf derived from our radar lidar observations.

14. *The definition of cloud fraction by area or volume.*
Observations show that the fraction of the volume of a grid box filled with cloud is much less than the cloud filled fraction of the projected area; yet models assume the two quantities are equal. We provide analytic expression relating the two quantities.

15. *A two-year climatology of the radar reflectivity of stratocumulus.*
Stratocumulus clouds containing only small droplets have a low radar reflectivity; we produce statistics of the fraction of such clouds detected radars of differing sensitivity.

Socio-economic relevance and policy implications:

A major objective of CLOUDNET is to develop a network of cloud observing stations and to demonstrate how such stations can improve the representation of clouds used in forecasting the weather and future climate. Clouds play a major role in the production of rain, floods and the hydrological cycle. Difficulties in representing clouds are a major contribution to the current spread in forecast for future global warming. Achievements 1-4 deal with improved means deriving cloud properties from radar and lidar; 5-8 will aid the practical implementation of radar and lidar in an operational cloud observing station; 9-11 report new retrieval techniques, and 12-15 show, for the very first time, how the data can be used to evaluate current representation of clouds with in these forecasting models.

Conclusions:

Considerable progress has been made in techniques for obtaining reliable radar and lidar signals from clouds, and transforming these observations into cloud properties held in models, and then to demonstrate how this can be used to evaluate models. With a large amount of data now being gathered we look forward to rapid further progress.

Keywords:

Cloud radar and lidar. Cloud properties. Forecast and climate models. Flooding and the hydrological cycle. Future climate change.

Publications (cumulative list)[2]

General rules about publicity and communications are defined within the Annex II ,"General conditions" Part B, to the contract, mainly obligations, responsibilities and reference to Community support. This should be prepared as a separate page to be annexed to the report and updated annually.

[2] Two copies of publications issued during reporting period should be annexed to the report, specific cases should be agreed by the Project Officer

Peer Reviewed Articles:

Authors	Date	Title	Journal	Reference
R J Hogan, H Flentje, P N Francis, A J Illingworth, M Quante and J Pelon	2003	Characteristics of mixed phase clouds. Part1: Lidar, radar and aircraft observations from CLARE '98	Q J R Meteorol Soc	**129**, 2089-2116
R J Hogan, A J Illingworth, J P V Poiares Baptista and E J O'Connor	2003	Characteristics of supercooled clouds: Part II A climatology from ground-based lidar	Q J R Meteorol Soc	**129**, 2117-2134
R J Hogan and A J Illingworth	2003	Parameterizing ice cloud inhomogeneity and the overlap of inhomogeneities using cloud radar data	J Atmos	**60**, 756-767
N Gaussiat, H Sauvageot, A J Illingworth	2003	Cloud liquid water and ice content retrieval by multi-wavelength radar	J Atmos and Ocean Technol	**20**,1264-1275
R J Hogan, D H Bouniol, D N Ladd, E J O'Connor and A J Illingworth	2003	Absolute Calibration of 94-GHz radars using rain	J Atmos and Ocean Technol	**20**, 572-580
D.P.Donovan	2002	First ice cloud effective particle size parameterization based on combined lidar and radar data	GRL	29, No. 1, 10.1029/2001GL013731
D.P.Donovan	2003	Ice-Cloud effective particle size parameterization based on combined lidar,radar reflectivity, and mean Doppler velocity measurements	GRL	In press
Baedi, R.; Boers,R.; Russchenberg, H.W.J	2003	Detection of Boundary Layer Water Clouds by Spaceborne Cloud Radar	J Atmos Oceanic Technol	19
Protat A, C.Tinel and J Testud	2002	Dynamic properties of clouds and dynamic/microphysical interactions from 94GHz radar and lidar	Phys and Chem of the Earth. B	In revision
C.Tinel, J Testud, A. Protat, and J.Pelon	2002	Microphysical and radiative properties ice clouds using a cloud radar-lidar algorithm	Phys and Chem of the Earth. B	In revision
M E Brooks, R J Hogan and A J Illingworth	2003	The definition of cloud fraction in GCMs by area and by volume	J.Atmos Sci	Submitted
E J O'Connor, A J Illingworth and R J Hogan	2003	A technique for auto-calibration of cloud lidar	J Atmos Oceanic Technol	Submitted
E J O'Connor, A J Illingworth and R J Hogan	2003	Retrieving stratocumulus drizzle parameters using Doppler radar and lidar	J Atmos Oceanic Technol	Submitted

E J O'Connor, R J Hogan and A J Illingworth.	2003	Radar detection and climatology of stratocumulus clouds.	J Appl Met.	To be submitted
N.Gaussiat, R.J.Hogan and A J Illingworth.	2003	Stratocumulus liquid water content from dual wavelength radar.	J Ocean Atmos Technol.	To be submitted
M E Brooks, R J Hogan and A J Illingworth.	2003	Comparisons of radar derived values of IWC and their representation in operational models of ECMWF and Met Office.		To be submitted

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Non refereed literature:

Authors / Editors	Date	Title	Event	Reference	Type[3]
Krasnov O and Russchenberg H	2002	An enhanced algorithm for the retrieval of liquid water cloud properties from simultaneous radar and lidar measurements. Part 1: The basic analysis of in-situ drop spectra.	European Conference on Radar Meteorology	ERAD 2002 Proceedings, 18 - 22 November 2002, Delft, The Netherlands, ERAD Publication Series Vol. 1 - pp. 173 – 178	paper
Krasnov O and Russchenberg H	2002	An enhanced algorithm for the retrieval of liquid water cloud properties from simultaneous radar and lidar measurements. Part II Validation using ground based radar. lidar and microwave radiometer data	European Conference on Radar Meteorology	(ERAD) 2002 Proceedings, 18 - 22 November 2002, Delft, The Netherlands, ERAD Publication Series Vol. 1 - pp. 173 – 178	paper
	2002	Polarimetric cloud studies at 3.3.GHz.	European Conference on Radar Meteorology	(ERAD) 2002 Proceedings, 18 - 22 November 2002, Delft, The Netherlands, ERAD Publication Series Vol. 1 - pp. 173 – 178	paper
Krasnov O and Russchenberg H	2002	The Comparative Study of the Relation Between Cloud Microphysics and Radar-to-Lidar Ratio for the Different Geographical Regions	Open Symposium on Propagation and Remote Sensing	URSI Commission-F, 12-15 February 2002, Garmisch-Partenkirchen, Germany 10 pp	paper

[3] Type: Abstract, Newsletter, Oral Presentation, Paper, Poster, Proceedings, Report, Thesis

		and Field Campaigns			
Krasnov O and Russchenberg H	2002	The relation between the radar to lidar ratio and the effective radius of droplets in water clouds: An analysis of statistical models and observed drop size distributions.	11th Conference on Cloud Physics, 3-7 June 2002, Ogden, Utah, AMS.		Proc. on CD-ROM
Krasnov O and Russchenberg H	2002	Use of simultaneous radar and lidar data for the retrieval of microphysical parameters in low-level water clouds.		15th Symposium on Boundary Layer and Turbulence, 15-19 July 2002, Wageningen, The Netherlands, AMS, pp. 88-91.	paper
	2002	Comparison of multiple-wavelength cloud radar observations in the BBC campaign		Conference CD of URSI, 27th General Assembly of the International Union of Radio Science, Maastrich, The Netherlands (2002).	
D.P. Donovan	2002	Effecive particle sizes in Cirrus derived from combined lidar, radar reflectivity and Doppler velocity measurements.	European Radar Conference, Delft, The Netherlands.		
D.P. Donovan	2003	Effective ice cloud Size distribution parameterization using combined lidar, radar reflectivity and Doppler velocity measurements	EGS-AGU-EUG Joint assembly, Nice, France		