TECHNOLOGICAL IMPLEMENTATION PLAN

A Framework for the further development, dissemination and use of the results of EC RTD Projects (including also thematic networks and concerted actions)

DATA SHEETS

Preliminary version at mid-term (optional, programme per programme)

X Final version before final term (contractual obligation)

Part 1: Overview and description of your project and its results
One form per project
Publishable

1.1: Executive summary (to be used for an accurate update of the programme synopsis of projects)
1.2: Overview of all results
1.3: Quantified data on the project
1.4.: Assessment of the European interests: This section enables the co-ordinator to explain the interest for the European Union (the competitiveness of its industries, the usefulness for (part of) its population,…) of the achieved results and of their foreseen impacts.
1.5.: Expected project impact

Part 2: Description of each Result - Search for collaboration through Commission services
One form per Result
Publishable

This section will be used to document your result(s) in CORDIS and to inform any appropriate audience

2.1: Description of the result(s)
2.2: Quantified data about the result
2.3: Further collaboration, dissemination and use of the result : This section enables each partner – individually or as a consortium – to describe its needs in further collaboration in view of the dissemination an use of its results(s).

Part 3: Description of the intentions by each partner
One form per partner
Confidential

This section enables each partner – individually or as a consortium – to describe its use and dissemination intentions (including a timetable of its future activities).
3.1: Description of the use and the dissemination of result(s), partner per partner
3.2: Quantified data for each partner's main result

- The Technological Implementation Plan data sheets are available as a predefined form in Microsoft Word format. The file may be downloaded from the European Commission's CORDIS web site at: http://www.cordis.lu/fp5/tip.htm or may be obtained by e-mail from your EC programme help desk or your Project Officer.
- The form should be completed electronically and returned preferably by e-mail to your project officer (Firstname.Lastname@cec.eu.int). Alternatively it can be sent on a diskette to the address provided by your Project Officer :
  - ✓ Part 1, 2 by the project co-ordinator;
  - ✓ Part 3 by the project co-ordinator or by each partner individually, as preferred.

Part 1 Overview and description of your project and its results

EC PROGRAMME :	**ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT**
PROJECT TITLE & ACRONYM:	**CLOUDNET: DEVELOPMENT OF A EUROPEAN NETWORK OF STATONS FOR OBSERVING CLOUD PROFILES.**
CONTRACT NUMBER :	**CLOUDNET EVK2 – 2000 – 00065**
PROJECT WEB SITE (if any) :	www.cloud-net.org
PARTNERS NAMES :	**1. University of Reading, UK (UR)** **2. Council for the Central Laboratory for the Research Councils, UK (RAL – CCLRC)** **3. Centre National de la Research Scientifique, Delegation Ile-de-France Ouest et Nord (CNRS-IPSL)** **4. Royal Netherlands Meteorological Institute (KNMI)** **5. Technical University of Delft (TUD)** **6. The Meteorological office (The Met Office)** **7. Vaisala Oyj (Vaisala)**

1.1 Executive summary

Please, synthesise (in 1 or 2 pages) your project original objectives and final outcome.

a) Original research objectives

The overall objectives of CLOUDNET are :

To optimise the use of existing data sets to develop and validate cloud remote sensing synergy algorithms.

To demonstrate the importance of an operational network of Cloud Remote Sensing stations (CRS-stations) to provide data for the improvement of the representation of clouds in climate and weather forecast models and for the use of GCOS.

The objectives of the five work packages are:

WP1 - Exploit Existing Cloud Data Sets.
To organise the existing data in to a format accessible by other partners.
To test first versions of algorithms to derive cloud characteristics from the data set.
To analyse the in-situ cloud aircraft data to validate the retrievals.

WP2 - Operate three cloud remote sensing stations.
To operate the stations for a minimum of one week per month for two years.
To quality control and archive the data.
To archive the model forecast data over each of the sites.

WP3 - Development of retrieval algorithms.
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.

WP4 - Compare retrieved cloud profiles with operational models.
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.

WP5 - Definition of instruments and algorithms for GCOS.
To define the optimal combinations of instruments, algorithms and data formats for a practical GCOS stations.

b) Expected deliverables

The action has the following deliverables:

D0 Project Publicity Brochure
D2 Existing data sets and initial analysis.
D3 Initial algorithm recommendation
D4 User Requirement Document
D5 CloudNET web side
D6 Year one data gathered
D7 Model data year one
D8 Year two of data gathered
D9 Model data year two
D10 Optimised algorithms and performance
D11 Comparison of algorithms with model.
D12 Recommendation for industry
D13 Report of final workshop
D14 Description of recommended GCOS station..

The completed deliverables are available on the web site:
www.cloud-net.org

c) Project's actual outcome ***(in terms of technical achievements or if appropriate task per task)***

Summary of the deliverables and original findings within each work package:

WP1 – Exploit Existing Cloud Data Sets. (D2)

1. Objective evaluation of radar/lidar retrieval of ice particle size and ice water content.
2. First climatology of ice particle size as a function of ice water content and temperature.
3. Characterisation of ice particles using both radar reflectivity and Doppler velocity.

WP2 – Operate three cloud remote sensing stations. (D6)

4. Development of a new technique using the rain return to calibrate the 94GHz cloud radars.
5. Development of an auto-calibration technique for lidars each time there is low level water cloud.
6. Demonstration of absolute cross-calibration for the three cloud radars at the three stations.

WP3 – Development of retrieval algorithms. (D10)

7. Correction of profiles and mapping on to the operational model grid.
8. Target classification.
9. Derivation of cloud fraction
10. Establishment of cloud phase using lidar depolarisation.
11. Accurate liquid water path (lwp) from dual frequency radiometers.
12. Liquid water content profiles by comparison with the adiabatic liquid water content.
13. Liquid water content from the profile of the radar return and the lidar extinction at cloud base.
14. Drizzle parameters below stratocumulus (Sc) cloud.
15. Ice water content using radar reflectivity combined with temperature.
16. Ice water content using radar reflectivity combined with Doppler velocity.
17. A comparison of the ice water content derived from different retrieval methods.

WP4 – Compare retrieved cloud profiles with operational models. (D11)

18. First evaluation of cloud fraction.
19. Model liquid water content.
20. Model ice water content.
21. High cloud occurrence.
22. Cloud fraction as a volume of the grid box or as a projected area of the grid box.
23. Analysis of model performance classified by weather regime.
24. Cloud fraction skill scores from 2002 to 2005.
25. Confirmation of the improvement of the Meteo-France cloud scheme.
26. Testing of proposed Met Office 'PC2' cloud scheme.
27. Parameterisation of ice effective radius in the KNMI RACMO model.

WP5 - Specification of a standard cloud observing station.

28. An economic combination of cloud radar with a simple ceilometer and low cost radiometers.
29. The use of low power FM/CW mm wave cloud radars and an X-band pulsed cloud radar.
30. Relaxation of radiometer specification.

d) Broad dissemination and use intentions for the expected outputs *(such as industrial development, standards, regulations and norms, improvement of environment, health, working conditions, employment, net economic benefits, etc)*

Advice to industrial partners on the optimum instruments and algorithms for an operational cloud Remote Sensing Station.

Comparison of the observations of cloud properties over three cloud remote sensing stations in UK, NL and F with the properties held in four operational forecast models for the grid box over these stations. Identification of systematic errors in the forecast models.

These outputs should enable modellers to improve the parameterisation of clouds within their models. Such improved parameterisations would lead to better weather forecasts of flooding and improved climate forecast of global warming.

1.2 Overview of all your main project results

No.	Self-descriptive title of the result	Category A, B or C*	Partner(s) owning the result(s) (referring in particular to specific patents, copyrights, etc.) & involved in their further use
1	Objective evaluation of radar/lidar retrieval of ice particle size and ice water content.	A	UR, IPSL, KNMI
2	First climatology of ice particle size as a function of ice water content and temperature.	A	KNMI
3	Characterisation of ice particles using both radar reflectivity and Doppler velocity.	A	KNMI.
4	Development of a new technique using the rain return to calibrate the 94GHz cloud radars.	A	UR, RAL
5	Development of an auto-calibration technique for lidars each time there is low level water cloud.	A	UR, RAL
6	Demonstration of absolute cross-calibration for the three cloud radars at the three stations.	A	RAL, UR, IPSL, KNMI
7	Correction of profiles and mapping on to the operational model grid.	A	UR, IPSL, KNMI
8	Target classification.	A	UR, IPSL, KNMI.
9	Derivation of cloud fraction.	A	UR, IPSL, KNMI
10	Establishment of cloud phase using lidar depolarisation.	A	IPSL
11	Accurate liquid water path (lwp) from dual frequency radiometers.	A	UR, RAL, IPSL
12	Liquid water content profiles by comparison with the adiabatic liquid water content.	A	UR, RAL.
13	Liquid water content from the profile of the radar return and the lidar extinction at cloud base.	A	Tud
14	Drizzle parameters below stratocumulus (Sc) cloud.	A	UR
15	Ice water content using radar reflectivity combined with temperature.	A	UR, IPSL
16	Ice water content using radar reflectivity combined with Doppler velocity.	A	IPSL
17	A comparison of the ice water content derived from different retrieval methods.	A	UR, IPSL, KNMI.
18	First evaluation of cloud fraction.	A	UR, MO
19	Model liquid water content.	A	UR

* A: results usable outside the consortium / B: results usable within the consortium / C: non usable results

No.	Self-descriptive title of the result	Category A, B or C*	Partner(s) owning the result(s) (referring in particular to specific patents, copyrights, etc.) & involved in their further use
20	Model ice water content.	A	UR, IPSL
21	High cloud occurrence.	A	IPSL
22	Cloud fraction as a volume of the grid box or as a projected area of the grid box.	A	UR
23	Analysis of model performance classified by weather regime.	A	UR, MO
24	Cloud fraction skill scores from 2002 to 2005.	A	UR, MO
25	Confirmation of the improvement of the Meteo-France cloud scheme.	A	UR
26	Testing of proposed Met Office 'PC2' cloud scheme.	A	UR, Met Office.
27	Parameterisation of ice effective radius in the KNMI RACMO model.	A	KNMIS
28	An economic combination of cloud radar with a simple ceilometer and low cost radiometers.	A	UR, IPSL, KNMI, VAISALA
29	The use of low power FM/CW mm wave cloud radars and an X-band pulsed cloud radar.	A	UR, KNMI, IPSL, RAL.
30	Relaxation of radiometer specification.	A	UR, RAL..

* A: results usable outside the consortium / B: results usable within the consortium / C: non usable results

1.3 Quantified Data on the dissemination and use of the project results

Items about the dissemination and use of the project results (consolidated numbers)	Currently achieved quantity	Estimated future* quantity
# of product innovations (commercial)	4	2
# of process innovations (commercial)		
# of new services (commercial)		
# of new services (public)		
# of new methods (academic)		
# of scientific breakthrough	30	10
# of technical standards to which this project has contributed		
# of EU regulations/directives to which this project has contributed		
# of international regulations to which this project has contributed		
# of PhDs generated by the project	6	
# of grantees/trainees including transnational exchange of personnel		

*# = number of ... / * "Future" means expectations within the next 3 years following the end of the project*

1.4. Comment on European Interest

All projects are expected to meet European interests. This section should provide an appraisal of your project in terms of European added value and support to the implementation of European Union policies.

1.4.1. Community added value and contribution to EU policies

a. European dimension of the problem
(The extent to which the project has contributed to solve problems at European level)

Three pilot cloud remote sensing stations have been set up and are operating in the UK, France and The Netherlands. In the final year of the project the Lindenberg Observatory of the DWD joined the project. Initially the project involved the models of ECMWF, Met Office, KNMI and MeteoFrance. During the final year the models of DWD (Germany) and Sweden (RCA) joined the project. We have one European industrial partner, a major company in the manufacture of meteorological instrumentation. Two other companies have attended some meetings as observers.

b. Contribution to developing S&T co-operation at international level. European added value
(Development of critical mass in human and financial terms; combination of complementary expertise and resources available Europe-wide)

The project initially involved groups from four EU countries (UK, F, NL and Finland) working together to develop common instruments, commons algorithms and a common means of comparing cloud properties to European forecast models. This has been extended to include Germany and Sweden.

c. Contribution to policy design or implementation
(Contribution to one or more EU policies; RTD connected with standardisation and regulation at Community and/or national levels)

1.4.2. Contribution to Community social objectives

a. Improving the quality of life in the Community :

The project involves comparing cloud observations with their representation in forecast models with the aim of identifying errors in their representation and then improving their forecasting. The impacts of this are twofold:

- **i) Improved flood forecasting through improved representation of clouds in forecast models.**
- **ii) Improved forecasts of future global warming – the current unacceptable range of uncertainty over predicted global warming over the next century stems largely from uncertainties over the representation of clouds in such models.**

b. Provision of appropriate incentives for monitoring and creating jobs in the Community (including use and development of skills) :

A specification for a new economical and low cost cloud observing stations has been drawn up. The cost of such an instrument would be in the order of 250,000 Euro and as such we consider that each National Met Service could purchase up to six of these instruments as part of their automatic operational weather observing system. There would also be the potential for sales outside the EU.

c) Supporting sustainable development, preserving and/or enhancing the environment (including use/conservation of resources) :

Improved forecasts of rainfall and flooding will lead to a reduction in the damage to the environment caused by recent severe flooding events.

1.5. Expected project impact (to be filled in by the project coordinator)

Remark: by replying to the following questions, the coordinator is asked to express his best estimation regarding the impact of the project.

Overall Policy Impact[1]

EU Policy Goals	I SCALE OF EXPECTED IMPACT OVER THE NEXT 10 YEARS[2] -1 0 1 2 3	II other Not applicable to project	II other Project Impact too difficult to estimate
1. Improved sustainable economic development and growth, competitiveness Θ	1		
2. Improved employment Θ	1		
3. Improved quality of life and health and safety Θ		0	
4. Improved education Θ		0	
5. Improved preservation and enhancement of the environment Θ	3		
6. Improved scientific and technological quality Θ	1		
7. Regulatory and legislative environment Θ		0	
8. Other ______ Θ			

[1] Coordinator should respond to section I or, if appropriate, to section II. If the project has had no impact, a "0" should be entered in section I. Scores other than zero in section I will prompt a more detailed subquestion on a separate screen. However, you may access in any case the subquestions by clicking on the symbol" Θ "following each main question.

[2] Indication for scale as follows: -1 represents negative impact, 0 no impact, 1 small positive impact, 2 medium positive impact , 3 is a strong positive impact

Indicate your replies below by putting in each box the number corresponding to the score you chose:

1. Economic development and growth, competitiveness	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	Scale of Expected Impacts over the next 10 years (2) After Project End -1 0 1 2 3
a) Increased Turnover for project participants - national markets	1	1
- international markets	1	1
b) Increased Productivity for project participants	1	1
c) Reduced costs for project participants	1	1
d) Improved output quality/high technology content	2	2

2. Employment	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	Scale of Expected Impacts over the next 10 years (2) After Project End -1 0 1 2 3
a) Safeguarding of jobs	0	0
b) Net employment growth in projects participants staff	0	0
c) Net employment growth in customer and supply chains	0	0
d) Net employment growth in the European economy at large	0	0

3. Quality of Life and health and safety	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	Scale of Expected Impacts over the next 10 years (2) After Project End -1 0 1 2 3
a) Improved health care	0	0
b) Improved food, nutrition	0	0
c) Improved safety (incl. consumers and workers safety)	0	0
d) Improved quality of life for the elderly and disabled	1	1
e) Improved life expectancy	1	1
f) Improved working conditions	0	0
g) Improved child care	0	0
h) Improved mobility of persons	0	0

4. Improved education	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	Scale of Expected Impacts over the next 10 years (2) After Project End -1 0 1 2 3
a) Improved learning processes including lifelong learning	1	1
b) Development of new university curricula	1	1

5. Preservation and enhancement of the environment	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	Scale of Expected Impacts over the next 10 years (2) After Project End -1 0 1 2 3
a) Improved prevention of emissions	0	0
b) Improved treatment of emissions	0	0
c) Improved preservation of natural resources and cultural heritage	1	1
d) Reduced energy consumption	1	1

	6. S&T quality	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	After Project End -1 0 1 2 3
a)	Production of new knowledge	3	3
b)	Safeguarding or development of expertise in a research area	3	3
c)	Acceleration of RTD, transfer or uptake	3	3
d)	Enhance skills of RTD staff	3	3
e)	Transfer expertise/know-how/technology	2	2
f)	Improved access to knowledge-based networks	2	2
g)	Identifying appropriate partners and expertise	2	2
h)	Develop international S&T co-operation	2	2
i)	Increased gender equality	1	1

	7. Regulatory and legislative environment	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	After Project End -1 0 1 2 3
a)	Contribution to EU policy formulation	0	0
b)	Contribution to EU policy implementation	0	0

8. Other (please specify)	Scale of Expected Impacts over the next 10 years (2) By Project End -1 0 1 2 3	After Project End -1 0 1 2 3

I, **project co-ordinator**, confirm the published information contained in this part 1 of the TIP.

Signature: **Name:**

Date: **Organisation:**

Part 2 Description of each result

A separate part 2 must be completed for each result. This may be done by the partner responsible for the result or by the project co-ordinator.

The part 2 must be consolidated at the consortium level and transmitted to the Commission by the co-ordinator.

PARTS 2 WILL BE DISSEMINATED BY THE COMMISSION

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
1	Objective evaluation of radar/lidar retrieval of ice particle size and ice water content.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Simultaneous radar and lidar backscatter return signals from ice clouds have the potential to provide, for the first time, accurate ice particle size and ice water content. Current retrievals are unreliable because it is difficult to correct for the severe attenuation of the lidar signal. Two new methods to correct for attenuation by using the radar return at the back of the clouds have been compared and evaluated in a series of blind tests. The first method (KNMI) is to iteratively adjust the lidar attenuation of the cloud so that D on the far side of the cloud is well behaved and constant over the last few detectable gates, whereas the second method (IPSL) is to adjust the attenuation so that N is constant over the last few gates. The two teams then fed the radar and attenuated lidar backscatter into their algorithms and reported back their inferred profiles of extinction coefficient and particle size; the retrievals are very close to the original data. The extinction coefficient is the most important, as this controls the radiative fluxes, and is very accurately retrieved, with an accuracy sufficient to constrain the long wave fluxes to 10W m^{-2}.

Benefit: Better profiles of ice water content and ice particles size. Could be applied to new satellite instumentation.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: *PU*=Public *CO*=Confidential
Refereed article	Hogan R. J., Donovan D. P., Tinel D., Brooks M. A., Illingworth A. J. and J. P. V. Poiras Baptista. 2006 Independent evaluation of the ability of spaceborne radar and lidar to retrieve the microphysical and radiative properties of ice clouds. JAOT 23, 211-227	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
2	First climatology of ice particle size as a function of ice water content.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Radiative properties of ice clouds are controlled by their optical depth which is affected by the size of the ice particles. The KNMI retrieval method has been applied to 7 months data from the US Government Atmospheric Radiation Measurement's (ARM) Southern Great Planes (SGP) site situated Oklahoma has been compared with previously suggested effective particle radius parameterisations derived from in-situ aircraft data. In general, our results confirm previous parameterisations, but there are some large differences probably due to differences in IWC. The results of this work have been used to formulate parameterisations of cirrus cloud effective particle radii and other relevant quantities that are suitable for inclusion in atmospheric models. This work strongly argues that in formulating ice-crystal size parameterisation that both IWC and temperature should be taken independently into account.

Applications – parameterisation schemes in operational forecast models and climate prediction models.

Benefits – Better representation of ice processes.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed Article	van Zadelhoff G. J., D. P. Donovan, H Klein Baltink, and R Boers. 2004 Comparing ice-cloud microphysical properties using CloudNET and Atmospheric Measurement Program data. JGR 109, D2414, doi 1029/2004JD004967	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
3	Characterisation of ice particles using both radar reflectivity and Doppler velocity.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The terminal velocity of ice particles is important in defining the lifetime of cirrus clouds. Current models assume a simple dependence of mean terminal velocity on ice water content, but in fact this velocity depends on ice particle shape, size and density, all of which are variable. Ice particle concentrations are very variable, so a given ice water content (IWC) could have a high concentration of small ice particles which would fall slowly, or a low concentration of larger ice particles which would fall more rapidly. To remove this dependence the ice water content is divided by the normalised ice particle concentration, which effectively gives the mean mass of particles in the spectra. Once the concentration has been removed from the IWC expression then the mean mass of the ice particles is much better correlated with the terminal velocity of the spectrum. Observations show slower velocities for a given mean mass at higher altitudes, one assumes this is because at colder temperatures the density of the ice particles is lower.

Applications: Better parameterisation schemes in weather forecasting and climate models.

Benefits: Improved forecasts of weather and future climate.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Donovan D. P. 2002 First ice cloud effective particle size parameterization based on combined lidar and radar data GRL **29**, No. 1, 10.1029/2001GL013731	PU
Non-refereed article	D.P. Donovan 2002 Effective particle sizes in Cirrus derived from combined lidar, radar reflectivity and Doppler velocity measurements. European Conference on Radar Meteorology, 18 - 22 November 2002, Delft, The Netherlands. ERAD 2002 Proceedings, Vol. 1 - pp. 173 – 178	PU
Non-refereed article	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	PU
Refereed article	Donovan D. P. 2004 Ice-Cloud effective particle size parameterization based on combined lidar, radar reflectivity, and mean Doppler velocity measurements JGR **108**, No. 18,	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
4	Development of a new technique using the rain return to calibrate the 94GHz cloud radars.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Accurate calibration of a radar so that the reflectivity, Z, is correct is an essential step but one which is often given insufficient attenuation. Our experience is that traditional engineering calculation of the link budget, can easily be out by more than a factor of two. Traditionally, for precipitation radars an improved calibration is carried out by comparing the radar signal with the rainfall rate measured by a ground based gauge a few km from the radar, but this direct approach is not possible for a cloud radar because the 94GHz signal is enormously attenuated by the rain. The new method we have developed relies on the theoretical 94GHz radar reflectivity of rainfall above 2mm/hr being reduced by Mie scattering so that it is constant and close to 19dBZ with little dependence on the raindrop concentration (N_L) or the shape of the spectra (μ).

Applications: Manufacture of cloud radars.

Benefits: A standard simple and absolute calibration for a radar.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	21	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: ***PU***=Public ***CO***=Confidential
Refereed Article	Hogan R. J, Bouniol D. H., Ladd D. N., O'Connor E. J. and A. J. Illingworth 2003 Absolute Calibration of 94-GHz radars using rain JAOT **20**, 572-580	PU
Refereed Article	Schutgens N. and D. Donovan 2004 Retrieval of atmospheric reflectivity profiles in the case of long radar pulses. Atmosph Research 72, 187-196	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
5	Development of an auto-calibration technique for lidars each time there is low level water cloud.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Traditionally calibration of visible lidars is achieved by comparison with Rayleigh scatter from the molecules in the air, but this is not possible for the common lidars operating near one micron. A method of automatically self-calibrating lidars has been developed which can be used every time low-level thick stratocumulus clouds are present. The method is to add up the lidar backscatter (in /m/sr) at each gate until the signal is extinguished to give the 'integrated backscatter'. The lidar calibration is then adjusted until the integrated backscatter is about 15sr. Typical calibration over a period of seven hours of low level cloud, after calibration, gives a constant value of integrated backscatter, apart from occasional short periods where the cloud is thinner. The method provides a calibration accurate to about 10%.

Applications: Manufacture of lidar systems for cloud and aerosol detection.

Benefits: A standard simple and absolute calibration for a lidar.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: *PU*=Public *CO*=Confidential
Refereed Article	O'Connor E. J., Illingworth A. J. and R. J. Hogan 2004 A technique for auto-calibration of cloud lidar JAOT **21**, 777-786	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
6	Demonstration of absolute cross-calibration for the three cloud radars at the three stations.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Accurate radar calibration is of major importance because radar reflectivity is one of the inputs to the cloud microphysical, radiative and dynamical properties retrieval algorthms. A successful cross-calibration of three CloudNET radars was achieved during March and April 2004. The Galileo 94GHz radar at Chilbolton was absolutely calibrated by comparing returns from Rayleigh scattering ice clouds which were simultaneously observed by a 3GHz radar which had itself been calibrated using the well known redundancy of polarisation in rain. The French **RASTA** radar was initially operated at Chilbolton and then moved onto Cabauw. The radars were cross calibrated by comparing the returns from Rayleigh scattering thin ice clouds.

Applications: Manufacture of cloud radars.

Benefits: A method of radar calibration.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
7	Correction of profiles and mapping onto the operational grid.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

This product facilitates the application of multi-sensor algorithms by performing much of the required preprocessing. It takes the radar, lidar, microwave radiometer, rain gauge and forecast model data corrects for attenuation, derives random and systematic measurement errors for the radar and lidar backsatter signal, and interpolates the observational datasets on to the same grid. The algorithm can be applied to all CloudNet and ARM datasets. The instruments at the sites can be different, so the data quality flags indicate which subsequent algorithms may be applied.

Applications: Comparing observations from a diverse mix of instruments with operational model data held on the model grid.

End-users and Applications: Evaluation of representation of clouds in the operational models used by National Met Services.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Illingworth et al. 2004 Observing cloud properties with ground-based mm-wavelength radar. 3rd European Radar Conference, Sweden. Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
8	Target classification

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

This regridded and corrected data is then analysed to categorise the targets and classify them as aerosols, insects, clutter, ice cloud, liquid cloud and so on, so that the appropriate cloud-retrieval algorithms can be invoked. Two fields are added : "category_bits" contains a categorization of the targets in each pixel and "quality_bits" indicates the quality of the data at each pixel.

The outputs are: a) A target categorization bit-field to indicate the presence of liquid droplets, drizzle/rain, ice particles, melting particles, aerosols and insects in each pixel

b) A data quality bit-field to indicate factors such as: the presence of radar ground clutter, whether the lidar echo is due to clear-air molecular scattering, and whether the radar has been attenuated by liquid water cloud or rain

Applications: Classifying target observed with a diverse mix of instruments into different types of hydrometeors.

End-users and Applications: Evaluation of representation of clouds in the operational models used by National Met Services.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Hogan R. J., Flentje H., Francis P. N., Illingworth A. J., Quante M. and J. Pelon. 2003 Characteristics of mixed phase clouds. Part1: Lidar, radar and aircraft observations from CLARE '98 QJRMS **129**, 2089-2116	PU
Refereed article	Hogan, R J, 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 QJRMS **129**, 2117-2134	PU
Refereed article	Baedi, R.; Boers,R.; Russchenberg, H.W.J 2003 Detection of Boundary Layer Water Clouds by Spaceborne Cloud Radar JAOT **19**, 1915–1927	PU
Website	*Hogan, R. J., and E. J. O'Connor, 2004: Facilitating cloud radar and lidar algorithms: the Cloudnet Instrument Synergy/Target Categorization product. Cloudnet documentation, available at http://www.met.rdg.ac.uk/~swrhgnrj/publications/categorization.html*	PU
Website	http://www.met.rdg.ac.uk/radar/cloudnet/data/products/categorize.html	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
9	Derivation of cloud fraction

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

A method for converting the radar and lidar observations of clouds taken with a resolution of 60m and 30seconds on to the grid of the operational model so that the fraction of pixels which are cloudy can be derived and hence the observed cloud fraction can be determined.

Users and applications: National Met Services hold cloud fraction in all their models. This enables them to compare their models with observations for this variable

Benefits: Improved forecasts from improved parameterisation schemes for cloud fraction.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Hogan, R. J., C. Jakob and A. J. Illingworth, 2001: Comparison of ECMWF winter-season cloud fraction with radar-derived values. J. Appl. Meteorol., **40,** 513-525	PU
Refereed article	Hogan, R. J., and A. J. Illingworth, 2003: Parameterizing ice cloud inhomogeneity and the overlap of inhomogeneities using cloud radar data. J. Atmos. Sci., **60,** 756-767.	PU
Non-refereed article	Illingworth et al. 2004 Comparison of observed cloud properties at three ground sites with their representation in operational models: The EU CloudNET project.14th ICCP conf, Bologna. Paper	PU
Refereed article	Brooks, M. E., R. J. Hogan and A. J. Illingworth, 2005: Parameterizing the difference in cloud fraction defined by area and volume as observed with radar and lidar. J. Atmos. Sci., **62,** 2248-2260.	PU
Website	*http://www.met.rdg.ac.uk/radar/cloudnet/data/products/cloud-fraction-ecmwf-grid.html*	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
10	Establishment of cloud phase using lidar depolarisation.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Lidar depolarization measurements have been analysed and algorithms developed to determine cloud phase. The linear depolarization ratio is defined as the ratio of backscattered light intensities in the planes perpendicular and parallel to the plane of emission. The depolarization ratio is then calibrated by identifying for each observation session a low-level, cloud-free region and normalizing this region to the standard molecular depolarization ratio of 1.4%. The low depolarization ratios ($d < 0.1$) are associated with spherical water droplets whereas ice particles primarily located at colder temperatures (-70°C to -30°C) have higher ratios ($d \sim 0.2$-0.65). Depolarization ratios between $d=0.2$ and $d=0.4$ which are accompanied by a large lidar backscatter indicating a mixed phase cloud. Figure 4 shows a specific example of CAPRO-CP algorithm performance. Figure 5 shows the distribution of temperature and depolarization ratio for water clouds, ice clouds and mixed-phase clouds based on an analysis of the SIRTA lidar data base.

Applications and Users: Determination of cloud phase (liquid or ice)has a large effect on the radiative balance and subsequent evolution of forecasts. Phase must be correctly represented within forecast models.

t.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: *PU*=Public *CO*=Confidential
Refereed article	Protat A, Pelon J, Testud J, Grand N, Delville P, Labotie P, Vinson J-P, Bouniol D, Bruneau D, Chepfer H, Delanoe J, Haeffelin M, Noel V, Tinel C 2004 Combinaison d'un radar nuage et d'un lidar pour l'etude des nuages faiblement precipitants. La Meteorologie 47, 23-33	PU
Refereed article	Noel, V., H. Chepfer, M. Haeffelin, Y. Morille: "Cloud Phase retrieval in midlatitude clouds from three years of lidar observations over the SIRTA observatory". 2006 Submitted to Annales Geophysicae, under revision.	PU
Refereed article	Morille Y., M. Haeffelin, P. Drobinski, J. Pelon, 2006 STRAT : An algorithm to retrieve the STRucture of the ATmosphere from single channel lidar data JAOT Submitted	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
11	Accurate liquid water path from dual frequency radiometers.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Liquid water path (LWP) have been inferred for many years from brightness temperature at 22.2 GHz and 28.8 GHz. The observed brightness temperature are first converted into an optical depth, and then the LWP and VWP (vapour water path) derived by solving the two simultaneous equations:

$$\tau_{22} = k_{l,22} \times LWP + k_{v,22} \times VWP + \tau_{d,22} + C_{22}$$

$$\tau_{28} = k_{l,28} \times LWP + k_{v,28} \times VWP + \tau_{d,28} + C_{28}$$

where C are instrument calibrations and k are the mass absorption coefficients. Because the values of k are somewhat uncertain and C can drift with time, the solution can lead to values of LWP when no cloud is present and even on occasion negative values of LWP. We have developed a new technique, based on an optimisation approach, whereby we identify cloud free periods using the ceilometer, and if LWP is ro we can eliminate VWP and obtain an equation linking C_{22} and $C_{28.}$ We then minimise the cost function for C_{22} and C_{28} and derive the calibration errors to be used during cloudy periods.

Applications and Users. Liquid water path is a crucial observed variable. This finding will be of use to companies manufacturing dual frequency radiometers and also to National Weather Services who purchase such instruments.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Gaussiat N., Sauvageot H. and A. J. Illingworth 2003 Cloud liquid water and ice content retrieval by multi-wavelength radar JAOT **20**,1264-1275	PU
Refereed article	Gaussiat N., Hogan R. J. and A. J. Illingworth. 2005 Stratocumulus liquid water content from dual wavelength radar. JAOT 22, 1207-1218	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
12	Liquid water content profiles by comparison with the adiabatic liquid water content.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

It is impossible to measure liquid water content using the radar reflectivity of clouds, because the presence of occasional drizzle droplets dominates the radar reflectivity but contributes little to the liquid water. In this new method we consider those clouds identified as liquid by the classification technique, use the lidar to estimate the height of the cloud base and the radar to locate cloud top, and use the model temperature and pressure to calculate the adiabatic liquid water content (LWC) in each cloud profile and hence the find the adiabatic liquid water path (LWP). The adiabatic LWP path is then compared to the LWP derived from the radiometers in the previous algorithm (3.5) and the dilution factor of the cloud is computed. The adiabatic liquid water profile is then scaled by this dilution factor to derive the true liquid water profile.

Applications and Users. Liquid water content is a crucial observed variable. This finding will be of use to companies manufacturing dual frequency radiometers and also to National Weather Services who purchase such instruments.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status:** ***PU*****=Public** ***CO*****=Confidential**
Website	http://www.met.rdg.ac.uk/radar/cloudnet/data/products/lwc-adiabatic-method.html	PU
Non refereed article	Gaussiat N., Hogan R. J. and A. J. Illingworth 2004 Cloud water content and cloud particle characteristics revealed by dual wavelength cloud radar observations.14th ICCP conf, Bologna. Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
13	Liquid water content from the profile of the radar return and the lidar extinction at cloud base.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The radar-lidar technique for the retrieval of the liquid water content in low level uses the radar reflectivity to lidar optical extinction ratio for the detection and characterization of the drizzle in the water clouds, overcoming the difficulties in use of the quantitative radar data for water clouds microphysical retrievals. One of this technique main advantages is that it does not use the microwave radiometer data to obtain the vertical profiles of LWC and the integral LWP, as other available remote sensing techniques use.

Applications and Users. Liquid water content is a crucial observed variable. This finding will be of use to companies manufacturing radars and lidars and also to National Weather Services who purchase such instruments.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Frisch, A. S., G. Feingold, C. W. Fairall, T. Uttal, and J. B. Snider, 1998: On cloud radar and microwave radiometer measurements of stratus cloud liquid water profiles. *J. Geophys. Res.*, 103 (D18), 23 195- 23 197.	PU
Refereed article	Löhnert, U., S. Crewell, C. Simmer and A. Macke, 2001: Profiling cloud liquid water by combining active and passive microwave measurements with cloud model statistics, *J. Atmos. Oceanic Technol.*, 12, pp. 1354-1366	PU
Non refereed article	Krasnov O and Russchenberg H 2002 An enhanced algorithm for the retrieval of liquid water cloud properties from simultaneous radar and lidar measurements. Part I: The basic analysis of in-situ drop spectra. European Conference on Radar Meteorology, 18 - 22 November 2002, Delft, The Netherlands. ERAD 2002 Proceedings, Vol. 1 - pp. 173 – 178	PU
Non refereed article	Krasnov O. and H. Russchenberg 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, 18 - 22 November 2002, Delft, The Netherlands. ERAD 2002 Proceedings, Vol. 1 - pp. 179 – 183	PU
Non refereed article	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	PU
Non refereed article	Krasnov, O.A. and H. W. J. Russchenberg, 2005: A synergetic radar-lidar technique for the LWC retrieval in water clouds: Description and application to the Cloudnet data. //The 32nd Conference on Radar Meteorology (Albuquerque, NM)	PU
Refereed article	Delanoe J, Protat A, Testud J., Heymsfield A, Banesemar A, Brown P, and Forbes R. 2005 Cloud dynamical, microphysical and radiative properties from Doppler cloud radar measurements JAM, JGR In preparation.	PU
Non refereed article	May G., H. W. J. Russchenberg and O. A. Krasnov 2005 Radar-lidar synergy for space-based retrieval of water cloud parameters 32nd AMS Conference on Radar Meteorology, Albuquerque Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
14	Drizzle parameters below stratocumulus cloud.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Drizzle particle size can be estimated from the ratio of the lidar to the radar backscatter, the concentration of drops is then found from the absolute value of the radar reflectivity, and the Doppler spectral width provides an estimate of the shape of the drop spectrum. Once the drop spectrum is known then the liquid water content of the drizzle and the drizzle water flux can be determined; the theoretical terminal velocity can be computed, and compared with the observed terminal velocity so that the air velocity can be found. The retrieval is only applicable to the drizzle below cloud base

Users and Applications: The production of drizzle is intimately connected with the lifetime and evolution of stratocumulus decks. Such clouds have an important impact on the earth's radiation budget.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	O'Connor E., Hogan R. J. and A. J. Illingworth. 2004 Characteristic of drizzling and non-drizzling stratocumulus as revealed by vertical pointing cloud radar and lidar. 14th ICCP conf, Bologna. Paper	PU
Refereed article	O'Connor, E. J., R. J. Hogan and A. J. Illingworth, 2005: Retrieving stratocumulus drizzle parameters using Doppler radar and lidar. J. Appl. Meteorol., 44(1), 14-27.	PU
Website	http://www.met.rdg.ac.uk/swr99ejo/publications/drizzle_retrievals.pdf	Pu
Website	http://www.met.rdg.ac.uk/radar/cloudnet/data/products/drizzle.html	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
15	Ice water content using radar reflectivity combined with temperature.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The presence of low cloud can often block ground-based lidars from sensing higher level ice clouds. Hence it is desirable to be able to estimate IWC from radar reflectivity alone. It has been shown by Hogan et al. (2005) that ice water content may be estimated from radar reflectivity and temperature using relationships such as the following for 94 GHz:

log10(IWC[g m-3]) = 0.00058Z[dBZ]T[degC] + 0.0923Z[dBZ] - 0.00706T[degC] - 0.992

with a similar one for 35 GHz.

Application: Ice water content of clouds is a fundamental variable in weather forecasting and climate prediction models. .

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Website	http://www.met.rdg.ac.uk/clouds/publications/Z_T_retrievals.pdf	PU
Website	http://www.met.rdg.ac.uk/radar/cloudnet/data/products/iwc-Z-T-method.html.	PU
Non refereed article	Gaussiat N. and A. J. Illingworth 2003 Investigating the density of ice particles using dual-wavelength Doppler data. 31st Int Conf on Radar Meteorology, Seattle. AMS 2003 Radar Conf Proceedings, pp. 137-139 Paper	PU
Refereed article	Delanoe J, Protat A, Testud J., Heymsfield A, Banesemar A, Brown P, and Forbes R.. 2005 Statistical properties of the normalized ice particle size distribution JGR 110, D 10201.	PU
Refereed article	Hogan, R. J., M. P. Mittermaier and A. J. Illingworth, 2005: The retrieval of ice water content from radar reflectivity factor and temperature and its use in the evaluation of a mesoscale model. Q. J. R. Meteorol. Soc., in press.	PU
Refereed article	Hogan R J, Mittermaier MP and A J Illingworth 2006 The retrieval of ice water content from radar reflectivity factor and temperature and its use in evaluating a mesoscale model JAM 45, 301 -317	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
16	Ice water content using radar reflectivity combined with Doppler velocity.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The difficulty with deriving ice water content (IWC) from Z alone is that the particle size is unknown. In this new method the observed Doppler velocity, Vd, is used to derive a mass weighted particle diameter, Dm which then enables the computation of a more accurate ice water content, together with information on ice particle density, size, effective radius and visible extinction. The difficulty is that the observed values of Vd is the sum of both the terminal velocity (Vt) and the air velocity (W), so the approach is to find mean relationship between Z and Vt over a 20 or 30 minute assuming that the perturbations due to up and down draughts (W) will average out during this time, as shown in Figure 12. For each observed values of Z one can then compute an estimate of the actual terminal velocity Vt, as shown in Figure 13. The final stage is to use the combined value of Z and Vt at each pixel to derive a better ice water content. Dm can be derived assuming that when normalized the ice spectrum is of the standard form (Delanoe et al, 2005) and then a more accurate IWC can be derived from Dm and Z (Delanoe et al, 2006).

Application: Ice water content of clouds is a fundamental variable in weather forecasting and climate prediction models. .

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Protat A, Tinel C. and J. Testud 2002 Dynamic properties of clouds and dynamic/microphysical interactions from 94GHz radar and lidar. European Conference on Radar Meteorology, 18 - 22 November 2002, Delft, The Netherlands. ERAD 2002 Proceedings, Vol. 1 - pp. 155 – 158 paper	PU
Non refereed article	Protat A., Bouniol D. and Martial Haeffelin. 2004 Evaluation of vertical air velocity and its distribution in four operational forecast models using continuous Doppler cloud radar measurements. 14th ICCP conf, Bologna. paper	PU
Refereed article	Delanoë, J., A. Protat, J. Testud, D. Bouniol, A. Heymsfield, A. Bansemer, P. Brown and R. Forbes: Statistical properties of the normalized ice particle size distribution. J. G.R., 110, D 10201, 2005.	PU
Refereed article	Protat A, Delanoe J, Bouniol D, , Heymsfield A, Banesemar A, Brown P, and Forbes R 2005 Evaluation of ice water content retrievals from cloud radar reflectivity and temperature using al large airborne in-situ microphysical data base. JGR Submitted	PU
Refereed article	Delanoe J, Protat A, Testud J., Heymsfield A, Banesemar A, Brown P, and Forbes R. 2005 Cloud dynamical, microphysical and radiative properties from Doppler cloud radar measurements JAM, JGR In preparation.	PU
Refereed article	Delanoë, J., A. Protat, J. Testud, D. Bouniol, A. Heymsfield, A. Bansemer, and P. Brown: RadOn, a new method for retrieval of the dynamical, microphysical and radiative properties of ice clouds from Doppler cloud radar observations. J Atmos Oceanic Tecnol, submitted, 2006.	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
17	A comparison of the ice water content derived from different retrieval methods.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

. Four competing algorithms for retrieving IWC have considered:

i) IWC is derived from reflectivity, Z, alone..
ii) An improved value of IWC can be obtained by using Z and temperature.
iii) An improved value of IWC can be obtained by using Z and Doppler velocity.
iv) IWC can be obtained from the combined radar and attenuation corrected lidar return

The four methods are compared and recommendations made as to which is the most appropriate to use.

Application and Users: Ice water content (IWC) is one of the most fundamental parameters held in models, which requires validation from observations

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Tinel C., Testud J., Protat A., and J. Pelon 2002 Microphysical and radiative properties of ice clouds using a cloud radar-lidar algorithm European Conference on Radar Meteorology, 18 - 22 November 2002, Delft, The Netherlands. ERAD 2002 Proceedings, Vol. 1 - pp. 184 – 187 paper	PU
Non refereed article	Bouniol D., Protat A., M. Haeffelin. 2004 A systematic retrieval of ice cloud microphysical and radiative properties using a synergetic radar/lidar algorithm. 14th ICCP conf, Bologna. Paper	PU
Refereed article	Protat A, Pelon J, Testud J, Grand N, Delville P, Labotie P, Vinson J-P, Bouniol D, Bruneau D, Chepfer H, Delanoe J, Haeffelin M, Noel V, Tinel C 2004 Combinaison d'un radar nuage et d'un lidar pour l'etude des nuages faiblement precipitants. La Meteorologie 47, 23-33	PU
Refereed article	Tinel C., J. Testud, J. Pelon, R J Hogan, A. Protat, J. Delanoe and D. Bouniol. 2005 The retrieval of ice cloud properties from cloud radar and lidar synergy. JAM 44, 860-875.	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
18	First evaluation of cloud fraction.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The large quantity of near-continuous data from the three Cloudnet sites enables us to make categorical statements about the cloud fraction climatology of each of the models, much more than was possible previously from limited and unrepresentative case studies. Cloud fraction has been derived from the Target Categorization dataset, and calculated on the grid of each of the various models. Briefly:
ECMWF model. Cabauw observations from 2001-2002 reveal that an overestimate of the frequency of occurrence of low cloud (by around 50%) led to an overestimate of the mean cloud fraction in the boundary layer. **Met Office mesoscale model.** Frequency of cloud occurrence is very well represented below around 5 km, with somewhat of an underestimate above. **Met Office global model.** Below 2 km the mean amount when present is very accurate although frequency of occurrence (and hence overall mean cloud fraction) is underestimated by up to a factor of 2.
KNMI RACMO model. Frequency of occurrence is around 30-50% too high below 7 km, with the largest error in the boundary layer between 1 and 2 km. **SMHI RCA model.** Below 2 km the amount when present is reasonably good, but both frequency of occurrence and mean cloud fraction tend to be around 50-60% too high.

Applications and Users: These are the first objective analyses of the cloud fraction represented in the various operational models.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Illingworth A. J., Hogan R. J., Brooks M. E., and E. J O'Connor. 2002 The use of cloud radar and lidar data for validating clouds in operational forecasting models. 2nd Workshop on Spaceborne Cloud Profling Radar and Lidar, July 02, Tokyo, Japan Oral	PU
Non refereed article	Illingworth A.J. et al 2005 Cloudnet, Evaluating clouds in six operational forecast models using cloud radar and lidar observations. 32nd AMS Conference on Radar Meteorology, Albuquerque Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
19	Model liquid water content.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Liquid water content (LWC) has been estimated from the observations using the scaled adiabatic method, whereby the Target Categorization from the radar and lidar diagnoses which pixels in each profile are liquid, from which an adiabatic LWC profile is calculated. This profile is then scaled to match the liquid water path derived by microwave radiometer. Although stratocumulus LWC can often deviate from adiabatic, these clouds are typically thin so errors in attribution of liquid water with height would typically only be of the order of 200 m, much less than the model errors that have been uncovered. As before, a complete set of monthly and yearly comparisons are available on the Cloudnet web site.
Of all the models, the Met Office mesoscale generally agrees closest with the LWC observations, while a number of errors are evident in the other models. ECMWF (which has prognostic cloud water content) tends to overestimate the spread of LWC values while Meteo-France (which diagnoses water content from humidity) tends to have too narrow a distribution. The RACMO model largely shares its cloud scheme with ECMWF, and consequently its LWC errors are rather similar (not shown).

Applications and Users: These are the first objective analyses of the liquid water content represented in the various operational models.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Illingworth et al 2005 Comparison of observed cloud properties at three ground bases sites with their representation in operational models: The EU CloudNET project. Scientific Assembly, IAMAS 2005, Beijing Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
20	Model ice water content.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

. Ice clouds represent the largest uncertainty as there are currently no reliable global observations of ice water content (IWC). In Cloudnet Three techniques have been developed to retrieve IWC, supplementing the radar reflectivity by either lidar backscatter (Donovan 2003, Tinel et al. 2005), Doppler velocity (the radar-only "RadOn" method; Delanoe et al. 2005) or temperature (Hogan et al. 2006). While the radar-lidar method is expected to be the most accurate, the attenuation of the lidar signal means that it is only applicable to around 10% of the ice clouds over the Cloudnet sites. Comparisons between the methods indicate a substantial degree of scatter, although for the higher values of IWC they report approximately the same long-term mean values.

Relevance and Users: The Atmospheric Model Intercomparison Project (AMIP) has highlighted the worrying order-of-magnitude spread in mean cloud water content between different climate models, despite them all being constrained by observed top-of-atmosphere fluxes. These results indicate that for operational forecast models the disagreement is not so severe.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X

Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: *PU*=Public *CO*=Confidential
Non refereed article	van Zadelhoff G. J. and D. P. Donovan. 2004 Comparing ice-cloud microphysical properties using CloudNET and ARM data. 14th ICCP conf, Bologna. Paper	PU
Non refereed article	Haeffelin M et al. 2005 Evaluation of mid-latitude ice cloud properties using MM5 mesoscale model and remote-sensing measurements at SIRTA atmospheric observatory Scientific Assembly, IAMAS, Beijing Paper	PU
Refereed article	Chiriaco M., R. Vautard, H. Chepfer, M. Haeffelin, J. Dudhia, Y. Wanherdrick, Y. Morille et A. Protat 2006 The Ability of MM5 to Simulate Ice Clouds : Systematic Comparison between Simulated and Measured Fluxes and Lidar/Radar Profiles at SIRTA Atmospheric Observatory MWR In press	PU
Refereed article	Delanoe J, Protat A, Bouniol D, Testud J., Heymsfield A, Bansemer A, and Brown P 2006 An ice cloud climatology over Europe from two years of continuous cloud radar observations. JClimate Submitted	PU
Refereed article	Delanoe J, Protat A, Bouniol D, Testud J., Heymsfield A, Bansemer A, and Brown P 2006 Evaluation of operational weather forecast models using two years of cloud radar observations; JAM Submitted	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
21	High cloud occurrence.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The mean cloud fraction derived from radar and lidar at altitudes above around 8 km is substantially less than that predicted by all the operational models involved in Cloudnet. There are known problems with the observations at these altitudes: the small particle size in high cirrus and the distance from the instruments means that cloud can fall below the sensitivity limit of the radar. Likewise, the lidar observations at these altitudes are frequently obscured by intervening low cloud and the lidar ceilometers used at most sites are not sufficiently sensitive to see all the cirrus, especially during the day when their sensitivity is reduced due to the elevated sky background. The approach in the Cloudnet model comparisons has been to remove from the model those high ice cloud that are deemed undetectable by the radar bringing it into closer agreement with the observations, but meaning that we are unable to truly evaluate cloud fraction at these altitudes.

Application   This supports the need for cloud-observing stations to continuously operate a high sensitivity lidar, rather than just a lidar ceilometer, in order that clouds at all levels can be evaluated.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	Details (Title, ref. number, general description, language)	Status: *PU*=Public *CO*=Confidential
Refereed article	Protat, A., A. Armstrong, M. Haeffelin, Y. Morille, J. Pelon, J. Delanoë, and D. Bouniol 2006 The impact of conditional sampling and instrumental limitations on the statistics of cloud properties derived from cloud radar and lidar at SIRTA GRL Accepted	PU
Refereed article	Morille Y., M. Haeffelin, P. Drobinski, J. Pelon, 2006 STRAT : An algorithm to retrieve the STRucture of the ATmosphere from single channel lidar data JAOT Submitted	PU
Refereed article	Chiriaco M., R. Vautard, H. Chepfer, M. Haeffelin, J. Dudhia, Y. Wanherdrick, Y. Morille et A. Protat 2006 The Ability of MM5 to Simulate Ice Clouds : Systematic Comparison between Simulated and Measured Fluxes and Lidar/Radar Profiles at SIRTA Atmospheric Observatory MWR In press	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
22	Cloud fraction as a volume of the grid box or as a projected area of the grid box.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Cloud fraction is an essential variable needed by models when grid boxes are partially filled with clouds. It is always assumed that the fraction of the volume of the grid box (Cv) that is saturated is also the fraction of the grid box area (Ca) that is cloud covered and controlling the radiative fluxes, but this is only true if the clouds have vertically oriented edges, so in general Ca>Cv. A one-year Chilbolton data set has been analysed to quantify the size of this effect as a function of grid box dimensions and the results expressed in terms of an analytical correction factor. This correction factor could be easily applied in models.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Hogan, R J, and A J Illingworth 2003 Parameterizing ice cloud inhomogeneity and the overlap of inhomogeneities using cloud radar data JAS **60**, 756-767	PU
Refereed article	Brooks M. E., Hogan R. J. and A. J. Illingworth 2005 Parameterizing the difference in cloud fraction defined by area and by volume as observed with radar and lidar. JAS 62, 2248-2260.	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
23	Analysis of model performance classified by weather regime.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The Cloudnet comparisons provide very useful information about the biases in models, but it can be difficult to determine the cause of the various errors that have been uncovered. However, the utility of the mean profiles of cloud fraction, and other retrieved quantities, has been enhanced by the use of the model forecast of the meteorological parameters to categorize the profiles. This categorization uses the vertical velocity at 300 hPa and 750 hPa, smoothed with a 3-hour running mean, from the UK Met Office Mesoscale, the ECMWF and Meteo-France models. These data are normalized, so as to be inter-comparable, and averaged to form an “ensemble mean” vertical velocity that is split into descending, neutral and ascending terciles of the distribution. Above the boundary layer, cloud is generally found in the ascending tercile of this distribtution. To categorize the boundary layer the same process is applied to the gradient of potential temperature between 950 hPa and 1000 hPa, yielding three boundary-layer classes of stable, neutral and convective. Combining these criteria yield twelve different meteorological regimes.

Application: This approach enables the National Met Services to identify the weather regimes where the cloud representation is correct and those where it fails. This gives them guidance in how the schemes can be improved.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Brook M. E. Hogan R. J. and A. J. Illingworth. 2004 A long comparison of cloud properties observed by vertically pointing radar and lidar with their representation in operational NWP models 14th ICCP conf, Bologna paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
24	Cloud fraction skill scores from 2002 to 2005.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The comparisons so far have evaluated the *climatology* of the model, For the quality of a specific *forecast* we use skill scores. Firstly the observed and modelled cloud fraction values are converted to binary fields using a threshold cloud fraction value. Then a contingency table is constructed, containing the number of times cloud occurred both in observations and model (A), the times cloud occurred neither in the observations nor the model (D), and the times that it occurred in the model or the observations but not both (B and C). Numerous skill scores can be calculated from the values A-D but to be useful they should ideally have the properties that they are independent of the frequency of occurrence of the event, and that a random forecast should produce a score of zero. Most simple scores such as hit rate and false alarm rate have neither of these properties, so we have used the Equitable Threat Score (ETS) and the Log-Odds Ratio, which have been found to vary only weakly with cloud fraction threshold, and produce zero for a random forecast. A perfect forecast would have an ETS of 1.

Application: Using objective skill scores National Weather Services can quantify the performance of their model in representing clouds and see if any improvements are occurring.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X

Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
25	Confirmation of the improvement of the Meteo-France cloud scheme.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The cloud cover in models has traditionally been evaluated by comparison with total cloud cover from human observations at synoptic stations. Between 2003 and 2005 two major changes were introduced in to the cloud scheme of the MeteoFrance model that were designed and tuned to improve cloud radiative forcings and improve the capability of predicting winter cyclogenesis. Synoptic human observations suggests that the result of these changes is a marked worsening in the representation of total cloud cover. This is in stark contrast to the comparison with the vertical profiles in cloud fraction derived from Cloudnet data which show a dramatic improvement between 2002 and 2004. Before April 2003, the frequency of occurrence of cloud was around 50% too high, but the mean amount when present was only 20-25% of the observed values, with the result that the model predicted only a third to a half of the observed mean cloud fraction below 8 km. There was an associated very poor representation of the PDF. After April 2003 the change in the scheme resulted in a substantial improvement in both the mean profiles and the PDFs.

Application and Users: This provides a striking example of the advantage in the objective analysis provided by CloudNET as opposed to the ambiguities of the previous subjective approaches.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X

Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
26	Testing of proposed Met Office 'PC2' cloud scheme.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

There are several areas of ongoing work in the Met Office to investigate how improvements may be implemented in the model cloud scheme to bring it into closer agreement with the Cloudnet observations. This is part of a larger activity to implement the new "PC2" cloud scheme, in which cloud fraction is to be carried as a prognostic variable. The CloudNET data has been to test the performance of this new scheme in the representation of mixed phase clouds and its ability to produce clouds which fill the grid box with cloud to produce a c loud fraction of 100%.

Application and Users. This example shows the direct feedback Cloudnet can provide as to the efficiency of proposed new cloud schemes in operational forecast models.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X

Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Non refereed article	Wilson D. R., Kerr-Munslow A. M. and A. C. Bushell. 2004 The behaviour of different cloud process parametrizations in a large-scale model 14th ICCP conf, Bologna. Paper	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
27	Parameterisation of ice effective radius in the KNMI RACMO model.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

In many atmospheric models ice cloud effective radius, R_{eff}, is treated as a function of temperature. Usually a single function is used globally. Analyses of two years of Cloudnet data have revealed that a significant correlation between average effective particle size, temperature and IWC does exist. The relationship found for the Cloudnet data (the Cabauw and Chilbolton results were nearly identical in this regard) is qualitatively similar to that found for the ARM data (Donovan 2003 & van Zadelhoff et al. 2004), that is, the average value of R_{eff} was found to increase with both increasing temperature and IWC. However our results indicate that the same R_{eff}-vs-Temperature (or even R_{eff}-vs-T and/or IWC) relationship cannot accurately represent the observed relationship over both the Cloudnet and ARM sites, but it was found that the mean profiles of R_{eff} as a function of normalized height into the cloud for different cloud physical thickness ranges are quite similar over all the sites considered in this study (van Zadelhoff et al. 2004). This finding is consistent with the physical picture of particle formation near cloud top followed by particle growth (mainly aggregation) as the ice particles fall followed by sublimation near cloud bottom. Using the new findings, a new parameterization that treats ice cloud R_{eff} as a function of cloud physical thickness has been formulated.

Application and Users: A new scheme for representing ice within models has been proposed and tested within an operational model.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐ X
Guidelines, methodologies, technical drawings	☐
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
Refereed article	Hogan, R. J., C. Jakob and A. J. Illingworth, 2001: Comparison of ECMWF winter-season cloud fraction with radar-derived values, *J. Appl. Meteorol.*, **40,** 513-525.	PU
Refereed article	Donovan, D. P., 2003: Ice-cloud effective particle size parameterization based on combined lidar, radar reflectivity, and mean Doppler velocity measurements, *J. Geophys. Res.*, 108(D18), 4573, doi:10.1029/2003JD003469.	PU
Refereed article	Hogan, R. J., and A. J. Illingworth, 2003: Parameterizing ice cloud inhomogeneity and the overlap of inhomogeneities using cloud radar data. *J. Atmos. Sci*., **60,** 756-767.	PU
Refereed article	Hogan, R. J., A. J. Illingworth, E. J. O'Connor and J. P. V. Poiares Baptista, 2003: Characteristics of supercooled clouds. Part 2 – A climatology from ground-based lidar. *Q. J. R. Meteorol. Soc.*, **129,** 2117-2134.	PU
Refereed article	van Zadelhoff, G.-J., D. P. Donovan, H. Klein Baltink, and R. Boers, 2004: Comparing ice cloud microphysical properties using CloudNET and Atmospheric Radiation Measurements Program data., *J. Geophys. Res.*, **109,** 24,214-24,229, doi:10.1029/2004JD004967.	PU
Refereed article	Tinel, C., J. Testud, R. J. Hogan, A. Protat, J. Delanoe and D. Bouniol, 2005: The retrieval of ice cloud properties from cloud radar and lidar synergy. *J. Appl. Meteorol.*, **44,** 860-875.	PU
Refereed article	Brooks, M. E., R. J. Hogan and A. J. Illingworth, 2005: Parameterizing the difference in cloud fraction defined by area and by volume as observed with radar and lidar. *J. Atmos. Sci.*, **62,** 2248-2260.	PU
Refereed article	Delanoe, J., A. Protat, D. Bouniol, J. Testud, A. Heymsfield, A. Bansemer and P. Brown, 2006: RadOn; a new method for retrieval of the dynamical, microphysical and radiative properties of ice clouds from Doppler cloud radar observations. *J. Atmos. Oceanic. Technol.*, submitted.	PU
Refereed article	Hogan, R. J., M. P. Mittermaier and A. J. Illingworth, 2006: The retrieval of ice water content from radar reflectivity factor and temperature and its use in evaluating a mesoscale model. *J. Appl. Meteorol.*, **45,** 301-317.	PU

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
28	An economic combination of cloud radar with a simple ceilometer and low cost radiometers.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

Three instruments are required for the cloud observing station: a Dopplerised cloud radar, a ceiometer and a pair of microwave radiometers one near 22Ghz and the other closer to 30GHz. The two active instruments should record cloud profiles every 30 seconds with a spatial resolution of 60m. The aim is to detect all radiatively significant clouds, that is those with an optical depth above 0.05. The cloud radar should have high sensitivity of -55dBZ at 1km so that it can detect thin ice clouds at a range of 10km.

Applications and Users: The detailed specification is supplied to industry.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐

Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
		CO

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
29	The use of low power FM/CW mm wave cloud radars and an X-band pulsed cloud radar.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

A Dopplerised cloud-radar with a sensitivity of -55dBZ at 1km for a 30second dwell can be implemented either at mm-wave as in the CloudNET or, potentially, at X-band. For mm-wave radars at the ground 35GHz is the preferred frequency. The technology is mature, and amplifier tubes operate at 35GHz for several years with only a small loss of power. In addition the attenuation due to oxygen, water vapour and liquid cloud water is relatively small. In contrast the amplifier tubes at 94GHZ appear to have a limited lifetime.
A potentially low cost alternative which should be further investigated is the use of a conventional pulsed radar at X-band.

Potential Applications. This low cost approach to constructing a cloud radar fulfils the requirements to detect ice cloud.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐

Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
		CO

2.1 : Description of the result(s), one form per result

No. & TITLE OF RESULT (same as in table 1.2)

No.	Self-descriptive title of the result
30	Relaxation of radiometer specification.

SUMMARY *(200 words maximum)*

Provide an overview of the result which gives the reader an immediate impression of the nature of the result, its relevance and its potential; Briefly describe the current status/applications of the result (if appropriate) with non confidential information on entities potentially involved.

The CloudNET algorithm for deriving liquid water path from the brightness temperatures observed near 22 and 30GHz forces the retrieved liquid water path to zero when the lidar reveals that water clouds are absent. This is achieved by adjusting the radiometer calibration offsets in an optimal manner when liquid cloud is absent. This approach avoids the unphysical retrieval of negative liquid water or the retrieval of large steady positive values of lwp when the sky is clear. The technique is very tolerant of large brightness temperature . Most important from the instrument design point of view is that this lwp retrieval is tolerant to offsets of up to 5K in the brightness temperatures.

Potential Applications. This low cost approach to constructing a dual frequency microwave radiometers fulfils the requirements to obtain accurate liquid water path.

Please categorise the result using codes from Annex 1

Subject descriptors	536	213	211	271	269

CURRENT STAGE OF DEVELOPMENT

Please tick one category only

Scientific and/or Technical knowledge (Basic research)	☐
Guidelines, methodologies, technical drawings	☐ X
Software code	☐
Experimental development stage (laboratory prototype)	☐
Prototype/demonstrator available for testing	☐
Results of demonstration trials available	☐
Other (please specify.):	☐

DOCUMENTATION AND INFORMATION ON THE RESULT

List main information and documentation, stating whether public or confidential.

Documentation type	**Details (Title, ref. number, general description, language)**	**Status: *PU*=Public *CO*=Confidential**
		CO

INTELLECTUAL PROPERTY RIGHTS

Type of IPR	**KNOWLEDGE: Tick a box and give the corresponding details (reference numbers, etc) if appropriate**					**Pre-existing know-how Tick a box and give the corresponding details(reference numbers, etc) if appropriate**	
	Current				**Foreseen**	**Tick**	**Details**
	Tick	**NoP** [1)]	**NoI** [2)]	**Details**	**Tick**		
Patent applied for	☐				☐	☐	
Patent granted	☐				☐	☐	
Patent search carried out	☐				☐	☐	
Registered design	☐				☐	☐	
Trademark applications	☐				☐	☐	
Copyrights	☐				☐	☐	
Secret know-how	☐				☐	☐	
Other - please specify :	☐				☐	☐	

1) Number of **P**riority (national) applications/patents
2) Number of **I**nternationally extended applications/patents

MARKET APPLICATION SECTORS

Please describe the possible sectors for application using the NACE classification in Annex 2.

Market application sectors	33	73l			

2.2. Quantified data about the result

Items (about the results)	**Actual current quantity [a]**	**Estimated (or future) quantity [b]**
Time to application / market (in months from the end of the research project)		24
Number of (public or private) entities potentially involved in the implementation of the result :	1	
of which : number of SMEs :	0	
of which : number of entities in third countries (outside EU) :	0	
Targeted user audience: # of reachable people	100	
# of S&T publications (referenced publications only)	10	
# of publications addressing general public (e.g. CD-ROMs, WEB sites)	1	
# of publications addressing decision takers / public authorities / etc.	10	
Visibility for the general public	No	

[a] *Actual current quantity = the number of items already achieved to date.*
[b] *Estimated quantity = estimation of the quantity of the corresponding item or the number of items that you foresee to achieve within the next 3 years.*

2.3. Further collaboration, dissemination and use of the result

(Optional; to be completed if partner is willing to set up new collaborations, and seeking dissemination support from the CORDIS services.)

COLLABORATIONS SOUGHT

Please tick appropriate boxes ( ) corresponding to your needs.

R&D	Further research or development	☐	**FIN**	Financial support	☐
LIC	Licence agreement	☐	**VC**	Venture capital/spin-off funding	☐
MAN	Manufacturing agreement	☐	**PPP**	Private-public partnership	☐
MKT	Marketing agreement/Franchising	☐	**INFO**	Information exchange	☐
JV	Joint venture	☐	**CONS**	Available for consultancy	☐
			Other	(please specify)	☐

POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE

Please, clearly describe your input, the value and interest of the applications and the dissemination and use opportunities that you can offer to your potential partner.

The customers for the work completed under CloudNET are the National Weather Services and Climate Prediction Centres and also our Industrial Partner who is involved in manufacturing meteorological information and is interested in the Cloud Observing Station the specification of which is one of our deliverables. We are maintaining our contact with this company.

We are already in contact with The National Weather Services and Climate Prediction Centres. Representatives of those from the UK, F, NL, Sweden and Germany (incl ECMWF) attended our final CloudNET symposium. They are participating I the cloudnet project in that their model data is on the cloudnet web site as are the statistics of the performance of their models in their ability to correctly represent clouds. These national weather services have expressed a wish for the CloudNET infrastructure to be supported in the future so that they can continue to benefit from the model evaluation provided by CloudNET.

PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE

Please, clearly describe the profile and the expected input from the external partner(s).

I confirm the information contained in part 2 of this Technological Implementation Plan and I authorise its dissemination to assist this search for collaboration.

Signature: **Name: Anthony Illingworth**

Date: 1 March 2006 **Organisation: University of Reading**

Part 3 Description of the intentions by each partner

This part 3 must be completed by each partner who is essential for the dissemination and use (i.e. result owners and/or major project contributors and/or major dissemination and use contributors). Each will detail its own use and dissemination intentions concerning the result(s) they are involved with. This description must be made result by result.

These different parts may be transmitted to the Commission either assembled at the consortium level, or individually by each partner to safeguard confidential matters if necessary (through any appropriate media). Obviously, when all partners are implementing a single dissemination and use scheme all together, a single part 3 is needed.

PARTS 3 WILL ALWAYS BE KEPT CONFIDENTIAL BY THE COMMISSION

3.1 : Description of the use and the dissemination of result(s), partner per partner

MANDATORY INFORMATION :

CONTRACT NUMBER :	**EVKV2-2000-00065**
PARTNER's NAME :	**UNIVERSITY OF READING**

CONTACT PERSON(S):

Name	Anthony J Illingworth
Position/Title	Professor.
Organisation	University of Reading
Address	Earley Gate Reading RG6 6BB, UK
Telephone	(44) 118 378 6508
Fax	(44) 118 378 8905
E-mail	a.j.illingworth@reading.ac.uk

No, TITLE AND BRIEF DESCRIPTION OF MAIN RESULT(S)

1	Thirty results are listed in section 2. They are all of the same status described below.
2	
3	
4	
5	

FOR EACH MAIN RESULT:

TIMETABLE OF THE USE AND DISSEMINATION ACTIVITIES WITHIN THE NEXT 3 YEARS AFTER THE END OF THE PROJECT

Mention the use and dissemination related activities, the main associated partners, the related milestones and give an indicative timescale		
Activity	**Brief description of the activity, including main milestones and deliverables (and how it relates to data in sections 2.2 and 3.2).**	**Timescale (months)**
1-30	**All these activities relate to findings which can be used by a) National Weather Services and Climate Prediction Centres to aid them in evaluating and improving the way their models can represent clouds. We are in contact with these centres and b) Companies manufacturing meteorological equipment fro observing clouds using radar lidar and microwave radiometers. Again we are in contact with these companies with in Europe..**	

FORESEEN COLLABORATIONS WITH OTHER ENTITIES

Please tick appropriate boxes ( ) corresponding to your most probable follow-up.

R&D	Further research or development	☐	**FIN**	Financial support	☐
LIC	Licence agreement	☐	**VC**	Venture capital/spin-off funding	☐
MAN	Manufacturing agreement	☐	**PPP**	Private-public partnership	☐
MKT	Marketing agreement/Franchising	☐	**INFO**	Information exchange, training	☐
JV	Joint venture	☐	**CONS**	Available for consultancy	☐
			Other	(please specify)	☐

3.2 : Quantified data for each partner's main result

Items	Currently achieved quantity [a]	Estimated future quantity [b]
Economic impacts (in EURO)		
# of licenses issued (within EU)		
# of licenses issued (outside EU)		
Total value of licenses (in EURO)		
# of entrepreneurial actions (start-up company, joint ventures…)		
# of direct jobs created [c]		
# of direct jobs safeguarded [c]		
# of direct jobs lost		

[a] *The added value or the number of items already achieved to date.*
[b] *Estimated quantity = estimation of the quantity of the corresponding item or the number of items that you foresee to achieve in the future (i.e. expectations within the next 3 years following the end of the project).*
[c] *"Direct jobs" means jobs within the partner involved. Research posts are to be excluded from the jobs calculation*
 # = number of ...

I confirm the information contained in part 3 of this Technological Implementation Plan and I certify that these are our exploitation intentions

Signature: **Name: Anthony Illingworth**

Date 1 march 2006