

BALTEX Cloud Liquid Water Network: CLIWA-NET

Kick-Off Workshop Report

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1 Introduction

CLIWA-NET focuses on observations of cloud liquid water and vertical structures, and the evaluation and improvement of model parameterisations. The specific objectives are:

- ❑ Implementation of a prototype of a European Cloud Observation Network
- ❑ Development of an adequate observing system for the detection of icing conditions for aircraft
- ❑ Objective evaluation and improvement of state-of-the-art cloud parameterisations for climate and weather forecast models, with a focus on integrated cloud liquid water and vertical structure of clouds
- ❑ design of a “low cost” microwave radiometer in co-operation with industry
- ❑ Contribute to BALTEX/BRIDGE.

The CLIWA-NET project will establish a prototype of a European cloud observing system by co-ordinating the use of existing, ground-based passive microwave radiometers and profiling instruments. In total 12 stations within the BALTEX modelling area will contribute to this CLIWA-NET Network (CNN). CNN will be operated in August/September 2000 (CNN I) and April/May 2001 (CNN II).

A microwave radiometer calibration campaign will be organised in combination with a regional network (100x100 km²) during the BALTEX BRIDGE Cloud campaign (BBC). The BBC campaign will take place in August/September 2001.

The data from the ground-based remote sensing instruments will feed high quality cloud information, with high temporal but poor spatial resolution, into the calibration of satellite-based estimates of cloud water content with high spatial resolution. New procedures will be developed to fully exploit the synergy.

The retrieved CLIWA-NET data-sets will be used for an objective evaluation of the performance of state-of-the-art cloud parameterisation schemes. The focus will be on liquid water path (LWP) and vertical structure of cloud amount and cloud water. Three lines of research will be pursued:

- ❑ Evaluation of cloud related output from leading European atmospheric models
- ❑ Investigation of the sensitivity of model cloud parameters to the employed horizontal grid spacing in the meso-scale range from (1-10 km)
- ❑ To develop/improve/test cloud parameterisations and underlying assumptions.

The cost and complexity of the available microwave radiometers presently hamper the implementation of an operational network. For this reason, the design of a low-cost operational microwave radiometer by a commercial company is included in this project.

The project will be carried out under the umbrella of BALTEX. The co-ordination of the experimental periods within the BALTEX/BRIDGE program assures the availability of a large variety of supporting data and infra-structure. The major aim of BALTEX/BRIDGE is to provide an extensive data base of observations to be used by the modelling groups of the BALTEX community. By incorporating CLIWA-NET in the BALTEX/BRIDGE program, the exploitation of the data in a broader context is guaranteed. Furthermore,

access to the standard meteorological observations for the Baltic area is obtained through the BALTEX Meteorological Data Centre.

In this kick-off workshop report the results from the discussions during and after the Kick-Off meeting (4-6 April) are presented. The observational plan was the major deliverable from the WP2000 group. In this Kick-Off workshop report a summary of the contents of the observational plan is given. The Observational plan is available as a separate document. In Section 3 the outcome of the discussions from the satellite group (WP3000) is described. The result of the modelling discussions are reported in section 4 and in Appendix 5 (Description of Model output). A description of the retrieval algorithms for the microwave radiometers is given in section 5. As promised in the CLIWA-NET project this Kick-Off workshop report also includes the CLIWA-NET User's Requirement Document (section 6 and Appendix 6). Concluding remarks are made in section 7.

Many of the documents that are referred to in this report can be found at the central CLIWA-NET web site: www.knmi.nl/samenw/cliwa-net. Also the results from the campaigns, satellites and model output can be found at this web site.

2 CLIWA-NET observational plan (WP2000)

In July 2000 the CLIWA-NET observational plan was published and distributed among the participants. For reasons of efficiency the full observational plan is not copied into this report but distributed as a separate document. Below a brief overview of the content of the CLIWA-NET observational plan is given.

In the observational plan the experimental campaigns (CNN I and II and BBC) are described for. Here we summarise the most important points for the CNN campaigns in section 2.1. In section 2.2 an overview of the BALTRAD network is given. A description of the BBC campaign is given in section 2.3. In this first version of the observational plan this description is not yet complete. Especially for the BBC campaign much more information has become available (e.g. BBC management plan, Overview BBC suggested flight patterns, Instrument lay-out). All these documents are available from the CLIWA-NET web site and new information will be made available there.

2.1 CNN Network

A network of ground based stations within the BALTEX modeling area will be operated during two campaigns. Since both periods are also BALTEX Enhanced Observation Periods (EOP 1, 3) additional data sets will be available (e.g. radiosondes):

- August 1 to September 29, 2000 (CNN I)
- April 2 to May 31, 2001 (CNN II)

The position of the stations within the BALTEX modelling area are given in Figure 1. An overview of all stations and the operated instrumentation can be found in the CLIWA-NET observational plan. The closest locations, where routine meteorological radiosondes are launched are also given.

The data from the instruments from the stations will undergo different processing levels, which are defined as follows:

Level 0A: Raw data at the instrument's specific temporal resolution. Highest resolution as possible should be used, however, should not exceed 1 second.

Level 0B: Quality checked: continuous time series, missing data were replaced by dummy numbers.

Level 1A: Derived products from single instruments (e.g. LWP, IWV,...).

Level 1B: Quality checked 1A.

Level 2A: Evaluated (synergetic) products derived from multiple instrumentation at different temporal resolutions (e.g. LWP, liquid water profile LWC..).

It is expected that every participating group will deliver Level 0A and 0B products. If any revised data sets come up they can be labelled with C and so on.



Figure 1: Position of stations during the CLIWA-NET observation periods CNN-I and -II

Since we do not expect raw data exchange more often than once a day, we will not need the exact time in the file name. Data files will be formatted in ASCII. Every data file will contain a header including the exact starting time (in decimals of an hour), the ending time (in decimals of an hour), the number of lines and the number of columns in the first line. The second line of the header will include the description of the parameters in the specific columns. Missing data should be replaced by -999.99.

Example files for the data format are available from the CLIWA-NET www-site. Partners will deliver example files by the end of May 2000 to MIUB to guarantee smooth processing during the campaigns. A „dry run“ will be performed in the end of June to test the infrastructure.

Data products at levels 1 and 2 will be produced and archived at Bonn University. Level 1 and 2 products will be available via anonymous ftp or www. Raw data will be distributed among the participants on request only.

2.2 BALTRAD

The BALTRAD network contains a number of nodes which are located relatively proximate to the positions of several locations where other instruments will be operating during the CNN campaigns. The primary weather radar defined for these activities is located in the town of Hemse on the island of Gotland in the Baltic Sea. Additional radars are those located at the airports in Helsinki and Hamburg, respectively, along with the cities of Kiruna, Göteborg, and Berlin.

While the Doppler radars operated in Finland and Germany have Doppler capacity out to full operational range, the Swedish radars have a maximum Doppler-mode range of 120 km and a non-Doppler mode range of 240 km. This poses a limitation when using the data for monitoring precipitation but it allows for the collection of high quality radial wind velocity data, with an unambiguous velocity interval of ± 48 m/s, due to the use of a staggered pulse repetition frequency of 900/1200 Hz.

The BALTRAD network operates round the clock with a maximum resolution in time of 15 min and in space of 2 km. The wind profiles have a resolution in altitude of 200 m. These characteristics are all well documented and the data is available regularly on CD-ROM from the BRDC. During the CNN campaigns time series of reflectivity at the CLIWA-NET and the wind profiles above the radar locations will be delivered to the data centre at the University of Bonn.

2.3 BALTEX BRIDGE Cloud Campaign (BBC)

The BALTEX BRIDGE Cloud campaign will take place in August/September 2001. Different microwave radiometers are taking part in CNN I and II. The instruments differ in viewing geometry, frequencies and calibration methods. To establish the accuracy of each microwave radiometer type and thus the reliability of the network, it is important to have an intercomparison of these instruments. This intercomparison will take place at Cabauw, an experimental site in the centre of the Netherlands.

After the intercomparison the microwave radiometers will be distributed over a network of cloud observation station around Cabauw (see Figure 2). The instruments at the BBC stations will be installed from Wednesday August 15 onwards. The network will be operated starting Monday August 20, 2001 and end on Friday September 28, 2001. For this period it is planned to launch a radiosonde from De Bilt or Cabauw every three hours.

In table 1 an overview is given of the instruments that will be involved in the BBC campaign. These instruments will be located at the central facility in Cabauw. The microwave radiometers will be distributed over five stations around Cabauw, except for the MICCY instrument, which will be located in Cabauw. At every station an Impulsphysik LD40 lidar ceilometer and a Heimann KT15.85 infrared radiometer will be installed.

Not all instruments listed in table 1 are funded from the CLIWA-NET budget. Some contributions are paid for by the groups themselves, others receive funding through other research projects. The 4D Wolken project is a German initiative focussing on the radiative transport in broken clouds. Their experimental effort is combined with the BBC campaign.

During the campaign also aircraft observations will take place. These aircraft observations aim:

- to provide in-situ observations for water and ice clouds to validate the remote sensing results;
- to provide a link between the ground based and the satellite observations;
- to obtain detailed radiation measurements;
- to provide turbulence measurements within clouds.

In total three aircraft are involved. The Merlin IV is funded by CAATER. The Paternavia aircraft from the Institut für Troposphärenforschung Leipzig and the Cessna from the Free University of Berlin are funded by the 4D Wolken project.

The same data formats as for the CNN campaigns will be used.

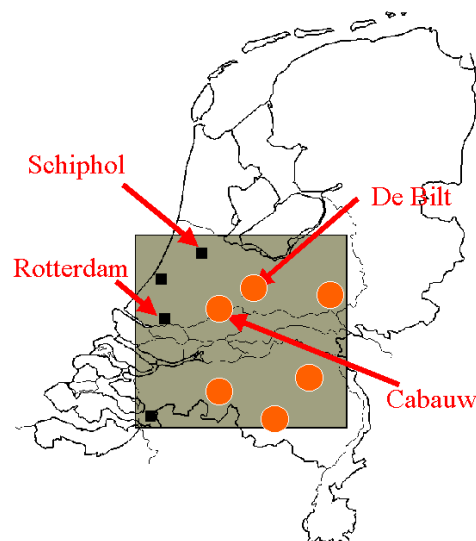


Figure 2: Map of the BBC Network. The red dots indicate the stations where a microwave radiometer will be installed. The grey area has a typical size of 120x120 km². The aircraft will be located at Rotterdam Airport.

Table 1: Overview of the instruments installed in Cabauw during the BBC campaign

Radars	1.2 GHz windprofiler + RASS (KNMI) 3 GHz radar TARA (TUDelft) 35 GHz radar (KNMI) 94 GHz radar MIRACLE (GKSS) 94 GHz radar (IFT Leipzig), test	
Lidars	1064nm, 532 nm backscatter lidar (RIVM) CT75K ceilometer (KNMI) LD40 ceilometer (KNMI)	
Microwave Radiometer	22 channel MICCY (UBonn) 89, 157, 183 GHz MARSS (UKMO) During microwave intercomparison also: 24, 37 GHz (CETP) 24, 31 GHz (DWD) 21, 31 GHz (Chalmers) 21, 32 GHz (UBern) 13, 22, 37, 89 GHz (St. Petersburg)	
Radiation	SW in & out, SW direct & diffuse, LW in & out (KNMI) Oxygen-A band spectrometers (UHeidelberg) IR radiometer (KNMI) Albedometer (IFT Leipzig) Sunphotometer (IFT Leipzig) radiation (TUD)	
Meteo	Cabauw meteo tower, 2 – 200 m	temperature dew point temperature wind direction wind speed
	Tethered balloon (Univ. Utrecht), 0 - 1.4 km	temperature pressure RH wind
	Radio soundings De Bilt (KNMI): 0,6,12,18 UTC Cabauw (National Army): 3,9,15,21 UTC	temperature pressure RH wind direction wind speed
Other	Digital video camera (KNMI)	

3 CLIWA-NET satellite observations (WP3000)

The objective of WP 3000 is 1) to infer cloud liquid water path (LWP) maps for the entire BALTEX area from a combination of visible, thermal, and microwave satellite observations, and 2) to improve the quality of these data by integrating the more accurate surface observations of LWP from the 12 CLIWA-NET ground-stations. To this end, the availability of satellite data and remote sensing algorithms, as well as the strategies for combining satellite-born with ground-based measurements of LWP have been discussed during the Kick-Off meeting.

3.1 Availability of satellite data and definition of data formats

During the CLIWA-NET CNN campaigns cloud liquid water path (LWP) will be inferred from the microwave radiometers AMSU onboard NOAA15 and SSM/I onboard DMS/P, as well as from the solar/thermal multi-channel radiometer AVHRR onboard NOAA12, NOAA14, and NOAA15. It is planned to add NOAA16 (launch: August 2000) for forthcoming campaigns because of its favourable afternoon orbit. The unprocessed NOAA data (HMF-format) are archived by SMHI. Calibration and navigation of the raw satellite data will be performed at SMHI and at IfMK with the help of the AAPP software distributed by EUMETSAT. Calibrated and navigated SSM/I and AMSU data are available from NASA's Satellite Active Archive Center. The estimated overpass times for the NOAA satellites are:

- NOAA-12: morning orbit 6:00 CET, afternoon orbit 16:00 CET
- NOAA-14: night orbit 5:30 CET evening orbit 15:30 CET
- NOAA-15: morning orbit 8:15 CET afternoon orbit 18:15 CET

A more detailed observational plan for the satellite overpass times at the CLIWA-NET ground stations for the first EOP (August/September 2000) will be provided end of July with actual satellite orbit parameters.

3.2 Availability of remote sensing algorithms

LWP retrieval from AMSU brightness temperatures are based on classical regression algorithms as described in the literature (reference). SSM/I data are transformed into LWP by means of neural network algorithms developed at the IfMK. LWP from AVHRR reflectance measurements is obtained from the KLAROS scheme developed at KNMI. This scheme requires surface reflectivity maps for the region under consideration. A reflectivity map for the BALTEX area will be provided by SMHI. A Linux version of the KLAROS scheme has been installed at the IfMK and processing of data is under way. The format for KLAROS input data still needs to be clarified. First approximate intercomparisons of liquid water paths retrieved from co-located AMSU and AVHRR data (both NOAA15) over open ocean areas have been performed at IfMK and show a generally good agreement. Problems are expected for intercomparisons within the BALTEX area due to land contamination within the AMSU radiometer field of view.

3.3 Integration of surface observations into the satellite data

Adjusting the satellite based LWP estimates to the ground based measurements is rendered difficult by the fact that one needs to quantitatively compare spatial (satellite) with temporal (ground station) pattern which both obey a strong degree of irregularity. Therefore, it is planned to perform a comparison by means of both classical statistical and spectral analysis. The corresponding tools have been installed at the KNMI. A first spectral analysis has been performed with collocated AVHRR data and ground based microwave radiometer measurements obtained during the field experiment CLARA'96. The results show that a meaningful comparison of spatial and temporal LWP retrievals requires a minimum of 2000 data points in each data set.

4 CLIWA-NET Cloud Modelling (WP4000)

The CLIWA-NET Kick-Off Meeting offered a good opportunity to discuss a variety of aspects concerning the model component described in WP4000. Given the first observational campaign CNN1 coming up within a few months after the Kick-Off meeting, the primary aim of the discussions was to come at a comprehensive description of model output required for a meaningful evaluation. The remainder of the workpackage WP4000 session was devoted to various other aspects most of them being less urgent than the set-up topic as they will play at a latter stage of the project.

4.1 Set-up description of model output

Prior to the meeting KNMI had prepared a draft concept on the description of model output concerning the evaluation aspects addressed in WP4100. This document was circulated among all participants to serve as a starting point. Replies, suggestions and comments to this draft and lengthy discussions during the Kick Off Meeting turned it into a final document (see Appendix 5) which will be used by the participating institutes to prepare the model output.

4.2 Model evaluation of cloud parameters

ECMWF and DWD contribute to the model evaluation with forecast products from their operational suites. The ECMWF global model naturally covers the entire CLIWA-NET network, whereas the DWD regional domain only covers the central and southern part of the network. The Rossby Centre (SWECLIM/HIRLAM) and KNMI (RACMO) will operate their research models near-real time. The regional model domains allow to extract output for the entire network. Preliminary choices for the model area could be a rather large domain (182x182 points) or a somewhat smaller domain, 110x170 points, oriented parallel to the network SW-NE axis.

Rosby Centre will run the HIRLAM reference code and the modified code to include the Rossby Centre moist physics package. Both versions will be operated in NWP forecast mode with data assimilation. A possible extra option will be to test running one version of the code without data assimilation. This will allow for an evaluation of the importance of assimilation in the short range forecast of cloud fields. KNMI will run the reference version and alternatives for cloud processes of its regional model RACMO. The model is operated without data-assimilation. Initial and lateral boundary fields are taken from ECMWF analyses/forecasts.

4.3 Representing the diurnal cycle of clouds

The diurnal cycle of cloudiness and radiation is a key issue for climate modelling. The Rossby Centre will perform extended (multi-month) integrations with the Rossby Centre Regional Atmosphere Model (RCA) forced by ECMWF analysed boundary conditions and observed SSTs. The diurnal cycle of cloudiness and associated radiative fluxes will be evaluated against satellite and land based measurements. In particular a long term climatology of cloud fraction, derived from the AVHRR sensors and archived at SMHI, will be used with collocated surface radiation measurements. An evaluation of the diurnal cycle of cloudiness and cloud forcing of the surface/atmosphere will be made.

4.4 Horizontal Resolution

The Rossby Centre will perform integrations with the Rossby RCA for particular case studies derived from the BBC campaign. These integrations will be done in parallel with integrations of the DWD Lokalmodell made by the University of Bonn. The Rossby RCA will be run at 32km, 18km and 8km resolution with parameterised convection. The highest resolution will allow an overlap with the resolution being used by the non-hydrostatic Lokalmodell (running at resolutions from 10 to 1 km). A key question in this is at what resolution are certain processes, related to the water cycle (in particular convection), resolved and therefore should no longer be parameterised.

4.5 Parameterisation development of cloud processes

KNMI and the Rossby Centre will collaborate in an attempt to determine more physically based approaches to the onset and growth of sub-grid scale cloudiness. Use will be made of the high resolution observations from satellites and during the BBC campaign. It is expected that a better understanding of the variability of clouds and water on scales smaller than 50km will ensue. Where possible, this variability will be related to larger-scale meteorological variables. It is hoped that collaboration with Cloud Resolving Models participating in the EUROCS EU project, will allow this work to develop faster.

The Rossby Centre, in collaboration with the Research group at SMHI, will attempt to build a composite relationship between cloud top temperature and in-cloud water phase. This relationship will be compared with model derived relationships to determine if model clouds have the same physical processes governing phase changes as seen in reality. An attempt will be made to improve the factors governing the phase change of water substance in model clouds.

The Rossby Centre in collaboration with KNMI will address the cloud overlap problem. The vertical structure of clouds significantly affects the radiative balance of the atmosphere. Cloud overlap assumptions are required in the model radiation calculations and also for interpretation of the satellite and radar data. The Rossby center will evaluate existing cloud overlap assumptions, like maximum, random and a mixture of those comparing the model results with cloud radar profiles and other measurements. The evaluation may show if the overlap assumption should be made a function of height or horizontal cloud extent. Other model variables, like the vertical velocity, may also give a guidance to how continuous (contiguous) the clouds are in the vertical and whether horizontally adjacent grid boxes are linked. The various assumptions will be tested at different vertical and horizontal resolutions in the present HIRLAM radiation scheme. But it might also be necessary to perform the tests in a scheme with more vertical interactions like the ECMWF radiation scheme.

5 Description of the Algorithms

The retrieval of LWP and IWV from the multi-spectral microwave measurements is performed using statistical multiple regression algorithms based on a European radiosonde data set comprising the months July, August, September and October for the years 1995-1998. After quality checks about 20,000 soundings were used for training (one half of the data) and evaluation (other half of the data) of the algorithm. The general procedure for development and evaluation of the algorithm is outlined in Figure 3. At first the cloud water profile is determined from the radiosondes temperature and humidity profile by using a 90 % threshold in relative humidity and calculating the modified adiabatic LWC [Karstens et al, 1994]. With this humidity threshold about half of the radio sondes were diagnosed as cloudy. Then radiative transfer calculations including Mie scattering using MWMOD [Simmer, 1994] were performed for the different frequencies and observation angles of the CNNI radiometer. To simulate the error in the measured brightness temperature normal distributed noise (e.g. $\sigma=1$ K) was added to the results. The coefficients of the statistical algorithm

$$LWP = a + b \cdot T_{B1} + c \cdot T_{B1}^2 + d \cdot T_{B2} + d \cdot T_{B2}^2 + \dots$$

were determined from the training data set and evaluated using the test data set. The addition of noise is quite important to make the algorithm robust not only against noise but also against bias (absolute errors). We have shown that with 1 K noise the derived LWP RMS has about the same value as the LWP bias which will occur in case of an absolute error in the brightness temperature of about 0.75 K. This emphasizes that in cloud-free conditions a derivation from zero LWP in the range of the specified RMS is in the allowed range.

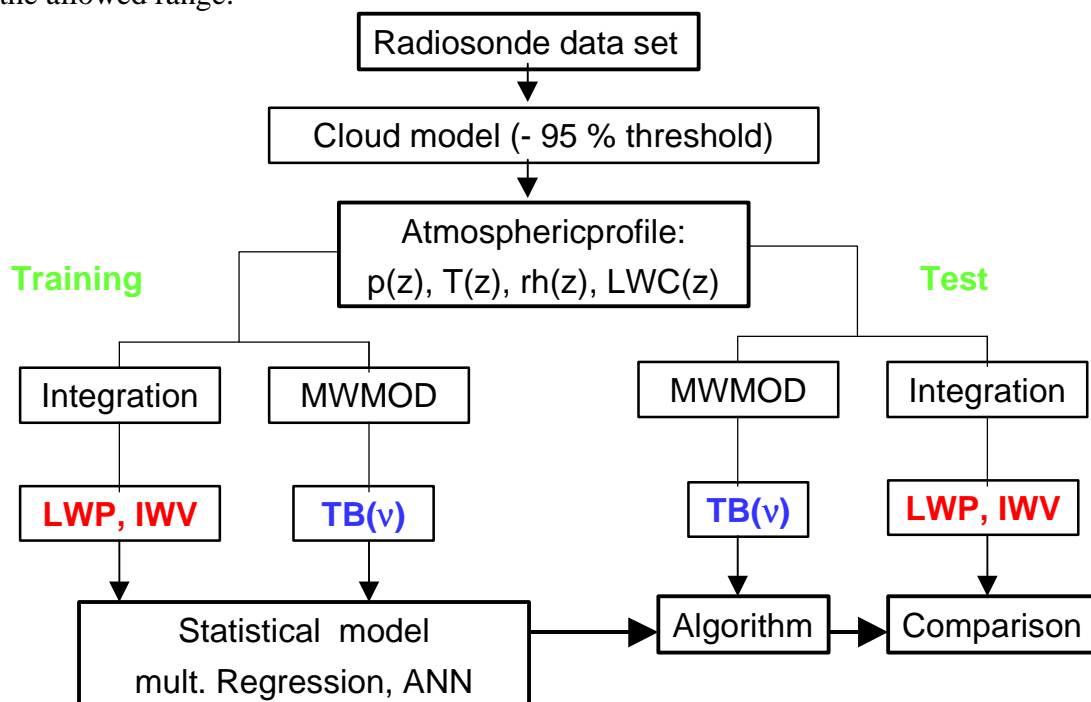


Figure 3: Illustration of the statistical algorithm development.

5.1 Accuracy of Level1a Products

According to the procedure described in the previous section algorithms were developed and applied to the level0a data. The accuracy in LWP and IWV as evaluated from the test data set is shown in Figure 4. The single stations show differing accuracies: e.g. radiometers with a higher number of frequencies have lower error bars. Some stations have multiple occurrence: GE, GE1 and GE2 are the algorithms used during different times of the campaign due to the malfunction of individual channels. HE and HE2 differ by the inclusion of the 18.7 GHz in HE algorithms which was not working all the time. For cloud liquid water it is obvious that the algorithm with of quadratic terms of the brightness temperatures outperforms the linear one for all stations. It is obvious that the effect is strongest for multifrequency measurements. The use of higher order terms or even an artificial neuronal network (ANN) would improve only marginally. For IWV the quadratic algorithm also performs better than the linear one except at stations which used the center of the water vapor line (22.235 K). As an average the RMS in LWP is 30 gm^{-2} and 1.3 kgm^{-2} for IWV.

The accuracy of the derived level 1a products IWV and LWP depends obviously on the accuracy of the level 0a brightness temperatures. For the first algorithm development we assumed a noise level of 1 K as an educated guess for the radiometer performance. As shown in Tab. 1. some of the radiometers have higher estimated absolute errors which will be included in future retrieval algorithms.

It should be noted that the algorithm was derived only for LWP values between 0 and 0.5 kgm^{-2} . and hence, give only reasonable results in this range. LWP values higher than 0.5 kgm^{-2} should be handled with care. This upper threshold was chosen because mostly precipitation occurs at LWP values this high. The transition to precipitation will be investigated in detail in workpackage WP2500.

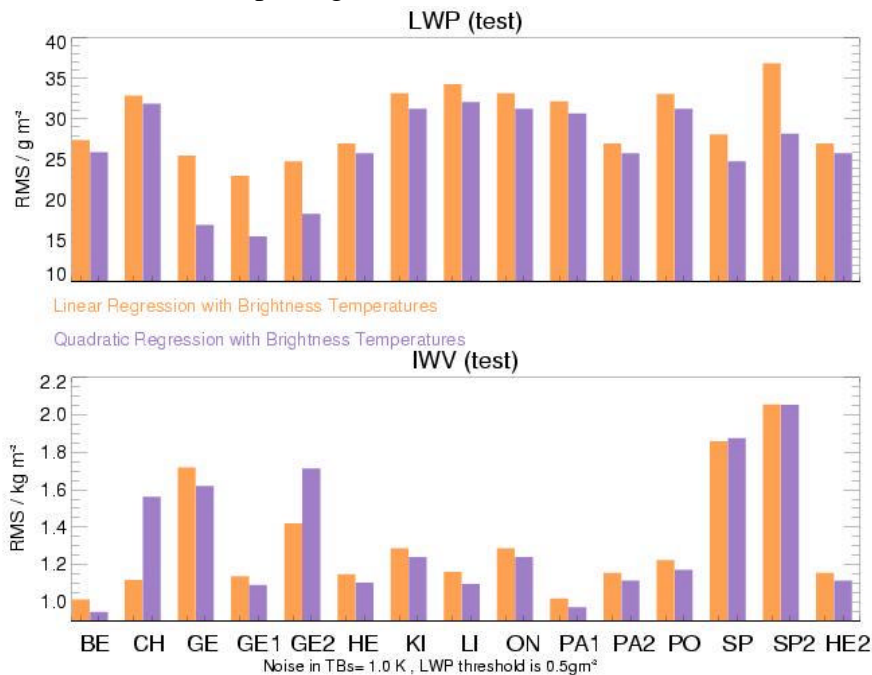


Figure 4: RMS errors of level1a products (LWP and IWV) for all CLIWA-NET stations.

6 User Requirements Document (URD)

To increase the impact of the project beyond the scientific circle of the consortium members a User's Advisory Group (UAG) was established. This group consists of 5 persons with different backgrounds:

- Dr. Koos Verbeek, KNMI (Focal point of GCOS activities in the Netherlands)
- Dr. Bertram Arbesser Rastburg, ESTEC (Telecom applications)
- Mr. Frank Wouters, ECOFYS (voltaic systems)
- Dr. Harald Neumann, Lufthansa (icing conditions for aircraft)
- Mr. Jan Lonnqvist, Vaisala (Meteorological instruments)

It should, however, be mentioned that the national weather services and the general community, are important users of the improved cloud forecasts. The involvement of several weather services (KNMI, DWD, SMHI, ECMWF) within the project guarantee the efficient transfer of improvements into the operational environment.

As a first start all the members of the UAG were interviewed. The possible application of CLIWA-NET results was a central topic in these discussions. The outcome of these discussions is reported in the URD (see Appendix 6). The URD was published and distributed in March 2001 and is available from the CLIWA-NET web site.

Abbreviations and Acronyms

AMSU	Advanced Microwave Sounding Unit
APOLLO	AVHRR Processing over Land Cloud and Ocean
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BALTEX	Baltic Sea Experiment
BBC-campaign	BALTEX BRIDGE Cloud campaign
CETP	Centre des Environnements Terrestre et Planetaires
CLIWA-NET	BALTEX BRIDGE Cloud Liquid Water Network
CNN-I campaign	CLIWA-NET Network campaign
DOW	Description Of Work
DWD	Deutsche Wetter Dienst
ECMWF	European Centre for Medium-range Weather Forecasts
ERS	Earth Resources Satellite
ESA	European Space Agency
ESTEC	ESA Technical Centre
GKSS	GKSS-Research Center Geesthacht
HIRLAM	High Resolution Limited Area Model
HUT	Helsinki University of Technology
IFM	Institut für Meereskunde Kiel
IPCC	Intergovernmental Panel on Climate Change
IWV	Integrated Water Vapor
KLAROS	KNMI Local Implementation of APOLLO Retrievals in an Operational System
KNMI	Royal Netherlands Meteorological Institute
LWP	Liquid Water Path
MIUB	Meteorological Institute University of Bonn
RACMO	Regional Atmospheric Climate Model
RAL	Rutherford Appleton Laboratory
RCA	Rosby Center Atmospheric model
RPG	Radiometer Physics GmbH
SMHI	Swedish Hydrological and Meteorological Institute
UNIBE	Institute of Applied Physics, University of Bern,
URD	User's Requirement Document
UAG	User's Advisory Group

Appendix 1: Minutes of the meeting

1) Day One: 05 April 2000

- Welcome of all participants (see Appendix 1) and introduction to CLIWA-NET by A.van Lammeren (KNMI)
- Presentation of current activities and instrumentation in relation to CLIWA-NET by the CLIWA-NET participants (see agenda Appendix 2)

2) Day Two: 06 April 2000

- Specification of working concepts within WP 2000, WP 3000, WP 4000
- WP 2000 session**

a) detailed description of CLIWA-NET stations

- i) available instrumentation (MWR accuracies missing !)
- ii) distribution of IR-radiometers (KNMI) to stations
- iii) products to be delivered
- iv) additional measurements desirable (e.g. short & long wave radiation measurements)
- v) video camera proposed for all sites

b) required time accuracies

- i) GPS clock at each station
- ii) instruments at each station should not differ by more than 2 – 3 s
- iii) station times should agree within 15 s

c) data delivery

- i) via ftp to Bonn (special user accounts on separate computer)
- ii) in the first weeks of CNN I (August 2000) data delivery every day
- iii) afterwards data delivery about 2 to 3 times a week
- iv) data delivery not required on weekends
- v) example file to Bonn at the latest by June 1, 2000
- vi) „dry run“ before CNN I at the end of June

d) data formats

- i) same format as in the dutch CLARA campaign
- ii) additionally elevation and azimuth angle to be included
- iii) time in digital hours (UTC !)
- iv) maximum one file per day

e) sampling strategy: compilation of MWR parameters

- i) lowest temporal resolution as possible (~5 s)
- ii) standard observation angle: 90° elevation
- iii) special observing strategy for fast scanning MWRs (between 30° and 90°)
- iv) no tipping curve calibrations during satellite overpass +/- 90 min (WP 3000)

- f) Baltrad
 - i) time series of reflectivity scans (ppi and rhi) of ~6 stations will be delivered to Bonn once a day
 - ii) image products will be directly exchanged with WP 3000 and WP 4000

- g) satellite overpasses
 - i) most important observation phases of all instrumentation one hour before and after overpasses. Modified to 1.5 hours after communication with WP3000
 - ii) instruments with non-continuous operation (e.g. cloud radar) will operate then
 - iii) no maintenance work on instrumentation during this time

- h) BBC campaigns
 - i) fall back scenario (e.g. in case of unsuitable conditions) – draft will be ailed
 - ii) instrument maintenance by KNMI staff at dutch airports
 - iii) inference problems at airports
 - iv) backup stations in case of interference problems (?)

- 3.) **Day Three: 07.04.00**
 - reports from WP 2000, WP 3000, WP 4000 sessions
 - interfacing between WPs
 - wrap up
 - graphics: input needed for Glossy brochure
 - CLIWA-NET LOGO to be determined by contest
 - CLIWA-NET papers desired by EU
 - next workshop: 13.12.00-15.12.00 in Bonn (after CNN I)

Appendix 2: Participants CLIWA-NET KICK-OFF

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Appendix 3: Agenda

CLIWA-NET Kick-Off Meeting

April 5-7, 2000

Hotel Opduin, Texel, The Netherlands

Wednesday April 5, 14:00 – 17:30

- 14:00 – 14:10 Welcome, Opening of the meeting
- 14:10 – 14:30 Outline of the CLIWA-NET project
- 14:30 – 18:00 Introduction of the CLIWA-NET partners
-
- 14:30 – 14:45 Susanne Crewell, Meteorological Institute University of Bonn, MIUB
- 14:45 – 15:00 Cecile Mallet, Centre des Environnements Terrestre et Planetaires, CNRS
- 15:00 – 15:15 Martti Hallikainen, Helsinki University of Technology, HUT
- 15:15 – 15:30 Th. Rose, Radiometer Physics GmbH, RPG
- 15:30 – 15:45 Jürgen Güldner, Deutsche Wetter Dienst, DWD
- 15:45 – 16:00 Gunnar Elgered, Chalmers University of Technology, Chalmers
- 16:00 – 16:15 Christian Matzler, Institute of Applied Physics, University of Bern, UNIBE
- 16:15 – 16:30 Break
- 16:30 – 16:45 Colin Jones/Daniel Michelson, Rossby Center and Swedish Hydrological and Meteorological Institute, SMHI
- 16:45 – 17:00 Andreas Macke, Institut für Meereskunde Kiel, IFM
- 17:00 – 17:15 Markus Quante, GKSS-Research Center Geesthacht, GKSS
- 17:15 – 17:30 Charles L. Wrench, Rutherford Appleton Laboratory, CCLRC
- 17:30 – 17:45 Boris Kutuza, Institute of Radioengineering and Electronics, IRE
- 17:45 – 18:00 André van Lammeren, Royal Netherlands Meteorological Institute, KNMI
- 18:00 Closing of the session

Thursday April 6, 9:00 – 17:30

- 9:00 – 9:10 Today's Agenda
- 9:10 – 9:40 Data from BALTRAD, Daniel Michelson
- 9:40 – 12:30 Work package meetings
 WP 2000, Chair Susanne Crewell (MIUB)
 WP 3000, Chair Andreas Macke (IFM-Kiel)
 WP 4000, Chair Erik van Meijgaard (KNMI)
- 12:30 – 14:00 Lunch
- 14:00 – 17:30 Work package meetings
 WP 2000, Chair Susanne Crewell (MIUB)
 WP 3000, Chair Andreas Macke (IFM-Kiel)
 WP 4000, Chair Erik van Meijgaard (KNMI)
- 19:00 Dinner in Hotel Opduin

Friday April 7, 9:00 – 14:30

- 9:00 – 9:15 Today's Agenda
- 9:00 – 9:45 Report from WP 2000, Susanne Crewell (MIUB)
- 9:45 – 10:15 Report WP 3000, Andreas Macke (IFM-Kiel)
- 10:15 – 10:45 Report WP 4000, Erik van Meijgaard (KNMI)
- 10:45 – 11:15 Break
- 11:15 – 12:30 Interfacing WP200, 3000 and 4000; Open Discussion
- 12:30 – 13:30 Lunch
- 13:30 – 14:30 Wrap-up (time frame, next meeting, action items, web site, User's
advisory group, etc...)
- 14:30 Closing of the meeting

Appendix 4: Action List CLIWA-NET Kick-Off Meeting

	Responsible	Remarks	Status
WP1000			
- Quarterly Progress Report	André	Input from WP-managers needed	
- Availability e-mail exploder	André		
- Draft Data Policy	André		
- Mail contract No.	André		
- Meeting plan	André		
- Link www-sites	André		
- User Req. Document	André		
<i>User's Advisory Group</i>			
- Contact GCOS secretariat	André		
- Send official letters	André		
- Organise 1 st UAG meeting	André		
WP2000			
- Observational plan	Susanne / André		
- Update data formats	Susanne / André		
- Mail info on Cloud video	André		
<i>CNN</i>			
- Distribute IR-radiometers	André	Agree on final list first	
- CT25K for Helsinki UT	André	Contact Vaisala	Vaisala is contacted
- Test files to Bonn	Susanne	June 1st	
- Dry run	Susanne	End of June	
- Availability of radiation measurements	Susanne		
<i>BBC</i>			
- Fall back scenario	André		
- 3 hourly radiosondes	André		
WP3000			
- Observational plan	Andreas/Arnout		
- Minimum duration of observational periods	Andreas/Arnout	For instruments which do not operate continuously	
- Add SSMI LWP to products	Andreas		
WP4000			
- Description of model output	Erik		
- Need for fall velocity?	Erik		
- Radiation in spectral bands	Erik		

Appendix 5: Description of the Model output

A5.1 Setup Model Evaluation CLIWANET

The objective of Cliwanet Workpackage WP4100 includes a comprehensive evaluation of output from atmospheric models with observations retrieved from the CLIWA-network. The focus will be on cloud parameters with emphasis on cloud liquid water path. Observed quantities are inferred from ground-based measurements (see WP2000) during three 2-month observational campaigns, i.e. CNN1 (Aug/Sep 2000), CNN2 (Apr/May 2001), and BBC (Aug/Sep 2001). Next to this, 2-dimensional fields of precipitation (3h/12h accumulated values) produced by the BALTRAD (the Baltic Radar Centre) and 2-dimensional fields of cloud liquid water inferred from NOAA/AVHRR satellite overpasses (see WP3200) will be made available for model evaluation.

Crucial for a meaningful evaluation is the extraction of an adequate and useful combination of model quantities from the forecast runs. During the Kick-off meeting this item was discussed at length and the results are summarized hereafter in a prescriptive format.

A5.2 Institutes and Models

DWD (Lokallmodell), ECMWF, Rossby Center (HIRLAM/SWECLIM) and KNMI (RACMO/HIRHAM)

Horizontal and vertical resolution of models:

- DWD/MIUB-Lokallmodell: 7 km, 35 layers
- RossbyCenter-HIRLAM: 18 km, 24 layers
- KNMI-RACMO: 18 km, 24 layers
- ECMWF-model: 55 km, 60 layers

A5.3 Specification of Model Time Series Output per Station

A5.3.1 Temporal aspects of output

- Frequency of output:
 - DWD/MIUB-Lokallmodell: 15 minutes
 - HIRLAM/RACMO: 15 minutes
 - ECMWF-model: 60 minutes
- Forecast range
 - DWD/MIUB-Lokallmodell: 12-36 hours starting 12:00 UTC (optional is starting at 00:00 UTC and 18:00 UTC)
 - HIRLAM/RACMO: 12-36 hours starting 12:00 UTC (and if feasible 00:00 UTC)
 - ECMWF model: 12-36 hours starting 12:00 UTC

A5.3.2 Spatial coverage of subdomains

The area around each station will be about 50x50 km²

Avoid the central point to be a sea point (except for Gotland).

- DWD/MIUB-Lokallmodel: 7x7 gridpoints
- HIRLAM/RACMO: 3x3 gridpoints
- ECMWF-model: 1 gridpoint

Export model output averaged over the subdomain. For ECMWF this is trivially exporting the direct model output for each of the specified grid points. For DWD/MIUB, SMHI and KNMI, this requires some intermediate processing likely to be done inside the model. Besides the averaged values, they should also export minimum values, maximum values, and direct model values of the grid point nearest to the station coordinates. An alternative for DWD/MIUB, SMHI and KNMI, is exporting model output of all gridpoints involved in each of the subdomains and do the processing at a later stage. For DWD/MIUB the latter implies the export of $12 \times 27 = 324$ sets of model output which might be a bit overdone.

General Information:

- Name participating institute, model and experiment
- Reference date [yyyymmdd]
- Reference time [hhmn]
- Name CLIWANET station
- Longitude grid point [decimal]
- Latitude grid point [decimal]
- Surface Geopotential grid point [m²/s²]

A5.3.3 Single-level parameters

Surface pressure is assumed instantaneous. All other values should be averaged (fluxes, cloud cover) or accumulated (precip) over the past temporal interval.

1. Verifying date [yyyymmdd]
2. Verifying time [hhmn]
3. Surface Pressure [Pa]
4. Sensible heat flux at surface [W/m²]
5. Latent heat flux at surface [W/m²]
6. Momentum flux at surface [Pa] ($\rho \langle u'w' \rangle$)
7. Downward SW-flux at surface [W/m²]
8. Upward SW-flux at surface [W/m²]
9. Downward LW-flux at surface [W/m²]
10. Upward LW-flux at surface [W/m²]
11. Downward SW-flux at TOA [W/m²]
12. Upward SW-flux at TOA [W/m²]
13. Upward LW-flux at TOA [W/m²]
14. Precipitation Convective [m/s]
15. Precipitation Large Scale [m/s]
16. Precipitative Fraction in GridBox [0..1]

17. Total Cloud Cover [0..1]

A5.3.4 Multi-level parameters

All multi-level values are assumed instantaneous.

1. Verifying date [yyyymmdd]
2. Verifying time [hhmn]
3. Model layer value
4. Pressure [Pa]
5. Temperature [K]
6. Zonal wind component [m/s]
7. Meridional wind component [m/s]
8. Vertical wind speed [Pa/s]
9. Turbulent Kinetic energy [m2/s2]
10. Specific Humidity [kg/kg]
11. Specific Liquid Water [kg/kg]
12. Specific Ice Content [kg/kg]
13. Cloud fraction [0..1]
14. Short Wave In-Cloud Optical Thickness [0..1]
15. Long Wave In-Cloud Emissivity [0..1]
16. Liquid Precipitative Flux at lower interface [W/m2]
17. Solid Precipitative Flux at lower interface [W/m2]

A5.3.5 File Structure

All time series are formatted as ASCII. The principle rule is that all information within one record refers to a single verifying time (apart from the general information). To avoid (too) long records there are more records (typically nlev+1) referring to the same verifying time.

All files must start with the following header lines. If any of the header information changes, repeat the entire header before adding new information to the same file.

Headerlines

- line 1: '#',A16 ... name institute
- line 2: '#',A16 ... name participant
- line 3: '#',A16 ... name model
- line 4: '#',A16 ... name experiment
- line 5: '#',I10,I6.4 ... initial date[yyyymmdd]/time[hhmn] model run
- line 6: '#',A16 ... name or acronym CLIWANET station
- line 7: '#',2F8.2 ... longitude/latitude receptorpoint
- line 8: '#',E16.5 ... surface geopotential height [m2/s2]
- line 9: '#',E16.5 ... land sea mask gridbox []

FORMAT FILE WITH SINGLE-LEVEL FIELD INFO:

(start with header line: next 4 lines form one record ...)

```

line 10: '#   vdate vhrm'
          , '           PSURF           SENF           LATF           MOMF'
SWSD'
```

```

, '          SWSU          LWSU          LWSU          SW0D
SWSU'
, '          LW0U          PRECONV          PRECLS          PRECFRAC
TOTCOV'
  Loop over time-index
  line 11 ... : data with FORMAT: I9,I5.4,E14.6,14E13.5

FORMAT FILE WITH MULTI LEVEL FIELD INFO:

(next 2 lines form one record ...)
  line 10: '#   vdate vhrm lev'
, '          PRES          TEMP          UU          VV
WMEGA'
, '          TKE          QVAP          QLIQ          QICE
CLFRAC'
, '          SWCLTAU          LWCLEMIS          PRFLLIQ          PRFLICE'
  OUTER Loop over time-index
  INNER Loop over level-index
  line 11 ... : data with FORMAT: I9,I5.4,I4,14E13.5

```

Naming of files is as follows. Files with single-level (multi-level) parameters are named SLEV_XX_dtgin (MLEV_XX_dtgin), where XX is substituted by the 2-character acronym of the actual CLIWANET station (see first column [table](#)). If information of more or all stations is contained in one file, leave XX as XX. The suffix dtgin refers to the initial datum time group of the model run in yyyyymmddhh format.

A5.3.6 Co-ordinates and altitudes CLIWANET Stations

acronym	station	operator	LAT	LON	ALT	CNN 1	CNN 2	BB C
BE	Bern	UNIBE	46.95 N	7.73 E	575 m	x	x	-
CA	Cabauw	KNMI	51.97 N	4.93 E	-1 m	x	x	x
CH	Chilbolton	CLRC	51.14 N	1.44 W	84 m	x	x	-
GE	Geeshacht	GKSS	53.41 N	10.42 E	58 m	x	x	-
GO	Gotland	SMHI	57.24 N	18.39 E	56 m	-	x	-
HE	Helsinki	SMHI	60.18 N	24.83 E	14 m	x	x	-
KI	Kiruna	Chalmers	67.87 N	21.06 E	492 m	x	x	-
LI	Lindenberg	DWD	52.22 N	14.12 E	112 m	x	x	-
ON	Onsala	Chalmers	57.40 N	11.93 E	11 m	x	x	-
PA	Palaiseau	CETP	48.80 N	2.30 E	175 m	x	-	-
PO	Potsdam	DWD	52.38 N	13.05 E	100 m	x	x	-
SP	St. Petersburg	IREE/MGO	59.95 N	30.70 E	72 m	x	x	-

A5.4 Specification of Model Field Output

A5.4.1 Precipitation

Within CLIWANET (WP2200/2300/2400) high quality precipitation fields (3-hour and 12-hour accumulated fields) will be inferred from the BALTRAD network intended for use in model evaluation (WP4100). These products will be made available off-line on a monthly basis. To utilize this product atmospheric models must archive accumulated precipitation, preferably at 3-hour intervals, for the CLIWANET network domain.

Archiving of Accumulated Precipitation Fields:

- DWD/MIUB-Lokallmodel: 3 and 12 hours
- RossbyCenter-HIRLAM: 3 and 12 hours
- KNMI-RACMO: 3 and 12 hours
- ECMWF-model: 12 hours

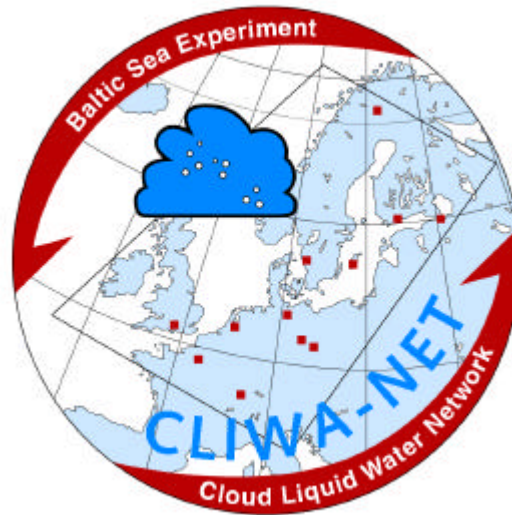
A5.4.2 Cloud Liquid Water Path

A significant task formulated within WP3200 includes the retrieval of LWP (liquid water path) from satellite observations (over sea from AMSU data, over sea and land from AVHRR data). As the NOAA/AVHRR overpasses are to a certain extent irregularly distributed in time, it is not possible to define the instants of overpass beforehand. But it is probably sufficient to have model fields of cloud cover, liquid water column, and cloud top temperature at 6-hour intervals (if feasible 3-hour frequency would be preferable).

Archiving of Cloud Parameter Fields:

- all models: at least every 6 hours, preferably every 3 hours
- parameters: total cloud cover, liquid water path, cloud top temperature

Appendix 6: CLIWA-NET User Requirement Document



CLIWA-NET User Requirement Document

Authors: André van Lammeren (KNMI) and Susanne Crewell (MIUB)

Version 1.0
Date 12-3-01

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A6.1 Introduction

CLIWA-NET focuses on observations of cloud liquid water and vertical structures, and the evaluation and improvement of model parameterisations. The specific objectives are:

- Implementation of a prototype of a European Cloud Observation Network
- Objective evaluation and improvement of state-of-the-art cloud parameterisations for climate and weather forecast models, with a focus on integrated cloud liquid water and vertical structure of clouds
- Design of a “low cost” microwave radiometer in co-operation with industry (SME)
- Development of an adequate observing system for the detection of icing conditions for aircraft
- Contribute to BALTEX/BRIDGE.

The CLIWA-NET project will establish a prototype of a European cloud observing system by co-ordinating the use of existing, ground-based passive microwave radiometers and profiling instruments. In total 12 stations within the BALTEX modelling area will contribute to this CLIWA-NET Network (CNN). CNN will be operated in August/September 2000 (CNN I) and April/May 2001 (CNN II).

A microwave radiometer calibration campaign will be organised in combination with a regional network (100x100 km²) during the BALTEX BRIDGE Cloud campaign (BBC). The BBC campaign will take place in August/September 2001.

The data from the ground-based remote sensing instruments will feed high quality cloud information, with high temporal but poor spatial resolution, into the calibration of satellite-based estimates of cloud water content with high spatial resolution. New procedures will be developed to fully exploit the synergy.

The retrieved CLIWA-NET data-sets will be used for an objective evaluation of the performance of state-of-the-art cloud parameterisation schemes. The focus will be on liquid water path (LWP) and vertical structure of cloud amount and cloud water. Three lines of research will be pursued:

Evaluation of cloud related output from leading European atmospheric models

Investigation of the sensitivity of model cloud parameters to the employed horizontal grid spacing in the meso-scale range from (1-10 km)

To develop/improve/test cloud parameterisations and underlying assumptions.

The cost and complexity of the available microwave radiometers presently hamper the implementation of an operational network. For this reason, the design of a low-cost operational microwave radiometer by a commercial company is included in this project.

The project is carried out under the umbrella of BALTEX. The co-ordination of the experimental periods within the BALTEX/BRIDGE program assures the availability of a large variety of supporting data and infra-structure. The major aim of BALTEX/BRIDGE is to provide an extensive data base of observations to be used by the modelling groups of the BALTEX community. By incorporating CLIWA-NET in the BALTEX/BRIDGE program, the exploitation of the data in a broader context is guaranteed. Furthermore, access to the standard

meteorological observations for the Baltic area is obtained through the BALTEX Meteorological Data Centre.

A full description of the CLIWA-NET project can be found in the “Description Of Work” (DOW).

To increase the impact of the project beyond the scientific circle of the consortium members a User's Advisory Group (UAG) was established. This group consists of 5 persons with different backgrounds:

Dr. Koos Verbeek, KNMI (Focal point of GCOS activities in the Netherlands)

Dr. Bertram Arbesser Rastburg, ESTEC (Telecom applications)

Mr. Frank Wouters, ECOFYS (voltaic systems)

Dr. Harald Neumann, Lufthansa (icing conditions for aircraft)

Mr. Jan Lonnqvist, Vaisala (Meteorological instruments)

It should, however, be mentioned that the national weather services and the general community, are important users of the improved cloud forecasts. The involvement of several weather services (KNMI, DWD, SMHI, ECMWF) within the project guarantee the efficient transfer of improvements into the operational environment.

As a first start all the members of the UAG were interviewed. The possible application of CLIWA-NET results was a central topic in these discussions. The outcome of these discussions is reported in this document.

This document will be updated in the course of the project. So, if any reference is made to this document please also state the version number. The latest version of this document is available through the CLIWA-NET web site (<http://www.knmi.nl/samenw/cliwa-net>)

A6.2 Discussion with Koos Verbeek, KNMI (The Netherlands)

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU). GCOS is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system. It addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.

GCOS does not itself directly make observations nor generate data products. It stimulates, encourages, coordinates and otherwise facilitates the taking of the needed observations by national or international organizations in support of their own requirements as well as of common goals. It provides an operational framework for integrating, and enhancing as needed, observational systems of participating countries and organizations into a comprehensive system focussed on the requirements for climate issues. GCOS builds upon, and works in partnership with, other existing and developing observing systems such as the Global Ocean Observing System, the Global Terrestrial Observing System, and the Global Observing System and Global Atmospheric Watch of the World Meteorological Organization.

The UNFCCC (United Nations Framework Convention on Climate Change) is the highest level political and diplomatic response by the international community to the need to try to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. A key commitment to which all parties agree is to "Promote and cooperate in ... systematic observation and development of data archives related to the climate system ...". GCOS is the recognised mechanism through which this will be achieved.

Possible Contribution of CLIWA-NET

One of the gaps in the Global Climate Observing System is the lack of reliable/systematic observations of clouds in general and more specifically, parameters like vertically integrated cloud liquid water (LWP). Cloud water/ice and its vertical structure are very important parameters, which link dynamics, water vapour, precipitation and radiation.

In the CLIWA-NET project it will be demonstrated that a cloud observing system based on the intelligent integration of existing ground-based observations and (operational) satellite remote sensing data will be able to fill this gap. In this way we will obtain a consistent, validated, high quality, high-resolution data set on integrated cloud liquid water fields and vertical structure of cloud water on a continental and regional scale.

The low-cost microwave radiometer, which design is included in CLIWA-NET bears the potential to be part of a future cloud observing system.

In the Netherlands Dr. Koos Verbeek acts as the national focal point for all GCOS activities. In the discussion with him on the relationship between GCOS and CLIWA-NET it was recognised that at this moment it is not clear how a three-year project like CLIWA-NET can contribute to a long-term program like GCOS. It was decided that Dr. Alan Thomas, director of GCOS, will be contacted to discuss this topic. This is of course also an issue for the other projects with the EU-5th framework topic on "European Component of Global Observing Systems".

A6.3 Discussion with Bertram Arbesser Rastburg and Nicola Floury, ESTEC

Areas of interest

Future satellite links will operate at frequencies above 30 GHz. This means that clouds will attenuate the signals and thus affect the quality of the link. Convective clouds and precipitation will extinguish the signal completely. For these clouds the frequency of occurrence needs to be known for large areas (typical size Europe) with a resolution of typically 500 km and long time series. There is an interest in the annual, seasonal and diurnal cycle.

Possible contributions of CLIWA-NET

Within the CNN network detailed cloud parameters at twelve stations distributed over central and North Europe are measured. For the Nordic part the precipitation fields from the BALTRAD network are available. This data will provide the necessary input for accurate attenuation calculations. The 4 months of continuous observations will provide information on the diurnal cycle. Some month to month variability might also be derived.

An important objective of the CLIWA-NET project will be the validation and further improvement of satellite retrieval algorithms (based on operational meteorological satellites). These improved algorithms may then be applied for areas larger than the present BALTEX modelling area. This will lead to a more reliable long term data base of cloud parameters needed for the attenuation calculations. This aspect is not part of the CLIWA-NET project but the results may be used for this.

At present a new technology is being developed. In case of strong attenuation at one site it is possible to redistribute the power from the satellite. More power is transmitted to areas with strong attenuation, less power goes to cloud free areas. This technique needs accurate attenuation forecasts which of course relies strongly on reliable cloud information. The parameter of interest is the total attenuation along the slant path of the satellite link.

One objective of CLIWA-NET is the evaluation and improvement of cloud parametrizations. The evaluation of four different operational weather forecast models will give an objective assessment of the quality of cloud forecasts. Based on these results one can judge whether the present day models have an adequate accuracy for use in an operational satellite “dynamic power adjustment” system.

[Note: need more information on required forecast time, resolution and accuracy]

There is also an interest in knowledge of the cloud field structures at smaller scales (typically 2 km). This is important for deciding on the ground station density for crucial data links. Interruption of these links by cloud or (convective) precipitation attenuation is not acceptable. Currently two receiving stations are located within a certain distance (typically 20 km). If one link is blocked the other station takes over. To optimise the distance between the station detailed information on the cloud statistics on small scales is needed (for different geographic locations).

The data from the BALTRAD weather radar systems give detailed information of spatial precipitation structures. The BALTRAD system covers most of Norway, Sweden, Finland and Denmark.

The BBC campaign will provide a high resolution data set on a area of typically 100x100 km² in the Netherlands.

In communication links scintillation phenomena are present. The strength of these scintillations increases with temperature and humidity. The present explanation is based on an interaction of radiowaves and turbulent eddies. These models have not been tested in detail with observations.

The BBC campaign will provide a detailed high resolution data set on cloud parameters and turbulence. The observed parameters would allow for a detailed evaluation of the present scintillation models. However, at this moment a beacon link set-up to measure the scintillation effects is not planned (e.g. ITALSAT or STENTAL satellite). We will investigate the possibility to include such a set-up in the experimental plan. Research groups within this research area will be contacted.

A6.4 Discussion with Frank Wouters, Ecofys, Cologne (Germany)

Areas of interest

1. Power management of an electric grid with a large fraction of photovoltaic systems
At present the base load of an electric grid is provided by constantly operating coal fired and nuclear power plants. These systems have a slow response time and operate around a constant output level. The peak power is provided by fast responding gas fired power plants. It is foreseen that in the future the burning of fossile energy carriers will decrease. The partition of weather dependent power systems like photovoltaic systems and wind turbines will increase. The necessary buffer will be provided by hydro power and biomass energy systems. At this moment it is not clear whether an electric grid with a large contribution of photovoltaic systems (e.g., 20%) can be operated stable and efficiently. An accurate, high-resolution cloud now-casting (about 15 min and 1 km) system may be needed to achieve this goal. With such a system one can predict the output power generated by the photovoltaic system and take necessary action on a grid level.

Possible contributions of CLIWA-NET

The evaluation of the different cloud parametrizations and forecast models within CLIWA-NET will provide an inside view on the accuracy of cloud forecasts. Here, the parameter of interest is the visible radiation at the surface. However, these kind of models do not meet the horizontal and spatial resolution required for this topic. The data from the BBC network will be used to evaluate the cloud forecast of the DWD-Lokalmodell which will be run for resolutions of up to 1 km. This evaluation might give an indication whether it is realistic to apply mesoscale NWP models for this line of work. Dedicated now-casting models might be more succesfull. Although it was not defined within CLIWA-NET it will be checked if the CLIWA-NET observations can be used to evaluate such a model (one is available at KNMI).

2. Climate control systems for large buildings
Modern climate control systems used for heating and cooling of large buildings have relatively slow response times. Modern heating and cooling systems have a high efficiency at small temperature differences (for which e.g. wall and floor heating needs to be installed). Future systems will have an even slower response time. Effective controlling of these systems will benefit from accurate cloud forecasts. The required forecast time is again on the order of 15 to 30 minutes.

Possible contributions of CLIWA-NET

The same contribution as mentioned above will be most relevant for this issue.

3. Fault detection in (large) solar photovoltaic systems
Accurate cloud data could be used in energy management systems for large solar photovoltaic systems. Various mechanisms can cause a system to perform under its maximum level: shading, clouds or a technical fault. Reliable insolation data could be used in an energy management system for such systems. Initial research has been done by the Fraunhofer-Gesellschaft, Freiburg, (<http://www.ise.fhg.de/Projects/Offnet/maint.html>) to use meteorological model fields for quality control. The estimated power generation estimated on the basis of

meteorological parameters is compared to the actually achieved one. This can be done on a daily basis.

Possible contributions of CLIWA-NET

CLIWA-NET will give insight view in the applicability of present NWP models for these studies. Also CLIWA-NET will give information on the representativeness of NWP model boxes for single points, and the desired horizontal resolution of the models.

A6.5 Discussion with Harald Neumann, Lufthansa Flight Training Center (LFT), Bremen (Germany)

Introduction

Icing conditions, eg. supercooled water layers or freezing rain, are a big hazard for air traffic. While commercial aircrafts are mostly equipped with de-icing systems only 1% of private planes contain these systems. Generally one can distinguish between thermal and mechanical de-icing, both requiring additional power. Jet engines operating at high (300-400 °C) can ventilate some hot air to melt away the ice from aircraft wings, while turbo props have to employ additional power to break away the ice. Due to this reason smaller aircrafts with not so much spare power and turbo props (e.g. City Hoppers) are more affected by icing conditions. This is especially true for overloaded, undermotorized military aircraft.

Areas of Interest

1. Icing forecast for flight planning

Lufthansa Flight Training Center is most interested in having forecasts for icing conditions available in the morning, covering the whole day and altitude levels up to 24,000 ft. Training flights could then be performed in low risk-areas. For commercial airtraffic, flight planning could be improved by forecasts covering 24 hours and altitude levels up to 45,000 ft. Ideally this forecast would be released as a function of the flight destination. Especially on northern bound routes up to 74 deg N (e.g., Frankfurt-Tokio with a path over Siberia or flights to North America), where icing condition can be present over long passages, efficient planing incorporates an accurate estimation on the inflight power consumption. Avoiding areas with icing conditions can significantly reduce the fuel consumption and lower the safety risk.

Possible contributions of CLIWA-NET

Within CLIWA-NET cloud parametrizations are evaluated. In most models a fixed temperature dependent ratio of ice and liquid water content is used. Cloud ice is not a prognostic variable. At this moment it is not clear if these models have any capability of forecast icing conditions at all. In a research version the LM has a prognostic ice phase. It will be interesting to keep the icing aspect in mind while the performance of this LM version is evaluated. We will study published literature on this topic

2. Icing forecast at airports

The starting and the landing phases of a flight are most pronounced to encounter icing conditions. Due to this problem chemical icing, which involves high cost and sometimes significant delays, often has to be applied before take-off. The presence of this icing conditions, however, is identified by pilot reports and not by an objective measurement system. The icing during takeoff can be so severe that events have been encountered that the available power was not enough to bring the aircraft higher than 4000 ft. Up to now aircrafts have to approach an airport always under the same angle (3 deg) and the same direction. It is foreseen that in the future this will change in order to increase the landing frequency. In this framework the landing and take-off direction could be adapted in order to avoid icing conditions.

Possible contributions of CLIWA-NET

The combination of microwave radiometers, lidar and radar will give a good possibility to detect super-cooled water layers in mixed phase clouds. One important question we will have to address is, if these super-cooled water layers are the only relevant icing conditions or that also other situations with significant icing might occur. It is at this moment not obvious that this question can be fully answered within the CLIWA-NET project.

3. Cold soak

The occurrence of rime on the aircraft frame is known as „cold soak“. During flight the metal frame of the aircraft cools down. When clouds are encountered during descent dew can build up and lead to rime especially on the aircrafts bellow. There are rules about the intensity of the cold soak, basically the readability of writings on the aircraft frame, which indicates when chemical de-icing has to be performed. It might in these cases be more efficient to fill up the aircraft with more fuel to increase the heat capacity.

Possible contributions of CLIWA-NET

Within the CLIWA-NET project the vertical structure and liquid water content of the clouds is accurately measured. This data can be used to estimate the probability of "cold soak" to occur.

4. Effective information distribution

To supply the pilots/dispatchers with the necessary information about the presence of icing conditions modern information distribution systems will be needed. This would employ a flight planning system, where only the destination and time of a flight should be needed as input, but also DATA LINK to provide commercial aircraft pilots during flight with upcoming dangers. For private pilots an icing forecast should be as easily available as a wind and sunset forecast.

Possible contributions of CLIWA-NET

This point is well recognised. The national meteorological institutes have a wide expertise in real time data dissemination techniques. This expertise can be used to address the above mentioned issue.

A6.6 Discussion with Jan Lonnqvist, Vaisala (Finland)

Introduction

Vaisala is the largest manufacturer of meteorological instruments in the world. They are world leader in the production of radiosondes. They are also manufacturer of the CT25K lidar ceilometer which is used at different stations in the CLIWA-NET network. The lidar ceilometer at the Helsinki station was on loan from Vaisala.

Areas of interest

1. Use of remote sensing instruments at airports

The supply of a full set of meteorological instruments to airports is a major business area for Vaisala. They are aware of the icing and visibility problems and the interest of airport authorities to look for solutions. At this moment there are no operational solutions to address the Icing Aloft problem

CLIWA-NET contribution

The approach within CLIWA-NET to combine lidar, radar and microwave radiometer for the detection of super cooled water layers is of interest to Vaisala. It is important to demonstrate and quantify the capability of this combined set of instruments to detect super cooled water layers. However, the emphasis within CLIWA-NET will be on the "the proof of principle". It is not planned to demonstrate the operational use of such a system.

2. Future operational use of remote sensing data by National Meteorological Services (NMS)

Together with the airports the National Meteorological Services (NMS) are the most important customers of Vaisala. Vaisala is very interested in (future) operational use of new instruments by the NMS. They want to closely monitor new developments. For example the operational use of microwave radiometers, a kind of instrument which is not yet in the product list of Vaisala, is of interest to them.

CLIWA-NET contribution

Within CLIWA-NET several NMS are involved directly (KNMI, SMHI, DWD and ECMWF) or indirectly (UKMO, Meteo France). This may give a detailed inside on the use of new remote sensing data by these services.

3. New applications of ceilometer use

Vaisala is one of the leading manufactures of lidar ceilometers in the world. At many CNN stations Vaisala ceilometers are used. Any new application of lidar ceilometers data is of interest of the company (e.g. observations at higher altitudes).

CLIWA-NET contribution

Because of the wide spread use of lidar ceilometers within the project, many scientists are working with the data. Vaisala will have an overview of any new applications of this data.

A6.7 Concluding Remarks

The discussions with the members of the User's Advisory Group (UAG) resulted in an extensive overview of possible applications of CLIWA-NET results. The list of potential applications is very diverse (and very challenging).

Some discussions with members of the UAG need a follow up. For example, the discussion of the relationship between CLIWA-NET and GCOS has not been answered satisfactory. This requires a follow-up in the next few months.

After this first inventory we will have to demonstrate within the project how realistic some of the applications are. This will require an extra effort from some of the participants. We hope we can present some results to the members of the UAG at the first plenary UAG-meeting (presently planned for September 2001). This will most likely lead to an updated/extended version of this User's Requirement Document.