CLIWA-NET User Requirement Document

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

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Contents

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 km^2) 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)

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".

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

Areas of interest

1. 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 then 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.

2. 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

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

3. 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 km^2 in the Netherlands.

4. 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 evalution 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.

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.

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 commercal 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 ^{o}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 occurence 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.

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.

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.