Radiation measurements during CLARE '98 : an overview


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Radiation measurements during CLARE’98: an overview

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Abstract
During CLARE’98 several radiometers were operated. In this paper an overview of the instruments operated by KNMI, TUE and TUD/IRCTR is given. This includes the net- and shortwave radiometers operated by KNMI and the sky temperature observations as measured by two IR-radiometers. One IR-radiometer was pointing vertically upwards, the second instrument was mounted in the 25m antenna dish of the Chilbolton radar. A 20/30/50 GHz microwave radiometer (20/30 GHz is on loan from ESTEC) was used to derive the column integrated liquid water and water vapour. Satellite data from the AVHRR instrument were collected and analysed. A time-lapse S-VHS video system was used to monitor the clouds at day-time.

All systems were continuously operational during the CLARE’98 campaign, except for the upward pointing IR-radiometer, no technical problems were encountered. Data has been collected, calibrated and submitted to the CLARE’98 database.

1. Introduction
The CLARE’98 campaign which took place in Chilbolton, aimed at the study of mixed phase clouds with advanced remote sensing instruments. At the experimental site in Chilbolton, a large set of instrumentation was installed and operated. Together with the observations taken from three aircraft, this resulted in a data-set which can be used for extensive further research.

In this paper the contributions to the CLARE’98 from different Dutch research groups (KNMI, TUE and TUD/IRCTR) are described. In section 2 the IR-radiometers are described and in section 3 the shortwave and longwave observations. The microwave radiometer is described in chapter 4. An overview of the satellite data is given in section 5. A description of the time-lapse S-VHS video system is given in section 6. In section 7 a discussion on the available data is given.

2. IR-radiometer
A narrow band infrared radiometer (type Heimann KT15.85A) is used. The wavelength range of the used infrared radiometer is 9.6-11.5 μm. The opening angle of the lens is 50 mrad. The measurement range of the sensor is between +50 and -53°C with a typical accuracy of 1-2°C To obtain this accuracy, the temperature of the IR-radiometers housing is stabilized at 35°C. A precipitation detector controls the cover to shield the sensor. If precipitation is detected, the cover is closed. In this way the instrument is protected against rain. The data-acquisition is incorporated in the housing. Data is stored on memory cards. So, the instrument is completely stand-alone. Only 220V power has to be supplied. In order to limit the amount of stored data the histogram of observed temperatures within a 10-minute period is characterized by only a few
numbers. Every 10 minutes the following characteristics of the measured sky temperature, $T_{\text{sky}}$, are collected:

- $T_{\text{ave}}$, average sky temperature of the 10-minute period,
- $T_{\text{max}}$, maximum sky temperature in the 10-minute period,
- $\tau_{\text{max}}$, fraction of time that $T_{\text{max}} - 5^\circ\text{C} < T_{\text{sky}} < T_{\text{max}}$,
- $T_{\text{min}}$, minimum sky temperature in the 10-minute period,
- $\tau_{\text{min}}$, fraction of time that $T_{\text{min}} < T_{\text{sky}} < T_{\text{min}} + 5^\circ\text{C}$.

The sensitivity of $-50^\circ\text{C}$ limits the maximum height for the detection of optically thick clouds to a range of 8-10 km. In the case of thin clouds this maximum height is decreased significantly. So, it is important to realize that, high thin Cirrus clouds could be undetected.

During CLARE’98 two IR-radiometers were installed. The instrument on the roof of the workshop was pointing in the vertical direction. The data was written to the memory card every 10 minutes. In the period from 7-15 October, the instrument was operated continuously. After that an error in the data acquisition occurred and all data was lost.
Figure XX. Sky temperatures as observed by the two IR-radiometers. The drawn line without symbols is the data from the IR-radiometer mounted on the antenna. The lines with the symbols are the observations from the vertically pointing IR radiometer: minimum (triangle), average (circles) and maximum (square).

The second IR-radiometer was mounted in the 25m antenna of the 3 GHz radar (see FigureXX). Every 2 seconds data was stored on the data disk. Due to the limited storage capacity of the data disks approx. 9 hours of data could be stored on one disk. Before the aircraft took off, the system was switched on. Data was taken for the flights on October 7, 13, 14, 16 and 22.

In Figure XX results from October 13 are shown. In the data from the IR-radiometer mounted on the antenna the detailed structure is visible. This is the effect of the scanning of the antenna on the IR-radiometer. When the antenna is looking upward the contribution of the relatively “warm” atmosphere is minimal. When the antenna is oriented in any other direction the path through the atmosphere increases. This results in higher sky temperature. For comparison the 10-minute average, minimum and maximum sky temperatures of the IR –radiometer at the top of the roof is plotted in the same figure. There is a good agreement between the absolute values of the two IR-radiometers.

3. **Shortwave and Net-radiometer**
Both short-wave (SW) and long –wave (LW) were recorded for the duration of the campaign. SW radiation was measured with two Kipp CM-11 pyranometers; one up- and one downward looking.
Figure XX. Observed (drawn line) net SW and net LW fluxes at the surface for October 13, 1998. The dashed lines are the results from the ECMWF model.

The NET LW radiation was calculated from the net radiation measurements of a Schulze dual-dome radiometer and the SW observations. Data was recorded with a Campbell 21X datalogger. 10 Minute averages are available.

In Figure XX the observed net SW and net LW fluxes at the surface are presented for October 13. Also the ECMWF forecasted fluxes are shown for the grid point closest to Chilbolton. In general there is a good agreement between the observations and the ECMWF model results.

The same quantities are shown for October 20, in Figure XX. In this case the agreement is much worse. In both the net SW and net LW differences of 50 W/m² or more occur frequently. Apparently the ECMWF model had problems with forecasting the correct cloud situation.
4. **Microwave radiometer**

The microwave radiometer is composed of an antenna, a receiver, a positioner and a PC computer. Brightness temperature measurements are taken at the following frequencies 21.3/31.7/51.25/53.85/54.85 GHz. Regular tip curve calibrations were taken during the campaign. From the observations column integrated water vapour (V), liquid water path (L) and temperature information for the lower part of the atmosphere can be derived.

For V- and L-retrieval, two kind of algorithms have been used: linear models and a non linear model called the Matched Atmosphere Algorithm (MAA). Linear algorithms assume a linear relation between the attenuation or a L invariant parameter and V and L. A disadvantage of these algorithms is that they are time- and space independent. Constants for one site can be determined by calculating brightness temperatures (T_b) -, and V- and L values from a large set of radiosonde profiles and use these to derive the relationship (constants) between V and L. For CLARE’98 the linear algorithm has been used to process the data with typical “mid-latitude” constants. This approach may cause the L to become negative in certain cases.

![Image](XX.png)

*Figure XX. The microwave radiometer at the Chilbolton site*

5. **Satellite observations**

It was planned to archive the NOAA/AVHRR images, which included Chilbolton. However, due to technical problems at the receiving station at De Bilt, data was lost. To account for this loss data was retrieved from the data centre in Dundee. The satellite data from the overpasses which (more or less) coincide with the “high priority cases”, are now available for analysis. The data for all spectral channels was collected.

A derivative of the AVHRR Processing scheme Over cLouds, Land and Ocean (APOLLO) is used for detection of cloud contamination and fully cloudy pixels from AVHRR measurements [Saunders, 1986; Saunders and Kriebel, 1988]. Cloud properties that are retrieved using modified APOLLO extensions are: cloud cover, cloud top temperature, reflectivity, optical thickness, IR-emissivity and ice-detection.
As an example part of the satellite image for October 20 is shown in Figure XX. Chilbolton is in the center of the encircled area. For the pixels inside this area an analysis based on the APOLLO scheme was performed. In Figure XXb) the channel 4 cloud top temperature is plotted against the derived optical depth. The correlation between the two is clear, indicating the presence of a semi-transparent Cirrus cloud with a cloud top temperature of approx. 207 K.

Figure XX. AVHRR image of the area around Chilbolton for October 20 (14:20 UTC). Chilbolton is located in the encircled area. The pixels within the circle are used to generate the right hand figure: channel 4 cloud top temperature versus the derived optical depth.

6. The Timelapse S-VHS Video system

During the campaign, a cloud video tape is made with a S-VHS time lapse recorder. The view reaches from the western horizon to near zenith. (Opening angle lens: Vert.; 88 degrees, Hor.; 107 degrees). Every 3.2 seconds an image was stored on the tape. The tapes are mainly used as a visual archive of the actual sky situation.

For the CLARE data-base six MPEG video movies were made from this tape for the chosen priority legs. Each 1.5 minute MPEG-movie shows 4 hours of time lapsed video recording; approximately 2 hours before and 2 hours after aircraft passed overhead.

Figure XX. Snapshot of the VHS cloud video system for October 13, 14:08 UTC.
7. Concluding remarks
During the CLARE’98 campaign an extensive set of instrumentation was employed. In this paper we have described the instruments operated by several Dutch research institutes/universities. Most of the instrumentation operated without any technical problems during the campaign. The data has been calibrated and submitted to the CLARE’98 ftp site.

At present the data is intensively used for further research on sensor synergy algorithms and validation of satellite retrieval algorithms.

References