Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

40 Years Cabauw Observatory

1972 - 2012

10 highlights

16 NOV. 1970

unieke meetmast
voor knmi

KONINKLIJK NEDERLANDS
DE BILT
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verkeer en waterstaat
afd.voorlichting
plesmanweg 1_6 tel.070_624321 XVIII.e.20. D14

Preface

With the construction in 1972 of a 213 m high measuring tower near the village of Cabauw, KNMI realised a unique project. Building on the experience obtained between 1966 and 1973 through the operation of an 80 m mast near Vlaardingen, the aim was to facilitate and stimulate atmospheric research on the transport of air pollution. The first continuous measuring programme started on October 26, 1972. With the 27 measuring channels available, the mean vertical profiles of wind, temperature and visibility, as well as global radiation and the radiation balance were recorded every 2 minutes on paper tape.

Over the past 40 years improved and new instruments have been installed, digital data registration techniques rapidly were developed, and various remote sensing techniques were introduced, allowing for a variety of new and challenging research topics. Over the years cooperation with other research institutes and with universities in the Netherlands at the site has grown. In 2002 this led to the establishment of CESAR, the Cabauw Experimental Site for Atmospheric Research. It now hosts a suite of instruments to study the entire atmospheric column and its interaction with the land surface. Having developed into an internationally reputed high quality observatory, CESAR now plays a key-role in a number of international research networks and programmes on regional and global scale.

Apart from some technical revisions of the infrastructure, observations have been carried out on a near continuous basis, leading to rich databases allowing for research on a variety of weather conditions and climate. During a number of shorter campaigns, additional observations were carried out with research grade instruments. A substantial number of publications, often in collaboration with researchers in and outside the Netherlands came directly out of these efforts. Several of these publications have become milestones in atmospheric research.

On October 26, 2012, we celebrated the 40 year jubilee of the Cabauw Observatory. The programme is printed in this brochure. For the celebration 10 posters were designed that show some highlights of these 40 years. They are also presented in this brochure. For more information and photographs, visit http://www.cesar-observatory.nl/cabauw40/.

Dr. Roeland van Oss*, Head Regional Climate Department*

Programme

9:00	Welcome
9:30	Symposium • Opening by Dr. Ir. F.J.J. Brouwer (Director General of KNMI) • Dr. Roeland van Oss, 40 years Cabauw (KNMI) • Prof. Dr. Ir. Herman Russchenberg (Technical University of Delft, Climate Institute, Chair of CESAR) • Dr. Franz Berger (Director of Richard Aßmann Observatory, Lindenberg, Germany) • Prof. Dr. Susanne Crewell (University Cologne, Germany) • Prof. Dr. Tom Ackermann (University Washington, USA) • Prof. Dr. Anthony Illingworth (University Reading, UK)
12:00	Discussion session, chaired by Prof. Dr. Pier Siebesma (KNMI, TU-Delft)
12:45	Lunch
13:30	Site-seeing: energy balance terrain, remote sensing site, BSRN station and gasses/aerosols measurements
16:00	Drinks

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Start in the nineteen seventies building the mast

With the building of a 200 m high measuring tower, KNMI realises a unique project aiming at research on the spreading of pollution in the atmosphere (Ministry for Transport, Public Works and Water Management, November 1970). The experience obtained through the operation of an 80 m mast near Vlaardingen from 1966 to 1973 has been useful towards the design of the mast at Cabauw. In the 40 years since the instrumentation evolved, and the observatory was used for a variety of atmospheric research topics.

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Close to the ground the building below the mast would disturb measurements. Therefore a 10 m and 20 m side mast were erected for observations below 20 m. Photo J.G. van der Vliet, August 1973.

Prefabricated steel cylinders with a diameter of 2 m were mounted on top of each other, until the height of 213 m was reached. At 20 m intervals, three 9.4 m long horizontal booms were mounted on which measuring instruments can be placed. The booms can be swivelled upwards to allow for the replacement of instruments from a higher platform. The mast is guyed at four levels. Photo P.J. Rijkoort, around 1970.

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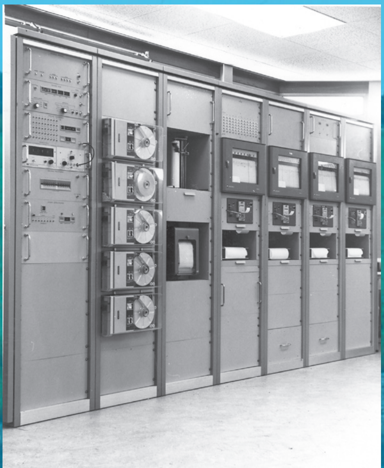
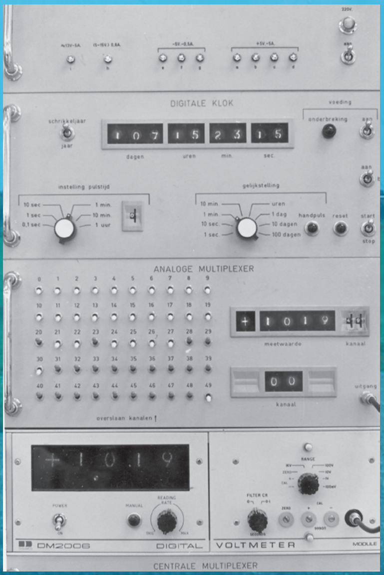
Start in the nineteen seventies instrumentation and data registration

At the start of the observations, mean vertical profiles of wind and temperature were measured. To that end, wind vanes and cup anemometers were installed at 10, 80 and 200 m, and psychrometers, measuring vertical temperature differences with thermocouples, at 2, 9, 20, 40, 80 120, 160 and 200 m. Visibility was measured at 1, 5, 20, 40, 60, 100, 140 and 180 m. Global radiation and the radiation balance were also recorded. At a later stage, additional instruments were added, e.g. to measure a humidity profile. In addition to the continuous programme measuring the structure of the boundary layer, special instruments can be installed for more detailed experiments. Reference: A.P. van Ulden, J.G. van der Vliet and J. Wieringa, Temperature and wind observations at heights from 2 m to 200 m at Cabauw in 1973. KNMI Scientific Report WR 76-7, 1976.

Wind vane and cup anemometer.
Photo J.G. Van der Vliet, August 1973.



In the pre-digital period data acquisition was realised with paper tape and analogue recorders.
Photo J.G. van der Vliet, August 1973.



A digital clock and an analogue multiplexer were used to sample the various measuring instruments. Note the switch for leap-years. At the start of the observations 27 channels were recorded every 2 minutes.
Photo J.G. Van der Vliet, September 1976.

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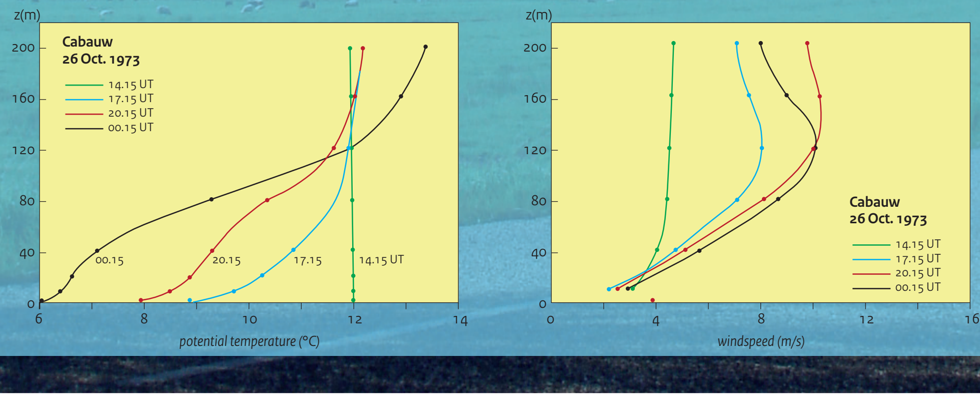
In-situ instruments; first results

To realise high precision measurements, several instruments were developed and built at KNMI, because they were not available on the market.

To measure turbulence the so-called bivane (also called trivane) was developed. It could rotate along a vertical and a horizontal axis and was equipped with a propeller. Together with a fast response dry- and wetbulb thermometer the vertical fluxes of momentum, sensible heat and evaporation could be derived. These instruments were only installed for special campaigns.
Photo May 1978.

Ventilated and shielded psychrometers to measure the vertical gradients of dry- and wetbulb temperature with Cu/Co thermocouples. They were also installed along the mast to observe vertical profiles. Photos 1975.

Transmissometer to measure visibility. Some instruments were also installed along the mast to measure the vertical profile of visibility. Photo November 1975.



Example of the diurnal cycle of the vertical profiles of wind and potential temperature, showing the development of a low level jet at 120 *m altitude. From A.P. van Ulden and J. Wieringa, Atmospheric Boundary Layer Research at Cabauw. Boundary-Layer Meteorology,* 78, 39-96, 1996.

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The continuous measuring programme 1986 - 1996

After revisions of the instrumentation and the data-registration, a continuous measuring programme was started in 1986. Its aim was to provide a database for boundary layer research and the validation of parameterizations. The programme included mean profiles of atmospheric parameters, soil parameters, radiation and surface fluxes. See table 1. Figures 1, 2 and 3 show some of the instruments. Moreover, the data were transmitted in real time to KNMI in De Bilt to support daily weather forecasting. The programme was run until 1996, when a major revision of the Cabauw facilities started. Reference: W.A.A. Monna and J.G. van der Vliet, Facilities for research and weather observations on the 213 m tower at Cabauw and at remote locations. KNMI Scientific Report WR 87-5, 1987.

An example of the use of the database is the PILPS project. In the Project for Intercomparison of Land-Surface Parameterization Schemes, Cabauw data for the year 1987 were used as inputs to 23 land-surface flux schemes designed for use in climate and weather models. These schemes were evaluated by comparing their outputs with long-term measurements of surface sensible heat fluxes into the atmosphere and the ground, and of upward longwave radiation and total net radiative fluxes, and also comparing them with latent heat fluxes derived from a surface energy balance. Analyses of the experimental results were focused on the energy budget, the water budget, and their linkage. the differences in experimental results among the land-surface schemes and observations were found to be significant (Figure 4). T.H. Chen et al., Cabauw Experimental Results from the Project for Intercomparison of Land-Surface Parameterization Schemes. J. Climate, 10, 1194-1215, 1997.

Z (m)	T	T_w	W	V	Q_1	Q_2	G
214					X		
200	X	X	X				
180				X			
140	X	X	X	X			
80	X	X	X				
60				X			
40	X	X	X				
20	X	X	X	X			
10	X	X	X	X			
2	X	X		X	X	X	
0.6	X	X					
0.0	X						
-0.02	X						
-0.05							X
-0.10							X

Table 1. *Mean vertical profile measurements of:*
dry-bulb temperature (T)
wet-bulb temperature (T_w)
wind speed and direction (W)
horizontal visibility (V)
shortwave radiation (Q_1)
shortwave shadowband, net, longwave up and down radiation (Q_2)
soil heat flux (G)

Figure 1. *Gill propeller vane 8002DX to measure wind speed and direction.*

Figure 2. *Eppley radiometers, measuring longwave upward and downward radiation.*

Figure 3. *The mixing height is monitored by a monostatic acoustic sounder from Aerovironment.*

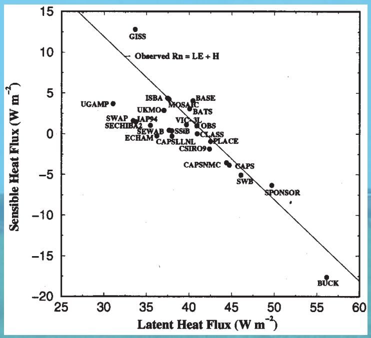

Figure 4. *Annually averaged sensible and latent heat fluxes are plotted for all models. Also shown is the corresponding observed value. The solid line represents points with the same net radiation as observed. Models show a substantial spread among the observational point. Some models are close to the solid line, which indicates that their net radiation is close to the observed value and only the partitioning over latent and sensible heat deviate from the observed partitioning.*

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Cabauw Experimental site for Atmospheric Research - A "Field Laboratory"

CESAR (Cabauw Experimental Site for Atmospheric Research), established in 2002, is an advanced atmospheric observatory. It hosts a suite of instruments to study the atmospheric column and its interaction with the land surface. With four major research institutes (KNMI, RIVM, ECN, TNO), three universities (Delft, Wageningen, Utrecht) and one European institute (ESA) collaborating in CESAR, it is the focal point of experimental atmospheric research in the Netherlands.

CESAR data are used for a wide range of applications, e.g.:

- Monitoring of long term tendencies of climate variables in the atmosphere
- Validation of space-borne observations and retrieval products
- Studies of atmospheric and land surface processes for climate and air quality modelling
- Evaluation of weather, climate and air quality models
- The development, implementation and assessment of new measurement techniques
- Training of young scientists at post-doc, PhD and master level.

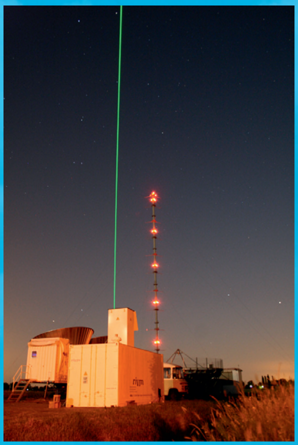

The Remote Sensing site hosts radars, lidars and microware radiometers


Part of the setup for measurement of the energy balance


The BSRN Site radiation sensors

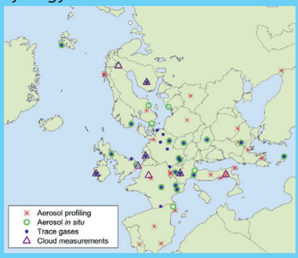

In-situ Air Quality monitors


The drizzle surveilance radar IDRA on top of the tower


The Raman lidar CAELI at night

CESAR – *National and International Collaboration*

Monitoring of essential climate variables and long range transport phenomena benefits from organisation in observational networks. CESAR is part of a range of networks. This enables synergy between the networks and stimulates collaboration.



A map of Europe showing monitoring locations for various atmospheric parameters in different networks. Note that Cabauw is one of the few locations where many networks coincide.

Acronym	Since	Organisation	Description
CWINDE	1999	COST/EUMETNET	The Co-Ordinated Wind Profiler Network in Europe
CLOUDNET	2001	EU	Development of a European pilot network for observing cloud profiles
CEOP	2003	GEWEX	Coordinated Energy and Water Cycle Observation Project
CARBOEUROPE	2004	EU	GHG surface flux network
EARLINET	2004	EU	European Aerosol Research Lidar Network
EMEP	2005	CLTAP*	Aerosol chemistry (station nr NL11)
BSRN	2005	GEWEX	Baseline Surface Radiation Network
AERONET	2006	NASA	Aerosol retrieval through sun photometers
NITROEUROPE	2006	EU	Nitrogen concentration network
IMECC	2006	EU	Near-Real-Time CO2 network
GEOMON	2006	EU/GEOSS	CO2 and CH4 surface obs. network
GRUAN	Proposed	WMO-GCOS	GCOS reference upper-air network
GAW		WMO	Monitoring of trace atmospheric constituents
ACTRIS	2011	EU	Aerosols, Clouds, and Trace gases Research InfraStructure Network

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TUDelft

ECN

National Institute for Public Health
and the Environment
Ministry of Heatth, Welfare and Sport

TNO

esa

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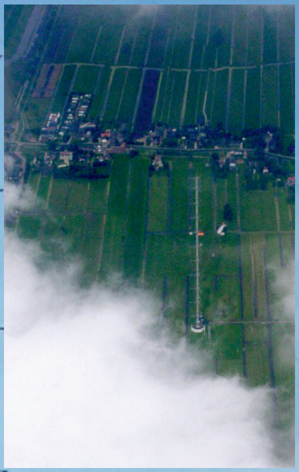
International Campaigns

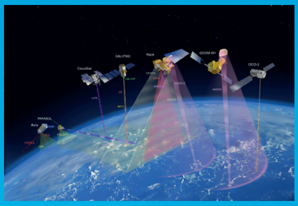
In the past ten years a range of campaigns was hosted at CESAR, or CESAR participated as a main station.

Campaign topics ranged from cloud macro-and microphysics with remote sensing and airborne in-situ sensors, to satellite validation with ground based remote sensing and balloon borne instrumentation.
The suite of instruments installed at Cabauw is at the basis of the design of the campaigns. Additional instruments are temporarily placed at the site. During a number of campaigns, research aircraft were used to overfly the Cabauw site.
Through various EU funded projects, CESAR offers trans-national access to visiting scientists to perform experiments in Cabauw.



Aerial view of the Cabauw site during BBC, 2001

Research aircraft at Rotterdam Airport during BBC, 2001



The top figure shows the A-train satellite formation. A numer of campaigns were conducted at Cabauw to validate and use data from those satellites. (DANDILIONS, ESA-CALIPSO, CINDI).
The middle picture shows the first launch of a sonde for nitrogen dioxide measurements that was developed at KNMI for validation of AURA/OMI air quality products. (DANDILIONS, 2006).
The photo at the bottom shows a researcher adjusting a MAX-DOAS instrument during CINDI, 2009.
The background picture shows the Zeppelin flying around the tower during PEGASOS, 2012.

Acronym	*Description*	*Year*
TEBEX	Tropospheric Energy Budget Experiment	1995
CLARA	Cloud macro- and microphysics	1996
CaPRIX	Test of VHF/UHF boundary layer windprofiler	2000
CNN-I	Cloud macro- and microphysics	2000
CNN-II	Cloud macro- and microphysics	2001
BBC	Cloud macro- and microphysics	2001
CREX-02	Small scale structure of rain	2002
BBC2	Cloud macro- and microphysics	2003
DANDELIONS	Aerosol and Nitrogen Dioxide OMI and Sciamachy	2005
SPE	Sound Propagation experiment	2005
DANDELIONS	Aerosol and Nitrogen Dioxide OMI and Sciamachy	2006
EAGLE	Land surface remote sensing	2006
SatLink	Linking Satellite Observations of Aerosol Optical Depth with Ground Level Observations of Particulate Matter (SATLINK)	2006
EMEP	Highly time resolved measurements of inorganic gases and aerosols	2006-2008
GOP	Quantitative Precipitation Forecasting	2007
EUCAARI-IMPACT	Cloud aerosol interaction	2008
ESA-CALIPSO	NASA/CNES Cloud Aerosol Lidar with Orthogonal Polarisation (CALIOP) correlative measurements	2009
CINDI	Cabauw Intercomparison of Nitrogen Dioxide measuring Instruments	2009
CLIC	Cabauw Lightmeter Intercomparison	2012
PEGASOS	Pan-European Gas-Aerosols-Climate interaction Study	2012

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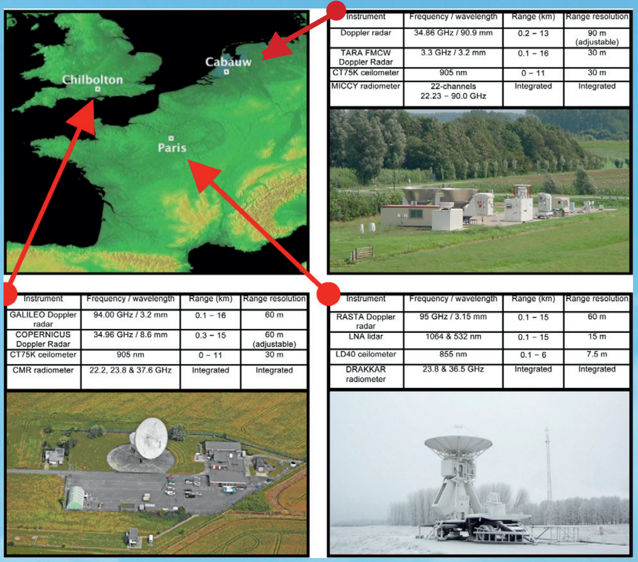
International cooperation; Cabauw, Palaiseau (France) and Chilbolton (UK)

Cloudnet; Development of a European pilot network of stations for observing cloud profiles. Cloud fraction, liquid and ice water contents derived from long-term radar, lidar, and microwave radiometer data in the period 2001-2004 at three observing stations are systematically compared to seven models to quantify and improve their performance. See also www.cloud-net.org/



Instrument	Frequency / wavelength	Range (km)	Range resolution
Doppler radar	34.86 GHz / 90.9 mm	0.2 – 13	90 m (adjustable)
TARA FMCW Doppler Radar	3.3 GHz / 3.2 mm	0.1 – 16	30 m
CT75K ceilometer	905 nm	0 – 11	30 m
MICCY radiometer	22-channels 22.23 – 90.0 GHz	Integrated	Integrated

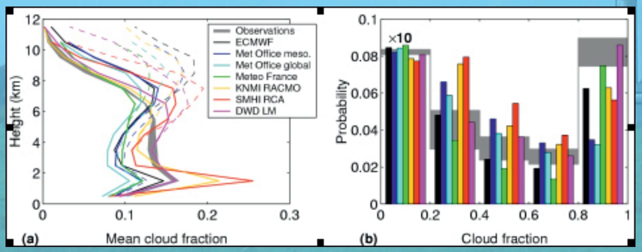
Instrument	Frequency / wavelength	Range (km)	Range resolution
GALILEO Doppler radar	94.00 GHz / 3.2 mm	0.1 – 16	60 m
COPERNICUS Doppler Radar	34.96 GHz / 8.6 mm	0.3 – 15	60 m (adjustable)
CT75K ceilometer	905 nm	0 – 11	30 m
CMR radiometer	22.2, 23.8 & 37.6 GHz	Integrated	Integrated

Instrument	Frequency / wavelength	Range (km)	Range resolution
RASTA Doppler radar	95 GHz / 3.15 mm	0.1 – 15	60 m
LNA lidar	1064 & 532 nm	0.1 – 15	15 m
LD40 ceilometer	855 nm	0.1 – 6	7.5 m
DRAKKAR radiometer	23.8 & 36.5 GHz	Integrated	Integrated

The three Cloudnet observing stations are equipped with a large suite of active and passive remote sensing instruments accompanied by standard meteorological instruments. Common instruments at each site were a Doppler cloud radar, a near-IR lidar ceilometer, and a dual-wavelength microwave radiometer. The radar–ceilometer synergy combined with model temperature profiles are used to identify the presence of cloud and its phase.
The observations at Cabauw, in cooperation with TU Delft, were augmented with 3-GHz Doppler radar measurements for better IWC and particle size retrievals. Palaiseau observations included additional cloud–aerosol depolarization lidar measurements for better characterization of high-altitude ice cloud properties. The Chilbolton 3-GHz radar provided calibration for all other radars in the project.

Vaisala CT75K ceilometer at Cabauw. Photo J. Warmer, November 2010.

The KNMI 35 GHz cloud doppler radar. Photo M. Brinkenberg, June 2010.



(a) Mean cloud fraction over the three sites for 2004 from the observations and the seven models, among which the KNMI model RACMO. The thick solid lines show the model after filtering to remove ice clouds too tenuous for the radar to detect. The thin dashed lines are for all model clouds.

(b) Corresponding histogram of observed and filtered model cloud fraction for clouds below 7 km.

Efforts to improve clouds in forecast models have been hampered by the difficulty of making accurate observations. The Cloudnet project has shown that continuous profiles of cloud fraction, liquid water content, and ice water content can be inferred reliably from a set of ground-based instruments comprising a cloud radar, a ceilometer, and a microwave radiometer. From A.J. Illingworth et al., CLOUDNET, Continuous Evaluation of Cloud Profiles in Seven Operational Models Using Ground-Based Observations. Bull. Amer. Meteor. Soc., 883-898, 2007.

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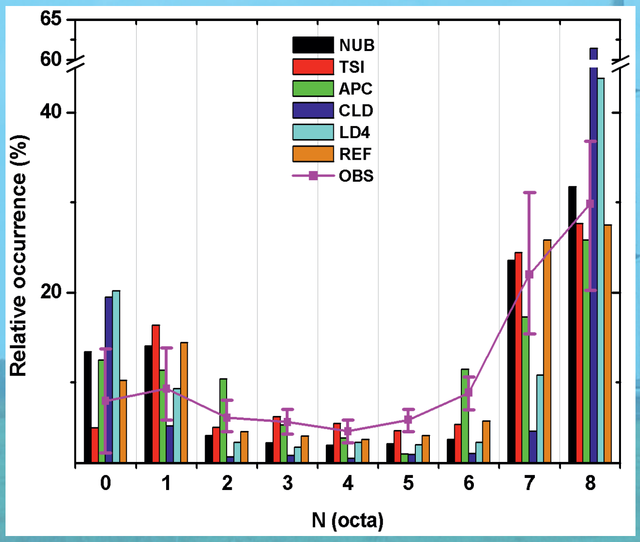
Automatic determination of cloud cover

In the last 20 years a number of instruments have been developed to determine cloud cover. The question is which instruments and techniques would best be able to replace the Human Observer. Five different ground-based remote sensing instruments operated at CESAR were used to observe fractional cloudiness. Three hemispheric (passive) methods observe the entire sky, while two (active) column methods only observe a small portion of the sky directly overhead. The outputs were compared against the (1971–2000) climatological record from the human observer at De Bilt and Rotterdam airport. A reference algorithm is used to reflect the combined performance of the five instruments.



Cloud fraction histogram for all instruments and the reference algorithm. The Observer data combined from Rotterdam and De Bilt are shown in the purple line with error bar. The error bar denotes the absolute maximum and absolute minimum values for the last 30 year climate record (1971–2000). NUB, NubiScope; TSI, Total Sky Imager; APC, Pyrgeometer algorithm; CLD Cloud radar – Cloud Lidar combination; LD4, Cloud Lidar; REF, reference; and OBS, Observer.

Columnar instruments

Cloud Radar (35 GHz), used in combination with the Lidar.

Cloud Lidars LD 40 and CT75K (shown), detecting cloud base hight.

Hemispheric instruments

NubiScope, an infrared pyrometer, scanning the whole hemisphere.

Total Sky Imager, a digital camera.

Pyrgeometer, observing global downward radiation, fed into an algorithm to estimate cloud cover.

The passive instruments, especially the NubiScope, are best able to reproduce the observations of the Human Observer. The NubiScope scans the entire sky every 6 minutes and registers the infrared radiation emanating from each point of the sky. From these observations cloud cover values can be calculated. However, the disadvantage of this instrument is that the altitude of the cloud is never exactly known. It is therefore suggested to investigate whether a combination of a hemispheric method such as the NubiScope with a column method such as the LD40 on the scanning platform of the NubiScope could determine both cloud cover and cloud base altitude. Reference: R. Boers et all., Optimized fractional cloudiness determination from five ground-based remote sensing techniques. J. Geophys. Res., 115, 2010, D24116, doi:10.1029/2010JD014661. 2010

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How to close the surface energy budget at cesar

Closing the surface energy budget (SEB) is one of the longest outstanding problems in micro-meteorology. At the earth's surface the net radiation (QN) should be balanced by the transport of heat into the soil (G) and to the atmosphere in the form of sensible (H) and latent heat (LE):

$$QN = H + LE + G$$

Many field studies report a significant imbalance in the SEB with almost always more net radiation than total heat flux (Figure 1). Over the years observational techniques have improved and the conclusion is widely accepted that in general the observed imbalance is significantly larger then the estimated measurement error, which points to a fundamental problem in our understanding of surface fluxes and how to measure them.

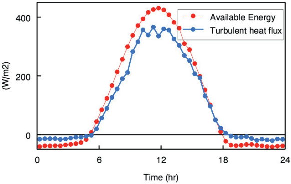

***Figure 1**. Typical clear sky day at Cabauw. The turbulent heat flux H+LE is smaller than the available energy Q_n-G.*

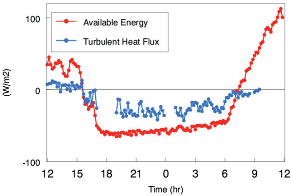

***Figure 2**. A night with snow cover, showing that the turbulent heatflux is smaller than the available energy Q_n. The soil heatflux can be neglected due to the thermal isolation of the snow cover.*

Radiation

Independent radiation transport models confirm the adequate accuracy of current state-of-the-art instruments as they are nowadays employed at the sites of the Baseline Surface Radiation Network of which Cabauw is one station.

Soil heat flux

If the soil heat flux at Cabauw for some reason would be underestimated by a factor of two, a large part of the SEB problem would disappear. However, occasional observations with a snow cover at Cabauw reveal that the problem in SEB-closure remains (Figure 2). This despite the very small soil heat fluxes and thus very small absolute errors in soil heat flux during snow cover. This shows that problems in soil heat flux observations alone cannot explain the observed SEB-imbalance.

Turbulent fluxes.

The observation of the turbulent heat flux requires instruments that resolve atmospheric fluctuations on time scales of 0.1 s and spatial scales of 0.1 m (figure 3). A number of corrections to arrive at the actual flux have to be applied, most of them well established, some of them less so. Especially contribution on the larger scale (> boundary layer height) are not measured with the eddy-correlation method and estimates of this contribution are uncertain.

Surface topography

Unclear at this stage is the role of ditches which cover approximately 10% of the surface at Cabauw, which always will give significant temperature contrasts at the surface. This can be the cause of secondary circulations. Night time secondary circulation may be important.

***Figure 3**. Sonic anemometer Gill R3 and Licor 7500 open path H2O sensor..*

At this stage the problem of the SEB-closure remains unsolved. Night- and day-time situations may have different problems. The night-time secondary circulation caused by ditches may be important. Analysis of night-time flow visualisation (with Delft University) is planned. From F.C. Bosveld, Update on Surface Energy Budget closure at CESAR. EMS, Łódź , Poland, 13 Sept. 2012.

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Observations of volcanic ash during the 2010 eruptions of Eyjafjallajökull

From 6 – 10 April 2010 a series of eruptons at Eyjafjallajökull caused enormous disruption of air traffic across western and northern Europe. The need for observations of the extent and properties of the volcanic ash was urgent. Two lidars at Cabauw, type: UV and Raman, played an important role in providing information on the vertical extent and concentration of the volcanic ash.

UV-lidar observations

Ash of the Eyjafjallajökull volcano was transported towards NW Europe over the Atlantic Ocean and North Sea because of prevailing NW winds (Figure 1).

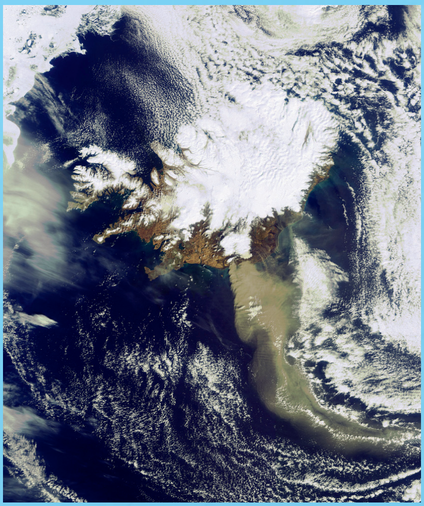

***Figure 1**. Medium Resolution Imaging Spectrometer (MERIS) image of Iceland showing the volcanic ash plume on 19 April 2010.*
Courtesy: European Space Agency.

First signs of the presence of volcanic ash over Cabauw were obtained from routine observations made by our UV lidar – a polarization sensitive backscatter lidar – on 16 April 2010.

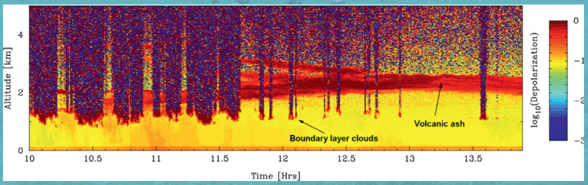

***Figure 2**. Degree of depolarization derived from the UV lidar in Cabauw on 16 April 2010. The red band indicates high degrees of depolarization which are caused by the highly irregular ash particles originating from the Eyjafjallajökull volcano. Before noon, boundary layer clouds block the lidar signal frequently.*

Figure 2 shows vertical slices of the depolarization ratio up to an altitude of 5 km. Strong signals of depolarization indicate the presence of irregularly-shaped particles, in this particular case: ash originating from the Icelandic volcano.

The relation between particle irregularity and degree of depolarization is illustrated in Figure 3.

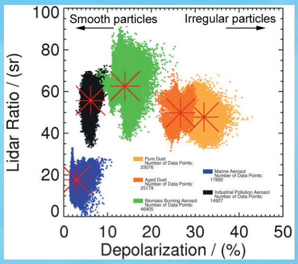

***Figure 3**. Lidar ratio as a function of degree of depolarization for spherically-shaped particles (left: industrial pollution aerosol) and irregular particles (right: pure dust). Aerosol classification from DLR airborne HSRL data.*

Raman-lidar observations

The manually operated multi-wavelength Raman lidar system (CAELI) also provided valuable information on the ash plume (Figure 4), in even greater detail than the UV lidar.

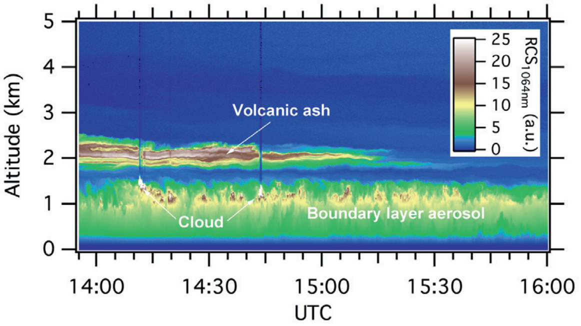

***Figure 4**. Backscatter signals derived from the Raman lidar system (CAELI) in Cabauw on 16 April 2010. The brown band indicates the presence of ash particles originating from the Eyjafjallajökull volcano. Below the volcanic ash, regular boundary layer aerosol is present, together with occasional clouds.*

Algorithm development

Data from both systems (UV and Raman) were used to produce quantitative estimates of ash concentration. In response to the demand for rapid estimates of ash concentration an experimental rapid and automated processing system was implemented for the automated UV lidar. In case of another eruption, the lidar observations made in Cabauw will provide near-real time quantitative information on the volcanic ash, which is extremely relevant for decision-making related to air traffic.

Colofon

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