CDS Dataset Description Document

“nubiscope 2dcloudmask la1, v1.0”

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Document Status

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1. General Overview

This document describes the CDS dataset *'cesar_nubiscope_2dcloudmask_la1_t10'*. Data in this CDS dataset are collected with a scanning pyrometer, called NubiScope [Möller and Sattler, 2007], which permanently located at Cabauw Experimental Site for Atmospheric Research (CESAR) [http://www.cesar-observatory.nl]. The NubiScope is owned and operated by the Royal Netherlands Meteorological Institute (KNMI).

The NubiScope is a passive remote sensing instrument which measures the sky temperature in the 8-14 μm thermal infrared atmospheric window. The presence of clouds is determined from the sky temperatures. Since the NubiScope operates in the thermal infrared and scans the entire sky the cloudiness can be obtained 24 hours a day and includes spatial information on the distribution of clouds over the sky.

The NubiScope operates fully automated and performs a scan of the entire hemisphere every 10 minutes. The scan itself takes about 6½ minutes and a new scan is started at every full 10 minute period, i.e. hh:00, hh:10, …etc.. The NubiScope measures the sky temperature at 36 azimuth and 30 zenith angles.

In addition the NubiScope also measures 2 surface temperatures at a nadir angle of 45° in the East and West direction respectively.

The NubiScope uses the brightness temperatures near the horizon to estimate the ambient temperature T_{zero}.

The radiation in the 8-14 μm atmospheric window contains a contribution of emission by water vapor. The clear sky reference temperature is adapted dynamically by the NubiScope if sufficient cloud free scenes at various elevations are available. The clear sky reference temperature in the zenith, T_{blue}, is used to describe the zenith angle dependency of the clear sky temperature.

When the atmospheric brightness temperature of a pixel is above the clear sky background value a cloud is assumed to present. The cloud evaluation is only performed for elevations above 20° since at low elevation the sky temperatures are affected too much by water vapor.

The NubiScope reports the total cloud fraction and the fraction of low, middle and high clouds. In addition to NubiScope also reports the obscuration type (fog, precipitation, cloud type) and cloud characteristics (cloud cover, layering and altitude).

The observed sky temperature for cloudy scenes is used to determine the cloud base height. The zenith temperatures and corresponding cloud base heights are reported.

The NubiScope also reports the housing temperature of the pyrometer $T_{housing}$.

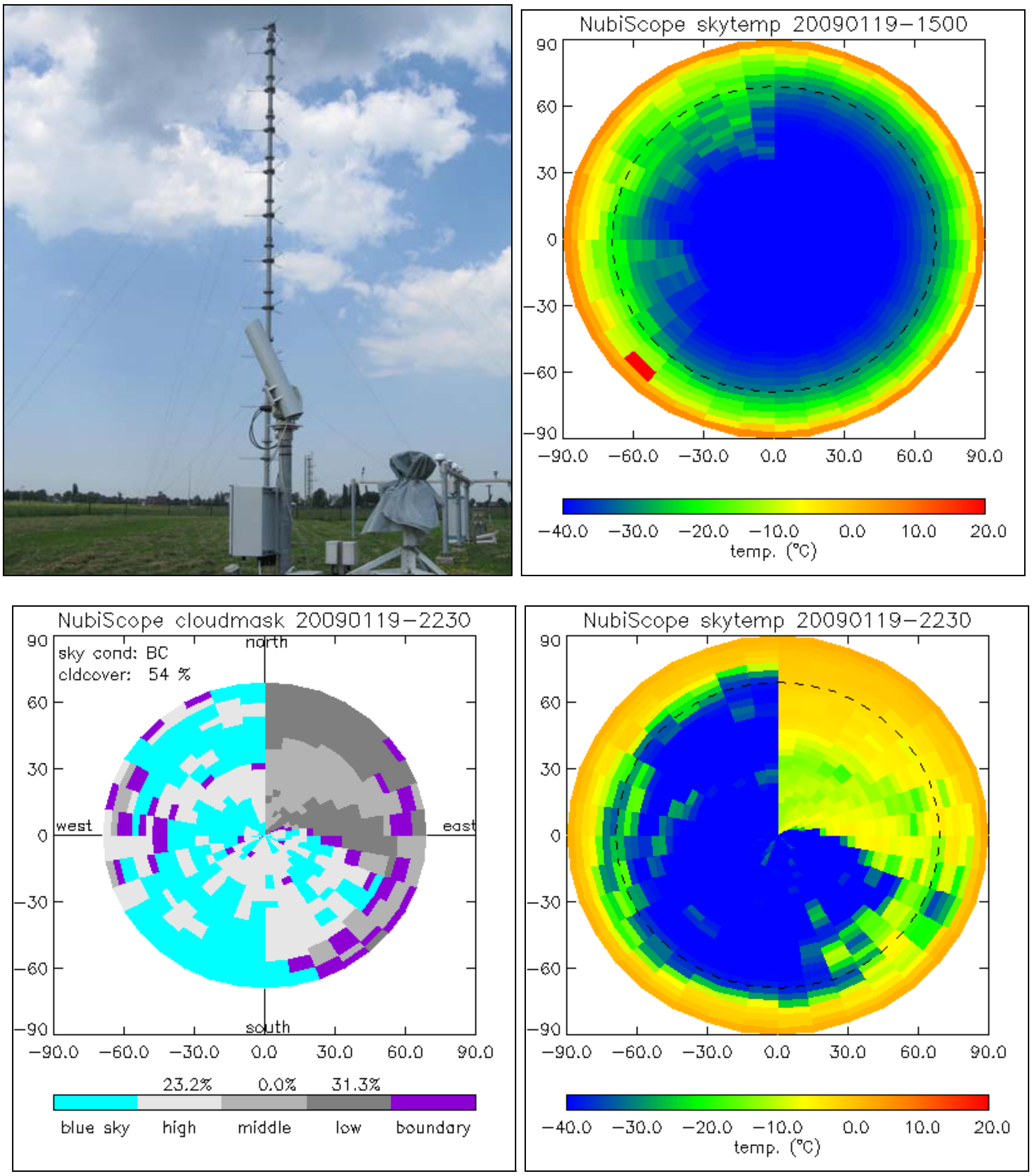

Figure 1: The NubiScope installed at the BSRN site of Cabauw (top left), example of observed sky temperature including a sun spot in the southwest direction (top right), and the observed temperature (bottom right) and derived cloud mask (bottom left) during a situation with partial cloudiness.

2. Contacts

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3. Deployment Locations and History

The NubiScope is deployed since May 2008 at the CESAR Observatory near the small village Cabauw in the central part of the Netherlands. The NubiScope is installed approx. 280 m south of the 213 m high meteorological tower, close to the BSRN station (see fig. 1 upper left panel). Initially the NubiScope was set-up for a two year evaluation period. However after this period the NubiScope remained on site and was operated continuously but without any re-calibration or cleaning. A preliminary test of the NubiScope was already performed in 2006 for two months during which the NubiScope was operated on the roof of the KNMI in De Bilt [Wauben W., 2006].

The first year of the field evaluation at CESAR covered the period from May 15, 2008 to September 29, 2009. During this period the pyrometer was taken several times back to KNMI in order to monitor the effect of contamination. This caused gaps in the data of about 2 days (see table 1 for dates). During the field test problems occurred with the Pan-and-Tilt Unit (PTU), which led to missing scans from January 2009 onwards and eventually the PTU stop working completely on March 2, 2009. This caused several large gaps in the data set and the entire NubiScope was taken back to KNMI in order investigate the problem. It turned out that water had entered the PTU and had damaged the unit. On April 3, 2009 the Bewator P16T PTU was replaced by an ENEO VPT-501 PTU of another manufacturer. The new PTU did not cause any problems since it was installed at CESAR.

The second period of the field evaluation lasted from December 18, 2009 to December 13, 2010. During this period the NubiScope was operated continuously at CESAR without cleaning or monitoring of the contamination of the pyrometer lens and the PTU functioned without any interruptions.

Near the end of 2010 the rain sensor mounted on the NubiScope stop operating properly. The rain sensor was dismounted in December 2010 and not replaced. Although the reading of the rain sensor doesn't affect the cloudiness calculation, it does affect the sky obscuration type (see data quality).

Table 1 time line of deployment history

start date	end date	description
2008-04-02	2008-04-16	preliminary deployment at CESAR
2008-05-13	ongoing	deployment at CESAR

2008-05-15	2009-09-29	first field evaluation period
2009-12-18	2010-12-13	second field evaluation period
2008-07-23	2008-07-31	Pyrometer housing tube mounted backwards
2009-01-23	2009-01-29	malfunctioning of PTU (no data)
2009-02-10	2009-02-12	malfunctioning of PTU (partial no data)
2009-03-04	2009-04-03	malfunctioning of PTU (no data)
2009-04-03		PTU replaced
2009-04-16		vertical alignment adjusted
2009-09-29	2009-12-18	NubiScope in workshop at De Bilt (no data)
2010-02-10		vertical alignment adjusted by 3 deg
2010-10-11	2010-12-12	rain sensor suspect
2010-12-13		rain sensor dismounted

Calibration against a black body at De Bilt

start date	end date	description
2008-06-11	2008-06-13	
2008-07-16	2008-07-18	
2008-08-13	2008-08-15	
2008-09-10	2008-09-16	
2008-10-15	2008-10-17	
2008-11-19	2008-11-21	
2009-01-07	2009-01-11	
2009-03-13		(see above)
2009-07-07	2009-07-10	
2009-10-26		
2009-11-26		
2010-12-13	2010-12-17	

Note: calibration causes a corresponding data gap in time.

4. Near-Real-Time Data Plots

Near real time data plots are created every 10 minutes and uploaded to the Internet with a delay of less than 10 minutes. Plots of the last 4 days are available from the KNMI website [http://www.knmi.nl/samenw/cloudnet/realtime].

5. Data Description

This dataset contains a subset of the data produced by the NubiScope software. In the dataset described here, data are presented on a daily basis. Monthly time series data (e.g. cloud cover, sky obscuration, temperature, zenith cloud base height) are available from the CDS dataset 'cesar_nubiscope_cloudcover_la1_t10'.

In table 2 the variables included in the CDS netCDF file are described.

Table 2. File content description.

Dimensions	Description
time	dimension of the time series variables
time_skytemp	dimension of time coordinate of zenith scans
str_len	length of the char variable 'cldtype'
azim	dimension of the azimuth coordinate of scans
zenith_cldmask	dimension of the zenith coordinate of the cloud mask data
zenith_skytemp	dimension of the zenith coordinate of the temp. scan data

global attributes	global attributes as specified by [4]

Primary Variables [dim]	**Description**	**Units**
time [time]	time in hours since begin of day at the start of the scan which takes 6.5 minutes	hour
time_skytemp [time_skytemp]	time in hours (UTC) since begin of day at the moment of a zenith scan	hour
azim [azim]	azimuth direction of a cloud mask pixel	degree North
azim_skytemp[time_skytemp]	azimuth direction of a zenith scan	degree North
zenith_cldmask[zenith_cldmask]	zenith direction of a cloud mask pixel	degree
zenith_skytemp[zenith_skytemp]	zenith direction of a scan pixel	degree
cldcover_total [time]	total cloudcover in percentage, corrected in case of cldtype = 'CI', 'LF' or 'DF' (see Data Quality)	%
cldcover_high [time]	cloud cover in percentage for clouds with cloud base higher than 5400 m	%
cldcover_middle [time]	cloud cover in percentage for clouds with cloud base between 2100 and 5400 m	%
cldcover_low [time]	cloud cover in percentage for clouds with cloud base lower than 2100 m	%
obscuration_type [str_len,time]	obscuration type as determined by NubiScope software	string
cldmask [time, azim, zenith_mask]	cloud mask retrieved by NubiScope software	-
skytemp [time_skytemp, zenith_skytemp]	IR sky brightness temperatures measured by NubiScope	C

Secondary Variables	**Description**
iso_dataset	metadata describing dataset details [4]
product	metadata describing file details, see [4]
station_details	metadata describing station details [4]
valid_dates	Boolean variable, '0' = no data present for a specific day, '1' = data present, array index is counted in days from start of month

6. Data Quality

A detailed analysis of the NubiScope and the data has been published as a KNMI Technical Report [Wauben et al., 2012]. It is strongly recommended to read this report for a better understanding and interpretation of the NubiScope data.

During the first year of operation some fine tuning of the algorithm was performed in consultation with the manufacturer. The data presented in this CDS dataset are the products as calculated by the NubiScope software (version v33h, dd 17/10/2010).

However some adjustments have been made:

1a) The NubiScope doesn't report always a cloud cover when cirrus is detected. In case the *obscuration_type* variable was 'CI' and *cldcover_total* was not calculated by the NubiScope the *cldcover_total* was derived from the *cldmask* variable (this variable is included in the CDS dataset 'cesar_nubiscope_2dcloudmask_la1_t10'). Here we used a simple approach and weighted each pixel with a high, middle or low cloud classification as one, and weighted each pixel with a 'margin' classification as 0.5. Although a zenith dependent weight function seems more appropriate it is not possible to reproduce the NubiScope values exactly from the cloud mask as the details of the internal processing are not published by the manufacturer [Wauben et al, 2012]. When the *cldcover_high* was not set in these cases, this variable was set to the same value as the *cldcover_total* variable.

1b) Also when the *obscuration_type* was indicated as 'LF' or 'DF' ('light fog' and 'dense fog' condition respectively) the *cldcover_total* and *cldcover_low* were set to 100%. Note that 'LF' occurs very rarely in this dataset.

Some other aspects of the dataset to take notice of:

2a) Sometimes the *obscuration_type* 'BC' (broken clouds) occurs with a *cldcover_total* of 100%.

2b) When the rain sensor of the NubiScope detects precipitation the precipitation flag 'PR' is raised and the *cldcover_total* is set to 100% by the NubiScope software. The rain sensor is also used to discriminate between rain and fog. However since the time that the rain sensor started malfunctioning and was dismounted (see table 1) the number of 'HP' (heavy precipitation) events is zero. After dismounting the rain sensor the number of 'DF' fog cases increased due to the missing rain flag information and incorrectly classifying rain episodes as 'DF' fog episodes. This behaviour has not been corrected in this dataset.

2c) As the NubiScope software code is proprietary and not available it is not possible to exactly reproduce the cloud cover numbers from the measured temperature scan data. Note also that if e.g. low cloud cover is 100% the middle and high cloud cover can be set to 0% by the NubiScope. However this is at least doubtful as information about middle and high clouds is (likely) shielded by the low clouds. Therefore it would have been more appropriate to set the numbers for middle and high cloud cover in such cases to 'not available' instead of '0'.

2d) For a few cases where the time of the original data was known to be incorrect the original NubiScope time stamp was adapted. This occurred only in the first one-and-half year operation, mostly after a reset. In summer 2009 a time synchronization was implemented that resets the internal clock of the NubiScope to UTC after each scan cycle.

7. Instrument Details

The NubiScope consists of a pyrometer mounted on a pan-and-tilt unit (PTU) [Möller and Sattler, 2007]. The pyrometer is a Heitronics KT15.82 IIP pyrometer which is

equipped with a type A detector and a type K6 lens which makes the pyrometer sensitive in the 8-14 μm thermal infrared window of the Earth's atmosphere with a field of view of about 3°. The temperature measurement range of this pyrometer is between −100 and +350 °C, but the NubiScope limits the observed brightness temperatures to −65 °C. The pyrometer factory calibration only covers temperatures above −10 °C, but the stability check of the pyrometer against a black body performed by KNMI covers the range −40 to +40 °C. The accuracy of the temperature measurements is specified as of ±0.5 °C ±0.7 % $\Delta(T_{housing} - T_{object})$. The stability of the pyrometer is specified as better than 0.1 ‰ per month.
The object emissivity in the pyrometer is set to unity and the integration time is 0.3 sec.

Initially the NubiScope used a Bewator P16T PTU but this was replaced by an ENEO VPT-501 PTU of another manufacturer. The NubiScope operates fully automated and performs a scan of the entire hemisphere every 10 minutes. The scan itself takes about 6½ minutes. The NubiScope measures the sky temperature at 36 azimuth directions ranging from 5° to 355° in steps of 10°. The NubiScope alternates between upward and downward zenith scans. During the zenith scan the NubiScope samples the brightness temperature at 30 zenith angles ranging from 1.5° to 88.5° in steps of 3°. Therefore each scan consists of a total of 36x30 = 1080 pixels. In addition the NubiScope also measures 2 surface temperatures at a nadir angle of 45° in the East and West direction respectively.

The NubiScope derives several parameters such as the ambient temperature and the clear sky temperature as well as cloudiness and cloud base height (see General Overview). Details of the algorithm to detect clouds, the derivation of the obscuration type and to calculate the cloud base height are not published by the manufacturer. The calculations are controlled by various parameters that are specified in the "kalib.dat" configuration file. These settings have been optimized by the manufacturer during the field test. The current settings are given in Appendix G of the report "NubiScope - Laboratory Tests and Field Evaluation" [Wauben et al., 2012]. All NubiScope data before 2011 have been reprocessed off-line using these settings in order to generate a homogenous dataset.

Furthermore gaps in the time series caused by data loss due to network communication problems were filled in using the data internally stored by the NubiScope on a flash disk for the period 2008-2010. Data collected from 2010 onwards were collected with the same settings as the reprocessed data.

After completion of each scan the NubiScope processes the sky temperatures and outputs the temperature and cloudiness results. The results are also stored on a flash disk of the NubiScope in various files. The temperature measurements are stored in daily binary files with name convention NYYMMDD.dat and the results of the processed NubiScope data are stored in daily files with name convention RYYMMDD.dat. Furthermore the cloud mask and zenith results of each scan are stored in MYYMMDDh.hmm and ZYYMMDDh.hmm, respectively. Finally, the NubiScope als generates a monthly log-file, denoted LYYMM.dat, which reports start and end of each remote connection, the update of parameter files and any errors.

8. References

[1] Möller, H. and T. Sattler (2007), NubiScope Instruction Manual, IMK Bad Vilbel and Sattler-SES Frankfurt am Main, Germany.

[2] Wauben, W (2006), Evaluation of the NubiScope, KNMI Technical Report No. 291, KNMI, De Bilt, The Netherlands. (http://www.knmi.nl/knmi-library/knmipubTR/TR291.pdf)

[3] Wauben W., H. Klein Baltink and F. Bosveld (2012), "NubiScope - Laboratory Tests and Field Evaluation", KNMI Technical Report No. xxx, KNMI, De Bilt, The Netherlands. *(in press, once printed a PDF-version can be downloaded from http://www.knmi.nl).*

[4] Klein Baltink H., Metadata Description Document, v1.1, 2010, KNMI.