Deutscher Wetterdienst
Wetter und Klima aus einer Hand

40 years of CESAR Observatory

from reference sites to a joint network

Franz H. Berger
and MOL-RAO coworkers

Tasks for routine 24/7 operations

1. **instrument testing** for future network use (relevant system expertise has to be available)
2. **application of new methods / methodologies for 24/7 operation** (based on the research experience from universities and research institutes) using well-tested and robust measurement systems/techniques
3. **providing reference data** sets using conventional data and remotely sensed data – including the synergy of surface and satellite based observations, e.g. for data assimilation
4. **long-term monitoring of atmospheric processes** – climate records at various spatial and temporal scales
5. **improved knowledge** about chemical and physical atmospheric processes **for model initialization / evaluation** and **ongoing parameterization** in numerical models

instrument testing

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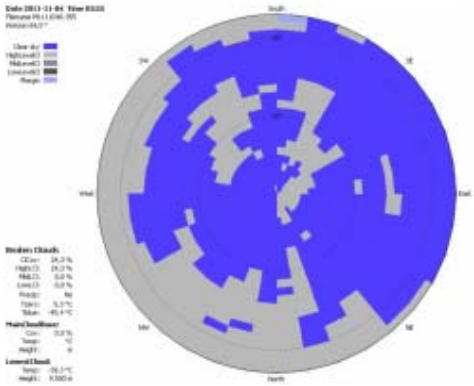
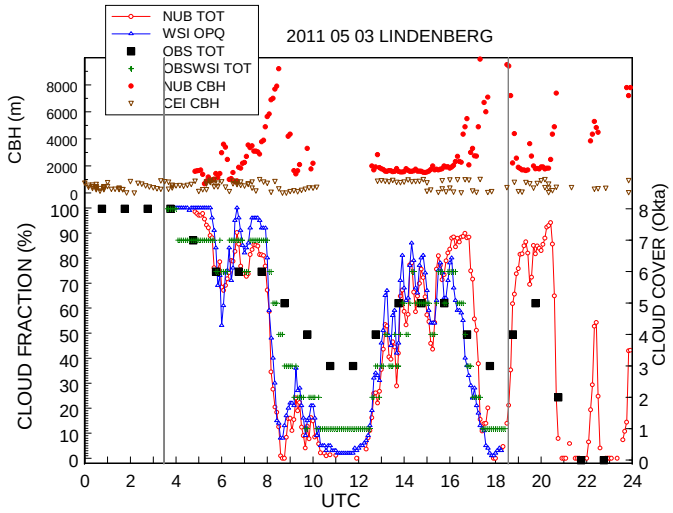
Comparison of a Duo-NubiScope with a Whole Sky Imager (WSI) Lindenberg

Duo-NubiScope
IR-Scanner of atmospheric emission 8 - 14 µm,
Scan: 0 ...90 zenith,
0... 360° azimuth in steps of 10°
Scantime: ca. 3 Minuten
Parameter: cloud cover (total and 3 layers, cloud base)



Whole Sky Imager (WSI) DAY/NIR from UCSD
- cloud cover (total, optical thick and thin, up to 2 Min. from sunrise to sunset)
- cloud distribution and pattern inclusively contrails
- radiance at 700,000 sky points



Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

DWD

Comparison of a Duo-Nub … nberg

Duo-NubiScope
IR-Scanner of atmospheric emission 8 - 14 µm,
Scan: 0 ...90 zenith,
0... 360° azimuth in steps of 10°
Scantime: ca. 3 Minuten
Parameter: cloud cover (total and 3 layers, cloud base)

NubiScope - Laboratory tests and field evaluation

Wiel Wauben, Henk Klein Baltink and Fred Bosveld

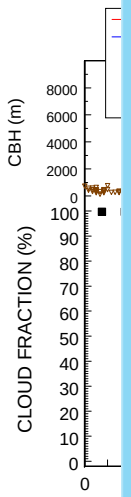
De Bilt, 2012 | Technical report; TR-334

) DAY/NIR

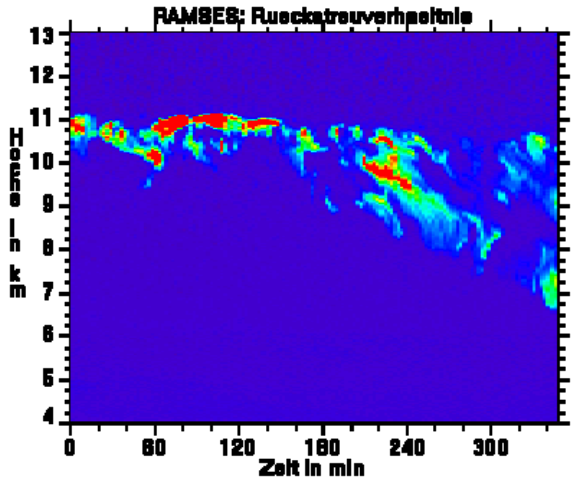
cal thick
om sunrise

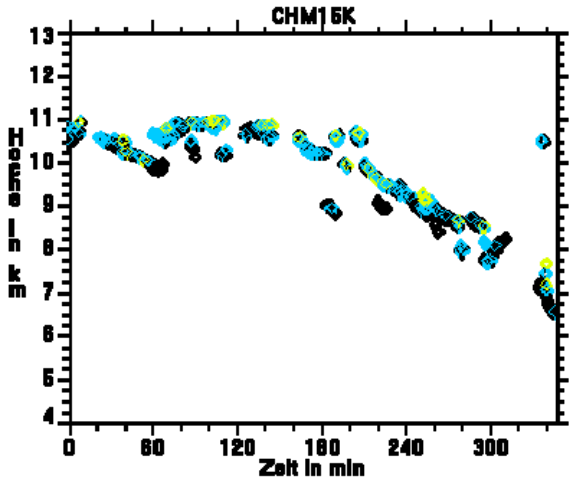
pattern

y points

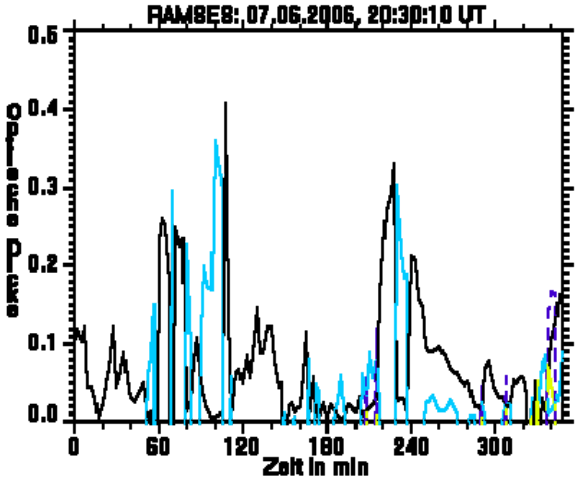


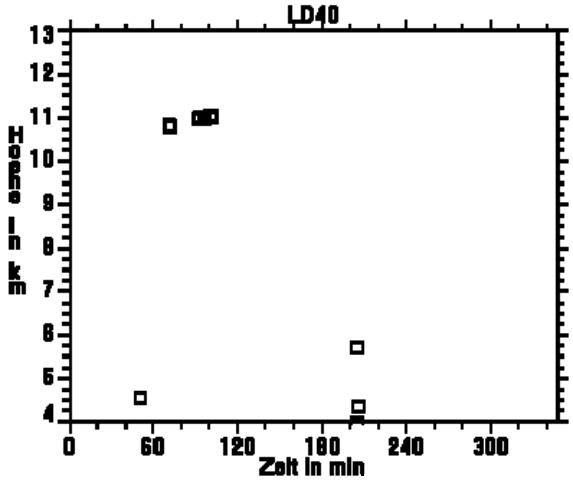
Cloud Base Height / Ice Clouds: 7.6.2006





CHM 15k





LD-40

application of new methods

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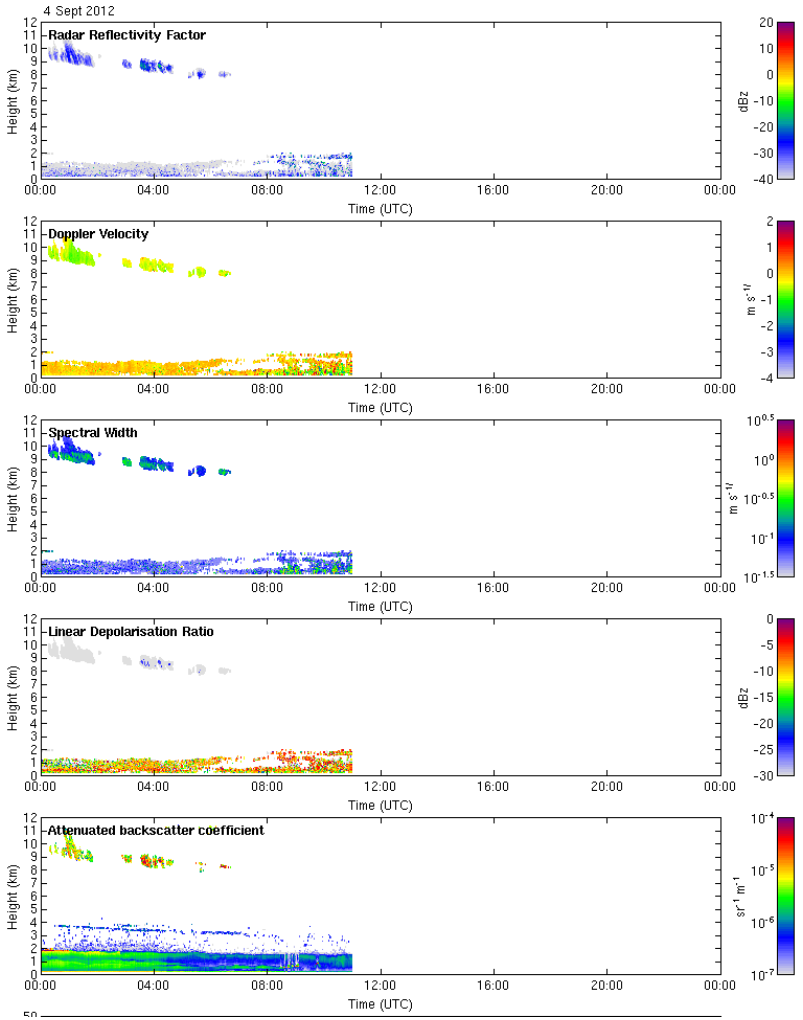
Cloudnet – Products

adaption of existing methods & use of sensor synergy

in collaboration with Reading, Palaiseau and Cabauw



GCOS BSRN

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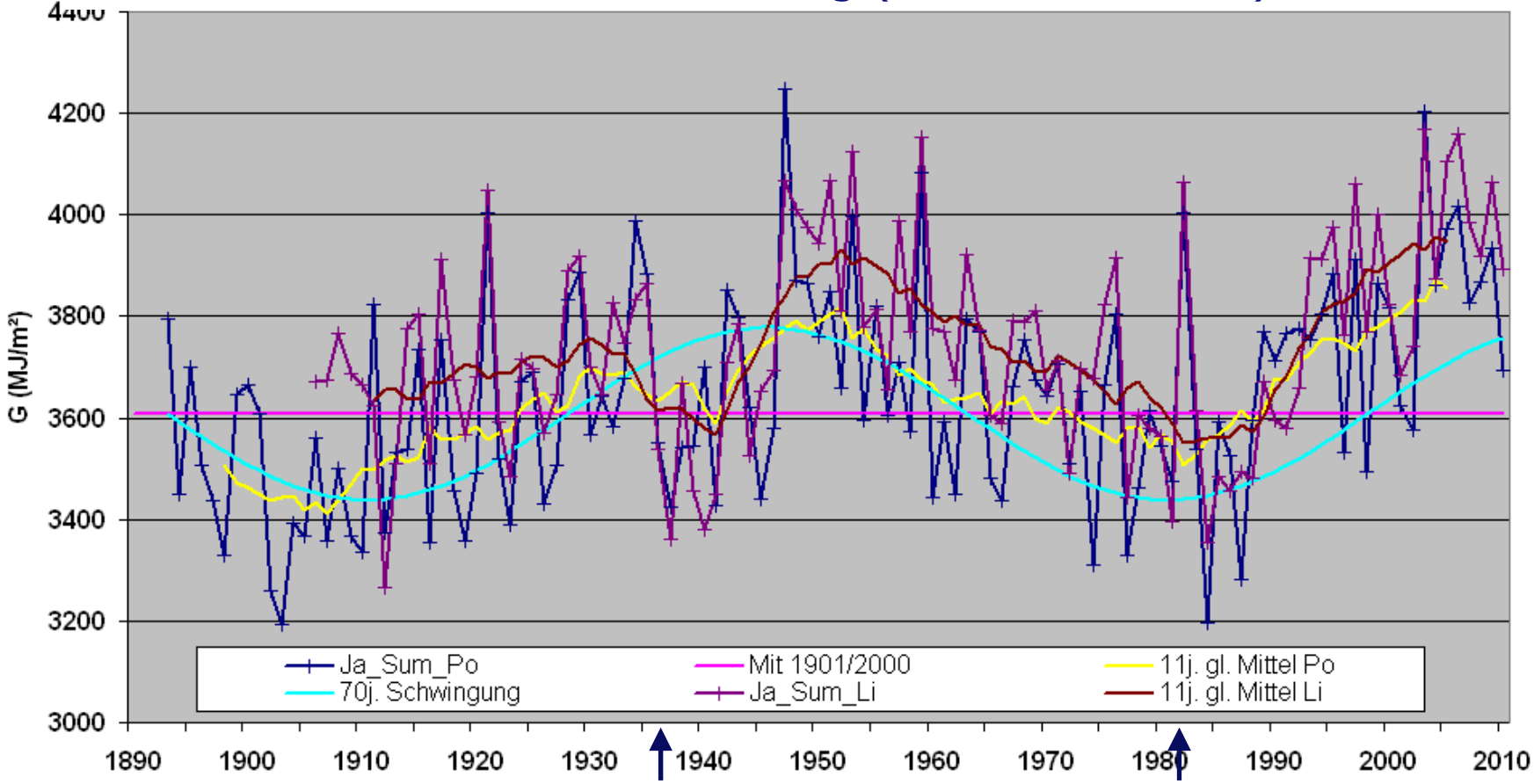
BSRN station

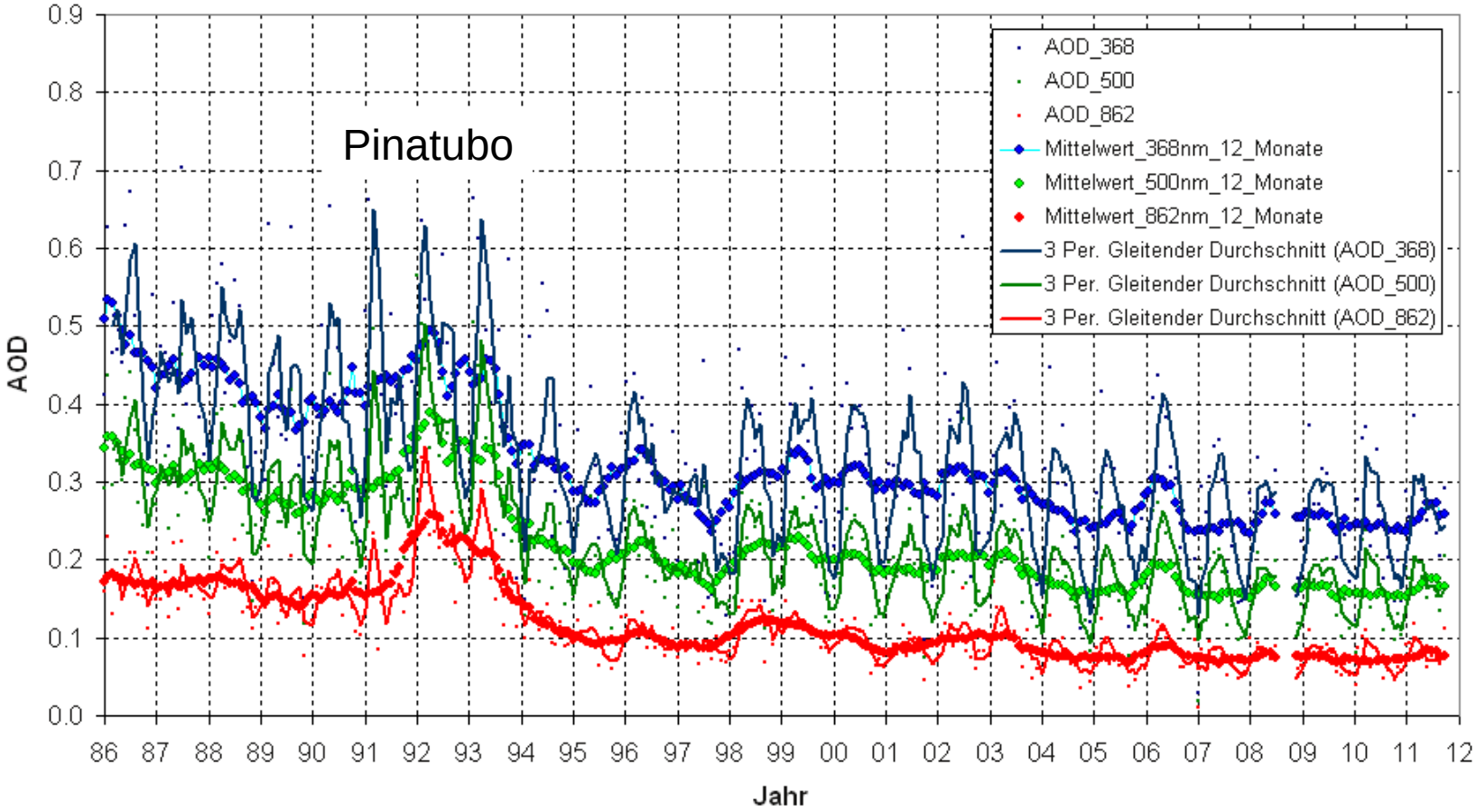
	Lindenberg	Cabauw
	φ=52,21°N	φ= 51.97°N
	λ=14,07°E	λ=4.93°E
	h=126m	h=0m
	1994, Oct. 1st	2005, Feb.
Direct, diffuse and global irradiance	x	x
Downward longwave irradiance	x	x
Upward shortwave and longwave irradiance		x
Narrowband direct irradiance (for Aerosol Optical Depth, AOD) with PFR	x	x
Narrowband diffuse and global irradiance (MFRSR)	x	x
UV-A/B irradiance	x	x
Total Ozon	x	
Sky images	WSI	TSI
Sunshine duration	x	x
AOD (Aeronet with CIMEL Photometer)	x	x
Star-Photometer (nightime AOD)	x	

Global Radiation

Potsdam and Lindenberg (1893/1906-2010)



aerosol optical thickness (since 1986)



EUMETNET CWINDE

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Wetter und Klima aus einer Hand

(March 2012)

28 profiler in Central Europe

+ Kiruna and La Reunion

10 Canadian profilers

EUCOS Monitoring

Oktober 2011

E-WINPROF OPERATIONAL REPORT

PROGRAMME : E-WINPROF		**NETWORK MANAGER:** Kevin Linklater	
REPORTING PERIOD: October '11		**DATE OF ISSUE: 14/11/11**	
UA203	UK Wind Profilers Data - At least 90% of agreed UK Wind Profiler Network synoptic observations, with RMS error less than 5m/s, available by OT+30 at EUCOS Data Portal.		98.9%

	Availability Messages received by EUCOS	**Timeliness** OT + 30min (EUCOS Portal)	**Quality** Met Office & EUCOS Monthly OB-FG
	optimal - 100%, min - 95%	optimal - 100%, min - 90%	RMS Difference < 5m/s
	Availability	**Timeliness**	**Quality**
Kiruna 02043	91%	0%	5.3
South Uist 03019	100%	100%	4.4
Isle of Man 03203	99%	99%	4.2
Aberystwyth 03501	99%	99%	4.3
Wattisham 03591	100%	100%	3.1
Chilbolton 03754	0%	0%	0.0
Camborne 03807	100%	100%	3.5
Dunkeswell 03840	100%	97%	3.5
Cabauw 06348	98%	100%	5.7
Payerne 06610	100%	100%	3.6
Schaffhn 06620	95%	100%	3.4
Grenchen 06632	100%	100%	3.9
Clermont-F 07453	100%	100%	3.9
Lannemezan 07626	0%	0%	0.0
Marignane 07650	100%	100%	4.9
Bilbao 08031	96%	100%	3.6
Madrid 08221	100%	100%	4.6
Nordholz 10135	100%	100%	2.6
Ziegendorf 10266	100%	100%	2.8
Lind 482 10394	98%	100%	2.7
Bayreuth 10678	100%	100%	2.7
Vienna 11036	83%	0%	4.2
Budapest 12842	90%	0%	6.2
Szeged 12982	94%	100%	4.0
Torino 16300	0%	0%	0.0
La Reunion 61980			

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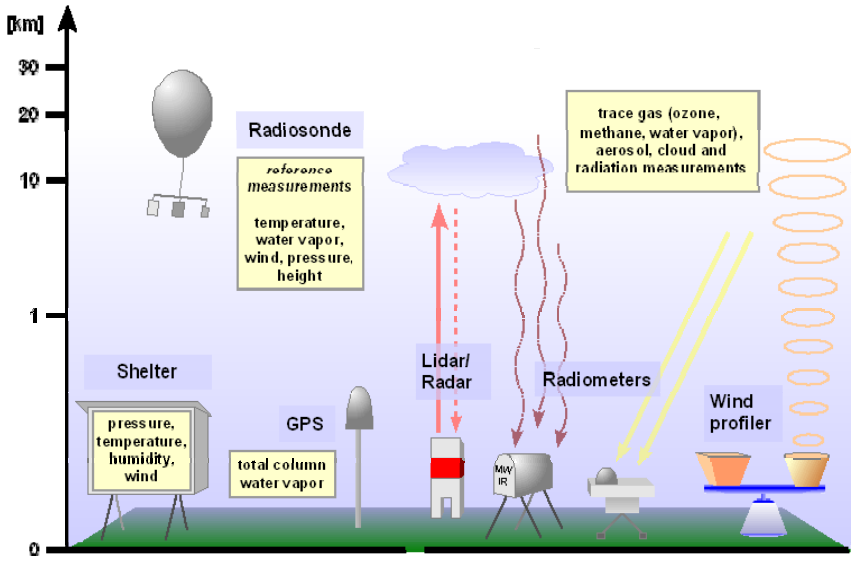
What is GRUAN?

- GCOS Reference Upper Air Network
- Ground based network for reference observations for climate within GCOS, with current focus on water vapor and temperature (troposphere and stratosphere)
- Currently 15 initial sites, with aim to expand to 30 to 40 sites worldwide

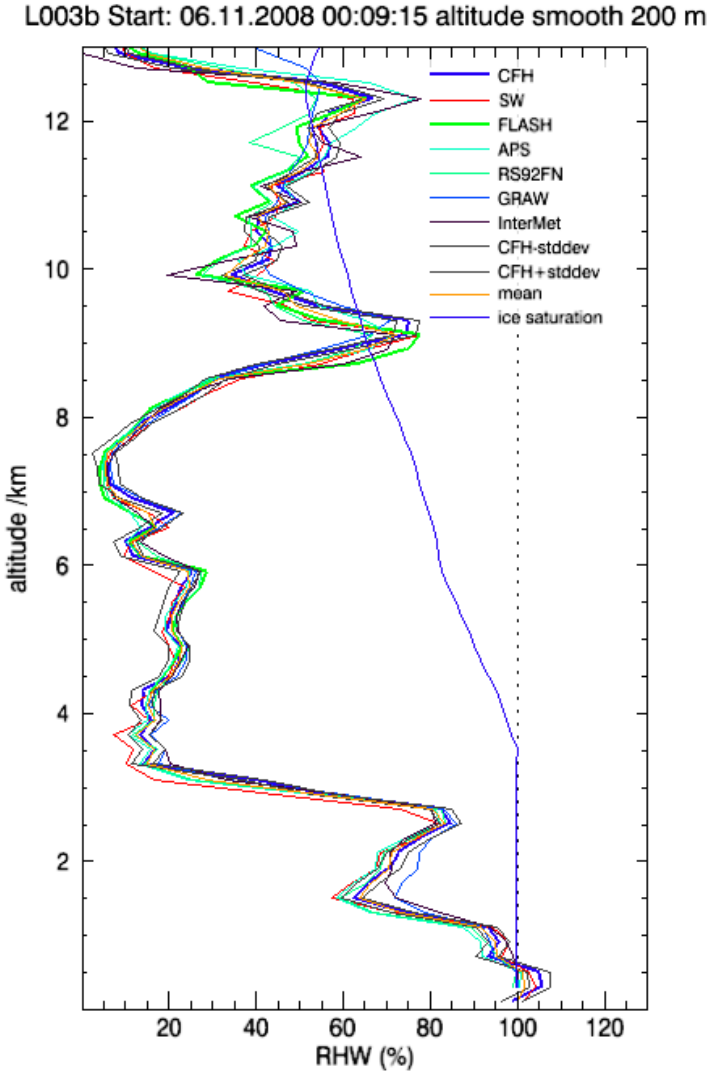
GRUAN goals

- maintain observations over decades
- validation of satellite systems
- **characterize observational uncertainties**
- **traceability to SI units or accepted standards**
- **comprehensive metadata collection and documentation**
- **long-term stability through managed change**
- validate observations through deliberate measurement redundancy



Priority 1: Water vapor, temperature, (pressure and wind)

Priority 2: Ozone, clouds, …


L003b Start: 06.11.2008 00:09:15 altitude smooth 200 m
CFH
SW
FLASH
APS
RS92FN
GRAW
InterMet
CFH-stddev
CFH+stddev
mean
ice saturation
altitude /km
RHW (%)
2
4
6
8
10
12
20
40
60
80
100
120

CEOP / BALTEX

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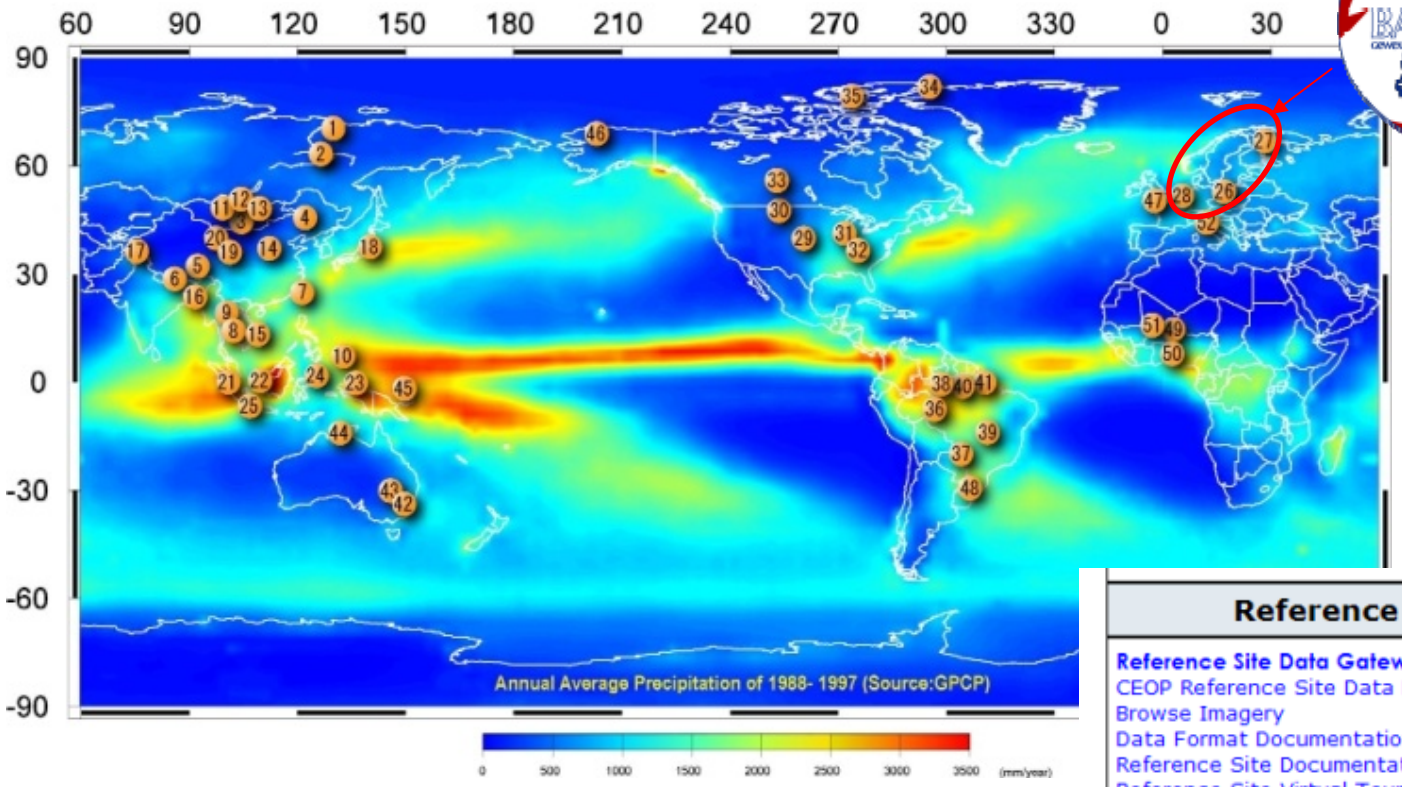
Wetter und Klima aus einer Hand

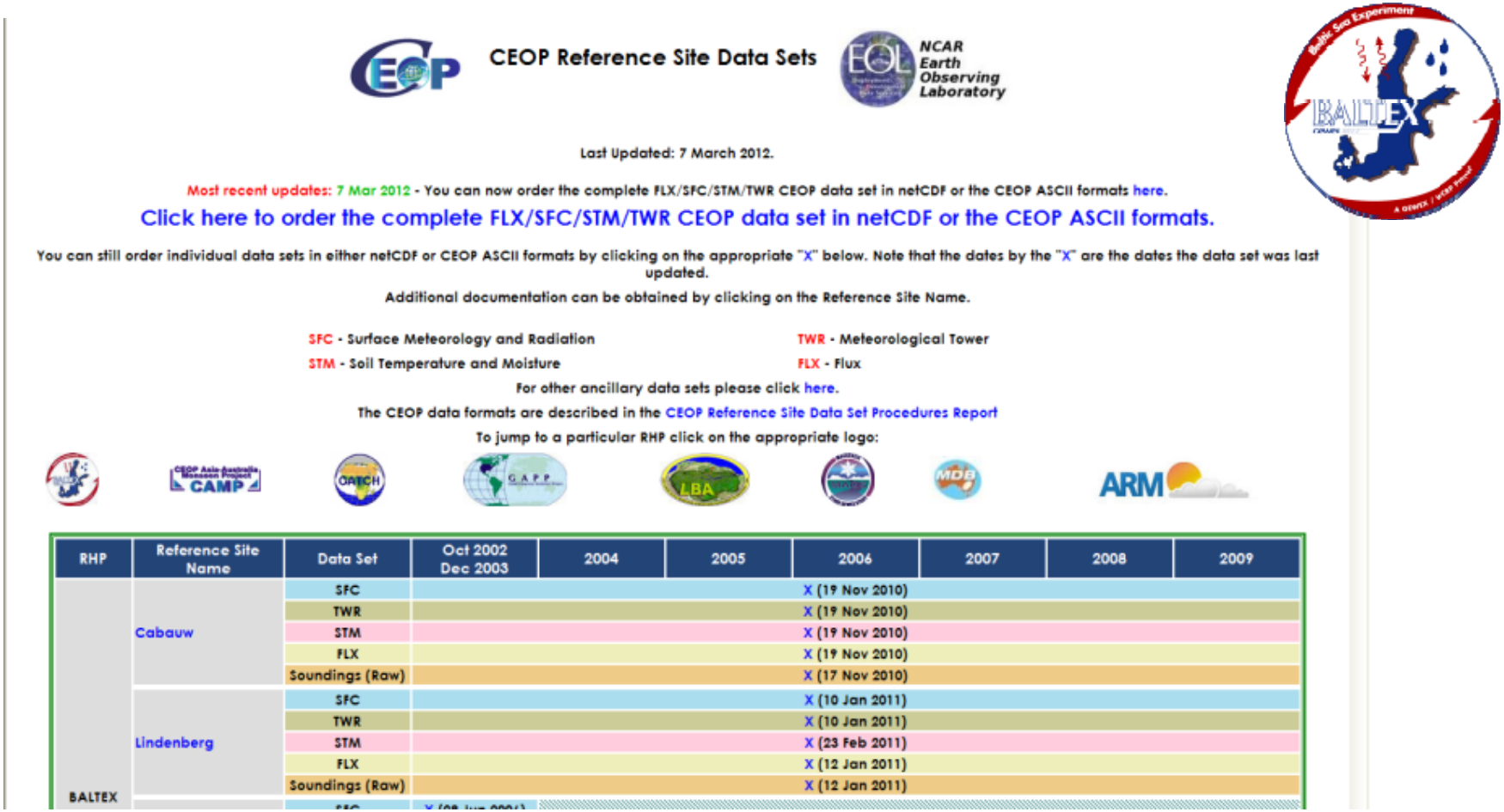
CEOP In-Situ Reference Sites



Reference Site Data

- **Reference Site Data Gateway**
- CEOP Reference Site Data Policy
- Browse Imagery
- Data Format Documentation
- Reference Site Documentation
- Reference Site Virtual Tour
- CEOP EOP-1 Data Sets
- Hydrology Reference Sites

Data Delivery Status of the BALTEX Sites to CEOP



CEOP Reference Site Data Sets

NCAR Earth Observing Laboratory

Last Updated: 7 March 2012.

Most recent updates: 7 Mar 2012 - You can now order the complete FLX/SFC/STM/TWR CEOP data set in netCDF or the CEOP ASCII formats here.

Click here to order the complete FLX/SFC/STM/TWR CEOP data set in netCDF or the CEOP ASCII formats.

You can still order individual data sets in either netCDF or CEOP ASCII formats by clicking on the appropriate "X" below. Note that the dates by the "X" are the dates the data set was last updated.

Additional documentation can be obtained by clicking on the Reference Site Name.

SFC - Surface Meteorology and Radiation
TWR - Meteorological Tower
STM - Soil Temperature and Moisture
FLX - Flux

For other ancillary data sets please click here.

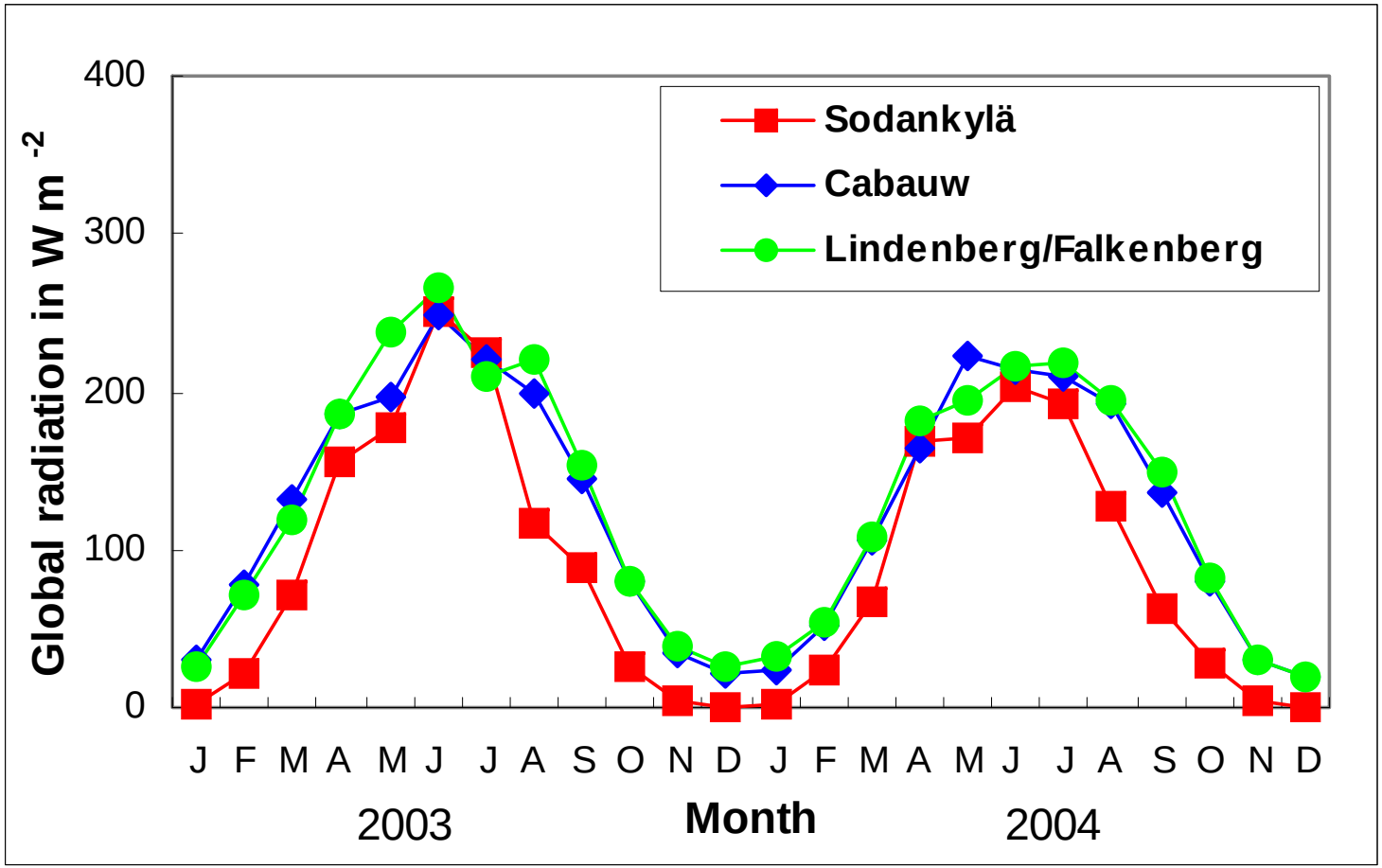
The CEOP data formats are described in the CEOP Reference Site Data Set Procedures Report

To jump to a particular RHP click on the appropriate logo:

RHP	Reference Site Name	Data Set	Oct 2002 Dec 2003	2004	2005	2006	2007	2008	2009
BALTEX	Cabauw	SFC				X (19 Nov 2010)			
		TWR				X (19 Nov 2010)			
		STM				X (19 Nov 2010)			
		FLX				X (19 Nov 2010)			
		Soundings (Raw)				X (17 Nov 2010)			
	Lindenberg	SFC				X (10 Jan 2011)			
		TWR				X (10 Jan 2011)			
		STM				X (23 Feb 2011)			
		FLX				X (12 Jan 2011)			
		Soundings (Raw)				X (12 Jan 2011)			

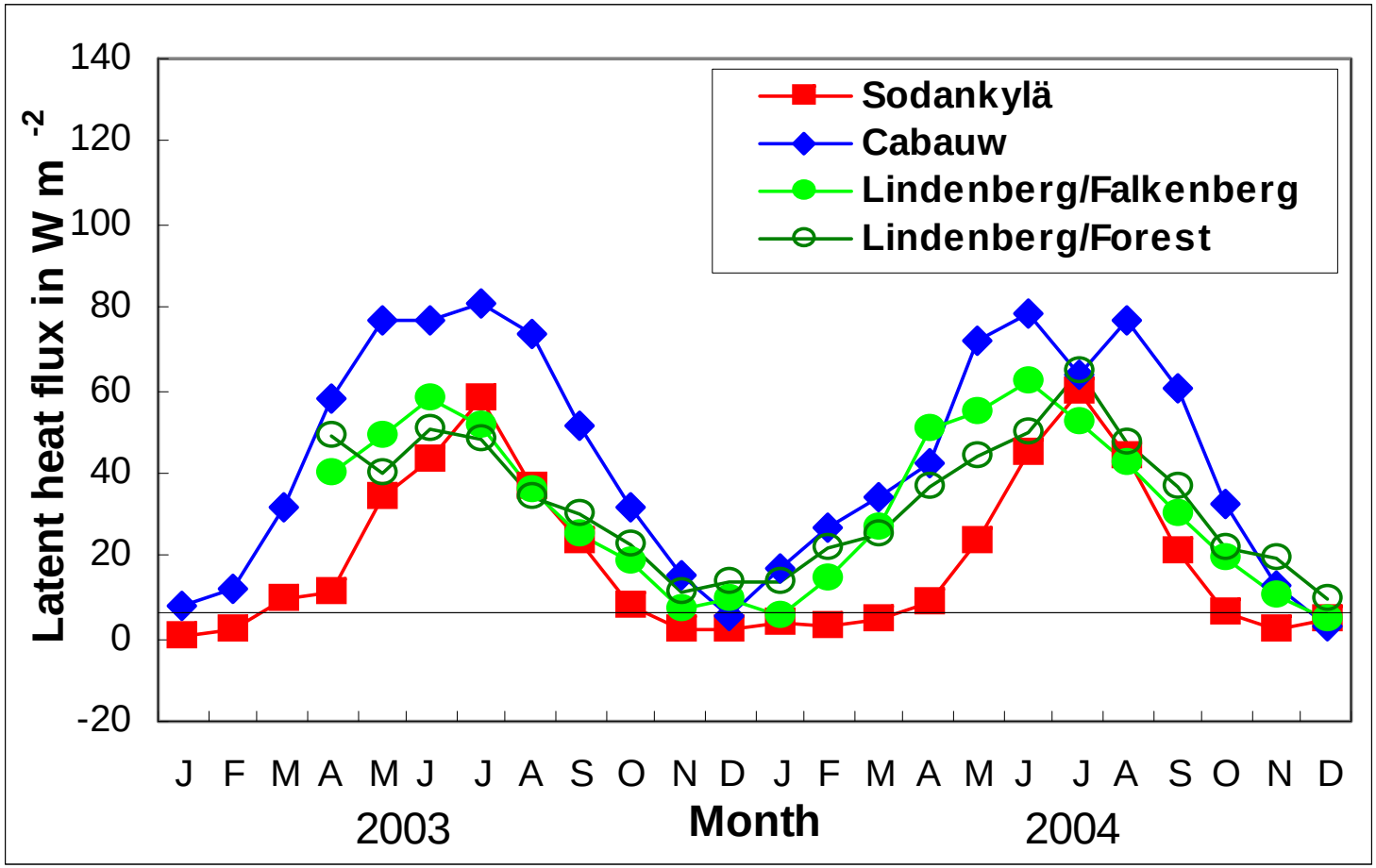
BALTEX / CEOP

Global radiation



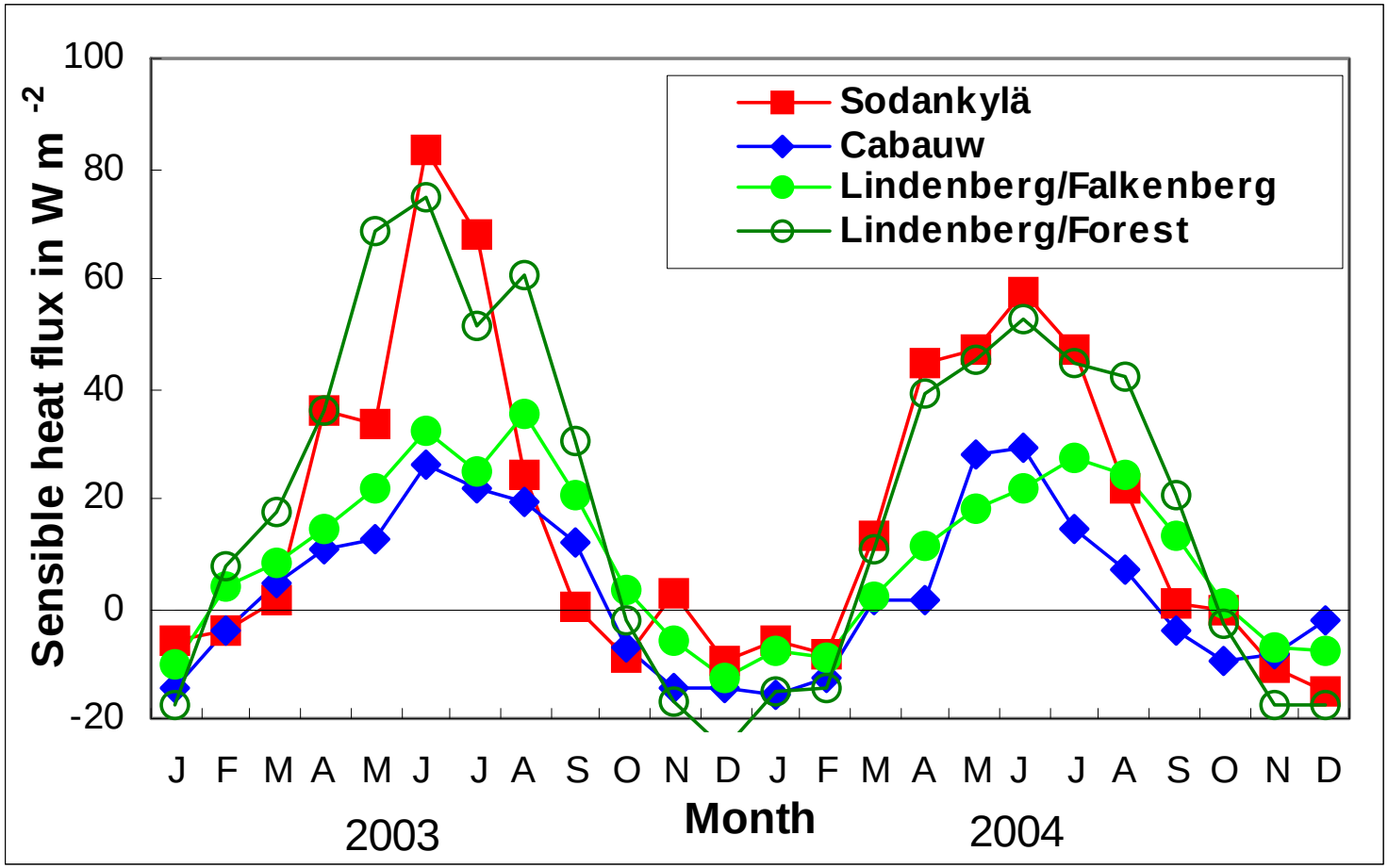
BALTEX / CEOP

latent heat flux



BALTEX / CEOP

sensible heat flux



model validation - GCM

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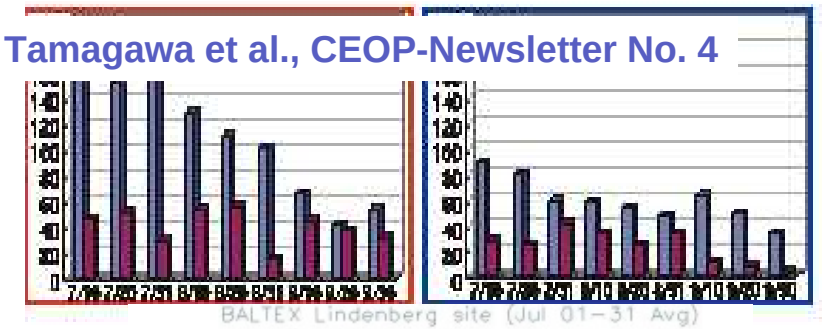
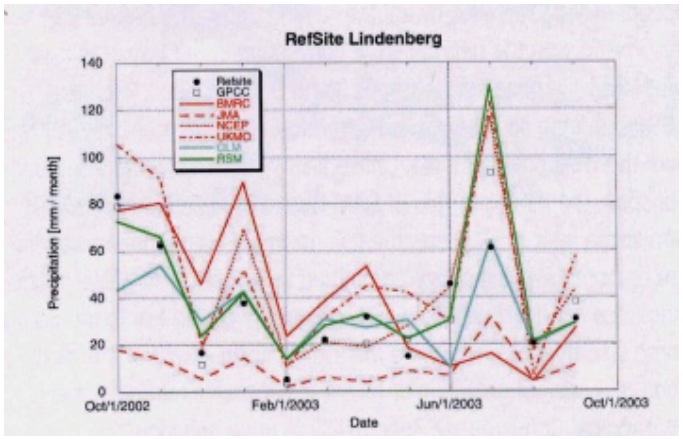
use of CEOP-data ➔ model validation

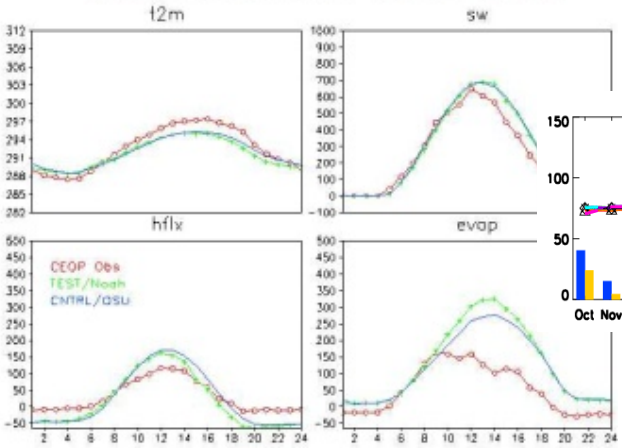
Rn H

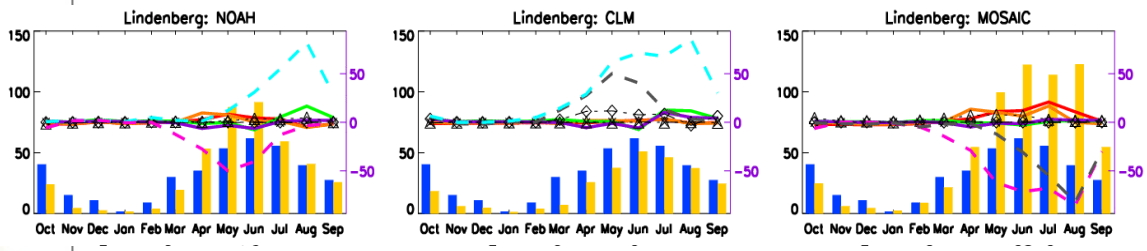


Tamagawa et al., CEOP-Newsletter No. 4



Rockel et al., CEOP-Newsletter No. 8





Kato et al., JMSJ (2007)

Lu & Mitchell, CEOP-Newsletter No. 5

model validation - NWP

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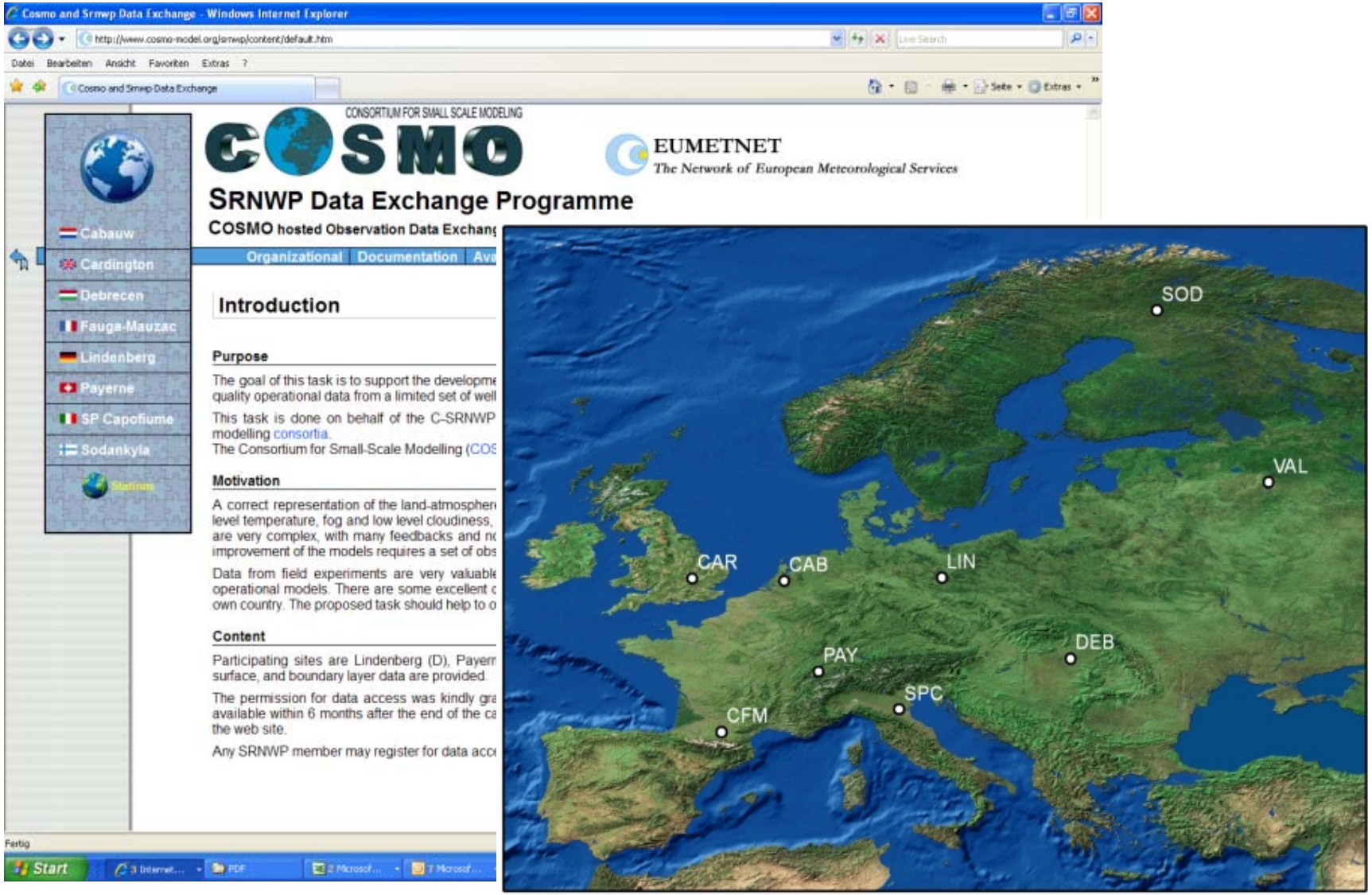


	site		description of instruments	mNN	soil type	local land use	land use (10 km)
LIN	Lindenberg Meteorological Observatory - Richard Aßmann Observatory (MOL-RAO)	http://www.dwd.de/mol	*v*	73	loamy sand Eutric Podzoluvisol	grass	60 % grassland/cropland, 30 % pine forest, 5% settlement, 5 % water
CAB	Cabauw Experimental Site for Atmospheric Research (CESAR)	http://www.cesar-observatory.nl/	*v*	-0.7	clay	open pasture for at least 400 m	
PAY	MeteoSwiss aerological station Payerne	http://www.meteoswiss.admin.ch/		490			82 % grassland/cropland, 10 % forest, 5 % settlement, 3 % water
CFM	Office National d'Etudes et des Recherches Aérospatiales (ONERA)	http://www.onera.fr/fauga-mauzac/index.php		186	loamy sand	grassland	grassland
SPC	Meteorological Site of San Pietro Capofiume		*v*	11	loamy sand CalcariFluvicCambi sols	grassland, surrounded by crop	
SOD	Finnish Meteorological Institute Arctic Research Centre (FMI-ARC)	http://fmiarc.fmi.fi/		179			28.2 % coniferous, 23.6 % transitional woodland/shrub, 17.2 % mixed forest, 12.9 % bog, 8.1 % broadleaved forest, 4.8 % water, 5.2 % other
CAR	UK Met Office Cardington	http://badc.nerc.ac.uk/data/cardington/instr_v7/index.html	available at BADC web site	29		grassland	

Status data set

Availability [%]

= 100	
>= 90 &&	< 100
>= 60 &&	< 90
>= 30 &&	< 60
>= 10 &&	< 30
>= 0 &&	< 10
= 0	

LIN

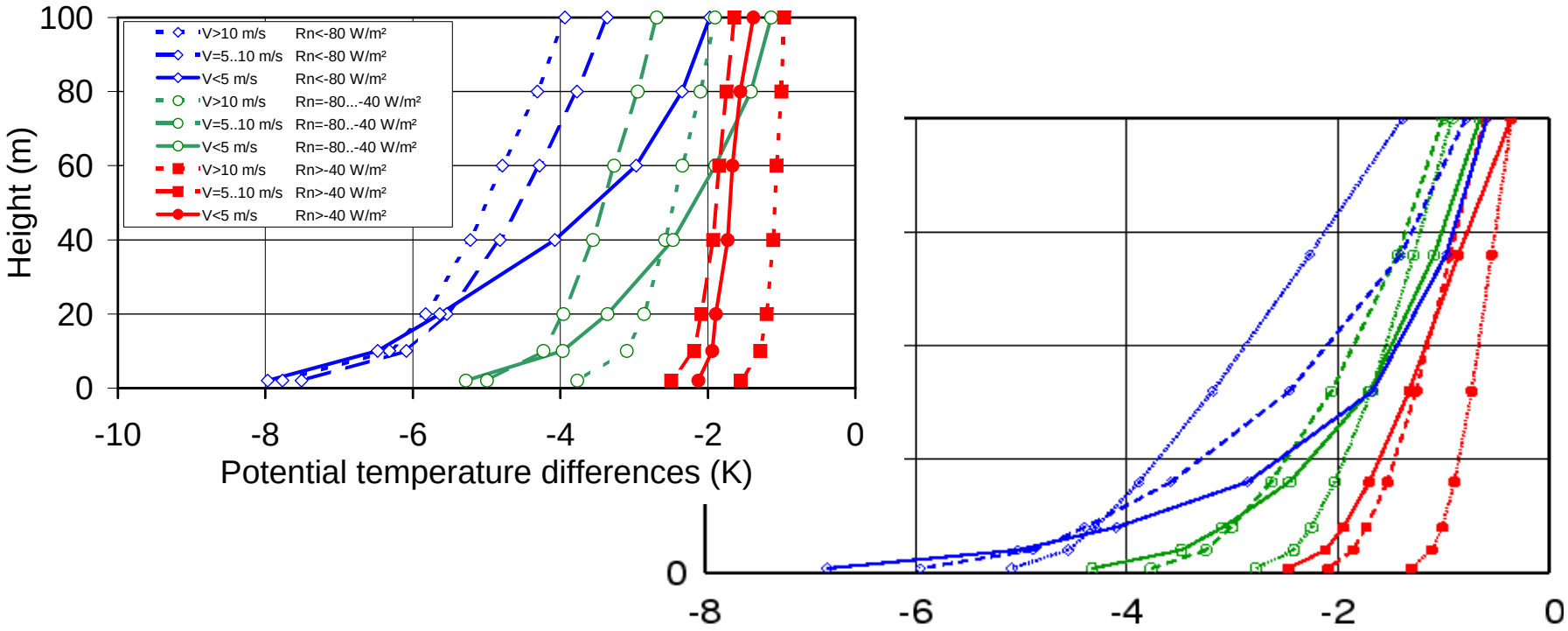
different time resolution
*1 30 min
*2 60 min
*4 24 h **if snow exists**

	2006	2007	2008	2009	2010
P0	99.9	99.9	100.0	100.0	100.0
RAIN	100.0	99.6	99.6	98.5	100.0
TAIR002	99.9	99.9	100.0	100.0	100.0
RH002	99.9	99.9	100.0	100.0	100.0
TD002	99.9	99.9	100.0	100.0	100.0
TAIR010	99.9	99.9	100.0	100.0	100.0
RH010	99.9	99.9	100.0	100.0	100.0
TD010	99.9	99.9	100.0	100.0	100.0
WSPEED010	98.4	99.8	99.9	99.1	97.6
WDIR010	99.2	99.9	100.0	100.0	100.0
TAIR020	99.9	99.7	100.0	99.9	100.0
RH020	99.4	99.7	100.0	97.5	100.0
TD020	99.4	99.7	100.0	97.5	100.0
TAIR040	99.9	99.9	100.0	100.0	100.0
RH040	99.9	99.9	100.0	100.0	100.0
TD040	99.9	99.9	100.0	100.0	100.0
WSPEED040	99.9	99.9	100.0	100.0	100.0
WDIR040	99.9	99.9	100.0	100.0	100.0
TAIR060	99.9	99.9	100.0	100.0	100.0
RH060	95.4	99.9	100.0	99.9	100.0
TD060	95.4	99.9	100.0	99.9	100.0
TAIR080	99.9	99.9	100.0	100.0	100.0
RH080	99.9	99.9	99.9	100.0	100.0
TD080	99.9	99.9	99.9	100.0	100.0
TAIR098	99.9	99.2	97.9	100.0	99.9
RH098	99.9	99.2	97.9	100.0	99.9
TD098	99.9	99.2	97.9	100.0	99.9
WSPEED098	99.9	99.9	99.8	100.0	99.9
WDIR098	99.9	99.9	100.0	100.0	100.0
RSWD	99.9	99.9	100.0	100.0	100.0
RSWU	99.9	99.9	100.0	100.0	100.0
RLWD	99.9	99.9	100.0	100.0	100.0
RLWU	99.9	99.9	100.0	100.0	100.0
CLC*2	100.0	100.0	100.0	100.0	100.0
USTAR*1	60.3	62.1	59.7	61.7	59.7
MOM*1	60.3	62.1	59.7	61.7	59.7
HS*1	64.6	65.7	63.3	65.6	63.5
LE*1	50.6	53.8	47.8	52.5	49.8
TSOIL005	99.9	99.9	100.0	100.0	99.8
TSOIL010	99.9	99.9	100.0	100.0	99.8
TSOIL015	99.9	99.9	100.0	100.0	99.8
TSOIL020	99.9	99.9	100.0	100.0	99.8
TSOIL030	99.9	99.9	100.0	100.0	99.8
TSOIL045	99.9	99.9	100.0	100.0	99.6
TSOIL050	99.9	99.9	100.0	100.0	99.8
TSOIL060	99.9	99.9	100.0	100.0	99.8
TSOIL090	99.9	99.9	100.0	100.0	99.8
TSOIL100	99.9	99.9	100.0	100.0	99.8
TSOIL120	99.9	99.9	100.0	100.0	99.8
TSOIL150	99.9	99.9	100.0	100.0	99.8
MSOIL008	99.9	99.9	100.0	100.0	100.0
MSOIL015	99.9	99.9	100.0	100.0	99.5
MSOIL030	99.9	99.9	100.0	100.0	71.1
MSOIL045	99.9	99.9	100.0	100.0	97.2
MSOIL060	99.9	99.9	100.0	100.0	98.1
MSOIL090	99.9	99.9	100.0	100.0	68.7
G005	99.9	99.9	100.0	100.0	99.2
G010	99.9	99.9	100.0	100.0	99.2
SNOW*4	21.5	4.6	3.5	14.3	25.8
SNOWN*4	6.2	3.9	0.0	0.0	0.0

CAB

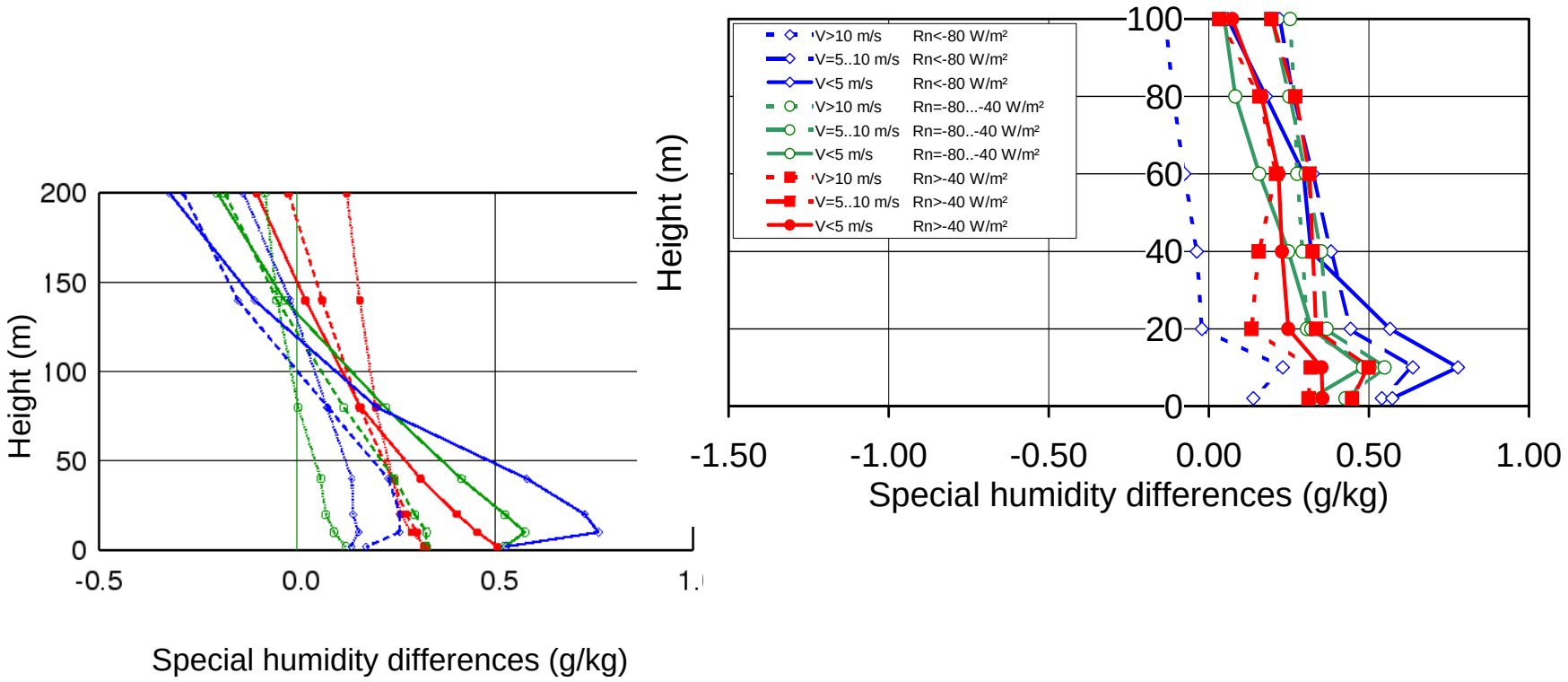
	2006	2007	2008	2009	2010
P0	99.9	99.4	99.9	100.0	98.6
RAIN	99.9	99.3	99.4	100.0	98.8
TAIR002	100.0	99.4	99.9	99.9	96.7
TD002	100.0	99.4	99.9	99.9	94.6
TAIR010	100.0	99.4	99.9	99.9	95.4
TD010	100.0	99.4	99.9	99.9	93.8
WSPEED010	99.3	99.4	99.4	99.9	97.9
WDIR010	99.3	99.4	99.5	100.0	98.0
TAIR020	100.0	99.4	99.9	99.9	97.0
TD020	100.0	99.4	99.9	99.9	95.1
WSPEED020	99.5	99.4	99.8	99.9	98.7
WDIR020	99.5	99.4	99.8	99.9	98.8
TAIR040	100.0	98.0	99.9	97.4	96.9
TD040	100.0	98.0	99.9	93.0	95.2
WSPEED040	99.8	99.4	99.9	99.8	98.3
WDIR040	100.0	99.4	99.9	100.0	98.6
TAIR080	100.0	99.4	99.2	99.9	97.6
TD080	100.0	99.4	97.3	99.9	97.6
WSPEED080	100.0	99.4	99.7	99.9	98.7
WDIR080	100.0	99.4	99.7	100.0	98.7
TAIR140	99.8	99.4	98.6	99.9	94.8
TD140	100.0	99.4	99.8	99.9	94.1
WSPEED140	100.0	99.4	99.8	99.8	98.6
WDIR140	100.0	99.4	99.9	100.0	98.6
TAIR200	99.4	97.8	95.4	99.1	95.9
TD200	99.8	98.6	95.7	99.1	96.9
WSPEED200	99.8	99.4	99.8	100.0	98.1
WDIR200	100.0	99.4	99.8	100.0	98.6
RSWD	100.0	94.4	99.9	99.9	98.5
RSWU	99.5	98.2	99.8	100.0	98.5
RLWD	100.0	96.3	97.5	99.2	98.5
RLWU	100.0	96.3	97.5	99.2	98.5
CLC*2	99.0	98.8	98.3	77.5	98.5
USTAR	83.3	88.7	88.9	89.8	90.9
MOM	83.2	88.7	88.8	89.7	87.8
HS	90.6	65.1	93.1	95.0	96.1
LE	73.7	64.8	59.3	64.7	67.6
TSOIL000	100.0	90.3	99.5	100.0	96.4
TSOIL002	100.0	98.1	99.5	100.0	96.4
TSOIL004	100.0	98.1	99.5	100.0	96.4
TSOIL006	0.0	7.8	0.0	0.0	2.8
TSOIL008	100.0	90.3	99.5	100.0	96.4
TSOIL012	100.0	98.1	99.5	100.0	96.4
TSOIL020	100.0	98.1	99.5	100.0	96.4
TSOIL030	100.0	98.1	99.5	100.0	96.4
TSOIL050	100.0	98.1	99.5	100.0	96.4
MSOIL008	100.0	98.1	99.5	100.0	95.4
G00	100.0	95.0	97.8	97.0	96.0
G005	100.0	97.9	99.5	100.0	96.4
G010	100.0	42.8	0.0	0.0	96.4

SBL structure Lindenberg vs. Cabauw: Temperature

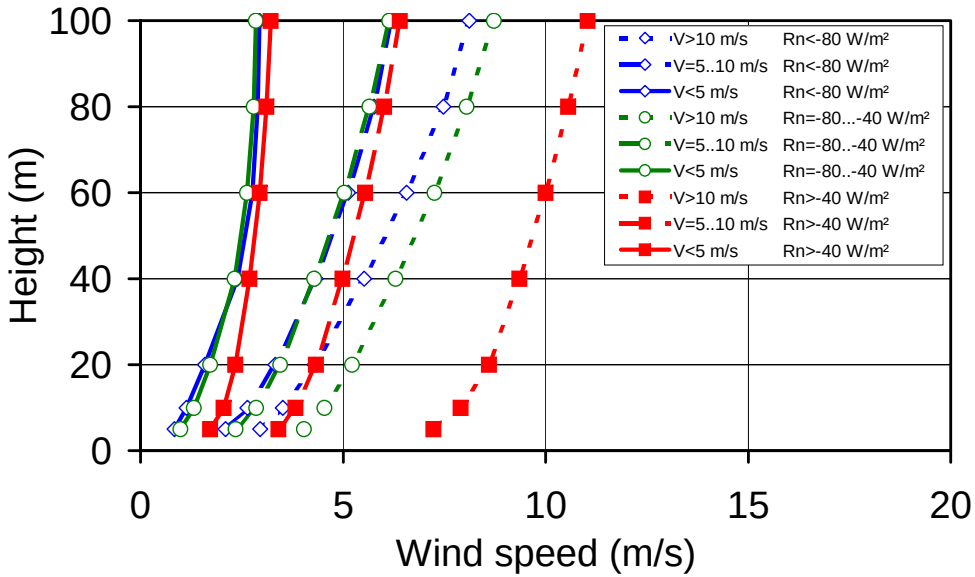


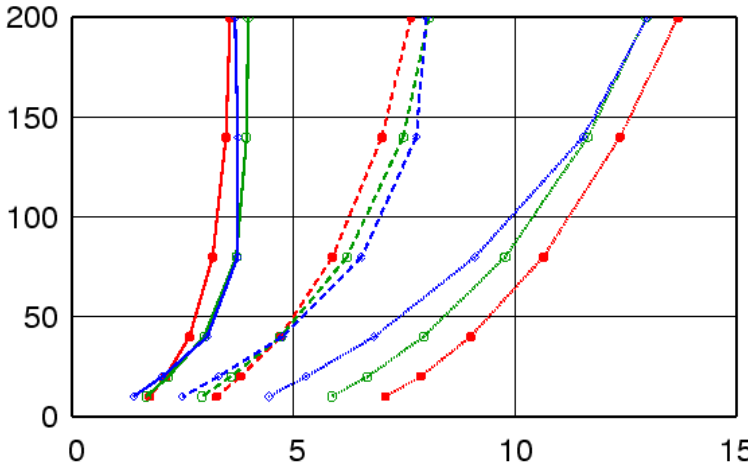
GABLS activity

SBL structure Lindenberg vs. Cabauw: Humidity



SBL structure Lindenberg vs. Cabauw: Wind speed





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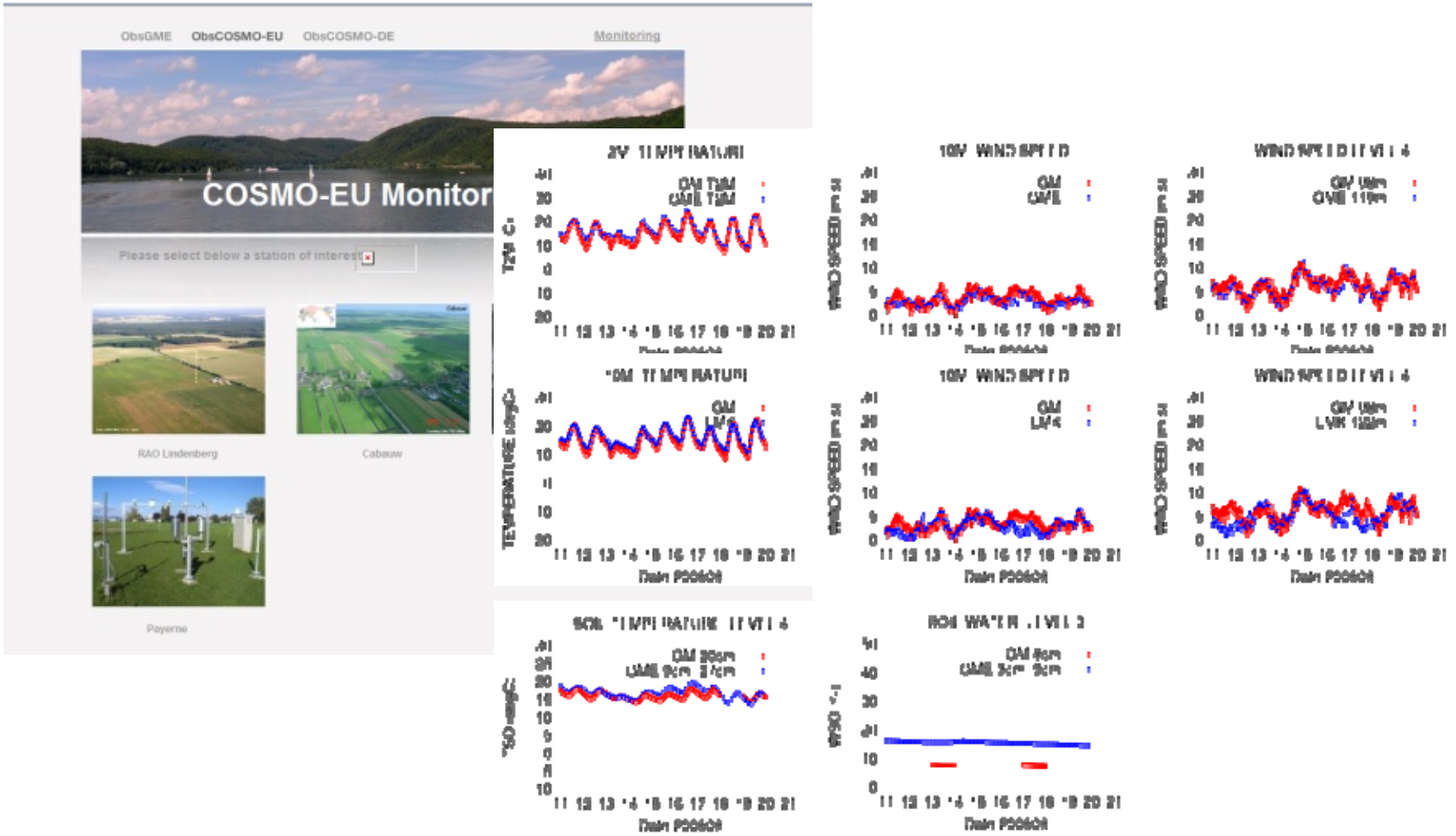
Wetter und Klima aus einer Hand

Daily Operational Model Validation at DWD



model validation – SCM

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

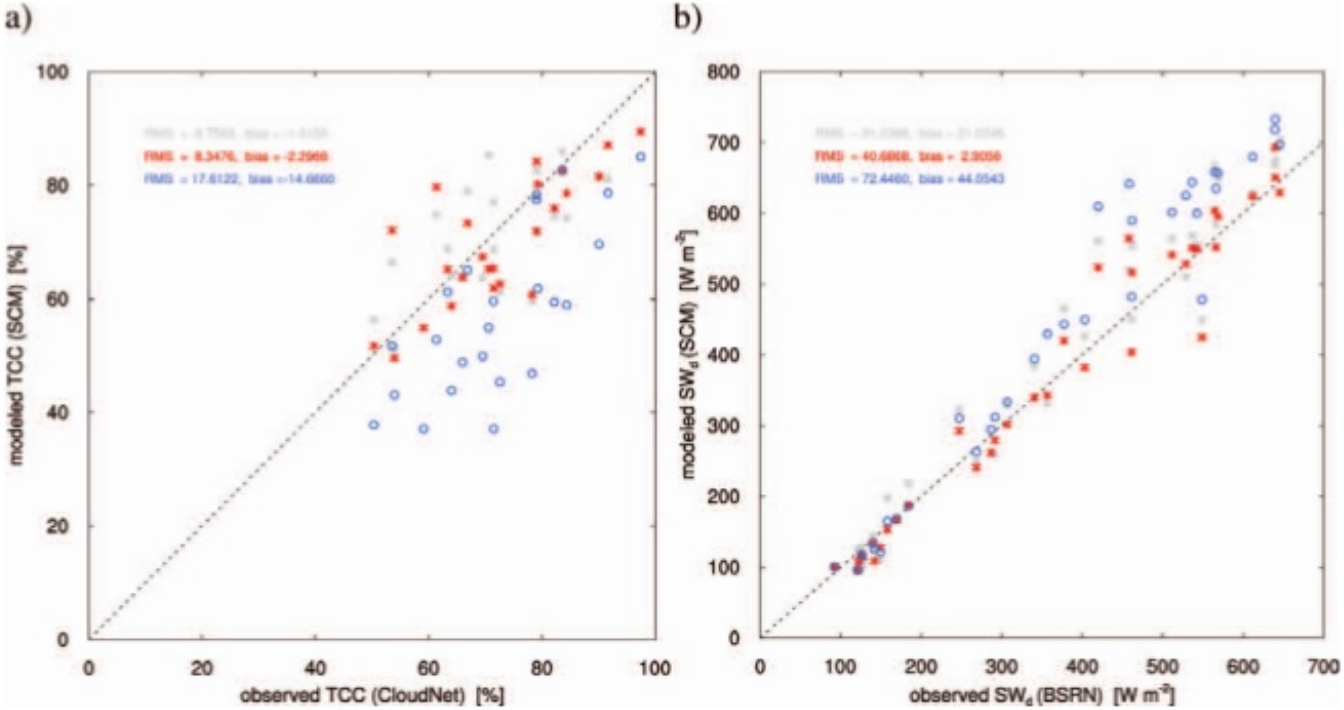


FIG. 5. Scatterplots of monthly-mean Cabauw observations (abscissa) against equivalent model results (ordinate) at 1200 UTC for the period 2007–09. (a) Total cloud cover (TCC), including the CloudNet column Ca product. (b) Downward shortwave radiation at the surface (SW$_d$), including measurements by the Baseline Surface Radiation Network (BSRN) station. Gray represents the GCM, red represents its SCM, and blue represents its SCM with a different boundary layer scheme. The annotations indicate the root-mean-square error (rmse) and the bias of each model relative to the diagonal.

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model validation – ECMWF

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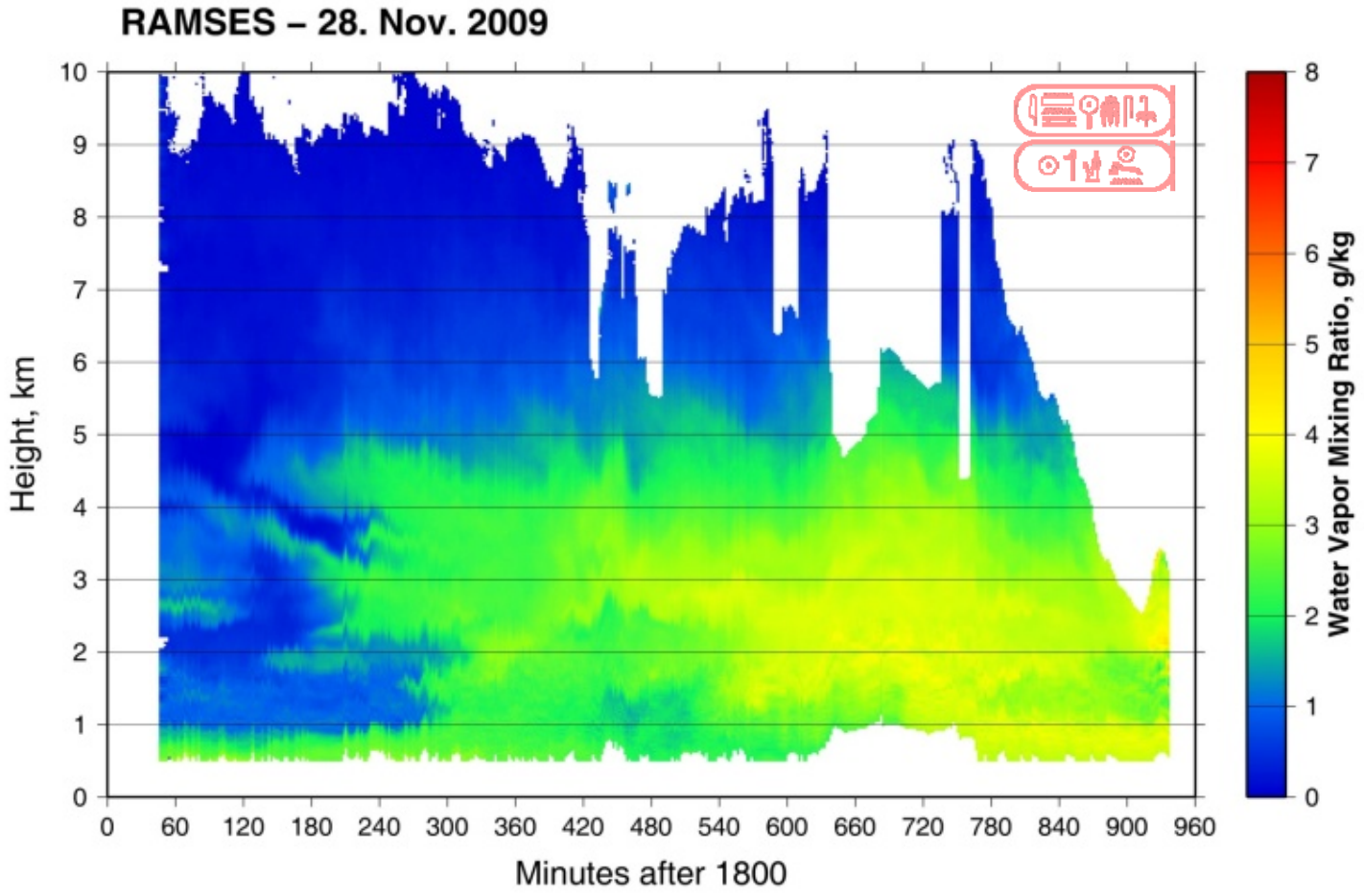
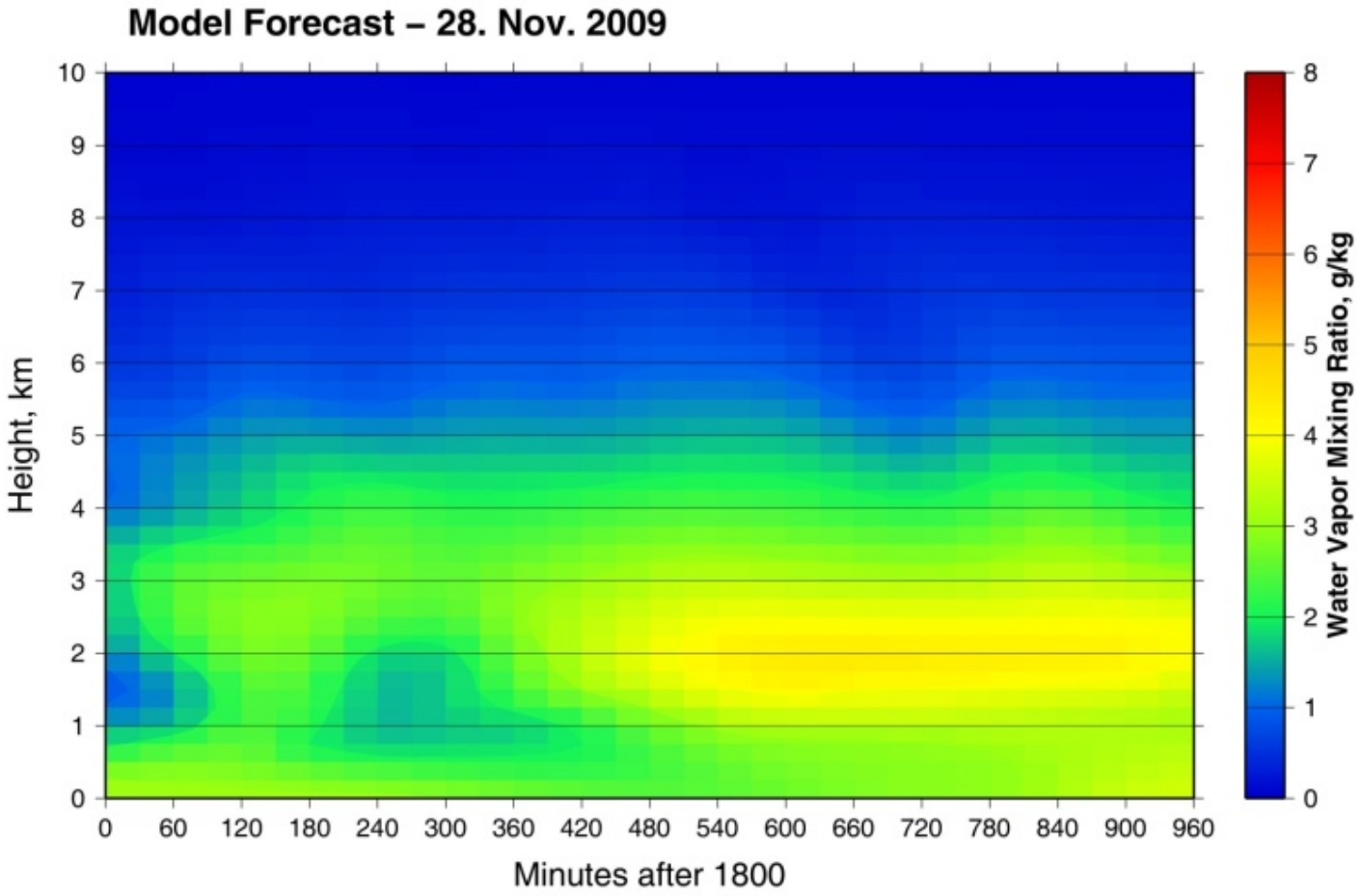
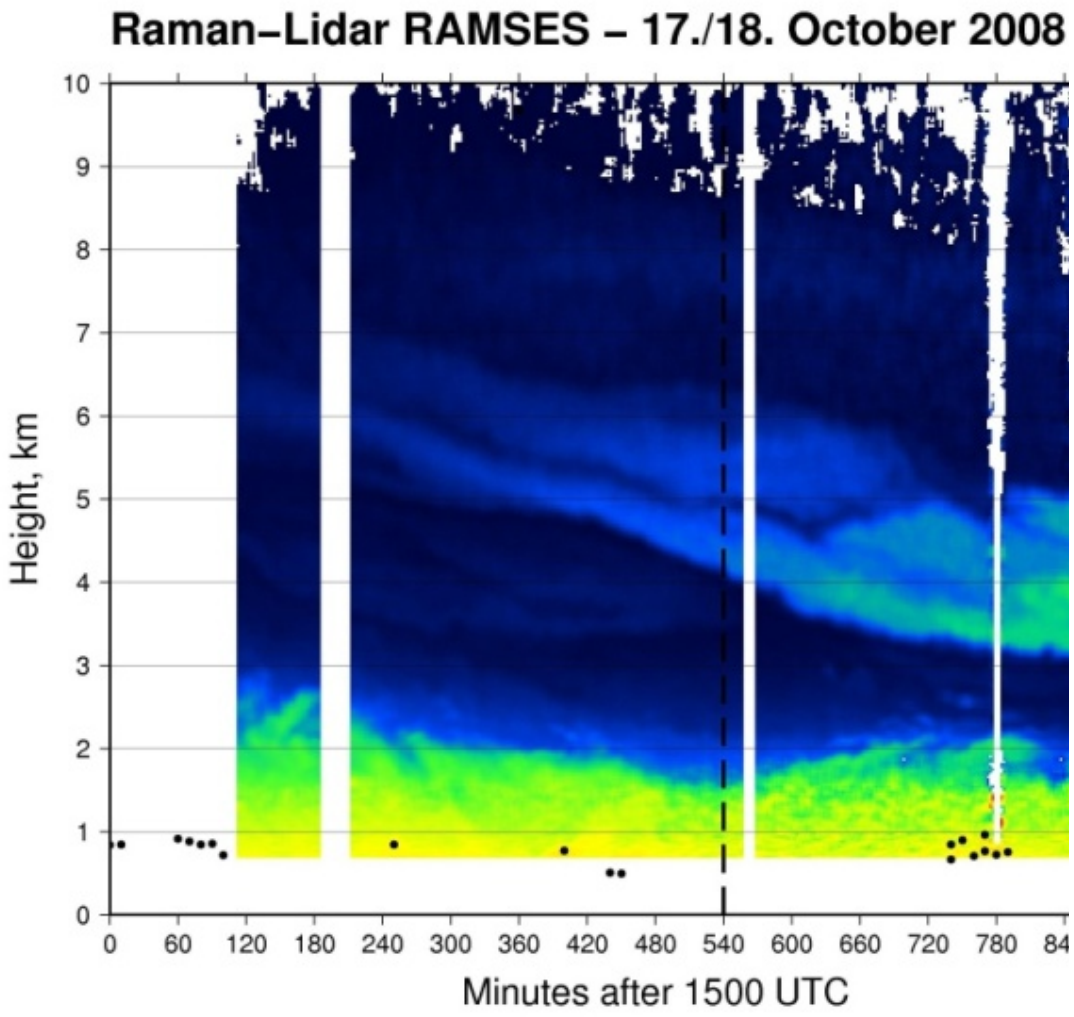
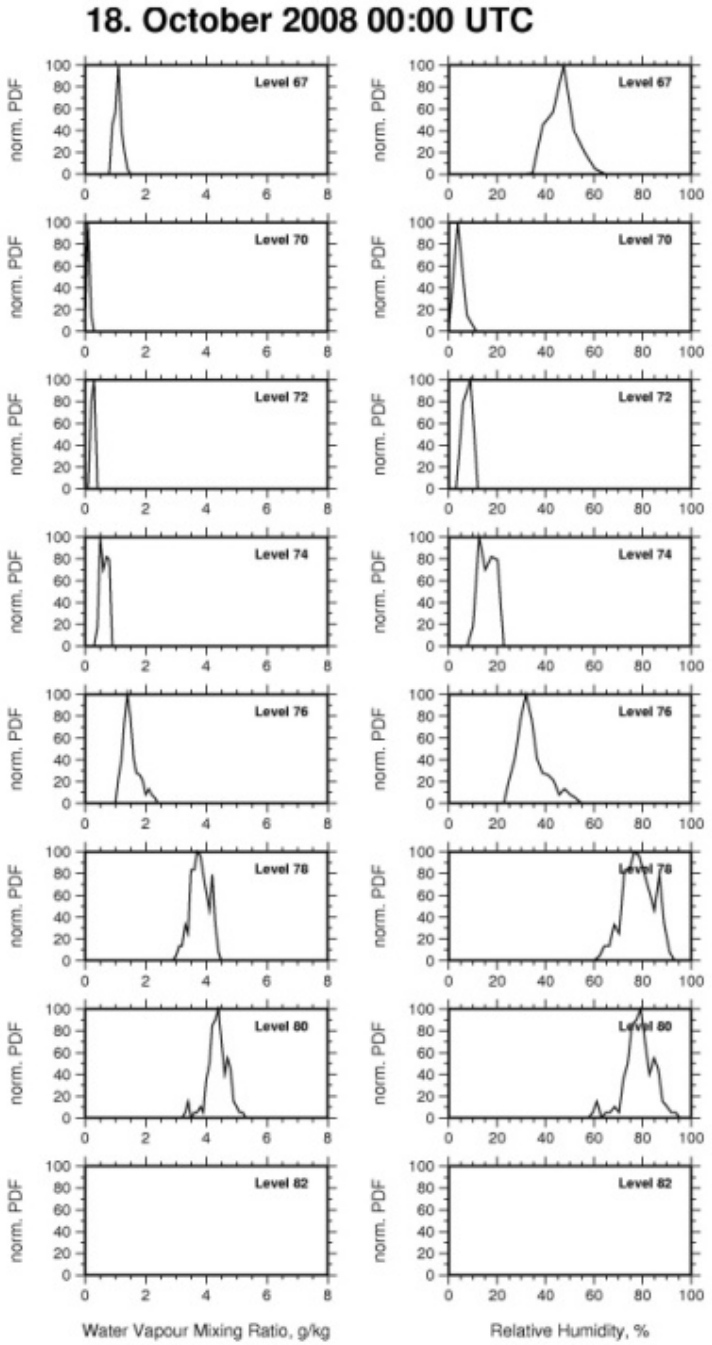



Model Forecast – 28. Nov. 2009
Height, km
Minutes after 1800
Water Vapor Mixing Ratio, g/kg
0
1
2
3
4
5
6
7
8
9
10
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960


Raman–Lidar RAMSES – 17./18. October 2008
Height, km
Minutes after 1500 UTC


18. October 2008 00:00 UTC
Level 67
Level 70
Level 72
Level 74
Level 76
Level 78
Level 80
Level 82
norm. PDF
Water Vapour Mixing Ratio, g/kg
Relative Humidity, %

Future Needs

- **Process oriented 3D / 4D long-term monitoring – at various spatial and temporal scales** – including conventional networks – to quantify atmosperic processes in larger domains

- measurement uncertainties for all products (reference product) – e.g. to ensure best possible satellite evaluation

- 3D/4D: synergy of surface, in situ, and remotely sensed observation (from space and surface)

- optimized and coordinated activities (model and observation) to improve forecast accuracies

joint network

of

reference sites

& additional sites in western & eastern Europe

Network of observatories operated by

- **Research Institutes:** Chibolton, Palaiseau, Potenza, Leipzig, Mace, Jülich, Kit Cube
- **Meteor. Services:** Lindenberg, Payerne Sodankylä
- **Meteor. Services / Research Institutes:** Cabauw (CESAR)

Primary Goals:

- harmonised analysis techniques
- common QA/QC procedures
- optimized data exchange
- real-time use for data assimilation

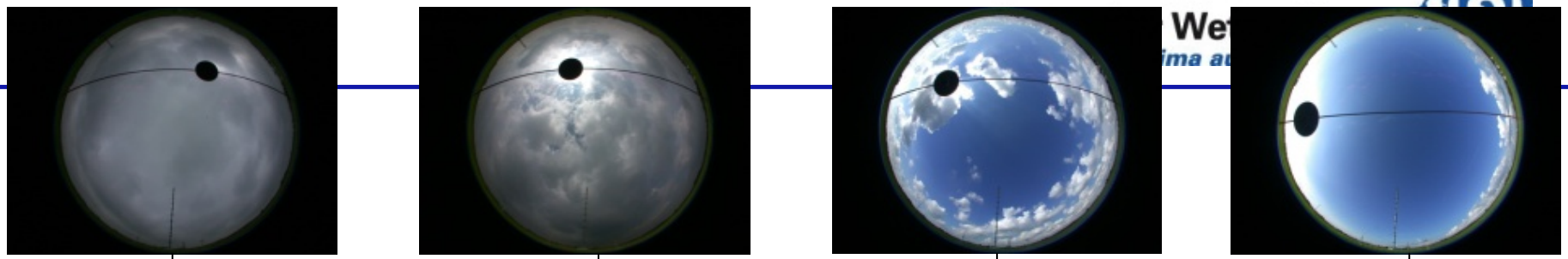
➔ use for NWP and climate scenarios
➔ to prepare a detailed data base for future research activities
➔ efficient use of resources

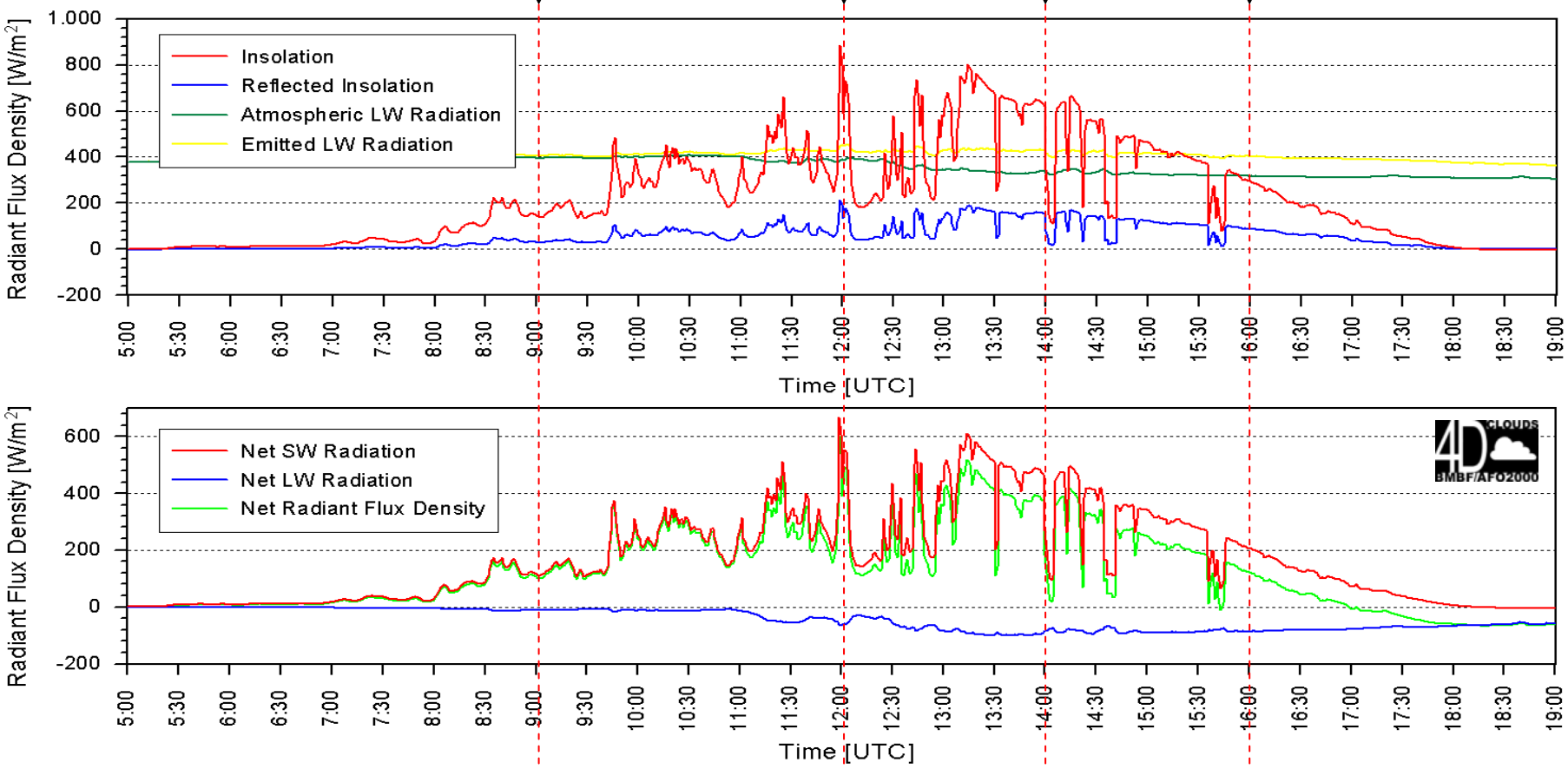
my first Cabauw measurements

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

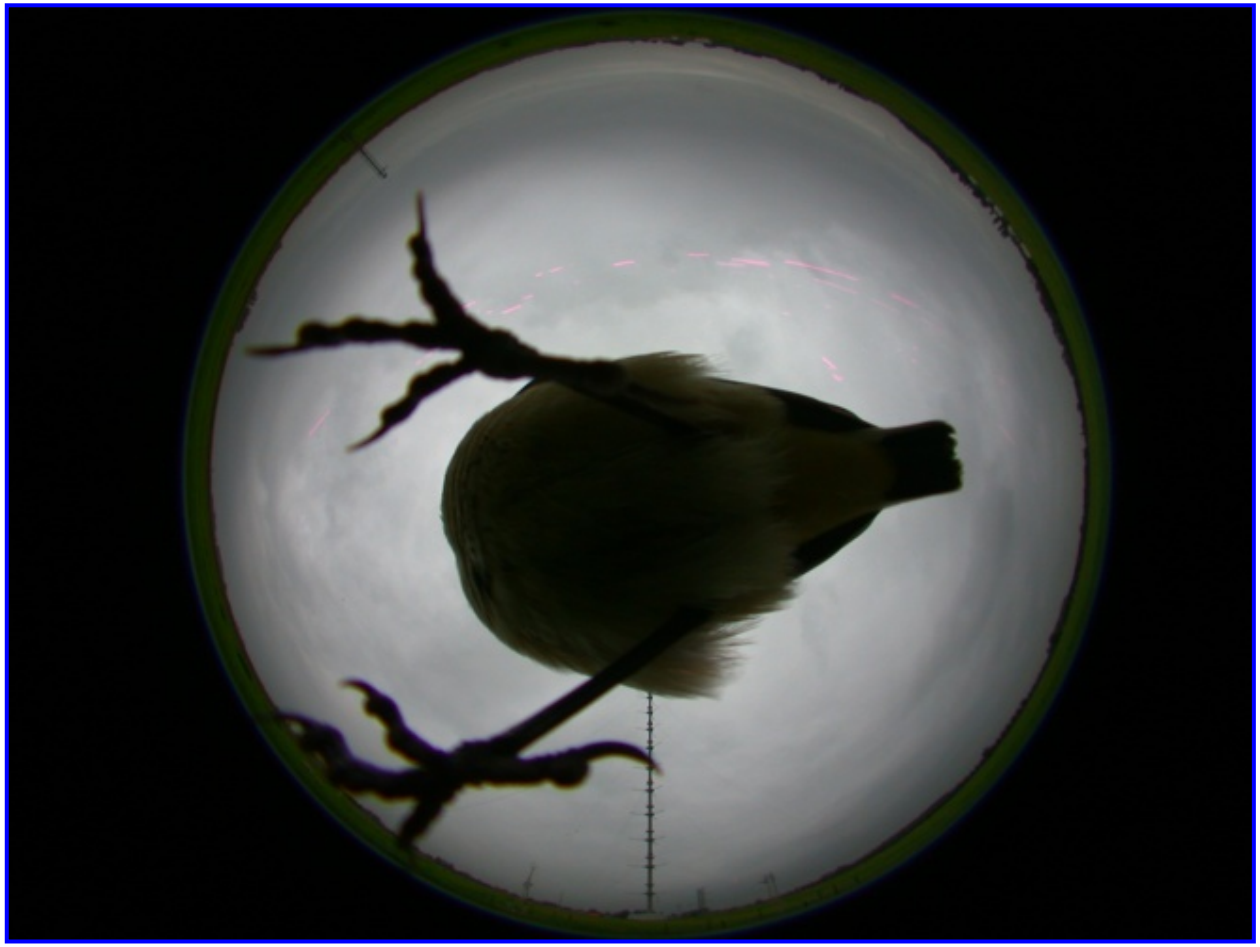
Clouds & Radiation

9.01 UTC 12.01 UTC 14.00 UTC 16.00 UTC





Clouds & Radiation & Birds



Thank you!