

# Radiometry at the German Weather Service: Networks, methods and outcomes

Stefan Wacker, Ralf Becker, Lionel Doppler



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- Who/Where
- Methods
- Results



DWD – BSRN station and Regional Radiation Center WMO at Meteorological Observatory Lindenberg

## DWD – 2021

- Available budget: approx. 211 million euros
- Investments: close to 41.5 million euros
- **Approx. 2200 staff members < 10 in radiometry**

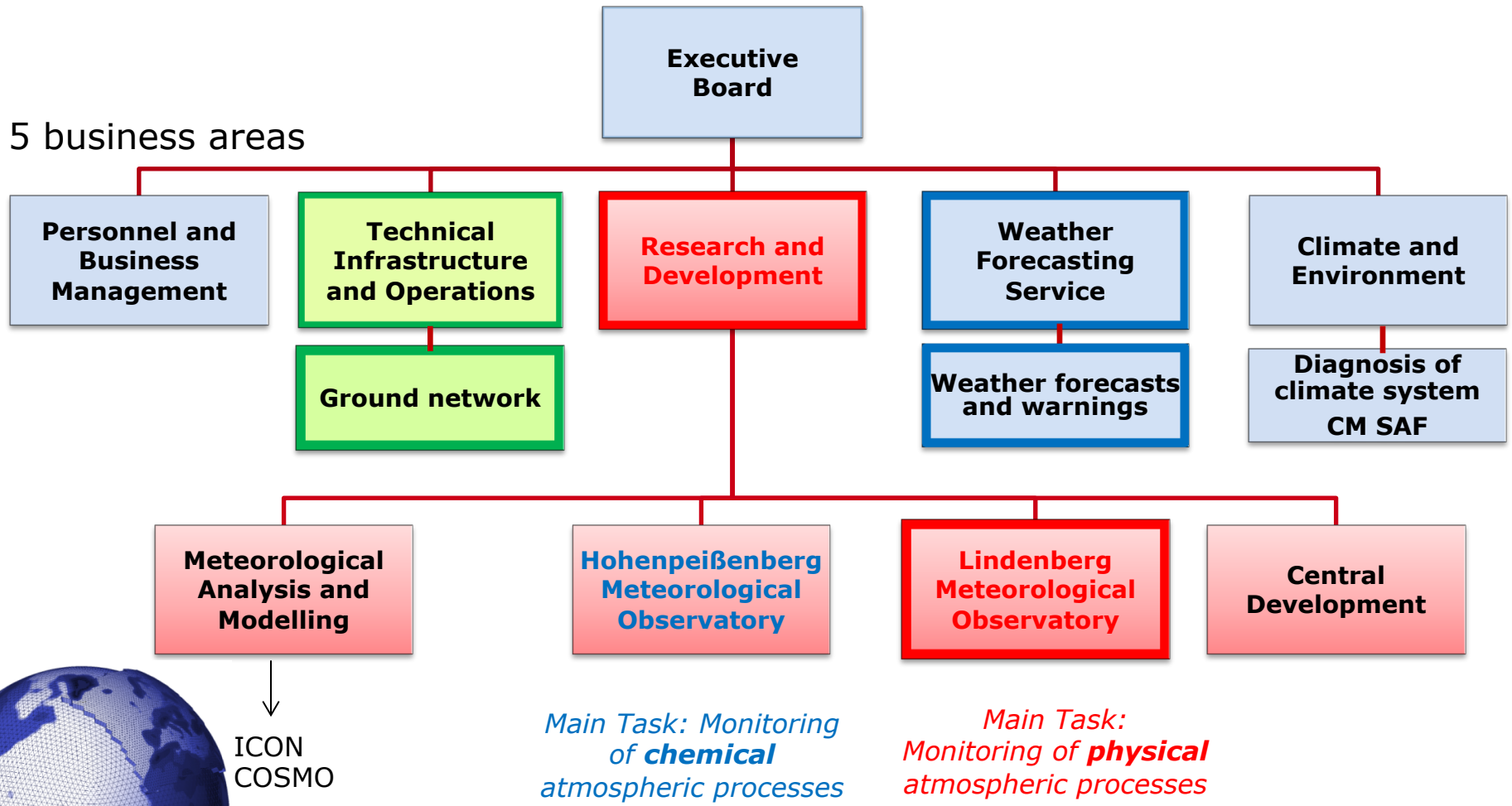


DWD – Headquarters Offenbach

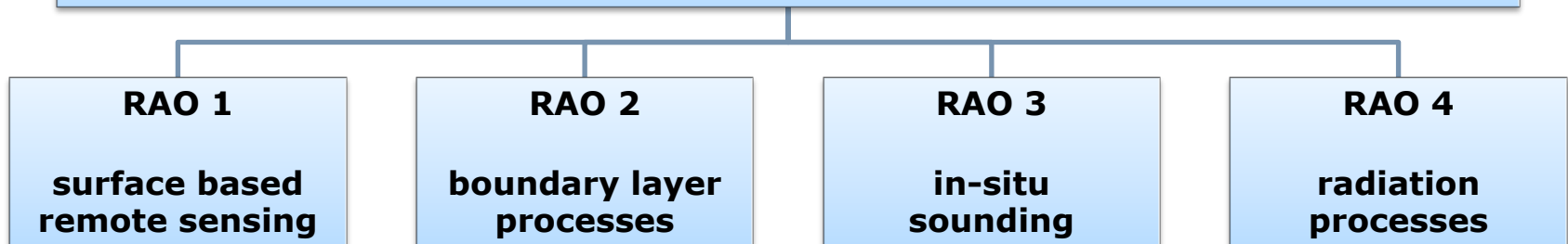
- **Headquarters** in Offenbach am Main
- **6 major branch offices** (Hamburg, Potsdam, Leipzig, Essen, Stuttgart, Munich), some with more than 100 staff members
- **5 regional climate offices** providing consultancy services in the field of climate and environment
- **181 main weather stations** (164 fully automated, 15 aeronautical met. stations at intern. Airports)
- 1737 secondary weather and precipitation stations
- Phenological stations, upper air stations, shipboard weather stations, moored buoys (North/Baltic sea)
- About 90,000 forecasts and about 200,000 weather and severe weather warnings

[https://www.dwd.de/SharedDocs/downloads/EN/general/facts\\_figures.pdf?blob=publicationFile&v=5](https://www.dwd.de/SharedDocs/downloads/EN/general/facts_figures.pdf?blob=publicationFile&v=5)

# DWD - organigram



## Meteorological Observatory Lindenberg – Richard Assman Observatory



Furthermore, MOL-RAO is a reference climate site & has 24 hours weather station

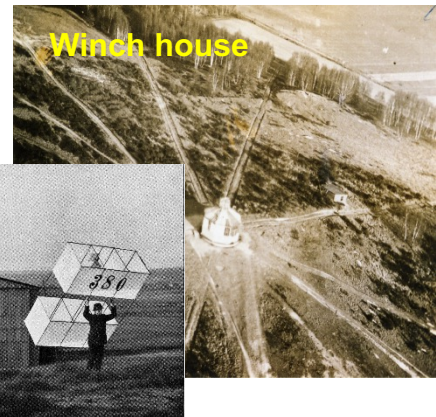
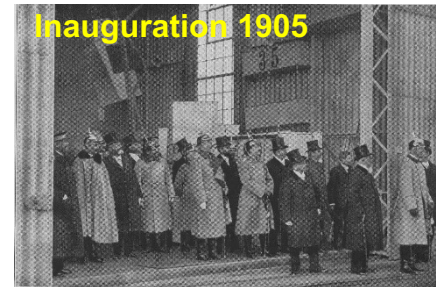
- 1. operation / maintenance of various ground based instruments**
- 2. Calibration services**
- 3. quality assurance / quality control**
- 4. updating & application of improved measuring techniques**
- 5. data analysis and interpretation**

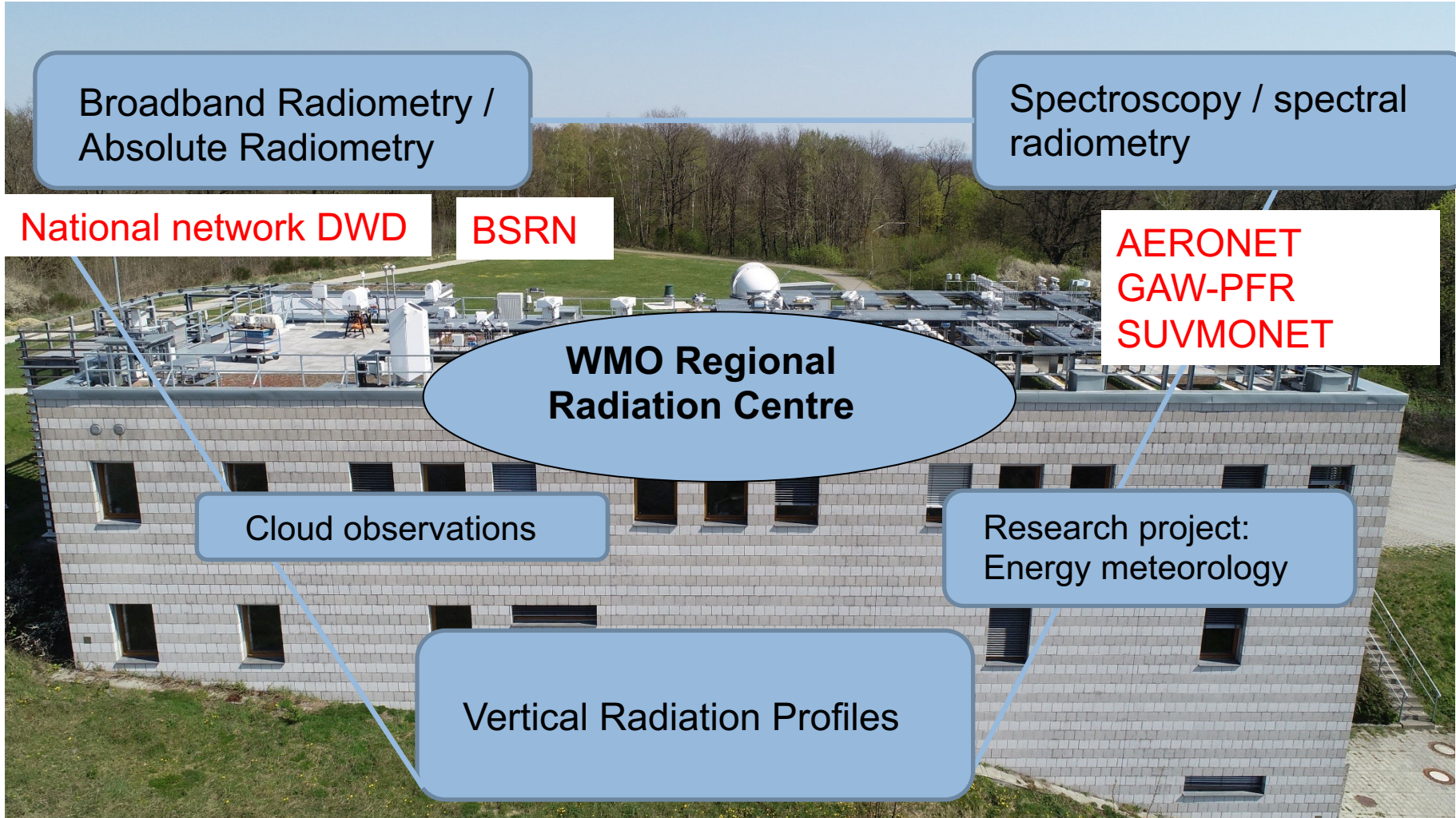


25 scientists, 6 engineers, 40 technicians

## Brief historical overview: MOL-RAO

1893	<b>First radiation measurements</b> at Potsdam Observ.
April 1905	first tethered balloons, kite
October 1905	inauguration ceremony MOL-RAO (emperor Willh. II)
April 1911	introduction of a first air traffic warning system
August 1919	Kite – World record (9750m)
since 1930	development of a radiosonde system
since 1947	routine radiosonde launches (4x daily)
since 1992	surface based remote sensing
since 1994	ABL measurements (GM Falkenberg)
<b>1994</b>	<b>BSRN station</b> Lindenberg
<b>2003</b>	Shut down Potsdam observatory (radiation) MOL-RAO: <b>WMO regional radiation centre</b>
since 2008	GRUAN Lead Centre
since 2011	WMO/CIMO Testbed

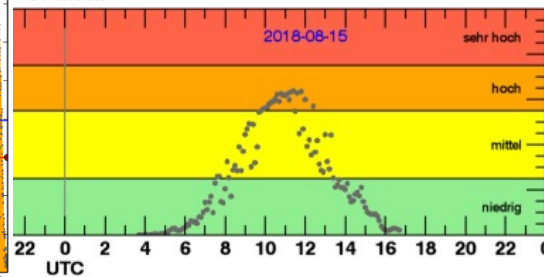
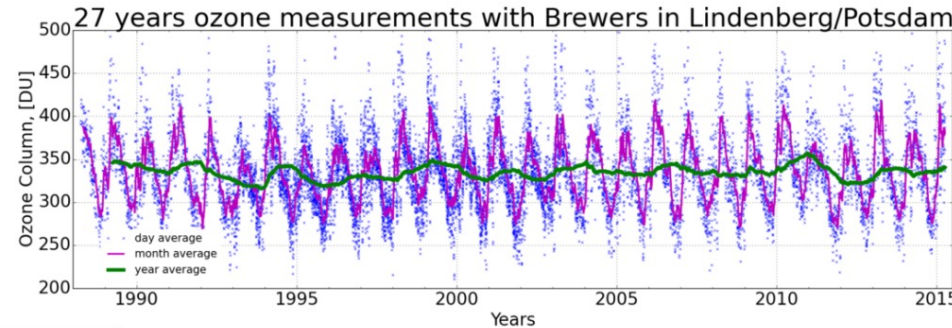
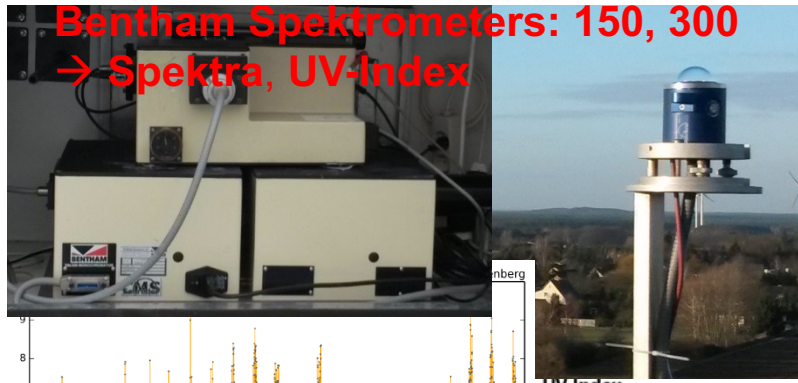




# Spectroscopy at MOL-RAO: UV-radiation

3 Brewer spectrometers  
1 Dobson

- Observation of UV-radiation (→ spectras and UV-index)
- Long-term observation of ozone column



sUVMoNet – UV network of the federal agency of radiation protection

contact: [lionel.doppler@dwd.de](mailto:lionel.doppler@dwd.de)





# Spectroscopy (visible and near infrared)

- Array detector spectroradiometers: Direct and global **spectral irradiance** (UV – near infrared)



Berlin



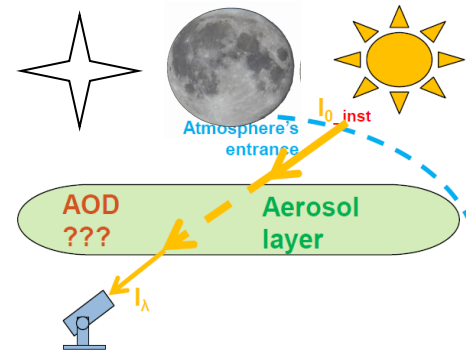
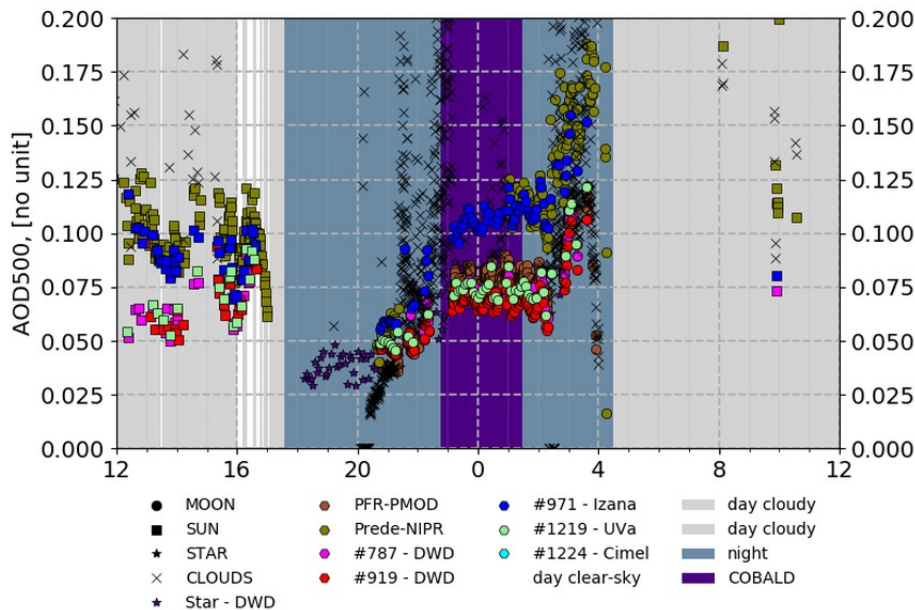
Precision spectrometer (PSR, 300-1020 nm)



SPJ-1009 (300-1700 nm)

contact: [lionel.doppler@dwd.de](mailto:lionel.doppler@dwd.de)

➔ Observation of the AOD and aerosol optical properties during day and night



contact: [lionel.doppler@dwd.de](mailto:lionel.doppler@dwd.de)

→ **National AOD network: „Zugspitze-Zingst Messtrasse“**

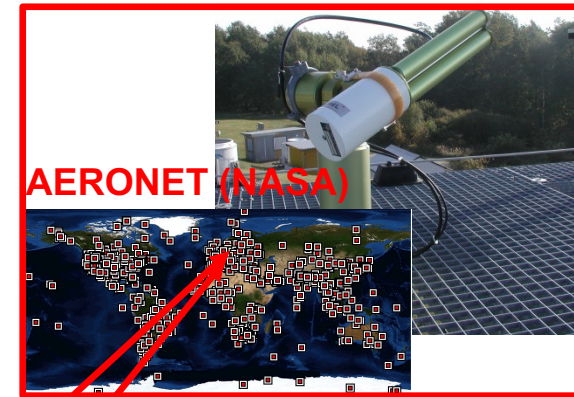
→ Contribution to international **networks**

→ **WMO: GAW-PFR**

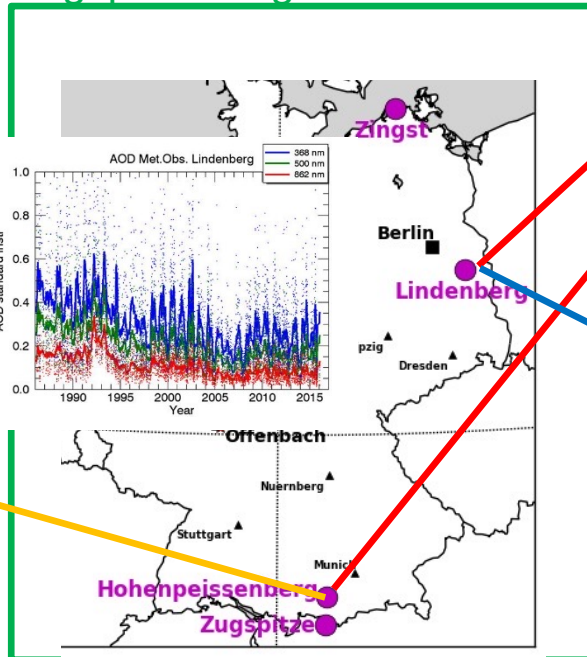
→ **AERONET (NASA)**

→ **Euroskyrad / SKYNET**

CIMEL



Zugspitze-Zingst network



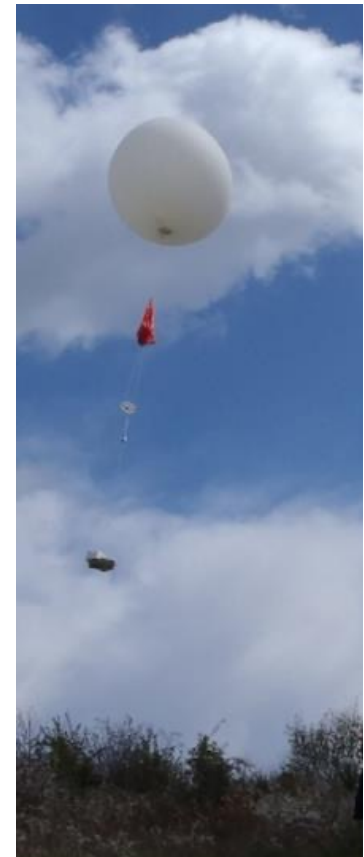
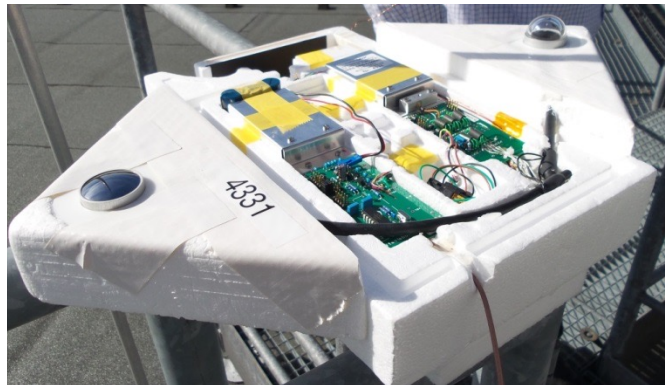
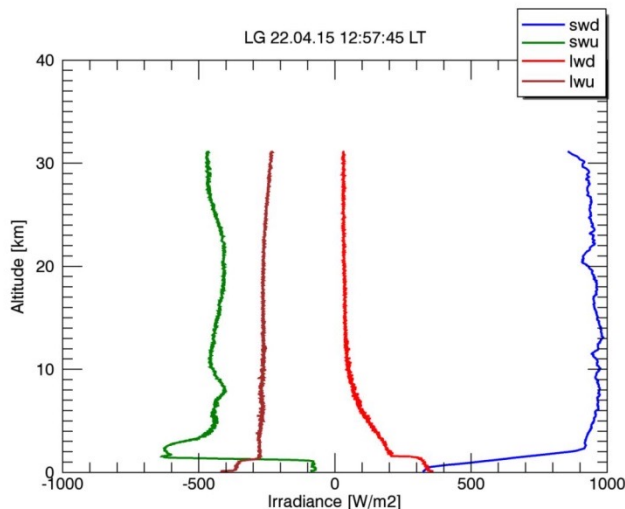
Euroskyrad



# Solar and thermal radiation profiles through the atmosphere

- ➔ Radiosonde ISOLDE (Irradiation SOunding LinDEnberg)
- ➔ Determination of down-welling and upwelling short- and long-wave radiative flux profiles up into the stratosphere once a month

MOL is currently the only site worldwide where vertical radiation profiles are measured using radiosondes

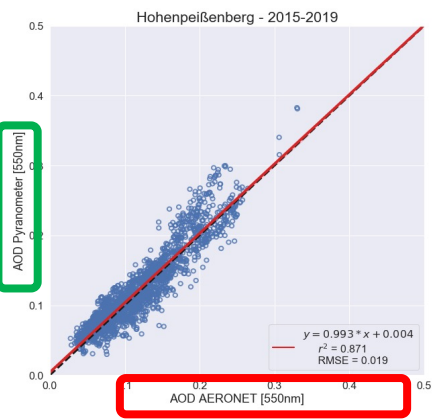
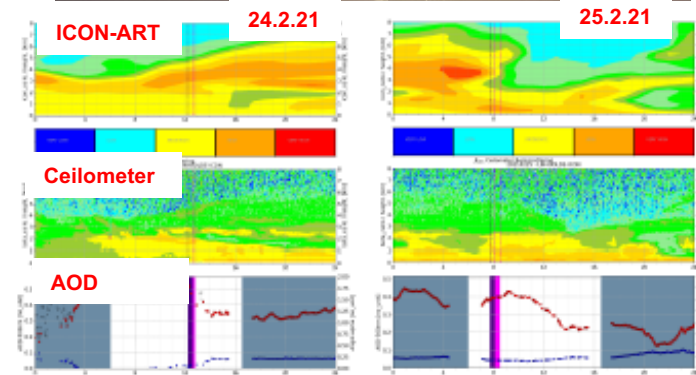


contact: [ralf.becker@dwd.de](mailto:ralf.becker@dwd.de)

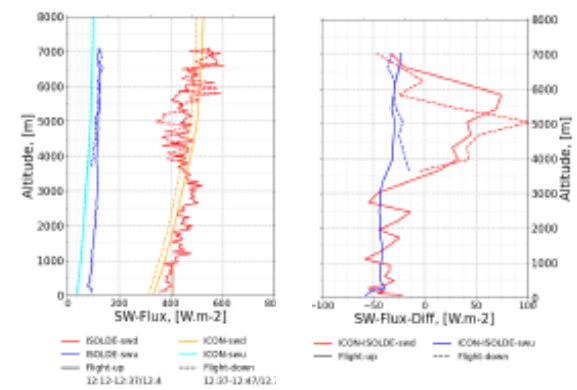
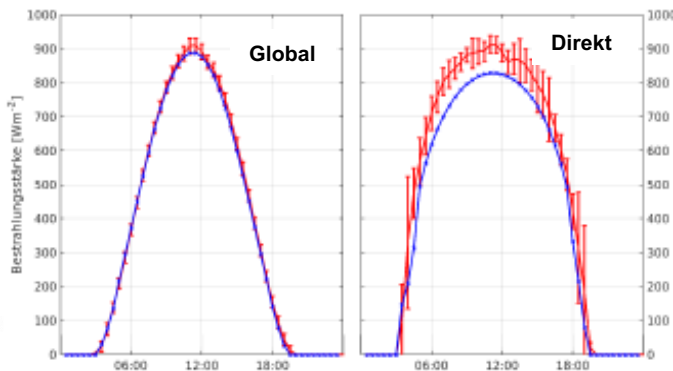
Joint project **PerduS/Permastrom**: DWD – KIT –  
Meteocontrol GmbH (2016-2024)

- ➔ Improving the German PV production prediction through an improved ICON-ART prediction for specific weather conditions (e.g., Saharian dust events, aerosol from wildfires...)
- ➔ Validation study: radiation, aerosols and clouds
- ➔ Determination of spectral AOD from broadband global and diffuse observation using lookup tables and „Optimal Estimation“ Retrieval method

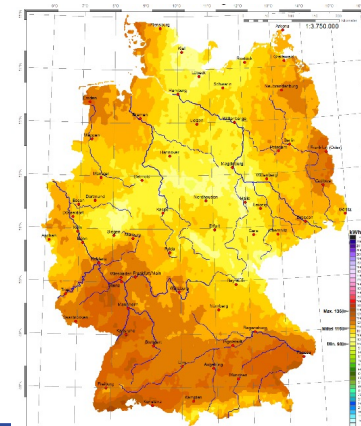
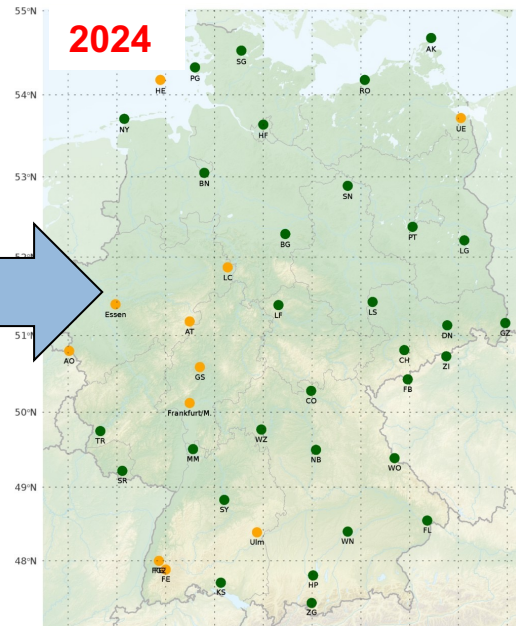
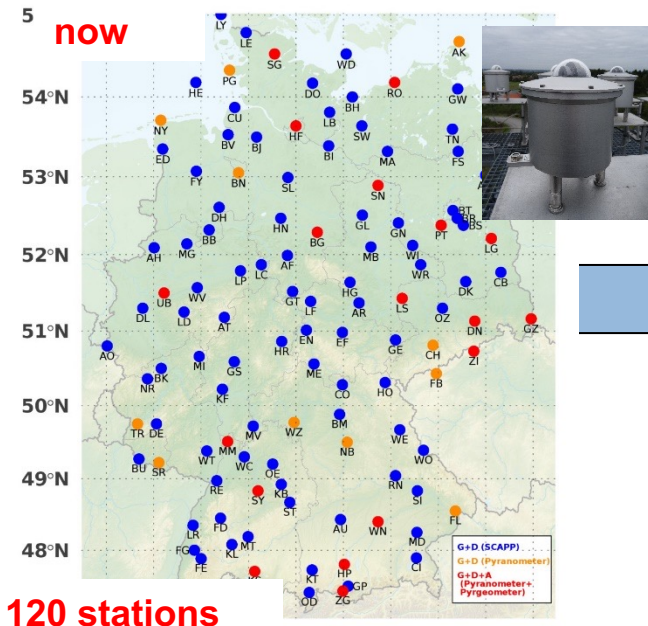
Saharian dust over  
Oder river, 25.2.2021  
Source: ISOLDE



Underestimation of direct radiation (UVSPEC\_NOW) due to applied AOD climatology

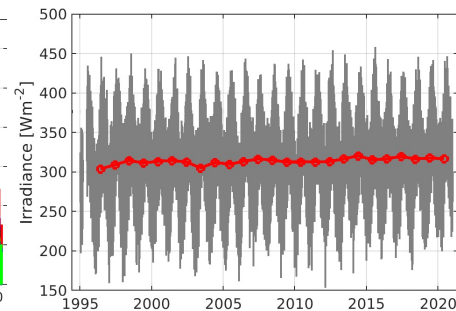
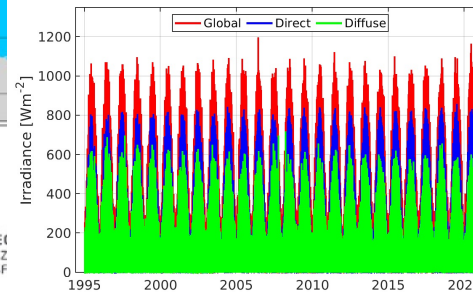
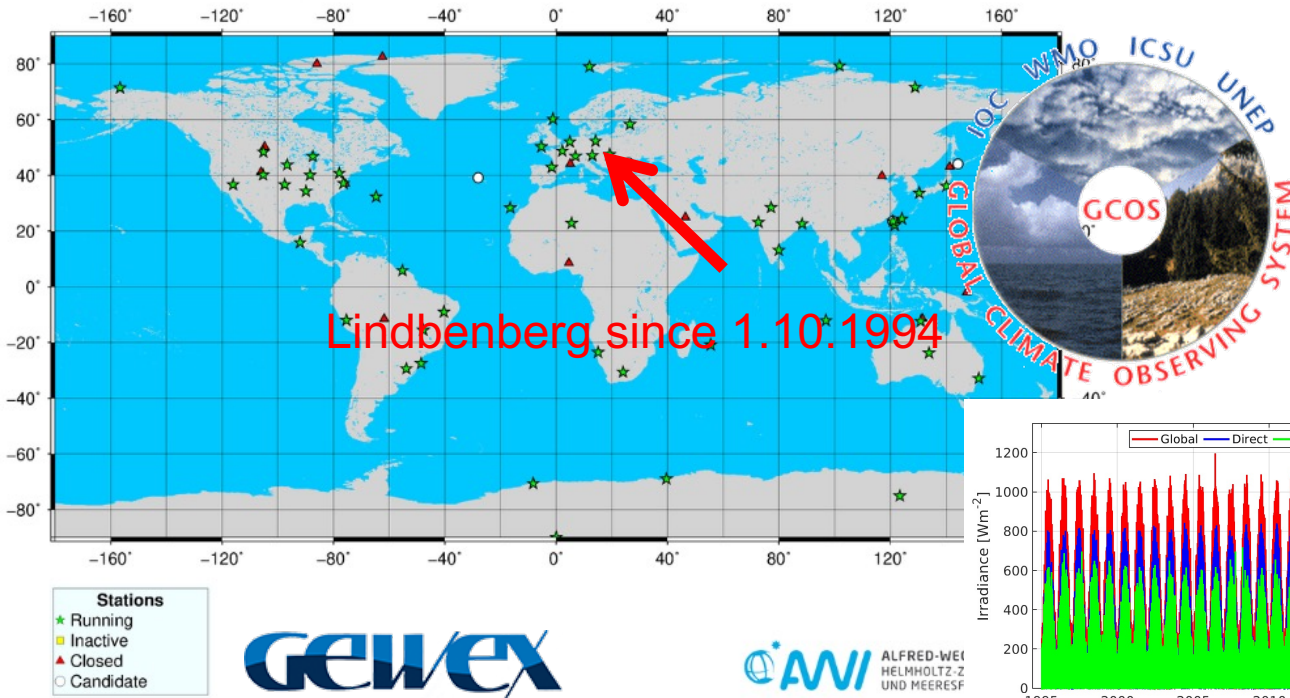


- ➔ Broadband radiation (solar and terrestrial) in the ground network of DWD since 1937
  - Stations are maintained by TI
  - Calibrations are conducted by MOL/RAO (every second year)
  - Support by MOL-RAO (Technical, quality control...)
- ➔ Reduction in number of stations to 42 until 2024
- ➔ Combination of satellite products with ground-based observations



## BSRN station at Lindenberg

Running, inactive, planned and closed BSRN Stations, May 2021



Continuous and redundant high precision observations of broadband downwelling short-wave (direct, diffuse, global) and long-wave radiation since 1994

# Regional and National Radiation Centre WMO (RA VI)

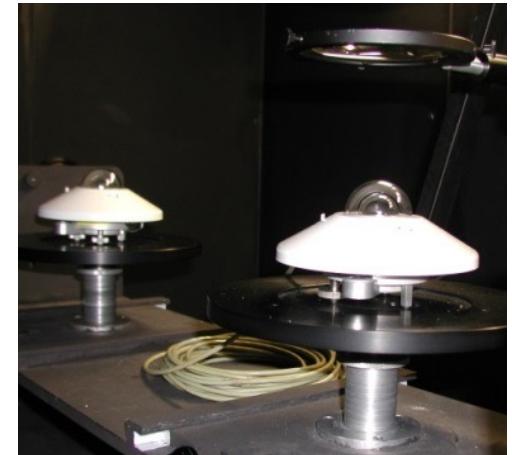
## Solar

DWD primary standard



- In situ calibration of pyrheliometers and (BSRN) pyranometers in front of the sun according to ISO 9059 and ISO 9846
- Calibration of network pyranometers in the laboratory according to ISO 9847

## Laboratory



## Thermal

- Night calibrations of network pyrgeometers under the sky using  $k_1=0$ ,  $k_2=1$  and  $k_3=0$
- Reference pyrgeometers traceable to WISG





# Solar Absolute Radiometry at MOL-RAO

MetObs Potsdam

1907



PMO6-811103 1982

1978/1982

MetObs Hamburg:  
PMO6-4/PMO6-5, 1 HF, 2 AHF



**2003**

MOL-RAO: Regional/National Radiation  
Centre WMO, Region VI

**2004/2006**

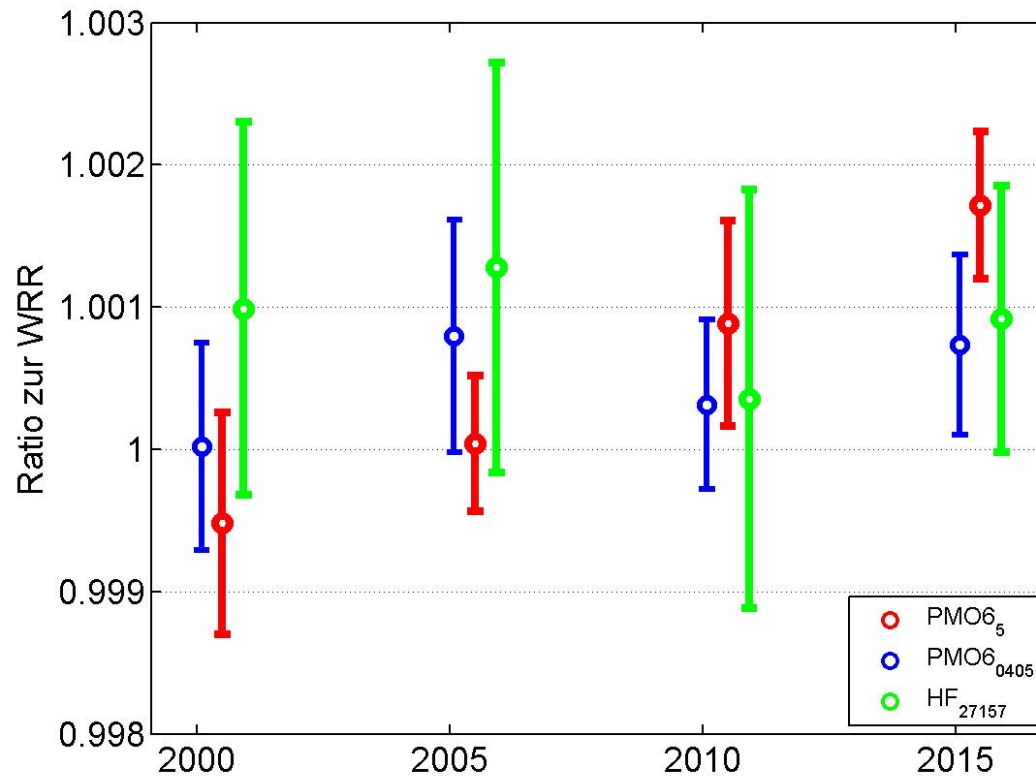
Control unit PMOcc: every 120 s irradiance  
New head for PMO6-811103 → PMO6 0405

**2019**

Control unit „Linard“: every 30 s irradiance



## Results from the four last IPC

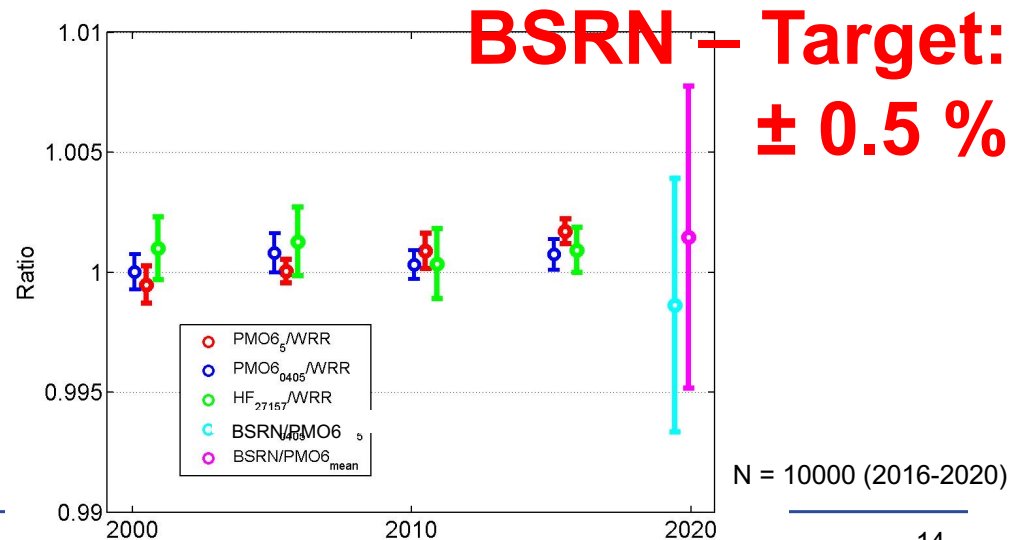
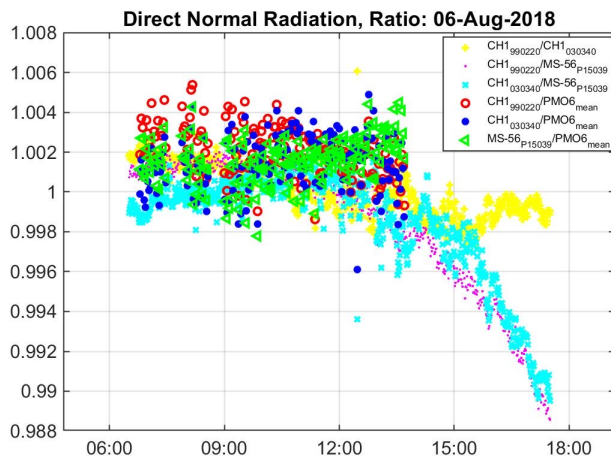
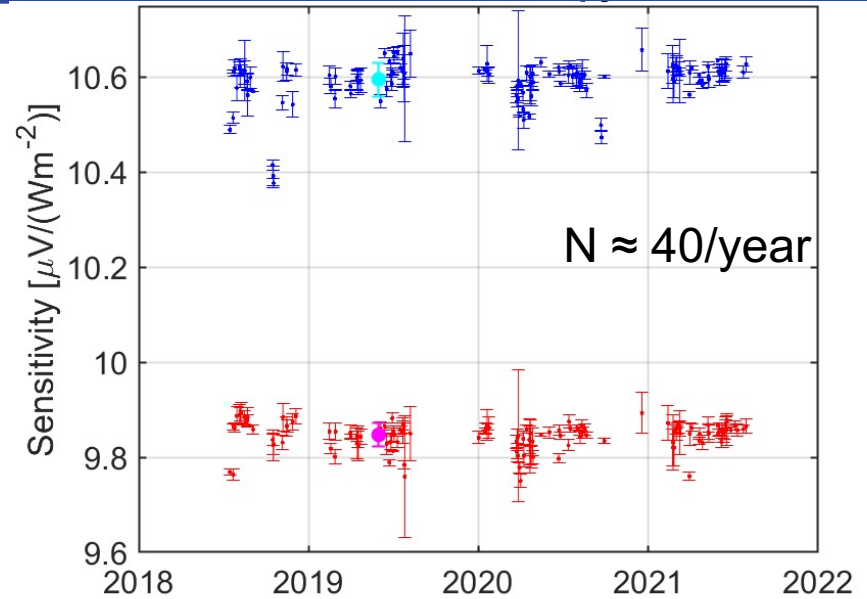


Errorbars: one standard deviation



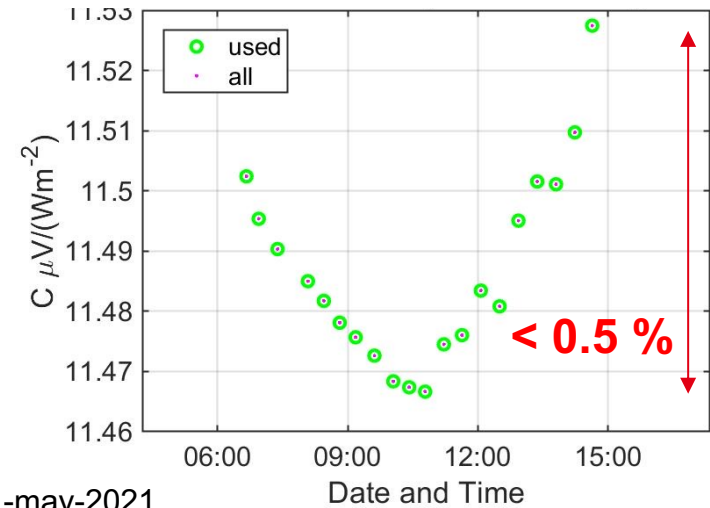
# Solar Absolute Radiometry at MOL-RAO

In situ calibration of BSRN pyrheliometers with respect to PMO6

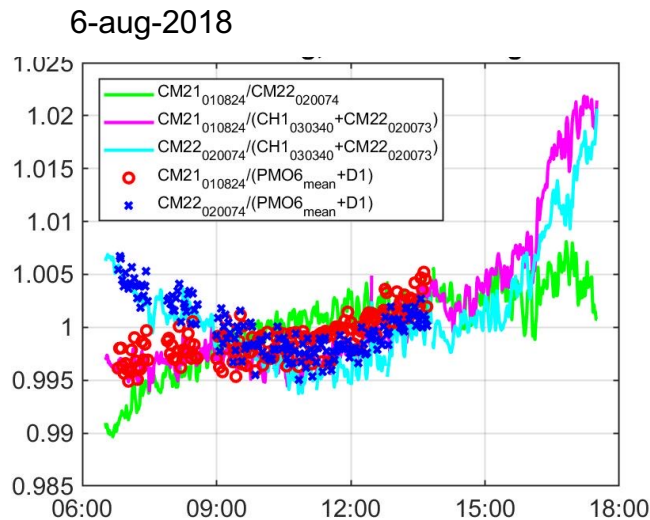
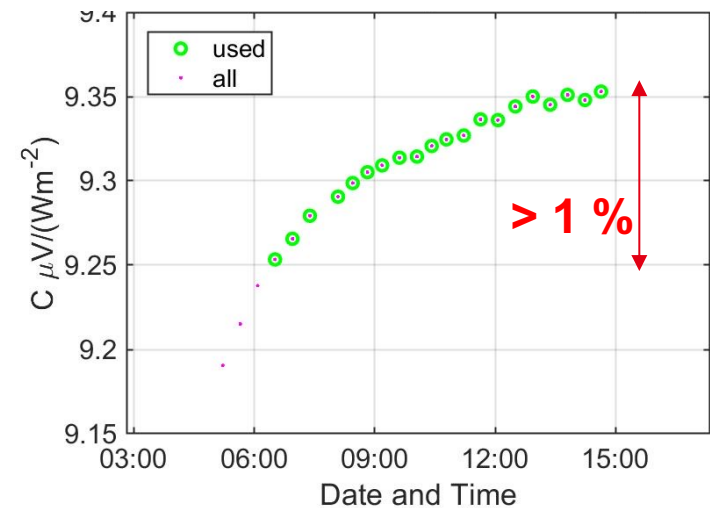


# Solar Absolute Radiometry at MOL-RAO

In situ calibration of BSRN pyranometers with respect to PMO6 and REFdiffuse (continuous sun-shade method)



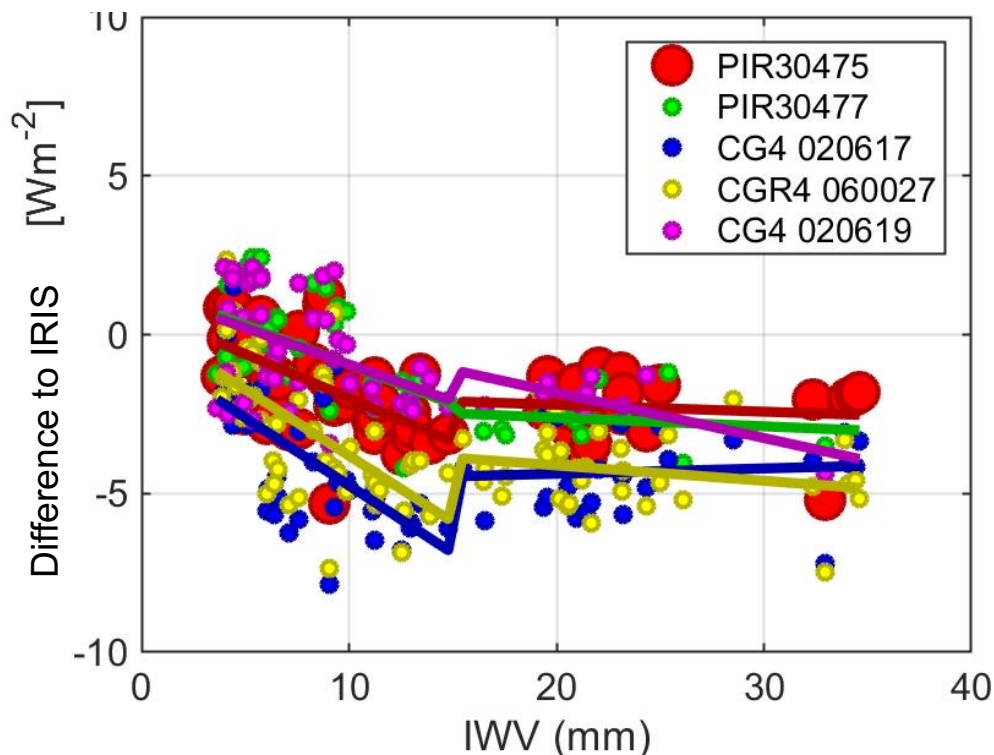
31-may-2021



# Additional long-wave observations

## IRIS from PMOD/WRC

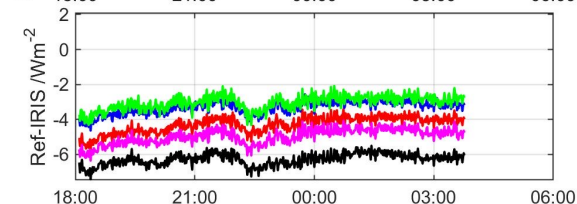
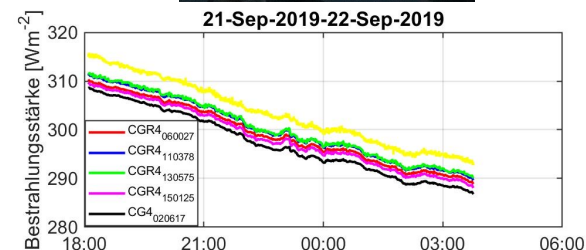
2014-2020



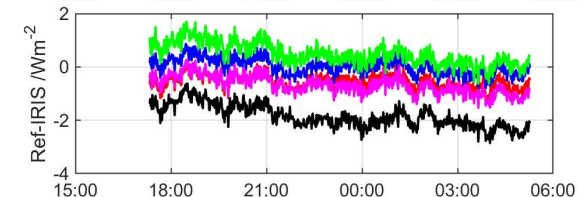
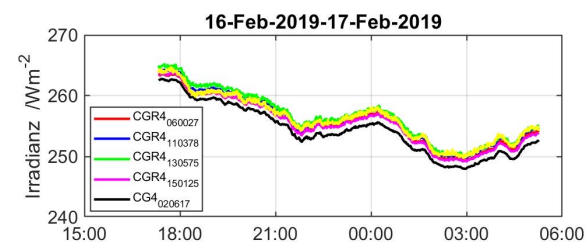
- ➔ Constant offset for IWV > 15 mm
- ➔ Linear decrease of the offset for IWV < 15 mm
- ➔ The quality of dataset is hampered (e.g. noise in IRIS due to active remote sensing instruments)



21-Sep-2019-22-Sep-2019



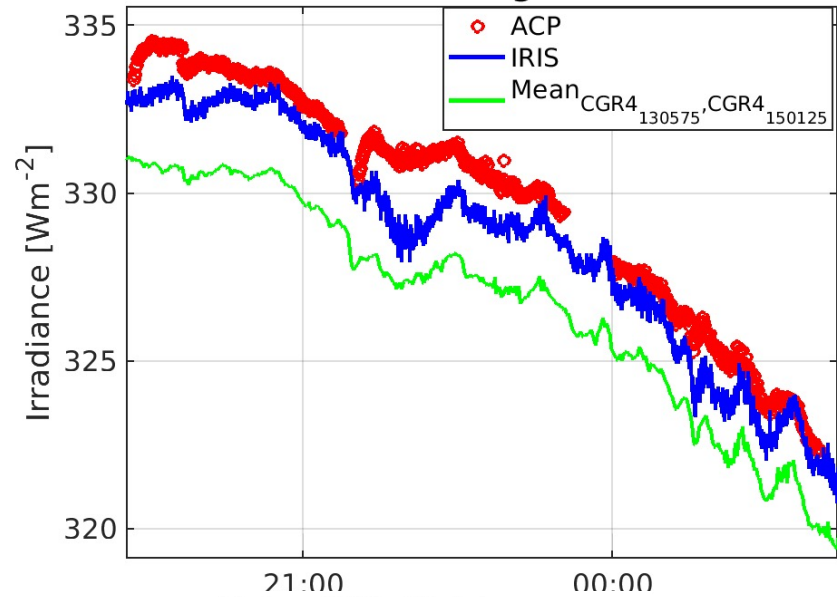
16-Feb-2019-17-Feb-2019



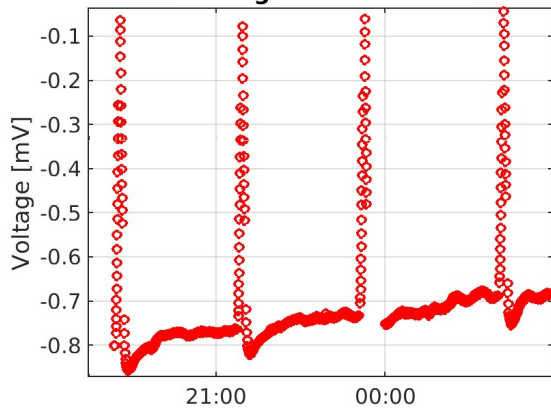
## ACP from NREL



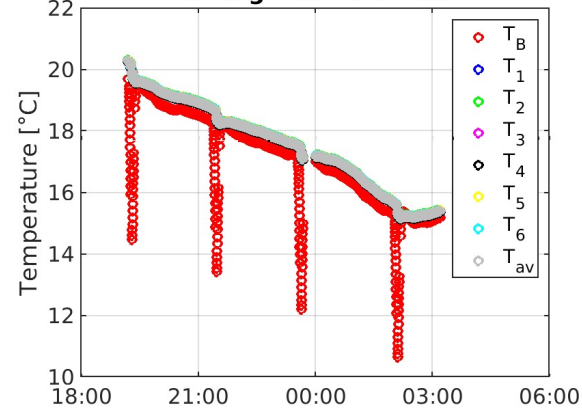
LIN: 11-aug-2021



11-Aug-2021: All data

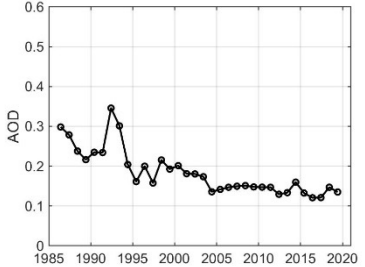
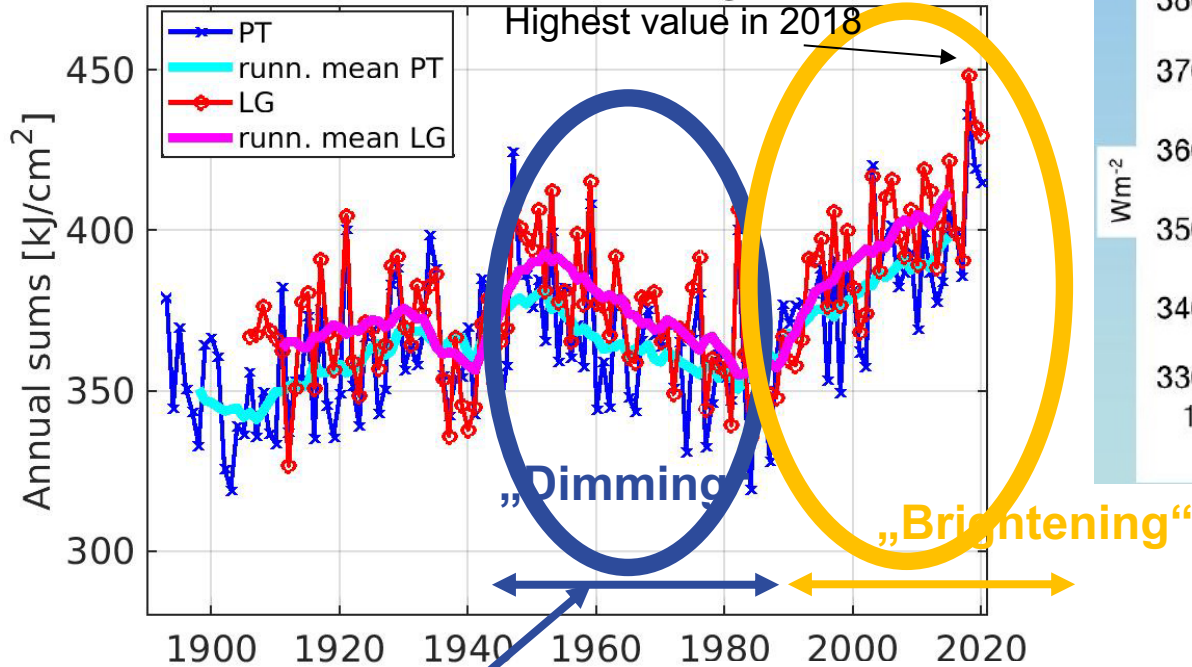


11-Aug-2021: All data



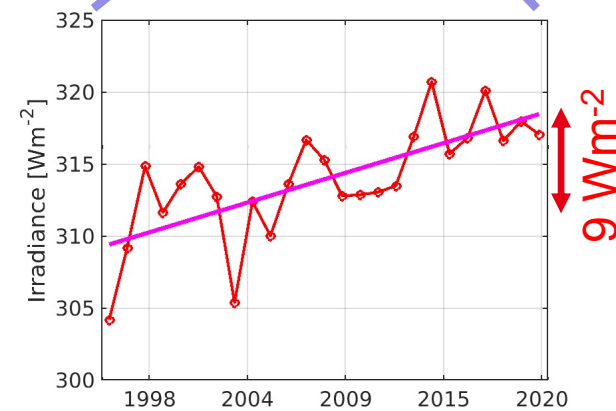
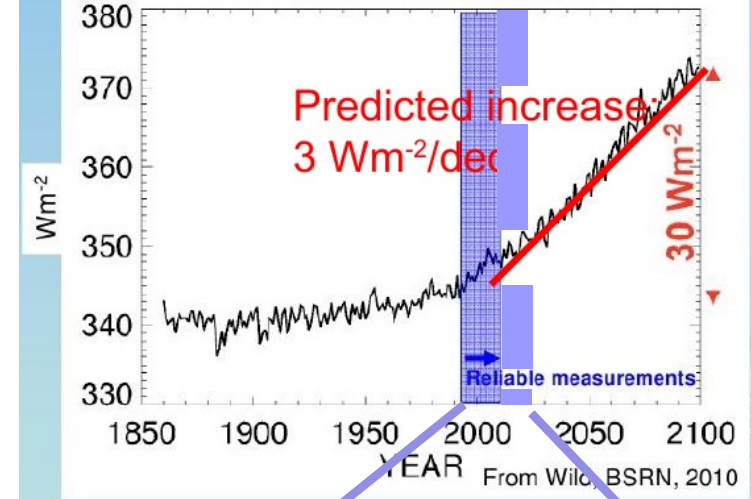
# Outcomes: Long-term series

## Global radiation at Lindenberg and Potsdam



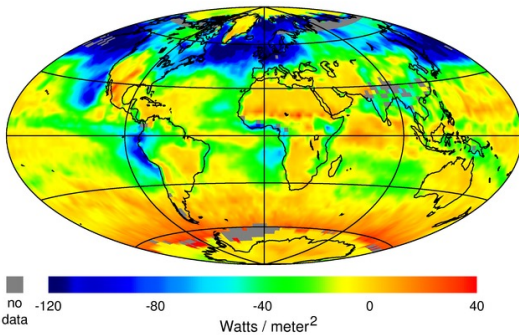
→ Changes in cloudiness

## Downward longwave radiation simulated in ECHAM5 HAM

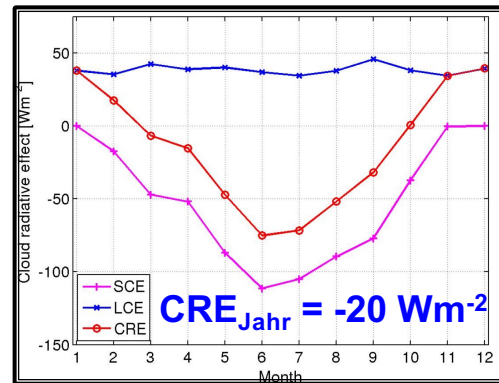


**-17 Wm<sup>-2</sup>**

Net Cloud Forcing from CERES/Terra

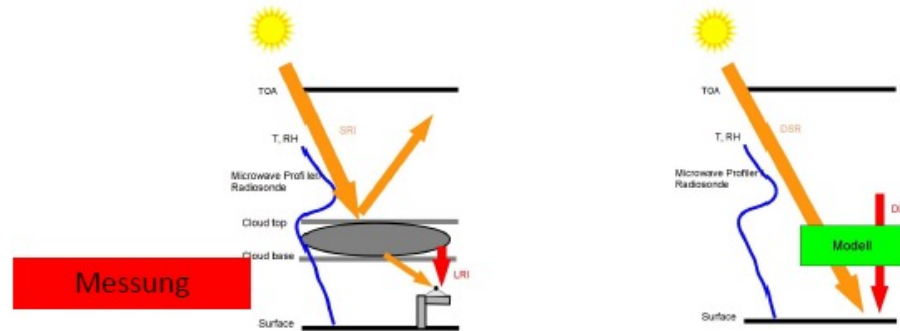


Source: [http://ceres.larc.nasa.gov/press\\_releases.php](http://ceres.larc.nasa.gov/press_releases.php)



Cloud radiative effect (CRE)

$$CRE_i = (\text{All-sky Messung})_i - (\text{cloud-free Modell})_i$$



CRE wird aus der der Differenz der all-sky Beobachtungen der kurz- und langwelligen Strahlungsflüssen ( $DSR_{obs}$  und  $DLR_{obs}$ ) und den entsprechenden Modellrechnungen für eine wolkenfreie Atmosphäre ( $DSR_{calc}$  und  $DLR_{calc}$ )

$$\rightarrow CRE_i = DSR_{obs,i} - DSR_{calc,i} + DLR_{obs,i} - DLR_{calc,i}$$

Annual mean CRE  $\approx -20 \text{ Wm}^{-2}$   
 $\rightarrow$  Clouds «cool the climate»



## Summary

- Broadband solar (global, diffuse) and thermal radiation are observed in the ground network of DWD at 42 stations (measurements initiated in 1937 at Potsdam)
- Additional activities:
  - Spectroscopic observations from the UV over visible into near infrared at LIN
  - Photometry at Zingst, Lindenberg, Hohenpeissenberg and Zugspitze
  - BSRN station at Lindenberg
  - Profiles of the radiation budget through Troposphere into Stratosphere
  - WMO Regional Radiation Centre

# Thank you – Questions, Remarks?

