Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Irradiance sounding up to the lower stratosphere

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Outline

Introduction

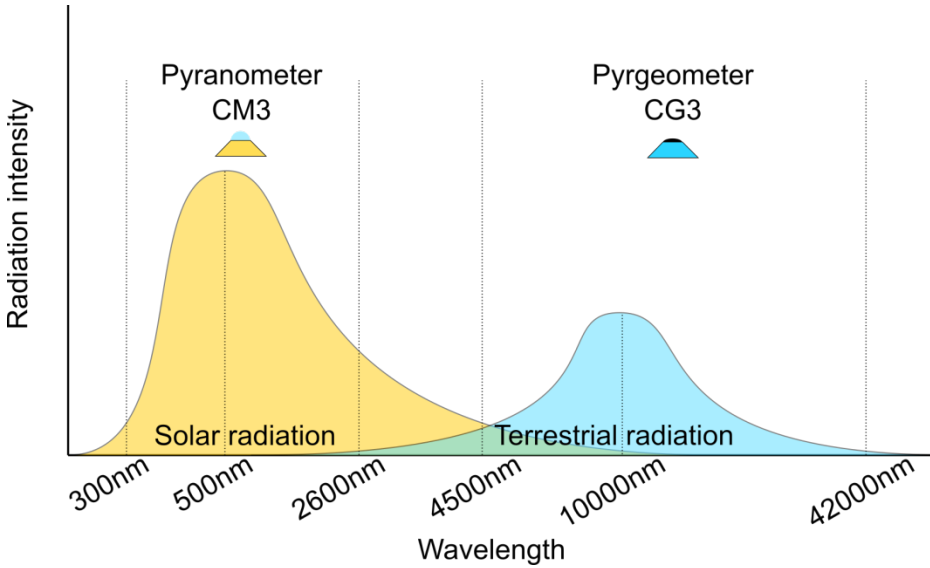
Technique

Data

S & O

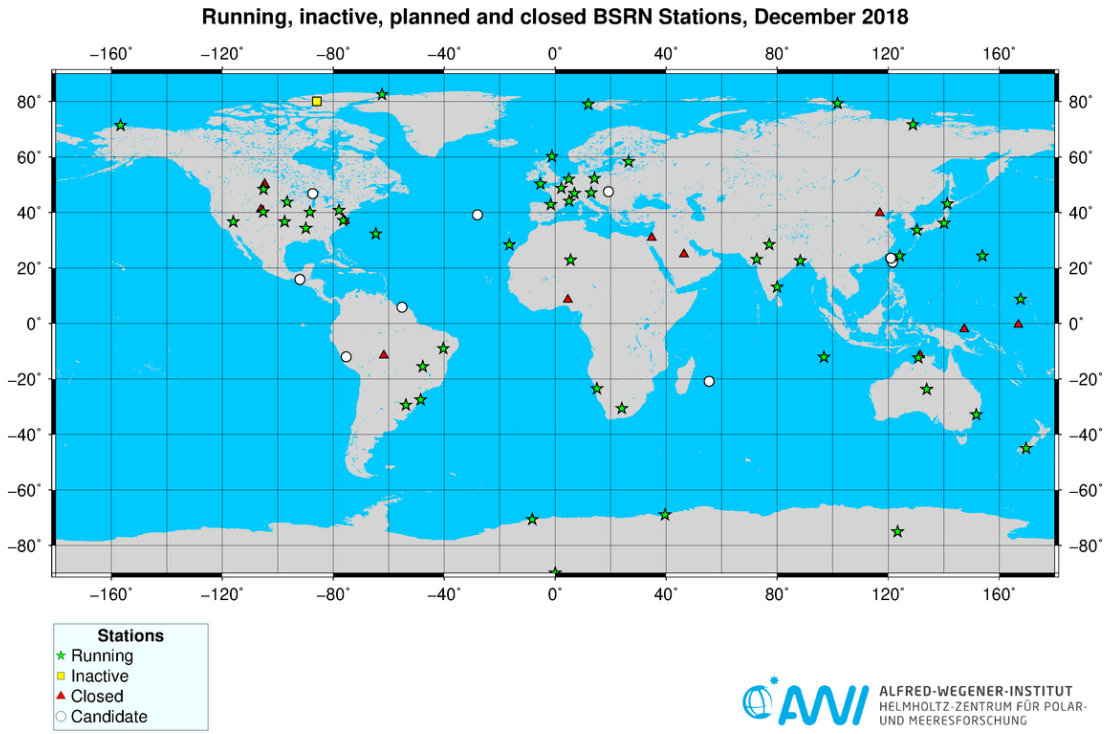
What are we doing?

- Observation of vertical profiles of all four components of net radiation using an adapted radiosonde: solar + terrestrial, upwelling + downwelling
- Usually reached peak height 32 km, thus the whole troposphere and lower stratosphere are subject of investigation
- Frequency of soundings currently about 10 times per year, sonde needs to be retrieved
- All-season probing but fair weather preferred (rain, storm, snowfall, strong convection excluded)



Motivation

- In-situ measurements of irradiances: feasibility, restrictions, adaptions needed with regard to near-surface equipment
- Clouds: to investigate flux divergence at cloud base and cloud top and to quantify radiative cooling/heating effects
- Clear sky: to characterize albedo as a function of altitude – a potential link between surface-based and top-of-atmosphere measurements



BSRN – Baseline Surface Radiation Network

ISOLDE – Irradiation SOunding LunDEnberg

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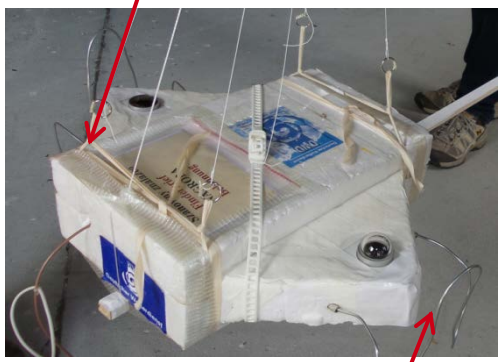
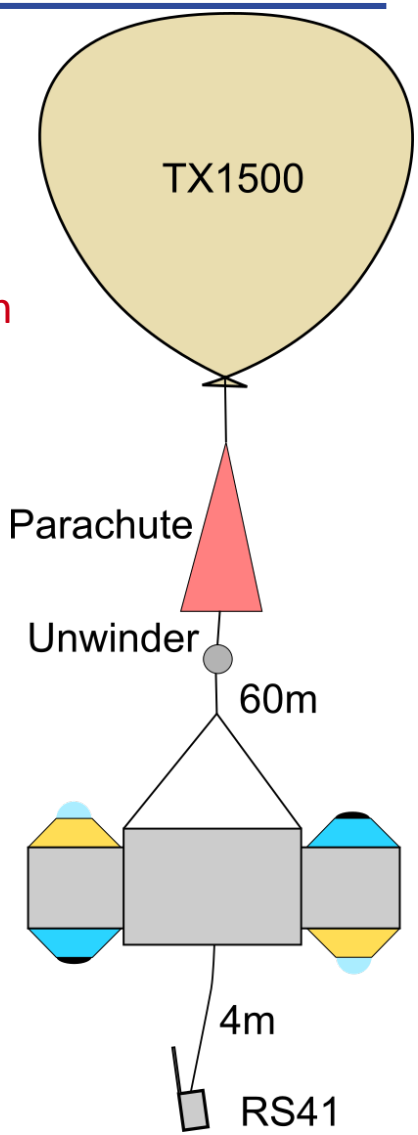
Kipp & Zonen CNR4 specifications:

	Pyrano CM3	Pyrgeo CG3
Spectral range	305 - 2800 nm	4.5 - 42 µm
Response time	< 18 s (95%)	< 18 s (95%)
Offsets	A: < ±15W/m2 B: < ±3W/m2 at 5K/h	-
Tilt error	< ±1% at 1000 W/m2	< ±1 %
Uncertainty w.r.t. daily totals	< ±5% (95%)	< ±10% (95%)
WMO/ISO classification	Good quality/ first class	n.a.





ISOLDE – Irradiation SOunding LunDEnberg

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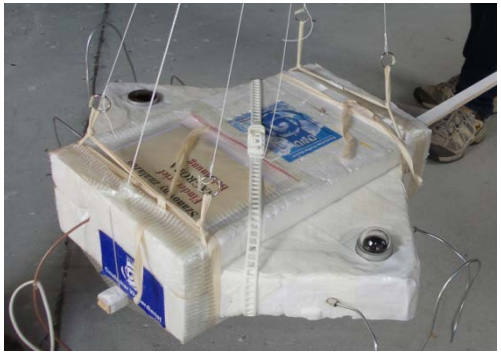
Measured quantities:

T, q, vh, vdir (@1 Hz): SRS + RS41

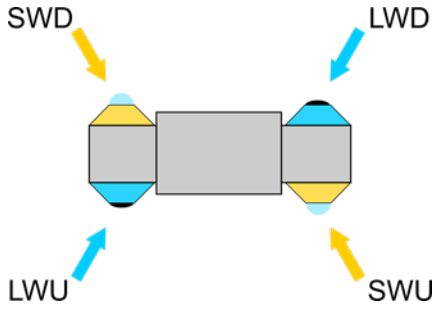
SWU, SWD, LWD, LWU



Add ons:

Temperature tracking at domes and instrument bodies

Correction for both pyrano & pyrgeo



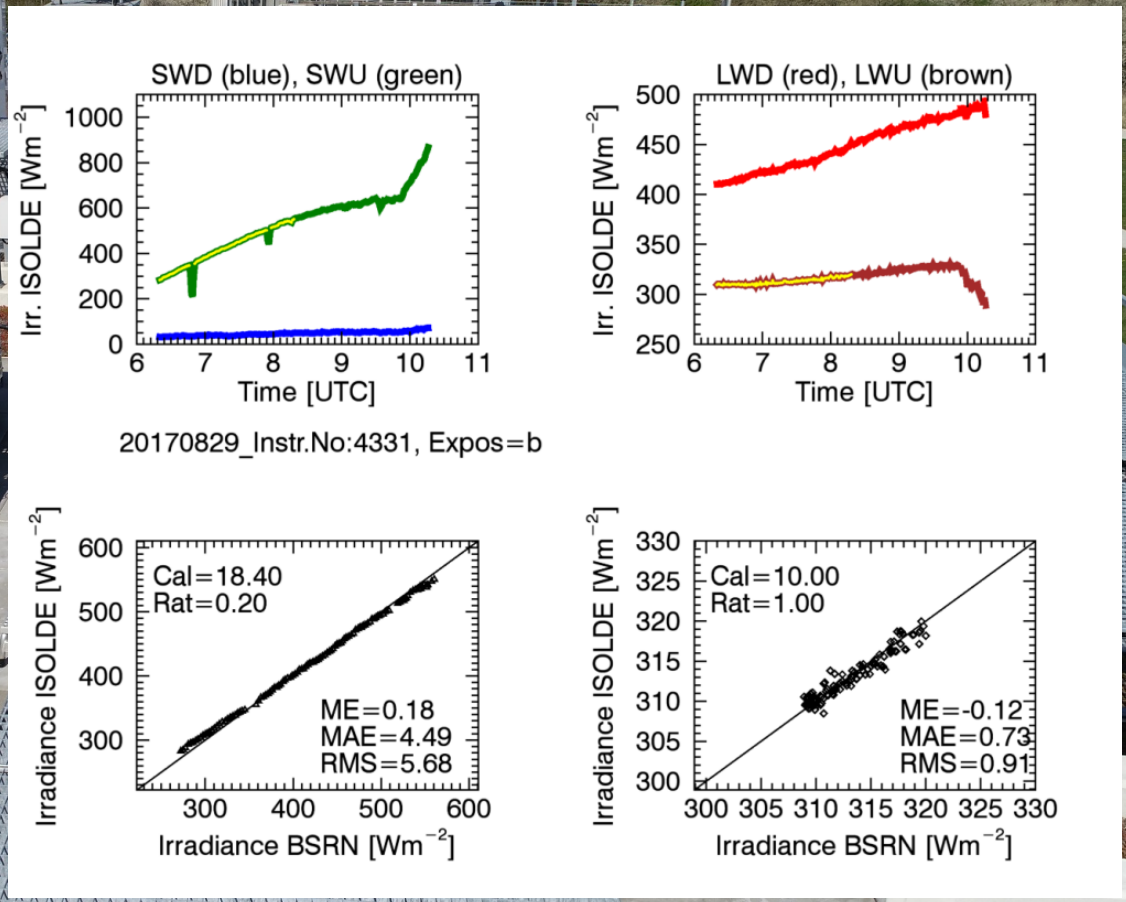
$$L_{LW} = \frac{U_{emf}}{C}(1 + k_1\sigma T_B^4) + k_2\sigma T_B^4 - k_3\sigma(T_D^4 - T_B^4)$$

Philipona et.al., 1995: C = sensitiivity, k1 << 1, k2 = 1, k3 = instrument specific

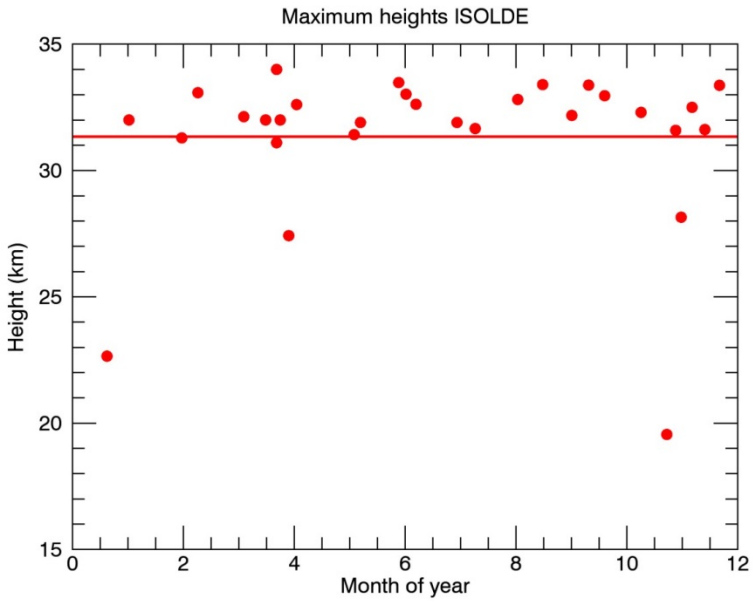
Calibration vs BSRN Lindenberg

Calibration by iteratively minimising the mean error and mean absolute error w.r.t to BSRN readings

-> selection of clear sky days/hours, further filtering using ratio diffuse/direct
-> top and bottom side sky viewing

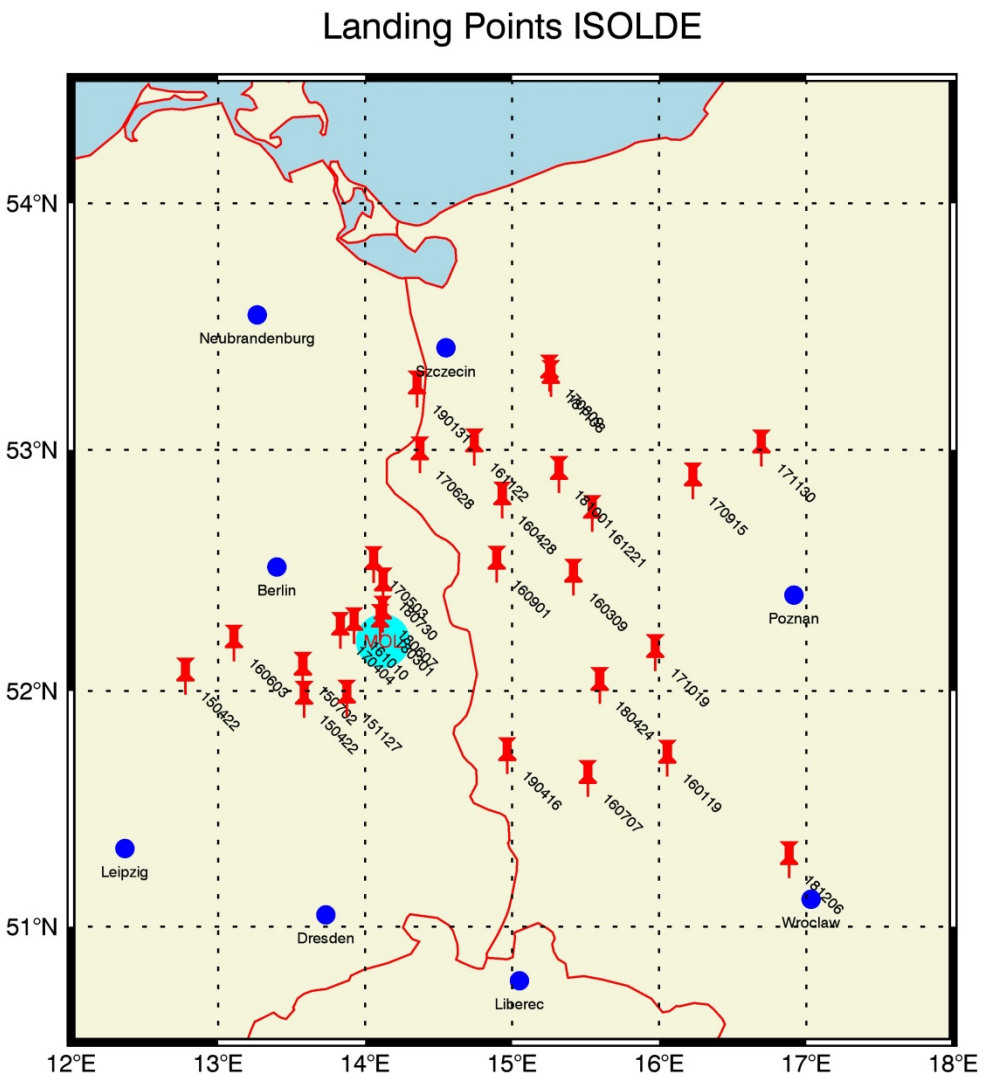


Reached altitude & landing

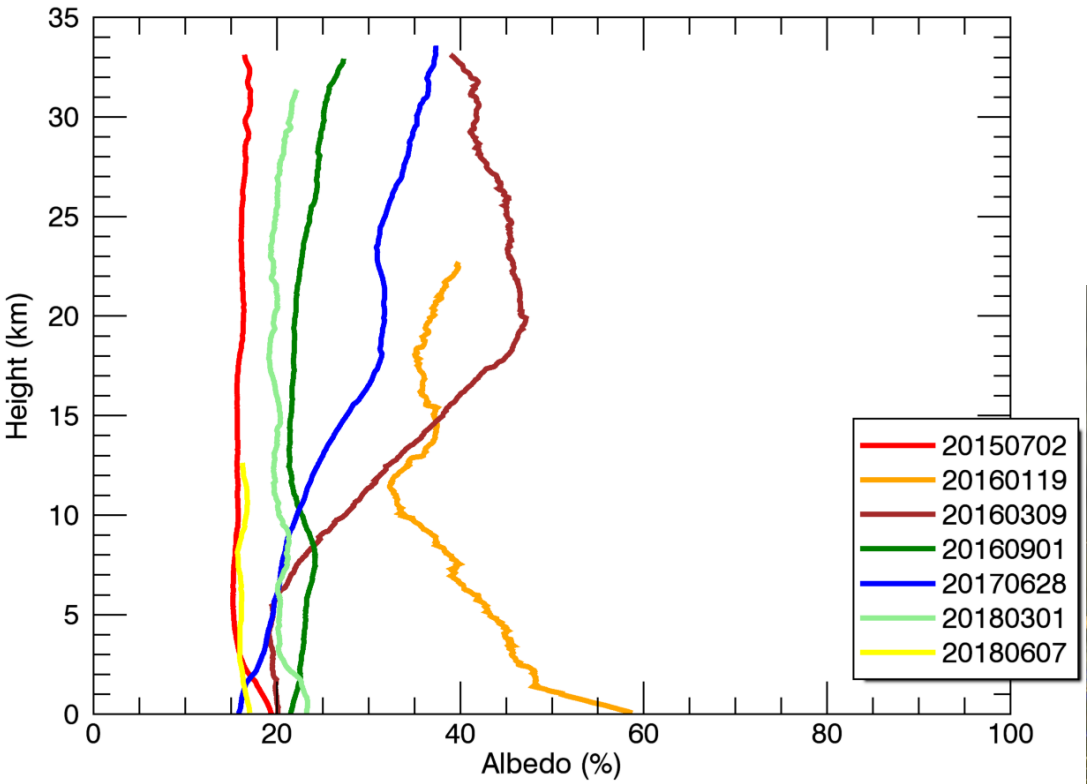


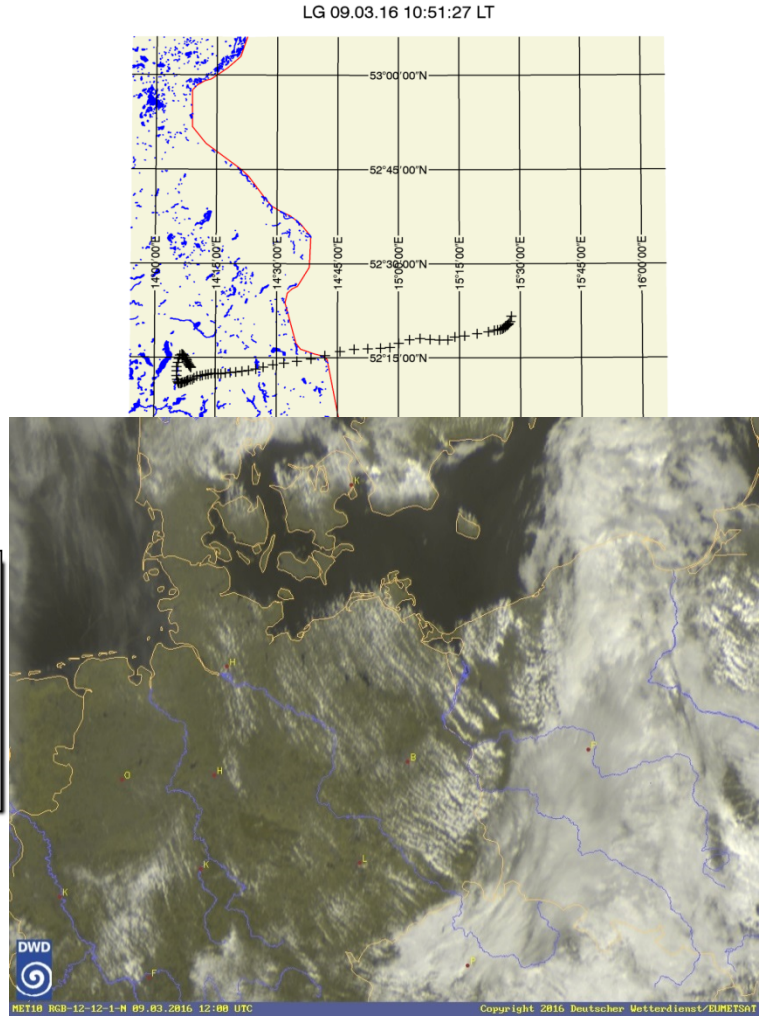
Mean burst height: 31.3 km

Predominantly westerly winds only partly provide invited sounding scenarios



Solar fluxes – clear sky



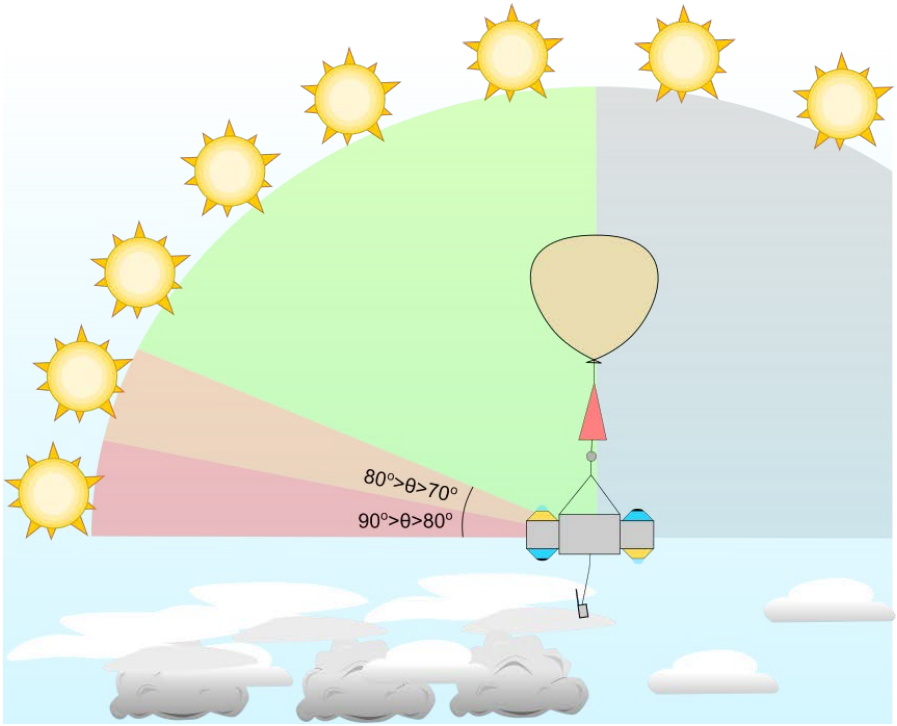


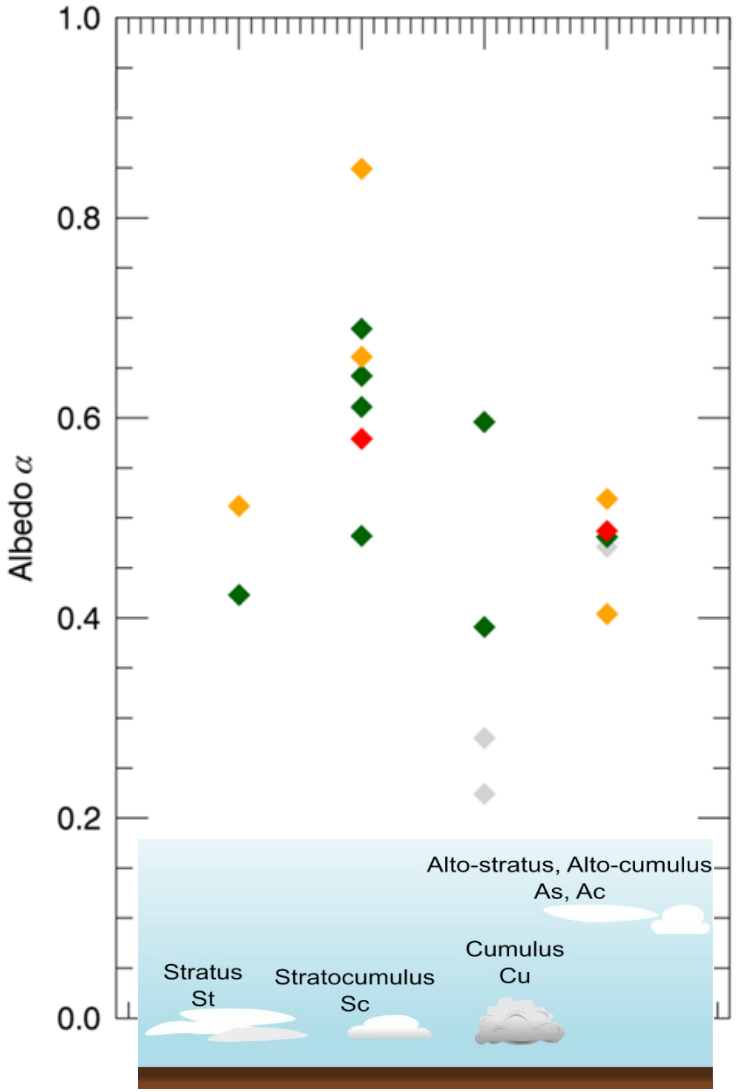
Solar fluxes – overcast, cloud top albedo

Stratocumulus (7x): 0.482 -0.849

Altocumulus/Altostratus (5x) 0.404 - 0.519.

If cloud cover N<6/8 (mixed scene): gray





Terestrial fluxes

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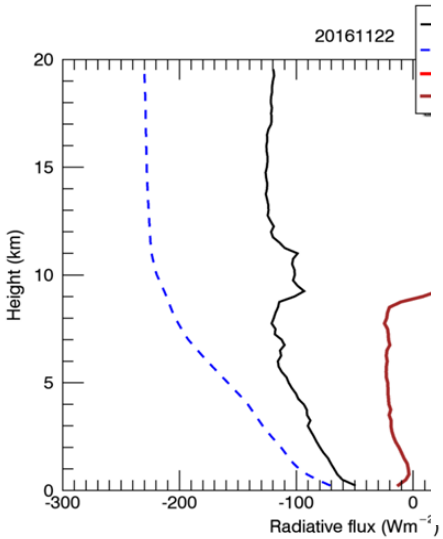
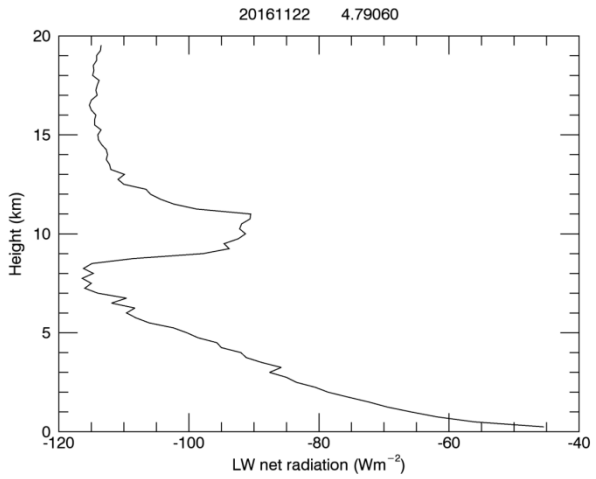
Cloud radiative effect (CRE)
in the free atmosphere

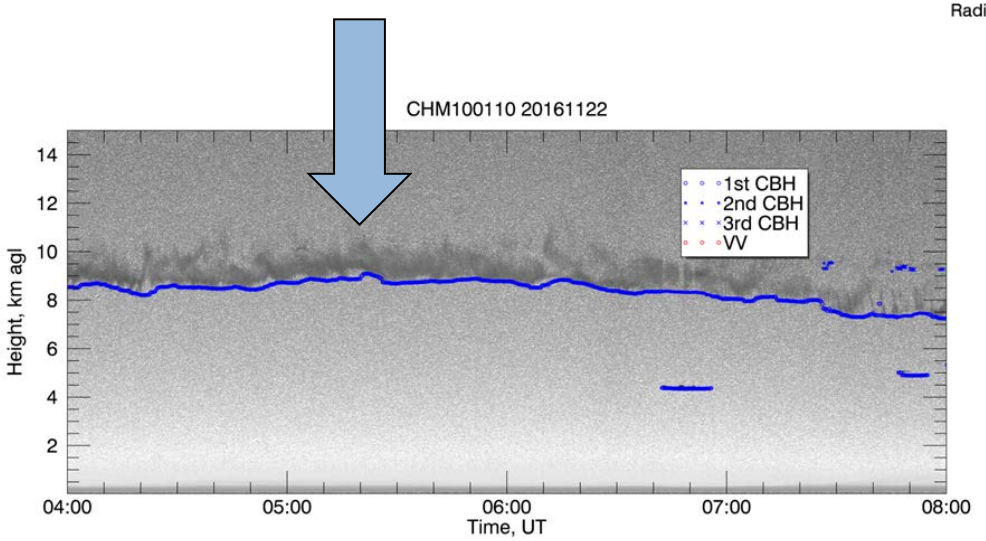
22.11.16 Ci @ 9 km:

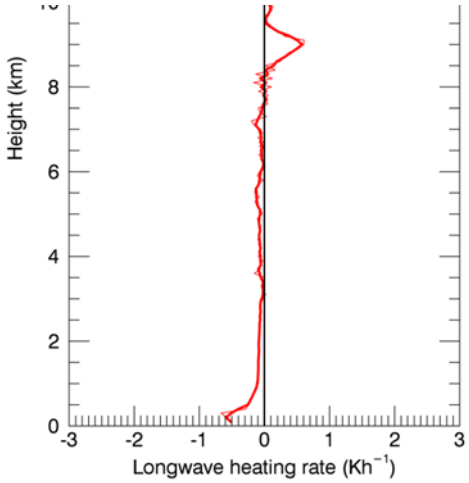
Observations + clear-sky-simulations

Ceilometer

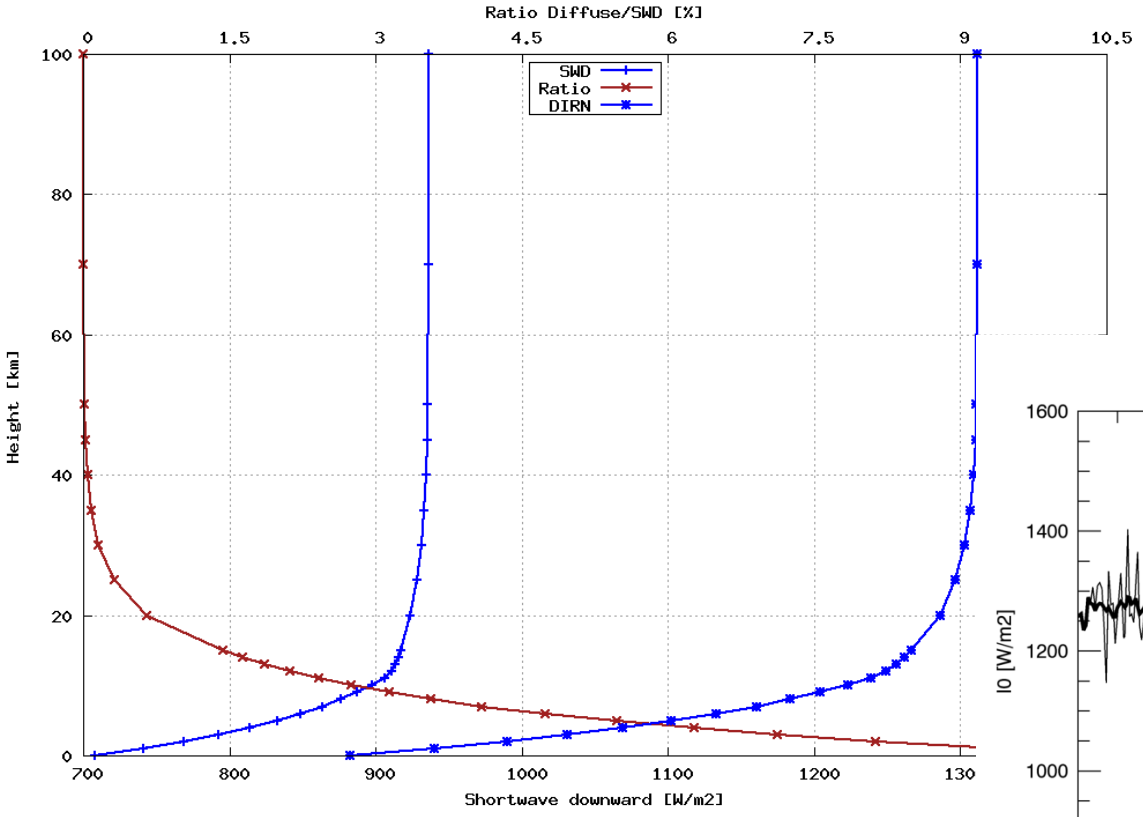






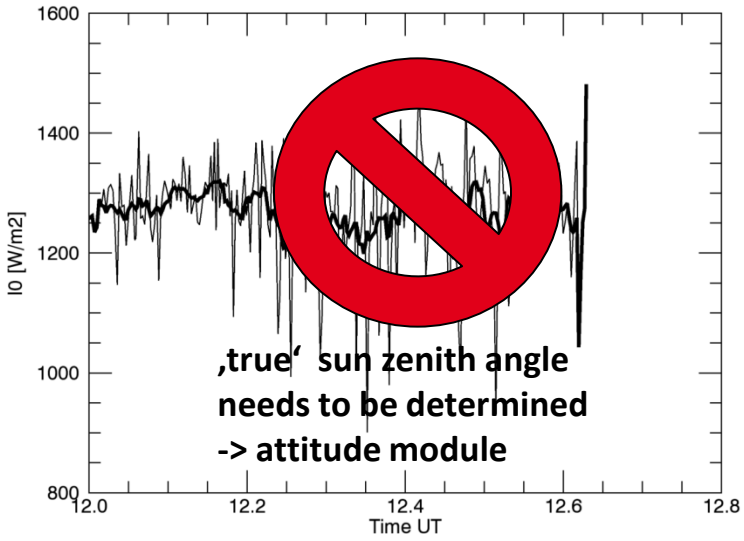


Estimation of Solar constant?



Z > 30 km:

Fraction of diffuse < 0.2%
(Diff/SWD < 0.002) ->
$I \cong$ SWD / cos μ ->
$I \cong I_0$



‚true' sun zenith angle needs to be determined -> attitude module

Solar constant = 1360.8 ± 0.5 W/m²

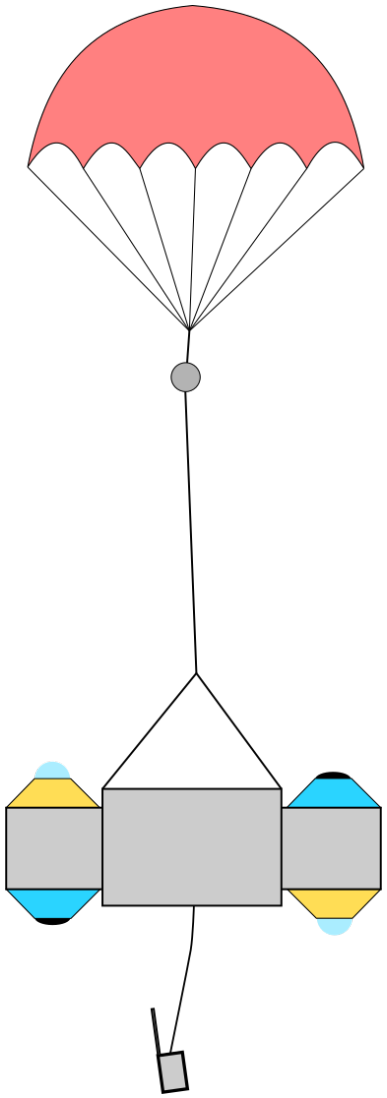
Summary & Outlook

What was achieved so far ?

- 30 soundings were performed in the timeframe Apr 2015 to Apr 2019
- 19x flights comprising single-phase clouds at all levels (Sc, St, Ac, As, Ci, Cs), 11x clear sky or broken clouds
- 5 flights with additional attitude tracking (yaw, roll, pitch)
- Sensor calibration using BSRN Lindenberg as reference

What is on the agenda ?

- Attitude logging at all upcoming flights (2019 -)
- Tests with faster sensors: to be started in 2019
- Data quality checks: basic threshold testing implemented, refining under construction
- Availability of data via GRUAN archive (2020 -)




Thank you for your attention !
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