



Towards Radiative Closure Using Ground-Based Observations from ACTRIS and measurements from EarthCARE's MSI and BBR



EUROPEAN SPACE AGENCY

TROPOS



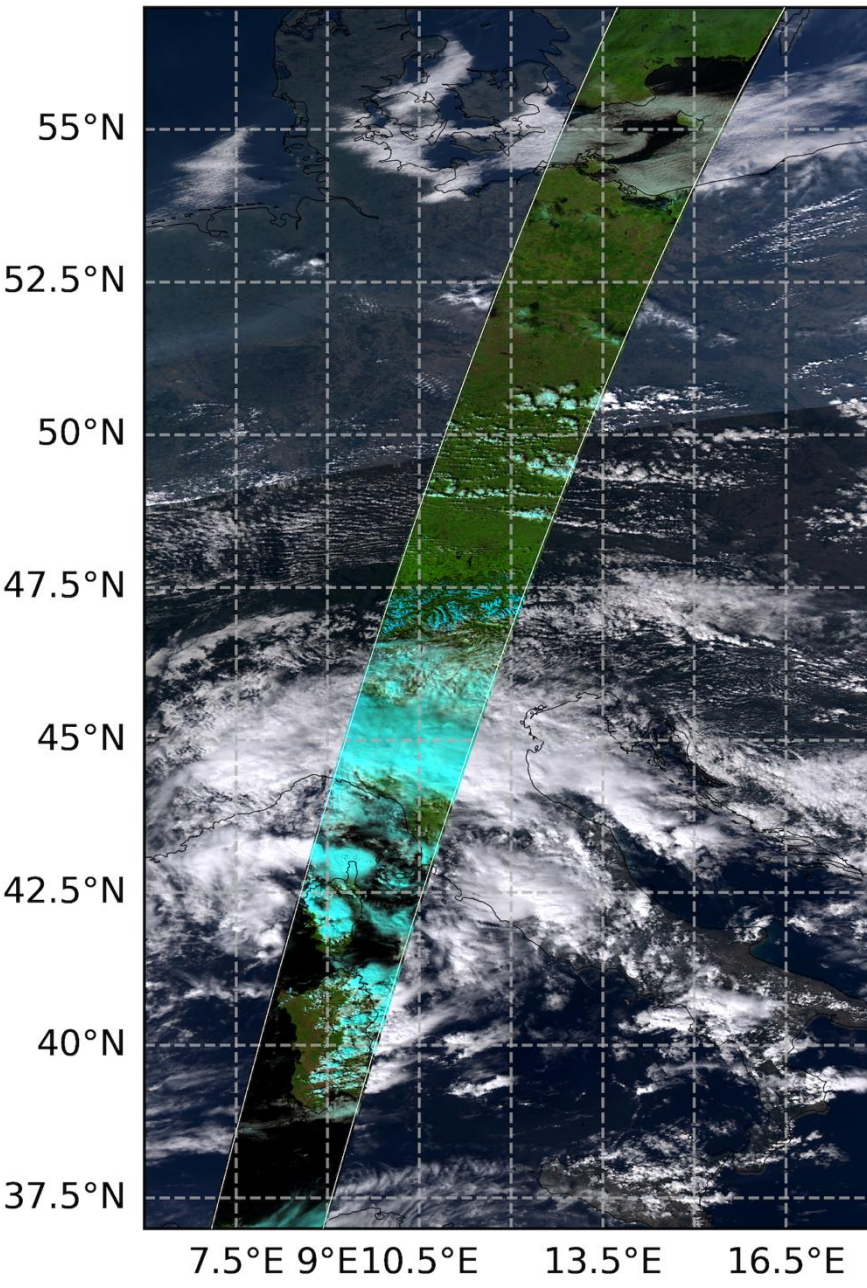
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Introduction

EarthCARE provides a unique combination of active and passive instruments onboard a single platform to investigate aerosol–cloud–radiation interactions. A central mission objective is the achievement of radiative closure by forward-simulating top-of-atmosphere (TOA) broadband fluxes from synergistic retrievals of the atmospheric state and comparing them with measurements from the BBR. Similarly, ACTRIS delivers synergistic, vertically resolved atmospheric retrievals from a ground-based perspective. Here, we transfer EarthCARE's radiative closure concept to selected ACTRIS/Cloudnet sites. Using 1D radiative transfer model MORTY-RTS, broadband SW fluxes at both BOA and TOA are simulated and first comparisons to ground-based measurements and BBR measurement as well as the 1D and 3D simulations from ACM-RT are done.

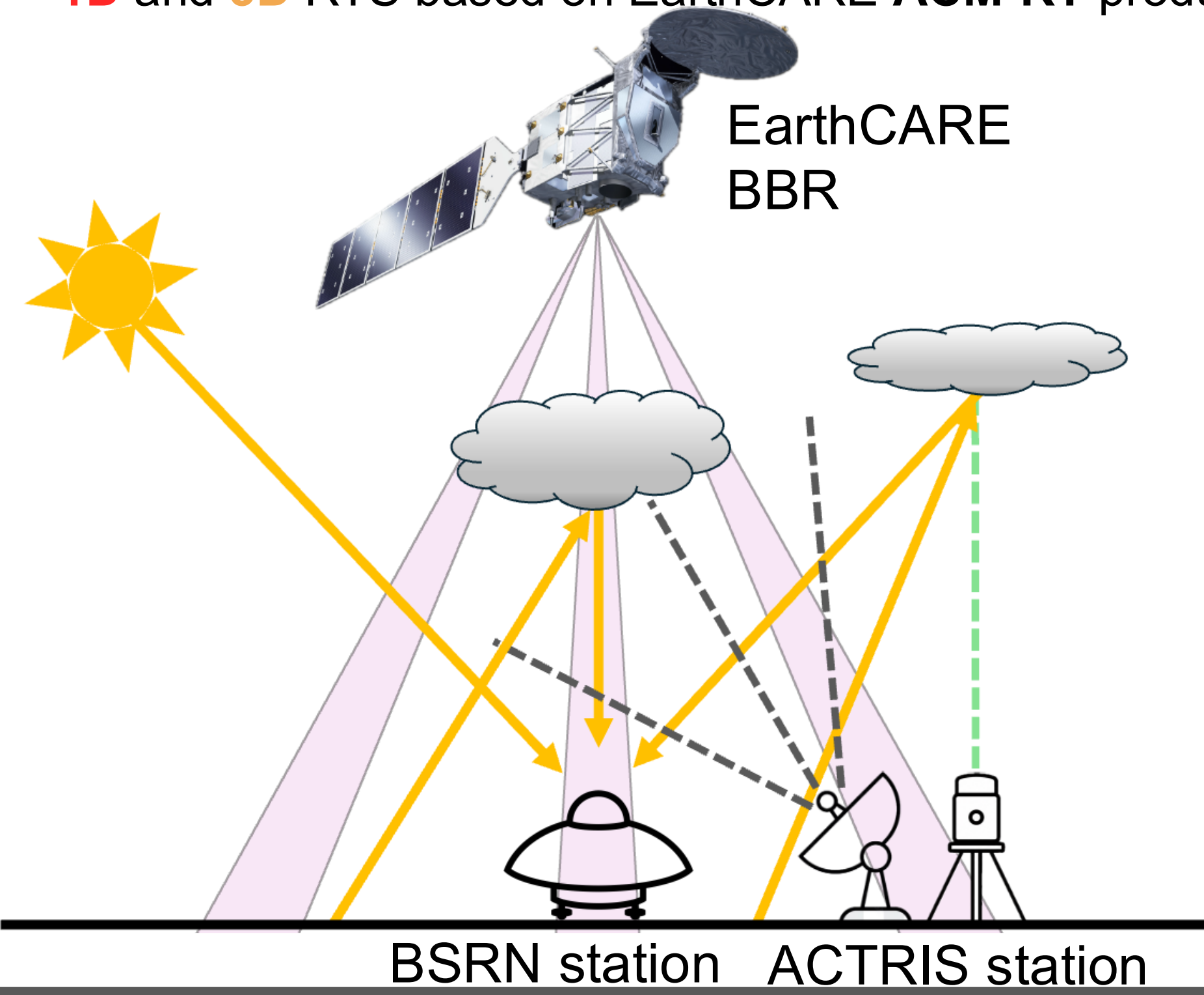


Methodology

- Search for EarthCARE overpasses
- Check for valid input data (ACTRIS/Cloudnet, Aeronet, surface reflection)
- Get mean band surface reflectance for assessment domain
- Calculate short wave TOA upward fluxes and BOA downward fluxes using MORTY-RTS
- Compare simulated fluxes with:
 - BOA -> BSRN measurements and ACM-RT
 - TOA -> BBR measurement and ACM-RT
- Additionally, MSI radiances are simulated using the MSI-Tool

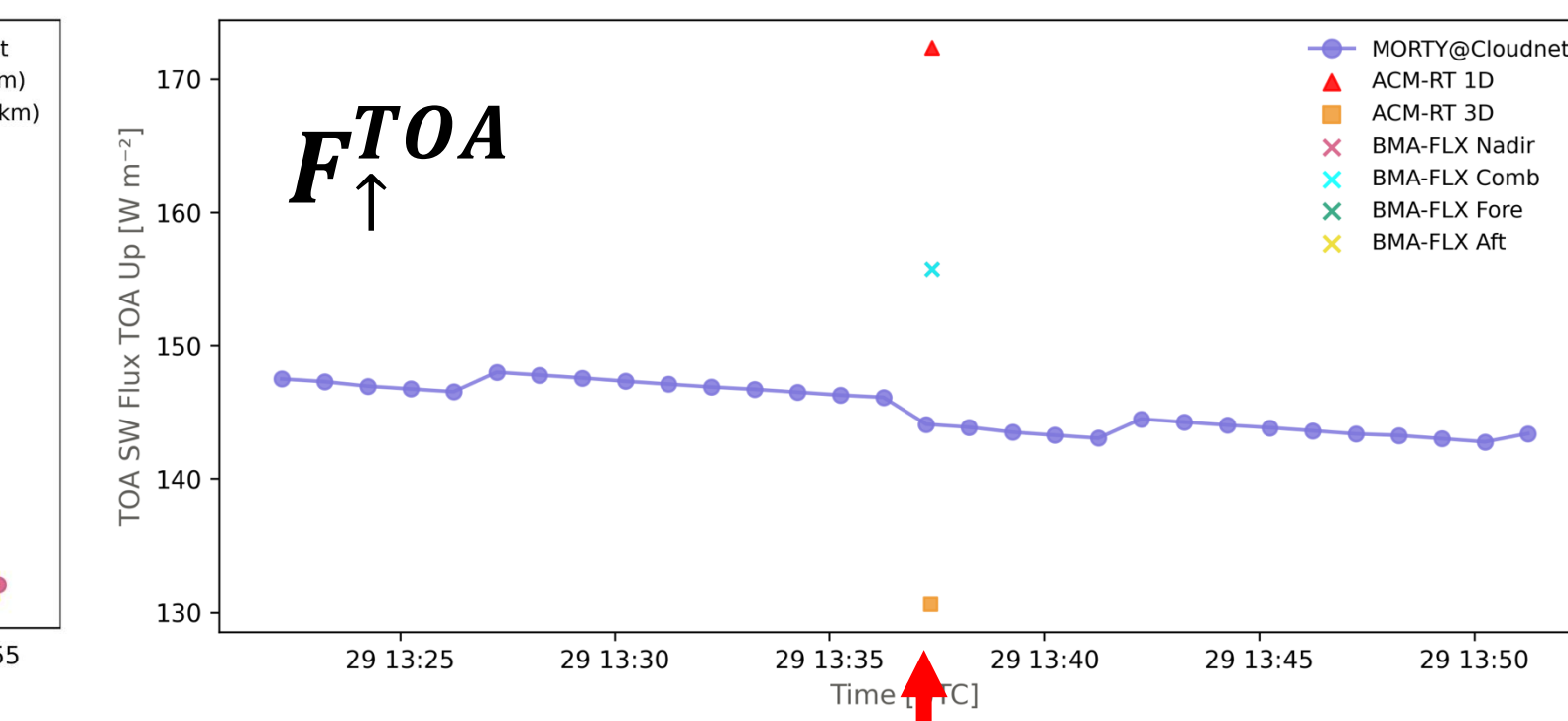
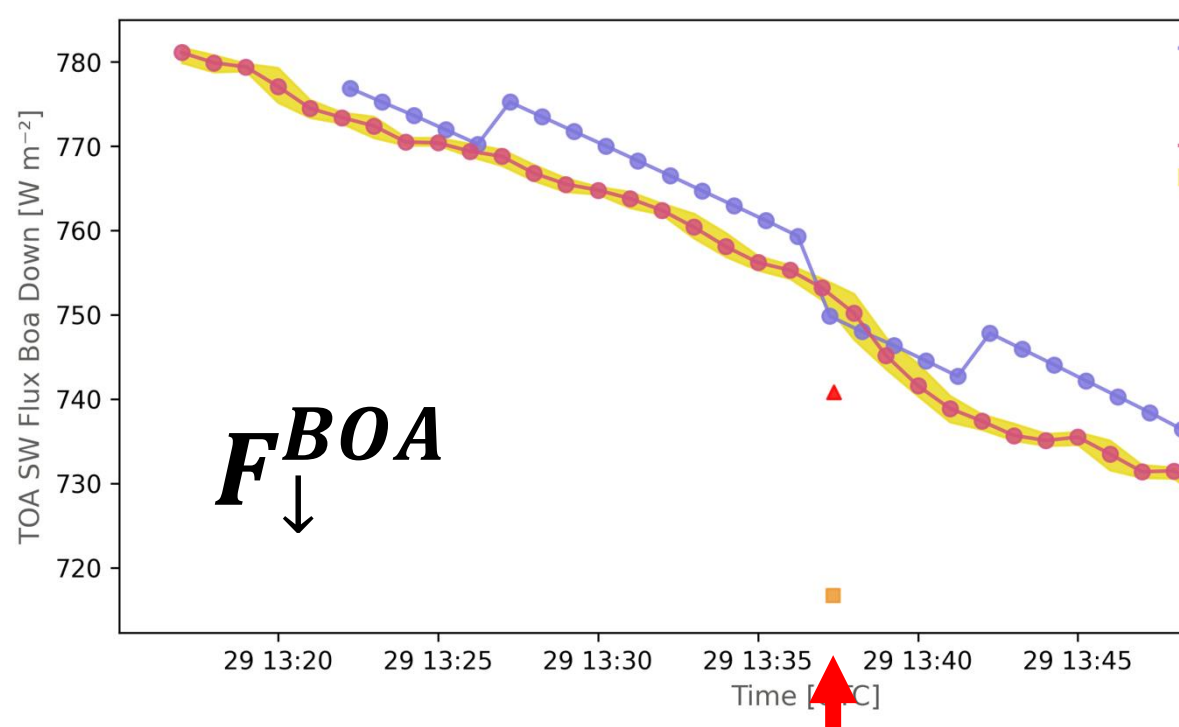
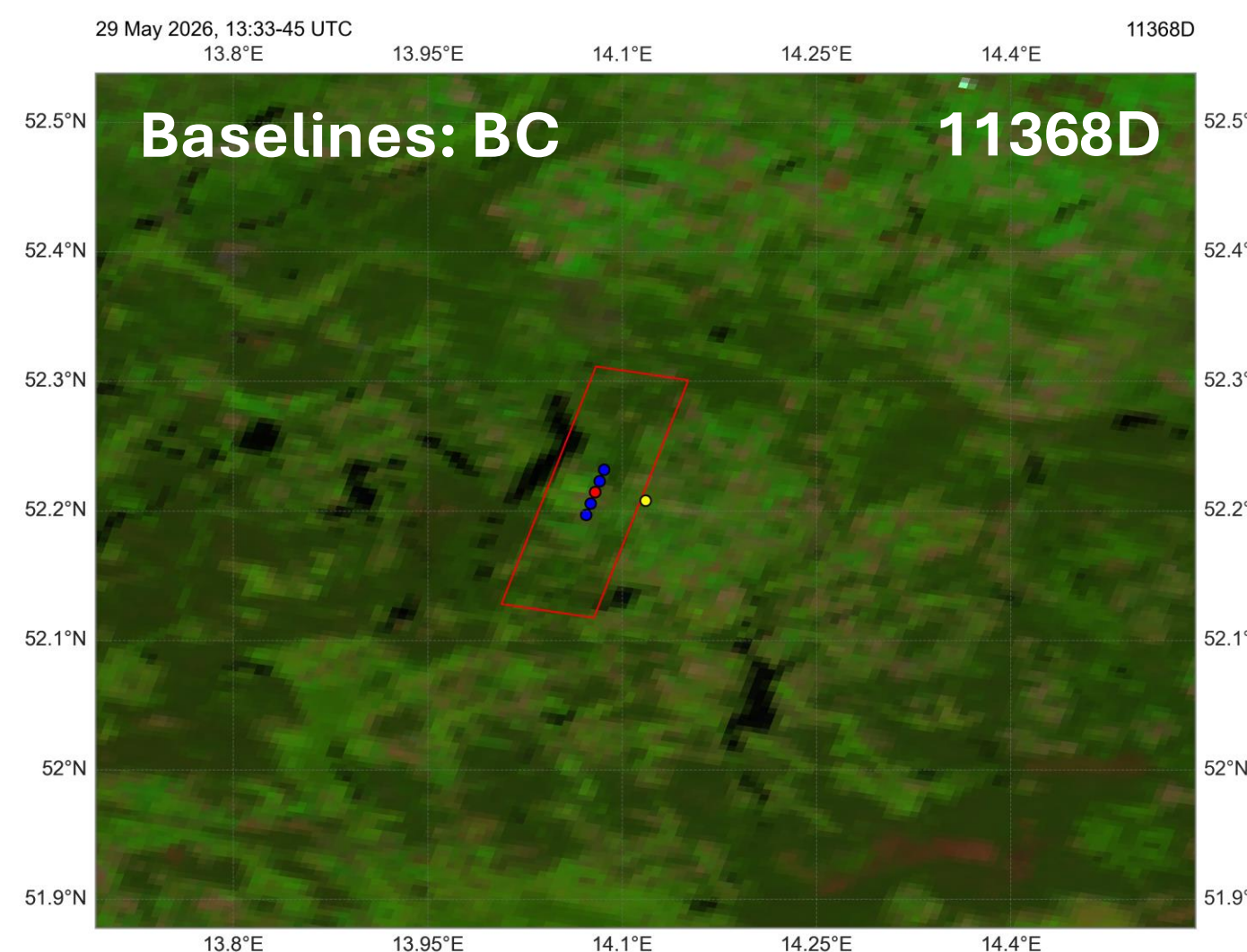
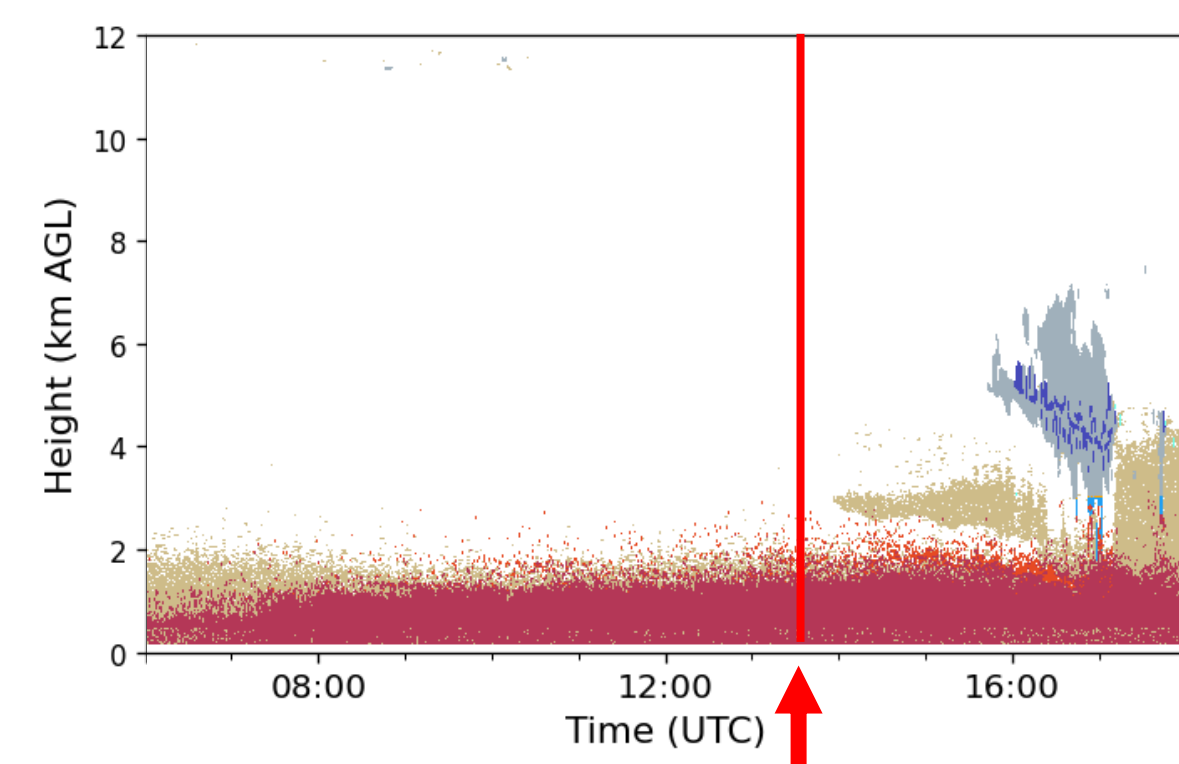
Data

- Downward fluxes bottom of atmosphere F_{\downarrow}^{BOA} 1 min mean + min/max, Baseline Surface Radiation Network (BSRN)
- F_{\downarrow}^{BOA} and F_{\uparrow}^{TOA} simulated using 1D RTS (MORTY-RTS) based on ACTRIS/Cloudnet input
- Upward fluxes at top of atmosphere F_{\uparrow}^{TOA} , based on EarthCARE BMA-FLX (assessment domain, fore, nadir, aft, comb) product (BA/BC)
- F_{\downarrow}^{BOA} and F_{\uparrow}^{TOA} 1D and 3D RTS based on EarthCARE ACM-RT product (BA/BC)



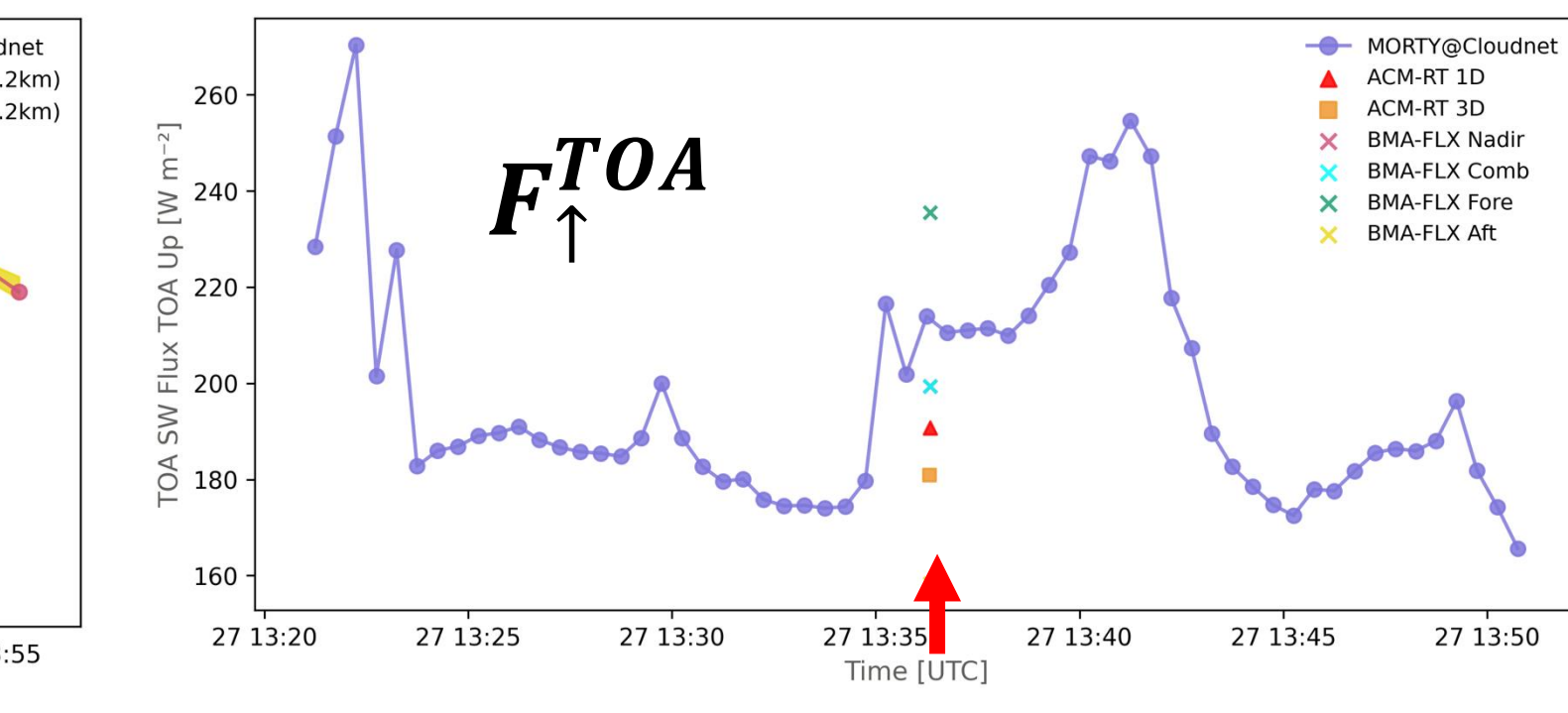
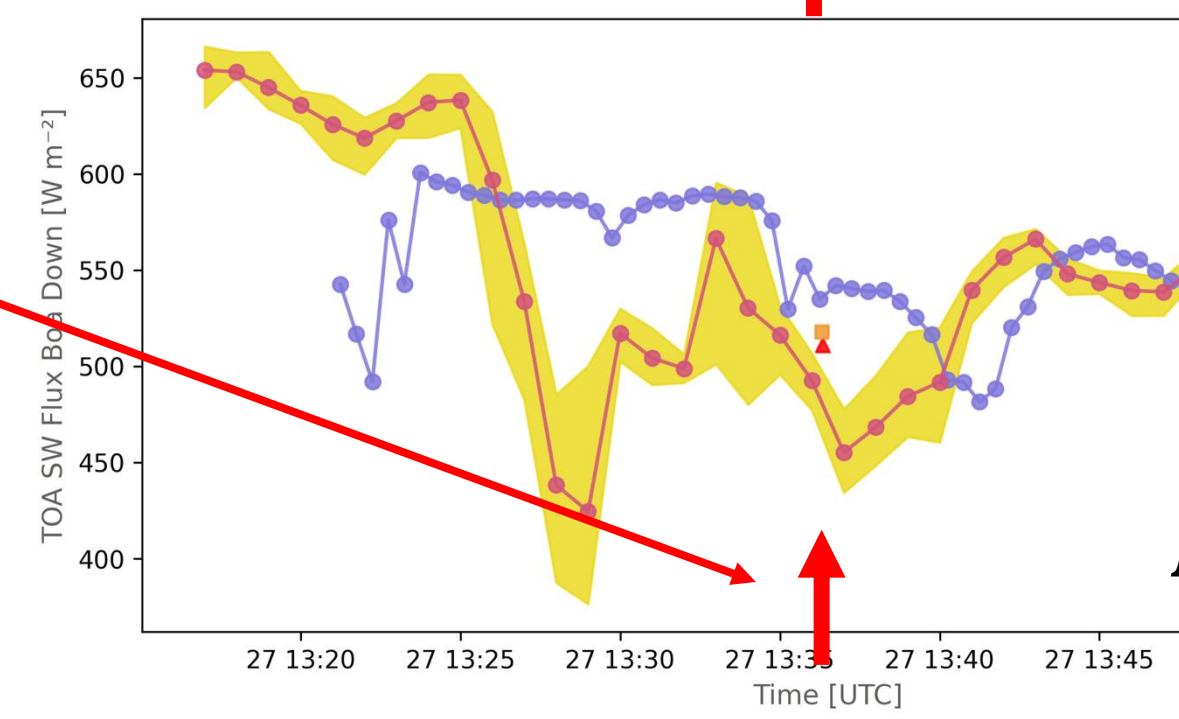
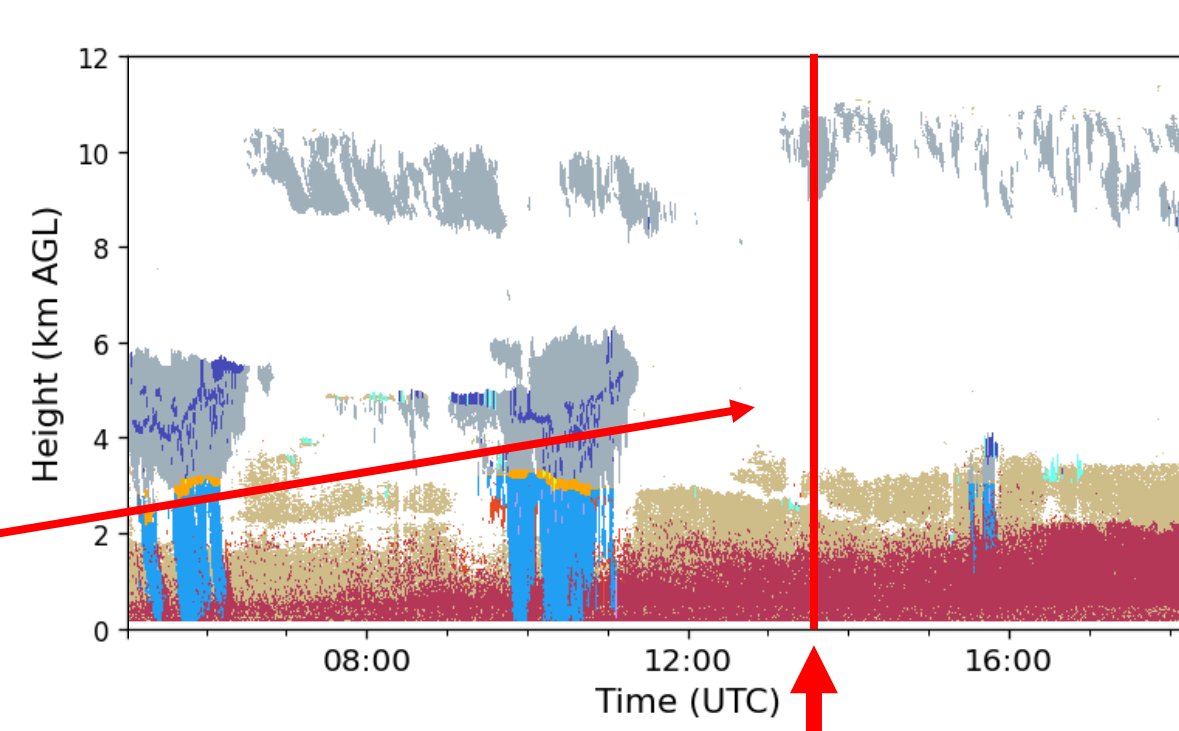
Clear sky case

Station: Lindenberg
Day: 29.05.2026



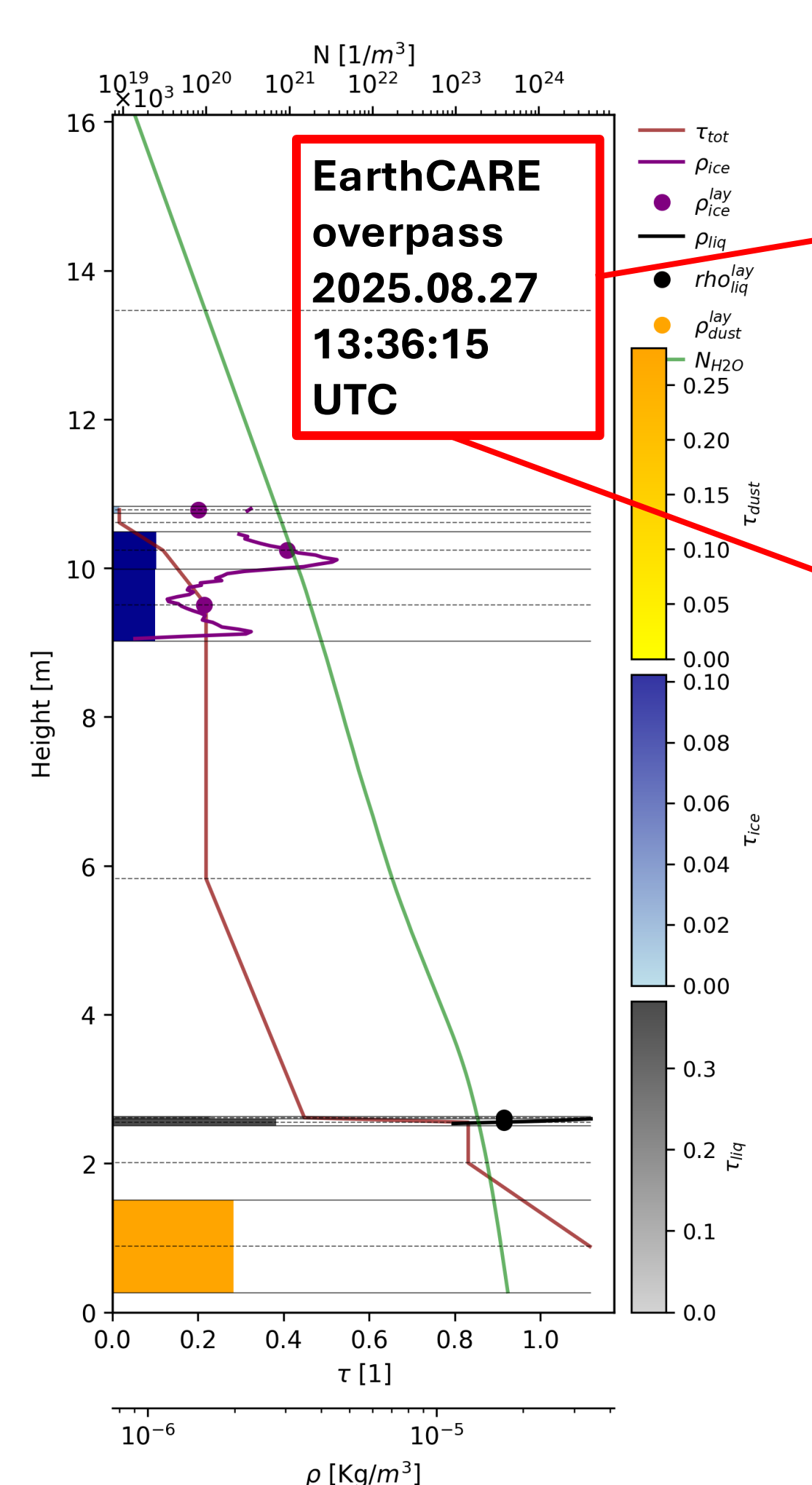
Cloudy case

Station: Lindenberg
Day: 27.08.2025



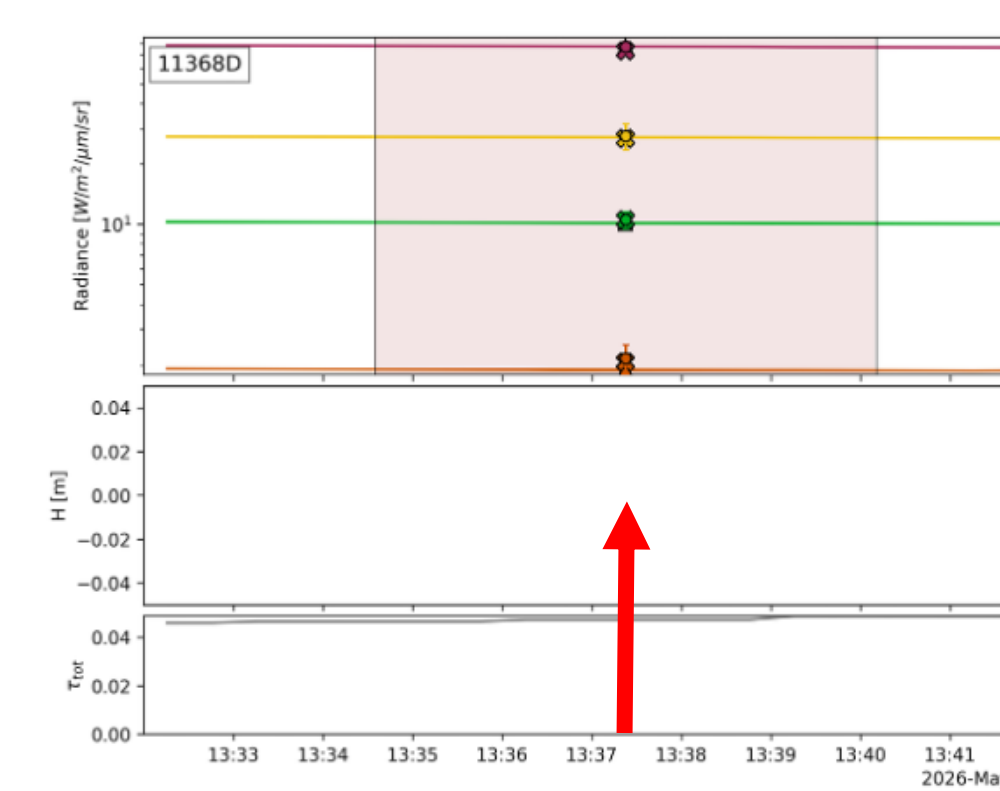
ACTRIS input data for RTS

- Land surface reflectance based on BRDF reconstructed using MODIS MYD09A1 dataset and PCs from Vidot and Borbás, 2014
- Atmospheric vertical profiles based on ACTRIS Cloudnet data
 - LWC (*_lwc-scaled-adiabatic.nc)
 - IWC (*_lwc-Z-T-method.nc)
 - IER (*_ier.nc)
 - DER (*_der.nc)
 - T, P (*_categorize.nc)
 - q (*_hatpro*.nc)
- Aerosols based on Aeronet measurements.
- Gas absorption calculated using CKDMIP dataset (Hogan and Matricardi, 2020)
- Reduced number of vertical layers with correct representation of:
 - Cloud top and cloud base
 - Inversions in relative humidity
 - In-cloud boundaries at $\tau = 0.1, 1$ and 3
- Solar spectra divided into 52 bands between 270 and 3995 nm

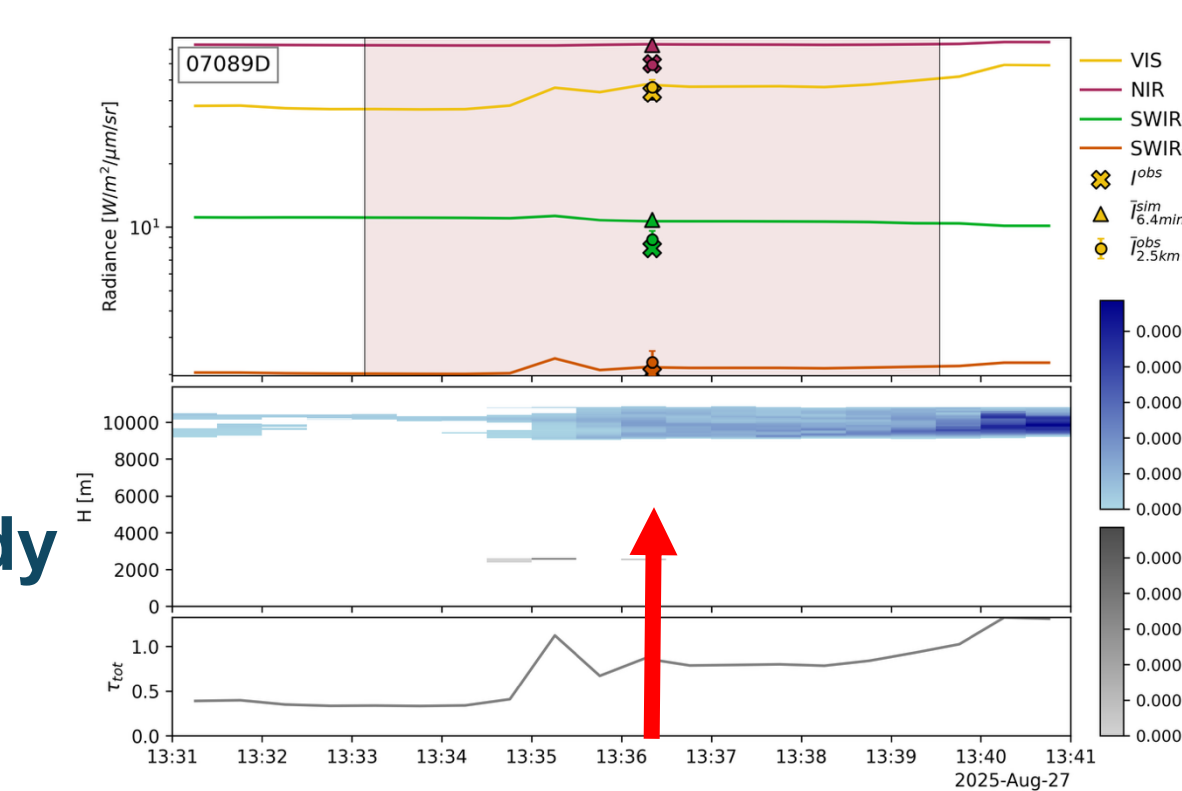


MSI VNS simulations

Clear sky case



Cloudy case



References

Acknowledgements
The data used in this study are generated by the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) and are available from the ACTRIS Data Centre using the following link: <https://cloudnet.fmi.fi/file/8c4640ea-6fce-4353-b851-f5368eae87e6>.
Wacker, S.; Behrens, K. (2026): Basic measurements of radiation at station Lindenberg. Meteorologisches Observatorium Lindenberg - Richard-Alßmann-Observatorium, PANGAEA, <https://doi.org/10.1594/PANGAEA.946382>
Vidot, J. and Borbás, É. (2014), Land surface VIS/NIR BRDF atlas for RTTOV-11: model and validation against SEVIRI land SAF albedo product. Q.J.R. Meteorol. Soc., 140: 2186-2196. <https://doi.org/10.1002/qj.2288>

MSI-Tool and MORTY-RTS (open source)



Summary

- Promising first results
- ACTRIS provides a ground-based counterpart to EarthCARE's radiative closure
- EarthCARE match-ups getting difficult with BBR turned off more than 75% of the time
- Strong arguments to combine/synchronize ground-based radiation networks with ACTRIS
- Closure studies will be performed in framework of C3SAR campaign at Lindenberg

EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK