Enhancing exploitation of ATLID, CPR and MSI
in synergistic cloud and aerosol retrievals

Shannon Mason (ECMWF), Robin Hogan (ECMWF) & many others

Outline

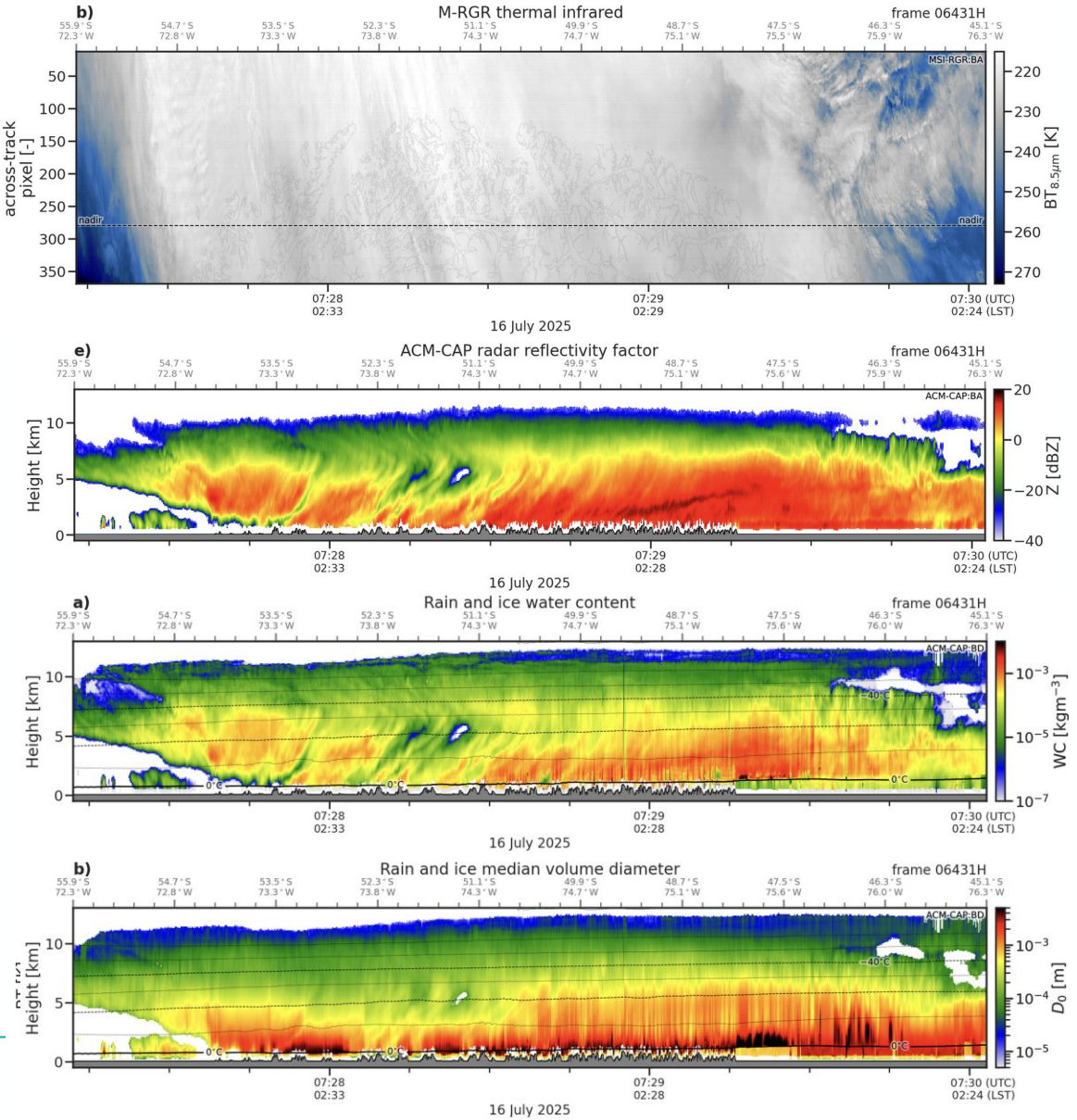
- ACM-CAP background
  - Known issues with operational baseline (BC)
  - Upcoming baseline (BD) will closely resemble the candidate for next reprocessing (CA)
- Recent evolution:
  - Improvements in CPR sedimentation velocity
    - Impacts on snow retrievals
    - Re-configuration of rain retrievals
  - ATLID backscatter & optical thickness
    - Improved aerosol retrievals
    - Optically thin ice clouds
  - Better use of MSI solar channels:
    - Improved models for surface albedo
    - Impact of assimilating near- and shortwave infrared channels
- Summary & outlook

CPR sedimentation velocity: rimed snow

With significant improvements in the postprocessing of Doppler velocity, we now have much greater confidence in the "sedimentation velocity" from C-CD *(Bernat Puigdomènech Treserras & Jiseob Kim talks next session)*

- Biggest impact in the presence of gravity waves, where ACM-CAP retrievals would attempt to interpret vertical air motion as changes in size/density of snow
- Adding temperature-dependent errors in our prior allows ACM-CAP to retrieve riming only at appropriate temperatures when justified by the sedimentation velocity

No substitute for in-situ validation: aircraft campaign flights in rimed snow (Emma Phillips poster P020)



CPR sedimentation velocity: warm vs cold rain

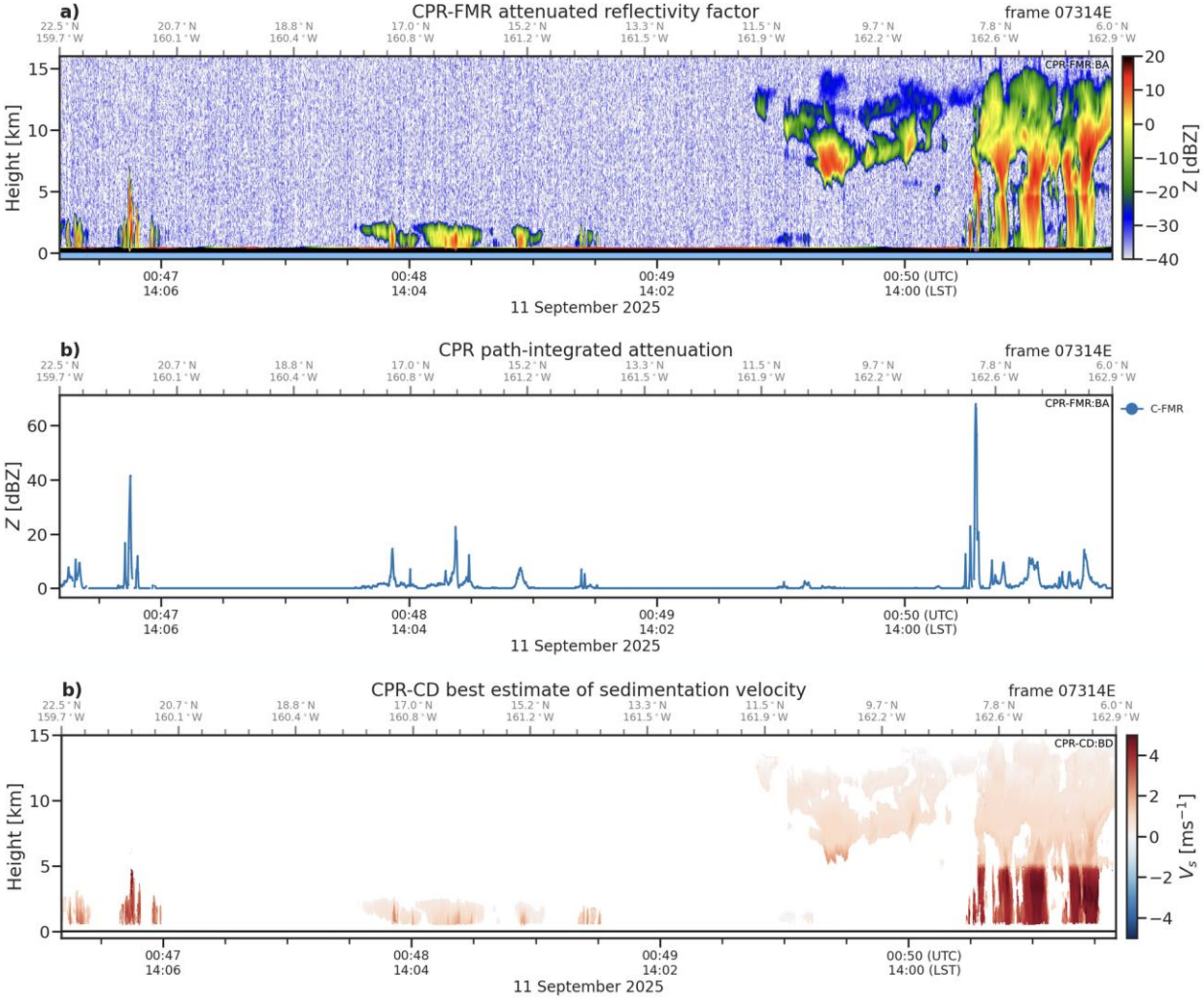
ACM-CAP retrieves rain rate and normalized number concentration

- The operational ACM-CAP representation of rain uses the Abel & Boutle relation between rain rate and drop size distribution:

  low rain rates → many, small drops

  high rain rates → fewer, larger drops

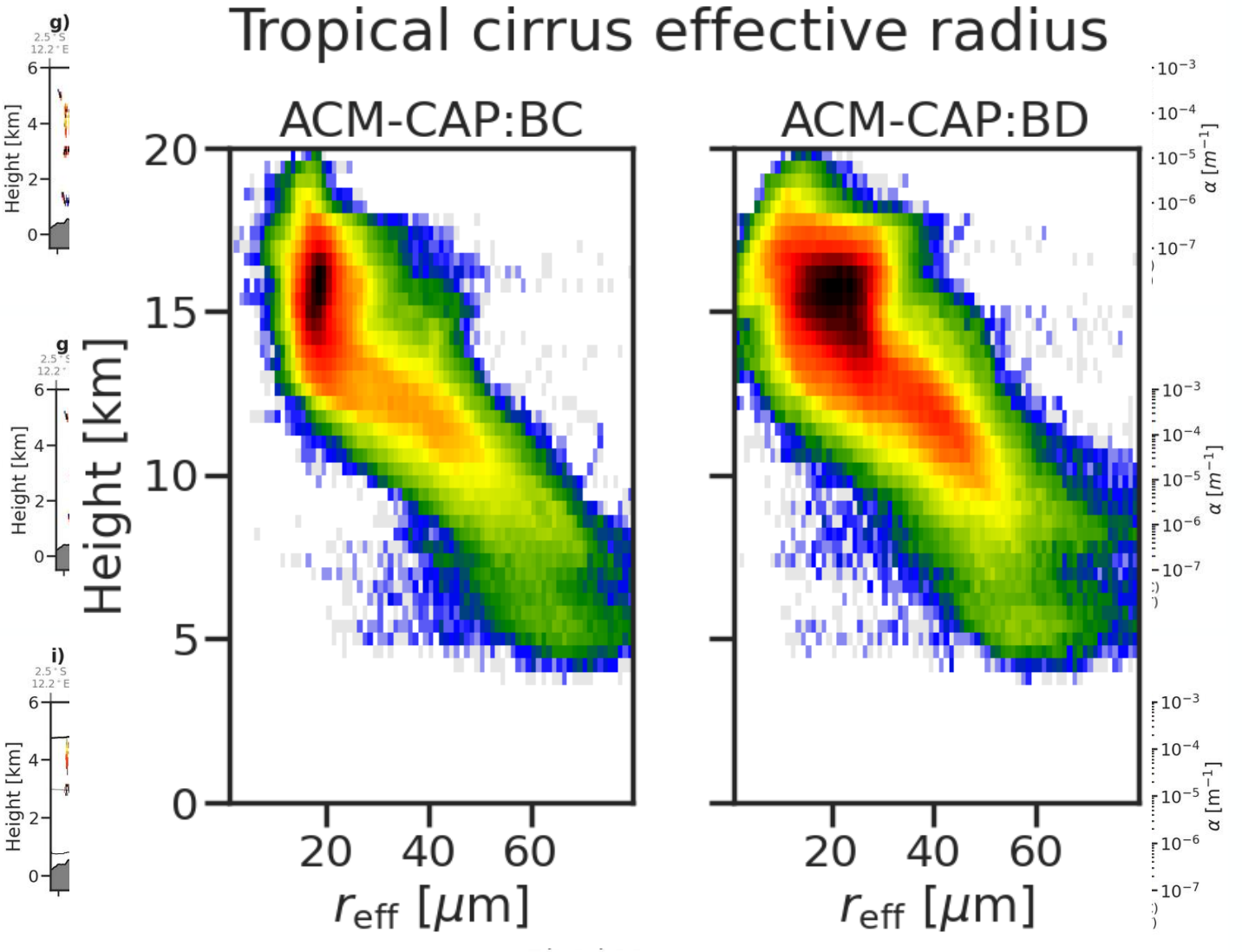
- This a-priori limited the impact of CPR Doppler/sedimentation velocity in warm rain, where we often see strong gradients of Doppler velocity implying rapid drop growth
- We now retrieve N_w with a weaker fixed prior (Marshall-Palmer value for cold rain; 100x higher for warm rain)



Linear treatment of ATLID backscatter improves cirrus & aerosol retrievals

We assimilate the logarithm of Rayleigh and Mie backscatter channels; this led to poor performance for the weakest lidar signals

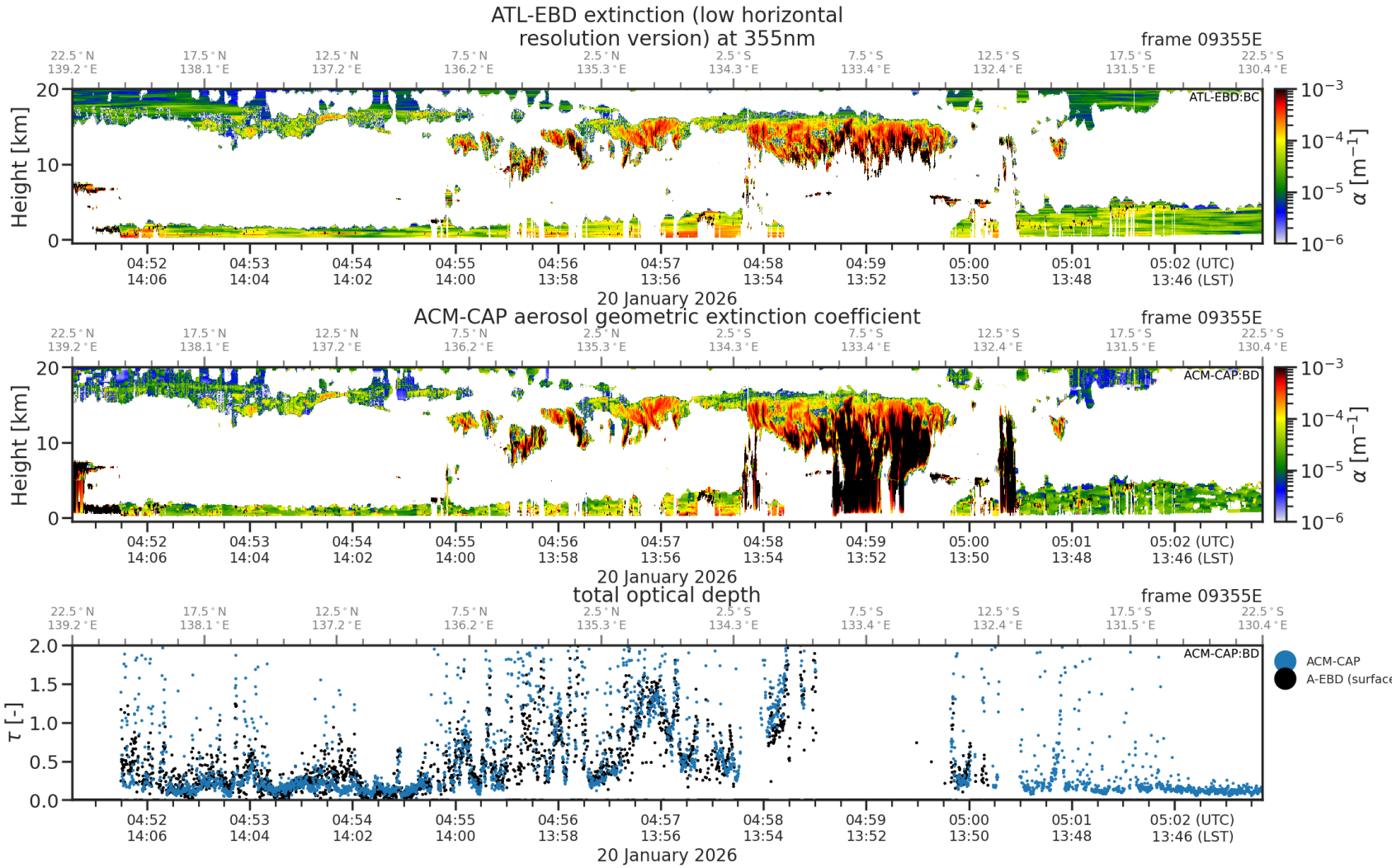
- We now assimilate the linear backscatter for both Rayleigh and Mie channels
- Improved aerosol retrievals: reduced Kalman smoothing artefacts, resolving aerosol layer features
- Improved cirrus retrievals: ATLID-only retrieval led to a flat ~20μm ice effective radius; improved range from 10-30μm



ATLID surface returns to constrain aerosol optical thickness

The A-EBD product now includes an optical depth estimate based on the ocean surface return *(GJ van Zadelhoff talk Friday)*

- Additional constraint on retrieved profiles of extinction in aerosol & cirrus
- Especially important to constraint aerosol layers near the surface, where attenuation of Rayleigh channel no longer available



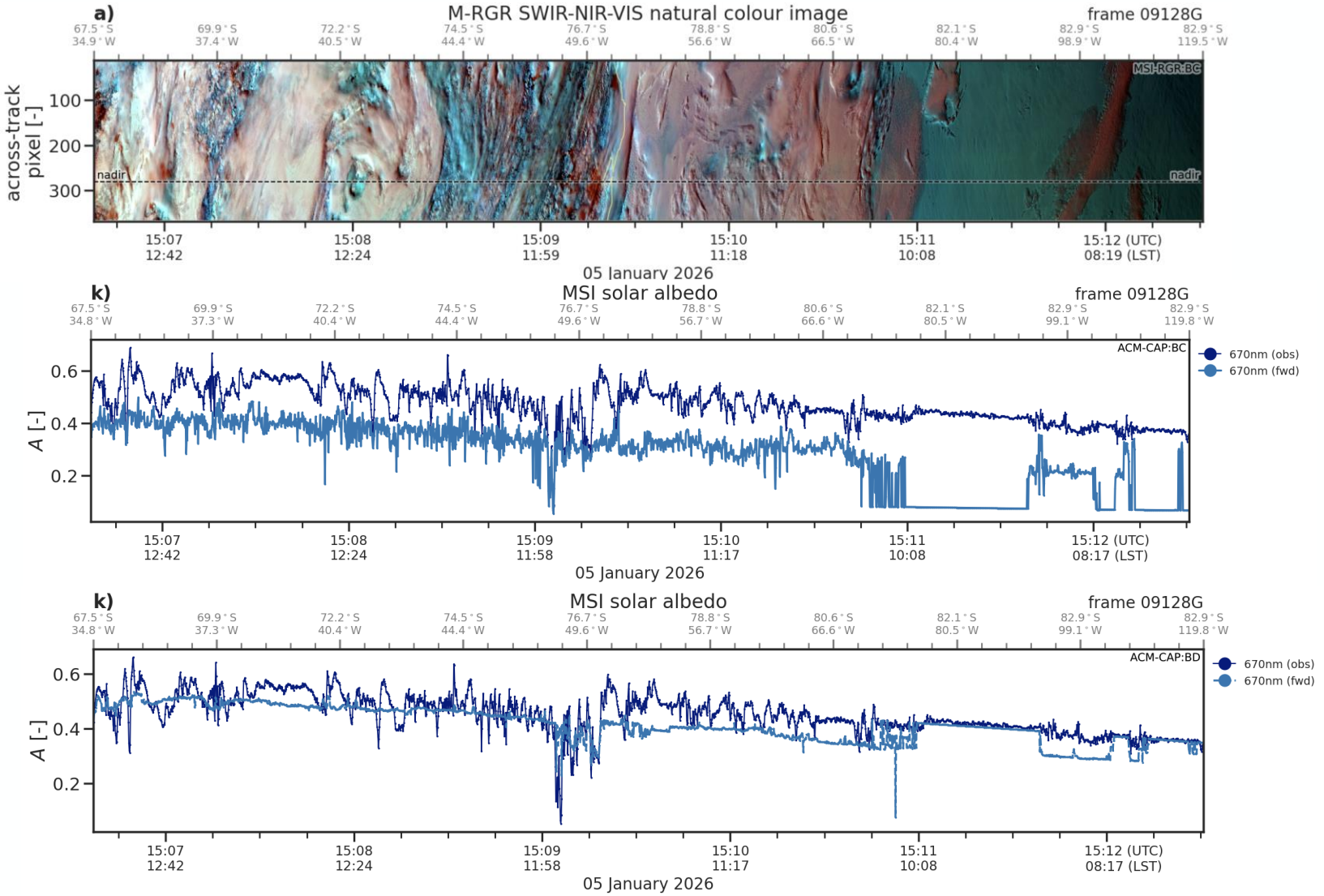
MSI solar radiances: improved surface albedo over sea ice & snow

ACM-CAP currently takes the surface albedo from the ECMWF model (AUX-MET) without properly accounting for sea ice and snow:

- Now representing snow cover and sea ice, but still spatially coarse w/ high uncertainties
- Missing sea ice & snow led to biases in cloud retrievals: too-high ice water content in attempt to match observed albedo

Future work:

- ATLID & CPR surface returns could be used to diagnose sea ice/snow cover at EarthCARE resolution



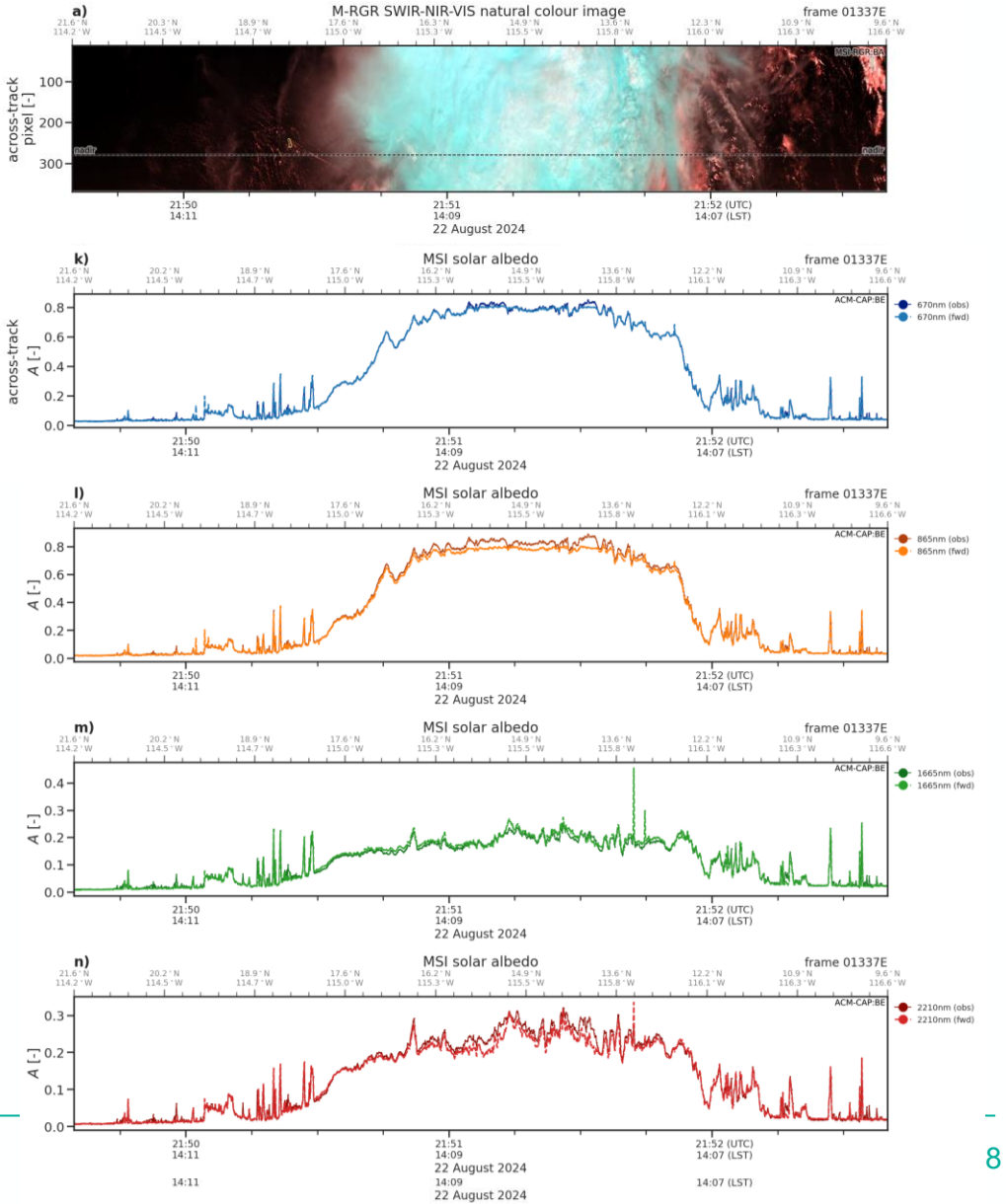
MSI solar radiances: near- and shortwave-infrared

ACM-CAP currently only assimilates the visible (860nm) and thermal infrared MSI channels.

- Recent updates to the FLOTSAM shortwave radiance model ***(Robin Hogan talk Thursday afternoon)*** allows us to assimilate all MSI channels, providing more information on cloud properties
- Now able to represent near-IR and SWIR channels in optically thick cloud and over oceans; need better spectral surface albedo information over land, snow & sea ice

Future work:

- Improved spectral & high-resolution characterisation of surface albedo & emissivity to be pre-processed in an upstream product and used across multiple processors (M-COP/M-AOT, ACM-CAP, ACM-COM)



Summary & outlook

Recent evolution of the synergistic retrieval (ACM-CAP:BD):

- Benefits from many upstream improvements, especially in C-CD's sedimentation velocity
- Constitutes significant improvements over the currently operational baseline (BC)
- Corresponding improvements in radiative closure

Tuning and evaluation still ongoing across as many regimes & campaigns as possible

- Huge thanks to many groups already providing feedback and iterating on ACM-CAP
- **Be in touch, let me know which frames you'd like processed:** shannon.mason@ecmwf.int