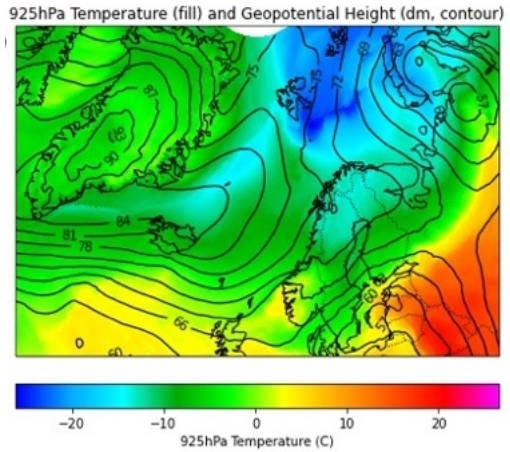
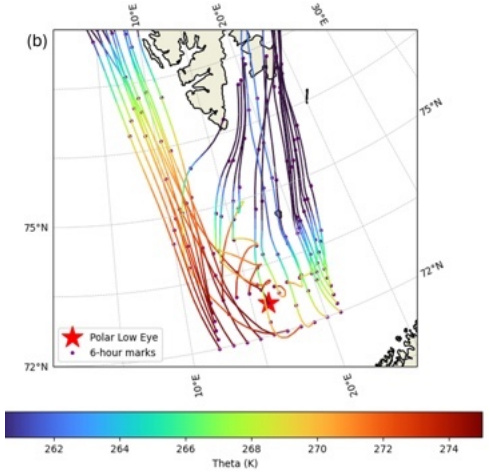
RF9 case study: surface processes and polar cyclogenesis (Newman et al. 2025)

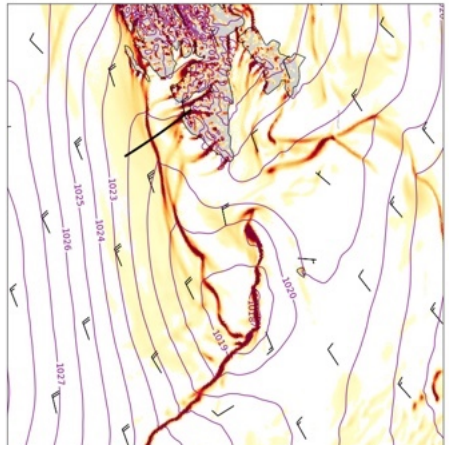
1. Synoptic environment was conducive for MCAO conditions



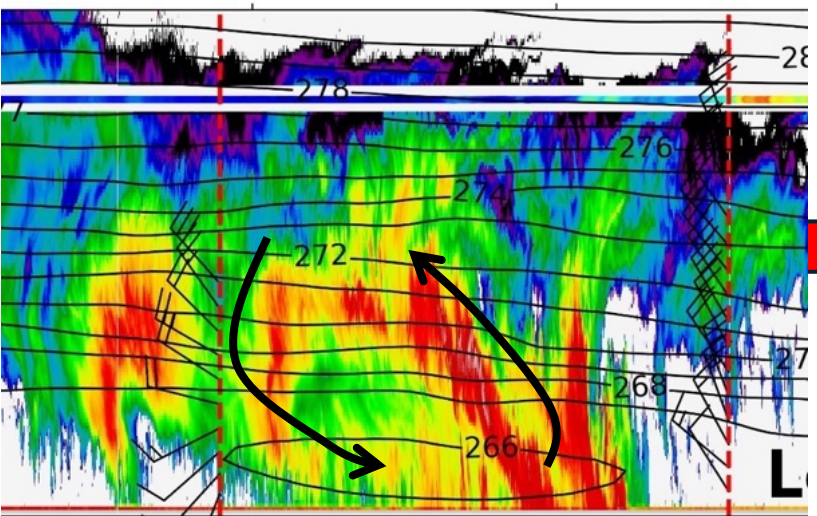
2. Differential surface heat fluxes along the prevailing northerly flow built shallow baroclinicity



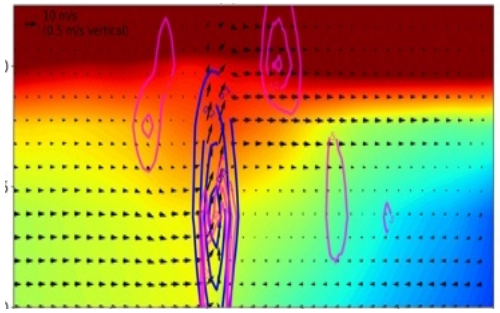
3. frictional PV generation in streamers off Svalbard terrain



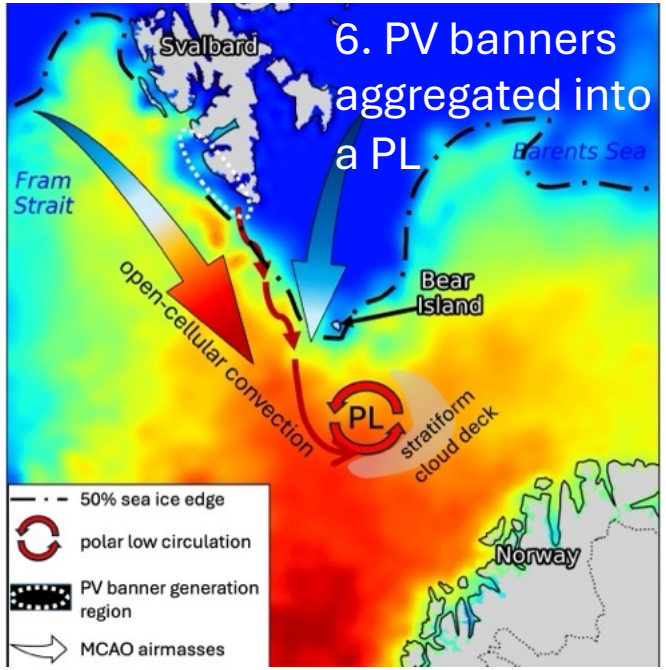
4. PV banners were concentrated by solenoidal circulations



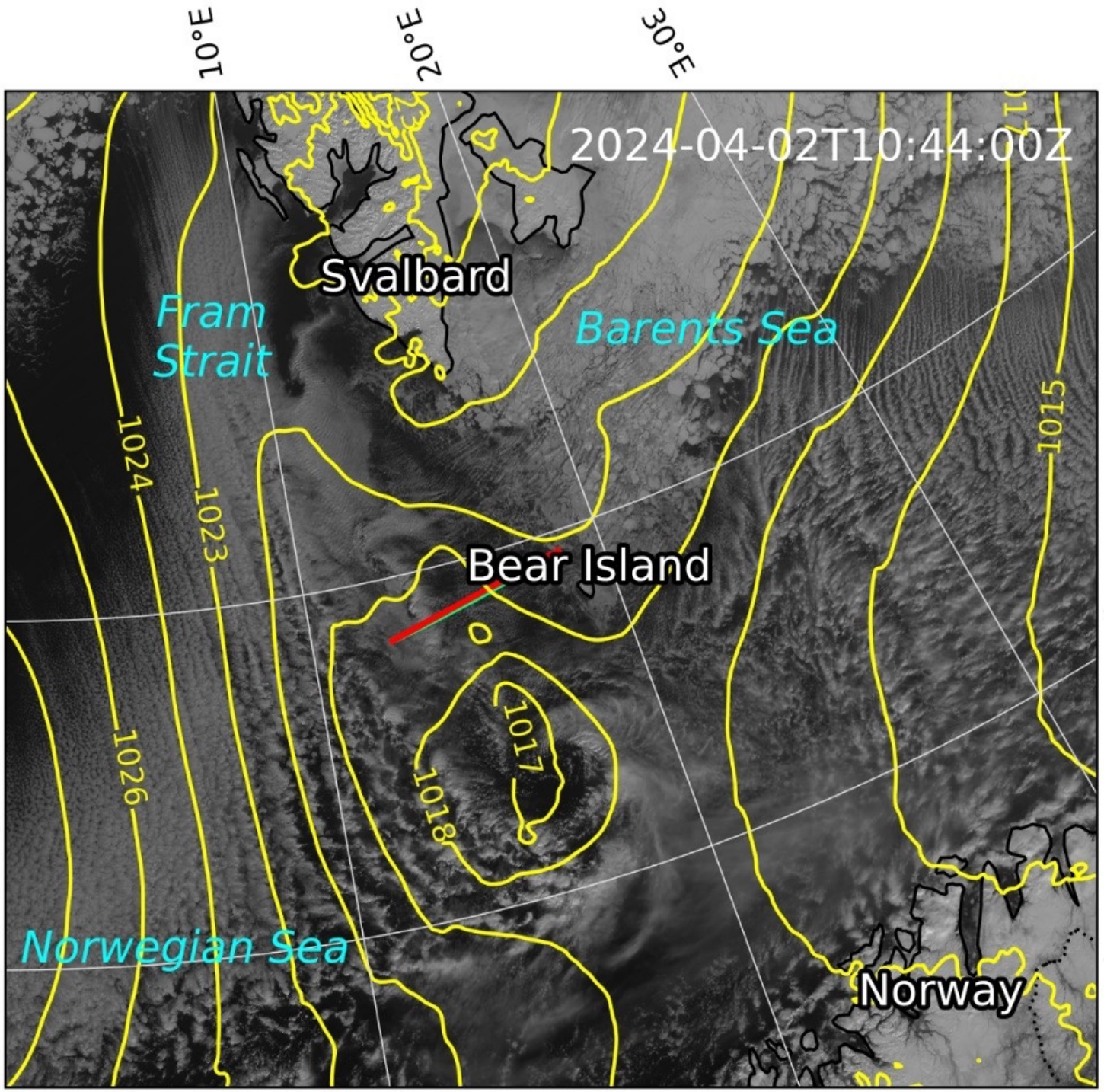
5. Diabatic heating within convergent snow bands enhanced PV

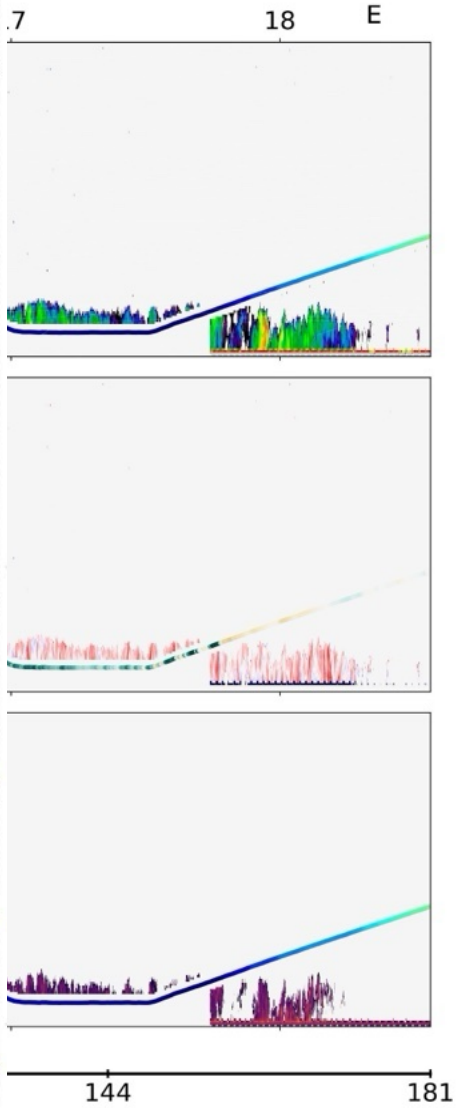


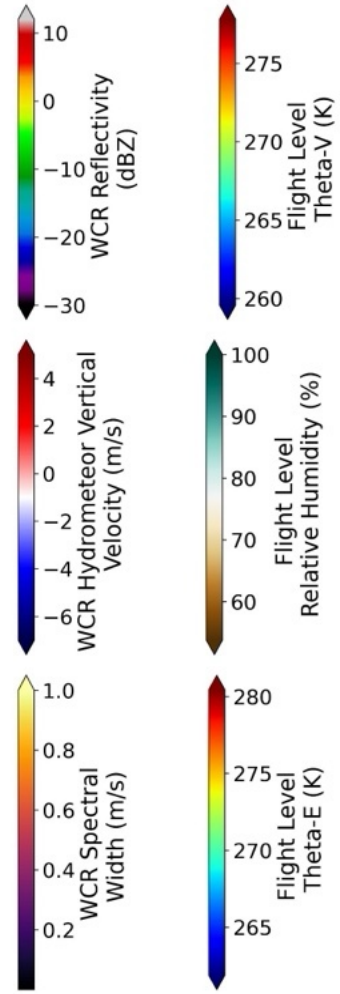
6. PV banners aggregated into a PL



bservations



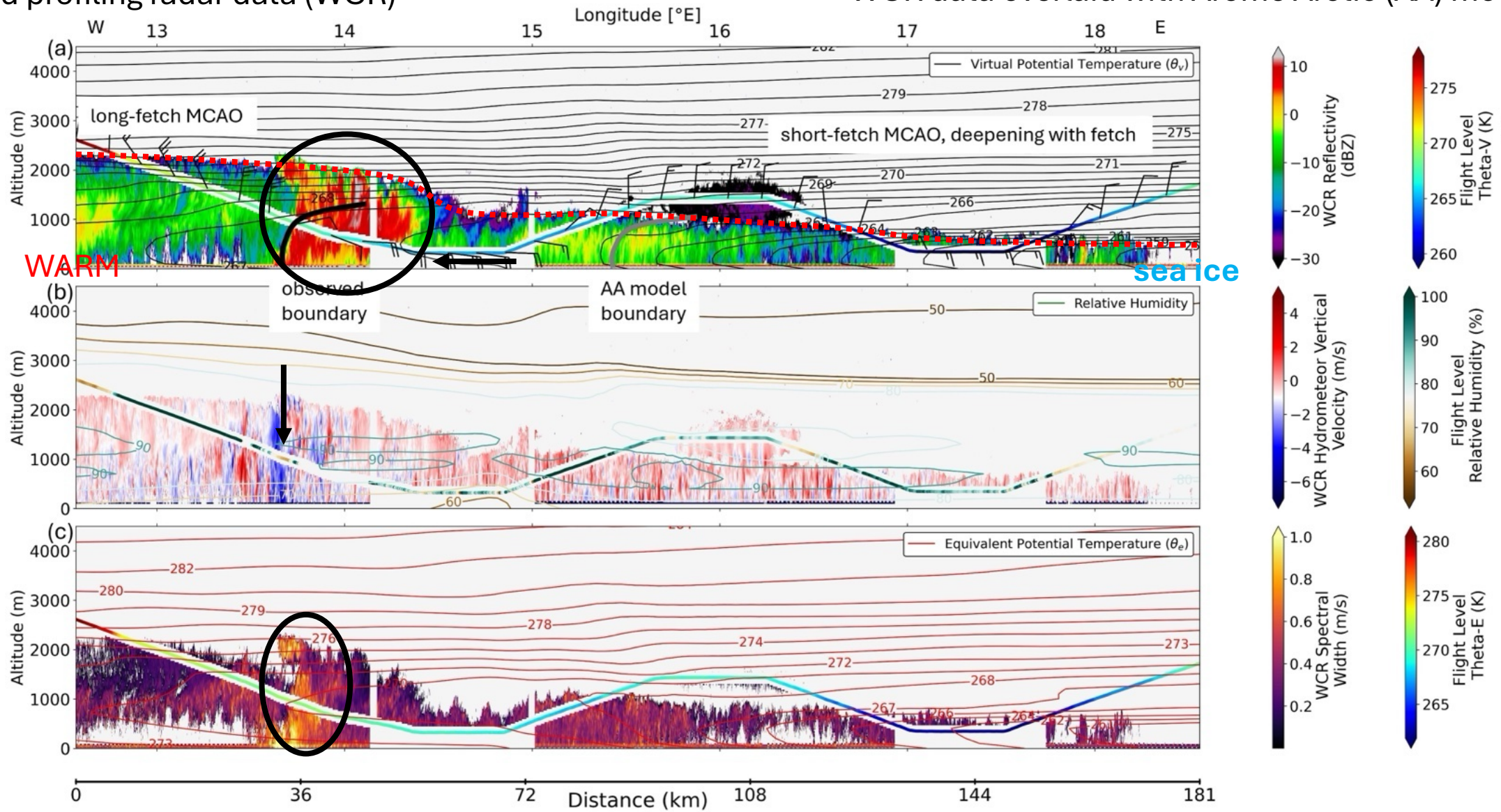




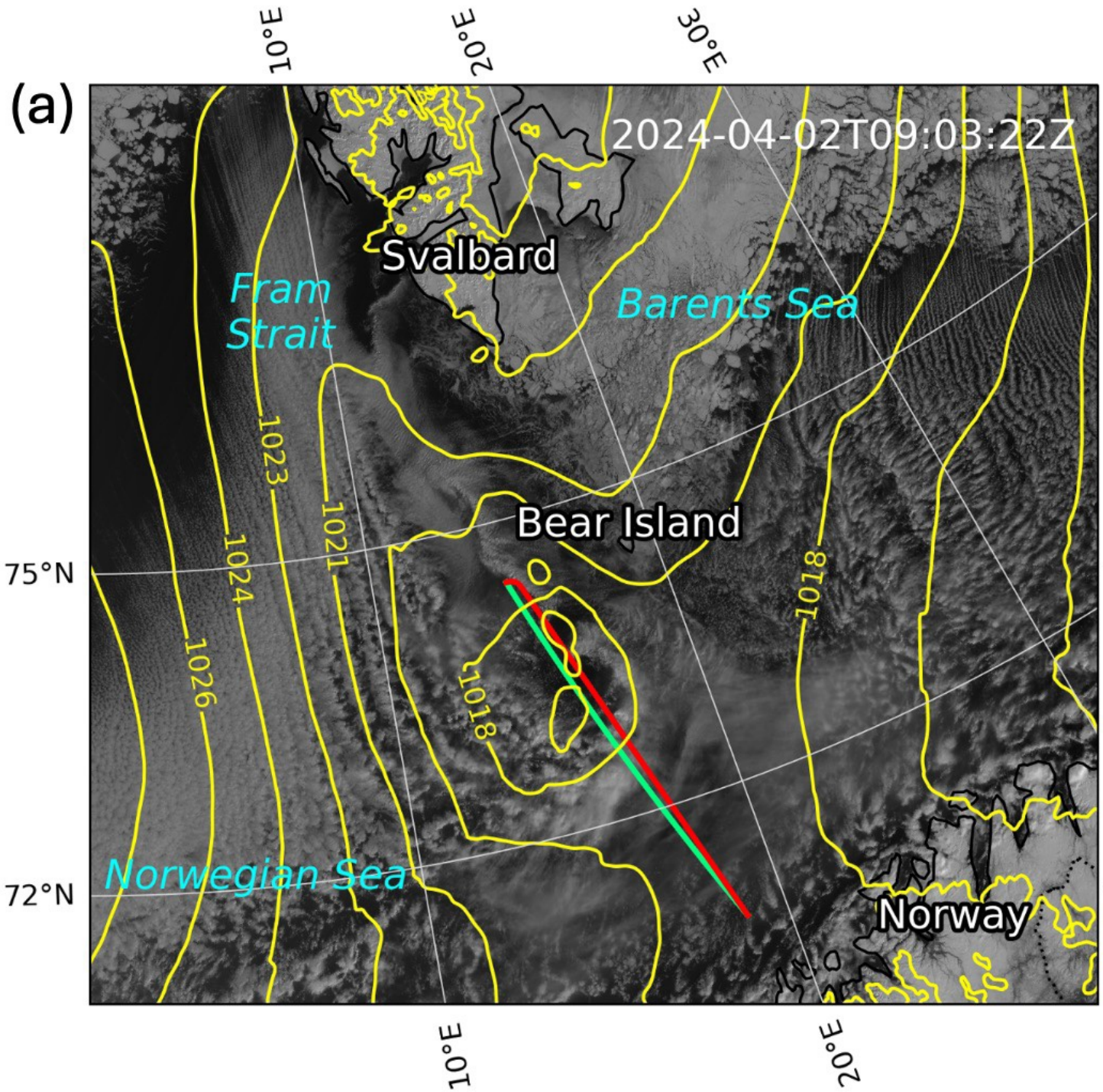
PV streamer vertical structure: RF9 observations

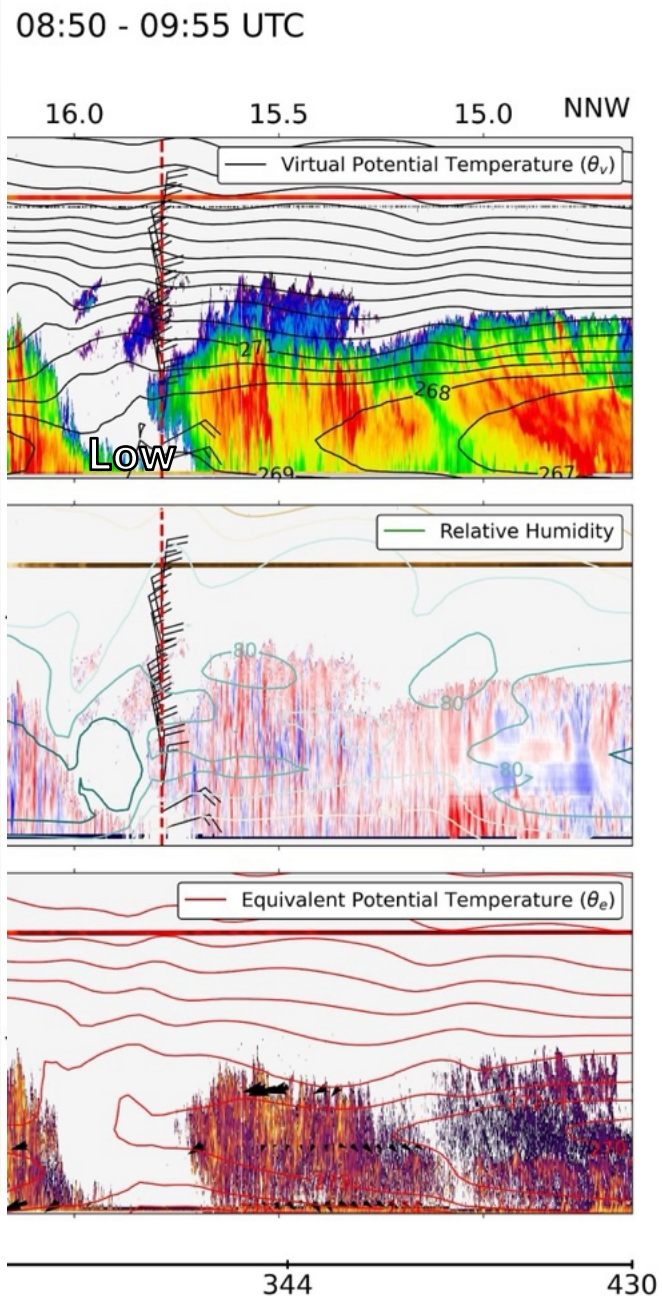
W-band profiling radar data (WCR)

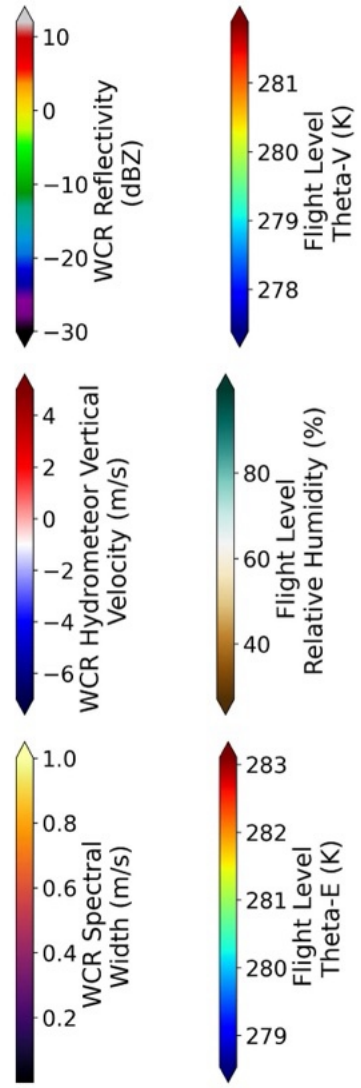
WCR data overlaid with Arome Arctic (AA) model output



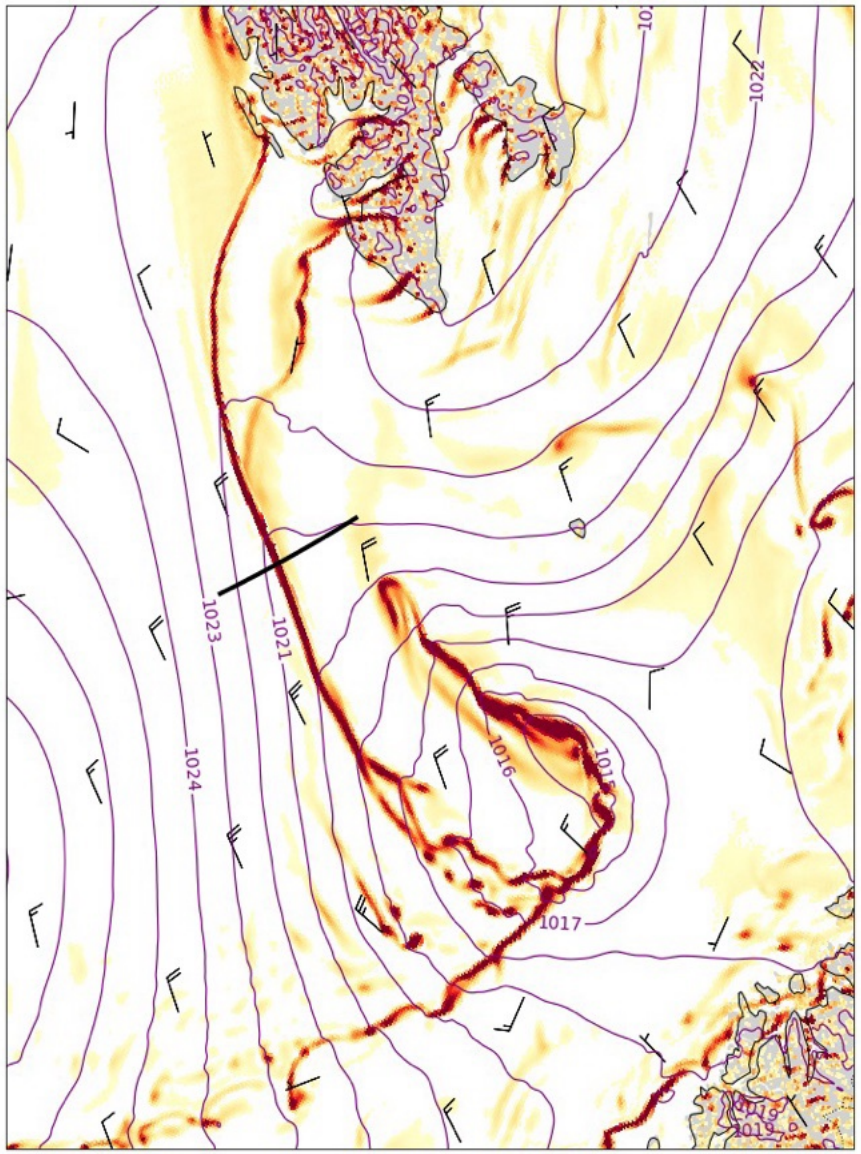
9 Observations





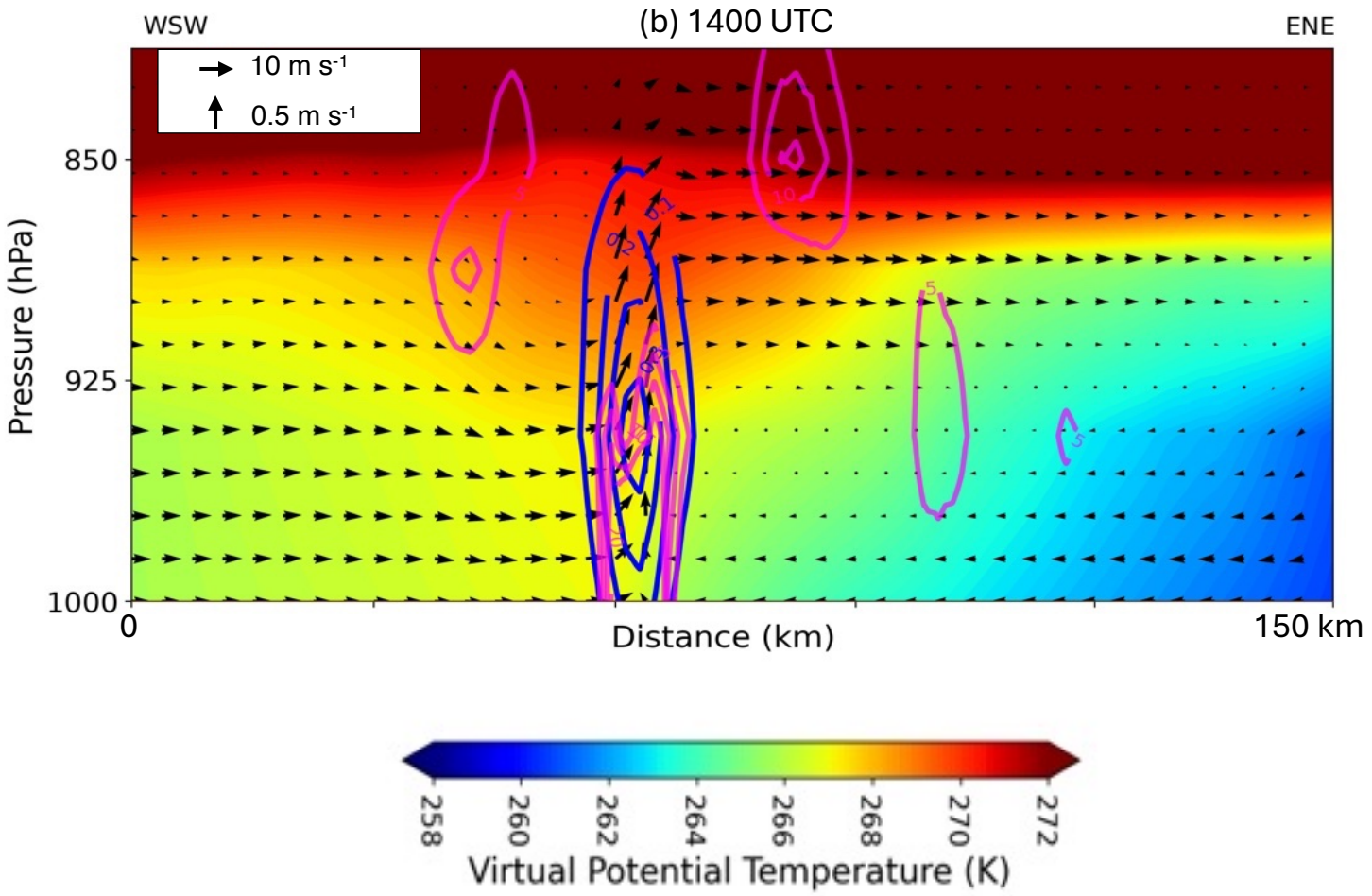


Transect across convergent cyclonic boundary (RF9)



IWC (g / kg)

Frontogenesis (K /(100 km * hr)



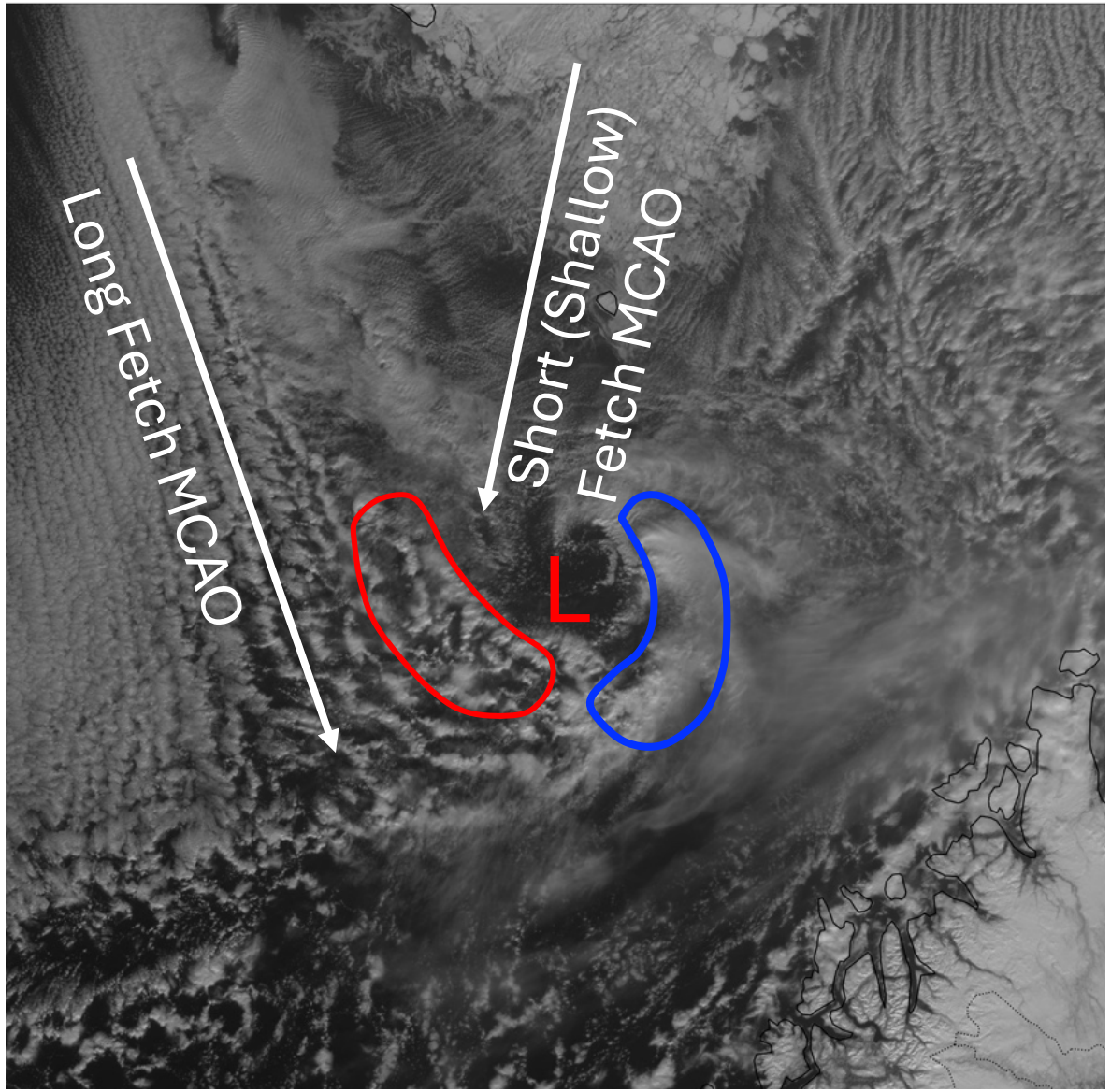
Frontogenetic, solenoidal forcing produces a convergent snow band that concentrates PV

Surface fluxes and cloud structure (RF9)

large surface heat fluxes, long fetch

deep convective BL

open-cellular convection

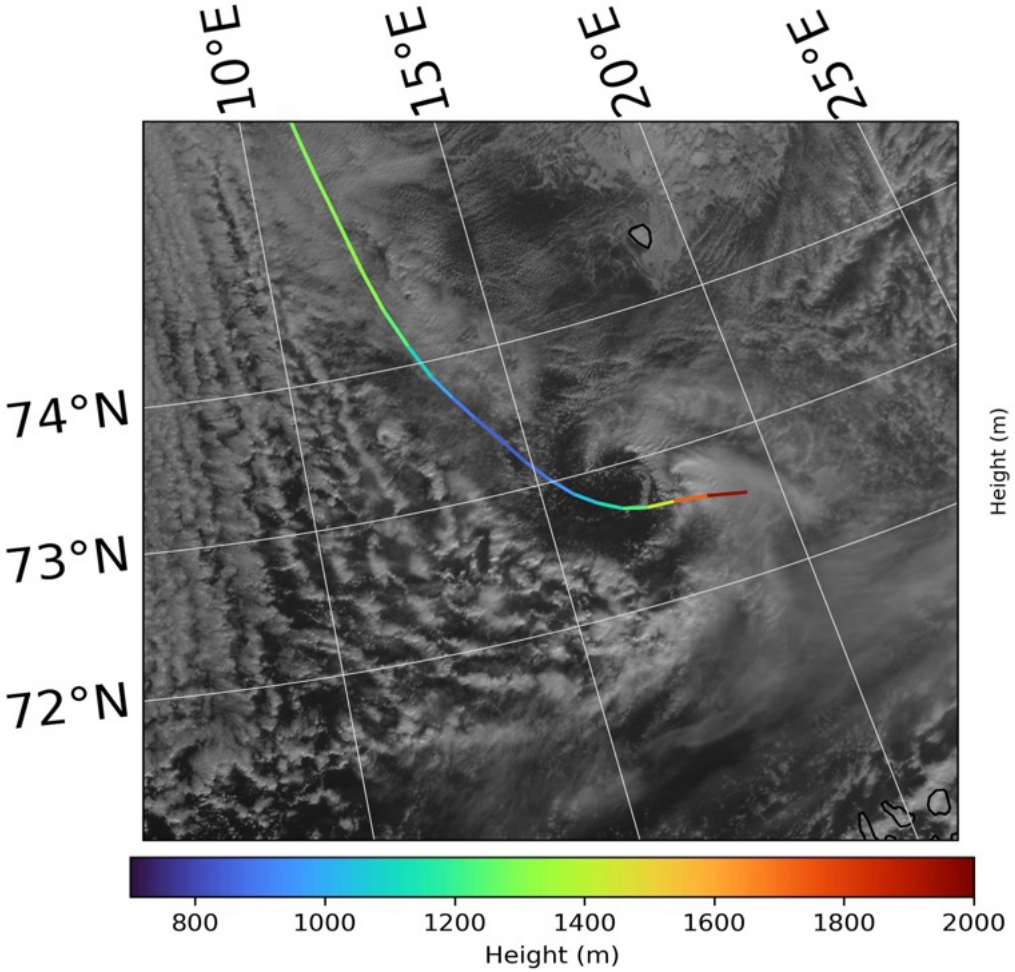


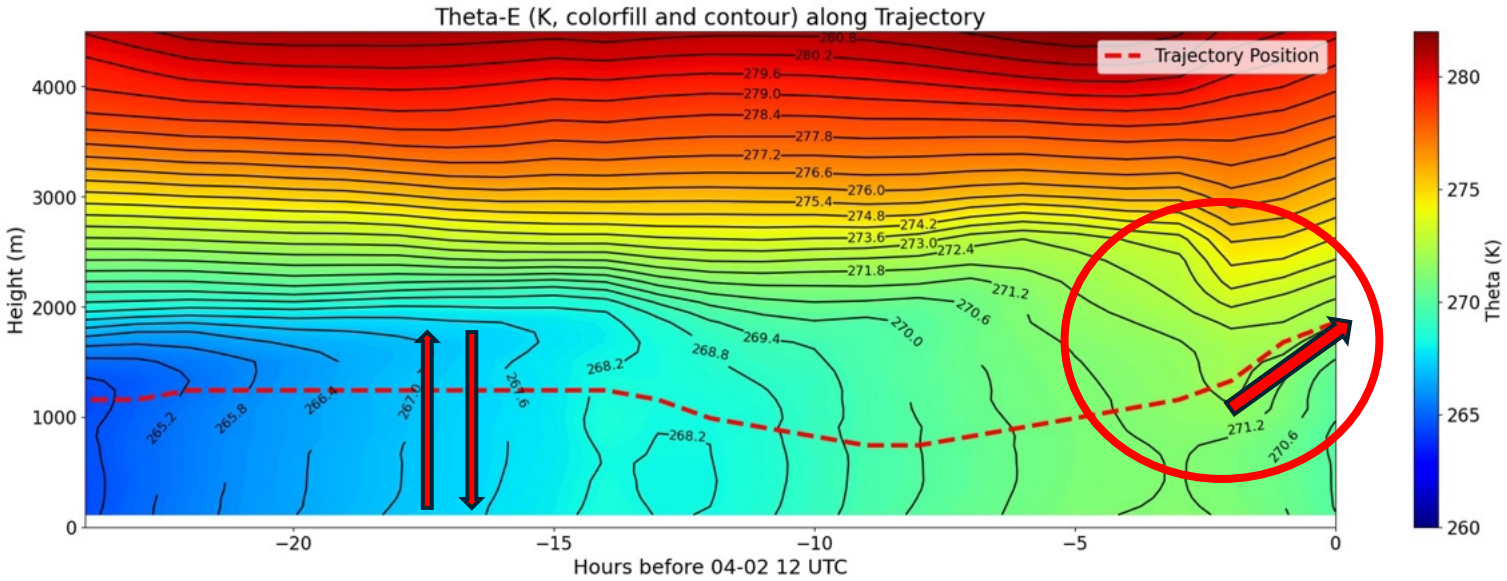
wrap-around region: suppressed heat fluxes

statically stable atmosphere

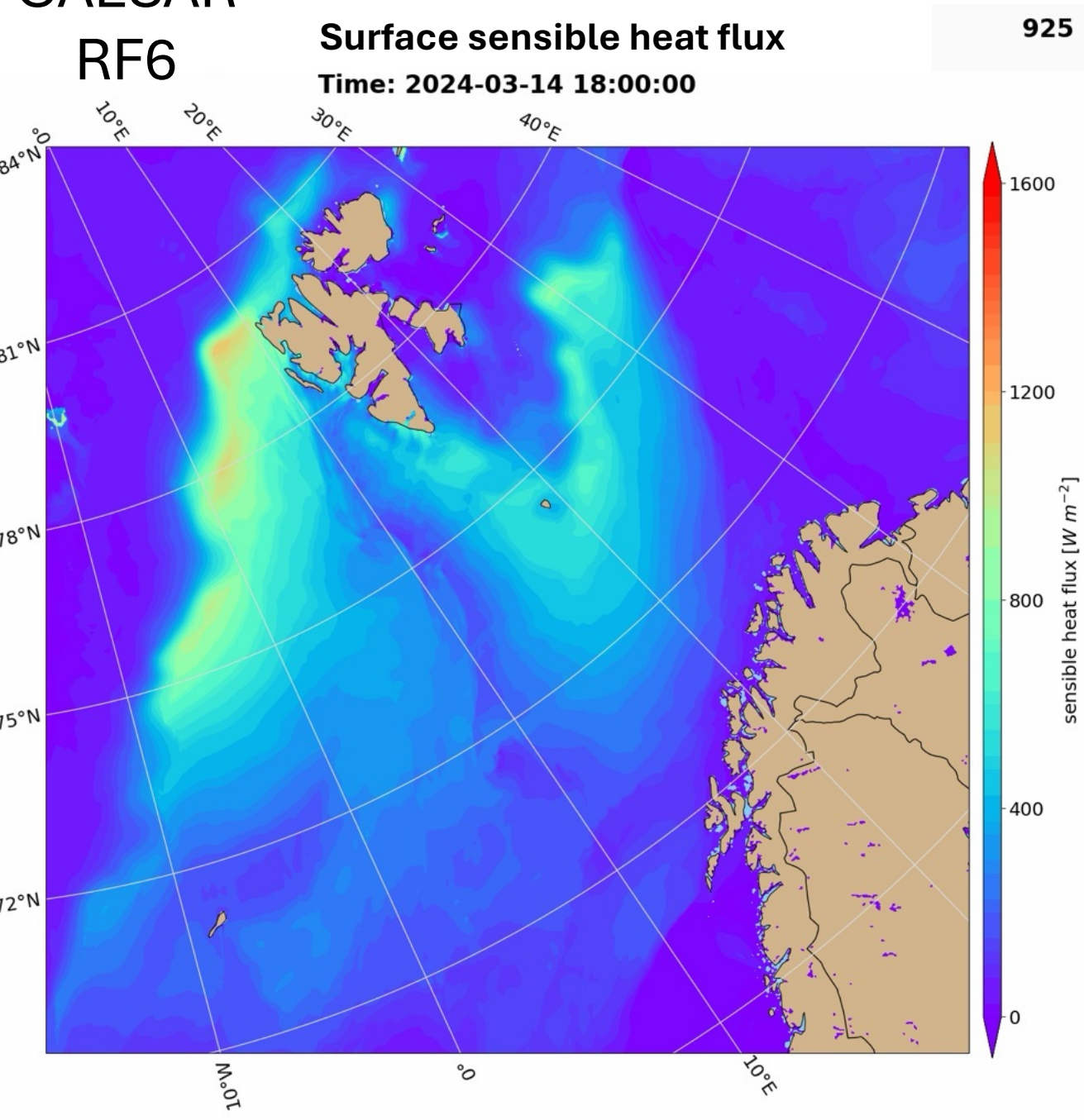
stratiform cloud region from moist isentropic ascent

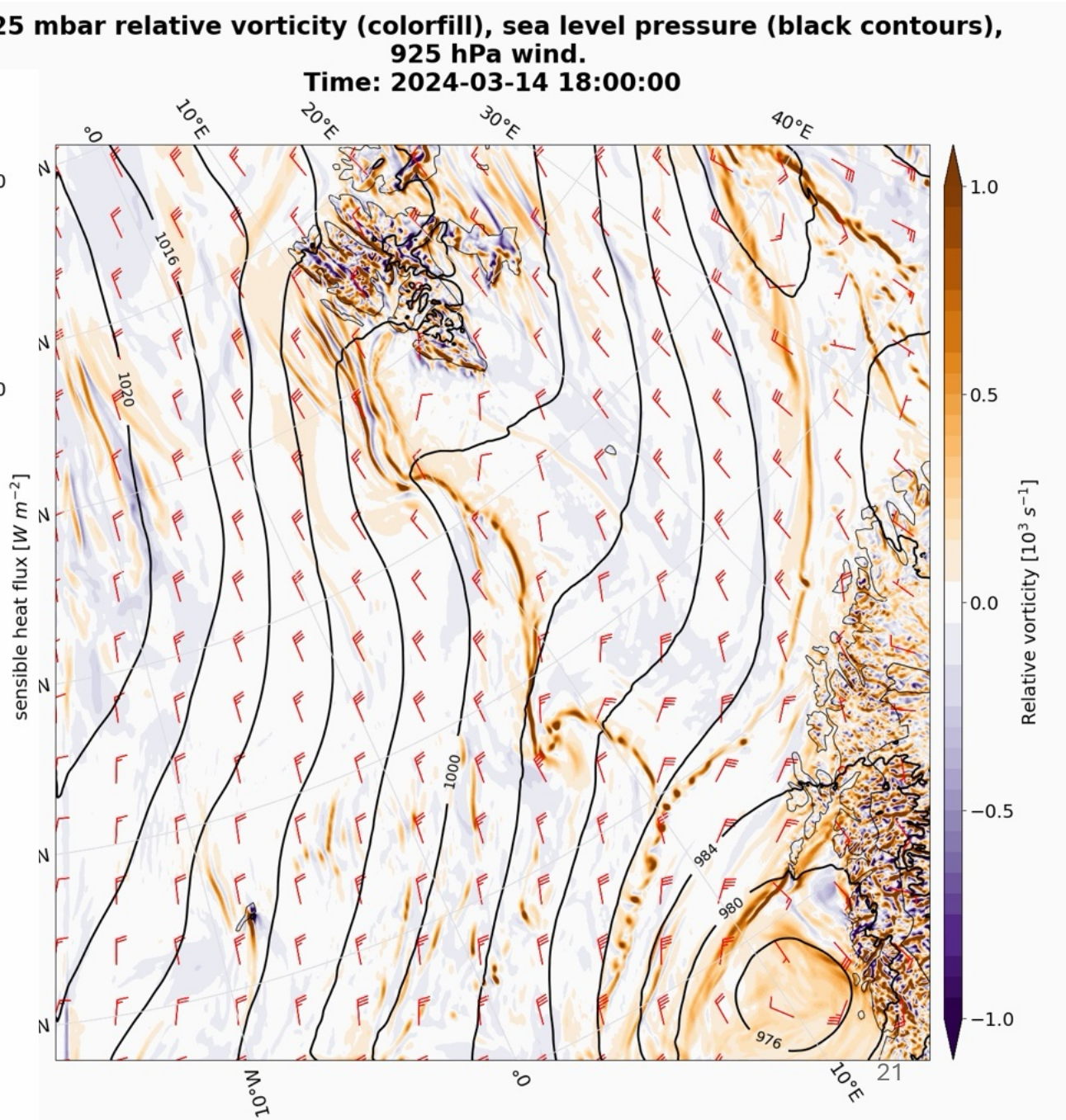
Surface fluxes and cloud structure (RF9)





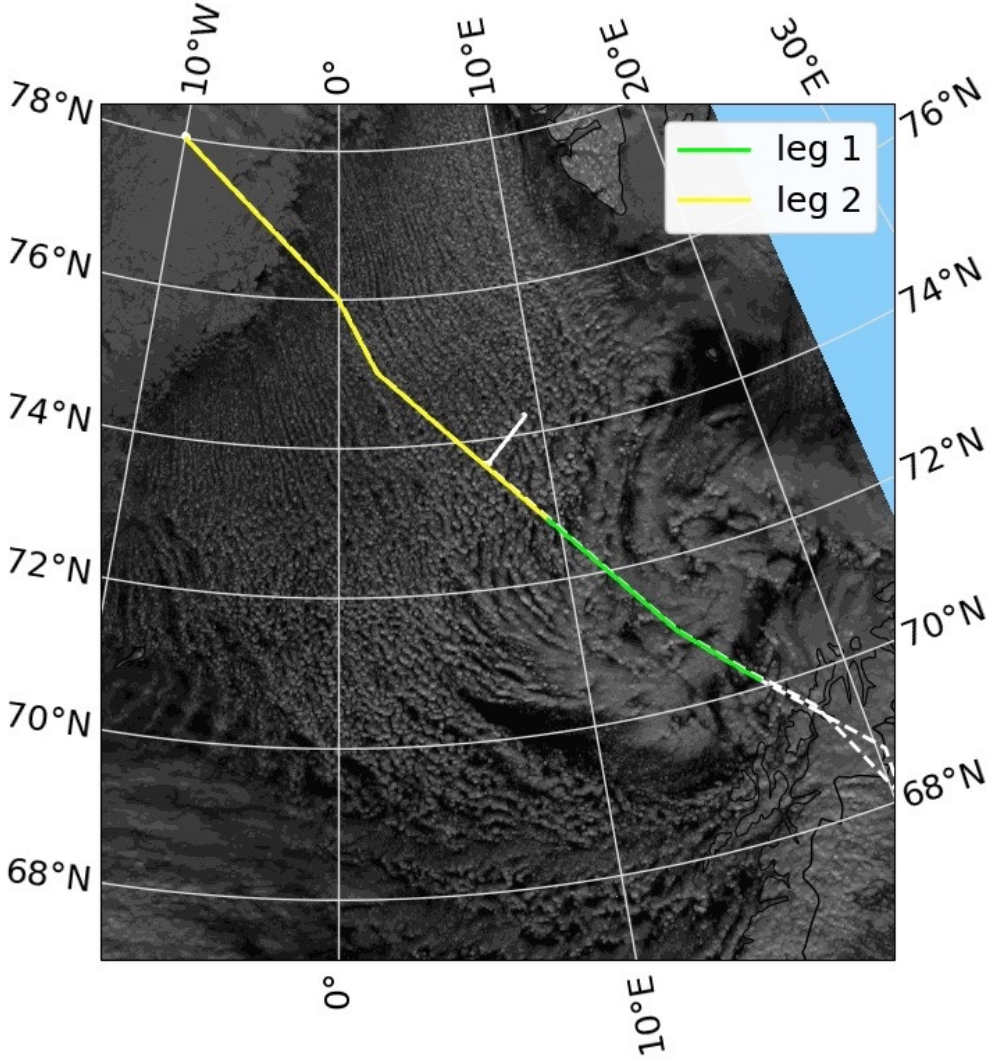
CAESAR RF6

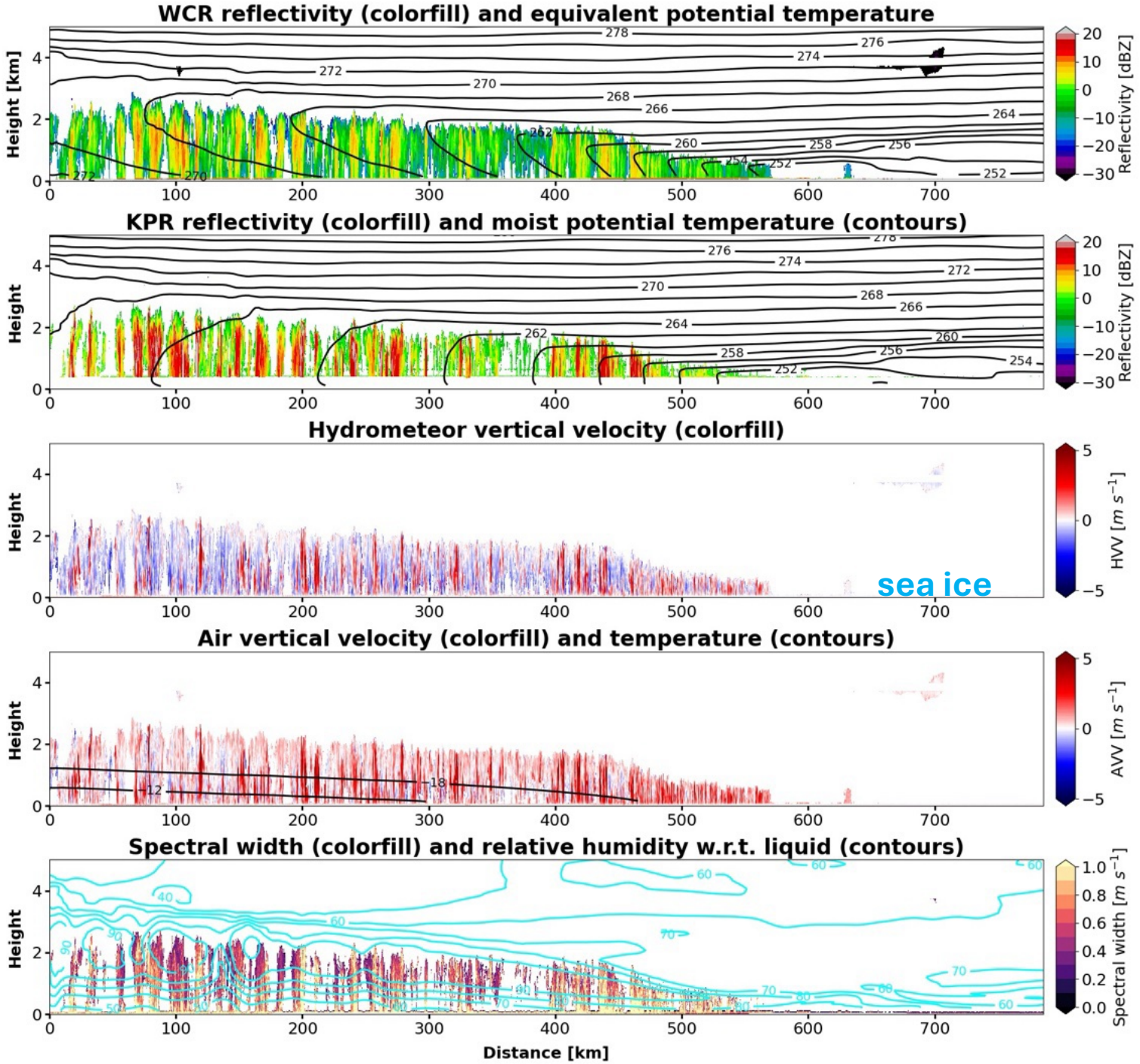

Surface sensible heat flux
Time: 2024-03-14 18:00:00
10°E
20°E
30°E
40°E
°0
84°N
81°N
78°N
75°N
72°N
10°W
°0
10°E
1600
1200
800
400
0


925 mbar relative vorticity (colorfill), sea level pressure (black contours), 925 hPa wind.
Time: 2024-03-14 18:00:00
°0
10°E
20°E
30°E
40°E
1016
1020
1000
984
980
976
10°W
°0
10°E
sensible heat flux [W m⁻²]
Relative vorticity [10³ s⁻¹]
1.0
0.5
0.0
−0.5
−1.0

RF6 Leg 2 WCR + AA

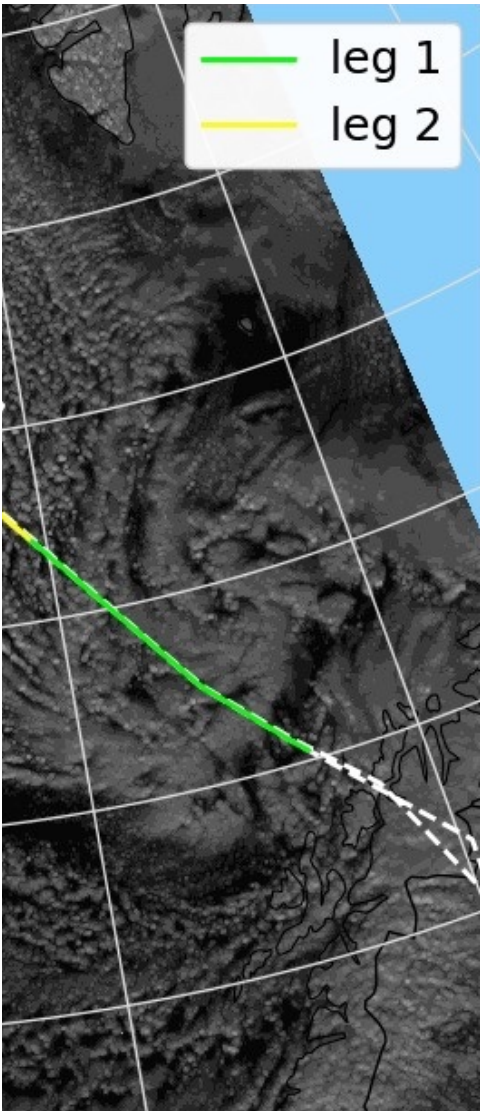
surface-driven
transition from rolls to open cells

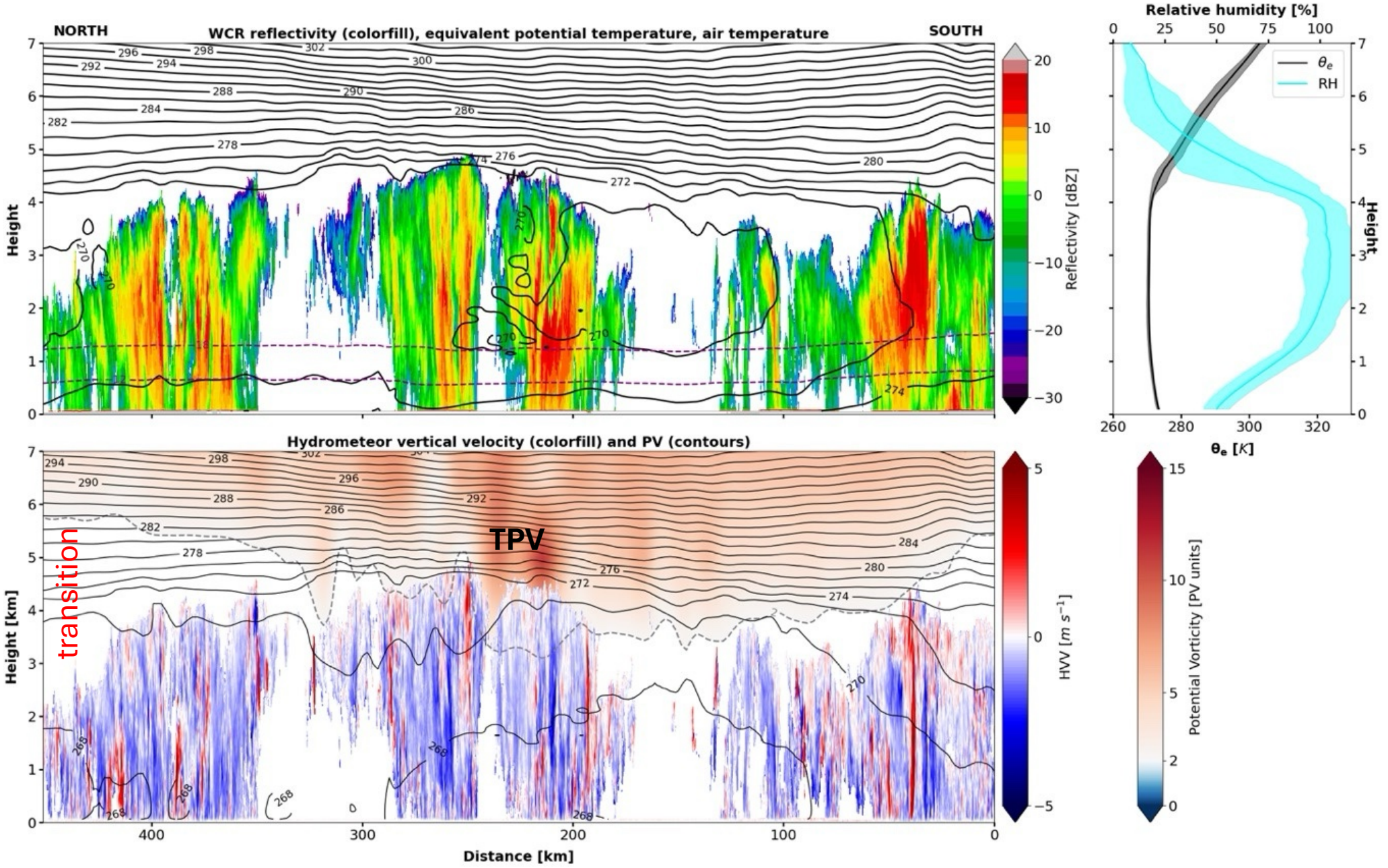




RF6 Leg 1: WCR + AA transect

tropopause-driven
transition from shallow to deep convection





Take-aways

- LES model output in open cells highlights the role of weak cold pool outflows in converging warm/moist air and triggering new cells.
- Vertical velocity spectra are characterized by sizes much smaller than other wind/thermodynamic field, esp. at low levels
- The polar low under lower M-values (RF9) developed a stratiform cloud band. Clouds were purely convective in the strongest CAO (RF6).
- Polar cyclogenesis in CAO conditions results from upper-level forcing (TPV), surface heat fluxes, vortex shedding by Svalbard, convergent cyclonic shear belts, and cloud diabatic heating