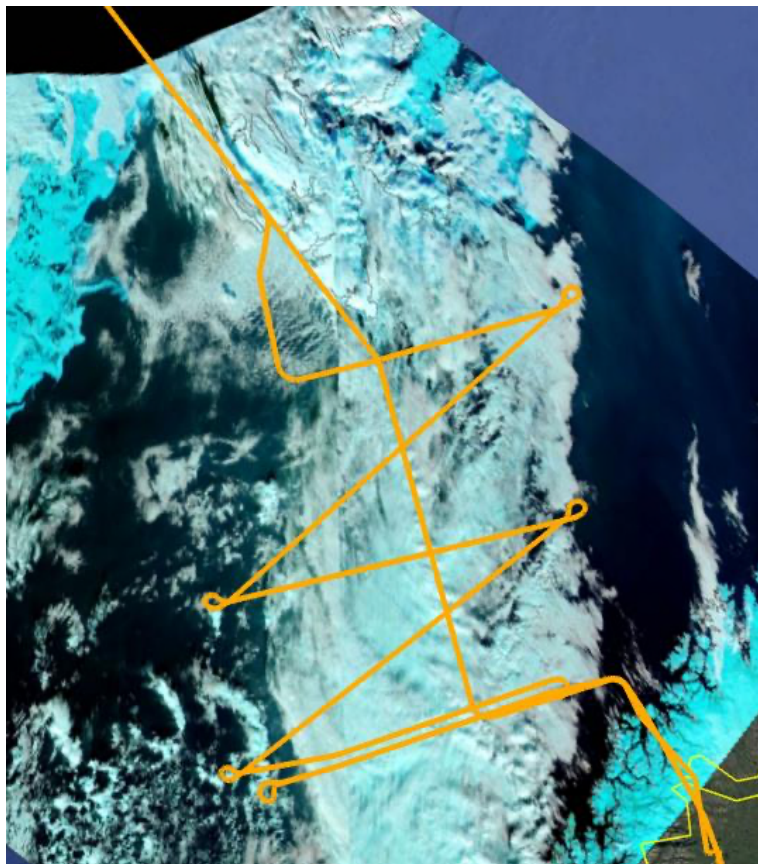


## HALO-(AC)<sup>3</sup> – 2022/03/16 – HALO research flight #06

### Objectives:

- To sample the vertical structure and the humidity transport within the decaying Atmospheric River (AR) in between Norway and Svalbard that was already visited during RF05 (2022/03/15) in its early and mature stages close to Greenland
- To derive the moisture flux within the AR using multiple WALES water vapor cross-sections and dropsonde curtains
- To fly a collocated leg with the FAAM BAe-146 across the Atmospheric River to collect simultaneous in situ data to the radar-lidar curtain from HALO
- To perform an overpass of the 35 GHz cloud radar (NyRAD35) in Ny-Ålesund, Svalbard to compare its sensitivity with the 35 GHz cloud radar of HAMP and to obtain simultaneous polarimetry data using coordinated RHI scans
- To sample the vertical structure and development of the shallow cloud deck over the ice sheet connected to the stationary cold front / surface low north of Greenland



**Fig. 1:** MODIS RGB composite satellite image with flight track of RF06 which transected the Atmospheric River multiple times

Mission PI HALO:

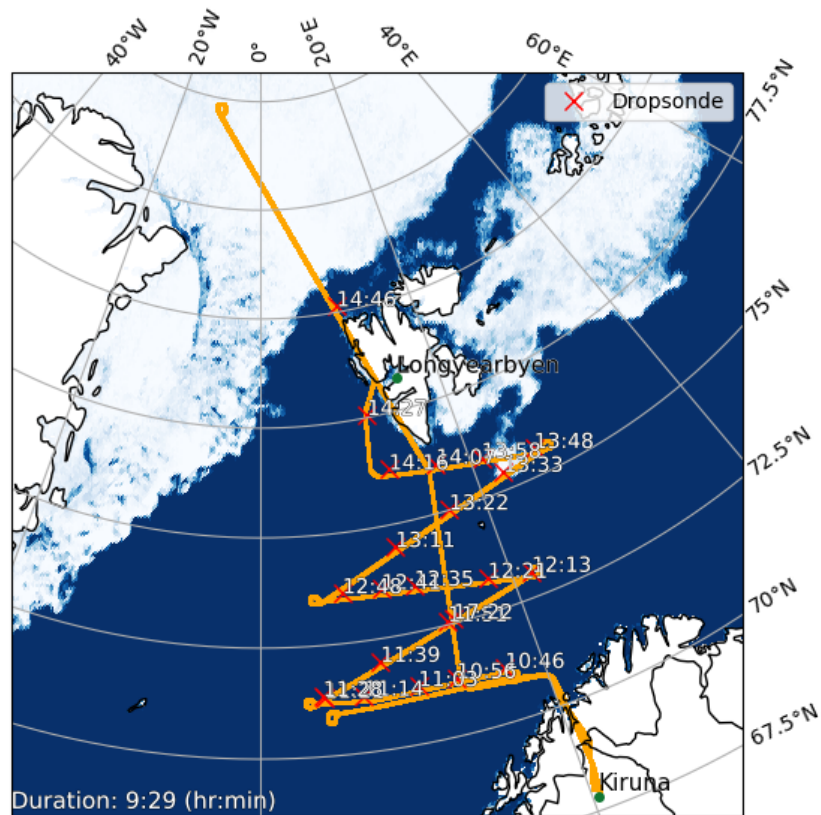
Florian Ewald

Flight times:

HALO Crew	
Mission PI	Florian Ewald
HAMP	Clémantyne Aubry
WALES	Georgios Dekoutsidis
SMART/VELOX	Johannes Röttenbacher
specMACS	Veronika Pörtge
Dropsondes	Sebastian Schmidt
Optional	Davide Ori
Pilots	Marc Puskeiler Michael Grossrubatscher
Engineer	Thomas Leder

HALO	
Take off	08:58 UTC
Touch down	18:26 UTC



**Fig. 2:** Map with flight track (orange line) and dropsonde launches (red cross) during HALO RF06. Sea ice fraction as observed by the Advanced Microwave Scanning Radiometer (AMSR2) by the University of Bremen (Spren et al., 2008).

## Weather situation as observed during the flight (compare to forecast):

The weather situation close to Norway up to the Fram Strait was dominated by a cold front connected to a low pressure system situated north of Greenland. Connected to the front, an Atmospheric River was transporting moist and warm air towards the Arctic which developed in the preceding days west of Greenland and drifted eastwards to the Norwegian Coast. The forecast predicted a weakening of the precipitation along the front. During the flight, signs of temporary steepening of pressure gradients, especially close to the Norwegian Coast, created stronger precipitation signals than forecasted. Connected to that, the eastwards advection of the cold front was a little bit delayed (by 50 NM) but its vertical extend with cloud tops up to 8 km was as forecasted.

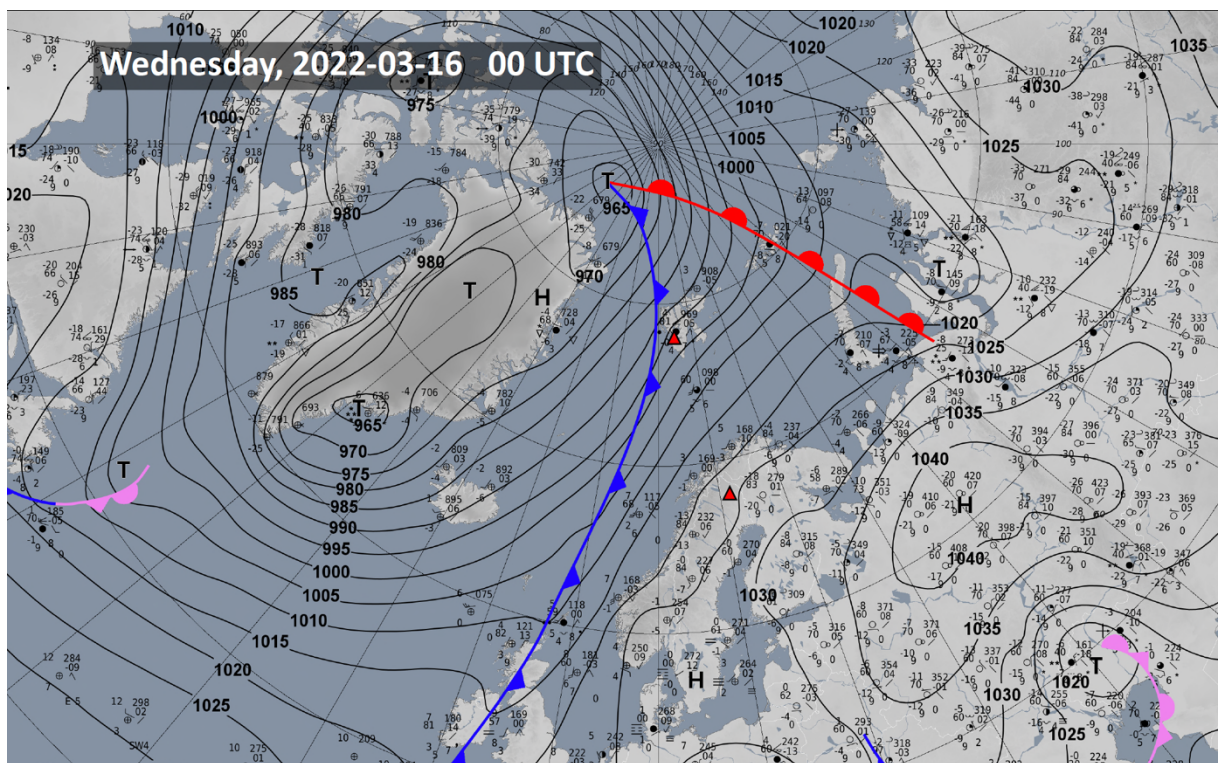


Fig. 3: Surface analysis for Wednesday, 2022-03-16 00 UTC from DWD for RF06

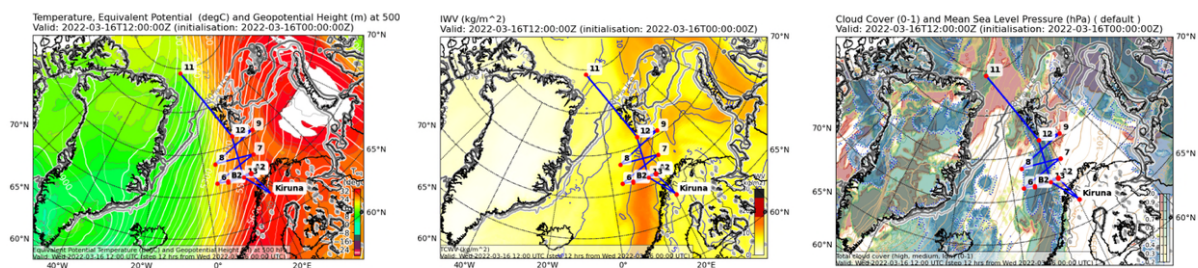


Fig. 4: Planned flight track from MSS overlain with forecasted (ECMWF, 2022-03-16 16 UTC): (left) Equivalent potential temperature, (center) Integrated water vapor, (right) Cloud cover



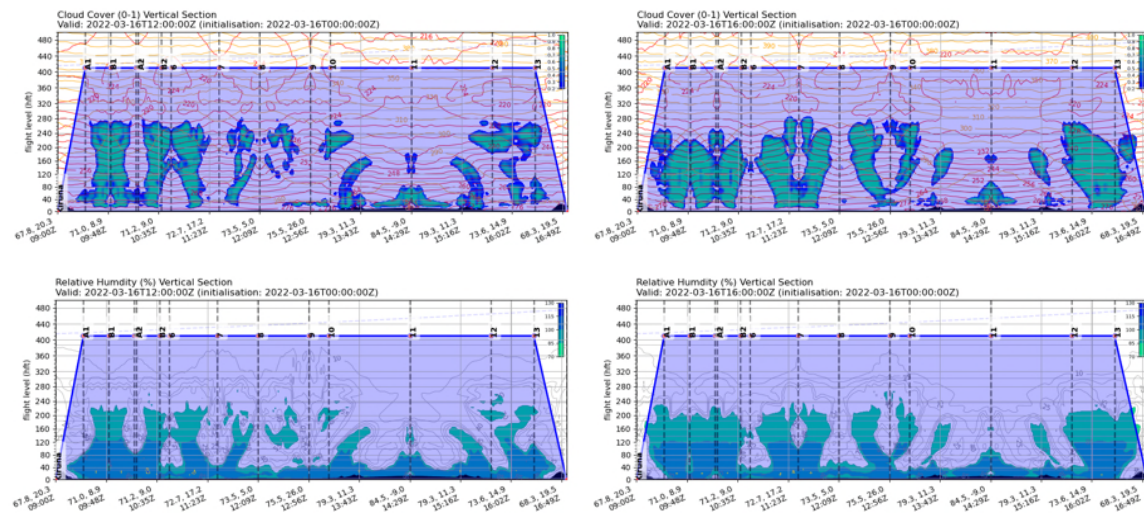


Fig. 5: Cross-sections for the planned flight track of (top) cloud cover and (bottom) relative humidity as predicted by ECMWF for (left) 12 UTC and (right) 16 UTC

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## Overview:

To goal of RF06 was to revisit and transect the Atmospheric River that was probed on the previous day during RF05 when it was situated between the Greenland and Norwegian Sea. While it exhibited a pronounced moisture flux with strong precipitation at the ground on the previous day, ECMWF/ICON predicted a weakening of the moisture flux and precipitation as the AR got more stretched into a filament structure. To validate this weakening, we planned to transect the AR in multiple cross-sections to investigate the spatial extend of the region with elevated water vapor concentration, as well as the cloud and precipitation region. To derive the remaining moisture flux of the AR, high-density dropsonde curtains were performed during the transect of the AR. A special goal of RF06 was the simultaneous collection of in situ and remote sensing data using a collocated flight leg of FAAM and HALO transecting the AR. A further objective was the overpass of Ny-Ålesund, Svalbard to compare the sensitivity of HAMP MIRA with the 35 GHz cloud radar (NyRAD35). In addition, the HAMP MIRA curtain with a low cirrus deck above NYA and light snowfall on the ground was supplemented with polarimetry data collected by NyRAD35 using a coordinated RHI scan. In a subsequent excursion to the north, we sampled the vertical structure and development of the shallow cloud deck over the ice sheet connected to the stationary cold front north of Greenland. Finally, we concluded RF06 by flying a longitudinal cross-section through the AR on our way back, discovering a strengthened precipitation region along the cold front between Svalbard towards the Norwegian Coast.



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### Instrument Status:

HALO	
BAHAMAS	
BACARDI	
HAMP Radar	
HAMP Radiometer	
WALES	
SMART	
VELOX	
specMACS	
Dropsondes	

**Table 1:** Instrument status as reported after the flight for all instruments on HALO.

Comments: VNIR shutter of specMACS was closed for the duration of the flight, 183 GHz radiometer stopped working for 1 hour and WALES DAQ was shortly interrupted

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### Detailed Flight Logs:



**Fig. 6:** HALO and the FAAM BAe-146 side by side in the Arena Arctica hangar before the coordinated flight

- 08:44 Engines on
- 08:49 Doors closed
- 08:52 Taxiing
- 08:58 Takeoff
- 09:30 Transfer towards point A1
- 09:30 All instruments running (VNIR shutter closed)
- 09:32 Takeoff FAAM BAe-146
- 09:34 Arrived at A1 (common leg with FAAM; east -> west direction) flying along 71°N, first stretch almost cloud free with a few showers, then almost closed shallow cloud deck



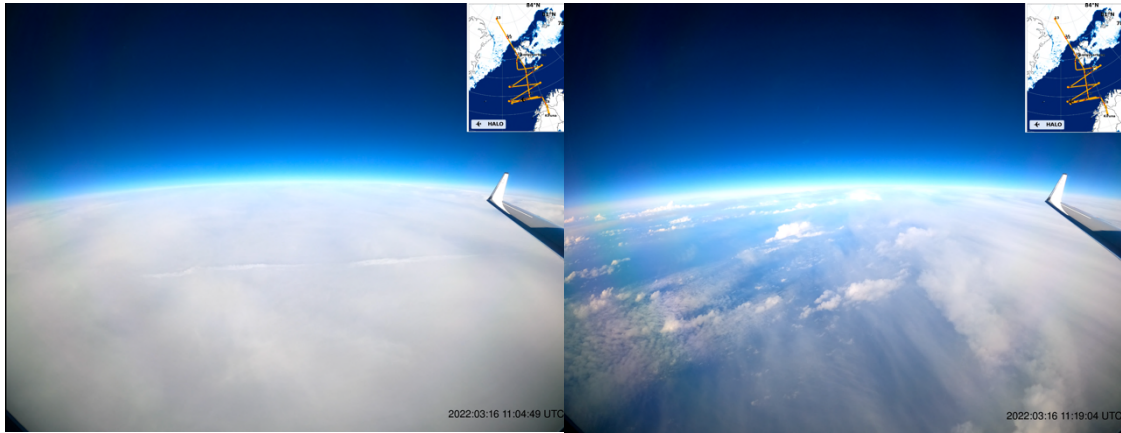
**09:50:21 UTC** (Begin 1<sup>st</sup> shuttle common leg)    **10:03:26 UTC** (End 1<sup>st</sup> shuttle common leg)

- 09:40 Decision to extend the common leg with an extension to the west by 50 NM (up to 5.2°E) to capture the full extent of the atmospheric river
- 09:48 Overpass over cold front of atmospheric river with thick cloud deck up to 8 km altitude, heavy precipitation on the ground at 14.2°E with melting layer at ~ 800 m. In the beginning and end several supercooled layers visible in the lidar
- 10:02 No precipitation on the ground after 8.5°E
- 10:05 Start of the second run (common leg with FAAM; west -> east direction)
- 10:30 Passed thick cloud layer of cold front, with shallow cloud deck below again



**10:17:51 UTC** (Begin 2<sup>nd</sup> shuttle common leg)    **10:30:56 UTC** (End 2<sup>nd</sup> shuttle common leg)

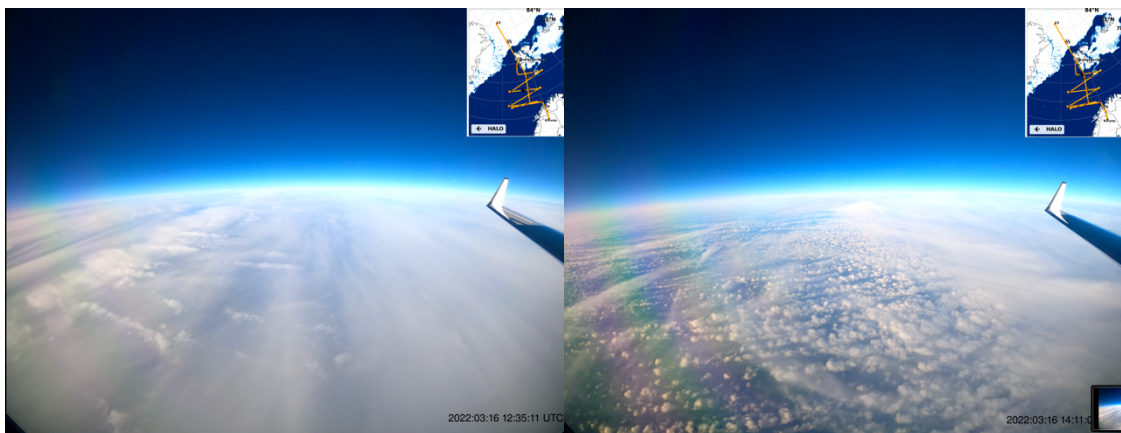
- 10:33 Overpass of FAAM BAe-146 during their approach for their first cloud run @ 7.8km
- 10:45 Start of third run along 71°N (west->east direction), sidestepped 10 NM to the north for dropsonde curtain through Atmospheric River



**10:17:51 UTC** (3<sup>rd</sup> shuttle, FAAM contrail)

**10:30:56 UTC** (End 3<sup>rd</sup> shuttle common leg)

- 10:46 Dropsonde 1 released (successful)
- 10:56 Dropsonde 2 released (successful)
- 11:03 Dropsonde 3 released (successful)
- 11:10 Dropsonde 4 released (failed) -> replacement DS 5 thrown (11:14) directly afterward
- 11:21 Dropsonde 6 released (failed) -> replacement DS 7 thrown (11:28) after next turn
- 11:10 Radiometer 90/119 stopped working ... restart procedure started
- 12:01 Radiometer 90/119 working again
- 11:39 Dropsonde 8 released (successful)
- 11:51 Dropsonde 9 released (successful)
- 12:13 Dropsonde 10 released (successful)
- 12:21 Dropsonde 11 released (successful)
- 12:31 Dropsonde 12 released (failed) -> replacement DS 13 thrown (12:35)
- 12:41 Dropsonde 14 released (successful)
- 12:48 Dropsonde 15 released (successful)
- 13:11 Dropsonde 16 released (successful)
- 13:22 Dropsonde 17 released (successful)
- 13:33 Dropsonde 18 released (successful)
- 13:40 Precipitation to the ground close to the cold front



**12:35:11 UTC** (2<sup>nd</sup> transect over AR edge)

**14:11:07 UTC** (3<sup>rd</sup> transect over AR edge)

- 13:48 Dropsonde 19 released (successful)
- 13:53 WALES DAQ down



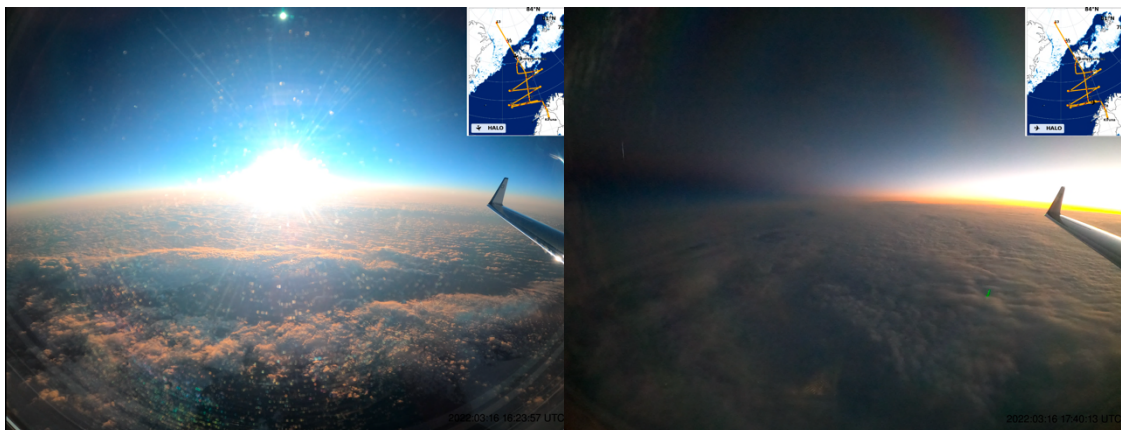
- 14:10 WALES DAQ running again
- 13:58 Dropsonde 20 released (successful)
- 14:07 Dropsonde 21 released (successful)
- 14:08 Decision to extend transect by 50 NM to capture full extend of AR with 2 additional sondes
- 14:16 Dropsonde 22 released (successful)
- 14:27 Dropsonde 23 released (successful)
- 14:39 Ny-Ålesund overpass, light snow fall at the ground with cirrus deck @ 5.8km
- 14:46 Dropsonde 24 released (successful)
- 14:52 Ice edge below @ 80.8°N, 8°E



**14:37:39 UTC** (overpass of Ny-Ålesund)

**14:52:29 UTC** (overflight of ice edge)

- 15:24 180° to return back from north excursion (thickening low level cloud deck towards the north)
- 16:07 Ice edge below again
- 16:25 Ny-Ålesund 2<sup>nd</sup> overpass, light snowfall at the ground
- 17:23 Dropsonde 25 released (successful)



**16:23:57 UTC** (2<sup>nd</sup> overpass of Ny-Ålesund)

**17:40:13 UTC** (sunset over AR remains)

Quicklooks:

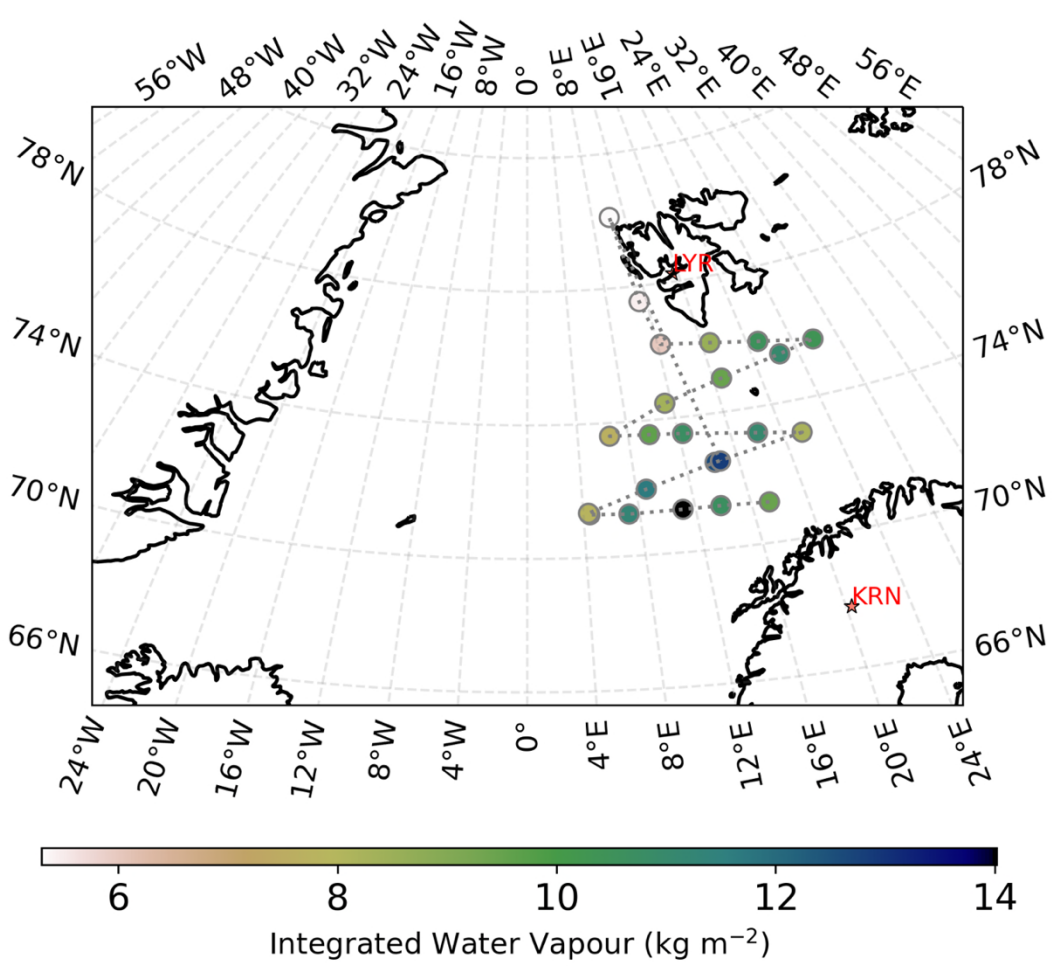


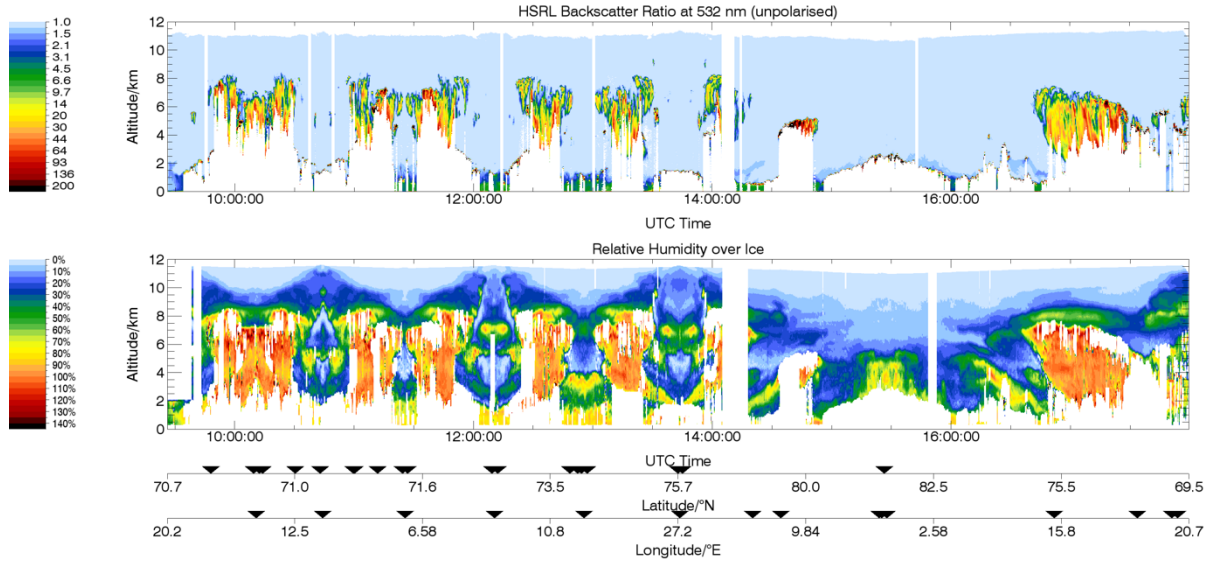
Fig. 7: Location of the dropsonde launches with the measured integrated water vapour as colormap



WALES

HALO-(AC)<sup>3</sup> 16-03-2022

HALO RF06



Data Version 1 Processed on 19-03-2022 Contact: DLR Institute of Atmospheric Physics Martin.Wirths@dlr.de

Fig. 8: WALES quicklook with (top) HSRL backscatter ratio at 532 nm and (bottom) relative humidity over ice

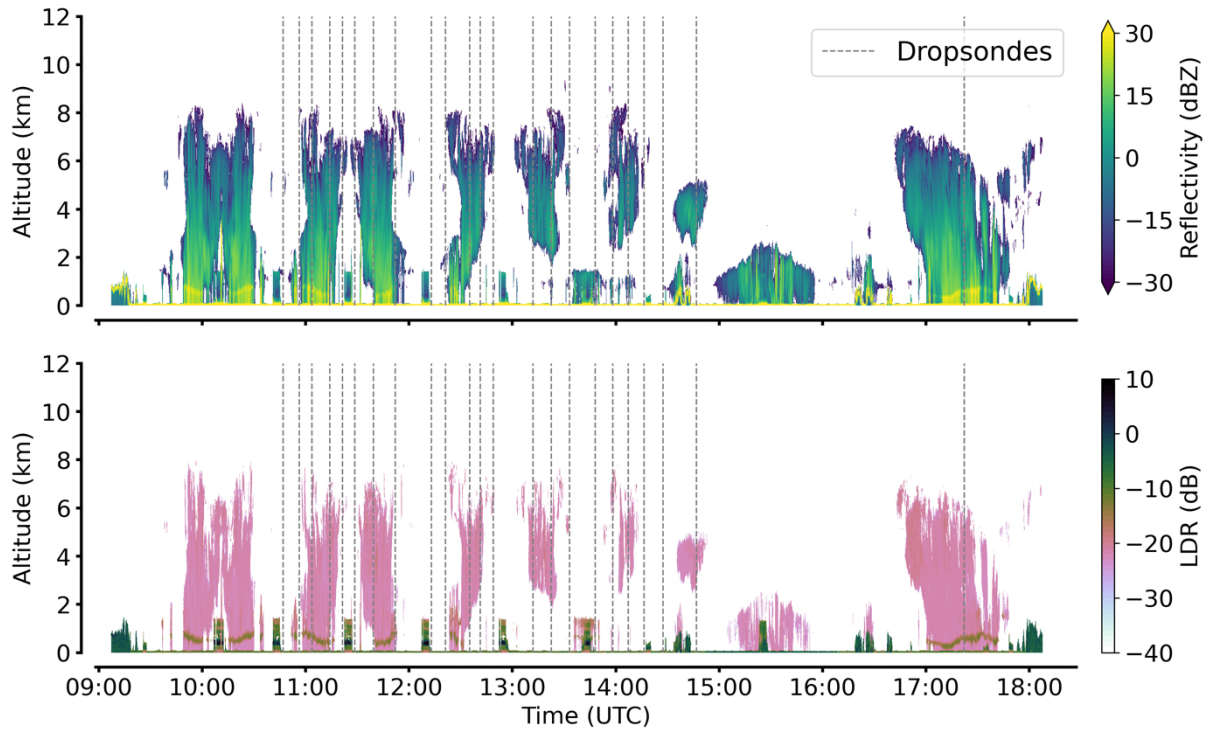
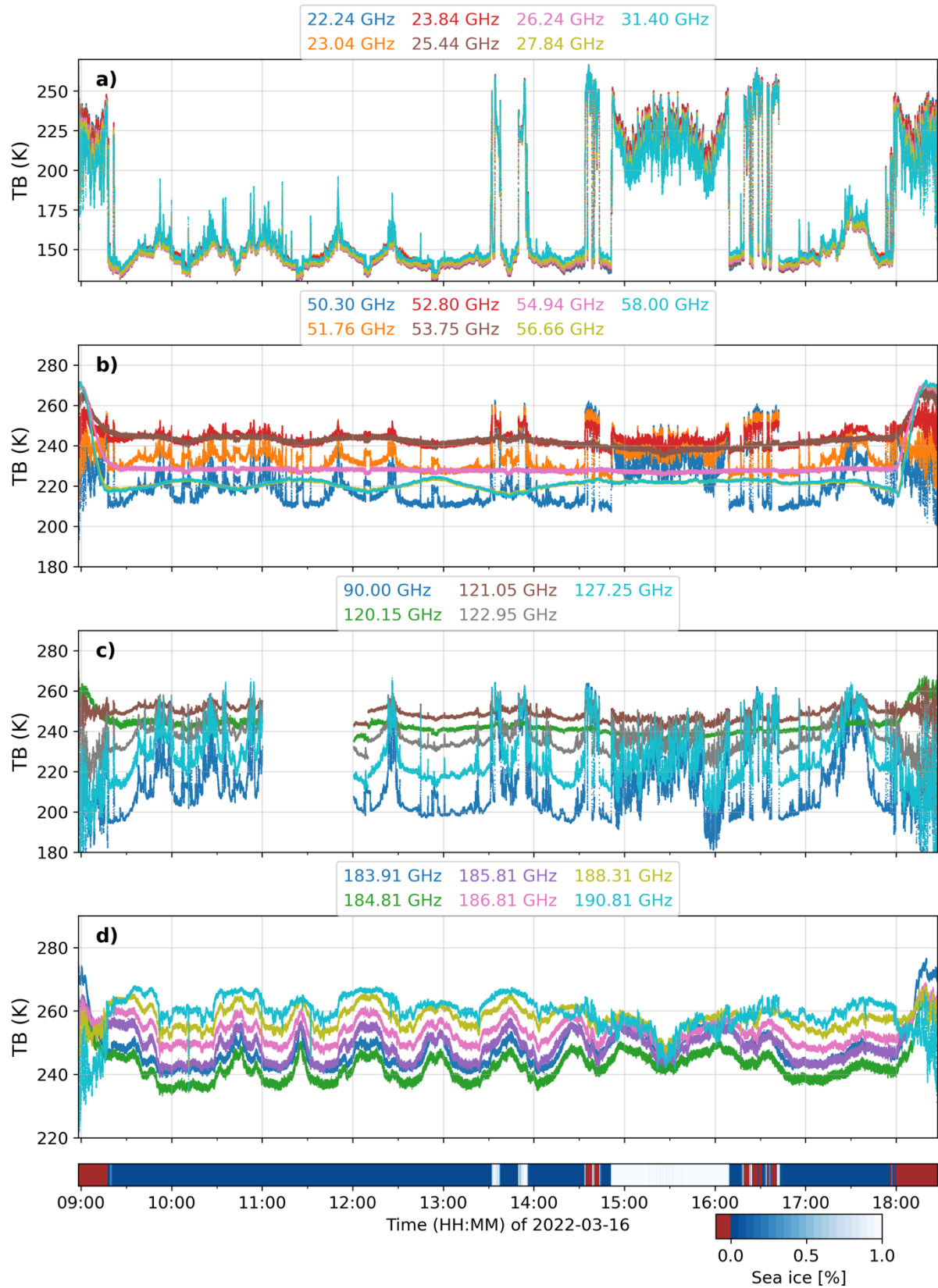
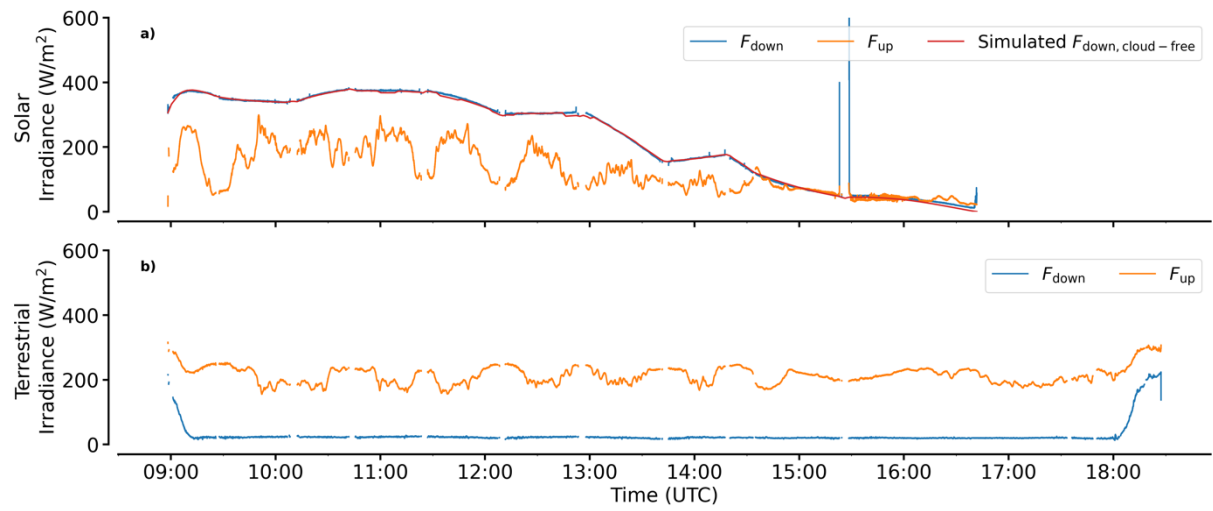


Fig. 9: HAMP MIRA quicklook with (top) effective radar reflectivity in dBZ and (bottom) the linear depolarization ratio in dB. The dashed lines indicate the dropsonde launches





**Fig. 10:** HAMP Radiometer quicklook of brightness temperatures measured at (a) K-band, (b) V-band, (c) 90 / 120 GHz and (d) 183 GHz.



**Fig. 11:** SMART quicklook with (a) measured solar irradiance and (b) terrestrial irradiance for the up-welling (orange) and down-welling (blue) direction. The red line shows the simulated solar irradiance without clouds

**Flight impressions (Personal camera):**



**09:15:59 UTC** (Cloud-free panorama of the Lyngenfjord after takeoff)

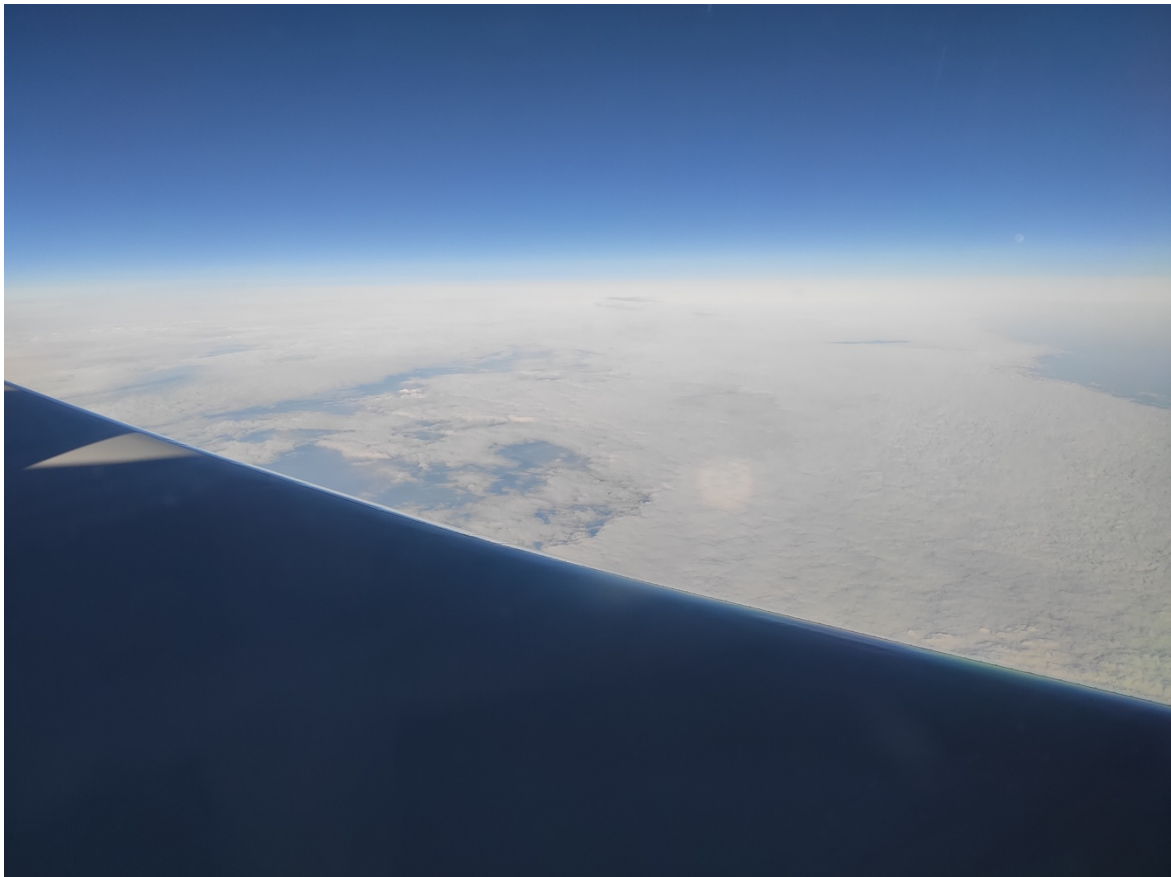


**10:07:22 UTC** (Above the AR at the end of the 1<sup>st</sup> shuttle of the common leg over the AR)

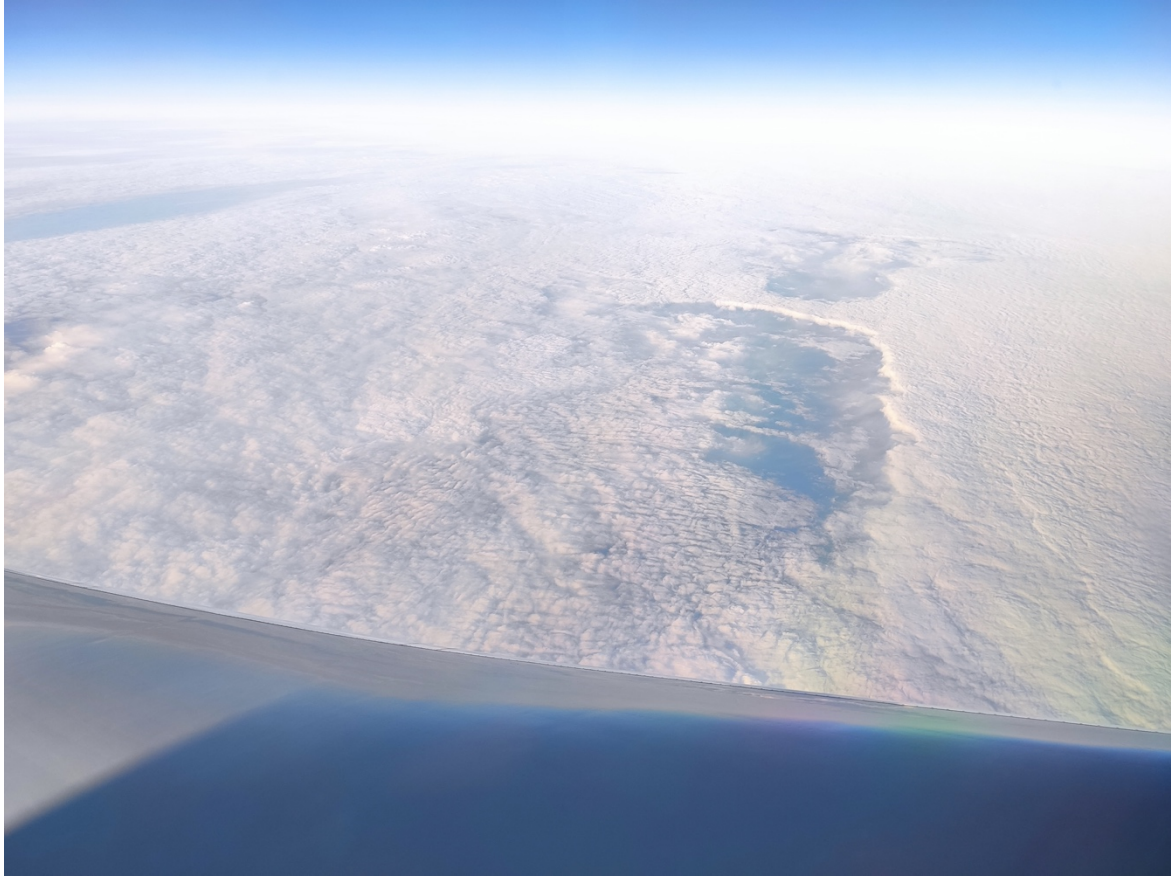




**11:26:12 UTC** (Cirrus at the backside of the atmospheric river after the 3<sup>rd</sup> shuttle)



**12:05:36 UTC** (Glory display over low cloud deck, upstream of the AR before the 2<sup>nd</sup> transect)



**13:40:40 UTC** (Broken low cloud deck, upstream of the AR before the 3<sup>rd</sup> transect)



**15:16:41 UTC** (Closed cloud deck, at the end of the north excursion close to the surface low)





**17:37:28 UTC** (Sunset over the remains of the AR close to the Norwegian Coast on our way back)



**18:56:06 UTC** (Thanks to the fine flight crew of RF06 – was a pleasure to fly with you!)