MOSAiC Flight #09 – 10 September 2020

Mission PI: Manfred Wendisch

Objectives

- Investigate cloud evolution along the wind direction and compare the clouds over sea ice and open water
- Collect data for comparison with models (11 dropsondes were released during the flight)
- Evaluate lee effects from Svalbard

Crew

Polar 5	
Pilot	William Houghton (Kenn Borek Air)
Co-Pilot	Michelle Lacey (Kenn Borek Air)
Mission-PI	Manfred Wendisch
Basis Data Acq.	Hannes Probst
	Clemens Gollin
SMART/Eagle Hawk	Marcus Klingebiel
Cloud Probes	Manuel Moser
MiRAC	Mario Mech

Flight times

Polar 5	
Take off	**08:29 UTC**
Touch down	**14:45 UTC**
Flight time (air)	**6 hours, 16 min**

Overview

During this flight, the differences of cloud properties over sea ice and open water were successfully observed along the wind direction. The synoptic situation was such that there was no other choice than to go to the North; in western direction mid-level clouds were too high. These mid-level clouds resulted from an occlusion south of Spitzbergen (see synoptic overview below). On the way to the North and backward plenty of clouds with different vertical structures, partly including precipitation, were observed by the active and passive remote sensing instruments onboard Polar 5. We encountered heavy cirrus above the maximum flight level (FL130), other parts of the flight track were cirrus-free. We even had a short portion of the flight track in cloud-free sky, when sampling the area north of Svalbard influenced by the lee effect of the island. After arriving at the northern part of the flight track at 82.5°N and 3°E we were visibly over sea ice. We probed a low-level cloud sheet touching the ground (top height about 1800-1700 ft) and a second (maybe rather synoptically formed, possibly remaining from the occlusion of the previous day) mid-level cloud (layer between about 8500-9000 ft). We performed vertically stacked horizontal flight patterns (about 5 minutes long corresponding to a distance of 10 NM, altogether 6 height levels): two in the lower cloud layer, one between the upper and the lower cloud, another one in the upper cloud and two above the upper cloud (see Figs. 5 and 6). Both clouds were rather homogeneous, only little turbulence was noticeable.

The lower cloud layer consisted of liquid water droplets. The upper cloud was an ice cloud. After completing the stacked flight pattern we arrived at FL100, stayed at this altitude heading against the wind in southeastern direction until reaching open water, where we repeated the stacked horizontal flight pattern, this time in seven altitudes (Figs. 7 and 8). We did not observe a gap in the low-level cloud deck on our way from the sea ice to the open water. Thus, cloud properties could probably be linked between the two places, also taking into account that we had followed the opposite wind direction. The clouds over the open water appeared bumpier and more heterogeneous compared to the one over sea ice. The synoptically driven mid-level cloud did not show up over sea ice, although high cirrus was omnipresent in this area. Then we returned to the south at FL100. We had to climb even higher to allow the remote sensing instruments to operate safely (lidar). We experienced an increasing ceiling of the mid-level clouds on our way to the south, and we partly probed the upper level of them. Eventually we received some icing and decided to climb even higher exceeding the cloud top to get rid of a little accumulated ice. We returned home safely.

Weather

The weather in the area around Svalbard was determined by a low pressure system in the south-east of the island. A respective occlusion caused a multitude of clouds at different levels in the south and the eastern directions of Svalbard. Therefore, the only direction that was possible for a research flight on this day was into the north.

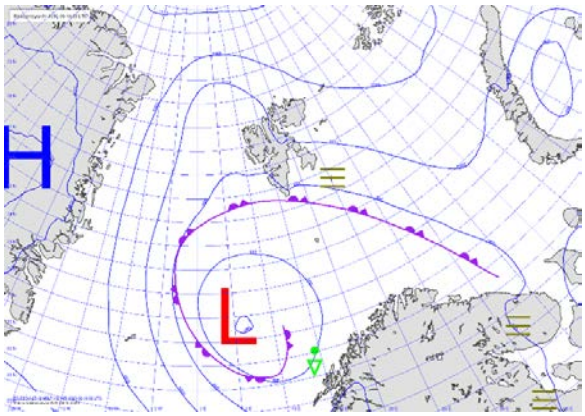


Figure 1: Surface weather map from 10 Sep 2020, 03 UTC.

Surface winds in the area northeast of the island (our target area) were from the southeast. Low-level clouds were omnipresent, the lee effect of the island caused some cloudless spot.

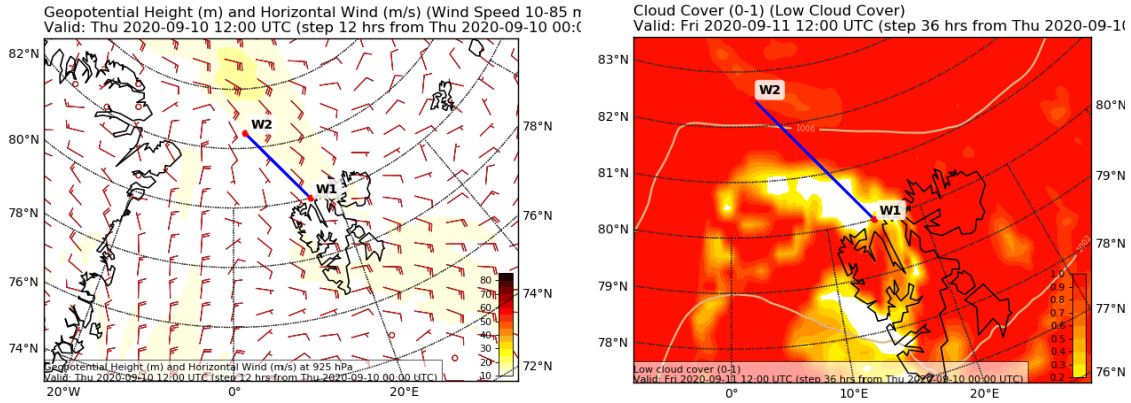


Figure 2: Wind at 925 hPa (left panel), and low-level cloud distribution (right panel) from ECMWF forecast.

A respective satellite image is shown in Fig. 3, already including the flight path.

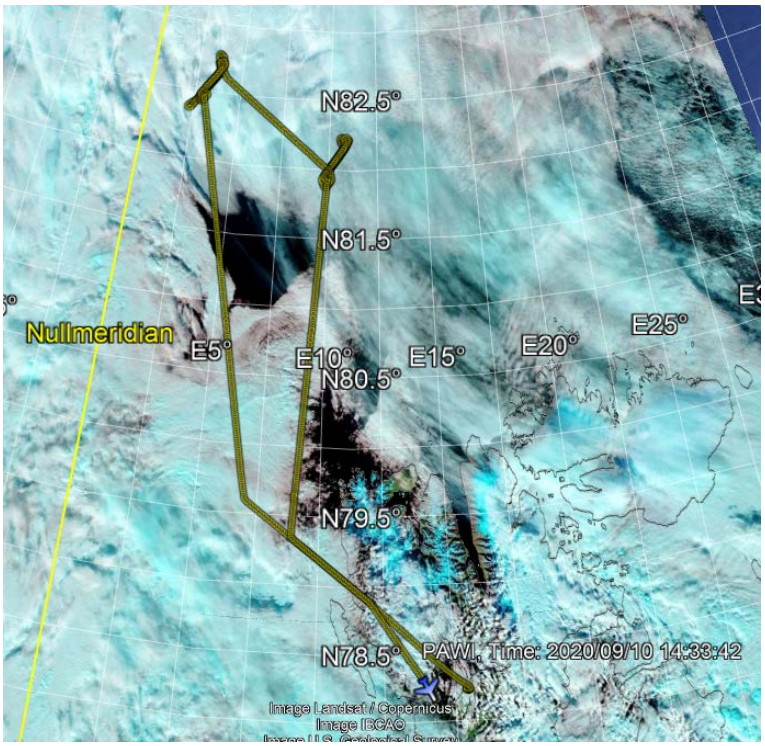


Figure 3: Flight path (green solid line) and overlaid MODIS satellite image observed during the flight of 10 September (source: https://wvs.earthdata.nasa.gov/).

Flight path

The actual flight path is given in Fig. 4.

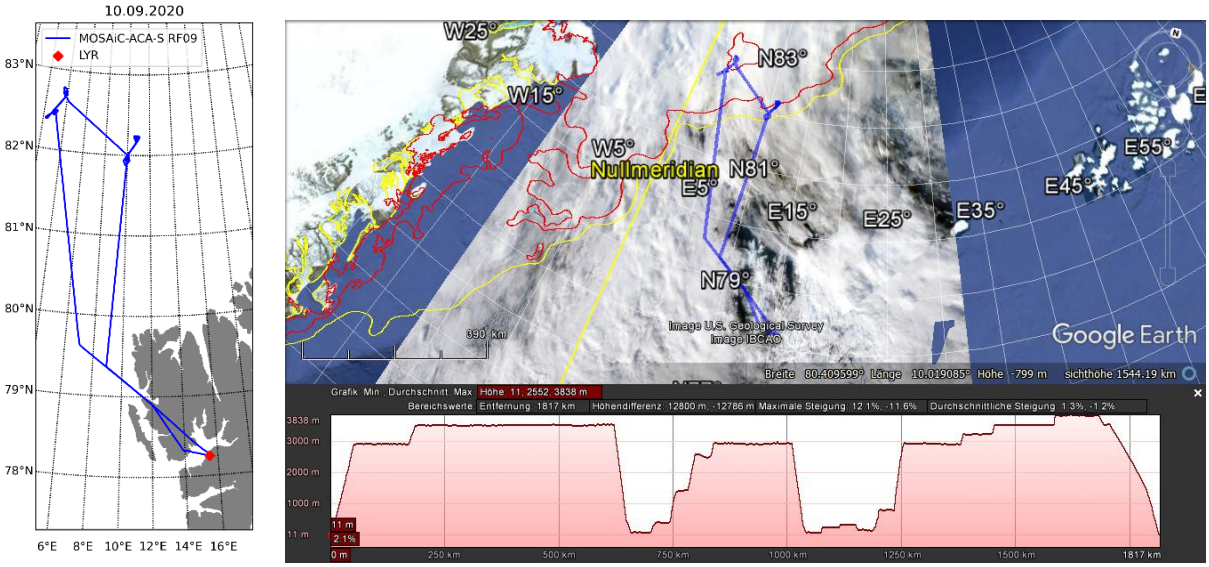
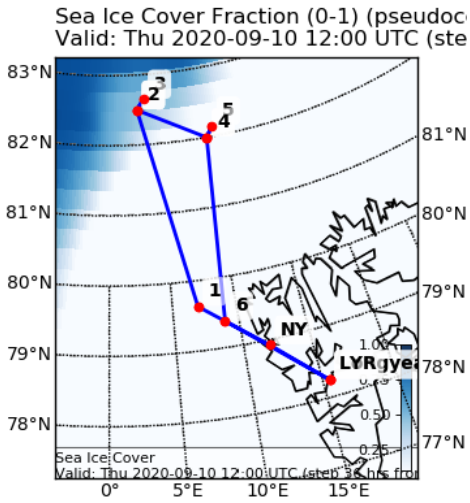


Figure 4: Left panel (top view): Flight path for the Research Flight (RF) 09 conducted on 10 Sep 2020. Top right panel (top view): Flight path (blue solid line), sea ice border (red and yellow lines), and overlaid MODIS satellite image of 10 September (source: https://wvs.earthdata.nasa.gov/). Lower right panel (side view): Flight altitude along the flight path.

Waypoints

LYR	78° 14,7‘	15° 28,9‘
NY	78° 55,4‘	11° 55,4‘
W1	79° 37,8‘	7° 00,0‘
W2	82° 30,0‘	3° 00,0‘
W3	82° 39,0‘	3° 45,6‘
W4	82° 00,0‘	10° 00,0‘
W5	82° 09,0‘	10° 45,0‘
W6	79° 22,2‘	8° 56,4‘



Some notes taken during the flight (all times in UTC)

08:04 Props and science power on
08:24 Taxi
08:29 Take off
08:35 Heading to Ny-Ålesund, clouds everywhere, ascending
08:42 Reaching FL100
08:44 Cloud penetration, some turbulence, -6°C
08:52 Over Ny-Ålesund
08:59 Nice Sc below, just few clouds above flight level
09:03 A mid-level cloud ahead of us, we climb to FL120 to stay above it, almost no Cirrus above
09:15 Dropsonde (DS) number 1 (**DS1**) released, Mario reports precip
09:16 Reaching W1, we stay above a thick cloud, no cirrus above
09:21 DS1 reaches ground, clouds below flight path become more scattered towards the North, we stay at FL120
09:25 Cloud gaps below
09:29 Again increasing cloud amount below, no cirrus above

Photo: Marcus Klingebiel (Uni Leipzig)

09:33 **DS2** released
09:38 DS2 touches ground, clouds become thinner, heterogeneous
09:45 Almost cloud-free below
09:50 **DS3** released into cloud-free region
09:55 DS3 arrives at ground, reports temp at surface of roughly 2°C
09:59 Again more clouds
DS4 launched
10:05 Cloud penetration
10:09 Circle to have time to adjust to W2
10:15 **DS5** launched
10:19 Reaching waypoint 2 (W2), start with the first leg of the horizontal stacked profile within cloud, see Figs. 5 and 6 for details.

- W2 → W3 at 12,000 ft
- W3 → W2 descending from 12,000 ft → 300 ft
- W2 → W3 at 300 ft (in cloud, liquid water)
- W3 → W2 at 1300 ft (in cloud, liquid water)
- W2 → W3 at 5000 ft (in cloud-free condition, between lower and upper cloud)
- W3 → W2 at 8600-8900 ft (in cloud, partly, patchy, ice)
- W2 → W3 at 10,000 ft
- Partly further clouds above flight level
- **DS6** released at FL100 between W2 and W3

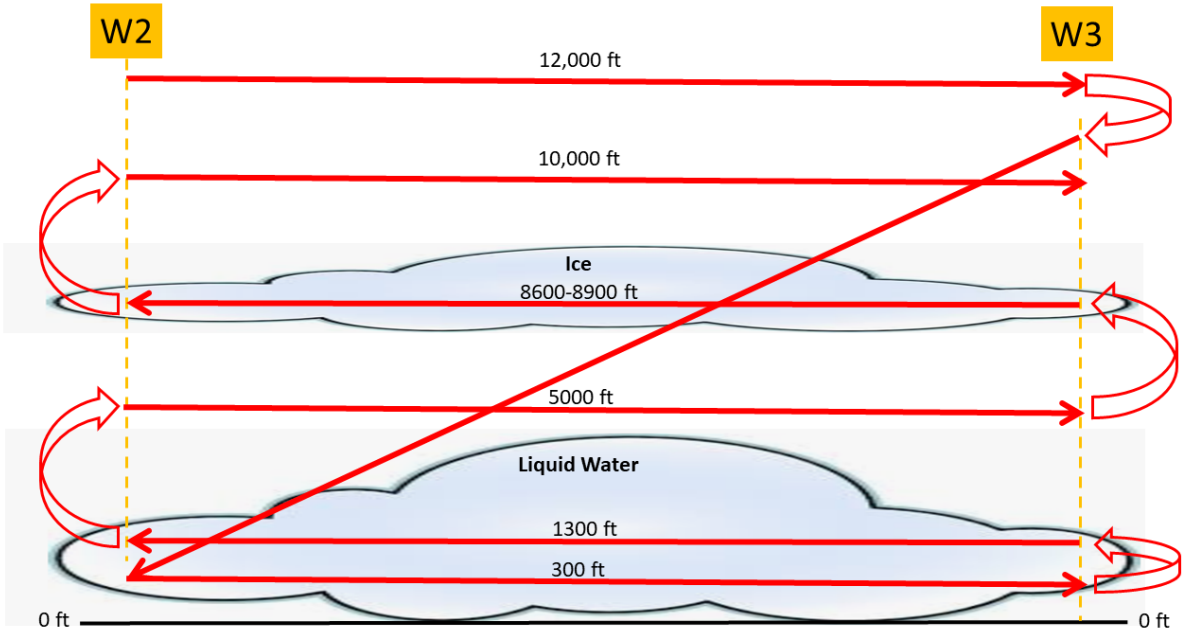


Figure 5: Sketch (side-view) of stacked profile between waypoint W2 and W3.

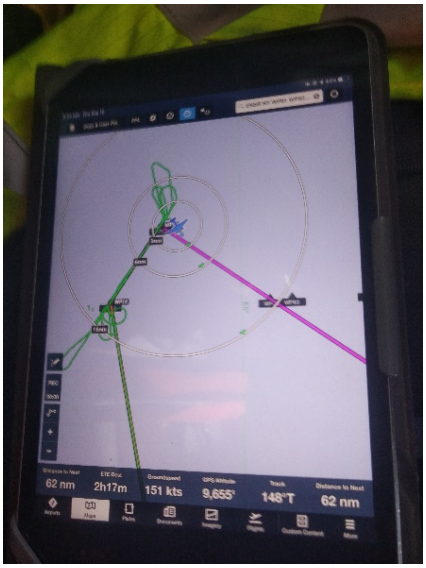


Figure 6: Top view of stacked profile between waypoint W2 and W3.

11:23 We leave W3, stay at FL100 on our way to W4, nice clouds below

11:31 Nice clouds below, Cirrus above, **DS7** between W3 and W4

11:47 We arrive at W4, procedure turn, cirrus above, low level clouds below, we start again with the stacked profile pattern, see Figs. 7 and 8

- 11:51 W4 → W5 descending from 10,000 ft → 300 ft
- 12:00 W5 → W4 at 300 ft (fully in cloud)
- 12:10 W4 → W5 at 800 ft (cloud gap at the end)
- 12:20 W5 → W4 at 1100 ft (with some cloud gaps)
- 12:30 W4 → W5 at 500 ft (fully in cloud)
- 12:40 W5 → W4 at 3000 ft (above cloud, cirrus above)
- 12:59 W4 → W5 at 10,000 ft (above cloud, cirrus above)
- 13:06 W5 → W4 at 10,000 ft (above cloud, cirrus above)

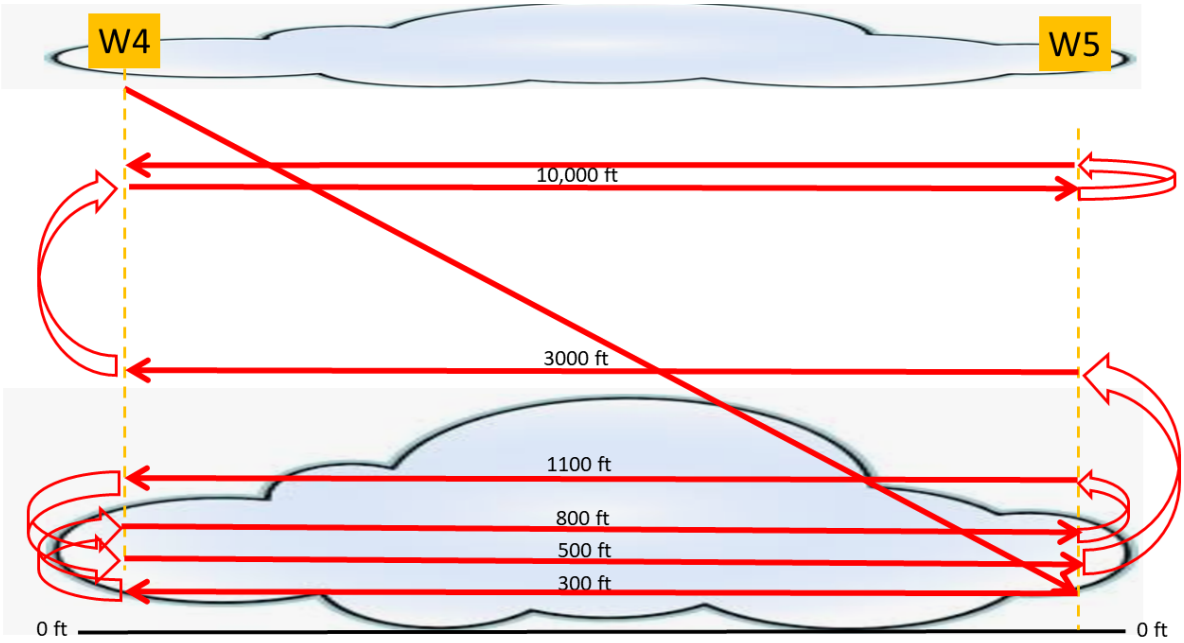


Figure 7: Sketch (side-view) of stacked profile between waypoint W4 and W5.

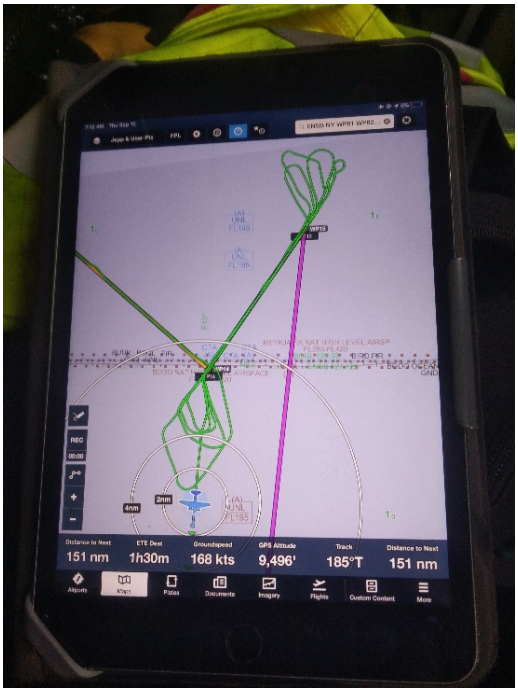


Figure 8: Top view of stacked profile between waypoint W2 and W3.

13:09 Launch of **DS8** at W4
13:20 Climb to FL110, because we need a distance to increasing cloud top of 1200 ft for the lidar, cirrus above
13:31 **DS9**, no cirrus above, we climb further to FL120 (lidar requirement)
13:45 No more cirrus above, below thick mid-level clouds
13:52 **DS10**,
13:54 We encounter cloud top, some icing starts, therefore, we go up to FL130 out of cloud.
14:04 **DS11**
14:05 We reach W6, thick cloud below, almost no cirrus above
14:20 Passing Ny-Ålesund
14:45 Landing

Dropsondes

11 dropsondes were released, with no failures.

Instrument status

All instruments except the sun photometer worked fine throughout the whole flight with some minor outages of the PIP.

Polar 5	
Basis data acquisition	
Nose Boom	
MiRAC-A	
MiRAC-P	
AMALi	
SMART	
Eagle/Hawk	
Sun Photometer	
Polar Nephelometer	
2D-S	
CCP	
PIP	
Drop Sondes	

Nice glories observed during flight

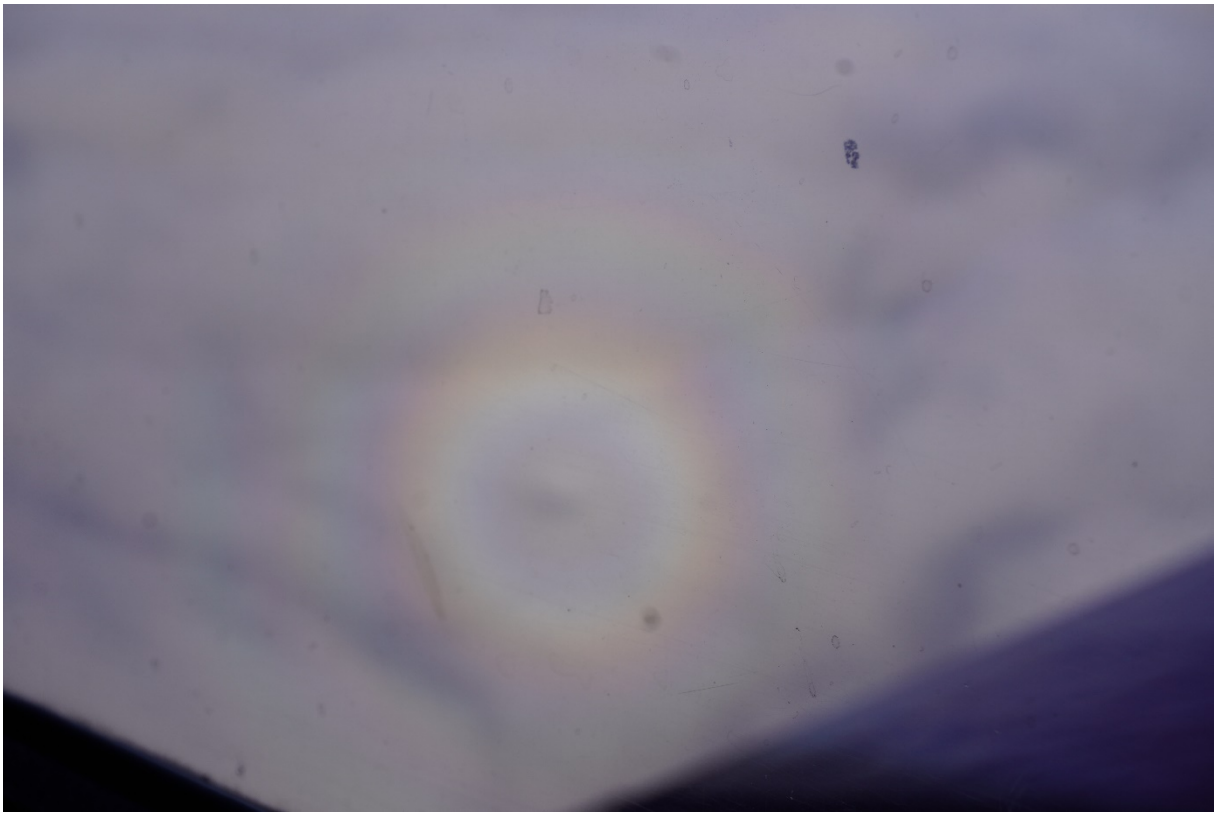


Photo: Manuel Moser (DLR)

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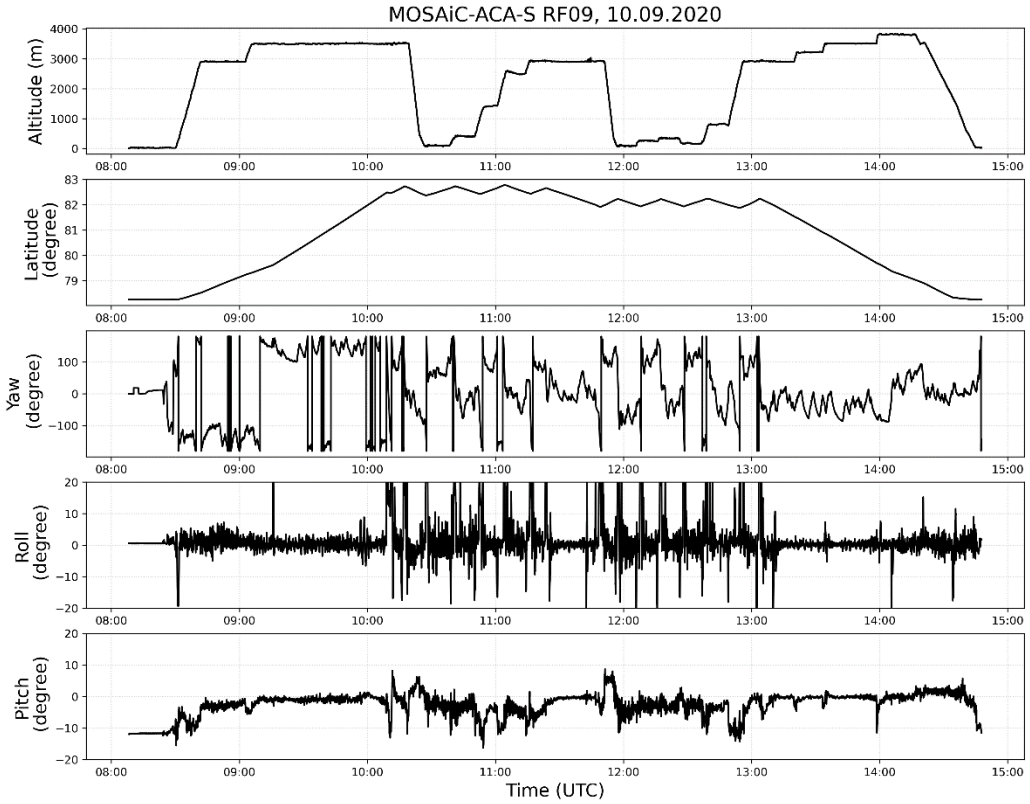
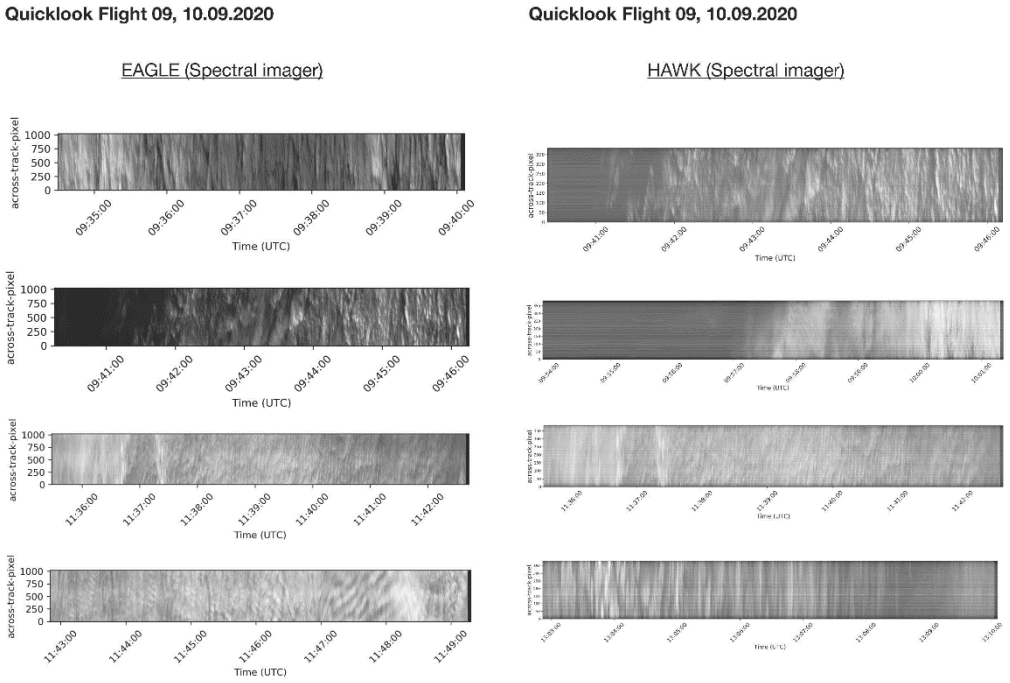
Quicklooks (not complete, dropsondes and further quicklooks are available in the Wiki)

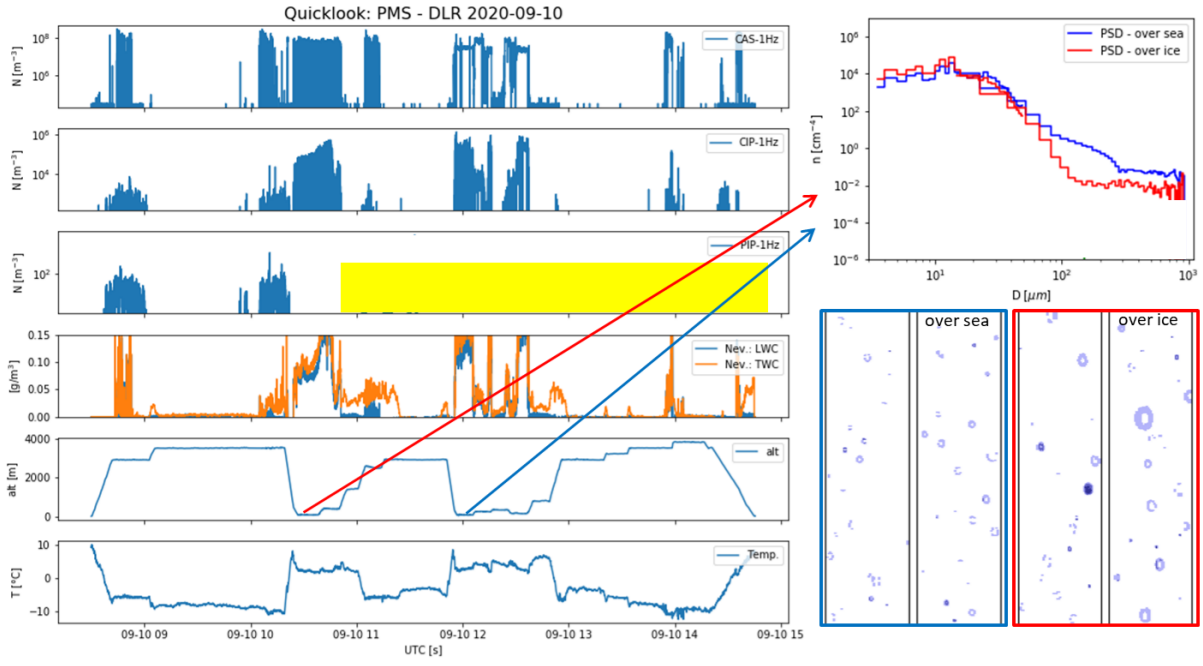
<u>Aircraft position and attitude data</u>



EAGLE/HAWK



Cloud microphysical properties



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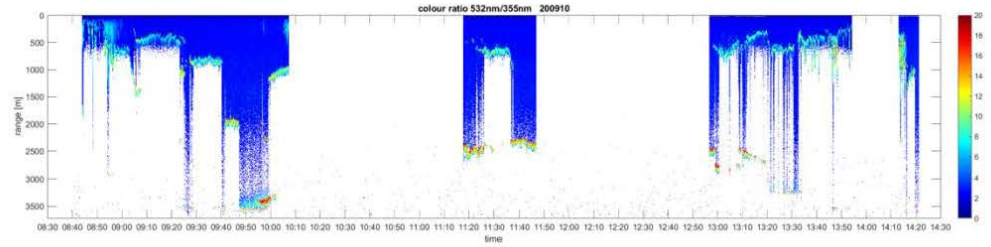

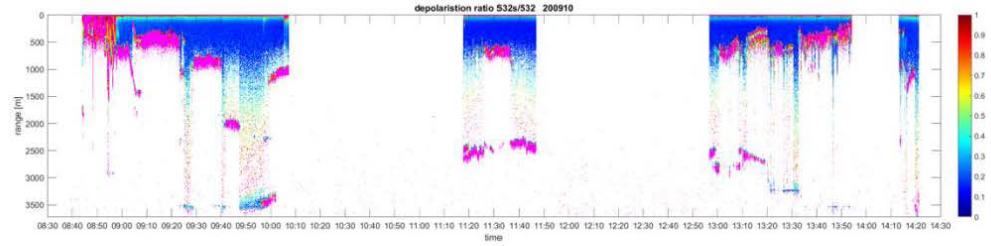

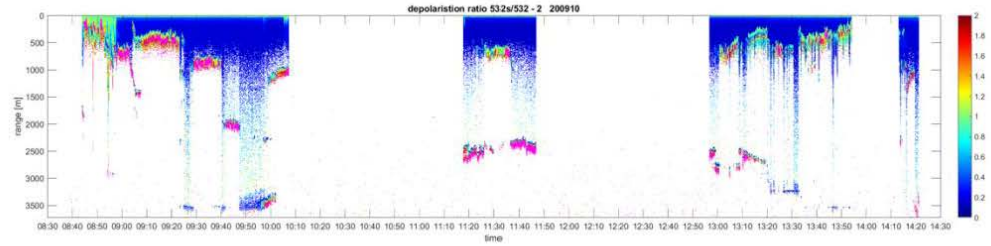

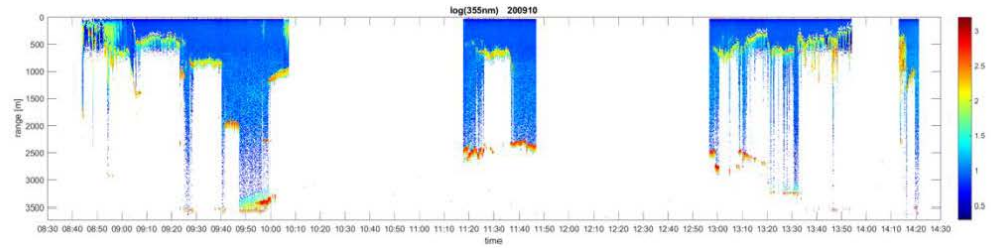

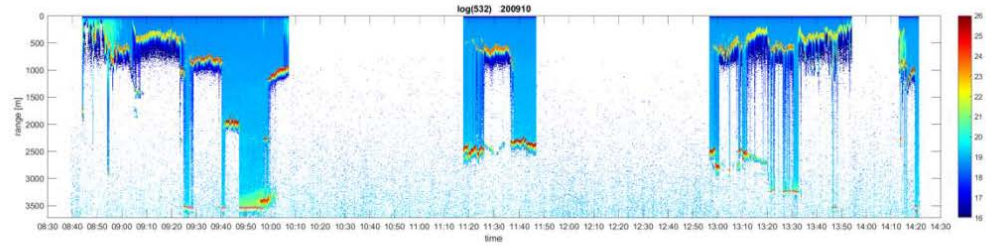

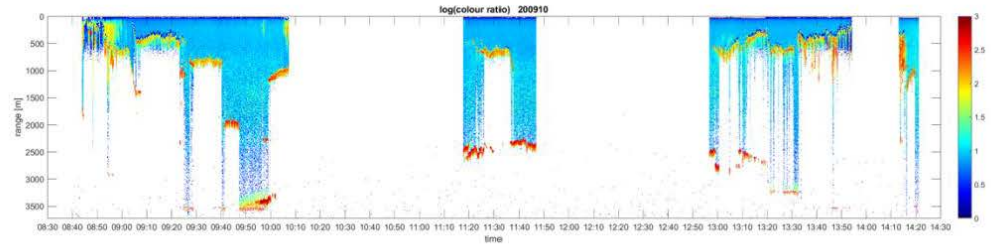

Thanks to all contributing to this successful flight!

Photo: Manuel Moser (DLR)