

MOSAiC-ACA Flight #10 – Polar 5 – 2020/09/11

Objectives:

Characterize the lee effect of Svalbard on atmosphere and cloud conditions in south-easterly wind conditions by dropsonds and remote sensing. Profile multi-layer clouds over sea ice and over open ocean by in situ observations in different altitudes.

Mission PI P5:

André Ehrlich

Polar 5 Crew	
Mission PI	André Ehrlich
Basis Data Acq.	Clemens Gollin
SMART/ Eagle/Hawk	Michael Schäfer
MiRAC / AMALi	Friedhelm Jansen
PMS	Valerian Hahn
Optional seat	Cristina Sans Coll

Flight times:

Polar 5	
Take off	08:19 UTC
Touch down	13:59 UTC

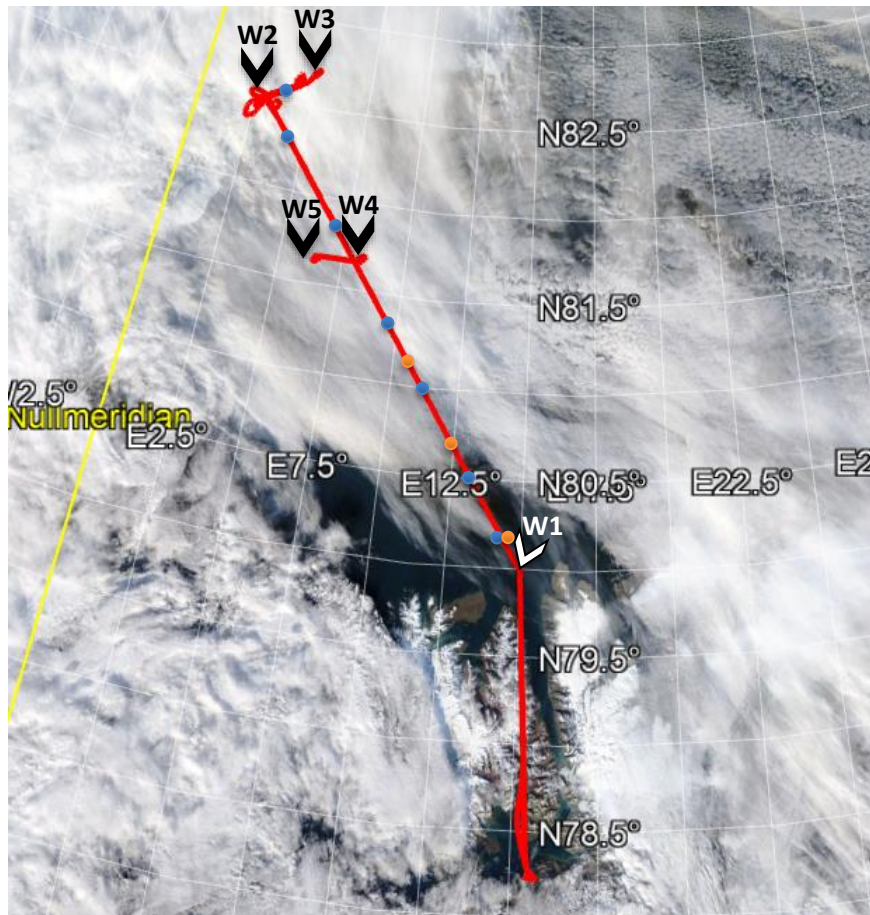
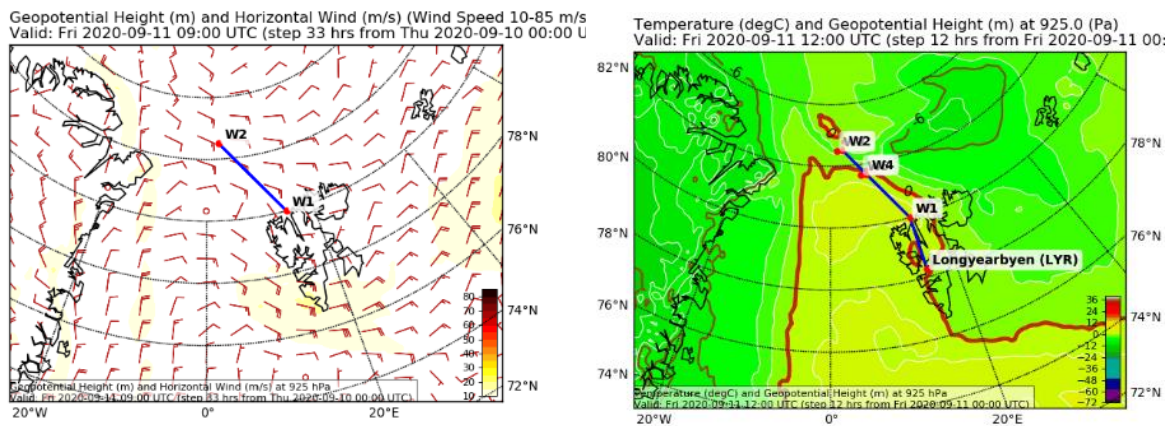


Fig. S5.1: MODIS (Terra) satellite composite and Flight Track of Polar 5. Blue dots indicate the location of dropsond releases outbound, green dots inbound.

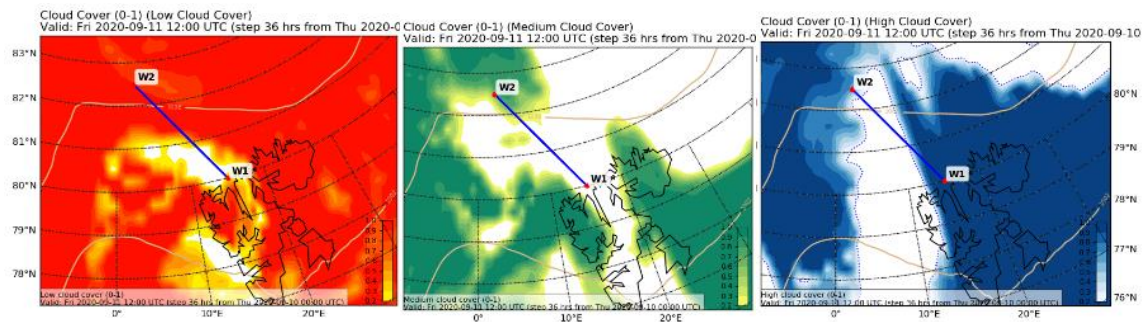
Weather situation as observed during the flight (compare to forecast):

Low pressure south of Svalbard caused a south-easterly flow around the island. A long front was still located west of Svalbard. This trough also generated a kind of front close to the west coast of Svalbard which was avoided in the flight plan. Similar to the day before, north of Svalbard a strong lee effect caused a cloud free area orientated in north-west direction. In this area also rather warm temperatures were predicted. North of the cloud-free lee hole, low clouds were forecasted by ECMWF and ICON. During the day, the cloud-free lee hole was predicted to narrow and close. This cloud free area was observed at its place but during both crossings. We could not identify a closing. The low clouds were observed always with clouds bases touching the ground, both over sea ice and over the ocean. This low cloud was more clearly forecasted by ICON, while ECMWF did show an elevated cloud base (model vertical resolution?).

Temperatures were observed as forecasted with often above freezing level. Inly in the mid-level clouds slight icing was observed.

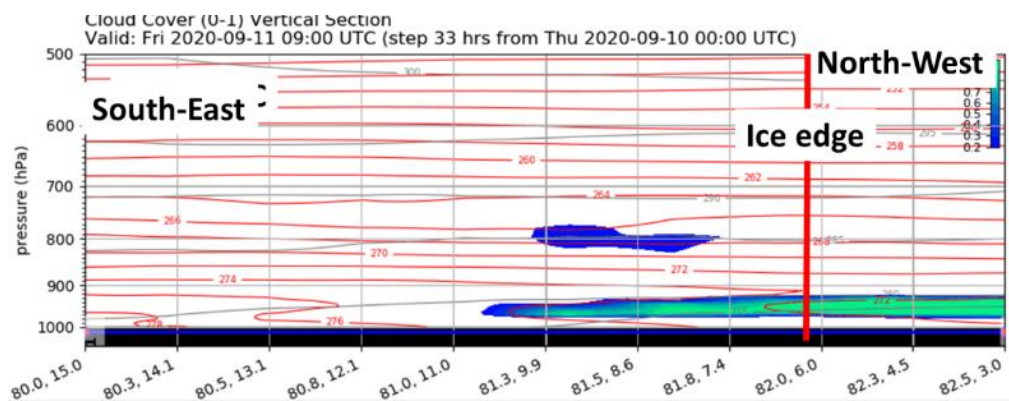


ECMWF Wind field and temperature in 925 hPa.

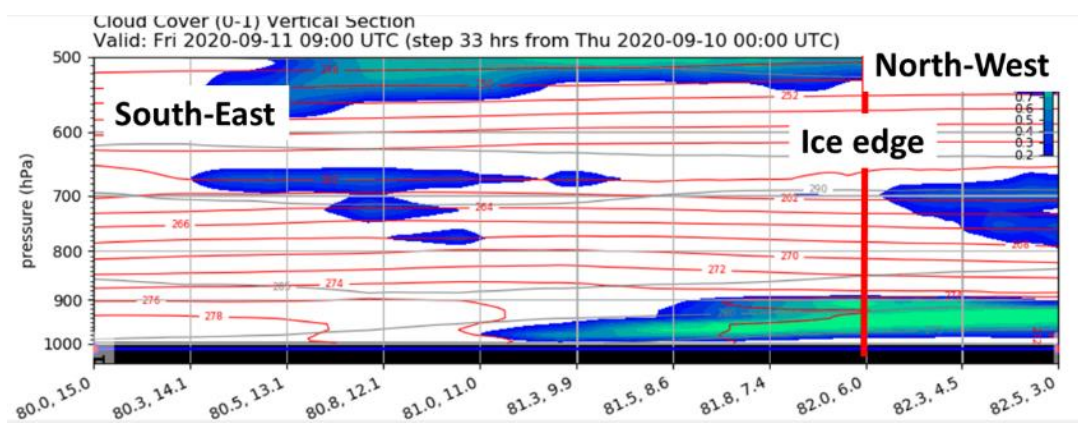


ECMWF Low, mid-level and high cloud cover.

Both models had midlevel at the northern edge of the flight track, but in different altitudes. High clouds were forecasted at the eastern and western end of the track. This complex situation was also observed during the flight. Even the end of mid-level clouds was just west of the flight track. However, the observed multi-layer structure and altitudes of the different cloud levels varied from the forecasts.



ECMWF cloud cover cross section along the flight track shown above.

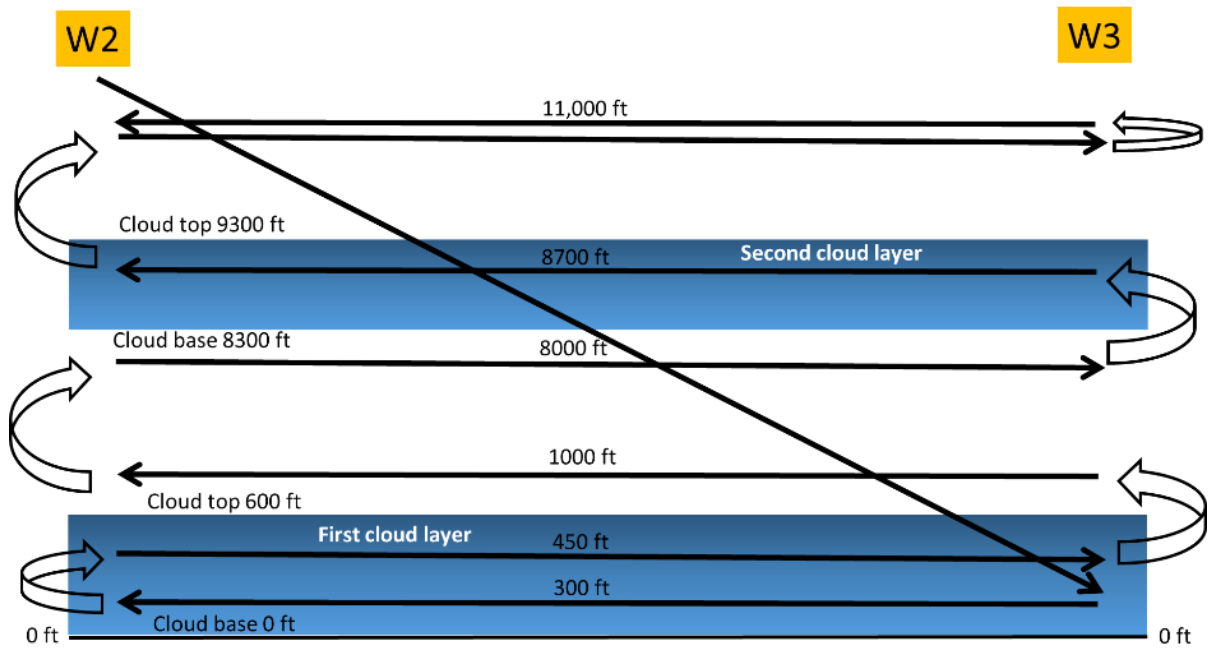


ICON cloud cover cross section along the flight track shown above.

Overview:

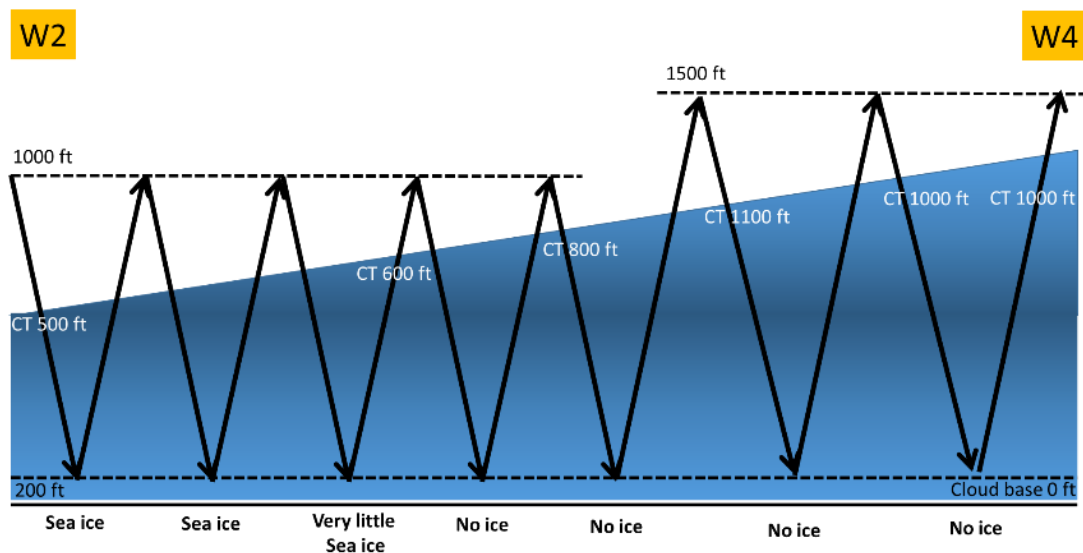
The flight started with crossing Svalbard to reach W1. The island was partly covered by low clouds. One higher second cloud layer required us to climb to 11 000 ft. North of Svalbard a large cloud gap in the lee was observed. From W1 we headed north-west. We started with releasing dropsonds in the cloud free area. To cover the atmospheric change in the transition from cloud-free to cloudy, we increased the frequency of dropsonde releases (max each 15min). The cloud remote sensing could document the change in cloud properties. Further north, a second thin cloud layer started. Close to the area for the stacked pattern in the north-west, the clouds visually became denser and more mighty.

The second cloud-layer ended in western direction close to the cloud track. Therefore, the coordinates for the first stack were adjusted, placing the stack pattern more into the east where the cloud fields looked rather homogeneous. During the descend we could observe two cloud layers, one very low, the other in about 9 000ft. Above another cloud layer was visible now very high above Polar 5. All layers have been homogeneous between the two waypoints which makes this stack a good dataset for analysis. The stack was flown as illustrated in the figure below:



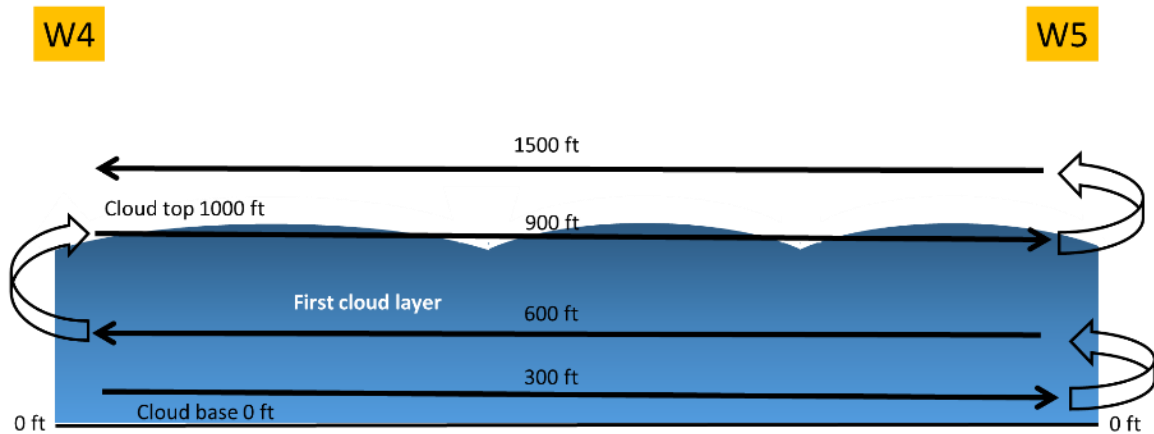
Altitudes of the first stack between W2 and W3.

Returning to location of the second stack, we descended to 200 ft and started a saw tooth pattern to repeatedly sample the low cloud as often as possible to obtain good statistics but also for following the changes of cloud properties. Other than expected, the cloud top altitude increased towards South. These clouds always reached the ground (first sea ice, then open ocean). During this leg, also mid-level and cirrus was present. The altitudes of the saw tooth pattern is illustrated below.



Saw tooth pattern between W2 and W4.

At the location of the second stack only one low cloud layer was present, except of high cirrus. A mid-level cloud was not visually obvious but was discovered later, when climbing to 10 000 ft. This stack was compiled of four different legs. The low cloud layer was significant thicker than in the north but also reached the ocean surface. The stack is illustrated below.



Altitudes of the second stack between W4 and W5.

After the second stack, the flight turned south flying at 11 000ft altitude. Three dropsondes were released. The last in the still existing cloud free area due to the lee effect.

Instrument Status:

Polar 5	
Basis data acquisition	Green
Nose Boom	Green
MiRAC-A	Green
MiRAC-P	Green
AMALi	Green
SMART	Yellow
Eagle/Hawk	Green
NIKON (with fish-eye)	Yellow
Sun Photometer	Red
Polar Nephelometer	Green
2D-S	Green
CCP	Yellow
PIP	Green
Drop Sondes	10 launched

Table S5.1: Instrument status as reported after the flight for all instruments on Polar 5.

Comments: SMART had a software failure, but could be reinitialized. About 90min data was lost. The CDP of the CCP had a storage problem in one of the legs of the first stack. Some minutes of data is lost. The Nikon Camera was operated only with fixed settings. Changes of shutter time, etc. could not be applied due to software issues.

Detailed Flight Logs:

LYR – WP1:

08:00 broken mid-level clouds at the airport
08:19 Take Off
08:22 Roller doors open
08:24 cloud top of the first layer ~4000 ft
08:26 second cloud layer with cloud top ~6000 ft
Many other thin layers visible
08:28 now over the top of all lower clouds with cloud top ~8000ft
08:31 broken clouds over the island, cloud fraction 50%
08:38 some mid-level clouds and cirrus ahead
08:49 now over mid-level cloud
Cloud top very close to aircraft with about 2800m cloud top → ascent to 11 000 ft
08:54 now cloud free in the lee of Svalbard

WP1 – WP2

09:01 DS#1 cloud free in the center of the lee cloud hole
09:10 DS#2 at the edge of the cloud hole
09:15 stratiform clouds below
09:19 DS#3 same conditions
09:29 DS#4 still stratus below, very thin
Lot of cirrus, almost homogeneous
09:35 still one single thin cloud layer
09:38 DS#5 thin second cloud layer below
Some precipitation from a layer above
09:42 ahead the low cloud layers become bigger and more structured at cloud top (like convection)
Lot of thick cirrus or higher mid-level clouds (as was forecasted)
??:?? DS#6

WP2 – WP3: Stack 1

Cloud field in western direction stops close to the flight track
→ shift WP3 to east
Sea ice cover about 70%
Lowest cloud layer: all liquid, sometimes cloud touch the ground
Strong wind at the surface – waves between ice floes
10:25 cloud hole
10:35 nice two layer cloud: not a very large field, but homogeneous between W2 and W3
10:44 second layer only before W2: not a nice cloud base, some patches also below
10:57 also a thick cirrus above
11:02 more turbulence in higher cloud top
Little icing
11:09 thick cloud above (rather mid-level than cirrus)

WP2 – WP4

11:31 still sea ice below clouds

11:35 second cloud layer is gone but still cirrus above

WP4 – WP5: Stack 2

11:59 stratiform low cloud, no second layer, lot of altostratus + cirrus

12:30 low clouds are not illuminated by the Sun → thick cirrus

Low clouds look dark

12:36 finish second stack

WP4 – WP1

12:44 again second cloud layer between 8000-9000 ft, cirrus above

12:47 DS#8

12:58 second cloud layer ends

13:04 DS#9 one cloud layer below getting thinner and becomes broken

13:13 low cloud layer almost ends

13:15 lee effect visible on the sea surface, no waves in lee

13:19 DS#10 cloud free, some cirrus above

WP1 – LYR

13:35 start descent

13:59 touch down



08:23 UTC – inhomogeneous clouds over Svalbard



08:45 UTC cloud free area in the lee of Svalbard



09:33 UTC The low clouds became more structured with higher clouds tops.



10:21 + 10:23: between the two cloud layers



12:21 + 12:26: Between the two cloud layers.

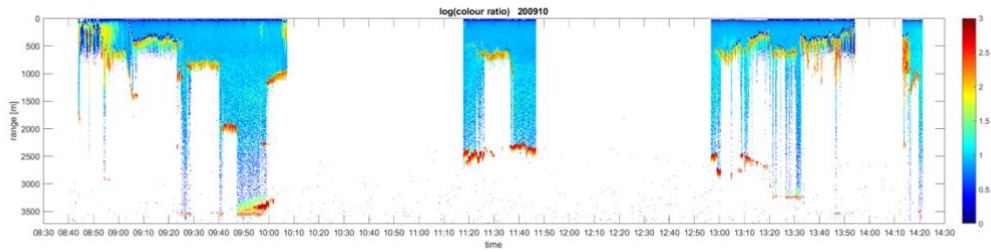
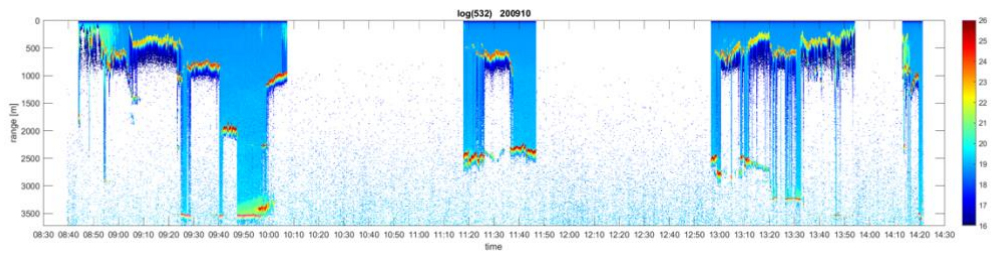
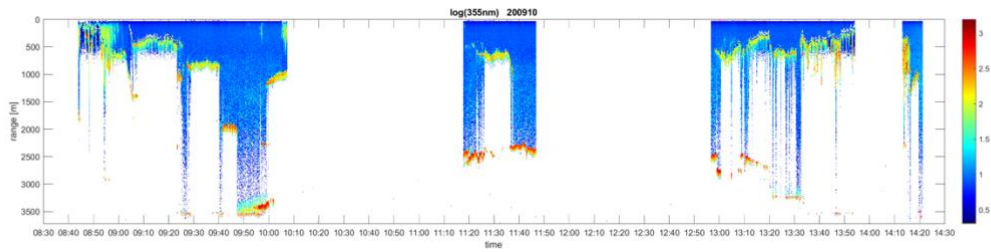
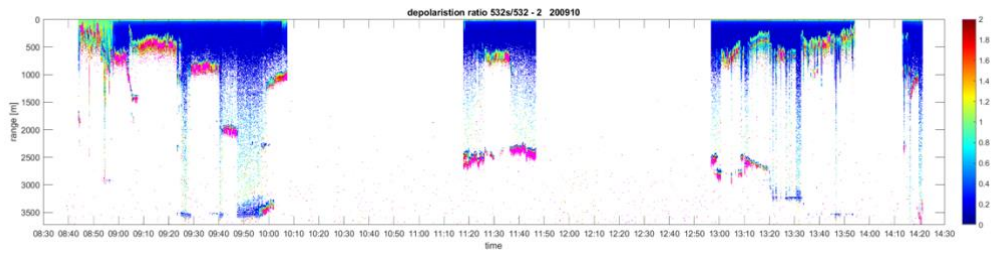
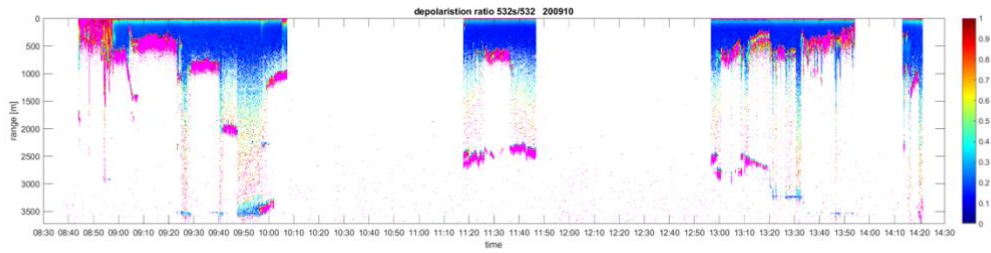
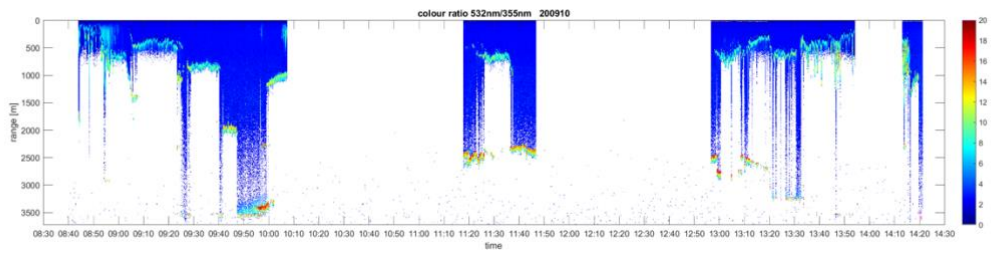


12:56: End of the low level cloud, right before the lee cloud hole.



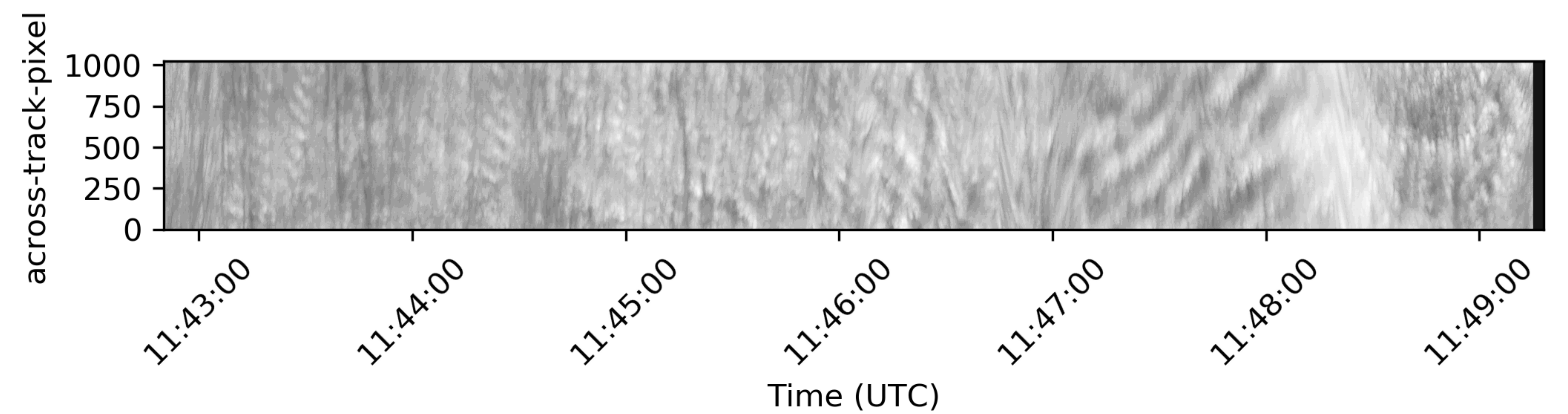
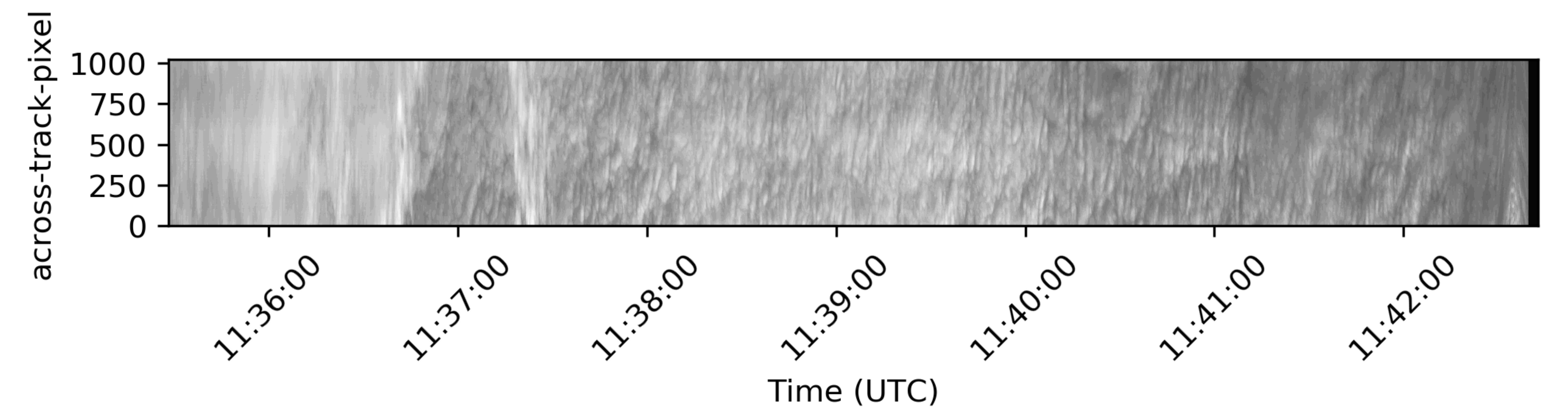
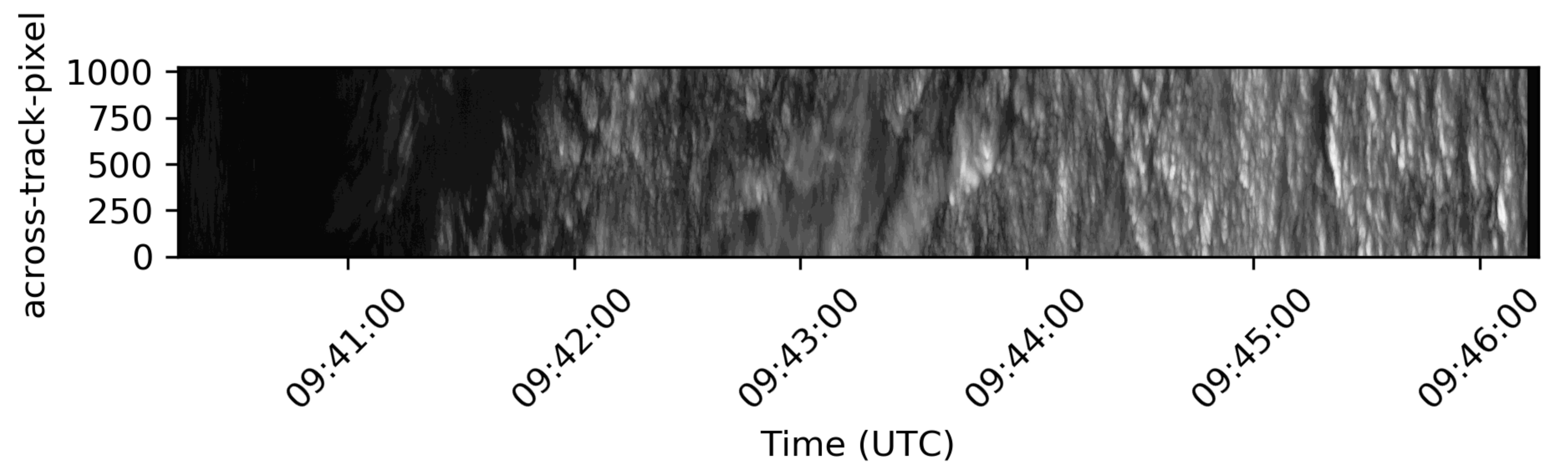
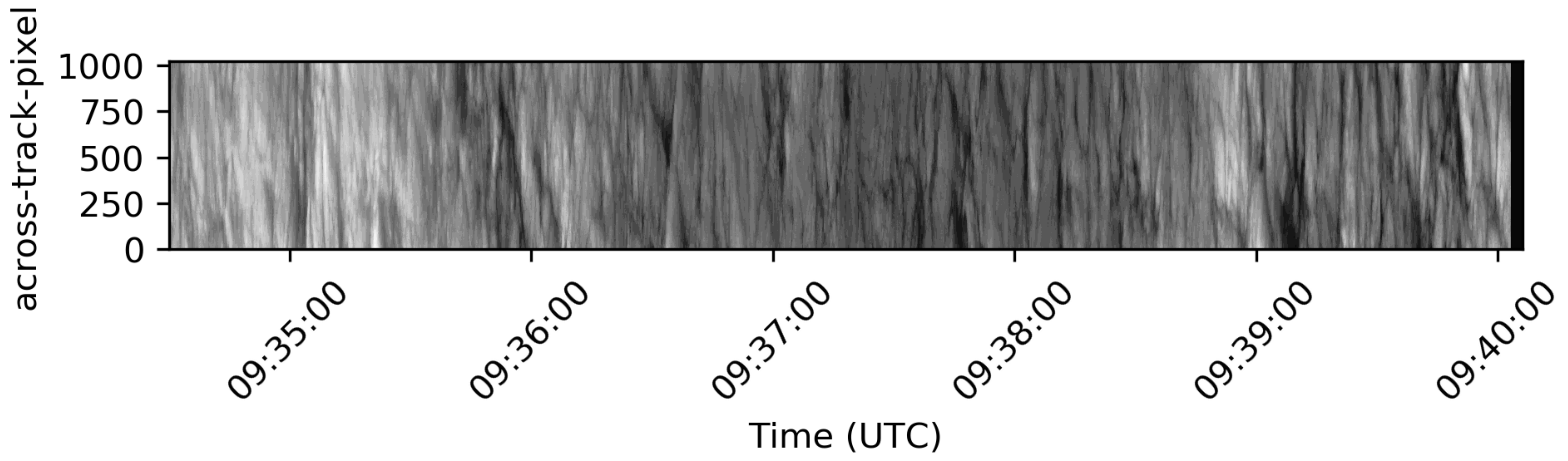
Quicklooks:

AMALI 20200910:



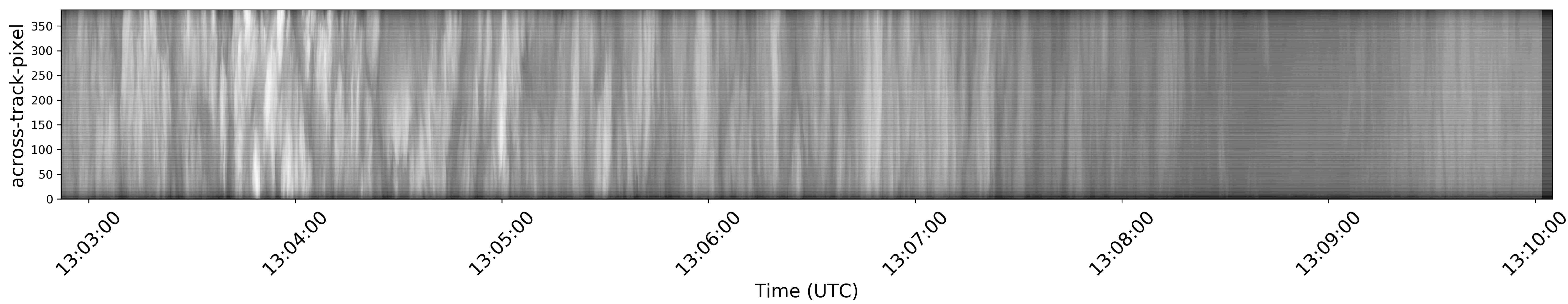
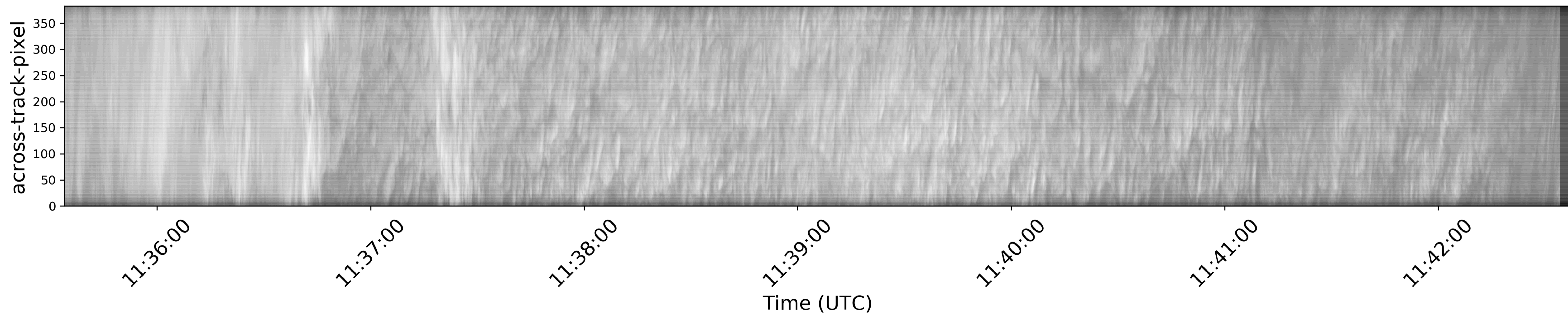
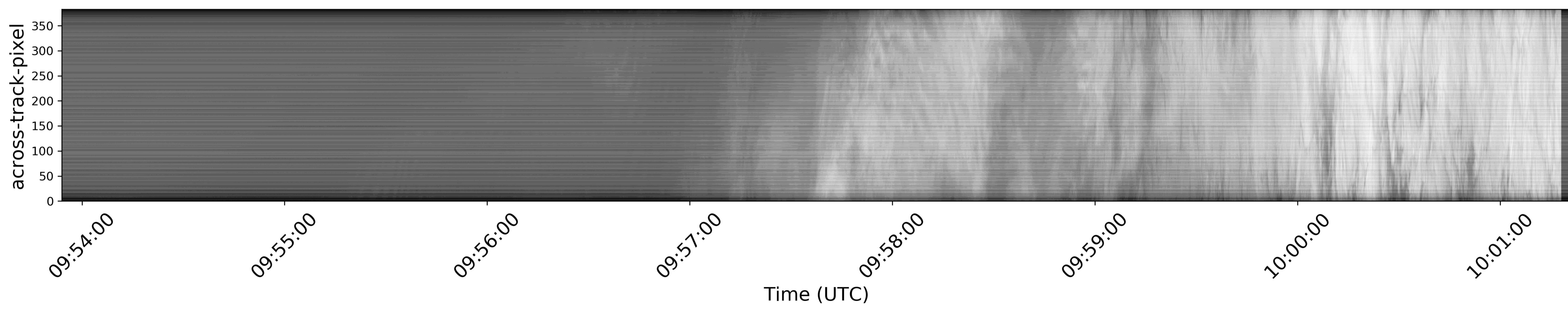
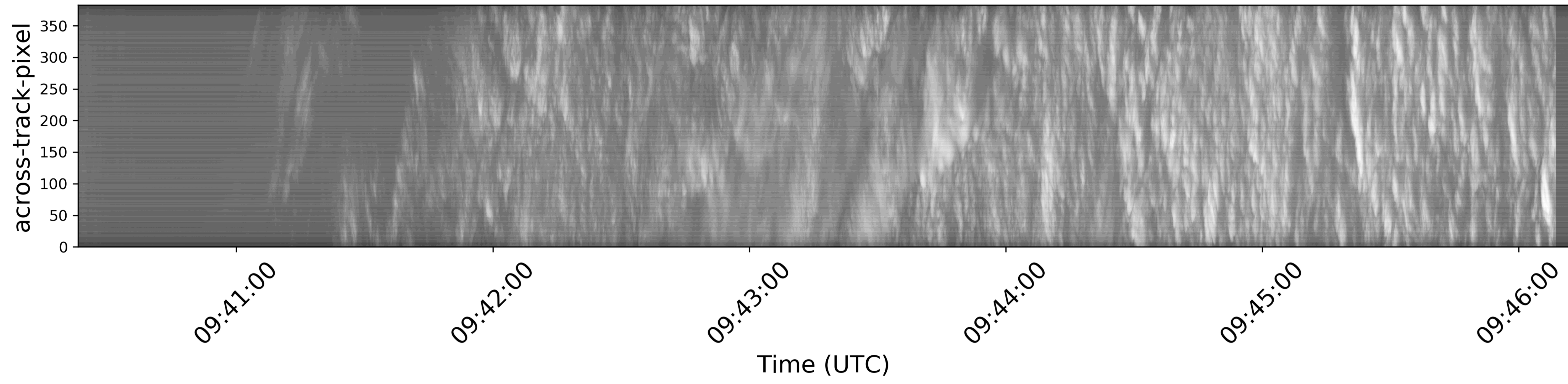
Quicklook Flight 09, 10.09.2020

EAGLE (Spectral imager)



Quicklook Flight 09, 10.09.2020

HAWK (Spectral imager)



Quicklook: PMS - DLR 2020-09-11

