2. WEATHER CONDITIONS

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The weather during MOSAIC Leg 5 was characterized by frequent fog and low clouds. At the start of the expedition on 12 August *Polarstern* was situated in the western Fram Strait below a temperature inversion at the edge of a high pressure system over Franz-Josef-Land which moved into the Laptev Sea by 14 August.

On 13 August *Polarstern* the travel to the North started with the goal to find a new MOSAiC ice floe in an area close to the North Pole. The cruise track went from the western Fram Strait towards Northwest and North of Greenland to the North. The ice situation North of Greenland was so weak that *Polarstern* only needed six days for the entire travel to the North Pole.

On 13 August a low moved along the eastern coast of Greenland towards the North. In the afternoon it was already at the northeastern coast and on 14 August it moved towards Ellesmere Island where it filled afterwards. In the forenoon of 13 August its occlusion with cold front character crossed *Polarstern*. Thereby the wind from Southeast increased to 6 Bft and the visibility temporary improved. The temperature dropped from 2°C to about 0°C and stayed around the freezing level during the next days.

On 14 August *Polarstern* got more and more influenced by a new deep low which had been developed at the eastern coast of Greenland close to Denmark Street on 13 August and which moved into the Barents Sea until 16 August. Thus, during 14 August the until then prevailing wind from Southeast backed to North while temporary decreasing to 3 Bft. On 15 August the wind came from North to Northwest with 5 Bft. Additionally to the fog, during that time period rain and drizzle occurred, on 16 August also as freezing precipitation.

The low changed its track direction on 16 August and moved into the Fram Strait by 21 August and at the same time it weakened significantly. In parallel, *Polarstern* was influenced by a high pressure system which moved from the North Pole to Severnaya Zemlya. Therefore, the wind rapidly decreased to 3 Bft on 16 August, veered to South until 19 August and remained weak. On 17 and 18 August the lower air layers temporary warmed to 1°C. In the morning of 17 August dense fog was still prevailing above the journey route, but in the afternoon and evening the conditions improved significantly: the cloud bases raised and the visibility became very good. This chance was used to perform the first helicopter flights. The good flight weather conditions remained until 18 August evening, allowing flight operations through the whole day. An extended fog field approached from the East which reduced the visibility significantly within a few minutes when it arrived in the evening. The fog stayed until 19 August and changed to low stratus clouds until noon.

Polarstern crossed the North Pole on 19 August and on 21 August it reached the MOSAiC-2.0 ice floe at 87.7°N 104.5°E.

Located at the edge of a high pressure system between North Pole and Severnaya Zemlya the fog frequency over *Polarstern* continued to be very high in the time period from 19 to 22 August, with weak winds from southern directions. At times the fog changed to low stratus clouds with freezing drizzle and temperatures mostly between 0 and -2°C.

On 22 August the nearly filled low in the Fram Strait started to move towards the North Pole and deepened again. Thereby the high was forced to move towards the New Siberian Islands and strengthened at the same time. In the early morning of 24 August the low was located directly over the MOSAiC floe and continued to move to the Queen Elizabeth Islands where it started to slowly fill on 25 August. Consequently, on 22 August the wind increased to 4 Bft and from 23 to 24 August backed from Southwest over East to Northwest while temporary decreasing to 2 Bft in the centre of the low. During the passage of the low on 24 August the air pressure over *Polarstern* rapidly decreased to 991 hPa and afterwards increased as fast as it was decreasing. By 23 August in upper levels the low brought considerably cooler air in (temperature below 0°C), leading to snow grains and snow on 23 August for the first time during the expedition (instead of freezing drizzle or rain). The temperature at the ground remained about 0°C.

In light intermediate high pressure influence on the back side of the low on 25 August the air cooled down to just below -4°C with weak winds from easterly directions and temporary only very thin fog.

In the night to 26 August the warm front of a new deep low moving from the Barents Sea to the North crossed us and made the temperature rapidly raise on 26 August to just above 0°C. The temperature stayed between 0 and 1°C until 30 August. On 26 August the low was located just south of the North Pole (seen in direction to Svalbard). It then moved southwestwards towards Greenland and filled at the northern coast of Greenland until 28 August. Consequently, on 26 August the wind rapidly increased to 5 Bft and shifted to South. In the night to 27 August it temporary reached 6 Bft and decreased afterwards to 4 Bft by 28 August.

Another low pressure system followed from the Kola Peninsula (27 August) over Svalbard (29 August) into the Fram Strait (30 August) where it slowly weakened. On 30 August, when the cold front occlusion of the low reached the research area, it caused a wind speed increase to 5 to 6 Bft and cooling down to 0 to -2°C. Below the occlusion snow grains precipitated from the low stratus clouds which often changed to fog. On 31 August the freezing fog caused a 1 cm thick ice layer on the ship and instruments on the ice floe.

In the meantime, the high pressure system over the New Siberian Islands moved from 25 August on to the East and stayed from 27 August to 4 September between the East Siberian Sea and the North Pole. Until 29 August it strengthened continuously and then slowly weakened until 1 September. Located at the flank of the high the wind decreased to 3 to 4 Bft until 31 August. Very low stratus clouds and fog still dominated.

From 26 August to 4 September *Polarstern* continuously drifted northnortheastwards due to the persistent winds from South to Southwest.

On 01 September the low started to move from the Fram Strait to the Northeast. It crossed the research area during the night from 4 to 5 September and then moved towards Ellesmere Island where it slowly filled. At the same time, the high between the New Siberian Islands and the North Pole strengthened. It then moved eastwards into the Chukchi Sea and Beaufort Sea by 5 September and weakened. In the increasing pressure difference the wind speed increased from 3 to 4 Bft to 5 to 6 Bft from 1 to 3 September. In the weak high pressure influence just before the approaching low on 2 September there was a temporary clearing of the sky which led to a temporary temperature drop to -3°C. In the area of the low pressure system on 3 and 4 September there was at times freezing drizzle which changed to snow grains and later snow. During the crossing of the low the wind backed from 4 to 5

September from South over Northeast to West and temporary decreased to 2 to 3 Bft on 5 September.

On 5 September a new low developed at the east coast of Svalbard. It rapidly deepened and moved northeastwards. Thereby it passed south of the research area from 6 to 7 September (995 hPa over *Polarstern*) around the North Pole and developed on 7 and 8 September into a deep gale force low (985 hPa) between Ellesmere Island and the North Pole, where it stayed and from 9 September on weakened. When the low approached, the weak wind of about 2 Bft veered by 6 September from West over North to East and rapidly increased to 6 to 7 Bft by 7 September, whereas it backed from East to North. In the night to 7 September the occlusion of the low brought new snow fall.

Afterwards on 7 September *Polarstern* got into intermediate high pressure influence. Thus, on 7 September the wind decreased to 3 to 4 Bft and backed continuously from North over West to South until 8 September. When the frontal clouds had moved away to the East, on 7 September there were some larger cloud gaps in the low stratus layer that have been used for several science related helicopter flights. In a huge nearly cloud free sequence from 7 September evening until early morning of 8 September the temperature rapidly dropped to nearly -7°C, but with the arrival of new clouds on 8 September it rose again to about -5°C. On 8 September more flight operations could be performed below a mid-level height cloud layer and only few very low cloud patches. On both days the visibility was very good.

At the same time another low developed in the western Barents Sea. It quickly moved northeastwards and passed the research area on 9 September in the South and continued towards Chukchi Sea while weakening. Therefore, on 9 September the wind above the research area continued to back to Northeast and increased to 5 Bft in the afternoon. The frontal clouds brought continuously snow fall in the night to 9 September and until 13 ships time (8 UTC). In total 6 cm of new snow was registered.

From 9 September afternoon on *Polarstern* got more and more into high pressure influence. Thus, until 10 September the wind decreased to 3 to 4 Bft. On 9 September evening temporary very cool air was brought in, as the wind temporary had shifted to North and the cloud cover cleared. Thereby, the temperature rocketed down to -9°C, but raised again to about -5°C below a very low cloud layer that arrived.
The high originated from Greenland. It was located over the North Pole on 10 September and moved into the Chukchi Sea and the Beaufort Sea on 11 September with a high pressure ridge still extending to the North Pole until 12 September. From 10 to 13 September the wind came from East and successively decreased to 2 Bft until 12 September. A low which moved from the Kara Sea over Severnaya Zemlya into the Beaufort Sea at the same time temporary stopped this trend with leading to a short wind speed increase to 4 to 5 Bft in the night to 11 September and through its morning.
Due to the increasing high pressure influence the low stratus cloud layer descended more and more and changed into fog on 10 September. At the same time the low cloud and fog layer thinned and started to vanish from 10 September afternoon on. A first opening in the cloud layer in the afternoon of 10 September was used for helicopter flights in the vicinity of *Polarstern*. From 10 September evening to 11 September noon it was mostly sunny with few fog banks at the horizon. Due to the reduced incoming long wave radiation during that time period the temperature cooled down to nearly -13°C. Until the approach of new low clouds on noon of 11 September the weather conditions had been perfectly used to perform more scientific flights. In the evening the low cloud layer changed to fog. It caused heavy hoar frost aggregation at the ship and on the scientific instruments on the ice floe. In the night to 12 September the temperature raised to about -6°C below the thick fog layer. In the morning the cloud bases temporary raised to 1000 FT AGL and the visibility improved, making another

helicopter flight possible. *Polarstern* and the MOSAiC floe were still surrounded by some large fog fields. One of them reached *Polarstern* in the afternoon.

A low pressure system from the eastern Barents Sea approached on 12 September. Its warm front occlusion crossed the research area in the afternoon of 13 September. The wind from East increased to 7 Bft and temporary 8 Bft by 13 September afternoon. In the approaching warm air mass the temperature raised to about 0°C by 13 September afternoon. Connected to the warm air inflow, during the night to 13 September dense advective fog occurred. The warm air that was flown in in upper heights caused freezing rain on 13 September.
The centre of the low reached the MOSAiC floe and the North Pole during the night to 14 September (989 hPa) and moved southwestwards to the Queen Elizabeth Islands until 17 September. At first the wind decreased to 5 Bft and shifted to Southwest. With the second crossing of the occlusion front on 14 September the wind increased to 7 Bft with gusts 8 Bft. On the back side cool air was transported in (temperature on 15 September nearly -5°C), whereas the rain more and more changed into snow.
On 15 September only few isolated snow showers occurred and the wind had weakened to about 2 Bft. In the cool air mass the visibility temporary was very good. In the morning of 15 September a short helicopter flight was performed until the cloud bases descended again.
On 16 September the wind from Southwest rapidly shifted to Northwest and temporary increased to 5 to 6 Bft, because the low was already located between the North Pole and Ellesmere Island.

Afterwards, from 17 September on *Polarstern* was influenced by a high pressure system which moved over the North Pole by 18 September and afterwards continued towards the Beaufort Sea. Thus, on 17 September the wind rapidly dropped to 1 Bft and slowly shifted to South. At the same day a short weather window when the clouds lifted slightly was used for another scientific helicopter flight. In the evening of 18 September there was a temporary temperature drop down to -11°C because of a cloud gap.

From 18 to 20 September a weak low moved from the northeastern coast of Greenland to the Northwest towards the Beaufort Sea and filled. The low transported warmer air and thus on 19 September even the air at the surface warmed to nearly -2°C below the frontal clouds. There was snow fall that temporary changed to freezing drizzle. At the same time the wind over the MOSAiC floe temporary increased to 5 Bft on 19 September. On the back side of the occlusion front there a larger cloud gap occurred on 19 September afternoon which was used for more flight operations, until new low clouds arrived in the evening.

From 20 September on high pressure again established over the North Pole. The high strengthened until 23 September and afterwards moved away into the East Siberian Sea. Due to the high pressure influence there were several larger cloud gaps which led to cooling on 20 and 21 September to about -11°C, on 22 September even to -15°C, which was the lowest temperature during MOSAiC Leg 5. In spite of some fog banks in the cloud gaps some more helicopter flights could be performed. The wind decreased to about 2 Bft on 20 and 21 September.

After four weeks of drift, on 20 September shortly after 18 ships time (13 UTC) *Polarstern* left the MOSAiC-2.0 ice floe at the position 89.14°N 110.42°E to start the way back to South. From 23 September on *Polarstern* followed the 86th latitude to the West.

At the same time a deep low moved from the southern Kara Sea to the northwest and was located between Franz Josef Land and Svalbard on 23 September and from 24 September on between Svalbard and the North Pole where it temporary weakened. With the approach of the deep low the wind over *Polarstern* shifted from South to East on 22 September and

rapidly increased. When the warm front occlusion crossed during the night to 23 September, the wind reached its maximum with 8 to 9 Bft and afterwards decreased to 5 Bft and shifted to Southeast. The warm front occlusion led to a rapid temperature raise to just below 0°C. Connected to the front sleet occurred which changed to drizzle and from late morning of 23 September on dense fog dominated. Being located close to the centre of the low, on 24 September the lowest air pressure was measured during this expedition part with 985 hPa (reduced to mean sea level). On 24 September the low moved eastwards while weakening. Thereby it was situated directly over *Polarstern* on 25 and 26 September, causing an abrupt wind shift from Southeast to West and drop to 2 Bft on 25 September. Cooler air was brought in until 26 September (cooling to -6°C). On 26 September the visibility was reduced due to light snow fall. In the evening of 26 September the wind shifted to Northwest and raised to 4 Bft, whereas temporary warmer air was brought in (-2°C) and dense fog dominated.

Another deep low moved on 24 September from the northern coast of Norway towards Northeast. On 25 September it moved between Novaya Zemlya and Franz Josef Land and reached Severnaya Zemlya on 26 September. Both lows merged to one low pressure complex which developed to an extended deep low on 26 September just south of the North Pole (seen in direction to the Laptev Sea). When *Polarstern* reached 86°N 32°E it then travelled towards South and on 27 September from 83.3°N 32°E it continued along the marginal ice zone in a southwesterly direction. The wind along the cruise track shifted on 26 September to West and increased to 6 to 7 Bft until 27 September. At the same time cooler air was brought in, leading to a temperature decrease to -10°C on 27 and 28 September.
Due to the slow weakening of the low starting on 27 September the strong west wind decreased to 3 to 4 Bft by 28 September. In a narrow cloud gap on 28 September helicopter operations could be performed, until new low clouds arrived in the afternoon, which changed to fog by 29 September due to a small intermediate high pressure system north of the Fram Strait. Until 29 September the wind decreased to 1 to 2 Bft and shifted to East.

On 29 September the wind rapidly increased from 1 to 7 Bft within only few hours and shifted from Northeast to North, because a deep low moved from 28 to 29 September from Iceland into the Fram Strait. On 29 September a small station outside of the ice area at 81.5°N 11.5°E was performed with 0.5 m swell from the South and in the afternoon additional 1 m wind sea. The low transported warmer air in, leading to a temporary temperature raise to -3°C on 29 September. During the journey of *Polarstern* towards the West back into the ice the temperature dropped again to -8°C during the night to 30 September. On 30 September there was a final ice station at 81.7°N 1.4°E, followed by the start of the transit to Svalbard in the evening. The occlusion of the approaching low reached *Polarstern* during the night to 30 September and led to snow fall and blowing snow still with wind from Northeast with 6 to 7 Bft. The snow fall faded out during the day, but low stratus clouds dominated. At the same time the temperature increased to nearly -4°C. The low reached Svalbard on 1 October and quickly filled there.

On its way from the ice edge to Svalbard *Polarstern* got more and more influenced by a high pressure system which originated from Greenland and established over the Fram Strait on 1 October. Thus, on 1 October the wind from North decreased to 4 Bft. In the open ocean at the same day wind sea with 0.5 m and two swells with 1 to 2 m from South and Northeast occurred, which decreased to 1 m in the evening.
During the travel South the temperature continuously increased and was already +2°C, when *Polarstern* reached Svalbard 2 October in the morning and travelled through the Isfjord to Longyearbyen. Also the water temperature showed a significant increase from -1.7°C at the ice edge to 4 to 5°C in the warm West Spitsbergen Current.
During the night to 2 October the high pressure system moved across Svalbard towards Southwest. Thus, the wind over *Polarstern* shifted to South and decreased to 3 Bft. Just before entering the Isfjord in the morning the wind rapidly increased to 6 Bft due to local

orographic effects along the coast of Svalbard. In the Isfjord the wind dropped to about 2 Bft and shifted at times to East to North depending on the location of the mountain valleys. At times the light rain from the low clouds caused moderate visibility. In the fjord the temperature decreased to 0°C.

Between the high and a lee low at the northeastern coast of Greenland strong winds from South occurred over the Fram Strait until 3 October. The low moved to Severnaya Zemlya until 4 October. When *Polarstern* left the fjord in the evening of 2 October, the wind shifted to Southeast to South and rapidly increased to 6 Bft. The sea increased to 2 m. During the night to 3 October *Polarstern* travelled along the west coast of Svalbard to the North, reached the Kongsfjord in the morning of 3 October and stayed until 4 October in front of Ny-Ålesund. Just before entering the Kongsfjord in the morning of 3 October the mean wind speed temporary increased to 8 Bft, due to the Venturi effect between Prins Karls Forland and Svalbard. Also the significant wave height increased to nearly 3 m and calmed to below 0.5 m in the fjord. In the fjord the wind shifted to Southeast due to the orography and decreased to 4 Bft. In the afternoon the wind continued to decrease to about 2 Bft from variable directions. In the fjord the temperature was about 4°C. With a southwesterly air flow in upper levels on 4 October humid air was transported in from the eastern coast of Greenland. Thus, in the afternoon the visibility in the Kongsfjord reduced significantly and drizzle precipitated from a very low cloud layer which temporary changed to fog on 5 and 6 October. On 4 October 16 ships time (14 UTC) *Polarstern* left the Kongsfjord and started the transit to Bremerhaven. Due to the still weak winds from Southeast the wind sea and swell remained below 0.5 m also after having left the fjord.

When travelling South during the night to 6 October *Polarstern* got into a fresh to strong wind from East between a strong high pressure system which came from the North and moved into the Barents Sea by 6 October and a deep low over Great Britain. In the morning of 6 October the maximum occurred with 6 Bft mean wind speed and 2 m sea, but as the wind decreased to 3 Bft until the evening, the significant wave height decreased to 1 m.

On 5 October the low close to Great Britain started to move northwards while weakening and merged with a low that was moving from southern Scandinavia to the Northwest. The merged low pressure system crossed *Polarstern* during the night to 8 October. Thus, in the morning of 7 October the wind shifted to Northeast and increased to 4 Bft. During the night to 8 October it dropped to 2 Bft below the centre of the low. The occlusion of the low caused light rain on 7 October afternoon. During the night to 8 October at times fog occurred. After the passage of the low the wind shifted to Southwest by 8 October and rapidly increased to 6 Bft. The sea raised to 1.5 to 2 m.

By 9 October the wind decreased to 4 Bft and the wind sea to 0.5 m, with a swell from West of 1.5 m. Another small low over southern Scandinavia made the wind shift to Northwest and caused more rain showers. Until afternoon the wind dropped to 1 Bft and slowly shifted to Northeast and in the evening it was already 3 Bft again. The significant wave height was about 1 m.

On 9 October a low moved from the east coast of Scotland to the East. On 10 October it moved along the southern coast of Norway and crossed northern Jutland on 11 October. When *Polarstern* entered the North Sea on 10 October the wind therefore shifted to North and increased to 5 to 6 Bft, but decreased continuously on 11 October. The sea temporary raised to 1 to 2 m and some rain showers occurred.

In the morning of 12 October *Polarstern* finally arrived in Bremerhaven with an air temperature of 12°C, weak wind from Northwest and few rain showers.