MEDITERRANEAN CLIMATE OUTLOOK FORUM
MEDCOF-15 Online Forum

MONITORING SUMMARY MEDCOF-15

for October 2020

Final version

Last update: 18 November 2020

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1 Oceanic Analysis

1.1 Sea surface temperature (SST) anomalies

In the **Pacific**: Cooling along the equator continued in October, especially in the central part of the basin. **The La Niña event is now well established.** The cooling extended further southward along the South American continent. The northern Pacific was mostly warmer than normal, but partly less than in September (negative Pacific Decadal Oscillation (PDO), October 2020 value of PDO Index after NOAA was -0.58).

Net cooling from **Asia to Australia** during the month, anomalies remained positive in October.

The **Indian Ocean** is still warmer than normal except in the southwest part. There was no significant west-east gradient, pointing to a neutral Indian Ocean Dipole (IOD).

In the **Atlantic**: positive anomalies in the tropics. In the North Atlantic, the western part is warmer than normal while the vicinity of Europe showed quite marked cold anomalies.

Mediterranean Sea: the eastern Mediterranean was partly 2-3°C warmer than normal in October with increasing anomalies. In contrast, the western Mediterranean cooled considerably and had below-normal temperatures in October.

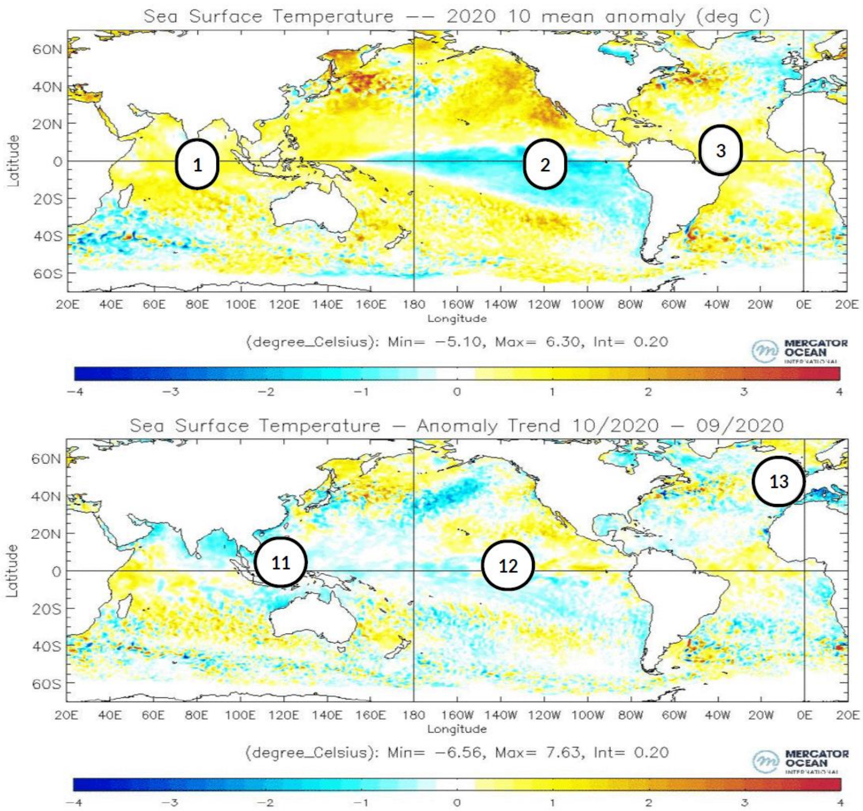


Fig. 1.1: Sea surface temperature (SST) anomalies for October 2020 (upper map) and anomaly trends (difference October minus September 2020). Source: Mercator-Ocean. Numbers: 1 - warm Indian Ocean, 2 - La Niña cold anomaly, 3 - warmer than normal, 11 – cooling, 12 - cooling in Nino3.4 box, 13 - cooling near Europe

1.2 La Niña development in recent months

The cold anomaly in the Nino3.4 box started in May 2020. Since July 2020, it has clearly increased.

Nino3.4 index taken from Mercator Ocean PSYV4R2 analysis for October 2020: -1.2 °C (see BOM site for weekly values: http://www.bom.gov.au/climate/enso/monitoring/nino3_4.png).

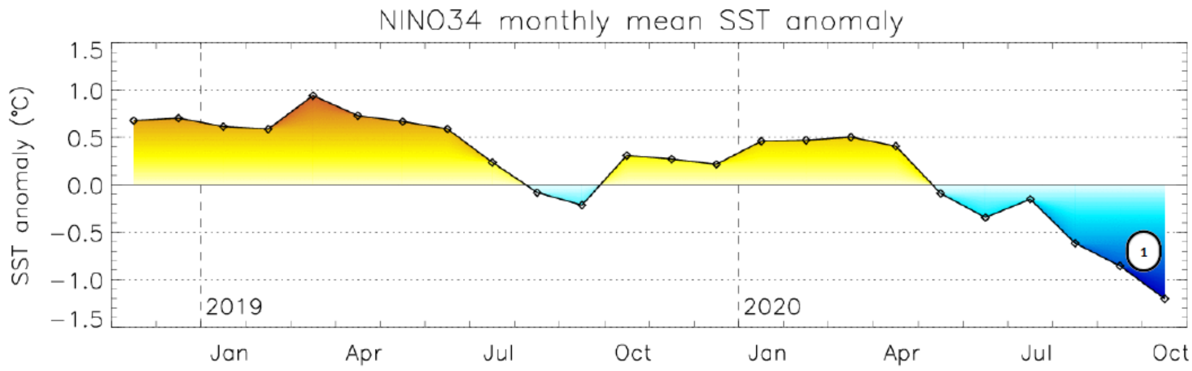


Fig. 1.2: Evolution of SST in the NINO3.4 box. Source: Mercator-Ocean. Number: 1 - The cold anomaly gets strong

1.3 Subsurface anomalies in the equatorial Pacific

In the subsurface, strong cooling continued in the eastern and central parts of the equatorial Pacific. Significant warming occurred in the western part. The strong east-west contrast has further strengthened.

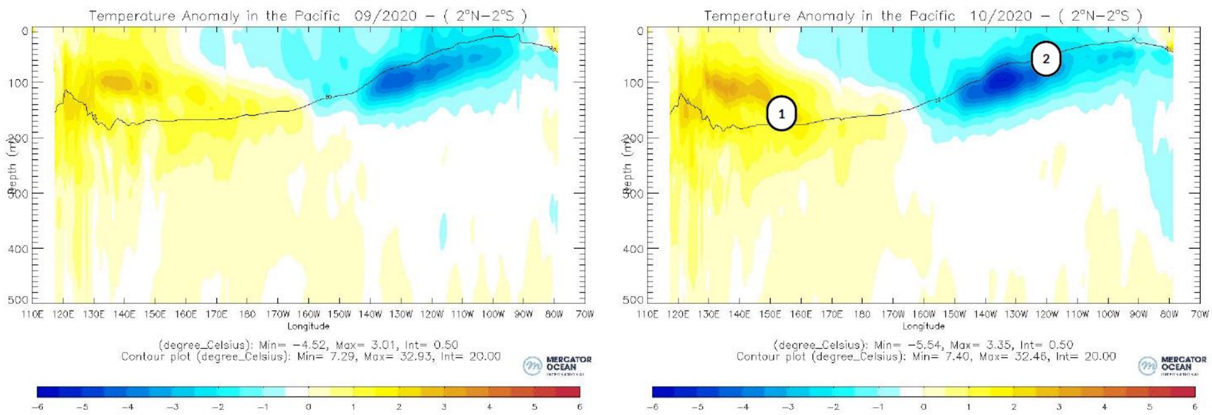


Fig. 1.3: Ocean temperature anomalies in the first 500 meters of the equatorial Pacific basin, monthly averages for September (left) and October 2020 (right). Source: Mercator-Ocean. Numbers: 1 - warming in the West, 2 - cooling in the East.

The strong subsurface contrast was clearly visible also in recent months and has little changed in October (Fig. 1.4). Note the reflection of the spring/summer Kelvin wave as a beautiful Rossby wave.

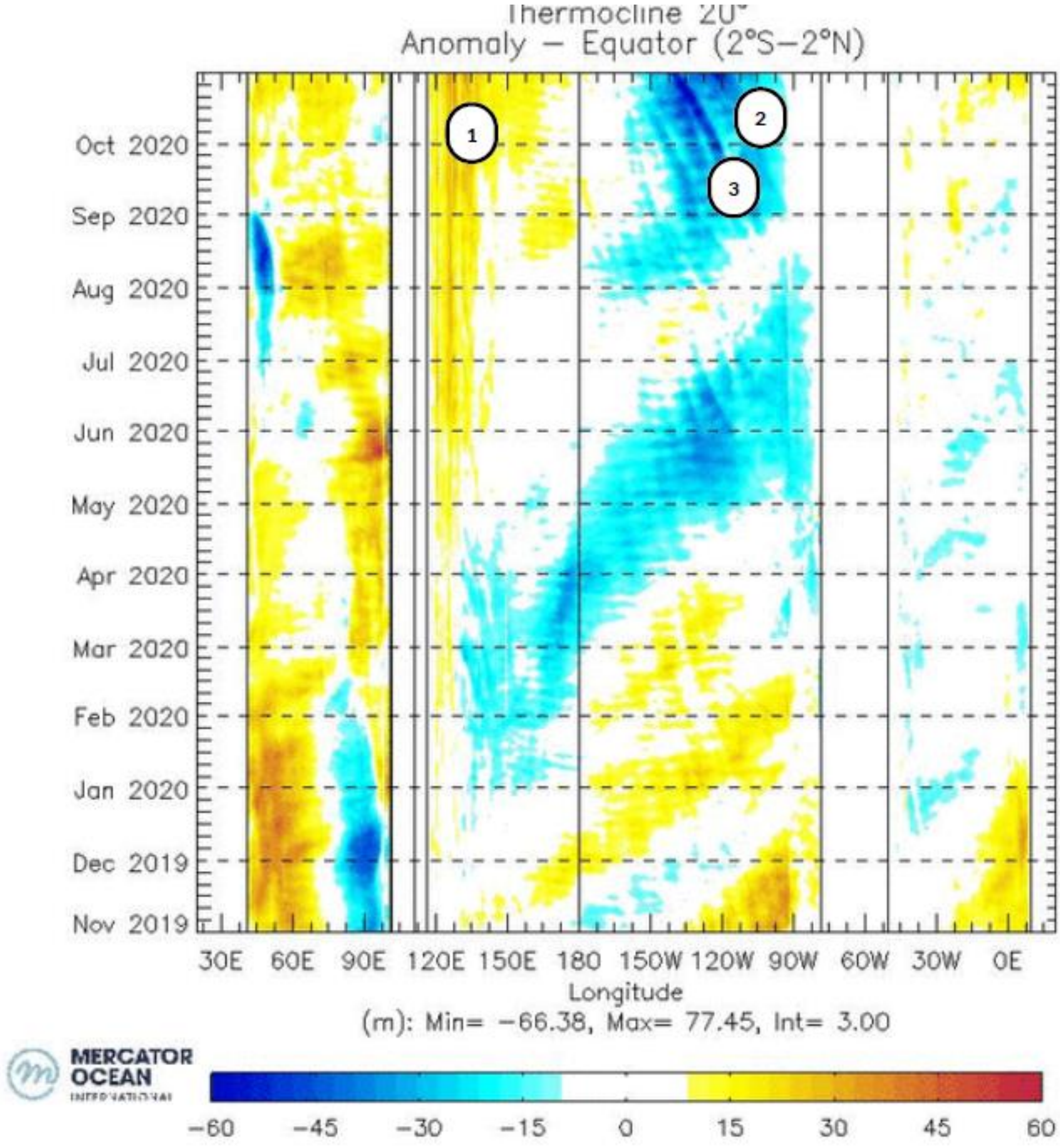


Fig. 1.4: Evolution of the anomalies of the depth of the thermocline (m) (materialized by the 20 ° C isotherm). Source: Mercator-Ocean. Numbers: 1 - Warm anomaly in the west part, 2 - Cold anomalies in the east part of the Pacific, 3 - Beautiful Rossby wave.

1.4 La Niña evolution in the following months

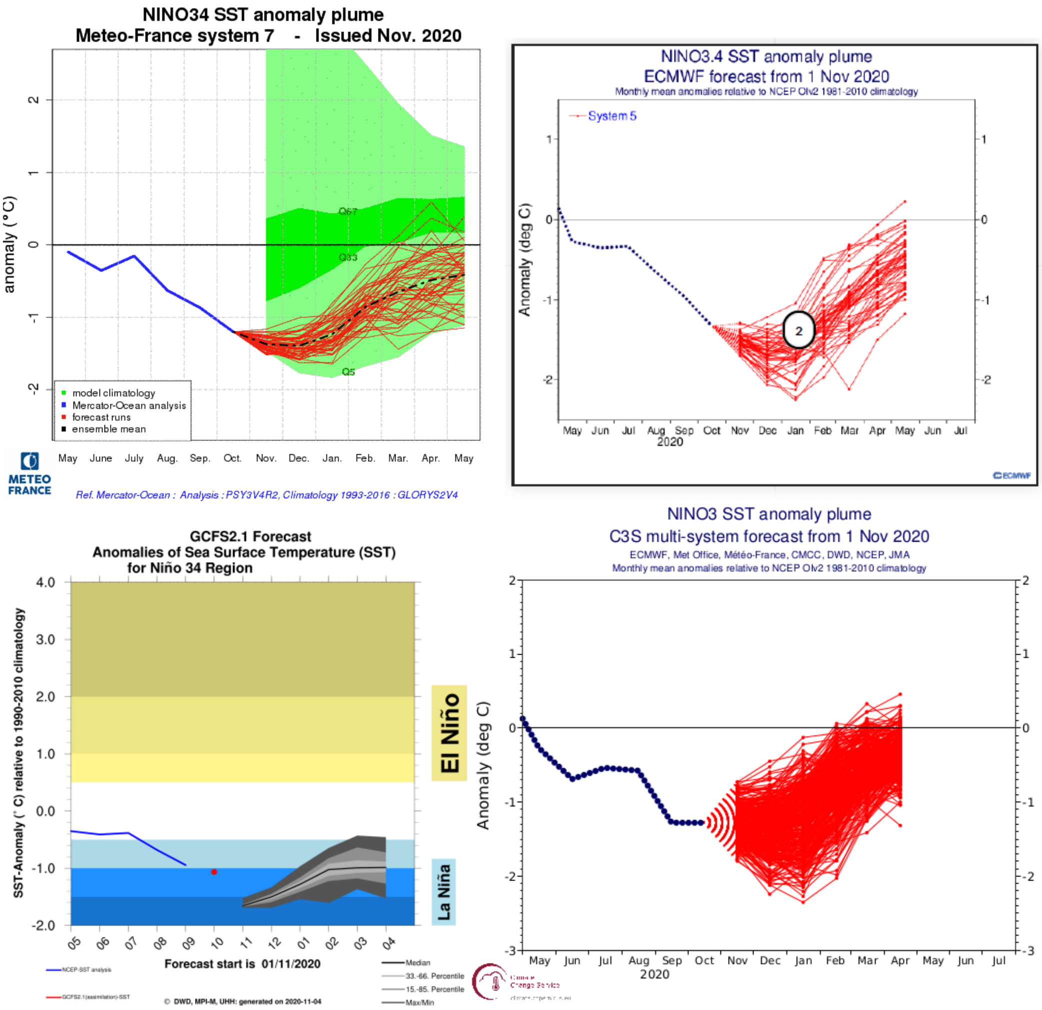


Fig. 1.5: Forecasts of SST anomalies in the Niño3.4 region from Météo France, ECMWF, DWD and Copernicus multi-model system (C3S, https://climate.copernicus.eu/charts/c3s_seasonal/c3s_seasonal_plume_mm?facets=undefined&time=2020110100,0,2020110100&area=nino3).

There is a good consistency of several forecast models on a strengthening of La Niña event in the following weeks, peaking at the end of the year, and weakening afterwards, but still a duration of La Niña until at least March or April 2021.

1.5 Pacific Decadal Oscillation (PDO)

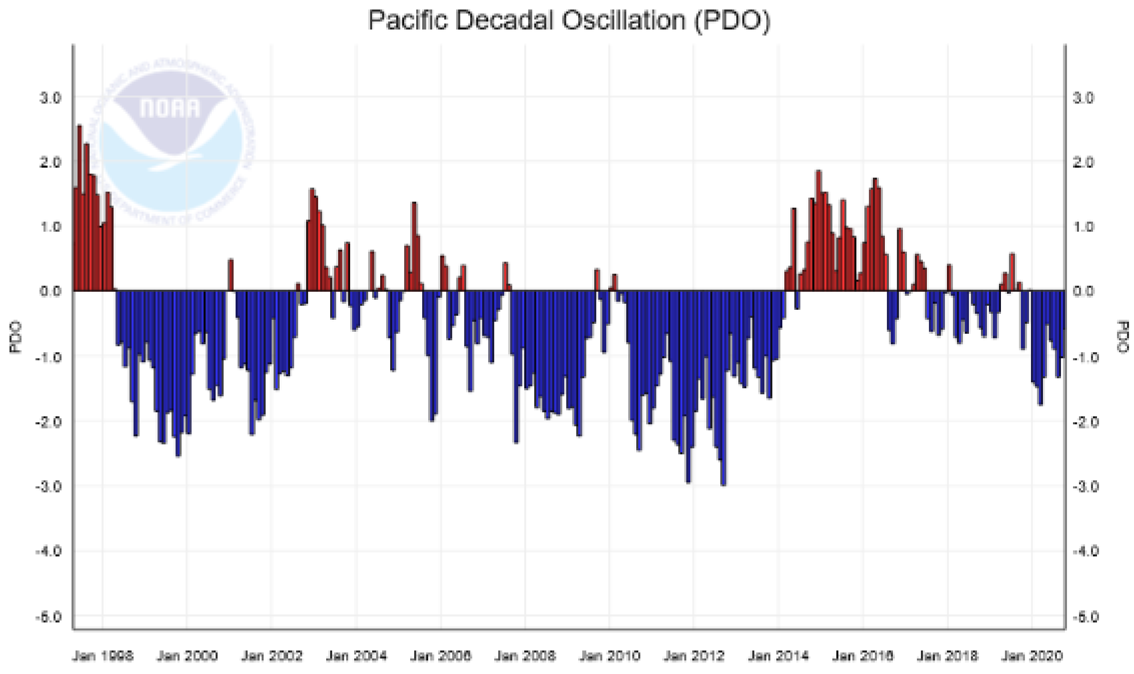


Fig. 1.6: Monthly Pacific Decadal Oscillation Index for recent years until October 2020. Source: DWD, https://www.ncdc.noaa.gov/teleconnections/pdo/

Pacific decadal Oscillation and combined impact with La Niña on atmospheric circulation:

The PDO index is negative since January 2020. A negative PDO phase in relation with a central Pacific La Niña favours a positive phase of NAO (Ding et al. 2017). This can be the case this winter 2020/21. Furthermore, La Niña favours an Atlantic ridge pattern in winter (after analysis by Météo France).

1.6 Indian Ocean Dipole (IOD)

The intensity of the IOD is represented by an anomalous SST gradient between the western equatorial Indian Ocean and the southeastern equatorial Indian Ocean. This gradient is named as Dipole Mode Index (DMI). When the DMI is positive, the phenomenon is referred as the positive IOD and when it is negative as negative IOD.

Dipole Mode Index (DMI) for October 2020 taken from Mercator Ocean PSYV4R2 analysis: -0.2°C (see BOM site for weekly values: http://www.bom.gov.au/climate/enso/monitoring/iod1.png), indicating near neutral conditions.

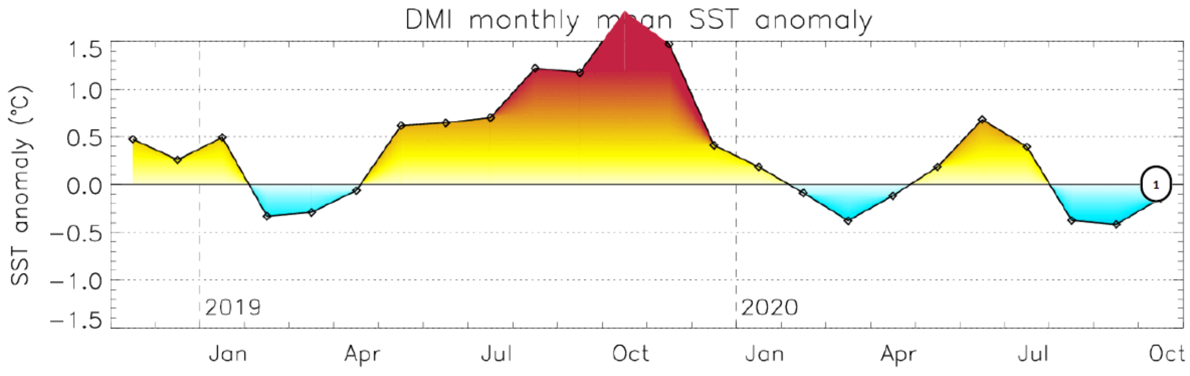


Fig. 1.7: Evolution of SST in the DMI box. Source: Mercator-Ocean. Number: 1 - Near neutral conditions

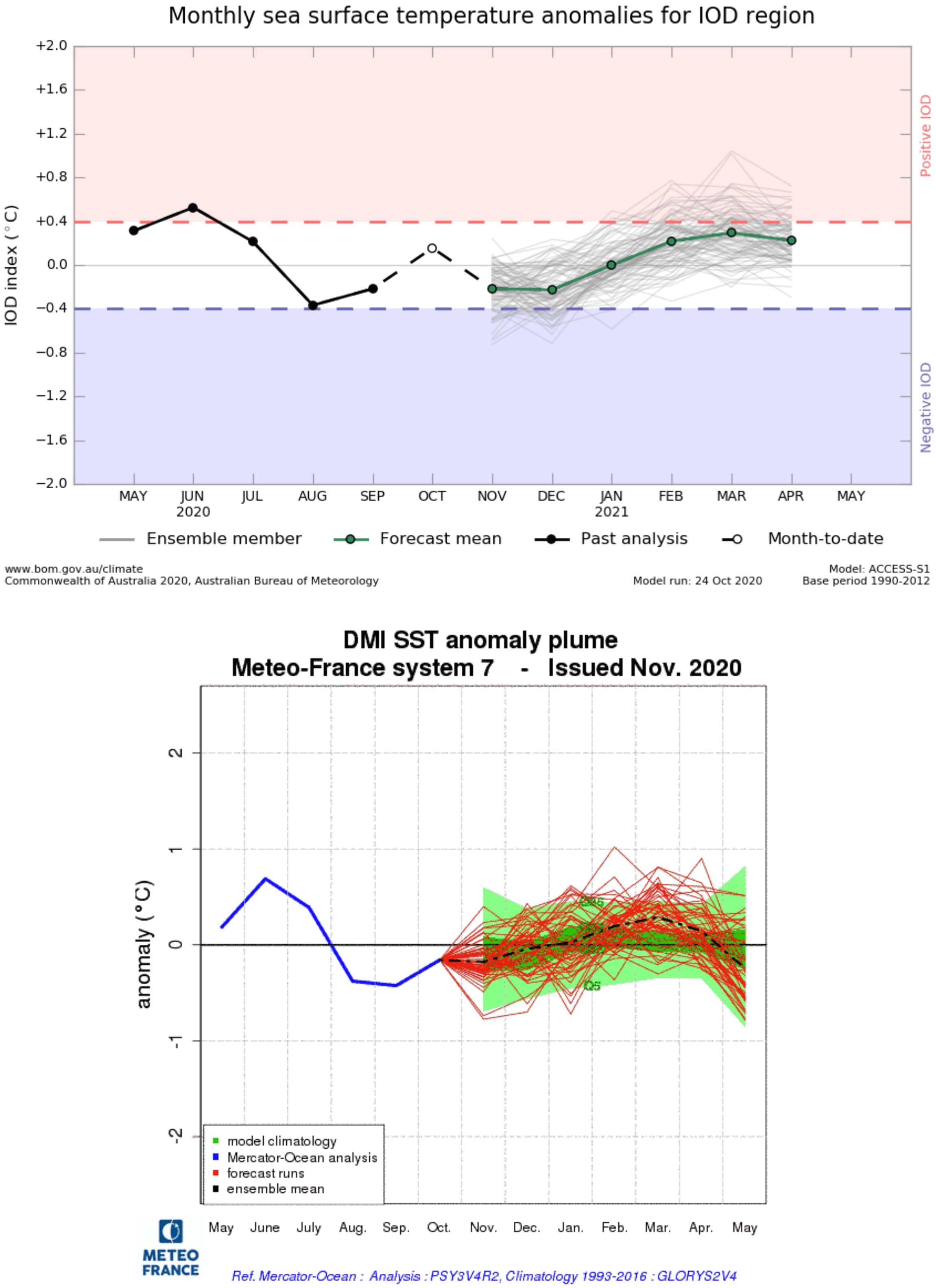


Figure 1.8: Indian Ocean Dipole (IOD) index (Dipole Mode Index (DMI)) with forecasts for the following months. Source: upper map: BOM, http://www.bom.gov.au/climate/enso/index.shtml#tabs=Indian-Ocean ; lower map: Météo France, http://seasonal.meteo.fr/content/PS-previ-plumes

The IOD was in a neutral phase since July 2020. Most forecast models predict a continuation of the neutral phase until at least April 2021 with only little variability. This means that no significant impact from IOD is expected for the following winter.

2 Atmospheric Circulation Analysis

2.1 Velocity Potential and Stream function anomaly field in the high troposphere

(insight into Hadley-Walker circulation anomalies):

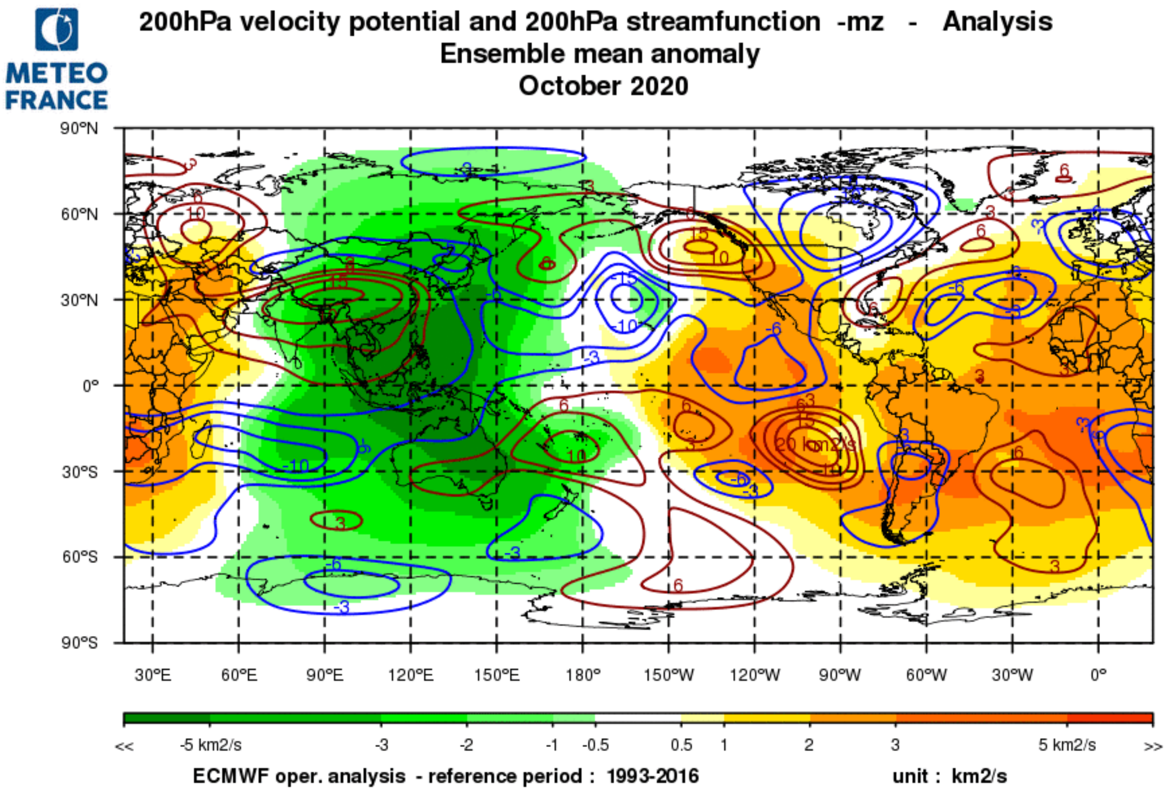


Figure 2.1: Anomalies of velocity potential (shaded) and stream function (isolines) at 200 hPa for October 2020. Green (orange/yellow) shading indicates a divergence-upward motion/anomaly (convergence-downward motion/anomaly). Positive (negative) stream function (red (blue) isolines) means anticyclonic (cyclonic) over the northern hemisphere, vice versa over the southern hemisphere. Source: Météo France, http://seasonal.meteo.fr/content/suivi-clim-cartes-ref93-16

The anomalies of the velocity potential and the divergence vectors show strong signals of upward motion over the Indian Ocean and the maritime continent and downward motion over the central and eastern equatorial Pacific. This is the typical signal of an atmospheric La Niña response and the dominating feature. The Madden-Julian Oscillation might have further enhanced the upward signal, which was active in the same area. The downward signal also extended over the Atlantic and Africa.

Stream function anomalies indicate some teleconnection in several parts of the globe including the North Atlantic.

2.2 Southern Oscillation Index (SOI):

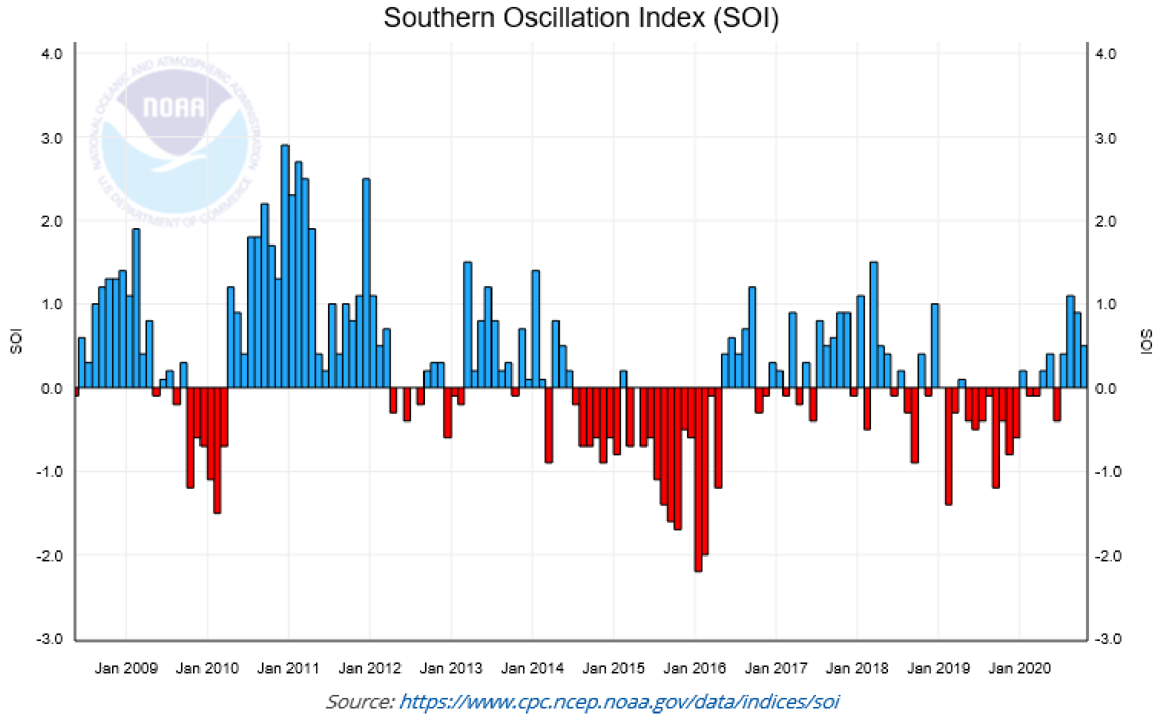


Figure 2.2: Southern Oscillation Index (SOI). Positive values mean La Niña response, negative values El Niño response. Source: https://www.ncdc.noaa.gov/teleconnections/enso/indicators/soi/

The SOI was positive since July 2020 (La Niña response). Interestingly, SOI has weakened from its highest value in August 2020 until October 2020, in contrast to SST anomalies. The weakening in October was displayed not only by NOAA, but also by BOM data (http://www.bom.gov.au/climate/current/soihtm1.shtml). It could be a sign of a beginning decoupling between ocean and atmosphere and needs to be further investigated when October maps are available and when looking at the forecasts.

2.3 Madden-Julian Oscillation (MJO):

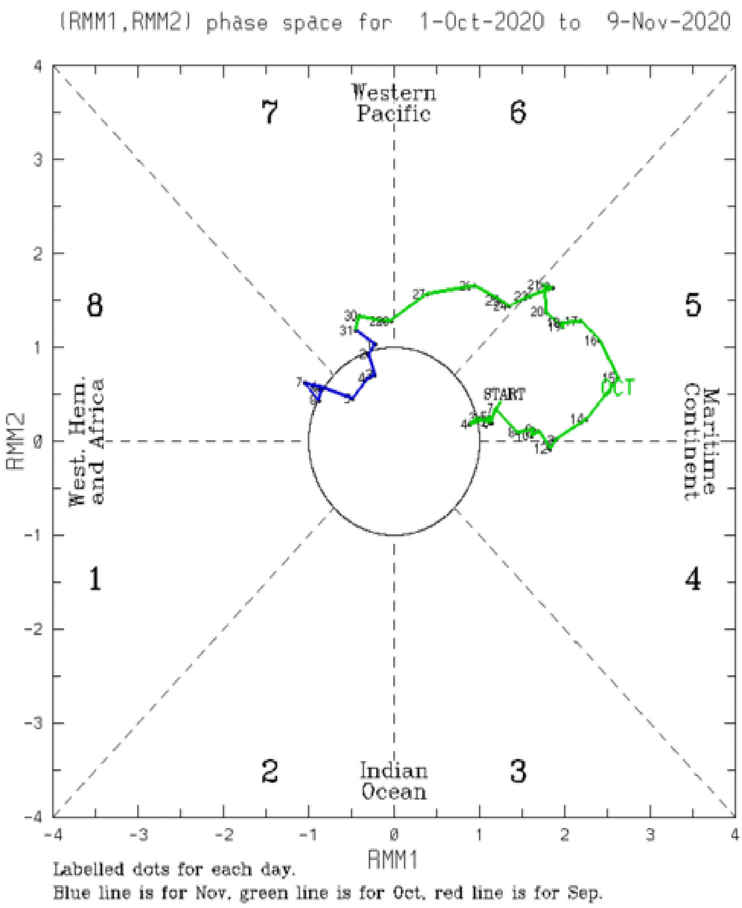


Figure 2.3: Phase diagram of the Madden-Julian Oscillation (MJO). Source: BOM, http://www.bom.gov.au/climate/mjo/

In October, MJO was active over the maritime continent and then moved to the western Pacific. It became weak in early November.

2.4 Geopotential height at 500 hPa

(insight into mid-latitude general circulation):

The 500-hPa geopotential had a rather meridional pattern in October 2020 over the North Atlantic and Europe. A large cyclonic anomaly extended over Western and Central Europe and the northern Balkans down to the western Mediterranean. On the other hand, an anticyclonic anomaly extended over Eastern Europe far south to the South Caucasus, Turkey and the Middle East. Southwestern Iberia also was under anticyclonic influence, and also North Africa was more anticyclonic than normal.

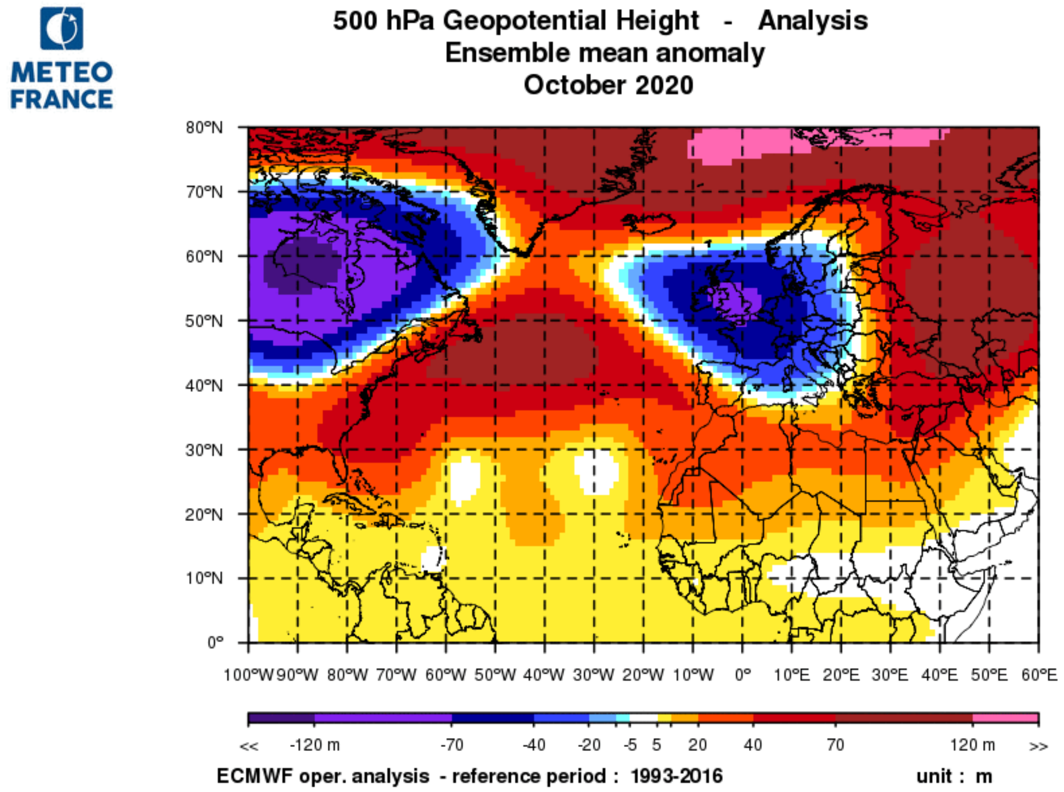


Figure 2.4: Anomalies of Geopotential height at 500hPa (Source: Météo-France, http://seasonal.meteo.fr/content/suivi-clim-cartes-ref93-16 , data from ECMWF)

2.5 Sea level pressure

The mean sea level pressure distribution for October 2020 indicates a zonal flow over the North Atlantic into Western and Central Europe, but rather a southerly flow over eastern Central Europe due to the Russian blocking high, which extended to parts of Eastern Europe.

However, cyclonic anomalies extended further southeast, particularly to the Balkan Peninsula, but to a lesser extent also to Italy, Greece and Turkey. The Azores High was more intense than normal, which affected particularly western Iberia and western Morocco.

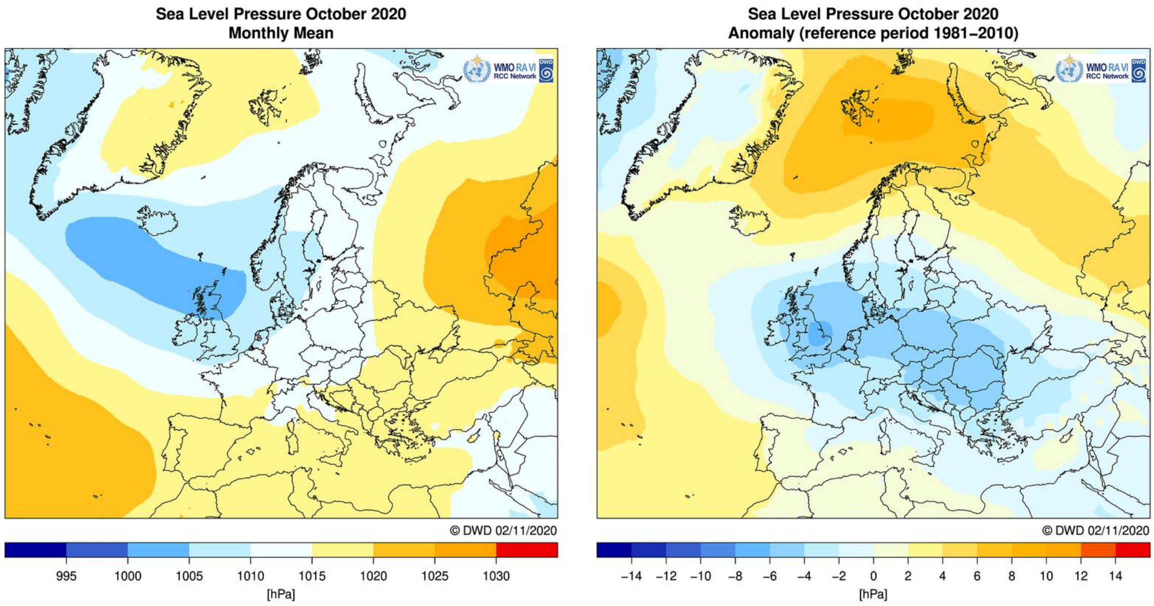


Figure 2.5: Mean sea level pressure over the North Atlantic, Europe and North Africa and 1981-2010 anomalies for October 2020. Source: DWD, https://www.dwd.de/DE/leistungen/rcccm/int/rcccm_int_ppp.html?nn=490674

2.6 Circulation patterns

Most dominating patterns for Europe in October 2020 were a negative East Atlantic – West Russia (EATL/WRUS-) pattern, a positive Scandinavia pattern (SCAND+) and a negative Polar-Eurasia pattern (POLEUR-). The zonal patterns NAO and EA were not significant.

EATL/WRUS- is displayed by a negative geopotential anomaly over Western Europe and the East Atlantic, and a positive anomaly over west Russia. Since the East European anticyclonic anomaly also extended to Scandinavia, a SCAND+ pattern was active. POLEUR- points to anticyclonic anomalies in the Arctic region, which means a weaker-than-normal polar vortex.

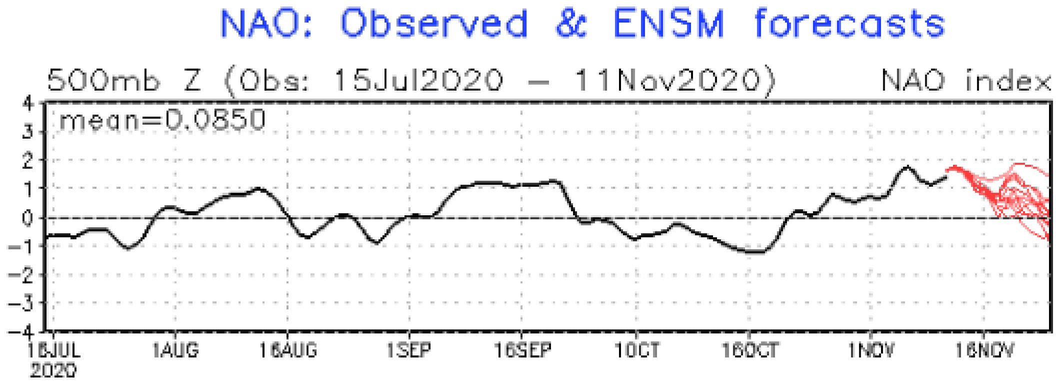
MONTH	NAO	EA	WP	EP-NP	PNA	TNH	EATL/WRUS	SCAND	POLEUR
OCT 20	-0.2	-0.2	-1.2	0.6	-1.1	---	-1.8	1.5	-1.0
SEP 20	1.1	1.9	-2.4	0.1	0.6	---	-0.9	-0.5	0.3
AUG 20	0.0	1.6	-0.2	-2.4	1.8	---	0.6	-1.6	-0.5
JUL 20	-1.2	0.5	-0.5	-2.0	1.2	---	-0.7	-2.3	-0.1
JUN 20	0.2	-0.1	-1.2	-0.7	0.9	---	-2.0	0.6	-0.2
MAY 20	-0.3	0.1	0.1	0.0	0.3	---	-0.5	-2.4	-1.1
APR 20	-1.3	0.6	-1.3	1.5	-1.4	---	1.8	-1.5	0.4
MAR 20	0.7	-0.1	1.3	0.4	-2.4	---	0.6	-0.9	1.7
FEB 20	1.0	1.4	1.5	-1.8	-0.1	1.7	-0.1	-2.7	-0.4
JAN 20	1.1	1.7	0.7	-0.6	-1.0	-0.9	0.7	-0.5	0.2
DEC 19	1.0	0.8	0.7	---	-0.1	-0.2	0.1	0.8	-0.4
NOV 19	0.2	0.1	-0.1	1.9	-0.1	---	-0.6	1.5	1.0
OCT 19	-1.0	0.7	-0.8	-0.5	-1.0	---	-0.5	0.2	-0.2
SEP 19	0.0	2.2	0.9	-1.5	1.6	---	0.8	-0.5	-0.1

Table 2.1: Evolution of the main atmospheric indices for the Northern Hemisphere for the last months:
http://www.cpc.ncep.noaa.gov/products/CDB/Extratropics/table3.shtml

North Atlantic Oscillation and Arctic Oscillation

NAO was in a negative phase most of the month of October 2020. In the last week of the month, NAO switched to a positive phase, which still persisted in November and intensified. Forecasts of the ENSM model of NOAA CPC for the next two weeks show a large ensemble spread, which implies much uncertainty, but most of them tend to a weakening of NAO until end of November 2020.

AO shows a rather similar development like NAO, also with an intensifying positive phase in November and again with high uncertainty in the forecasts for the next two weeks.



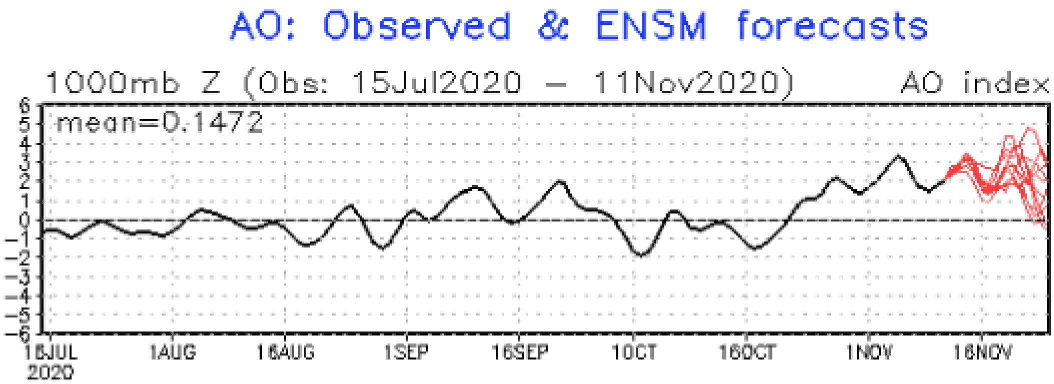


Figure 2.6: North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) indices. Source: NOAA CPC, https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml

Weather types

According to the Météo France weather type classification, there was a higher-than-normal frequency of Atlantic ridge and NAO+ types in September and October 2020. Both is typical for a central equatorial Pacific La Niña, which was active that time. Especially the number of days with NAO+ types increased from August to October 2020 steadily up to a number of 14 days (almost half of the month), which was very consistent to the development of La Niña. Blocking types were still the most frequent types in August and September, and even more frequent than Atlantic ridge types in October, but the frequency of blocking types decreased since August and was below normal in October.

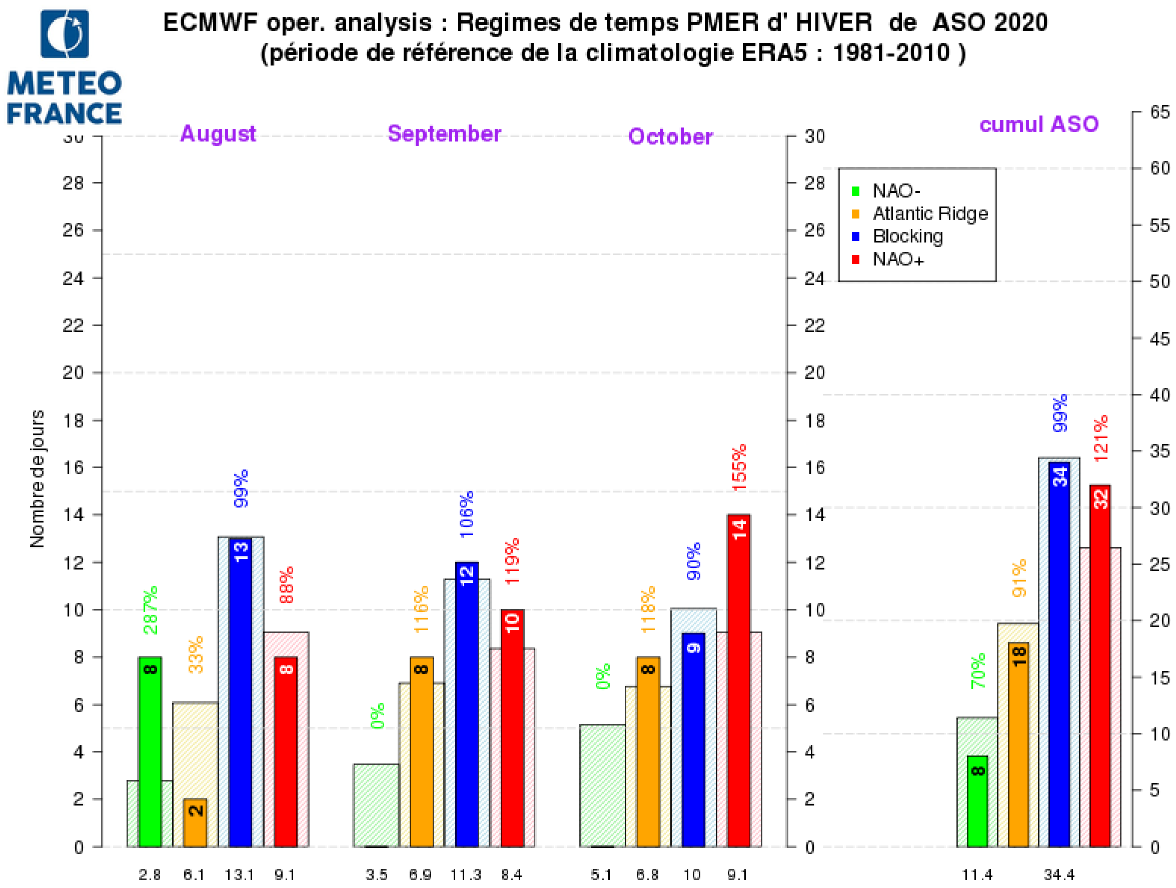


Figure 2.7: Distribution of weather types of the Météo France classification (winter regime) for August-October 2020. Percentage values refer to 1981-2010 normals. Source: Météo France, http://seasonal.meteo.fr/en/content/suivi-clim-regimes-trim

3 Snow cover

Snow cover in Europe was more frequent than normal in Scandinavia and northern European Russia in October 2020, but less in central European Russia, which means that snow extended less southward than usual.

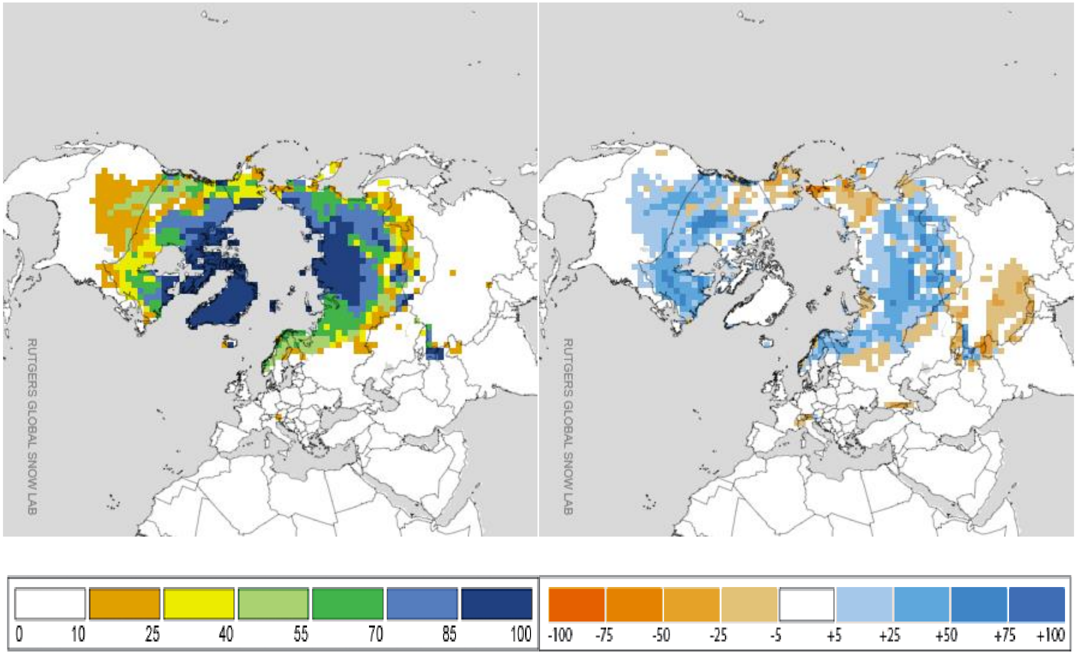


Fig. 3.1: Left: Monthly snow cover in October 2020 (percent of days snow covered). Right: 1981-2010 anomalies (percent difference from 1981-2010 mean). Source: Rutgers University Global Snow Lab, https://climate.rutgers.edu/snowcover

When Eurasian snow cover is above normal in October, than NAO- might be enhanced. This seems not to be the case this year.

4 Temperature

Europe/RA VI

According to Copernicus data, October 2020 was +1.6°C warmer than on 1981-2010 average (Fig. 4.1). It was the warmest October in the period from 1979 onwards. Based on NOAA data, the warming trend for October months 1979-2019 (data for 2020 are not available yet) is +0.33°C/decade for Europe. (https://www.ncdc.noaa.gov/cag/global/time-series/europe/land/1/10/1880-2020?trend=true&trend_base=10&begtrendyear=1979&endtrendyear=2020)

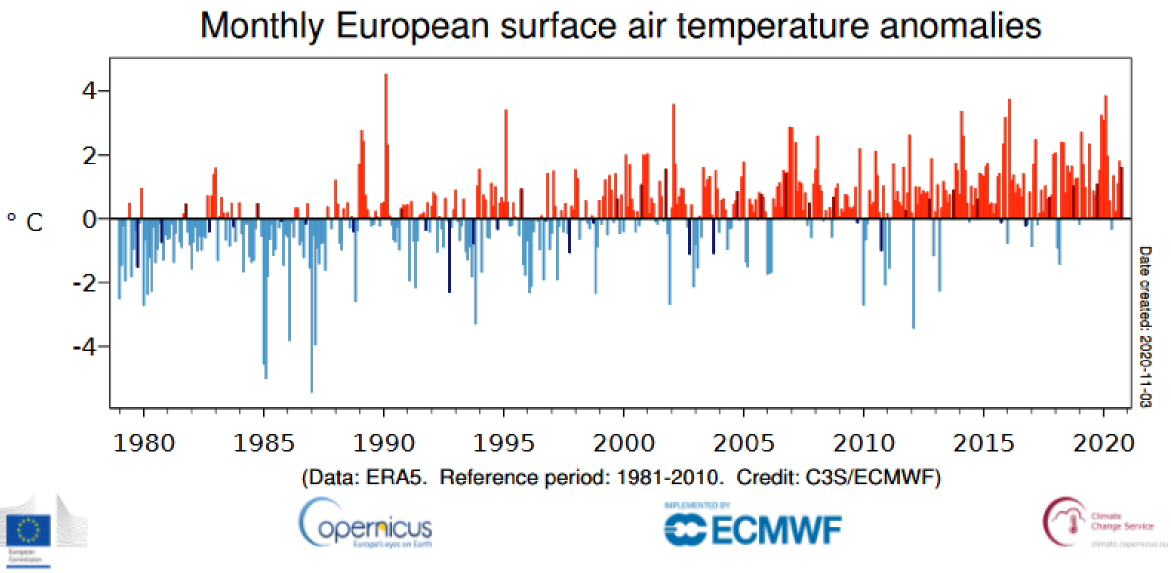


Fig. 4.1: Monthly European-mean surface air temperature anomalies relative to 1981-2010, from January 1979 to October 2020. The darker coloured bars denote the October values. Data source: ERA5. Credit: Copernicus Climate Change Service/ECMWF, https://climate.copernicus.eu/surface-air-temperature-october-2020

Although October 2020 was very warm on European average, the spatial distribution of anomalies was very uneven this month (Fig. 4.2). The eastern parts of the domain, from the Ukraine to the Middle East were at least +1°C warmer than normal, locally up to +6°C in Turkey. In contrast, the western parts (France, Iberia, Italy and western Mediterranean) were colder than normal, partly with anomalies colder than -1°C.

Monthly mean temperatures in the lowlands ranged from around +12°C in the northern Ukraine to around 25°C in parts of the Middle East. In higher elevations, mean temperatures were mostly between 5 and 10°C, in the Alps below.

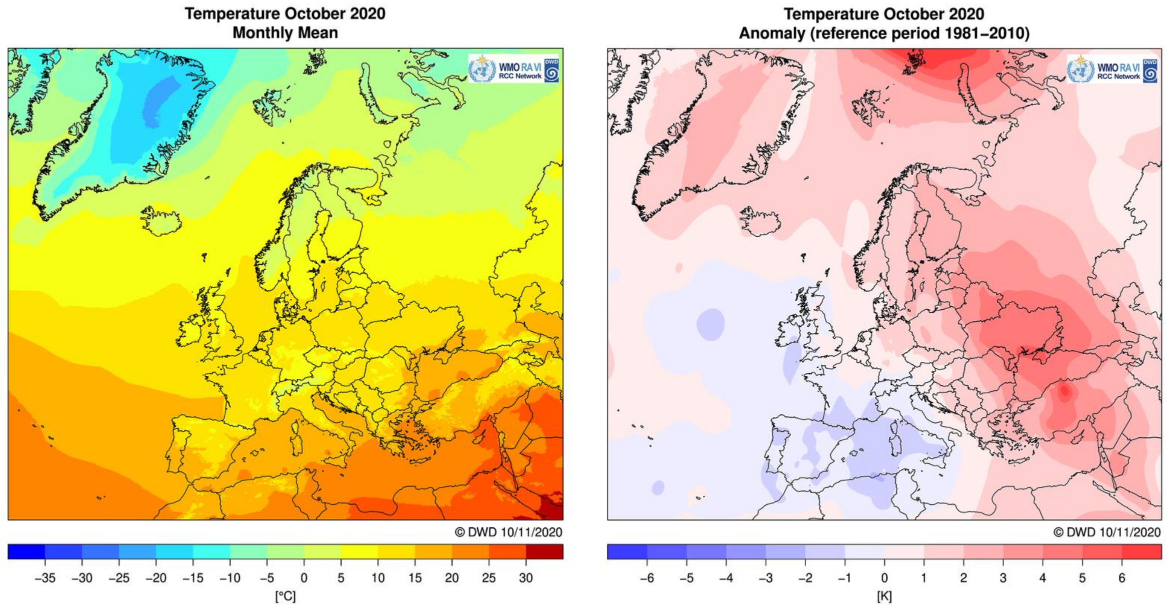


Fig. 4.2: Mean temperature (left) and anomalies (1981-2010 reference, right) in °C in the RA VI Region (Europe) interpolated from CLIMAT station data, for October 2020. Source: DWD,
http://www.dwd.de/EN/ourservices/rcccm/int/rcccm_int_ttt.html

In terms of terciles (Fig. 4.3), western parts of the domain (Iberia, southern half of France, Italy and the western Mediterranean) had temperatures mainly in the lower tercile in October 2020, only the northern half of France, partly the Baleares, eastern parts of Italy and parts of the western Balkans had temperatures in the middle tercile. The entire eastern part of the domain from central Balkans eastward had temperatures in the upper tercile.

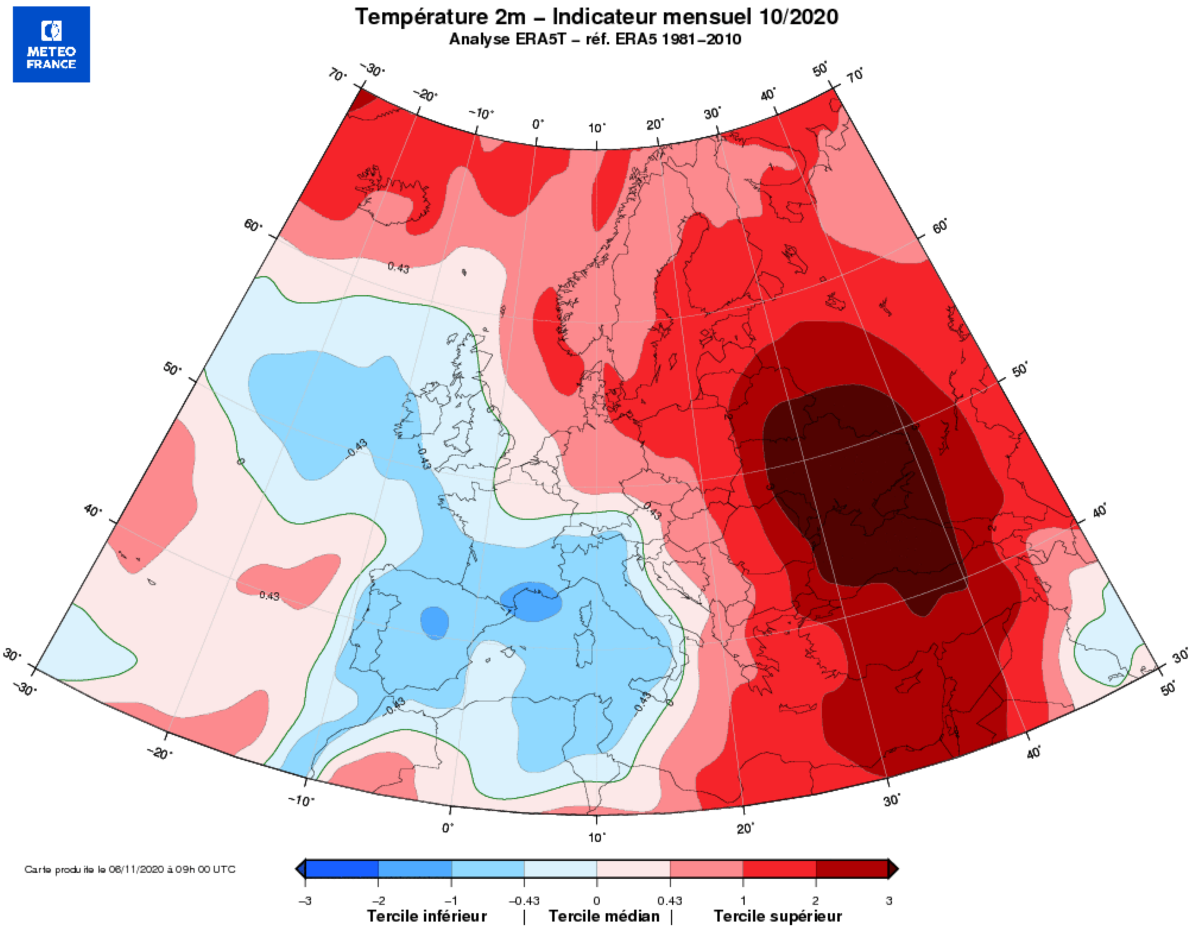


Fig. 4.3: Mean standardized temperature anomalies with terciles for October 2020. Source : Météo France, http://seasonal.meteo.fr/content/suivi-clim-cartes-ERA5 , data source : ERA5, ERA5T

North Africa

The graph in Fig. 4.4 shows the monthly trend of air temperature anomalies in degrees Celsius of October since 1979 through 2020. For each year, the positive anomaly is indicated by the red vertical bars and the negative anomaly is indicated by the blue vertical bars. The black line tracks the changes in the trend over time.

October 2020 was the warmest one since 1979, the land mean temperature of the region was above the normal 1981-2010; the anomaly reached +1.6 °C. The warming rate was about +0.42°C per decade.

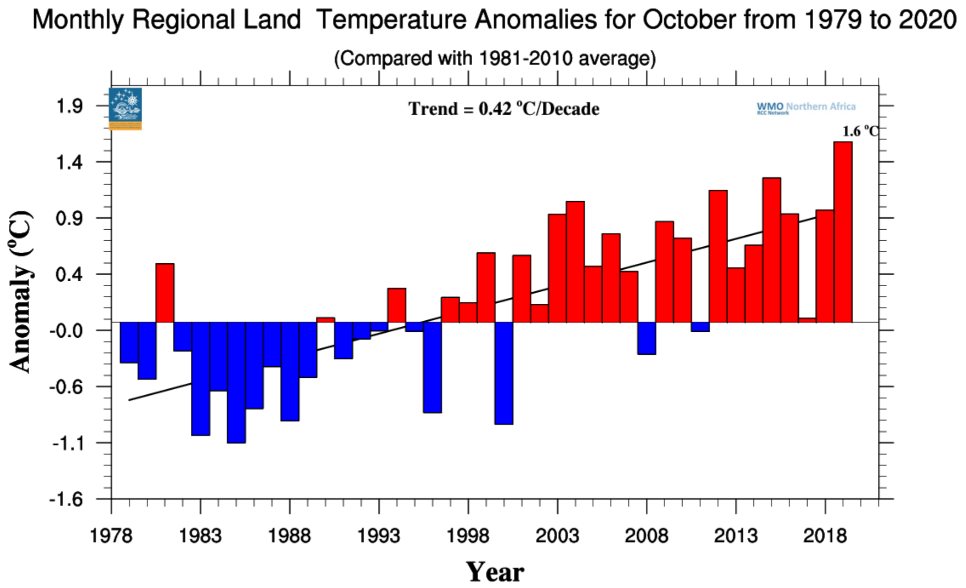


Figure 4.4: Monthly anomaly of mean temperature (October 2020), time series plot with trend line, Source: INM

Monthly mean temperature in October 2020 mostly ranged from 12°C to 30 °C, in small parts reaching 8°C, especially in the centre of Morocco and in the northeast of Algeria. In some parts of southern Algeria and in the southeast of Egypt, the mean temperature was above 30°C (Fig. 4.5 left).

Compared to 1981-2010 reference, temperature anomalies were mostly above normal. They were in a range between +1 and +3°C in the centre of Morocco, the Algerian Sahara, most part of Libya and Egypt, locally between +3 and +4 °C in the eastern centre of Algeria and the centre of Egypt. Temperature anomalies were below normal and mostly ranged between 0 and -1°C in almost all of Tunisia, the north and the southwest of Algeria, northern and southern regions of Morocco, and locally in the north of Libya, between -1 and -2°C in the north of Tunisia, locally in a small zone in the Algerian coastal region, and in the extreme south of Morocco (Fig. 4.5 right).

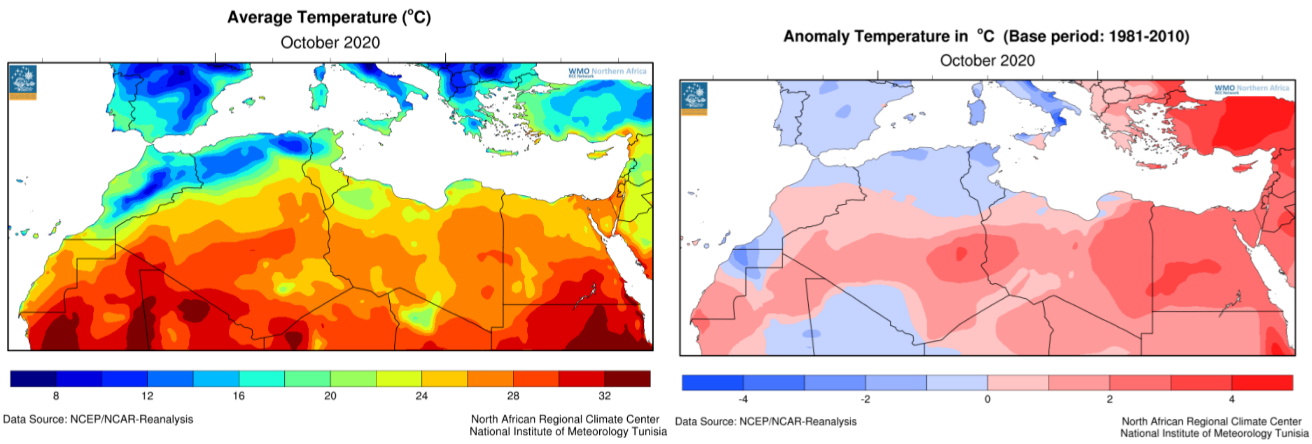


Figure 4.5: Left: Mean temperature; Right: Absolute anomalies of temperature in the RAI-NA Region (North Africa) Data from NCDC (National Climate Data Centre NOAA – reference 1981-2010),

https://www.meteo.tn/en/climate-monitoring-watch

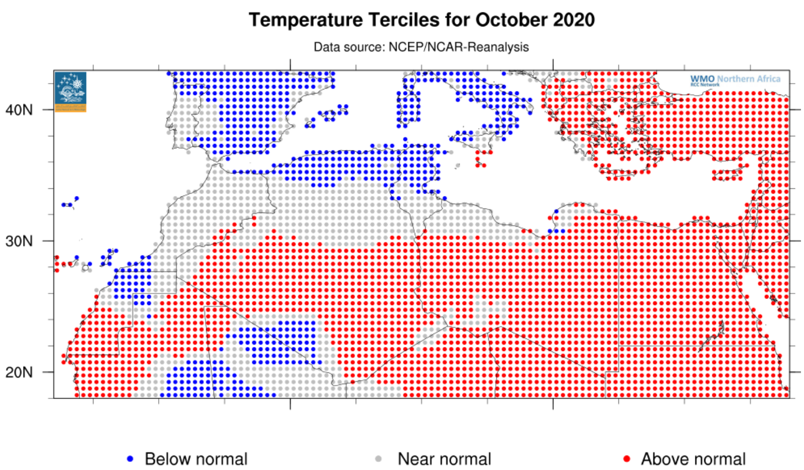


Figure 4.6: Tercile distribution for temperature of JJA 2020, 1981-2010 reference. Source: INM, Data from NCEP/NCAR reanalysis, http://www.esrl.noaa.gov

According to the tercile map (Fig. 4.6), the temperature anomalies were in the lower tercile over the north and the center of Tunisia, the north and the extreme south of Algeria and over the extreme south of Morocco. Over the most part of Morocco, the northern Algerian Sahara and the northwest of Libya the temperature anomaly was in the normal tercile, over the remaining regions the temperature was in the upper tercile.

5 Precipitation

Europe/RA VI

Precipitation in October 2020 showed a large contrast between west and east of the domain (Fig. 5.1). Western parts from western Iberia to the western Balkans had monthly totals mostly above 100mm, locally more than 200mm. Towards the east and the south, totals were much lower, down to zero in the seasonally dry areas of the Middle East.

Precipitation was above normal in a large area from western Iberia to the western Balkans, locally more than 250% of the normal. Easternmost parts of the domain and the western Mediterranean had below-normal precipitation, partly less than 20% of the normal.

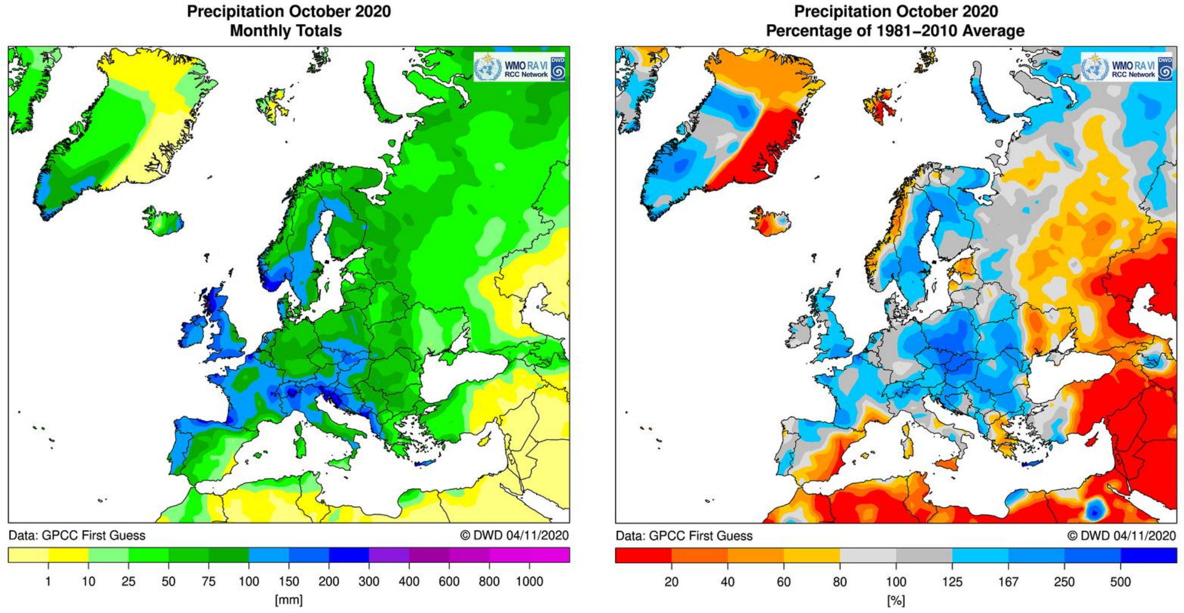


Fig. 5.1: Monthly precipitation totals (left) and percentage of 1981-2010 normal (right) for October 2020 in Europe/RAVI. Data from GPCC (First Guess version). Source: DWD, http://www.dwd.de/EN/ourservices/rcccm/int/rcccm_int_rrr.html

In terms of terciles (Fig. 5.2), precipitation totals were in the upper tercile in most of the northern parts of the domain from France to the western Ukraine. Large parts of the western Mediterranean and eastern parts of the domain from the eastern Ukraine and Georgia to Cyprus-Lebanon-Syria had precipitation in the lower tercile. The rest of the domain had precipitation in the middle tercile, particularly much of Iberia, southern France, Italy, parts of Greece and western Turkey.

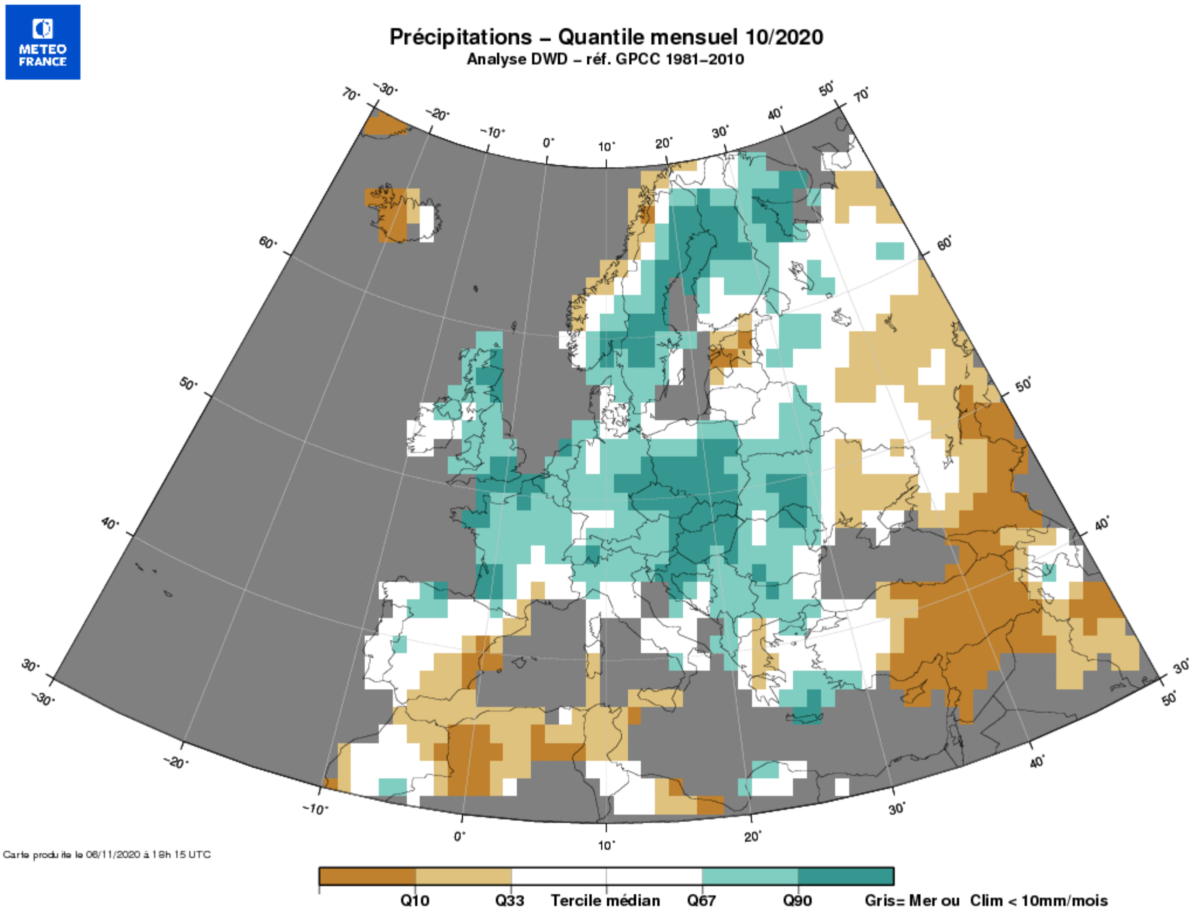


Fig. 5.2: Quantiles of monthly precipitation totals for October 2020. Source : Météo France, http://seasonal.meteo.fr/content/suivi-clim-cartes-ERA5 , data source : GPCC

North Africa

Monthly precipitation totals in October 2020 in the North African domain were mostly below 20 mm. Over the centre of Morocco, the extreme coastal zone of Algeria and north of Tunisia, rainfall amounts exceeding 40 mm were registered (Fig. 5.3 left).

Anomalies (1981-2010 reference) were mostly below normal during this month of the year with less than 20% of the normal. Over the centre and the south of Egypt and southeastern Libya, anomalies were near normal. These regions received between 75% and 125% of the normal. Locally in the extreme south of Algeria, the precipitation anomalies were above normal (Fig. 5.3 right).

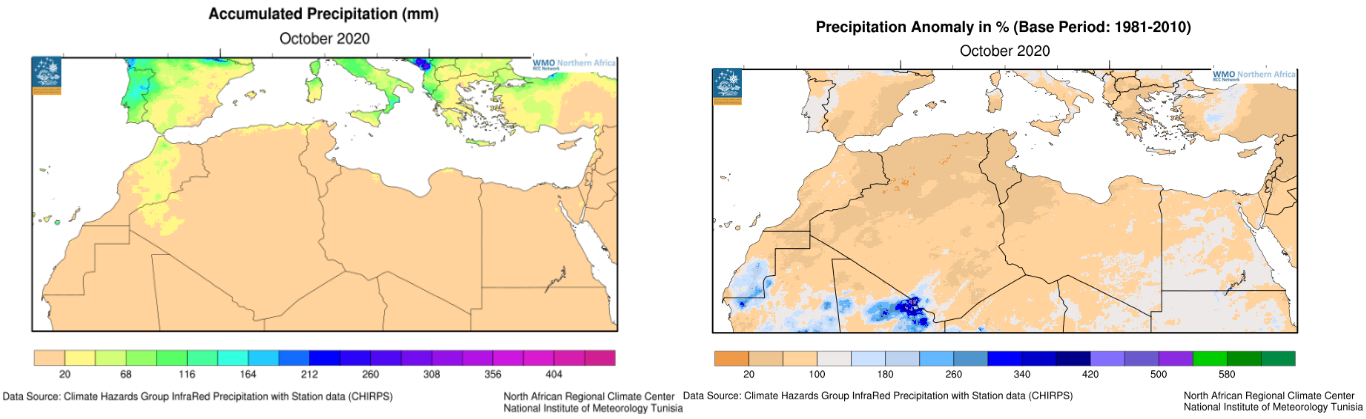


Figure 5.3: Left: Total precipitation; Right: Relative anomalies of precipitation in the RAI-NA Region (North Africa). Data from NCDC (National Climate Data Centre NOAA – reference 1981-2010).
https://www.meteo.tn/en/climate-monitoring-watch

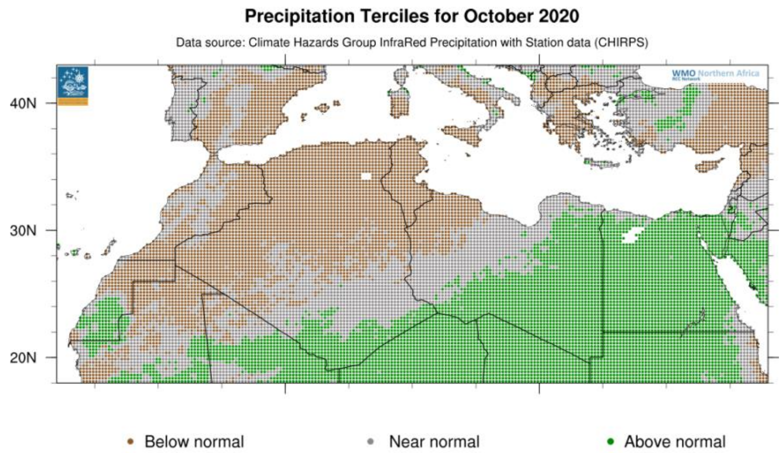


Figure 5.4: Terciles for precipitation (Reference period 1981-2010).

Source: INM, Data from CHIRPS: ftp://ftp.chc.ucsb.edu/

According to the tercile map, the precipitation anomalies were in the upper tercile over almost all of Egypt, the northeastern and the southern regions of Libya and over the extreme south of Algeria. Elsewhere the precipitation anomaly was mostly below normal (fig. 5.4).

6 Soil moisture

Europe/RA VI

Soil moisture in the upper 7cm was below normal in eastern parts of the domain in the eastern Ukraine, the South Caucasus region, Turkey, the Middle East and northern Greece, and in much of Iberia except the north. The rest of the domain had above-normal soil moisture.

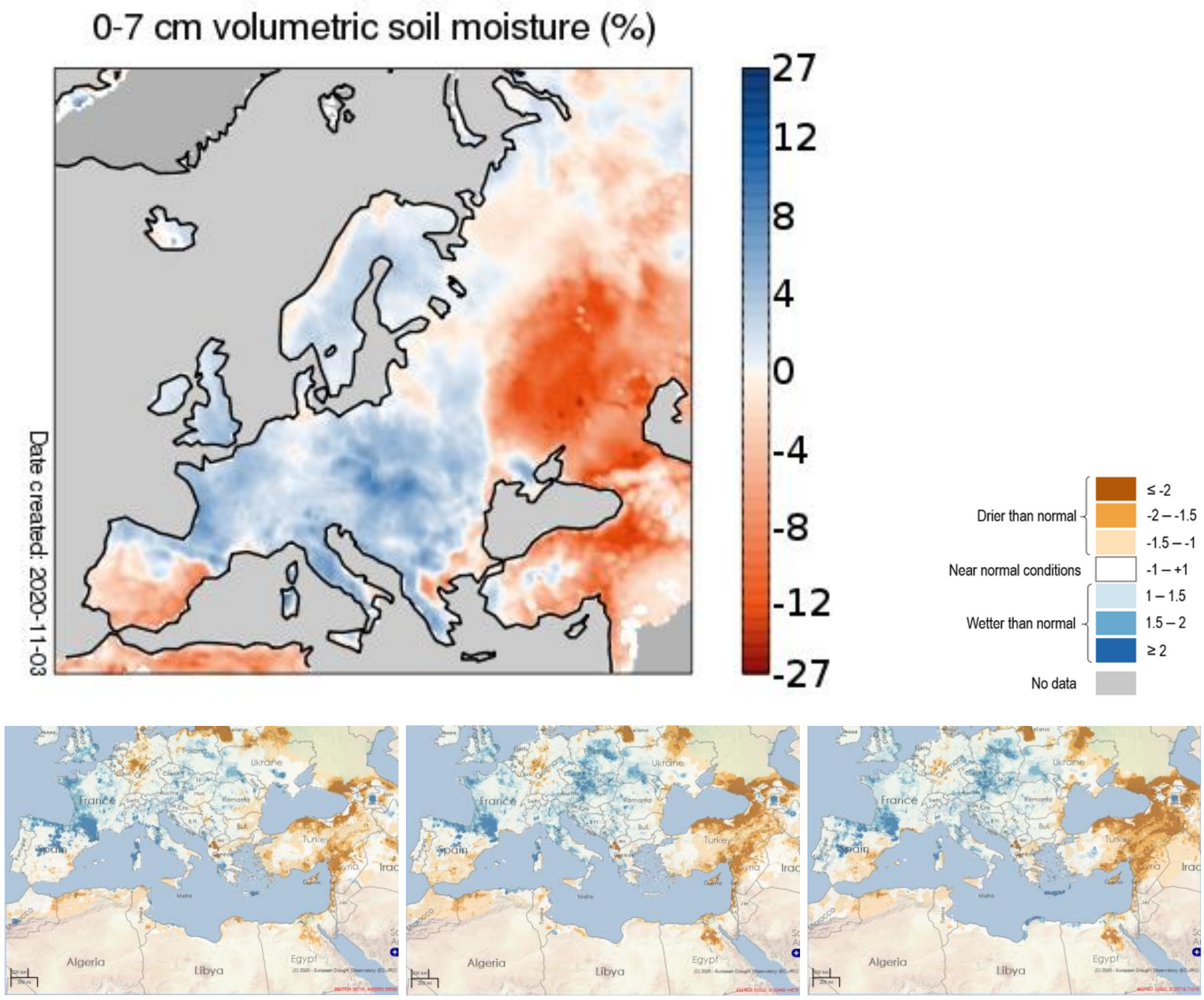


Figure 6.1: October 2020 soil moisture. Upper left: anomalies in % of the 1981-2020 normal, source: Copernicus, https://climate.copernicus.eu/precipitation-relative-humidity-and-soil-moisture-october-2020 . Lower maps: anomalies of the Soil Moisture Index as defined by the color scale on the upper right, 1995-2019 reference, source: European Drought Observatory (EDO), https://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1111

North Africa

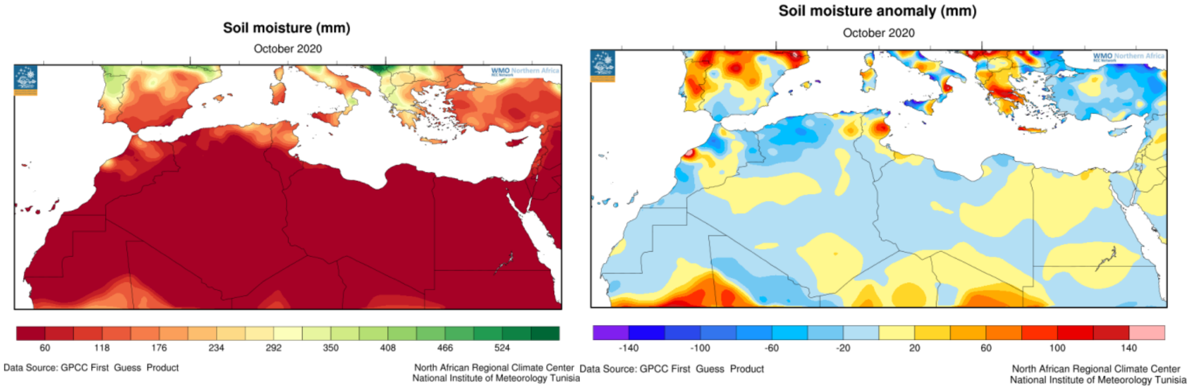


Figure 6.2: October 2020 soil moisture, left: monthly total, right: monthly anomalies, reference period: 1981-2010. Source: INM, data source: GPCC

In October 2020, soil moisture anomalies were near normal over the most parts of the domain. Over the north of Algeria and the northwest of Morocco, the anomalies were below normal. In the central east of Tunisia and the central west of Morocco, the soil moisture was above normal.

7 Arctic Sea Ice

Over the last 12 months, an extremely warm anomaly had been detected especially over Siberia.

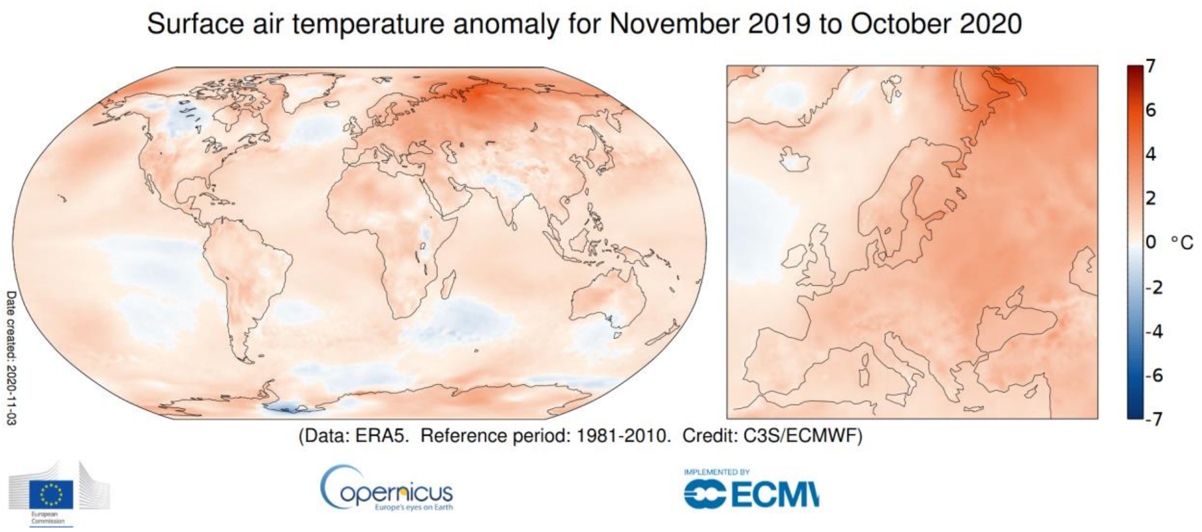


Fig. 7.1: Surface air temperature anomaly for November 2019 to October 2020 relative to the average for 1981-2010. Data source: ERA5. Credit: Copernicus Climate Change Service/ECMWF, https://climate.copernicus.eu/surface-air-temperature-october-2020#ebe2a2ad-5e92-4f53-a110-660910894acd

The warmth over Siberia led to a very low sea ice extent over the recent months. October 2020 had the lowest sea ice extent of all October months since at least 1979.

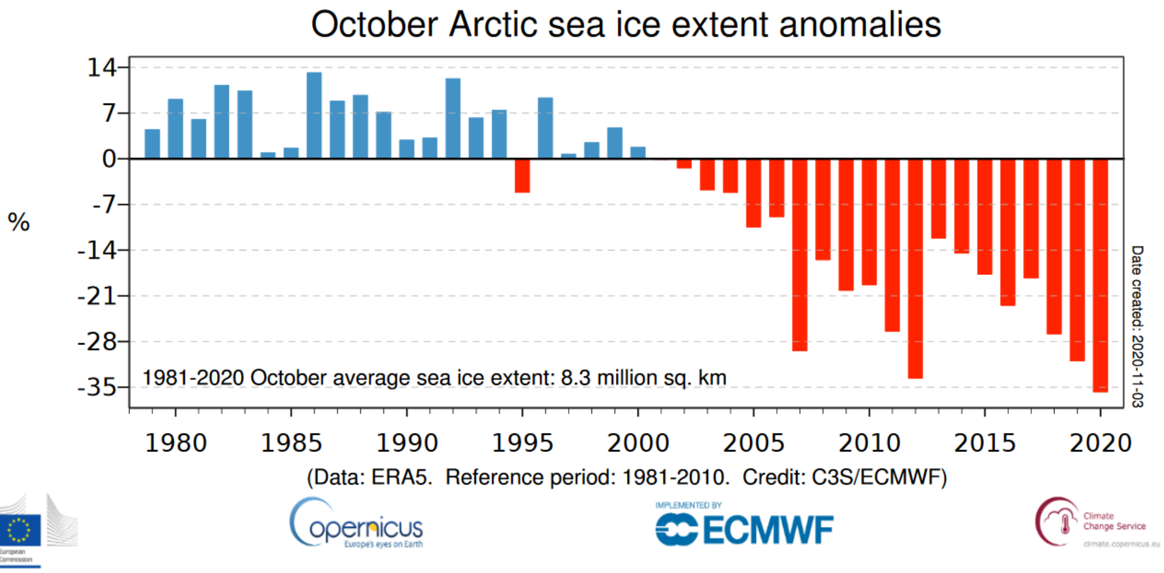


Fig. 7.2: Time series of monthly mean Arctic sea ice extent anomalies for all October months from 1979 to 2020. The anomalies are expressed as a percentage of the October average for the period 1981-2010. Data source: ERA5. Credit: Copernicus Climate Change Service/ECMWF, https://climate.copernicus.eu/sea-ice-cover-october-2020

The sea ice extent had especially a strong negative anomaly in the neighbor region of Siberia.

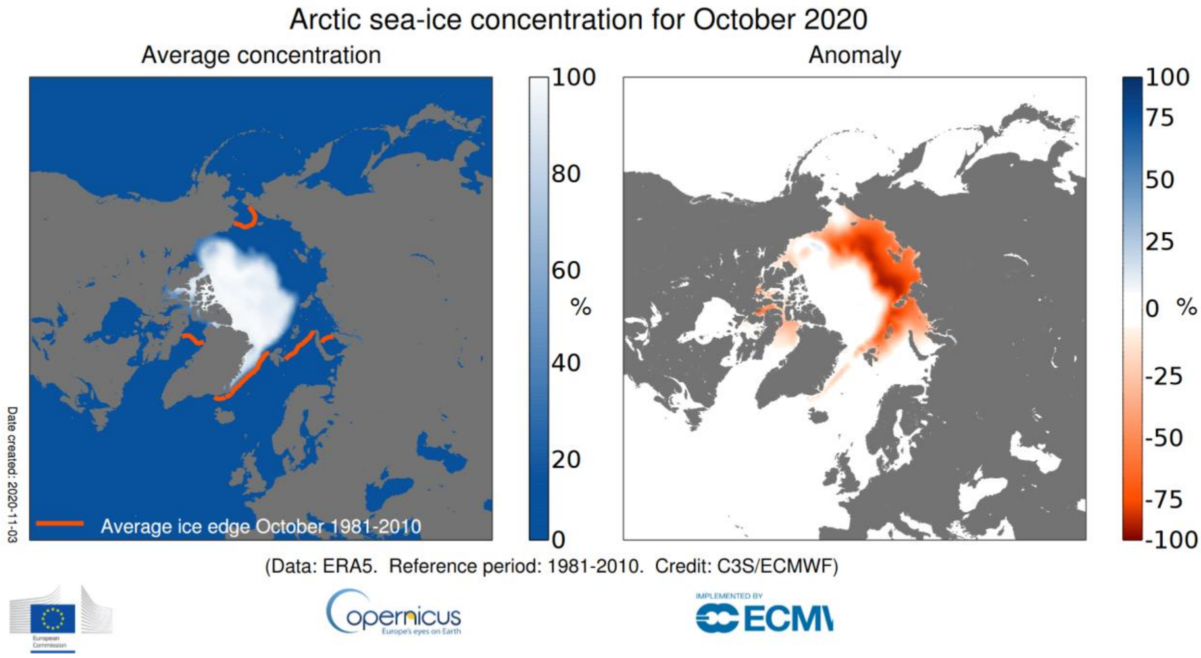


Fig. 7.3: Left: Average Arctic sea ice concentration for October 2020. The thick orange line denotes the climatological sea ice edge for October for the period 1981-2010. Right: Arctic sea ice concentration anomalies for October 2020 relative to the October average for the period 1981-2010. Data source: ERA5. Credit: Copernicus Climate Change Service/ECMWF, https://climate.copernicus.eu/sea-ice-cover-october-2020

A lower sea ice concentration causes an Arctic warming due to a lower albedo, and thus a decrease of the temperature difference between the Arctic and the middle latitudes. This can cause a weakening of the polar jetstream, see e.g. https://www.severe-weather.eu/news/arctic-ocean-sea-ice-2020-jet-stream-effect-winter-fa/ . The weakening of the jetstream leads to a higher frequency of meridional weather types, which would be contrasting to the higher NAO+ frequency observed up to now and expected from the central Pacific La Niña.

References:

Météo France monthly and seasonal climate monitoring maps: http://seasonal.meteo.fr

WMO RA I RCC Node on Climate Monitoring Website with monitoring results: https://www.meteo.tn/en/climate-monitoring-watch

WMO RA VI RCC Node on Climate Monitoring Website with monitoring results: http://www.dwd.de/rcc-cm

GPCC: http://gpcc.dwd.de

Copernicus Climate Change Service: https://climate.copernicus.eu

NOAA National Climate Data Center: https://www.ncdc.noaa.gov

NOAA National Centers of Environmental Prediction (NCEP): https://www.ncep.noaa.gov/

Rutgers University: https://climate.rutgers.edu

Deutscher Wetterdienst (DWD), Germany: https://www.dwd.de

EU Joint Research Centre: http://edo.jrc.ec.europa.eu

Australian Government – Bureau of Meteorology: http://www.bom.gov.au

Ding, S., W. Chen, J. Feng, and H. Graf, 2017: Combined Impacts of PDO and Two Types of La Niña on Climate Anomalies in Europe. *J. Climate*, **30**, 3253–3278, https://doi.org/10.1175/JCLI-D-16-0376.1.