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WMO RA VI
RCC-Network



MEDITERRANEAN CLIMATE OUTLOOK FORUM MEDCOF-21 Online Forum

ANALYSIS AND VERIFICATION OF THE MEDCOF-20 CLIMATE OUTLOOK FOR THE 2023 SUMMER SEASON FOR THE MEDITERRANEAN REGION (MED)

First draft version

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The following MedCOF verification report is based on

- the outcome of the consensus forecast of MedCOF-20,
- climate monitoring results of RA I NA RCC and RA VI RCC networks,
- the verification bulletin of Météo France,
- the analysis and verification report of SEECOF-30 for 2023 summer season for southeast Europe (SEE)
- national verification reports received from NMHSs or posted in RCOF forums of MedCOF, SEECOF or PRESANORD.

1 MedCOF-20 Climate outlook for the 2023 summer season

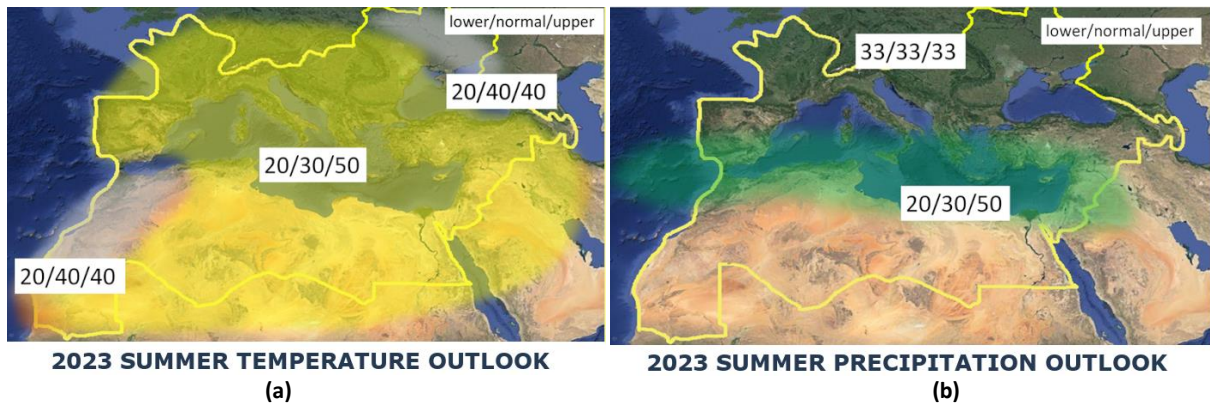


Figure 1: Graphical presentation of the climate outlook for the 2023 summer season for the Mediterranean region
(a) Temperature Outlook, (b) Precipitation Outlook

Sea surface temperature and general circulation

As stated in the MedCOF-20 consensus statement, observed sea surface temperatures and the forecast for the following three months June-August 2023 showed above-normal temperatures on the Tropical Pacific evolving towards a moderate El Niño event. Over the Indian Ocean, a positive phase of the Indian Ocean dipole (IOD) was observed. However, models did not agree on showing a teleconnection towards the MedCOF domain. Above-normal sea surface temperature anomalies over the Tropical and Eastern North Atlantic were suggested to continue. In the atmosphere, models tended to show more frequency of high latitude blocking, with zonal regimes less favored. Below-normal pressures were shown by most models, although there were spatial differences in the position of the main anomaly patterns.

Temperature

With this general context, above-normal temperatures were expected over most of the domain, with the exception of Northwestern Africa and the northeastern part of the MedCOF domain, where normal to above temperatures were expected. The warm signal seemed more intense over the rest of Northern Africa, Mediterranean Sea and parts of the Middle East. (Fig. 1a).

Precipitation

Precipitation forecasts showed a wet signal over most of the Mediterranean Sea. Although summer is climatologically very dry over Northern Africa, models showed a wet signal also over North Africa, so some precipitation events could be expected over mountain areas of northern Morocco, Algeria and Tunisia. The climatological forecast (33, 33, 33) over the southern part of the domain also takes into account that no meaningful forecast can be provided for these seasonally dry areas.

2 Analysis of the 2023 summer season

Analysis of the summer season temperature and precipitation anomalies and general circulation are based on maps and monthly or seasonal bulletins on the climate in the WMO Region RA I – NA and RA VI for the summer 2023 (WMO RA I RCC Node on Climate Monitoring: <https://www.meteo.tn/en/climate-monitoring-watch>; WMO RA VI RCC Offenbach Node on Climate Monitoring: <http://www.dwd.de/rcc-cm>), contributions from Météo France (<http://seasonal.meteo.fr/>), Regional Climate Outlook Forums for Southeastern Europe (SEECOF-30, <http://www.seevccc.rs>) and North Africa (PRESANORD, <http://acmad.net/rcc/presanord.php>), and national verification reports from MedCOF participants.

2.1 General circulation

2.1.1. Ocean

Sea surface temperatures (SST) in the equatorial tropical Pacific and near the west coasts of South America were all above the 1991-2020 normal in boreal summer 2023, with highest anomalies in the east (Fig. 2). This implies that an El Niño event has evolved as expected. Furthermore, SST in the tropical and mid-latitude eastern North Atlantic was more than 1 °C warmer than normal as forecasted. The Mediterranean Sea and the Black Sea, too, were warmer than normal, especially the western part with anomalies over +1 °C like in the eastern North Atlantic, whereas eastern parts of the Mediterranean Sea and the Black Sea had lower anomalies. Over the Indian Ocean, an east-west gradient is clearly visible in Fig. 2, implying a positive IOD phase as expected.

Jun-Jul-Aug 2023

Tocn(°C) Anomaly vs 1991-2020

0.53

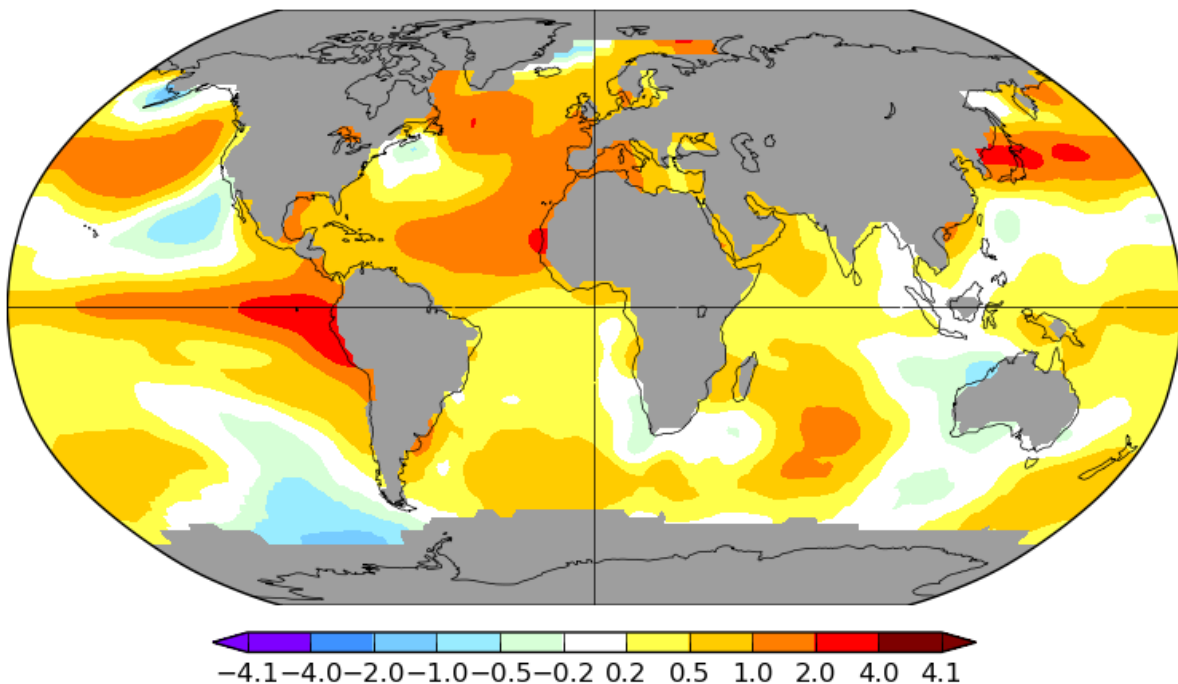


Figure 2: Sea surface temperature anomalies for boreal summer 2023 (June-August), 1991-2020 reference. Data from ERSSTv5 Ocean model analysis with 250km smoothing, source: NASA GISS, <https://data.giss.nasa.gov/gistemp/maps/>

When looking at the subsurface temperature anomalies in the central and eastern equatorial Pacific (Fig. 3), the development of El Niño can be seen. Water temperatures were well above normal in the eastern equatorial Pacific in the upper 100 m throughout boreal summer, and were increasing also in the central equatorial Pacific, first in the subsurface, later in the summer also near the sea surface.

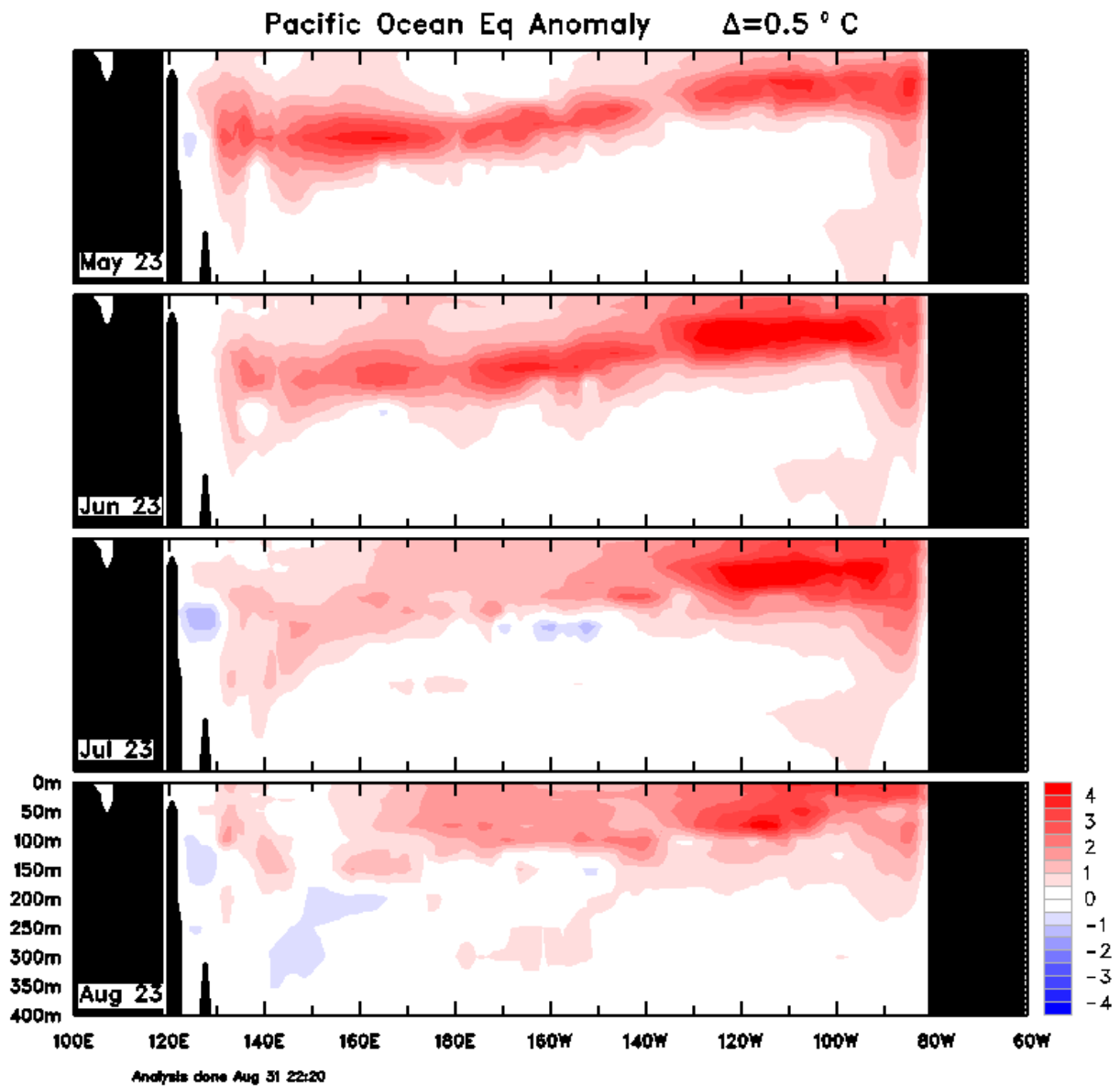


Figure 3: 4-month sequence of vertical temperature anomaly sections at the equatorial Pacific for May-August 2023. Source: Australian Government, Bureau of Meteorology (BOM), http://www.bom.gov.au/cgi-bin/oceanography/wrap_ocean_analysis.pl?id=IDYOC007&year=2023&month=08

Looking at the specific Niño regions (Tab. 1), SST was above normal (1971-2000 reference) throughout boreal summer 2023 in all regions. Anomalies exceeded the El Niño threshold of +0.5 °C in all regions and months. The Niño1+2 region, which is the easternmost, where El Niño occurs first, had the highest anomalies, the westernmost Niño4 region the lowest. Regarding the time evolution, August 2023 had the highest anomalies in all regions. This shows that El Niño was in an early development stage in summer 2023, turning from a light to a moderate El Niño event with tendency of further intensification.

YR	MON	NINO1+2	ANOM	NINO3	ANOM	NINO4	ANOM	NINO3.4	ANOM
2023	6	25.81	2.63	27.85	1.21	29.48	0.64	28.59	0.88
2023	7	25.05	3.21	27.47	1.59	29.50	0.71	28.37	1.07
2023	8	24.16	3.30	27.17	1.96	29.65	0.95	28.20	1.30

Table 1: Sea surface temperature and anomalies (in °C) for various Niño regions in boreal summer months 2023 (June-August), 1971-2000 reference. Data from ERSST.v5 ocean model analysis, source: NOAA, <https://www.ncdc.noaa.gov/teleconnections/ens/sst> with definitions of Niño regions, see also Fig. 4.

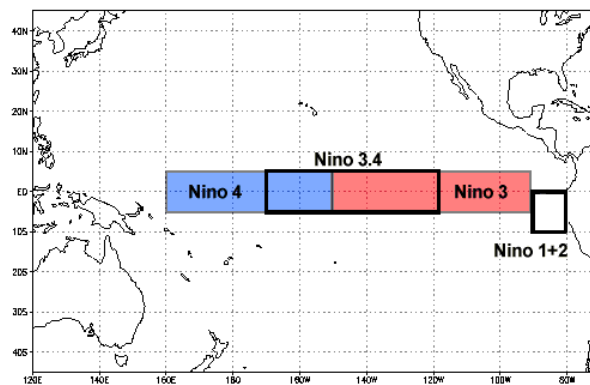


Figure 4: Niño regions. Source: NOAA NCEI, <https://www.ncei.noaa.gov/access/monitoring/ens/sst>

The Indian Ocean Dipole (IOD) index was neutral at the beginning of the month, but developed into a positive phase in August as expected (Fig. 5).

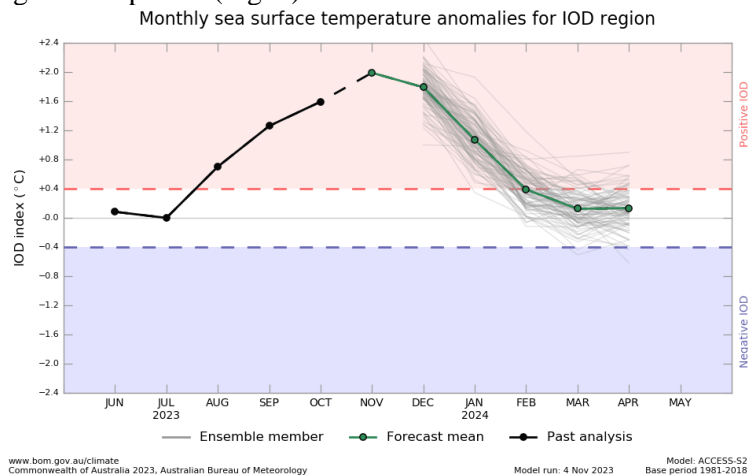


Figure 5: Monthly Indian Ocean Dipole (IOD) index. Source: Australian Government, Bureau of Meteorology (BOM), <http://www.bom.gov.au/climate/ens/sst/#tabs=Indian-Ocean>

2.1.2. Atmosphere

Seasonal anomalies of 500-hPa geopotential in summer 2023 (Fig. 6) show in fact a rather meridional circulation with a large blocking high over the southern half of Europe. In contrary to the outlook, the blocking was not so much over higher latitudes, but rather over the Mediterranean region directly.

ERA5 - Analysis
JJA 2023

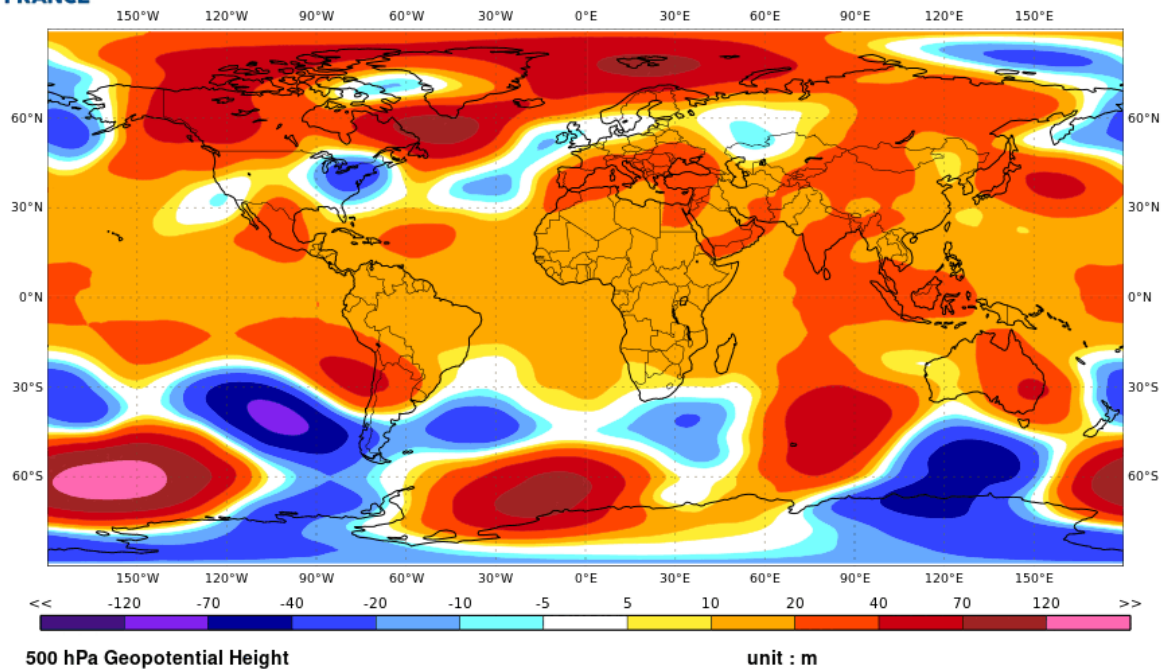


Figure 6: Seasonal anomalies of 500-hPa geopotential for summer 2023 (1993-2016 reference). Source: Météo France, data source: ECMWF, <http://seasonal.meteo.fr/content/suivi-clim-cartes-ref93-16?language=en>

Sea level pressure (SLP) anomalies (Fig. 7) show that the Azores High was weaker than normal on summer 2023 average. Slightly below-normal SLP, which was expected by the outlook, occurred mainly on most land surfaces of the RA VI part of the domain and over the western Mediterranean, but only partly over North Africa and less over the eastern Mediterranean.

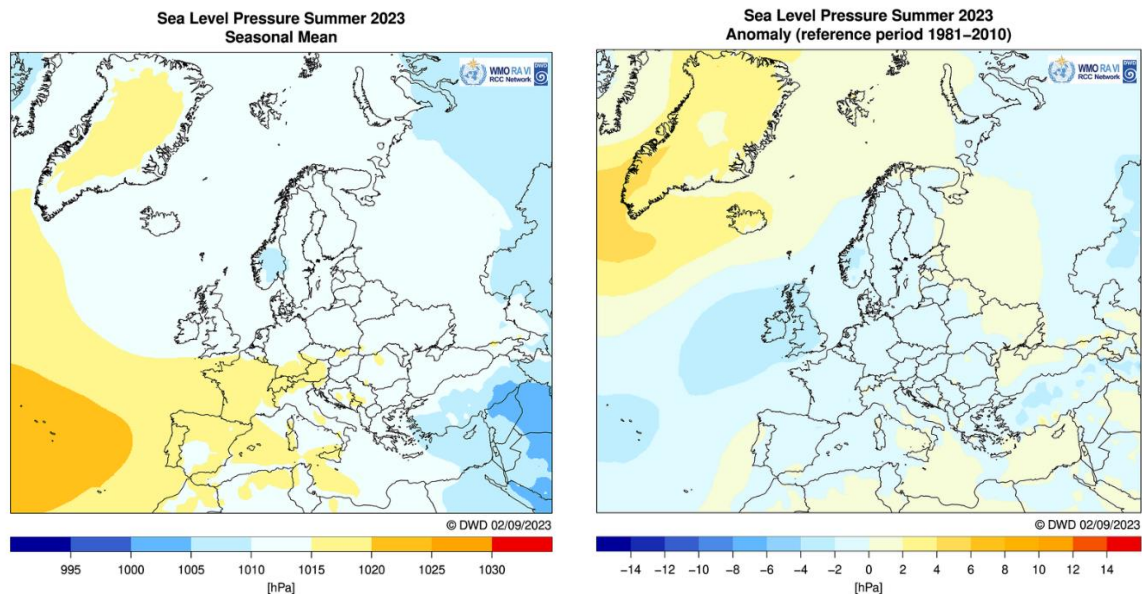


Figure 7: Seasonal mean sea level pressure and anomalies for summer 2023 (1981-2010 reference). Source: Deutscher Wetterdienst (DWD), data source: DWD numerical ICON model analysis. https://www.dwd.de/EN/ourservices/rccm/int/rccm_int_ppp.html

When looking at the 500-hPa geopotential maps for individual months (Fig. 8), it can be seen that the expected high-latitude blocking and the low pressure in the south occurred mainly in June 2023. In July 2023, however, the circulation changed to a completely anticyclonic situation over the MedCOF domain, which persisted partly also in August, though with some perturbations over the central Mediterranean. A similar development, though less pronounced for the Mediterranean region, can be seen on the monthly SLP maps (Fig. 9).

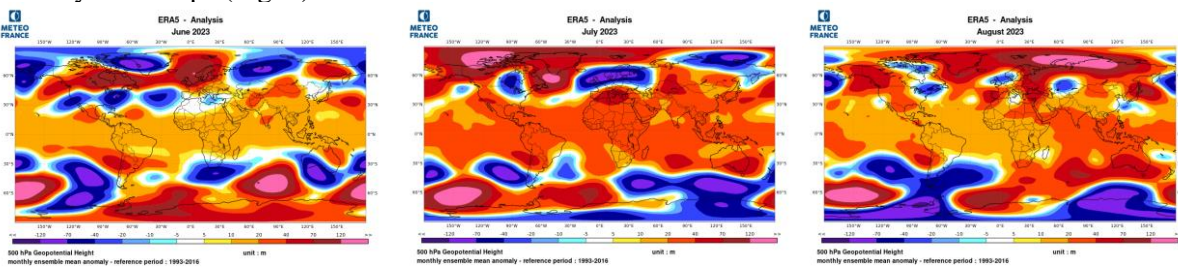
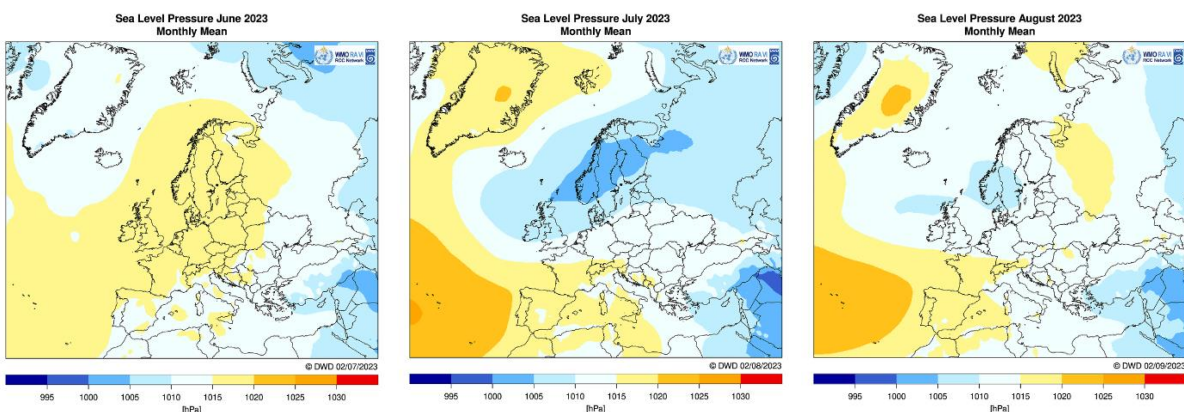


Figure 8: Same as Figure 6, but for the months June, July, and August 2023.



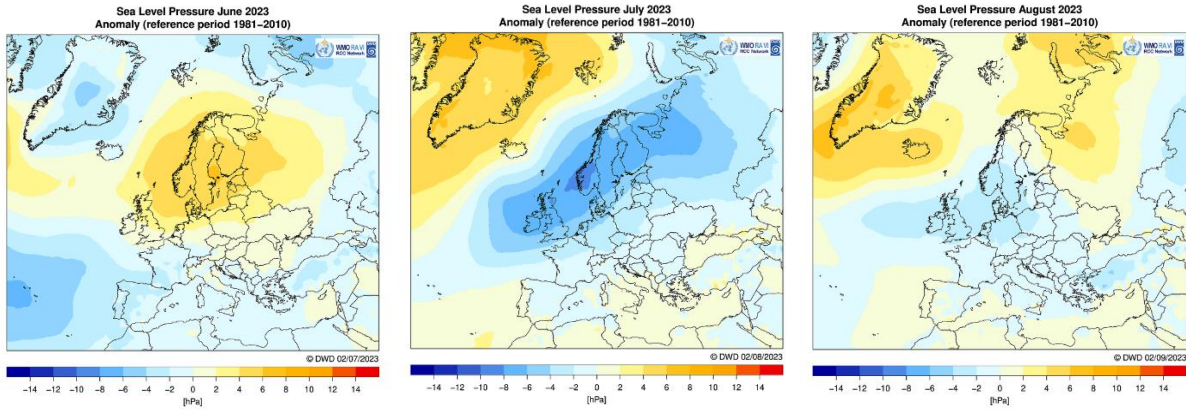


Figure 9: Same as Figure 7, but for the months June-August 2023.

According to the Météo France weather type classification, NAO- types (Greenland anticyclone) were the most frequent ones in summer 2023 (Fig. 10). They represent a meridional circulation with a kind of high latitude blocking. However, the “classical” summer blocking with a blocking high over Scandinavia occurred only on seven days in the whole summer season.

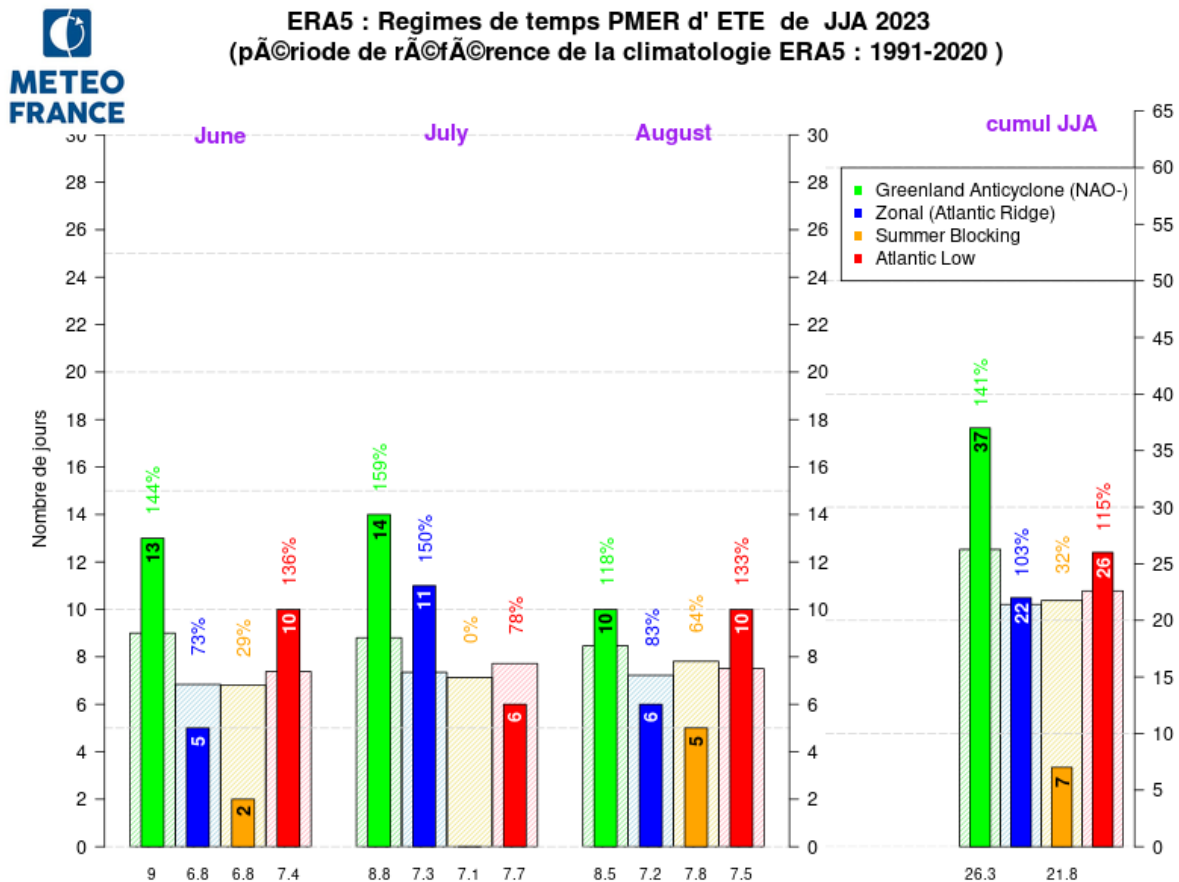


Figure 10: Number of days with circulation types of the Météo France classification for each month of the summer 2023 season and for the whole season (right), and in percent of the climatological frequency distribution 1991-2020. Source: Météo France, <http://seasonal.meteo.fr/content/suivi-clim-regimes-trim?language=en>

The NOAA CPC classification shows that quite different developments of individual circulation patterns took place during the season. While NAO was generally in a negative (meridional) phase, especially in July and August 2023, the EA pattern had a change from EA- in June to EA+ in July and August. The EA phase change stands for a significant change of circulation over Europe, switching to low pressure in the north and high pressure in the south. In addition, a negative East Atlantic West Russia (EA/WR) pattern came up in late summer, since the Russian High increased in intensity.

yyyy	mm	NAO	EA	WP	EP/NP	PNA	EA/WR	SCA	TNH	POL	PT	Ex.V
2023	6	-0.28	-1.12	0.33	-1.92	0.84	0.37	0.80	-99.90	0.18	-99.90	56.3
2023	7	-2.14	1.78	1.33	0.76	0.65	-1.83	-0.62	-99.90	0.04	-99.90	59.3
2023	8	-1.62	2.05	-0.37	-1.16	0.42	-2.35	-1.07	-99.90	-1.05	0.12	53.4

Table 2: Circulation indices of NOAA CPC patterns for the summer months 2022. ExV = explained variance in %. https://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh

2.2 Soil moisture

Due to widespread, partly abundant precipitation in some areas of the MedCOF domain in June 2023, soil moisture was mostly normal or above normal that month (Fig. 11). Only a few smaller areas had below-normal precipitation; most of them are located in the north of the domain (northeastern France, central Ukraine, Moldova). The other two months mostly had less precipitation, causing a drying of the wet areas closer to normal values. There were only a few exceptions, where much precipitation caused wet soils also in late summer, e.g. in Slovenia or the eastern Ukraine.

Dry soils can enhance warming due to missing evaporation, wet soils produce cooling as long as the air is not saturated. In summer 2023, soils have caused rather a cooling than a warming.



Figure 11: Soil moisture anomalies for the three summer months in 2023 (brown: below normal, blue: above normal, 1995-2022 reference). Source: European Drought Observatory (EDO), <https://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1111>

2.3 Temperature

Europe and Middle East (RA VI)

Temperature was higher than the 1991-2020 normal in almost the entire domain, except for a few places in southern Italy (Fig. 12). Anomalies in western parts of the domain (France, Portugal, Spain, western Mediterranean) were mostly between +1 °C and +2 °C. The other parts of the domain had mostly anomalies below +1 °C, only over some areas above.

Seasonal mean temperatures in the lowlands ranged from around 19°C in northwestern France and western Ukraine to around 32 °C in eastern Syria, in higher elevations mostly between 10 and 15 °C, partly higher.

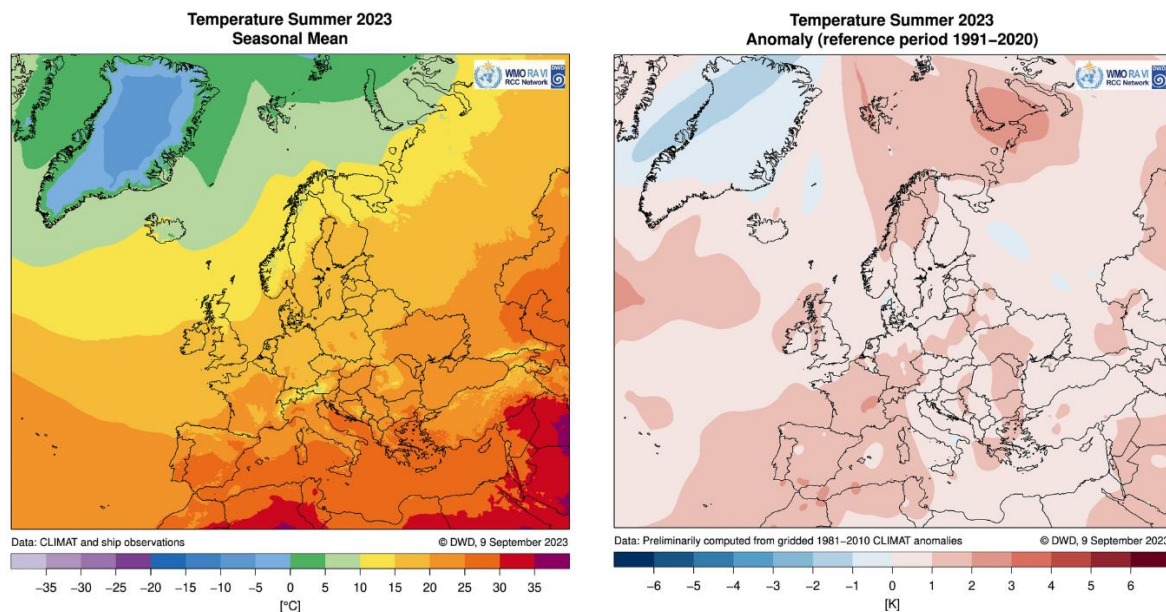


Figure 12: Surface air temperature for summer 2023. Left: seasonal mean, right: anomalies, 1991-2020 reference, source of both maps: WMO RAVI RCC, based on interpolated CLIMAT data, www.dwd.de/rcc-cm

In terms of terciles, when referring to the ERA5 reanalysis and the 1991-2020 reference, temperatures were in the upper tercile in almost the entire domain (Fig. 13-14). Exceptions were the eastern Ukraine and parts of central Türkiye, where temperatures were in the middle tercile. When using the 1981-2010 reference, only central Türkiye had temperatures in the middle tercile.

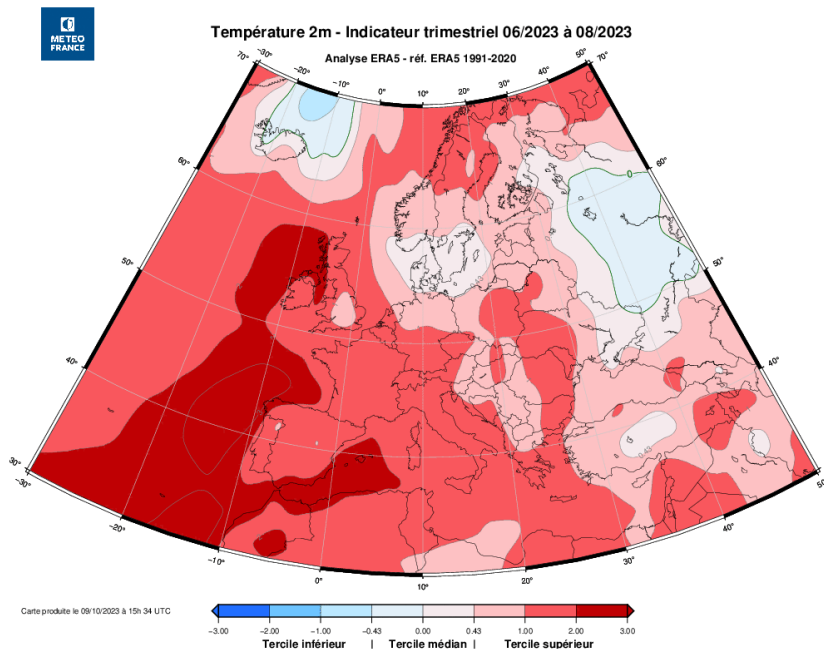


Figure 13: Seasonal normalized temperature anomalies of summer 2023 surface air temperature based on ERA5 reanalysis data, 1991-2020 reference. The data range between -0.43 and +0.43 represents the middle tercile, below -0.43 the lower tercile and above +0.43 the upper tercile. Source: Météo France, <http://seasonal.meteo.fr/content/suivi-clim-cartes-ERA5>

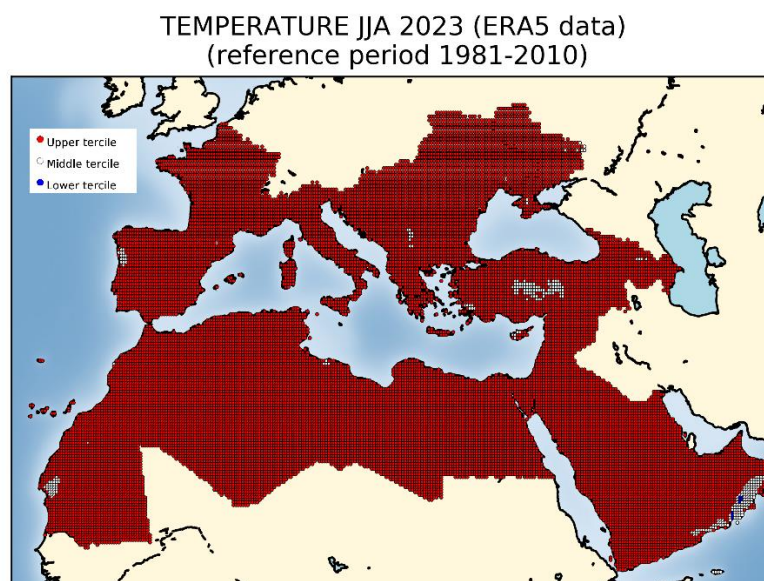
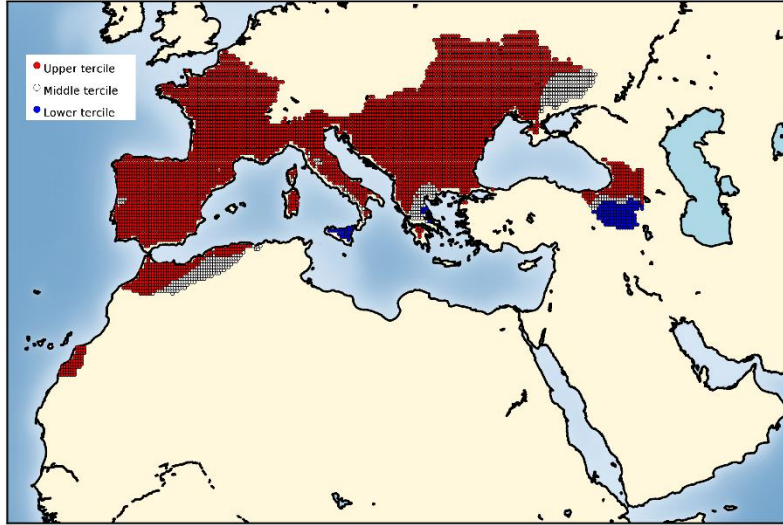


Figure 14: Terciles of summer 2023 surface air temperature based on ERA5 Reanalysis, 1981-2010 reference. Source: AEMET, data source: <https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5>
 E-OBS data show a few areas being in the lower tercile (1981-2010 reference), namely southern Italy (Sicily) and northeastern Türkiye, and some more areas in the middle tercile (eastern Ukraine, Greece, Fig. 15). All this is not supported by open ECA&D data, so this could be an effect of interpolation. On the other hand, a few individual ECA&D stations recorded temperatures in the middle or lower tercile, which cannot be seen in the other datasets, but can be real due to cooling after frequent local showers, because some of them can be found in exposed places (near coasts or mountains).

TEMPERATURE JJA 2023 (EOBS data)
(reference period 1981-2010)



TEMPERATURE JJA 2023 (ECA&D data)
(reference period 1981-2010)

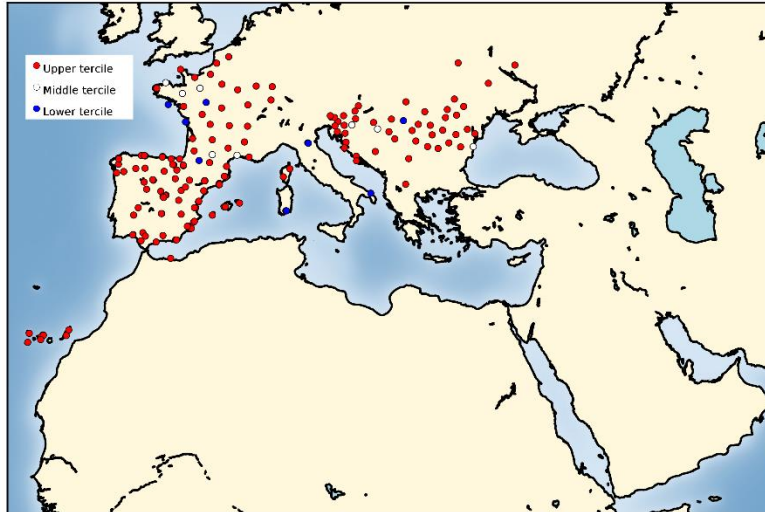


Figure 15: Tertiles of summer 2023 surface air temperature based on interpolated E-OBS grid data (upper graph) and individual ECA&D station data (lower graph), 1981-2010 reference. Note: E-OBS uses a higher number of stations than those which are freely available at ECA&D. Source: AEMET, data source: <http://www.ecad.eu/>

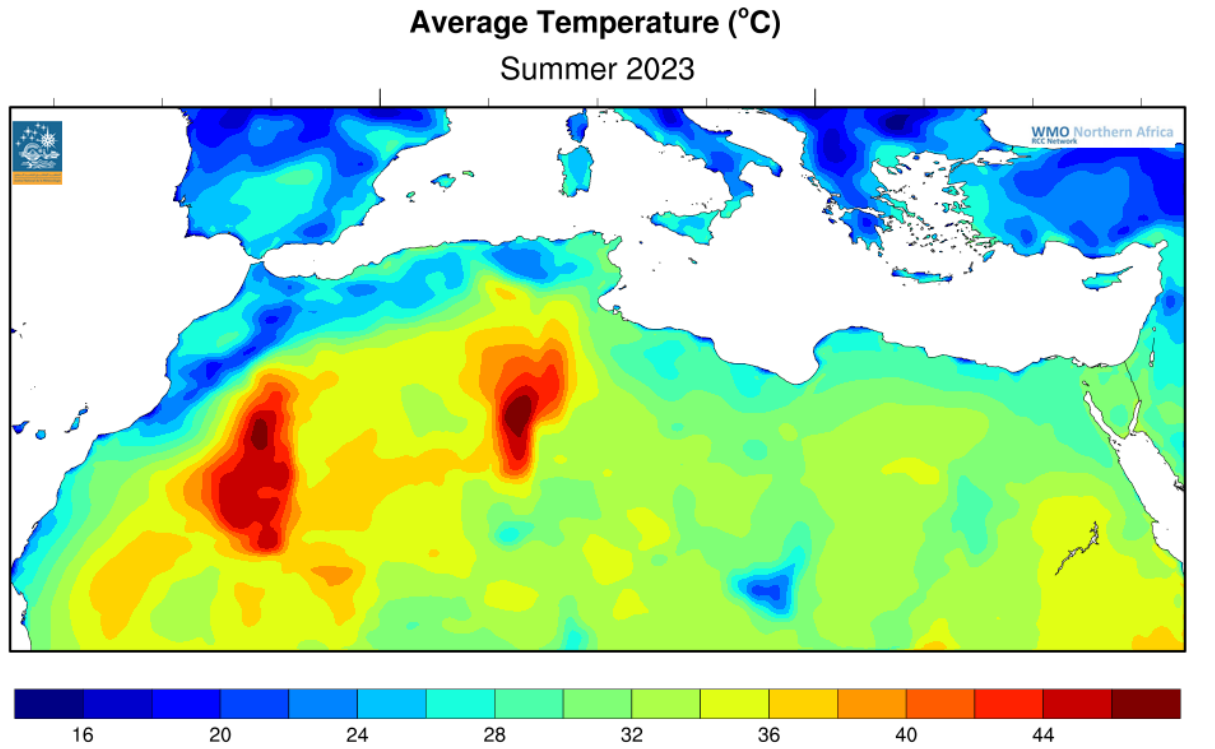
North Africa (RA I)

Seasonal mean temperatures ranged from 16 °C to 30 °C in northern parts of the domain in higher elevations mostly. Over the center of the domain, temperature means were ranging between 30 °C to 46 °C over the central west of Algeria, the south of Tunisia and the central east of Algeria (Fig. 16).

Temperature was higher than the 1991-2020 normal in almost the entire domain (Fig. 17). They were particularly high in extreme northern parts of the domain with anomalies between +2 °C and up to +4 °C

in northern parts of Tunisia, Algeria as well as Morocco and southern parts of Morocco (West Sahara). Anomalies in eastern parts of the domain were between +1 °C and +2 °C, especially places in eastern Libya and western Egypt. The south of Algeria was slightly colder than normal with anomalies up to -3 °C.

In terms of terciles, temperatures were in the upper tercile in almost the entire domain (Fig. 18). Only in an area in the south of Algeria, temperatures were mainly in the lower or middle tercile.

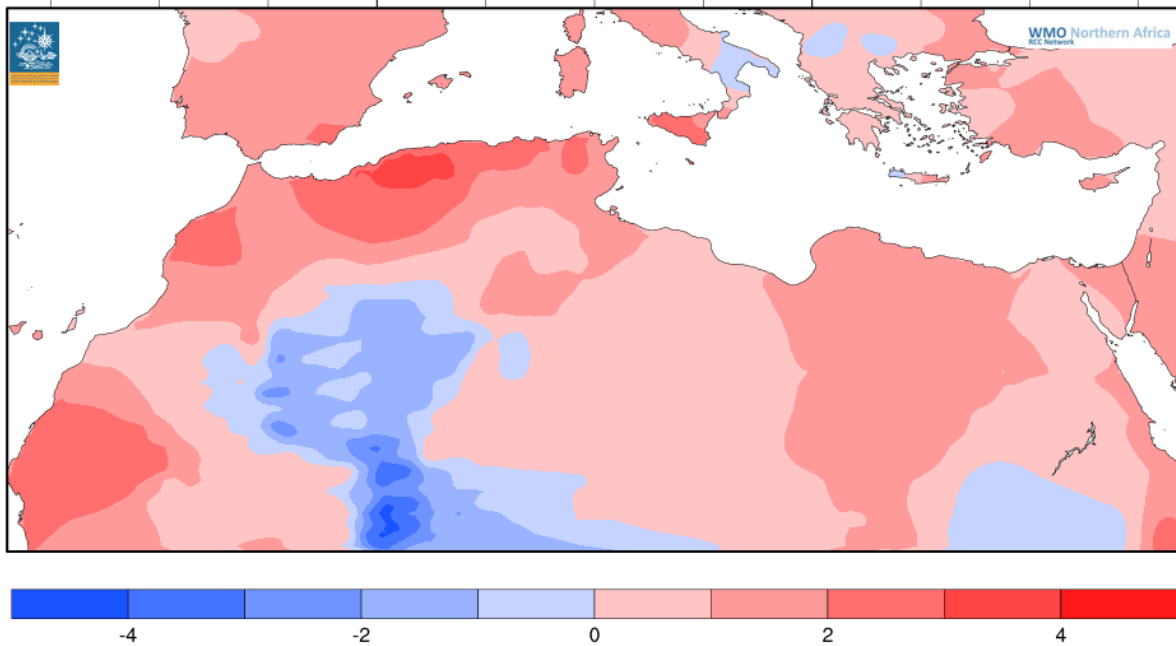


Data Source: NCEP/NCAR-Reanalysis

North African Regional Climate Center
National Institute of Meteorology Tunisia

Figure 16: Mean temperature for summer season 2023 in North Africa (in °C). Source: INM, (Data from NCEP/NCAR reanalysis, <http://www.esrl.noaa.gov>)

Anomaly Temperature in °C (Base period: 1991-2020) Summer 2023



Data Source: NCEP/NCAR-Reanalysis

North African Regional Climate Center
National Institute of Meteorology Tunisia

Figure 17: Temperature anomaly for summer season 2023 in North Africa (in °C), reference period 1991-2020.

Source: INM, Data from NCEP/NCAR reanalysis, <http://www.esrl.noaa.gov>

Temperature Terciles for Summer 2023

Data source: NCEP/NCAR-Reanalysis

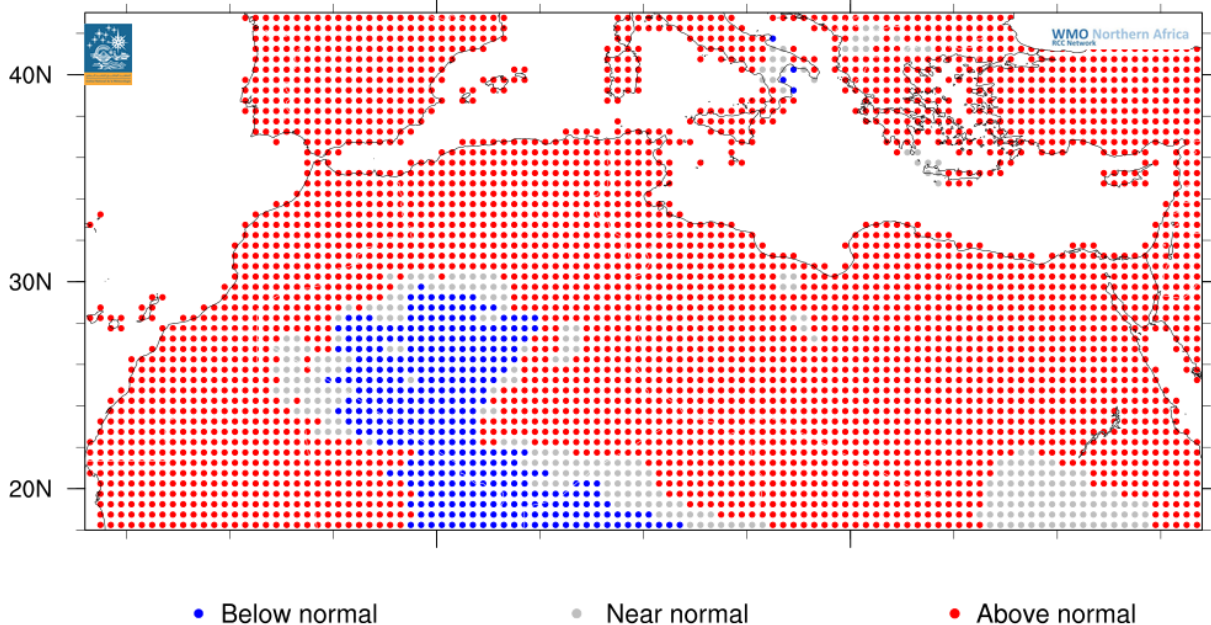


Figure 18: Tercile distribution for temperature of JJA 2023 in North Africa, reference period 1991-2020.

Source: INM, Data from NCEP/NCAR reanalysis, <http://www.esrl.noaa.gov>

2.4 Precipitation

Europe and Middle East (RA VI)

Precipitation was above normal in most of the domain (Fig. 19). There were only some limited areas with below-normal precipitation; these were located in southern Portugal, eastern and southeastern Spain, the southern half of France, southern Italy (Sicily), southern Greece, areas west and north of the Black Sea, southeastern Türkiye and northern Syria. Seasonal anomalies were mostly between -10 mm and $+10$ mm, in some areas slightly larger. Exceptionally high anomalies above $+30$ mm or $+50$ mm were recorded in some places, especially in northeastern Italy/Slovenia/northwestern Croatia, Montenegro, eastern Serbia, southwestern Ukraine, and western Azerbaijan.

Seasonal totals ranged from zero in most of the Middle East to above 450 mm in Slovenia and at the coasts of western Georgia. In percentages, Slovenia received up to 231% of normal precipitation and saw its wettest summer since at least 1950.

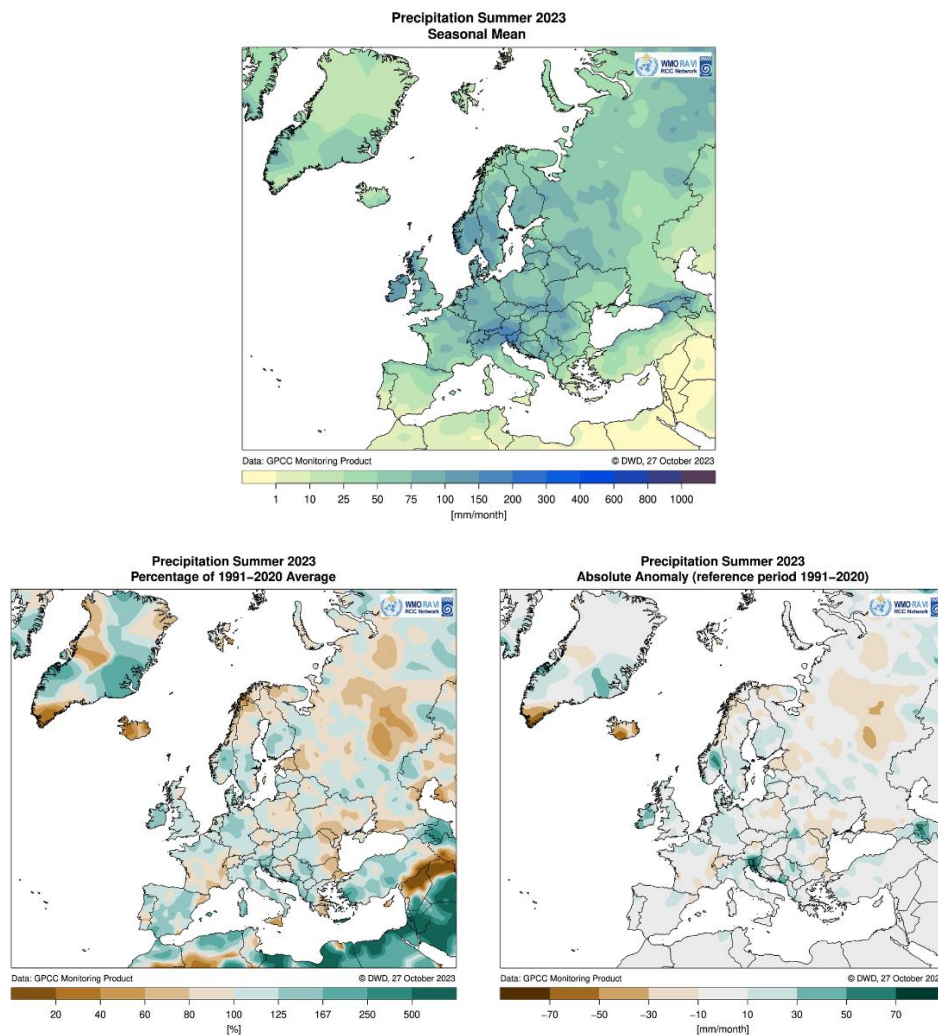
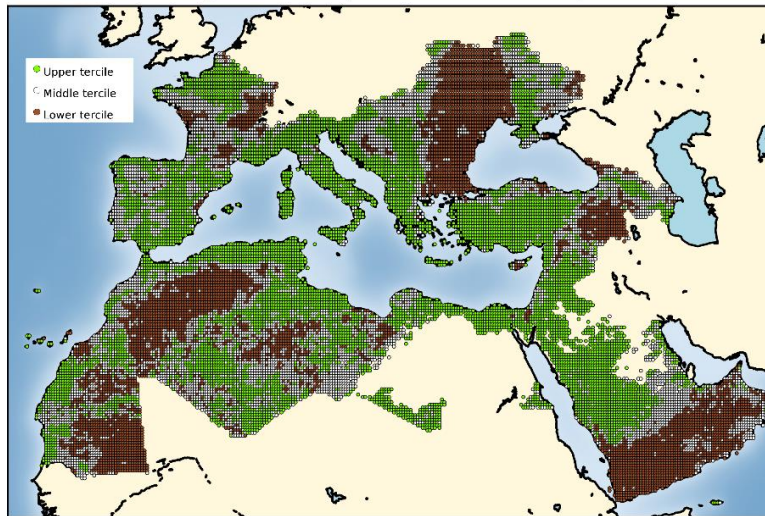


Figure 19: Precipitation for summer 2023 in Europe. Upper map: seasonal total in mm/month, lower maps: percentage of 1991-2020 average and absolute anomalies, source: WMO RAVI RCC, www.dwd.de/rcc-cm, data source: GPCC, <http://gpcc.dwd.de>

In terms of percentiles, precipitation was mostly in the upper or middle tercile (1981-2010 reference, Fig. 20-21). Only some areas had precipitation in the lower tercile. The largest of these areas extended from central Ukraine southwards to European Türkiye. Other larger areas were located in southeastern Türkiye and parts of France. The results of the different datasets ERA5, GPCC, E-OBS and ECA&D are quite similar to each other, except for some smaller areas.

PRECIPITATION JJA 2023 (ERA5 data)
(reference period 1981-2010)



PRECIPITATION JJA 2023 (GPCC data)
(reference period 1981-2010)

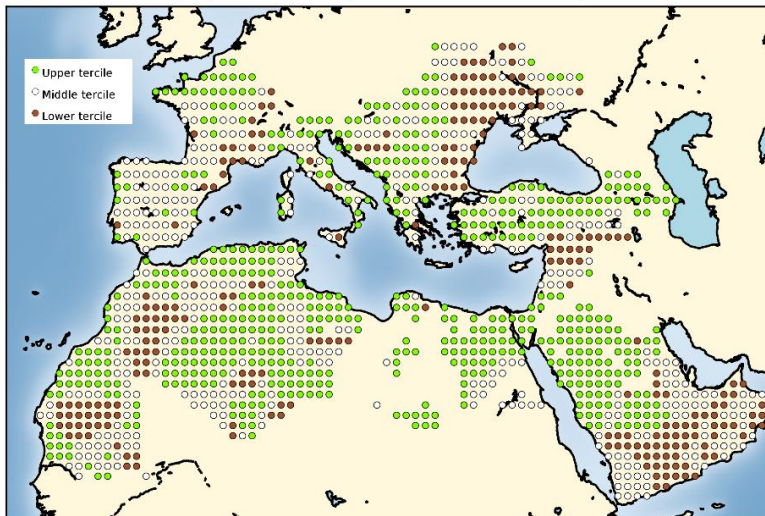
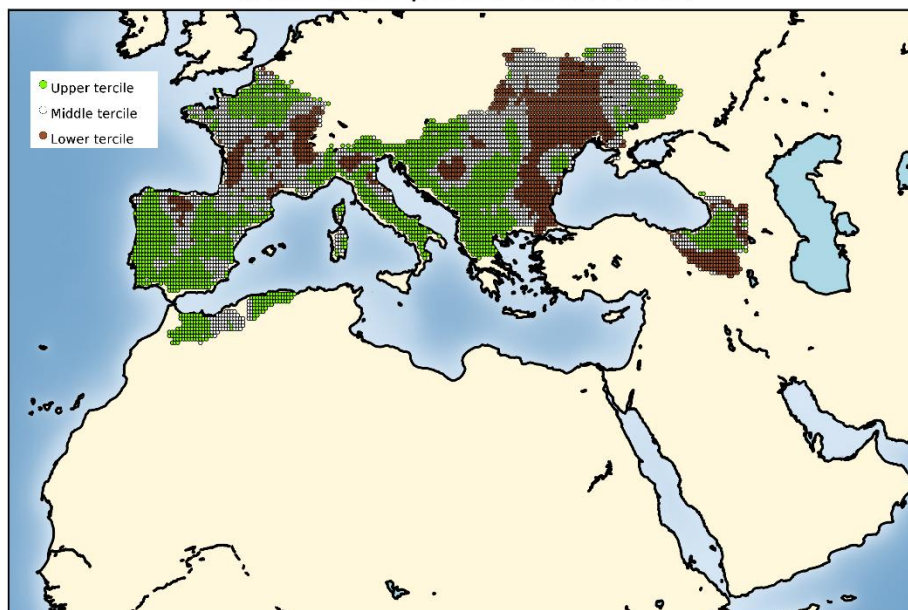


Figure 20: Terciles of summer 2023 precipitation based on ERA5 Reanalysis (upper graph) and GPCC (lower graph) grid data, 1981-2010 reference. Source: AEMET, data reference: ERA5: <https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5>, GPCC: <http://gpcc.dwd.de>

PRECIPITATION JJA 2023 (EOBS data)
(reference period 1981-2010)



PRECIPITATION JJA 2023 (ECA&D data)
(reference period 1981-2010)

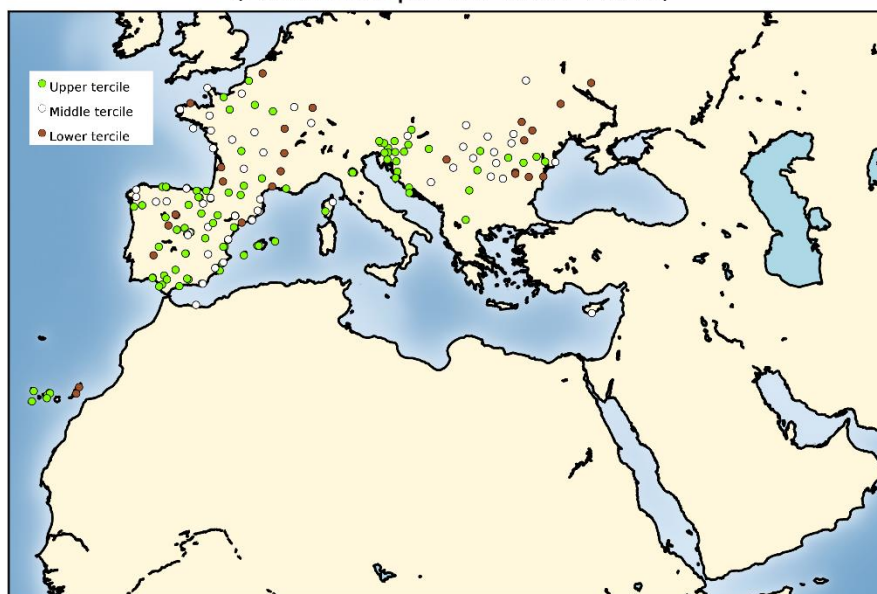


Figure 21: Terciles of summer 2023 precipitation based on interpolated E-OBS grid data (upper graph) and individual ECA&D station data (lower graph), 1981-2010 reference. Source: AEMET, data source: <http://www.ecad.eu/>

A more detailed analysis for south-eastern Europe, including high impact events, is given in the analysis and verification report of the SEECOF-29 CLIMATE OUTLOOK for the 2023 summer season for southeast Europe (SEE), provided by SEECOF-30:

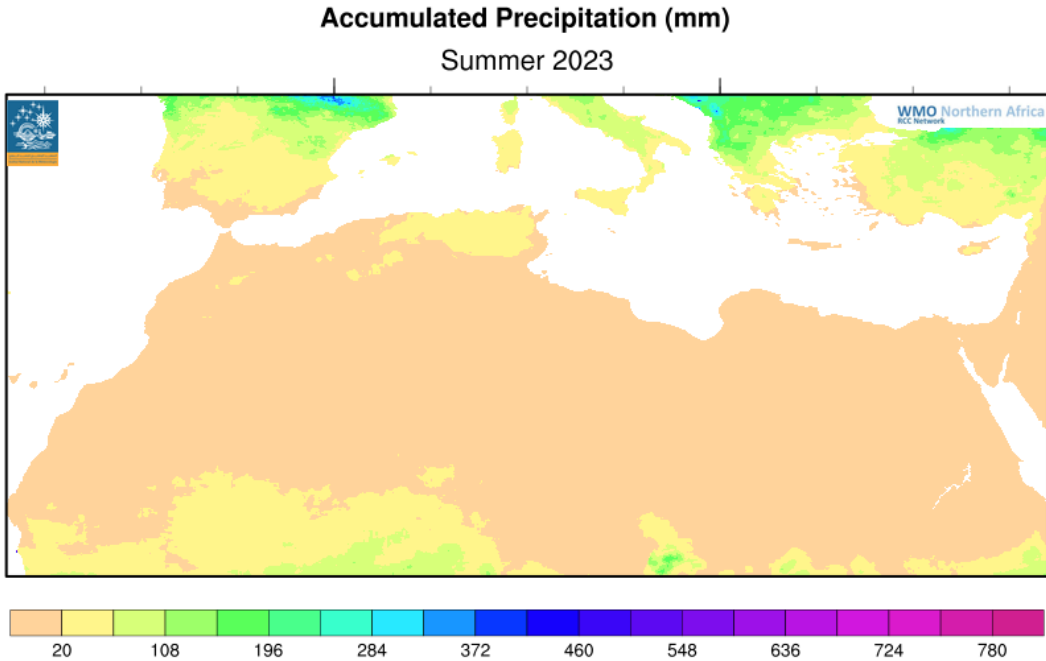
<http://www.seevccc.rs/SEECOF/SEECOF-30/STEP-1/Draft-Version-Final-assessment-of-SEECOF-29-climate-outlook-for-summer2023-season.pdf>

North Africa (RA I)

Overall, summer 2023 has been very dry in terms of rainfall, the accumulated precipitation didn't exceed 20 mm over the most parts of the North African countries, except locally the north-east of Algeria and the north and center of Tunisia, where precipitation was between 20 mm and 60 mm (Fig. 5).

Seasonal precipitation was characterized by positive anomalies in northeastern parts of (more than 250% of the long-term average). It was drier than normal mostly over the eastern parts of Libya, the north of Tunisia, northern and western parts of Algeria and the north of Morocco. Elsewhere, seasonal precipitations were normal to slightly above normal compared to the long-term average (Fig. 6).

In terms of percentiles, precipitation was in the upper tercile particularly in all Egypt, northern and eastern Libya, Tunisia, northern and some parts in the south of Algeria and the center of Morocco. The remaining regions were in the near-normal or below-normal tercile (Fig. 7).

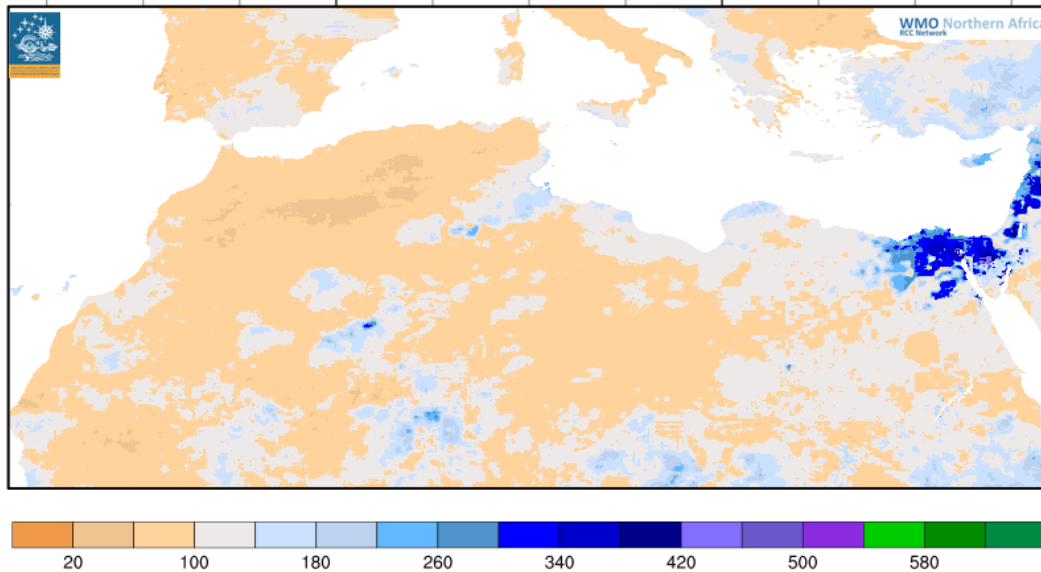


Data Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) North African Regional Climate Center National Institute of Meteorology Tunisia

Figure 22: Total precipitation for summer season 2023 in North Africa (in mm). Source: INM, Data from CHIRPS:
<ftp://ftp.chc.ucsb.edu/>

Precipitation Anomaly in % (Base Period: 1991-2020)

Summer 2023



Data Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

North African Regional Climate Center
National Institute of Meteorology Tunisia

Figure 23: Precipitation anomaly for summer season 2023 in North Africa (in %) (Reference period 1991-2020). Source: INM, data from CHIRPS: <ftp://ftp.chc.ucsb.edu/>

Precipitation Terciles for Summer 2023

Data source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

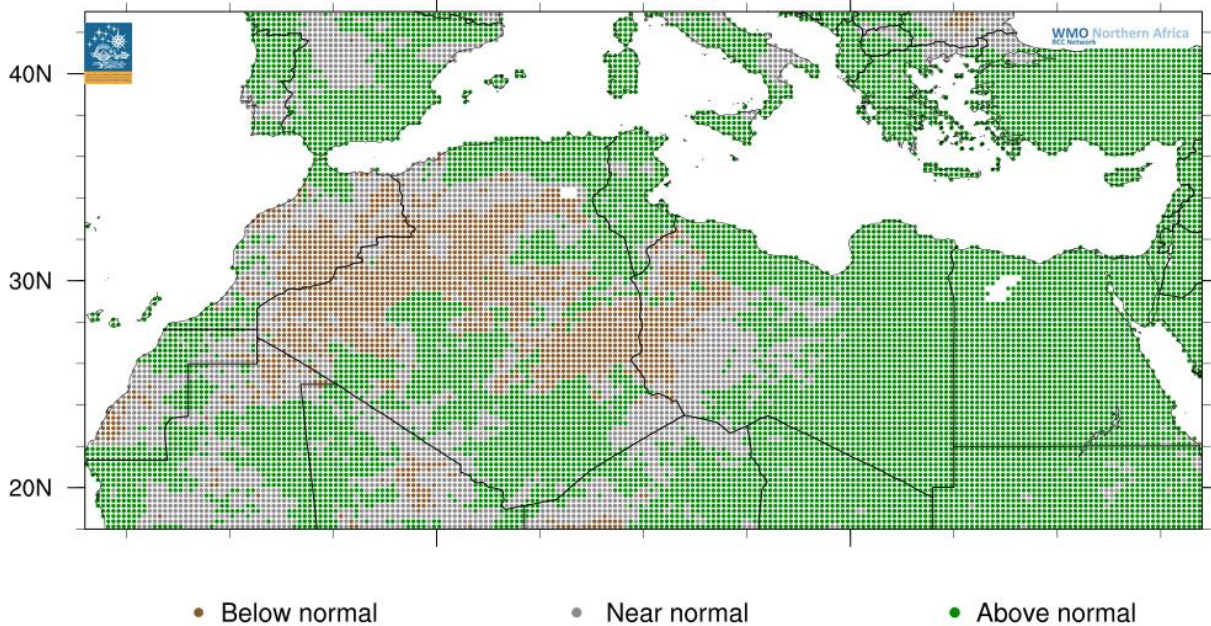


Figure 24: Tercile distribution for precipitation of JJA 2023 (Reference period 1991-2020). Source: INM, data from NCEP/NCAR reanalysis, <http://www.esrl.noaa.gov>

3 Verification of the MedCOF-20 climate outlook for the 2023 summer season

3.1 Temperature

Europe/RA VI

The MedCOF-20 outlook favored the wet scenario (above upper tercile) for most of the domain with 50% probability, with the exception of the Ukraine, where the middle and upper thirds were equally preferred (40% probability each).

The outlook was correct for almost the entire domain. Temperatures were above the upper tercile almost everywhere in the domain, except for central Türkiye, eastern Ukraine and some isolated places elsewhere. For the Ukraine the middle third was also forecasted, so this was correct.

North Africa (RAI)

The MedCOF-20 climate outlook for the summer 2023 season favored the upper third over the entire North African domain (20%, 30%, 50%) with the exception of Northwestern Africa, where normal to above temperatures were expected (20%, 40%, 40%).

The outlook of temperature was correct over almost all of the domain, except for northwestern Africa where temperatures were all in the above-normal third, and the south of Algeria where temperature were in the normal to below-normal thirds.

3.2 Precipitation

Europe/RA VI

The MedCOF-20 outlook favored a wet scenario (above upper tercile) over the southern parts of the domain with 50% probability. Elsewhere in the domain, no privileged scenario was given.

The outlook was mostly correct for the southern parts of the domain, since most of these areas had precipitation above the upper tercile. For the rest of the domain, most but not all places had precipitation above the upper tercile, some were in the middle or lower third.

North Africa

Precipitation forecasts showed a wet signal over North Africa coastlines (20%, 30%, 50%). Some precipitation events were expected mainly over mountain areas of northern Morocco, Algeria and Tunisia. No scenario for the rest of the domain was favored since no meaningful forecast can be provided for these seasonally dry regions.

Seasonal precipitation was characterized by positive anomalies over coastlines of North Africa including mainly the extreme north of Morocco, north of Algeria, and Tunisia. The outlook of precipitation was correct for the northern part of the domain. Seasonal precipitations were above the upper tercile over the north and east of Libya and Egypt with a particularly high positive anomaly over the extreme north of Egypt (precipitation amounts <20mm considering a seasonally dry region).

4. Users' perceptions of the MedCOF-20 outlook

Europe/RA VI

For the SEECOF domain, Users' perceptions are reflected in the national verification summaries for SEECOF-29, which are available on the SEECOF website:

<http://www.seevcc.rs/SEECOF/SEECOF-30/STEP-1/>

From the other countries, the following information was given:

- Greece: The Hellenic National Meteorological Service does not provide any seasonal outlook for the country.

- Israel: The NMHS has provided a summer outlook.

North Africa

No feedback known.

Appendix A: Contributors to verification of MEDCOF-20

- World Meteorological Organization as initiator and supporter of this activity

Europe and Middle East (RA VI)

➤ Climate Centres:

- WMO RA VI RCC Offenbach Node on Climate Monitoring, Deutscher Wetterdienst, Germany
- South East European Virtual Climate Change Center hosted by Republic Hydrometeorological Service of Serbia, Republic of Serbia

➤ National Meteorological and Hydrological Services:

- Météo France, Republic of France
- Deutscher Wetterdienst, Federal Republic of Germany
- Hellenic National Meteorological Service, Greece
- Israel Meteorological Service
- AEMET, Spain

➤ Further National Meteorological and Hydrological Services via SEECOF-30:

- Centre of Operational Hydrometeorology, Armenia
- Federal Hydrometeorological Institute, Federation of Bosnia and Herzegovina
- Republic Hydrometeorological Service, Republika Srpska, Bosnia and Herzegovina
- National Institute of Meteorology and Hydrology, Bulgaria
- Meteorological and Hydrological Service of Croatia, Republic of Croatia
- Meteorological Service of Cyprus
- National Environmental Agency (NEA), Georgia
- Hellenic National Meteorological Service, Greece
- Israel Meteorological Service
- State Hydrometeorological Service, Republic of Moldova
- Hydrometeorological Institute of Montenegro
- Hydrometeorological Service of Republic of North Macedonia
- Republic Hydrometeorological Service of Serbia, Republic of Serbia
- Slovenian Environment Agency, Slovenia
- Turkish State Meteorological Service, Republic of Türkiye
- Ukrainian Hydrometeorological Center, Ukraine

North Africa (RA I)

- WMO RA I North African RCC Tunisia Node on Climate Monitoring, National Institute on Meteorology, Tunisia National Institute of Meteorology, Tunisia

APPENDIX B: Analysis and verification of the MedCOF-20 climate outlook for the summer season 2023:
Europe/RA VI

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Albania *	Above normal	Above normal (20, 30,50)	Above normal	North: no signal (33,33,33) South: above normal (20,30,50)	
Armenia *	Above normal	Normal to above normal (20, 40,40)	Above and near normal	no signal (33,33,33)	
Azerbaijan *	Above normal	Normal to above normal (20, 40,40)	Above and near normal	no signal (33,33,33)	
Bosnia and Herzegovina (FBiH) (6)	Above normal in almost entire Bosnia and Herzegovina	Above normal (20, 30, 50)	Normal in central, north entire Bosnia and Herzegovina; Above normal - Mostar	no signal (33,33,33)	<p>Summer</p> <p>June – AMS Snjeznica 50 mm (precipitation) for 30 min. Local showers (northeast Bosnia) caused flooding on smaller rivers. Flooded houses and destroyed roads.</p> <p>July – Flooding on smaller rivers. Local showers caused flooding on smaller rivers. Flooded houses and destroyed agricultural areas. The wind broke and felled trees. (North Bosnia and Herzegovina). 12.-19.07. very warm and extremely warm period.</p>

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
The Republika Srpska, Bosnia and Herzegovina (5)	Above normal over entire RS entity	Above normal (20,30,50)	Normal over the most area of the RS entity	No predictive signal	Long lasting drought and very high temperatures caused wild fires in some parts of the Southern area, the most frequent affected region of the Republika Srpska.
Bulgaria (6)	Above normal	Above normal	Dry or Near normal	No predictive signal	<p>The month of June was with normal temperatures but the month of July of 2023 is one of the three hottest for the last 25 years. There was a long heat wave in the middle and late July that compared to the longest ever in Bulgaria. But there are no beaten monthly absolute maximum temperatures. The heat wave repeated in August but with lower strength. The maximum summer temperature is 43.0 °C in Ruse on 25 July. The above normal rain in West Bulgaria in June was the cause of local floods mostly in the northwest. Then in July and August the summer turned dry. In late August there were dry conditions in southeast where fire danger increased to extreme levels. It was also associated with sustained northeasterly winds.</p> <p>The hot weather in late August was broke by a cold front. A thunder storm on 30 August brought lightning activity in Ruse where 2 children were killed by a flash lightning at a stadium.</p>

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Croatia (5)	Above normal	Above normal (20,30,50)	Above normal (the largest part of the territory) Normal (the eastern part of Croatia)	No predictive signal	<p>Summer 2023 was warm and very warm. In all three months, heat waves were observed (one in June, July and August). In all three months, convective related severe weather phenomena (thunderstorms, hail, heavy rains, flash floods, waterspouts) were observed mostly all over Croatia.</p> <p>In June, relatively often, severe thunderstorms accompanied with large amount of precipitation in short time, hail and flash floods hit mostly continental part of Croatia. Flood damage and crops damage due to hail were reported and traffic on many local road were interrupted. In July convective activity was very frequent all over Croatia. Urban floods as a result of large amounts of precipitation in a short time were common. Flood damage and crops and infrastructural damage were also frequent due to very large hail. Severe thunderstorms hit large part of continental Croatia on 19th July.</p> <p>In Zagreb, due to very strong wind (wind gusts up to 115 km/h) and heavy precipitation, unfortunately three people died.</p> <p>In August, a few convective episodes hit mostly north Adriatic and continental part of Croatia and on 28th August whole country. Flash floods caused damage on houses and roads. From 4 to 8th August, due to heavy precipitation in Slovenia and Austria, high water levels were observed in north part of Croatia and the Mura, Drava and Sava rivers flooded relatively large area of northern Croatia. The total estimated damage amounts to 2.180.000,00 euros.</p>

Cyprus (5)	June Normal	June Normal	June Normal	June Below Normal	<p>In June all of the maximum were around normal. Extreme daily maximum temperatures were also recorded with great positive deviations, such as at the station of Paphos and Achna with extreme maximum temperatures of 34.1°C and 37.5°C, respectively, which in both cases were 6.5°C above the normal maximum temperature of each station, which is 27.6°C and 31.0°C, respectively. Extremely daily minimum temperatures were also recorded with great positive deviations, like the Achna station were the minimum temperature (23.7°C) was 4.8°C higher than the normal one (18.9°C). Also, at the station of Larnaca the minimum temperature (24.1°C) was 4.7°C above normal (19.4°C). On the 13th of June an EMMA yellow warning was issued, concerning rain and thunderstorms.</p> <p>In July the mean maximum and minimum temperature was above normal in all of the selected stations. Daily maximum temperatures above normal (deviating by 4°C or more from normal) were recorded, like the highest daily maximum temperature of Achna that was 42.6°C (with a normal of 33.2°C) and the highest daily maximum temperature of Paphos Airport that was 38.1°C (with a normal of 29.9°C). Highest daily minimum temperatures were also recorded, with positive departures greater than 4°C, like the station of Larnaka where a minimum of 29.9°C was by 7.9°C above station's normal (22.0°C) and the station of Achna where a minimum of 28.5°C was by 6.7°C above station's normal (21.8°C). During July, extremely high temperature warnings, EMMA warnings, have been issued at both the yellow risk level and the orange risk level for both the maximum and the minimum temperatures. Specifically, a total of 20 EMMA warnings for extremely high temperatures were issued; 15 of which were at the yellow risk level during the periods 13/7, 15-28/7 and 31/7, while 5 of them were at the orange risk level during the periods 13-16/7 and 23/7.</p> <p>In August all average daily maximum and minimum temperatures were above normal, while the positive deviation from normal of</p>
	July Above normal	July Normal	July Below normal	July SW part below normal, NE part Above Normal	
	August Above normal	August Normal	August Above normal	August South and East part Below normal and North and West part Above normal	

				<p>both the average daily maximum and average daily minimum temperature is notable for the forest station at Prodromos, which is located at an altitude of 1736 meters. At all reference stations precipitation was close to normal, except from the station at Prodromos where it was below normal and the station at Athalassa where it as well above normal. At this point it is worth mentioning that the largest contribution to the total August 2023 rainfall amounts, particularly over the inland and the southeastern areas of the island, is not only due to isolated thunderstorms of thermal instability during noon and early afternoon, but also due to a disturbance which affected the island late in the evening of the 28th of August. Such disturbances, of dynamic causes, the result of which is rainfall accompanied by intense thundery activity during the evening hours, is something that does not happen often in Cyprus, especially during the month of August. Extreme maximum temperatures with positive deviations of more than 4°C were recorded, as at Prodromos station where the highest daily temperature 38.4°C was 10.4°C above the normal (28°C), that is the highest daily maximum temperature ever recorded at this station since its operation date. Also, at the station at Athalassa the extreme maximum (45.3°C) was 8.3°C above normal. The extreme minimum (29.5°C) at Prodormos station was 11.4°C above normal which is also a record regarding the highest daily minimum temperature ever recorded at this station. At Larnaka airport the extreme minimum (27.2) was 4.9°C above normal. For the periods 1-4, 13-19 and 22-23 of August EMMA yellow warnings were issued, concerning high temperatures. At the same time, for the period 14-17 August EMMA orange warnings, once again concerning high temperatures, were also issued. For the periods 22 and 27-28 of August local showers accompanied sometimes with thunderstorms were recorded, resulting in accumulated precipitation of 4.9mm (or 245% of normal).</p>
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Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
France *	Above normal	Above normal (20, 30,50)	North and south-east above normal. In the rest normal or below normal.	no signal (33,33,33)	
Georgia (5)	Above normal	Above normal	Above and near normal	no signal (33,33,33)	No high impact events.
Greece (5)	Above normal (relative to the period 1981- 2010) for the whole country.	Above normal summer temperatures for the whole country (50% above normal, 30% around normal and 20% below normal). In general, the outlook was correct.	Near or above normal conditions mainly over southern parts of Greece. Dryer than normal conditions prevailed over the central parts of Greece.	Wetter than normal conditions over the central and southern parts of Greece (20, 30,50) around normal, 50% above normal). For the northern parts of Greece no large-scale precipitation signal is present in the forecasts (33,33,33)	From 12 to 26 July 2023 Heat wave named 'Cleon' : In mid July 2023, a long-lasting heat dome settled over the Mediterranean. The latest heat wave was an extension of a continuous heat wave that occurred in three successive phases; however, has never really stopped and affected Greece since midJuly.
Hungary*	Above normal	Above normal (20, 30,50)	Above normal	no signal (33,33,33)	

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Israel (5)	Above normal	Above normal (20, 30, 50)	Above normal (20, 30, 50)	Above normal (20, 30, 50)	No high impact events
Italy *	Above normal except a few places in southern where it was below normal	Above normal (20, 30,50)	Above normal in italian mainland. Below normal in Sicilia	North: no signal (33,33,33) South: above normal (20,30,50)	
Jordan *	Above normal	Above normal (20, 30,50)	above normal	above normal (20,30,50)	
Lebanon *	Above normal	Above normal (20, 30,50)	above normal	above normal (20,30,50)	

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Republic of Moldova (5)	Above normal	Above normal	Mostly below normal	Below, near or above normal (33%,33%,33%)	<p>On July 25-26, thunderstorms, hail, and squally winds with a maximum speed of 17-25 m/s were observed over most of the territory of the republic.</p> <p>On July 25, at the Soroca meteorological station, the wind speed reached 27 m/s, which is a extreme meteorological phenomenon.</p> <p>On July 26, a extreme meteorological phenomenon in the form of heavy downpour was observed at Baltata meteorological station: 53 mm of precipitation (80% of the monthly norm) fell in 2 hours. Heavy rains, in some places with hail and strong winds, caused damage to agricultural crops and economic objects.</p>
Montenegro (5)	Above normal	50% Above normal 30% Normal 20% Below normal	Normal in the small part of Montenegro in the north mountainous region; Above normal in the largest part of the country	No predictive signal (33,34,33)	<p>24.06.2023: Storm (heavy precipitation, thundering and wind gust) in whole country. In some hilly places it was followed by hail. Wind broke branches in Podgorica.</p> <p>26.07.2023: Strong wind on the southern coast.</p> <p>19.08.2023. Hail in Bijelo Polje and surrounding settlements (northern region). Many properties were flooded and basements. Sewage holes spilled over the gardens. The hail was falling 30 minutes affecting Plant production and several local roads.</p> <p>29.08.2023. Storm impact on Podgorica (capital town). Due to strong wind one tree fell and one person was injured.</p>
North Macedonia (5)	Above normal	Above normal (20, 30,50)	Above normal	above normal (20,30,50)	Exceeded maximum daily precipitation amount of 90.3mm on 11th June in Mavrovo

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Portugal *	Above normal	Above normal (20, 30,50)	Normal to above normal in most of Portugal. Some limited areas with below precipitation in southern Portugal	North: no signal (33,33,33) South: above normal (20,30,50)	
Romania *	Above normal	Above normal (20, 30,50)	Above normal in western Rumania. Normal to below normal in the rest of Rumania.	no signal (33,33,33)	
Serbia (5)	Above normal in most of Serbia	Above-normal (20, 30, 50) in entire Serbia	Above normal in most of Serbia, average and below average precipitation sums in some parts of northern and western Serbia	No predictive signal (33, 34, 33) in entire Serbia	11th warmest summer for Serbia since 1951. 3rd warmest summer for Serbia based on the minimum air temperature. Record-breaking number of tropical nights on Palic and Sombor. Rainy summer in the east, parts of southwestern, central and southeastern Serbia. 2nd wettest summer for Krusevac and Cuprija. Number of days with precipitation sums of 20 mm and above exceeded in Krusevac.

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Slovenia (5)	Warmer than normal (1991–2020 reference period)	Warmer than normal (1981–2010 reference period)	Wetter than normal (1991–2020 reference period)	No predictive signal (1981–2010 reference period)	

<p style="text-align: center;">Spain (5)</p>	<p>Overall, summer was a extremely warm character. Mean temperature over mainland was 23.4 °C, 1.3 °C above the seasonal mean (reference period: 1991-2020). Summer 2023 was the third warmest summer since the beginning of the series in 1961 and therefore also of the 21st century. Of the ten warmest summers in the series, nine belong</p>	<p>Probability for upper to above normal (20,30,50) can be expected over most of the domain, with the exception of Northwestern Africa and Northeastern part of MedCOF domain, where normal to above temperatures are expected (20,40,40).</p>	<p>Overall, summer has been very wet in terms of rainfall, with a value of mean precipitation of 87.2 mm, a value that represents 124% of the normal value of the quarter in the reference period 1991-2020. Summer 2023 was the sixteenth wettest summer since the beginning of the series in 1961, and the third wettest of the 21st century, after the summers of 2010 and 2018. Summer has been normal to wet in most of the Peninsula. It has only been dry in isolated points of the Peninsula and some coastal</p>	<p>Precipitation forecasts show wet signal (20,30,50) over most of the Mediterranean Sea. Although summer is climatologically very dry over Northern Africa, models show wet signal over North Africa, so some precipitation events can be expected over Mountain areas of northern Morocco, Algeria and Tunisia. The climatological forecast (33, 33, 33) over the Southern part of the domain also takes into account that no meaningful forecast can be provided for</p>	<p>Summer had four heat episodes:</p> <ol style="list-style-type: none"> a) 9-12 July b) 17-20 July c) 6 August - 13 August d) 18 August – 25 August <p>The two heat waves that took place in August were the longest and most intense, with maximum temperatures above 40.0 °C in a large part of the territory, reaching over 45.0 °C in some points of the province of Valencia and Andalusia.</p> <p>The highest summer temperatures were: 46.8°C (Valencia, 10 August), 45 °C (Cordoba/airport, 11 August), 44.3 °C (Granada/airport, 9 August)</p> <p>The highest values of daily summer precipitation were: 55.7 mm (Hondarribia, 21June), 55.6 mm (Lugo, 12 June), 52.2 mm (Teruel, 3 June), 49 mm (Cáceres, 8 June), 47.3 mm (Gijón, 25 June), 36.6 mm (Valencia, 3 July), 29.8 mm (Zaragoza, 3 July), 29.7 mm (Pamplona, 6 July), 72.3 mm (Ibiza/airport, 3 August), 47.4 mm (Pontevedra, 3 August) and 47.4 mm (Menorca, 27 August).</p>
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Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
	to the 21st century. Summer was extremely hot in large parts of the southern third of the Iberian Peninsula (IP) and in the western Cantabrian Sea, while it was very hot in the rest of mainland Spain. In the Balearic Islands it was very warm.		areas of Catalonia. Summer has been very wet in the interior of Galicia, points of the Basque Country and Navarre, northern Extremadura, the northern half of the Valencian Community, parts of Castilla-La Mancha and the western half of Andalusia.	these seasonally dry areas.	
Syria *	Above normal	Above normal (20, 30,50)	North: Below normal South: Above normal	above normal (20,30,50)	

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High Impact Events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Türkiye (6)	Above normal in the most of Turkey. Normal at inner parts.	Above normal (20, 30,50)	Above normal at the western and inner parts. Below normal at southeastern Türkiye	Wetter than normal conditions over the western part (20,30,50). For the eastern part no signal (33,33,33)	
Ukraine (5)	Above normal	Above normal (western part) Above and normal (eastern part)	Above normal (28% stations) Normal (31% stations) Below normal (41% stations)	Above normal 33 Normal 34 Below normal 33	During summer, meteorological extraordinary phenomenas were observed in many regions of the country. Heavy rains 30-80 mm precipitation with duration from 2 to 12 hours were recorded in the western, northern and north-eastern parts of the country and in Odesa region. Heavy showers 30-43 mm/hour. In Odesa was recoded 57 mm/hour 20/07/23. Storm winds and squalls (with speed 25-29 m/c) were fixed in Zakarpattia (Uzhhorod), Kyiv (Baryshivka) regions and Odesa. Localy caused loss power, telecommunications, utilities and transport.

Note:

- 1 – Basic climatological period (1961-1990)
- 2 – Basic climatological period (1971-2000)
- 3 – Basic climatological period (1951-2000)
- 4 – Basic climatological period (1980-2009)

5 – Basic climatological period (1981-2010)

6 – Basic climatological period (1991-2020)

7 – No information about the basic climatological period

*Data base: ERA5 1981-2010 for temperature, GPCP 1981-2010 for precipitation

North Africa (RA I)

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High impacts events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Algeria*	Below normal to normal in the south Above normal elsewhere	Normal to above normal over the west (20%, 40%, 40%) Above normal (20%, 30%, 50%)	Normal to below normal in the center Above normal elsewhere	Above normal in the north (20%,30%,50%) No clear signal elsewhere (33/ 33/33)	
Egypt*	Above normal	Above normal (20%, 30%, 50%)	Above normal	Above normal over coastlines (20%,30%,50%) No clear signal elsewhere (33/ 33/33)	No comment
Libya*	Above normal	Above normal (20%, 30%, 50%)	Normal to below normal over the west Above normal elsewhere	Above normal over coastlines (20%,30%,50%) No clear signal elsewhere (33/33/33)	No comment

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High impacts events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
Morocco*	Above normal	Above normal in the south (20%, 30%, 50%) Normal to above normal elsewhere (20%, 40%, 40%)	Above normal in the extreme north and in the center Normal to below normal elsewhere	Above normal in the north (20%,30%,50%) No clear signal elsewhere (33/ 33/33)	No comments
Tunisia (2)	Above normal	Above normal (20%, 30%, 50%)	Above normal	Above normal (20%,30%,50%)	<p>Precipitation: June 2023 was ranked the 6th rainiest June since 1950. The rainfall amounts recorded during this month reached 208.8% of the normal for the month of June (total cumulative rainfall for the 27 main stations for the month was 520 mm, while the normal was 249 mm).</p> <p>Temperature: July 2023 was the hottest ever recorded since 1950. The average temperature (27 main stations) recorded was higher than the reference average (1991-2020) with a significant difference of +4°C. With this anomaly, July 2023 was ranked the 1st hottest July since 1950. Several new records were registered for maximum temperature: On 24/07/2023: Tunis, 49°C; Bizerte, 48.9°C; Beja, 47.7°C</p>

Country	Seasonal temperature (JJA)		Seasonal precipitation (JJA)		High impacts events
	Observed	MedCOF-20 climate outlook for temperature	Observed	MedCOF-20 climate outlook for precipitation	
					<p>On 25/07/2023: Gabes, 49.1°C; Monastir, 48.3°C; Mahdia, 47.5°C; Djerba, 46.9°C</p> <p>On 29/07/2023: Sidi Bouzid, 47.6°C; Medenine, 49.1°C; Kebili, 48.9 °C; Matmata, 48.8°C</p>

Note:

(1) Basic climatological period (1981-2010)

(2) Basic climatological period (1991-2020)

* Data source: Temperature: NCEP/NCAR reanalysis data, precipitation: CHIRPS

References:

MedCOF 18 Outlook: http://medcof.aemet.es/images/doc_events/medcof18/step3/docStep3/Consensus%20Statement%20MedCOF18_v3.pdf

SEECOF Online Forum: <http://www.seevccc.rs/forum/>

PRESANORD <http://acmad.net/rcc/presanord.php>

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>

Météo France climate monitoring products: <http://seasonal.meteo.fr>

ECMWF ERA5 reanalysis: <https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5>

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