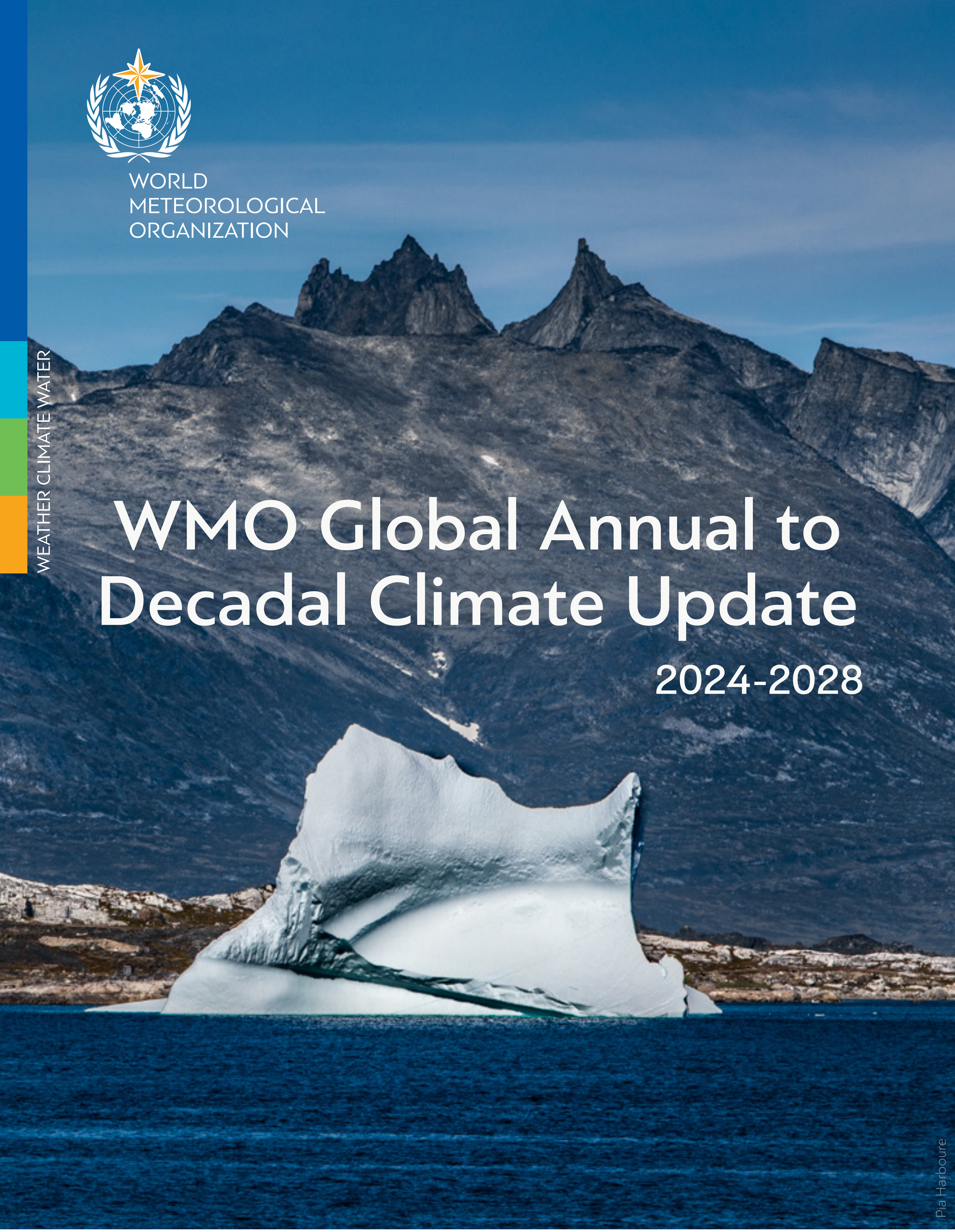


Pia Harboure

WORLD
METEOROLOGICAL
ORGANIZATION

WEATHER CLIMATE WATER

WMO Global Annual to Decadal Climate Update

2024-2028

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

CCCMA

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Met Office

WORLD METEOROLOGICAL ORGANIZATION

Global Annual to Decadal Climate Update

Target years: 2024 and 2024-2028

Executive Summary

The Global Annual to Decadal Climate Update is issued annually by the World Meteorological Organization (WMO). It provides a synthesis of the global annual to decadal predictions produced by the WMO designated Global Producing Centres and other contributing centres for the period 2024-2028. The latest predictions suggest that:

- The global mean near-surface temperature for each year between 2024 and 2028 is predicted to be between 1.1°C and 1.9°C higher than the average over the years 1850-1900.
- It is likely (80% chance) that global mean near-surface temperature will exceed 1.5°C above the 1850-1900 average levels for at least one year between 2024 and 2028. It is about as likely as not (47%) that the five-year mean will exceed this threshold.
- It is likely (86% chance) that at least one year between 2024 and 2028 will be warmer than the warmest year on record (currently 2023). The chance of the five-year mean for 2024-2028 being higher than the last five years (2019-2023) is also likely (90%).
- The 2023-24 El Niño has peaked and is likely to transition towards a La Niña during 2024.
- Arctic warming over the next five extended winters (November to March), relative to the average of the 1991-2020 period, is predicted to be more than three times as large as the warming in global mean temperature.
- Predicted precipitation patterns for 2024, relative to the 1991-2020 average, suggest an increased chance of low rainfall over North-East Brazil and an increased chance of wet conditions in the African Sahel, consistent with the warmer-than-usual temperatures in the North Atlantic.
- The Sudano-Sahelian (PRESASS) region is likely to see above average rainfall 2024-2028 for the July-September seasons, though this may not be the case for individual seasons.
- The predicted conditions in the North Atlantic for May-September 2024-2028 indicate above average tropical cyclone activity.
- Predictions of sea-ice for March 2024-2028 suggest further reductions in sea-ice concentration in the Barents Sea, Bering Sea, and Sea of Okhotsk.

Current Observations

This section is a brief summary of the observed climate of the last five years to provide a context for the predictions shown later in this report. Please refer to the WMO State of the Global Climate report for a more complete discussion. Climate anomalies over the last year and last five years with respect to the most recent long-period average, 1991-2020, are shown in Figure 1.

Near-surface temperatures in 2023 showed conditions that were mainly warmer than the long-term average, with a warmer tropical East Pacific, consistent with El Niño conditions, which prevailed for most of the year. The eastern North Atlantic had record surface temperatures along with southern Europe.

Over 2019-2023, apart from the eastern tropical Pacific and parts of Canada, Australia and India, the anomalies were mainly positive across the globe. The so-called 'warming hole' in the subpolar North Atlantic was no longer evident. Warm anomalies were greatest at high latitudes in the Northern Hemisphere, especially the Arctic, and generally larger over land than ocean. This period had La Niña conditions in three consecutive years.

In 2023 and in the last five years, sea-level pressure was anomalously low over Antarctica. The Aleutian Low for 2019-2023 was anomalously weak, consistent with the extended La Niña conditions that prevailed.

During 2019-2023, parts of Asia and the African Sahel were wetter than average, and southern Africa, western Australia, central and southern South America, western Europe and parts of North America were drier than average. These anomalies were generally also present for 2023, though less clearly. Eastern Europe experienced above average precipitation.

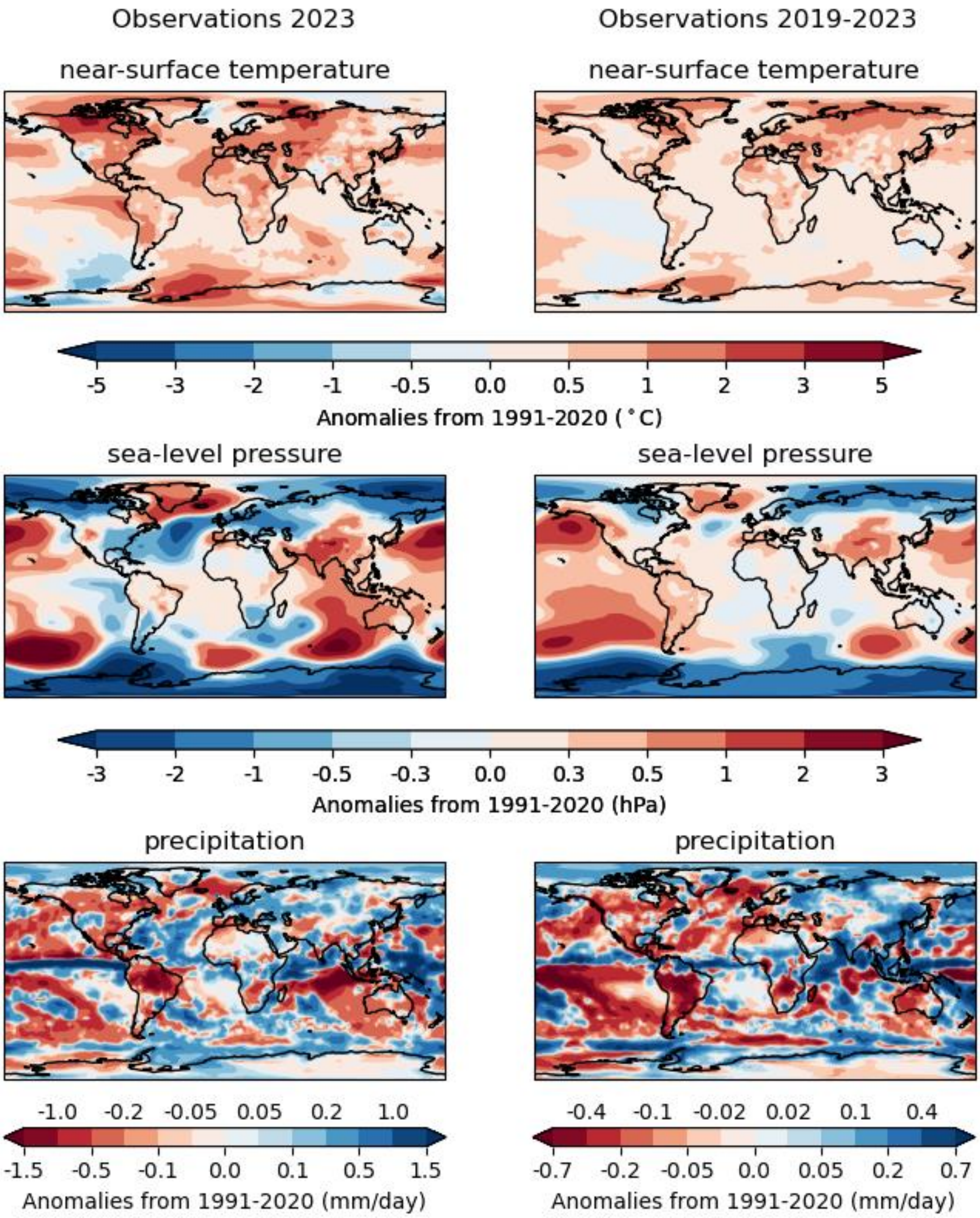


Figure 1*: Observed annual mean near-surface temperature (°C, top), pressure (hPa, middle) and precipitation (mm/day, bottom) anomalies relative to 1991-2020. The left column shows the year 2023, the right column refers to the average of the five-year period 2019-2023. Near-surface temperature is ERA5 2m temperature from ECMWF (Bell et al, 2021). Mean sea-level pressure is also from ERA5. Precipitation is from GPCP (Adler et al, 2003, updated).*

To highlight summer and winter differences, Figure 2 shows average anomalies over the last five years for two extended seasons, May to September and November to March. Both seasons had generally higher temperatures than the 1991-2020 average, apart from the tropical eastern Pacific, South Pacific and western North America (excluding Alaska) in November to March.

The sea-level pressure anomalies seen in the five-year mean in Figure 1 over Antarctica and the Aleutian Low were largest in November to March. East Asia and South Asia were wetter than average in May to September, but this hides large inter-annual variability in the monsoons. The

African Sahel also shows wet anomalies for this season. Australia and southern South America were mostly drier than average over the five years in both seasons.

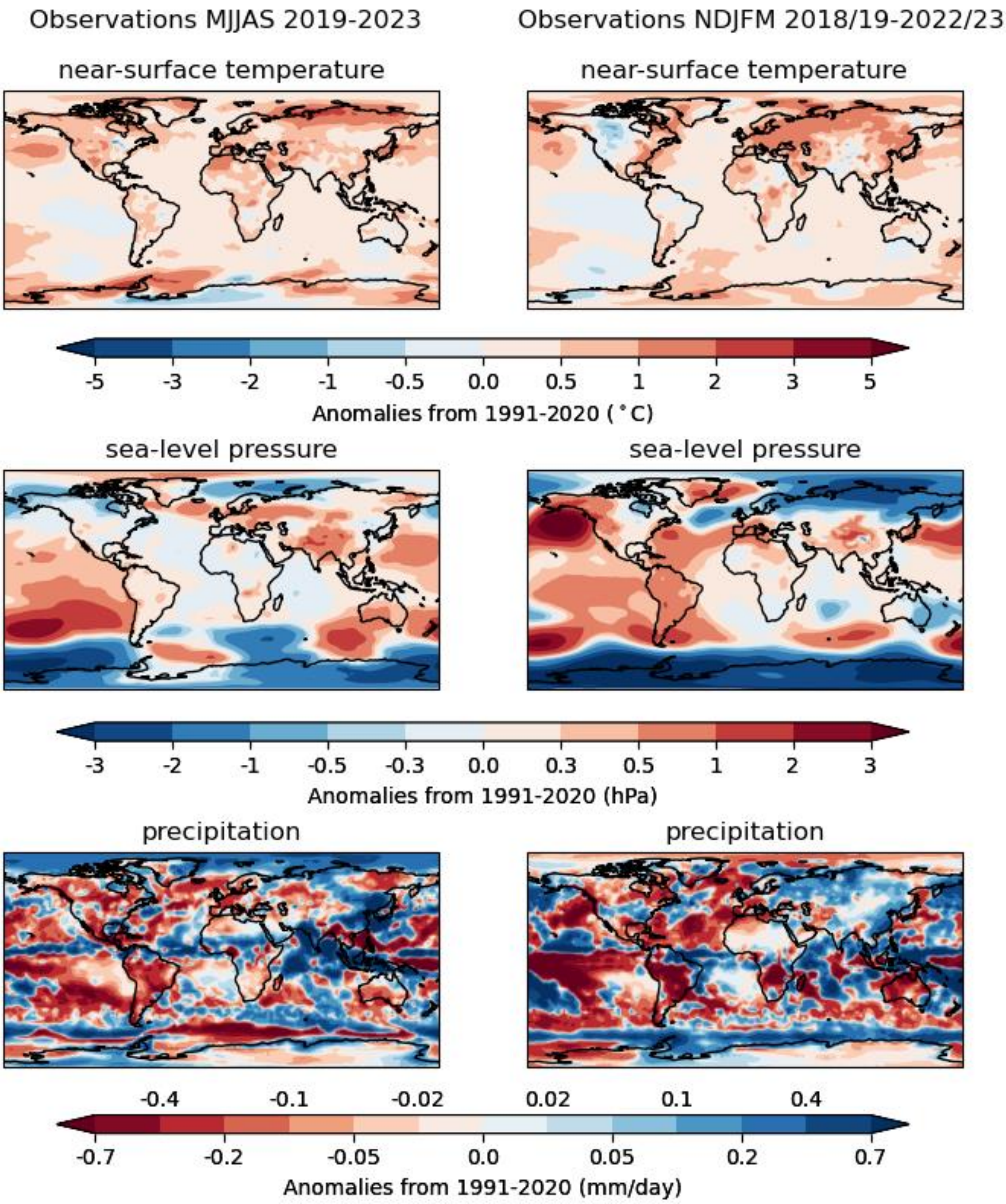


Figure 2*: Observed five-year seasonal mean near-surface temperature (°C, top), pressure (hPa, middle) and precipitation (mm/day, bottom) anomalies relative to 1991-2020. The left column shows anomalies for May to September averaged over 2019-2023, the right column shows anomalies for November to March averaged over 2018/2019-2022/2023. Observational datasets are the same as those in Figure 1.*

Global (land and sea) mean near-surface temperatures have increased since the 1960s (Figure 3). Last year, 2023, broke many records including the warmest year. The WMO State of the Global Climate report notes that the 10-year period 2014-2023 is likely the warmest 10-year period on record. In the North Atlantic, the anomalies of Atlantic Multidecadal Variability (AMV) have been near-zero or negative since 2013, but temperatures in the North Atlantic have in the last few years increased compared to the rest of the oceans. After a string of three negative (La Niña) December to February seasons, the tropical East Pacific had in early 2024 warm anomalies again (El Niño).

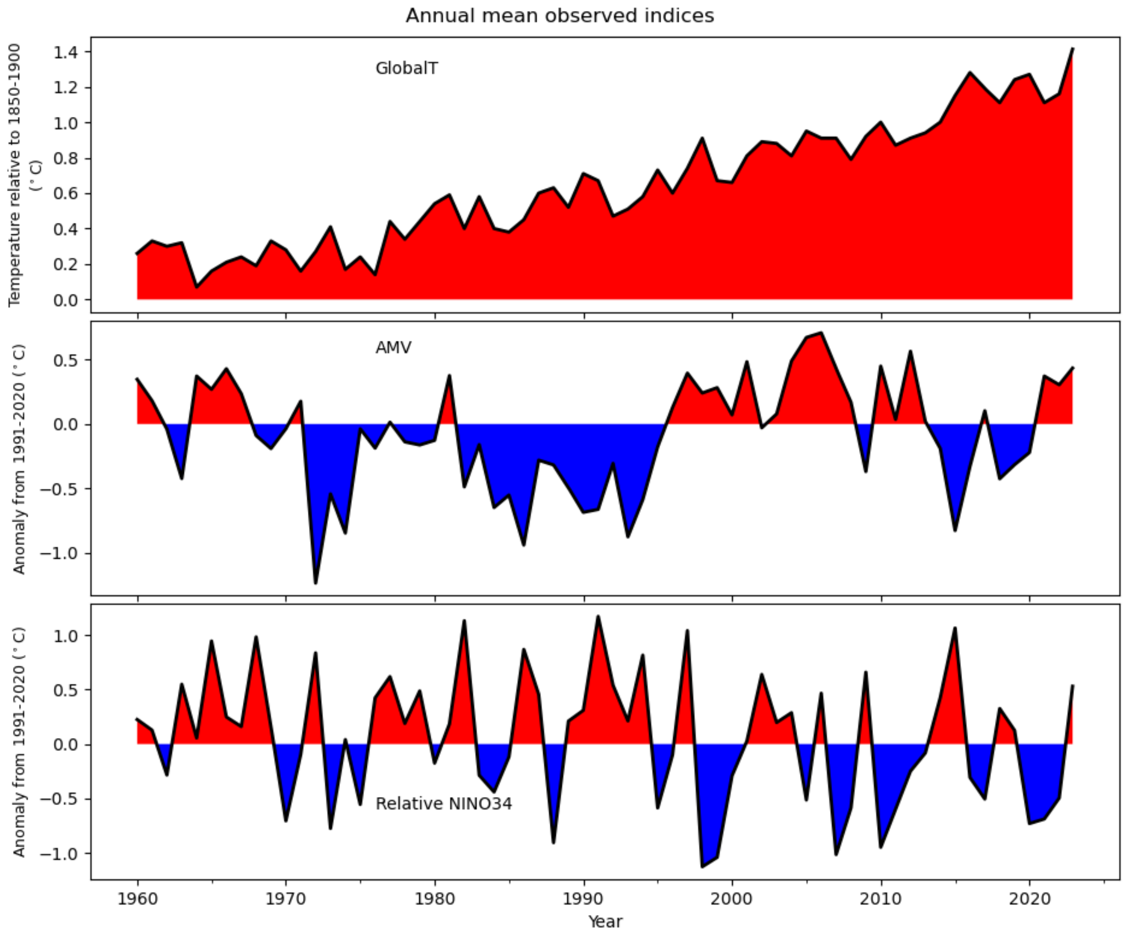


Figure 3: Observed climate indicators. Global annual mean near-surface temperature anomaly (top), annual mean Atlantic Multidecadal Variability (AMV) defined as the difference between two regions: 45°N-60°N,60°W-0°E minus 45°S-0°S, 30°W-10°E as in Roberts et al, 2013 (middle) and December to February Niño 3.4 defined as the average over 5°S-5°N, 170°W-120°W with the tropical average 20°S-20°N removed as in van Oldenborgh et al, 2021 (bottom). Six datasets are used in the calculation of global near-surface temperature and are the same as in the WMO State of Global Climate 2023 report. Anomalies are with respect to 1850-1900. The other two indices are based on 2m temperature from ERA5 as in Figure 1 and anomalies are relative to the 1991-2020 reference period.

Predictions from the WMO Lead Centre

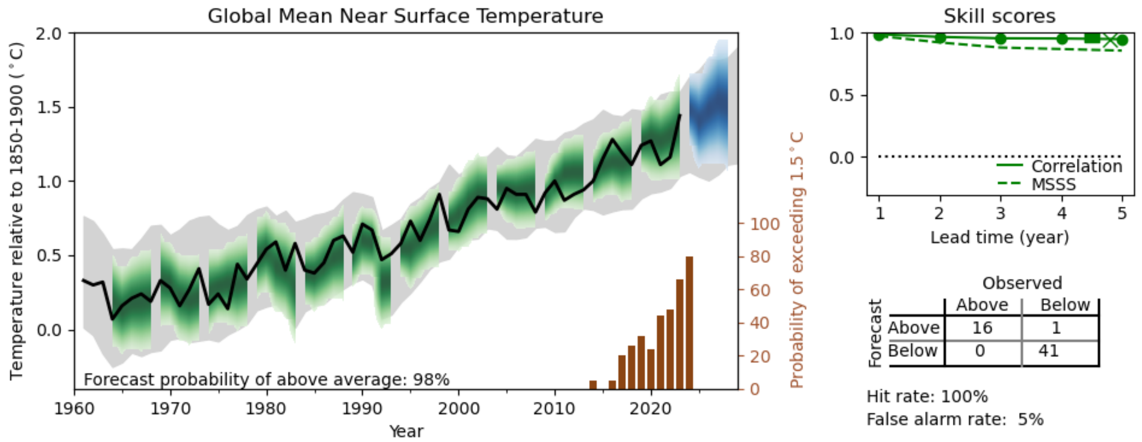
Predictions of climate indices and global fields are obtained from multi-model initialised annual-to-decadal climate predictions contributed to the WMO Lead Centre for Annual to Decadal Climate Prediction. This year there are 190 ensemble members from models contributed by 15 different institutes, including four Global Producing Centres: Barcelona Supercomputer Centre, Canadian Centre for Climate Modelling and Analysis, Deutscher Wetterdienst, and the Met Office. Predictions are started towards the end of 2023. Retrospective forecasts, or hindcasts, covering the period 1960-2018 are used to estimate forecast skill. Also shown for the climate indicators are uninitialised historical simulations and projections from the World Climate Research Programme's Coupled Model Intercomparison Project phase 6 (CMIP6). Please consult the "How to Use the Global Annual to Decadal Climate Update" section of this report for information on forecast confidence and see Hermanson et al (2022) for background information.

Predictions of Global Climate Indicators

Global temperatures are likely to continue at record levels in the five-year period 2024-2028 and stay well above the 1991-2020 reference (Figure 4). Annual mean global near-surface temperature for each year in this five-year period is predicted to be between 1.1°C and 1.9°C (90% confidence interval) higher than the period 1850-1900[1].

The chance of the annual mean global near-surface temperature in 2024-2028 exceeding 1.5°C above 1850-1900 levels for at least one year is 80% and is increasing with time (brown histogram and right-hand axis in Figure 4). It is as likely as not (47% chance) that the five-year mean will exceed this threshold. Note that the 1.5°C level specified in the Paris Agreement refers to long-term warming over 20 years, but temporary exceedances are expected to occur with increasing frequency as global temperatures approach the long-term threshold.

The chance of at least one year exceeding the warmest year on record, 2023, in the next five years is 86%. The chance of the five-year mean for 2024-2028 being higher than the last five years is 90%. Confidence in forecasts of global mean temperature is high since hindcasts show very high skill in all measures (right-hand panels of Figure 4).



[1] The difference between this period and the 1991-2020 reference is estimated as 0.88°C, but this difference is uncertain due to the incomplete observational network in the 19th century.

Figure 4: Multi-annual predictions of global mean near-surface temperature relative to 1850-1900. Annual global mean observations (see Figure 3) in black, forecast in blue, hindcasts in green. The extent of shading indicates the 90% confidence interval, with the intensity of shading indicating the level of likelihood at the indicated anomaly value. The grey shading shows the 90% confidence interval of unininitialised simulations, indicating the degree to which forecasts reduce the uncertainty compared to climate projections. The calibrated probability for above average (compared to 1991-2020) of the five-year-mean forecast is given at the bottom of the main panel. Hindcast skill scores are shown in the upper right panel; the square and the cross show the correlation skill and Mean Square Skill Score (MSSS) for five-year means, respectively. Statistically significant correlation skill (at the 5% confidence level) is indicated by solid circles/square. The contingency table for the prediction of above-average five-year means (compared to 1991-2020) is shown in the bottom right panel. Also inset in the main panel, in brown, referring to the right hand axis, is the probability of global temperature exceeding 1.5°C above 1850-1900 levels for at least one of the five following years, starting from the year indicated. This probability is calculated as in Smith et al (2018) by counting the proportion of ensemble members that predict at least one year above 1.5°C.

Predictions indicate an 84% calibrated probability (Bett et al, 2022) that Atlantic Multidecadal Variability (AMV) will be positive when averaged over the next five years (Figure 5). The hindcasts have medium skill in both measures and a medium hit rate, giving medium confidence in this prediction. The North Atlantic subpolar gyre, the main centre of action of the AMV, has had near-zero anomalies in the last five years (Figure 1). The predictions from different centres for the next five years vary between returning to cool temperatures to warming of the region (individual centre contributions can be [seen on the website](#)). This lack of agreement further reduces our confidence in the predictions for the AMV. Predictions for the Atlantic Meridional Overturning Circulation (AMOC), which is related to AMV and shows a decline, can be found in the Appendix.

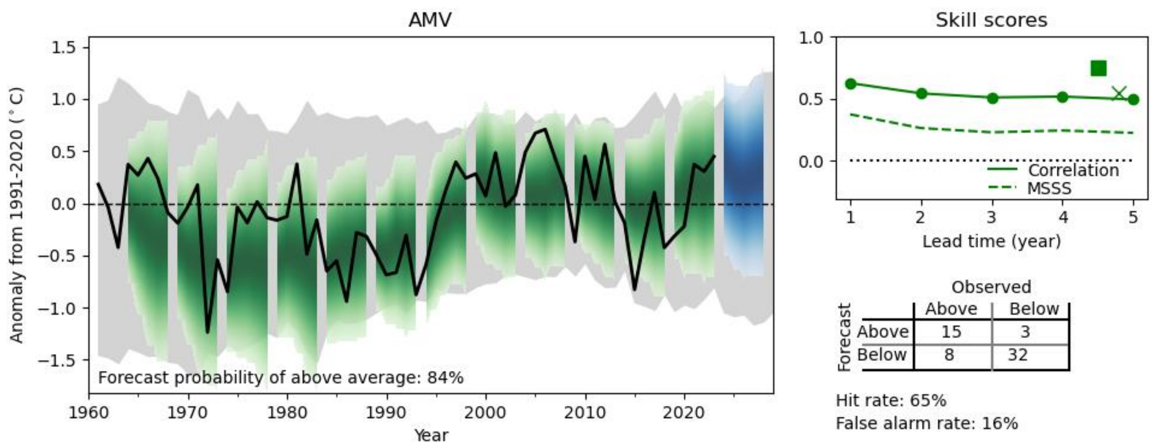


Figure 5: Multi-annual predictions of Atlantic Multidecadal Variability (AMV) relative to its 1991-2020 average, defined as the anomaly difference between two regions: 45°N-60°N, 60°W-0°E minus 45°S-0°S, 30°W-10°E as in Roberts et al (2013). Annual mean observations (see Figure 3) in black, forecast in blue, hindcasts in green. The extent of shading indicates the 90% confidence interval, with the intensity of shading indicating the level of likelihood at the indicated anomaly value. The grey shading shows the 90% confidence interval of unininitialised simulations, indicating the degree to which forecasts reduce the uncertainty compared to projections. The calibrated probability (as in Bett et al, 2022) for the most likely category (above or below climatology) of the five-year-mean forecast is given at the bottom of the main panel. Hindcast skill scores are shown in the upper right panel; the square and the cross show the correlation skill and Mean Square Skill Score (MSSS) for five-year means, respectively. Statistically significant correlation skill (at the 5% confidence level) is indicated by solid circles/square. The contingency table for the prediction of above/below average five year means is shown in the bottom right panel.

This year, 2024, started with El Niño conditions in the tropical East Pacific. This El Niño is predicted to decline, and the multi-model ensemble-mean temperature anomalies in the Niño 3.4 region are predicted to be negative for December 2024 – February 2025, indicating the onset of La Niña. There is a large ensemble spread (±0.5 ˚C) and skill is medium for year 1 (Figure 6). The five-year average temperature in the Niño 3.4 region relative to the whole tropics has a 69% calibrated probability of being below average. Skill is medium, giving medium confidence in this forecast.

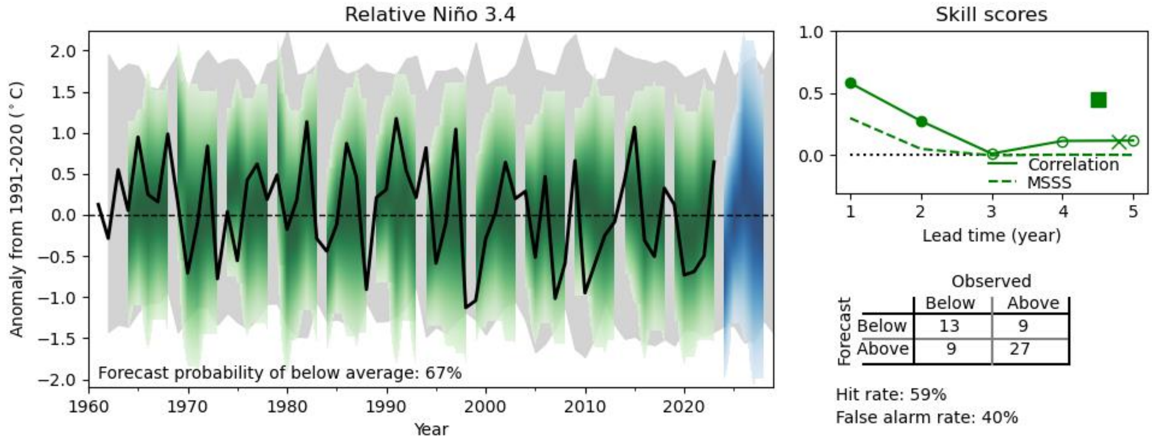


Figure 6: As Figure 5, but for December-February averaged Niño 3.4 relative to the tropical mean defined as the average over 5°S-5°N, 170°W-120°W with average over 20°S-20°N removed. This index is suitable for a warming climate (van Oldenborgh et al, 2021).

Regional Predictions for 2024

Near-surface temperatures in 2024 are likely to be higher than the 1991-2020 average in almost all regions across the globe except for parts of the South Pacific, Southern Ocean, and South Atlantic, where models disagree on the sign of the anomaly (stippled, Figure 7). Skill is estimated from hindcasts to be medium or high in most regions (Figure 8) giving medium to high confidence in the forecast.

Sea-level pressure forecasts suggest low anomalies in the Aleutian region and Antarctica and high anomalies over the South Atlantic, and west tropical and South Pacific. The skill is medium, giving medium confidence in this prediction. The pattern of low pressure over Antarctica and high pressure over the southern hemisphere mid-latitudes is consistent with a positive Antarctic Oscillation index (see also Figure 21). There is medium to low skill for these regions giving medium to low confidence.

Precipitation patterns suggest an increased chance of drier conditions over North-East Brazil and an increased chance of wetter conditions in the African Sahel due to a northward shifted Intertropical Converge Zone (ITCZ) in the Atlantic, possibly due to the relatively warm North Atlantic. Northern high latitudes are likely to have above average precipitation as expected from climate change. Western Australia is likely to be drier than usual. Correlation skill for precipitation in hindcasts is low despite being significant in these regions, giving low confidence in the forecast.

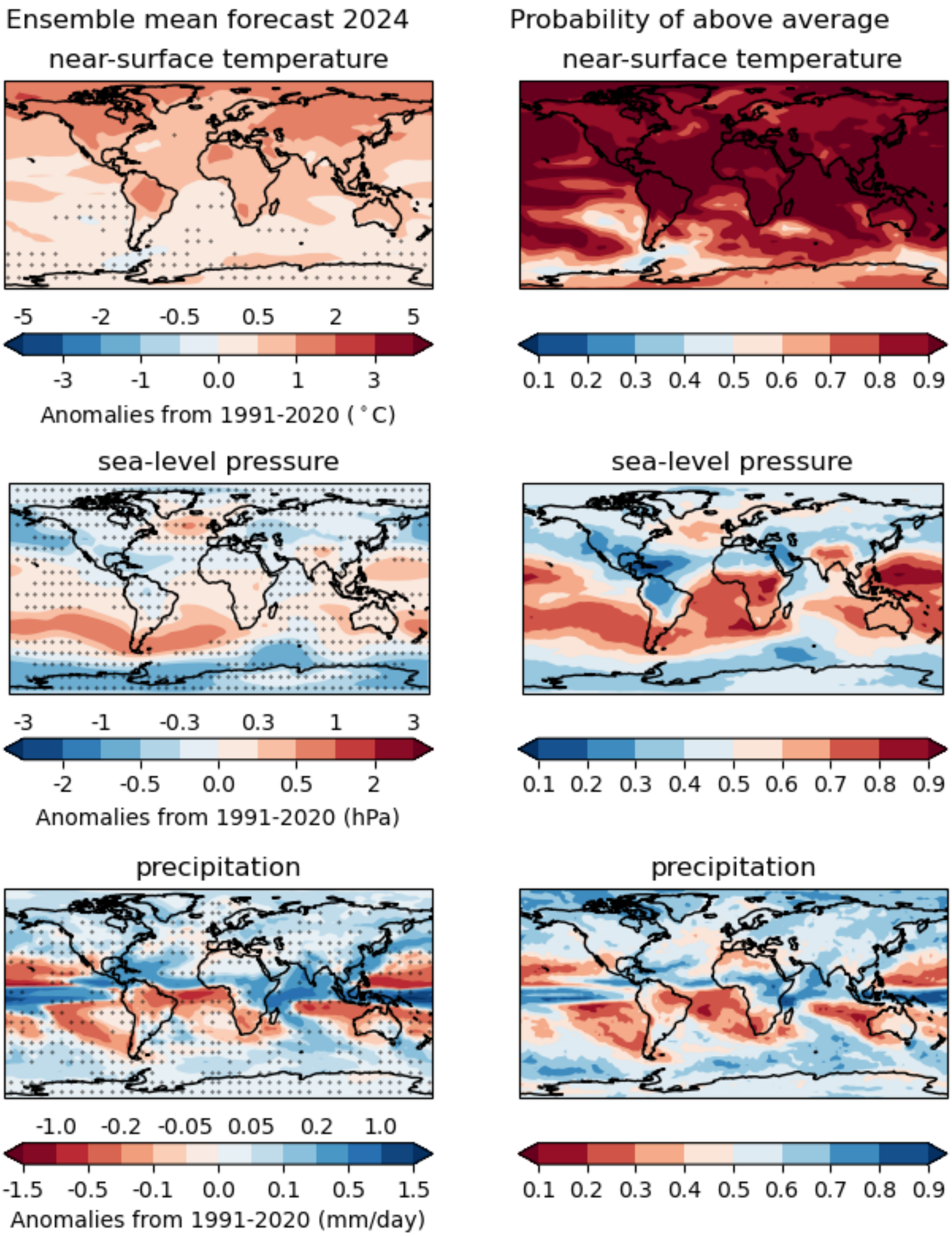


Figure 7: Annual mean anomaly predictions for 2024 relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day), stippled where more than 1/3 of models disagree on the sign of the anomaly, and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

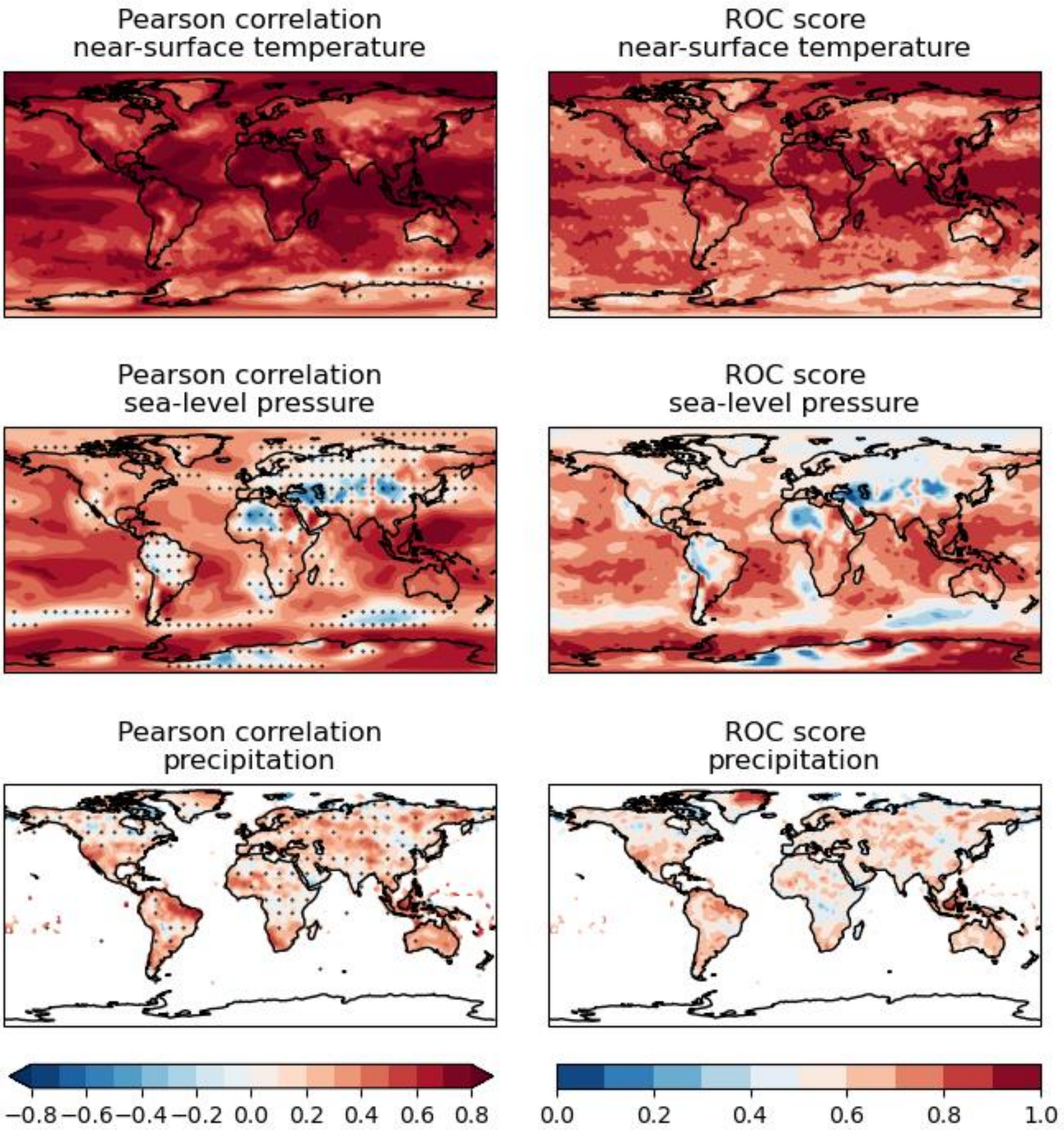


Figure 8: Prediction skill of annual means evaluated using hindcast experiments. Pearson correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is insignificant (at the 5% level).

Regional Predictions for 2024-2028

This section shows predictions for the average of the next five extended seasons for May to September and November to March.

For the May to September average, predicted temperature patterns over the years 2024-2028 show a high probability of temperatures above the 1991-2020 average almost everywhere, with enhanced warming over land in the northern hemisphere (Figure 9). Skill is very high in most regions, giving high confidence in this prediction (Figure 10).

For the same season, sea-level pressure is predicted to be anomalously low over the Mediterranean and surrounding countries, and high over the South Pacific and the mid-latitudes of the other oceans in the southern hemisphere. There is low to medium skill for most of these regions, giving low to medium confidence. Forecasts for negative pressure over the Mediterranean have not verified correctly in previous forecasts (Figures 16 & 17). Predictions of precipitation show wet anomalies in the Sahel, northern Europe, Alaska and northern Siberia, and dry anomalies for this season over the Amazon and western Australia. Skill is low to medium for these regions, giving low to medium confidence.

In the North Atlantic, the warm anomalies, low pressure, and positive precipitation anomaly suggest an increased chance of active tropical cyclone seasons over the next five years. This is also indicated by the high probability of above average AMV (Figure 5) and similar anomalies for 2024 (Figure 7). There is medium confidence in this prediction.

For the November to March average over the years 2024/25-2028/29 (Figure 11), the predictions show warm anomalies are likely almost everywhere, with land temperatures showing larger anomalies than those over the ocean. The Arctic (north of 60°N) near-surface temperature anomaly is more than three times as large as the global mean anomaly. The North Atlantic subpolar gyre, the location of the so-called warming hole, which has been linked to a reduction in the AMOC and changes to regional winds, is an area where the models disagree on the sign of the anomaly. Skill is high in most regions apart from parts of the North Pacific, some areas in Asia, Australia, and the Southern Ocean (Figure 12), giving medium to high confidence.

There will likely be a positive pressure anomaly over the tropical Pacific. This is consistent with a predicted increased chance of a positive Antarctic Oscillation / Southern Annual Mode (Figure 21). There is medium skill over the tropical Pacific, so confidence is medium for this prediction.

Precipitation predictions favour wetter than average conditions at high latitudes in the northern hemisphere for the next five extended winter seasons (November to March). The pattern of increased precipitation in the tropics and high latitudes and reduced precipitation in the subtropics, particularly in the southern hemisphere, compared to the 1991-2020 reference period is consistent with the climate warming. Skill is moderate over large parts of northern Eurasia, Greenland, and the Canadian Arctic Archipelago giving low to medium confidence in the forecast for an increased chance of precipitation in these regions.

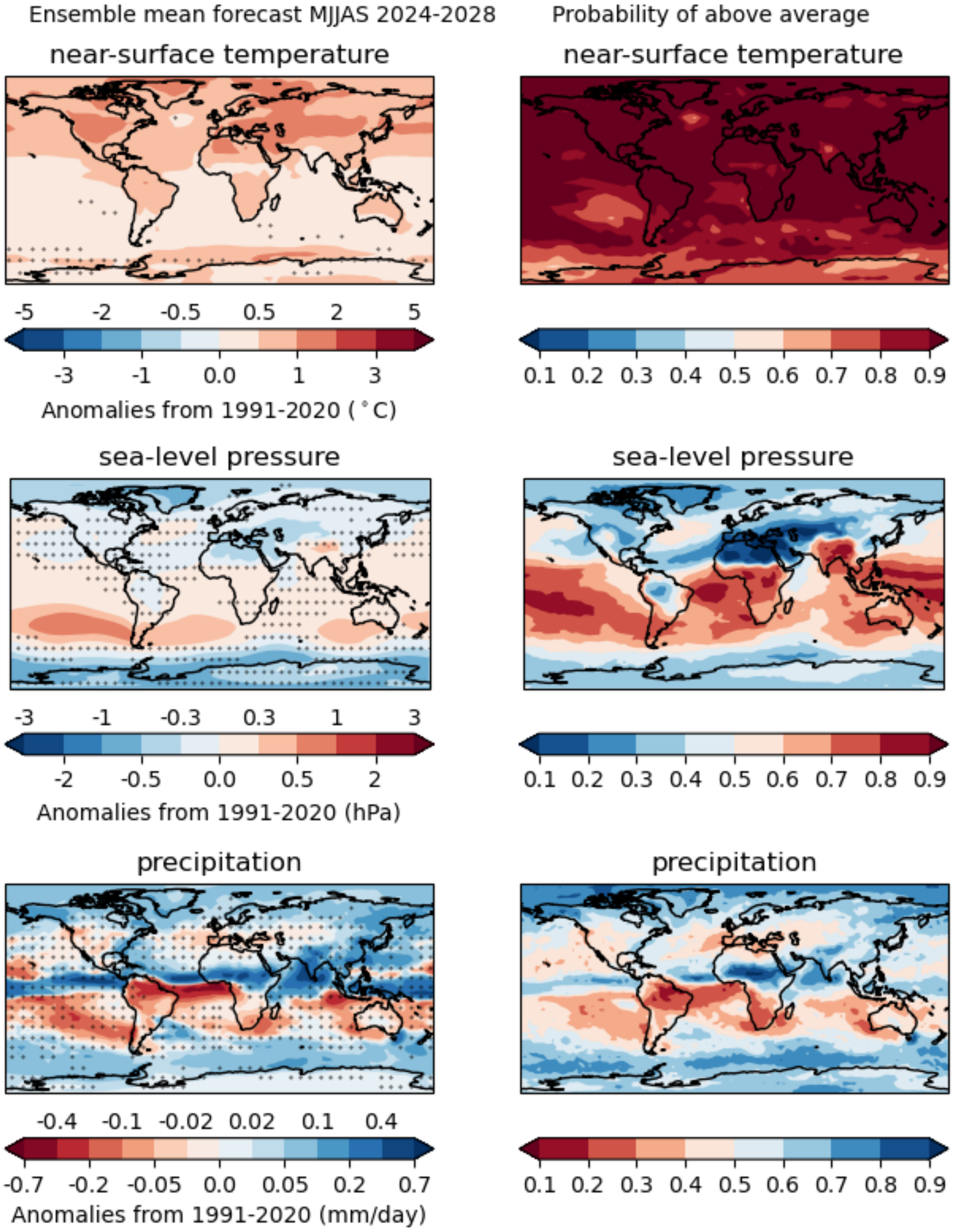


Figure 9: Predictions for 2024-2028 May to September anomalies relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day), stippled where more than 1/3 of models disagree on the sign of the anomaly, and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

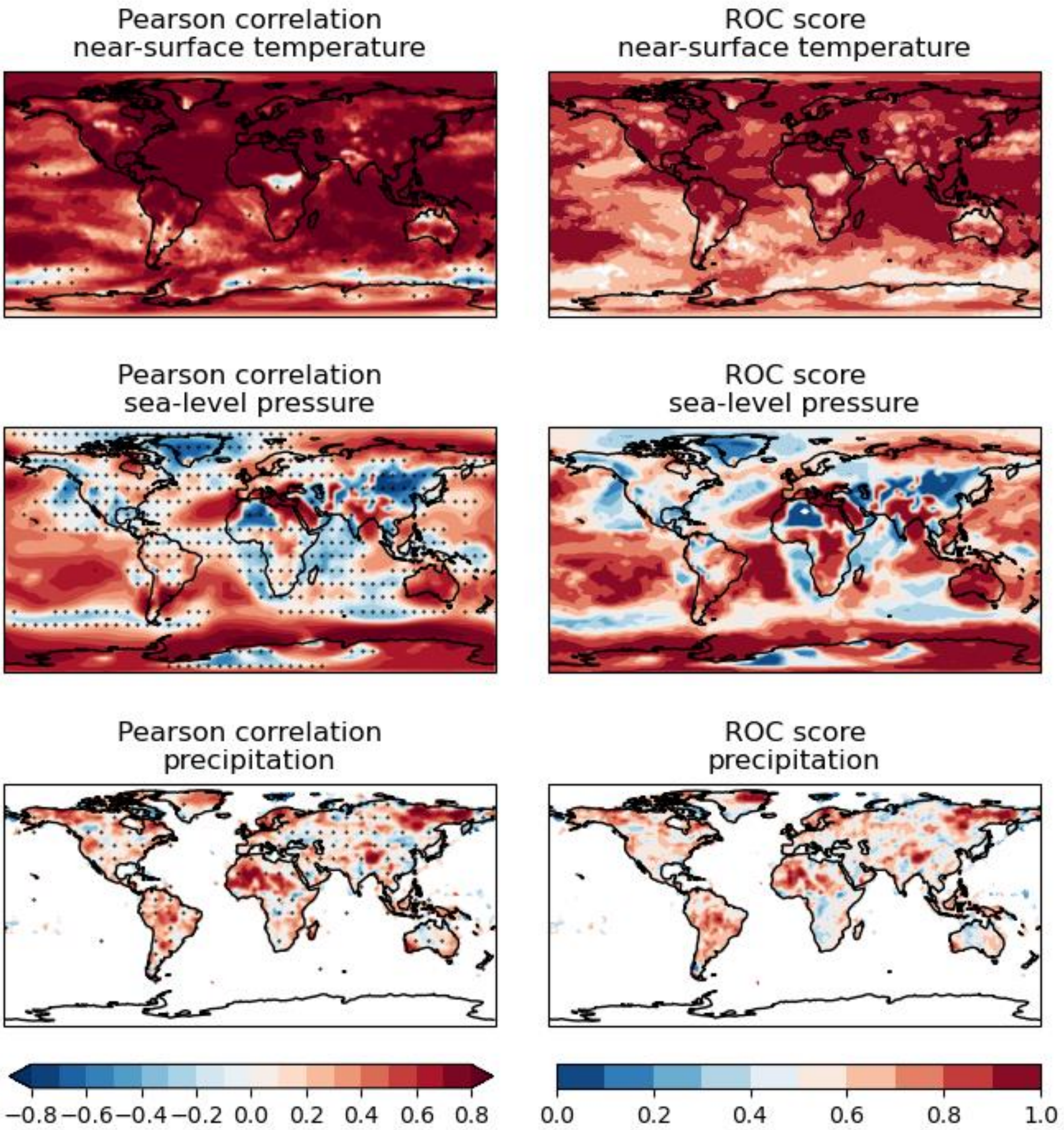


Figure 10: Prediction skill of five-year mean May to September anomalies evaluated using hindcast experiments. Pearson correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

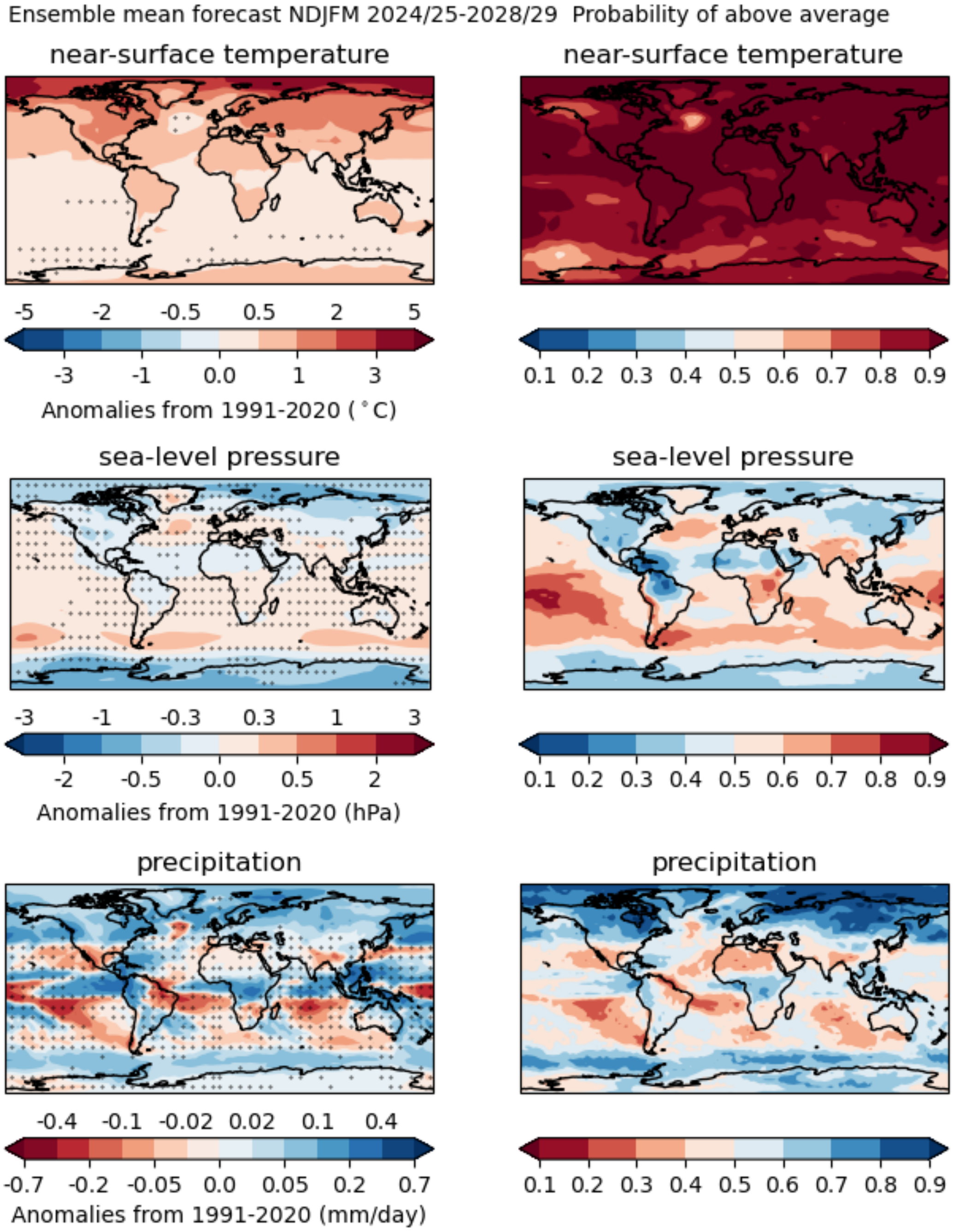


Figure 11: Predictions for 2024/2025-2028/2029 November to March anomalies relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day), stippled where more than 1/3 of models disagree on the sign of the anomaly, and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

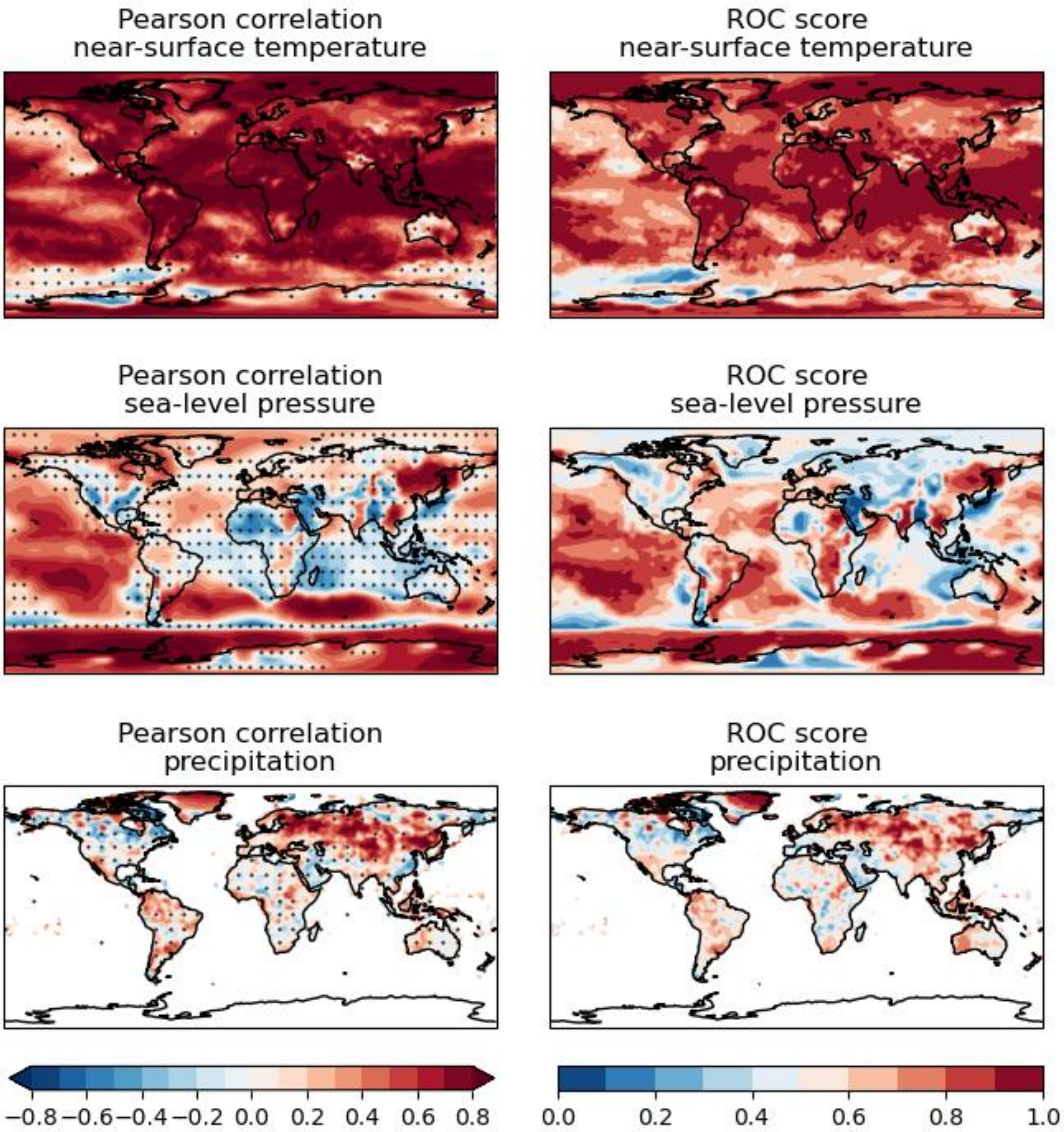


Figure 12: Prediction skill of five-year means November to March anomalies evaluated using hindcast experiments. Correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

Regional Forecast Indices

This section shows a regional forecast index based on notable forecast signals found in the previous section and where there is skill in the multi-model ensemble. The full set of regional forecasts and hindcasts can be found on the website on the "Regional" tab. The regions are based on the WMO Regional Climate Outlook Forums (RCOFs) and Regional Associations. The season used for the indices is the relevant season for that region, usually the wet season or monsoon season.

The Sudano-Sahelian Outlook Forum (PRESASS) region has seen a positive trend in July-September precipitation since the early 2000s. Following recent high rainfall years, 2023 had near-average rainfall. For 2024-2028, the rainfall is predicted to be above average with a 77% probability (Figure 13). Skill is medium, so giving medium confidence for this prediction.

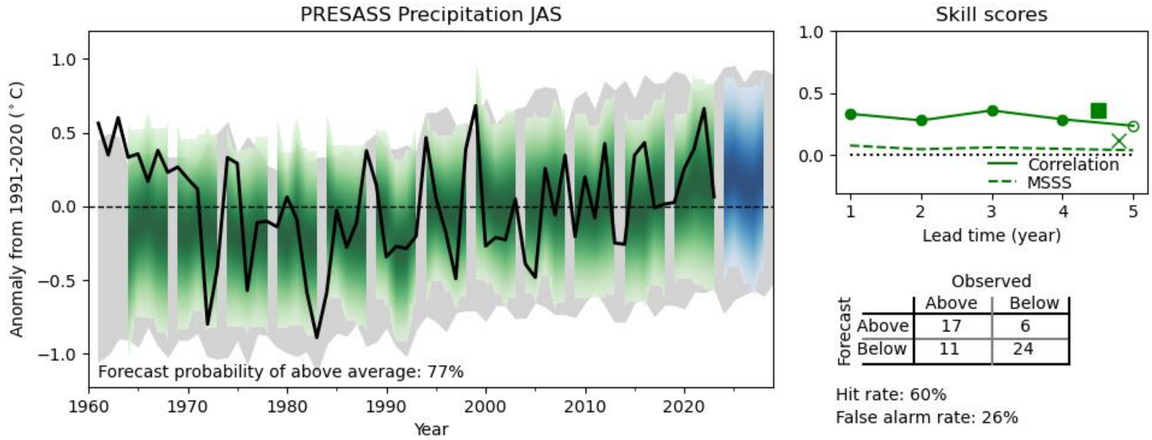


Figure 13: As Figure 5, but for July to September (JAS) averaged precipitation over the Sudano-Sahelian (PRESASS) region.

Sea-ice Forecasts

This year, for the first time, sea-ice concentration maps are shown (under the "Forecasts" tab) and sea-ice extent timeseries (under the "Timeseries" tab) on the website. Although there is a wide range of mean states and forecast skill, the multi-model ensemble mean is skilful, and these forecasts are issued to stimulate conversations to further improve this aspect of annual-to-decadal predictions.

The sea-ice concentration anomalies (Figure 14) for the Arctic in March (the time of maximum ice extent) show large predicted reductions for 2024-2028 in the Barents Sea, Bering Sea, and Sea of Okhotsk. There is also model agreement for reductions in the Greenland Sea and Labrador Sea. Skill is high in the North Atlantic and medium in the Pacific for these predictions (Figure 15). For Arctic sea-ice in September (minimum extent) 2024-2028, large reductions are predicted for all regions that normally have sea-ice at this time of year. There is high skill in predicting anomalies at the sea-ice edge, so there is high confidence for these reductions, except in the Arctic Archipelago where there is low confidence.

For Antarctic September (maximum extent) the predictions show a high probability of below normal sea-ice along the climatological sea-ice edge. Correlation skill is medium and the ROC score is low-to-medium so there is low-to-medium confidence in this prediction. Many models have unrealistically low sea-ice in Antarctica in March and so there is little model agreement on anomalies (stippling).

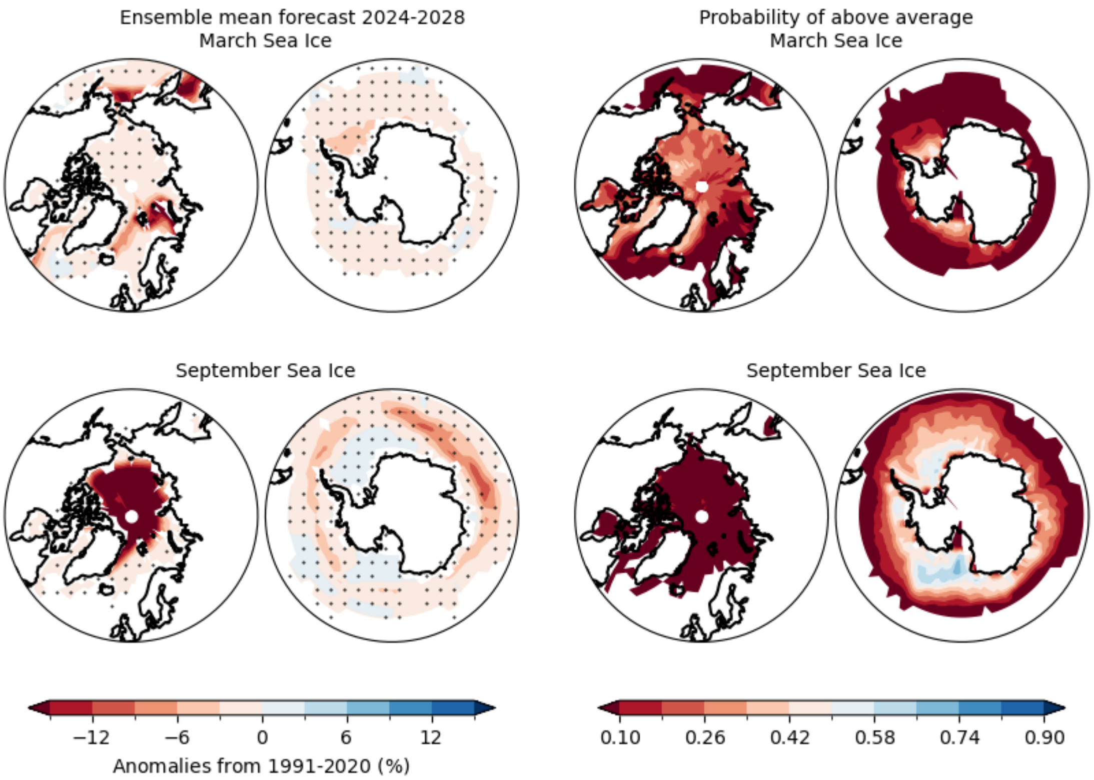


Figure 14: Predictions for 2024-2028 March and September sea-ice concentration anomalies relative to 1991-2020. Ensemble mean (left column) for March (top, %) and September (bottom, %), stippled where more than 1/3 of models disagree on the sign of the anomaly, and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

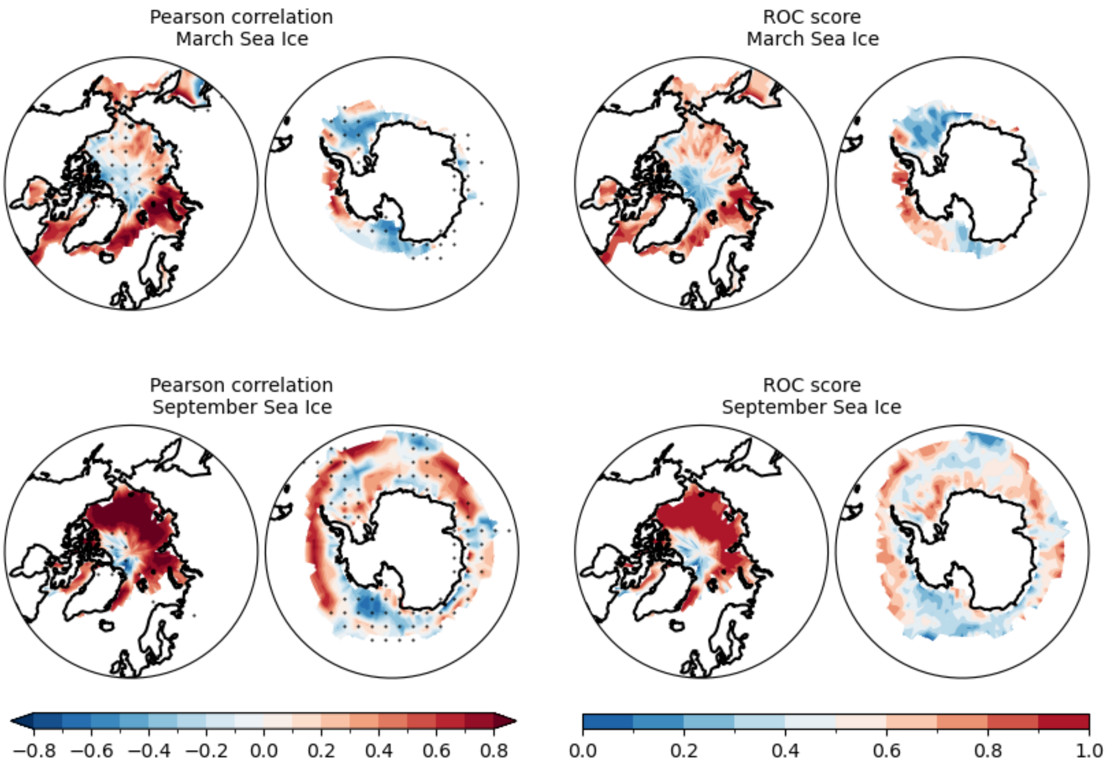


Figure 15: Prediction skill of five-year means of March and September sea-ice anomalies evaluated using hindcast experiments. Correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

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Evaluation of Previous Forecasts

This section assesses forecasts that were issued in real time for the most recent completed one- and five-year periods. The forecast for 2023, which was produced using simulations initialised at the end of 2022, is shown in Figure 16. Stippling in the right-hand panels indicates where observations are outside the predicted 90% confidence interval for a distribution fitted to the individual model ensemble means. For near-surface temperatures, the anomalies were underestimated in all models for many regions including the eastern North Atlantic, tropical East Pacific, western Europe, northwestern Africa, and the Weddell Sea. Cold anomalies in Scandinavia were not captured.

Sea-level pressure patterns agree reasonably well with the observations with anomalously low pressure over the Arctic and Antarctic and anomalously high pressure over much of the Pacific and Southern Ocean. However, the predicted anomalies are systematically too small and the confidence interval does not encompass the observed magnitude in most regions. Sea-level pressure anomalies in the North Atlantic were not captured.

The ensemble mean predictions of precipitation captured the correct sign of anomalies in many regions, including wetter conditions in central Europe, and drier conditions in Central America, the western Mediterranean and southern Australia. Despite this, the confidence interval did not encompass the observed values in most regions.

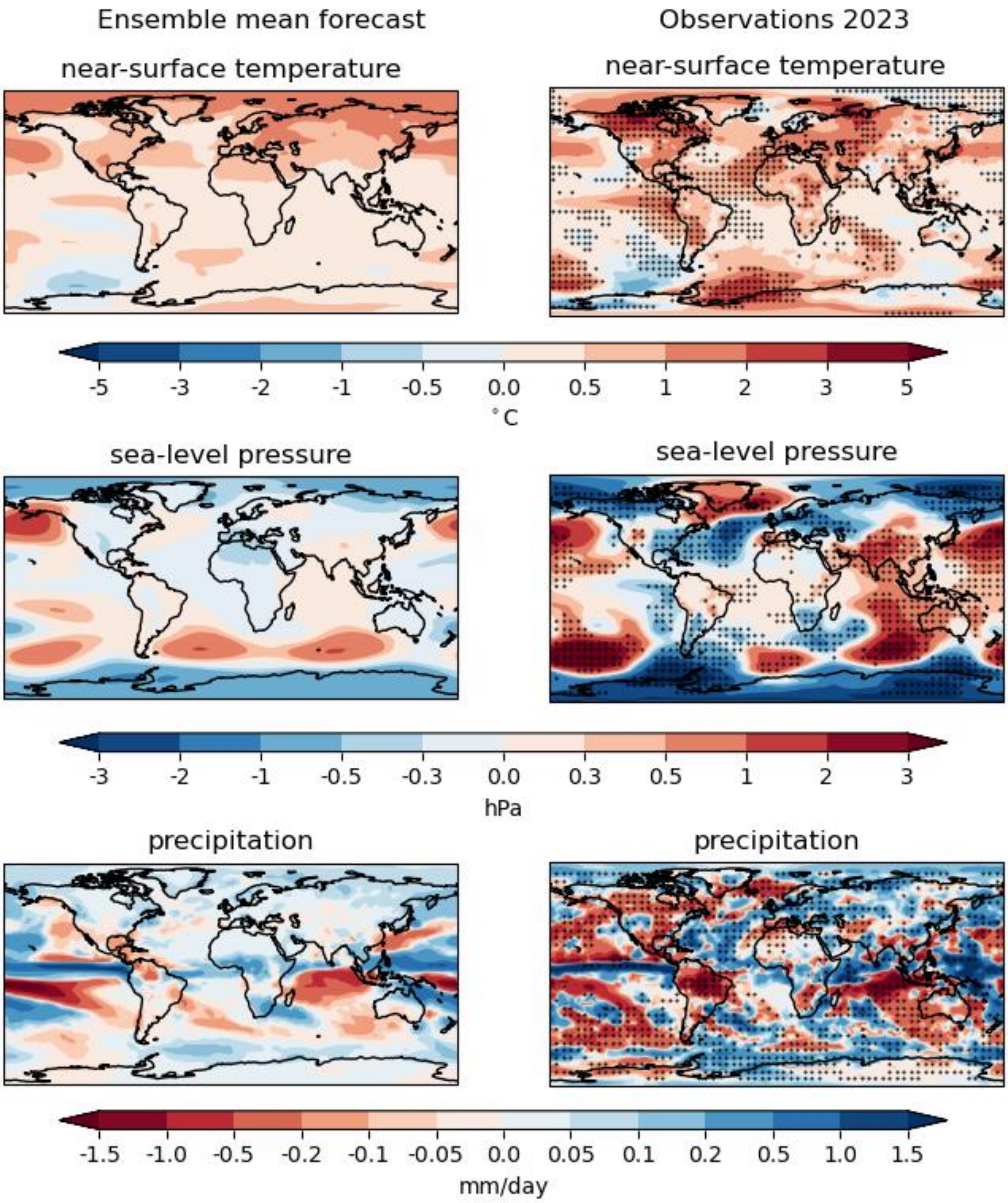

Figure 16: Evaluation of the one-year forecast for 2023 relative to 1991-2020. Ensemble mean forecast (left) and observed (right) anomalies. Top: temperature (°C); middle: sea level pressure (hPa); bottom: precipitation (mm/day). Stippling shows where the observations fall outside of the 90% range of the ensemble means of the forecast models. Observations are from the same sources as in Figure 1.

Average forecast temperature anomalies for the last five years 2019-2023 (from forecasts initialised at the end of 2018 relative to 1971-2000, Figure 17), generally agree well with observations of very warm conditions over the Arctic and Eurasia, and enhanced warming over the land compared to the ocean, especially in the northern hemisphere. However, the magnitude of warm anomalies in the Middle East and Siberia were underestimated. Relatively cool conditions in the northern North Atlantic, South Pacific and Southern Ocean were mostly captured within the confidence interval, though cool conditions in the eastern tropical Pacific and the interior plains of Canada were not captured.

Sea-level pressure patterns show reasonable agreement with the observations, with lower-than-average pressure over the Arctic and Antarctic and higher than average pressure over most ocean regions. However, as with the one-year prediction evaluated above, the forecast anomalies are often too small and the observations are outside the forecast range for the model ensemble means in many regions even when the multi-model ensemble mean shows the correct sign. Lower than average pressure over the Indian Ocean and higher than average pressure over parts of north and south America were not captured by the ensemble range.

Precipitation patterns over land show reasonable agreement with observations, including wetter than usual conditions across much of Asia and central Africa, and drier than usual conditions in southern Africa. Drier than normal conditions in western Canada, southern South America and western Europe were not captured.

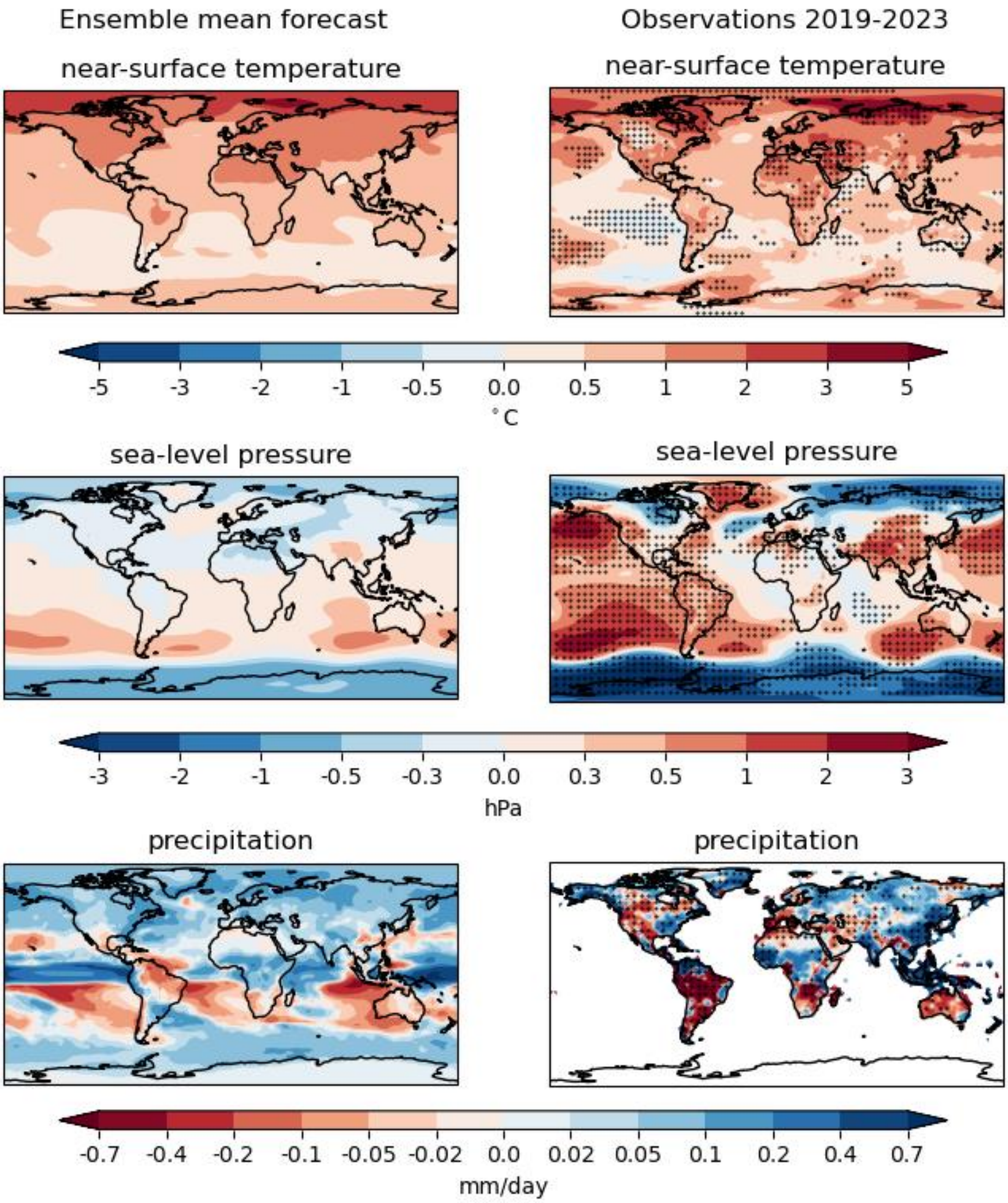

Figure 17: Evaluation of the five-year forecast for 2019-2023 relative to 1971-2000 (this was the forecast climatology at the time of issue). Ensemble mean forecast (left) and observed (right) anomalies. Top: temperature (°C); middle: sea level pressure (hPa); bottom: precipitation (mm/day). Stippling shows where the observations fall outside of the 90% range of the ensemble means of the forecast models. Observations are from the same sources as in Figure 1.

How to Use the Global Annual to Decadal Climate Update

The forecasts shown here are intended as guidance for Regional Climate Centres (RCCs), Regional Climate Outlook Forums (RCOFs) and National Meteorological and Hydrological Services (NMHSs). It does not constitute an official forecast for any region or nation, but RCCs, RCOFs and NMHSs are encouraged to appropriately interpret and develop value-added forecasts from this Climate Update.

Where the ensemble mean is shown, this only shows the most likely outcome. Other outcomes are possible and may be almost as likely. Signals with small spatial extent are likely unreliable and will likely have lower skill. See also Hermanson et al (2022) for more information.

The skill of interannual to decadal forecasts is different to that of weather and seasonal timescales and skill may vary considerably with region and season. It is important to view the forecast maps together with the skill maps provided to evaluate the confidence in a prediction. Skill and therefore the confidence in a forecast is evaluated from hindcasts. Note that skill of predictions from a given initial climate state may differ from average skill estimated over many different cases. Correlation skill is classified into five categories: very low (below 0.2, but still significant), low (between 0.2-0.4), medium (between 0.4-0.6), high (between 0.6-0.8) and very high (0.8 and higher).

Appendix – predictions for other indices

Predictions of Atlantic Meridional Overturning Circulation (AMOC) are important for the climate of countries surrounding the North Atlantic and for global heat transport. The AMOC has been measured at 26°N since 2004. The forecast shows reduced overturning in the North Atlantic tropics and mid-latitudes for 2024 (Figure 18, top row). It appears to indicate reduced deep-water formation, which would lead to a weaker AMOC, but skill cannot be evaluated due to insufficient observations, which only exist for particular locations.

The AMOC prediction for 2024-2028 (Figure 18, bottom row) shows anomalously low values in the ensemble mean below 1000m throughout the Atlantic basin, particularly in the northern hemisphere mid-latitudes. There is large variability in the ensemble (individual models are shown on the WMO Lead Centre for Annual to Decadal Climate Prediction web page, www.wmolc-adcp.org). Confidence is low as there are insufficient observations to evaluate skill.

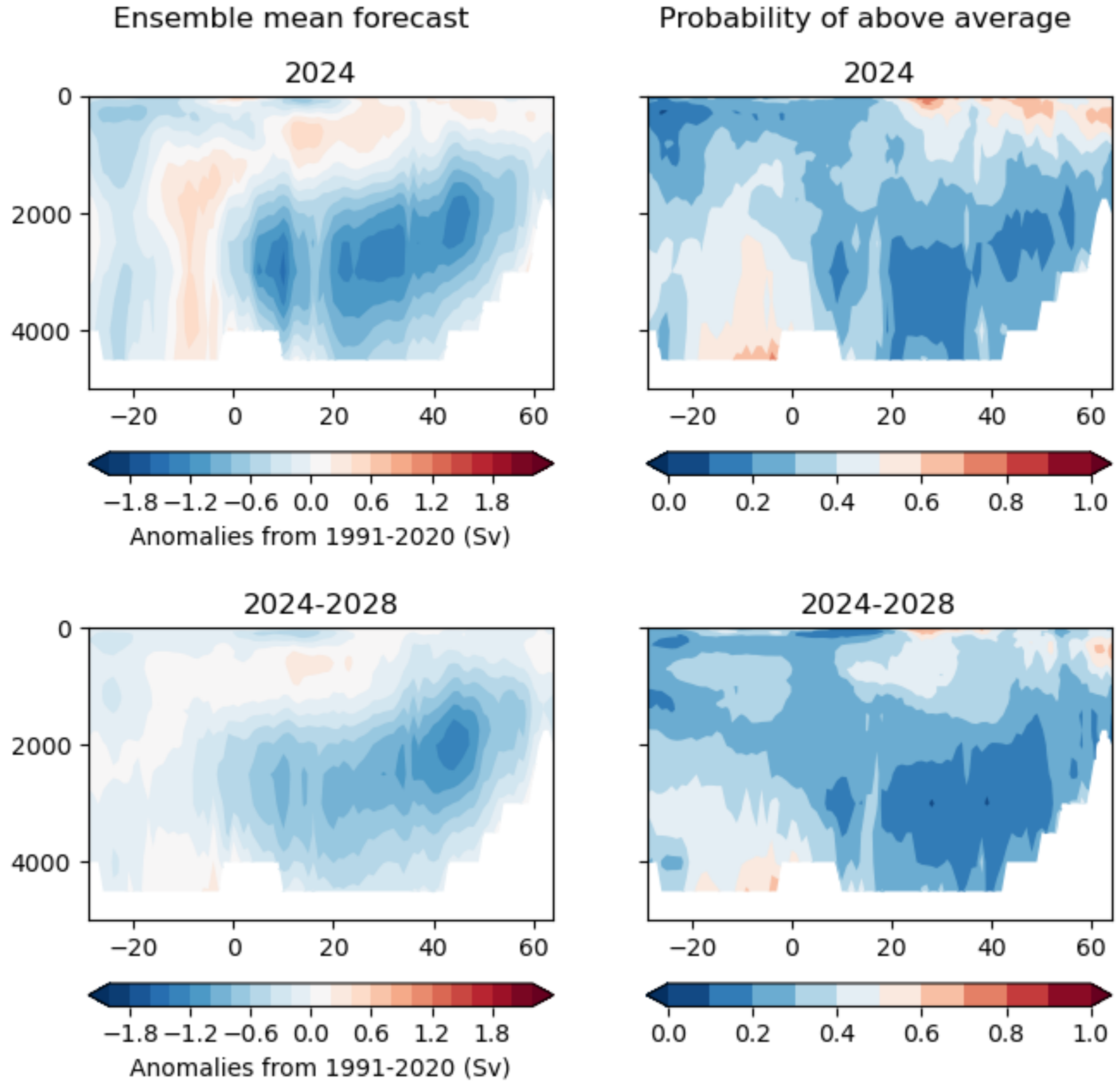

Figure 18: Atlantic Meridional Overturning Circulation (AMOC) forecast for 2024 (first row) and 2024-2028 (second row) relative to 1991-2020. The left column shows the ensemble mean prediction and the right column shows the probability of a stronger than average AMOC. As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

The AMOC close to 30°N is predicted to be near or slightly below recent observed values (Figure 19). After a stable period since the strong decline observed during the 2000s, the AMOC is predicted to decline at a rate similar to climate projections. However, confidence in this forecast is low because there are insufficient past observations to evaluate skill.

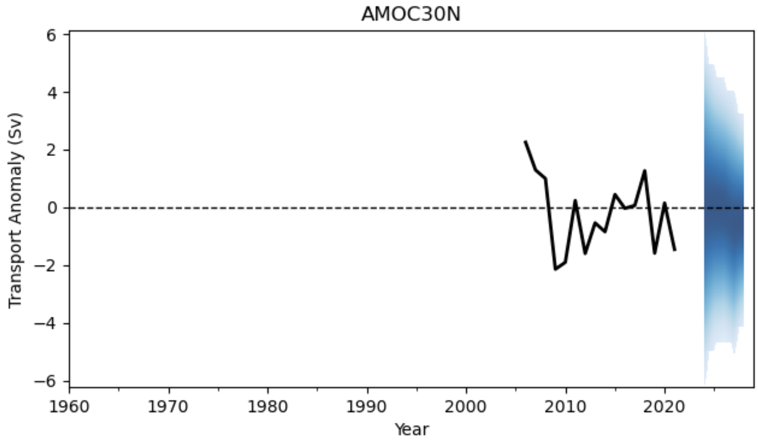

Figure 19: Atlantic Meridional Overturning Circulation close to 30°N and 1100m as in Roberts et al (2013). RAPID observations (26°N) in black (anomalies relative to its full time series 2005-2020) and model forecast in blue.

A positive phase of Pacific Decadal Variability (PDV) is characterised by warm anomalies in the tropical eastern Pacific and cold anomalies in the central North Pacific. Predictions for 2024 and the next five years show warming in both these regions and therefore do not show a typical PDV pattern. Nevertheless, the PDV index used here is predicted to be negative during 2024-2028 with an 81% calibrated probability (Figure 20).

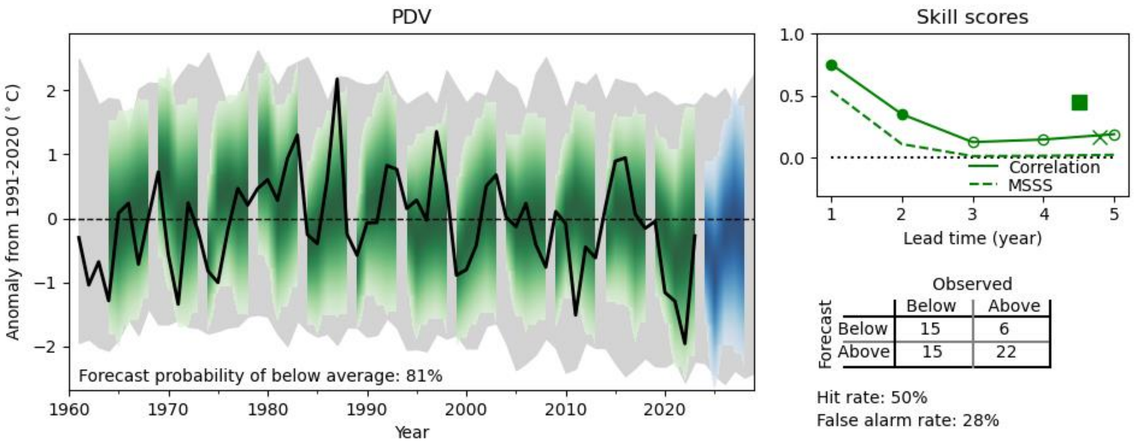

Figure 20: As Figure 5, but for Pacific Decadal Variability (PDV) defined as the difference in SST between the eastern tropical Pacific (10°S-6°N, 110°W-160°W) and the North Pacific (30°N-45°N, 145°W-180°W) as in Dong et al (2014).

The recent strong Antarctic Oscillation (AAO) or Southern Annual Mode (SAM) is predicted to remain above average (Figure 21). The calibrated probability of above average for 2024-2028 is 72%. Although skill is medium for individual years and high for the next five years, the hindcasts (green) underestimate the strengthening in the five years and the forecast (blue) is lower than recent observations leading to less confidence in the prediction.

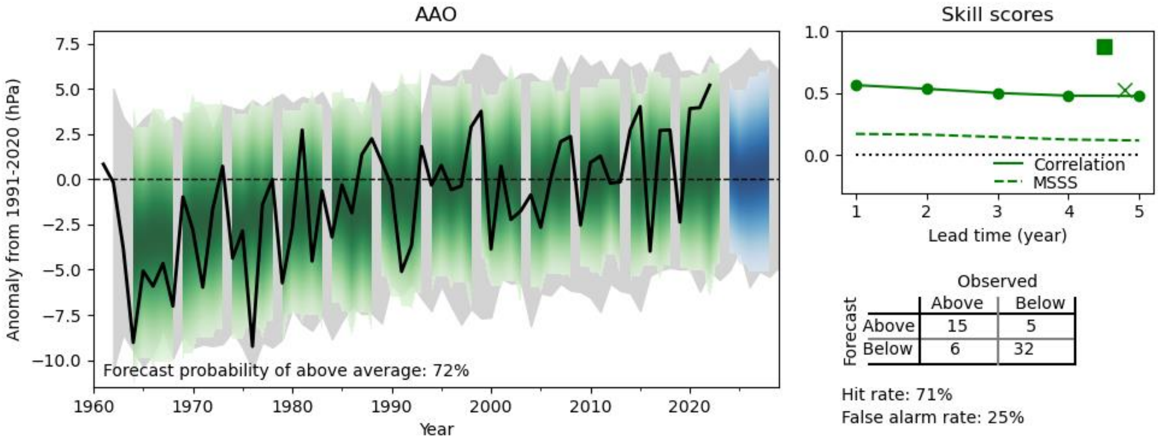

Figure 21: As Figure 5, but for the Antarctic Oscillation (AAO) defined as the difference in November to March mean zonal mean sea-level pressure between 65°S and 40°S as in Gong & Wang (1999).

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