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WMO Global Annual to Decadal Climate Update

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Global Annual to Decadal Climate Update

Target years: 2022 and 2022-2026

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 2022-2026. Latest predictions suggest that:

- The annual mean global near-surface temperature for each year between 2022 and 2026 is predicted to be between 1.1°C and 1.7°C higher than preindustrial levels (the average over years 1850-1900).
- The chance of global near-surface temperature exceeding 1.5°C above preindustrial levels at least one year between 2022 and 2026 is about as likely as not (48%). There is only a small chance (10%) of the five-year mean exceeding this threshold.
- The chance of at least one year between 2022 and 2026 exceeding the warmest year on record, 2016, is 93%. The chance of the five-year mean for 2022-2026 being higher than the last five years (2017-2021) is also 93%.
- There is no signal for the El Niño Southern Oscillation for December-February 2022/23, but the Southern Oscillation index is predicted to be positive in 2022.
- The Arctic temperature anomaly, compared to the 1991-2020 average, is predicted to be more than three times as large as the global mean anomaly when averaged over the next five northern hemisphere extended winters.
- Predicted precipitation patterns for 2022 compared to the 1991-2020 average suggest an increased chance of drier conditions over southwestern Europe and southwestern North America, and wetter conditions in northern Europe, the Sahel, north-east Brazil, and Australia.
- Predicted precipitation patterns for the May to September 2022-2026 average, compared to the 1991-2020 average, suggest an increased chance of wetter conditions in the Sahel, northern Europe, Alaska and northern Siberia, and drier conditions over the Amazon.
- Predicted precipitation patterns for the November to March 2022/23-2026/27 average, compared to the 1991-2020 average, suggest increased precipitation in the tropics and reduced precipitation in the subtropics, consistent with the patterns expected from climate warming.

Current Observations

This section is a short 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 2021 were warmer, but there were also some colder regions, compared to the long-period average. The pattern was dominated by a colder tropical East Pacific, consistent with La Niña conditions, and warmer anomalies in north-eastern North America, the Arctic, north Africa, and the Middle East. Over 2017-2021 the anomalies were largely positive. Warm anomalies were greatest at high latitudes in the Northern Hemisphere, especially the Arctic, and generally larger over land than ocean. In 2021 and in the last five years, sea-level pressure was anomalously low over Antarctica. In 2021, the Aleutian Low was anomalously weak, as expected for La Niña. This was also true for 2017-2021, as La Niña was more frequent than El Niño in this period (see below for more discussion on El Niño).

During 2017-2021, parts of Eurasia, eastern USA and the African Sahel were anomalously wet, and southern Africa, Australia, southern Brazil, and western Europe anomalously dry. These anomalies were generally also present for 2021, though less clearly, with the notable exception of eastern Australia which was anomalously wet.

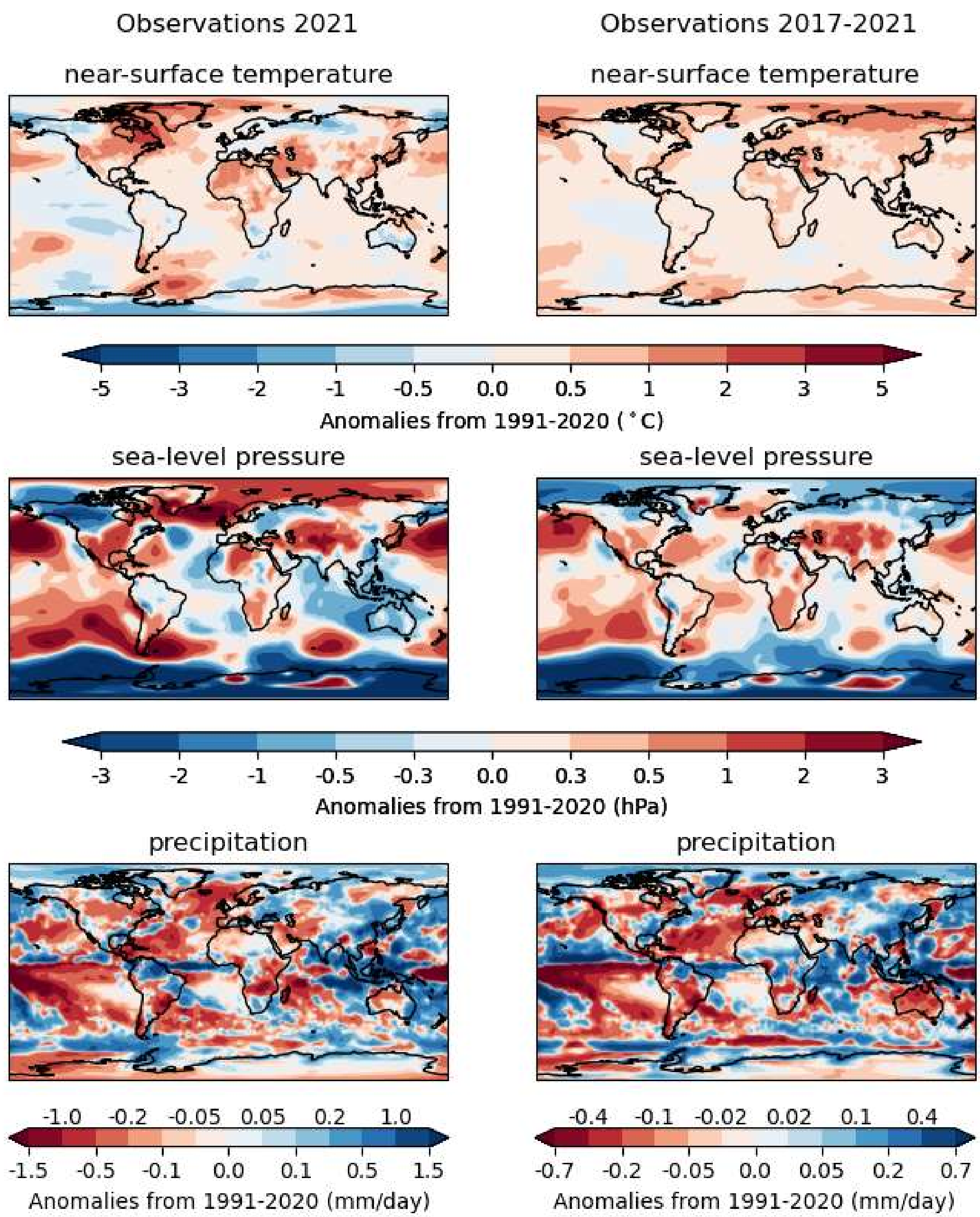

***Figure 1**: Observed annual mean near-surface temperature (°C, top), pressure (hPa, middle) and precipitation (mm/day, bottom) anomalies relative to 1991-2020. The left column shows the year 2021, the right column refers to the average of the five-year period 2017-2021. Near-surface temperatures are ERA5 2m temperature from ECMWF. Sea-level pressure is HadSLP2r (Allan and Ansell, 2006, updated). Precipitation is 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. Arctic anomalies were largest in November to March. The sea-level pressure anomalies seen in the five-year mean in Figure 1 over Antarctica were largest in May to September. The anomalies seen in Aleutian Low were largest in November to March when La Niña conditions are strongest. Eastern USA and the African Sahel were anomalously wet in May to September. Australia and southern Brazil were anomalously dry over the five years in both seasons.

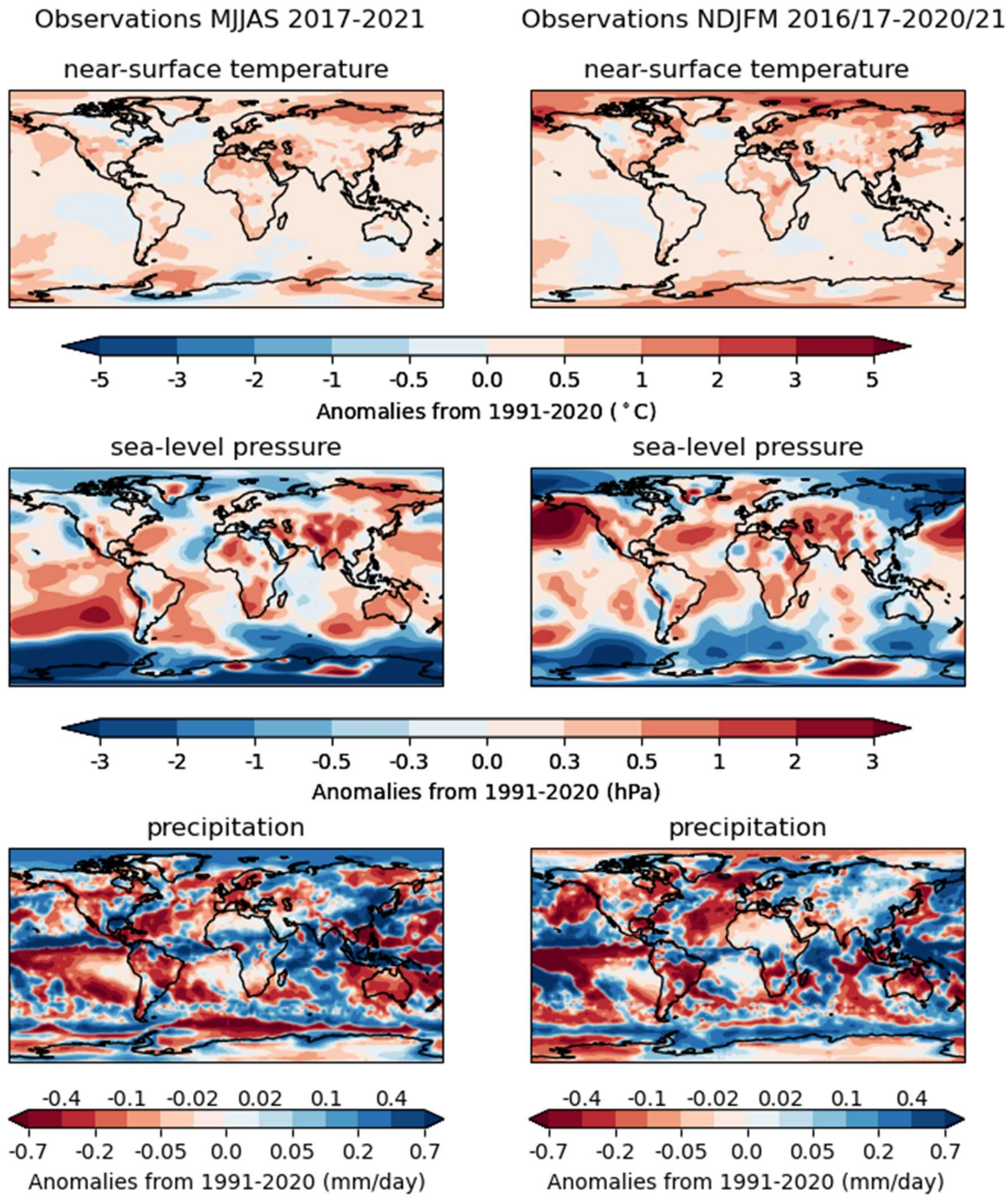

Figure 2*: Observed five-year seasonal mean near-surface temperature (°C, top), pressure (hPa, middle) and precipitation (mm/day, bottom) anomalies relative to 1991-2020. The left column shows anomalies for May to September averaged over 2017-2021, the right column shows anomalies for November to March averaged over 2016/2017-2020/2021. 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). The WMO State of the Global Climate report notes that the period 2015-2021 is the warmest seven-year period since records began in 1850. The North Atlantic Multidecadal Variability (AMV) has been near-zero or negative since the late 2000s and the subpolar North Atlantic was anomalously cold over the last five years (Figure 1). The negative anomalies are consistent with the weakening of the Atlantic Meridional Overturning Circulation (AMOC) since 2005 (Figure 16 in the Appendix). Since one of the largest El Niño events on record occurred in 2015/16, annual mean anomalies in the tropical East Pacific relative to the rest of the tropics have been negative or neutral, apart from a weak El Niño in 2018/19.

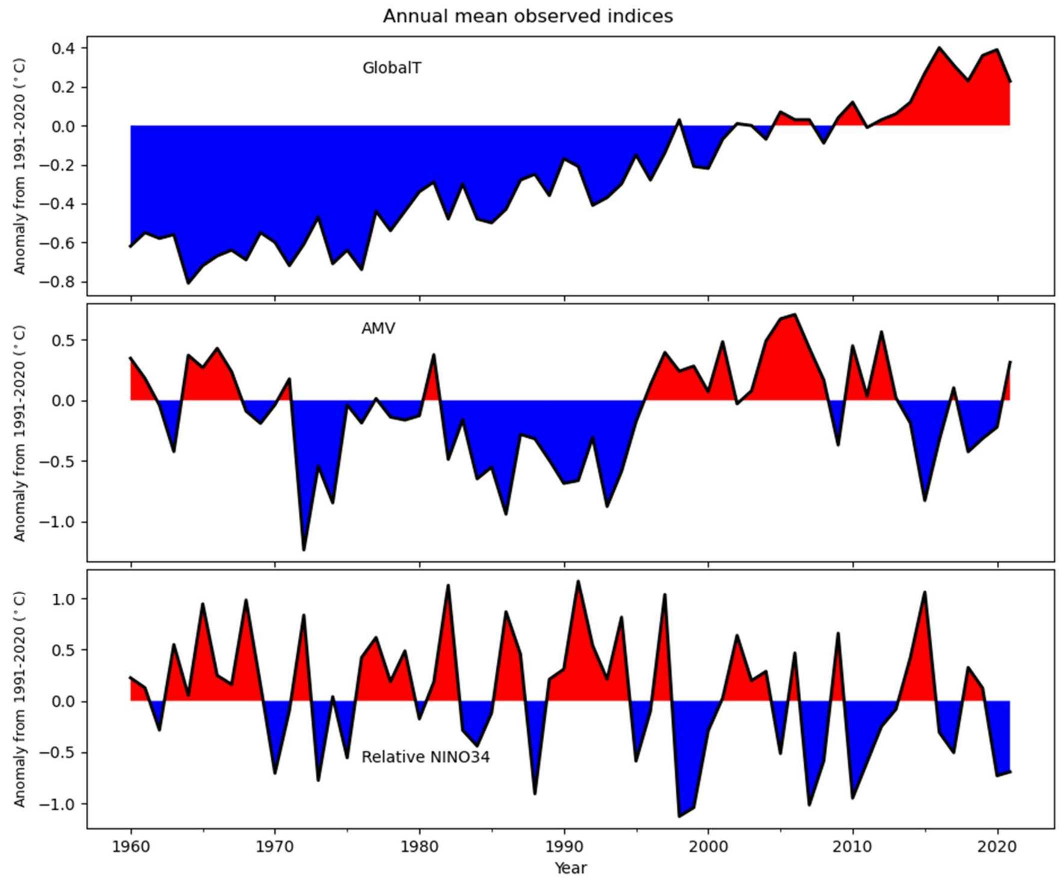

Figure 3: Observed climate indicators. Global annual mean near-surface temperature anomaly (top), annual mean Atlantic Multidecadal Variability (AMV) defined as the difference between two regions: 45°N-60°N,60°W-0°E minus 45°S-0°S, 30°W-10°E as in Roberts et al, 2013 (middle) and December to February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

Predictions from the WMO Lead Centre

Predictions of climate indices and global fields are obtained from multi-model initialised decadal climate predictions contributed to the WMO Lead Centre for Annual to Decadal Climate Prediction (www.wmolc-adcp.org). Predictions are started at the end of 2021. 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). See Hermanson et al (2022) for more information.

Predictions of Global Climate Indicators

Global temperatures are likely to increase in the five-year period 2022-2026 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 1.7°C (range of 90% confidence intervals) higher than preindustrial levels, which is defined as the average over the period 1850 to 1900. The difference between preindustrial and the 1991-2020 reference is estimated as 0.88°C, but this difference cannot be accurately estimated due to the incomplete observational network in the 19th century.

Using this estimate of the difference, the chance of the annual mean global near-surface temperature for at least one year exceeding 1.5°C above preindustrial levels is 48% and is increasing with time (brown histogram and right-hand axis in Figure 4). There is a small chance (10%) of the five-year mean exceeding this threshold. Note that the Paris Agreement level of 1.5°C refers to the long-term warming, 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, 2016, in the next five years is 93%. The chance of the five-year mean for 2022-2026 being higher than the last five years is also 93%. Confidence in forecasts of global mean temperature is high since estimates of skill from hindcasts show very high skill in all measures (right-hand panels of Figure 4).

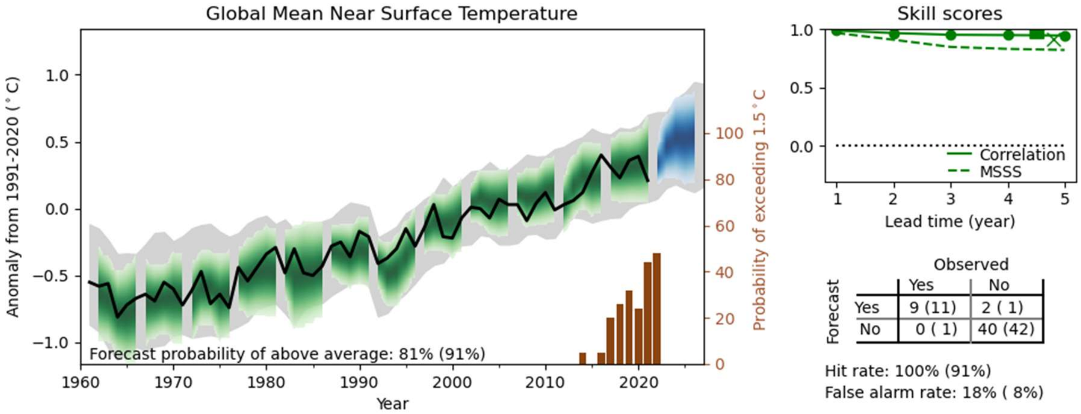

Figure 4: Multi-annual predictions of global mean near-surface temperature relative to 1991-2020. Annual global mean observations (see Figure 3) in black, forecast in blue, hindcasts in green and unininitialised simulations in grey. The shading indicates the 90% confidence range. The calibrated probability for the most likely category (above or below climatology) of the five-year-mean forecast is given at the bottom of the main panel (in brackets the probability for next year). 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 is shown in the bottom right panel (in brackets values for above average in the next year). 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 preindustrial 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 a 59% probability that Atlantic Multidecadal Variability (AMV) will be positive when averaged over the next five years (Figure 5). However, AMV is likely to be lower than recent peak values seen in the 2000s. The hindcasts have medium skill in both measures and a medium hit rate, giving medium confidence in this prediction. Predictions for the Atlantic Meridional Overturning Circulation, that is related to AMV, can be found in the Appendix.

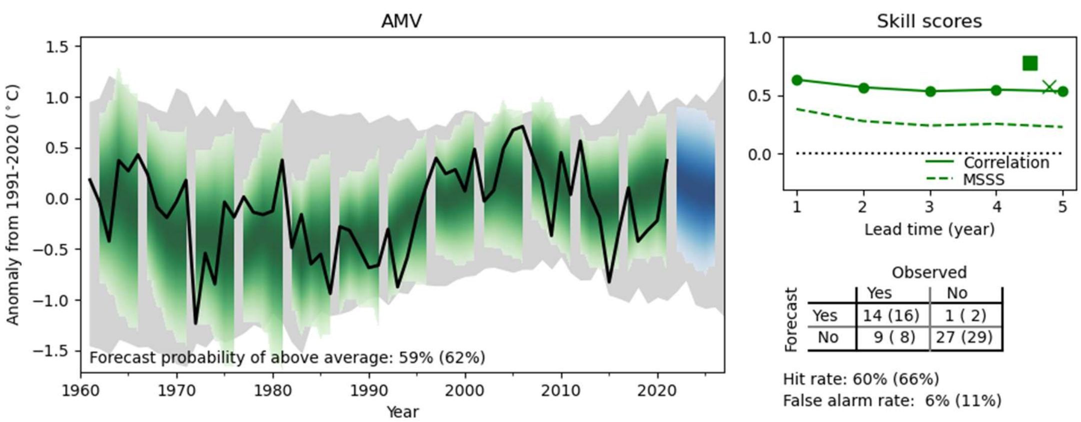

Figure 5: Multi-annual predictions of Atlantic Multidecadal Variability (AMV) relative to its 1991-2020 average, defined as the anomaly difference between two regions: 45°N-60°N,60°W-0°E minus 45°S-0°S, 30°W-10°E as in Roberts et al (2013). Annual mean observations (see Figure 3) in black, forecast in blue, hindcasts in green and unininitialised simulations in grey. The shading indicates the 90% confidence range. The calibrated probability for the most likely category (above or below climatology) of the five-year-mean forecast is given at the bottom of the main panel (in brackets the probability for next year). 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 is shown in the bottom right panel (in brackets values for above average in the next year).

The La Niña of 2021/22 is predicted to decline, and the five-year average prediction shows no signal favouring either phase of the El Niño-Southern Oscillation (Figure 6). Skill is medium, giving medium confidence in this forecast.

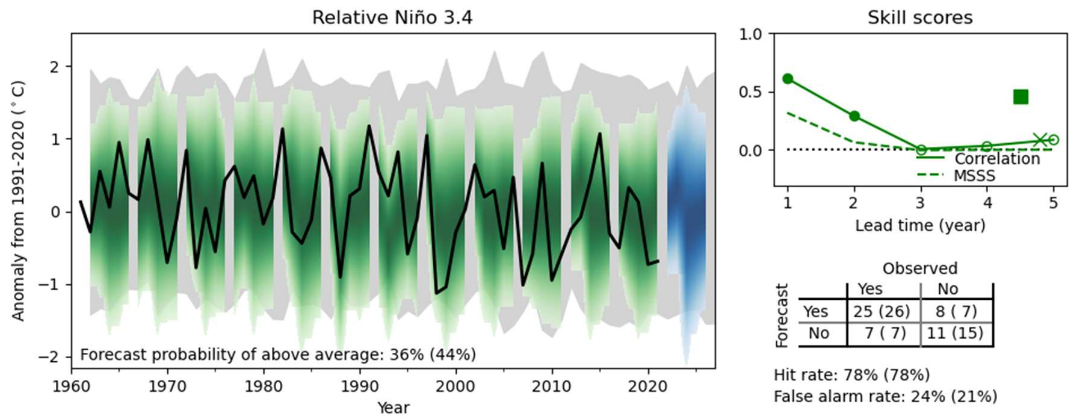

Figure 6: As Figure 5, but for December-February averaged Niño 3.4 relative to the tropical mean defined as the average over 5°S-5°N, 170°W-120°W with average over 20°S-20°N removed. This index is suitable for a warming climate (van Oldenborgh et al, 2021).

Regional Predictions for 2022

Temperatures in 2022 are likely to be higher than the 1991-2020 average in almost all regions except parts of the Southern Ocean, South Atlantic, and Pacific Ocean (Figure 7). Alaska, western Canada, and India are likely to be cooler. 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 anomalous low pressure over the Arctic consistent with an increased likelihood of a positive phase of the Arctic Oscillation (AO, see Figure 19 in the Appendix). The skill is low but significant, giving low confidence in this prediction. The forecast also suggests high pressure anomalies are likely over the tropical east Pacific and low over the Maritime Continent consistent with a positive Southern Oscillation index. There is medium skill for these regions giving medium confidence.

Precipitation patterns suggest an increased chance of drier conditions over southwestern Europe and southwestern North America and wetter conditions in northern Europe, the Sahel, north-east Brazil, and Australia. Correlation skill for hindcasts is very low despite being significant in these regions, giving low confidence in the forecast.

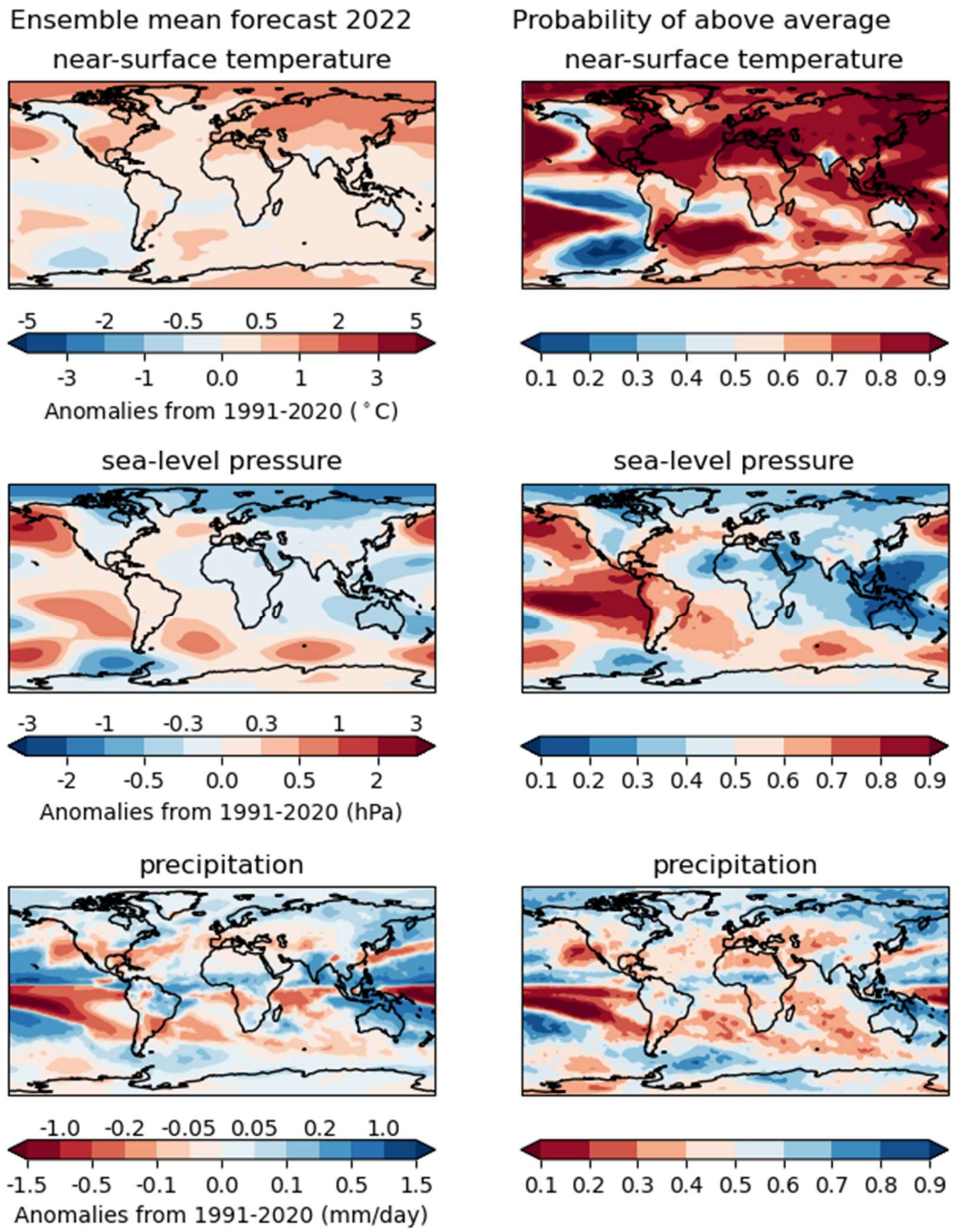

Figure 7: Annual mean anomaly predictions for 2022 relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day) and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

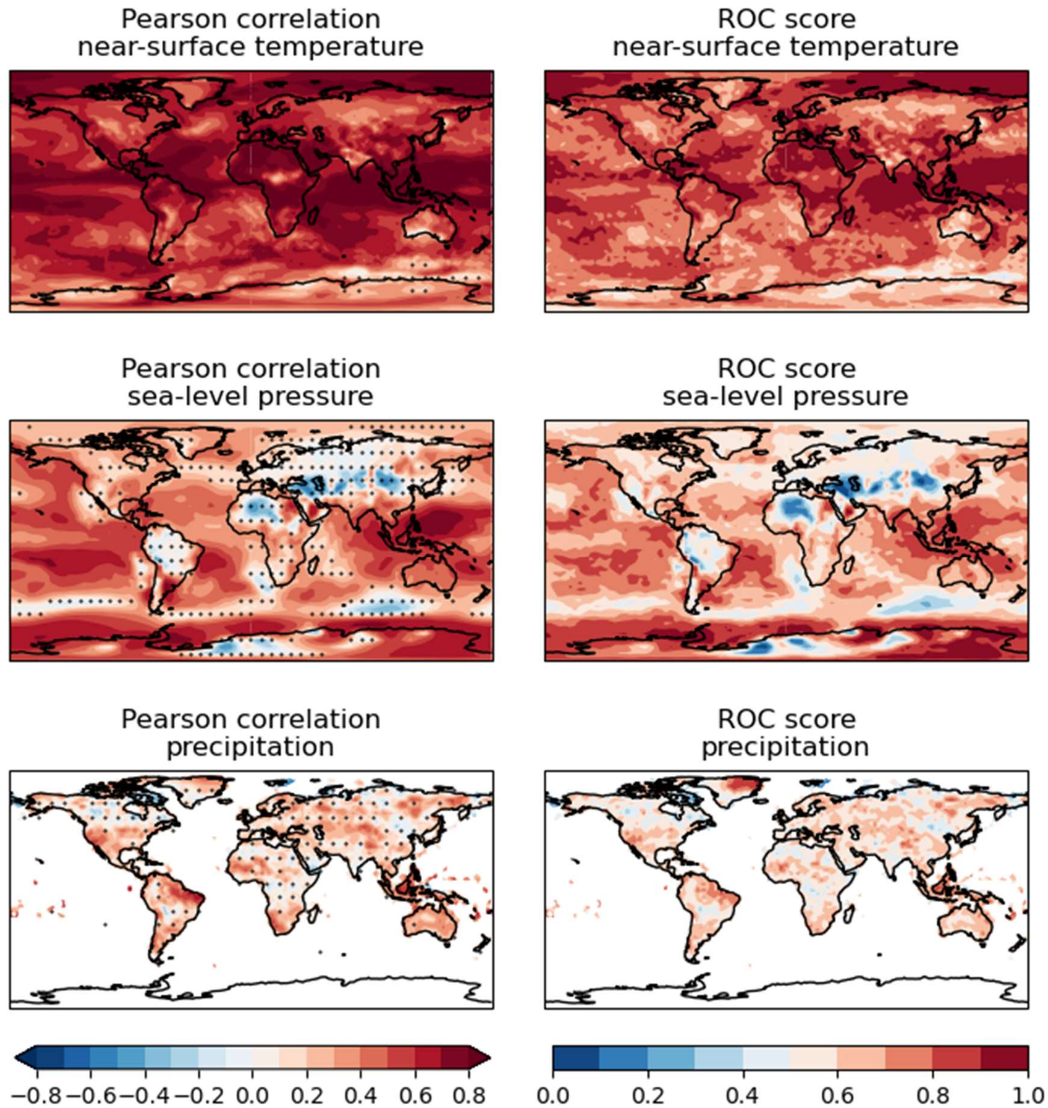

Figure 8: Prediction skill of annual means evaluated using hindcast experiments. Pearson correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significant (at the 5% level).

Regional Predictions for 2022-2026

In this section, we show 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 2022-2026 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, southern South America, central Africa, and Australia. There is medium skill for these regions, giving medium confidence. Predictions of precipitation show wet anomalies in the Sahel, northern Europe, Alaska and northern Siberia, and dry anomalies for this season over the Amazon. Skill is low to medium for these regions, giving low to medium confidence.

For the November to March average over the years 2022/23-2026/27 (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. 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.

High sea-level pressure in the eastern Pacific and Southern Ocean, and low pressure over Antarctica is evident for November to March 2022/23-2026/27. High pressure anomalies in the southern hemisphere mid-latitudes and low pressure over Antarctica are consistent with a positive Antarctic Oscillation (AAO) index (see Appendix Figure 18). Skill is medium over these regions giving medium confidence in the forecast.

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 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.

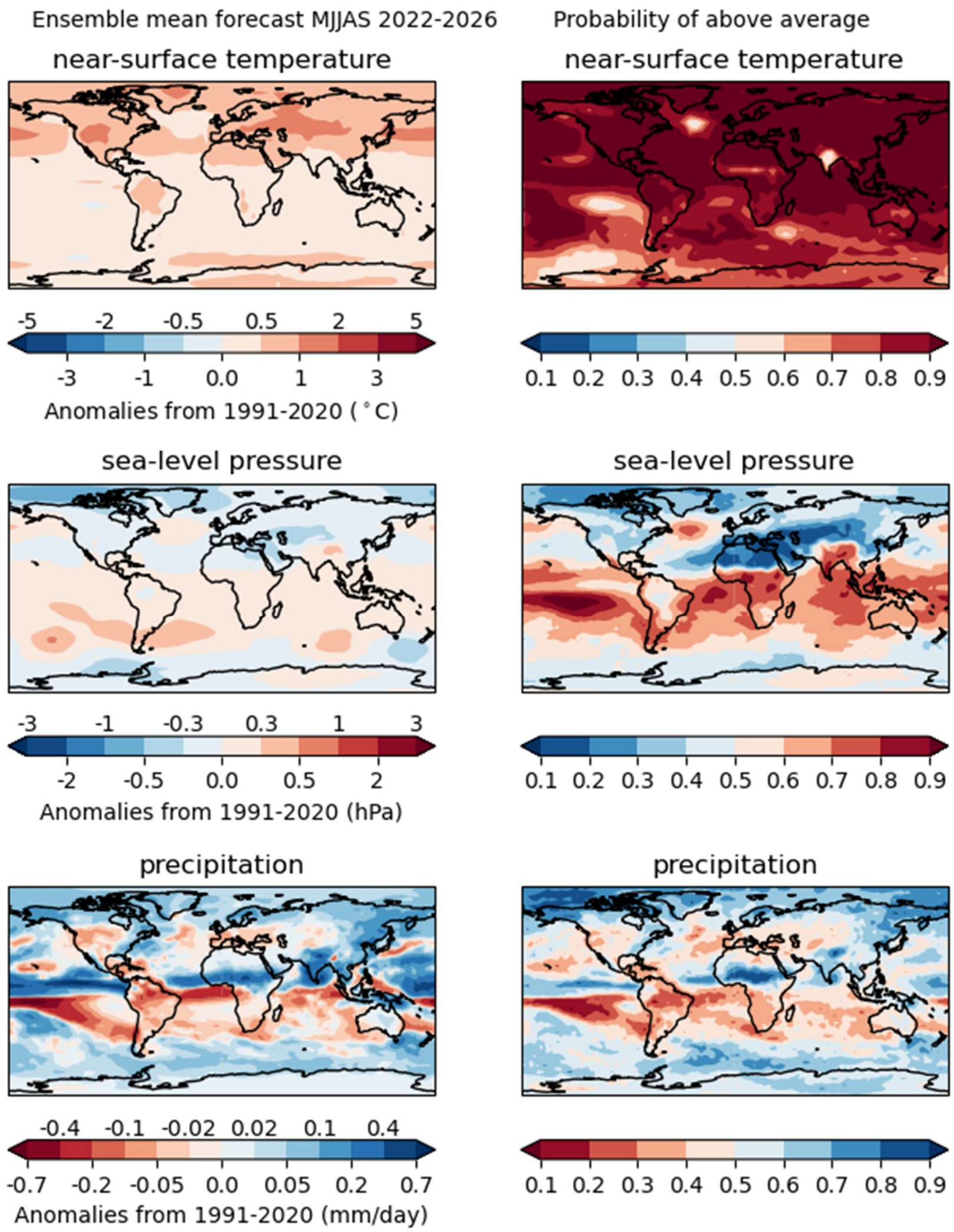

Figure 9: Predictions for 2022-2026 May to September anomalies relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day) and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

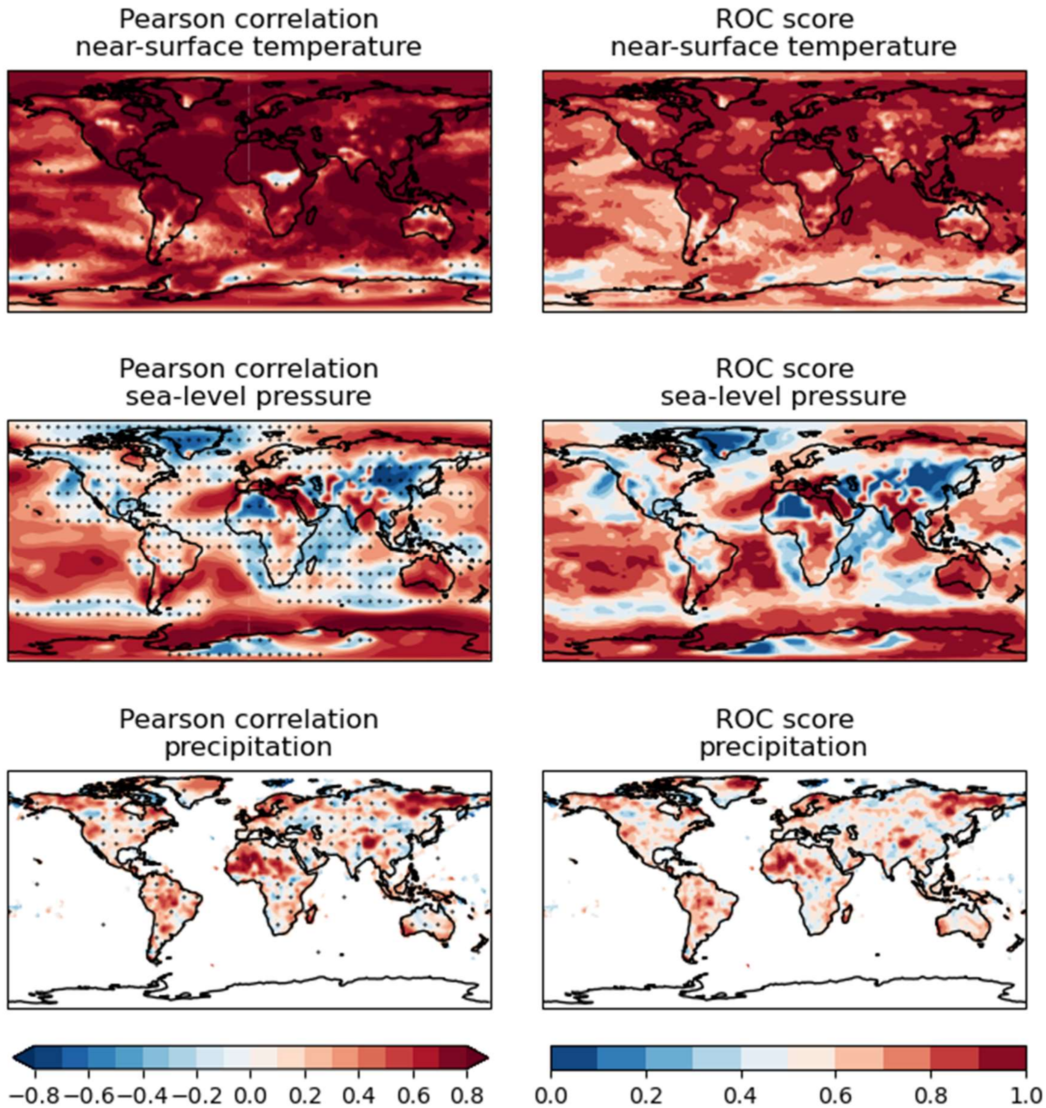

Figure 10: Prediction skill of five-year mean May to September anomalies evaluated using hindcast experiments. Pearson correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

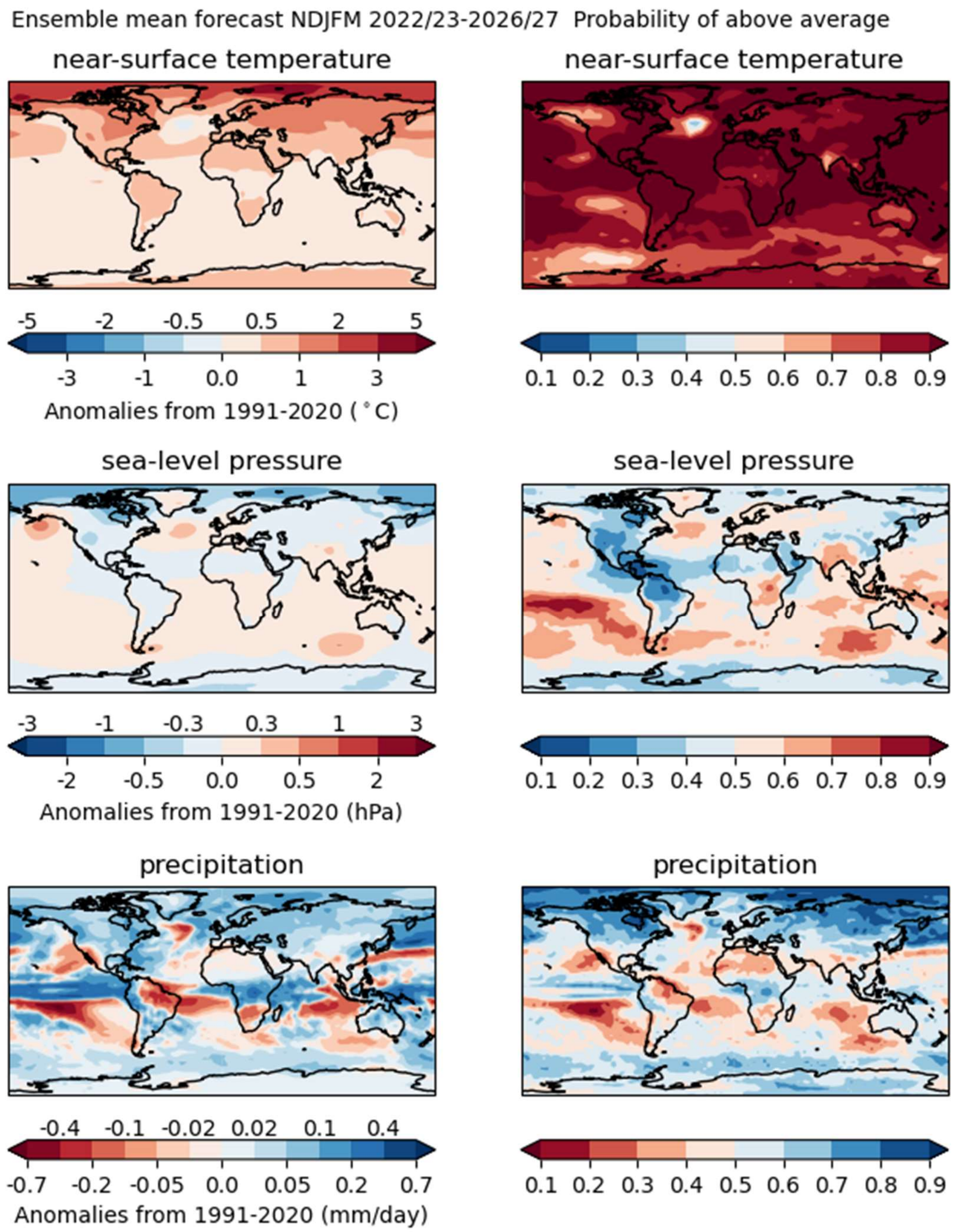

Figure 11: Predictions for 2022/2023-2026/2027 November to March anomalies relative to 1991-2020. Ensemble mean (left column) for temperature (top, °C), sea level pressure (middle, hPa), precipitation (bottom, mm/day) and probability of above average (right column). As this is an uncalibrated two-category forecast, the probability for below average is one minus the probability shown in the right column.

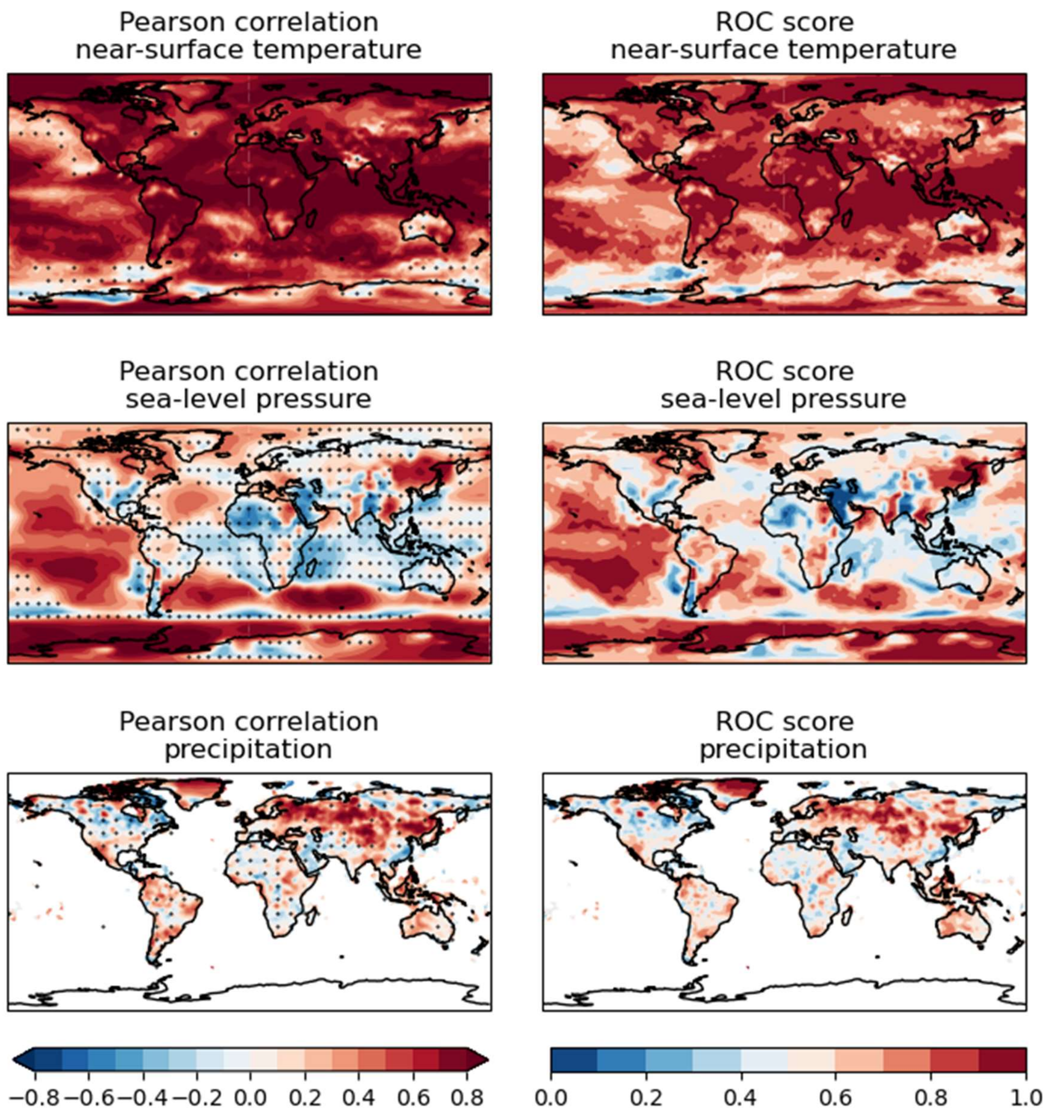

Figure 12: Prediction skill of five-year means November to March anomalies evaluated using hindcast experiments. Correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

Evaluation of Previous Forecasts

This section assesses the most recent one year and five-year mean forecasts, that were made in real time, for which observations are available. The forecast for 2021, which was run at the end of 2020, is shown in Figure 13. Stippling in the right-hand panels indicates disagreement between the forecast and subsequent observations. For near-surface temperatures the forecast shows generally good agreement with the observed pattern, but the anomalies were underestimated over North Africa and the Middle East, and overestimated in the Arctic. Cooler than average conditions in northern Russia, Scandinavia, and Antarctica were not captured.

Sea-level pressure patterns agree reasonably well with the observations, with anomalously low pressure over Antarctica and the Indian Ocean and generally anomalously high pressure over the Pacific. However, the predicted anomalies are small and the ensemble spread does not encompass the observed magnitude in most regions. Sea-level pressure anomalies in the North Atlantic were not captured by the ensemble. There is low or no skill for sea-level pressure over Africa and Eurasia for this lead-time (Figure 8).

The ensemble mean predictions of precipitation captured the correct sign of anomalies in several regions, including wetter conditions across the Sahel and India, and drier conditions in South America and southern Africa. Despite this, the ensemble spread did not encompass the observed values in most regions.

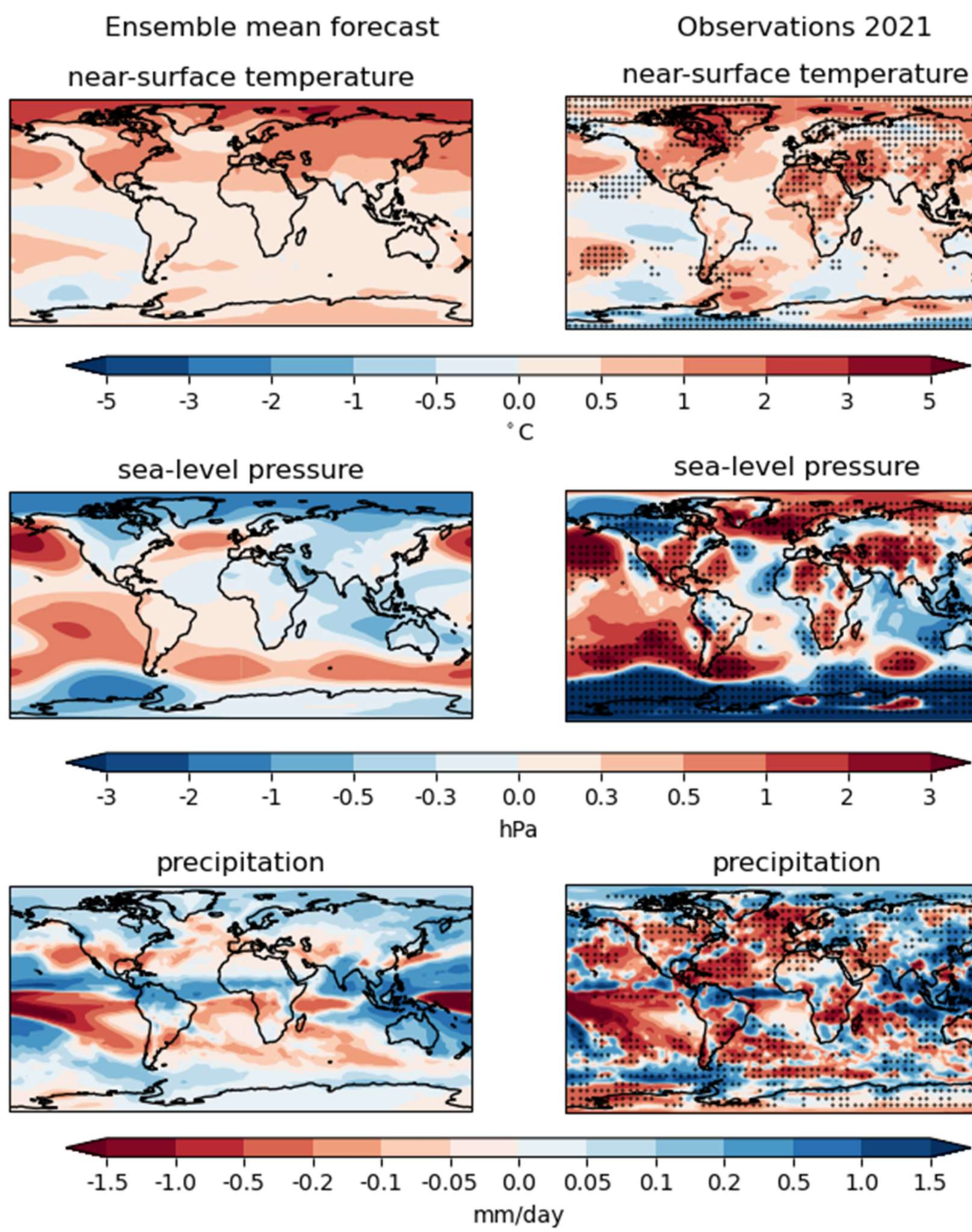

Figure 13: Evaluation of the one-year forecast for 2021 relative to 1981-2010. Ensemble mean forecast (left) and observed (right) anomalies. Top: temperature (°C); middle: sea level pressure (hPa); bottom: precipitation (mm/day). Stippling shows where the observations fall outside of the 90% range of the forecast ensemble.

Average forecast temperature anomalies for the last five years 2017-2021, from forecasts run at the end of 2016 (Figure 14), generally agree well with observations of very warm conditions over the Arctic and Eurasia, and enhanced warming over the land compared to the ocean. However, the magnitude of the Middle East warm anomalies was underestimated. Relatively cool conditions in the northern North Atlantic, South Pacific and Southern Ocean were also mostly captured within the ensemble spread. Other cooler conditions in Canada and the East Pacific were not as well captured.

Sea-level pressure patterns show some 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 small and the observations are outside the forecast range in most regions even when the ensemble mean shows the correct sign. Higher than average pressure over Eurasia and Africa was not captured by the ensemble.

Precipitation patterns over land show reasonable agreement with observations, including wetter than usual conditions across much of Eurasia and central Africa, and drier than usual conditions in southern North America, north-east Brazil, and southern Africa. Drier than normal conditions in western Canada, Australia and western Europe were not captured.

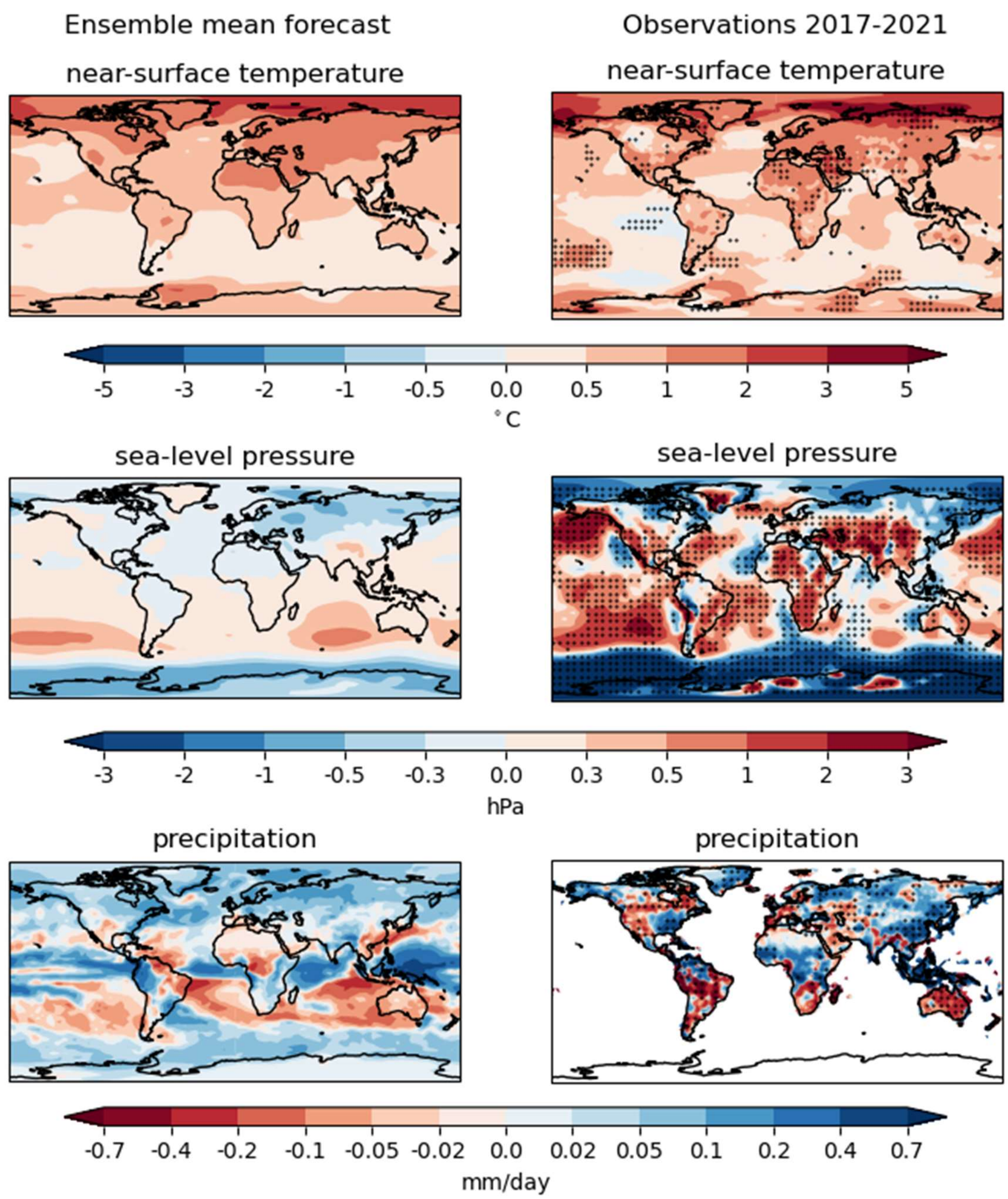

Figure 14: Evaluation of the five-year forecast for 2017-2021 relative to 1971-2000. Ensemble mean forecast (left) and observed (right) anomalies. Top: temperature (°C); middle: sea level pressure (hPa); bottom: precipitation (mm/day). Stippling shows where the observations fall outside of the 90% range of the forecast ensemble.

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. 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 is only an estimate. Correlation skill is classified into five categories: very low (around 0.2 and lower, but still significant), low (around 0.3-0.4), medium (around 0.5-0.6), high (around 0.7-0.8) and very high (around 0.9 and higher).

Appendix – predictions for the AMOC and other indices

Predictions of Atlantic Meridional Overturning Circulation (AMOC) show reduced overturning in the mid-latitudes for 2022 (Figure 15, top row), but skill cannot be evaluated due to insufficient observations which only exist for particular locations. AMOC is important for the climate of countries surrounding the North Atlantic and for global heat transport. It has been measured at 26°N since 2004.

The AMOC prediction for 2022-2026 (Figure 15, bottom row) shows anomalously low values in the ensemble mean 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.

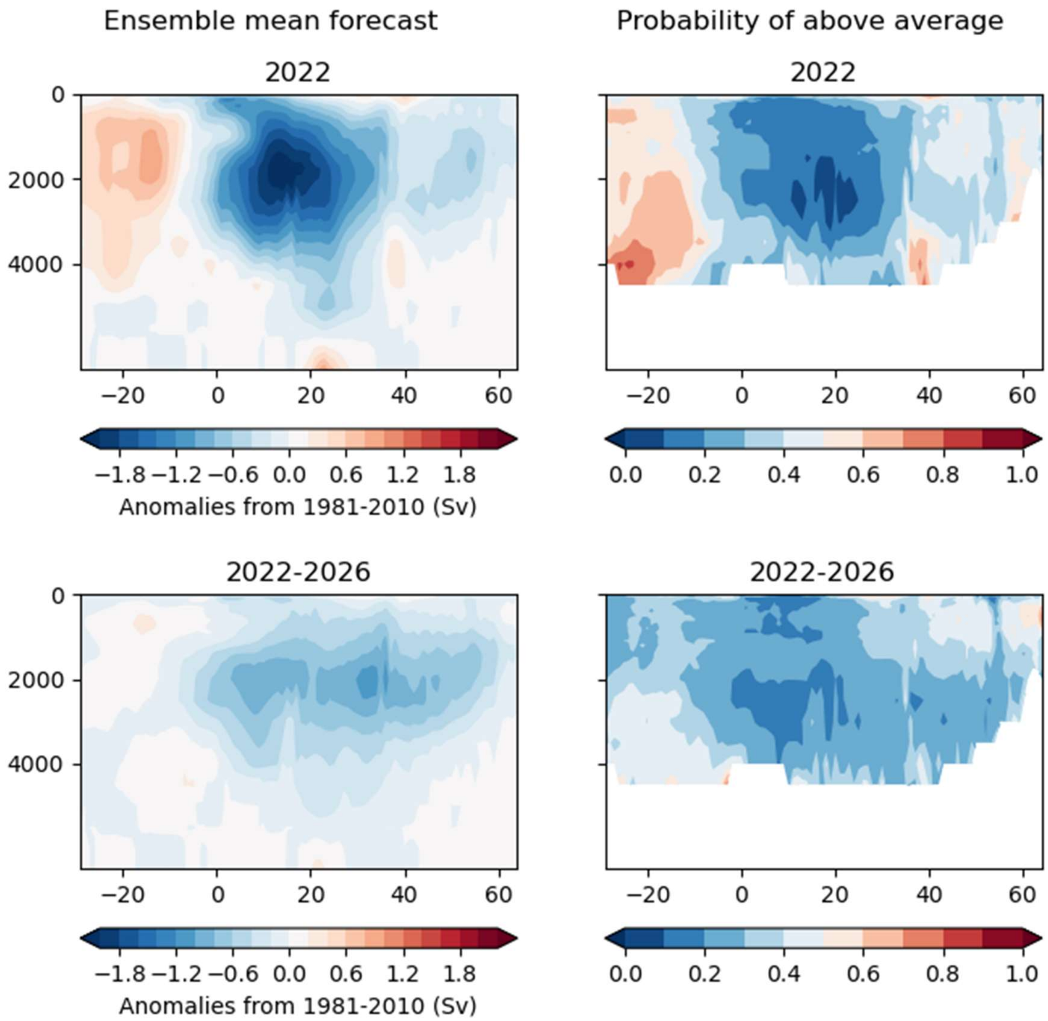

Figure 15: Atlantic Meridional Overturning Circulation (AMOC) forecast for 2022 (first row) and 2022-2026 (second row) relative to 1991-2020. The left column shows the ensemble mean prediction and the right column shows the probability of a stronger than average AMOC.

The AMOC close to 30°N is predicted to be near or slightly below recent observed values (Figure 16). The strong decline observed during the 2000s is not predicted to continue, in line with the recent recovery. However, confidence in this forecast is low because there are insufficient past observations to evaluate skill.

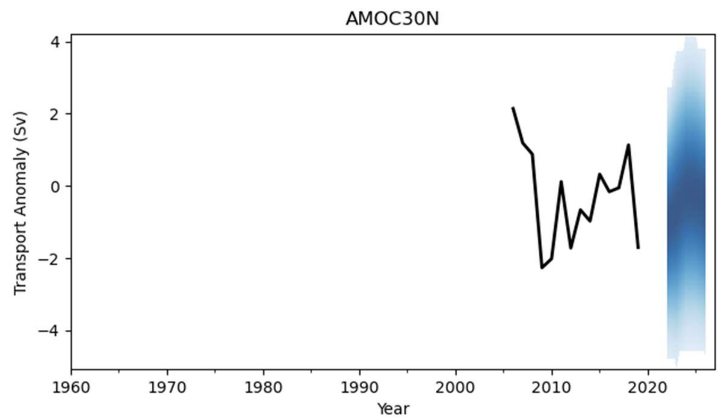

Figure 16: Atlantic Meridional Overturning Circulation close to 30°N and 1100m as in Roberts et al (2013). RAPID observations (26°N) in black (anomalies relative to its full time series 2005-2019) and model forecast in blue.

Pacific Decadal Variability (PDV) is predicted to be negative during 2022 with a 68% probability for below average (Figure 17). High skill in year 1 gives high confidence, but beyond two years there is no significant skill. There is 73% probability of below average PDV for coming five-year period.

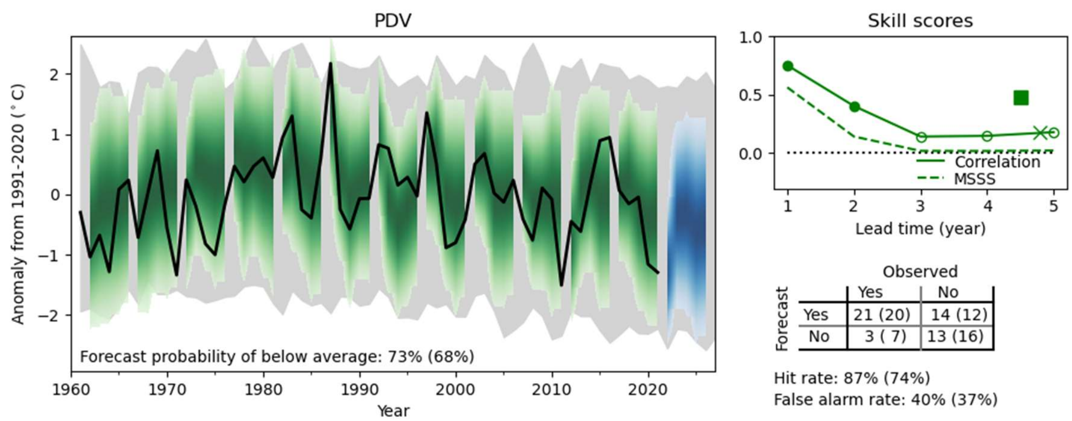

Figure 17: As Figure 5, but for Pacific Decadal Variability (PDV) defined as the difference in SST between the eastern tropical Pacific (10°S-6°N, 110°W-160°W) and the North Pacific (30°N-45°N, 145°W-180°W) as in Dong et al (2014).

The recent strong Antarctic Oscillation (AAO) is predicted to weaken and the probability of below average is 36%. Although skill is medium to high for individual years and for the next five years, the hindcasts (green) do not capture the strengthening of the AAO from 2005 very well and the forecast (blue) is lower than recent observations.

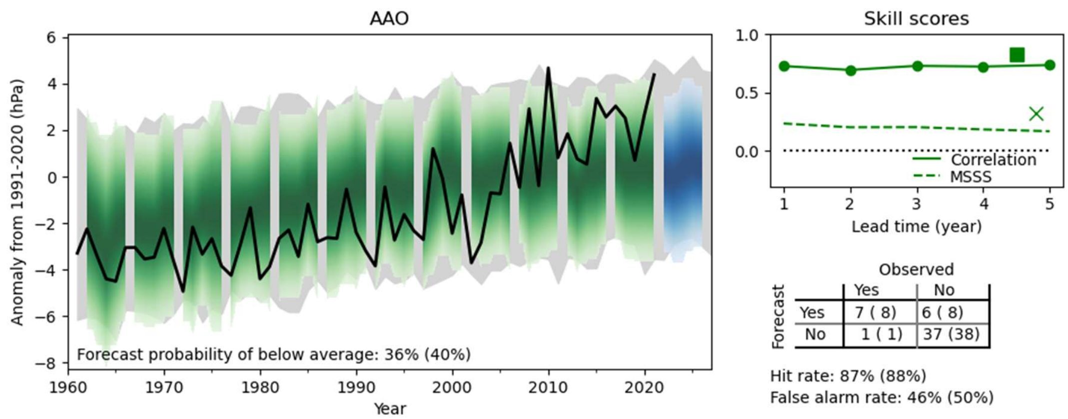

Figure 18: As Figure 5, but for the Antarctic Oscillation (AAO) defined as the difference in annual mean zonal mean sea-level pressure between 65°S and 40°S as in Gong & Wang (1999).

The Arctic Oscillation averaged over the next five years is most likely to be below normal, but with a low probability of 23% (Figure 19). Skill is low and significant, but probabilistic skill shows a low hit rate and many false alarms.

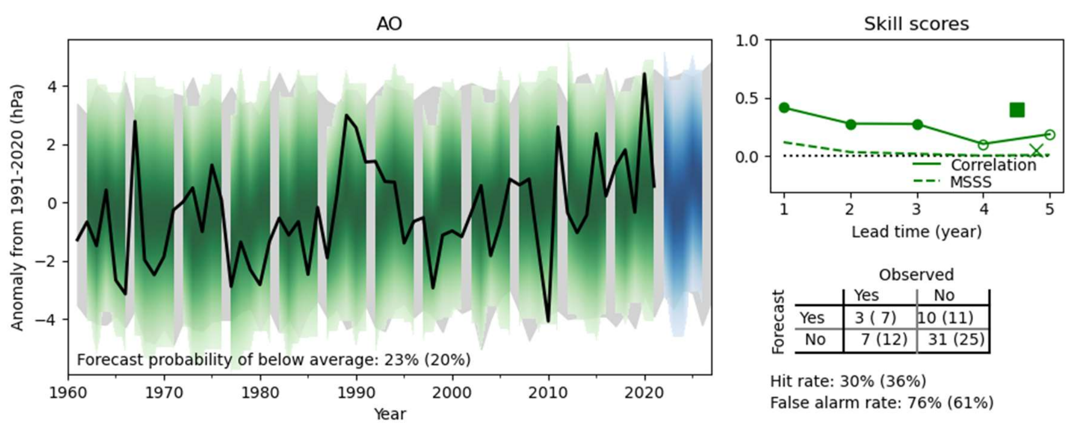

Figure 19: As Figure 5, but for Arctic Oscillation defined as the difference in annual mean zonal mean sea-level pressure between 80°N and 45°N, similar to Gong & Wang (1999), but for the Northern Hemisphere.

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