WORLD METEOROLOGICAL ORGANIZATION

Global Annual to Decadal Climate Update

Target years: 2020 and 2020-2024

Executive Summary

This update presents a summary of annual to decadal predictions from WMO designated Global Producing Centres and non-designated contributing centres for the period 2020-2024. Latest predictions suggest that:

- Annual global temperature is likely to be at least 1°C warmer than preindustrial levels (defined as the 1850-1900 average) in each of the coming 5 years and is very likely to be within the range 0.91 – 1.59°C
- It is unlikely (~20% chance) that one of the next 5 years will be at least 1.5°C warmer than preindustrial levels, but the chance is increasing with time
- It is likely (~70% chance) that one or more months during the next 5 years will be at least 1.5°C warmer than preindustrial levels
- It is very unlikely (~3%) that the 5 year mean temperature for 2020-2024 will be 1.5°C warmer than preindustrial levels
- In 2020, large land areas in the Northern Hemisphere are likely to be over 0.8°C warmer than the recent past (defined as the 1981-2010 average)
- In 2020, the Arctic is likely to have warmed by more than twice as much as the global mean
- The smallest temperature change is expected in the tropics and in the mid-latitudes of the Southern Hemisphere
- In 2020, many parts of South America, southern Africa and Australia are likely to be dryer than the recent past
- Over 2020-2024, almost all regions, except parts of the southern oceans are likely to be warmer than the recent past
- Over 2020-2024, high latitude regions and the Sahel are likely to be wetter than the recent past whereas northern and eastern parts of South America are likely to be dryer
- Over 2020-2024, sea-level pressure anomalies suggest that the northern North Atlantic region could have stronger westerly winds leading to more storms in western Europe

Current Observations

The climate over the last year and five last years as anomalies to 1981-2010 is shown in Figure 1.

Most regions were warmer than average. Warming was largest at high latitudes in the Northern Hemisphere, and generally larger over land than ocean for the five-year mean 2015-2019. Parts of the Southern Ocean and the northern North Atlantic were cooler than average.

In the last five years, sea-level pressure was anomalously low in both polar regions, with strongest negative anomalies over Antarctica. Hence both the Arctic and Antarctic Oscillations have been positive on average. In 2019, both the Arctic and Antarctic Oscillation indices were less positive.

Most of Eurasia, eastern USA and central Africa have been wetter than average, with southern Africa, eastern Australia, Indonesia, north-east Brazil and western Europe drier than average.

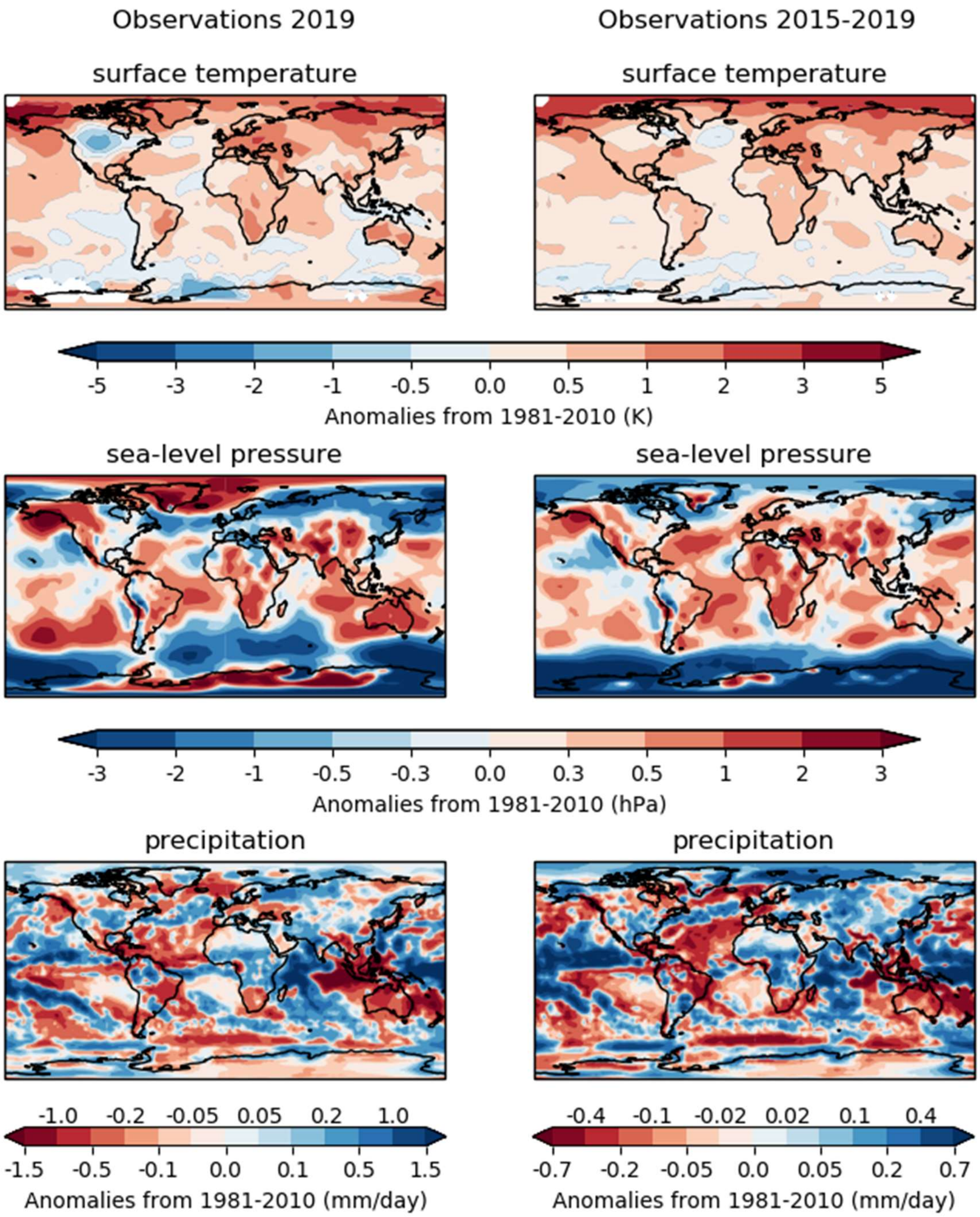

Figure 1: Observed temperature (top), pressure (middle) and precipitation (bottom) anomalies relative to 1981-2010. The left column shows 2019 and the right column shows the five-year period 2015-2019. Temperatures are an average of three observational data sets: HadCRUT4 (Morice et al., 2012), NASA-GISS (Hansen et al., 2010), and the NCDC (Karl et al., 2015). Sea-level pressure is HadSLP2r (Allan and Ansell, 2006). Precipitation is GPCP (Adler et al, 2003).

Global mean temperatures have increased steadily since the 1960s (Figure 2). The 5-year period 2015-2019 is the warmest since records began in 1850. Since the mid-1990s the North Atlantic Ocean has been in a warm phase of Atlantic Multidecadal Variability (AMV). However, since 2015 the subpolar North Atlantic between 45-65°N has cooled significantly, consistent with extreme winter heat loss in the 2013/2014 and a weakening of the meridional ocean circulation. Since one of the largest El Niños on record in 2015/16, annual mean anomalies in the tropical East Pacific have been mainly positive apart from weak La Niña conditions during northern hemisphere winter in 2017 and 2018.

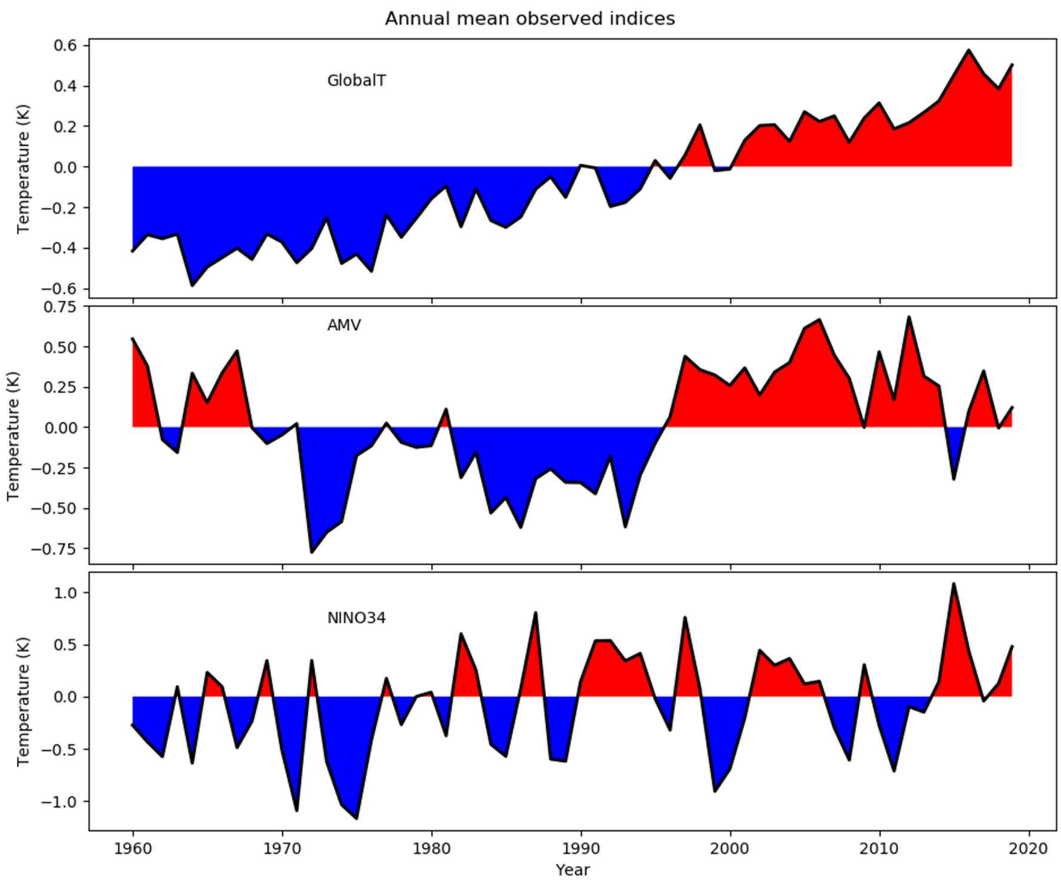

Figure 2: Observed annual mean climate indicators relative to 1981-2010. Global mean temperature (top), Atlantic Multidecadal Variability (AMV) defined as the difference between two regions: 45°N-60°N,60°W-0°E minus 45°S-0°S, 30°W-10°E (middle) and NINO3.4 defined as the average over 5°S-5°N, 170°W-120°W (bottom). The temperature data is the same 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 contributing to the WMO Lead Centre for Annual to Decadal Climate Prediction (www.wmolc-adcp.org) and are started at the end of 2019. Retrospective forecasts (hereafter hindcasts) covering the period since 1960 from decadal prediction experiments submitted to Coupled Model Intercomparison Project phase 5 (CMIP5) are shown for below for climate indices and are used to estimate forecast skill. The last CMIP5 hindcast started in 2005, so there is a small gap between the hindcasts and the prediction for this year. Also shown are uninitialised (historical) simulations from CMIP5 for the climate indices.

Predictions of Global Climate Indicators

Figure 3 shows that in the five year period 2020-2024, the annual mean global surface temperature is predicted to be between 0.91°C and 1.59°C above pre-industrial conditions (taken as the average over the period 1850 to 1900, which is 0.61°C cooler than the 1981-2010 reference used in Figure 3). The chance of at least one year exceeding 1.5°C above pre-industrial levels is 24%, with a very small chance (3%) of the five-year mean exceeding this threshold. Confidence in forecasts of global mean temperature is high since hindcasts show high skill in all measures. However, the coronavirus lockdown is likely to cause changes in emissions of greenhouse gases and aerosols that are not included in the forecast models. The impact of changes in greenhouse gases is likely small, the reduction in anthropogenic aerosols is likely to increase global mean temperatures by less than 0.1°C.

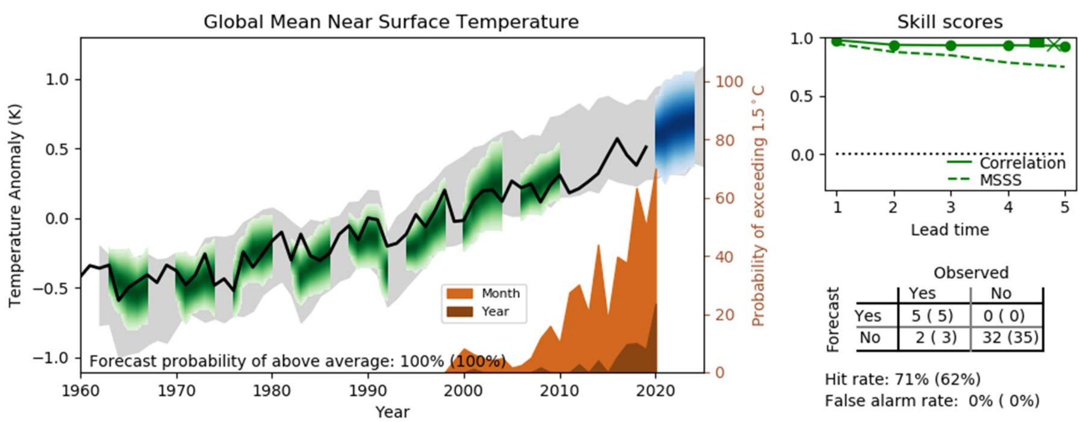

Figure 3: Multi-annual predictions of global mean surface temperature relative to 1981-2010. Annual mean observations in black, forecast in blue, hindcasts in green and unininitialised simulations in grey. The shading indicates the 90% confidence range. The probability for above average in the five year mean of the forecast is given at the bottom the main panel (in brackets the probability for above average in the 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. 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, referring to the right hand axis, is the probability of global temperature exceeding 1.5°C above pre-industrial levels for a single month or year during the five years starting in 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 (or month) above 1.5°C.

Predictions indicate an 85% probability that Atlantic Multidecadal Variability (AMV) will be positive when averaged over the next five years (Figure 4). However, AMV is likely to be lower than recent peak values seen in the 2000s. The hindcasts have reasonably high skill in all measures giving medium to high confidence in this prediction. Predictions for the Atlantic Meridional Overturning Circulation can be found in the appendix.

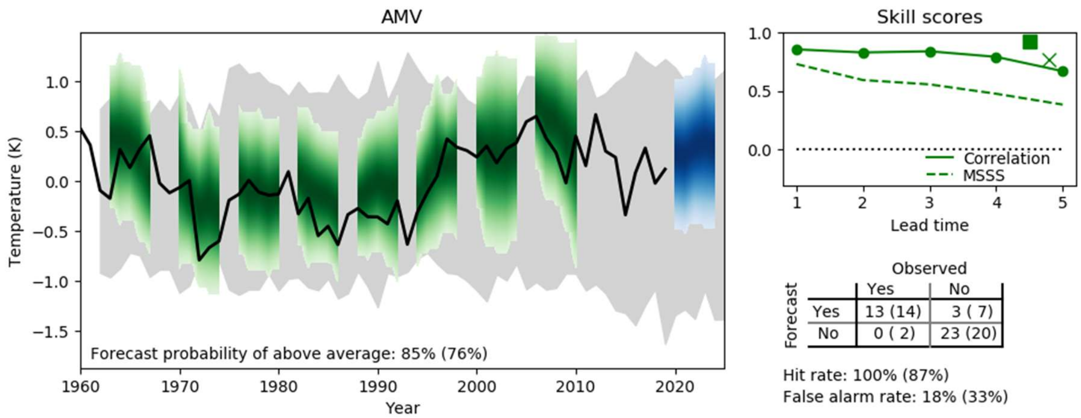

Figure 4: Multi-annual predictions of Atlantic Multidecadal Variability (AMV) relative to its 1981-2010 average, defined as the difference between two regions: 45°N-60°N,60°W-0°E minus 45°S-0°S, 30°W-10°E as in Roberts et al (2013). Annual mean observations in black, forecast in blue, hindcasts in green and unininitialised simulations in grey. The shading indicates the 90% confidence range. The probability for above average in the five year mean of the forecast is given at the bottom the main panel (in brackets the probability for above average in the 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. 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).

Neutral conditions in the NINO3.4 region are predicted for 2020 (Figure 5). The five-year average prediction shows a continuation of the slight warming trend seen since the 1970s. Skill is moderate but significant, giving low to medium confidence in this forecast.

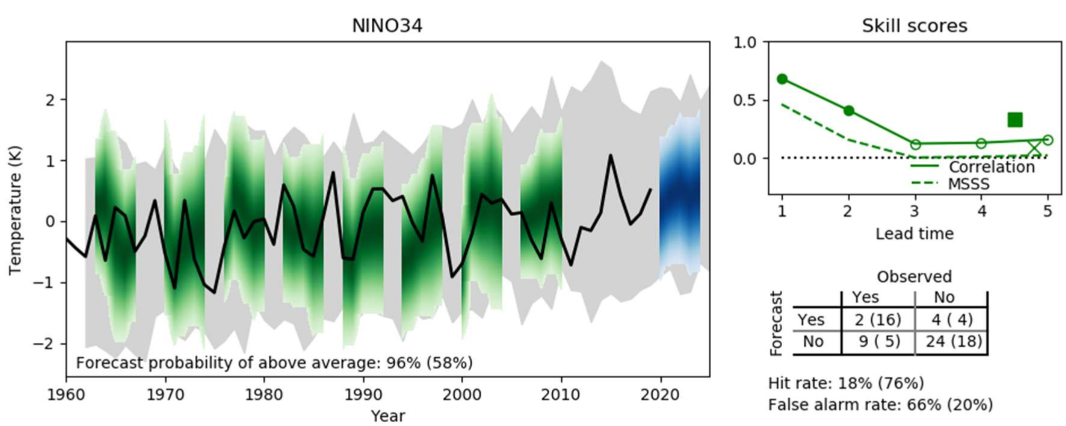

Figure 5: Multi-annual predictions of Nino3.4 defined as the average over 5°S-5°N, 170°W-120°W. See Figure 4 for an explanation of the panels.

Regional Predictions for 2020

Temperatures in 2020 are predicted to be higher than the 1981-2010 average in almost all regions except parts of the Southern Ocean and south-east Pacific (Figure 6). Skill is reasonably high in most regions giving high to medium confidence (Figure 7).

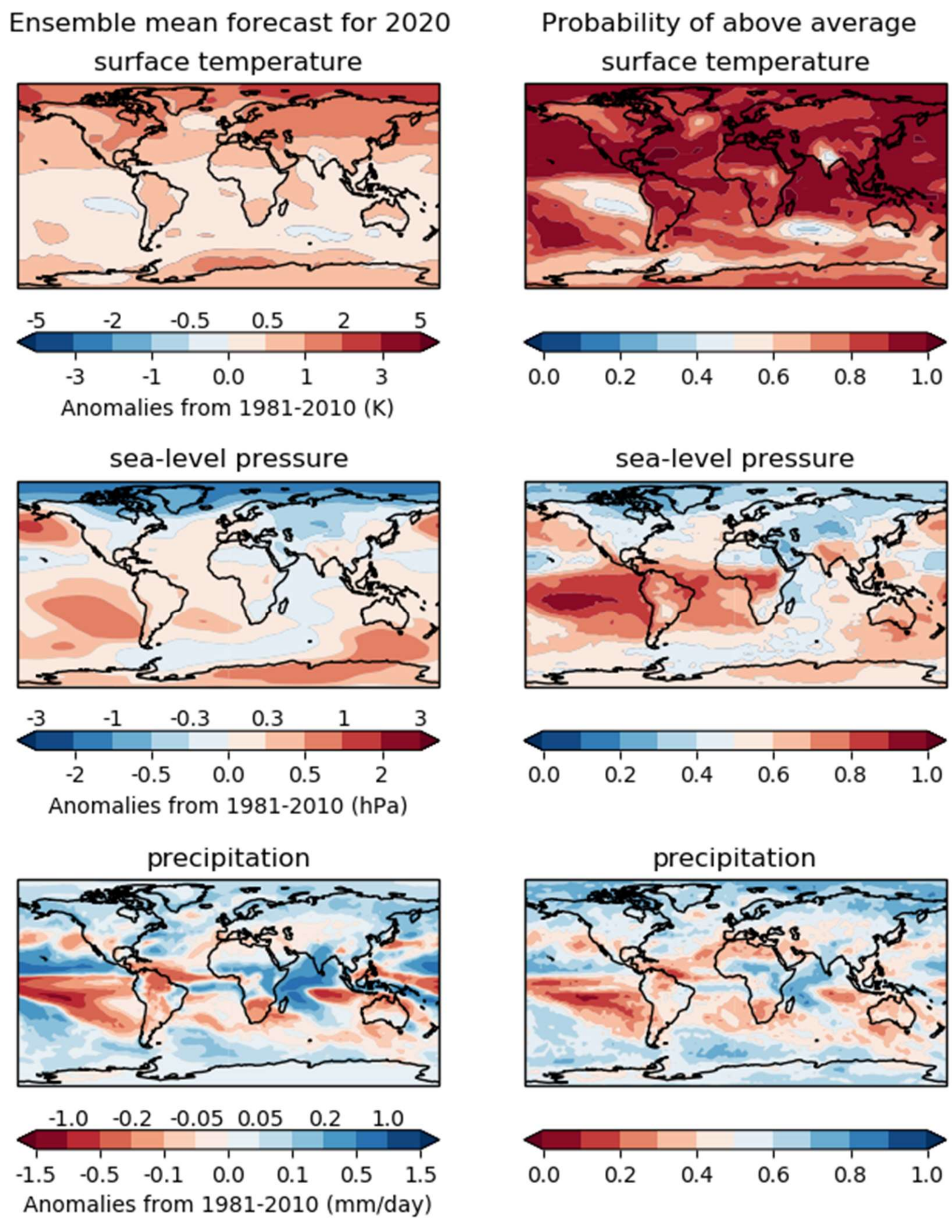

Figure 6: Annual mean anomaly predictions for 2020 relative to 1981-2010. Ensemble mean (left column) and probability of above average (right column). As this is a two-category forecast, the probability for below average is one minus the probability shown in the right column.

Sea-level pressure forecasts suggest anomalous low pressure over the north pole consistent with a positive Arctic Oscillation (AO, see the appendix for a plot of the index). The skill plots show moderate but significant correlations, giving medium confidence in this prediction. The forecast also suggests high pressure anomalies are likely over the tropical east Pacific and Atlantic (medium confidence).

Precipitation patterns suggest an increased chance of drier conditions over northern South America, northern Australia, southern Africa and wetter conditions in northern Europe and Alaska. Correlation skill is moderate though significant in these regions, giving low to medium confidence in the forecast.

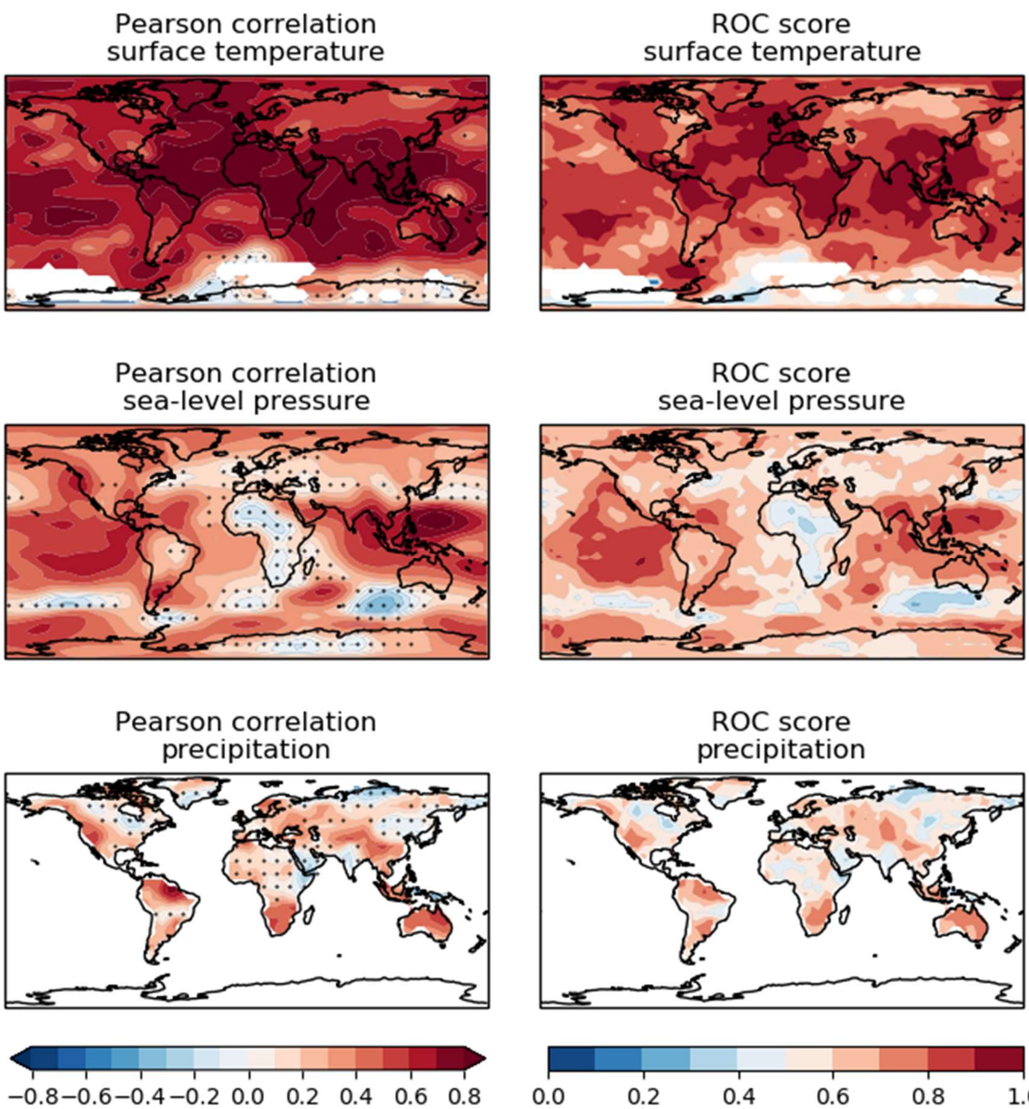

Figure 7: Prediction skill of annual mean hindcasts evaluated using CMIP5 experiments. Correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significant (at the 5% level).

Regional Predictions for 2020-2024

Predicted temperature patterns for 2020-2024 show a high probability for temperatures above the 1981-2010 average almost everywhere, with enhanced warming at high northern latitudes and over land compared to ocean (Figure 8). The Arctic (north of 60°N) anomaly is more than twice as large as the global mean anomaly. Skill is high in all regions apart from the eastern Pacific and Southern Ocean (Figure 9).

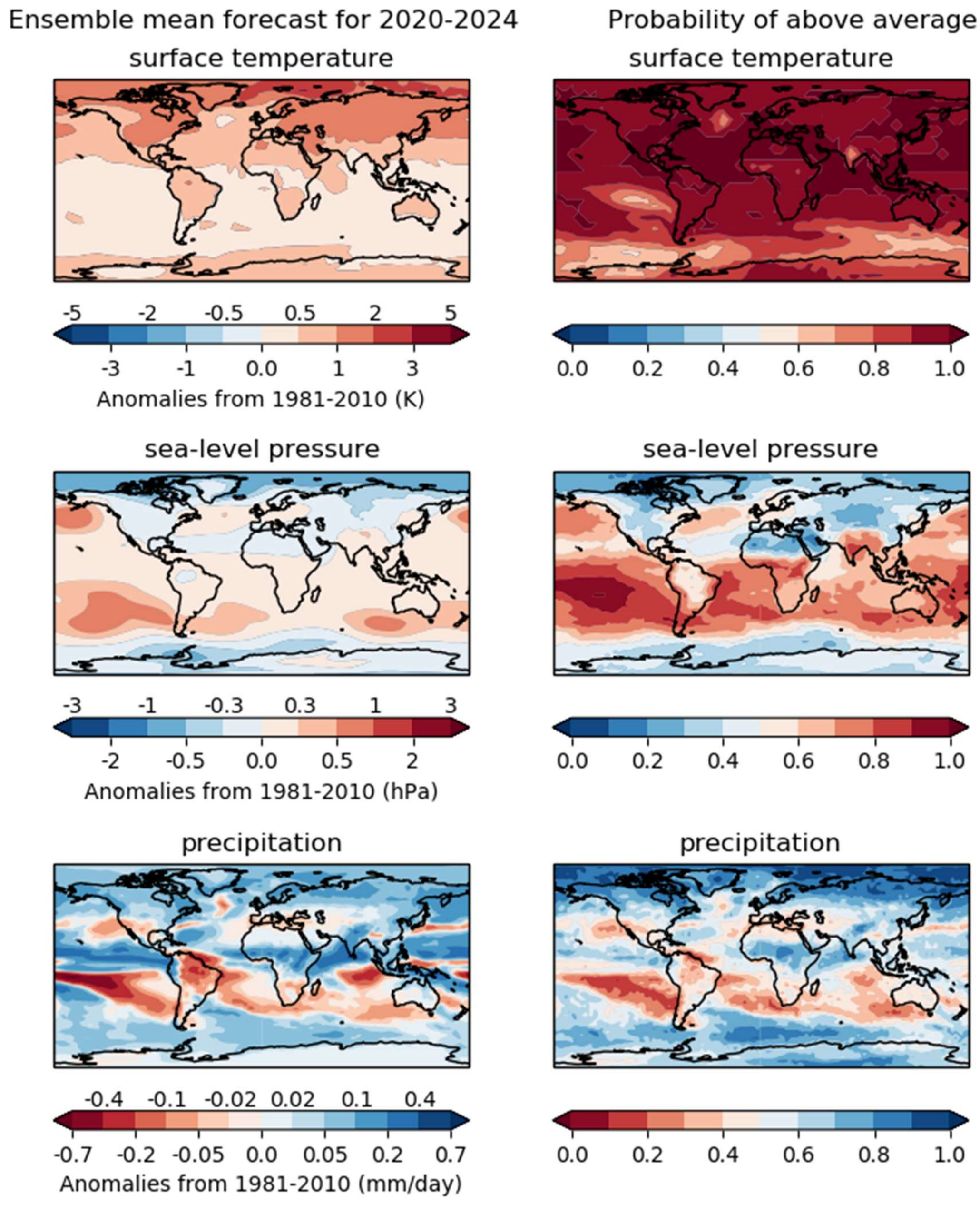

Figure 8: Predictions for 2020-2024 anomalies relative to 1981-2010. Ensemble mean (left column) and probability of above average (right column). As this is a two-category forecast, the probability for below average is one minus the probability shown in the right column.

Sea-level pressure maps for 2020-2024 show increased probabilities for low pressure over both poles compared to the 1981-2010 reference period, consistent with positive Arctic Oscillation (AO) and Antarctic Oscillation (AAO) indices (see appendix), and for high pressure over most ocean regions. The subtropical North Atlantic, however, shows an increased chance of low pressure which, combined with higher temperatures, suggests an increased chance of tropical cyclones in this basin. The increased north-south pressure gradient in the northern North Atlantic may also be indicative of stormier conditions over western Europe compared to 1981-2010. Skill is moderate and significant over these regions giving medium confidence in the forecast.

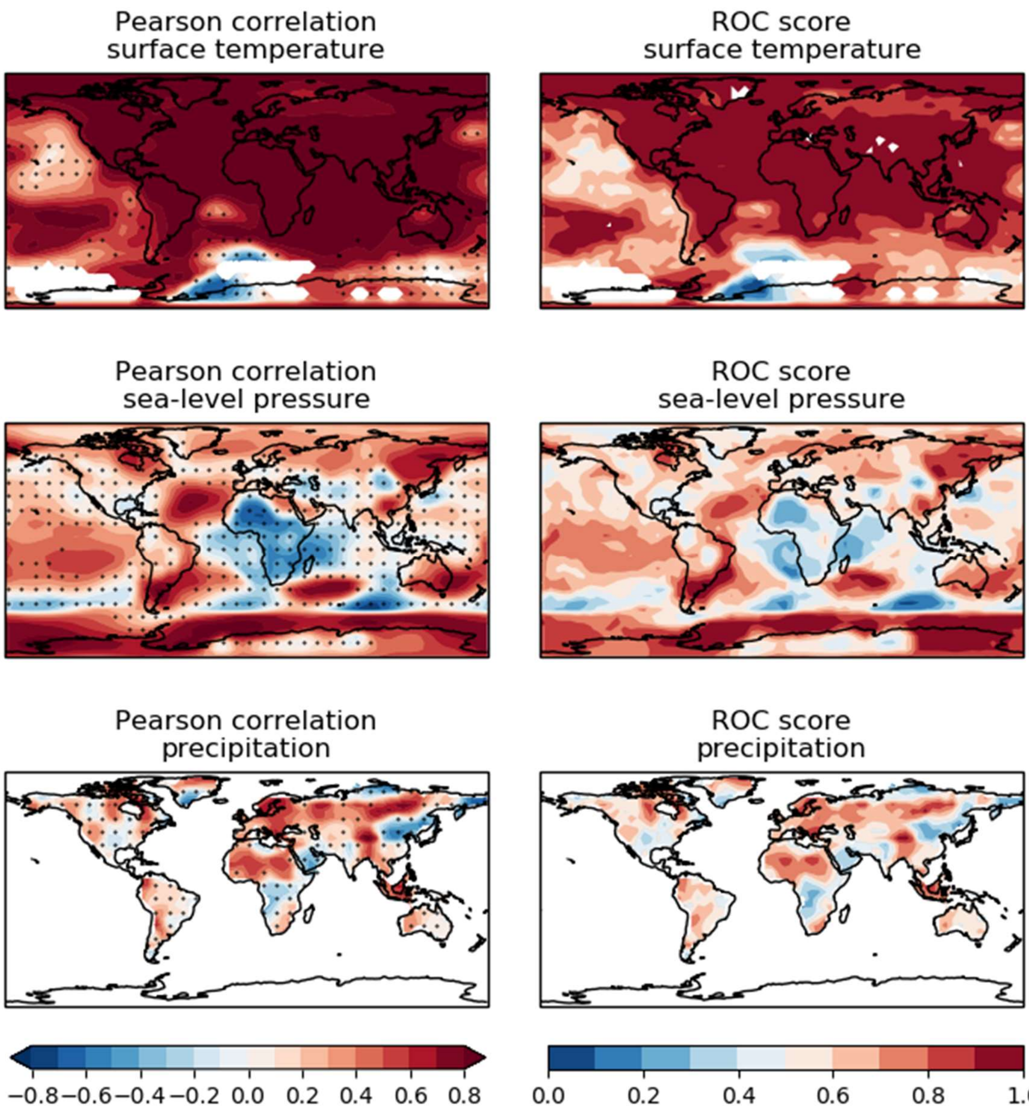

Figure 9: Prediction skill of five-year means evaluated using CMIP5 experiments. Correlation (left) and ROC score for predictions of above average conditions (right). For correlation stippling shows where skill is not significantly positive (at the 5% level).

Precipitation predictions for 2020-2024 favour wetter than average conditions at high latitudes in both hemispheres, but confidence is low because observations are insufficient for assessing skill except over land. Overall the pattern of increased precipitation in the tropics and midlatitudes and reduced precipitation in the subtropics compared to the 1981-2010 reference period is consistent with an increased hydrological cycle expected as the climate warms. There is moderate but significant correlation skill over the Sahel, parts of South America and across northern Europe and Eurasia, giving medium confidence in the forecast for an increased chance of precipitation in these regions.

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 2019 surface temperatures, which was run at the end of 2018 (Figure 10) is in very good agreement with the observed pattern including very warm conditions over the Arctic and Eurasia, and relatively cool conditions in the Southern Ocean, northern North Atlantic and tropical Pacific. Observed cooler conditions in parts of North America and a warm western Indian Ocean were not well predicted.

Sea-level pressure patterns agree reasonably well with the observations, with high pressure over the north pole, Australia and the eastern Indian Ocean and generally low pressure over northern Eurasia and the Antarctic. However, the predicted anomalies are small and the ensemble spread does not encompass the observed magnitude in many regions.

The ensemble mean predictions of precipitation captured the correct sign of anomalies in several regions including wetter conditions across the Sahel and central Africa, and drier conditions in Australia and southern Africa. Despite this, the ensemble spread did not encompass the observed values in some regions including northern Europe, SE USA, most of Australia and the Middle East.

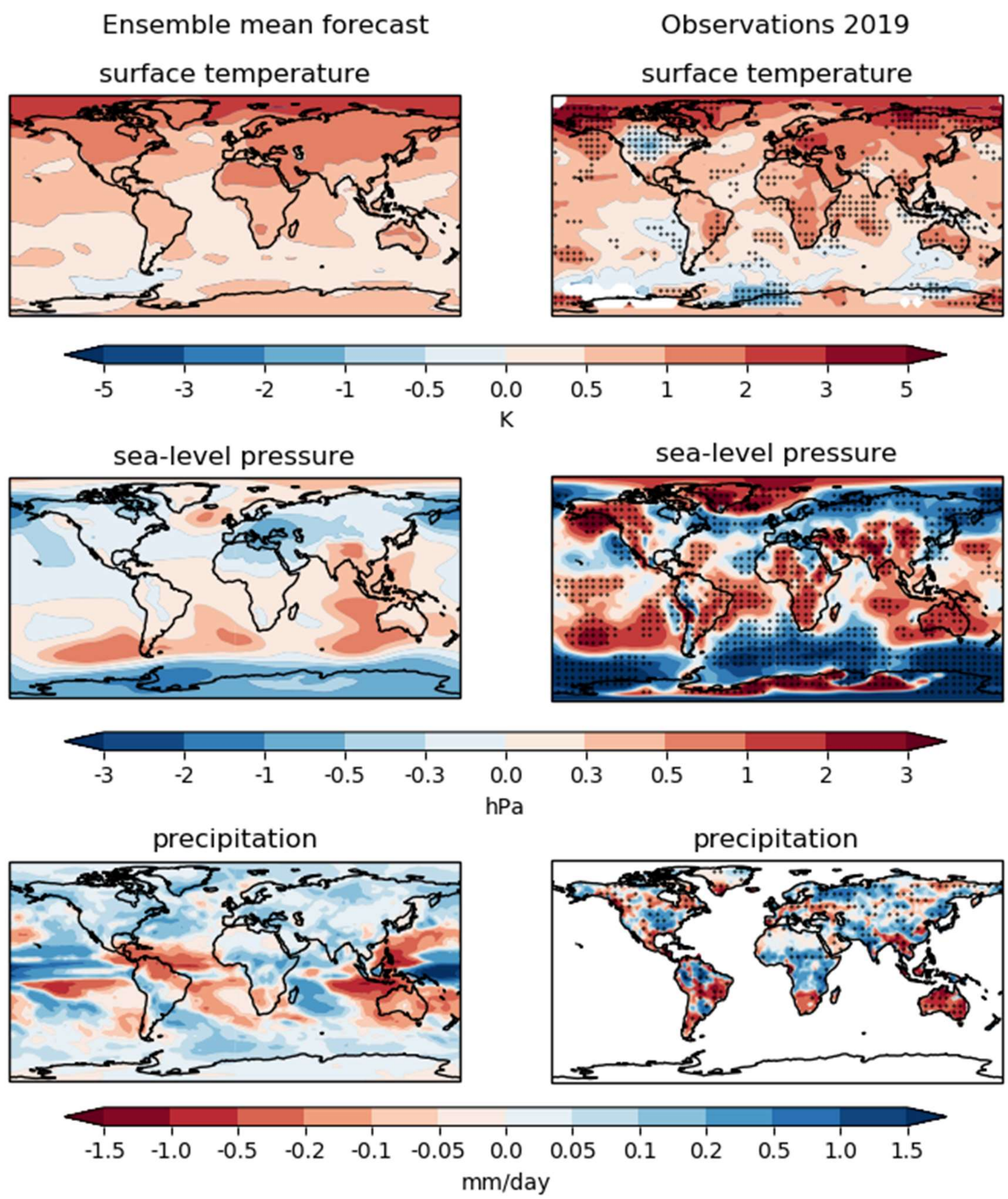

Figure 10: Verification of the one-year forecast for 2019 relative to 1971-2000. Ensemble mean forecast (left) and observed anomalies (right). Stippling shows where the observations fall outside of the 90% range of the forecast ensemble.

Forecast temperature anomalies for the mean of the last five years 2015-2019, which was run at the end of 2014 (Figure 11) generally agree well with observations of very warm conditions over the Arctic and Eurasia, and enhanced warming over the land compared to the ocean. Cooler than average conditions in the Southern Ocean and northern Atlantic are not seen in the ensemble mean but are mostly within the forecast range and the ensemble mean shows less warming in these regions.

Sea-level pressure patterns show some agreement with the observations, with low pressure over the Antarctic and high 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 many regions even when the ensemble mean shows the correct sign. Regions of high pressure over the North Atlantic and Eurasia were not captured by the ensemble.

Precipitation patterns show reasonable agreement with observations, including wetter conditions across much of Eurasia and central Africa, and drier conditions in SW USA, north-east Brazil, southern Africa and north-eastern Australia. Dry conditions in western Canada and Europe were not predicted.

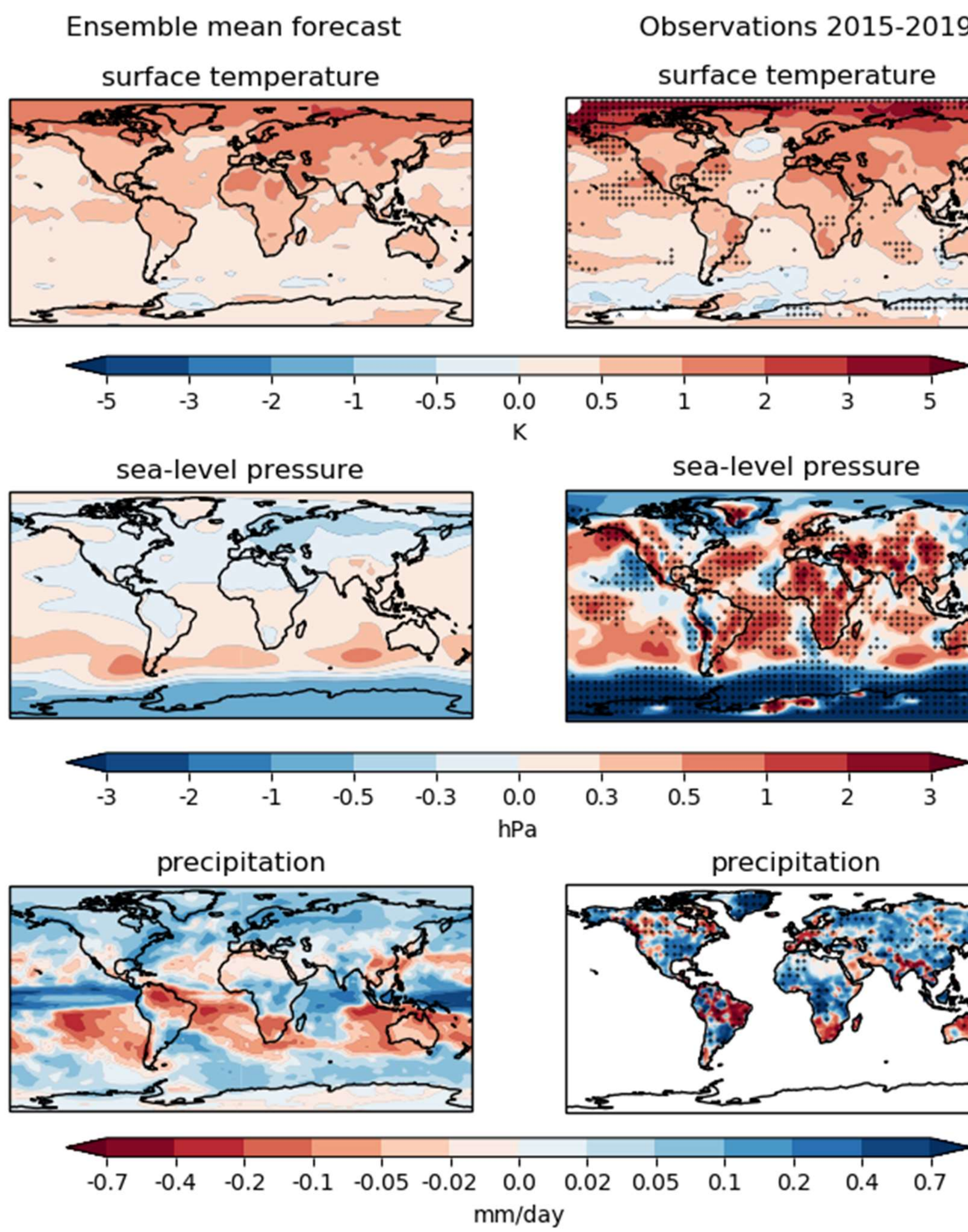

Figure 11: Evaluation of the five-year forecast for 2015-2019 relative to 1971-2000. Ensemble mean forecast (left) and observed anomalies (right). Stippling shows where the observations fall outside of the 90% range of the forecast ensemble.

Appendix – predictions for the AMOC and other indices

Predictions of Atlantic Meridional Overturning Circulation (AMOC) show reduced overturning in the mid-latitudes for 2020 (Figure 12, top row), but skill cannot be evaluated due to insufficient observations.

The AMOC prediction for 2020-2024 (Figure 12, bottom row) shows lower than average values in the ensemble mean throughout the Atlantic basin, particularly in the northern hemisphere mid-latitudes. There is large variability in the ensemble and most models predict stronger overturning as can be seen by the probability for above average in the North Atlantic. Confidence is low as skill for this circulation is not known.

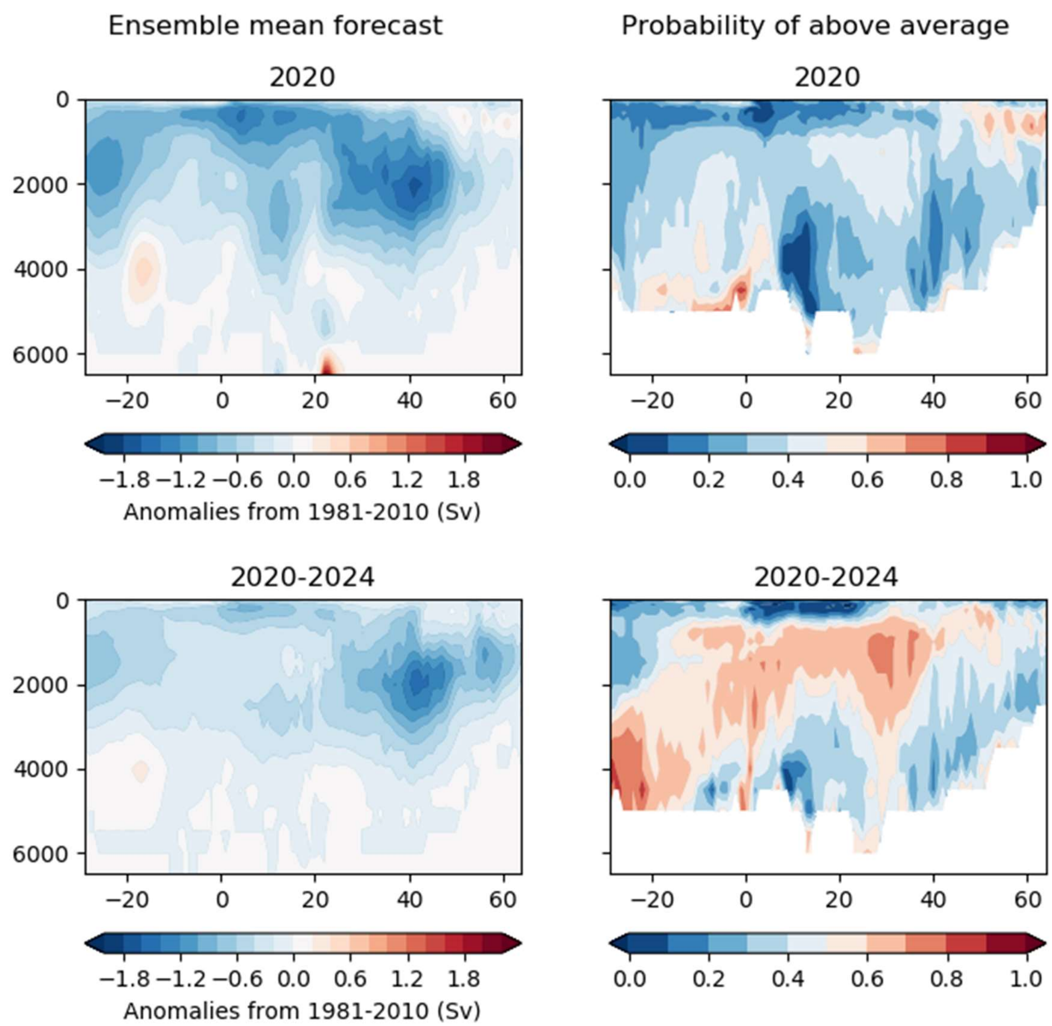

Figure 12: Atlantic Meridional Overturning Circulation (AMOC) forecast for 2020 (first row) and 2020-2024 (second row) relative to 1981-2010. The left column shows the ensemble mean prediction and the right column shows the probability of a stronger than average AMOC.

The AMOC close to 30°N is predicted to be close to, or slightly below recent values (Figure 13). 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.

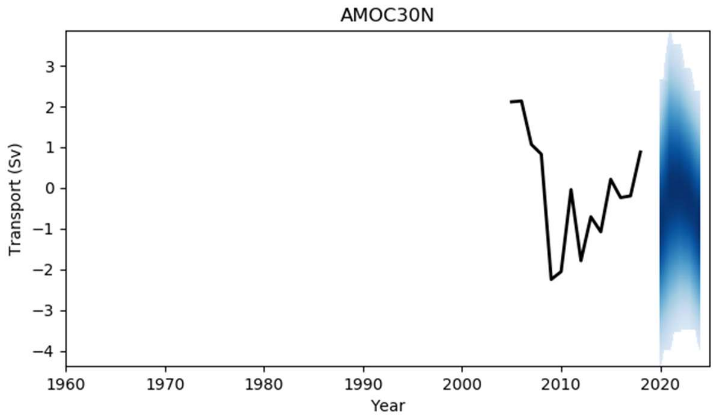

Figure 13: Atlantic Meridional Overturning Circulation at about 30°N and 1100m as in Roberts et al (2013). RAPID observations (26°N) in black (anomalies relative to its full time series 2005-2018) and model forecast in blue.

Pacific Decadal Variability (PDV) is predicted to be negative during 2020 with a 79% probability for below average (100% minus the 21% in brackets in Figure 14). Beyond two years there is no significant skill.

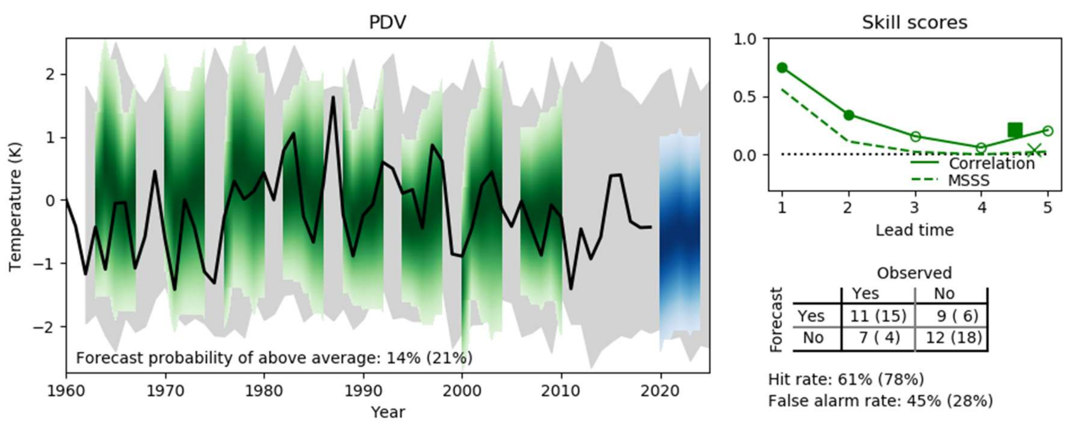

Figure 14: As Figure 4, but for Pacific Decadal Variability (PDV) defined as the difference in SST between the eastern tropical Pacific (10°S-6°N, 110°W-160°W) and the North Pacific (30°N-45°N, 145°W-180°W) as in Dong et al (2014).

The recent strong Antarctic Oscillation (AAO) is predicted to weaken, but stay above average (Figure 15). Although skill is significant for individual years and for the next five years, the hindcast (green) starting in 2005 did not capture the strengthening of the AAO and the forecast (blue) is much lower than recent observations. Confidence is therefore low to medium for this forecast.

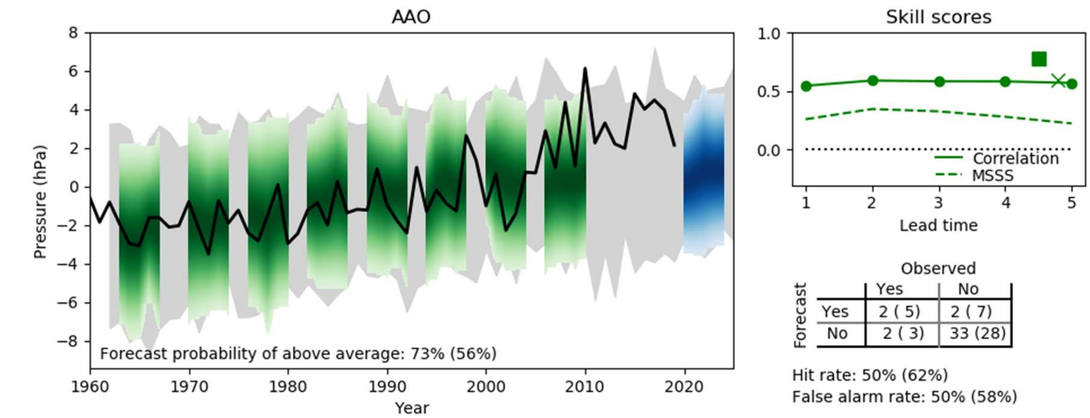

Figure 15: As Figure 4, but for the Antarctic Oscillation (AAO) defined as the difference in zonal mean sea-level pressure between 65°S and 40°S as in Dong & Wang (1999).

The Arctic Oscillation averaged over the next five years is likely to be above normal (Figure 16). Hindcasts show modest but significant correlation but probabilistic skill is low, so there is low to medium confidence in this prediction.

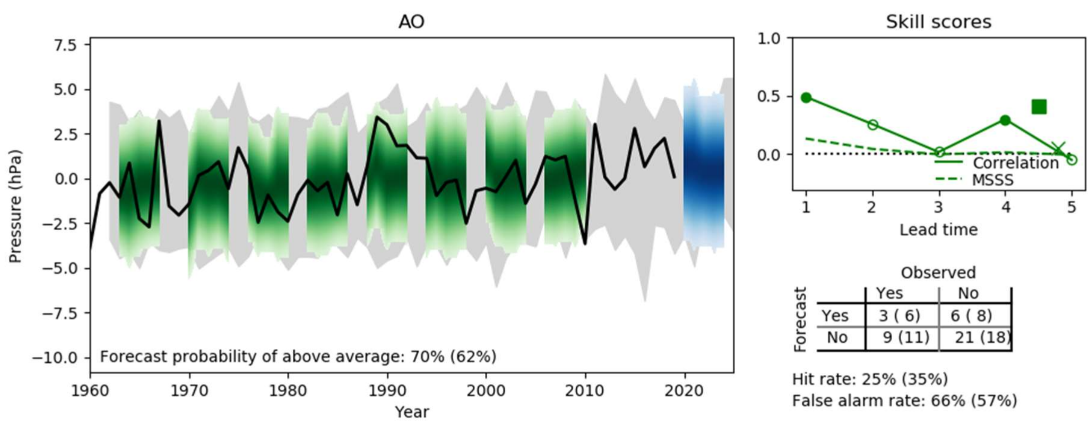

Figure 16: As Figure 4, but for Arctic Oscillation defined as the difference in zonal mean sea-level pressure between 80°N and 45°N, similar to Dong & Wang (1999), but for the Northern Hemisphere.

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