2011/12 Tropical Cyclone Season Forecast for the Australian Region Using a New Bayesian Regression Model

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a. Australian region tropical cyclone forecast model

We provide here an Australian region (90°-170°E) seasonal forecast of 2011/12 tropical cyclone event probabilities and likelihood prepared using Bayesian regression models developed on large-scale climate data and cross-validated over the 40-year period from 1968/69-2007/08 (Werner 2011; Werner and Holbrook 2011a,b,c). To include climatological information in the most meaningful way, these models have been developed based on the strength of relationships between large-scale climate 'predictor' variables and tropical cyclone genesis (TCG) events for the upcoming Australian region tropical cyclone season (November – April). A step-by-step predictor selection based on the probabilistic root-mean squared error and skill score ensured the most skilful model was developed.

The forecast model of the Australian region and eastern Australian subregion (135°-170°E) tropical cyclone *counts* (events) is based on a Bayesian approach using the Poisson regression on indices of subtropical central Pacific June-July-August (JJA) average convective available potential energy (CAPE), the tropical northeast Pacific May-June-July average meridional winds at 850 hPa (v_{850}) and subtropical central South Pacific June-July-August geopotential height at 500 hPa (Werner and Holbrook 2011a).The Australian region model shows considerable cross-validated hindcast skill during the observational period from 1968/69-2007/08 with correlation coefficients between the observed annual TCG event totals and cross-validated model hindcasts of r = 0.73 for the Australian region and r = 0.79 for the eastern Australian subregion. A separate model for the southeast Indian Ocean (Western Australian subregion; 90°-135°E), based on indices of the JJA tropical central Pacific sea level pressure (SLP) and v_{850} shows correlations between cross-validated hindcasts and observed annual TCG counts of r = 0.67 over the same period (Werner and Holbrook 2011c).

A separate model of the spatial distribution of Australian region TCG-event probabilities is seasonally forecast on a 2.5° x 2.5° grid using a separate Bayesian model developed on the logistic regression (Werner and Holbrook 2011b). The model builds on SLP, NINO4 and v_{850} indices, combined with spatial information from CAPE and shows an average improvement in cross-validated hindcast skill over climatology of 15% during the 40-year period 1968/69-2007/08. The average distribution of TCG-event probabilities and cross-validated hindcasts of TCG-event distributions during observed ENSO events match remarkably well over most of the study domain.

The models, as well as model forecast skill for the past three Australian region tropical cyclone seasons (following the training period 1968/69-2007/08), are discussed in detail in the PhD thesis of Angelika Werner (2011) and can be provided on request.

b. Climatic conditions

The climatic conditions during the austral winter (JJA) of 2011, and in the lead-up to the onset of the Australian region TC season of 2011/12, have been evolving towards a La Niña event year, based on forecasted classifications from NOAA using NINO3.4 anomalies (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml).

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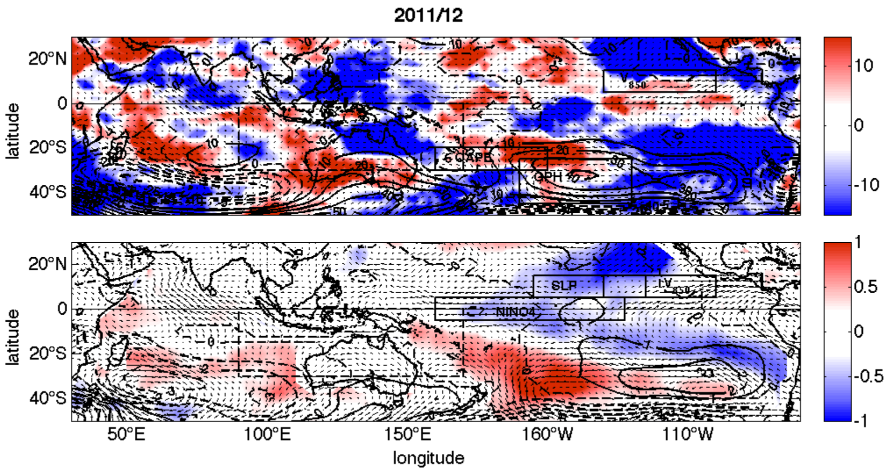

Figure 1 upper panel: Map of anomalies during June-July-August 2011. Wind vectors describe the wind flow anomalies at 850 hPa. Shaded areas represent changes of CAPE ($m^2\ s^{-2}$), contour lines show positive anomalies and dashed contour lines negative anomalies of geopotential height at 500 hPa (m). Also indicated are the locations of the predictor indices CAPE, v_{850} and GPH and the Australian TC region. lower panel: As above, but shaded areas represent changes of SST (°C), contour lines show positive anomalies and dashed contour lines negative anomalies of SLP (hPa). Also indicated are the locations of the predictor indices NINO4, v_{850} and SLP and the Australian TC region.

Figure 1 shows the large-scale climate anomalies used to derive the model predictors.

Interestingly, the sea surface temperature anomaly (SSTA) pattern shown in the lower panel shows almost negative El Niño Modoki conditions in the Pacific, with weak positive SLP anomalies (SLPA) in the tropical central Pacific. There are strong SLPA in the southern mid-latitudes, which are also evident in the geopotential height field anomalies (GPHA) at 500 hPa (upper panel), indicating stronger pressure systems there, which increase blocking of the mid-latitude air masses towards lower latitudes. The central Indian Ocean is slightly warmer than normal with weak negative SLPA in the southern Indian Ocean. A reduced trade wind component can be seen in the tropical east Pacific corresponding to the Modoki-like SSTA. The CAPE anomaly pattern (upper panel) shows enhanced convection in the subtropical West Pacific, and reduced convection in the subtropical East Pacific and over Northern Queensland.

For the predictors used in our models, the CAPE index suggests higher than normal tropical cyclone activity, v_{850} is slightly positive indicating a reduced inflow into the East Pacific tropics, and the GPHA is positive leading to increased blocking of mid-latitudinal air-masses. The SLPA index is neutral and NINO4 is weak negative. Spatially, in the TC formation regions, CAPE is neutral, albeit with a negative anomaly over northern Australia and weak positive anomalies at the outer southern boundaries of the Australian region. Overall, the predictors favouring increased TCG-event likelihood are almost in balance with those suppressing this likelihood.

Table 1 Number of TCGs forecasted for the Australian region and its subregions West and East for the TC season 2011/2012. Shown are the number of tropical cyclones forecasted with the highest probability, the median and the 75%, 90%, 95% and 99% quantiles of storms expected.

2011/2012

	Max(p)	Median	75%	90%	95%	99%
Australian	13	13	16	19	20	23
West	6	6	8	9	11	13
East	6	6	7	9	10	13

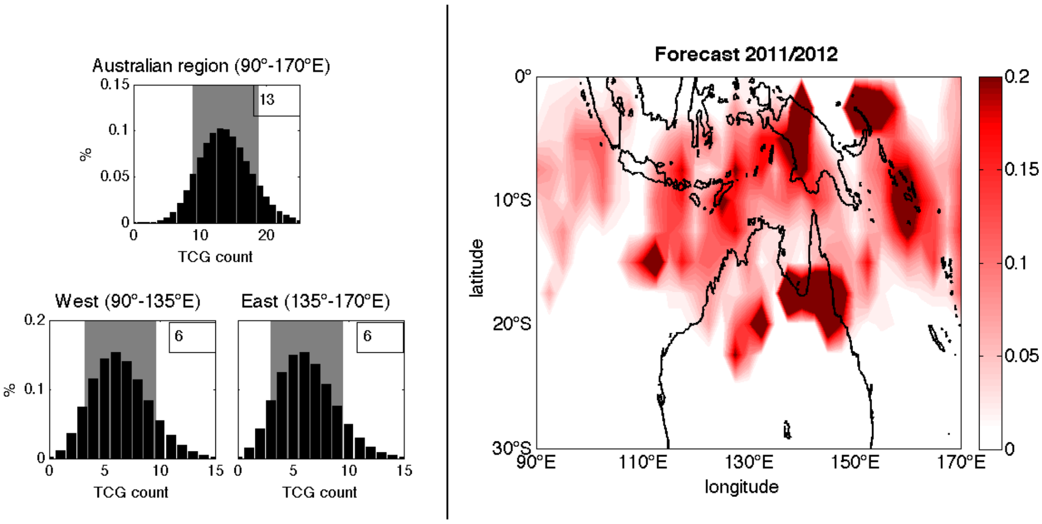

Figure 2 left side: Probability distributions of the annual total number of TCG occurrences forecasted for the season 2011/12 for the Australian TC region and its subregions West and East. Model standard deviations are indicated by the shading. Right side: Spatial (2.5°x2.5° resolution) probability of TCG forecasted for the season 2011/12 for the Australian TC region.

c. Model Forecasts

Figure 2 shows the model forecasts for the Australian region TC season of 2011/12. For the Australian region, 13 TCG events are expected, including 6 TCG events expected for both the Australian West and East subregions. Table 1 summarises the statistics of the probabilistic forecasts. The median for the Australian region is 13 TCG events, with a 25% chance of experiencing 16 or more TCG events. There is a 5% probability of more than 20 TCG events occurring in the Australian region during the 2011/2012 season. There is a 5-10% chance that we may see at least 10 TCG events in either of the two subregions. Overall, the forecast is mirroring the average conditions we expect from the large-scale climatology, and discussed in the previous section and shown in Figure 1.

The spatial distribution of TCG-event probabilities in Figure 2 shows maxima in the southeast Indian Ocean around 10°-15°S, 110-120°E and 5°-15°S, 120°-130°E. In the Pacific, local probability maxima are found to the east of Papua New Guinea and along the North Queensland coast in the Gulf of Carpentaria and between Mackay and Cairns.

Caveat: This forecast is an experimental product and is provided "as is" and without any warranty, including the implied warranties of merchantability and fitness for a particular purpose. The reader is forewarned that the methods/forecasts are new and subject to future change and improvement. The names of the authors may not be used to imply any kind of endorsement.

References

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