Met Office
Hadley Centre

Forecast of seasonal rainfall in northeast Brazil for March-May 2020

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FORECAST OF NORTHEAST BRAZIL SEASONAL RAINFALL FOR MARCH-MAY 2020 USING EMPIRICAL AND DYNAMICAL METHODS AND ATMOSPHERE AND OCEAN DATA UP TO MID FEBRUARY 2020

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PART 1: Forecast

Overall Summary

Above average rainfall is favoured

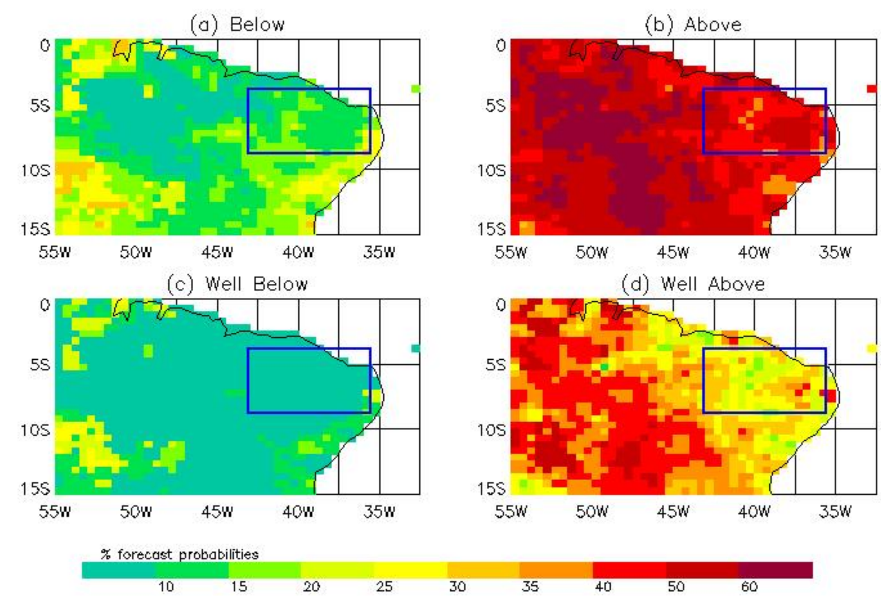


FIGURE 1: Forecast probabilities (%) of the (a) below normal and (b) above normal tercile categories and the (c) well-below-normal and (d) well-above-normal quintile categories of precipitation, March-May 2020. The tercile and quintile categories are defined over the 1981-2010 climatology (by definition, the climatological frequency of each tercile and quintile category is 33% and 20% respectively). The blue rectangle outlines the Standard North East Brazil region (SNEBR – see text).

The forecast for March-April-May (MAM) 2020 (Fig. 1) was produced by combining output from the Met Office GloSea5 dynamical forecast system with statistical predictions from pre-season sea surface temperatures in the tropical Atlantic and Pacific. The detailed methodology is described in Part 2. For this forecast the GloSea5 component comprised an aggregation of 42 GloSea5 predictions (ensemble members) initialised between 20 January and 9 February which cover the period March to May. For more details about GloSea5, see http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/user-guide/technical-glosea5.

For most of the region shown in figure 1a and b, the combined (GloSea5 plus statistical) forecast probabilities for the above average rainfall tercile category are centred near 50%, a substantial enhancement over the climatological chance of 33%. In contrast probabilities for the below average category are generally near or below 20%, well below the climatological expectation. Probabilities of the well-above quintile category are above the 20% chance level in most regions (Figure 1d), particularly in the west whilst probabilities for the well below quintile category are generally markedly below the 20% chance level (<10% over large areas). The combined tercile forecast is generally consistent with direct output for MAM 2020 from the GloSea5 system alone (February initialisation), as available at: http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/glob-seas-prob.

Current SST Patterns

Latest SSTs can be viewed at http://www.emc.ncep.noaa.gov/research/cmb/sst_analysis/images/monanomv2.png. Neutral ENSO conditions are currently present in the tropical Pacific and are expected to remain neutral through the forecast period (probability of 60% see: https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml). Neutral ENSO is not historically associated with a shift in likelihood to either above or below average rainfall in NE Brazil. In the Atlantic, SST is warmer than average in the Gulf of Guinea and colder than average off the coast of southeast Brazil and near average just north of the equator. Fluctuations of SST anomalies across these three regions (the Atlantic tripole pattern) are known to influence rainfall in N E Brazil and the current tripole index favours above normal rainfall. Infact, the index is at a record high, (highest since 1912 at least), but the concurrent ENSO neutral conditions moderates the strength of the overall signal and the magnitude of the probabilities. The dominance of the Atlantic influence is present in both the GloSea5 and statistical forecast components.

Forecast for the SNEBR

For consistency with forecasts for previous years, a forecast has also been calculated for quintile category probabilities for the Standard North East Brazil Region (SNEBR) which covers 43.125^{o}W-35.625^{o}W, 3.75^{o}S-8.75^{o}S and is marked by the blue rectangle in Figure 1. Quintile category forecasts have been issued for this (or a very similar) region since 1987.

Forecast probabilities for quintile categories of mean rainfall for SNEBR are shown in the table below. Probabilities for the Above category (33%) and the Well-Above category (29%) are substantially elevated above the climate chance (20%); while probabilities for Below (12%) and Well-Below (3%) are substantially depressed. The predicted probability for Near Normal (23%) is similar to the climate chance.

Category	**Well-Below**	**Below**	**Near Normal**	**Above**	**Well-Above**
Probability (%)	**3**	**12**	**23**	**33**	**29**

Part 2: Background

1. Introduction

Real-time forecasts of mean rainfall during the northeast (NE) Brazil rainy season (approximately February-May) have been issued by the Met Office for each season since 1987 following research by Ward and Folland (1991) and by Folland et al (2001). Forecasts are issued in December and February using the latest available ocean and atmosphere information. Output from the Met Office Global Seasonal (GloSea) dynamical seasonal forecast system and observed sea-surface temperature (SST) based statistical predictors are combined to produce probability forecasts for tercile and quintile categories. Canonical Correlation Analysis (CCA) is used to calibrate and combine the forecasts, making use of the Climate Predictability Tool (CPT) package developed by the International Research Institute for climate and society (IRI). (http://iri.columbia.edu/our-expertise/climate/tools/cpt/). CCA (Barnett and Priesendorfer, 1987) identifies patterns in the predictor data from hindcasts which correlate well with and thus could be physically related to patterns of observed rainfall. CCA adjusts for spatial errors in the model forecast (for example errors in the positioning of spatial anomalies).

The probability maps in the forecast have half-degree latitude / longitude representation made possible by the availability of the “Climate Hazards Group InfraRed Precipitation with Station data version 2.0” (CHIRPS2.0) (Funk et. al. 2015).

Also presented are assessments of forecast skill measured using retrospective forecasts (hindcasts). The skill measures used are Pearson and Spearman correlation and the Relative Operating Characteristic (ROC) score (Broecker, 2012) which is a WMO standard assessment measure for seasonal forecasts.

2. Forecast Method

2.1 Statistical Predictors

The statistical predictors are the same as in previous forecasts. They are two indices representing tropical Atlantic SST anomaly patterns and Pacific SST anomaly patterns (Folland et. al. 2001), obtained by projecting current (December-February) SST anomalies onto empirical orthogonal function (EOF) patterns of historical SST in the Pacific and tropical Atlantic (Figure 2 a,b) which are known to be related to NE Brazil rainfall.

2.2 GloSea5 Dynamical Forecasts

For the forecast, we use the latest version of our Global Seasonal forecasting system, GloSea5-GC2, see http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/notice. To allow assessment of a range of outcomes, GloSea5 is run in ensemble mode. A number of predictions (ensemble members) are generated using a lagged-start approach with 2 members run each day (simulating uncertainty in initial conditions), and also applying slight perturbations to model physics parameters to address uncertainties in model formulation. For more details about GloSea5, see http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/user-guide/technical-glosea5.

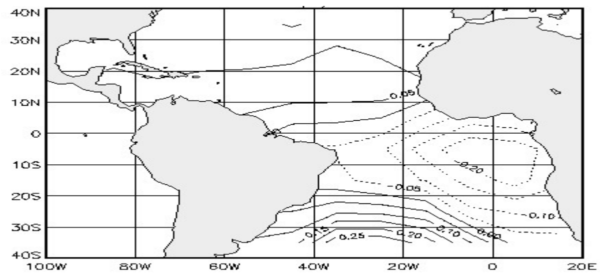
Post-processing of the rainfall output from the GloSea5 system includes an EOF analysis using a domain that covers the NE Brazil region (5°N-20°S, 60°-30°W). The use of EOFs is considered preferable to use of direct gridded model output as the EOFs represent large-scale modes of variability and models predict larger scale patterns more reliably than individual gridpoint values (MacLachlan et al 2014; Ndiaye et al, 2011). The EOFs are calculated from ensemble mean hindcasts produced for the period 1993-2016 The number of EOFs is selected to maximise overall correlation skill in predicting NE Brazil rainfall. In order to identify useful predictors, a set of CCA hindcasts of NE Brazil rainfall were carried out using GloSea5 rainfall. Skill was maximised when 1 rainfall EOF (displayed in Figure 2c) was used. This pattern (GloSea5 precipitation Figure 2c) shows a consistent signal across the NE Brazil region and is very similar to the corresponding first EOF of observed rainfall. This predictor pattern is used for the combined forecasts.

2.3 Combined Forecast

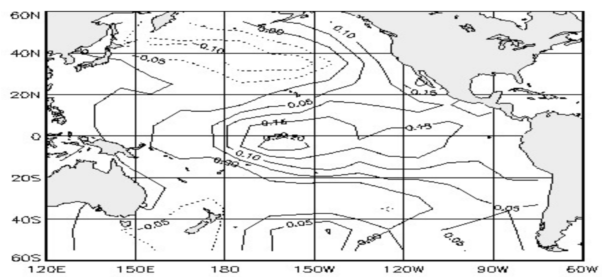
The combined forecast has 3 predictors as described above and plotted in Figure 2.

Timeseries of the projections of these 3 predictor patterns are used along with observed rainfall to train a CCA model over the period 1993-2016 (the period for which both GloSea5 hindcast data and pre-season predictor SST indices are available), then projections on recent observations and GloSea forecast data are used to produce a forecast, using CCA as implemented in CPT.

(a)



(b)



(c)

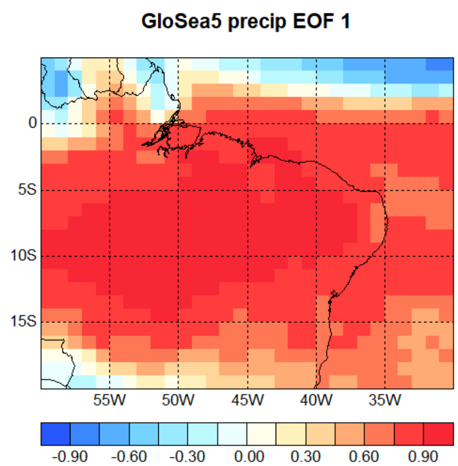


Figure 2. The 3 predictors used for the combined forecast. (a) tropical Atlantic SST pattern, (b) tropical Pacific SST pattern, (c) GloSea5 precipitation EOF 1 pattern

3. Forecast Format and Skill

Forecasts for each gridpoint are converted from a deterministic value to a probability density function (PDF) by fitting a normal distribution based on the CCA forecast mean and the CCA hindcast standard error.

Forecasts are presented as probabilities for 3 tercile categories which are equiprobable over a representative climatology period (1981-2010 in this case). Forecasts are also presented for two outer quintile categories (representing rainfall totals above and below the outer quintiles respectively) and are also referred to as the well-above-normal and well-below-normal quintile categories.

3.1 Forecast Skill

The skill of the combined forecasts measured using Pearson correlation, Spearman correlation and ROC skill is presented in Figure 3. In general correlation and above normal ROC skill peaks between 2°S and 10°S whilst below-normal ROC skill is highest further south.

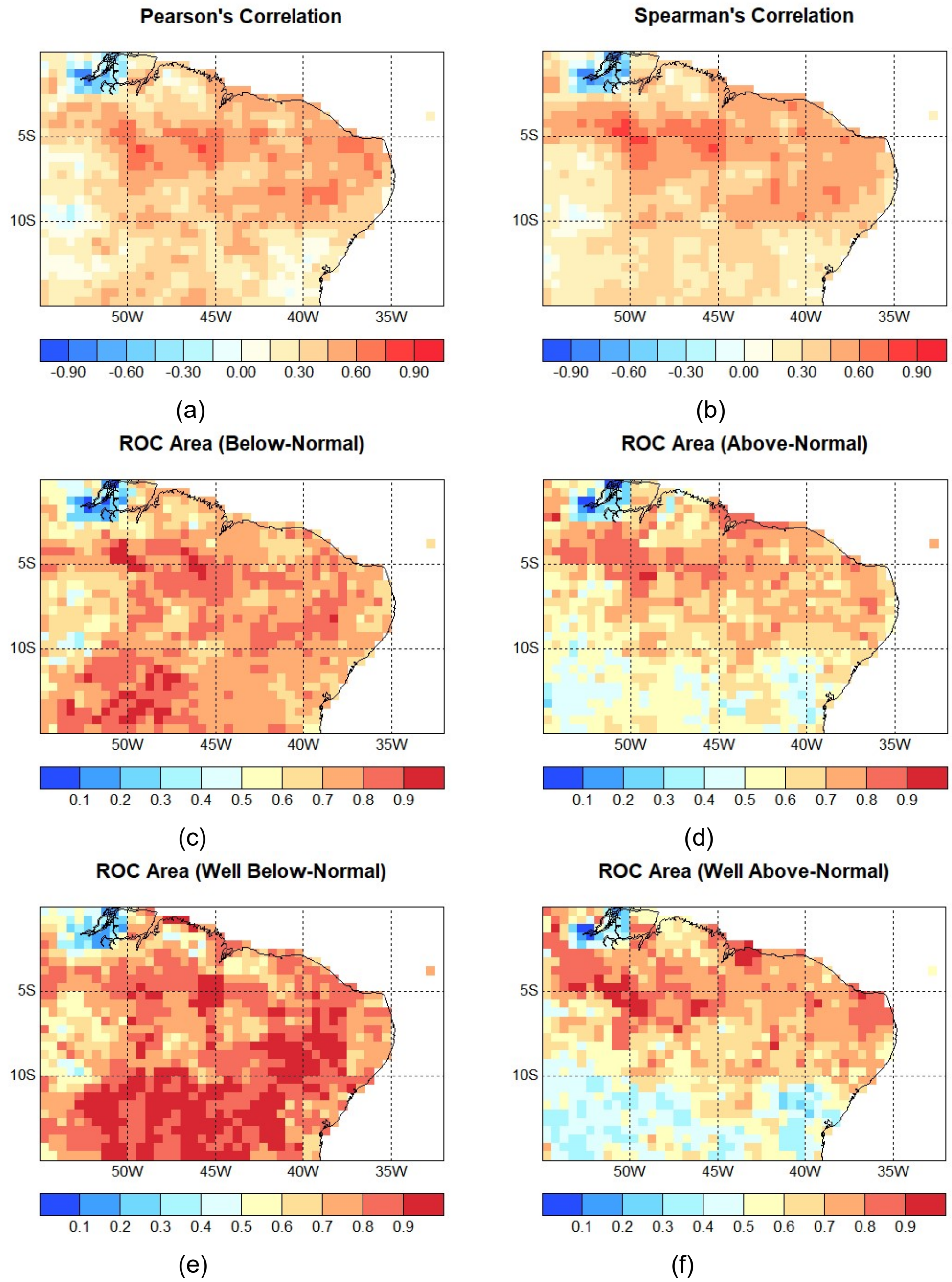


FIGURE 3 Skill of combined forecasts measured using (a) Pearson Correlation, (b) Spearman Correlation, (c) ROC of below-normal tercile category forecasts and (d) ROC of above-normal tercile category forecasts (e) ROC of driest (well-below-normal) quintile category forecasts and (f) ROC of wettest (well-above-normal) quintile category forecasts evaluated over March-May 1993-2016.

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