Met Office
Hadley Centre

Forecast of seasonal rainfall in northeast Brazil for March-May 2021

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FORECAST OF NORTHEAST BRAZIL SEASONAL RAINFALL FOR MARCH-MAY 2021 USING EMPIRICAL AND DYNAMICAL METHODS AND ATMOSPHERE AND OCEAN DATA UP TO FEBRUARY 2021

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PART 1: Forecast

Overall Summary

Below average rainfall is favoured over much of the east, while above average rainfall is favoured over much of the west.

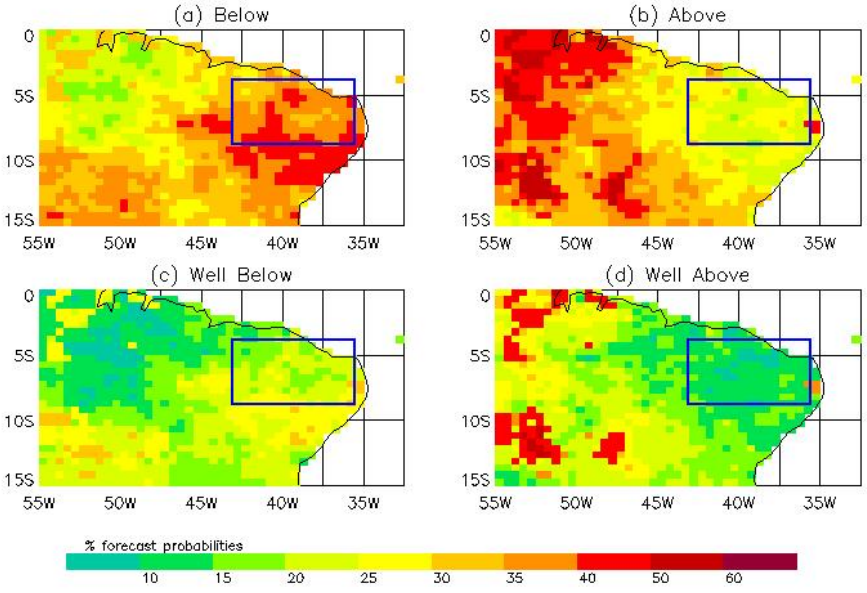


FIGURE 1: Forecast probabilities (%) of the (a) below normal and (b) above normal tercile categories and the (c) well-below-normal and (d) well-above-normal quintile categories of precipitation, March-May 2021. The tercile and quintile categories are defined over the 1981-2010 climatology (by definition, 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) 2021 (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 18 January and 7 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 the eastern half of the region shown in figure 1a and b, the combined (GloSea5 plus statistical) forecast probabilities for the below average rainfall tercile category are centred near 40%, slightly above the climatological chance of 33%. In contrast probabilities for the above average category are generally around 25%, below the climatological expectation. The reverse is true in the western half with the wet category being slightly favoured. Likewise, probabilities of the well below quintile category are predominantly above the 20% chance level in the east (Figure 1d), whilst probabilities for the well above quintile category are generally above the 20% chance level in the west. The same east-west gradient can be seen in the direct output for MAM 2021 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 SST anomalies can be viewed at https://psl.noaa.gov/map/clim/sst.shtml (see latest month anomalies).A moderate La Niña event is present in the tropical Pacific. La Niña events are historically associated with above average rainfall in NE Brazil. In contrast, in the Atlantic, SST is colder than average in the tropical Atlantic directly East of Brazil and warmer than average off the coast of southeast Brazil and over a small area just north of the equator. This “tripole” configuration of SST anomalies favours below average rainfall in NE Brazil. Therefore forcings from the Atlantic and Pacific on NE Brazil rainfall are in the opposite sense with the Atlantic appearing to be more influential in the east and the Pacific more influential in the west.

Forecast for the SNEBR Region

For consistency with forecasts for previous years, a forecast for quintile category probabilities has also been calculated using the same method as for the forecast in figure 1, for the Standard North East Brazil Region (SNEBR) which covers 43.125˚W-35.625˚W, 3.75˚S-8.75˚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 the SNEBR region are shown in the table below. The probability for the Well-Above category, at 15%, is moderately depressed below the chance value of 20%. The other categories (Above, Near-Normal, Below and Well-Below) are all within 2% of the chance value.

Category	Well-Below	Below	Near Normal	Above	Well-Above
Probability (%)	21	22	22	20	15

Note 1: Quintiles are defined over the 1981-2010 period.

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 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.

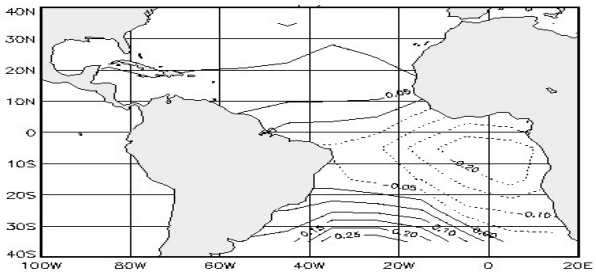
Post-processing of the rainfall output from the GloSea5 system includes an EOF analysis using a domain that covers the NE Brazil region (5°N-20°S, 60°-30°W). The use of EOFs is considered preferable to use of direct gridded model output because the EOFs represent large-scale modes of variability and 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. The EOF1 loading pattern (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 together with the two statistical predictors in the combined forecasts.

2.3 Combined Forecast

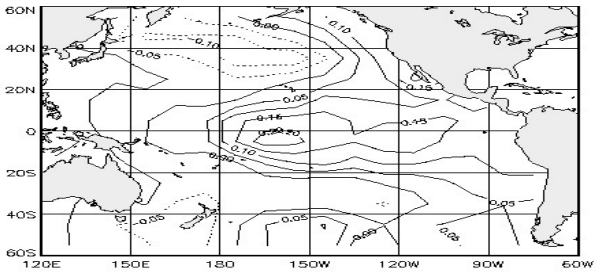
The combined forecast uses the 3 predictors described in 2.1 and 2.2 above and depicted in Figure 2.

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)

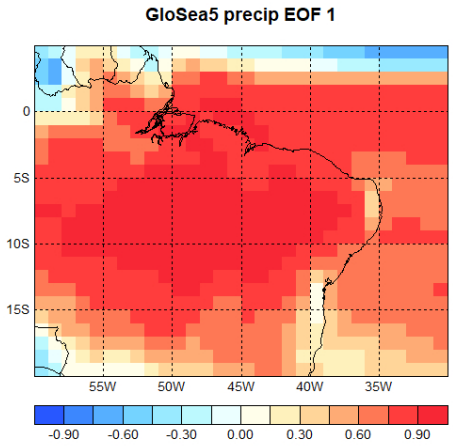


Figure 2. The 3 predictors used for the combined forecast. (a) tropical Atlantic SST pattern, (b) tropical Pacific SST pattern, (c) GloSea5 precipitation EOF 1 pattern

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.

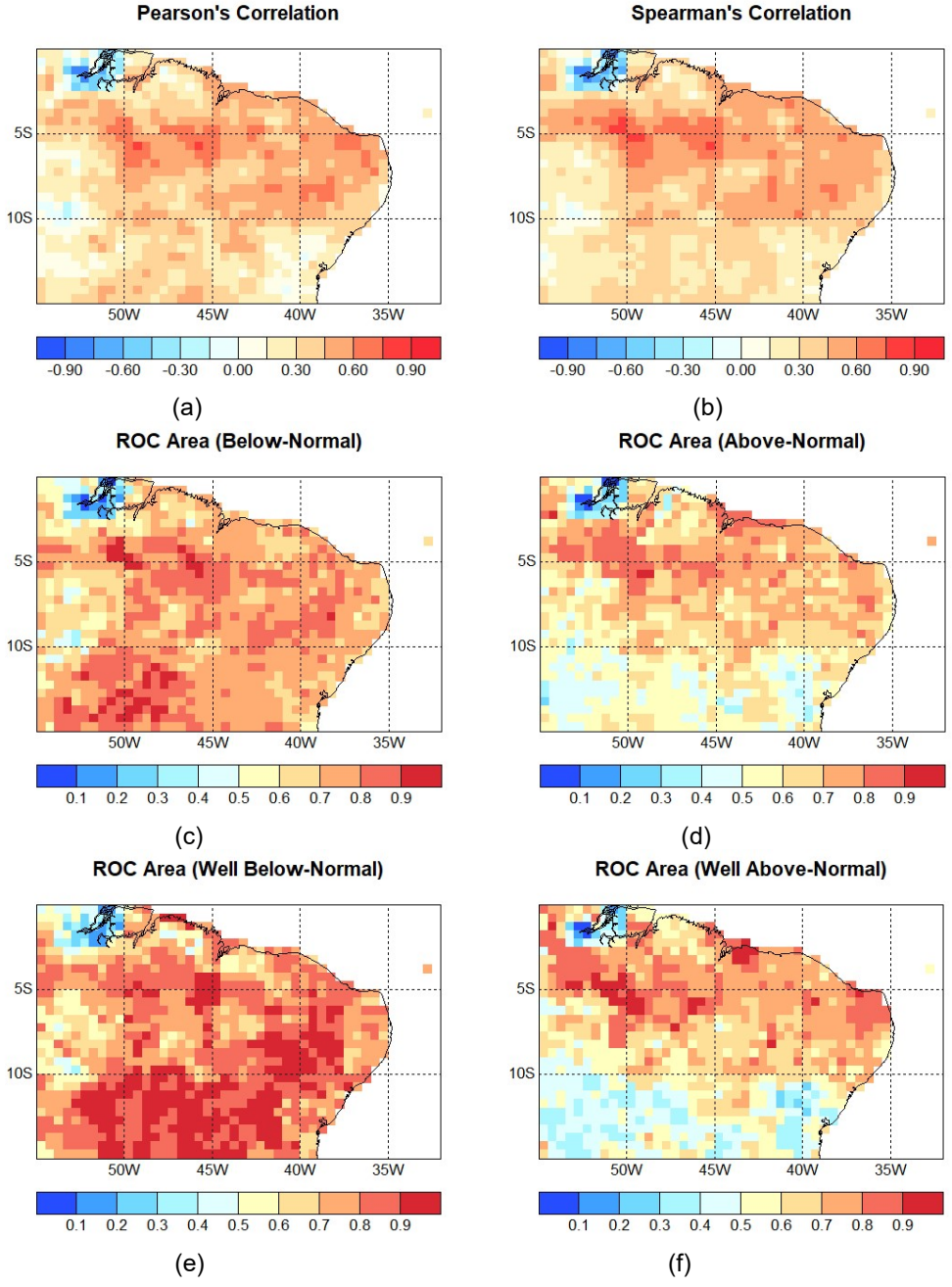


FIGURE 3 Skill of combined forecasts measured using (a) Pearson Correlation, (b) Spearman Correlation, (c) ROC of below-normal tercile category forecasts and (d) ROC of above-normal tercile category forecasts (e) ROC of driest (well-below-normal) quintile category forecasts and (f) ROC of wettest (well-above-normal)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

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