From subseasonal to seasonal forecasts over South America using the Eta Model

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Introduction

Forecasts at seasonal and sub-seasonal time ranges are useful for planning actions in various socio-economic sectors such as energy, agriculture, water supply, etc. Higher spatial resolution forecasts are more suitable for dealing with local problems. However, the skill of the seasonal forecasts are generally limited and the skill of subseasonal forecasts of little knowledge. Therefore, to investigate the level of the forecast skill are crucial for making the information useful.

The objective of this work is to evaluate the Eta model skill for seasonal and sub-seasonal forecasts over South America.

The Eta model

The Eta model (Mesinger et al. 2012; Mesinger et al. 1988; Black 1994; Janjić 1994) has been used by the Center for Weather Forecasts and Climate Studies (CPTEC) to provide operational weather forecasts for South America since 1996 (Chou, 1996). One of the major feature of the model is the vertical eta coordinate, or the so-called step-mountain coordinate (Mesinger 1984). The reason for the choice of the Eta model at CPTEC was the advantage of the eta over the sigma coordinate to reproduce the summer circulation over South America (Figueroa, 1992). The major windstorm, the zonda wind, is reproduced accurately by the Eta model (Seluchi et al., 2003; Antico et al. 2017)) at different temporal scales. The model is setup at 40 km and 15 km resolution, for medium range forecasts, 5 km over Southeast Brazil for high-resolution ensemble forecasts, and 1-km for power plant emergency forecasts.

Seasonal forecasts started operationally in 2002 (Chou et al. 2005) and a modified version for climate change studies was developed (Pesquero et al. 2010; Chou et al. 2012; Chou et al. 2014) to support various impact, vulnerability, and adaptation studies (MCTI, 2016; Tavares et al. 2017). The upgraded version of the model (Mesinger et al. 2012) includes the 'cut-cell' feature for the coordinate, the piecewise linear scheme for vertical advection, among other features. The model versions use the Betts-Miller-Janjic (Janjić 1994) scheme for cumulus parameterization, Ferrier (Ferrier et al. 2002) or Zhao (Zhao et al. 1997) scheme for cloud microphysics parameterization, GFDL radiation package which parameterizes long (Schwarzkopf and Fels 1991) and short waves (Lacis and Hansen 1974), and the NOAH land-surface scheme (Ek et al. 2003).

These features are incorporated in the updated version for seasonal forecasts (Chou et al. 2018) and for subseasonal forecasts.

The seasonal forecasts

The domain adopted for the seasonal forecasts encompasses the entire South America and Central America continents (Figure 1). Model resolution is 40 km in the horizontal and 38 layers in the vertical. The forecast length is 4 months, and an additional approximately 0.5-month for land-surface spin-up time. Five ensemble members are constructed by assuming small perturbations in the initial conditions, which consider model runs starting between the dates 13 and 17 of month before the forecast season. For example, the model forecast run for the season October-November-December-January (ONDJ) starts on September 13, 14, 15, 16, and 17. The Eta model is driven by the CPTEC global atmospheric model at T62L28 resolution, and uses the persisted sea surface temperature anomaly.

Over the most part of the continent, the seasonal precipitation forecasts are underestimated, especially during the rainy season. On the other hand, overestimate of seasonal precipitation is forecast over the equatorial Intertropical Convergence Zone (ITCZ) region, along the eastern coast of the continent and along the eastern slopes of the tropical Andes mountains.

A single member of the forecast run driven by the CPTEC Coupled Ocean-Atmosphere global model show some reduction of these systematic seasonal precipitation errors.

Considering the increase of spatial resolution provided by the Eta regional climate model (RCM), Figure 2 explores the use of the increased temporal resolution for the upper Sao Francisco river basin located in Southeast Brazil. Monthly precipitation for the season OND averaged over 7 years is compared against two observational dataset. The comparison shows that the monthly precipitation forecasts reproduce the increasing trend of precipitation, but underestimate the amounts in all months. In addition, the forecast run driven by the OAGCM show some reduction of the underestimate error. The improvement of these precipitation forecasts using the OAGCM have also been shown by Pilotto et al. (2012).

The subseasonal forecasts

The subseasonal forecasts produced by the Eta model for 50 days ahead are driven by the CPTEC OAGCM forecasts at T62L28 resolution, and the respective forecasted sea surface temperature. The 20 members of the ensemble are constructed as lagged-ensemble forecasts. This is done by taking the initial conditions 10 days before and running at 00 Z and 12 Z, for 60-day integration length. The Eta model was setup at 40-km resolution. Figure 3 shows the 10-day accumulated precipitation in the São Francisco river basin for the period between February 10 and March 31, 2015. Therefore, the initial conditions were taken for

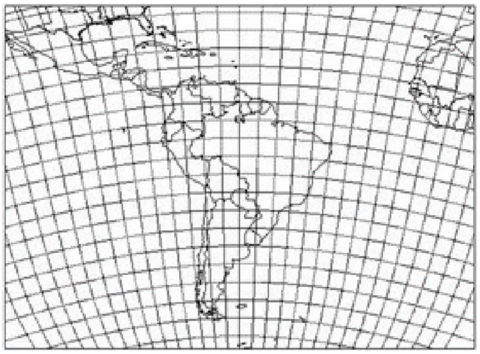

Figure 1 – Model domain for the Eta season-al forecasts.

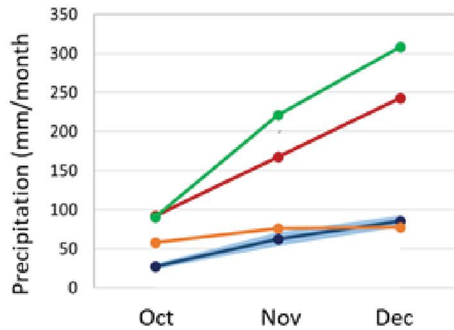

Figure 2 – Seasonal Precipitation (mm/month) forecasts for the months of October, November, and December, averaged over the years between 2001 and 2007. The curves are CRU (red), CMORPH (green), Eta-OAGCM (orange), and Eta-AGCM (blue).

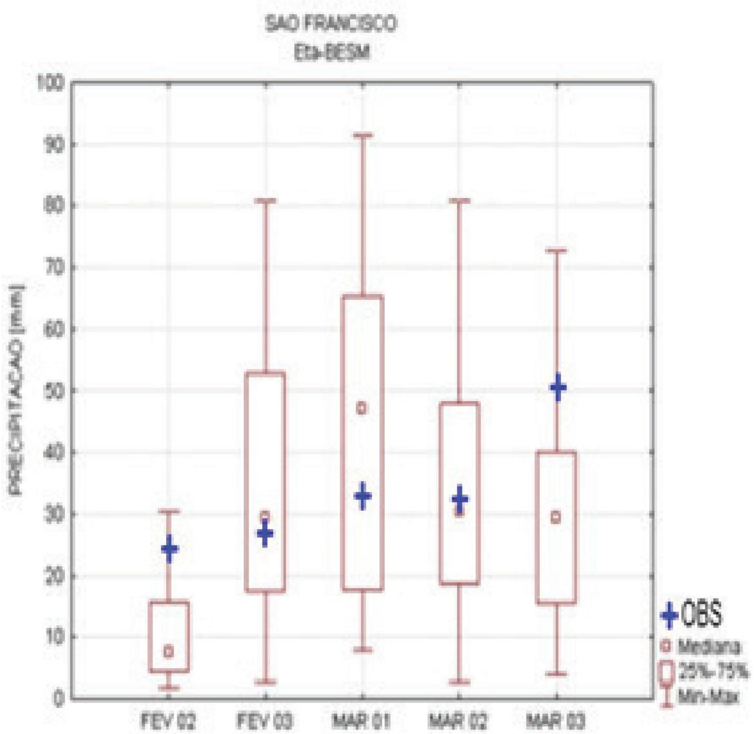

Figure 3 – Boxplot of subseasonal (50-day) precipitation (mm/10day) forecasts in the Sao Francisco basin, between Feb. 10 and Mar. 31, 2015. Observations are indicated in crosses.

the period between February 1st and 9th, 2015.

Unlike the seasonal forecasts, subseasonal forecast over Sao Francisco river basin does not show large underestimate. The forecasts between the second and the fourth 10-day period show reasonable agreement with observations as these values lie within the 25th and 75th percentile. The first and fifth period show precipitation underestimate. For the month of March, the total precipitation forecast is about 108 mm whereas observation is 101 mm and observed climatology for the month is 136 mm for the basin. Therefore, these forecasts show potential for useful in planning activities.

Conclusions

The Eta model runs at CPTEC/INPE for high-resolution weather forecasts, for ensemble forecasts, at short and medium ranges. Here some evaluations of Eta model precipitation forecasts at seasonal and sub-seasonal ranges are shown. The lateral boundary condition are crucial for seasonal range as precipitation errors patterns change. The seasonal forecasts have reduced errors when driven by the CPTEC OAGCM. At sub-seasonal range, the precipitation errors tend to show different pattern and no clear underestimate. Additional seasonal range runs produced by modifying Eta model physics are being evaluated and considered as candidates for ensemble members. At sub-seasonal ranges, higher spatial resolution may improve the forecast skill. The construction of hindcasts is ongoing. Despite the errors, the precipitation forecasts have shown potential for planning applications.

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