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Dynamical downscaling of GloSea5 over Ethiopia

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ABSTRACT

We have implemented dynamical downscaling of the Met Office GloSea5 global seasonal forecasting system and analysed its ability to generate skilful forecasts of characteristics of the June-September rainy season in Ethiopia that are of societal relevance. The downscaling used a regional model with a resolution of 25 km, and the same atmosphere and land configuration as the global model, to produce a 3-member ensemble of seasonal hindcasts for the period 1991–2011 and a larger 15-member ensemble for four of these years comprising two anomalously dry and two anomalously wet years. The regional model was also driven by the quasi-observed ERA-Interim dataset. To provide context for the assessment of the downscaled seasonal forecasts and to show the limit for the skill of a global seasonal forecast downscaling system for the region.

A mainly qualitative assessment of GloSea5 and downscaled GloSea5 forecasts demonstrated that the downscaled forecasts could be considered a faithful disaggregation of the coarse resolution GloSea5 forecasts. Forecasts of average seasonal rainfall anomalies in the three regions of Ethiopia studied were captured in three of the four years with the wet season of 2006 incorrectly forecast in all three regions, and the 21 year 3-member hindcast had a correlation of 0.65 with observations. Whilst exploring the potential for the downscaled GloSea5 to generate skillful forecasts of rainy season onset and dry spells we note that both the global and regional model have skill with onset correctly predicted as being early or late in more than 75% of cases for some regions.

Practical Implications

We have implemented dynamical downscaling of the Met Office GloSea5 global seasonal forecasting system and analyzed its ability to generate reliable forecasts of characteristics of the main June-September rainy season in Ethiopia that are of societal relevance. Such a downscaling system could plausibly be run operationally either at the Met Office, or by a regional institution provided a suitable method for timely transfer of boundary data is found. Or an analysis of the downscaled hindcasts could generate statistical relationships to add high resolution detail to operational GloSea5 forecasts. Our analysis shows that there is the potential to provide useful local information on the intensity and extent of the rainy season in much of Ethiopia relevant to seasonal planning of agriculture and water resources. Further investigation is now required to better quantify this skill (which in turn will require the availability of a reliable, long-term, high spatial and temporal resolution observed precipitation dataset) and to measure and understand how to apply the information available for use by national, regional and local stakeholders.

1. Introduction

In Ethiopia, the seasonal rains between June and September, locally known as the Kiremt, account for 50–80% of annual rainfall totals over the regions that have high agricultural productivity and contain the major water reservoirs. Skillful forecasts of the rains are therefore of great societal interest, and of use in a number of sectors such as food security, drought early-warning systems and human health. There is also a demand for forecasts at more local scales relevant to the needs of end users. More specifically, information about key features is of primary importance for human activities (e.g. agriculture, water resource planning, hydropower production, tourism) and has been widely used for planning purposes. For the agriculture sector, different studies have highlighted a direct link between crop yields and rainfall onset/cessation date and the occurrence of dry spells (Shaw, 1987; Oladipo and

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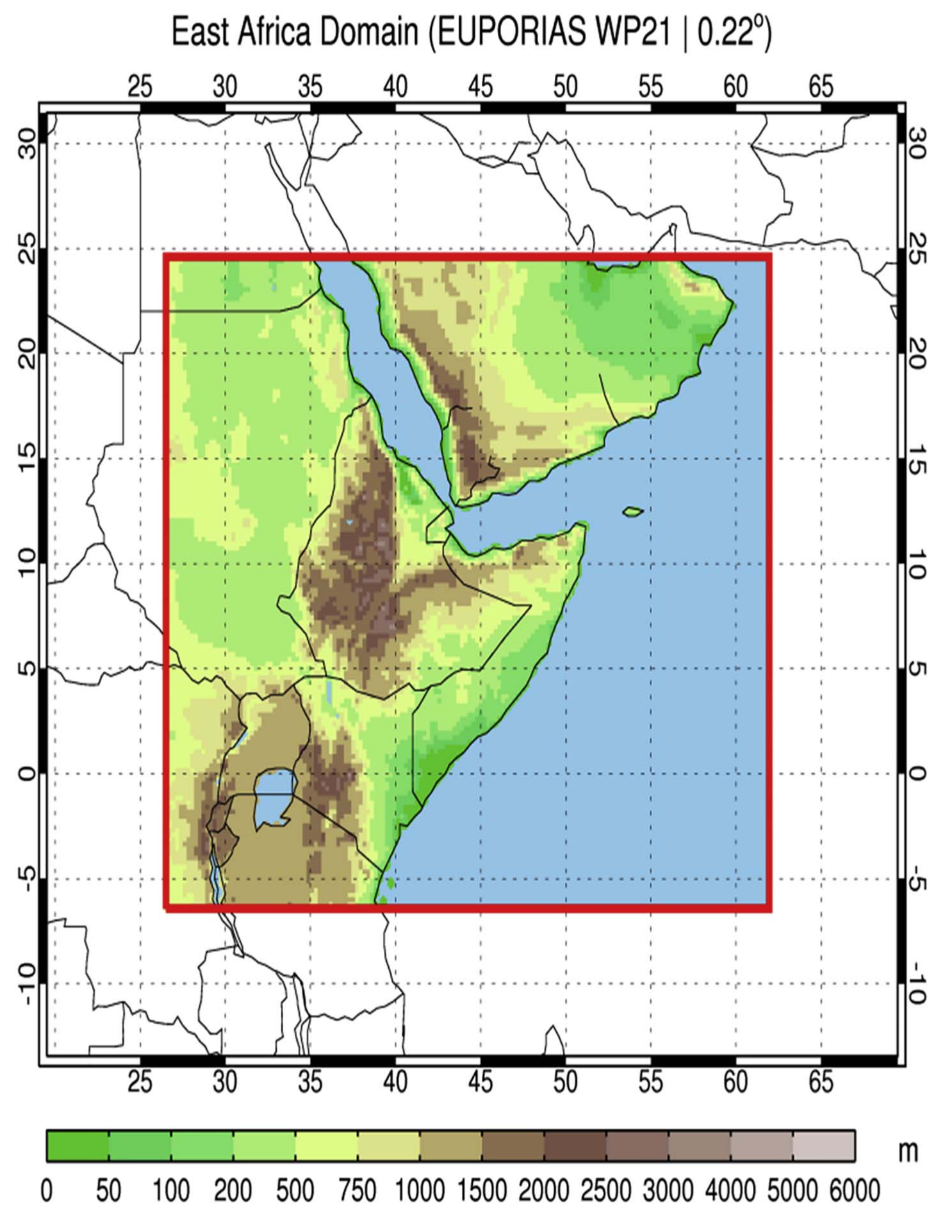

Fig. 1. The RCM domain, excluding the 'rim region' where the lateral boundary conditions are applied. The plot also shows the topography of the region.

Kyari, 1993) and a great importance has been attached to the identification of these parameters (e.g., Stern et al., 1981; Sivakumar, 1992). A good representation of these features would be a vital requirement for a useful and usable seasonal forecast. Such information is crucial for planning Ethiopia's food supply (Degefu, 1987; Gissila et al., 2004). The World Food Programme require rainfall data as input to their Livelihood, early assessment and protection (LEAP) early warning system, and have previously planned to assess data from EUPORIAS WP21: the work package that this downscaling was performed under.

Seasonal forecasts aim to capture potential predictable signals in climate drivers such as global and regional sea surface temperatures and their influence on regional circulation patterns and important aspects of local climate such as seasonal rainfall totals. These forecasts are generated using either dynamical or statistical methods, or a combination of these and have become an operational activity in a number of national weather services worldwide (Graham et al., 2011). Statistical methods rely on the availability of observations in order that relationships between predictors and predictands can be derived. Examples of statistical approaches applied in the region, include the analog method used by the National Meteorological Agency of Ethiopia (Korecha and Sorteberg, 2013) and an ensemble of linear regressions (Segele et al., 2015). Dynamical approaches typically involve running a large number of dynamical climate model simulations that have been initialized with estimates of the observed large-scale state of the oceans (temperature, salinity, currents), atmosphere (temperature, humidity, winds) and land-surface (temperature, moisture content). Global seasonal prediction systems use models that range in resolution from 50 to 200 km.

Dynamical downscaling involves running a limited area higher resolution (compared to that of the driving global model) atmospheric and land surface model (called a Regional Climate Model, or RCM), with the driving global model providing input in the form of atmospheric lateral boundary conditions, and sea surface temperatures. In the context of a downscaling seasonal forecasting system, such a model will be used to downscale the global simulations.

Ethiopia is a region where dynamical downscaling has the potential to perform well. On the one hand, Ethiopian climate anomalies are known to be influenced by sea surface temperatures via large scale phenomenon such as the Tropical Easterly Jet, ITCZ, and low level winds from the Indian Ocean (e.g. Diro et al., 2011a). On the other hand, the complex