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METEOROLOGY

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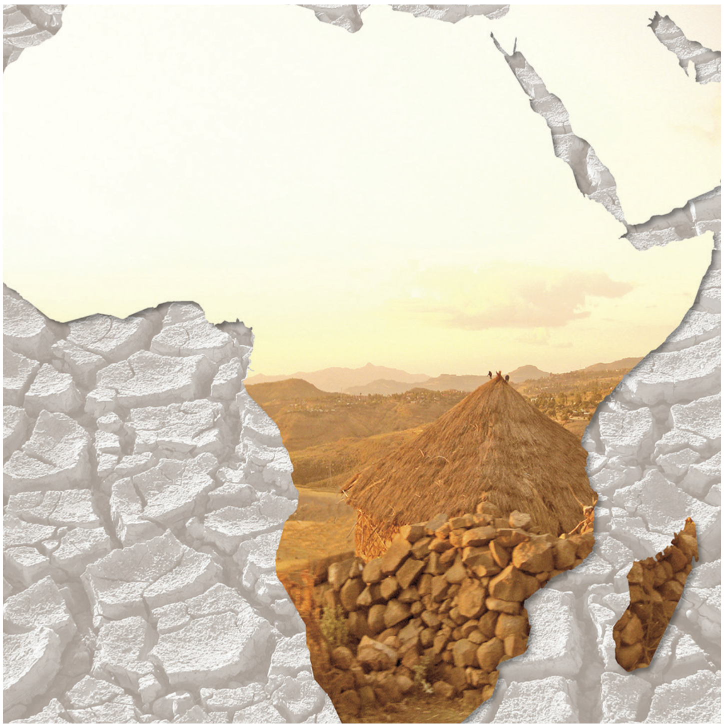

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Monitoring and forecasting the 2010/11 drought in the Horn of Africa

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The 2010/11 drought in the Horn of Africa affected approximately 12 million people, and might have been the worst in the last 60 years. It resulted from a precipitation deficit in the October–December 2010 and March–May 2011 rainy seasons; both were captured by the ERA-Interim reanalysis. Soil moisture anomalies of ERA-Interim also identified the onset of the drought condition early in October 2010 with a persistent drought still present in September 2011. The precipitation deficit in October–December 2010 was associated with a strong La Niña event, which was predicted by the ECMWF seasonal forecasts from June 2010 onwards, as well as a dry precipitation anomaly in the region. The March–May 2011 anomaly was only captured by the forecasts starting in March 2011.

Monitoring drought

ERA-Interim precipitation compares reasonably well with several global precipitation datasets based on a variety of sources (satellite and gauges). This agreement is especially consistent for the October–December rainy season, while during March–May the ERA-Interim has some difficulties in capturing the inter-annual variability of precipitation in the region. However, during 2010/11 both rainy seasons were correctly represented by ERA-Interim with anomalous dry conditions (Figure 1). The rainfall anomaly early in October-December 2010 led to the depletion of soil moisture. This anomaly was persistent throughout 2011due to the consecutive dry season in March–May, and only recovered to normal conditions later in September 2011 (Figure 2). ERA-Interim soil moisture intra-seasonal to inter-annual variability can be affected by the soil moisture analysis that is based on near-surface air temperature and relative humidity (ECMWF Newsletter No. 127). Therefore, its use as a monitoring tool should be carefully evaluated.

An evaluation of the Normalized Difference Vegetation Index (NDVI) satellite estimates, which is independent from ERA-Interim, showed temporal consistency between the soil moisture anomalies and NDVI anomalies (Figure 2). These results are encouraging since they link remote sensing of vegetation characteristics with soil moisture. The reduction of NDVI, or vegetation activity, was also enhanced by a warm near-surface temperature anomaly during October–December 2010 and March–May 2011. Ultimately these conditions caused a failure in crops and livestock production and, since the region is mainly dependent on traditional rainfed agriculture, there was a famine. These results indicate that ERA-Interim precipitation could be used for drought monitoring purposes in the region, and complemented with soil moisture due to its temporal integration of precipitation (forcing) and evaporation (demand) anomalies.

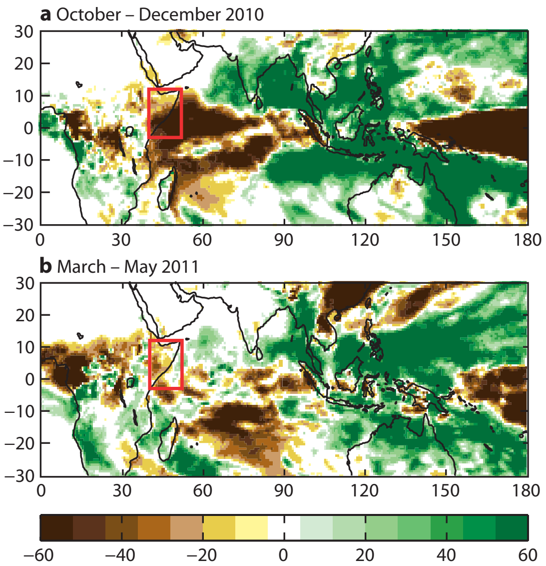

Figure 1 Spatial patterns of ERA-Interim precipitation anomalies (mm month-1) during (a) October–December 2010 and (b) March– May 2011 for the 1979–2011 mean ERA-Interim climate The box indicates the Horn of Africa area

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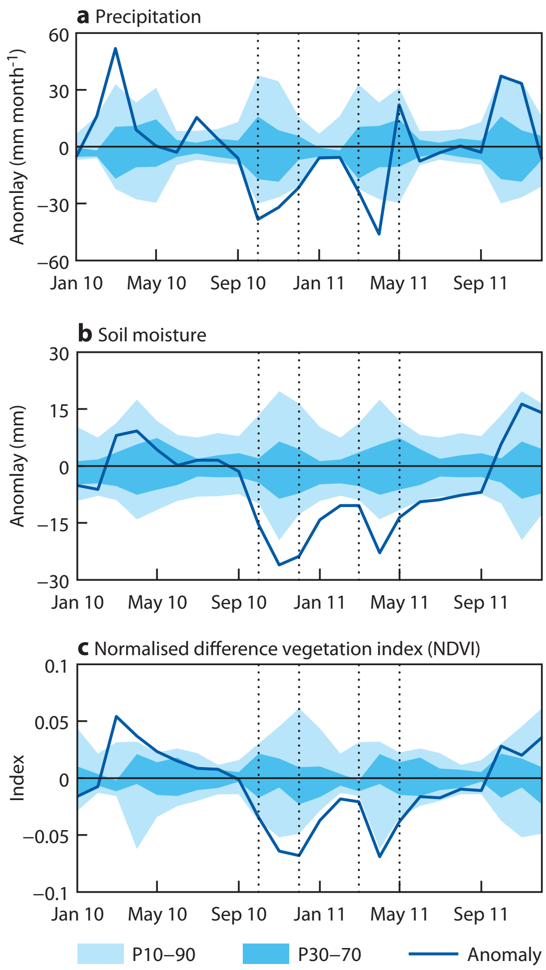

Figure 2 Time series of anomalies of (a) ERA-Interim precipitation, (b) ERA-Interim soil moisture and (c) Normalized Difference Vegetation Index (NDVI) from MODIS satellite data for 2010/11. The results are based on spatial averages over the Horn of Africa region (see box in Figure 1) of the anomalies (solid blue), and the climatological distribution between percentiles 10 to 90 (light blue) and percentiles 30 to 70 (dark blue). The vertical dashed lines indicate the October–December 2010 and March–May 2011 seasons.

Seasonal forecasts

The biannual migration of the Intertropical Convergence Zone (ITCZ) across East Africa is the main driver of the precipitation seasonality in the region. This results in two rainy seasons (October–December and March–May). El Niño conditions (warm sea surface temperatures in the Pacific Ocean) tend to generate an equatorial Indian Ocean sea surface temperature pattern referred to as the positive phase of the Indian Ocean Dipole. In this phase, there is a warming of the western Indian Ocean that intensifies and shifts the ITCZ, leading to wetter conditions. Therefore, the Horn of Africa precipitation during the October–December season is indirectly influenced by El Niño (or La Niña – colder sea surface temperatures in the Pacific Ocean) conditions that cause a warming (cooling during La Niña) in the western Indian Ocean. On the other hand, there is no strong relationship with any large-scale climate anomaly and precipitation in the Horn of Africa during the March–May season.

The ECMWF seasonal forecasts generally have a good skill in forecasting El Niño/La Niña conditions, and this was the case in 2010. The forecasts starting in May 2010 pointed to a La Niña situation four months in advance and were consistent during the following forecast months (Figure 3). Results using the z-score (a way of standardizing data by removing the mean and dividing by the standard deviation) show that the October–December 2010 dry anomaly (i.e. negative z-score) was consistently predicted by the seasonal forecasts from July 2010 onwards (Figure 4a). The forecasts valid for March–May 2011 pointed to normal conditions, except for the forecasts starting in March 2011(Figure 4b). These results are consistent with the overall evaluation of the ECMWF forecasts of precipitation using retrospective forecasts for the period 1981–2005 showing that there is:

- Skilful forecasts up to four months in advance for the October–December season.
- Low predictability for the March–May season, where only the forecasts starting in March have skill.

This information can guide users when interpreting the seasonal forecasts for the region, and presents an example of an application of ERA-Interim and seasonal forecasts for drought monitoring and forecasting. This methodology can be adapted and refined for other regions, taking into account the local specificities, other data sources (e.g. in-situ observations – monitoring) and the user's needs.

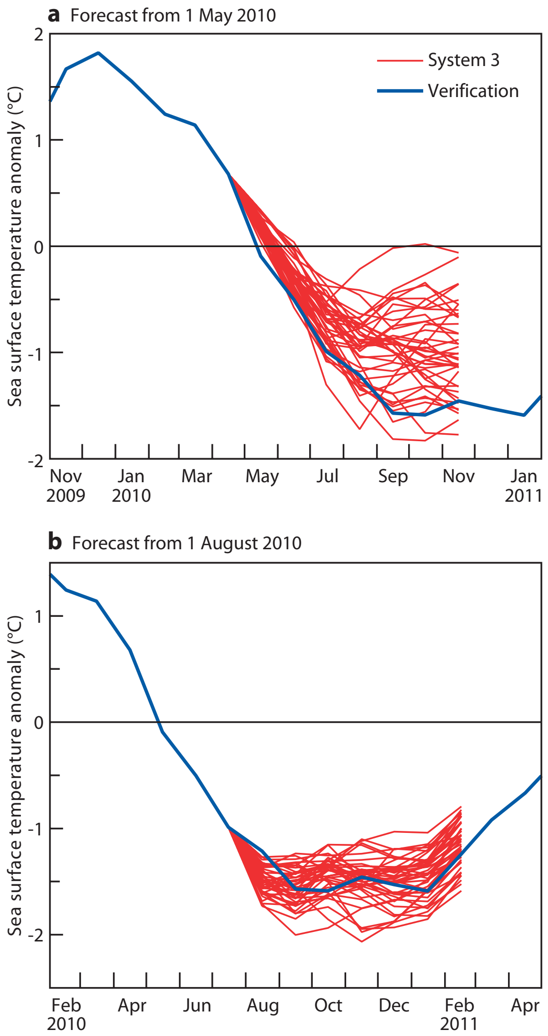

Figure 3 ECMWF seasonal forecasts of sea surface temperature anomaly issued in (a) May 2010 and (b) August 2010 for NINO3 4 (5°S–5°N, 170°W–120°W; the area with a large variability on El Niño time scales) using System 3 and verification of the forecasts

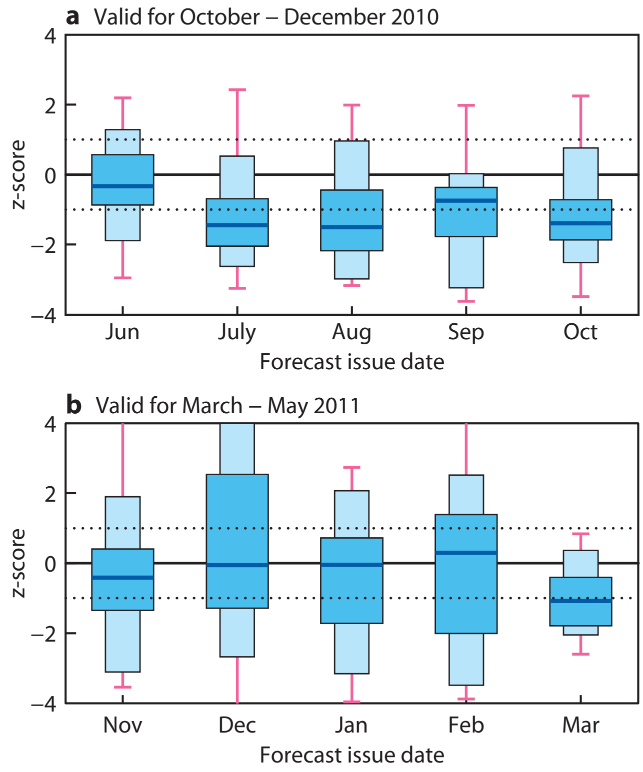

Figure 4 Distribution of z-scores for seasonal forecasts of precipitation valid for (a) October–December 2010 and (b) March–May 2011 for various initial forecast dates (horizontal axis) averaged over the Horn of Africa region (see box in Figure 1). The box plots extend from the minimum to percentiles 10, 30, 50 (blue line), 70, 90 and maximum.

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Concluding remarks

ECMWF products, such as the ERA-Interim and the operational medium- to long-range weather forecasts, can provide useful and reliable information to national and international organizations. Consequently they can support early warnings and mitigation strategies in the region (in the absence of more reliable ground truth) that suffers from the lack of in-situ networks and infrastructures. The region and its population are highly vulnerable to future droughts, thus global monitoring and forecasting of droughts are going to become increasingly important in the future.

The results outlined here are part of an ongoing effort in a EU-funded FP7 project, DEWFORA (http://www.dewfora.net), aimed at developing a framework for the provision of early warning and response to mitigate the impact of droughts in Africa.

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