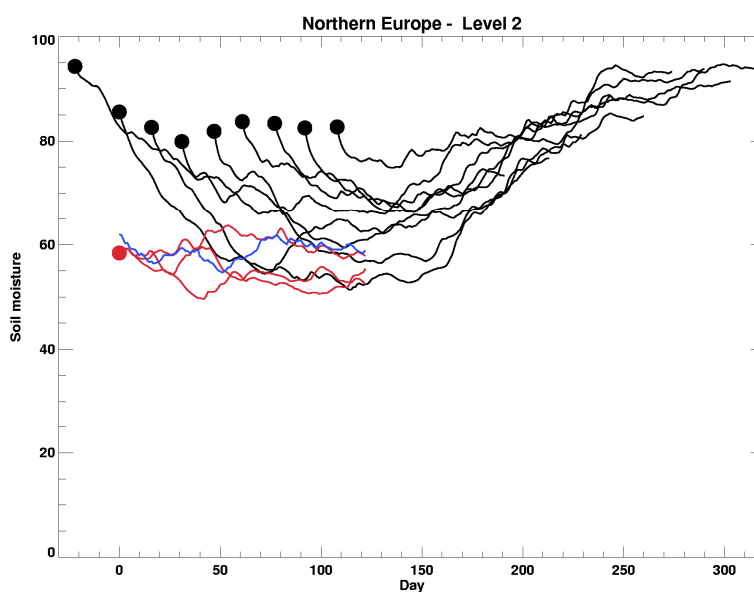




Technical Report No. 52

SEASONAL FORECAST MODEL EXPERIMENTS WITH WATCH SOIL MOISTURE DATA



Author names: David Fereday

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Authors:	David Fereday
Organisations:	United Kingdom Met Office
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Introduction

Seasonal forecasting is an active area of research, with the potential for large economic and social benefits from the development of improved forecasts. There is considerable scope for better forecasts through improved simulation of physical mechanisms that offer predictability on monthly or longer timescales. One such source of predictability is soil moisture, which affects surface climate - for example, wetter soil can lead to lower surface air temperature and increased precipitation in certain circumstances. In addition, soil moisture anomalies can persist for several months, so this mechanism allows some potential predictability of surface climate.

Here, the impact of two alternative soil moisture datasets on the Met Office seasonal forecasting system GloSea4 is investigated. The first soil moisture dataset comes from ERA-Interim reanalysis produced by ECMWF, and is currently used operationally to produce seasonal hindcasts. The second dataset was created as part of the WATCH project by forcing the JULES land surface model with an upgraded version of ERA40 reanalysis data, described in [1].

Data and Methods

GloSea4 is the Met Office seasonal forecast system. It uses multiple runs of the coupled climate model HadGEM3 to simulate the atmosphere, ocean and land surface. Both forecasts and hindcasts are produced. Hindcasts are run for the years 1996-2009 and are initialised with ERA-Interim reanalysis data for those years, while the forecasts are initialised with analysis from the Met Office short range forecast model. The hindcasts are needed because over time, the model drifts away from the true climate towards its own preferred state. The hindcasts are used to estimate this model drift and hence to correct the forecasts.

The land surface model used in GloSea4 has four vertical levels representing soil layers of thickness of (in order from the top level to the bottom level) 0.1m, 0.25m, 0.65m and 2m. The soil properties vary with location. The soil moisture data used to initialise the GloSea4 hindcasts comes from ERA-Interim reanalysis. Comparison of different land surface models shows that the soil moisture values they produce can vary widely. This means that one cannot, for example, take soil moisture data from one model and use it to initialise a different model without an adjustment to account for the difference between the models. Since the reanalysis fields come from a different model to that used in the hindcasts, the soil moisture fields are rescaled to have the same mean and variance as a HadGEM3 control run.

The WATCH soil moisture dataset covers the period 1988-2001. To compare the WATCH forced experiments with GloSea4 runs, a year from the GloSea4 hindcast period (1996-2009) is needed. The year 2000 was chosen since the WATCH data showed this to be a fairly dry in summer in Europe, suggesting soil moisture could have affected surface air temperature and precipitation. The WATCH dataset is also rescaled to be compatible with the GloSea4 system, so that the soil water stress is preserved.

A start date of 1 May was chosen to focus on the summer season, where soil moisture influences on surface climate are more evident. Three runs of four months' duration each were carried out with the WATCH data, to compare with the three hindcasts that were started on the same date. The only difference between the two sets of runs is the initial soil moisture data, allowing an investigation of the effect of the soil moisture on the hindcasts to be made.

Results

The model output was analysed by taking averages of the soil moisture, surface air temperature and precipitation for different regions around the world, as defined by [2]. Analysis of the soil moisture shows that in many of the global regions, all four soil levels are initially much drier in the WATCH-forced runs compared to the hindcasts.

An important question is whether the soil moisture model evolves realistically in the model. For the WATCH-forced runs, this can be assessed by looking at the WATCH soil moisture data for the months following the 1 May 2000 start date, since the data provide the best estimate of how the soil moisture should evolve. Operational hindcasts are started at roughly weekly intervals throughout the year, so the evolution of earlier starting hindcasts can be checked against the initial conditions of later starting hindcasts for consistency.

These checks show that initially, the hindcasts tend to dry out quickly in many regions. The soil moisture values fall below the initial values for later hindcasts, suggesting that the initial drying phase is not realistic. In contrast, the WATCH forced runs lack a rapid initial drying phase. The soil moisture tends to evolve in a way consistent with the subsequent WATCH data for later parts of the run (figure 1). This suggests that the WATCH forced runs have initial soil moisture fields in better balance with the model.

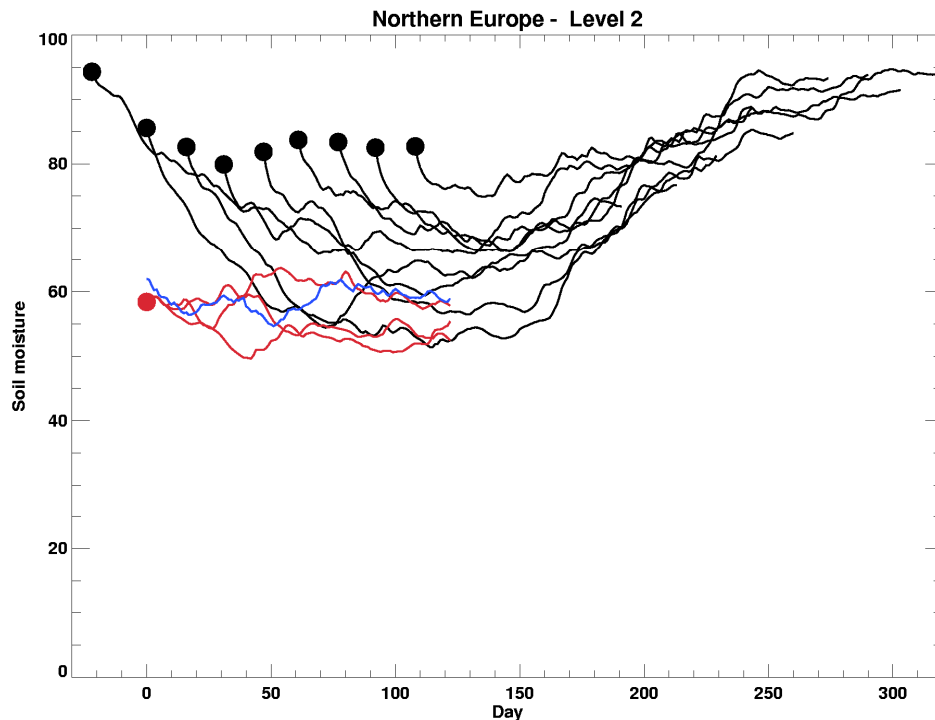


Figure 1: Soil moisture evolution in the layer covering the depths 0.1-0.35m. Day 0 corresponds to 1 May 2000. Red lines show the three WATCH-forced runs. Blue line shows the scaled WATCH soil moisture data. Black lines show soil moisture from hindcast runs starting on dates from mid April to early August 2000. Soil moisture units are kg/m^2 .

The importance of the soil moisture for the seasonal forecasts is the effect it has on surface air temperature and precipitation. This can be analysed for the GloSea4 system by comparing these variables in the WATCH-forced runs and the hindcasts. The comparison shows that there is indeed an effect in some regions such as the Mediterranean basin. The clearest effect is on temperature, with the drier WATCH forced runs warmer as would be expected (figure 2). The precipitation data is much noisier, making differences between the two sets of runs hard to discern. Nevertheless, there are still some regions where the WATCH-forced runs appear drier than the hindcasts, including the Mediterranean basin again (figure 3).

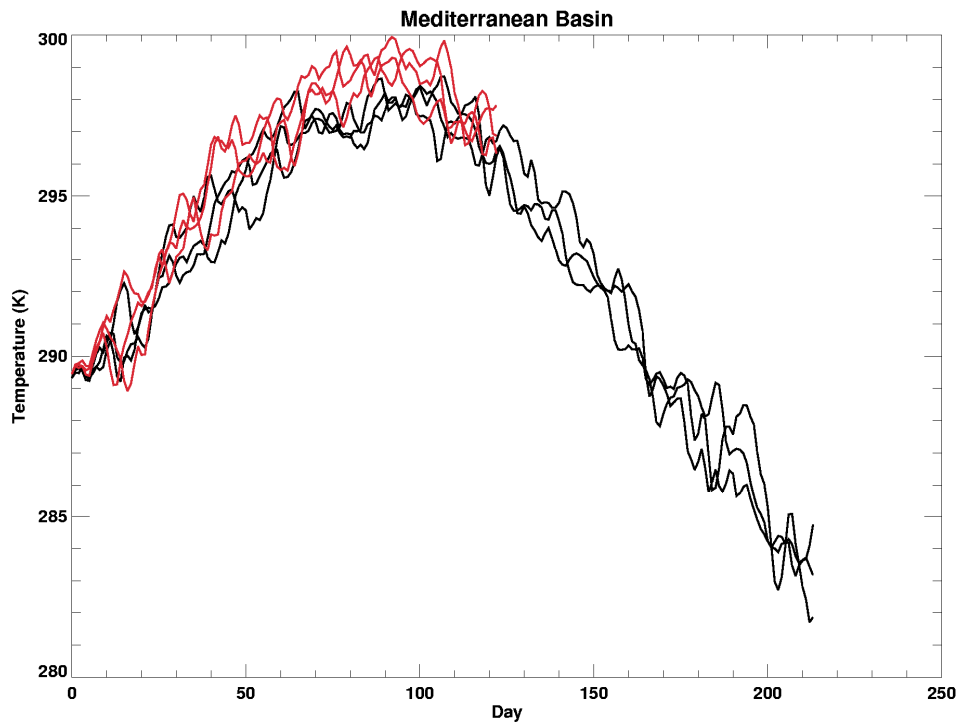


Figure 2: Temperature evolution for the Mediterranean basin region for the WATCH-forced runs (red) and the hindcasts (black). Day 0 corresponds to 1 May 2000.

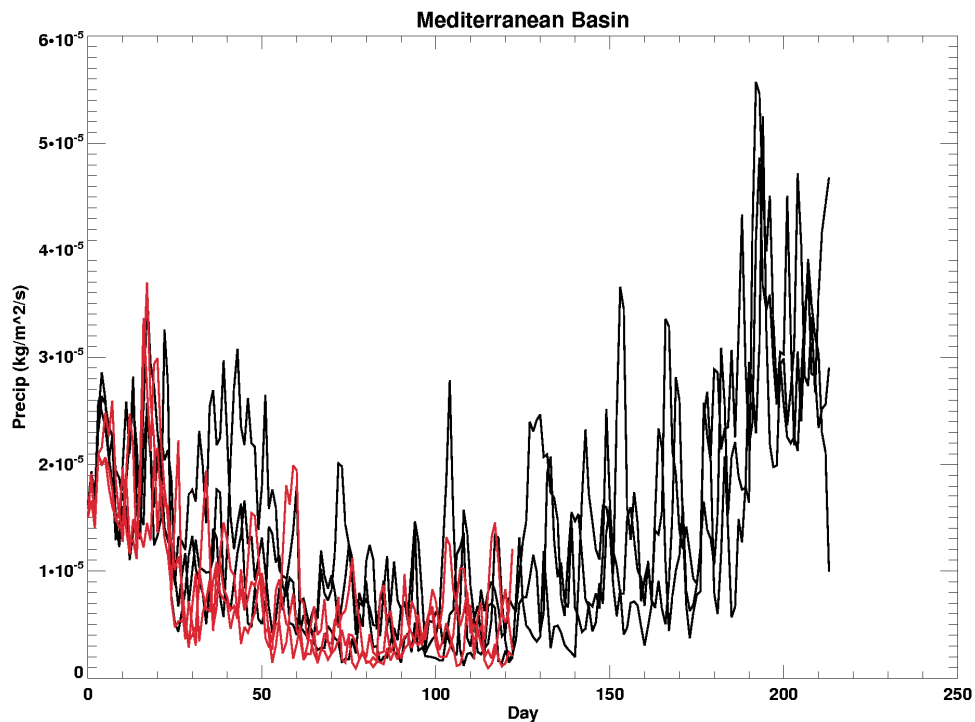


Figure 3: Precipitation evolution for the Mediterranean basin region for the WATCH-forced runs (red) and the hindcasts (black). Day 0 corresponds to 1 May 2000.

Conclusions

The results presented here show that the choice of soil moisture initialisation for the GloSea4 system is important. The hindcasts produced with the currently used soil moisture initialisation method show a rapid initial drying in many regions which looks unrealistic. By contrast, the model runs initialised with WATCH data tend to start significantly drier but evolve in a manner consistent with the subsequent WATCH data.

The results also show that the initialisation has a clear impact on temperature and precipitation in certain regions, with reduced precipitation and higher temperatures consistent with reduced soil moisture. A possible drawback with the soil moisture initialisation in the current GloSea4 hindcasts is that it uses data generated with one land surface model for hindcasts run with a different model. A future version of the WATCH data used here would help to overcome this problem if it could be produced with the same land surface model and settings as used in the GloSea4 system.

Acknowledgements

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References

1. WATCH Technical Report number 22
2. F. Giorgi and R. Francisco (2000) Uncertainties in regional climate change predictions. A regional analysis of ensemble simulations with the HADCM2 GCM, *Clim. Dyn.* 16 (2-3), 169-182