SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	European energy transition: Energy security in a highly-renewable system
Computer Project Account:	spnlwiel
Start Year - End Year :	2019 – 2019
Principal Investigator(s)	Karin van der Wiel
Affiliation/Address:	KNMI (Royal Netherlands Meteorological Institute) Utrechtseweg 297 Postbus 201, 3730 AE De Bilt The Netherlands
Other Researchers (Name/Affiliation):	Frank Selten (KNMI)

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

The aim of this special project was two-fold.

- For a JPI-Climate Belmont Forum project two large ensemble experiments with the EC-Earth global climate model had been produced on the ECMWF facilities. We wanted to run a third large ensemble experiment to be better able to investigate climate change effects on extreme events.

- Building on results from the same project regarding high-impact events for European energy security. We set out to do short-term prediction experiments, for a first estimation of the predictability of selected extreme energy events.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

System updates on the ECMWF facilities meant we were no longer able to run the model in exactly the same configuration. This was important, especially for the predictability experiments where we need bit-reproducibility. Dominique Lucas from ECMWF was very helpful in solving this issue. The solution was to unload and load modules, to reset the old configuration. The specific order of loading modules was important here too.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

We encountered no problems with the administrative aspects of the special project.

Summary of results

(This section should comprise up to 10 pages, reflecting the complexity and duration of the project, and can be replaced by a short summary plus an existing scientific report on the project.)

We produced a third large ensemble experiment with the global climate model EC-Earth. This ensemble experiment compliments two existing large ensemble experiments, making complete the set of experiments based on the EC-Earth model. A similar set of experiments based on the HadGEM2-ES model exists, creating a unique research data set for analysis of climate variability and climate extremes.

The large ensemble data sets are a unique research resource; hence we expect to use it in many different future research projects. Furthermore, we hope to share it with other scientists, forming new collaborations and broadening the use of the resource. To achieve this, we are looking into uploading the data to an open access location and writing a data description paper.

Our second aim was to investigate predictability of high-impact events for European energy security. From the EC-Earth large ensemble experiment (2000 simulated years, present-day conditions) we selected 1-in-10 year high shortfall events of 1-day duration. The associated meteorological conditions are shown in Fig. 1. These events are characterized by a large high pressure system over central Europe, leading to low wind speeds (low energy production) and low temperatures (high energy demand). Together, this leads to extreme high energy shortfall.

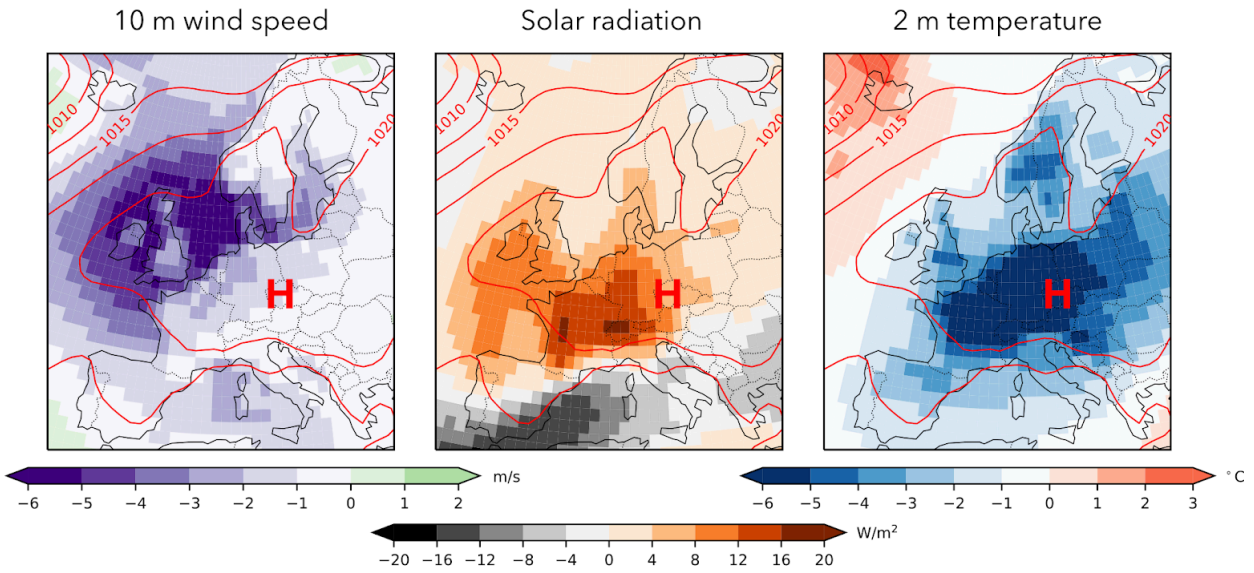

Fig. 1 Meteorological conditions during 1-in-10 year high energy shortfall events (composite mean over 200 simulated events). Shaded colours show anomalies of 10 m wind speed, solar radiation and 2 m temperature, red contours show surface air pressure. Figure based on Van der Wiel et al. (2019a).

For a selection of these events we performed a perfect-predictability experiment, i.e. with perfect knowledge of the initial conditions. At different lead times we initialized an ensemble of model runs, different in terms of stochastic physics alone. 50 members in each small forecast ensemble were used to estimate forecasted extreme event probability. Fig. 2 shows an example of such an experiment.

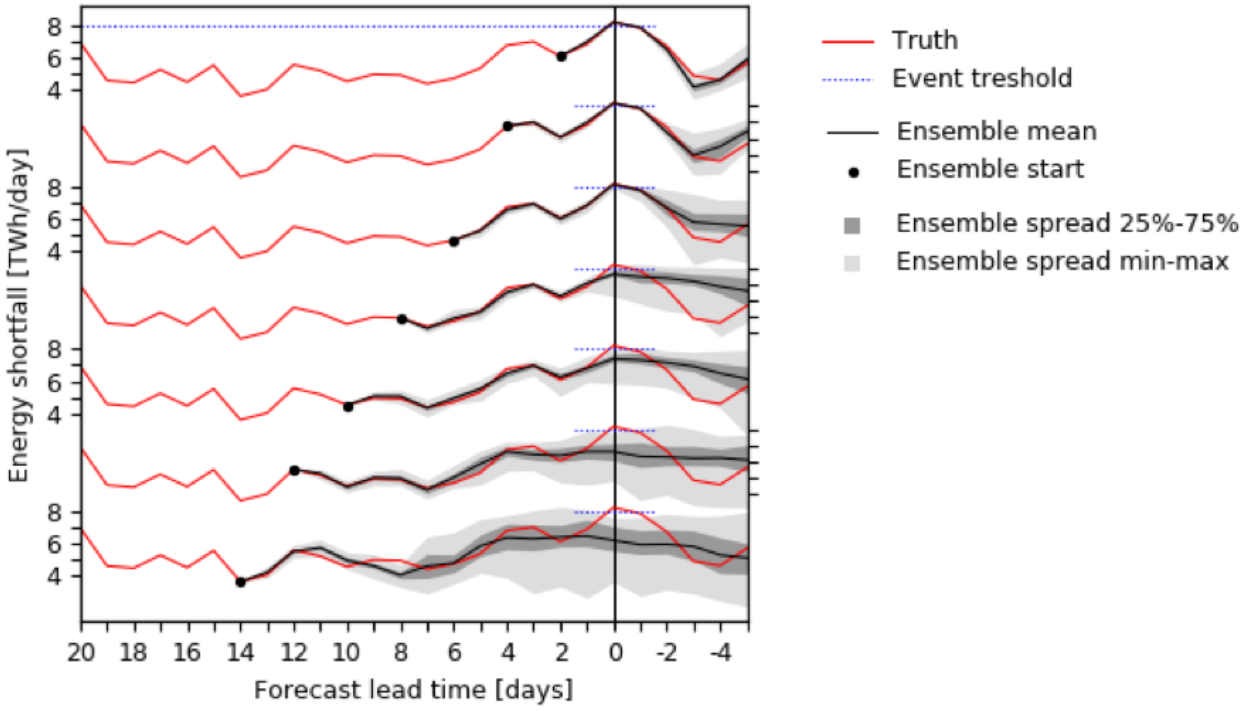

Fig. 2 Example EC-Earth prediction experiment. Red lines show the event as selected, black dots the forecast initial conditions, grey shading shows min-5%-25%-75%-95%-max of the 50 member ensemble, black line shows ensemble mean, blue dotted line the 1-in-10 year event threshold.

Note that these experiments are an initial investigation only, since it is a one-sided experimental setup. We only create prediction experiments for extreme events, or normal days without an extreme event. We can have a good forecast when the event is forecasted, a bad forecast when it is missed, but false alarms are no possibility.

For each forecast we then investigate the probability of threshold exceedance (1-in-10 year return time, 8 TWh/day). On average about 4 days ahead there is certainty about the event occurring (p > 99 %), from there there is a loss of probability to about p = 1 % at 15 days lead time (Fig. 3). There is variability in predictability between events, at 6 days lead time p varies between 50 and 100 %.

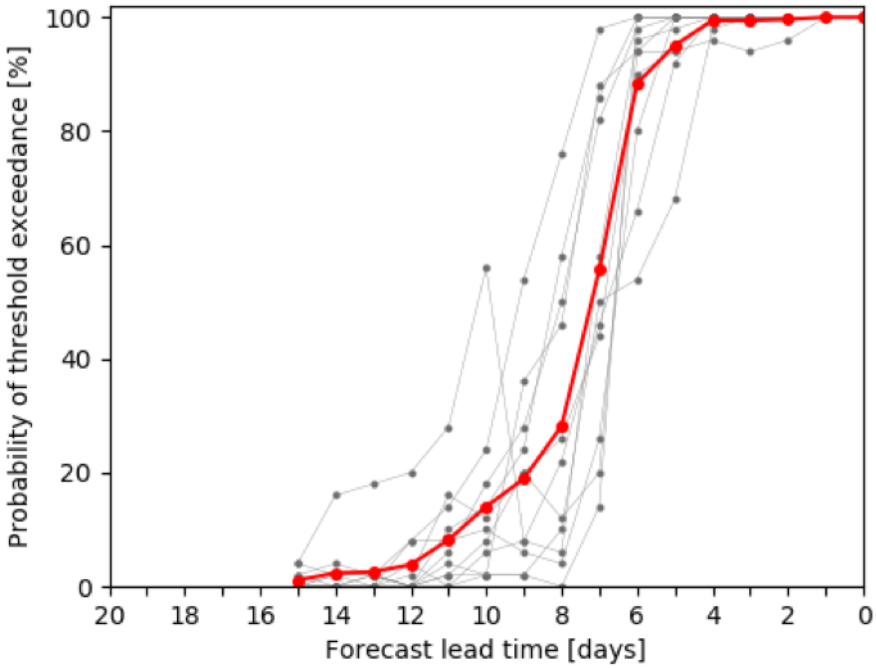

Fig. 3 Forecasted probability of a 1-in-10 year high shortfall event to occur as a function of lead time. Grey dots/lines for individual forecasts, red dots/line shows the mean.

Further analysis is needed to determine the unexpectedly high probabilities at 1-4 days lead time, followed by the very sharp decline. We hypothesize this has to do with the stochastic physics, which may take time to propagate from small scales to larger scales and hence only impact the energy calculations after a few days.

Due to long term illness of one of the researchers, some of the analysis goals have yet to be achieved at this moment in time.

List of publications/reports from the project with complete references

- K van der Wiel, LP Stoop, BRH van Zuijlen, R Blackport, MA van den Broek, FM Selten (2019): Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall. Renewable & Sustainable Energy Reviews, 111, pp. 261-275.
- K van der Wiel, HC Bloomfield, RW Lee, LP Stoop, R Blackport, JA Screen, FM Selten (2019): The influence of weather regimes on European renewable energy production and demand. Environmental Research Letters, 14, pp. 094010.

Several papers using the large ensemble data have been submitted or are in preparation.

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

The large ensemble data sets are a unique research resource; hence we expect to use it in many different future research projects. Furthermore, we hope to share it with other scientists, forming new collaborations and broadening the use of the resource. To achieve this, we are looking into providing the data in an open location and writing a data description paper.