Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

THEME ENV.2012.6.1-1

G.A. no 308378

WP 1.2 Dissemination

Deliverable 12.5 Cross-cutting theme report 19-36

Date: 16/10/2015

<table>
<tr><td>Deliverable Title</td><td colspan="4">Cross-cutting theme report 19-36</td></tr>
<tr><td>WP number and title</td><td colspan="4">WP 1.2 Dissemination</td></tr>
<tr><td>Lead Beneficiary</td><td colspan="4">UOXF</td></tr>
<tr><td rowspan="4">Contributors</td><td colspan="2">Antje Weisheimer</td><td colspan="2">UOXF</td></tr>
<tr><td colspan="2">David Stephenson, Stefan Siegert</td><td colspan="2">UNEXE</td></tr>
<tr><td colspan="2">Bart van der Hurk</td><td colspan="2">KNMI</td></tr>
<tr><td colspan="2">Johanna Baer</td><td colspan="2">UNIHH</td></tr>
<tr><td>Creation Date</td><td colspan="2">24/10/2015</td><td>Version number</td><td>2</td></tr>
<tr><td>Deliverable Due Date</td><td colspan="2">31/10/2015</td><td>Actual Delivery Date</td><td>28/10/2015</td></tr>
<tr><td rowspan="4">Nature of deliverable</td><td>X</td><td colspan="3">R - Report</td></tr>
<tr><td></td><td colspan="3">P - Prototype</td></tr>
<tr><td></td><td colspan="3">D - Demonstrator</td></tr>
<tr><td></td><td colspan="3">O - Other</td></tr>
<tr><td rowspan="4">Dissemination Level/ Audience</td><td></td><td colspan="3">PP - Public</td></tr>
<tr><td>X</td><td colspan="3">PU - Restricted to other programme participants, including the Commission services</td></tr>
<tr><td></td><td colspan="3">RE - Restricted to a group specified by the consortium, including the Commission services</td></tr>
<tr><td></td><td colspan="3">CO - Confidential, only for members of the consortium, including the Commission services</td></tr>
</table>

Version	Date	Modified by	Comments
1	24/10/2015	UOXF	First draft
2	28/10/2015	IC3	Format changes

INDEX

1. Executive summary

This report summarises how the project partners have collaborated in months 19-36 to address the objectives of the three cross-cutting themes (CCT):

- CCT1: Forecast quality assessment (lead by WP 2.1)
- CCT2: Dealing with uncertainty (lead by WP 4.4)
- CCT3: Case studies and extremes (lead by WP 2.2)

2. Project objectives

Not applicable.

3. Detailed report on the deliverable

The report is available on Annex I.

4. References

Not applicable.

5. List of publications

Not applicable.

6. Efforts for this deliverable

How many person-months have been used up for this deliverable?

Partner	Person-months (actual)	Person-months (in-kind)	Period covered
11. UNEXE	1	-	M19-36
4. KNMI	1	-	M19-36
5. UOXF	1	-	M19-36
Total	**3**		M19-36

7. Sustainability

This report shows the information exchange and the interactions between WPs and the partners involved as well as the common protocol that facilitates the interaction between the research themes (RT).

Annex I

CCT1: Forecast quality assessment (lead by WP 2.1)

Overview of theme

Forecast-quality assessment (verification) is fundamental in SPECS in building credibility in forecast systems and testing for improvements in forecast skill.

Summary of main achievements in months 19-36

SPECS partners UNEXE and IC3 have produced two useful new software packages in the open source R language (www.r-project.org) for assessing and comparing the forecast quality of ensemble forecasting systems. These packages are freely available on the CRAN archive (https://cran.r-project.org/web/packages) and provide additional functionalities to existing R packages on CRAN such as **verification**, **SpatialVx**, and **ternvis**.

The **SpecsVerification** package, developed by UNEXE, has new comparative verification tools that allow one to test for improvements in forecast quality measures between pairs of ensemble forecasting systems. The **s2dverification** package, developed by IC3, provides access to verification functions via fast data loading routines and visualisation functions suitable for large data volumes typical of ensemble forecasting systems.

In addition, WP2.1 has produced and disseminated short reports on forecast quality:

- Preliminary report and catalogue of performance of existing s2d systems (CSIC lead; milestone MS22; available from http://www.specs-fp7.eu/wiki/index.php/File:MS22_v1.pdf)
- Fact sheet #5: How detectable are improvements in forecast quality? (UNEXE lead; April 2015; available from http://www.specs-fp7.eu/Fact%20sheets)

A report on “Common and model-dependent bias in s2d systems” (deliverable D21.2 led by MPG) was due to be delivered in month 36 but is likely to be delayed by a few months (see WP2.1 section in the periodic report).

In addition, UNEXE has advised various SPECS and EUPORIAS partners on good verification practice in specific problems and is working with IC3 to develop new methods for testing for improvements in correlation skill between two ensemble systems.

Forecast quality (verification) plans for months 37-54

- Comparison and consolidation of new forecast verification software packages e.g. with each other and with other packages used by SPECS partners (e.g. EasyVerification used by CSIC and developed by MeteoSuisse in the EUPORIAS project);
- Documentation of the new software packages e.g. joint articles in EOS and J. Stat. Software;
- Publish a paper on testing for improvements in correlation skill and include the code in the SpecsVerification package;
- Based on feedback from the verification breakout group at the 4th general assembly, possibly adding some new functionality to SpecsVerification (UNIEXE) such as:
    - Uncertainty on MAE and bias measures;
    - Effective sample size option for serially correlated observations;

- Extrapolation of hindcast scores to different ensemble sizes used for future forecasts

CCT2: Dealing with uncertainty (lead by WP 4.4)

Overview of theme

All known sources of climate forecast uncertainty that influence prediction error will be considered, at a minimum, at the discussion level of the results and communicated to the stakeholders using adequate wording. Communicating uncertainty to the stakeholders and collaborating with them to learn how to make the most of a probabilistic framework should be among the basic priorities.

Summary of main achievements in months 19-36

The work package 4.4 “Addressing model inadequacy” is dedicated to bring together work from different partners in the project on methodologies to address model error uncertainty in climate forecasts. Here, the approach taken by the groups at UOXF, METEOF and ECMWF is the explicit representation of uncertainties in the physical model formulations within the models. For example, rather than acknowledging uncertainty of the model simulation of convective cloud systems (which has important implications for the radiative balances at the top of the atmosphere and the surface, the hydrological cycle and the general circulation of the atmosphere) in a qualitative a posteriori way, new modeling schemes are being developed that include a quantitative estimate of the uncertainties already at the level of the physical model equations that are being solved numerically. Such schemes are relatively new and can be seen as a shift of the traditional modelling ansatz for unresolved physical processes away from purely deterministic schemes towards schemes that include elements of stochasticity, reflecting the inherent uncertainty in representation of these processes in models. The second periodic report of WP 4.4 discusses details of the progress that has been made by the partners during the last 18 months of the project.

Uncertainty not only arises from the physical model formulations that are being solved numerically. Initial condition uncertainty is another major component for climate predictions on seasonal to decadal time scales. WP 3.2 “Improvements in ensemble generation” implements and tests a variety of techniques for ensemble generation with the aim, amongst others, to study the uncertainty due to initial conditions. The methods used range from conceptual models to the application in seasonal-to-decadal forecast systems. So far it has been found that the effects of different methods to generate perturbations to initial conditions on hindcast skill are not obviously discernable between different methods. The effects on hindcast skill vary between variables, regions/processes and lead time, and hence, no single method can be expected to provide universal improvement.

In order to communicate to stakeholders and the general public the SPECS-wide work on uncertainties in probabilistic climate forecasts, a new factsheet on “Climate forecast reliability” was produced. It very much was based on a collaborative effort between partners UOXF, UREAD, IC3, the Met Office and UNEXE. The factsheet describes what we understand by a reliable forecasting system and how, in a chaotic system as the climate system, the reliability of probabilistic forecasts can be quantified. It summarizes how reliable current forecasting systems are and discusses reasons for unreliability and strategies for the future to improve forecast reliability.

In March 2015 ECMWF hosted a workshop on “Stochastic Parametrization” which reviewed progress in the simulation of uncertainties in forecasting models and examined the scope for further improvements. UOXF was organizing the workshop with over 40 participants, including SPECS partners from UOXF, METEOF and the Met Office. This workshop provided an opportunity for scientists working in this area to present ongoing work and to discuss preliminary results and new ideas. Many speakers at this third workshop showed how aspects of model behaviour can be improved by using stochastic schemes, but they also indicated that the way models react depends on the models themselves. Thus, although it is clear that stochastic schemes improve probabilistic forecasts, it is difficult to draw general conclusions on which scheme performs best, and on their relative benefits. The next few years should provide more clarity on whether there is a 'best approach' that can be followed to further advance the simulation of uncertainties in forecasting models.

CCT3: Case studies and extremes (lead by WP 2.2)

Overview of theme

CCT3 organises the joint analysis of a number of periods in which extreme events occurred or where the mean climate state was anomalous compared to expectation. The theme is cross cutting in the sense that different developments of seasonal to decadal prediction systems in SPECS such as forecast quality, initialization technique, ensemble size, resolution, are investigated with respect to representing and forecasting extreme events. Therefore multi-model analyses using the SPECS data are the main tool to meet the goals of CCT3.

Summary of main achievements in months 19-36

In the first project period a widely circulated questionnaire on which events to choose as a focal point for CCT3 was compiled and published on the SPECS wiki. At the general assemblies held in De Bilt (2013) and Toulouse (2014) this list was discussed and reviewed again, and a classification scheme (decadal/seasonal, benchmark/process cases) was proposed (see progress report M24).

At the Norrköping general assembly (2015) a status review and final action plan was discussed and agreed. It was concluded that the original classification of events needed a slight reformulation. Particularly it was considered that a multi-year evaluation of seasonal forecasts of specific events (droughts) was necessary to yield firm assessments of the forecast quality and its dependence on model and experimental configuration. So also the case study experiment addressing seasonal forecasts is carried out in a multi-year framework.

Three main case study subjects remain under consideration: the hiatus period, the seasonal forecasting of heat waves, and process analysis of heavy precipitation events in Europe.

The 1990s warming of the North Atlantic

Coordination: UREAD

Approach: Analysis understanding case studies of North Atlantic decadal changes (primarily the 1990s warming, and the 1960s cooling) in a multi-model experiment with initialised decadal forecasting systems. The analysis will be performed on hindcasts that are being performed in other SPECS work packages (particularly WP3.1 and WP4.3) and requires no new experiments to be performed.

Status: A small number of modelling groups have already completed the forecasts as part of other tasks, and others have committed to provide these forecasts (8 models in total, so far). The analysis is being coordinated by Jon Robson (UREAD). Simplified diagnostics have been requested, and have been calculated by the modelling groups. The initial quality and control of data, and initial analysis will take place in November/December 2015. The planned outcome is for at least one multi-author paper describing the overall results.

European heat waves

Coordination: METEOF

Approach: Multi-model analysis of 30+ years of seasonal forecasts, zooming in on predictability of European heat waves. Special analyses are devoted to comparing predictability of a number of well-known heat waves (2003, 2010 and 2012). Multiple model configurations are applied, including global seasonal forecasting systems, and downscaled forecasts using both dynamical and statistical methods. Benchmark simulations consist of runs with prescribed soil moisture conditions (generally leading to very high skill in most cases). Using observed instead of predicted SST has no impact on heat waves (except near the coasts of the Mediterranean Sea in 2003 and 2012, because the SST is warmer than usual these summers). Using improved soil initial conditions is beneficial on average, but has little impact on the 2003 case.

Status: A small number of global and regional model experiments are completed. New experiments are added (including some with soil moisture nudging). A paper will be coordinated by Constantin Ardilouze (METEOF).

<u>European heavy precipitation events</u>

Coordination: KNMI

Approach: Several techniques are applied to describe the processes and precursors leading to a better understanding and predictability of heavy precipitation events in Europe, including downscaling and application of tracking algorithms.

Status: Tracking algorithm compiled and applied to a few Central European cases. Overview paper to be prepared by Jonathan Eden (KNMI).