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EUPORIAS

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European Provision Of Regional Impact Assessment on a

Seasonal-to-decadal timescale

Deliverable D42.3

Report assessing the benefit of this climate service prototype

Deliverable Title	Release an impact forecast for the prototype services and analysis of its impact	
Brief Description	The document summarises how the impact forecast were produced and disseminate in each of EUPORIAS prototypes and how the information was used by the users.	
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1. Executive Summary

Deliverable D42.3 promised to deliver a set of real-time impact predictions related to the climate service prototypes that have been developed as aprt of the proejct. Being a demonstration deliverable this is fulfiled through the release of the predictions themselves. This document provides a written evidence of the fulfilliment of deliverable.

2. Project Objectives

With this deliverable, the project has contributed to the achievement of the following objectives (DOW, Section B1.1):

No.	Objective	Yes	No
1	Develop and deliver reliable and trusted impact prediction systems for a number of carefully selected case studies. These will provide working examples of end to end climate-to-impacts-decision making services operation on S2D timescales.	X	
2	Assess and document key knowledge gaps and vulnerabilities of important sectors (e.g., water, energy, health, transport, agriculture, tourism), along with the needs of specific users within these sectors, through close collaboration with project stakeholders.		
3	Develop a set of standard tools tailored to the needs of stakeholders for calibrating, downscaling, and modelling sector-specific impacts on S2D timescales.		
4	Develop techniques to map the meteorological variables from the prediction systems provided by the WMO GPCs (two of which (Met Office and MeteoFrance) are partners in the project) into variables which are directly relevant to the needs of specific stakeholders.		
5	Develop a knowledge-sharing protocol necessary to promote the use of these technologies. This will include making uncertain information fit into the decision support systems used by stakeholders to take decisions on the S2D horizon. This objective will place Europe at the forefront of the implementation of the GFCS, through the GFCS's ambitions to develop climate services research, a climate services information system and a user interface platform.	X	
6	Assess and document the current marketability of climate services in Europe and demonstrate how climate services on S2D time horizons can be made useful to end users.		

LEAP

Detailed Report

The objective of the LEAP Prototype was to integrate seasonal precipitation forecasts into an existing early warning software platform, in order to enable earlier projections of needs for humanitarian interventions in Ethiopia. The impact of the prototype was expected to be significant. The potential predictability of rainfall in East Africa has been knows for a relatively long-time. At the same time, qualitative seasonal scale predictions are already considered by national and international stakeholders in the area as one of the key sources of information during the periodic assessments that are regularly conducted during the crop season. Therefore, the integration of seasonal forecast data into LEAP had been identified as an important component of the overall LEAP early warning system since its establishment in 2008.

Besides the favourable overall framework, there are at least three technical aspects of the LEAP prototype that were also conducive to a potential positive impact of the pilot.

First, LEAP is particularly focused on droughts at a relatively large scale (national, sub-regions). Although the orography of Ethiopia is rather complex, the underlying requirement is that the seasonal forecast is able to capture one particular class of extreme event (severe rainfall deficit) at a spatial scale that might be compatible even with the coarse resolution of global forecast.

Secondly, the underpinning drought indicator (the Water Requirement Satisfaction Index, WRSI) is constructed as a long term water budget, which cumulates the effect of rainfall anomalies throughout the main crop season. Therefore, the requested skill of the seasonal forecast is on the long term, persistent anomalies that are more likely related to large scale anomalies of the climate system, such as those related to El Nino.

Finally, the transfer function that is adopted to convert water budget anomalies into needs for humanitarian interventions has a logarithmic shape, which enhances the effects of large deviations and smooth’s out the presence of relatively small deviation from the norm.

For these reasons, the skill of the new predictions was expected to outperform the intrinsic skill of the seasonal forecasts.

Main results

An interface between the LEAP software platform and the sources of seasonal forecast data has been implemented by making full use of the R libraries that have been made available through the European Climate Observations, Modelling and Services initiative (ECOMS) and its User Data Gateway (https://meteo.unican.es/trac/wiki/udg/ecoms) developed and maintained by University of Cantabria.

Moreover, the way in which “needs estimates” are calculated has been redesigned in the LEAP platform, in order to exploit the availability of ensemble forecasts. Before EUPORIAS, LEAP was only able to handle a single stream of observed rainfall date.

With this new component in LEAP, it is now possible to compare the “needs computation” based on the usual satellite rainfall estimates and the needs computation based on hindcast products (ECMWF-System4 in Figure 1). The skill of the forecast in capturing the inter-annual variability of estimated needs is remarkable. Note that the needs estimates, based on satellite products, are usually available in September-October (end of the crop season), while needs estimates based on forecast products would be available already in May, at the beginning of the crop season. Estimated needs do not necessarily match the actual historical beneficiaries, which are identified on the basis of additional factors that might not be directly related to the occurrence of a drought (including the fact that the national Production Safety Net Programme, partially covers for the assistance to annual emergencies).

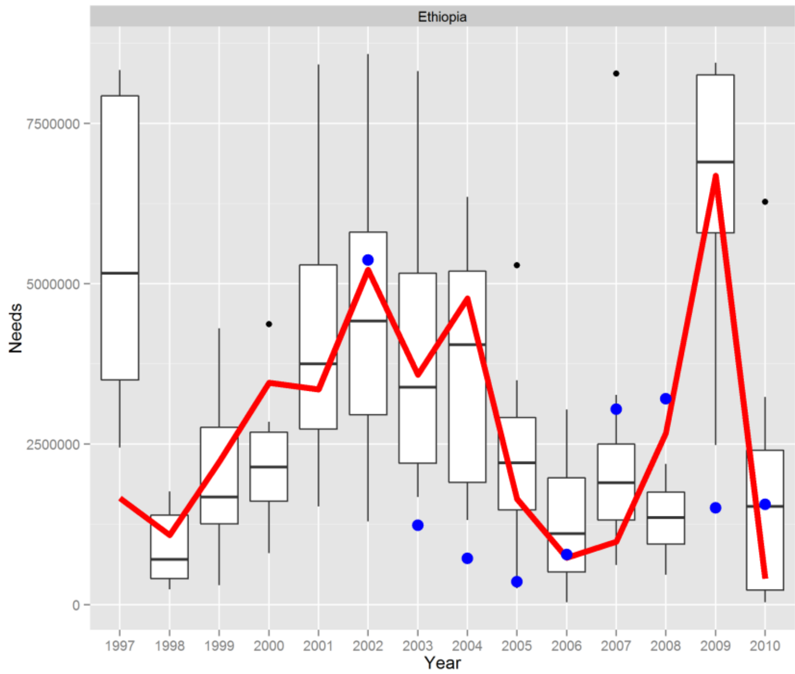

Figure 1: Hindcast for the needs for humanitarian interventions in Ethiopia based on satellite rainfall estimates (red lines) and seasonal forecast products (box-plot). Historical actual needs are also reported (blue circles)

Deviations from DOW

Notwithstanding the remarkable degree of predictability of the climate impact indicator, a full assessment of possibility of affecting decisions in the real world has not been possible. This was due to external constraints that were not entirely dependent on the structure of the project. Some of the aspects had been considered has potential risk factors on the prototype risk register.

First, due to the regular staff overturning at WFP, the Ethiopian Country Office and Headquarters staff members that had first contributed to the design of the prototype did not have the opportunity to contribute to its implementation. In particular, a key staff member, who was also the connection with the external stakeholder - the Ethiopian DRMFSS, has not been available to work on the prototype in the WFP Country Office. This has partially slowed down the activities and contributed to weaken the necessary interactions between the EUPORIAS project members and the external stakeholder.

Secondly, a severe drought has hit different parts of Ethiopia during the main crop season of 2015. As a results, all of the available resources at DRMFSS have been concentrated on emergency operations and the meetings that had been agreed in order to coordinate a common work plan towards the release of a first LEAP base seasonal forecast outlook for the next rainy season have not taken place.

The issuing of outlooks on humanitarian needs are considered as politically sensitive and it was decided not to proceed with the production of the seasonal outlook which, although feasible with the same technical platform which is used to produce Figure 1 in this report, would not be positively received without the full involvement of national authorities in Ethiopia. In particular, a close coordination with the National Met Agency has been lately recognized as an important partner and it was not possible to sufficiently involve it in the process.

Lessons Learnt

There are two key lessons learnt during this phase of the development of the prototype.

On the positive side, we demonstrated that exploring the potential use of seasonal forecast for practical applications and for the computation of impact indicators, may result in prediction skills that would not be expected from the simple consideration of the skills of the raw climatic component of the forecast. A significant outcome of this work is the evidence that extremely useful information can be extracted from data which do not necessarily show outstanding predicting skills.

On the negative side, we have experienced that even in the presence of skilful information, the lack of a full ‘owner’ of the activities and of a deep involvement by the ultimate problem-holder, can dramatically weaken the process of designing and implementing a climate service. Indeed, this particular experience demonstrates that the creation of a climate service is *de facto* a result of the joint effort of at least two peer components: a problem holder and a climate expert or service provider.

RIFF PROTOTYPE

The development phase of RIFF

For the development phase of its prototype RIFF, Météo-France's strategy aimed to assess impacts of seasonal forecasts on the decision making process of the target users. The priority was to conduct this verification as soon as possible in the project. That is the reason why we have chosen to use a development version of Météo-France's hydro-meteorological model chain (Figure 2) to prepare some decision support products in collaboration with one specific stakeholder.

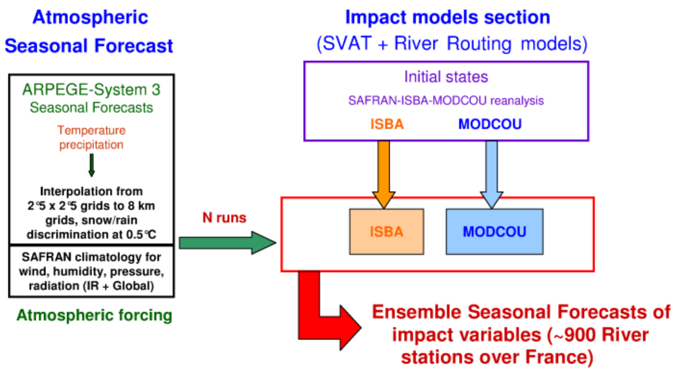

Figure 2: The seasonal hydrological forecast suite used to produce riverflow forecasts during the development phase of RIFF

The real-time (pre-operational) version of RIFF

For the pre-operational phase, we had to review some chains links. On the one hand we had to correct some simplifications (especially the downscaling of climate forcing), on the other hand we had to update model versions. We also had to set up a delivery mechanism, efficient for both the provider and the stakeholders.

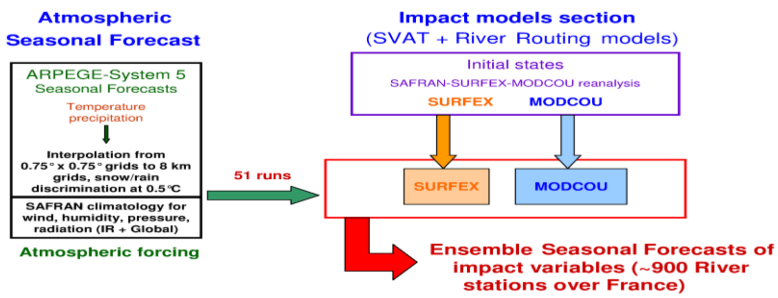

Figure 3: The real-time seasonal hydrological forecast suite used to produce riverflow forecasts

Model versions

In order for the prototype to run in real-time, atmospheric forcing needs to come from an operational model. We used the new Météo-France model ARPEGE-system 5 (see technical documentation on http://www.cnrm.meteo.fr/IMG/pdf/system5-technical.pdf), which offers a finer resolution (0.75° instead of 2.5° with ARPEGE-system 3) and many improvements in terms of modelling (a better representation of stratosphere, an ice-model etc…).

The hydrological model ISBA is replaced by SURFEX (Masson et al, 2013). Compared to ISBA, we benefit from a correction of the downward long-wave radiation input, use of a diffusive approach surface scheme instead of a force restore scheme for the soil modelling, use of sub-grid relief and drainage parameterizations.

Downscaling method and river-flow post-treatment

We have changed the downscaling method of forcing upstream from SURFEX. An empirical quantile mapping is now applied to seasonal forecasts of temperature and precipitation, to obtain a finer local adaptation of atmospheric forcing. Forecasted quantiles are calculated by a smoothing applied on raw model quantiles, like in Mahlstein, 2015 (Figure).
The same method is now applied to riverflow outputs from MODCOU. It replaces a former one, based on a monthly quantile-quantile correction that sometimes created some breaks in the timeseries.

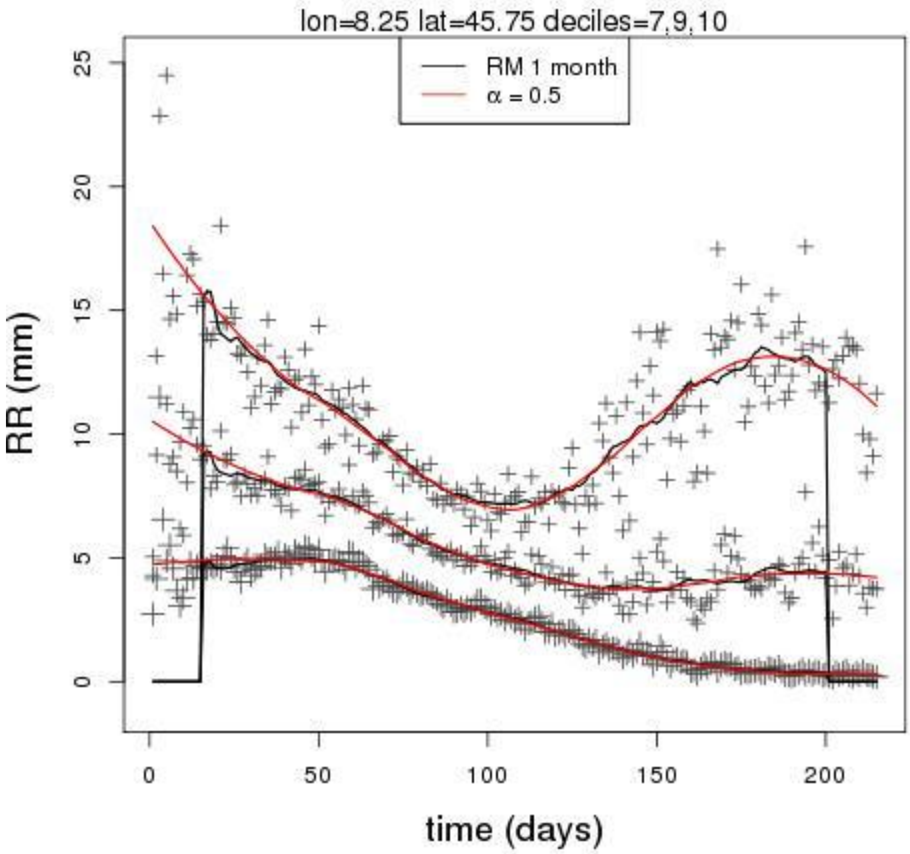

Figure 4: ARPEGE-S5 daily Precipitation forecast, deciles 7,9 and 10, at latitude 45.75°N, longitude 8.25°E. Symbols "+" represent raw quantile data, black lines represent a 30-days running mean, green lines represent a LOESS-fitting

Tailored products and delivery platform

The tailored products defined with our stakeholders in the development phase of RIFF, especially designed to evaluate the impact of Climate Information onto DMP (Placebo Concept), are the base for the real time production even though they need to be slighted adapted (Figure).

At the moment, the final representation is not fully defined with our users. The main modification concerns the representation of uncertainties with both confidence level (as in meteorology) calculated on a hind-cast period of the model, and information about predictability of the current situation coming from the seasonal forecast bulletins.

We have to note also that the dissemination to our stakeholders will include both tailored products and data in input of impact model used in their DMP.

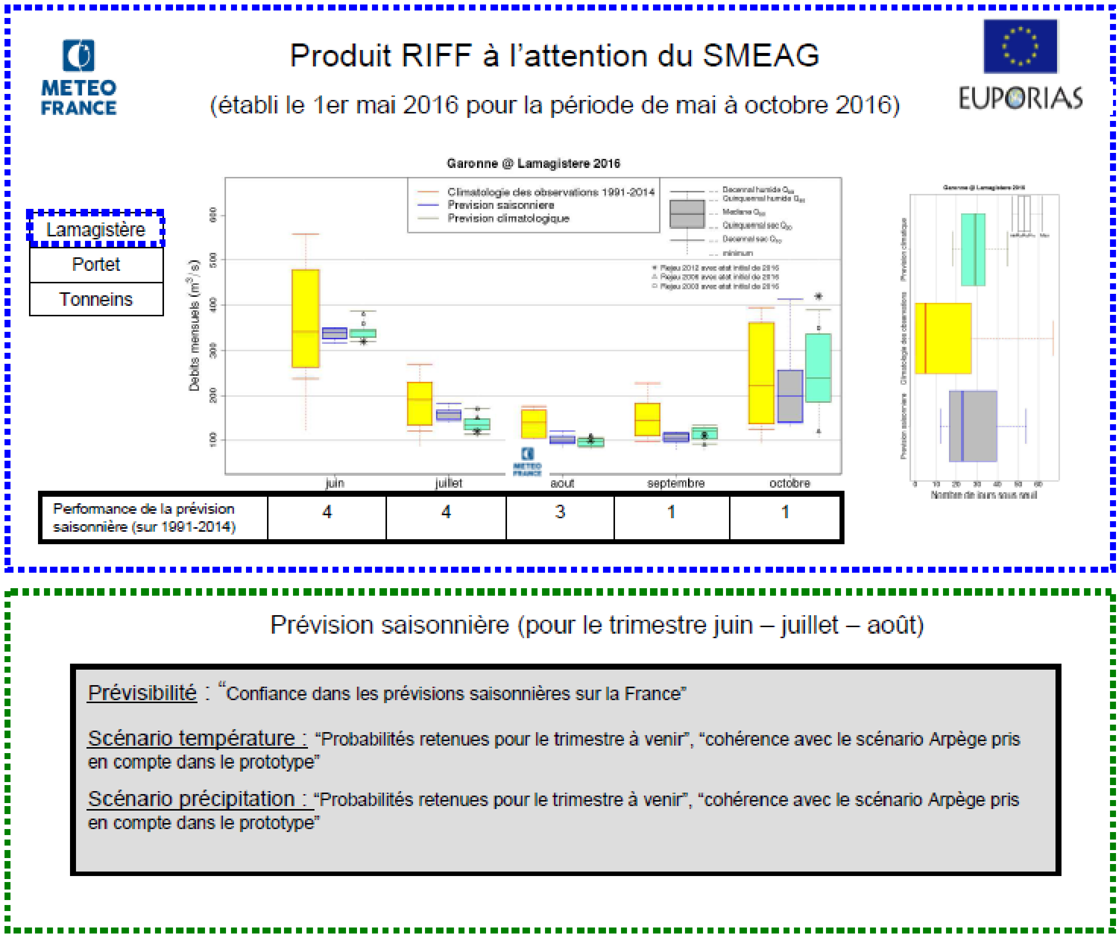

Figure 5: Model of real time product for RIFF prototype

During the development phase, there was no specific need for a platform to deliver data or products. In an operational perspective, we have naturally decided to rely on the delivery platform we use for operational seasonal forecast. This web platform (http://elaboration.seasonal.meteo.fr) allows us to build specific spaces for each user. The user has to identify himself (this also assures the confidentiality of its products) in order to be able to access his data and products.

The real time experiment of summer 2016 will be conducted in close collaboration with our two stakeholders and this should still allow for improvements in the representation of climate information and the way to access it, to be made.

Lessons learnt

The stakeholders' involvement, directly linked to their interest in such a service, is essential all through the development process. After the theoretical experiment using the hindcast period, the application during the summer 2016 of a 'real case' will indicate if the RIFF product is evolved enough to be relevant under actual conditions, where the decision making process could interfere with external factors.

The products built during the hindcast experiment phase are not exactly the same as the real time products. Moreover, in real time, the atmospheric conditions uncertainty could be quantified by taking into account additional information, like other models or an expert judgement concerning specific predictability of the situation.
The climate service has to provide a scientific support about what is shown and their limits. Information has to be prioritized. A focus has to be made about the used vocabulary, in accordance with the final user. The user should easily appropriate it in the aim to be able to diffuse it to a collegial decision committee.
Providing both product and numerical data for impact models could also improve the service.

References

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RESILIENCE PROTOTYPE

Introduction

Predicting the future variability of energy resources beyond the first two weeks can allow end users to take calculated, precautionary actions with potential cost savings. For energy traders, wind farm managers and many others actors in the wind power industry, it is crucial to understand how wind conditions are going to change in the next few months. Current energy practices use an approach based on a retrospective climatology. This methodology can be improved by probabilistic predictions, which build upon recent advances in global climate models able to simulate the physical processes governing the whole climate system, at least at some spatial and temporal scales.

The RESILIENCE prototype has been developed with the aim to support users to better understand the future variability in wind power resources and to bridge the gap between energy practitioners and the climate scientific community. To do so, the prototype provides seasonal wind speed predictions tailored to the wind energy sector.

Creating an operational prediction

The RESILIENCE prototype uses the ten-metre wind speed forecasts from the ECMWF System 4 (S4) operational seasonal prediction system (Molteni et al., 2011), which is based on a fully coupled global climate model.

Atmospheric computations are highly sensitive to small variations in initial conditions, which can produce very different final outcomes. Furthermore, our knowledge of initial conditions is always imperfect, as observations are discontinuous. To deal with that, ensemble predictions are used to estimate the multiple possible evolutions of the atmosphere-ocean system, and the probabilities associated with them. The operational S4 forecasts are produced at the beginning of each month with 51 ensemble members. Each member of the ensemble uses slightly different initial conditions and different realizations of stochastic representations of sub-grid physical processes occurring in the atmosphere. The simulations are performed for up to seven months into the future.

To evaluate the quality of the S4 prediction, we compare the predicted ten-metre wind speed with the corresponding variable of the ERA-Interim reanalysis (Dee et al., 2011). This reanalysis uses the ECMWF Integrated Forecast System (IFS) atmospheric model that assimilates observational data of many types, including in-situ observations and satellite measurements. Given the sparsity of global wind observations, we used a reanalysis as the best available estimate of wind speed and temperature.

Data processing: calibration and post-processing

Like every variable predicted with a coupled model, wind speed is affected by biases resulting from the inability to perfectly reproduce numerically all the relevant processes responsible for climate variability. S4 seasonal predictions require post-processing in order to statistically resemble the observational reference and minimise forecast errors. The RESILIENCE prototype performs this fundamental step using a calibration method and to produce usable, tailored and high quality information.

Calibration allows obtaining predictions with average statistical properties similar to those of a reference data set. For such purpose, we have applied the variance inflation technique (von Storch, 1999). This technique modifies the predictions forcing them to have the same interannual variance as the reference dataset and corrects the under- or overestimation of the ensemble spread without modifying the ensemble-mean correlation.

The statistical post-processing parameters are determined by comparing the past forecasts with the observations, which are based on the same dataset used for verification. Post-processing is carried out in cross-validation mode. Cross-validation estimates the corrected forecast by omitting the particular forecast, which needs to be corrected from the forecast average (i.e. all the available samples are used as training data, also including years after the target season but excluding the target season). This procedure is useful in order to emulate as much as possible real-time forecast situations.

Skill: forecast quality assessment

As any other forecast, seasonal forecast systems need to be systematically compared to a reference, preferably observations, to assess their overall quality in a multifaceted process known as forecast quality assessment (Mason and Stephenson, 2008). This is a fundamental step in the prediction process because a prediction has no value without an estimate of its quality based on past performance (Doblas-Reyes et al., 2013).

The three scoring measures used in the RESILIENCE prototype are the ranked probability skill score, the reliability diagram and the rank histogram. They consider probabilistic forecasts, also known as ensemble forecasts, so that the forecast uncertainty is fully taken into account. The goal is to offer the most general and, a priori, relevant information for a user in the wind energy sector instead of the traditional view offered by climate scientists where only the ensemble-mean correlation is shown.

The skill estimates, based on the performance of the system in the past, inform users about the expected performance of future forecasts (Weisheimer and Palmer, 2014). A particular measure of the predictive skill for the probabilistic seasonal forecast for categorical events is the ranked probability skill score (RPSS) (Epstein, 1969; Wilks, 2011), a squared measure comparing the cumulative probabilities of categorical forecast and observation vectors relative to a climatological forecast strategy. The RPSS is based on the ranked probability score (RPS), which is a measure of the squared distance between the forecast and the observed cumulative probabilities. In the present case, the RPSS has been computed based on categorical forecasts for terciles. The individual observations in the verification time series can fall in any of the three categories with a probability determined by the probability density function (PDF) for the target season.

The RPSS and CRPSS range from 1 (for perfect predictions) to $-\infty$. Skill scores below 0 are defined as unskillful, those equal to 0 are equal to the climatology forecast, and anything above 0 is an improvement upon climatology, up to 1, which indicates a ‘‘perfect’’ forecast.

Creating a user interface platform

Project Ukko is a visualisation interface developed as a part of a design study on potential applications of seasonal to decadal (S2D) climate predictions. This tool presents a novel solution to the informational challenge of putting probabilistic information into usable form for decision makers in industry.

The aim of this interactive visualisation interface is to support users to better understand and explore probabilistic wind speed predictions generated by the RESILIENCE prototype. To achieve this objective, an interdisciplinary team that included climate scientists, design researchers and a data visualisation designer provided complementary perspectives to the conceptual design of the visualisation interface.

In Project Ukko, an information-rich, highly-scannable interactive map represents the predicted wind speed, the prediction skill and the probabilistic prediction of wind speed in multi-dimensional glyphs. A visual device (probability cone) communicates the distributions of the probabilistic prediction values.

Release of an impact forecast

The main milestone of the RESILIENCE prototype was to provide one operational prediction with one month lead for the winter period at the end of the EUPORIAS project. In November 2015, RESILIENCE launched its operational forecast for the winter season (from December 2015 to February 2016) that was presented in the annual event of the European Wind Energy Association (EWEA). The operational prediction was made available on-line for all users through the User Interface Platform named Project Ukko (www.project-ukko.net), an interactive interface designed to allow wind industry users to easily explore probabilistic predictions.

Although the primary user of RESILIENCE is the energy trading sector, understanding and quantifying wind resources is a key element for multiple user profiles in the wind energy sector both in pre-construction (e.g. wind farm developers, financial teams) and post-construction (e.g. O&M teams, grid operators). Over the EUPORIAS project, the BSC (formerly IC3-Climate Forecasting Unit) has interacted closely with energy stakeholders with different profiles to develop the RESILIENCE prototype.

The launch of the operational prediction through project-ukko.net was disseminated among the contacts of VORTEX (partner of the SPECS project, a sister project from EUPORIAS), reaching more than 70 users in the energy sector. The prediction was also disseminated with a poster presentation in the EWEA conference and through a stakeholder workshop organized jointly by EUPORIAS and SPECS projects within the EWEA annual event. This workshop was attended by General Electric Spain, EDF R&D, AWS Truepower, ZSW, WeatherTech, SIEMENS, ENECO, Iberdrola Renovables, Casa dos Ventos and Meteo-France.

Further dissemination of the forecast was fostered by Future Everything (partner leading the design of the User Interface Platform), reaching not only specialised media on design and technological advances (e.g. Scientific American, WIRED) but also general media such as the BBC Worldwide and BBC Click or the Guardian Tech Weekly.

Preliminary analysis of its impacts

The overall feedback from all the energy stakeholders that accessed the predictions was very positive. Nevertheless, the global attitude towards the prediction was of curiosity and interest. Many of the stakeholders indicated that at this stage of the development it was too early for their companies to consider including seasonal wind speed predictions in their decision making processes.

Despite acknowledging the potential value of climate predictions on post-construction phases, wind farm owners and operation and maintenance teams showed lower interest and more reluctance to the idea of using new methodologies. Wind farm developers were more prone to accept new methodologies for resource assessments or site-selection. However, the current development of climate predictions was not perceived as mature enough for them.

In general, the users with more interest in the economic potential of seasonal predictions were wind resource assessment consultancies and energy traders. Both agents showed a more open predisposition to consider climate predictions as a complementary service, either as part of their services portfolio for consultancy companies or as a potential source of information about the energy market for traders.

Providing an operational prediction was a good opportunity to engage with stakeholders and demonstrated that the research on climate predictions had advanced enough to provide an operational service. Moreover, the effect of el Niño 2015 and its impact on wind resource anomalies was an incentive for the private sector to approach the science behind seasonal climate predictions; particularly to understand wind anomalies occurring during winter 2014/2015 in the area of the United States.

Regardless of their baseline attitude towards new methodologies, all potential users requested or showed interest in seeing comparisons and results of the prototype predictions in the past (hindcasts) to evaluate the difference between predictions based on climatology and climate predictions in their areas of interest (see D42.2 as an example).

In conclusion -despite having an operational prediction was a necessary step to demonstrate the prototype feasibility- providing assessment reports in hindcast mode and alternative methodologies to evaluate the prediction performance is a much needed step to change the energy stakeholders' perception and acceptance of this novel methodology.

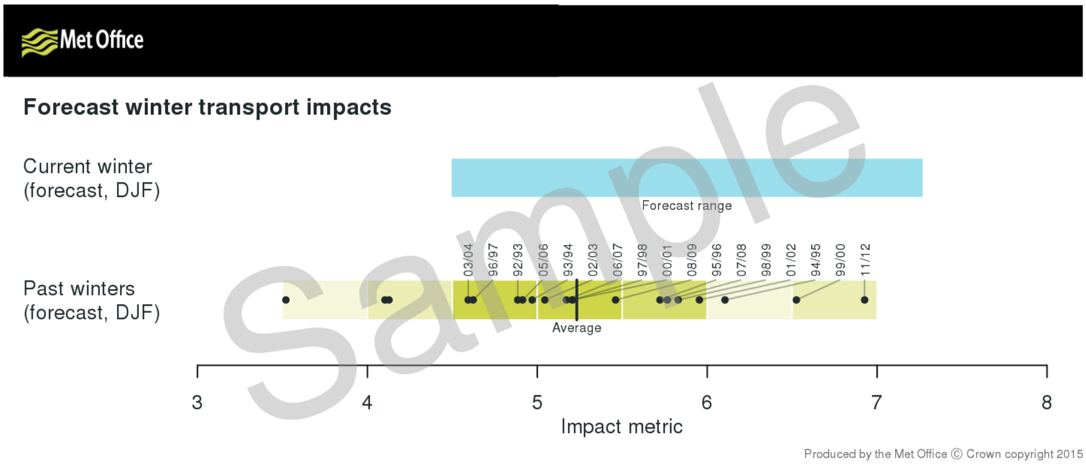
SPRINT PROTOTYPE

Forecast dissemination

The forecasts were disseminated to a large stakeholder group, coordinated by DfT, covering multiple transport modes and functions. Including, representatives from rail, road, local authority, urban transport, devolved administration organisations and aviation organisations.

Throughout winters 2014/15 and 2015/16, a 3-month outlook was provided to DfT as part of a monthly briefing, making use of the publicly-available "Contingency Planners' Outlook" (CPO) material. The monthly briefings took the form of a monthly teleconference in which the forecast was presented using pre-prepared material disseminated ahead of the meeting. In Winter 2015/16, as well as discussing the CPO, monthly risk-based forecasts were also trialled, of specific UK transport impacts during the winter period, at lead times of one to three months which were visually displayed as shown below. This has been possible due to new research that found a relationship between the North Atlantic Oscillation Index (NAO) and winter weather impacts on transport (Palin et al., 2016), making use of the findings of Scaife et al., 2014 who demonstrated skilful prediction by the Met Office's operational seasonal forecast system (GloSea5) of the NAO and European winter (Dec-Feb) climate.

Original format



Revised format

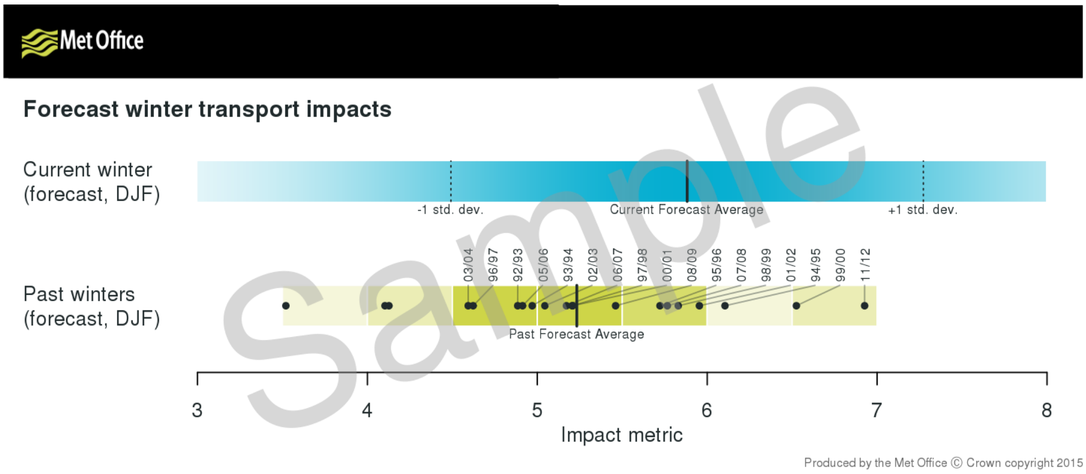


Figure 6: Initially agreed (top) and subsequently revised (bottom) formats for the impact forecasts, for a generic example impact metric. Forecast range of impacts for the next 3 month period is shown by the blue bar. Past winter forecasts from the hindcast are shown by the green bar, where darker shading represents higher frequency and the black dots show the value for each individual year

Following stakeholder feedback the format was altered to display greater detail of the uncertainty in the forecasts (Figure 6). The revised format is the same as the original except the forecast range (blue bar) is shaded as per the probability distribution of the forecasts to show how the likelihood reduces further from the forecast average, but does not reduce to zero (i.e. suggesting an outcome is impossible), as may be interpreted if giving the forecast range as mean +/- 1 standard deviation as in the original format.

A survey was issued in December 2015 asking stakeholders to indicate whether they preferred the original or revised format. Ten of the twelve respondents expressed a preference for the revised format.

Stakeholder feedback

Stakeholder engagement has formed an integral part of the project. As well as the in-person/teleconference briefings undertaken, stakeholders have also been engaged via surveys and workshops. Where possible, feedback thus obtained has been incorporated into the ongoing service development, providing prompt improvements where possible.

A project closure and evaluation workshop was held on 10th March 2016. The aims of the workshop were:

- To remind the stakeholder group about the nature of the service provided during the project,
- To gather feedback from the stakeholder group about the service, in addition to that already gathered during the project, and
- To assess the appetite for the service to continue beyond the project.

Table 1: Key feedback points from the Mar 2016 workshop together with proposals for addressing these in a future service

Topic	Feedback	Proposed approach to address feedback
Temporal coverage	The service should span a larger part of the year, even if the skill of the forecast is lower for some of this period	Offer service Sep-Apr inclusive (not just Oct-Feb)
Forecast lead time	Most people use the 1-month lead time forecasts and less so the 3-month lead time forecasts (e.g. in Nov they would use Dec forecast and less so the Dec-Jan-Feb forecast)	Focus more on 1-month but retain 3-month for those interested
Scientific content	Some stakeholders very interested in science behind the forecasts Briefing material in general very positively received, with several participants saying the language used was appropriately pitched for general consumption Others wanted “plainer English” or “clear and concise” material and requested more of a focus on clear messaging rather than the underlying science	Provide different types of briefing material, at different levels of technical detail, to enable users to drill down to their desired level, and/or pass to others for wider dissemination
Technical delivery	A better technical solution for delivery of the briefings is required, but this should take into account the limitations of some users’ local IT arrangements	Deliver forecasts by Webex, for those with access to web conferencing facilities. Webex has an audio (i.e. teleconference) option for those without web conferencing.

Stakeholders were supportive of a continuation of the service in future, and made many useful suggestions for improvements to the service they have already received. On many topics, opinions were diverse across the group, but **Error! Reference source not found.** highlights the themes which emerged as relevant to all.

References

Palin, E.J., Scaife, A.A., Wallace, E., Pope, E.C.D., Arribas, A. and Brookshaw, A. (2016) Skilful seasonal forecasts of winter disruption to the UK transport system. *Journal of Applied Meteorology and Climatology,* **55**, 325–344. http://dx.doi.org/10.1175/JAMC-D-15-0102.1

Scaife, A. A. and co-authors (2014) Skillful long-range prediction of European and North American winters. *Geophysical Research Letters*, **41**, 2514–2519. http://dx.doi.org/10.1002/2014GL059637.

THE EUPORIAS LAND MANAGEMENT PROTOTYPE

The Met Office, the University of Leeds, KNMI (Netherlands) and other partners are working closely with Clinton Devon Estates (CDE) and the National Farmers Union (NFU) to develop prototype seasonal weather forecasts for UK land managers. Seasonal weather forecasts (typically for 1-3 months ahead) are currently only skilful during the wintertime, so initial work on the prototype has focused on providing winter forecasts. . The prototype project ends at the end of May 2016, after which the project team will focus on writing a peer-reviewed paper on the prototype.

Delivery of the prototype

Production of the first draft forecasts during winter 2014/2015 was based around the UK contingency planners forecasts (CPF), which provide 3 month outlooks for temperature and precipitation for the UK as a whole each month, and we used a simple downscaling method to scale the UK forecasts to Devon. We provided these outlooks for the county of Devon, working with a small representative user group of farmers (4-5) from CDE, and collected feedback on them via email and post. The outlooks were provided each month from October to March.

During winter 2015/2016, we have been using a web microsite to provide 14 day site-specific forecasts for temperature and precipitation alongside three month outlooks, across the wider area of South West England, working with a larger stakeholder group (about 20, covering both CDE and NFU). We also made, and continue to make extensive use of a collaborative wikidot site for project team communications such as meeting minutes and working documents.

During winter 2015/2016, we have moved to providing our forecasts (14 day and 3 month) via a web microsite. Initially this was via a static page for the 3 month outlooks, updated manually on a monthly basis, following the Met Office seasonal forecast meetings. 14 day forecasts are provided via an interactive map (and updated every 6 hours), with forecasts run at the Met Office producing archive files which are retrieved and processed to produce graphics files, transferred to the microsite via ftp.

The 14 day forecasts and three month outlooks are now provided via an API, and hence the Met Office transmits data to the API in JSON format (currently via ftp). Ongoing work will include the 3 month outlooks into the API.

The users received a login to access the website, which was also used to gather feedback on forecast content, relevance (use) and understanding via SurveyMonkey, which will probably move to EC-survey once the API is fully implemented. Initial statistics show the website has been accessed up to 400 times a day (given about 20 users). The users interact with the website both on mobile devices and via desktop PCs.

Ongoing work is also developing a mobile app based on the prototype services and we are also developing the forecasts based on feedback from the farmers, including a) additional weather variables, b) improved presentation and c) including information on county-scale climatology and tercile categories to improve understanding, most of which has already been implemented (e.g. Figure 7). We plan to deliver the app via the Apple and Google App stores. The screenshots below (Figure 8) illustrate what the app will look like. The app will collect feedback from the users, and use this to help further improve content and presentation. The prototype has benefitted from considerable interaction with the users throughout the project, as described below.

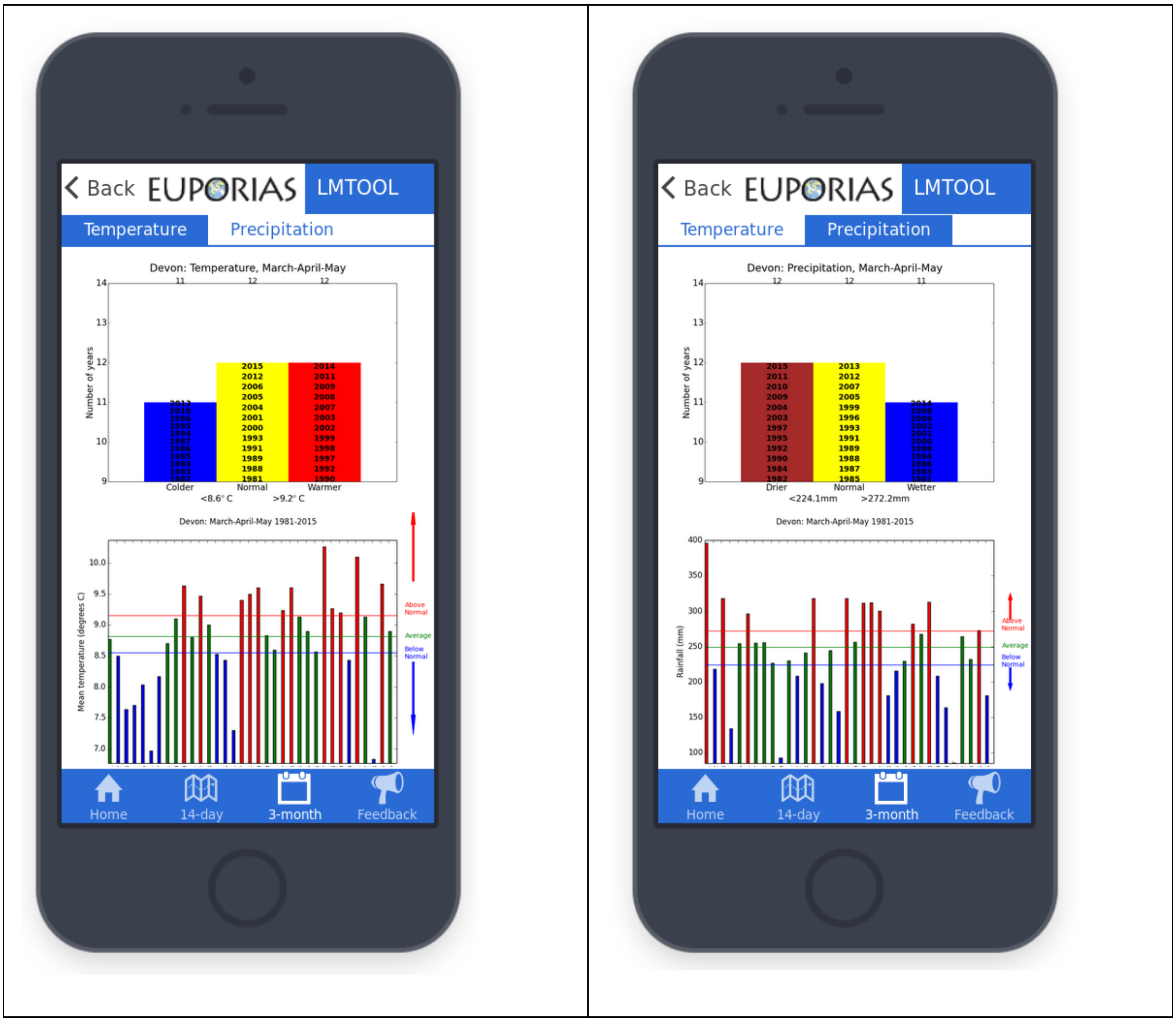


Figure 7: Local (county-average) climatological information in the LMTool, illustrating how recent years relate to the tercile categories, and the actual values

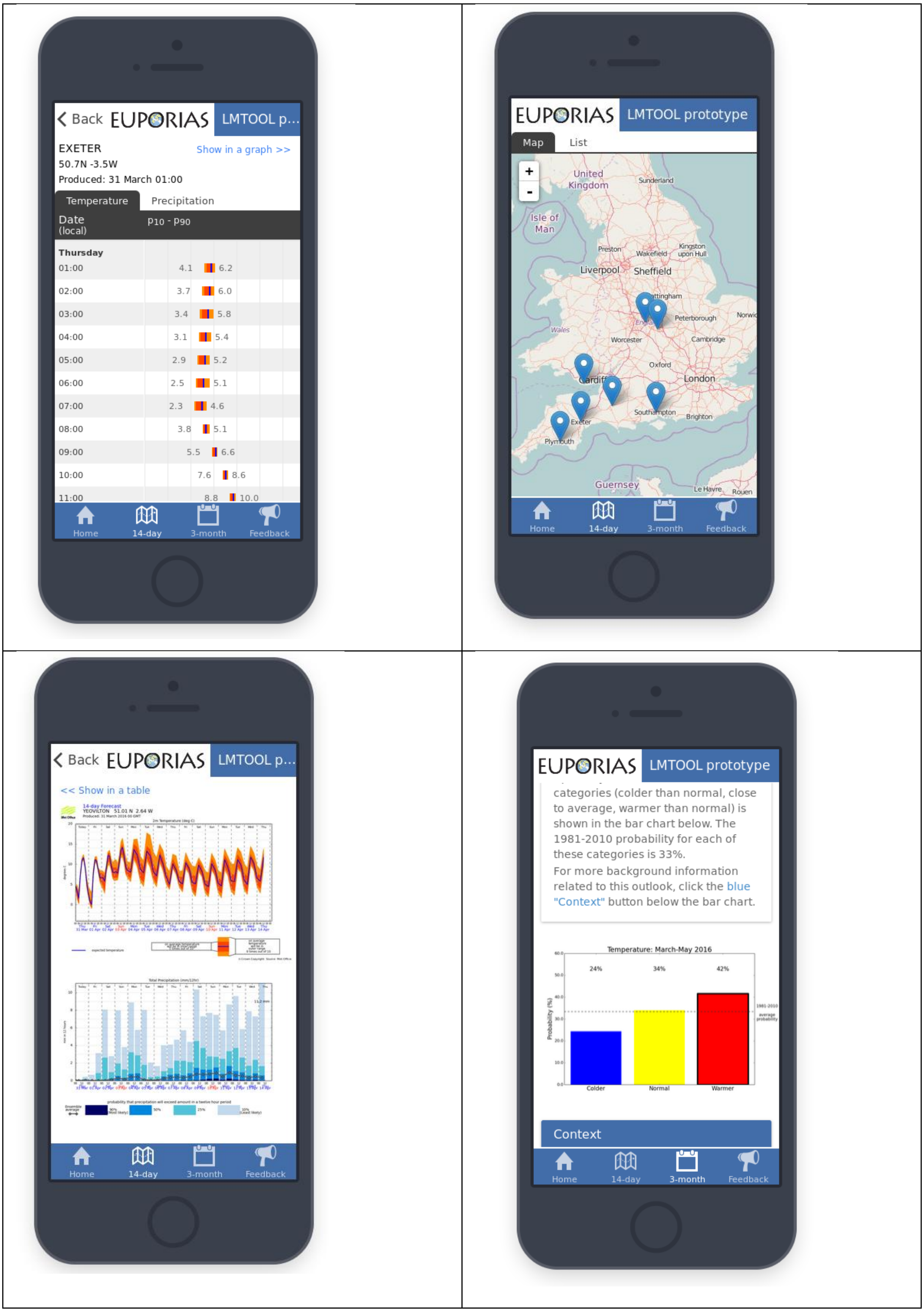


Figure 8: Screenshots of the LMTool app in development

Interactions with users

Figure 9 illustrates how we interacted with users in the project.

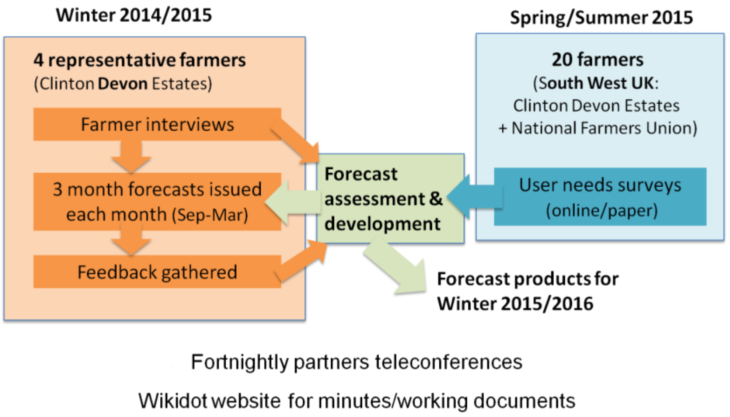


Figure 9: Summary of approach and progress in the land management prototype

In brief, we:

- interviewed a representative subset of CDE farmers on their needs for weather information
- developed a draft three month forecast and sent this to the farmer subset each month during winter 2014/2015
- provided background information on our prototype for the microsite (http://lmtool.predictia.es/en/)
- surveyed a wider group of farmers from CDE and NFU on their needs for long-term weather information to support decision making, and on their preferences for visualisation, and held a workshop to then
- Built on findings from stakeholder engagement and feedback on our draft forecasts to develop a second version of the forecast for winter 2015/2016.
- Begun to provide 14 day forecasts and three month outlooks via our microsite (http://lmtool.predictia.es/en/content/euporias-lmtool-forecasts-south-west-england - login required)

As noted above, feedback was gathered via workshops and hard copy/email forms, and later by online surveys in SurveyMonkey.
CDE were chosen as an initial stakeholder due to their proximity to the lead partner, making interaction easier, and their wide-ranging interest in land management activities. Several scoping meetings were held initially with CDE, with high-level management contacts, leading to CDE identifying a representative group of farmers for the project team to work with, and a lead contact at CDE. We agreed with CDE to extend the focus of the project during the second winter, to both include a wider range of CDE contacts (voluntary invitation from the project team) and from NFU (approximately 12 contacts provided by a central NFU colleague).

In general, the stakeholder engagement work (feedback forms, interviews and survey) found the following:

- Interest in more specific variables (temperature, rainfall, rain/dry days/spells, heavy rain events, wind speed and direction)
- Interest in more local, shorter-term forecasts alongside three month outlooks
- Requirement for delivery via a website, and/or app
- Poor understanding of the three month outlooks, if unfamiliar with them, and not explained in detail

CONCEPT ON A PROTOTYPE FOR A (SECTOR-SPECIFIC) CLIMATE WATCH

Background

Task 42.2 of the DOW envisages a prototype for a Climate Watch based on the existing Climate Watch system of the WMO RA VI RCC (hosted by DWD) and in collaboration with corresponding stakeholders. Referring to the results of D41.1 the recipients of Climate Watch Advisories (CWAs) are National Meteorological and hydrological Services (NMHSs) which use this information for own user- or sector-specific warnings or climate service products on the national scale. CWAs are considered to be of relevance for most NMHSs if used at all. Respectively, the potential value of CWAs is considered to be high if modified or optimized with respect to information content, quality and dissemination structure.

Scope

The goal of the Climate Watch prototype is to serve the needs of stakeholders of a specific sector, i.e. the existing Climate Watch is supposed to be augmented by sector-specific information and by respective tailoring of the provided information. The CW prototype will be developed on the back of one specific problem representative for one specific sector. *The CWA must not be considered as an impact forecast and must not replace an impact forecast. It is an advisory to climate conditions which might become critical due to the climatological and sector-specific context as well as historical events.*

Case-study

The selected stakeholder for the Climate Watch prototype will be the German Federal Institute of Hydrology (BfG) which is a close partner of DWD and a potential recipient of a Climate Watch Advisory provided by the WMO RA VI RCC. The considered problem will be low-flow conditions on the river Rhine which is a typical seasonal problem (see D11.2) and the end-users will be decision-makers of the inland navigation sector. The prototype will be developed in a hindcast-mode based on a case-study on low-flow conditions in summer/autumn 2015. This event had serious impacts on inland navigation sector on the River Rhine and was also issue of a Climate Watch Advisory. A verification of the CW prototype in a forecast mode is desired but very dependent on the climate conditions during the project run-time until October 2016. The information content and structure of the CW-prototype will be developed iteratively in close cooperation with the stakeholder.

Content

The existing CWAs will be augmented with existing hydrological information potentially useful for decision-makers of the inland navigation sector to assess and integrate the climate information. Such hydrological information might be: preceding discharge information of the affected area as well as preceding and current conditions of the hydrological budget of the catchment (i.e. soil moisture, snow conditions, evapotranspiration, etc.) to assess a potential severity of impact of the issued climate conditions. Also historical impact statistics may be interesting for decision-makers and thus content of a respective CWA. For that the Climate

Knowledge Database will be used to analyze similar historical climate events and also impact information from the inland navigation sector.

Frame conditions

Sector-specific tailoring of CW-information affects parameters, temporal- and spatial scale, timing and lead-time of issued warnings. For the water-sector both, temperature and precipitation are desired. The temporal scale of 4 weeks will be used for a start. This time frame is chosen since: (i) this is used for current Climate Watches; (ii) hydrological forecasts provide any skill; and (iii) it is useful for decision-makers. The potential of seasonal scales for CWAs will be checked.

CONCLUSIONS AND FINAL REMARKS

This deliverable represents the last act of WP42 and thus we feel it is important to use it to document, at least in part, the process that we have been going through in the project and the lessons we have learnt during this process.

The first and most obvious point to make is that EUPORIAS developed five (plus one) prototypes of climate services. This is twice as many as the project promised to develop in the DOW. Out of these six prototypes, five managed to deliver (or are in the process of delivering at the moment of writing) a real-time impact prediction. This represents an incredible success for the project which greatly exceeds what was foreseen at the onset. The reasons why one of the prototypes has not managed to provide a real-time forecast are presented in the document and, to a significant degree, are due to factors the project had no direct control over.

All prototypes developed their predictions in close collaboration with the final users. Even though this generally required more time and energy than we originally assumed, we fell somehow short of our original ambition of developing products for extremely well identified users. There are several reasons for that. First, all partners in the project felt the effort they put into the development of the prototype could have a longer-lasting impact if they could reutilise some of the tools or the lessons learnt in another context. This inevitably determined a constraint on how user-specific each prototype was going to be. Secondly, we worked on the assumption that the target users had one specific decision that the prototype could inform. This turned out to be strictly correct only for a small minority of cases. In most circumstances the users were interested in the climate information we could provide to inform a set of decisions and management practices. This too pushed for keeping the tool more generic than we originally envisaged. Such an aspect is also linked to another point we feel is important. For most users, climate information doesn't live in isolation, but represents one of many factors to consider when looking at their decision. In particular the distinction between observations, weather predictions, climate predictions and climate forecast is much less evident from them then it is for the providers. Re-scoping the prototypes across these artificial boundaries, as it was the case for the land-management tool for the 15-day forecast, added an extra layer of complexity to some of the prototypes; but also highlighted the need for climate services to build bridges with other time-scales and disciplines.