EUMETNET

SRNWP – EPS WORKING GROUPS

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WG 1

Topic	Interaction of EPS with data assimilation in the convection-permitting scale (Inger-Lise Frogner)
Purpose	To further merge the fields of EPS and DA for the convection-permitting scale, to better predict high-impact weather including uncertainty estimates.
Objectives	Increase our understanding and competence on how to produce a sufficiently accurate initial analysis including estimation of its uncertainty that enables a *timely* production of reliable probabilistic prediction for the convection-permitting scales
Deliverables	A better assessment of the potential of an EnDA system for useful and reliable operational probabilistic predictions on convection-permitting scales.
Description	Weather predictability is inherently limited by unstable atmospheric dynamics and physics. Uncertainties on small spatial scales penetrate upscale over the forecast range (the “butterfly effect”). Simultaneously, uncertainties on the synoptic scales strongly influence the error growth on smaller scales through cascade processes and uncertainty advection. For the smaller scales, perturbations grow faster and saturate at smaller magnitudes. The only well documented exception is connected with interactions between large-scale atmospheric features and fixed small-scale surface structures, for which the error growth rates are determined by the large scale features. Otherwise, as model spatial resolution increases, forecasts will increasingly contain spatial details which are likely to have little predictive value beyond lead times of a few hours, when the predictability limits of smaller resolved scales are reached. Even for rare events the conditional probability on the flow situation might be high making the hazardous events predictable from a probabilistic point of view. The development of ensembles at these resolutions is necessary to probabilistically forecast high-impact weather events of short duration and with small spatial extent. In order to realize this goal, considerable new developments on a range of issues are needed. In particular, fast (within a fraction of an hour) and frequent (at least 3-hourly) determination of initial states and their uncertainty, taking flow-dependency and the multivariate balances into account, is imperative. Amongst the many challenges for convection-permitting EPS and data-assimilation four are considered here. We believe that a common effort on these topics will considerably increase the success-potential and thus benefit all the participating institutes. **Construction and evaluation of a candidate EnDA system**The weather phenomena we seek to resolve are dominated by spatial scales whose error saturation level is considerably smaller than the meso- and synoptic scales, and even smaller than traditional uncertainties in the analyzed initial fields. If we want our system to contribute more than what can be achieved by dynamic downscaling, we need to establish methods for data-assimilation and obtain real-time observational data that together provide both a very accurate "best" analysis and alternatives which reflect its flow-dependent uncertainty. An increased initial state accuracy can be obtained by exploiting high-resolution observations (e.g. radar), and by utilizing information on flow-dependent model uncertainty. The EnKF, EnSRF, LETKF, EnVAR and 4DEnVAR are currently seen as strong candidates to test as EnDA systems; both for flow-dependent estimation of background error in DA and for generation of EPS initial states. The choice of EnDA system for this project will depend on the partners involved and the resources for this topic. More than one system could be tested; again this depends on the resources and the capabilities and interests of the partners of the project. Evaluation criteria would include computational cost and timeliness for operational production, analysis/forecast accuracy and the quality of the probabilistic prediction. **Sensitivity to the domain size, resolution and cycling interval.** With the short predictability on these scales it is important to have a fast production, whilst at the same time having the processes of interest resolved. As the errors on these scales saturate quickly, the forecasts becomes old and useless after a time-interval of a few hours. The domain size should be large enough to allow the inserted perturbations to breed within the LAM domain. This is in particular important at northerly latitudes where the small scale instabilities are related not only to convective activity but also to larger-scale fast-moving features such as fronts and depressions. Also the ensemble spread of feature position tends to increase with lead time, whilst ensemble DA requires several members to have features overlapping the observed feature. So, given that we only have a small ensemble, we might make more use of it if there is a shorter time between DA cycles. The more frequent updates may exaggerate imbalance and increase cost, so experiments with a range of cycle times dependent on the domain size and model resolution are needed. An optimal DA configuration could thus improve both analysis accuracy and the timeliness of updates. **Sensitivity study on LBC and DA**An ensemble forecast requires perturbed Lateral Boundary Conditions, yet DA often assumes the LBCs are perfect. The LBCs should also be consistent with nearby Initial Conditions. Experiments with DA that allows updating of externally imposed lateral boundary data are needed. One also needs to address the handling of the LBC increment that arises when switching to a new run of the driving global system which provides the lateral boundary data. **Link with land surface**There needs to be a close link with WG2 (Modeling and data assimilation of ground surface properties). For these scales we believe it is very important to take into account surface issues along with the atmospheric issues. The specification of the lower boundary condition has a crucial role in the forecast, e.g. soil moisture is a key variable for the quality of weather parameters such as precipitation, screen-level temperature, humidity and low-level clouds. One idea is including land surface fields such as soil moisture and snow-cover within the state vector which is manipulated by the atmospheric DA, so that the atmospheric and land-surface states are updated in a way which respects their mutual correlation as predicted by the ensemble. This kind of link could be lost if the atmospheric and land DA are pursued as completely separate activities.
Resources	Running and testing a convection-permitting EnDA system is resource demanding, both in terms of manpower and computational cost. Several cases studies as well as longer trial periods are needed for testing what is proposed here. Collaboration in the framework of this proposed project could be an important factor for the success of these experiments, as work and computational cost can be divided between the participating institutes
Time	3-5 years

WG 2

Topic	Modeling and data assimilation of ground surface properties (Theresa Gorgas)
Purpose	Addresses the uncertainties related to surface and soil properties and their relevance for convection-permitting EPS. Surface and soil conditions are known to have a major impact on lower boundary layer conditions, for the initiation of convection, and for the time, duration and intensity of precipitation. Wg2 therefore aims at identifying those parameters which are relevant for influencing convection from a predictability point of view, and at finding ways to simulate their uncertainty in an efficient way. A special focus shall be on soil moisture conditions as they are known to play a major role in the soil-atmosphere interactions.
Objectives	1. Ensemble data assimilation of surface/soil property data. This should be done in close collaboration with Wg1. The focus is on the assimilation of available data resources for soil moisture conditions and snow coverage, which influence the latent heat transfer between soil and atmosphere. 2. Perturbation of soil scheme parameters. Simulations of physical processes of soil and surface are not straightforward and often include multiple parameters. The uncertainty of these processes can be estimated by perturbing the parameters which are most efficient in influencing the soil and surface conditions. 3. Involve uncertainty of land use data in the perturbations. The aim is to gain knowledge out about the impact of uncertainties in land use data and terrain property data, e.g. roughness lengths, vegetation and soil texture characteristics. The main question is at which scale these characteristics really influence the forecasts?
Deliverables	Enhanced knowledge about the impact of different soil and surface properties on forecasts. Software routines for the proper design of ensemble perturbations for these properties.
Description	The preferred main approach for simulating the influence of uncertainties of the soil and surface states will be sensitivity tests. In doing so, it will be most efficient to observe the feedback of perturbations for near surface parameters, such as 2m temperature, 2m humidity and accumulated precipitation. For these parameters, observation densities are high and their quality (for in situ observations) is known. Observations for, e.g., soil moisture or snow coverage, are often beyond the scale of their uncertainties or their uncertainties are not sufficiently known (e.g. for satellite-based data). 1. Ensemble data assimilation of surface/soil property data: The uncertainty of the used data can be estimated in two ways. First, if two or more independent data sets are available, uncertainty can be simulated by simply assimilating the multiple data sets to different ensemble members to observe their impact. Another approach is to perturb known uncertainties of the used data sets in a stochastic manner before the assimilation. This is possible if data sets include some uncertainty information (such as quality flags or values of spatial and temporal variability) or if data increments can be derived from comparisons with a reference data set (e.g. satellite versus In-situ observations). 2. Perturbation of soil scheme parameters: This includes stochastic perturbation of parameters used for the simulation of physical processes such as infiltration, overland and subsurface flows. Also parameterized tendencies which are used in the soil schemes, such as surface temperature, liquid and solid water contents, snow density and albedo can be perturbed in the same way. When generating the perturbations the balance of the whole system should be preserved. Another challenge is to find suitable scales (in terms of spread of the perturbations, space and time) and a useful design for the perturbations (e.g. according to the covariance structure of the parameters). 3. Involve uncertainty of land use data in the perturbations: One issue will be to find out which land use or terrain properties lead to non-linear error growths in the forecasts (e.g. by triggering non-linear processes) or which of them have rather linear influence (e.g. causing biases in the forecasts).
Resources	The sensitivity studies will need considerable computational costs and manpower. Accurate estimation is depending on the decision regarding the intended experiments. A schedule of experiments should be designed to divide experiment into more important (i.e. large impact on forecasts is expected) and less important (experiments for fine tuning). Other labor-intensive issues are the preparation of data sets (for assimilation and for validation), the set-up of test suites and evaluation tools. The computational costs will be depending on the used model set-up (members, domain, resolution) and on the time scales of parameters which are focused in the experiments (longer time scales of soil parameters than of atmospheric parameters). Longer test periods will be useful.

WG 4

Topic	Use and interpretation of probabilistic products (Dick Blaauboer)
Purpose	In the framework of the cooperation between European Meteorological Services, the issue of providing products for the operational activities is certainly central. Ensemble forecasts, thanks to the quantification of the forecast uncertainty, are able to fulfil the needs of a range of applications, from forecasting to specific applications like civil protection, aviation, energy market. Cooperation in Europe in the field of ensemble products definition, preparation and visualisation will enable to answer the needs of the users which require transnational applications.
Objectives	Provide the best possible support, uniform all over Europe, for specific operational applications. Define user needs, both from forecasters and end users, develop generic products that can be derived from standard EPS output.
Deliverables	Transnational generic ensemble products which are defined in a generic way and visualised in a generic format, tailored for the specific applications.
Description	The proposed tasks of this projects are: •Analysis of the main users and applications at the NMSs, especially focusing on transnational applications (aviation?). [1]) •Identify the application(s) for which products should be developed [2]) •Inventory of available software, already developed by members •Define a set of products [3]). Definition includes the development of the methodologies to compute/elaborate the products, e.g.: ➢ensemble members selection (for downstream applications and/or for visualisation) ➢spatialisation (upscaling, downscaling) ➢development of post-processed parameters [4]) ➢EPS-grams (compare to ECMWF) ➢Spaghetti plots ➢Averages and standard deviations ➢Probability maps for various parameters (exceeding certain thresholds) ➢Timeseries (stacked probability bars) ➢Combination with other modelling products ➢Tools to combine elementary products for end users (product generator) ➢… •Develop SW for product preparation and visualisation, homogeneous over the addressed area, applicable on standard EPS output •Definition of interface with EPS output •Definition of output of the product preparation/generation SW •Pre-requisite for the full area coverage: implement prototypes of CP ensembles which cover areas not yet covered. Ensembles may be run in cooperation between few adjacent countries.
Resources	FTEs: •one person involved per each NMSs, 0.3 FTEs per year (in kind?), to ensure coordination and good fulfilment of NMS's needs with respect to users •1 (or 2?) FTE per year (common) for developing the SW for product preparation and visualisation, depending on available software As for the implementation of ensembles over areas not yet covered, this can be financed by each country/group of countries by itself or few countries can act as service providers. Money?
Time	3 years: first year for review, contact with users, definition of the methodologies for elaborating the products, second year for SW development (benefit of Interoperability Project) and visualisation tools development, third year for real-time testing, coordinated with the user(s).