Ensemble forecasts and their applications

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The “WHY (needs)” question

- In order to predict localized and high impact weather an ensemble prediction system is crucial

- Need to efficiently treat the large (and growing) volume of data
  - post processing at the HPCs
  - carefully design an archive strategy
  - ...

The “WHAT (goals)” question - general

- Continue introduction, assessment and optimization of relevant perturbation methods and settings, also aimed for (sub)-km scales, to improve the ensembles. Develop perturbations that represent errors close to their source and that respect balances
- Continuous and seamless high-resolution ensemble prediction on timescales from nowcasting to 2-3 days ahead (could also merge in ECMWF forecasts)

The “WHAT (goals)” question - pp and products

- Develop EPS post processing, tools and products to facilitate (swift) interpretation by users

- Reforecasts
  - Assess the need for reforecasts (for producing EFI/SOT and for use in calibration/post-processing), compared to using the existing operational archive
  - Investigate the usefulness of different configurations, eg deterministic for long period or ensemble for shorter period - keeping the cost the same. Is it affordable?

The “WHAT (goals)” question - link with physics

- Explore the possibility of fully stochastic parameterization schemes
- Investigate how machine learning algorithms as surrogates for physical parameterizations will influence model uncertainty description

The “WHAT (goals)” question - link with DA

- The ensemble should be suitable for data assimilation purposes
  - investigating the impact ensemble generation techniques have on sampling of the climatological as well as error-of-the-day covariances
  - impact of ensemble size, model resolution

- The various ensemble assimilation methods (EDA/BRAND/LETKF/3-4DEnVar) available for a canonical ensemble setup should be intercompared

The “HOW (tasks)” question

- Assess the optimal domain size and ensemble size with respect to spatial and temporal evolution of the uncertainties
- Assess the potential benefit of higher resolution (with and without calibration), especially for extreme weather. Assess the trade off between resolution and ensemble size
- Assess ensemble configurations: combinations of several EPS/deterministic runs, dual resolution ensembles
- Assess the benefit of running EPS vs. deterministic and the benefit of EPS nowcasting
- Need experimentation to decide if sub-km EPS is worth the cost vs. improving the ensemble at existing resolutions
- Move towards more physically based perturbations

The “HOW (tasks)” question

- Experts in ensemble methodology, calibration, statistics, machine learning, post processing, system aspects and computer science needed

- To have EPS on (sub)-km scale from now-casting up to 3 days with sufficient number of members needs considerable increase in computational resources and/or better use of existing resources through the use of eg. single precision and machine learning is needed

Common working environment

There are different views of what a common working environment is

What we agree on:

Interoperability is crucial for the cooperation, in order to bring components of the common codes to a high-level of independently testable components. We see the common code as a mandatory condition for the cooperation (NB: here the term “common code” does NOT include scripting system)

Common working environment

What we disagree on:

Common scripting system: Some think it is important to have a fully common system, including scripts. Others think scripting system should not be part of the common working environment, in fact some argue that we should not use scripting system at all in research mode

Common working environment

We see two ways forward for the common working environment, and the group is split between what they think is the best option:

1. No common scripting system. Continue to work in separate systems, but share code and experiences (as we do today). This could include common software for creating perturbations (eg surface perturbations, like is the case today). We could set up a common benchmark domain and do intercomparison exercises, for some it is also possible to utilize overlapping areas for this.
2. Include a common, modernized scripting system

Common working environment

- Pros of a common scripting system
  i. better coordination of development work, the possibility to carry on complex developments by several partners located at different Institutes in a coordinated way, possible to do coordinated experiments
  ii. faster implementation into the CSCs
  iii. Less need to duplicate work
- Cons of a common scripting system
  i. Big task to create the common scripting system

Other questions addressed by the group

- We know too little about machine learning and the application as surrogates for physical parameterizations and the use for error representations
  - follow developments ongoing in eg. ESCAPE2 WP4

- We lack knowledge about computational science aspects and HPC technology evolution

Ensemble calibration

WHY (needs)

- Calibration of ensemble will further enhance its usefulness
  - adapt better to (end) users’ needs
- Long archives are needed
  - for calibration at member states/centres
  - external users

WHAT (goals)

- **Calibrated** continuous and seamless high-resolution ensemble prediction on timescales from nowcasting to 2-3 days ahead
  - may require use recent measurements and other EPSs
  - separate calibration systems and blending vs. unified approach
- Calibration approaches that ...
  - pay special attention to extreme and high impact weather
  - provide probabilistic forecasts at any location
  - account for weather type dependencies
  - make use of the latest statistical/machine learning methods
- Assessment of the need of reforecasts compared to operational archive

HOW (tasks)

- ensure sufficient expertise to make use of advances in statistical/machine learning methods and to adapt these to ensemble calibration
- keep focus on research(?) by sharing knowledge, testing/adapting methods etc.
  - operational systems are mostly about processing data
    - highly dependent on local environment for storage etc.
    - but could benefit from infrastructure in a common verification system ...
  - implementations of methods from scratch is usually not needed
    - only few lines of code is often needed in R, Python, Julia