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Construction of a continuous meso-scale EPS

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- **Inspirations from GLAMEPS/HarmonEPS/DMI-EPS**
- **COMEPS**
- **Summary**

DMI
Danish Meteorological Institute

Motivation for convection-resolving NWP

Extremes often associated with limited scales and predictability

Requirement of meso-scale NWP for extreme weather

A NWP system that models interesting weather phenomena
- Resolving fine scales dynamics and physics

Data assimilation that initiates model states
- Assimilation of observations with adequate flow dependency

Above with uncertainty information: EPS
- Similar (cloud resolving) resolution as for deterministic model
- Sufficiently large ensembles with good spread, skill and reliability
- Timely and frequently updated forecast

Configuration of an operational mesoscale EPS

Targeted features

We wish to construct an EPS that inherits some features similar to other EPS

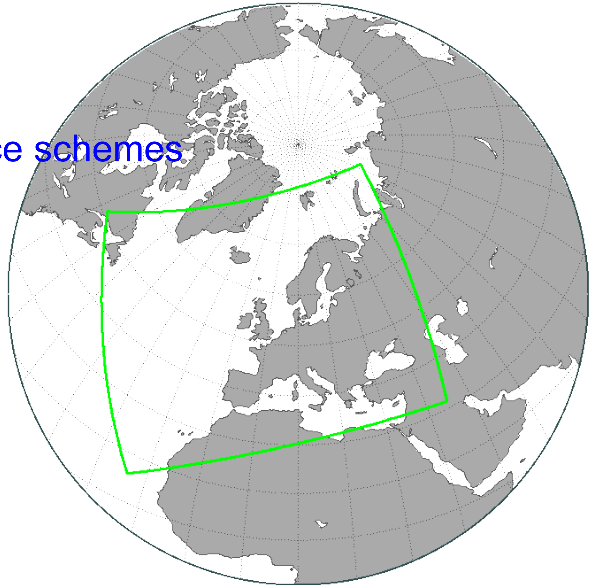
- Multi-model and/or multi-physics (GLAMEPS, DMI-EPS, HarmonEPS)
  - AROME 2.5 km + HIRLAM 3 km in a trasition period. Later with HARMONIE only
- DA and Initial perturbation: EDA/ETKF (HarmonEPS)
- Boundary perturbation: SLAF (DMI-EPS, HarmonEPS)
- Stochastic physics (ECMWF, GLAMEPS, DMI-EPS)
- Calibrated forecast (GLAMEPS)
- Time-lagged (GLAMEPS)

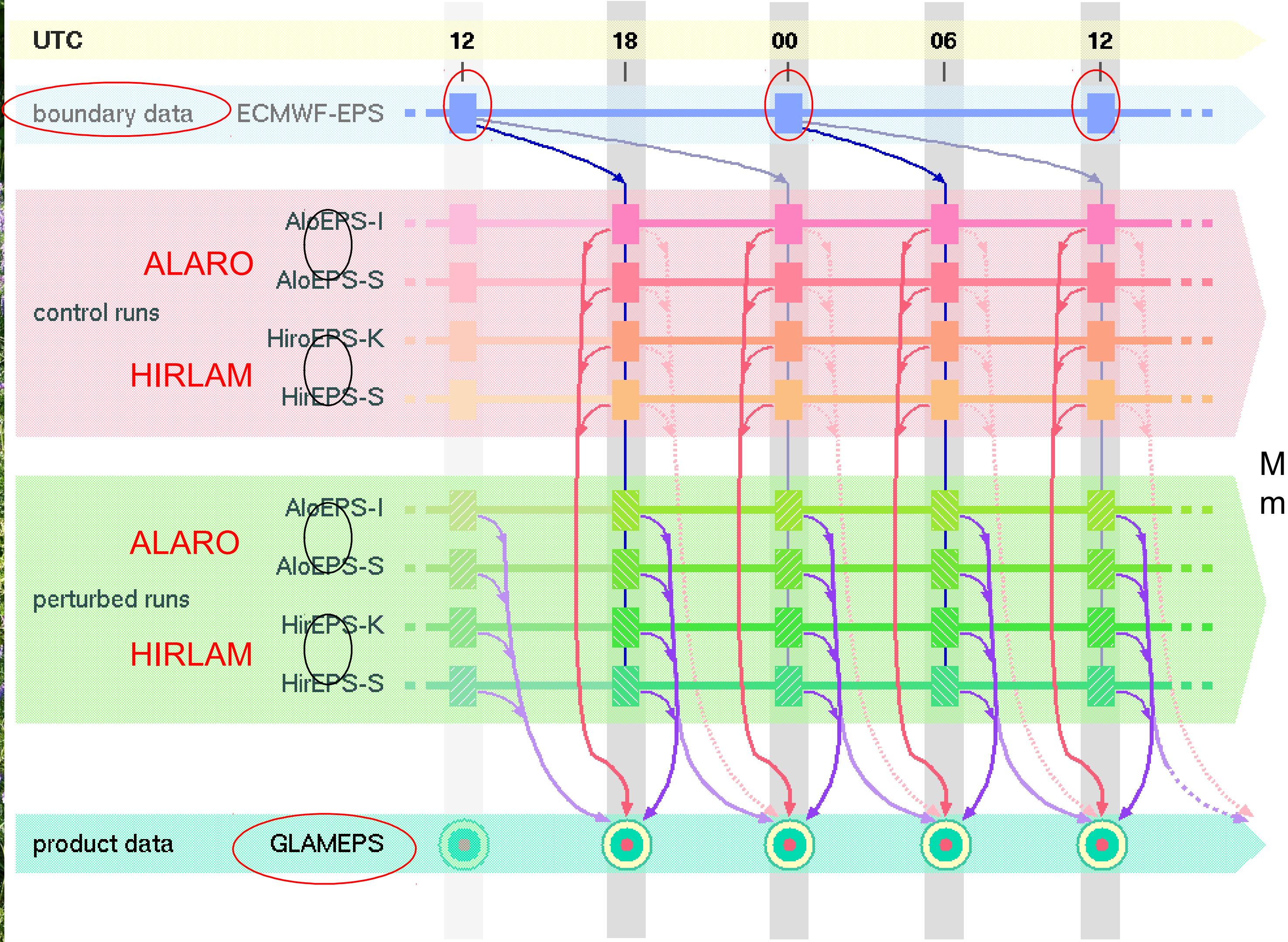
In addition, we want to ensure

- Adequate refreshing frequency without temporal inconsistency
- **Affordability!**

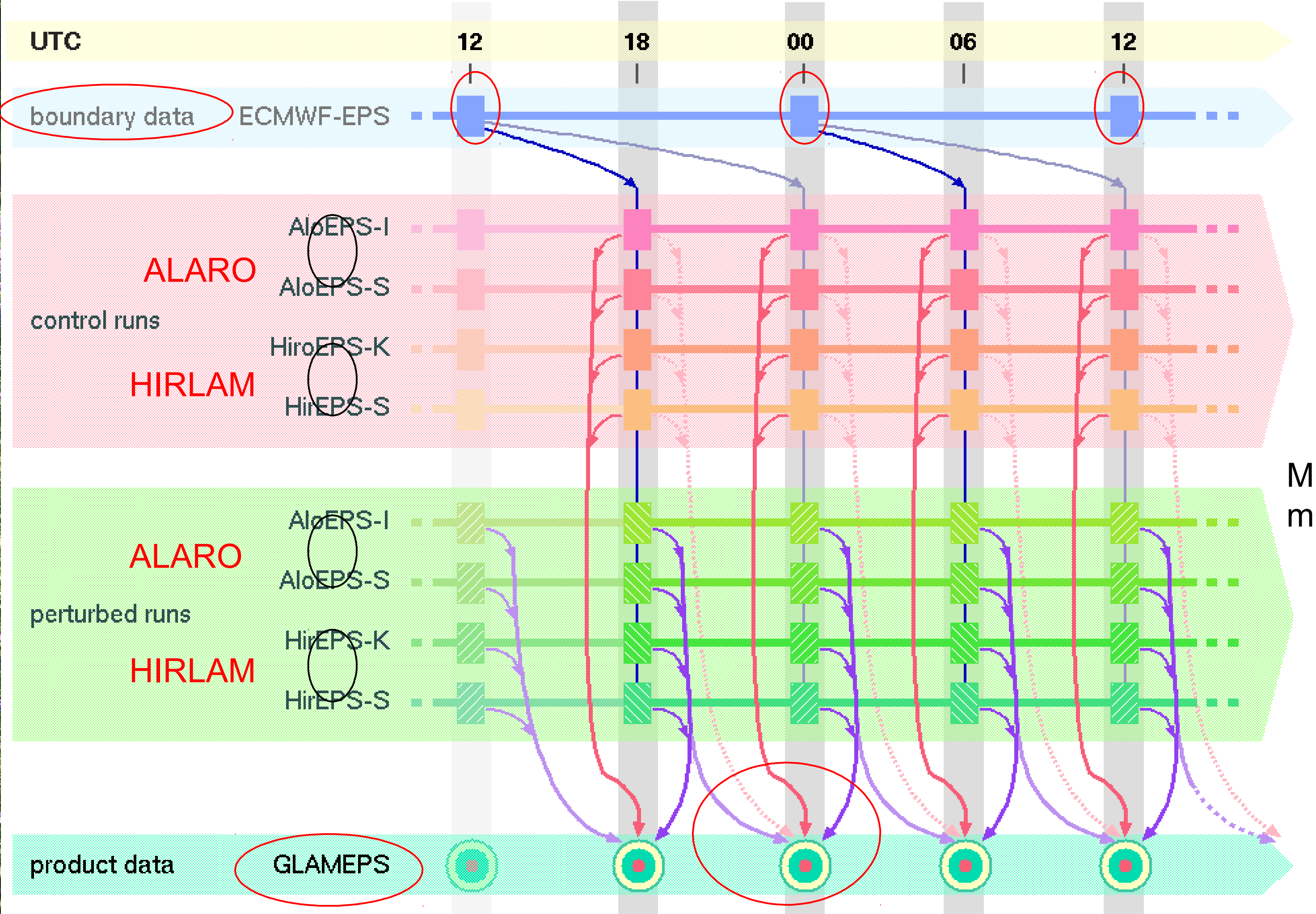
Inspirations from HIRLAM-EPS experiences

- DMI-EPS (x25)
- Harmonie-EPS (x12)
- **GLAMEPS (x52)**
  - operational EPS with HIRLAM and ALARO models
  - 52 members
  - Horizontal resolution ~ 8 km
  - Initial and lateral boundary perturbations from ECMWF-ENS
  - Multi-model: HIRLAM sub-ensemble + ALADIN sub-ensemble
  - Multi-physics: two HIRLAM cloud schemes + two ALARO surface schemes
  - Stochastic physics with HIRLAM sub-ensemble members
  - Time lagging by combining members from consecutive 6h
  - Calibratio step to reduce effects of model clustering





Multi-model
multi-physics

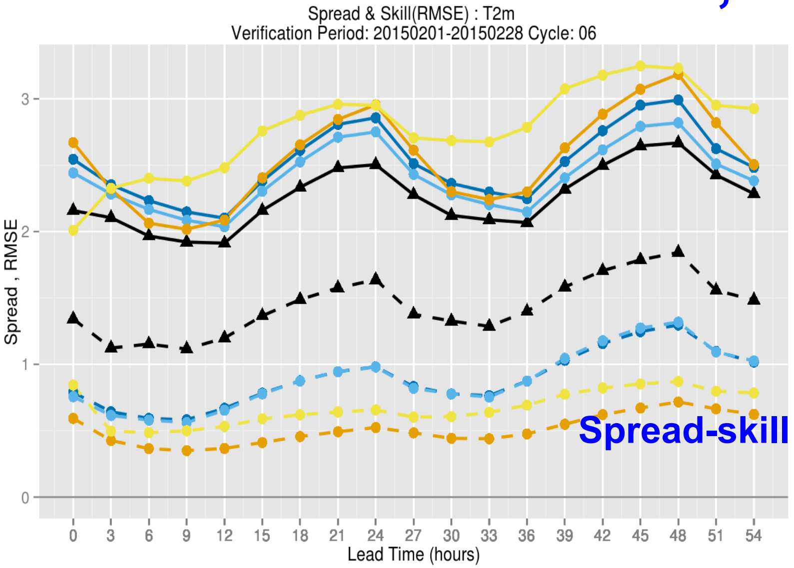


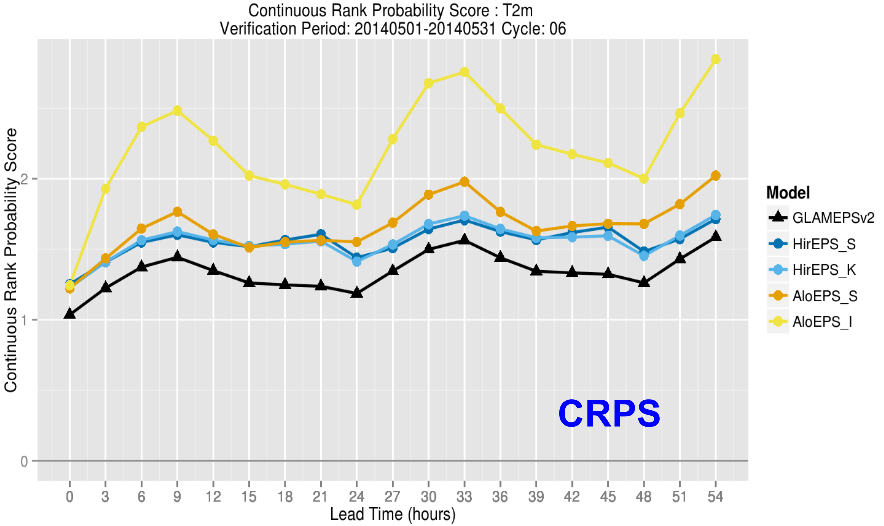
Multi-model
multi-physics

Time-lagged

GLAMEPS experience:

Multi-model, multi-physics add skills





HIRLAM-KF

HIRLAM-STRACO

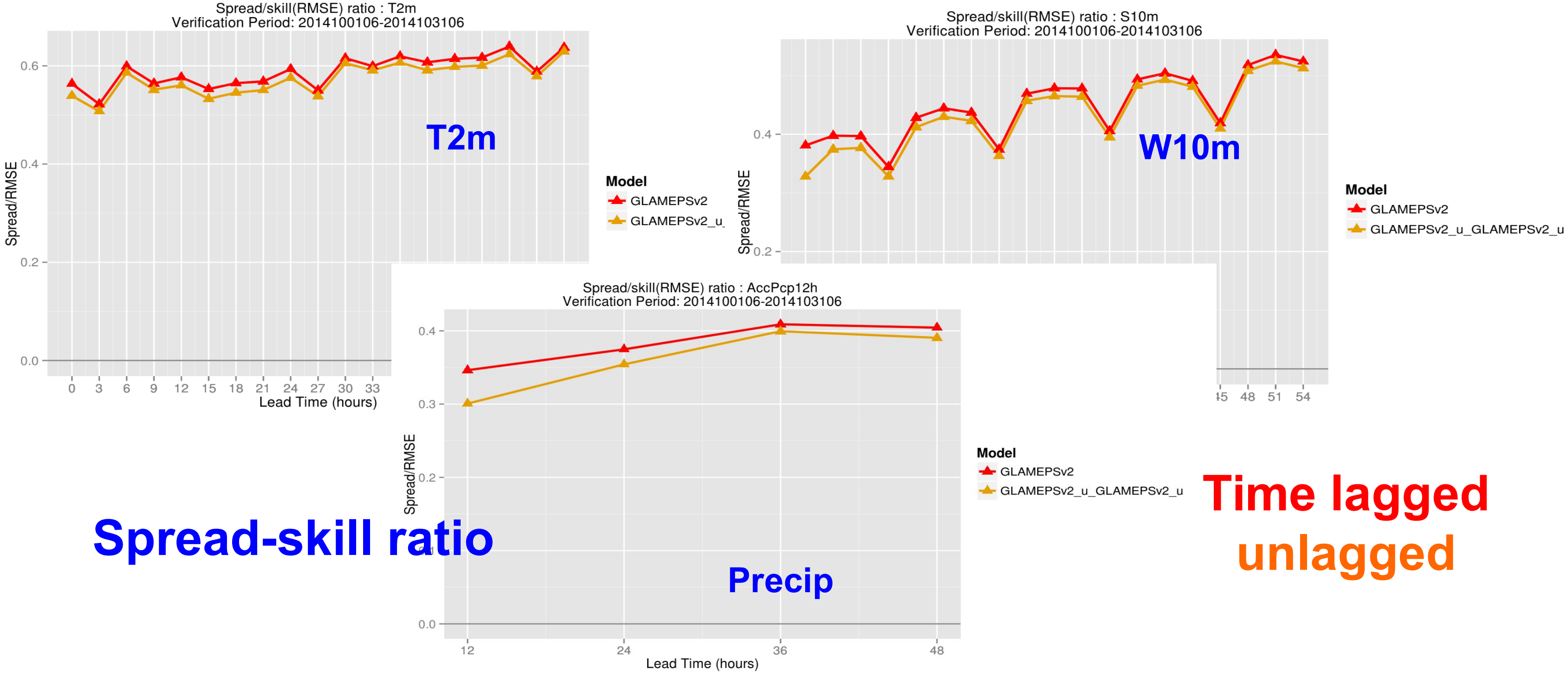
ALARO surfex

ALARO ISBA

(Yang, 2015: Where does the added values in GLAMEPS come from?, HIRLAM-ALADIN ASW 2015)

GLAMEPS experience:

Time lagging add skills



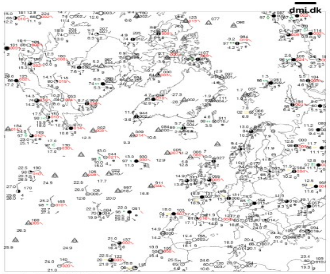
Spread-skill ratio

Time lagged
unlagged

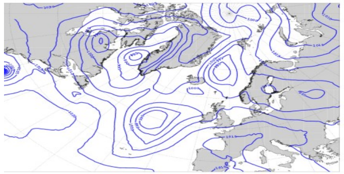
(Yang, 2015: Where does the added values in GLAMEPS come from?, HIRLAM-ALADIN ASW 2015)

Configuration of mesoscale EPS

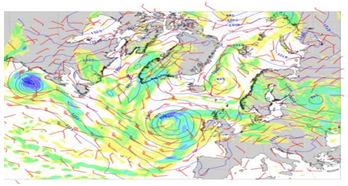
Major technical challenge: affordability



Observations



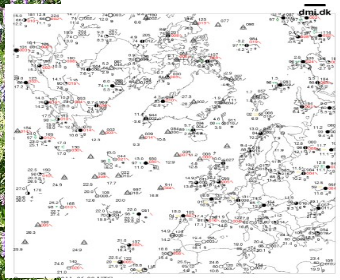
Analysis



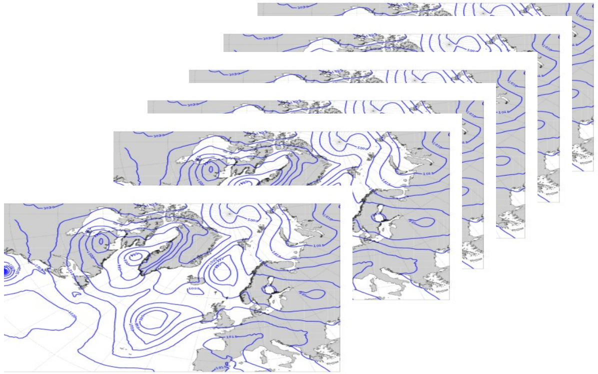
Forecast

Configuration of mesoscale EPS

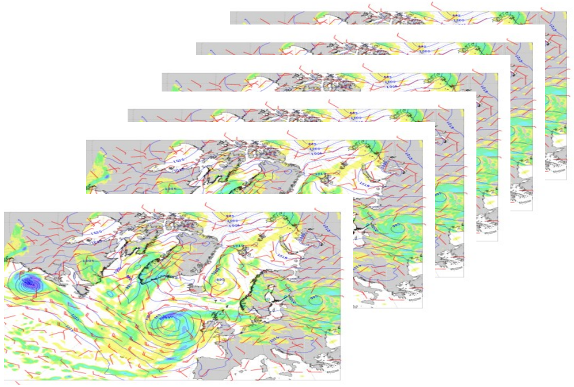
Major technical challenge: affordability



Observations



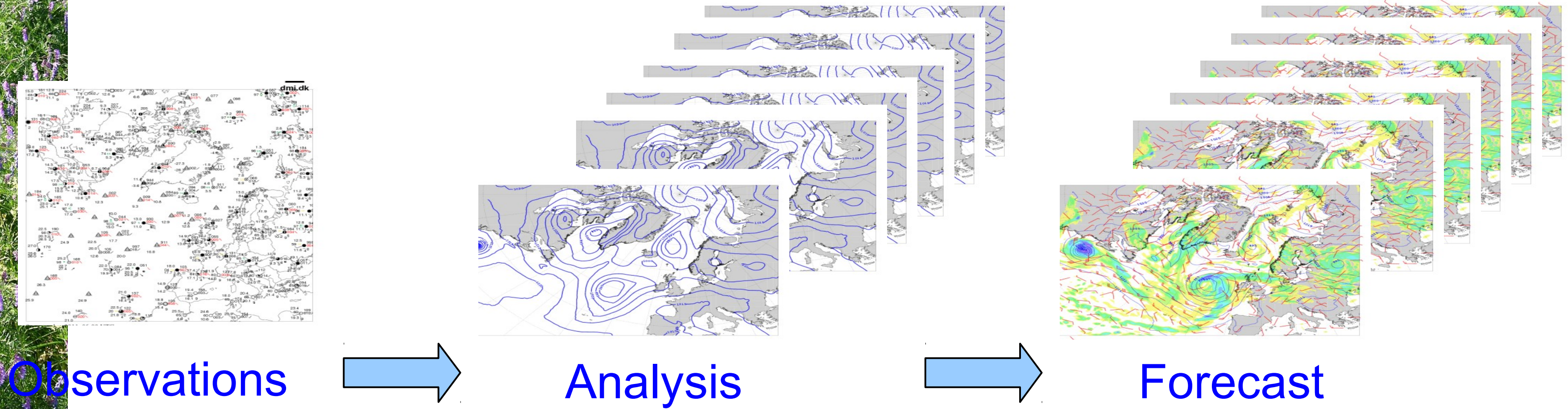
Analysis



Forecast

Configuration of Convection-Permitting EPS

Major technical challenge: affordability



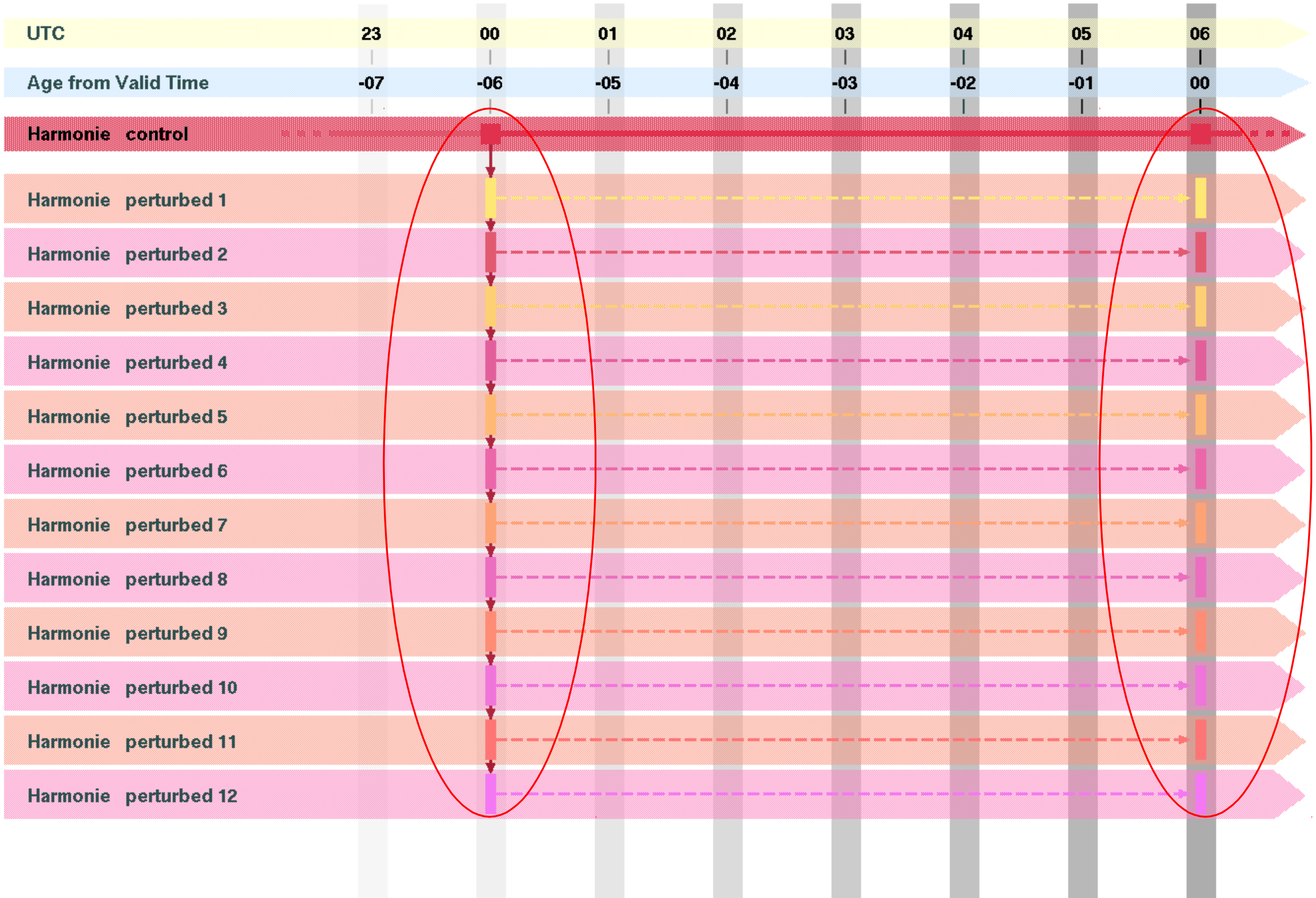
- An EPS needs sufficient ensembles
- Ensemble model resolution shall not be too coarse
- EPS forecast update frequency shall not be too low

Configuration of mesoscale EPS

Major technical challenge: affordability

How to construct a mesoscale EPS that is affordable?

COntinuous
Mesoscale
Ensemble
Prediction
System
@ DMI

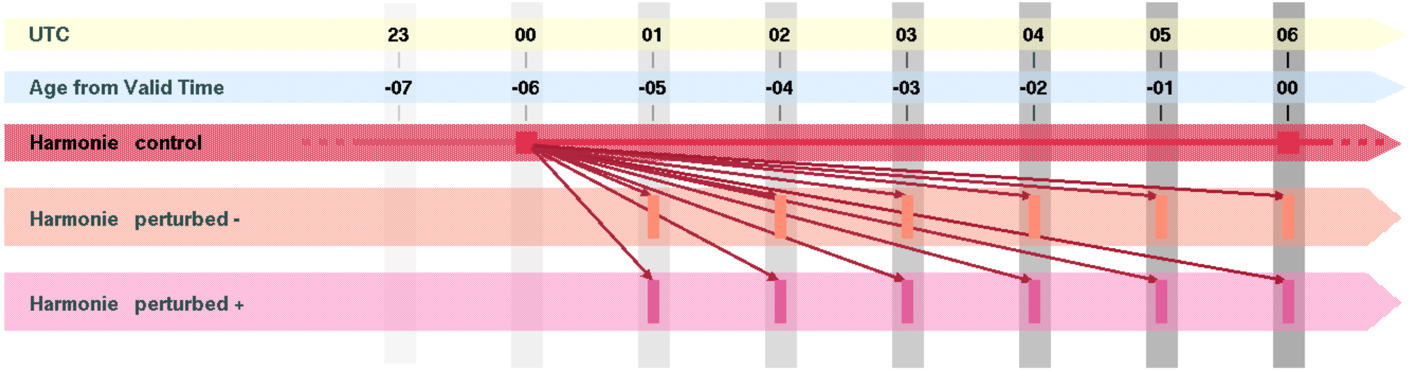


Target: EPS with 10+ ensemble members

Usual scenario:

Launch every 6h

Delivery every 6h


UTC
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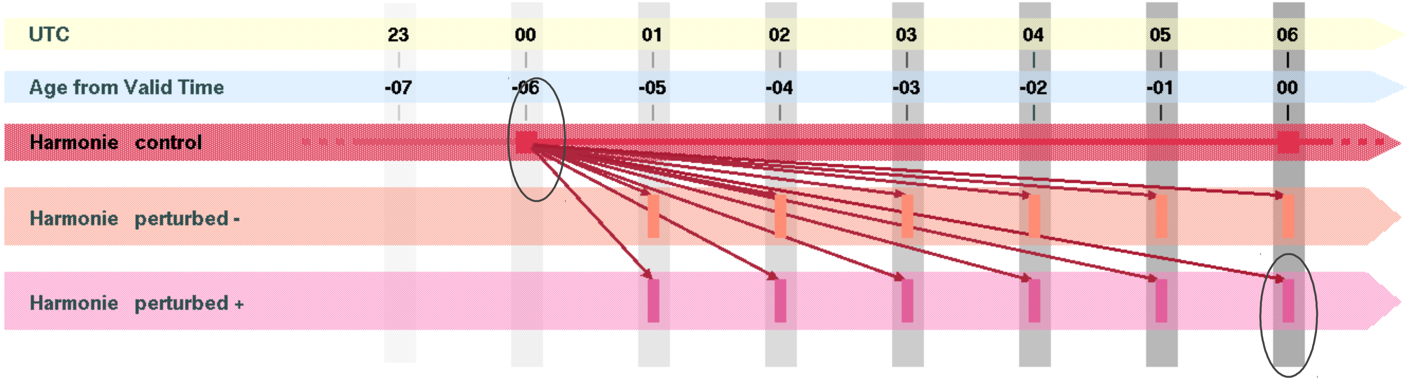
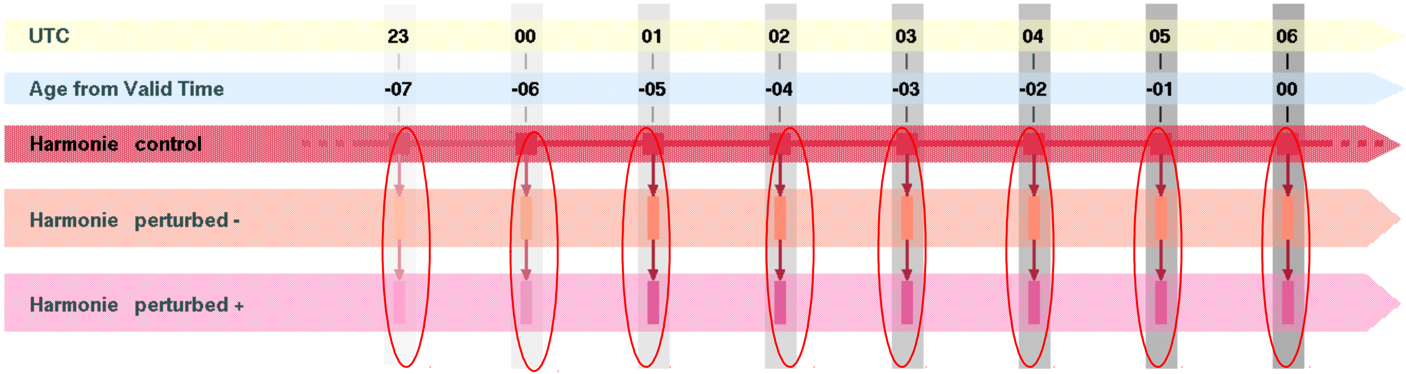
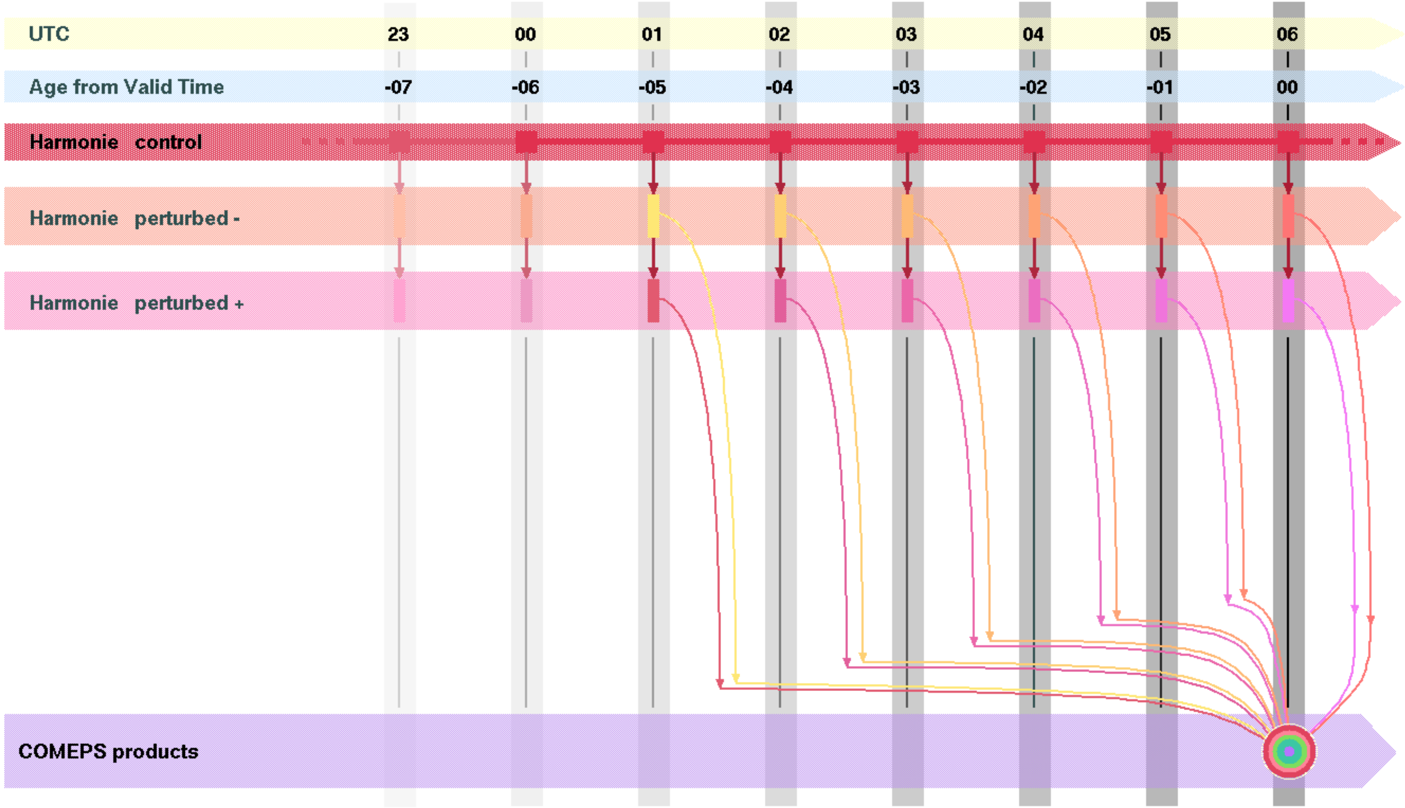


Since DMI can only afford to run a few members in one go, we can
->
split the perturbed ensemble runs in consecutive time with same originating control
--> major delay in delivery time



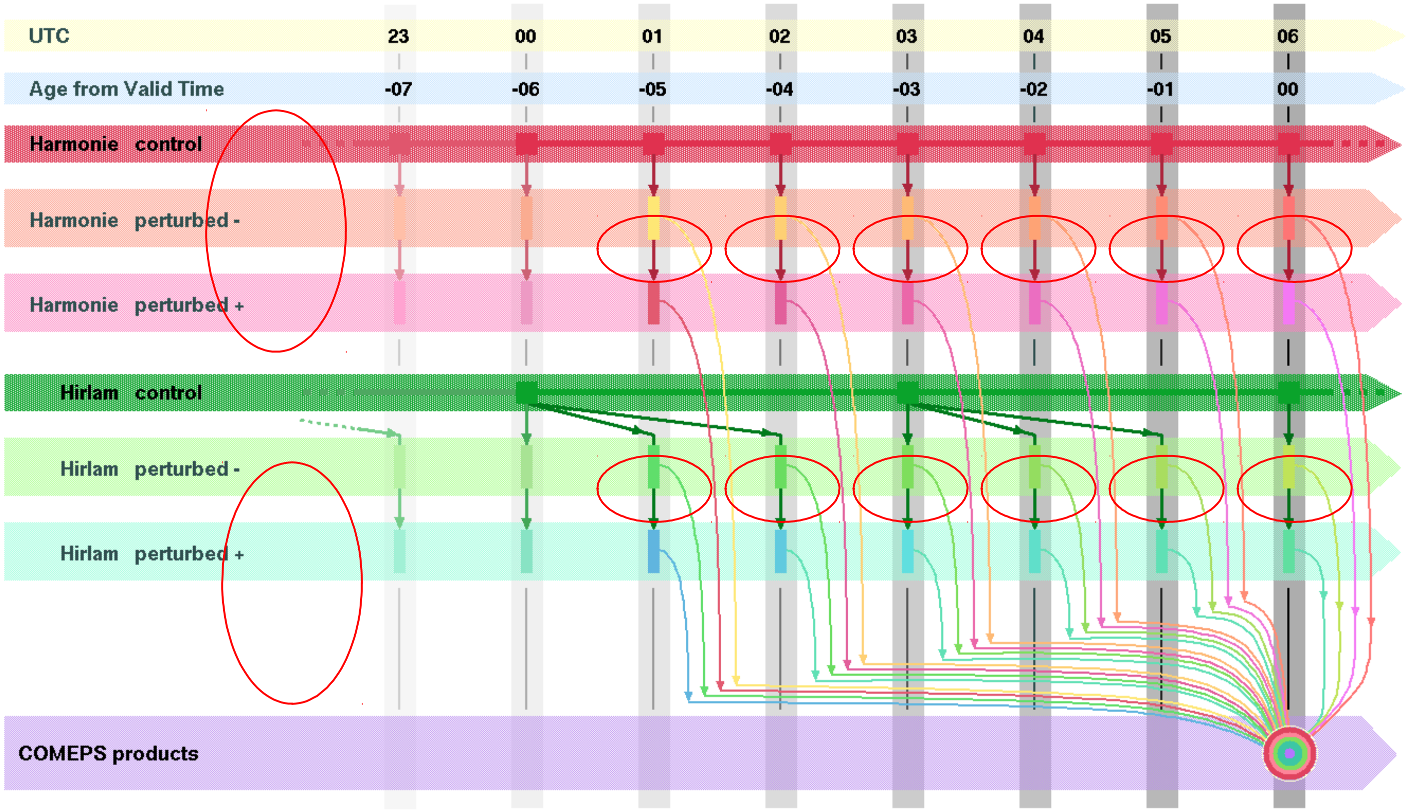
COMEPS design
->
Split the runs in consecutive time
--> **let the perturbation to be around updated controls**

COMEPS flow chart



COMEPS design
->
Split the runs in consecutive time
--> let the perturbation to be around updated controls
-> collect ensemble forecasts from consecutive launch time to form <u>time-lagged ensemble</u>

COMEPS flow chart

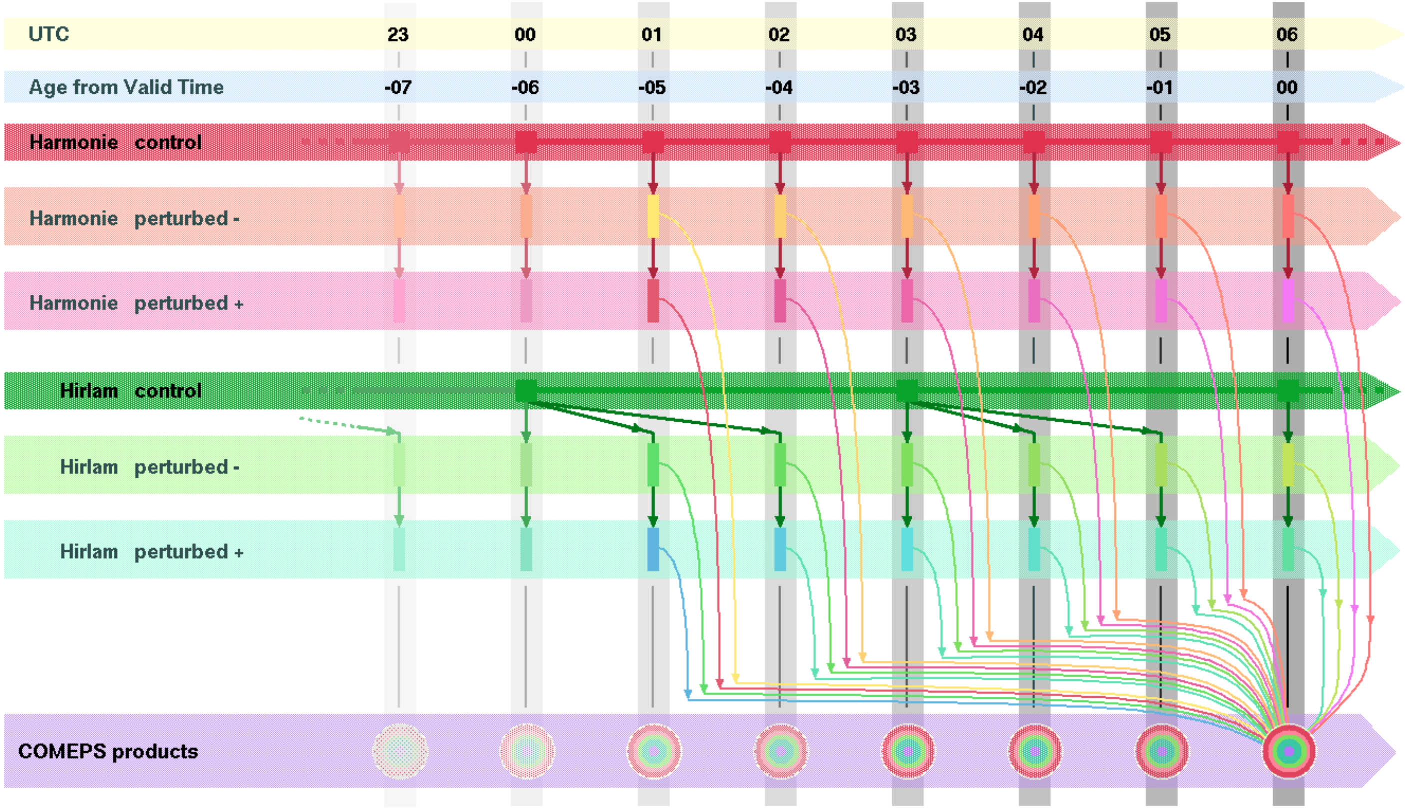


COMEPS flow chart

COMEPS 2016 -> Construct EPS with two sub-ensembles,with HIRLAM & HARMONIE models. **Each hour with 1 control and 2 perturbed members per model**

-> configure perturbed members with physics perturbation

-> this forms a 24+ member EPS



COMEPS 2016
->
This can be done at each consecutive time window and update as often as every 1 hour.
-> an EPS RUC!
-> increased temporal consistence

COMEPS flow chart

Summary

- Strongly convective weather often associated with limited temporal and spatial scales, hence limited predictability. Need probabilistic forecast across lead time.
- Experiences from GLAMEPS/DMI-EPS/Harmoneps point to advantage for
  - Convection permitting forecast models
  - Assimilation of asynoptic data especially humidity info (radar, satellite, AO, GNSS,modern social media...)
  - Spread-enhancing configuration characteristics
    - multi-model, multi-physics/stochastic physics, SLAF boundary perturbation, time-lagging
  - Frequent update (frequent ensemble and product generation)
- DMI-COMEPS is a convection permitting EPS system with RUC features
  - 24 perturbed members, 2.5 km grid, HARMONIE+HIRLAM sub-ensembles
  - Continuous (hourly) ensemble launch of 4 perturbed members
  - Continuous (hourly) production by time lagging
  - Currently in test set-up, targeted to be operational late 2016

DMI