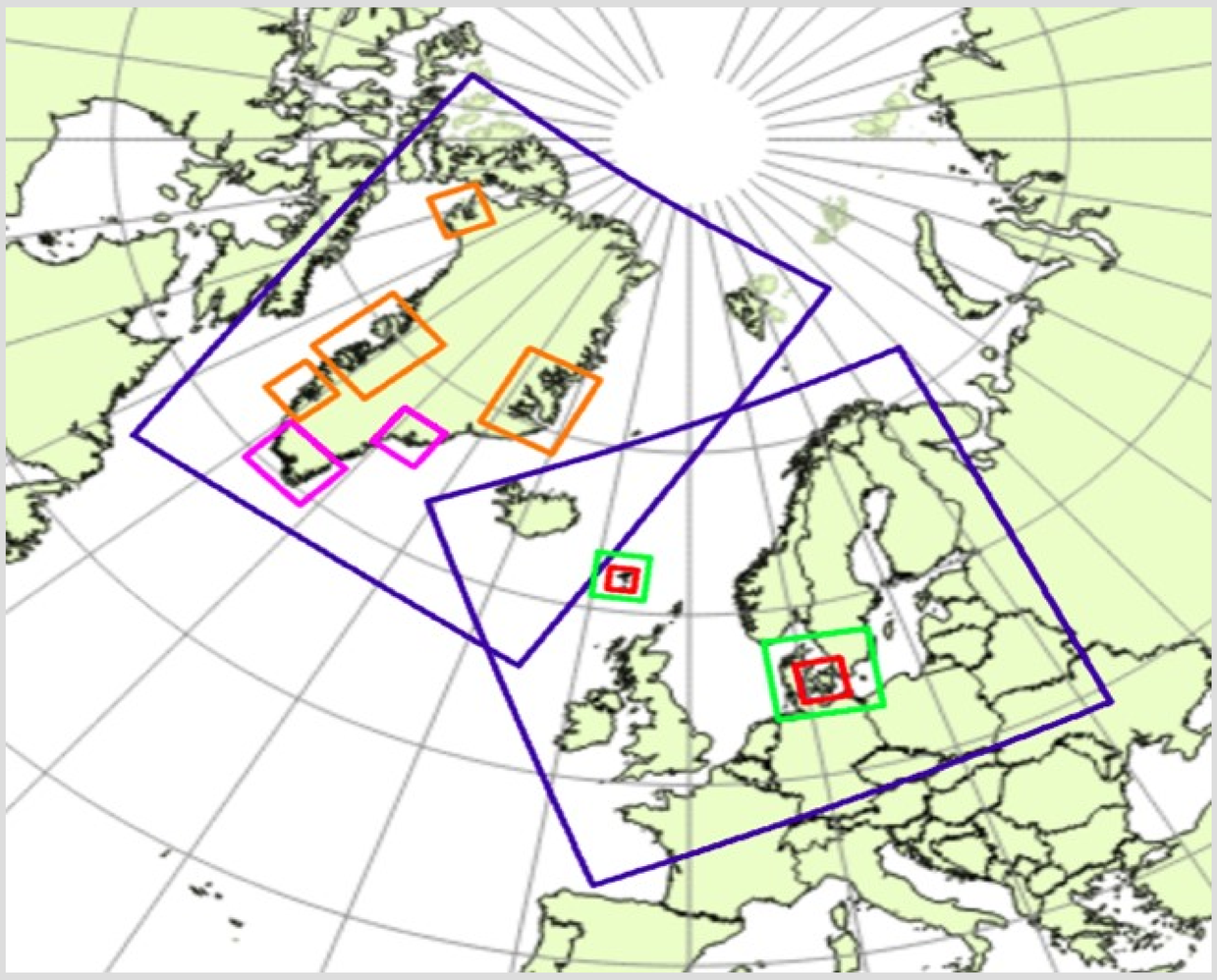
Danish Meteorological Institute

NWP status 2021

by Xiaohua Yang, Henrik Feddersen, Kasper Hintz, Mats Dahlbom, Bent Hansen Sass and colleagues

Operational, pre-operational and exerimental NWP domains at DMI



Operational

Main suites: 2.5 km

COntinuous **M**esoscale **EPS**, 19 member, hourly probabilistic forecast, 57h
Iceland-**G**reenland model with 3h refresh, 66h

Pre-operational

nowcasting
750m, hourly refresh full data assimilation 9h
Regular HighRes
500m, Faroe Islands, downscaling, 24h

Regular, Sub-km

TASillaq, 750m, 51h
South **G**reen**L**and, 750m, 51h

On-demand
750m: Nuuk, Qaanaq, 51h
1 km: Scoresbysund, Diskobugt , 51h

Experimental, on-demand

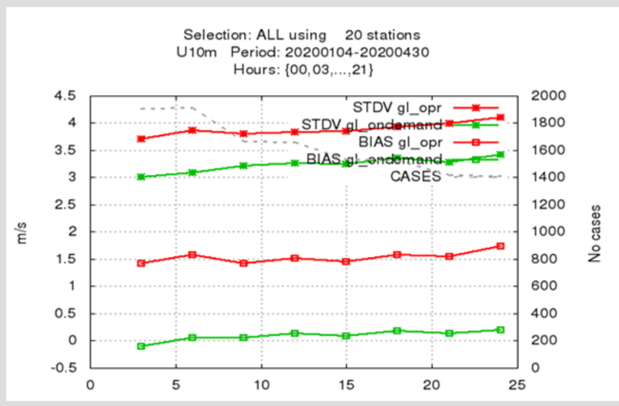
150m: Faroe Islands, downscaling, 24h

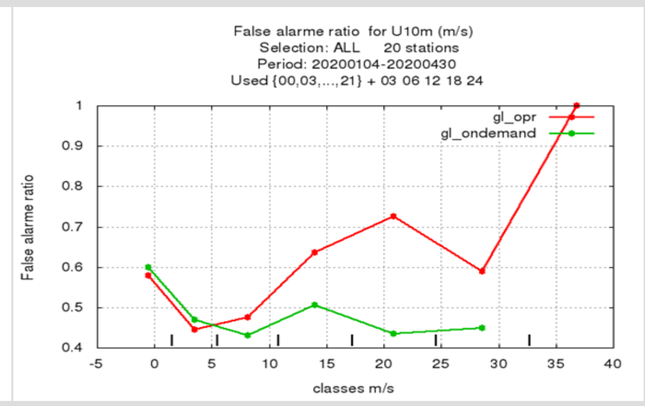
200m, Zealand
downscaling, 24h

Operational, on-demand hectometric-scale Harmonie-arome

Four sub-km, on-demand setup are introduced into the operational NWP suites in early 2021 to improve wind forecast for coastal Greenland areas, which often suffer severe over-forecasting for windy situation associated with poor representation of orographic effects.

The on-demand suites are triggered by either forecast of high wind speed by Harmonie-2.5km, or by observations. It can also be launched by duty forecasters. Contact person : Xiaohua Yang (xiaohua@dmi.dk)





Verification of wind speed forecast during pre-operational phase (Jan-Apr 2020) for 4 high resolution, on-demand suits in comparison to the operational Harmonie-arome at 2.5 km. The sub-km forecasts are found to reduce over-prediction in wind speed and alleviate false alarm situation for high wind situations.

Ensemble prediction system COMEPS

COMEPS is DMI's ensemble prediction system based on three parallel HarmonEPS suites each time-shifted one hour and using overlapping data assimilation windows. The resulting EPS includes time-lagged members that are updated every hour. The main characteristics of the version of COMEPS that will be operationalized later this year are:

* Using Harmonie cy43h2.2
* 1 control + 3 perturbed members per hour
* SLAF LBC perturbations
* Parameter perturbations (XRIMAX, CROUGH, STATNW)
* Ensemble of data-assimilations (CCMA perturbations of observations)
* Option to run in single precision
  - and possibly increase the number of perturbed members
* Hourly control member from COMEPS to replace 3-hourly deterministic run

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New observation types are activated in CY43 compared with CY40, e.g.
Polar-AMV , ASCAT, IASI, ATMS, and CrIS (from noaa-20), and mwhs from FY3-D.
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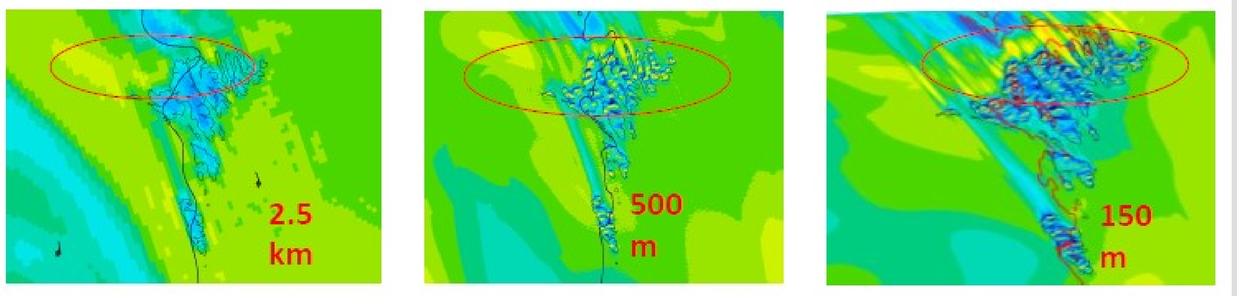
Experimental hectometric-scale Harmonie-arome at 100-200m range



At 150-m grid resolution, Harmonie-arome is found to improve significantly prediction of a winter storm for Faroe Islands, North Atlantic, on March 10 2021, which experienced hurricane scale wind but missed by main forecasts at ECMWF (9 km), and DMI (2.5km and 500m). The
150-m Harmonie-arome represented a clearly better the event. Similar finding also valid for the hurricane on March 27 2021, indicating that hectometric scale model is needed to resolve extreme storm events reinforced by small scale orographic effects

In connection with feasibility investigation with 100 m-scale NWP for the EU DestinE project, experiments have been carried out to run Harmonie-arome at downscaling mode for Faroe Islands and for Denmark. In view of the promising results an experimental on-demand setup has been set up to use high resolution downscaling to improve detection of extreme wind. -

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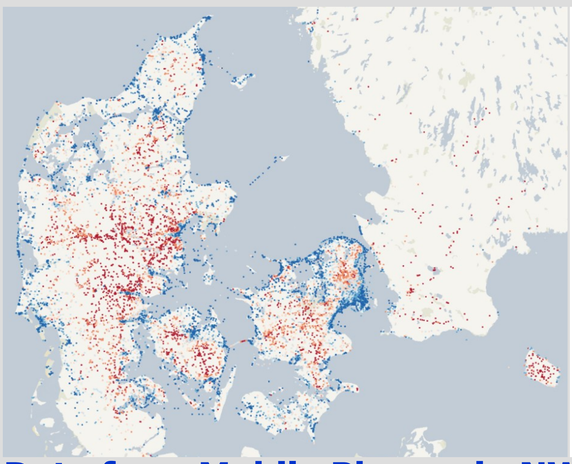

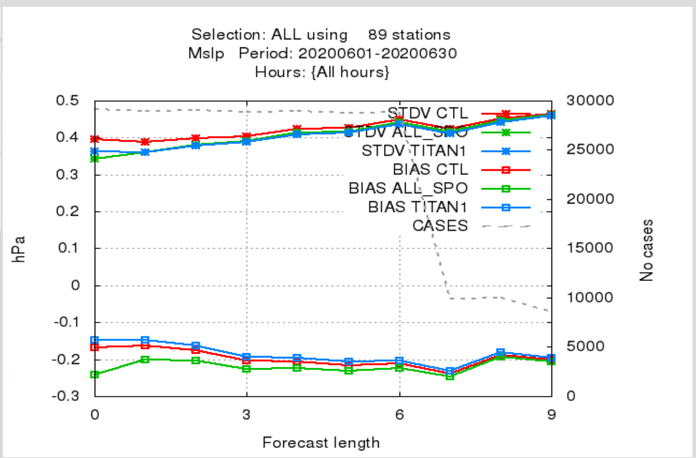

Data from Mobile Phones in NWP !

Significant progress has been made in the context of assimilating data from mobile phones. The Figure above to the left shows all data received between 5 UTC and 6 UTC 20th June 2020. The Figure to the right shows the MSLP verification up to +9 hours forecast length using MONITOR software. The verification is based on 2 – hour cycling (12 forecasts per day), using data from the entire month of June 2020. Source code is based on Harmonie CY43h211. **ALL_SPO** applies to all smartphone data given to the 3D-VAR analysis system. **TITAN1** applies to results using screening with TitanLib from Met.Norway. An improvement is seen in both bias and standard deviation.

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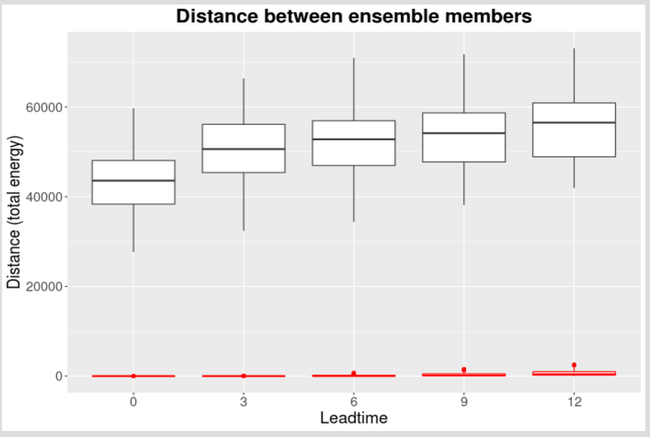

Boxplot showing the distribution of distance (measured using a total energy norm) between single and double precision unperturbed ensemble members (red), and distance between a perturbed and unperturbed member (black) for lead times between 0 and 12h. The boxplot shows min and max, the 25th and 75th percentiles and the median of the distribution.

Setups in single precision

We have studied if it is feasible to run the forecast members of HarmonEPS in single precision. On DMI's Cray XC50 HPC we find that a forecast member in single precision runs 30% faster than in the default double precision. The uncertainty introduced by running in single precision is negligible compared to the spread between the perturbed members and the control (see figure), so the accuracy of single precision is sufficient for ensemble members.

However, single precision in our implementation of HarmonEPS is not as stable as double precision. Investigations are ongoing to improve the numerical stability of single precision forecast runs.

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Spatial verification of precipitation extremes.

Separate scores are computed (SLX-components) for identified maxima and minima in a NWP domain. SLX stands for **St**ructure of **L**ocal E**X**-tremes. Scores are between 0 and 1, with 0 being poorest score and 1 perfect score. The methodology is described in *Meteorological Applications* , http://dx.doi.org/10.1002/met.2015 .

SLX $_{ob\_max}$: How well does forecast maximum match observed maximum in its neighbourhood ?
SLX $_{ob\_min}$: How well does forecast minimum match observed minimum in its neighbourhood ?
SLX $_{fc\_max}$: How well does observed maximum match forecasted maximum in its neighbourhood ?
SLX $_{fc\_min}$: How well does observed minimum match forecasted minimum in its neighbourhood ?
SLX $_{ave}$: Average of the 4 other scores.

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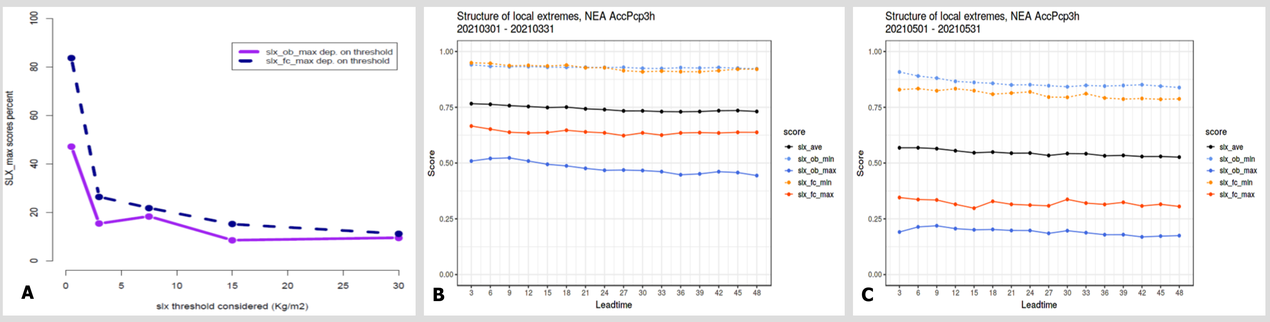

Figure A shows scores of observed- and forecasted maxima related statistically to the precipiation thresholds : As expected the scores tend to become smaller as the precipitation threshold increases (more `extreme´precipitation event). Data used : 3 hour accumulation , forecasts up to 48 h , all available data from DMI in opertional runs June - August 2021.

Figure B shows components of SLX-scores up to 48 hours for the month of March 2021. (Neighborhood size =0 , single point of extreme)
Figure C shows components of SLX-scores up to 48 hours for the month of May 2021. (Neighborhood size =0 , single point of extreme)

It is seen that the scores of May 2021 are substantially lower than the corresponding one for March 2021. Precipitation in May 2021 was much above normal, having several difficult precipitation episodes to predict.

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