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A proposed high-resolution EPS for forecasting polar lows

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0. Background

At high latitudes, polar lows are one of the dominant feature of violent weather during winter. Polar lows are short-lived (typically less than 24 h) maritime mesoscale (typically 200 – 600 km in diameter) cyclones. In the Atlantic sector they occur frequently (on average 4-6 times per month) during winter but with irregular intervals and significant inter-annual variability. Polar lows are embedded in a northerly flow which forces cold air masses from the high Arctic over the ice-free ocean in the Nordic and Barents Seas

Forecasts of polar low are currently issued based on deterministic model forecasts supplemented by the most recent observations such a satellite images. The often large uncertainty in the development and intensification stages makes the forecasting challenging.

Forecasting the future state of the atmosphere requires prediction of mechanisms that operate on a range of spatial scales. The errors in these various mechanisms grow at different rates. A coarser mesoscale model (e.g. 12 km horizontal resolution) would have fully parameterised convection and severe weather events associated with smaller scale features cannot be reliably forecast beyond a day.

Convection-permitting EPS are needed for better resolution. However, high- resolution local data assimilation is challenging. Direct dynamical downscaling of a coarser resolution EPS is therefore a sensible first approach for high-resolution modelling.

The nested ensemble prediction system

EC-EPS
Operational EPS from ECMWF
~32 km horizontal grid spacing
20 member + 1 control forecast
Initialized at 00 and 12 UTC

↓

LAMEPS
12 km HIRLAM
Initial and lateral boundary conditions from EC-EPS
20 member + 1 control forecast (from the HIRLAM 3D-var analysis)
Initialized at 06 and 18 UTC
60 h lead time

↓

UMEPS
'On-demand' downscaling of the 20 + 1 members from LAMEPS
4km Unified Model (MetUM)

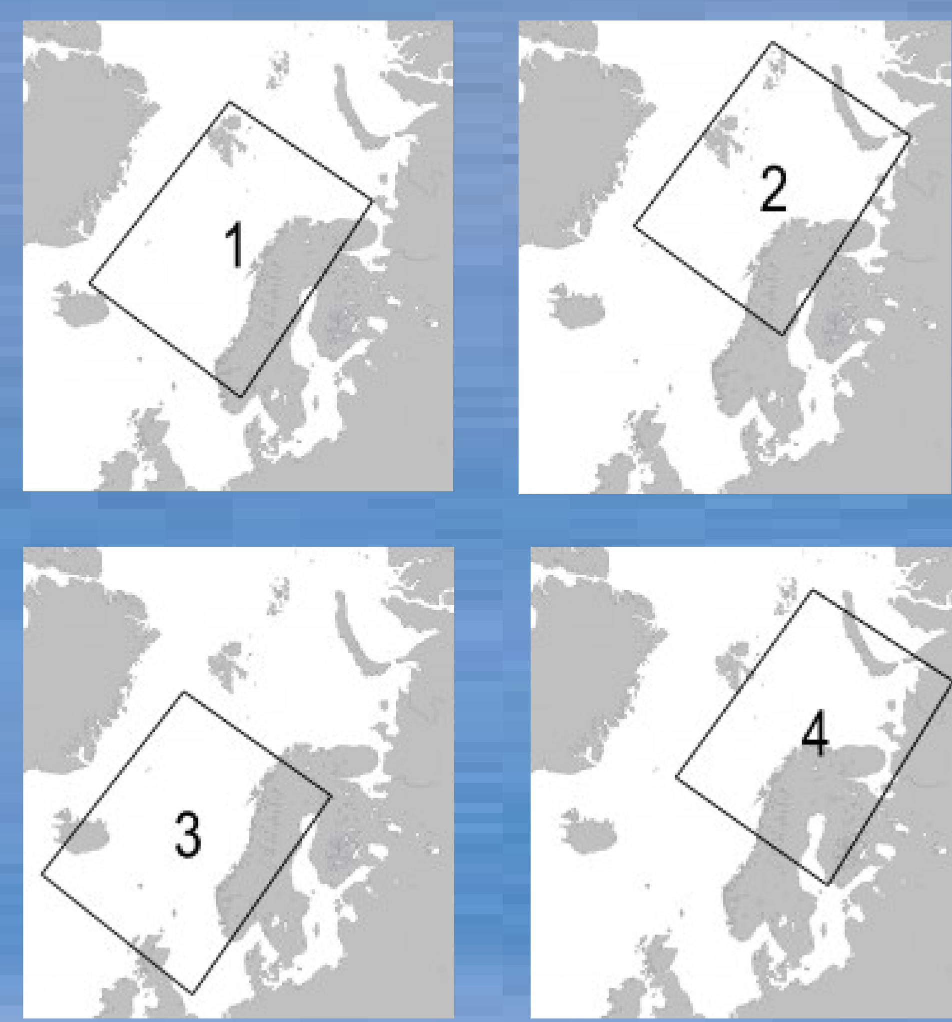

Fig 1 The UMEPS integration domains all 400 x 500 grid points

1. UMEPS

As illustrated schematically above, the proposed high-resolution, limited area ensemble prediction system to enable early warnings of polar lows, UMEPS, employs the Met Office MetUM at 4-km resolution to downscale the 21 ensemble members of the HIRLAM-based LAMEPS. LAMEPS is run twice daily with 12-km resolution. LAMEPS includes a 3DVar-based control forecast, although initial and boundary perturbations are taken from EPS at ECMWF.

The added value of UMEPS has been extensively evaluated for one polar low (Kristiansen et al. 2011). With a short-range, high-resolution UMEPS, potentially valuable warnings of extreme weather can be given up to 2 days in advance. The results suggest that the forecast quality depends crucially on the size and location of the UMEPS model domain. When sufficiently large (400 x 500 grid points), the influence from data imposed at the lateral boundaries was reduced by a careful domain selection.

2. 'On-demand' system

Due to its computational cost, one UMEPS domain cannot cover the Nordic and Barents Seas. We have therefore selected 4 partly overlapping domains presented in Fig. 1. In an operational environment one of these domains is selected a priori by the forecasters to be run 'on-demand'. A good global or large regional ensemble forecast is needed to guide the choice of domain. Unfortunately, this is not the case for all polar lows. Therefore, an on demand high-resolution forecast system cannot be expected to improve complete failures in the coarser resolution forecasts.

Probabilistic forecasts needs to be produced for a representative number of cases to be verified with standard measures for quality and value. UMEPS will therefore be run every day during the polar lows season but automated instead of 'on-demand' on days without favorable conditions for the development of polar lows.

Figure 2 shows a polar low on 11 March 2011. It has a weakly defined center with widespread convection.

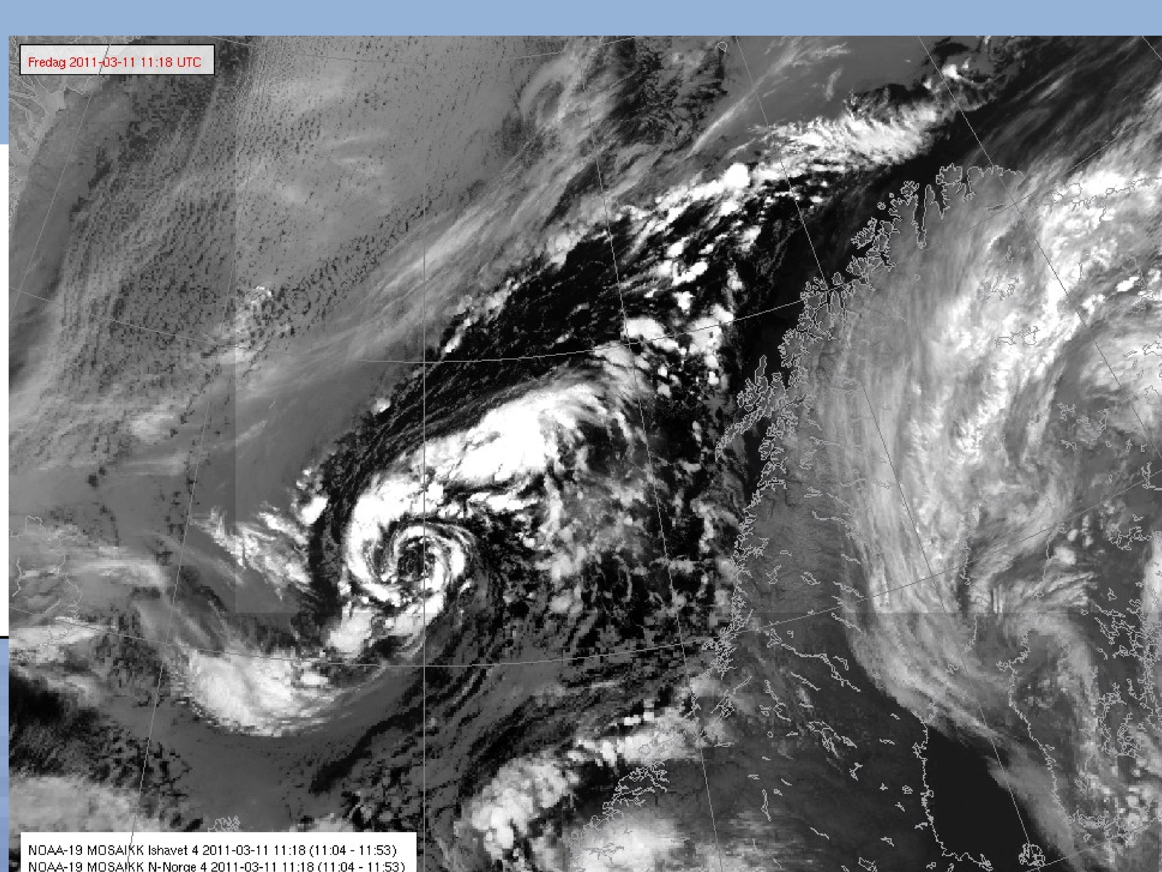

Fig 2 IR image taken at 1118 UTC 11 March 2011. The IR image is taken from the thermal infrared channel 4 of the AVHRR onboard the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites.

3. Forecast products

A challenge is how we best present a forecast to the end user, e.g. the general public or even the forecaster in duty. Even a "perfect" forecast has little value to the users if they are uncertain about how to interpret and understand it or contain information of little relevance for their specific needs. The development of visualization products such as strike probability maps, are therefore integral in the system. Figure 3 shows a 42 h forecast of the 10/11 March polar low at the time when it reaches the Norwegian coast. The probability for the wind speed exceeding strong gale is shown in colour and the probability for precipitation above 2.5 mm/3h is in gray.

A tracking algorithm is performed on the 925hPa vorticity field of the different ensemble forecasts. Scales < 200km and > 600 km are removed with a spectral spatial filter, and the maximum vorticity is traced. The tracks are constrained to fulfill criteria based on characteristics of polar lows. The tracks are employed to estimate the strike probability of the polar low, Fig. 3.

We have identified and investigated 8 polar low events from a two-month period during the winter 2011. A set of non-events are also selected for reference. The aim is to launch the system on the new web portal BarentsWatch the coming season.

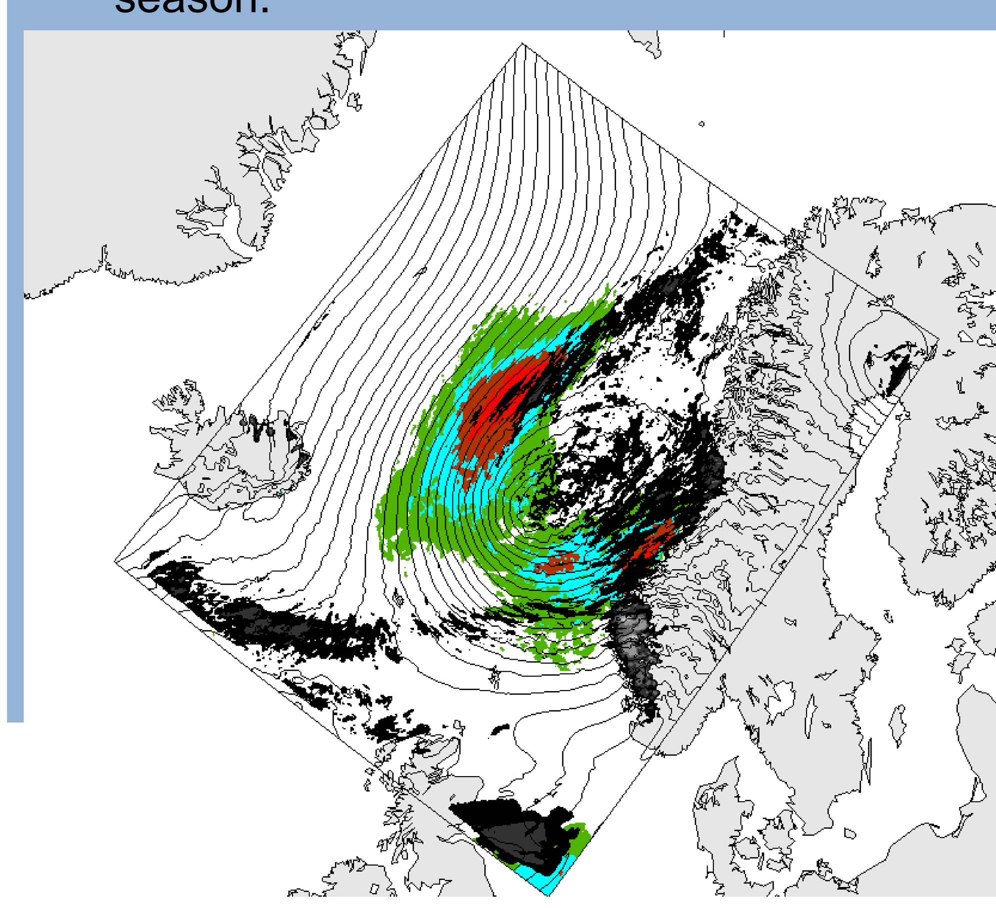

Fig 3 Forecast probability of (colour) 925 hPa wind speed > 20 m/s; (gray) precipitation intensity > 2.5 mm/3h; and (contour) Z1000 of the control at lead time T+42 (00 UTC 12.03.2011).

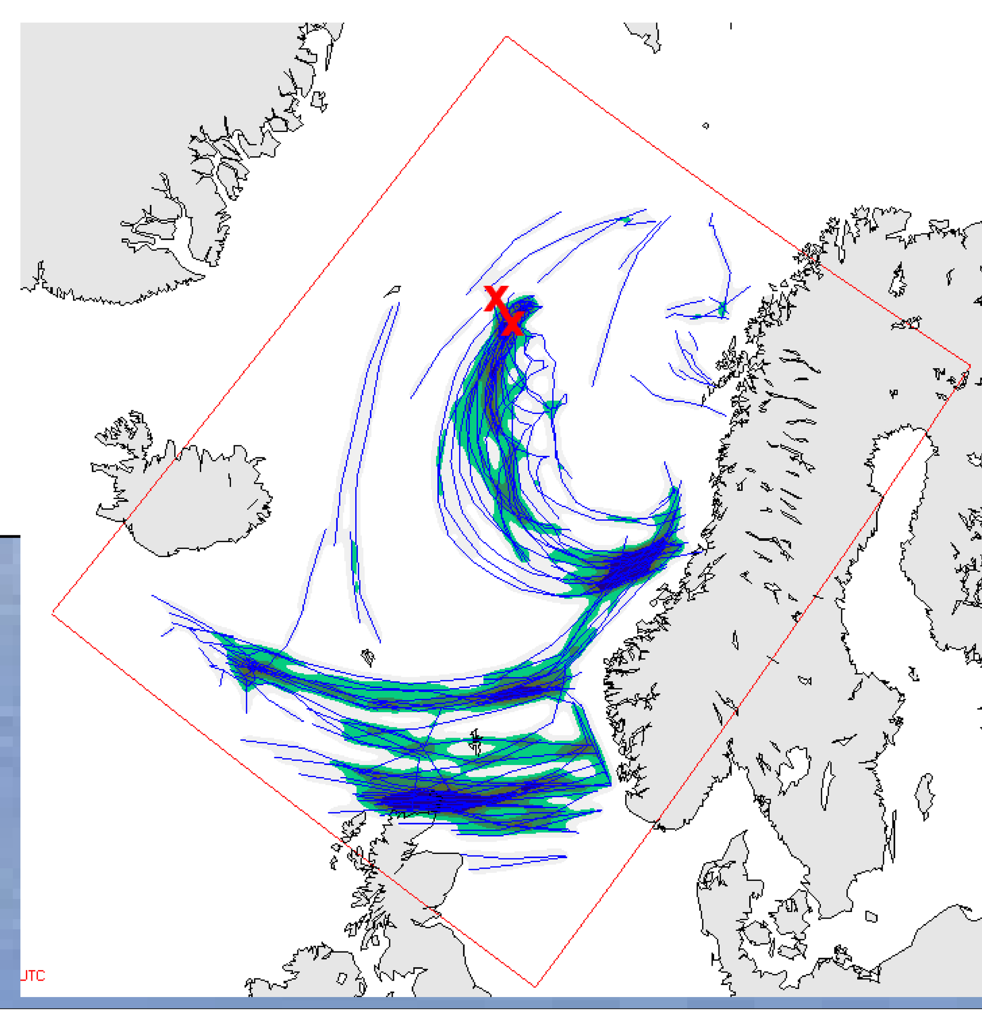

Fig 4 Polar low strike probability map. The strike probability predicts the location of the centre of the low any time in a 60 hour window. The forecast probability is based on the tracks from all ensemble members. The x-es show the observed location of the centre of the low up til forecast initialization time.

Reference

KRISTIANSEN, J., SØRLAND, S. L., IVERSEN, T., BJØRGE, D. and KØLTZOW, M. Ø. (2011), High-resolution ensemble prediction of a polar low development. Tellus A.