Short-range limited-area ensemble forecasts for two European winter storms: The impact of moist singular vectors and horizontal resolution

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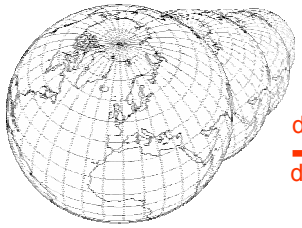
Summary

High-resolution short-range ensemble forecasts based on moist singular vectors (SVs) are analyzed for the European winter storms Lothar and Martin, (December 1999). It is shown that forecasts using the moist SV configuration predict higher probabilities for strong wind gusts during the storm period compared to forecasts with the operational SV configuration. Similarly, the forecasts with increased horizontal resolution lead to higher probabilities compared to the low resolution forecasts. Overall, the two case studies suggest that currently developed operational high-resolution limited-area ensemble prediction systems (EPSs), such as COSMO-LEPS, have a great potential to improve early warnings for severe winter storms, particularly when the driving global EPS employs moist SVs.

SLEPS: Short-range Limited-area Ensemble Prediction System

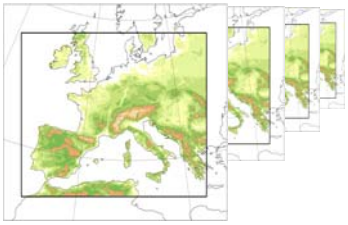
Global Ensemble



IFS (ECMWF), Δx~80 km, moist SVs

dynamical downscaling

Limited-area Ensemble

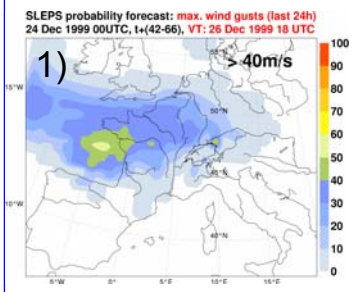


LM, Δx~10 km

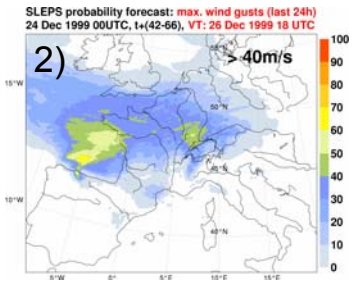
SLEPS:

- 51 ensemble members
- 72-h integration periods
- Lokal Modell (LM; see Steppeler et al., 2003) with 10 km grid-spacing and 32 levels
- Initial and lateral boundary conditions from members of the global IFS EPS of the European Centre for Medium-Range Weather Forecasts (ECMWF)
- ECMWF EPS runs based on moist SVs (Coutinho et al., 2004) rather than the operational ones. The inclusion of moist processes in the calculation of SVs results in a more realistic ensemble spread for the first two days.

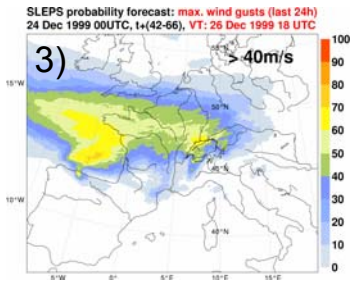
Wind gust predictions for storm Lothar using different SLEPS configurations



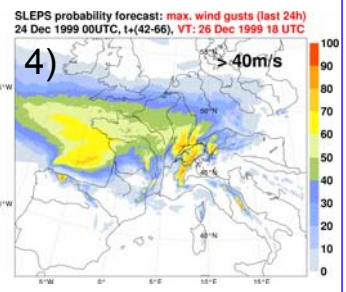
opr SVs, Δx~80 km.



opr SVs, Δx~10 km but same orography as for Fig. 1.

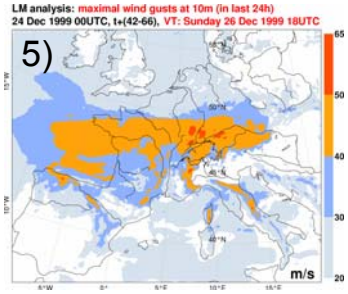


moist SVs, Δx~10 km but same orography as Fig. 1.



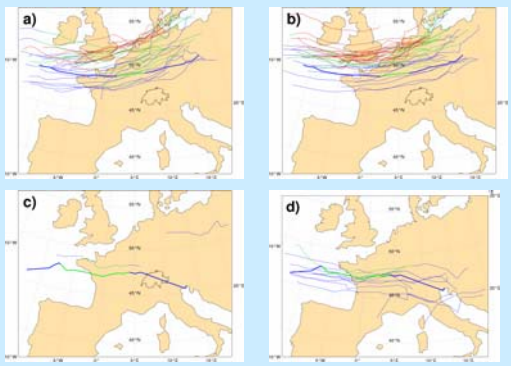
moist SVs, Δx~10 km.

Proxy observations



- Figures 1-4: +2-day SLEPS forecasts for storm Lothar with different configurations. The figures show the probability of maximum 10-m wind gusts (Brasseur 2001 formulation) exceeding 40 m/s. They exhibit that both moist SVs and the higher horizontal resolution enhance the predicted probabilites for strong wind gusts. Very similar results have been found for storm Martin.
- Figure 5: Maximal wind gusts from LM analysis (Δx~10 km) using nudged observations and ERA-40 data as lateral boundary conditions. The analysis is used as proxy observations for the study.

Predicted storm tracks



Predicted storm tracks (thin lines) and storm track of the LM analysis (bold line) for (top) storm Lothar and (bottom) storm Martin (24-h time frames) from (a, c) opr SVs and (b, d) moist SVs experiments. For each member, the track with the earliest and southernmost starting point of all tracks with a minimum SLP below 980 hPa and at least 1000 km west-east elongation is considered. SLPs below 970 and 960 hPa are indicated with green and red lines, respectively.

References:

- Brasseur, O., 2001: Development and application of a physical approach to estimating wind gusts. *Mon. Wea. Rev.*, **129**, 5-25.
- Coutinho M., H. Hoskins, and R. Buizza, 2004: The influence of physical processes on extratropical singular vectors. *J. Atmos. Sci.*, **61**, 195-209.
- Steppeler, J., G. Doms, U. Schättler, H. W. Bitzer, A. Gassmann, U. Damrath, and G. Gregoric, 2003: Meso-gamma scale forecasts using the nonhydrostatic model LM. *Meteorol. Atmos.*, **115**, 488-504.

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