Modeling Fronts Over the Sea and the Effect of Grid Size

T. Sīle, J. Seņņikovs, U. Bethers University of Latvia email: tija.sile@lu.lv

EIROPAS REĢIONĀLĀS ATTĪSTĪBAS FONDS

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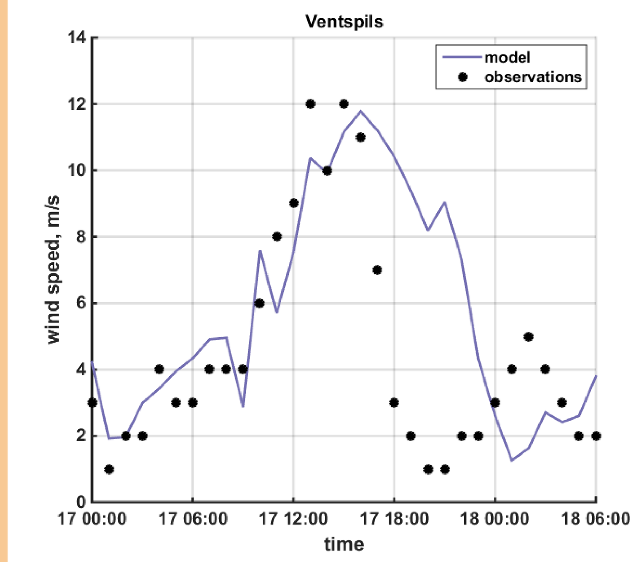
Introduction:

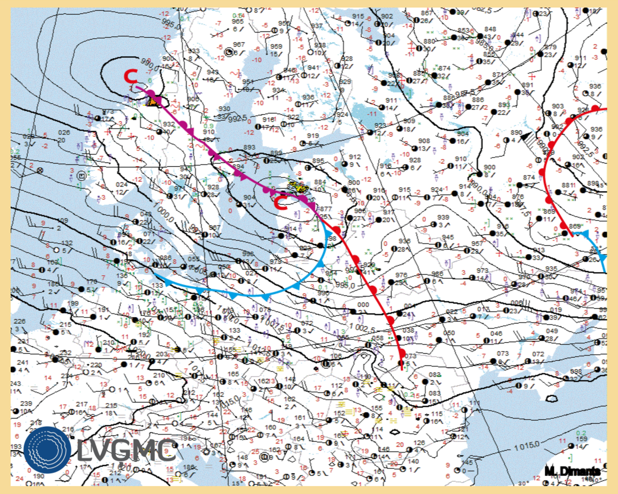
The analysis of secondary frontal wave processes and cyclogenesis is complicated by the number of factors that can influence their development. As a result Numerical Weather Prediction (NWP) models sometimes fail to correctly describe their evolution. One such case of a secondary low on an occluded front is analyzed using the Weather Research and Forecast (WRF) model and its parameters are varied to explore the possible reasons for dissimilarities with observations.

Why does it matter?

Incorrect location or timing of frontal processes can lead to large errors in forecasted wind speed and direction. Wind fields are used to calculate sea currents. Both parameters are used when planning search and rescue operations on the sea.



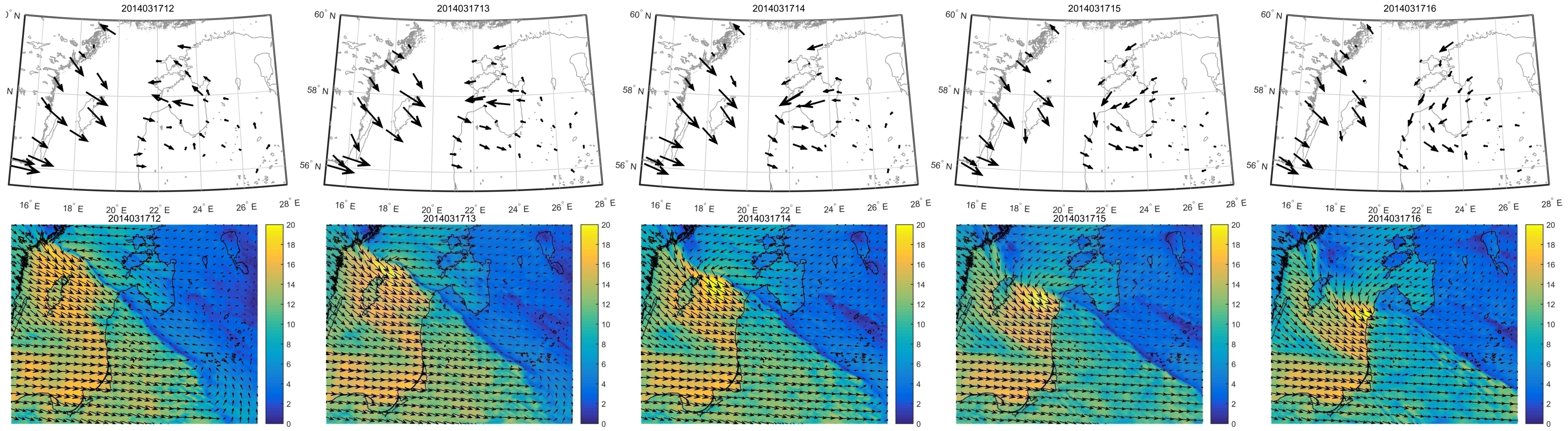
Fontal analysis 12:00 UTC



17.03.2014. Occluded front moves from South to North over the Baltic Sea and a secondary low forms over the territory of Latvia. The model results can reproduce well the first part of the process – movement and intensification of the front until it reaches the Gulf of Riga (~ 12 UTC).

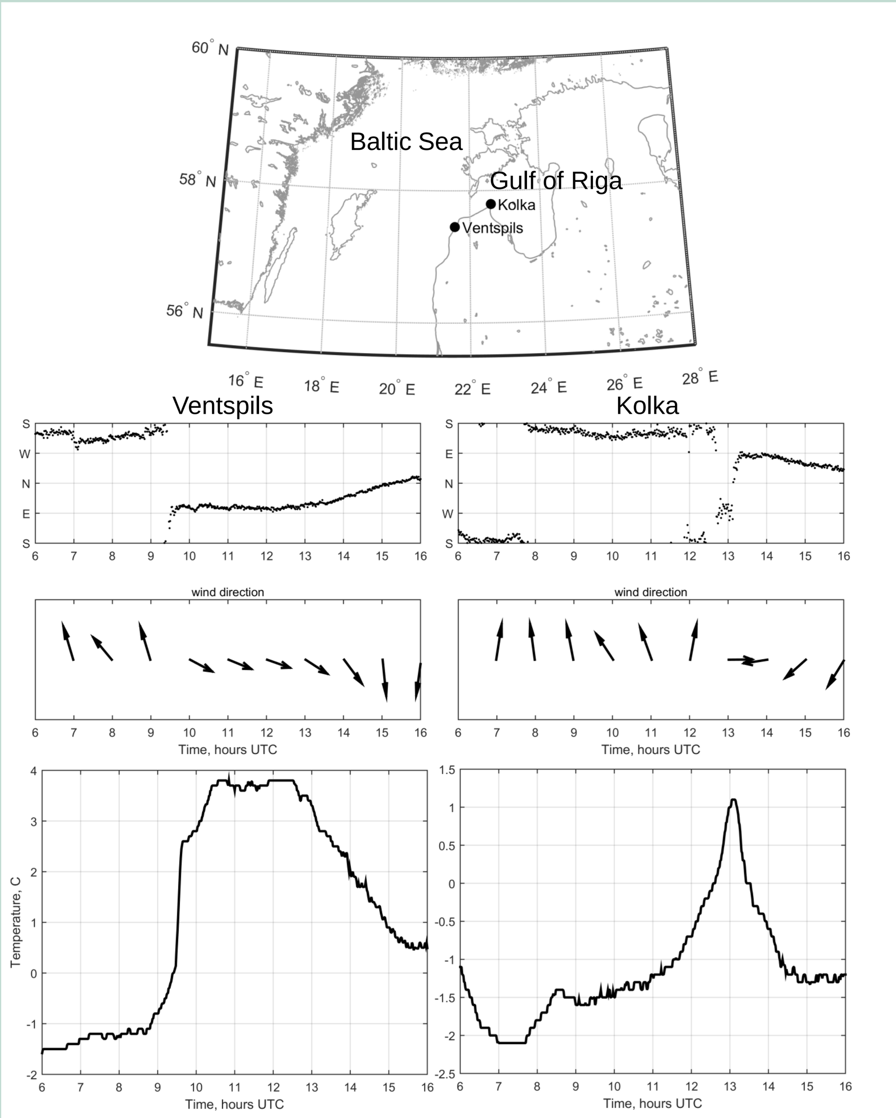
The model results show that the cyclonic circulation starts to form on the Western part of the Sea and slowly propagates east, however the observations show much faster onset of frontolysis. Model results show frontal waves but the observations cannot confirm their existence.

WRF, YSU, 3km



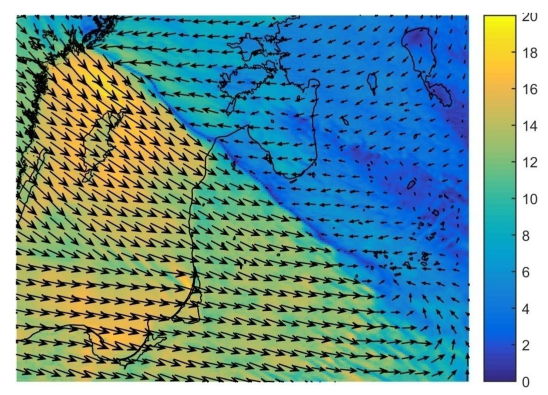
All model runs initialized 16.03 6:00 UTC

Insights from observational time series:



As the spatial scale of interest is small (~ 100 km), it useful to look at observational time series with the temporal resolution smaller than 1 hour.
Time series for two coastal stations for temperature and wind direction are shown. Hourly wind vectors are shown for clarity.
The front passes Ventspils at 9:30 UTC and both a sharp increase in temperature and a change in wind direction can be observed. The front arrives at Kolka between 12 and 13 UTC, however soon the Western wind associated with this front is sharply replaced by cyclonic circulation – Eastern wind and cold air. In Ventspils station the post-frontal Western wind is gradually replaced by cyclonic North wind.
Is it possible to estimate the spatial width of the front from these data? The distance between the stations is 75 km, which means that the front moves with speed 25 km/h or 6.5 m/s. The wind direction in Ventspils station completely changes in 12 min which corresponds to approximate frontal width of 5 km.

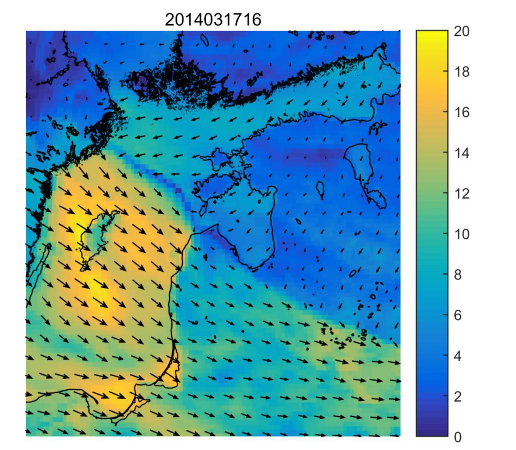
MYJ PBL, 3km



Using MYJ PBL scheme instead of YSU subtly influences the frontal waves and the process is slower but larger scale wind fields remain the same.

Influence of PBL (Planetary Boundary Layer) parametrization scheme.

YSU PBL, 9km



The results using lower resolution grids are similar, but the process takes place slower and frontal waves are less pronounced. Results suggest that the wavelength of frontal waves is limited by grid size, with finer resolution producing results that are closer to observations.

Does grid cell size influence the results?

Discussion:

Although there is a certain agreement between model results and observations, it is reasonable to conclude that the 3 km grid resolution is insufficiently fine. Results suggest that finer resolutions could allow for solutions where frontal waves have smaller wavelengths that could influence the timing and location of frontolysis.

References
WRF model: Skamarock, William C. and Klemp, Joseph B. A time-split nonhydrostatic atmospheric model for weather research and forecasting applications. Journal of Computational Physics. 227, 2008, pp. 3465–3485.

Acknowledgments
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ECMWF ERA-Interim reanalysis data was used as Boundary and Initial conditions.