ALARO experience in Poland

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Presentation plan

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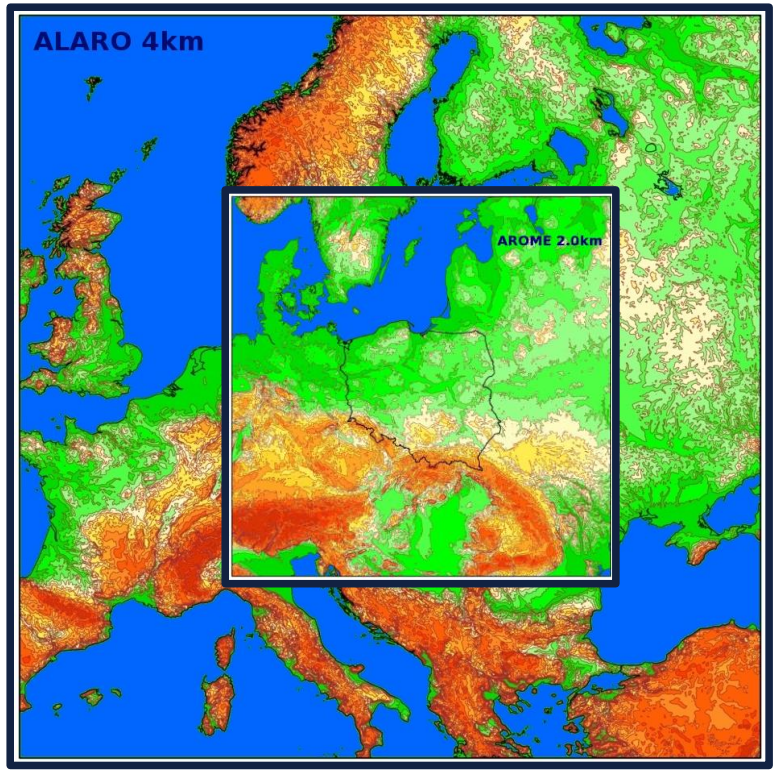
1. Operational model configurations - ALARO & AROME
2. ALARO - climatological and other applications
3. Multimodel – artificial intelligence
4. Case study of low clouds in Helsinki –13-15 March 2022
5. Case study of winter storm – 17 February 2022

1. Models configurations

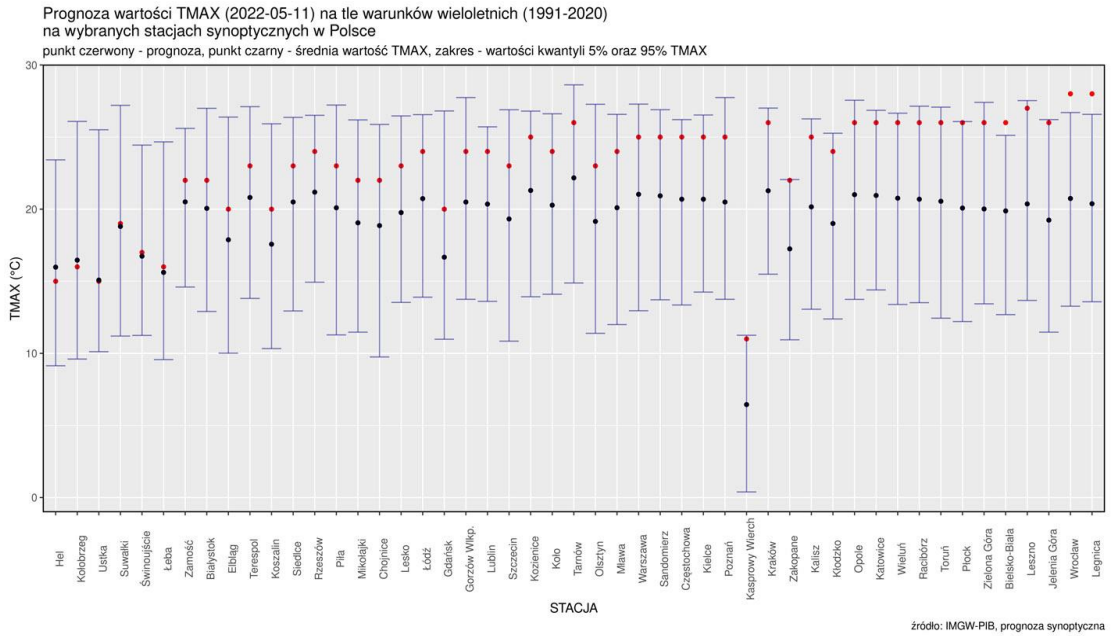
ALARO-v1B NH (**CY43T2**)	AROME (**CY43T2**)
4.0 km horizontal res. 789x789 grid points 70 vertical model levels	2.0 km horizontal res. 799x799 grid points 70 vertical model levels
3h coupling frequency and **1h** output	3h coupling frequency and output: **1 h** standard **10 min**. for INCA Nowcasting
72 h forecast range	**30 h** forecast range
LBC from **ARPEGE** with **9.4km**	LBC from **ALARO-1B NH**
Time step **150s**.	Time step **50s**

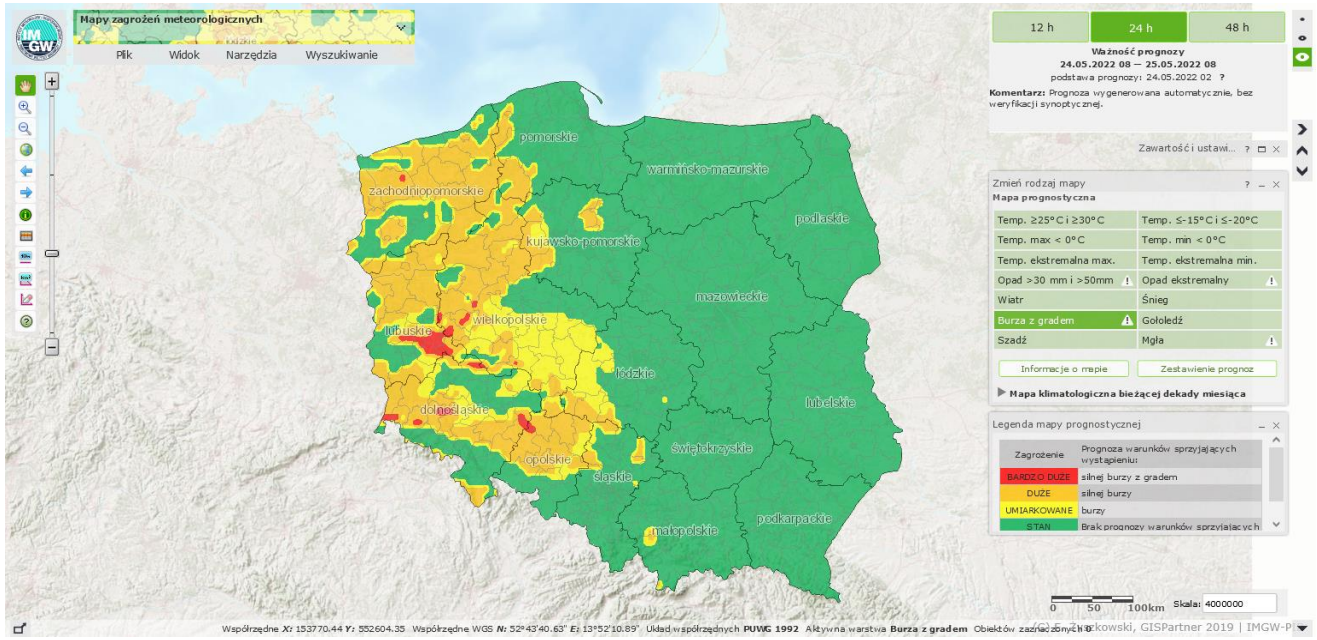


Operational machine characteristics

Cluster of HP BL460c_GEN8 servers connected with Infiniband network, OS Scientific Linux 6, Intel Xeon E5-2690 processors – with maximum 1552 cores (**97 nodes with 16 cores each**), each core RAM **128 GB**, disc array – **64 TB.**

2. Climatological and other applications





Warning system based on ALARO forecasts for unusually **warm or cold conditions** for given time of the year for synoptic stations in Poland

ISOK – EU project. Part of it is related to generation of **automatic warnings** (storm, high/low temperature, snow, fog, precipitation, icing, rime) **from ALARO forecasts** with algorithms developed during the project.

Renewable energy production forecasts with ML and ALARO forecasts (wind farms).
New project, for **landslides monitoring** with ALARO/A-LAEF **precipitation forecasts**.
Universal Thermal Climate Index - human biometeorological parameter for cities

4. Multimodel – artificial intelligence

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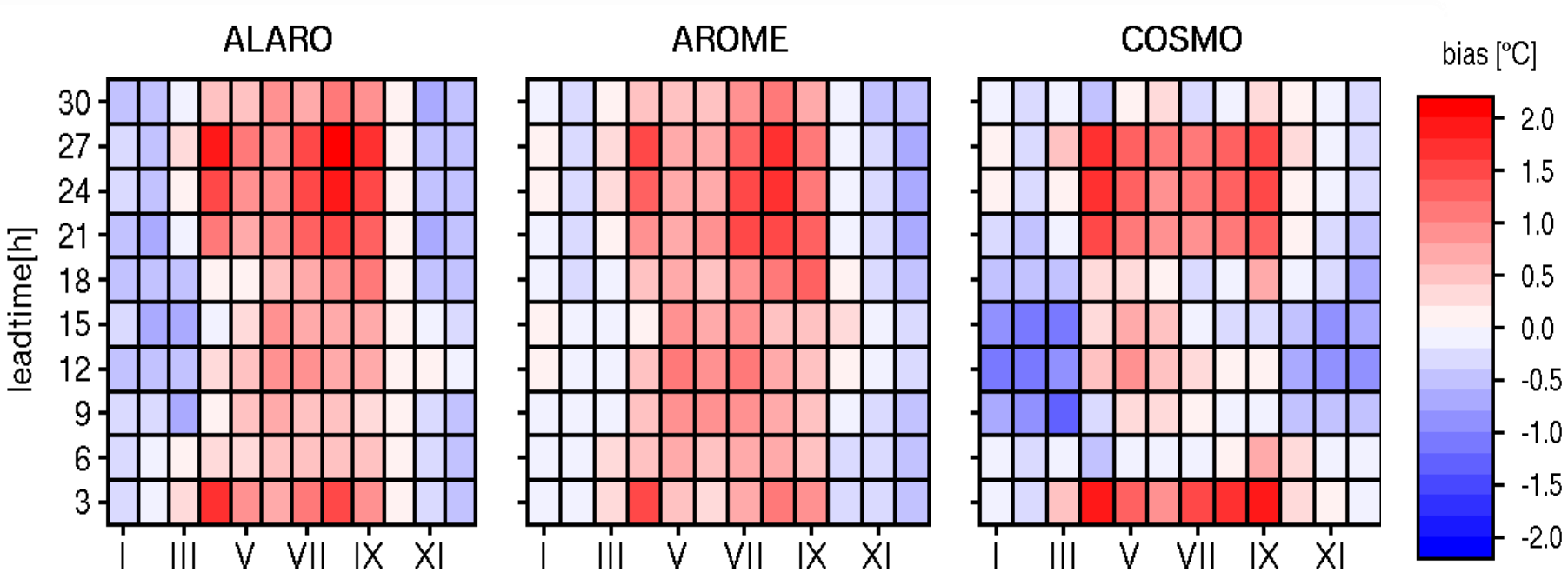
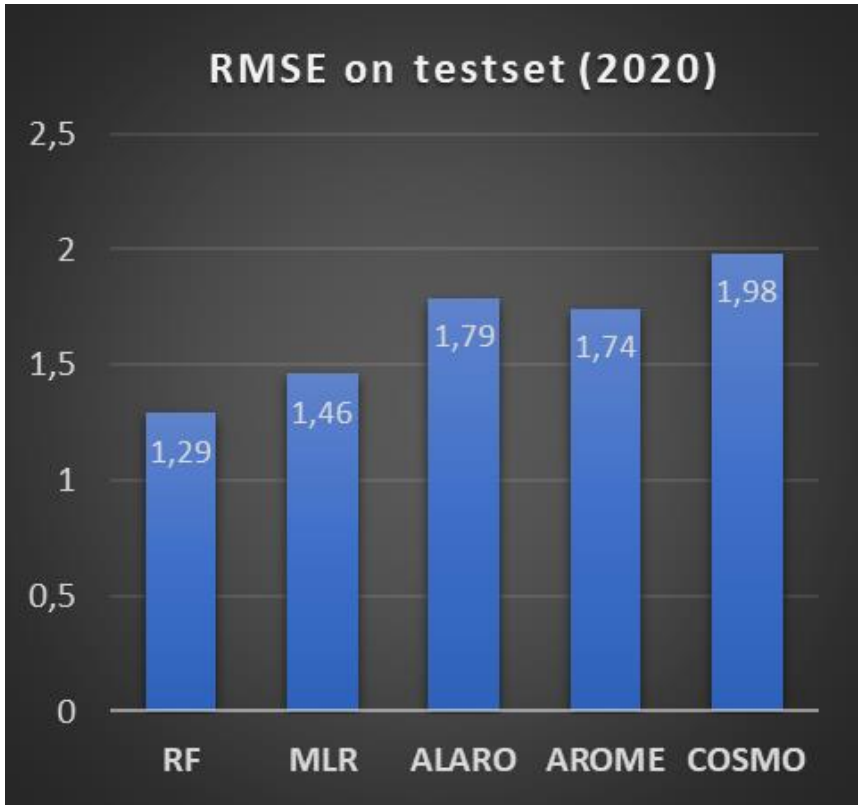
EXPERIMENT BASICS:

- forecasts of T2m from 3 deterministic numerical models: AROME (2km), ALARO (4 km), COSMO (7 km)
- predictors include forecasts of other elements (air pressure, wind, cloudiness), environmental variables (elevation, TPI) and temporal variables (day of year, month)
- forecast length: 30h
- run: 00 UTC
- timestep: every 3h
- 58 synoptic stations in Poland
- training set: 2018-2019 (~290k cases)
- test set: 2020 (~193k cases)
- method: random forests
- reference – multilinear regression

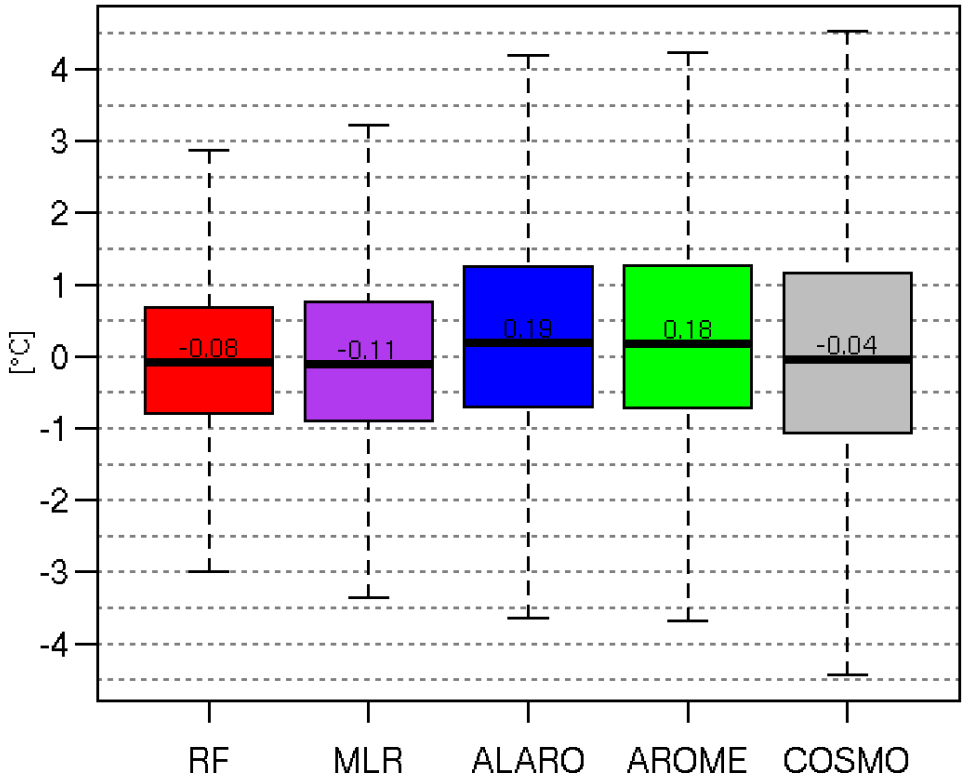


Mean air temperature bias across months (X axis) and leadtimes (Y axis)

4. Multimodel

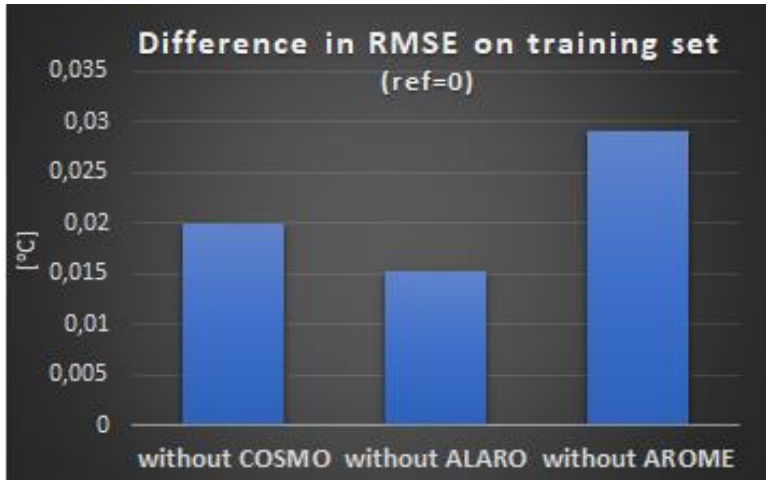


SS_{RMSE} = 11,6% against MLR
25,8% against AROME



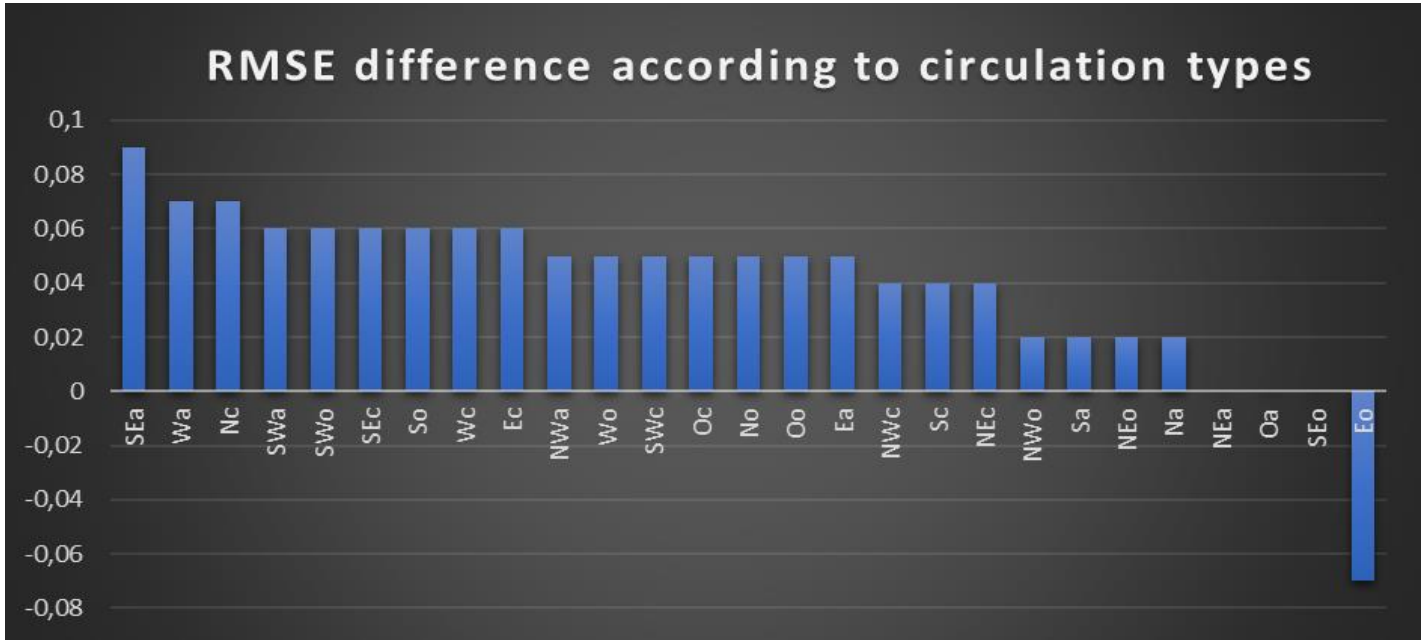
Bias distribution for different models

4. Multimodel – after removing ALARO



RMSE on testset: 1,29 -> 1,33

Multimodel without ALARO forecast



SEa – south-east anticyclonic
Wa – west anticyclonic
Nc – north anticyclonic
…
Eo – east undefined

6. Low clouds in Helsinki – 13/15 March 2022

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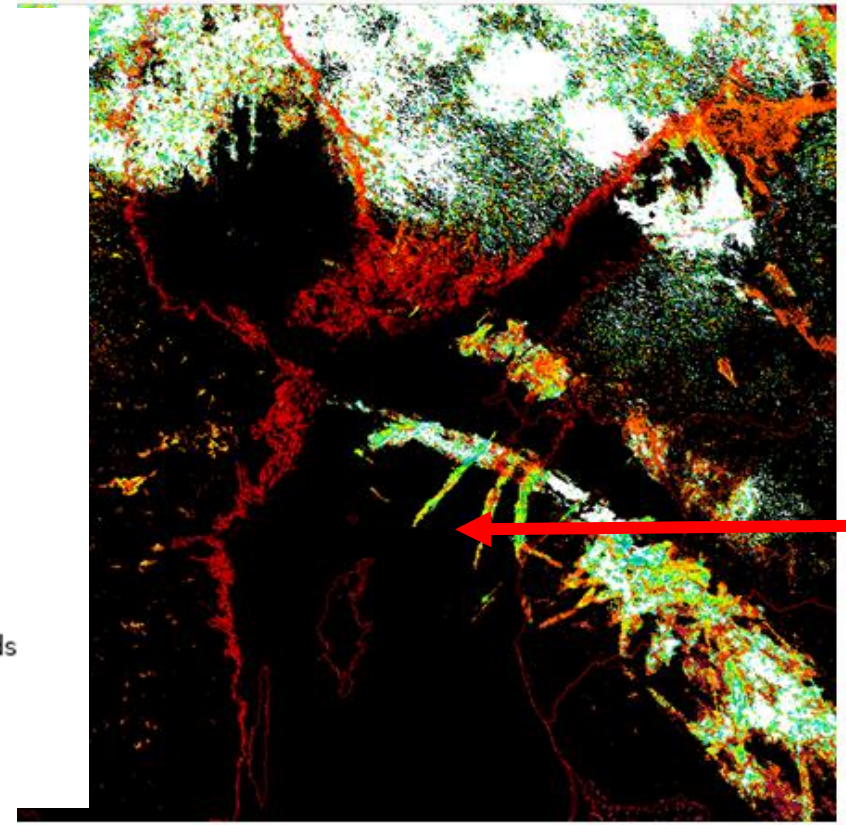
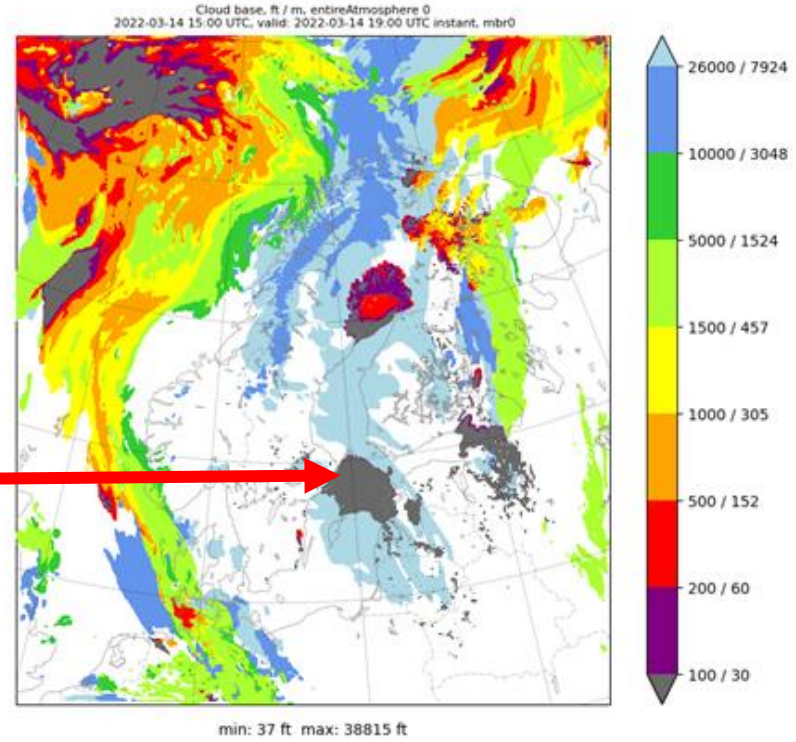
Metop-C, 2022-03-14 18:36 UTC

MEPS cloud base 2022-03-14 19 UTC

Legend

- Cloudfree land
- Cloudfree sea
- Snow covered land
- Snow/ice covered sea
- Very low stratus
- Low clouds
- Mid level clouds
- High opaque clouds
- Very high opaque clouds
- Very thin cirrus
- Thin cirrus
- Thick cirrus
- Thin cirrus above mid/low clouds
- Fractional/broken low clouds
- Unclassified





The cloud layer is in a quasi-stationary state.

Carl Fortelius: "Unobserved fog over the northern Baltic Sea" *ACCORD 2 meeting*

6. Low clouds in Helsinki – 13/15 March 2022

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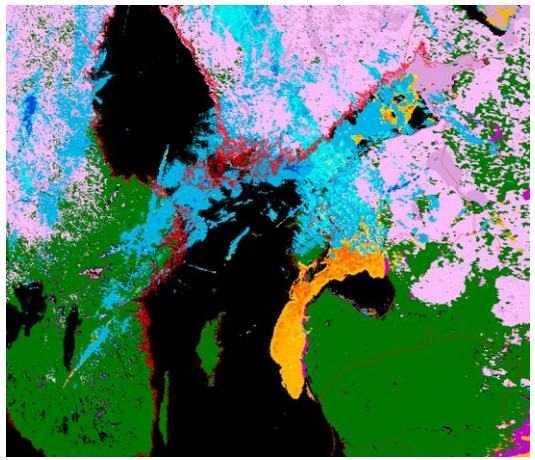
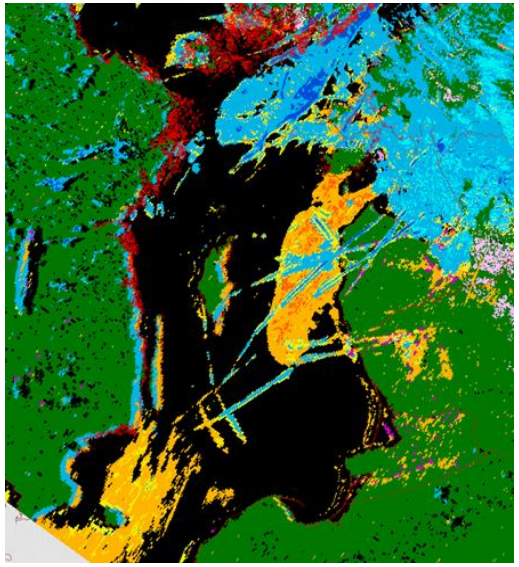
NOAA obs. at 13 March 2022

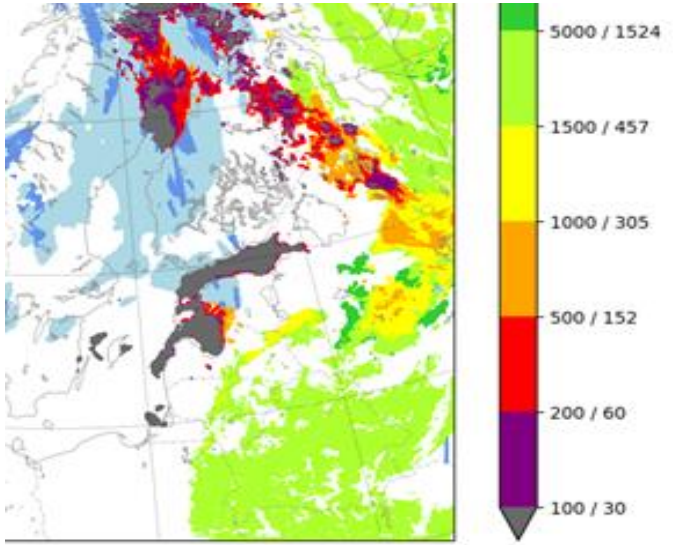
10 UTC

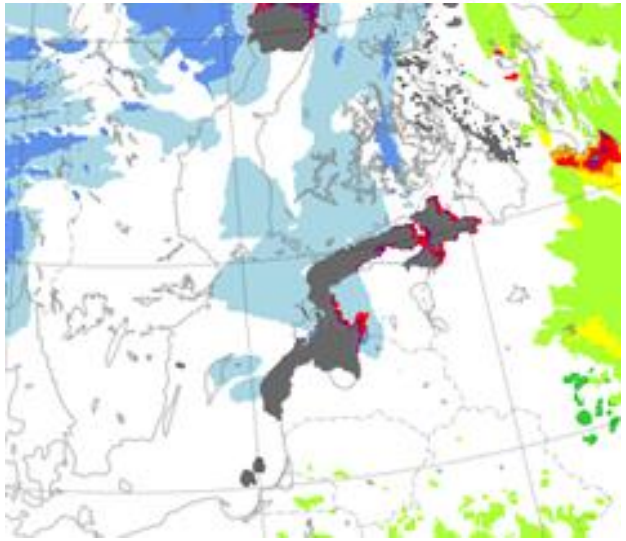


16 UTC



HARMONIE-AROME forecast





Other models:

ALARO (boundary data ARPEGE)

WRF (boundary data from GFS and ICON)

COSMO (boundary data ICON)

6. Low clouds in Helsinki – 13/15 March 2022

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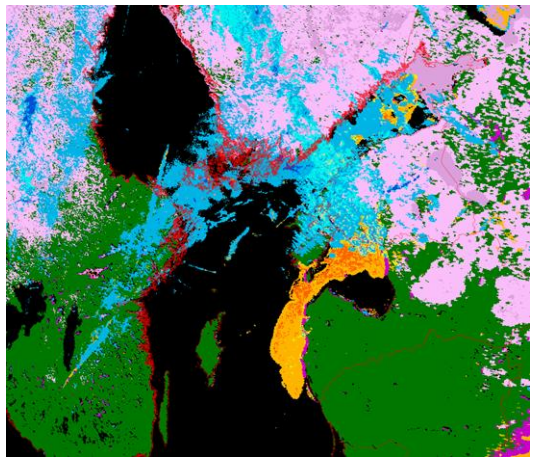
NOAA obs. at 13 March 2022

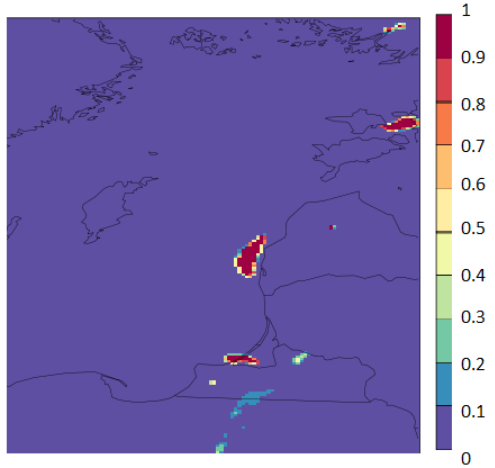
ALARO forecast- low cloudiness

WRF forecast (boundary data ICON) lowest vert. level

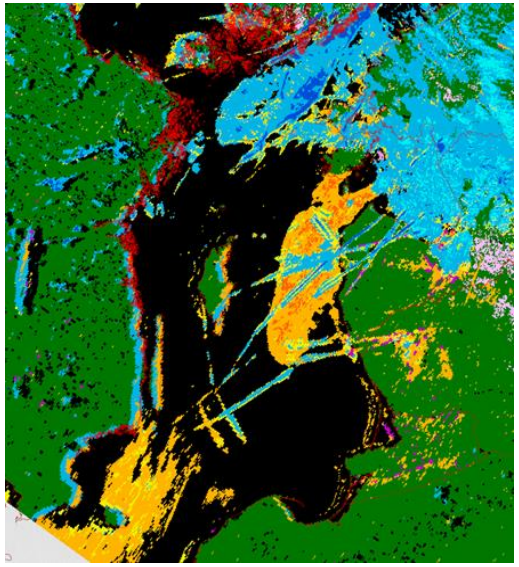
WRF (with GFS data) lowest vert. level

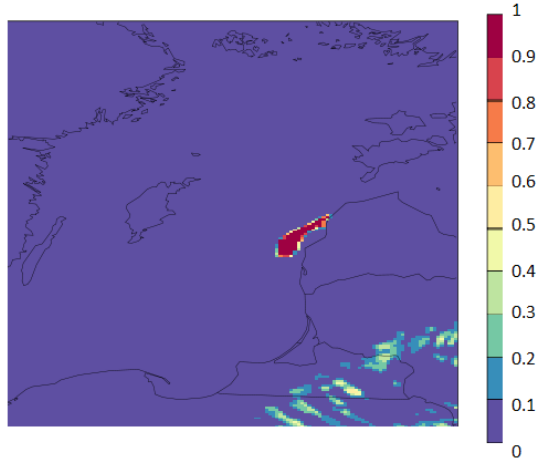
10 UTC





16 UTC





COSMO – no low clouds

6. Low clouds in Helsinki – 13/15 March 2022

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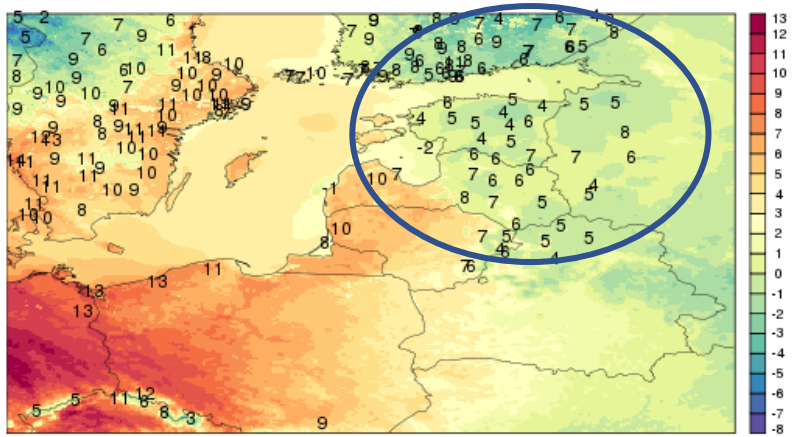
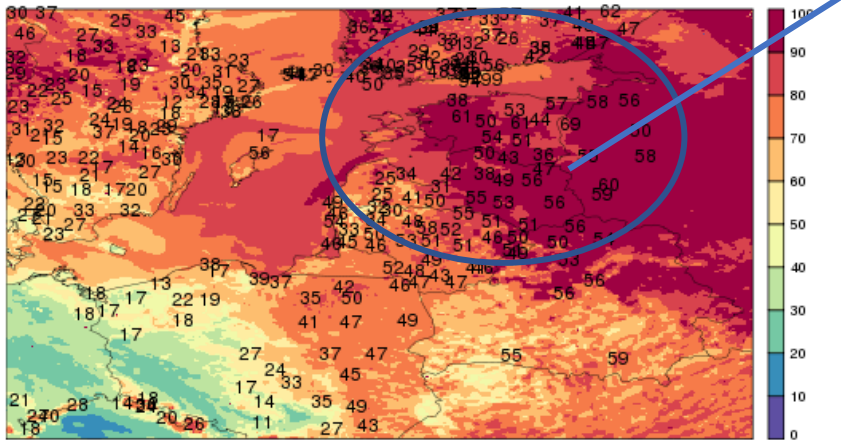
ALARO model – **too low air temperature** and **too high air humidity** in selected regions

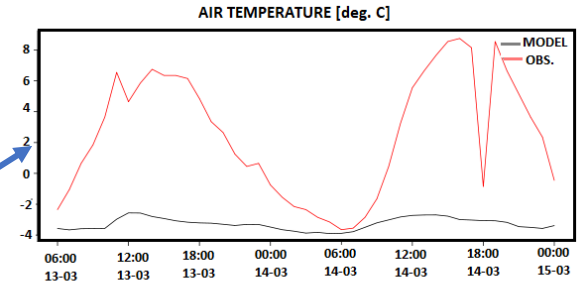
2022/03/13 15 UTC

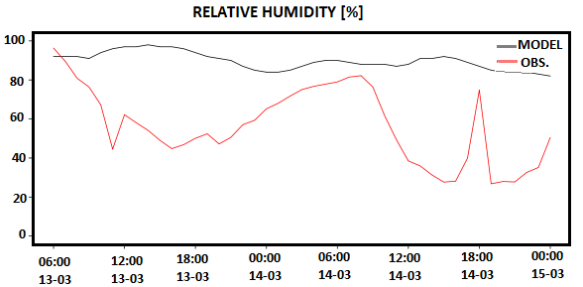
Air temperature at 2 m a.g.l.



Relative humidity at 2 m a.g.l.

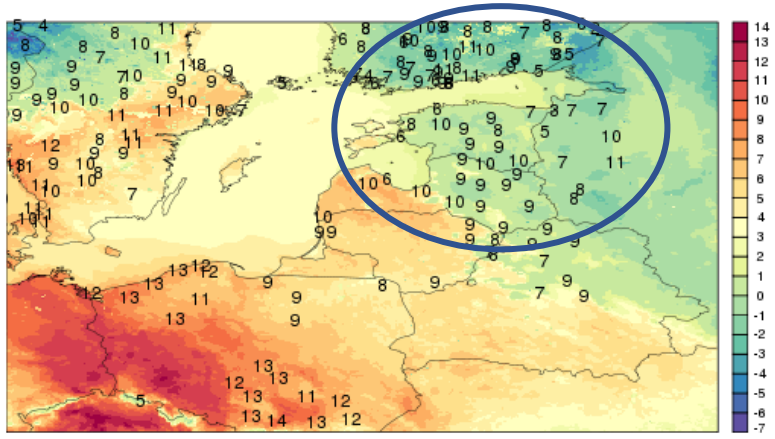




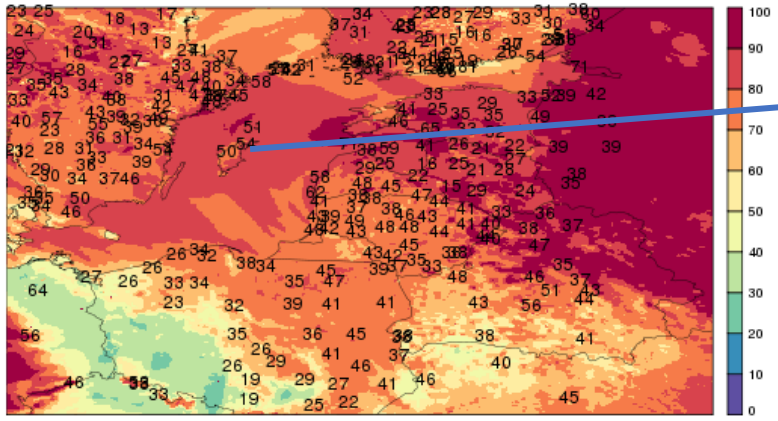


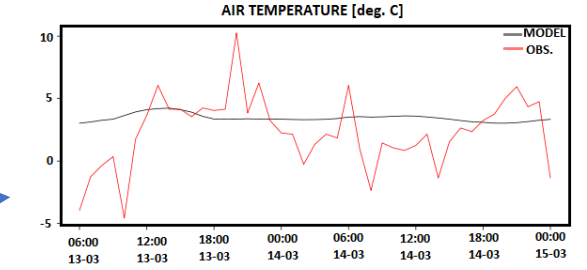
2022/03/14 15 UTC

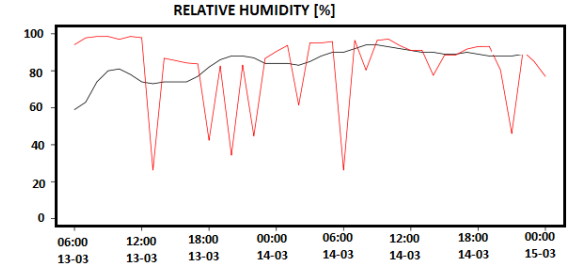
Air temperature at 2 m a.g.l.



Relative humidity at 2 m a.g.l.







6. Low clouds in Helsinki – 13/15 March 2022

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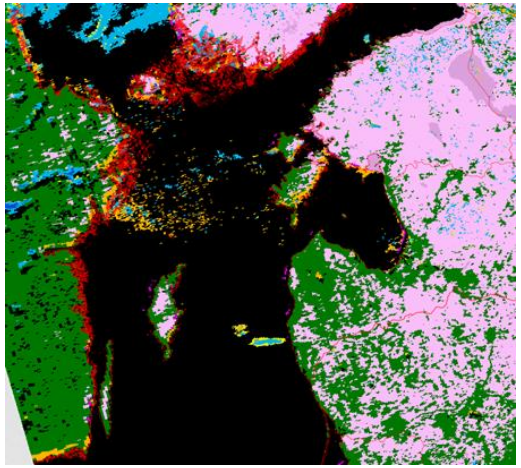
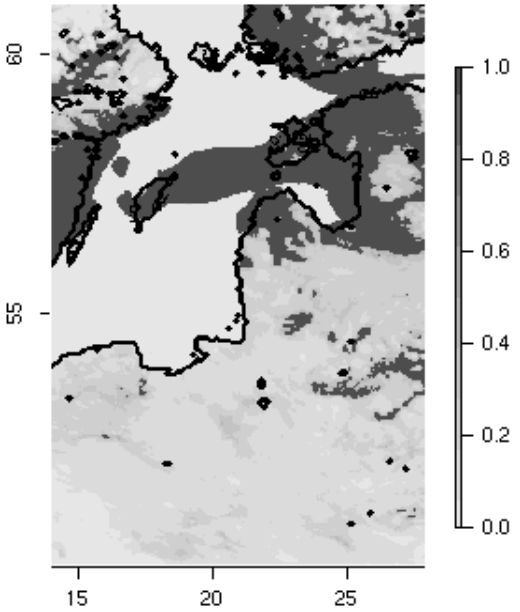
NOAA obs. at 14March 2022

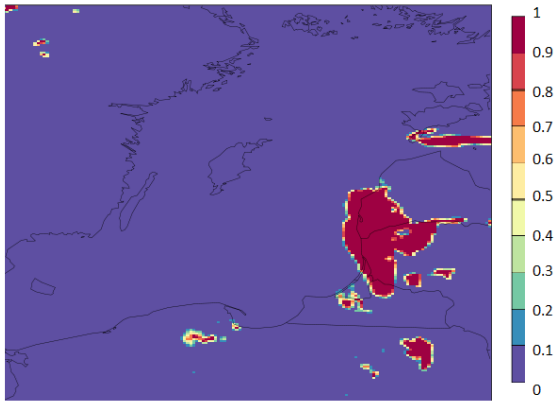
6 UTC



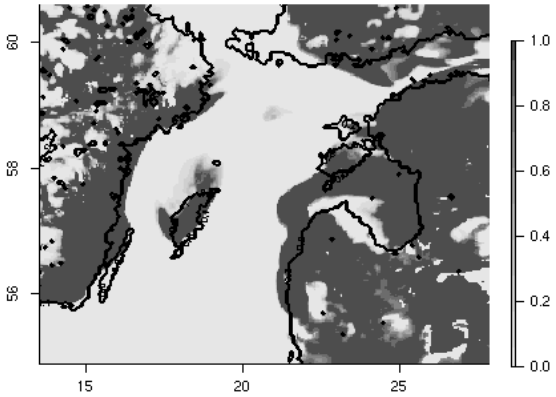
WRF forecast (ICON data)



ALARO forecast- low cloudiness



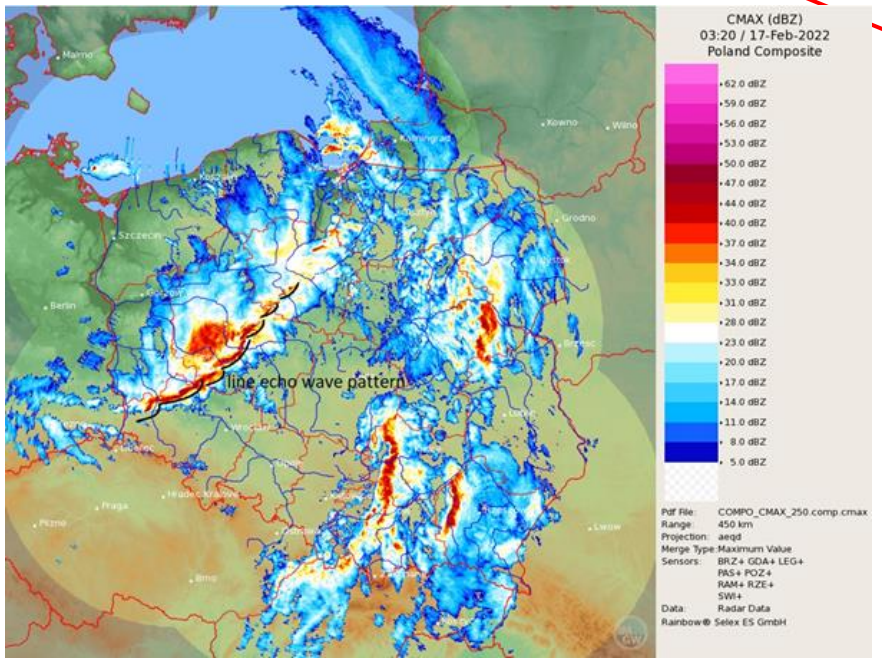
WRF forecast (GFS data)



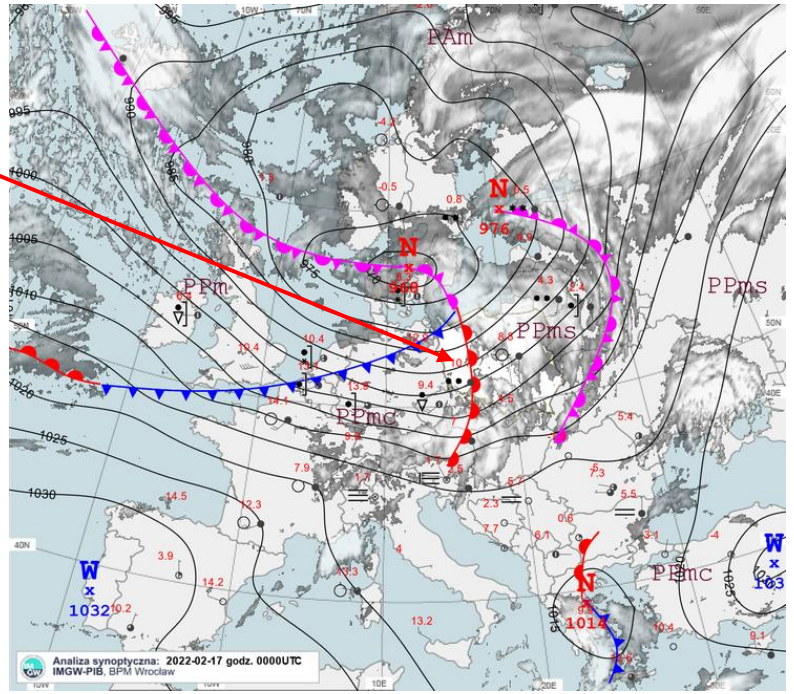
7. Winter storm – 17 February 2022

Very strong **witer** storm with **tornadoes** – **Line Echo Wave Pattern**
Advection of **warm air** preceding **cold air front**
Fluctuations on **squall line** resulted in local tornadoes

Maximum reflectivity – radar data
(3 UTC 17.02.2022)

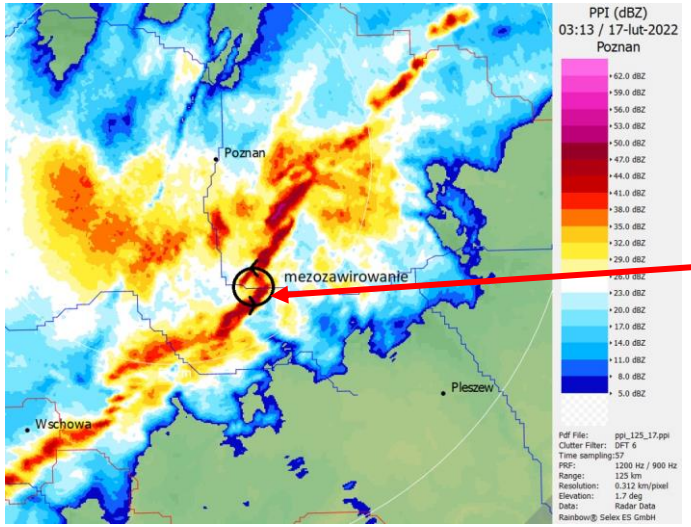


Synoptic map at 0 UTC 17.02.2022

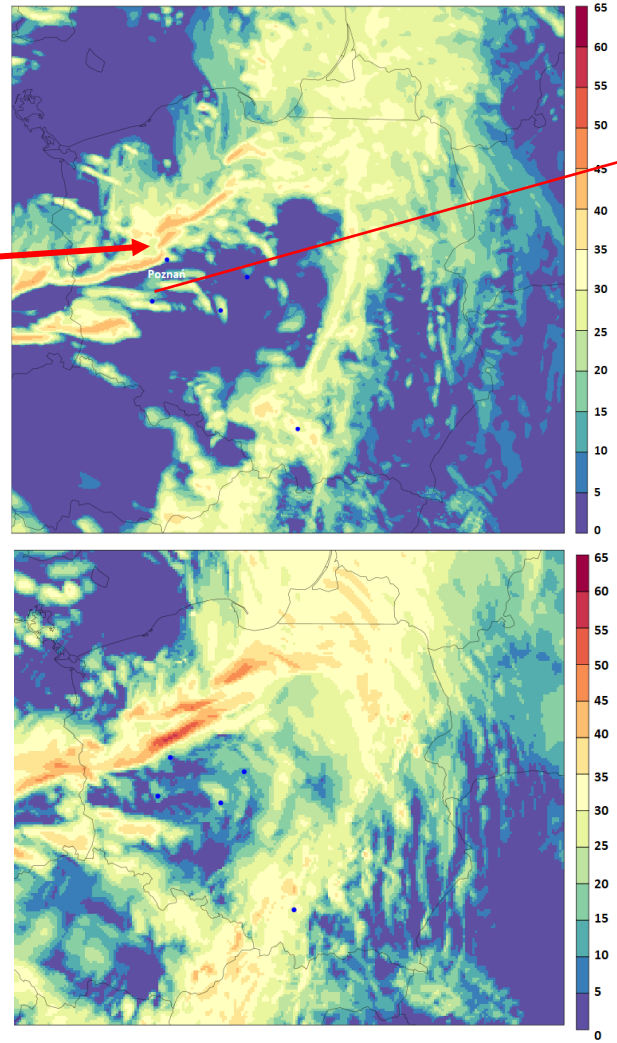


7. Winter storm – 17 February 2022

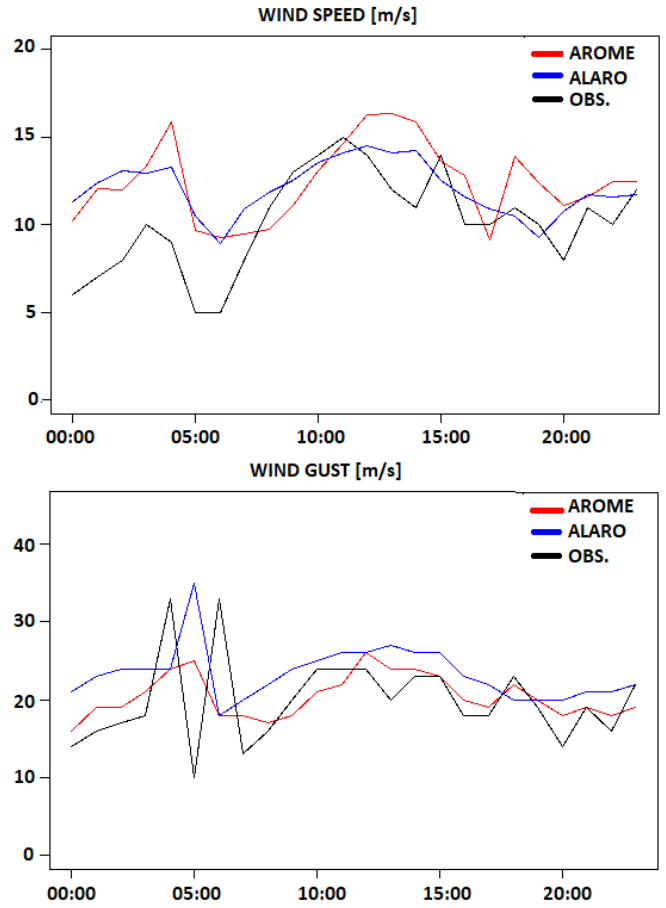
Maximum reflectivity – radar data (3:10 UTC 17.02.2022)



Maximum reflectivity – AROME (top) and ALARO (bottom) models r18 (3 UTC 17.02.2022)



ALARO & AROME, start at 18 UTC



Stronger reflectivity and wind gusts in **ALARO** in comarison with **AROME**

7. Winter storm – 17 February 2022

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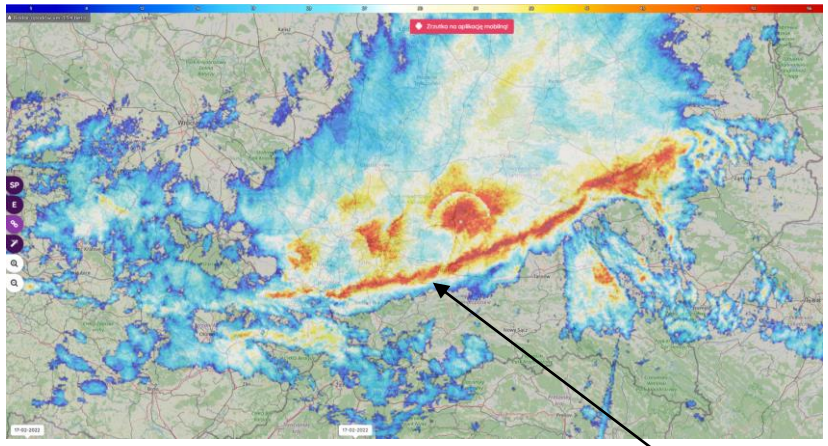
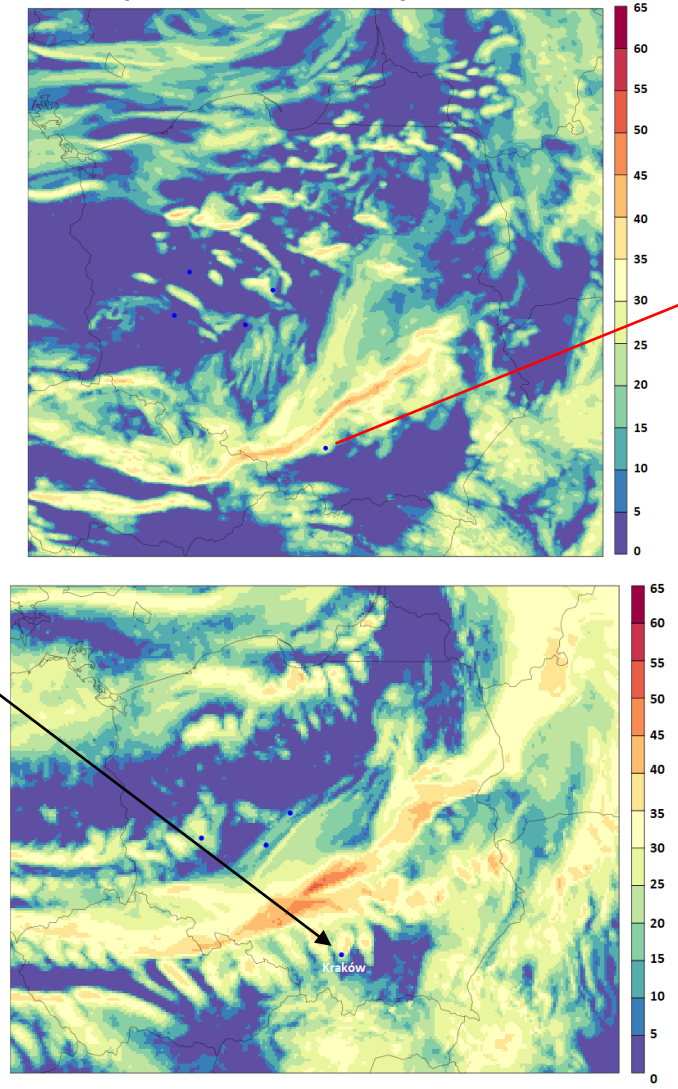
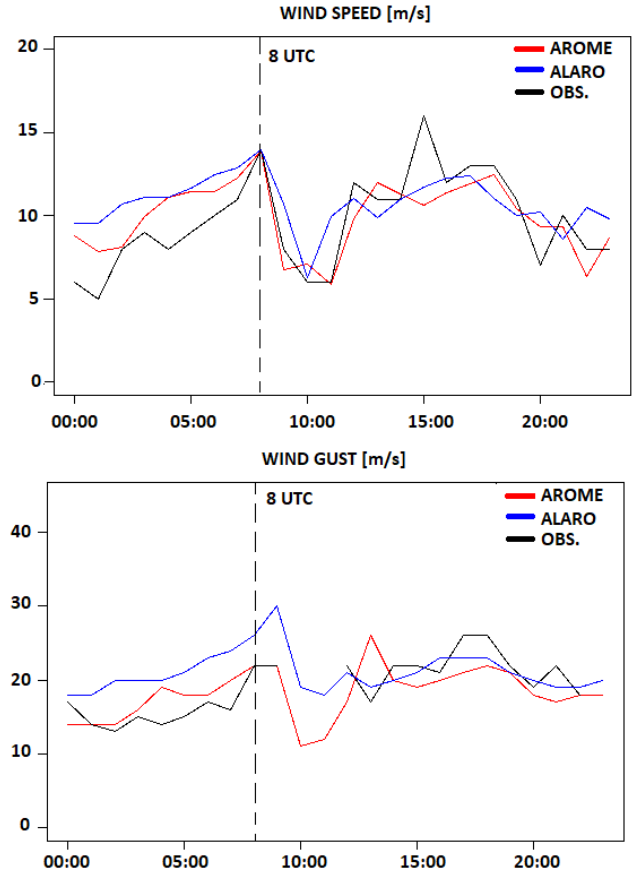
Maximum reflectivity – radar data (8 UTC 17.02.2022)



https://old.radar-opadow.pl/

Maximum reflectivity – AROME (top) and ALARO (bottom) models: start 18 UTC (8 UTC 17.02.2022)





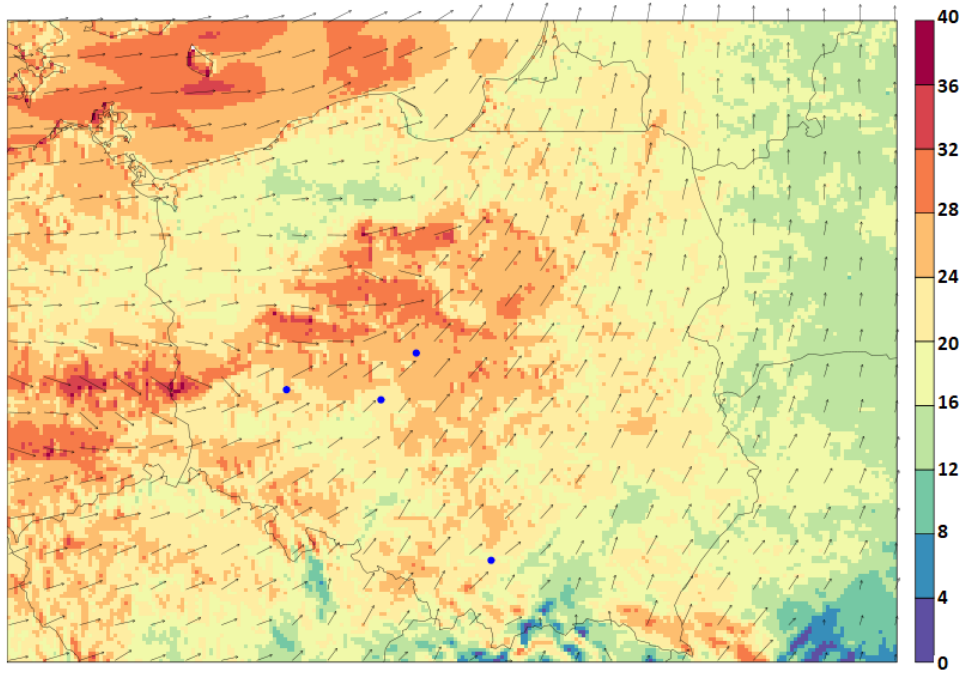
Expertise: possible wind gusts in Kraków up to 28 m/s (measured 22-23 m/s)

Overturned crane in Kraków − two dead people

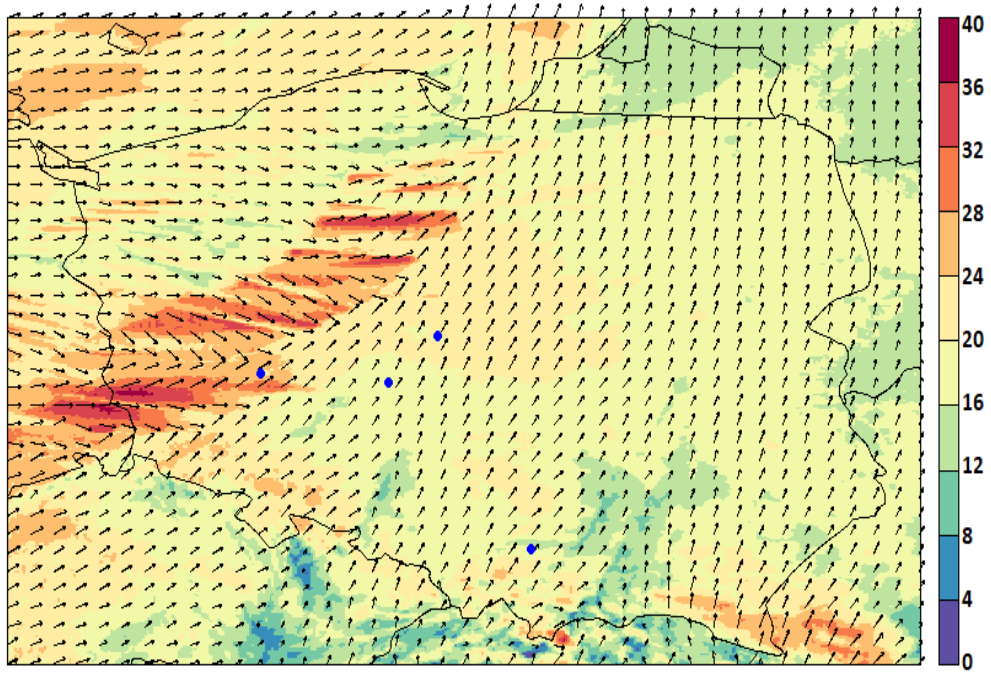
7. Winter storm – 17 February 2022

Wind gust spatial differences

Wind gust – ALARO model: start 18 UTC (4 UTC 17.02.2022)



Wind gust – AROME model: start 18 UTC (4 UTC 17.02.2022)



Thank you

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