Effect of the uncertainty in meteorology on air quality model predictions

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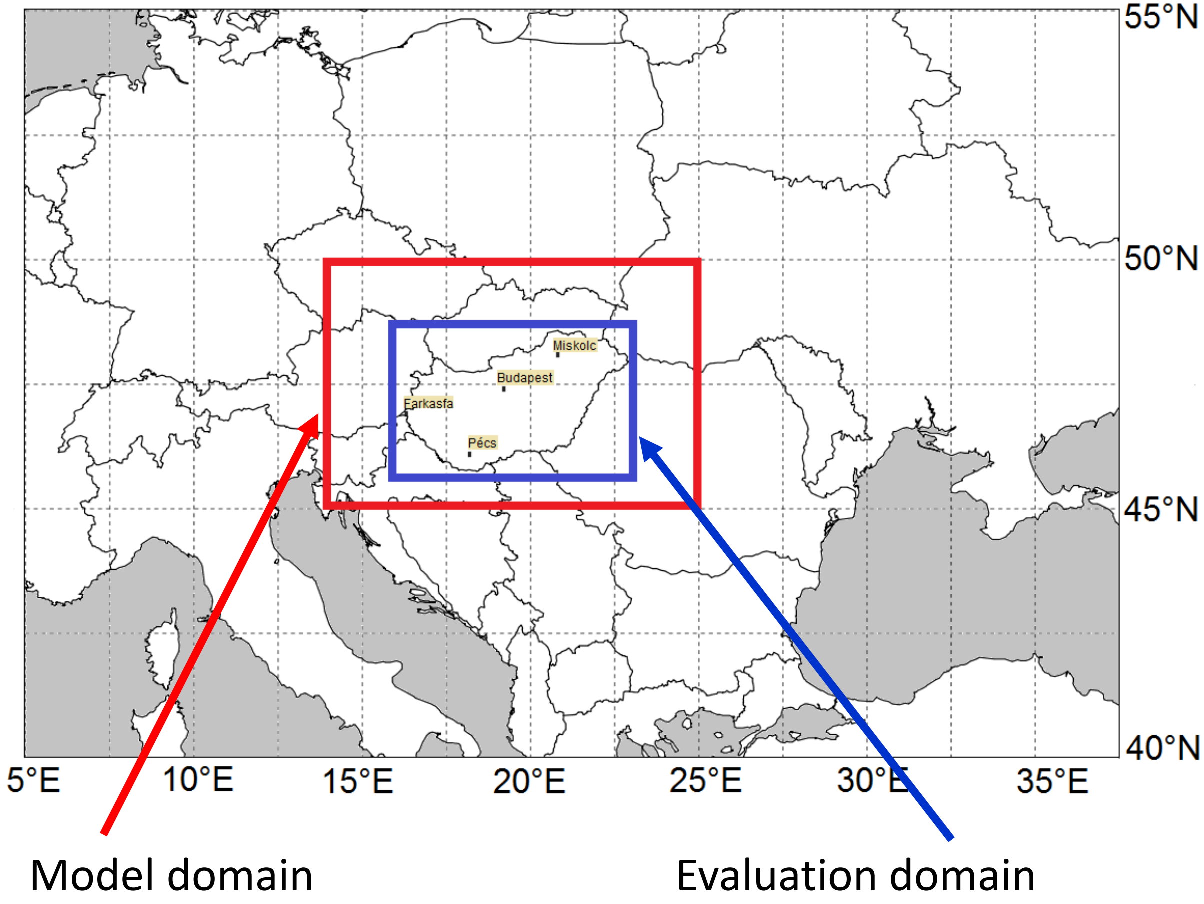
The aim of the research

- Analysing the response of a chemical transport model to changes in the value of meteorological parameters
- Previous step: PhD dissertation of Homolya Emese
  - changing the value of the meteorological parameters "by hand"
  - Disadvantage: the physical consistency was not met
  - advantage: we were able to force more drastic changes
- Physical consistency: using EPS members
- Focusing on PM_{10}
- Focusing on episode situations
- Examined meteorological parameters:
  - Wind speed
  - Boundary layer height

Applied model system



Grid resolution: 0.1° (~10 km)

Setup of the modelling system:

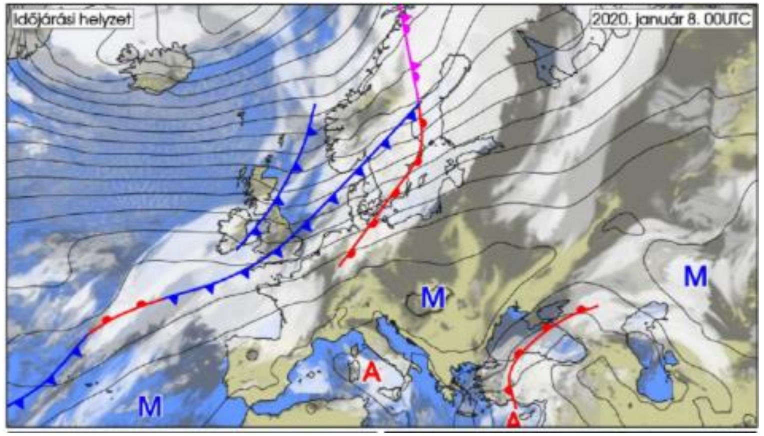
CTM	CHIMERE (version 2017)
Meteorology	AROME and AROME-EPS (11-members)
Emission	EMEP (2015)
Biogenic emission	MEGAN
Boundary conditions	LMDz-INCA + GOCART (climatological)
Initial conditions	use the previous simulation
Run duration	24 hours
Spin up	1 day

Analyzed episode situations:

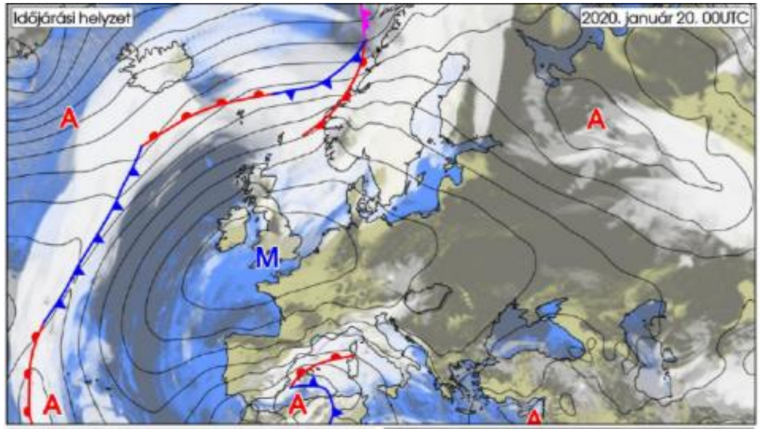
6–13 January 2020
17–22 January 2020
09–14 November 2020

Evaluated episode situations

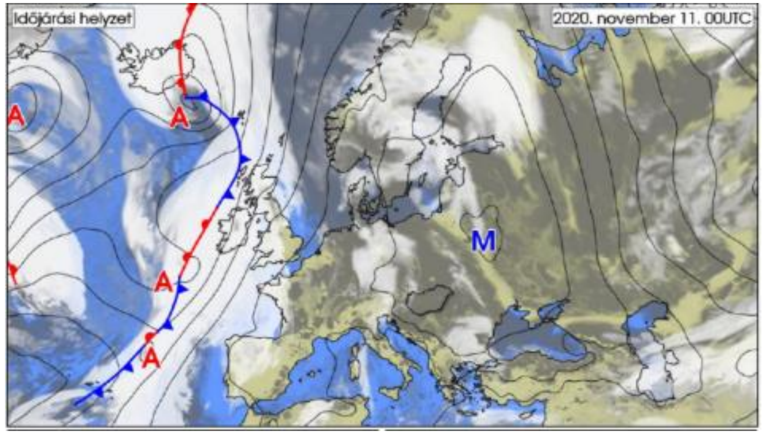
6–13 January 2020



17–22 January 2020

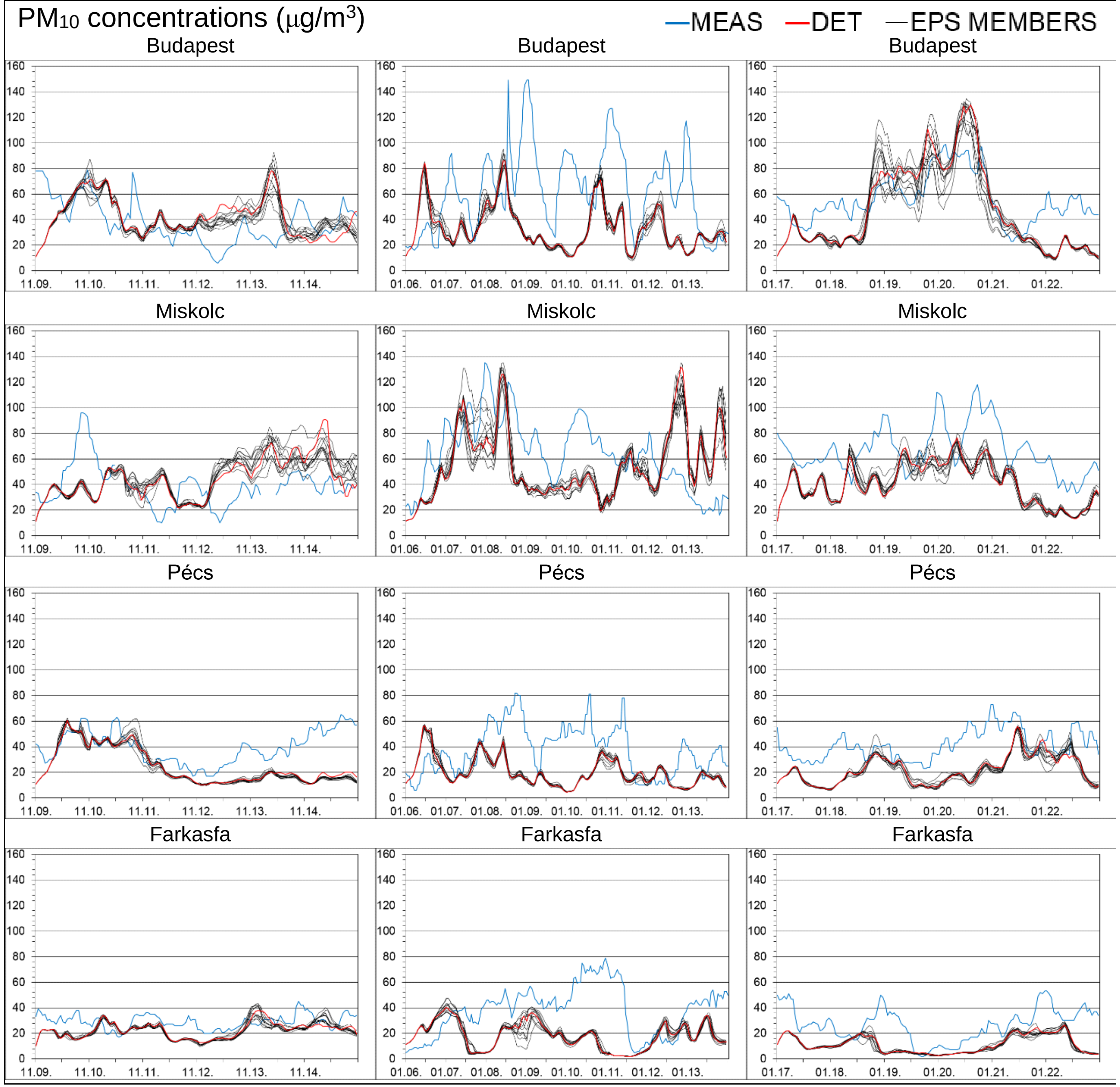


09–14 November 2020



- The synoptic events were **anticyclonal** in Central Europe during these periods.
- A **cold pool** is a special meteorological situation that is related to inversion in the upper atmosphere and is coupled with **low surface air temperatures**.
- It most frequently evolves in areas that are surrounded by **chains of mountains**.
- Events in anticyclones trigger the development of cold pool as they foster downward motions in the air. By serving as a **barrier for mixing motions, inversion causes the air to stabilize**, and it hinders the movement of the air mass out of the basin.

PM$_{10}$ hourly concentration measurements vs. forecast

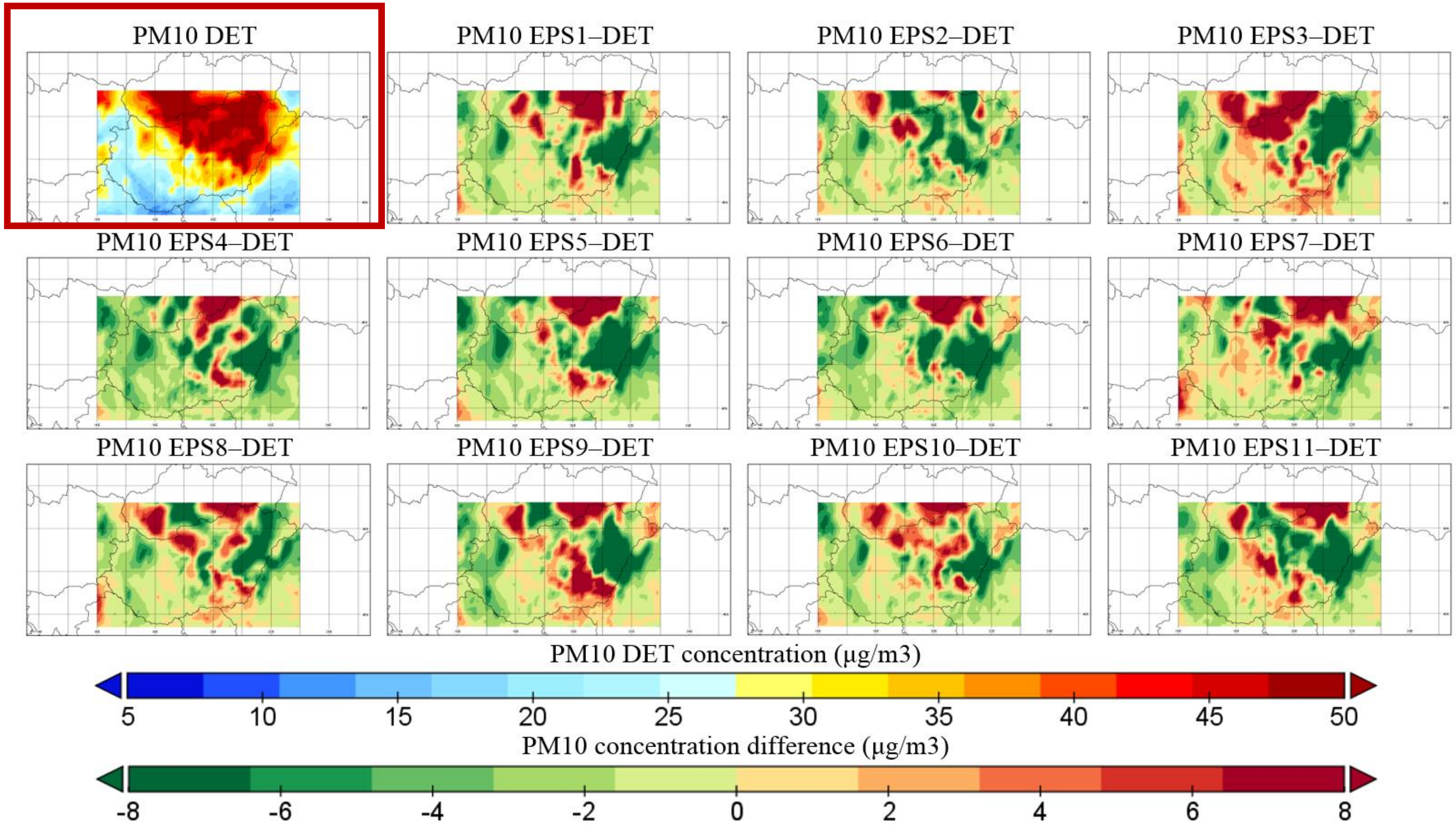


09–14 November 2020 6–13 January 2020 17–22 January 2020

Legend:

- Blue: measurements
- Red: model simulation - deterministic
- Black: model simulation - EPS members

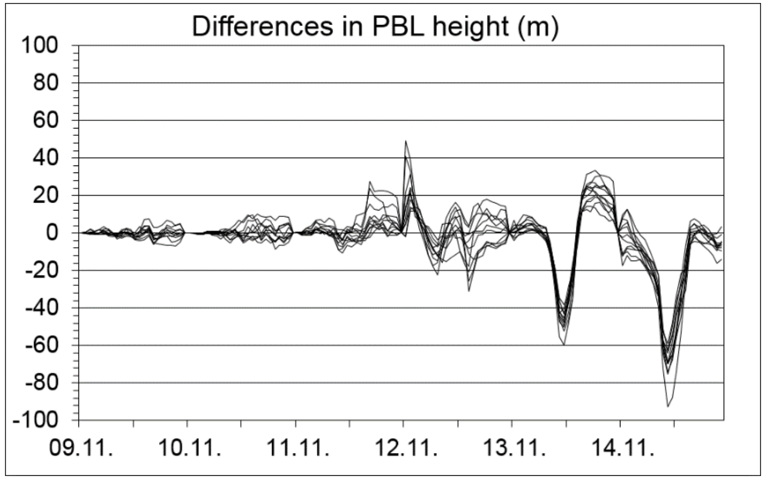
PM10 concentration, daily average
13 November 2020



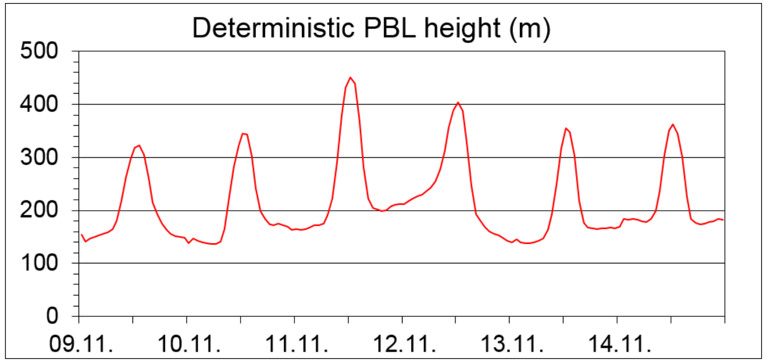
Areal averages

09–14 November 2020

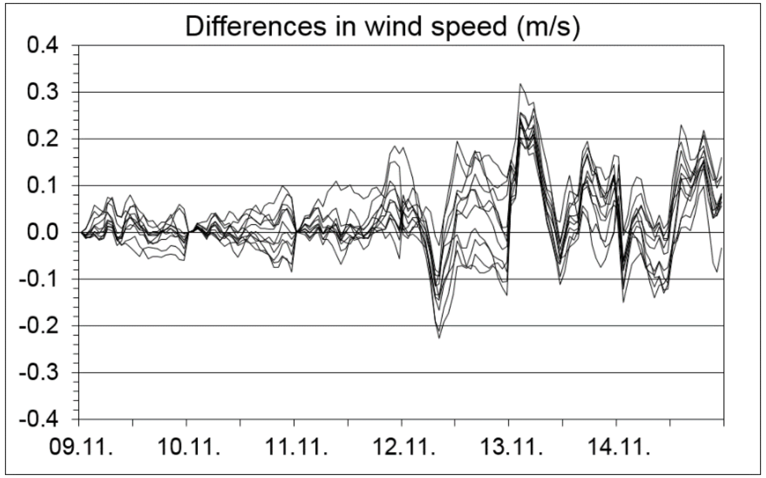
Boundary layer height



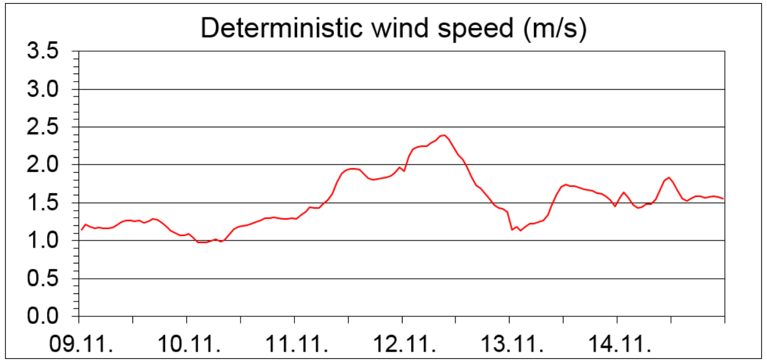
The biggest differences :	+49 m
	–93 m



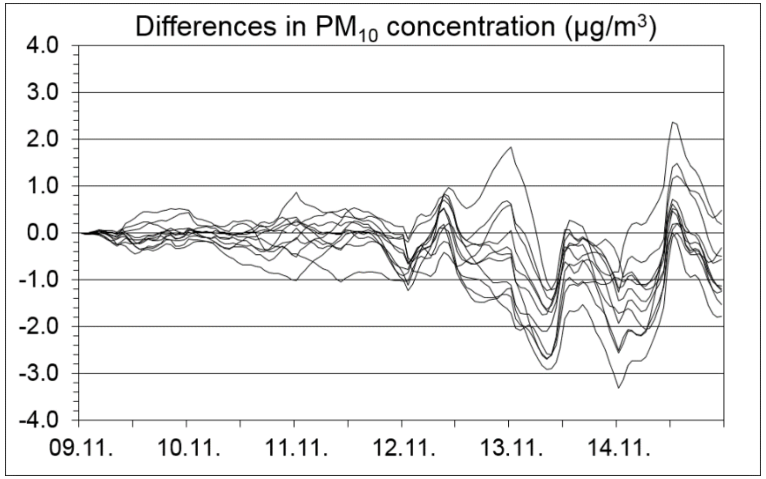
Wind speed



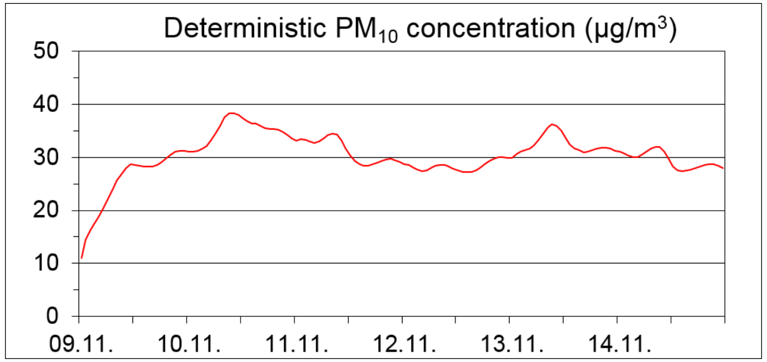
The biggest differences:	+0.3 m/s
	–0.2 m/s



PM_{10} concentration



The biggest differences:	+2.4 μg/m^3
	–3.3 μg/m^3



Analyzed categories

Definition of the categories:

light wind: < 2 m/s
strong wind > 2 m/s

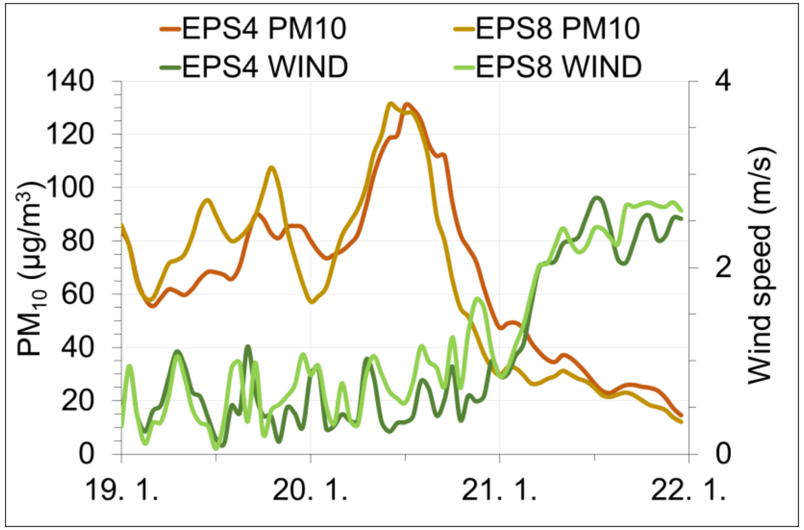
	Budapest	Miskolc	Pécs	Farkasfa
Light wind	January 19–21, 2020	November 13–15, 2020	January 21–22, 2020	November 12–15, 2020
Strong wind	November 12–13, 2020	January 09–12, 2020	November 12–13, 2020	January 19–20, 2020

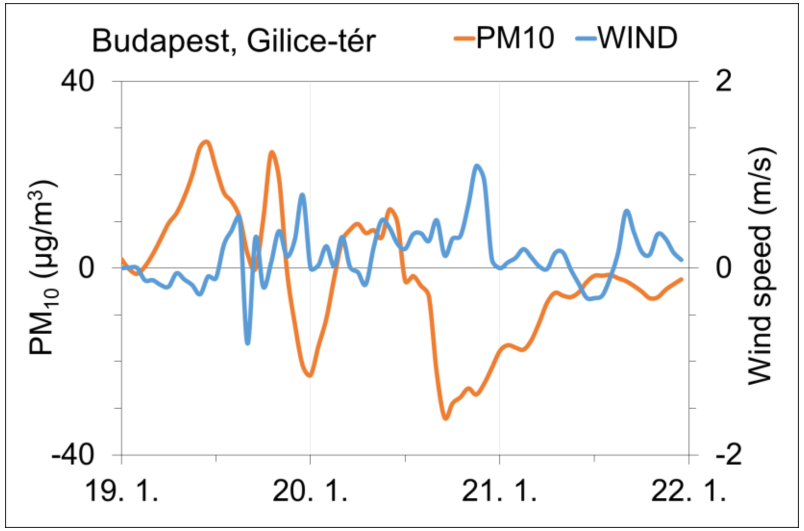
low PBL height: < 400 m
high PBL height: > 400 m

	Budapest	Miskolc	Pécs	Farkasfa
Low PBL height	January 21–23, 2020	January 17–19, 2020	November 13–15, 2020	November 13–15, 2020
High PBL height	November 13–15, 2020	January 21–23, 2020	January 19–21, 2020	November 11–13, 2020

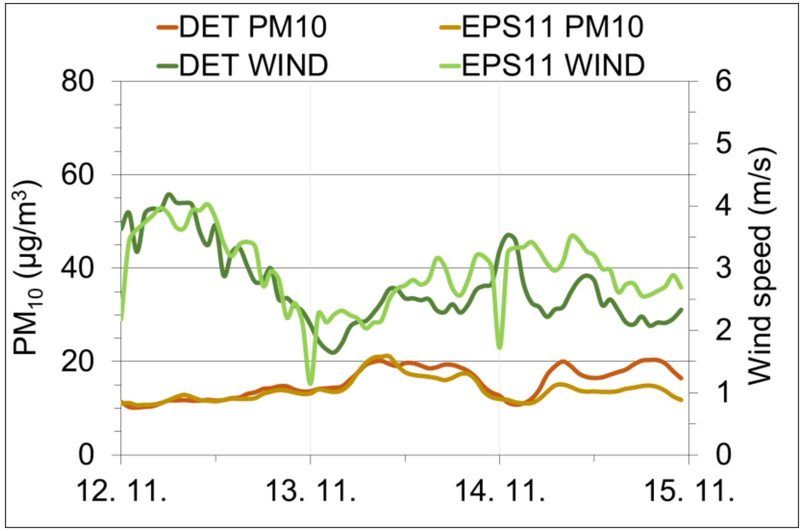
Effect of the wind on the air quality forecast

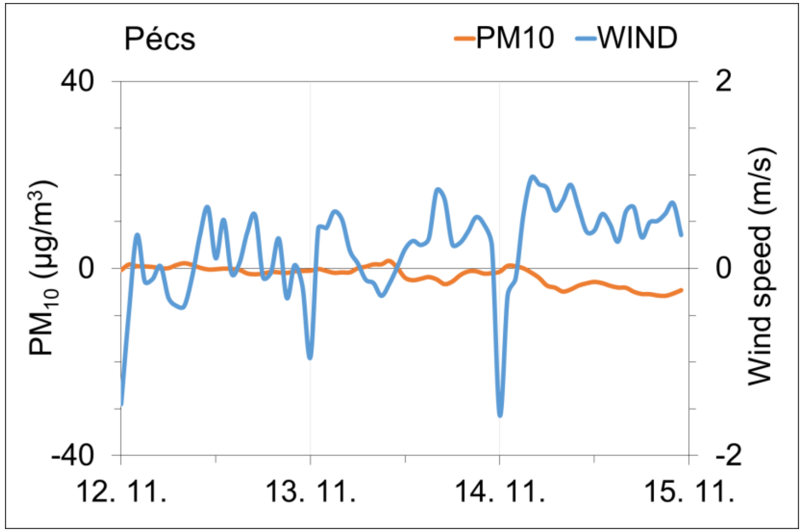
light wind





strong wind

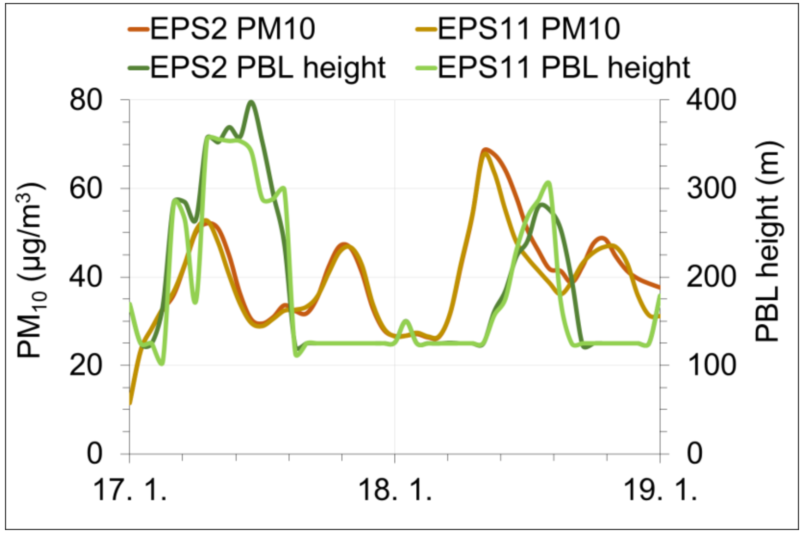


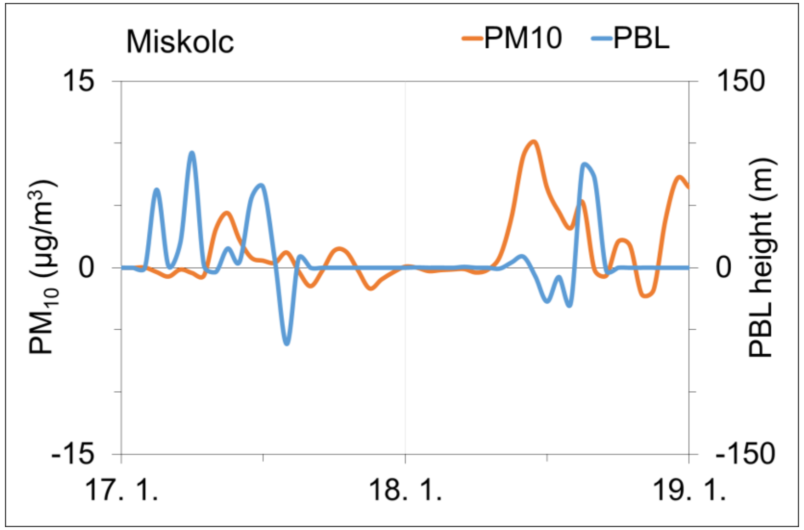


wind	
light	$< 2\ m\ s^{-1}$
strong	$> 2\ m\ s^{-1}$

Effect of the PBL height on the air quality forecast

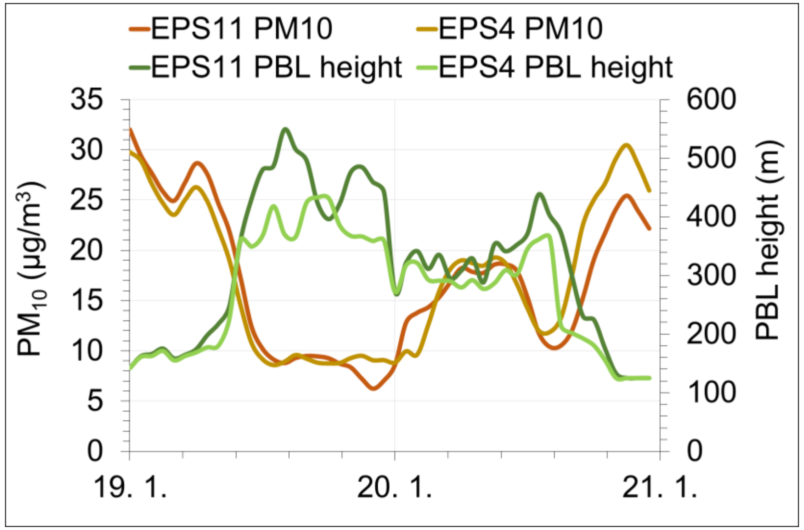
low PBL

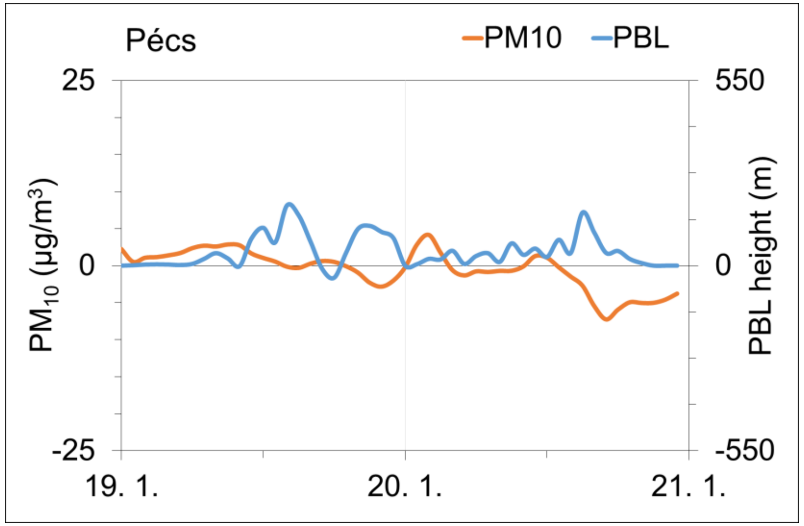




PBL height	
low	< 400 m
high	> 400 m

high PBL





Conclusions

- Local accumulation of air pollutants significantly depends on the current meteorological conditions.
- Key meteorological parameters: wind speed, planetary boundary layer, (precipitation)
- Using EPS members → do not improve the PM_{10} prediction:
  - Explanation: in the first two days there is no big difference between the EPS members

Wind:

- Strengthening of wind speed causes the accumulated air pollutants to diffuse, thereby leading to an improvement in air quality.
- Decreasing wind speeds favor the accumulation of pollutants and induce a decline in air quality.
- The differences in the concentration fields due to the modified meteorology are more pronounced in the case of lower wind speeds than they are in the case of higher wind speeds.

PBL height:

- Increasing boundary layer height is coupled with the decrease of pollutant concentrations.
- Decrease in the planetary boundary layer height leads to a definite increase in concentrations.
- The differences in the concentration fields due to the modified meteorology are more pronounced in the case of higher boundary layer than they are in the case of lower boundary layer height.

Results can be found in the journal ***Időjárás***

Zita Ferenczi, Emese Homolya, Krisztina Lázár, and Anita Tóth: Effect of the uncertainty in meteorology on air quality model predictions. Időjárás 125, 625–645.

Thank you for your attention!

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