INFLUENCE OF PERTURBATION OF SURFACE TEMPERATURE ON TEMPERATURE INVERSION AT SELECTED SYNOP STATIONS IN POLAND

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INTRODUCTION

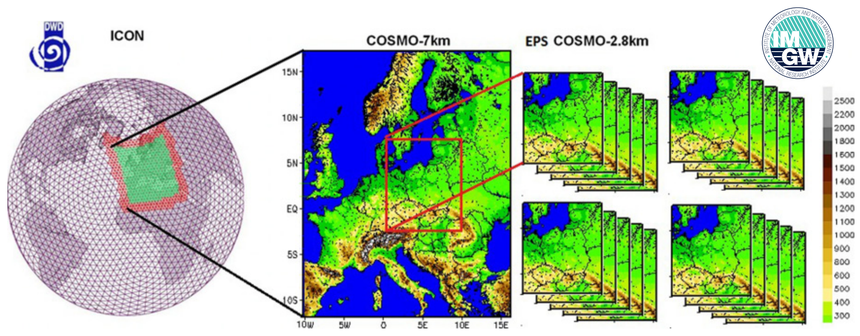
A nocturnal surface-based temperature inversion refers to a phenomenon in the lower troposphere where air temperature increases with height.

Such inversions are of interest because they play a significant role in enhancing the risk of frost events during the autumn–spring period and in promoting the accumulation of air pollutants near the surface, with potential adverse impacts on human health.

DATA AND METHODS

For the modeling, we used the COSMO-2k8 ensemble prediction system with perturbations applied to the surface level soil temperature (T_SO).

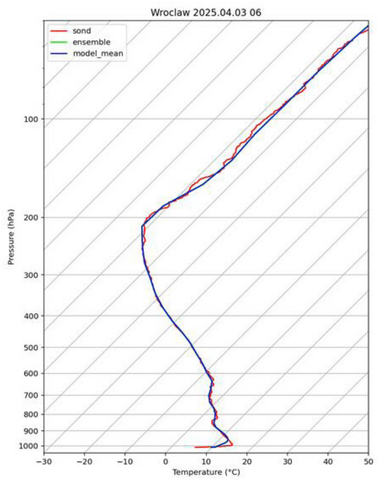
The key conditions for nocturnal inversion formation are: the absence of cloud cover, which enhances radiative cooling, and weak winds or calm conditions, which minimize vertical air mixing and thus intensify near-surface cooling.



Based on these criteria, we analyzed meteorological observation (SYNOP) data for the period 2011–2025 and selected nights when the average cloud cover over Poland did not exceed 0.5 oktas and wind speed remained below 3 m/s. An additional requirement was sunset before 18 UTC (the forecast initialization time) to exclude the influence of incoming solar radiation. For the selected cases, SYNOP data were analyzed to identify stations where cloud cover remained at 0 oktas and wind speed did not exceed 3 m/s throughout the modeling period.

A sufficient number of cases met the criteria; however, for the initial analysis, the Wrocław station was chosen, as it conducts both standard meteorological observations and radiosonde launches.

RESULTS



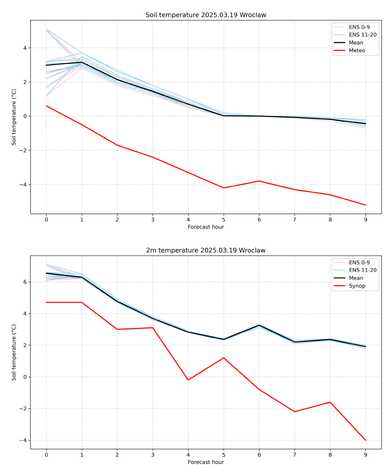
At the first stage modeling used the COSMO-2k8 ensemble with T_SO perturbations, along with a separate deterministic run. The 20 ensemble members were split into two groups:

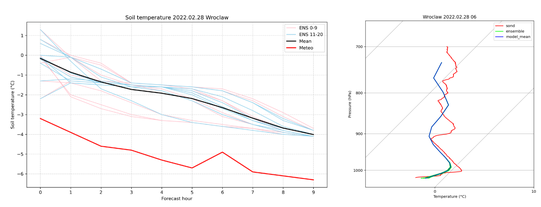
- group 1 (members 1–10) with perturbations in initialconditions only;
- group 2 (members 11–20) with perturbations in both initial and boundary conditions

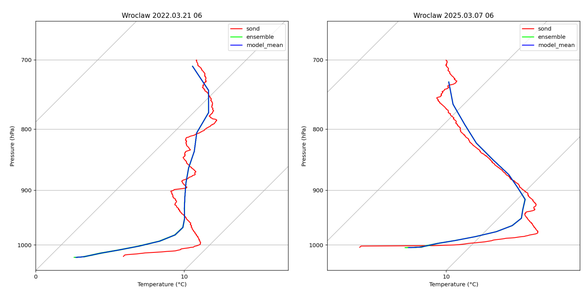
The soundings showed good agreement in the vertical distribution of air temperature between the model data and the aerological observations in the tropopause region and above.

For almost all simulated events, a characteristic feature is the rapid decrease in the amplitude of surface temperature values among ensemble members.

As a result, the amplitude of air temperature values at 2 m and higher levels also decreases.







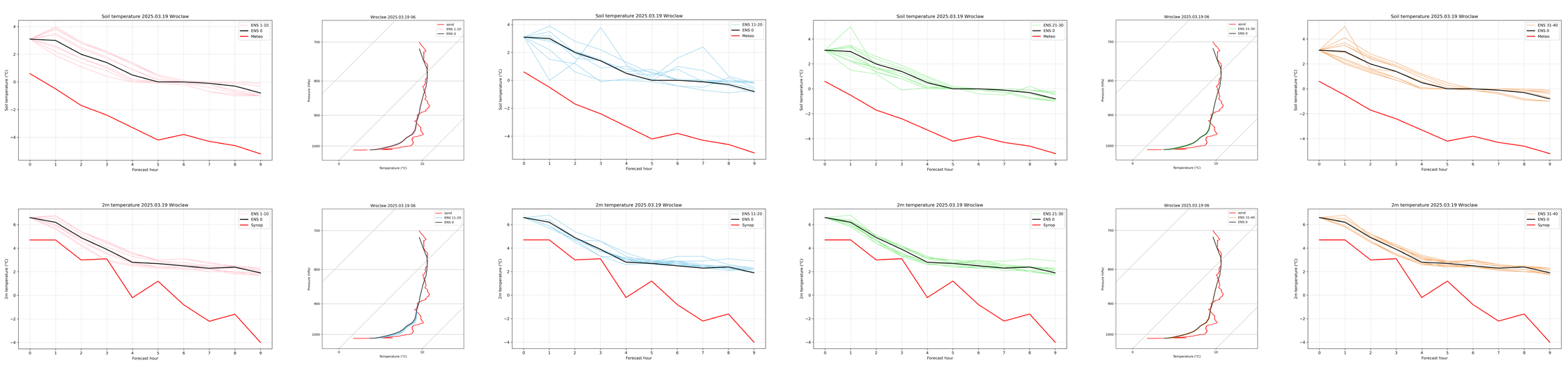
However, in the near-surface layer, most cases show significant deviations between the modeled and observed temperature profiles, both positive and negative.

However, for the case of 2022.02.28, when the amplitude of surface temperature values persists throughout the modeling period, a greater spread in air temperature values is observed, leading to improved temperature forecasts.

At the second stage, a new approach to introducing perturbations into the T_SO was implemented. A new 40-member ensemble with different methods of initialization of perturbations was generated to hold the spread during the model forecast. The members were divided into four groups of 10:

- group 1 (members 1–10): perturbations applied only to the initial conditions, with temperature deviations of ±0.5 and ±1.0 K and noise amplitude of 1–2 K during the first two time steps.
- group 2 (members 11–20): perturbations applied to both the initial and boundary conditions, with gradual accumulation of shift and amplitudes from 0.05 to 1.0 K; due to the simulation time step, the maximum amplitude over 12 h reaches ±0.3 K.
- group 3 (members 21–30): perturbations up to ±1.0 K, accumulated during the first ~100 minutes (240 steps).
- group 4 (members 31–40): perturbations up to ±1.0 K, accumulated rapidly during the first ~17 minutes (40 steps).

The new perturbation scheme demonstrated not only the preservation of spread among individual ensemble members, but also its propagation up to a height of about 900 hPa, which was not observed in previous simulations.



NEXT STEPS

Future work will include the analysis of the obtained results for other aerological sounding stations as well as for the remaining synoptic stations within territory of Poland. In addition, the simulations will be repeated using the ICON model.