Comparing The P3 and Thompson Microphysics Schemes Of The February 3rd, 2020 Cold Air Outbreak Using The WRF Model

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Background and Motivation

- Cold Air Outbreaks (CAOs) in the marine boundary layer occur when cold, polar air moves over warmer ocean surfaces, causing significant weather changes. Accurate modeling of these events is crucial for improving weather forecasts and understanding climate variability.
- This study compares two microphysics schemes in the Weather Research and Forecasting (WRF) model: the P3 (Predicted Particle Properties) scheme and the Thompson scheme. The P3 scheme offers a detailed representation of cloud processes, while the Thompson scheme uses a simpler, empirical approach.
- We focus on a CAO event from February 3rd, 2020 to evaluate the performance of these schemes. By analyzing the differences in cloud structure, precipitation rates, and radiative properties, we aim to identify which scheme better represents CAO characteristics. This comparison will enhance our understanding and modeling of CAOs, leading to more accurate weather predictions.

Methodology

Domain Setup
- Configured with WPS, centered over the Norwegian and Barents Seas (see Figure 1).
- Inner Domain centered over the AMF 1 site (Andenes, Norway)

Model Configuration
- Initial/boundary conditions from ERA5 reanalysis.
- There are 45 vertical levels
- Horizontal resolution:
  - dx: 9000m for outer domain, 3000m for inner domain
  - dy: 9000m for outer domain, 3000m for inner domain

Microphysics Scheme
- **P3:** Detailed cloud process representation (Morrison et al. 2009)
- **Thompson:** Simpler, empirical approach

Data Analysis
- Compared cloud structures, latent heating, sensible heat flux, and radiative properties.
- Validated with COMBLE observational data.

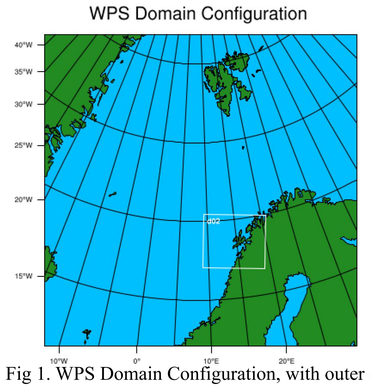

Fig 1. WPS Domain Configuration, with outer domain over Norwegian Sea and inner domain over the Andenes AMF1 site.

Results

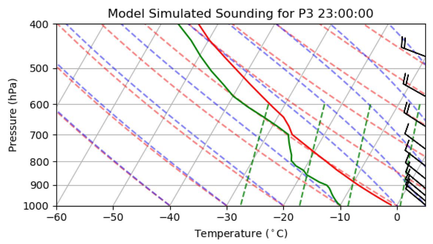

Fig. 2a P3 model simulated sounding at 2000 UTC.

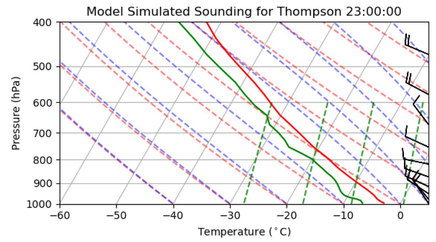

Fig. 2b Thompson model simulated sounding at 2000 UTC.

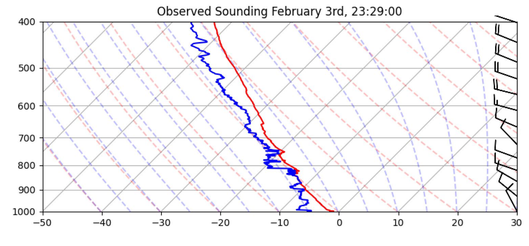

Fig. 3 Observed sounding at Andenes, Norway AMF-1 site at 2329 UTC

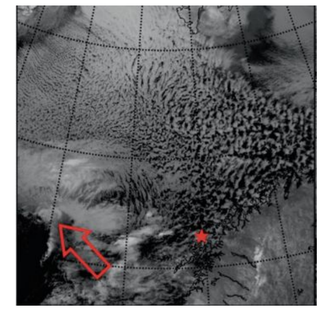

Fig. 4 Observed Infrared Satellite February 3rd, 2020 2045 UTC. Source: Lackner et al. (2023).

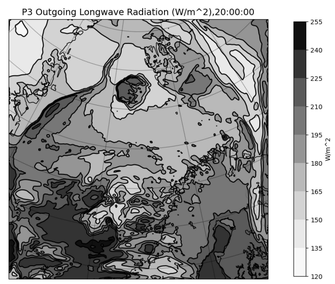

Fig. 5a Simulated TOA outgoing longwave radiation for the P3 model output at 2000 UTC

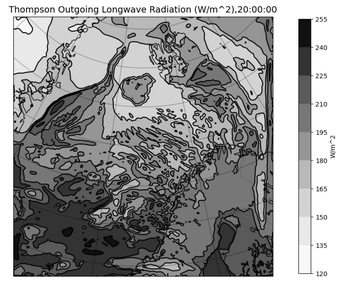

Fig. 5b Same as Fig. 5a, but for the Thompson model output.

- Very minimal differences between the P3 and Thompson longwave radiation outputs
- The Thompson output has a more accurate longwave radiation Output

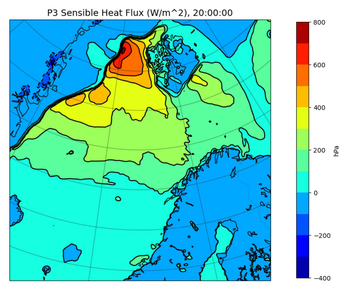

Fig. 8a Simulated sensible heat flux for the P3 model output at 2000 UTC.

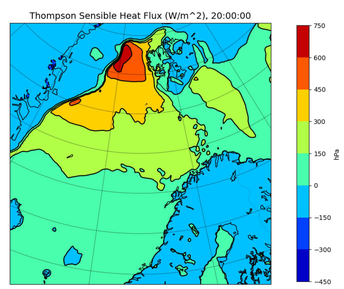

Fig. 8b Same as Fig. 8a, but for the Thompson model output.

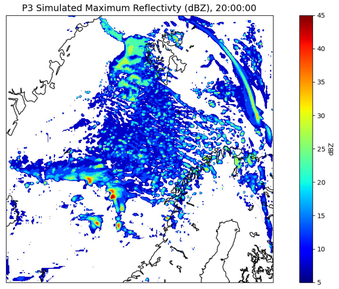

Fig. 6a Simulated composite reflectivity for the P3 model output at 2000 UTC.

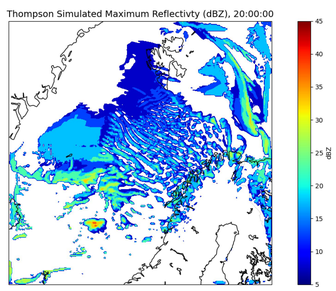

Fig. 6b Same as Fig. 6a, but for the Thompson model output.

- P3 Model reflectivity is more defined, some could be contributed to the different variables used to plot these figures.
- Thompson microphysics does not pick up on as many details in the reflectivity.
- The P3 microphysics picks up on more reflectivity and more cellular characteristics.

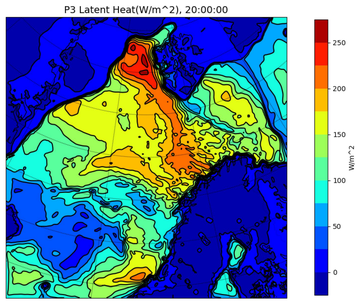

Fig. 7a Simulated latent heat flux for the P3 model output at 2000 UTC

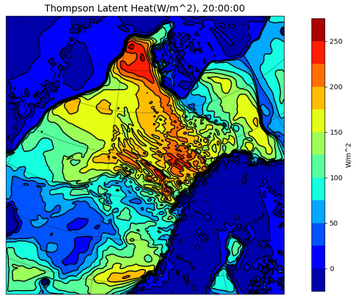

Fig. 7b Same as Fig. 7a, but for the Thompson model output.

- Very minimal differences between the P3 and Thompson microphysics outputs.
- The Thompson output picks up on slightly more latent heating

- There are very minimal differences for sensible heat flux at surface between the two outputs.

Conclusions

- The Thompson microphysics scheme performed better simulating the cold air outbreak than the P3 microphysics scheme.
- The Thompson microphysics scheme gave a more accurate simulation of the cloud characteristics.
- There were very minimal differences between all the products besides reflectivity.
- The P3 simulated sounding was more accurate.

Acknowledgements

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Scan for references