Modelling Cold Air Outbreaks from the Cold Air Outbreak Experiment in the Sub-Arctic Region (CAESAR) Campaign

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Abstract

Utilizing data collected from research flights RF02 and RF07 from the Cold Air Outbreak Experiment in the Sub-Arctic Region (CAESAR), Cold Air Outbreaks (CAOs) can be modeled and verified to improve understanding of CAOs. CAESAR utilized a C130 plane to collect in-situ measurements with which this research was conducted.

Motivation

CAOs are significant weather events in the arctic that impact the global radiation balance. Without the proper Ensuring that weather events are modelled correctly can significantly improve forecast accuracy. By completing models of two different CAO cases, different modelling schemes can be tested and compared for their accuracy.

Data and Methodology

Data:

1. MET Norway Equivalent Radar Fraction (dBz) data
2. NCAR High Rate Flight data
3. Two WRF model simulations
   a. Research Flight (RF) 02
      i. 9 km outer domain (d01)
      ii. 3 km inner domain (d02)
      iii. Two 1 km nested domains (d03,do4)
   b. RF07
      i. 9 km outer domain (d01)
      ii. 3 km inner domain (d02)

Methodology:

4. Compare IR satellite imagery to model OLR
5. Compare radar ERF to 10 cm reflectivity output
6. Compare observed LWP to modelled LWP

Parameter	RF02 Schemes	RF07 Schemes
Microphysics	Morrison (option 10)	P3 (option 52)
Surface Layer	Revised MM5 (option 1)	Revised MM5 (option 1)
Surface	Noah Land Surface (option 4)	Noah Land Surface (option 4)
Cumulus (only d01)	Grell Freitas (option 3)	Multi-Scale Kain Fritsch (option 11)
Boundary Layer	MYNN 2.5 (option 5)	MYNN 2.5 (option 5)
Lw/Sw Radiation	RRTMG (option 4)	RRTMG (option 4)

Results

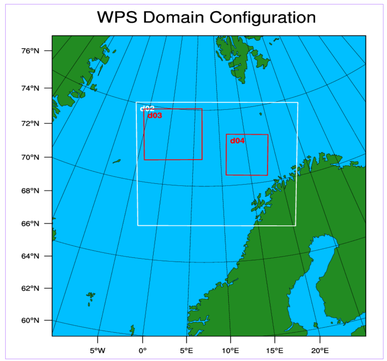

Figure 1a: Model domain for RF02.

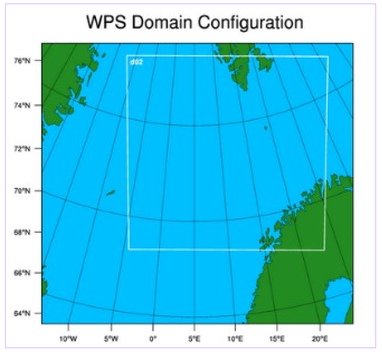

Figure 1b: Model domain for RF07.

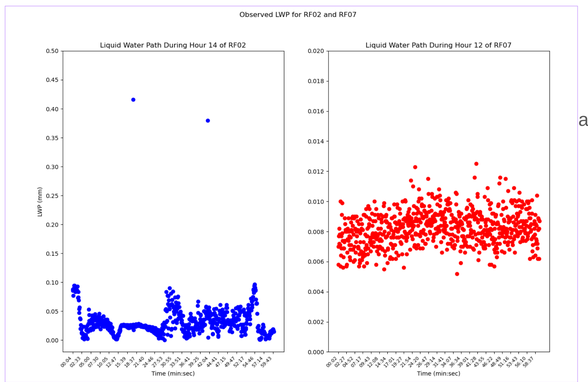

Figure 2: Observed Liquid Water aths from RF02 and RF07. RF02 has higher LWP values, correlating to it being a weaker, Mode B, CAO. RF07 has lower LWP values, correlating to it being a stronger, Mode A, CAO, Geerts (2022).

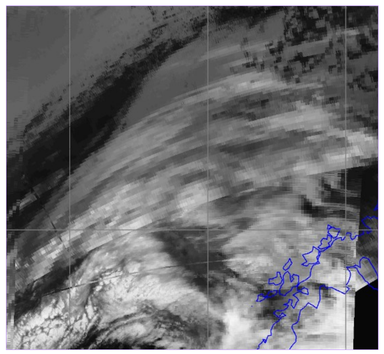

Figure 3a: MODIS IR Satellite during RF02 at 1450Z.

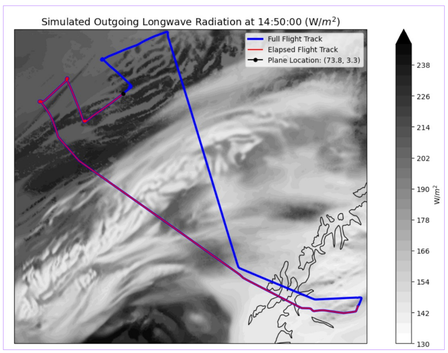

Figure 3b: Simulated Outgoing Longwave Radiation during RF02 at 1450Z in D02.

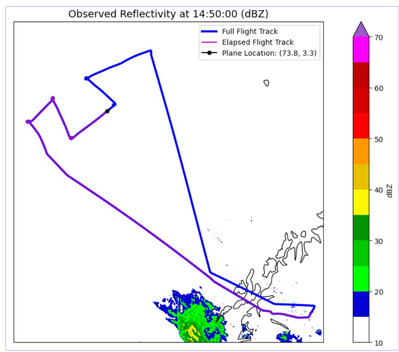

Figure 4a: MET Norway reflectivity during RF02 at 1450Z (coast only).

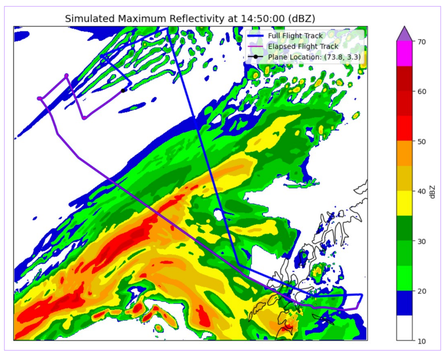

Figure 4b: Simulated 10CM reflectivity during RF02 at 1450Z in D02.

Results cont.

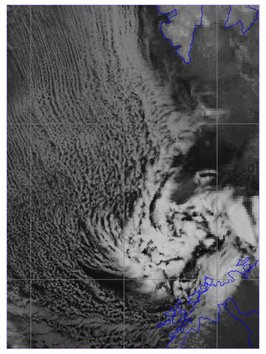

Figure 5a: MODIS IR Satellite during RF07 at 1245Z.

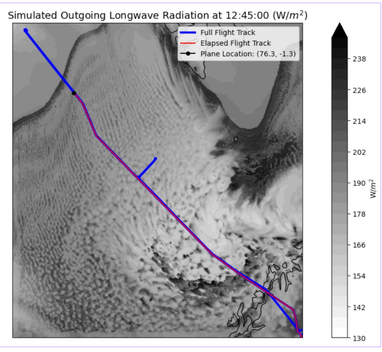

Figure 5b: Simulated Outgoing Longwave Radiation during RF07 at 1245Z in D02.

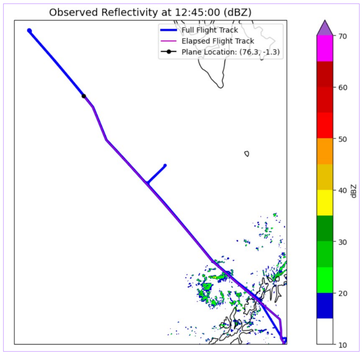

Figure 6a: MET Norway reflectivity during 1245Z (coast only).

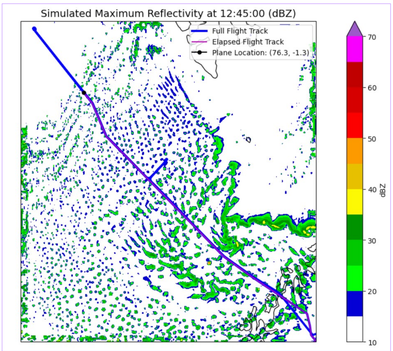

Figure 6b: Simulated 10CM reflectivity during RF07 at 1245Z in D02.

Conclusions and Acknowledgements

- Figure 6 shows that the RF02 model might be delayed by some time since the precipitation bands are not aligned.
- Both models overestimated cloud intensity, displayed in Figures 3 and 5. This is seen by the lack of contrast in the model plots compared to the satellite imagery.
  - The cumulus scheme could potentially interfere with the models' reading on atmospheric moisture, so another model run without the cumulus scheme may be prudent.
- Geerts, B., and Coauthors, 2022: The COMBLE Campaign: A Study of Marine Boundary Layer Clouds in Arctic Cold-Air Outbreaks. *Bull. Amer. Meteor. Soc.*, **103**, E1371–E1389, https://doi.org/10.1175/BAMS-D-21-0044.1.
- The model reflectivity for RF02 was greatly overestimated, which may be due to the MP scheme.
- Future research in Model LWP and WCR comparison will be completed.
- Thank you to NSF NCAR EOL for providing flight data (https://data.eol.ucar.edu/).
- Thank you to MET Norway for providing radar data.
- Thank you NSF for funding our research for CAESAR, award number 2317116.
- Thank you to Dr. Wang and Daniel for being wonderful guides during this project.