Cloud morphology in simulated marine cold-air outbreaks over the Norwegian Sea during COMBLE: sensitivity to aerosol treatment and ice production

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1) Selected Cold-air outbreaks during the COMBLE campaign

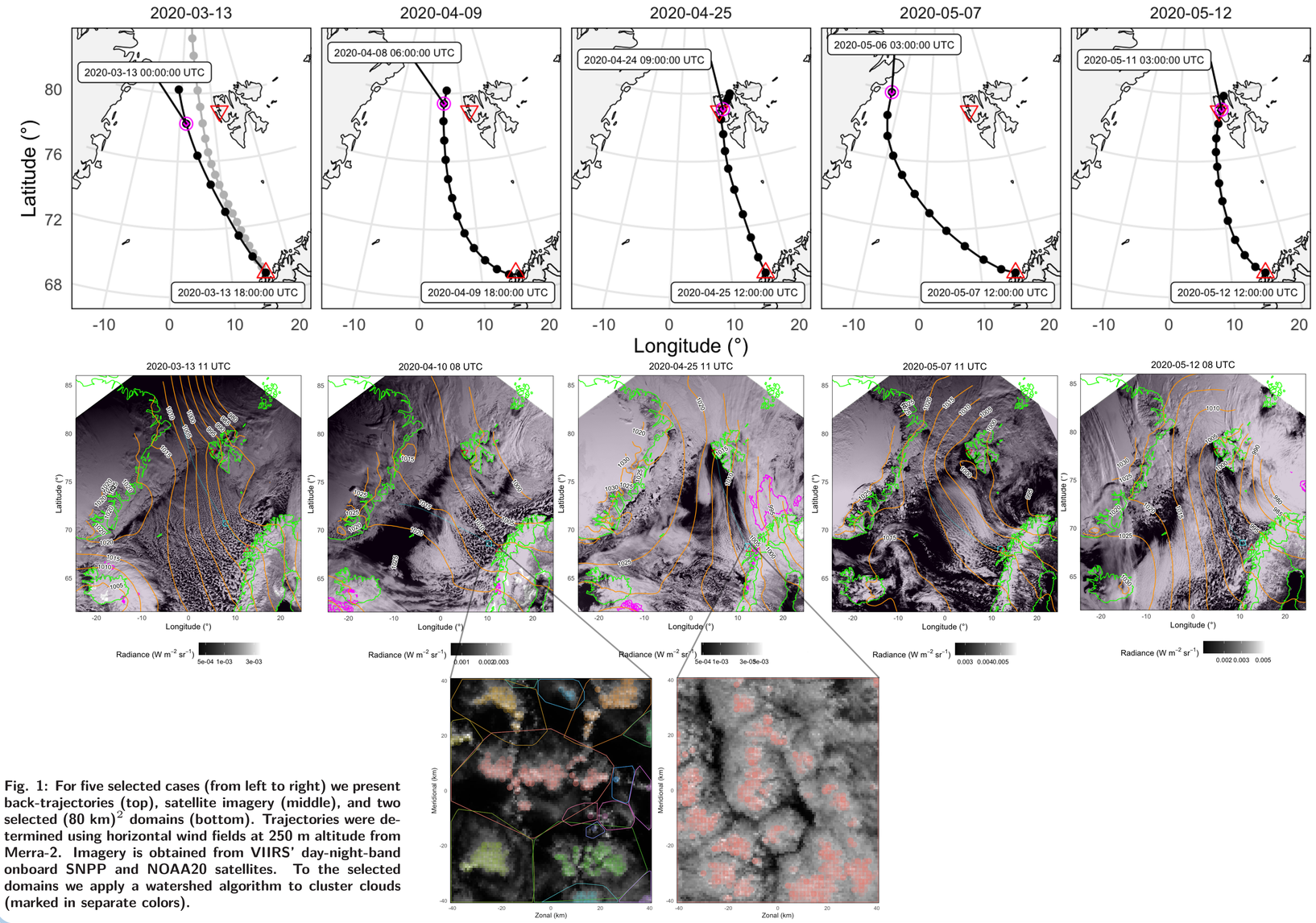

Fig. 1: For five selected cases (from left to right) we present back-trajectories (top), satellite imagery (middle), and two selected (80 km)^2 domains (bottom). Trajectories were determined using horizontal wind fields at 250 m altitude from Merra-2. Imagery is obtained from VIIRS' day-night-band onboard SNPP and NOAA20 satellites. To the selected domains we apply a watershed algorithm to cluster clouds (marked in separate colors).

3) Analyzing Cloud Morphology in LES

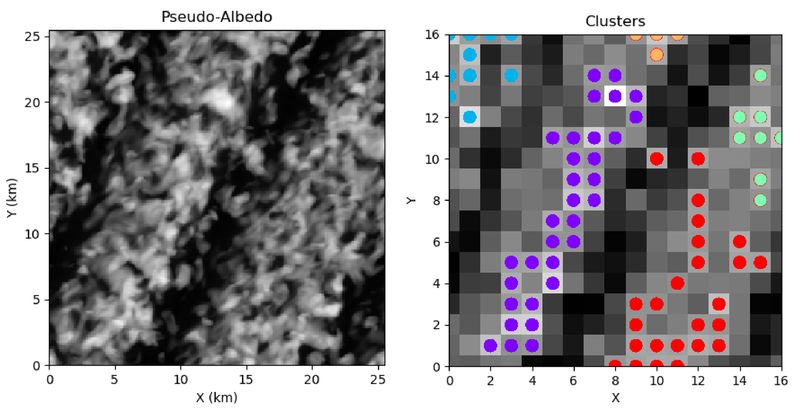

Fig. 3: A 2D pseudo-albedo field from a preliminary simulations (left) and after coarsening and clustering (right).

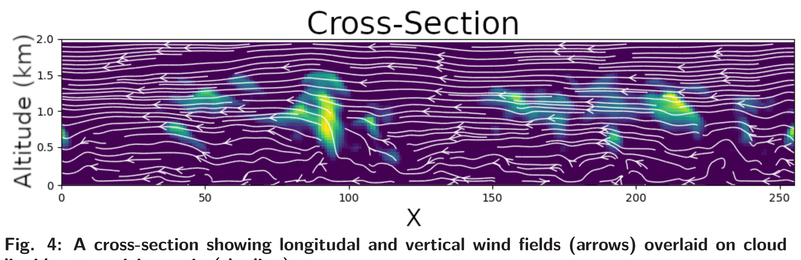

Fig. 4: A cross-section showing longitudal and vertical wind fields (arrows) overlaid on cloud liquid water mixing ratio (shading).

4) Understanding Case Differences

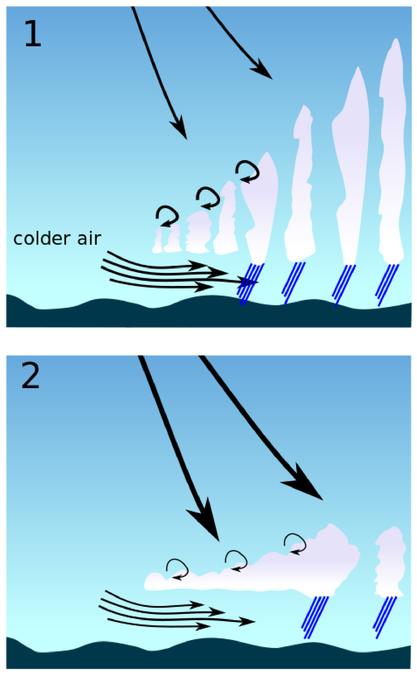

Fig. 5: A sketch showing reanalysis-based meteorological differences (not shown) and the resulting morphology (see above imager) driven by hypothesized microphysical processes.

Key Points

- Selected cold-air outbreak cases show of a wide range of cloud morphological transitions, consistent with a gamut of meteorological and aerosol conditions.
- For one case, LES demonstrate the importance of prognostic, multi-modal aerosol and show homogeneous freezing at final stage.
- In the near future, implement a prognostic ice nucleating particle scheme tied to prognostic multi-modal aerosol.

2) LES of 2020-03-13 case

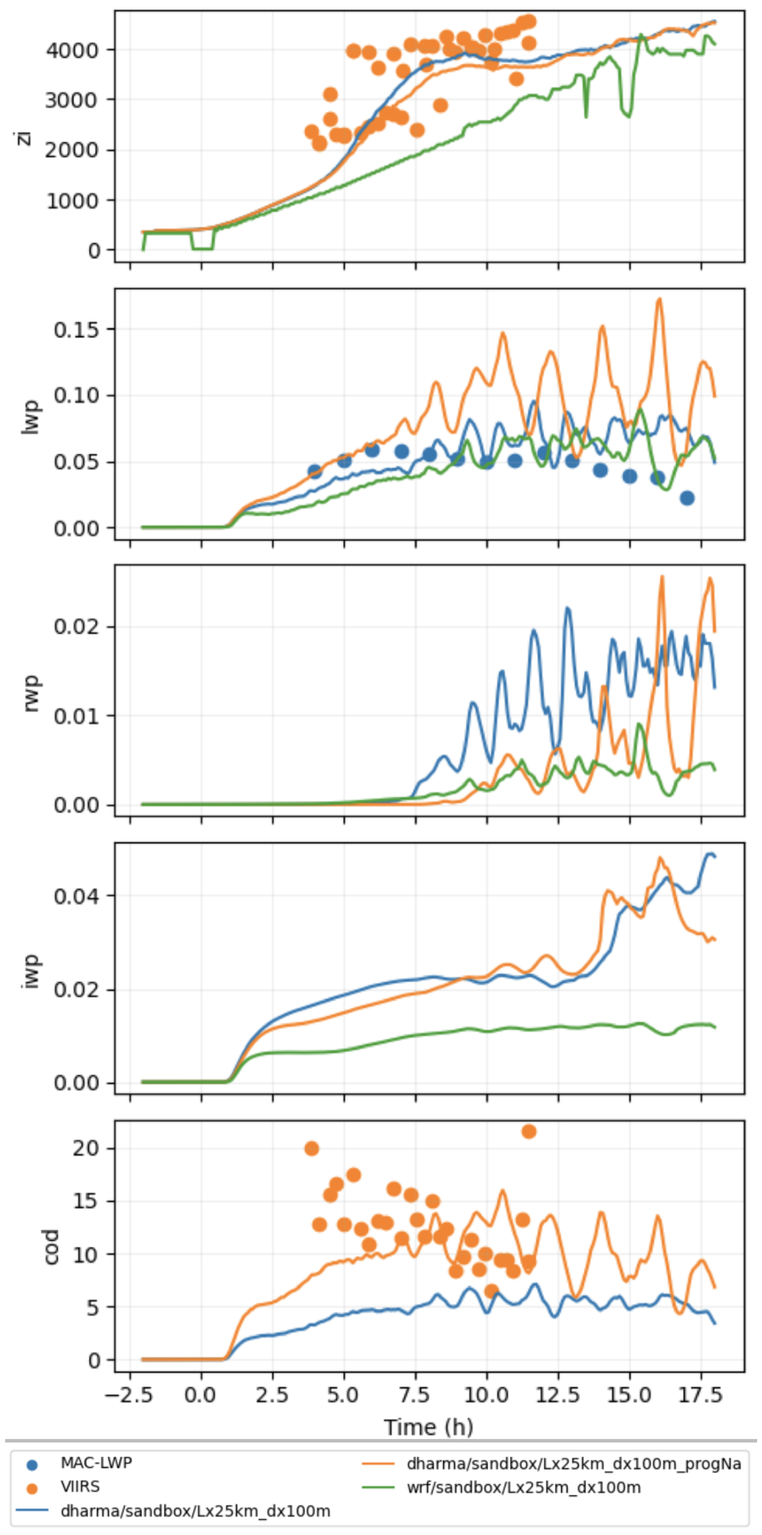

Fig. 2: Simulations with varying models and setups (colored lines). Where available we include observational targets (colored points) from overpassing satellites carrying imagers (VIIRS) and microwave radiometers (MAC-LWP). From top to bottom are domain-wide averages: inversion height (zi) liquid water path (LWP), rain water path (RWP), ice water path (IWP), cloud optical depth (cod).

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