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Large-eddy simulation of a cold air outbreak over the North Atlantic Ocean

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Cold air outbreaks are a common winter time feature over Northern Europe where cold air breaks free from the polar cap and sweeps over open oceans towards the continent. They may bring snow and increase the severity of particular types of hazardous mesoscale weather events. The convection typically begins as organised rolls and eventually changes into open cellular convection as the boundary layer evolves. Cold air outbreaks are challenging for numerical weather prediction models as the depth of the boundary layer and the scale of the convection approaches the model resolution. The cloud morphological evolution during such events can have important impacts on the transport of heat and moisture as well as radiative effects. High latitude Short Wave errors are one of the largest biases in climate models.

In the present study, which is conducted as part of the WGNE Greyzone project, a large-eddy simulation model, the UCLA LES, is used to investigate a cold air outbreak crossing from the Norwegian Sea into the Atlantic Ocean. The large-eddy simulation is based on observations taken during the UK Met Office CONSTRAIN campaign from January 31st 2010 and associated simulations with the UK Met Office Unified Model, a numerical weather prediction model. The day was characterised by northerly flow and stratocumulus clouds in the early stage of the event. As air advects over warmer seas the stratocumulus transitions into mixed-phase cumulus clouds, prior to reaching land.

We present the results of sensitivity experiments in which the role of surface fluxes, cloud microphysics, and cloud droplet number concentrations are investigated. Implications for parameterizations of heat, moisture and momentum mixing within the convective boundary layer as well as cloud microphysical processes in numerical weather prediction and climate models are discussed.