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Polar Lows - Moist Baroclinic Cyclones Developing in Four Different Vertical Wind Shear Environments

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Polar lows are intense mesoscale cyclones that develop in polar marine air masses. Motivated by the large variety of their proposed intensification mechanisms, cloud structure, and ambient sub-synoptic environment, we use self-organising maps to classify polar lows.

We identify five different polar-low configurations which are characterised by the vertical wind shear vector, the change of the horizontal-wind vector with height, relative to the propagation direction. Four categories feature a strong shear with different orientations of the shear vector, whereas the fifth category contains conditions with weak shear. This confirms the relevance of a previously identified categorisation into forward and reverse-shear polar lows. We expand the categorisation with right and left-shear polar lows that propagate towards colder and warmer environments, respectively.

For the strong-shear categories, the shear vector organises the moist-baroclinic dynamics of the systems. This is apparent in the low-pressure anomaly tilting with height against the shear vector, and the main updrafts occurring along the warm front located in the forward-left direction relative to the shear vector. These main updrafts contribute to the intensification through latent-heat release and are typically associated with comma-shaped clouds.

Polar low situations with a weak shear, that often feature spirali-form clouds, occur mainly at decaying stages of the development. We thus find no evidence for hurricane-like intensification of polar lows and propose instead that spirali-form clouds are associated with a warm seclusion process.