Interactions between Arctic boundary layer and low level mixed-phase clouds

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Observing Mixed-Phase Clouds

- Low-level stratiform liquid containing clouds have a major influence on Arctic surface radiation balance1.
- Focus on mixed-phase cloud microphysics
  - How does the environment at measurement sites influence cloud properties (life cycle, altitude, geometric thickness, water content...)?

Observations at Ny Ålesund

- Comprehensive cloud observations carried out at the AWIPEV station2.
- Ground based remote sensing, surface meteorology and instrument synergy (Cloudnet).
- Here using data from June 2016 – February 2018 and only considering occurrences of persistent low-level mixed-phase clouds.
  - Criteria: Co-located ice and liquid found; liquid layer persists > 1h; cloud liquid located close to cloud top; cloud top < 2.5 km

Turbulence and cloud properties

- The thermodynamical coupling of the cloud to the surface constrains the extent of interactions possible with the underlying surface: Surface is a potential source of humidity and aerosol.
- Turbulence and thermodynamical structure has been linked with microphysical processes (liquid and ice formation, sublimation of precipitation)3.

Evaluating cloud-surface coupling

Using potential temperature (θ) -profiles from soundings to determine coupling state3.

- Profiles map closely to sounding time, and surface observations. Cloud boundaries and decoupling height determined by the sounding profile are also shown.

Turbulence below of coupled and decoupled clouds

Intensity of turbulence in the sub-cloud layer is estimated using wind lidar - VAD scan with 4 beams

Using retrieved vertical wind (w) to calculate w variability (σw) and skewness (S3)

Four beam retrieval for \( u'w' \) and \( v'w' \)

→ \( u'(z) = \sqrt{(u'w'^2 + v'w'^2)} \)

Fig 4. Mean (lines) ± standard deviation (shaded areas) profiles of turbulence parameters retrieved from wind lidar (see details above). Cloud coupling is determined using the combination of MWR and surface observations.

Cloud properties

Fig 5 (above). The fraction of observed cases that are coupled varies seasonally.

Fig 6 (right). Coupled clouds are on average lower than decoupled ones. The height of the liquid layer also varies seasonally, being lowest in summer and highest in winter (not shown).

Conclusion

- Methods to evaluate cloud-surface coupling and the intensity of below cloud turbulence developed.
- Coupling influences turbulence, but how does it influence micro-physics?
- Future work: Using radar Doppler moments to dive into micro-physics.