# Influence of sea ice leads and polynyas on Arctic cloud properties

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B07

## 1. Summary

Research questions:

**Q1** How is **cloud cover** changed in the presence of leads or polynyas?

**Q2** How are macro-, microphysical and radiative **cloud properties** influenced by leads or polynyas?

**Q3** Are there **differences** in Q1 and Q2 for different locations (Western Arctic vs. Central Arctic)?


*Fig. 1: Sea ice lead with developing sea smoke. Photo: Jörg Hartmann, AWI*

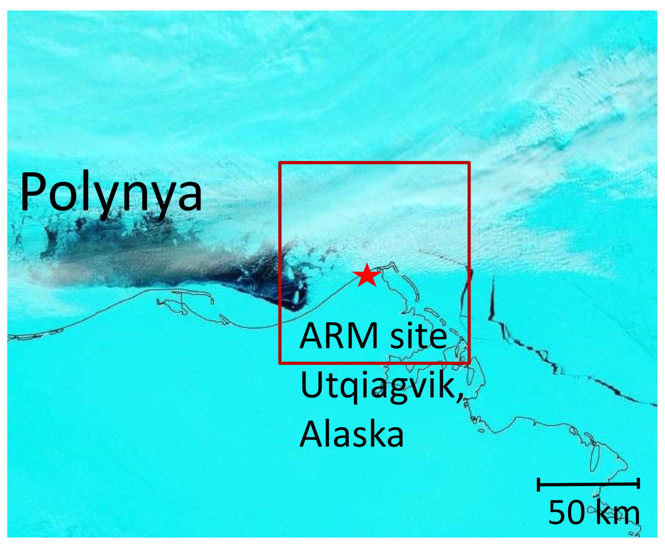



*Fig. 2: MODIS satellite image of polynya on April 22, 2015.*

## Hypothesis

**Sea ice leads or polynyas increase the amount of boundary layer clouds, change their microphysical and radiative properties, and thus enhance Arctic amplification.**

## 2. Research rationale

State-of-the-art

- Winter: > 50% of ocean-air heat exchange via open water patches
- Influence of open water on Arctic atmosphere largest in winter
- Formation of clouds in lee of sea ice leads and polynyas [Lüpkes et al., 2008b, JGR]
- Arctic amplification → changing lead distribution
- Positive feedback loop: more leads/polynyas → more warming/moisturizing of atmos. → more low-level clouds → further warming

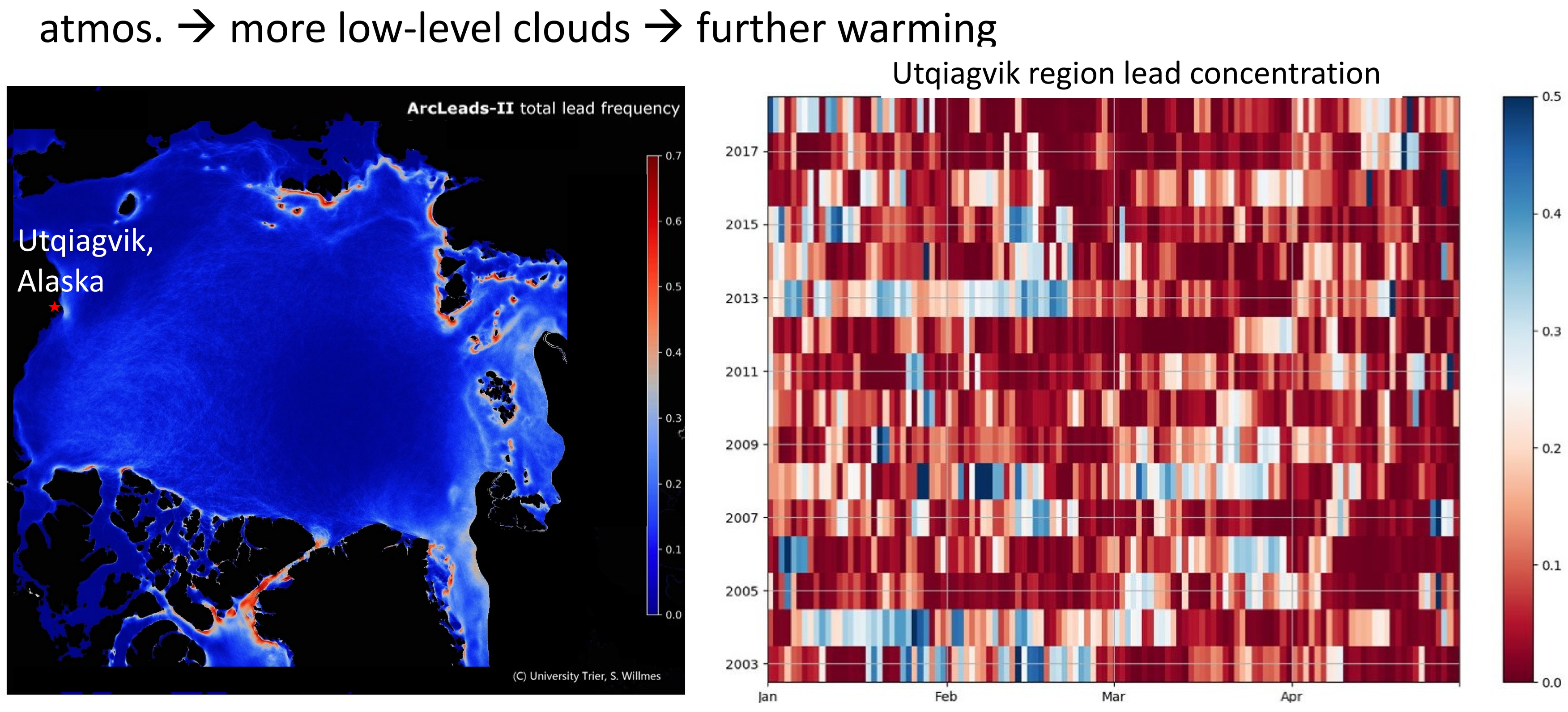



*Fig. 3: Left: Total lead frequency in Jan – April (2003-2018) determined with MODIS-based ArcLeads-II product. Right: Associated daily lead concentration in Utqiagvik. Images produced by S. Willmes.*

Preliminary work

- 8 years experience in ground-based cloud remote-sensing including ARM Utqiagvik data set and mixed-phase cloud focus [Kalesse et al., 2016a, Mon. Wea. Rev.]
- Development of new cloud radar Doppler spectra peak identification tool [Kalesse et al., 2019, AMT]

## 3. Research plan phase II

- Objective: 1. Create comparative cloud climatologies of **surface-coupled** clouds during onshore winds in the **presence and absence** of leads or polynyas
- Locations: Coastal ARM station Utqiagvik (Barrow) in Alaska in the Western Arctic and MOSAiC drifting observatory in the Central Arctic
- Datasets:

1. Ground-based remote-sensing of clouds


*Fig. 4: ARM site for remote-sensing of clouds and atmosphere in Utqiagvik (Barrow), Alaska*


*Fig. 5: MOSAiC, **A01***

2. Satellite-derived maps of sea ice concentration and lead fraction

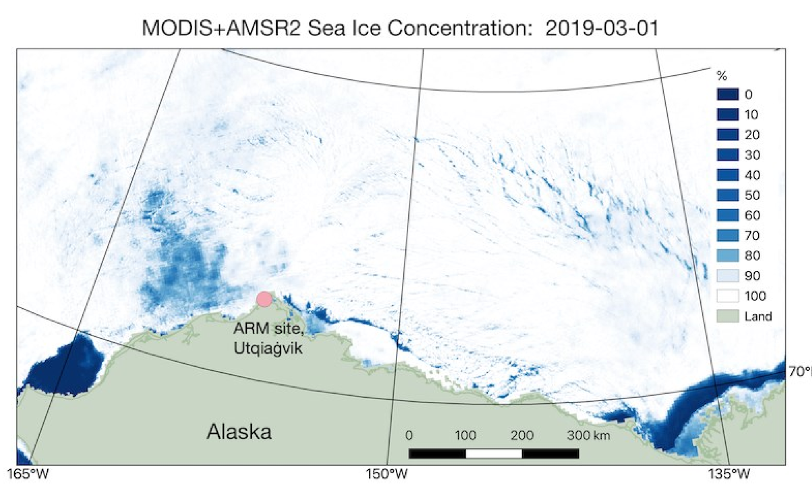



*Fig. 6: MODIS AMSR2 sea ice concentration, **D03***

Data set: ARM station at Utqiagvik (Barrow) Alaska (NSA; 71°19'N, 156° 36'W) + MOSAiC data

**WP1 Cloud climatologies**
- cloud fraction, height, thickness, layers, thermodyn. phase, surface coupling
- KAZR cloud radar, HSRL lidar, MWR

**WP2 Identification of leads/polynyas**
- AMSR-E/2 sea ice conc. (5 km, D03)
- lead fraction Sentinel-1 SAR (250 m, D03)
- (binary) MODIS ArcLeads product (1 km)

**WP3 Atmospheric conditions**
- atmospheric T, stability, moisture
- radio soundes/ECMWF diagn. analyses

**WP4 Airmass origin/cloud variability**
- back trajectory analysis
- Low-level X-SAPR PPI scans + CloudSat-CALIPSO, MODIS

**WP5 Cloud Radiative Effect (CRE) Estimation**
- broadband SW + LW surface sensors
- 1D RT calculations

**WP6 Comparative Analysis**
- How do leads or polynyas influence winter/early spring clouds?
  - Cloud fraction/height/thickness?
  - Cloud thermodynamic phase?
  - Cloud radiative effect at surface?

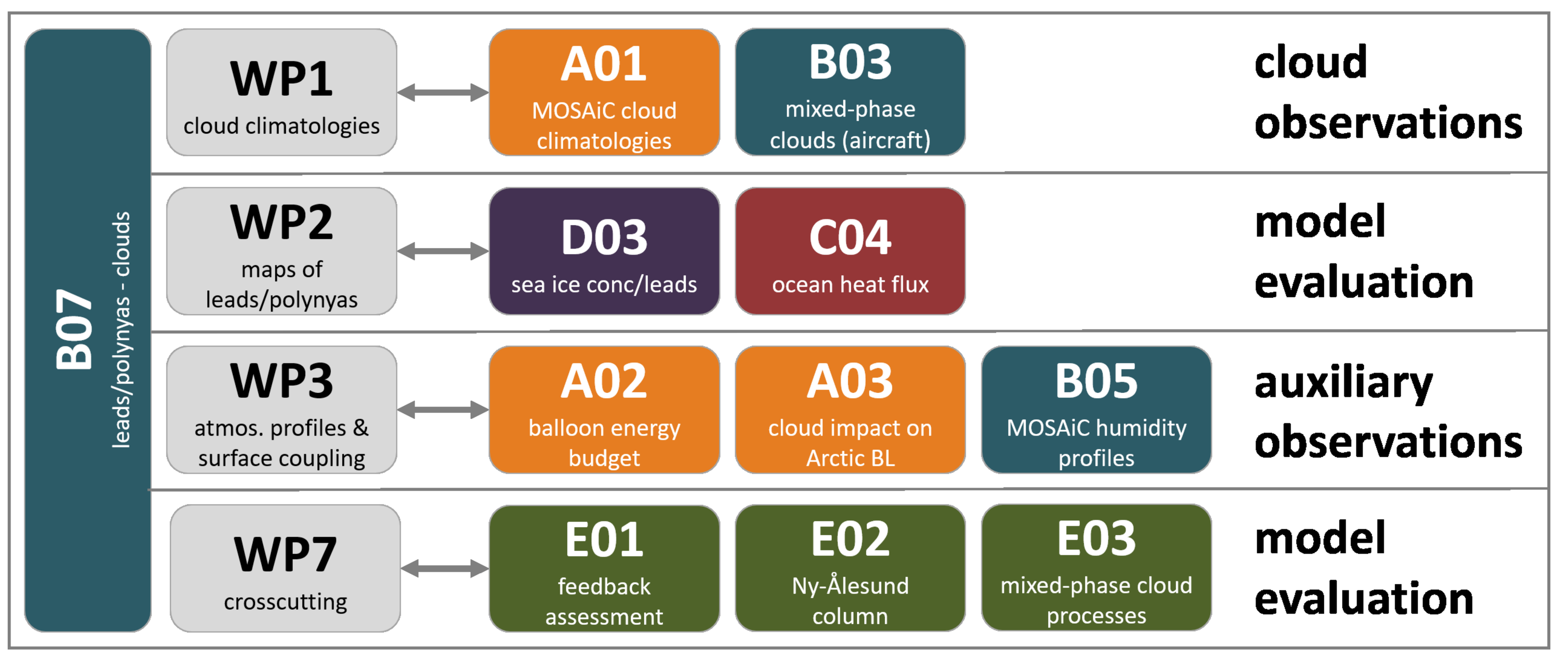
→ Combi. of different remote-sensing obs.
- ground-based, satellite-based
- active, passive
- atmosphere, sea ice

## 4. Role within (AC)³ & perspectives

Collaborations within (AC)³

Contributions to cross-cutting activities (CCA)

- CCA1: Lapse rate feedback in Alaska
- CCA2: Relate statistics of thermodynamic profiles and surface inversion strength to e.g. surface wind speed and sea ice lead or polynya properties
- CCA3: Study regional dependency of mixed-phase cloud representation in ICON model




Perspectives

Compare of cloud statistics in Utqiagvik, Alaska with upcoming **EarthCARE** satellite mission (cloud thermodynamic phase)

Link cloud statistics in Utqiagvik, Alaska with **aerosol properties** (concentration of cloud condensation nuclei and ice nucleating particles)

**Trend-assessment** of changes of leads or polynya statistics near Utqiagvik, Alaska and related cloud climatologies

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