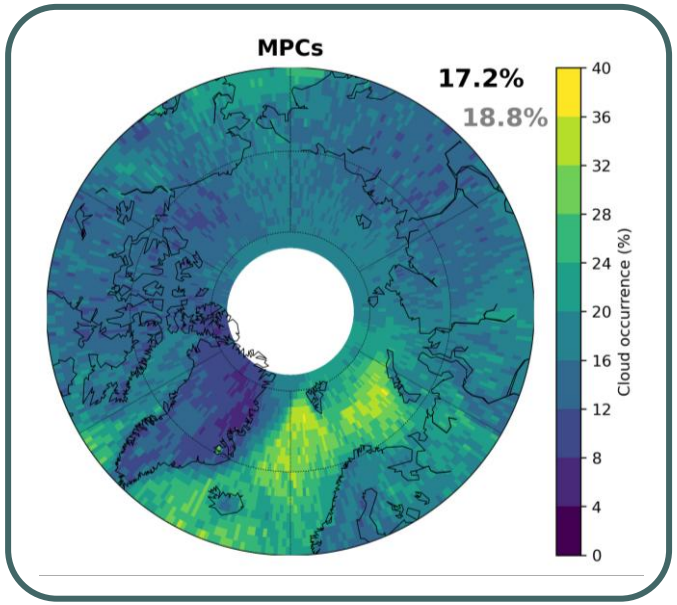
Microphysical Properties and Ice Crystal Habits of Low-Level Arctic Mixed-Phase Clouds from Four Airborne In Situ Campaigns over the Svalbard Seas

Presented by **Aymeric DZIDUCH**[(1)]

Co-authors : Antoine Baudoux, Guillaume Mioche, Antoine Canzi, Benjamin Doiteau, Manuel Moser, Emma Järvinen, Étienne Vignon, Jean-Christophe Raut, Anderson Da Silva, Régis Dupuy, Christophe Gourbeyre, Jean-Luc Baray, Marie Monier, Fred Szczap, Guillaume Penide, Julien Delanoë, Odran Sourdeval, Alfons Schwarzenboeck, Stephan Mertes, Franz Martin Schnaiter, Christiane Voigt, Mario Mech, Susanne Crewell, Andreas Herber, Christof Lüpkes, André Ehrlich, Manfred Wendisch and Olivier Jourdan

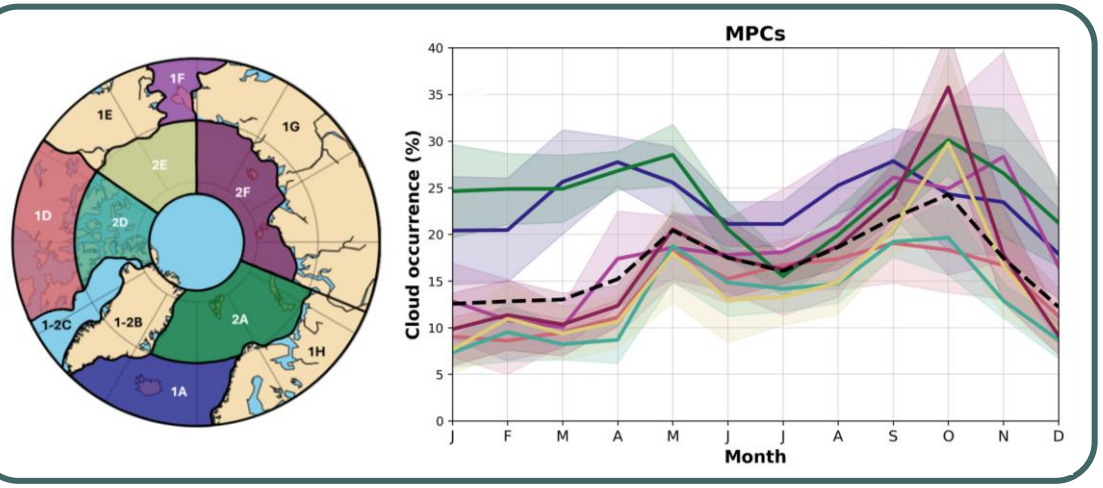
[(1)] Laboratoire de Météorologie Physique, Université Clermont Auvergne, France

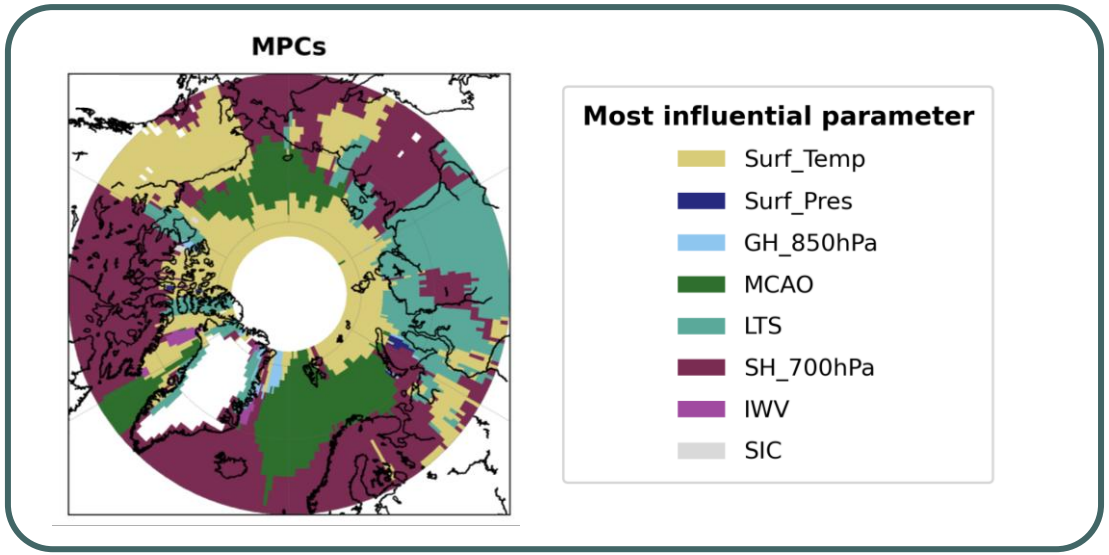
Motivation



- Reassessment of low-level cloud occurrence using satellite observations: **CALIPSO/CloudSat with DARDAR data**.
- Low-level mixed-phase clouds below 3 km near Svalbard occur approximately **40 % of the time**.
- **Two seasonal peaks** are observed, in late spring and autumn.
- Multilinear regression shows that the **Marine Cold Air Outbreak index** strongly influences MPCs occurrence over the Svalbard seas.

Dziduch et al., 2026





Campaigns and Methods

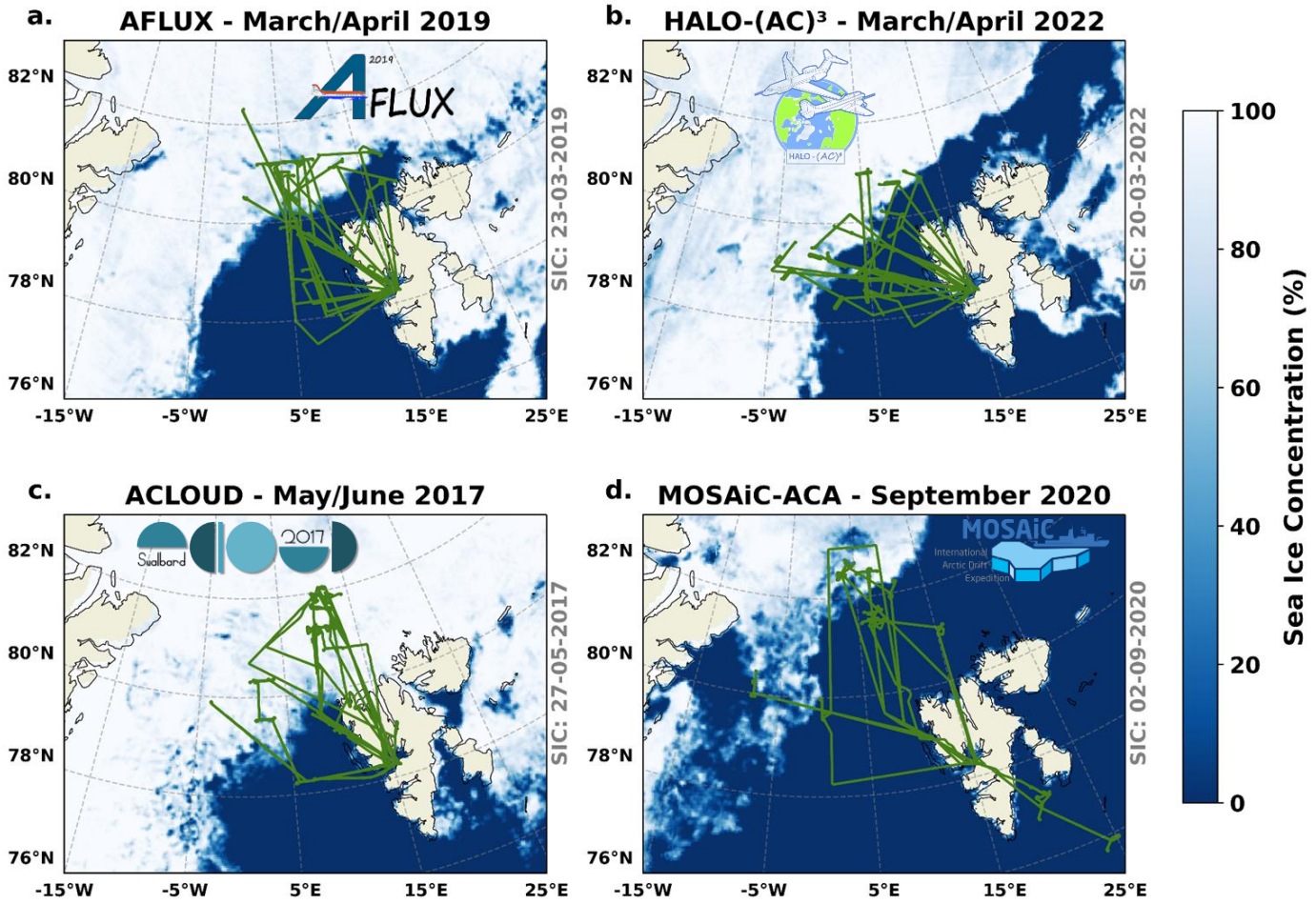
- Four Arctic airborne campaigns were conducted around Svalbard: **ACLOUD**, **AFLUX**, **MOSAiC-ACA**, and **HALO-(AC)³**.

- In situ cloud sampling was performed onboard the Polar aircraft, with more than **45 hours of in-cloud measurements**.

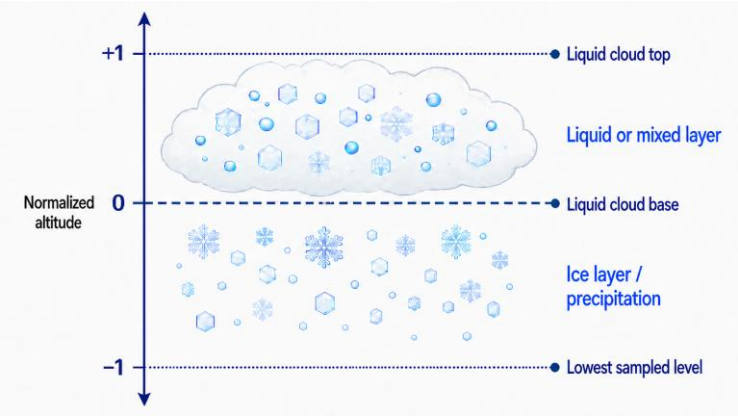
- **Cloud microphysical properties** measured using airborne probes:
  - CDP/CAS for cloud droplets (1 - 50 µm)
  - 2D-S, CIP, and PIP for ice crystals (10 – 6400 µm)

- **Ice crystal images** were classified using a convolutional neural network (Jaffeux et al., 2022), providing morphological classes.

- Meteorological regimes were identified using the **Marine Cold Air Outbreak index**, based on ERA5 potential temperature differences between the surface and 850 hPa.



Microphysical Profiles

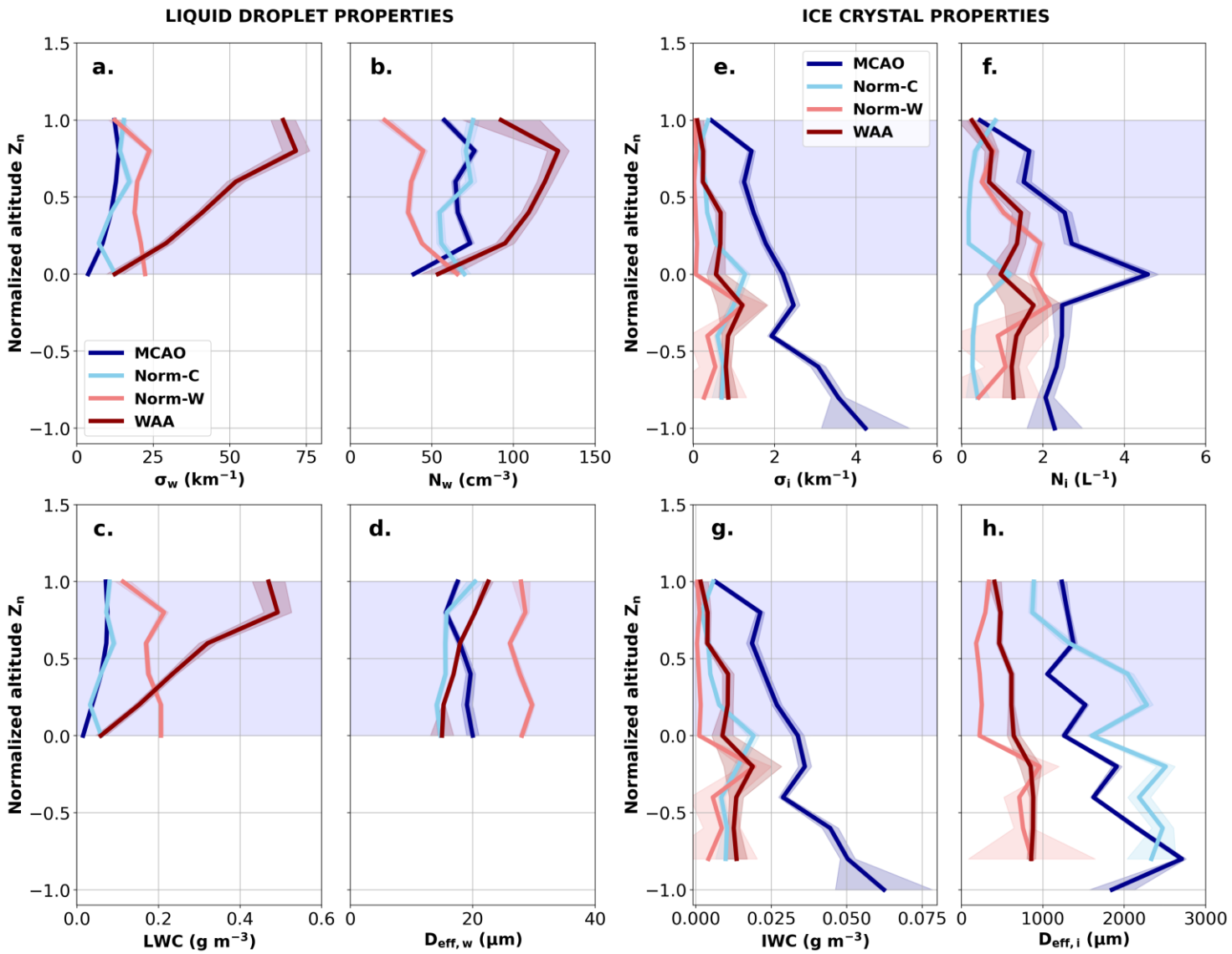


MCAO: strong liquid-ice interaction

- stable LWC profile (~0.1 g m^{-3})
- efficient vertical glaciation
- peak N_i (> 4 L^{-1})
- precipitation (IWC > 0.06 g m^{-3} & $D_{eff,i}$ > 2000 µm)

WAA: liquid-dominated structure

- high LWC near cloud top (~0.5 g m^{-3})
- adiabatic development
- cloud-top temperature inversion promotes glaciation



Ice Crystal Habits

Morphological classes

- Spherical Particle (SP)

PRISTINE CRYSTALS

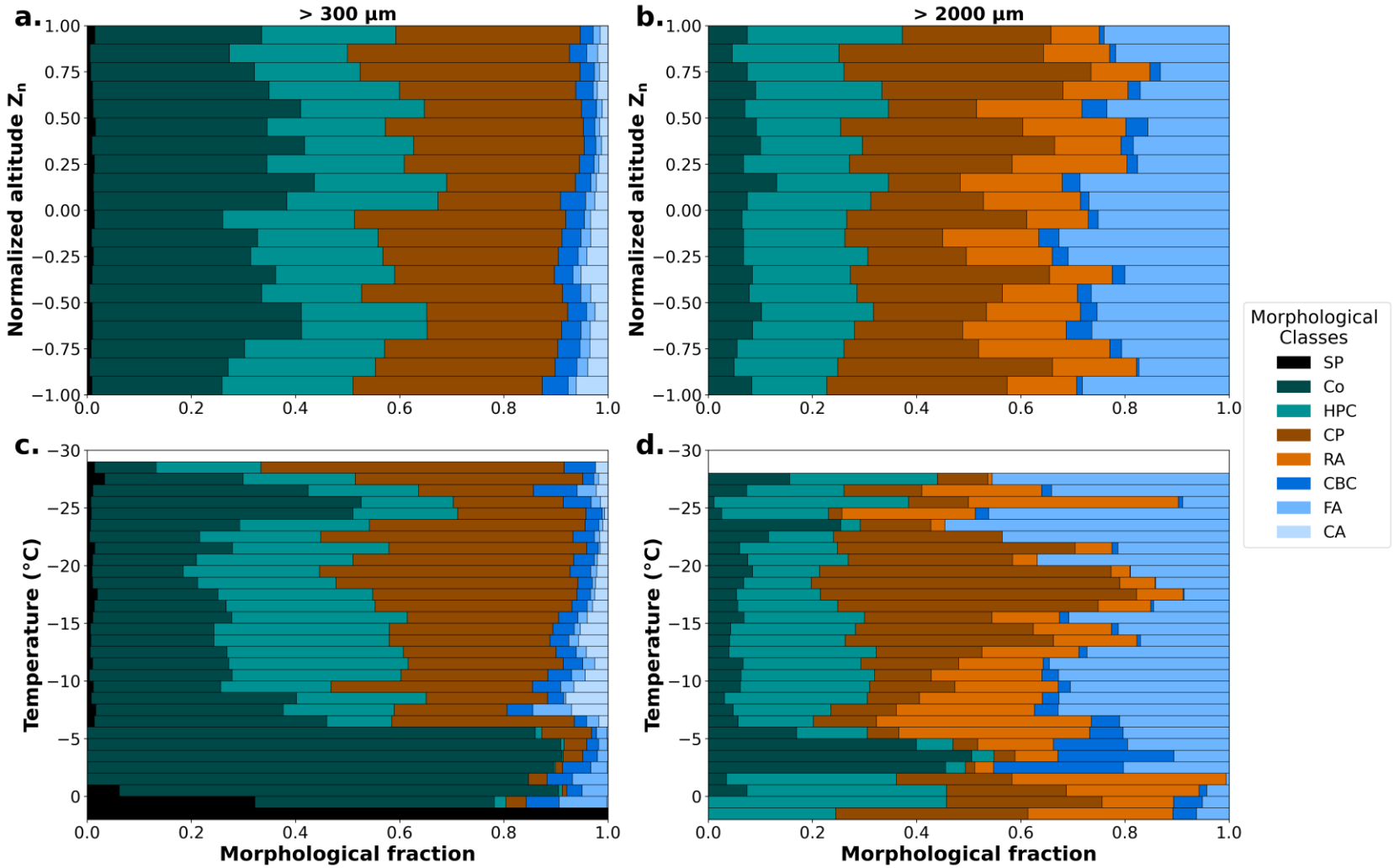
- Column (Co)
- Hexagonal Planar Crystal (HPC)

RIMING PARTICLES

- Compact Particle (CP)
- Rimed Aggregates (RA)

AGGREGATES

- Combination of Bullets or Columns (CBC)
- Fragile Aggregates (FA)
- Complex Assemblages (CA)



Overview of all campaigns :

> 300 µm : ≈ 490 000 images (CIP – 2D-S)
> 2000 µm : ≈ 245 000 images (PIP)

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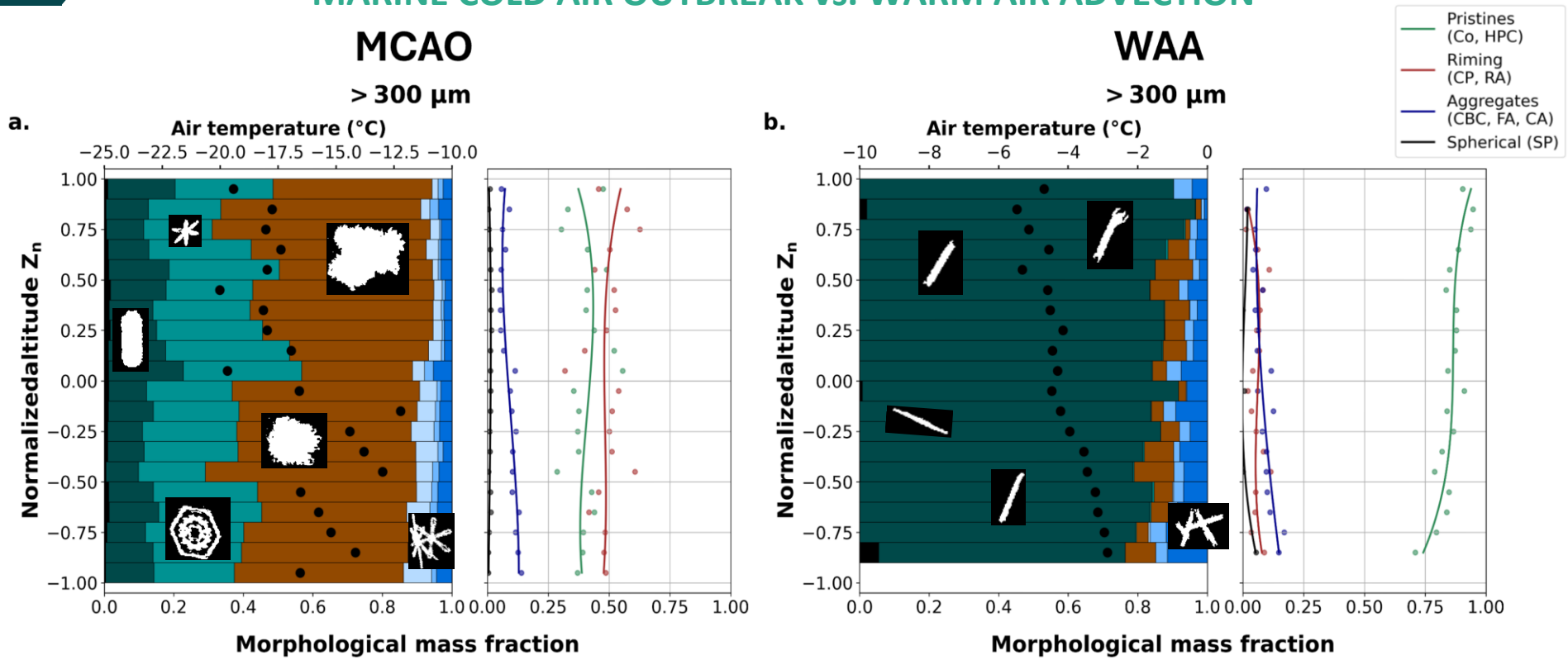
MARINE COLD AIR OUTBREAK vs. WARM AIR ADVECTION



- **WAA**: growth by **vapor deposition**, limited interaction between crystals and liquid droplets (low aggregation and riming).

- **MCAO**: **morphological dynamism** due to turbulence, **riming** growth is favored.

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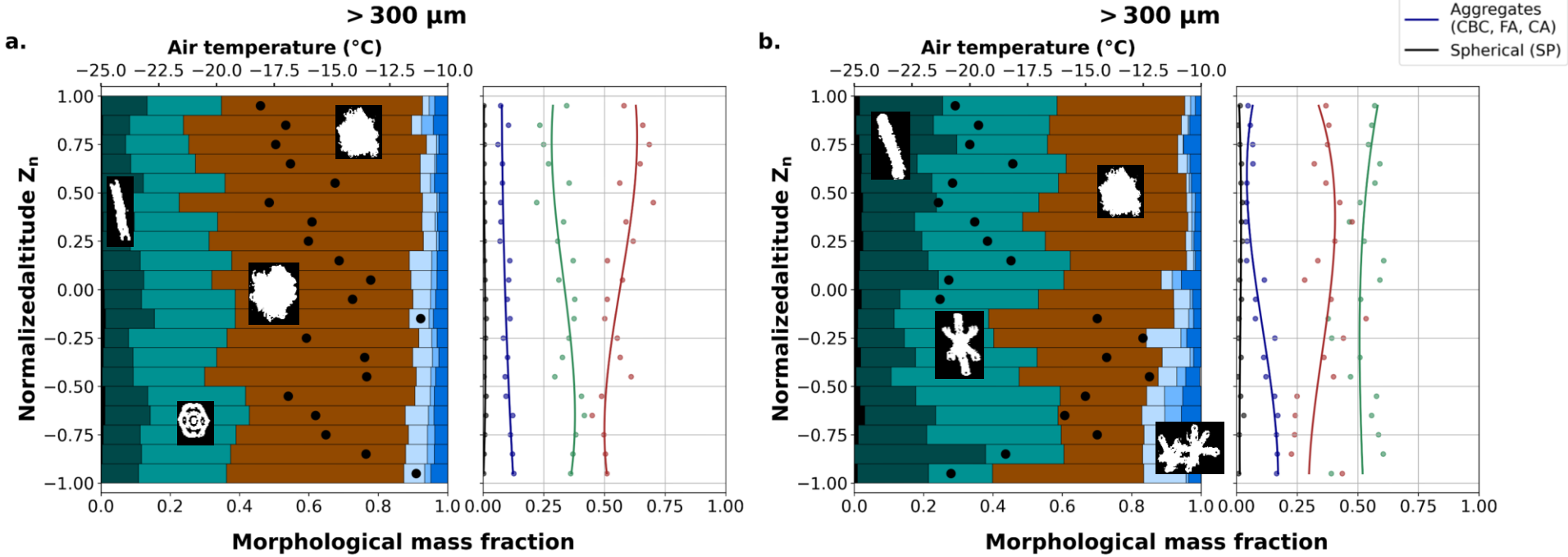
SURFACE INFLUENCE DURING MARINE COLD AIR OUTBREAK

OO : SIC < 20 %

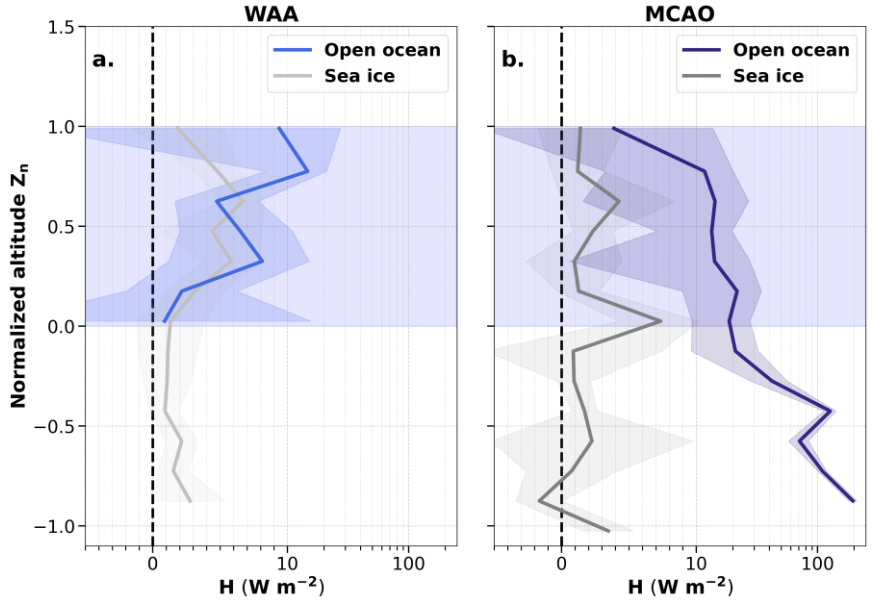
MIZ + SI : SIC > 20 %

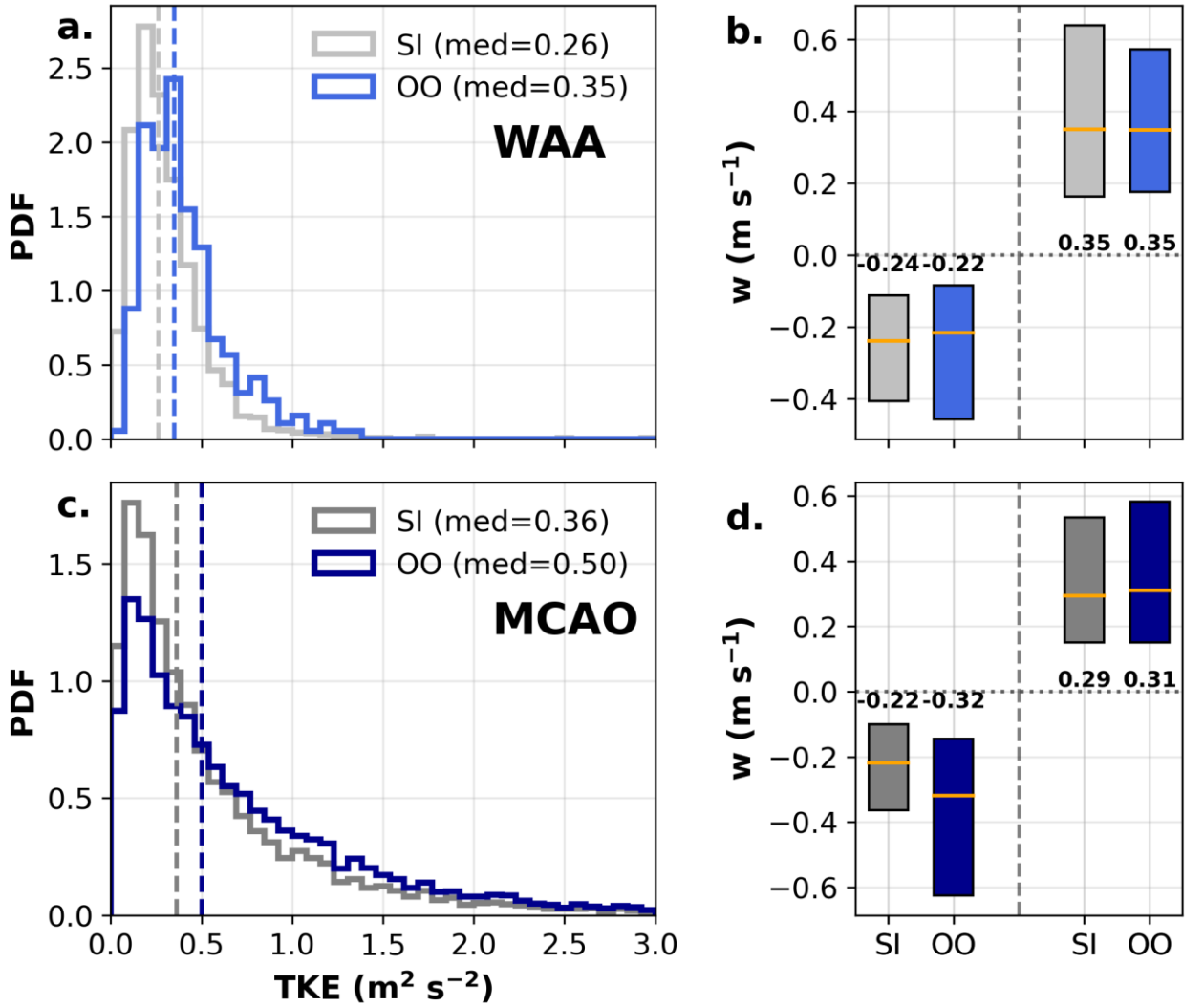


- **Rimed mass** is 1.5 to 2 times higher over the ocean → more turbulence.
- **Pristine particles** dominate over sea ice → more stable conditions and weaker vertical mixing.

Turbulence

- Stronger turbulence during MCAO, especially over open ocean.
- **Higher vertical velocity variability** over open ocean than over sea ice.
- Enhanced **surface heat fluxes** (up to 200 W m^{-2}) over open ocean during MCAO.
- Stronger vertical mixing promotes **droplet–ice interactions**.
- **Turbulence favors riming processes.**
- WAA cases show **weaker turbulence**, consistent with reduced ice growth efficiency.





Conclusion

Microphysical profiles:

→ Data: more than **400 legs** from four campaigns, corresponding to approximately 45 hours of in-cloud measurements.

→ **Mixed-phase structure influenced by air-mass intrusions (MCAO/WAA).**

Ice crystal habits:

→ **Quantitative data** on ice crystal habit in low-level mixed-phase clouds.

→ Characteristic **habit peaks.**

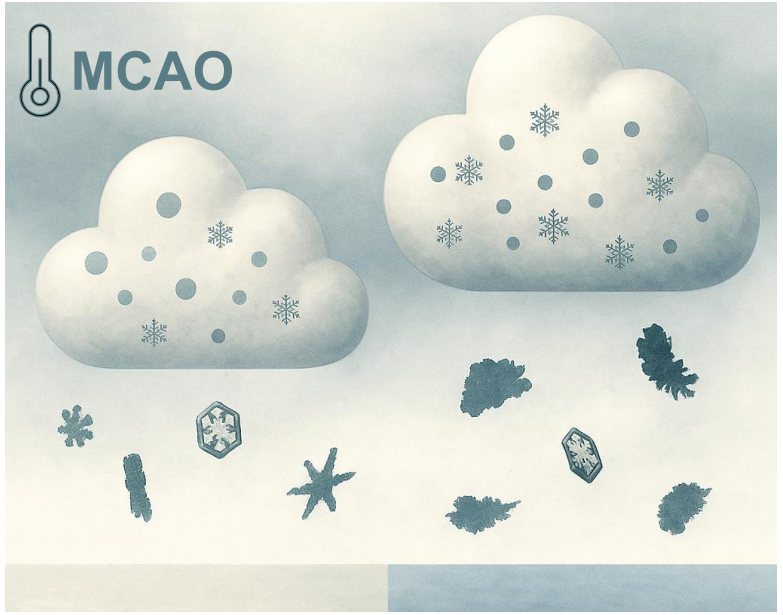
→ **Influence of surface type on ice crystal habits.**

Turbulence:

→ **MCAO:** a strong turbulent driver with shallow convection.

→ **WAA:** limited turbulence in a stratified atmosphere.

→ **Surface impact.**



Thank you for your attention !