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Long-term statistical analysis of mixed-phase cloud micro-physical properties in relation to sea ice condition

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Faculty of Physics and Earth Sciences

San Francisco, 15th December, 2023

AGU23
San Francisco, CA & Online Everywhere
11-15 December 2023

Central Arctic

MOSAiC EXPEDITION

RV *Polarstern* drifting with the sea ice across the central Arctic from Sept. 2019 to Oct. 2020

Ship-base remote sensing observations of clouds aloft the RV *Polarstern*

EGU European Geosciences Union

Atmospheric Chemistry and Physics

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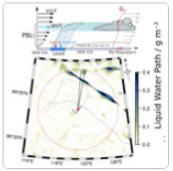
24 Nov 2023

Asymmetries in cloud microphysical properties ascribed to sea ice leads via water vapour transport in the central Arctic



Pablo Saavedra Garfias ✉, Heike Kalesse-Los, Luisa von Albedyll, Hannes Griesche, and Gunnar Spreen

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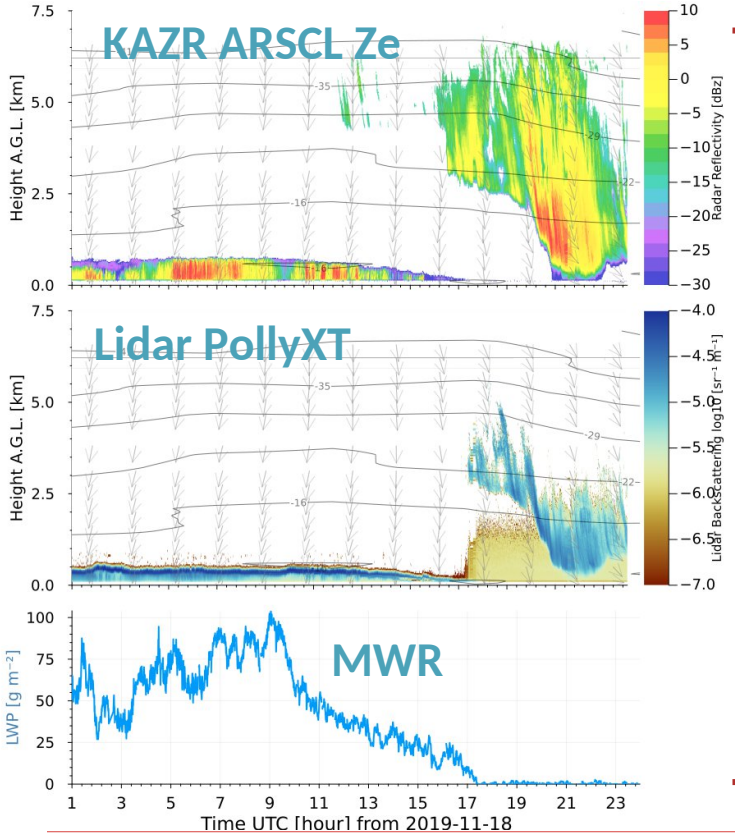
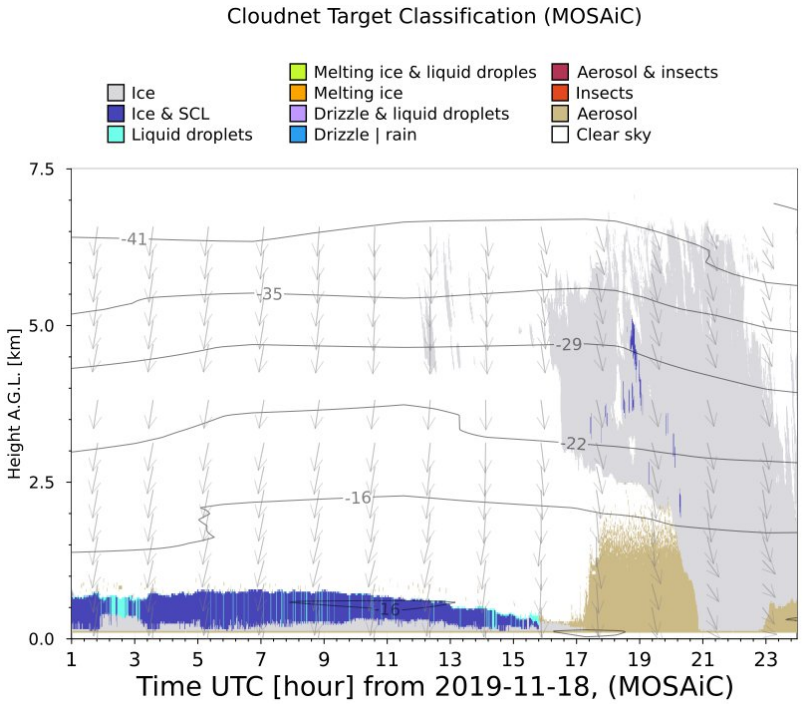
CLOUD CLASSIFICATION

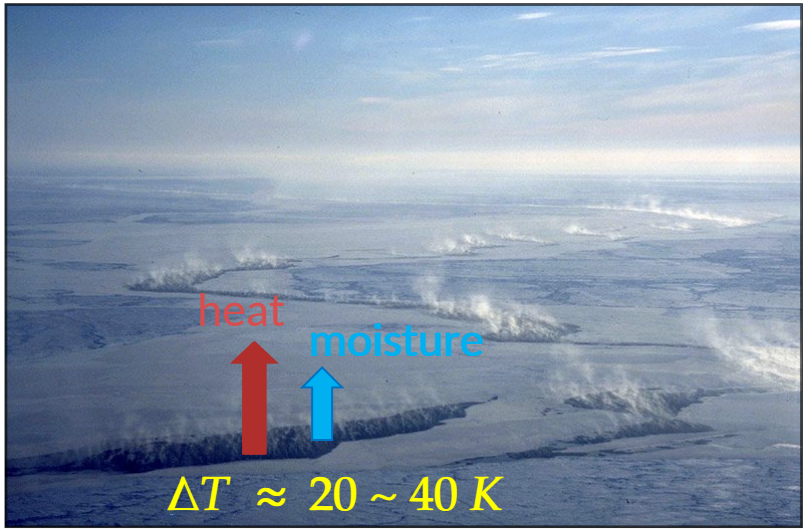


Cloudnet



Cloud properties: LWC, IWC, ice & droplets r_{eff}, cloud top temperature, cloud base & depth

SEA ICE – CLOUDS INTERACTION IN THE ARCTIC

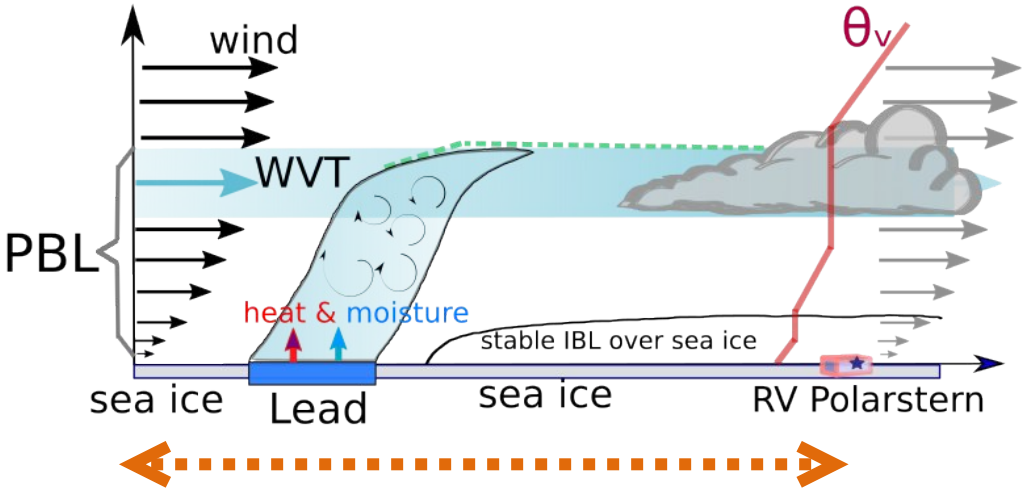


(University of Hamburg, Germany)

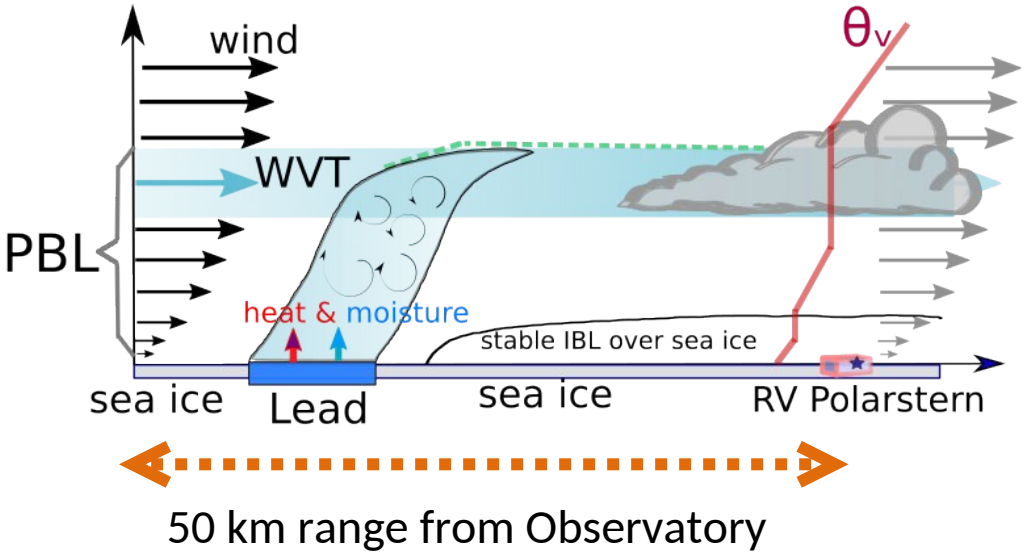
have an effect on Arctic clouds by changing their macro-, micro-physical and radiative properties.

SEA ICE – CLOUDS INTERACTION IN THE ARCTIC

- Water vapor transport (WVT) as mechanism to entangle sea ice leads with observed clouds,

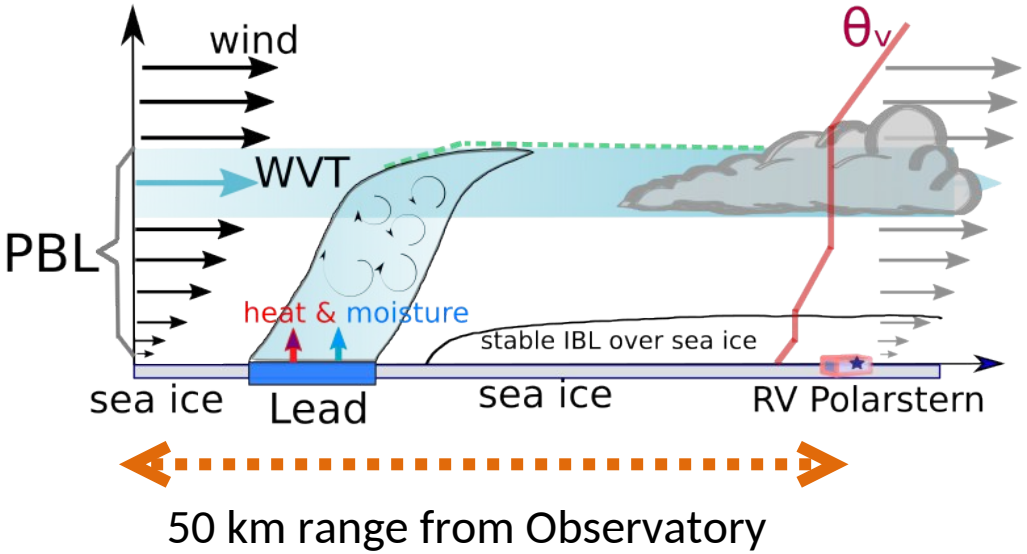


SEA ICE – CLOUDS INTERACTION IN THE ARCTIC



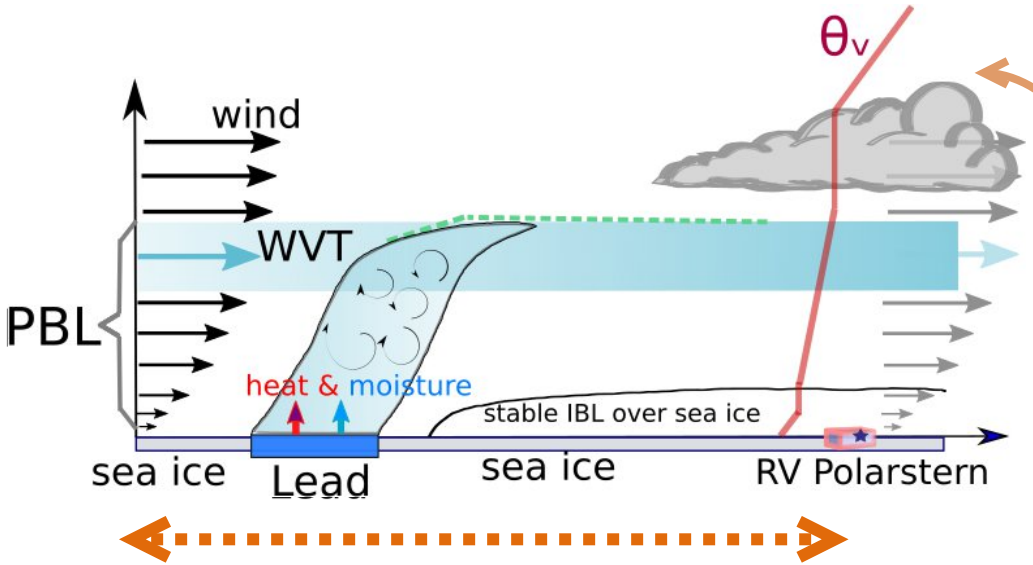
- Water vapor transport (WVT) as mechanism to entangle sea ice leads with observed clouds,
- Wind direction from max. ∇_zWVT within the boundary layer,

SEA ICE – CLOUDS INTERACTION IN THE ARCTIC



- Water vapor transport (WVT) as mechanism to entangle sea ice leads with observed clouds,
- Wind direction from max. ∇_zWVT within the boundary layer,
- Clouds **coupled** to WVT (interaction with WVT / leads),

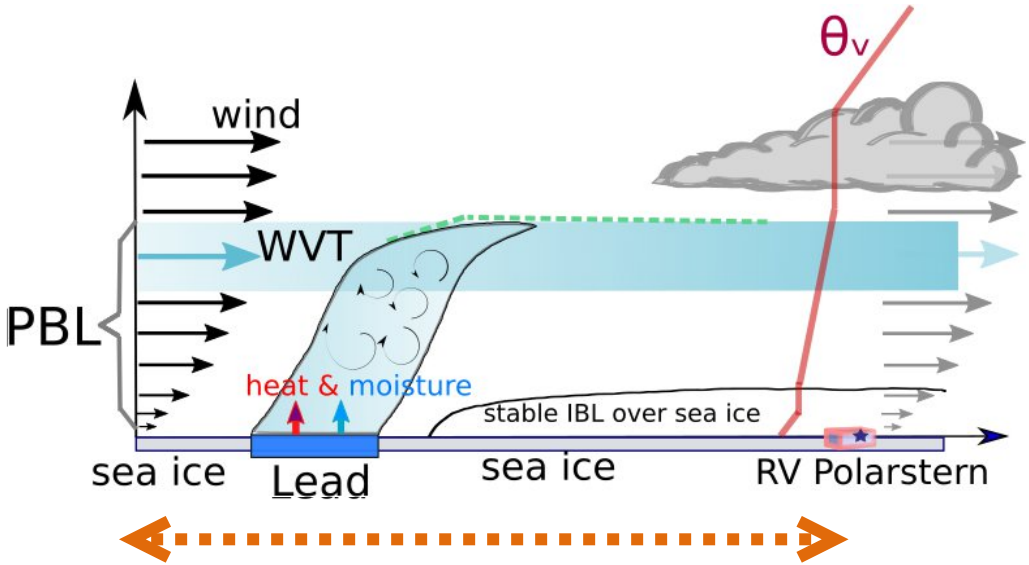
SEA ICE – CLOUDS INTERACTION IN THE ARCTIC



50 km range from Observatory

- Water vapor transport (WVT) as mechanism to entangle sea ice leads with observed clouds,
- Wind direction from max. ∇_zWVT within the boundary layer,
- Clouds **coupled** to WVT (interaction with WVT / leads),
- Clouds **decoupled** to WVT (no interaction with WVT / leads),

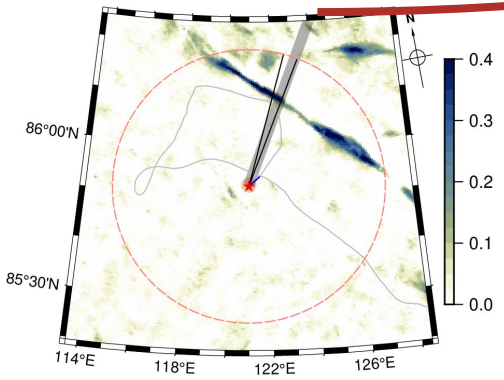
SEA ICE – CLOUDS INTERACTION IN THE ARCTIC

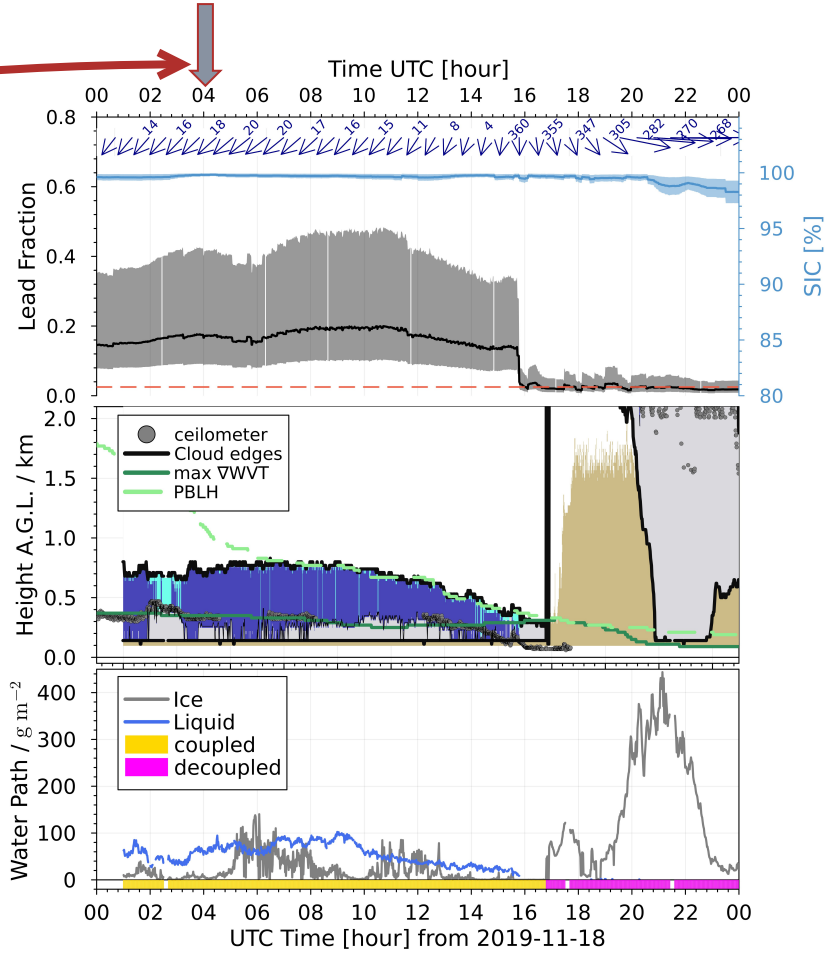


50 km range from Observatory

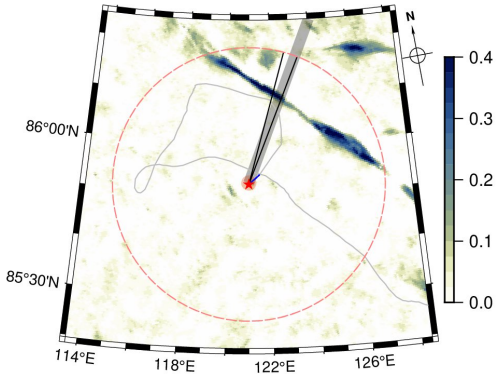
- Water vapor transport (WVT) as mechanism to entangle sea ice leads with observed clouds,
- Wind direction from max. ∇_zWVT within the boundary layer,
- Clouds **coupled** to WVT (interaction with WVT / leads),
- Clouds **decoupled** to WVT (no interaction with WVT / leads),
- Only upwind leads are relevant,

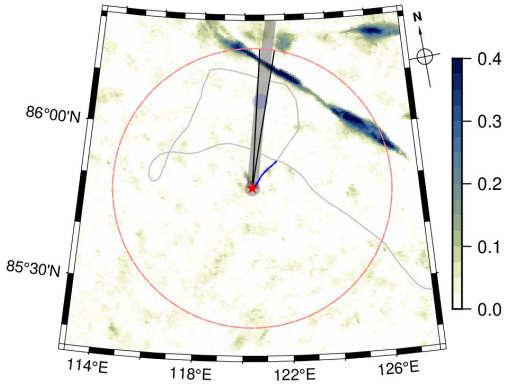
CLOUD PROPERTIES AND SEA ICE

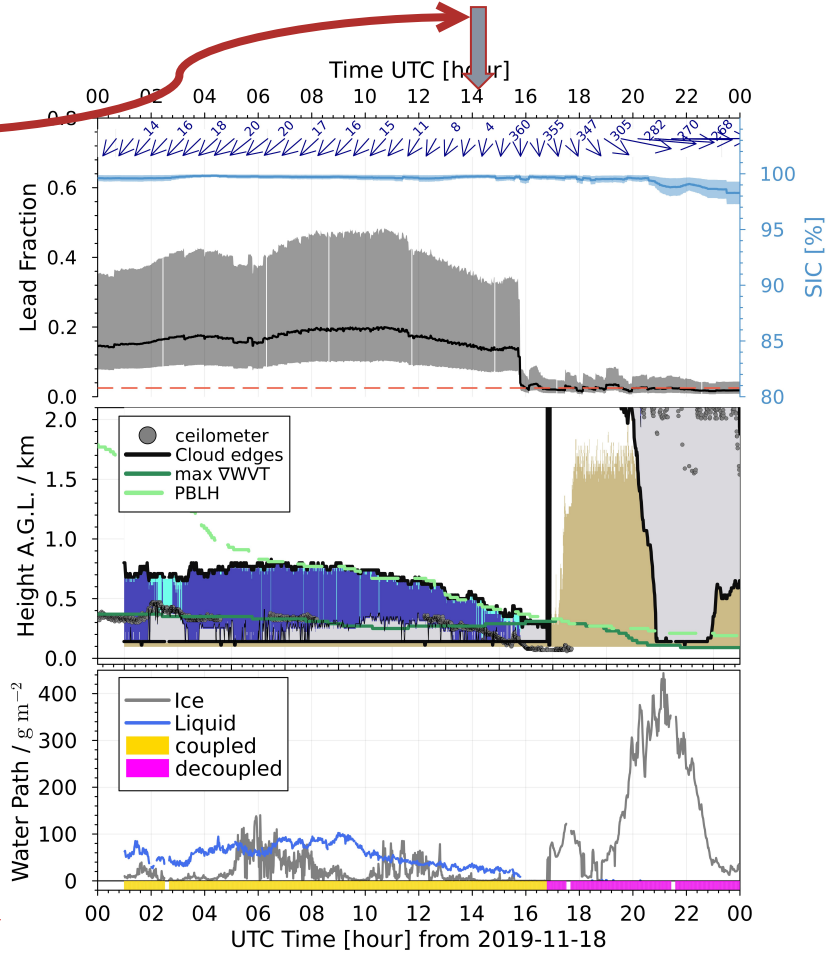




CLOUD PROPERTIES AND SEA ICE







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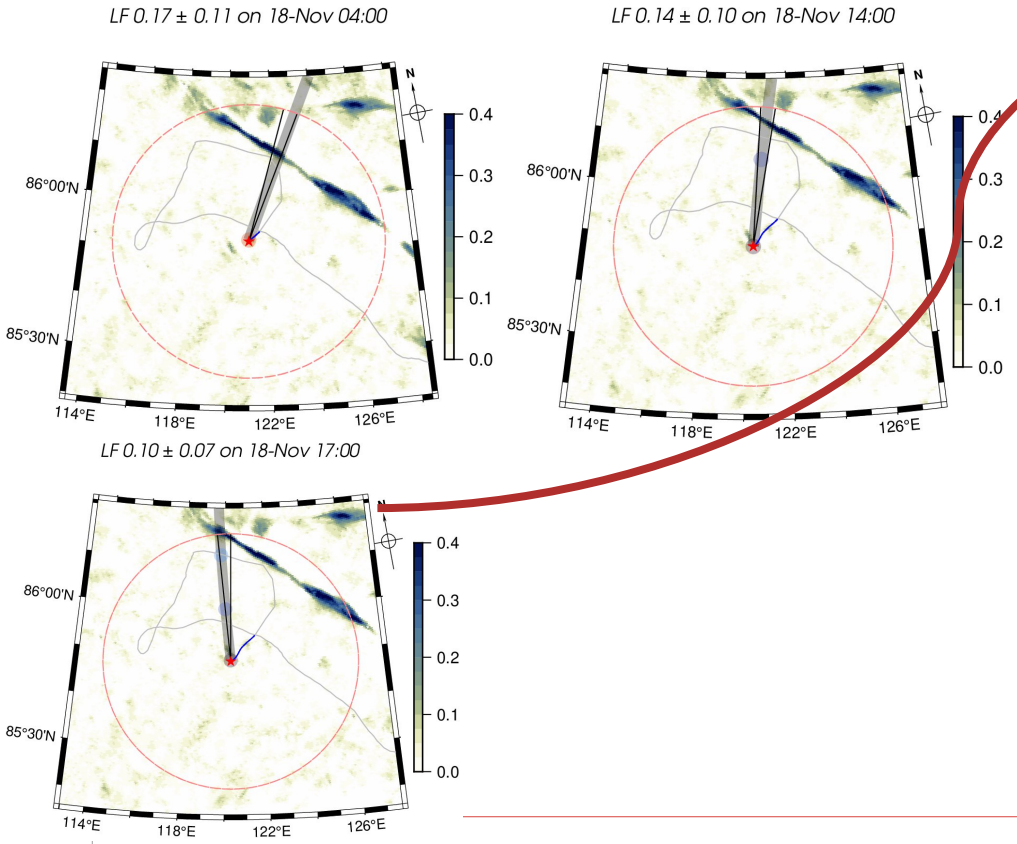
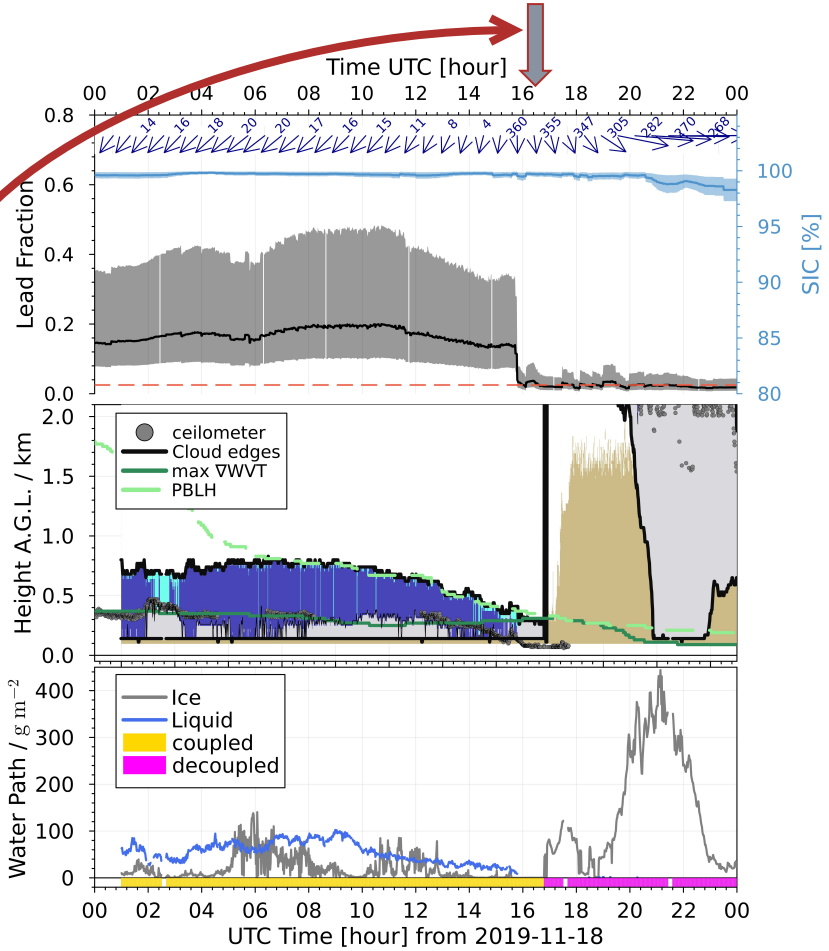
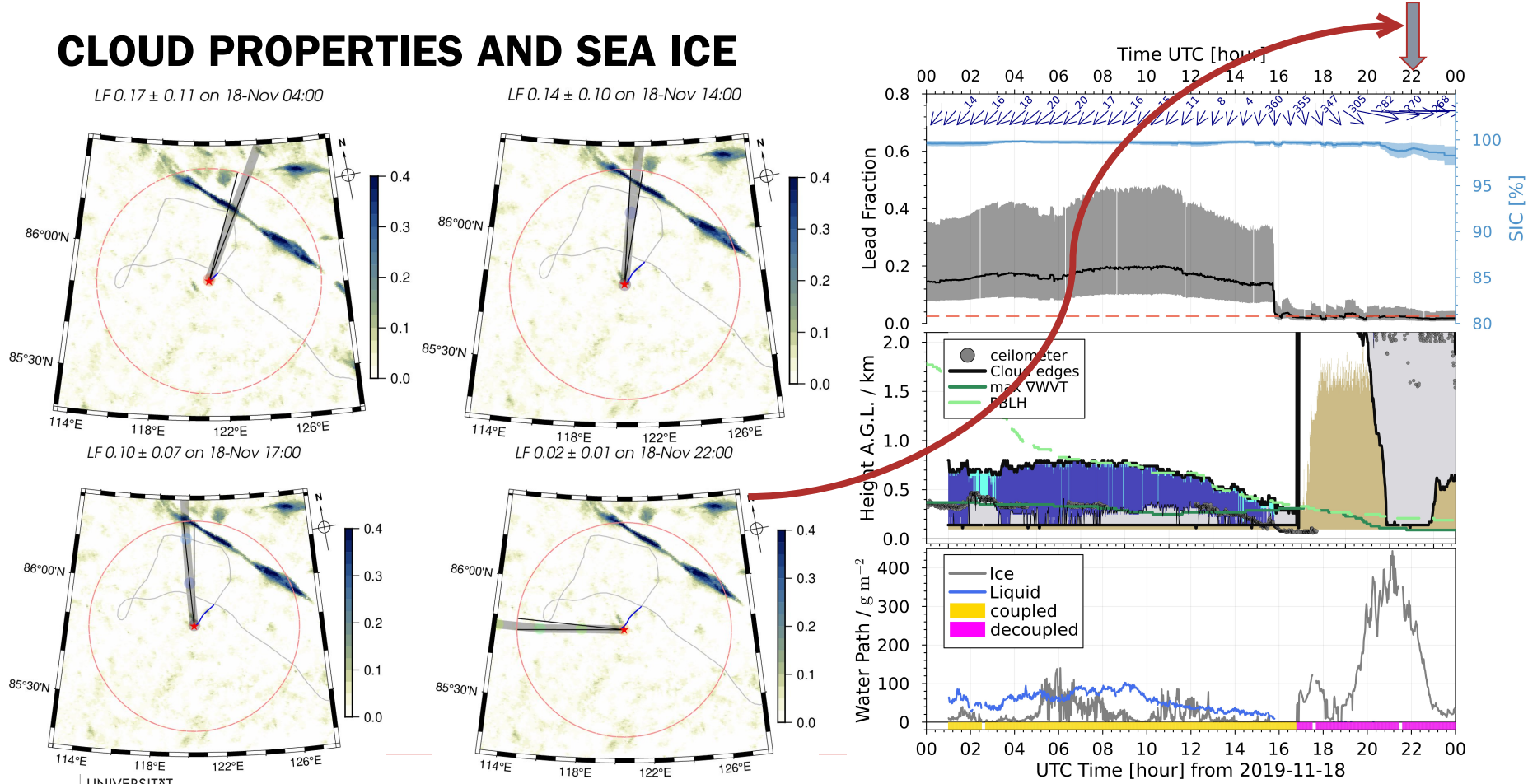




CLOUD PROPERTIES AND SEA ICE



STATISTICS FOR MOSAiC EXPEDITION

Data from Nov 2019-April 2020

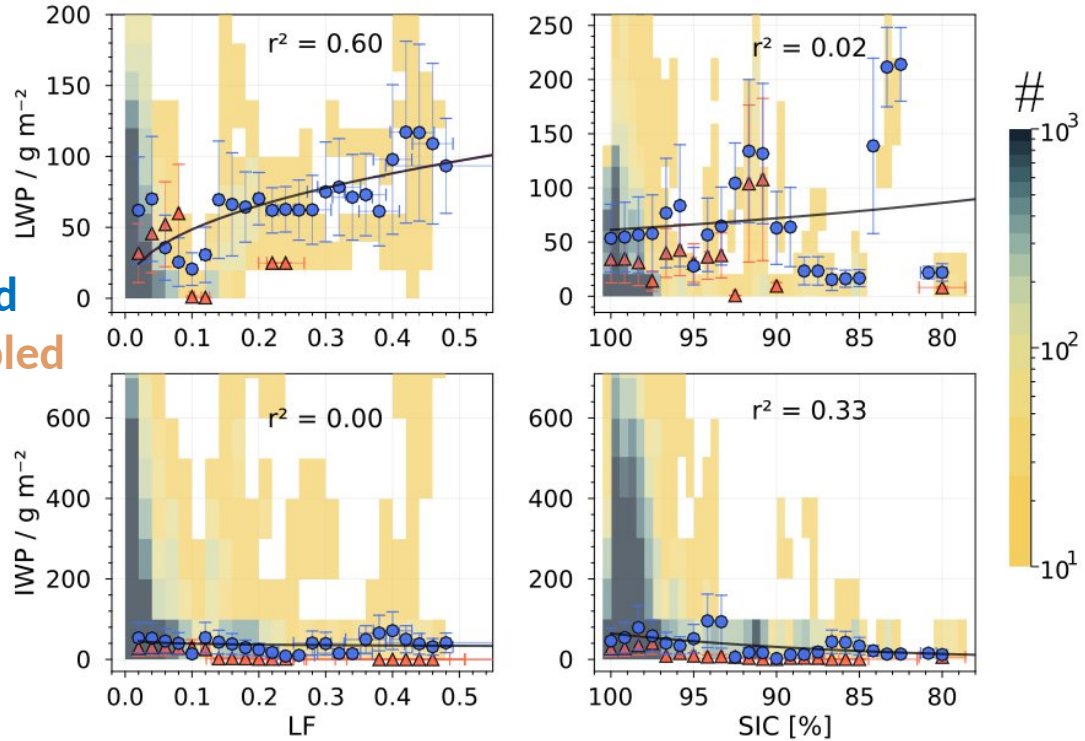
Color histogram: all data

Symbols: only Cloud top < 3 km

o Coupled

^ Decoupled

LWP & IWV versus LF and SIC



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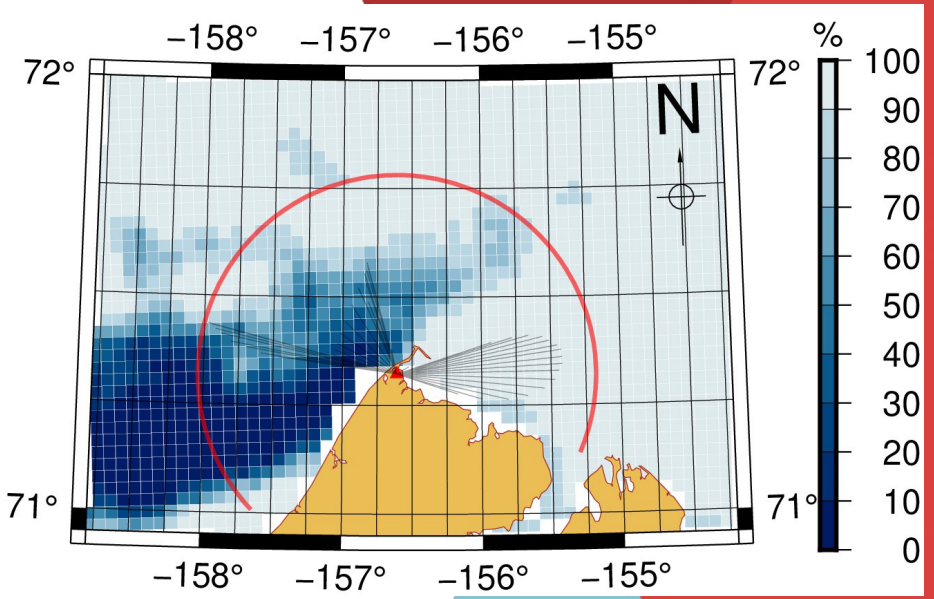
Western Arctic

ARM SITE (NSA) UTQIAĠVIK

Similar remote sensing capabilities as the RV *Polarstern* during MOSAiC

Long-term wintertime observations period from **2012 to 2022** for the months Nov-Apr.

AMSR2
Sea ice concentration (SIC) @ 3.12km grid.
University of Bremen

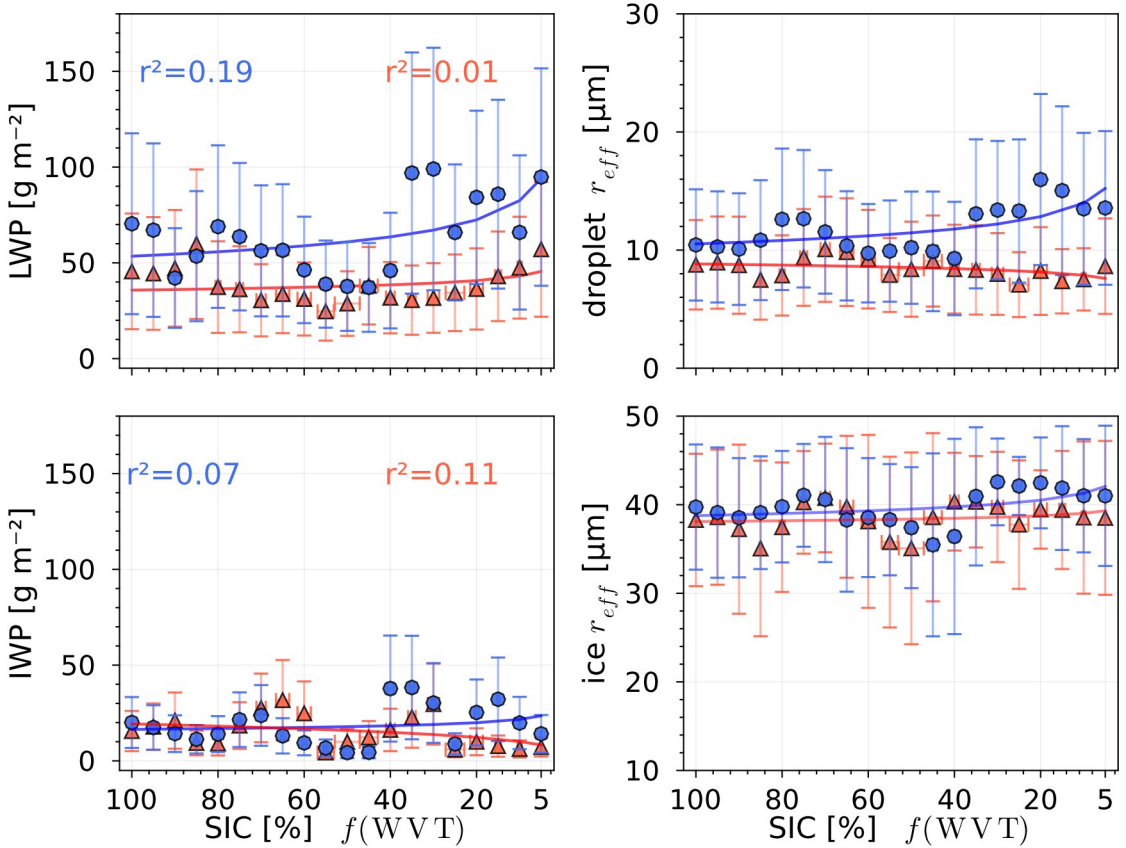


STATISTICS FOR UTQIAGVIK (NSA) 2012 - 2022

LWP & IWV versus SIC@3.12 km

Only Cloud top < 3 km

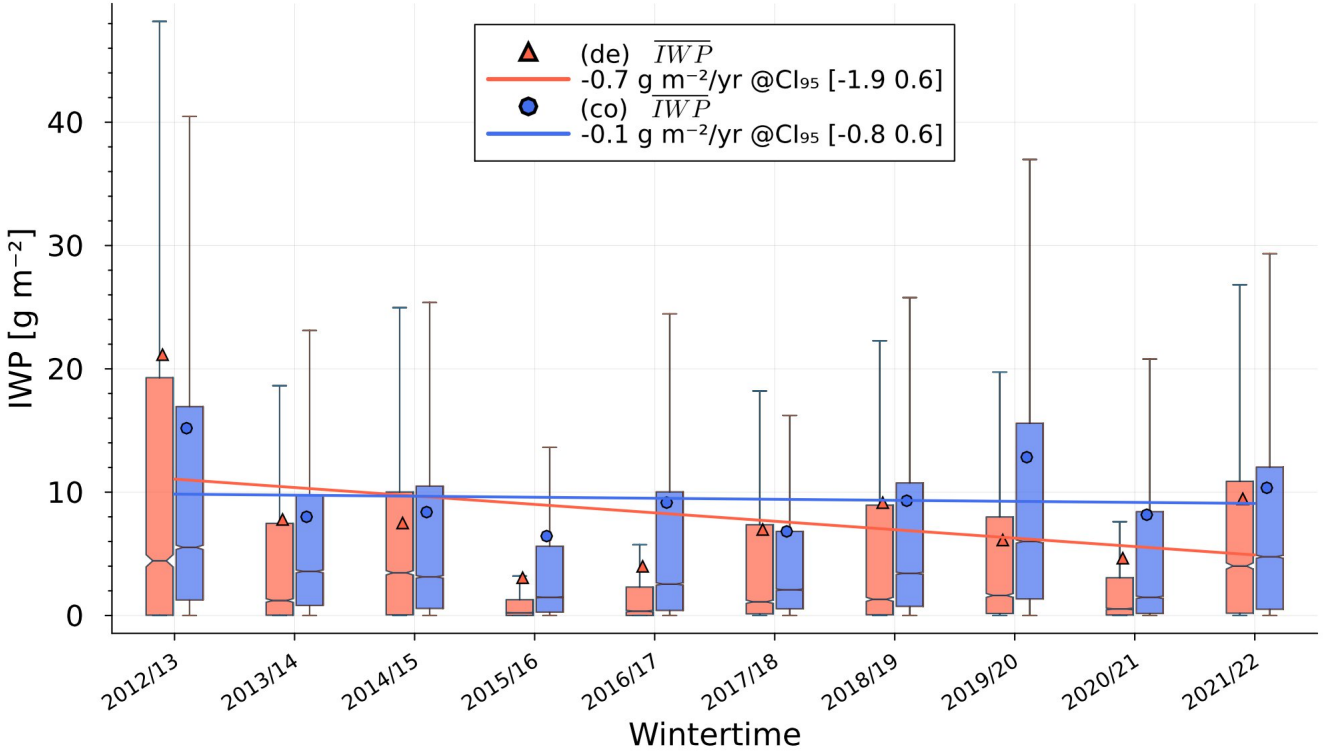
o Coupled
^ Decoupled



ICE WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

Wintertime from Nov. to Apr.

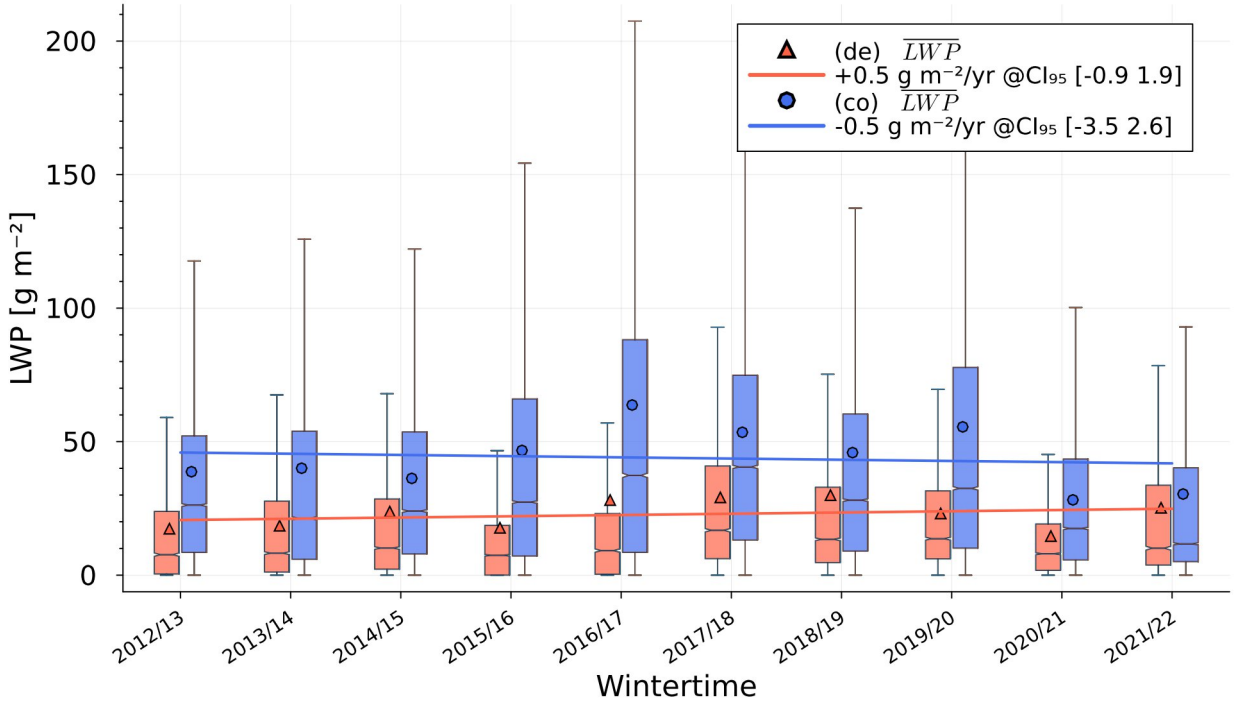
o Coupled
^ Decoupled



LIQUID WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

Wintertime from Nov. to Apr.

o Coupled
^ Decoupled



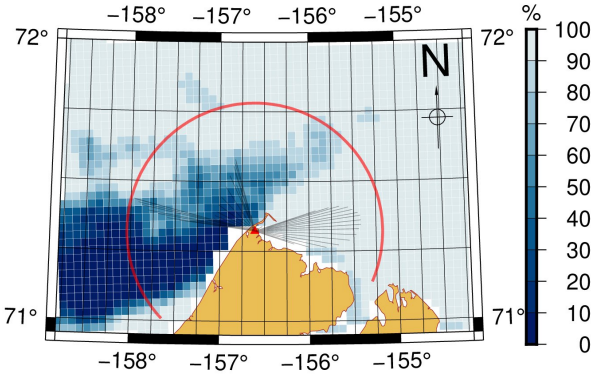
LIQUID WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

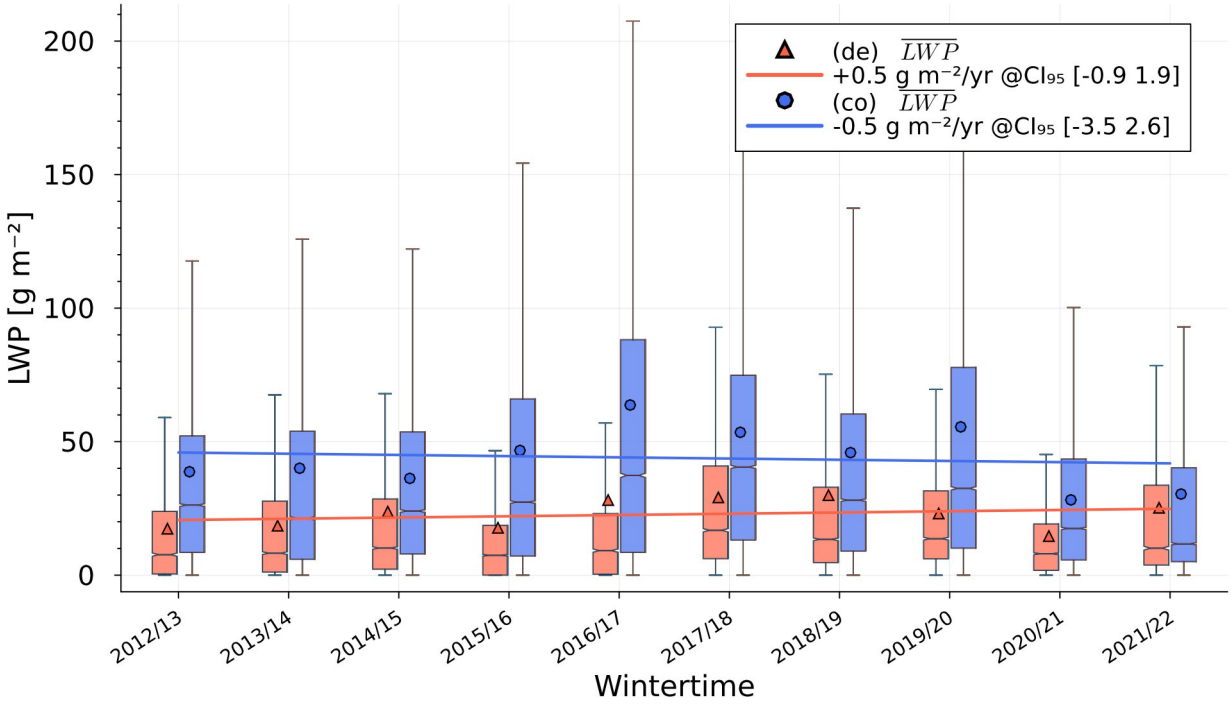
Wintertime from Nov. to Apr.

o Coupled

^ Decoupled

Is the yearly variability influenced by sea ice?





LIQUID WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

Wintertime from Nov. to Apr.

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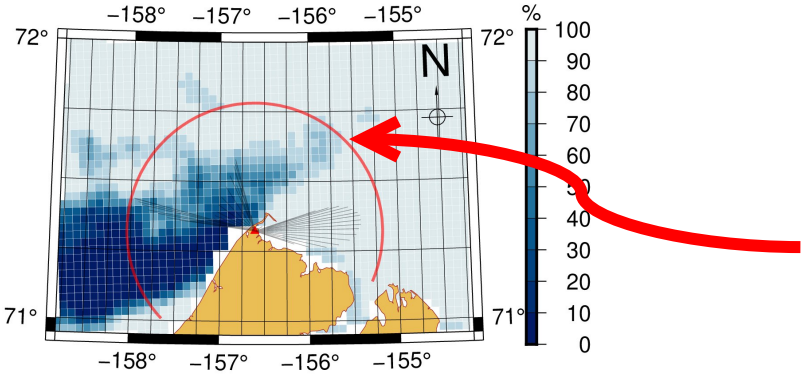

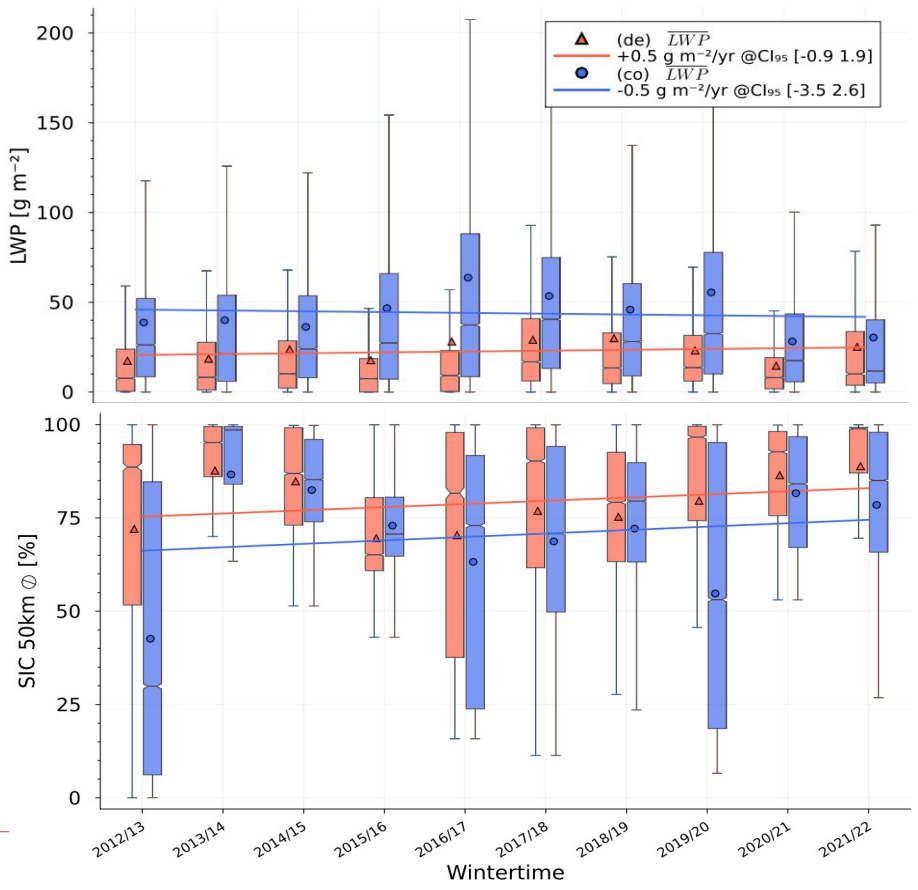

LIQUID WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

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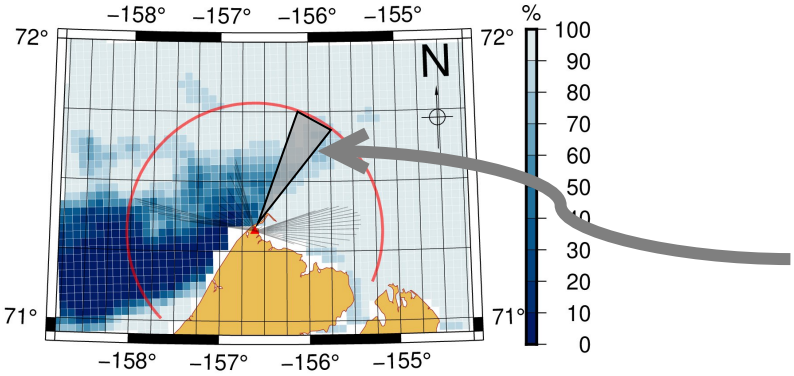

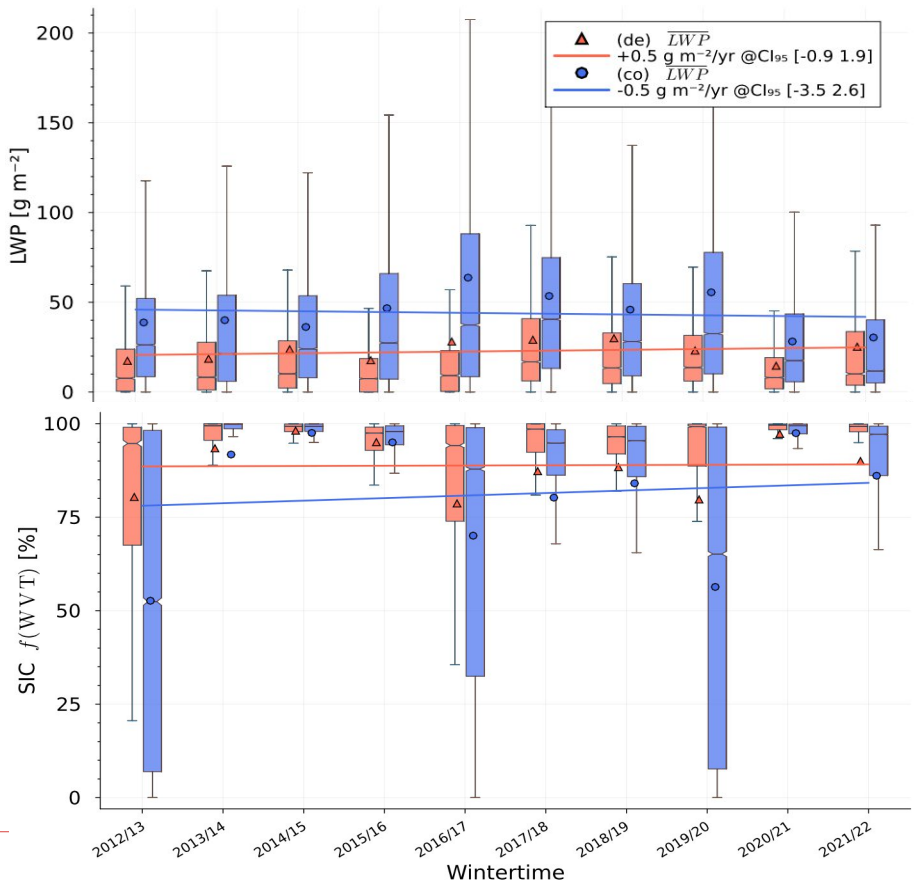

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CONCLUSIONS

- MOSAiC findings confirmed at Utqiagvik site for 2012 to 2022:
  - enhancement of LWP with sea ice openings,
  - IWP no relationship with sea ice openings,
  - lower base height, deeper cloud layer, warmer cloud top temperature,
- wider variability for mixed-phase cloud properties during years with anomalous low sea ice during winter,
- 10 years obs. do not show **significant** trend in cloud properties.

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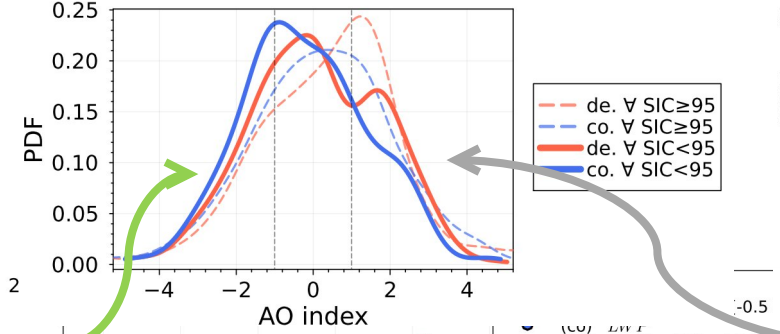
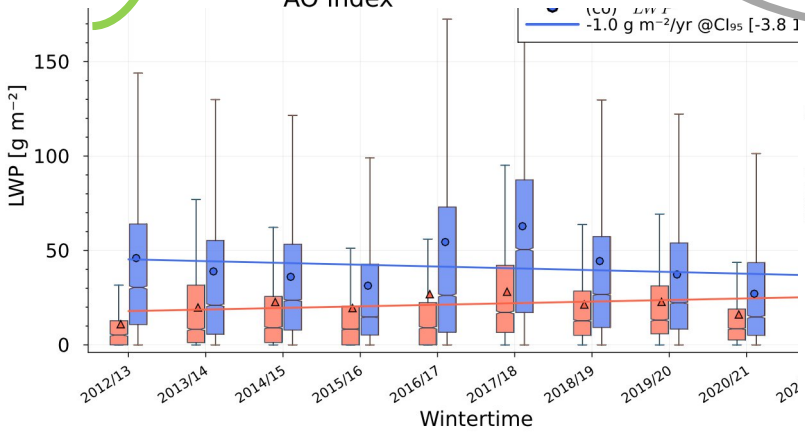
THANK YOU

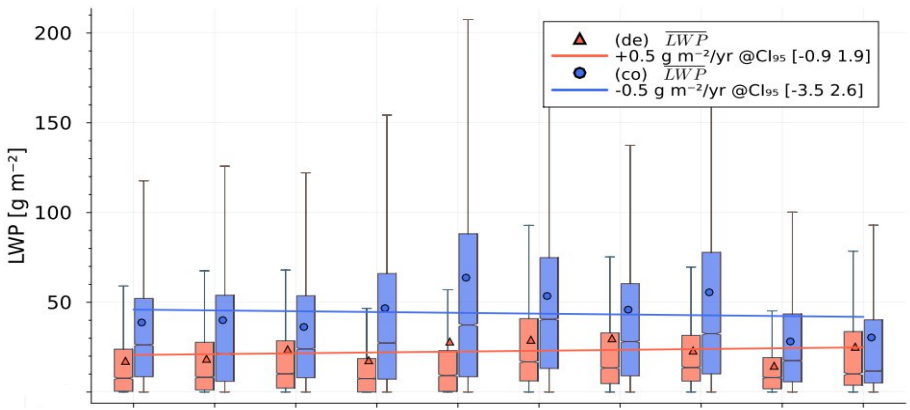
(AC)³ ARM MOSAiC International Arctic Drift Expedition AWI Universität Bremen TROPOS Leibniz-Institut für Troposphärenforschung

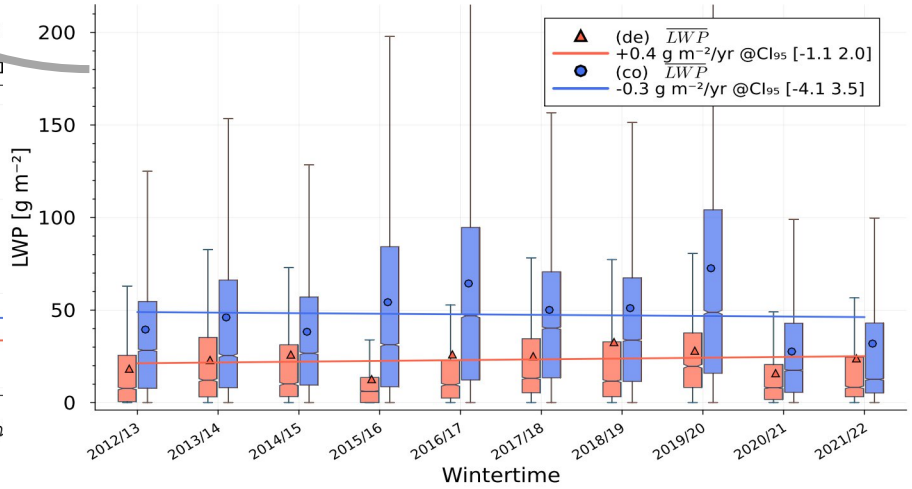
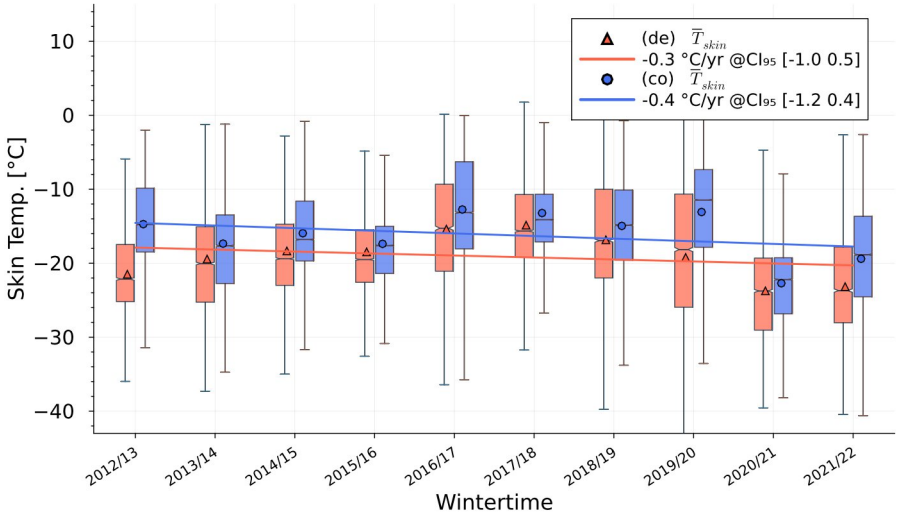
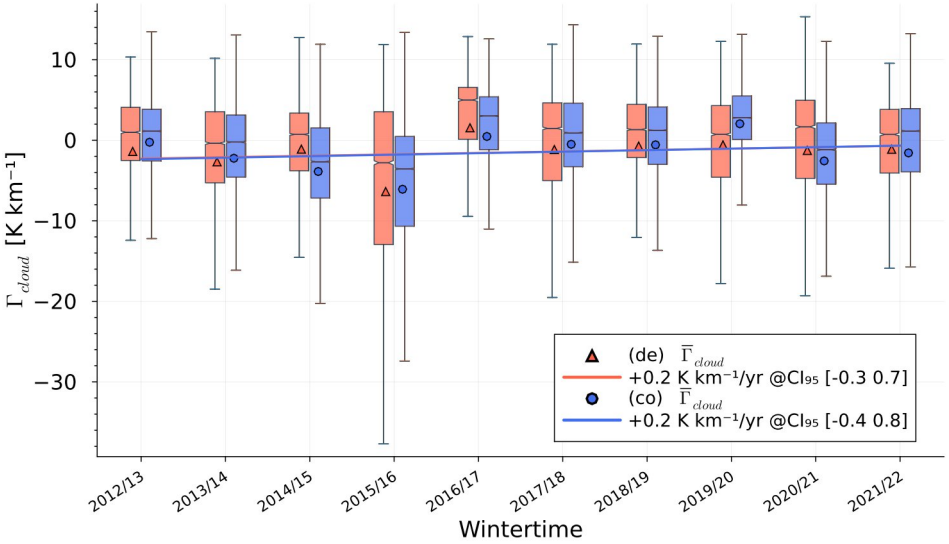
LIQUID WP TIME SERIES FOR UTQIAGVIK 2012 - 2022

Is the trend influenced by large scale climate variability?









THERMODYNAMIC TIME SERIES FOR UTQIAGVIK 2012 - 2022