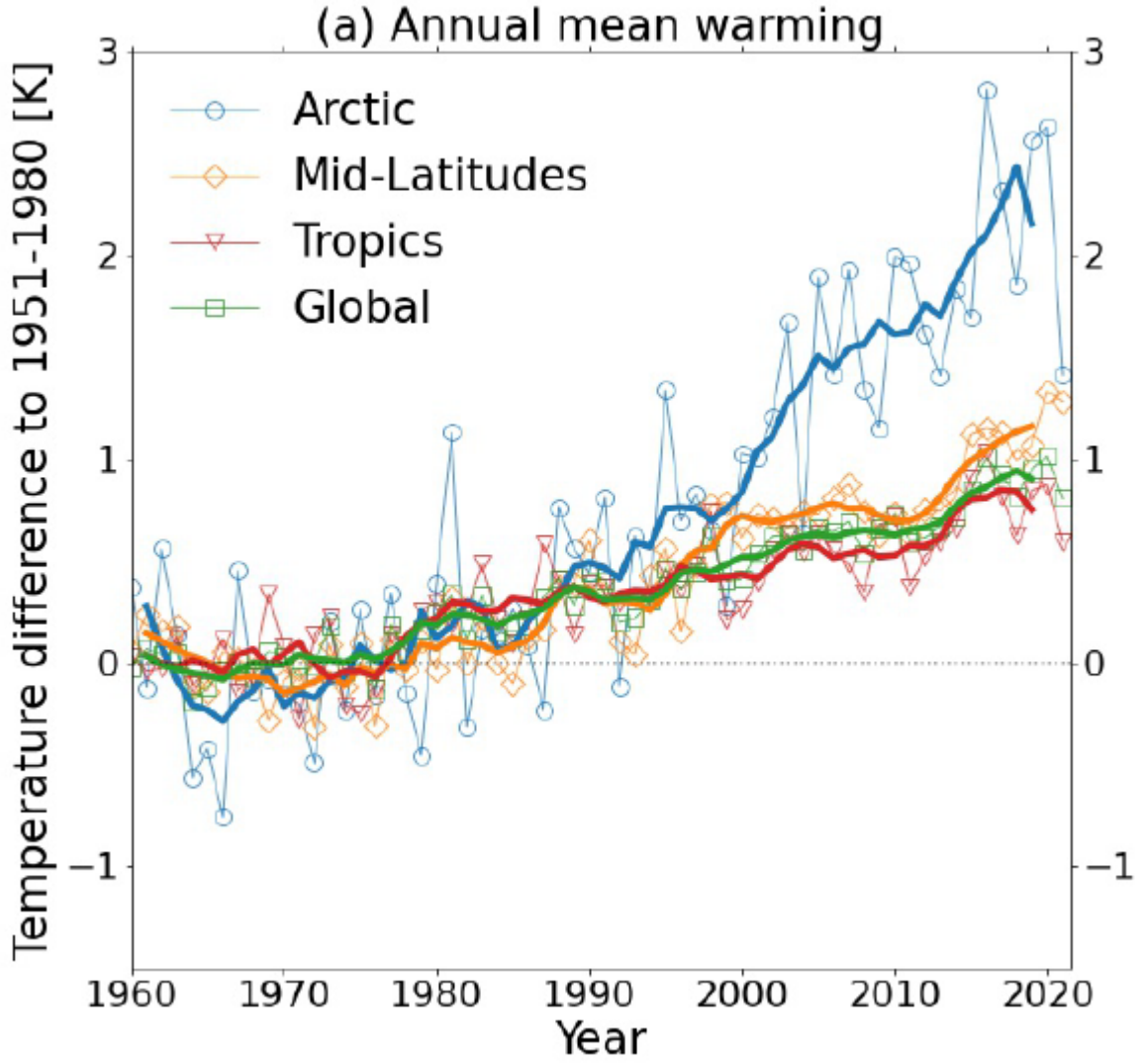
Arctic mixed-phase clouds as observed during (AC)^3 airborne campaigns and their representation in the ICON-LEM model

Mario Mech, Vera Schemann, Susanne Crewell

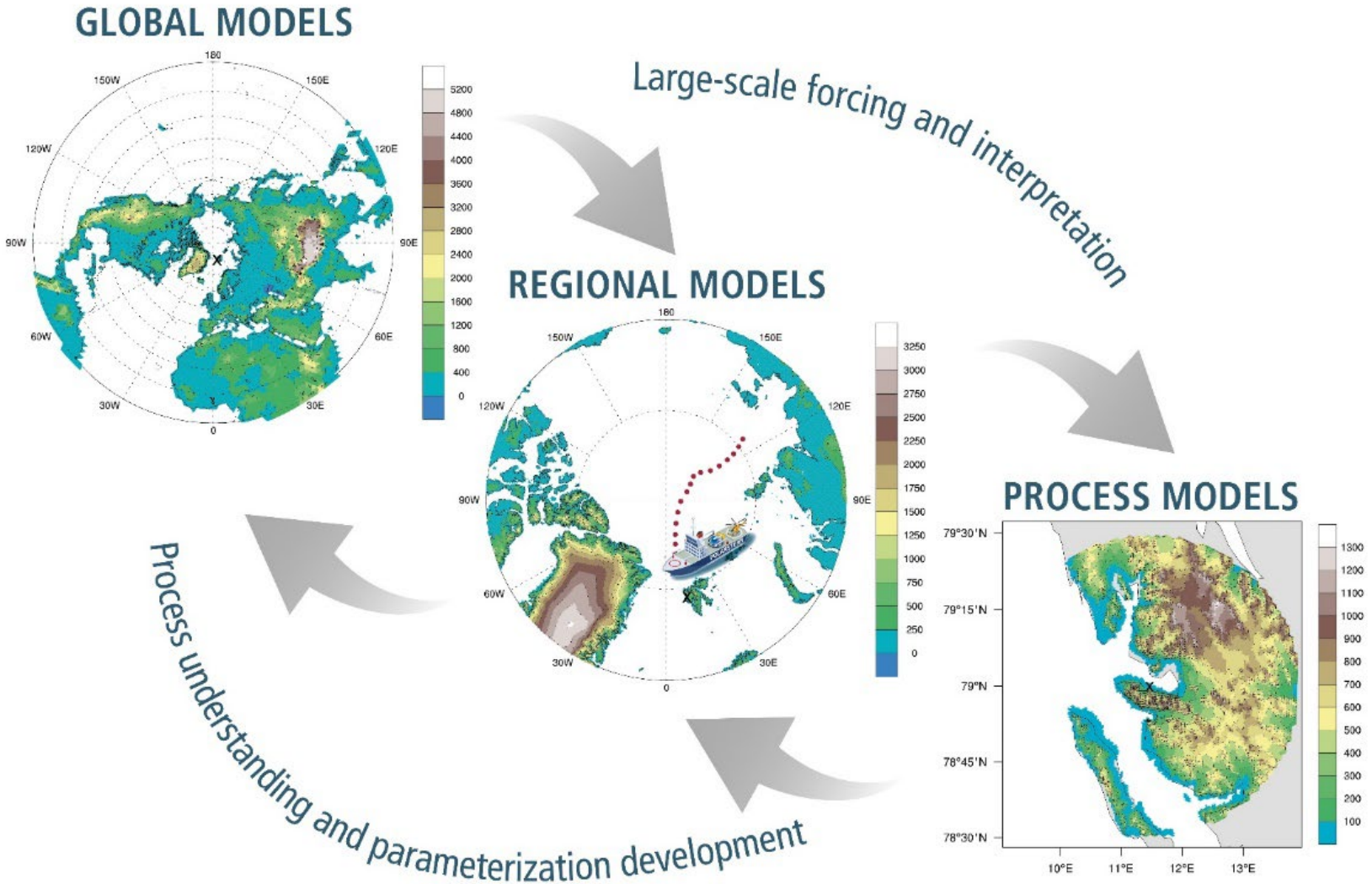
Arctic Amplification

- Arctic is warming at much stronger pace than the rest of the world
- Reasons for Arctic Amplification are poorly understood
- Special conditions of the Arctic challenge observations and modelling
- Collaborative Research Centre TR172 „Arctic Amplification“



Wendisch et al., BAMS in review

Strategy: Combine observations and modelling



Wendisch et al., AC3 Proposal 2019

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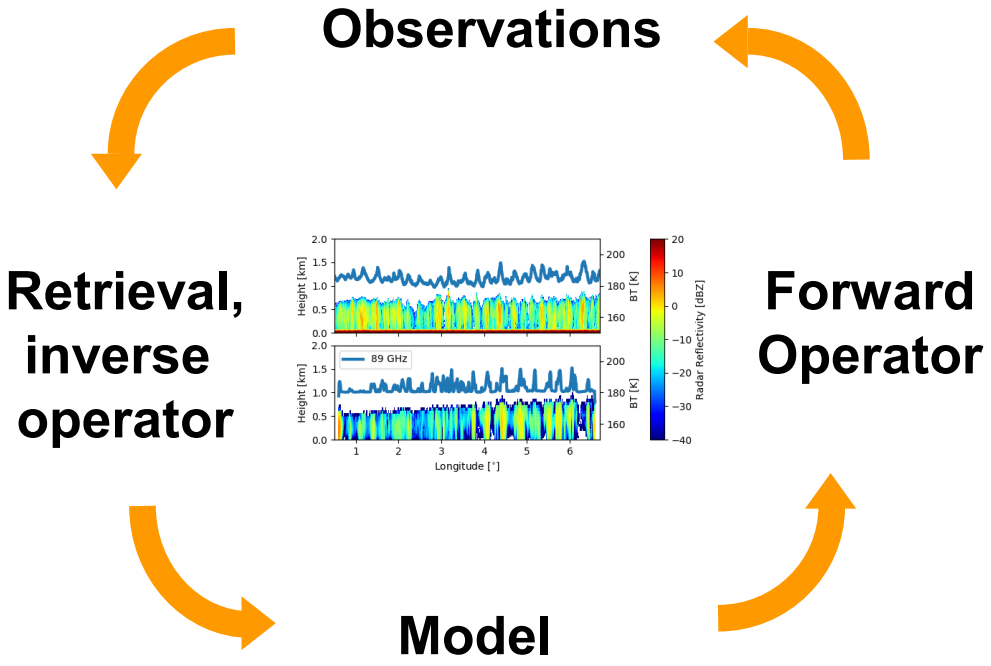
Combine observations and modelling

Passive and Active Microwave radiative TRAnsfer model (PAMTRA)

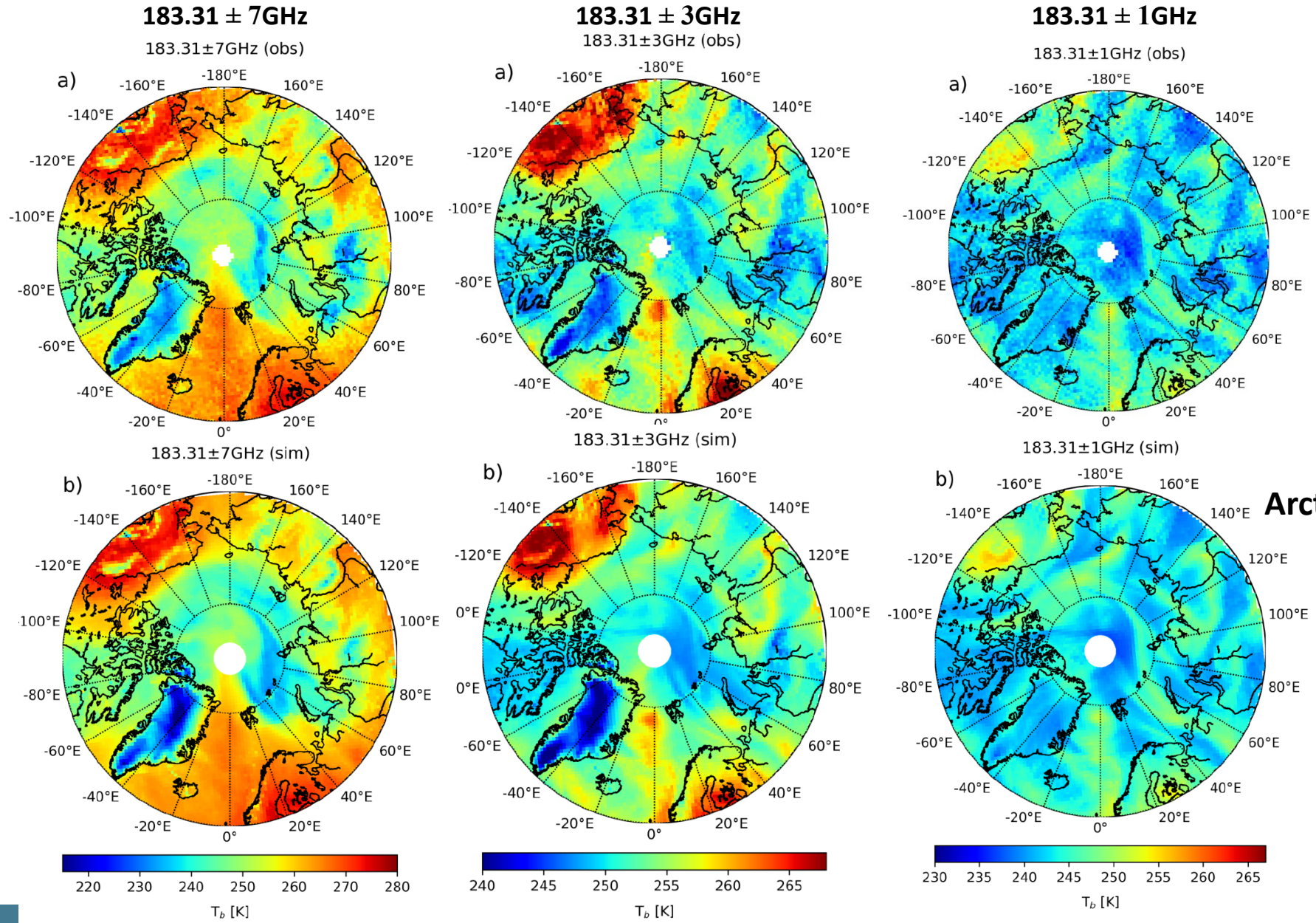
- Ground-based, airborne and spaceborne geometries
- Flexible handling of hydrometeors allowing to ingest in-situ measurements as well as different moment schemes



Mech et al., 2020, *Geoscientific Model Development*, https://doi.org/10.5194/gmd-13-4229-2020

See Poster this noon

Satellite perspective



Observations
AMSU-B

Arctic System Reanalysis
PAMTRA

Ana Radovan

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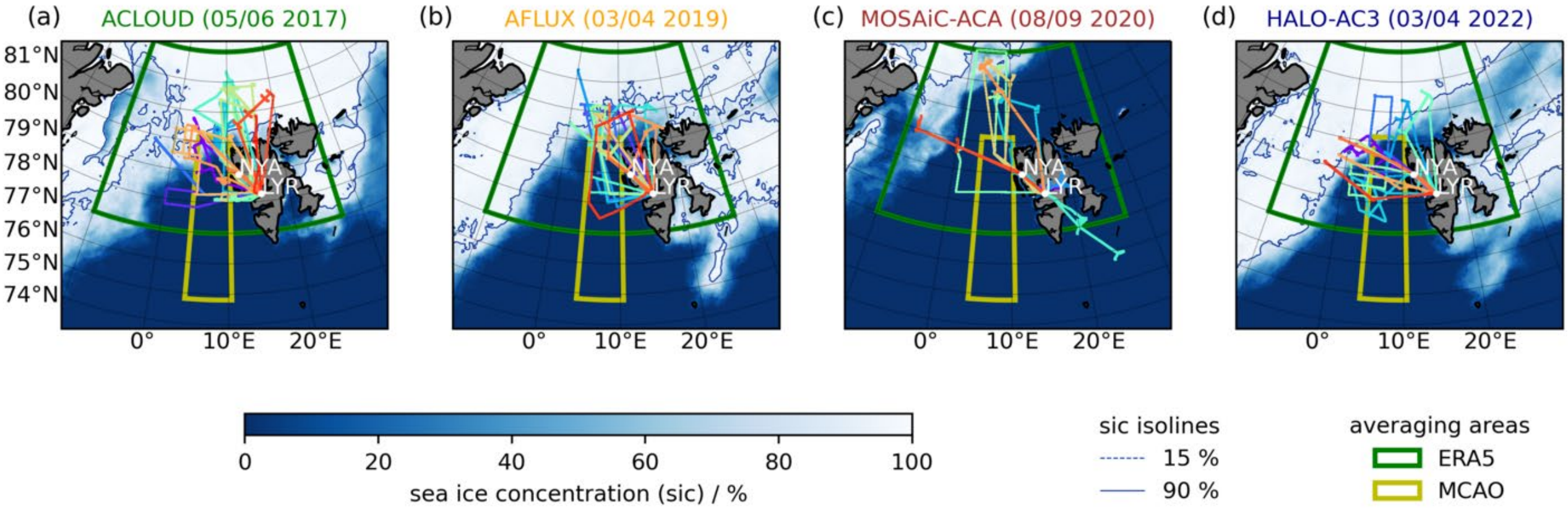
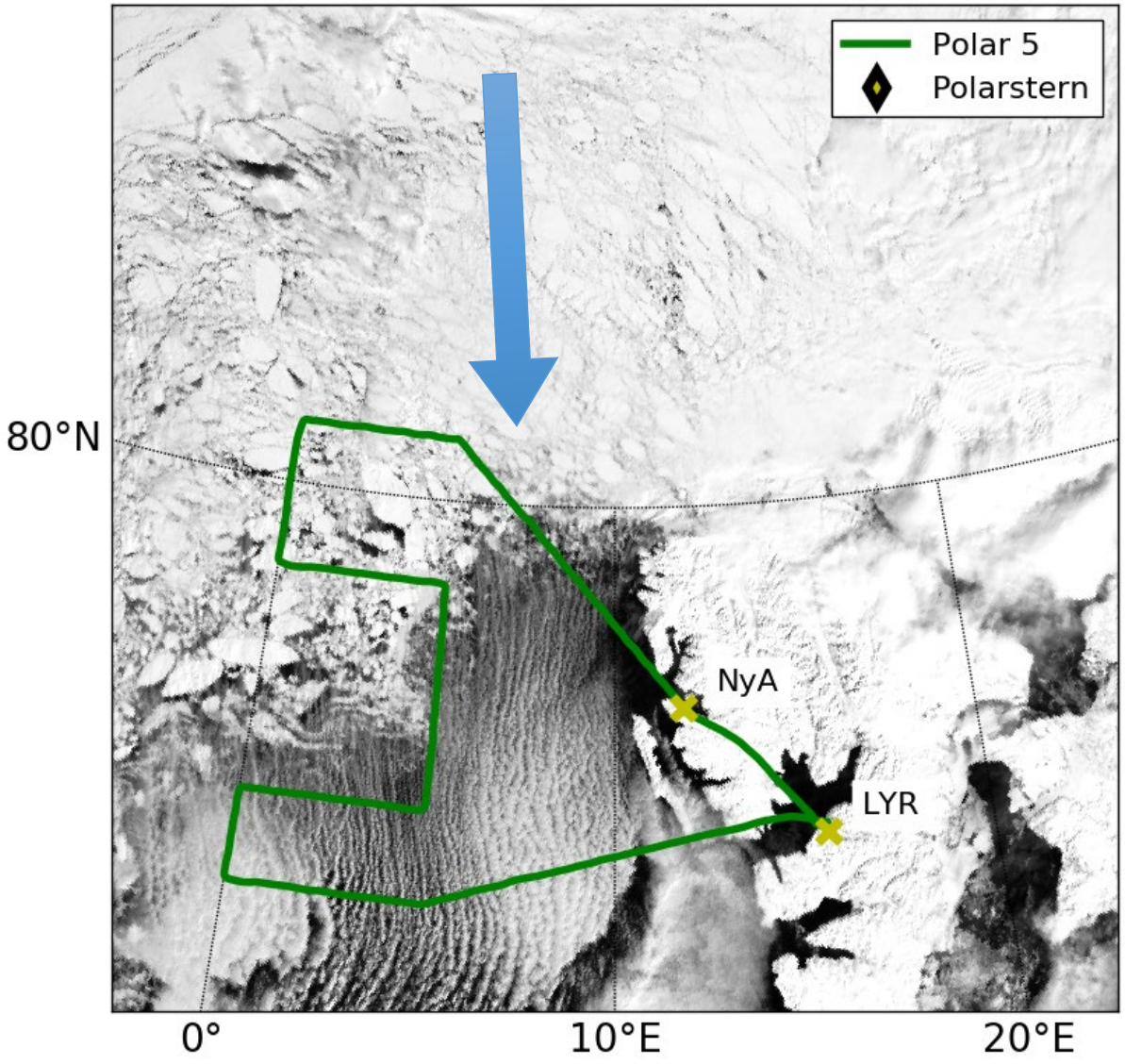
Airborne Observations

Polar 5 Aircraft, Alfred-Wegener Institute



Cold Air Outbreak – 25 May 2017

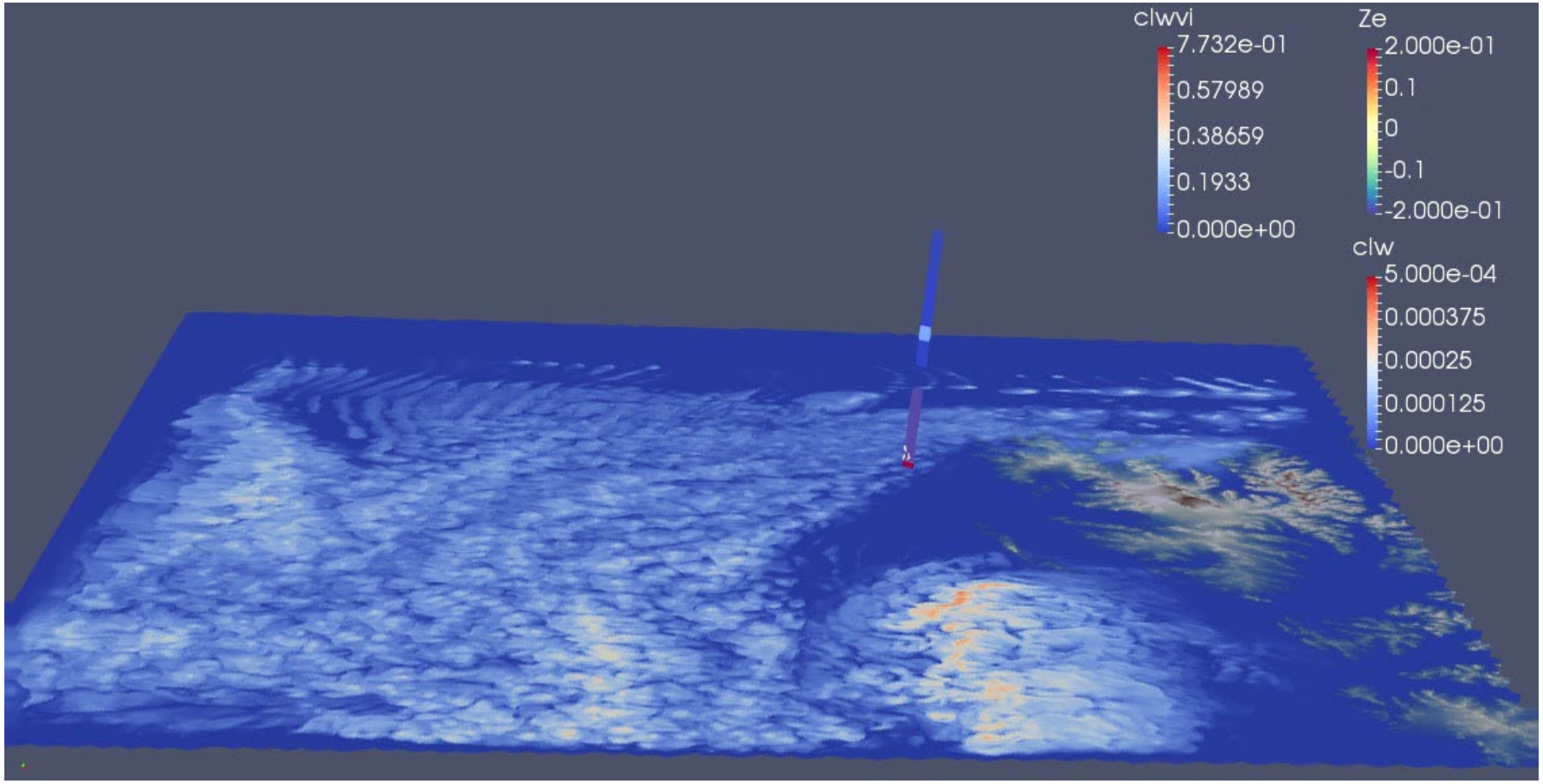


Microwave Radar/radiometer for Arctic Clouds MiRAC

- W-Band Radar
- 89 to 340 GHz passive channels

Mech et al. 2019, *AMT*, doi.org/10.5194/amt-12-5019-2019.

ICON-LEM Simulations



MiRAC-A radar reflectivity profiles
ICON-LEM cloud liquid and ice water content

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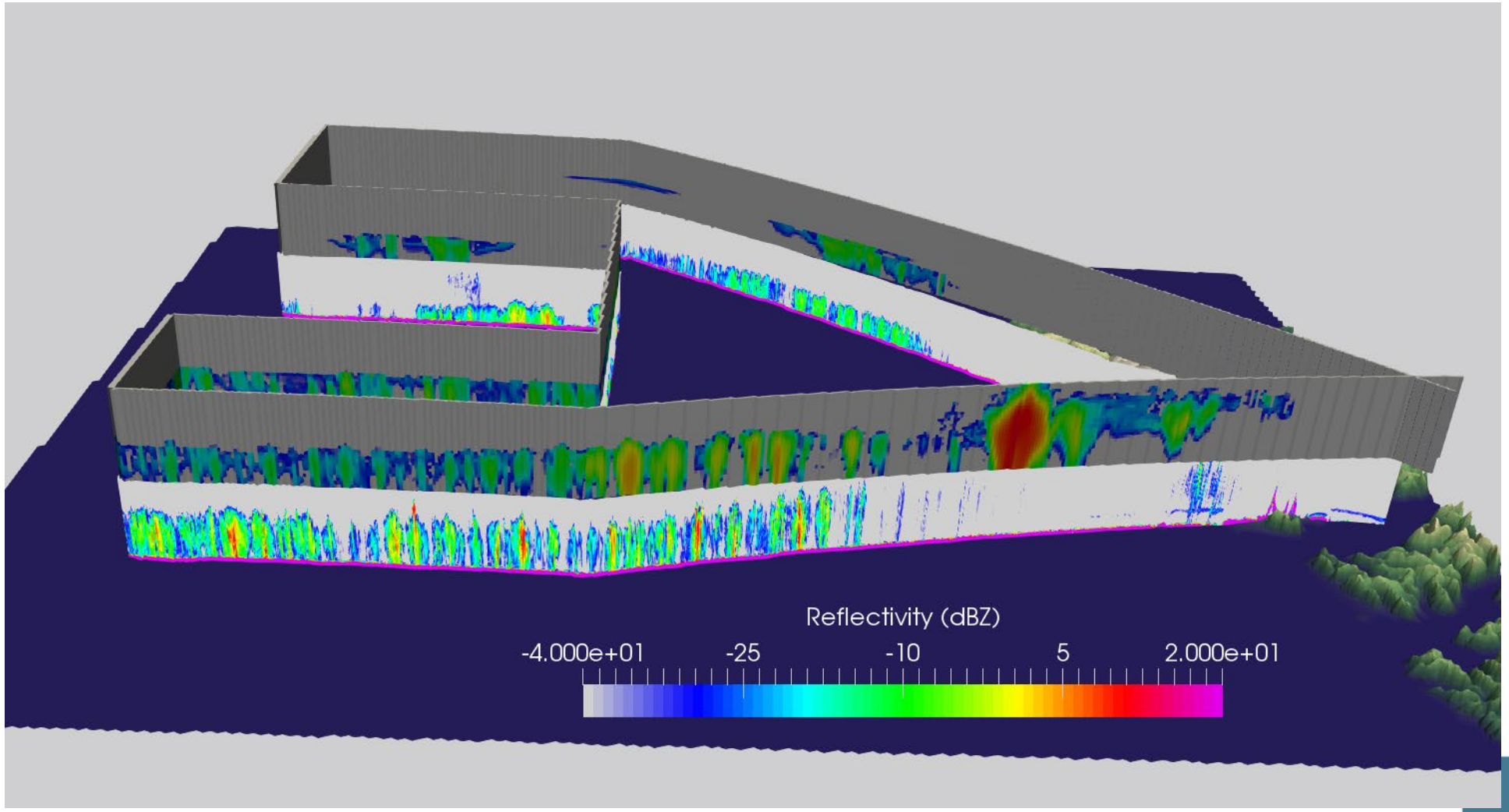
Model to Observation



Passive and Active Microwave radiative Transfer Model
PAMTRA (https://github.com/igmk/pamtra)

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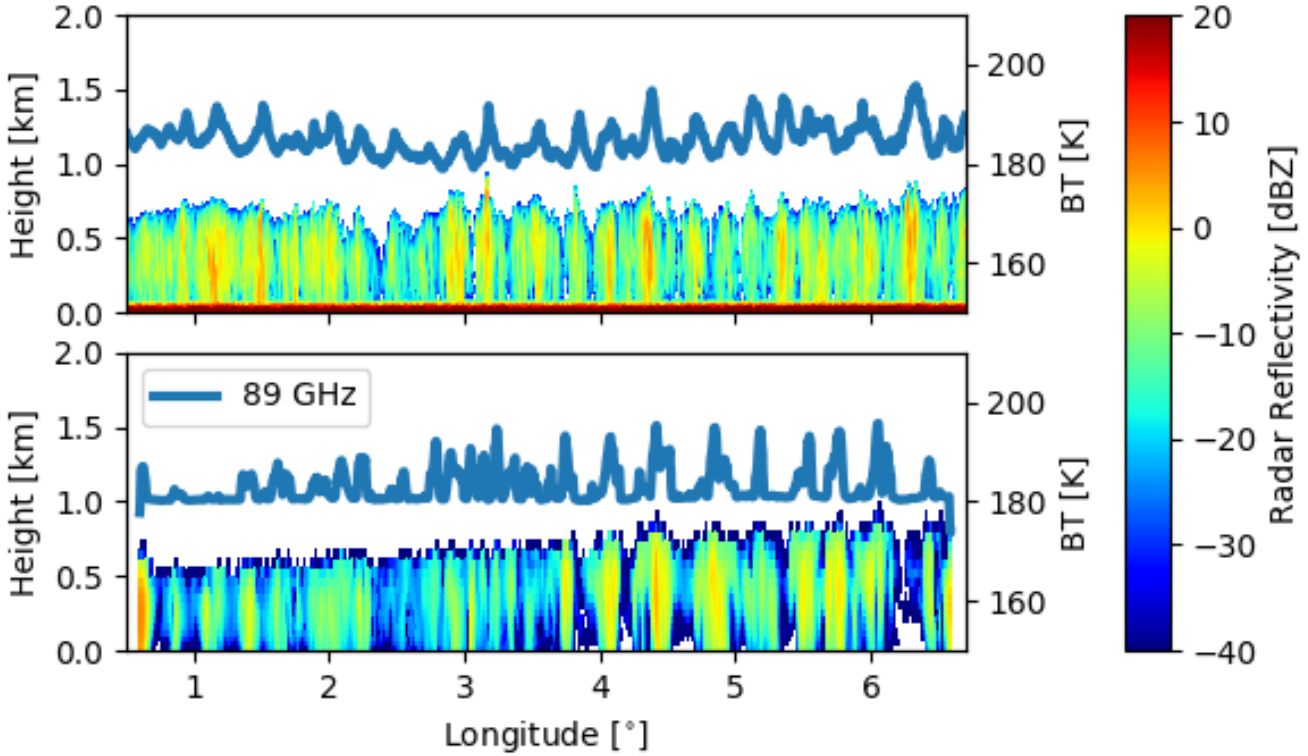
Adding information from passive channels

Measurements

ICON



- 89 GHz brightness temperature is highly sensitive to cloud liquid
- **ICON simulations depend strongly** on initial conditions, microphysical scheme and CCN/IN concentration
  → synergy with in-situ and lidar measurements for further constraints

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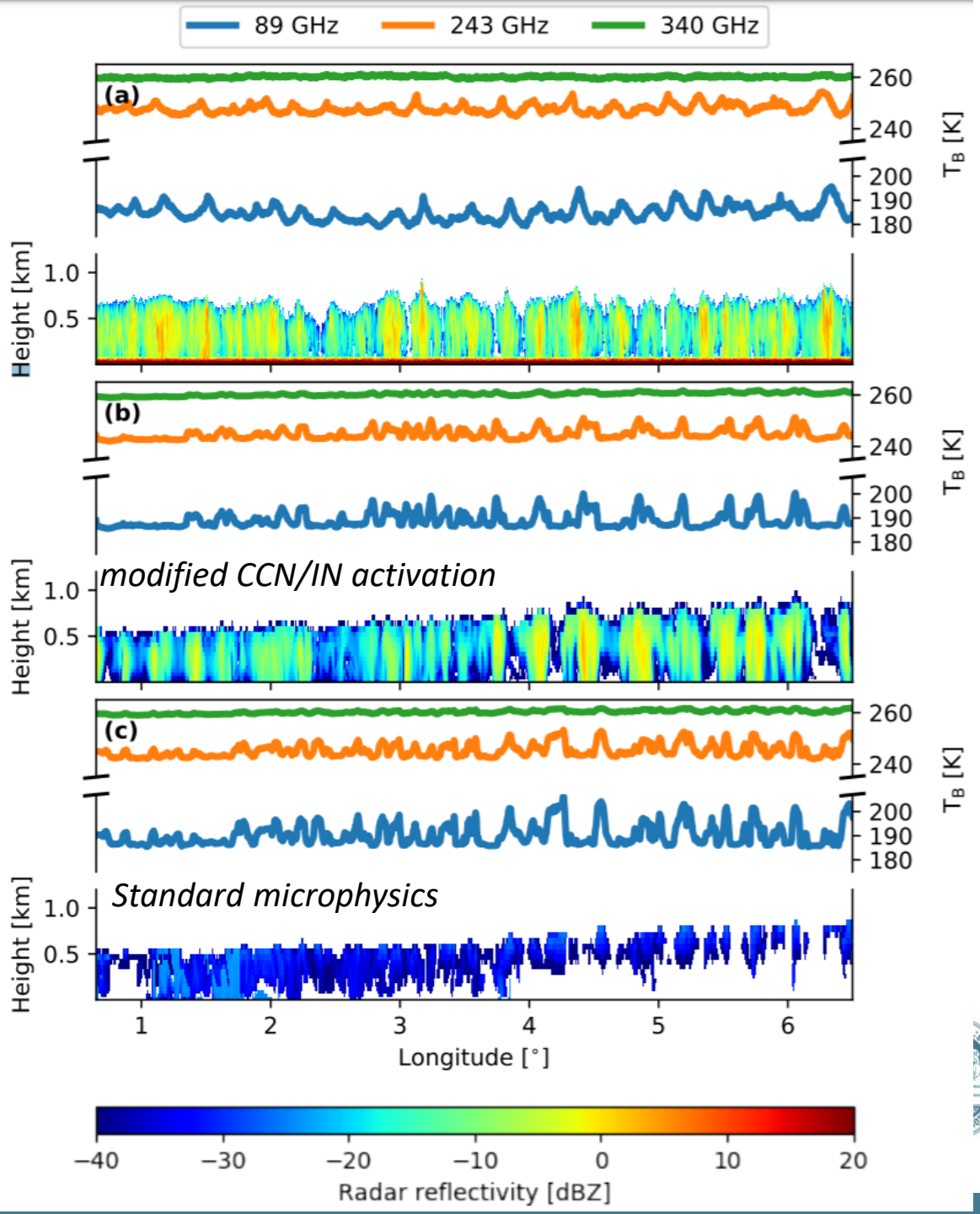
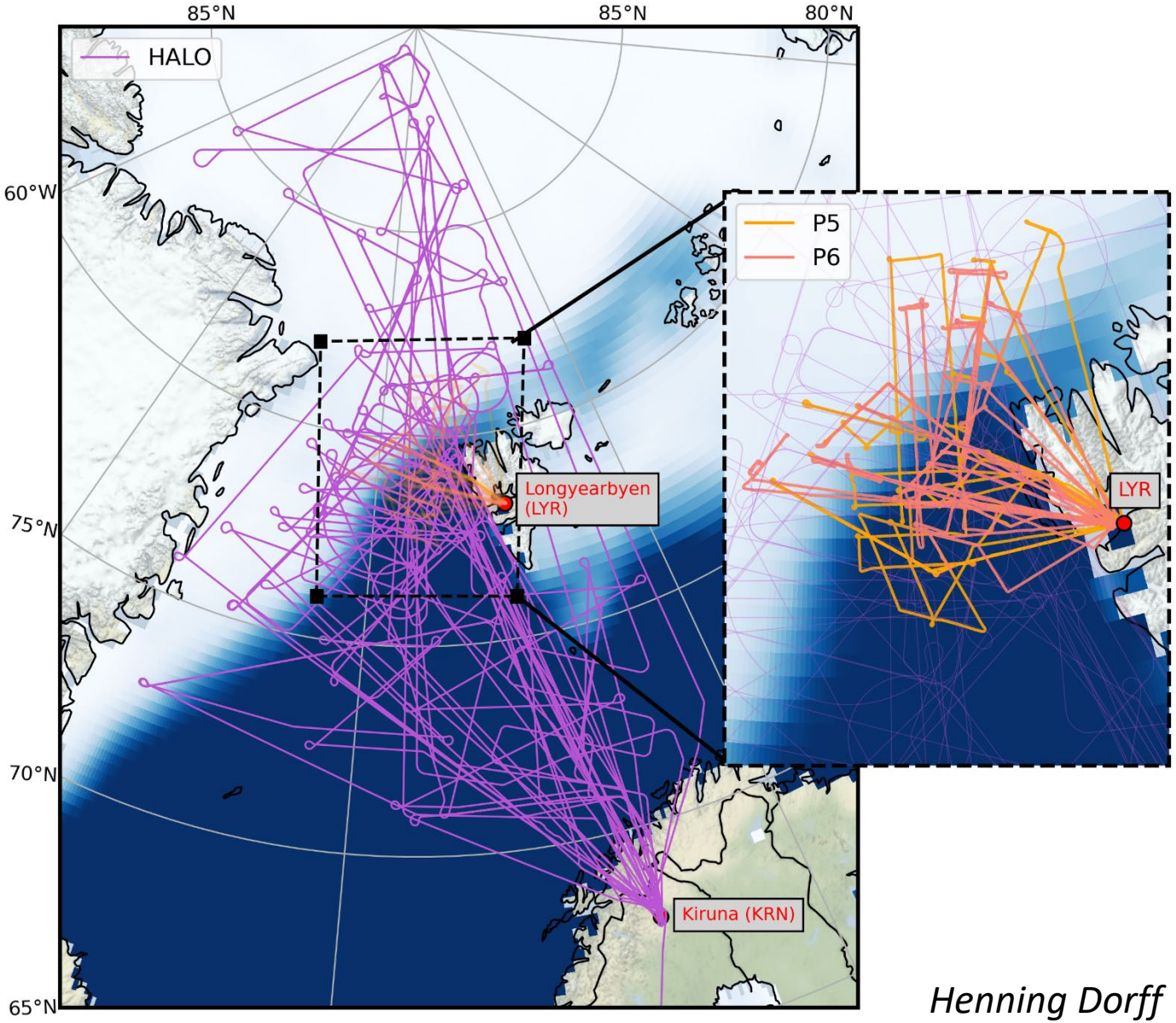
Active and passive

- **Passive** microwaves indicate liquid water amount (approx 100 gm^{-2})
- **Active** microwaves most sensitive to snow
- **ICON** standard configuration generates too little snow
- **Modified ICON** microphysics yield better distribution between liquid / ice microphysical scheme



HALO-AC^3 March/April 2022

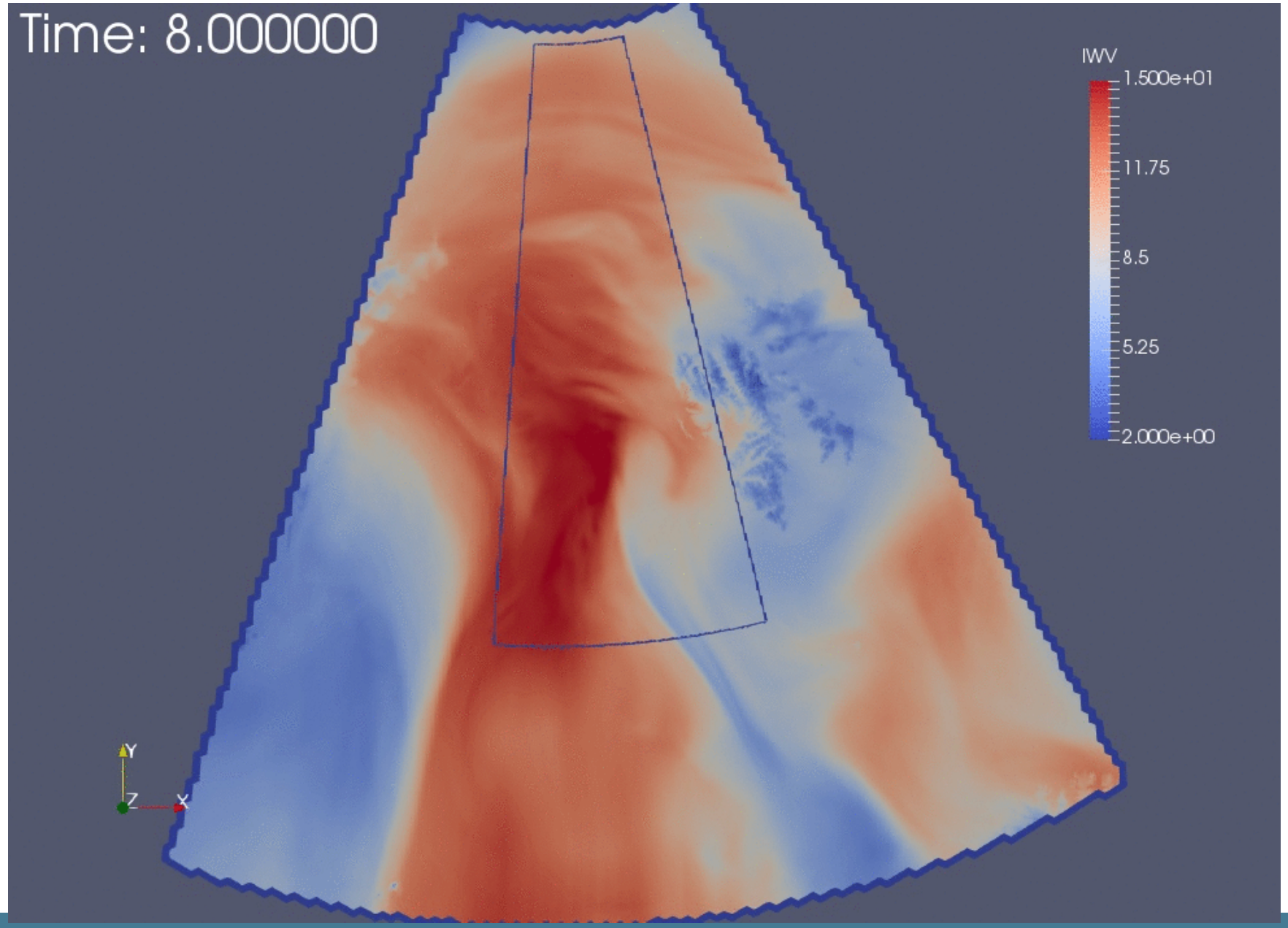


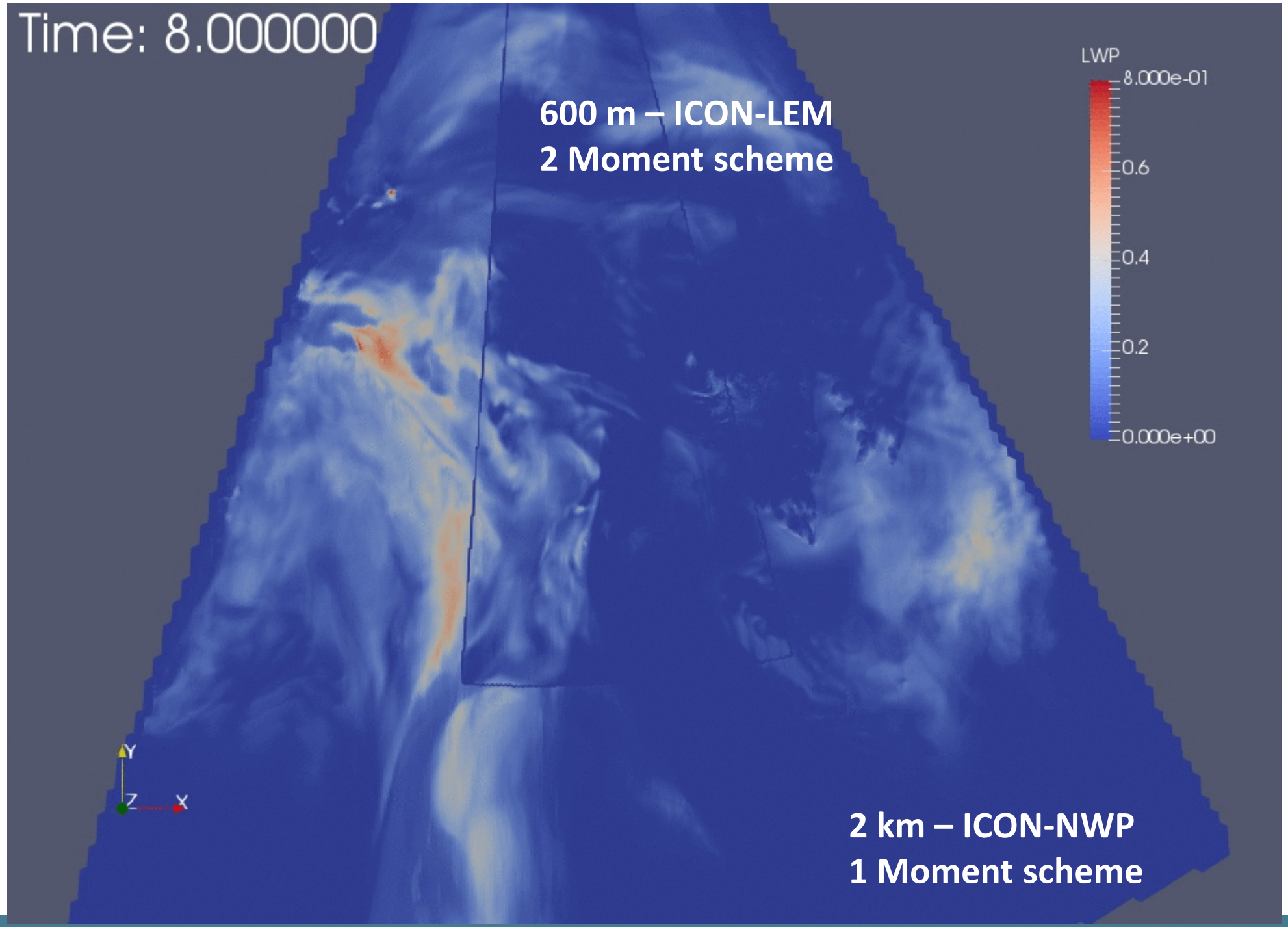
- Total distance = 113 103 km
- 347 drop sondes
- restrictions with air spaces

Henning Dorff

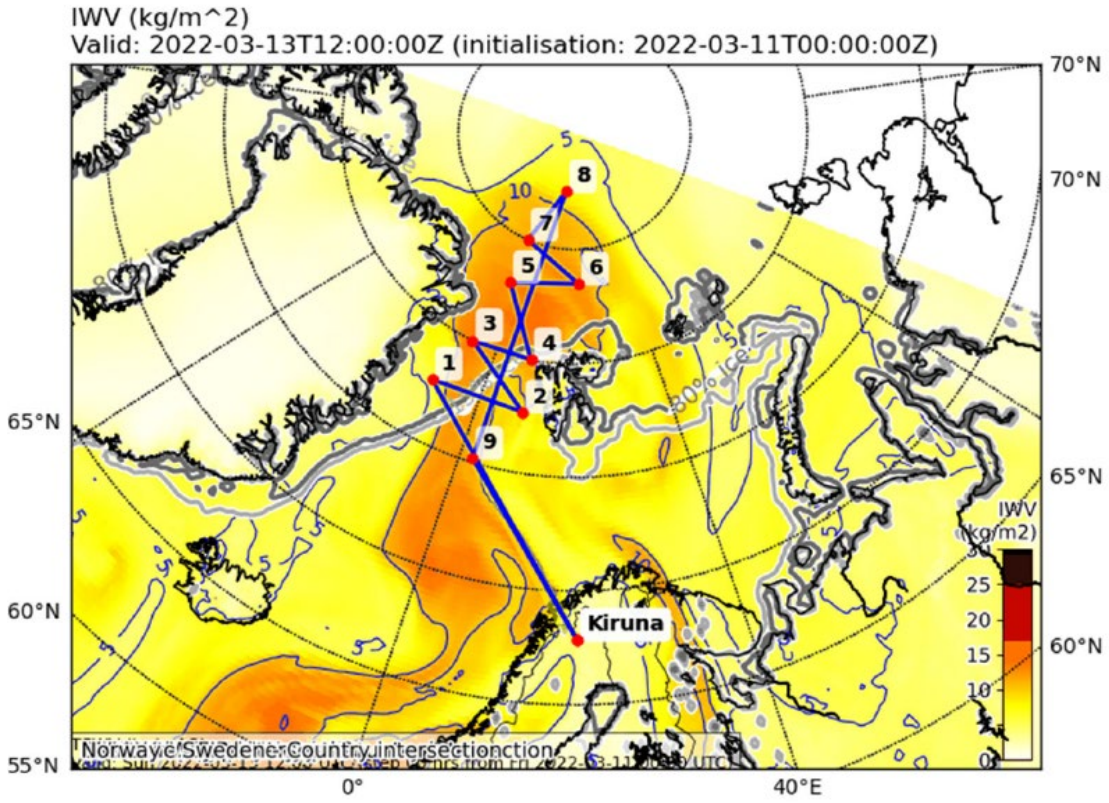
Warm Air Intrusion

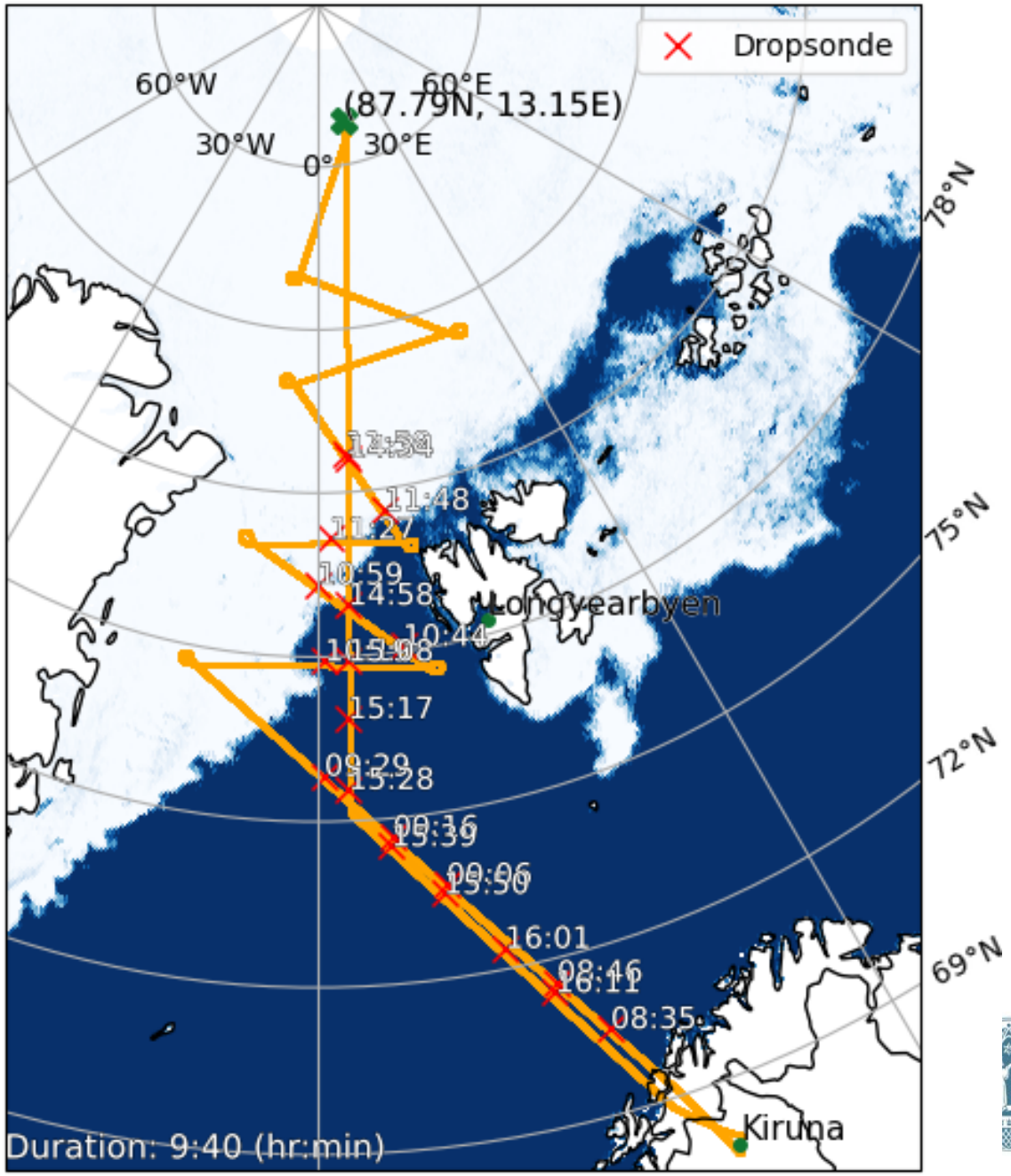
Integrated Water vapor




Time: 8.000000
600 m – ICON-LEM
2 Moment scheme
LWP
8.000e-01
0.6
0.4
0.2
0.000e+00
Y
Z
X
2 km – ICON-NWP
1 Moment scheme

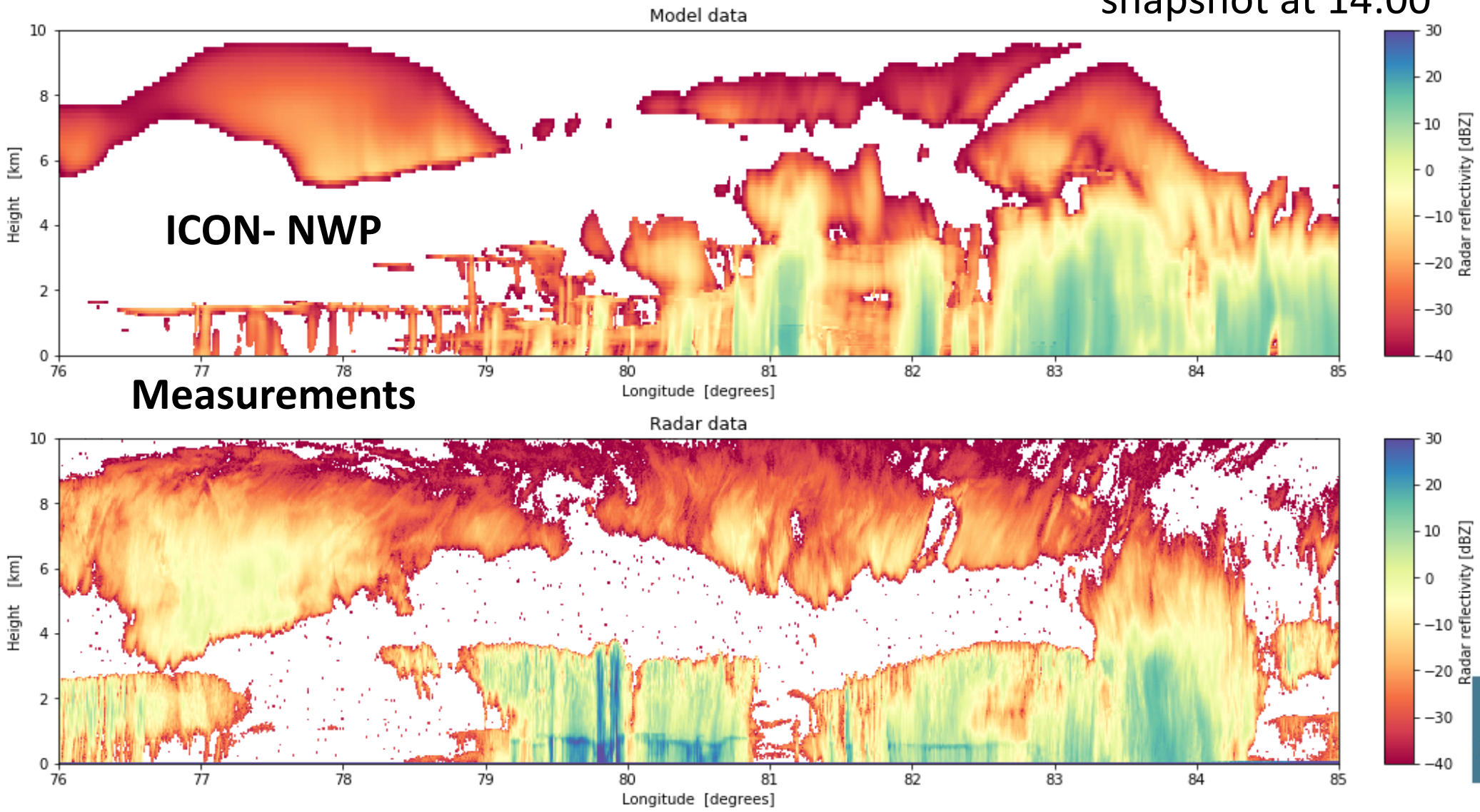
Warm Air Intrusion 13.3.2022





Northbound Leg

snapshot at 14:00



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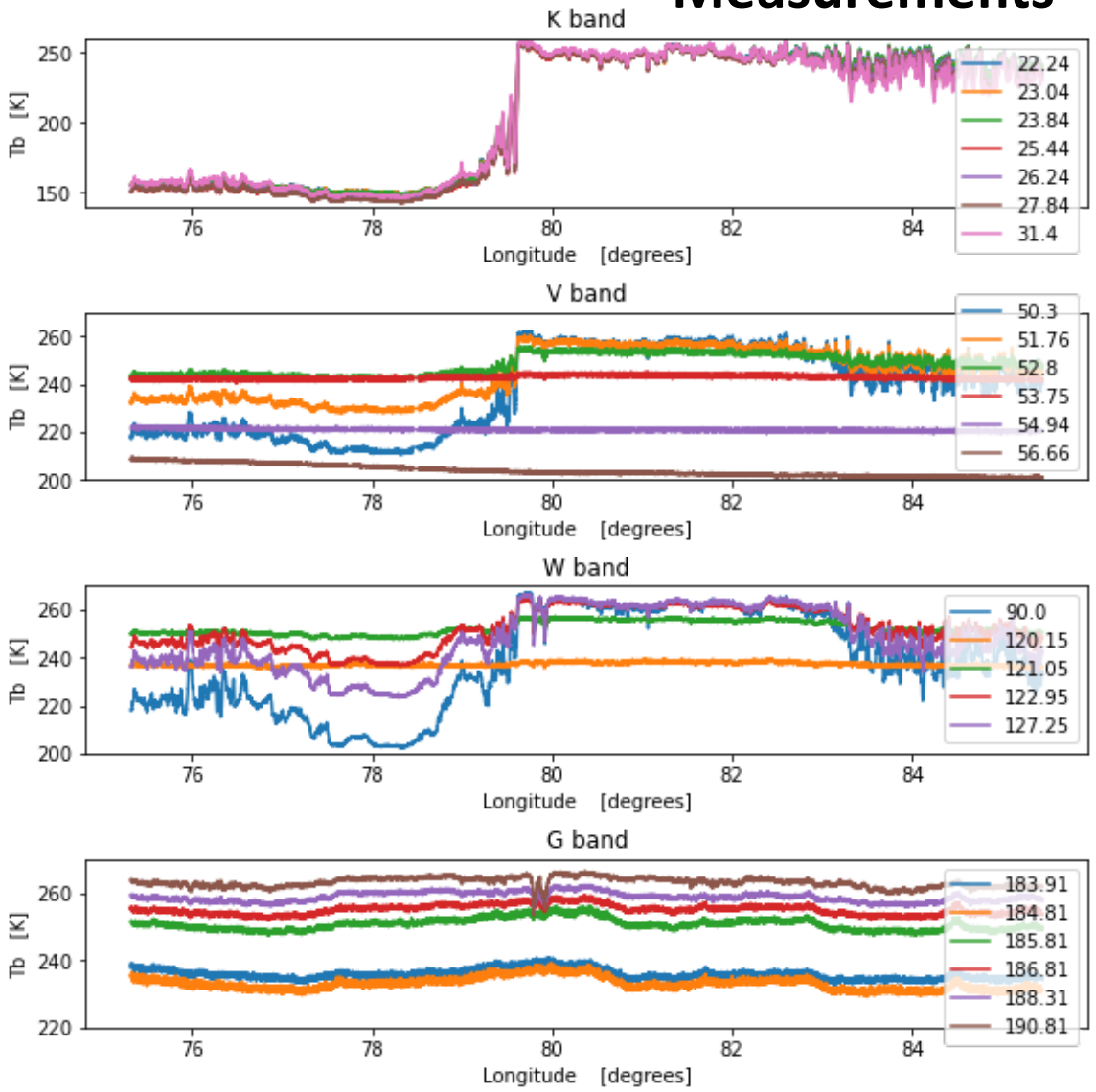
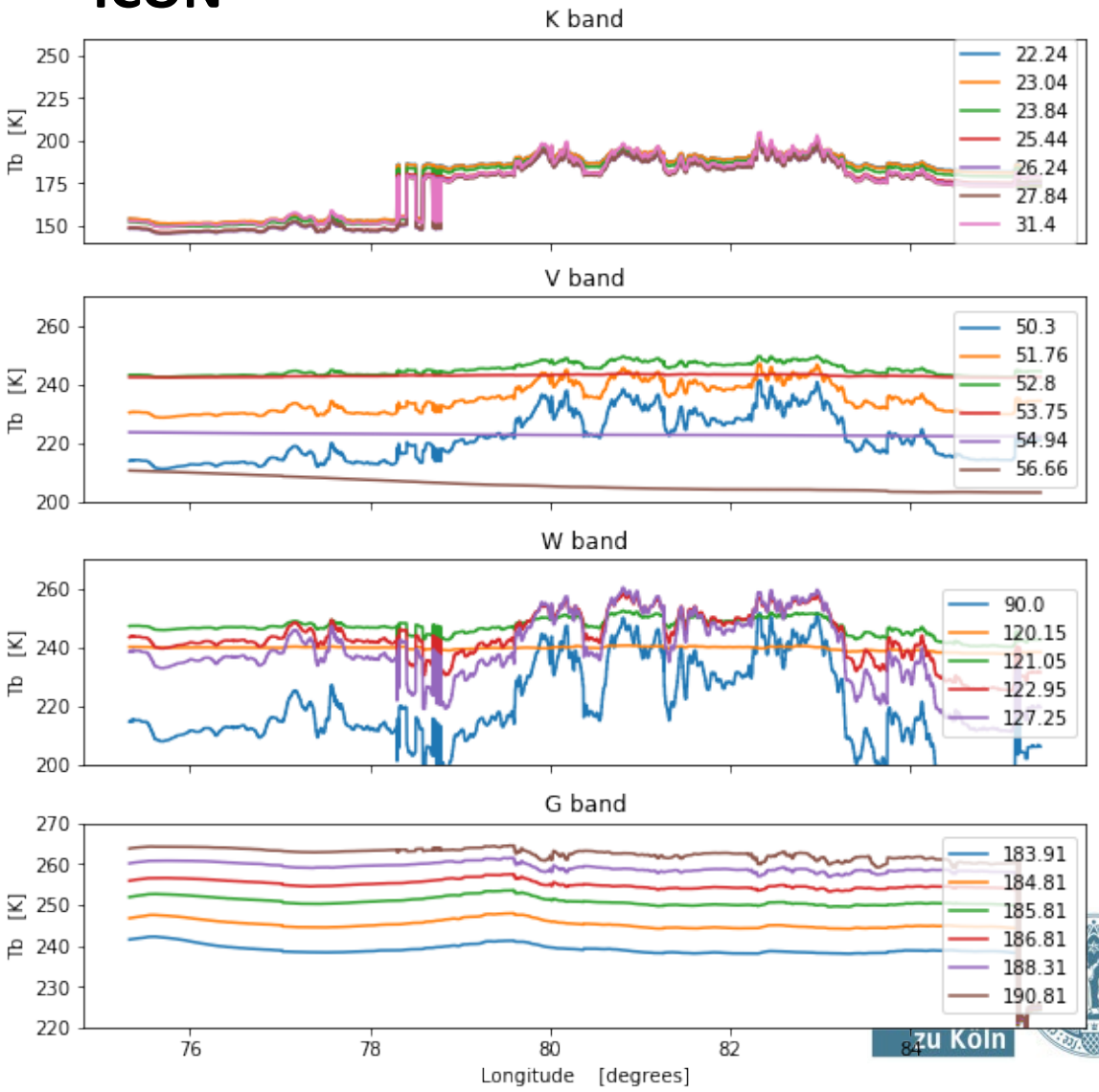
Passive channels

Measurements

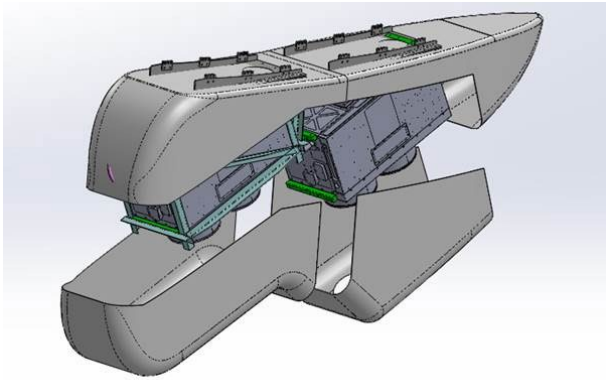


ICON

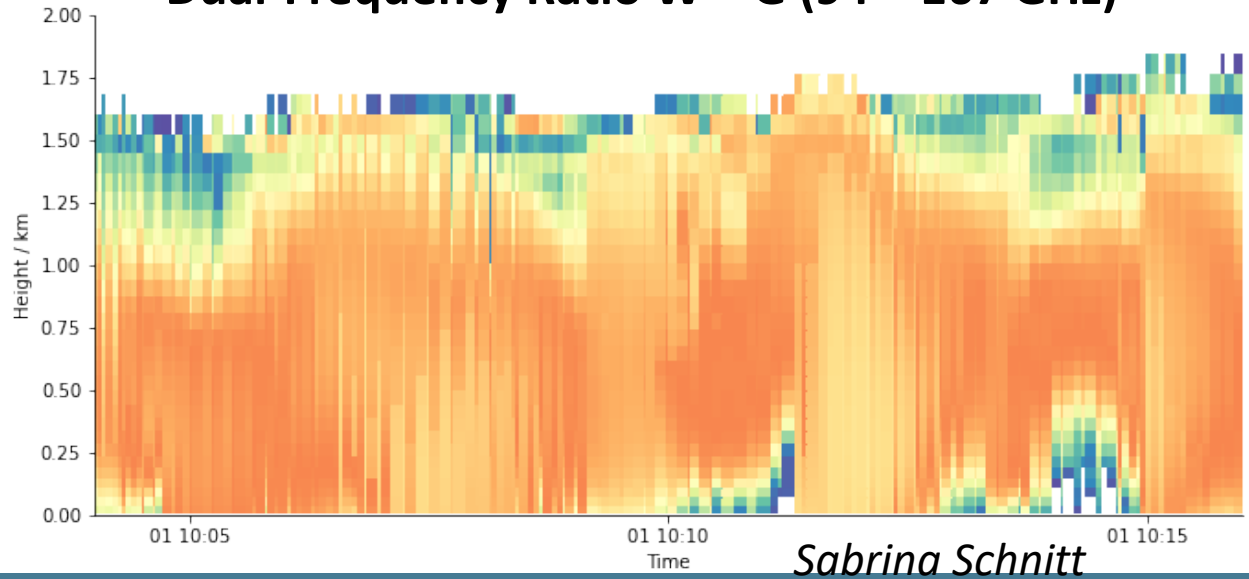


Conclusions and Outlook

- Role of small scale processes for Arctic Amplification is still challenging
- HALO-AC^3 campaign provides unique data to investigate air mass transformation
- High-resolution airborne observations, ICON LEM (600m) and PAMTRA radiative transfer are combined to better understand cloud processes
- Setup allows assessment of future measurement systems



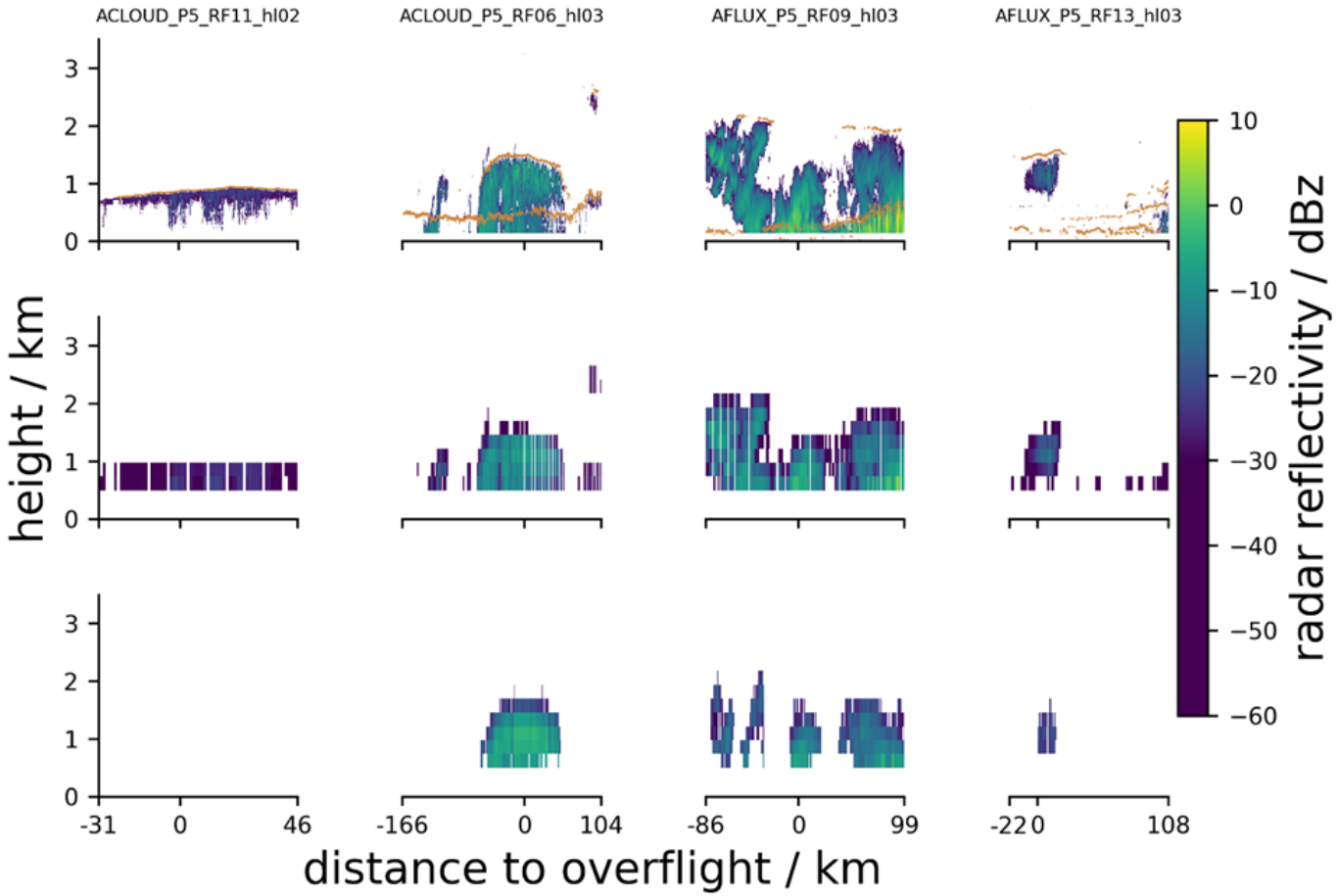
Dual-Frequency Ratio W – G (94 – 167 GHz)



Sabrina Schnitt


Thanks for your attention

CloudSat comparison: underflights



- blind zone
- coarser resolution:
  - less structures
  - new clouds evolve
- Good cloud top height agreement exept during last flight
- some cloud structures are not detected by CloudSat