

# Idealized large-eddy 100m resolution COSMO simulations of selected boundary-layer mixed-phase clouds with observational data from the RACEPAC campaign

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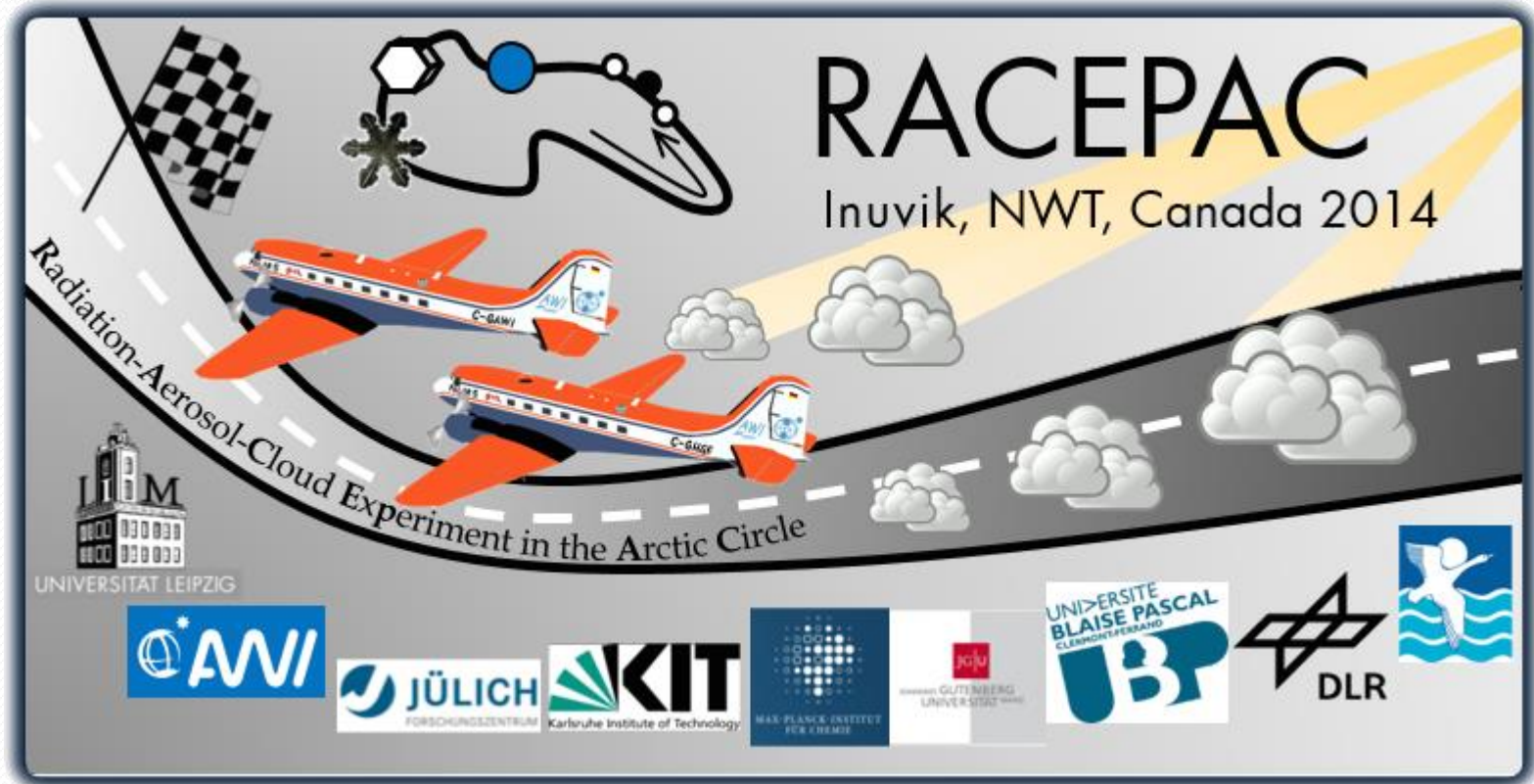
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# Content

- The RACEPAC experiment
- Flight #1 characteristics
- The COSMO setup
- First results
- Outlook

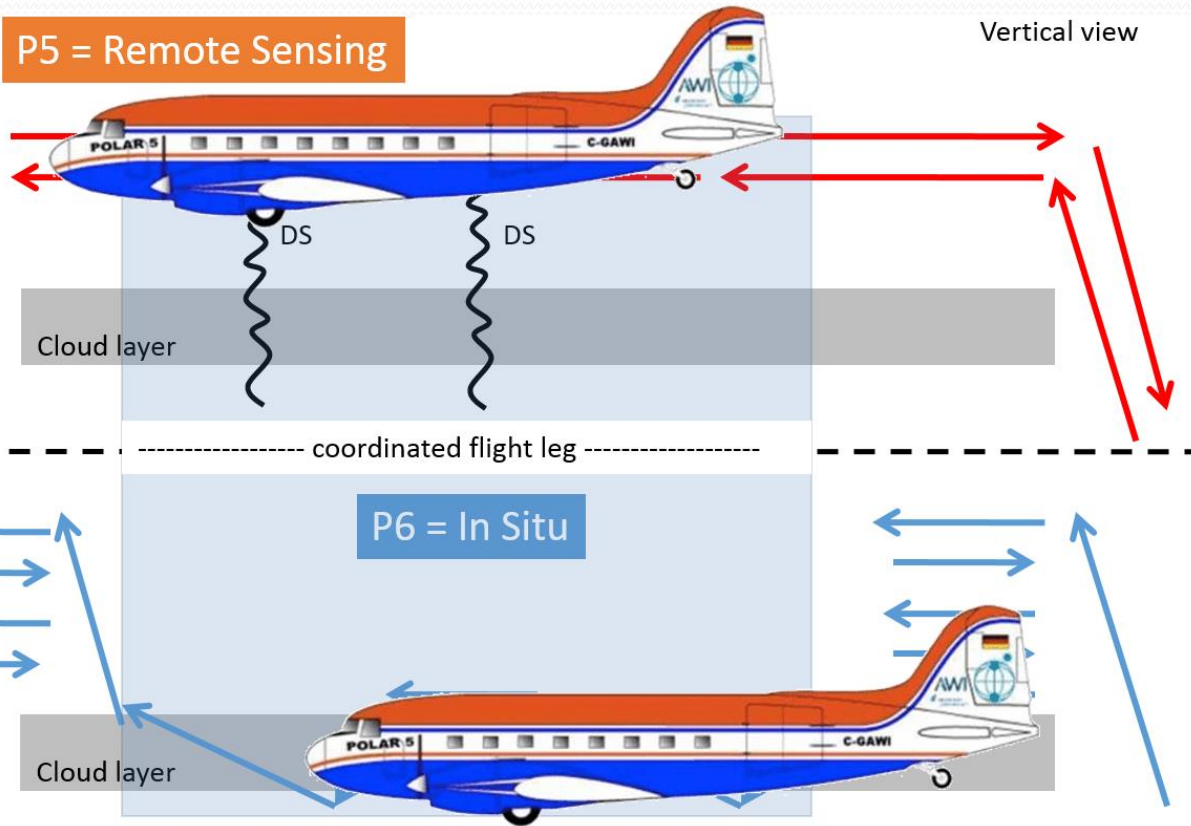


Radiation-Aerosol-Cloud Experiment in the Arctic Circle, 24. APR to 23. MAY 2014

Goal: Better understanding of cloud microphysics and interaction of radiation and clouds in the Arctic.

P5 = Remote Sensing

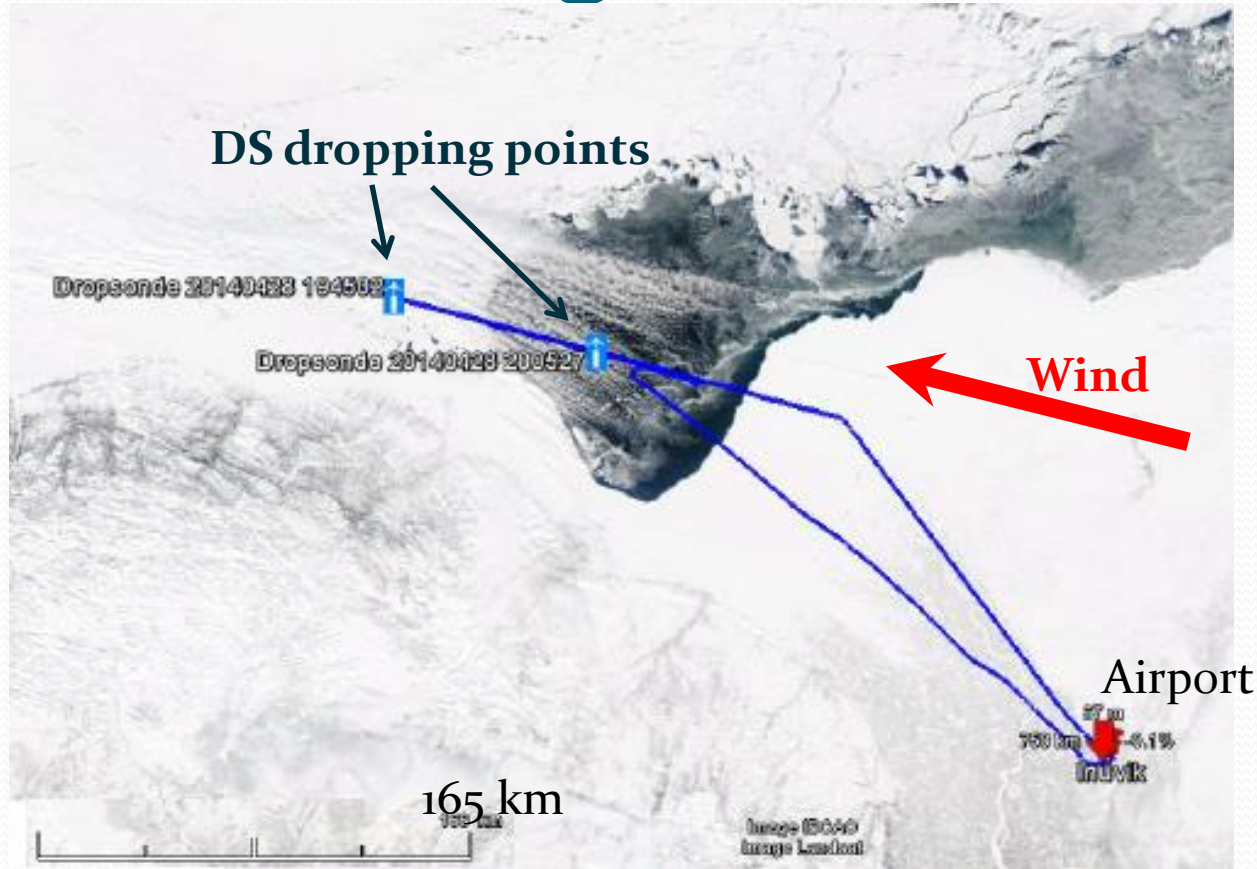
Vertical view



In Situ measurements in the cloud plus remote sensing from above cloud.

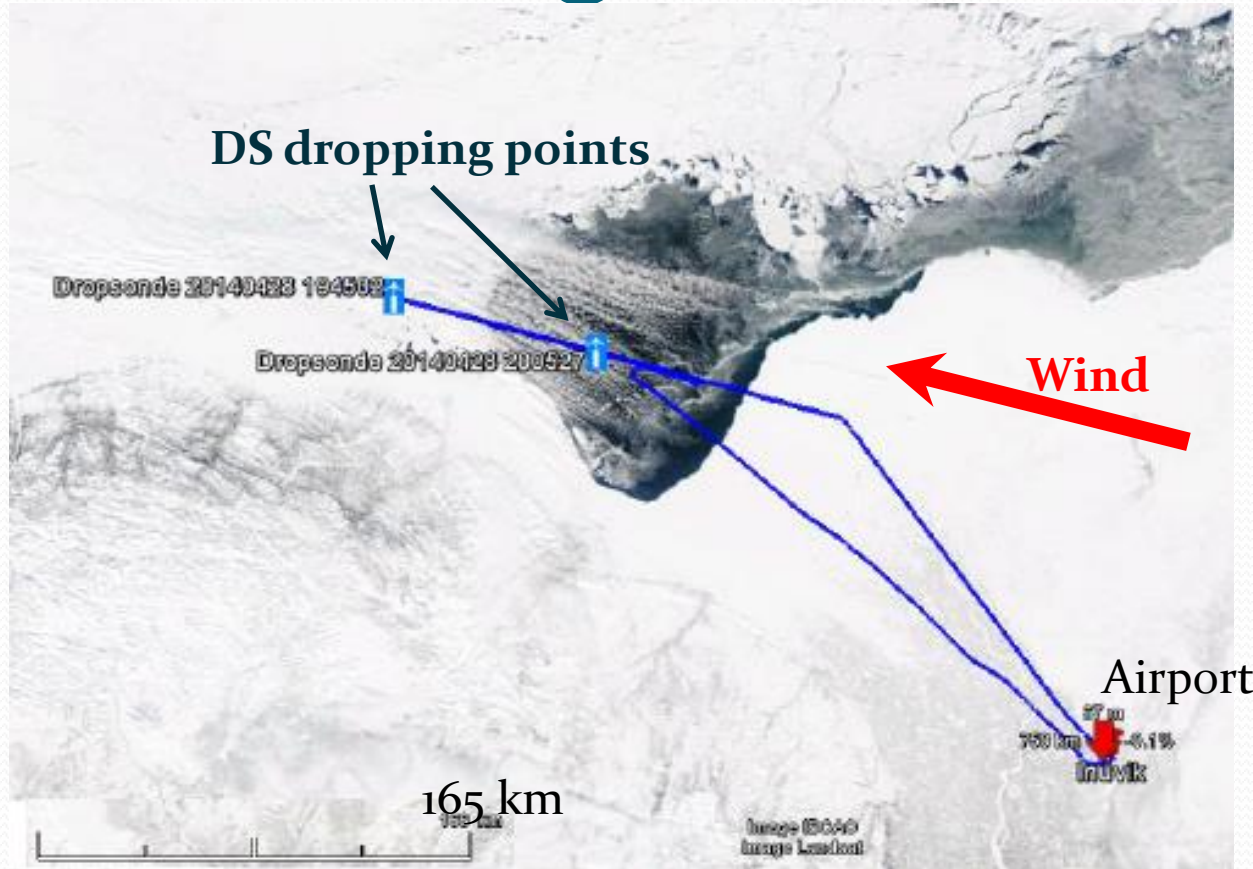


# RACEPAC Flight 1 Overview



- Cloud over sea ice and open water
- Dropsonde vertical profile over ice and water
- Continuous cloud, thinner at the Eastern Edge

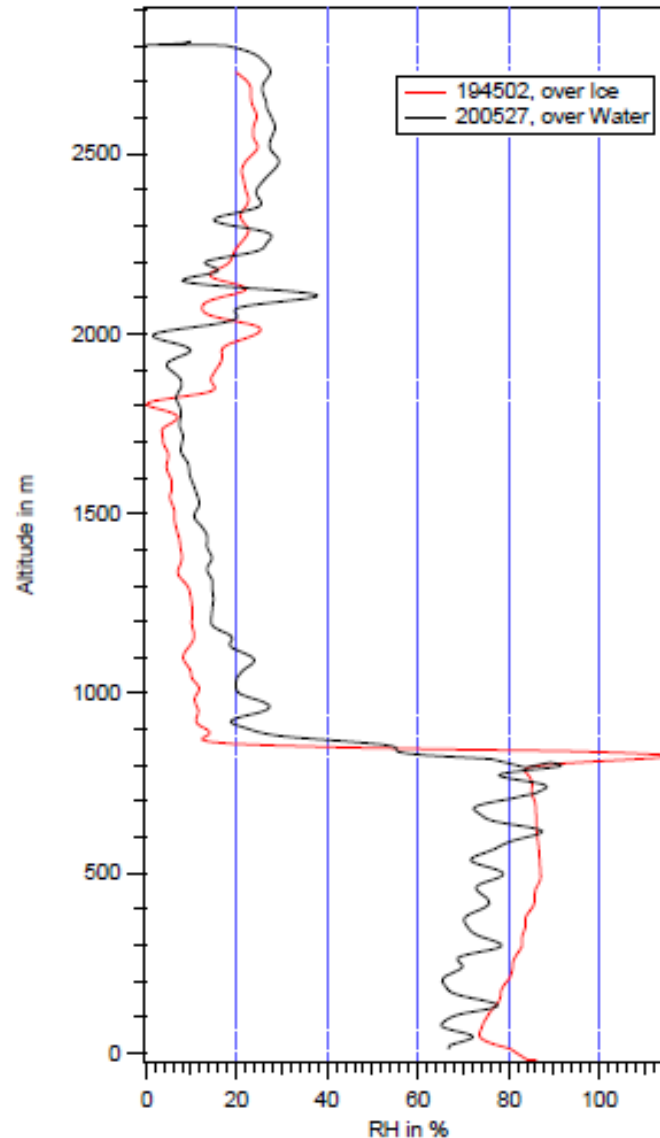
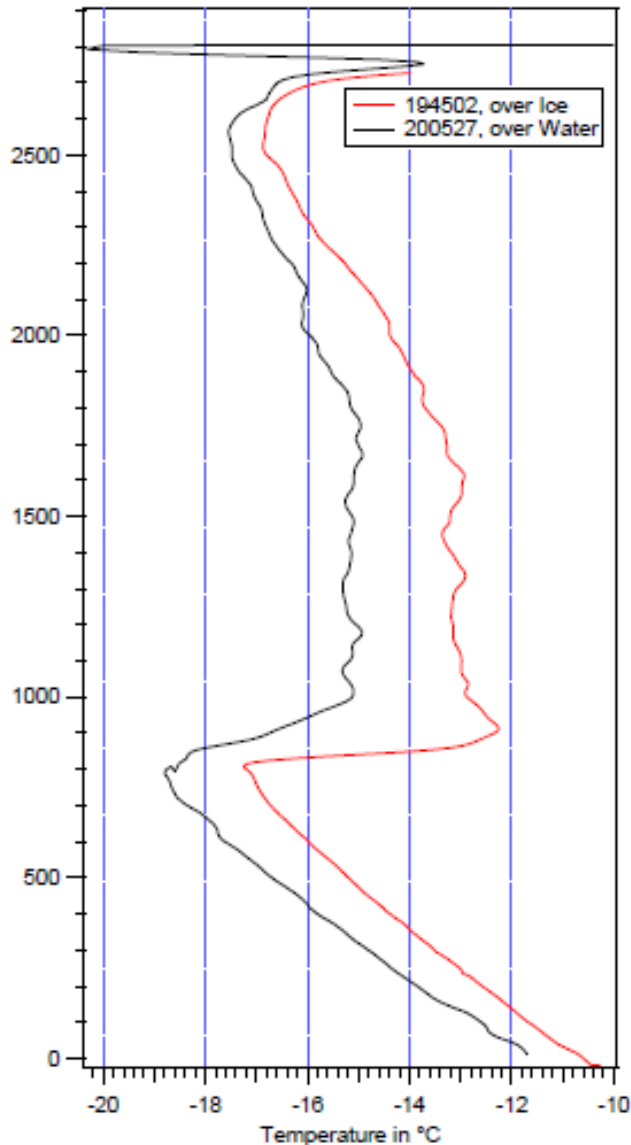
# RACEPAC Flight 1 Overview



## Research goals

- Can we simulate differences in the cloud over water and ice?
- Explain difference in low level jet as seen by Dropsondes

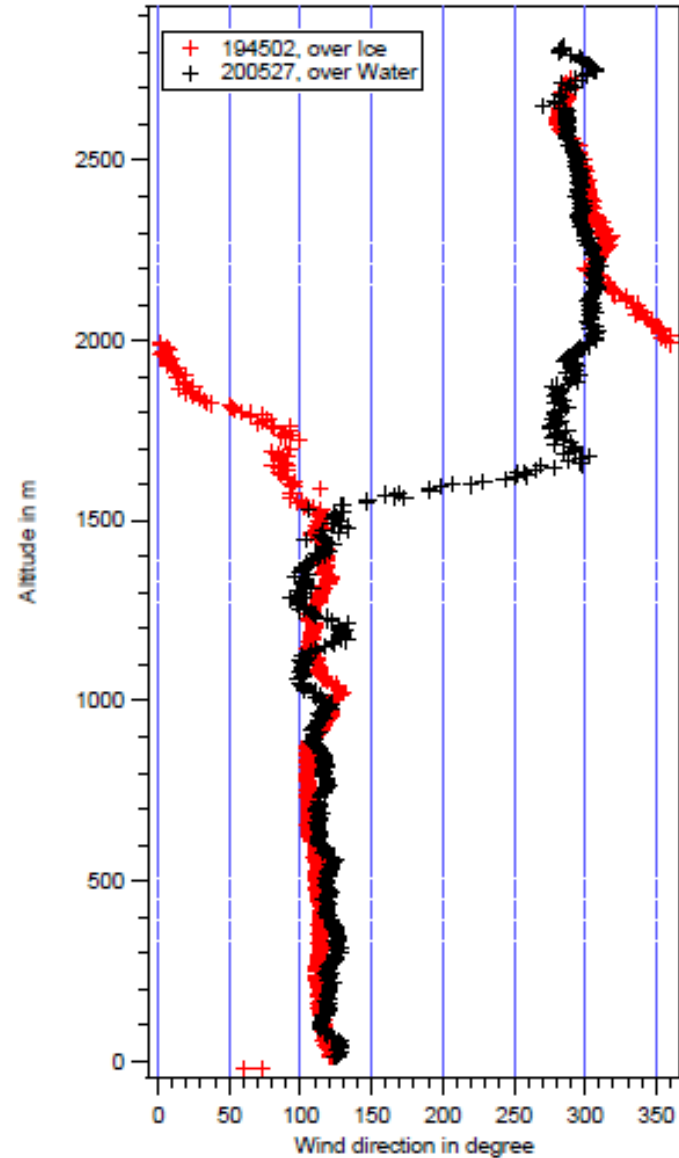
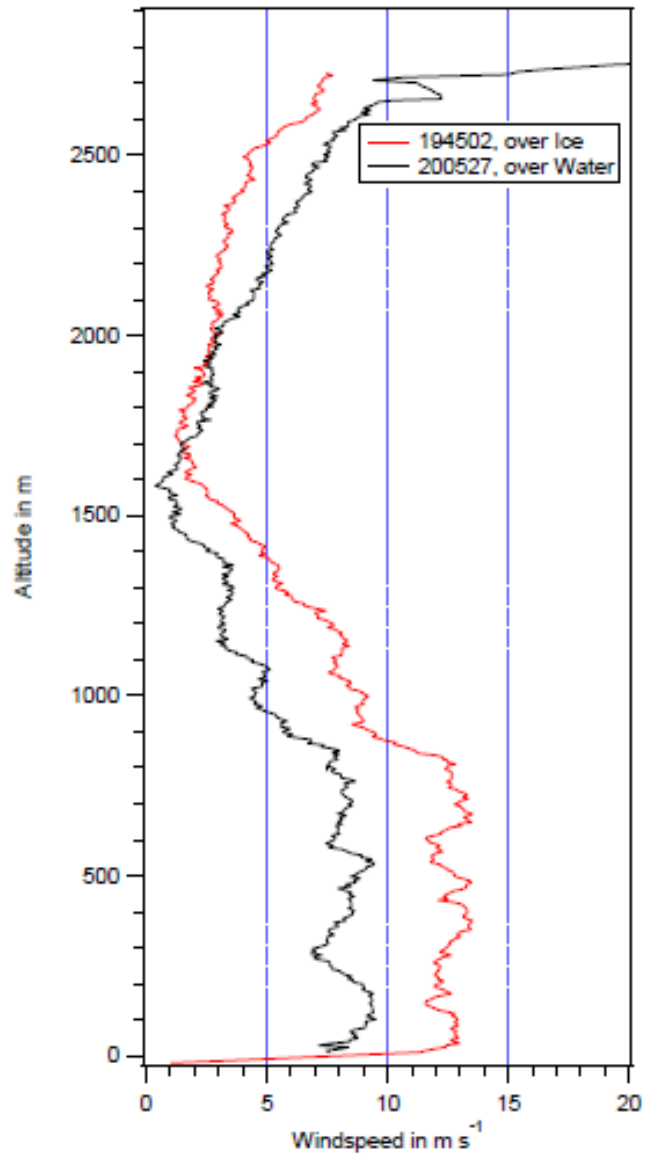
# Dropsonde profiles: T & RH



Red: Over Sea Ice  
Black: Over Water

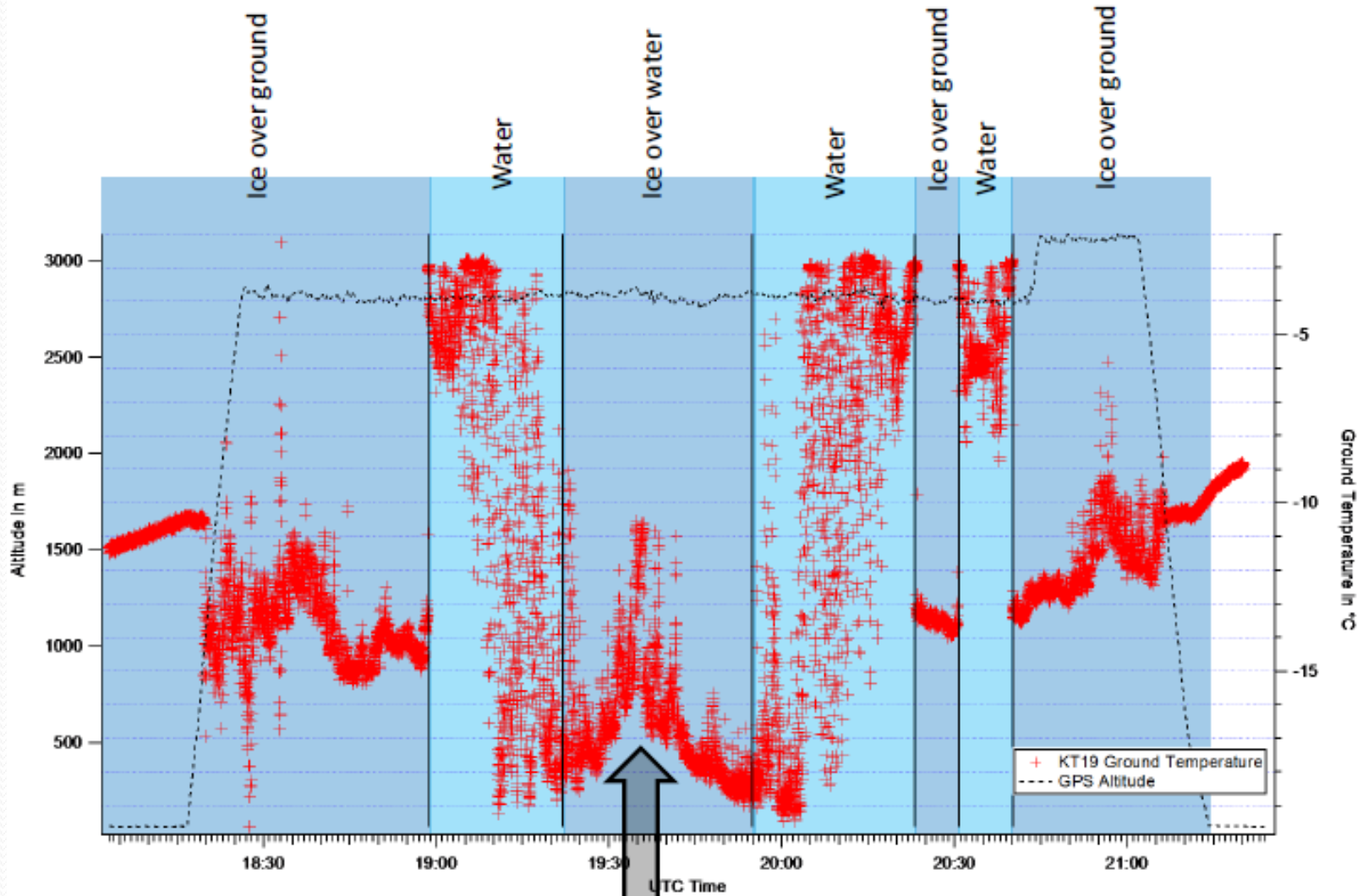
Data corrected for  
instrumental  
inertia (3.9s - T,  
5.0s - RH)

# Dropsonde profiles: Wind

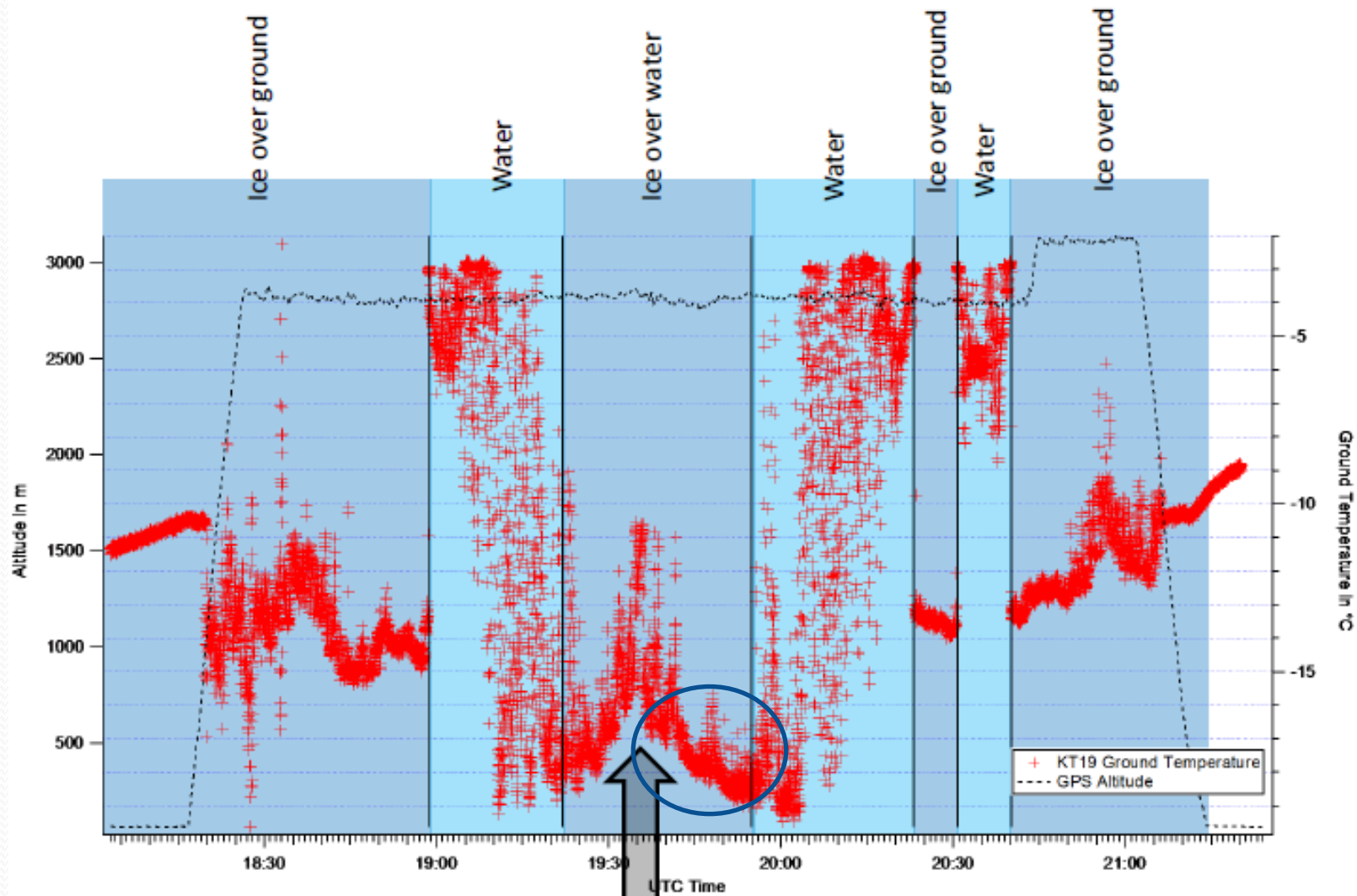




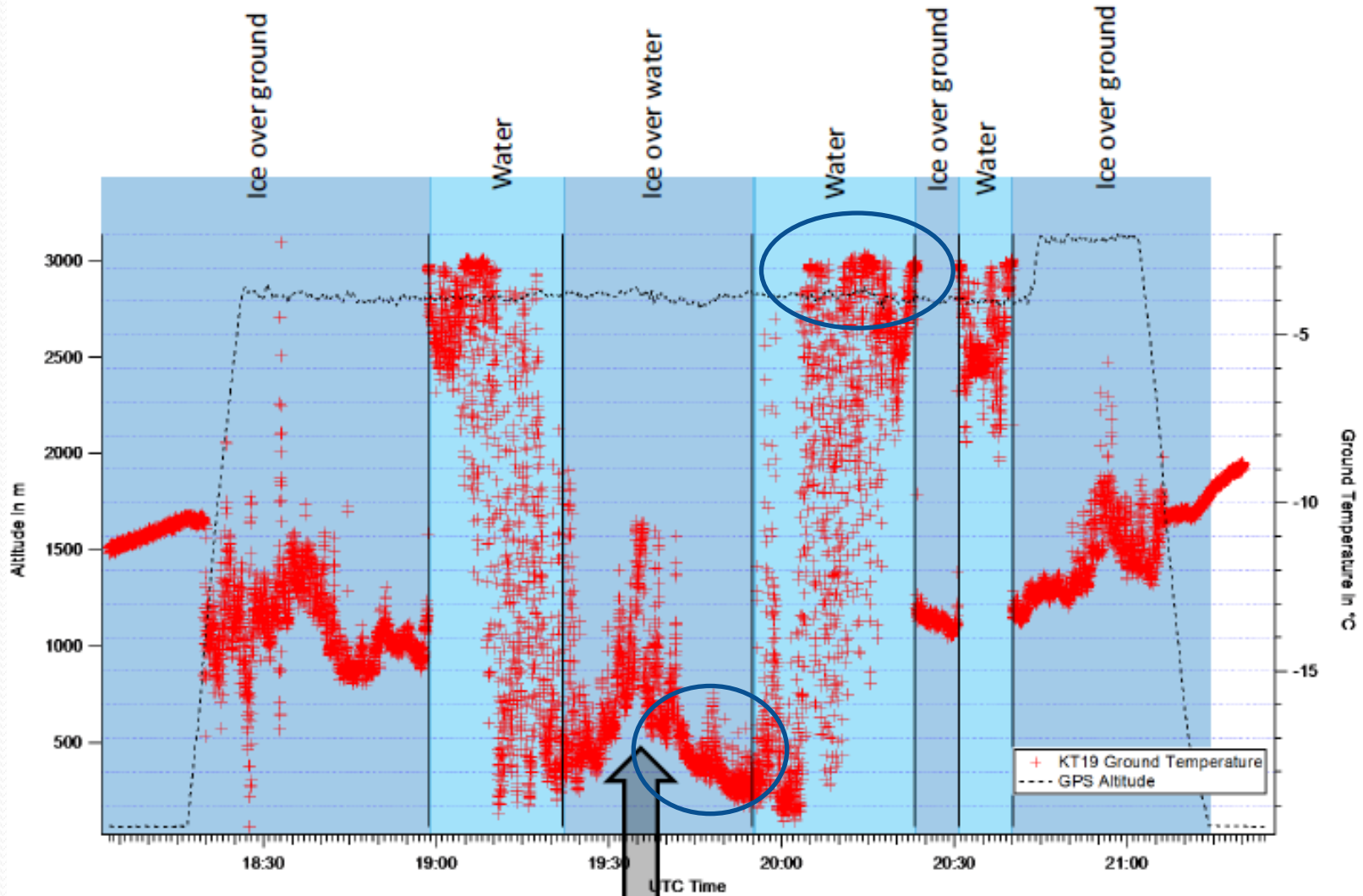
# Surface temp. - KT19 IR sensor (P5)



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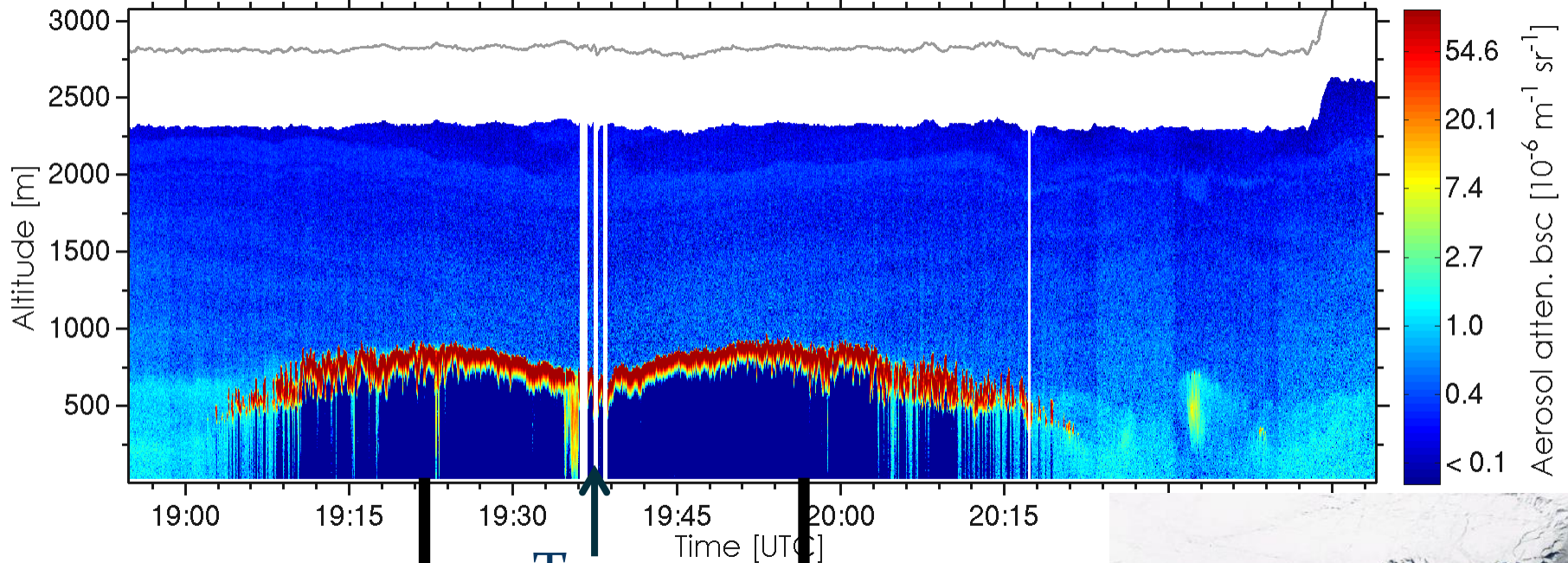


# Surface temp. - KT19 IR sensor (P5)



# LIDAR: cloud tops

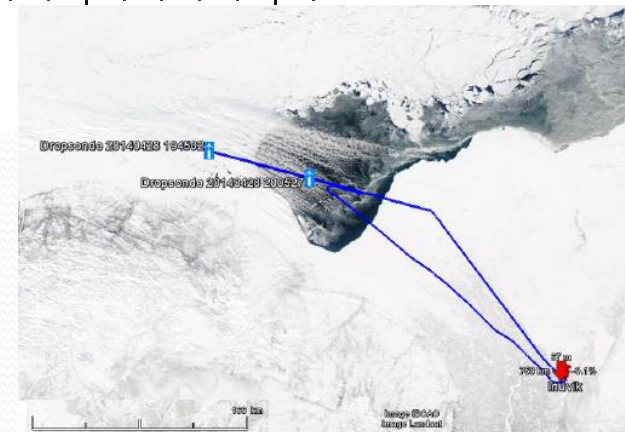
532 nm Aerosol atten. bsc. (analog), AMALi 28-Apr-2014 18:54:52, 5 s, 7.5 m



Water

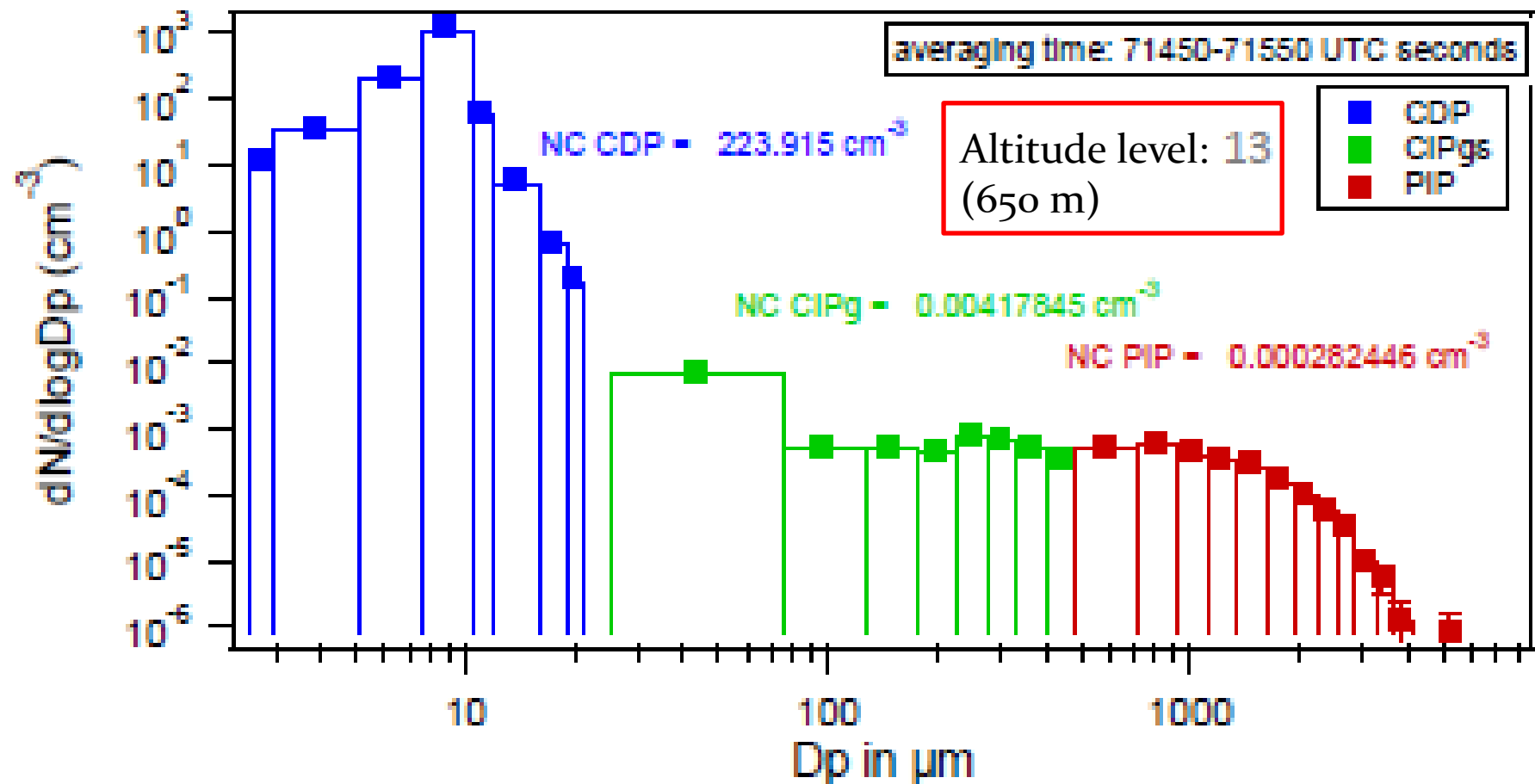
Sea Ice

Water



Note that LIDAR sees the cloud top only and can not evaluate cloud water content / cloud thickness

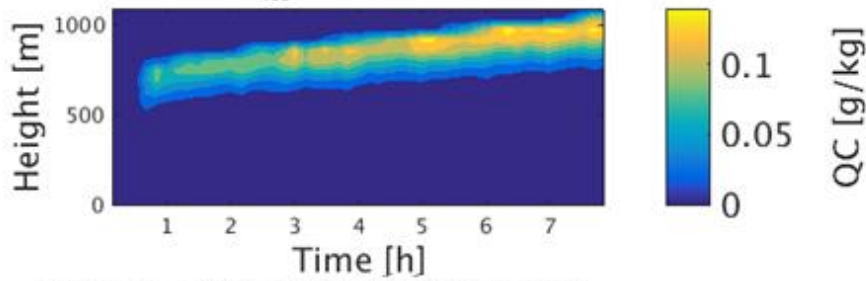
# P6 in-situ size distributions



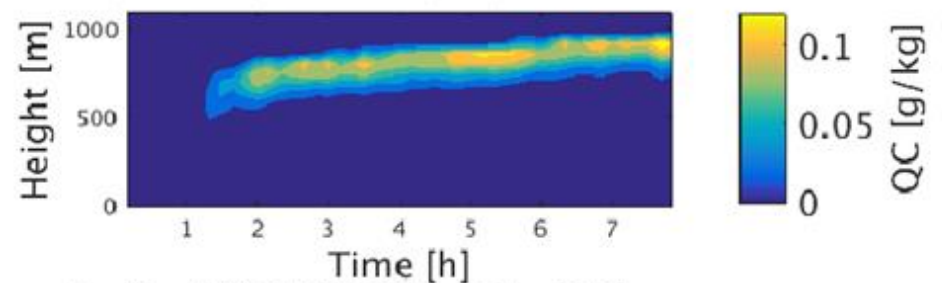
# Model Setup

- COSMO idealized simulations
- Model height 22km, exponential vert. layers
- Grid 64x64x200 Res.: 100 m x 100 m x Gal-Chen-Exp. (0, 17, 42, 71, 104 m ... 22 km)
- DS #1 Input / KT19 surface temperature
- CDNC 200 (0-400) /cm<sup>3</sup>, INC 4000 (0-8000) /m<sup>3</sup>
- April 28th 2 pm @ 70° lat + 7-9 h in 2 s time-steps
- 2-Moment Cloud Scheme & 3D Turbulence Scheme
- QV of first 100 m's as a constant QV up to top of mixing layer. Higher air from dropsonde & reference atmosphere.

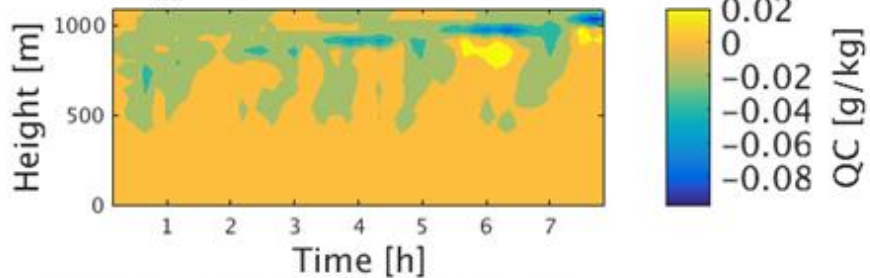
Reference: Water,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-2^\circ C$



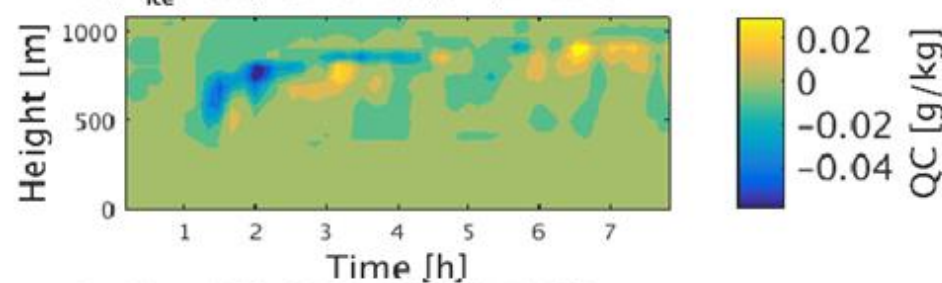
Reference: Ice,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-17^\circ C$



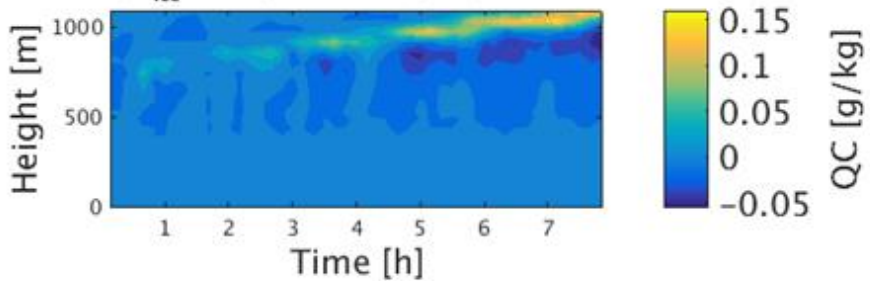
Water,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-3^\circ C$



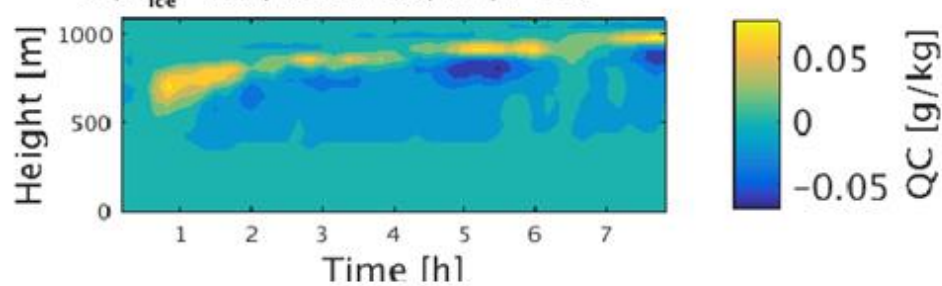
Ice,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-21^\circ C$



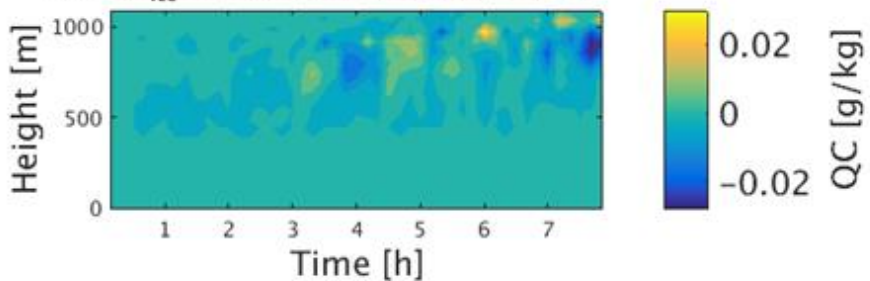
Water,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=1^\circ C$



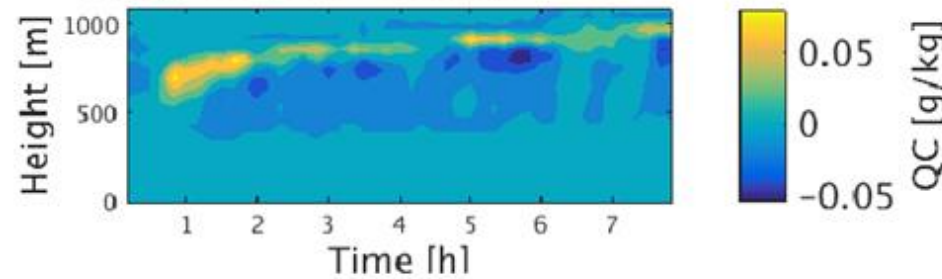
Ice,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=1^\circ C$



Water,  $N_{ice}=4000$ ,  $CDNC=400/cm^3$ ,  $T=-2^\circ C$



Ice,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-3^\circ C$

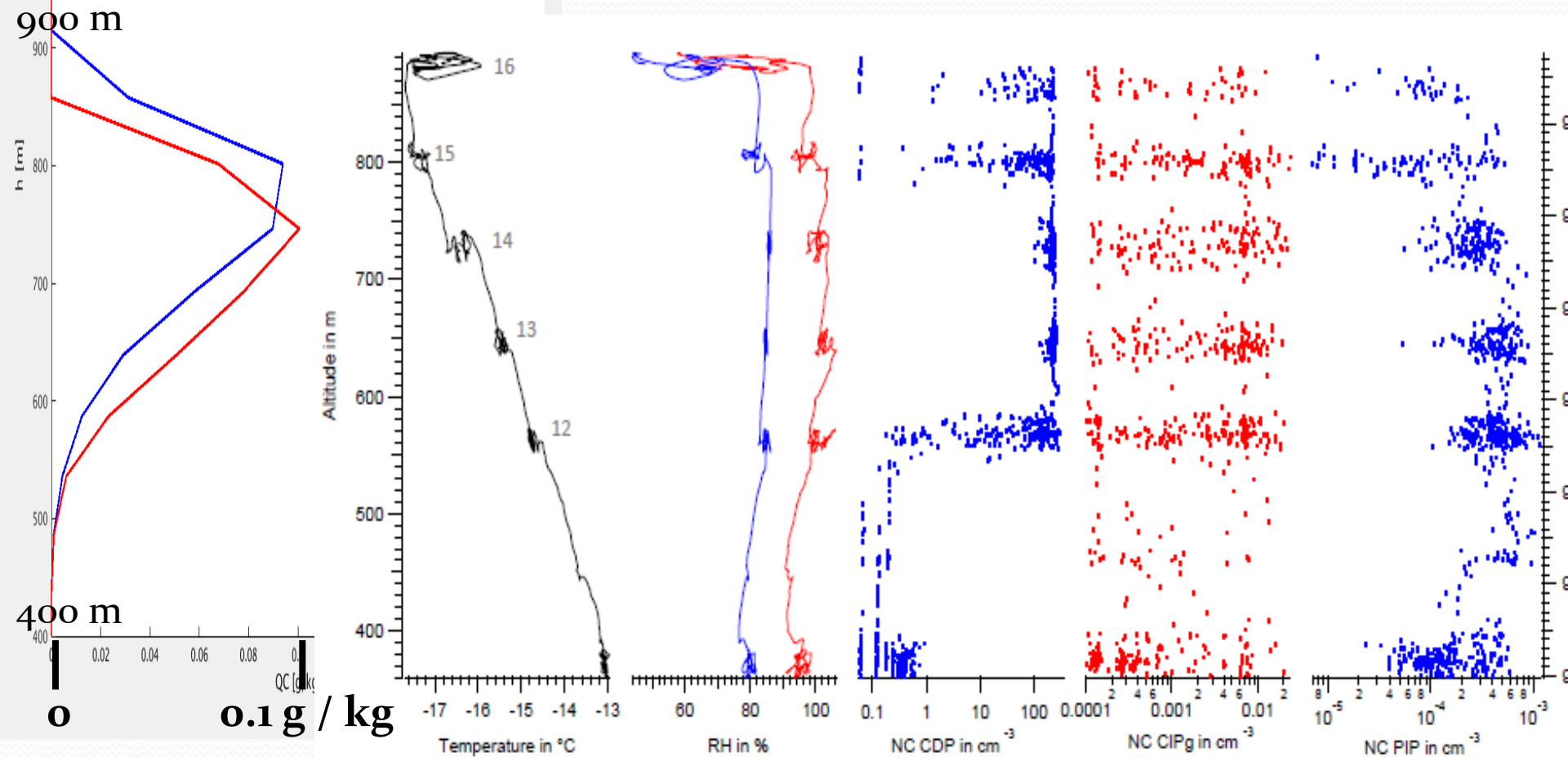


time: + 2h

QC +8h Water,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-2^\circ C$   
QC +8h Ice,  $N_{ice}=4000$ ,  $CDNC=200/cm^3$ ,  $T=-17^\circ C$

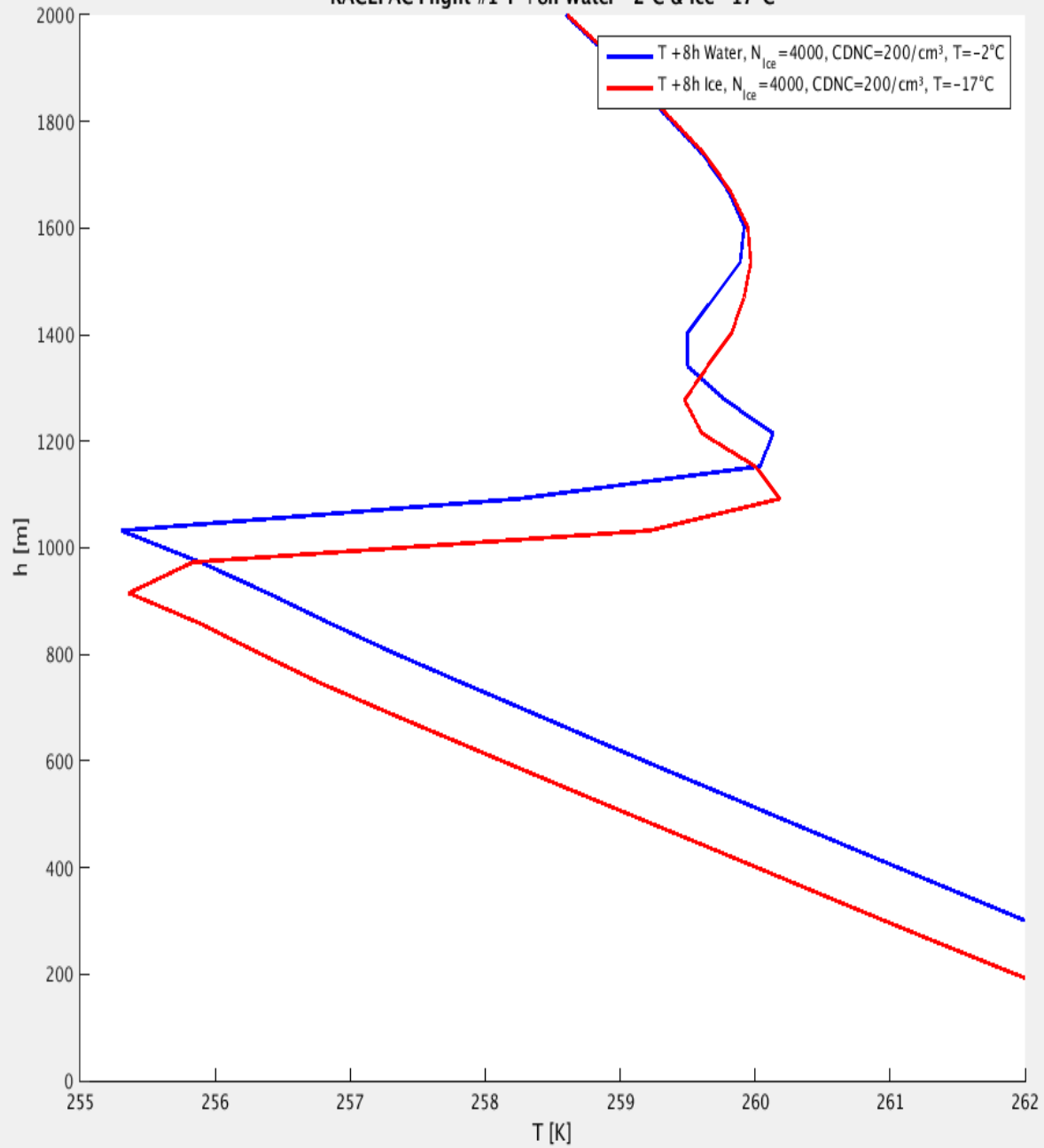
QC over Ice  
QC over Water

# Model QC & emp. NC

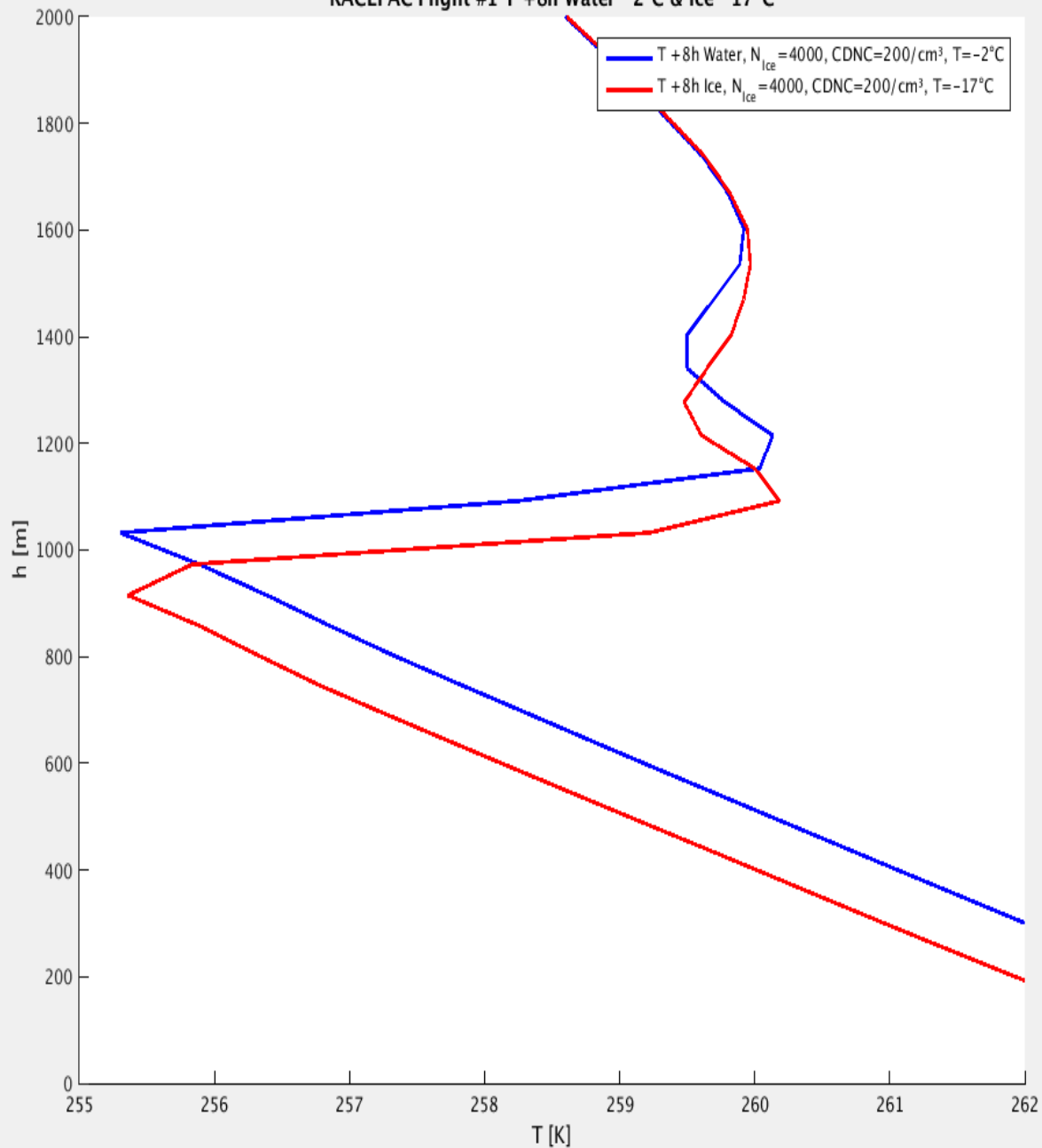




### RACEPAC Flight #1 T +8h Water -2°C & Ice -17°C



RACEPAC Flight #1 T +8h Water -2°C & Ice -17°C

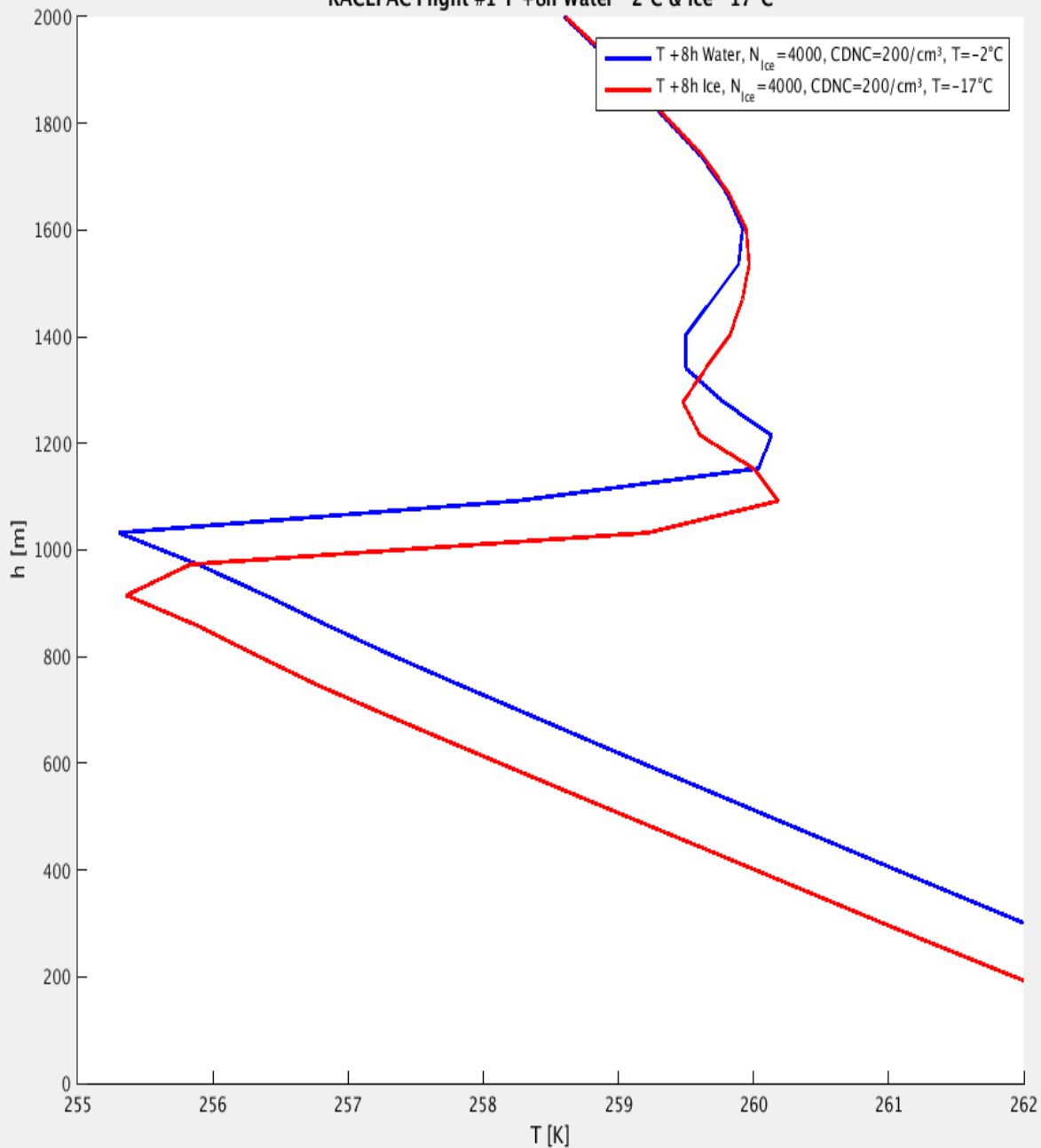


total heat flux  
(sensible + latent)



Water

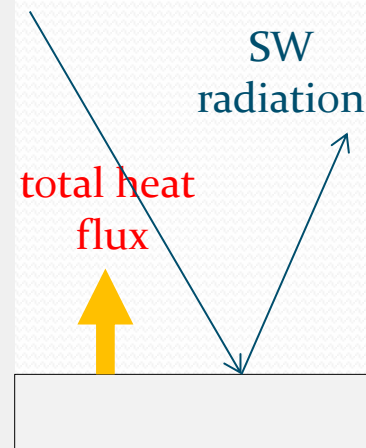
RACEPAC Flight #1 T +8h Water -2°C & Ice -17°C



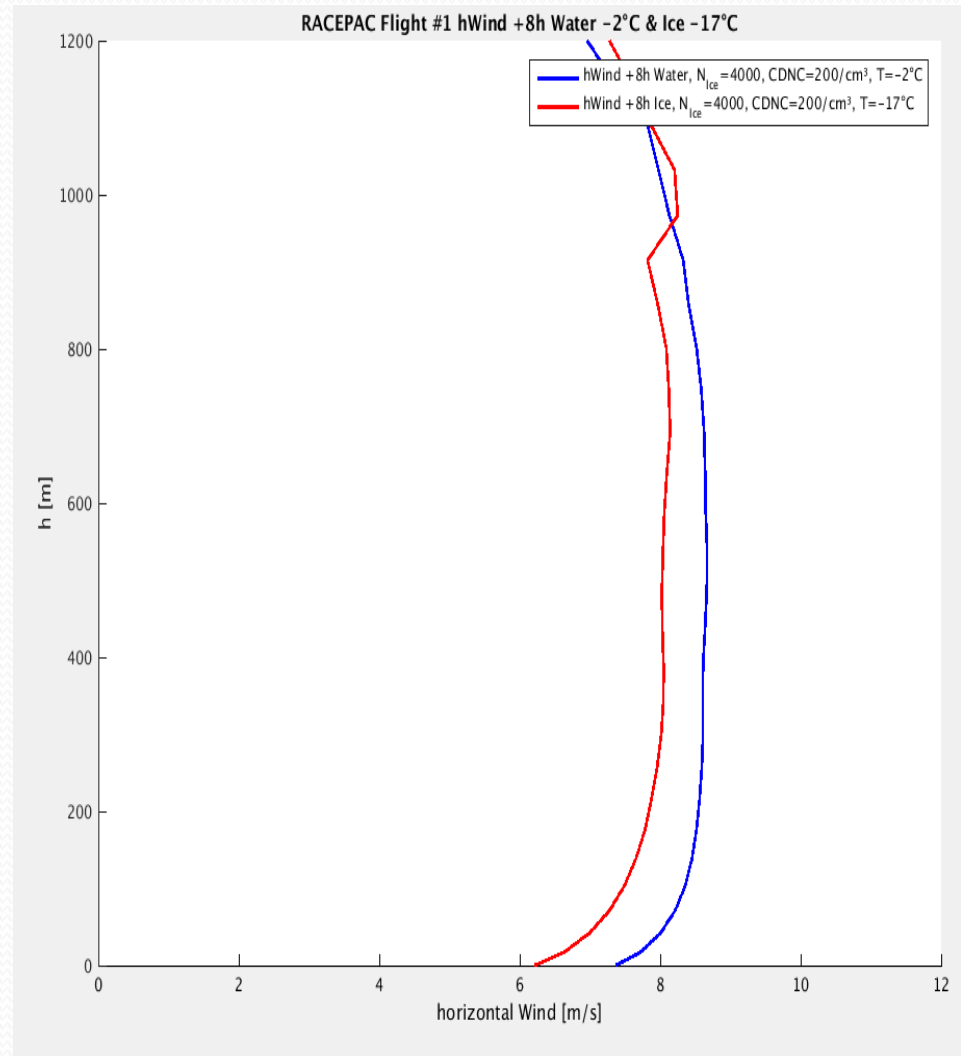
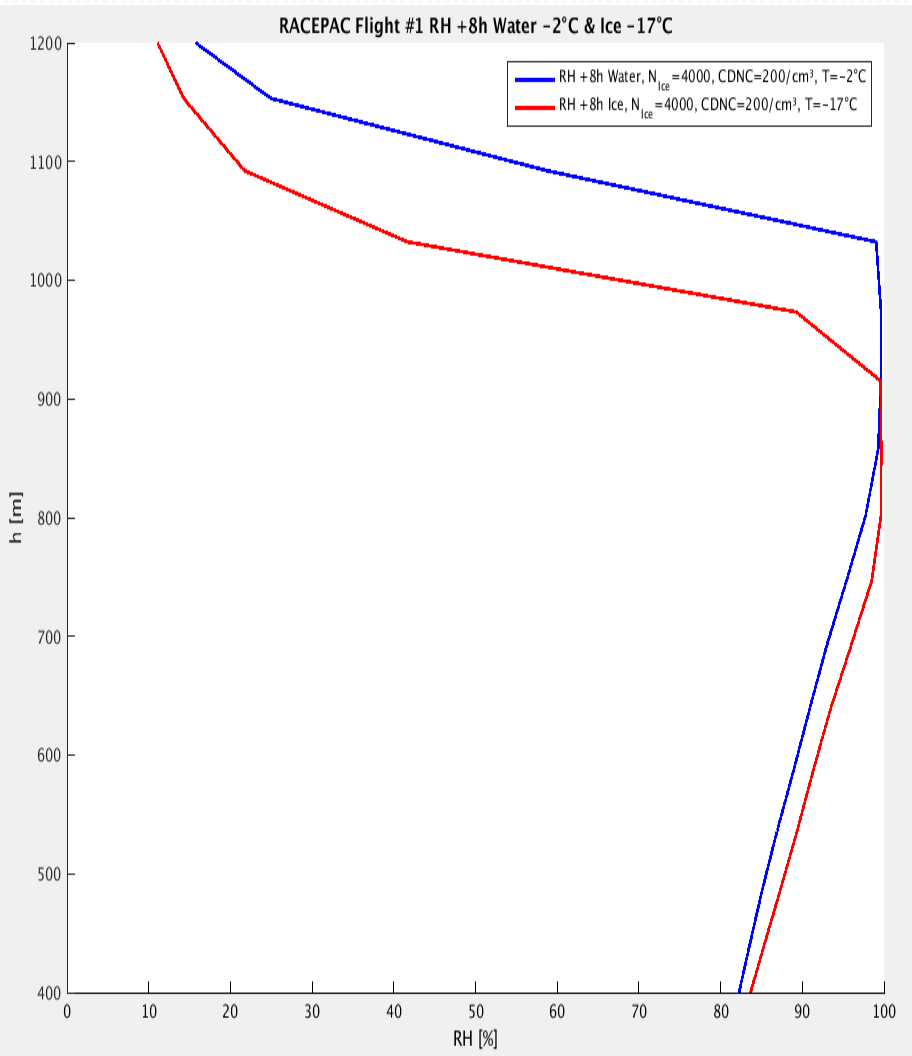
total heat flux  
(sensible + latent)  
+ moisture



Water



Sea Ice



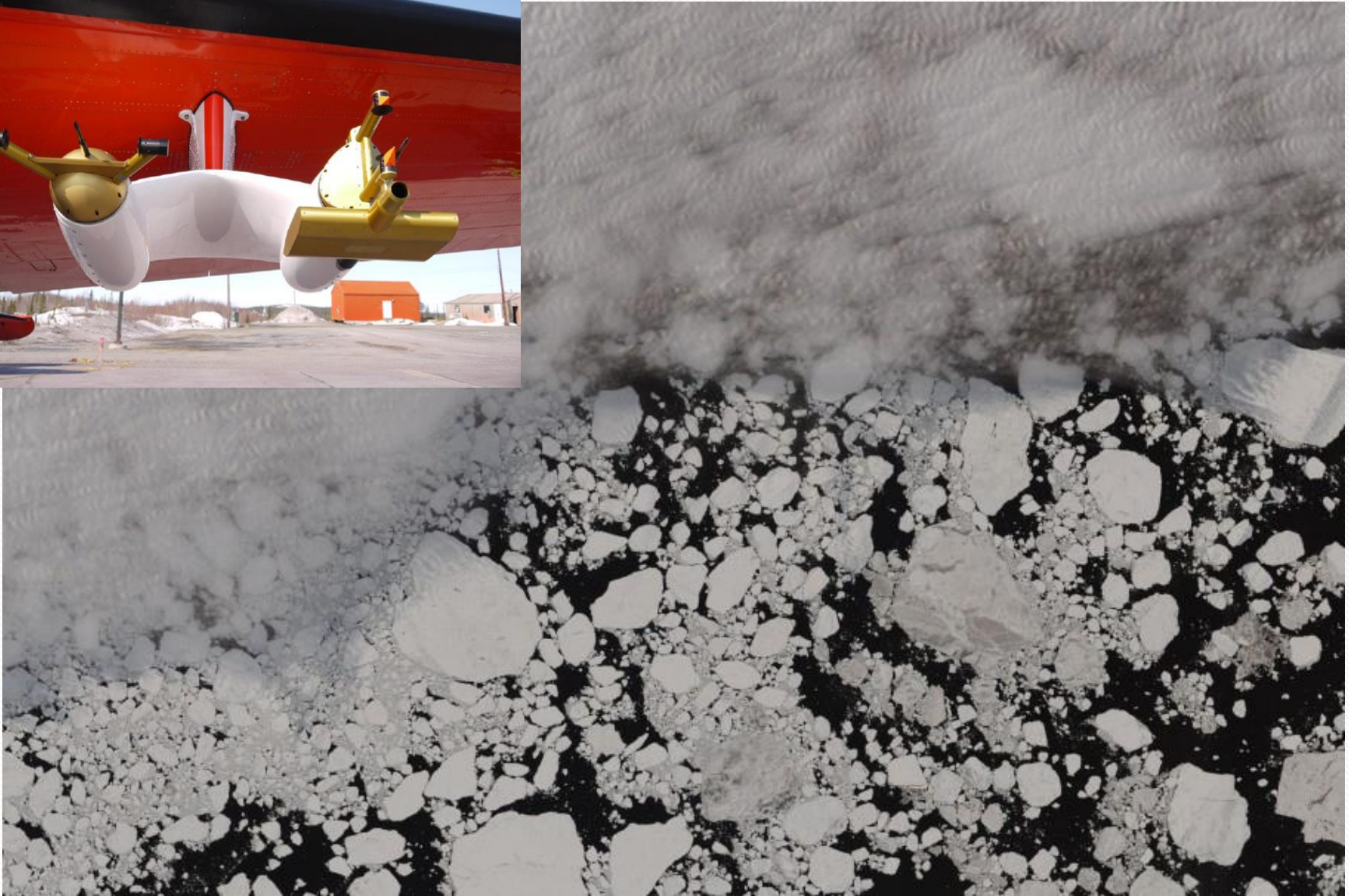
# Conclusion

- Model and observed clouds are generally consistent.
- COSMO predicts a slightly higher and thicker cloud above open water – not confirmed by observations.
- Modelled wind velocities cannot explain observed wind differences of the over water / ice dropsondes. Wind energy dissipation and momentum transfer are, however, sensitive to the surface.
- CDNC, surface temperature and INC variations reinforce these findings

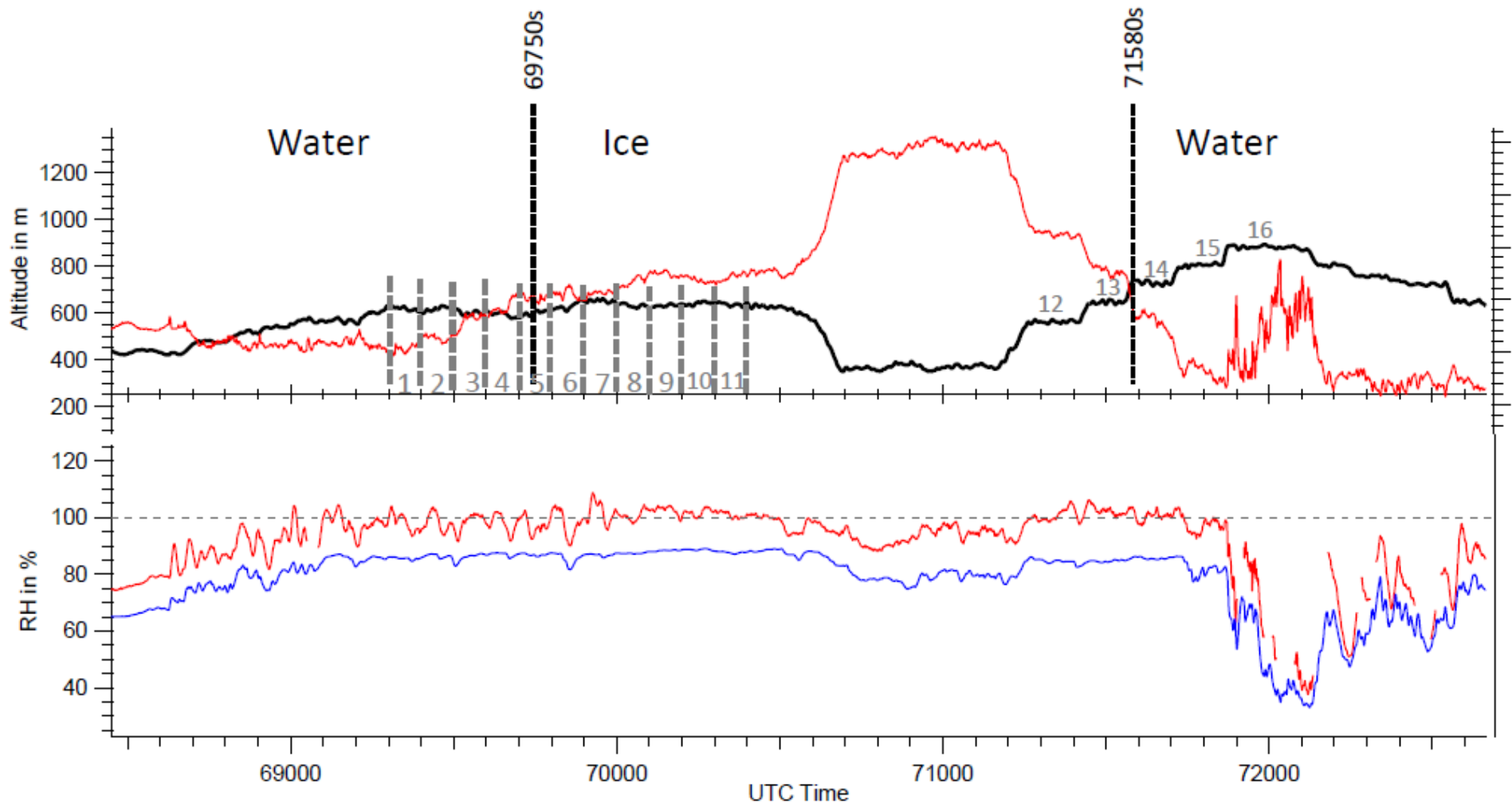
# Outlook

- Modify surface roughness according to different wave roughness formulae and a range of empirical ice roughnesses
- Sensitivity to vertical profiles
- Modelling of RACEPAC flight #11 (Arctic precipitation) and flight #6.

# Thank you!

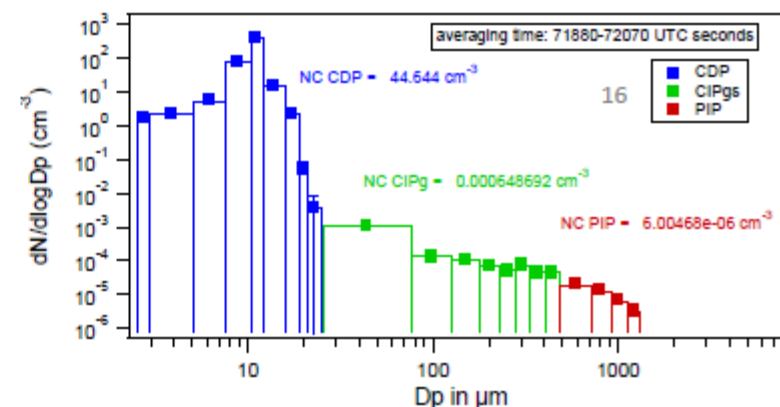
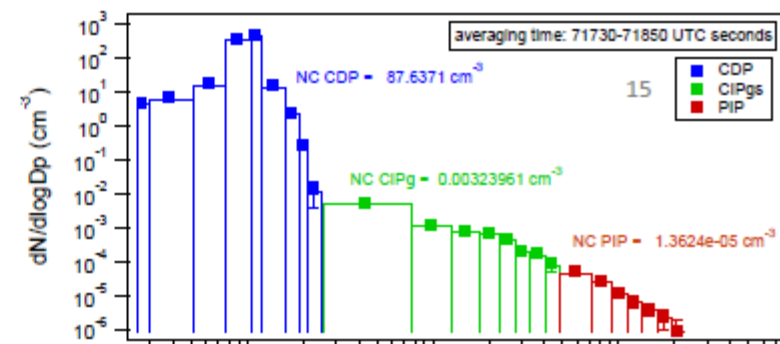
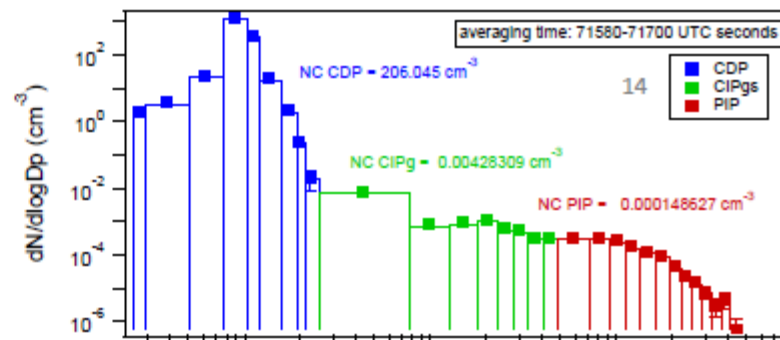
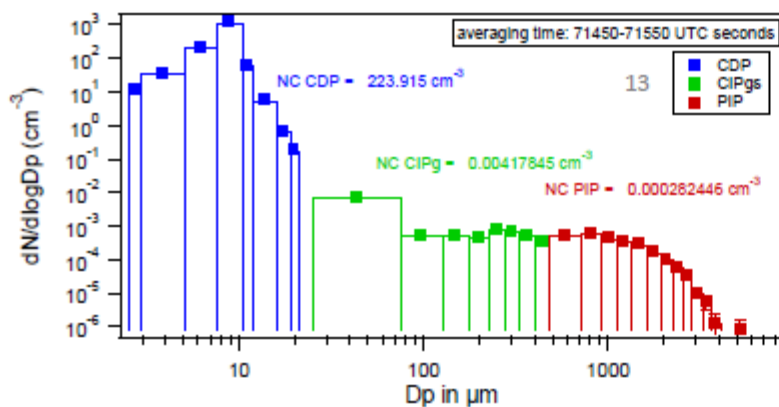
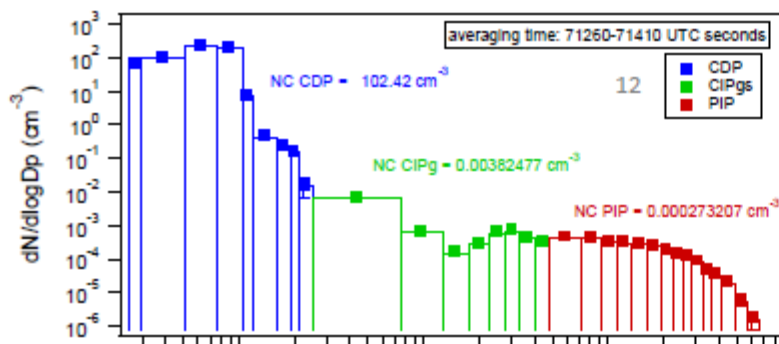


# P6 microphysics flight path

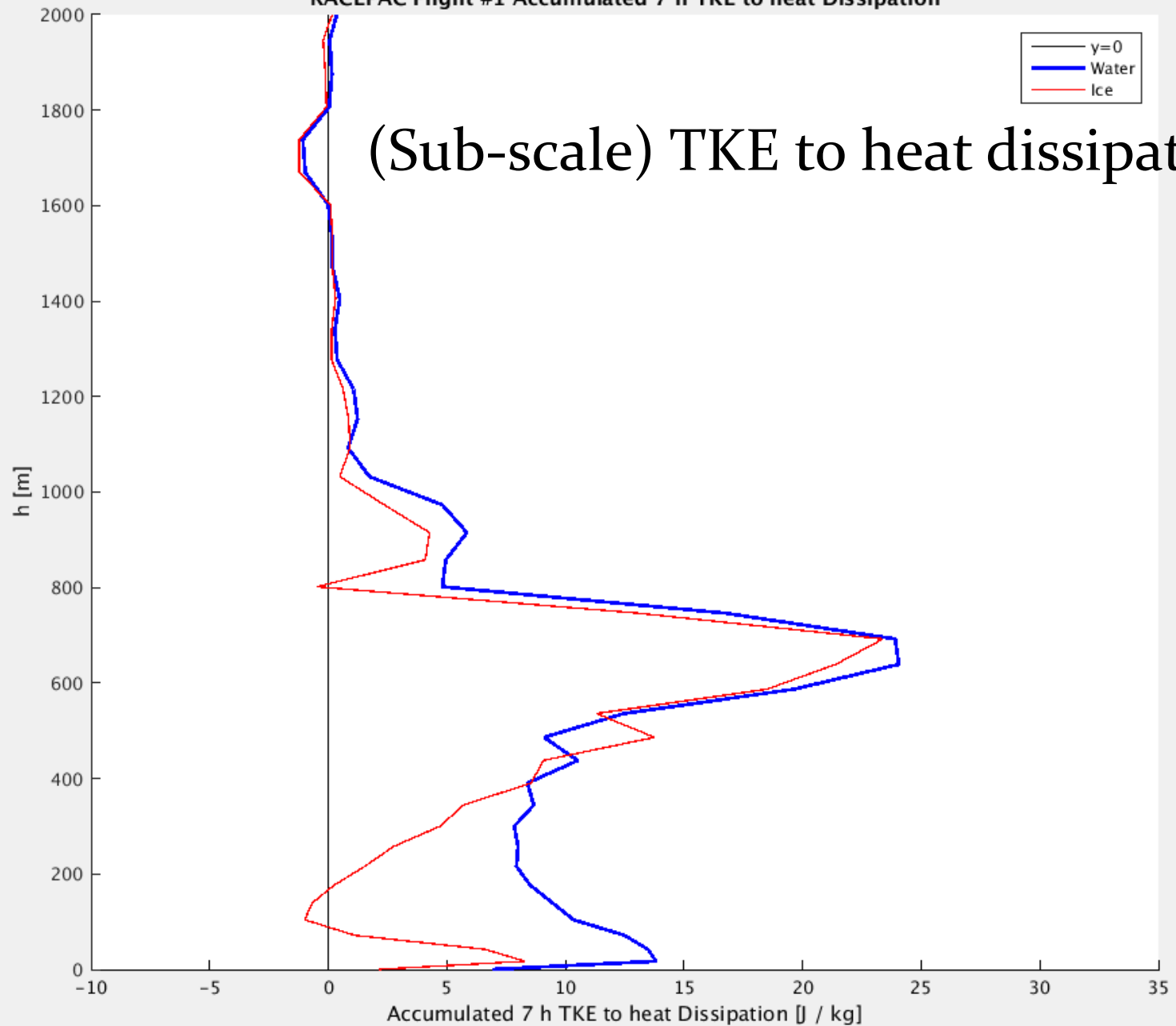




# P6 Microphysics



RACEPAC Flight #1 Accumulated 7 h TKE to heat Dissipation



(Sub-scale) TKE to heat dissipation

# Over Water

