Experience from Arctic field campaigns: Weather forecasting and evaluations, and model comparisons

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Data without models is chaos…

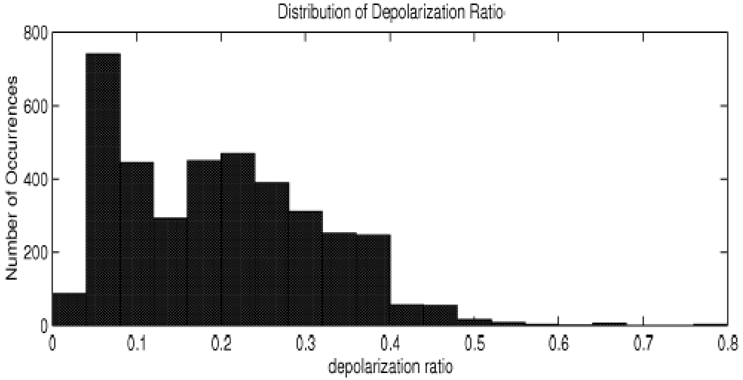
…but models without data is guesswork

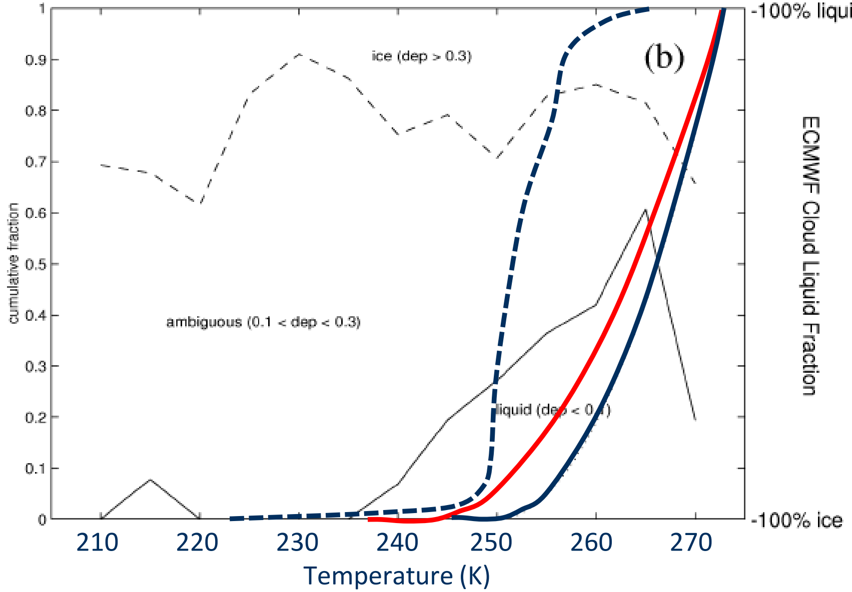
(Patrick Crill, Stockholm Uni.)

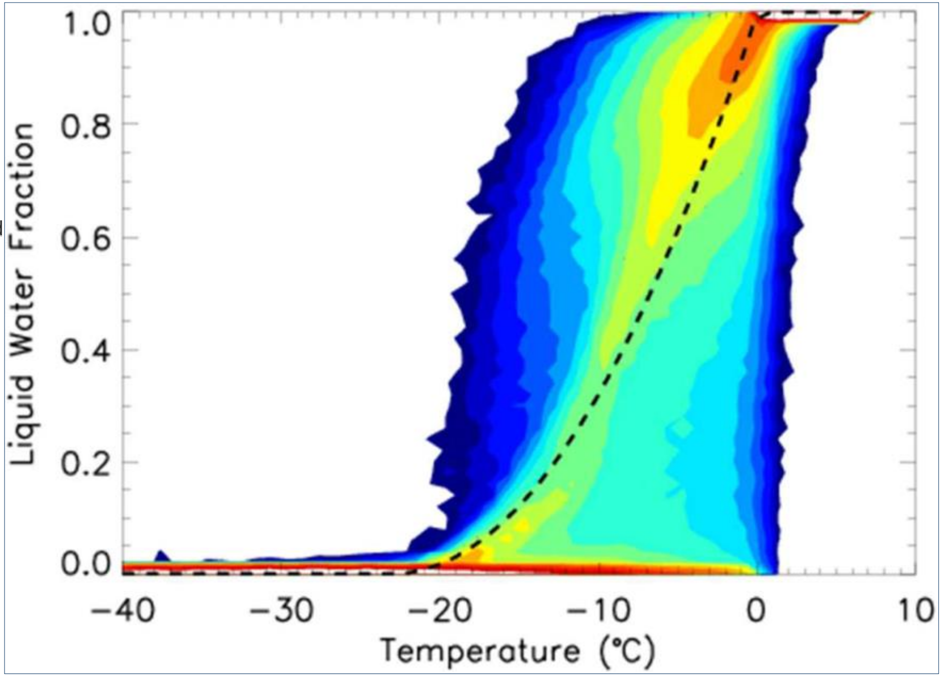
On the utility of field observations for NWP:

- *To help formulate the conceptual models, shaping how we think about processes that need parameterization*
- *To reveal the process relationships, the understanding of the system, necessary improve model formulations*
- *Evaluate models – in several different ways*

Conceptual models 1: Mixed-phase clouds in cold climates…







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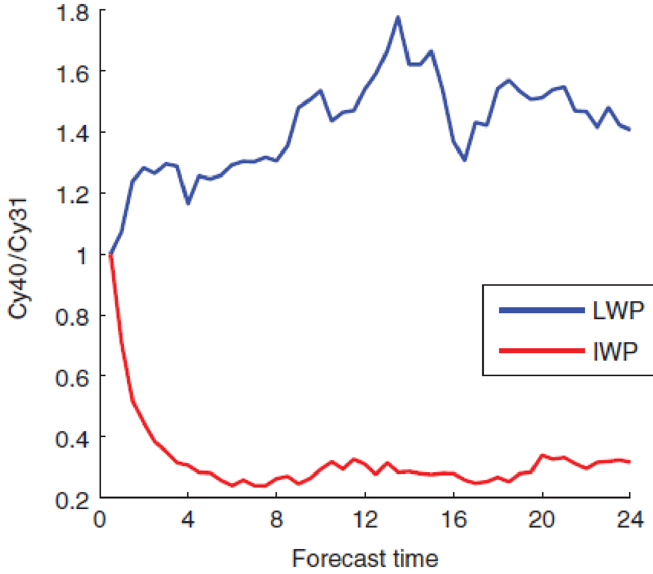

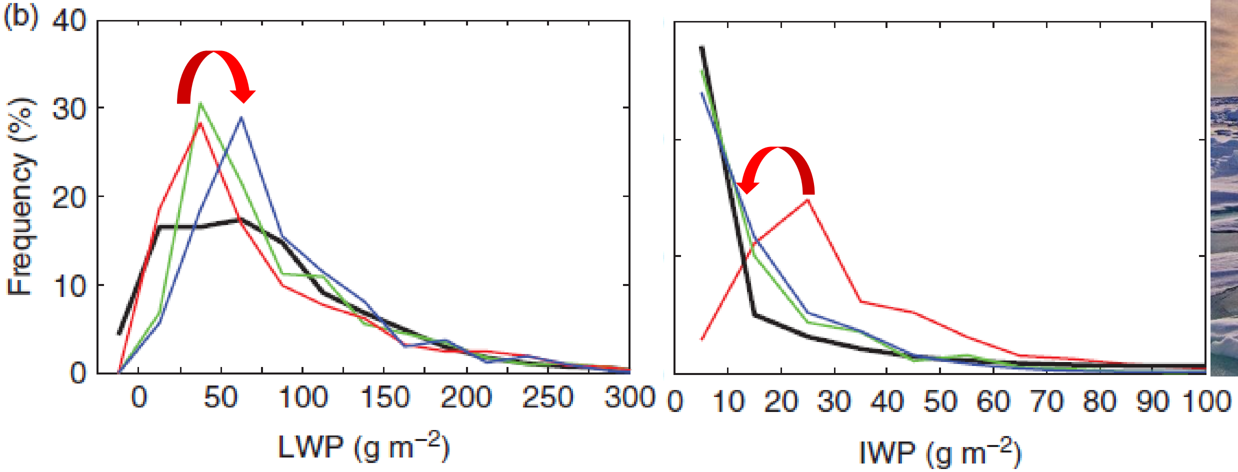

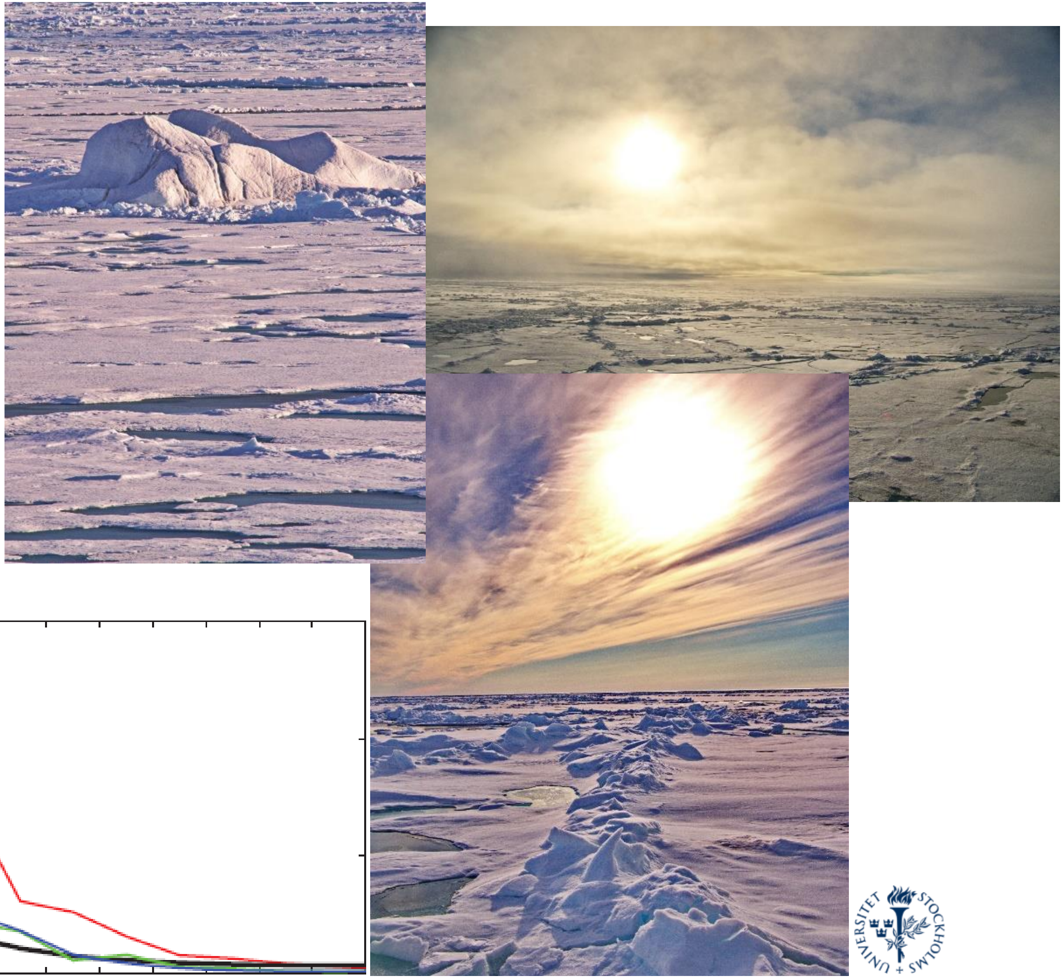

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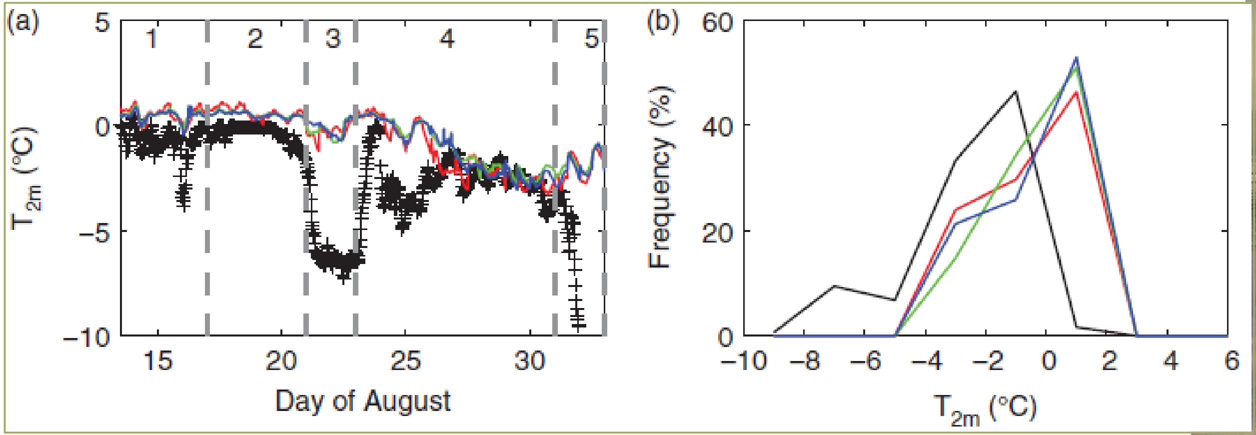

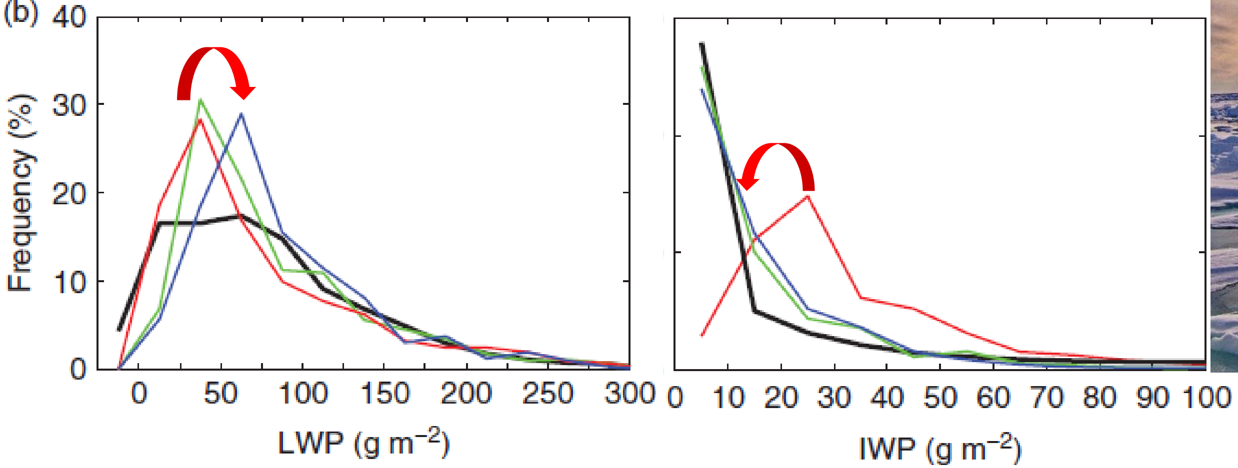

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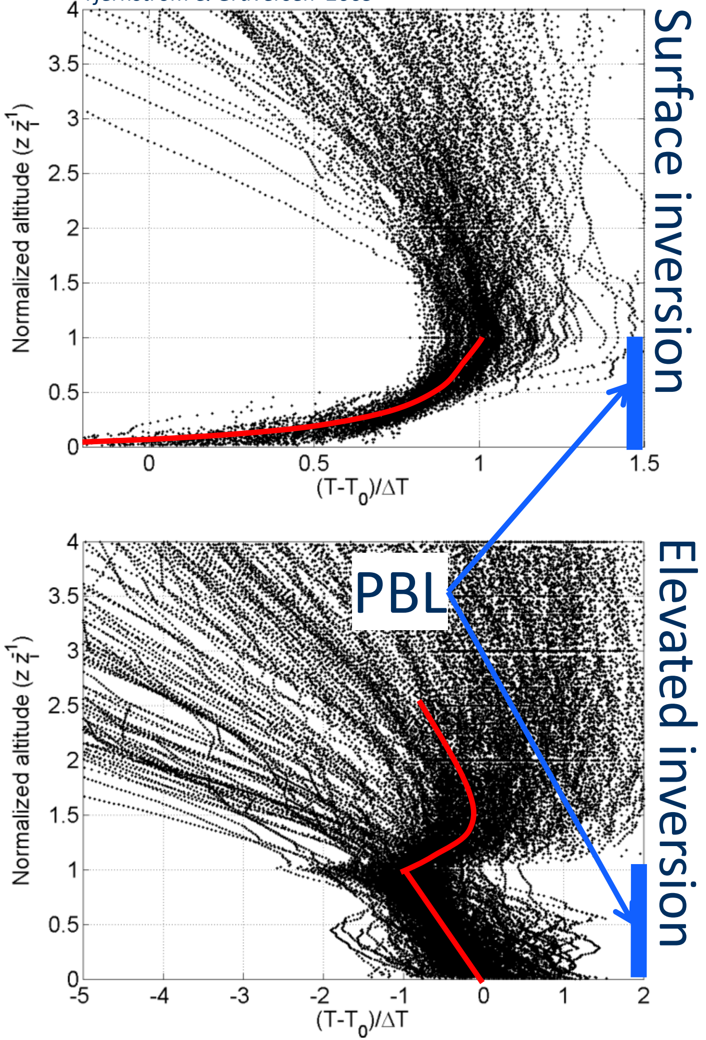
Tjernström & Graversen 2009



Conceptual models 2: Lower-troposphere vertical structure…

	Winter	Spring	Summer	Autumn	
Surface	53%	15%	9%	61%	Inversion base < 15 m
Elevated	47%	85%	91%	39%	Inversion base > 15 m

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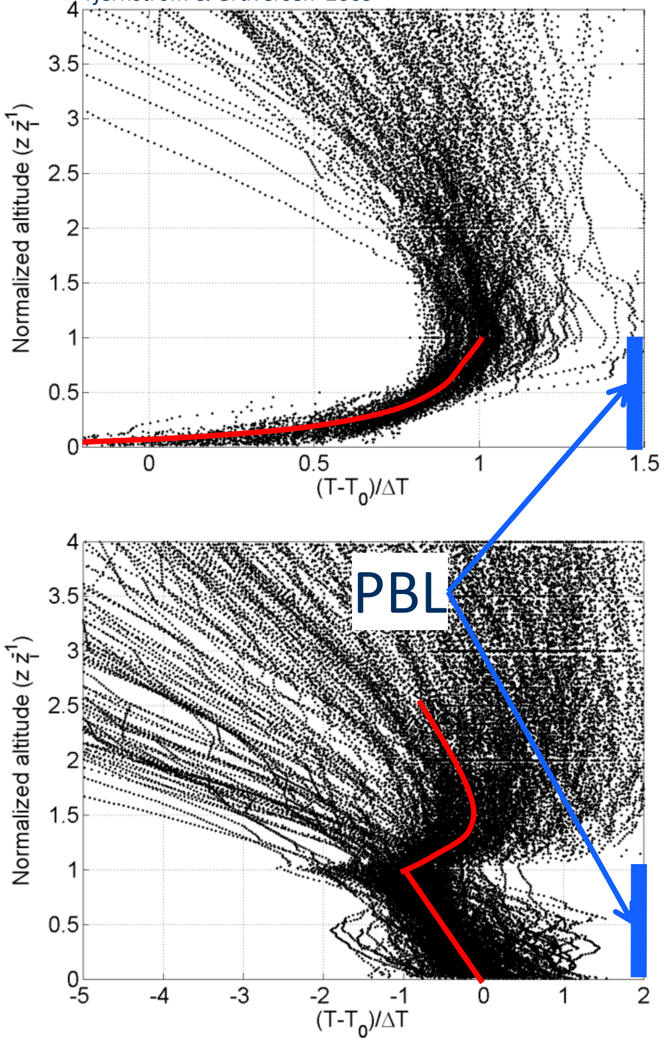
Tjernström & Graversen 2009



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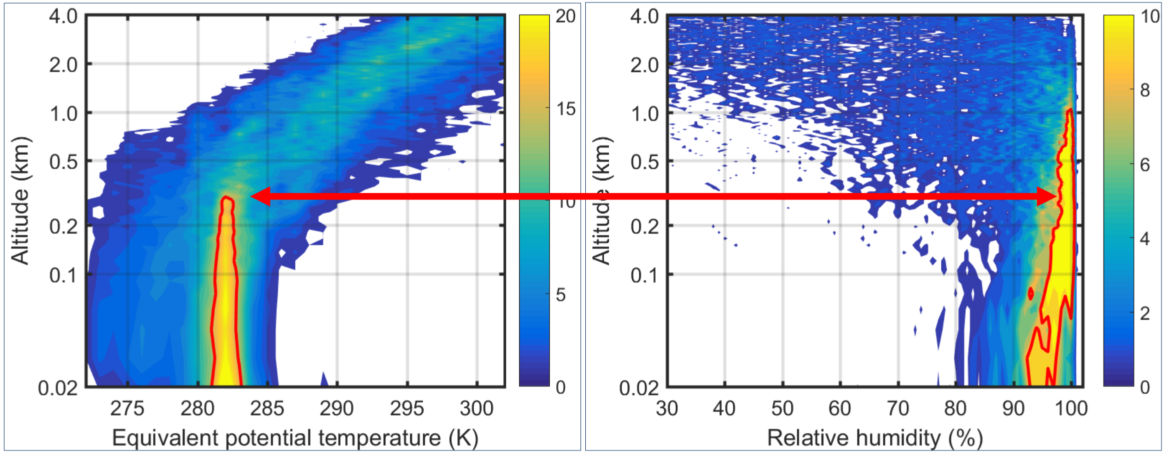

Composite from four different summer campaigns

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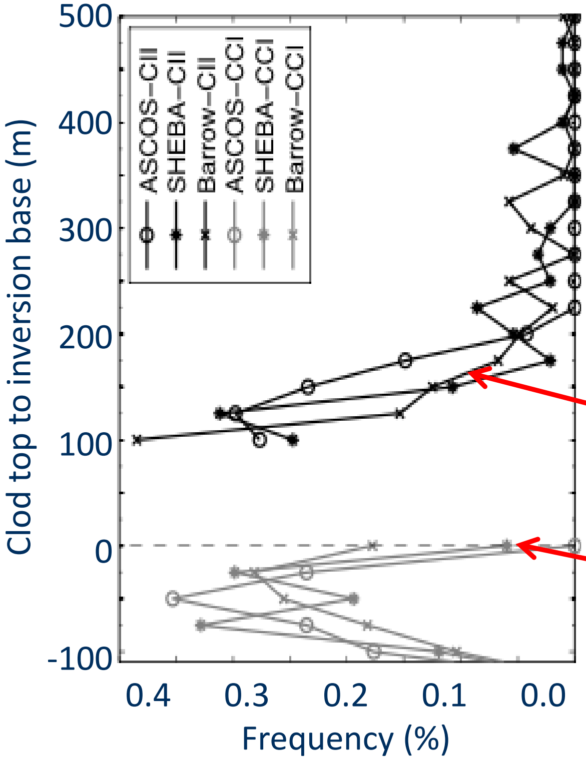

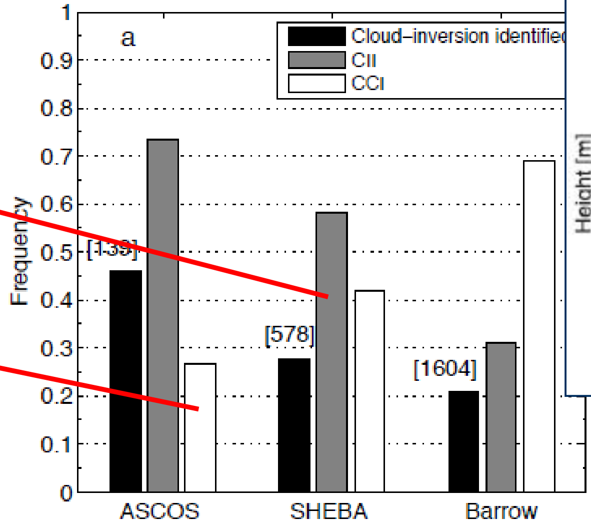

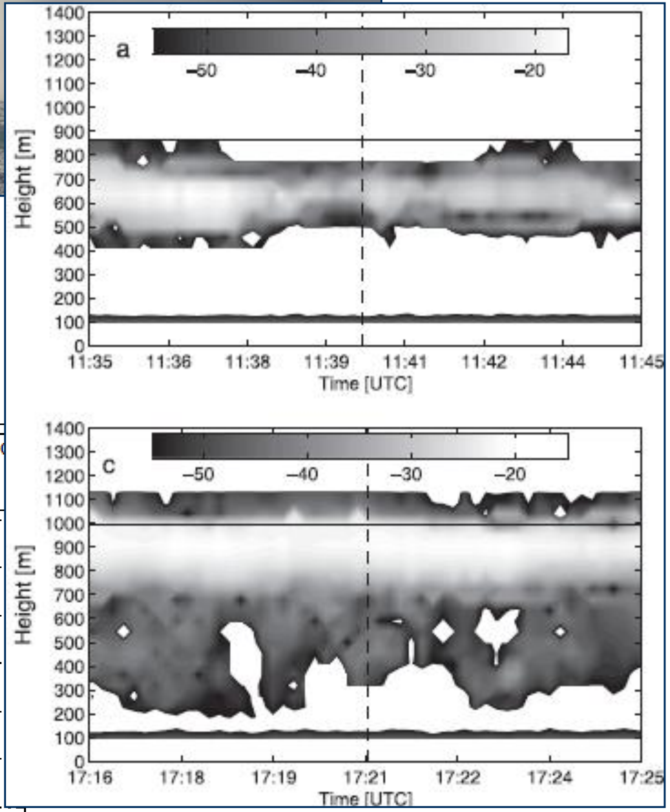

Sedlar et al. 2012

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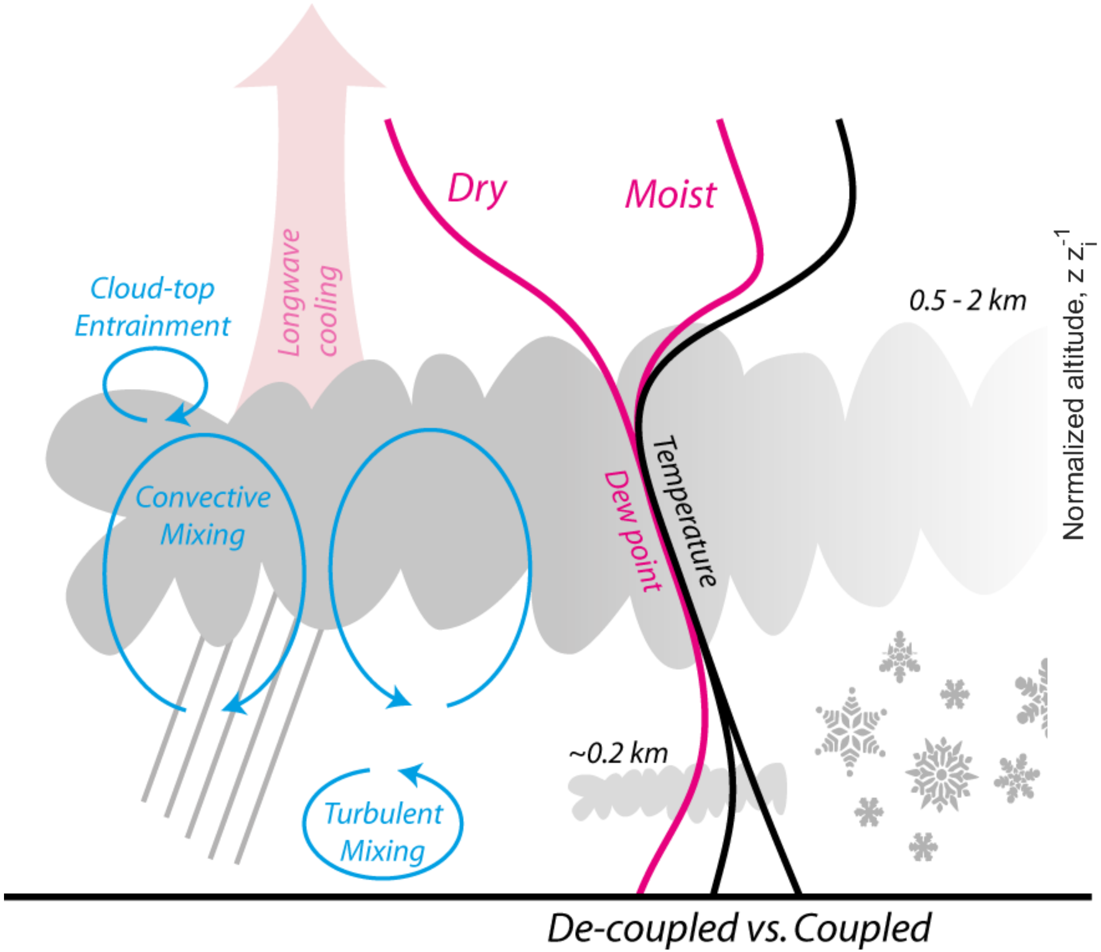

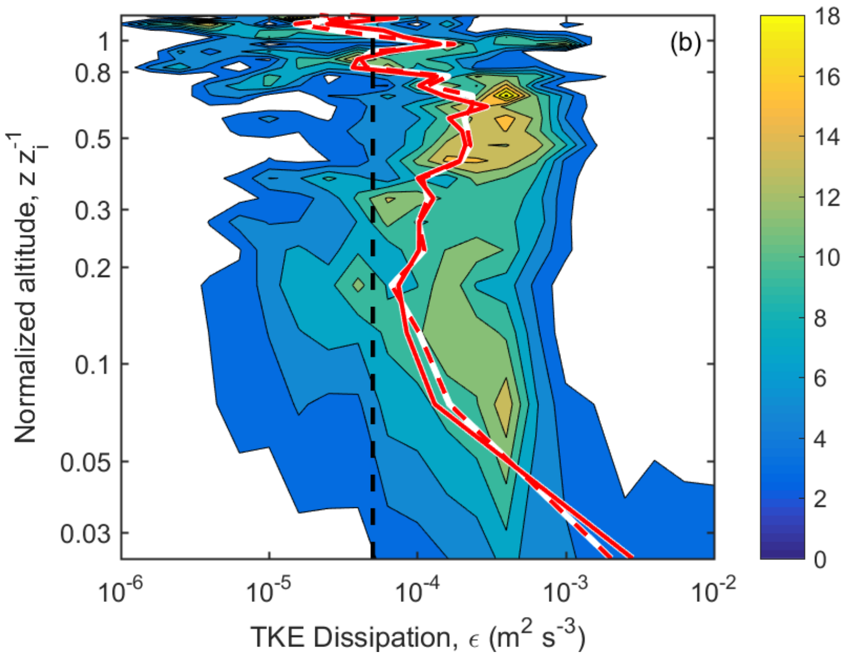

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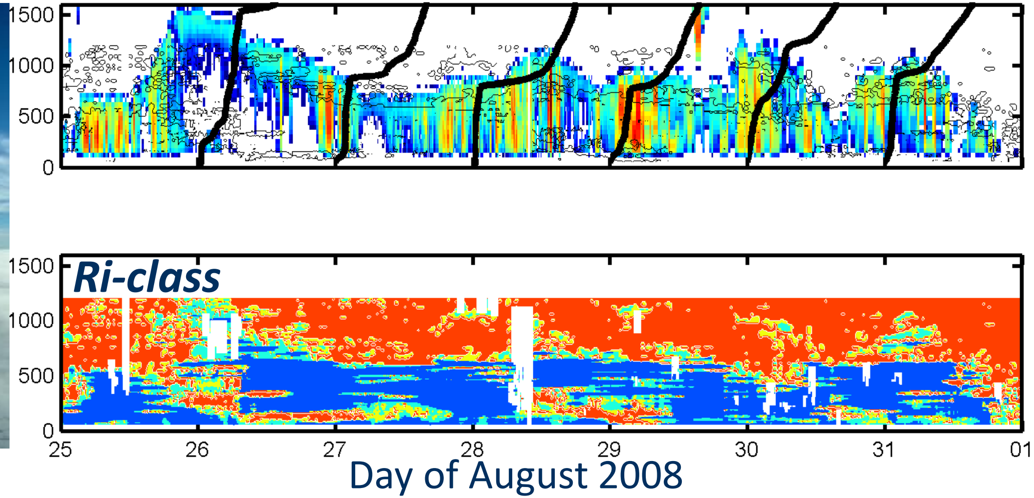
Brooks et al. 2017



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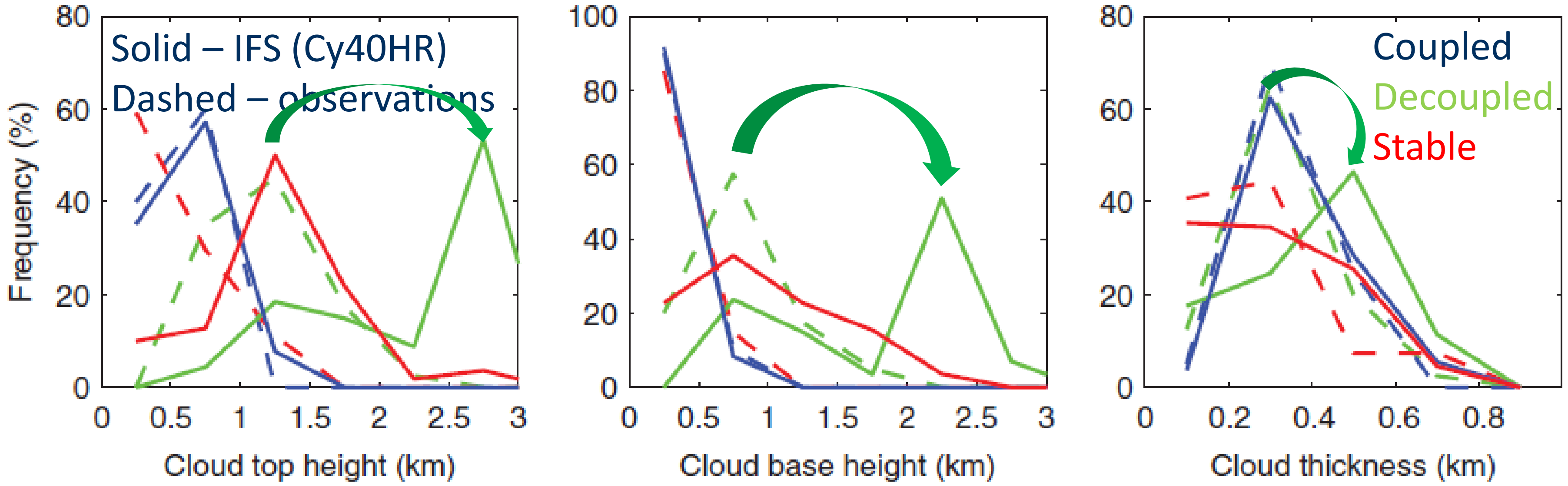
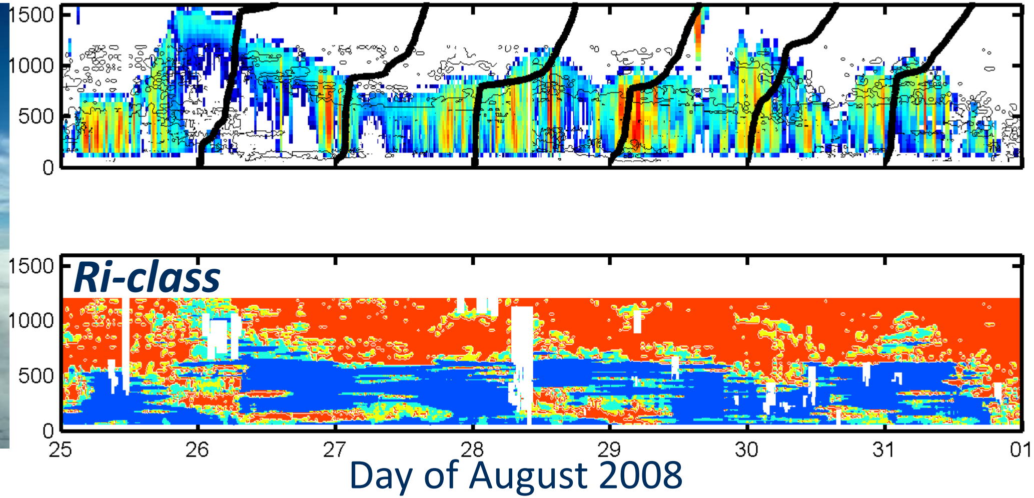


Sotiropoulou et al. 2014



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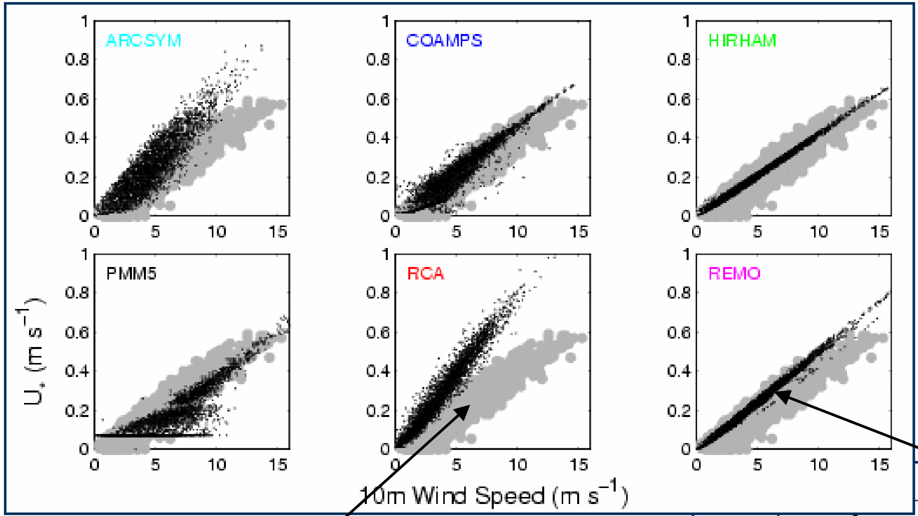
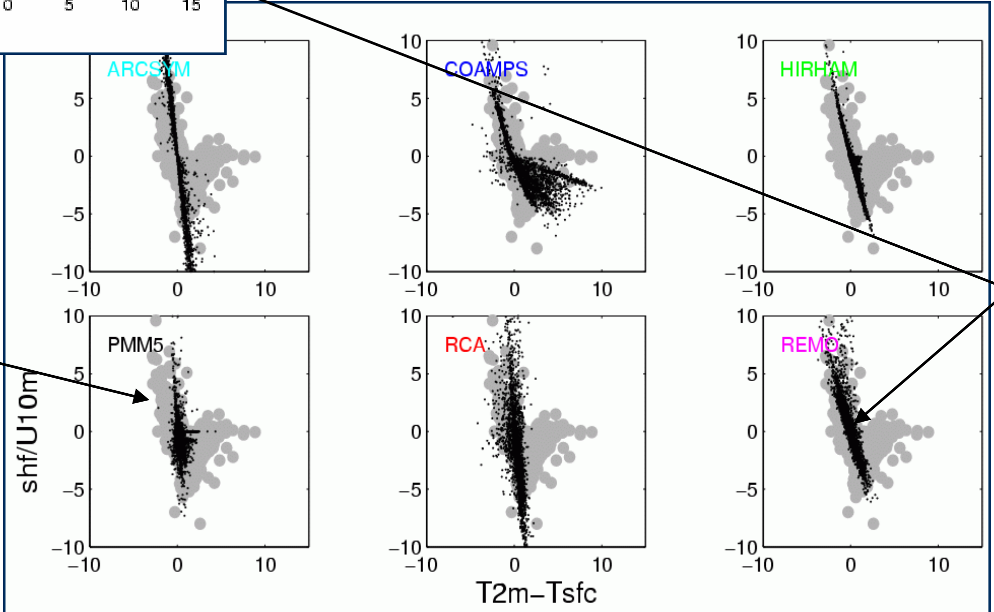
Process relationships 1:

Turbulent surface fluxes (this is really old)…

Flux ~ C_x*U*Δ

Shape and spread!





Observations

Models

Tjernström et al. 2005

ARCMIP

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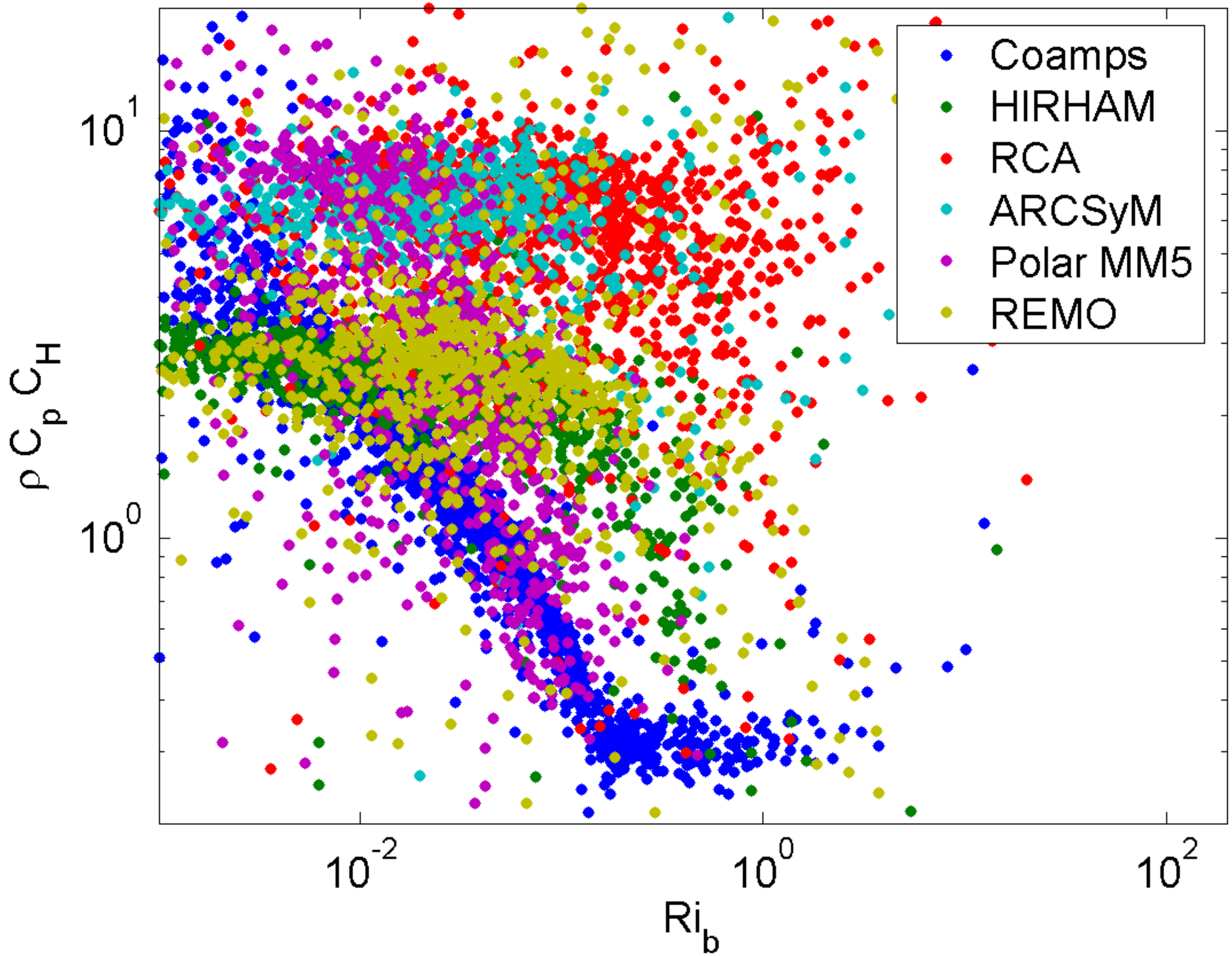

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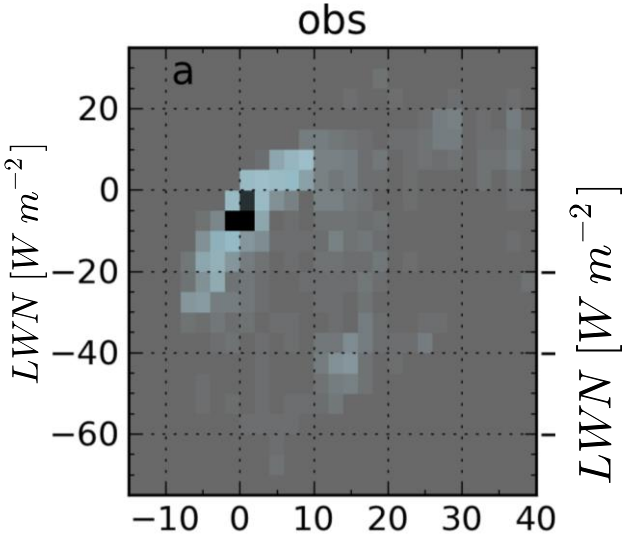
Process relationships 2:

Cloud/radiation interactions



$$LTS = \theta_e(950hPa) - \theta_e(sfc)$$

Courtesy Sedlar et al. 2005

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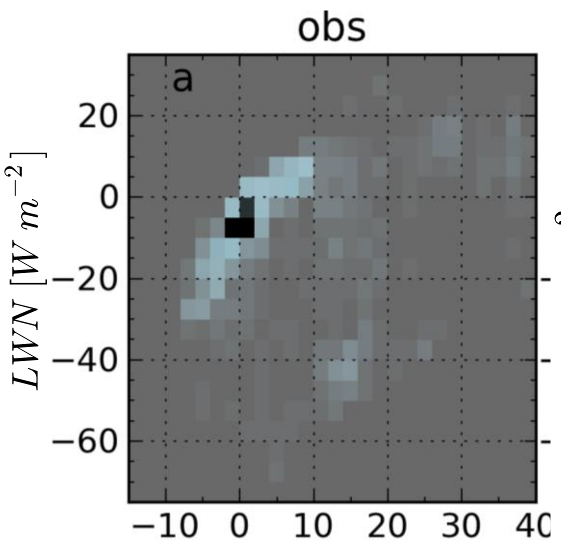

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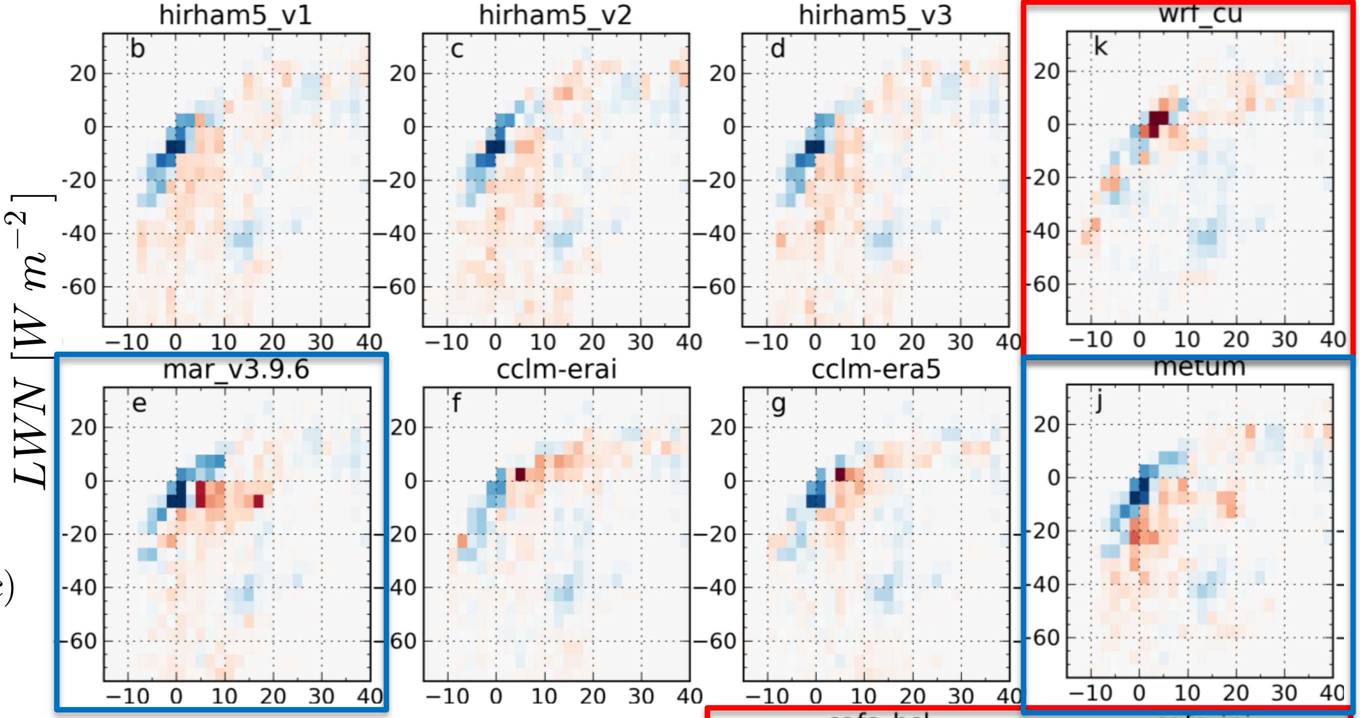

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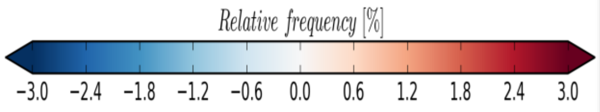
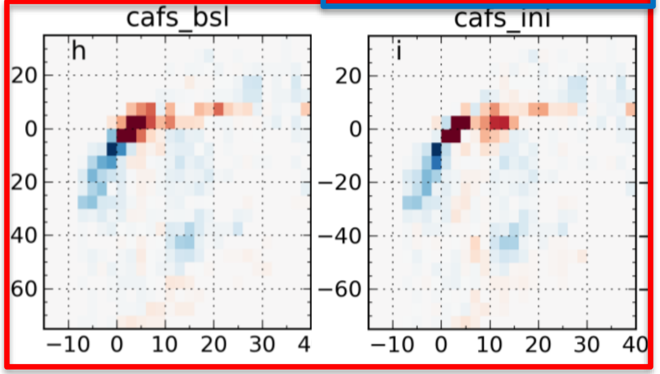
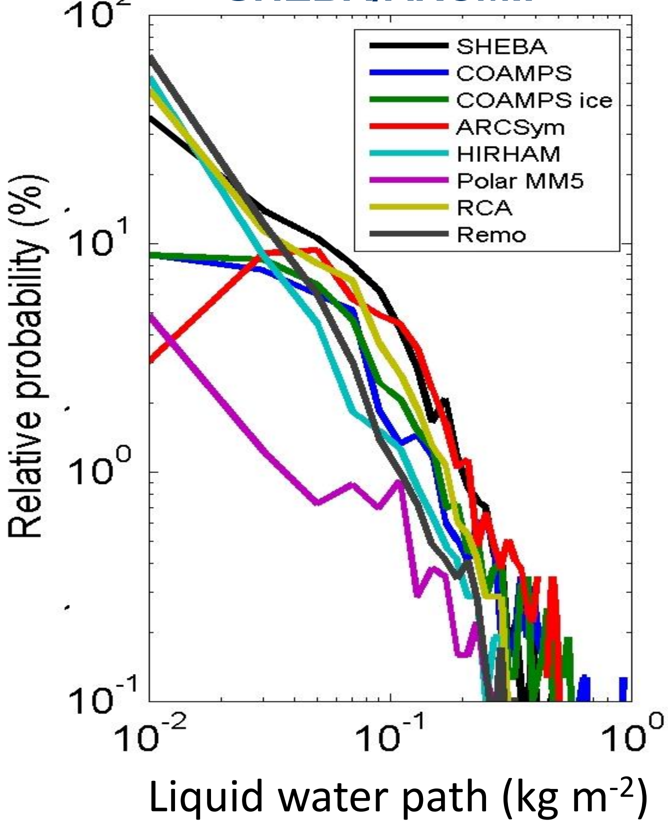




WCRP CORDEX

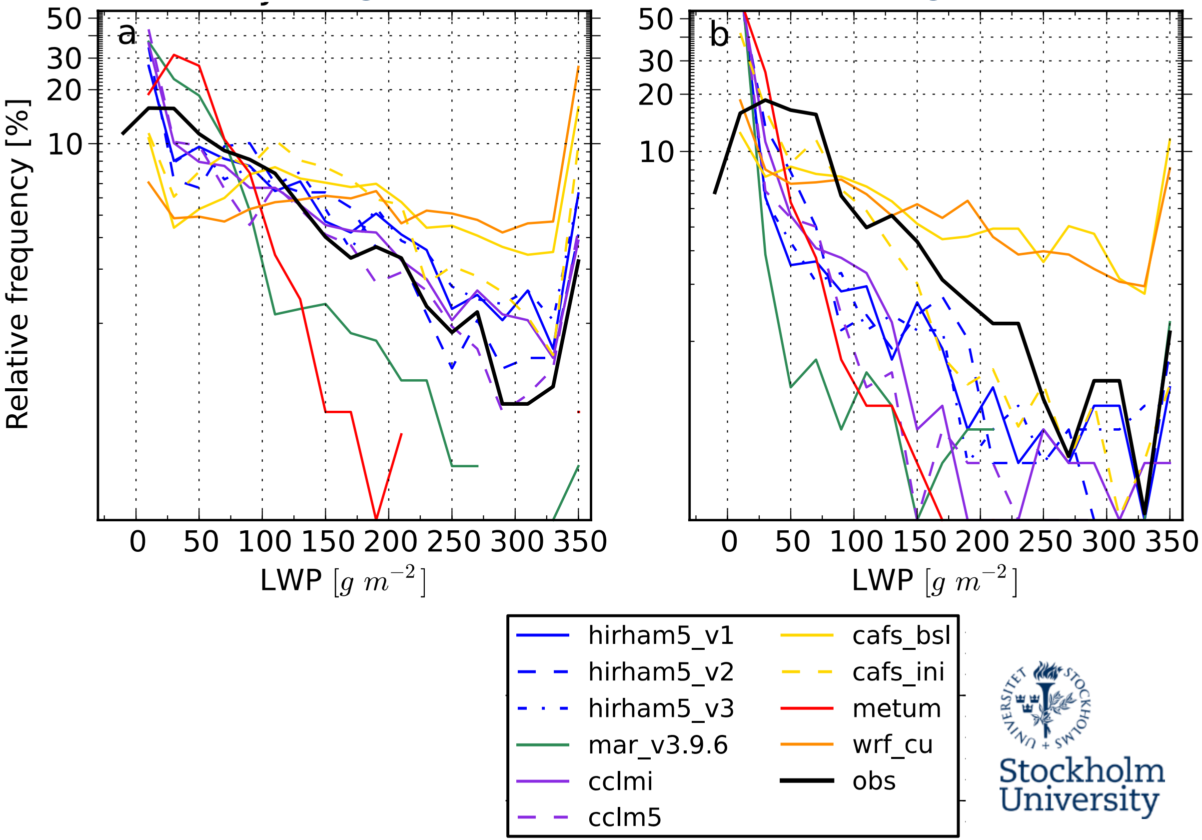
Model evaluations : "Climate"

SHEBA/ARCMIP



ACSE/CORDEX

Leg 1 / Leg 2



Tjernström et al. 2007
Courtesy Sedlar et al. 2005

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Data without models is chaos…
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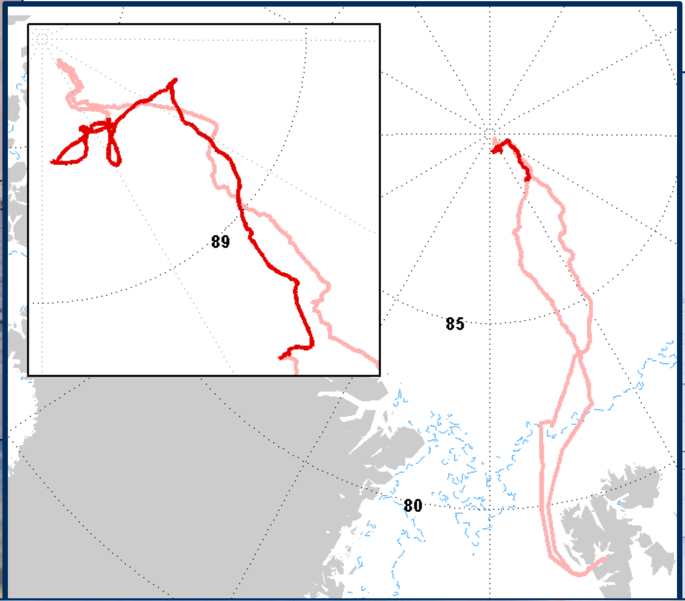
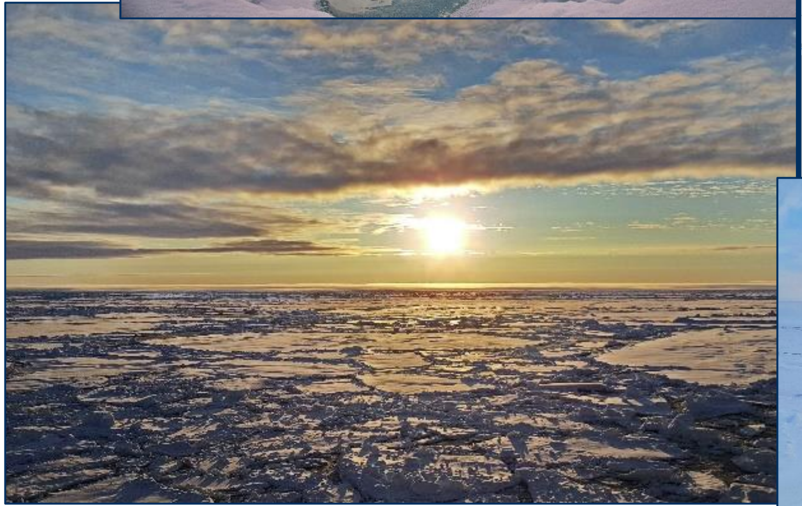
<u>On the utility of NWP for field Arctic observations:</u>

- *When operating on the ice in the Arctic Ocean, safety is the paramount issue; for this accurate NWP is key*
- *Planning logistics like operations helicopter flights or snowmobiling on the ice requires accurate NWP*
- *Deployment of observing systems, such as UAVs or tethered platforms require accurate and detailed information on PBL structure and clouds*

Arctic Ocean 2018

1 August – 21 September





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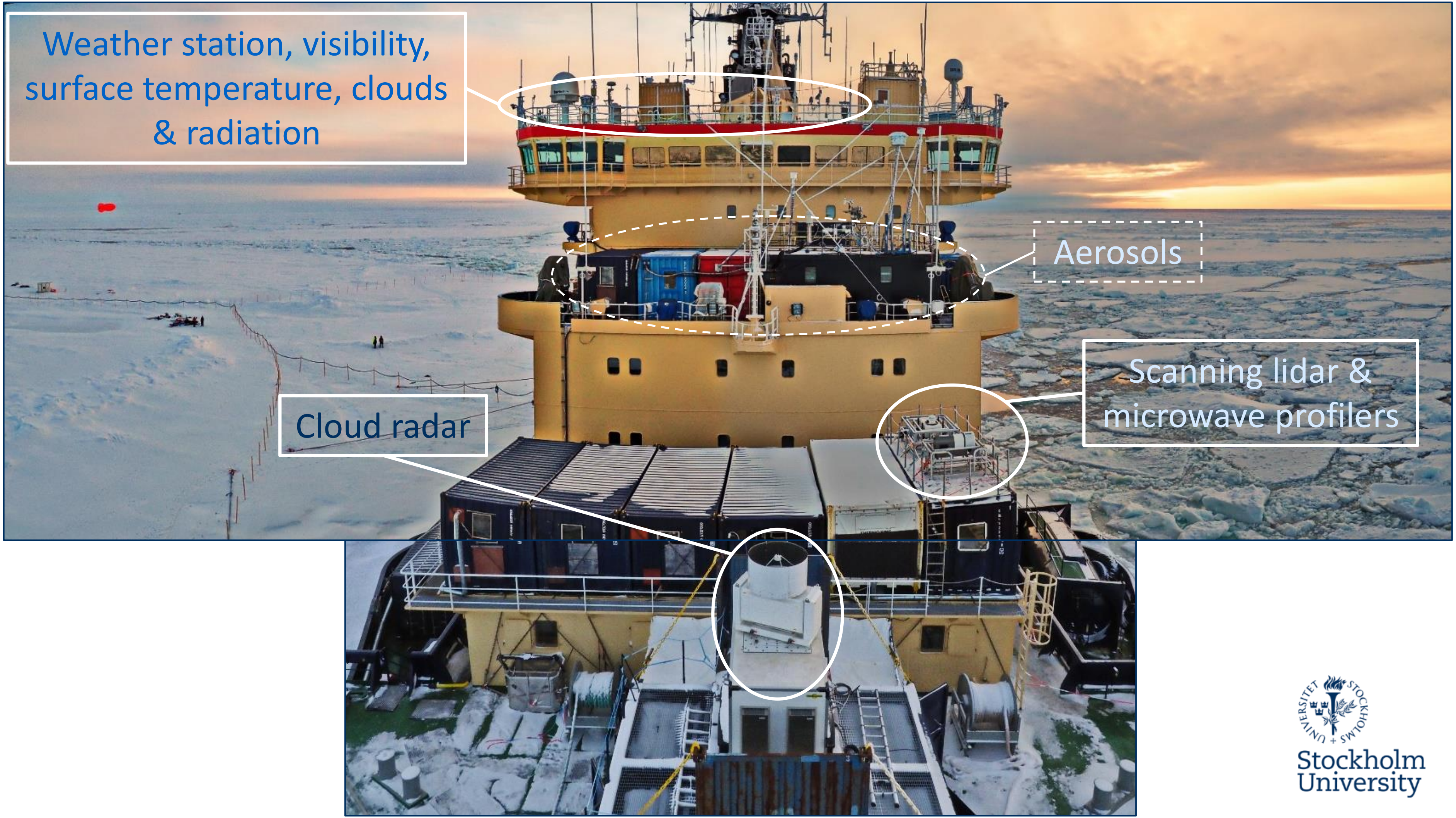

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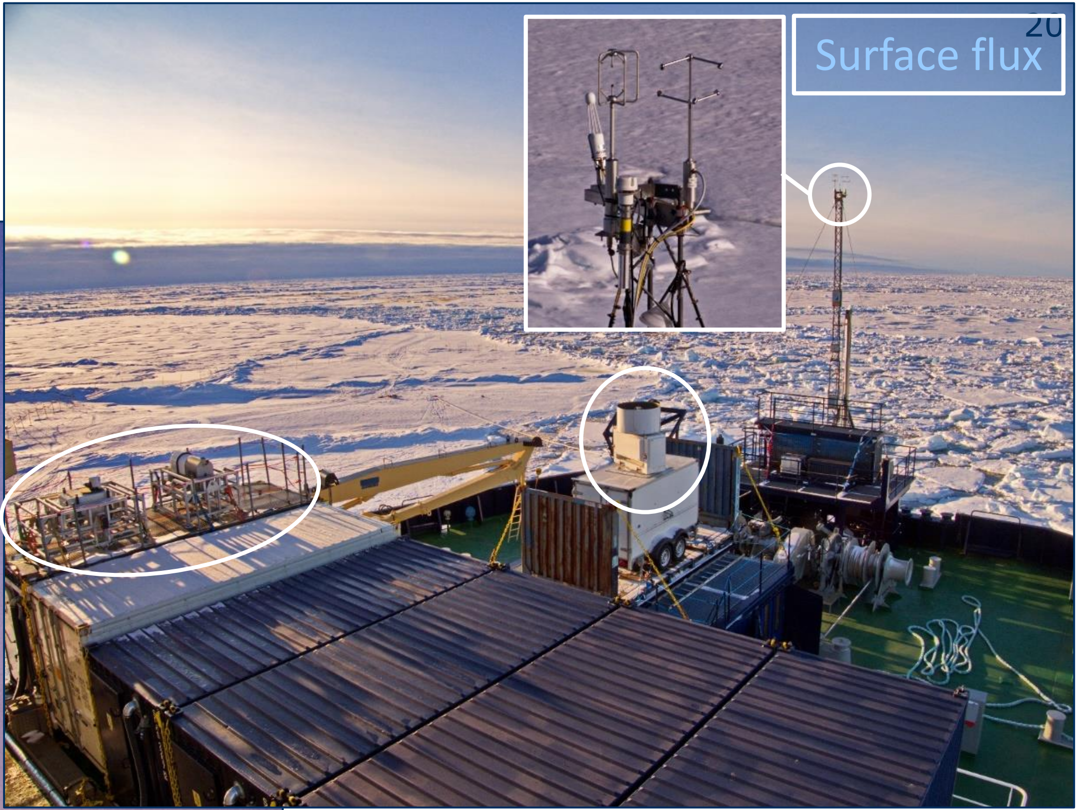

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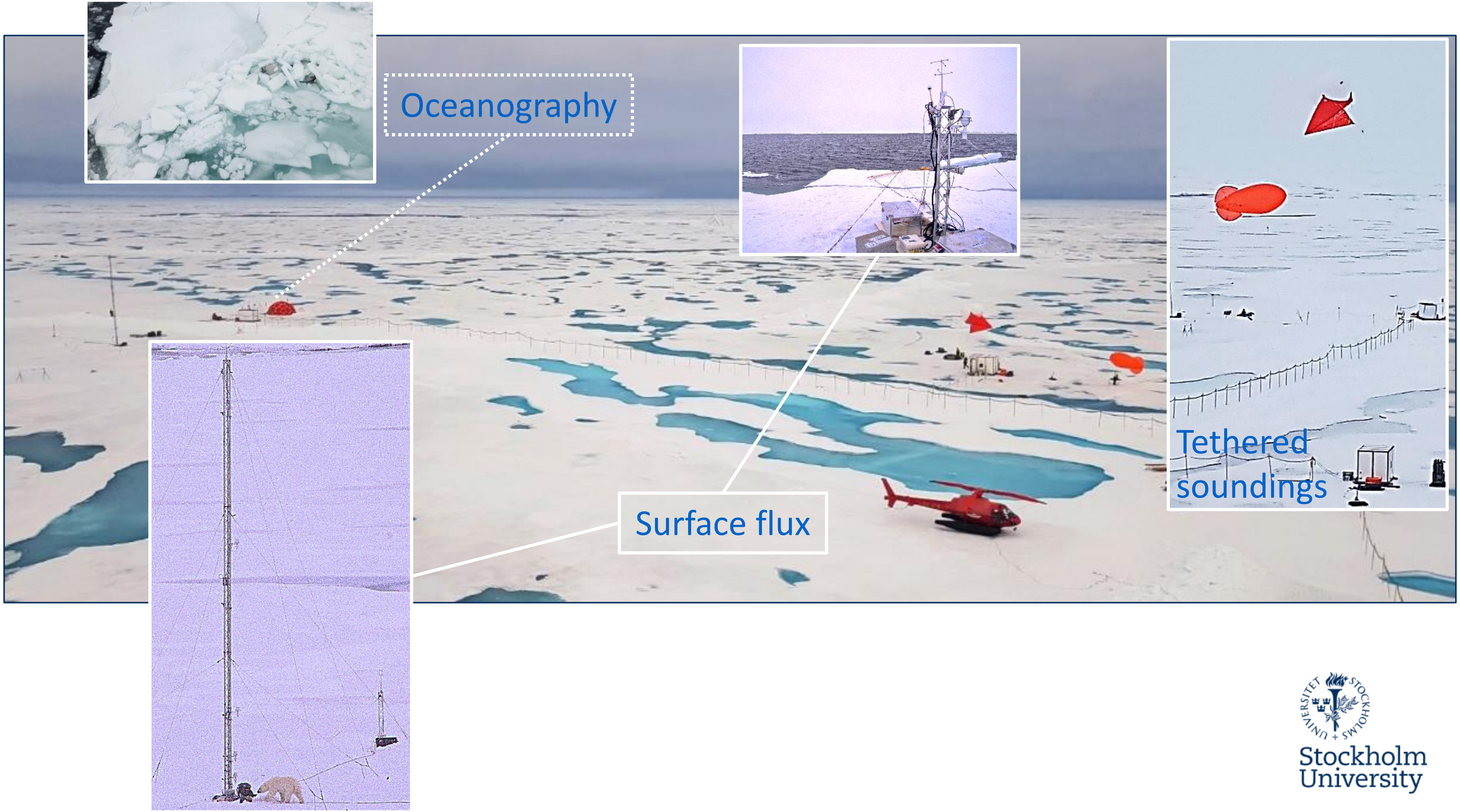

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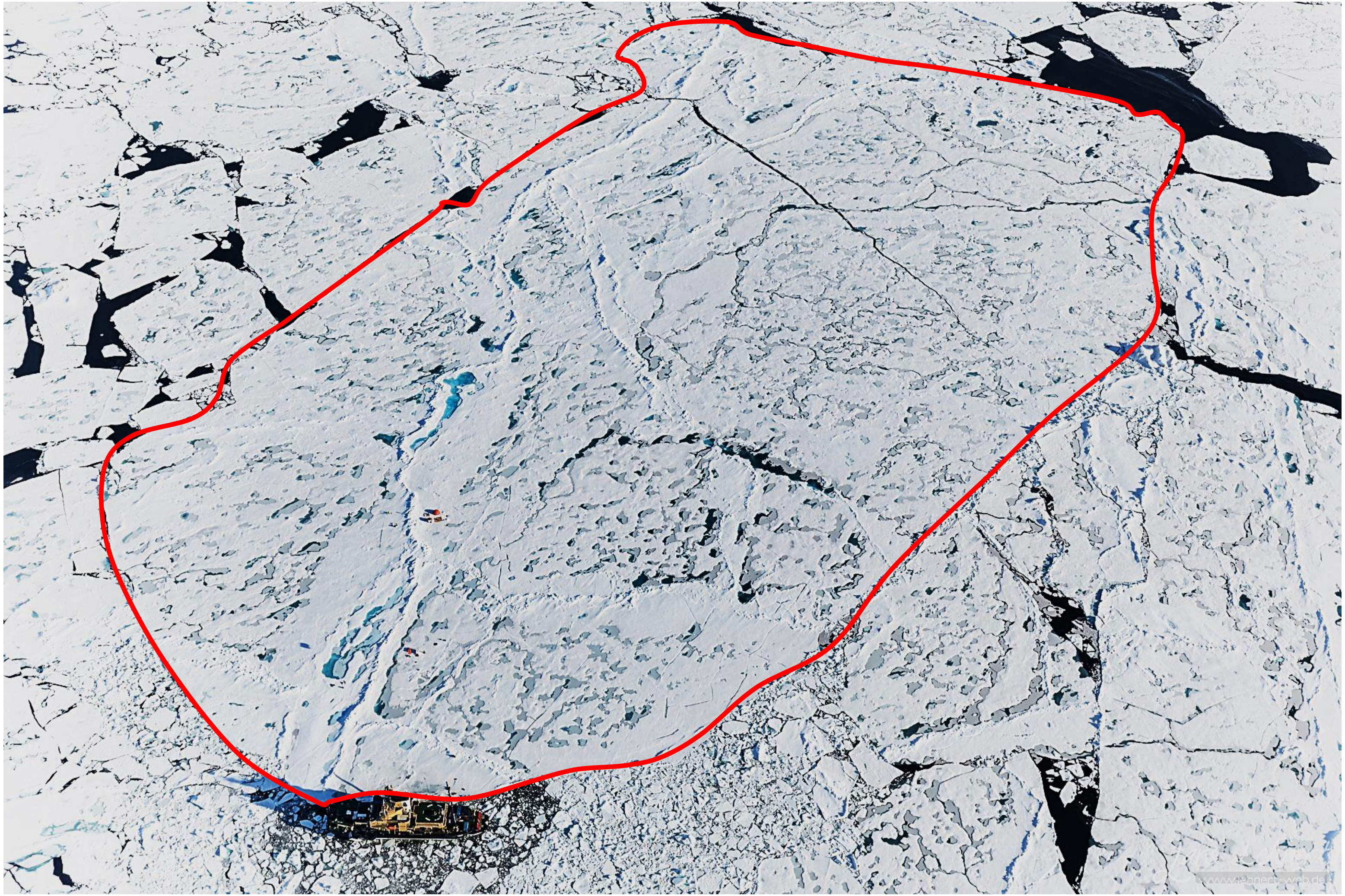

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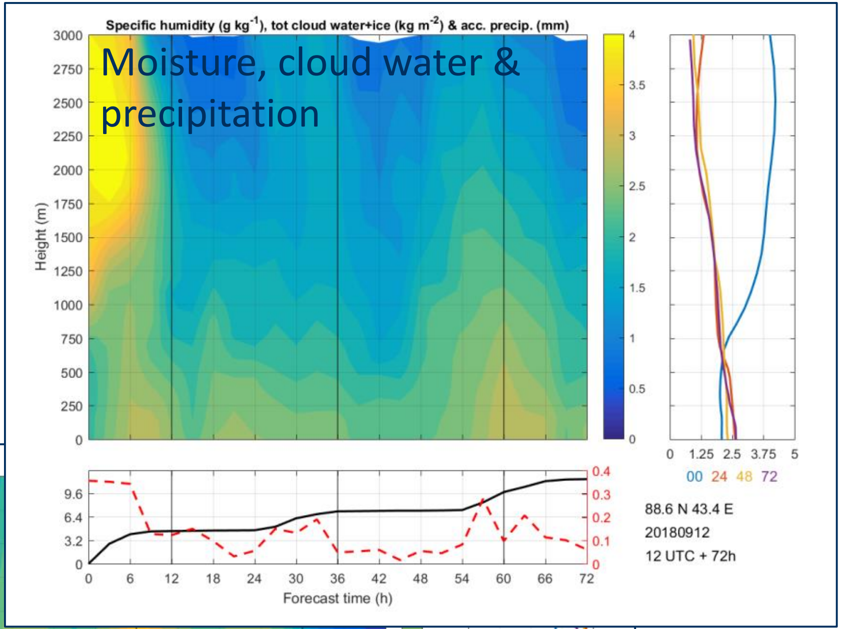
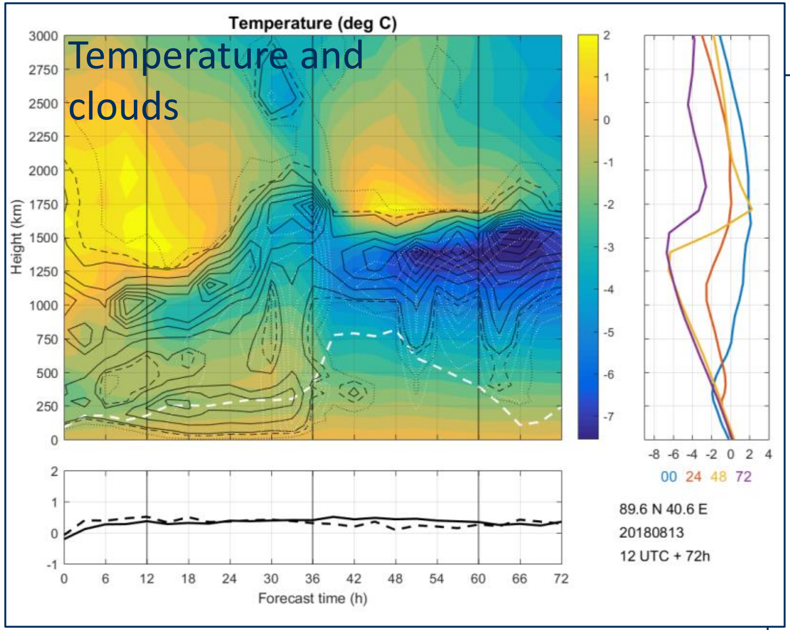
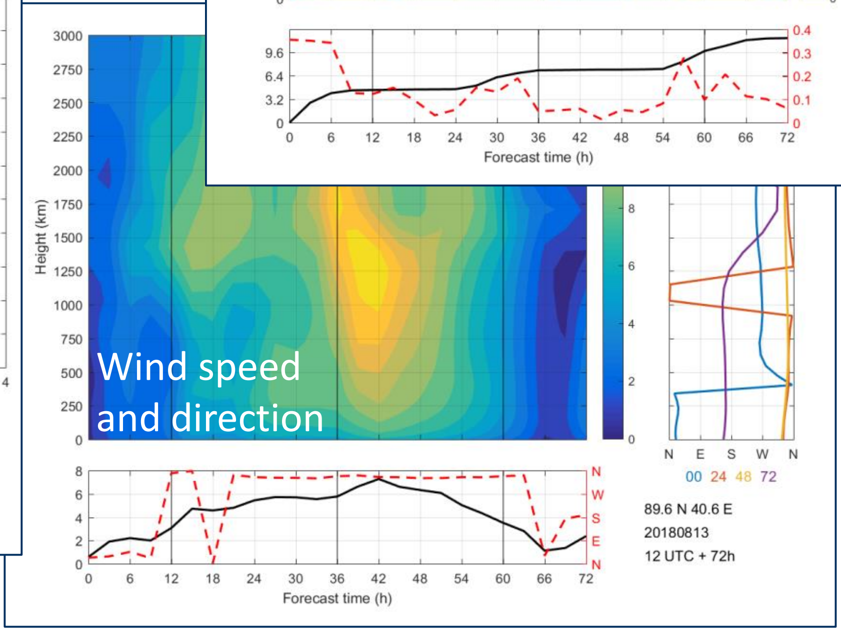
Forecasting on board:

- Ship's operational forecasting for helicopter flights and general safety and logistics (visibility & clouds, winds & precipitation)
- Science planning, special forecasts provided by APPLICATE (PBL structure and clouds)







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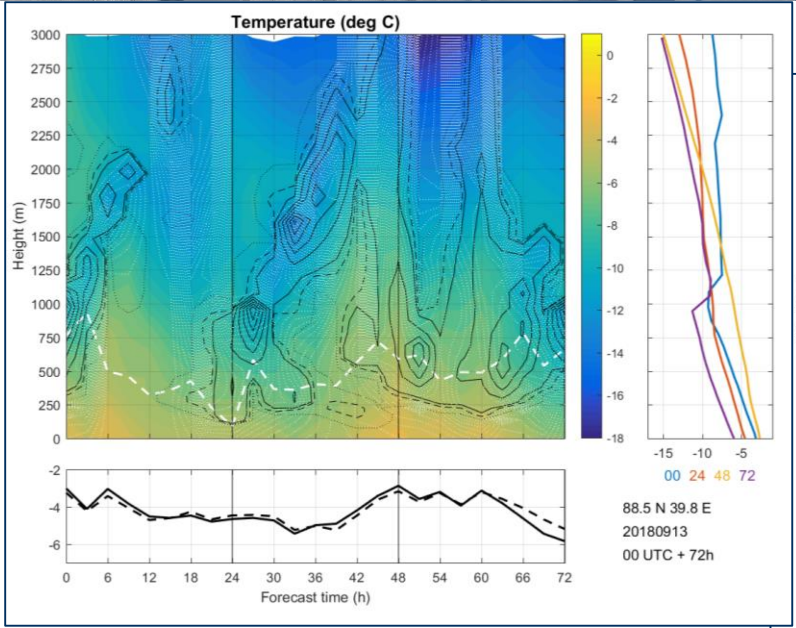

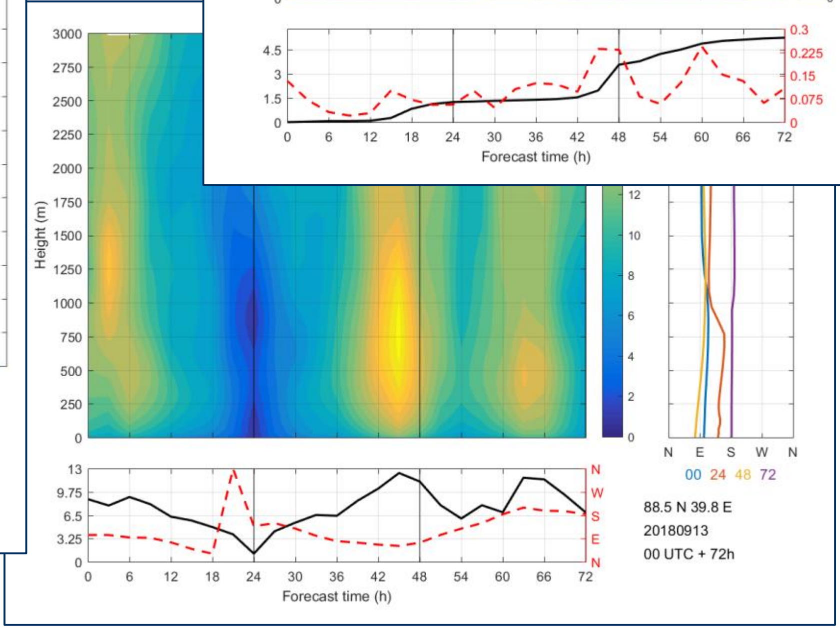

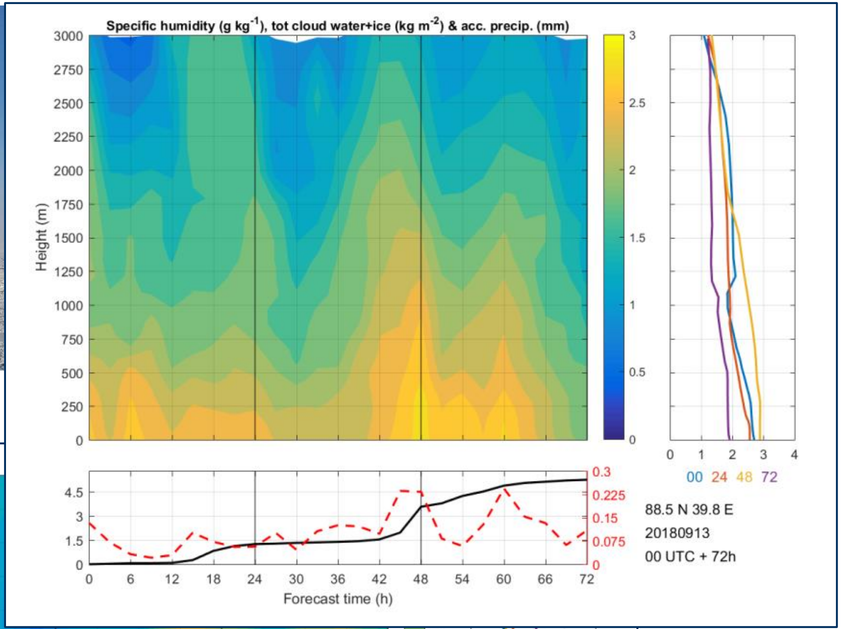

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Forecasting on board:

- Low bandwidth – think about methods..
- Cultural differences – think about education…
- Forecast quality (subjective evaluation of IFS):
  - Cloud forecasts essentially *useless*
  - Temperature forecasts *less than useful*, probably partly because of clouds
  - Major precipipitation is *good* but often ”drizzling” a little in between
  - Moisture forecsts *very useful* – mostly for fog & cloud forecasting
  - Winds were scaringly *accurate*!

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Forecast quality (objective evaluation of IFS):

- Using our own weather station (@ 20 m) & sondes in near-real-time
- Weather station data averaged over ~10 minutes, centered on model time
- Model results vertically interpolated to sounding resolution(!)
- Soundings released 30 minutes prior to nominal time; no time interpolation
- Median bias, 25-75 percentiles, pdf

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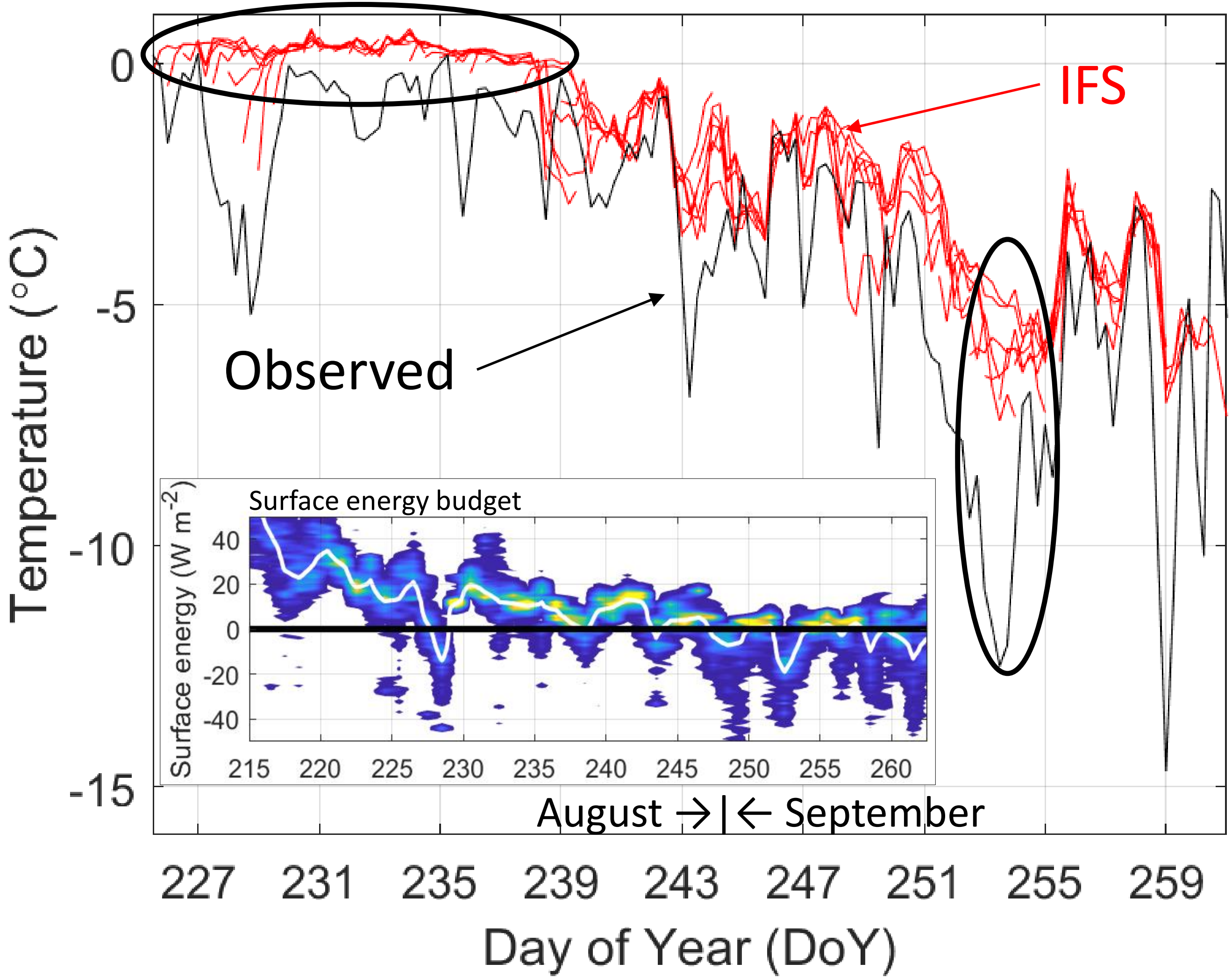

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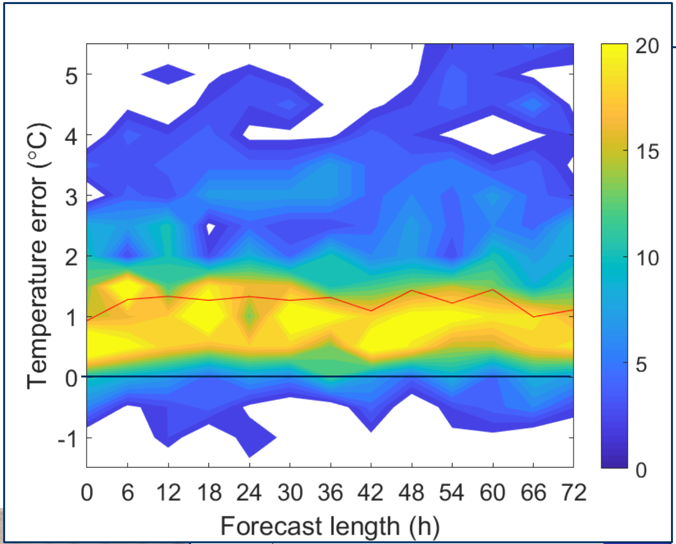
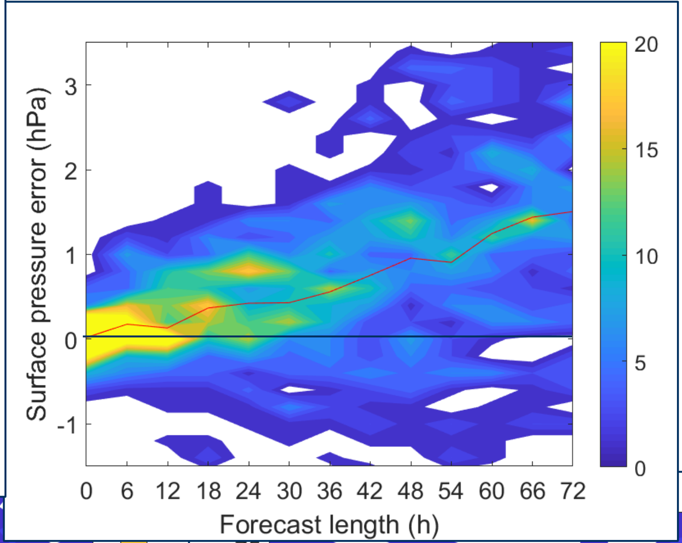
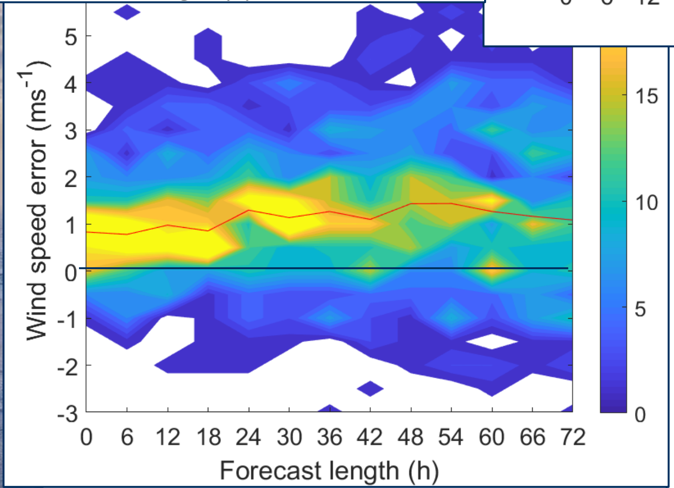
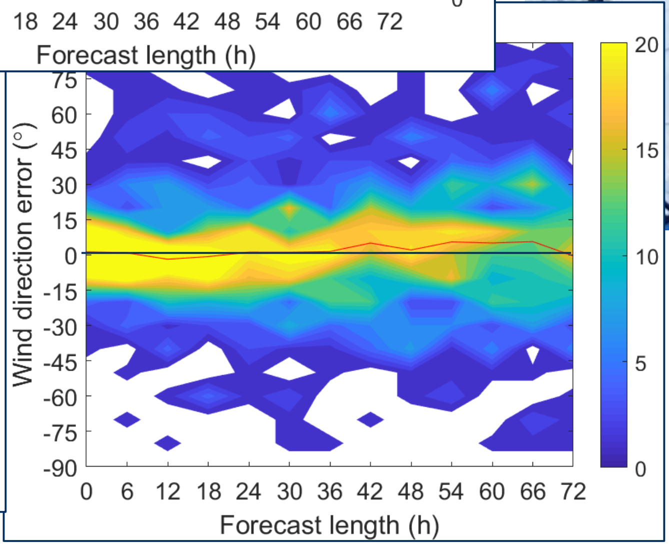
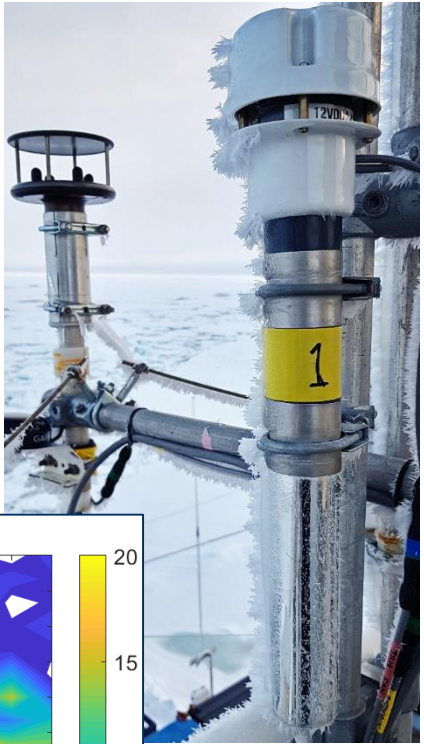
Some near-surface (@20 m) variables











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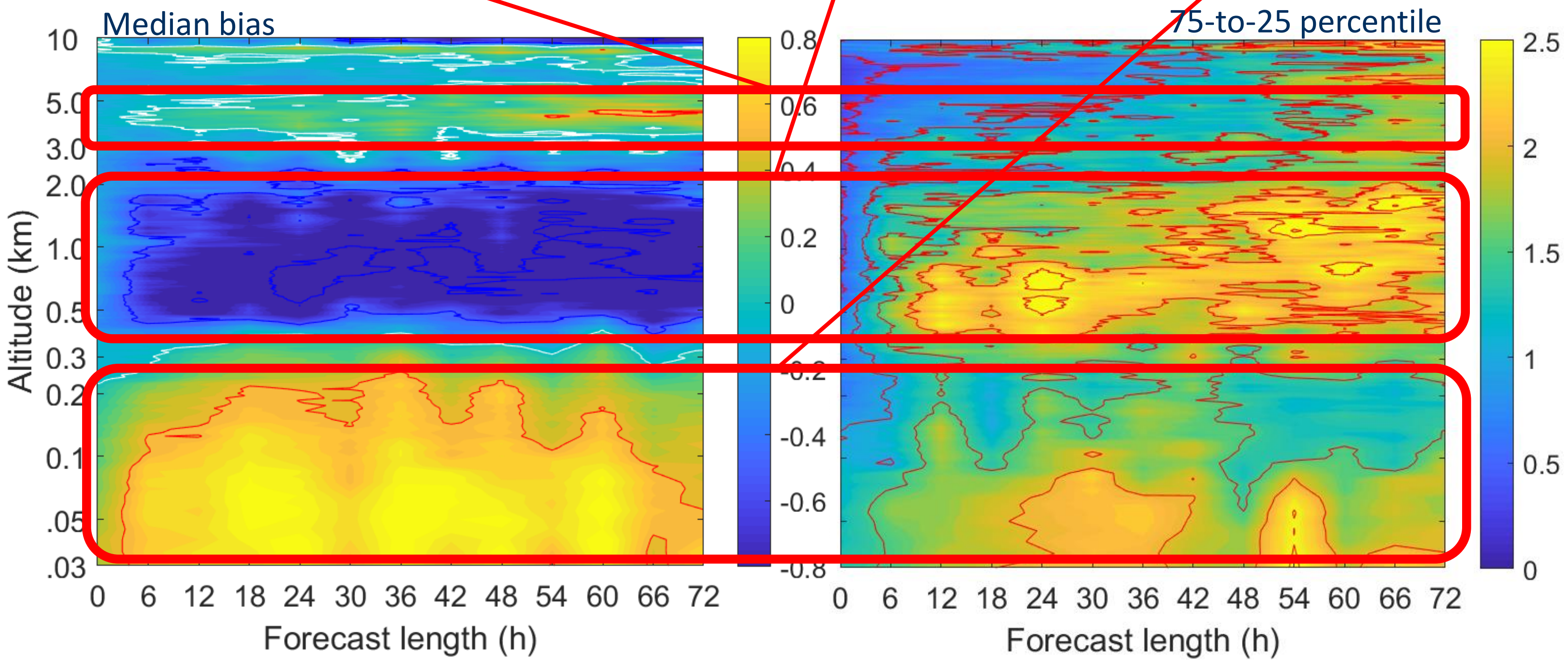
Thermal structure

Lower troposphere cold bias, ~-1 °C 0.5 to 3 km

Boundary layer warm bias, ~1 °C below ~300 m

Middle troposphere warm bias, ~0.5 °C 3 to 6 km



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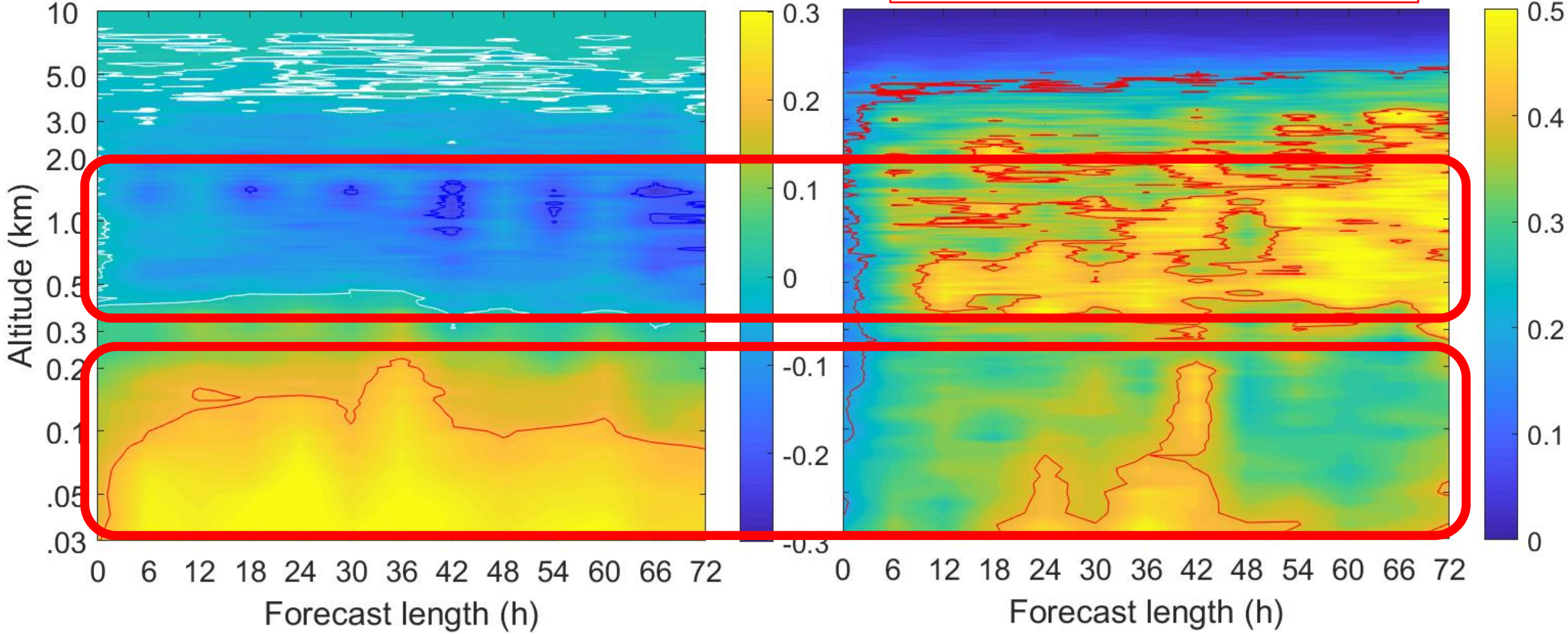
Moisture structure

Same layering, moist bias in the PBL and dry above, but around zero where moisture is low. Also a weird periodicity ~1km that seems to grow



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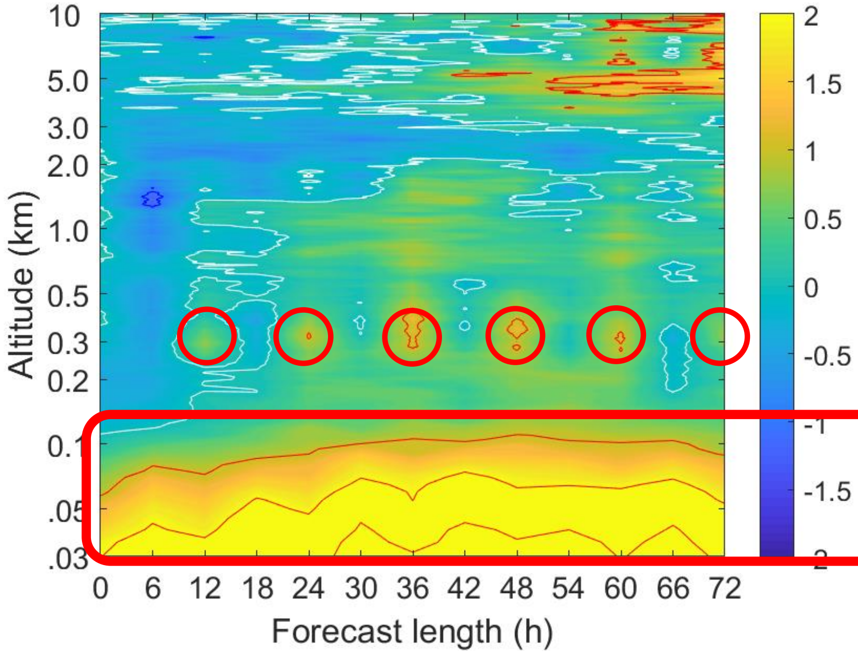
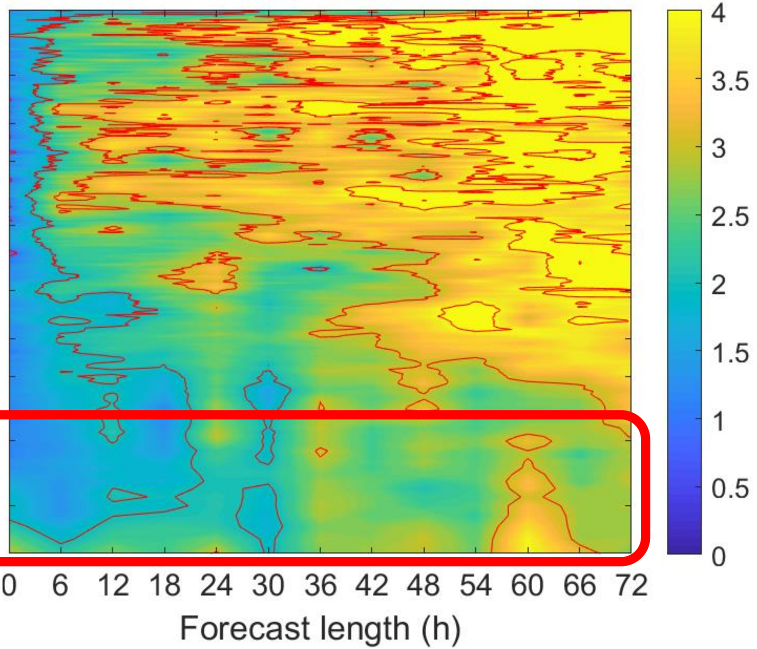
Scalar wind speed

High bias in PBL, low down partly a measurements artifact but also real

Also note weird periodicity at PBL top





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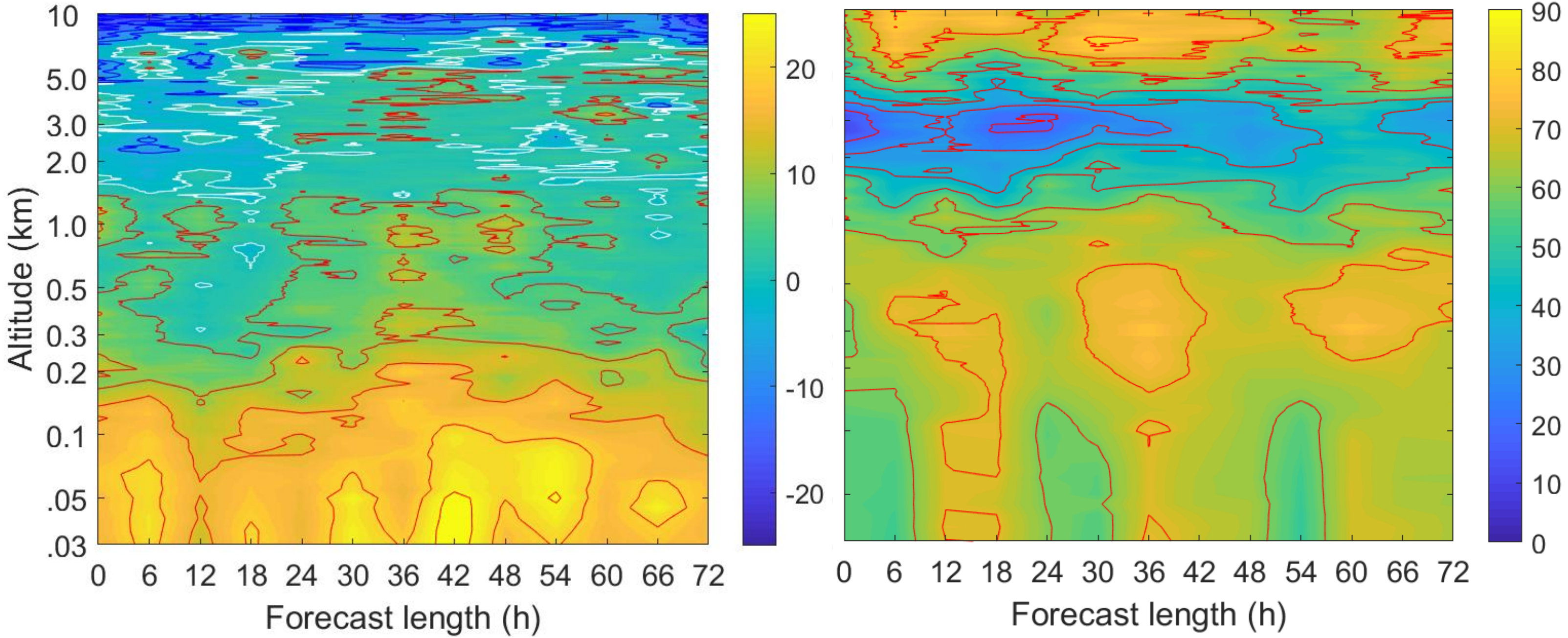
Wind direction



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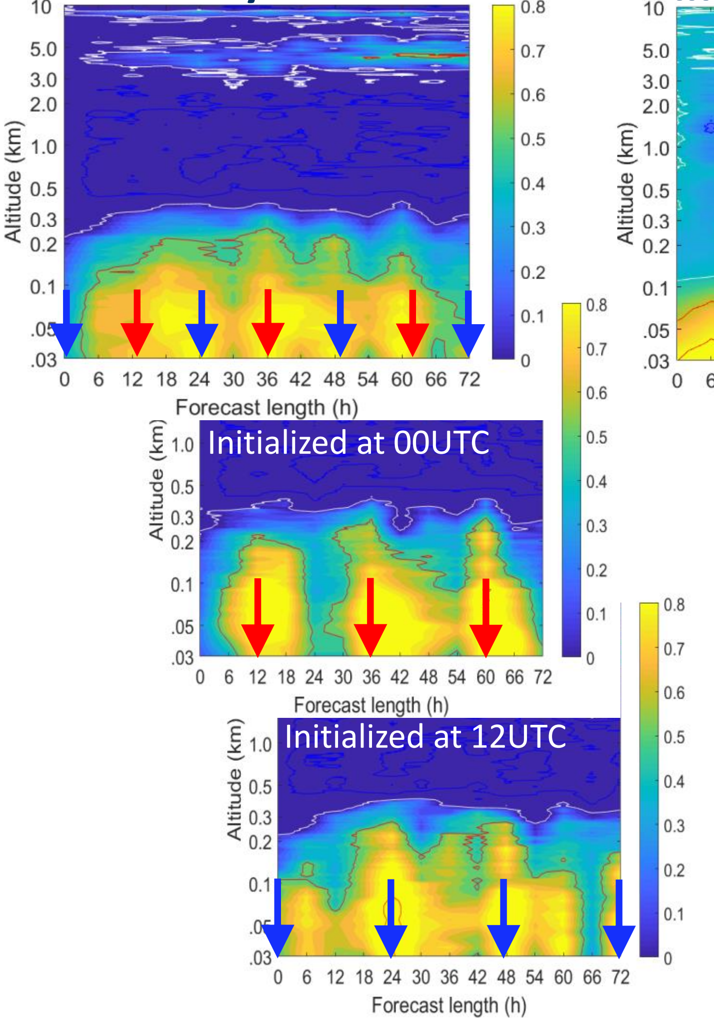
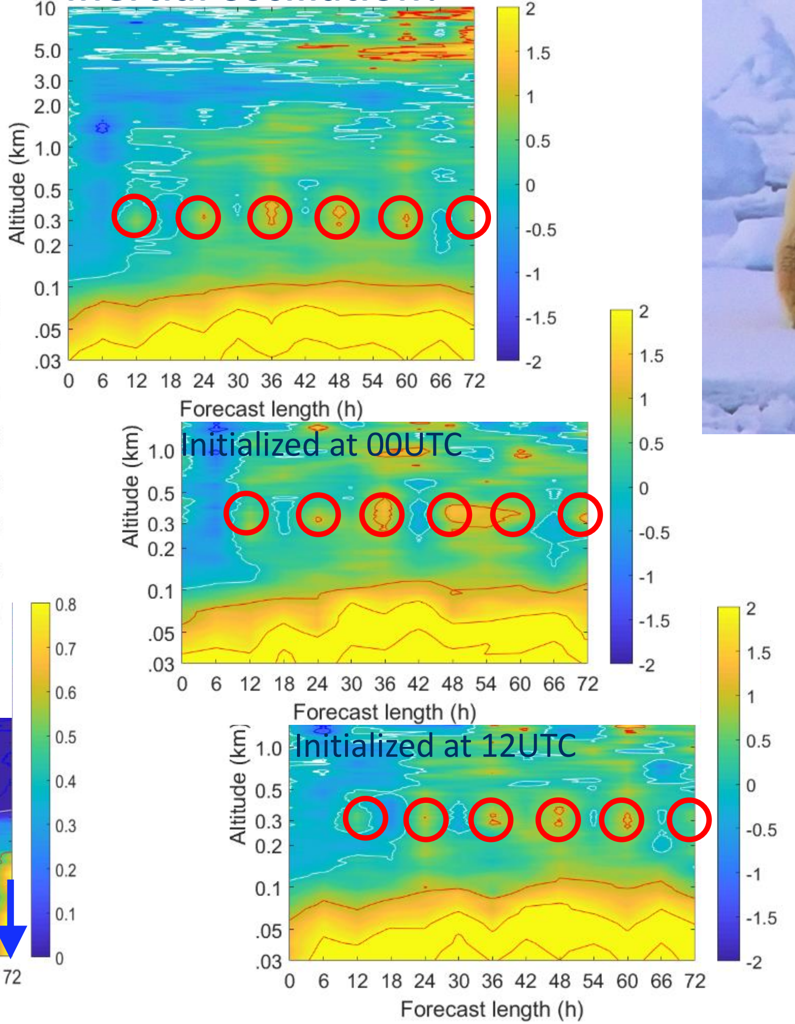
Diurnal cycle?



Inertial oscillation?



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Some parting thoughts…

- Field campaign observations comes in all along the whole chain of developing model physics:
  - Discovery and understanding
  - Parametrization, closure and calibration
  - Testing and evaluation

  This is often (always?) an iterative process

- Accurate forecasting is vital for any field campaign but needs to be adapted to particular conditions. Arctic field campaigns have special problems (keep it simple dummy!); *there is no one size fits all*

- In Arctic summer IFS has a severe cloud problem, a mysterious PBL warm bias with a diurnal cycle that does not exist, and some other strange oscillations

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