Why modelers should care about field projects

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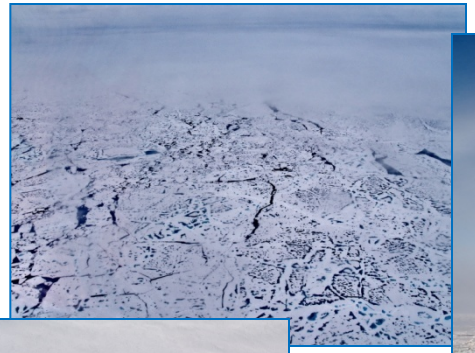
Data without a model is chaos…
…but a model without data is guesswork

(Patrick Crill, Stockholm Uni.)

- *Expanding our knowledge – reveal things we didn't know already*
- *Reveal process relationships – understanding the system to improve model formulations*
- *Evaluate models – in different ways*



In the central Arctic, almost all *in situ* atmospheric observations are “field data”, one way or the other

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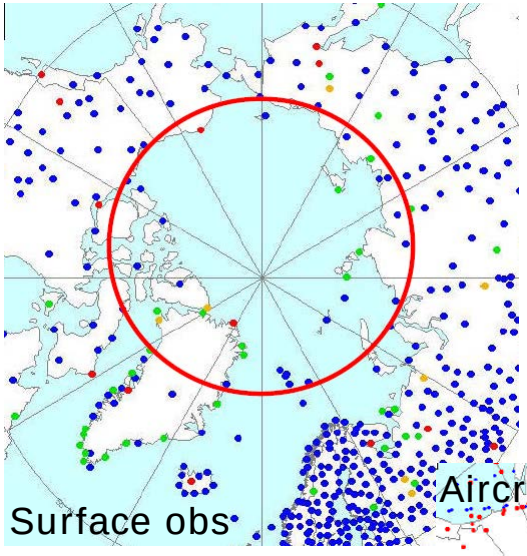

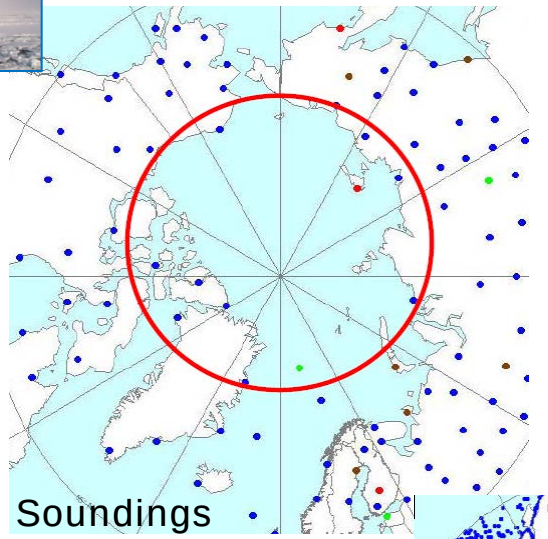

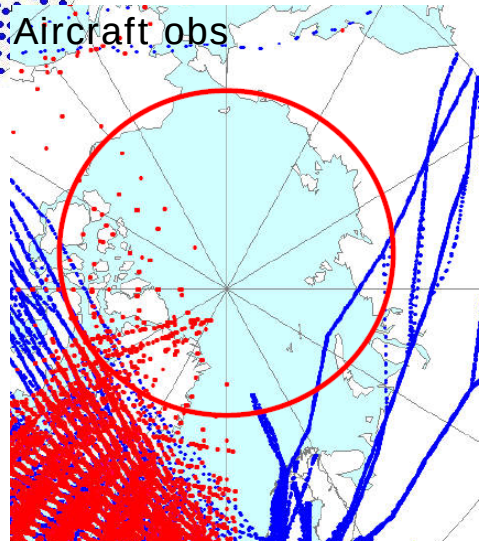

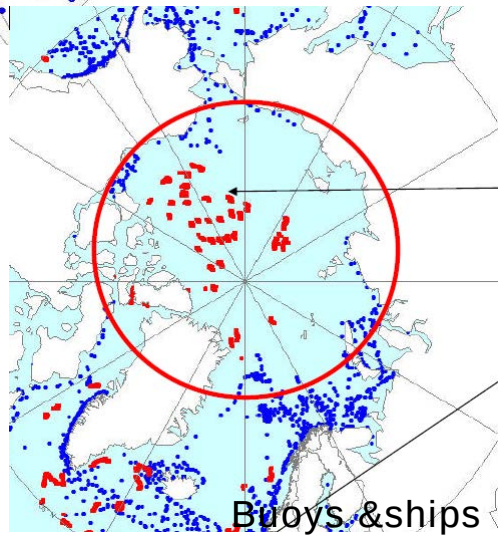

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Expanding knowledge:

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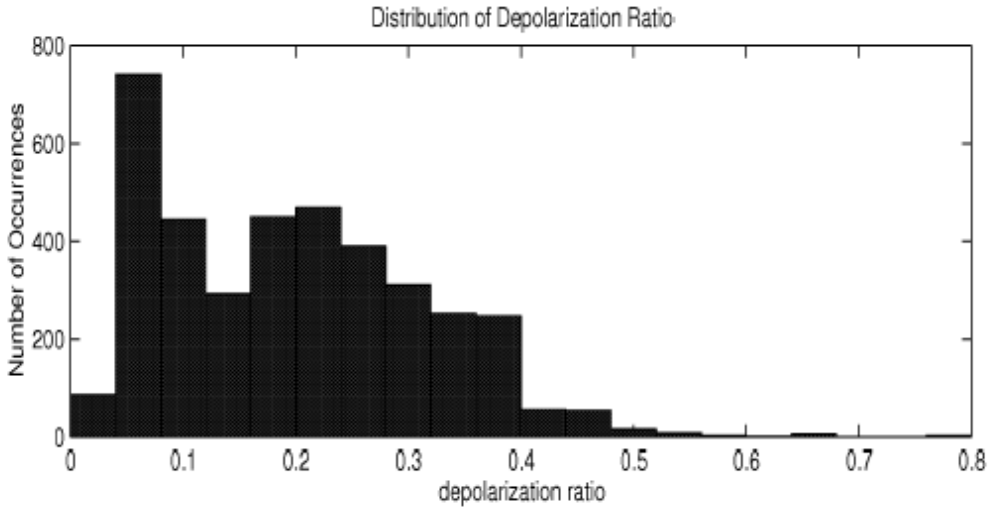
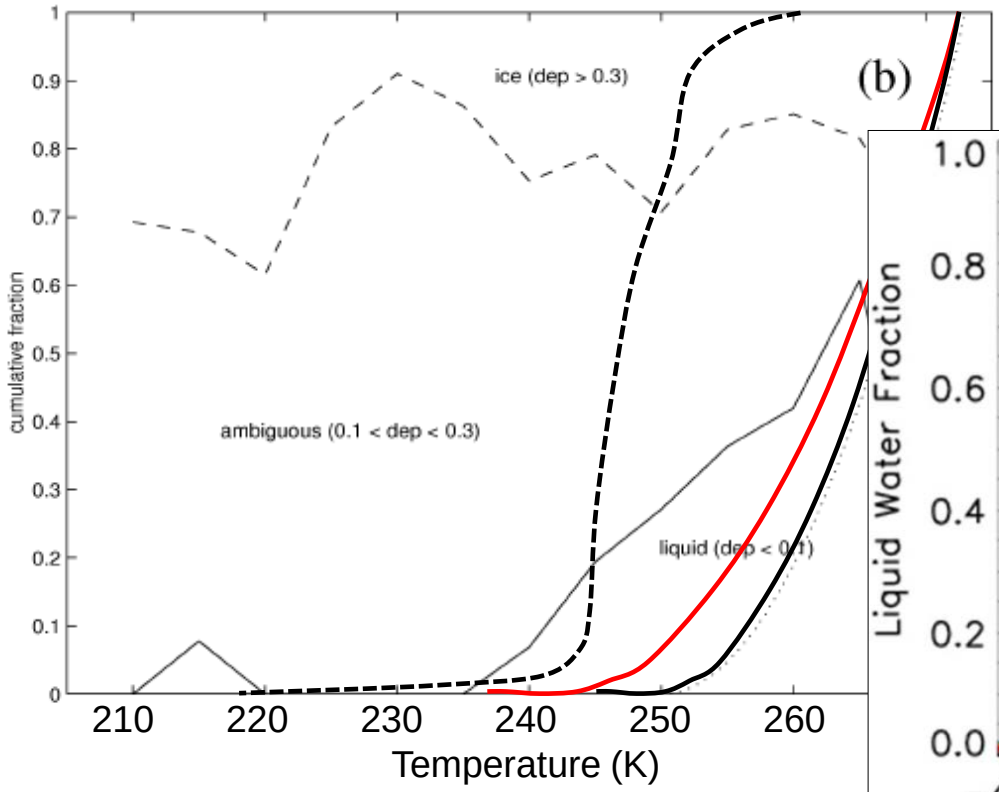
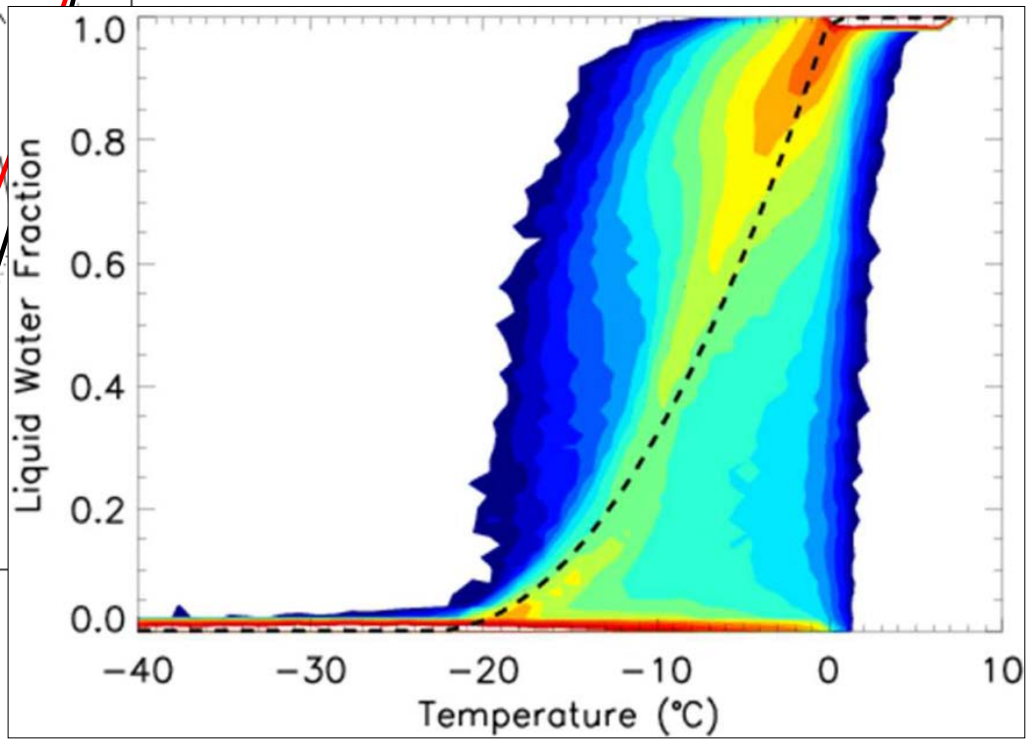
Mixed-phase clouds in cold climates…

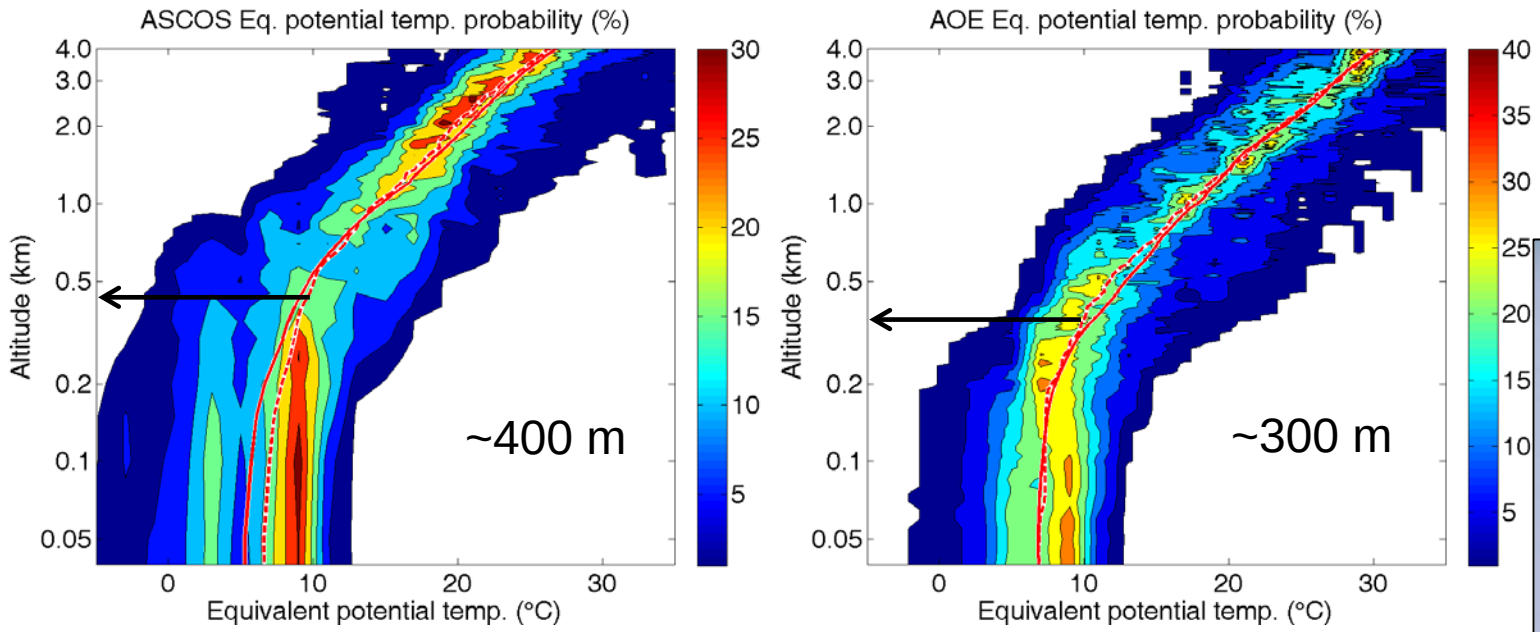


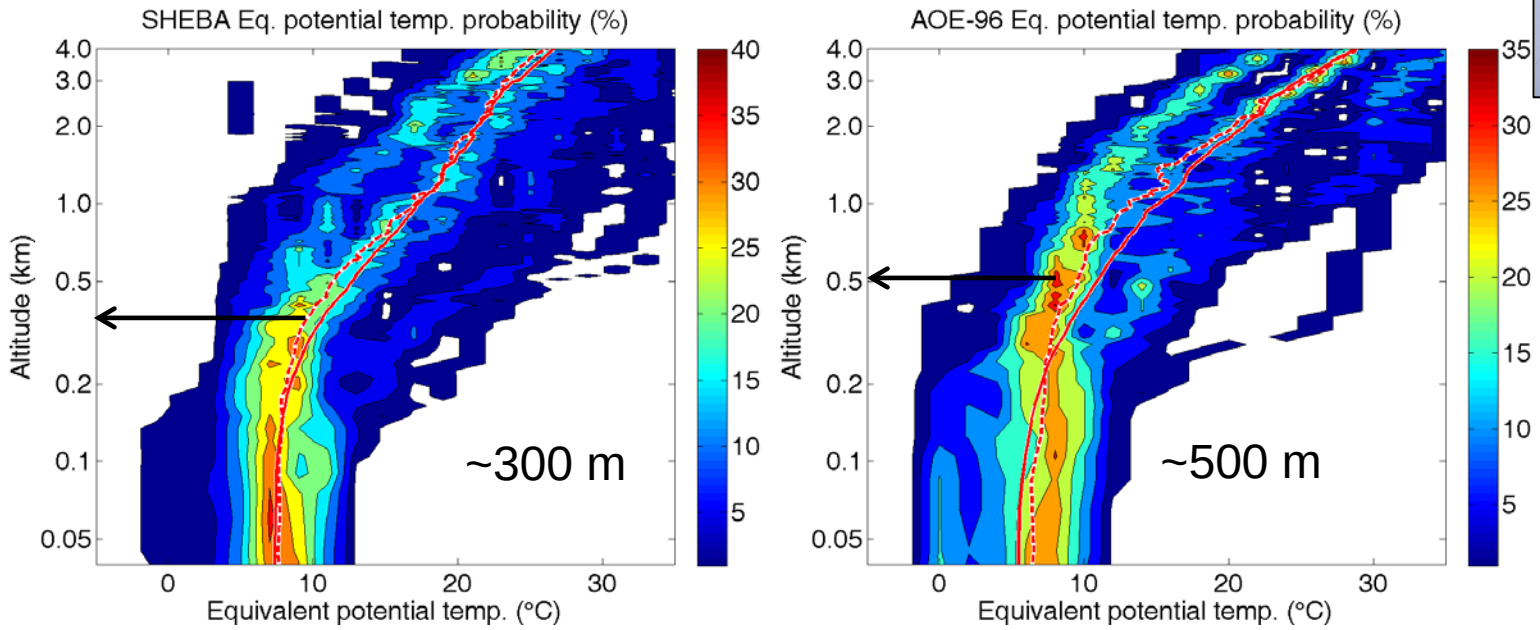


-100% liquid

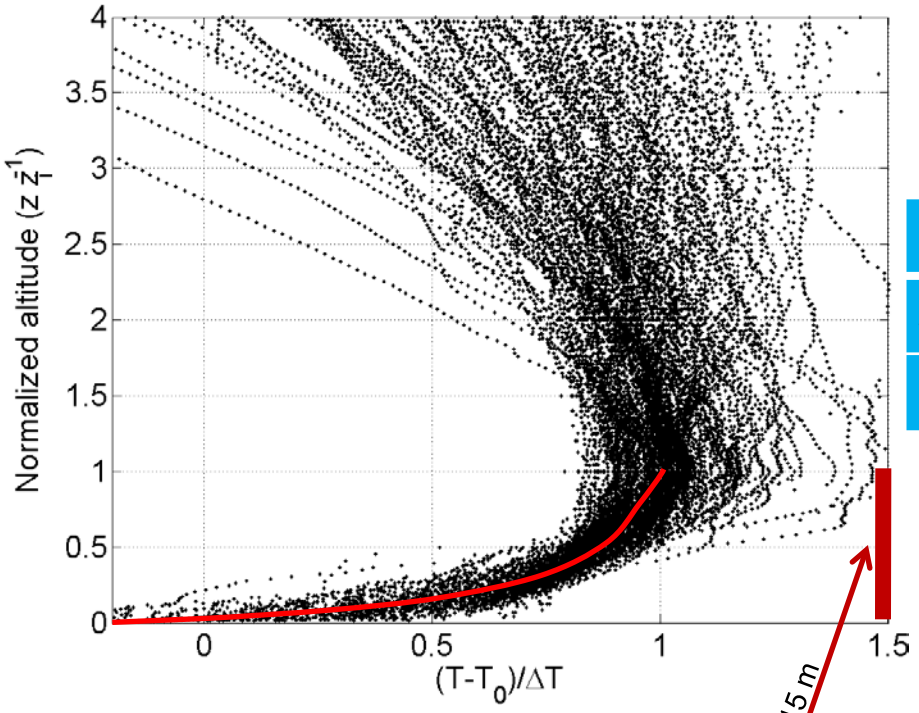


Vertical thermal structure





Surface inversion



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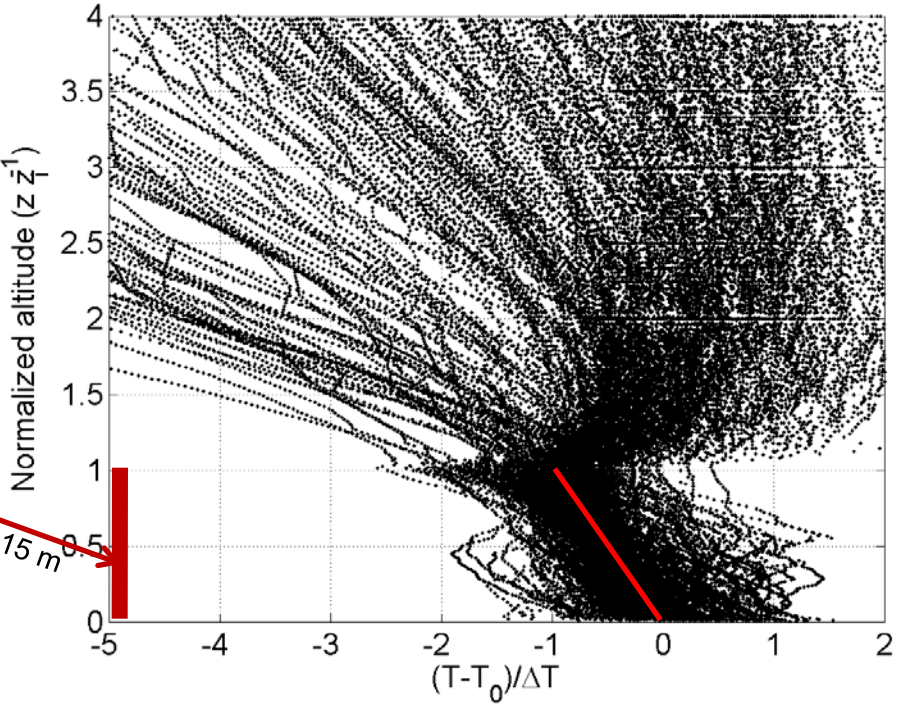
	Winter	Spring	Summer	Autumn
Surface	53%	15%	9%	61%
Lifted	47%	85%	91%	39%

Lifted inversion

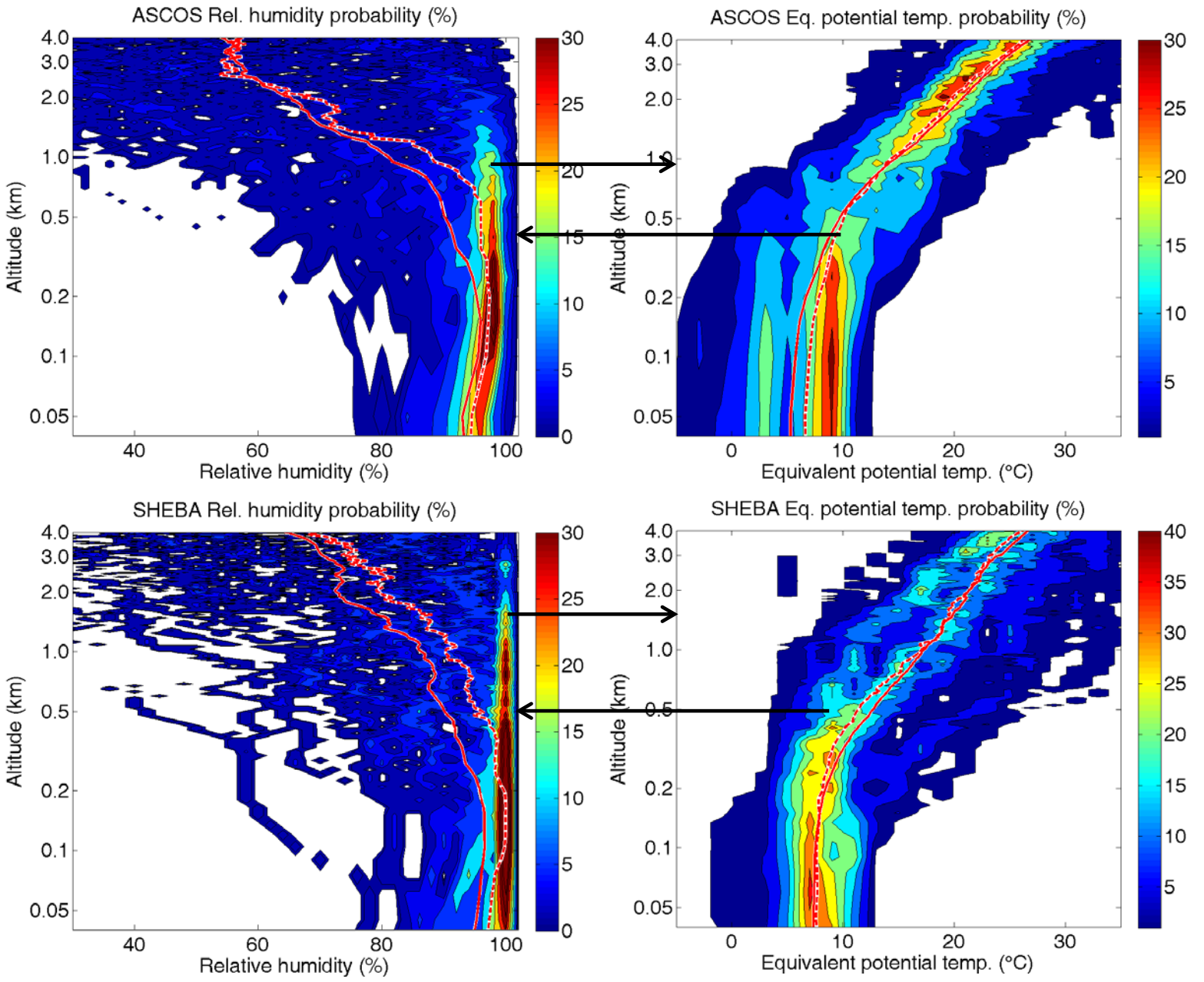


Inversion base < 15 m

Inversion base > 15 m

”Boundary layer”

Tjernström & Graversen 2009



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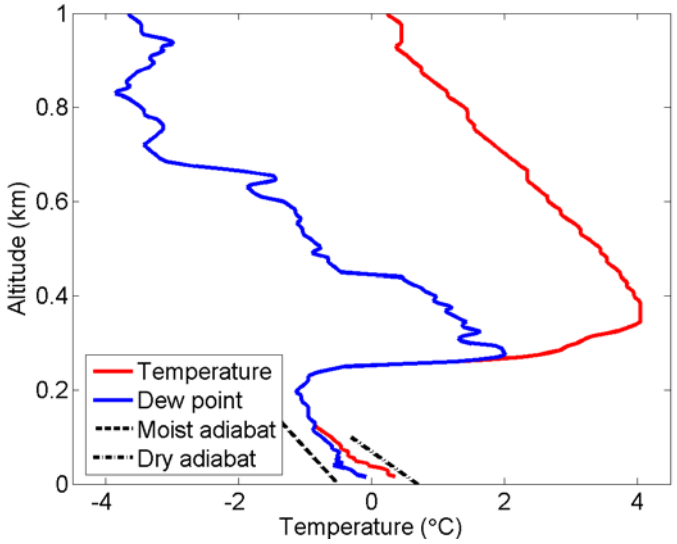
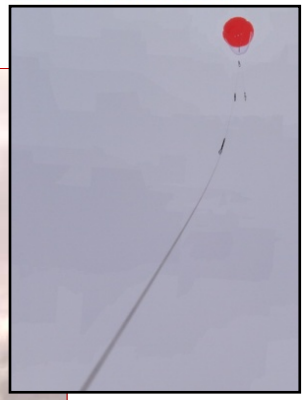
Vertical thermal structure

Tjernström et al. 2012

”Moisture invesions”





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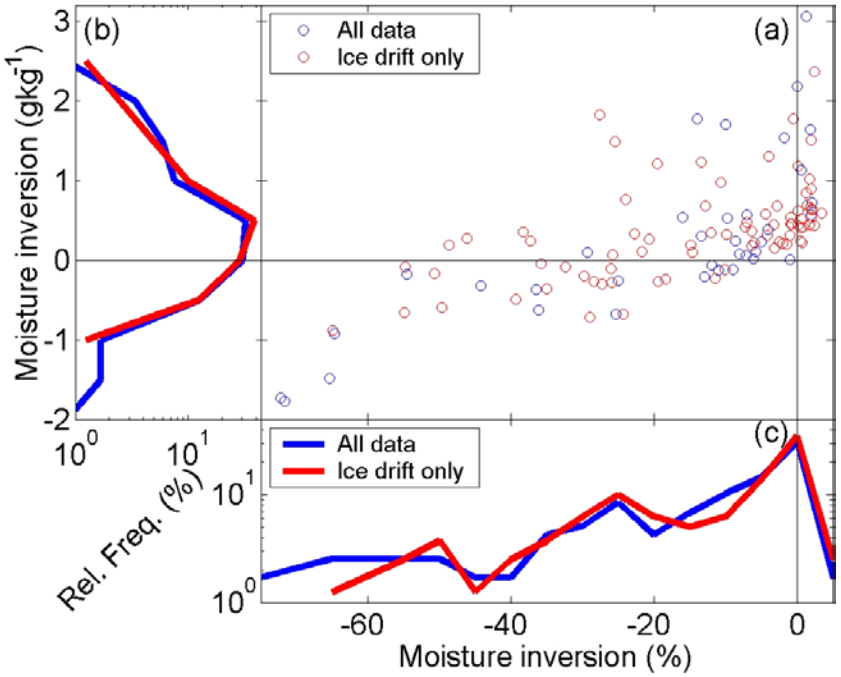
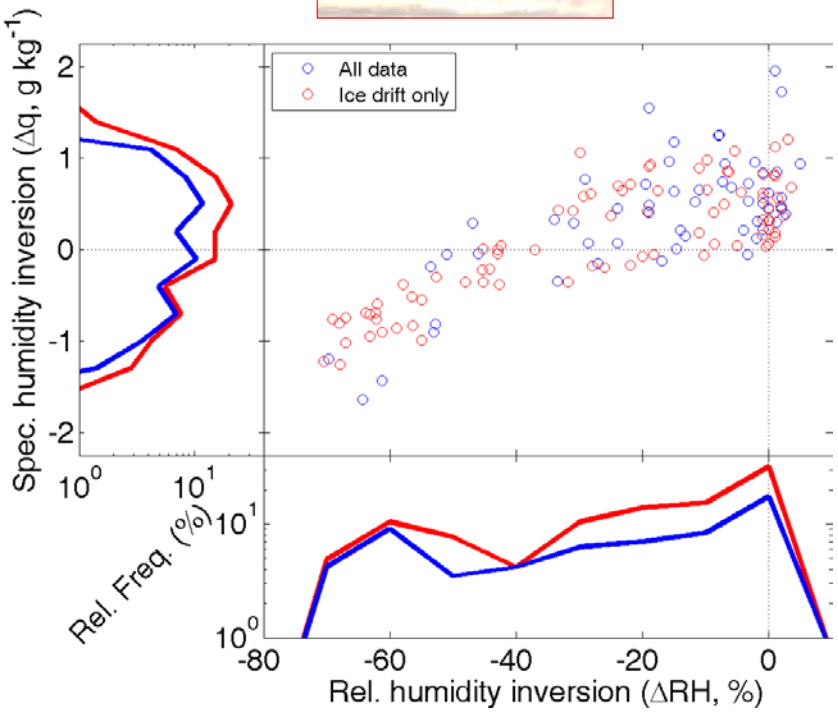
AOE-2001



ASCOS



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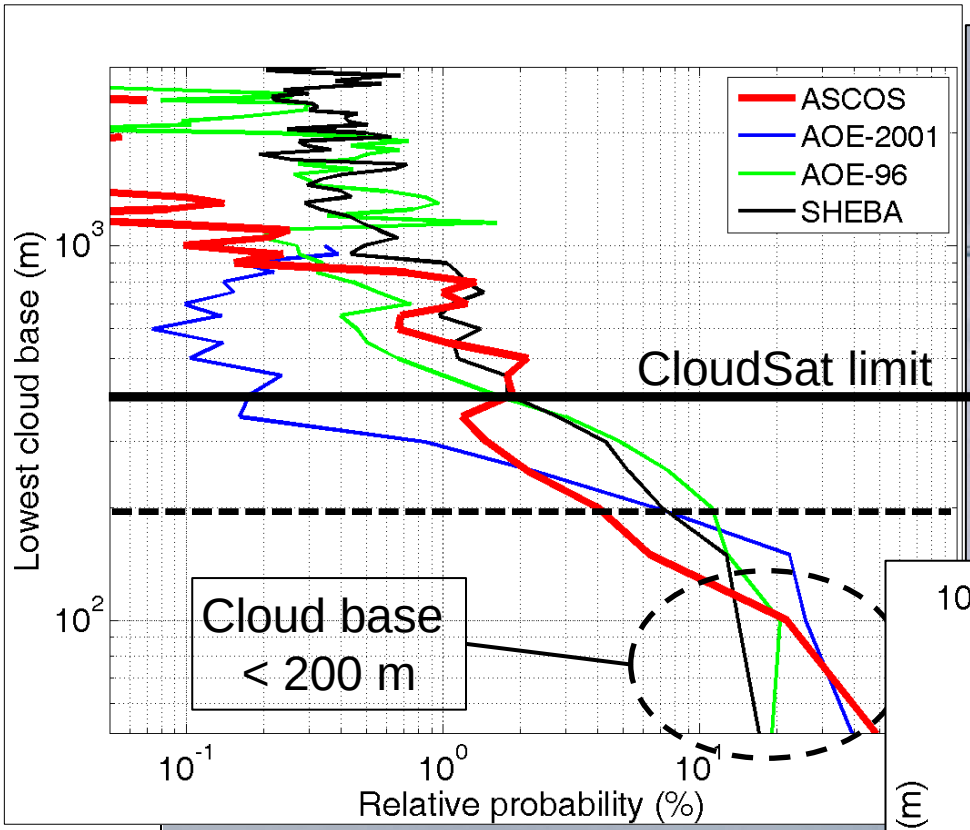

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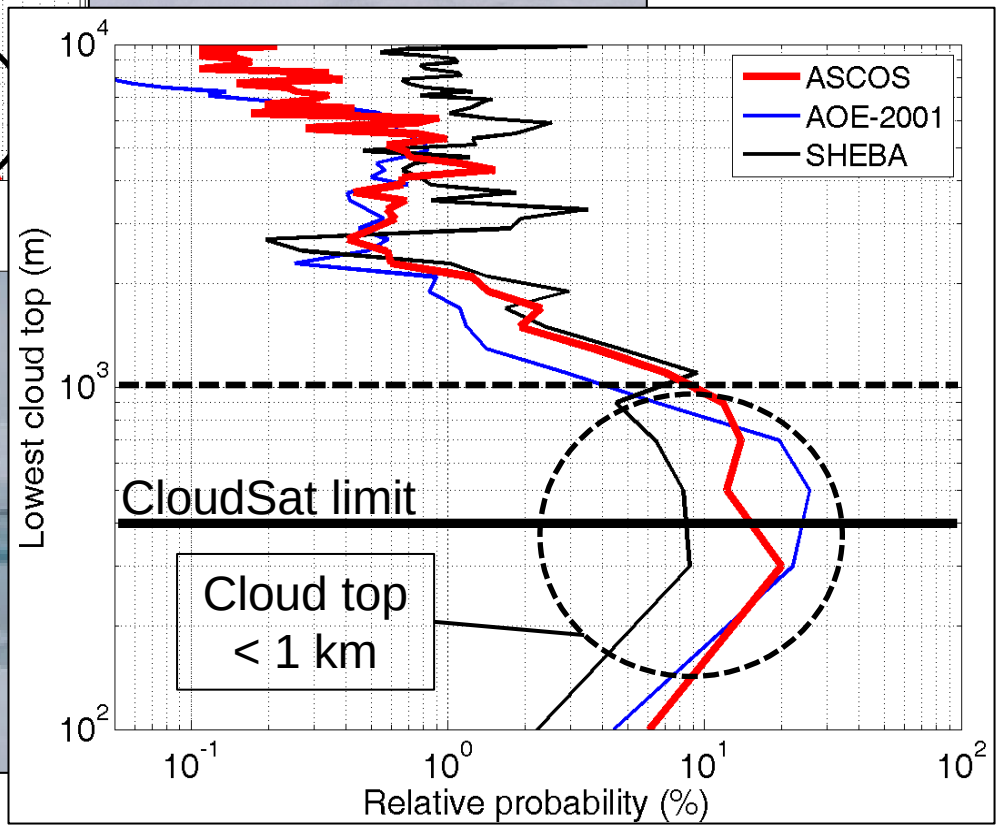

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Tjernström et al. 2012

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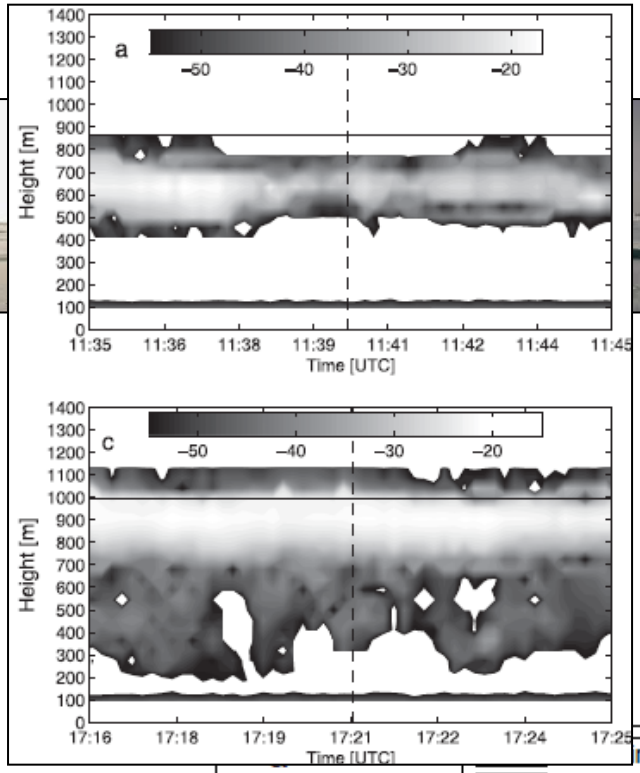

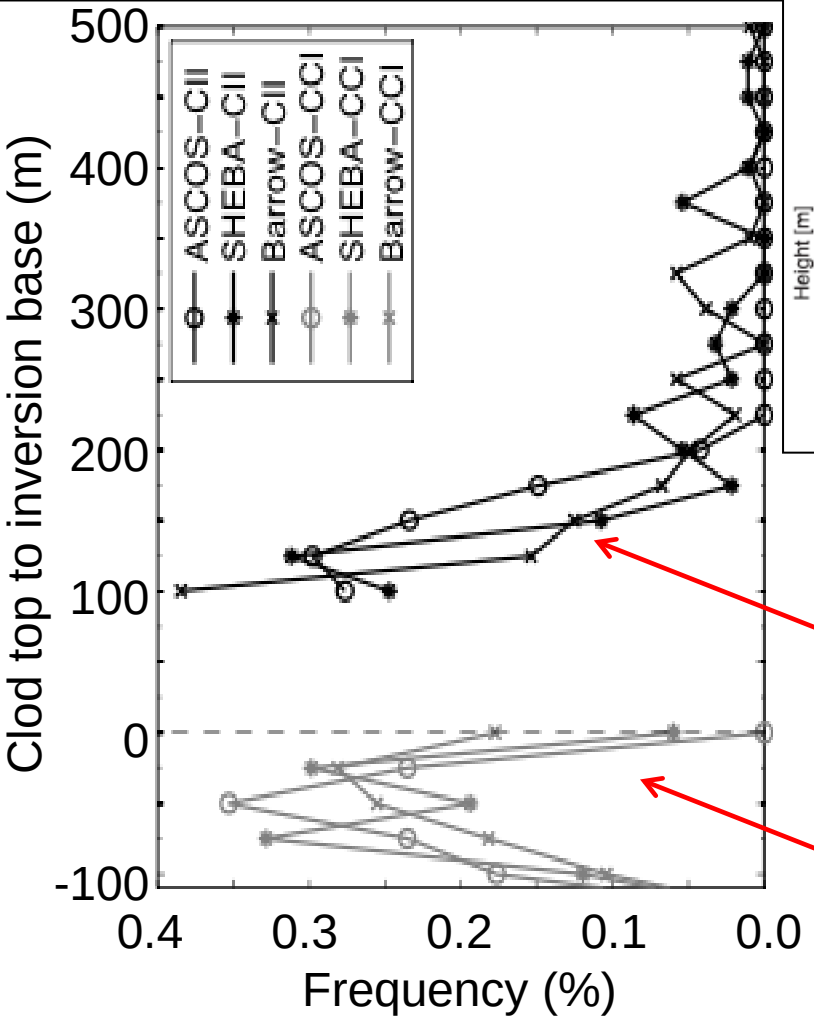

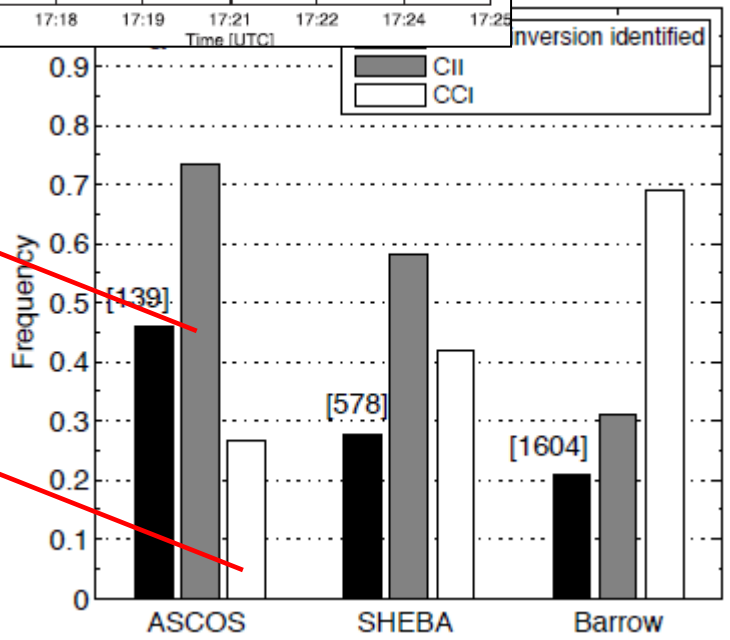

Sedlar et al. 2012

Aerosols, CCN and cloud interactions

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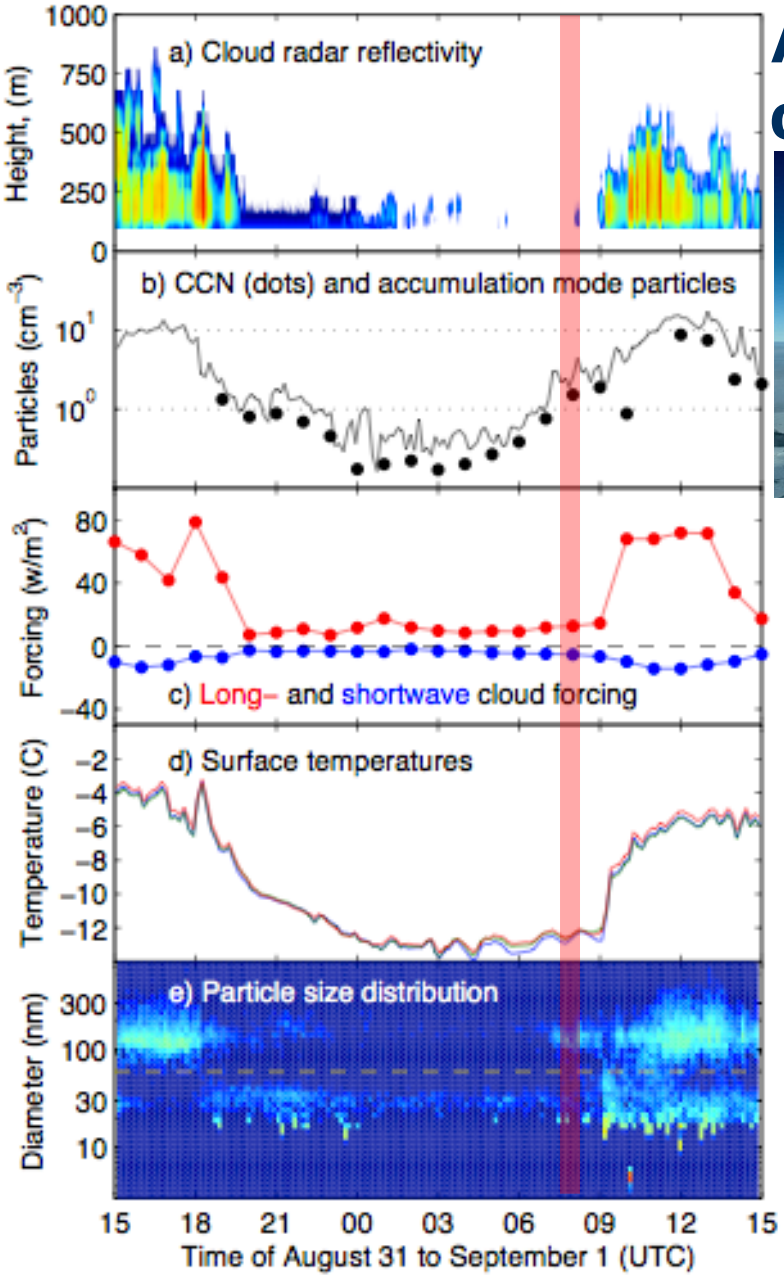

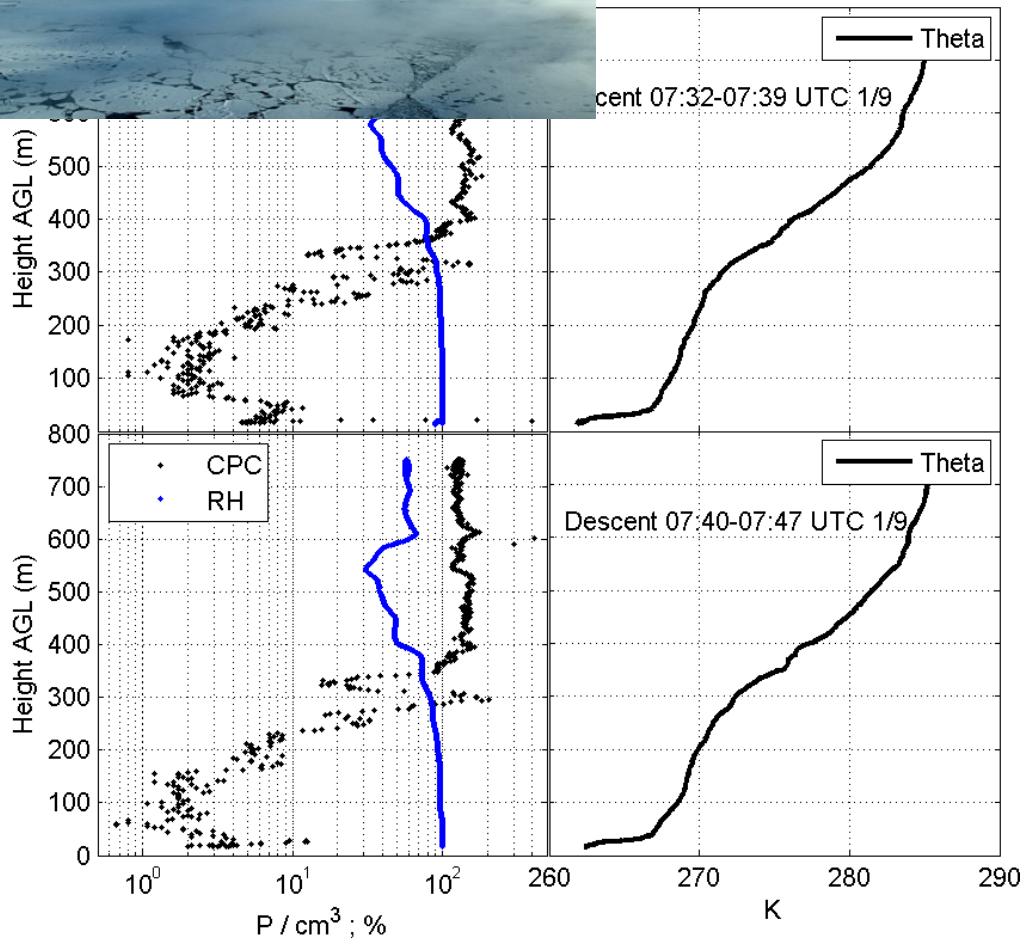

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Mauritsen et al. 2011

Optically thin clouds

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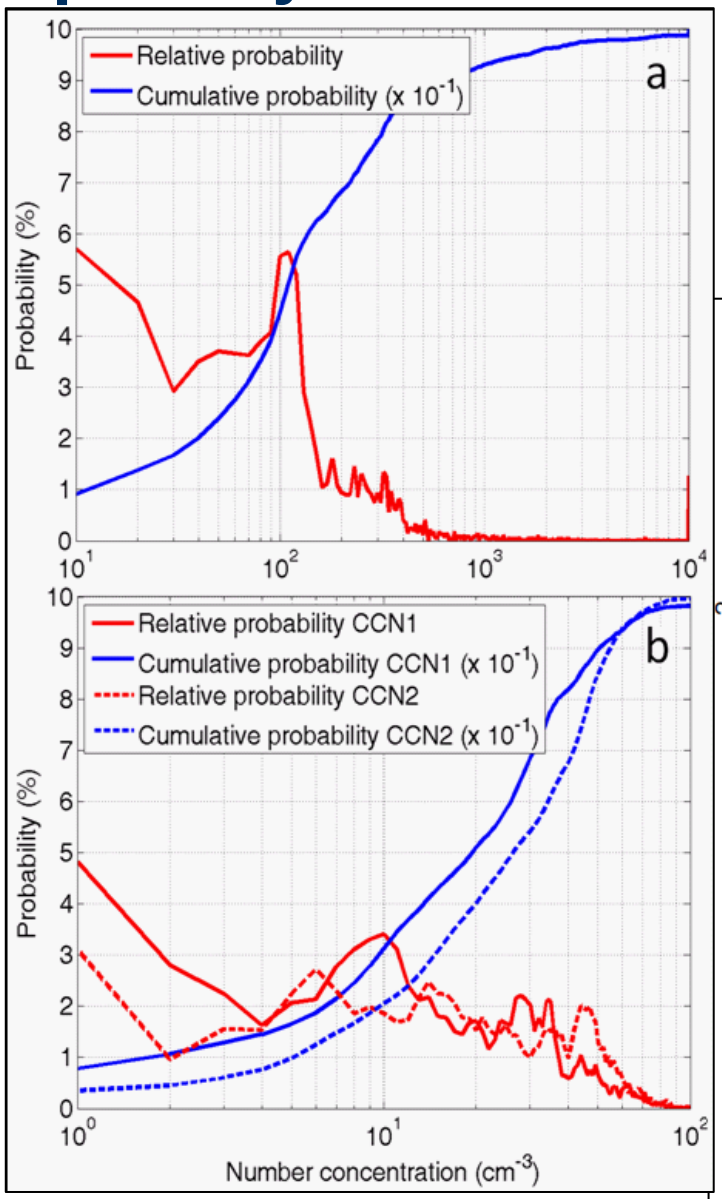

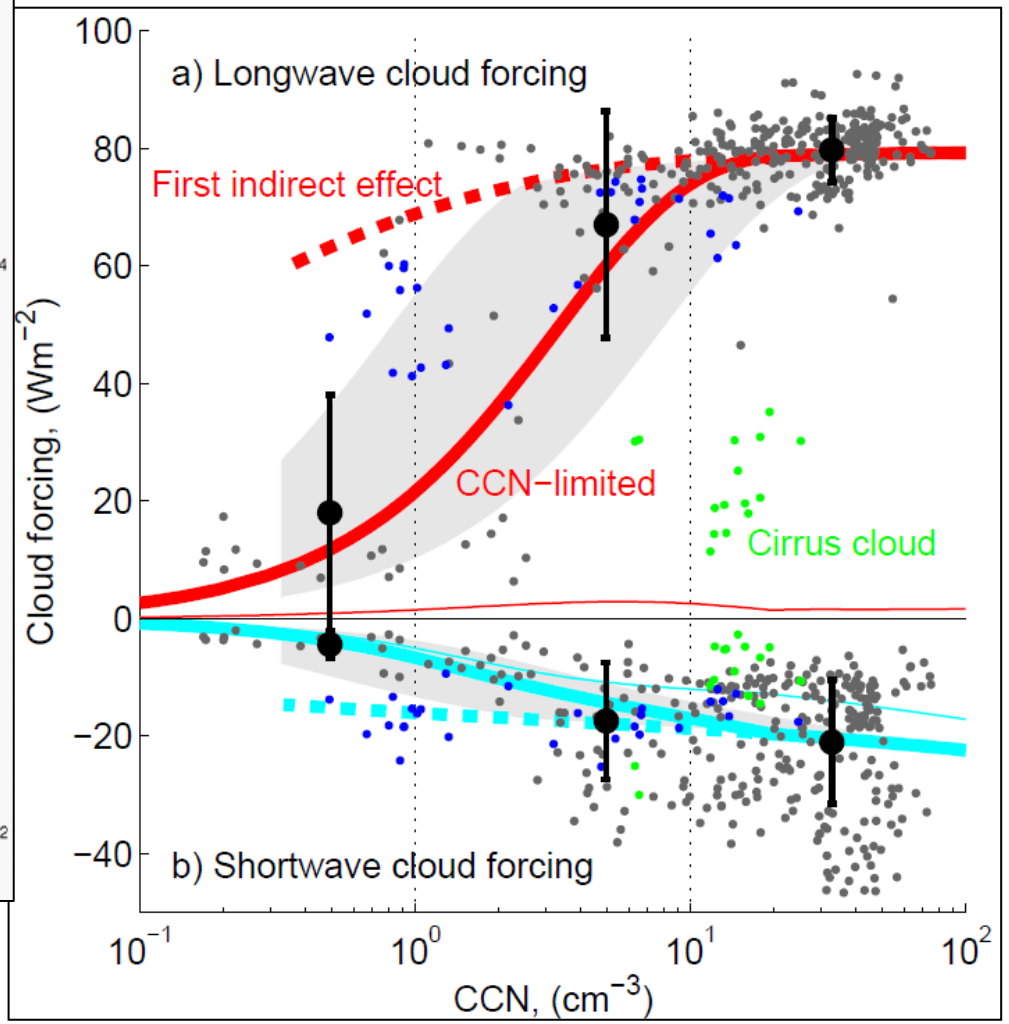

Optically thin clouds – arosol/cloud interactions

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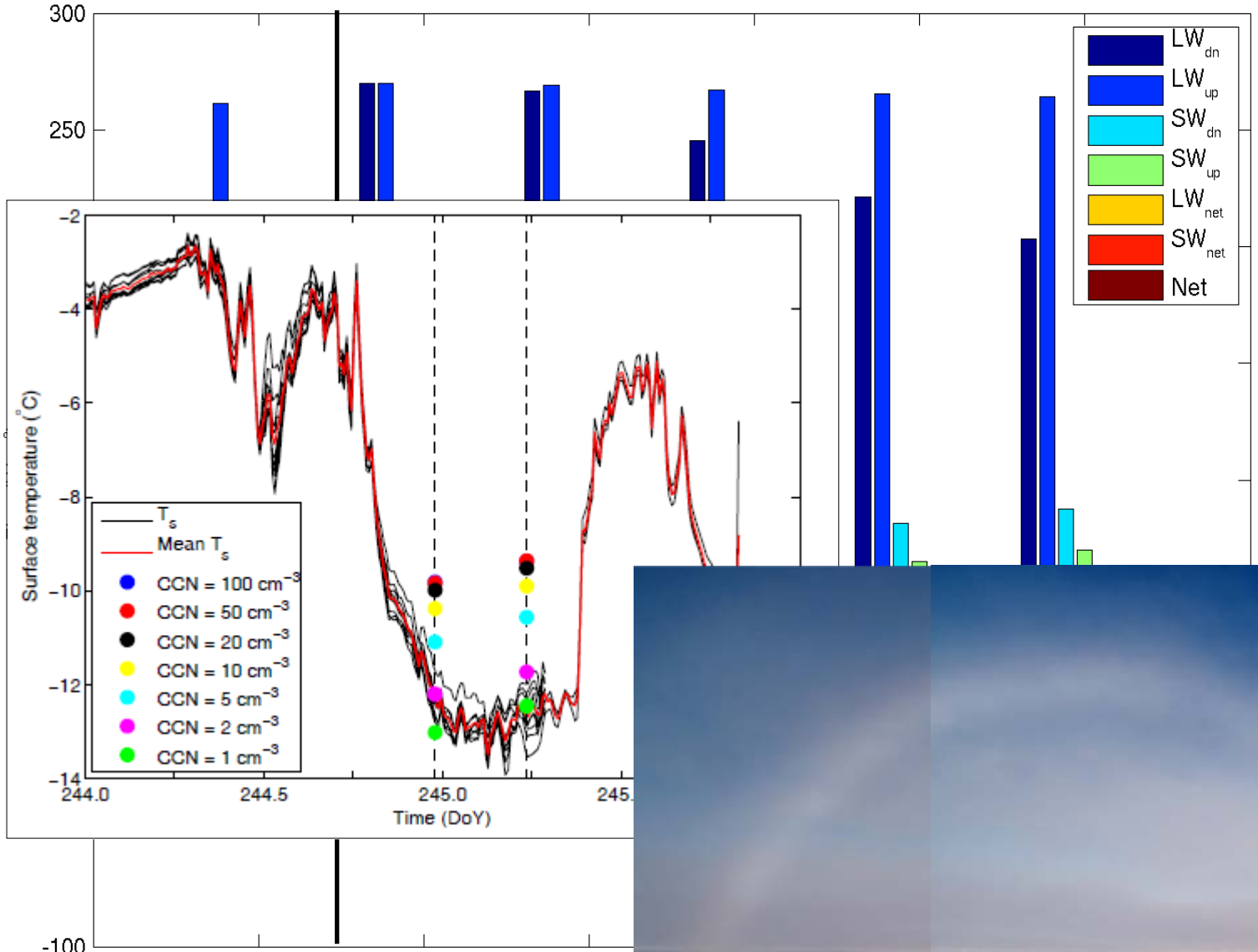
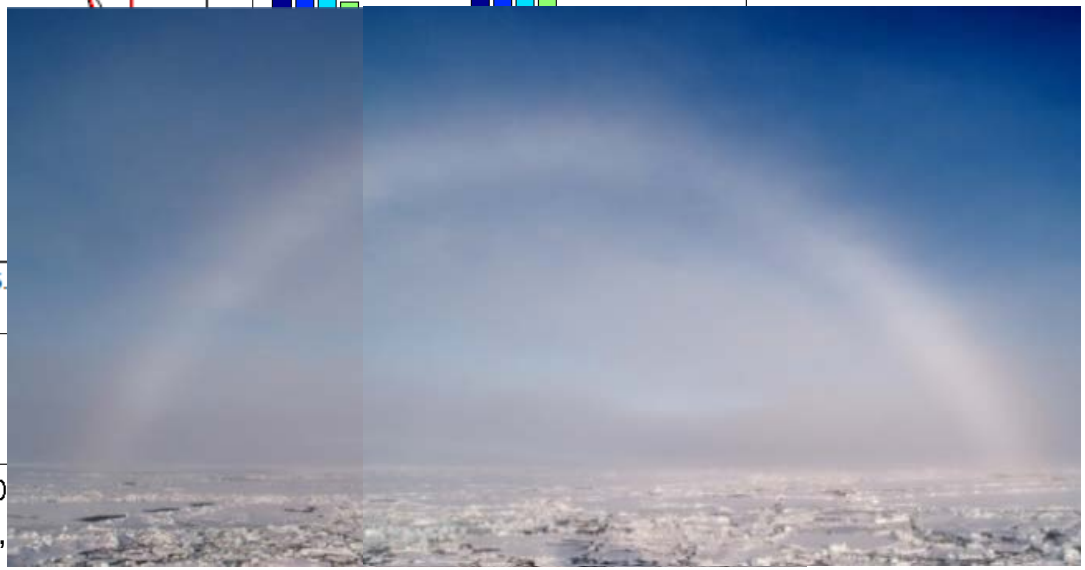
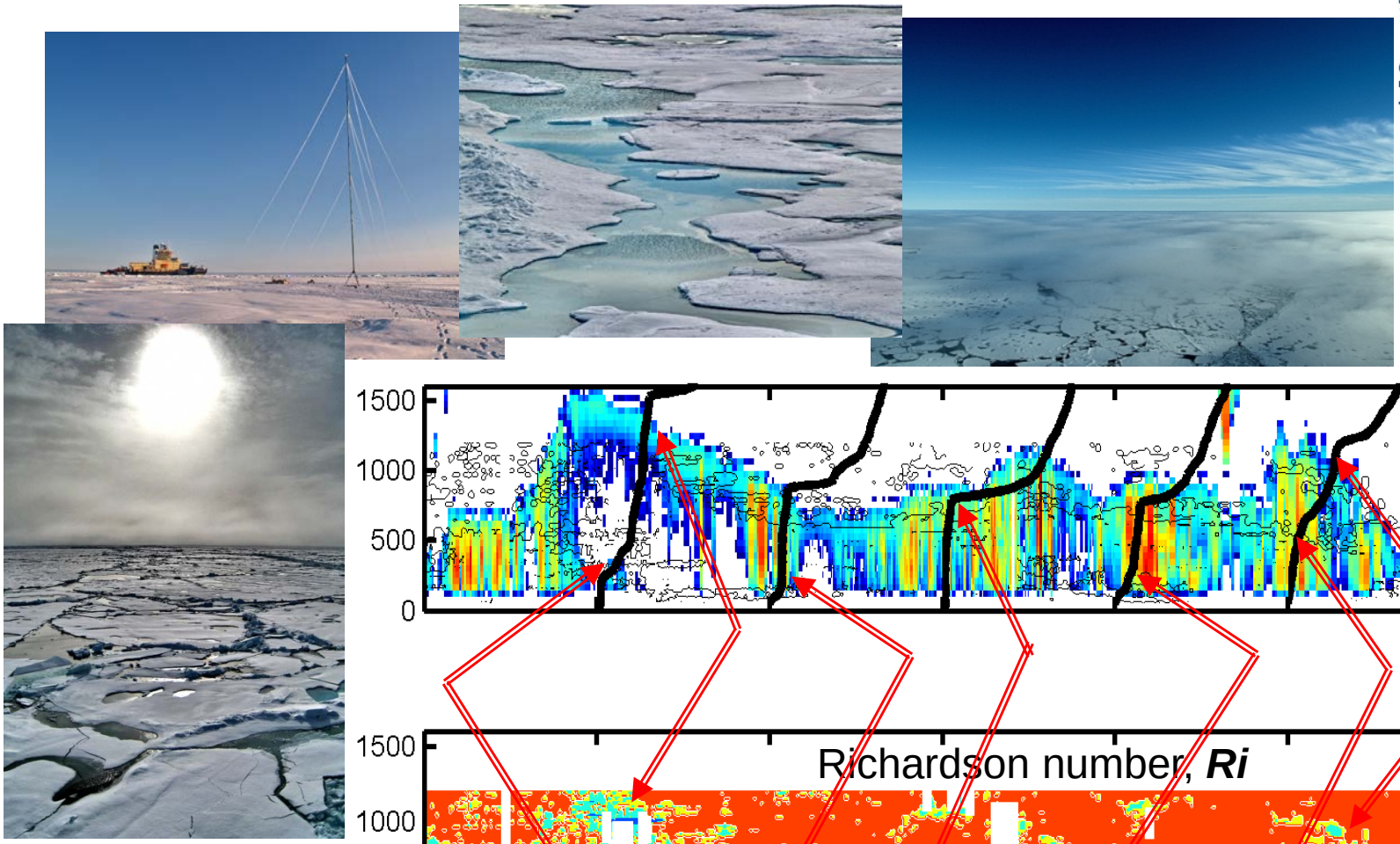




Birch et al. 2012



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$$Ri = \frac{\frac{g}{\Theta}\frac{\partial \Theta}{\partial z}}{\left(\frac{\partial U}{\partial z}\right)^2}$$

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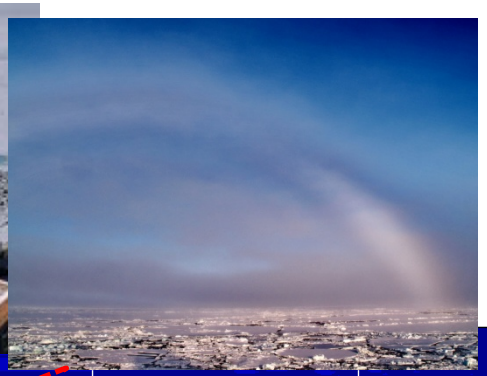

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Cloud generated turbulent layer

Partial decoupling layer

Surface based boundary layer

Altitude (km)

1
.8
0.5
0.3
0.2
0.1
0.05

-0.3 0 0.1 0.25 1 3

Richardson number

20
15
10
5
0

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Process relationships: understanding the system

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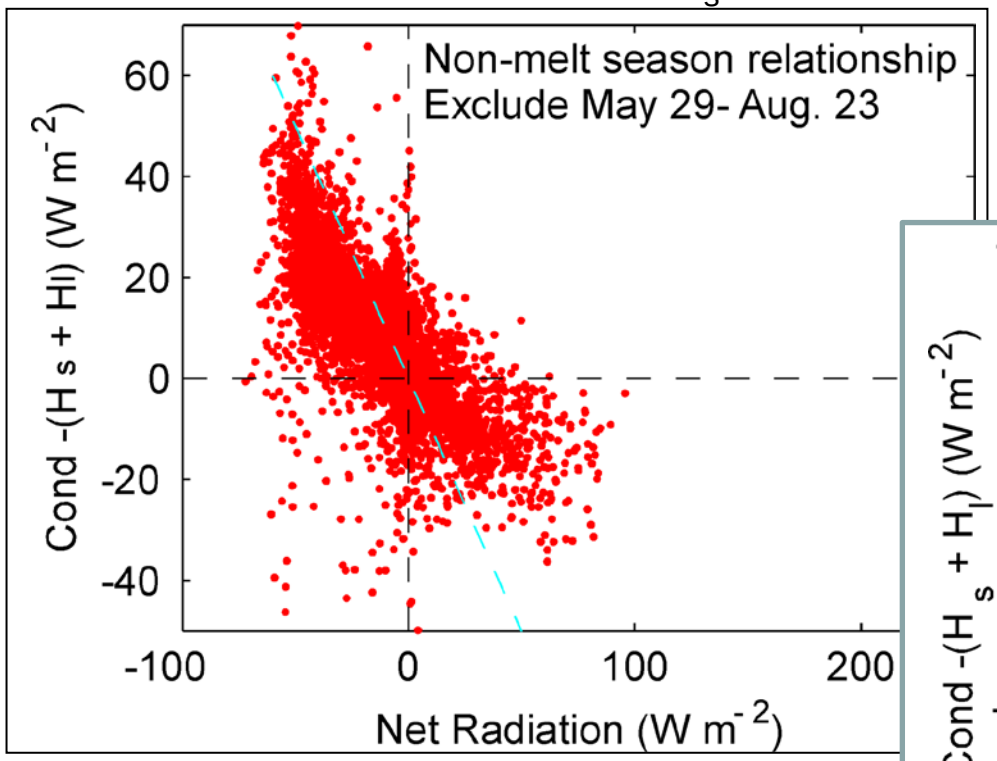
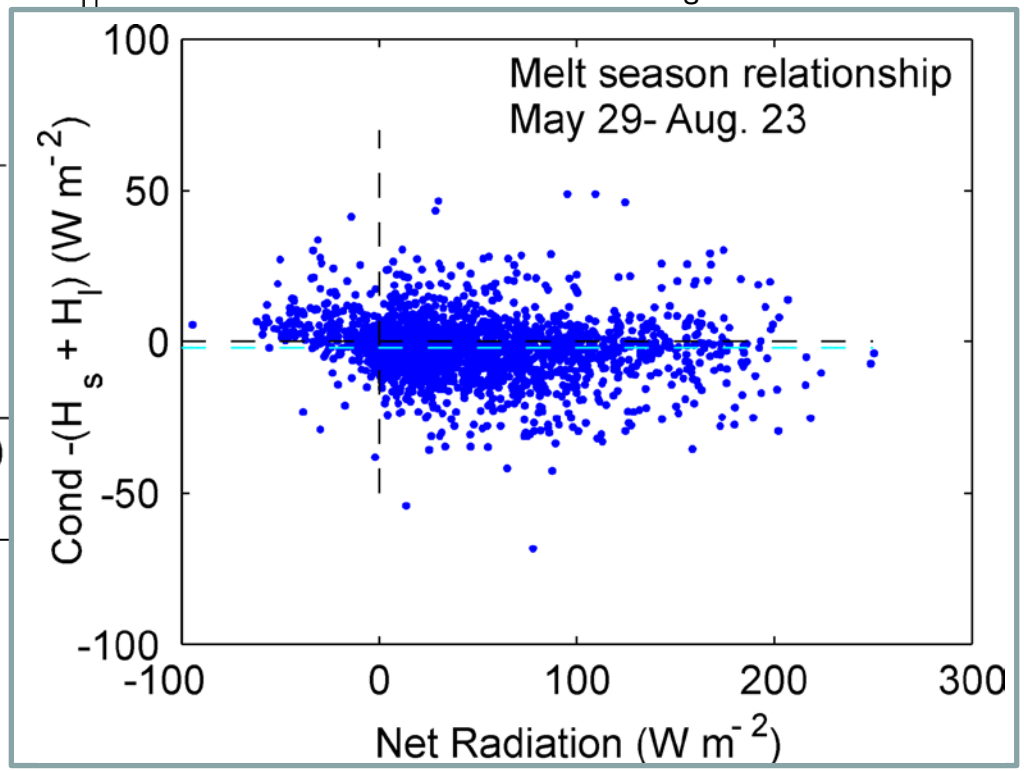
Non-melt season: Variable $T_s < 0°$ C

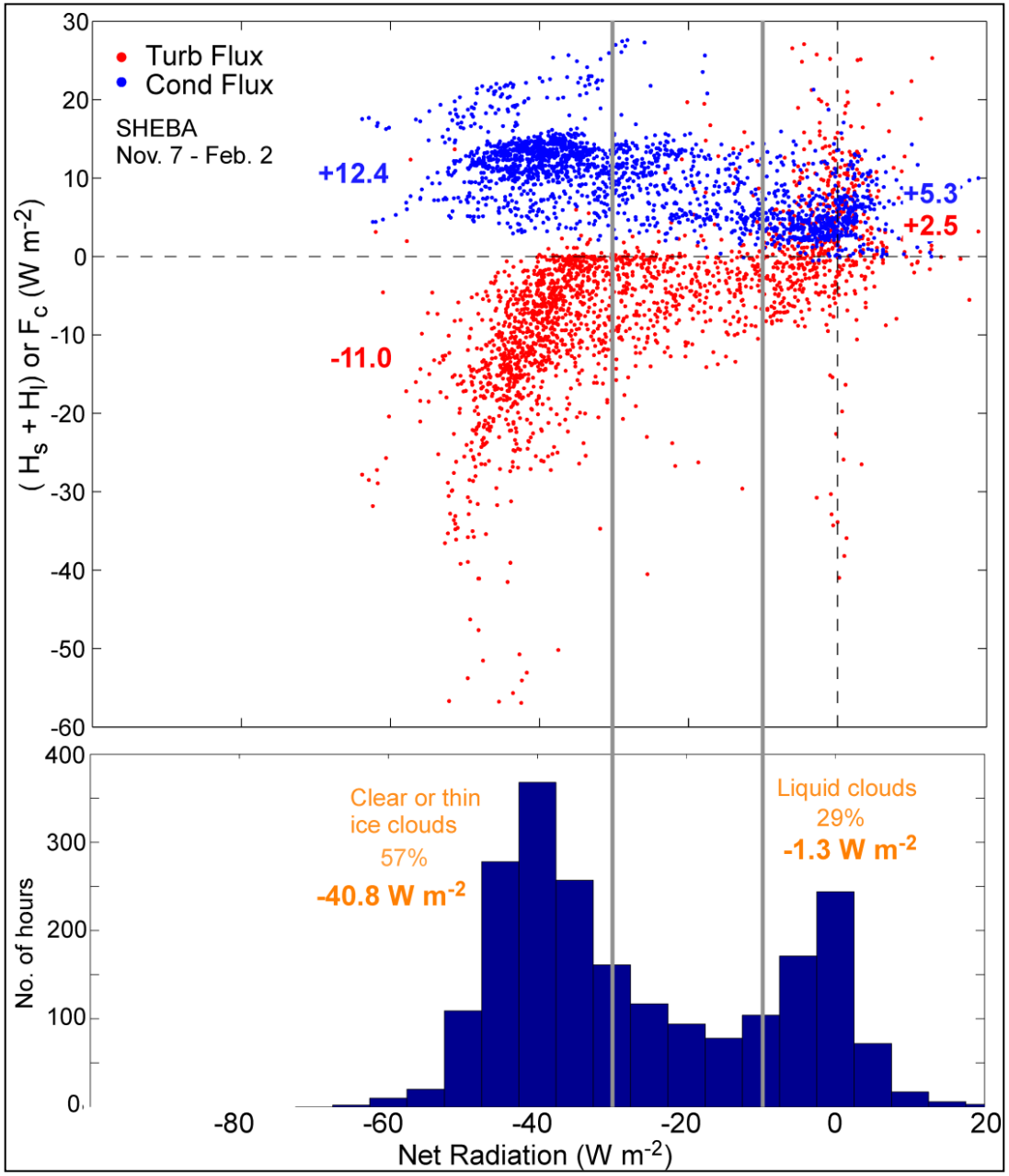


Melt season: Fixed $T_s \approx 0°$ C



Persson 2011

SHEBA Polar Night



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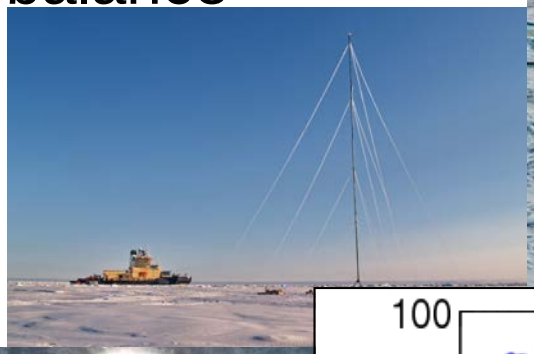
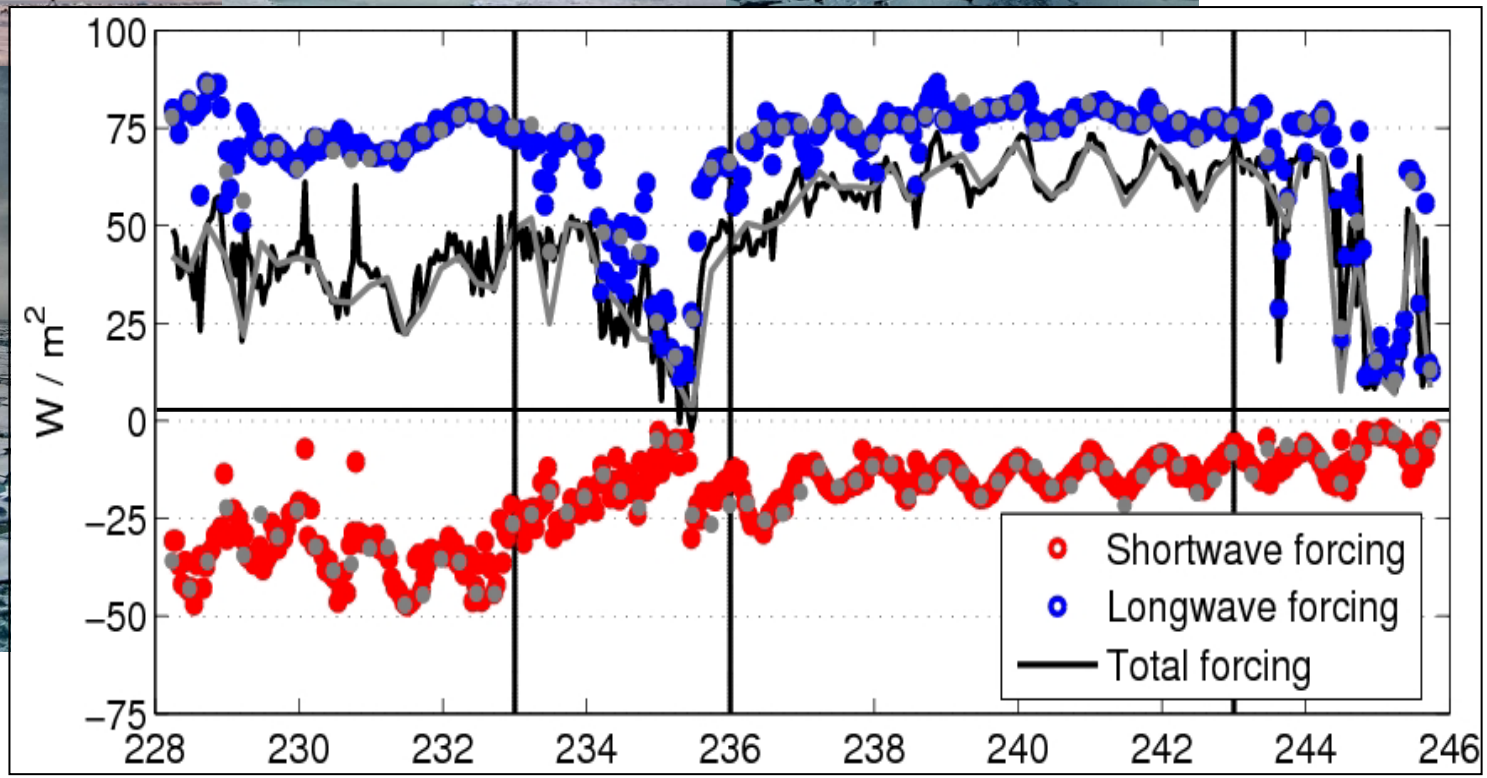
Courtesy of Persson 2012

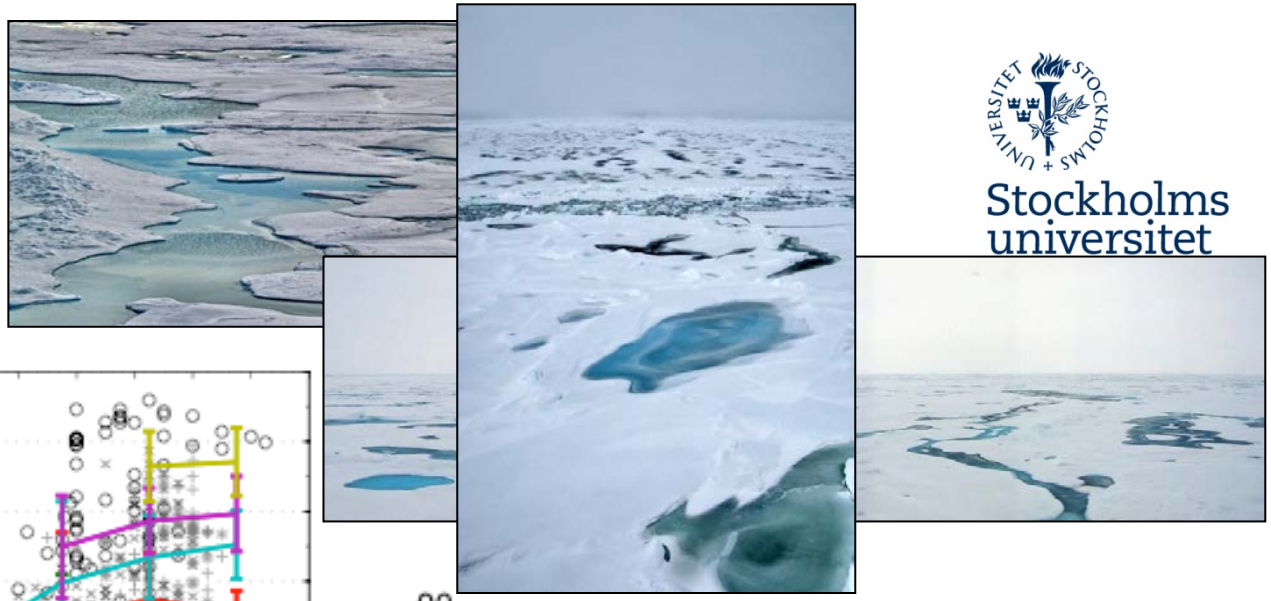
The effects of clouds on the surface energy balance

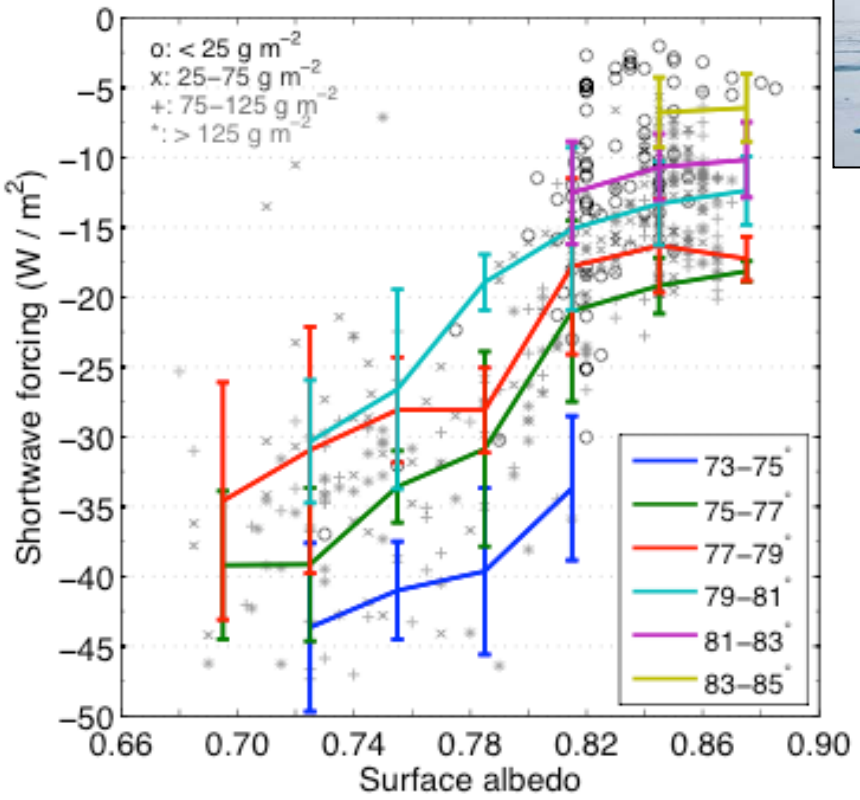


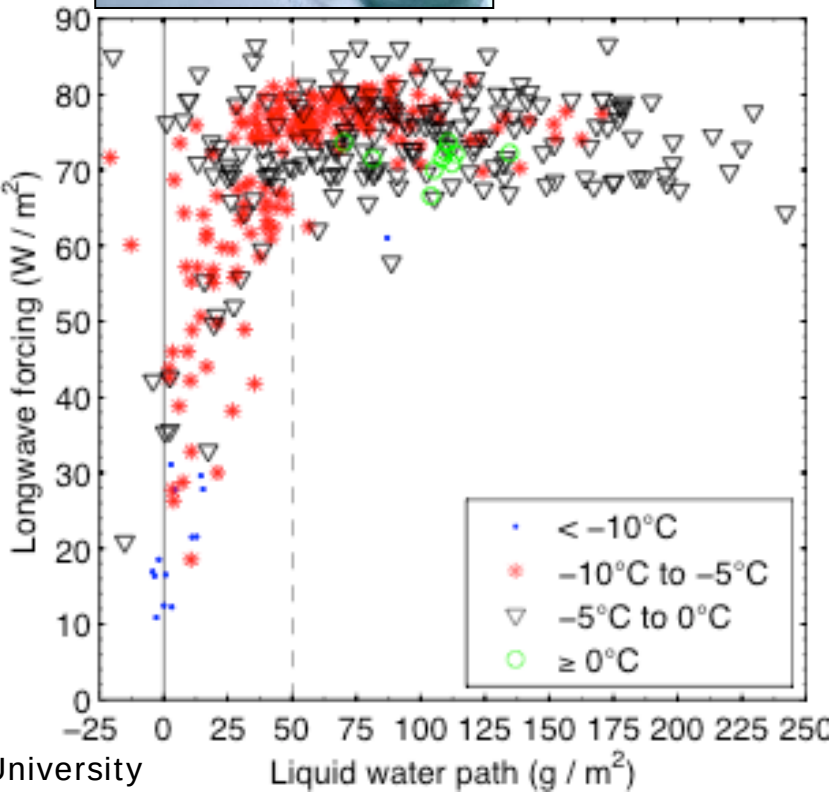


Sedlar et al. 2010

Dependences in cloud forcing…







Sedlar et al. 2010

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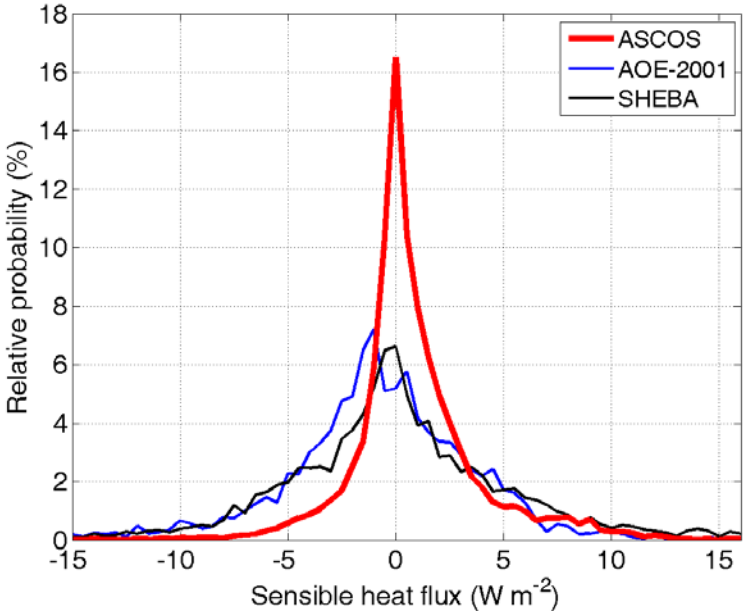

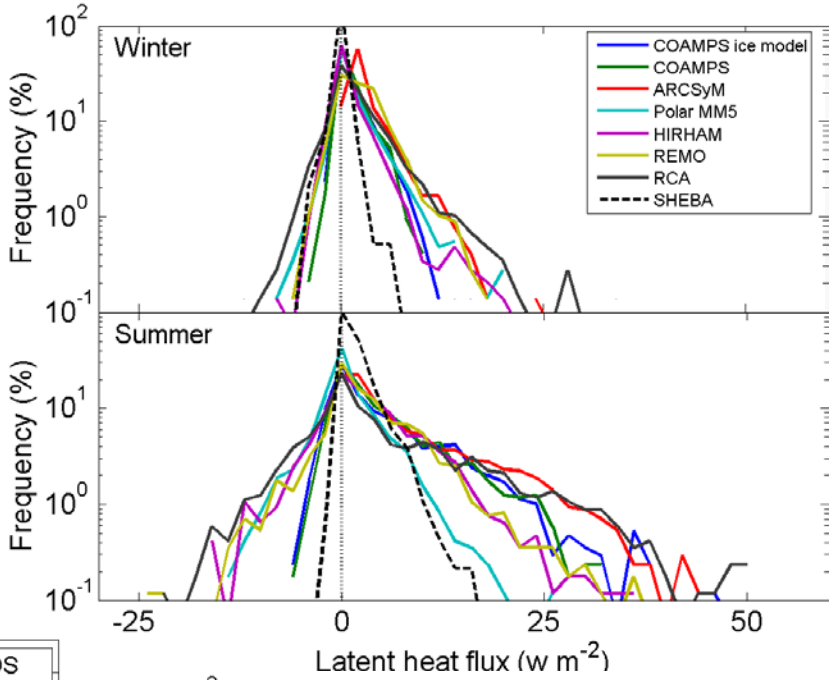

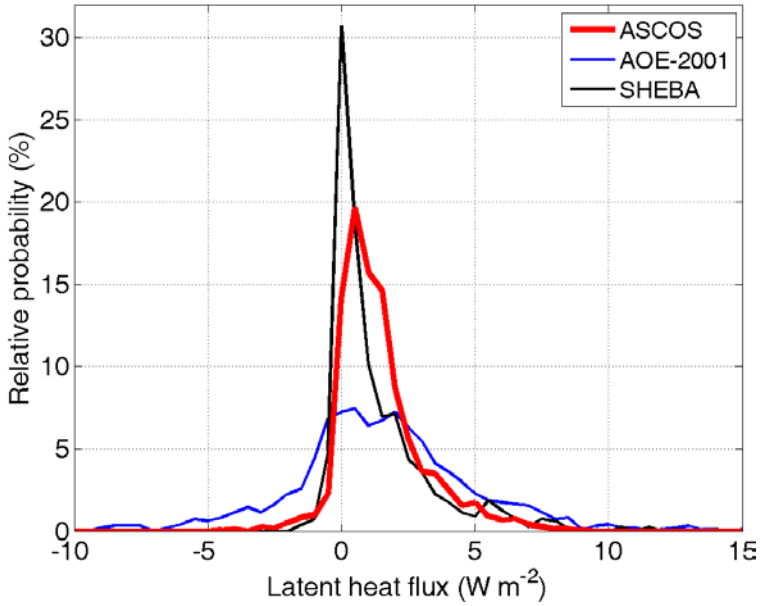

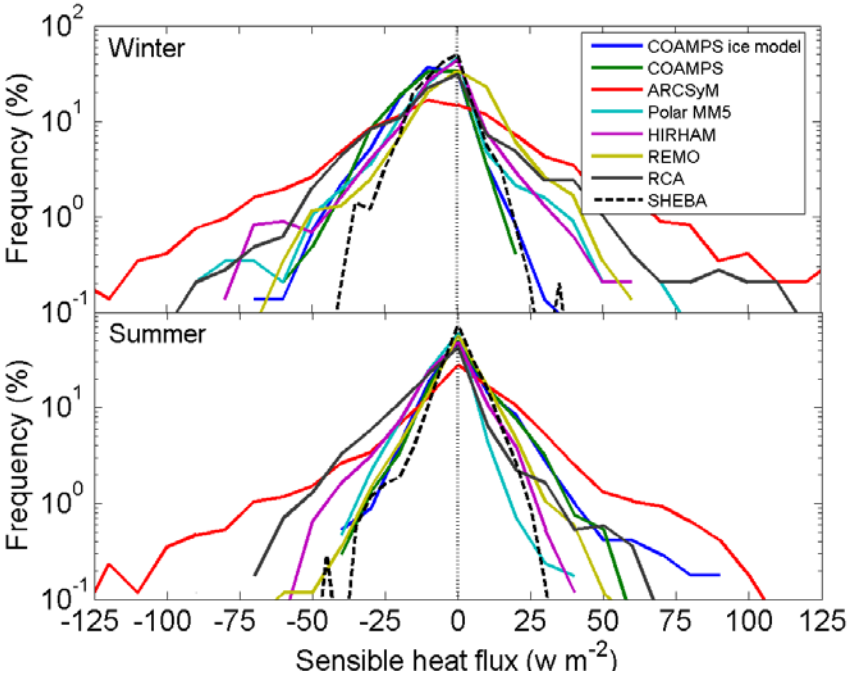

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Tjernström et al. 2012

Climate & bias…?

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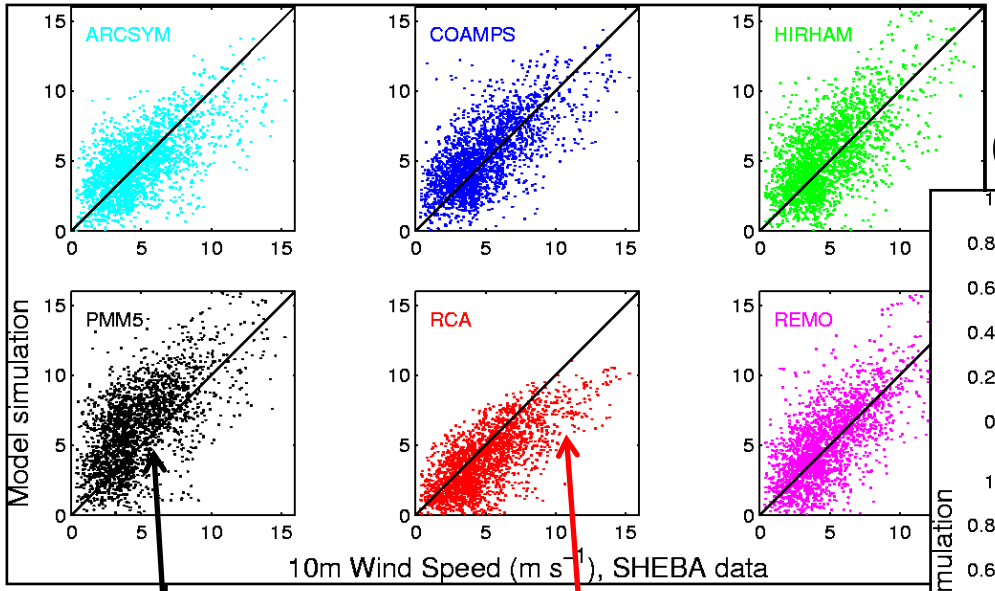
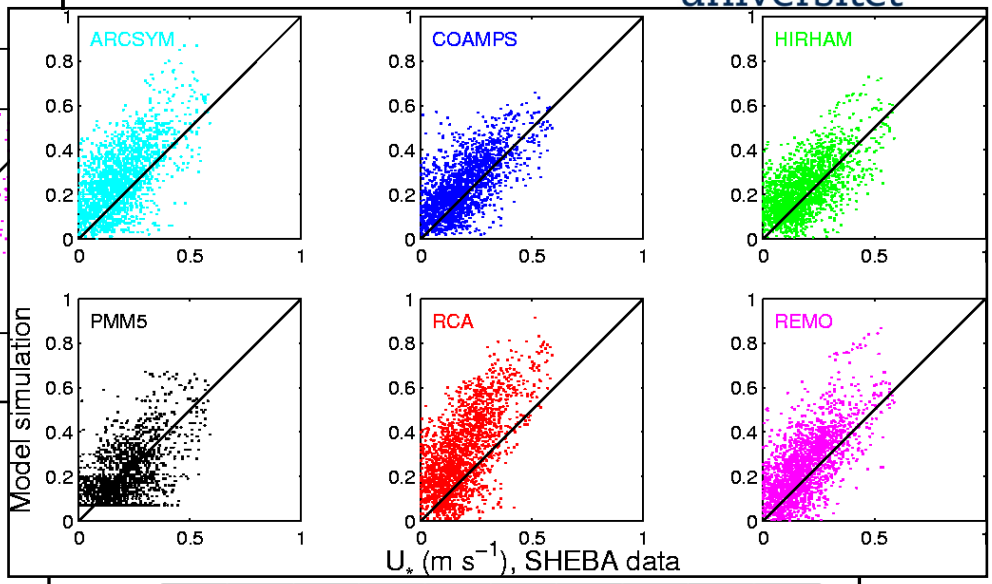
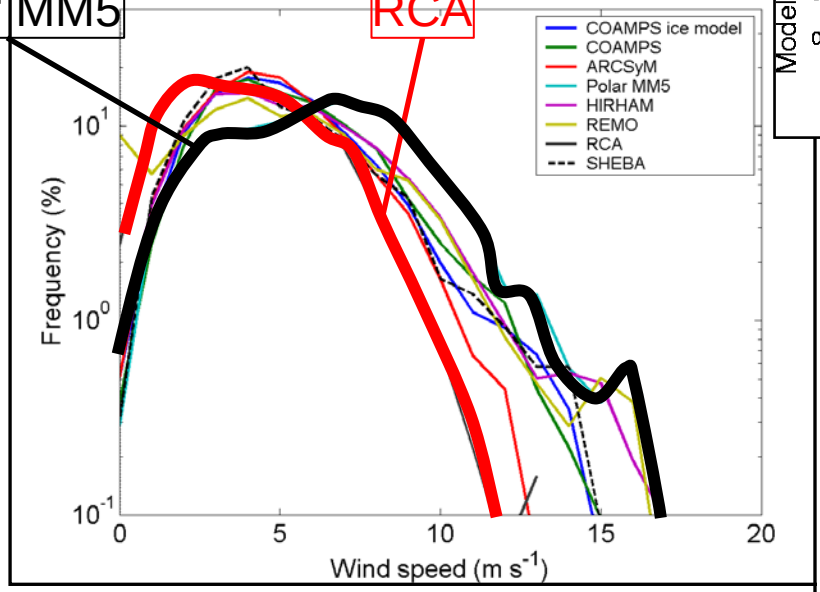
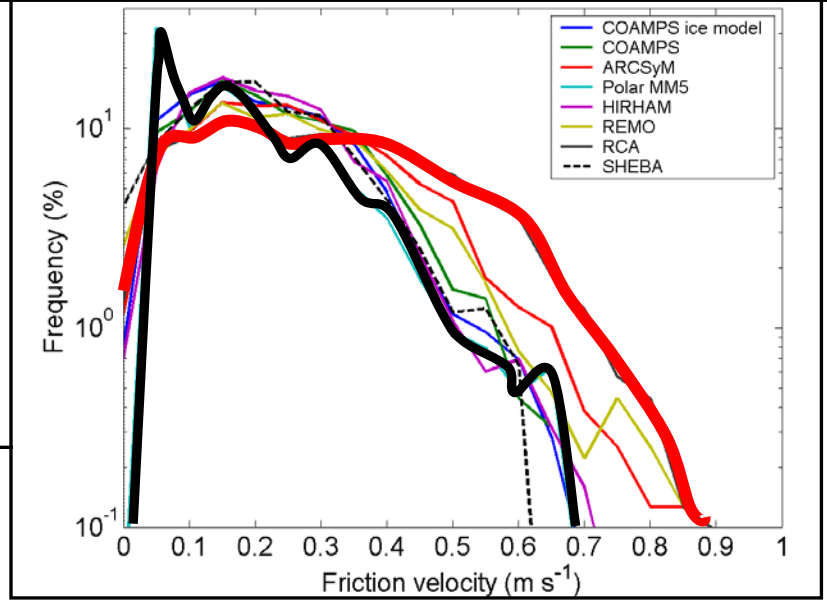




Polar MM5

RCA





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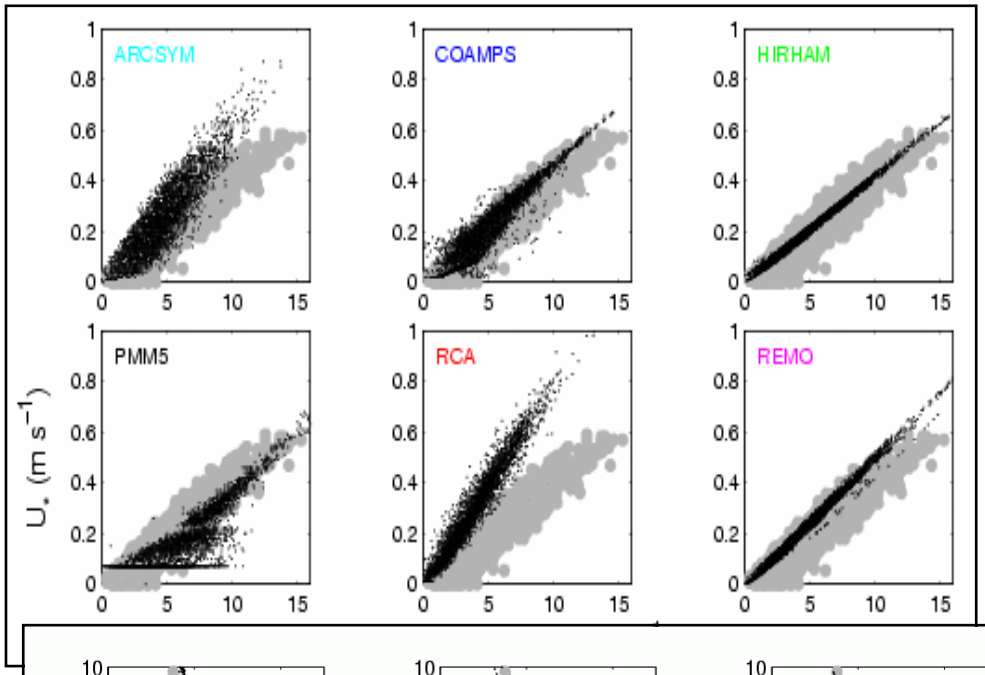

First order approximation:

$U_* / U_{10} \sim C_D^{1/2}$

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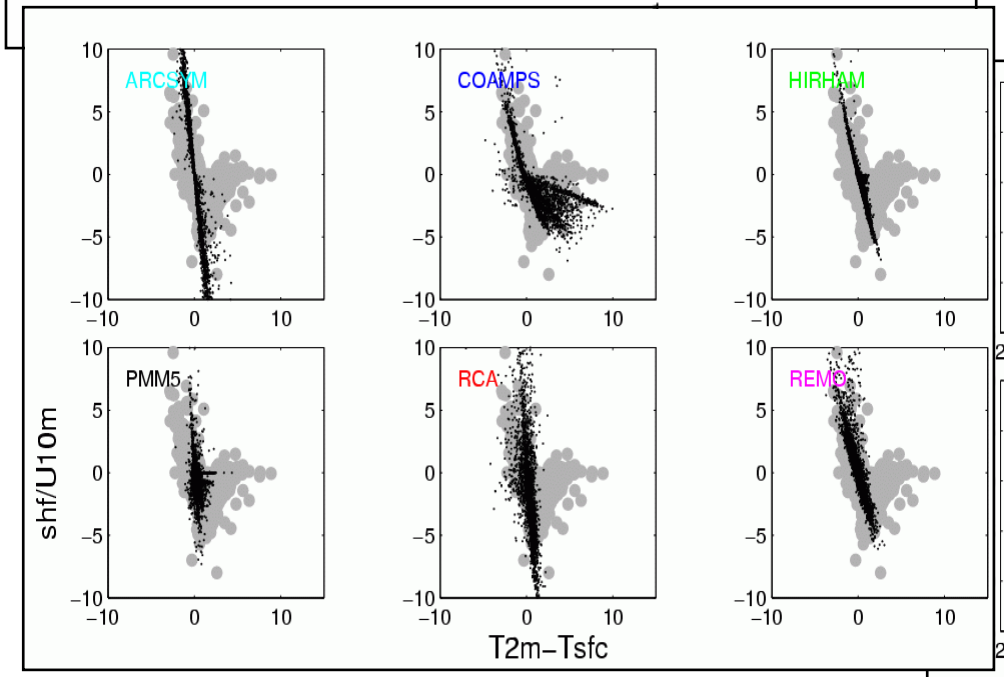
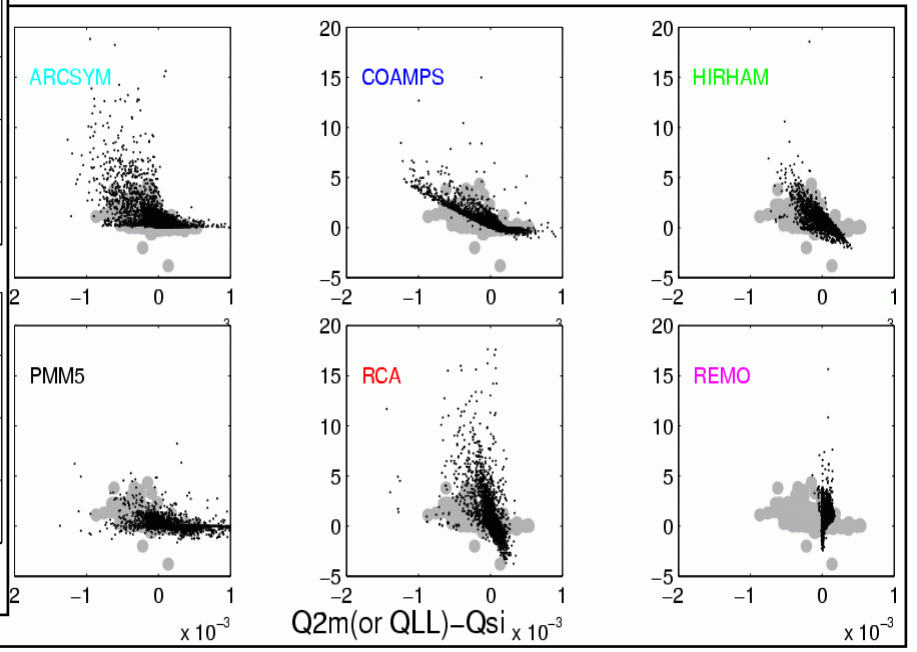
$F_H / U_{10} \sim - C_H (T_2 - T_s)$

$F_Q / U_{10} \sim - C_H (q_2 - q_s(T_s))$





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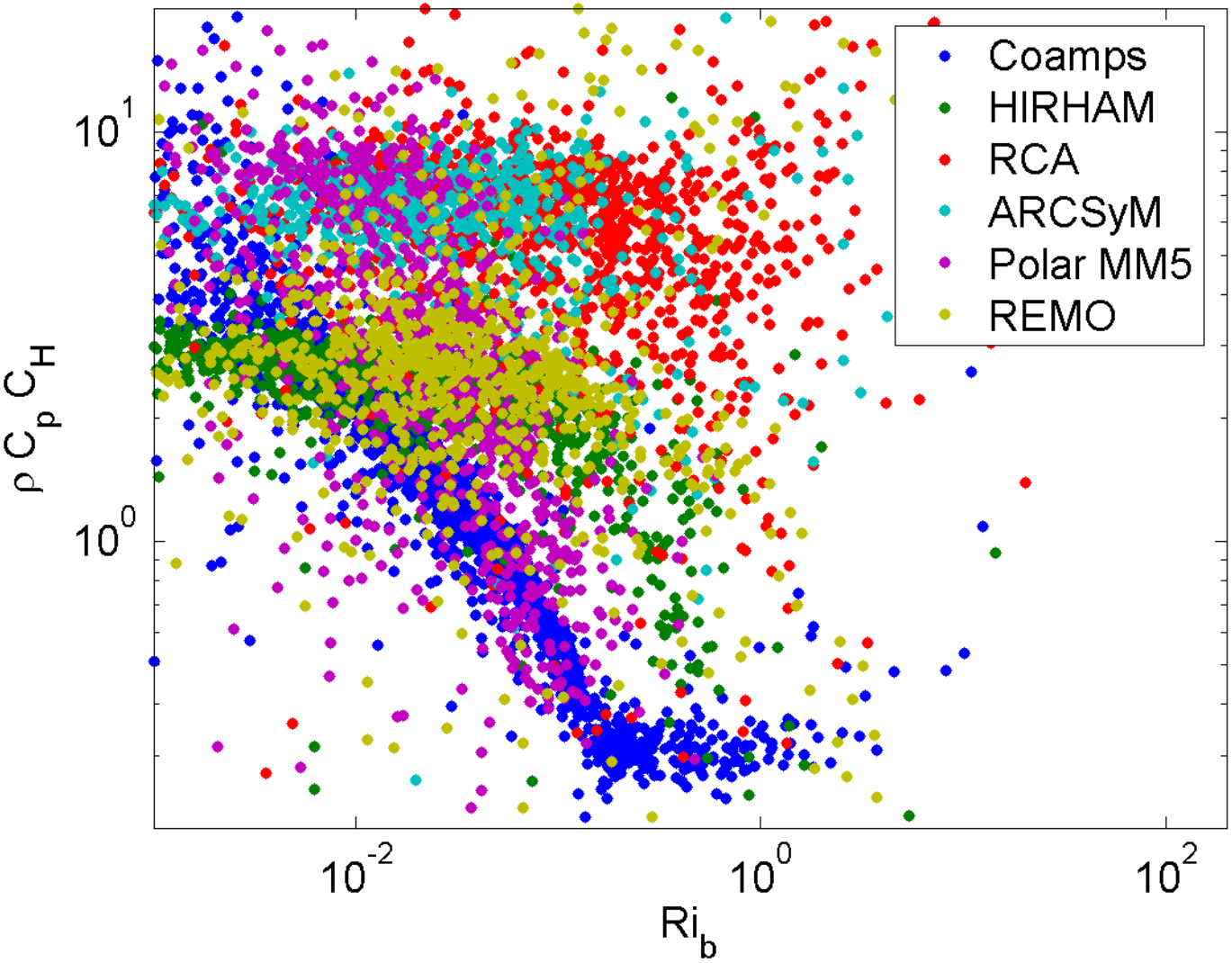
Tjernström et al. 2005

Shit in, shit out...?



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Compensating errors in radiation…

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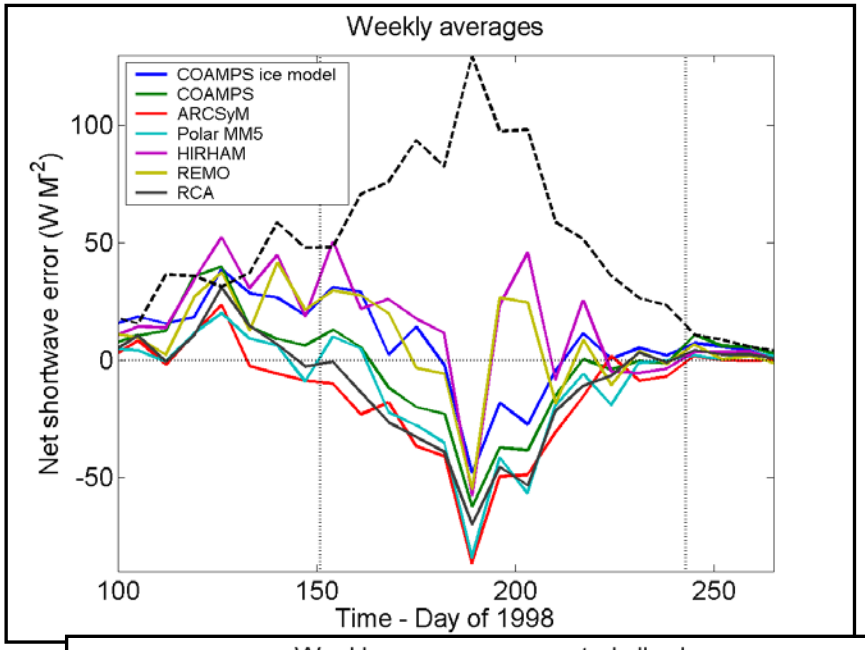

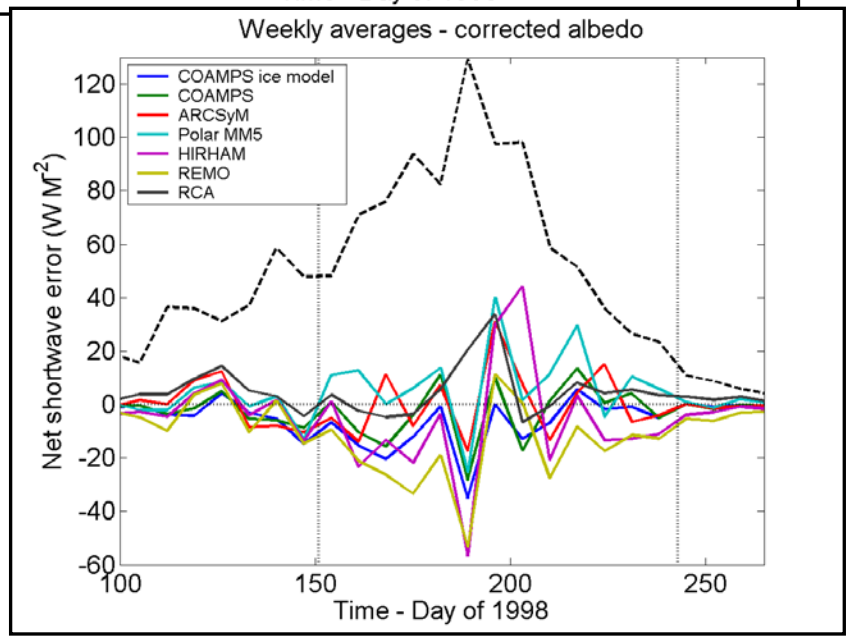

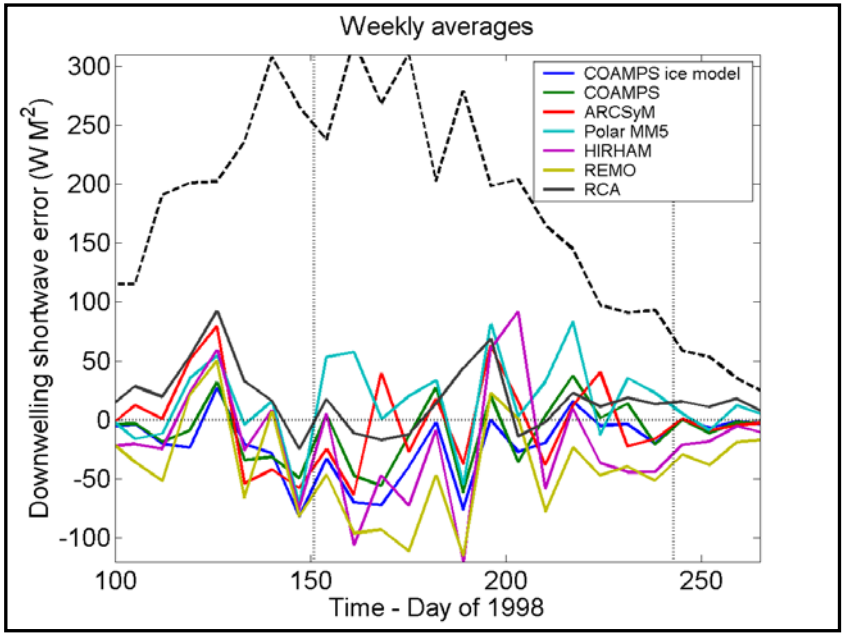

Clouds in regional models

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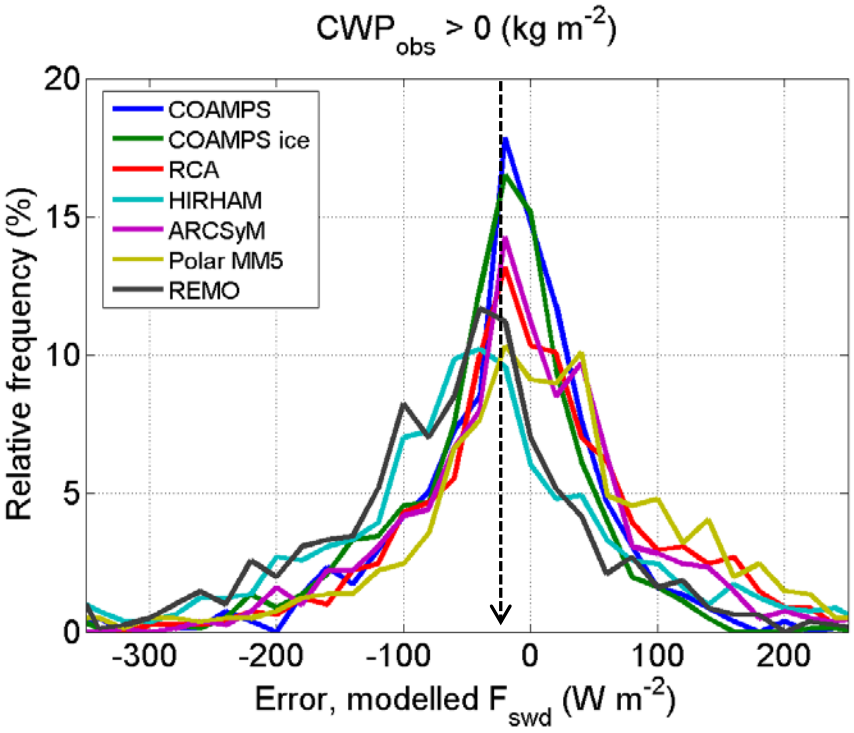

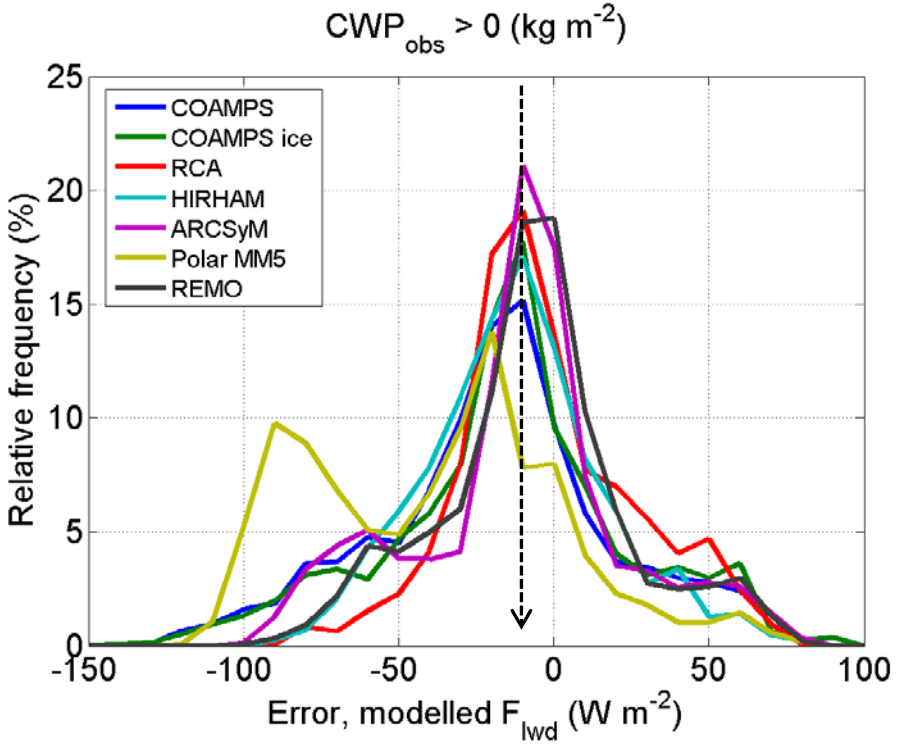

2013-06-25 / Michael Tjernström, Stockholm University

Tjernström et al. 2008

Clouds in regional models

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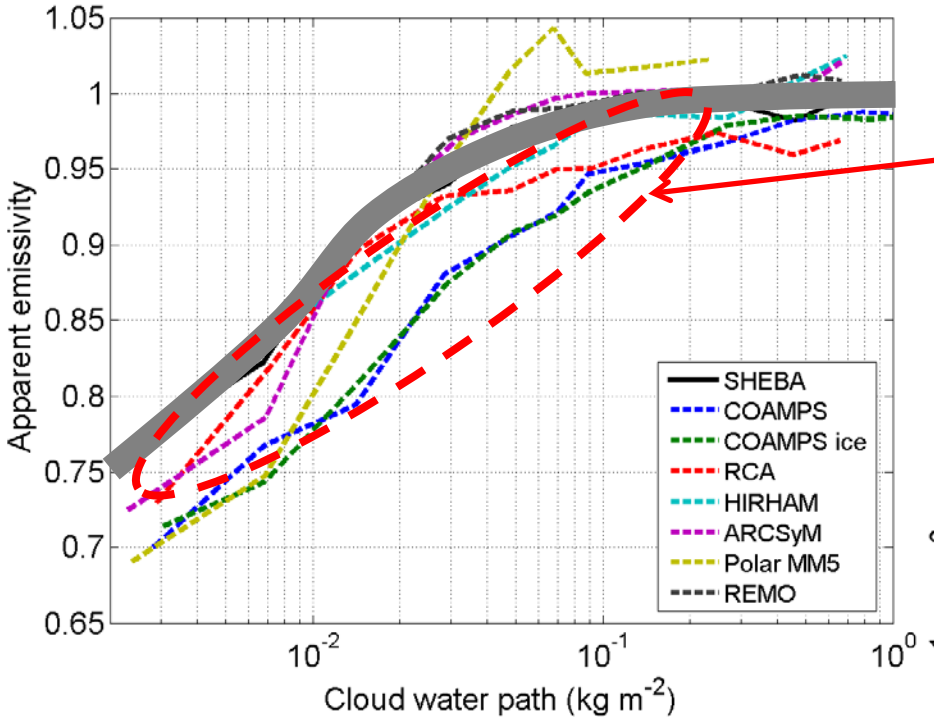
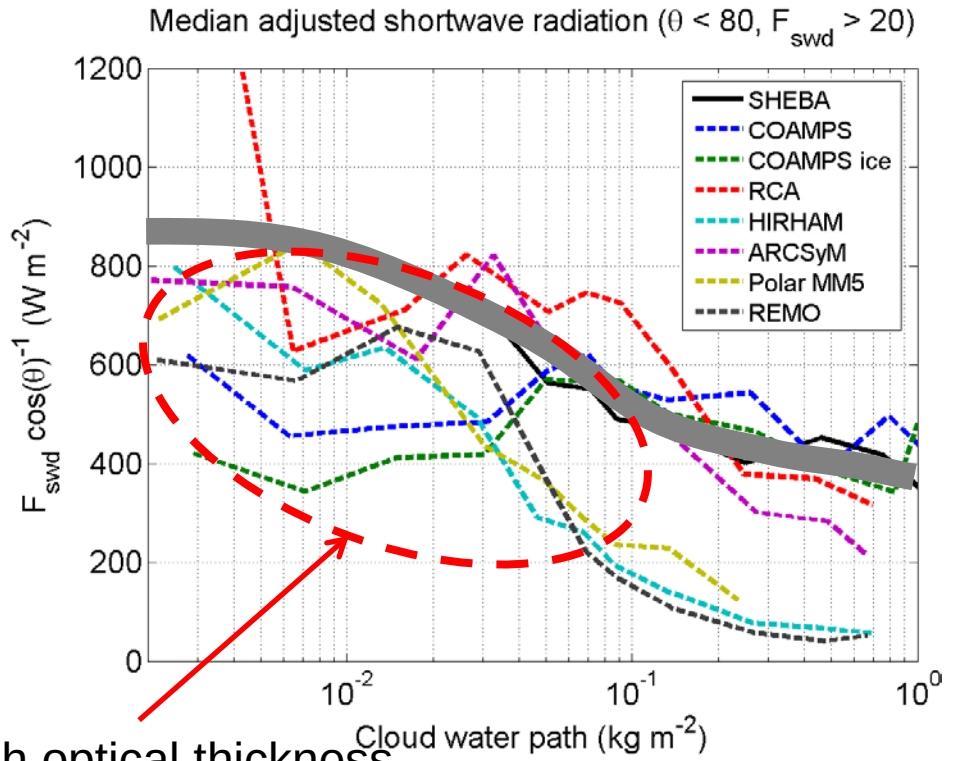


Too low optical thickness
in longwave calculations



Too high optical thickness
in shortwave calculations

27 May, 2010 / Michael Tjernström, Stockholm University

Tjernström et al. 2008

Two versions of the Arctic System Reanalysis, (ASR) Polar-WRF driven by ERA Interim, and ERA-Interim by itself…

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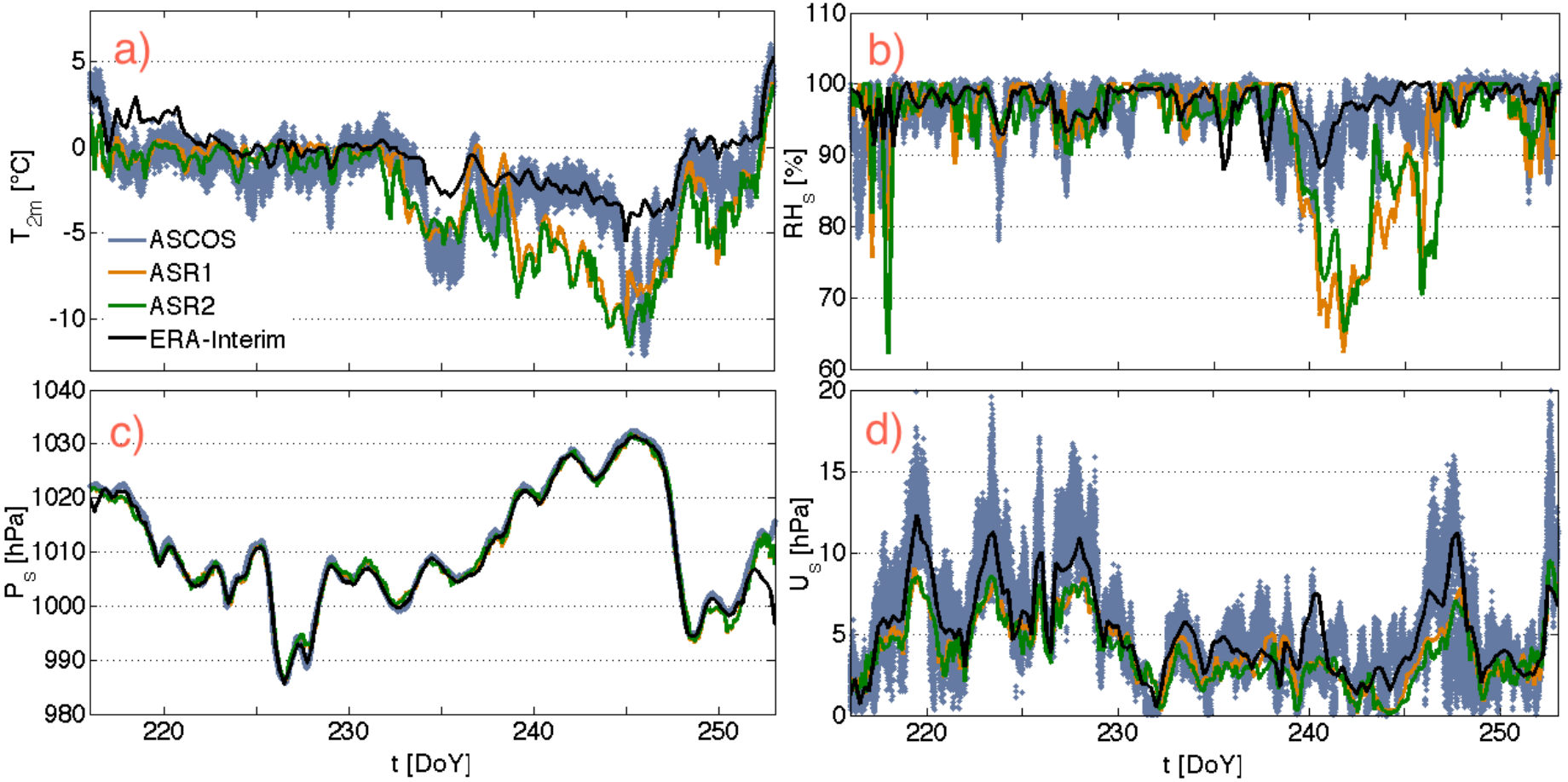

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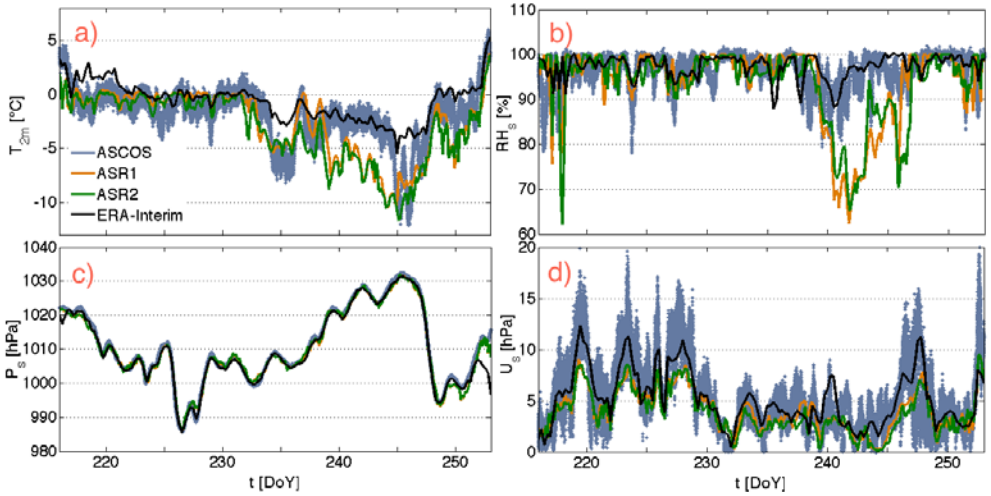

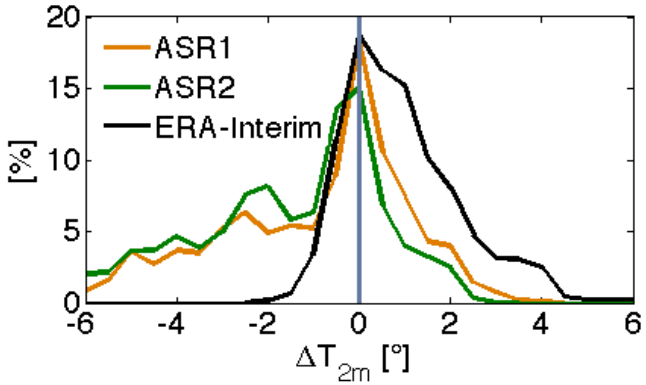

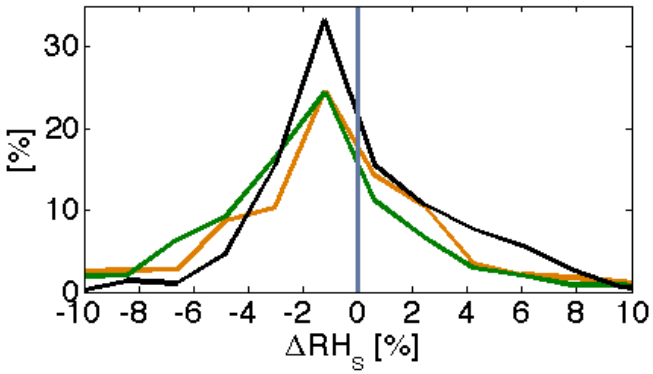

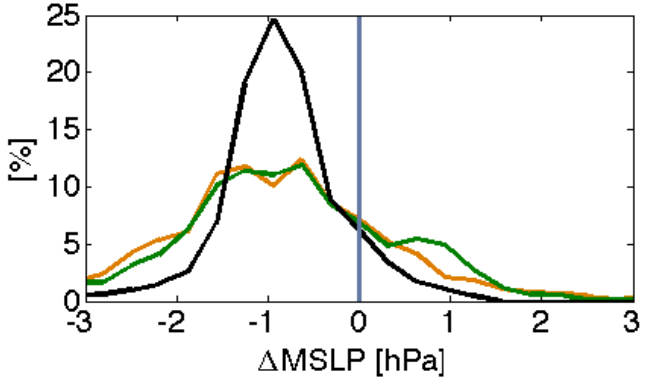

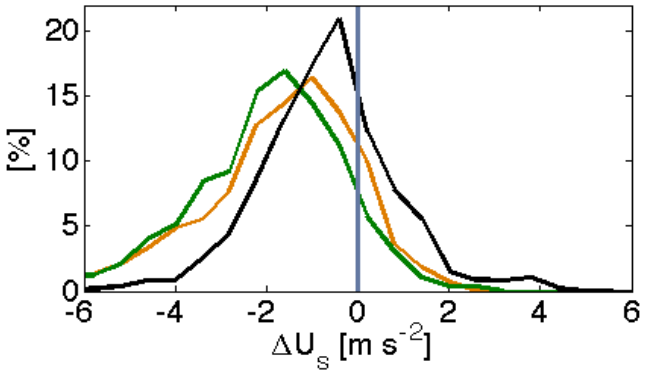

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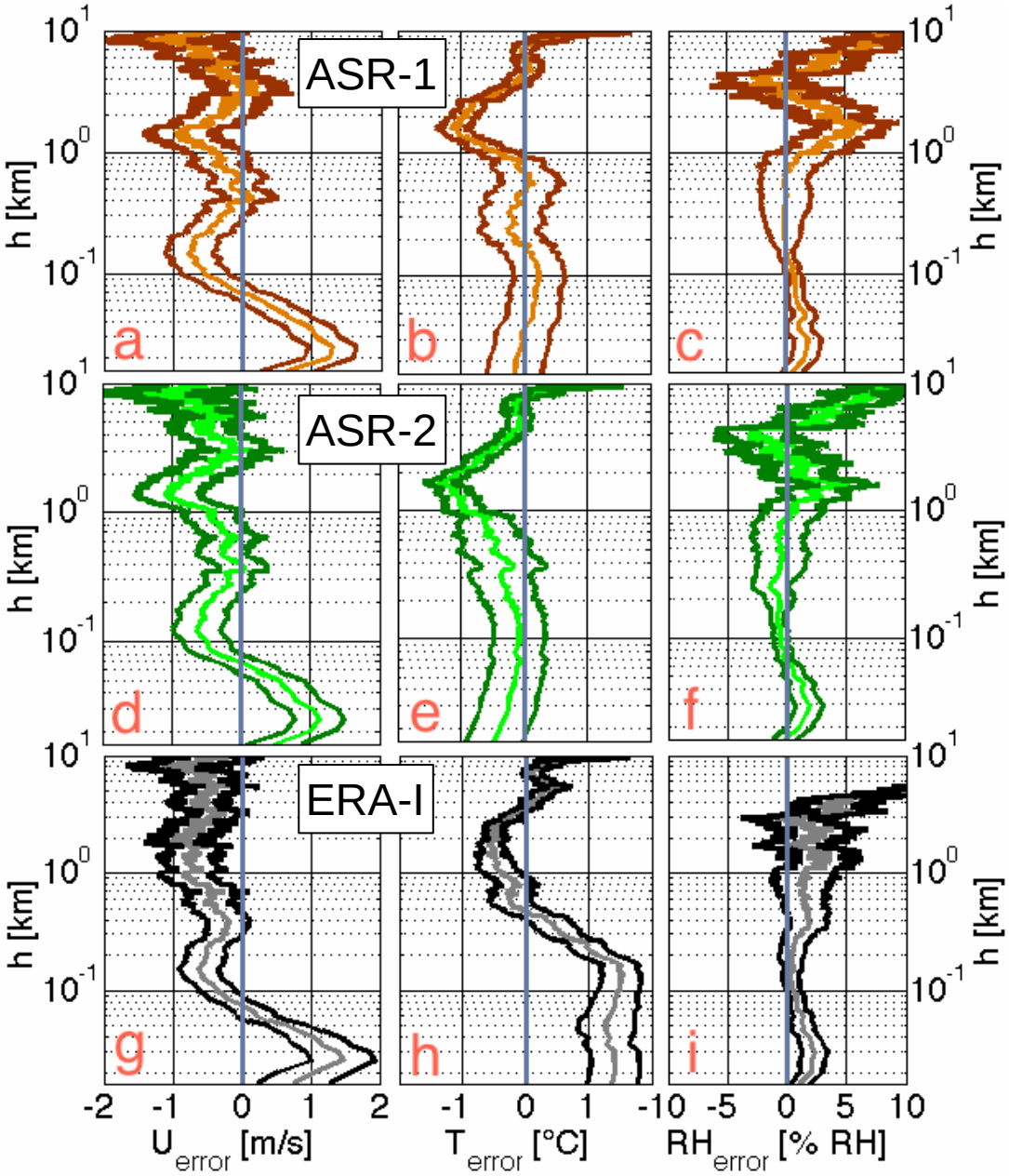
Vertical profiles…



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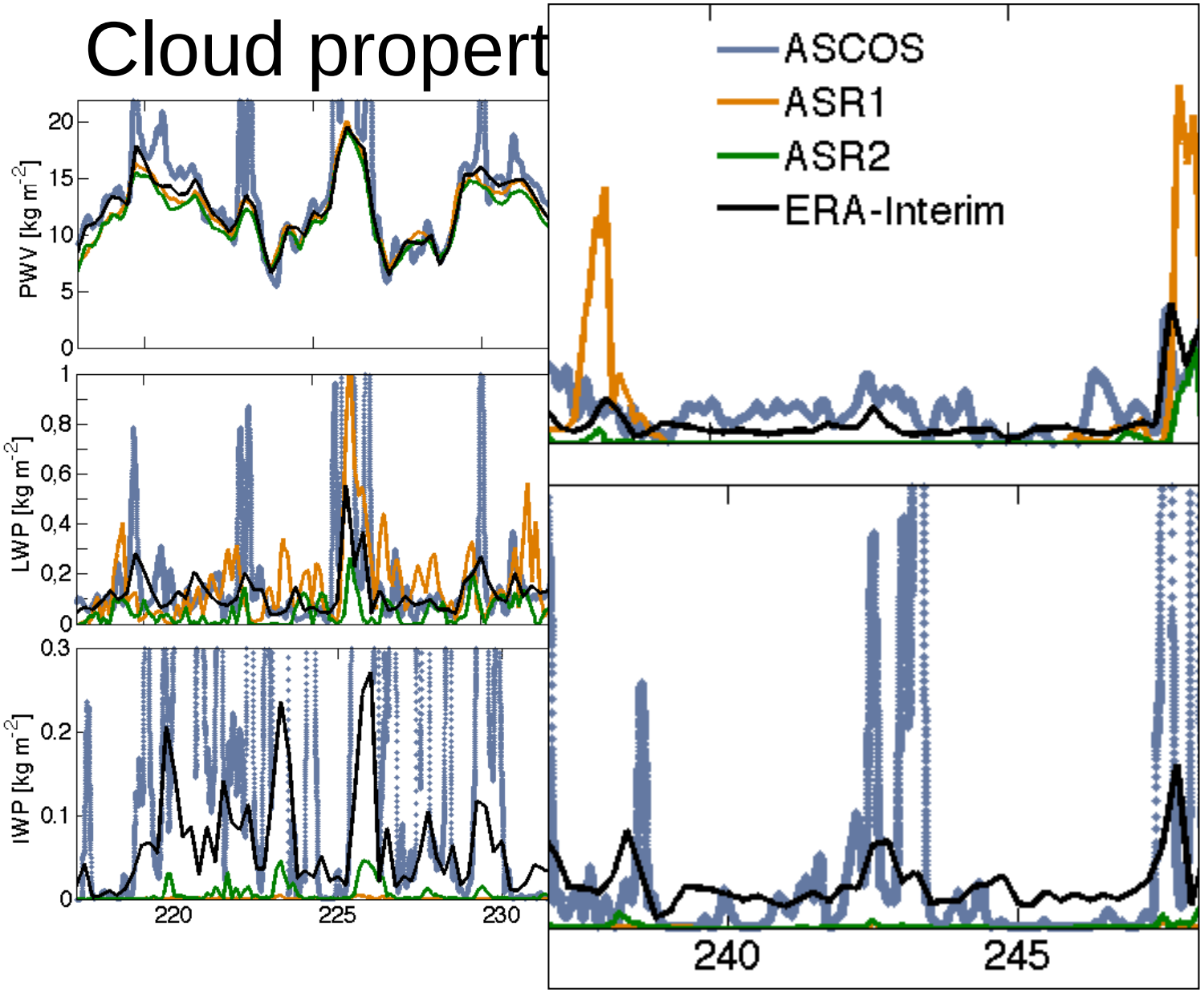
Cloud propert



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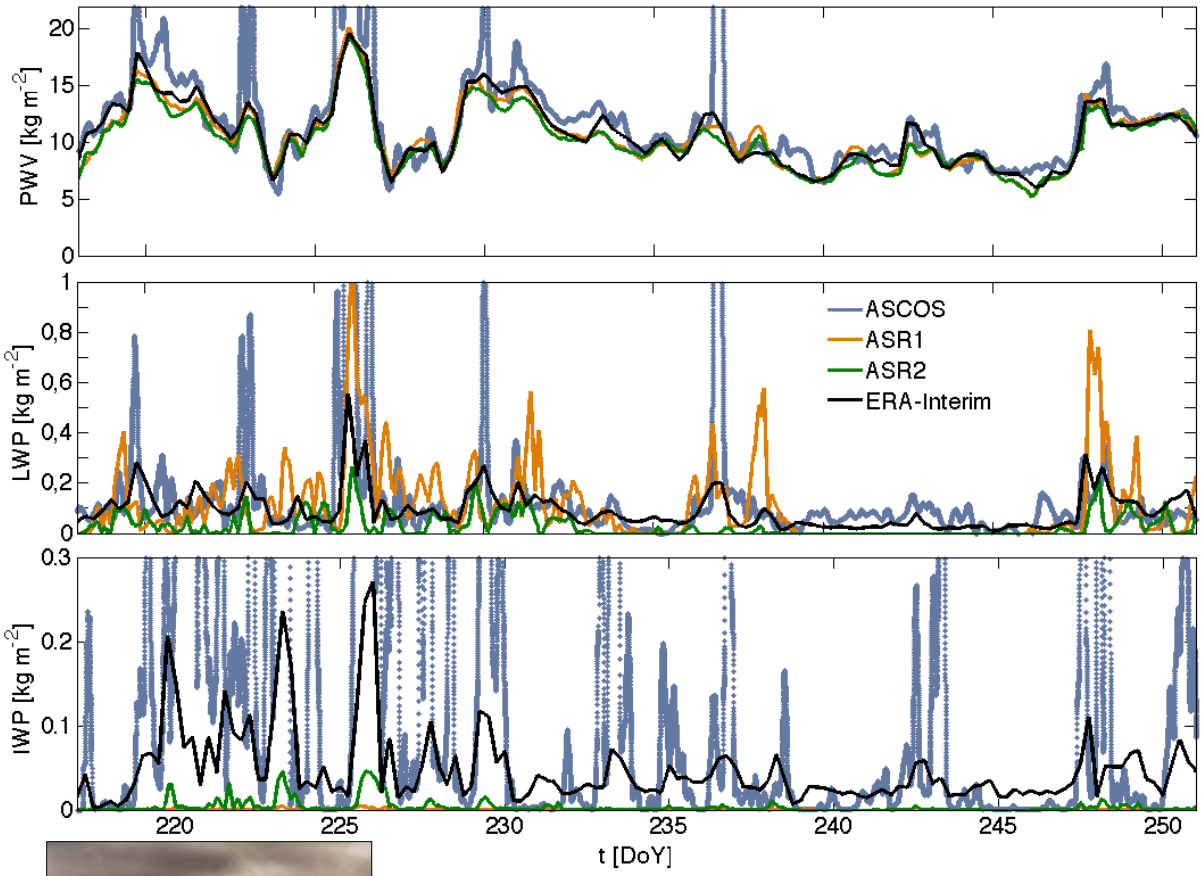

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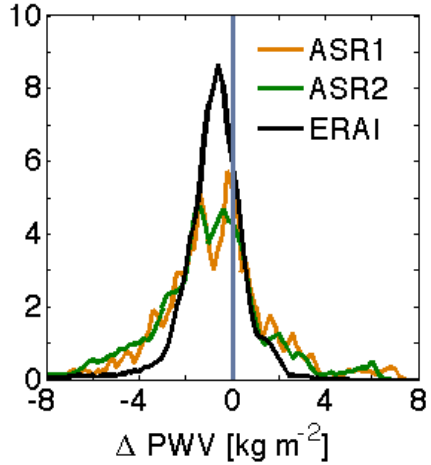

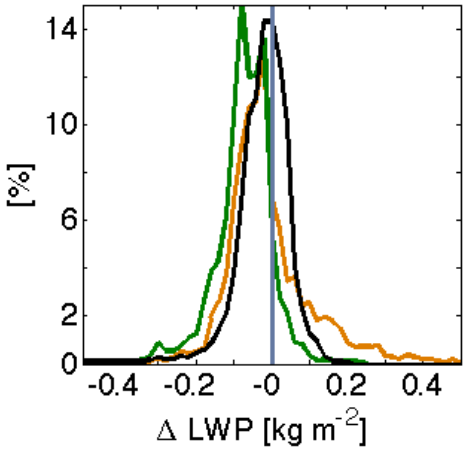

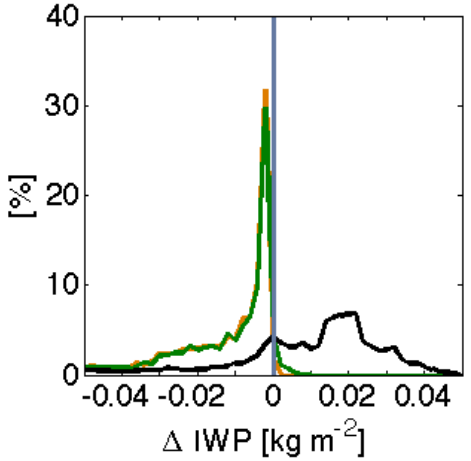

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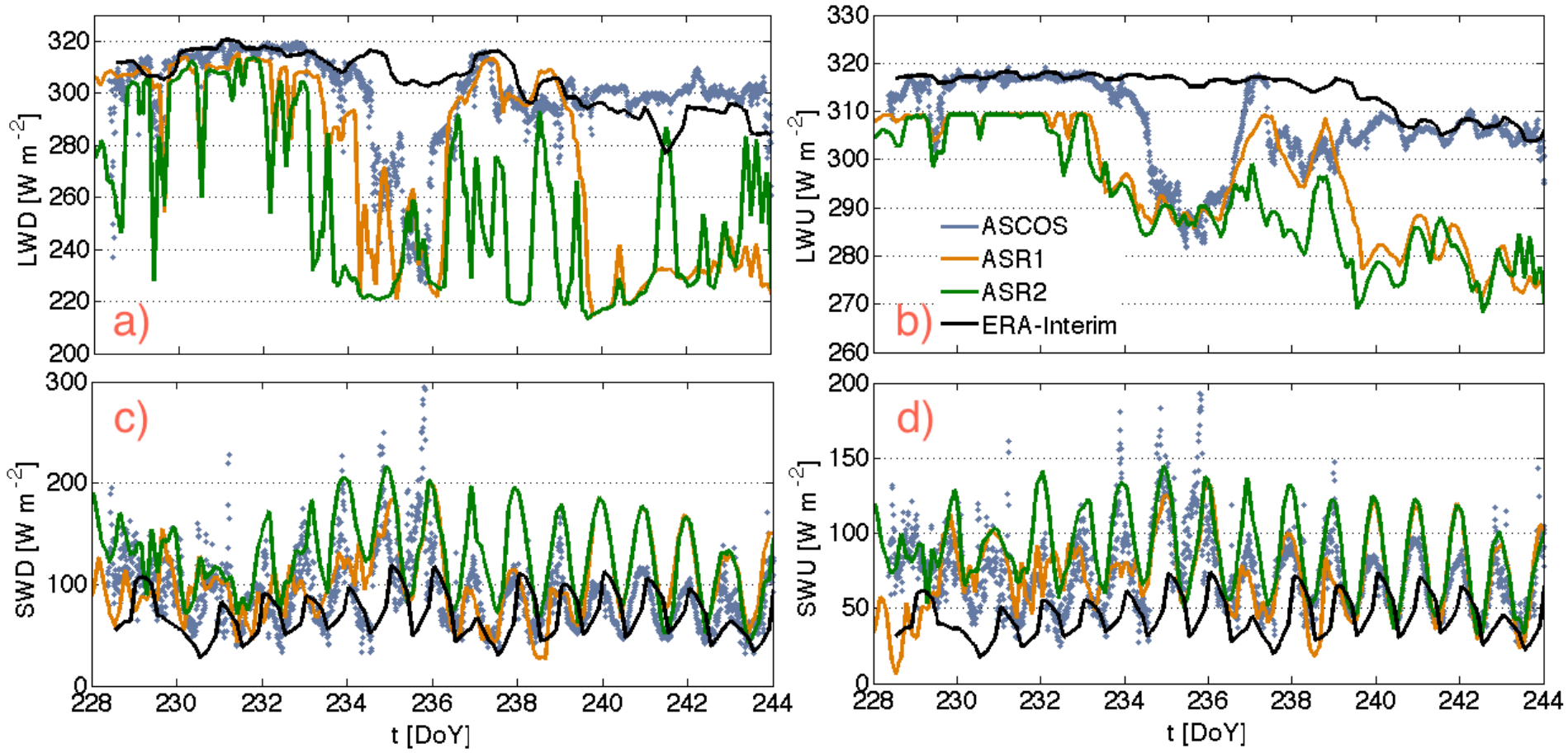

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Some thoughts

- A poor model will always be a poor model, no matter how much data assimilation is used. Poor models do poor forecasts – eventually
- A good model is a model with a realistic climate – for the right reasons. To make a good model requires an *inevitable empirical component*
- Even if a model *can* be evaluated against routine observations, a correct result may still come from compensating errors in different processes; hence the need to evaluate *processes*
- Special Challenges:
  - Stable winter boundary layers
  - Mixed phase clouds
  - Optically thin clouds and aerosols

Some recommendations

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- Close collaboration between modeling and observational centers - and the academic community, using the best characteristics of each group
- For the PPP: Start with a canvas of what good field experiment data is already available and set up a series of modeling experiments – do it now!
- Longer term field observations in the Arctic are extremely expensive and very demanding and it is difficult for the academic community to access the levels of policymaking where decisive funding action can be taken; national met centers have a more direct access to government – let's scratch each other's back
- International coordination is key…!