School of Earth and Environment
INSTITUTE FOR CLIMATE & ATMOSPHERIC SCIENCE
UNIVERSITY OF LEEDS

Arctic Clouds - Evaluating modelled cloud with field observations

Ian Brooks

Jutta Vüllers, Gillian Young, Peggy Achtert, Ryan Neely, Barbara Brooks, Michael Tjernström, John Prytherch, Jonny Day, Ewan O'Connor, Rebecca Atkinson, Joseph Sedlar, Thorsten Mauritsen, Matthew Shupe, Ola Persson, Cathryn Birch,…

Arctic BL & Cloud Development

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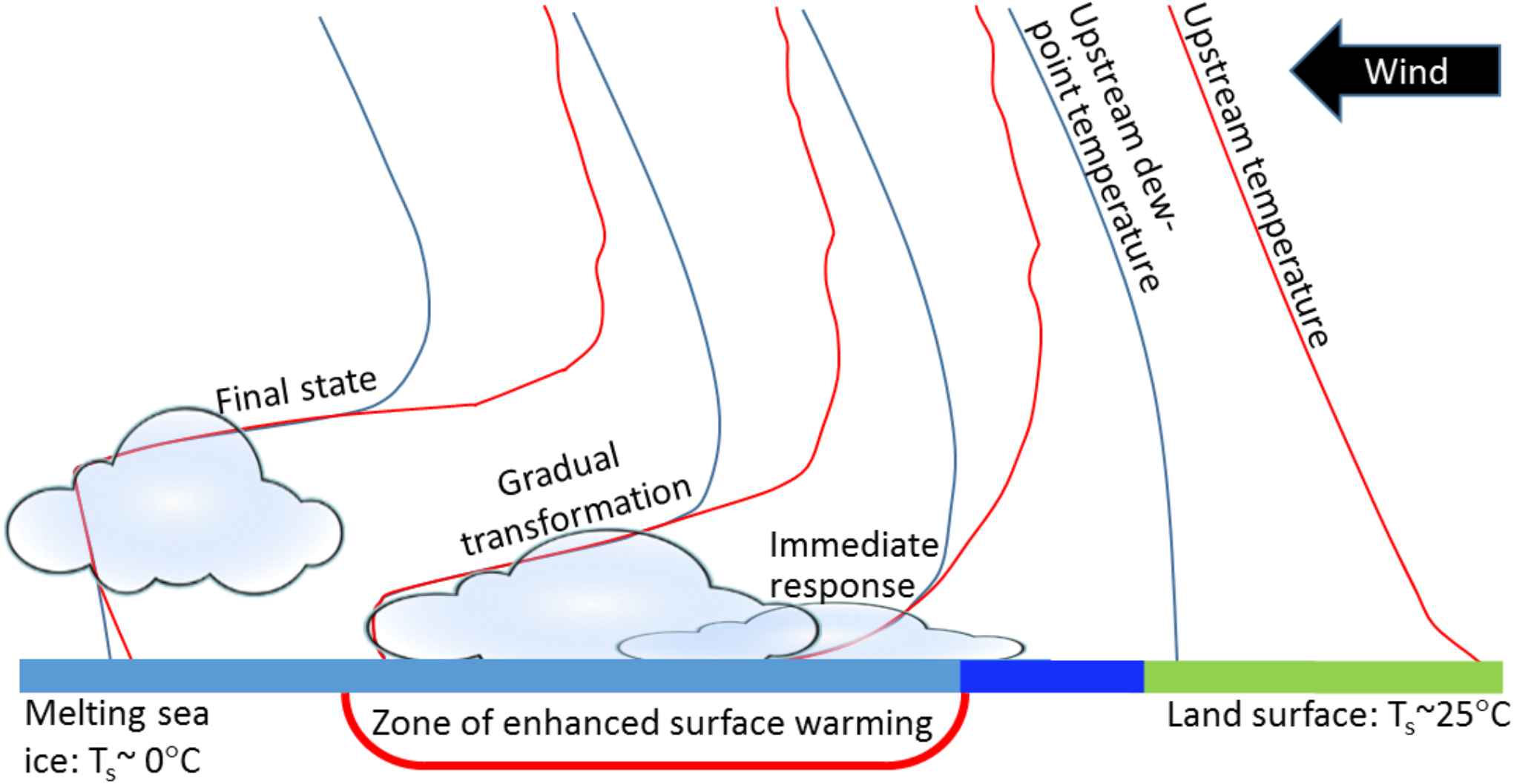
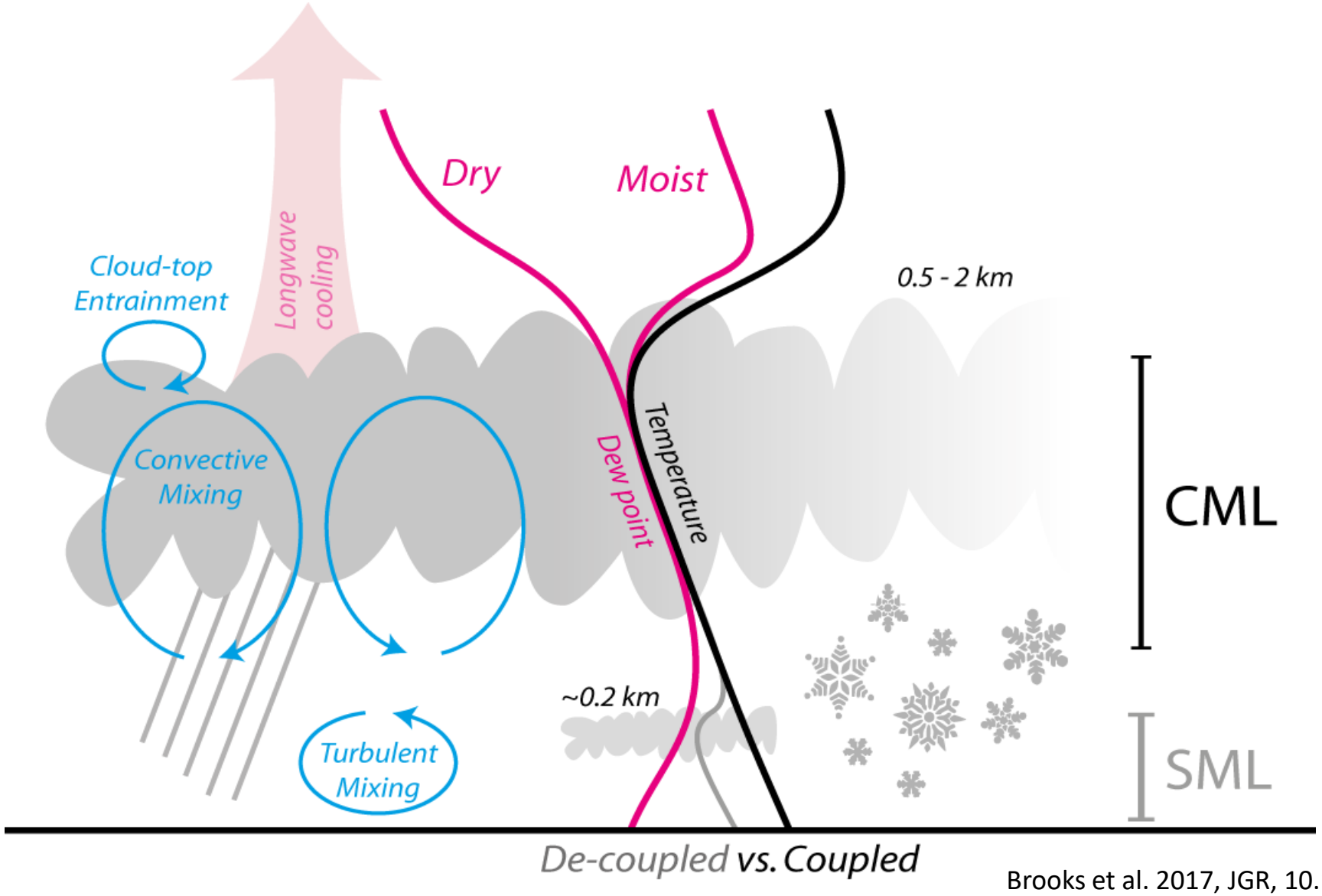
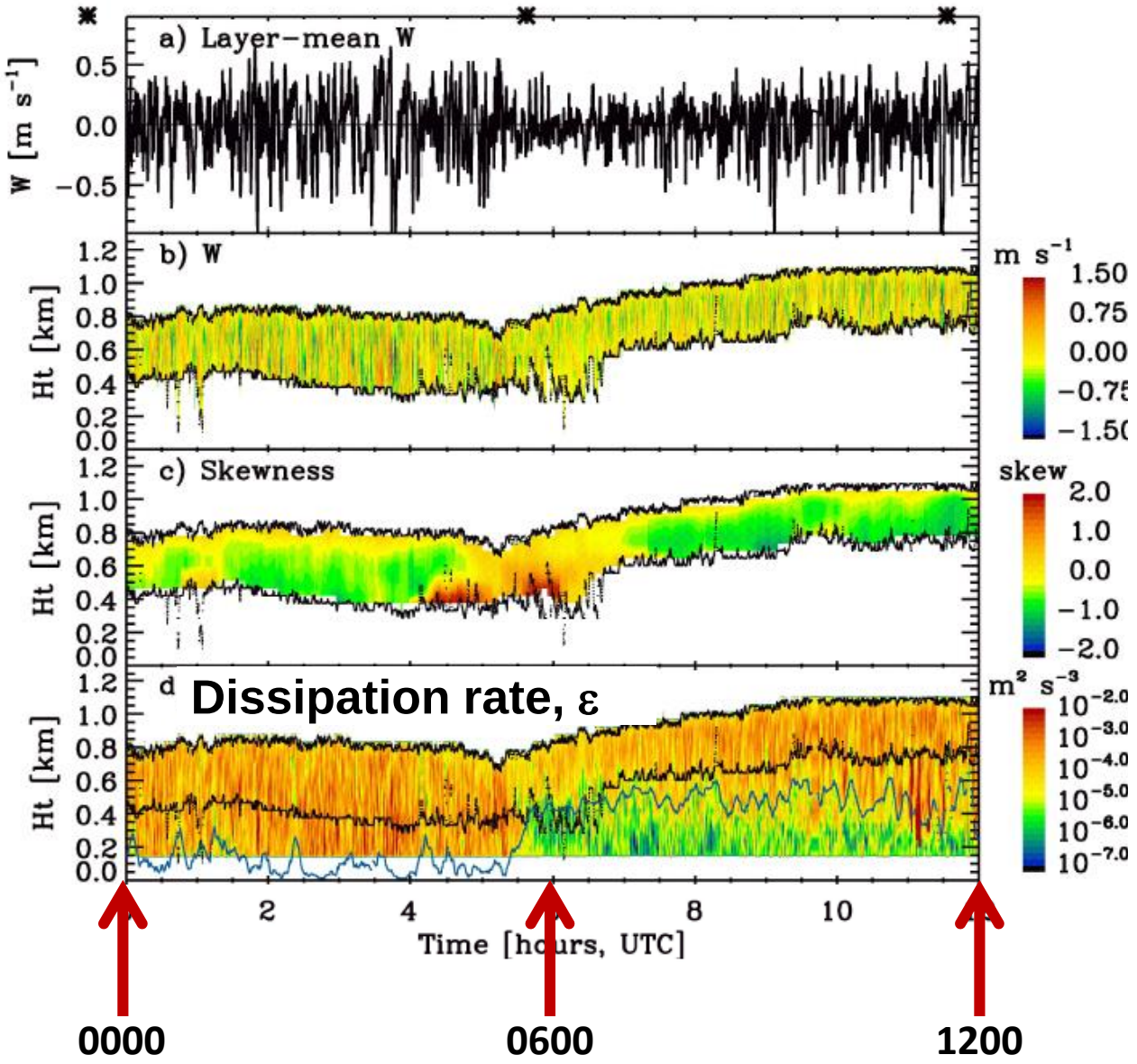
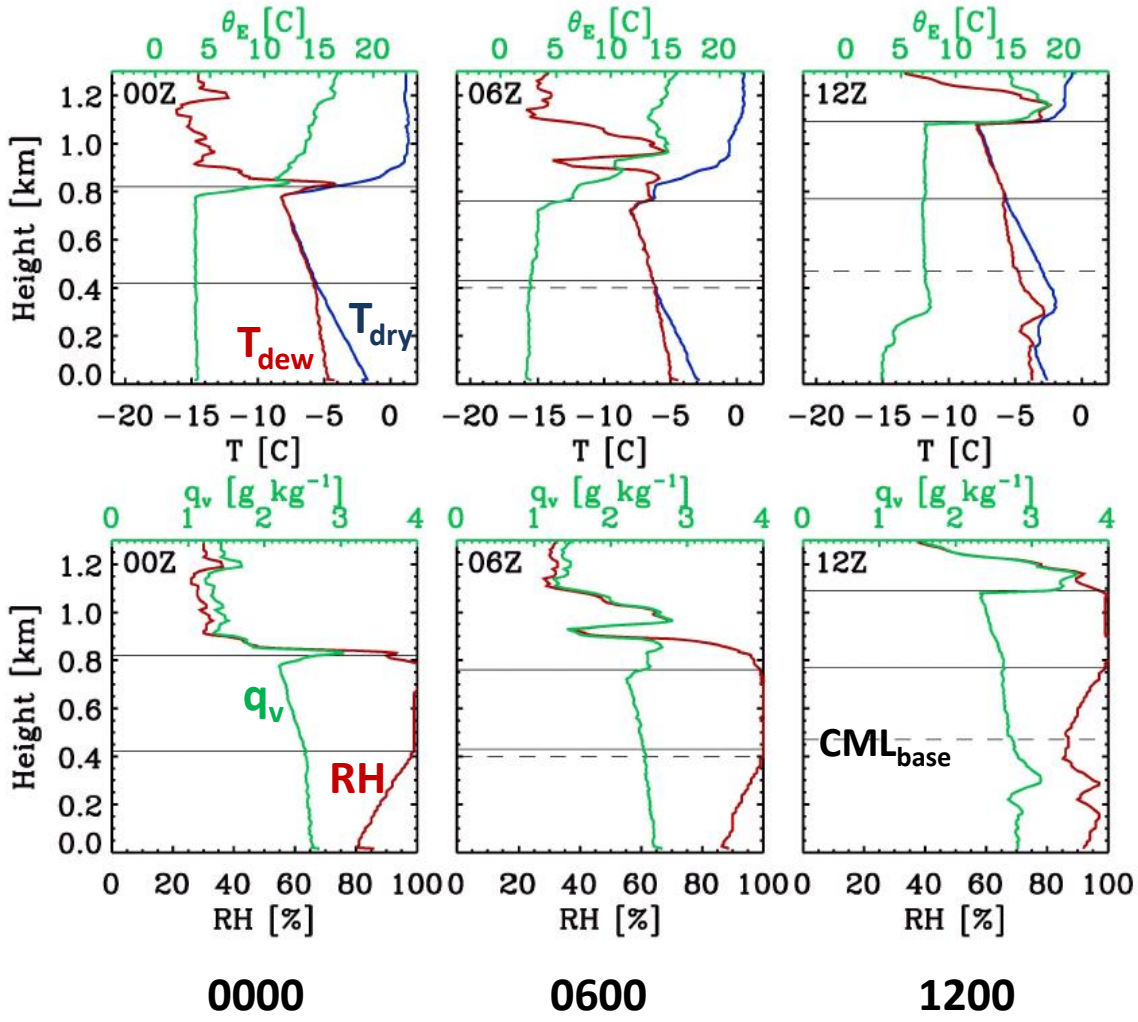


Tjernström et al. 2019, J. Clim., 32, doi:10.1175/JCLI-D-18-0216.1; Tjernström et al. 2015, *GRL*. 42. doi:10.1002/2015GL064373



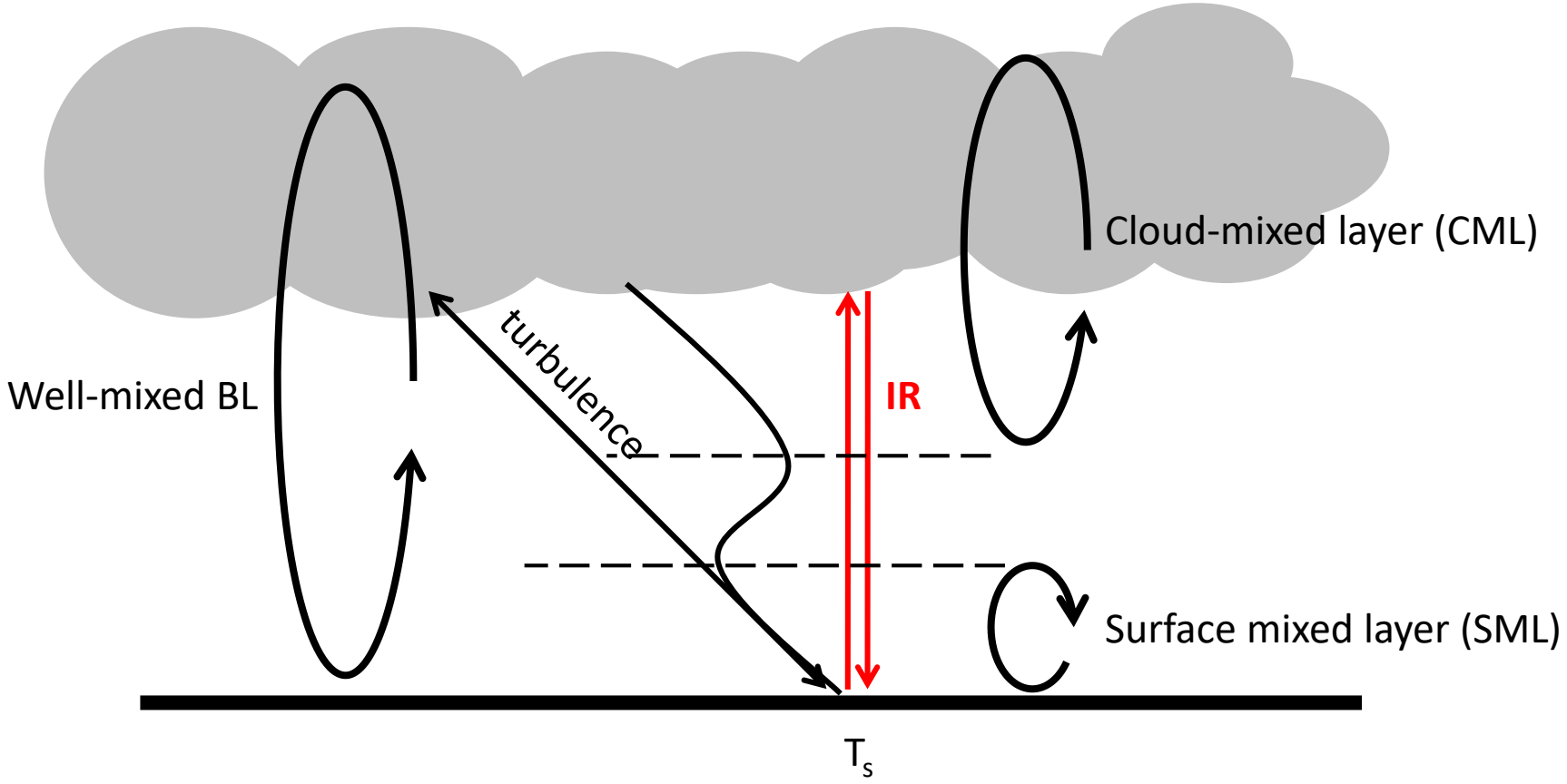
Brooks et al. 2017, JGR, 10.1002/2017JD027234



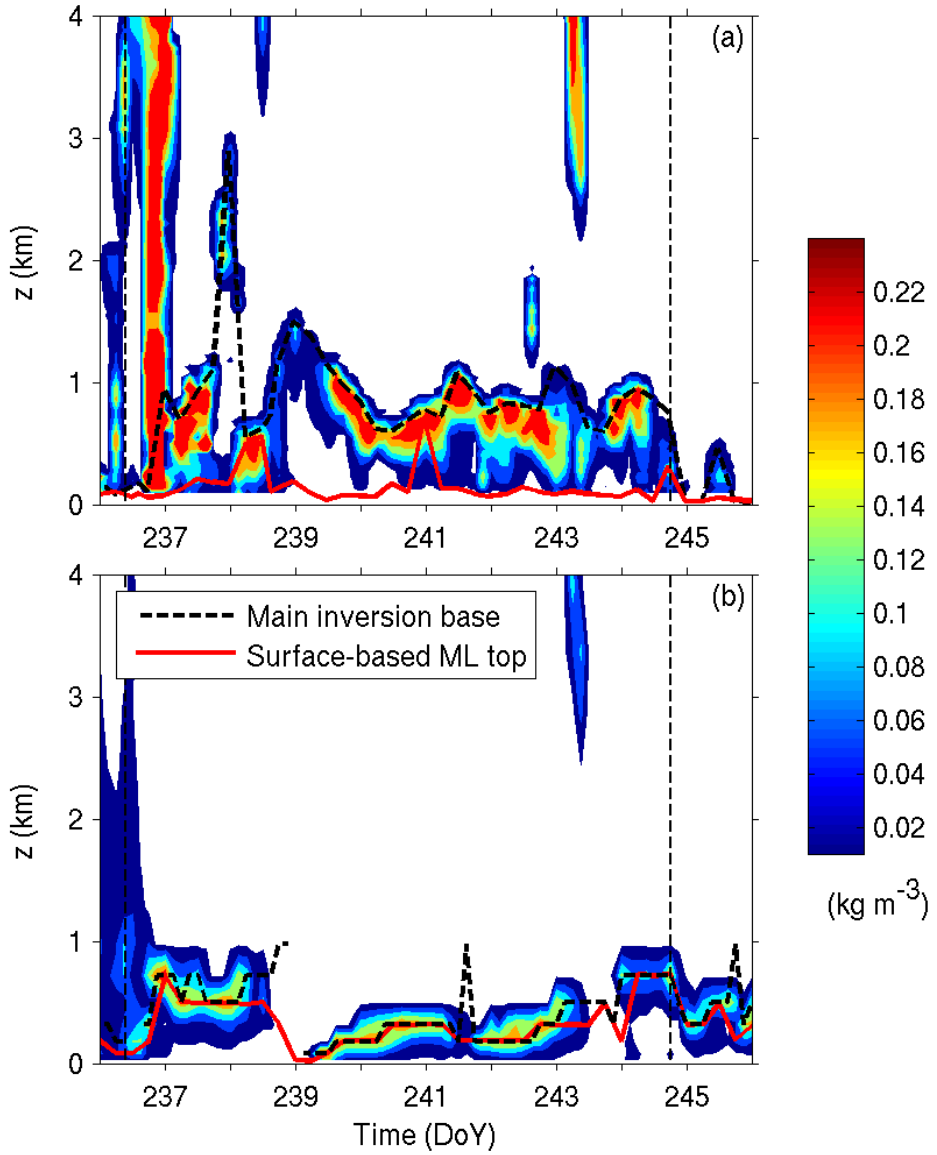


Aug 28, 2008 (doy = 241)

Shupe et al. 2013: *Atmos. Chem. Phys.* **13**, 9379–9400, doi:10.5194/acp-13-9379-2013


Cloud-mixed layer (CML)
Well-mixed BL
turbulence
IR
Surface mixed layer (SML)
T_s

Observed vs modelled cloud



Global models do a poor job of representing Arctic stratus.

- BL too deep & too well mixed
- Cloud too thin & too low
- Cloud water content too low

→ radiative properties wrong
→ surface energy budget wrong
→ BL structure wrong – feedback on cloud

Birch et al. 2012, **12**, 3419–3435, doi: 10.5194/acp-12-3419-2012

Observed vs modelled cloud

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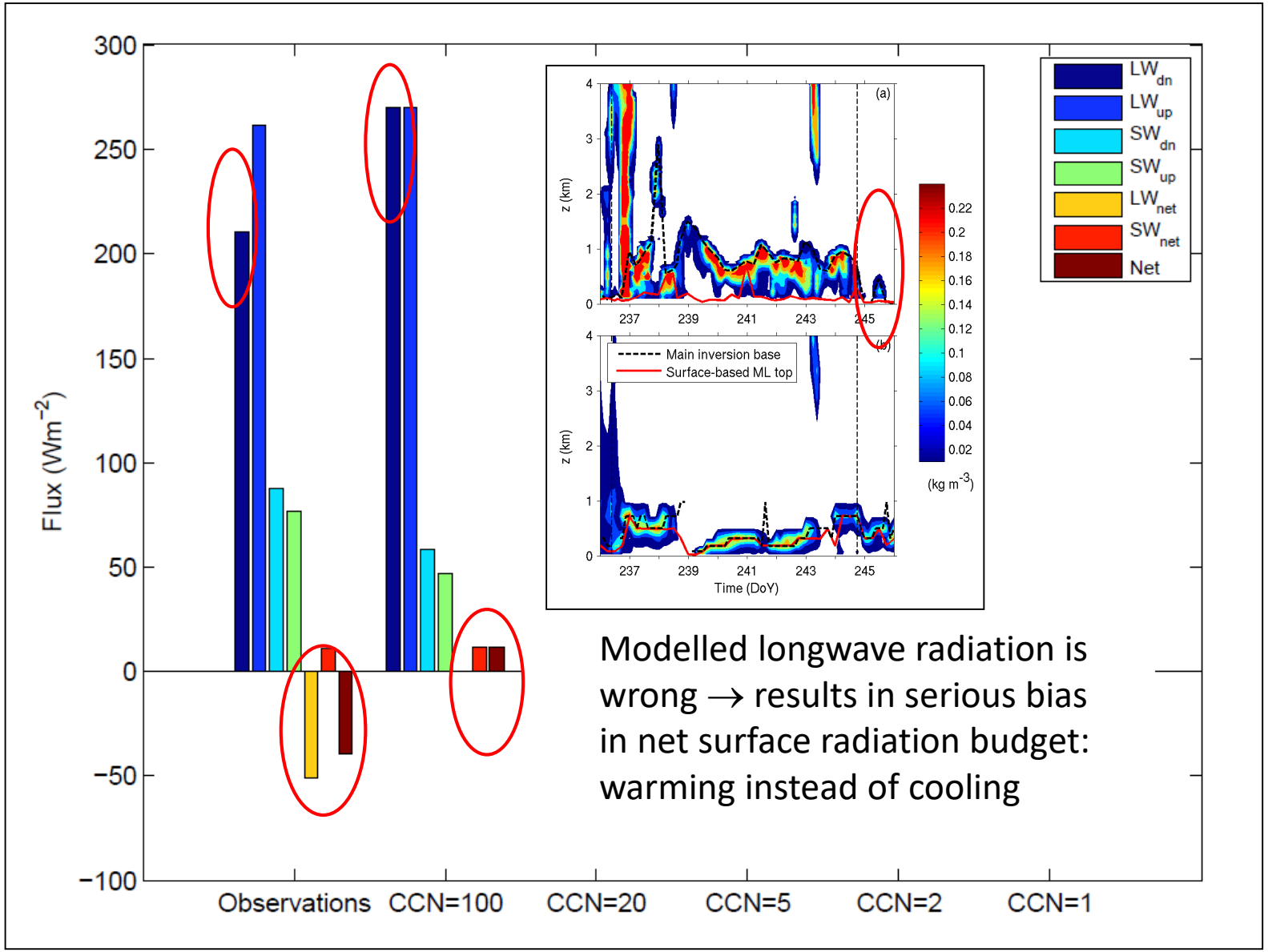

Modelled longwave radiation is wrong → results in serious bias in net surface radiation budget: warming instead of cooling

Observed vs modelled cloud

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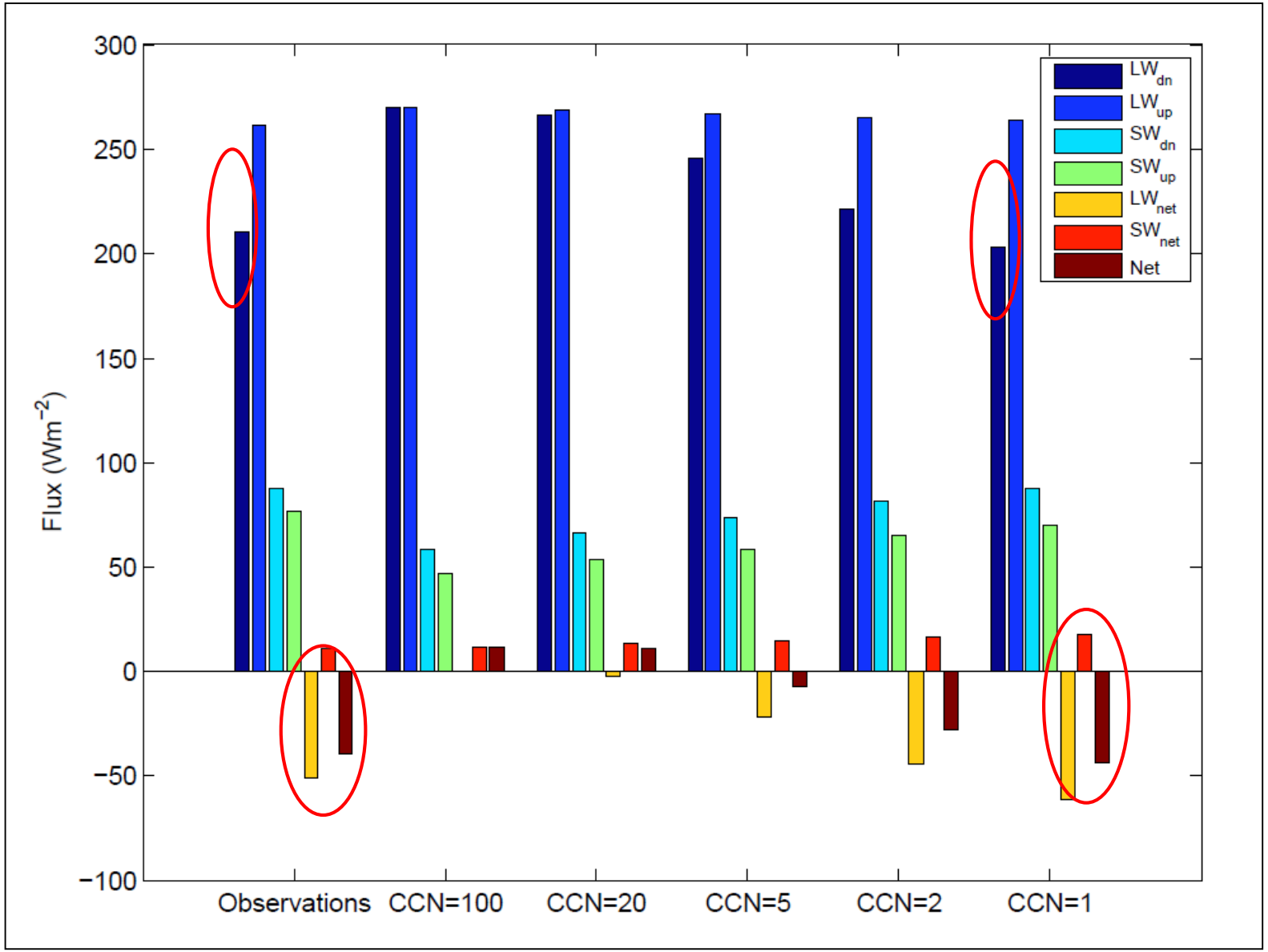
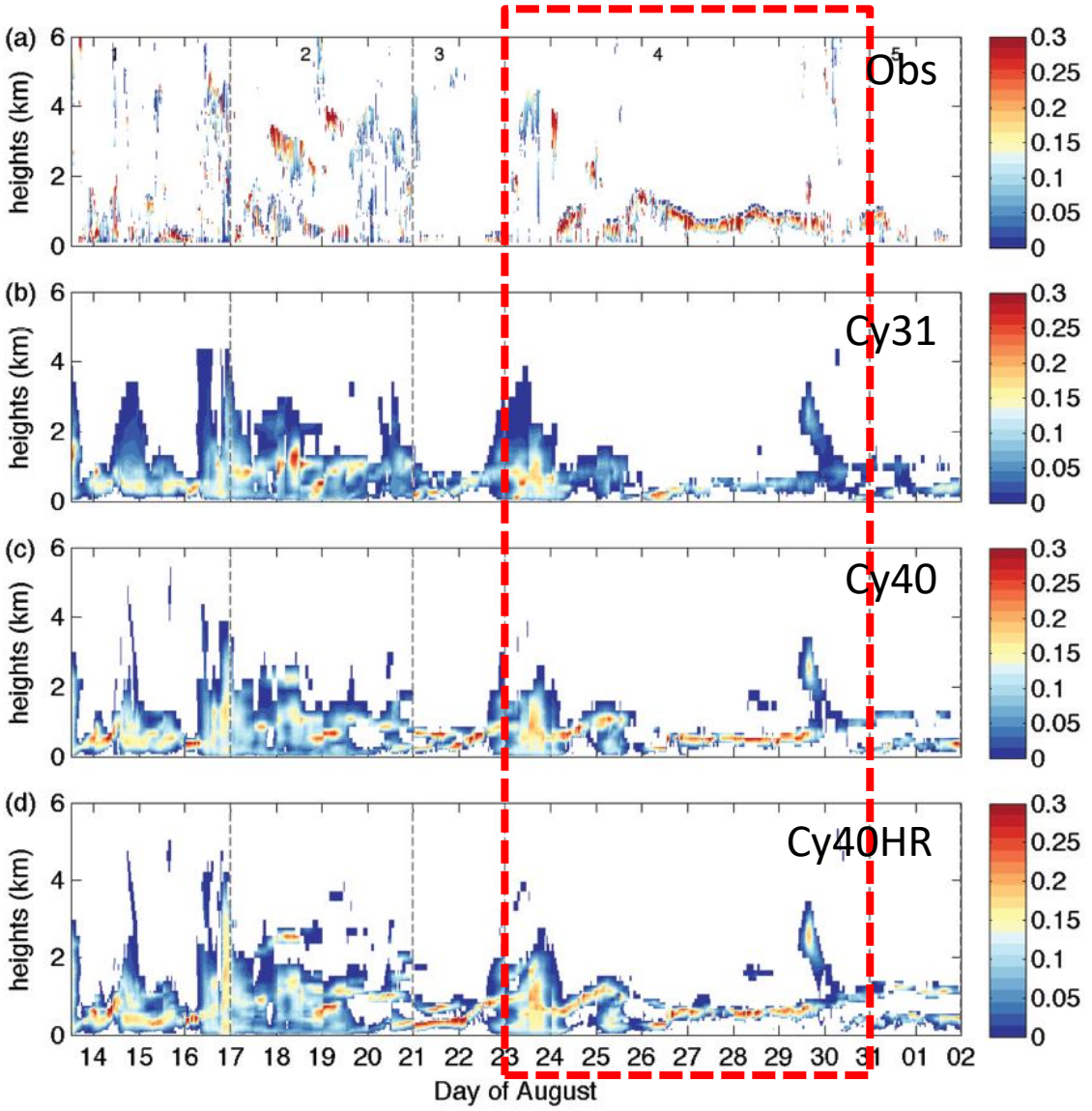


Observed vs modelled cloud (IFS)

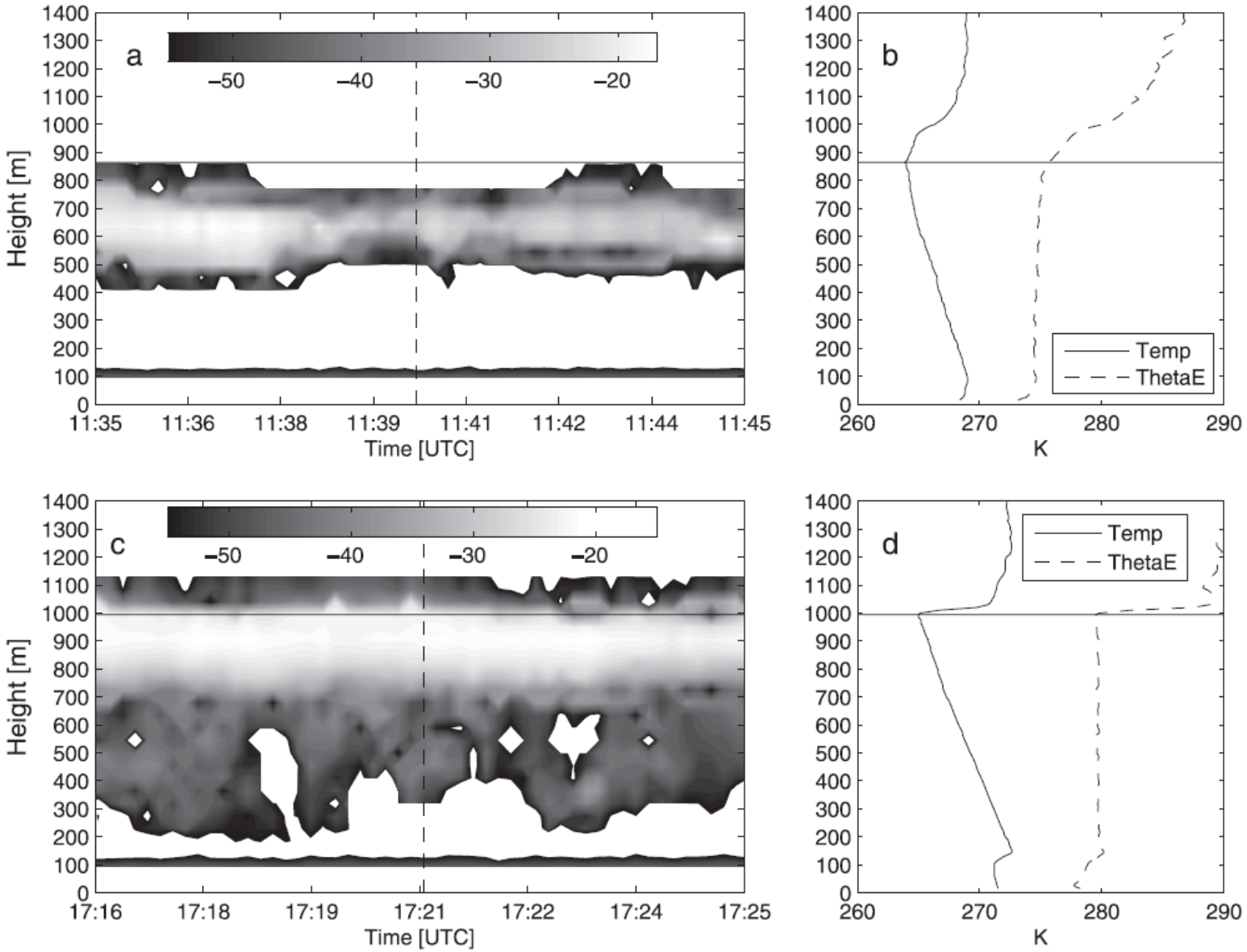


Global models (still) do a poor job of representing Arctic stratus.

- IFS Cy40 (new cloud scheme) improves cloud representation, but...
- **Little improvement in surface radiation**
- **Fails to represent clearing & cloud-free conditions (aerosol/CCN issue?)**
- **Fails to reproduce frequent decoupling of cloud from surface (BL mixing scheme issue)**
- **Fails to reproduce coincident temperature & humidity inversions**

Sotiropoulou et al. 2016, QJRMS, doi:10.1002/qj.2658

Cloud Forced Mixing



Cloud radar backscatter (dB) & radiosonde profiles for:

TOP: cloud capped by temperature inversion

BOTTOM: cloud extending into inversion

Both cases from ASCOS

Sedlar et al. 2012, J. Clim.
doi: 10.1175/JCLI-D-11-00186.1

Cloud Forced Mixing

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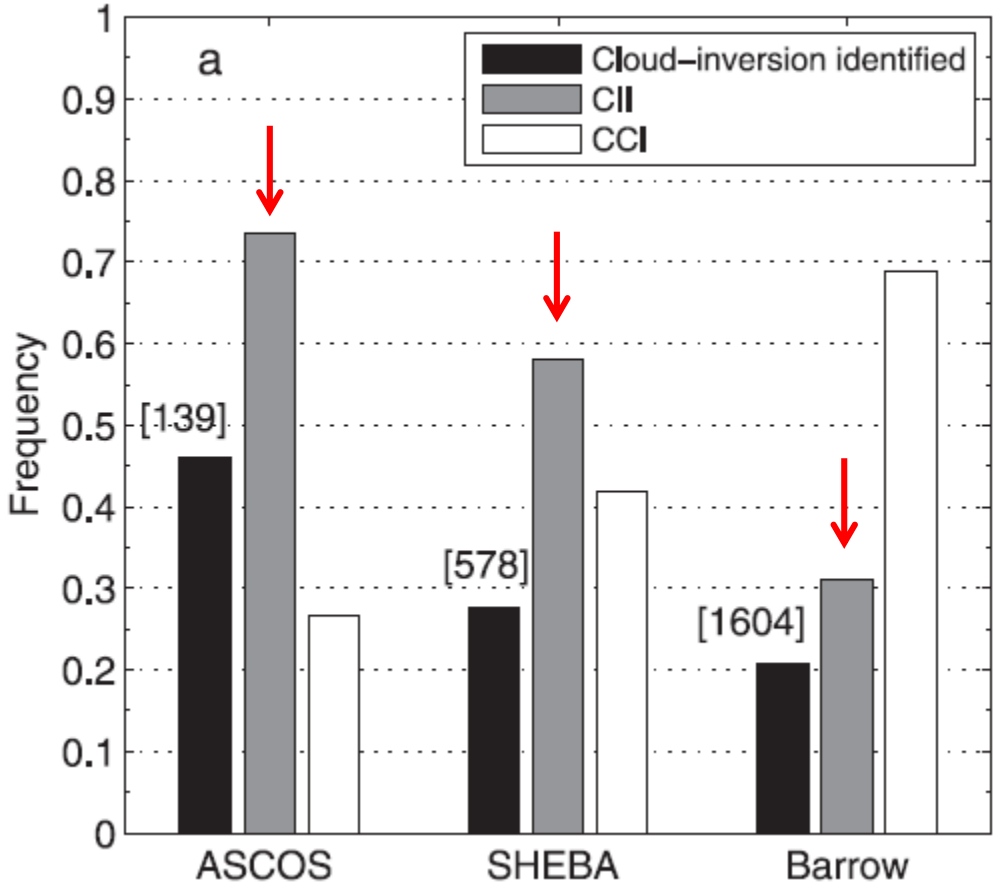

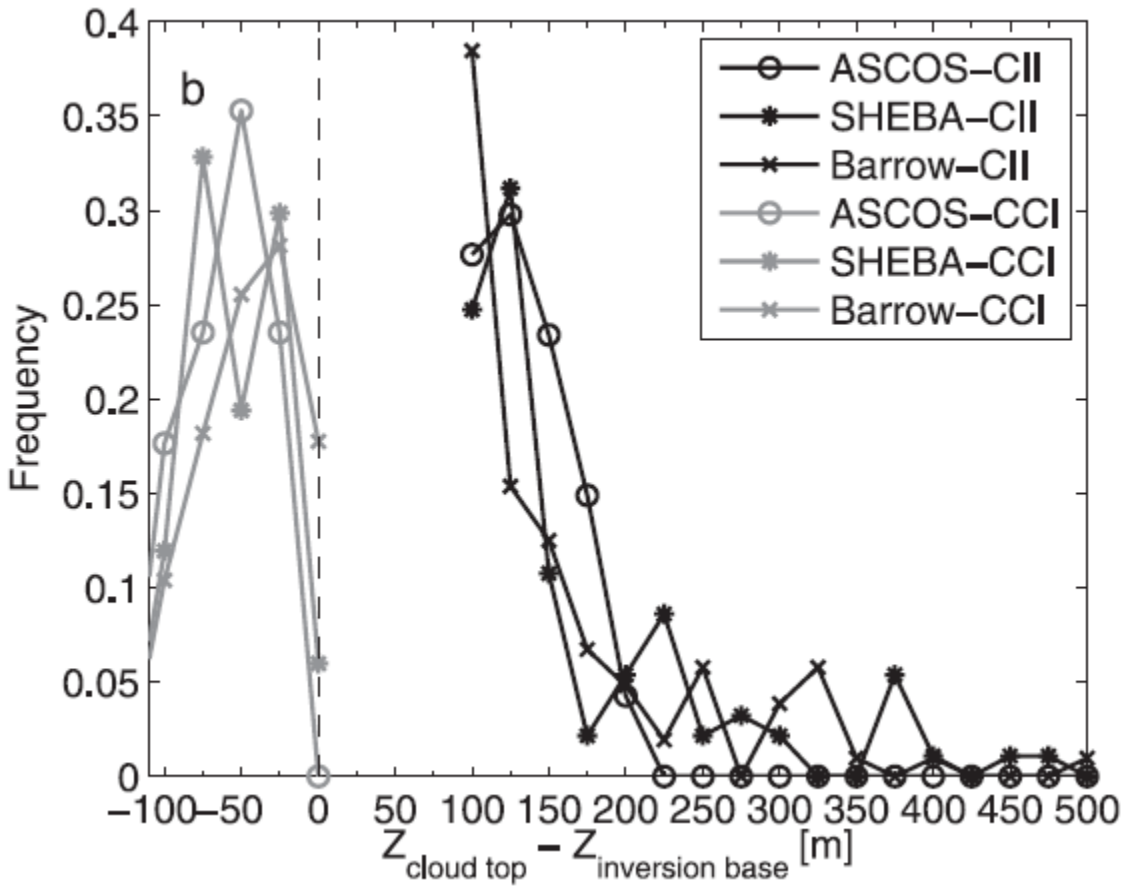

Sedlar et al. 2012, J. Clim. doi: 10.1175/JCLI-D-11-00186.1

Cloud Forced Mixing

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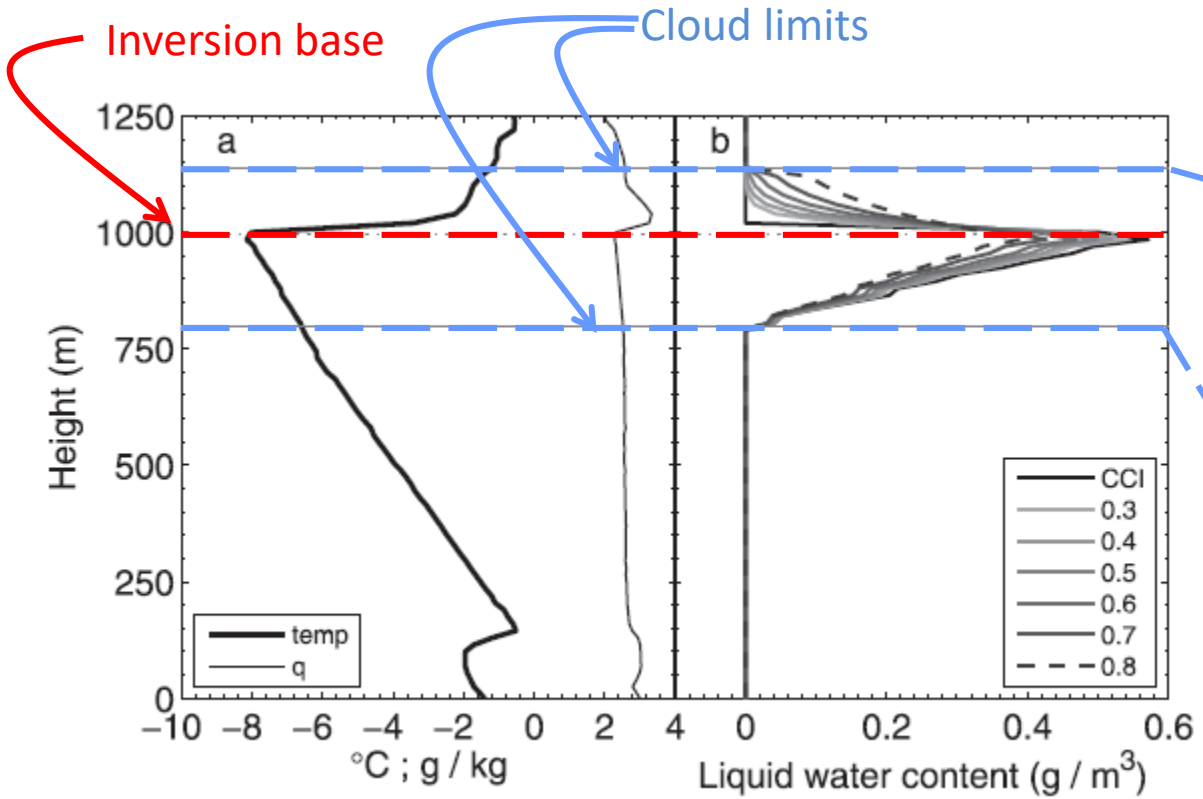

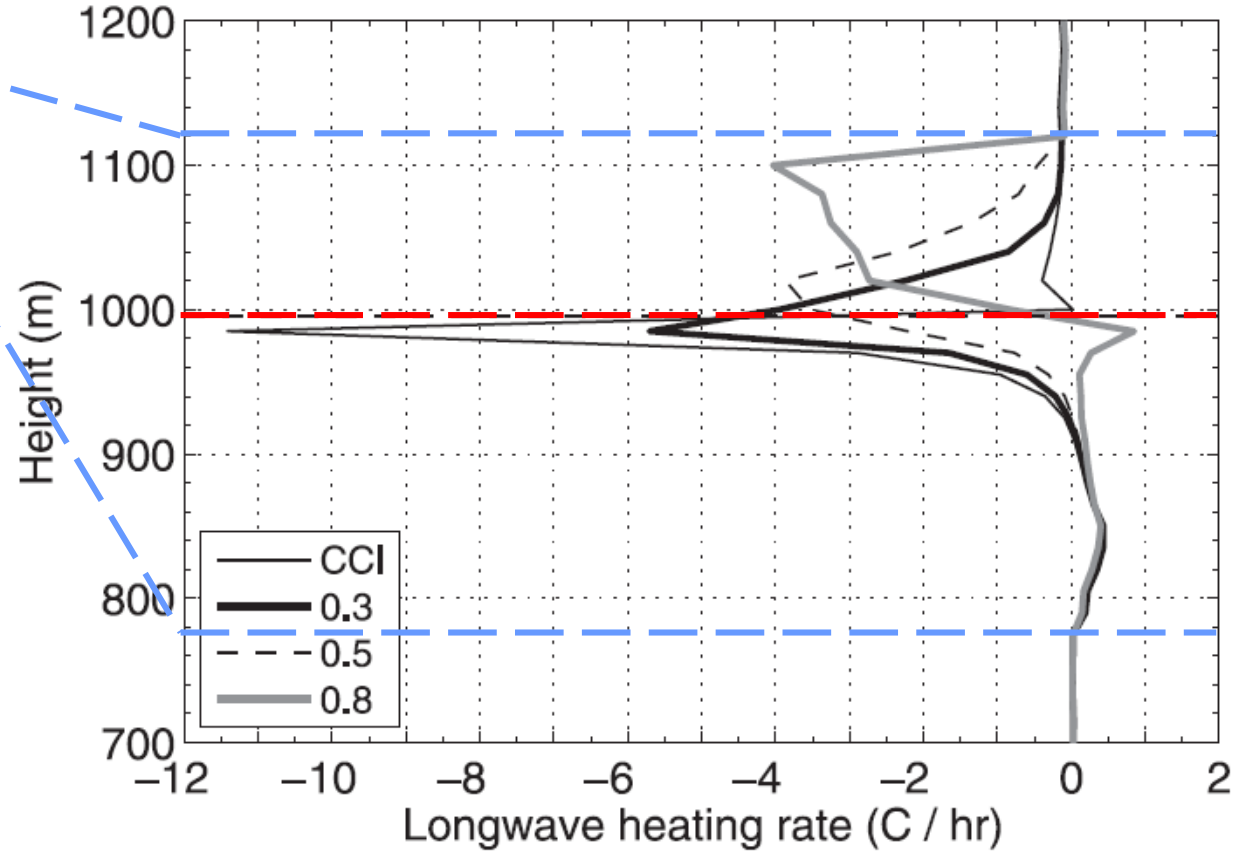

Sedlar et al. 2012, J. Clim. doi: 10.1175/JCLI-D-11-00186.1

Cloud Forced Mixing

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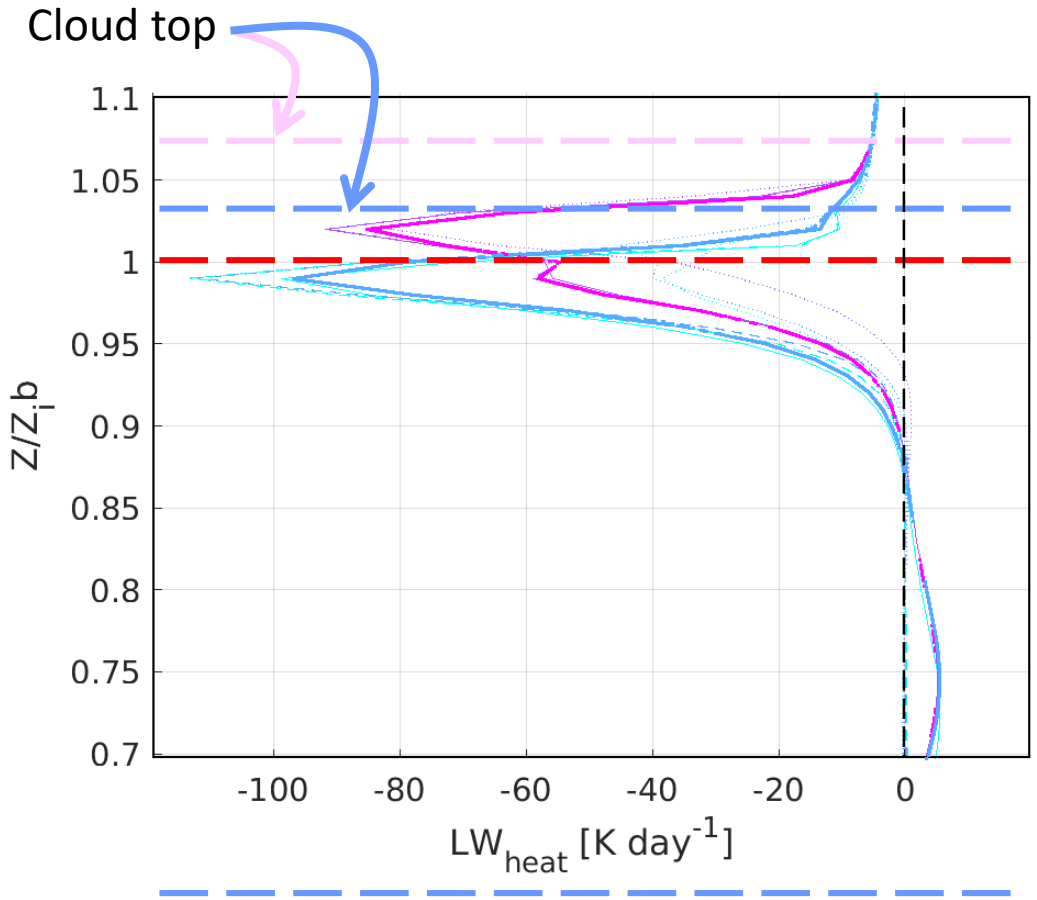

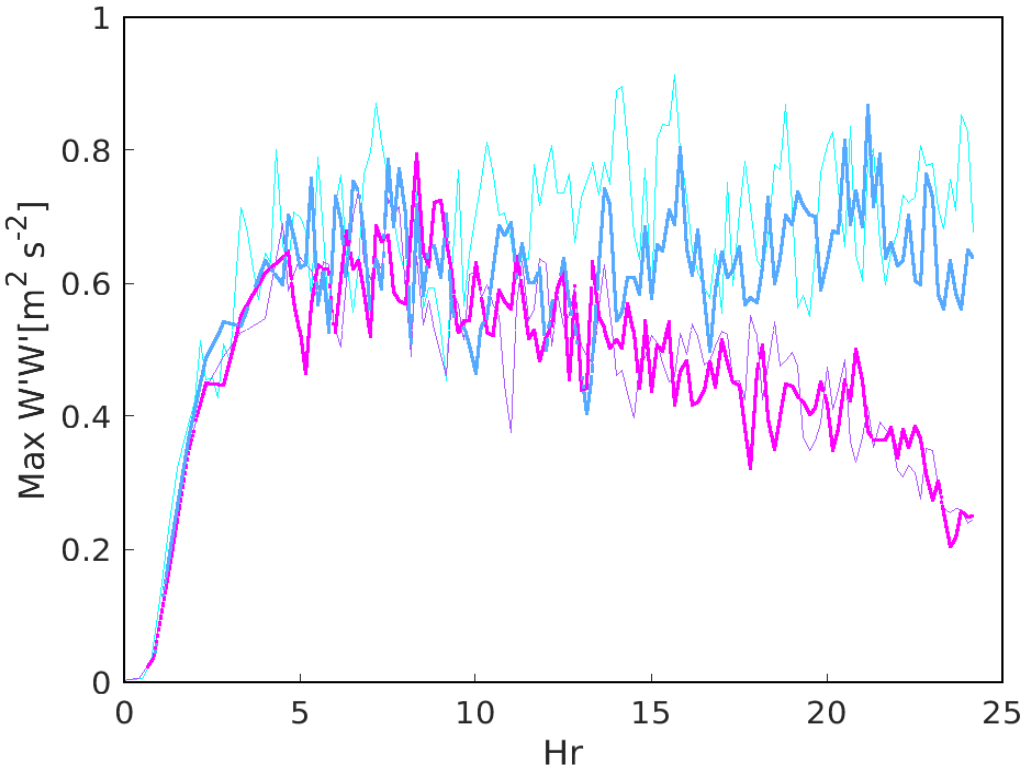

Observations in central Arctic Ocean

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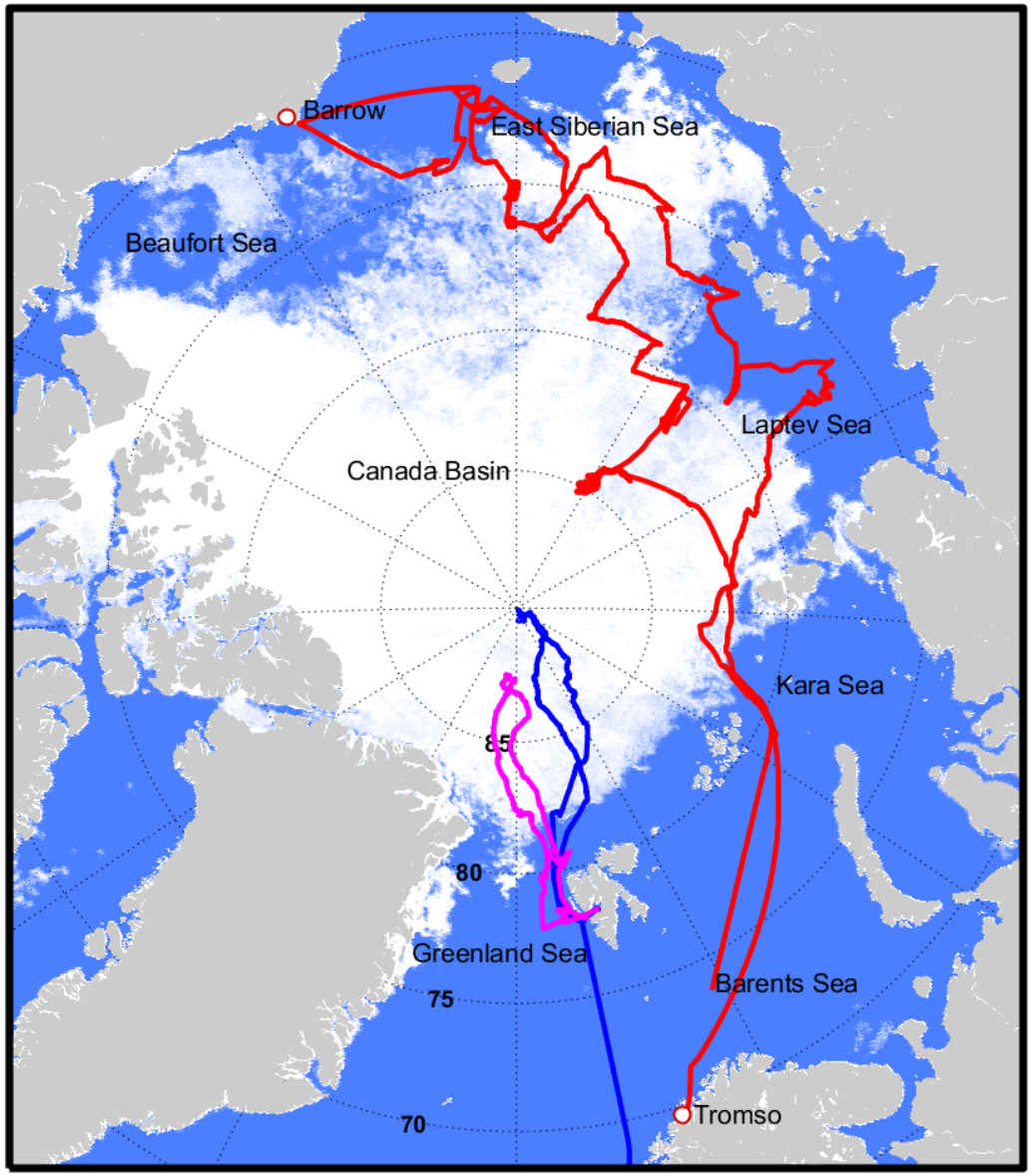

ASCOS – Aug 2 – Sep 9 2008

ACSE – Jul 5 – Oct 5 2014

AO2018 – Jul 20 – Sept 21

AO2018 Remote Sensing Cloud Measurements

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Cloudnet retrieval scheme

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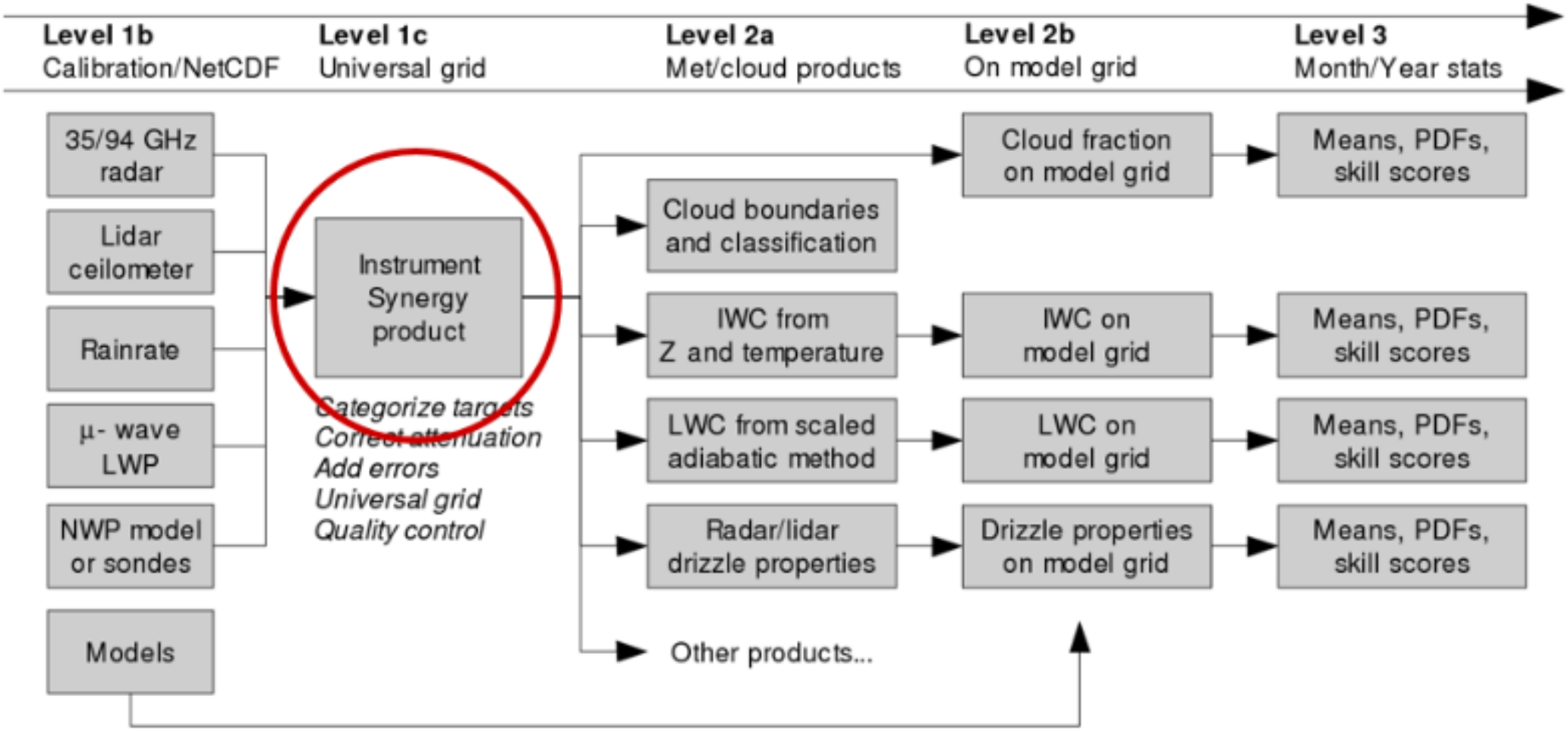

Illingworth et al., Bams, 2007

Cloud radar & lidar

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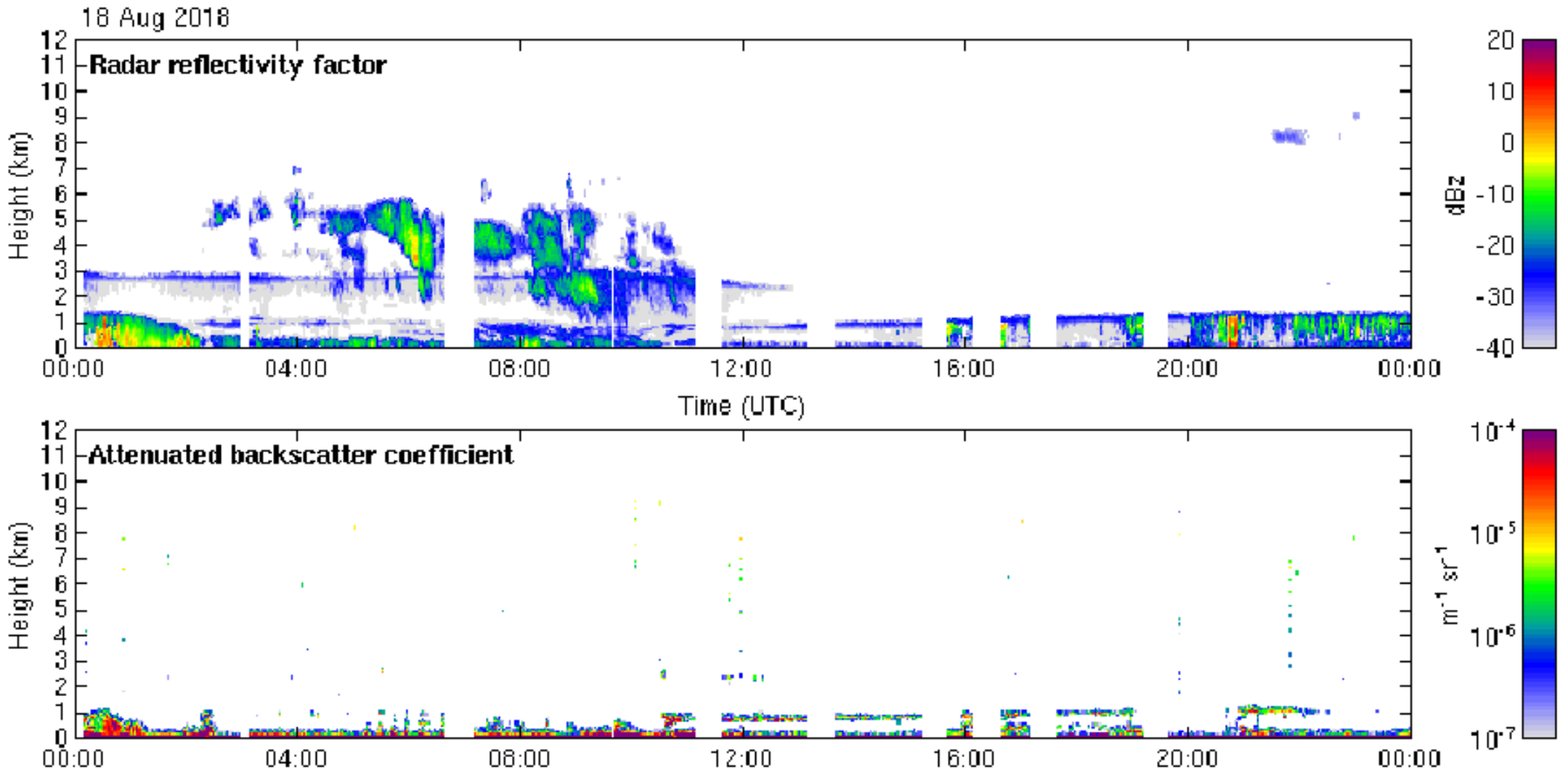

Cloudnet target classification

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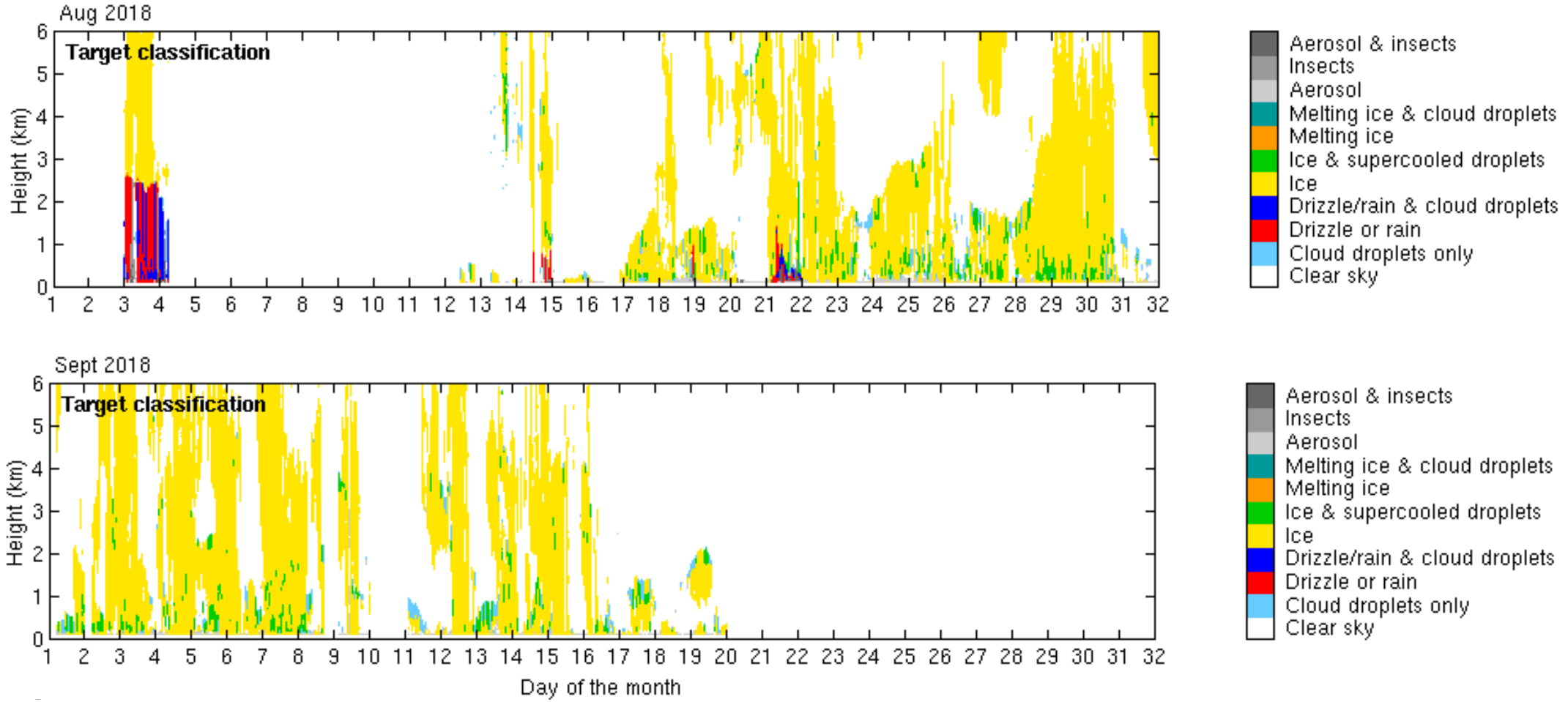

AO2018 Observed Cloud Statistics

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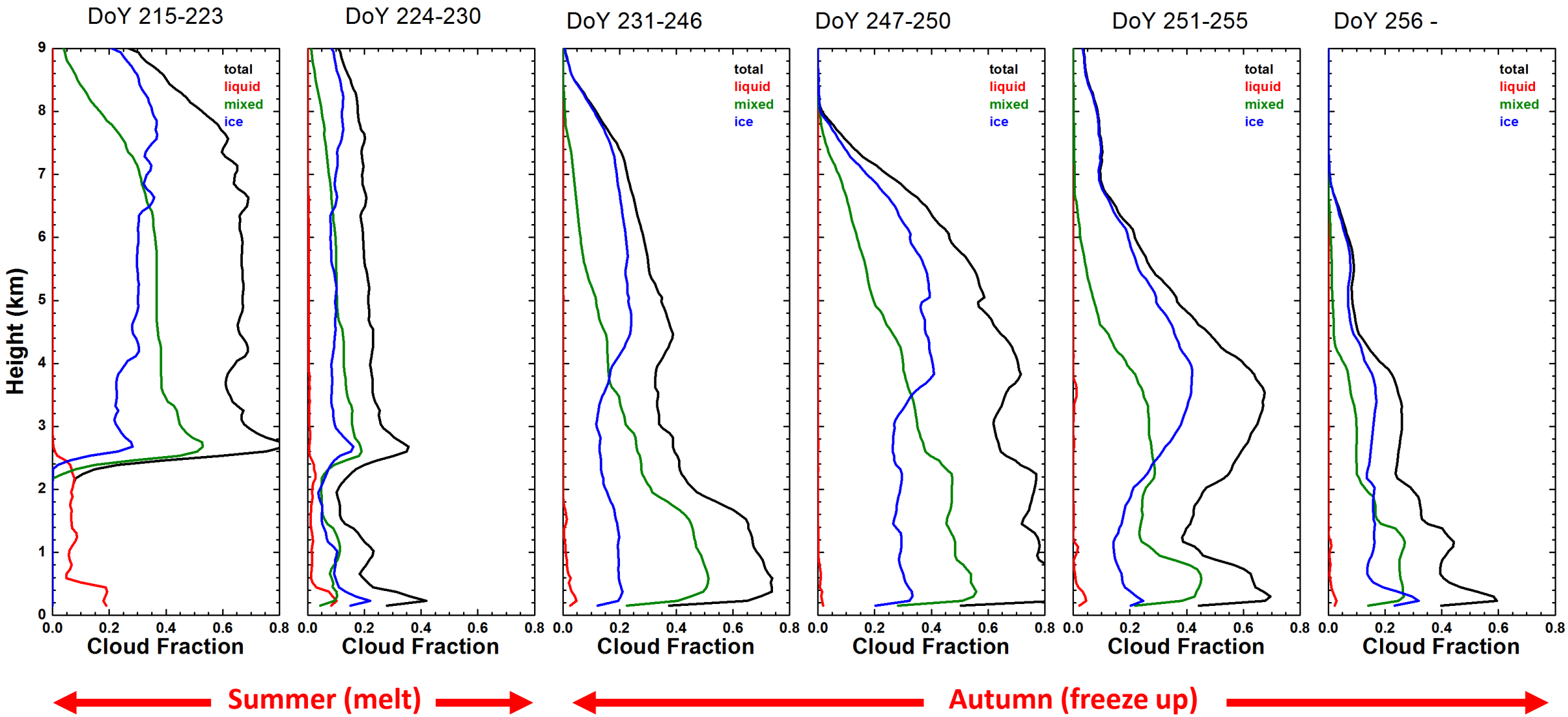

AO2018 vs ASCOS (2008)

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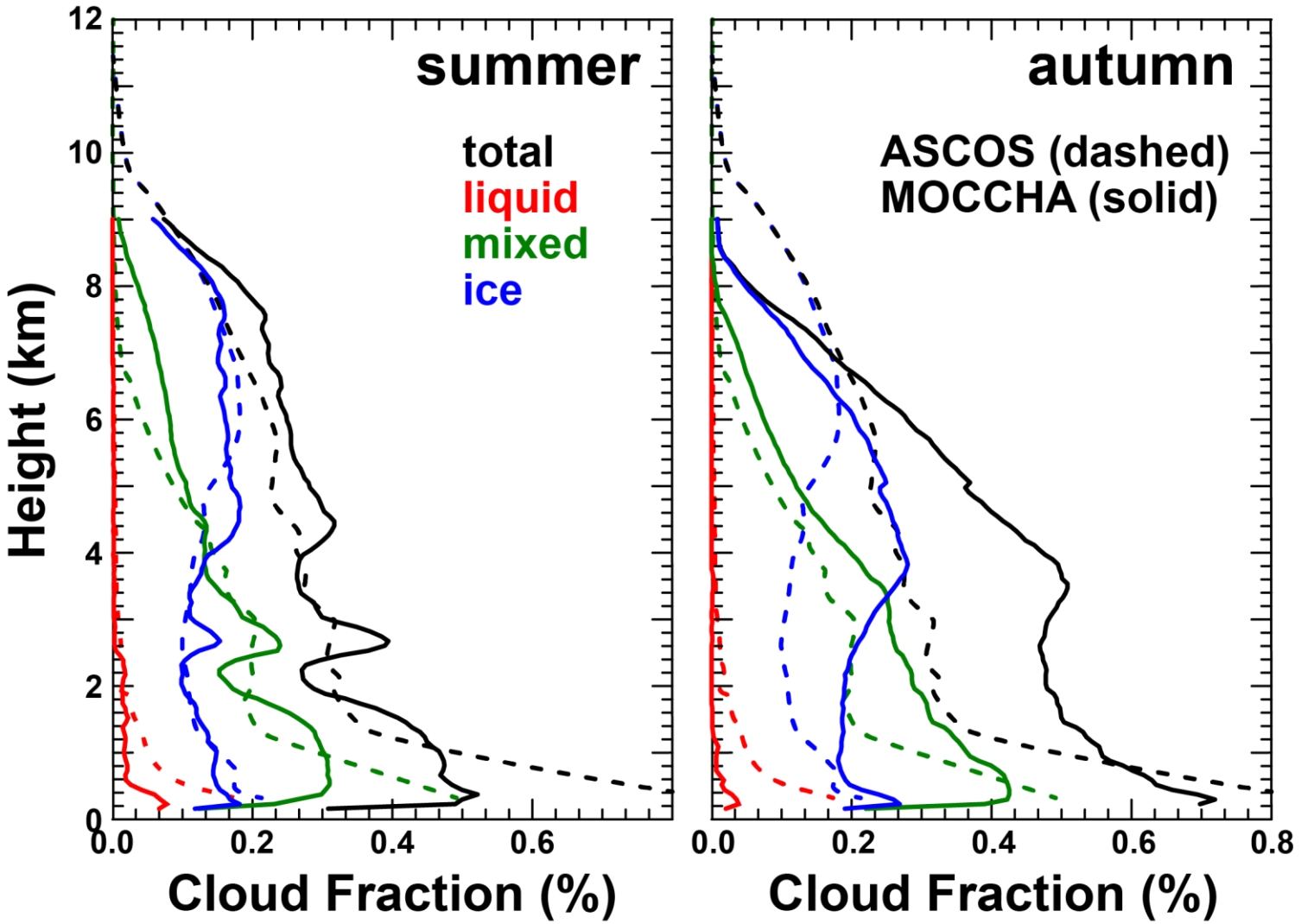

AO2018 : IFS Model vs. Observations

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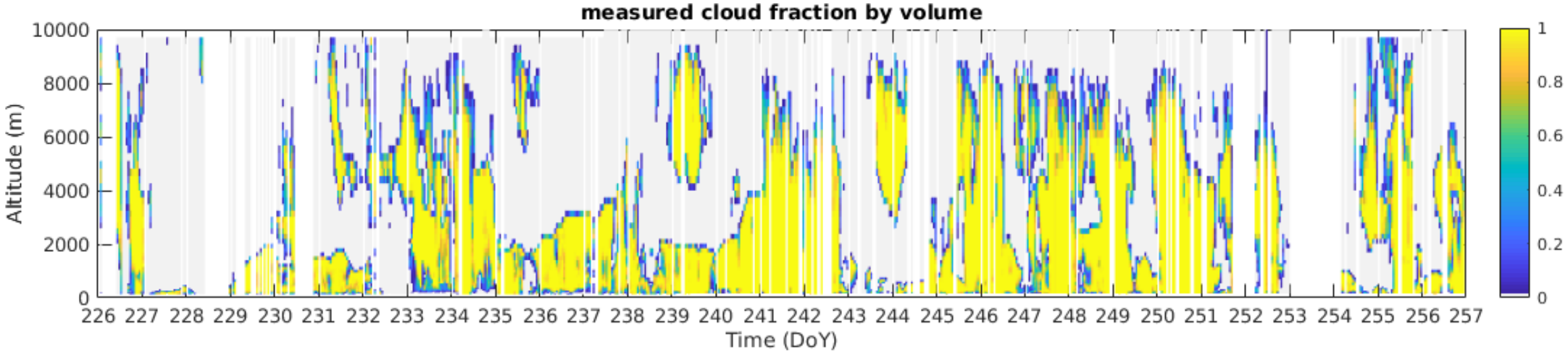

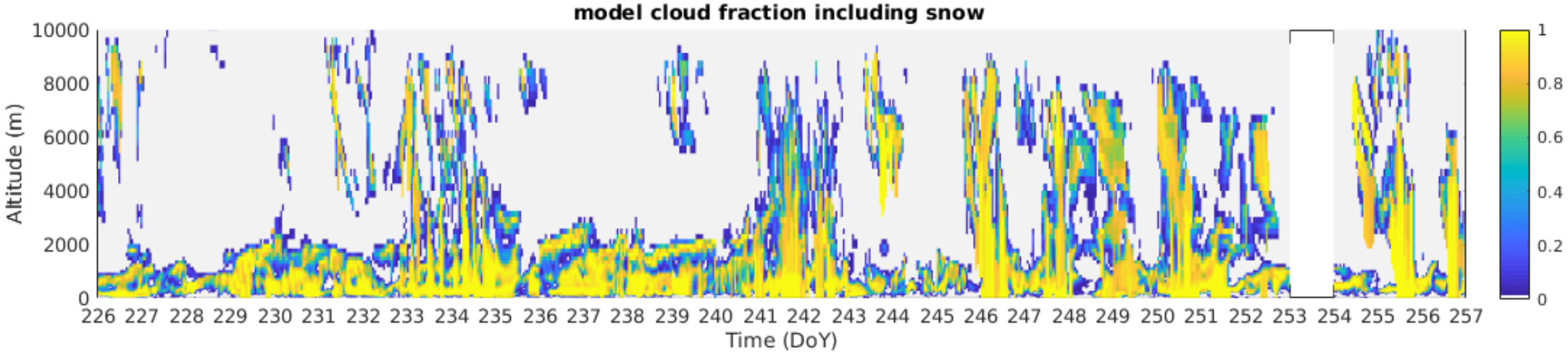

AO2018 : IFS Model vs. Observations

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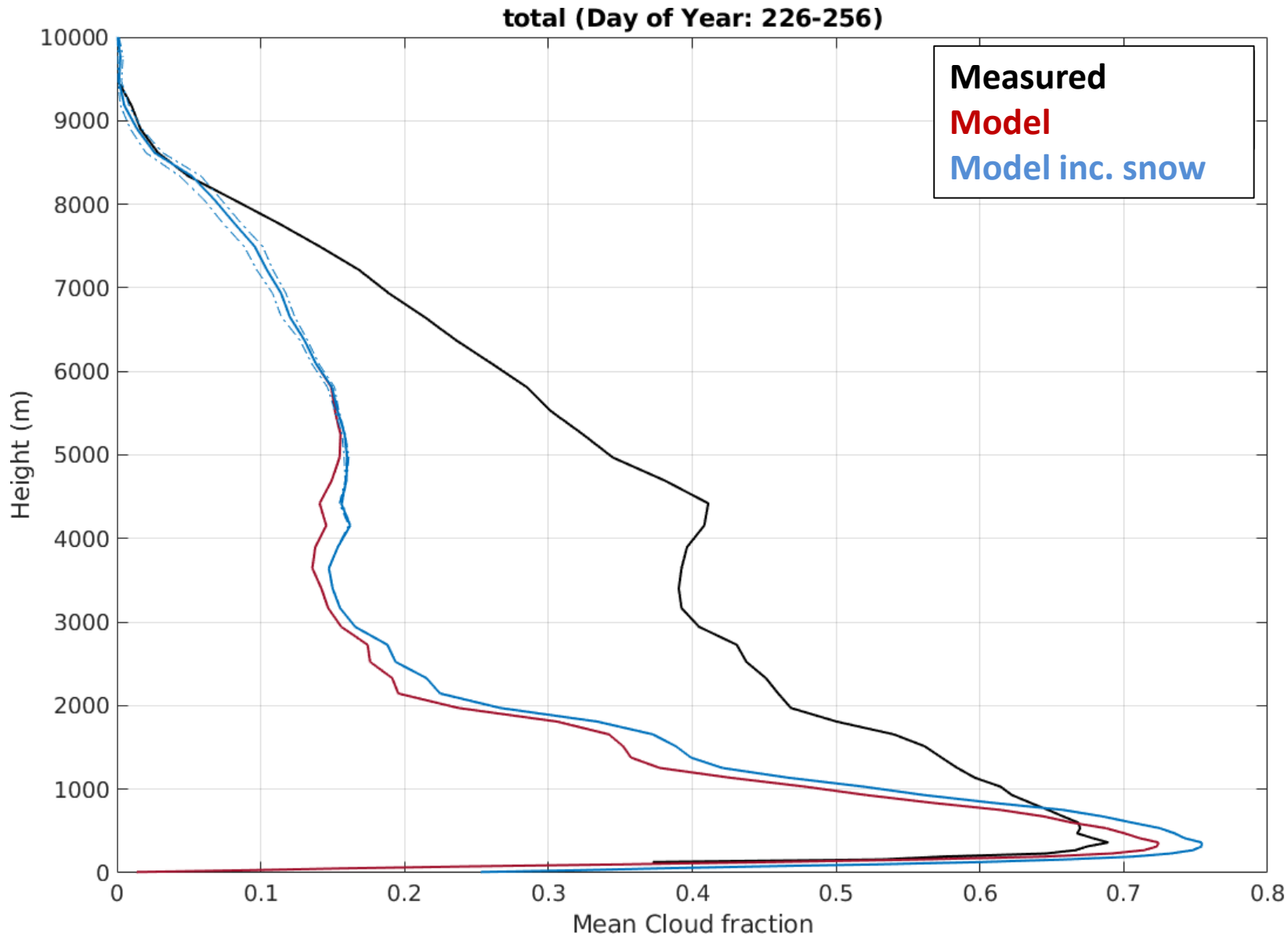

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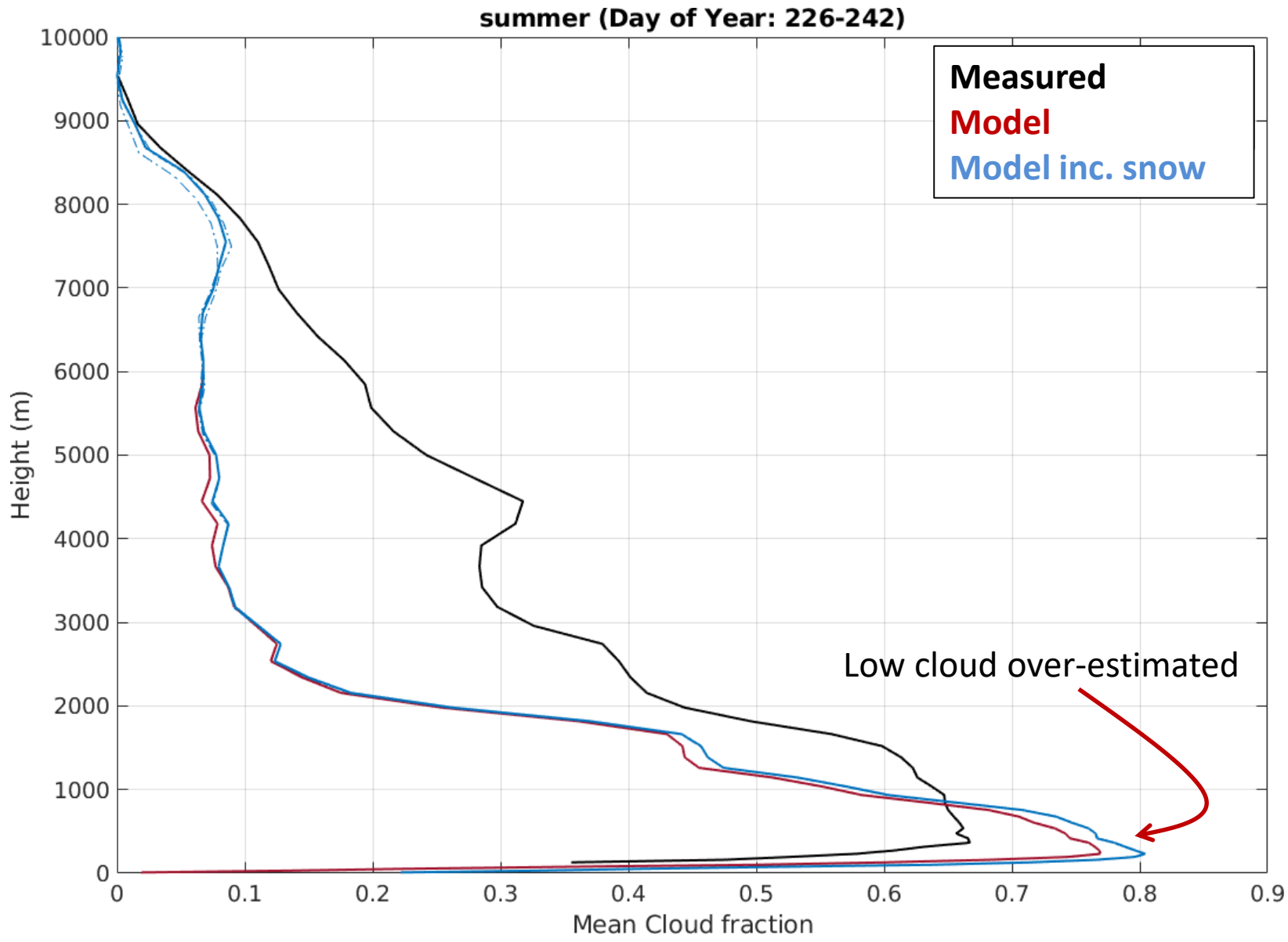

AO2018 : IFS Model vs. Observations

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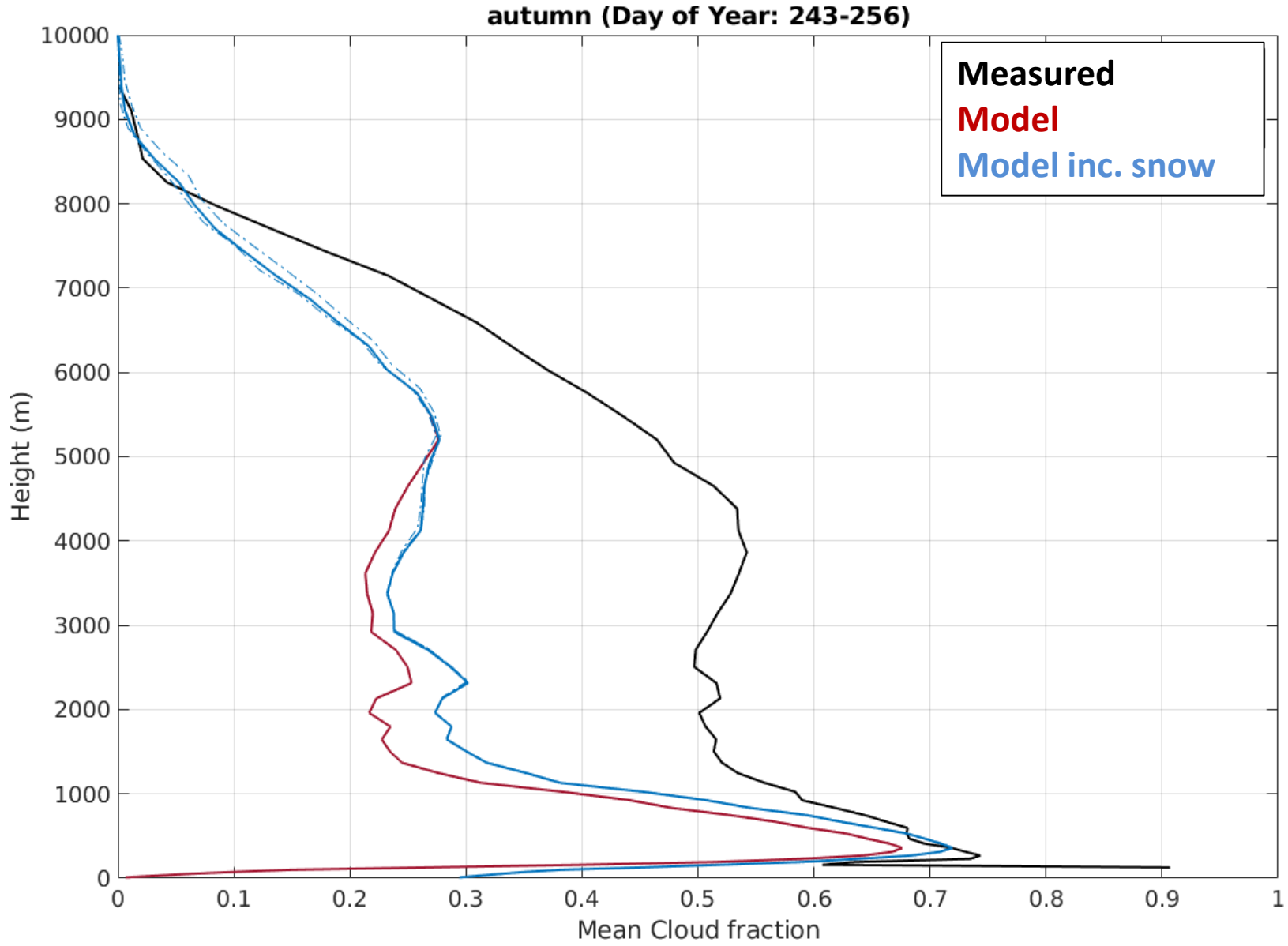

Ongoing Work

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- Evaluate modelled cloud statistics from (IFS, MetUM, ERA5) for 2014 & 2018 campaigns
  - Bulk properties
  - LWP, IWP
  - Impact of aerosols on cloud properties (AO2018 partner measurements)
  - INP / cloud-ice relationships
- BL-cloud interactions
  - Thermodynamic & turbulent structure
- Cloud parameterisation (MetUM CASIM) evaluation and development


Thank You...