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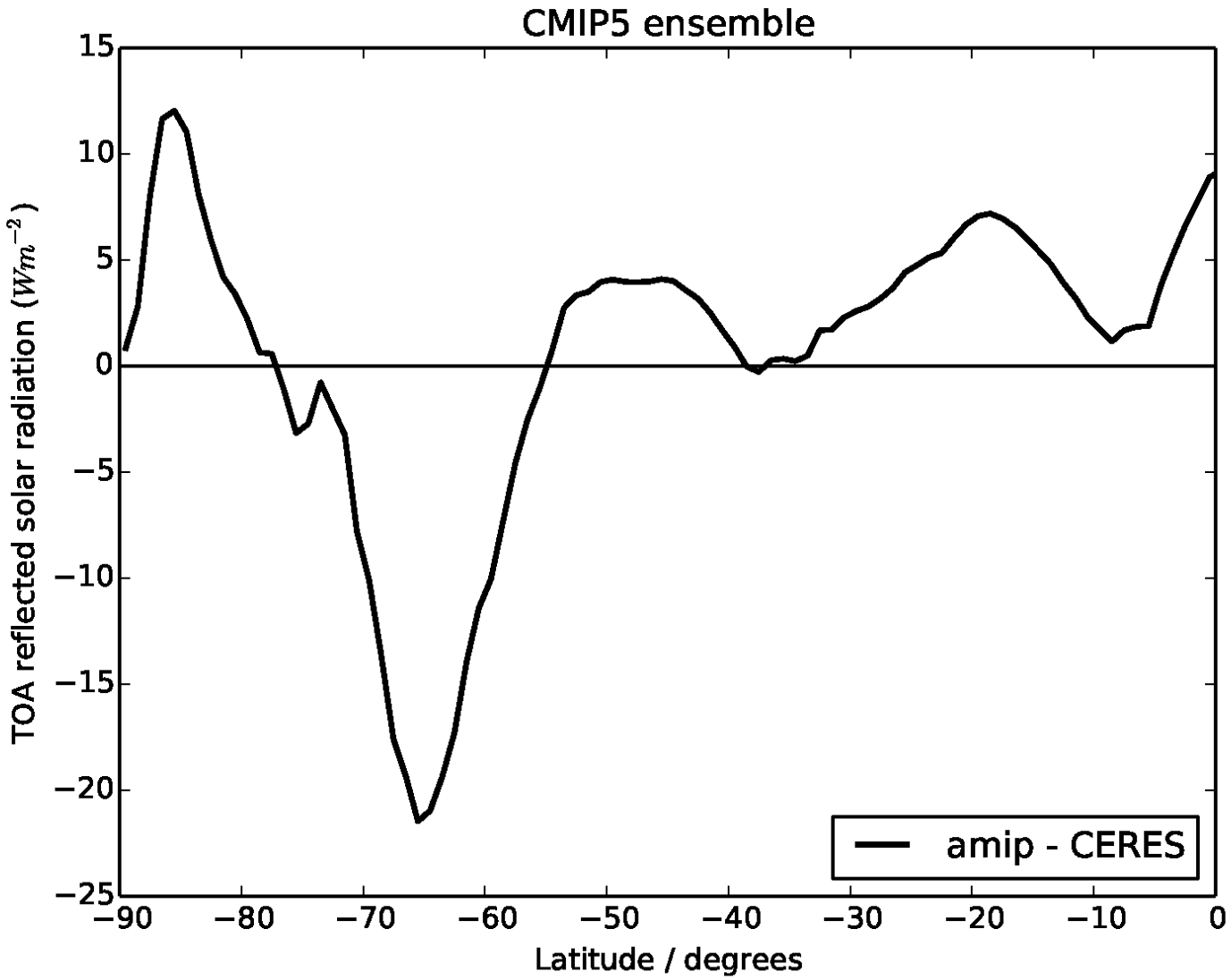
Supercooled liquid clouds and the Southern Ocean radiation budget

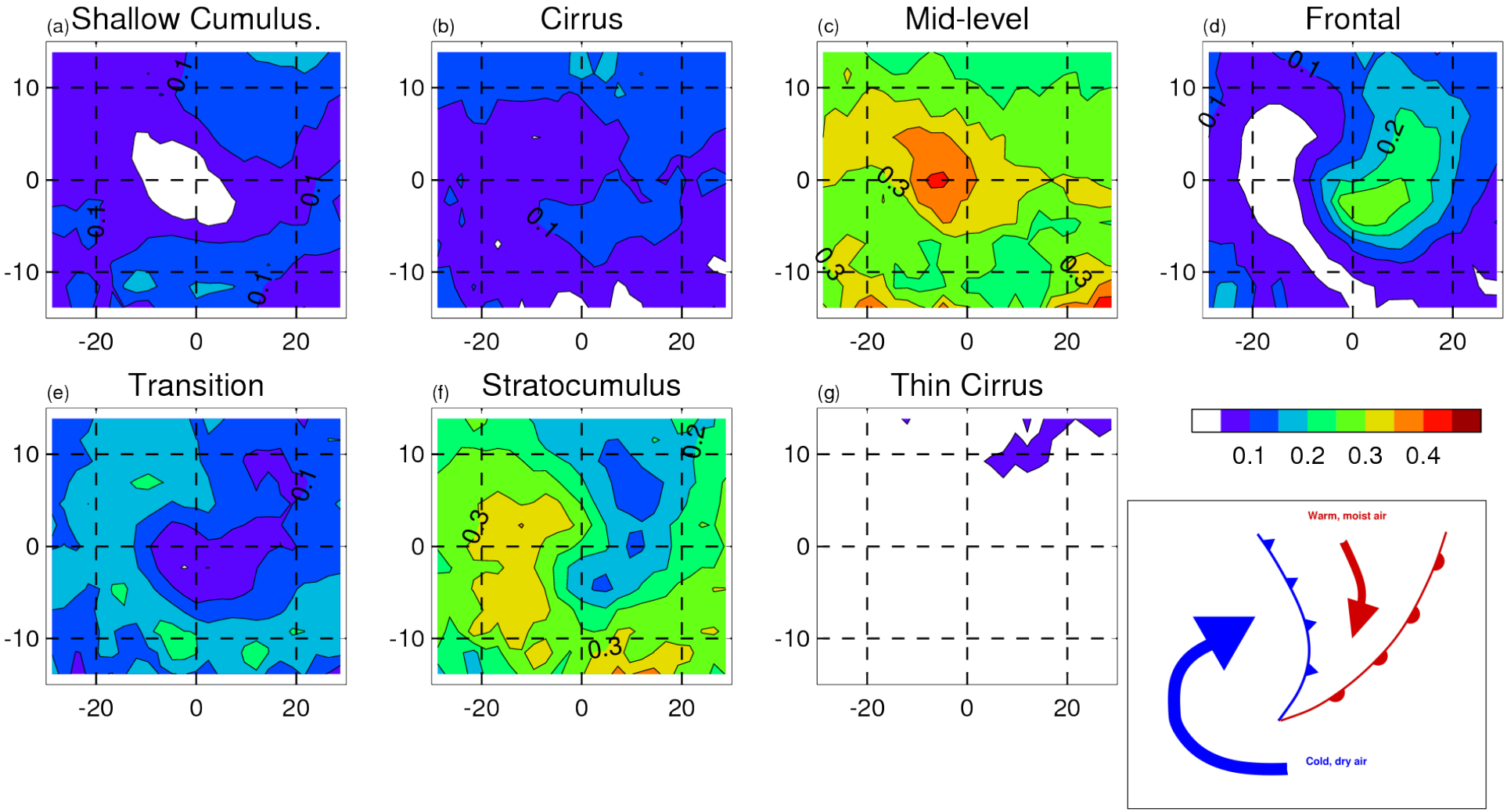
Alejandro Bodas-Salcedo

Thanks: P. G. Hill, K. Furtado, K. Williams, P. Field, J. Manners, P. Hyder, and S. Kato T. Andrews, A. Karmalkar, and M. A. Ringer

Large SW biases over the Southern Ocean



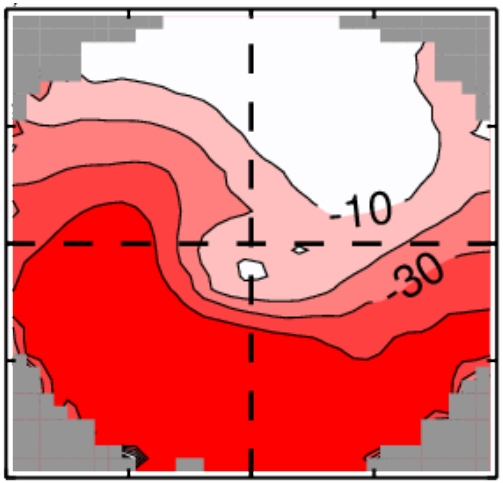
Cluster RFO: ISCCP



(Bodas-Salcedo et al., *J. Climate*, 2012. DOI:10.1175/JCLI-D-11-00702.1)

Which clouds contribute most to the error?

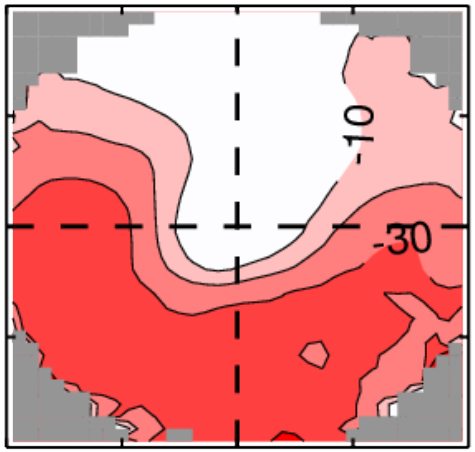
HadGEM2-A

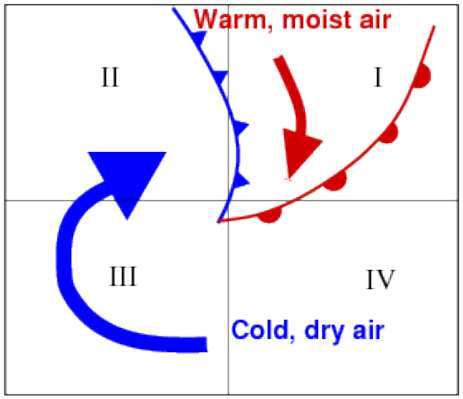


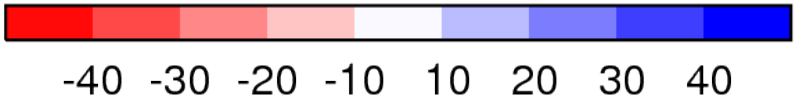
- Southern Ocean [40°S, 70°S]

- 7 DJF seasons

ERAI

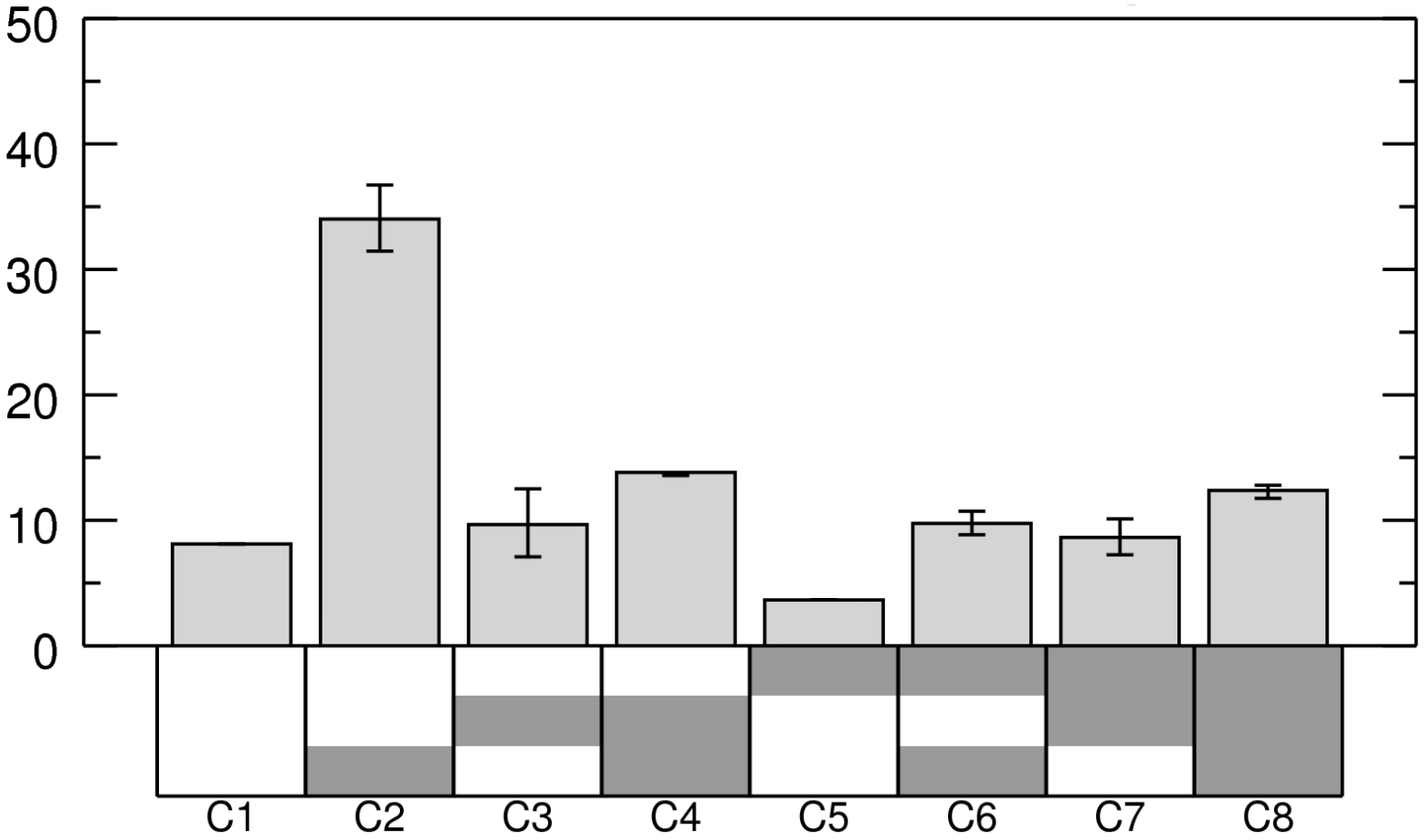






(Bodas-Salcedo et al., *J. Climate*, 2014. DOI:10.1175/JCLI-D-13-00169.1)

CALIPSO cloud in ISCCP mid-level regime



(Bodas-Salcedo et al., *J. Climate*, 2014. DOI:10.1175/JCLI-D-13-00169.1)

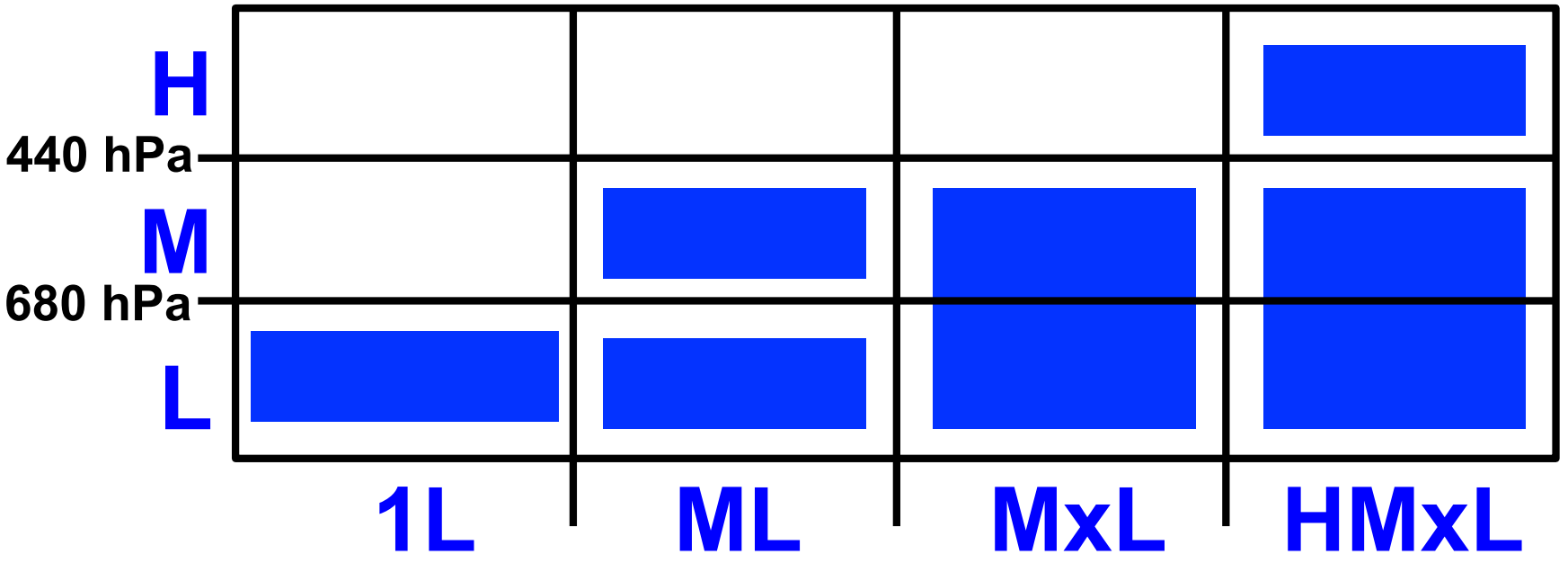
Methodology

RT calculations with full description of cloud vertical structure:

- **C3M data (Kato et al., JGR, 2010 & 2011)**
- **Edwards-Slingo RT code**
- **5 DJF seasons (2006-2010)**
- **40S to 70S**

Cloud vertical structure (CVS)

- Reduce dimensionality by using CVSs and cloud top phase classification
- A CVS is a combination of layers that contain cloud



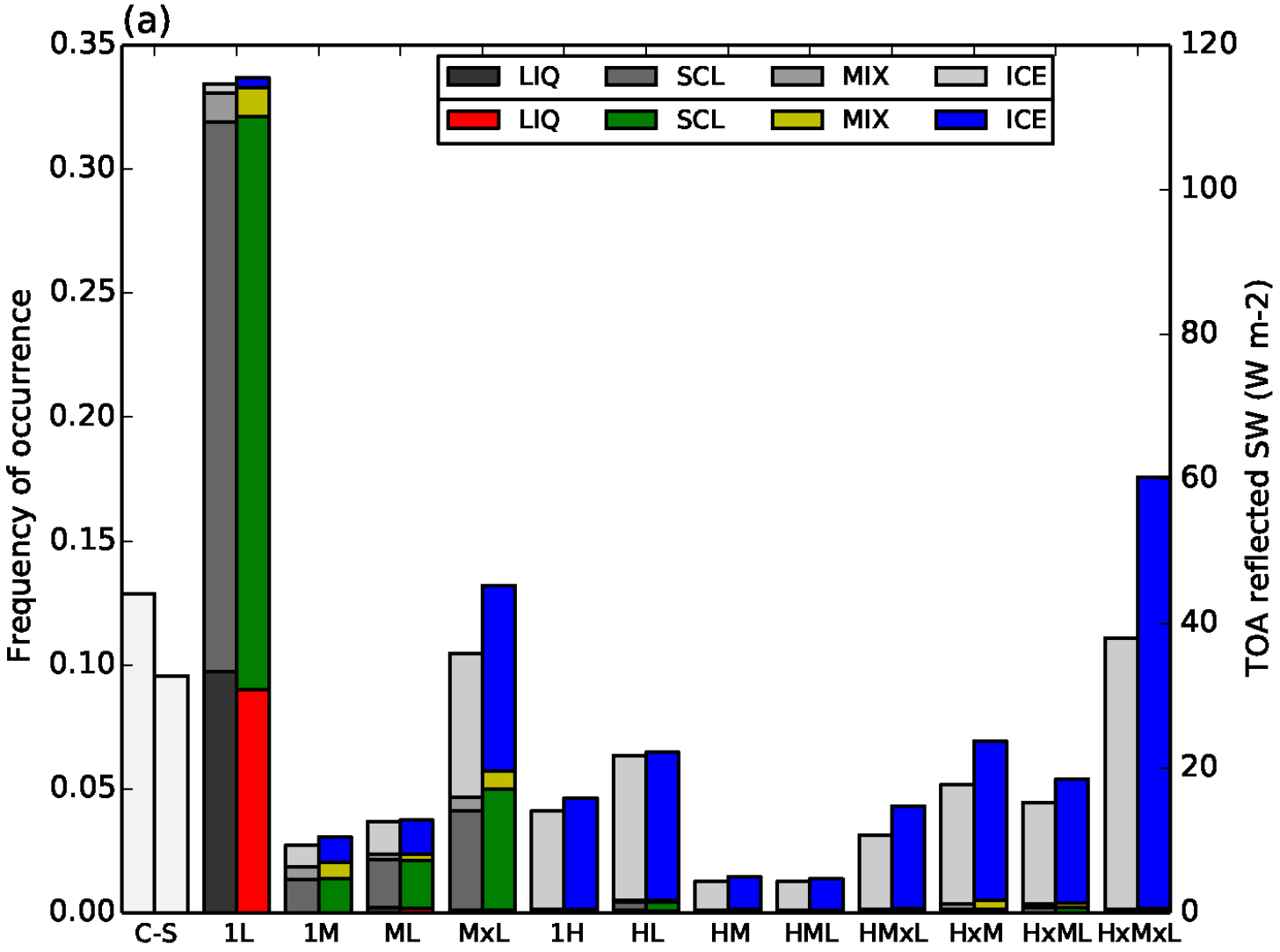
(After Tselioudis et al., *J. Climate,* 2013)

Contribution to TOA SW

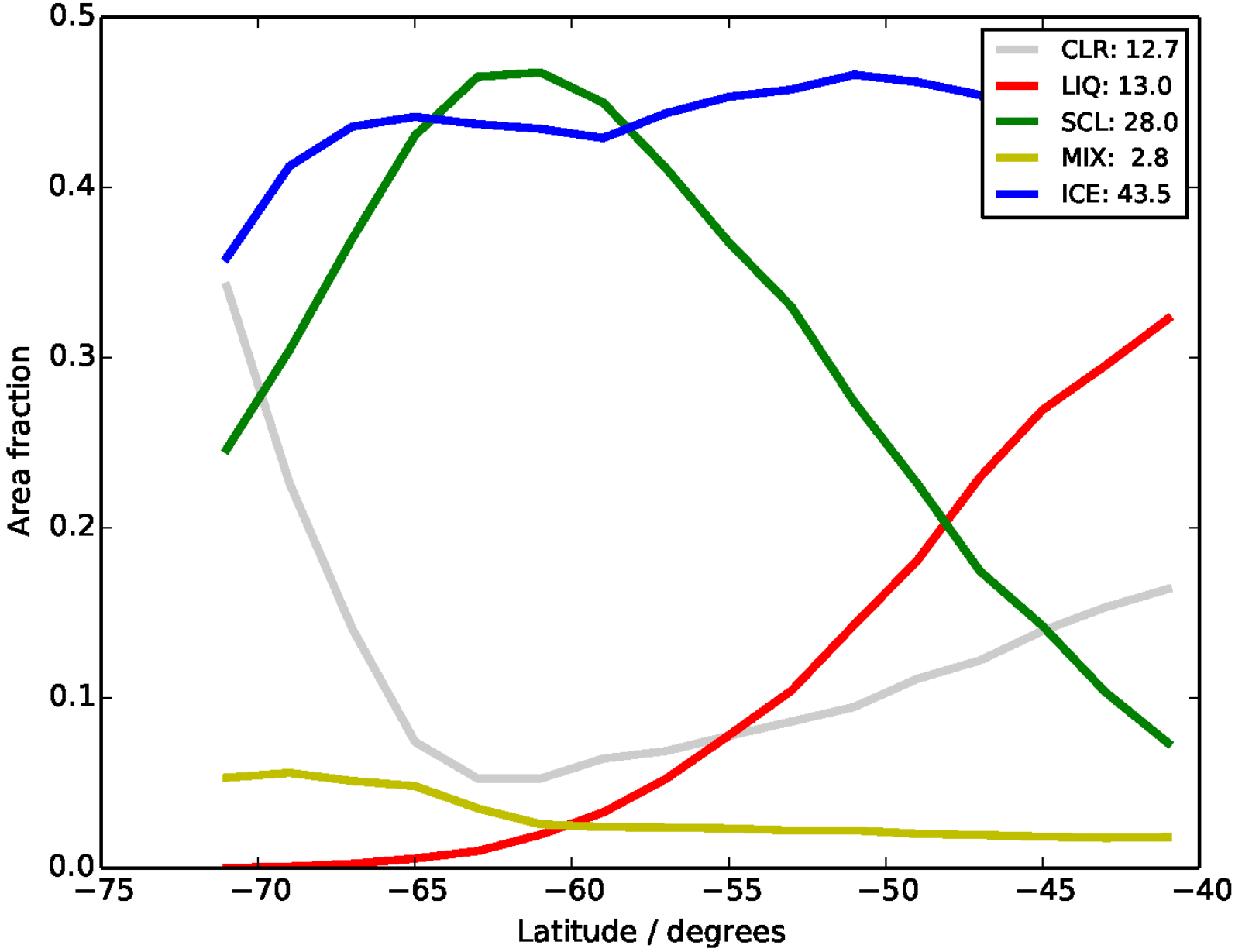
DJF, 40S to 70S

- L: ~30%
- M*: ~18%
- H*: ~43%

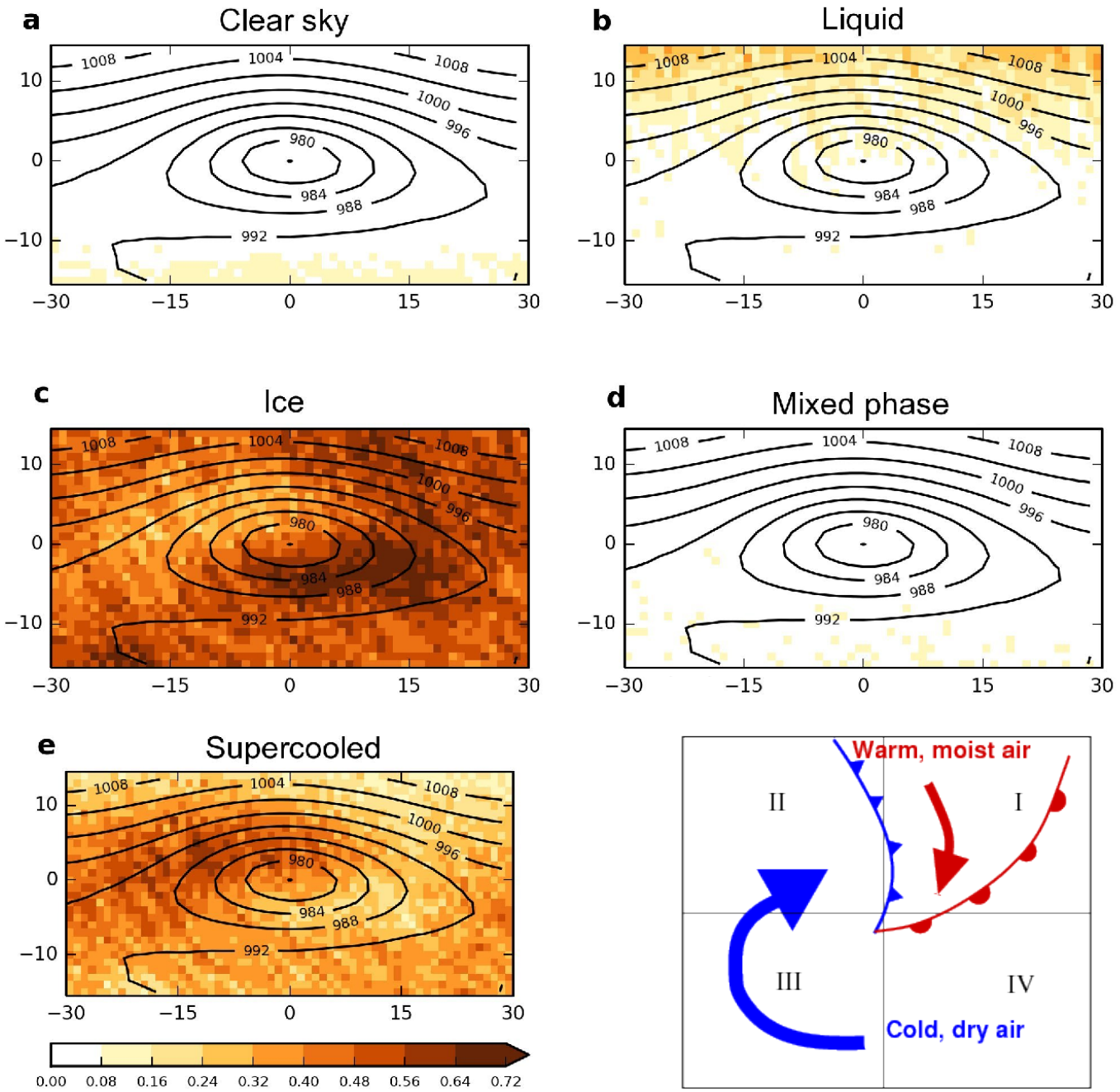
- ICE: 45%
- SCL: 30%
- LIQ: 11%
- MIX: 6%



(Bodas-Salcedo et al., *J. Climate*, 2016. DOI:10.1175/JCLI-D-15-0564.1)



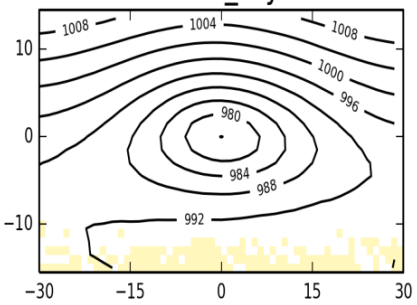
(Bodas-Salcedo et al., *J. Climate*, 2016. DOI:10.1175/JCLI-D-15-0564.1)



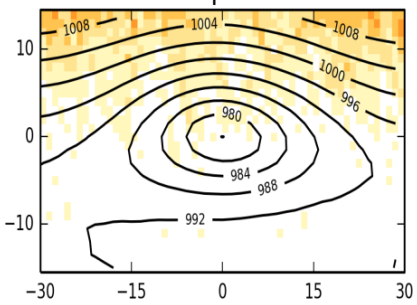
(Bodas-Salcedo et al., *J. Climate*, 2016. DOI:10.1175/JCLI-D-15-0564.1)

SH DJF

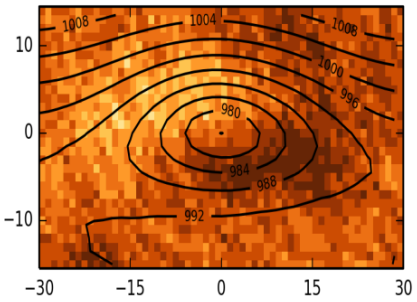
clear_sky



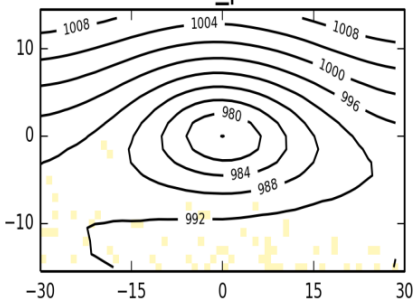
liquid



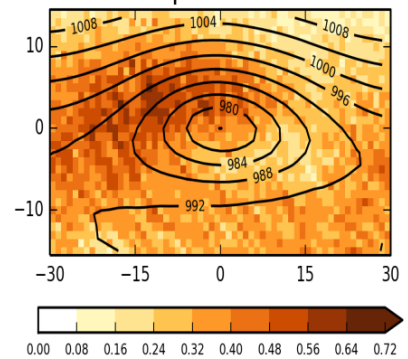
ice

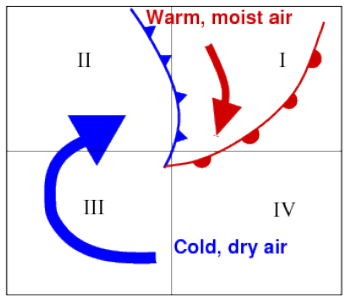


mixed_phase



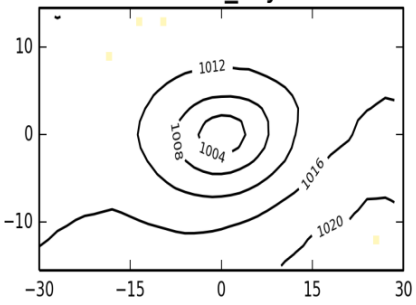
supercooled



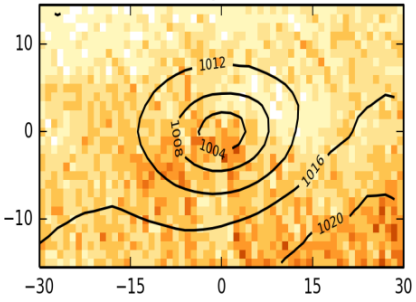


NH JJA

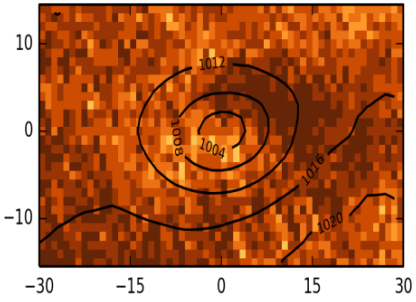
clear_sky



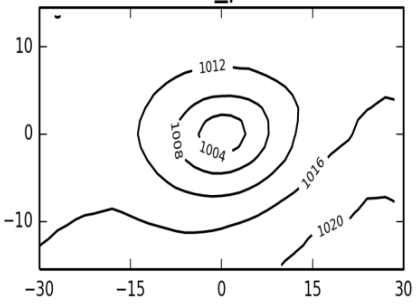
liquid



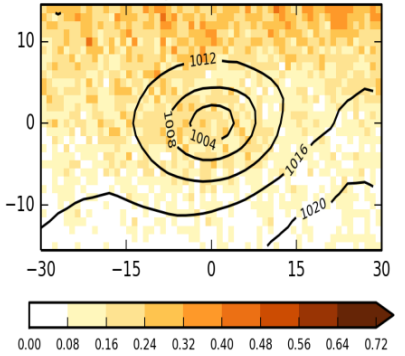
ice

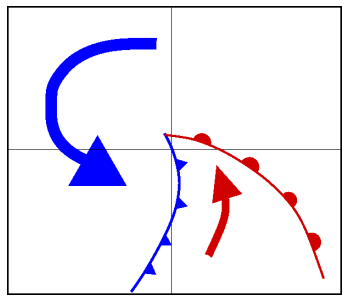


mixed_phase

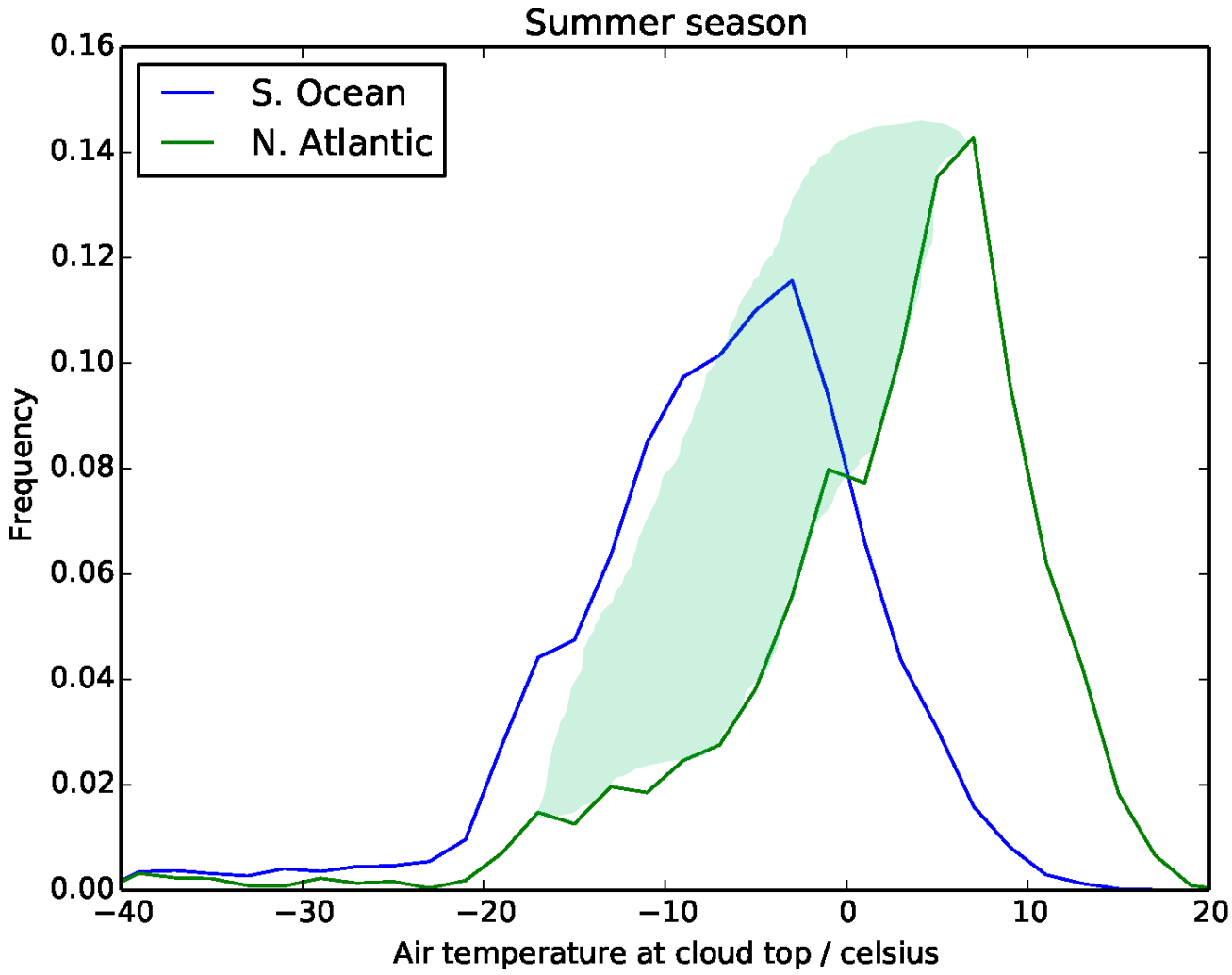


supercooled

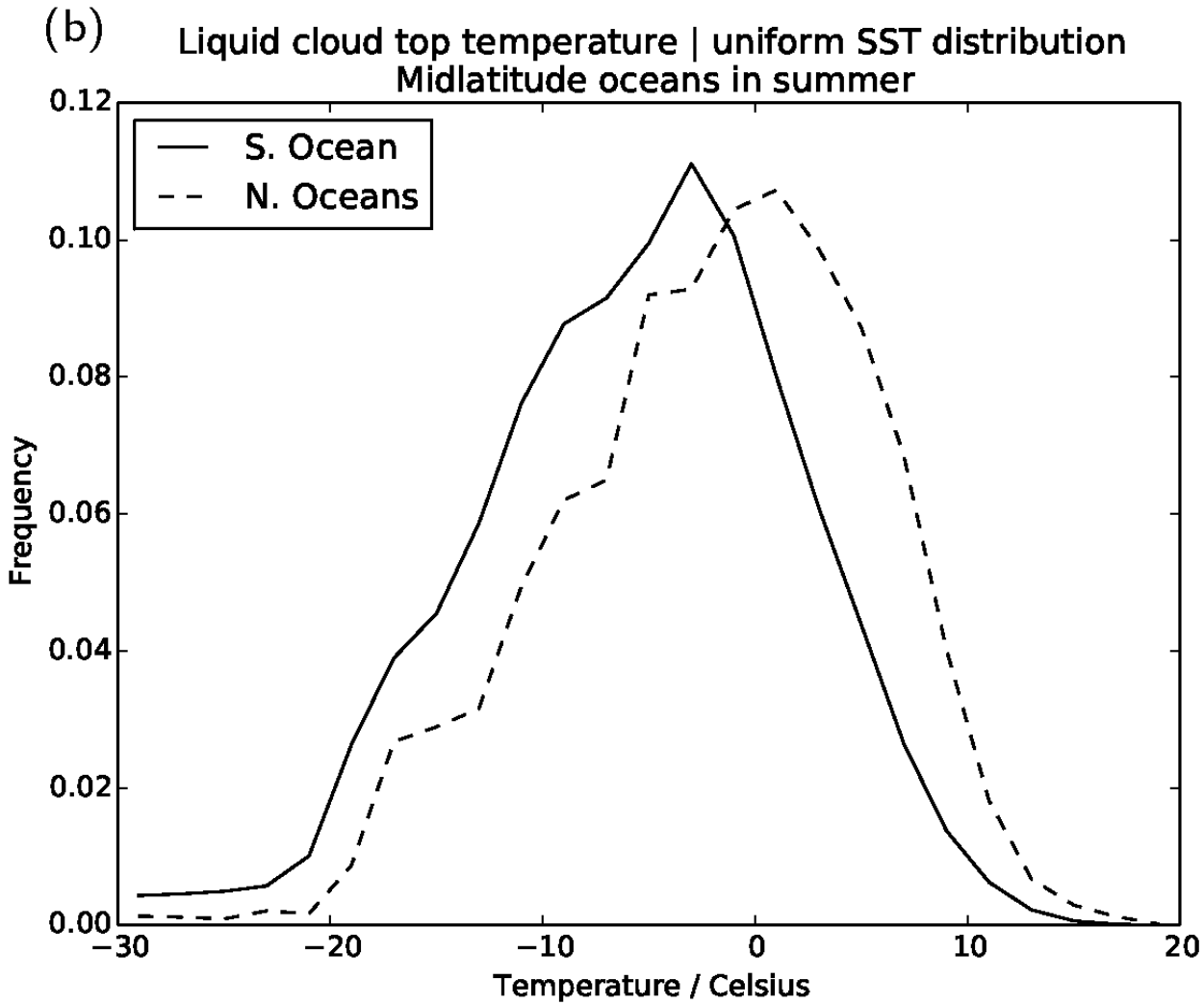




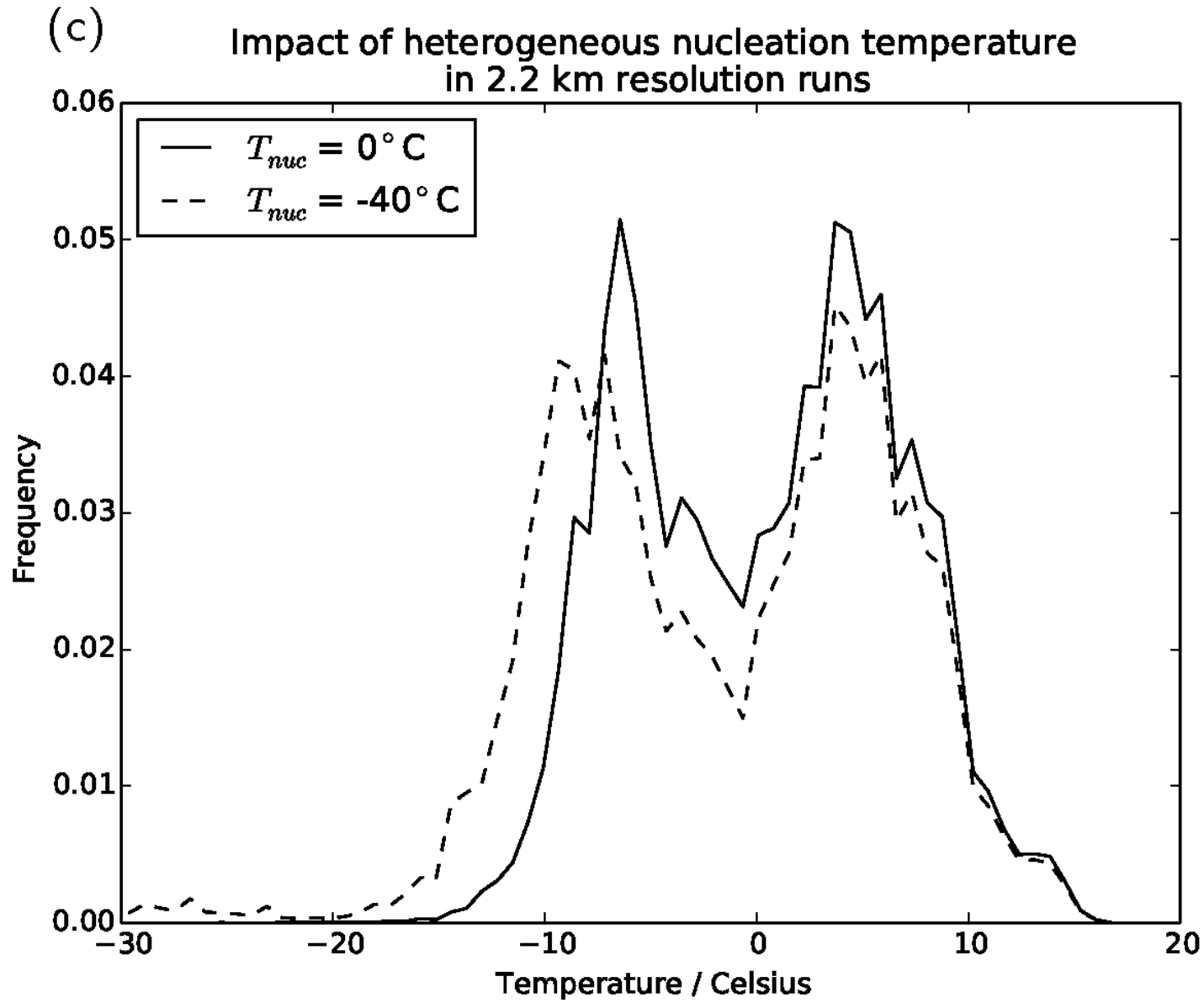
The North-South divide



What controls the N-S differences?



(Bodas-Salcedo et al., *J. Climate*, 2016. DOI:10.1175/JCLI-D-15-0564.1)



(Bodas-Salcedo et al., *J. Climate*, 2016. DOI:10.1175/JCLI-D-15-0564.1)

Summary

- Supercooled liquid clouds contribute 30% of the DJF TOA reflected SW.
- Supercooled liquid clouds are at the root of radiation biases in models.
- Need to improve representation of processes that control supercooled clouds.
- Strong negative SW feedbacks where supercooled liquid clouds dominate TOA radiation => negative feedbacks over the Southern Ocean may not be credible.

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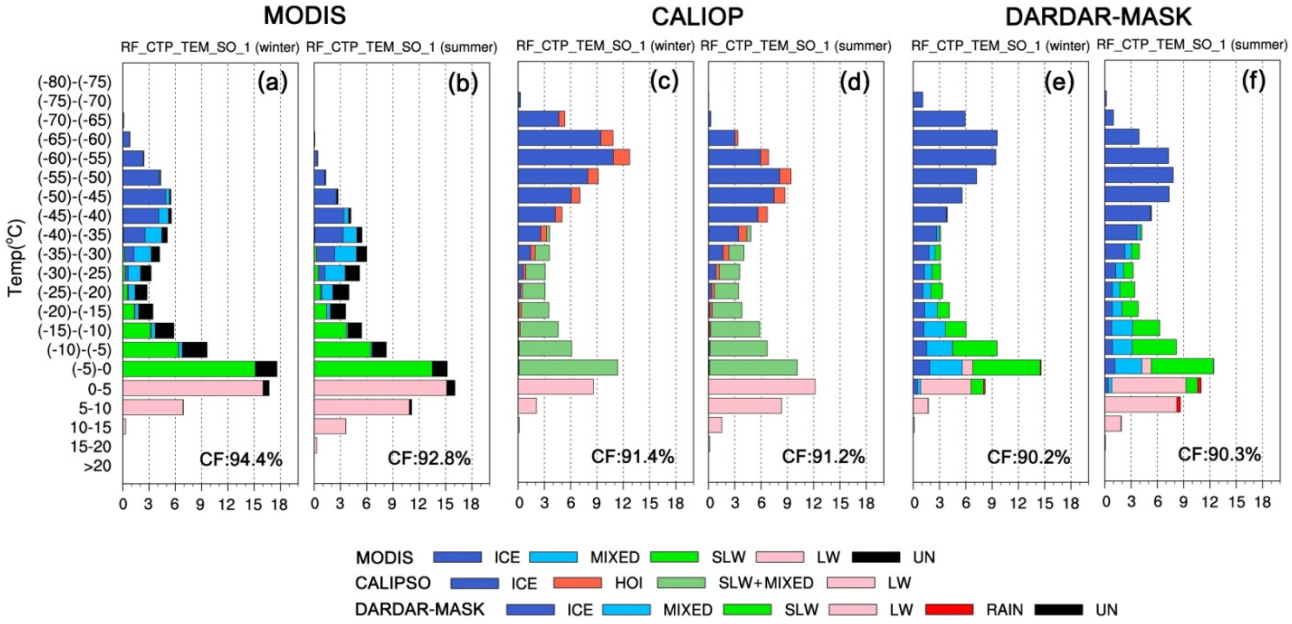
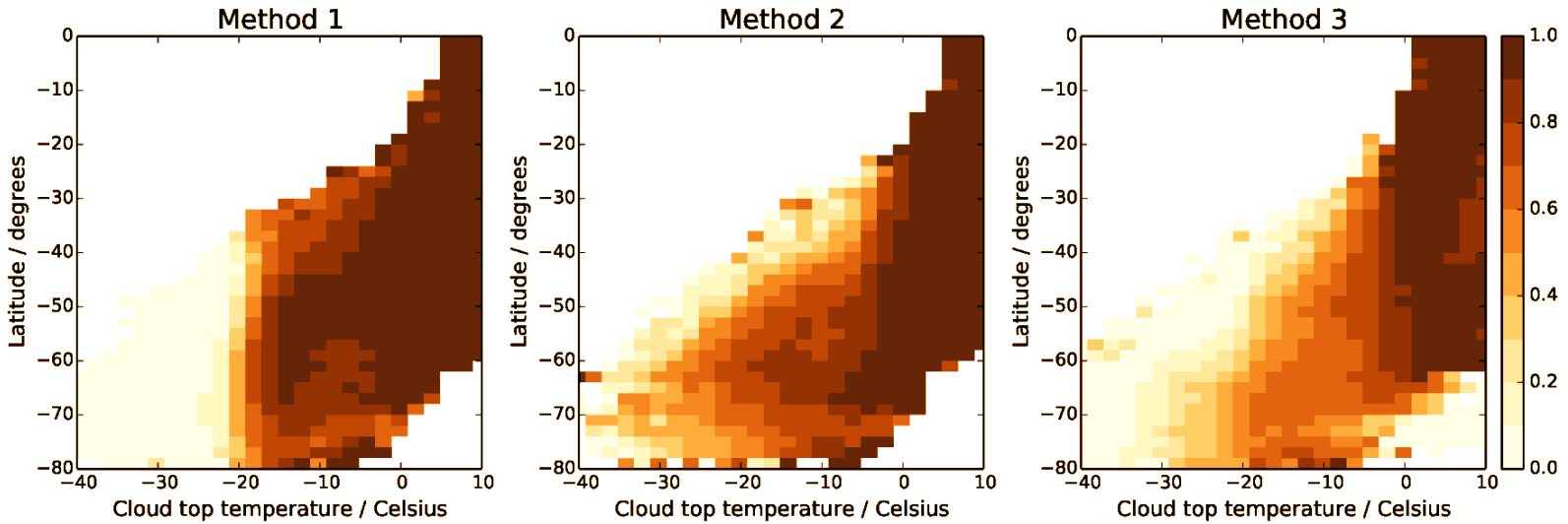
Thanks!

Cloud phase retrievals are uncertain

(Huang et al., *J. Climate*, 2015. DOI:10.1175/JCLI-D-14-00169.1)





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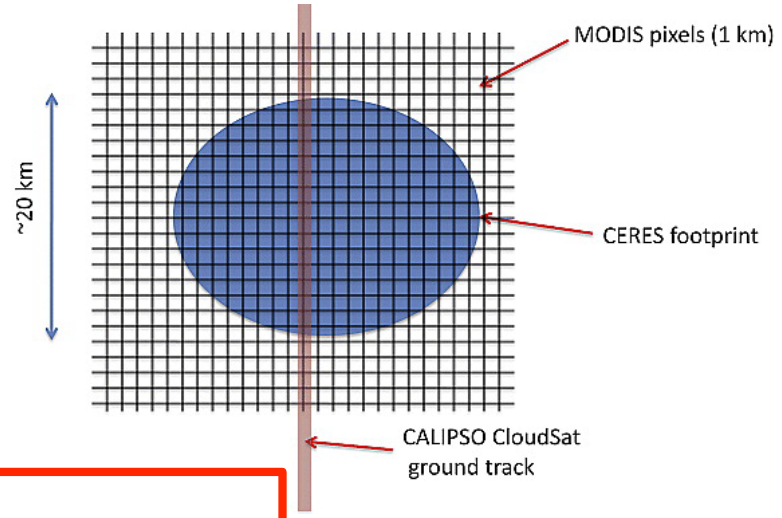
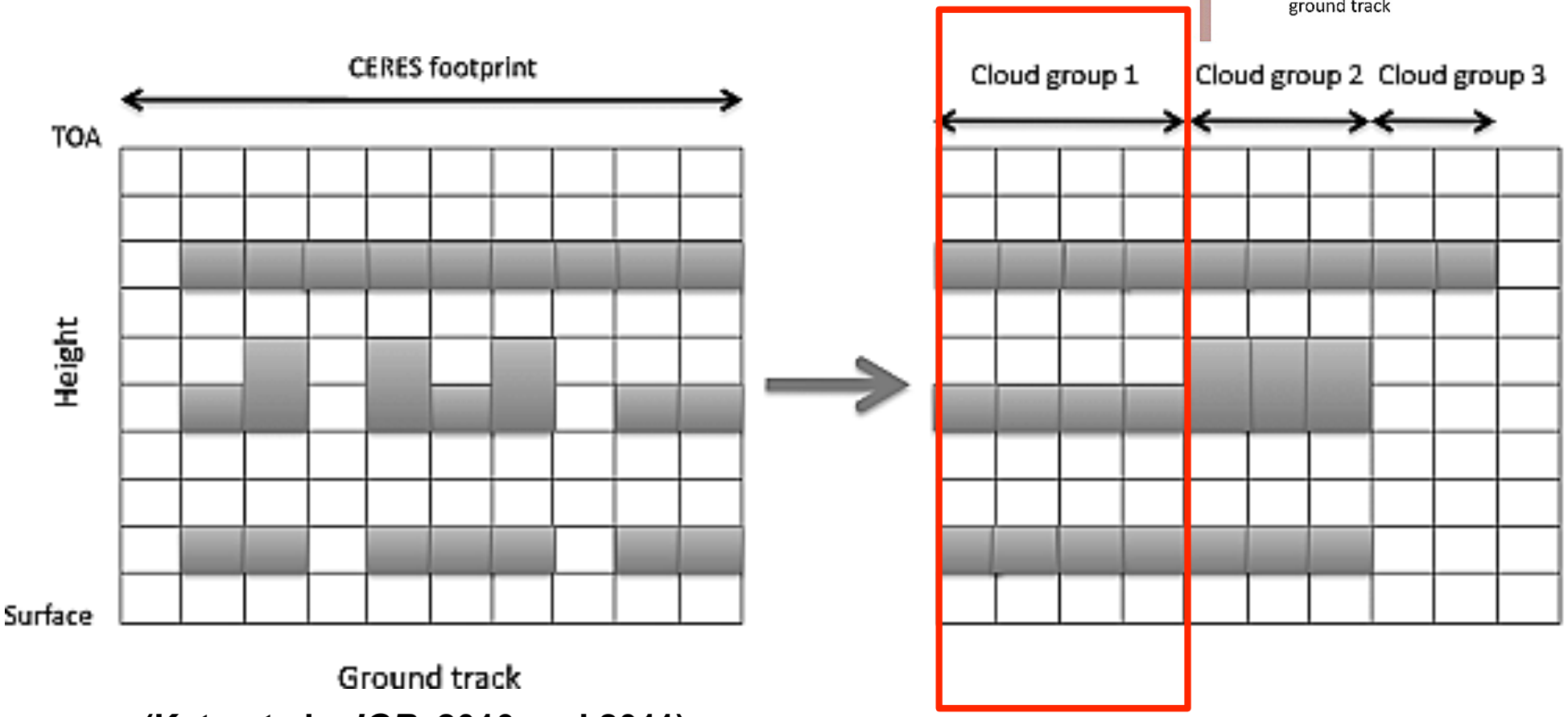
Methodology





(Kato et al., *JGR*, 2010 and 2011)

RT calculations

Evaluation of radiative transfer calculations

- 5 DJF seasons
- [40S, 70S]
- ~15 million profiles