The Southern Ocean radiation budget: the role of cloud phase and vertical structure

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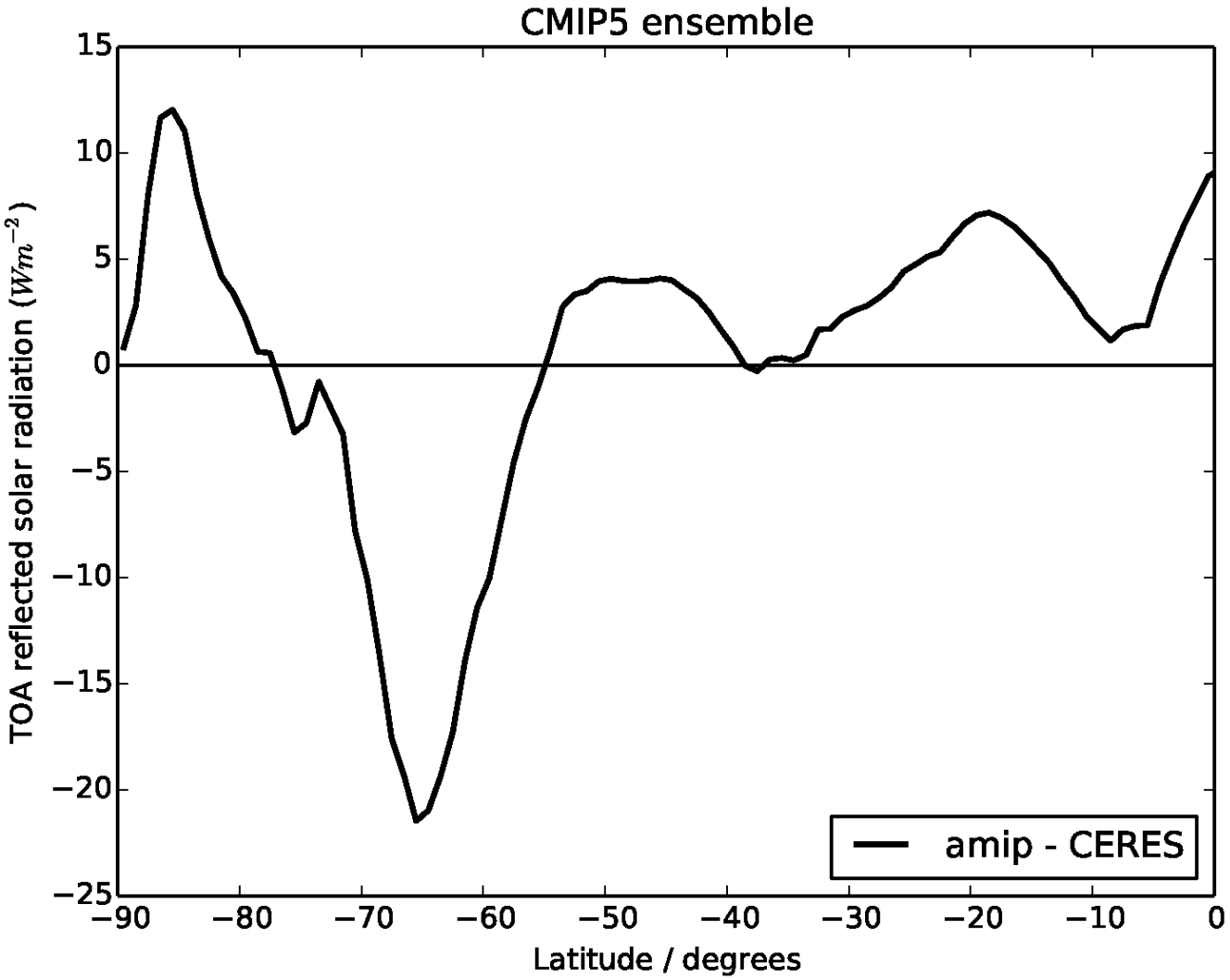
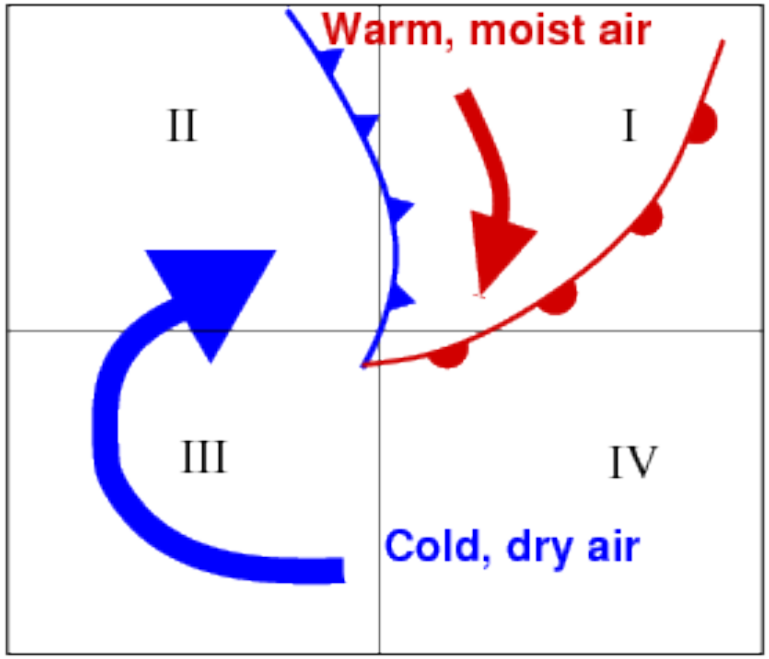
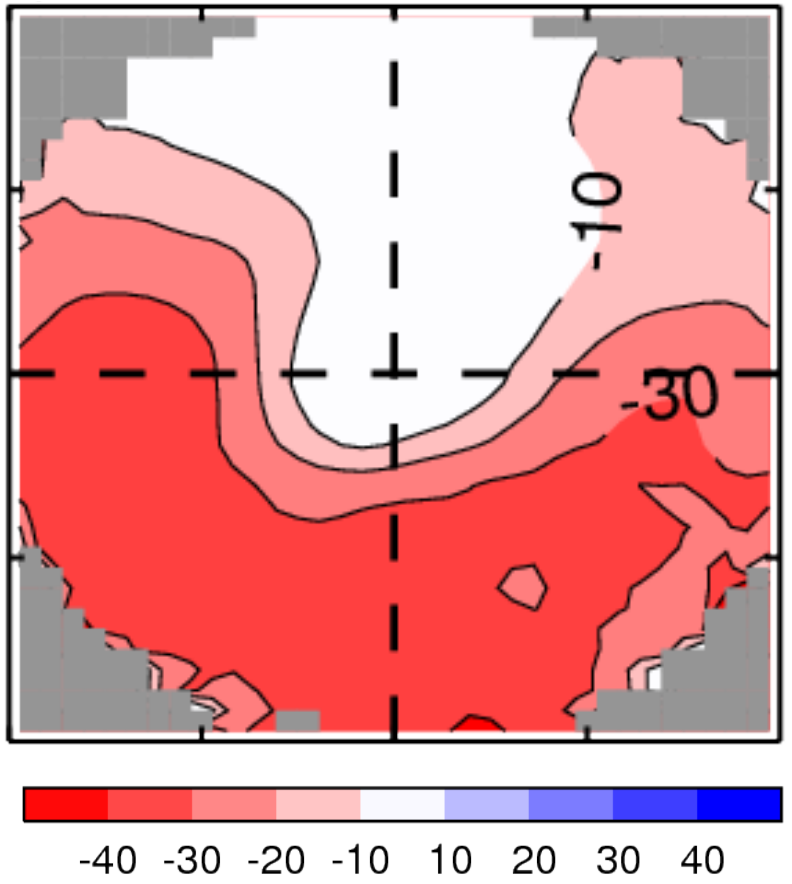
CFMIP meeting, 8-11 June 2015, Monterey, California

Large SW biases over the Southern Ocean



Which clouds contribute most to the error?





(Bodas-Salcedo et al., *J. Climate*, 2014)

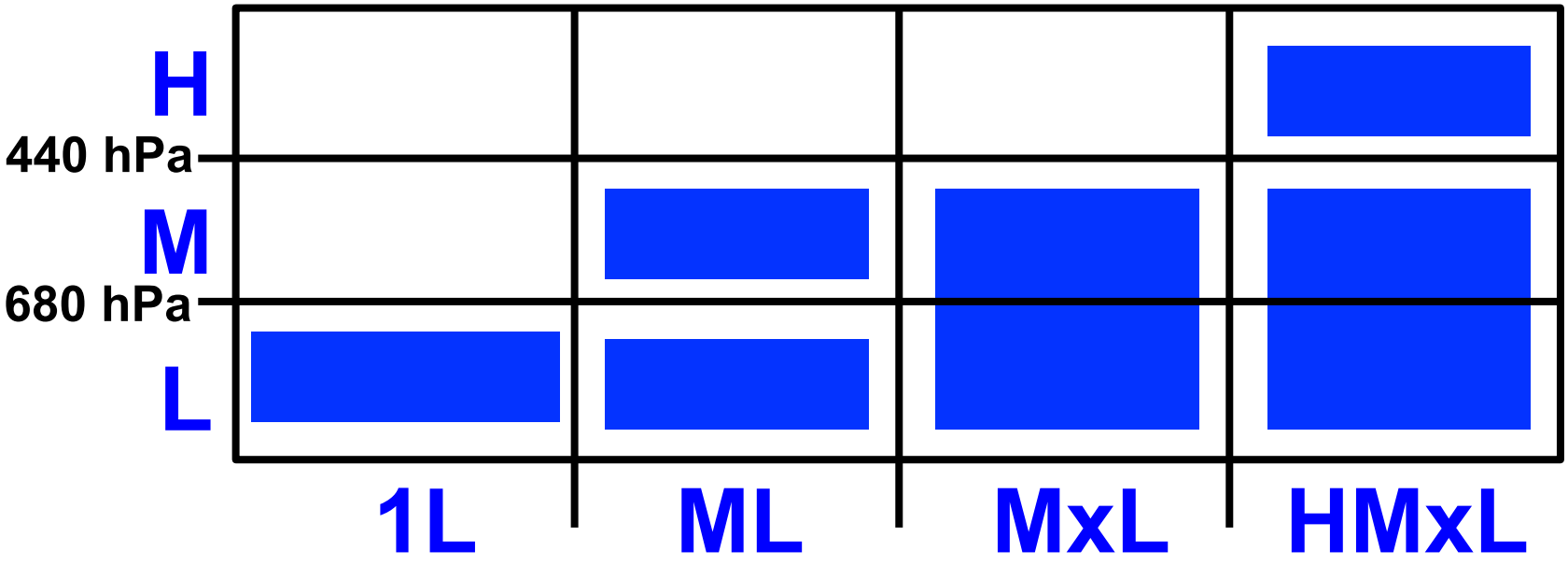
Methodology

RT calculations with full description of cloud vertical structure:

- **CERES/CloudSat/CALIPSO/MODIS (Kato, JGR, 2011)**
- **Edwards-Slingo RT code**
- **5 DJF seasons (2006-2010)**
- **40S to 70S**

Cloud vertical structure (CVS)

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



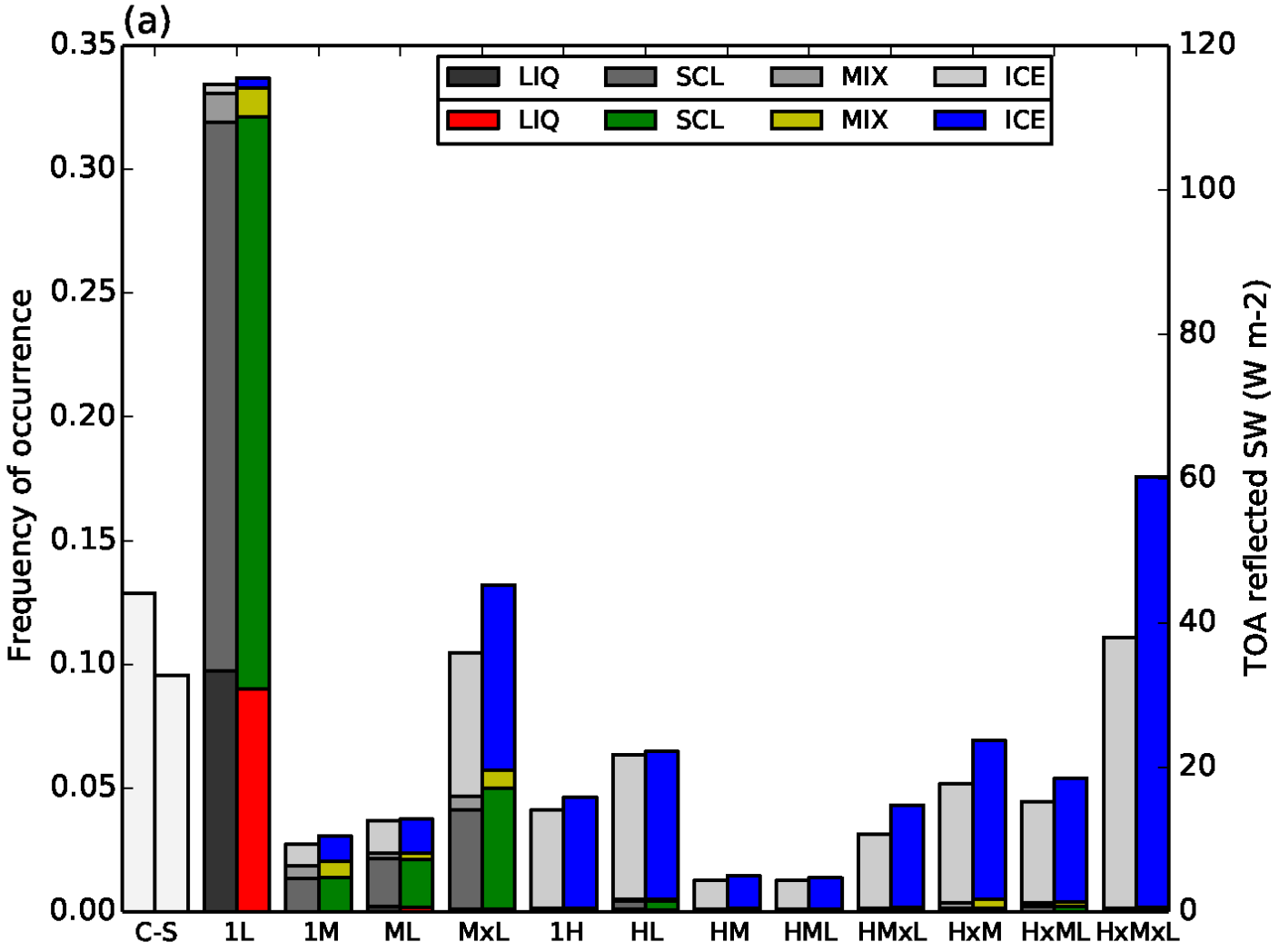
(After Tselioudis et al., *J. Climate,* 2013)

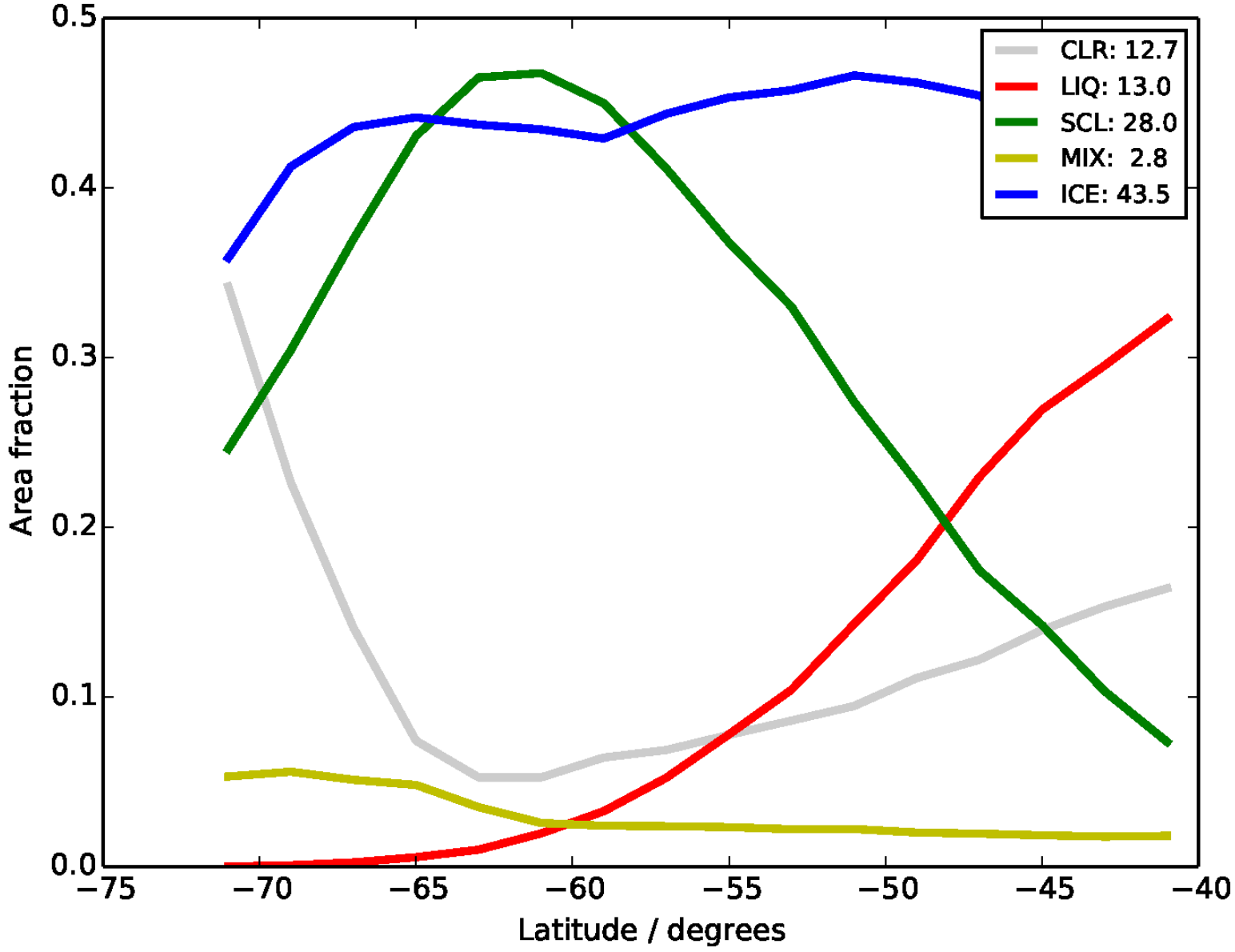
Contribution to TOA SW

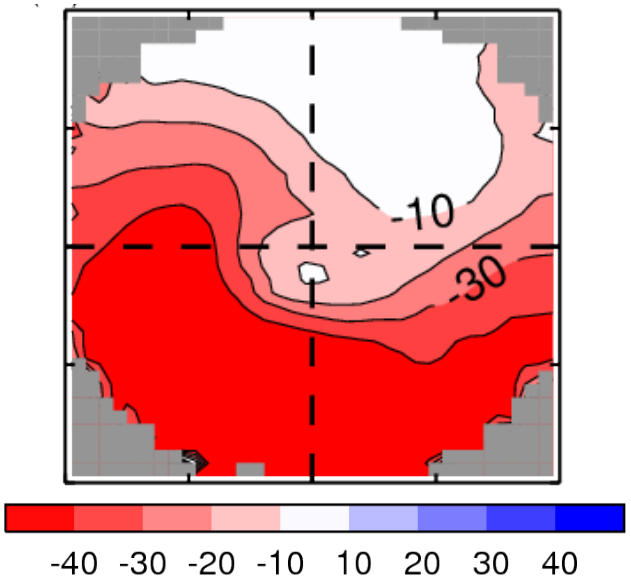
DJF, 40S to 70S

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

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

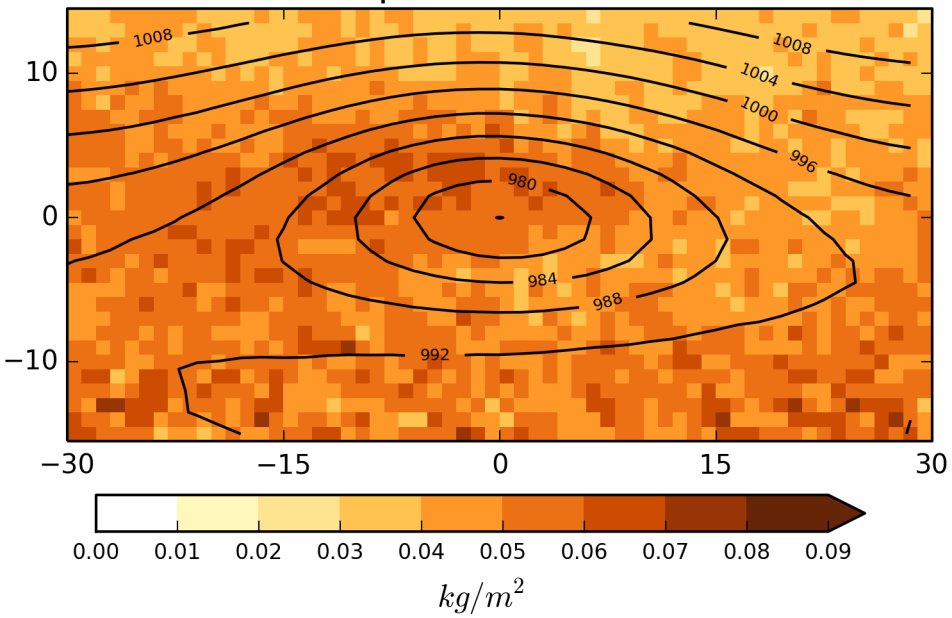






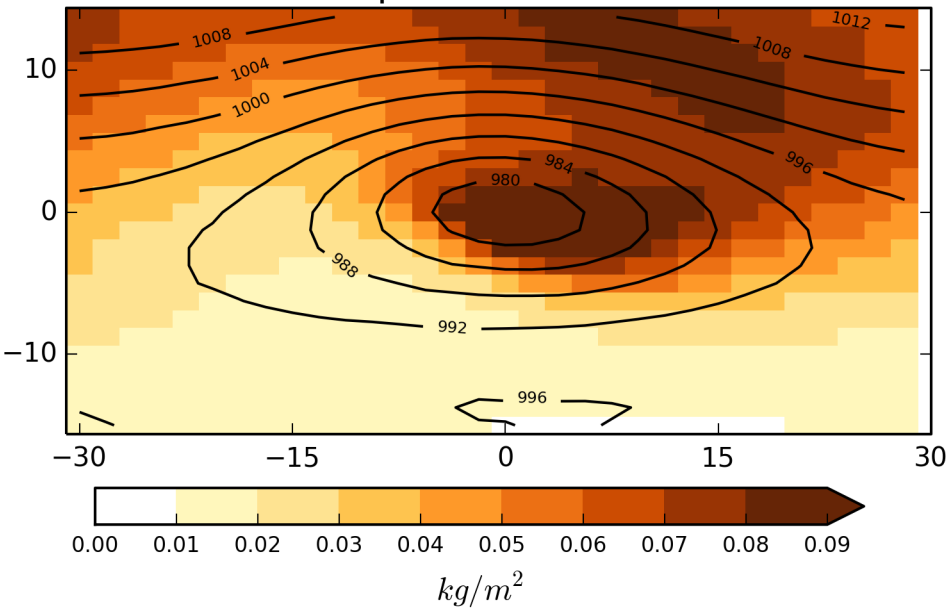
SH DJF - CCCM

Liquid Water Path

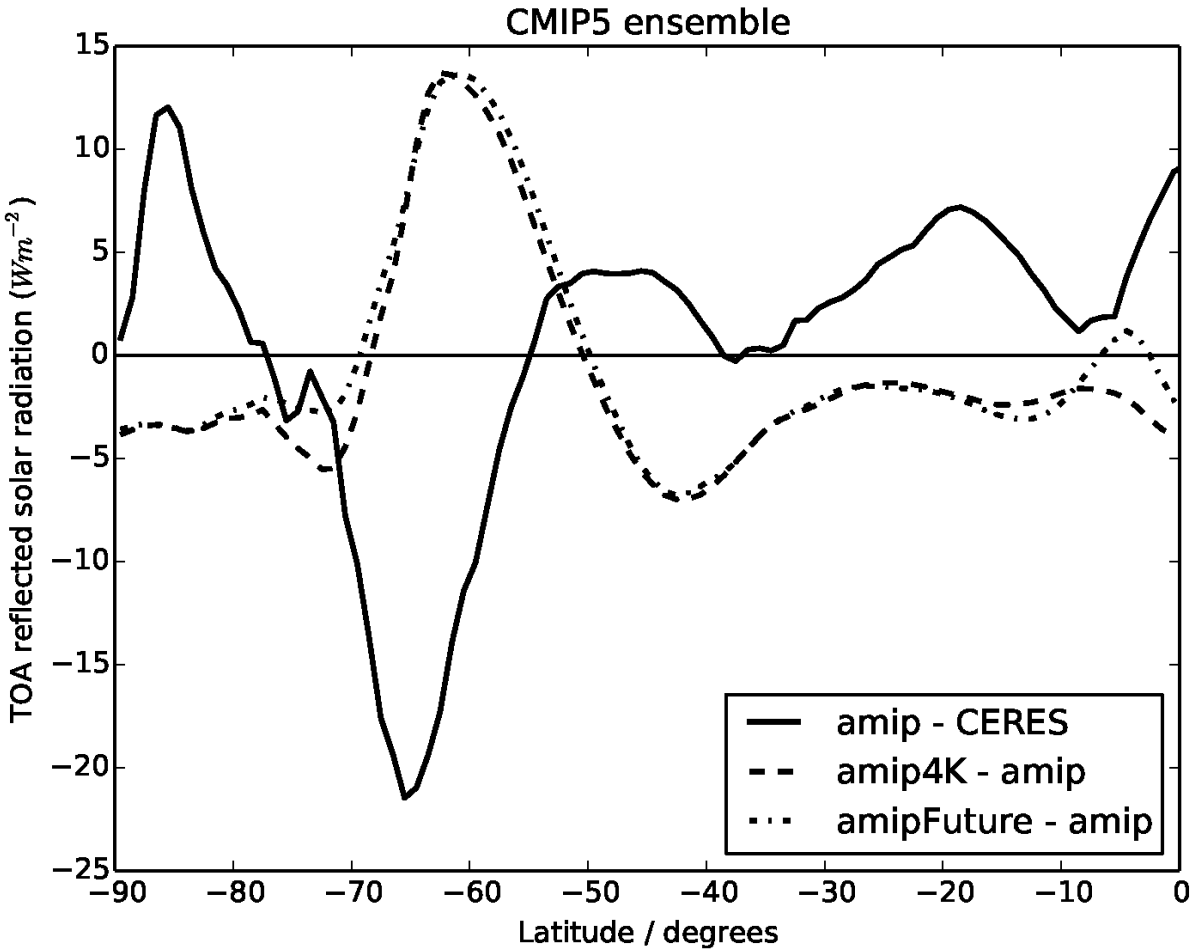


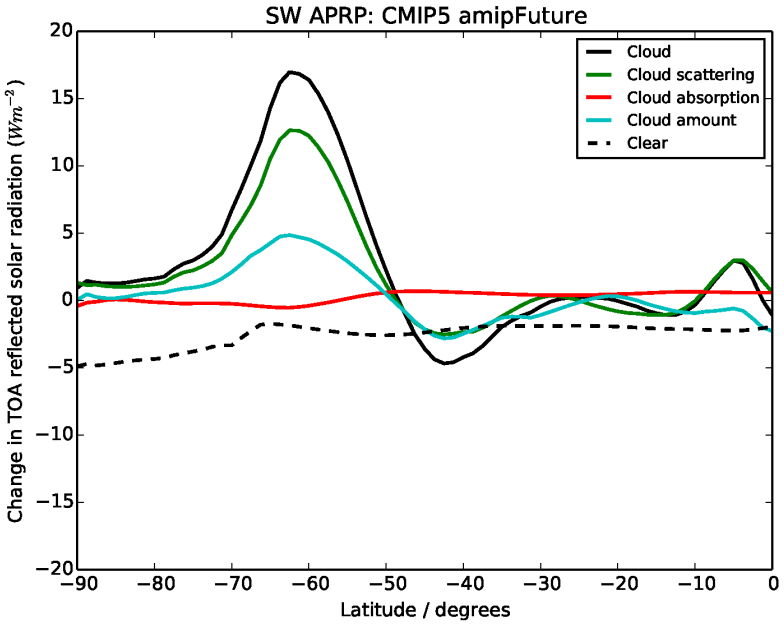
SH DJF - HadGEM2-A

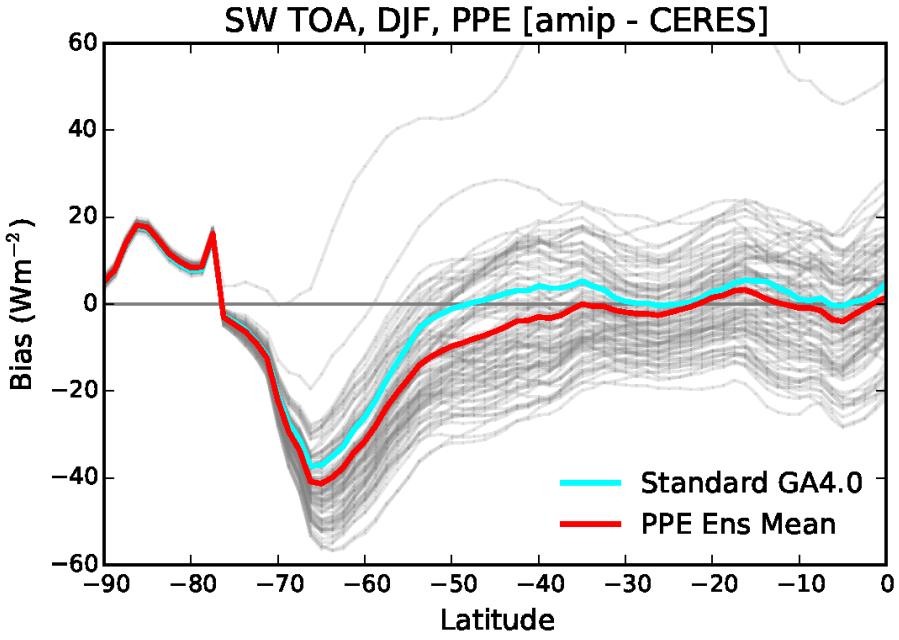
Liquid Water Path

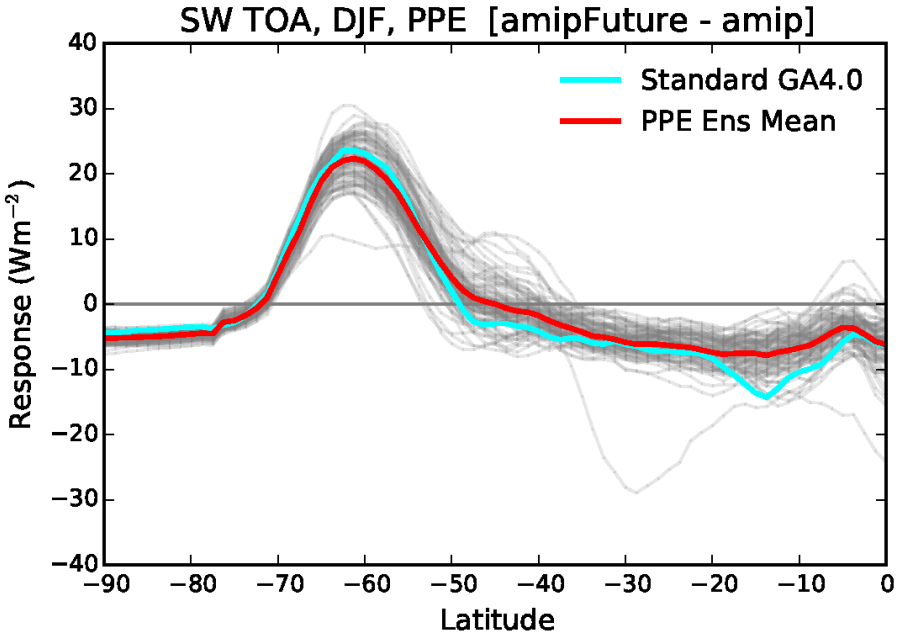


Negative SW feedback where large biases exist









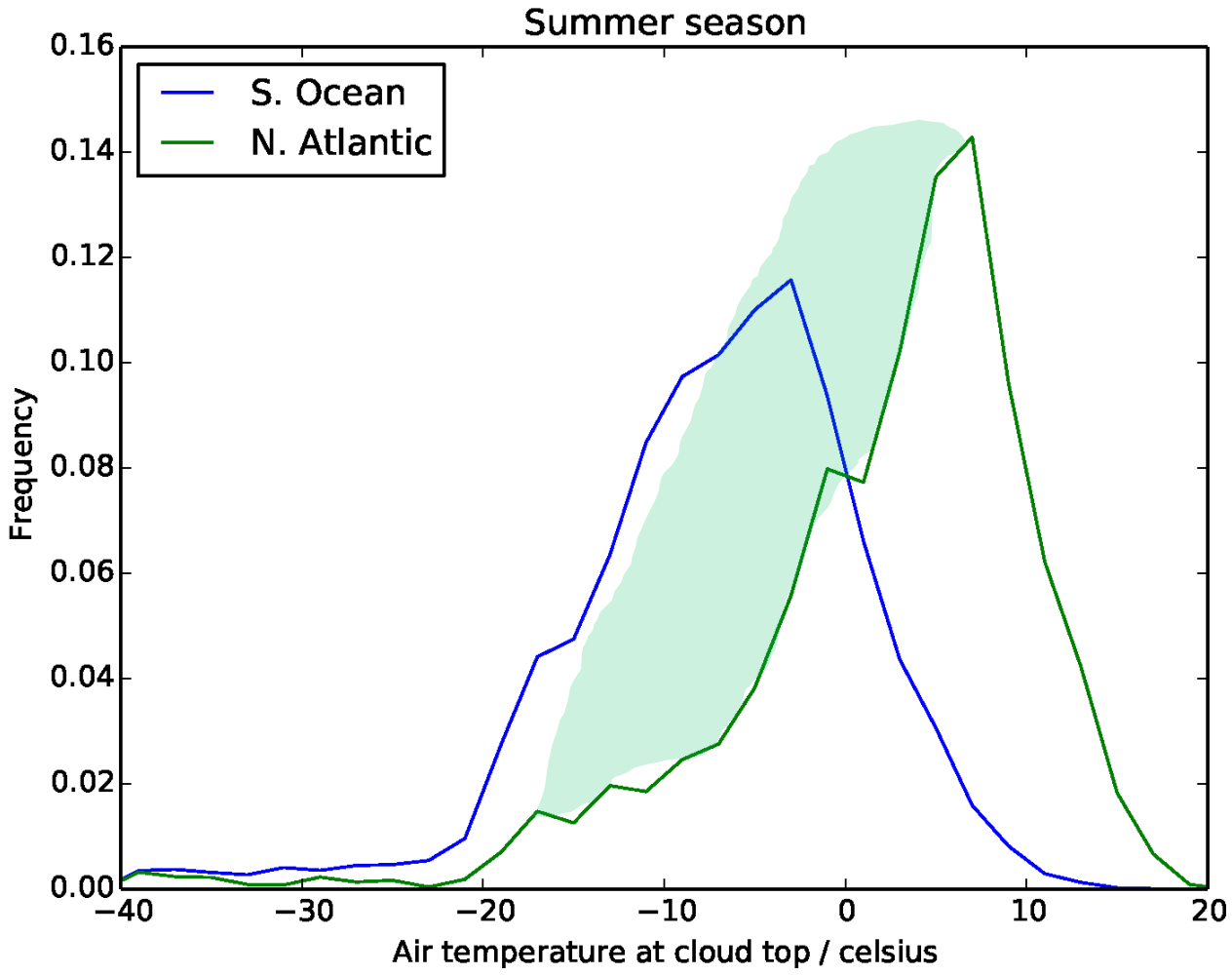
Summary

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

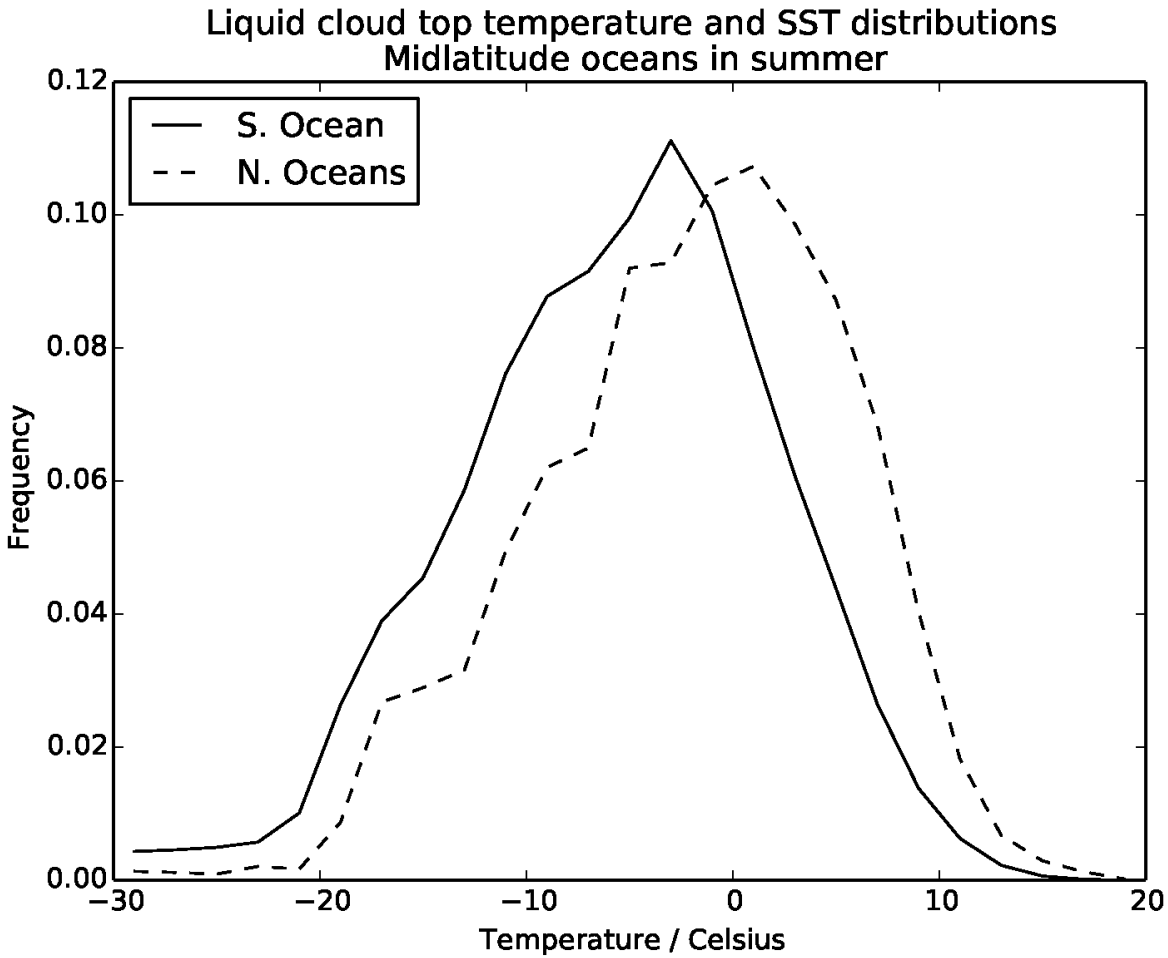
Met Office
Hadley Centre

Thanks!

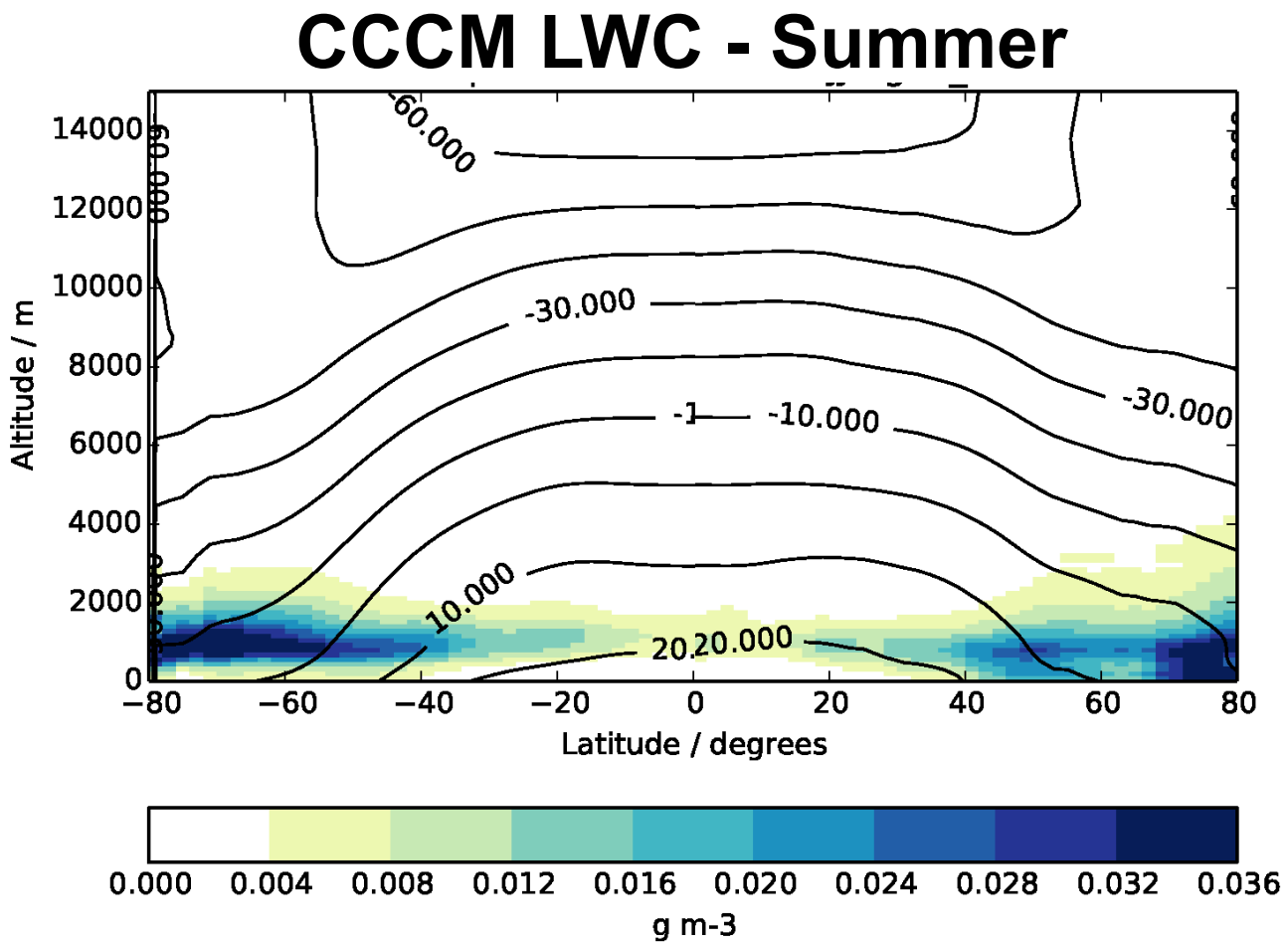
The North-South divide



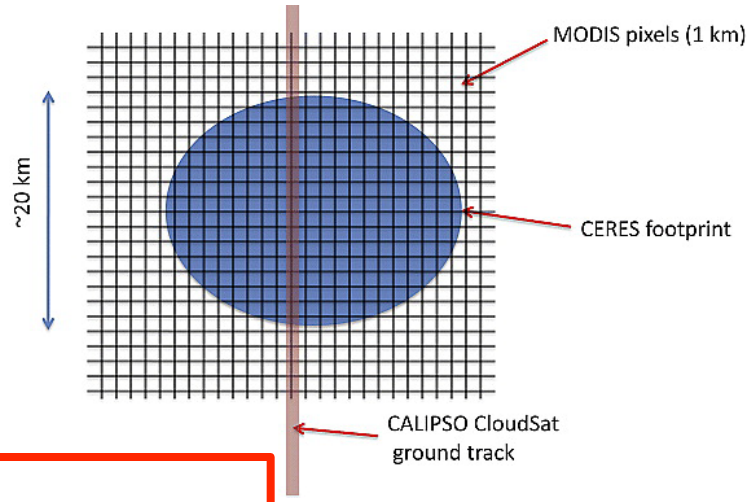
What controls the N-S differences?

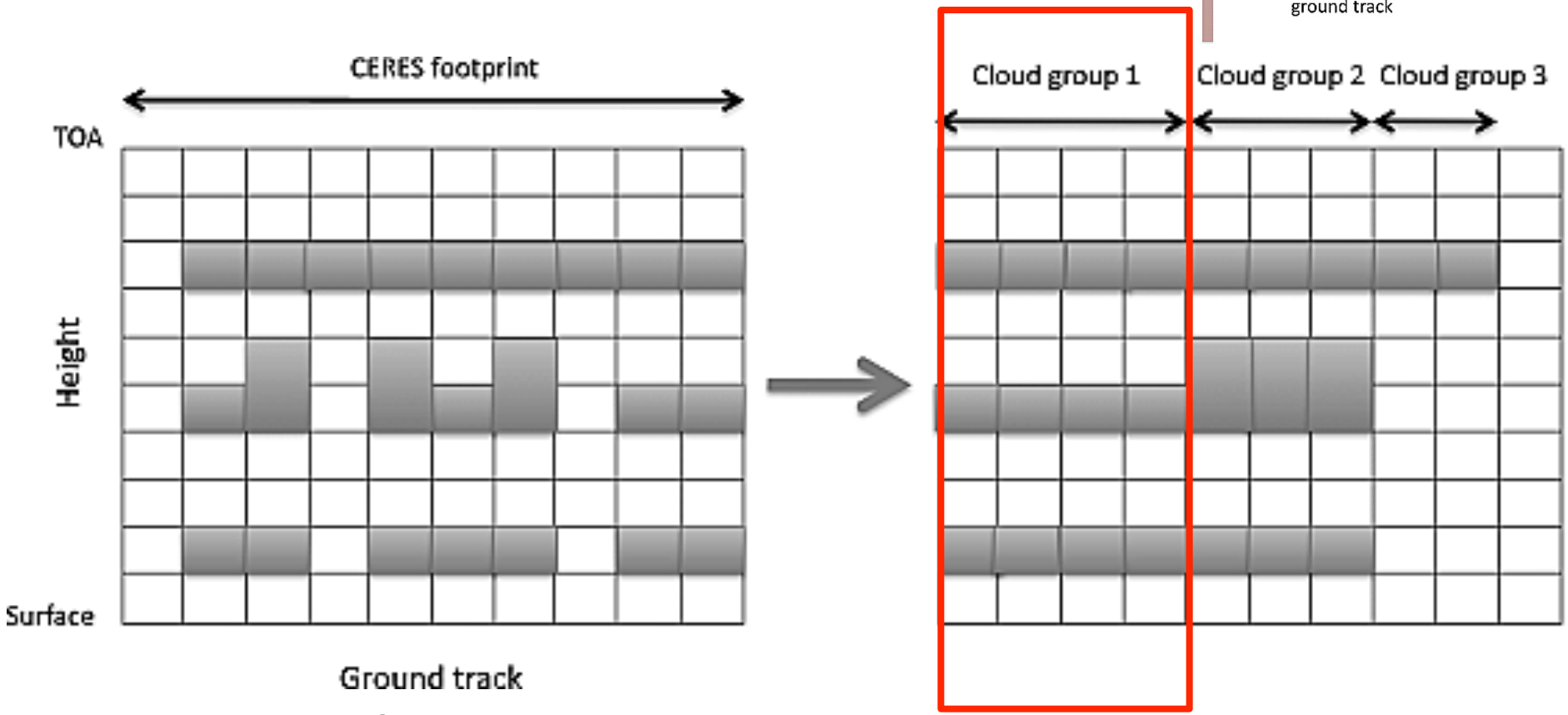


Is the Northern Hemisphere like the Southern Ocean?



Methodology



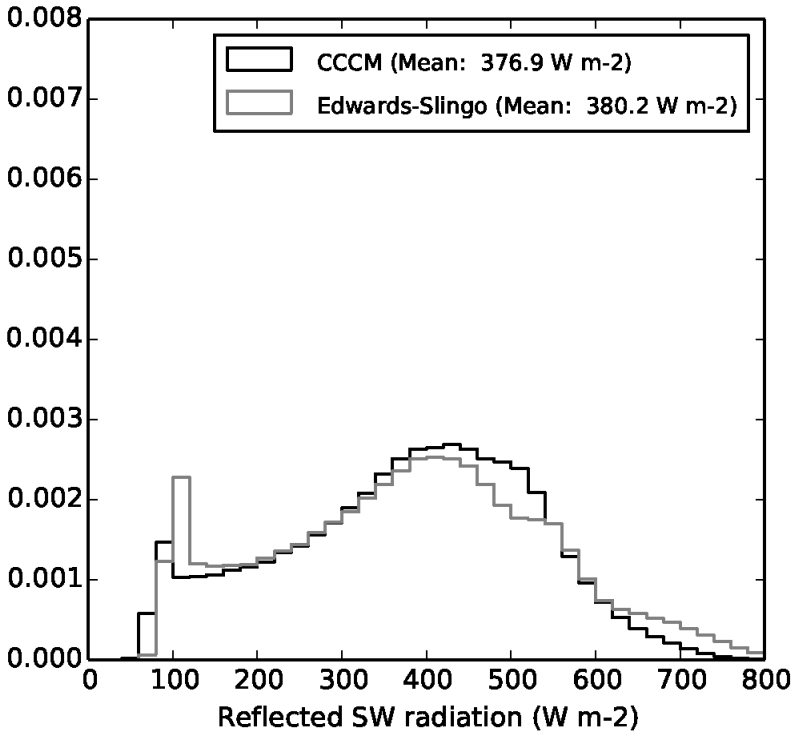


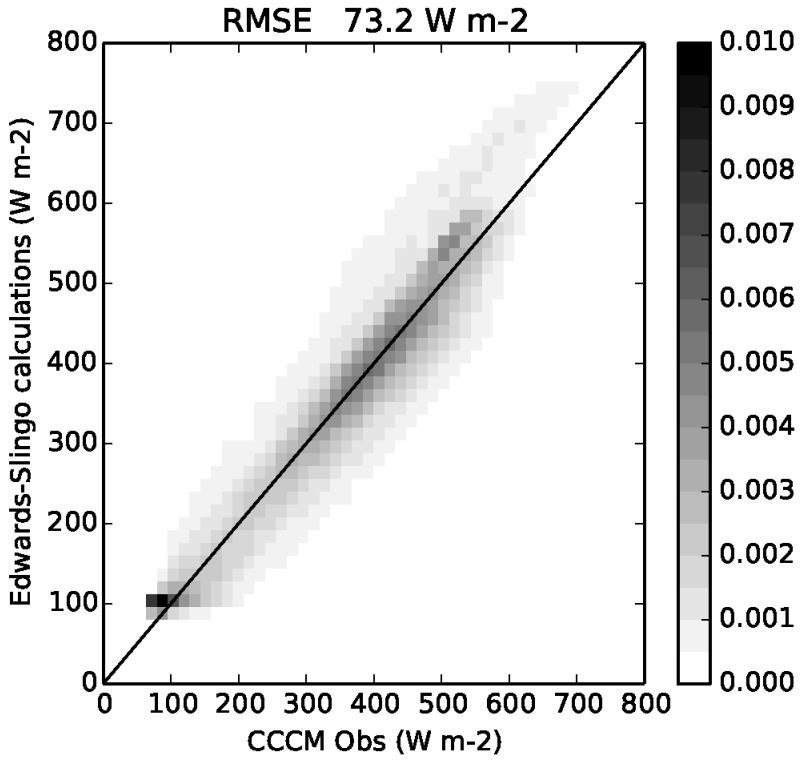
(Kato et al., *JGR*, 2010 and 2011)

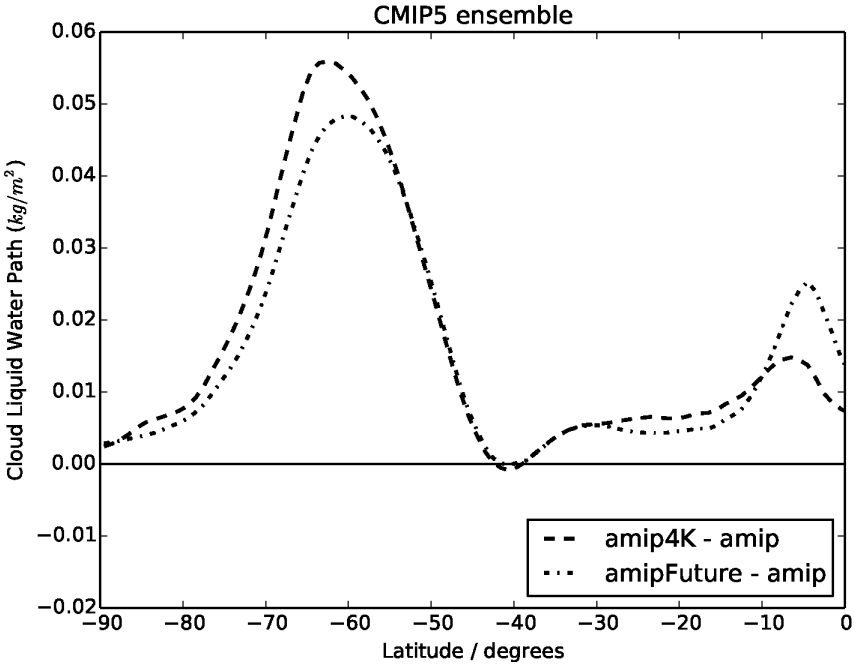
RT calculations

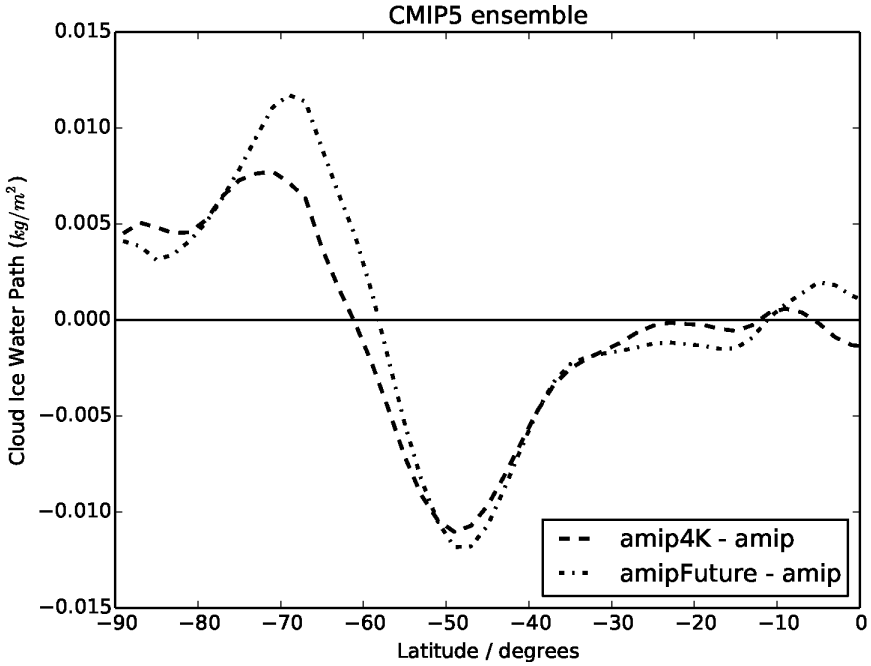
Evaluation of radiative transfer calculations

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



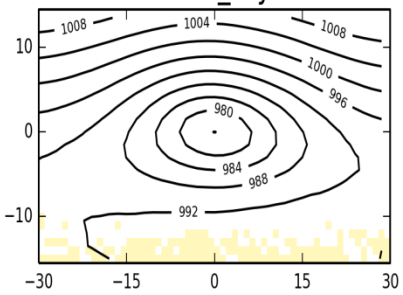




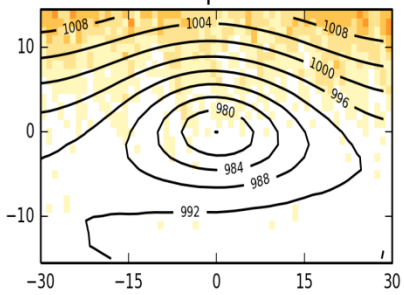


SH DJF

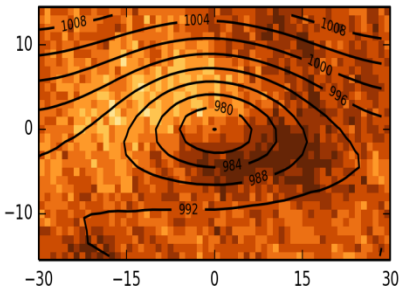
clear_sky



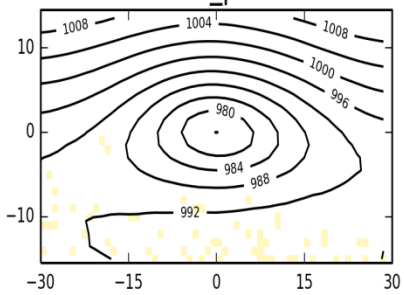
liquid



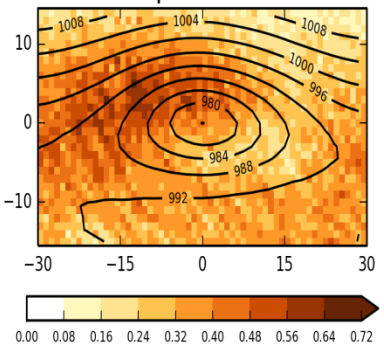
ice



mixed_phase

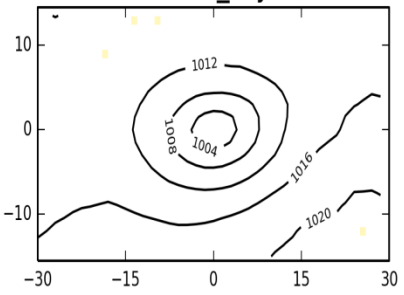


supercooled



NH JJA

clear_sky



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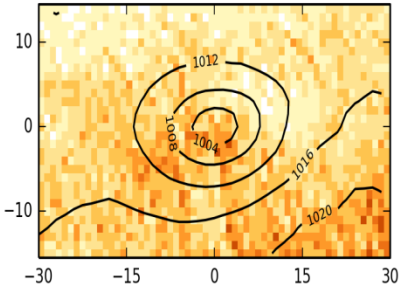

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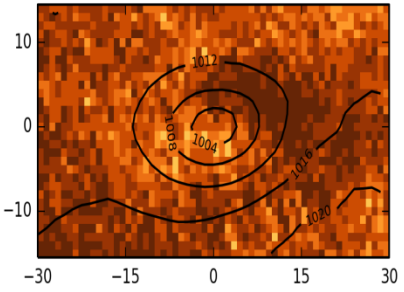

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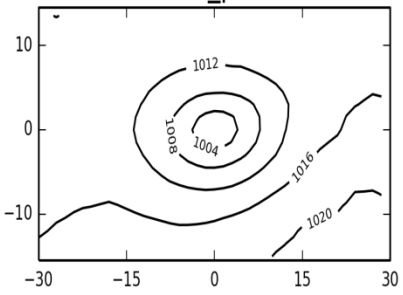

supercooled