Cloud liquid water path and radiative feedbacks over the Southern Ocean

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Cloud scattering dominates SW feedback

(Bodas-Salcedo et al., GRL, 2016. DOI: 10.1002/2016GL070770)
(Ceppi et al., *J. Climate*, 2016)
Total SW Cloud Feedback

(Also: Tselioudis et al., J. Climate, 1992; Gordon and Klein, JGR, 2014; Ceppi et al., GRL, 2016)
ISCCP regimes and cyclone composites

(Bodas-Salcedo et al., *J. Climate*, 2012)
\(\Delta \text{NetSW amip4K-amip}\)
\(\Delta \text{LWP amip4K-amip}\)
\(\Delta \ln(\text{LWP})\)
Potential role of biases in the control climate

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

(Bodas-Salcedo et al., J. Climate, 2016)
- L: ~30%
- M*: ~18%
- H*: ~43%

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

(Bodas-Salcedo et al., *J. Climate*, 2016)
Conclusions

• LWP and SW feedbacks depend on cloud type. The strength of the negative feedbacks in the midlatitudes will strongly depend on the LWP and cloud phase in the present-day climate.

• Strong negative SW feedbacks where supercooled liquid clouds dominate TOA radiation => negative feedbacks over the Southern Ocean may be overestimated (e.g. Tan et al., Science, 2016; Terai et al, JGR, 2016).

• Supercooled liquid clouds contribute 30% of the DJF TOA reflected SW. At the root of radiation biases in models.

• Cloud-phase change may not be the only mechanism that contributes to SW feedbacks.
Future work

• Better characterisation of cloud phase.

• Observational estimates of LWP and absorbed SW radiation sensitivities by cloud type.

• Use of idealised simulations: separate the contribution of thermodynamic and microphysical feedbacks to the total feedback in the midlatitudes.

• Use methods that separate cloud types so that the mechanisms that control the LWP and radiative feedbacks are clearly decoupled.
Thanks!
Methodology

• Cyclone compositing (Field and Wood, J. Clim., 2007)
• ISCCP cloud regimes (Williams and Webb, Clim. Dyn., 2009)
• RT calculations:
  • C3M data (Kato et al., JGR, 2010 & 2011)
  • SOCRATES RT code
  • 5 DJF seasons (2006-2010)
  • 40S to 70S
• Model experiments: amip, amip4K, amipFuture
Datasets

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

- Data from CMIP5: AMIP, amip4K, amipFuture
Bias in cold-air side correlates with climatological bias

![Bias in cold-air side correlates with climatological bias](image)
Evaluation of radiative transfer calculations

- 5 DJF seasons
- [40S, 70S]
- ~15 million profiles
(c) Impact of heterogeneous nucleation temperature in 2.2 km resolution runs

- $T_{nuc} = 0^\circ C$
- $T_{nuc} = -40^\circ C$
Temperature of liquid clouds over midlatitude oceans

- S. Ocean
- N. Oceans
- N. Atlantic
- N. Pacific

Air temperature at cloud top / celsius

Frequency

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(Bodas-Salcedo et al., J. Climate, 2016)
Liquid cloud top temperature | uniform SST distribution
Midlatitude oceans in summer

- S. Ocean
- N. Oceans

Temperature / Celsius

Frequency

(Bodas-Salcedo et al., *J. Climate*, 2016)
CCCM data + RT calculations

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