Supercooled liquid clouds and the Southern Ocean radiation budget

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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?

- Southern Ocean [40°S, 70°S]
- 7 DJF seasons

(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%

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

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

Summer season

Air temperature at cloud top / celsius

Frequency

S. Ocean

N. Atlantic
What controls the N-S differences?

(b) Liquid cloud top temperature | uniform SST distribution
Midlatitude oceans in summer

(Bodas-Salcedo et al., J. Climate, 2016. DOI:10.1175/JCLI-D-15-0564.1)
Impact of heterogeneous nucleation temperature in 2.2 km resolution runs

- $T_{\text{nuc}} = 0^\circ \text{C}$
- $T_{\text{nuc}} = -40^\circ \text{C}$
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.
Thanks!
Cloud phase retrievals are uncertain

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

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

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

RT calculations
Evaluation of radiative transfer calculations

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