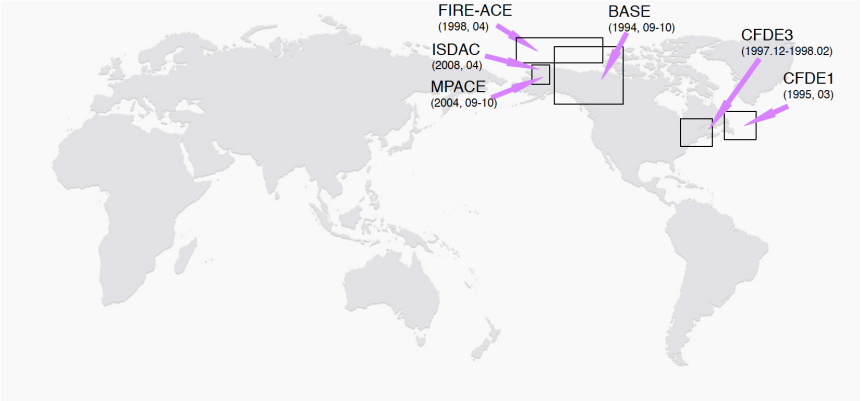
Pacific Northwest
NATIONAL LABORATORY

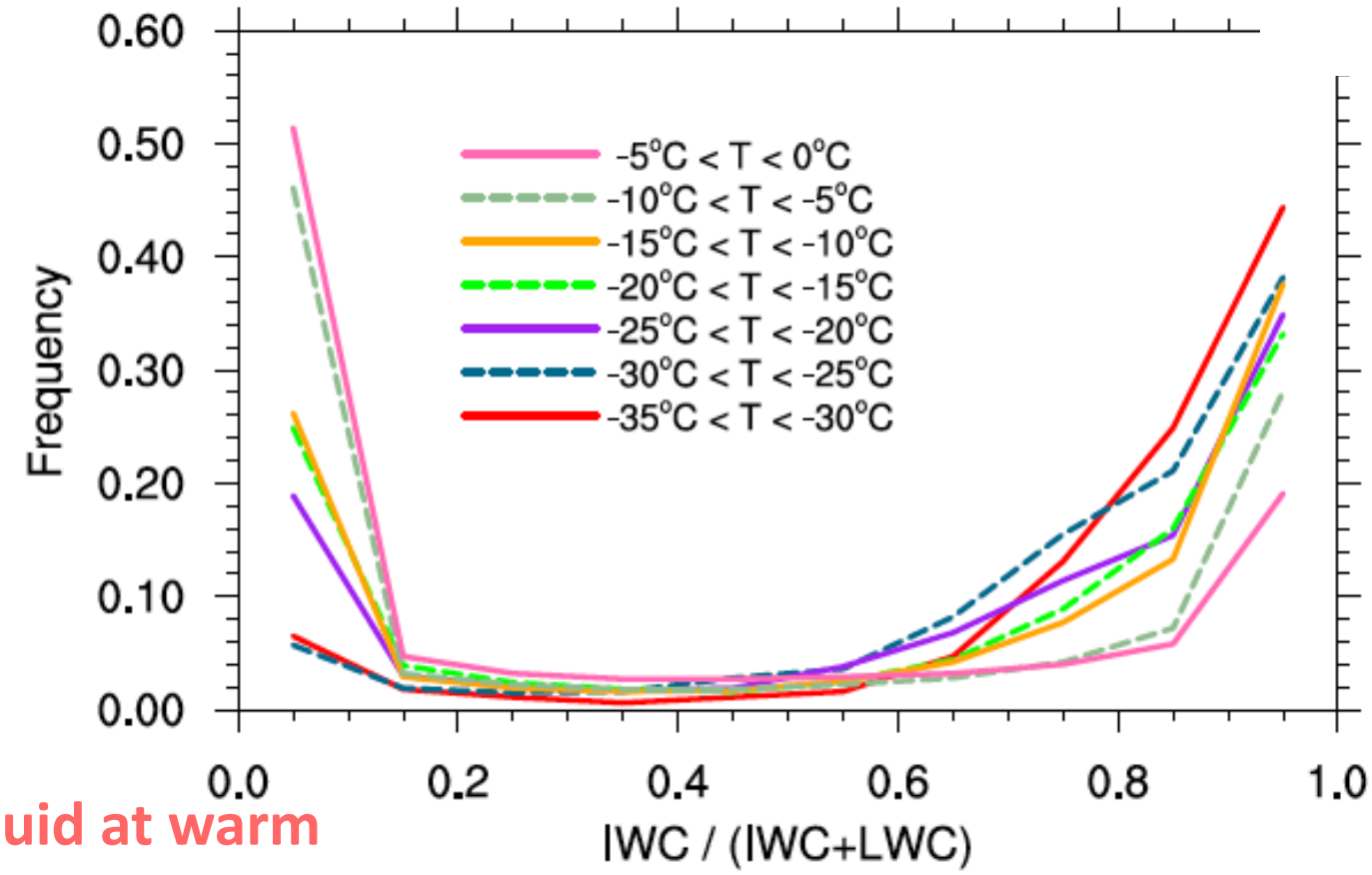
Cloud phase and downward LW flux in the Arctic

Kai Zhang and the EAMv1 development team

Cloud Phase – Ice Mass Fraction



Aircraft Observation

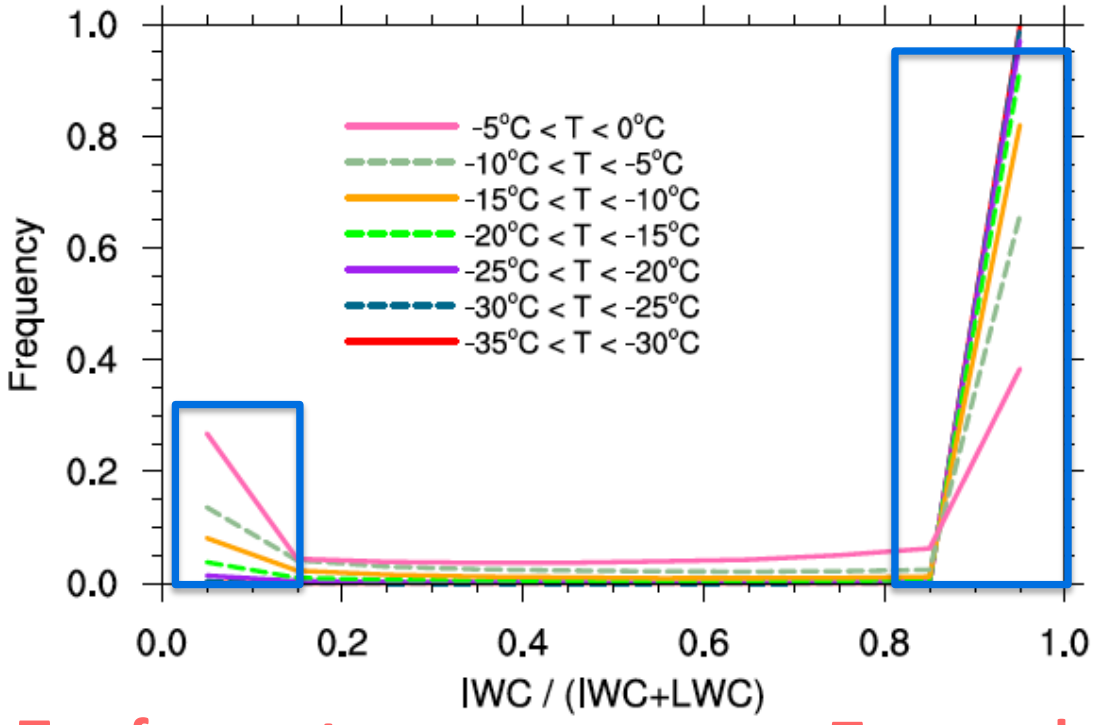


More ice at cold temperatures

More liquid at warm temperatures

Cloud Phase – Ice Mass Fraction

EAMv0

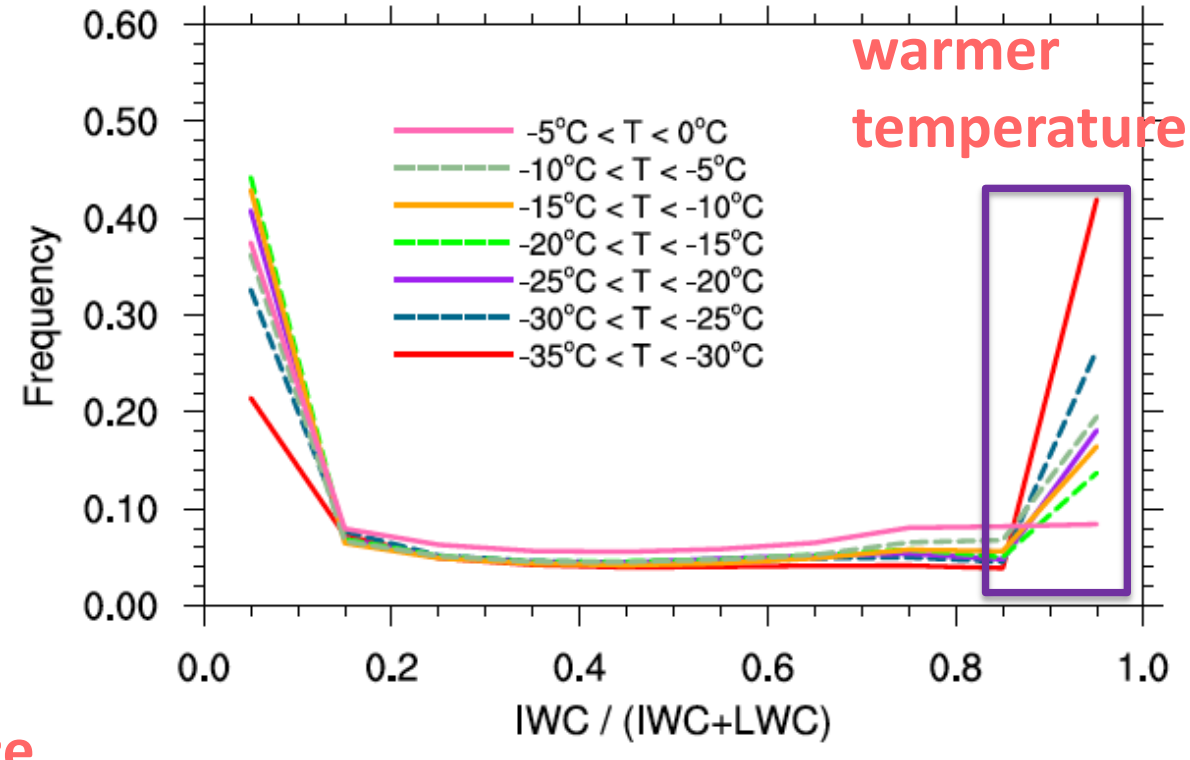


Too few water

Too much ice

EAMv1

Too few ice at warmer temperature



Important changes from V0 to V1

E3SM V0

E3SM V1

Ice nucleation in mixed-phase clouds

- Meyers et al. (1992) for immersion/condensation and deposition freezing (NOT dependent on aerosols)
- Young (1974) for contact nucleation

- Classical Nucleation Theory (CNT) based scheme for immersion, deposition, and contact freezing (dependent on aerosols)

  Hoose et al. (2010); Wang et al. (2014)

Bergeron process tuning

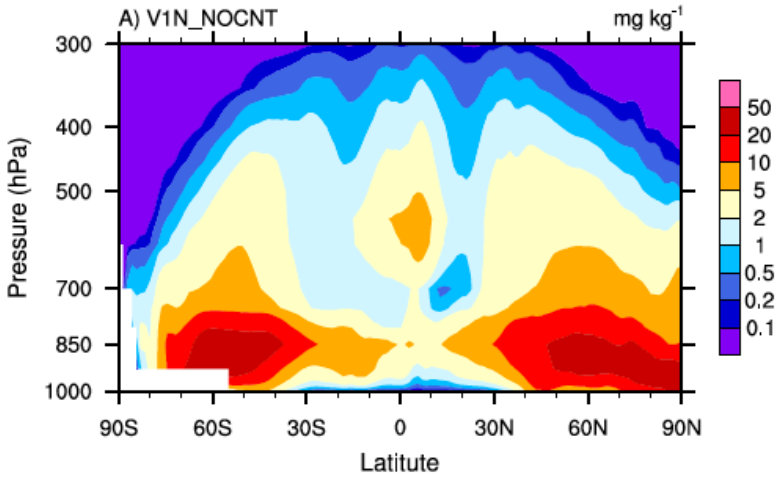
- No tuning

- Bergeron process rate scaled to 1/10

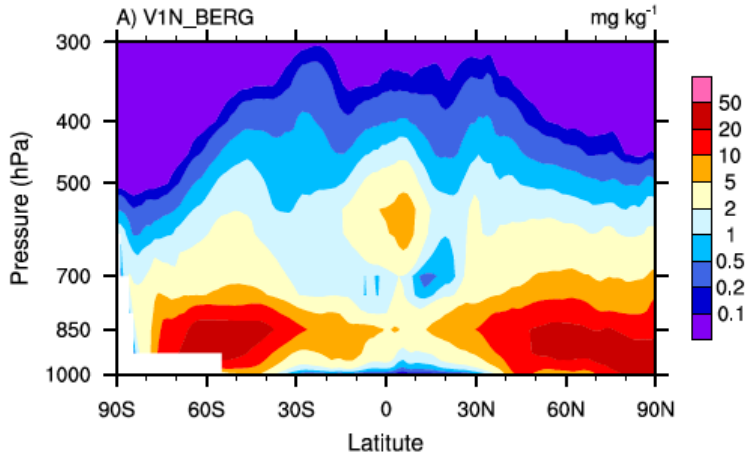
Change of cloud liquid mass

large-scale horizonal winds are nudged

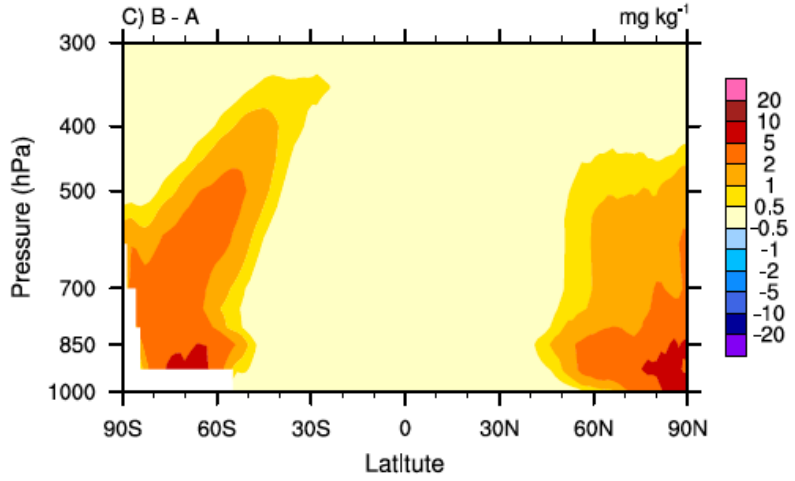
Meyers



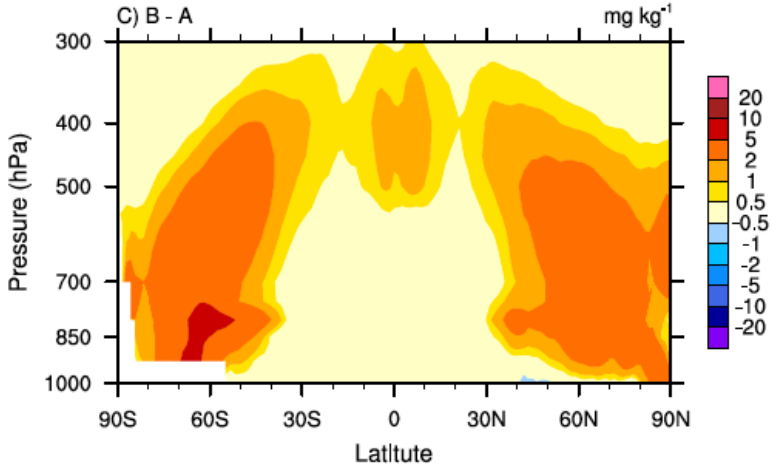
NO_BERG_tuning



CNT (CTRL) - Meyers

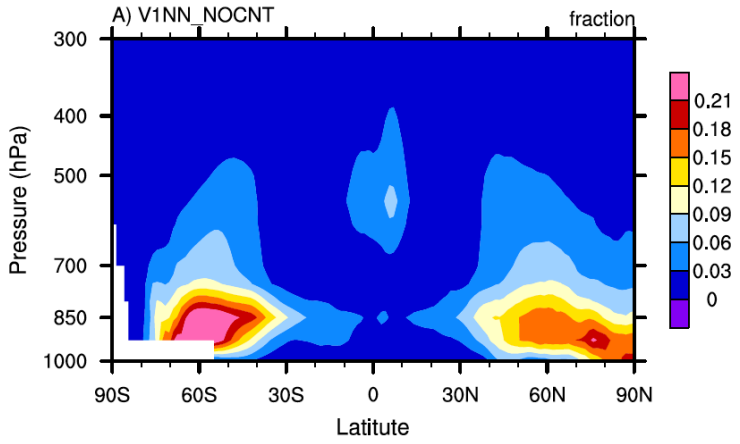


0.1_BERG_tuning (CTRL) - NO_BERG_tuning

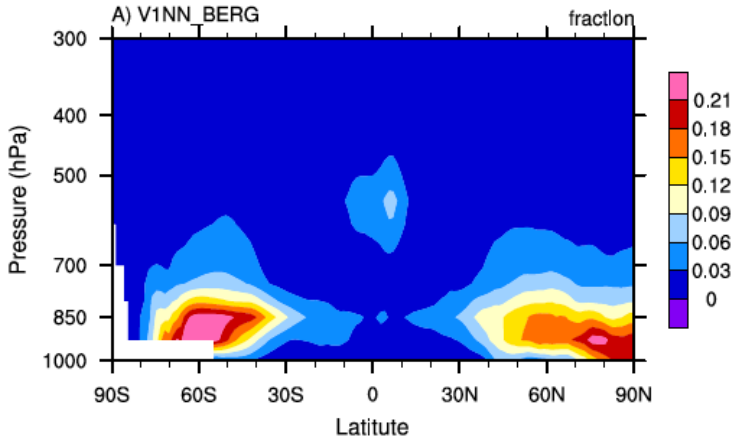


Change of frequency occurrence of liquid clouds

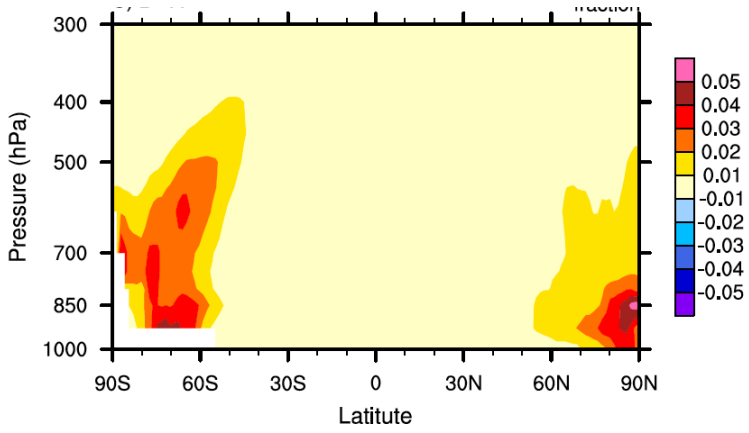
Meyers



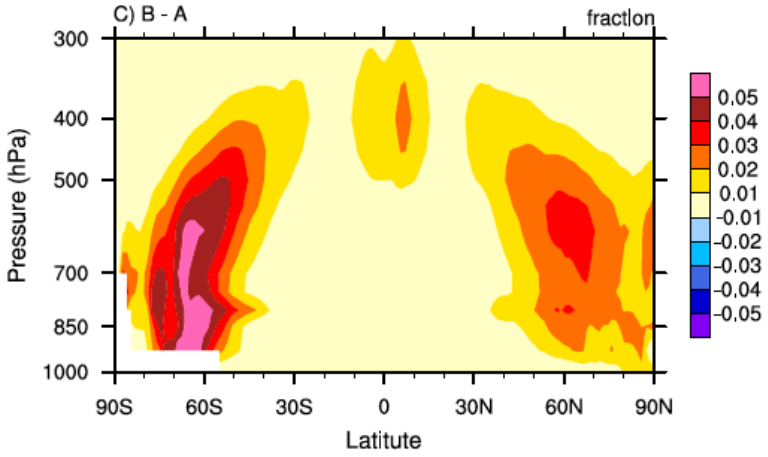
NO_BERG_tuning



CNT (CTRL) - Meyers

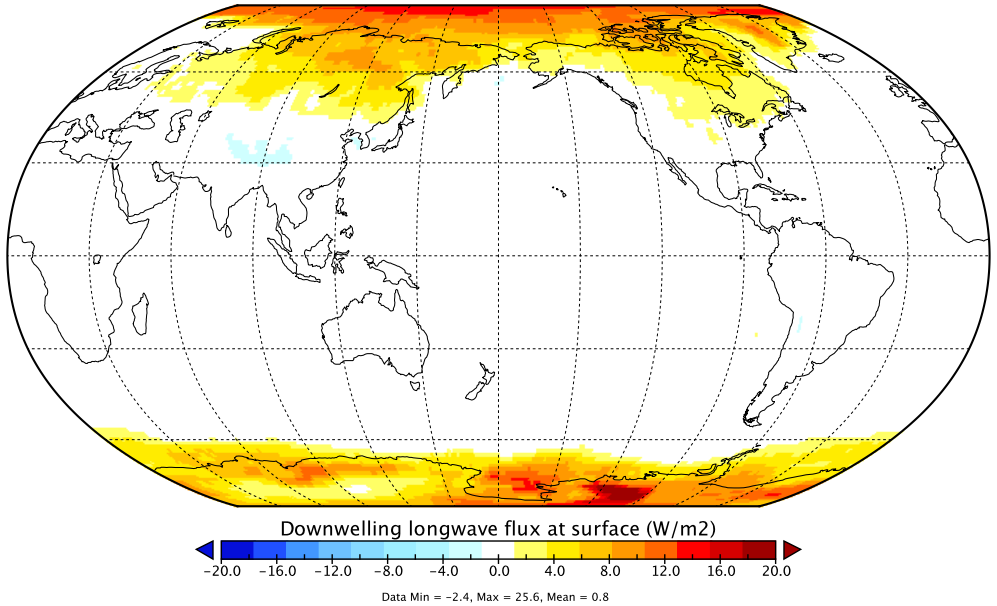


0.1_BERG_tuning (CTRL) - NO_BERG_tuning

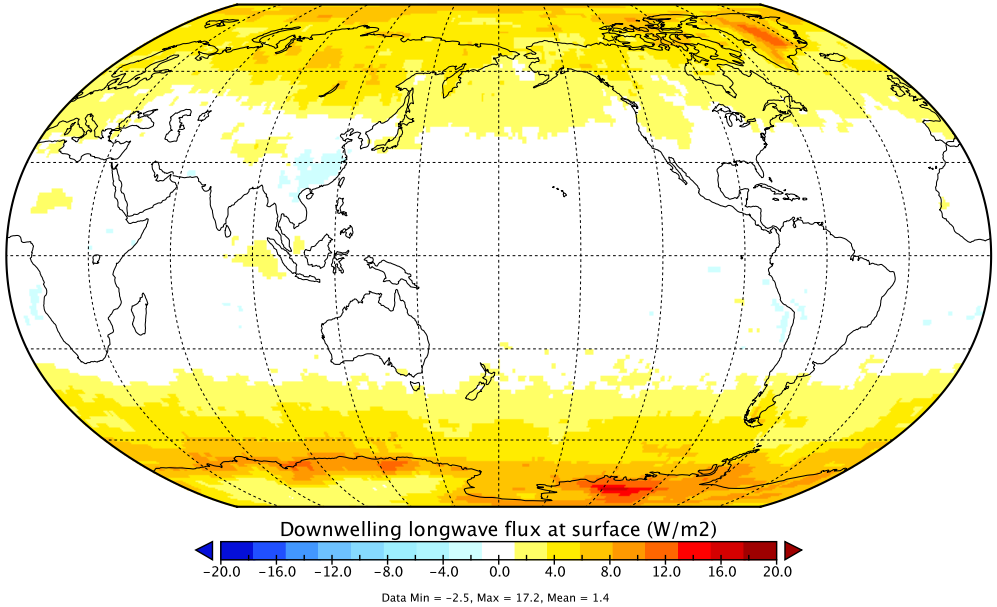


Impact on surface downward LW flux (that warms the surface)

CNT (CTRL) – Meyers

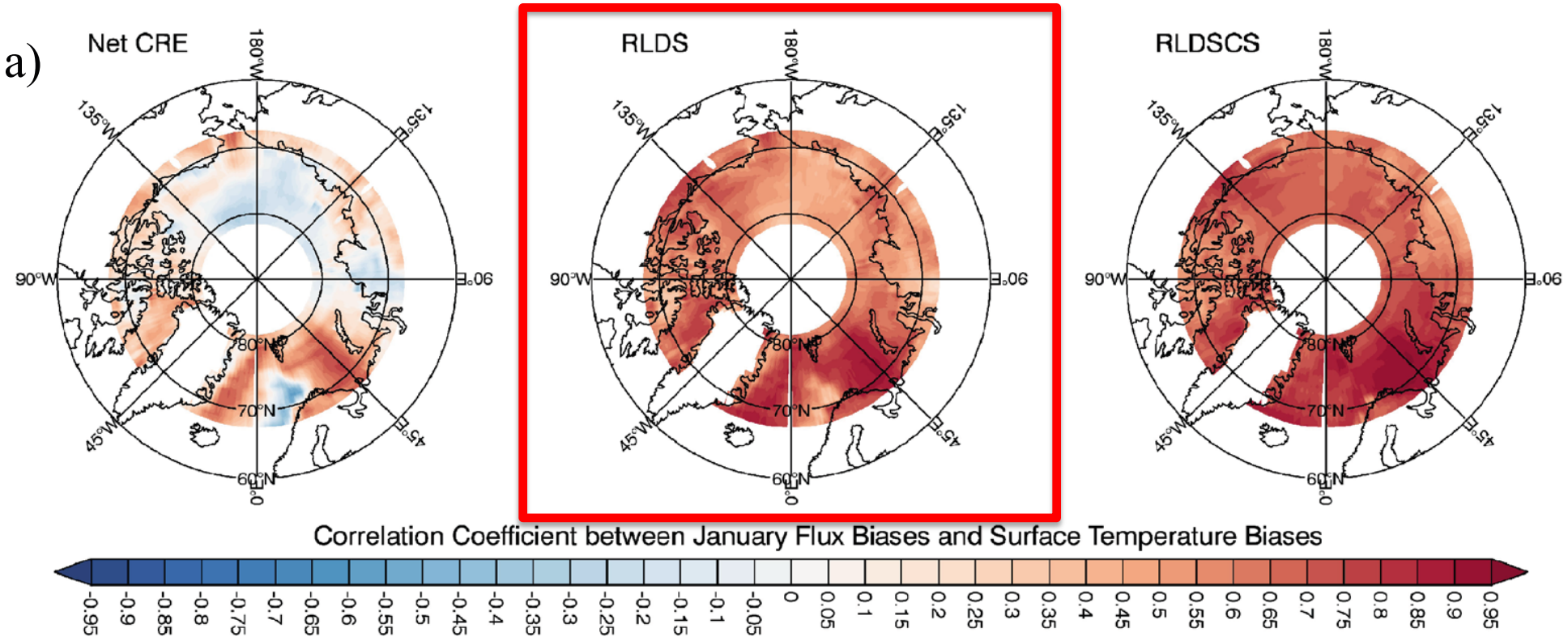


BERG_0.1_tuning (CTRL) – NO_tuning



- More dense liquid clouds cause strong increase in down-welling LW flux
- This will further lead to strong surface warming

Correlation between downward LW flux and TS



Boeke et al. (2016)

Summary

- Changes in IN scheme and Bergeron process tuning both have a large impact on cloud phase
- More liquid cloud leads to stronger downward LW flux and surface warming
- The problem can be addressed partly by
  - adjusting the Bergeron process tuning parameter to a more reasonable value
  - transporting more INPs (e.g. dust) to the Arctic (more IN)

Not shown:

- CLUBB tends to cause stronger downward LW flux in summer (but not in winter)