Rethinking cloud seeding strategy for marine cloud brightening intervention: experiment with CESM2 and its implications

— Jack Chen, Yaga Richter, Walker Lee,
Doug MacMartin, and Ben Kravitz

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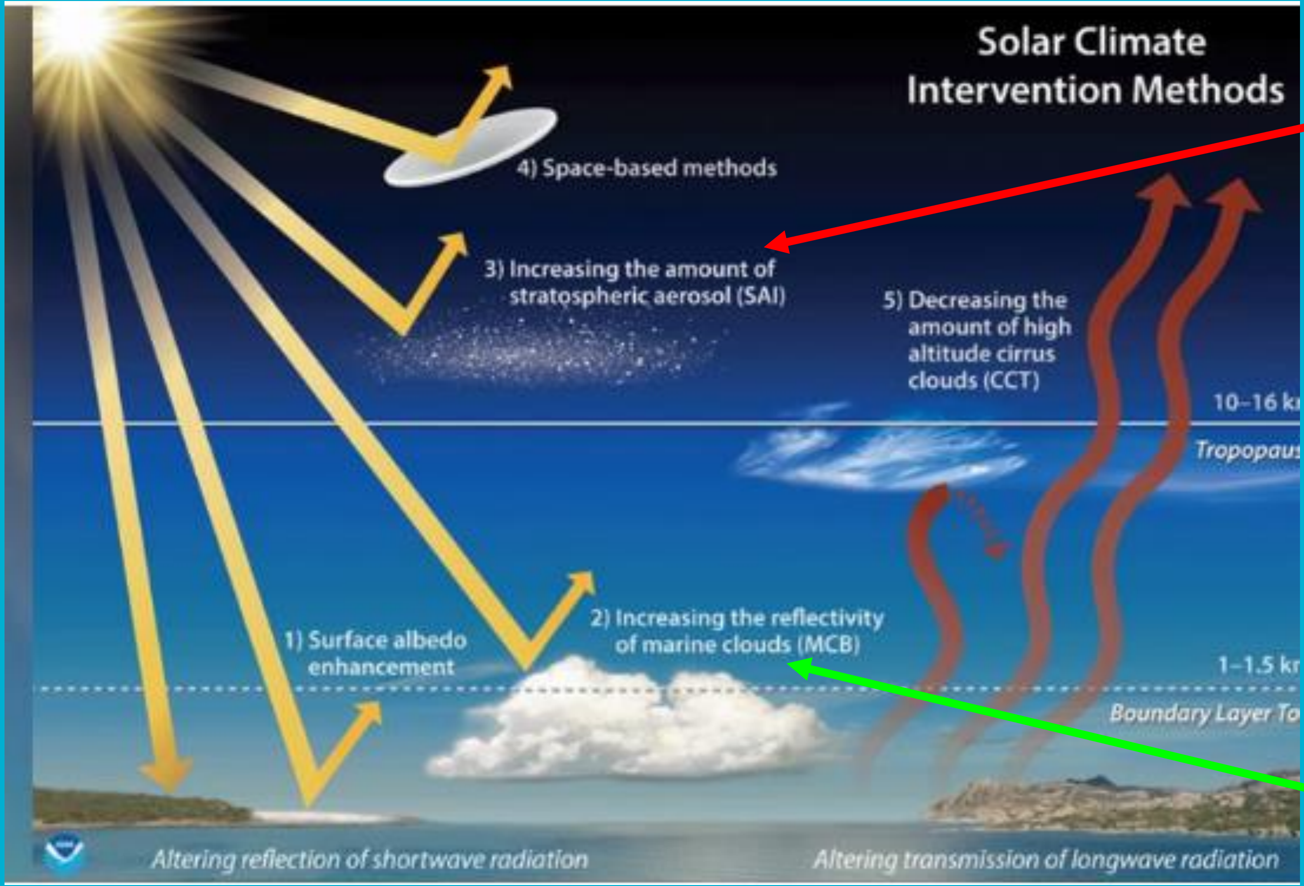
2024 CESM workshop

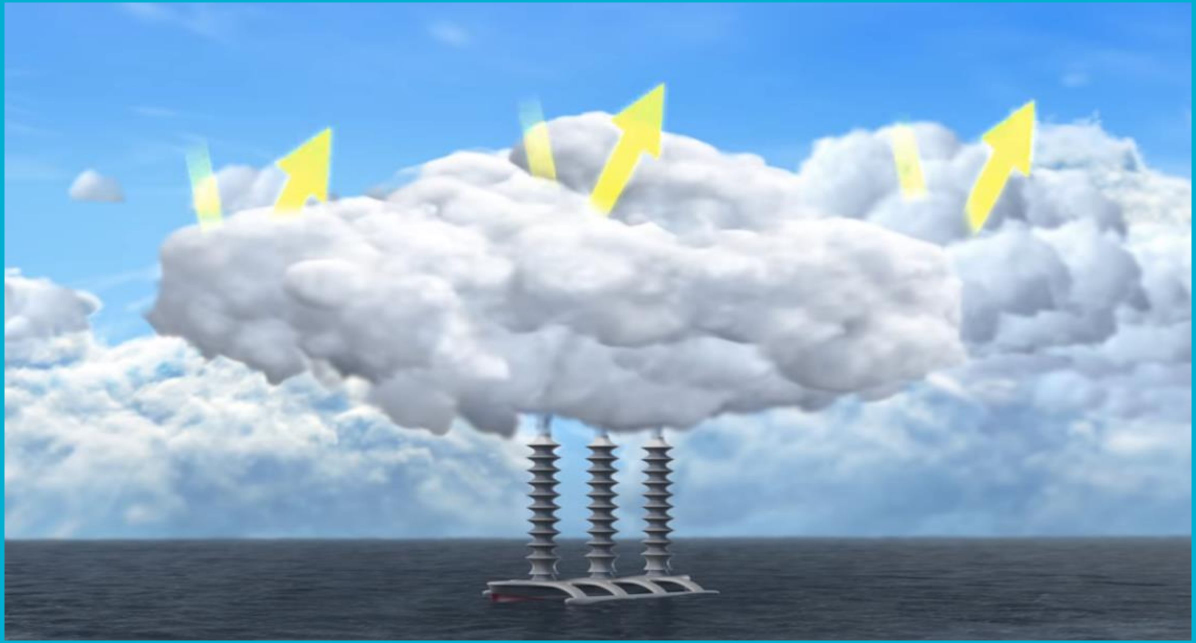
solar climate intervention methods



SAI
stratospheric
aerosol
injection

MCB
marine cloud
brightening

marine cloud brightening climate intervention

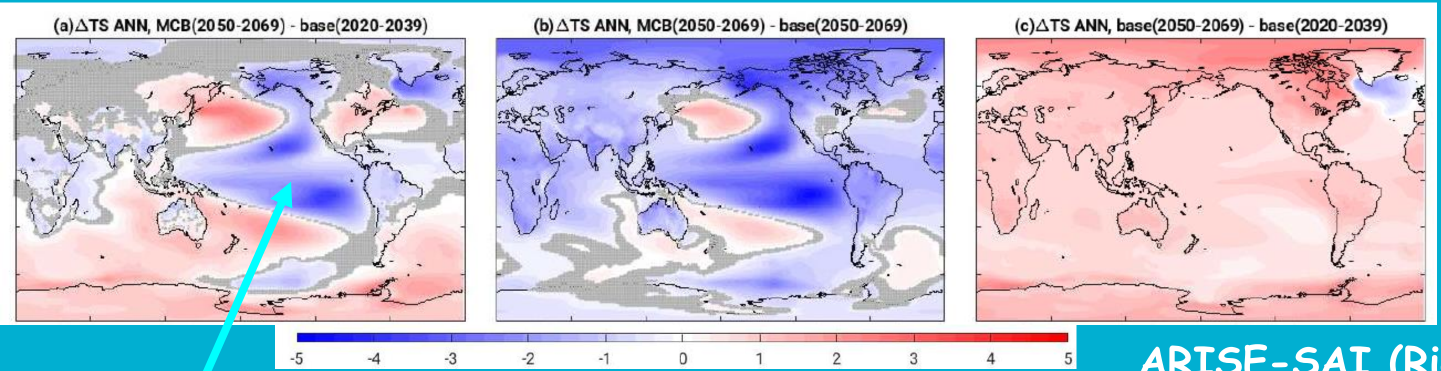


indirect effects of cloud seeding due to smaller cloud drops:

1. Twomey effect: clouds become more reflective of solar radiation

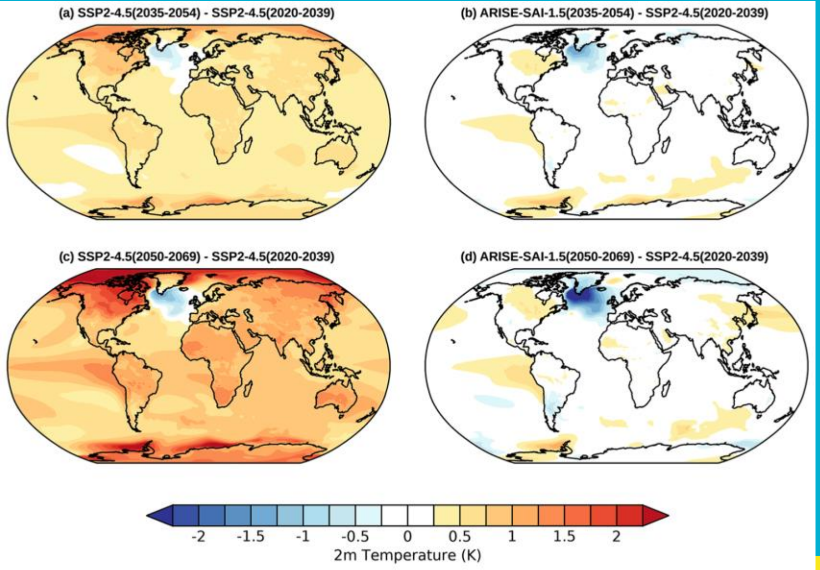
2. Albrecht effect: clouds become more persistent (less precipitation)

temperature response: MCB vs SAI

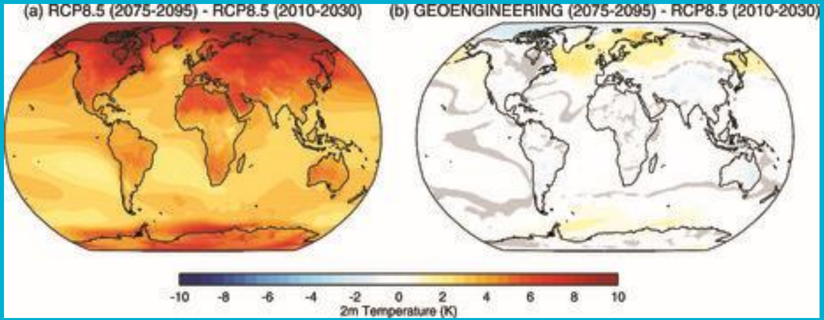


La Nina-like response (typical for MCB)

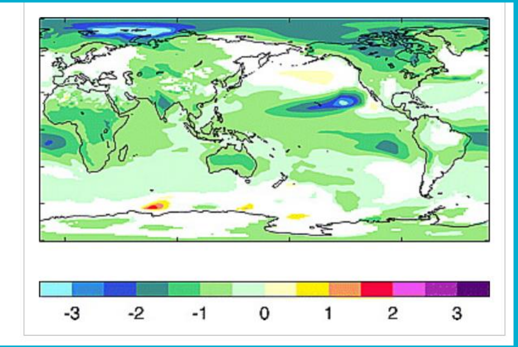
ARISE-SAI (Richter et al., 2022)



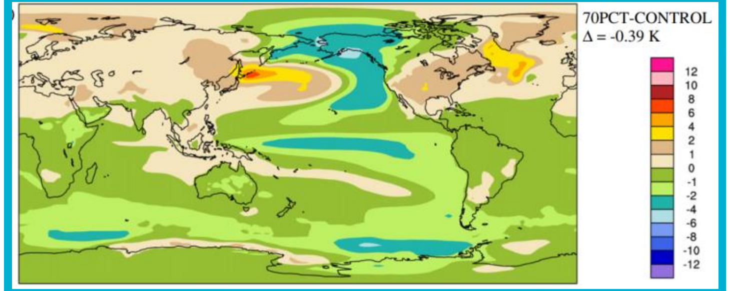
GLENS (Tilmes et al., 2018)



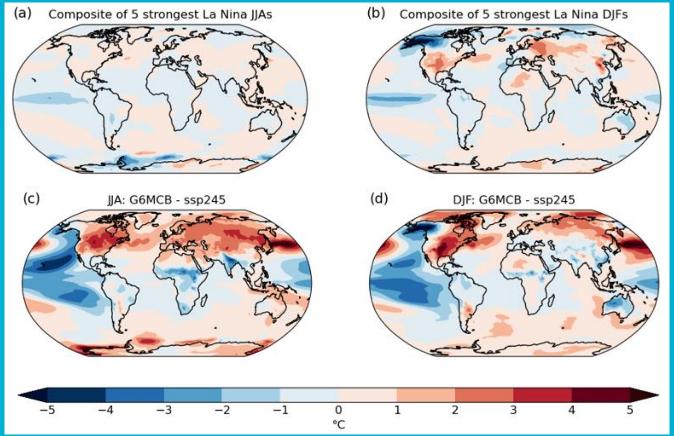
previous MCB studies - La Nina-like response



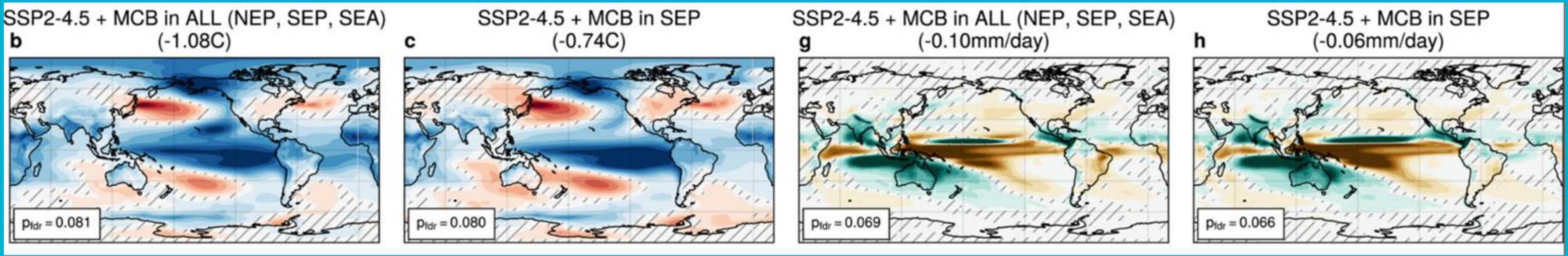
Jones et al., 2009



Rasch et al., 2009

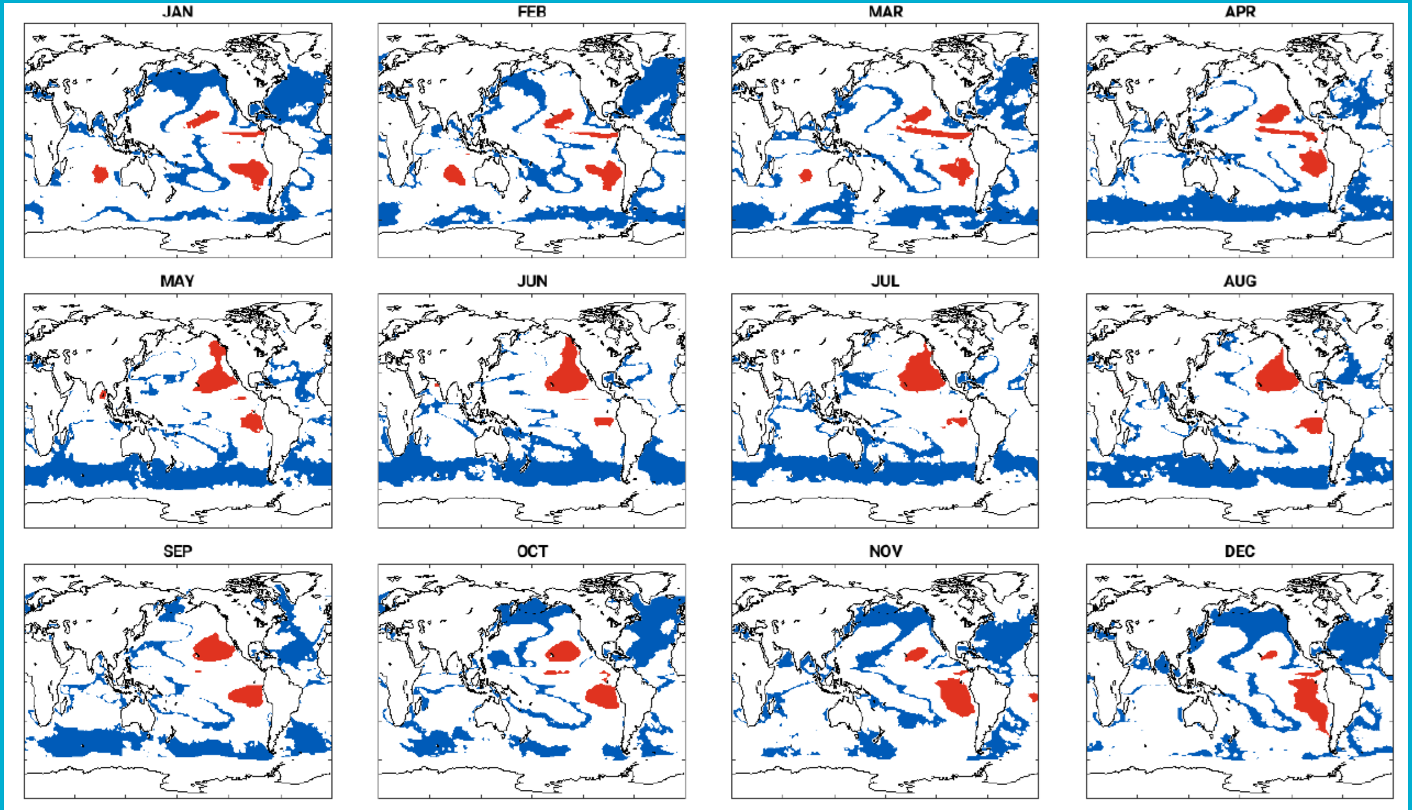


Haywood et al., 2023

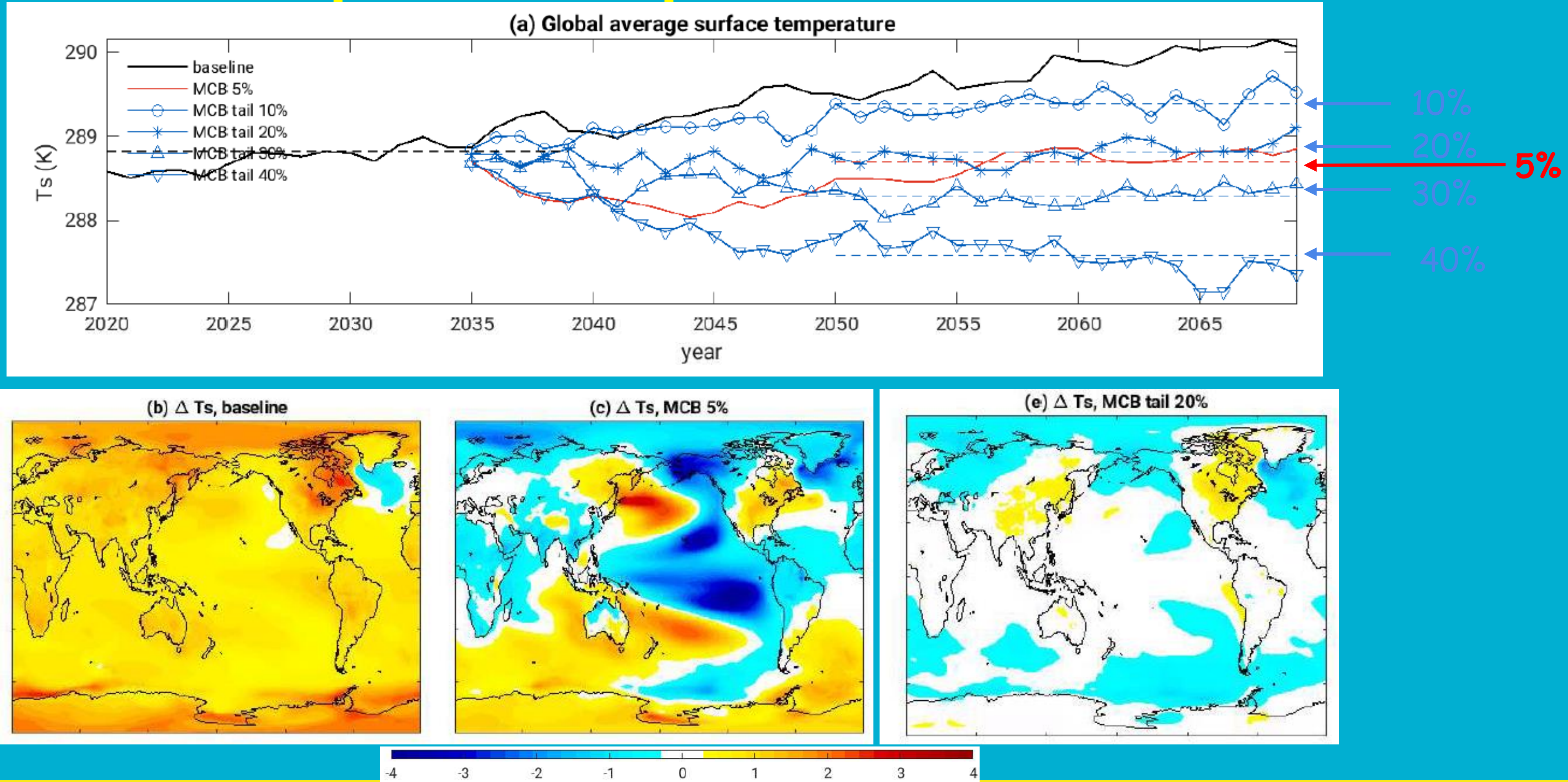


Hirasawa et al., 2023

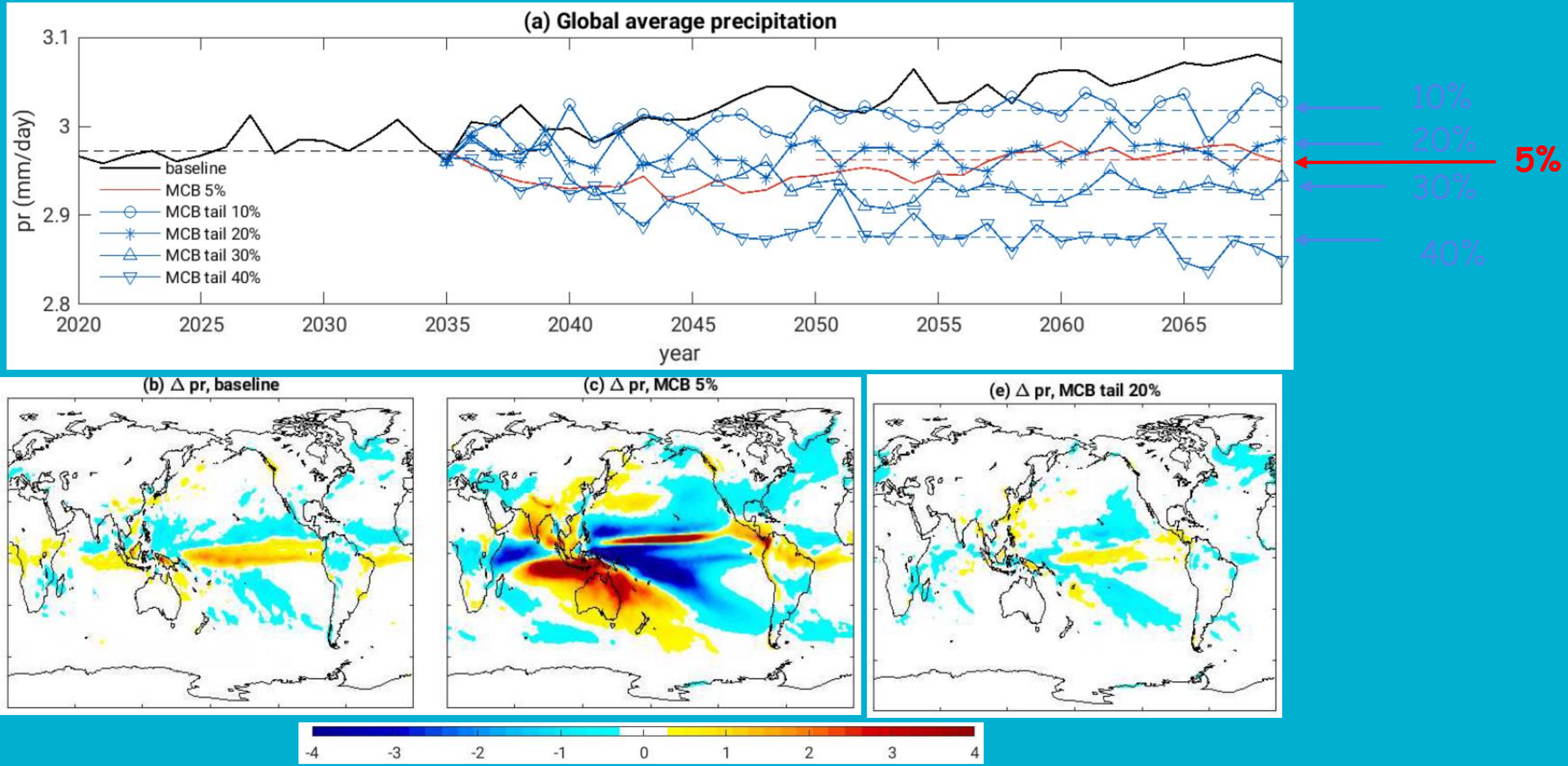
seeding masks (CESM2):
most susceptible (5%) vs least susceptible (30%)



surface temperature response due to MCB



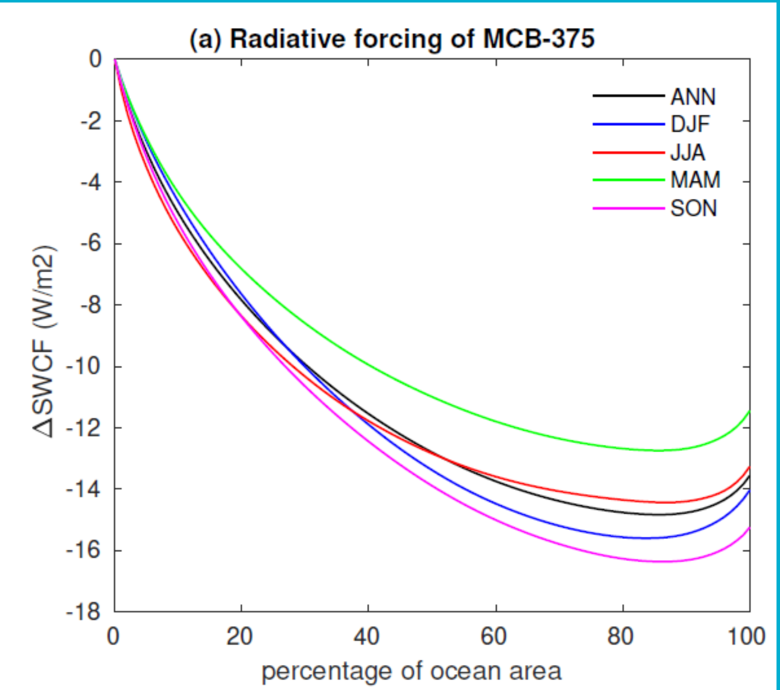
precipitation response due to MCB intervention

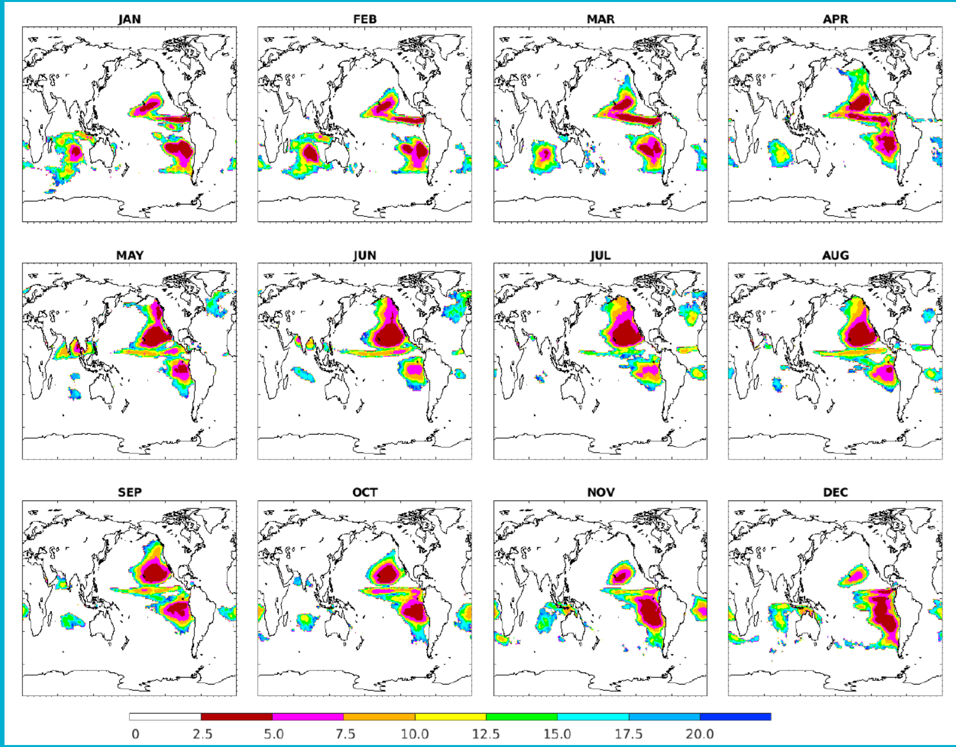


Summary and conclusions

1. Most previous MCB simulations target regions more/most susceptible to cloud seeding, but this strategy induces a La Nina-like surface temperature response.
2. There is evidence indicating that such MCB deployment disrupts ENSO and the world would be stuck in La Nina.
3. It is shown that cloud seeding over regions least susceptible could greatly alleviates such side effects, and the cooling is much more evenly distributed over the globe.
4. Cloud seeding over most susceptible regions induce intense local cooling which in turn alters the circulation of the atmosphere and the ocean.
5. Cloud seeding over least susceptible regions induce mild local cooling which is spread very evenly over the globe.

susceptibility for cloud seeding (Rasch et al., 2009)

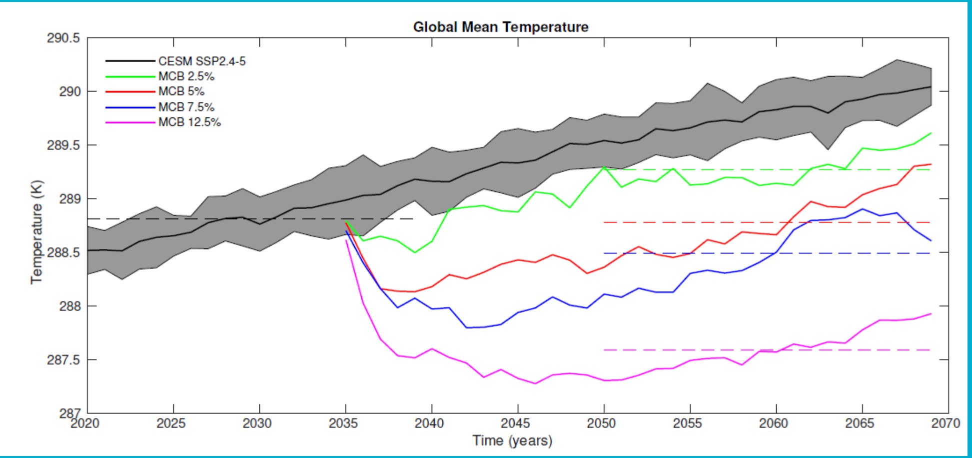




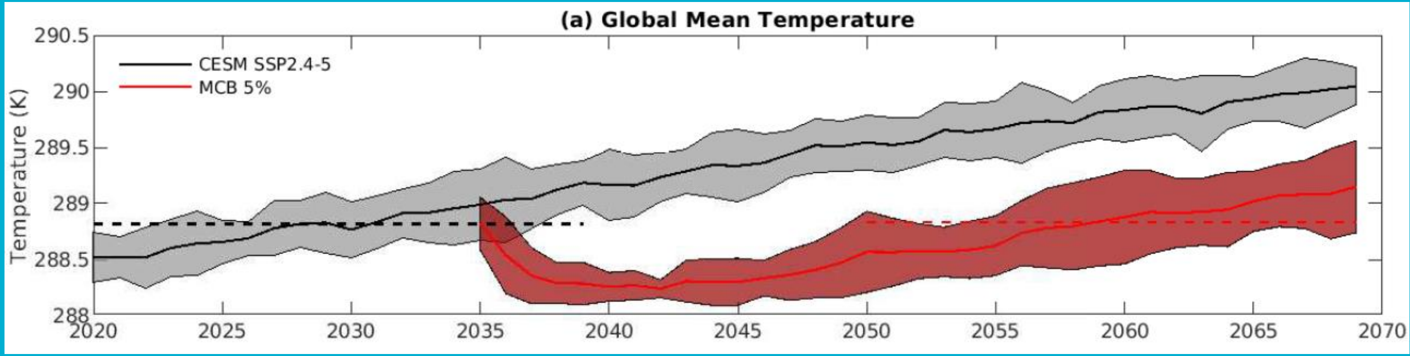
two 20-year CESM2 simulations conducted: 1) baseline, 2) cloud seeding over ocean

susceptibility for each grid point determined by shortwave cloud forcing difference

MCB intervention simulated by CESM2 under SSP2-4.5



cloud seeding over 5% ocean surface is sufficient to restore future surface temperature to set target



10-member ensemble confirms 5% cloud seeding meets temperature target

new cloud seeding strategy: prioritize regions least susceptible