Understanding the responses of stratocumulus-to-cumulus transition to aerosol injections through large-eddy simulations

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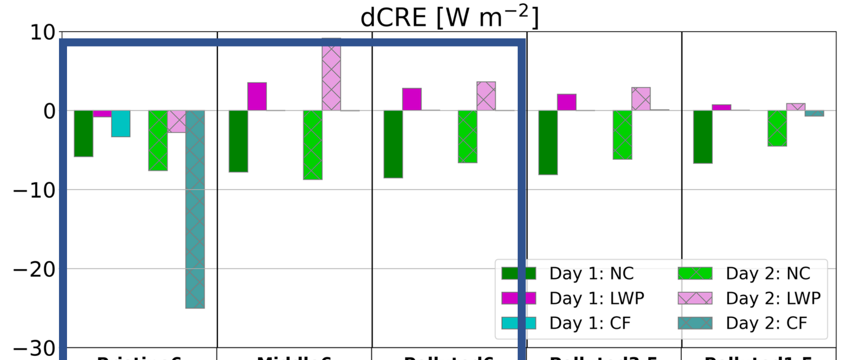
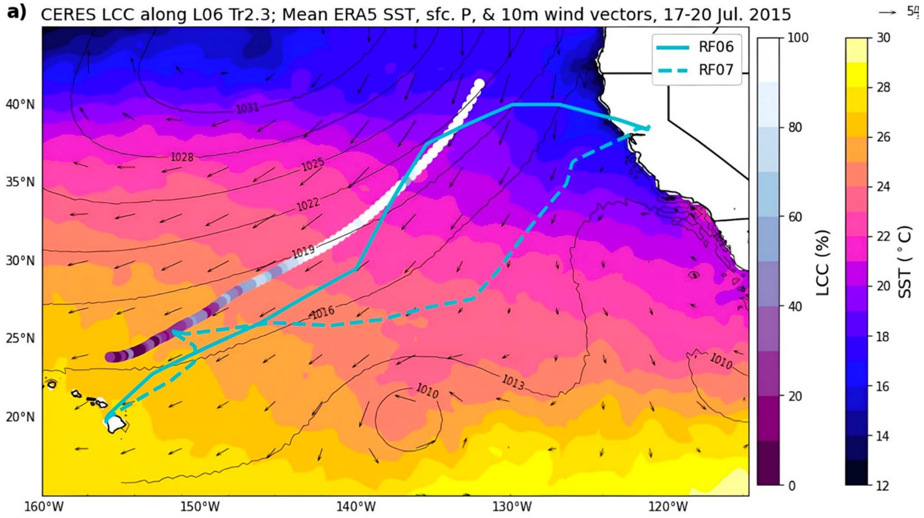
Ship tracks in subtropical marine low clouds (CGILS-S12) were simulated.



	Pristine6	Middle6	Polluted6	Polluted3.5	Polluted1.5
NC	-5.8 | -7.6	-7.8 | -8.7	-8.5 | -6.6	-8.1 | -6.2	-6.7 | -4.5
LWP	-0.8 | -2.8	3.5 | 9.1	2.8 | 3.6	2.1 | 2.9	0.7 | 0.9
CF	-3.3 | -25.0	-0.0 | -0.0	0.0 | -0.0	-0.0 | 0.1	0.0 | -0.7
dCRE	-10.1 | -36.6	-3.9 | -1.3	-5.0 | -3.4	-4.8 | -3.3	-4.6 | -4.0
RES	-0.2 | -1.2	0.4 | -1.7	0.7 | -0.4	1.2 | -0.1	1.4 | 0.3

Moist

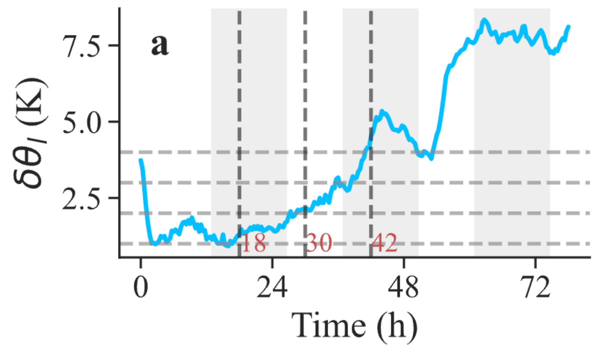
Limitations: Idealized **time-invariant meteorological forcings** and approximately **steady-state aerosol concentrations** constitute the background conditions (Chun et al. 2023)



Stratocumulus-to-cumulus transition (SCT). CSET field campaign, which took place in July over the Northeast Pacific. This is a clean case. (Albrecht et al., 2019; Erfany et al., 2023)

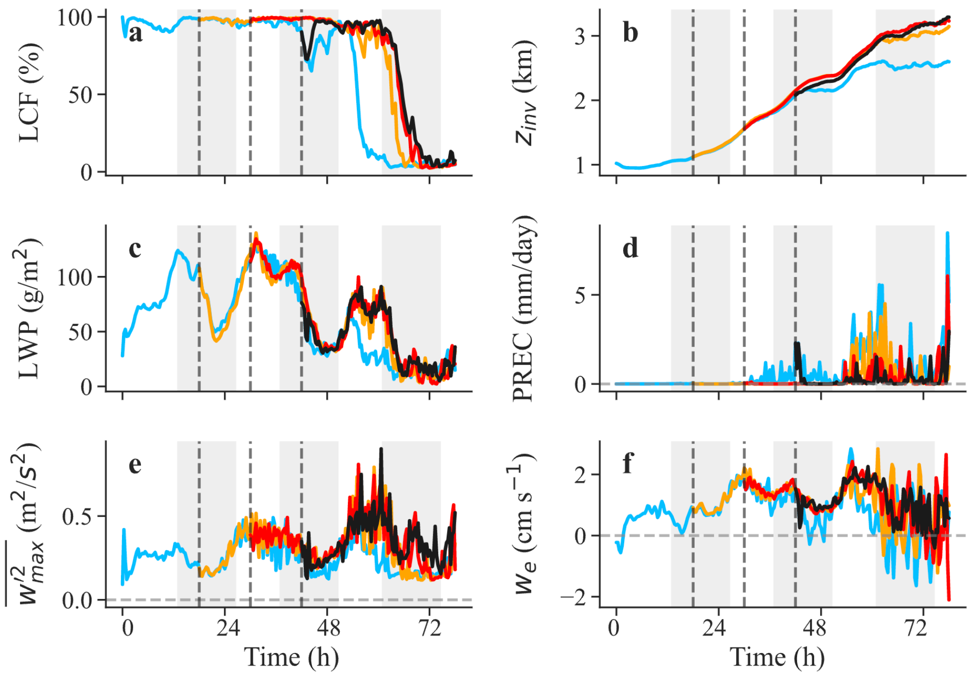
Selection of aerosol injection time

Degree of the PBL stratification



Early injection → aerosols possibly removed quickly, not influencing SCT

Late injection → more decoupled PBL may notably suppress aerosol vertical transport



Clean_CTL

Clean_INJ1:

Inject aerosols at 18 hr

Inject aerosols at 30 hr

Inject aerosols at 42 hr

PBL Na budget analysis:

Decreasing rate of aerosols removed by entrainment and accretion

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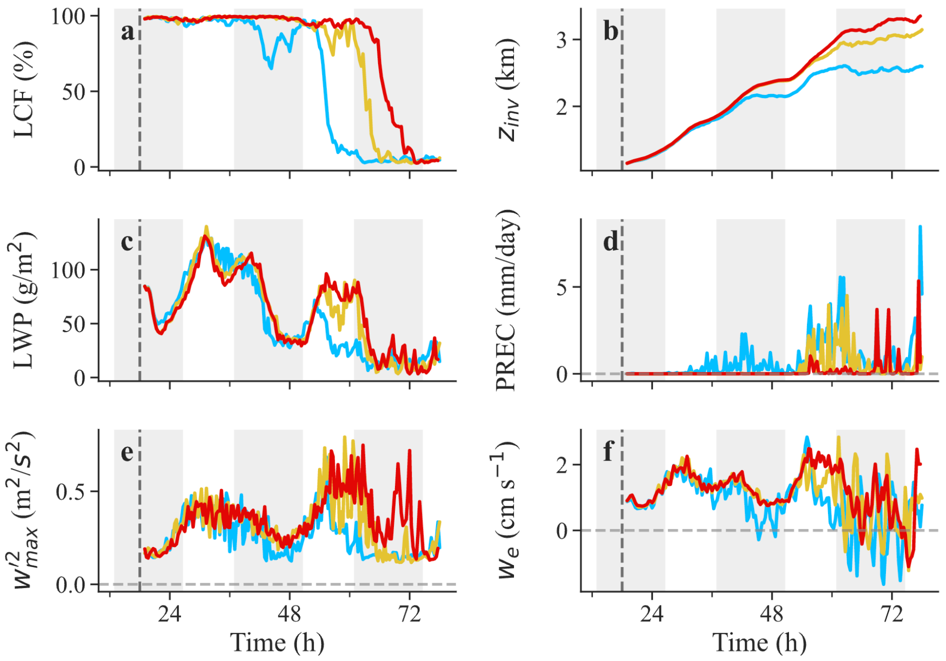
Decreasing rate of aerosols due to PBL stratification over time

Responses of SCT to aerosol injection

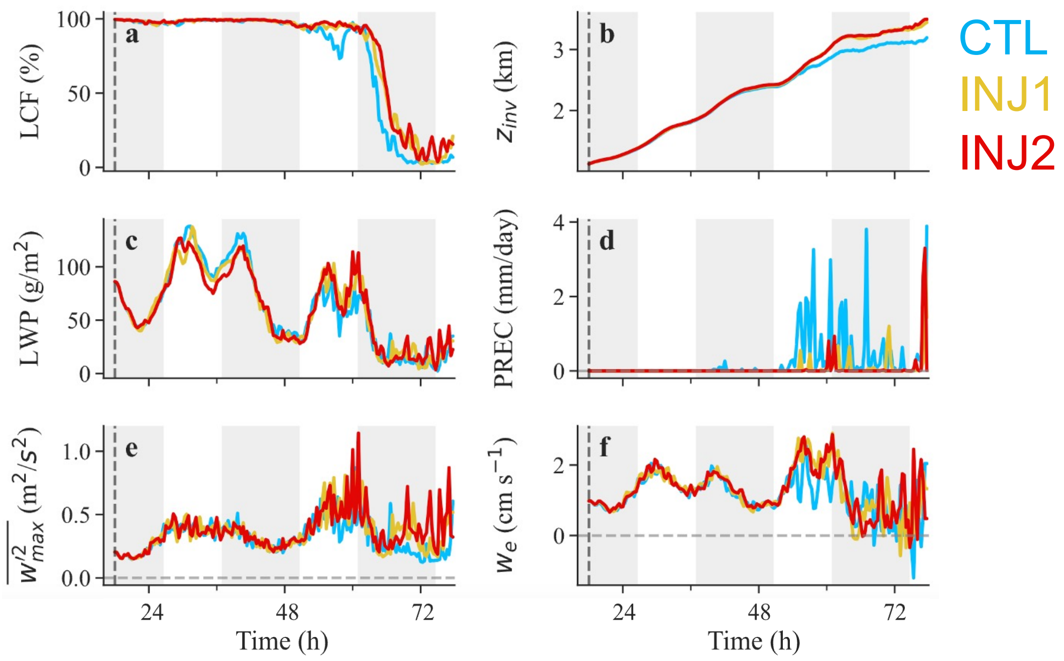
Clean



Injecting aerosols delay the SCT notably.

Moistening from decreased surface precipitation *versus* **drying** from increased entrainment of overlying air

Polluted

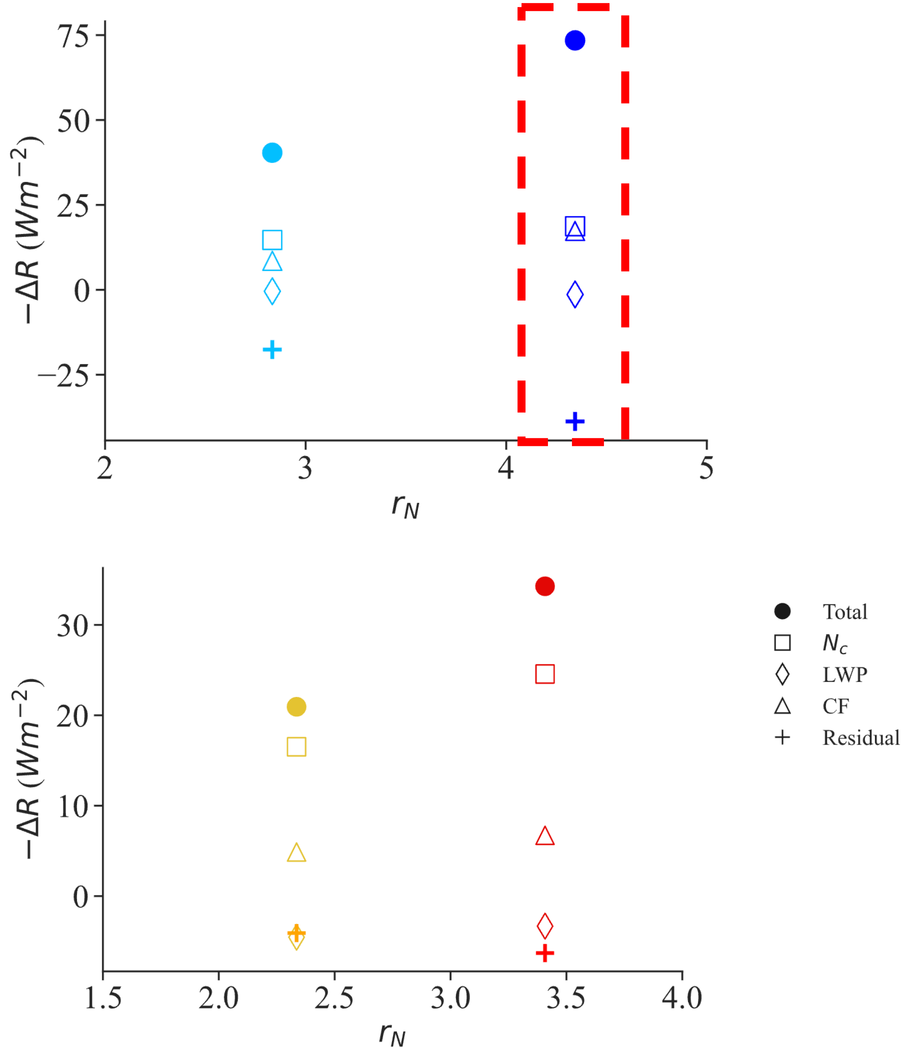


The SCT is not notably affected by injecting aerosols.

Radiative responses to aerosol injection

Clean

Polluted



(the ratio of the perturbed to baseline CDNC)

Aerosol injection time does not affect SCT notably.

To cool the earth climate, an efficient way is to inject more aerosols to a clean MBL at the initial stage.