Washington University in St. Louis
School of Engineering & Applied Science

Large contribution of organics to condensational growth and formation of cloud condensation nuclei (CCN) in remote marine boundary layer

Guangjie Zheng[1,2], Chongai Kuang[2], Janek Uin[2], Thomas B. Watson[2], and Jian Wang[1,2,*]

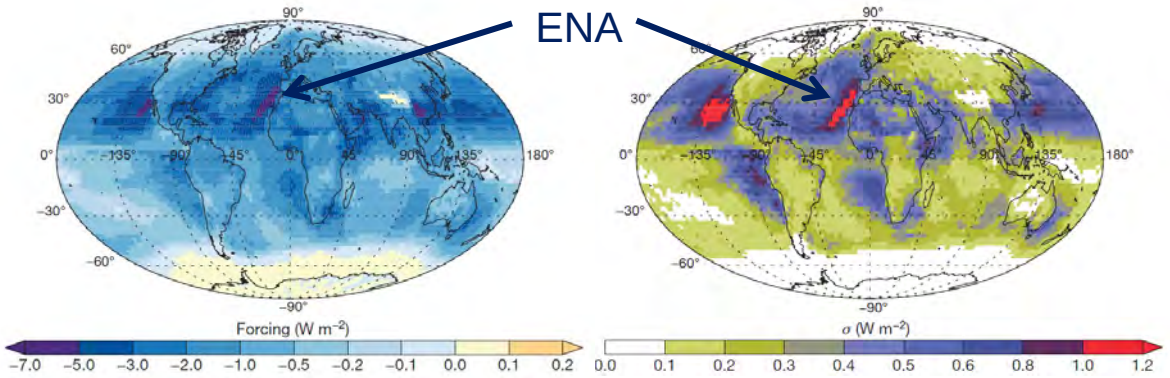
[1] Washington University in St. Louis
[2] Brookhaven National Laboratory

June 25, 2020
ARM/ASR PI Meeting

Motivation

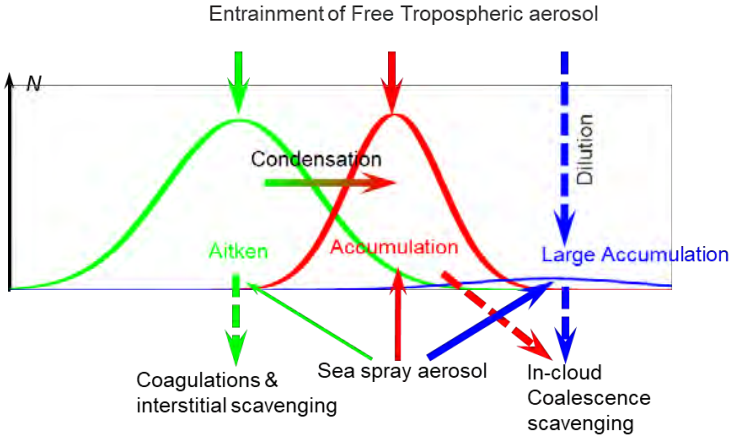
- Marine low clouds: extensive coverage, strong climate effects

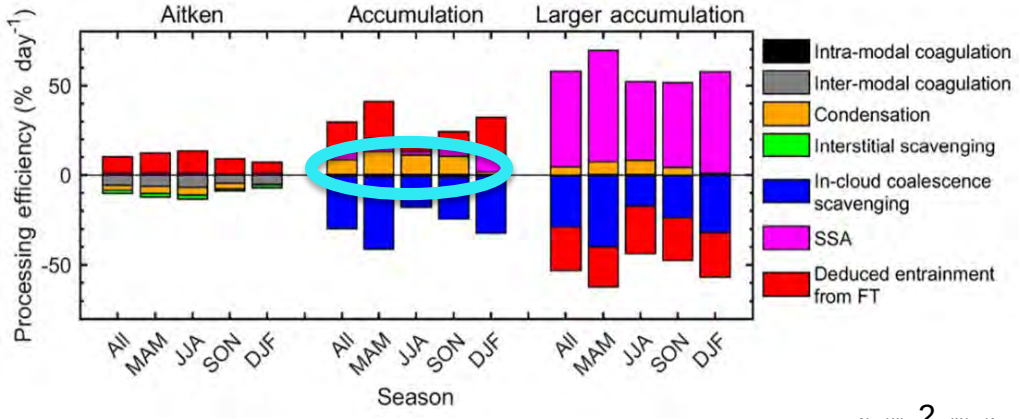
Properties of marine low clouds are sensitive to the change in CCN populations



Simulated Aerosol 1st indirect forcing & its uncertainties. Adapted from Carslaw et al. (2013)

- Condensation growth: an important CCN source in remote MBL

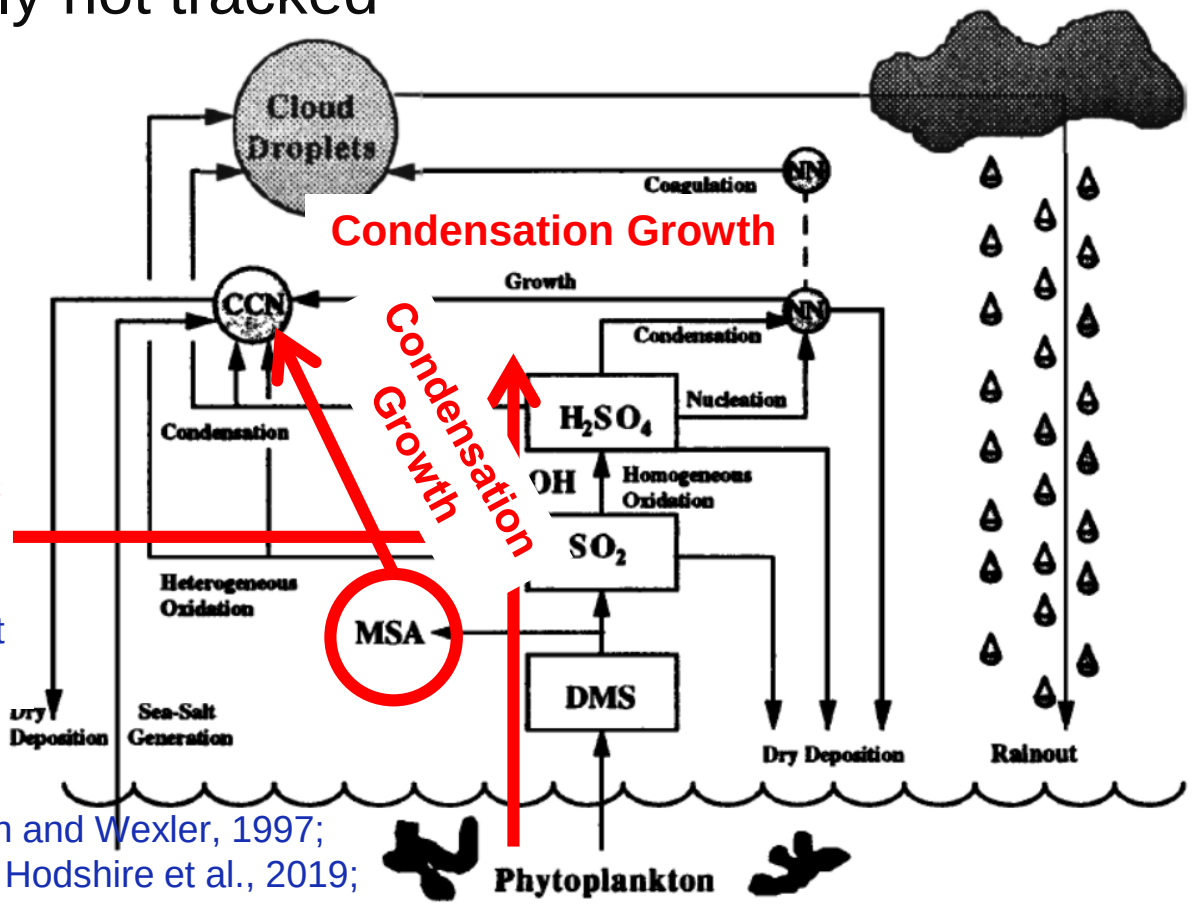




Modified from Zheng et al., (2018);
See also: Pierce et al., (2006); Pierce et al., (2007); Yu et al., (2009); Sanchez et al., (2018), etc.

Major condensing species: sulfate vs. organics

- SO_4^{2-}: included in current global models
- Organics: usually not tracked



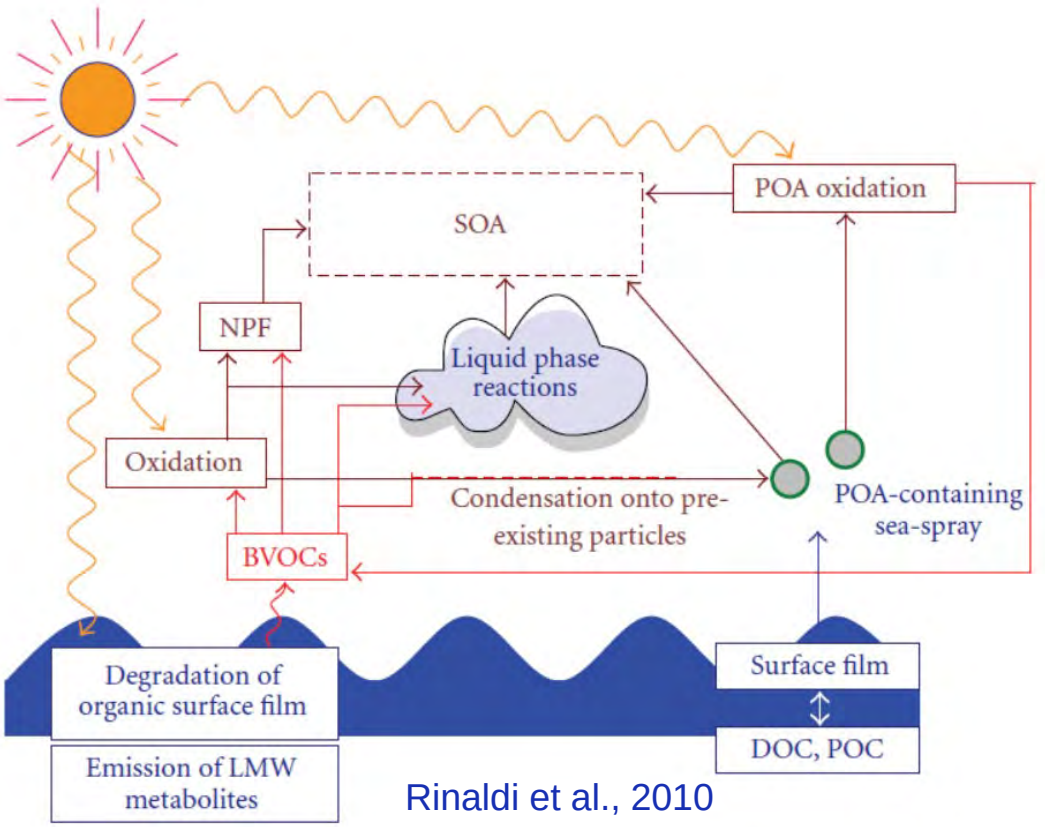
Anthropogenic / volcanos
(e.g.,Kloster et al.,2006; Savoie et al., 2002)

(e.g., Kerminen and Wexler, 1997; Karl et al., 2011; Hodshire et al., 2019; Dall'Osto et al., 2012; Willis et al., 2016; Kim et al., 2017)

Pandis et al., 1994

Major condensing species: sulfate vs. organics

- SO_4^{2-}: included in current global models
- Organics: usually not tracked



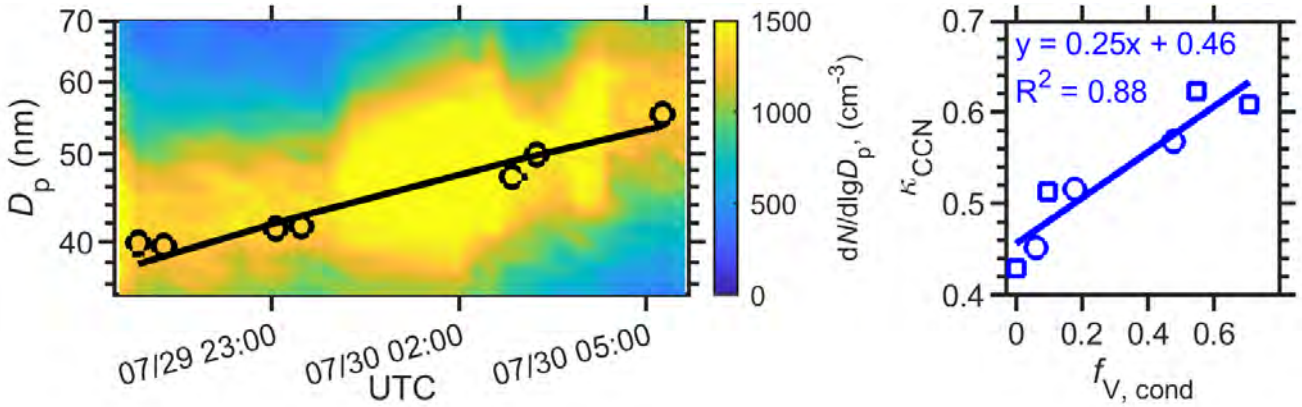
Rinaldi et al., 2010

(See also: Mungall et al., 2017; Wurl et al., 2011; Brüggemann et al., 2018)

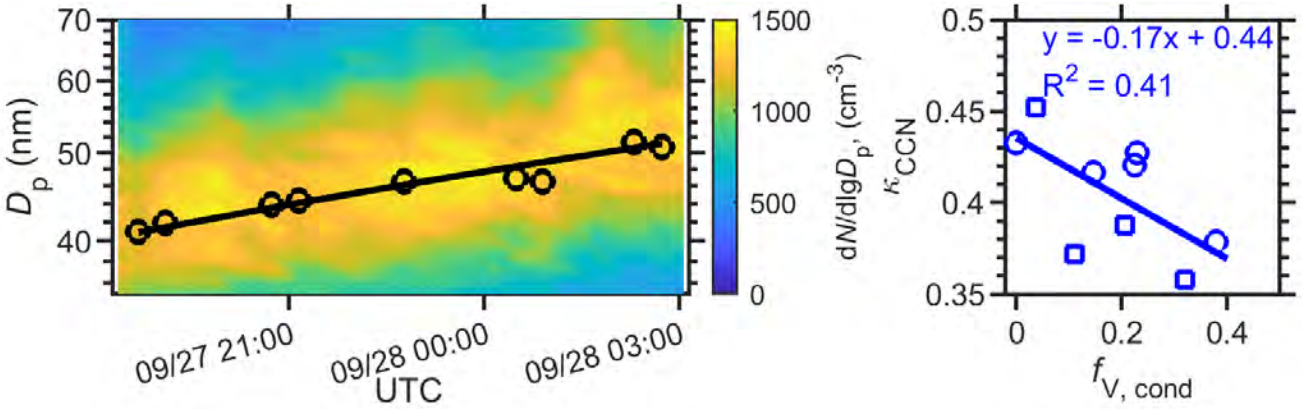
Constraining major condensing species from κ_c

- Large κ difference between sulfates and organics
  - MSA: ~0.36; other Org : < ~0.3;
  - $(NH_4)_2SO_4$: ~0.61; NH_4HSO_4:~0.8; H_2SO_4 ~0.9

Inorganic (sulfate) dominated growth event (κ_c = 0.71)



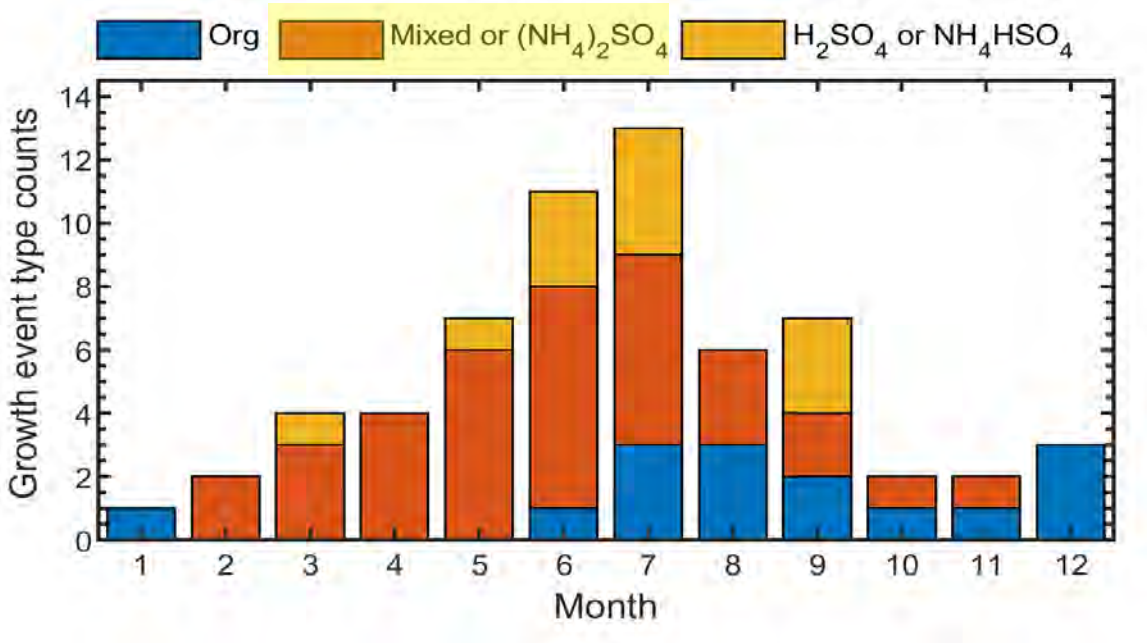
Organic dominated growth event (κ_c = 0.27)



5

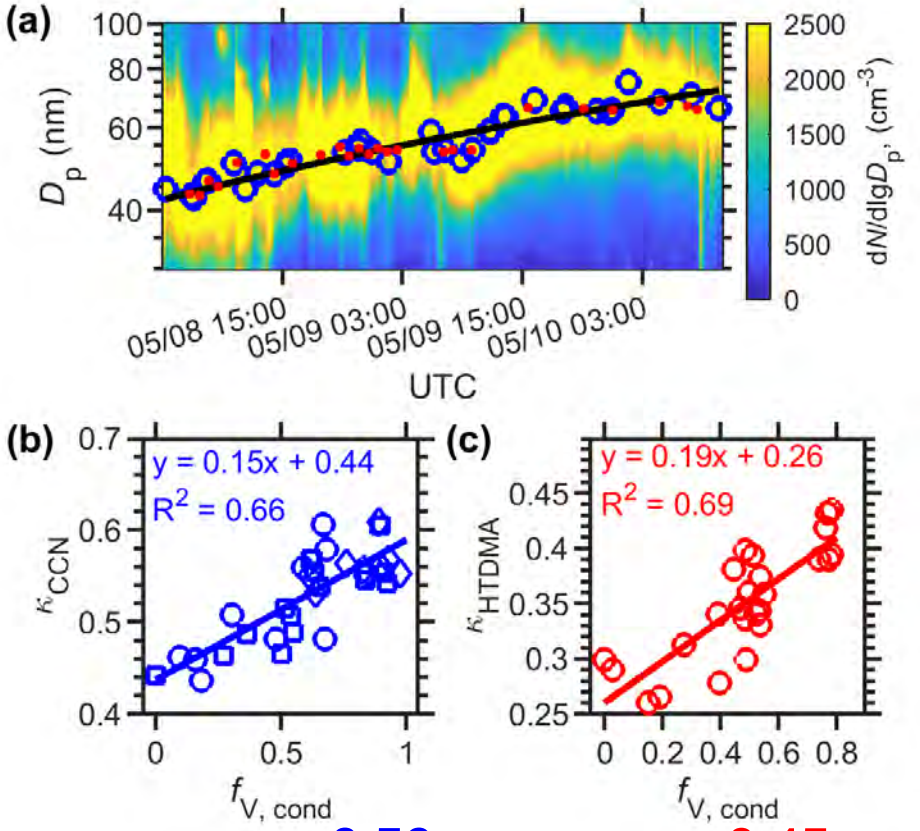
Monthly variation of major condensing species

- A total of 62 events was observed
  - More events observed in summer due to the relatively stable air masses
- Classification of growth events according to κ_c value:
  - Organic – dominated ($\kappa_c < 0.45$)
  - NH_4HSO_4 - H_2SO_4 dominated ($\kappa_c > 0.65$)
  - $(NH_4)_2SO_4$ dominated or mixtures ($0.45 < \kappa_c < 0.65$)



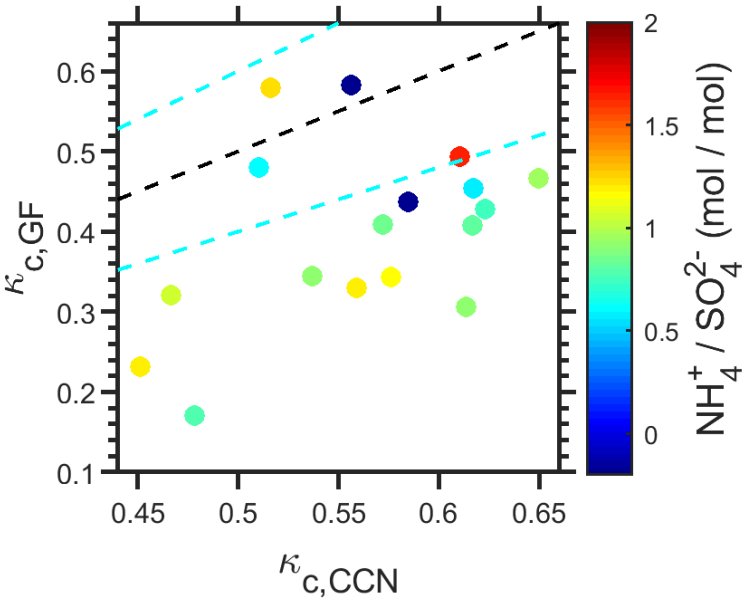
Sulfate or a mixture of bisulfate, sulfuric acid, & organics?

- Insights from the difference between κ_c measured by SCCN ($\kappa_{c,CCN}$) and HTDMA ($\kappa_{c,GF}$)
  - $(NH_4)_2SO_4$ – less difference (κ_{GF} ~0.53, κ_{CCN} ~0.61) (Petters et al., 2007)
  - Organics: usually larger gap between κ_{GF} and κ_{CCN} (e.g., Petters et al., 2009)



$\kappa_{c,CCN}$ = 0.59

$\kappa_{c,GF}$ = 0.45



$\kappa_{c,GF}$ << $\kappa_{c,CCN}$;

NH_4^+/SO_4^{2-} <2

→mixture

Summary

- Organics contribute significantly to the condensation growth and the formation of CCN over remote oceans like ENA.
  - Condensing species were dominated by NH_4HSO_4 / H_2SO_4 during only 11 of 62 (18%) growth events observed.
  - During most (58%) of the growth events, the condensing species is a mixture of sulfate/SOA
  - This contribution is usually not included in current global models
- See more details in: Zheng et al. 2020, submitted to ACP

ASR Atmospheric System Research

ARM CLIMATE RESEARCH FACILITY