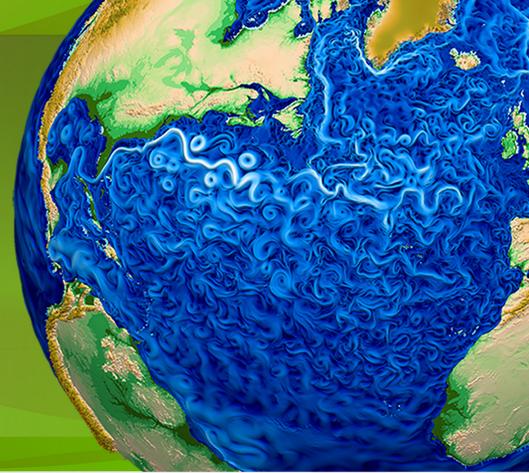


R:

Climate sensitivity to marine organic aerosol emissions in ACME v0

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Objective and approach

Marine organic matter in sea spray aerosol:

- Organic matter from ocean phytoplankton enters sea spray aerosol through bubble bursting mechanism, and is a previously missing aerosol source.
- Natural background aerosols are an important controlling factor for aerosol indirect effects.
- The influence of ocean biogeochemistry on sea spray chemistry is represented in the OCEANFILMS model (Burrows et al., ACP, 2014; Elliott et al., GRL, 2014), which has been implemented in ACME.
- Sensitivity experiments were conducted to determine the model's simulated aerosol chemistry and climate response.

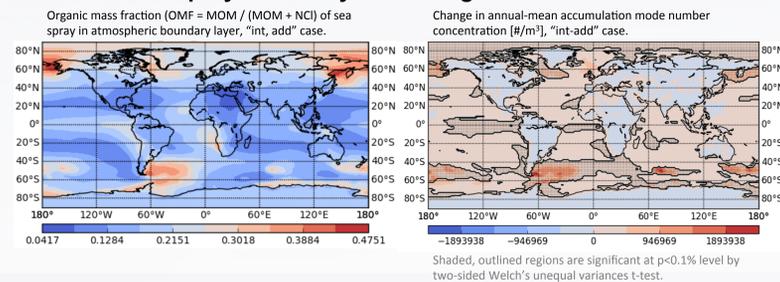
Simulation configurations:

10-y atmosphere-only simulations. One control experiment and 4 sensitivity cases: "int, add"; "int, replace"; "ext, add"; "ext, replace"

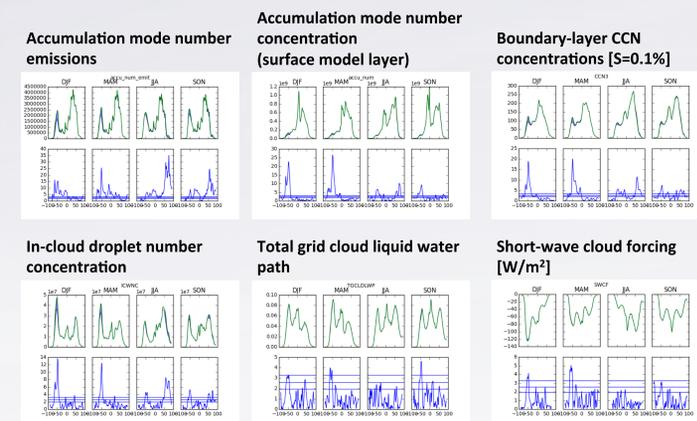
- "int": marine organics internally mixed with sea salt aerosol
- "ext": marine organics externally mixed with sea salt aerosol
- "add": organics increase number and mass of emitted sea spray
- "replace": number and mass of emitted sea spray remain constant

This poster focusses on results from "int, add", which observations suggest is the most realistic case.

Simulated sea spray chemistry and change in number:



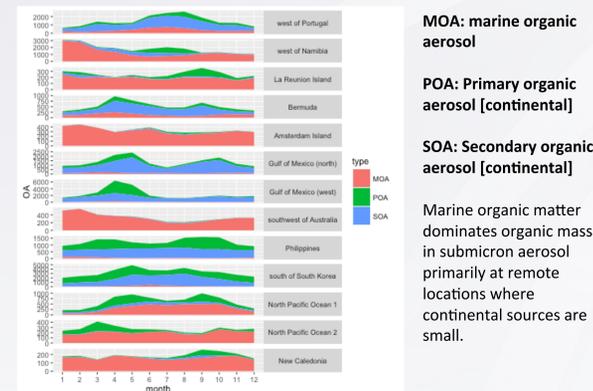
Zonal mean seasonal changes in aerosol and cloud properties



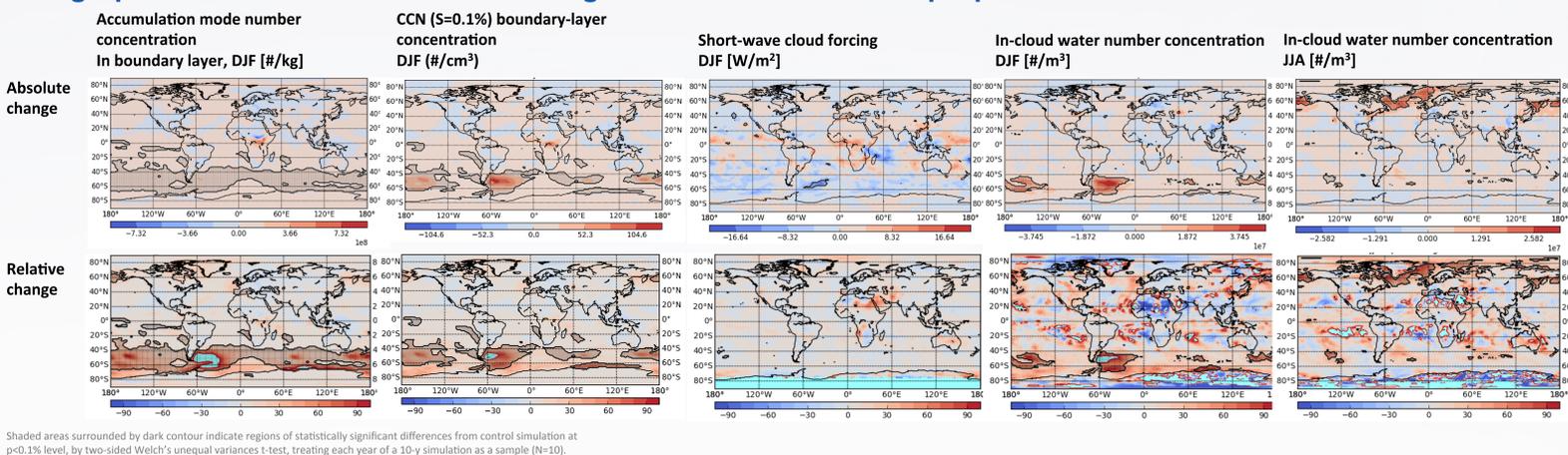
Top panels: zonal seasonal means of model variables. Control: blue; experiment: green. Shading highlights differences significant at p<0.1% level.

Bottom panels: Welch's two-sided unequal variances t-statistic, with p<0.1%, p<1%, and p<5% significance levels.

Submicron organic aerosol mass at selected stations



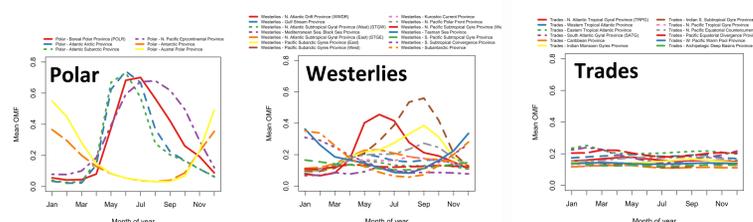
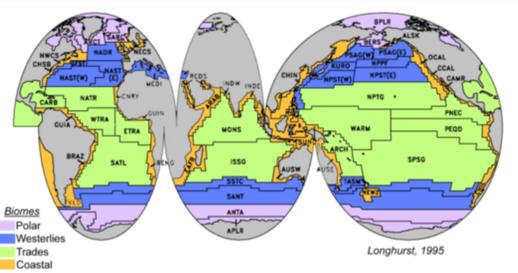
Geographic distribution of seasonal changes in aerosol and cloud properties



Simulated and observed seasonal cycles

OMF in Longhurst biogeographical provinces

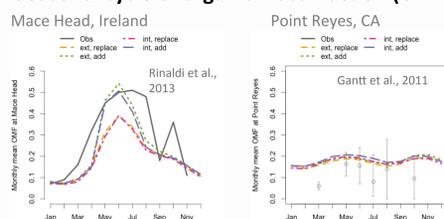
- Seasonal cycle of sea spray chemistry varies between ocean biomes.
- Largest seasonal variations are at high latitudes.



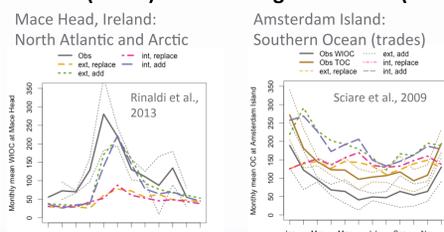
Comparison with observed seasonal cycles

- Long-term observations of sea spray chemistry available from Mace Head, Ireland; Point Reyes, CA; Amsterdam Island (Southern Ocean).
- Model simulates seasonal cycles that approximate observations.
- Model simulated differences between locations qualitatively agree with observations.

Seasonal cycle of organic mass fraction (OMF)



Seasonal cycle of water insoluble organic carbon (WIOC) and total organic carbon (TOC)



Summary and Impact

Summary:

- Representing marine organic matter in sea spray, a previously missing aerosol source, improves representation of the natural background aerosol, an important factor controlling the magnitude of aerosol indirect effects.
- Marine organic matter has important seasonal impacts on remote marine aerosol concentrations, particularly in the Southern Ocean, where summertime aerosol number is **doubled** in some regions by marine organics.
- In the Northern Hemisphere, summertime marine aerosol number and composition are impacted, but marine sources are small relative to natural and anthropogenic continental sources, and climate impacts are mostly not statistically significant.
- Previous work inferred that marine organic aerosol contributes to determining seasonal and large-scale spatial patterns of cloud drop number concentration over the Southern Ocean (McCoy, Burrows, et al., Sci. Adv., 2015); magnitude of simulated responses is consistent with this.

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Burrows, S.M., Ogunro, O., Frossard, A.A., Russell, L.M., Rasch, P.J. and Elliott, S.M., 2014. A physically based framework for modeling the organic fractionation of sea spray aerosol from bubble film Langmuir equilibria. Atmos. Chem. Phys., 14(24), pp.13-601. Elliott, S., Burrows, S.M., Deal, C., Liu, X., Long, M., Ogunro, O., Russell, L.M. and Wingenter, O., 2014. Prospects for simulating macromolecular surfactant chemistry at the ocean-atmosphere boundary. Environmental Research Letters, 9(6), p.064012.