

Model Representations of Marine Organic Aerosol

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Research Questions and Motivation

Research Questions:

What do observations of aerosols tell us about marine aerosols?

What can we learn about marine organics from available model information?

Motivation:

- Arctic Sensitivity to climate change
- Large and uncertain forcing effect of aerosols globally
- Poor and inconsistent representation of marine aerosols in GCMs
- “CLAW” hypothesis: 1987 - 2014
- Tsigardis, 2014: “Only the models that include a marine source of mPOA are able to capture the OA concentrations at remote marine stations”

Data, methods, and tools

Data:

- Observations of aerosol size distribution from Freud et al., 2017
- Historical CMIP6 runs of NorESM-ML and CESM2-WACCM from r1i1p1f1

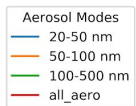
Methods:

- Compare organic aerosol in different models by normalizing to “total” aerosol
- Risks adding confounding variables that will also vary between models

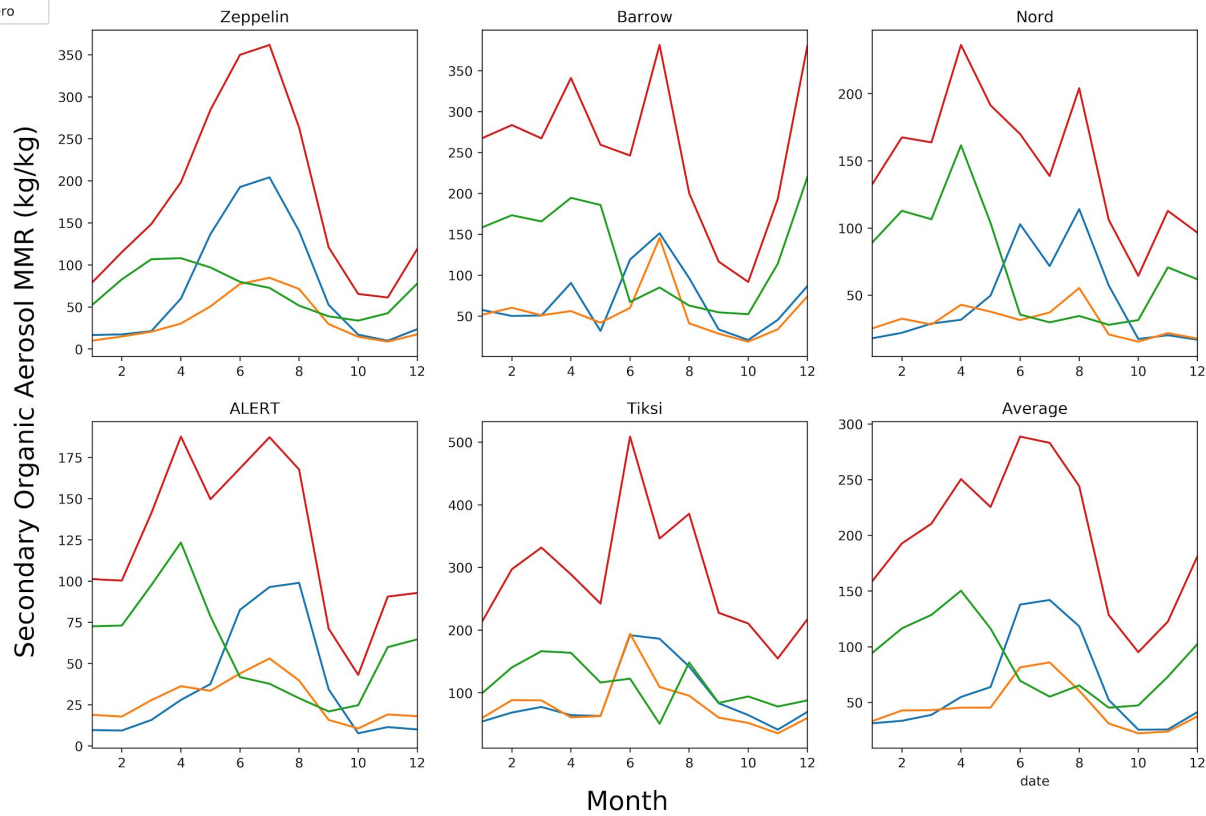
$$OA_{ratio} = \frac{OA}{OA + BC + SO_4}$$

Can we observe marine aerosol?

- Small number of stations that observe aerosol size distributions, limited years
- Large variability between stations
- General trend supports hypotheses about aerosol transport and creation
- **Cannot distinguish marine aerosol from this data**



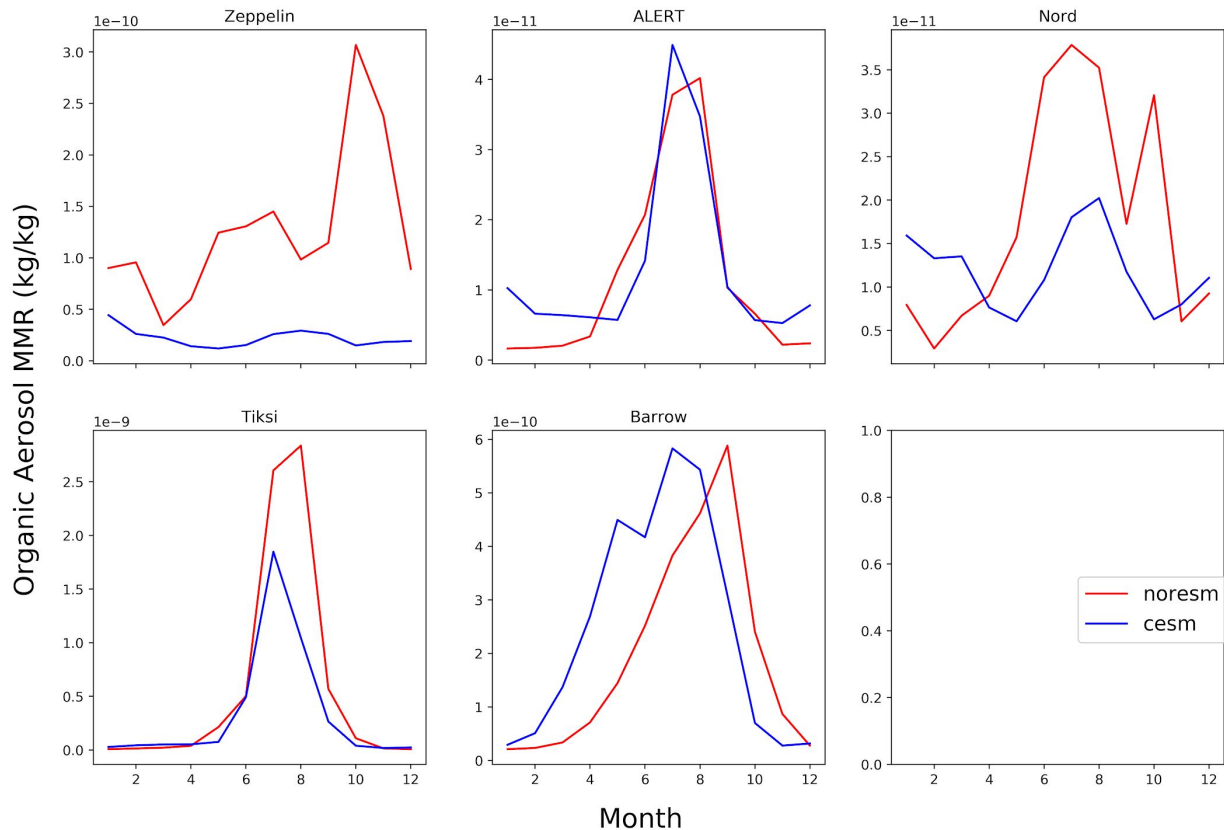
Annual Aerosol Trends by Observatory



Can we recover marine organic aerosol from models?

- NorESM has a direct marine primary organic aerosol emission source while CESM does not.
- **There is not a consistent bias between organic aerosol in these models when sampled at observatories**
- What about secondary organic aerosol?

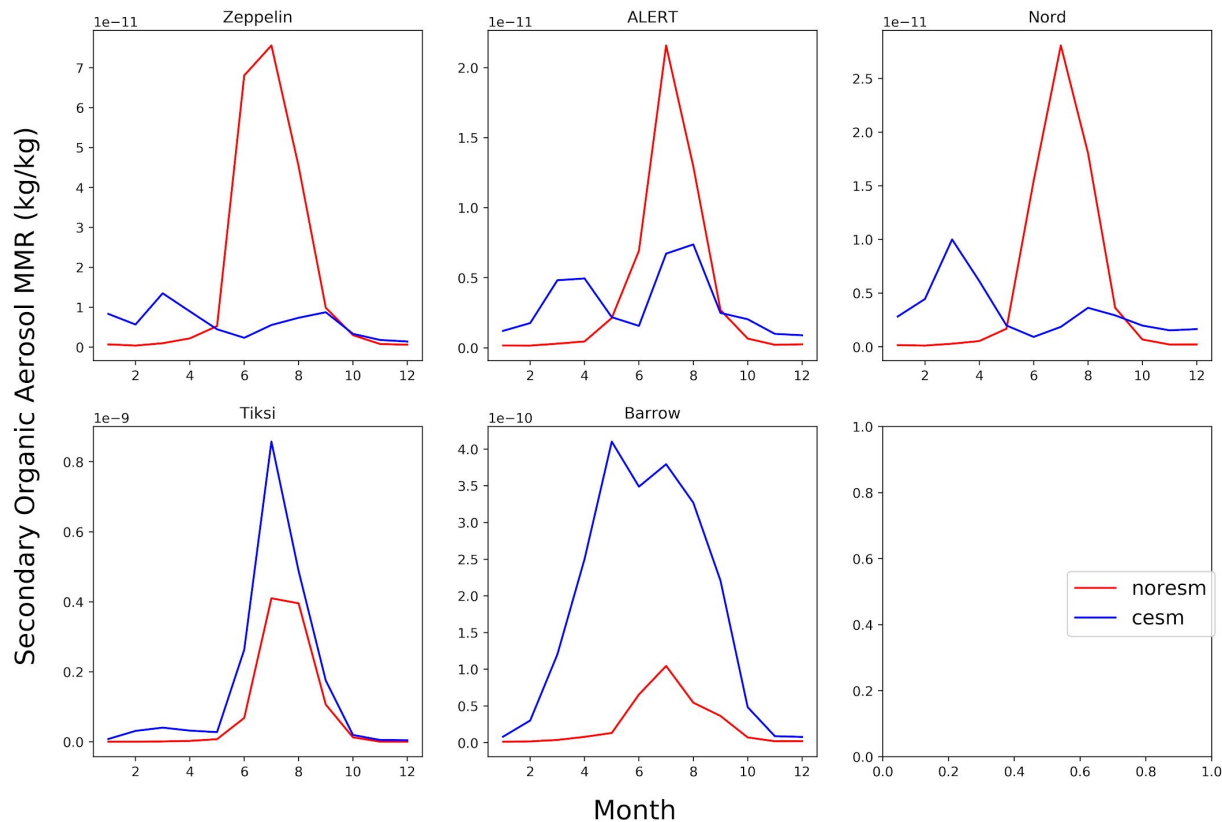
Modelled Organic Aerosol Annual Trends by Observatory (NorESM vs. CESM)



Can we recover marine organic aerosol from models?

- Secondary organic aerosol shows greater differences between models, but still no trend when sampled at observatories
- Variability between models is too large for a direct comparison...
- **Is there a good metric for comparing these models?**

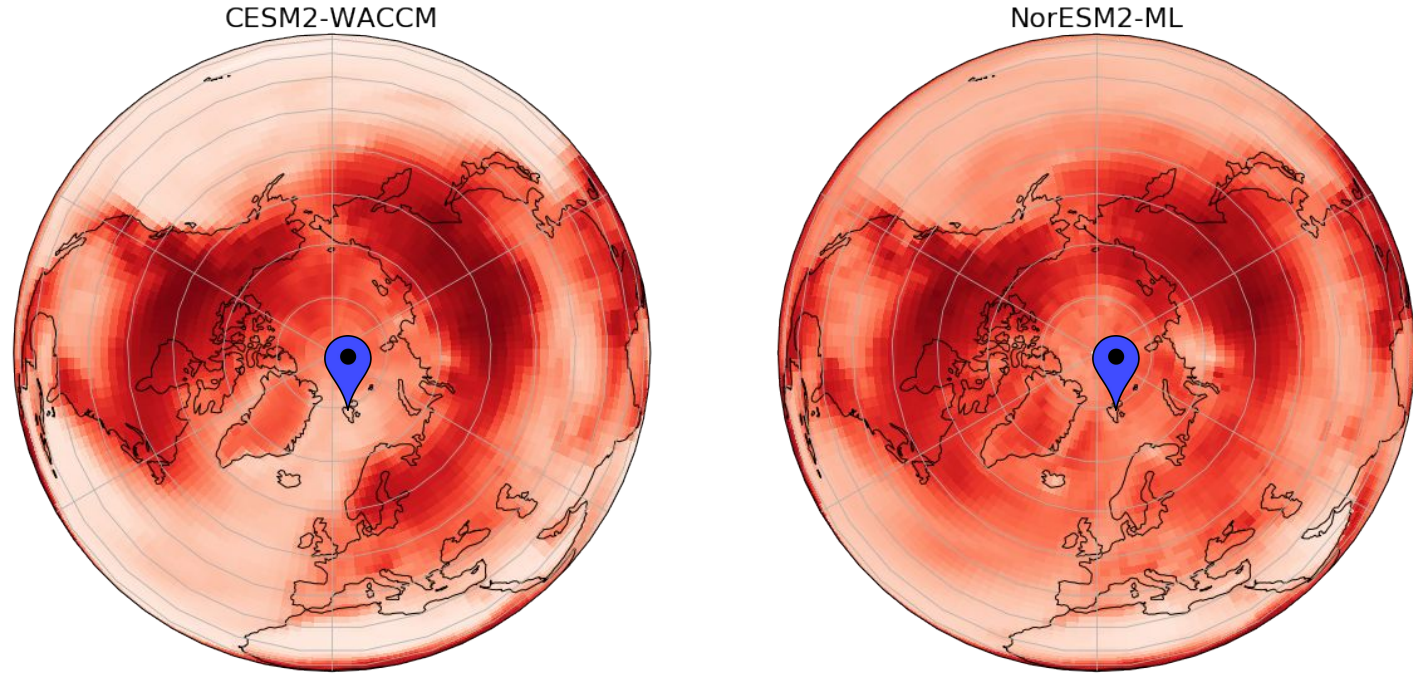
Modelled Secondary Organic Aerosol Trends by Observatory (NorESM vs. CESM)



Organic Aerosol Fraction in models (2006-2008)

- Qualitatively, the models show similar regional trends

Ratio of Organic Aerosol to "Total" Aerosol

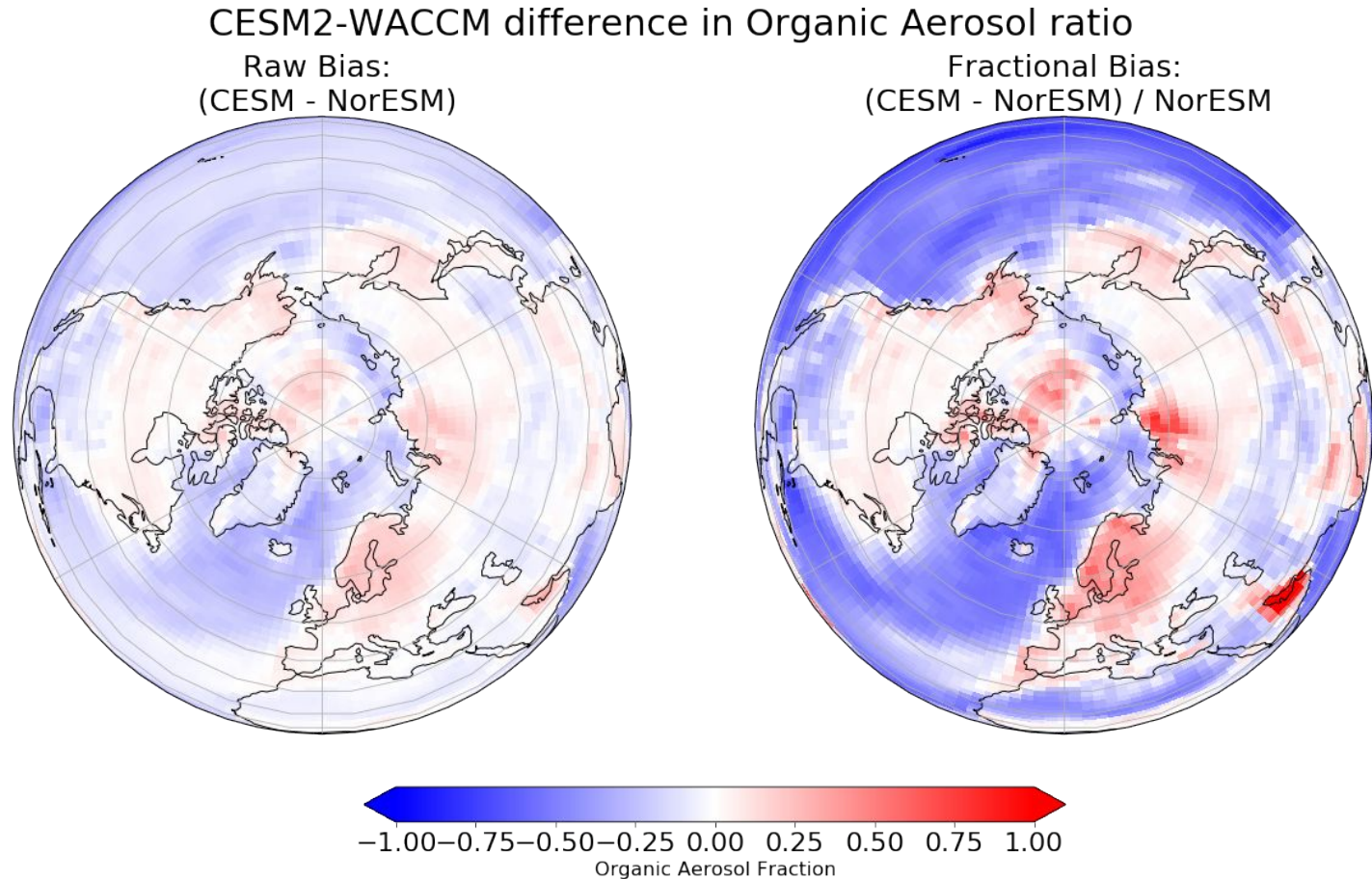


Data Source	OA_{ratio}
Observation	0.266
NorESM	0.348
CESM	0.253



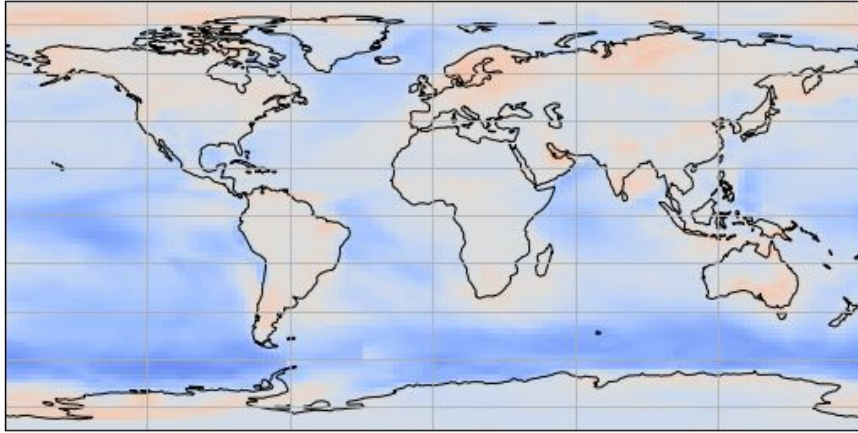
Organic Aerosol Fraction in models (2006-2008)

- CESM and NorESM have significant differences in organic aerosol fraction
- Unclear trend in the Arctic, what about globally?

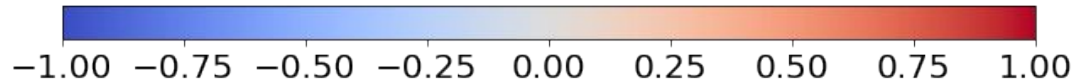
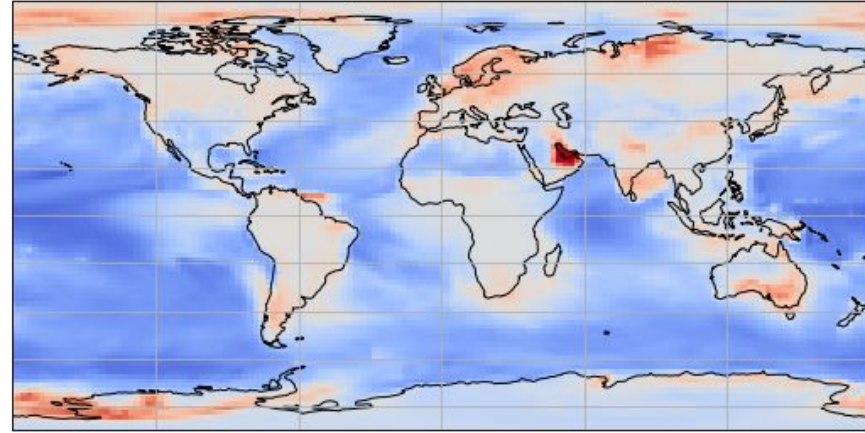


Global differences in modelled organic aerosol fraction

Raw Bias: (CESM - NorESM)



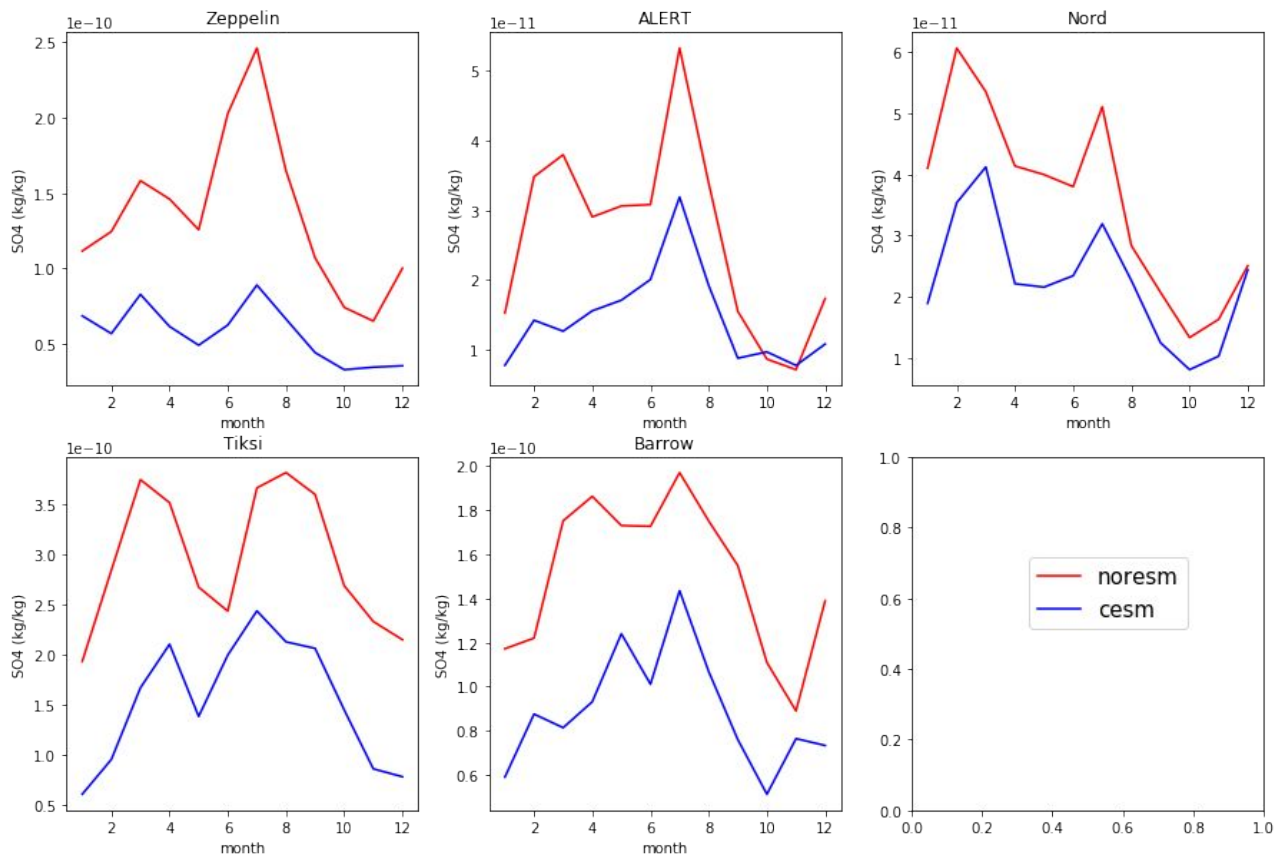
Fractional Bias: (CESM - NorESM) / NorESM



- Globally, CESM consistently has lower organic aerosol fraction over the ocean
- In the Arctic, the trend is unclear
- Variations cannot be attributed to sea salt aerosol (not included in oa fraction), but can they be attributed to marine aerosol?

SO4 trends, responsible for Arctic ratio biases?

SO4 Trends by Observatory between NorESM and CESM



Conclusions:

- General ocean trend in fractional organic aerosol between CESM2 and NorESM
- Drawing of any definitive or local conclusion is hindered by the lack of widespread observations, or a consistent framework on treating marine organic aerosol between models

Further work:

1. Use observational data of aerosol components for a direct comparison with GCMs
2. Overhaul methods, find a better metric for comparing oa between models
3. Include more models in global comparison to look for a trend
4. Expand the scope of include observations outside of the Arctic

Can we recover marine organic aerosol from models?

$$OA_{ratio} = \frac{OA}{OA + BC + SO_4}$$

- Normalize the contribution of organic aerosol to other aerosols
- Risks adding confounding variables that will also vary between models
- Does not include aerosol contributions from NH_4 or sea salt
- Look for Arctic and global trends, since observations don't provide a good comparison

Available aerosol measurements

Show observational data on the size distribution, and the single point from Zeppelin on oa, ss, and so₄

- We can see a general trend from the observational data, but it isn't nearly enough to draw conclusions or to constrain models

GCM aerosol partitioning at the observatory sites

- Mention the differences between NorESM and CESM2 in terms of marine oa
- Look at the differences between these models at the sites where we have data
- We can't make a real comparison, but we can look for similar trends that might suggest a relation between these things
- Mention where the models show good agreement, and where they disagree a lot (soa). Does soa matter if it is a small portion of the total aerosol?

Global trends between models

- Looking at the Arctic and the whole globe, can we see any trends that could have to do with marine organic aerosol.
- Since we can't compare a single model (no MIP), we use similar models and calculate a fractional aerosol value (latex equation here)
- No, not really. CESM has less oa general in the oceans, but then more in the high Northern latitudes. The differences are significant, as we saw in the comparison made and the observatories
- Could this have to do with ice, or ocean productivity?