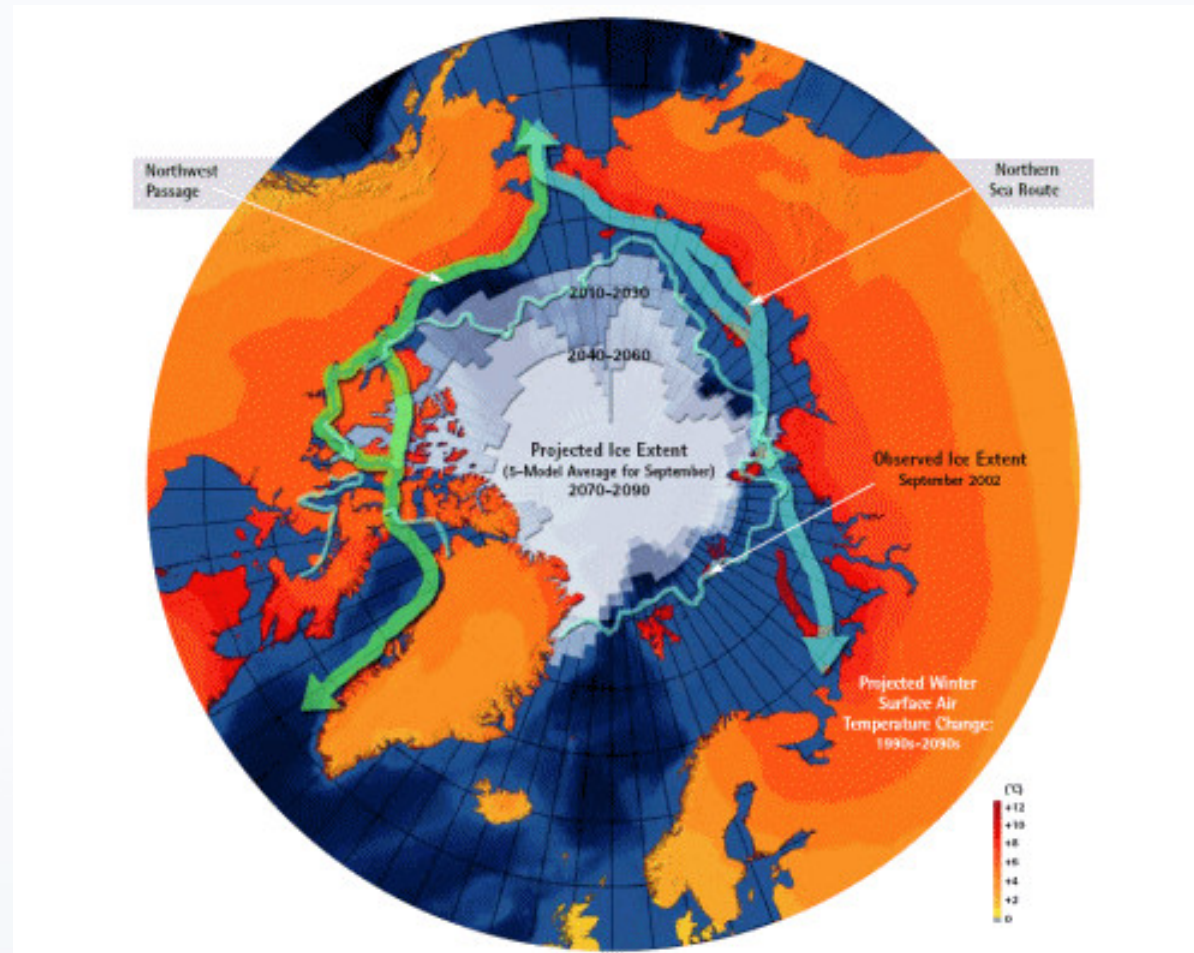
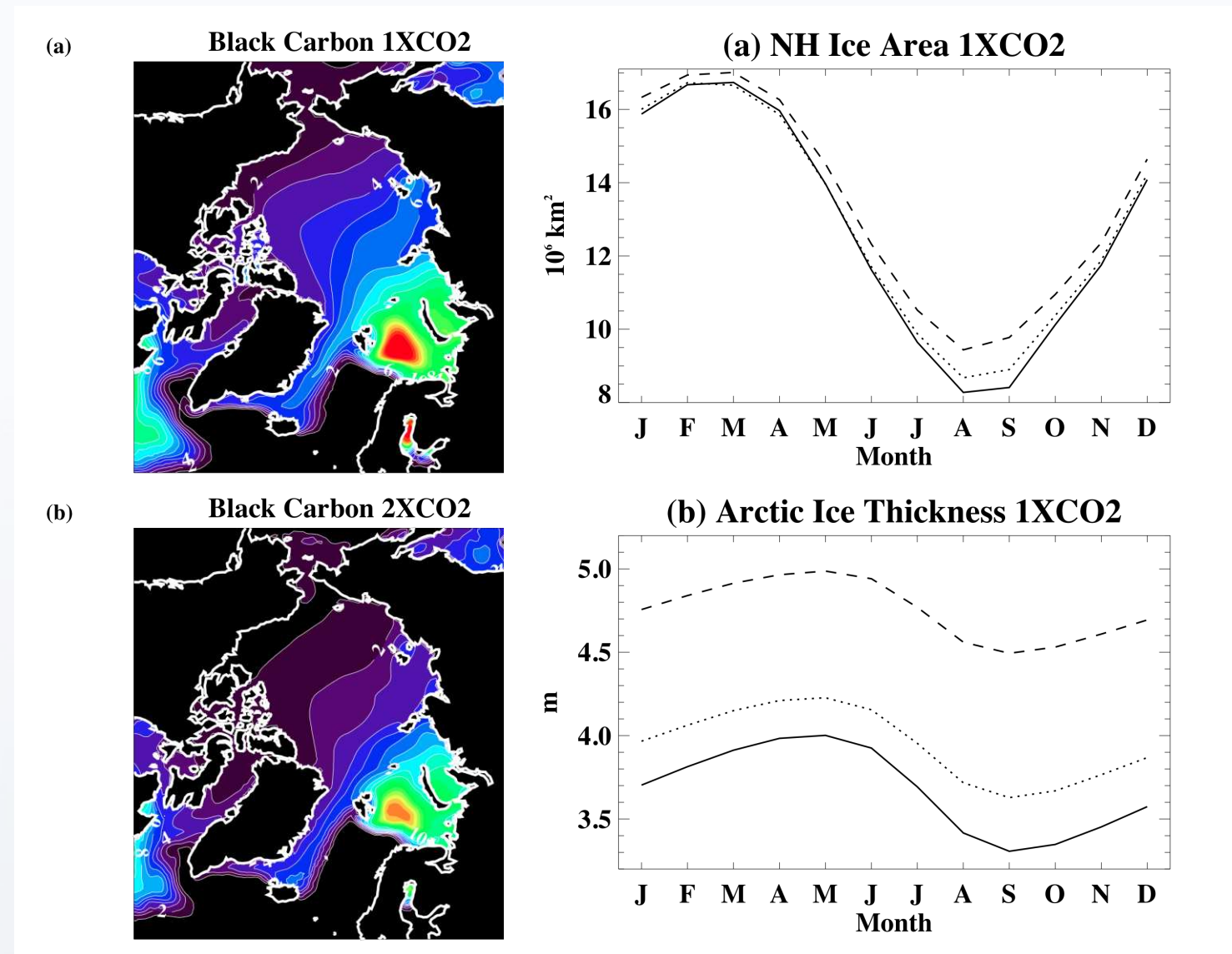


Potential impacts of black carbon emissions from increased Arctic shipping.

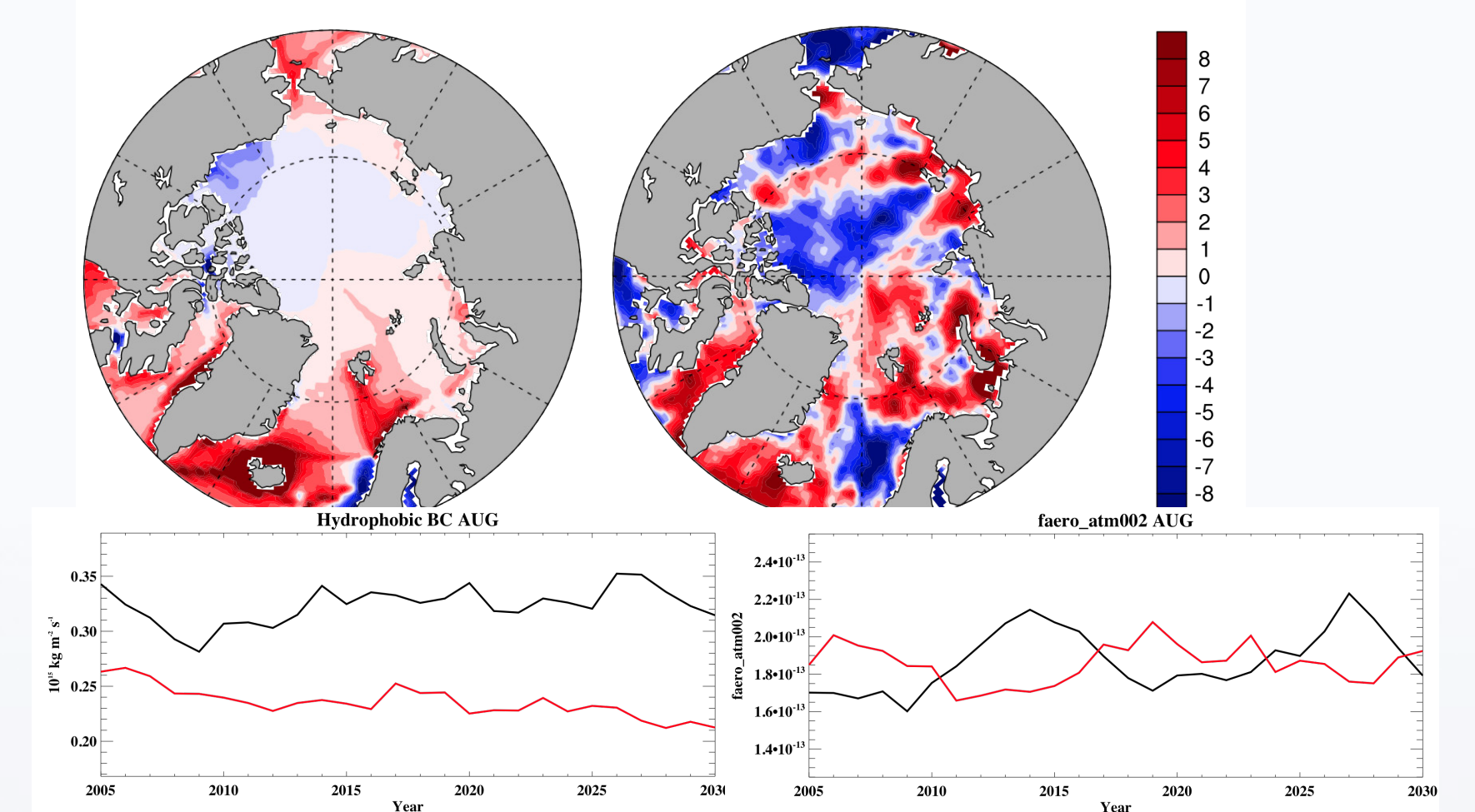
David A Bailey, Marika M Holland, Jean-François Lamarque, NCAR Earth System Laboratory
Daniel Lack, NOAA/ESRL
Mark Flanner, University of Michigan
James Corbett, University of Delaware



Sea ice area and extent is projected to decrease over the 21st century. This would imply the opening of coveted Arctic sea routes.



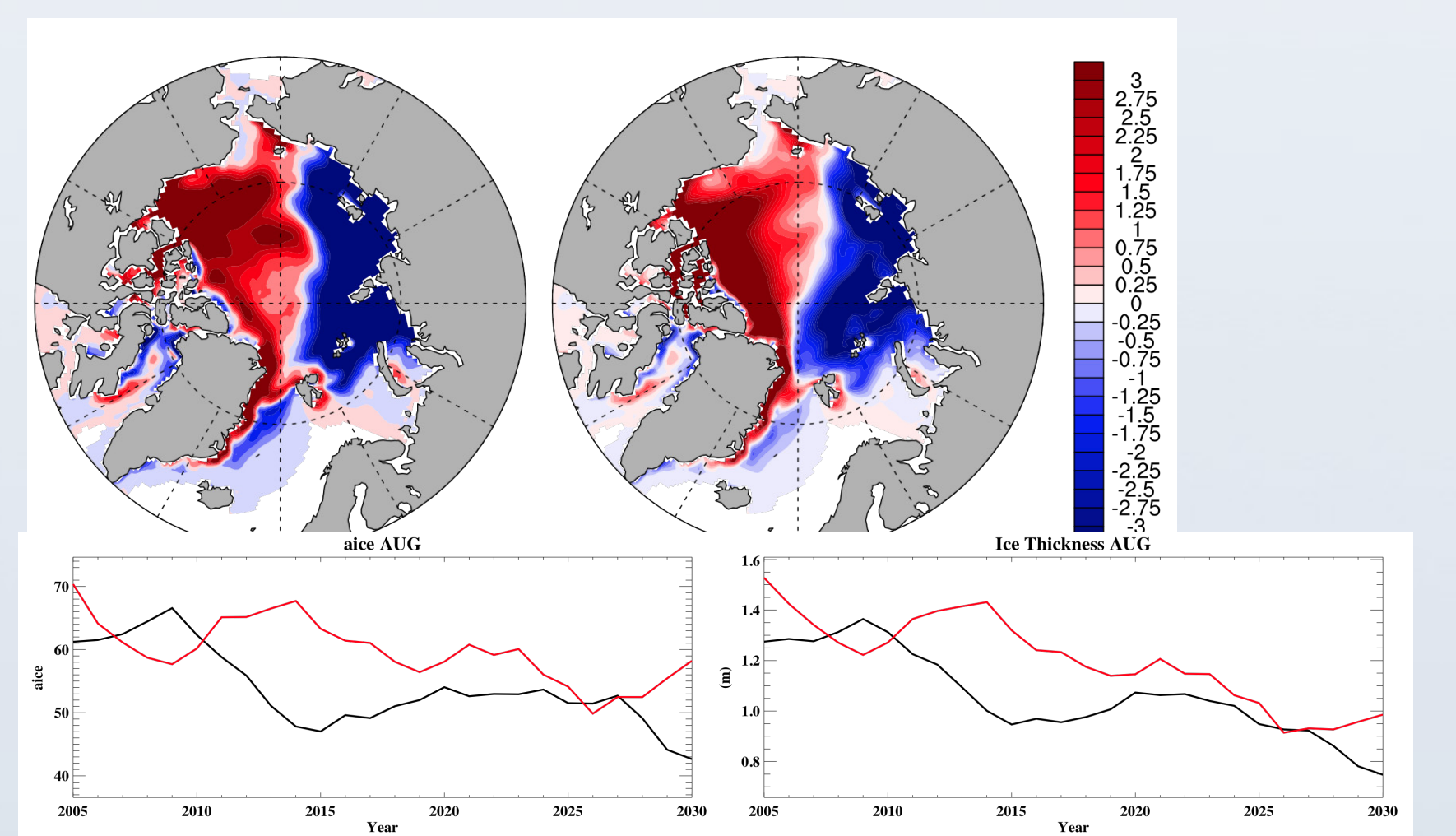
Sea ice volume and thickness is decreased by the presence of climatological black carbon aerosol. More sensitive to melt ponds. The solid line is the control run with black carbon and melt ponds. The dotted line is with no black carbon. The dashed line is without melt ponds.



Main change in BC aerosol emissions due to ships is in the hydrophobic category. The hydrophilic BC is more susceptible to synoptic atmospheric variations. The time series are regional sums in the Kara and Barents Seas. Black is with ships and red is without.



Are we already there?



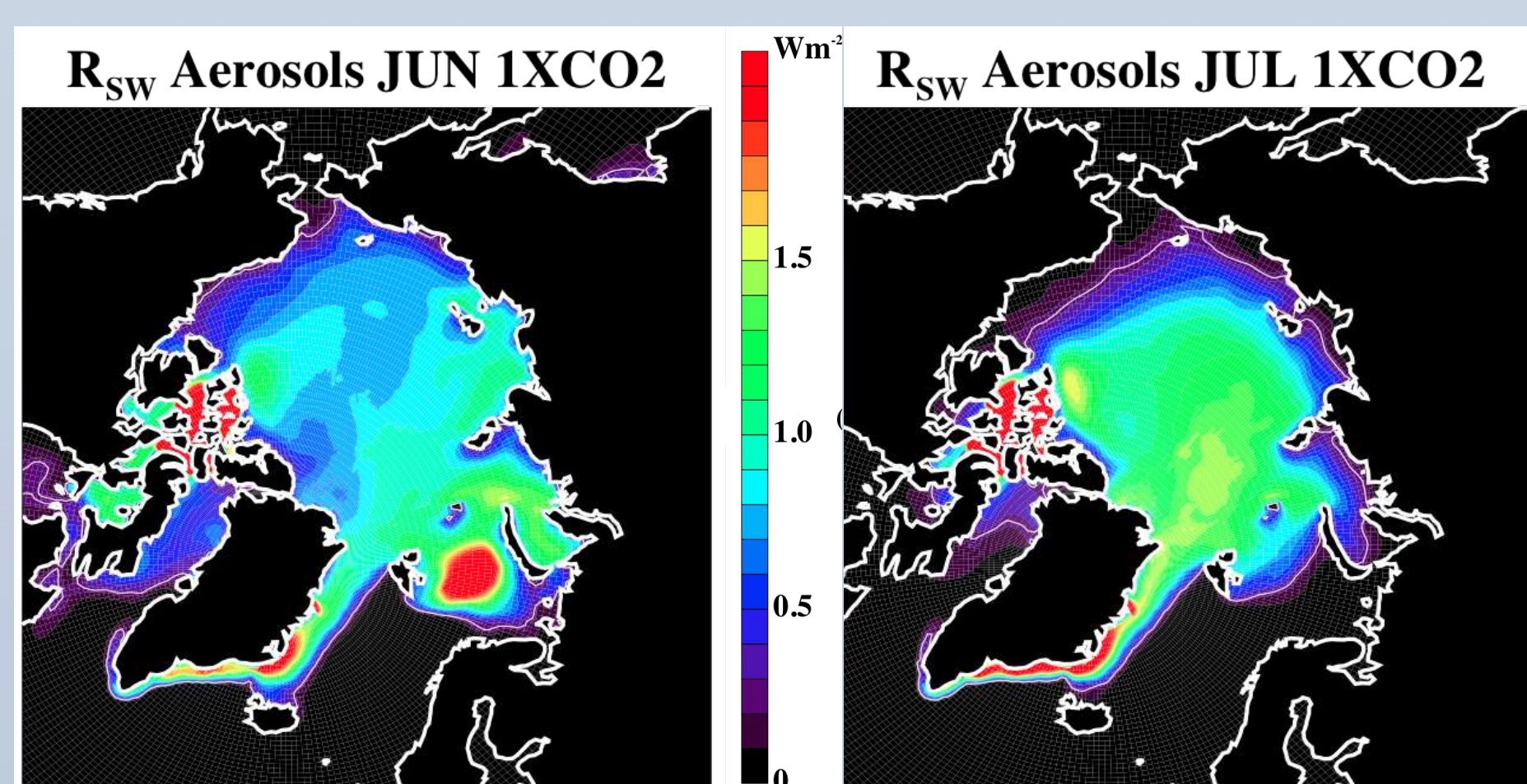
When comparing the ice area and thickness between ensemble means of the shipping and no shipping experiments we see a strong dipole pattern. However the time series in the Kara and Barents Sea seems to indicate these are only marginally different. Black is with ships and red is without.

CCSM4/CESM1 include black carbon (BC) deposition (and cycling) on (in) the sea ice / snow and radiative diagnostics (below).

BC affects the surface albedo.

CESM sends BC from atmosphere (CAM/DATM).

CESM also allows for prognostic BC, but prescribed dust, etc.



The change in absorbed solar radiation over sea ice due to pre-industrial aerosol (black carbon and dust) deposition for June and July.

Experiment Setup

Use RCP8.5 21st century forcing and shipping emission inventories (top panel) as was done for IPCC runs (control).

Initialize from 20th century ensemble members.

Merge hypothesized shipping inventory increases (D. Lack, J. Corbett) with control run emissions (sensitivity).

BC binned into hydrophobic and hydrophilic aerosols.

Summary

CESM1 includes new functionality for BC and other aerosols.

Shipping signal is relatively small compared to natural variability / background concentrations and very localized.

Some indications of a shipping signal in the Barents/Kara Sea.

Partly due to emissions dataset construction, ratio of hydrophilic to hydrophobic BC, and perhaps length of experiments.

Additional work is required to determine the relative effects of the enhanced shipping emissions on the surface albedo (increased shortwave absorption) versus the atmospheric shading (reduced shortwave insolation) in our experiments.

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