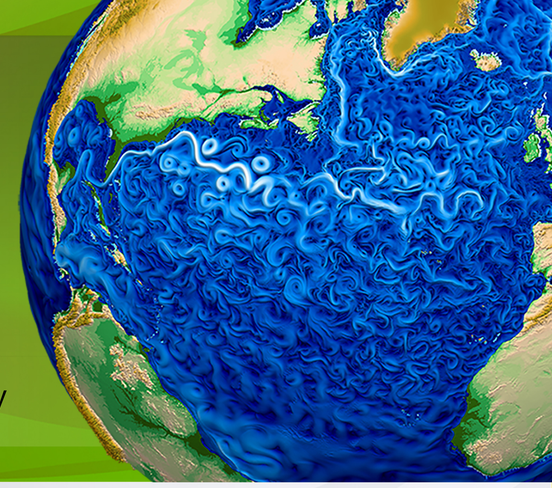
R: Dust Aerosols in ACME and Sensitivity to Model Resolution

Yan Feng[1], Hailong Wang[2], Kai Zhang[2], Wuyin Lin[3], Po-Lun Ma[2], Jasper Kok[4], and Natalie Mahowald[5]
[1]Argonne National Laboratory; [2]Pacific Northwest National Laboratory; [3]Brookhaven National Laboratory; [4]UCLA; [5]Cornell University



Objective

Dust aerosols affect Earth's climate through direct and indirect perturbations of global energy balance, and interactions with atmospheric chemistry and biosphere. Therefore, it is important to quantify the model representation of dust aerosols for implications on both coupled water cycle and biogeochemical simulations with the ACME model. In particular, increasing model resolution from ne30 to ne120 could affect the emissions and removal of dust by resolving meteorology and orography at finer scales, and also by tuning the scale-dependent parameters in the model.

The primary goals of this study are to:

(1) evaluate dust simulations in the low and high res v1 model; and

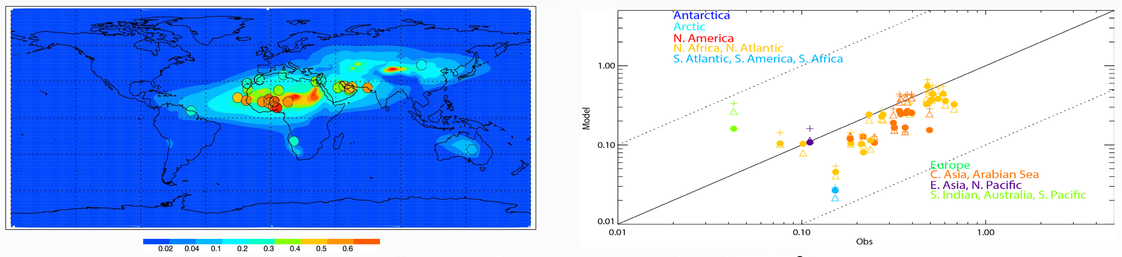
(2) examine the impact on dust deposition fluxes and other aerosol simulations in the high res configuration, after optimizing dust aerosol optical depth (AOD) to the low res simulations.

V1 (beta0) model experiments examined

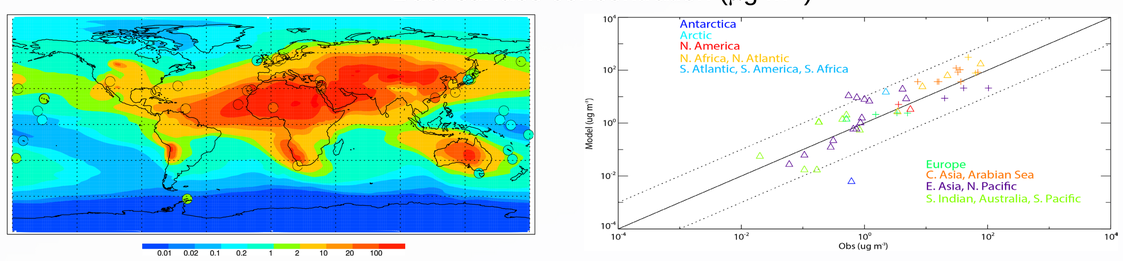
#	Resolution	Compset	Parameters tuned	Analysis periods
Exp I	Low Res (ne30L72)	FC5AVIC-04P2	control	Years 7-11
Exp II	High Res (ne120L72)	FC5AVIC-04P2	R5	Years 2-4
Exp III	High Res optimized (ne120L72)	FC5AVIC-04P2	R5 (dust and sea salt emission factors reduced)	Year 5

Evaluation of dust in the low- and high- res

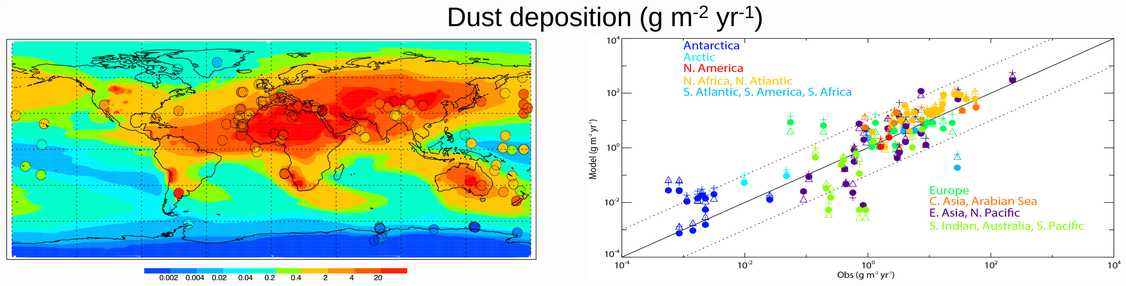
Dust AOD



Dust surface concentration (μg m^{-3})



Dust deposition (g m^{-2} yr^{-1})

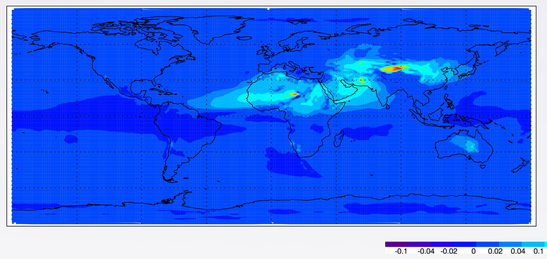


Left panels show the low-res dust simulations with observational data (filled circles) superimposed; right panels show the model-data comparisons in 9 regions. In the middle-right panel, symbols denote observational data sources. Otherwise, symbols denote for low res (filled circles), high res (plus), and high res optimized (triangles) results.

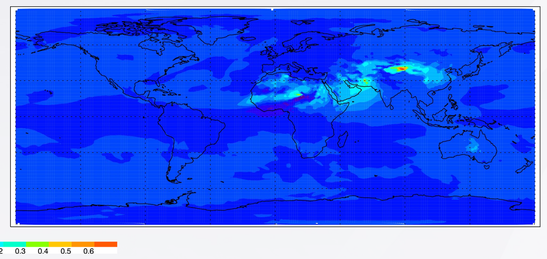
Changes due to increase of model resolution

Dust AOD

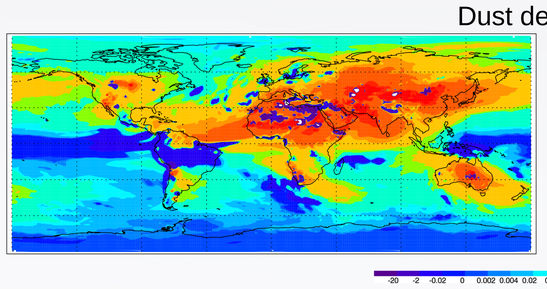
High res – Low res

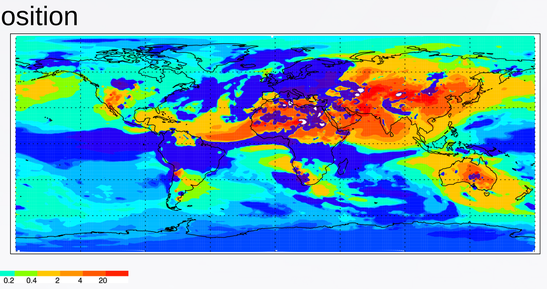


High res optimized – Low res



Dust deposition





Comparison with observations

	AOD			Deposition (Tg/yr)		
	All-mean	All-median	N Africa/N Pacific	All-mean	All-median	S Pacific
Exp I	0.22	0.24	0.26	13.8	4.0	0.24
Exp II	0.3	0.29	0.33	21.0	5.0	0.25
Exp III	0.25	0.24	0.24	17.2	3.8	0.41
Obs	0.33	0.34	0.39	8.4	2.5	0.6

Impact on global budgets and AOD

- Increase of model resolution has two-fold effects:(1) for dust or other "state-dependent" or natural aerosols such sea salt, their emissions are increased, leading to larger global aerosol burdens and AODs; (2) aerosol removal especially wet removal is enhanced, which lowers burdens and AODs;
- For dust, the impact on emissions dominates increasing AOD by 42%. Reduction of dust emissions optimizes the global mean dust AOD, but under-predicts the dust AODs in source regions;
- The high-res model improves the predicted spatial distribution of dust deposition fluxes (R^2 =0.92 vs 0.88), but still overestimates deposition fluxes by a factor of 2 compared with data;
- The next step is to quantify impact on dust and aerosol forcing with increased model res. We will also optimize dust AODs in different source regions using long-term AERONET data. This could lead to significant improvement in estimating dust forcing and nutrient deposition for BGC.

Global	Dust AOD	Emission (Tg yr^{-1})	Dry depo (%)	Wet depo (%)	Burden (Tg)	Lifetime	Total AOD
Low res	0.026	4702	78%	22%	22.9	1.8	0.143
High res	0.037 (+42%)	6044 (+29%)	73%	27%	34.3	2.1	0.145
High res optimized	0.030	4950	72%	28%	28.5	2.1	0.125 (-13%)

ACME Accelerated Climate Modeling for Energy

For additional information, contact:
Yan Feng
Scientist
Argonne National Laboratory
(630) 252-2550
yfeng@anl.gov

climatemodeling.science.energy.gov/acme

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