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ACAG Atmospheric Composition Analysis Group

Impact of GCHP Spatial Resolution on Global Geophysical Satellite-Derived Fine Particulate Matter

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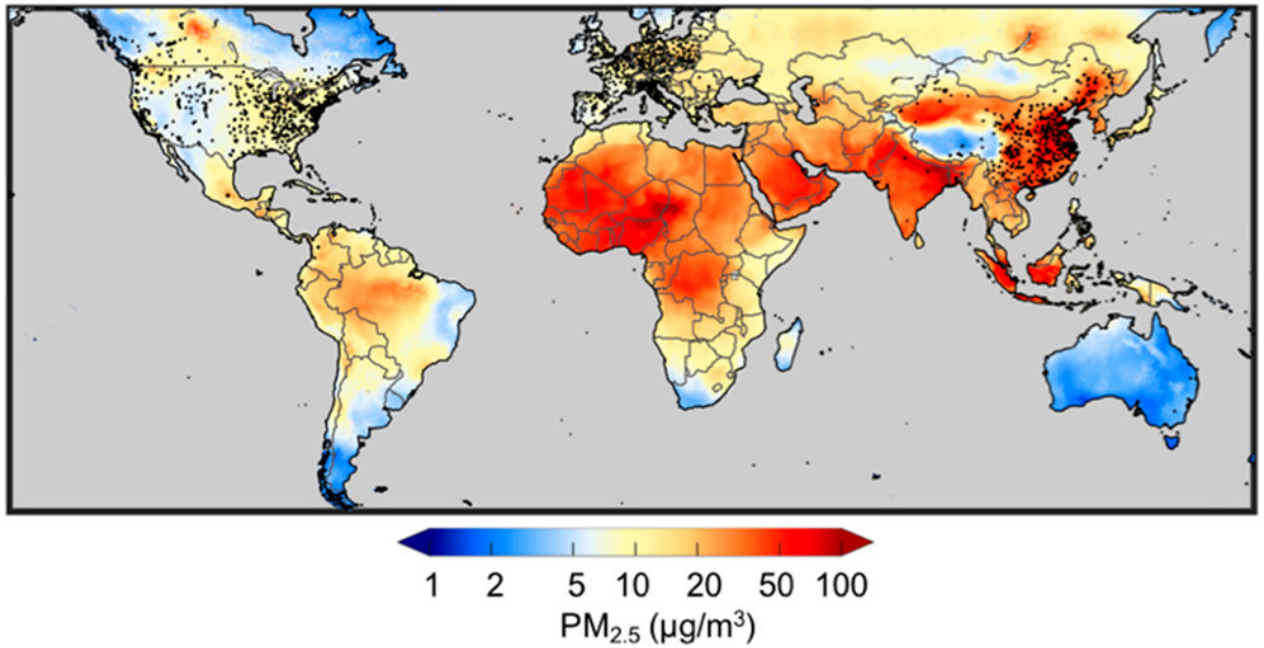
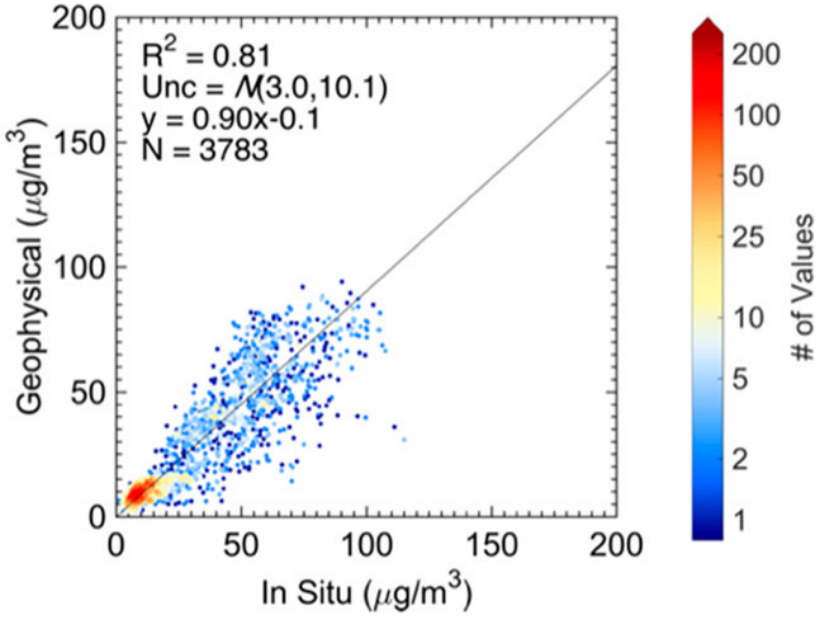
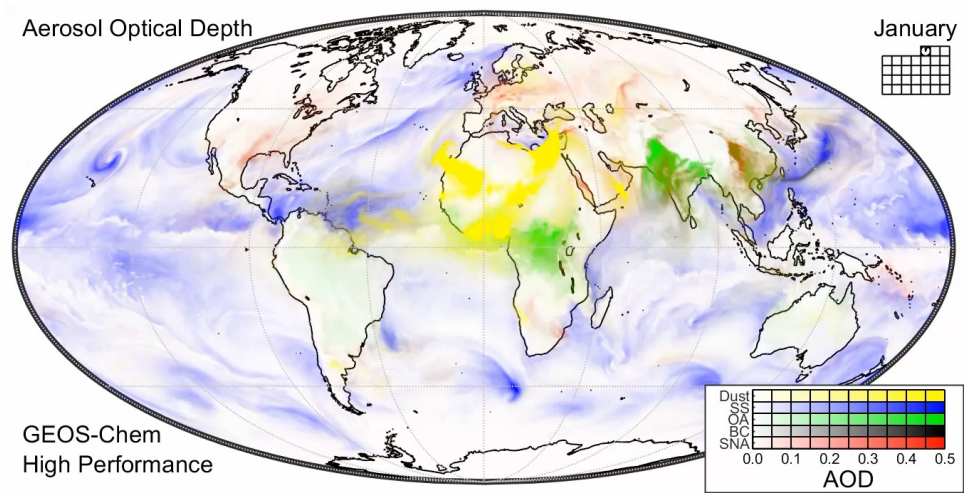
Model spatial resolution effects on satellite-derived $PM_{2.5}$





Ref: Hammer et al., 2020, *Environ. Sci. Technol.*



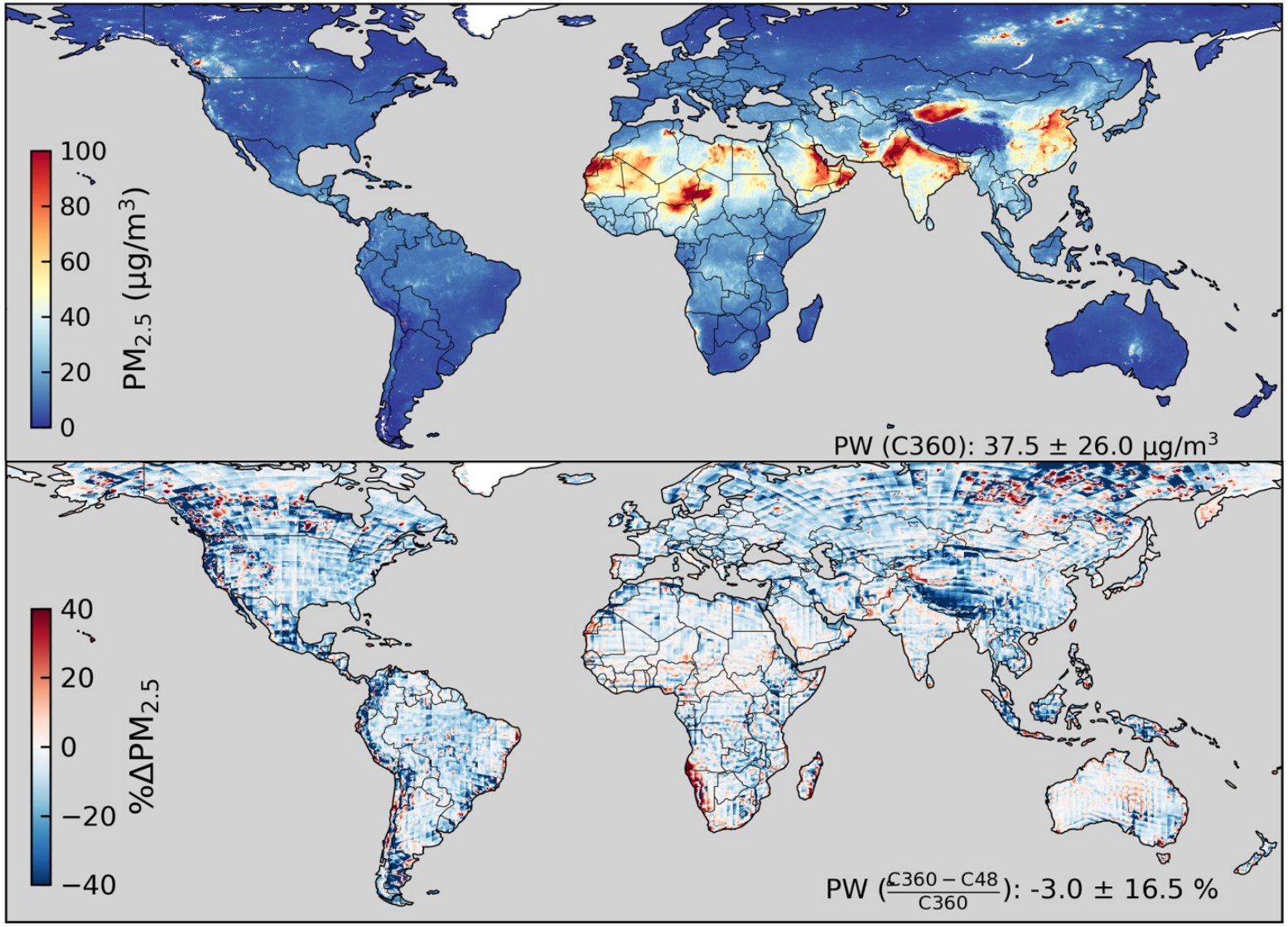
$$\text{Geophysical } PM_{2.5} = \frac{PM_{2.5,sim}}{AOD_{sim}} AOD_{sat}$$

η: simulated surface $PM_{2.5}$ to AOD ratio

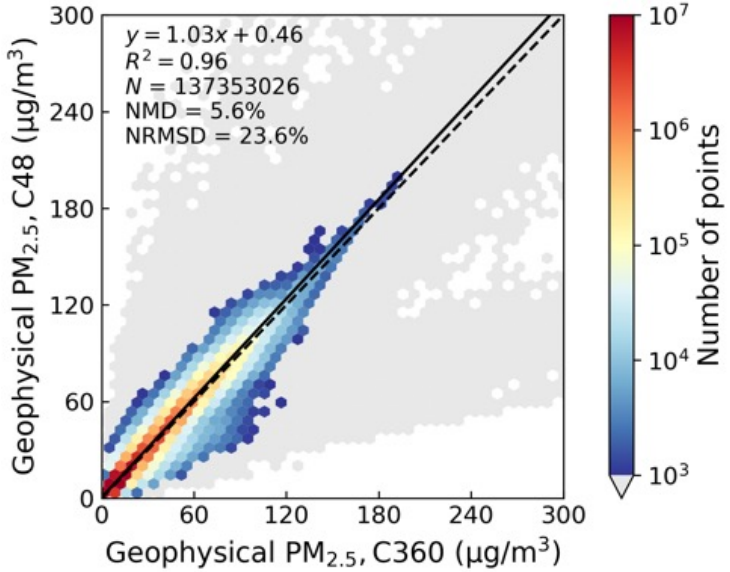
C360 (~25 km) vs. C48 (~200 km)

→ Benefits of finer model resolution on satellite-derived $PM_{2.5}$?

Global distributions of satellite-derived $PM_{2.5}$ across resolution



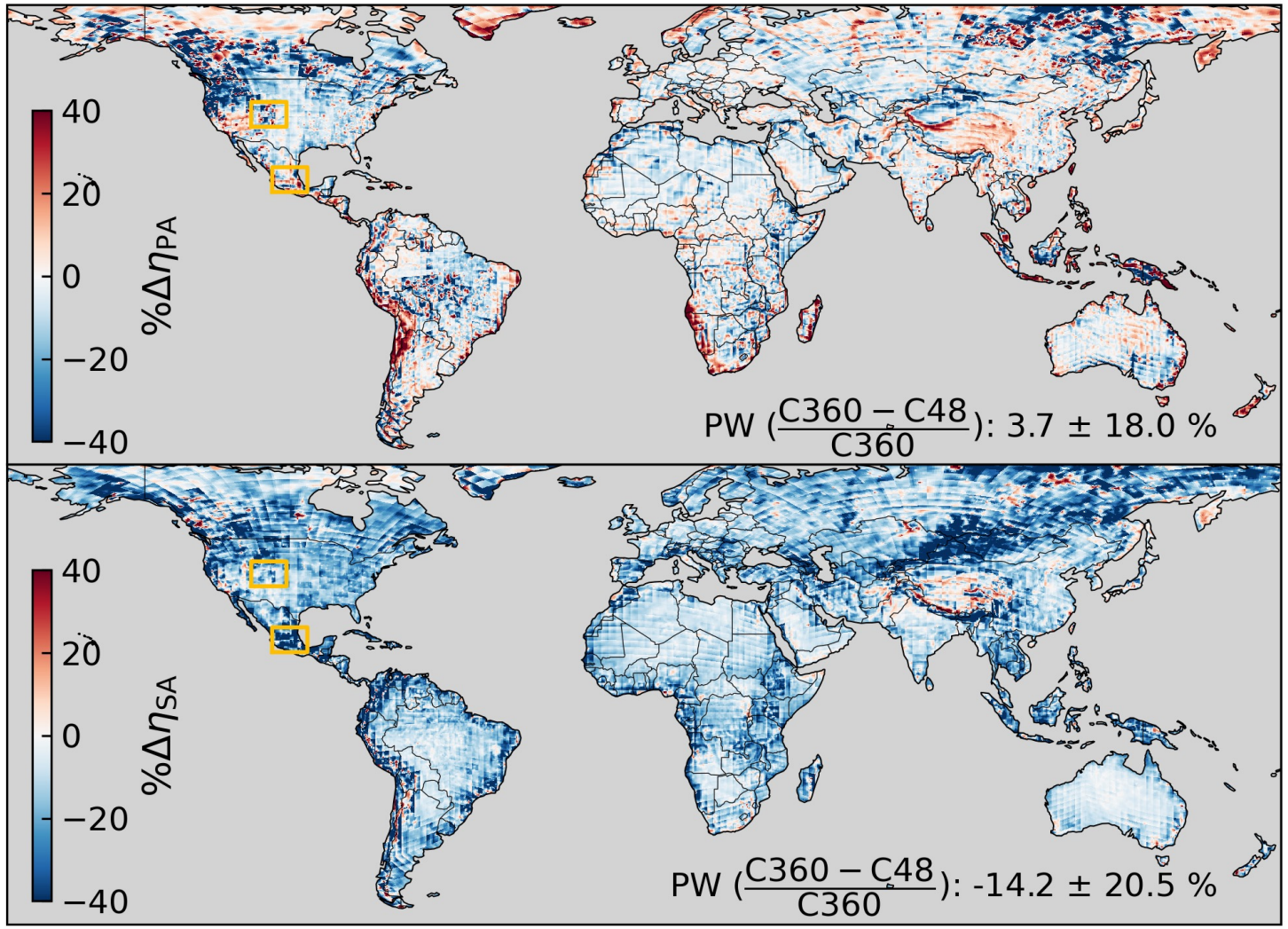
- Global similarity across resolution (R^2 = 0.96)
- Local heterogeneity: isolated sources and mountainous regions



PW: population weighted

Opposite resolution sensitivities of primary and secondary components

- Better resolved spatial representation of primary aerosols;
- Reduced surface to column ratio of secondary aerosols



PW: population weighted

- Speciated surface to column ratio:

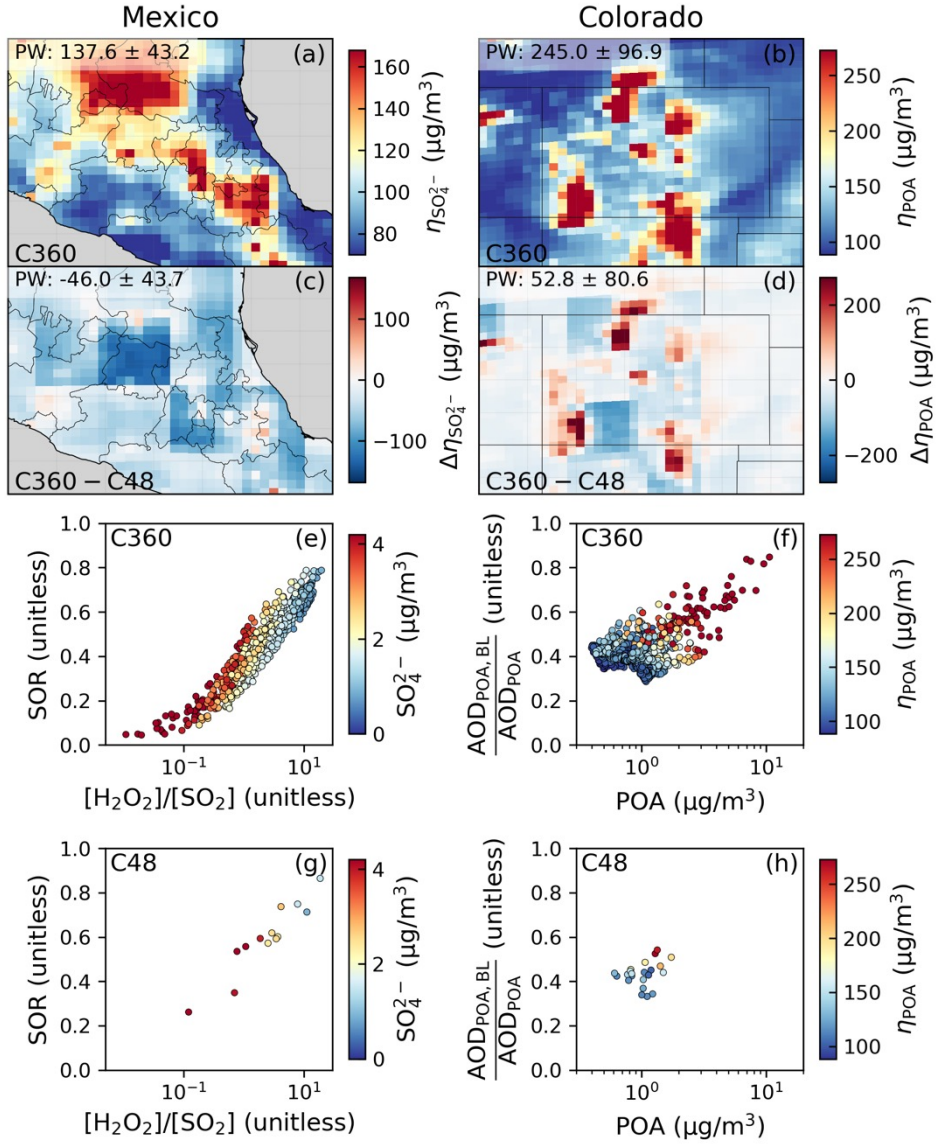
$$\eta_i = \frac{C_{sfc,i}}{\mathrm{AOD}_i}$$

where i for different species.

- Primary aerosol:
  PA = POA + BC + Dust + SS

- Secondary aerosol:
  SA = SOA + SO_4^{2-} + NO_3^- + NH_4^+

Opposite resolution sensitivities of primary and secondary components



Note: $\mathrm{SOR} = \frac{[SO_4^{2-}]}{[SO_4^{2-}]+[SO_2]}$

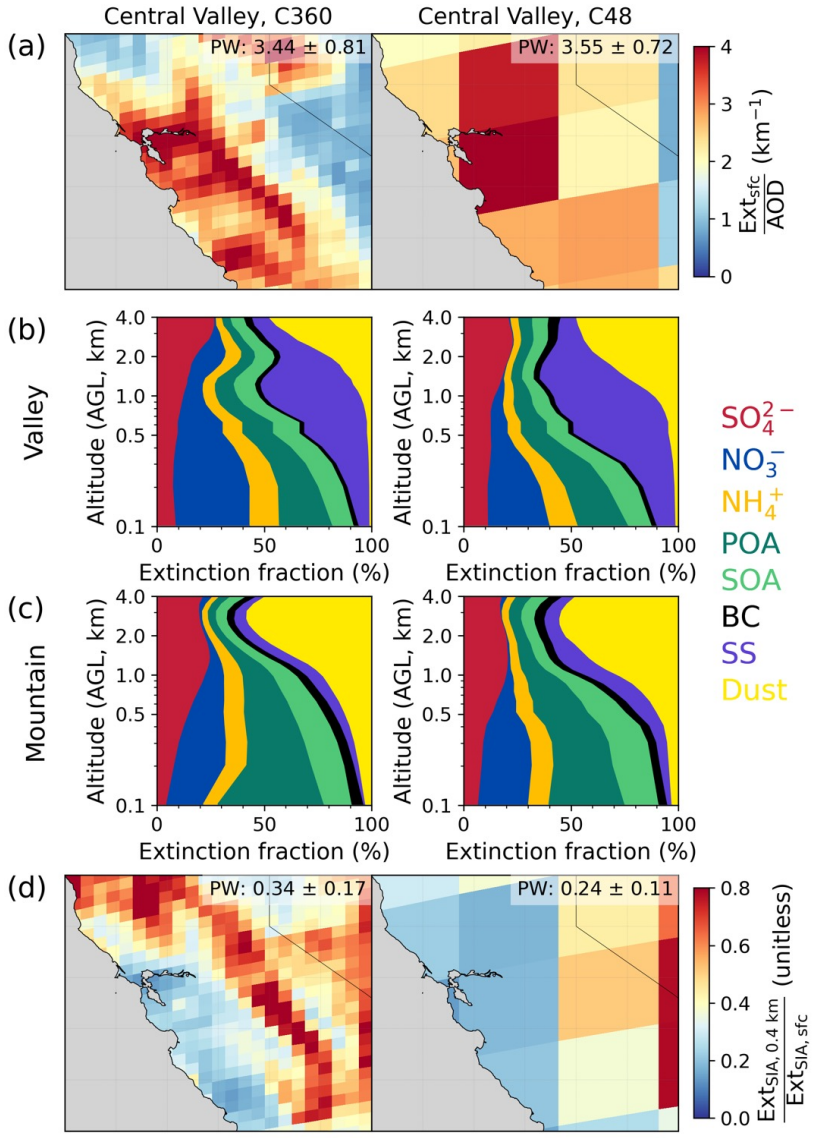
Surface driven spatial heterogeneity of η

- SO_4^{2-}: reduced local oxidation of SO_2 over strong source regions
- POA: covariation of surface and total column abundance → reduced heterogeneity

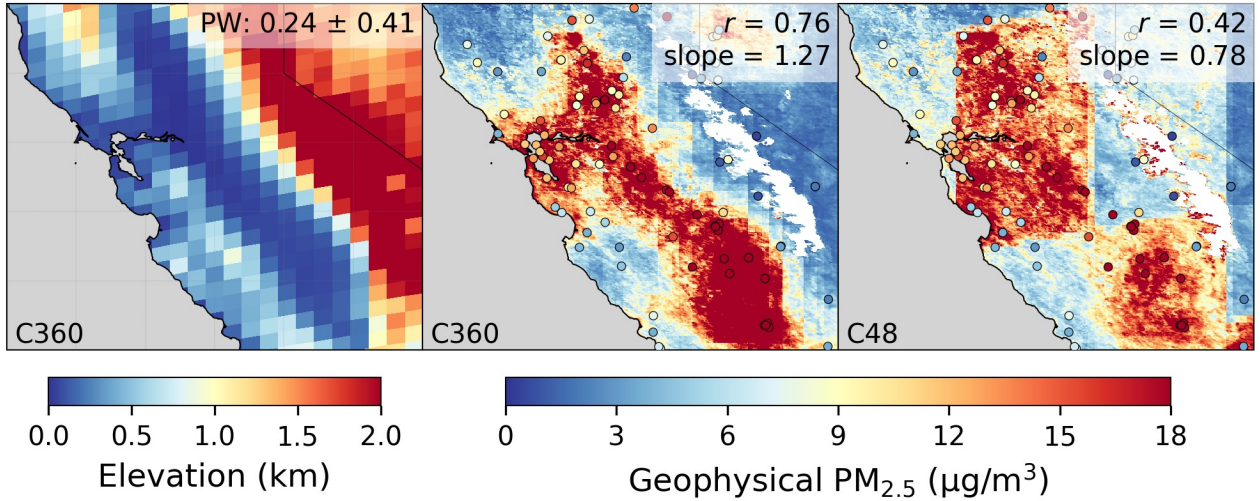
		$PM_{2.5}$	SO_4^{2-}	POA
η_i	PW-NRMSD (%)	17.9	32.2	28.8
	PW-NMD (%)	-1.3	-13.7	7.5
C_{sfc}	PW-NRMSD (%)	23.1	41.8	42.0
	PW-NMD (%)	0.7	-18.6	9.5
AOD	PW-NRMSD (%)	19.1	29.4	30.3
	PW-NMD (%)	2.8	-2.9	3.3

Note: $\eta_i = \frac{C_{sfc,i}}{\mathrm{AOD}_i}$, where i for different species.

Spatial representation: better resolved mountain-valley contrast



- Distinct mountain-valley contrast better resolved at fine resolution
- Compositional separation of vertical profiles
  - Valley: Dominant near-surface nitrate
  - Mountain: Nitrate transported aloft
- Enhanced agreement against observations



Take-aways

- Pronounced global similarity of geophysical satellite-derived $PM_{2.5}$ (R^2 = 0.96, slope = 1.03) across model resolution
- Opposite resolution sensitivities between primary and secondary components
  - Primary hotspots: Covariations between surface $PM_{2.5}$ and AOD
  - Secondary reductions: reduced surface concentrations
- Regional vertical heterogeneity
  - Vertical concentration stratification: local near-surface pollution vs. regional transport aloft
  - Compositional mountain-valley contrast