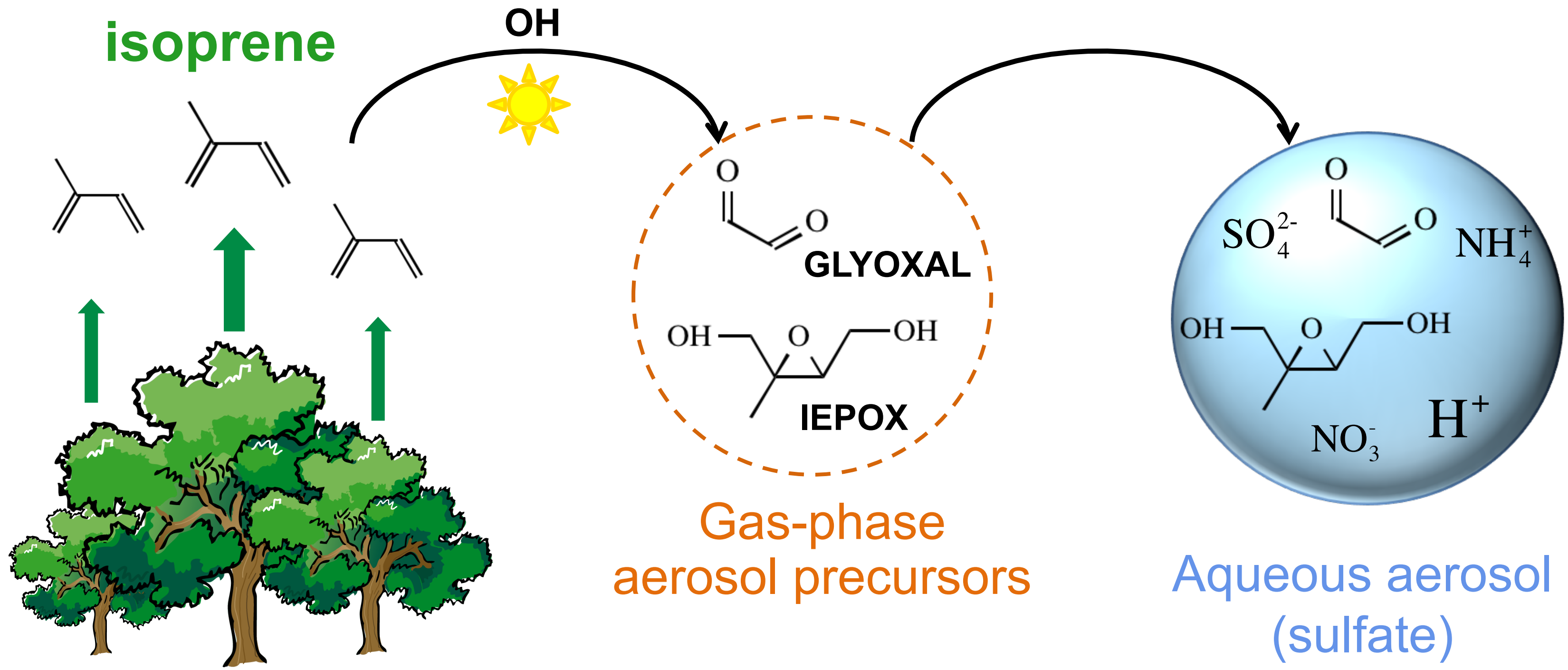
Modelling biogenic secondary organic aerosol

Co-benefit of SO_2 emission controls to decrease biogenic organic aerosol and sulfate



Coauthors: **D. J. Jacob**, J. L. Jimenez, P. Campuzano-Jost, D. A. Day, W. Hu, J. Krechmer, L. Zhu, P. S. Kim, C. C. Miller, J. A. Fisher, K. Travis, K. Yu, T. F. Hanisco, G. M. Wolfe, H. L. Arkinson, J. R. Turner, L. J. Mickley, H. O. T. Pye, K. D. Froyd, J. Liao, V. F. McNeill

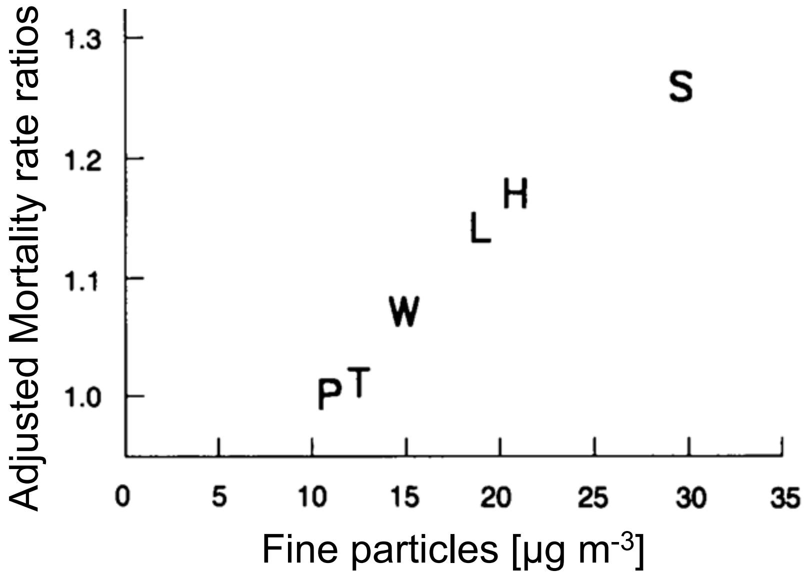
Schlumberger Foundation Faculty for the Future

National Research Foundation

Eloïse A Marais
(e.a.marais@bham.ac.uk)

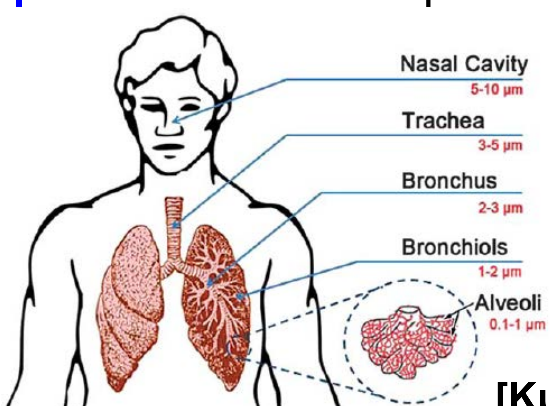
Aerosols Impact Climate, Human Health, and Visibility

Fine particles are associated with **increased mortality**



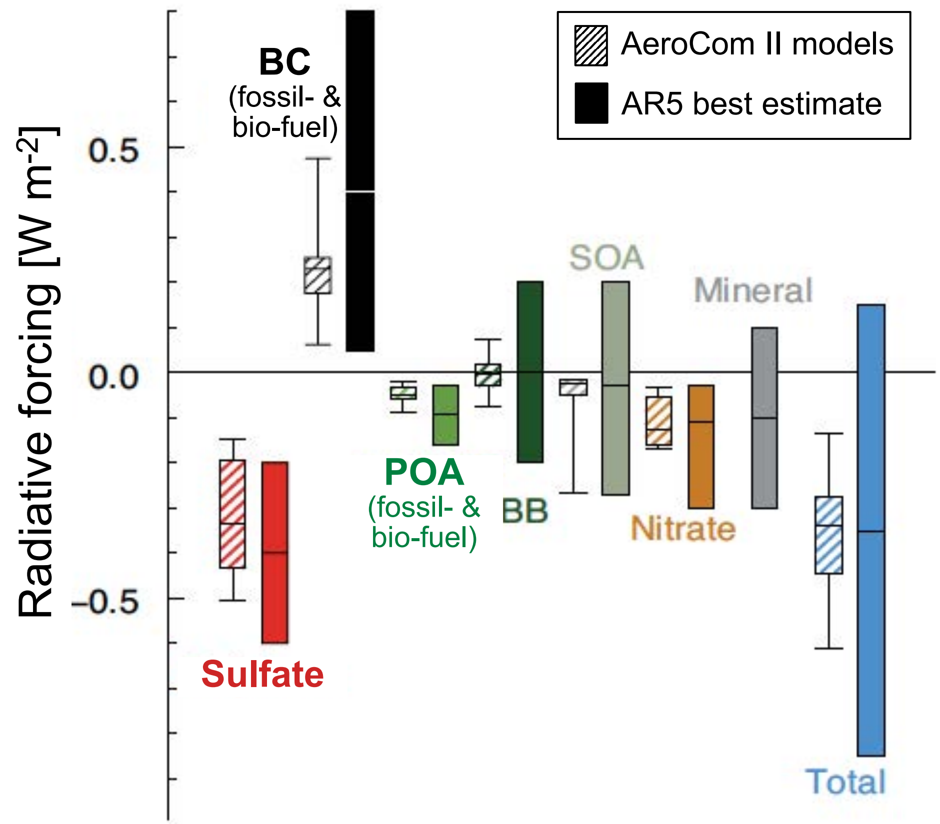
[Dockery et al., 1993]

Fine particles travel deep into the lungs



[Kumar et al., 2014]

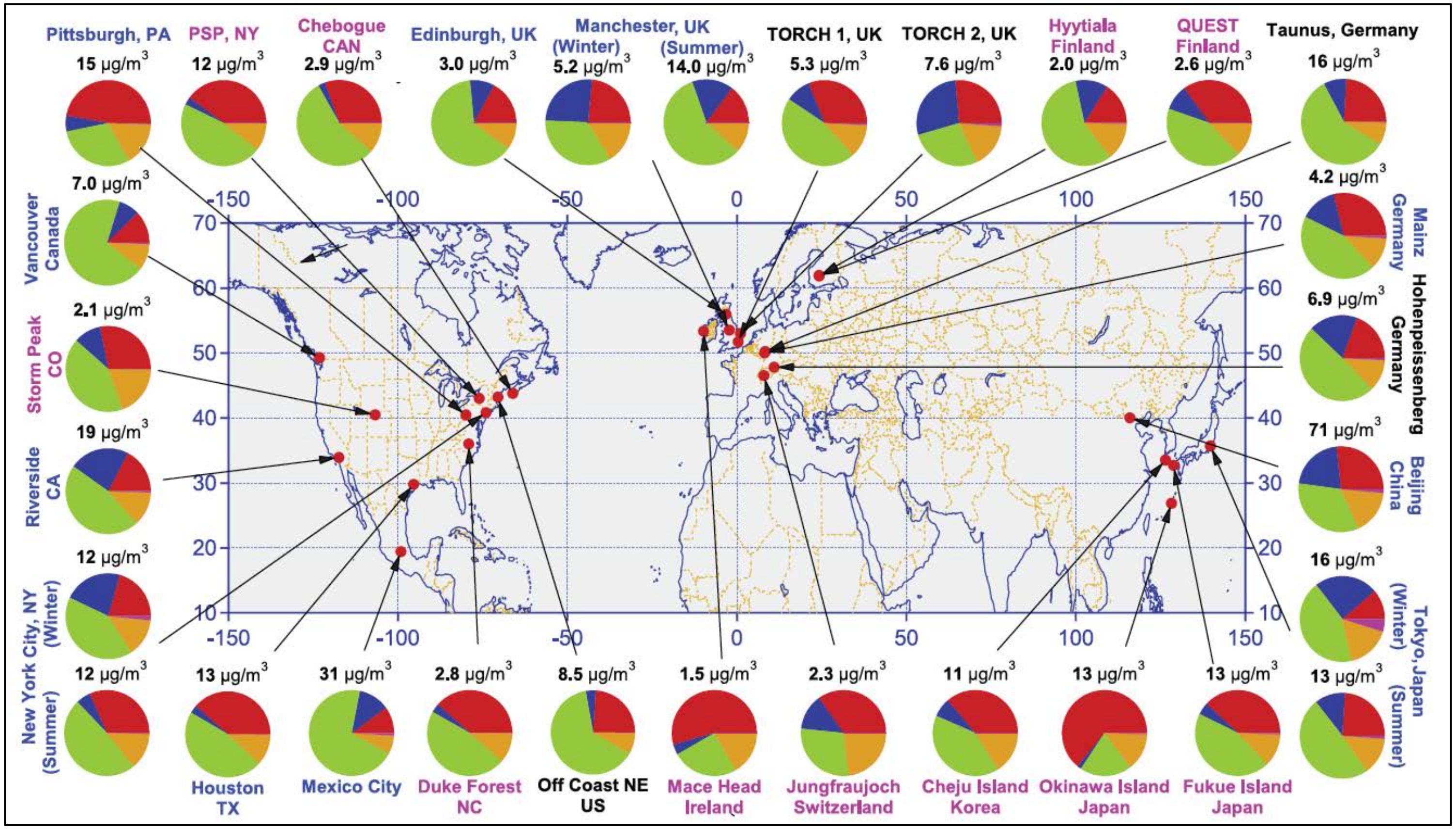
Aerosols impact climate, but the effect is very uncertain

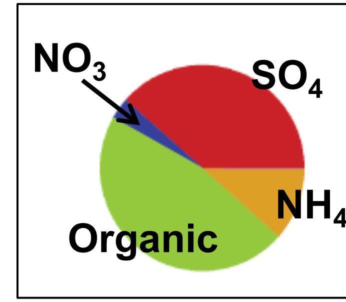


[IPCC AR5, 2013]

Organic Aerosol is Ubiquitous in the Atmosphere

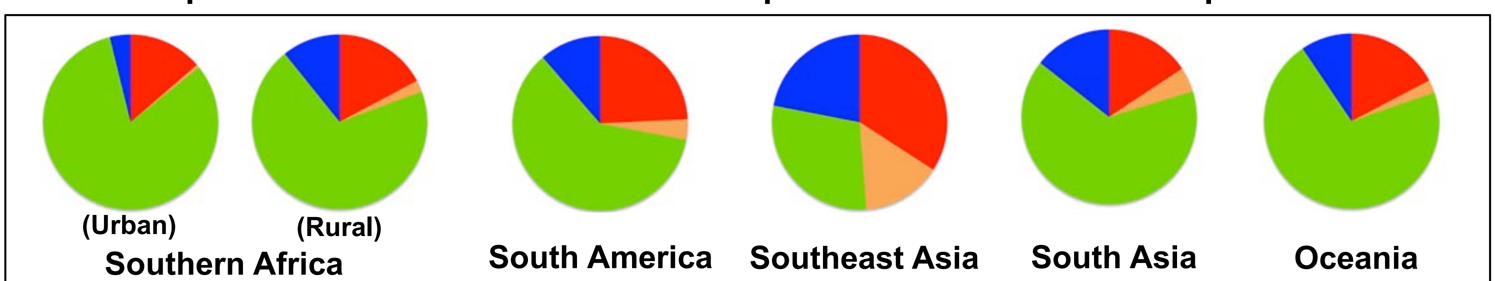
Northern hemisphere aerosol components





[Zhang et al., 2007]

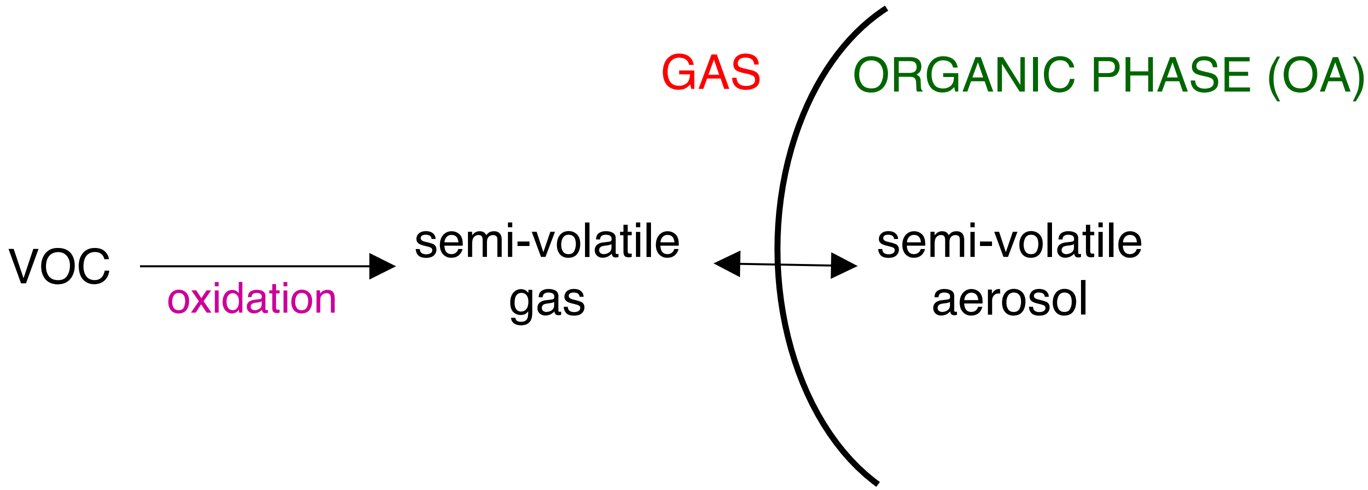
Tropics and southern hemisphere aerosol components



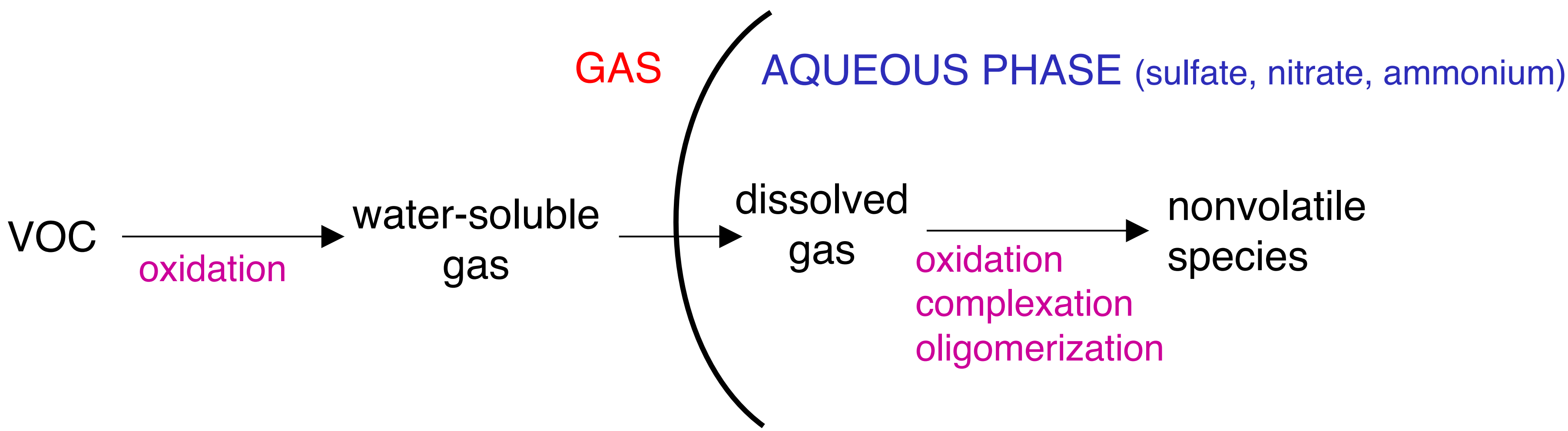
[IPCC, 2013]

Two approaches to represent secondary organic aerosol

A. **Classical model** for reversible uptake by pre-existing organic aerosol



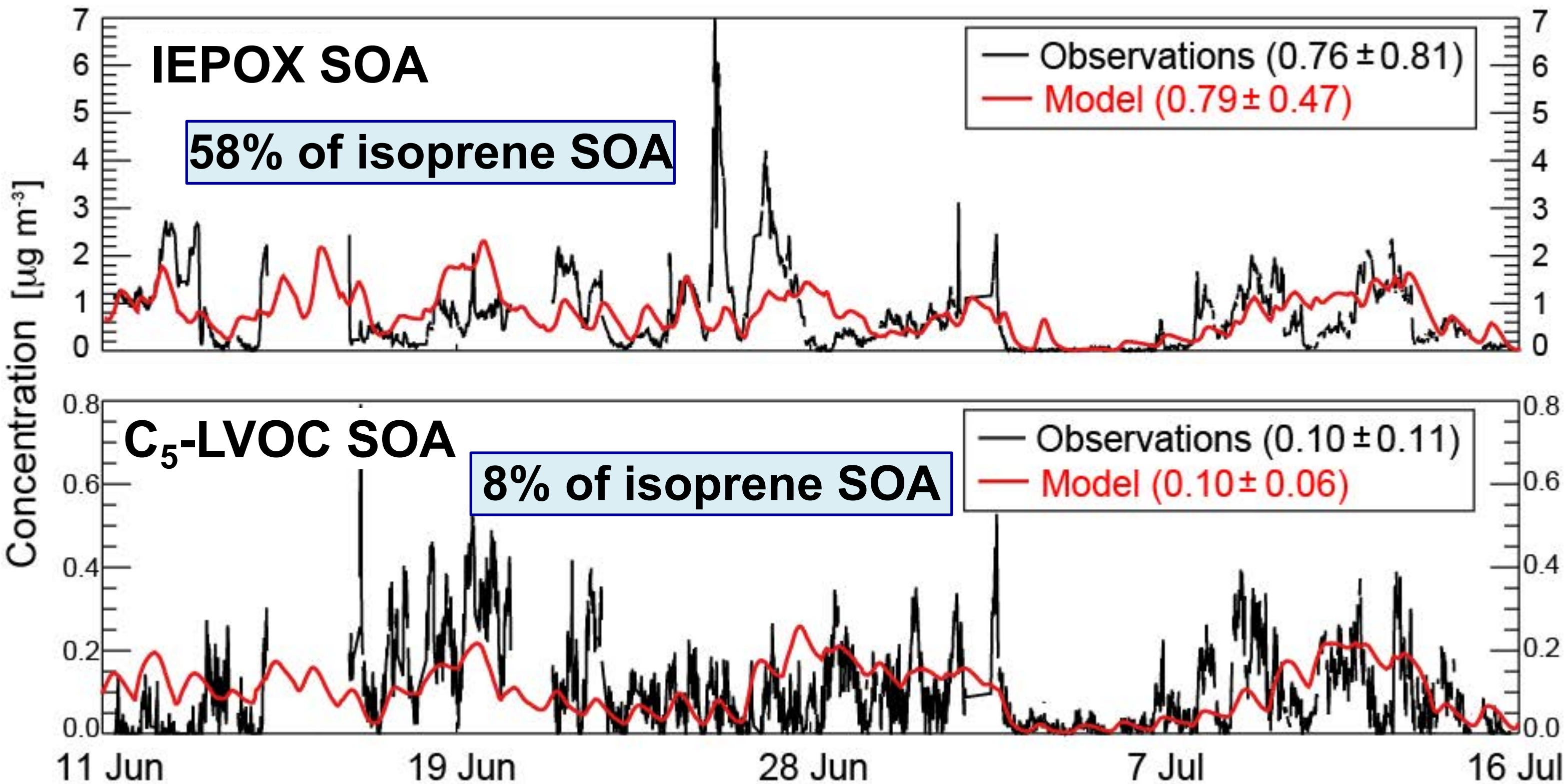
B. **Alternate model** for irreversible uptake by aqueous aerosol



Observational Constraints on Isoprene SOA Components

$$\mathrm{ISOP} \xrightarrow[87\%]{\mathrm{OH},\ \mathrm{O_2}} \mathrm{ISOPO_2} \xrightarrow[35\%]{\mathrm{HO_2}} \mathrm{ISOPOOH} \xrightarrow{\mathrm{OH}} \begin{cases} \xrightarrow{75\%} \mathrm{IEPOX} \\ \xrightarrow{0.5\%} C_5\text{-LVOC} \end{cases}$$

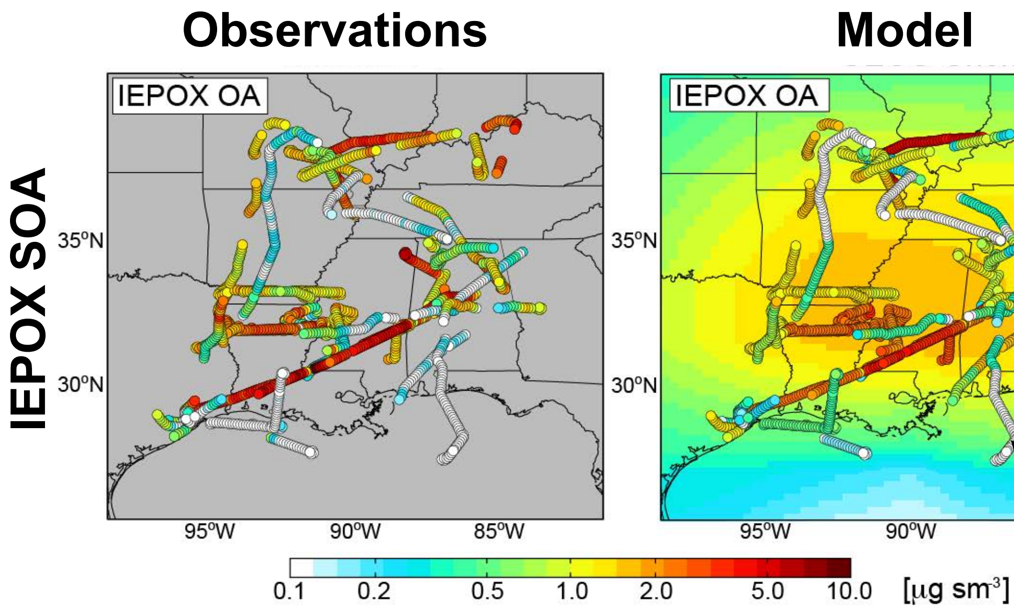
Secondary organic aerosol from IEPOX and C_5-LVOC at Centreville, AL (SOAS campaign; Jun-Jul 2013)



[Data from D. A. Day, W. Hu, J. Krechmer, J. L. Jimenez]

Spatial Distribution of IEPOX SOA

SEAC^{4}RS (Aug-Sep 2013) boundary-layer IEPOX SOA and sulfate



Mean IEPOX SOA:
AMS: 1.4 ± 1.4 μg sm^{-3}
GC: 1.3 ± 1.2 μg sm^{-3}

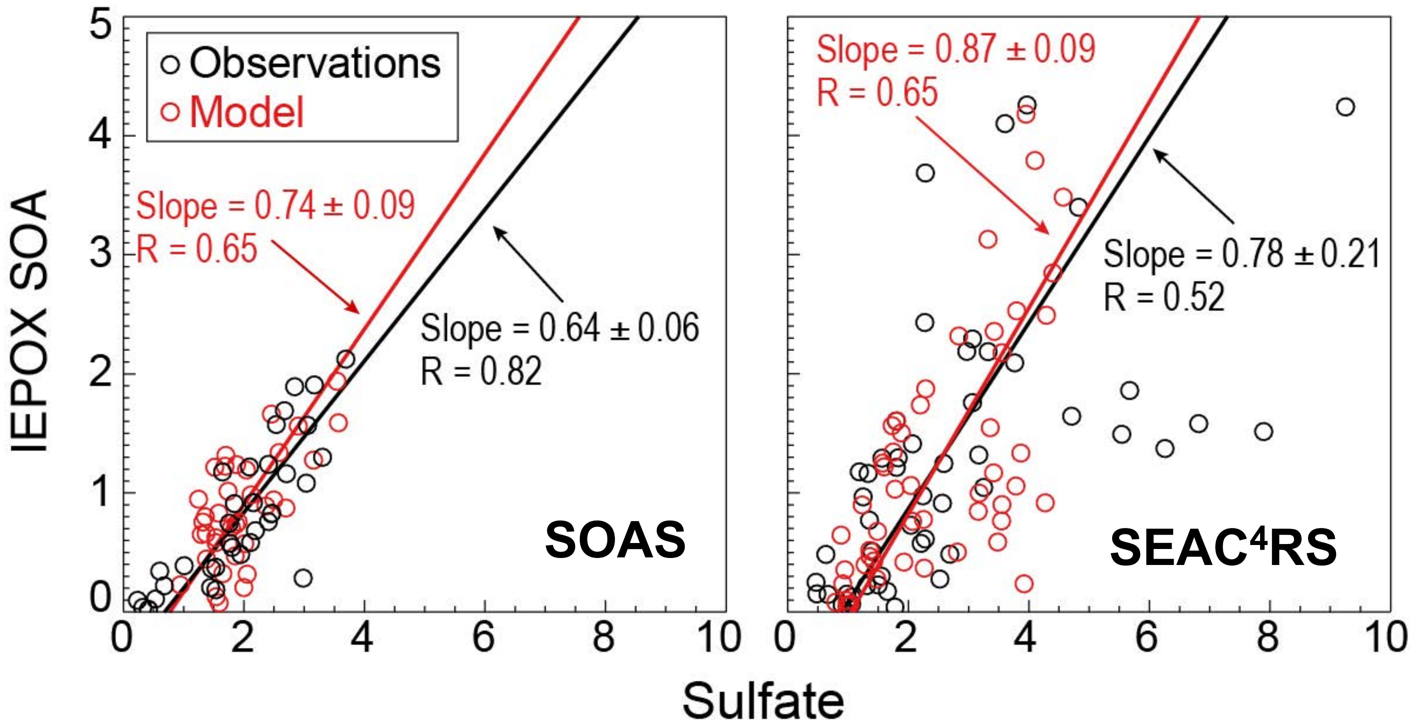
Background is daytime mean during SEAC^{4}RS

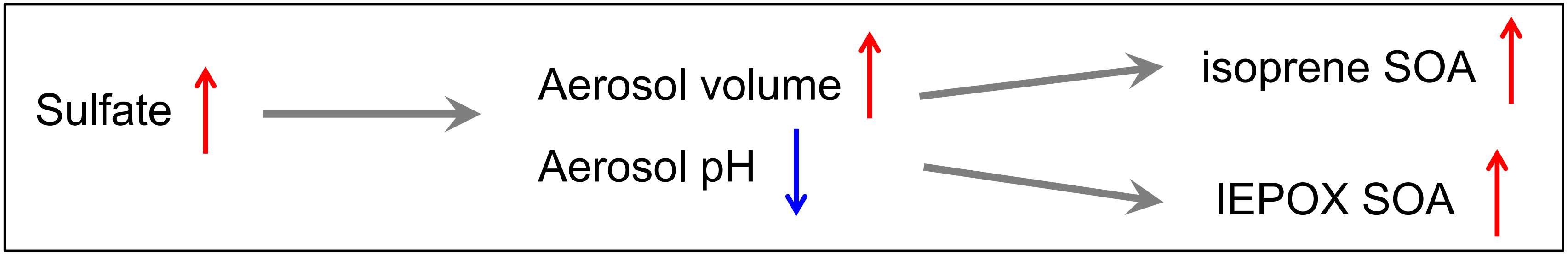
Points are data along the SEAC^{4}RS flight tracks

[Data from P. Campuzano-Jost, J. L. Jimenez]

What modulates IEPOX OA in the Southeast US?

IEPOX SOA and Sulfate correlation during SOAS and SEAC^{4}RS

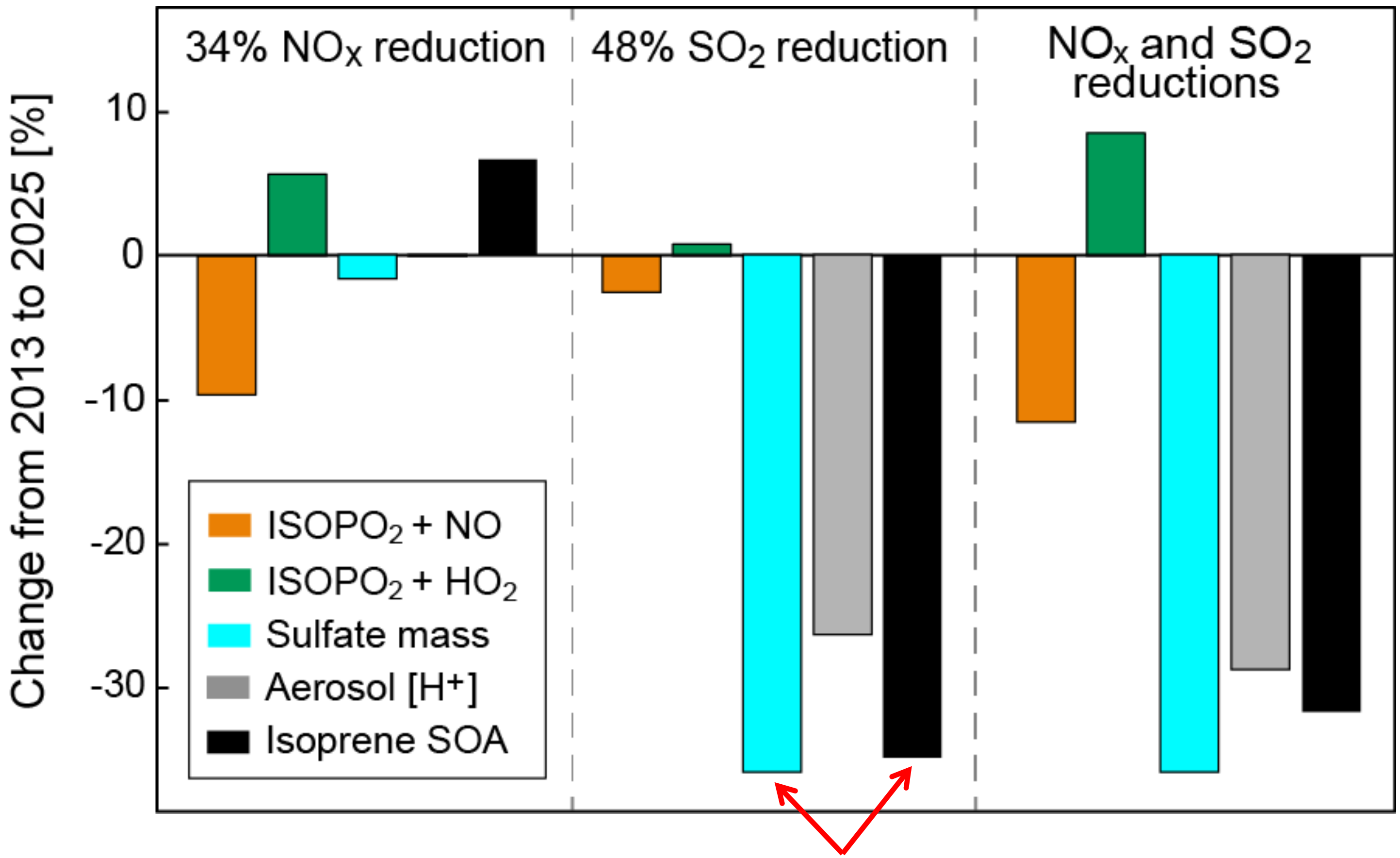




Effect of Anthropogenic Emission Reductions

USEPA projects emissions decline by **48% for SO_2** and **34% for NO_x** from 2013 to 2025

Test the impact on isoprene SOA using GEOS-Chem sensitivity simulations

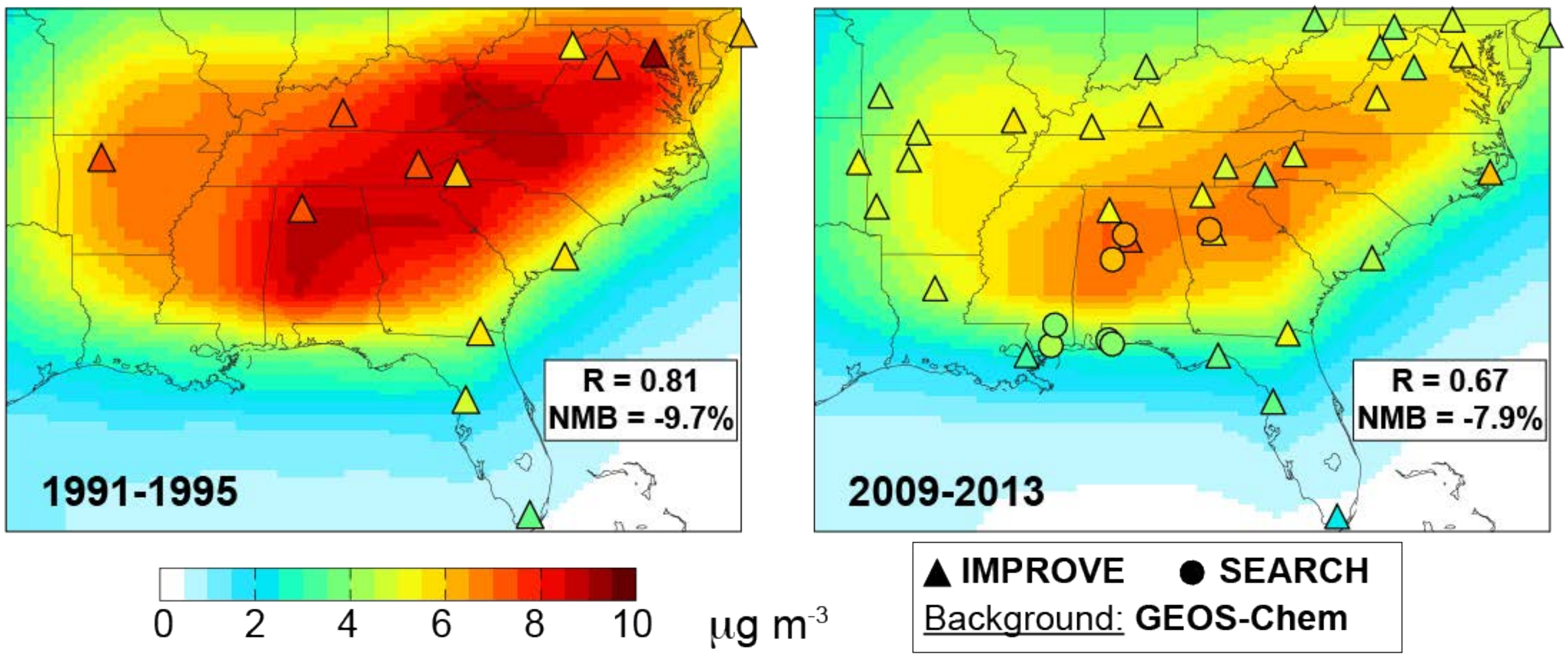


Near-equivalent response in **sulfate** and **isoprene SOA**

Factor of 2 co-benefit for $PM_{2.5}$ from SO_2 emission controls

Spatial distribution of organic aerosol trends

Spatial distribution of five-year mean summertime OA from the model and observations at the start and end of the record

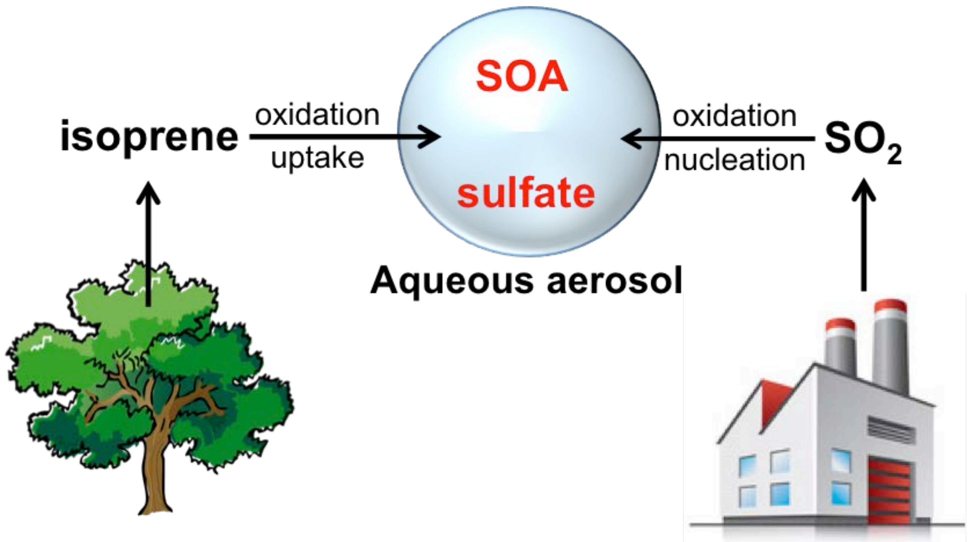


OA declines by **25%** in the observations and **23%** in the model.

No significant change in OA spatial distribution in the observations or model supports biogenic SOA driving the OA trend.

Small model normalized mean bias (NMB) and similar change in OA in the model and observations

Concluding Remarks



- Biogenic isoprene secondary organic aerosol (SOA) formation by reactive uptake to aqueous aerosol is modulated by sulfate that in turn drives changes in aqueous aerosol volume and acidity.
- Observations in the Southeast US show a large long-term (1991-2013) decline in summertime (Jun-Aug) OA, but the cause of this trend is uncertain.
- The GEOS-Chem model, updated to include aqueous-phase isoprene SOA formation, reproduces the observed trend.
- The model attributes decreases in OA to decline in the isoprene SOA yield as sulfate decreases (driving lower aqueous aerosol volume and acidity).
- This SO_2 emission controls to decrease sulfate have had a large air quality co-benefit in the Southeast US by also decreasing organic aerosol (OA).