Influence of humidity-dependent stomatal conductance of VOCs on ozone and secondary organic aerosols

UCL GEOS-Chem

erc

UK Centre for Ecology & Hydrology

Preliminary Data!

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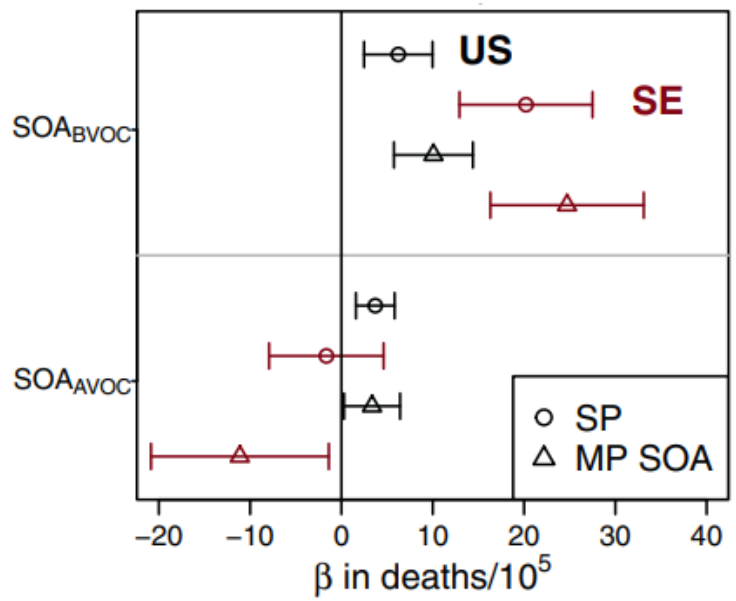
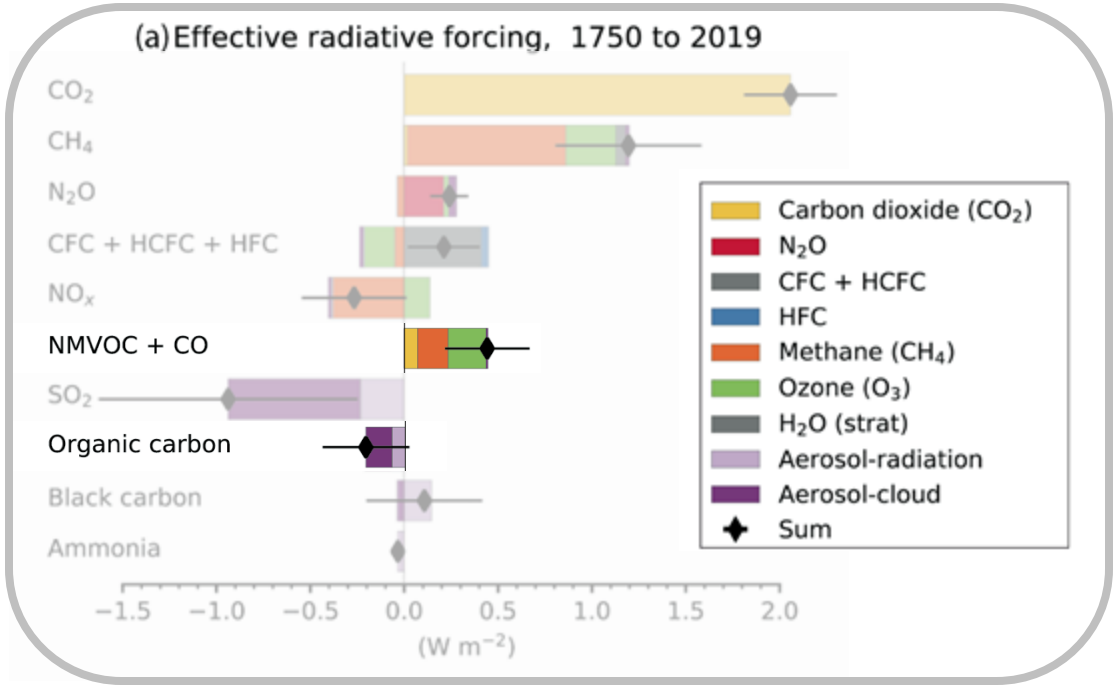
SOA pathways impact health and climate

SOA contributes to US mortality rates

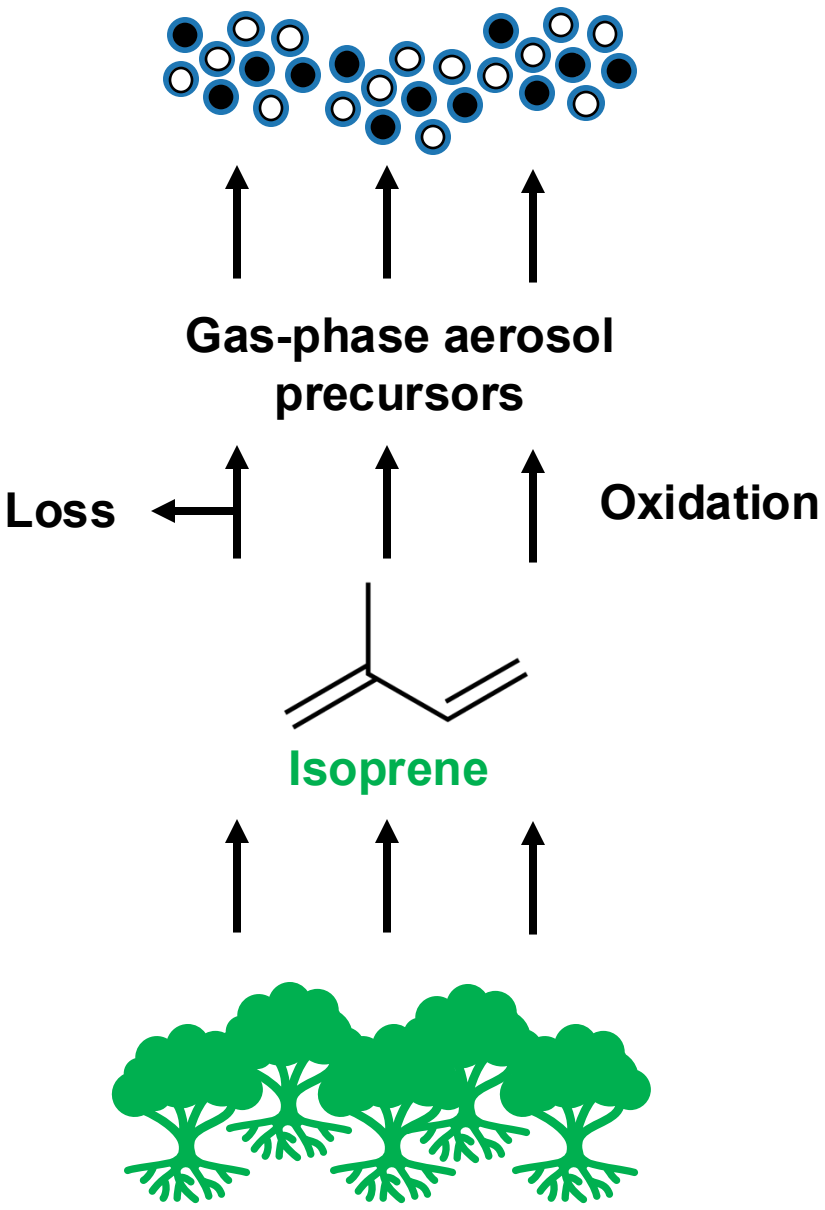


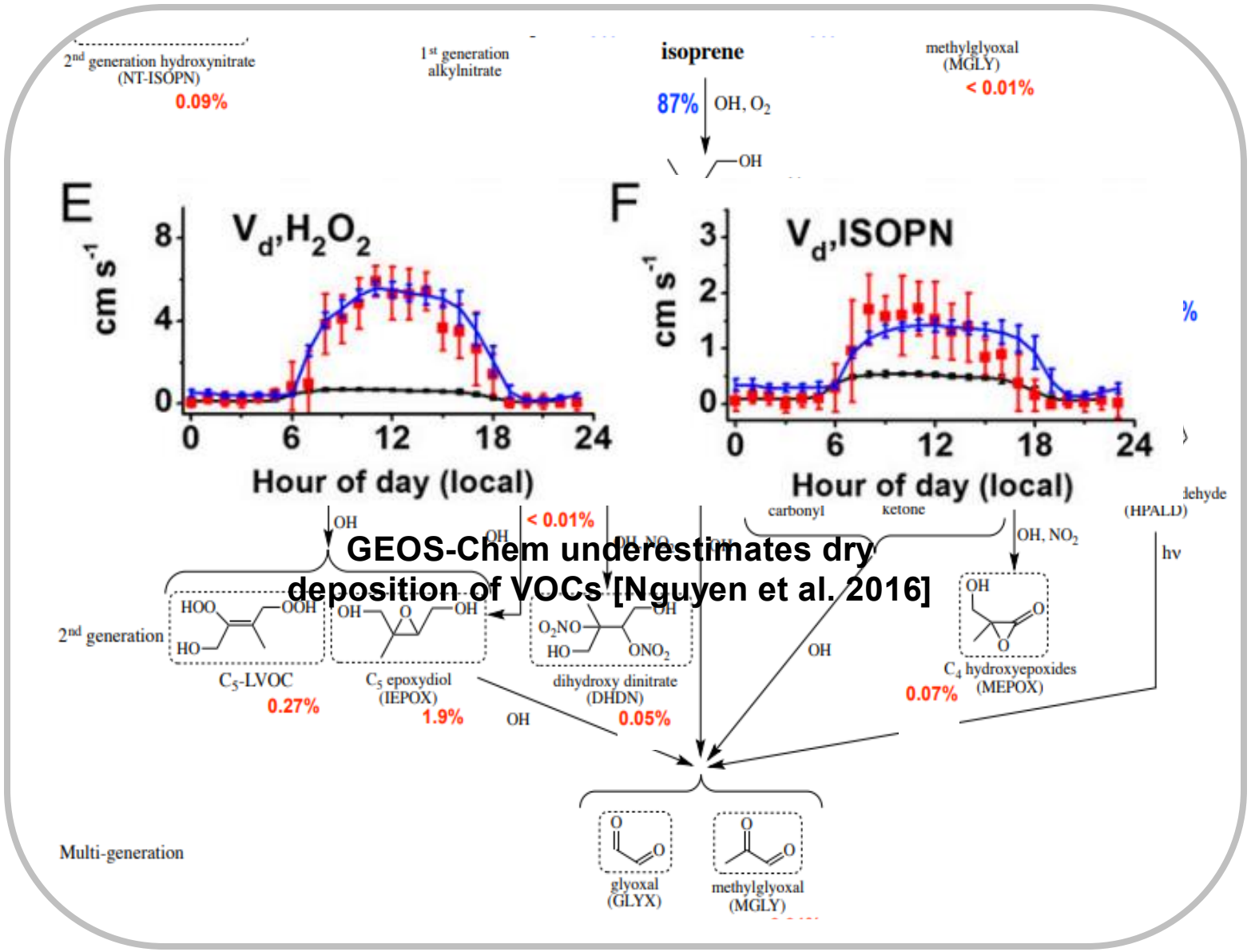
SOA affects climate



[Pye 2021, IPCC 2021]

Isoprene oxidation pathways alter SOA and oxidant budgets

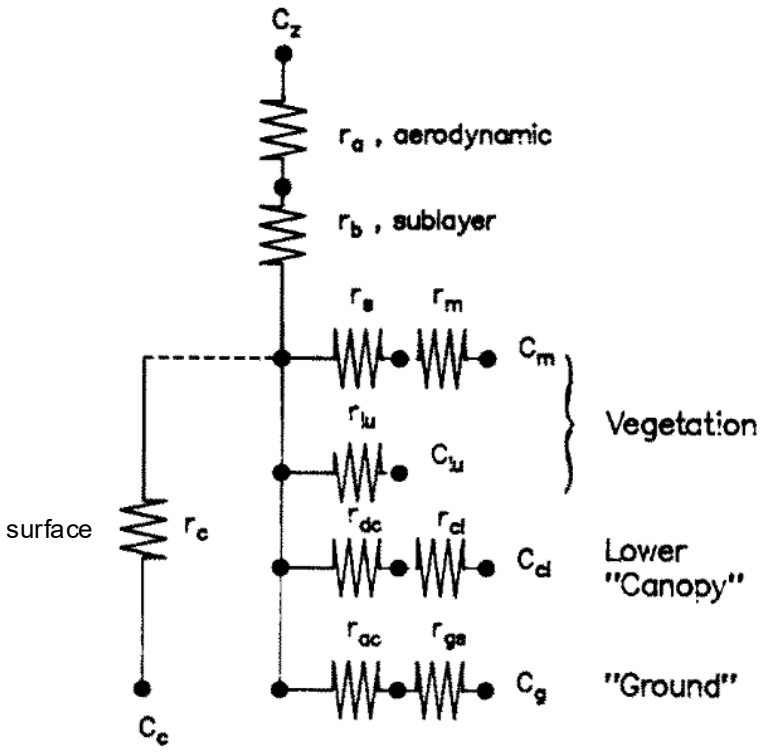




[Marais 2016]

The Wesely Scheme for Calculation of Dry Deposition Velocity

Resistance-in-series scheme



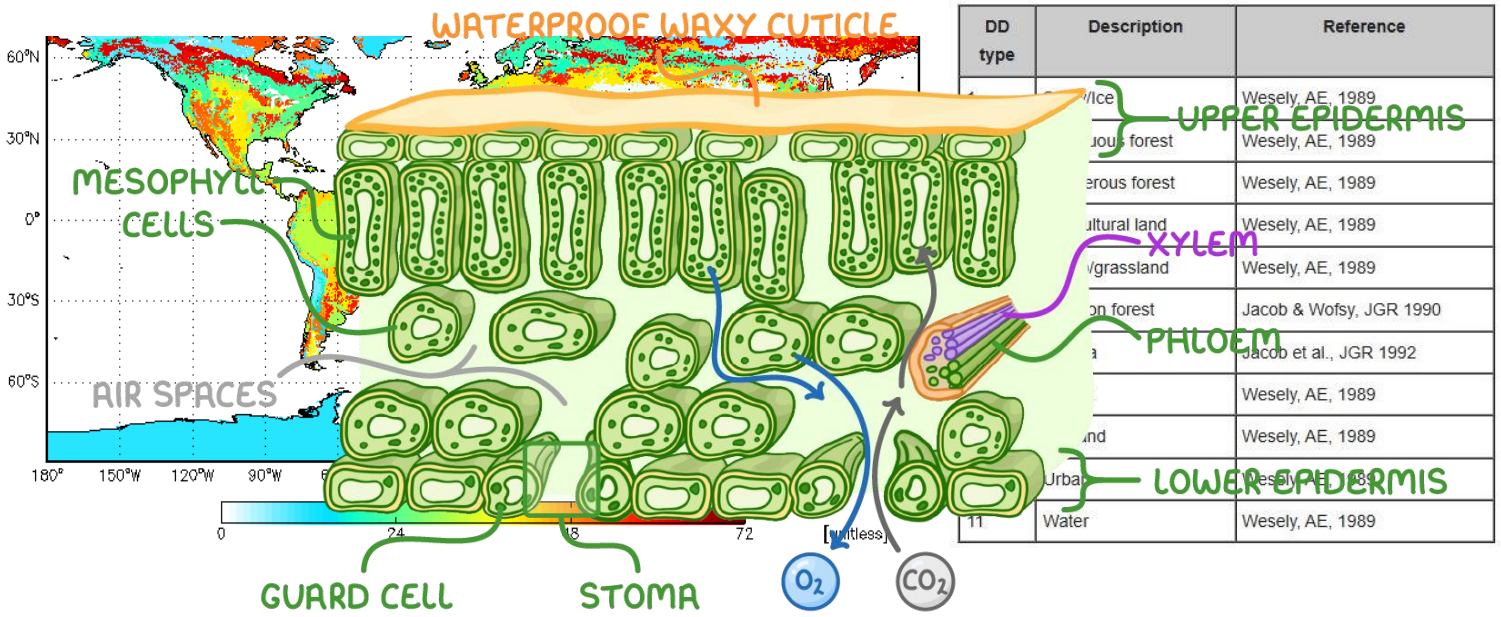
$$V_d = \frac{1}{r_a + r_b + r_c}$$

The surface resistance, r_c, for organic compounds is extrapolated from extensive measurements of SO_2 and O_3.

Vegetation

$$r_c = \left[\frac{1}{(r_s + r_m)} + \frac{1}{r_{lu}} + \frac{1}{(r_{dc} + r_{cl})} + \frac{1}{(r_{ac} + r_{gs})} \right]^{-1}$$

Stomatal — Mesophyll — Leaf cuticle



DD type	Description	Reference
	/Ice	Wesely, AE, 1989
	uous forest	Wesely, AE, 1989
	erous forest	Wesely, AE, 1989
	ultural land	Wesely, AE, 1989
	/grassland	Wesely, AE, 1989
	on forest	Jacob & Wofsy, JGR 1990
	a	Jacob et al., JGR 1992
		Wesely, AE, 1989
	nd	Wesely, AE, 1989
	Urba	Wesely, AE, 1989
11	Water	Wesely, AE, 1989

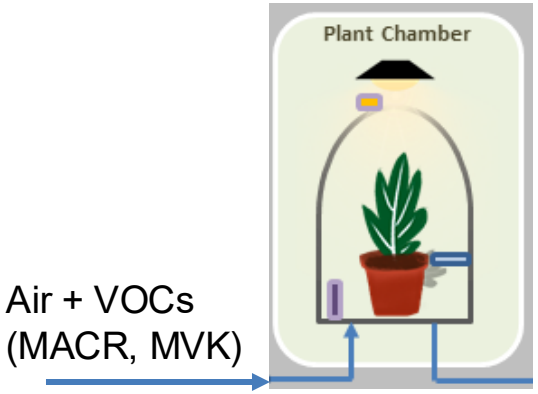
Each term in the surface resistance is landtype dependent.

[Wesely 1989]

Measuring RH-Dependent Fluxes of Specific VOCs

Vegetation

$$r_c = \left[\frac{1}{(r_s + r_m)} + \frac{1}{r_{lu}} + \cdots\right]^{-1}$$



Leaf Cuticle (Non-stomatal) Resistance (R_{lu})

$$r_{lux} = r_{lu}(10^{-5} \times H^* + f_0)$$

Solubility

Reactivity

$r_c \approx r_{lux}$

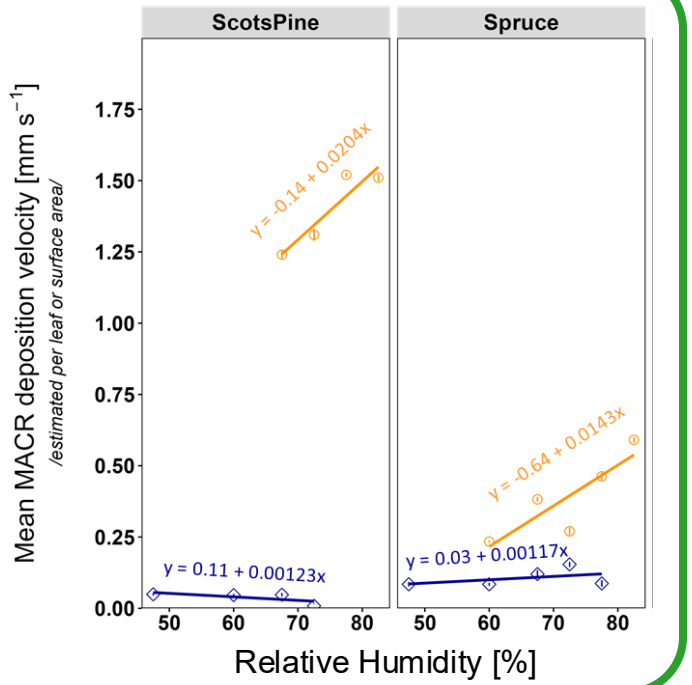
$$f_0 = \frac{r_{lu}}{r_{lux}} - (10^{-5} \times H^*)$$

f0 reduced from 1.0 to 0.6

Stomatal Resistance (R_s)

V_d (stomatal) = V_d (day) - V_d (night)

$$R_s = R_s \times (1728.7 \times RH)^{-1.819} \text{ for RH > 60\%}$$



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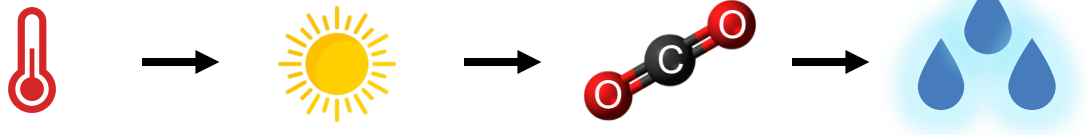
[Medinets et al. *in draft*]

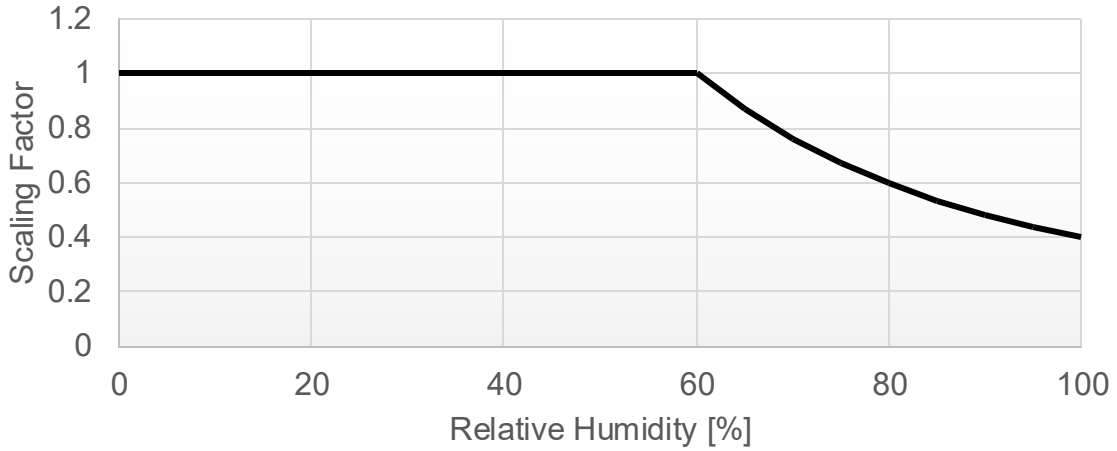
Implementation into GEOS-Chem

Updated Parameterization for Stomatal Resistance



[Wesely 1989] → [Wang 1996] → [Franks 2013] → **[This Work]**

Rs Dependence on Relative Humidity



Reduced f_0 for MACR and MVK (1.0 to 0.6) →

GEOS-Chem

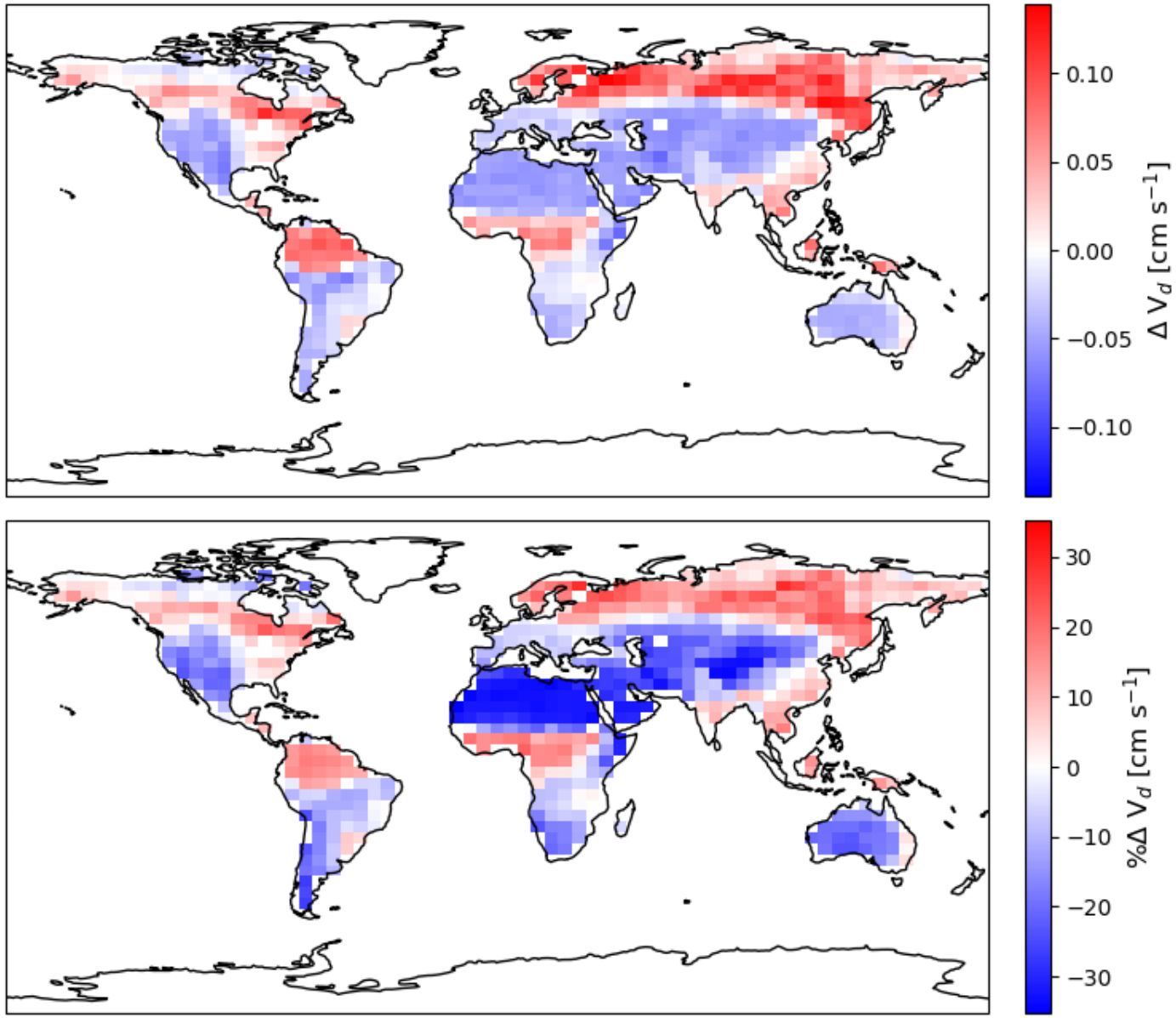
v14.2.3
ComplexSOA + svPOA
July 2022
Global - 4°x5°x47
Nested EU - 0.25x0.3125

⇢ **Deposition Velocity**
Concentration
Isoprene-derived SOA
$PM_{2.5}$ / PM_{10}

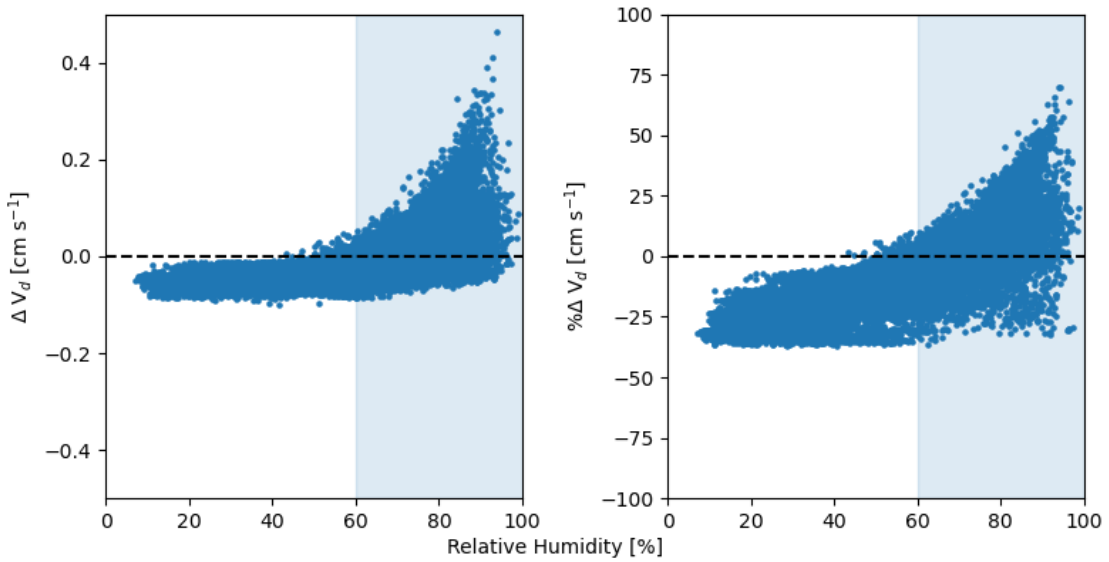
[Medinets et al. *in draft*]

Updated deposition velocities for MACR in July 2022

Monthly Mean Change



Daily Mean Change (>70% Land Fraction)



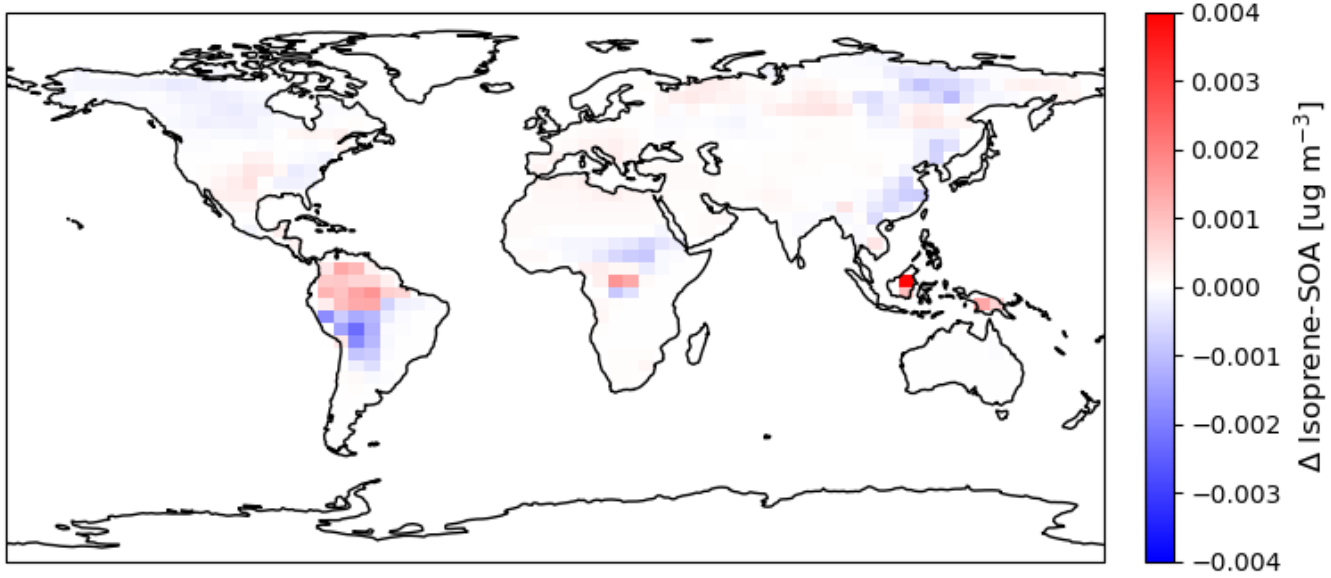
f_0 ↓	V_d ↓ 35%
RH Scaling	V_d ↑ 29%

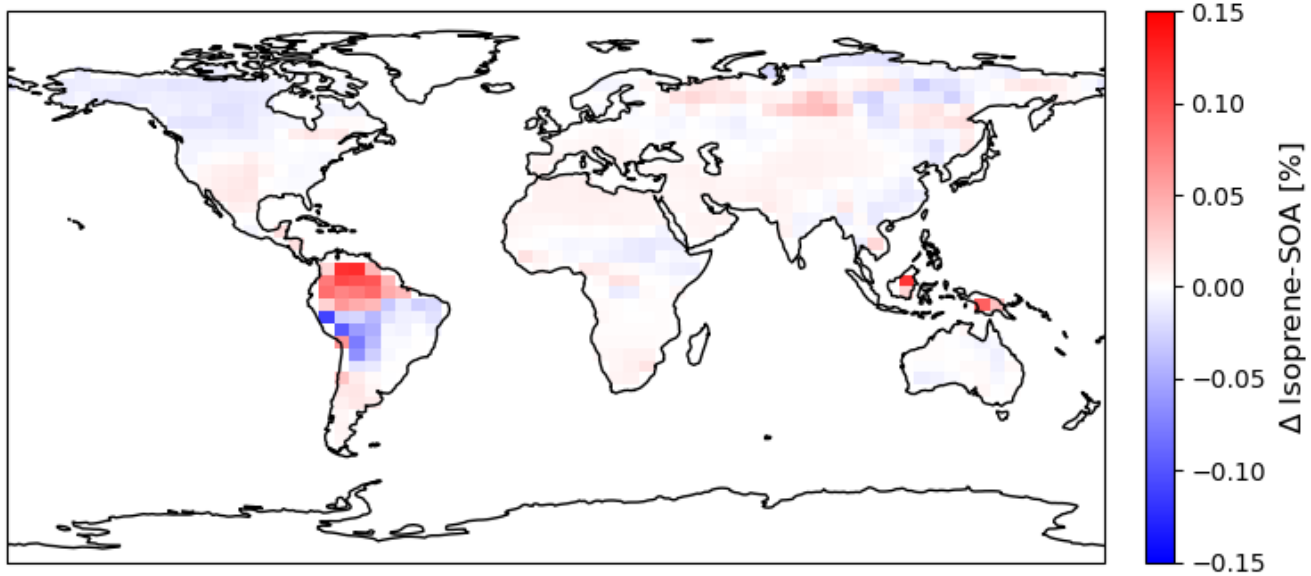
Increases in deposition velocity lead to changes in MACR concentration of -23 – 48 pptv (~±6%).

[Medinets et al. *in draft*]

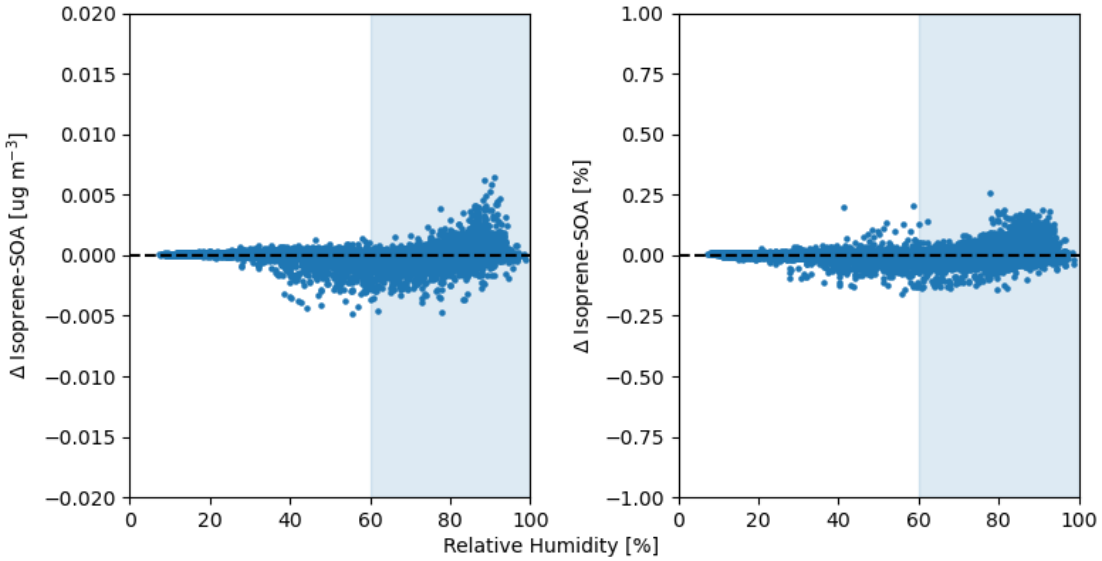
Implications for isoprene-derived SOA in July 2022

Monthly Mean Change





Daily Mean Change (>70% Land Fraction)



The new parameterization has a very small impact on isoprene-derived SOA (±0.12%), $PM_{2.5}$ and ozone… but this may increase if we scale other VOCs.

[Medinets et al. *in draft*]

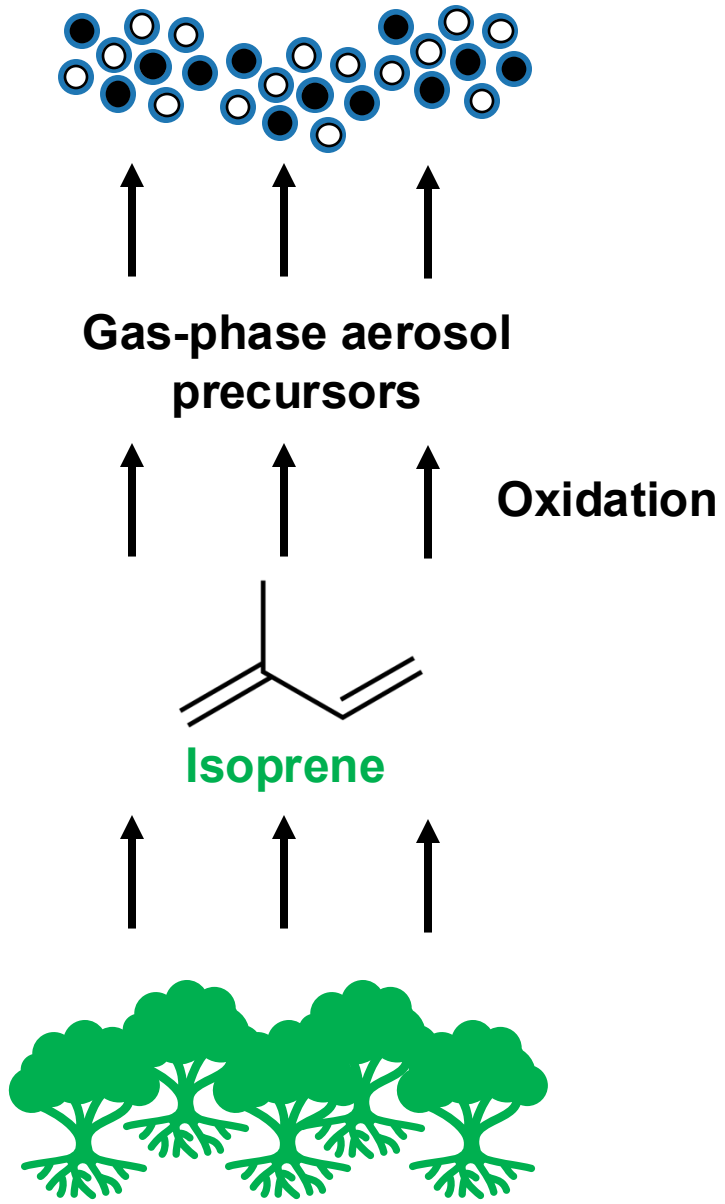
Concluding Remarks

Outcomes

- Updated the parameterization of MACR and MVK dry deposition in GEOS-Chem.
- Deposition velocity increased by up to 29% near Equator and high mid latitudes and decreased by up to 35% in dry regions.
- Updated deposition velocities have a negligible impact on isoprene-derived SOA mass or oxidant budgets.

Next Steps

- Nested simulations to assess impacts in regions with high isoprene emissions and high VOC concentrations.
- Scale the RH-dependence and f_0 to other VOC species.
- Compare updated concentrations to observations.



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