

Beyond water solubility: physicochemical controls on VOC dry deposition in a mixed temperate forest

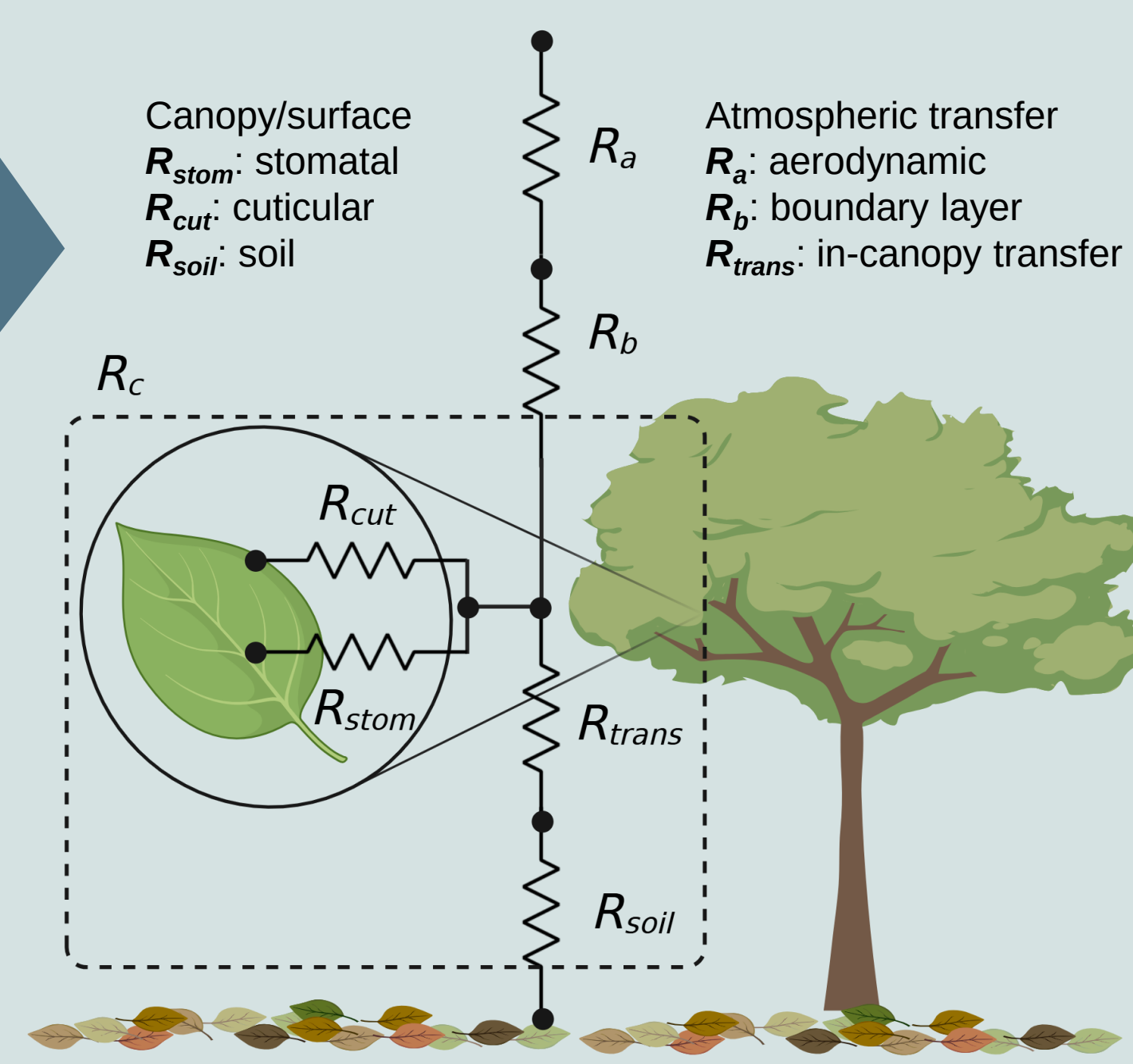
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CONTEXT

- The **dry deposition** of **VOCs** to ecosystems is an important sink in global budgets.
- While stomatal deposition is relatively well constrained, **non-stomatal deposition** to surfaces (leaf cuticles, soil) remains poorly characterized.
- The most detailed description of non-stomatal deposition originates from the model of **Zhang et al. (2003)**, in which the deposition of a given tracer was estimated from **SO₂** and **O₃** measurements, with very few validations for VOCs so far.
- Objectives:
 - Evaluate** and **improve** the non-stomatal components of Zhang model for VOCs;
 - Gain new insights into the **mechanisms** governing **non-stomatal** deposition.

METHODOLOGY



Measurements (Dumont et al., 2026)

- Site**: Vielsalm station, Belgium – mixed temperate forest (ICOS site BE-Vie)
- Fluxes**: VOCs (PTR-TOF-MS) + ozone (FOS) at **51 m** (TOP) and **3 m** a.g.l. (TRUNK)
- Depositions**: non-negligible depositions for **11 VOC-related m/z + O₃**

Modelling

Big-leaf two-layer (canopy+soil) resistive model

$$v_a = \frac{-flux}{conc} = \frac{1}{R_a + R_b + R_c}$$

→ Estimation of **canopy conductance**:

$$G_c = \frac{1}{R_c} = G_{stom} + G_{cut} + G_{tr,soil}$$

During **night-time**, the stomatal pathway is estimated to be negligible.

From TRUNK measurements, we estimate:

$$G_{soil} = G_{c,trunk}$$

From TOP measurements:

$$G_{cut} = G_{c,top} - G_{tr,soil}$$

RESULTS

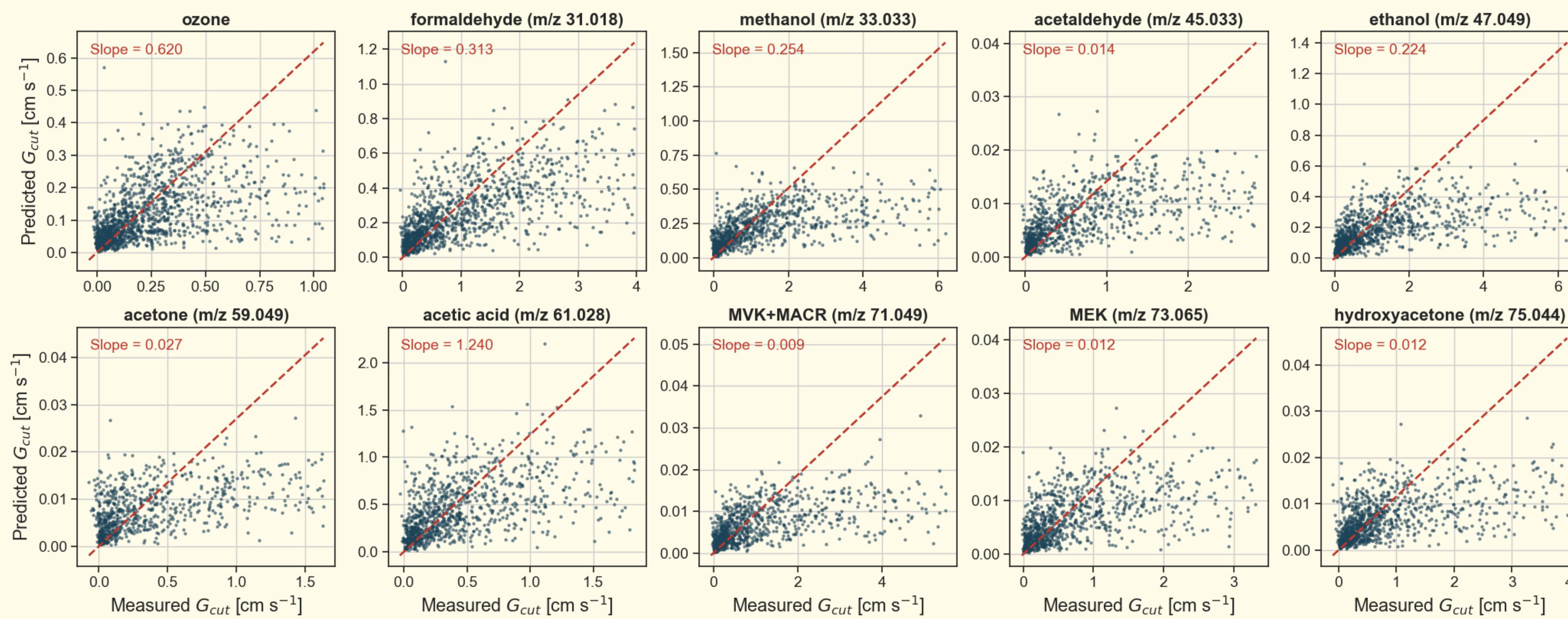


Fig1. Comparison between measured and predicted (Zhang model) cuticular conductances.

B. How can we improve existing parametrizations?

Cuticular conductance

$$G_{cut,VOC_i} = G_{cut0,VOC_i} \cdot e^{b_{cut}(RH^3 - RH_{ref}^3)} \cdot \left(\frac{u_*}{u_{*,ref}}\right) \cdot LAI^{1/4}$$

- Stronger dependence on RH** than estimated in the Zhang model
- Dependence on u_* similar to Zhang → the **turbulence** affects **in-canopy transport** and deposition.
- VOCs and O₃ follow **similar relationships** with RH and u_* → supports the assumption made by Zhang.

Soil conductance

$$G_{soil,VOC_i} = G_{soil0,VOC_i} \cdot \left(\frac{RH}{RH_{ref}}\right)^{b_{soil}}$$

- New evidence that **soil deposition depends on RH**, a process not included in the Zhang model.
- No significant u_* effect detected.

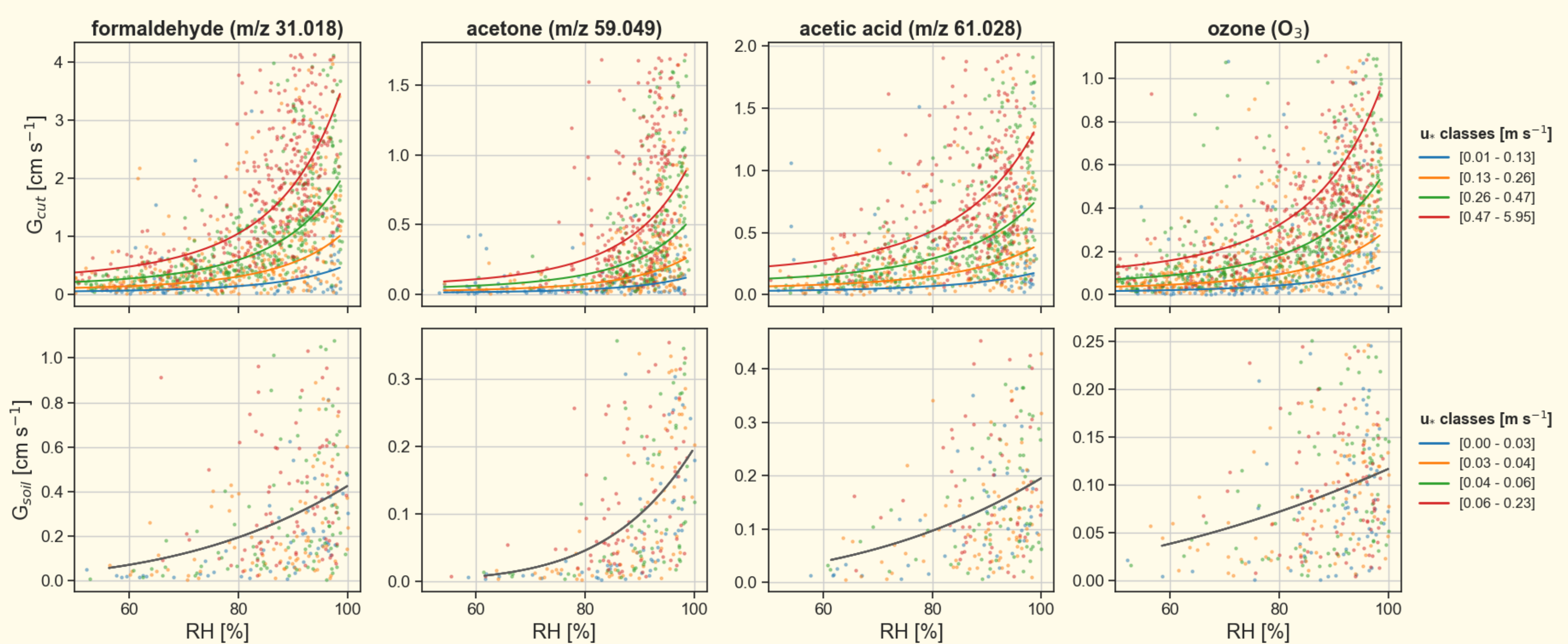


Fig2. New parametrizations of cuticular (G_{cut}) and soil (G_{soil}) conductances as functions of relative humidity and friction velocity for a subset of tracers.

C. Which mechanisms could explain VOC deposition?

- H : dissolution into water films present on surfaces
- K_{ow} : dissolution into waxy leaf layers or cellular membranes
- p^0 : partitioning from the gas phase onto atmospheric particles
- $pE^0(W)$: consumption through redox reactions with cellular metabolites

→ $G_{cut/soil0,VOC_i}$ can be estimated for new VOCs if we know their physicochemical properties

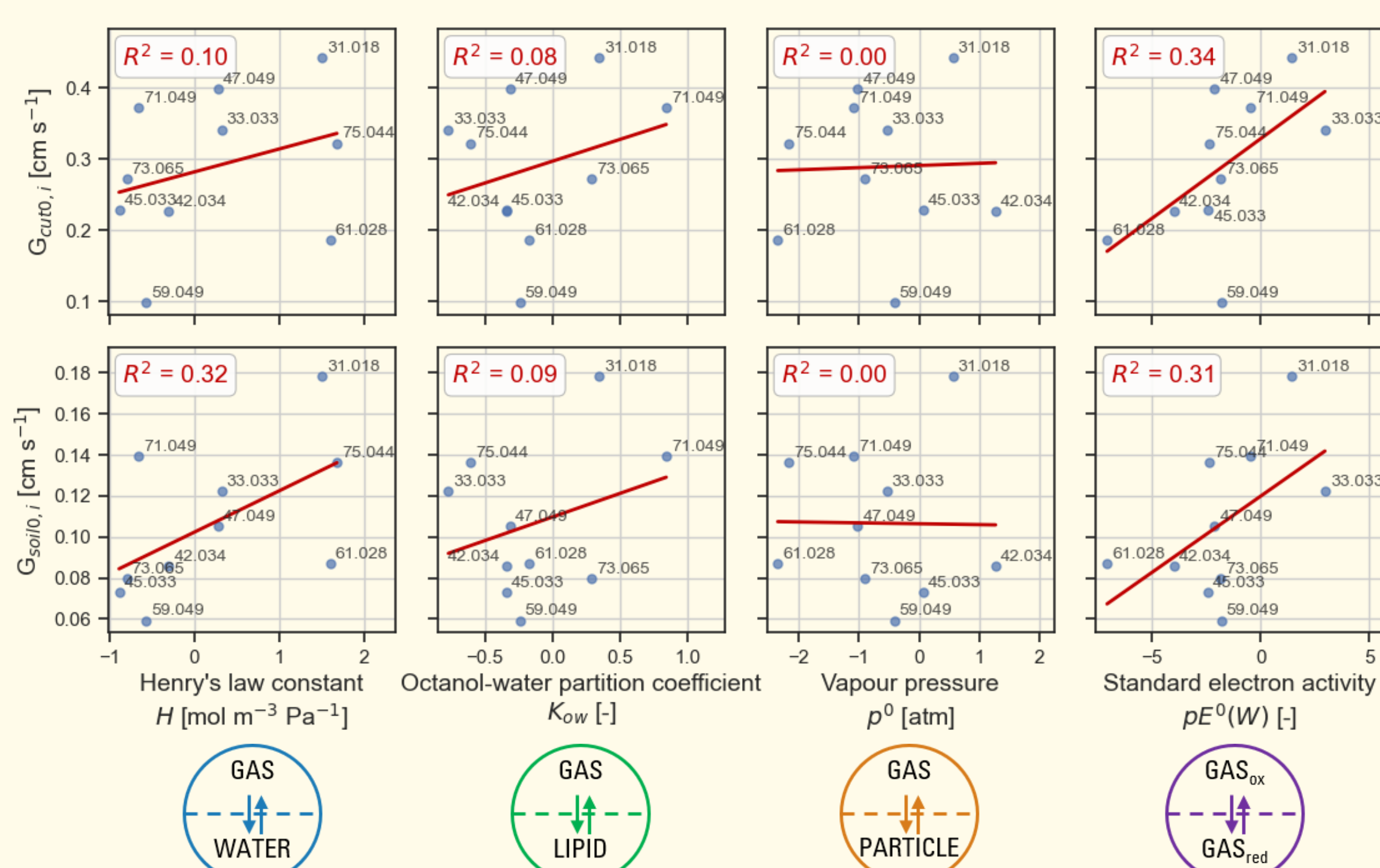


Fig3. Dependence of $G_{cut0,i}$ and $G_{soil0,i}$ parameters on VOC physicochemical properties.

Take-home messages

- Existing models **underestimate** surface conductances for the VOCs investigated
- Humidity** and **turbulence** control surface conductances
- Reference conductances scale with VOC **reactivity** and **solubility**, rather than lipid affinity or volatility

Perspectives

- Mechanisms**
Integrate biological mechanisms (biological consumption)
- Generality**
Validate the new parameterizations across VOCs and ecosystem types
- Atmospheric relevance**
Assess their impact in atmospheric models