

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

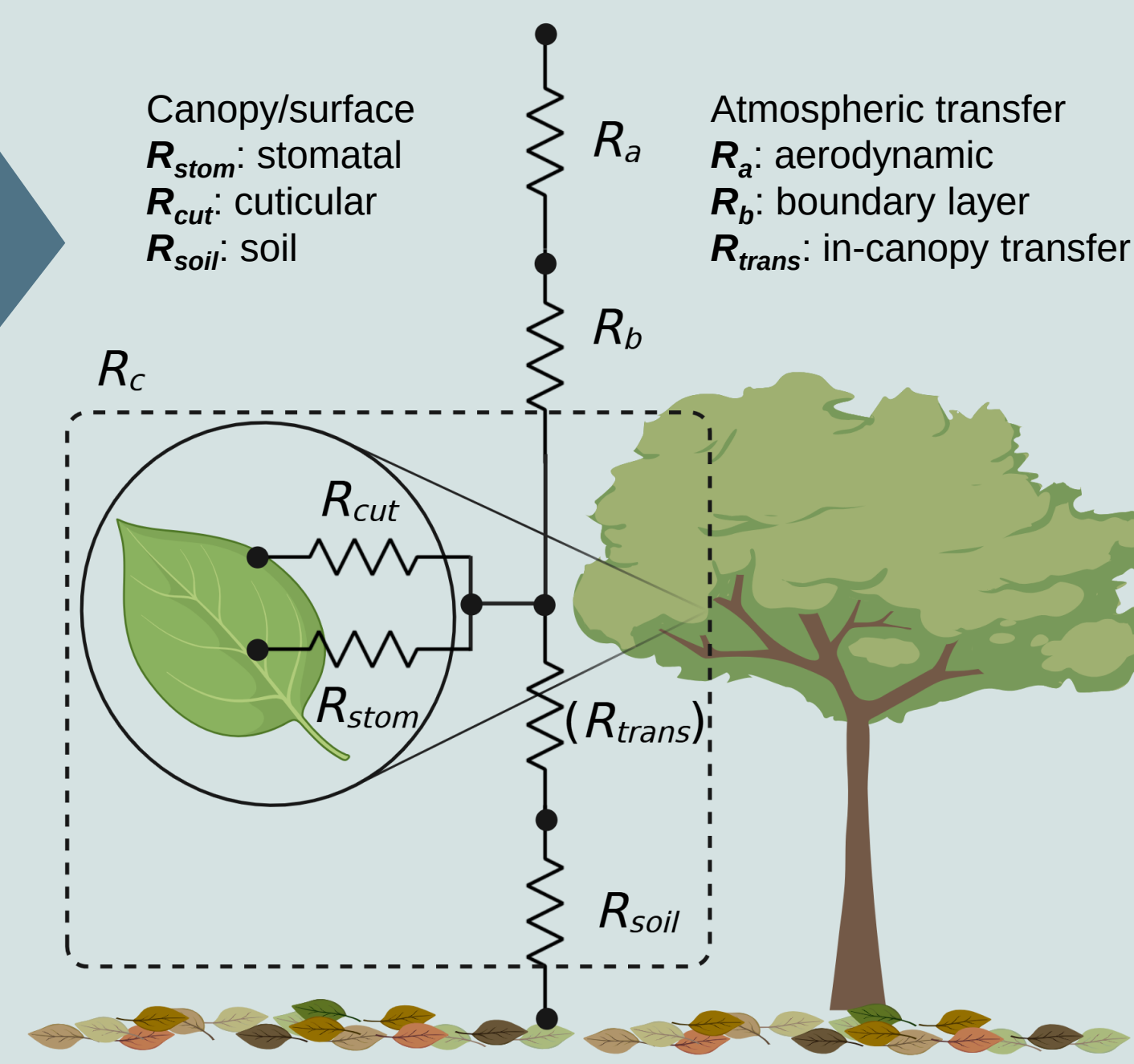
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CONTEXT

- 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

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

→ Estimation of **canopy conductance**:

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

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

From TOP measurements, we estimate:
 $G_c \approx G_{cut} (+G_{soil})$

From TRUNK measurements:
 $G_c \approx G_{soil}$

RESULTS

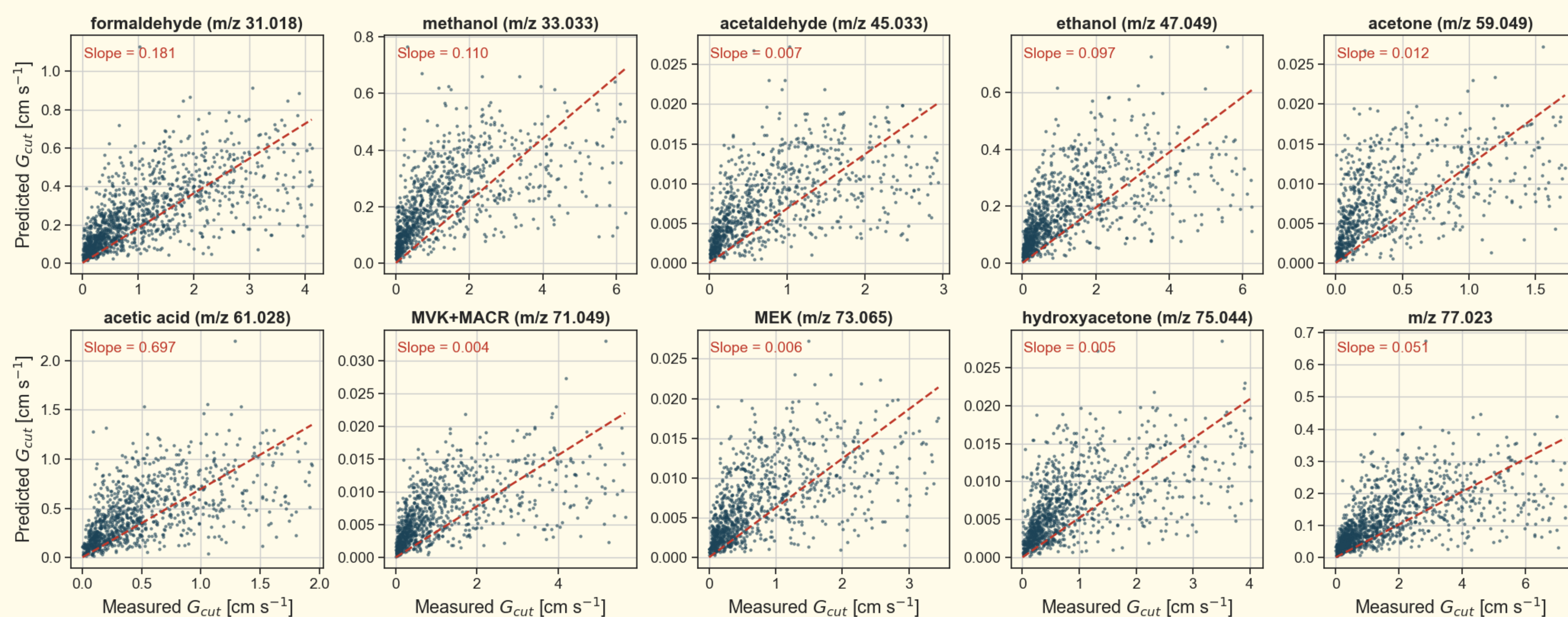


Fig1. Comparison between measured and predicted (Zhang model) cuticular conductances.

B. How can we improve existing parametrizations?

Cuticular conductance

$$G_{cut,i} = G_{cut0,i} \cdot \exp(b_{cut,i} \cdot RH^3) \cdot LAI^{1/4} \cdot u_*$$

- Stronger dependence on RH** than estimated in the Zhang model, and not constant across VOCs.
- 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

$$G_{soil,i} = G_{soil0,i} \cdot RH^{b_{soil,i}}$$

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

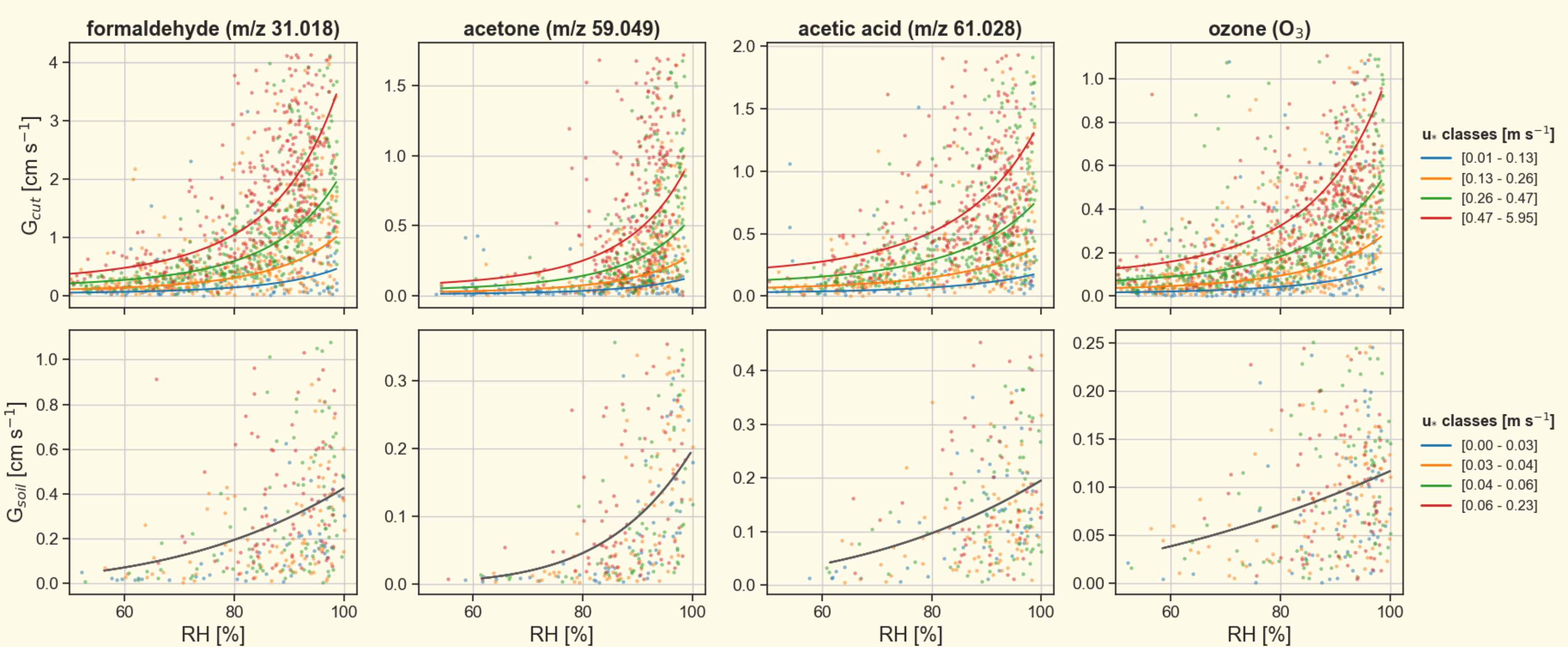


Fig2. New parametrizations of cuticular (G_{cut}) and soil (G_{soil}) conductances as functions of relative humidity and friction velocity for a subset of tracers.

C. Which mechanisms could explain VOC deposition?

base-deposition → $G_{cut0,i}$ and $G_{soil0,i}$

- higher for more **water-soluble** (H) and **lipid-soluble** (K_{oa}) VOCs
- higher for **less volatile** (p^0) VOCs

Potential mechanisms = dissolution into water and lipid phases, and gas-condensed phase partitioning.

RH sensitivity → $b_{cut,i}$ and $b_{soil,i}$

- inverse relationships
- VOCs with low base deposition appear more sensitive to humid conditions.

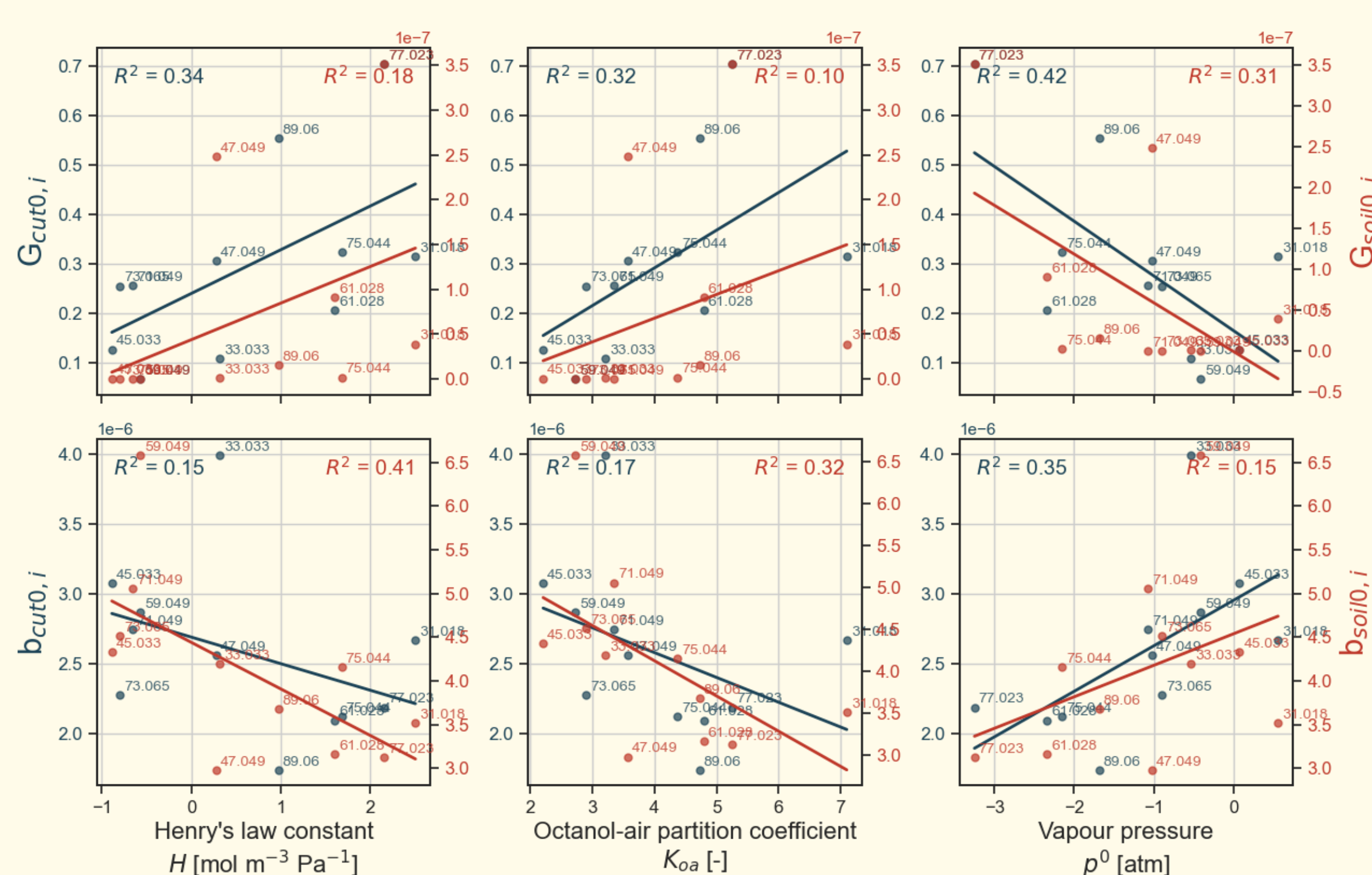


Fig3. Dependence of G_{cut} and G_{soil} parameters on VOC physicochemical properties.

Perspectives

- Investigate the **seasonal variations** (spring, summer, autumn) of non-stomatal deposition.
- Provide a **complete partitioning** of the three deposition pathways (stomatal, cuticular, soil) for the subset of measured VOCs.
- Use **additional VOC flux datasets** to:
 - **validate** the new parametrizations of non-cuticular conductances;
 - evaluate the **dependence** of surface deposition on **VOC physicochemical properties** (H , K_{oa} , p^0).
- Assess the impact of the newly developed parametrizations within:
 - a 1D **multi-layer** canopy model (FORECAST);
 - a Chemical Transport Model.