

Underestimation of potassium in forest dry deposition?

A simulation experiment in rural Germany

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Introduction

- Calculation of dry deposition (DD) to forests is challenging
- The [ICP Forests network](#) measures DD of Na⁺ at around 300 forest monitoring stations across Europe
- DD of other substances is usually calculated assuming similar substance ratios in wet deposition (WD) and DD (Ulrich 1994)

$$\frac{DD_X}{DD_{Na}} \stackrel{?}{=} \frac{WD_X}{WD_{Na}} \longrightarrow DD_X \stackrel{?}{=} DD_{Na} \frac{WD_X}{WD_{Na}} \quad (\text{Eq. 1})$$

- We tested this assumption by comparing model-based DD_{K+}/DD_{Na+} ratios to measured WD_{K+}/WD_{Na+} ratios

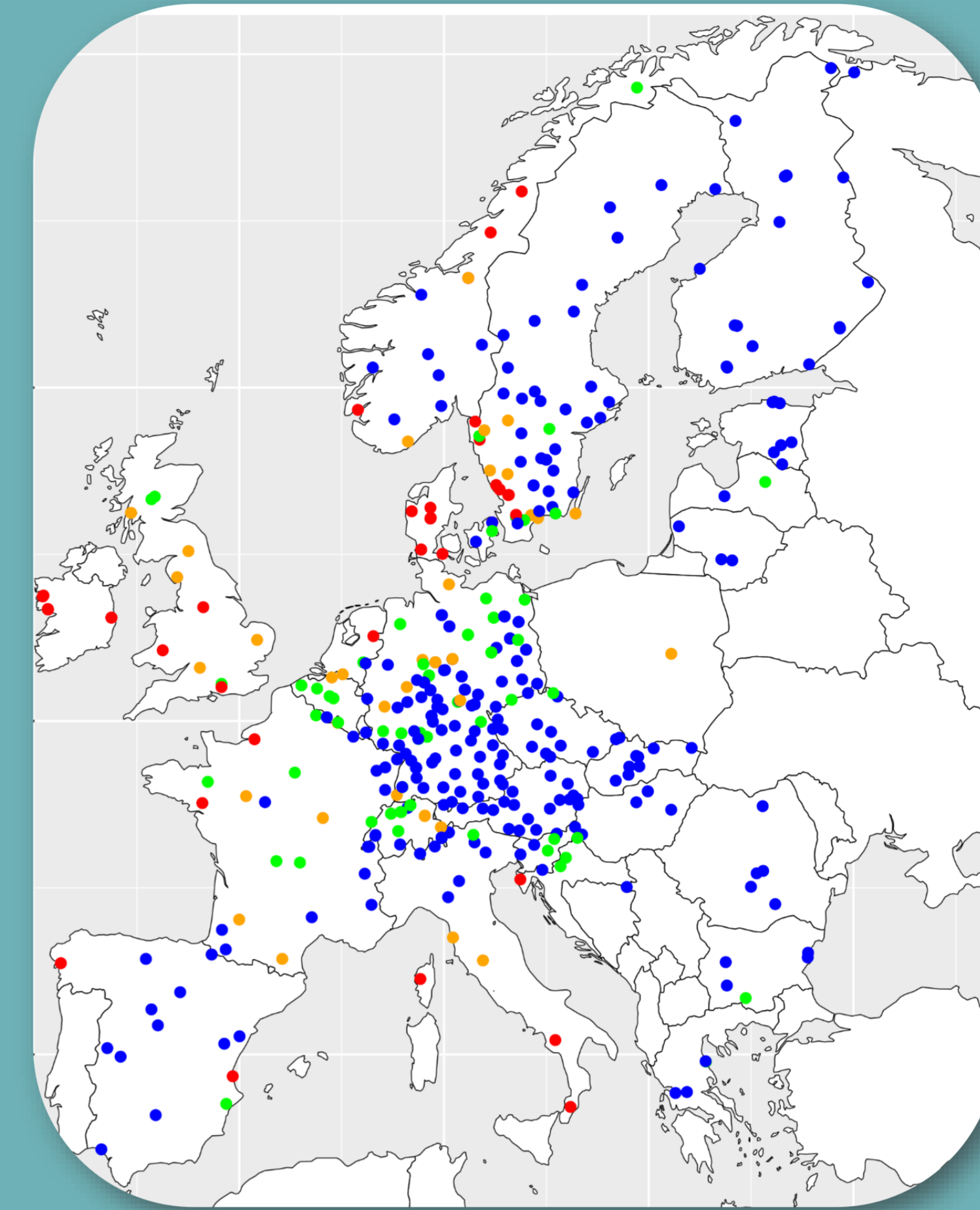


Figure 1: Temporal average Na⁺ dry deposition at ICP Forests monitoring sites (kg Na⁺ ha⁻¹ a⁻¹)



Methods

- Data: Air quality research site Melpitz in rural Germany
 - Six years of daily PM₁₀ and PM_{2.5} measurements for Na⁺ and K⁺. Weekly WD.
 - Further distribution of aerosol mass among six size bins based on a local impactor study
- DD model:
 - Emerson et al. (2020) update of Zhang et al. (2001)
 - Implemented in R: <https://github.com/AndSchmitz/ddpart>
 - Receptor: “Virtual” broadleaf and conifer forest

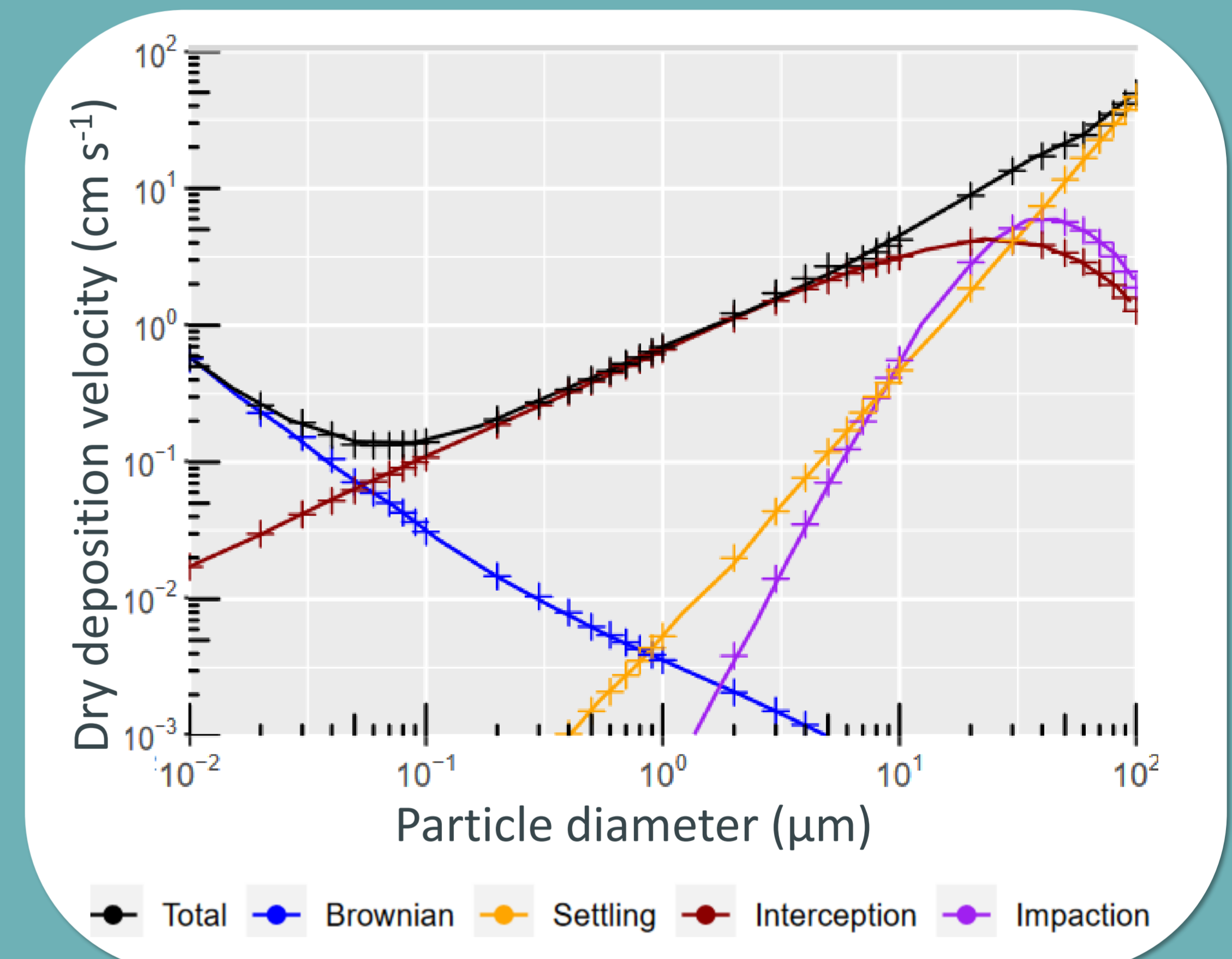


Figure 2: Emerson et al. (2020) dry deposition model

Results

- DD model indicates 66% (broadleaf) to 77% (conifer) higher DD_{K+} compared to eq. 1

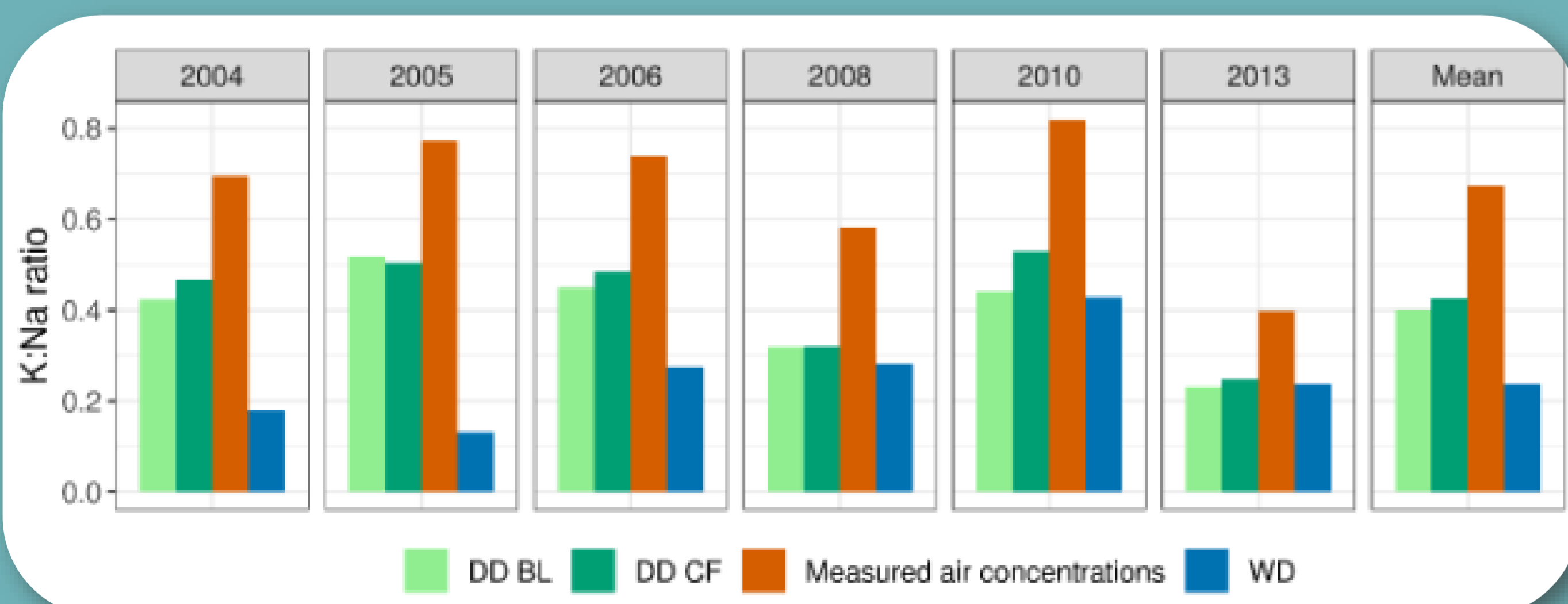


Figure 3: K⁺:Na⁺ ratios in modelled dry deposition to broadleaf (DD BL) and conifer forest (DD CF), measured PM₁₀ concentrations and measured wet deposition (WD) at the Melpitz site

Discussion

- Caveats:
 - Particles >10 µm diameter present?
 - Uncertainty in DD modelling
- Looking for: Approaches to model substance ratios in DD at sites without air concentration measurements

$$\frac{DD_X}{DD_{Na}} = f(WDX, WDNa, \dots)$$
- Looking for: Size-resolved air concentration measurements (Na⁺, K⁺, Ca²⁺, Mg²⁺, ...) covering particles larger than 10 µm diameter

References

Ulrich (1994): Nutrient and Acid-Base Budget of Central European Forest Ecosystems. In: D. L. Godbold und A. Hüttermann (Hg.): Effects of Acid Rain on Forest Ecosystems

Emerson, Ethan W., Hodshire, Anna L., DeBolt, Holly M., Bilsback, Kelsey R., Pierce, Jeffrey R., McMeeking, Gavin R., Farmer, Delphine K. (2020): Revisiting particle dry deposition and its role in radiative effect estimates. In: Proc. Natl. Acad. Sci. USA 117 (42)

Zhang, L. (2001): A size-segregated particle dry deposition scheme for an atmospheric aerosol module. In: Atmospheric Environment 35 (3)

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