Comparison of two Surface Reflectivity Models and Validation with Measurements

Outline:

1. Introduction
2. Models
3. Experimental Data
4. Results
5. Conclusions & Summary

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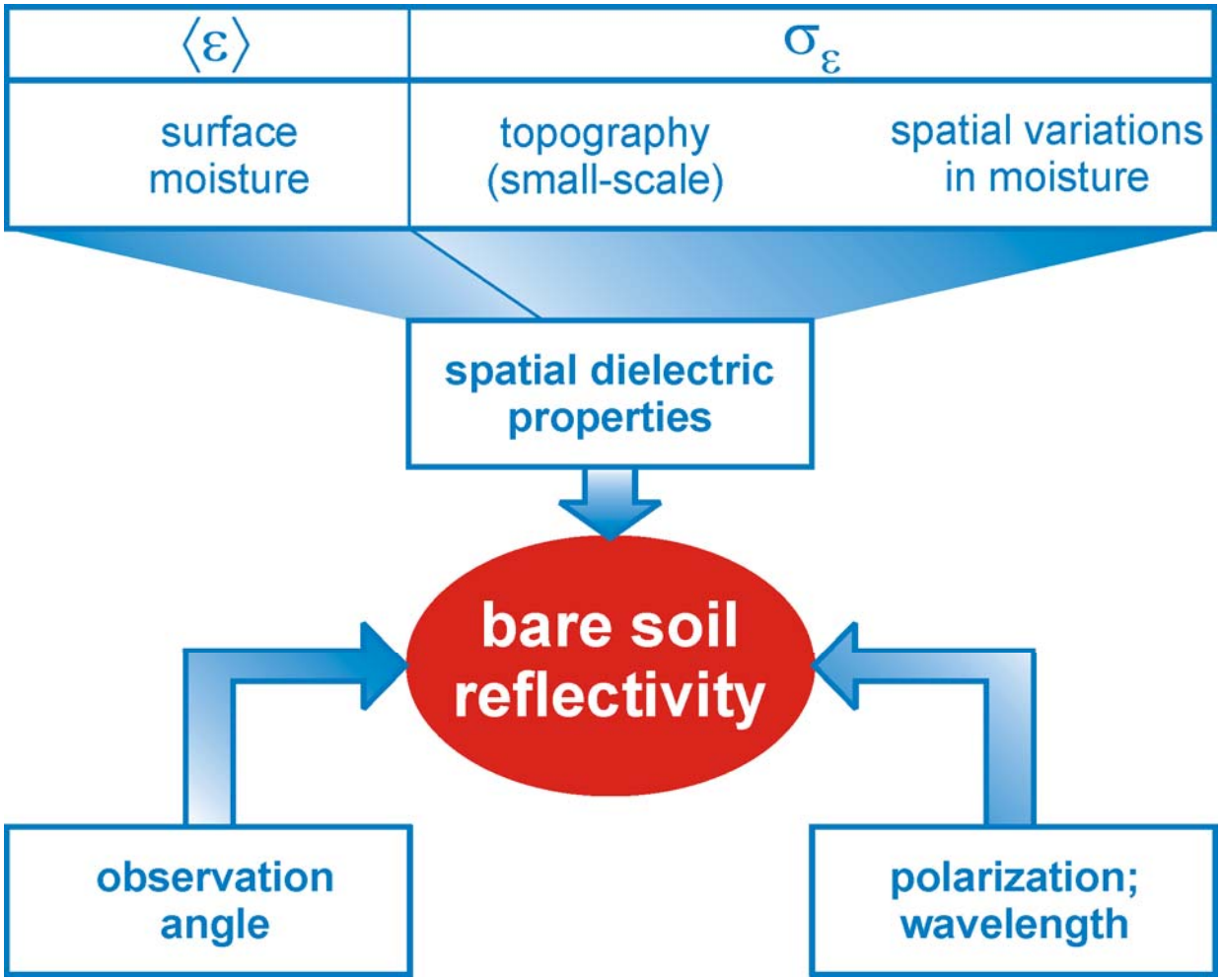
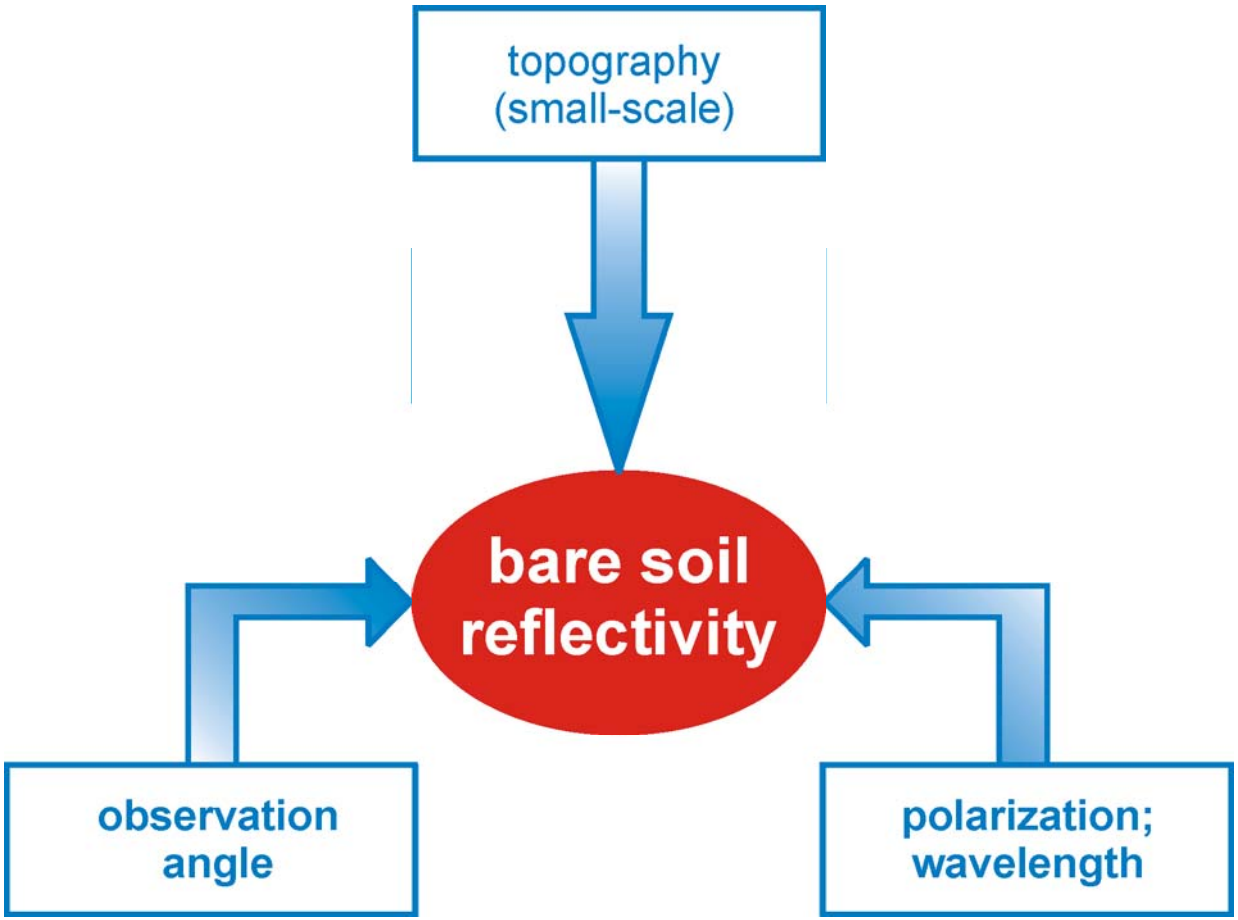
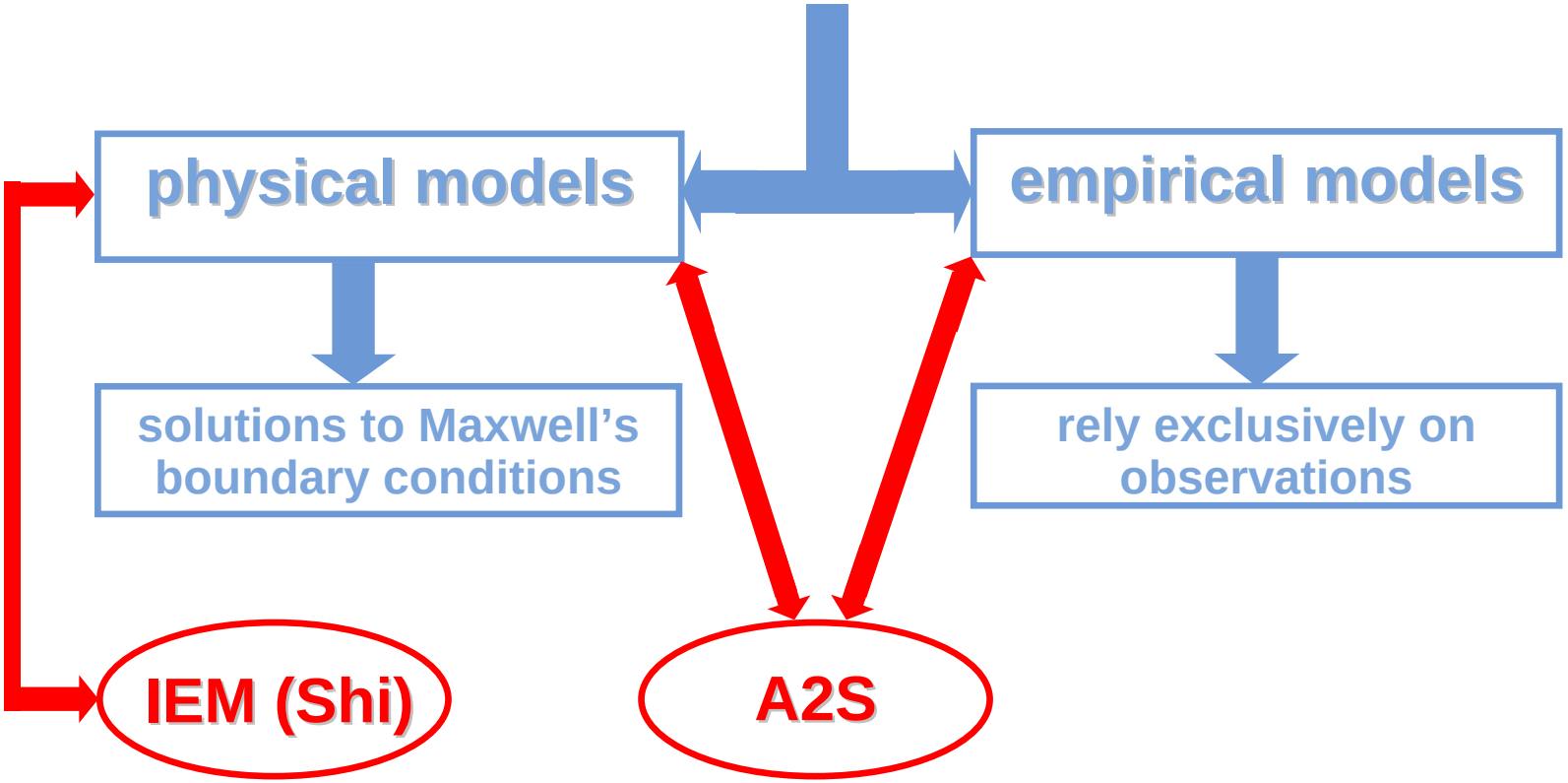
L-band reflectivity of a bare soil is affected by…



L-band reflectivity of a bare soil is affected by…



Surface Reflectivity Models



the two models investigated are:

IEM model:

Shi's parametrization

(fast model)

A2S transition model:

physical: Impedance matching.

empirical: Bragg limit.

Refractive mixing.

Concept of the A2S model

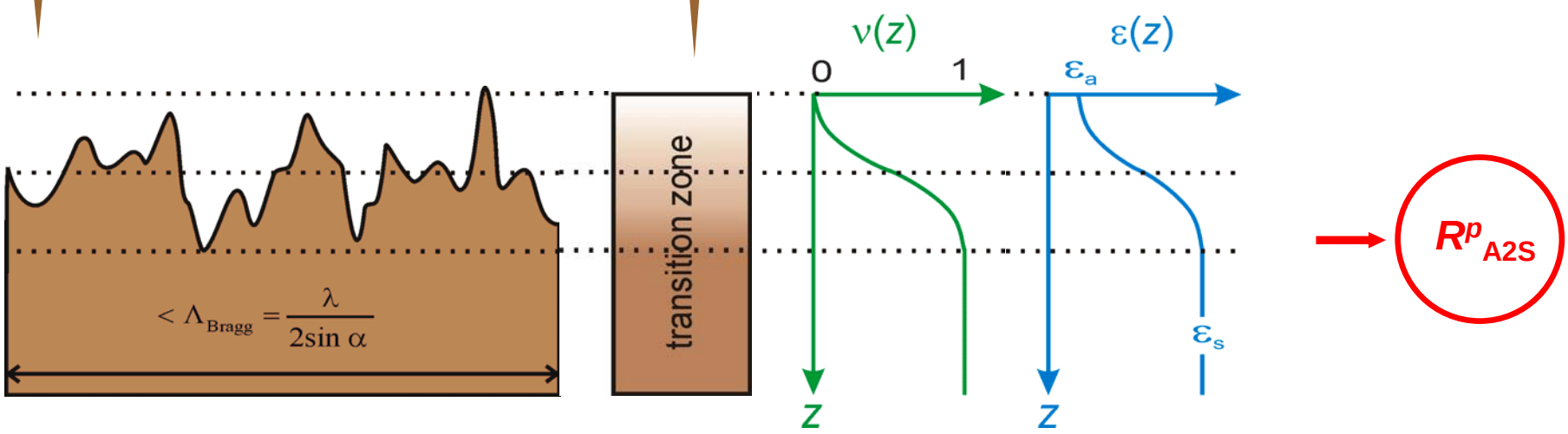
…features smaller than the resolution limit…

…gradual transition zone…

…volumetric soil fraction profile…

…dielectric profile…

$$\varepsilon(z) = \left[\nu(z) \cdot \varepsilon_s^{1/2} + \left[1 - \nu(z)\right] \cdot \varepsilon_a^{1/2} \right]^2$$



R^p_{A2S}

2. Models

A2S- and IEM- Modeled Reflectivities

IEM model
(Shi's parametrization)

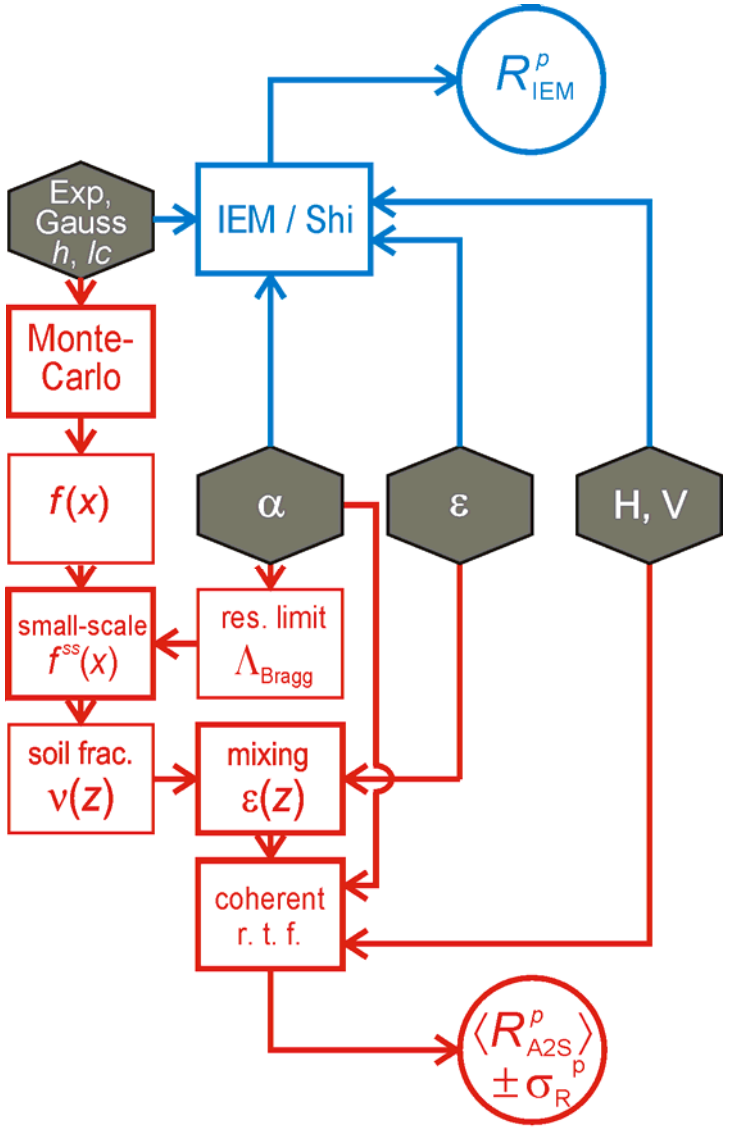
common inputs for model comp.

inputs to the A2S model

extracting small-scale features

dielectric profile

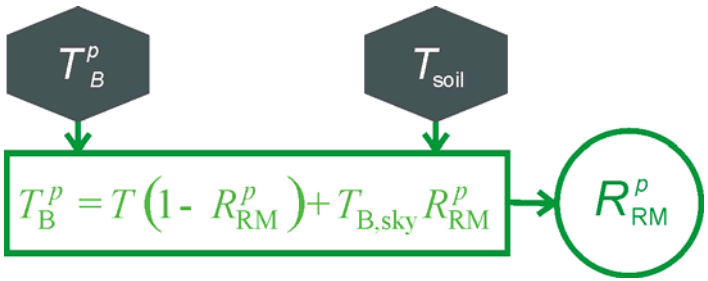
A2S reflectivity

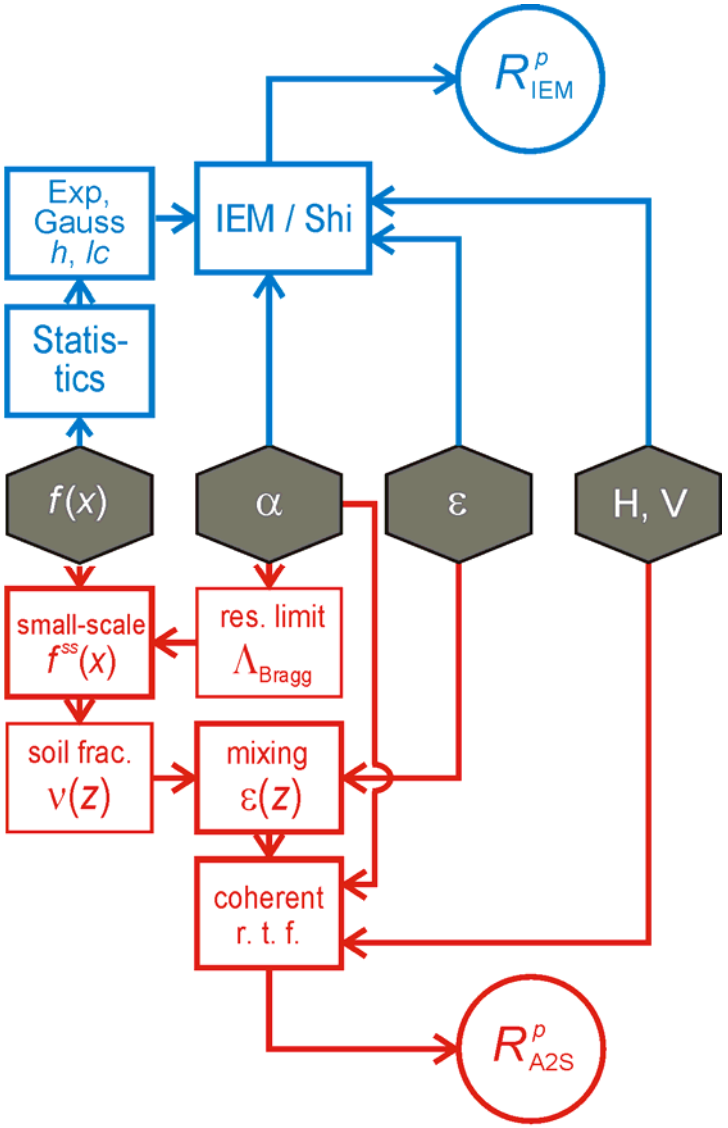


Modeled and Measured Reflectivities

common inputs for evaluating the models using measured topographies

Reflectivities derived from Radiometer measurements





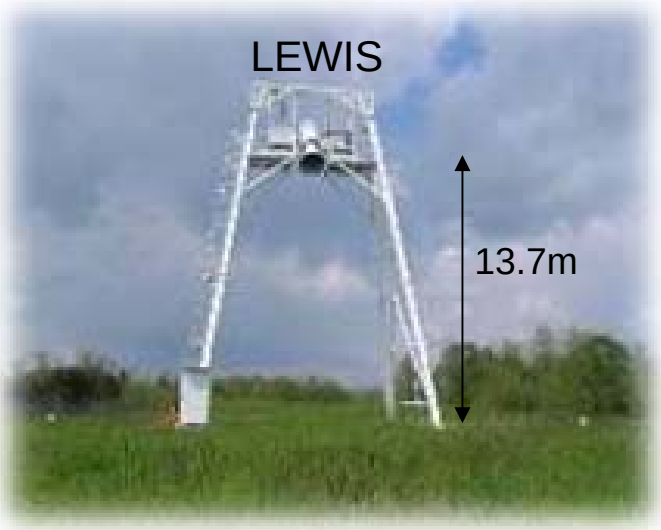
SMOSREX Data (near Toulouse, France)

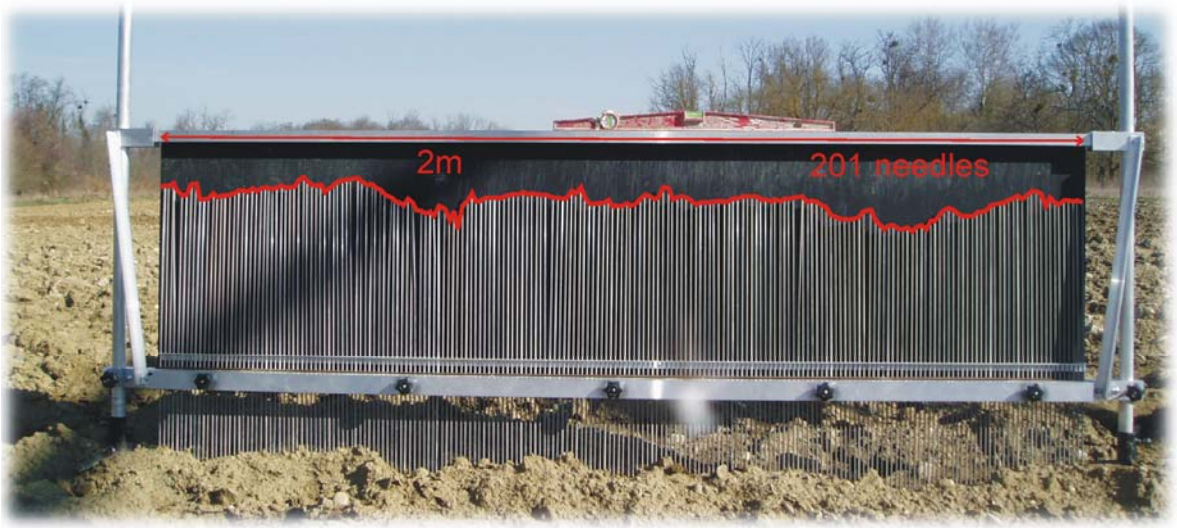
- **11 days:**
  DoY = 13, 20, 32, 51, 75, 93, 124, 150, 181, 328 in 2006 and DoY = 71 in 2007

- **T_B^H, T_B^V over bare soil:**
  Lewis; α = 20° - 60°; Δt = 3 h

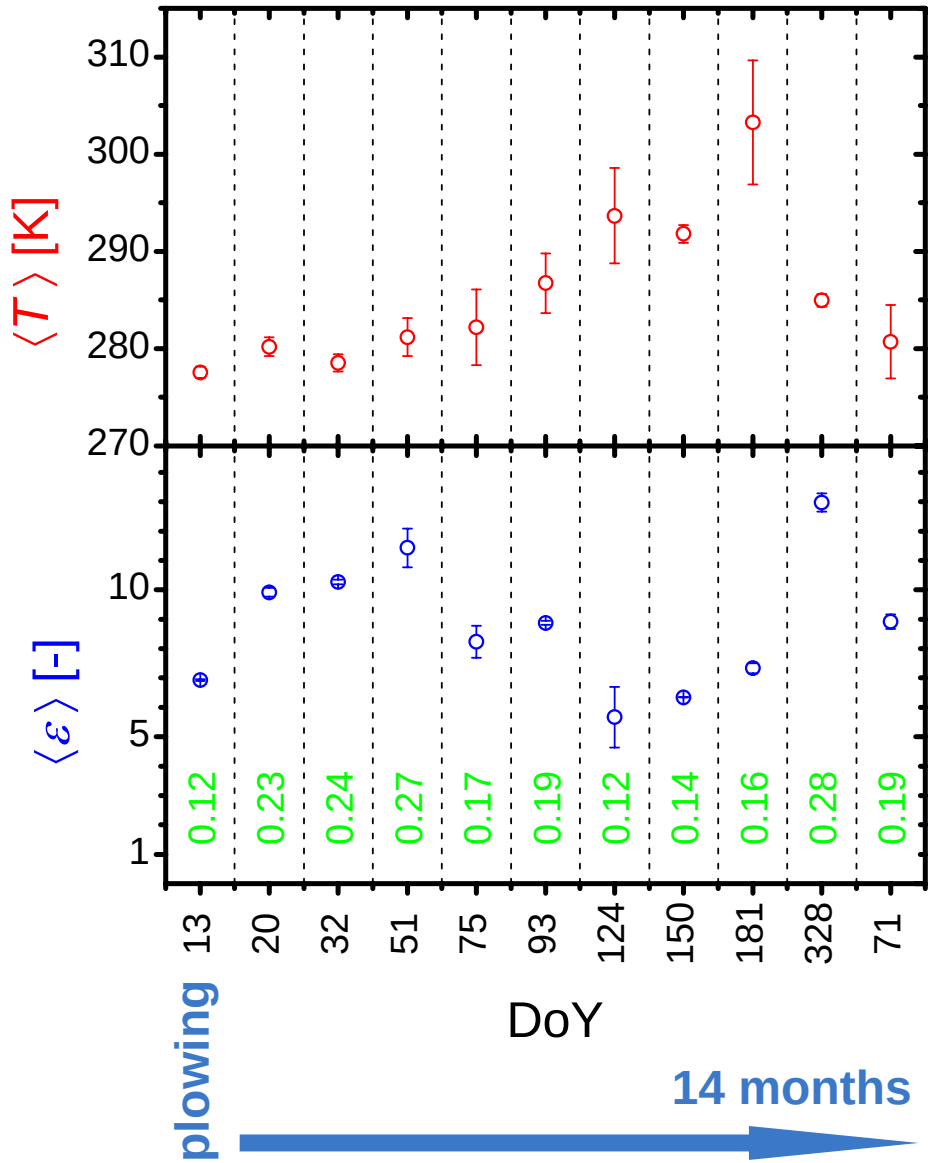
- **In-situ T and ε:**
  thermistors & Theta-probes

- **topography profiles:**
  needle board; 11-16 per day





Daily Mean Soil Temperature and Permittivity

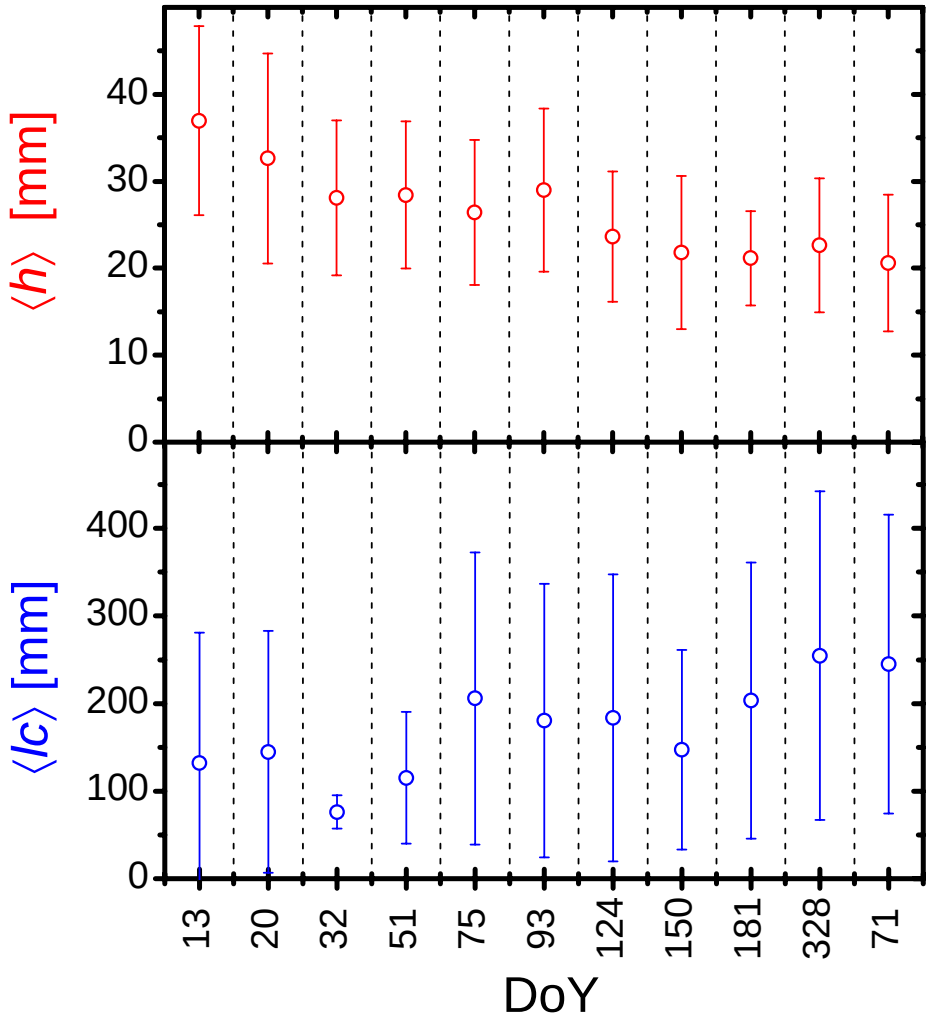


- Several probes installed within the topmost 6 cm.
- One measurement per 30 minutes

- Volumetric moisture [m^3m^{-3}] (Topp et al., 1980)

3. Experimental Data

Daily Mean RMS-height and Correlation length

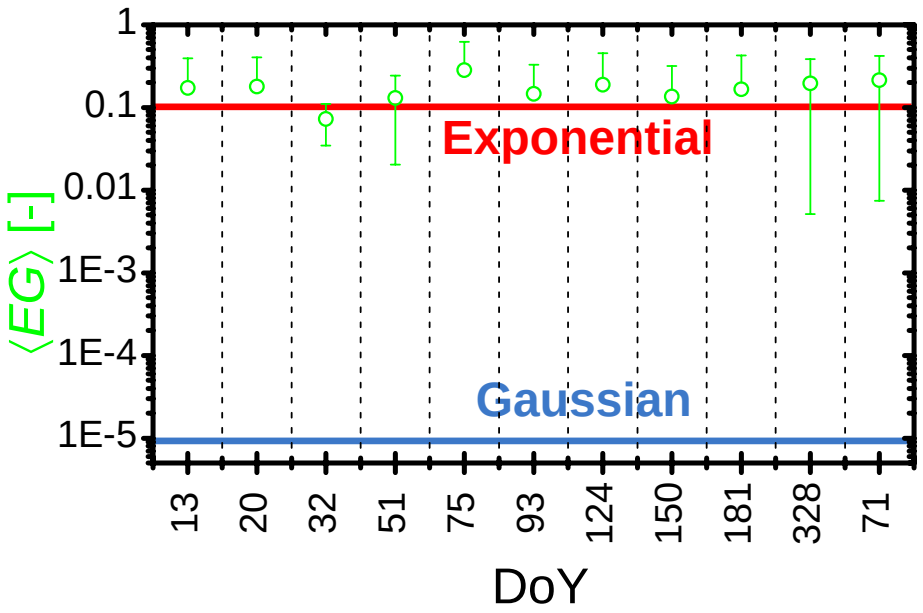


- **Surface RMS-height decreases from $\langle h \rangle \approx 39$ mm to $\langle h \rangle \approx 20$ mm**

- **Surface correlation length $\langle lc \rangle$ does not increase significantly with time.**

Standard deviations σ_h and σ_{lc} do not decrease with time.

Daily Mean Spectral Indicator



$$EG = \frac{\text{spatial wavelenghts} \leq \text{ correlation length}}{\text{total power spectrum}}$$

$$EG = \frac{\sum_{k \geq 2\pi/lc} |c_k|^2}{\sum_{k} |c_k|^2}$$

$$\langle EG \rangle \approx 0.17$$

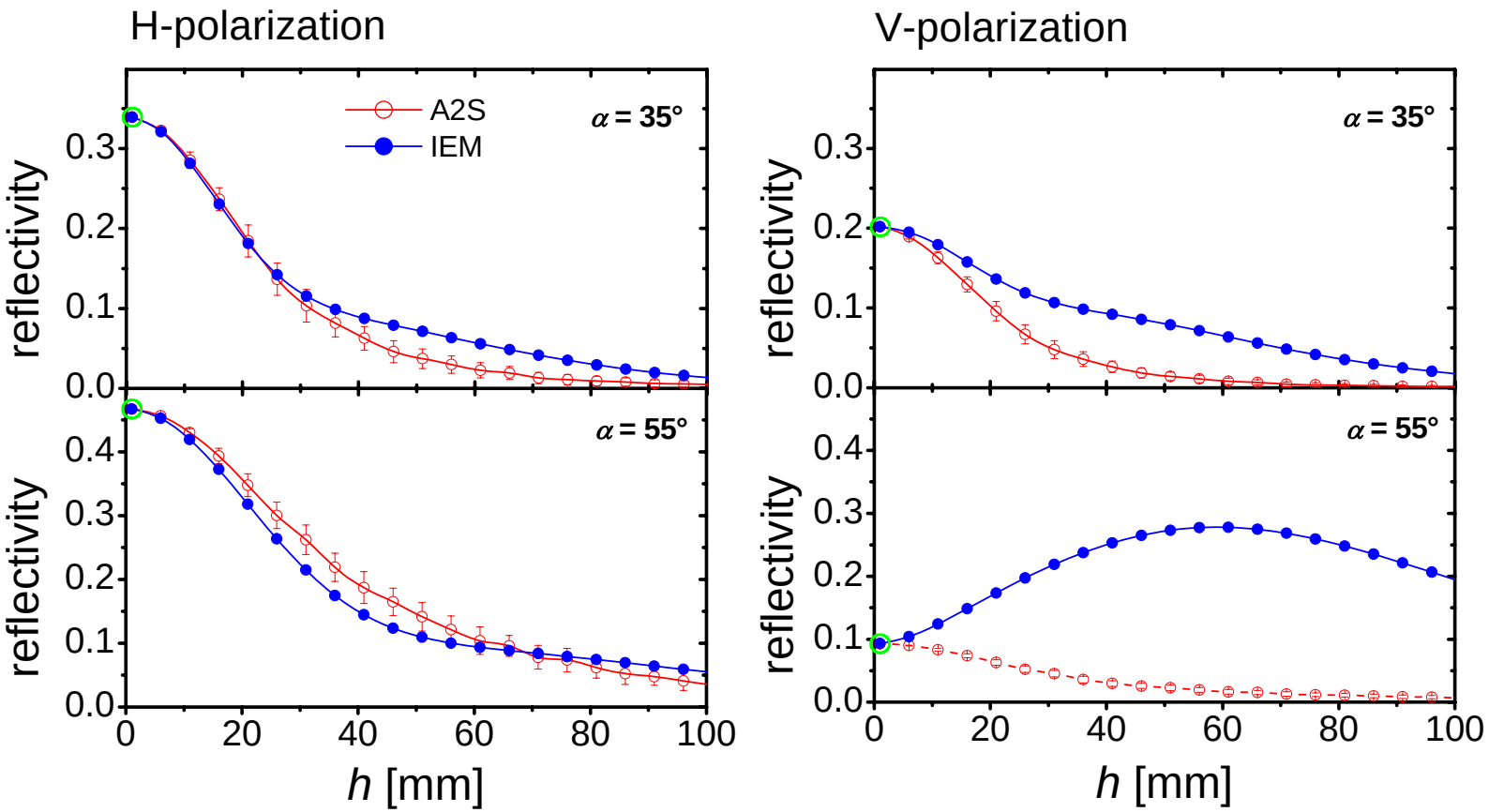
$$EG_S \equiv \frac{\int_{k_{lc}}^{\infty} W_S(k)\,dk}{\int_{0}^{\infty} W_S(k)\,dk}$$

spectral power densities:

$$W_G(k) = \frac{h^2 lc}{2\sqrt{\pi}} \exp\left(-\frac{k^2 \cdot lc^2}{4}\right) \qquad W_E(k) = \frac{h^2 lc}{\pi\left(1 + k^2 lc^2\right)}$$

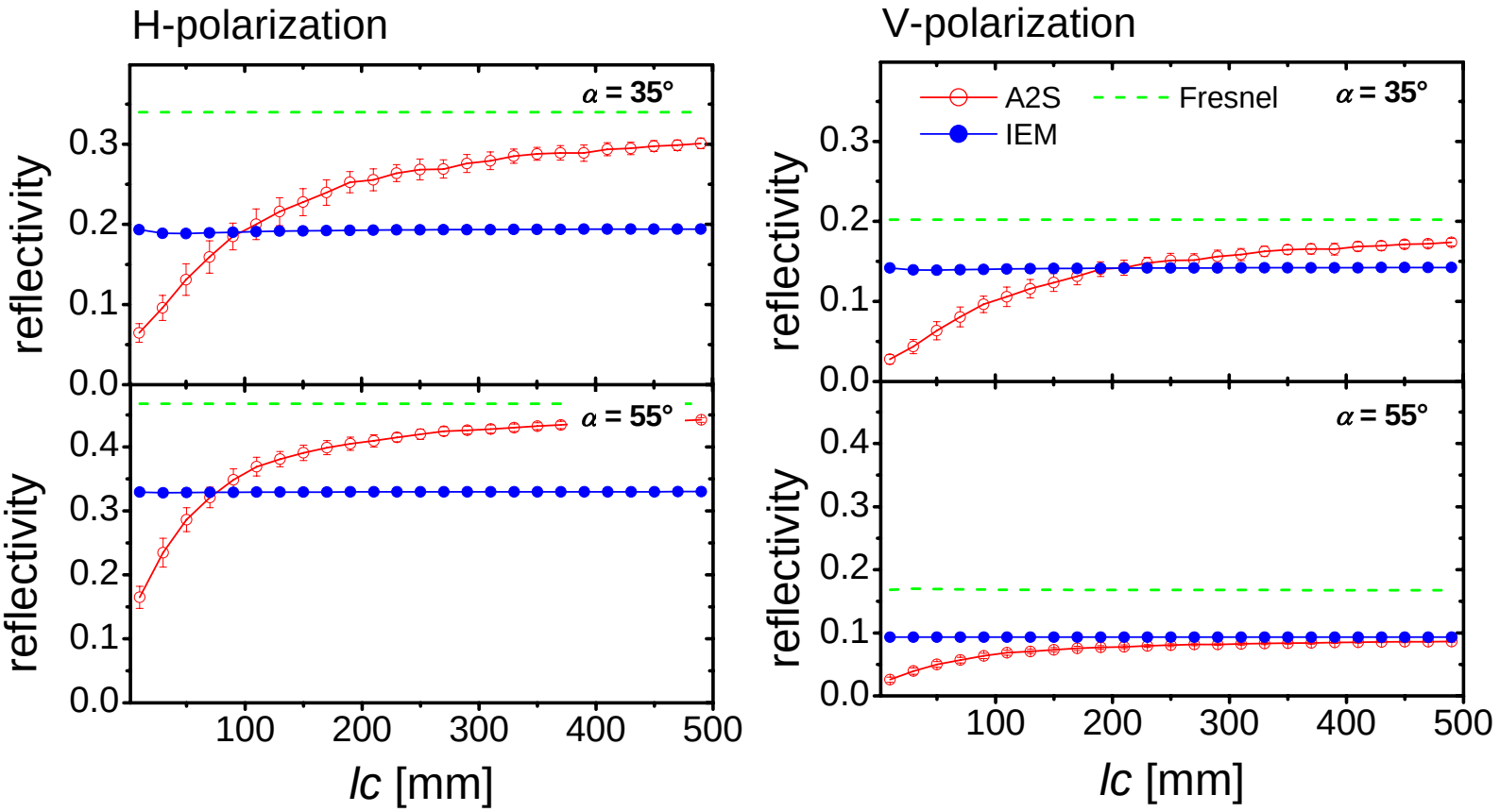
⇒ **The correlation function of a naturally weathered bare soil surface is Exponential**

Comparison between A2S- and IEM Model



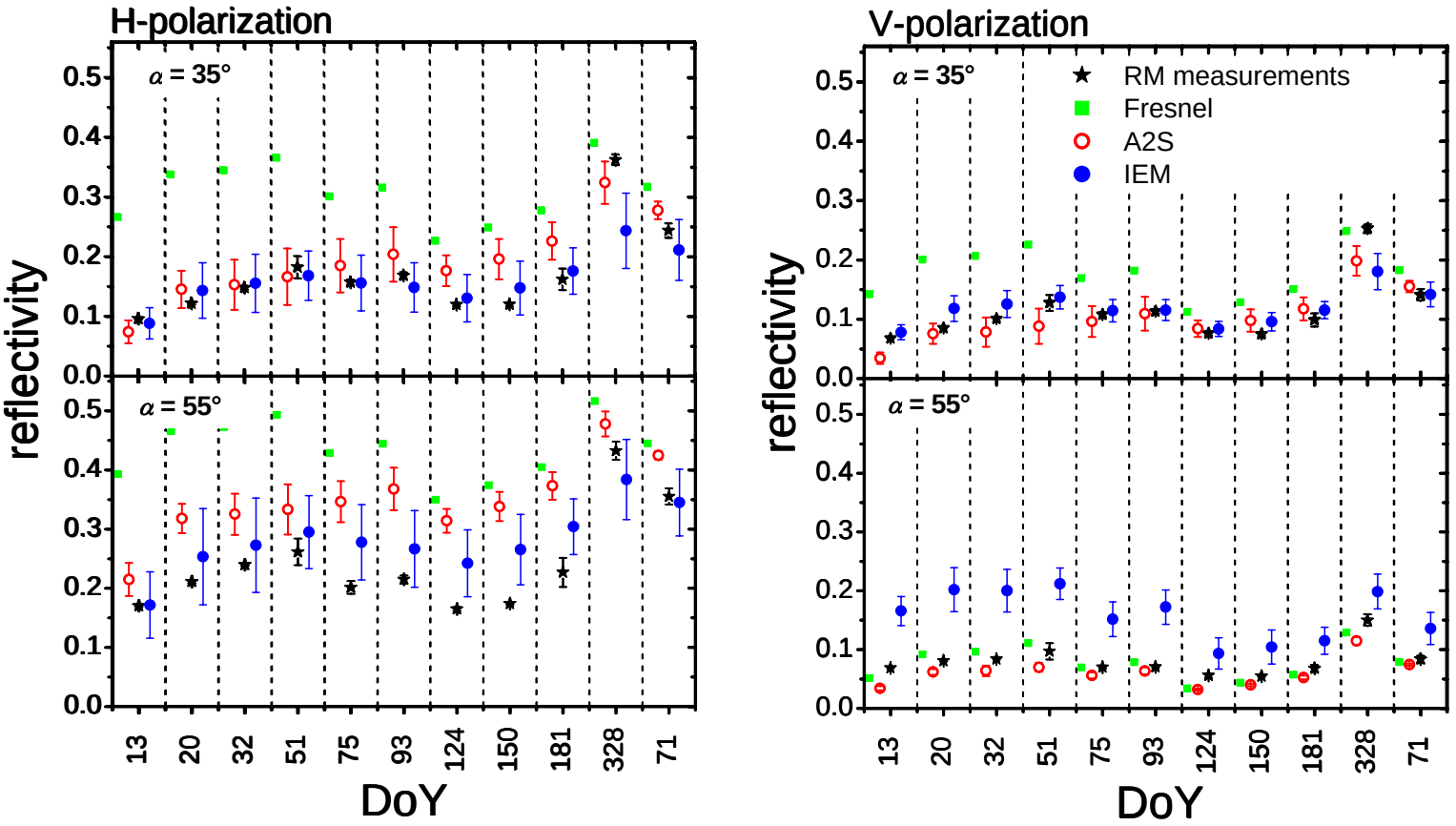
- Variation of h; $\varepsilon = 10$
- Both models reproduce the Fresnel reflectivity for $h \rightarrow 0$
- Similar results for p = H (reflectivity decreases with h, $\propto$ Exp($-h^2$))
- IEM reflectivity: p = V, $\alpha = 55°$ increase with h; polarization cross-talk, not observed

Comparison between A2S- and IEM Model



- Variation of *lc*; $\varepsilon = 10$
- **IEM reflectivities** are not much sensitive with respect to *lc*
- **A2S reflectivities** increase with *lc* to approach values smaller than the **Fresnel reflectivities**.
- *lc* ↑ ⇒ proportion of the spatial small-scale features ↓ ⇒ R_{A2S} ↑

Comparison with Measurements



α [°]	*p*	OK_F	δ_F [%]
35	H	0	97
35	V	1	68
55	H	0	92
55	V	3	16

$$\delta_F = \frac{100}{n_{DoY}} \sum_{i=1}^{n_{DoY}} \frac{\left| \left\langle R_F^p \right\rangle_i - \left\langle R_{RM}^p \right\rangle_i \right|}{\left\langle R_{RM}^p \right\rangle_i}$$

4. Results

5. Conclusions & Summary

- The impact of roughness on the soil reflectivity was analyzed (IEM-model ⇔ A2S-model ⇔ experimental data)
- Distinct differences between the models
- Depending on the polarization and the observation angle, either the IEM-or the A2S-model performs better.
- Polarization cross-talk was overestimated by the IEM-model
- Detailed information on the soil topography might be not sufficient for accurate predictions of soil reflectivity. The impact of dielectric heterogeneities and anisotropies of the bulk soil in the topmost centimeters can be dominant.

Thank you for your Attention

Mike Schwank