

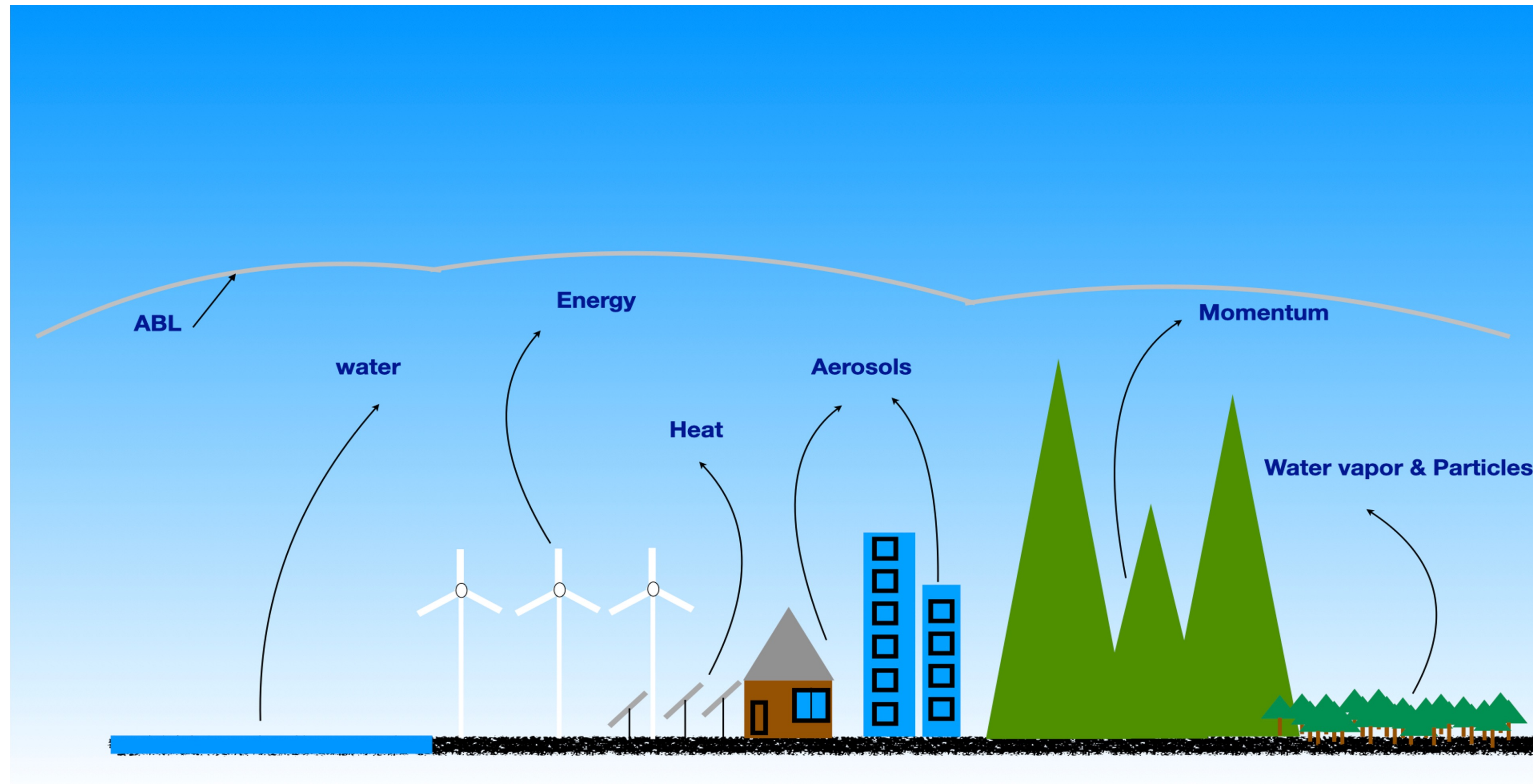
Surface Heterogeneity Measure and Its Application in Energy Imbalance Problem

Hawwa Kadum

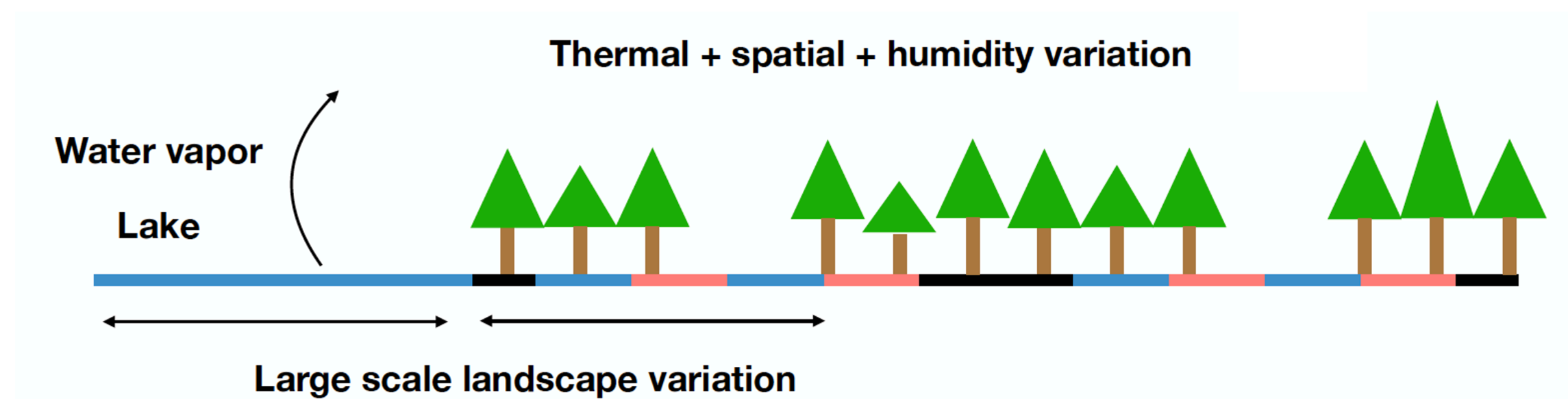
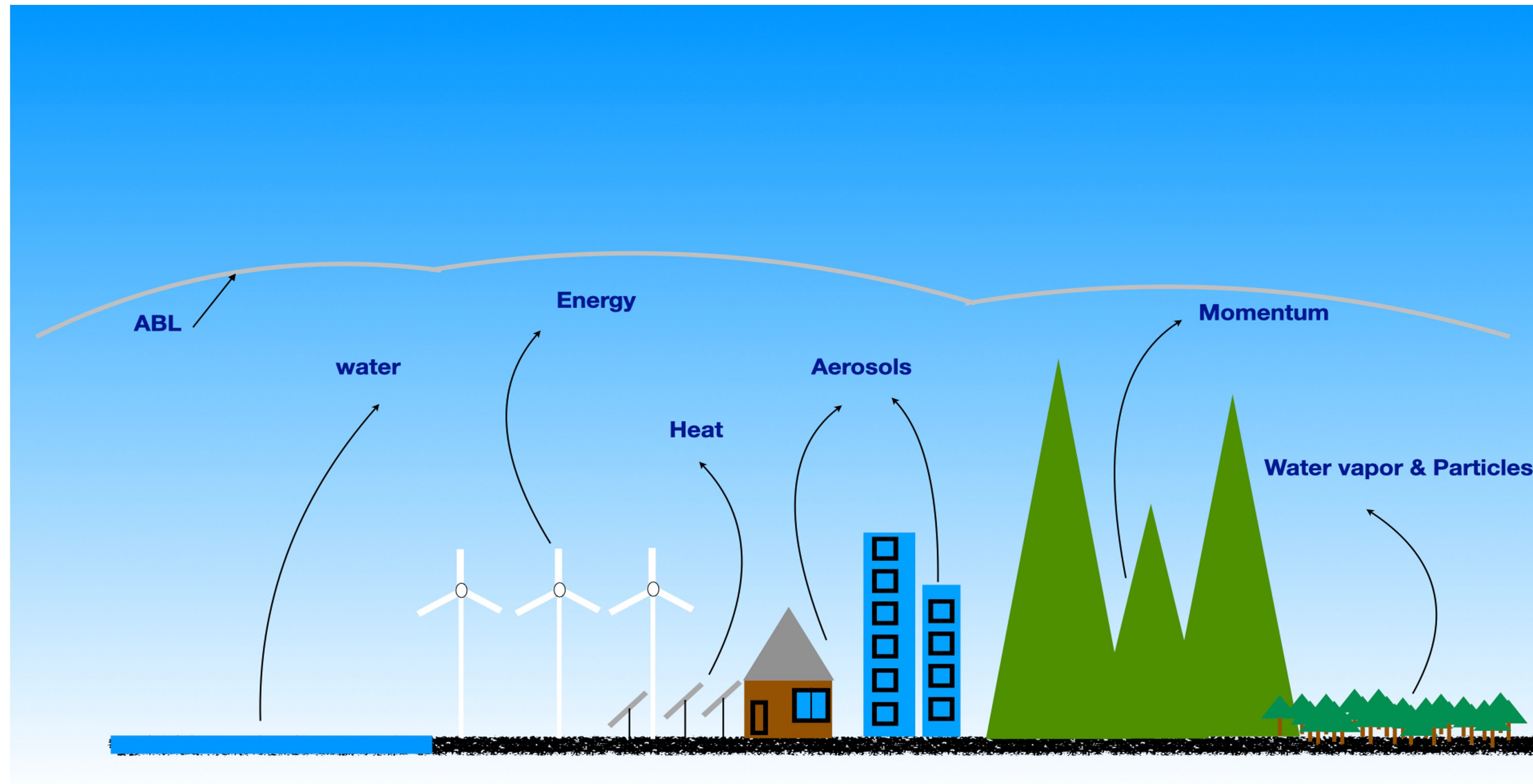
Luise Wanner, Sreenath Paleri, Ankur Desai, Matthias Mauder

EGU General Assembly 2022, Austria

Introduction:

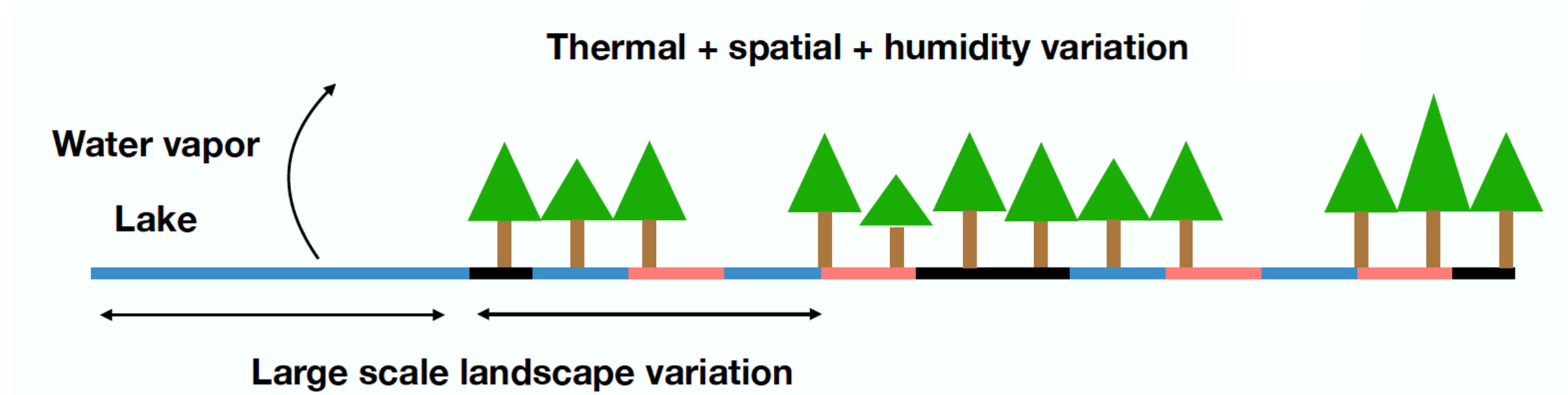


Introduction:

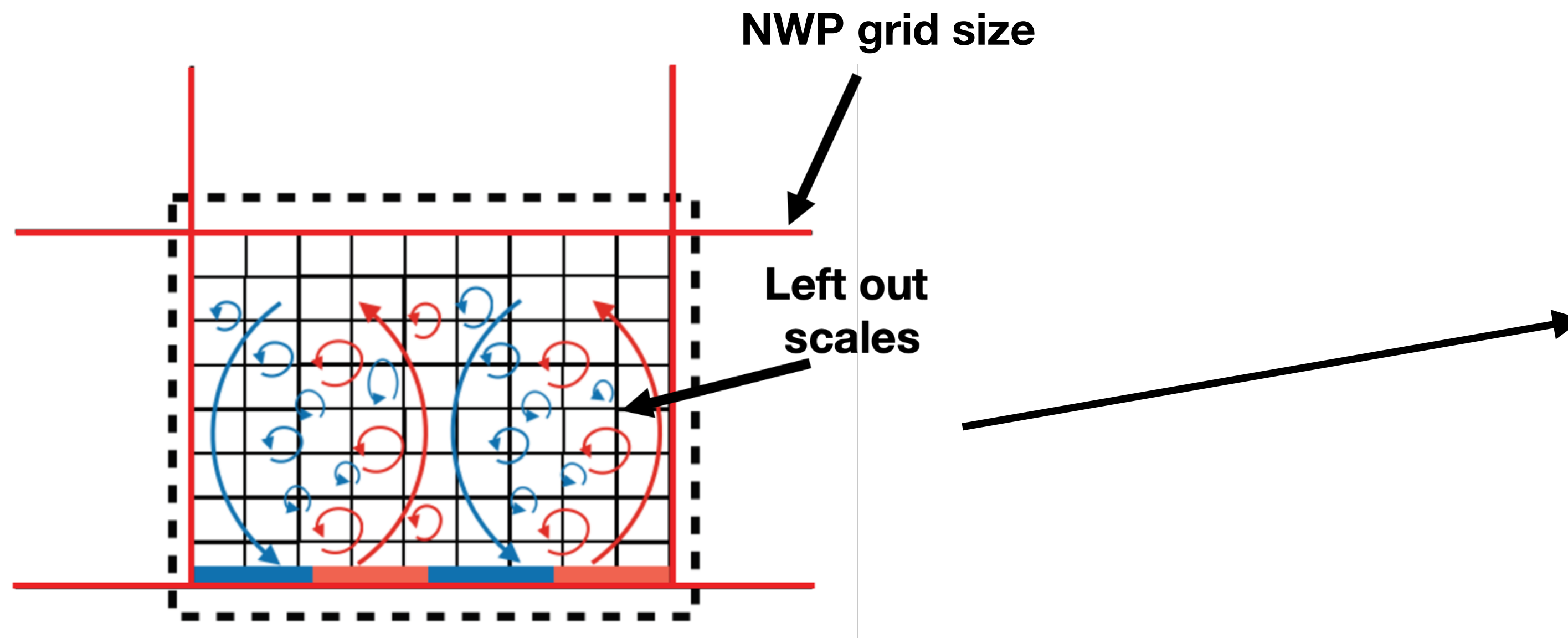


- Across a wide range of scales.
- Cased by various heterogeneity types.

Challenge: Numerical weather prediction models (NWP)



- Across a wide range of scales.
- Cases by various heterogeneity types.

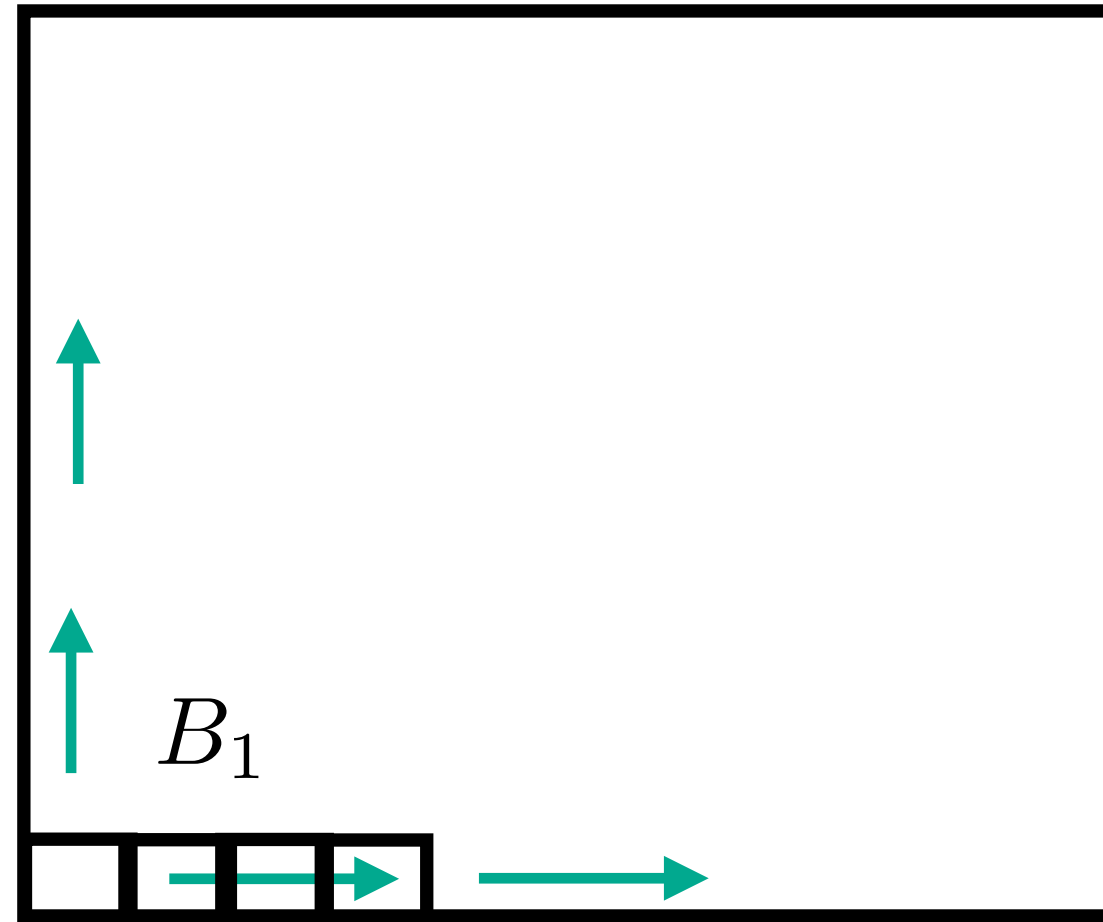


Modeling

Agreed upon measure

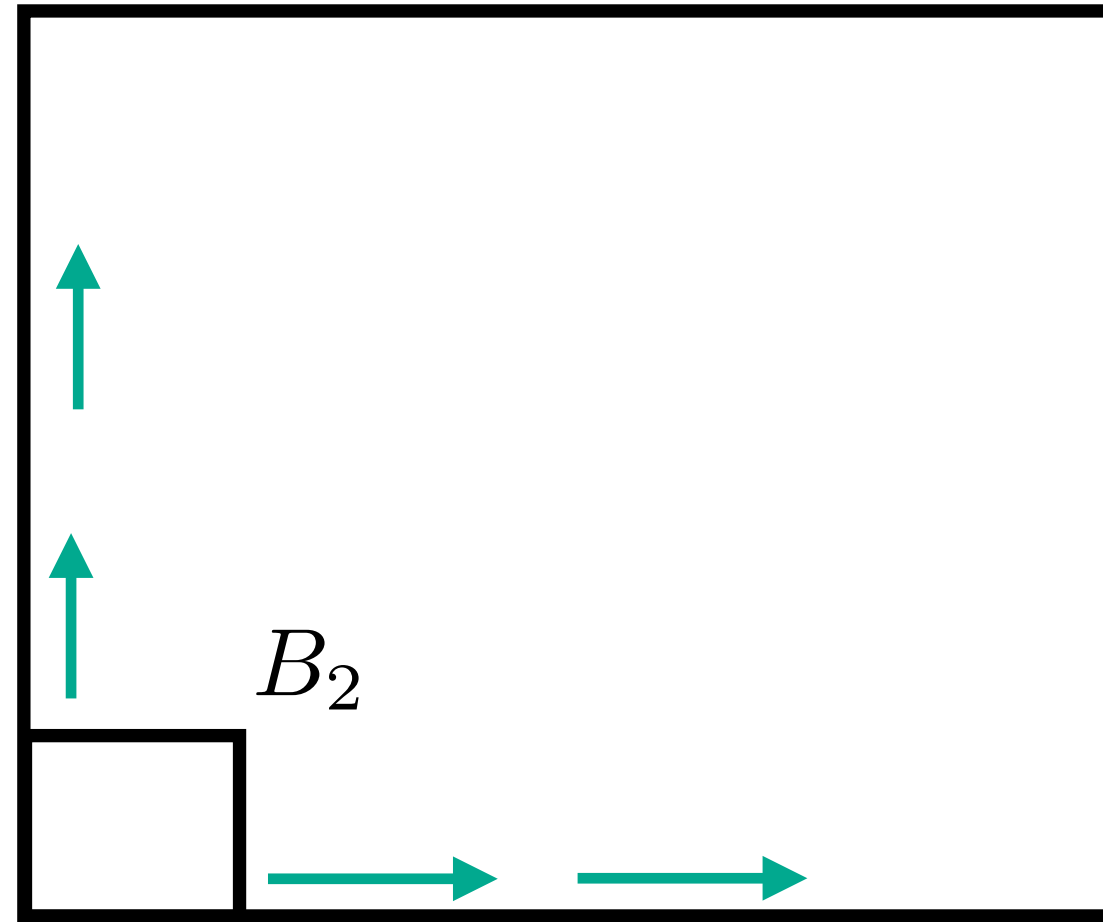
- Represent the various heterogeneity types
- Practical to obtain
- Practical to use

Heterogeneity Measure: Lacunarity



$$\text{Lacunarity}(B) = \frac{\sum s^2 Q(s, B)}{(\sum s Q(s, B))^2} = \frac{s'^2(B)}{\bar{s}^2(B)} + 1,$$

Heterogeneity Measure: Lacunarity



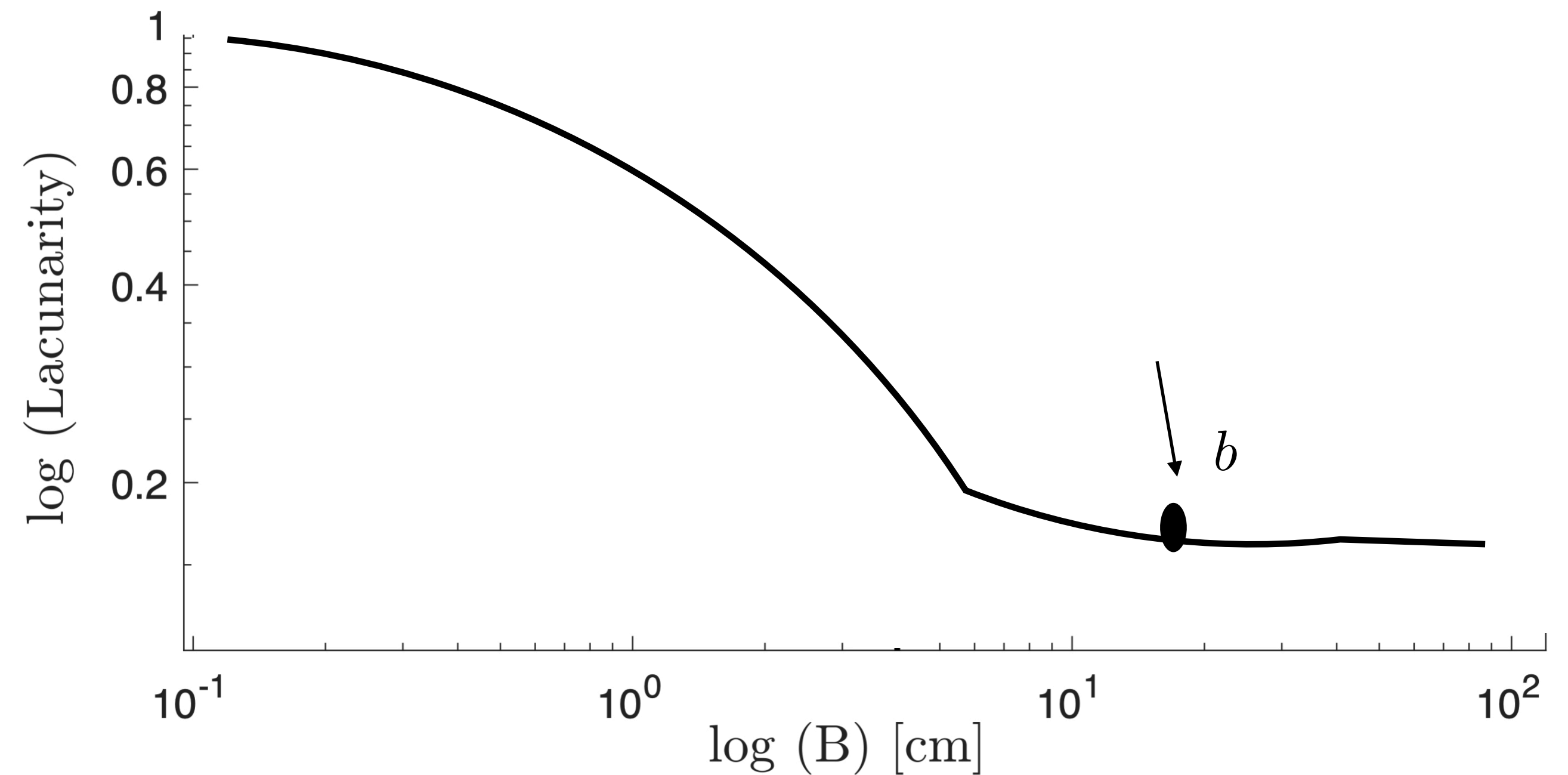
Modeling

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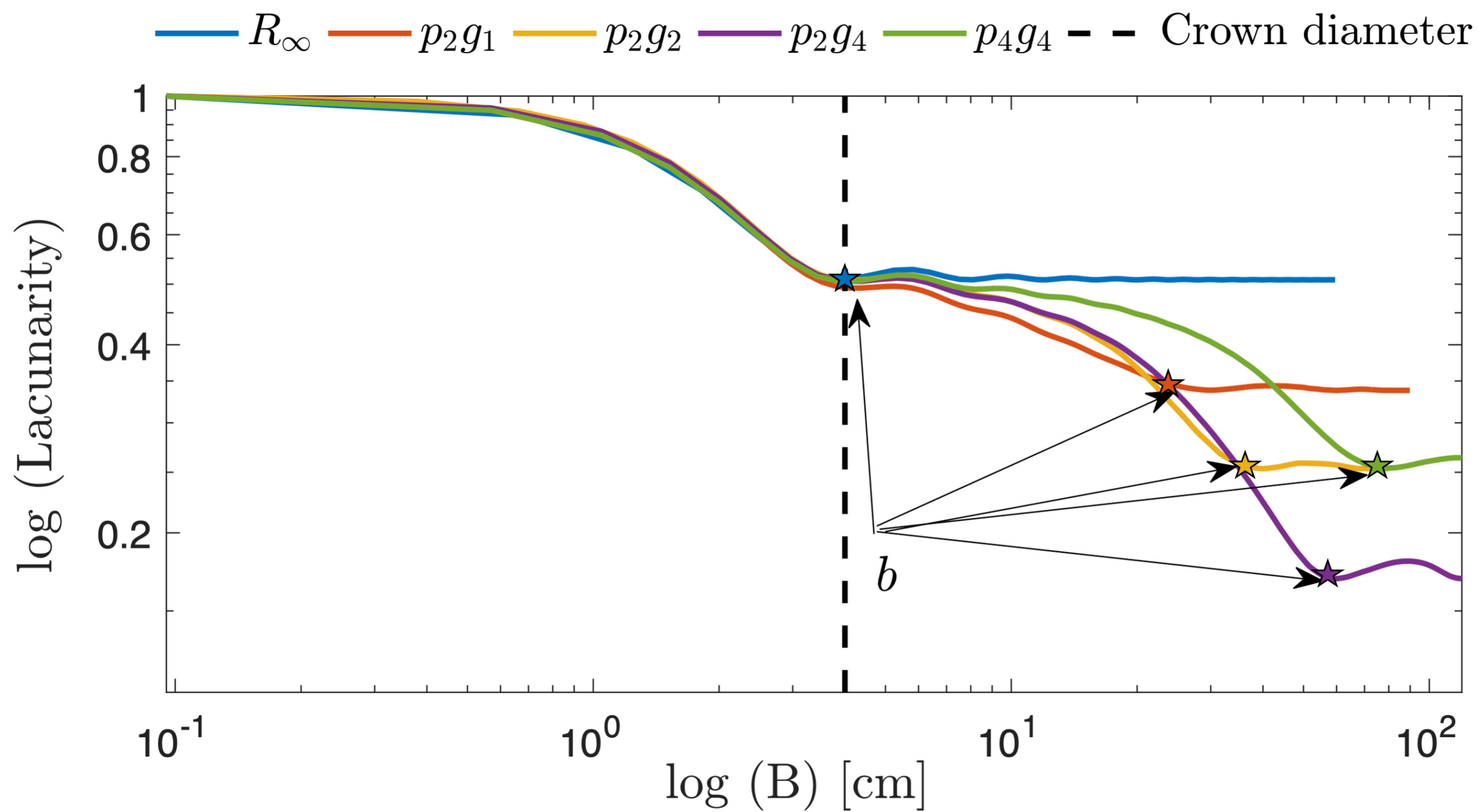
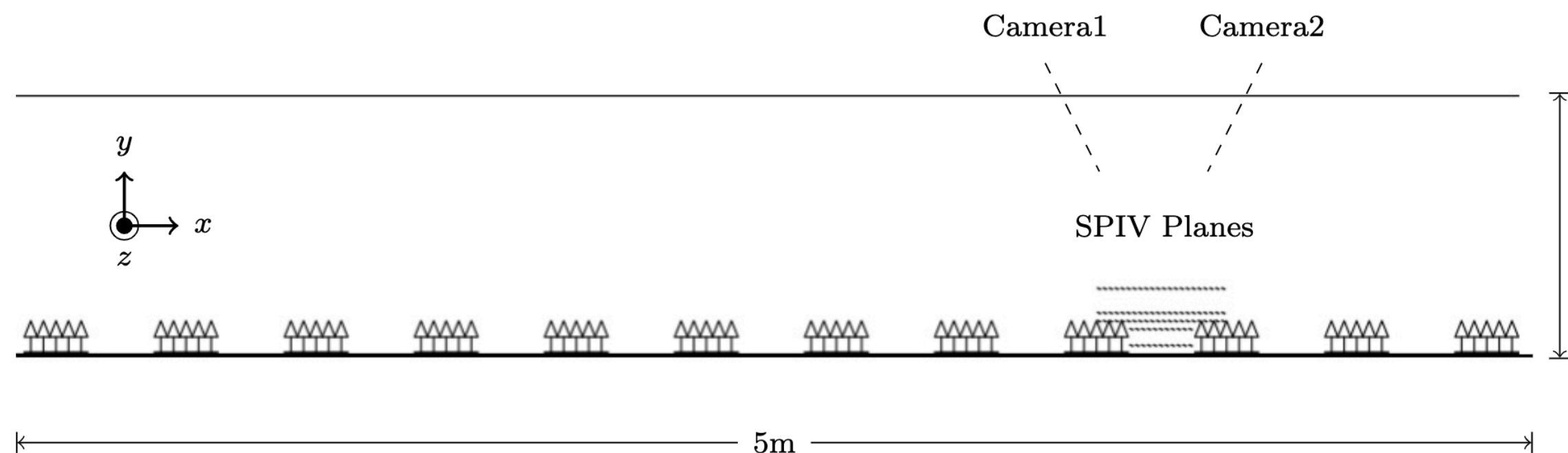
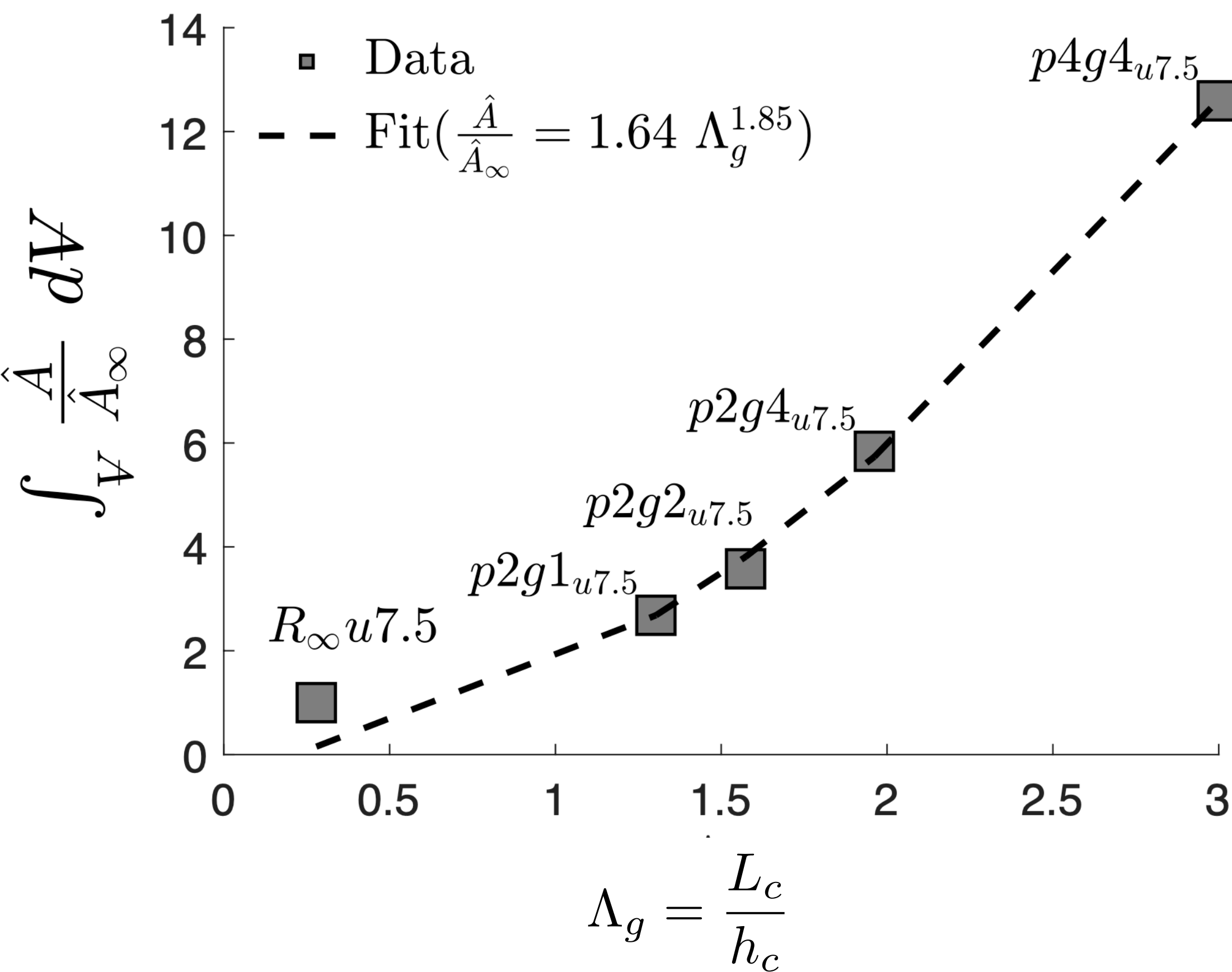
$$\text{Lacunarity}(B) = \frac{\sum s^2 Q(s, B)}{(\sum s Q(s, B))^2} = \frac{s'^2(B)}{\bar{s}^2(B)} + 1,$$



Lacunarity Results

$$L_c = \int_0^b \text{Lacunarity } dx.$$

Upper canopy



Energy Balance Closure Model:

LES PALM version 6 model
Domain: 12 km X 12 km
CHEESEHEAD19 project
Sep 24 12:00 - 17:30
Resolution: 6m x 6m x 4m

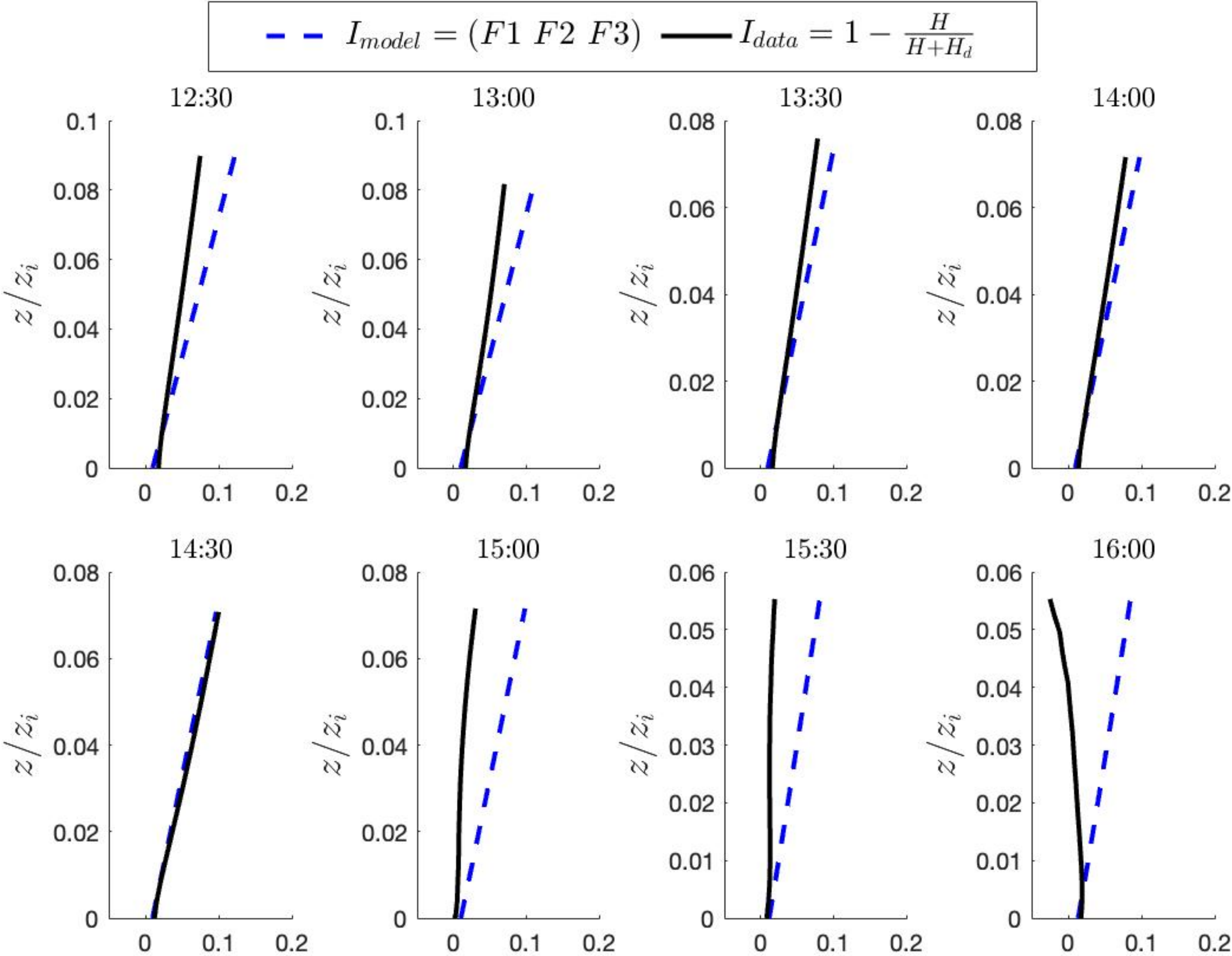
$$I_{model} = F_1\left(\frac{z}{z_i}\right) F_2\left(\frac{u_*}{w_*}\right) F_3(\mathcal{H}) \quad \dots (1)$$

$$\mathcal{H} = \frac{g L_c \Delta T}{U_g^2 \langle T_s \rangle} \quad \dots (2)$$

$$I_{data} = 1 - \frac{H}{H + H_d}$$

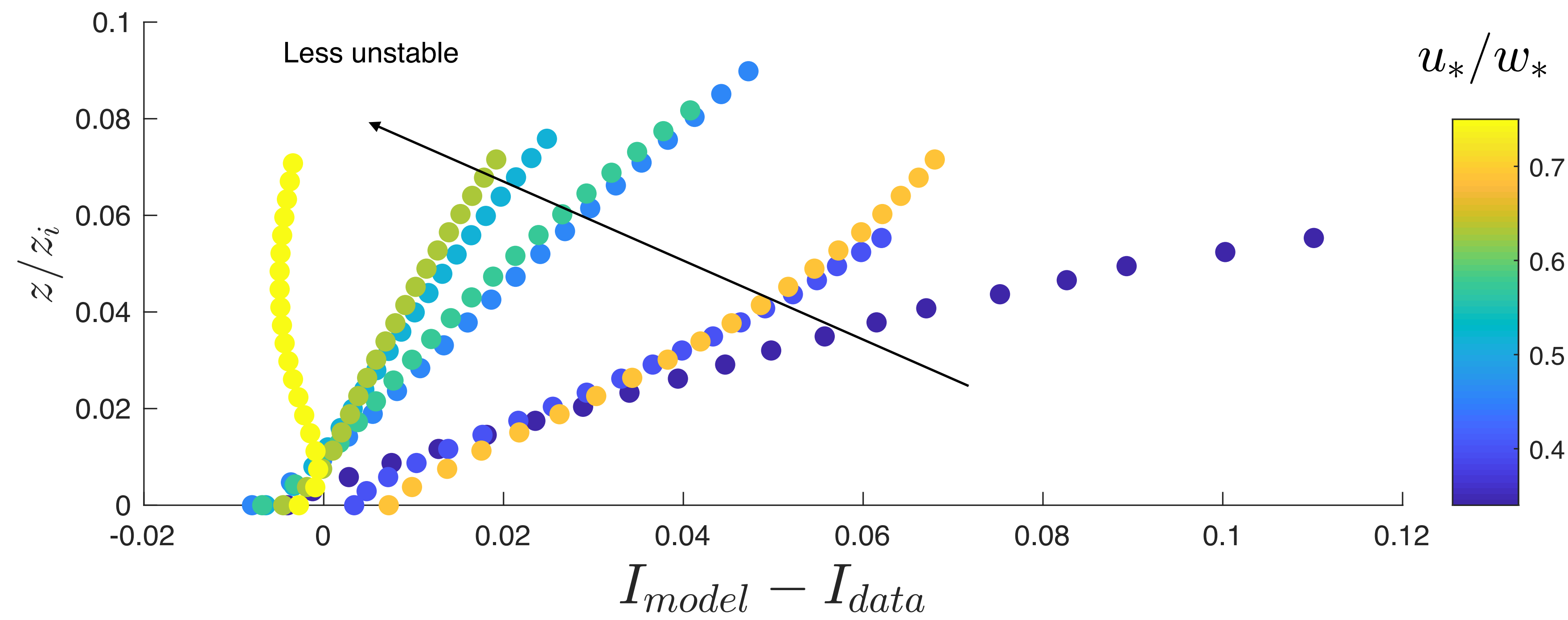
$$H = \langle \overline{w'\theta'} \rangle \quad H_d = \langle \overline{w''\theta''} \rangle \text{ Dispersive flux}$$

$$I \text{ is } \frac{\text{Missing (dispersive) flux}}{\text{Total flux}}$$



Energy Balance Closure Model:

I is $\frac{\text{Missing dispersive flux}}{\text{Total flux}}$



Conclusions

- The Lacunarity scale L_c applies successfully in the EBC model.
- It provides a promising solution to some of the challenges in modeling surface heterogeneity.
 - Describes various heterogeneity types.
 - Relatively easy to obtain.
 - Practical to use.

Future work

- Apply the Lacunarity scale and the EBC model to observation data.
- Apply the model to CO_2 and latent heat flux imbalance.
- Conduct a parametrization study to describe the relationship between surface heterogeneity scale and transport terms.