ScinDi: Disaggregation of Scintillometer Fluxes

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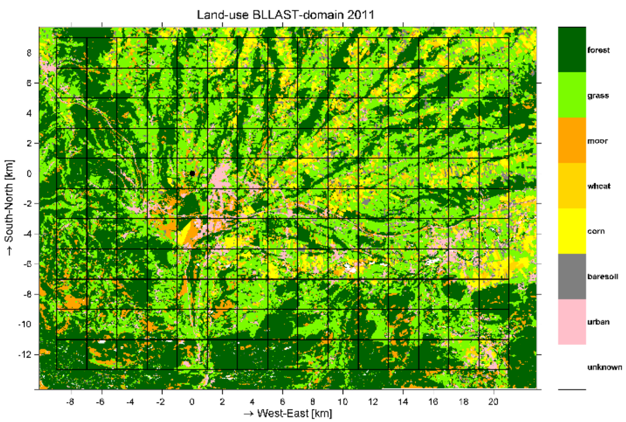
WAGENINGEN UR
METEOROLOGY AND AIR QUALITY

Background: Barcelona Workshop

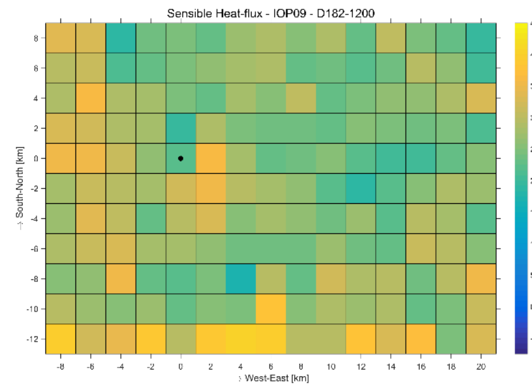
GOAL: 2-km grid flux maps (*H* + *LvE*) for the BLLAST domain centered around the Valimev tower for all IOP's

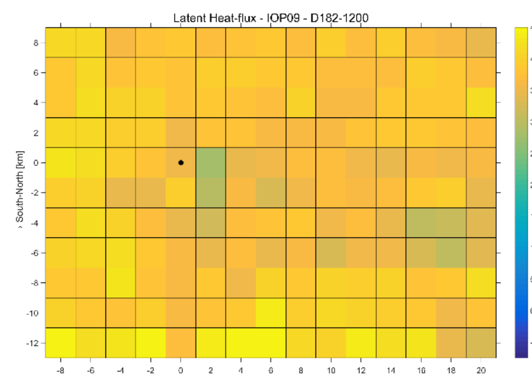
LU-map



Flux-data

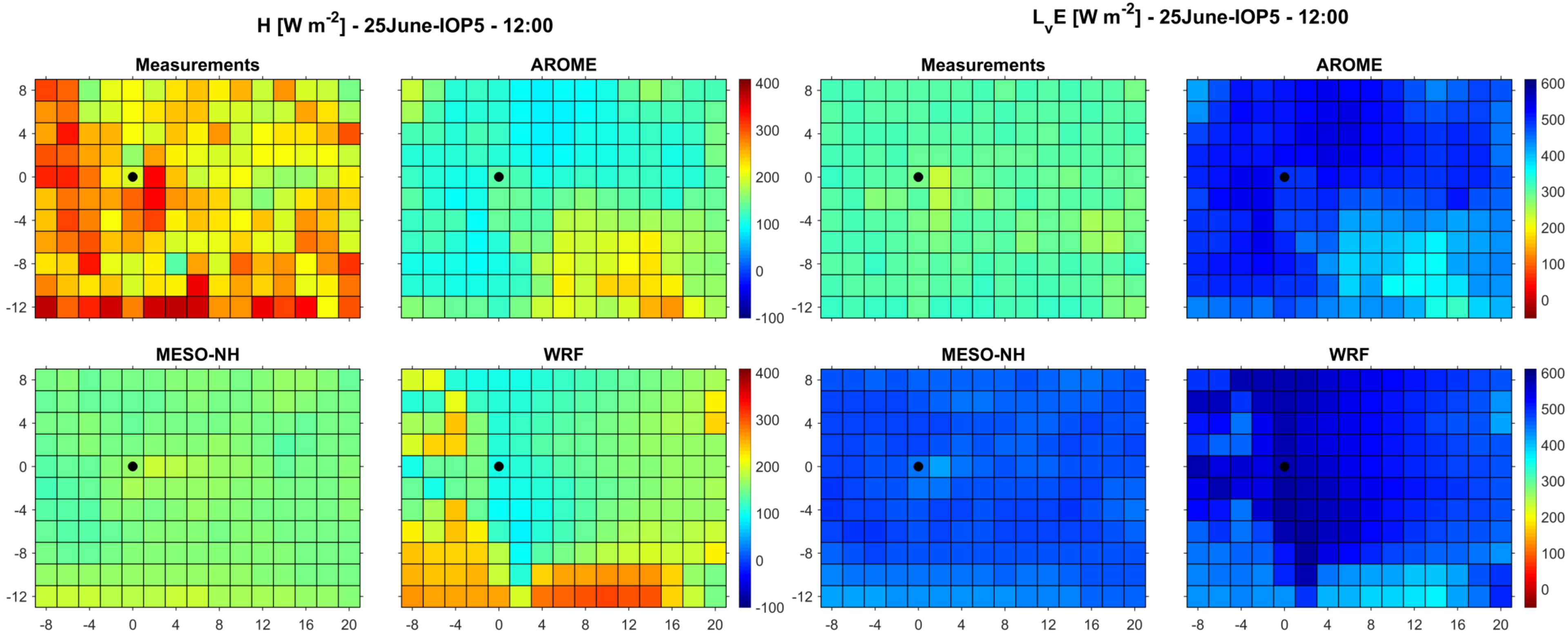
→





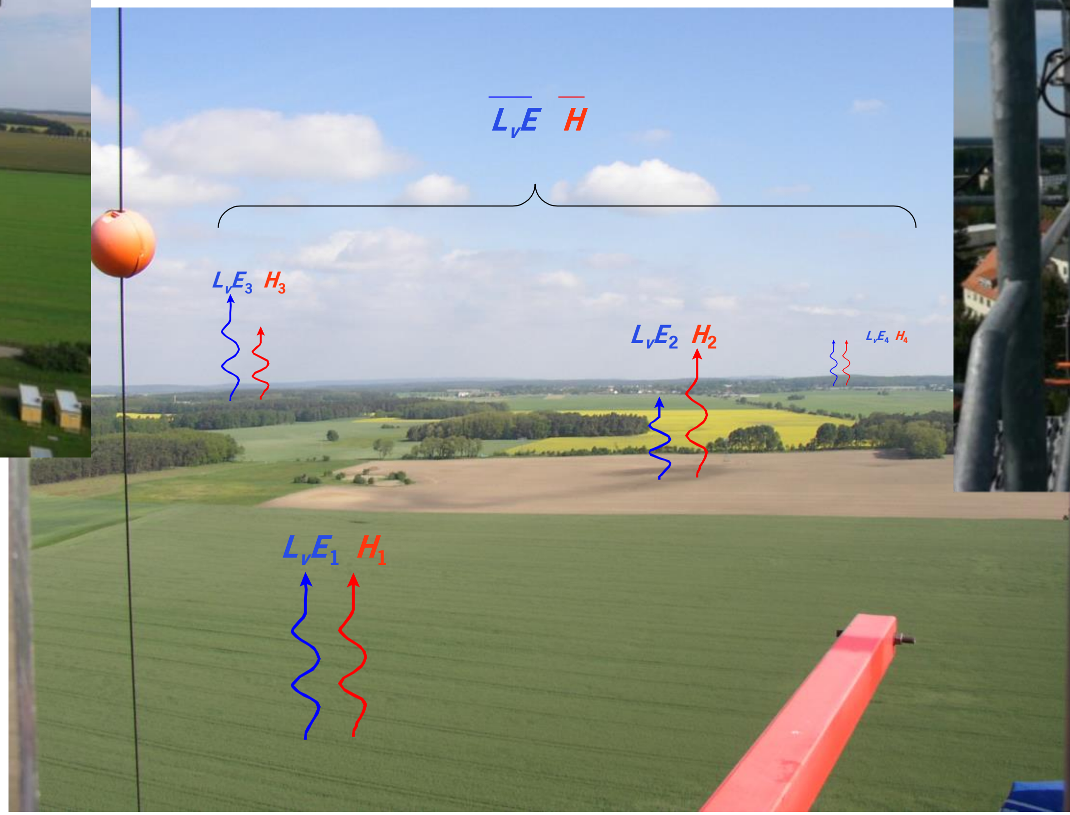
Flux-maps

GOAL: Assess the impact of land-use definition on meso-scale model performance (scalar fluxes → $H + L_vE$)



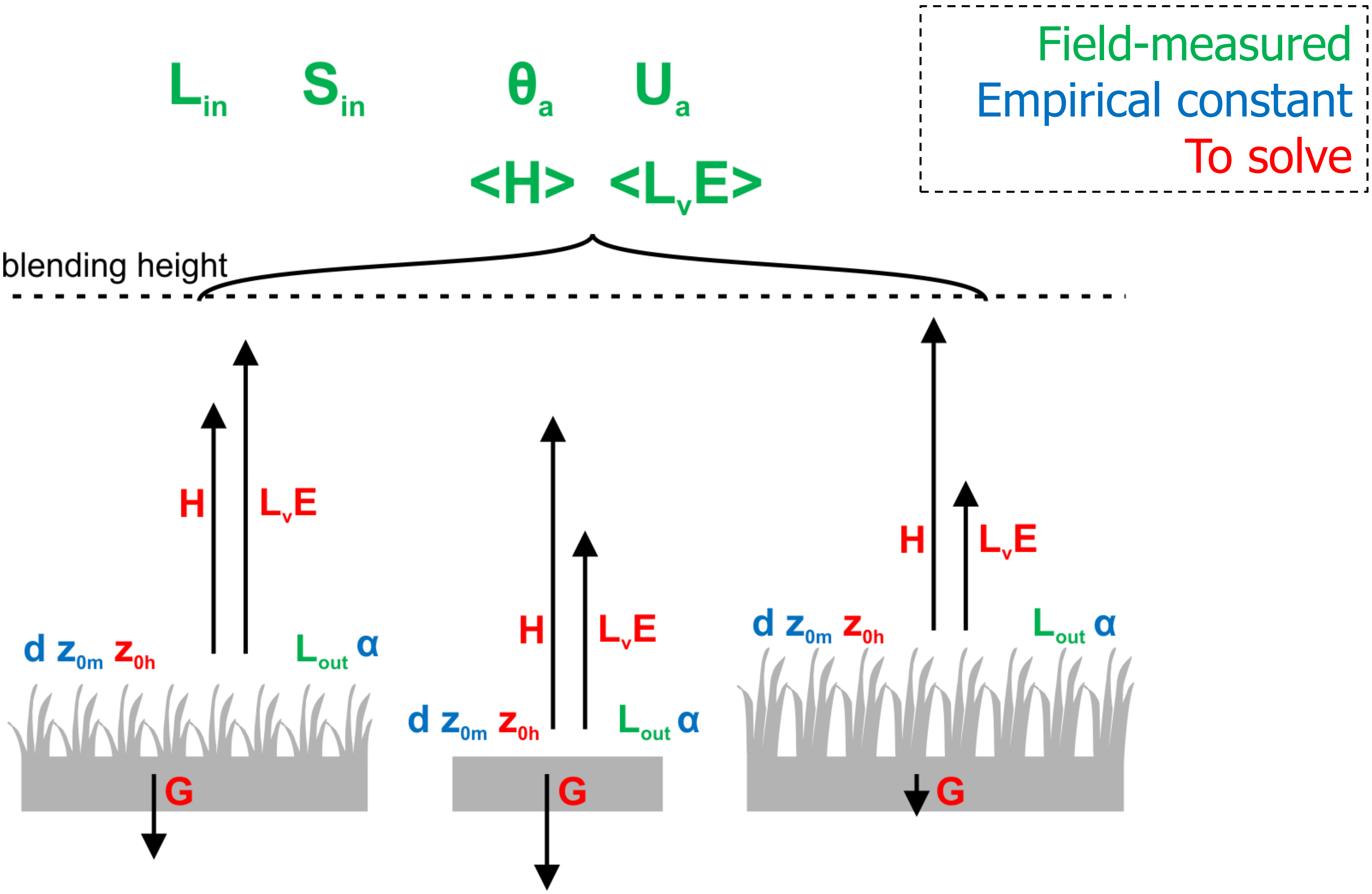
GOAL: Estimate field scale flux estimates from an area-integrated flux method (scintillometry) using a disaggregation technique (ScinDi)

Scintillometer method – area averaged fluxes at multi-km scale



km spatial scale

Schematic of ScinDi



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$L_{out} \leftrightarrow \theta_s$

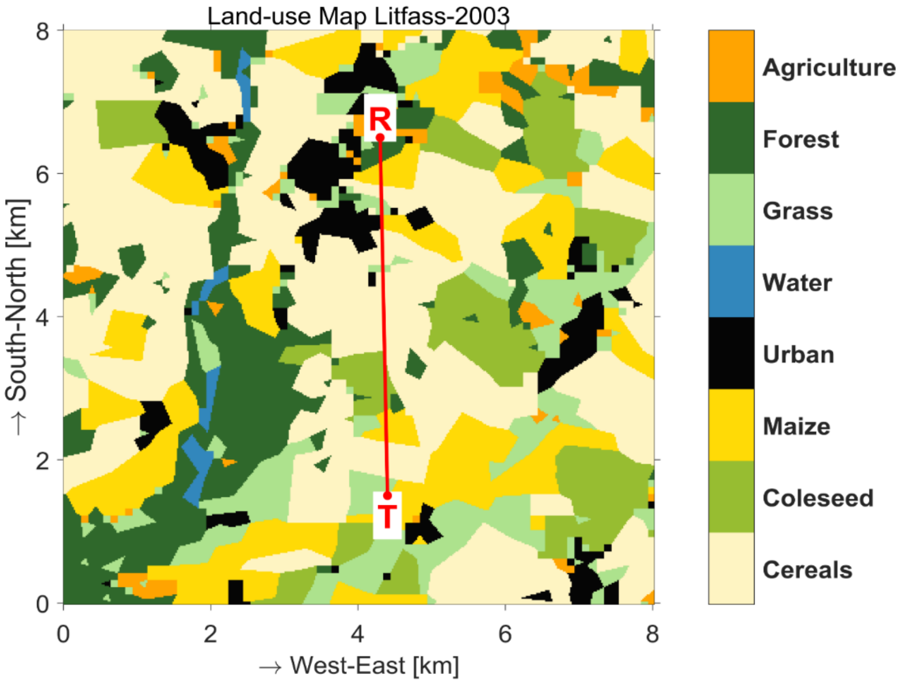
Data: Litfass-2003 Experiment

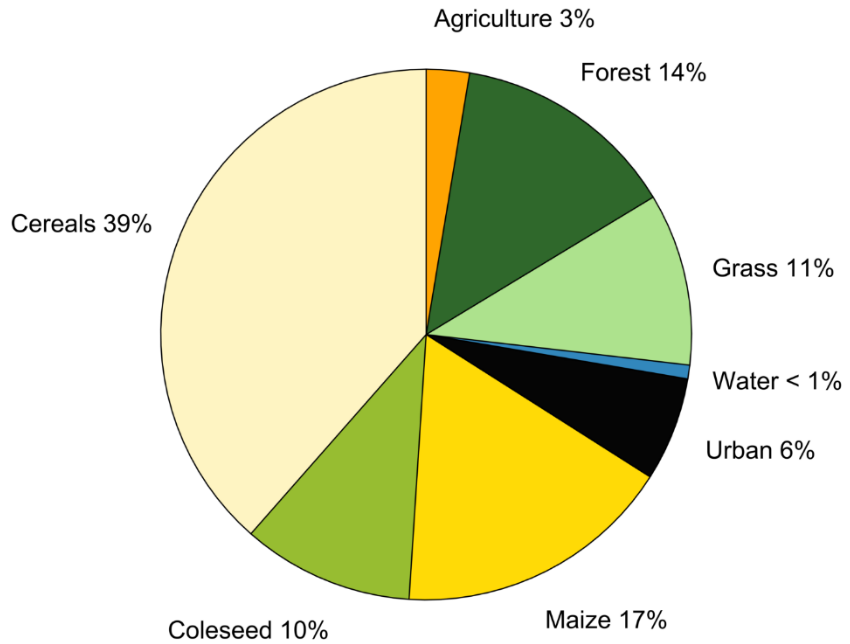
Meteorologisches Observatorium Lindenberg – Deutscher Wetterdienst

Data: Litfass-2003 Experiment

EB measurements over all (representative) land-uses in the domain

Data: Verified LandUse map





LU fractions, f_i, over whole domain

i → index of LU type

Assumption: All LU-types behave the same across the LU-map

ScinDi Method

Measured variable
Empirical constant
To solve

H, similarity theory

$$H_i = -\rho c_p \frac{\theta_a - \theta_{s,i}}{r_{ah,i}(z, z_{0m,i}, z_{0h,i}, U_a, L_{mo,i})}$$

Forest: $z_{0h,i} = 0.1\ z_{0m,i}$

Other: $z_{0h,i} = z_{0m,i} \exp\left(-0.1\ Re_i^{0.5}\right)$

L_vE, energy budget

$$L_vE_i = R_{n,i} - G_i - H_i - NCT_i$$

$$R_{n,i} \equiv S_{in}(1 - \alpha_i) + L_{in} - L_{out,i}$$

$$G_i = f_G R_{n,i}$$

$$NCT_i = f_{NCT} R_{n,i}$$

Optimisation, tile aggregation

$$< H > - \sum f_i H_i = 0$$

$$< L_vE > - \sum f_i L_vE_i = 0$$

ScinDi Method: Reference → No optimisation

Measured variable
Empirical constant
To solve

H, similarity theory

$$H_i = -\rho c_p \frac{\theta_a - \theta_{s,i}}{r_{ah,i}(z, z_{0m,i}, z_{0h,i}, U_a, L_{mo,i})}$$

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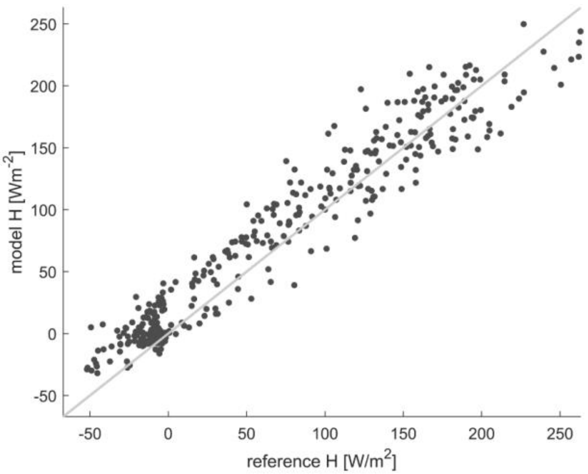
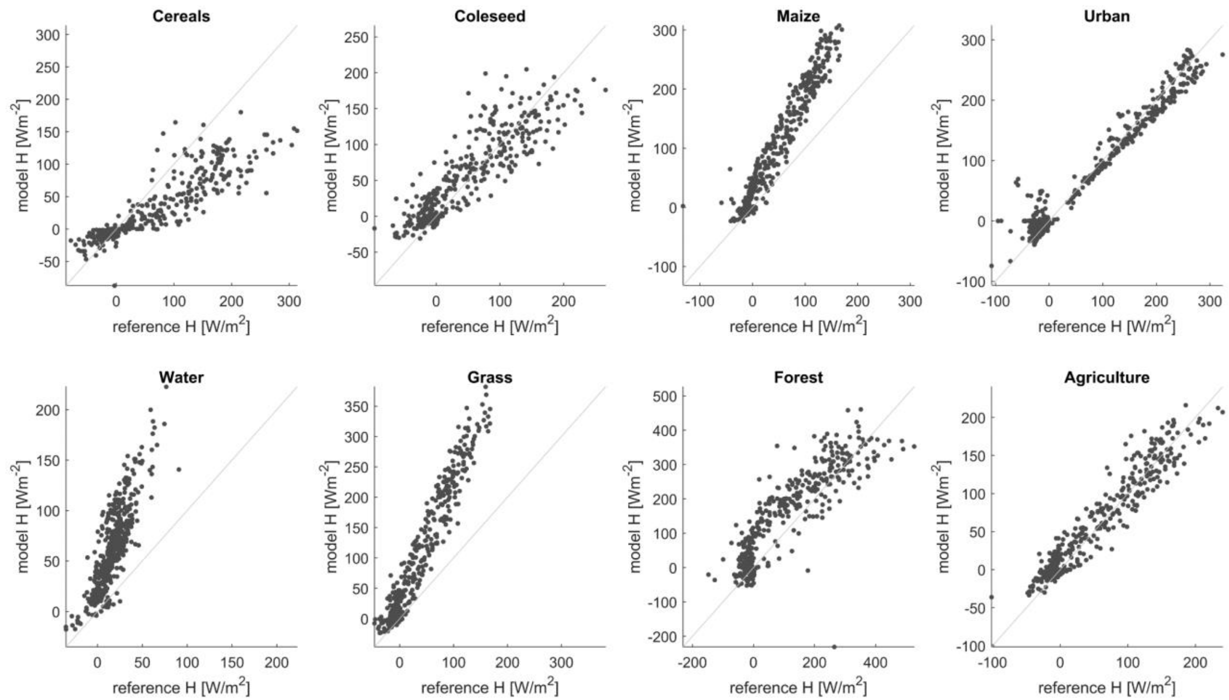
H – sensible heatflux

Domain scale

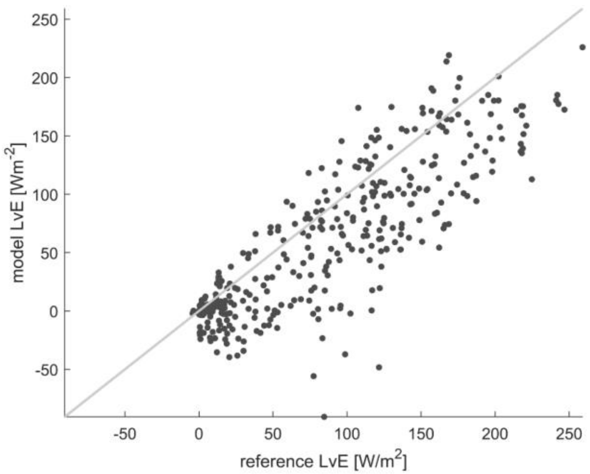


Individual fields (tiles)

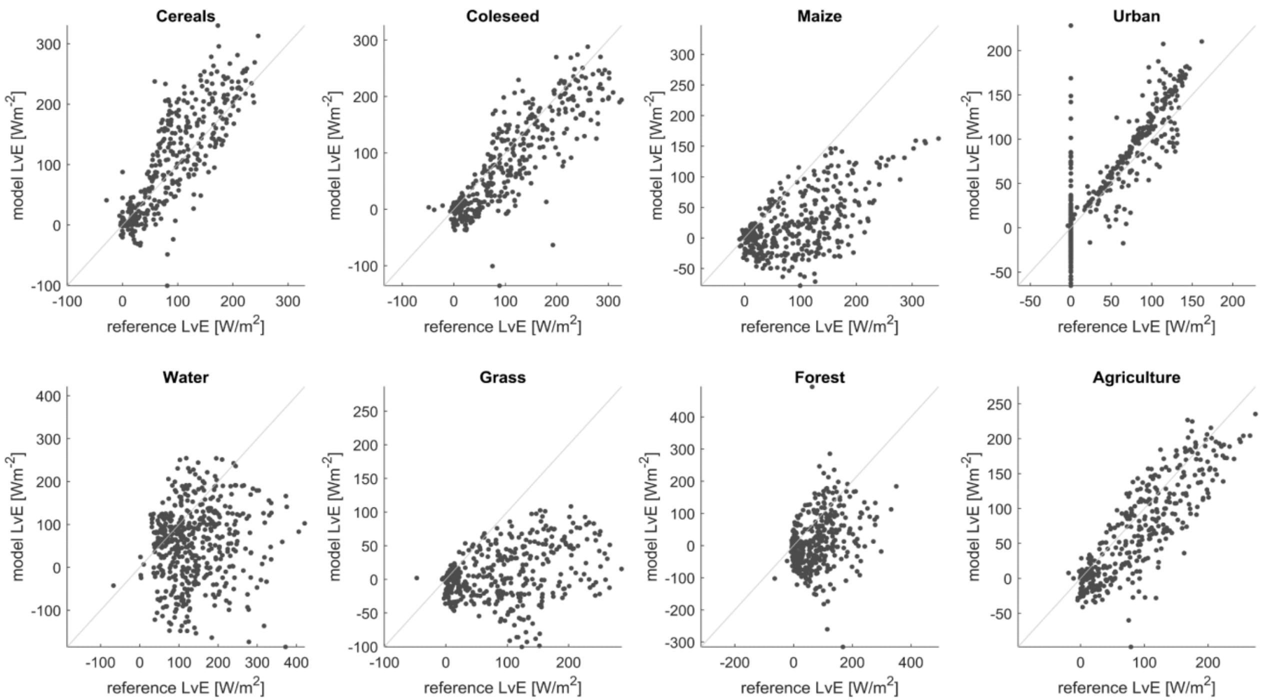


L_vE – latent heatflux

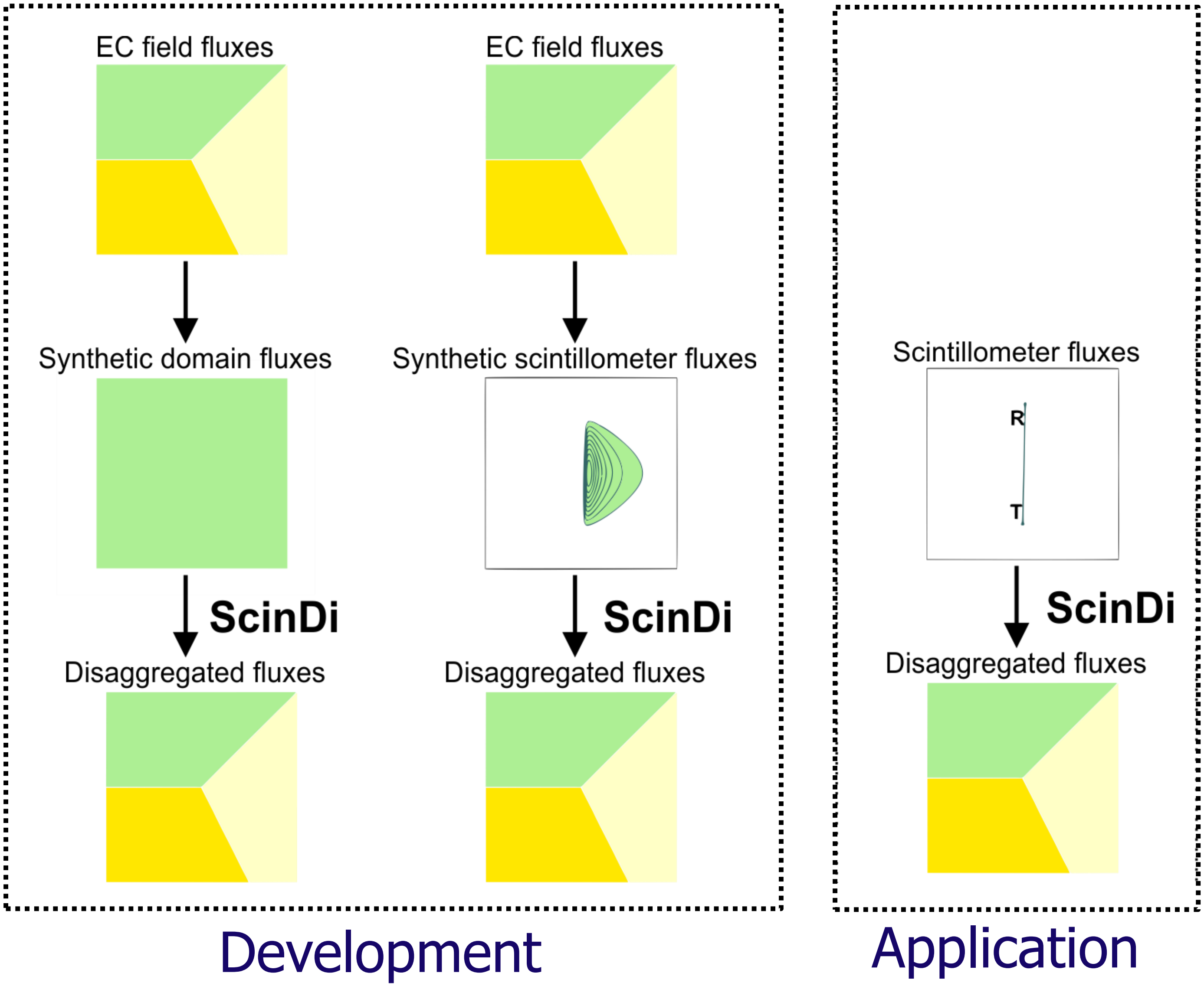
Domain scale



Individual fields (tiles)



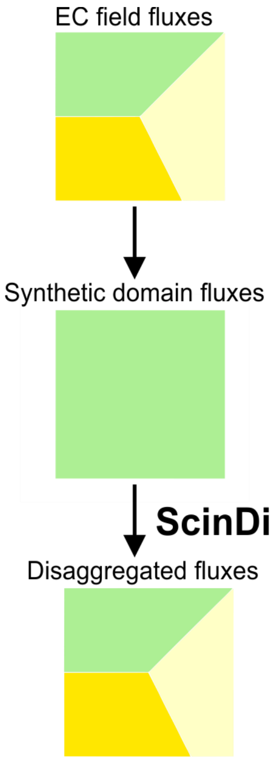
Strategy



EC field fluxes
EC field fluxes
Synthetic domain fluxes
Synthetic scintillometer fluxes
ScinDi
ScinDi
Disaggregated fluxes
Disaggregated fluxes
Scintillometer fluxes
R
T
ScinDi
Disaggregated fluxes
Development
Application

Model Development - I

Domain fluxes from EC measurements



ScinDi Method – Optimisation1

Measured variable
Empirical constant
To solve
To be optimised

H, similarity theory

$$H_i = -\rho c_p \frac{\theta_a - \theta_{s,i}}{r_{ah,i}(z, z_{0m,i}, z_{0h,i}, U_a, L_{mo,i})}$$

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$$R_{n,i} \equiv S_{in}(1 - \alpha_i) + L_{in} - L_{out,i}$$

$$G_i = f_G R_{n,i}$$

$$NCT_i = f_{NCT} R_{n,i}$$

Optimisation, tile aggregation

$$H'_i = a_i H_i$$

$$LvE'_i = b_i LvE_i$$

$$< H > - \sum f_i H'_i = 0$$

$$< L_vE > - \sum f_i L_vE'_i = 0$$

ScinDi Method – Optimisation2

Measured variable
Empirical constant
To solve
To be optimised

H, similarity theory

$$H_i = -\rho c_p \frac{\theta_a - \theta_{s,i}}{r_{ah,i}(z, z_{0m,i}, z_{0h,i}, U_a, L_{mo,i})}$$

~~Forest: $z_{0h,i} = 0.1\ z_{0m,i}$~~

~~Other: $z_{0h,i} = z_{0m,i} \exp(-0.1\ Re_i^{0.5})$~~

L_vE, energy budget

$$L_vE_i = R_{n,i} - G_i - H_i - NCT'_i$$

$$R_{n,i} \equiv S_{in}(1 - \alpha_i) + L_{in} - L_{out,i}$$

$$G_i = f_G R_{n,i}$$

$$NCT_i = f_{NCT} R_{n,i}$$

Optimisation, tile aggregation

$$z_{0h,i} = z_{0m,i} \exp(a_i\ Re_i^{0.5} + b_i)$$

$$NCT'_i = c_i\ NCT_i$$

$$< H > - \sum f_i H'_i = 0$$

$$< L_vE > - \sum f_i L_vE'_i = 0$$

ScinDi Method – Optimisation3

Measured variable
Empirical constant
To solve
To be optimised

H, similarity theory

$$H_i = -\rho c_p \frac{\theta_a - \theta_{s,i}}{r_{ah,i}(z, z_{0m,i}, z_{0h,i}, U_a, L_{mo,i})}$$

~~Forest: $z_{0h,i} = 0.1\, z_{0m,i}$~~

~~Other: $z_{0h,i} = z_{0m,i} \exp(-0.1\, Re_i^{0.5})$~~

L_vE, energy budget

$$L_vE_i = R_{n,i} - G_i - H_i - NCT'_i$$

$$R_{n,i} \equiv S_{in}(1 - \alpha_i) + L_{in} - L_{out,i}$$

$$G_i = f_G R_{n,i}$$

$$NCT_i = f_{NCT} R_{n,i}$$

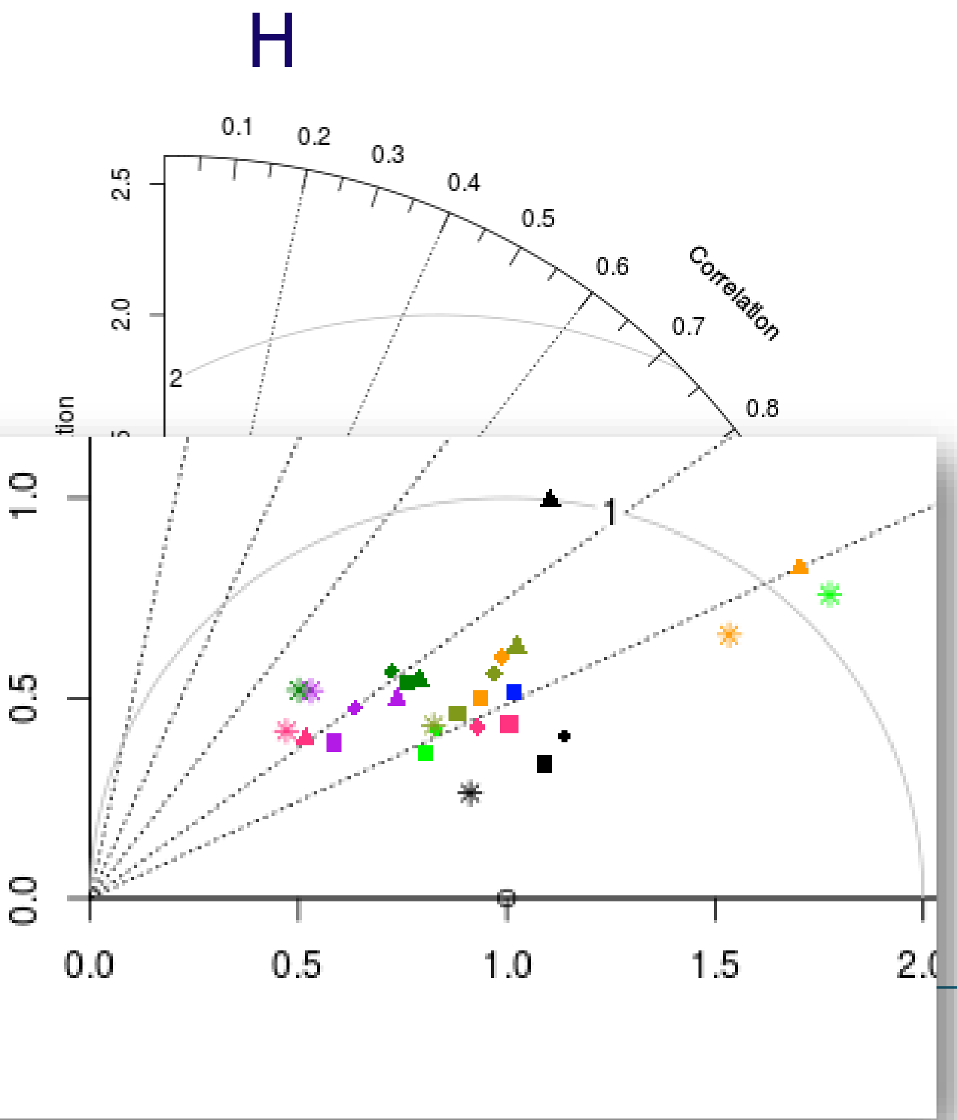
Optimisation, tile aggregation

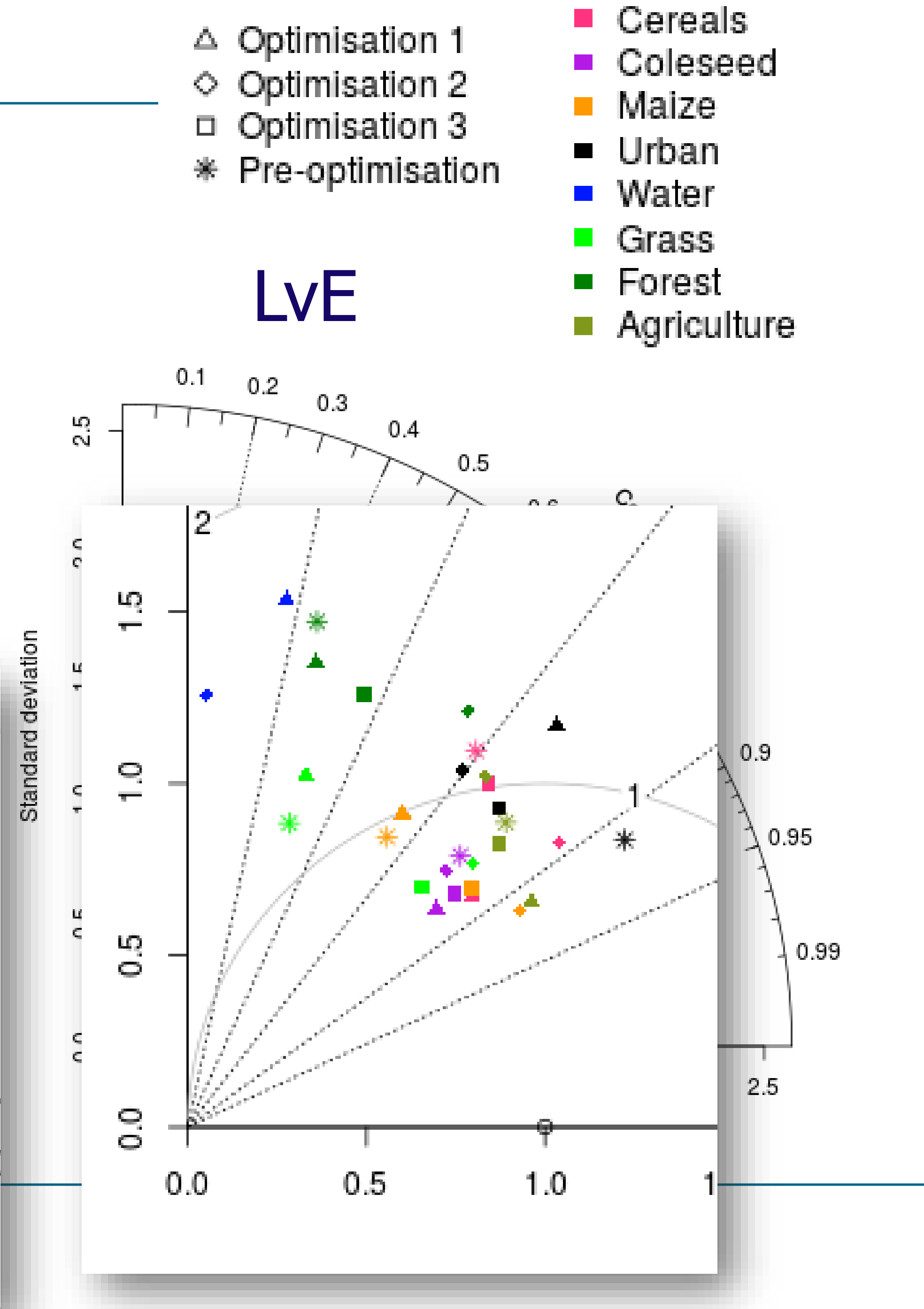
$$z_{0h,i} = z_{0m,i} \exp(a_i\, Re_i^{0.5} + b_i)$$

$$< H > - \sum f_i H'_i = 0$$

~~$< L_vE > - \sum f_i L_vE'_i = 0$~~

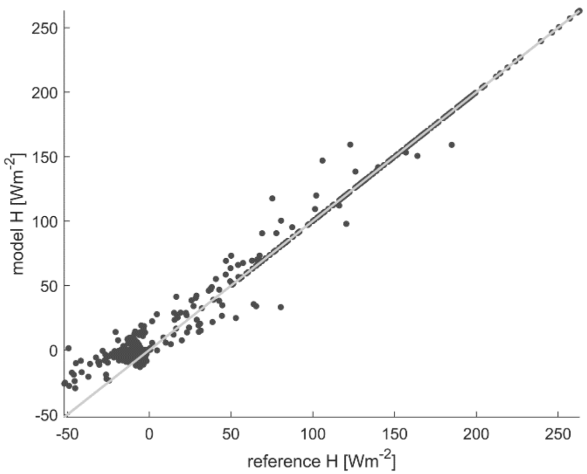
ScinDi Method – Results



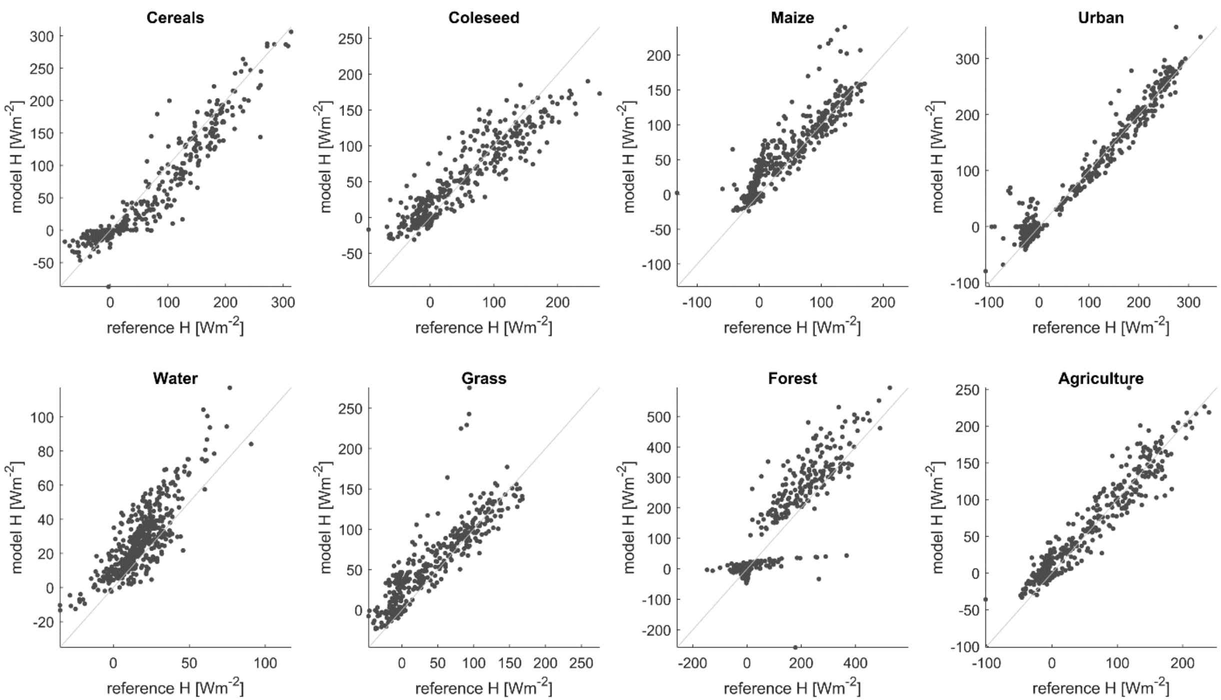


H – sensible heatflux

Domain scale

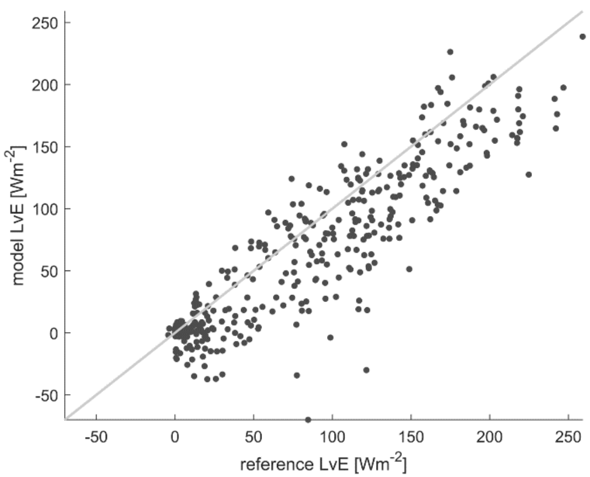


Individual fields (tiles)

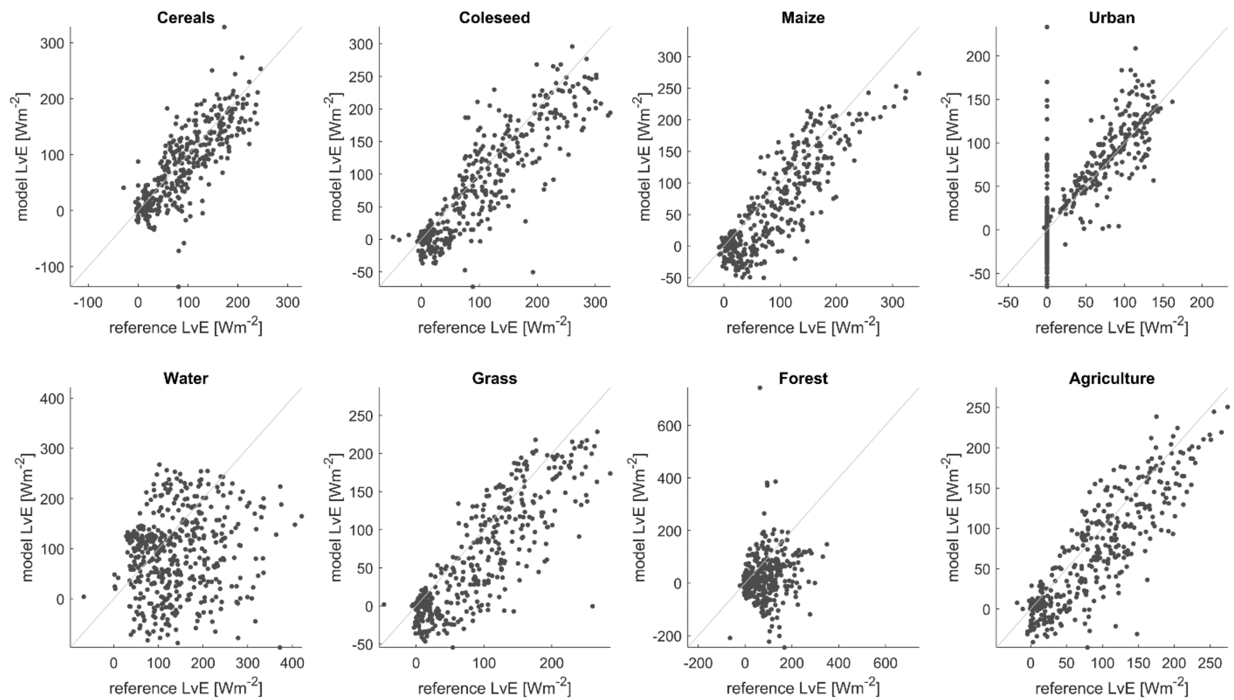


L_vE – latent heatflux

Domain scale

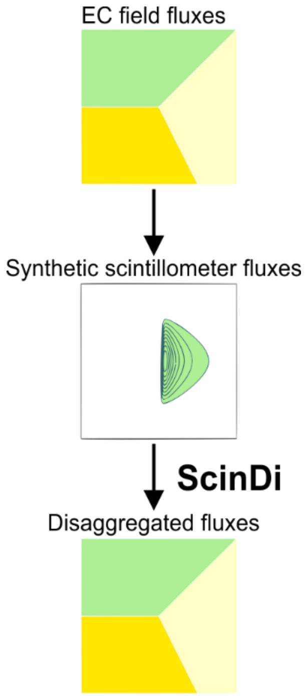


Individual fields (tiles)



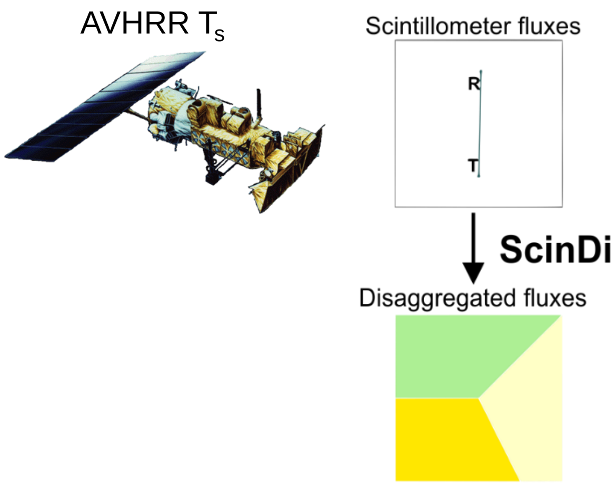
Model Development - II

Scintillometer footprint fluxes from EC measurements

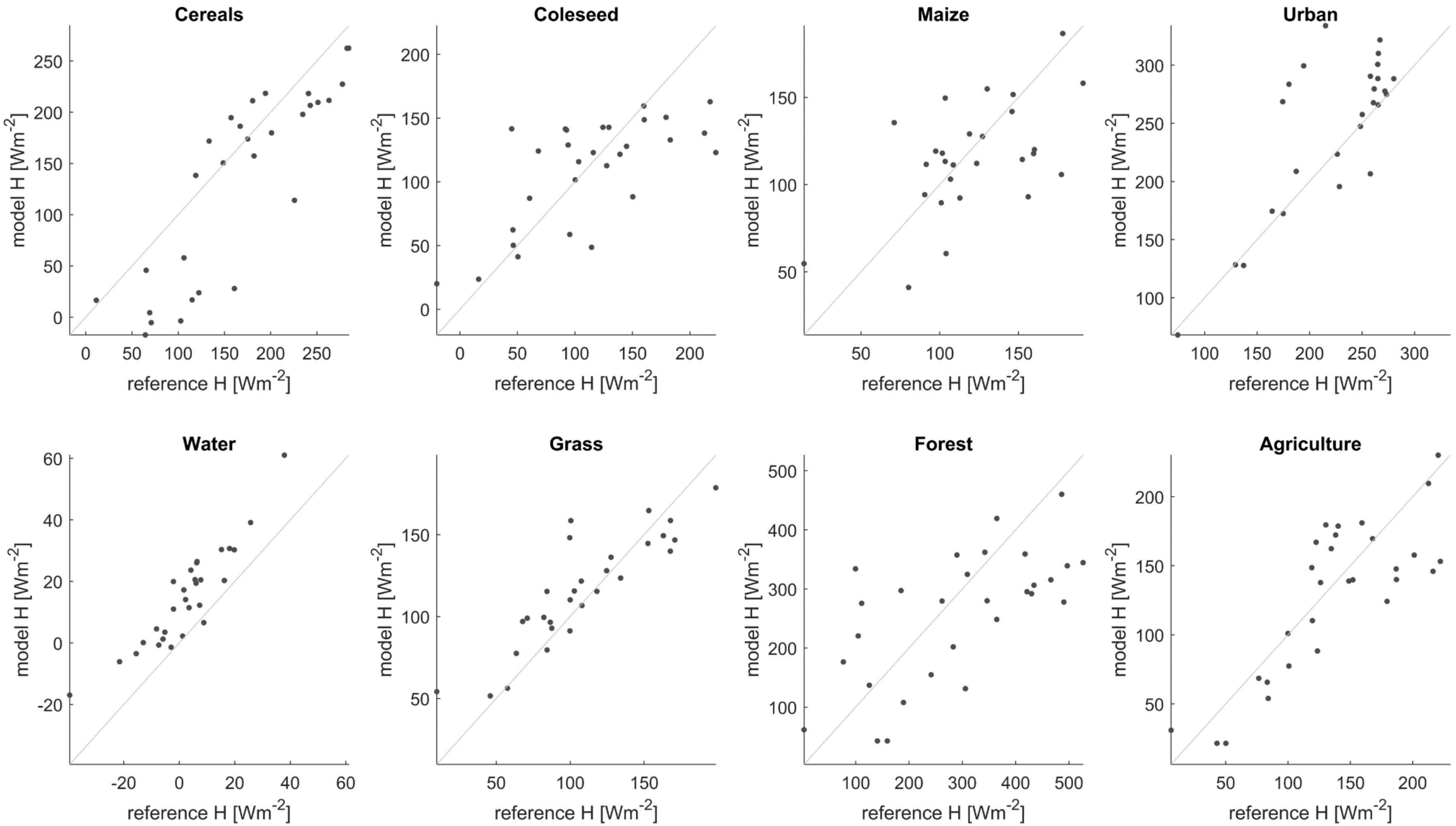


Model Application

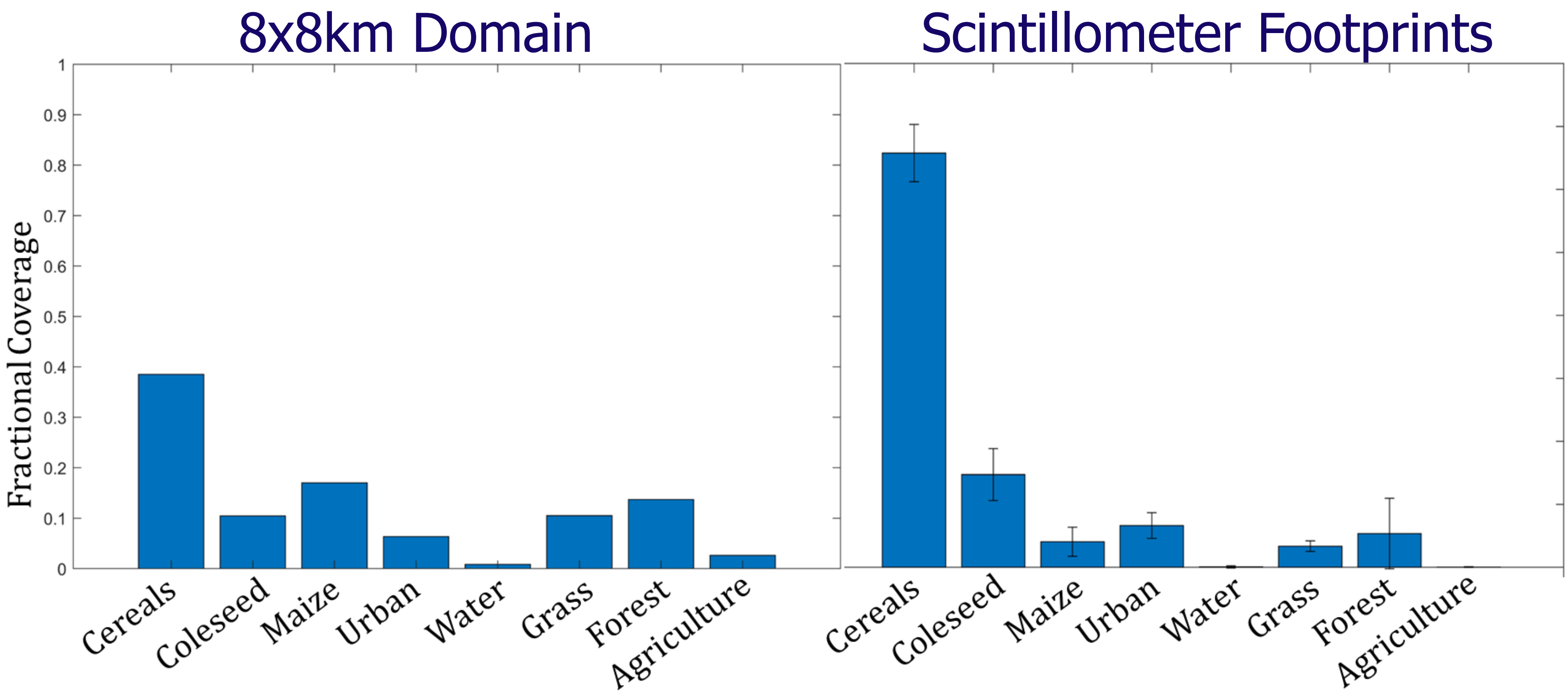
- Direct Scintillometer fluxes
- NOAA polar orbiting satellite AVHRR:
  - One value per day ~midday
  - Cloud obscured are filtered
  - From T_s-map to one T_s per LU-type



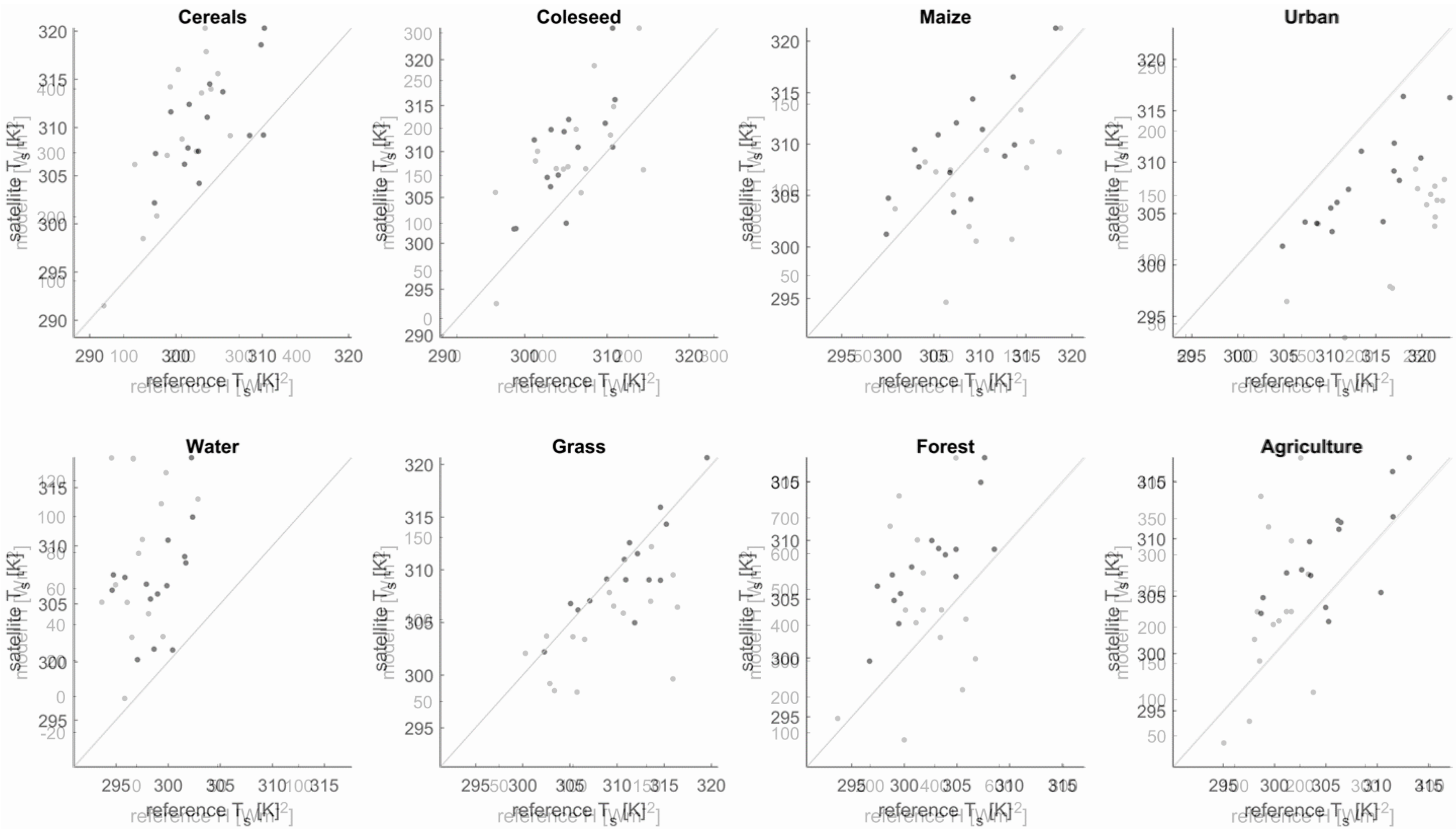
ScinDi Application: scintillometer fluxes



Scintillometer Footprint Fractional Coverage



ScinDi Application: scintillometer fluxes & AVHRR T_s



Conclusions - Discussion

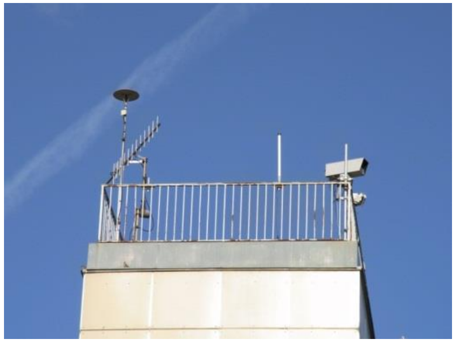
In short:

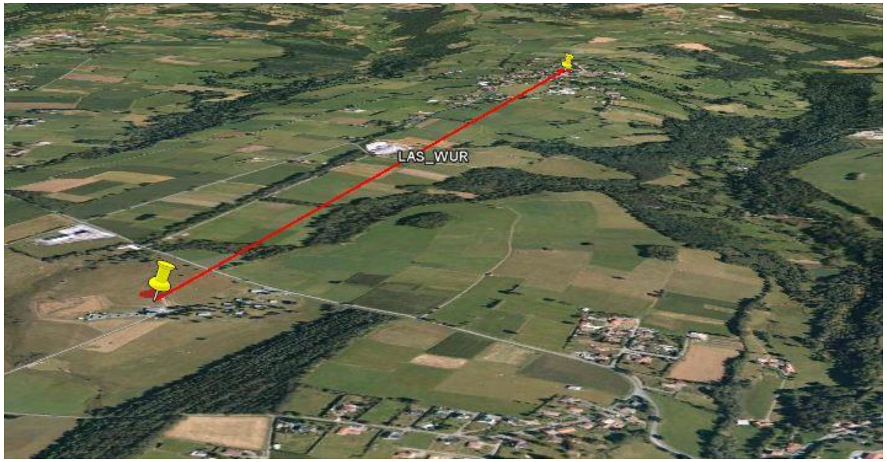
- ScinDi approach OK for H
- ScinDi approach poor (in terms of scatter) for LvE

Outlook:

- Include T_s products at higher temporal (MSG, 15min) and/or spatial (LANDSAT, 30m) resolution
- Create flux-maps based on this method
- We can do this for BLLAST as well!

BLLAST - LAS

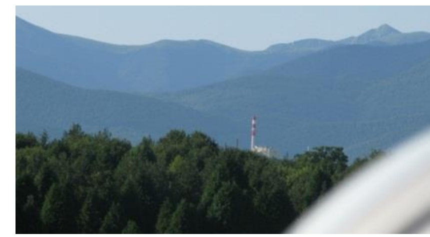




LAS	
Operated by	WUR-MAQ
Manufacturer	WUR-MAQ
D	0.15m
λ	940nm
Phys Variable	C_n^2
Turbulent Flux	H

Set-up			
	Location	**Z (a.s.l.)**	**L**
Transmitter	CRA	11.4m	2687m
Receiver	Church Campistrous	18.4	

BLLAST - XLAS



XLAS	
Operated by	Meteo France
Manufacturer	Kipp&Zn
D	0.30m
λ	880nm
Phys Variable	C_n^2
Turbulent Flux	H

Set-up			
	Location	**Z (a.s.l.)**	**L**
Transmitter	Knauf Factory	65m	3988m
Receiver	CRA	18m	

Thank you