Meso-scale models confronted with true landuse- and flux maps

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Wayne Angevine, Maria-Antonia Jimenez, Fleur Couvreux, …

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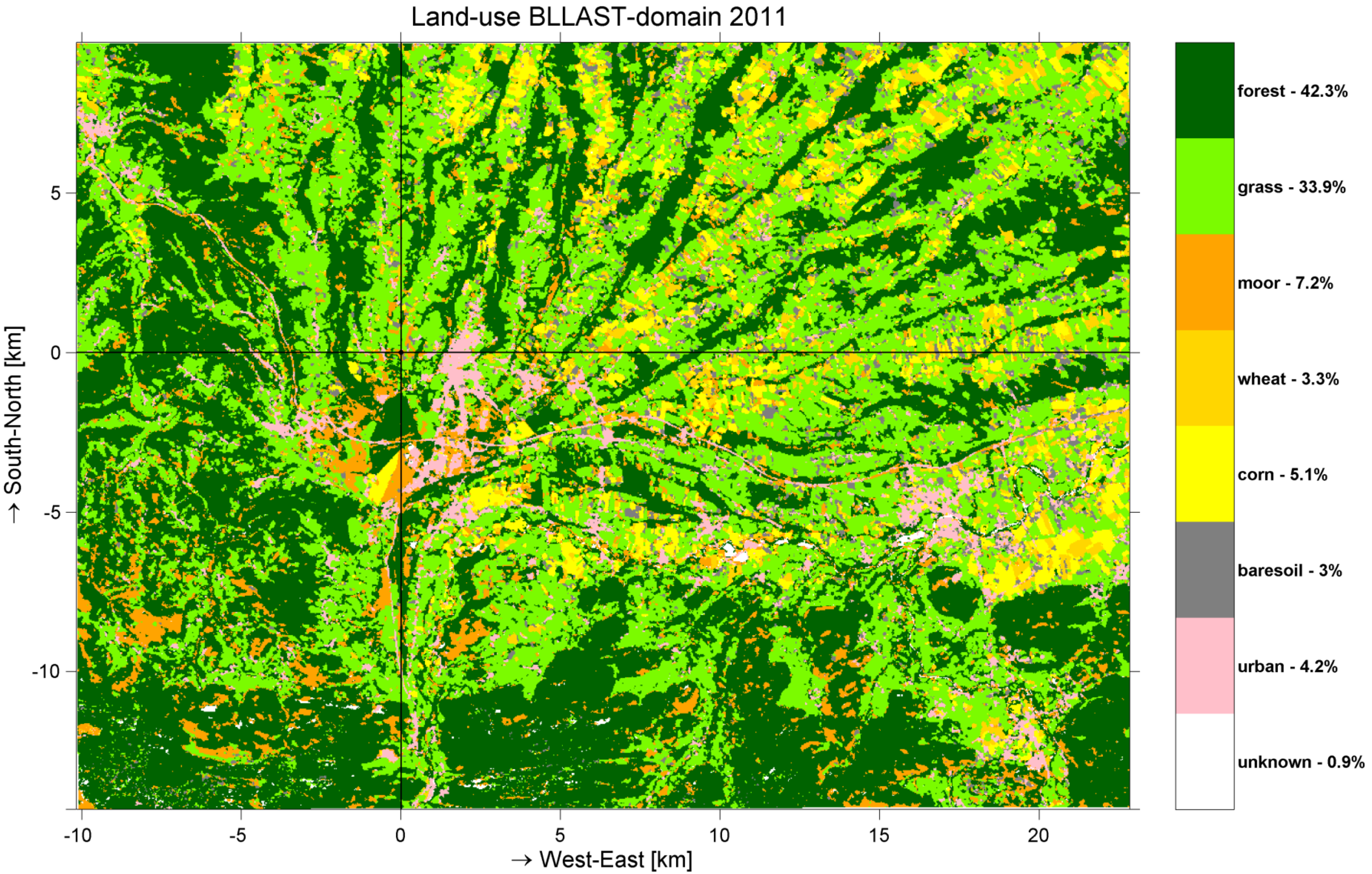
GOAL: Assess the impact of land-use definition on the model performance (scalar fluxes → $H + L_vE$)

- **Reference:**
  - Flux-maps based on measured fluxes and a detailed, verified LU-map (recap last workshop)

- **Confrontation reference ("truth") with models:**
  1. Compare true LU-map with model landuse-maps
  2. Compare true flux-maps with model flux-maps
  3. Flux maps based on model LU-model and measured fluxes

Simplified Land-use map - 30m resolution



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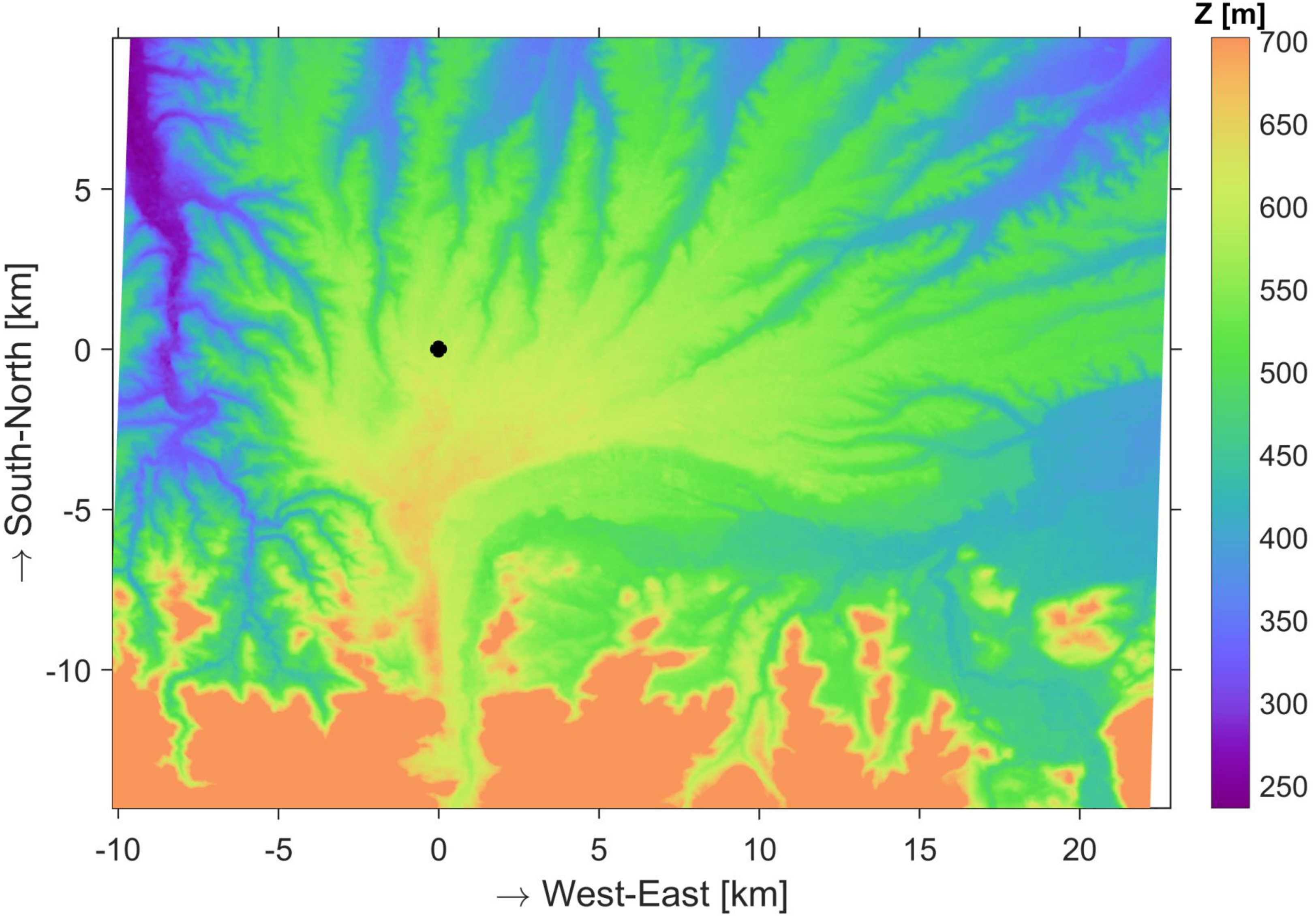
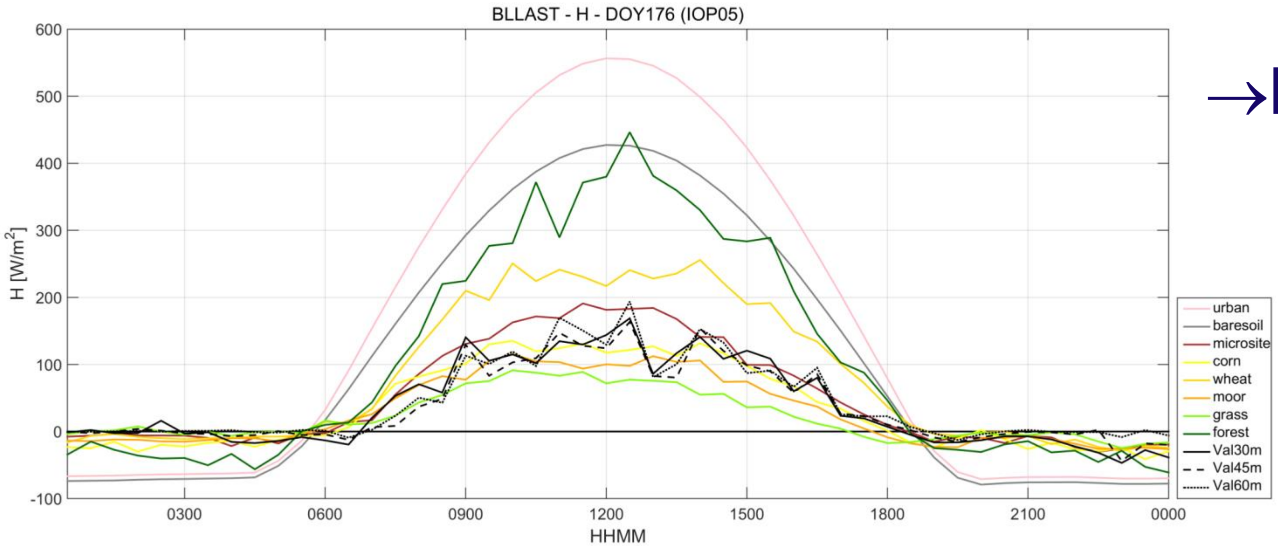
Digital Elevation Map

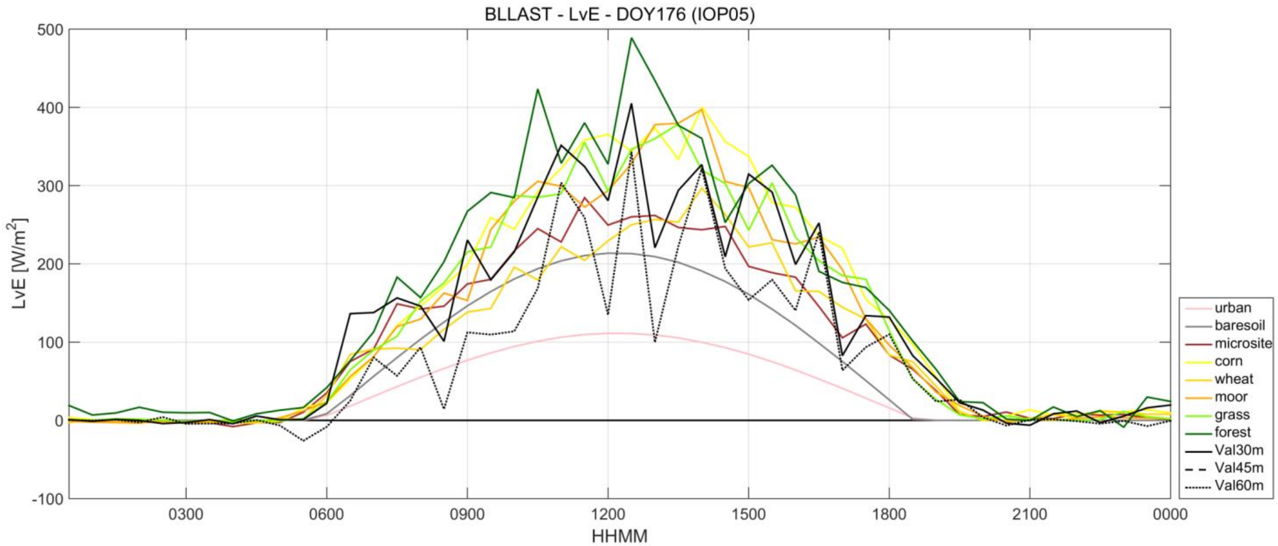


H and LvE fluxes for 25June2011 – DOY176 – IOP5



→H

LvE→



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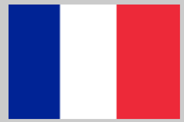
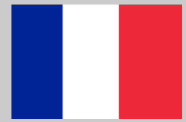
List of Assumptions:

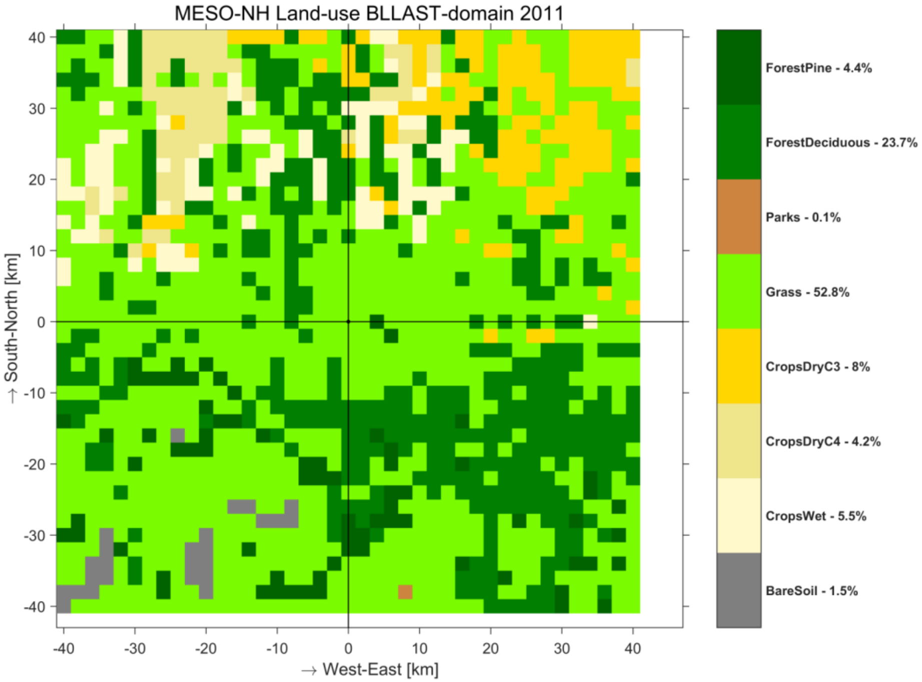
- Accuracy of the LU-map
- Measured fluxes cover only 1 vegetation type (uniform FP)
- **Measured fluxes representative for other surfaces with same/similar vegetation type**
  - Vegetation growing stage
  - Soil type and water content
  - Radiation and wind forcing
  - ...
- Simple EB-model to estimate Urban/Bare-soil fluxes
- **Topography not taken into account**
- ....

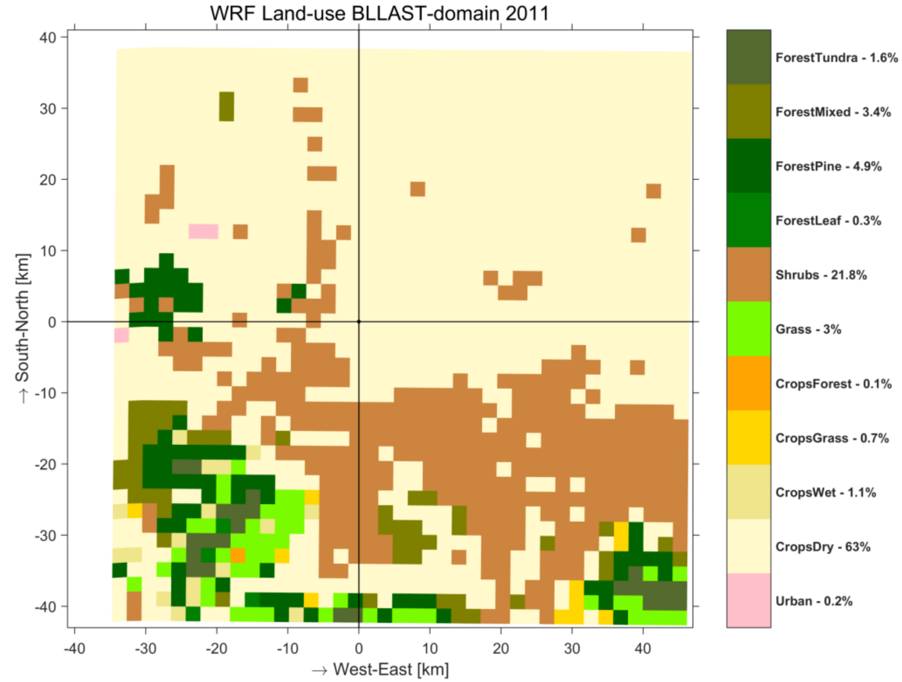
The Models

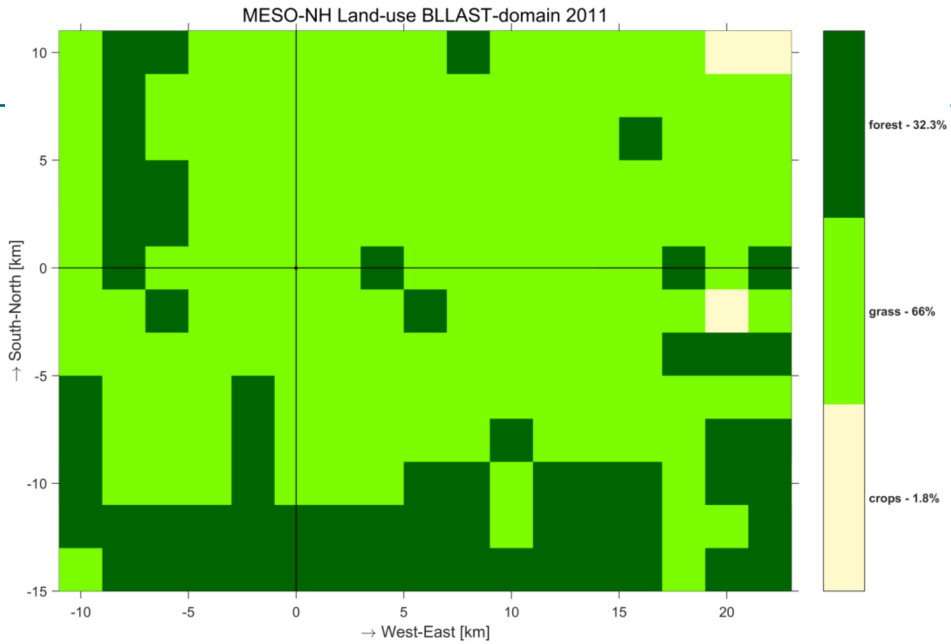
	AROME	MESO-NH	WRF
Origin			
Resolution	2.5km	2km	2km
Domain	225x225	120x120	99x99
LU-map	x	✓	✓
LU-classes/pixel	-	12	1

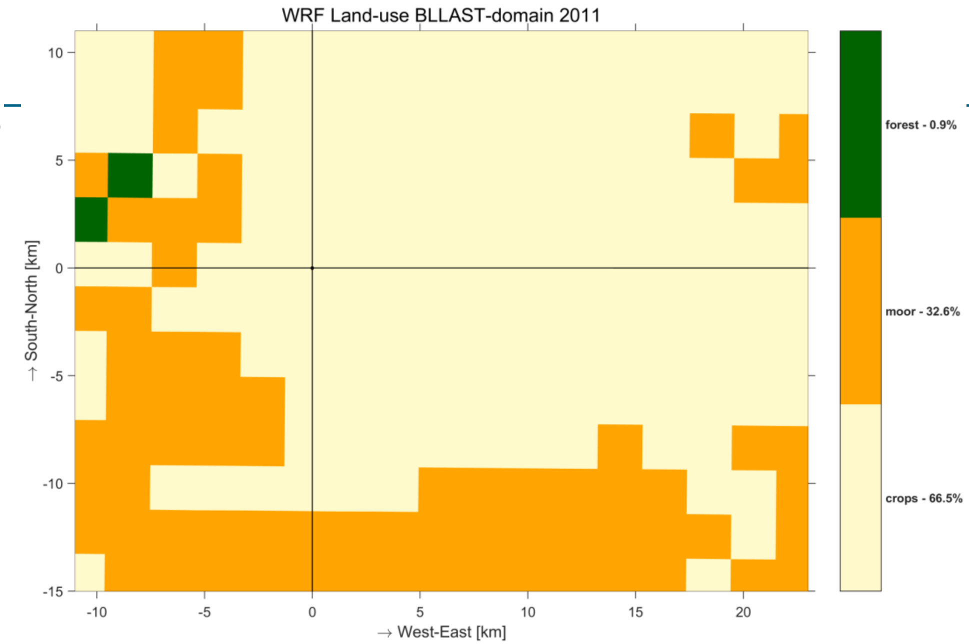
1. Compare true LU-map with model landuse-maps
2. Compare true flux-maps with model flux-maps
3. Flux maps based on model LU-model and measured fluxes

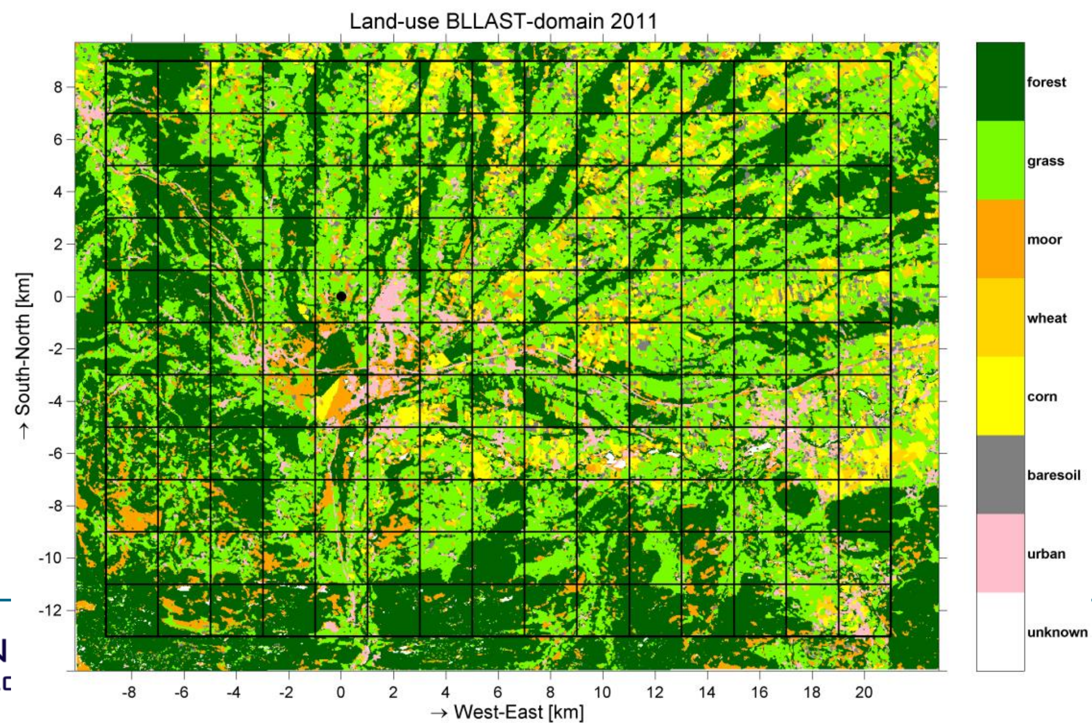
1. LU-maps models – 40x40km



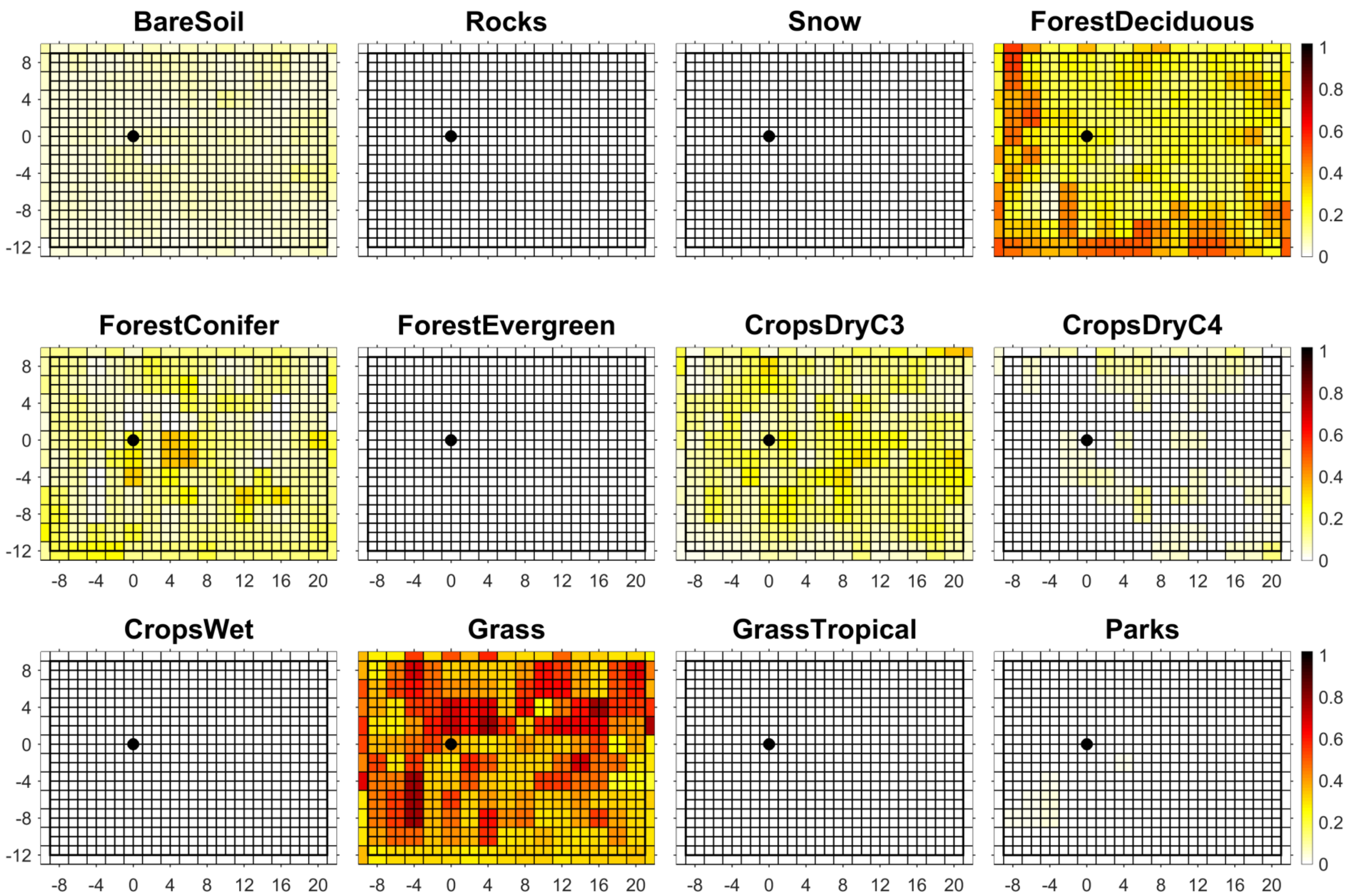



MESO-NH Land-use BLLAST-domain 2011
→ South-North [km]
→ West-East [km]
forest - 32.3%
grass - 66%
crops - 1.8%

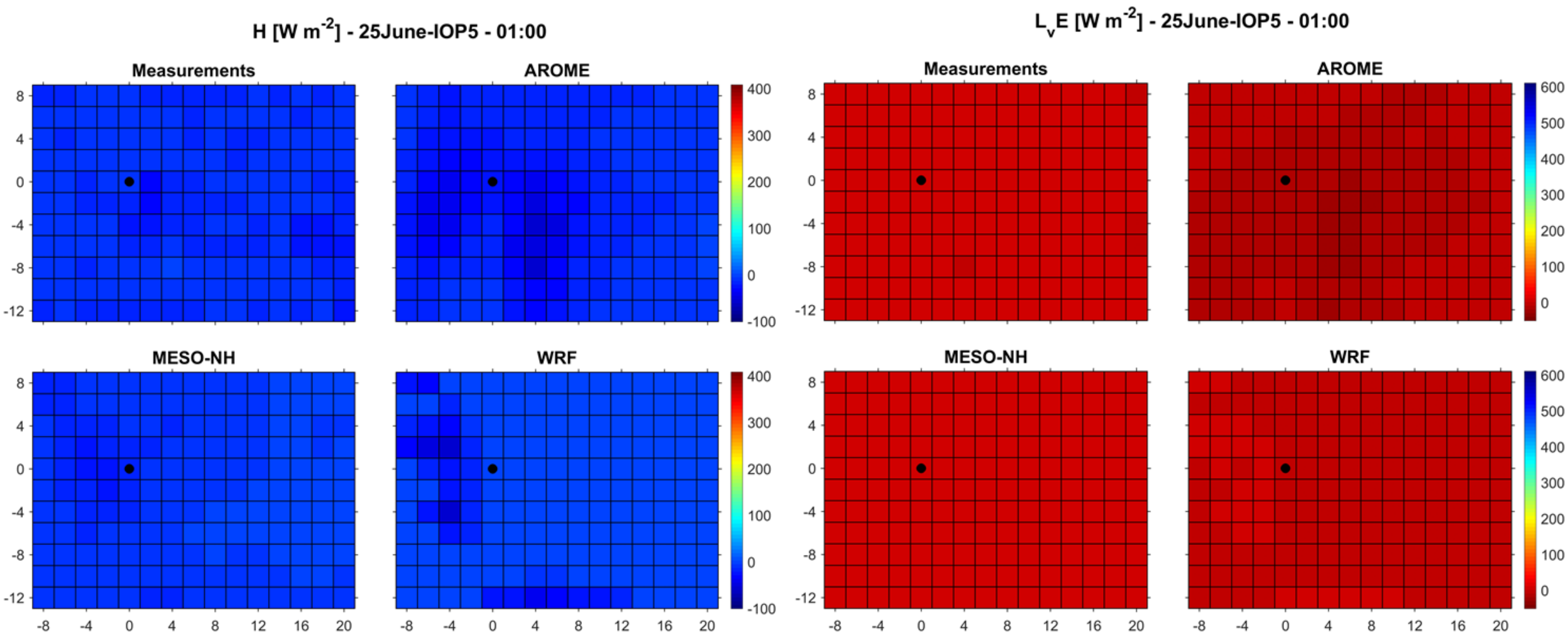

WRF Land-use BLLAST-domain 2011
→ South-North [km]
→ West-East [km]
forest - 0.9%
moor - 32.6%
crops - 66.5%


Land-use BLLAST-domain 2011
→ South-North [km]
→ West-East [km]
forest
grass
moor
wheat
corn
baresoil
urban
unknown

1. MESO-NH: 12 LU-classes with percentage contribution



2. FLUX-maps – 2km resolution



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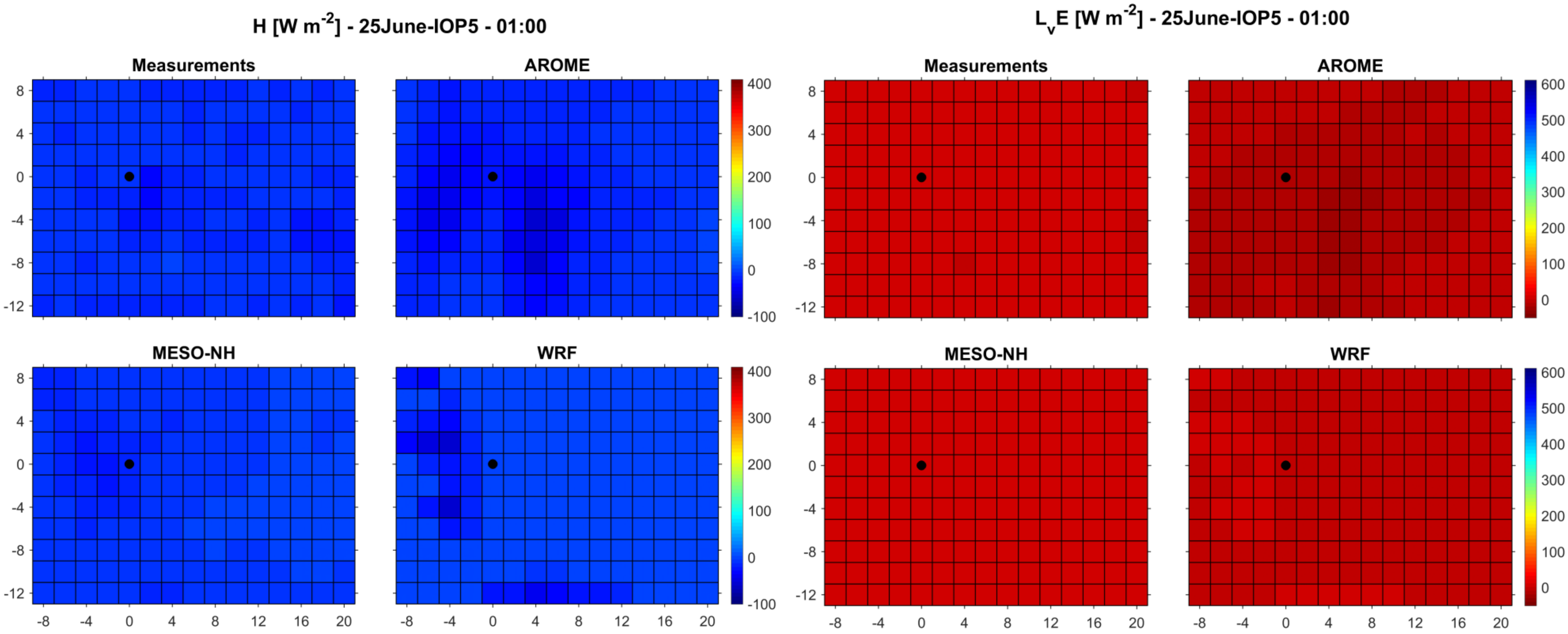
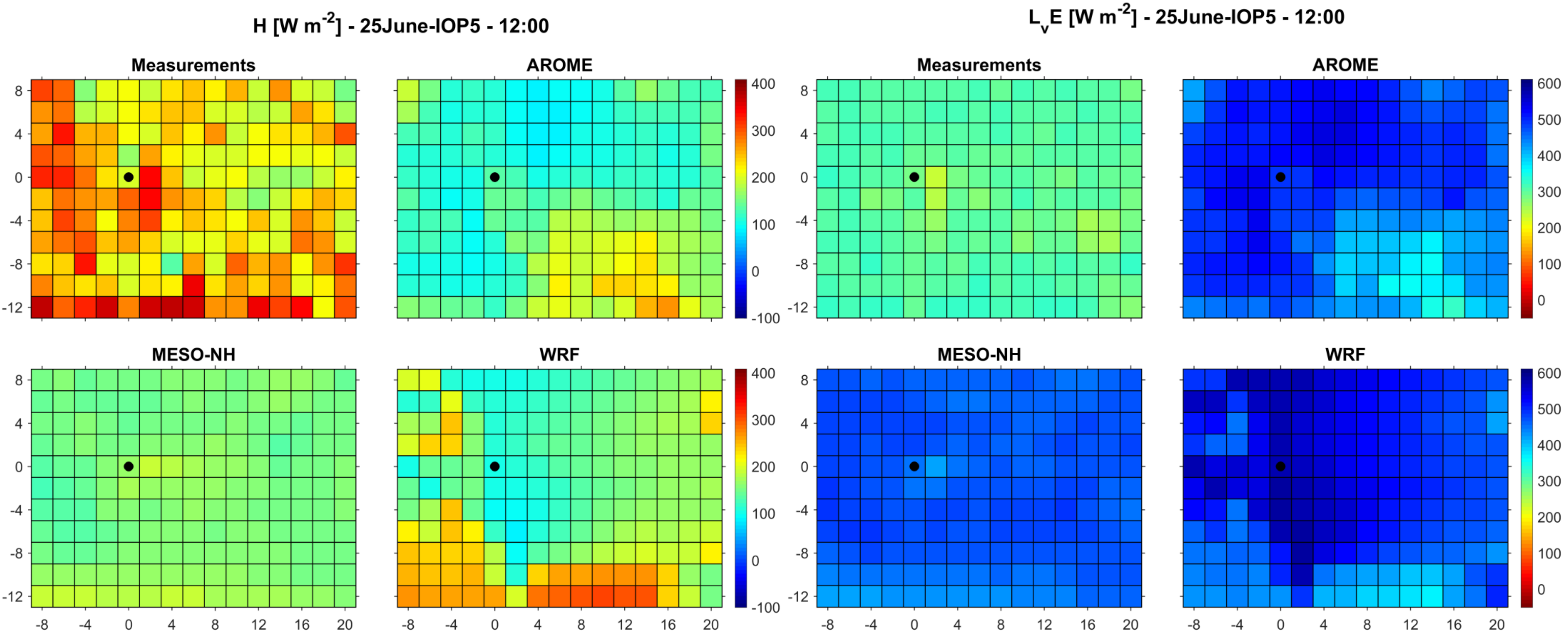
2. FLUX-maps – 2km resolution

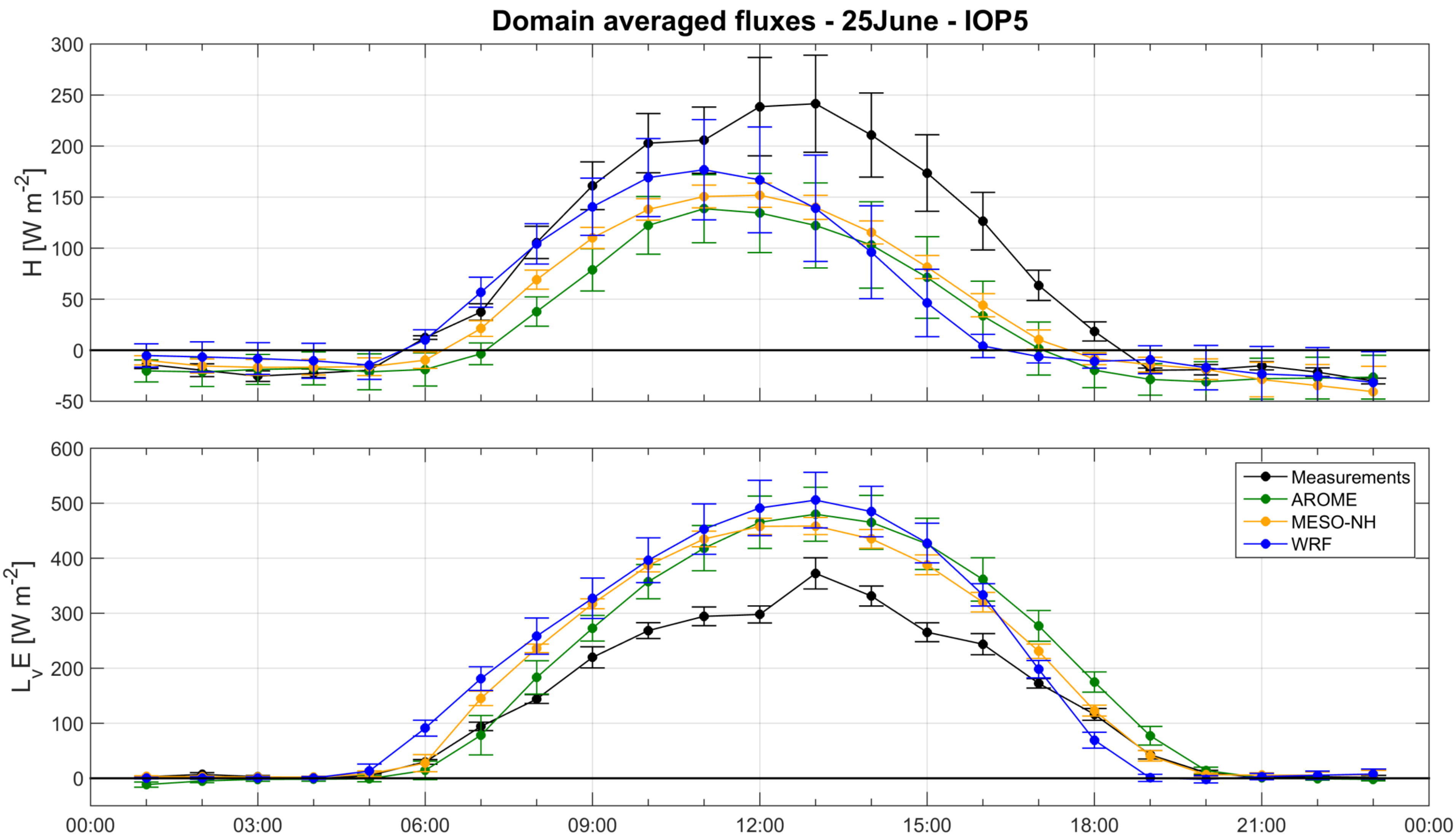


2. FLUX-maps – 2km resolution

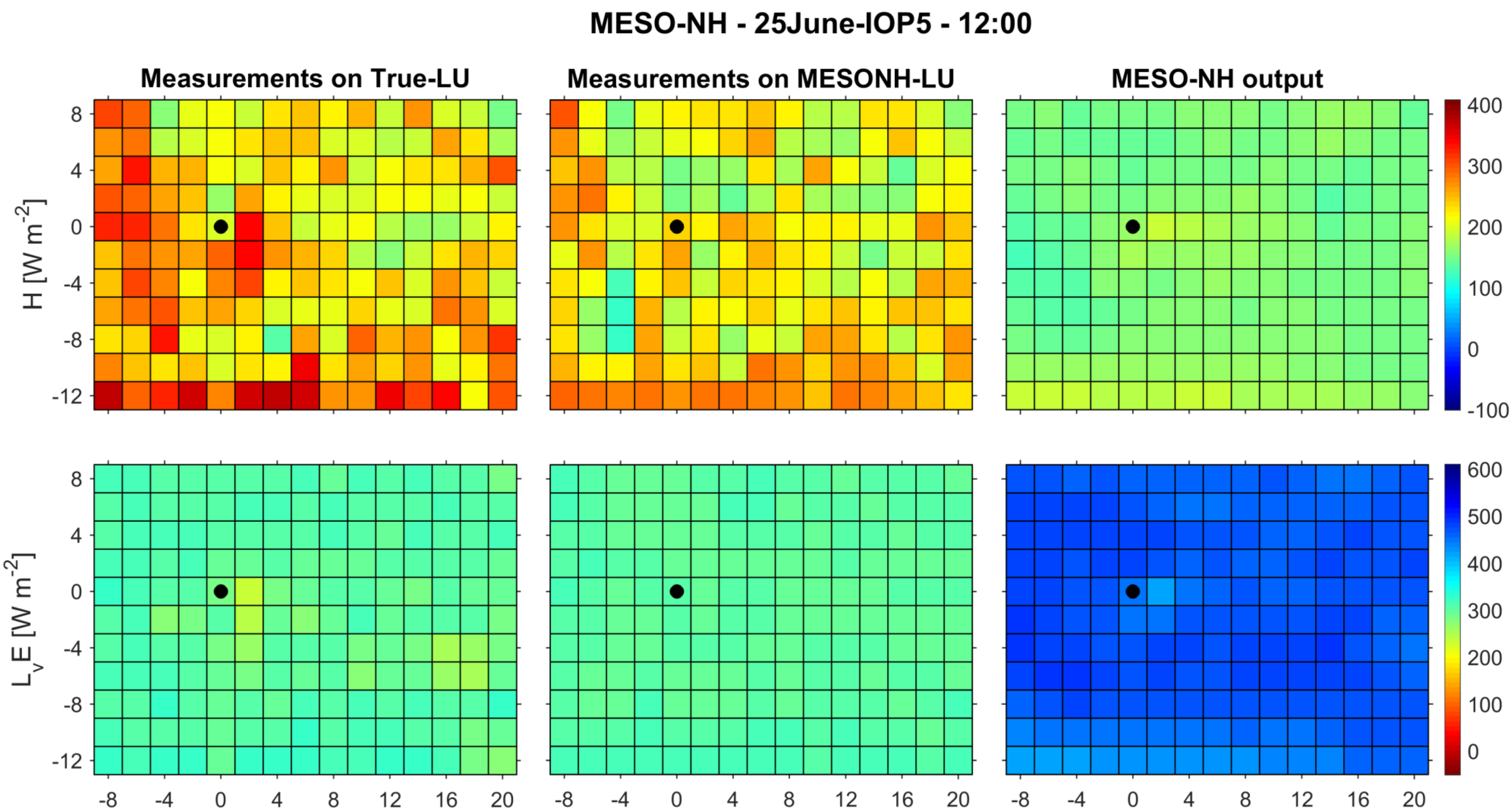


- All models: *H* too low and L_vE too high
- *H* more spatial variability than L_vE
- MESO-NH: least spatial variability
- WRF: most spatial variability

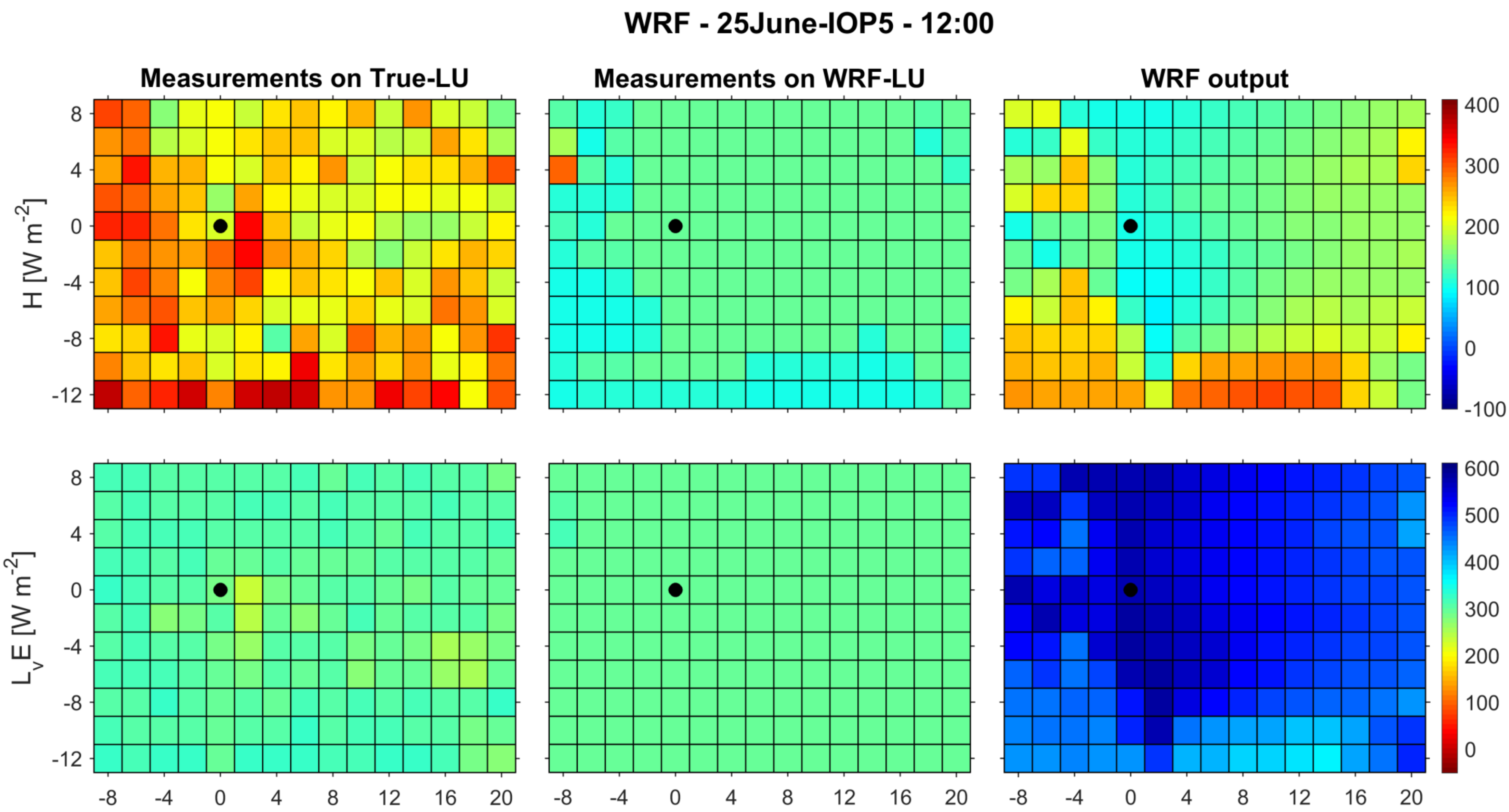
2. FLUX-timeseries from aggregated maps



3. FLUXmaps MESO-NH including **measured fluxes on model LU-map**



3. FLUXmaps WRF including **measured fluxes on model LU-map**



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Conclusions

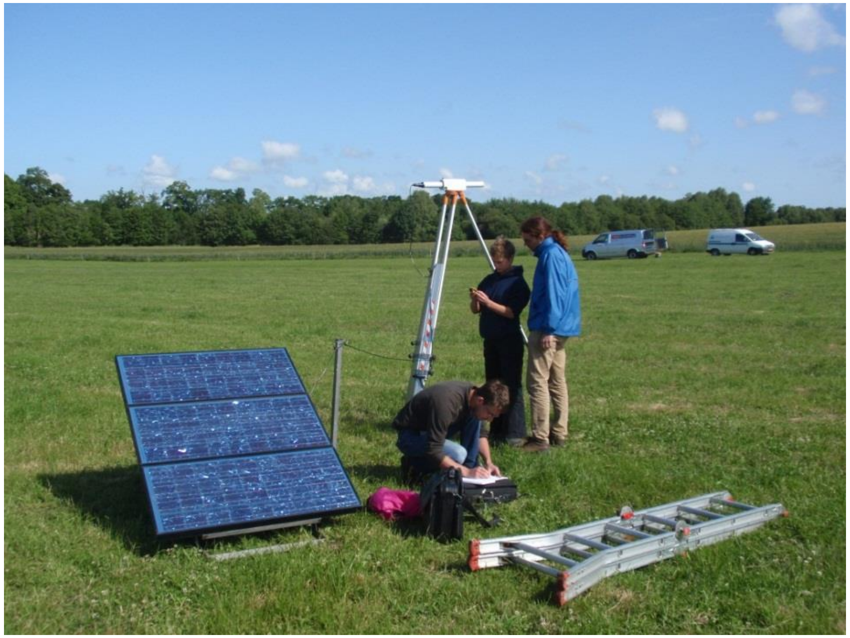
- Models agree better on fluxes than on the underlying LU-map
- Weak link LU-map and fluxes:
  - MESO-NH: detailed LU-map, smeared fluxes
  - WRF: coarse LU-map, detailed fluxes

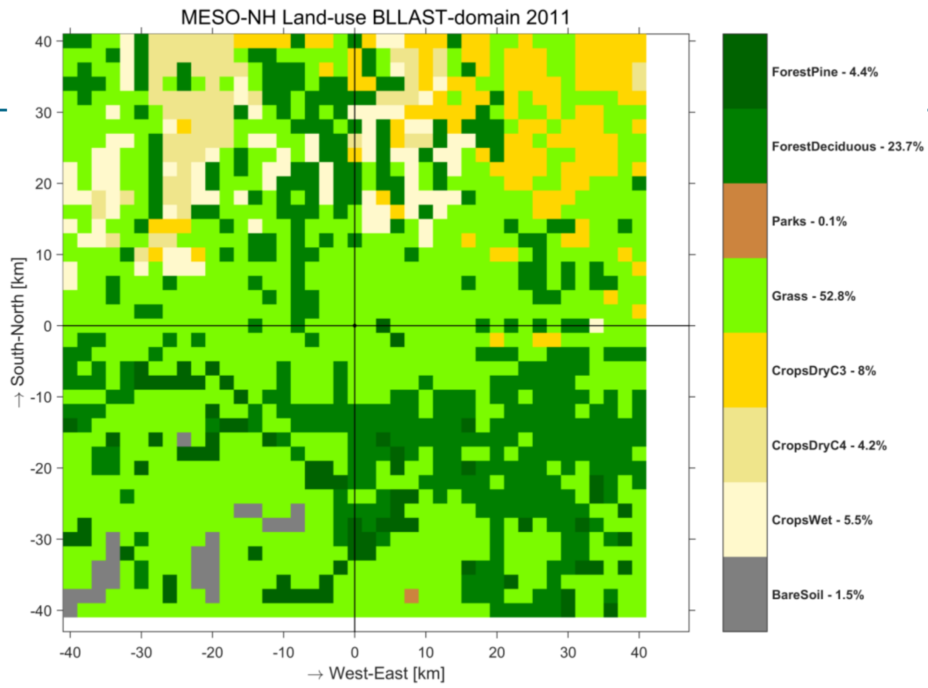
→ **Overall:** Model performance insensitive to LU-definition

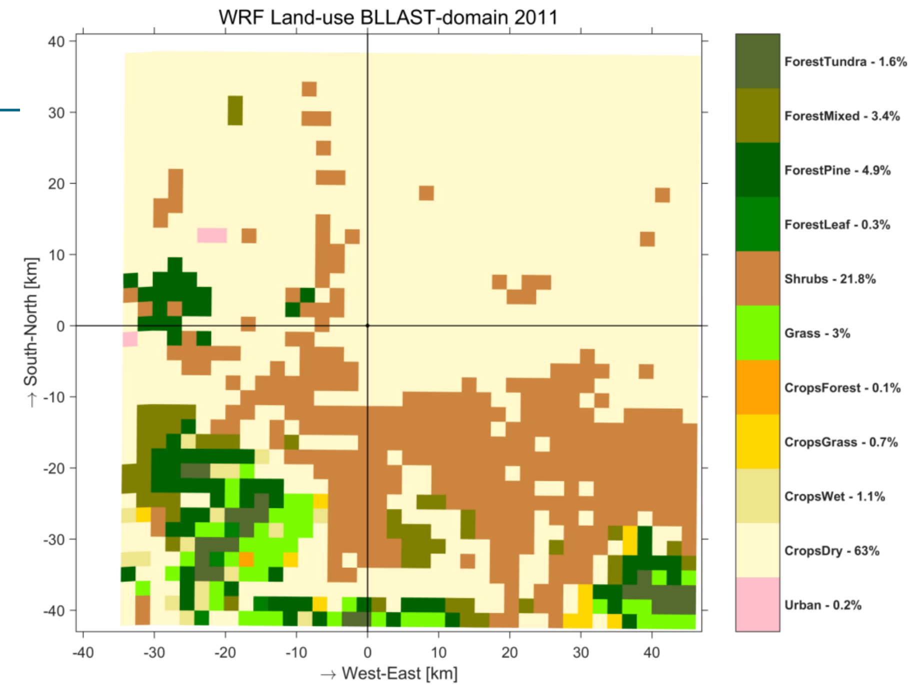
Alternatively:

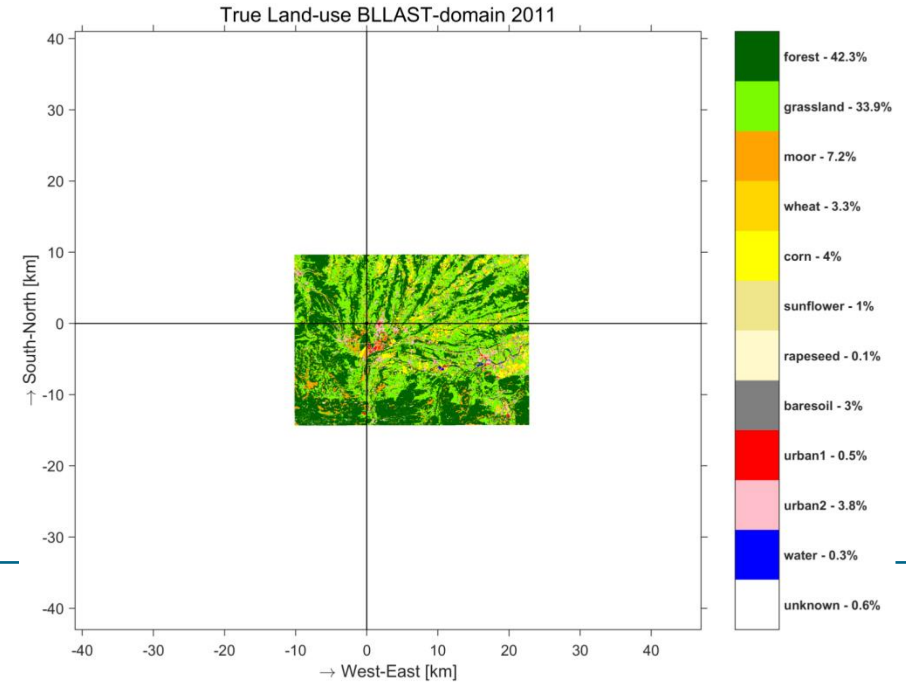
- Link LU-definition and flux controlling parameters are weak?
- LU-definition less important than other dynamics in the model? (**Soil Moisture and spin-up time...**)

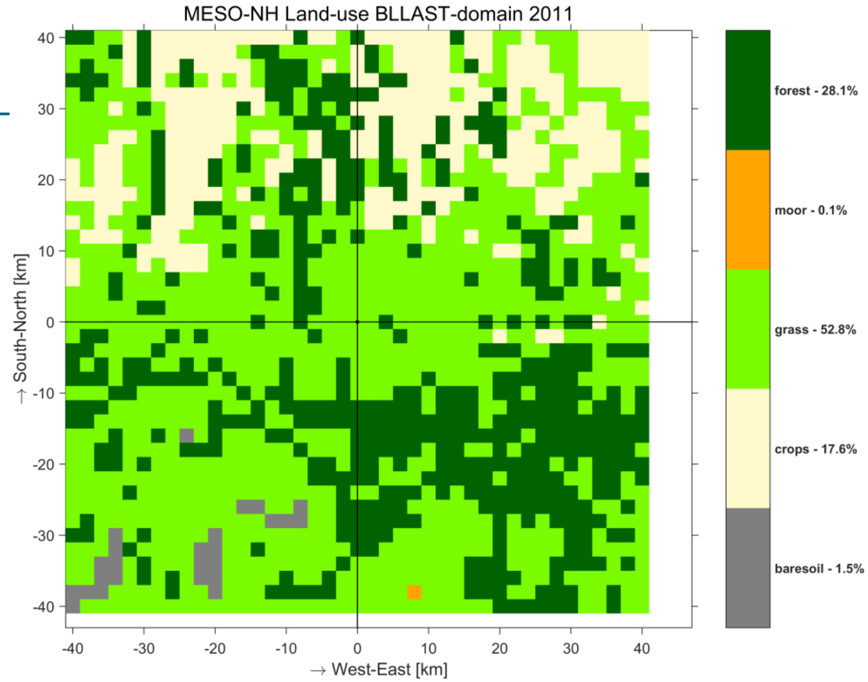
Thank you

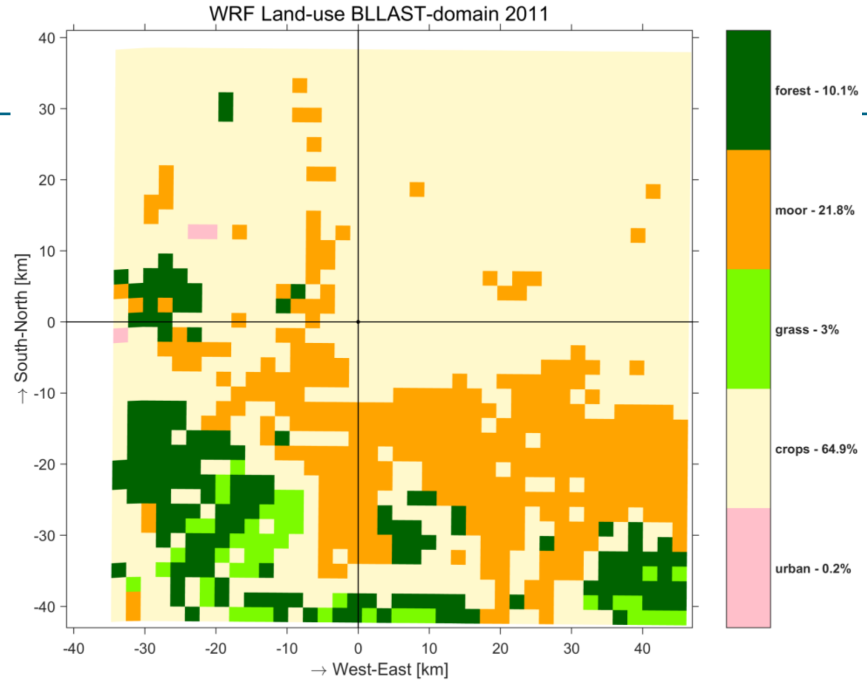



MESO-NH Land-use BLLAST-domain 2011
↑ South-North [km]
→ West-East [km]
ForestPine - 4.4%
ForestDeciduous - 23.7%
Parks - 0.1%
Grass - 52.8%
CropsDryC3 - 8%
CropsDryC4 - 4.2%
CropsWet - 5.5%
BareSoil - 1.5%

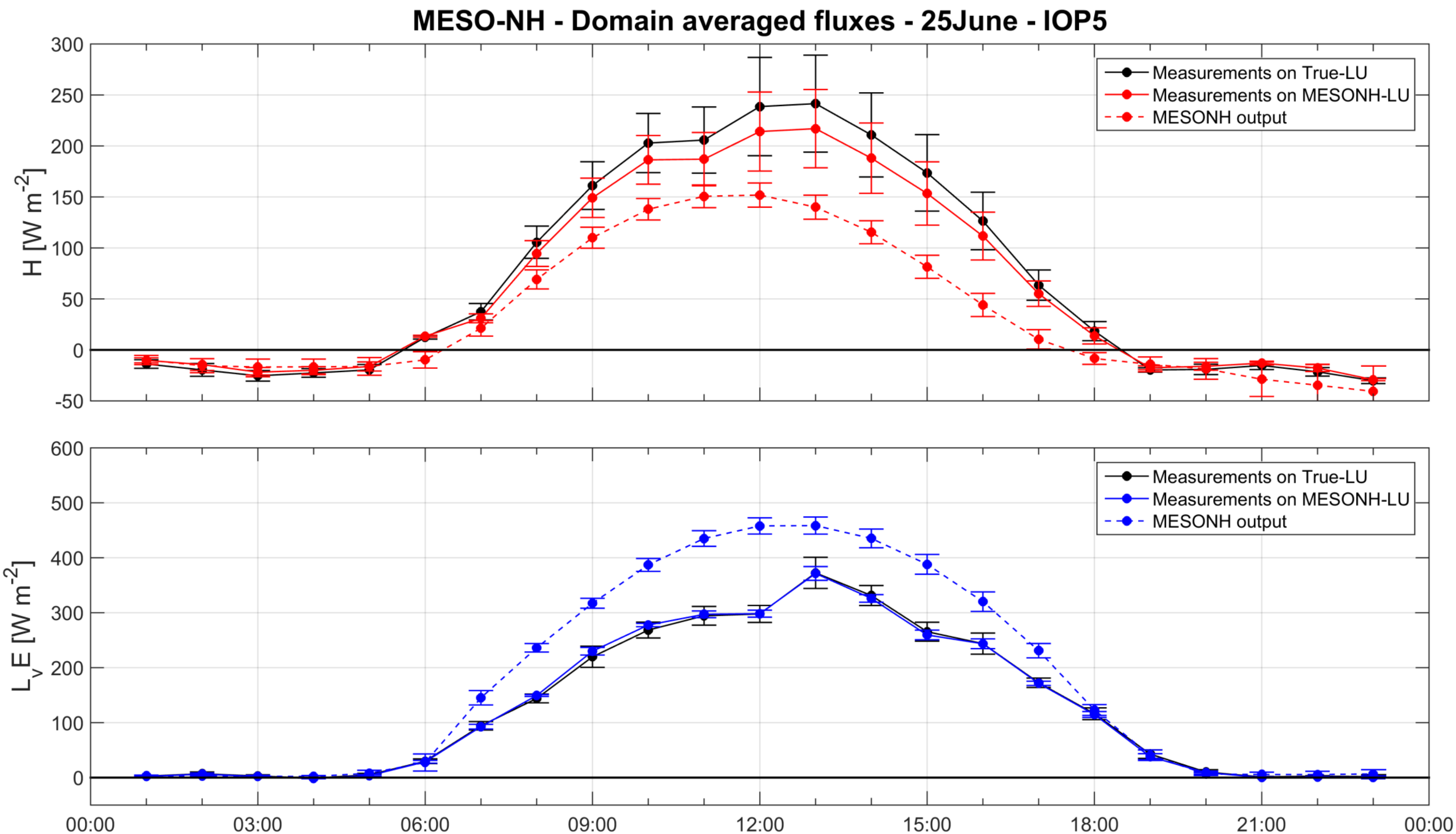

WRF Land-use BLLAST-domain 2011
↑ South-North [km]
→ West-East [km]
ForestTundra - 1.6%
ForestMixed - 3.4%
ForestPine - 4.9%
ForestLeaf - 0.3%
Shrubs - 21.8%
Grass - 3%
CropsForest - 0.1%
CropsGrass - 0.7%
CropsWet - 1.1%
CropsDry - 63%
Urban - 0.2%


True Land-use BLLAST-domain 2011
↑ South-North [km]
→ West-East [km]
forest - 42.3%
grassland - 33.9%
moor - 7.2%
wheat - 3.3%
corn - 4%
sunflower - 1%
rapeseed - 0.1%
baresoil - 3%
urban1 - 0.5%
urban2 - 3.8%
water - 0.3%
unknown - 0.6%

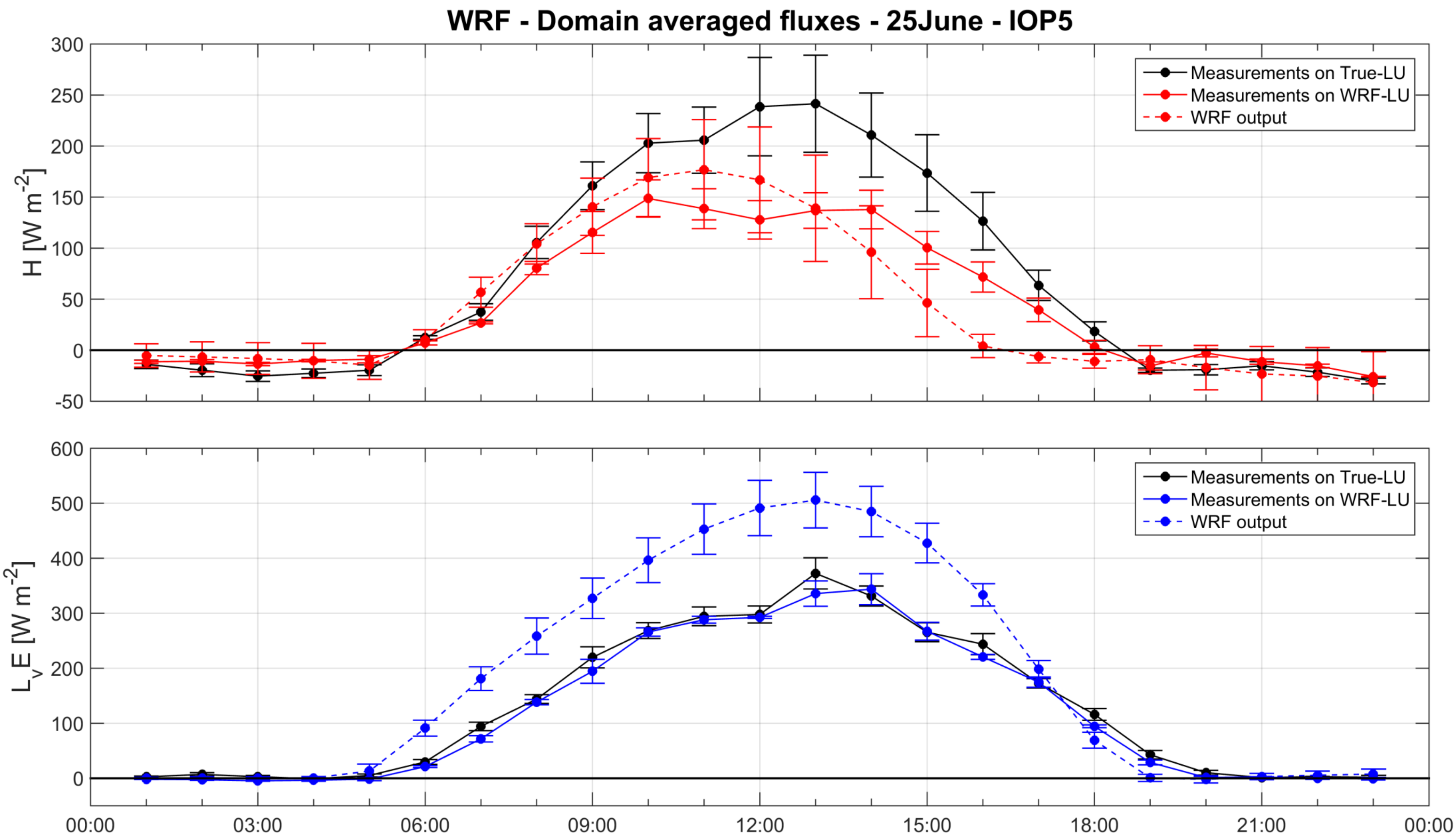

MESO-NH Land-use BLLAST-domain 2011
→ South-North [km]
→ West-East [km]
forest - 28.1%
moor - 0.1%
grass - 52.8%
crops - 17.6%
baresoil - 1.5%


WRF Land-use BLLAST-domain 2011
→ South-North [km]
→ West-East [km]
forest - 10.1%
moor - 21.8%
grass - 3%
crops - 64.9%
urban - 0.2%

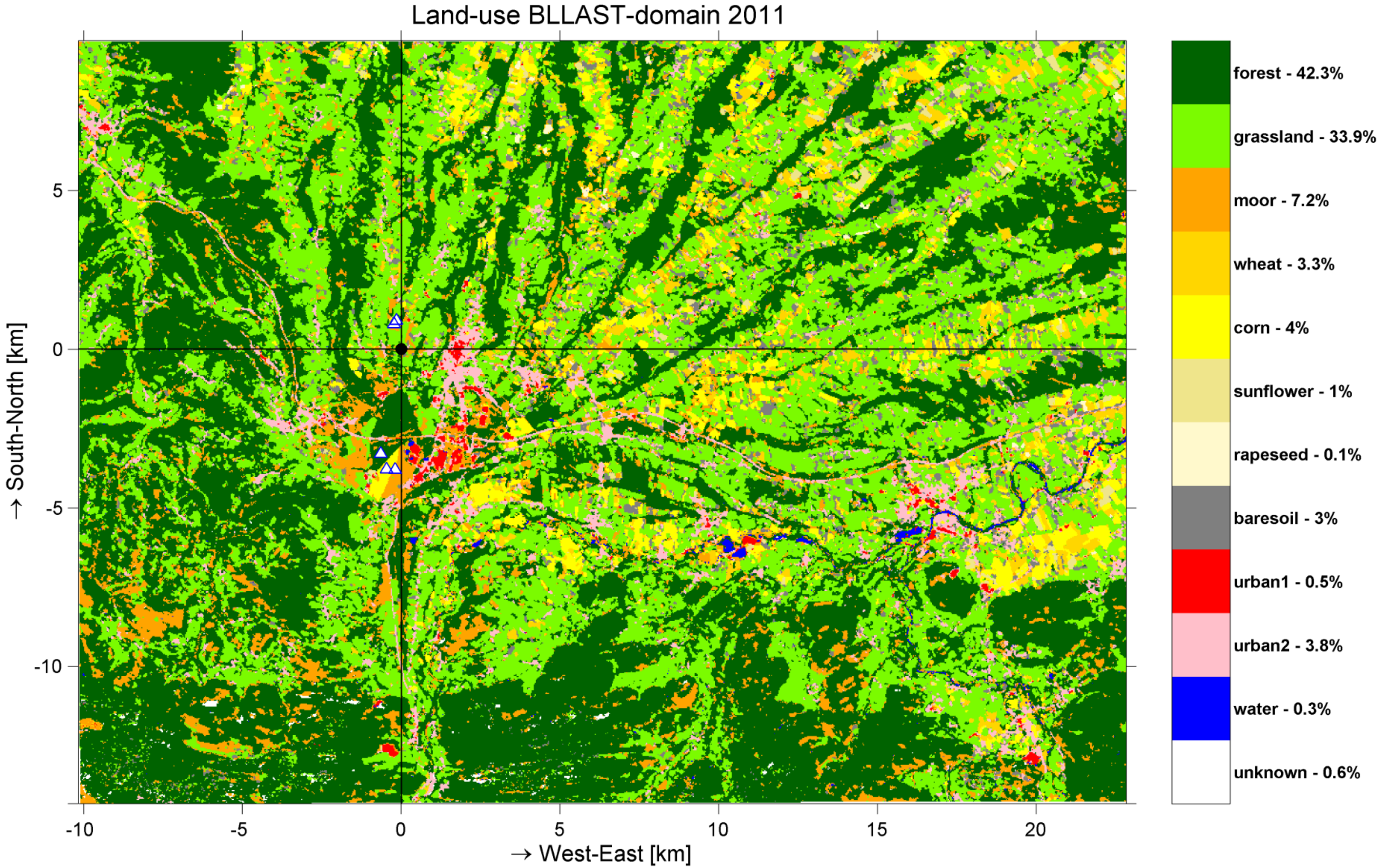
3. FLUX-timeseries from aggregated maps – MESO-NH



3. FLUX-timeseries from aggregated maps – WRF



Available data - Landuse map 30m resolution



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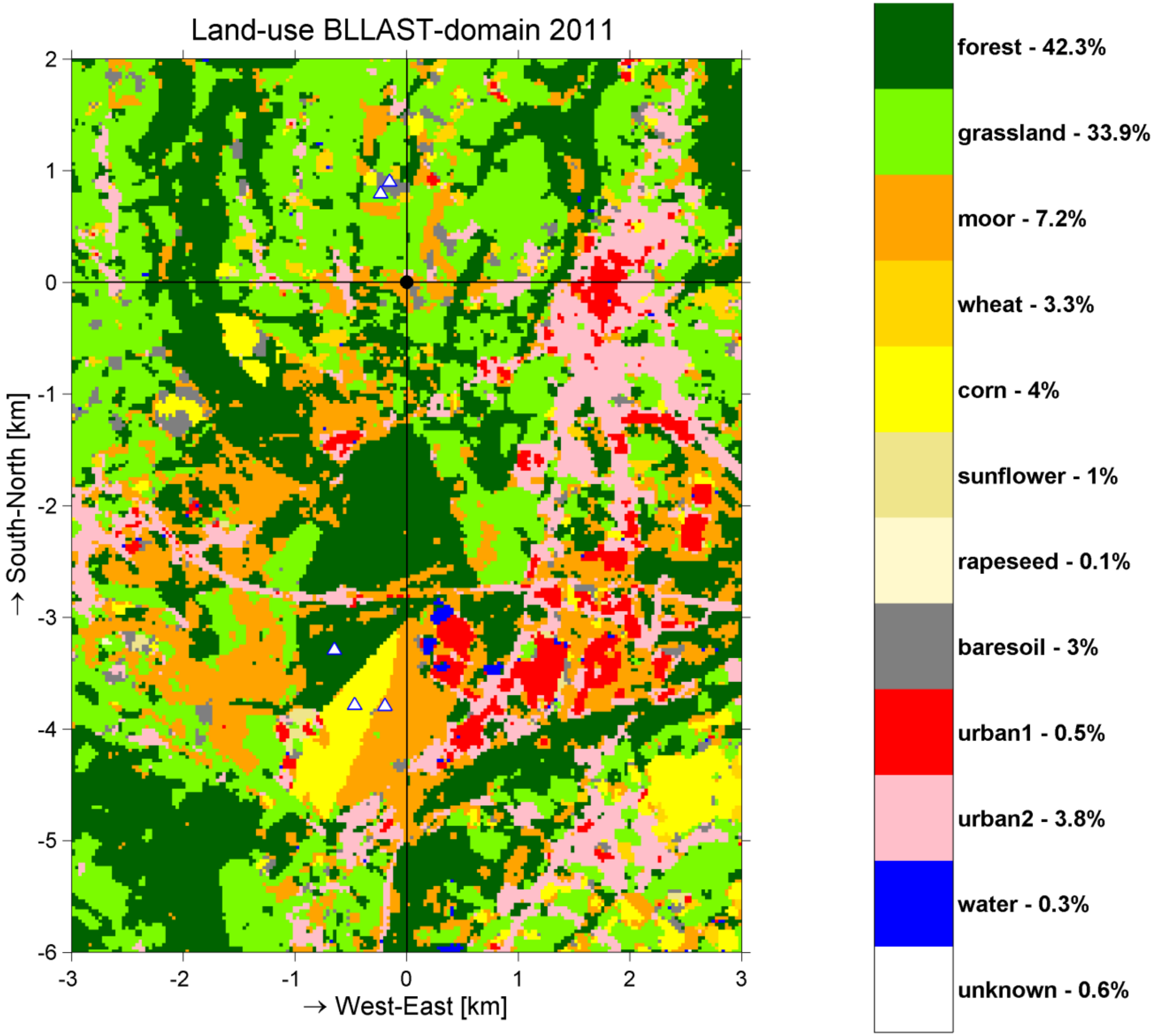
Available data - Landuse map + EC stations



→ forest (EC)

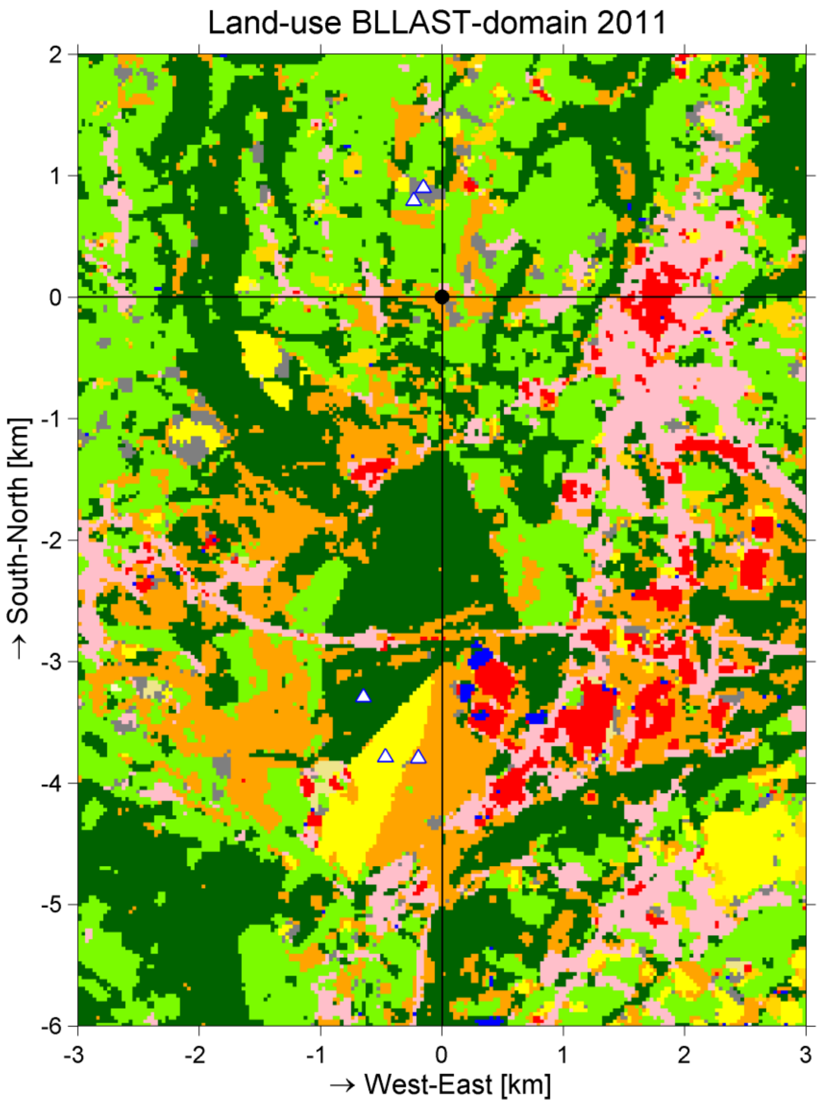
→ grassland (EC)

→ moor (EC)

→ wheat (EC)

→ corn (EC)

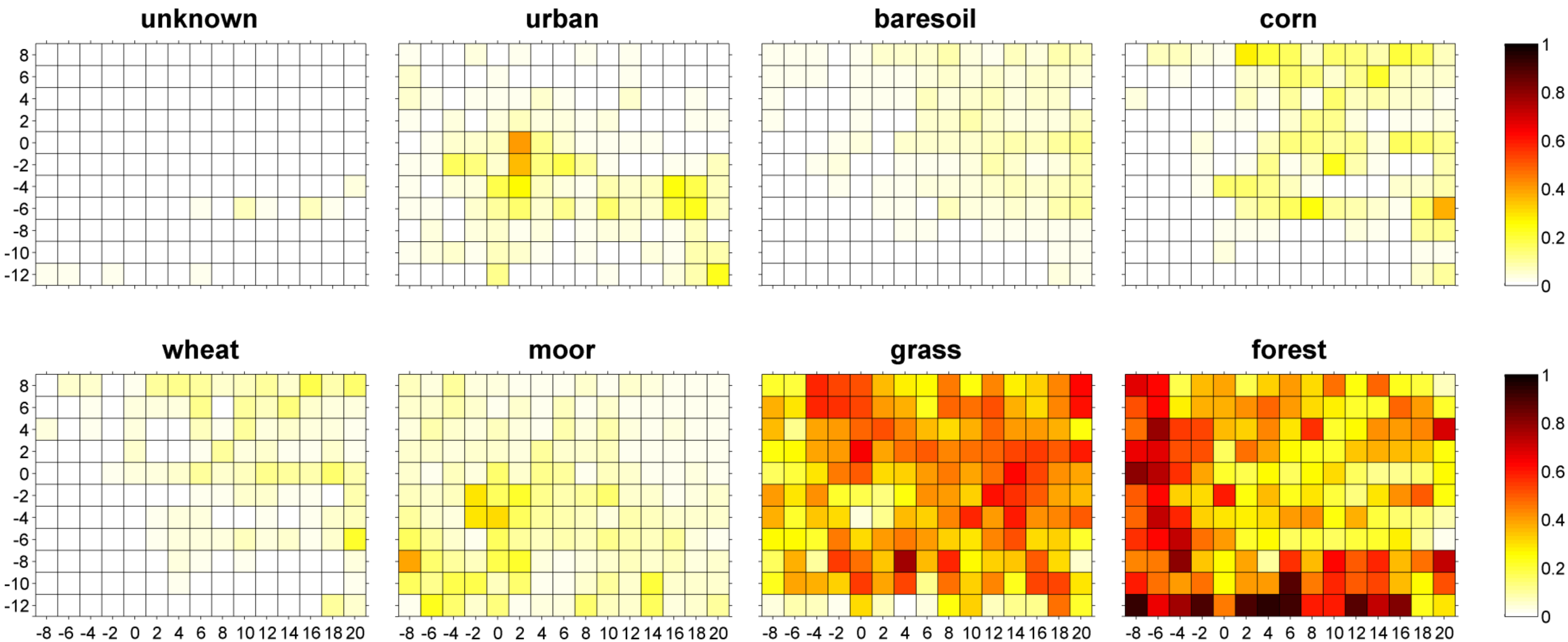
LU-flux assignment – Direct-method



Land use	Assignment
forest - 42.3%	→ forest (EC)
grassland - 33.9%	→ grassland (EC)
moor - 7.2%	→ moor (EC)
wheat - 3.3%	→ wheat (EC)
corn - 4%	→ corn (EC)
sunflower - 1%	→ corn (EC)
rapeseed - 0.1%	→ corn (EC)
baresoil - 3%	→ baresoil (EB-model)
urban1 - 0.5%	→ urban (EB-model)
urban2 - 3.8%	→ urban (EB-model)
water - 0.3%	→ unknown (*)
unknown - 0.6%	→ unknown (*)

Upscaling - % contribution of each LU

$$\overline{H_{i,j}} = b_{1_{i,j}} H_{LU1} + b_{2_{i,j}} H_{LU2} + \cdots + b_{n_{i,j}} H_{LU_n}$$



LU-flux assignment – Direct-method – Model Urban and Bare-soil fluxes

$$R_n = (1-\alpha)S_{in} + L_{in} - \varepsilon\sigma T_s^4$$

$$G = G_{frac} R_n$$

- To solve
- Measured
- Set Constant
- Phys Constant

day-time:

$$H = \beta \frac{R_n - G}{1+\beta}$$

$$L_v E = \frac{R_n - G}{1+\beta}$$

night-time:

$$H = R_n - G$$

$$L_v E = 0$$

Set Constants				
	α	ε	G_{frac}	β
Urban	0.15	0.92	0.3/0.5	5
Bare-soil	0.17	0.96	0.3/0.5	2

Lemonsu et al. (2004) and Grimmond&Oke (1999)

LU-flux assignment – Direct-method – Model Urban and Bare-soil fluxes

$$U_* = \sqrt{\frac{U(z_m)}{r_{am}}} \quad with\, r_{am}(z_m, z_{0m}, L_{mo})$$

$$T_s = \frac{Hr_{ah}}{\rho c_p} + T(z_h) \quad with\, r_{ah}(z_h, z_{0h}, L_{mo})$$

→ z_{0h} scaling after Kanda, 2007 (urban) and Zilitinkevitch, 1995 (bare-soil)

- to Solve
- Measured
- Set Constant
- Phys Constant

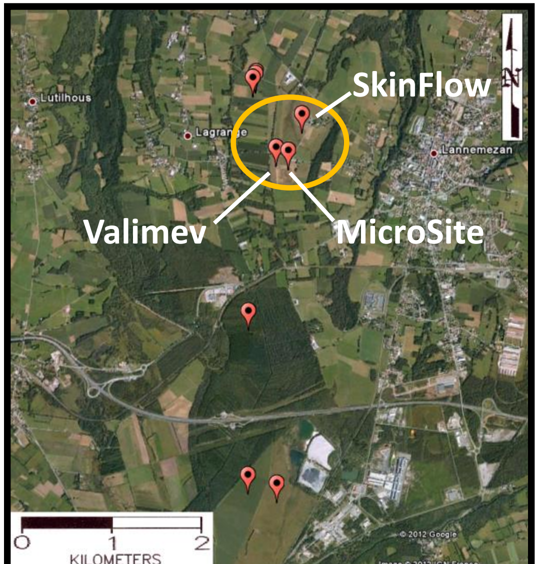
Set Constants			
	z_m & z_h	z_{0m}	d
Urban	30m	0.5m	3m
Bare-soil	30m	0.05m	0m

Super Site 1

MicroSite *(20 Hz)*
•2m: CSAT3 & LICOR7500

Valimev tower *(10 Hz)*
•30m: CSAT3 & LICOR7500
•45m: Gill
•60m: CSAT3 & Krypton

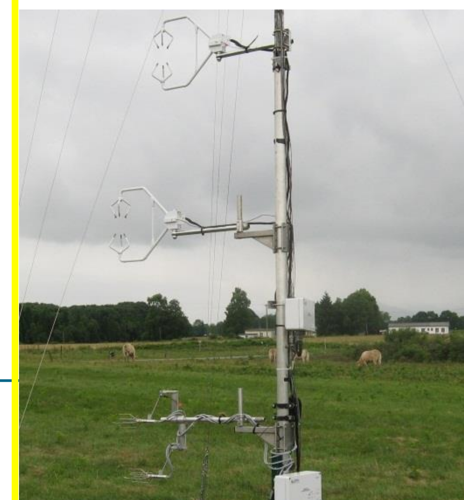
SkinFlow mast *(20 Hz)*
•Lowest 2 levels: Kaijo Denki & T-couple
•2,3,5,8m*:* CSAT3 & T-couple



MicroSite
University of Bergen

Valimev tower
Laboratoire d'Aérologie

SkinFlow mast
University of Utah & Wageningen University



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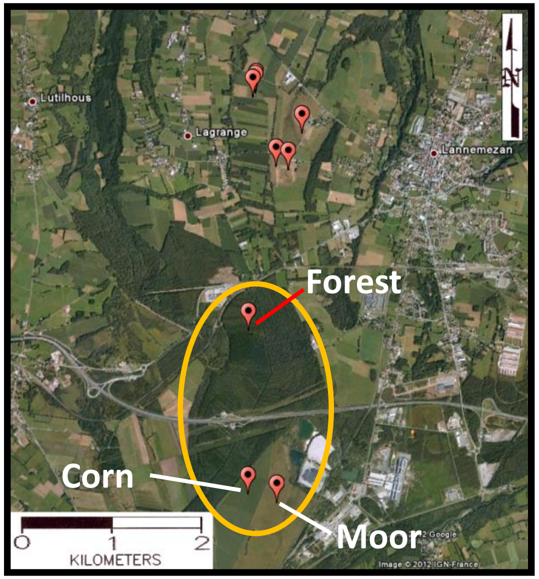
Super Site 2

Overview

Forest mast *(10 Hz)*
- 20m: CSAT & T-couple
- 30m: CSAT & LICOR

Corn & Moor *(20 Hz)*
- CSAT & LICOR



Forest mast
University of Utah &
Wageningen University

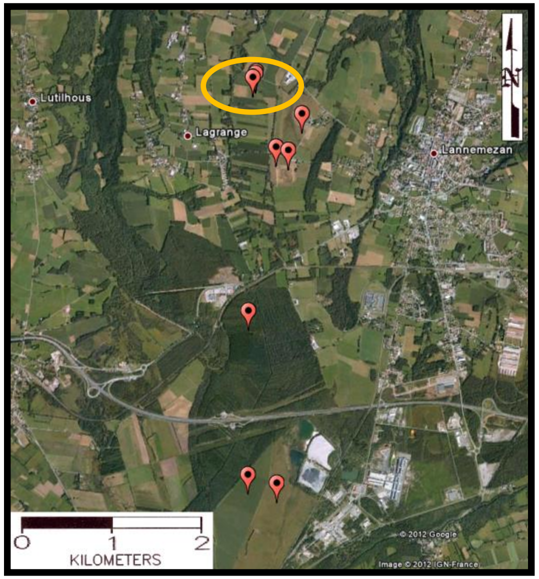
Corn
Météo France

Moor
Météo France

Edge Site

EDGE SITE

Grass, Edge, Wheat *(20 Hz)*
•CSAT & LICOR



Edge
Wageningen University

Wheat
University of Bonn

Grass
Forschungszentrum Jülich & Bonn University