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Coupling a high resolution SVAT scheme with a mesoscale model by the mosaic and tile approach

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QPF-Hydro Symposium, Boulder, 5 June 2006

EVA-Grips

DEKLIM

Relevance of surface-atmosphere exchange for QPF

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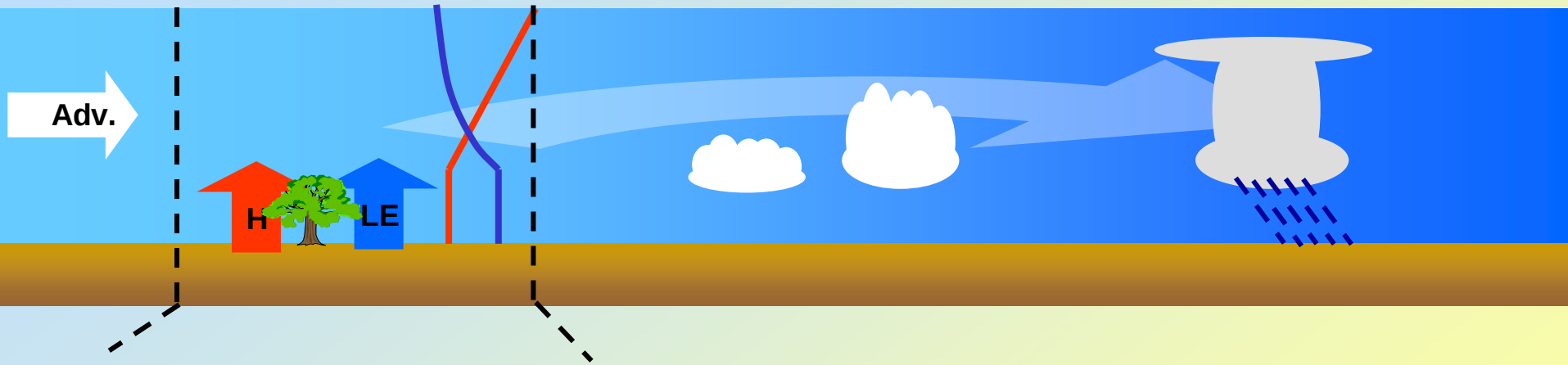
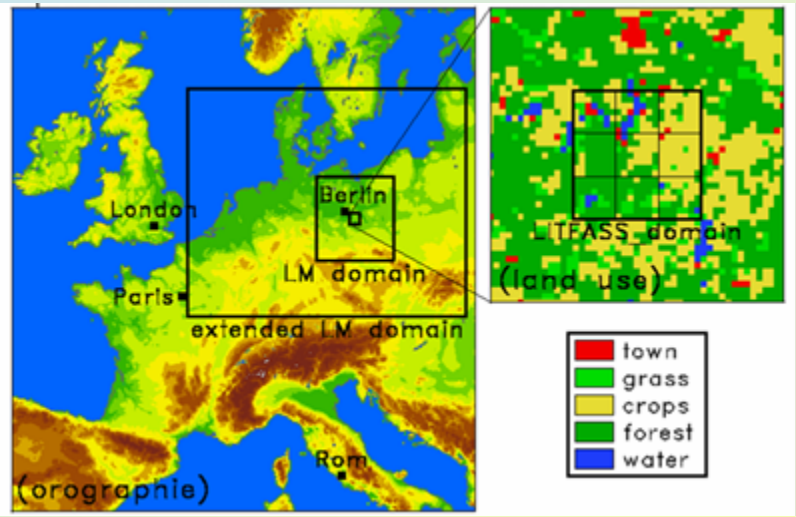


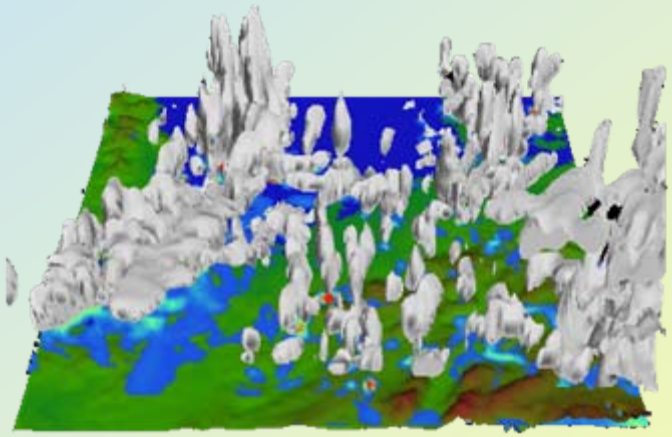
- Surfaces fluxes determine the **lower boundary condition** of an atmospheric model.
- Sensible and latent heat fluxes affect near **surface weather conditions** and **boundary layer evolution**.
- Surface fluxes have the potential to **trigger precipitation processes**.

Data and model

LITFASS-2003 Experiment

- Measurement of surface fluxes
- Domain: 20x20km^2 in Central Europe.
- Period: 30 days, 19 May – 17 June 2003.





Mesoscale NWP model “Lokal-Modell” (LM)

- Operationally used by German Meteorological Service (DWD) at 7km resolution; also applied as a regional climate model.
- Non-hydrostatic model with a comprehensive package of parameterizations.
- Standard version assumes homogeneous surface conditions within each grid box.

Small scale variability of surface fluxes

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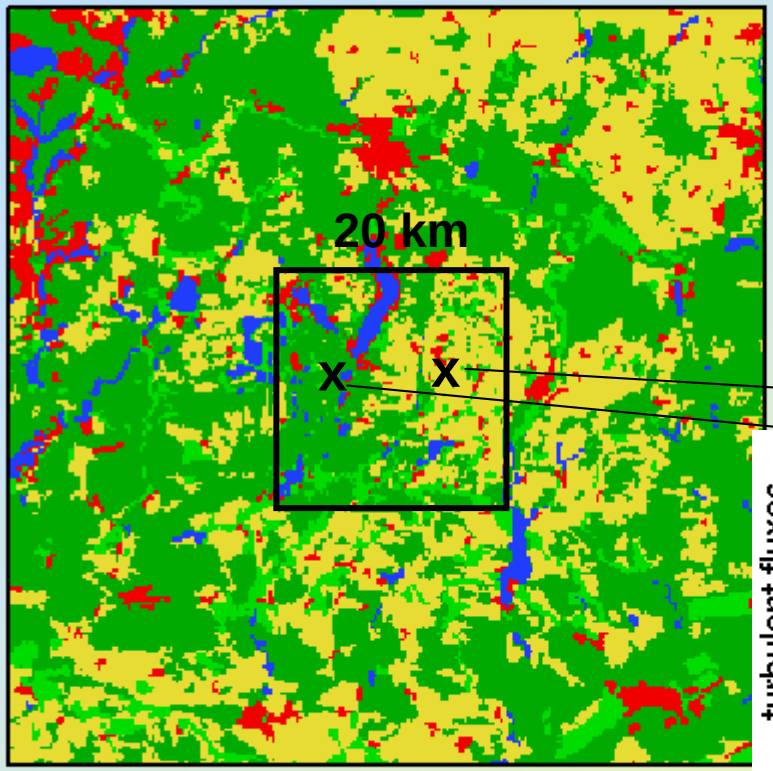
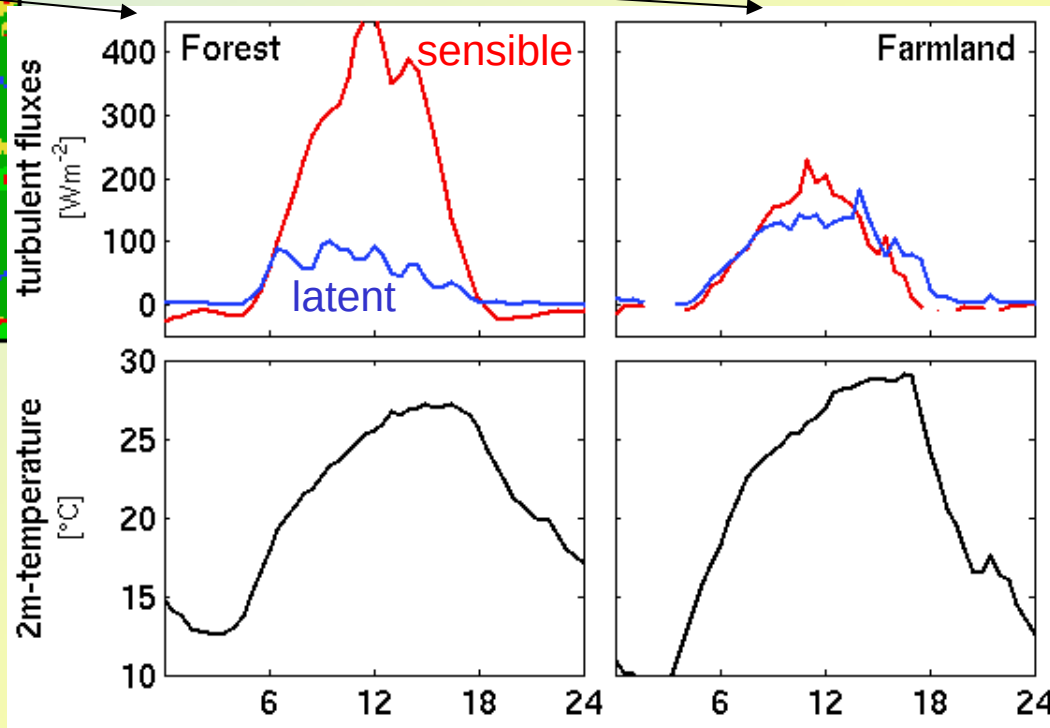
Land use



Measurements during LITFASS-2003 at 30 May 2003.



Modeling small scale flux variability

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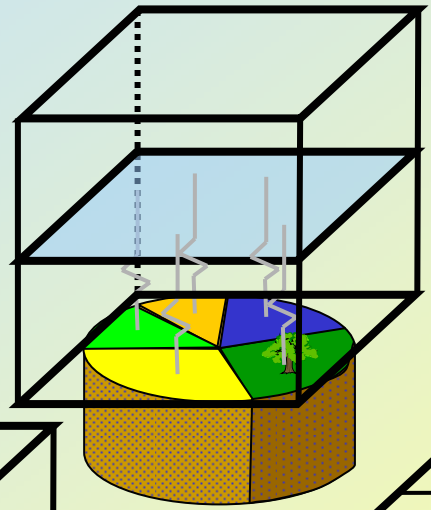
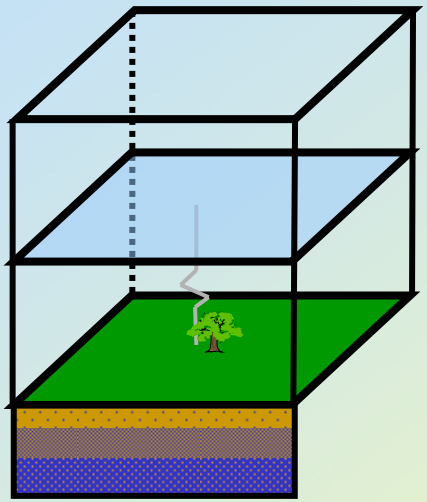
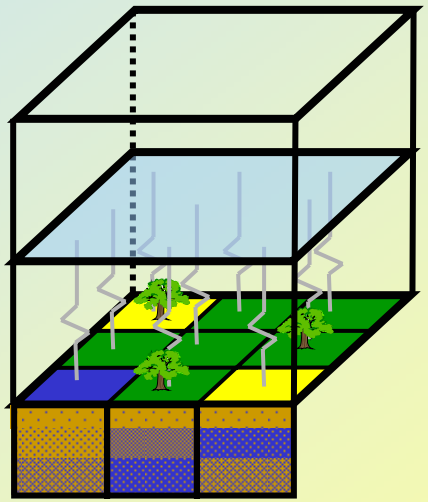
Tile

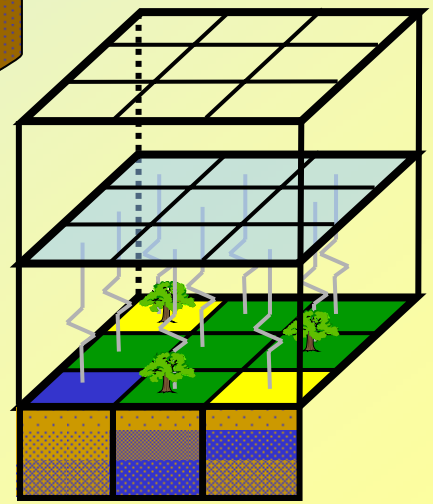
Resolution of
atmosphere: low
surface: high

(Avissar and Pielke, 1989)









Standard

Resolution of
atmosphere: low
surface: low

Mosaic

Resolution of
atmosphere: low
surface: high

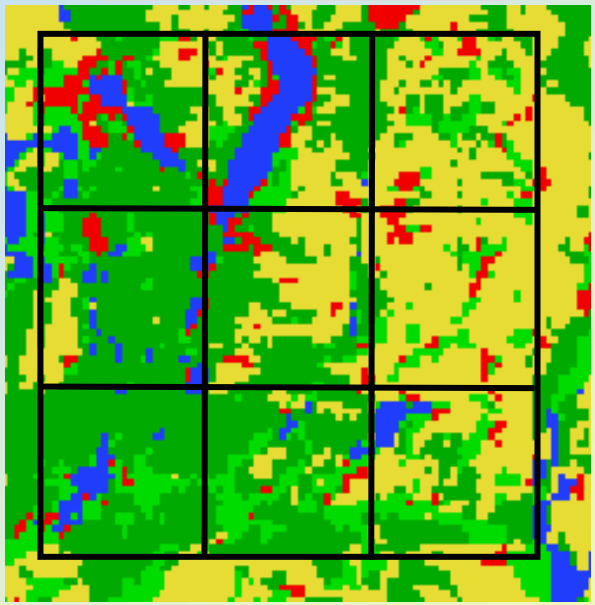
Full grid refinement

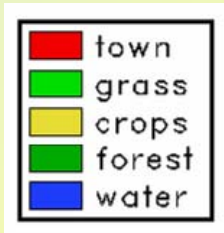
Resolution of
atmosphere: high
surface: high

(Seth et al., 1994)

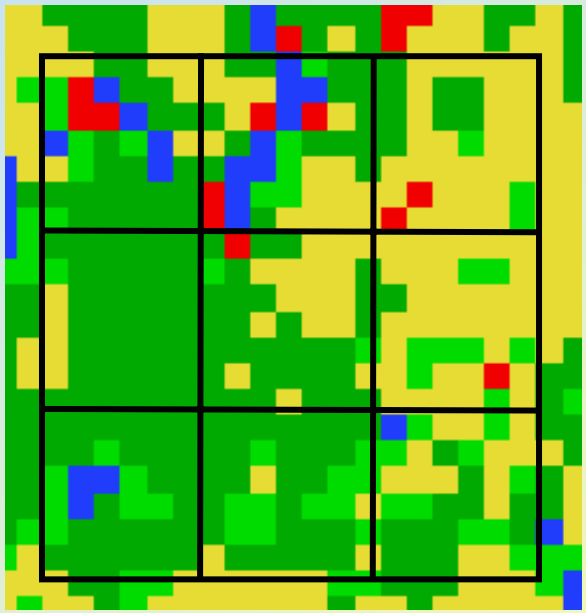
Mosaic- and Tile-Representation

Reality

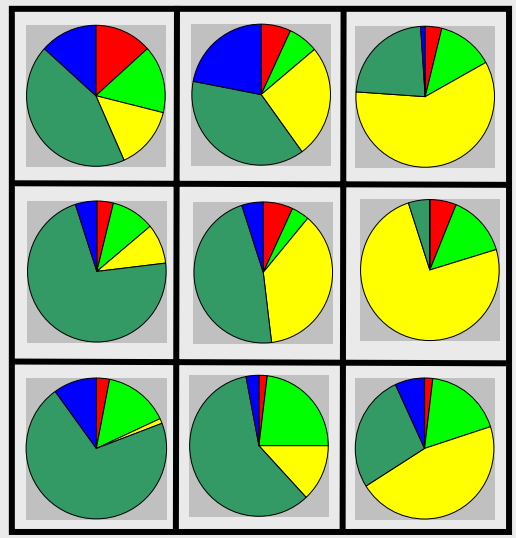




Mosaic



Tile



Evaluation using observations –
Mean daily cycle

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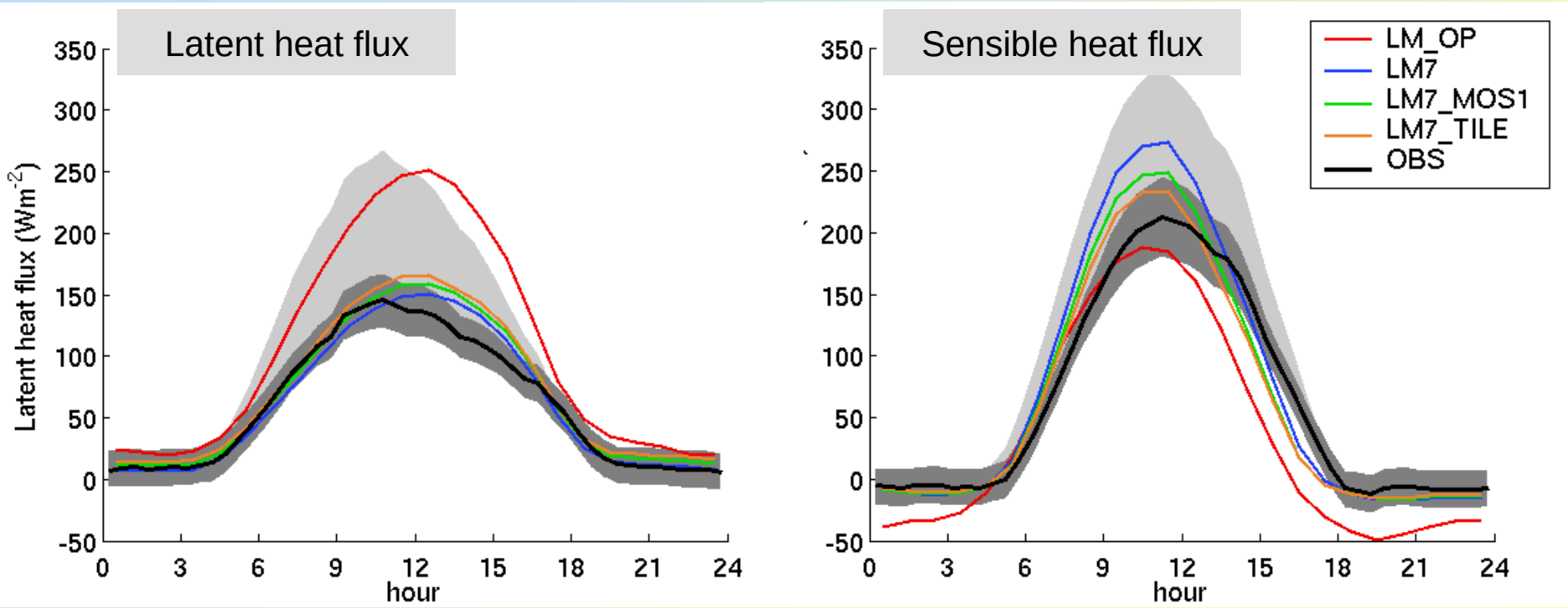
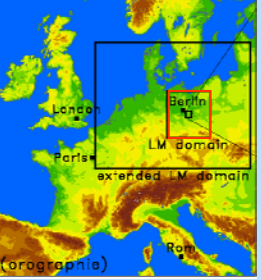
Atmospheric resolution: 7 km; Surface resolution: 1 km / 8 classes



(30 days during LITFASS-2003 experiment, LITFASS area mean)

- Large differences between operational LM (LM_OP) and LM7 using improved soil moisture data (see Poster).
- Deviations due to various parameterizations are small – smaller than measurement uncertainties.



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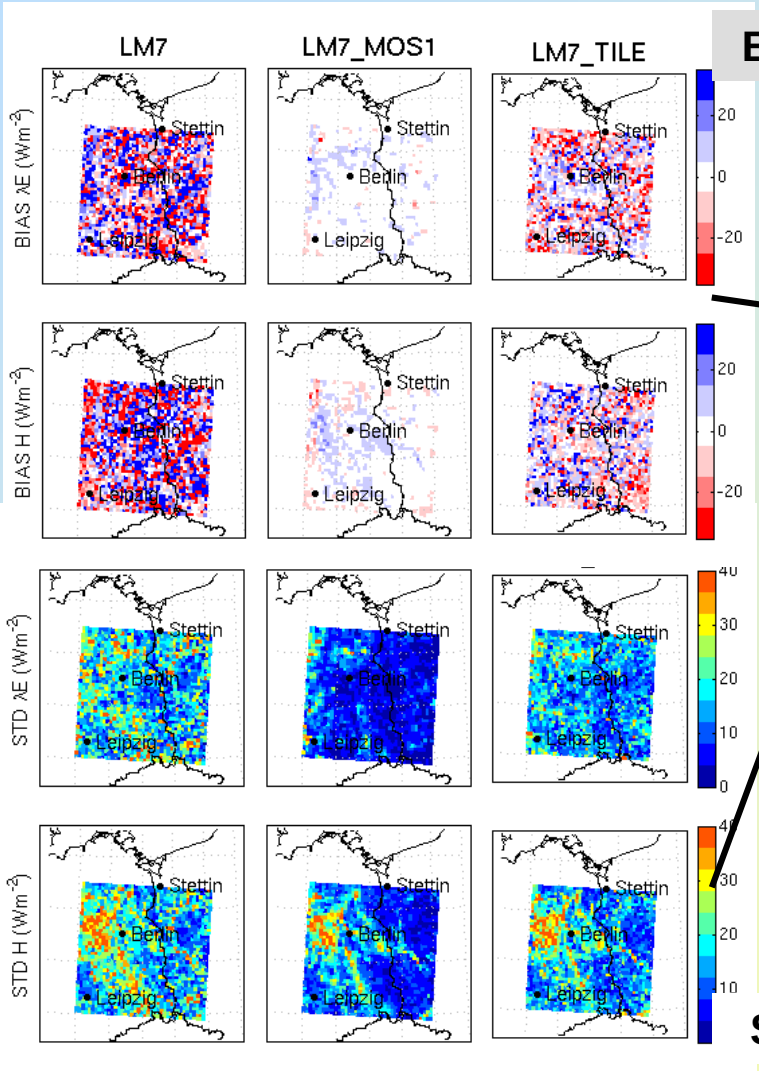
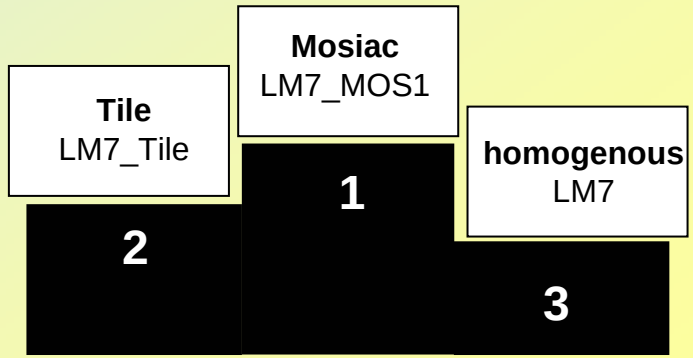
Consistency with respect to LM-1km simulations



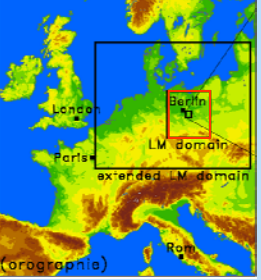
LE / H (Wm^{-2})	LM7	LM7_ MOS1	LM7_ TILE
BIAS domain average	2 / 2	1 / 1	-3 / 0
|BIAS| grid point scale	27 / 28	3 / 4	16 / 14
STD	19 / 19	8 / 12	15 / 16



Computational costs (1 km surface resolution):

- Mosaic: factor 2
- LM-1km: factor 330

Atmospheric resolution: 7km



Scale dependent RMSE I

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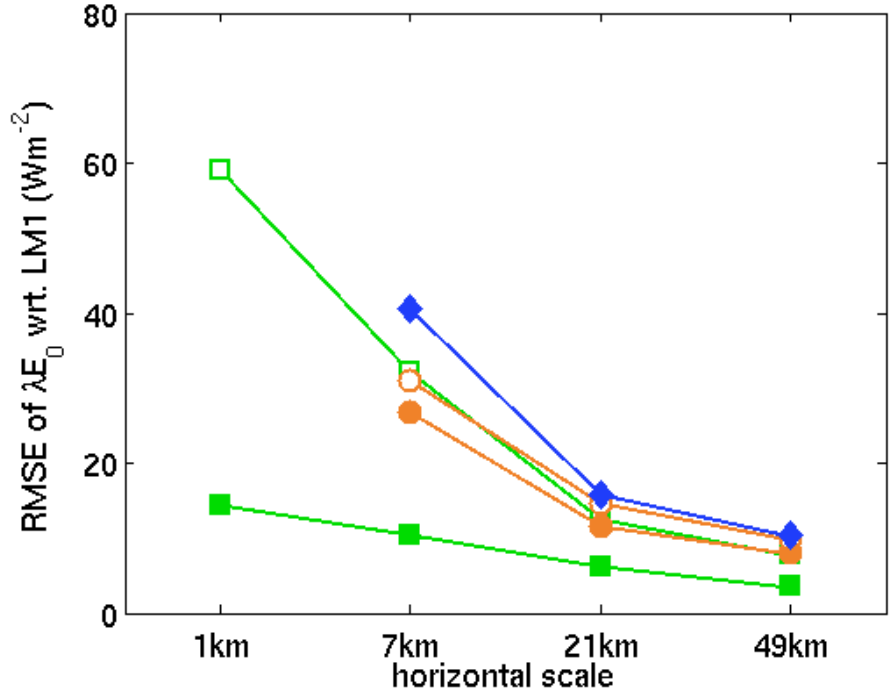
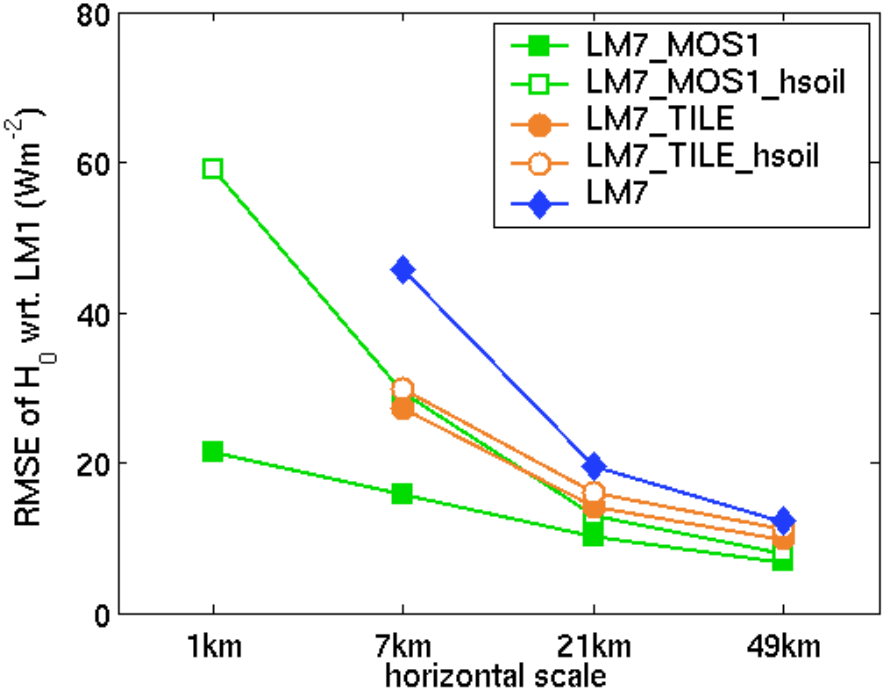
Atmospheric resolution: 7 km – NWP mode:

Latent heat flux

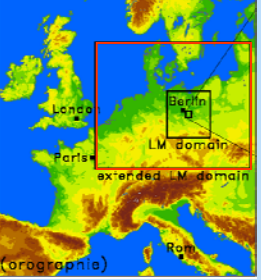


Sensible heat flux



(with respect to LM1-Simulations, 9 days, 12UTC values)

- Errors decrease if larger scales are considered.
- Non-homogeneous soil conditions are important (see *_hsoil simulations).



Again, scale dependent RMSE, but for coarse scale runs

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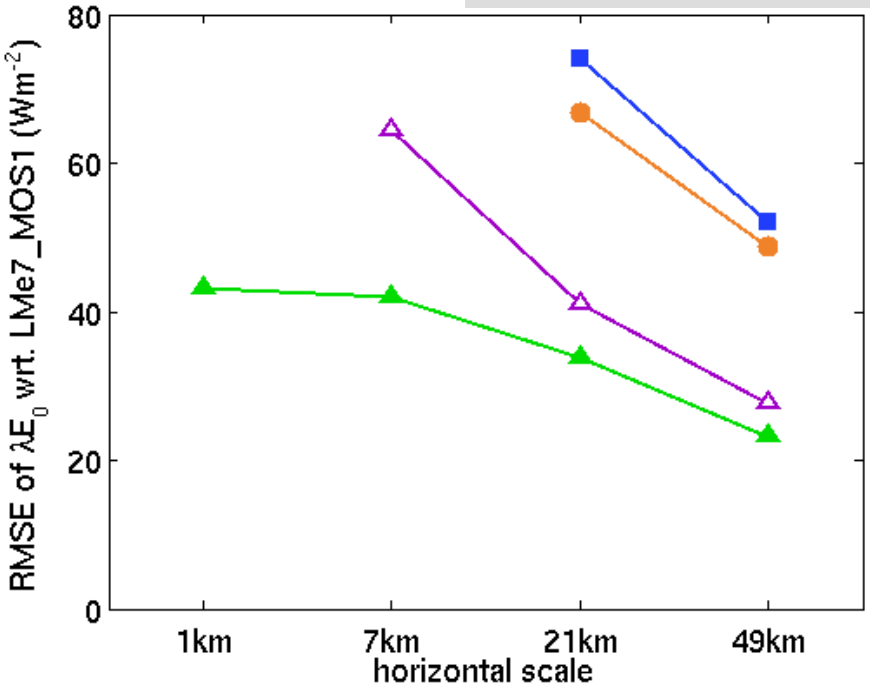
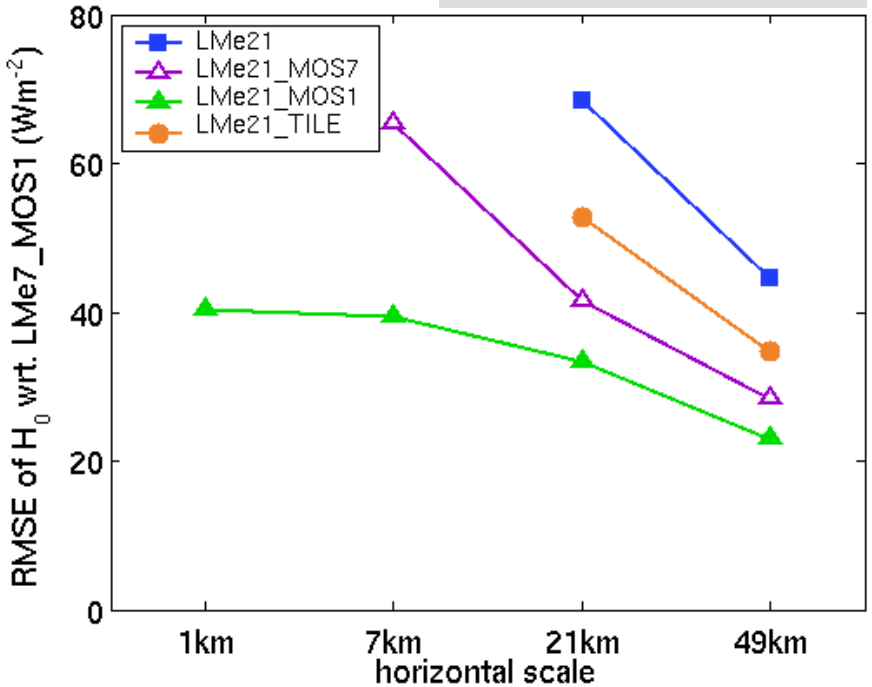
Atmospheric resolution: 21 km – regional climate model:

Latent heat flux



Sensible heat flux



(with respect to LMe7_MOS1-Simulations, 9 days, 12UTC values)

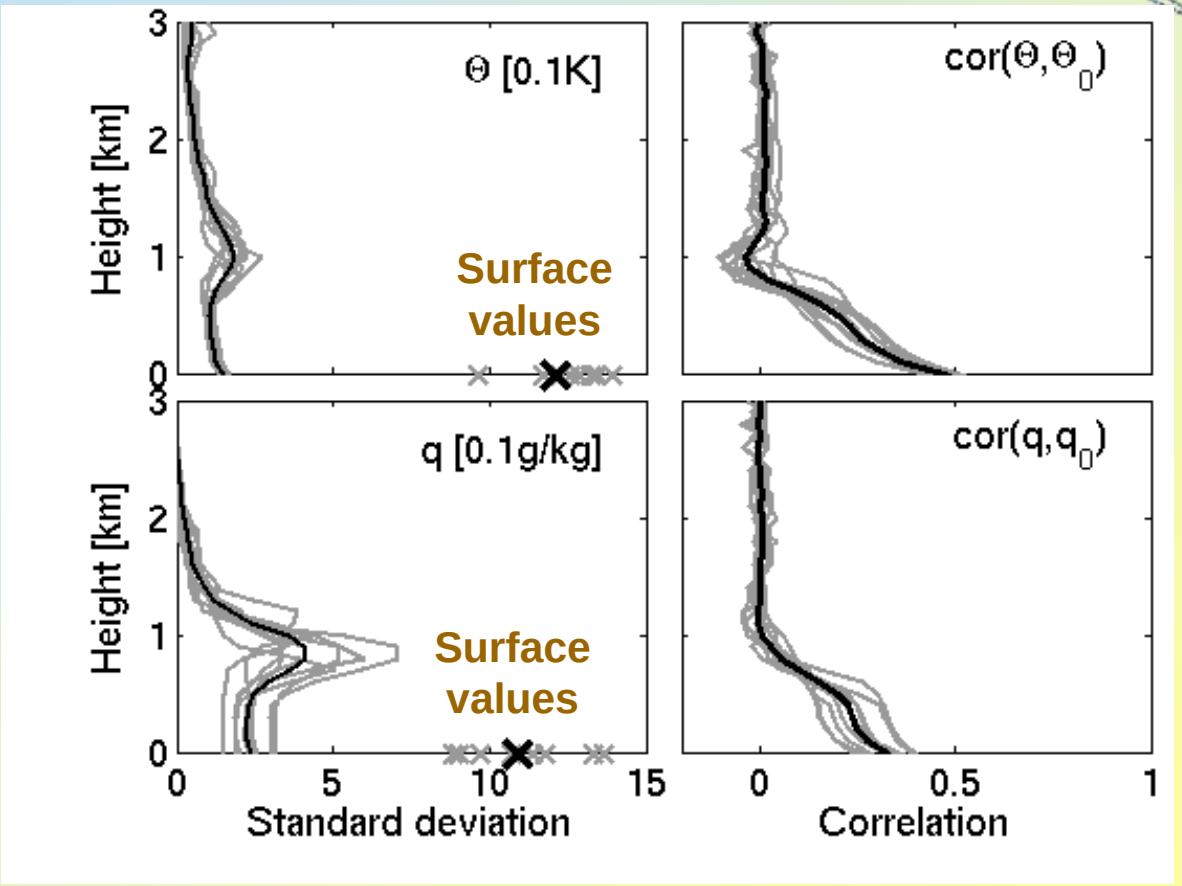
- Again, same ranking of approaches!
- LMe21_MOS7 is better than LM21_Tile, although both use the same number of sub-pixels ➔ coarse mosaic is preferable!

Profiles of variance

Flux-gradient relation:

$$\lambda E = -\lambda K_h |v_h| (q_{atm} - q_{sur})$$

Atmospheric values **Surface values**



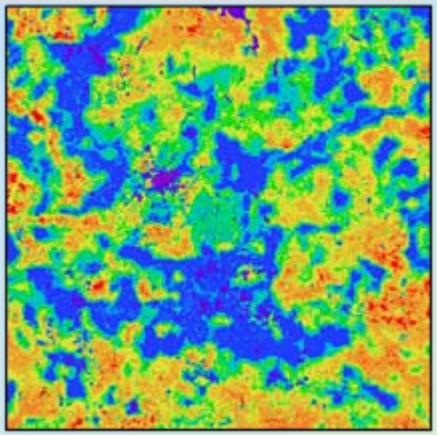
Analysis of LM1-Simulations

- Variance of state variables at the surface is one magnitude higher than within the atmosphere.
- Small correlations of surface and atmospheric values ➔ atmosphere is diffusive.

Explained Spatial Variance

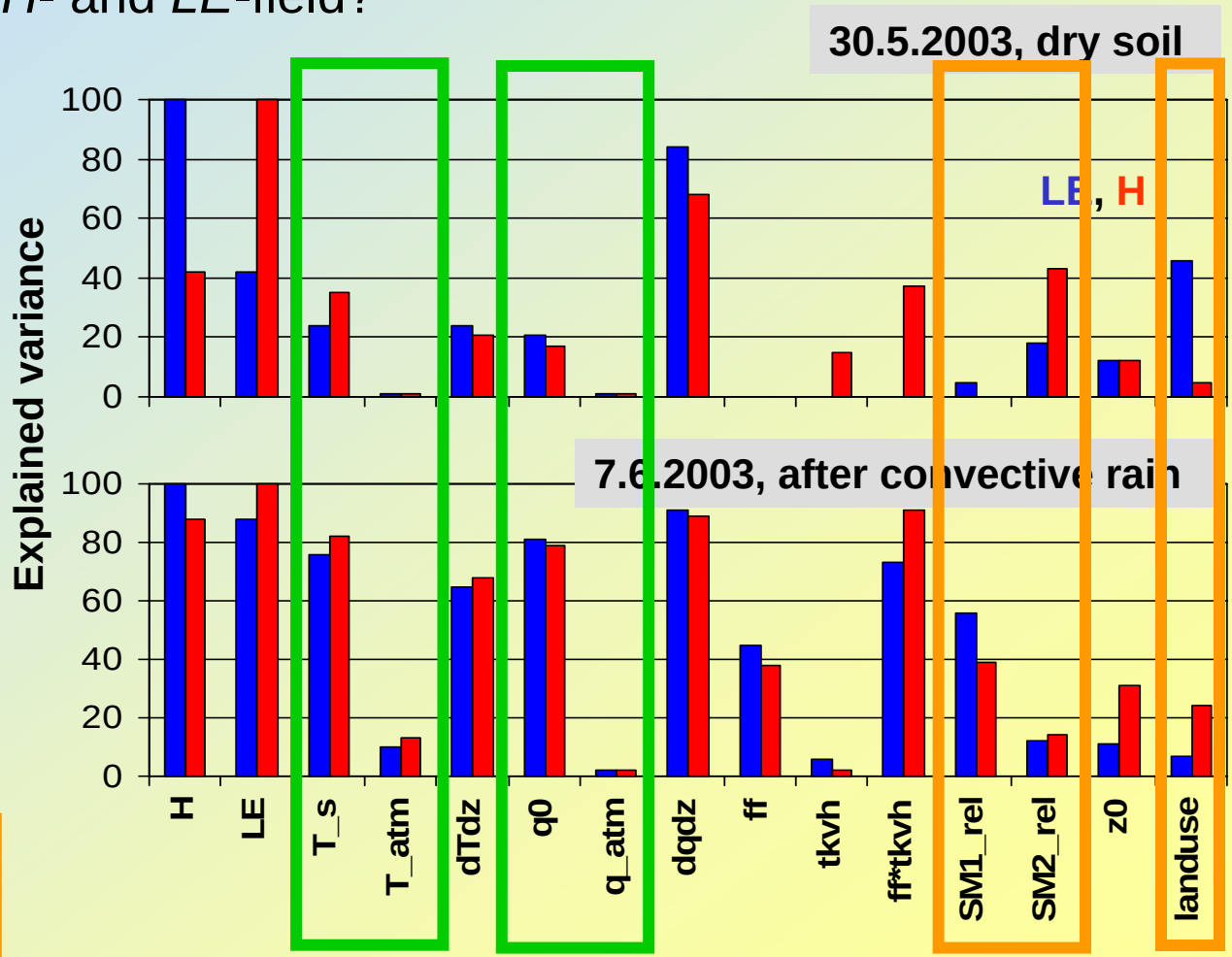
Which variables determine the modeled spatial structure of the *H*- and *LE*-field?

Example: LE-Field, 30.5.03 12UTC



Surface variables versus atmospheric variables

Land use versus soil moisture



(LM1-Simulations, analysis restricted to extended LITFASS domain (49x49km^2))

Conclusions

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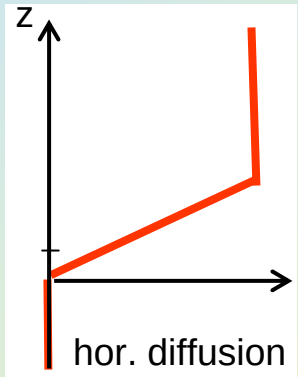
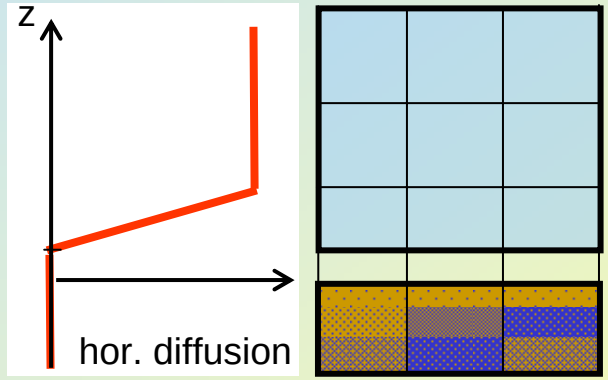
- **Mosaic and tile approach** are very accurate methods to simulate high resolution surface fluxes with much less computational demands than total grid refinement.
- **Heterogeneity effects** are dominant on small scales and less important on larger scales.
- **Variability in surface fluxes** is explained dominantly by the variability of surface quantities.
- **Mosaic approach is better than tile approach** since it can take heterogeneity due to multiple factors into account.

Physical Interpretation

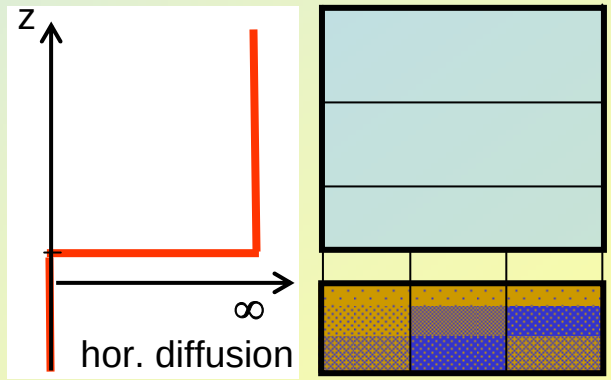
Different assumptions about
subgrid-scale horizontal diffusion

Reality

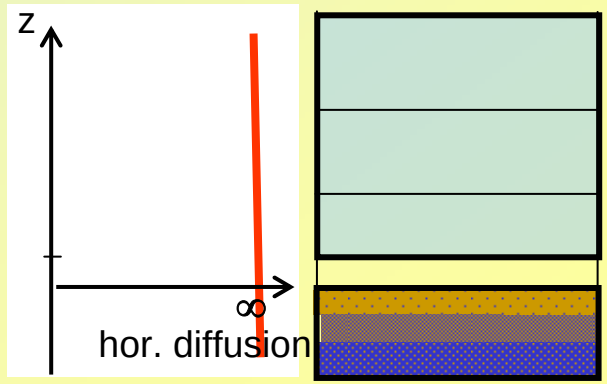




Refinement



Mosaic/ Tile



Standard