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Quantifying the effect of model scales with the inclusion of groundwater on simulated surface-energy fluxes.

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Motivation:

- Development of numerical modeling tools to study the effect of water-table induced soil moisture variability on land-atmosphere interactions.

- Groundwater model e.g., ParFlow can simulate vertical flux of soil moisture, combined with integrated surface and sub-surface drainage.

- Aggregation of slope with coarsening horizontal grid resolution (modeling scale) can affect the simulated soil moisture pattern.

Science Questions:

1. How does the modeling scale affect the simulated soil moisture?
2. What is the effect on soil temperature and surface energy fluxes?

Methodology:

- Modeling Tool, Test Domain, Experiment Setup

Results and Discussion

Modeling Tool : TerrSysMP

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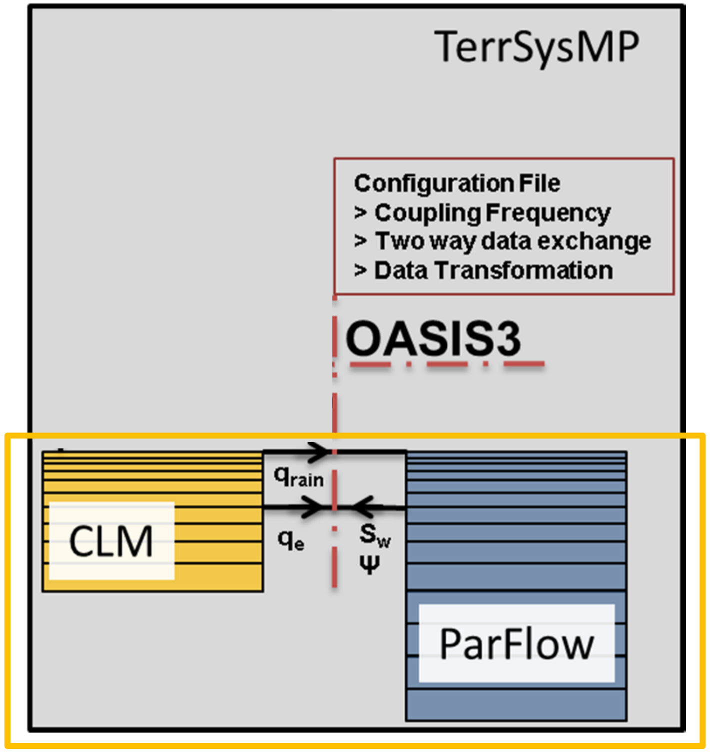

TerrSysMP
(Shrestha et al. 2014)

COSMO
Convection permitting configuration (COSMO-DE) (Baldauf et al. 2011)

CLM
CLM3.5 (Oleson et al. 2008)

ParFlow
Integrated surface-groundwater flow model (Kollet and Maxwell 2006, Maxwell 2012)

OASIS3
External coupler with multiple executable approach (Valcke 2013)

Offline Simulation:
Hydrological Component of TerrSysMP (CLM – ParFlow)
COSMO-DE analysis data used as offline forcing

P Shrestha, M Sulis, M Masbou, S Kollet, C Simmer, 2014: A scale-consistent Terrestrial Systems Modeling Platform based on COSMO, CLM and ParFlow. Mon. Wea. Rev., 142, 3466-3483

Test Domain

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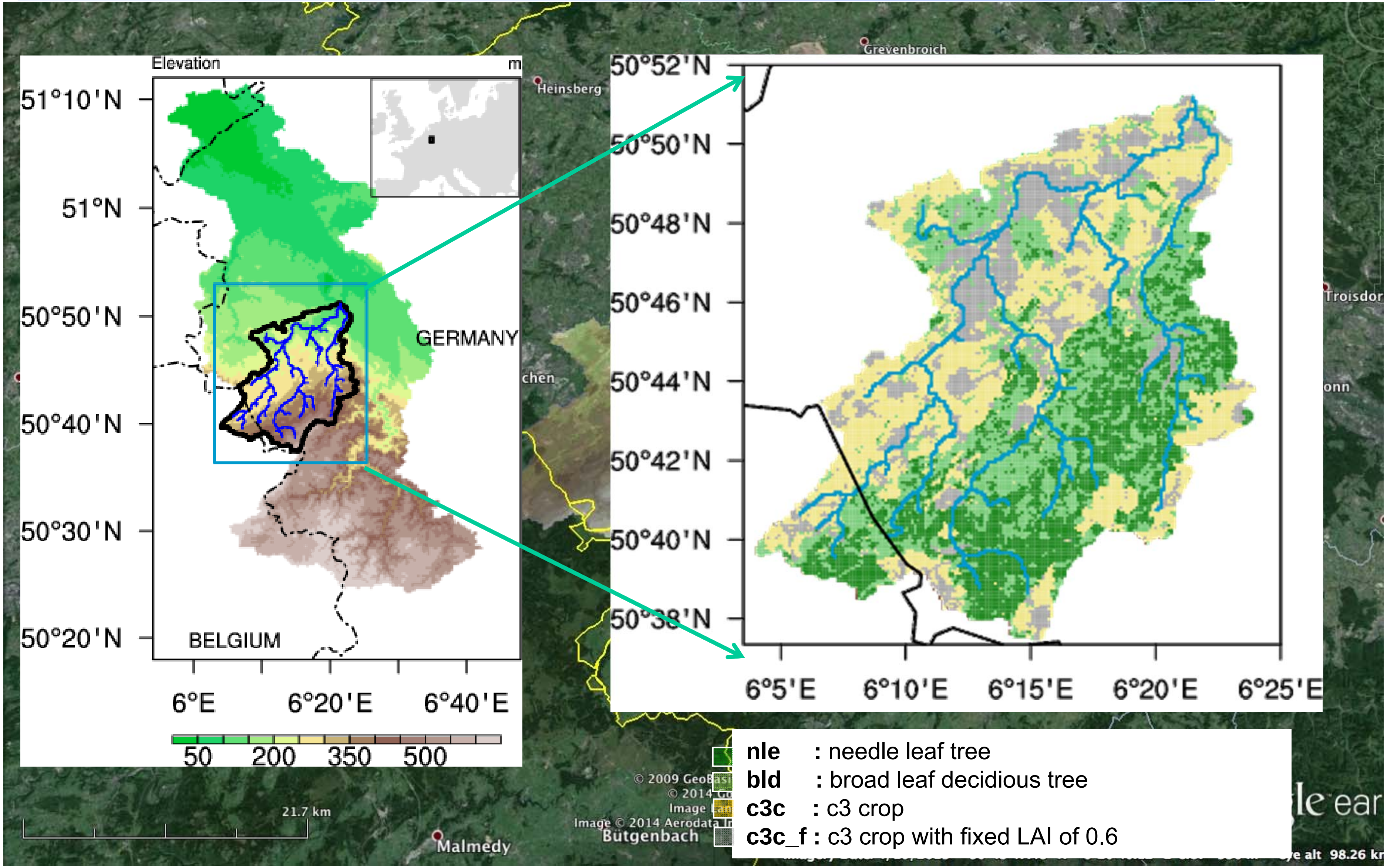

nle : needle leaf tree
bld : broad leaf decidious tree
c3c : c3 crop
c3c_f : c3 crop with fixed LAI of 0.6

Experiment Setup

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- Four runs (**D0120**, **D0240**, **D0480**, **D0960**)
- 90 m SRTM topography interpolated/aggregated to coarser resolution
- r.watershed tool in GRASS GIS used for flow direction estimate
- 15 m landuse data (TR32 database) aggregated to coarser resolution
- Uniform soil texture (clay-loam) used
- Initialization from spinup at different resolution
- Model runs were integrated over a year at hourly time-step.
- Time-averaged output at interval of 120 hours used for analysis

Effect of Model Scale on Soil Moisture

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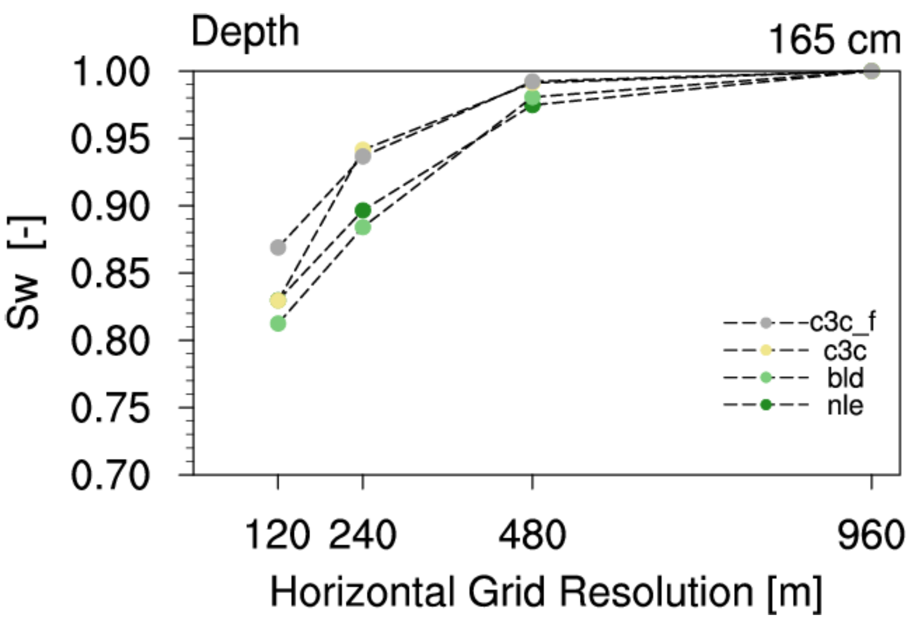
Spatio-temporal Mean (Jan. – Dec.)



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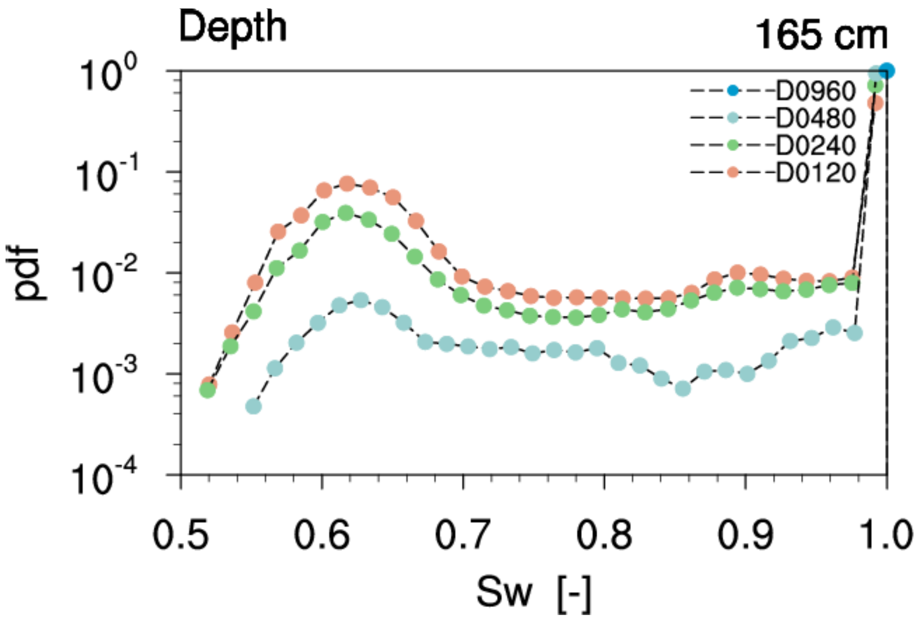

Sw: Relative Soil Moisture [-]

Effect of Model Scale on Soil Temperature

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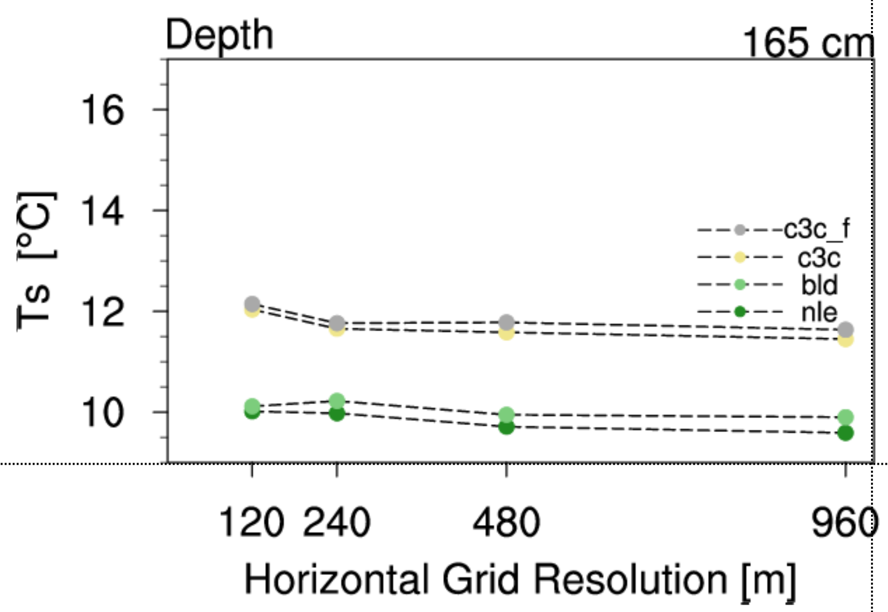
Spatio-temporal Mean (Apr. – Sept.)



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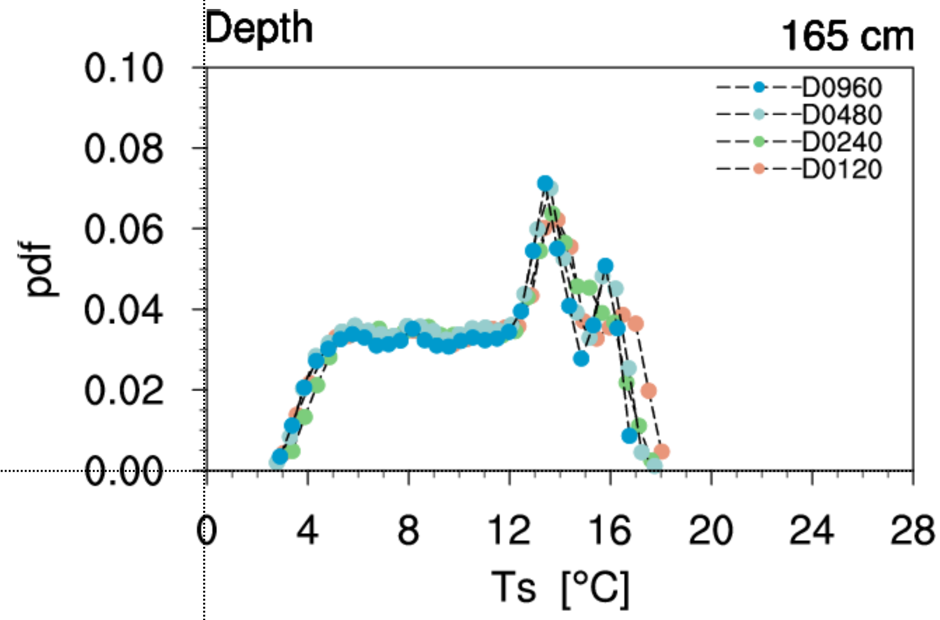

Ts: Soil Temperature [°C]

Effect of Model Scale on Surface Fluxes

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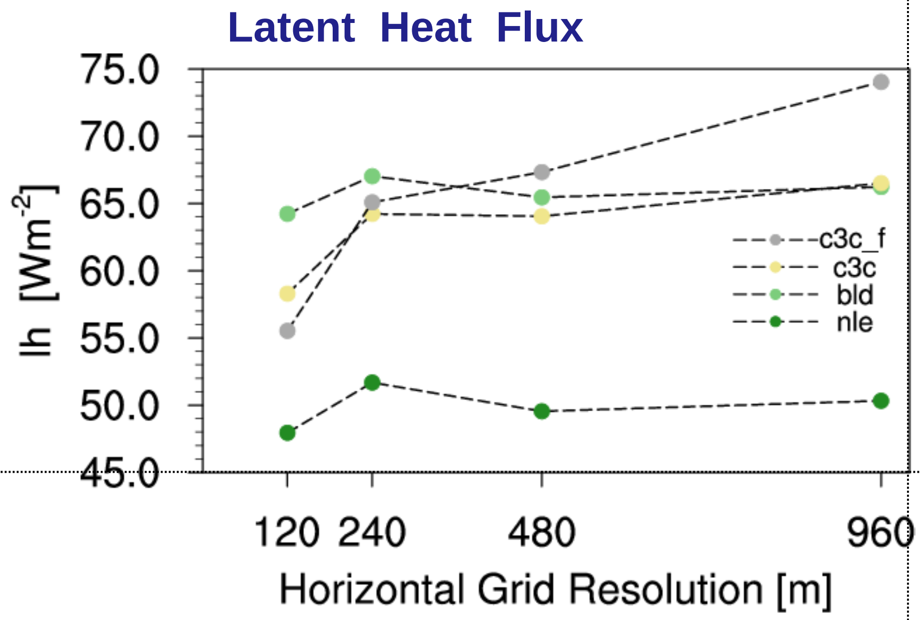
Spatio-temporal Mean (Apr. – Sept.)



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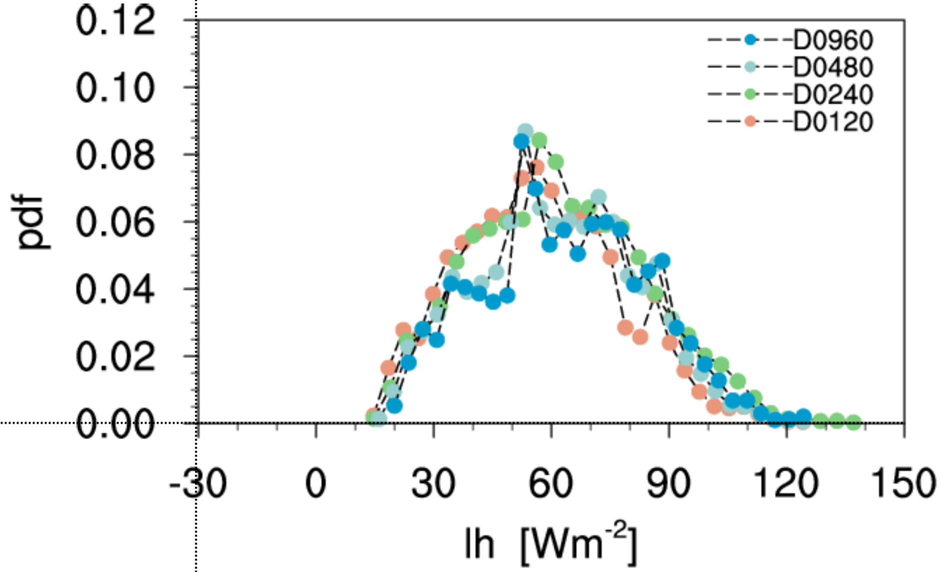

Change from 120m ~ 960m	c3c	c3c_f
sh (Wm^{-2})	-6.6	-14.3
lh (Wm^{-2})	+8.2	+18.5

sh : Sensible Heat Flux [Wm^{-2}], lh: Latent Heat Flux[Wm^{-2}]

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Discussion: Effect of coarsening on Slopes

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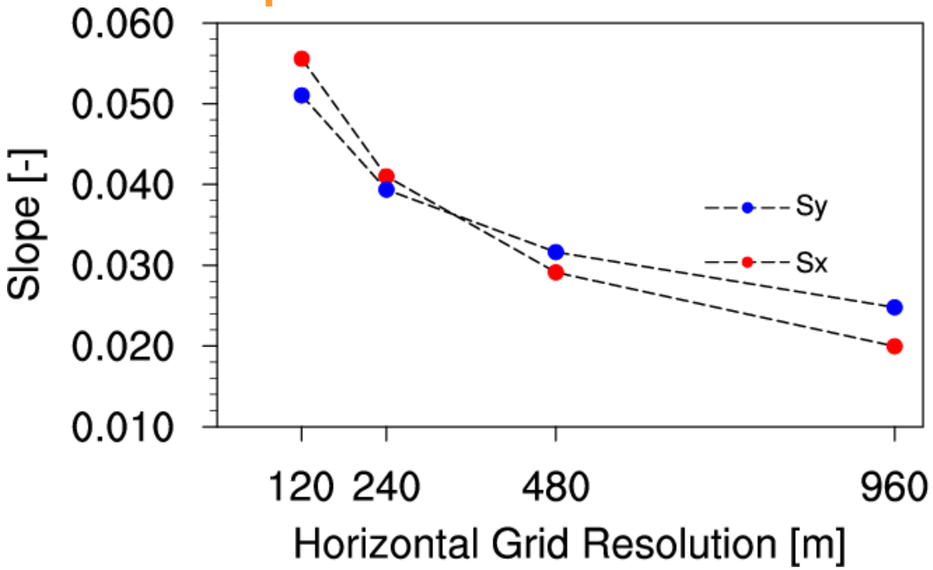
Spatial Mean



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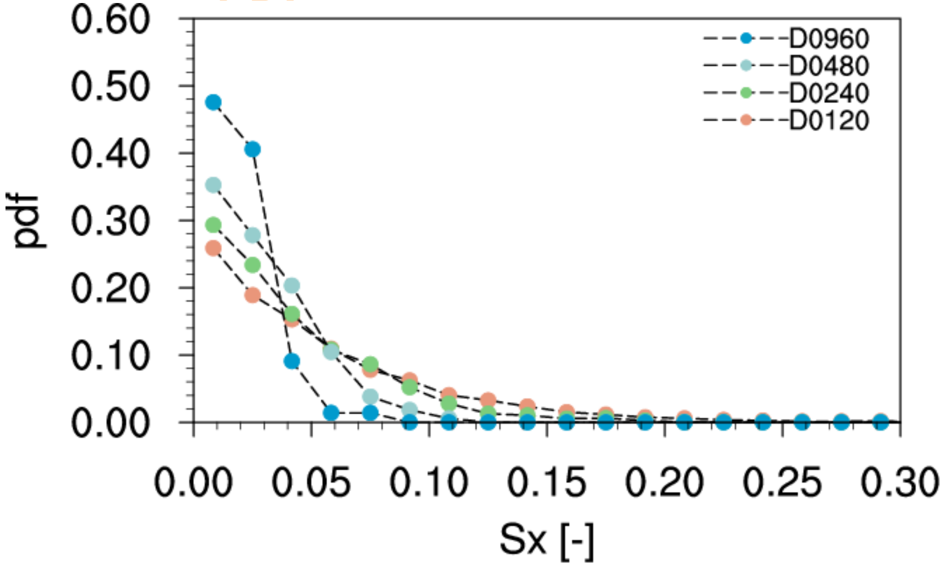

Coarsening of model scale:

- Decrease in mean subcatchment slope
- Shift in the pdf of x-dir (Sx) and y-dir (Sy) slope towards lower magnitude.
- Reduction in surface drainage
- Reduction of base flow

Conclusions:

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1. 20% increase in mean relative soil moisture (Sw) , Δx 120 m → 960m
2. Vegetation cover attenuates the scale dependence of soil moisture
3. Magnitude of attenuation depends upon the transmissivity of radiation
4. Consistent decrease in mean soil temperature (Ts) and sensible heat flux (sh)
5. Increase in mean latent heat flux (lh)
6. sh changed by -6.6 / -14.4 Wm-2 for c3c and c3c_f
7. lh changed by +8.2 / +18.5 Wm-2 for c3c and c3c_f
8. PDF of lh shift towards higher value
9. PDF of Ts and sh shift towards lower value

- **Coarsening of model scales affect mass and energy balance of the system**
- **Modeling scale is important to study the effect of groundwater on land-atmosphere interactions, when coupled to atmospheric model**

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