The impact of high resolution soil on surface fluxes in JULES

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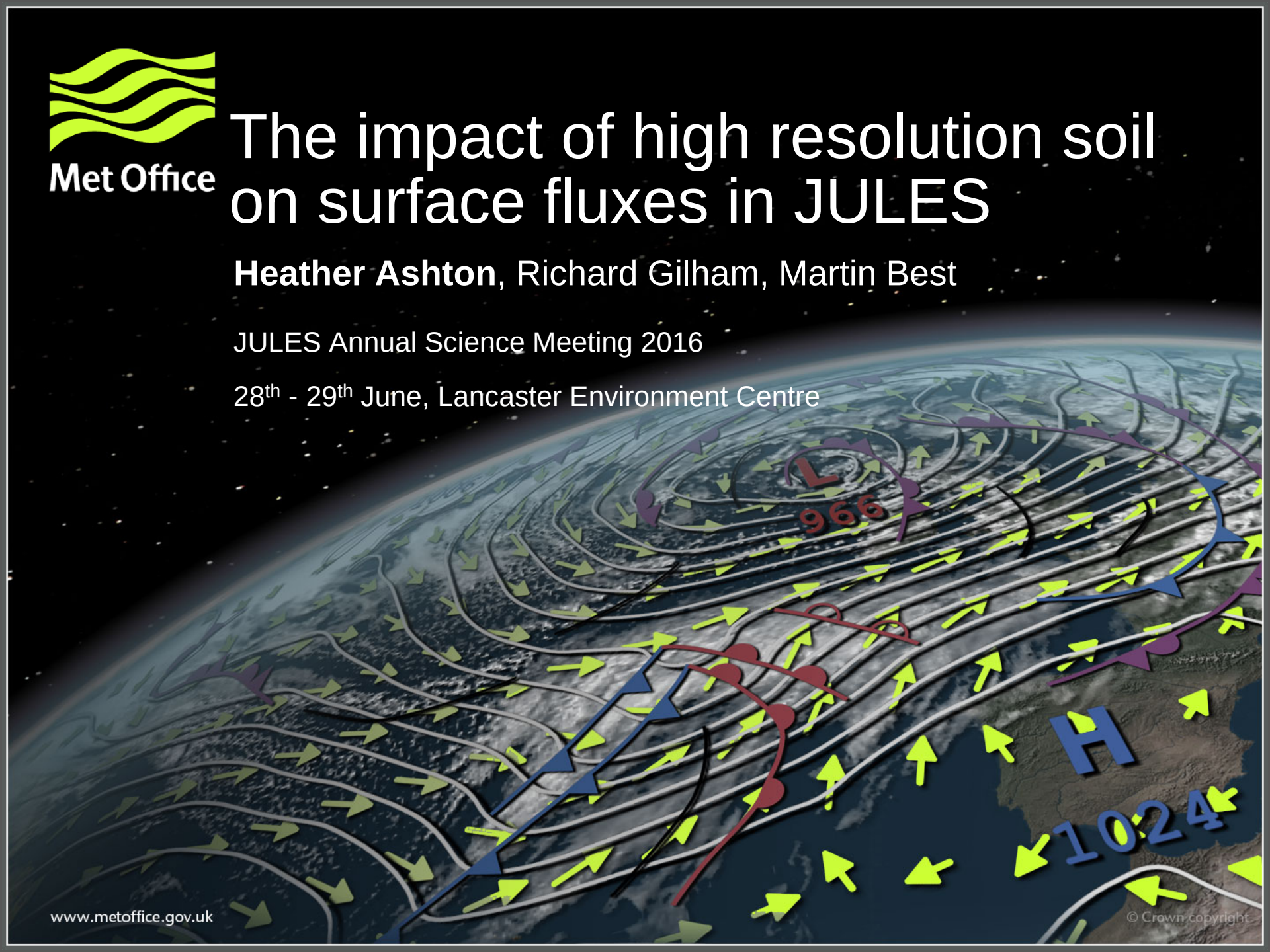


Outline

- Motivations
- New JULES with flexible surface and soil tiling capability
- Experimental configurations
- Results
- Conclusions

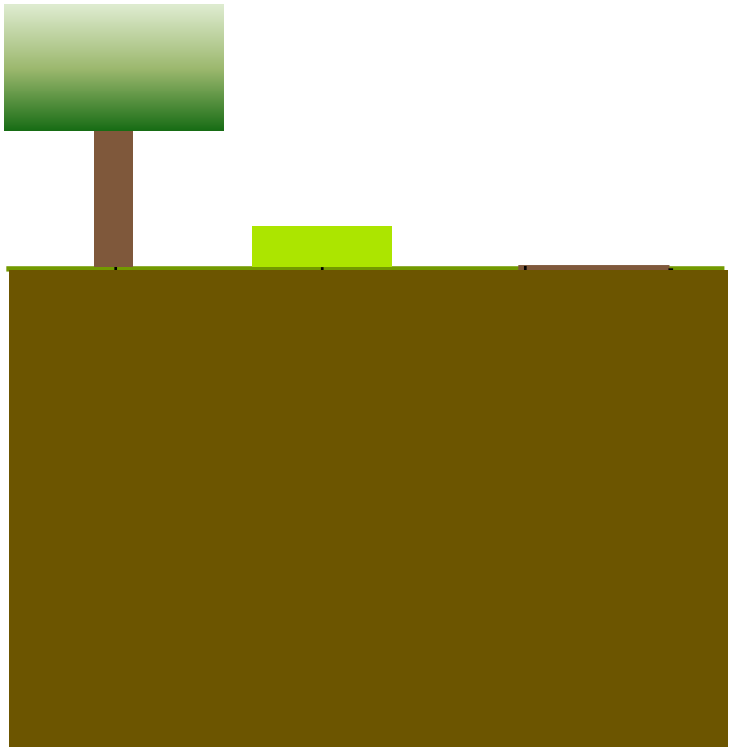
Motivation

• Evapotranspiration from a vegetated surface depends on how much water can be extracted by the plants.

• Dependant on the root zone distribution and the type of soil(s) present.

‘Real world’

‘Modelling world’



How can we model soil heterogeneity?

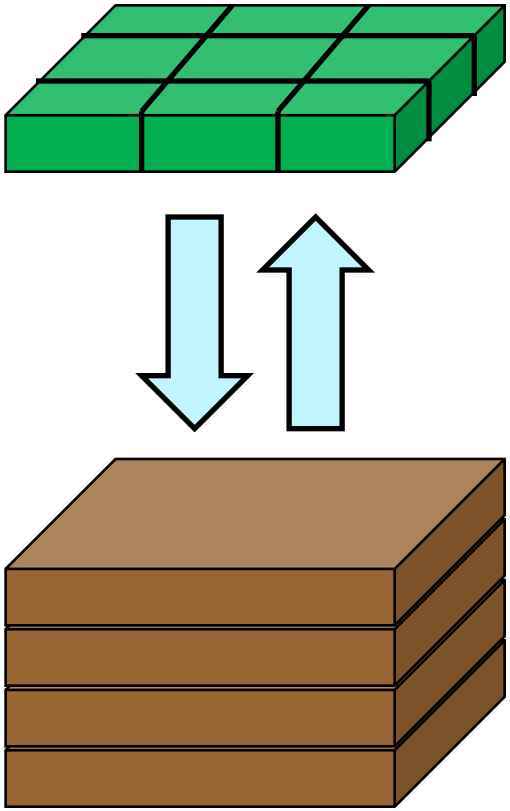
Introducing soil tiles…

Surface types (trees, grasses, bare soil...)

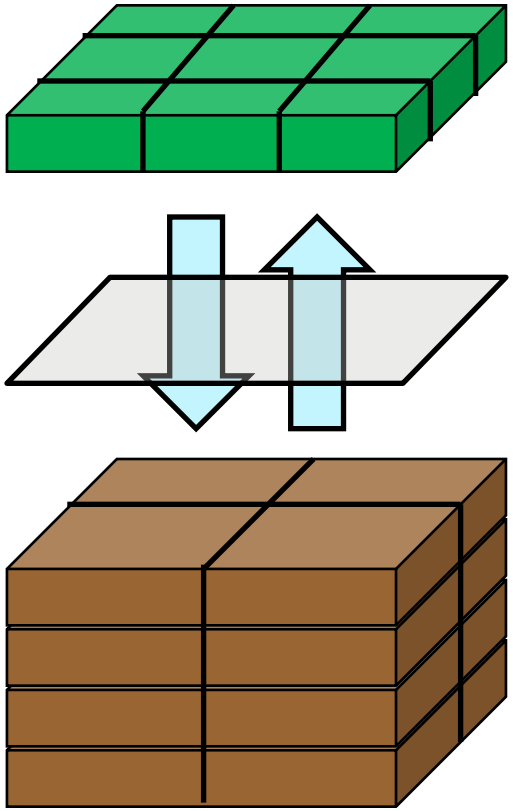
Surface-soil processes (infiltration, extraction, evaporation...)

Soil types (clay, loam...)

Standard JULES



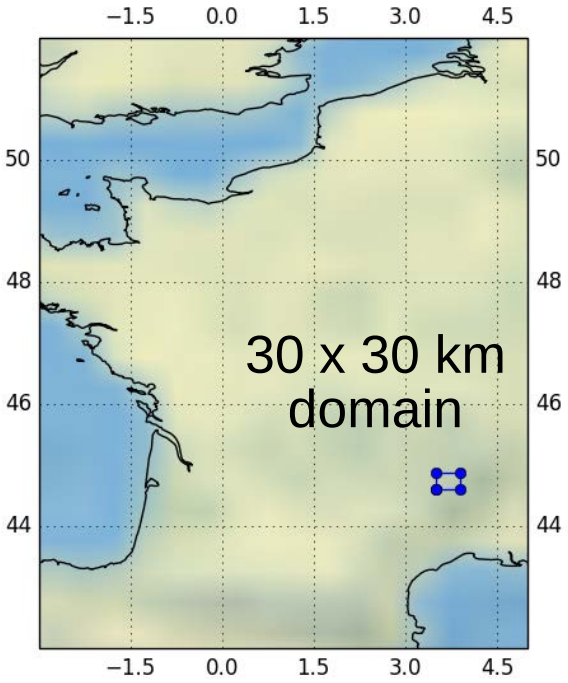
Soil-tiled JULES



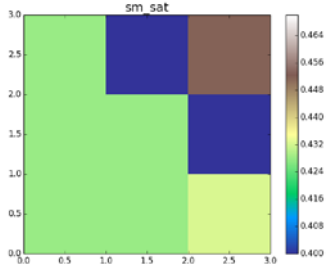
Transmogrifier
- Manages overlap of surface and soil tiles
- Proportionate distribution of fluxes
- Highly flexible configuration options

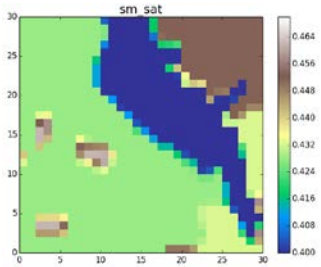
Domain and Setup

- JULES vn3.4.1 with operational UK forecast model configuration
- HWSD soils, IGBP surfaces
- 1km meteorological driving data from offline Unified Model nested suite run (1 year - 2011).

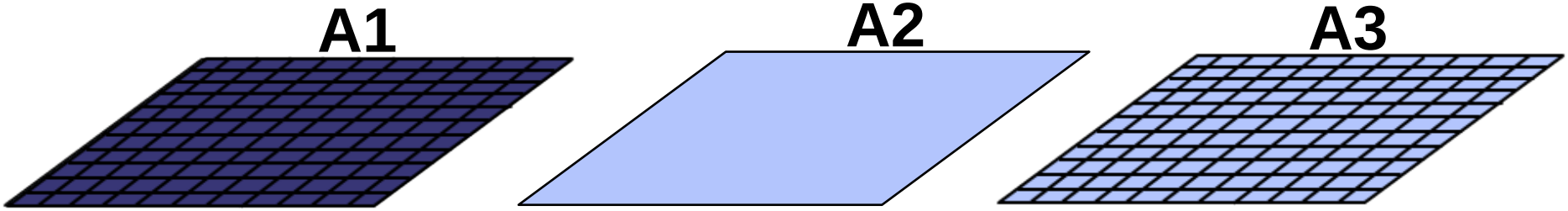


- Synthesis experiment
- Domain choice based on
  - i. Heterogeneity in soil type
  - ii. Intensity of summertime convective rainfall





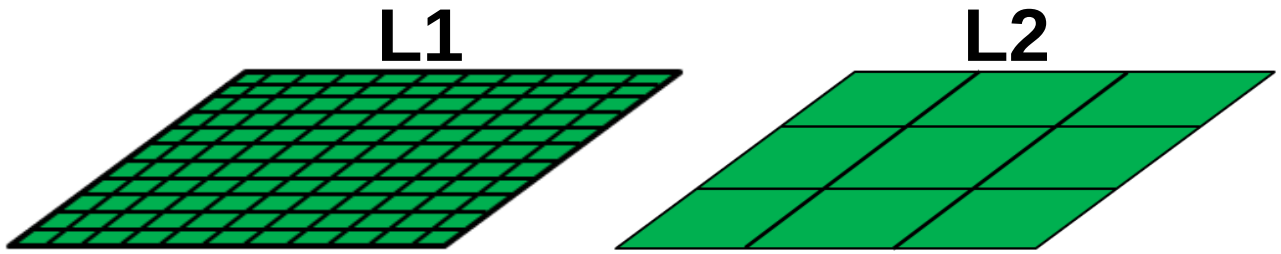
Atmosphere & Land Configurations



1km

10km

1km Average Meteorology

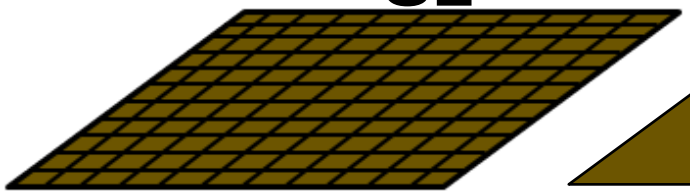


1km – 100 predominant surface types

10km – 9 surface types

Soil Configurations

S1

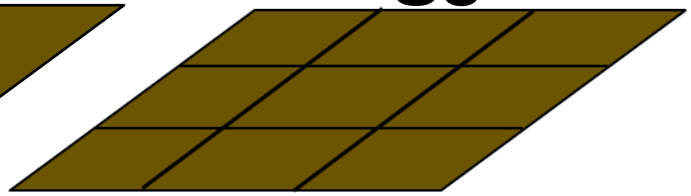


1km –
100 Soils

S2

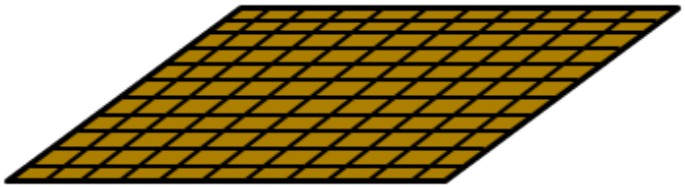
10km – 1 predominant soil

S3

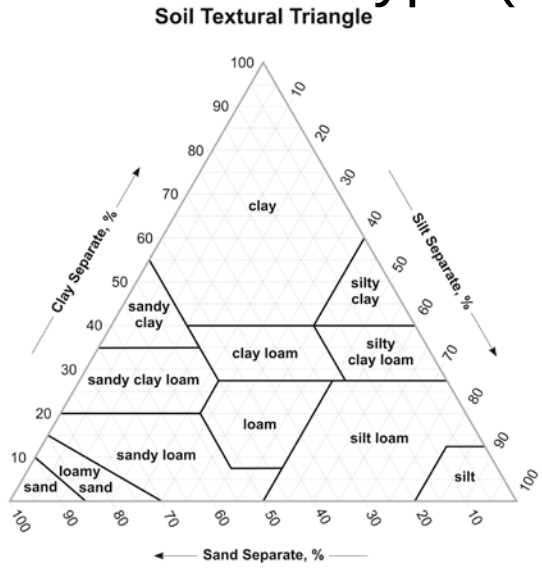


10km – predominant soil for each surface type (i.e. x9)

S4

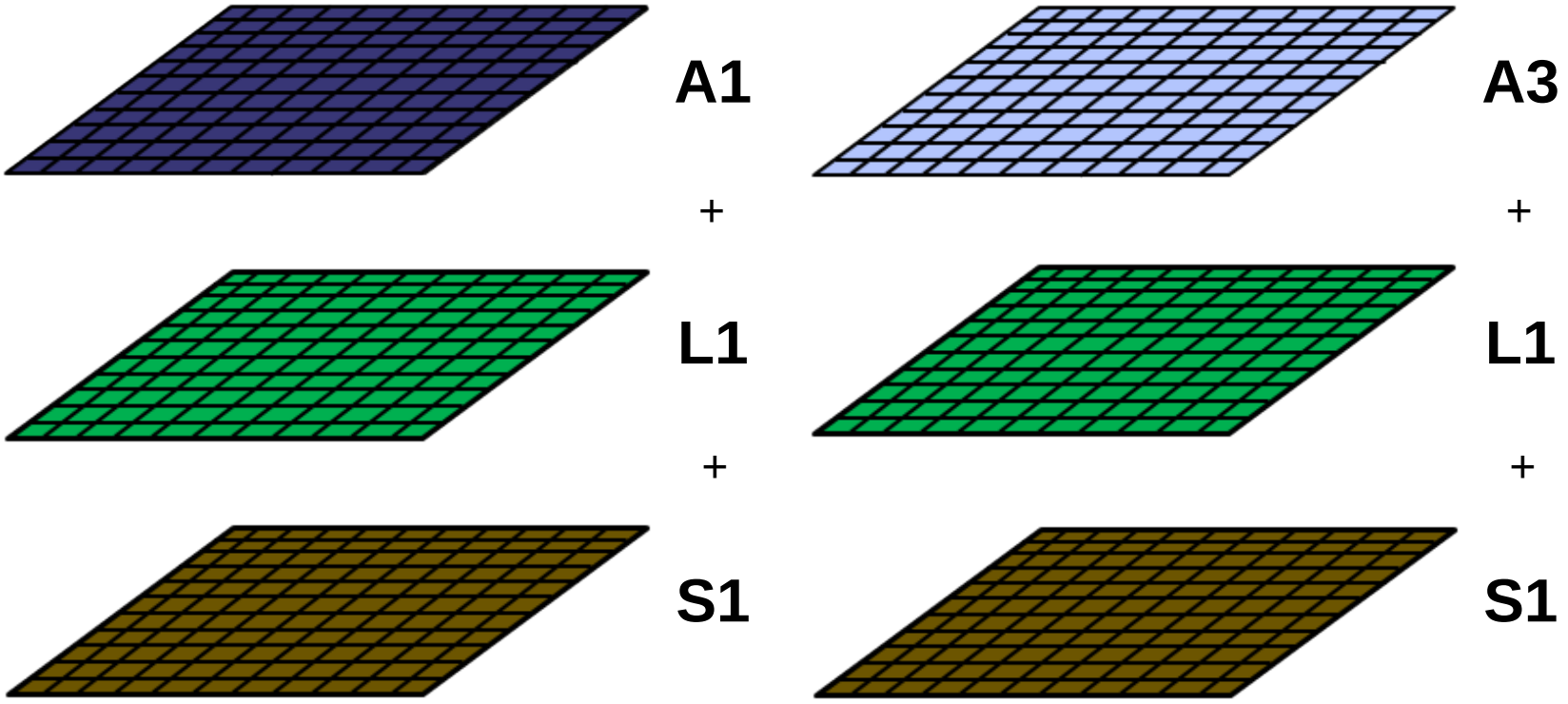


1km – 12 soil textural classes



High vs. Low Resolution Forcing

1km runs with High Resolution Forcing Vs.
Low Resolution Forcing, No Soil Tiling

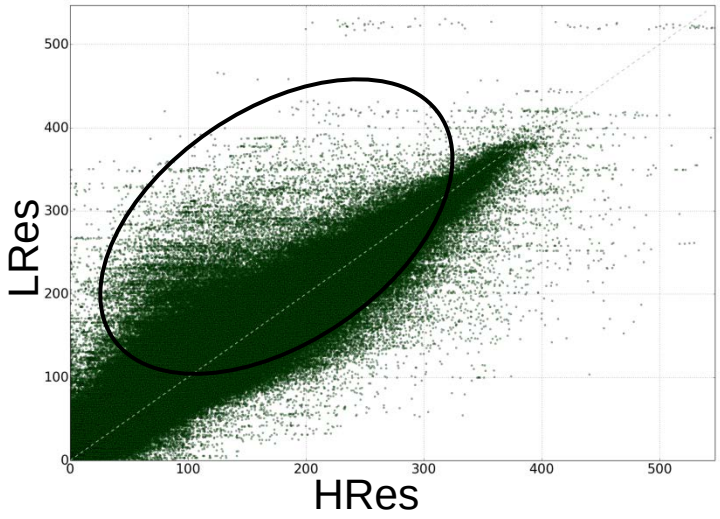


‘HRes’

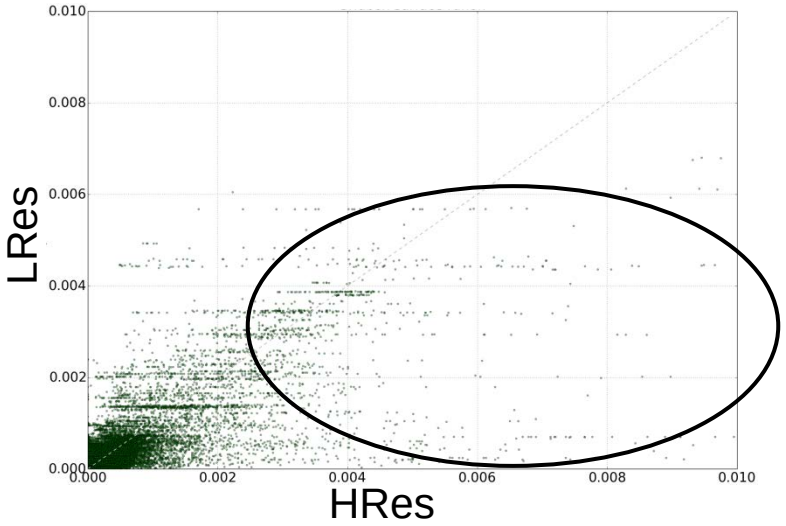
‘LRes’

Resolution Impact of forcing data

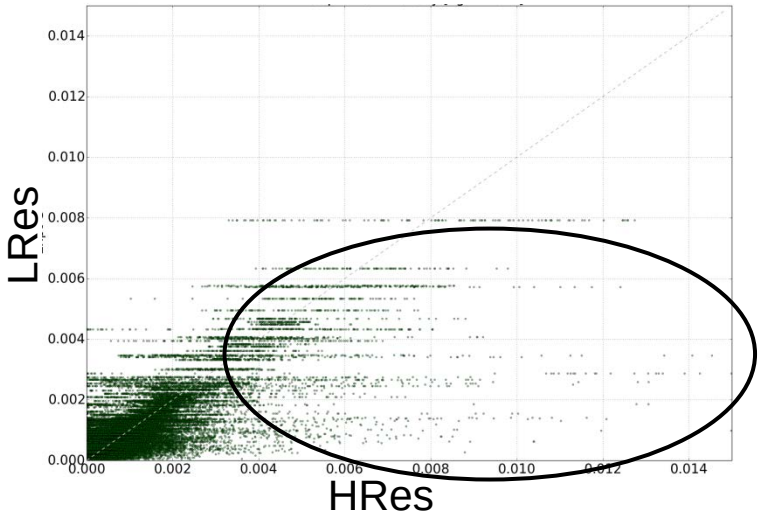
JJAS Latent Heat Flux



JJAS Surface Runoff



JJAS Precipitation Rate



Positive latent heat bias from LRes run

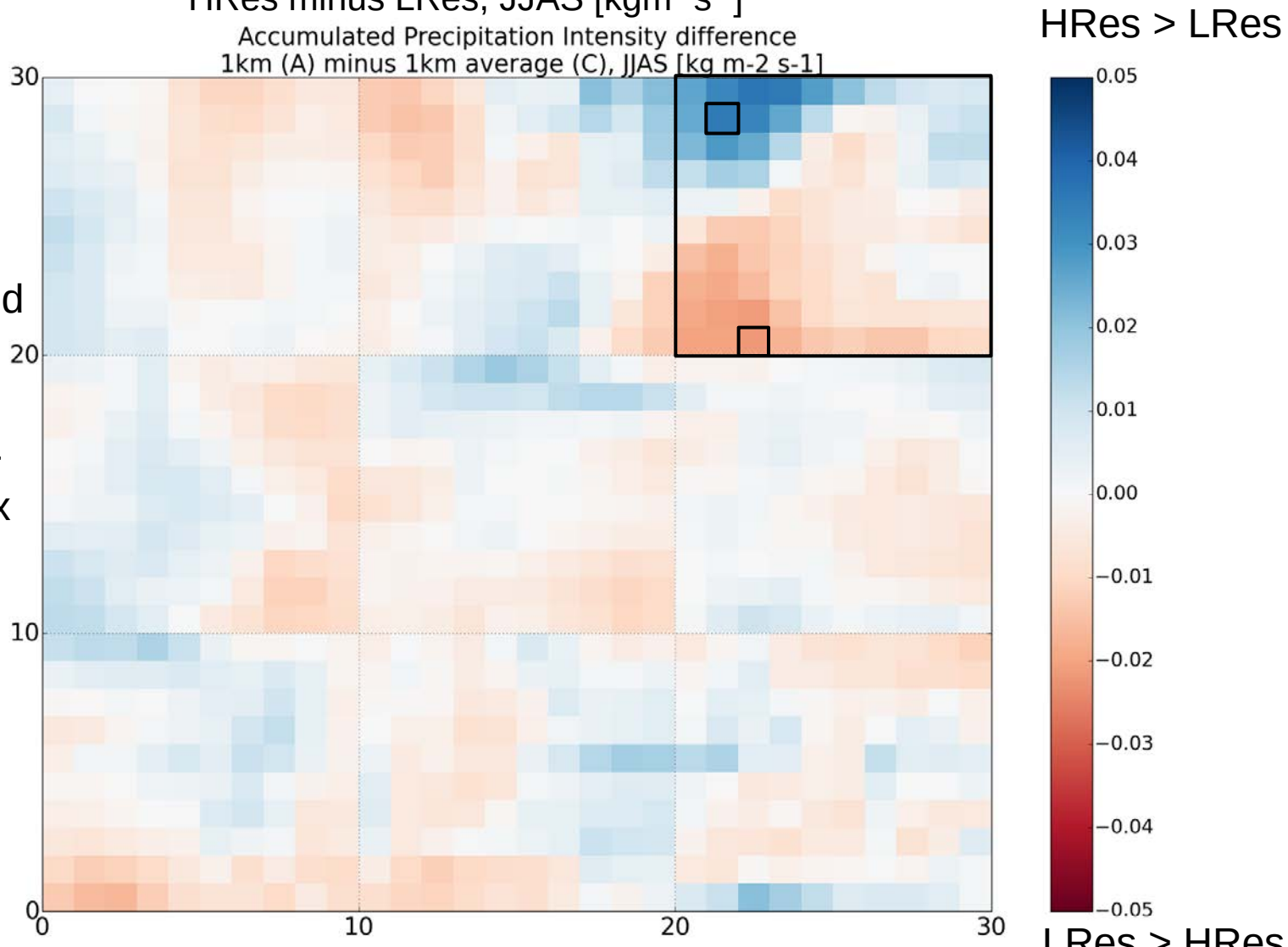
More intense precipitation rates captured in higher resolution meteorological forcing → more surface runoff

Resolution Impact of forcing data

Accumulated Precipitation Intensity Differences
HRes minus LRes, JJAS [$kgm^{-2}s^{-1}$]

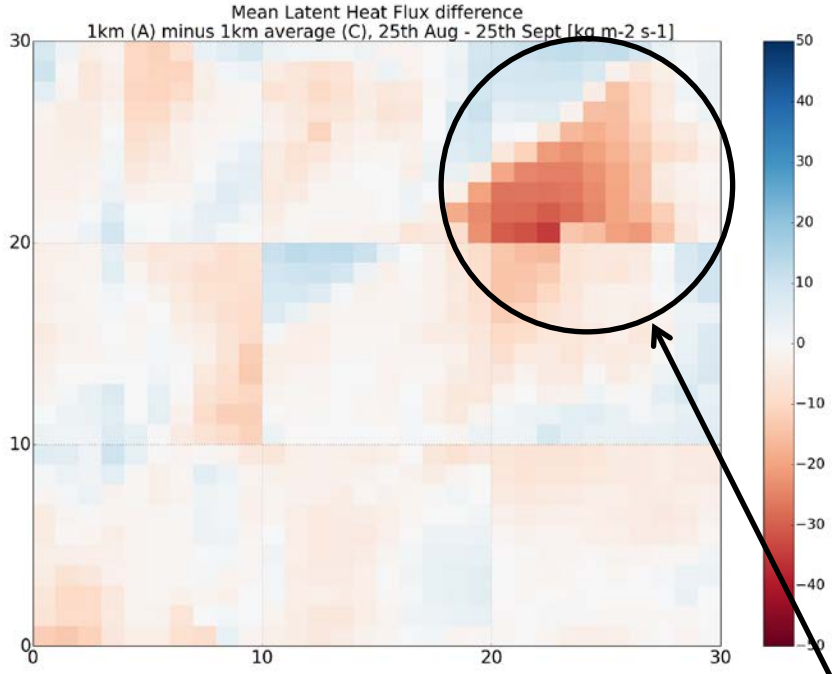
HRes:-
Spatial variability over 10x10km grid box

LRes:-
Single value over 10x10km grid box

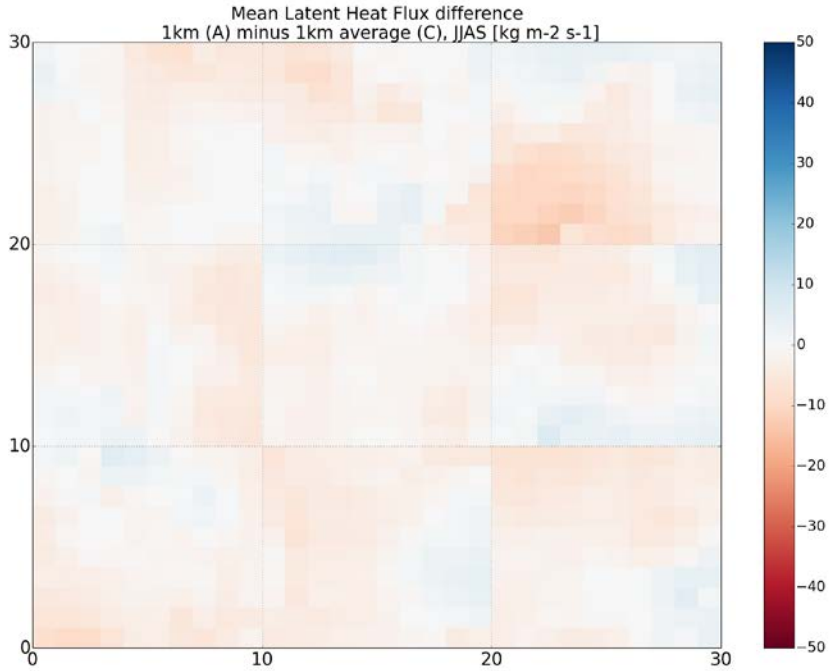


Resolution Impact of forcing data

Mean Latent Heat Flux Difference (HRes minus LRes)



25th Aug – 25th Sept 2011

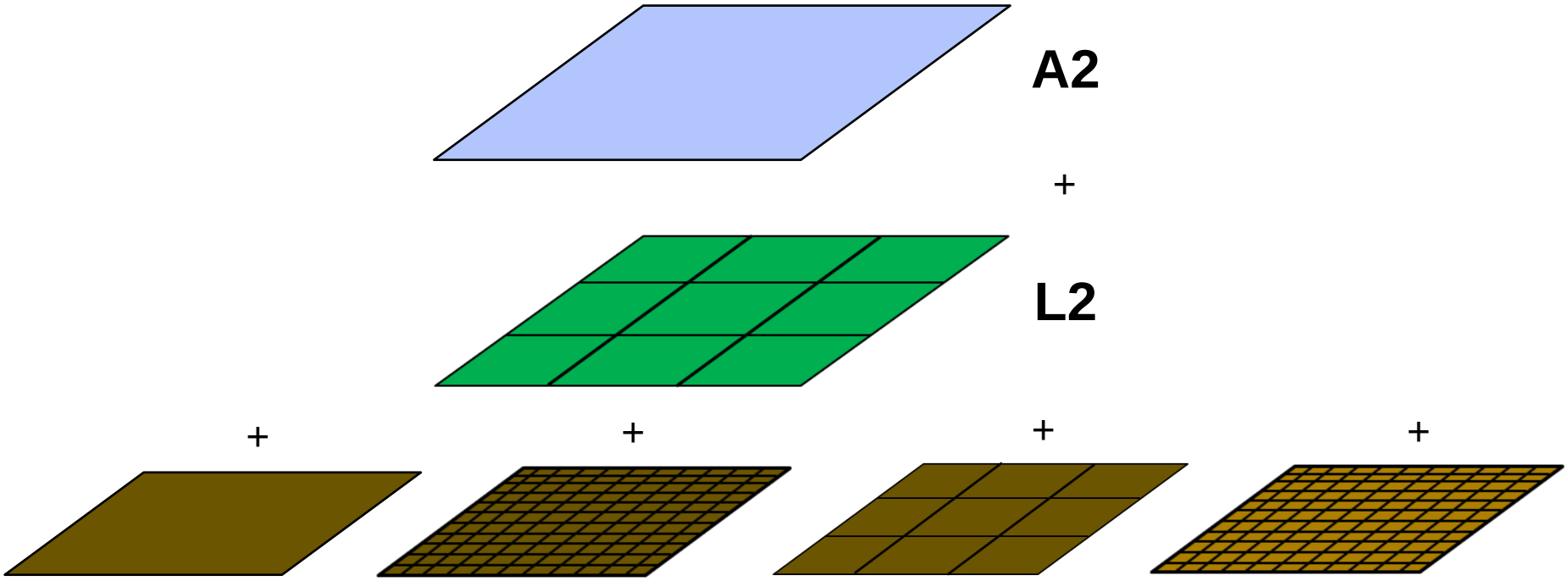


June – Sept 2011

Larger latent heat flux difference

Compare all soil tiling experiments back to LRes Run...

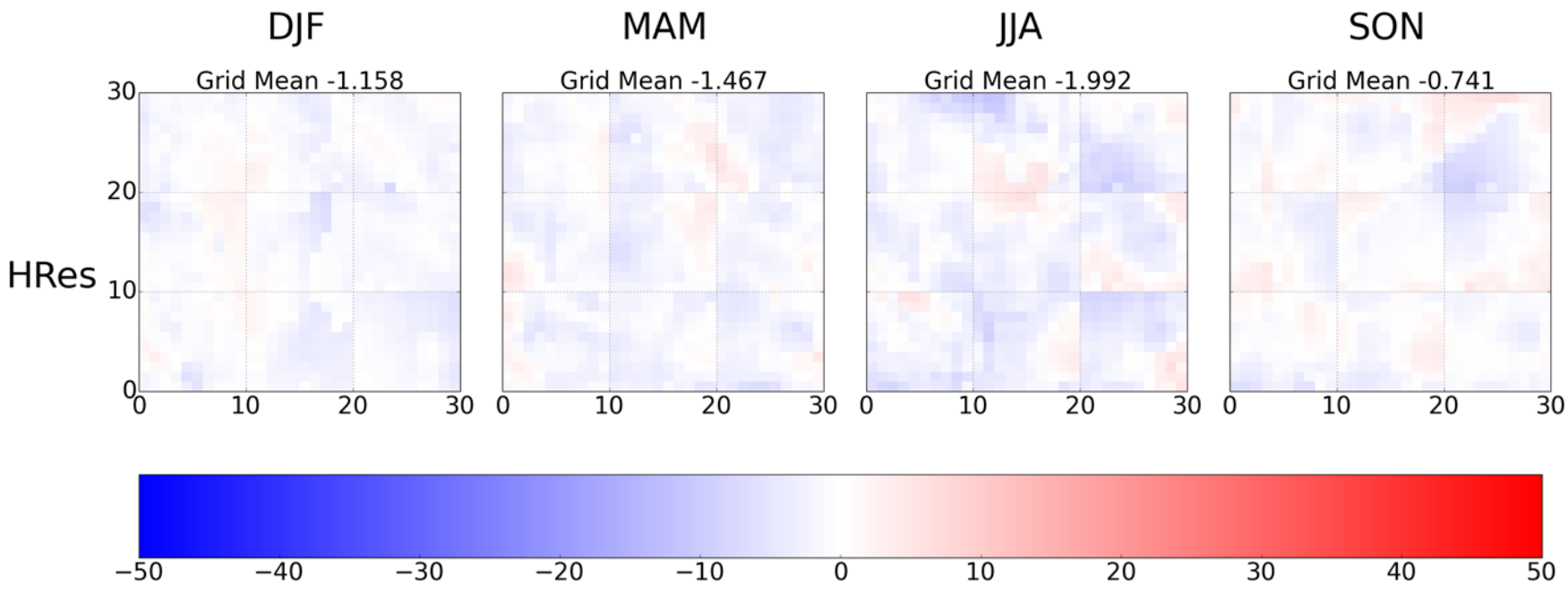
Soil Tiling Experiments



S2	S1	S3	S4
Expt B: 10km, no soil tiling Default Configuration	Expt D: 10km, soils tiled by 1km high res. soils defined by HWSD	Expt E: 10km, soils tiled by surface type	Expt F: 10km, soils tiled by 1km high res. soils defined by texture class
'DC'	'Cont'	'Surf'	'Tex'

Seasonal mean differences in Latent heat flux (Wm^{-2})

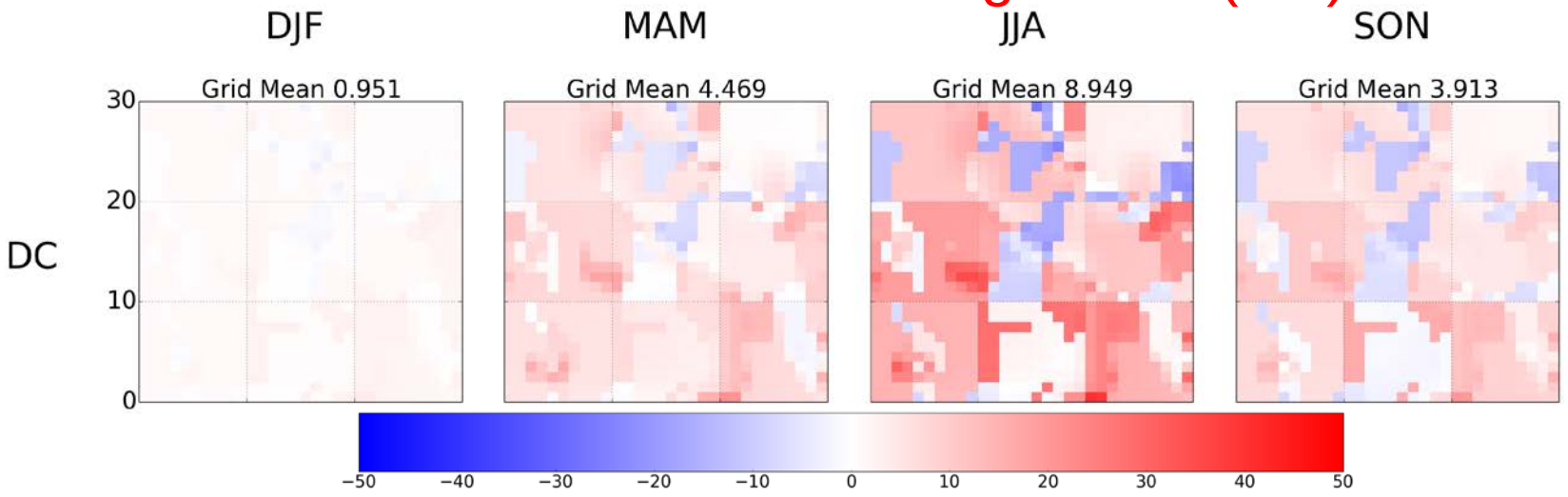
HRes minus LRes

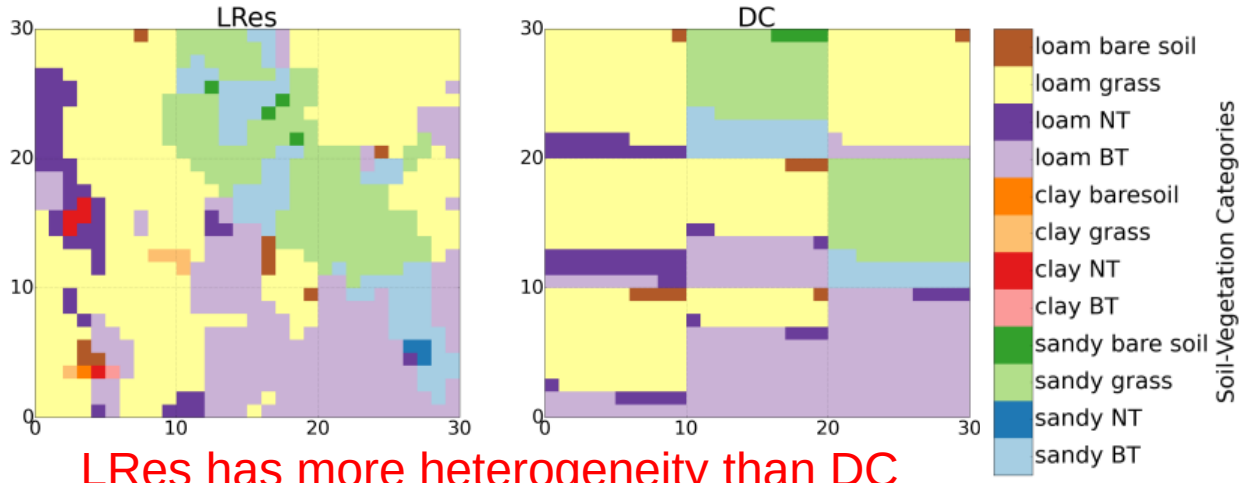


- Demonstrates impact of changing resolution
- Seasonal differences to be of order ± 10 Wm^{-2}
- Same order of magnitude to differences generated by other experiments

Seasonal mean differences in Latent heat flux (Wm^{-2})

Default 10km JULES configuration (DC) minus LRes



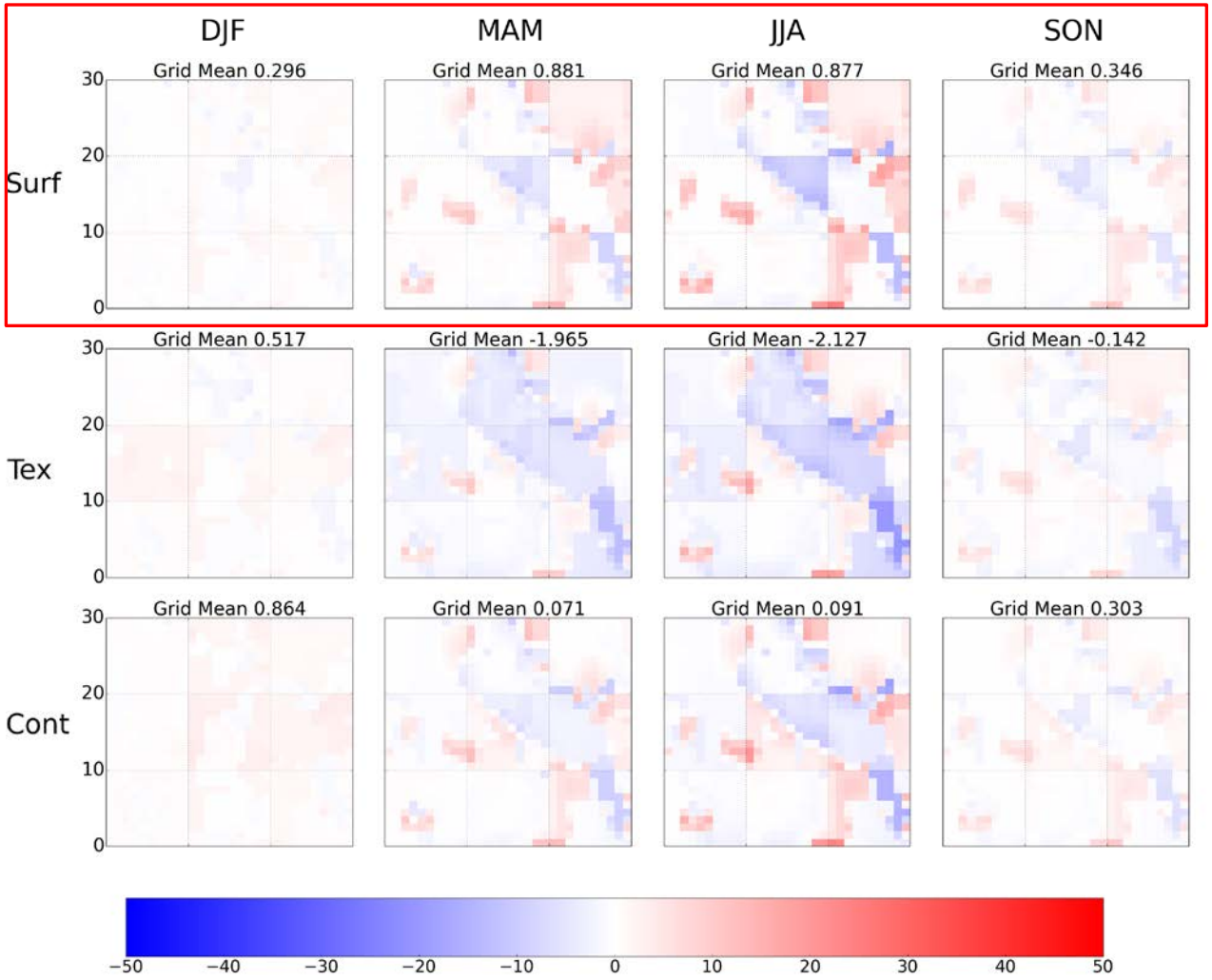


LRes has more heterogeneity than DC

- Differences mostly +ve
- Surface tile fractions differ between runs.
- Impacts the amount of water extracted from the soil by the surface tiles

Seasonal mean differences in Latent heat flux (Wm^{-2})

Soil tiling expts minus LRes



- Increasing soil heterogeneity has generated a better 10km simulation than the DC.
- Majority of benefit has come from tiling by surface type.
- High resolution soils allows more degrees of freedom.

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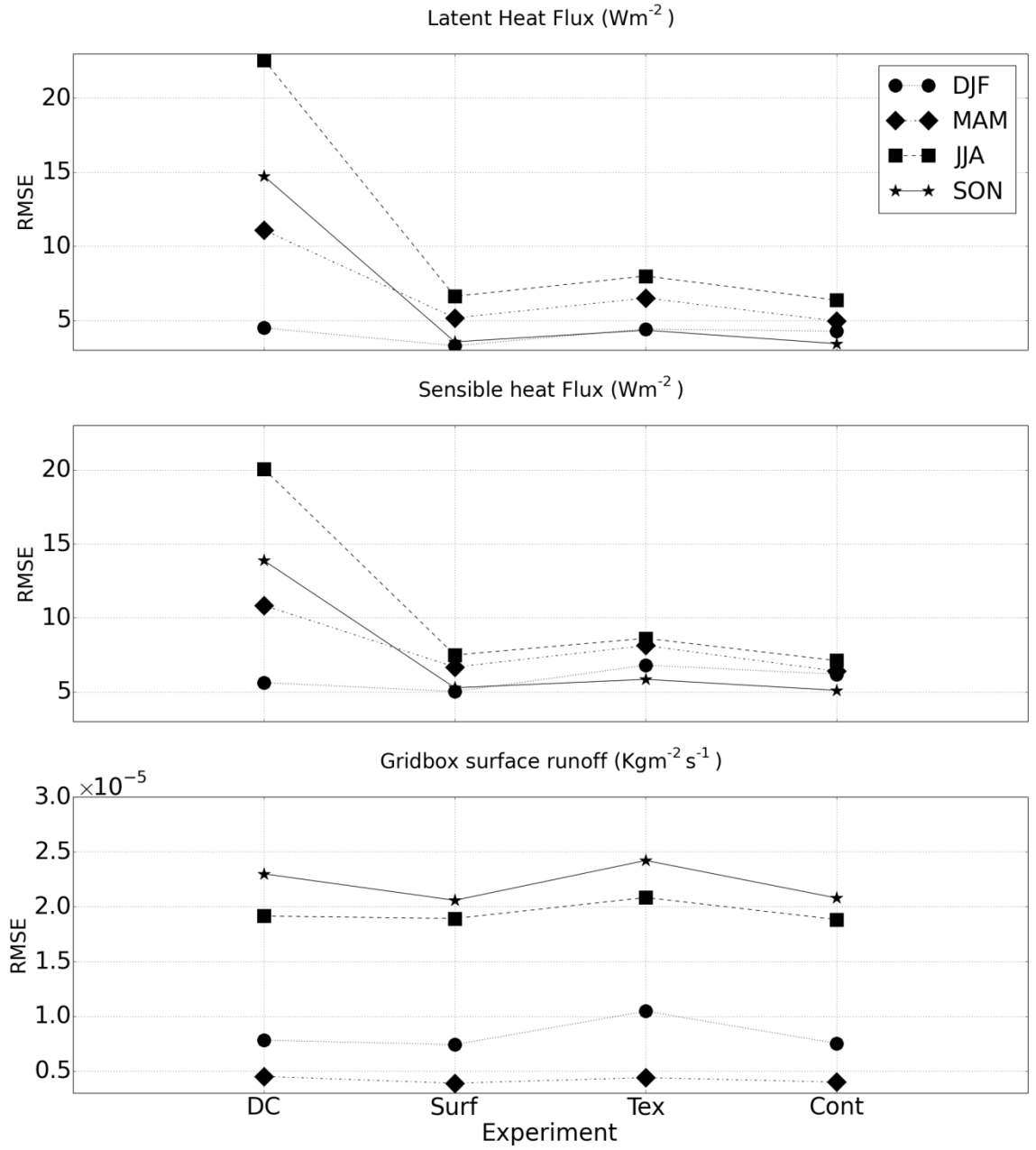
Grid mean RMSE for each experiment in order of increasing soil complexity:

- Largest differences between DC and Surf.
- Adding increased complexity adds very little benefit.
- Very little change in surface runoff.



Conclusions 1

- This study has explored the impacts of using high resolution soils.

- Changing the resolution of the forcing data (from1km to 10km) has an impact on model simulations.

- Strong seasonal differences in LE between LRes and DC, Surf, Cont and Tex, with largest differences in JJA.

- DC simulation has a large positive difference in LE due to having multiple surfaces sharing the same soil column.

Conclusions 2

- Tiling by surface (Surf) gives the largest improvement compared to DC, **but** Cont is the best method to represent the soil complexity - largest decrease in RMSE

- The high resolution experiments (Cont and Tex) don't give much additional benefit compared to Surf. Make the assumption that evaporation in linear with soil moisture stress.

- The results of this study could be different if lateral flow between soil columns was explicitly modelled.

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Any questions?