ETH zürich

Collective impacts of orography and soil moisture on deep convection

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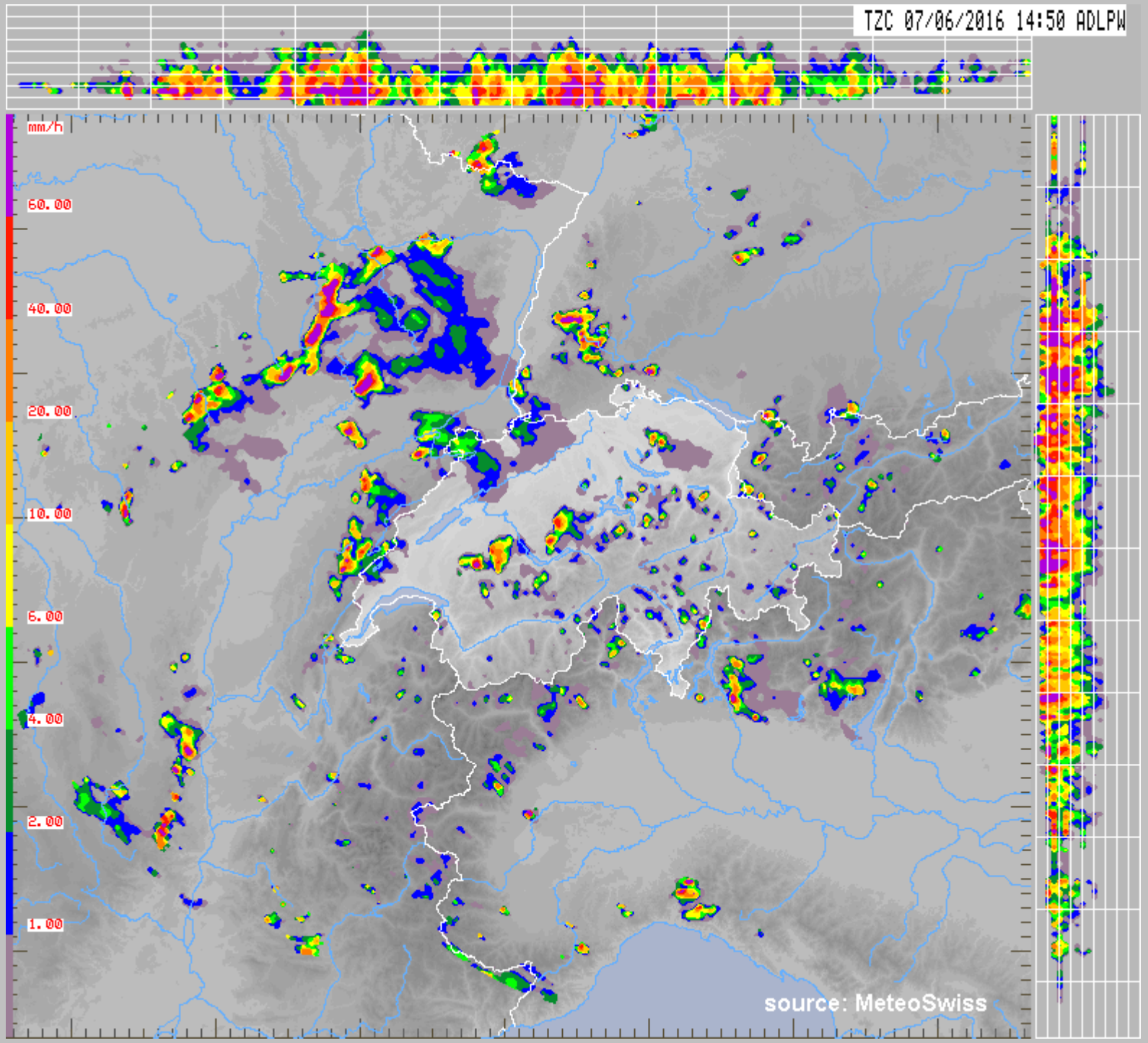
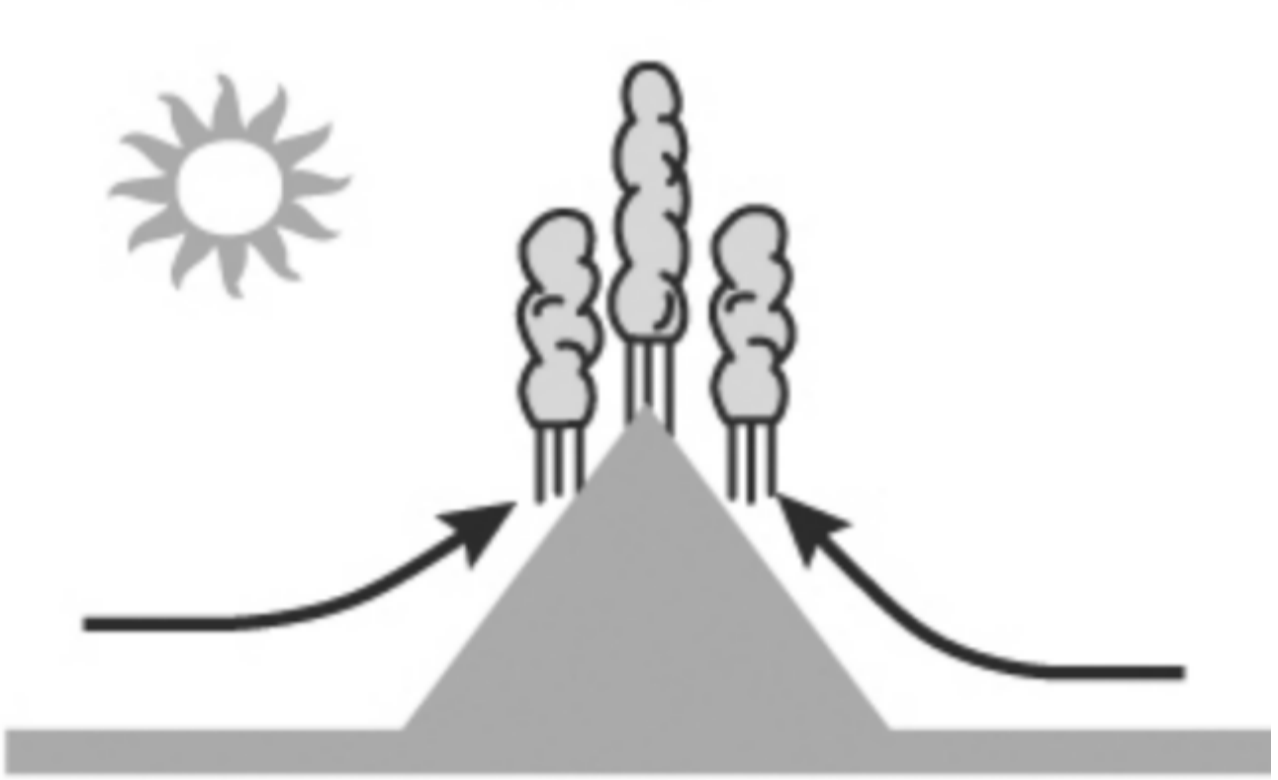
Offenbach 7th March 2017

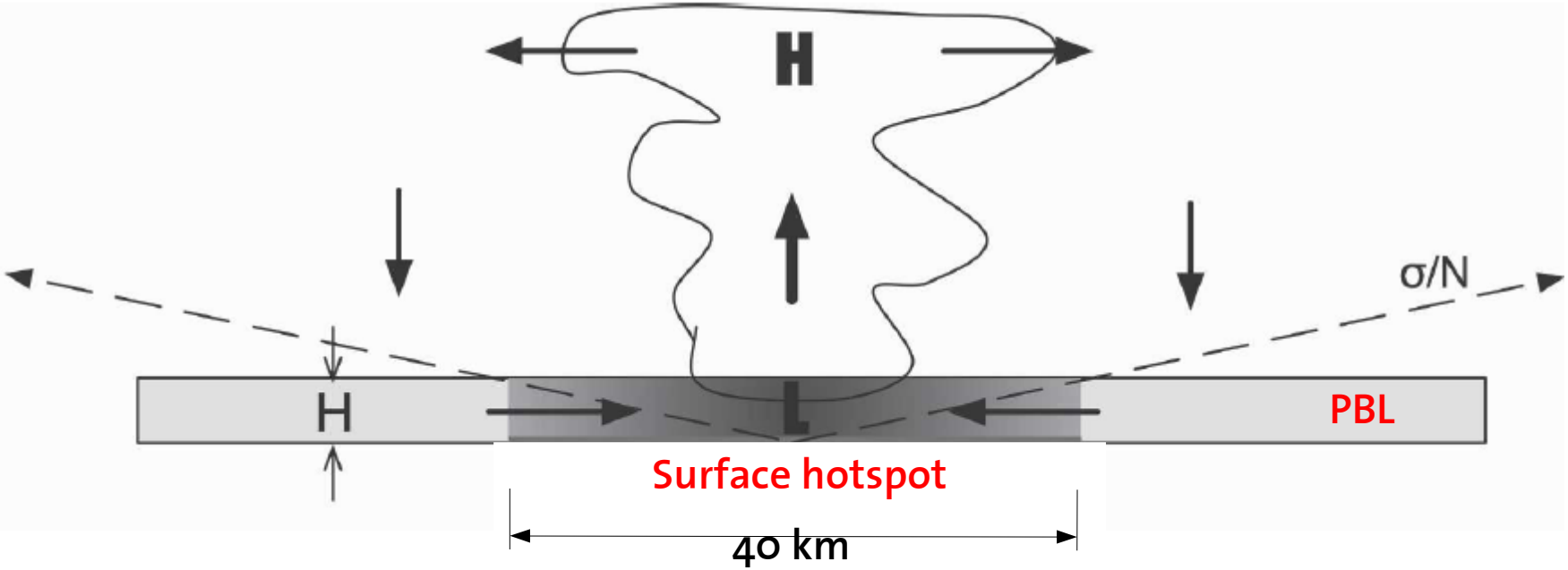

TZC 07/06/2016 14:50 ADLPW
mm/h
60.00
40.00
20.00
10.00
6.00
4.00
2.00
1.00
source: MeteoSwiss

Mountains as elevated hotspots



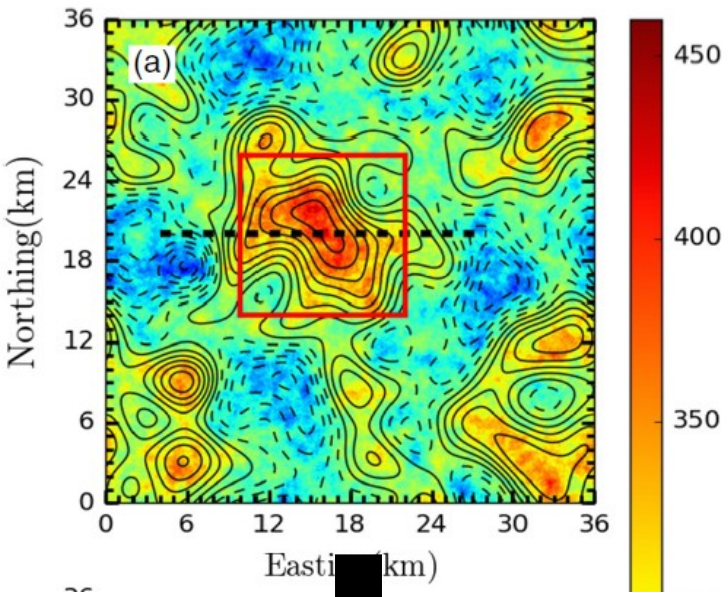
Houze (2012; Rev. Geophys.)

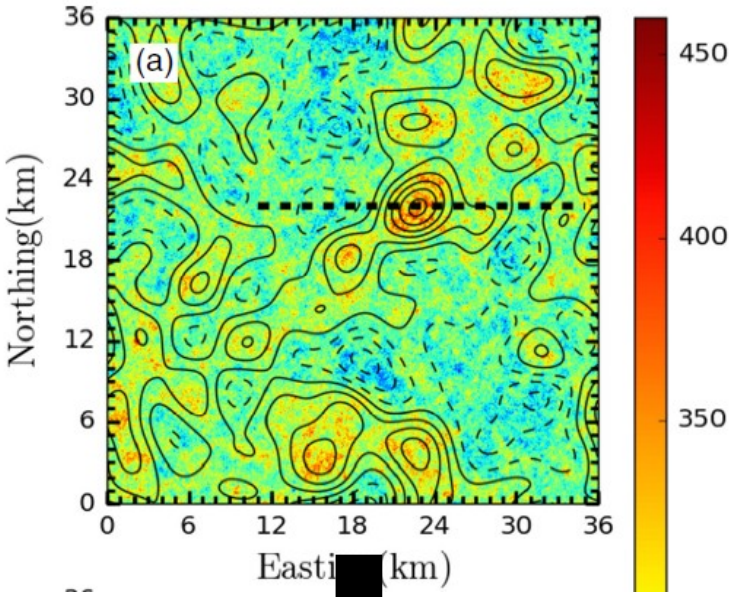
In absence of orography?



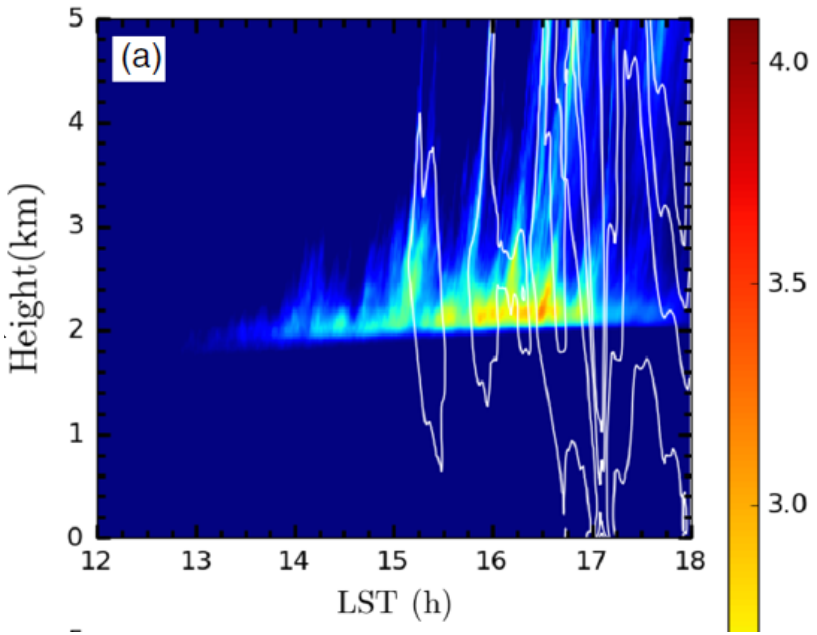
Robinson et al. (2007; JAS); Cronin et al. (2014; JAS)

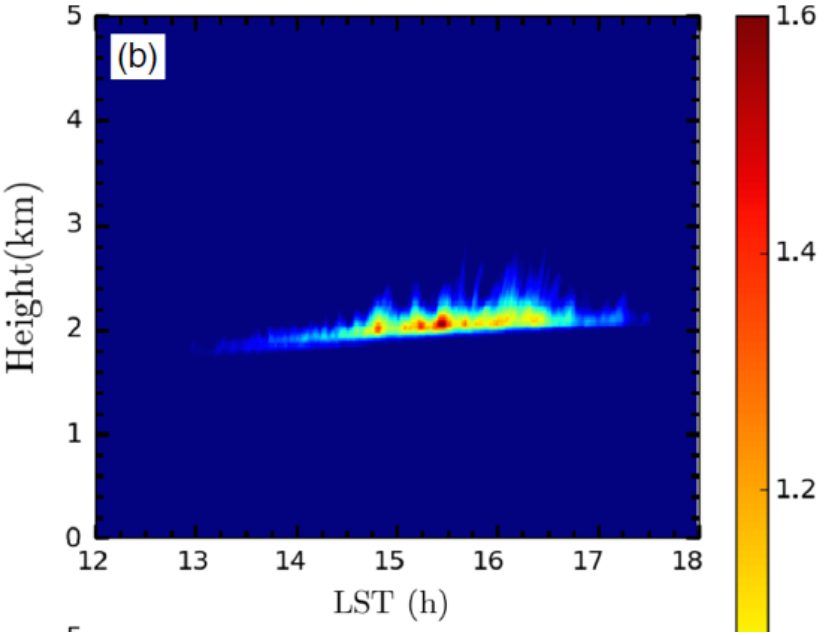
Sensible Heat Flux





Cloud Water

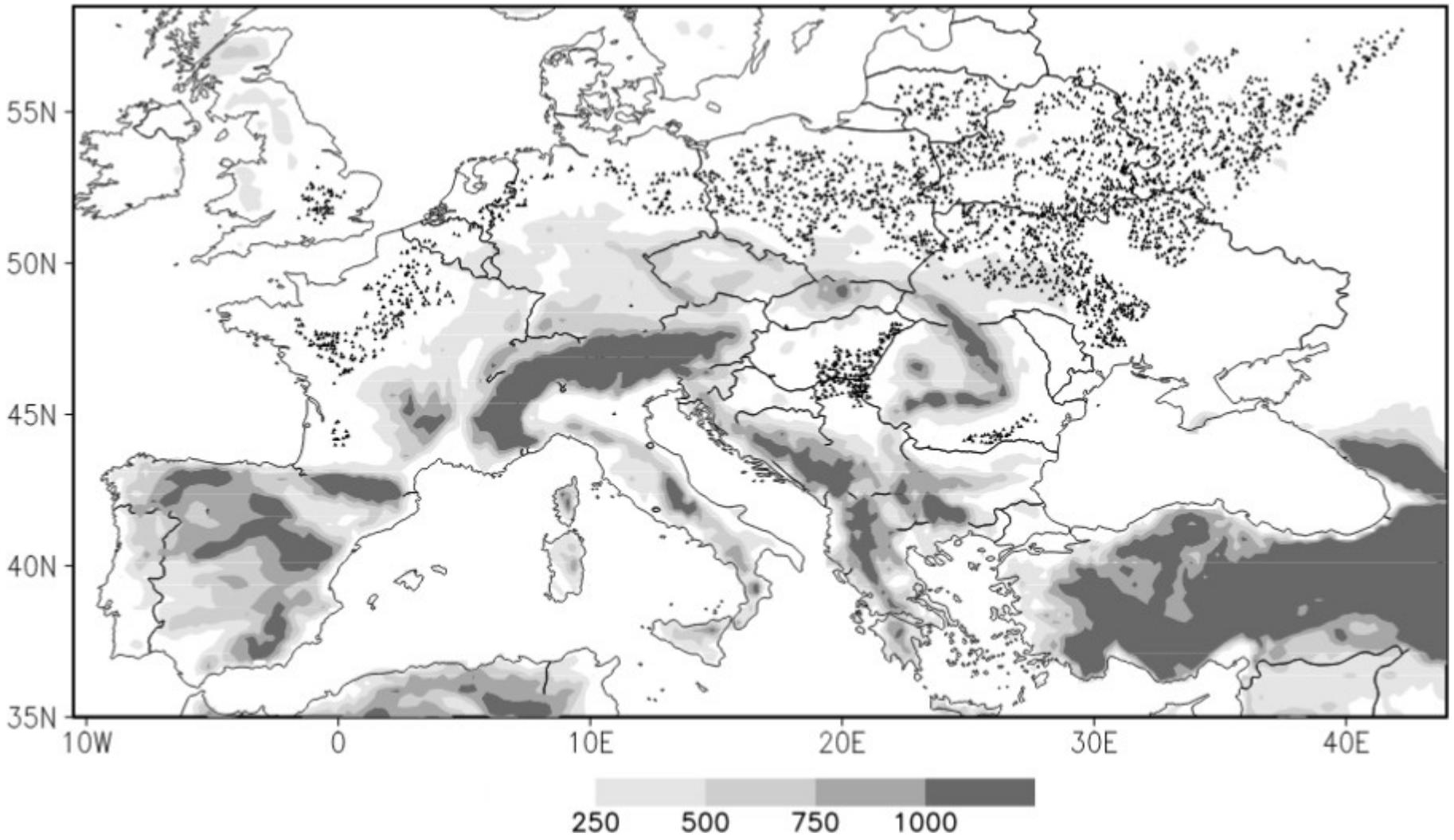




Kang and Ryu (2016,QJRMS)

Soil moisture heterogeneity → Patchiness of surface heat fluxes → Deep convection

Observational evidence over flat terrain



Taylor (2015; GRL)

- How do the impacts of soil-moisture heterogeneity and an isolated mountain quantitatively compare in terms of convective vigor, location and timing?

- To what extent is the combined impact additive?

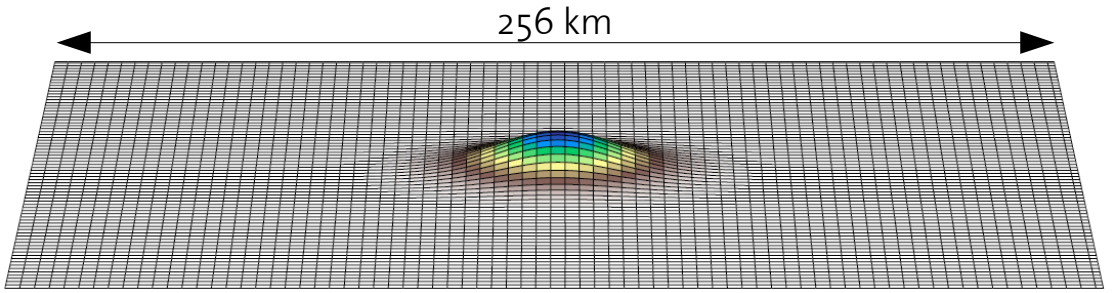
Numerical experiments

- Cosmo v4.28
- 256 x 256 x 50 grid points
- $\Delta x = 1$ km
- $T = 5$ days, 5 ensemble members

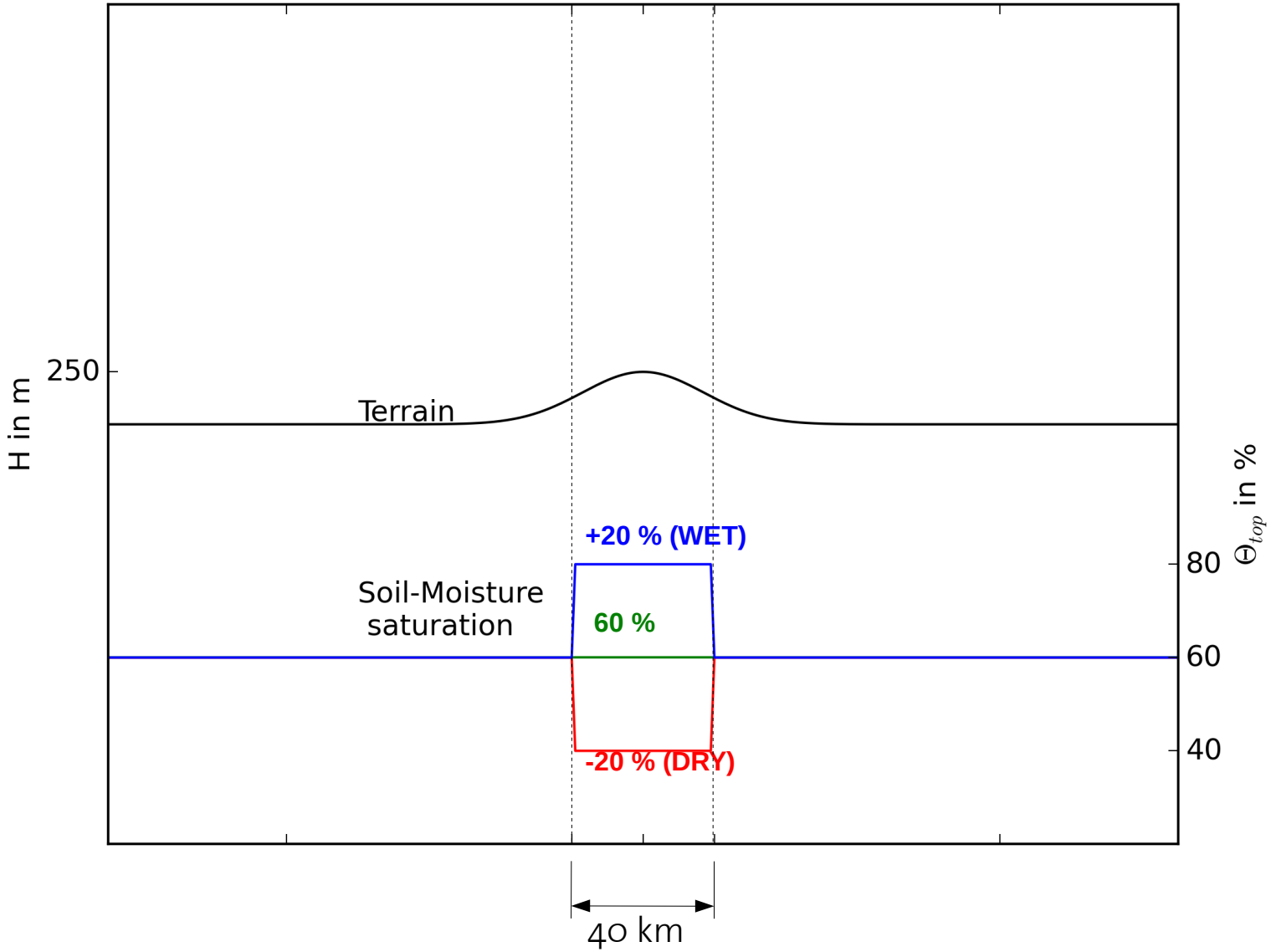
- Idealized landsurface
- Cyclic boundary conditions
- TERRA_ML, soil moisture prescribed
- Mideurope summer insolation

- Sounding: - 7 K/km, RH profile after Schlemmer et al. (2011), no wind

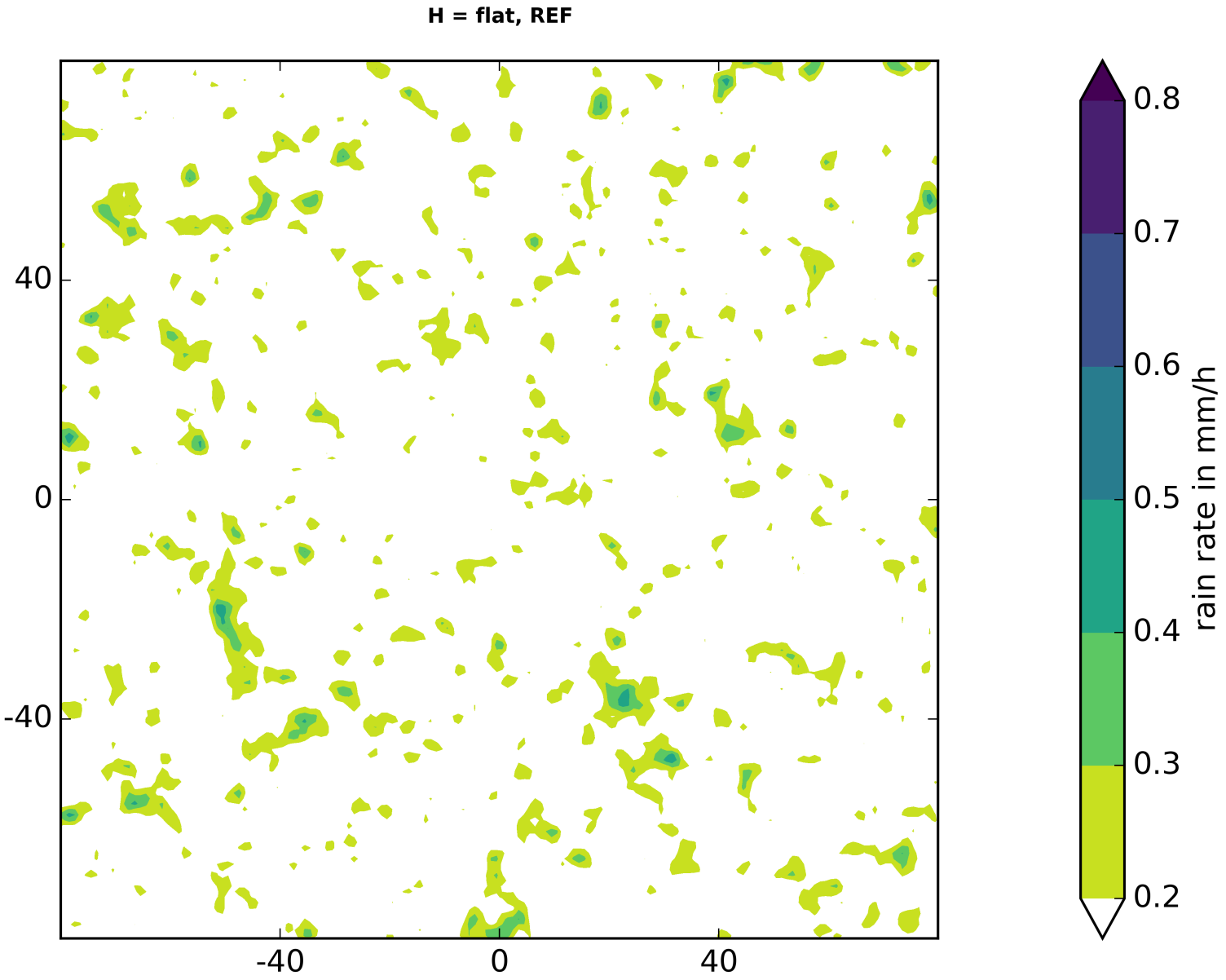
- Ensemble and day mean of days 2 -5



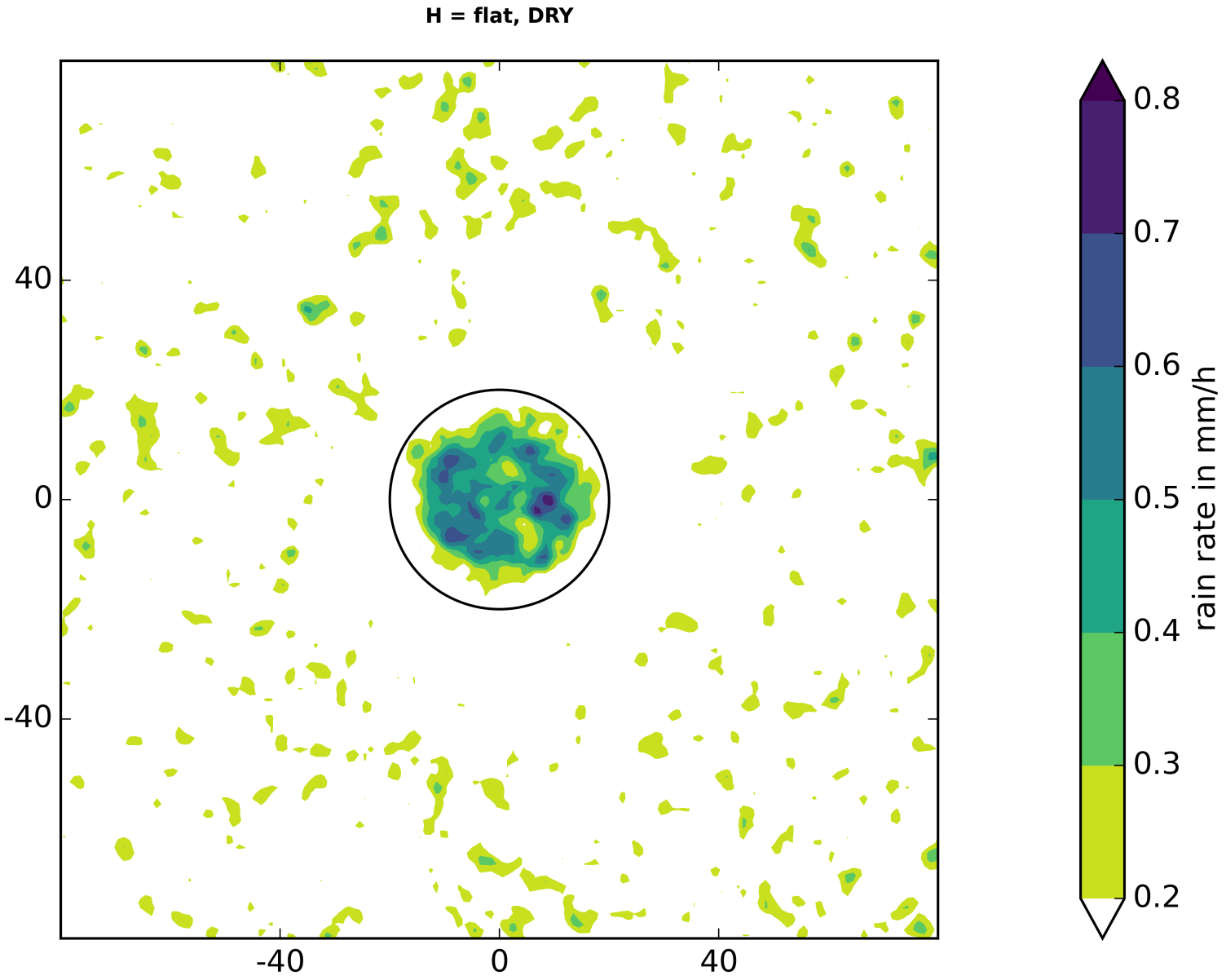
Top-hat shaped perturbation of soil moisture



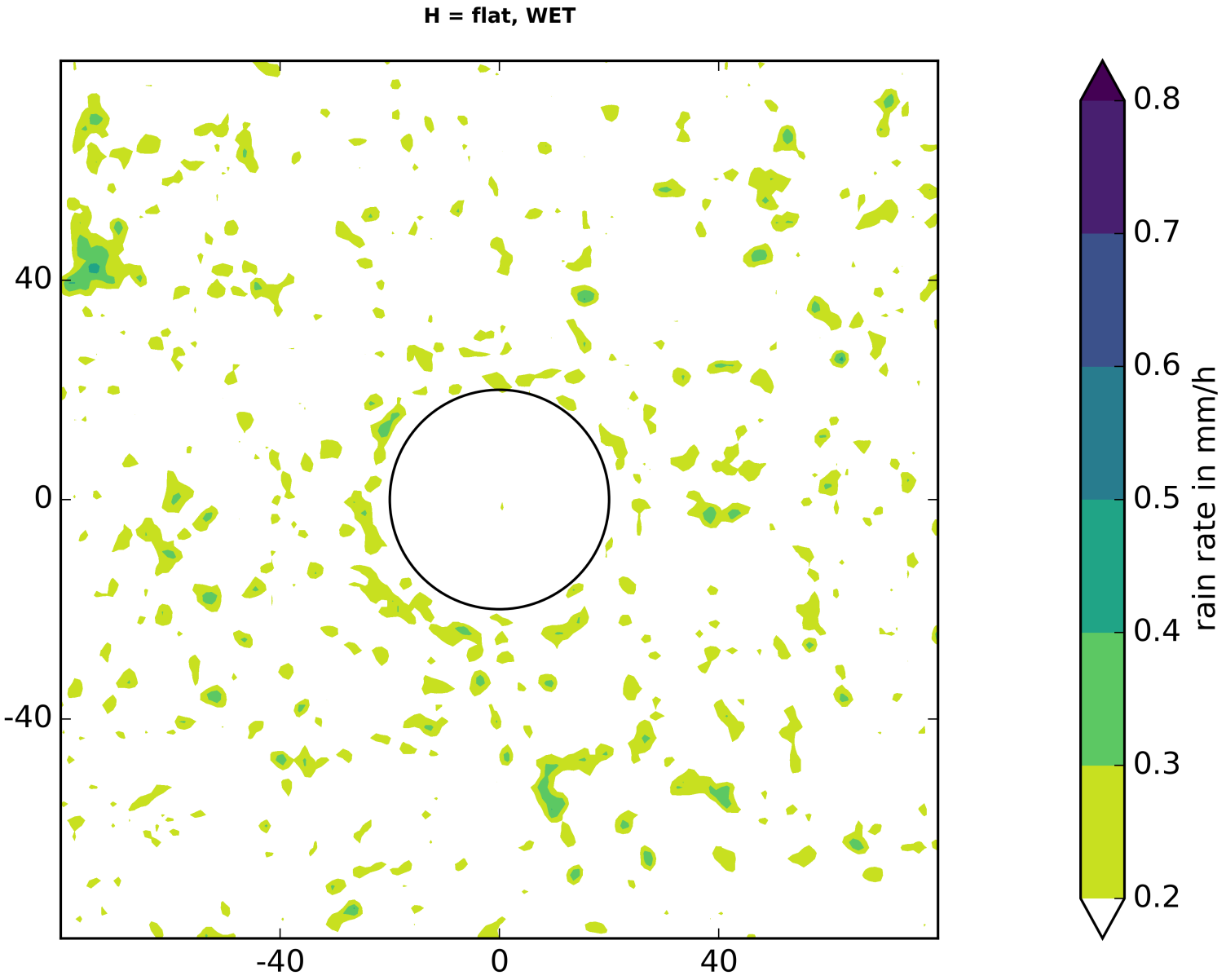
Random distribution of rain over homogeneous soil



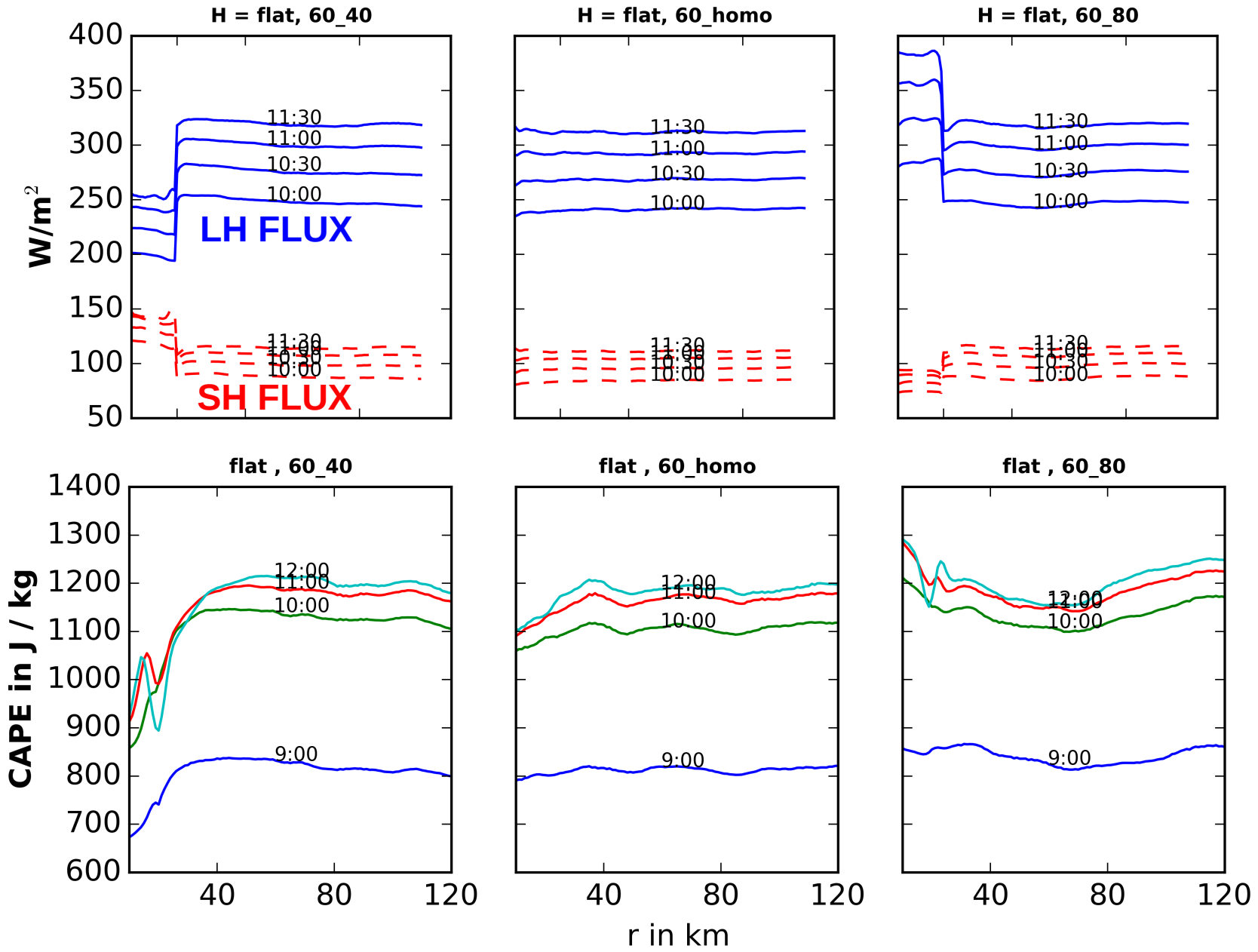
Rain preferentially falls over dry anomaly



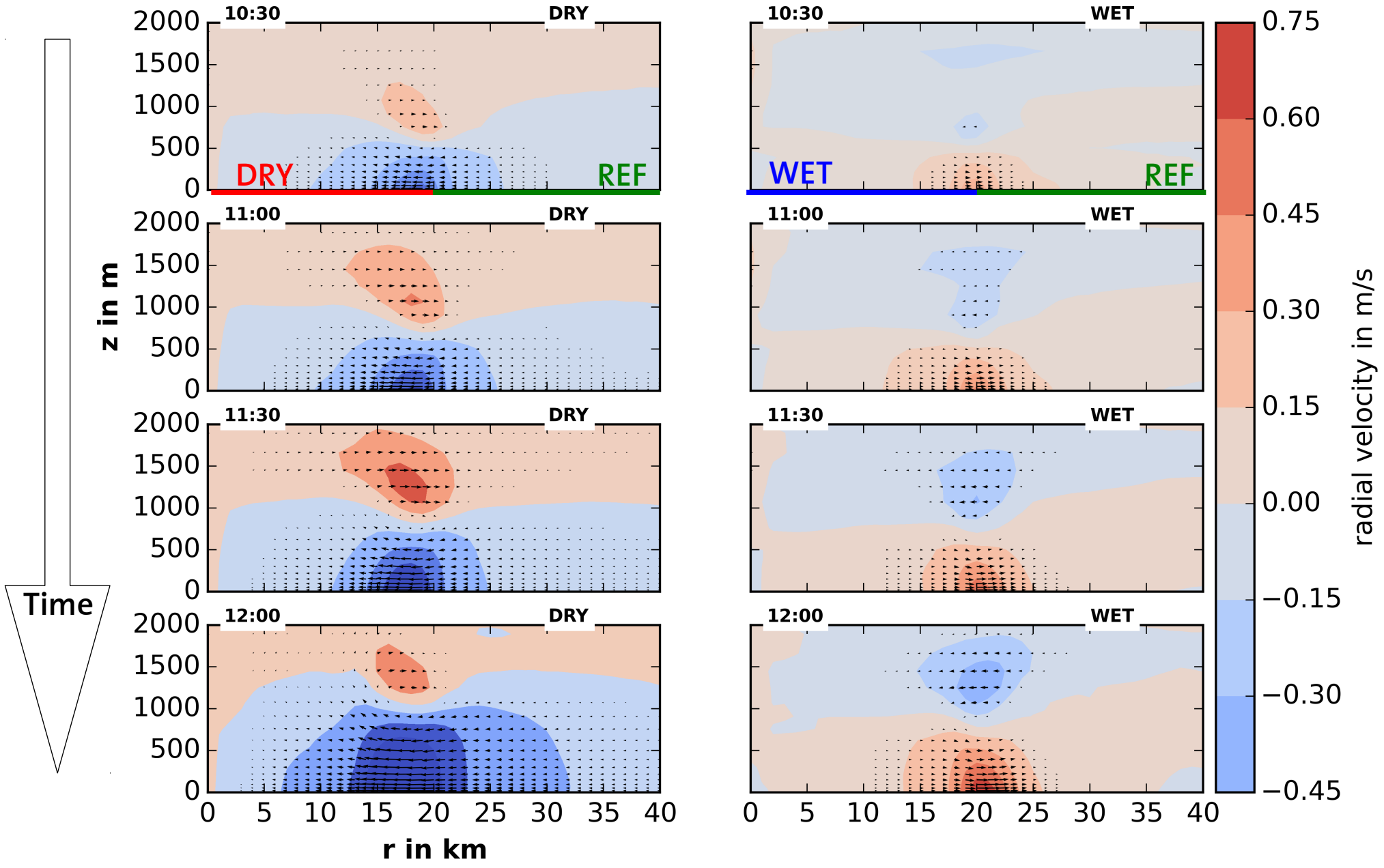
Moist anomaly tends to suppress rain

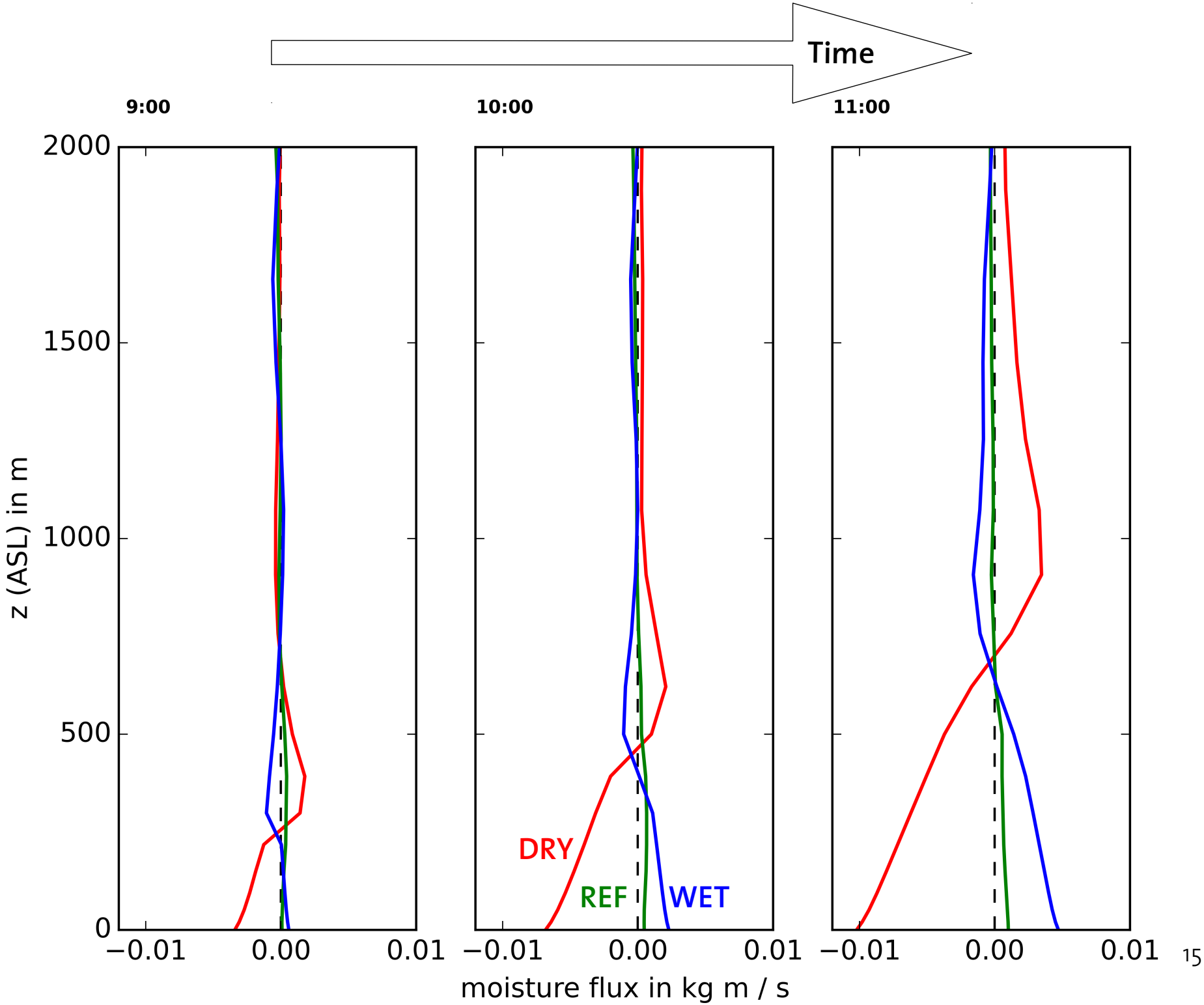


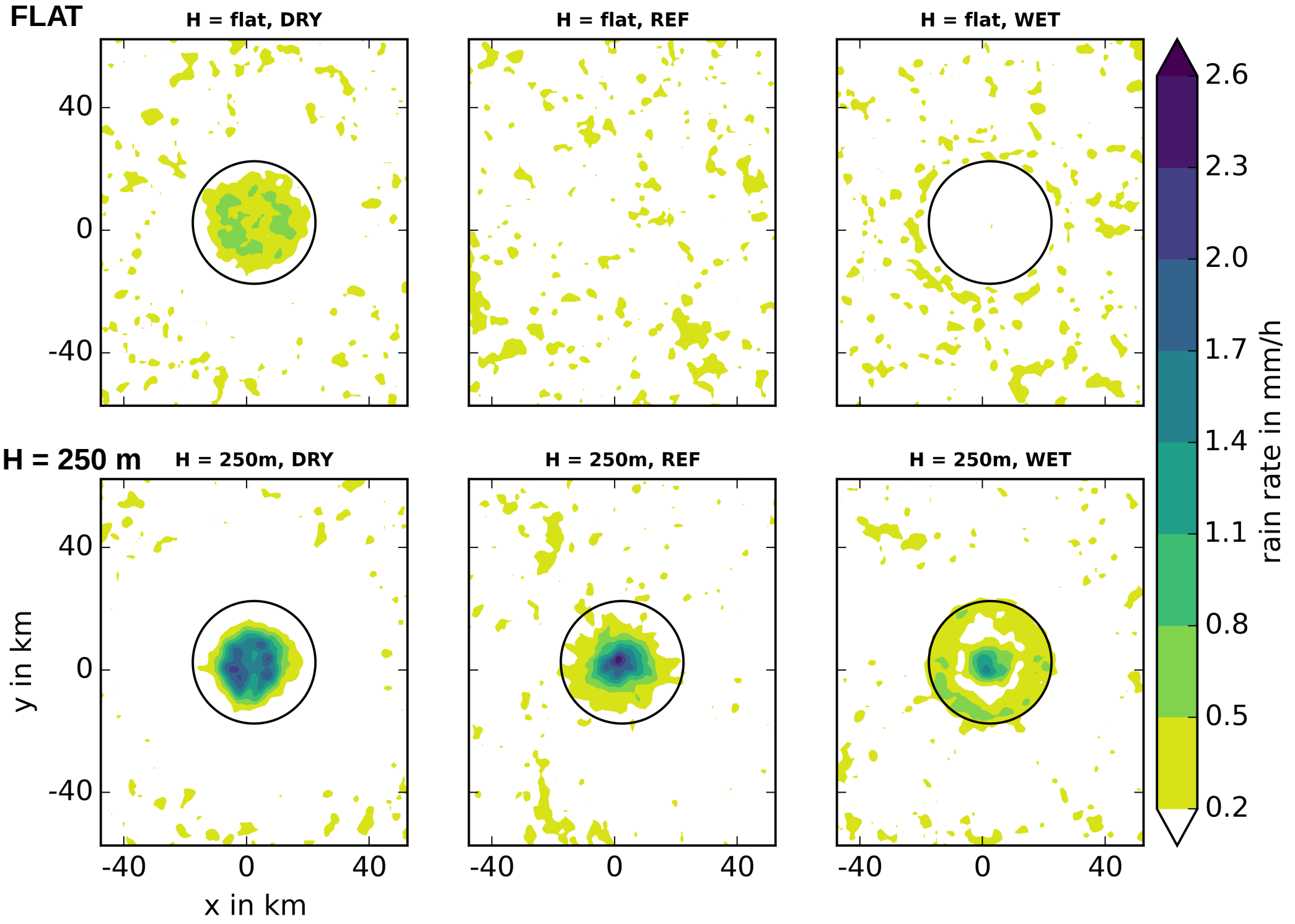
Column-based, purely thermodynamic explanation fails



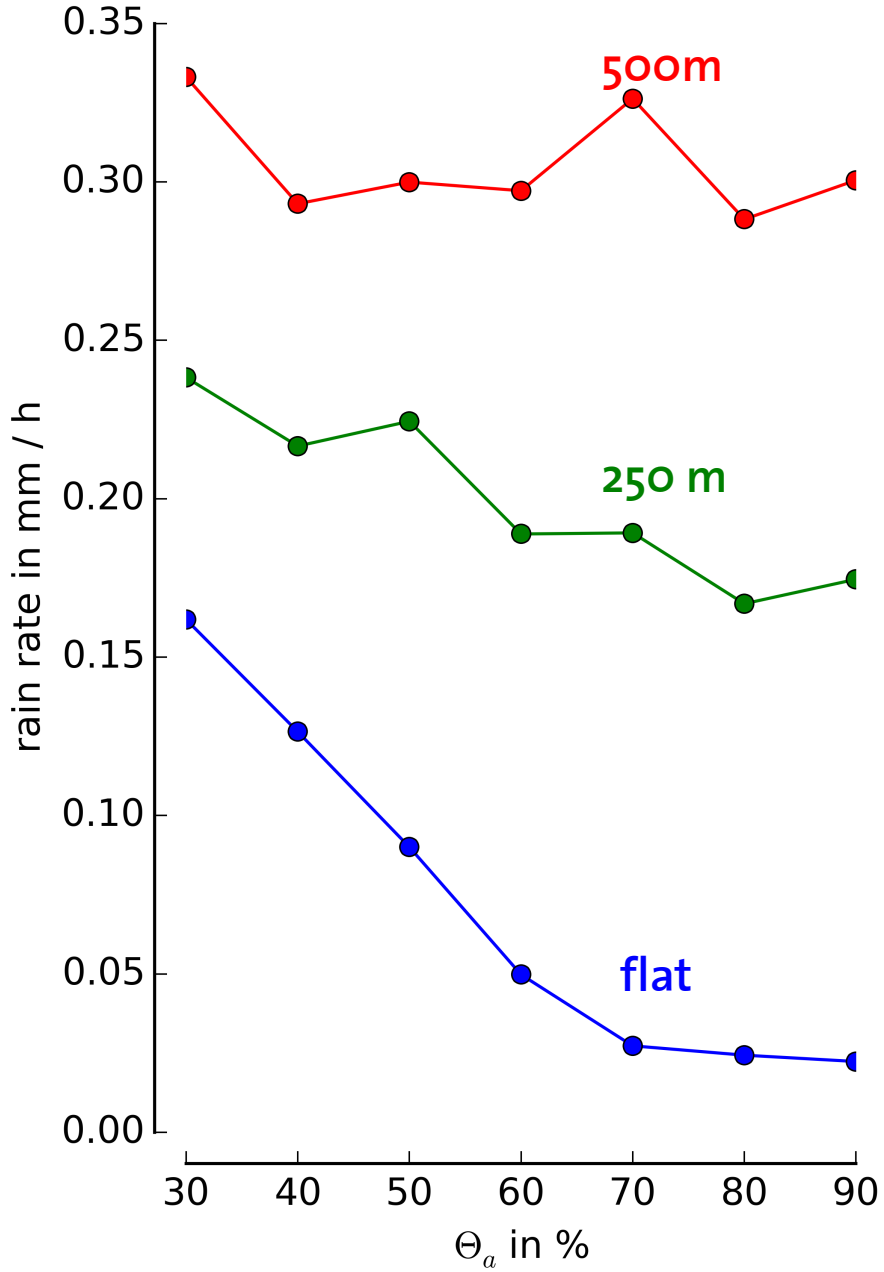
Circular mean of flow: soil-moisture induced circulations



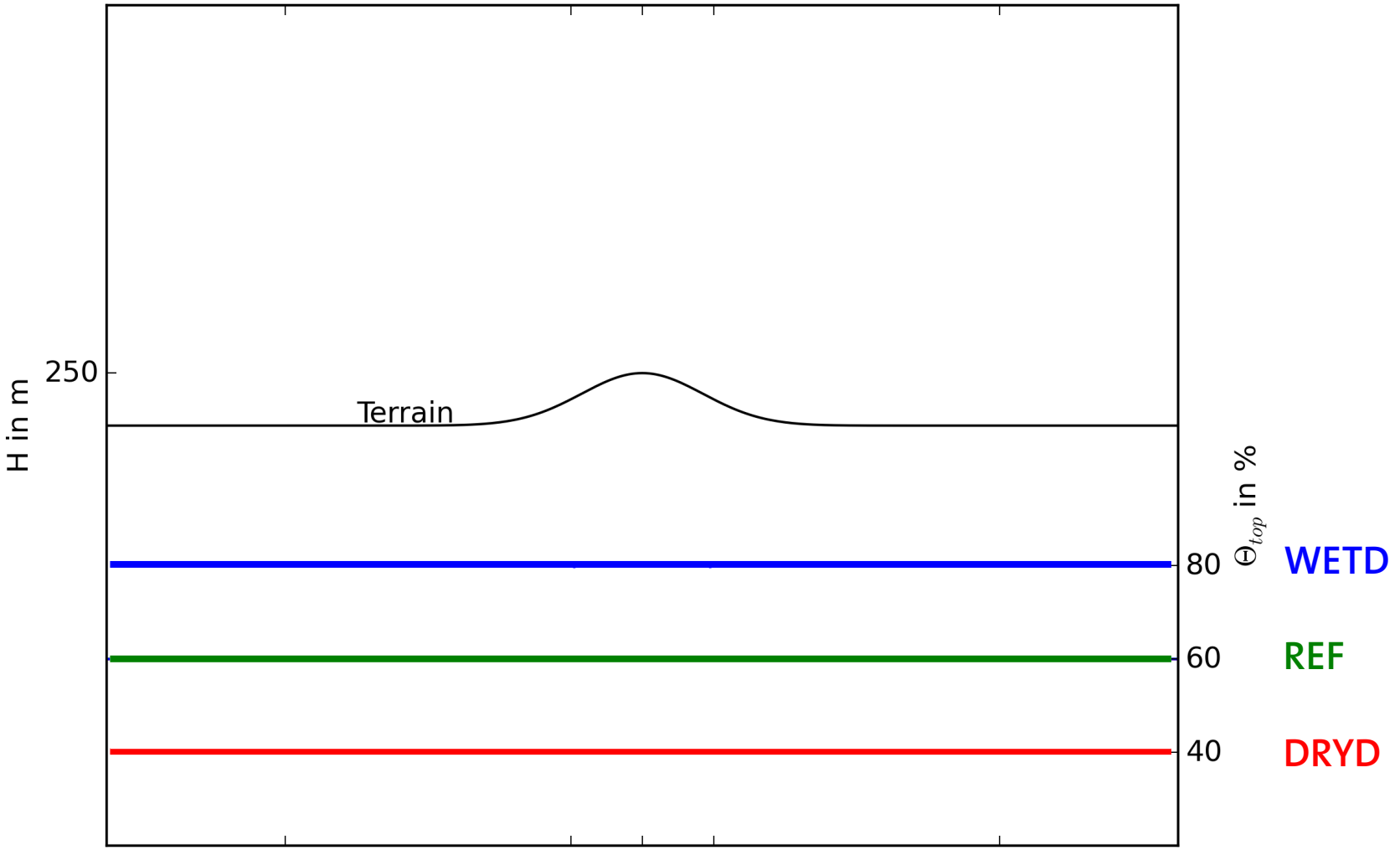

Time
9:00
10:00
11:00
2000
1500
1000
500
0
z (ASL) in m
−0.01
0.00
0.01
DRY
REF
WET
moisture flux in kg m / s


FLAT
H = flat, DRY
H = flat, REF
H = flat, WET
H = 250 m
H = 250m, DRY
H = 250m, REF
H = 250m, WET
40
0
-40
y in km
-40
0
40
x in km
2.6
2.3
2.0
1.7
1.4
1.1
0.8
0.5
0.2
rain rate in mm/h

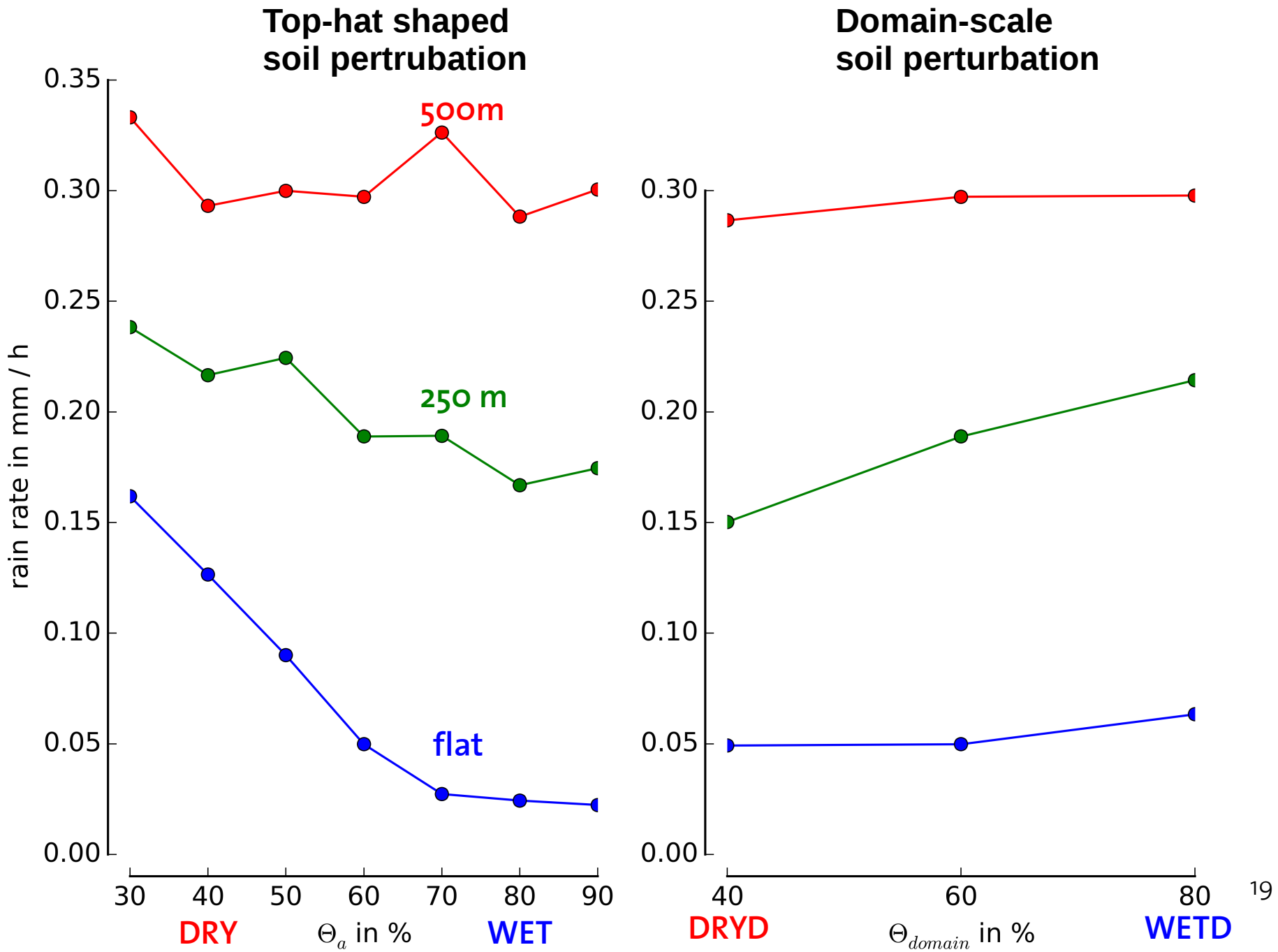
Negative response to local soil moisture



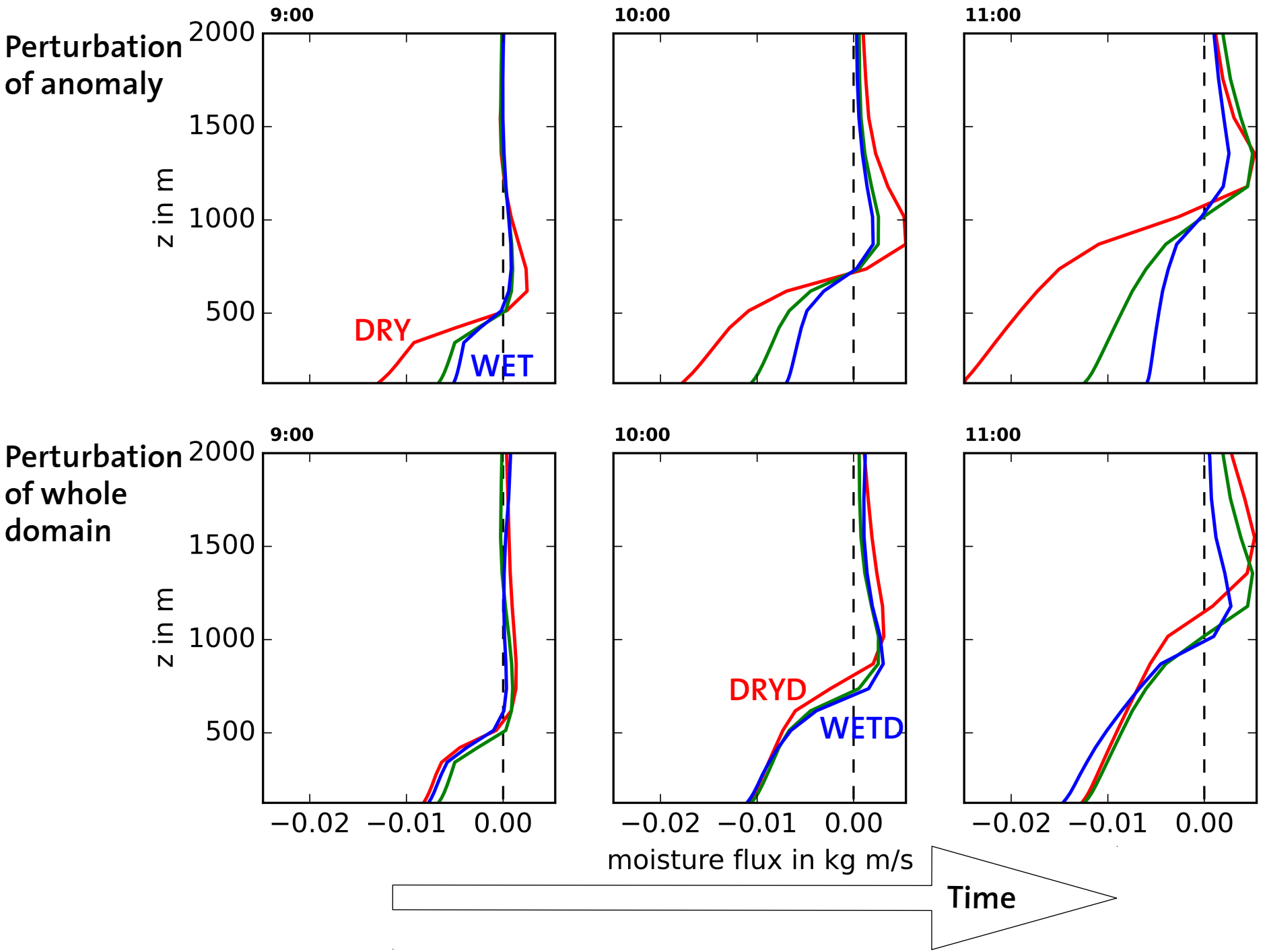
Domain-scale soil-moisture perturbation



Opposite response signs



Enhancement / suppression of radial moisture fluxes for H = 250 m



Summary

- Strong negative and linear response of convective intensity to saturation of local soil-moisture heterogeneity.
- Positive, yet weaker, response to uniform perturbation of soil moisture in the whole domain.
- Isolated mountain of modest height (250 m) outperforms very dry anomaly in terms of convective intensity
- Reasonable additivity (mountain + soil-moisture heterogeneity) for H = 250 m.
- Soil-moisture heterogeneity induced enhancement / suppression of precipitation is of dynamic origin (moisture advection)