Soil moisture-temperature feedbacks at meso-scale during heat waves over Western Europe

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Summer heat waves in Europe : Key drivers

① Synoptic circulation

➢ Heat waves over southern Europe associated with a zone of strong high pressure pushing Atlantic perturbations northward (Cassou et al., 2005).

② SST

➢ Warm Mediterranean Sea SST reduces meridional gradient of temperature ➙ northward shift of the descending branch of the Hadley cell (Feudale and Shukla, 2010).

➢ Tropical SST and convection anomalies favor certain North Atlantic weather regimes (Cassou, 2008;).

③ Soil moisture and feedbacks

➢Drier soil initiate larger positive feedbacks (Fischer et al.,2007a,b; Seneviratne et al., 2010).

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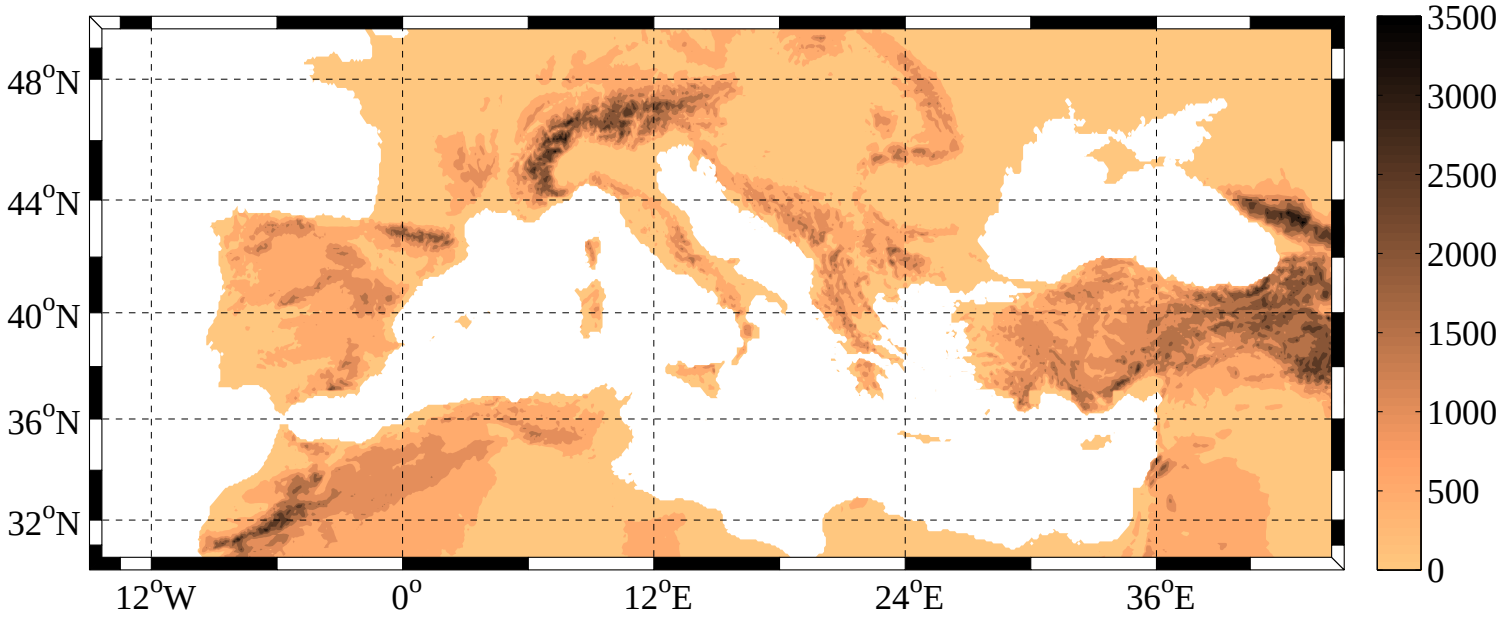
④ What more remains to be done ?

- The mesoscale variability of heat waves.



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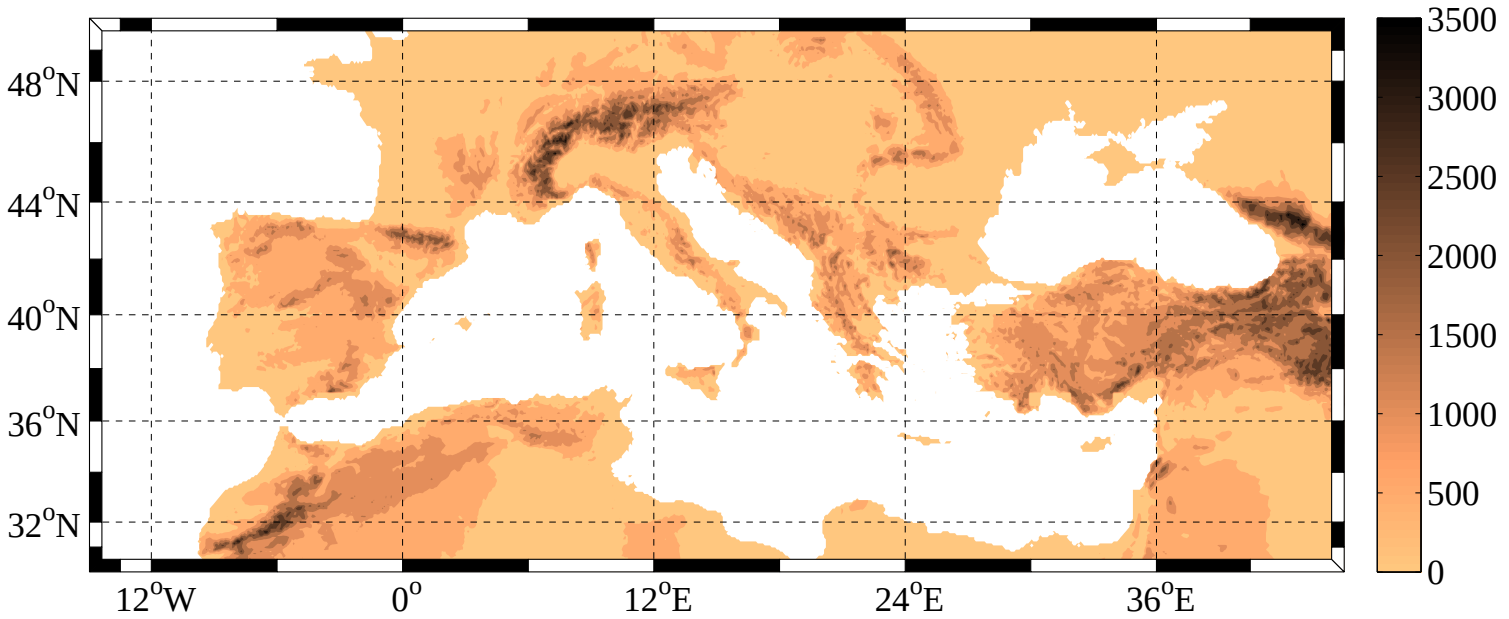
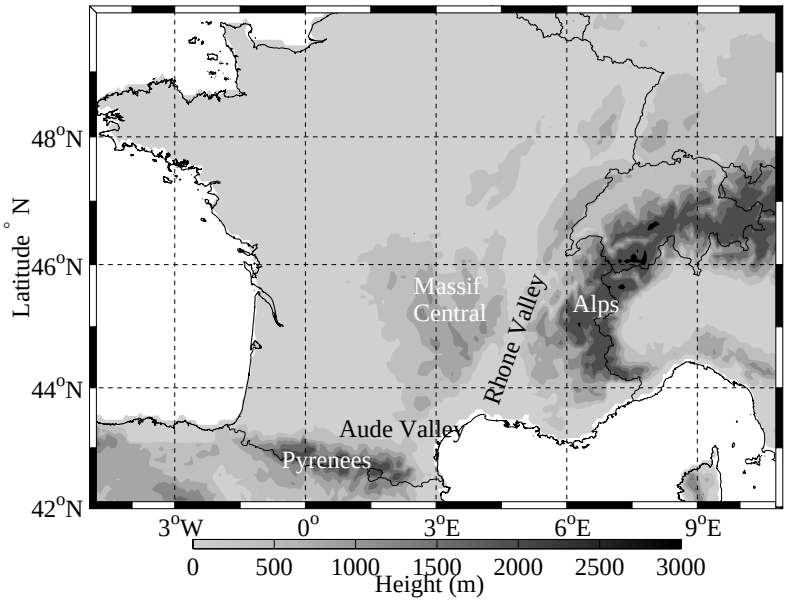


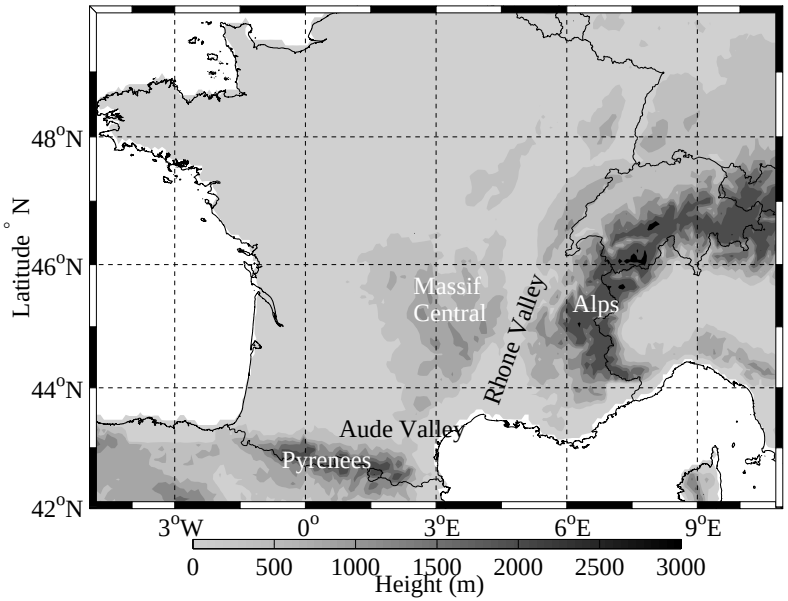
Sensitivity study

- Western Europe heat waves.
- Two CORDEX simulations at 20 km resolution with the WRF model driven by ERA-Interim over France (1989-2008).



Sensitivity study

- Western Europe heat waves.
- Two CORDEX simulations at 20 km resolution with the WRF model driven by ERA-Interim over France (1989-2008).
- Two differents LSMs are used. The first land-surface model resolves the hydrology (RUC) whereas the second land-surface model prescribes a high soil moisture availability (SLab).



➢ Soil moisture-temperature feedbacks at meso-scale during heat waves over France in the HyMeX/MED-CORDEX simulations. Stéfanon *et al.*, submitted to *Climate Dynamics*

Average state and heat waves

Data	RUC	SLab	ECA&D
Mean °C	24.6	20.2	24
95^{th} percentile anomaly °C	5.5	4.2	5.4

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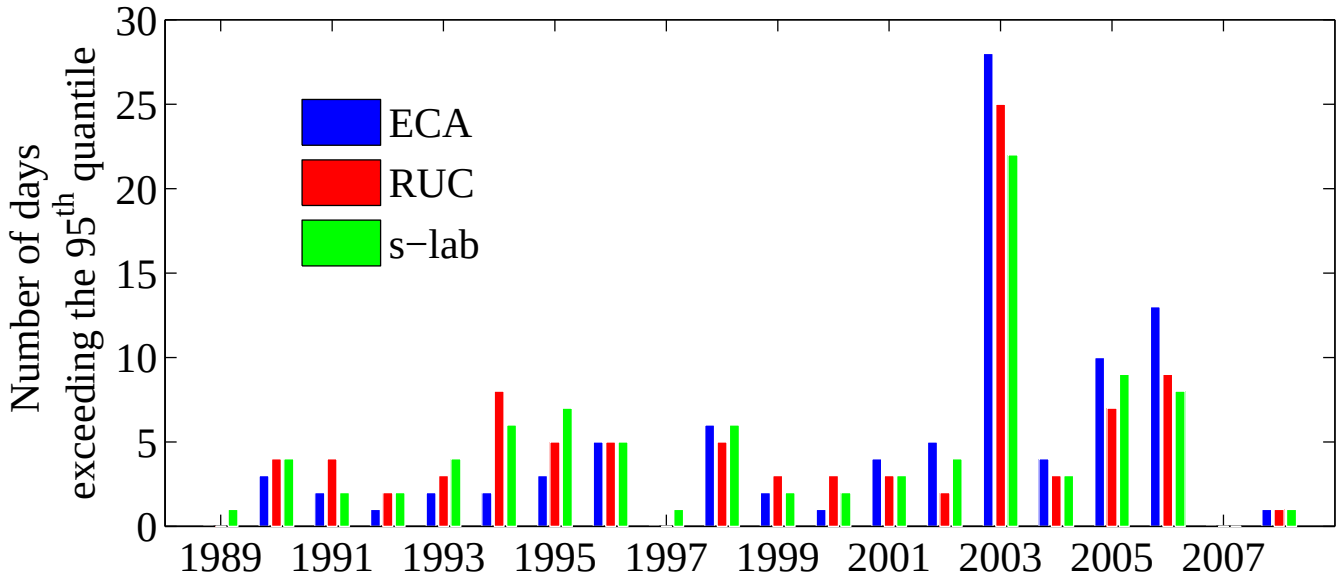
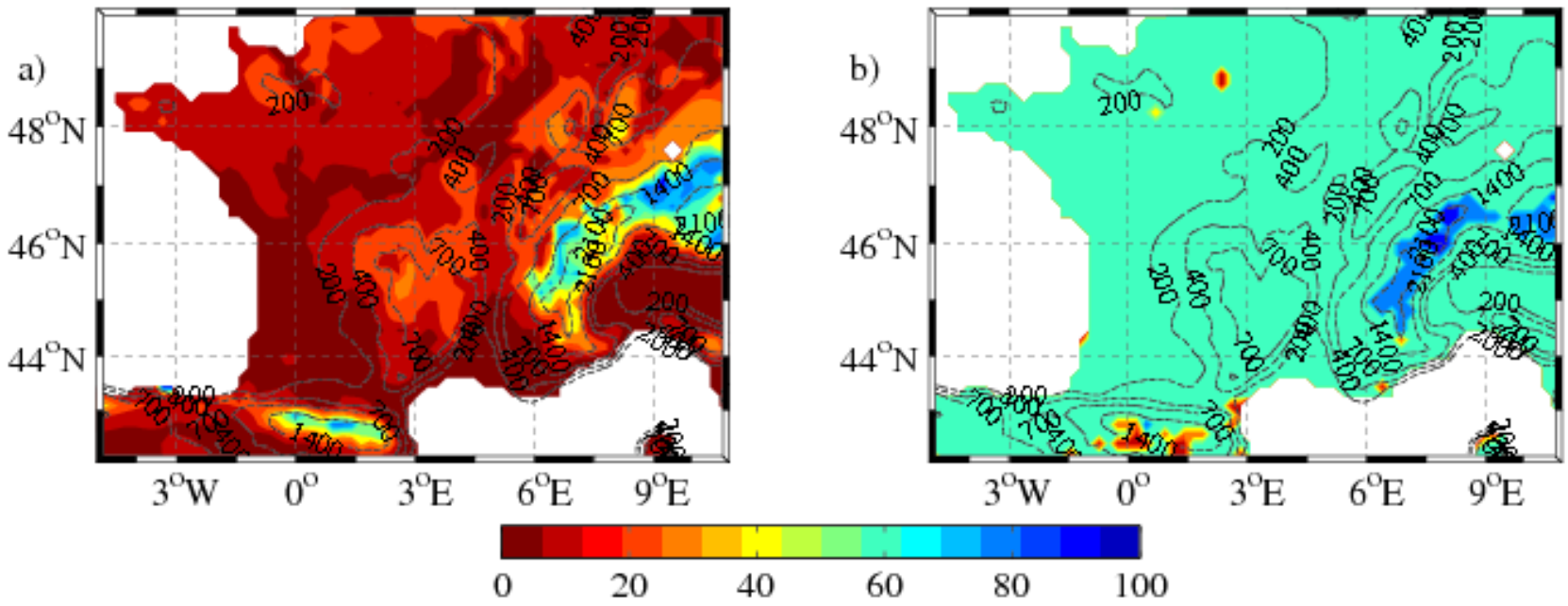


Moisture availibity comparison

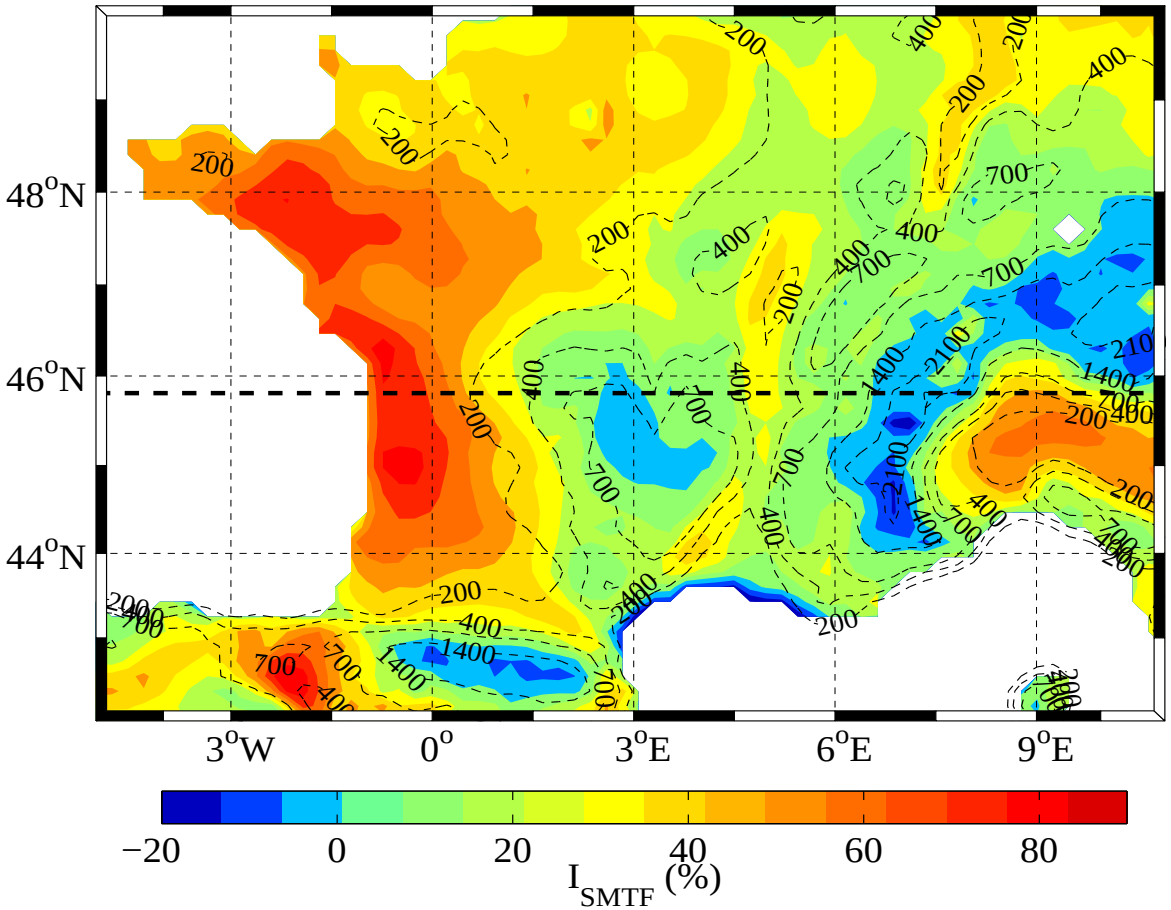


Soil moisture availibility (%) during heat wave days

Soil moisture availibility = 0% wilting point.

Soil moisture availibility = 100% saturation field.

Soil moisture temperature feedback



$$I_{SMTF}(\%) = 100 \times \frac{\Delta T_{RUC} - \Delta T_{SLab}}{\Delta T_{SLab}}$$

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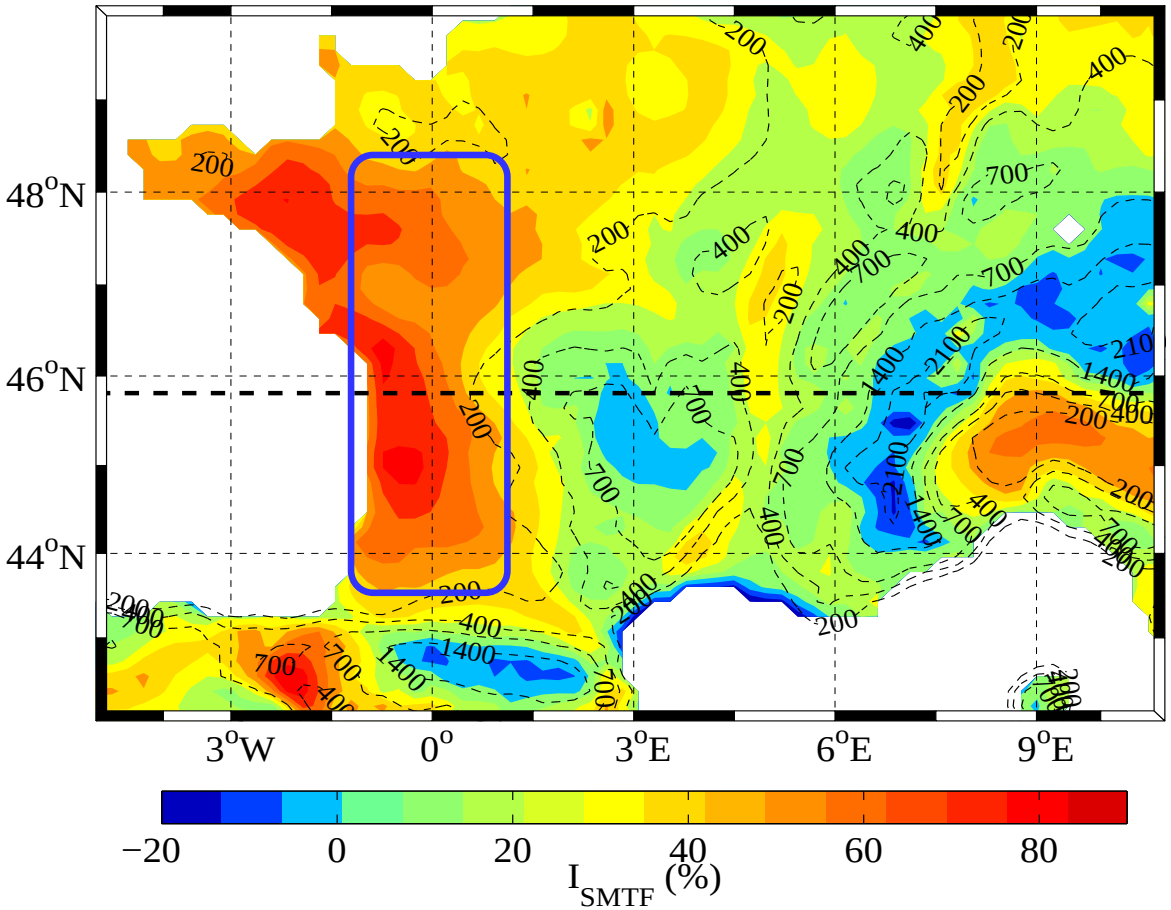
Soil moisture temperature feedback



- Plains areas (3.5°C).

$$I_{SMTF}(\%) = 100 \times \frac{\Delta T_{RUC} - \Delta T_{SLab}}{\Delta T_{SLab}}$$

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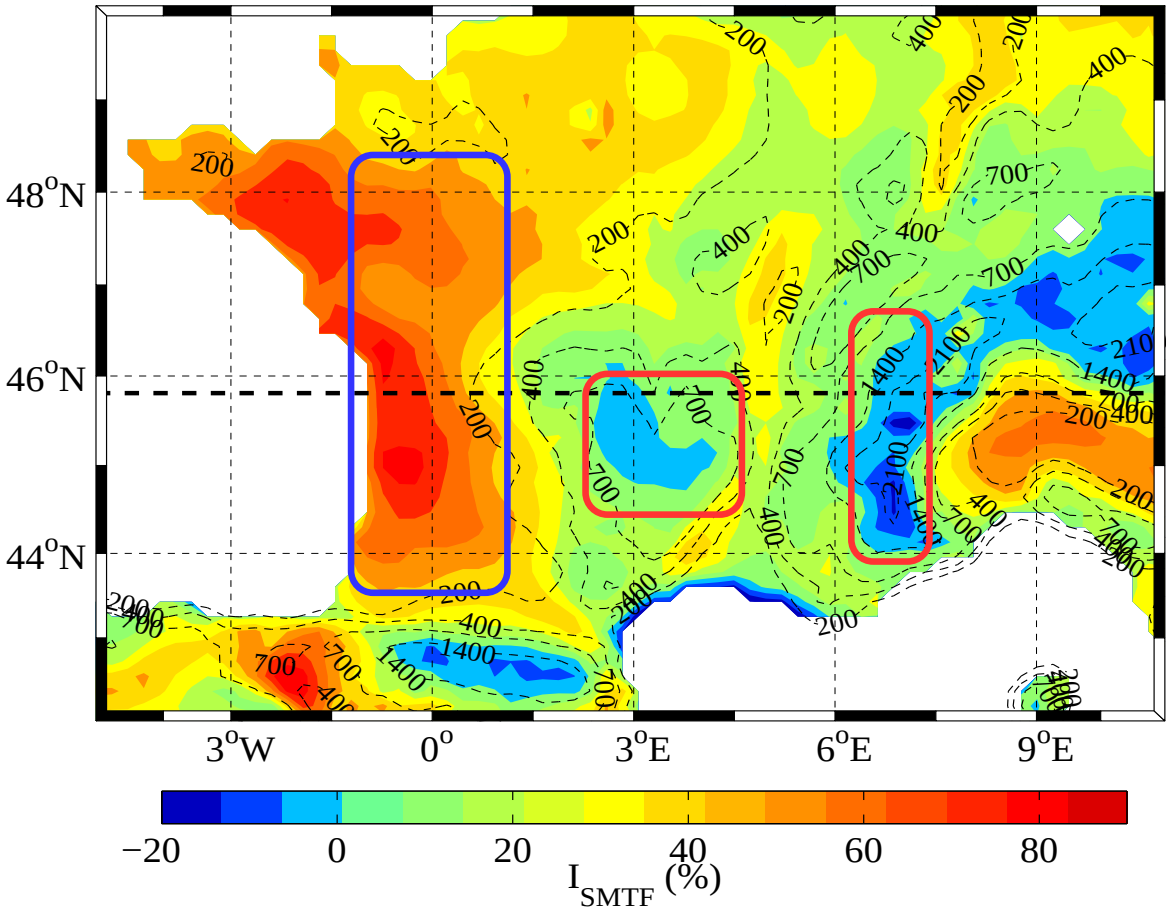

- Plains areas (3.5°C).
- Mountainous regions (-1.2°C).

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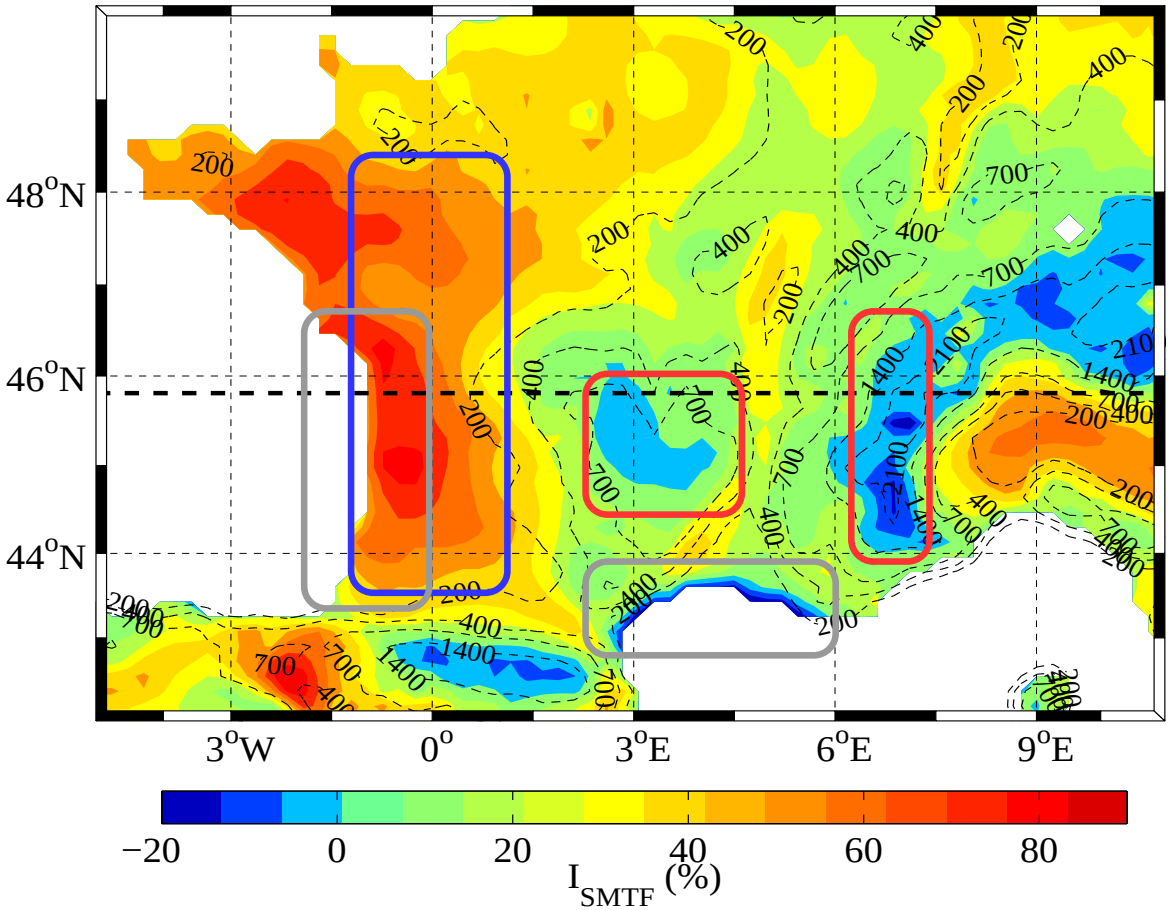
Soil moisture temperature feedback



- Plains areas (3.5°C).
- Mountainous regions (-1.2°C).
- Coastal areas (?).

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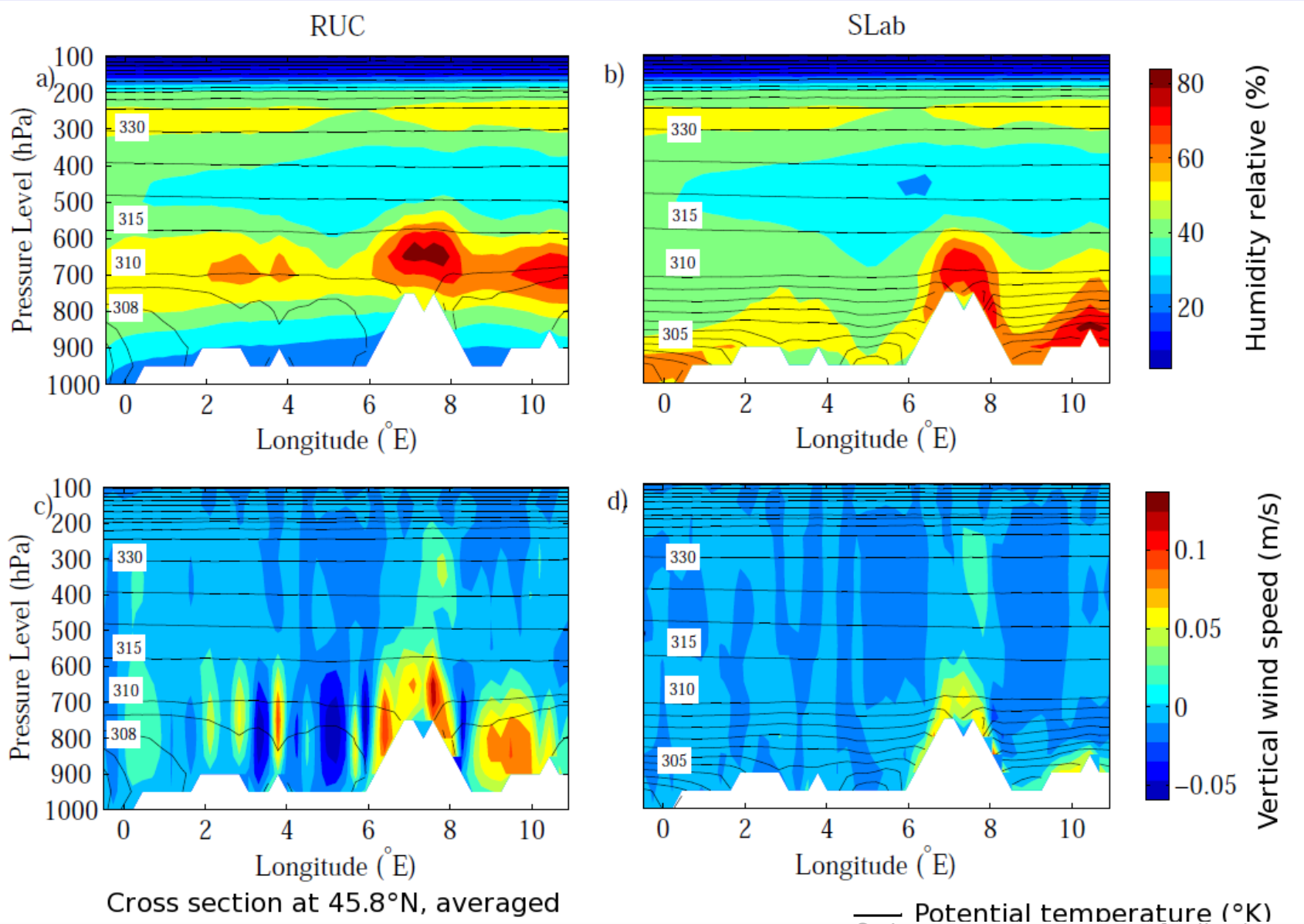
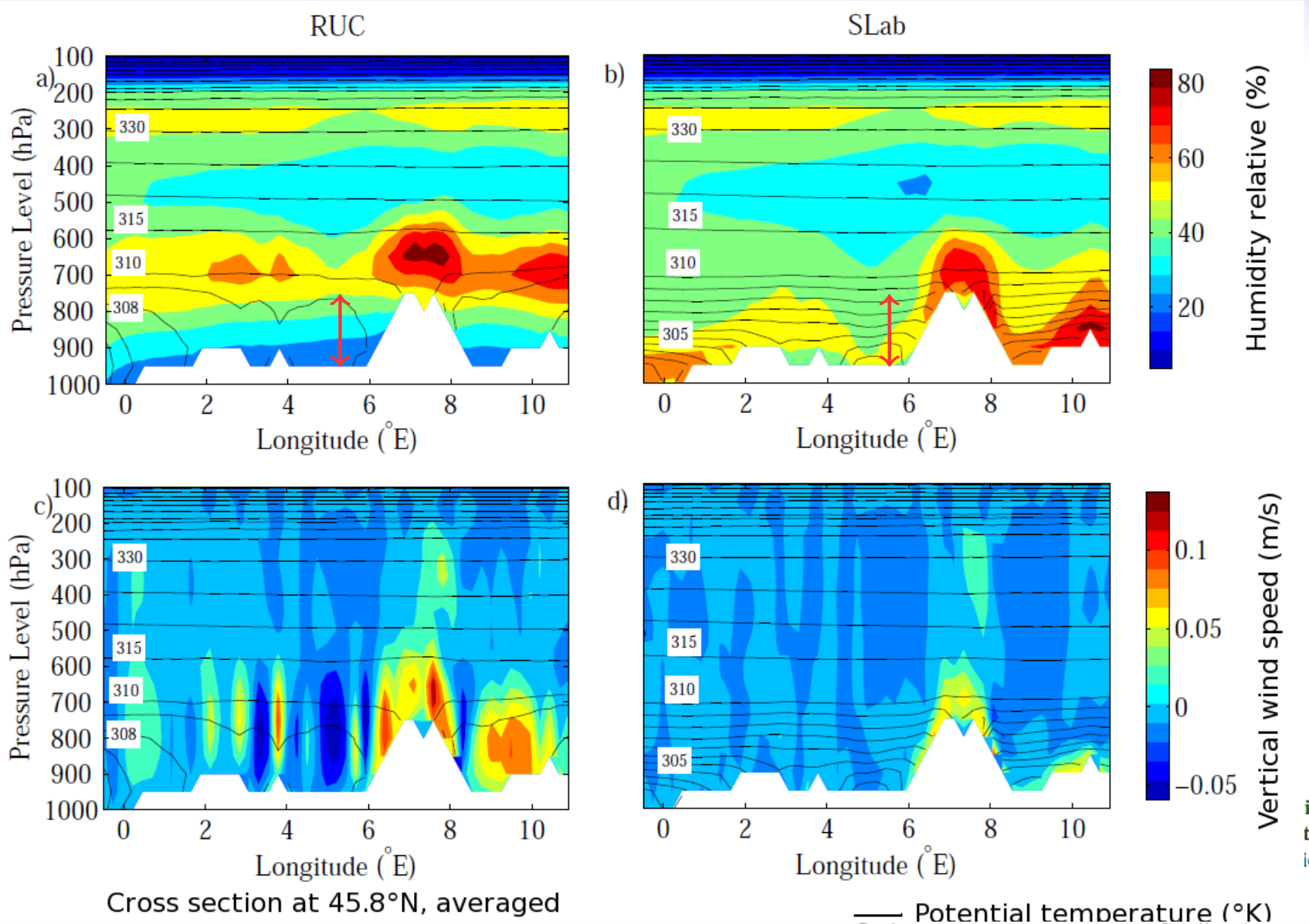
Mountains


RUC
SLab
a)
b)
c)
d)
Pressure Level (hPa)
Longitude (°E)
330
315
310
308
305
Humidity relative (%)
Vertical wind speed (m/s)
Cross section at 45.8°N, averaged
Potential temperature (°K)

Mountains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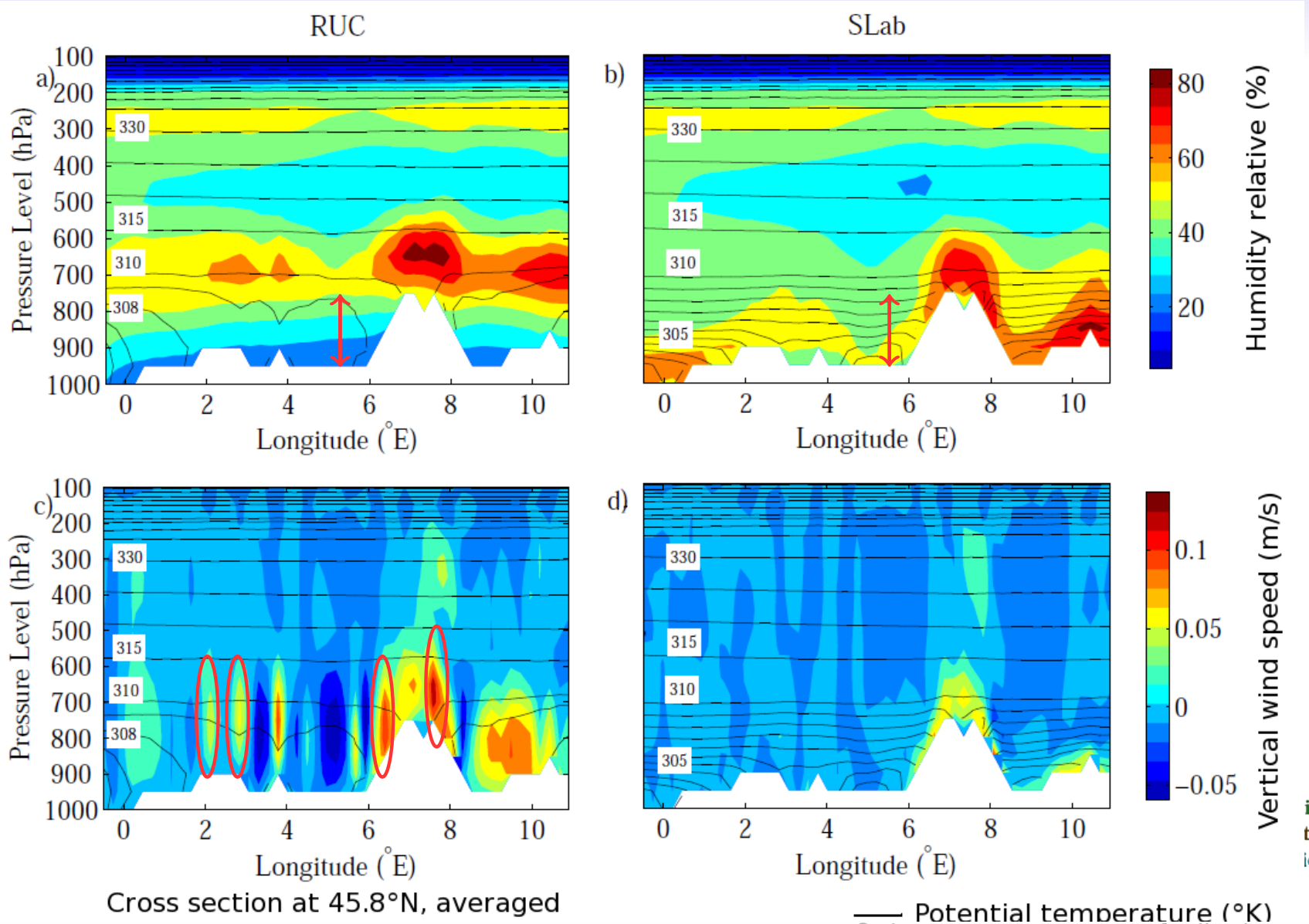
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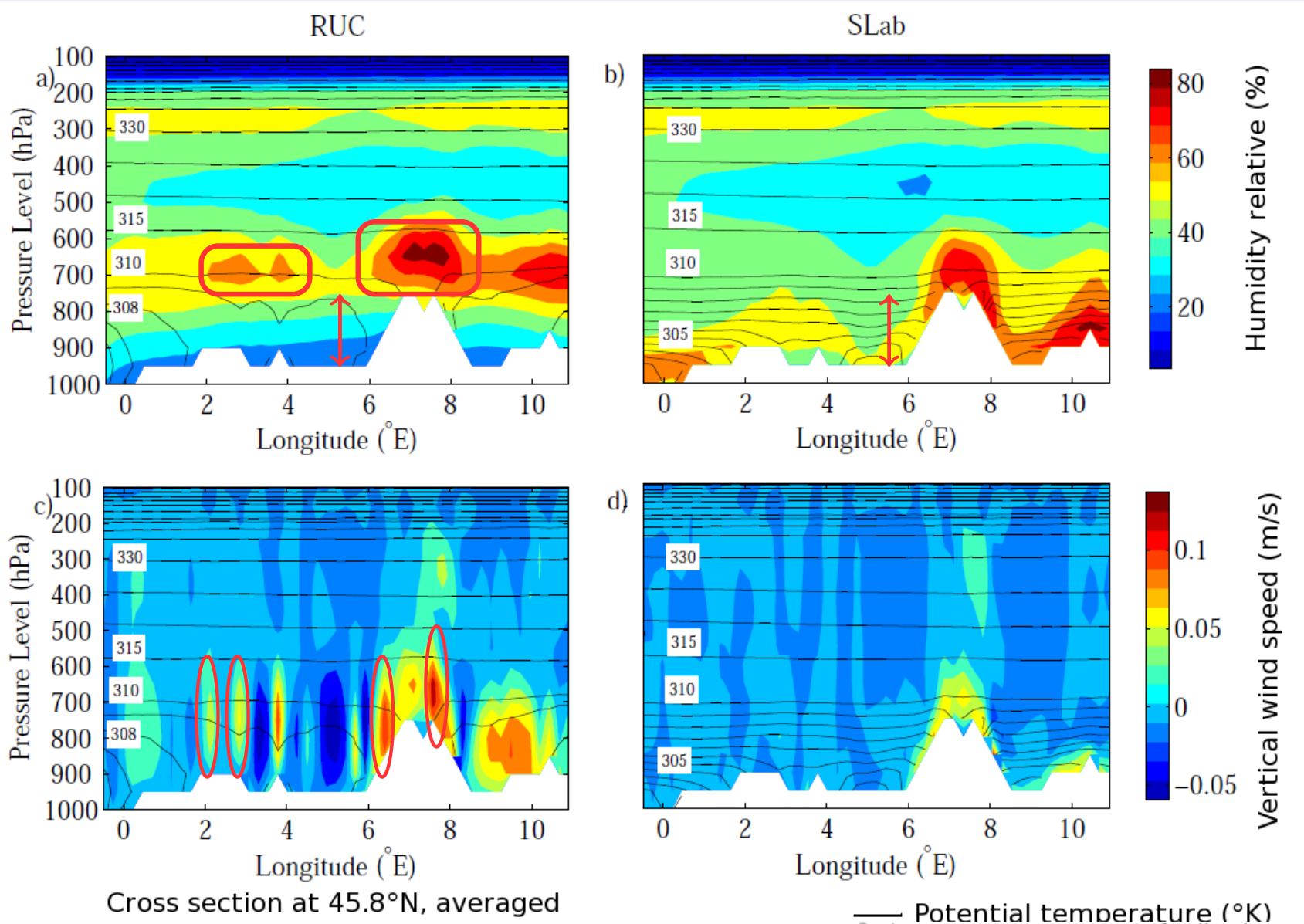
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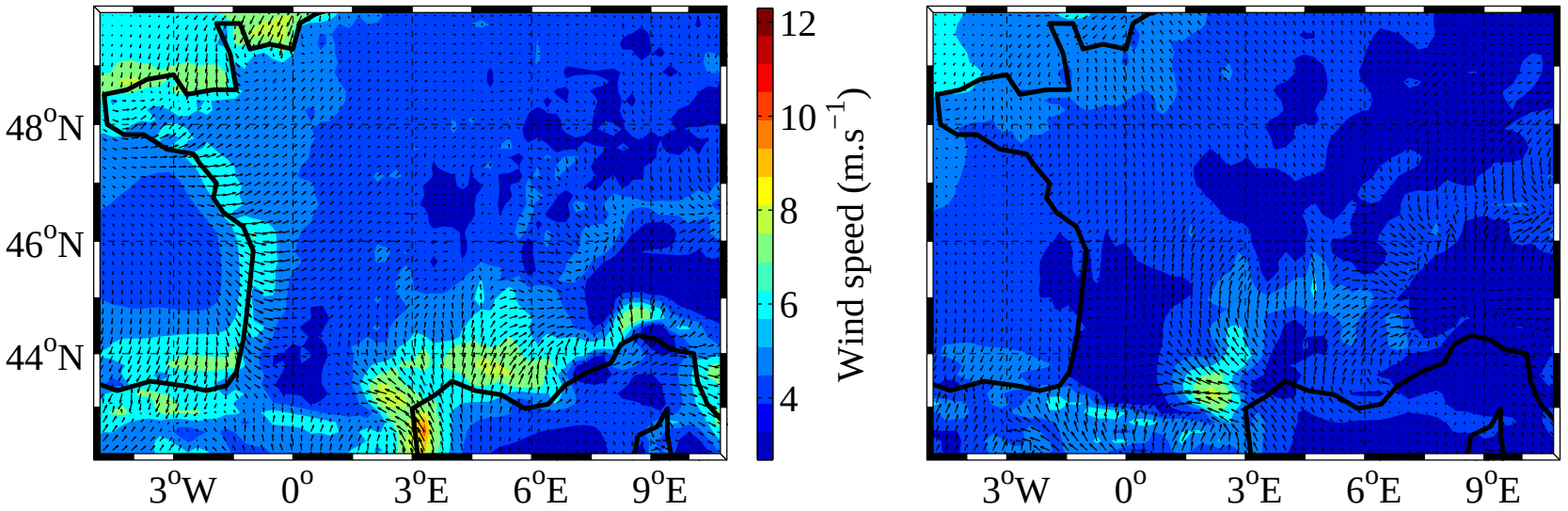
Coastlines



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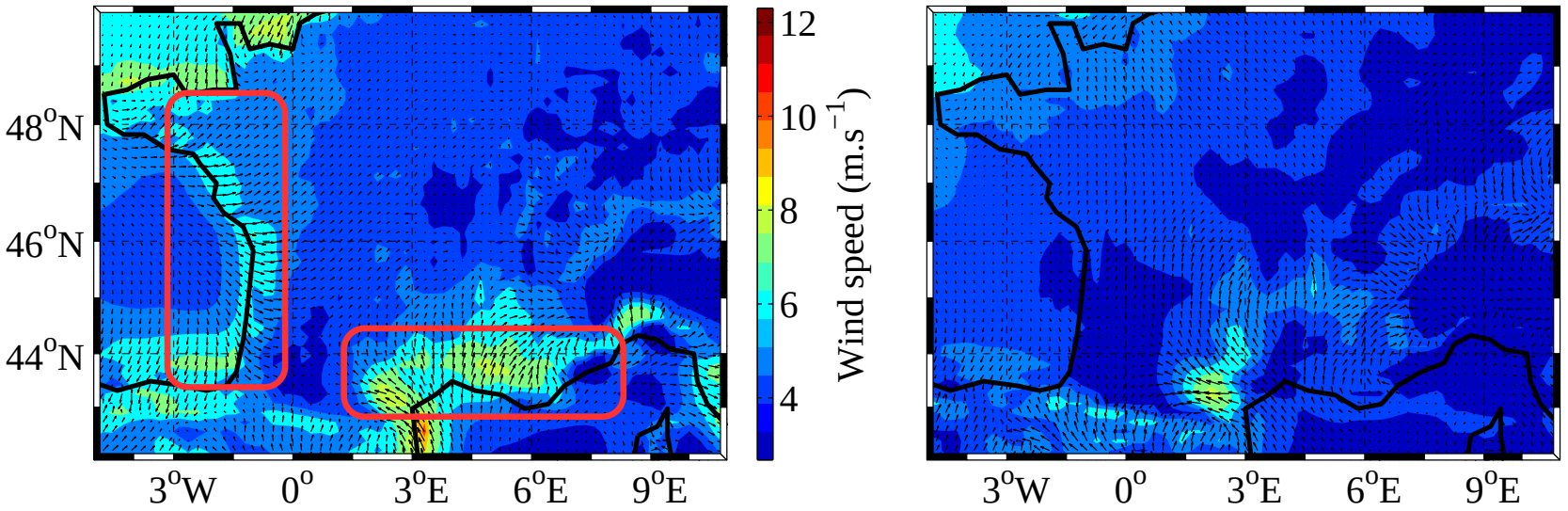

Location	Atlantic	Mediterranean
Breeze cooling	– –	– –
Surface heating	✚ ✚ ✚ ✚	✚
Total	✚ ✚	–

Conclusions

- Soil moisture depletion increases temperature anomaly over plains whereas it is decreased over mountainous and coastal areas.
- Amplitude of soil moisture temperature feedback is near 5°C or 100% of synoptic variability.
- Mesoscale processes as shallow convection and sea-breeze are the drivers of the negative loop (up to -1.2°C).