Investigating the relationship between soil moisture and evapotranspiration at different surfaces: Do we improve fluxes just improving the land use in models?

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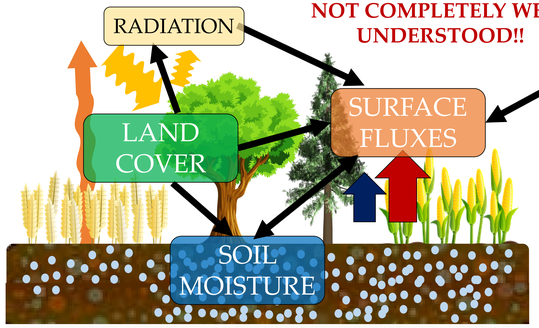
Introduction



THESE RELATIONSHIPS ARE NOT COMPLETELY WELL UNDERSTOOD!!

ATMOSPHERIC VARIABLES (temperature, humidity, wind)

THESE VARIABLES PRESENT BIASES WHEN MODELLED **(MAIN MOTIVATION!)**

Figure 1. The land cover (type and state of vegetation) affects the net radiation through changes in albedo, surface temperature and emissivity. It also affects the available soil moisture by changing the water retention, runoff, evaporation and transpiration. Thus, the final sensible (red arrow) and latent (blue arrow) heat fluxes are affected by the net radiation, the land cover and the water availability in the soil. These delicate processes depend on each other and representing them in numerical models is a challenge, which affects the simulation of important variables such as 2-m temperature or 10-m wind speed.

Final Objective

To learn more about these relationships in order to improve model forecasts

Data & Strategy

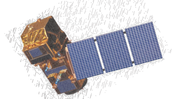
IN SITU DATA

Data from ICOS[1] in France and from EBD[2] and IFAPA[3] in Spain

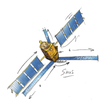
Soil Moisture ⟷ Surface Fluxes

Comparison of correlations and relationships between soil moisture (SM) & latent heat flux (Le) over different vegetation and periods.

SATELLITE DATA



Land Use



Soil Moisture

High-resolution realistic land use (LU) from CESBIO[4] used to improve the LU representation in the models.
1-km soil moisture (DISPATCH[5]) to evaluate the SM spatial variability simulated by models.

MODELS

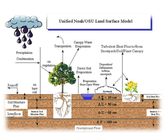


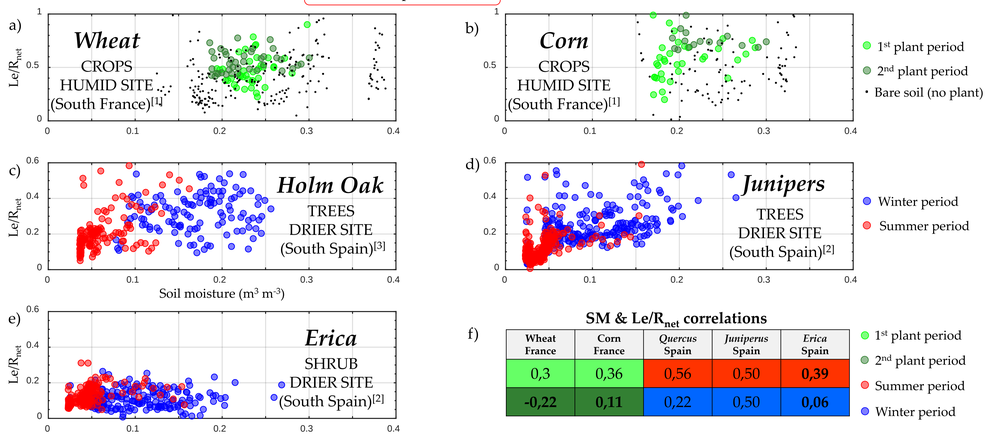
Figure from Noah land-surface model site

Weather Research and Forecasting (WRF) model[6] & noah-mp land-surface scheme[7].
Sensitivity experiment: To what extent can we improve the modelled fluxes with improved LU maps?

Results

IN SITU data

2 areas analysed: Southern France (humid) and Southern Spain (drier)



f) **SM & Le/R_{net} correlations**

Wheat France	Corn France	*Quercus* Spain	*Juniperus* Spain	*Erica* Spain
0,3	0,36	0,56	0,50	**0,39**
-0,22	**0,11**	0,22	0,50	**0,06**

1st plant period
2nd plant period
Summer period
Winter period

Figure 2. a-e) Scatter plots of soil moisture (x-axis, in $m^3\ m^{-3}$) and latent heat flux (Le) divided by net radiation (R_{net}) (y-axis, no units) for different species in different areas (indicated in the plots). Daily values are used, calculated as the mean of each variable between 10 and 14 h local time. Periods indicated in legend (right). f) Table with correlations between soil moisture and Le/R_{net} for different sites and periods.

Different SM & Le/R_{net} relationships depending on:

- Type of plant
- Season / plant period
- Region

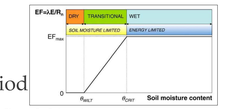


Figure 3. Soil moisture regimes and corresponding ET. Figure from Seneviratne et al. 2010[8].

- Crops already grown in sites no water-limited do NOT respond (Le/R_{net}) to SM changes (dark green symbols in Fig. 2 a and b).
- Some sites do NOT respond to SM changes (e.g. Erica sp., very well adapted to extremes?) (Fig. 2e)
- Different tree species respond differently to SM changes in periods of low activity (winter) (Blue symbols in Fig. 2 c and d).
- What about models? Do they represent well these relationships?

MODELS

First step:
Model Sensitivity Experiment
"Improving LU data"

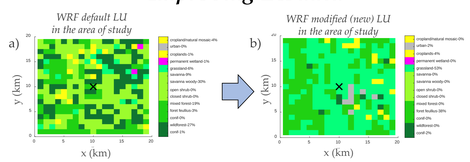


Figure 4. a) WRF default LU map used in the reference simulation (Mod. IGBP-MODIS NOAH). The central point is the main site (60-m tower) of the BLLAST field campaign[9] in Southern France (2011) which data are used for the evaluation. b) More realistic LU used in a new simulation, obtained from CESBIO[4] LU data (30-m res).

Area-averaged fluxes & satellite SM data for model evaluation (1 km pixels)

Spatial evaluation (19x19 pixels)

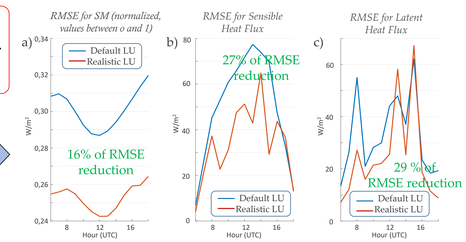


Figure 5. **a)** Normalized SM RMSE calculated for a 19x19 km area around the site of study. For the evaluation of the soil moisture heterogeneity, DISPATCH[5] data are used. **b)** Sensible heat flux (SH) mean RMSE for the same area. **c)** Le mean RMSE for the same area. *Pixels where the dominant LU is forest or urban are not evaluated due to uncertainties in the measurements. Part of these RMSE reductions are due to improvements in the R_{net} through changes in albedo (not shown).

Sensibility experiment using more realistic LU representation:

- Improvement of albedo.
- Improvement of R_{net}.
- Improvement of SM spatial heterogeneity.
- Improvement of Le and SH.
- What happens in drier areas? Is it worth to improve also the vegetation state in the models? → FUTURE WORK

Conclusions

The relationship between soil moisture and evapotranspiration depends on the area (humid or drier), the vegetation type and the analysed period (state of vegetation).

A better representation of the vegetation (LU) map in models improves the simulation results, especially through albedo improvements.

***In situ* data, satellite data and models can be combined to investigate land-atmosphere interactions.**

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[9] Model evaluation: BLLAST. Lothon et al (2014). Atmos Chem Phys, 14(20), 10931-10960.