Land-atmosphere-climate interactions: exercise 2

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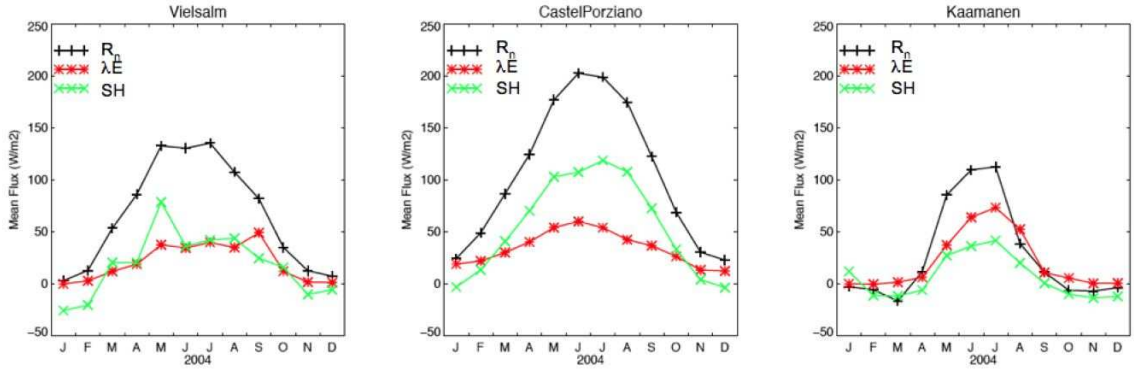
Solutions will be handed out
Compulsory for students who need a 'testat' (old system); optional for other students (masters etc.)

1 Soil moisture and the land energy budget

a. Assume that in a given spring the net radiation at the surface is $20\,Wm^{-2}$ larger than the climatological value. If all the additional radiation goes into latent heat, what is the resulting increase in evaporation in $[mm/day]$ (use latent heat of water: $L = 2.5 \cdot 10^6\,Jkg^{-1}$).

b. The increased evaporation induces a decrease in soil moisture. As soon as the wilting point is reached ($\approx 30\%$ saturation) the evaporation shuts down and the energy goes into other processes. Assuming that the plant wilting point is reached at the beginning of the summer already (June), how would the following quantities look like for the rest of the summer: sensible heat flux, surface temperature, cloud cover.

c. The following figure shows monthly net radiation (R_{net}), latent heat flux (LE) and sensible heat flux (SH) during 2004 at three CarboEurope flux tower sites covering a wide range of climate zones: Vielsalm, Belgium (temperate mixed forest); Castelporziano, Italy (summer-dry Mediterranean evergreen forest); and Kaamanen, Finland (Arctic tundra). Briefly comment on the differences in net radiation, sensible and latent heat fluxes.



2 Analysis of the 2003 European summer heatwave

On the lecture's web page, monthly data of four simulations investigating the 2003 European summer heatwave are given for France, the region where the heatwave was most pronounced (data courtesy from Erich Fischer, ETH Zurich). Analyse the role of soil moisture for the evolution of the heatwave using timeseries of different climate variables (surface temperature, latent and sensible heat fluxes, net radiation, precipitation and soil moisture content) from the following simulations:

- 2003 simulation (CTL)
- climatology of 1970-2000 simulation (CLIM)
- idealized simulation for 2003 with reduced spring soil moisture (DRY25)
- idealized simulation for 2003 with increased spring soil moisture (WET25)

For DRY25 and WET25 the soil moisture content (of the CTL run 2003) was changed by $\pm 25\%$ at the 1^{st} of April. Try to link the findings from **1** with the timeseries of 2003 (link between soil moisture, sensible and latent heat fluxes, net radiation, precipitation, temperature). First compare CTL to CLIM and then DRY25 and WET25 to CTL data. Focus primarily on spring and summer.
We suggest to use matlab, R, Excel etc. to plot the data (or do it by hand) and to plot all 4 curves of each quantity in one single plot. Example codes for matlab (example.m) and R (example.R) are given on the web page. Example solutions will only be provided in matlab.

3 Idealized lifting of an air parcel

An air parcel with $T = 10°C$ and $U = 85\%$ is lifted from the atmospheric boundary layer ($z = 0$) to the height $z = 2km$.
a. Calculate the saturation water vapour pressure and the dew point temperature of the air parcel at $z = 0$.
b. Estimate the condensation niveau for an adiabatic lifting.
c. Calculate the temperature of the air parcel in 2 km height.