Brief solution to exercise 1: Tethys-Chloris (T&C)

Part A: input preparation, model setup and validation

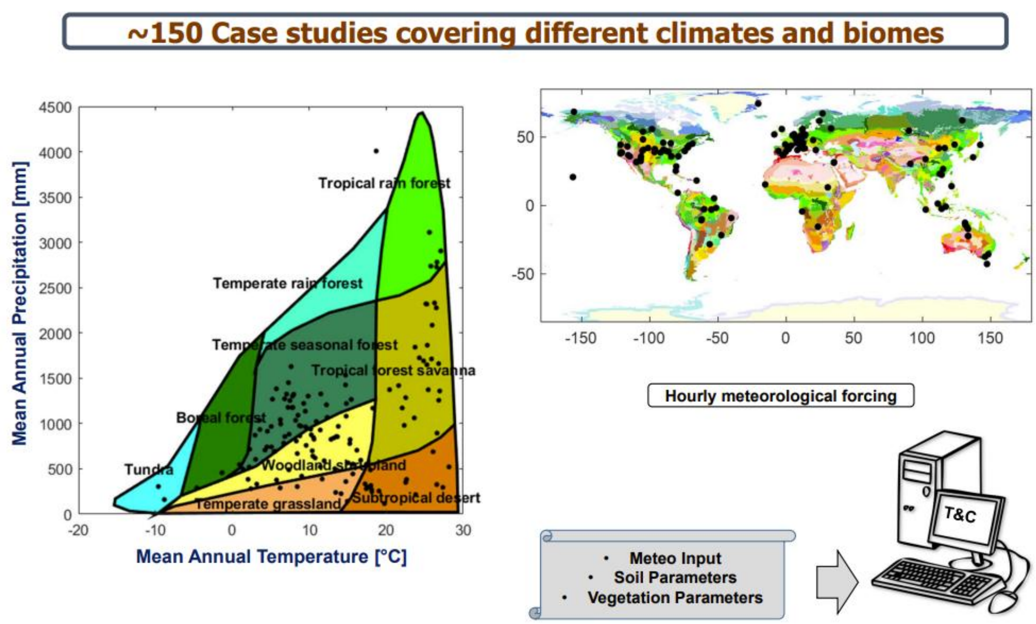
Prepare the meteorological input file

- *What meteorological data is extracted from the file as input and for validation?*

A: In 'read_fluxnet2015_tandc_teaching.m', line 254 shows the variables used for model validation (you can find the description of FLUXNET data at this page in the website: FluxNet2015 Data). Not all saved variables are used in later model validation. In line 273, the meteorology forcing are saved to run T&C, one can check the exercise slides or 'T&C_Variable_LIST_PlotScale.pdf' for explanations of each variable.

- *How different are the two case studies in terms of climatic conditions? To what biomes do they belong according to the Whittaker classification (Whittaker, 1970)?*

A: You can find the Whittaker biome on slide 9 (see below). According to it, both Chamau (mean annual precipitation ≈1135mm, mean air temperature ≈10 °C) and Laegeren (mean annual precipitation ≈1175mm, mean air temperature ≈8.6 °C) lie in the area of temperate seasonal forest (it does not necessary to be forest).



Exercise 1, slide 9

Understand the case studies

- *What are the mean annual precipitation and mean temperature in Chamau?*

A: See the answers to previous questions. You can either calculate it from your input file, which will be period-specific, or find this information from its Fluxnet information page.

- *What is the vegetation type and landcover in Chamau? Is there any land management?*

A: The vegetation type in Chamau is grassland and in Laegeren is mixed forest. In Chamau there is regular grass cut management. Mpar_L(1).jDay_cut indicates the Julian days when the grass is cut, and Mpar_L(1).LAI_cut indicates the LAI after grass cutting.

- *What temporal patterns do you expect in Leaf Area Index (LAI) and Gross Primary Productivity (GPP)?*

A: The LAI and GPP will have a regular sharp drop after grass cutting.

- *What are the soil depth and soil texture? How many soil layers are set?*

A: As an example in Chamau. The last element of Zs is 1300, so the soil depth is 1300mm. There are 13 layers in Chamau, because Zs has 14 elements (0 to 10 is the first layer, 10 to 20 is the second layer, so the number of layers is the number of elements in Zs minus 1).

Table 1. Look-up table for some vegetation parameters

Parameter /Location	Chamau	BAY	Davos	Hainich	HARVARD	Laegeren
Species	C3 Grassland Managed and smooth meadow grass,	H: Evergreen Forest [Norway Spruce].	H: Evergreen Forest [Norway spruce]	H: Deciduous forest [Beech, ash, and maple]	H: Deciduous Forest [red oak and red maple]	H: Deciduous Forest [Beech] (Para only for deciduous)
aSE	2	0	0	1	1	**1**
Sp_LAI_In	0.2	0.1	0.1	0.15	0.2	**0.2**
d_leaf	0.8	0.25	0.25	4	4	**4**
Ha	55	72	72	76	76	**76**
Tcold	-2	-20	-20	3	5.5	**3.5**
Tlo	0	8.5	4.5	5	5.5	**3**
Vmax	96	40	44	76	62	**70**

A: The missing parameters in Laegeren can be derived from the provided table. The strategy here is to borrow the first guess of parameters from places with similar vegetation types, and similar climate conditions if possible. In this case, the missing parameters are for the deciduous forest, that is the same type of vegetation in Hainich and HARVARD, so the parameters can be similar to the values in these two places and then can be adjusted in the model calibration. Note however that, while parameters here were provided in a Table for simplicity, in general these should be extracted from existing databases – e.g. SoilGrids, TRY Plant Trait Database – or from the literature. This may be the case in your group project.

Ready to run the simulation

- *What is the time period covered by the meteorological data?*

A: It depends on the dataset you download. Use datevec(Date(1)) and datevec(Date(end)) to check the start and end times of your data.

Result checking and model validation

- *What data is used for model validation in the script?*

A: Usually we calibrate the model using latent heat, GPP, sensible heat, net radiation, soil moisture, and LAI. These measurements are not always available. So in Chama,u the validation is using latent heat, GPP, sensible heat, and net radiation, in Laegeren the validation is using latent heat, GPP, and sensible heat.

- *What is the temporal resolution of these variables, both from measurements and from the model simulation?*

A: For simulation results, energy-related fluxes are simulated hourly (latent heat, sensible heat, and net radiation), while vegetation-related fluxes are simulated daily (GPP). These variables are measured every 30 minutes, and the preprocessing aggregated them to an hourly time step.

- *Plot the observed data (similar to Figures 4 and 5 below) and identify potential errors (such as missing values, clear outliers in the measurements, if any). If errors are found in the observed data, fix or discard the affected periods before proceeding with validation.*

A: Please refer to the provided validation_solution code.

Table 2. Effect of variations in some key parameters on daily GPP/LAI dynamics.

Parameters	Unit	Meaning	Impact on GPP/LAI pattern
Tcold_H / Tcold_L	°C	Air temperature threshold for shedding of leaves, High/Low Vegetation	**Increase shedding temperature will reduce GPP and the other way around. Because leaves are less/more resistance to cold temperature.**
Vmax_H / Vmax_L	$\mu mol\ CO_2/m^2\ s$	Maximum Rubisco capacity at 25°C leaf level, High/Low Vegetation	**Increase Vmax will increase GPP and LAI and the other way around.**
Tlo_H / Tlo_L	°C	Threshold temperature for leaf onset, High/Low Vegetation	**Lower threshold temperature for leaf onset means earlier leaf onset in spring and higher LAI in the beginning. But will not hugely impact on maximum GPP and LAI.**

Part B: Sensitivity analysis and scenarios

1. Sensitivity analysis

Modify the soil/vegetation parameters listed below and explore how these parameters impact key ecohydrological variables (increase, decrease, in percentage). Here is an example in Laegeren.

Variables	GPP	ET (Latent hear, QE)	Leakage
Soil properties			
(Sand) Psan=88% Pcla=5%		Little impact	
(Silt loam) Pan=10% Pcla=5%	-	-	+
(Clay) Psan=25% Pcla=50%		Little impact	
Vegetation properties			
Root depth decrease to 500 [mm]	-	-	+
Root depth increase to 1200 [mm]		Little impact	
Specific leaf area -50%	-	-	+
Specific leaf area +50%	+	+	-
Vmax = 50 [μmol CO_2/ m^2 s]	-	-	+
Leaf carbon nitrogen ratio -50%	-	-	+
Leaf carbon nitrogen ratio +50%	+	+	-

2. Analysis of simple scenarios

Run some additional simulations changing the meteorological forcing and explore how the modified forcing impacts target ecohydrological variables (increase, decrease, in percentage).

Variables	GPP	ET (Latent heat, QE)	Leakage
Meteorological forcing			
Ta +3ºC	+	+	-
Pr -50%	-	-	-
CO_2 +300 ppm	+	-	+

A: Only the general increase/decrease trend is provided in the table because the exact number will depend on the simulation period we run the model.