ALTOS

Managing water resources within Mediterranean agrosystems by accounting for spatial structures and connectivities.

Task 3.1: modelling individual processes

- Water fluxes within heterogeneous rooting systems or under drip-irrigated orchards.
  - Targets: subsurface distribution of hydraulic redistribution and water flows.
  - Methodological innovations: hydraulic redistribution modelling with respect to root sap.
  - Partners: INAT, CESBIO, UNICA, IRTA.
  - Study areas: Merguellil, Segre, Orroli.
- Evapotranspiration.
  - Targets: surface - atmosphere exchanges within heterogeneous / multi-strata crops and above hilly crops.
  - Methodological innovations: modelling of exchange coefficients, including model development / parameterization / calibration. Comparing simulations from new parameterization against those from previous parameterizations to highlight benefits.
  - Partners: INRGREF, INAT, LISAH, UCAM, CESBIO, UNICA, IRTA.
  - Study areas: Merguellil, Cap Bon, Tensift, Segre, Orroli.
- Dam - aquifer exchanges.
  - Targets: water flows from dam leaks to underlying aquifer.
  - Methodological innovations: modelling of exchange coefficients, including model development / parameterization / calibration.
  - Partners: CERTE, LISAH, UNICA.
  - Study areas: Cap Bon.

Partner

Univ. of Cagliari

Task 3.1. modeling individual processes (leader: CESBIO)

UNICA

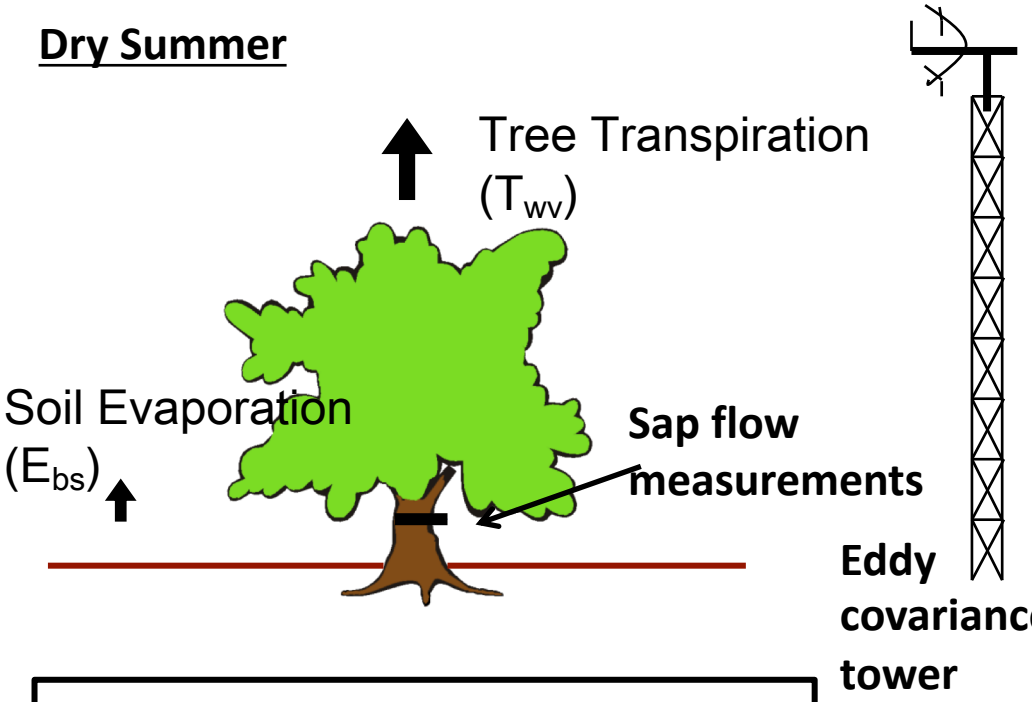
Dipartimento di Ingegneria Civile , Ambientale e Architettura

Università di Cagliari, Italy

PI: ***Nicola Montaldo***

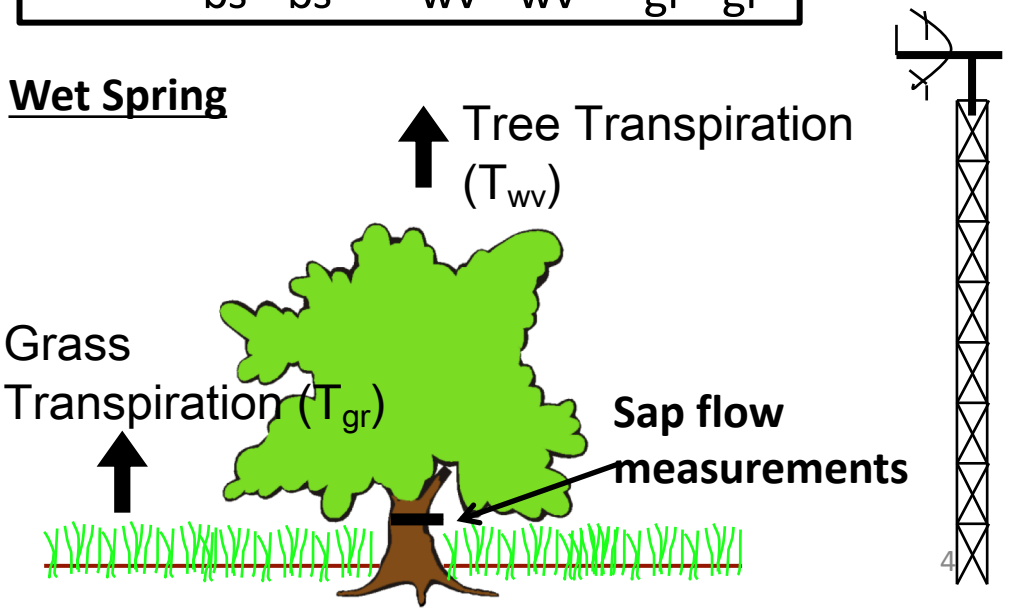
Giulio Vignoli, Roberto Corona, Serena Sirigu, Alessandro Seoni, Antonio Mascia, Andrea Saba

Dry Summer



$$ET = E_{bs} f_{bs} + T_{wv} f_{wv} + T_{gr} f_{gr}$$

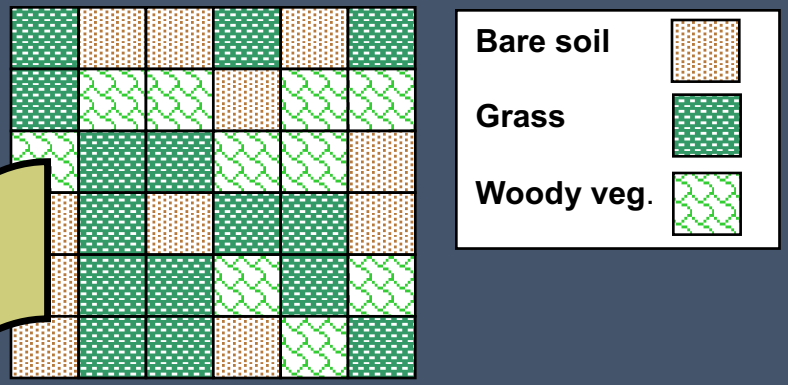
Wet Spring



The Vegetation Dynamic (VDM) - Land Surface model (LSM)

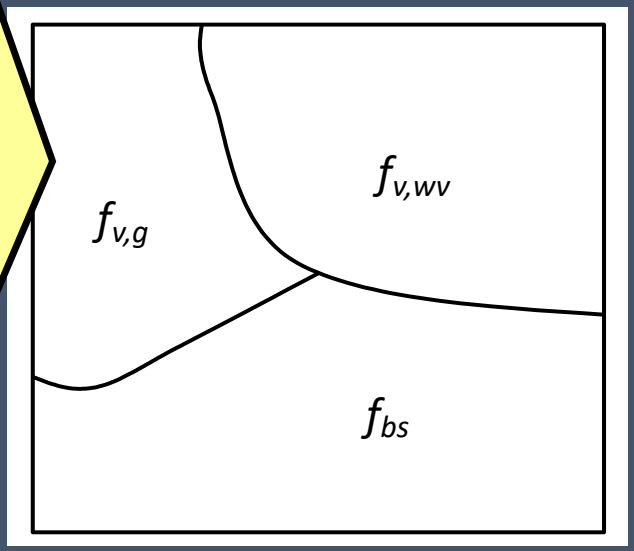
Patch mosaic

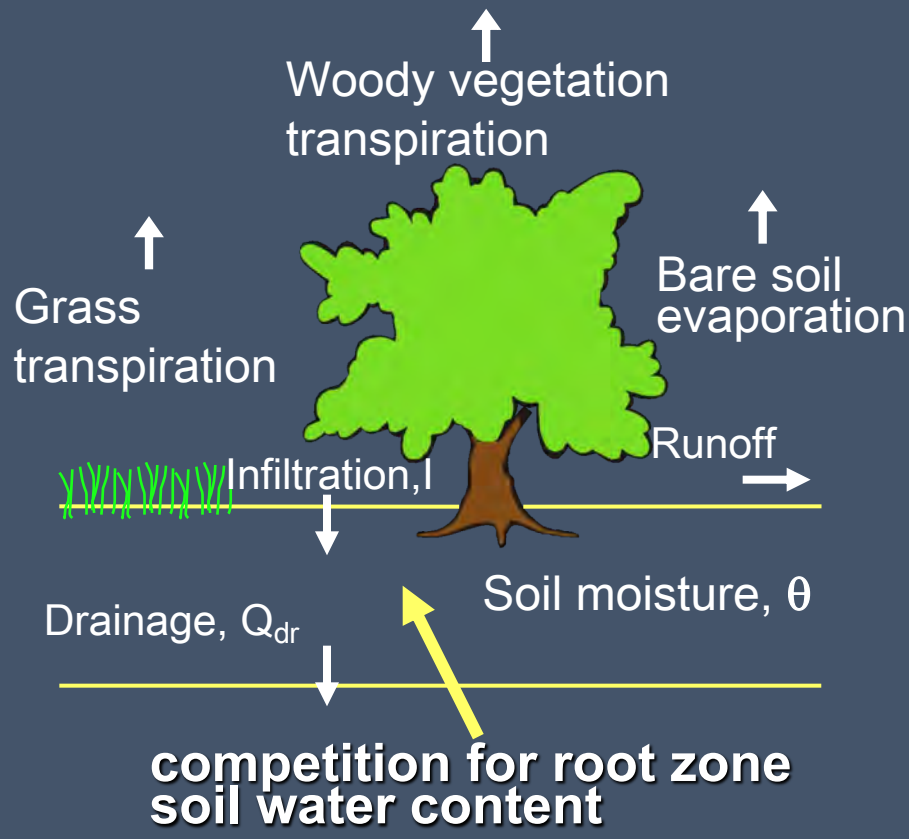
Patchs



Decomposition of the Landscape

($f_{v,g}$+$f_{v,wv}$+ f_{bs}=1)





competition for root zone soil water content

- Root zone budget: $\frac{\partial \theta}{\partial t} = \frac{1}{d_{rz}}\left(I - ET - Q_{dr}\right)$
- $Q_{dr} = K_{sat} \cdot \left(\frac{\theta}{\theta_{sat}}\right)^{2 \cdot b + 3}$

(Montaldo et al., 2005, WRR
Montaldo et al., 2008 HESS)

- Evapotranspiration $ET = E_{v,g} + E_{v,w} + E_{bs}$

$E_{bs} = f_{bs}\,\alpha(\theta)\,E_p$

Penmann-Monteith

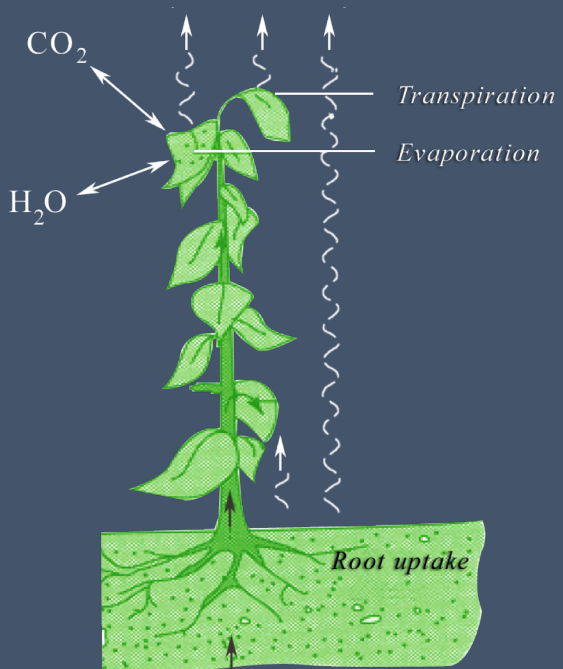
$$r_{a,k} = \frac{\ln\left(\frac{z_m - d_{o,k}}{z_{om,k}}\right)\ln\left(\frac{z_v - d_{o,k}}{z_{ov,k}}\right)}{k^2 u}$$

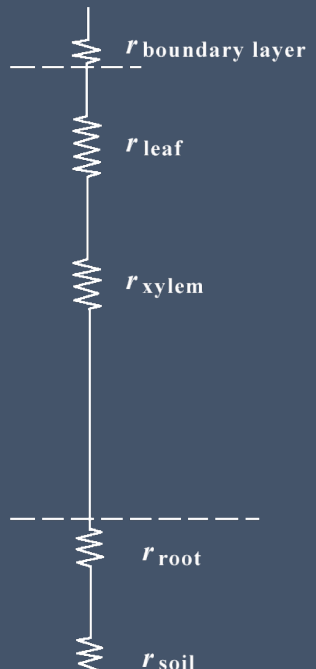
$$E_{v,k} = f_{v,k} \cdot \frac{\Delta \cdot (R_{n,k} - G_k) + \frac{\rho_a \cdot c_p \cdot VPD}{r_{a,k}}}{L_v \cdot \rho_w \cdot \left[\Delta + \gamma \cdot \left(1 + \frac{r_{c,k}}{r_{a,k}}\right)\right]}$$

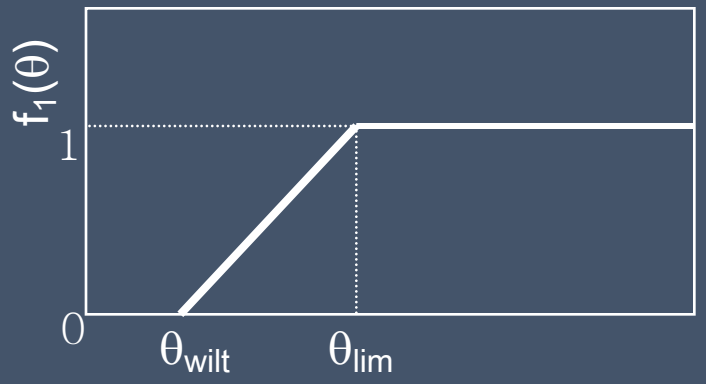
$$r_{c,k} = \frac{r_{s\,min,k}}{LAI_k f_{1,k}(\theta) f_{2,k}(T) f_{3,k}(VPD)}$$

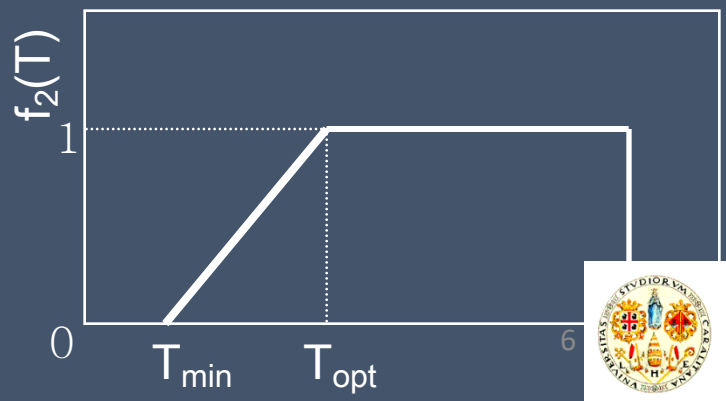
Canopy resistance

with *k*= *w* (woody vegetation) or *g* (grass)









Vegetation dynamic model of the generic vegetation type

- Green (leaves) biomass

$$\frac{dB_g}{dt} = a_g P_g - R_g - S_g$$

- Stem biomass

$$\frac{dB_s}{dt} = a_s P_g - R_s - S_s$$

- Root biomass

$$\frac{dB_r}{dt} = a_r P_g - R_r - S_r$$

- Dead biomass

$$\frac{dB_d}{dt} = S_g - L_a$$

Production Destruction

- P_g : *Gross photosynthesis*
- a_g, a_s, a_r *allocation coefficients, dinamically estimated*
- $R_x = m_x \cdot f(T) \cdot B_x + g_x \cdot (a_x \cdot P_g)$

Maintenance and growth respirations

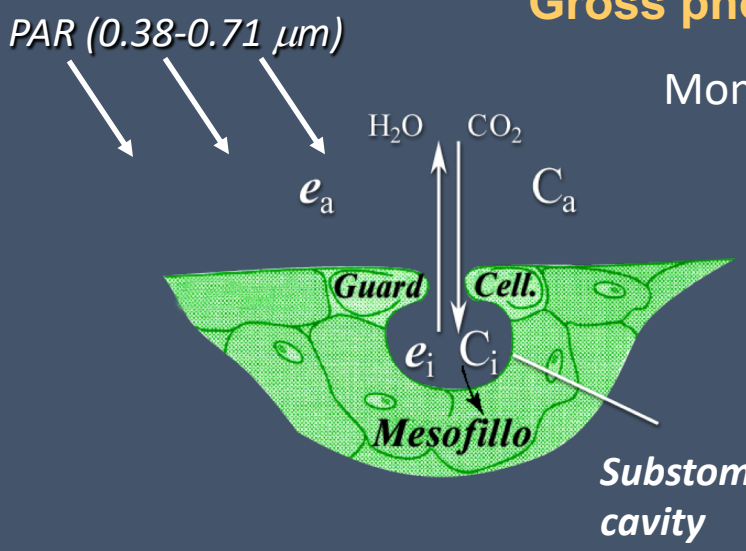
- $S_x = d_x \cdot B_x$ *Senescence*
- $L_a = k_a \cdot B_d$ *Litter fall*

- $LAI = B_g \cdot c_g$
- $LAI_d = B_d \cdot c_d$
- $LAI_t = LAI + LAI_d$

Derived from Montaldo et al., [WRR, 2005]; Nouvellon et al., 2001

Gross photosynthesis

Montaldo et al., [WRR, 2005]

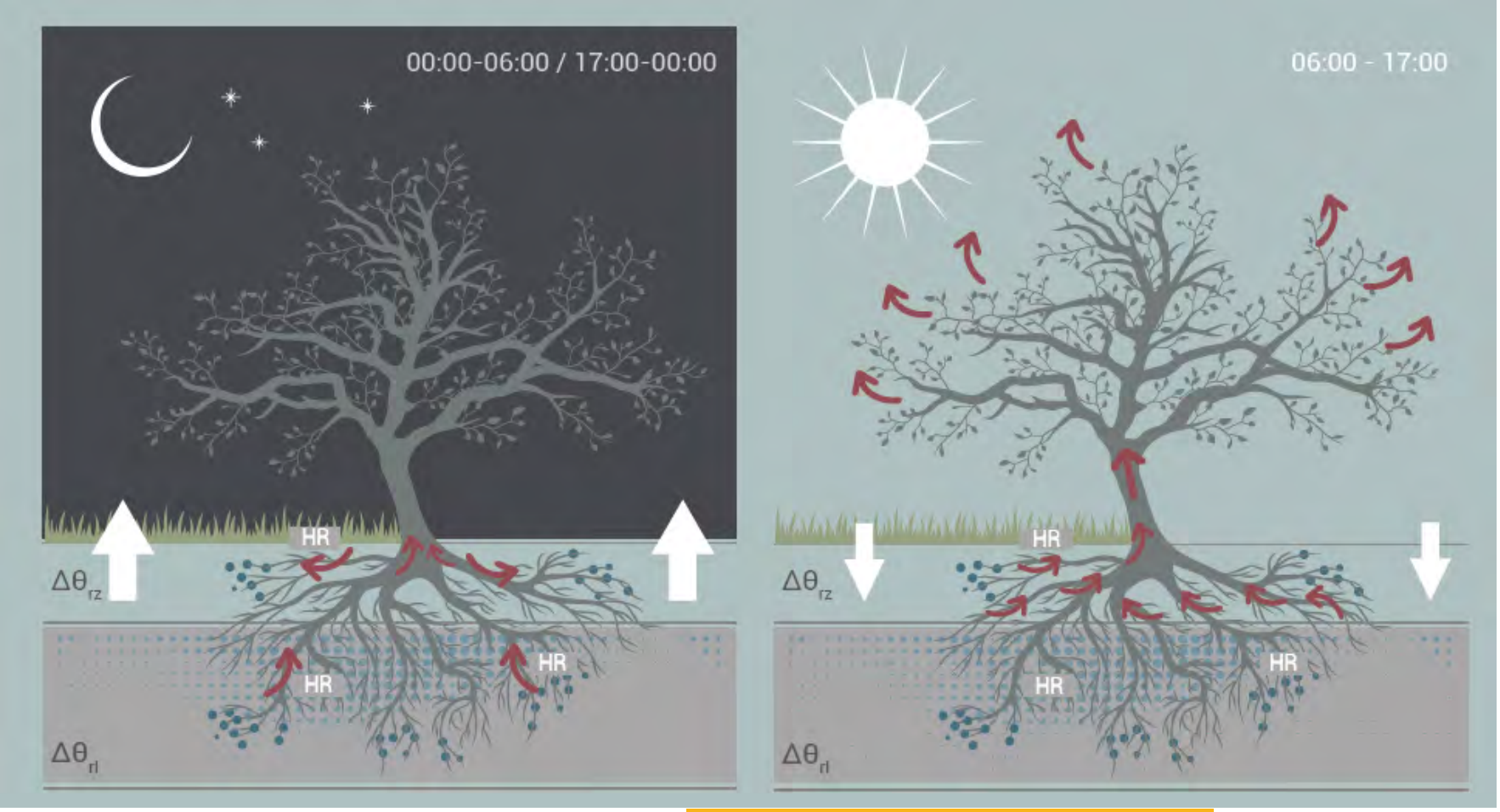


$$r_c = \frac{r_{s\,min}}{LAI \cdot f_1(\theta) \cdot f_2(T) \cdot f_3(VPD)}$$

$$P_g = \varepsilon_P(PAR) f_{PAR} PAR \frac{1.37 r_a + 1.6 r_{c,\min}}{1.37 r_a + 1.6 r_c}$$

$f_{PAR} = 1 - e^{-k_e LAI}$ fraction of PAR absorbed by the canopy

ε_P is the leaf photochemical efficiency [g dry mass/ PAR]



We are adding Hydraulic redistribution

$$HR = -C_{r,max} R_e \frac{\Delta \psi}{d_r}$$

$$R_e = f^{-1}\left[\left(\psi, \psi_{50}, b_{R_e}\right)\right]$$

Partner

CERTE

ALTOS

Managing water resources within Mediterranean agrosystems by accounting for spatial structures and connectivities.

WP3: Modelling fluxes and storages

Task 3.1: modelling individual processes (leader: UNICA).

CERTE contribution

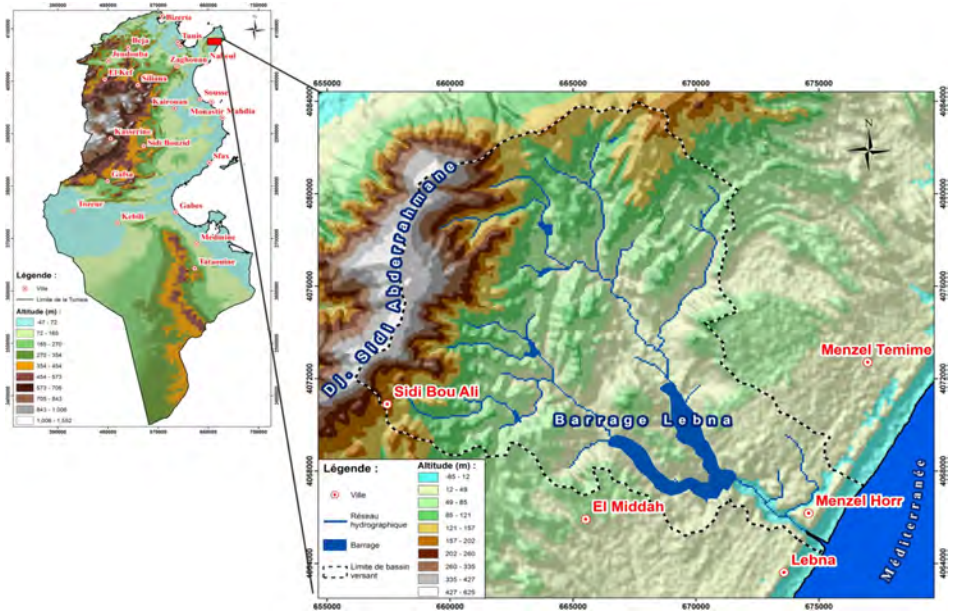
Dam - aquifer exchanges.

Modelling Lebna Dam - aquifer exchanges.

Goals: modelling and studding the relationships: surface water / groundwater and Dam / Aquifer.

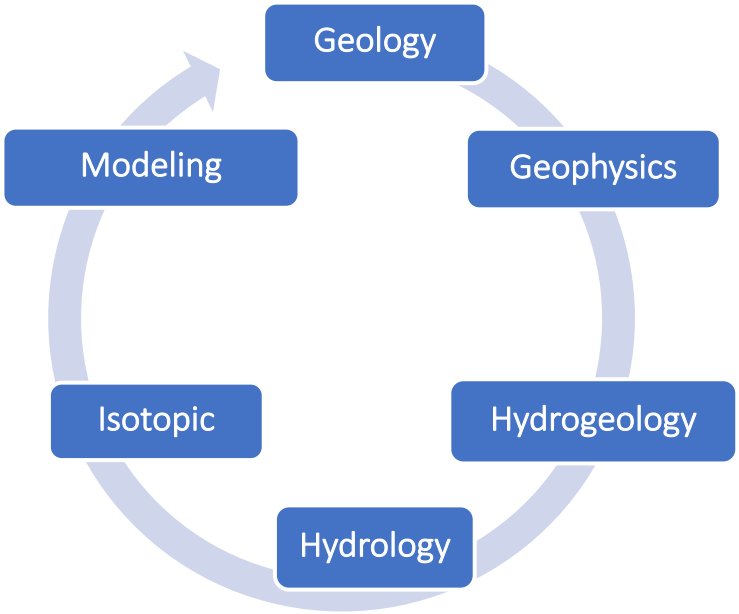
Team: **PhD** (N Ouhichi), F Lachaal, O Grünberger, R Hamdi, and C Leduc,

Period: 2021-2022



Geologique map

Methodology



Partnership: LISAH

Project: LMI-NAILA

Aquifer recharge, LGR, CERTE

Partner

CESBIO

ALTOS

CESBIO-IRD

Task 1.1

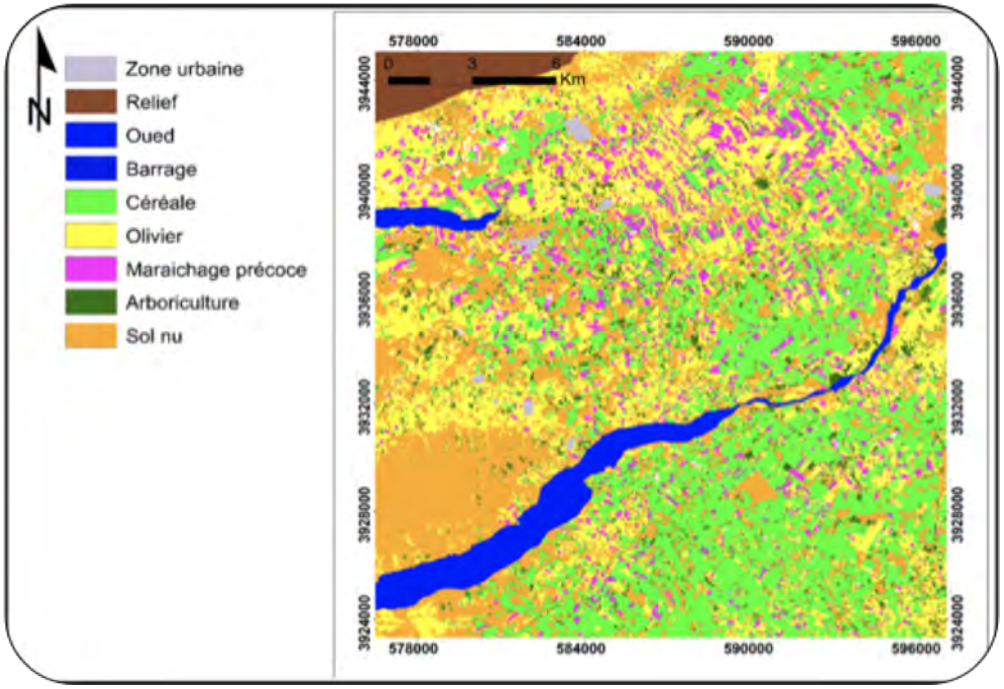
- Tree geometry: Taous rainfed Olive (Tunisia)
  - proxidetection (PRI, ...) > maybe FLEX + LiDAR, TIR (within activities of TRISHNA TIR mission, with directional aspects)
  - DART 3D radiative transfer tool
  - ➢ PhD student + ALTOS Postdoc contract

- Spatial variability in soil infiltrability: Merguellil
  - Analysis of S1 time series
  - ➢ PhD student

- Climate variability: Merguellil
  - Downscaling of ERA5 using WRF and MODIS
  - ➢ PhD student

Task 1.2

- Land Use: Merguellil and Tensift
  - Developping and testing methods to derive seasonal (crop succession, min. twice a year) LU maps with S2 and minimum training data
  - ➢ 2 ALTOS funded traineeships



Task 2.1

- Evapotranspiration, soil moisture and crop growth
  - Irrigated (Tensift) and rainfed (Taous, Tunis) olive trees: joint use of eddy covariance / sap flow / isotopic measurements and optical / radar / thermal infrared remote sensing data, joint use of times series from insitu and remote sensing data.
  - ➢ CNES MOCTAR (Tensift) and TRISHNA (Taous) projects

- Dam - aquifer transfers and upstream - downstream surface / subsurface transfers.
  - Tensift: water budget calculation from hydrometric measurements (surface and subsurface inputs, water uses) and climate forcing data (rain, evaporation), piezometric network data
  - ➢ VI contract

Task 2.2

- Canopy scale heterogeneity induced by row and multi-strata structures and / or drip irrigation (Tunisia Taous site).
  - joint use of sap flow sensors (installed in both tree roots and trunks), eddy-covariance devices and in-situ remote-sensing to characterize the 3D functioning.
- Landscape scale heterogeneities induced by soil, topography and canopies (Tensift).
  - joint use of eddy covariance data at sub-catchment scales (few tenths of hectares), of scintillometry data across field transects, and of remote sensing data with embedded metric to kilometric resolutions à analysis of spatiotemporal dynamics.

Task 3.1

- Development of a Soil-Vegetation-Atmosphere Transfer model adapted to heterogeneous orchards (drip irrigation, intercrop…)
  - Test of MAESPA model over Tensift and Merguellil
  - Review of possible simplications (geometric features for 3D row/isolated tree; and esp. Radiation, multiple 1D approaches for soil moisture transfer…)

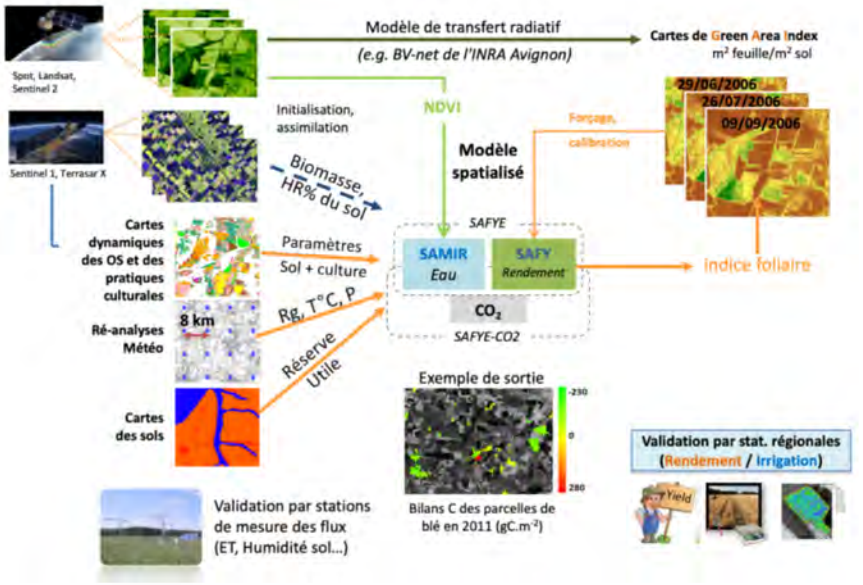
➢ ALTOS Postdoc Contract

Task 3.2

- Coupling distributed hydrology modelling along with crop growth modelling (Cap Bon)
  - coupling of MHYDAS distributed hydrological modelling and SAFYE crop growth/ET model within the OpenFLUID platform.

  > Expertise provided from CESBIO on SAFYE Python version

- Hydrological modelling and climate forcing (Tensift)
  – Methodological innovations: comparing SAMIR-WEAP-MODFLOW simulations against SAFRAN-ISBA-MODCOU ones to highlight the impact of spatial variability in climate forcing at the catchment extent.



Link with other projects

- CHAAMS (ERANETMED 3, 2018-2021, FR*2, MA, TU, LI)
- ACCWA (H2020/RISE, 2019-2023, SP, FR, TU, MA +)
- FLUXMED (JPI WATER, 2020-2022, IT, FR, TU +)
- IDEWA (PRIMA, 2020-2023, FR, MA+)
- Hi-LIASE (ANR, 2021-, FR, SP +)
- CNES funded: TRISHNA (FR, TU, MA +), MOCTAR (FR, MA), …
- ESA funded: IRRIGATION+ (MA, SP, ?), SEN-ET (SP, TU test site)
- Many PRIMA submitted in 2020 (icl. DroughtTools PI IRTA)

Partner

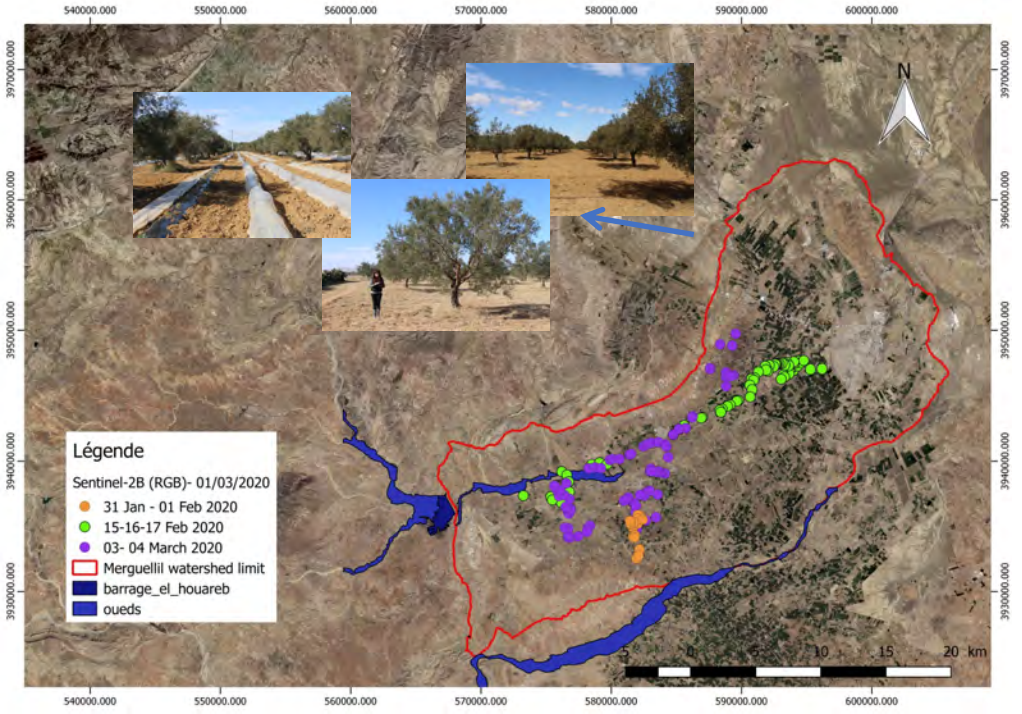
INAT

Task 3.1: modelling individual processes

- **Objectives:**
  - monitoring of Soil moisture
  - Interaction water soil plant (olive in our case study)

- **Method**
  - planned measures and field trip
  - Soil humidity
  - LAI
  - Available satellite data
    - **Sentinel-1** (Open Data)
    - **Sentinel-2** (Open Data)
    - **Cosmo-SkyMed** (OPTIMED)
    - **Pleiades** (ALTOS)
- Study area : Merguellil Plain
- Partner : UNICA , CESBIO, IRTA
- PhD contracts

Figure Map of field observations in 2020 (Merguellil Plain)



Partner

INRGREF

Task 3.1: modelling individual processes (leader: UNICA).

Evapotranspiration

Lebna watershed

Hilly topography no program for the next year

Citrus orchard

- Svat modelling scheduled (PHD thesis) link with fluxmed

- Is it possible to test the new parametrisation on the citrus orchard?

Partner

IRTA

Task 3.1: modelling individual processes (leader: UNICA).

IRTA Contribution

Confirmed activities : Improvements in the parameterization of TSEB in order to improve the accuracy in the estimates of T

Activities	Period	Study areas	Team
Evaluate the impact of an accurate modeling of the wind profile within the canopy on the TSEB model flux estimates, considering the effect of the foliage density in the wind attenuation. Two sonic anemometers will be placed at two different heights in a vineyard to validate the wind profiles estimates based on the algorithms presented in Massman (1987, 2017) and Goudriaan(1977)	2020	Vineyard (Lleida) and probably apple orchard	C Jofre J Bellvert M Pàmies A Pelechá O García-Tejera
Improve the accuracy of Priestley-Taylor and S-W models for estimating LE at potential conditions -> re-adjustement considering the stomatal response to VPD	2020-2021		

Partner

LISAH

Modelling ETR and water fluxes / LISAH

Objectives: modelling ETR over hilly crop fields

Method: modelling of exchange coefficients, on the basis of kB-1 parameterization

Means

- Available dataset, almost analysed

Modelling ETR and water fluxes / LISAH

Partnership

- INRGREF

Roadmap

- Paper on kB-1 parameterisation to be finalized

Difficulties

--> possibility (work load)?

Modelling lake - aquifer exchanges / LISAH

Objectives: modelling water flows from dam leak towards underlying aquifer

Method: modelling of exchange coefficients, on the basis hydraulic charge related to hydraulic charge, underlying piezometry, and hydraulic conductivity of underlying substratum

Mean: Distributed Hydro-Agricultural Model - reservoir development is almost finalized (LISAH PhD student)

Modelling lake - aquifer exchanges / LISAH

Partnership

- Not yet identified

Roadmap

- Implementation of DHAM-reservoir within Lebna.
- Validation strategy to be defined : period, required data

Difficulties

See also works on dam - aquifer with CERTE

Modelling pollutant transport and fate / LISAH

Objectives: modelling the effect of pesticide practices on underground water contamination within irrigated perimeter

Method:

- Resolving two dimensional Richard's equation (TDRE) over data from both soil column and field experiment
- Using TDRE to simulate pollutant transport for different pesticide practices.

Modelling pollutant transport and fate / LISAH

Means

- Former NAILA works on DTRE inversion by means of soil columns experiments
- HYDRUS-2D software
- 1 PhD (ALTOS granted)

Partnership

- INAT

Modelling pollutant transport and fate / LISAH

Roadmap

- To be defined, including PhD hiring and work program