A Satellite Supported Inverse Biophysical Modeling Approach for the Detection of Irrigated Agricultural Land and the Determination of the Amount of Irrigation in Arid and Semi Arid Regions.

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Water Scarcity

- Less than 1 % of the world's fresh water is available for human use.
- 70% is used for agriculture , 20% for industrial use and 10 % for domestic use
- In the MENA regions, withdrawal as percentage of the total renewable water resource is more than 50 %,
- In some other places such as Libya and Saudi Arabia, water use for irrigation has already (by the year 2000) reached several times the annual renewal rate .

No global (regional or local) estimates on :

- How much water is being used for agriculture ?
- Where is this water used ?
- What is the future trajectory of agricultural water use in the near future as agriculture expands for the same of often decreasing amount of precipitation?

Goal and Objectives

The goal of this proposal is to develop a new approach for detecting irrigated agricultural lands in arid and semi-arid regions and to quantify the amount of irrigation water required for agricultural production as influenced by climate, crop type, soil characteristics and irrigation efficiencies.

The primary objectives of the proposed work are:

Principal

1- Detection of irrigated agricultural lands: [P. Zhang] : Develop a new, satellite and model-based, methodology to detect irrigated agricultural lands in arid and semi-arid regions.

2- Quantification of the irrigation requirement [L. Bounoua] : Develop inverse biophysical model to quantify the amount of water used for irrigation in agricultural lands.

3 – Large scale application [L. Bounoua] : Refine the methodologies over multiple local scale sites in arid and semi-arid regions and apply the validated algorithms over large scale agricultural areas in the MENA regions ("hot spots").

4- Socio-economic application [A. Karnieli, M. Messouli] : Develop and apply simple but realistic change scenarios based on agricultural products demand as influenced by climate, population, technology and local socio-economic factors, to explore the implications of these changes in terms of their impact on agricultural production and water resources and their adaptability to a changing climate.

Land Cover Land Use Change Science Team Meeting

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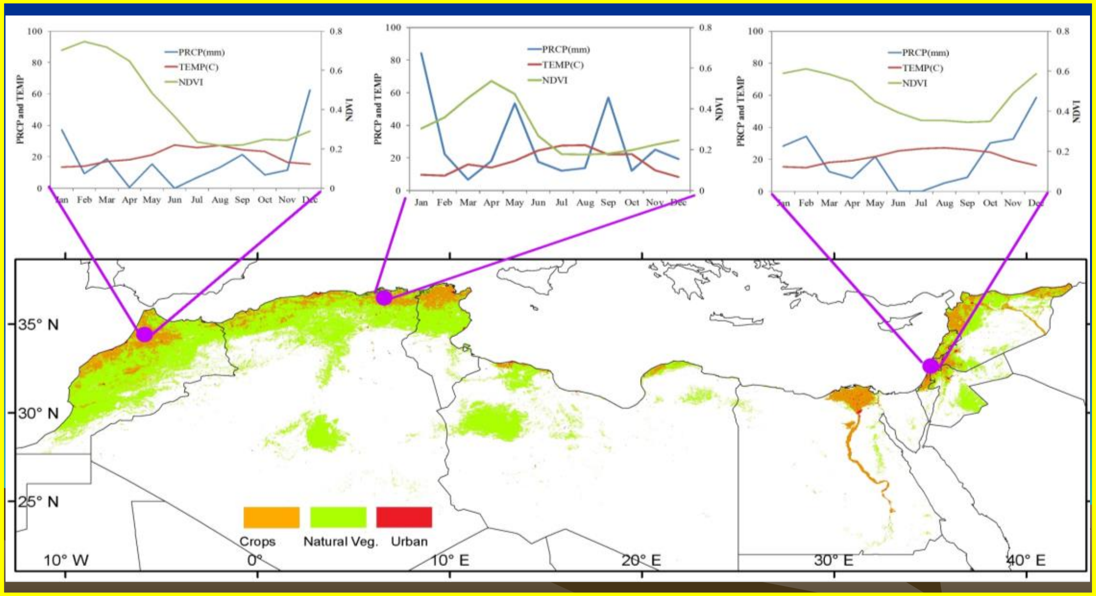
Data Preparation

1- Land:
- MODIS Land Cover and Land Use map at 500m
- NDVI at 500m and 16-day composite
- A set of Derived biophysical parameters [Fpar, Lai, Gf, Zo, dd, C1, C2]

2- Climate Data
- All climate data to drive the model were obtained from the Modern Era Retrospective Reanalysis [MERRA 0.25x0.25 deg.] performed by the GSCF – GMAO
- We use several parameters at hourly time scale including Temperature and Precipitation

3- We also conducted field surveys asking for specific information at farm level such as irrigated area (ha), monthly irrigation amount., soil properties …



Study Area
MENA
- Testing and validating the model on farms in:
  - Morocco
  - Algeria
  - Israel
  - (Jordan)
- We select 3 regions
  - Doukkala (Morocco)
  - Mitidja (Algeria)
  - NW Negev (Israel)

Objective 1- step 1 – Detection of irrigated agricultural lands (at quarter degree)

0.25

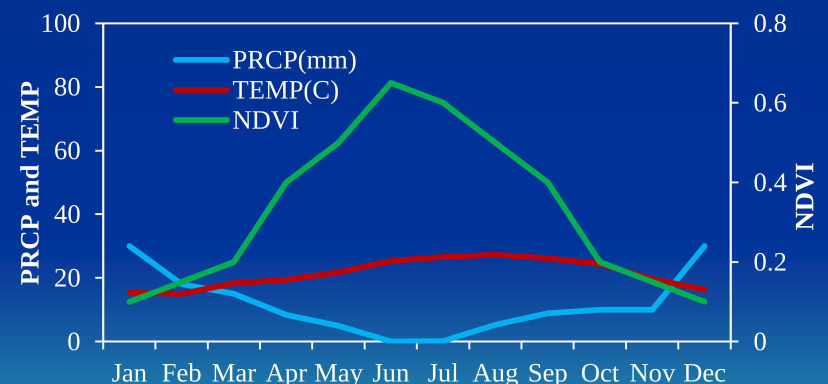
0.25

Crop map
from MODIS

16-day
MODIS NDVI
time series

Hourly
Precipitation
Temperature
(MERRA)

Detection algorithm consists of confronting the phenology with local climatology



0.25

Irrigated
Agriculture
Area

The detection algorithm is based on an-out-of-phase relationship between the ndvi, representing the vegetation density and the precipitation annual cycle within the range of growing season optimum temperature.

Objective 1 – Step 2– Detection of irrigated agricultural lands (500 meter)

500 m MODIS crop

500 m MODIS NDVI

→

PCA analysis and supervised classification

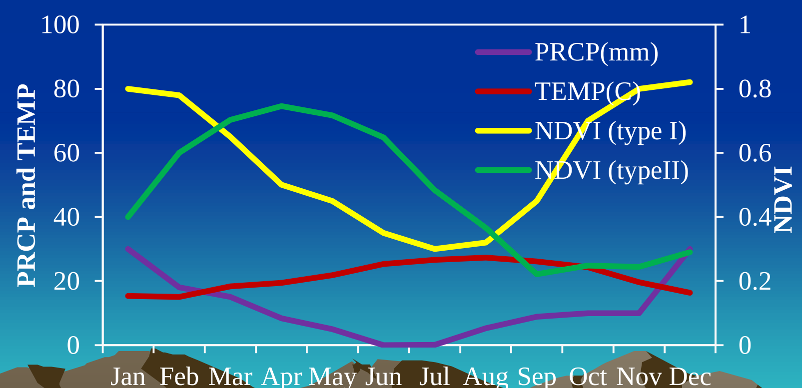
→

6 typical crop rotations

↓

Aggregate by rotation

Detection process helps to separate different crop rotations within the same quarter degree pixel.



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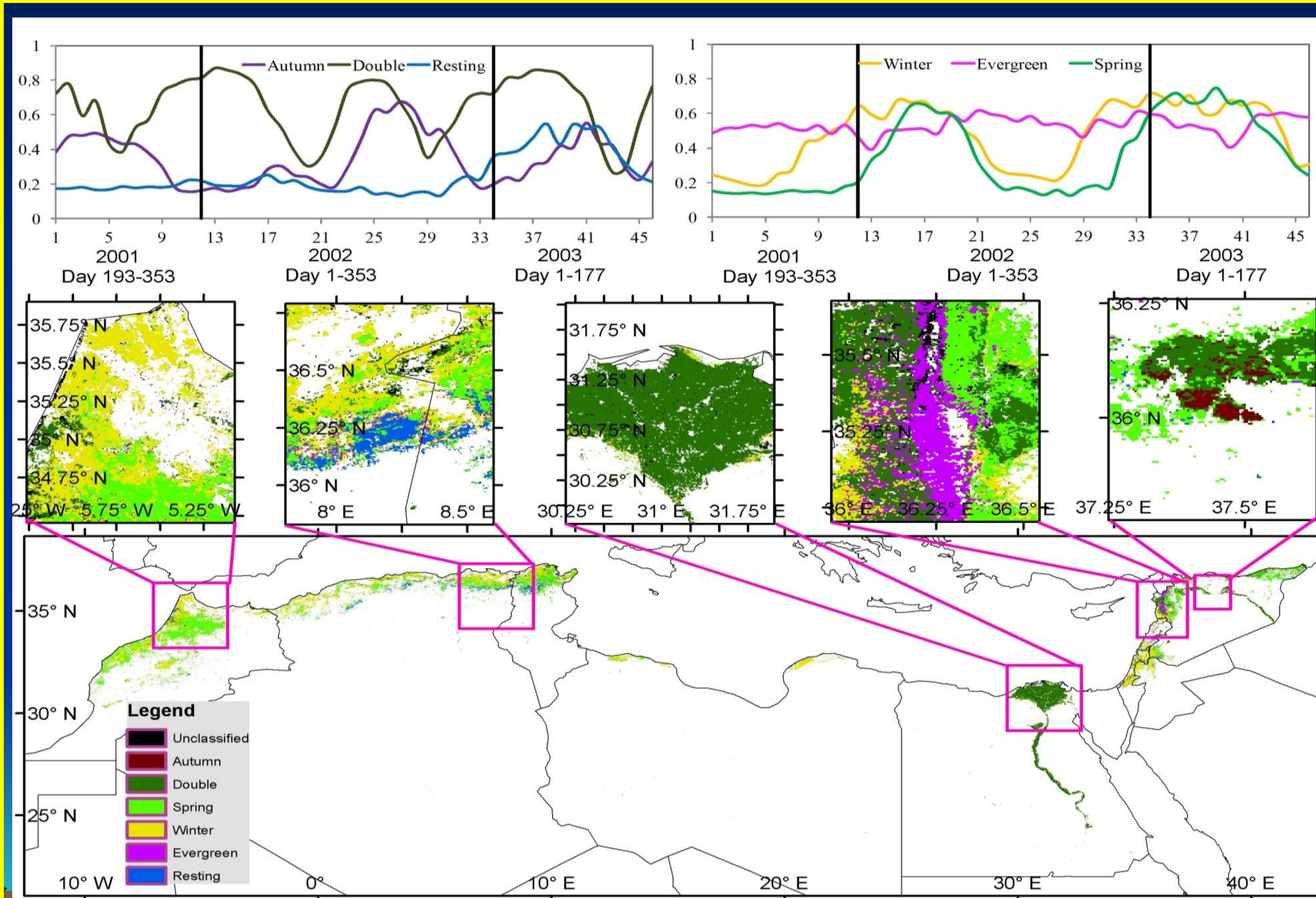
Crop and NDVI series for each crop rotation

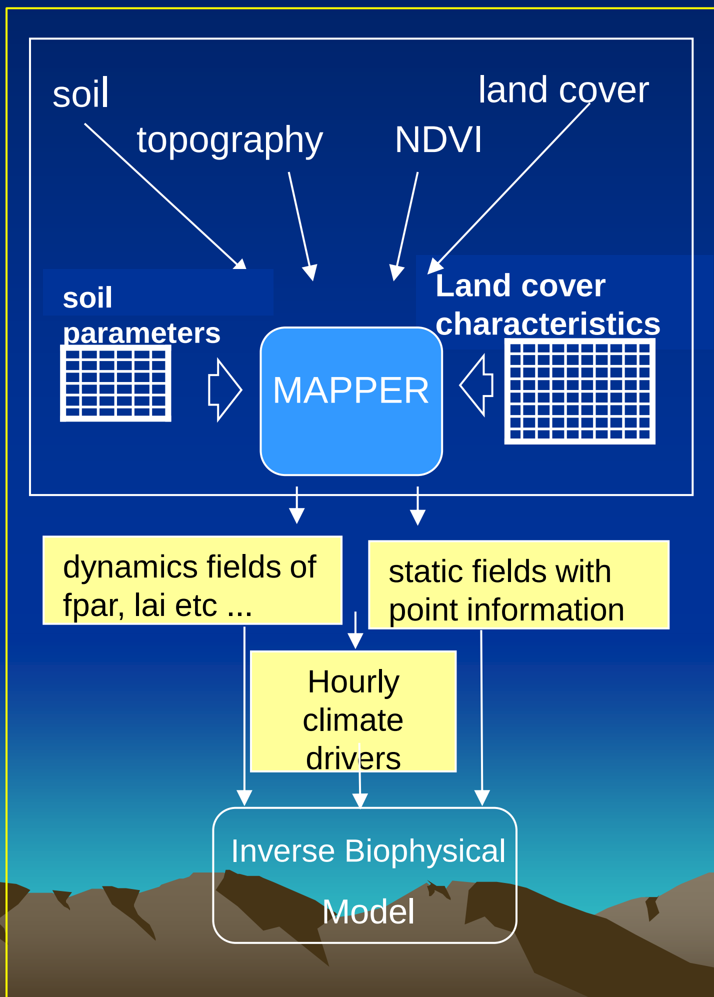
Objective 1 – Results

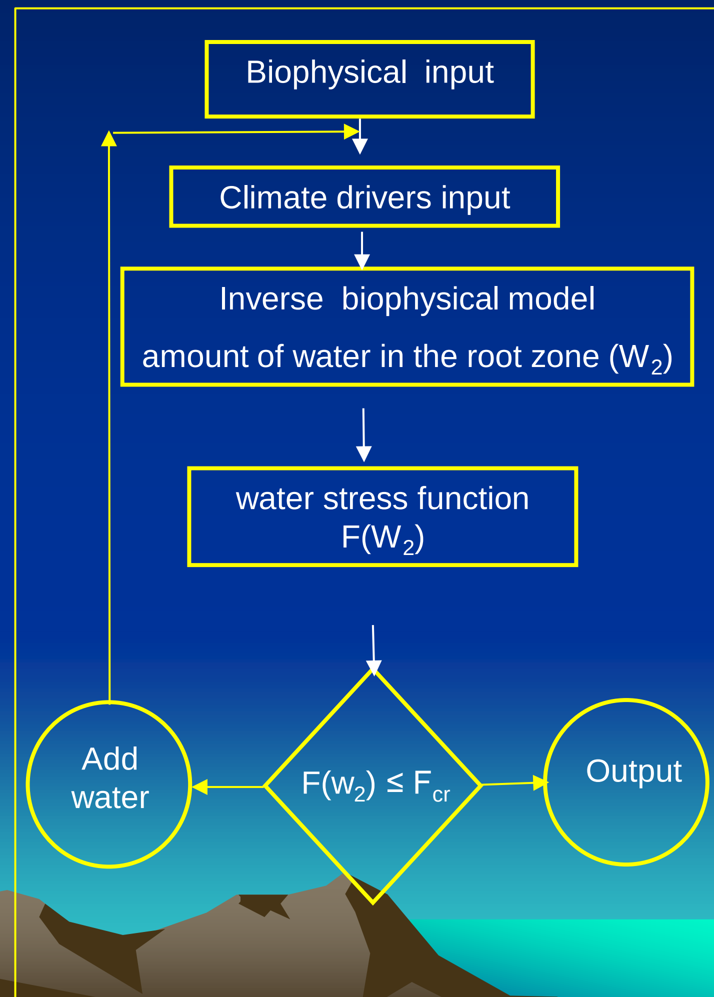


The PCA analysis and the classification allow us to locate different crop rotations at MODIS scale (500m)

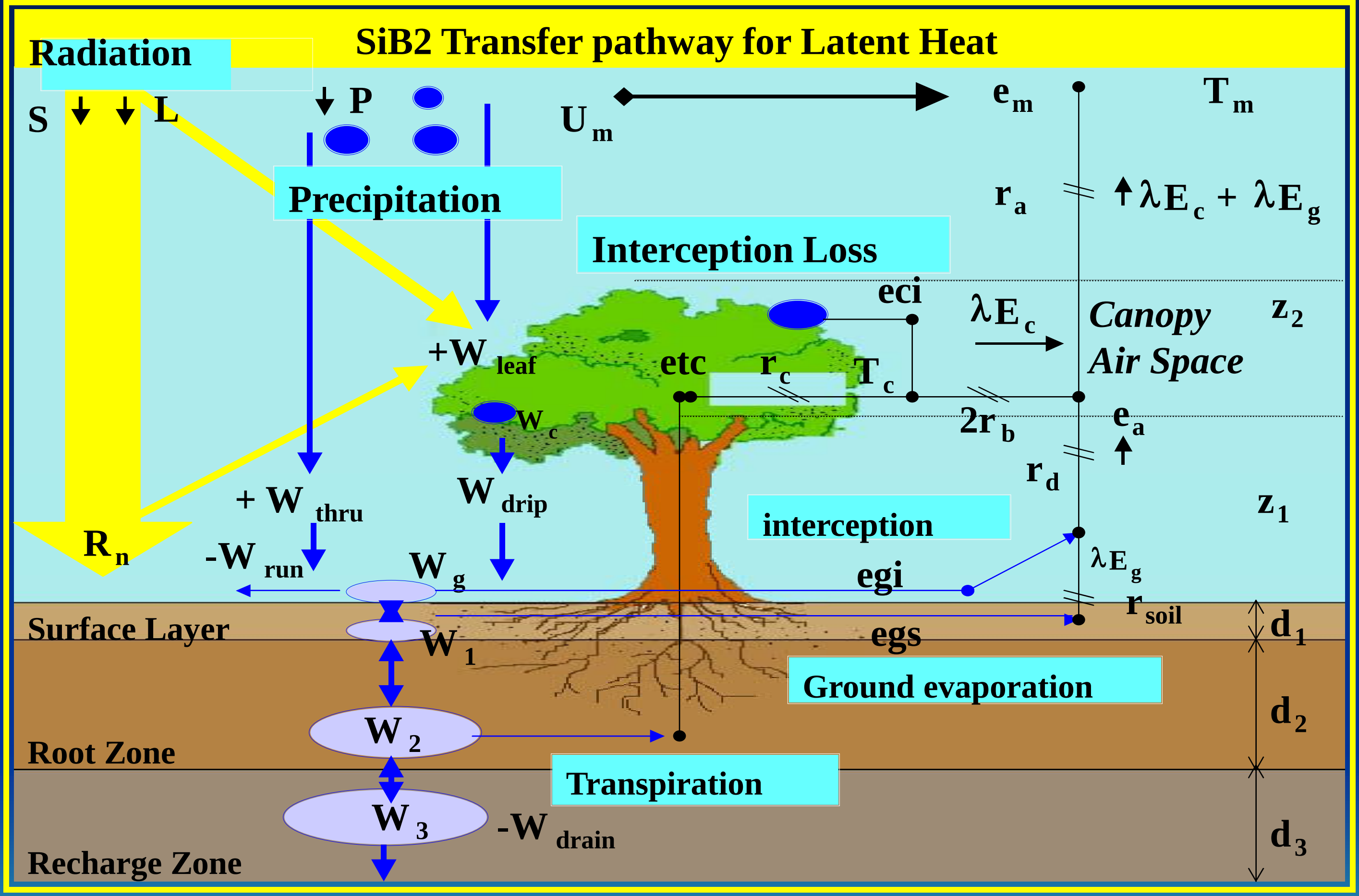
Model

We postulate that the degree to which irrigated lands vary from equilibrium conditions is related to the amount of irrigation water used.



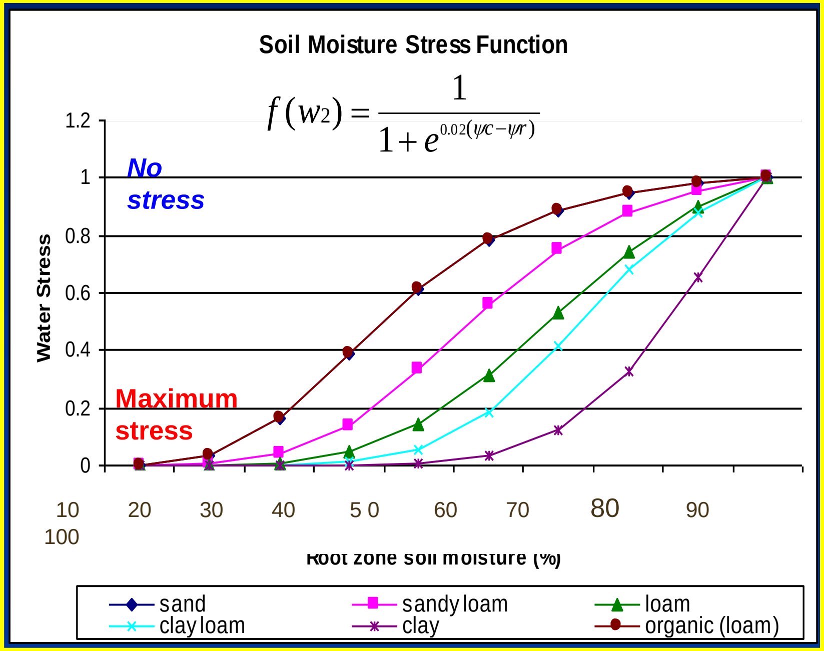


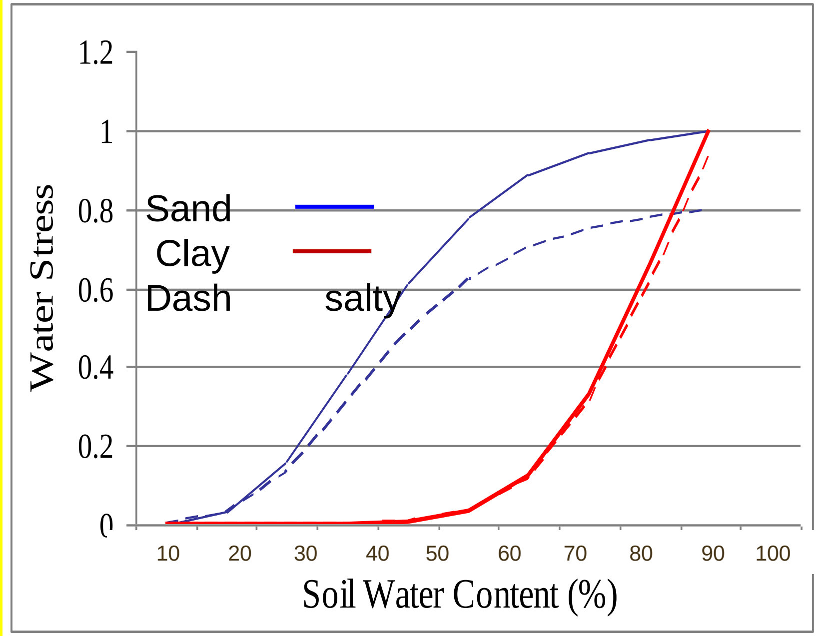
Model



Schematic functioning of the Simple Biosphere Model (SiB2) showing the pathway for the latent heat flux calculation.

Water Stress Function





The water stress function depends on the root zone soil moisture itself a function of precipitation amount, soil physics and soil hydraulic properties.

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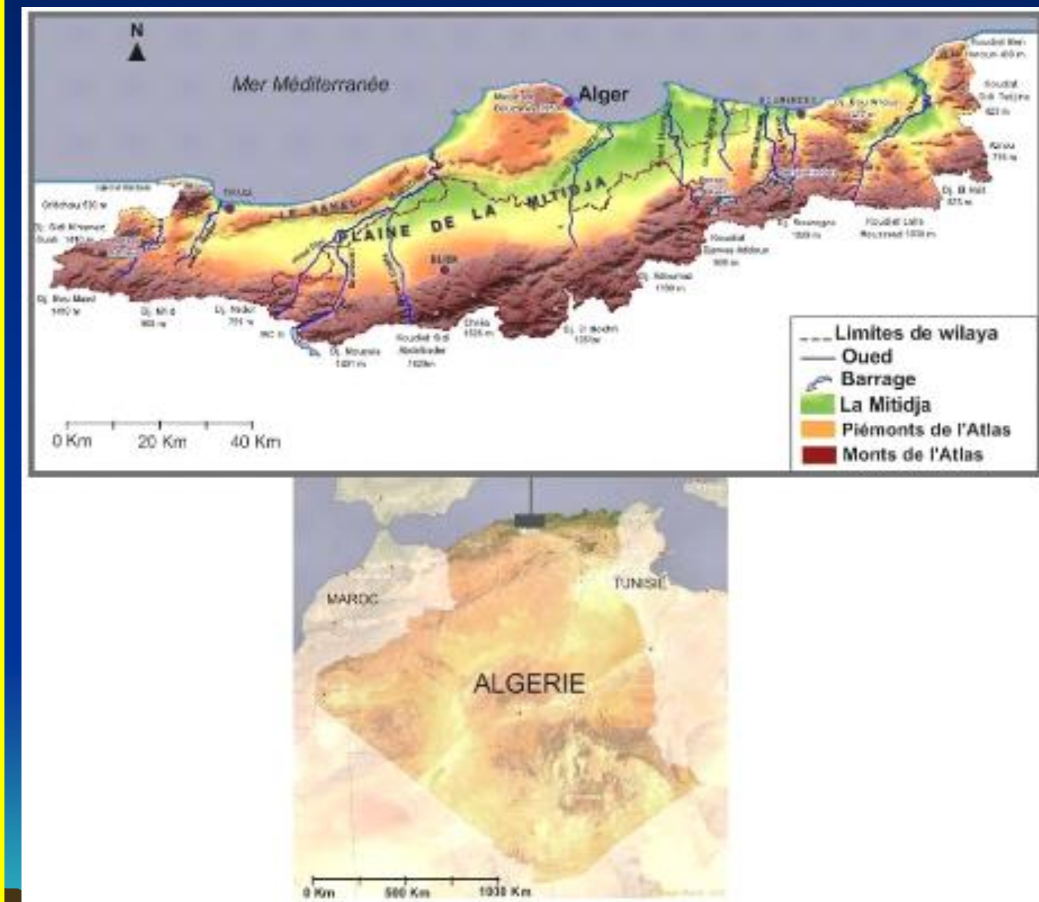

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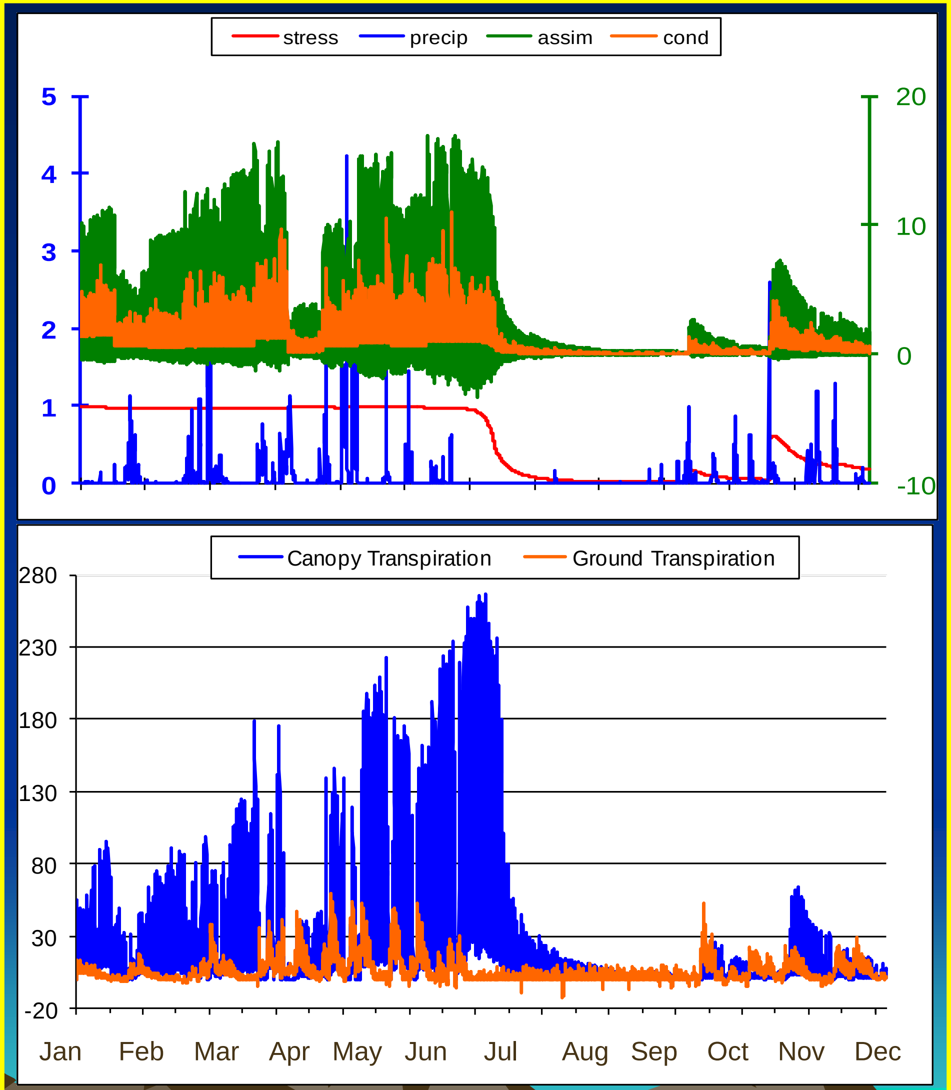
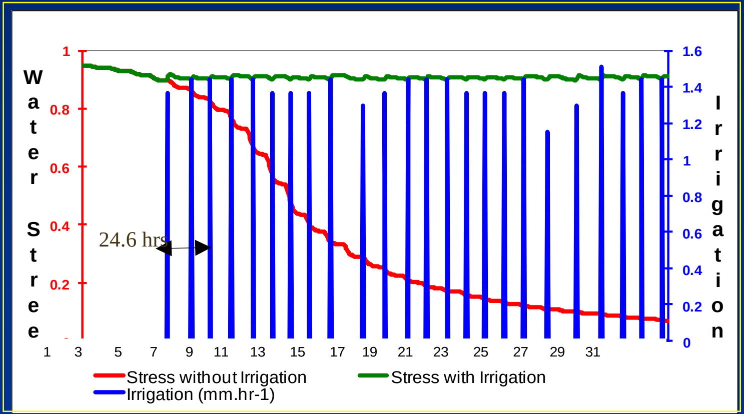
Model Response- control



(A) Assimilation and conductance (right axis); Precipitation and Water stress (left axis), (B) Canopy and ground Transpiration

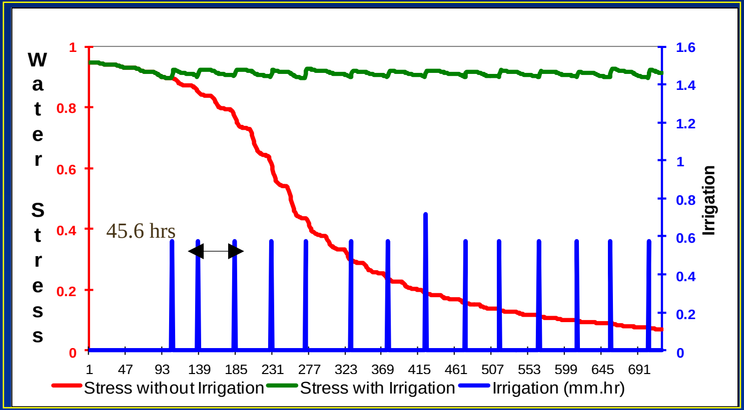
Model Response

Spray Irrigation



Irrigation maintains a water stress level around the 0.9 threshold and provides an irrigation amount of about 1.4 mm per occurrence with an average frequency of occurrence of 24.6 hours.

Drip Irrigation



Since water is added directly to the roots, there is no canopy interception loss. The drip delivery provides an irrigation amount of about 0.6 mm with a frequency of occurrence of 45.6 hours.

The approach provides a **physiological benchmark** water requirement for observed canopies to which reported irrigation water use can be compared in order to improve both estimates and delivery systems.

Results

Eastern Mitidja, Algeria

Potato, Sweet Peppers, Eggplant, Carrot, Turnip ,Zucchini, Beans

	Delivery	Amount ($m^3\ ha^{-1}\ yr^{-1}$)	% of reported
Reported	All	1904.20	100
Modeled	Spray	1170.00	61.5
Modeled	Drip	300.00	16

Doukkala, Morocco

French beans

	Delivery	Amount ($m^3\ ha^{-1}\ yr^{-1}$)	% of reported
Reported	All	6000.00	100
Modeled	Spray	4278.00	71.3
Modeled	Drip	1380.00	23

Northwest Negev, Israel

Potato Rozna

	Delivery	Amount ($m^3\ ha^{-1}\ yr^{-1}$)	% of reported
Reported	All	3530.70	100
Modeled	Spray	2965.00	83.9
Modeled	Drip	1023.00	29

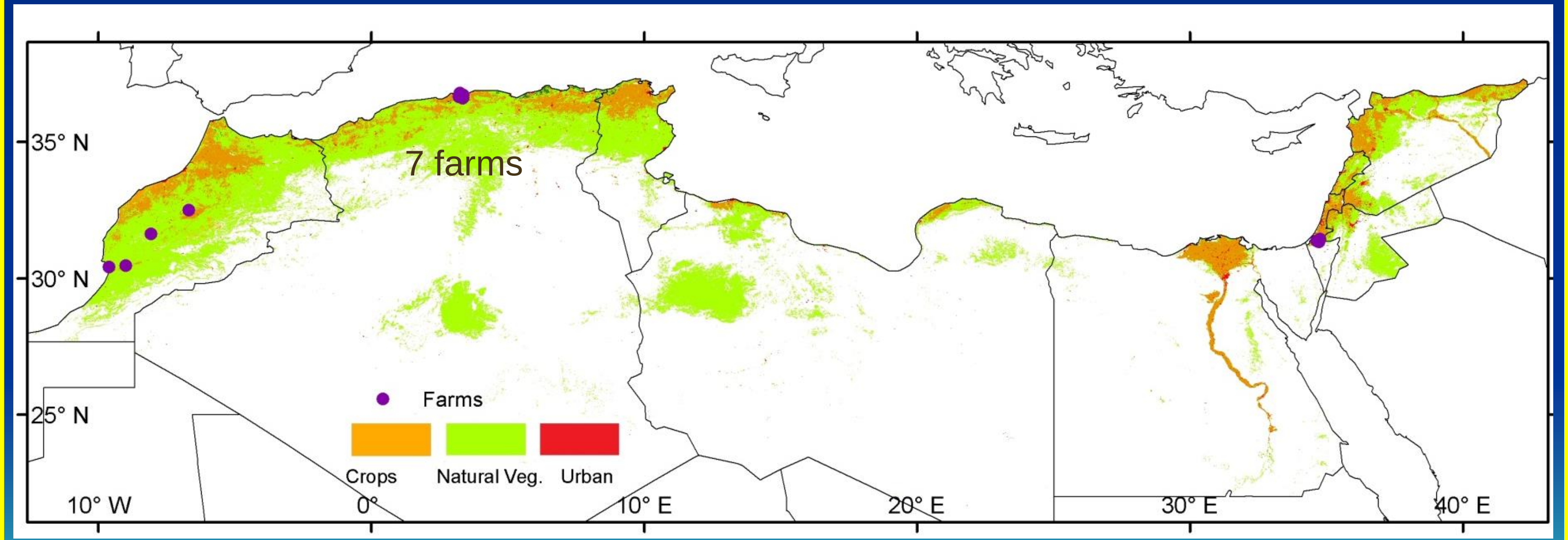
Potato Valor

	Delivery	Amount ($m^3\ ha^{-1}\ yr^{-1}$)	% of reported
Reported	All	3668.90	100
Modeled	Spray	3118.00	85.0
Modeled	Drip	1110.00	30

The approach provides a **physiological benchmark** water requirement for observed canopies to which reported irrigation water use can be compared in order to improve both estimates and delivery systems.

Objective 3 – Use the Algorithm over the MENA region

After validation of the model over several farms over the region we will run the model over MENA



End