SAT-IRR

SATELLITE FOR IRRIGATION SCHEDULLING

Le Page Michel, S. Khabba, L. Jarlan, S. Er Raki, H. Kharrou, O. Hagolle, A.Tavernier, M. Huc, M. Kasbani , J. Toumi, M. Yousfi

CESBIO

IRD
Institut de recherche pour le développement

ORMVAH

TREMA
Laboratoire Mixte International

Université Cadi Ayyad de Marrakech Maroc

cnes

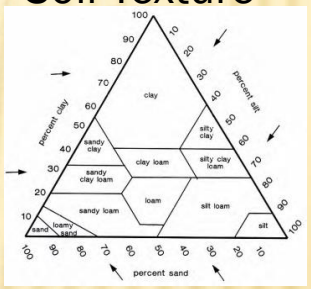
PLAN

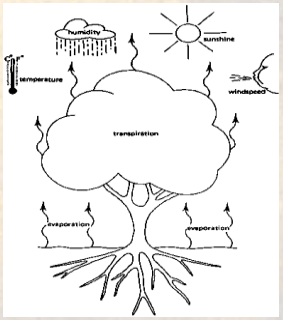
1. An introduction to Current Irrigation Schedulling Tools
2. Update to the results of the Irrigation schedulling experiment with SPOT4-Take5
3. Limits to the FAO-56 model constrained by Remote Sensing and Objectives of Sat-Irr
4. Implementation of a prototype Web Service based on Landsat 8

IRRIGATION SCHEDULLING?

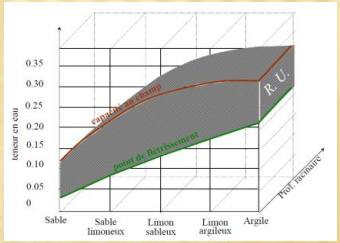
- Aims
  - Maximize yield while minimizing water stress (but other things too…)
  - Minimize water losses by evaporation, percolation or run-off
- Four principal components

Soil Texture

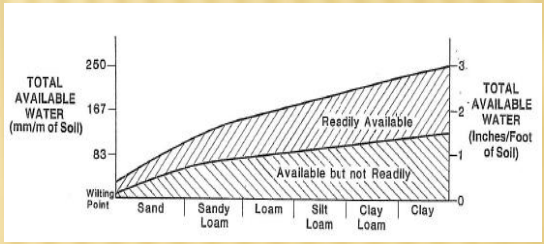




Crop Water Needs



Available Water Capacity



Soil Water Content

ESTIMATE/MEASURE WATER NEEDS AT THE PLOT LEVEL

- Touching and feeling the soil
- Measure the soil water amount
  - Tensiometry (watermark)
  - Electric resistency (gypsum)
  - Capacitive sensor (Sentek..)
- Plant health
  - Température de la canopée (IRT)
  - Turgidité de la plante
- Hydric Budget
- Other techniques are less used

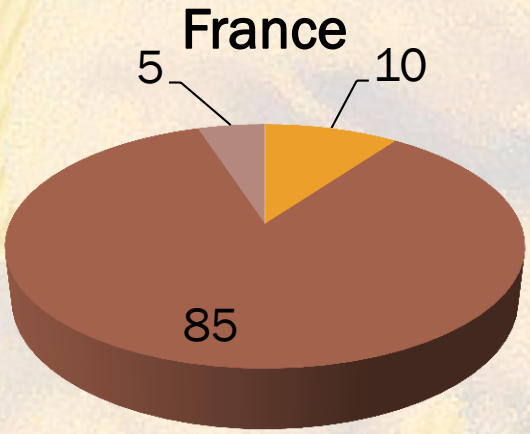
Farmer ‘s equation = (Time + Money + Precision) vs Gain

IRRIGATION METHODS

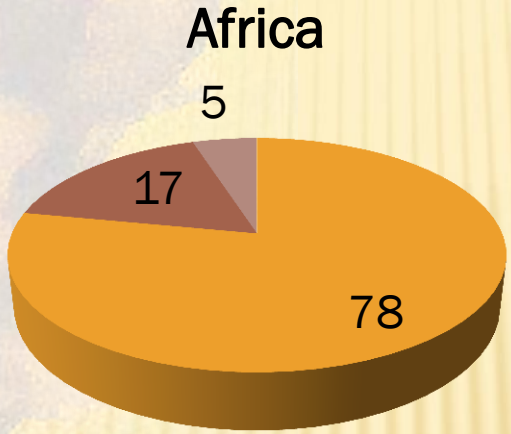
Familly	Techniques	Efficacity	Advantages	Disavantges
Flooding	• Basin • Furrow • Border	40-70%	• Low investment • Easy • Low handling • Low energy	• Low efficacity • Leveling • Human resources
Sprinkler	• Rotative sprinkler • Water cannon • Pivot	60-80%	• All terrains • Low human resources	• Investment • Available pressure • Wind
Localized	• Drip • Porous canal • Micro-sprinkler	80-95%	• Efficacity • All terrains • Low human resources • Fertirrigation	• Investment • Water filtering

- Reduction of evaporation with natural or artificial mulches

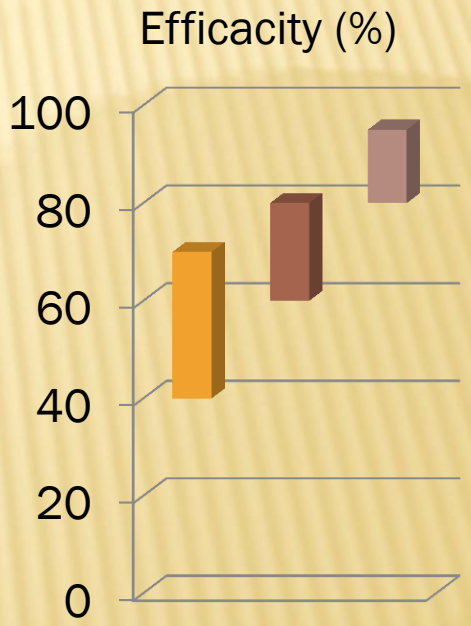
THE LOCALIZED METHODS ARE STILL NOT VERY USED AND ALREADY OPTIMALS



~1.5 Millions Ha



~12.5 Millions Ha



Flooding

Sprinkler

Localized

Margat, 2000 and FAO Aquastat

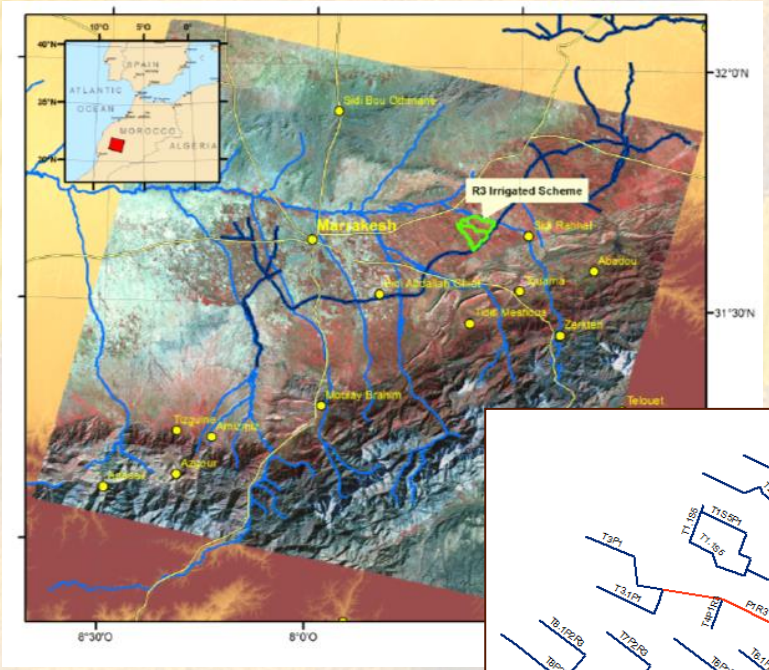
PART 2..

UPDATE ON

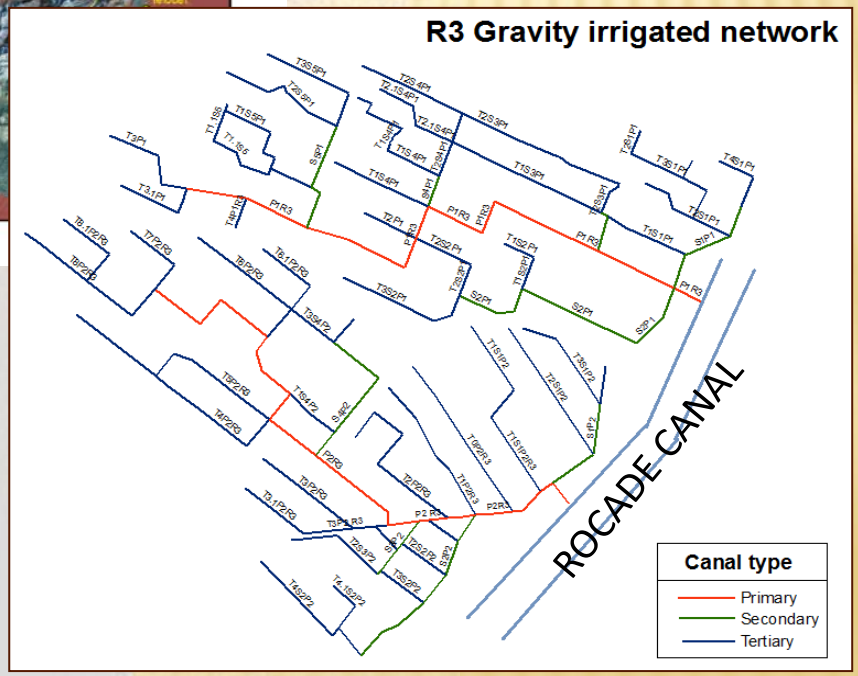
THE LIFE-SIZE AND NEAR REAL-TIME TEST OF IRRIGATION SCHEDULING WITH SPOT4-TAKE5 IN MOROCCO

Le Page et al, *Remote Sensing, 2014*

WHEAT IRRIGATION IN AN OPEN CANAL NETWORK



High ET
Low Rainfall



HYDRIC BUDGET IN SAMIR

P+I

ET0

Kcb

fc

T

E

E=Ke*ET0

Ke=min(Kr*(Kcmax-Kcb),(1-fc)*Kcmax)

Kr= (TEW-De)/TEW-REW)

TEW=(qfc-qwp*0.5)*Ze

REW= fixed

T=Ks*Kcb*ET0

Ks=(TTW-Dr)/(TTW-RTW)

TTW=(qfc-qwp)*Zr

RTW=TTW* (0.55+0.04*(5-ETc)

fc

1-fc

Surface compartment

Root compartment

Deep Compartment

Drainage

Ze : fixed

Zr : varies with LU and fc

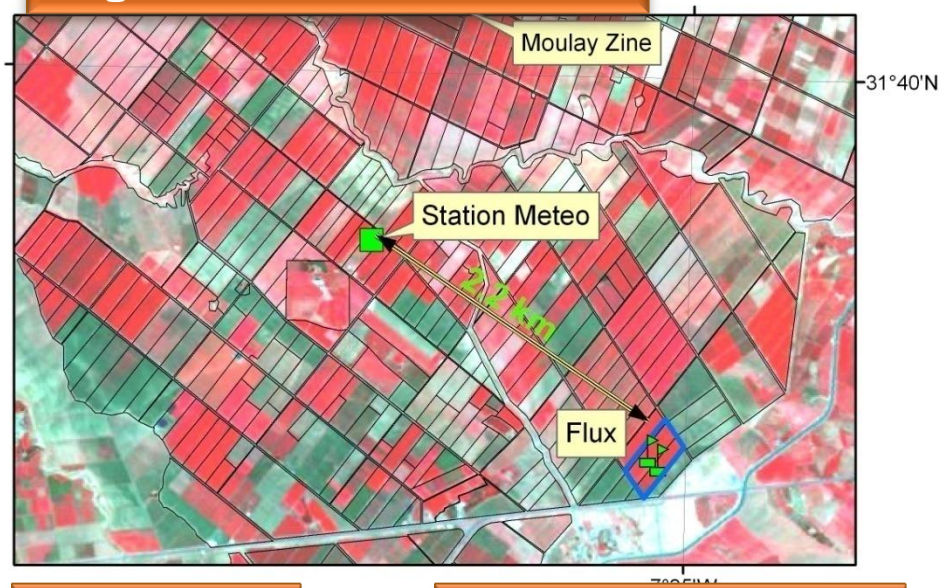
Zd : Tot-Zr

Total Soil Depth

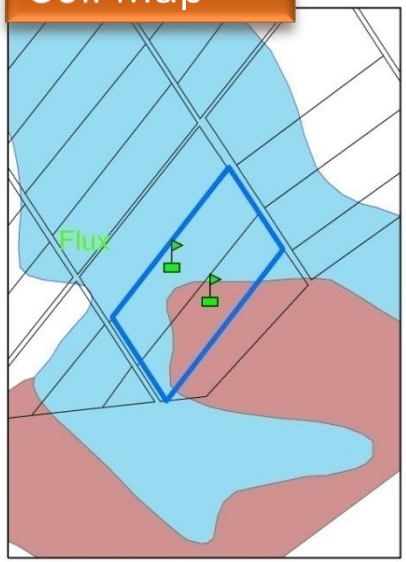
2 PLOTS OF ~4HA

- Same Soil Texture (Clay: 36%, Sand 20%)
- Durum Wheat sowed 23/12/12
- Reference: Irrigation as usual
- Test: « Sat » Irrigation

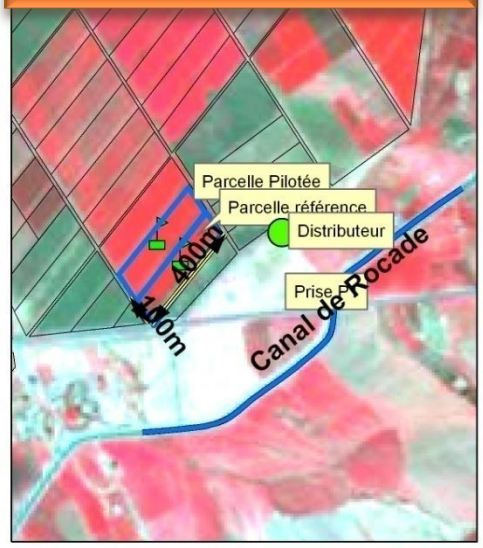
Irrigated Sector



Soil Map



Experimental plots



Profondeur m	SOIL_TYPE	TEXTURE	FC_MIN	FC_MAX	WP_MIN	WP_MAX	REW_MIN	REW_MAX
0.300		Silty clay		0.30	0.42	0.17	0.29	8.00	12.00

ON SITE MEASUREMENTS

METEO (forcing)

- Alfalfa maintained to 15cm
- Installed January 3rd, 2013
- ET0 very comparable to the meteo station of Marrakech

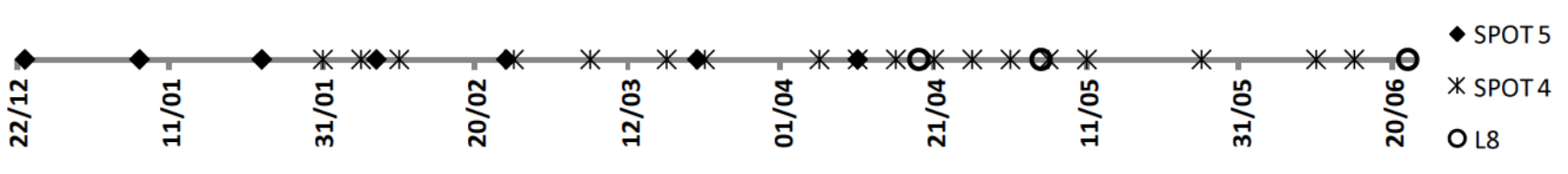
FLUX (validation)

+ South installed on Dec, 24th 2012
+ Nord installed on Dec, 25th, 2012

- Soil Texture (Parametrization)
- Areal Biomass (Yields estimates)
- Technical itinerary and irrigations inputs
- Cropscan Measurements and LAI (Validation)

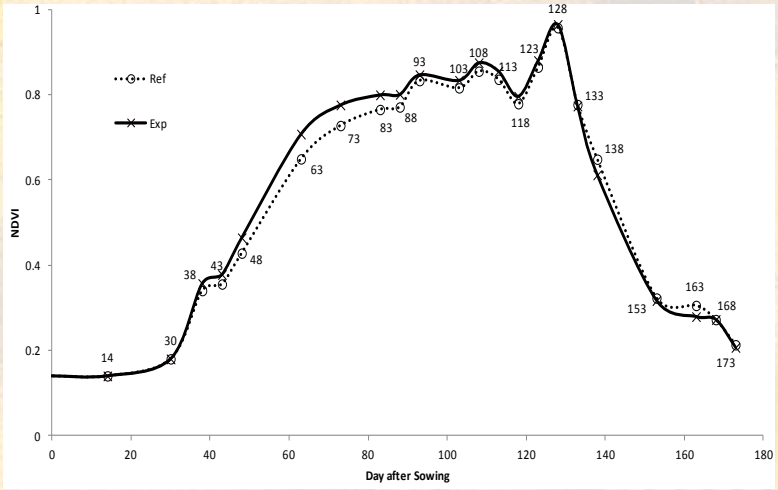
18 CLEAR IMAGES (64%)

- SPOT5 (ISIS #691)
  - 6 imgs
  - Orthorectified
- SPOT4 (Project Take5)
  - 12 imgs (until 21/04)
  - Orthorectified
- PHOTOMETER SAADA
  - Down from Jan, 27th to Feb, 26th, grrrrr

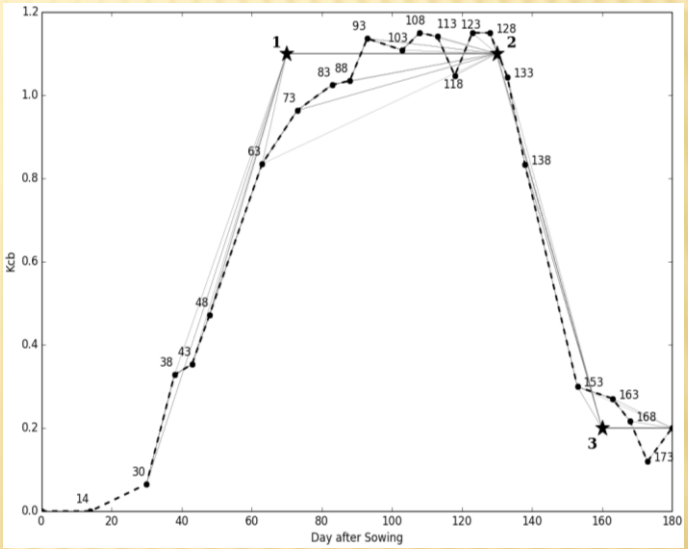


RESULTS

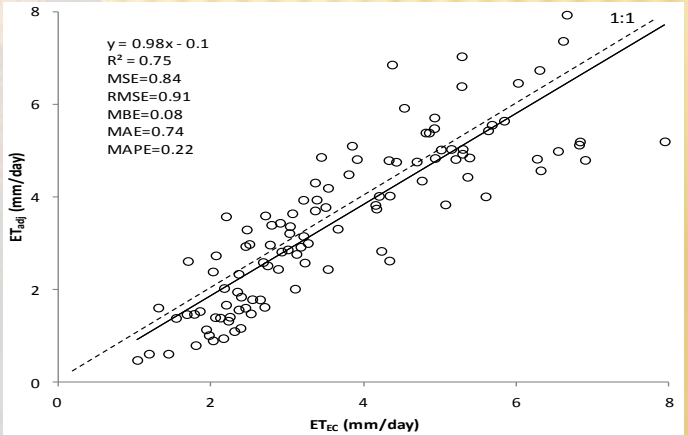
- NDVI of the two plots



- Kcb extrapolations

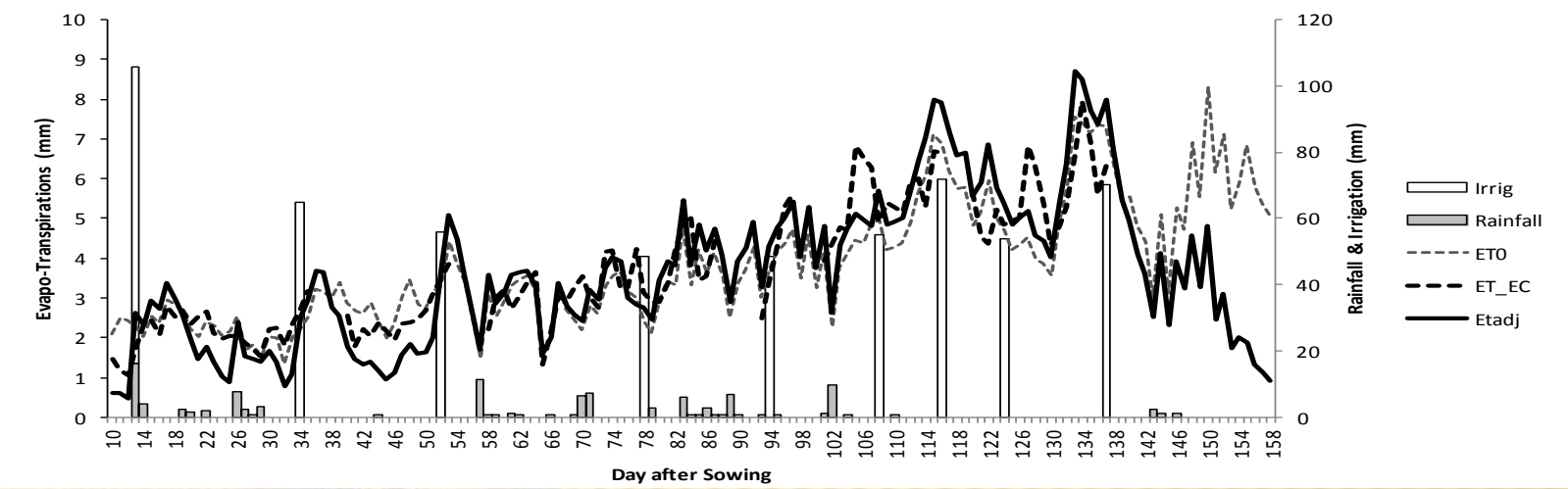


- ETa results



RESULTS ON E-T

RMSE	0.84 mm/d
Sum_diffs	11 mm



On the 62 dates, RMSE is 0.84 mm/day compared to Eddycov Measurements.

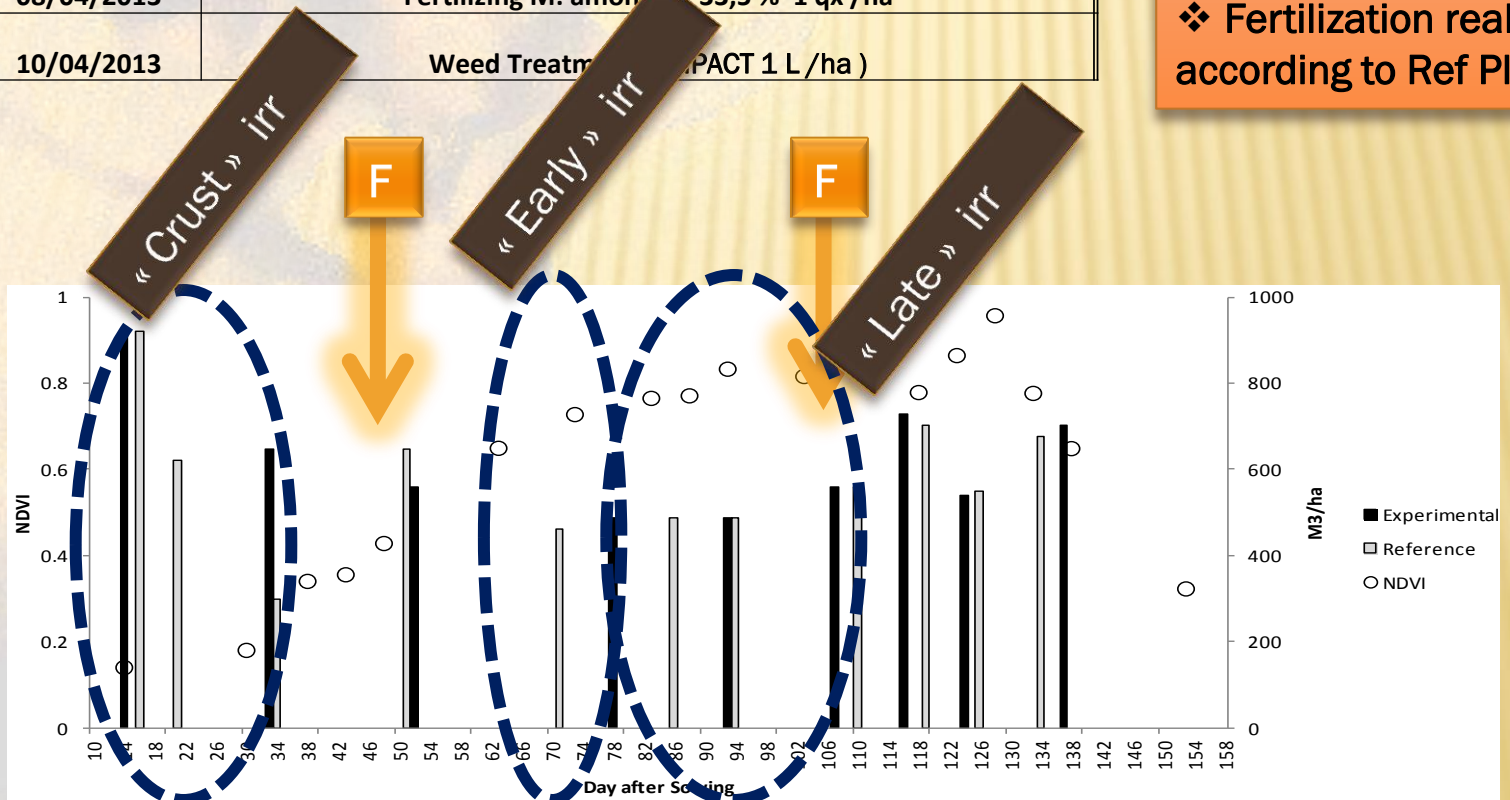
- This is the usual error range of our previous FAO modelling of ET

- A small delay is visible at irrigation time. It is mainly due to the duration of the water turn (20 to 30h).

TECHNICAL ITINERARIES

23/12/2012	Soil preparation (Schezell)
24/12/2012	Soil preparation (Cover croup 2 ftimes)
	Sowing: Durum Wheat (V /SARAGOLA 200 Kg /ha)
	Fertilizing (DAP) 200kG /Ha
12/02/2013	Weed treatment (TRAXOS 75cl /ha ; lintur 150 g/ha)
08/04/2013	Fertilizing M: amoni[illegible] 33,5 % 1 qx /ha
10/04/2013	Weed Treatm[illegible]PACT 1 L /ha)

- 9 irrigations versus 11 irrigations
- 562mm against 640 mm
- Three big differences on Irrigation
- Fertilization realized according to Ref Plot



BALANCE SHEET

Reference			Experimental					
#	Dates (DaS)	Quantity (mm)	#	Dates (DaS)	Quantity (mm)	Water Balance	Absolute Difference (WB-Exp)	Percentage (WB-Exp)
1	9 January (17)	92	**1**	7 January (14)	91.8	-	-	-
2	14 January (22)	62.1	-	-	-	-	-	-
3	26 January (34)	30	**2**	26 January (34)	64.8	-	-	-
4	13 February (52)	64.8	**3**	14 February (53)	56	38	18	32
5	4 March (71)	46	**4**	12 March (79)	48.6	56	−7.4	−15
6	20 March (87)	48.6	-	-	-	-	-	-
7	27 March (94)	48.6	**5**	28 March (95)	48.6	49	-0.4	-1
8	13 April (111)	56	**6**	10 April (108)	56	53	3	5
9	22 April (120)	70.2	**7**	19 April (117)	72.9	47	25.9	36
10	29 April (127)	55	**8**	27 April (125)	54	48.9	5.1	9
11	7 May (134)	67.5	**9**	10 May (137)	70.2	-	-	-
Total Irrigation		640.8			562.9			
Total with Rainfall		739.8			661.9			

- ET0: 604 mm
- Rain: 99 mm
- Irrigation: **less total water** (562mm against 640 mm) and **less water turns** (9 against 11), but irrigation doses are not controllable.
- **Fair results on Yields** in spite of the crust problem:
  - Minus 20% on straw
  - Equal grain yield
  - Better Water productivity on grain (1.34 m^3/kg against 1.52 m^3/kg for the reference plot)

PART 3.

TOWARD A WEB SERVICE FOR IRRIGATION SCHEDULLING

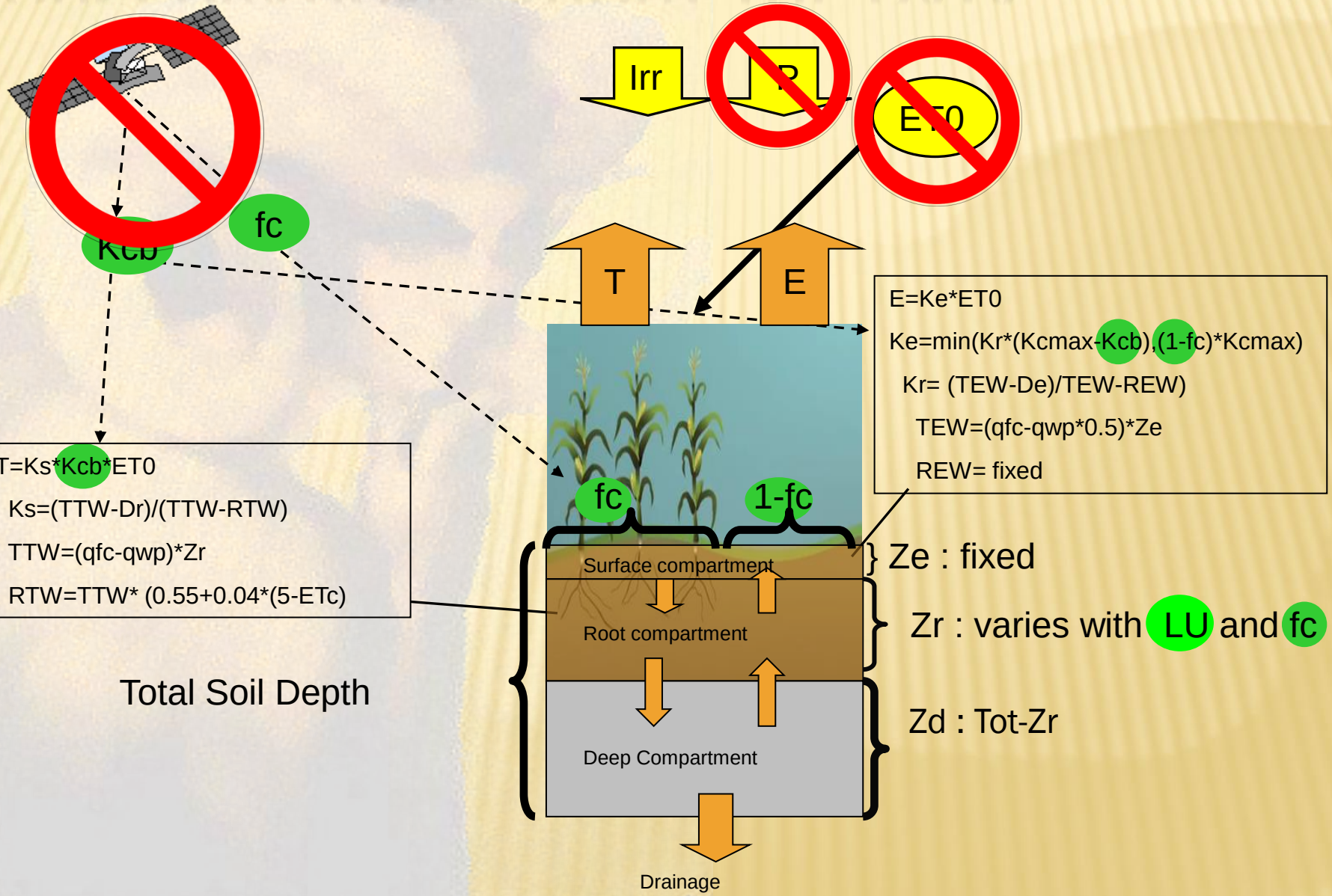
OBSERVATIONS ABOUT OUR IMPLEMENTATION OF THE FAO-56 METHOD DRIVEN BY REMOTE SENSING (SAMIR)

- A tool built on propietary products
  - IDL language and ENVI software
- A tool still too complicated
  - Satellite image handling
  - Large Parameterization
  - Multi-objective
- An end-user tool for the Desktop

OBSERVATION ABOUT THE IRRIGATOR

- Trust into the FAO-56 method, but it remains rarely used (time, means)
- No competence in imagery
- Meteo Data rarely/not used (in Morocco)
- In flooding and sprinkle irrigation, a uniform dose of water is applied to the plot
- The irrigator is the only one to know the exact date and dose of irrigation applied on its plots
- In Morocco, low-speed 3G connexions is generally available

OBSERVATIONS ABOUT THE DATA



SAT-IRR GOALS

- Recommend dates and irrigation doses of a plot throughout the season ("irrigation schedulling“)
- Make it simple

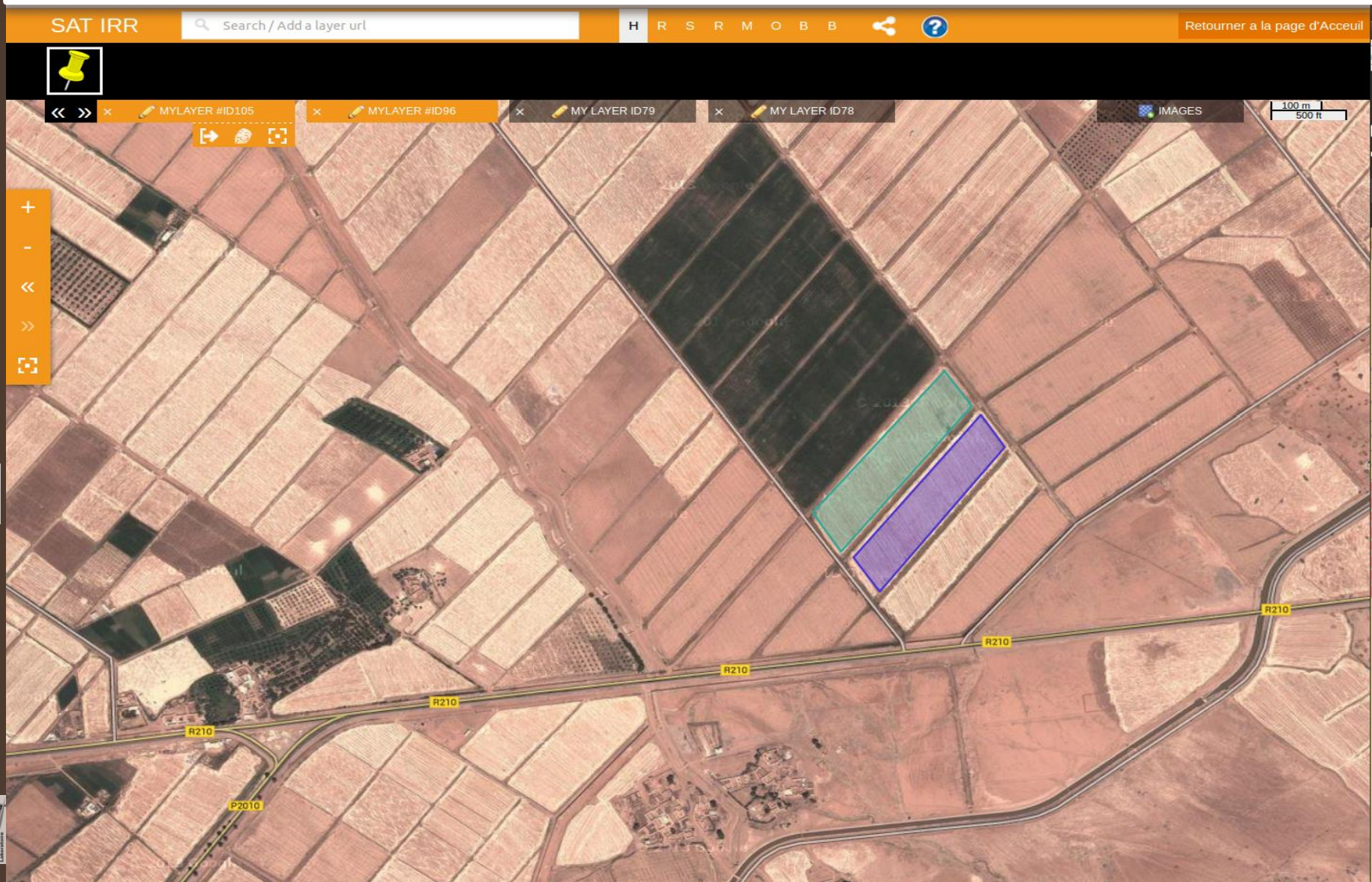
- Opensource based

- Thrifty in calculation, storage and internet outflow.

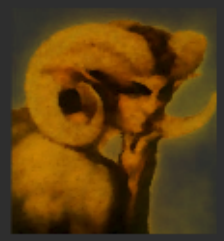
PART 4.

IMPLEMENTATION OF A PROTOTYPE WEB-APP BASED ON LANDSAT-8

DRAW MY PLOTS



DESCRIBE MY PLOTS



SAT IRR Satellite for Irrigation scheduling

ACCUEIL | QUI SOMME NOUS | ACCÈS UTILISATEUR | CARTE | CONTACT

Bonjour oulad sayad younes

Mes Parcelles

	Nom	Description	Date de semi	Station Meteo	Modifier	Supprimer
○	mimi	]	2014-01-02	null		
○	parcelle 5	Coton	2013-11-22	BENI-MELLAL		
○	Parcelle 1	description Parcelle 1	2013-12-10	SAFI		
○	Ble2	]		null		
○	Ble1	]		null		
○	parcelle 6	aa	2013-12-02	SAFI		
○	parcelle 3	azazaza	2013-12-09	NOUASSEUR		
○	michel	]		null		

SAT - IRR

DESCRIBE MY PLOTS

SAT - IRR

SAT IRR Satellite for Irrigation scheduling

ACCUEIL | QUI SOMME NOUS | ACCÈS UTILISATEUR | CARTE | CONTACT

Bonjour oulad sayad younes

Description des Parcelles

Description parcelle

Parcelle

Choisissez une parcelle: Ble2

Culture

Choisissez la culture: Blé

Sol

Choisissez le type de sol: Argile

Mode d'irrigation

Choisisr le mode d'irrigation: Irrigation gravitaire

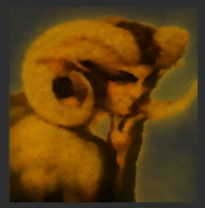
Date de semi

Entrez la date de semi:

Validez

IRRIGATE MY PLOTS

SAT - IRR



SAT IRR *Satellite for Irrigation scheduling*

ACCUEIL | QUI SOMME NOUS | ACCÉE UTILSATEUR | CARTE | CONTACT

Bonjour oulad sayad younes

Irrigation des parcelles

Irrigation parcelle

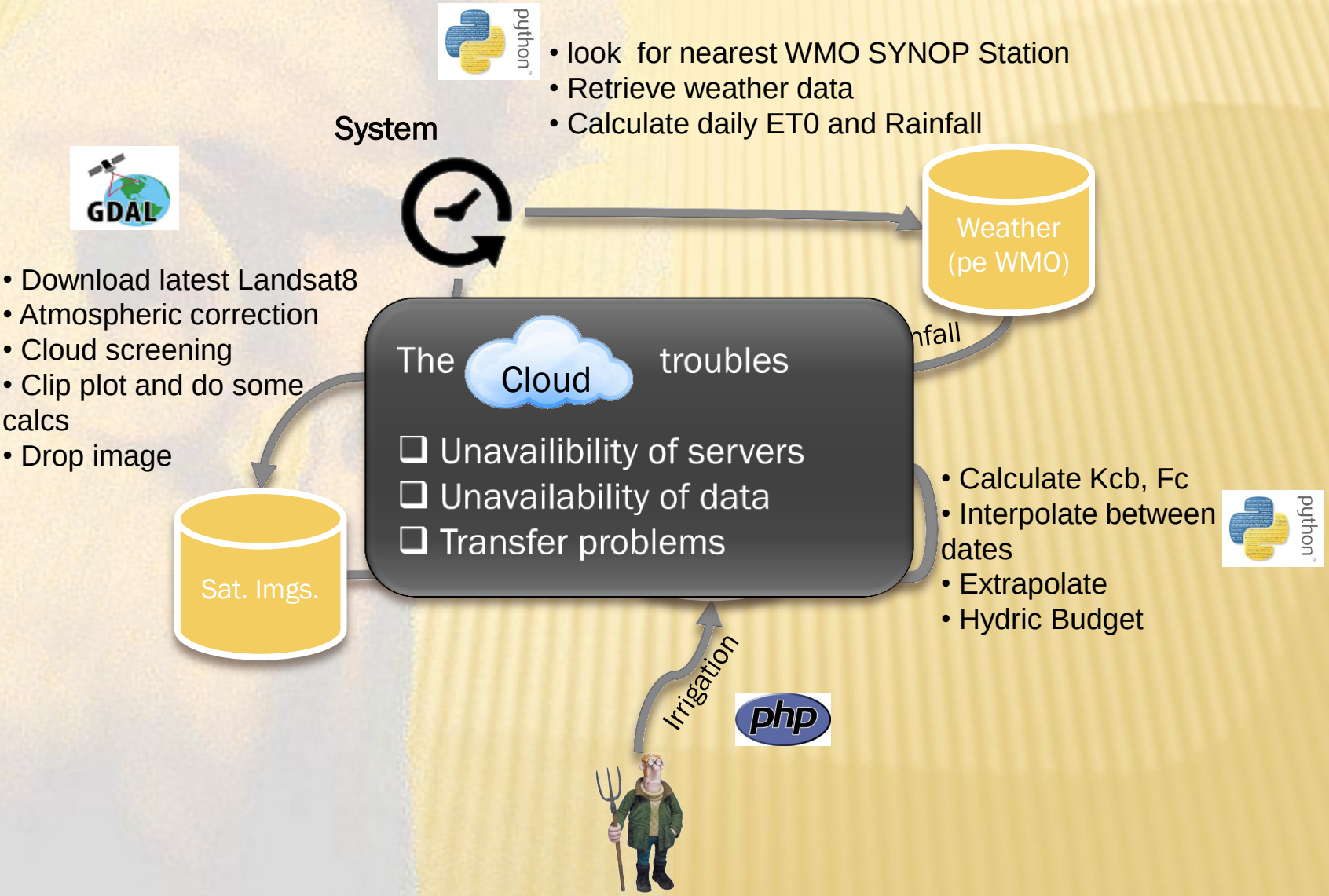
Choisissez une parcelle : parcelle 5

Dose en Millimètres : 60

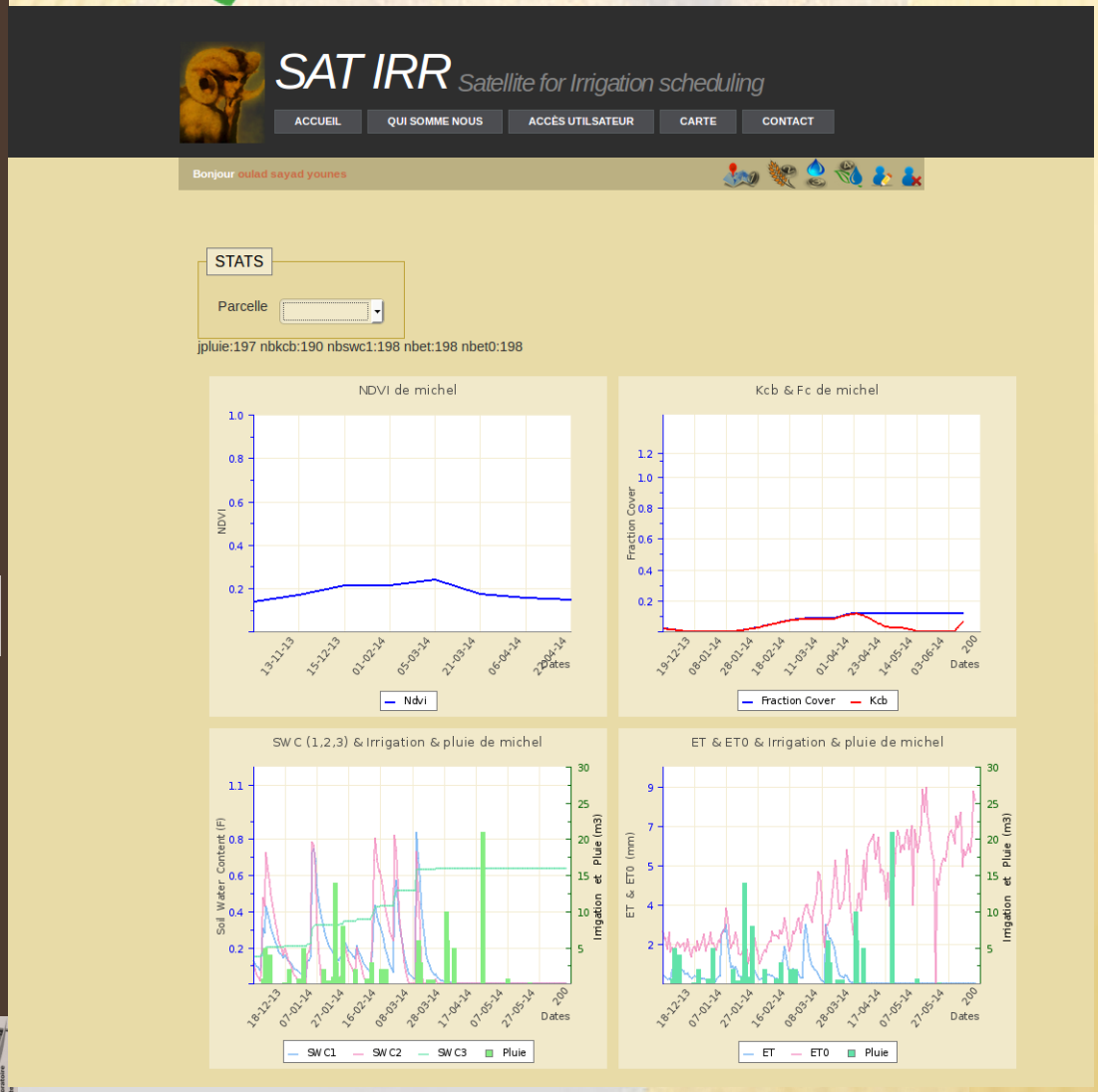
Date : 2014-01-23

Validez | Annuler

THE PLOT TIME SERIES IS FED EVERY DAY



CONSULT MY PLOTS



- Improve displays!
- Irrigation alert (Email, SMS?)
- Offer a temporal window for irrigation

CONCLUSION

- Potential clients
  - Irrigator under flood or sprinkler irrigation
  - Manager of an Irrigated Sector
- Evolutionnary service

Topic	Currently (Base Service)	Evolution (Advanced Service)
Spatial Resolution	Landsat8 (ftp)	Sentinel2 (WCS)
Weather Forcing	WMO stations	Local Stations or Weather Model Reanalysis
Weather Forecasting	Climatologies FAO stations	Weather Model
Model	FAO-56 forced with NDVI	Assimilation T° (Tseb?)
Kcb Forecasting	FAO-56 standard curve	NDVI+GDD extrapolation
Yield Forecasting	---	Efficiency model under dev.

Toumi et al, *Remote Sensing*. Take5 Special issue, under preparation

VÂLA !

TREMA
Laboratoire Mixte International

IRD
Institut de recherche pour le développement

CESBIO

ORMVAH

Université Cadi Ayyad de Marrakech Maroc

cnes