Estimation of Water needs and Biomass of Maize crops using Formosat-2 satellite Data and SAFYE Model

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BACKGROUND

▪ Water resources are under increasing pressure as a result of global change and of rising competition among the different stakeholders. It is therefore important to **develop models** which optimise **irrigation** while maintaining reasonable **production rates**.

▪ Combining **high spatial and temporal resolution (HSTR) satellite image series** and **crop models** has a great potential to describe main processes related to the carbon and water cycles at **local to regional scales**.

OBJECTIVES

▪ How much can the combination of visible remote sensing observations and agronomical modeling, improve the determination of **Maize crop Water Needs** and **Dry Aboveground Mass** (DAM) production ?

→ Calibration and validation of SAFYE model (field scale) and development of an operational method that can be applied to larger areas in further applications

DATA

▪ Unique set of **Formosat-2** high resolution images during 3 years (2006/2008/2012)
→ remote sensed **Green Area Index** (GAI) from BVNET tool

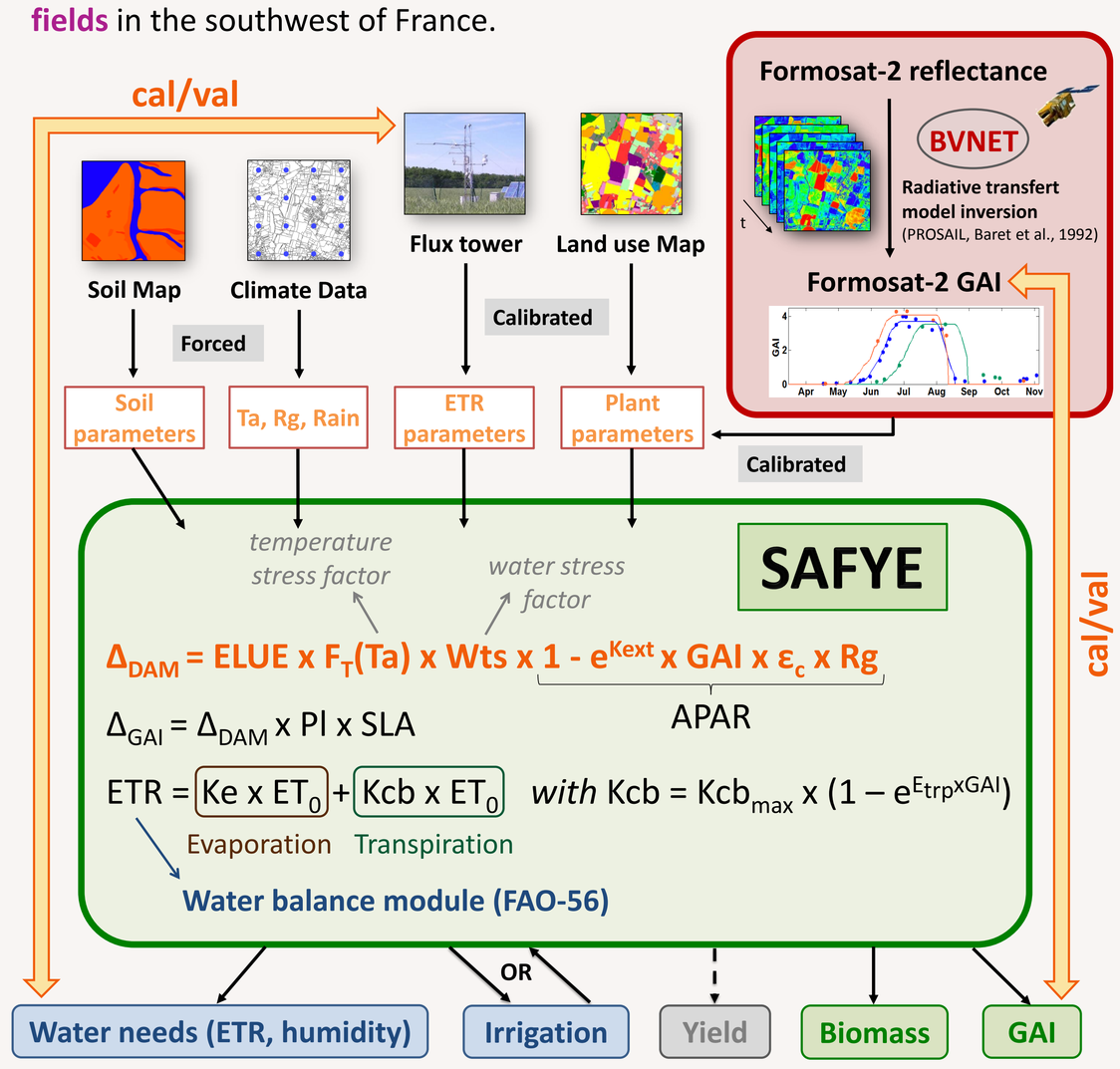
▪ ***In situ* measurements**: LAI, DAM, ETR flux data, irrigation, Soil Water Content

▪ Meteorological dataset (weather station on field)

METHODOLOGY

▪ The **FAO-56 method** (Allen *et al.*, 1998) to calculate crop actual evapotranspiration (ETR) was adapted and coupled with a model (Simple Algorithm For Yield estimates, from Duchemin *et al.*, 2008) that simulates plant development based on Monteith theory (Monteith, 1972).

▪ The resulting model, **SAFYE**, was tested against data collected on **maize fields** in the southwest of France.



Rg: Global radiation; Ta: Air temperature; SLA: Specific leaf area

Calibrated parameters : Kcb and partition-to-leaf function (Pl)

GAI time series from satellite data and SAFYE

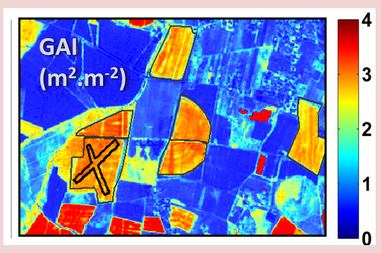


Fig. 1: Map of GAI from BVNET *(Formosat-2 26/07/2006).* SAFYE model calibration was made over a field transest represented by the black cross in the maize plot.

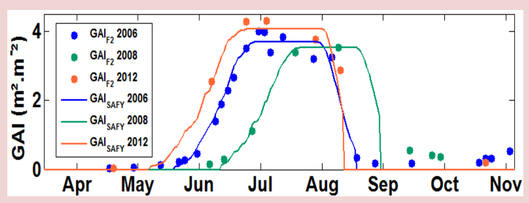


Fig. 2: Time series of BVNET Formosat-2 GAI (dots) and simulated GAI with SAFYE (lines).

BIOMASS validation at field scale

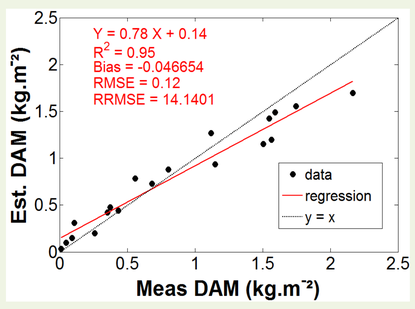
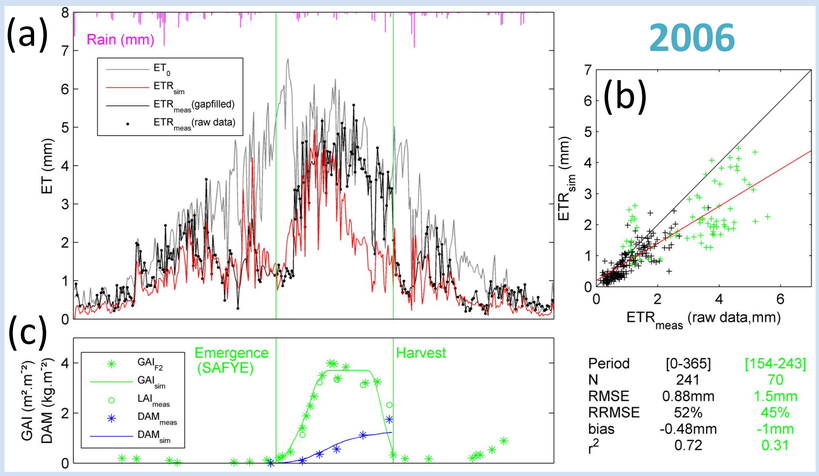


Fig. 3: Comparison of measured (destructive protocol) and estimated DAM on the field transect for the 3 years studied (2006/2008/2012).

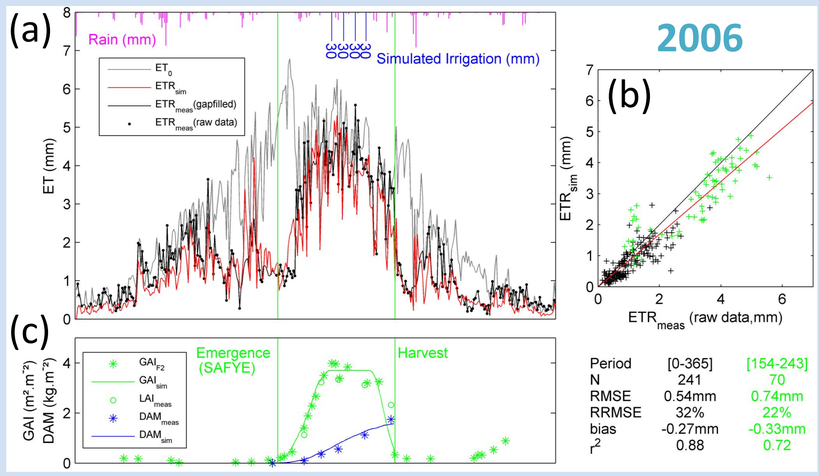
WATER needs and supplies

Without irrigation



	[0-365]	[154-243]
Period		
N	241	70
RMSE	0.88mm	1.5mm
RRMSE	52%	45%
bias	-0.48mm	-1mm
r^2	0.72	0.31

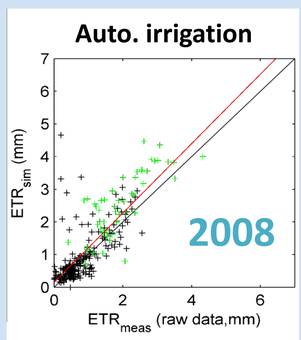
With automatic irrigation



	[0-365]	[154-243]
Period		
N	241	70
RMSE	0.54mm	0.74mm
RRMSE	32%	22%
bias	-0.27mm	-0.33mm
r^2	0.88	0.72

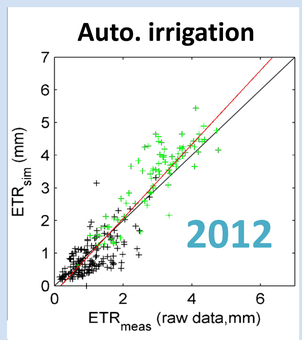
Fig. 4-5 : (a &b) Comparison of Simulated and Measured ETR in 2006 with the associated scores (vegetated period in green). (c) Comparison of Simulated and Measured GAI and Biomass time series.

Auto. irrigation



	[0-365]	[177-255]
Period		
N	239	51
RMSE	0.67mm	0.86mm
RRMSE	63%	44%
bias	0.22mm	0.6mm
r^2	0.63	0.59

Auto. irrigation



	[0-365]	[142-236]
Period		
N	231	82
RMSE	0.57mm	0.67mm
RRMSE	33%	23%
bias	0.019mm	0.39mm
r^2	0.85	0.76

Fig. 6-7: Comparison of Simulated and Measured ETR.

✓ **Improved estimates of ETR *(RRMSE from 52 % to 32 %)* and Biomass *(RRMSE from 21 % to 17 %) using automatic irrigation algorithm (Fig. 4-5)***

✓ ***Automatic irrigation (120 mm) is close to actual irrigation (148 mm)***

✓ **Acceptable ETR estimations (Fig. 6-7)**

✓ **Good estimates of Biomass (not shown here) *($RRMSE_{DAM}$ = 11 % and 12 %)***

CONCLUSION

▪ This simple approach, combining HSTR remote sensing data with a simple crop model based mainly on efficiencies (Monteith for carbon and FAO-56 for water), resulted to **good estimates** of crop biomass (RRMSE = 14 %) and seasonal ETR ($RRMSE_{2006}$ = 32 %). We were able to describe the main processes of the plant related to the carbon and water budgets, even if errors persist mainly due to the difficulty to describe intermediate variables such as **soil water content**.

▪ Towards **regional scale** : The model outputs will be validated using networks of *in situ* sensors and water used over a **large number of maize plots** in the Neste watershed (southwest of France), thanks to **SPOT4-Take5 2013 dataset** and AROME meteorological data.

Towards Spatialisation

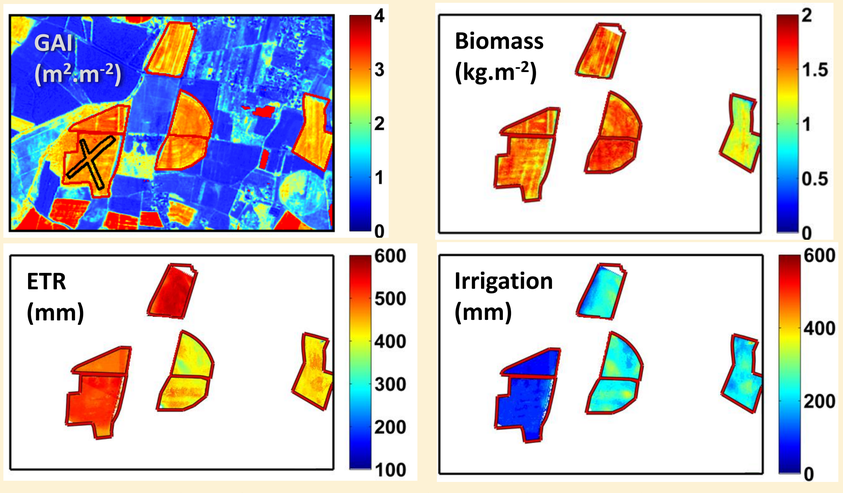


Fig. 8: Map of GAI (*Formosat-2 26/07/2006*), seasonal Biomass, ETR and irrigation volumes on 6 irrigated maize fields during year 2006.

References

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Duchemin et al., A simple algorithm for yield estimates : Evaluation for semi-arid irrigated winter wheat monitored with green leaf area index, *Environmental Modelling & Software, 23, 876–892, 2008.*

Monteith, Solar radiation and productivity in tropical ecosystems, *Journal of Applied Ecology, 9, 747–766,* 1972.