

Hydrological functioning of irrigated maize crops in southwest France using Eddy Covariance measurements and a land surface model

- Oluwakemi Dare-Idowu
- Lionel Jarlan
- Aurore Brut
- Valerie Le-Dantec
- Vincent Rivalland
- Eric Ceschia
- Aaron Boone

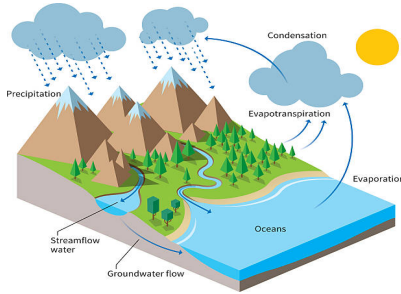


ICOS



April 26, 2021

General Context



Catchment Hydrology



Water Resource Management

Scientific Questions

1. What is the best representation of the energy budget for maize?
2. How well do these models partition the ET using sap flow?
3. What is the inter-annual variability of the water budget terms?

Experimental site & selected Maize seasons

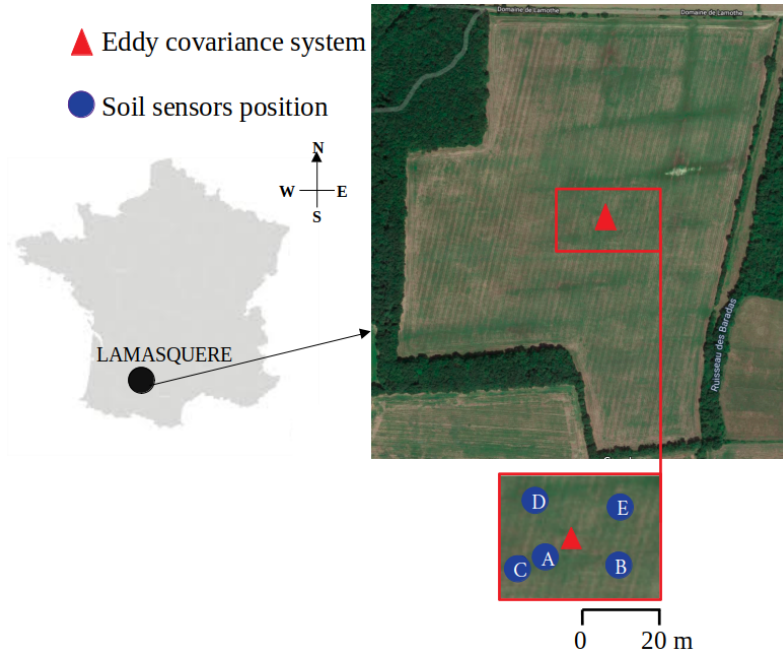


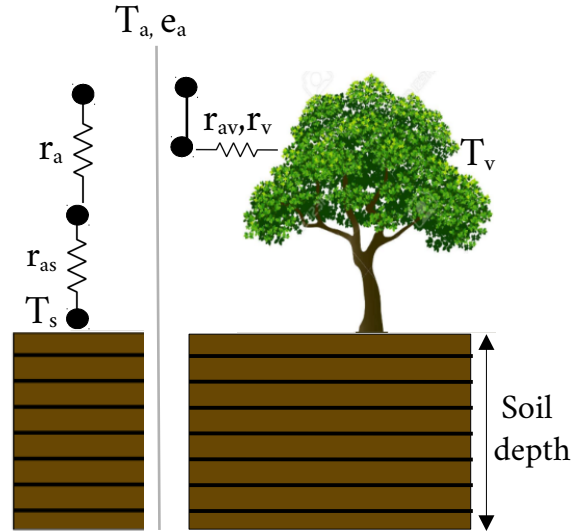
Figure 1: Experimental site setup

Photo credit: Google maps

Crop Year	Rain (mm)	Air Temp (°C)	Max LAI (m ² m ⁻²)	Sowing Date	Harvest Date
Maize 2008	389	19.9	3.9	20/05/2008	12/09/2008
Maize 2010	384	17.4	4.0	21/04/2010	20/09/2010
Maize 2012	441	18.0	5.9	27/04/2012	27/08/2012
Maize 2014	423	17.9	5.2	14/05/2014	24/09/2014
Maize 2015	411	18.5	6.6	05/05/2015	08/09/2015
Maize 2019	420	18.1	4.8	22/04/2019	12/09/2019

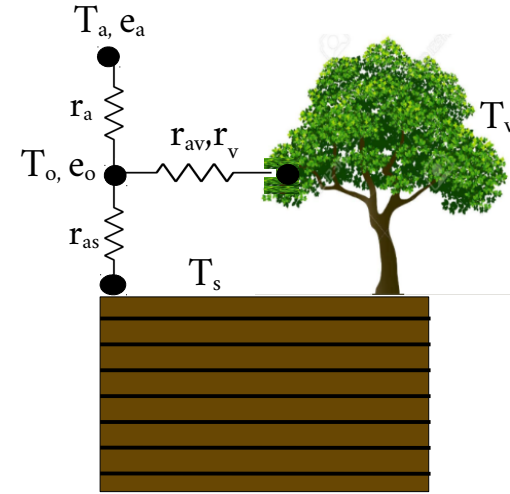
Table 1: Maize seasons, climatic and growth characteristics

Model Description



ISBA

(Interactions between Soil, **B**iosphere and Atmosphere)



MEB

(Multi Energy Balance)

Composite soil-vegetation scheme	Distinguishes vegetation and soil surface temperature
Soil and veg properties are aggregated using the veg fraction	Uses the concept of sunlit and shaded leaves
*Does not recognize the litter layer	*Includes litter-related processes
Coupled to the multi Diffusion approach for heat and soil water flow	Coupled to the multi Diffusion approach for heat and soil water flow

Quality Check of EC Data and Flux Correction for model assessment

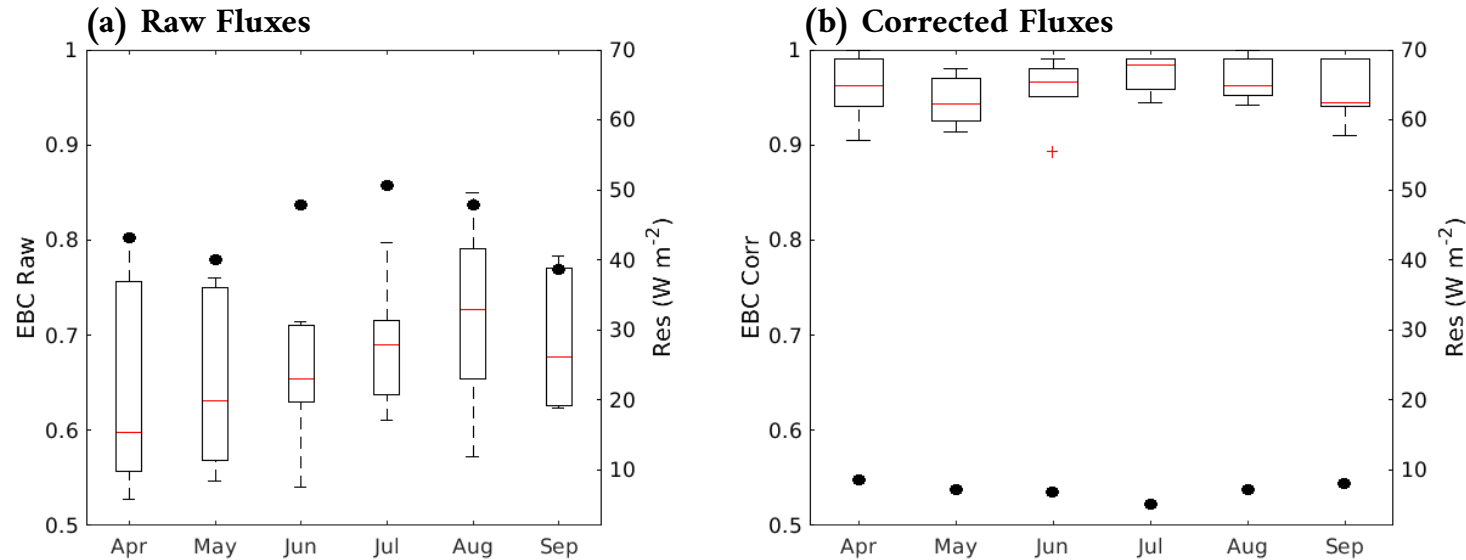


Figure 2: Comparing the EBC (box plot) and mean residual energy (black circle) for (a) the raw EC fluxes, and (b) corrected fluxes

1. Good data quality as EBC ranged between 0.6 and 0.78; and acceptable residuals.
2. Closure within the range reported by close-by agricultural sites.
3. Closure of corrected fluxes has a minimum of 0.94, and a maximum residual of 9.5 W m^{-2} .

Bowen Ratio Correction
Teixeira et al., 2012

$$\text{LE}_{\text{BR}} = \frac{\text{Rn} - \text{G}}{1 + \beta}$$

$$\text{H}_{\text{BR}} = \frac{\text{Rn} - \text{G}}{1 + 1/\beta}$$

Performance assessment of ISBA and MEB

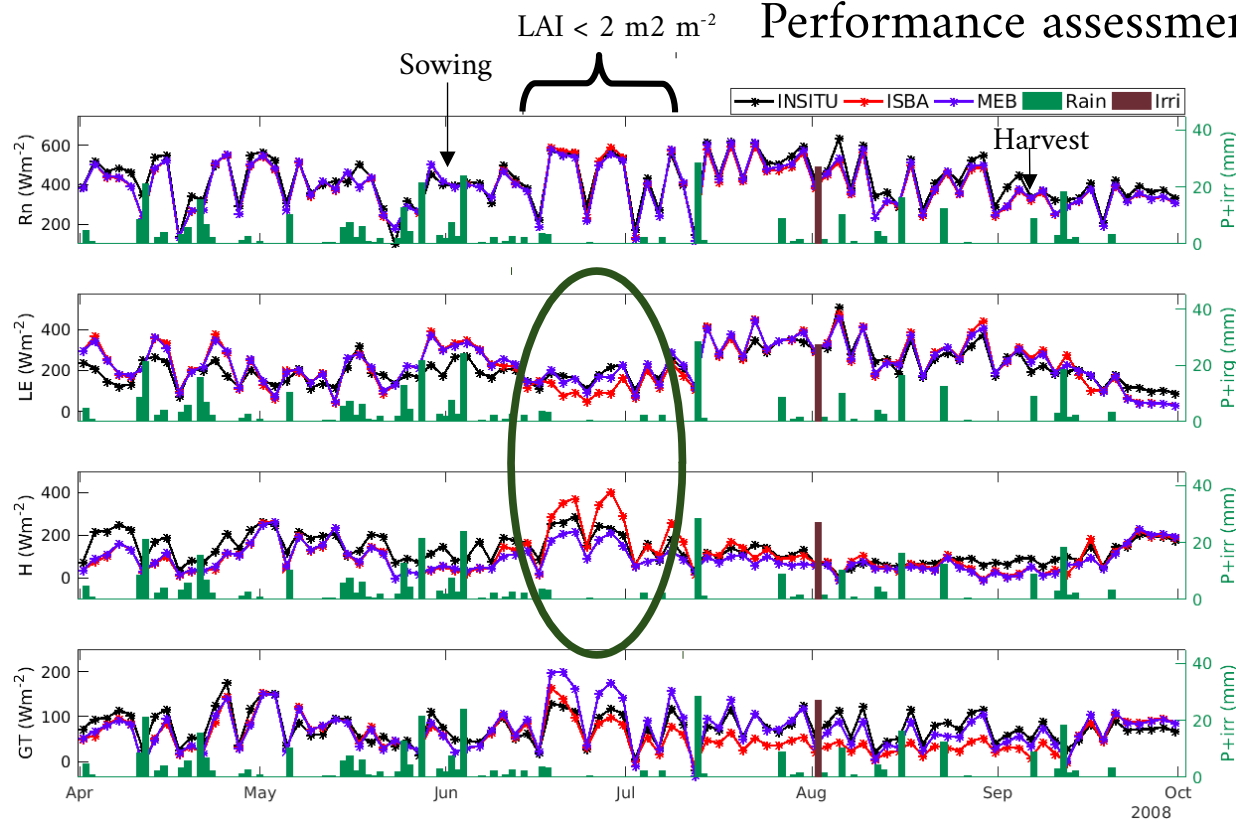


Figure 3: Day time series comparing *in situ* data with estimates of ISBA and MEB

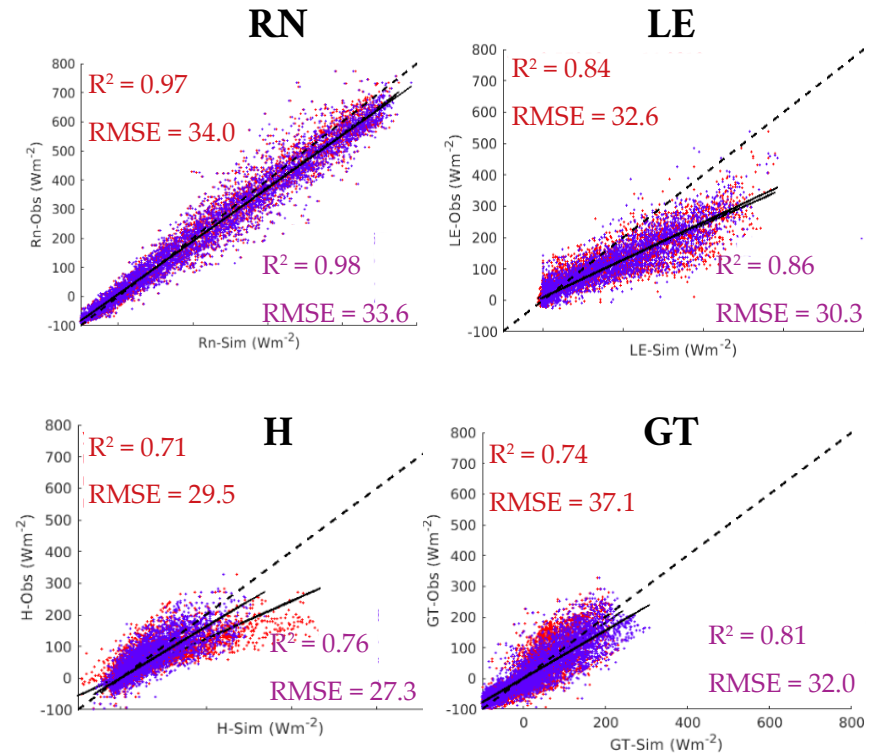


Figure 4: Half-Hourly Flux comparison

1. Both models reproduced the dynamics of the components of the energy balance properly (RMSE lower than 32 Wm^{-2}).
2. MEB presented better reproduction; R^2 was 2.3%, 6.6%, and 8.6% higher for LE, H, and G respectively than in ISBA.

Performance assessment of ISBA and MEB for 6 maize seasons

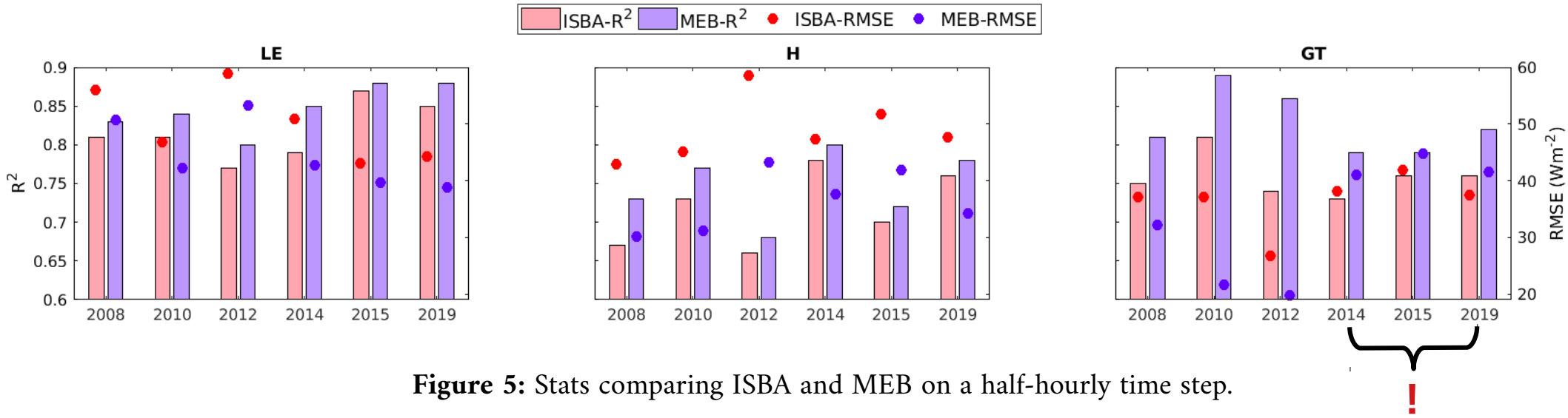


Figure 5: Stats comparing ISBA and MEB on a half-hourly time step.

1. MEB's R^2 was 3.6%, 4%, 8.2% higher than ISBA's for LE, H, and G respectively.
2. In MEB, RMSE was 11% lower in LE, 26% in H, and 9% in G in comparison with ISBA.
(except in 2014, 2015, and 2019 probably owing to the recalculation of G).

Evapotranspiration Partitioning Performance Check

Sap flow campaign: 02/07/2015 - 25/08/2015

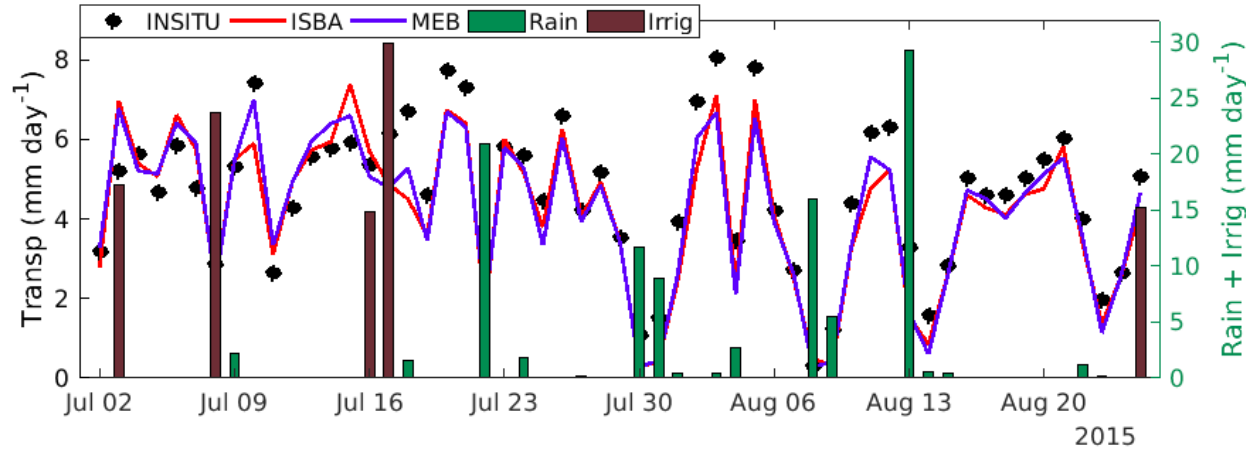


Figure 6: Series comparing sap flow data with estimates of ISBA and MEB.

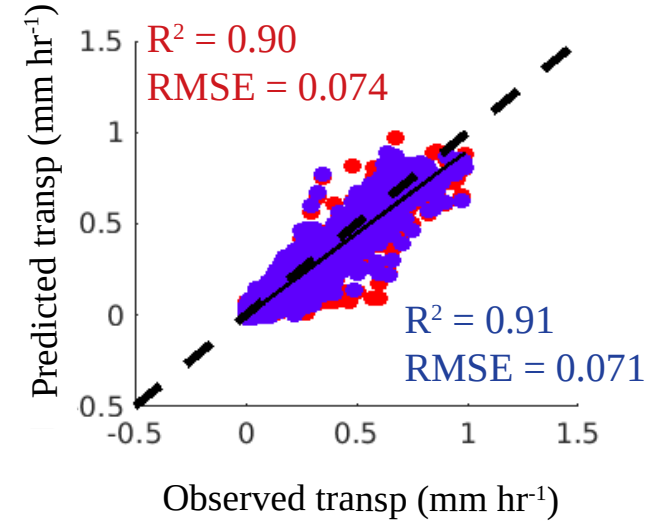


Figure 7: Scatterplot btw sap & models

1. Both ISBA and MEB partitioned ET well with R^2 of 0.90 and 0.91 respectively.
2. Metrics of ISBA $\approx$ MEB because field was homogeneous ($LAI > 4.0 \text{ m}^2 \text{ m}^{-2}$).
3. Total transpiration (ISBA= 230 mm < MEB = 232 mm < SAP = 256 mm).

Inter-annual variability of the ET components

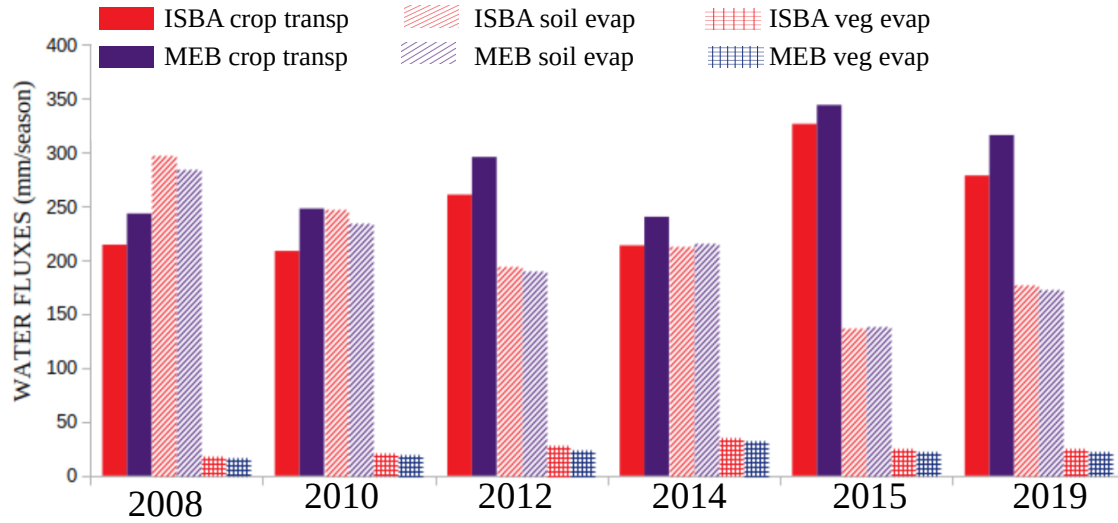


Figure 8: Evapotranspiration partitioning for all maize years

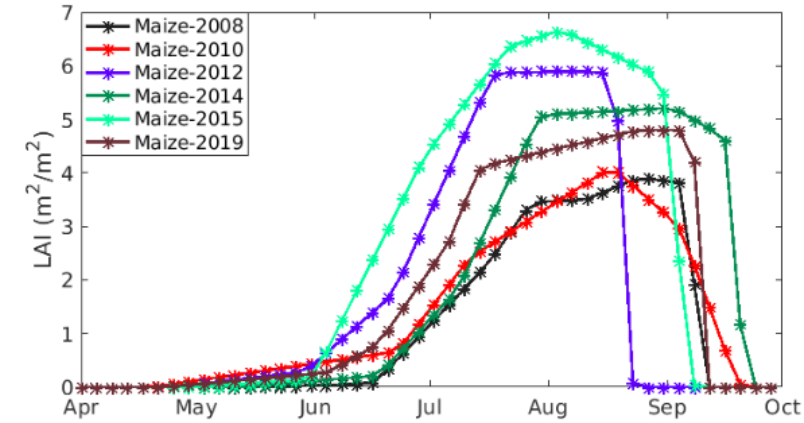


Figure 9: 4-days mean of leaf area index.

1. ISBA underestimated transpiration (~ 31 mm) in comparison with MEB.
2. ISBA overestimated soil evaporation (~ 8 mm) in comparison with MEB.
3. Strong positive correlation between transpiration and LAI ($R^2 = 0.60 - 0.79$).

Water Balance in the growing season of 2008

$$P + \text{Irrig} + \Delta S = ET + D + R$$

P = Rainfall

ET = Evapotranspiration

E_{tr} = crop transpiration

E_s = soil evaporation

ΔS = soil water storage

$$S = \sum_{i=1}^5 \theta_i z_i$$

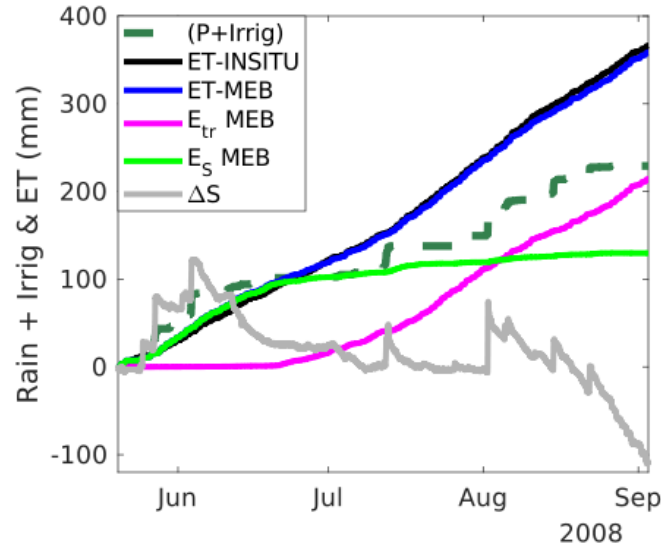


Figure 10: Comparison of cumulated rain+irrig with ET insitu and MEB

P + Irrig	ET insitu	ΔS	D
229.1	366.3	109.2	-27.9

1. Only 63% of input water was effectively used.

Conclusion

1. MEB is recommended for sparse, and seemingly homogeneous canopies like maize.
2. ISBA is recommended for bare and completely homogeneous surfaces.

References

1. Dare-Idowu, O.; Jarlan, L.; Brut, A.; Le-Dantec Valerie; Rivalland, V.; Ceschia, E.; Boone, A. Hydrological functioning of irrigated maize crops in southwest France using Eddy Covariance measurements and a land surface model. MDPI waters (under review).
2. Masson, V., Le Moigne, P., Martin, E., Faroux, S., Alias, A., Alkama, R., Voldoire, A. (2013). The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes. Geoscientific Model Development, 6(4), 929–960.
3. Boone, A.; Samuelsson, P.; Gollvik, S.; Napoly, A.; Jarlan, L.; Brun, E.; Decharme, B. The interactions between soil-biosphere-atmosphere land surface model with a multi-energy balance (ISBA-MEB) option in SURFEXv8-Part 1: Model description. Geosci. Model Dev. **2017**, 10.

Thank You For Listening

