The following supplement accompanies the article

Crop–climate ensemble scenarios to improve risk assessment and resilience in the semi-arid regions of West Africa

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Supplement.

1. Testing external data for gap filling

In order to complete the minimum data set required for simulations in DSSAT-CSM we completed the missing daily solar radiation, wind speed and relative humidity using data provided by the Prediction of Worldwide Energy Resource (POWER) (http://power.larc.nasa.gov/cgi-bin/cgiwrap/solar/agro.cgi?email=agroclim@larc.nasa.gov). The data contained in the agroclimatology archive of this portal are based primarily upon solar radiation derived from satellite observations and meteorological data from assimilation models. To check the data for conformity before use in gap-filling of our 1981-2010 baseline, we computed the daily potential evapotranspiration (ETP) at Bambey, Sarria and Niamey (Fig. 2s). We compare ETP computed using data observed at each station to ETP computed using gap-filled wind (m/s) and radiation (W/m^2) extracted from the POWER data portal (ETP_{POWER}). In all of our validation sites, ETP values are relatively similar. This shows that the POWER data exhibits certain conformity to observations in the baseline of our study. Therefore it can be used for gap-filling of missing and doubtful outliers found in the daily values of wind and radiation time series.

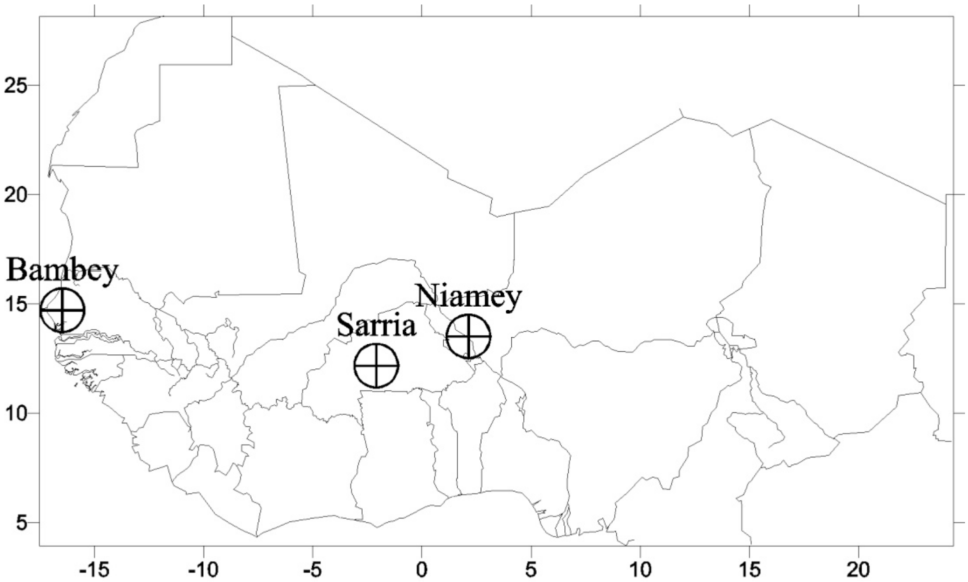

Fig. S1. Experimental stations used in the framework of DSSATv4.5 evaluation process

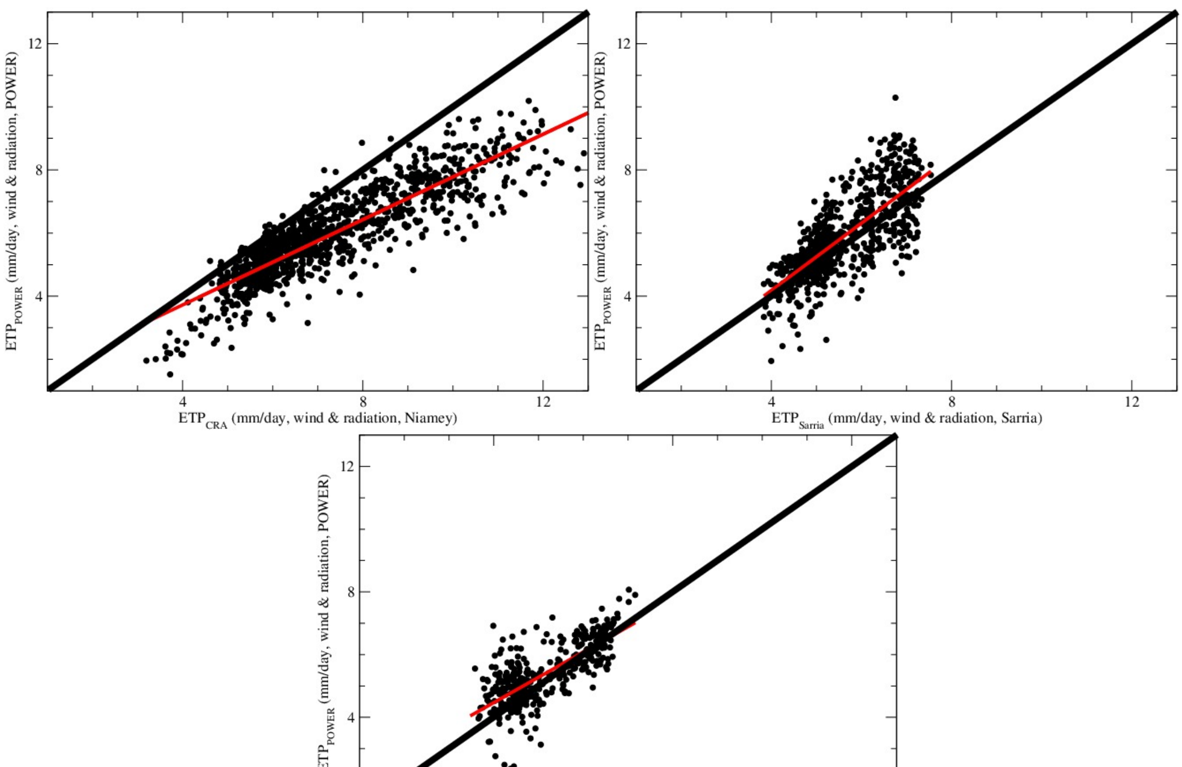

Fig. S2. Comparison of potential evapotranspiration (ETP) generated using observed data set at experiemental stations to ETP_{POWER} generated base on gap-filled data using wind/radiation from the Prediction of Worldwide Energy Resource (POWER) data portal (http://power.larc.nasa.gov/)

2. Crop Model Evaluation

The last release of DSSAT4.5 integrates many millet and maize cultivars. It was calibrated for pearl millet cultivars [HKP, Souna 3, Zatib,] using experimental data collected at AGRHYMET (Niamey) in 2002-2003 (detailed descriptions of the experiments are provided in Alhassane et al. (2006)), at Bambey station (Senegal) in 1996-1997. We determined some genetic coefficients for the cultivars and added soil characteristics of the experimental sites to simulate growth and production. Some results are shown in Table 1s. The model simulates describes relatively well the phase duration of Anthesis date and growth cycle (planting to physiological maturity) of all cultivars. The simulation errors on production (grain and biomass yields) are generally in the range of acceptable values.

Table S1. Phase duration of planting-anthesis and planting-physiological maturity (in days-after-sowing, DAS) of three pearl millet cultivars simulated by DSSATv.4.5

Cultivar	**Millet ZATIB**				**Millet HKP**				**Millet Souna 3**			
Phase (DAS)	Anthesis		Maturity		Anthesis		Maturity		Anthesis		Maturity	
Year	2002	2003	2002	2003	2002	2003	2002	2003	1996	1997	1996	1997
Observation (DAS)	64	64	109	101	56	64	104	97	64	70	95	97
Simulation (DAS)	68	69	100	99	63	65	98	98	59	70	98	97

Table S2. Grain and above ground biomass yields simulated by DSSATv.4.5

Cultivar	**Treatment**		**Grain yield** (kg.ha^{-1})			**Above ground biomass** (kg.ha^{-1})		
	Nitrogen level	**Year**	**Observation**	**Simulation**	**Error**	**Observation**	**Simulation**	**Error**
HKP	0 kg.ha^{-1}	2002	1036	1275	48	3750	6050	67
		2003	827	1730	275	4118	7509	1157
	50 kg.ha^{-1}	2002	1232	1275	75	4317	6050	237
		2003	1096	1730	198	4590	7509	1157
	100 kg.ha^{-1}	2002	1393	1275	105	4758	6050	324
		2003	1249	1730	42	5299	7509	484
Souna 3	0 kg.ha^{-1}	1996	783	537	102	5025	7834	241
		1997	1431	1600	142	5111	10802	853
	50 kg.ha^{-1}	1996	752	537	97	5342	7834	378
		1997	1477	1677	172	5882	11344	1149
	100 kg.ha^{-1}	1996	767	537	142	5658	7834	504
		1997	1685	1677	152	9083	11344	642
Zatib	0 kg.ha^{-1}	2002	1216	1319	90	3942	6633	455
		2003	1036	2119	160	4410	8675	503
	50 kg.ha^{-1}	2002	1377	1319	99	4583	6633	455
		2003	1859	2119	249	3653	8675	535
	100 kg.ha^{-1}	2002	1553	1319	40	5367	6633	167
		2003	1593	2119	49	6049	8675	484

3. Testing the crop model sensitivity

To test model performance with regards to the various on-farm crop management practices, we use high quality data available from surveys conducted in rural areas around Niamey (Niger), and Sarria (Burkina Faso). For example, in Niamey, the agronomic surveys were conducted across a dozen villages within a limited area of 100km x 100km around the city. They studied a network of observation plots representative of a diversity of producers and crop management practices. The number of plots per village varied between 13 and 30, selected at random according to the production surface area. The survey provided practical information about farmers' cultivars, seedling density, sowing dates, sowing type (dry/wet seedling), soil type, fertilization (amount, type of fertilizers, dates of incorporation), tillage, weeding techniques, date of harvest, grain yield and above-ground biomass weights. Daily rainfall was recorded at the village rainfall station, but radiation, temperature (Tmax, Tmin), wind speed and relative humidity were taken from the nearest synoptic station at the airport of Niamey.

To complete the validation process the model was subjected to these on-farm practices and observations. As crop management practices vary across farmers and farming systems of the WASS, we defined five sensitivity factors base on the records of the surveys. These factors are defined in a set of treatments referred to as "*runs*" used in a set of sensitivity test simulations. Each *run* has a number indicating its characteristics:

- *run0*:

  - Planting dates are fixed according to those reported by the surveys and the harvest dates are defined at physiological maturity.
  - 0 kg Nitrogen level, 500 kg/ha organic manure (crop residues)
  - Plant density at emergence: 30000plts/ha, 20000plts/ha and 18000plts/ha

- *run1*:

  - Planting dates are automatically identified by CERES-millet over a time interval one month after/before the average date reported by the surveys. Over this time interval, the planting date is defined when 40% soil moisture in the top 20 cm depth is reached, minimum temperature does not drop below 11°C for millet cultivars (below 8°C for maize), and maximum temperature does not exceed 35°C. Production is harvested at maturity.
  - 0 kg Nitrogen level, 500 kg/ha organic manure (crop residues)

- Plant density at emergence: 30000plts/ha, 20000plts/ha and 18000plts/ha

- *run2*:

- Planting and harvest dates are fixed according to those reported by the surveys
- 100 kg of N-P-K (15-15-15) at sowing, 500 kg/ha organic manure (crop residues)
- Plant density at emergence: 30000plts/ha, 20000plts/ha and 18000plts/ha

- *run3*:

- Planting and harvest dates are fixed according to those reported by the surveys
- 100 kg of N-P-K (15-15-15) at sowing, 50 kg/ha Urea at 40 days after sowing and 500 kg/ha organic manure (crop residues)
- Plant density at emergence: 30000plts/ha, 20000plts/ha and 18000plts/ha

- *run4*:

- Planting dates are automatically identified by CERES-millet over a time interval one month after/before the average date reported by the surveys. Over this time interval, the planting date is defined when 40% soil moisture in the top 20 cm depth is reached, minimum temperature does not drop below 11°C for millet cultivars (below 8°C for maize), and maximum temperature does not exceed 35°C. Production is harvested at maturity.
- 100 kg of N-P-K (15-15-15) at sowing, 50 kg/ha Urea at 20 days after sowing, 50 kg/ha Urea at 40 days after sowing and 500 kg/ha organic manure (crop residues)
- Plant density at emergence: 30000plts/ha, 20000plts/ha and 18000plts/ha

Each sensitivity simulation provides of sets of crop model ensemble outputs. The ensemble outputs are used to compute an average value call the "ensemble mean". The overall ensemble mean of the sensitivity test simulations at individual plots (Ens-mean) and the results from survey (observations) are aggregated to the village level. A comparison of the Ens-mean and observations shows a good performance of the model on above-ground biomass in Niamey and Sarria (Fig. 3s). Grain yields are overestimated, but still within the range of acceptable values with respect to observations. Therefore, genetic coefficients defined for the millet cultivars (Souna 3, HKP and Zatib) are quite good, giving the model a certain robustness in the WASS context. As for maize, we identified two cultivars widely used in the region. Unfortunately our survey records have little information on these cultivars. We then rely on the tremendous works done on maize, available in the literature of the crop model and used the genetic coefficients of OBATAMPA and EV-8443 from the release package of DSSAT4.5.

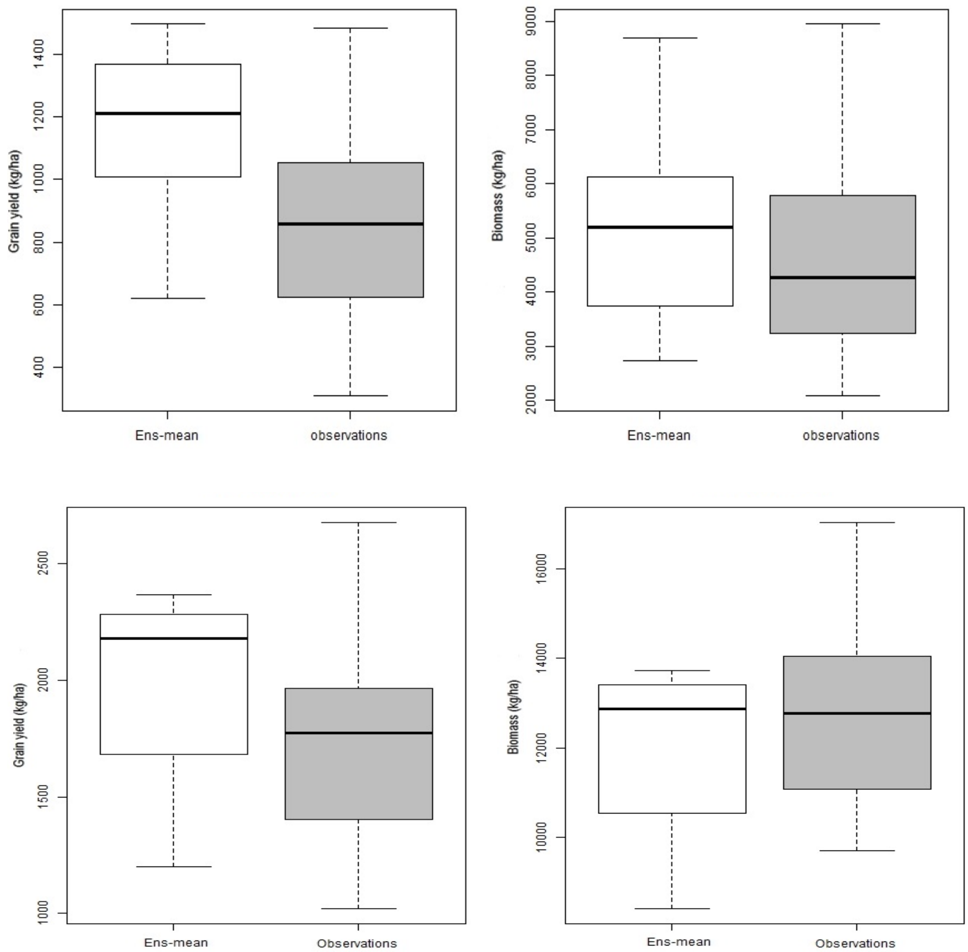

Fig. S3. Grain and biomass yields of millet cultivars from ensemble simulations (Ens-mean) of DSSAT versus on-farm observations from field surveys conducted in 2004, 2005, 2006 in 10 rural villages around Niamey (Niger) (upper panel) and 2007/2008 at Sarria (Burkina-Faso) (lower panel). The *Ens-mean* results from some sensitivity test simulations based on different plants density, fertilization levels and sowing dates.