1. Model  
     
   MONICA, Version 2.0.2   
   (MONICA - The Model for Nitrogen and Carbon in Agro-ecosystems, developed by Claas Nendel)
2. Contact Person:  
     
    Xenia Specka ([specka@zalf.de](mailto:specka@zalf.de))  
   (Other contributor: Tommaso Stella, tommaso.stella@zalf.de)
3. How many parameters did you estimate (i.e. change from initial default values)?  
     
    We changed two parameters.
4. Which parameters did you estimate (please give the name and a short explanation and units of each)?

1. Parameter - stageTemperatureSum2   
Description: refers to the number of degree days for the second developmental stage in MONICA, whereas stage 2 refers to the time from emergence to double ridge  
Unit: °C-day

2. Parameter: stageTemperatureSum3  
Description: refers to the number of degree day for the third developmental stage in MONICA, stage3 = double ridge to heading

1. Why did you choose those parameters to calibrate?  
     
   These parameters affect directly the crop phenology. As we only had phenology data for calibration available no other parameters affecting yield etc. could be calibrated.
2. Which of the measured variables did you use for calibration (e.g. both date of stem elongation and of heading)?

We used both measured dates for the calibration: heading corresponds to the beginning of stage 3, whereas stem elongation was assumed to occur when the threshold of 25% of the growing degree days for stage 3 is reached.

1. Describe your calibration approach. For example, if you had a criterion to minimize, like  i.e. the total sum of squared errors for days to BBCH30 and for days to BBCH55, please specify.

We minimized the RMSE (root mean squared error) between all the observed and simulated phenology DOYs (day of year) as an objective function. The Shuffled Complex Evolution (SCE-UA) algorithm was used to identify the global optimum.

1. Did you set lower and upper limits to the parameter values, or use other prior information about the parameter values? If so, please give the values for each parameter. How did you decide on those limits or that prior distribution?

For both the parameters, we set upper and lower limits as the default value (from previous calibrations) ± 50%: (80, 240) and (190, 570) are the boundaries for stageTemperatureSum2 and stageTemperatureSum3, respectively. A uniform parameter distribution within those boundaries was assumed.

1. What software did you use?

We used SPOTPY (Houska et al., 2015), a Python-based optimization tool for statistical parameter optimization (see <http://fb09-pasig.umwelt.uni-giessen.de/spotpy/>).

1. Did you estimate parameter uncertainty? If so, please give the uncertainty values for your parameters (for example, standard deviation for each parameter), and indicate how you estimated the uncertainty.

No, we did not: the algorithm selected for calibration (SCE-UA) does not allow investigating parameter uncertainty. If needed, we can perform the exercise again with other algorithms providing this information.

1. We provided as input variables multiple variables for weather (daily max and min T etc), multiple variables for soil characteristics (e.g. water holding capacity by layer), management (sowing date, irrigation, fertilization) and initial conditions (water, NO3). Did your model require other input variables that weren’t provided with the data? Please list them and give the values you assigned them. (We are interested to see if different groups make different decisions here, which could help explain why different groups running the same model obtain different results). Also, please indicate if you made changes to the input data we provided, and explain why.

Additionally to your provided variables the MONICA model usually requires the relative humidity for the calculation of the potential evapotranspiration. To take part in the AgMIP calibration study we extended the model allowing to directly passing ET0 as input variable to the simulation. For future simulations, MONICA is now able to use external ET0 values provided in the climate data files.

1. Which of the following affect phenology according to the model you used:

The following factors influence crop phenology: Daily average temperature, Vernalization, Day length, Water stress, N stress.

1. Any other comments

Additional to the automatic calibration using SPOTPY we also performed a trial and error calibration in which the same parameters where manually changed. As an objective-function the cumulated MAE (mean absolute error) was calculated. But as both approaches produced comparable results we just submitted the results of the automatic calibration with SPOTPY. If you wish we can also submit the results of the manual calibration for the MONICA model.

References

Houska T, Kraft P, Chamorro-Chavez A, Breuer L (2015) SPOTting Model Parameters Using a Ready-Made Python Package. PLoS ONE 10(12): e0145180. doi:10.1371/journal.pone.0145180