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Concepts and methods developed for probabilistic evaluation of a number of alternative adaptation options (postponed to M 36)

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Protocol for conducting an impact response surface analysis (IRS2) to study adaptation options for wheat cultivation in Spain using an ensemble of crop models in MACSUR (CropM/WP4) -- Last update: May 2015 (v.10)

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(MRR,IL and RF take the lead; together with IM, AR, FT, NP, SF, MB, TC, TP and RR they form the core group responsible for this study; in addition, MT, HH assisted in designing the study and establishing the database)

Abstract/Executive summary

The purpose of this document is to define the protocol for a second study (IRS2) based on impact response surfaces (IRSs) in the frame of CropM/WP4. General considerations of IRS construction are described in the protocol developed for Phase I of the IRS analysis (IRS1)

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PROTOCOL IN BRIEF

1. Procedure for crop model calibration

Please adhere as closely as possible to the following guidelines:

1. All available data will be used for calibration (contained in the files described above)
2. The level of atmospheric CO2 explicitly or implicitly assumed by the model must be set to 360 ppm.

3. Modellers should use the same vector of genotypic parameters for both sites.
4. Depending on the features of each model, calibrate the model in the following sequence:
i. simulation of phenology
ii. growth and yield
More specifically, the order would be: anthesis date, physiological maturity date, crop yield, biomass and yield components.

2. Crop model simulations for constructing impact response surfaces (IRS2)

Crop model simulations will be conducted for the Spanish location also used in IRS1, Lleida, for winter wheat. First we present instructions for standard simulations without adaptation. Then we present instructions for including adaptation measures.

1. Instructions for standard simulations
Standard simulations are those that consider the baseline climate and its perturbations, different CO2 levels, rainfed or irrigated and two soil types. Standard simulations do not consider adaptation measures.

Baseline period: The period 1981-2010 is used as the baseline (weather data for the year 1980 is included for a sowing date in the autumn).

Time step: The simulations will be performed on a daily time step.

Management: Water-limited (rainfed) and no nutrient limitation conditions are assumed.

Soil: Two actual soil profiles representative of the variability around Lleida site (two of the three used for calibration).

CO2 concentration (Table 1): Three levels of CO2 will be simulated, representing three 20-yeartime slices for periods centred on 1995, 2030 and 2050 (which are the midpoints of the probabilistic climate projections from Harris et al., 2010). We will use the A1B projections (average for the BernCC model) from the IPCC TAR report. Modellers are asked to check what level of baseline CO2 was assumed (explicitly or implicitly) in their models and set it accordingly.

Table 1: Levels of CO2 to be considered for the three 20-year time slices for periods centred on 1995, 2030 and 2050.

Period	Present (centred on 1995)	2020-2039	2040-2059
CO_2 concentration (ppm)	360	447	522

Sowing date: This is fixed at day 302 (day of the year; 28/29 October in leap/non-leap years) for all years of simulations assuming no adaptation. Adjustments to sowing dates are one possible adaptation response (see below).

Modifying temperature and precipitation values for perturbed simulations: Observed daily temperature is modified between -1 °C and + 7 °C at 1 °C intervals and daily precipitation between -40 % and +30 % at 10 % intervals (ranges defined based on projections from Harris et al. 2010, Table 2). A "change factor" approach is used in combination with a seasonal pattern of the T and P-changes. Thus each of the 30 baseline years is modified according to 72 different combinations of temperature and precipitation (n = 2160 versions of yearly weather data for each location). Seasonal pattern of climate perturbation: we have scaled the magnitude of monthly temperature and precipitation changes relative to the baseline (1981-2010) climate to replicate the CMIP3 multi-model ensemble mean pattern of change for the A1B emissions scenario. This is done while retaining the annual mean changes at the increments indicated in Table 2.

Table 2. Ranges and intervals for modifying baseline daily precipitation and temperature data (where N is the number of perturbations).

Variable	*Min*	*Max*	*Intervals*	*N*
Precipitation	- 40 %	+ 30 %	10	8
Temperature	-1 °C	+ 7 °C	1	9
Total				72

3. Instructions for simulations including adaptation measures

The core group has already performed preliminary simulations to select and identify adaptation measures to be simulated by all participants, according to the protocol shown in Annex 3. This aimed to limit the number of simulations run by all groups. The adaptation measures to be explored are restricted to changes in sowing dates, cultivar phenology and supplementary irrigation. A "full irrigation" scenario also serves as a reference for identifying yield ceilings and associated water requirements. In the following, sowing date for the standard simulations is referred to as 0d and the standard cultivar as Cv0.
A limited number of adaptations (54) will be simulated by all participants. These are described below.

Changes in vernalisation requirements: if possible with your model:
- standard cultivar (Cv0, winter type wheat with vernalisation requirements, WW)
- the same cultivar without vernalisation requirements (spring-type wheat, SW)

Therefore, 2options: WW and SW

Crop cycle length: two adapted cultivars will be defined modifying the 30-year average growing season length (days) of Cv0:
- Cv1: cultivar with a crop cycle 10% shorter than Cv0, parameterized with unperturbed 1980-2010 weather data and no change in sowing date, maintaining pre-post-anthesis ratio. Modellers are asked to check that anthesis occurs in all years.
- Cv2: cultivar with a crop cycle 10% longer than Cv0 , parameterized with unperturbed 1980-2010 weather data and no change in sowing date, maintaining pre-post-anthesis ratio. Modellers are asked to check that anthesis occurs in all years.

Therefore, 3 options: Cv0, Cv1 and Cv2

Sowing date: Besides the standard sowing date (0d):
- an advance of 15 days (-15d)
- a delay of 30 days (+30d)

Therefore, 3options

Irrigation: Besides standard water management (Rainfed, R):

- no water limitation/full irrigation (I)
- supplementary irrigation with 40 mm at flowering (SI). It is expected that this can be implemented using one of three methods (please specify which option applies):
    - if in your model, it is possible to link events to phenological stages; then proceed to the implementation of the SI option
    - if in your model, it is possible to link events to dates only; then a first run should be done for computing the flowering date, and then in a second run, the 40 mm would be applied at that time or
    - if neither of the two foregoing options is feasible; then skip this SI adaptation

Therefore, 3 options

Combining these options results in 2x3x3x3= 54 adaptation combinations. All of these should be simulated (where possible) for the perturbed weather (including seasonal pattern), 2 CO_2 levels (those representing 2020-2039 & 2040-2059 periods, Table 1), 2 soil profiles and a 30 year period. Other model parameters should be kept as in standard simulations.
The total set of simulations is summarised in Table 3. Modellers are requested to indicate which combinations they are planning to simulate when they return their calibration results.

4. Post-processing and reporting

The core group will analyse the results returned by modelling groups. Modellers should be prepared for possible queries or new requests if problems are encountered during the analysis phase. All active members of the modelling groups participating in the exercise will naturally be invited to contribute inputs to the preparation of a co-authored manuscript for submission to a journal (yet to be determined).

Table 3. Summary of model simulations to be conducted in IRS2, including variants required for the standard runs, adaptation runs and runs to examine the effect of the seasonal pattern of climate perturbation.

Variants	Number of runs		
	With seasonal pattern		Without seasonal pattern
Period	**Baseline**	**2020-2039 & 2040-2059**	**Baseline**
Standard runs (no adaptation):			
Soil types	2	2	2
CO_2 levels	1	2	1
Temperature adjustments	9	9	9
Precipitation adjustments	8	8	8
Years	30	30	30
Subtotals	*4320*	*8640*	*4320*
Adaptation runs:			
Vernalisation		2	
Phenology		3	
Sowing date		3	
Irrigation		3	
Subtotals		*54*	
Totals	4320	457920*	4320
GRAND TOTAL			**466560**

*Excluding from the adaptations the combination corresponding to standard runs

Time schedule

- 25 May 2015: Protocol and calibration data to be delivered – similar set-up to IRS1
- 3 July 2015: Modellers return calibration results: CropM_WP4_ IRS2_calibration_output_MODELLER NAME.xlsx
- Mid-July 2015: Perturbed climate delivered
- 30 October 2105: Modellers return perturbed/adaptation simulation results
- November 2015: Analysis of results
- March 2016: Preliminary results could be presented at the International Crop Modelling
- Symposium “Crop Modelling for Agriculture and Food Security under Global Change", Berlin
- March-May 2016: First paper draft ready for internal review (submission before summer)

References

Harris GR, Collins M, Sexton DMH, Murphy JM, Booth BBB (2010) Probabilistic projections for 21st century European climate. Natural Hazards Earth System Sciences 10:2009–2020