**BCD3 Protocol,** version 07th Dec 2017\_Final version

**Why climate change impact projections by different crop models are so different?**

A collaborative study based on previous BCD1 and BCD2 studies

1. **Introduction**

In the previous studies, we found that different crop models produce quite different climate change impact projections even under same climate projection. Crop model structure contributes to the largest uncertainty in climate change impact projection. In this study, we aim to investigate why climate change impact projections by different crop models are so different? This is done by conducting a simple sensitivity analysis covering the main climatic drivers (daily maximum and minimum temperatures, precipitation, irradiation and CO2) and their interactions, as well as by thorough review of response functions and possible additional assumptions that may explain deviations in responses. Different from previous model comparisons and impact response surface studies, this study is expected to, for the first time, look insights into the various reasons underlying the differences in future climate change impact projections from different crop models, through combining future climate impact projection, crop response surfaces to major climate drivers and their interactions. The results will not only uncover the reasons underlying the differences in future climate change impact projections from different crop models, but also provide suggestions for each crop model that which response function may need to be improved or if there are some other improvement needs in the modelling process (calibration, assumptions etc.).

The study will be done with barley for the Jokioinen and Lleida study sites utilizing experiences gained and calibrations done for the previous BCD studies. Since we have already laid good foundations, an additional small effort will produce another important result.

1. **Models and model protocol**

**2.1. Two Sites**

Table 1. Characteristics of two sites (based on 1980-2010 baseline)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Lon | Lat | Annual  precipitation (mm) | maximum temperature (℃) | minimum temperature(℃) | Cultivars | Soil  (AWC, mm) |
| Jokioinen, Finland | 23°30'E | 60°49'N | 627.71 | 8.72 | 0.57 |  |  |
| Lleida, Spain | 0º35'44''E | 41º37'42''N | 340.57 | 21.39 | 8.70 |  |  |

**2.2. Eight Crop Models**

Table 2. Models and groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model name** | **Two character model name** | **Group** | Reference | Homepage |
| APSIM | AP | D Cammarano (Hutton) |  |  |
| CROPSYST | CS | M Ruiz-Ramos & I Minguez (UPM) |  |  |
| HERMES | HE | K. C. Kersebaum (ZALF) |  |  |
| MCWLA | MC | Fulu Tao (LUKE) |  |  |
| Monica | MO | C Nendel (ZALF) |  |  |
| SIMPLACE | SI | H Hoffmann & F Ewert (UniBonn) |  |  |
| SiriusQuality | SQ | A Dambreville &  Pierre Martre  (INRA) |  |  |
| WOFOST | WO | T Palosuo (LUKE) & Reimund Roetter |  |  |

* 1. **Modelling protocol**

***For Jokioinen and Lleida, respectively, use the same model settings and the one set of calibrated parameter in BCD2 to conduct the sensitivity simulation in this BCD3 phase:***

**2.3.1. Temperature response (T)**

* CO2 (360 ppm) and Daily maximum and minimum temperature are changed by -3, -2, -1, 0, 1, 2, 3, 4, 5, 6,7 ºC, based on the weather data of 1981-2010.
* Use the weather data file respectively: FI8110TM3, FI8110TM2, FI8110TM1, FI8110TM0, FI8110TA1, FI8110TA2, FI8110TA3, FI8110TA4, FI8110TA5, FI8110TA6, FI8110TA7 (replace FI by SP for Lleida)
* Output file name: OFI8110TM3, OFI8110TM2, OFI8110TM1, OFI8110TM0, OFI8110TA1, OFI8110TA2, OFI8110TA3, OFI8110TA4, OFI8110TA5, OFI8110TA6, OFI8110TA7 (replace FI by SP for Lleida)

**2.3.2. Precipitation response (P)**

* CO2 (360 ppm) and Daily precipitation is changed by: -20%, -10%, -5%, 5%, 10%, 20%, based on the weather data of 1981-2010.
* Use the weather data file respectively: FI8110PM20, FI8110PM10, FI8110PM05, FI8110PA05, FI8110PA10, FI8110PA20 (replace FI by SP for Lleida)
* Output file name: OFI8110PM20, OFI8110PM10, OFI8110PM05, OFI8110PA05, OFI8110PA10, OFI8110PA20 (replace FI by SP for Lleida)

**2.3.3. Solar Radiation (R)**

* CO2 (360 ppm) and Daily Solar Radiation is changed by: -15%, -10%, -5%, 5%, 10%, 15%, based on the weather data of 1981-2010.
* Use the weather data file respectively: FI8110RM15, FI8110RM10, FI8110RM05, FI8110RA05, FI8110RA10, FI8110RA15 (replace FI by SP for Lleida)
* Output file name: OFI8110RM15, OFI8110RM10, OFI8110RM05, OFI8110RA05, OFI8110RA10, OFI8110RA15 (replace FI by SP for Lleida)

**2.3.4. CO2 response (C)**

* 1980-2010 weather data and CO2 concentration is: 360 ppm, 450 ppm, 560 ppm, 640 ppm, 720 ppm
* Use the weather data file for all the simulation: FI8110PM00 (SP8110PM00 for Lleida)
* Output file name: OFI8110C360, OFI8110C450, OFI8110C560, OFI8110C640, OFI8110C720 (replace FI by SP for Lleida)

**2.3.5. Interactions between T×P×R×C**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** |
| **T** | +2ºC | +2ºC | +4ºC | +4ºC | +2ºC | +2ºC | +4ºC | +4ºC |
| **P** | -10% | 10% | -20% | 20% | -10% | 10% | -20% | 20% |
| **R** | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| **CO2** | 450 | 450 | 450 | 450 | 560 | 560 | 560 | 560 |
| **Input FI\*** | FI8110IM01 | FI8110IM02 | FI8110IM03 | FI8110IM04 | FI8110IM05 | FI8110IM06 | FI8110IM07 | FI8110IM08 |
| **output FI\*** | OFI8110IM01 | OFI8110IM02 | OFI8110IM03 | OFI8110IM04 | OFI8110IM05 | OFI8110IM06 | OFI8110IM07 | OFI8110IM08 |

**\***Replace FI by SP for Lleida

1. **Output templates**

* Please use the output template for each output file and try to fill all the information according to the template format (The compulsory information include: sowing date, flowering date, maturity date, LAI, above biomass at flowering and maturity, yield, PET, ET).
* Please rename the output file exactly

1. **Schedule and Submission**

* Protocol distribution for comments: Dec.1
* Comments and registrations sent to Fulu by 7. Dec.
* Circulation of the improved Protocol and send out input data and launch the activity: Dec.10
* Please submit all the output files to Fulu Tao ([fulu.tao@luke.fi](mailto:fulu.tao@luke.fi)) by Jan 31, 2018.

For each of the two sites, total 36 output files including T(11), P(6), R(6), C(5) and Interactions(8).