User-guide for Running Climate-Agriculture Modeling Decision Tool Graphical User Interface (CAMDT GUI)[1]

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To begin:

Run "CAMDT_2016_0802.py".
The user can adjust the size of the pop-up window to see the full contents of the CAMDT-GUI as shown in Figure 1.

1) Simulation setup

On the first page "Simulation setup", user can set up simulation mode and crop growing period.

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[1] This manual was developed by the International Research Institute for Climate and Society–Columbia University as an output of the Bicol Agri–Water Project with funding support from the United States Agency for International Development (USAID). Responsibility for the information and views set out in this document lies entirely with the author.

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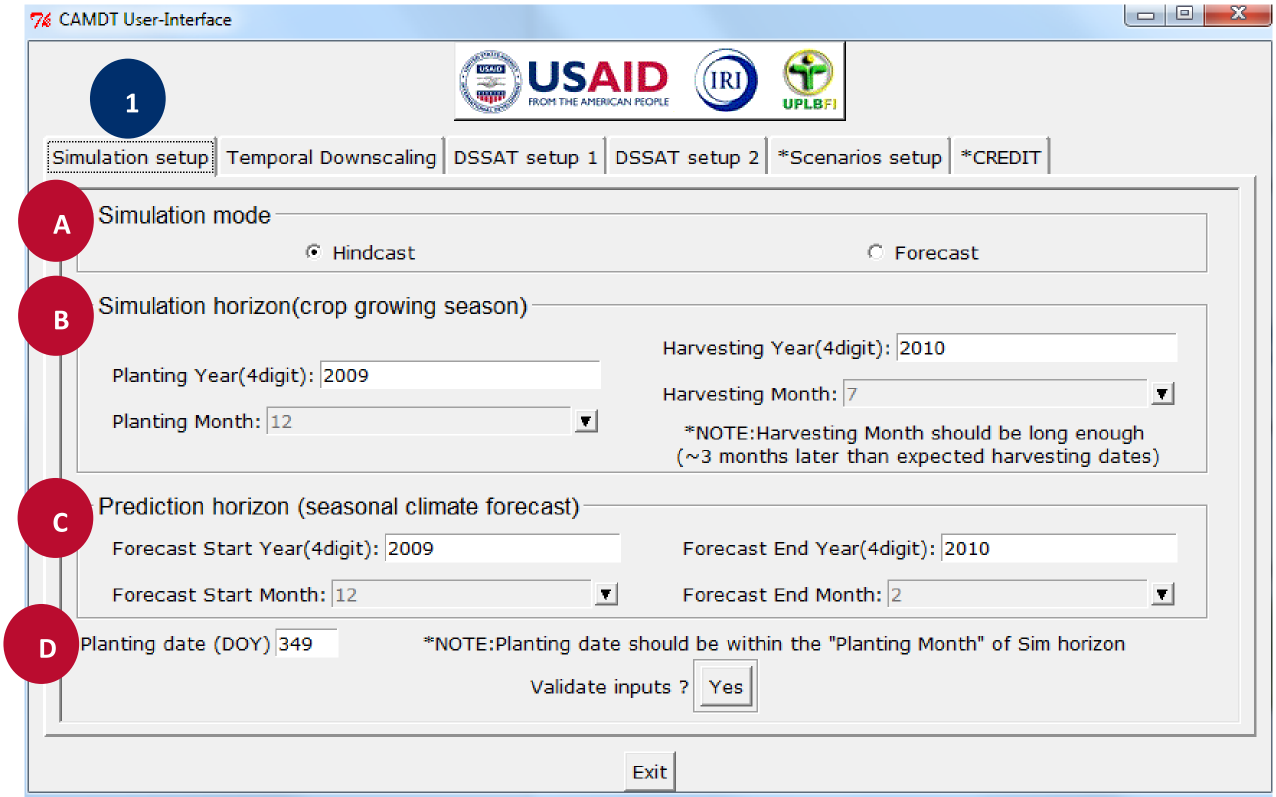


<Figure 1. Simulation setup screen>

A – SIMULATION MODE. User can select two simulation options: Hindcast and Forecast.

- **Hindcast mode** - To run the crop simulation model (DSSAT) for past events (i.e., for the period when observed weather data are available).

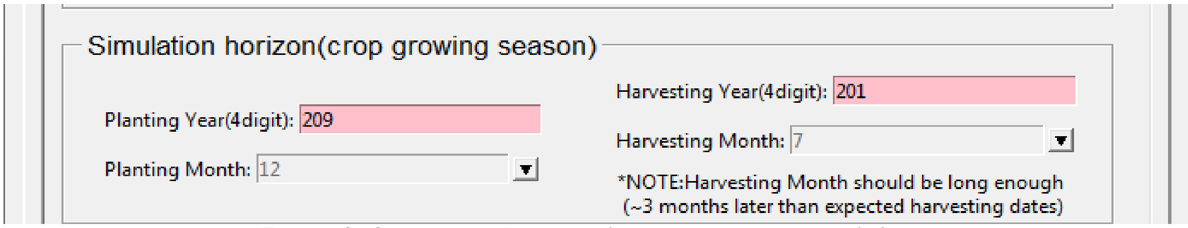
- **Forecast mode** - For more operational purposes for the coming season (i.e., when observed weather data is not fully available for a whole crop growing season).

B - SIMULATION HORIZON (CROP GROWING SEASON). Designate a crop growing period by typing/selecting a planting year/month and harvesting year/month.

Typical rice growing period in the Philippines is three months and thus approximate harvesting month would be March 2010 if planting month is December 2009 as shown in Figure I. However, when generating *N* weather realizations based on Seasonal Climate Forecast (SCF) (see Figure 3); some weather realizations representing dry weather may give water stress delaying crop growth, which results in delayed harvest time. Therefore, **it is always recommended to give enough time (longer than actual growing period) for harvest month in Figure I so that DSSAT can finish simulations even for extremely delayed growths**.

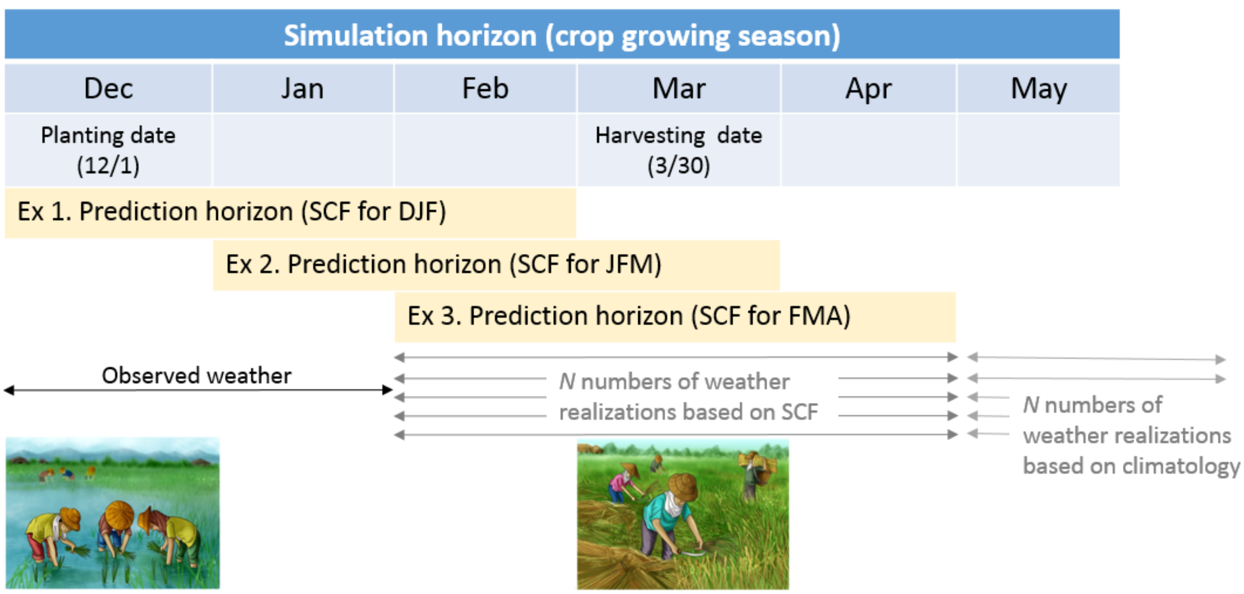
For instance, user can put harvest month as July 2010 rather than actual harvesting month (e.g., March, 2010). If user put harvest month as March 2010, DSSAT may generate error-message for some simulations when crop maturity is delayed to April.

Note: Entry Fields in red indicate invalid planting/harvesting year inputs (e.g. not 4 digit number such as 209 instead of 2009) (see *figure 2*).



<Figure 2. Simulation horizon (crop growing season) frame>

C - PREDICTION HORIZON (SEASONAL CLIMATE FORECAST). Used to specify the period for which SCF is released. Prediction horizon can be set for 2~6 month period. It is meaningless to put the prediction horizon beyond the crop growing season (simulation horizon) designated in the previous step. As shown in Figure 3, the *prediction horizon* can be set for Dec-Jan-Feb (DJF) or Jan-Feb-Mar (JFM) or Feb-Mar-Apr (FMA) depending on when the users run the CAMDT. For instance, when the users run the CAMDT on February 5th, 2010, he/she should set up the *prediction horizon* from February to April. In this case, observed weather data will be used to run the DSSAT until January 31, and then *N* weather realizations downscaled from probabilistic SCF will be used to run DSSAT for FMA season (see Figure 3). Weather conditions beyond the SCF (e.g., May in Figure 3) are generated based on climatology because no SCF information is available for this period.



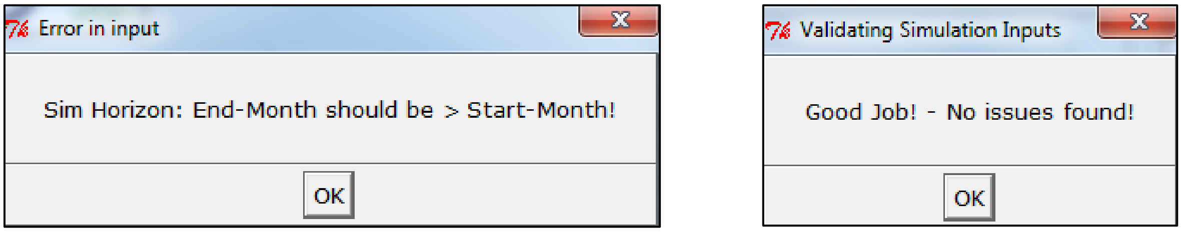
<Figure 3. Illustration of prediction horizon (SCF)>

D – PLANTING DATE. The user should provide planting date in DOY (Day of Year) format. This planting date **should match with the planting month in the previous *Simulation horizon* (B) section.** In Figure 1, the planting day DOY, 349 (December 14), corresponds to the planting month (December, 2009).

After all information are provided in section A, B, C and D, user needs to validate the input.

Validate inputs: If the user wants to check if all the inputs are correct, click the "Yes" button next to "Validate inputs?". This button will check if there are any mismatches among the inputs. For example, if the user put planting month and harvesting month as 2009/12 and 2009/7 respectively, the user will get a pop-up error message in Figure 4(a). Once the mistake is fixed in harvesting month from 2009/7 to 2010/7, the user will get a message shown in Figure 4(b).

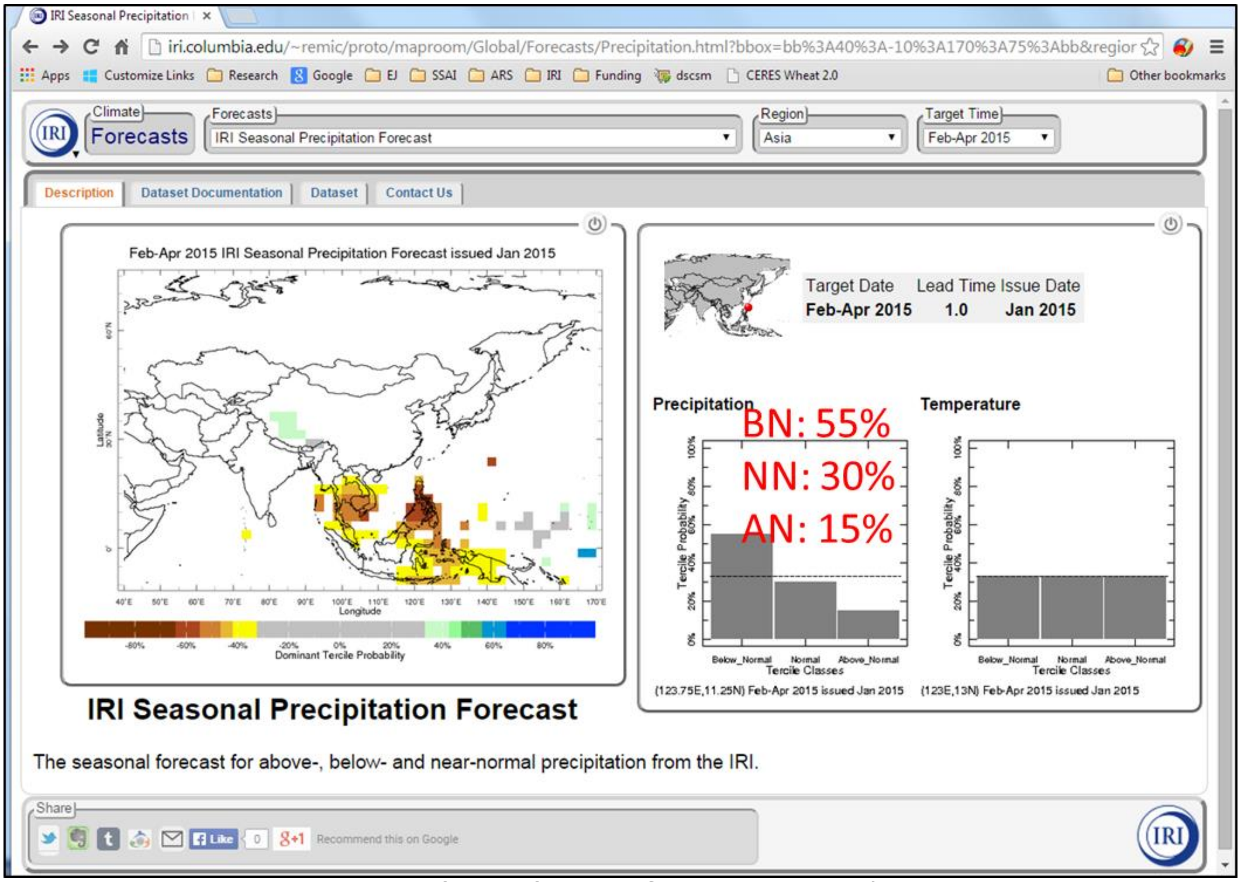
(a) (b)



<Figure 4. Pop-up message if the input is correct or not>

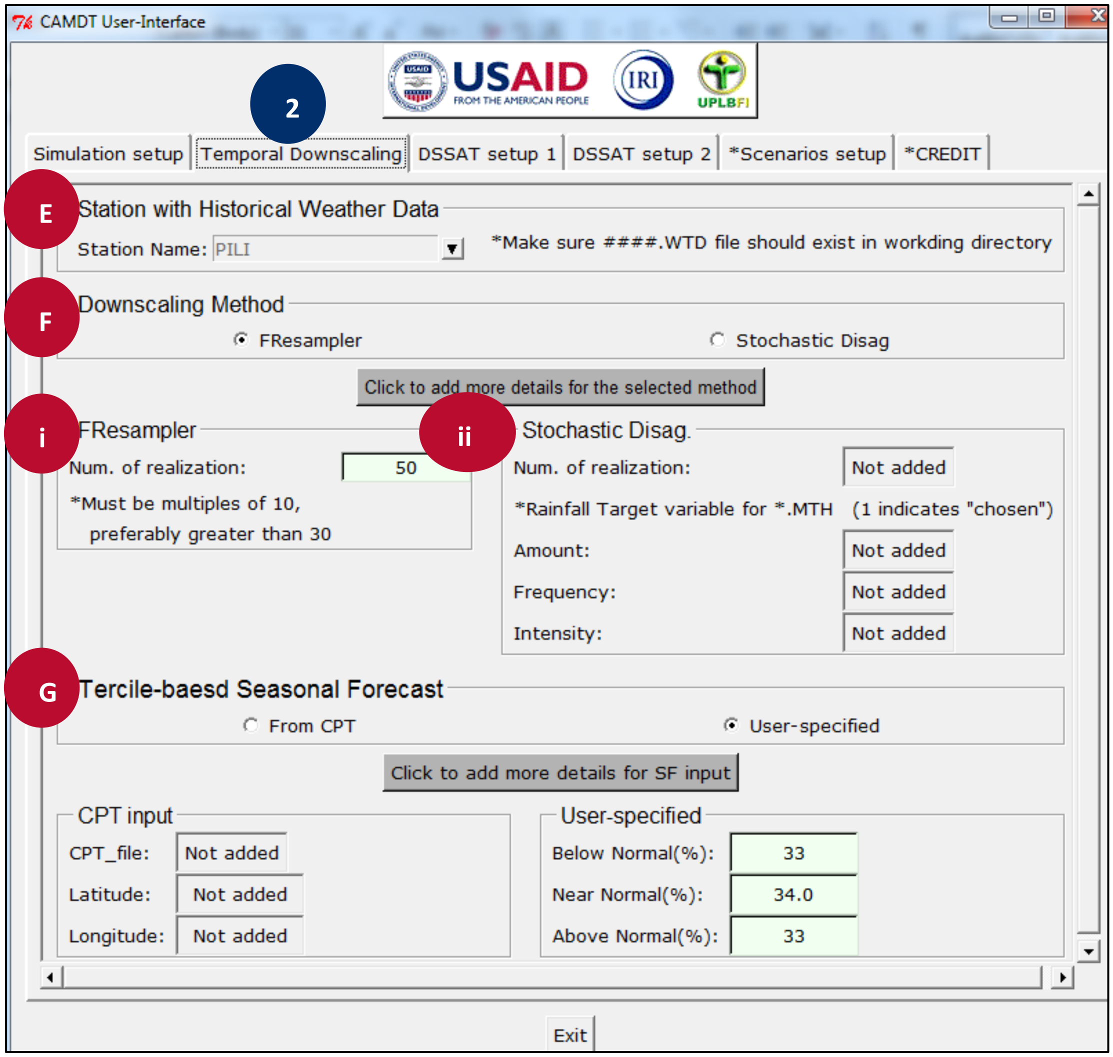
2) Temporal Downscaling

Most of the publically accessible seasonal climate forecasts (SCF) by the NOAA-Climate Prediction Center, IRI or the UK Met Office are released in the format of tercile probability: below-, near- and above-normal probability as shown in Figure 5. Therefore, the tercile-based SCF should be converted to daily weather sequences to force the DSSAT simulations. This temporal downscaling process can be set up in “Temporal Downscaling” page on the CAMDT in Figure 6.



<Figure 5. Sample Seasonal Climate Forecast of IRI>

The temporal downscaling process requires a long-term weather record to be used for parameterization of the *Stochastic Disag* method and to serve as a sampling pool for the *FResampler* method.



<Figure 6. Temporal Downscaling Screen >

E – STATION WITH HISTORICAL WEATHER DATA. Select a weather station in the drop-down menu which has long-term daily weather data and is closest to the area/fields of interest. The weather station has an ID which consists of exactly 4 characters (e.g., PILI in Figure 6).

The long-term daily weather data should be contained in a text file of which name is same as the station ID. That is, for the PILI station in Figure 6, the user should have PILI.WTD file as shown in Figure 7. Since the *.WTD is the main input file for the temporal downscaling, the file should be found in the main working directory which will be set up in Figure 22. In this exercise, PILI.WTD should be in the folder "~\GUI_test_2016".

The *.WTD file has similar format to the DSSAT weather input file (*.WTH) shown in Figure 8. The *.WTD file contains all historical daily weather (SRad, Tmin, Tmax and Rainfall) data in ONE file while each *.WTH file contains only one-year data (i.e., PILI**75**01.WTH has data for the year of 1975 and PILI**76**01.WTH for 1976 and so on).

Note that both *.WTD and *.WTH files are format-sensitive and therefore location of each column and number of spaces should be carefully checked in advance. In addition, since the DSSAT does not allow any missing data, **user should fill the missing values in advance before running the CAMDT (i.e., *.WTD should not have any missing values such as -99)**.

```
PILI.WTD
@  DATE   SRAD  TMAX  TMIN  RAIN
1975244  18.6  32.9  23.5   0.0
1975245  14.4  28.0  23.2  12.4
1975246  15.5  30.7  23.1   3.3
1975247  13.9  32.5  23.4  18.0
1975248  15.6  32.5  24.5   0.2
1975249  14.4  32.0  23.0   1.3
1975250  16.0  32.5  22.8   0.8
1975251  14.8  32.8  23.4   4.6
1975252  14.7  32.8  24.6   2.0
1975253  15.5  32.8  24.1   0.0
1975254  16.3  33.0  23.8   2.8
```

<Figure 7. Sample *.WTD format >

```
PILI7501.WTH
*WEATHER DATA : PILI

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  PILI   13.555  123.270    35  27.5   1.8 -99.0 -99.0
@DATE  SRAD  TMAX  TMIN  RAIN  DEWP  WIND   PAR  EVAP  RHUM
75244  18.6  32.9  23.5   0.0
75245  14.4  28.0  23.2  12.4
75246  15.5  30.7  23.1   3.3
75247  13.9  32.5  23.4  18.0
75248  15.6  32.5  24.5   0.2
75249  14.4  32.0  23.0   1.3
75250  16.0  32.5  22.8   0.8
75251  14.8  32.8  23.4   4.6
```

<Figure 8. Sample *.WTH format >

F – DOWNSCALING METHOD. There are two temporal downscaling methods available in CAMDT: *Stochastic Disag* and *FResampler* method.

i. ***Stochastic Disag*** - A conditional weather generator designed for the stochastic disaggregation of monthly rainfall into daily realizations.

STEP 1:
Run *EstimatePrm.exe* with arguments *.CLI and *.WTD files to estimate the model parameters of *Stochastic Disag*. Command for running *EstimatePrm.exe* is hidden behind the CAMDT, but user should make sure both *.CLI and *.WTD files are prepared in advance under the working directory.

An example of *.CLI file is shown in Figure 9 for the PILI station. The *.CLI file provides only the geo-location of the weather station to the parameter estimation program. Therefore, the information within the red box in Figure 9 is only necessary.

```
PILI.CLI
*CLIMATE:PILI

@ INSI      LAT     LONG  ELEV   TAV   AMP  SRAY  TMXY  TMNY  RAIY
  PILI   13.567  126.250    89  27.3   1.6  16.7  31.9  22.7  2302
@START  DURN  ANGA  ANGB REFHT WNDHT SOURCE
  1975    41  0.25  0.50 -99.0 -99.0 Calculated_from_daily_data
@ GSST  GSDU
     1   365
```

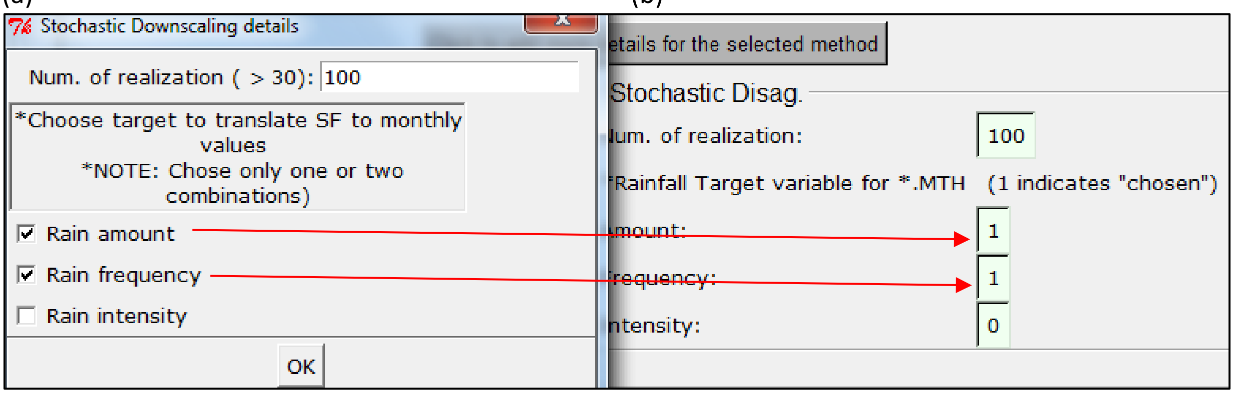
<Figure 9. Sample *.CLI format>

STEP 2:

For the parameter estimation to determine monthly target information (again, *Stochastic Disag* basically generates daily weather realizations from monthly rainfall), user can choose different monthly targets: one of the rainfall characteristics (rainfall amount, frequency, intensity), or combination of two characteristics (e.g., amount & frequency), **but not the three at the same time**. When user selects the *Stochastic Disag* method and clicks the button "Click to add more details for the selected method" in Figure 6, a pop-up window appears so that user can select monthly targets (Figure 10 (a)).

In addition, user can specify how many weather realizations would be created. The larger number of realizations is the better to fully represent uncertainties from the SCF. Typically 100 realizations are reasonable while at least 30 realizations are recommended. The selected monthly target(s) and number of realizations are copied to the main CAMDT window. The selected monthly targets are indicated as "1" and non-selected one(s) are as "0" as shown in Figure 10(b).

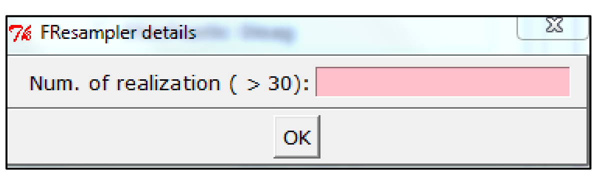
(a) (b)



<Figure 10. Pop-up window when user selects *Stochastic Disag* method and clicks the button "Click to add more details for the selected method">

ii. ***FResampler*** - Creates weather realizations by sampling historical records based on tercile-based SCF. It samples a seasonal chunk of daily weather data that includes SRad, Tmin, Tmax and Rainfall with replacement. Unlike the *Stochastic Disag,* the *FResampler* method does not require any further information except number of realizations in running it. **Note that number of realization should be multiples of 10.**

When user selects the *FResampler* method and clicks the button "Click to add more details for the selected method" in Figure 6, a simple pop-up window (Figure 11) appears so as for the user to determine number of realizations. Again, user input is copied to the main window.

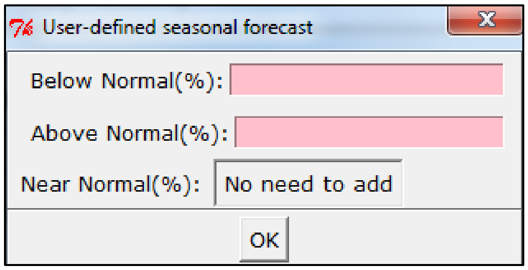


<Figure 11. Pop-up window when user select the *FResampler* method and clicks the button "Click to add more details for the selected method">

G – TERCILE-BASED SCF. Can be typed directly by a user or taken from a Climate Predictability Tool (CPT) output (text) file.

OPTION 1:

If user selects "**user-specified**" radio button and clicks "Click to add more details for SF input", a pop-up window appears to provide probabilities of below- and above-normal (Figure 12).

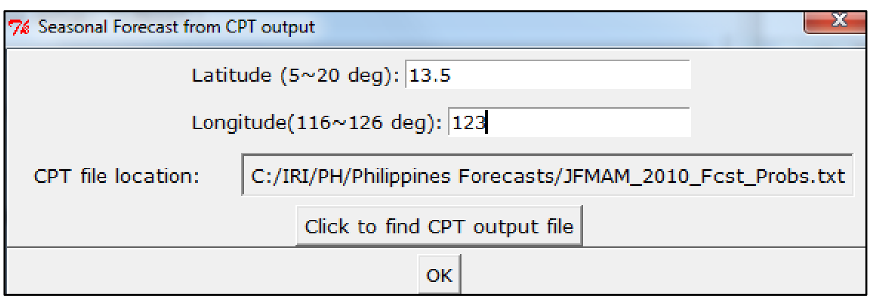


<Figure 12. Pop-up window when user selects "user-specified" radio button and clicks "Click to add more details for SF input">

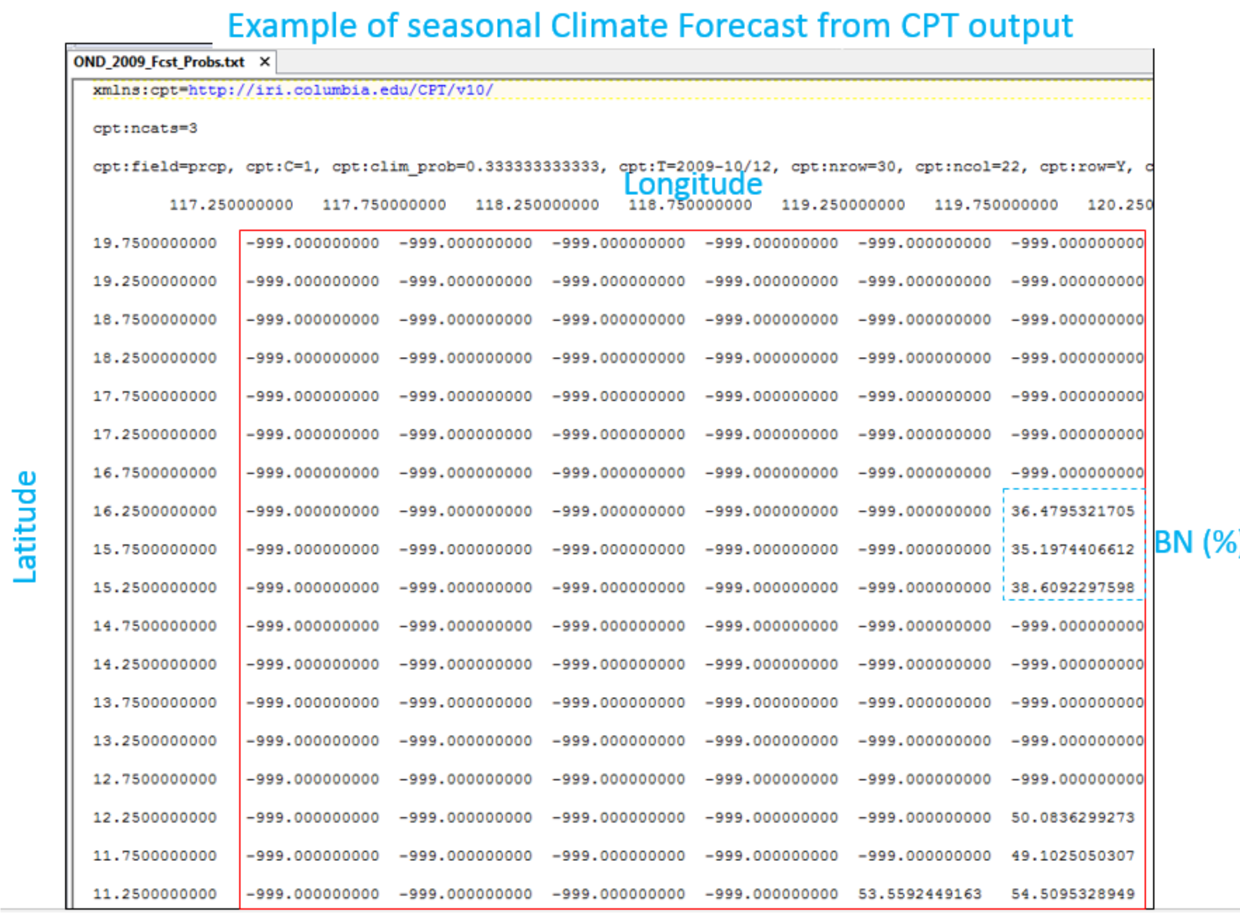
OPTION 2:

If user selects "**From CPT**" option, another pop-up window appears to provide latitude and longitude of the target location and specify CPT output file (Figure 13).

The CPT is a software package developed by IRI "*for constructing a seasonal climate forecast model, performing model validation, and producing forecasts given updated data*" (http://iri.columbia.edu/our-expertise/climate/tools/cpt/). The CPT produces tailored SCFs for the whole Philippines (latitude: 5~10N, longitude: 117~126W) in a text output file. Figure 14 shows an example of CPT output text file for OND of 2009. Based on the user-specified geo-location, the CAMDT extracts probabilities of BN, NN and AN from the chosen text file. Again, your inputs on the pop-up window are copied to the main window.



<Figure 13. Pop-up window when user selects "From CPT" radio button and clicks "Click to add more details for SF input">

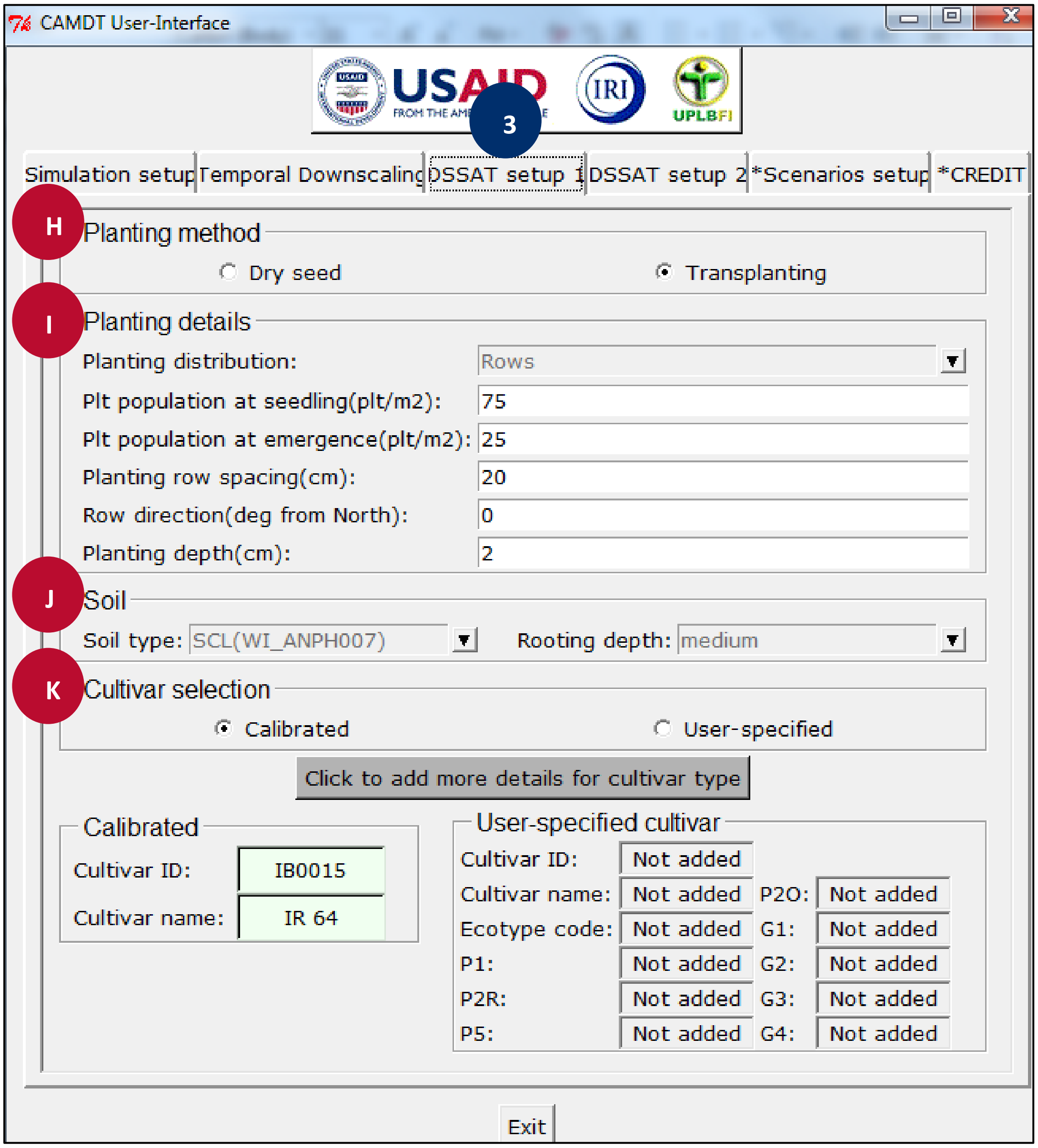



```
xmlns:cpt=http://iri.columbia.edu/CPT/v10/

cpt:ncats=3

cpt:field=prcp, cpt:C=1, cpt:clim_prob=0.333333333333, cpt:T=2009-10/12, cpt:nrow=30, cpt:ncol=22, cpt:row=Y, c

        117.250000000   117.750000000   118.250000000   118.750000000   119.250000000   119.750000000   120.250

19.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
19.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
18.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
18.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
17.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
17.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
16.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
16.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   36.4795321705
15.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   35.1974406612
15.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   38.6092297598
14.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
14.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
13.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
13.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
12.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000
12.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   50.0836299273
11.7500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   49.1025050307
11.2500000000   -999.000000000   -999.000000000   -999.000000000   -999.000000000   53.5592449163   54.5095328949
```

<Figure 14. Sample CPT output text file for Oct-Nov-Dec (OND) of 2009>

3) DSSAT Setup 1

Next step is to provide crop management inputs for DSSAT on "DSSAT setup 1" and "DSSAT setup 2" pages (Figure 15 and 18). These inputs will be used to fill out the DSSAT-experimental file (*.RIX or *.SNX) shown in Figure 16. The DSSAT-experimental file called File-X can contain much more information such as initial soil condition, tillage, management options etc. However, in CAMDT, inputs from the user were simplified as much as possible so that the user is not overwhelmed by too many options.



<Figure 15. DSSAT Setup 1 screen >

H – PLANTING METHOD. Since the current version of CAMDT focuses on rice, there are two planting methods available: dry seed or transplanting.

I - PLANTING DETAILS. User can type (overwrite) in this section although some default values are already given for guidance.

J – SOIL. Soil physical or chemical characteristics are critical factors for crop growth. Due the unavailability of soil database from the Bicol region in the Philippines, a few soil profiles extracted from WISE (World Inventory of Soil Emission Potentials) soil database (WI.SOL) were added to CAMDT. More soil profiles from WI.SOL can be added to the CAMDT by simply modifying Python script (see *CAMDT_Python_user_guide.docx* for details). For each available soil profile, user can set up different rooting depths (shallow, medium or deep).

PILI0001.SNX

```
*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH  SPRL
 1 09349   -99    75    25     T     R    20     0    2.     0    23    25     3     0

*IRRIGATION AND WATER MANAGEMENT
@I  EFIR  IDEP  ITHR  IEPT  IOFF  IAME  IAMT IRNAME
 1   -99   -99   -99   -99   -99   -99     1 UNKNOWN
@I IDATE  IROP IRVAL
 1 09344 IR008   2.0
 1 09344 IR010   0.0
 1 09349 IR011   0.0
 1 09349 IR009  50.0

*FERTILIZERS (INORGANIC)
@F FDATE  FMCD  FACD  FDEP  FAMN  FAMP  FAMK  FAMC  FAMO  FOCD FERNAME
 1    17 FE005 AP012     1  35.0   -99   -99   -99   -99   -99 UNKNOWN
 1    32 FE005 AP012     1  35.0   -99   -99   -99   -99   -99 UNKNOWN

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME.................... SMODEL
 1 GE              1     1     S 09319  2150  IRRI, PILA JAN 85 UREASE
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES  CHEM  TILL   CO2
 1 OP              Y     Y     N     N     N     N     N     N     M
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO HYDRO NSWIT MESOM MESEV MESOL
 1 ME              M     M     E     R     S     C     R     1     G     S     2
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA              R     R     D     R     M
```

<Figure 16. DSSAT-experimental file *.SNX>

K – CULTIVAR. In DSSAT-CERES-Rice, crop growths are simulated using genetic coefficients defined in Table 1. These coefficients have different values for each rice variety and should be carefully calibrated before model simulation using field experiment data. The DSSAT 4.5 version has genetic coefficients calibrated for a number of rice varieties. In CAMDT, three calibrated rice cultivars (IR54, 58, 64) from *RICER45.CUL* file were added. In addition, we calibrated two new varieties using field experiment data at PhilRice Central Experiment Station, Muñoz, Nueva Ecija in the Philippines: inbred PSB Rc82 (110 days to maturity) and hybrid Mestiso 20 (111 days to maturity).

<Table 1. The Genetic Coefficient for DSSAT Rice Model>

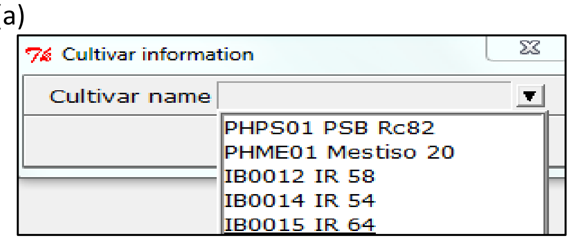
Coefficients	Definition
P1	Time period (expressed as growing degree days [GDD] in °C above a base temperature of 9 °C) from seedling emergence during which the rice plant is not responsive to changes in photoperiod. This period is also referred to as the basic vegetative phase of the plant.
P20	Critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P20 developmental rate is slowed, hence there is delay due to longer day lengths.
P2R	Extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in °C) for each hour increase in photoperiod above P20.

P5	Time period in GDD °C from beginning of grain filling (3 to 4 days after flowering) to physiological maturity with a base temperature of 9°C.
G1	Potential spikelet number coefficient as estimated from the number of spikelets per g of main culm dry weight (less lead blades and sheaths plus spikes) at anthesis. A typical value is 55.
G2	Single grain weight (g) under ideal growing conditions, i.e. nonlimiting light, water, nutrients, and absence of pests and diseases.
G3	Tillering coefficient (scaler value) relative to IR64 cultivar under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.0.
G4	Temperature tolerance coefficient. Usually 1.0 for varieties grown in normal environments. G4 for japonica type rice growing in a warmer environment would be 1.0 or greater. Likewise, theG4 value for indica type rice in very cool environments or season would be less than 1.0.

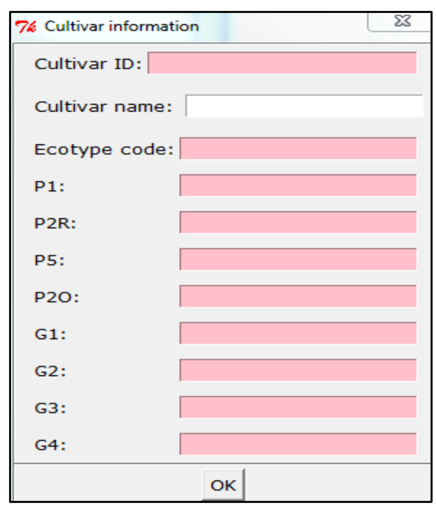
In total, those five cultivars are available for DSSAT simulation in the current version of CAMDT (Figure 17(a)), but again additional cultivars from *RICER45.CUL* file can be easily added by modifying Python script of the CAMDT. If users want to simulate using the given cultivars, "Calibrated" option should be chosen under the "Cultivar selection" group (Figure 15). Once the user click "Click to add more details for cultivar type" button, a new pop-up window appears to select a cultivar type as shown in Figure 17(a).

In case user is an expert of DSSAT and has his own calibrated parameters for a certain cultivar, he can add newly calibrated parameters by selecting "User-specified" option under "Cultivar selection" group and clicking "Click to add more details for cultivar type" button in Figure 15. Then new coefficients can be directly typed on the new window (Figure 17(b)) and these coefficients will be written into *RICER45.CUL* file under the working directory.

(a)



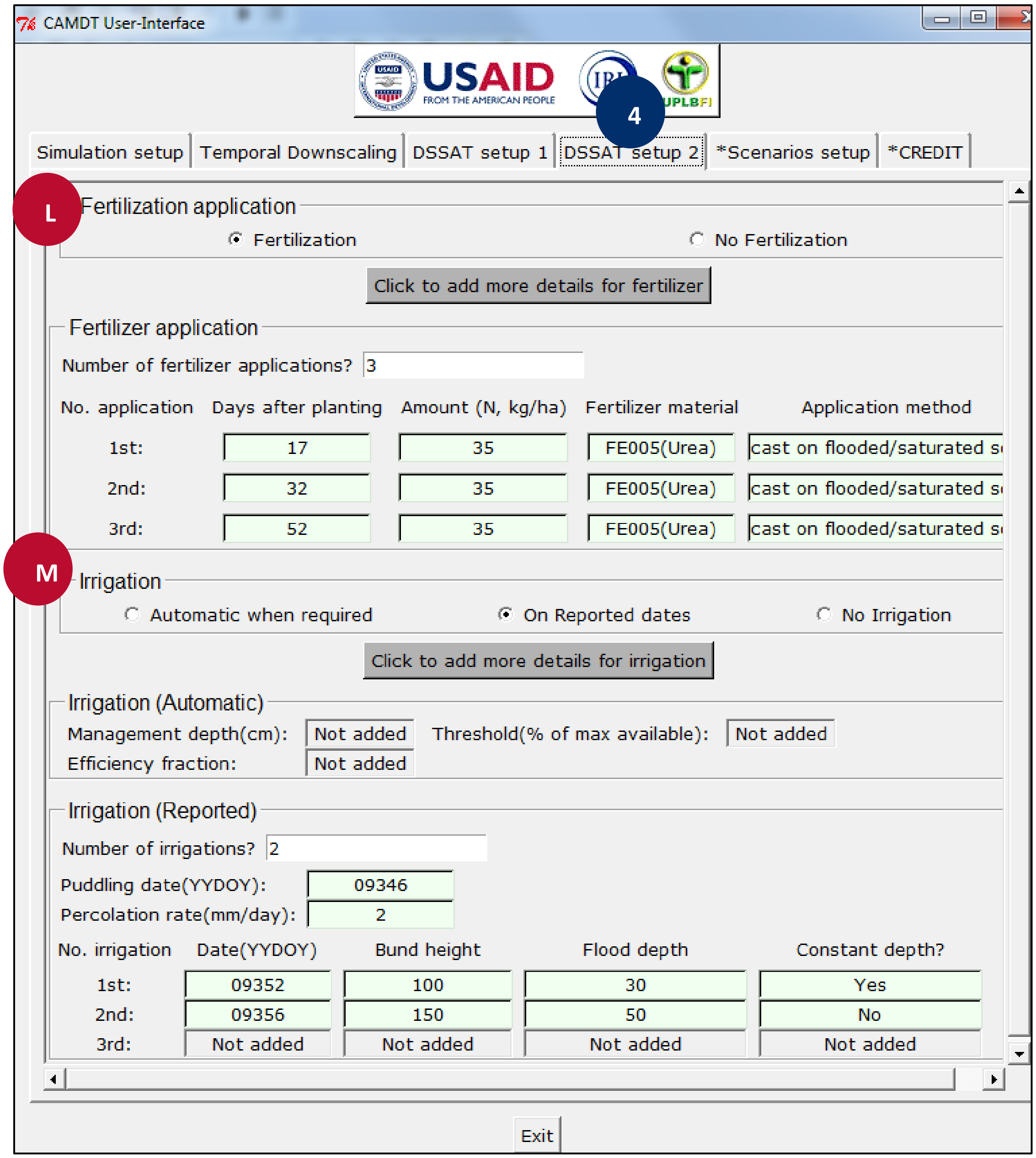
(b)



<Figure 17(a). Pop-up window when user selects "Calibrated" then click "Click to add more details for cultivar type" Fig. 17 (b). Pop-up window when user selects "User-specified cultivar" then click "Click to add more details for cultivar type" >

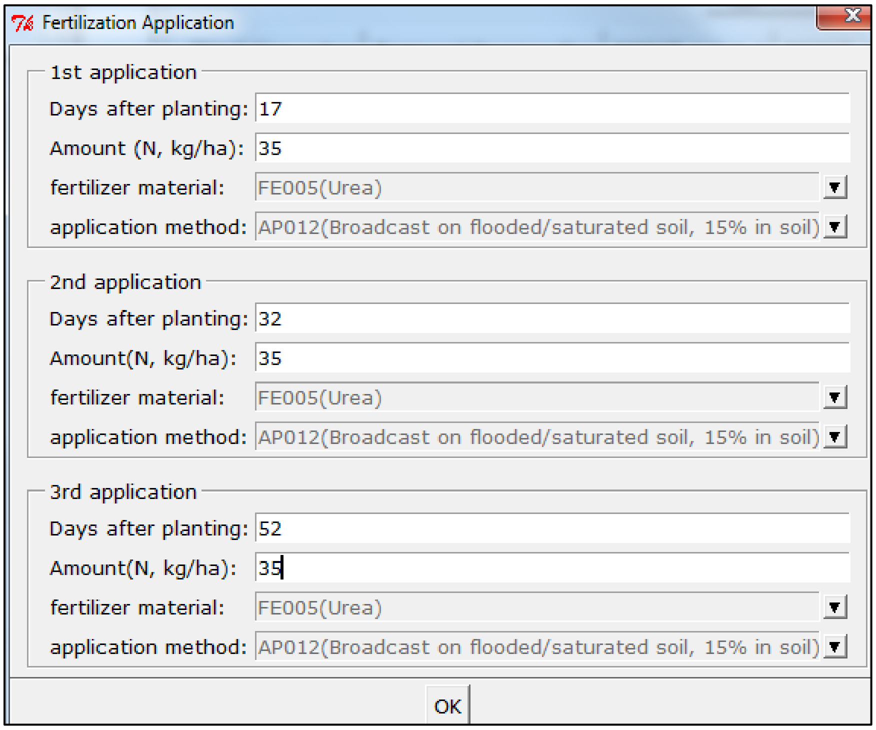
4) DSSAT Setup 2

The “DSSAT setup 2” page in Figure 18 is to get user’s inputs for fertilizer and irrigation applications.



<Figure 18. DSSAT Setup 2 screen >

L – FERTILIZATION APPLICATION. First, user should select if fertilizer would be applied (by selecting “Fertilization” button) or not (by selecting “No Fertilization” button). If “Fertilization” was selected, user can give more detailed inputs (fertilizer material, amount and application methods) by clicking the button “Click to add more details for fertilizer”. Again, for simplicity, the CAMDT allows fertilizer application up to maximum of three times. Figure 19 shows an example of how to fill out the Fertilizer Application section. Once user filled out the pop-up window, the inputs will be copied to the main window. User should also type “number of fertilizer applications” on the blank box in the “Fertilizer Application” group (Figure 18).

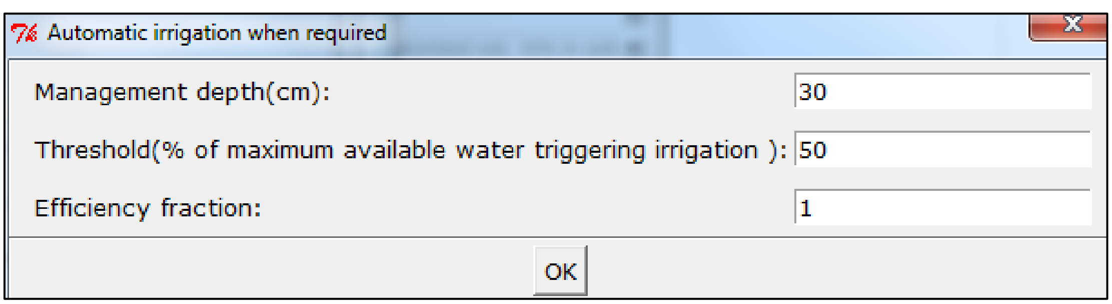


<Figure 19. Pop-up window when user select "Fertilization" then click "Click to add more details for fertilizer">

M – IRRIGATION. An irrigation option needs to be chosen. There are three options available: 1) Automatic when required, 2) On Reported dates and 3) No Irrigation.

OPTION 1:

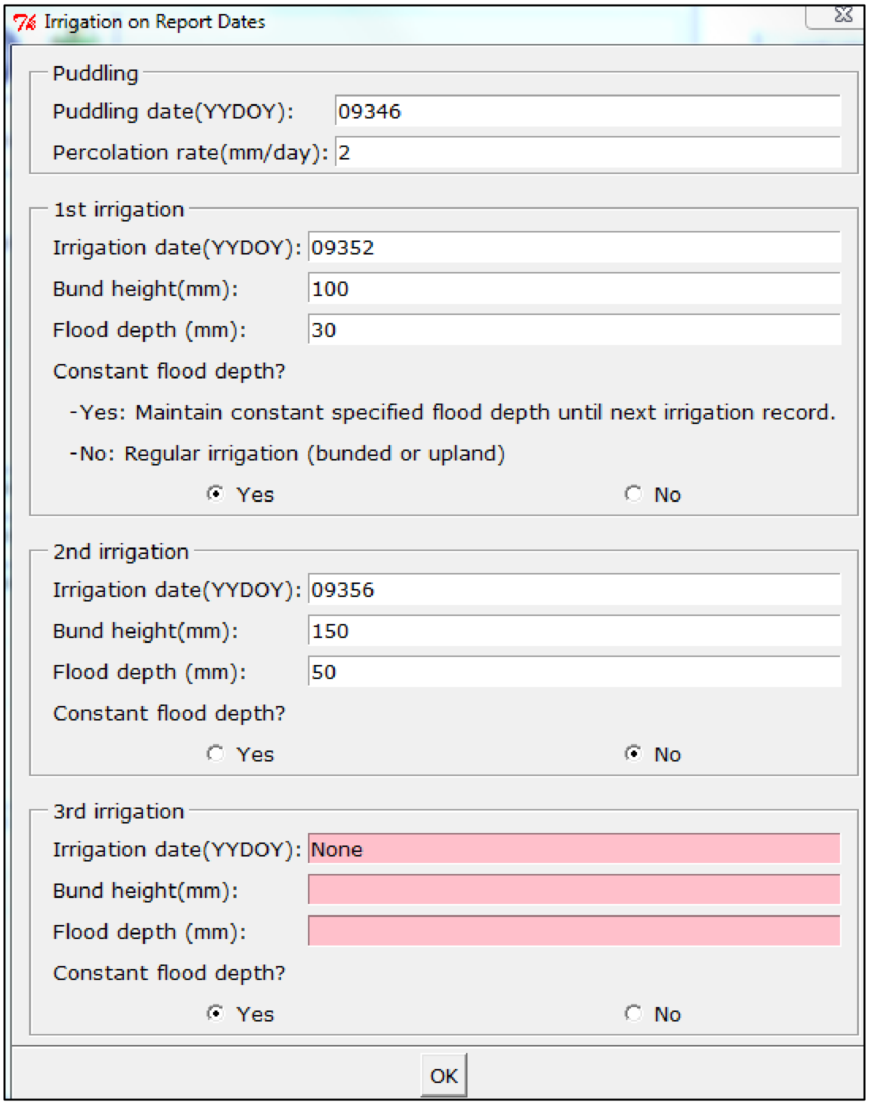
"**Automatic when required**" can be used to simulate crop growth with no water stress by triggering irrigation whenever soil water content drops down below a certain threshold (% of maximum available water in soil). Three inputs shown in Figure 20 are required when "Automatic when required" is selected on the main window in Figure 18.



<Figure 20. Pop-up window when user selects "Automatic when required" then click "Click to add more details for irrigation">

OPTION 2:

More realistic irrigation applications can be possible with the option "**On Reported dates**". Since we assume "lowland" rice, initial puddling is assumed and related information (puddling date, and percolation rate) is required (Figure 21). For the rest of irrigation, user needs to provide irrigation date, bund height, flood depth and if the flood depth would be constant or not. If user checks "yes" to the question, "Constant flood depth?" (as shown in Figure 21), the DSSAT assumes the flood depth maintains constant flood depth until next irrigation record. Otherwise (when "No" is chosen), regular irrigation concept is applied. Once user clicks "ok" button of the pop-up window, all the inputs provided will be copied to the main window. Do not forget to type "Number of Irrigations" on the main window in Figure 18.



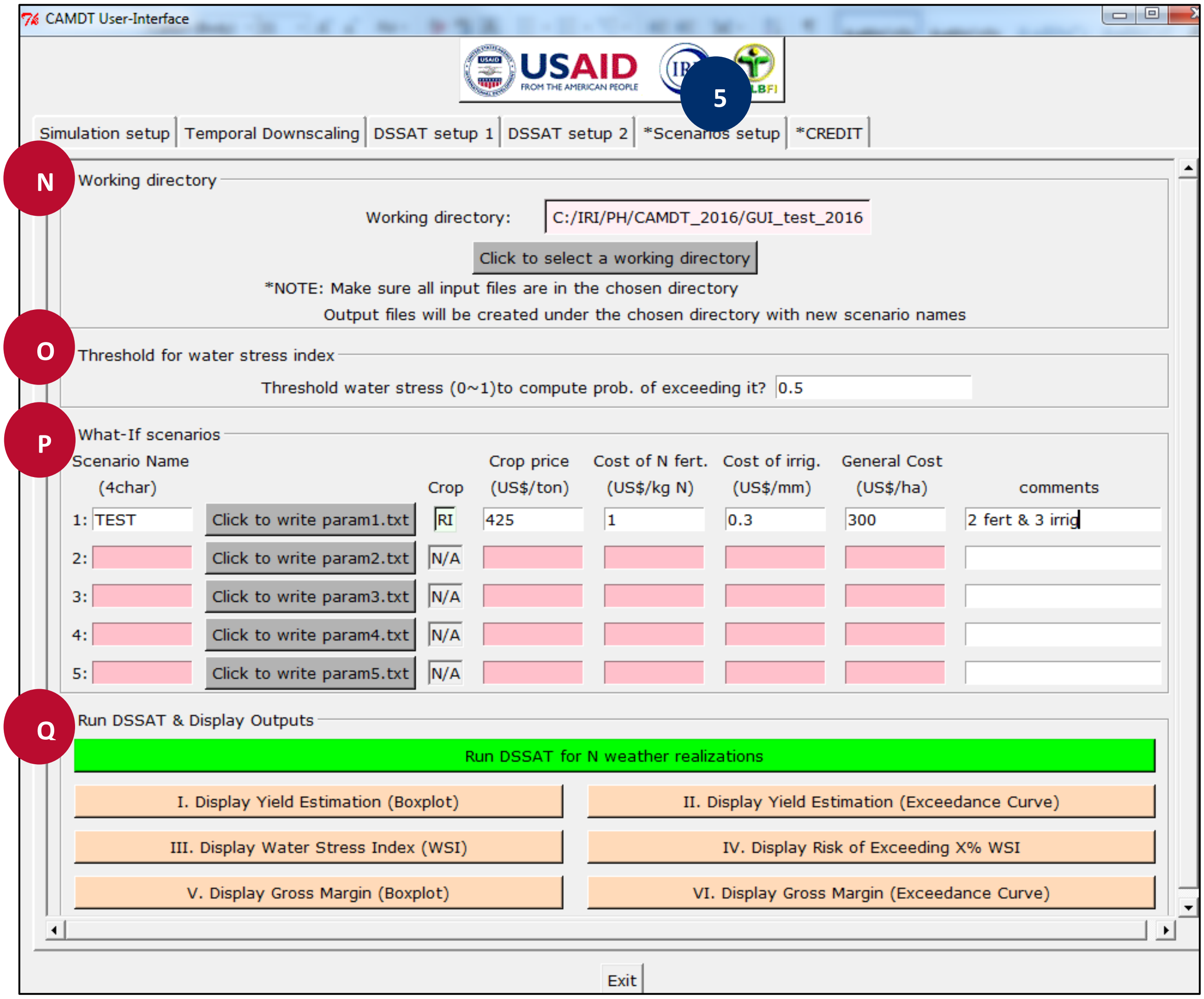
<Figure 21. Pop-up window when user selects "On Reported dates" then click "Click to add more details for irrigation >

OPTION 3:

If "**No Irrigation**" is selected, user can proceed to "Scenario setup".

5) Scenario Setup

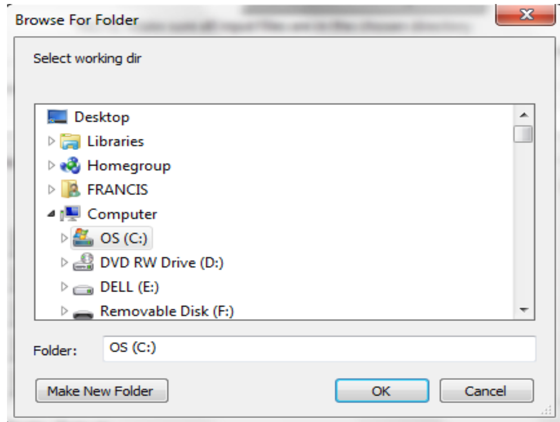
In this section, user can set up "what-if" scenario(s) and run DSSAT for the scenarios.



<Figure 22. Scenarios setup screen >

N – WORKING DIRECTORY. User needs to designate a working directory where all required input files are located. The list of necessary input files is shown in Table 2. Please make sure all those input files are saved in the working directory. Once user clicks "Click to select a working directory" button, a new pop-up window will appear so that user can select a folder (as shown in Figure 23) to save the simulation results. New folders which contain simulation result for each scenario will be created under the working directory you designated.

> Note: The working directory **SHOULD NOT** have any spaces. For example, "C:\Users\eunjin han\Documents\CMDT" will result in an error due to the space in the name of "eunjin han" folder. Therefore, make a folder name as "eunjin_han" instead of "eunijn han".



<Figure 23. Pop-up window when user click “Click to select a working directory”>

<Table 2. Required input files for CAMDT>

Category	File name/type	
Executables	CAMDT_PH_exe.exe	to get user's input from the CAMDT and to run temporal downscaling and DSSAT
	FResampler_Colombia.exe	to run a temporal downscaling method - *FResampler*
	predictWTD_Colombia.exe	to link a temporal downscaling method (*Dis Ag*) with seasonal climate forecast
	Disag.exe	to run a temporal downscaling method - *DisAg*
	EstimatePrm.exe	to estimate parameters for *DisAg*
	exportPHNT.exe	to convert outputs from *DisAg* to weather input files for DSSAT
	dscsm045.exe	DSSAT 4.5 executable
	minpt040.exe	auxiliary file to run DSSAT
	DSSAT_AnalysisTool.exe	to post-process DSSAT output to extract yield and water stress index
input related to weather station	*.CLI (e.g., PILI.CLI)	need to run *DisAg*
	*.WTD (e.g., PILI.WTD)	long-term daily weather data
DSSAT input files	RICER045.CUL	contains genetic coefficients for rice growth simulation
	RICER045.SPE	Contains species coefficients for rice growth simulation
	WI.SOL	DSSAT soil input file
	*.WTH(e.g., PILI0101.WTH)	yearly weather input files for DSSAT (need to run DSSAT with observed weather)

O – THRESHOLD FOR WATER STRESS INDEX. User needs to define threshold to compute water stress. Water stress (WS) is defined as ($1 - ET_{act}/ET_{crop}$), where ET_{crop} is potential daily root water uptake (demand of the atmosphere) and ET_{act} is actual transpiration due to soil moisture constraint. Therefore, WS=1 means the highest stress while WS=0 means no stress. Since we run *N* numbers of simulations with different *N* weather realizations downscaled from a SCF, we will get *N* different WS values after all simulations.

Using the WS results, we can calculate probability of exceeding a certain WS value. For instance, when user set the threshold as 0.5, the CAMDT will count how many WSIs are greater than 0.5 out of total simulation results. If there are 30 WSs greater than 0.5 on a certain DAP (Days after planting) out of 100 realizations, the probability of exceeding 50% level water stress on that day is 30% given a SCF. The result, 30% can be interpreted as "risk index". This approach shows the "risk" of having passing the threshold at that day of year. High WS at critical growth stages is potentially lethal for crops.

P – WHAT-IF SCENARIOS. "What-If scenarios" in Figure 22 is to make a name of the scenario. **The scenario name should be exactly 4 characters** (any combination of letters and numbers are fine). Once user clicks the button "Click to write param1.txt" next to the scenario name box, "Crop" box will turn to green with "RI" (rice) and the CAMDT will create a text file, "param_####.txt" where #### is the scenario name you typed. This text file contains all information which user provided on the pages of CAMDT user-interface (from "Simulation setup" to "Scenario setup" pages). This "param_####.txt" is the main input file to the *CAMDT_PH_exe.exe* which is the actual core program to run the temporal downscaling and the DSSAT.

Q – RUN DSSAT & DISPLAY OUTPUTS. User can run *CAMDT_PH_exe.exe* by typing a command line on MS-Dos window as shown in Figure 24. Instead of doing this, however, user can click the green button, "Run DSSAT for N weather realizations" within "Run DSSAT & Display Outputs" box of the CAMDT. Then MS-Dos window will show progress of the temporal downscaling and the DSSAT simulation (Figure 25).

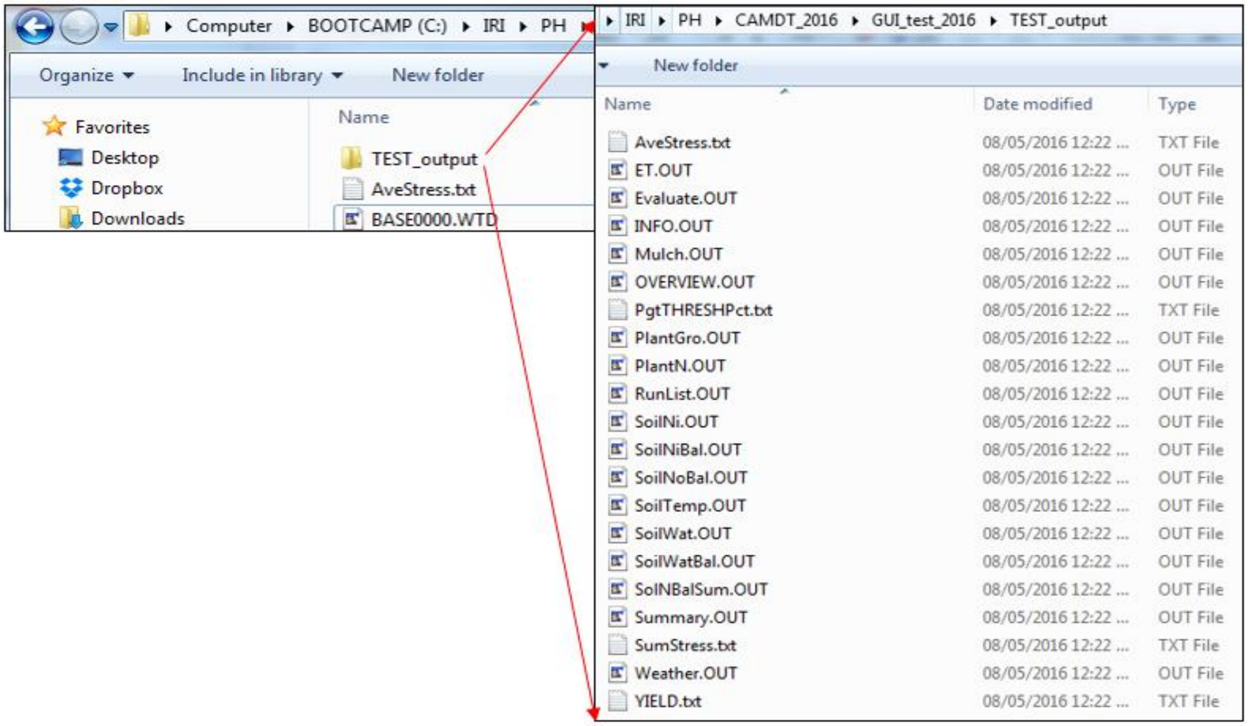
```
Command Prompt
C:\Windows\system32>cd C:\IRI\PH\CAMDT_2016\GUI_test_2016

C:\IRI\PH\CAMDT_2016\GUI_test_2016>CAMDT_PH_exe.exe param_TEST.txt
```

<Figure 24. Command line on MS-Dos>

```
C:\IRI\PH\CAMDT_2016\GUI_test_2016\CAMDT_PH_exe.exe

RUN     TRT FLO MAT TOPWT HARWT  RAIN  TIRR   CET  PESW  TNUP  TNLF   TSON TSOC
            dap dap kg/ha kg/ha    mm    mm    mm    mm kg/ha kg/ha  kg/ha t/ha
  1 RI    1  67  98 11271  5622   204   216   503    33   108    32  12978  198
  2 RI    2  64  98 12158  5975   335   180   499   128   140    19  12980  198
  3 RI    3  63  96 11700  5483   257   209   506    59   122    26  12980  198
  4 RI    4  67 106 13112  6643   263   249   533    97   145    17  12964  198
  5 RI    5  66 101 13158  6402   152   258   498    33   128    20  12978  198
  6 RI    6  64  99 12564  6213   170   256   519    27   123    21  12975  198
  7 RI    7  63  97 12523  6005   312   213   537    74   133    22  12976  198
  8 RI    8  63  96 11700  5483   257   209   506    59   122    26  12980  198
  9 RI    9  66 101 13158  6402   152   258   498    33   128    20  12978  198
 10 RI   10  63  97 12523  6005   312   213   537    74   133    22  12976  198
 11 RI   11  67  98 11271  5622   204   216   503    33   108    32  12978  198
 12 RI   12  63  96 11700  5483   257   209   506    59   122    26  12980  198
```

<Figure 25. MS-Dos window showing the progress of temporal downscaling and DSSAT simulation>

Once all simulations ran successfully, user should be able to find a new folder "####_output" (in this exercise "TEST_output") under working directory as shown in Figure 26. The folder contains all the DSSAT output files (*.OUT) as well as some additional post-processed files (AveStress.txt, YIELD.txt and PgtTHRESHPct.txt). For more information about DSSAT output, please refer to DSSAT documentation.



<Figure 26. Output folder>

The CAMDT helps the user to display some of interesting outputs (predicted yields, water stress and gross margin) easily. To display output variables, you can click the buttons in orange (from “I. Display Yield Estimation (Boxplot)” to “VI. Display Gross Margin (Exceedance Curve)”) in Figure 22.

<u>Display of Yield Estimation using Boxplot and Exceedance Curve</u>

The first two buttons “I. Display Yield Estimation (Boxplot)” and “II. Display Yield Estimation (Exceedance Curve)” can be used to display predicted yields in two different ways (using boxplot and exceedance curve).

OPTION 1:

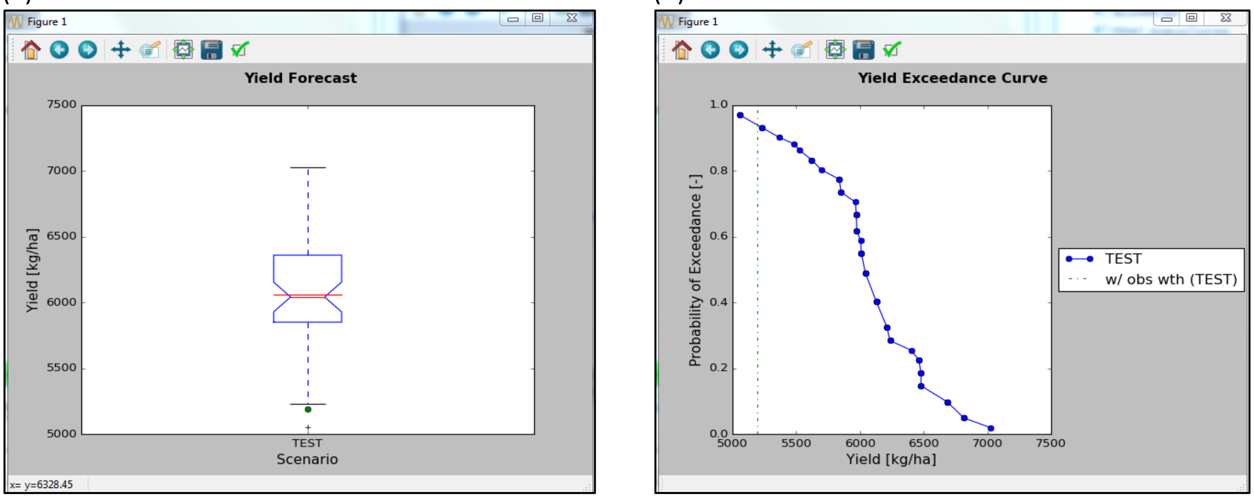
A **box plot** is used to display the distribution of quantitative data. The box shows the quartiles of the dataset while the whiskers extend to show the rest of the distribution, except for points that are determined to be “outliers”. From the boxplot, you can have an idea of median (indicated by the red line in the middle of the notch) and mean (indicated by the extended red line in Figure 27(a)). The notch in Figure 27(a) displays a confidence interval around the median (typically 95% confidence interval) and the blue box shows an interquartile (i.e., 50% of data) between the 1st (i.e., 25th percentile) and 3rd (i.e., 75th percentile) quartiles.

The two black bars indicate low/upper whiskers. The green dot is the simulated yield using observed weather. This green dot can be used as a reference to check how the SCF we used was accurate compared to actual weather condition during the target season (This green dot appears only when user selected “Hindcast” mode in Figure 1). In 2010, El Niño resulted in a drier weather in JFM and a drier SCF 39.73% BN, 39.2% NN and 20.45% AN was forecasted. Therefore the green dot show very low yield compared to the forecasted yields from climatology (33% AN, 34%NN and 33% BN we set in Figure 6).

OPTION 2:

The **yield exceedance curve** in Figure 27(b) shows the full distribution of the predicted yields using the weather realizations downscaled from the given SCF. Exceedance probability (P) is computed as $P = m \times (n + 1)^{-1}$, where m is the rank of a forecasted yield (m=1 is the largest value) and n is the total number of simulated years (yields). Uncertainties in forecasted yields are reflected in the spread of the exceedance curve or size of the interquartile of the boxplot. Again the green dotted line in Figure 27(b) is from the observed weather.

(a) (b)

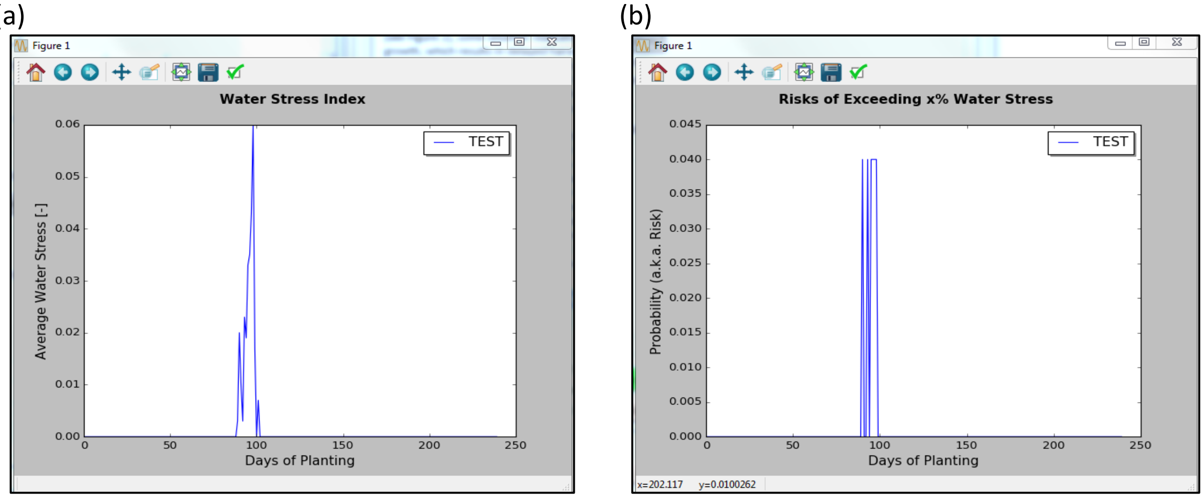


<Figure 27(a). Display of Yield Estimation using Boxplot; Figure 27(b). Display of Yield Estimation using Exceedance Curve>

<u>Display of Average Water Stress (WS) and Risk of Exceeding X% WS</u>

Next two buttons, "III. Display Average Water Stress (WS)" and "IV. Display Risk of Exceeding X% WS" can be used to display average water stress and risk of water stress during the crop growth. In this exercise, since we set up regular flooding depth (not constant flooding depth) for the second irrigation (by selecting "No" in Figure 21), water stress happened around the DAT=100 (Figure 28(a)). However, because the water stress was minimal (less than 0.06) and it happened during the maturity stage, there was no serious yield loss due to water stress. There are also risks of exceeding 50% of water stress around DAP=100 (Figure 28(b)).

(a) (b)

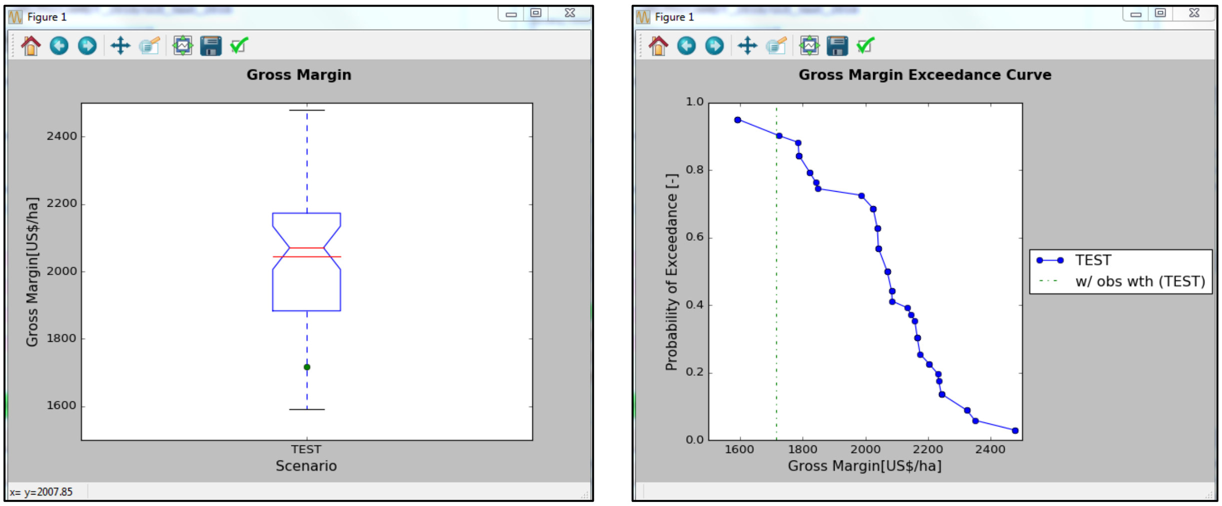


<Figure 28(a) Display of Average Water Stress (WS); Figure 28(b) Display of Risk of Exceeding X% WS>

Display of Gross Margin using Boxplot and Exceedance Curve

Expected gross margins can also be calculated once a user provides an expected crop price [\$ ton^{-1}], cost for fertilizer [\$ kg^{-1} N], cost for irrigation [\$ mm^{-1}], the general cost [\$ ha^{-1}]. The general cost includes the cost of buying seeds, labor and/or maintaining/renting tools or machines. If we assume expected rice price = 425 [\$ ton^{-1}], cost for fertilizer =1[\$ kg^{-1} N], cost for irrigation =0.3 [\$ mm^{-1}] and general cost=300 [\$ ha^{-1}], the expected gross margins are calculated for all predicted yields and distribution of them are displayed in Figure 29(a) and (b) using a boxplot and exceedance curve same as yield distribution.

(a) (b)

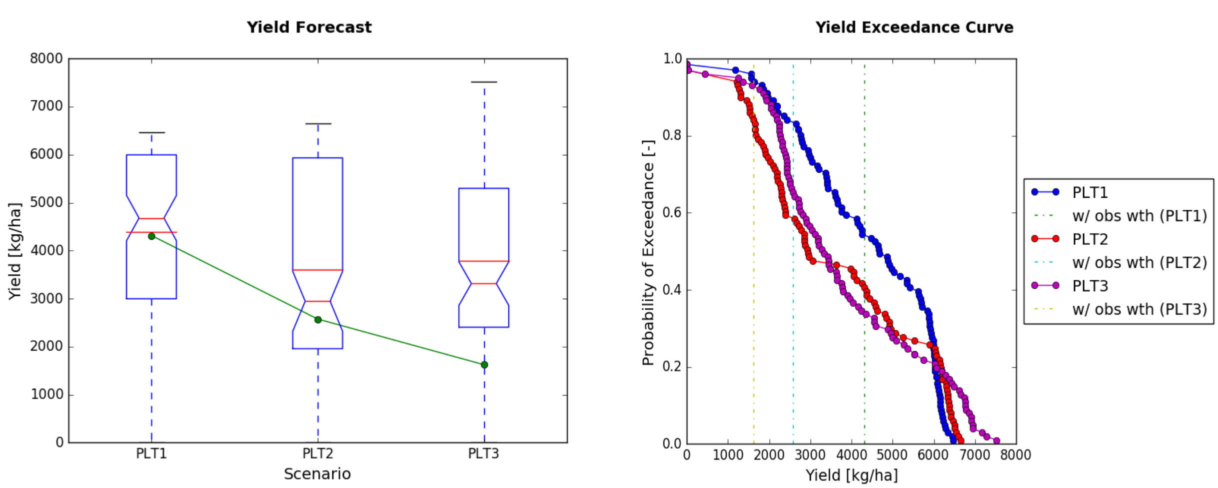


<Figure 29(a) Display of Gross Margin using Boxplot; Figure 29(b) Display of Gross Margin using Exceedance Curve>

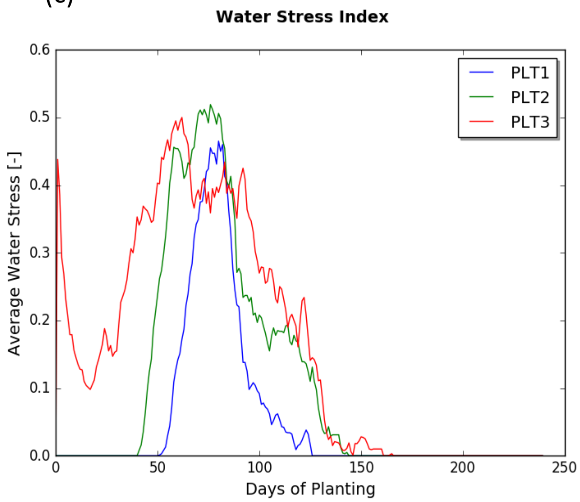
In this excise, we tried only one scenario. However, if users want to make another scenario (say by changing the planting date), users can simply go back to the page they want to make a change, make changes whatever they want and then type a new scenario name on the second line in Figure 22. If users click "Click to write param2.txt" button, the newly updated information will be saved into another "param_#####.txt" file. Users can create up to 5 different scenarios for comparison.

For example, by running CAMDT with three different planting dates, users can find an optimal planting date as shown in Figure 30.

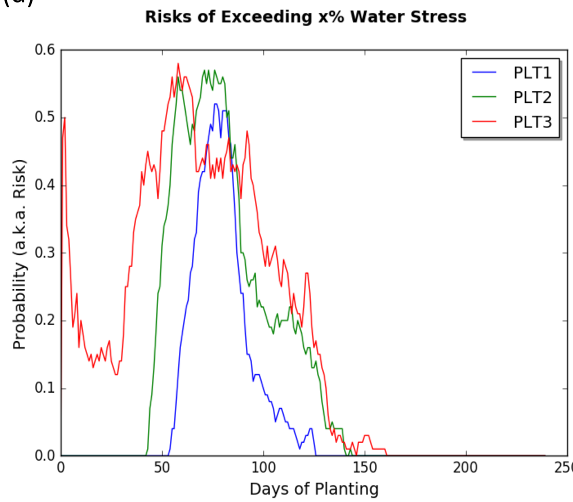
(a) (b)



(c)



(d)



<Figure 30(a). Display of Yield Forecast of three different planting dates; Figure 30(b). Display of Yield Exceedance Curve of three different planting dates; Figure 30(c). Display of Water Stress Index of three different planting dates; Figure 30(d). Display of Risk of Exceeding x% Water Stress of three different planting dates>