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MANUAL FOR MODIFIED CAMDT/DSSAT CROP YIELD PREDICTION MODEL

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ACKNOWLEDGEMENT

This manual is an adaptation of the Climate Agriculture Modelling Decision Tool (CAMDT). We are grateful to IRI for availing CAMDT and subsequent consultations on it from which we were able to make some modifications to suit current usage. At the same time, we acknowledge the developers of Decision Support System for Agrotechnology Transfer (DSSAT) for availing their crop-modelling tool. In this work, CAMDT is used as a wrapper of DSSAT.

PREFACE

Developing crop capability prediction methodologies is an important piece in the process to capacitate the producers and users of climate information as part of the decision support system in agriculture and food security. Decision support systems informed by crop yield prediction models require a number of processes: data collection and analytics; techniques development; and how the methodology is applied, i.e. user guide. This manual has three User Guides (User Guide 1, User Guide 2 and User Guide 3) that can be referred to either separately or also in tandem, the latter of which leads to the generation of crop yields. These User Guides are presented as part of the manual.

USER GUIDE 1

FORMATTING & EXPORTING DAILY CLIMATOLOGICAL DATA FROM NASA WEBSITE INTO CAMDT/DSSAT FORMATS

Authors: Bradwell J Garanganga and Trymore Nyakutambwa

Acronyms

CAMDT	Climate Agriculture Modelling and Decision Tool
CSM	Cropping System Model
DSSAT	Decision Support System for Agrotechnology Transfer
GUI	Graphical User Interface
NDJ	November, December, January season
IRI	International Research Institute for Climate and Society
NASA	National Aeronautics and Space Administration of USA
WTD	File with daily Weather data aggregated over many years
WTH	File with one Year's daily Weather data

INTRODUCTION

Crop capability prediction modelling platforms used in this User Guide are the Climate-Agriculture-Modelling and Decision Tool (**CAMDT**) as the weather generator, for the Decision Support System for Agrotechnology Transfer (**DSSAT**), the crop weather simulation model. **CAMDT/ DSSAT** platforms are very sensitive to the data formats. In this regard, there will be need to manipulate the climatological data for exporting into **CAMDT/DSSAT** programmes to be compatible for ingestion into these environments. For instance, using the example of data downloaded from NASA (National Aeronautics and Space Administration) website (https://power.larc.nasa.gov/data-access-viewer/) there is need for downloaded daily climatological data to be manipulated into and across both MS Excel and CSV environments. The authors have already reformatted climatological data from MAPAI, Mozambique, provided with this note. The necessary steps to be followed in order to make the data formats compatible with **CAMDT/DSSAT** are presented in the following sections.

i. CAMDT Output Weather Files

CAMDT **PYTHON** software code is responsible for reading a weather station's historical weather data (for so many years USUALLY >= 30) and combine it using ***n*** realisations (USUALLY >= 30) to generate, via HINDCAST or FORECAST, daily Weather patterns for the desired planting season or horizon. This horizon usually spans from November for NDJ planting season, to June (Harvesting) for Southern Africa. **CAMDT** therefore generates daily weather patterns for November to June (8-months block).

This 8-months block weather pattern is consumed by **DSSAT** as the crop modelling software's weather input component. The four (4) tables below show weather files output by **CAMDT** for the desired simulation horizon (Planting = November 2009 to harvesting = July 2010, the temporal downscaling method used is **Forecast Resampler (FResampler)**, which automatically executes 100 realisations. *See tables Table 1.a, 1.b, 2.a and 2.b.*

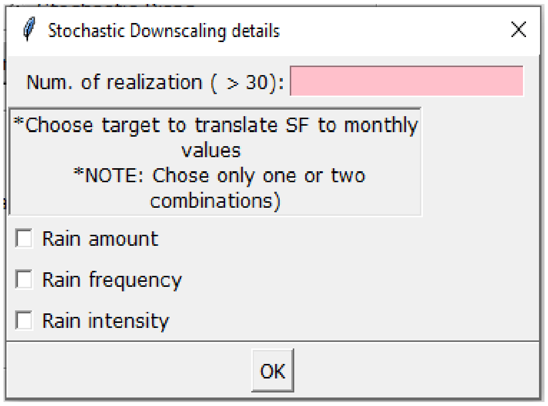
ii. Temporal Downscaling: FResampler versus Stochastic Disaggregation

CAMDT uses Two (2) methods for Downscaling probabilistic Seasonal Climate Forecasts (SCF) for decision support in agriculture: **1. Parametric** and **2. Non-parametric**

Highlights

- Non-parametric performs like the parametric method in downscaling probabilistic climate forecast.
- Non-parametric method is sensitive to data volume and sampling size.
- The parametric method is sensitive to data volume and type of rainfall information.
- Downscaling median not enough; downscaling distribution sampling points is needed.

Seasonal climate forecasts (SCF) are produced operationally in tercile-probabilities of the most likely categories, e.g., Below-, Near- and Above-normal rainfall. Inherently, these are difficult to translate into information useful for decision support in agriculture. For example, probabilistic SCF must first be downscaled to daily weather realizations to link with process-based crop models, a tedious process, especially for non-technical users. Here, we present two approaches for downscaling probabilistic seasonal climate forecasts – a Parametric method, **predictWTD**, and a Non-parametric method, **FResampler1**. The **predictWTD**, which is based on a conditional stochastic weather generator, is not very sensitive to types of rainfall information (amount, frequency or intensity) in constraining or conditioning the stochastic weather generator. Conditioning the stochastic weather generator on both rainfall frequency and rainfall intensity distorted the distribution of the downscaled seasonal rainfall total. Both **predictWTD** and **FResampler1** are sensitive to the length of climate data, especially for a wet SCF; climate data longer than 30 years is suitable for reproducing the theoretical distribution of SCF. FResampler1 performs as well as **predictWTD** in downscaling probabilistic SCF, however, it requires the generation of more realizations (~100), to ensure stable simulations of the seasonal rainfall total distributions.



Stochastic Downscaling details

Num. of realization (> 30):

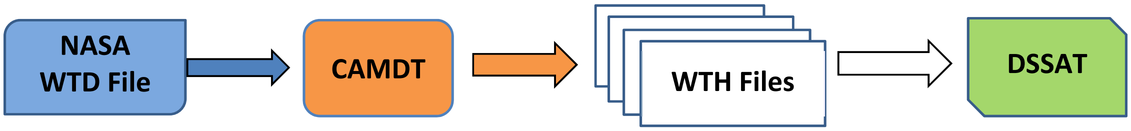
*Choose target to translate SF to monthly values
*NOTE: Chose only one or two combinations)

☐ Rain amount
☐ Rain frequency
☐ Rain intensity

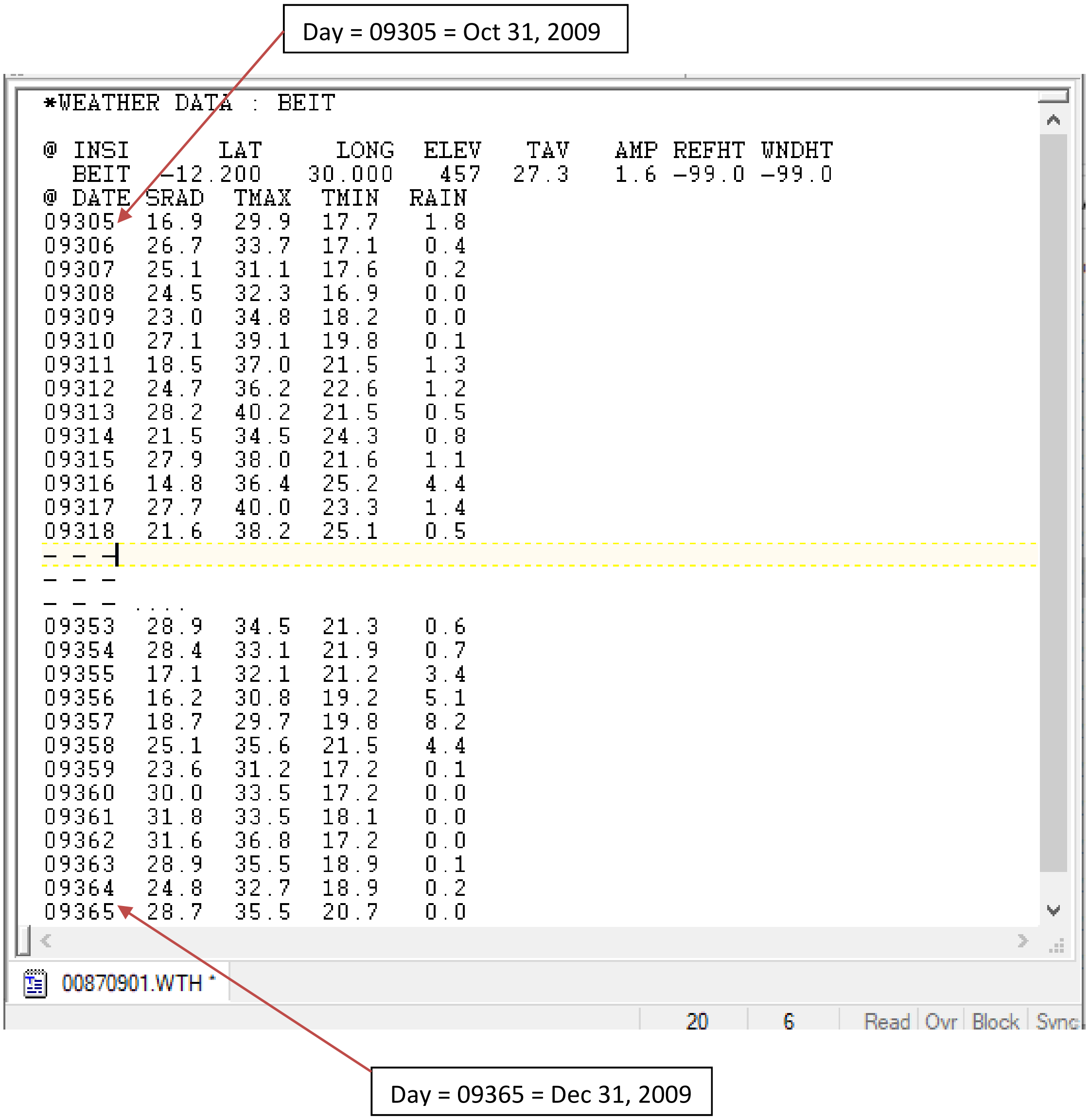
<Figure 1.> Sample Parametric or Stochastic Disag (predictWTD) setup when running CAMDT

In this User Guide, a sample of 37 years was downloaded from NASA (1984 to 2020) and used in the simulations. The four (4) tables below show examples of **Stochastic Disag** generated weather data for 37 years, downscaled to daily values for Nov 2009 to June 2010 being the simulation horizon.

iii. CAMDT Weather Tables ready for DSSAT ingestion



<Figure 2.> Flow of Weather Data from NASA or Weather Station Observation to DSSAT



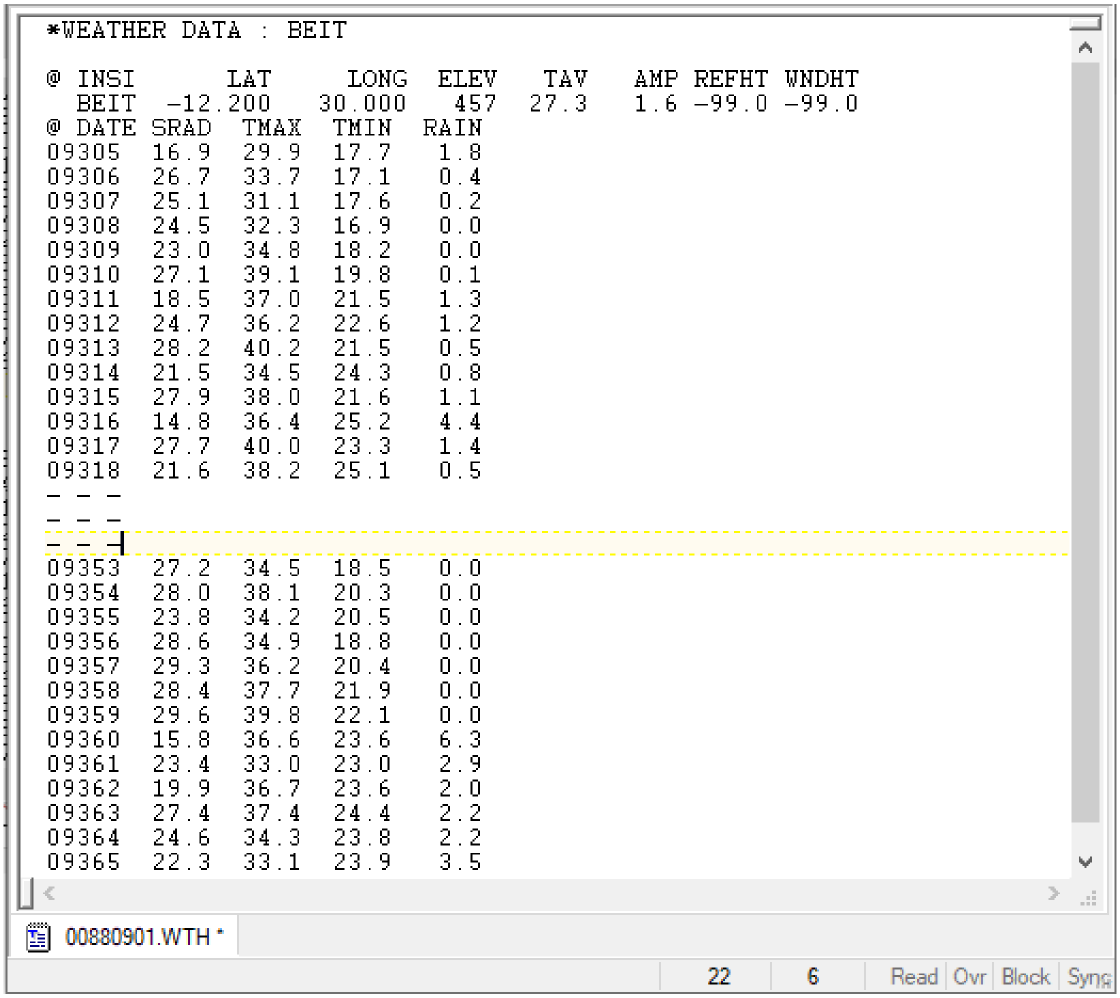
Day = 09305 = Oct 31, 2009

```
*WEATHER DATA : BEIT

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  BEIT  -12.200   30.000   457  27.3   1.6 -99.0 -99.0
@ DATE  SRAD  TMAX  TMIN  RAIN
09305  16.9  29.9  17.7   1.8
09306  26.7  33.7  17.1   0.4
09307  25.1  31.1  17.6   0.2
09308  24.5  32.3  16.9   0.0
09309  23.0  34.8  18.2   0.0
09310  27.1  39.1  19.8   0.1
09311  18.5  37.0  21.5   1.3
09312  24.7  36.2  22.6   1.2
09313  28.2  40.2  21.5   0.5
09314  21.5  34.5  24.3   0.8
09315  27.9  38.0  21.6   1.1
09316  14.8  36.4  25.2   4.4
09317  27.7  40.0  23.3   1.4
09318  21.6  38.2  25.1   0.5
- - -
- - -
- - -  ....
09353  28.9  34.5  21.3   0.6
09354  28.4  33.1  21.9   0.7
09355  17.1  32.1  21.2   3.4
09356  16.2  30.8  19.2   5.1
09357  18.7  29.7  19.8   8.2
09358  25.1  35.6  21.5   4.4
09359  23.6  31.2  17.2   0.1
09360  30.0  33.5  17.2   0.0
09361  31.8  33.5  18.1   0.0
09362  31.6  36.8  17.2   0.0
09363  28.9  35.5  18.9   0.1
09364  24.8  32.7  18.9   0.2
09365  28.7  35.5  20.7   0.0
```

Day = 09365 = Dec 31, 2009

*<Table 1.a> **CAMDT** generated daily Weather pattern for November and December (planting season is Nov 2009 to January 2010) – Freesampler Iteration # 0087*

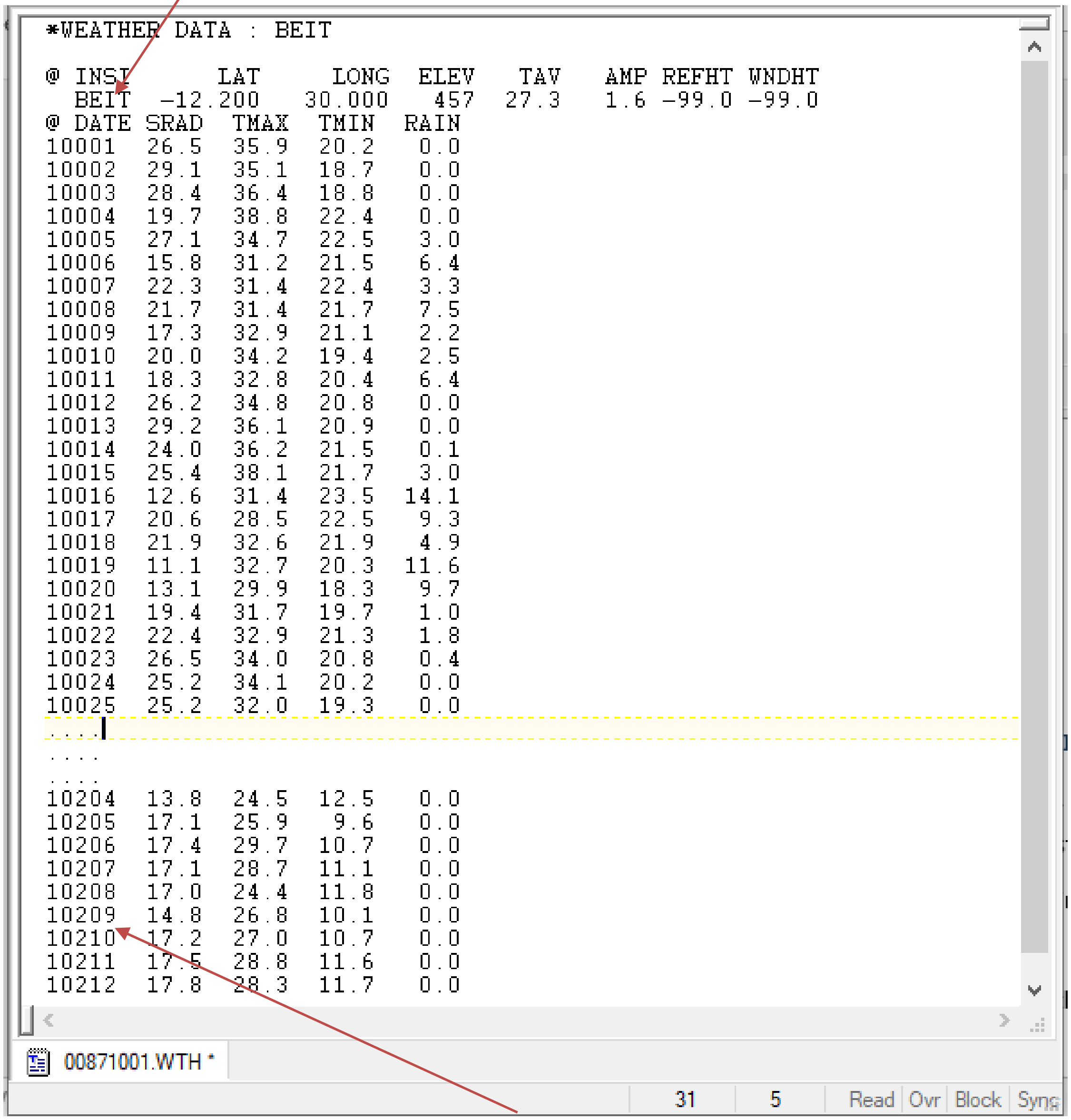


```
*WEATHER DATA : BEIT

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  BEIT  -12.200   30.000   457  27.3   1.6 -99.0 -99.0
@ DATE SRAD  TMAX  TMIN  RAIN
09305  16.9  29.9  17.7   1.8
09306  26.7  33.7  17.1   0.4
09307  25.1  31.1  17.6   0.2
09308  24.5  32.3  16.9   0.0
09309  23.0  34.8  18.2   0.0
09310  27.1  39.1  19.8   0.1
09311  18.5  37.0  21.5   1.3
09312  24.7  36.2  22.6   1.2
09313  28.2  40.2  21.5   0.5
09314  21.5  34.5  24.3   0.8
09315  27.9  38.0  21.6   1.1
09316  14.8  36.4  25.2   4.4
09317  27.7  40.0  23.3   1.4
09318  21.6  38.2  25.1   0.5
- - -
- - -
- - -
09353  27.2  34.5  18.5   0.0
09354  28.0  38.1  20.3   0.0
09355  23.8  34.2  20.5   0.0
09356  28.6  34.9  18.8   0.0
09357  29.3  36.2  20.4   0.0
09358  28.4  37.7  21.9   0.0
09359  29.6  39.8  22.1   0.0
09360  15.8  36.6  23.6   6.3
09361  23.4  33.0  23.0   2.9
09362  19.9  36.7  23.6   2.0
09363  27.4  37.4  24.4   2.2
09364  24.6  34.3  23.8   2.2
09365  22.3  33.1  23.9   3.5
```

<Table 1.b> ***CAMDT*** *generated daily Weather pattern for November and December (planting season is Nov 2009 to January 2010) – Freesampler Iteration # 0088*

Day = 10001 = Jan 1, 2010

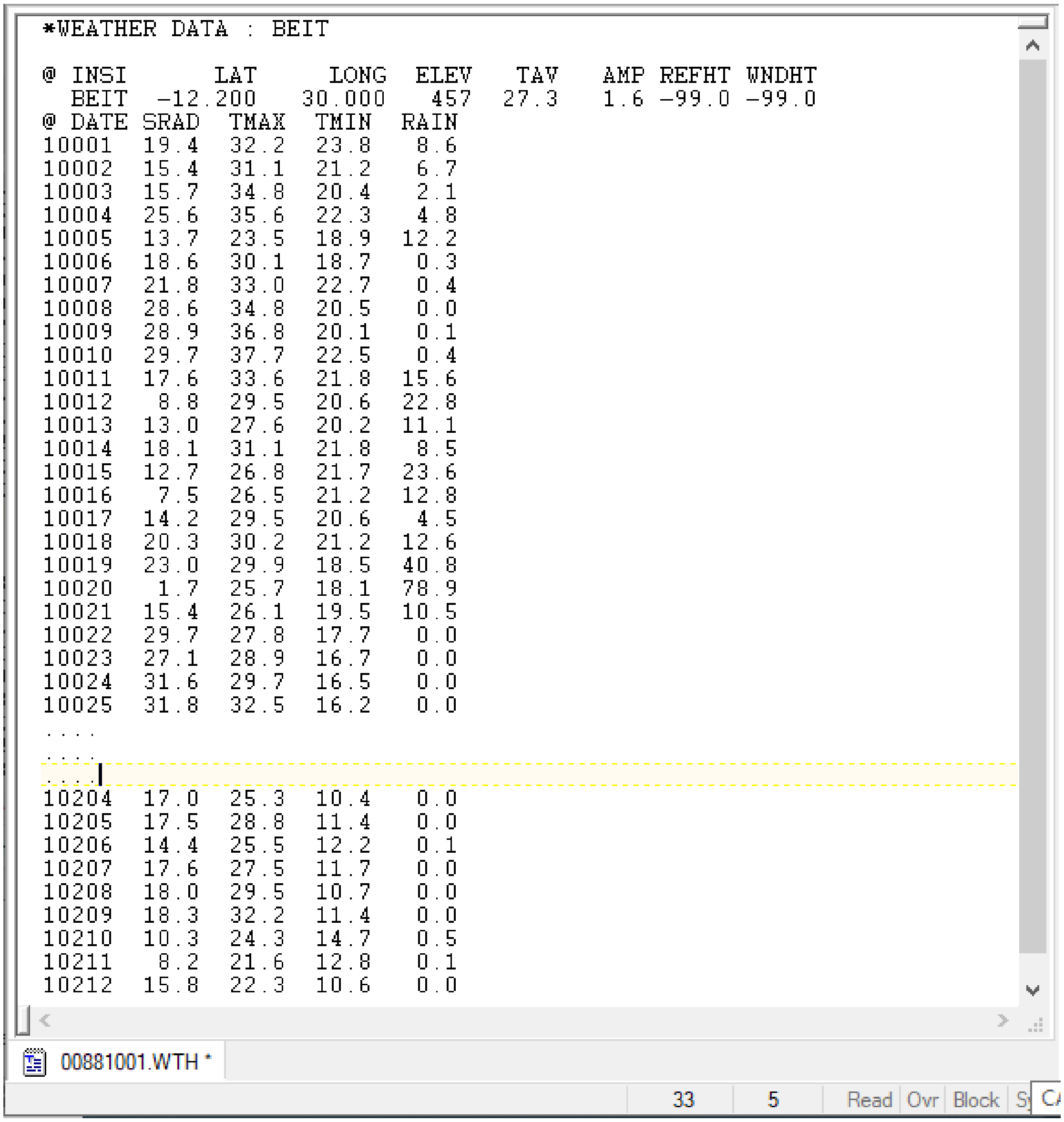


```
*WEATHER DATA : BEIT

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  BEIT  -12.200   30.000   457  27.3   1.6 -99.0 -99.0
@ DATE SRAD  TMAX  TMIN  RAIN
10001  26.5  35.9  20.2   0.0
10002  29.1  35.1  18.7   0.0
10003  28.4  36.4  18.8   0.0
10004  19.7  38.8  22.4   0.0
10005  27.1  34.7  22.5   3.0
10006  15.8  31.2  21.5   6.4
10007  22.3  31.4  22.4   3.3
10008  21.7  31.4  21.7   7.5
10009  17.3  32.9  21.1   2.2
10010  20.0  34.2  19.4   2.5
10011  18.3  32.8  20.4   6.4
10012  26.2  34.8  20.8   0.0
10013  29.2  36.1  20.9   0.0
10014  24.0  36.2  21.5   0.1
10015  25.4  38.1  21.7   3.0
10016  12.6  31.4  23.5  14.1
10017  20.6  28.5  22.5   9.3
10018  21.9  32.6  21.9   4.9
10019  11.1  32.7  20.3  11.6
10020  13.1  29.9  18.3   9.7
10021  19.4  31.7  19.7   1.0
10022  22.4  32.9  21.3   1.8
10023  26.5  34.0  20.8   0.4
10024  25.2  34.1  20.2   0.0
10025  25.2  32.0  19.3   0.0
....
....
....
10204  13.8  24.5  12.5   0.0
10205  17.1  25.9   9.6   0.0
10206  17.4  29.7  10.7   0.0
10207  17.1  28.7  11.1   0.0
10208  17.0  24.4  11.8   0.0
10209  14.8  26.8  10.1   0.0
10210  17.2  27.0  10.7   0.0
10211  17.5  28.8  11.6   0.0
10212  17.8  28.3  11.7   0.0
```

Day = 10212 = July 31, 2010

*<Table 2.a> **CAMDT** generated daily Weather pattern for January to June (planting to harvesting: Nov 2009 to July 2010) – Freesampler Iteration # 0087*



```
*WEATHER DATA : BEIT

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  BEIT  -12.200   30.000   457  27.3   1.6 -99.0 -99.0
@ DATE SRAD  TMAX  TMIN  RAIN
10001  19.4  32.2  23.8   8.6
10002  15.4  31.1  21.2   6.7
10003  15.7  34.8  20.4   2.1
10004  25.6  35.6  22.3   4.8
10005  13.7  23.5  18.9  12.2
10006  18.6  30.1  18.7   0.3
10007  21.8  33.0  22.7   0.4
10008  28.6  34.8  20.5   0.0
10009  28.9  36.8  20.1   0.1
10010  29.7  37.7  22.5   0.4
10011  17.6  33.6  21.8  15.6
10012   8.8  29.5  20.6  22.8
10013  13.0  27.6  20.2  11.1
10014  18.1  31.1  21.8   8.5
10015  12.7  26.8  21.7  23.6
10016   7.5  26.5  21.2  12.8
10017  14.2  29.5  20.6   4.5
10018  20.3  30.2  21.2  12.6
10019  23.0  29.9  18.5  40.8
10020   1.7  25.7  18.1  78.9
10021  15.4  26.1  19.5  10.5
10022  29.7  27.8  17.7   0.0
10023  27.1  28.9  16.7   0.0
10024  31.6  29.7  16.5   0.0
10025  31.8  32.5  16.2   0.0
....
....
....
10204  17.0  25.3  10.4   0.0
10205  17.5  28.8  11.4   0.0
10206  14.4  25.5  12.2   0.1
10207  17.6  27.5  11.7   0.0
10208  18.0  29.5  10.7   0.0
10209  18.3  32.2  11.4   0.0
10210  10.3  24.3  14.7   0.5
10211   8.2  21.6  12.8   0.1
10212  15.8  22.3  10.6   0.0
```

<Table 2.b> ***CAMDT** generated daily Weather pattern for January to June (planting to harvesting: Nov 2009 to July 2010) – Freesampler Iteration # 0088*

iv. Introduction to DSSAT crop Modelling

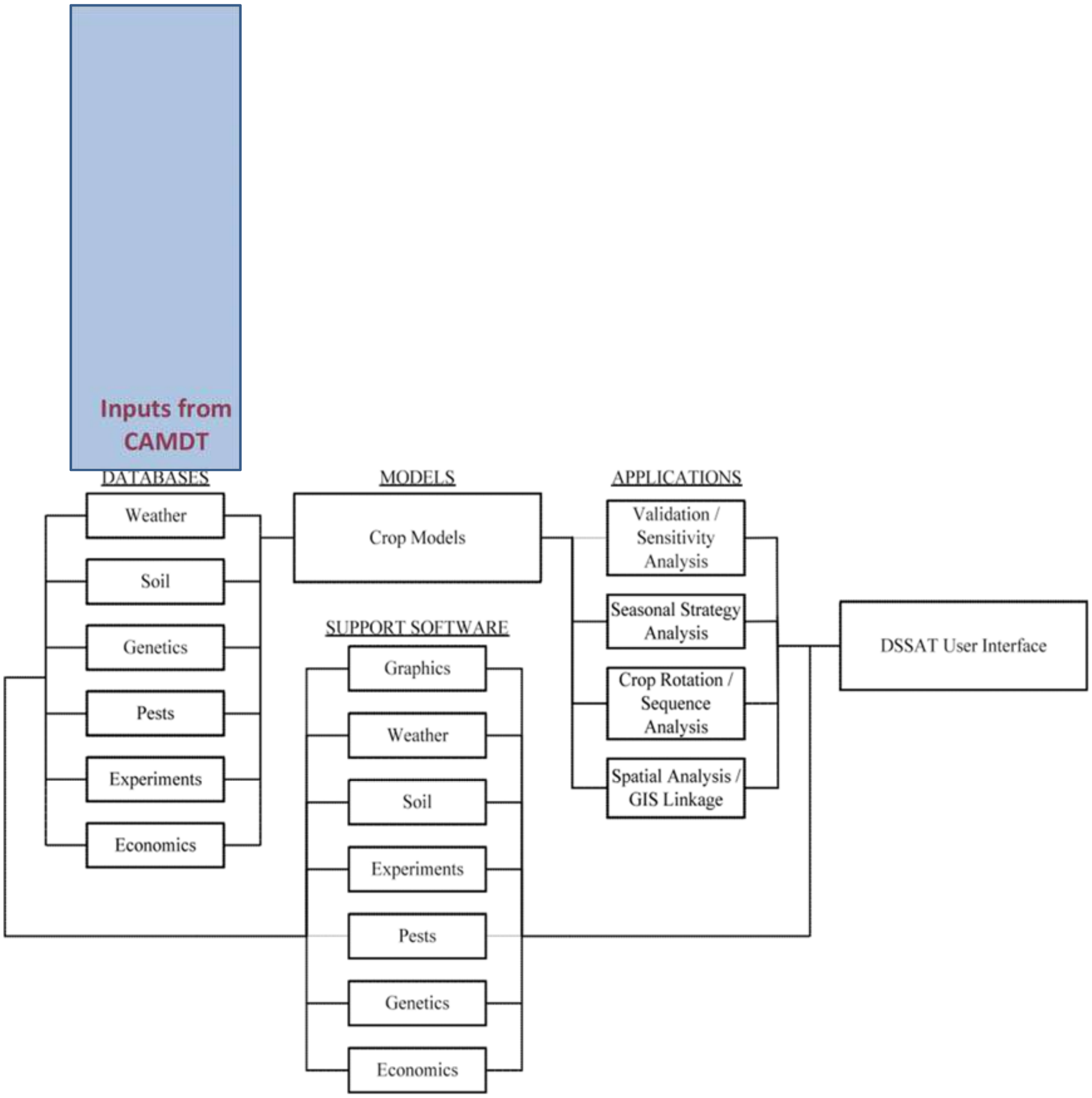
Information needs for agricultural decision making at all levels are increasing rapidly due to increased demands for agricultural products and increased pressures on land, water, and other natural resources. The generation of new data through traditional agronomic research methods and its publication are not sufficient to meet these increasing needs. Traditional agronomic experiments are conducted at particular points in time and space, making results site- and season-specific, time consuming and expensive. Unless new data and research findings are put into formats that are relevant and easily accessible, they may not be used effectively. The Decision Support System for Agro-Technology transfer (**DSSAT**) was originally developed by an international network of scientists, cooperating in the International Benchmark Sites Network for Agrotechnology Transfer project (IBSNAT, 1993; Tsuji, 1998; Uehara, 1998; Jones et al., 1998), to facilitate the application of crop models in a systems approach to agronomic research.

The aims of the **DSSAT** - **CSM** are:

1. to simulate monocrop production systems considering **weather, genetics, soil water, soil carbon and nitrogen, and management** in single or multiple seasons and in crop rotations at any location where minimum inputs are provided,
2. to provide a platform for easily incorporating modules for other abiotic and biotic factors, such as soil phosphorus and plant diseases,
3. to provide a platform that allows one to easily compare alternative modules for specific components to facilitate model improvement, evolution, and documentation, and
4. to provide a capability for easily introducing the **CSM** into additional application programs in a modular, well documented way.

v. Overall description of the DSSAT cropping system model

The **DSSAT-CSM** simulates growth, development and yield of a crop growing on a uniform area of land under prescribed or simulated management as well as the changes in soil water, carbon, and nitrogen that take place under the cropping system over time. The **DSSAT-CSM** is structured using the modular approach described by (Jones et al. (2001) and Porter et al. (2000)).


Inputs from CAMDT
DATABASES
Weather
Soil
Genetics
Pests
Experiments
Economics
MODELS
Crop Models
SUPPORT SOFTWARE
Graphics
Weather
Soil
Experiments
Pests
Genetics
Economics
APPLICATIONS
Validation / Sensitivity Analysis
Seasonal Strategy Analysis
Crop Rotation / Sequence Analysis
Spatial Analysis / GIS Linkage
DSSAT User Interface

<Figure 3.> Overview of DSSAT Inputs and Modules

SECTION A. REQUIRED SOFTWARE TOOLS

1. *MS Excel*
2. *digiSoft Excel Sheet_Splitting_Template.xlsm*
3. *Visual Studio Code Editor*
4. *Python v3.8.x*
5. *Bulk Rename Utility*

SECTION B. FORMATTING NASA WEATHER DATA FOR CAMDT WTD FILE

1. *Start* ***with downloading a country's NASA daily climatological data (CSV or Excel format),***

a. ACCESS TO NASA CLIMATOLOGICAL DATA, STREAMLINING AND REFORMATTING FOR INGESTING INTO CAMDT MODEL

In order to access NASA data, one needs to visit:

https://power.larc.nasa.gov/data-access-viewer/

Note that NASA climatological data has twelve parameters.

NASA/POWER SRB/FLASHFlux/MERRA2/GEOS 5.12.4 (FP-IT) 0.5 x 0.5 Degree Daily Averaged Data

Dates (month/day/year): 01/01/1985 through 03/05/2015

Location: Latitude -17.7982 Longitude 31.0774

Elevation from MERRA-2: Average for 1/2x1/2 degree lat/lon region = 1351.06 meters Site = na

Climate zone: na (reference Briggs et al: http://www.energycodes.gov)

Value for missing model data cannot be computed or out of model availability range: -999

b. PARAMETER(S):

T2MDEW	MERRA2 1/2x1/2 Dew/Frost Point at 2 Meters (C)
T2M_MAX	MERRA2 1/2x1/2 Maximum Temperature at 2 Meters (C)
T2M_MIN	MERRA2 1/2x1/2 Minimum Temperature at 2 Meters (C)
T2M_RANGE	MERRA2 1/2x1/2 Temperature Range at 2 Meters (C)
QV2M	MERRA2 1/2x1/2 Specific Humidity at 2 Meters (g/kg)
T2MWET	MERRA2 1/2x1/2 Wet Bulb Temperature at 2 Meters (C)
TS	MERRA2 1/2x1/2 Earth Skin Temperature (C)
ALLSKY_SFC_LW_DWN	MERRA2 1/2x1/2 All Sky Surface Longwave Downward Irradiance (W/m^2)

YEAR MO DY T2M_RANGE TS T2MDEW T2MWET T2M_MAX T2M_MIN T2M PRECTOT QV2M RH2M PS ALLSKY_SFC_LW_DWN

-END HEADER-

1985 01 01   15.93   21.92   11.90   11.91   29.00   13.08   20.60   0.17   10.15   57.92   86.70   8.03

1985 01 02   16.11   21.87   10.91   10.91   28.62   12.50   20.34   0.15   9.49   55.11   86.76   8.51

1985 01 03   12.15   22.15   14.57   14.57   27.49   15.33   20.74   1.37   12.05   68.14   86.75   9.37

1985 01 04   9.63   22.28   16.35   16.35   27.08   17.45   21.16   1.70   13.46   74.04   86.70   9.24

c.   STEPS TO STREAMLINE AND REFORMAT DATA

CAMDT has a very easy format for data ingestion: first row is just geography i.e. latitude, longitude, elevation. @ INSI   LAT   LONG   ELEV   TAV   AMP   REFHT   WNDHT

PILI   13.567   126.250   89   27.3   1.6   -99.0   -99.0

Actual data format for ingesting into CAMDT is:

@ DATE   SRAD   TMAX   TMIN   RAIN

Columns are read for Date, Radiation, Temperature Max, Temperature Min and Rainfall. Whereas, NASA data has many different parameters. In this case, NASA data includes: Year, Month, Day Tdew (we delete) temp max, temp min, etc i.e. :

1985 01 01   15.93   21.92   11.90   11.91   29.00   13.08   20.60   0.17   10.15   57.92   86.70   8.03

1985 01 02   16.11   21.87   10.91   10.91   28.62   12.50   20.34   0.15   9.49

But we only want to extract data points in the following columns: Year, Month, Day, --,Tmax, Tmin, --, --, --, --,radiation,--, --, --, rainfall.   Two dashes separated by comma represent column.   Once this is done the reformatted NASA data should read seamlessly into CAMDT, so the errors will disappear.

We need, therefore, to select SRad (radiation), Tmax, Tmin, Prec (Rainfall) and reformat NASA data into the generic CAMDT data format. This requires that we trim off (or delete) the columns with the unnecessary variables. This we can do in three steps.

STEP 1

From NASA data sets, we only want to extract data points in the following columns: --,--, day, --,Tmax, Tmin, --, --, --, --,radiation,--, --, --, rainfall.   Remember to log in the year and month in some convenient row which will not be read by CAMDT.

--,--, day 1, --Tmax, Tmin, --, --, --, --, radiation,--, --, --, rainfall.
--,--,day 2, --Tmax, Tmin, --, --, --, --,radiation,--, --, --, rainfall.
--,--,day 3, --Tmax, Tmin, --, --, --, --,radiation,--, --, --, rainfall.

Take NOTE that dashes (--) and commas (,) have been used above only in order to illustrate better the issues we are trying to resolve. The data columns will NOT have these dashes or commas.

STEP 2

Data should read:

DATE, TMAX, TMIN, SRAD, PRECIP (I.E. RANFALL)
DAY 1, TMAX, TMIN, SRAD, PRECIP.

STEP 3

Move column 4 (Radiation) to column 2.

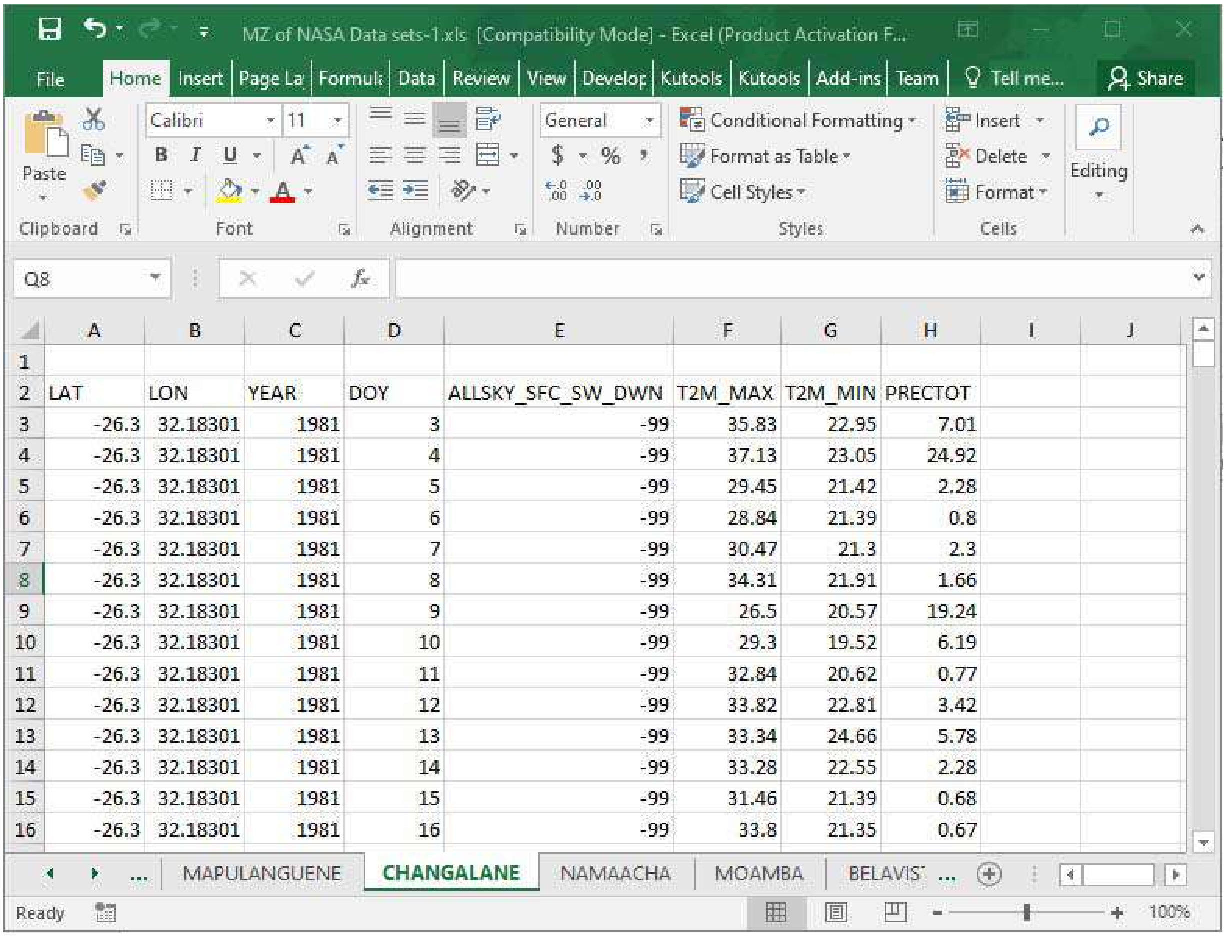
Once completing the Third Step NASA dataset is now in the same format as CAMDT as per following sample:

DATE, SRAD, TMAX, TMIN, RAIN

```
00001  16.4  28.6  19.7   0.0
00002  12.5  27.0  18.4   0.0
00003   7.5  24.0  19.7   2.2
```

2. *Each Meteorological Station will have its own individual Excel worksheet,*
3. *Open the NASA Workbook and go the Worksheet for the desired Meteorological Station*
4. *The data format in Excel should look like below, Fig. A.1:*
5. *Select the desired Weather Station's Worksheet, e.g. CHANGALANE*
6. *Press Ctrl + A to select all data columns and rows in that Worksheet*
7. *Press Ctrl + C to copy all the selected data on the Worksheet*
8. *Open a New Excel Workbook and Paste the data copied from CHAGALANE Worksheet*
9. *Save that Workbook as CHANGALANE.xlsx*

dAMS
digiSoft AgroMeteorology
Science


MZ of NASA Data sets-1.xls [Compatibility Mode] - Excel (Product Activation F...
File
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Page La
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Data
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Develop
Kutools
Kutools
Add-ins
Team
Tell me...
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Calibri
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General
Conditional Formatting
Format as Table
Cell Styles
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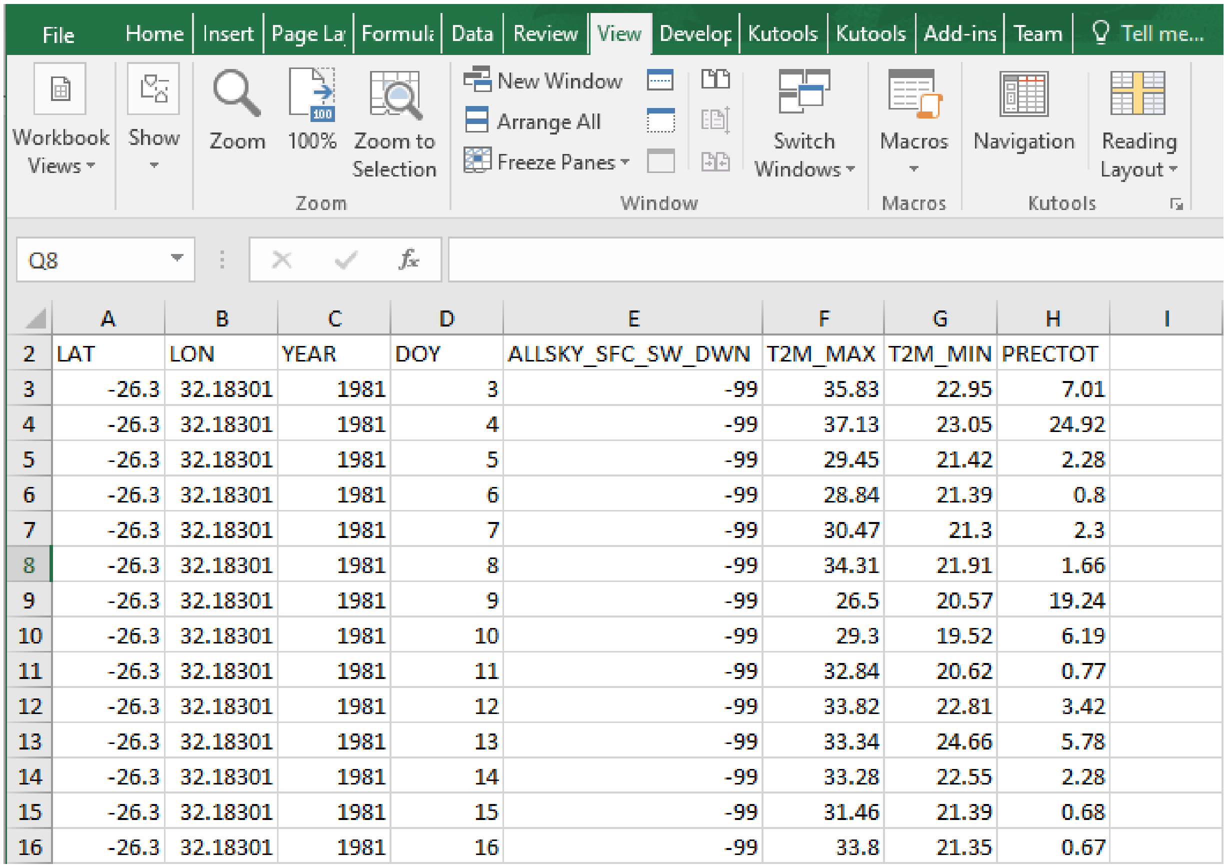
Delete
Format
Editing
Clipboard
Font
Alignment
Number
Styles
Cells
Q8
MAPULANGUENE
CHANGALANE
NAMAACHA
MOAMBA
BELAVIS
Ready
100%

LAT	LON	YEAR	DOY	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
-26.3	32.18301	1981	3	-99	35.83	22.95	7.01
-26.3	32.18301	1981	4	-99	37.13	23.05	24.92
-26.3	32.18301	1981	5	-99	29.45	21.42	2.28
-26.3	32.18301	1981	6	-99	28.84	21.39	0.8
-26.3	32.18301	1981	7	-99	30.47	21.3	2.3
-26.3	32.18301	1981	8	-99	34.31	21.91	1.66
-26.3	32.18301	1981	9	-99	26.5	20.57	19.24
-26.3	32.18301	1981	10	-99	29.3	19.52	6.19
-26.3	32.18301	1981	11	-99	32.84	20.62	0.77
-26.3	32.18301	1981	12	-99	33.82	22.81	3.42
-26.3	32.18301	1981	13	-99	33.34	24.66	5.78
-26.3	32.18301	1981	14	-99	33.28	22.55	2.28
-26.3	32.18301	1981	15	-99	31.46	21.39	0.68
-26.3	32.18301	1981	16	-99	33.8	21.35	0.67

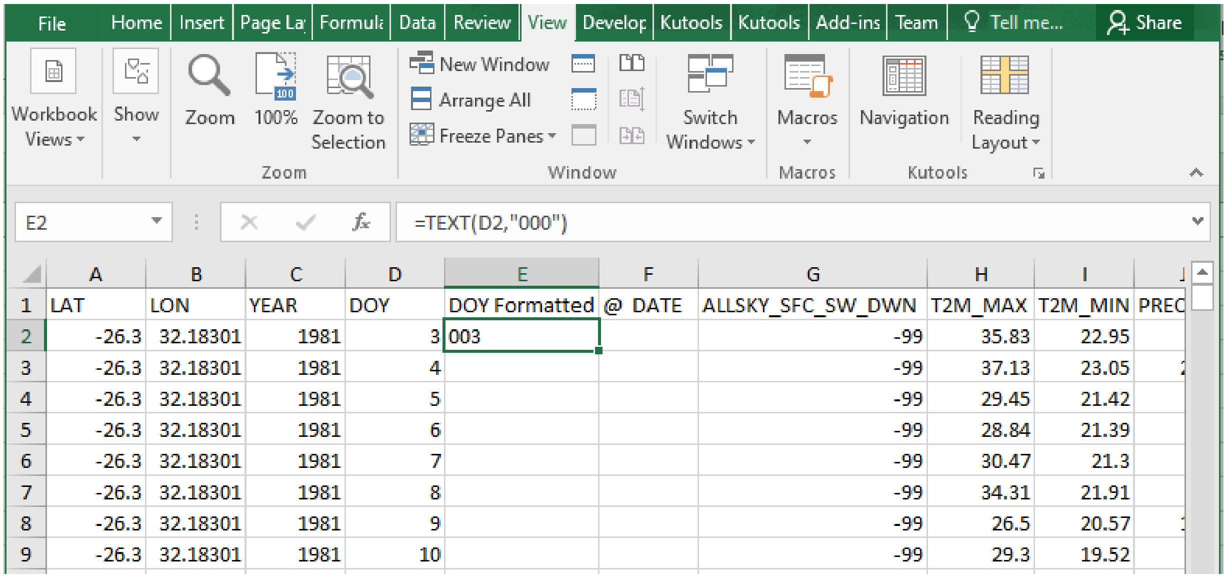
Fig. A.1 Sample of daily climatological data from NASA website


File
Home
Insert
Page La
Formula
Data
Review
View
Develop
Kutools
Kutools
Add-ins
Team
Tell me...
Workbook Views
Show
Zoom
100%
Zoom to Selection
Zoom
New Window
Arrange All
Freeze Panes
Switch Windows
Window
Macros
Macros
Navigation
Reading Layout
Kutools
Q8

	A	B	C	D	E	F	G	H	I
2	LAT	LON	YEAR	DOY	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT	
3	-26.3	32.18301	1981	3	-99	35.83	22.95	7.01	
4	-26.3	32.18301	1981	4	-99	37.13	23.05	24.92	
5	-26.3	32.18301	1981	5	-99	29.45	21.42	2.28	
6	-26.3	32.18301	1981	6	-99	28.84	21.39	0.8	
7	-26.3	32.18301	1981	7	-99	30.47	21.3	2.3	
8	-26.3	32.18301	1981	8	-99	34.31	21.91	1.66	
9	-26.3	32.18301	1981	9	-99	26.5	20.57	19.24	
10	-26.3	32.18301	1981	10	-99	29.3	19.52	6.19	
11	-26.3	32.18301	1981	11	-99	32.84	20.62	0.77	
12	-26.3	32.18301	1981	12	-99	33.82	22.81	3.42	
13	-26.3	32.18301	1981	13	-99	33.34	24.66	5.78	
14	-26.3	32.18301	1981	14	-99	33.28	22.55	2.28	
15	-26.3	32.18301	1981	15	-99	31.46	21.39	0.68	
16	-26.3	32.18301	1981	16	-99	33.8	21.35	0.67	

Fig. A.2 Sample of Mozambique's CHANGALANE daily climatological data from NASA website

10. Insert 2 columns between Column **D** and Column **E** as below, Fig. A.3:

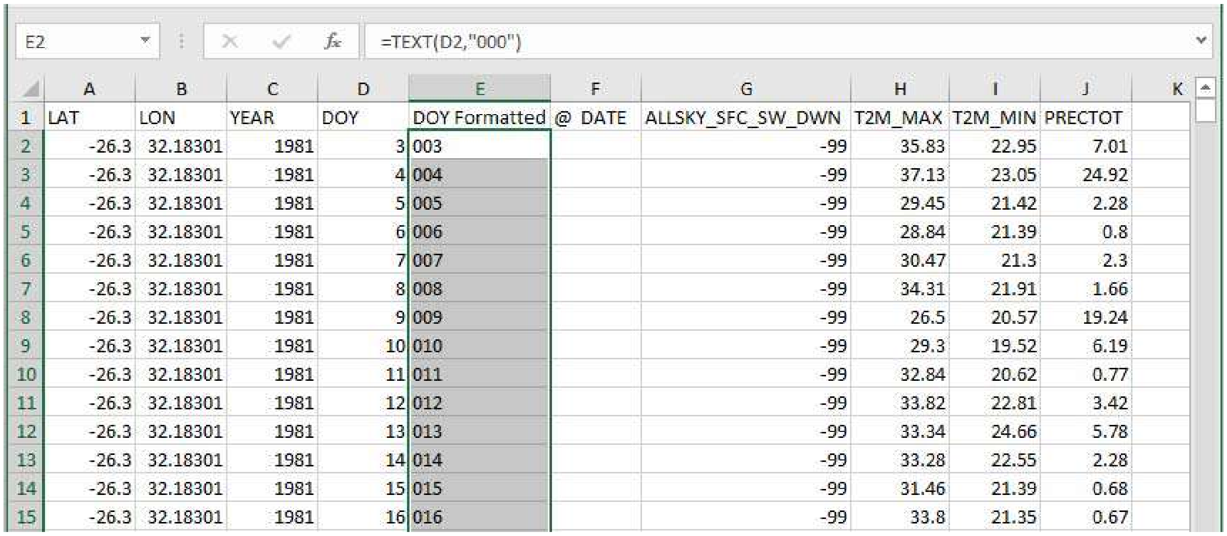

File
Home
Insert
Page La
Formula
Data
Review
View
Develop
Kutools
Kutools
Add-ins
Team
Tell me...
Share
Workbook Views
Show
Zoom
100%
Zoom to Selection
Zoom
New Window
Arrange All
Freeze Panes
Switch Windows
Window
Macros
Macros
Navigation
Reading Layout
Kutools
E2

=TEXT(D2,"000")

	A	B	C	D	E	F	G	H	I
1	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN
2	-26.3	32.18301	1981	3	003		-99	35.83	22.95
3	-26.3	32.18301	1981	4			-99	37.13	23.05
4	-26.3	32.18301	1981	5			-99	29.45	21.42
5	-26.3	32.18301	1981	6			-99	28.84	21.39
6	-26.3	32.18301	1981	7			-99	30.47	21.3
7	-26.3	32.18301	1981	8			-99	34.31	21.91
8	-26.3	32.18301	1981	9			-99	26.5	20.57
9	-26.3	32.18301	1981	10			-99	29.3	19.52

Fig. A.3 Sample of daily climatological data from NASA website with two additional columns (E & F)

11. Insert formula in **E3** as shown above (=TEXT(D3,"000"), drag or copy the formula in **E3** all the way down to the last row, as Fig. A.4:

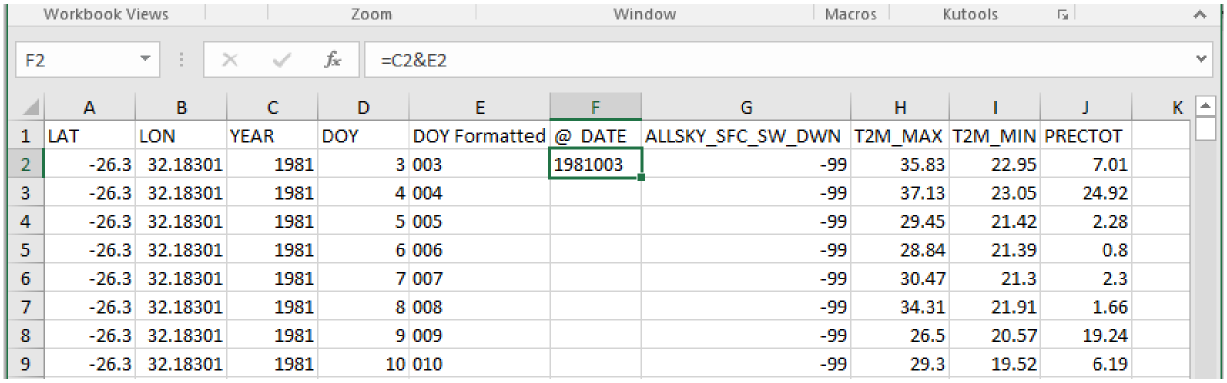


=TEXT(D2,"000")

	A	B	C	D	E	F	G	H	I	J	K
1	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT	
2	-26.3	32.18301	1981	3	003		-99	35.83	22.95	7.01	
3	-26.3	32.18301	1981	4	004		-99	37.13	23.05	24.92	
4	-26.3	32.18301	1981	5	005		-99	29.45	21.42	2.28	
5	-26.3	32.18301	1981	6	006		-99	28.84	21.39	0.8	
6	-26.3	32.18301	1981	7	007		-99	30.47	21.3	2.3	
7	-26.3	32.18301	1981	8	008		-99	34.31	21.91	1.66	
8	-26.3	32.18301	1981	9	009		-99	26.5	20.57	19.24	
9	-26.3	32.18301	1981	10	010		-99	29.3	19.52	6.19	
10	-26.3	32.18301	1981	11	011		-99	32.84	20.62	0.77	
11	-26.3	32.18301	1981	12	012		-99	33.82	22.81	3.42	
12	-26.3	32.18301	1981	13	013		-99	33.34	24.66	5.78	
13	-26.3	32.18301	1981	14	014		-99	33.28	22.55	2.28	
14	-26.3	32.18301	1981	15	015		-99	31.46	21.39	0.68	
15	-26.3	32.18301	1981	16	016		-99	33.8	21.35	0.67	

Fig. A.4 Sample of daily climatological data from NASA website showing DOY formatted column

12. Go to Cell **F3**, type the formula as shown below, drag or copy the formula in **F3** all the way down to the last row:

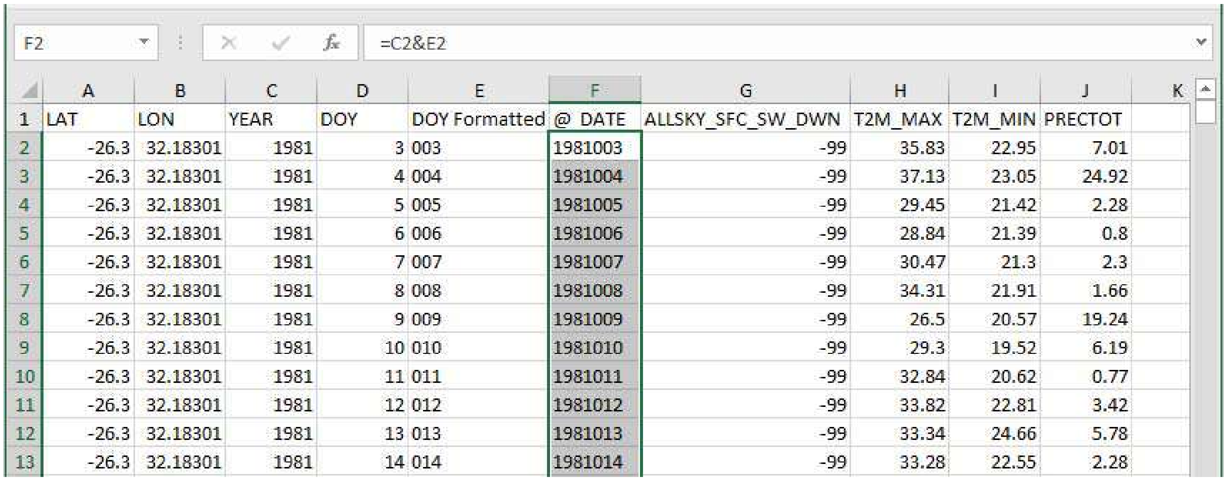


=C2&E2

	A	B	C	D	E	F	G	H	I	J	K
1	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT	
2	-26.3	32.18301	1981	3	003	1981003	-99	35.83	22.95	7.01	
3	-26.3	32.18301	1981	4	004		-99	37.13	23.05	24.92	
4	-26.3	32.18301	1981	5	005		-99	29.45	21.42	2.28	
5	-26.3	32.18301	1981	6	006		-99	28.84	21.39	0.8	
6	-26.3	32.18301	1981	7	007		-99	30.47	21.3	2.3	
7	-26.3	32.18301	1981	8	008		-99	34.31	21.91	1.66	
8	-26.3	32.18301	1981	9	009		-99	26.5	20.57	19.24	
9	-26.3	32.18301	1981	10	010		-99	29.3	19.52	6.19	

Fig. A.5 Sample of daily climatological data from NASA website with @ DATE formula, column F.

The Worksheet should look like below, Fig A.6:

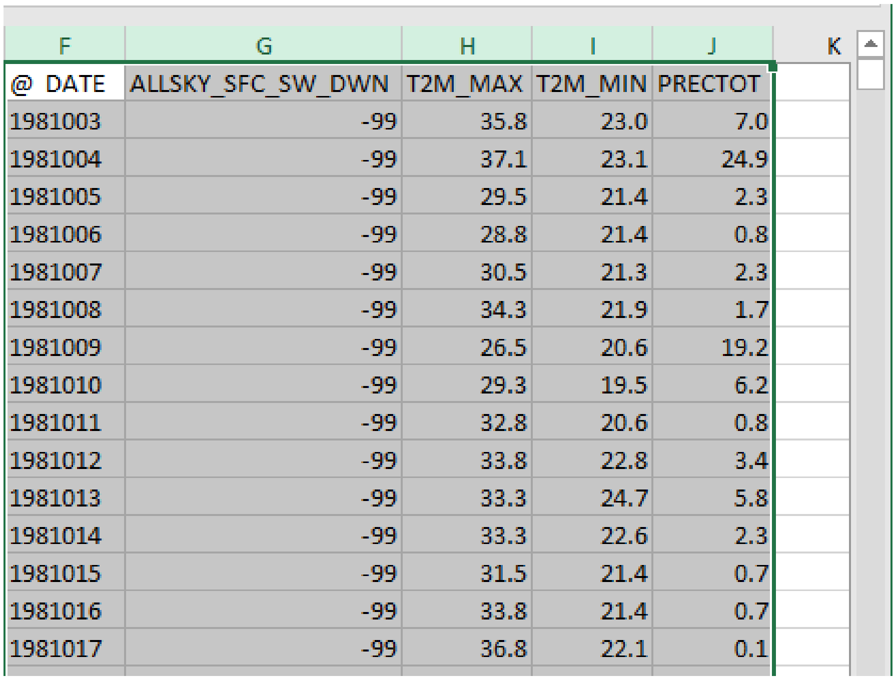


F2 =C2&E2

	A	B	C	D	E	F	G	H	I	J
1	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
2	-26.3	32.18301	1981	3	003	1981003	-99	35.83	22.95	7.01
3	-26.3	32.18301	1981	4	004	1981004	-99	37.13	23.05	24.92
4	-26.3	32.18301	1981	5	005	1981005	-99	29.45	21.42	2.28
5	-26.3	32.18301	1981	6	006	1981006	-99	28.84	21.39	0.8
6	-26.3	32.18301	1981	7	007	1981007	-99	30.47	21.3	2.3
7	-26.3	32.18301	1981	8	008	1981008	-99	34.31	21.91	1.66
8	-26.3	32.18301	1981	9	009	1981009	-99	26.5	20.57	19.24
9	-26.3	32.18301	1981	10	010	1981010	-99	29.3	19.52	6.19
10	-26.3	32.18301	1981	11	011	1981011	-99	32.84	20.62	0.77
11	-26.3	32.18301	1981	12	012	1981012	-99	33.82	22.81	3.42
12	-26.3	32.18301	1981	13	013	1981013	-99	33.34	24.66	5.78
13	-26.3	32.18301	1981	14	014	1981014	-99	33.28	22.55	2.28

Fig. A.6 Sample of daily climatological data from NASA website with @ DATE formula, column F up to last row.

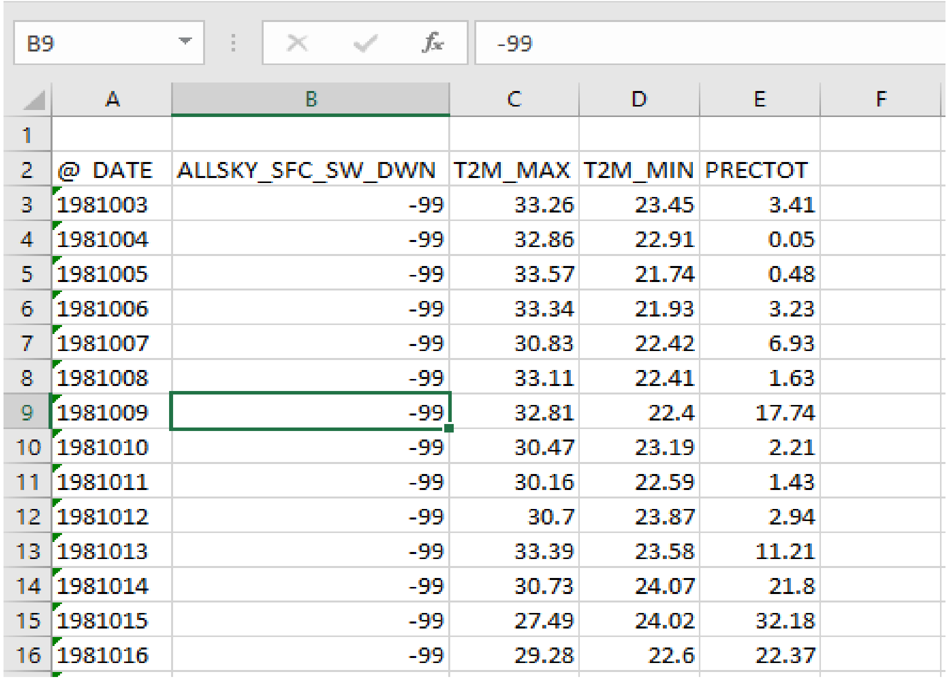
13. Highlight columns **G** to **J**, Click Right mouse button inside the selected range, choose Number then decrease Decimal Places: to 1. See Figure A.7 below:



F	G	H	I	J
@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
1981003	-99	35.8	23.0	7.0
1981004	-99	37.1	23.1	24.9
1981005	-99	29.5	21.4	2.3
1981006	-99	28.8	21.4	0.8
1981007	-99	30.5	21.3	2.3
1981008	-99	34.3	21.9	1.7
1981009	-99	26.5	20.6	19.2
1981010	-99	29.3	19.5	6.2
1981011	-99	32.8	20.6	0.8
1981012	-99	33.8	22.8	3.4
1981013	-99	33.3	24.7	5.8
1981014	-99	33.3	22.6	2.3
1981015	-99	31.5	21.4	0.7
1981016	-99	33.8	21.4	0.7
1981017	-99	36.8	22.1	0.1

Fig. A.7 Daily climatological data formatted to 1 decimal place.

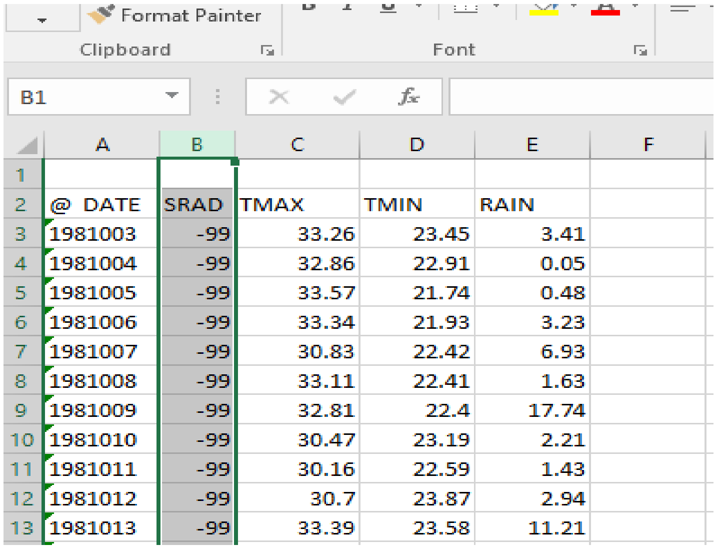
14. Now Copy Column **F** to Column **J** by highlighting on the Column names, copy the selected columns, Open a New Sheet in the same Excel Workbook, highlight column **A**, click on the little arrow below the <Paste Button> , Select <Paste Special> then choose <Values and Number Formatting>, Press <OK> to paste



	A	B	C	D	E	F
1						
2	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT	
3	1981003	-99	33.26	23.45	3.41	
4	1981004	-99	32.86	22.91	0.05	
5	1981005	-99	33.57	21.74	0.48	
6	1981006	-99	33.34	21.93	3.23	
7	1981007	-99	30.83	22.42	6.93	
8	1981008	-99	33.11	22.41	1.63	
9	1981009	-99	32.81	22.4	17.74	
10	1981010	-99	30.47	23.19	2.21	
11	1981011	-99	30.16	22.59	1.43	
12	1981012	-99	30.7	23.87	2.94	
13	1981013	-99	33.39	23.58	11.21	
14	1981014	-99	30.73	24.07	21.8	
15	1981015	-99	27.49	24.02	32.18	
16	1981016	-99	29.28	22.6	22.37	

Fig. A.7.1 Sample of daily climatological data from NASA website with column headers of parameters.

Rename the columns headers @ DATE, SRAD, TMAX, TMIN and RAIN as below and delete the blank row above the column headers (Excel sheet row 1), Fig. A.7.2:



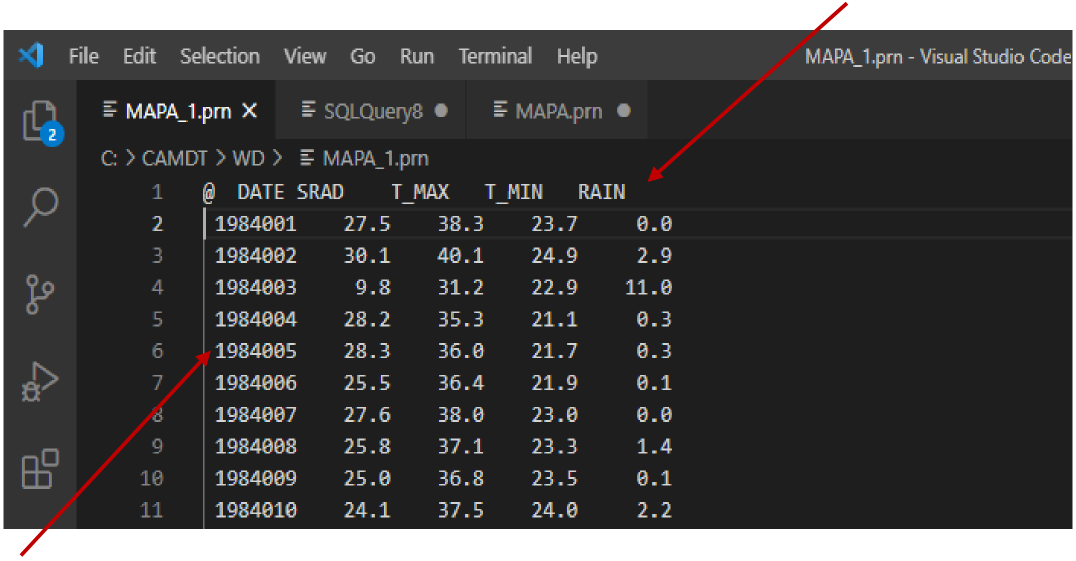
	A	B	C	D	E	F
1						
2	@ DATE	SRAD	TMAX	TMIN	RAIN	
3	1981003	-99	33.26	23.45	3.41	
4	1981004	-99	32.86	22.91	0.05	
5	1981005	-99	33.57	21.74	0.48	
6	1981006	-99	33.34	21.93	3.23	
7	1981007	-99	30.83	22.42	6.93	
8	1981008	-99	33.11	22.41	1.63	
9	1981009	-99	32.81	22.4	17.74	
10	1981010	-99	30.47	23.19	2.21	
11	1981011	-99	30.16	22.59	1.43	
12	1981012	-99	30.7	23.87	2.94	
13	1981013	-99	33.39	23.58	11.21	

Fig. A.7.2 Sample of daily climatological data from NASA website with new column headers of parameters.

** NOTE: Because DSSAT/CAMDT do not allow missing data (as usually represented by-99). From our inspection, SRAD is missing from 1981 to most of 1983 perhaps due to equipment failure. Therefore, it is more convenient to start Observation year with 1984. Carefully inspect the rest of the data entries for all Years (e.g. 1984 to 2019) for -99 values and change to extrapolated/interpolated values based on the values of nearest neighbours i.e. surrounding the -99. Ensure that your data set will not have -99; otherwise CAMDT will not run!

1. Export the desired Excel Sheet, e.g. MAPAI to COMMA SEPARATED CSV (MAPAI, a Meteorological Station in Mozambique which has been manipulated and formatted to be compatible with CAMDT/DSSAT)
2. Open CSV into Excel and format all 4 columns to number, to 1 decimal point
3. Export from Excel formatted to "Formatted (space delimited)" (*.prn) and choose "Yes" for "Maintaining format?", saving it as MAPA.PRN
4. **a.** Open MAPA.PRN using Microsoft VS Code Editor and Align all columns (download VS Code if not installed on your computer)

UnAligned column Headers

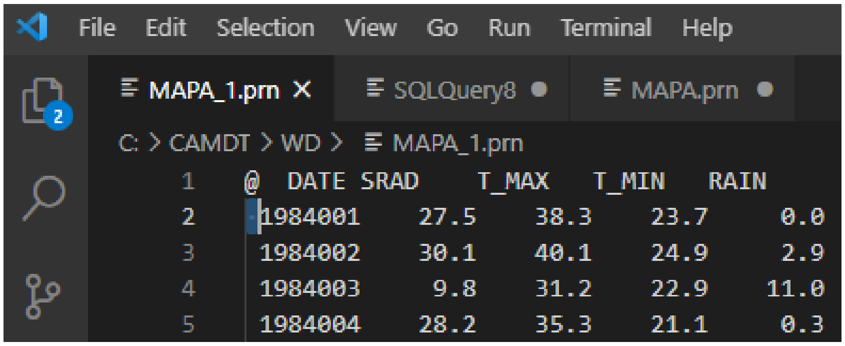

File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn - Visual Studio Code
MAPA_1.prn ×
SQLQuery8 ●
MAPA.prn ●
2
C: > CAMDT > WD > MAPA_1.prn

```
 1  @  DATE SRAD    T_MAX   T_MIN   RAIN
 2   1984001   27.5    38.3    23.7     0.0
 3   1984002   30.1    40.1    24.9     2.9
 4   1984003    9.8    31.2    22.9    11.0
 5   1984004   28.2    35.3    21.1     0.3
 6   1984005   28.3    36.0    21.7     0.3
 7   1984006   25.5    36.4    21.9     0.1
 8   1984007   27.6    38.0    23.0     0.0
 9   1984008   25.8    37.1    23.3     1.4
10   1984009   25.0    36.8    23.5     0.1
11   1984010   24.1    37.5    24.0     2.2
```

1 space before DATE column

Fig. A.11.1a Sample of daily climatological data Unaligned MAPA.PRN from Excel CSV

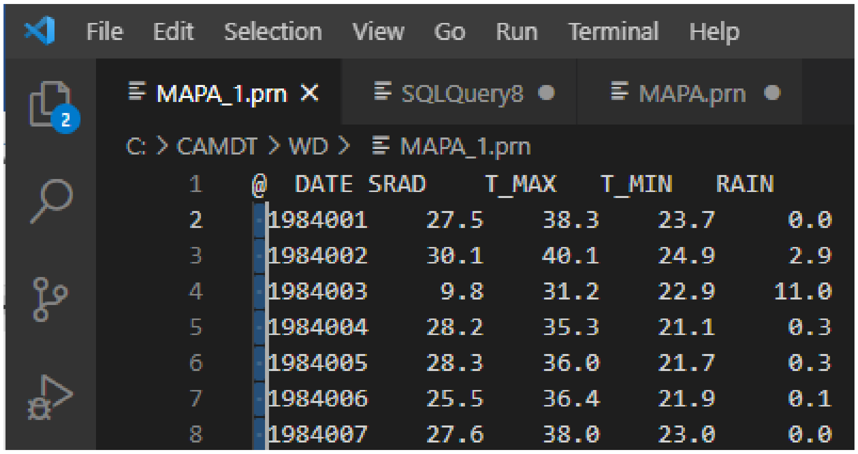
b. Place the cursor on row 2 to the left of the first date and select the space as shown below, Fig. A.11.1.b:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn ×
SQLQuery8 ●
MAPA.prn ●
2
C: > CAMDT > WD > MAPA_1.prn

```
 1  @  DATE SRAD    T_MAX   T_MIN   RAIN
 2   1984001   27.5    38.3    23.7     0.0
 3   1984002   30.1    40.1    24.9     2.9
 4   1984003    9.8    31.2    22.9    11.0
 5   1984004   28.2    35.3    21.1     0.3
```

Fig. A.11.1b Sample of part of process to Aligned MAPA.PRN from Excel CSV, selecting the space

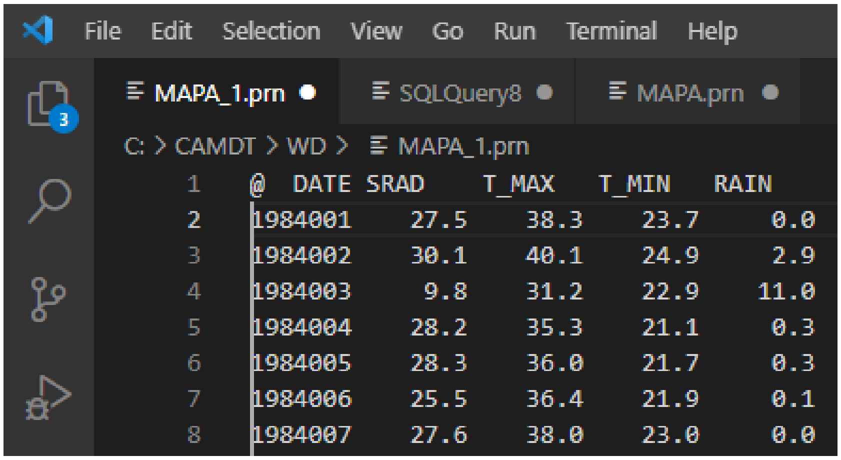
c. Press Ctrl + Shift + Alt, then PgDn/PgUp or Down/Up Arrows to select up to 5000 lines as below, Fig A.11.1.c:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn ×
SQLQuery8 ●
MAPA.prn ●
C: > CAMDT > WD > MAPA_1.prn
2

```
1   @  DATE SRAD    T_MAX   T_MIN   RAIN
2    1984001    27.5    38.3    23.7     0.0
3    1984002    30.1    40.1    24.9     2.9
4    1984003     9.8    31.2    22.9    11.0
5    1984004    28.2    35.3    21.1     0.3
6    1984005    28.3    36.0    21.7     0.3
7    1984006    25.5    36.4    21.9     0.1
8    1984007    27.6    38.0    23.0     0.0
```

Fig. A.11.1c Sample of part of process to Aligned MAPA.PRN from Excel CSV, with the selected blocks of rows

d. Press Backspace to delete the space to the left of the DATE column data as shown below:

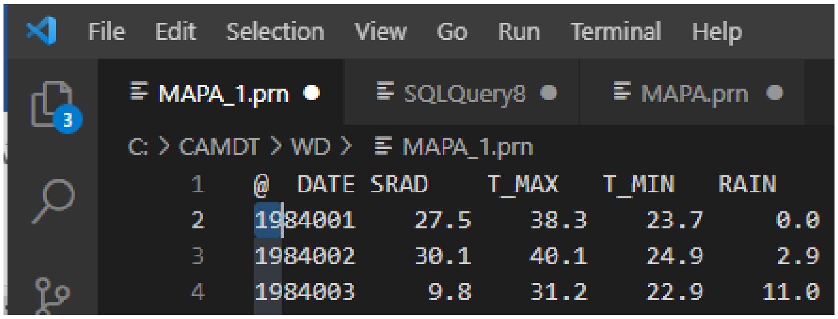

File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn ●
SQLQuery8 ●
MAPA.prn ●
C: > CAMDT > WD > MAPA_1.prn
3

```
1   @  DATE SRAD    T_MAX   T_MIN   RAIN
2   1984001    27.5    38.3    23.7     0.0
3   1984002    30.1    40.1    24.9     2.9
4   1984003     9.8    31.2    22.9    11.0
5   1984004    28.2    35.3    21.1     0.3
6   1984005    28.3    36.0    21.7     0.3
7   1984006    25.5    36.4    21.9     0.1
8   1984007    27.6    38.0    23.0     0.0
```

Fig. A.11.1d Sample of part of process to Aligned MAPA.PRN from Excel CSV, deleting the spaces left of DATE column for selected blocks of rows

e. Push SRAD Header to the right by 1 space (Not shown diagrammatically, i.e. no corresponding Fig A 11.1.e)

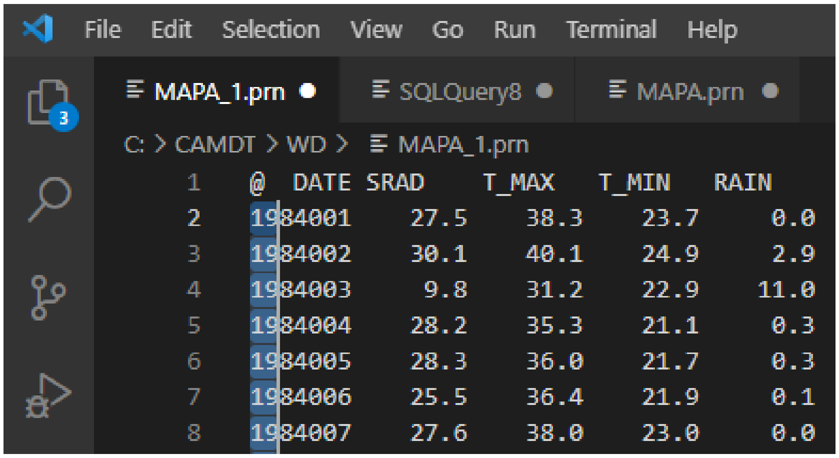
f. Place the cursor on row 2 below the @ character and mark 19 as shown below, Fig A.11.f:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn ●
SQLQuery8 ●
MAPA.prn ●
C: > CAMDT > WD > MAPA_1.prn
3

```
1   @  DATE SRAD    T_MAX   T_MIN   RAIN
2   1984001    27.5    38.3    23.7     0.0
3   1984002    30.1    40.1    24.9     2.9
4   1984003     9.8    31.2    22.9    11.0
```

Fig. A.11.1.f Sample of part of process to Aligned MAPA.PRN from Excel CSV, with blocked 19 i.e. from left of DATE column for selected blocks of rows

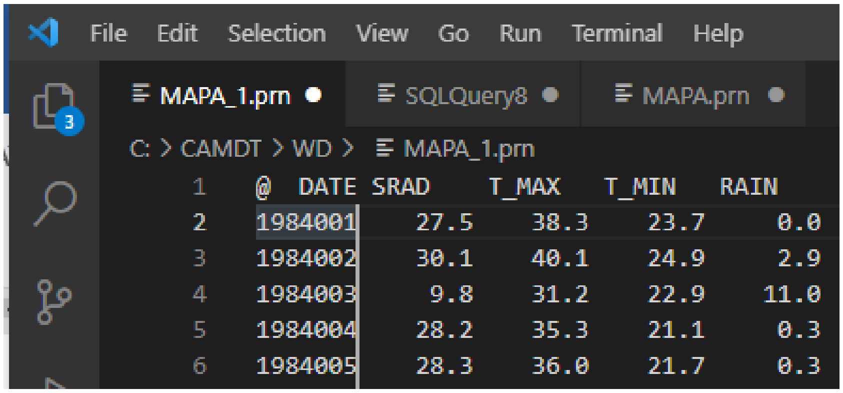
g. Press Ctrl + Shift + Alt, then PgDn/PgUp or Down/Up Arrows to select up to 5000 lines as below, Fig. A.11. g:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn
SQLQuery8
MAPA.prn
C: > CAMDT > WD > MAPA_1.prn
3

```
1  @  DATE  SRAD     T_MAX    T_MIN    RAIN
2  1984001     27.5     38.3     23.7      0.0
3  1984002     30.1     40.1     24.9      2.9
4  1984003      9.8     31.2     22.9     11.0
5  1984004     28.2     35.3     21.1      0.3
6  1984005     28.3     36.0     21.7      0.3
7  1984006     25.5     36.4     21.9      0.1
8  1984007     27.6     38.0     23.0      0.0
```

Fig. A.11.1.g.1 Sample of part of process to Aligned MAPA.PRN from Excel CSV, with blocked 19 i.e. from left of DATE column for blocks of rows

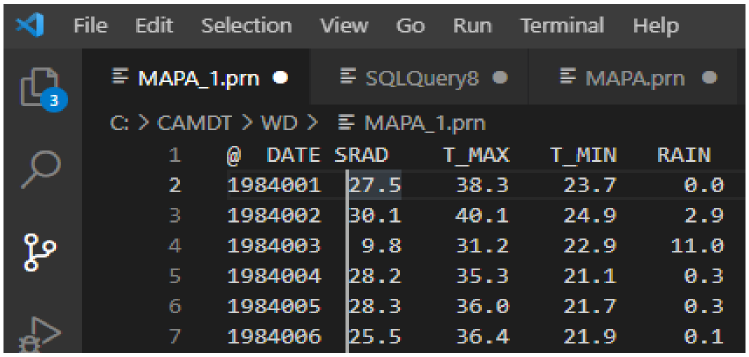
Let go of the keys, move the cursor to the space below the DATE data or row 2 as below, Fig. A.11.1.g.2:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn
SQLQuery8
MAPA.prn
C: > CAMDT > WD > MAPA_1.prn
3

```
1  @  DATE  SRAD     T_MAX    T_MIN    RAIN
2  1984001     27.5     38.3     23.7      0.0
3  1984002     30.1     40.1     24.9      2.9
4  1984003      9.8     31.2     22.9     11.0
5  1984004     28.2     35.3     21.1      0.3
6  1984005     28.3     36.0     21.7      0.3
```

Fig. A.11.1.g.2 Sample of part of process to Aligned MAPA.PRN from Excel CSV, with cursor on date data, row 2

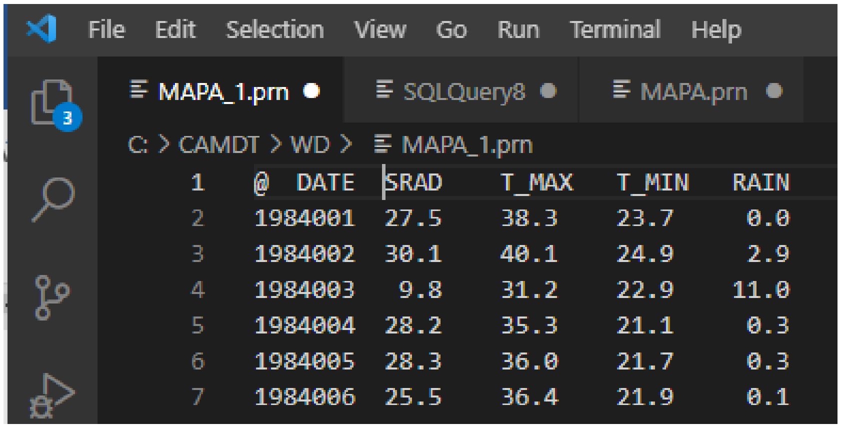
Press Delete until there are 2 spaces left between the DATE data and the left-most of the SRAD data as below, Fig. A.11.1.g.3:


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn
SQLQuery8
MAPA.prn
C: > CAMDT > WD > MAPA_1.prn
3

```
1  @  DATE  SRAD     T_MAX    T_MIN    RAIN
2  1984001  27.5     38.3     23.7      0.0
3  1984002  30.1     40.1     24.9      2.9
4  1984003   9.8     31.2     22.9     11.0
5  1984004  28.2     35.3     21.1      0.3
6  1984005  28.3     36.0     21.7      0.3
7  1984006  25.5     36.4     21.9      0.1
```

Fig. A.11.1.g.3 Sample of part of process to Aligned MAPA.PRN from Excel CSV, two spaces between DATE and SRAD

Push SRAD to the right by 1 space, Fig. A.11.1.g.4.


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA_1.prn
SQLQuery8
MAPA.prn
3
C: > CAMDT > WD > MAPA_1.prn

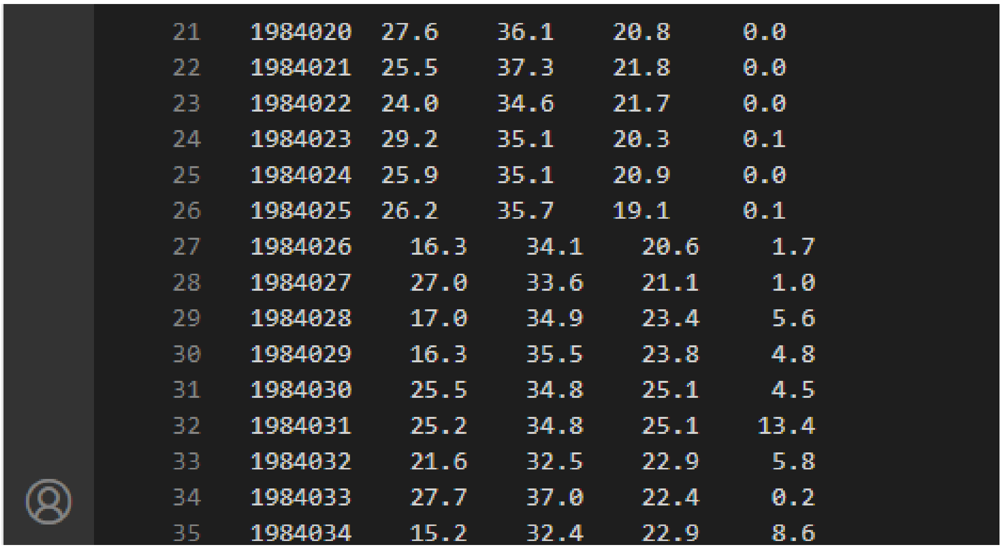
```
@  DATE  SRAD     T_MAX    T_MIN    RAIN
1984001  27.5     38.3     23.7      0.0
1984002  30.1     40.1     24.9      2.9
1984003   9.8     31.2     22.9     11.0
1984004  28.2     35.3     21.1      0.3
1984005  28.3     36.0     21.7      0.3
1984006  25.5     36.4     21.9      0.1
```

Fig. A.11.1.g.4 Sample of part of process to Aligned MAPA.PRN from Excel CSV, SRAD moved one space to the right.

h. Repeat aligning the remaining columns using the same marking procedures (SRAD, T_MAX, T_MIN)

i. Repeat aligning the space between DATE data and SRAD data continuing from the last row that was aligned until the last row, Fig. A.11.1.i.1 :

Last aligned Row



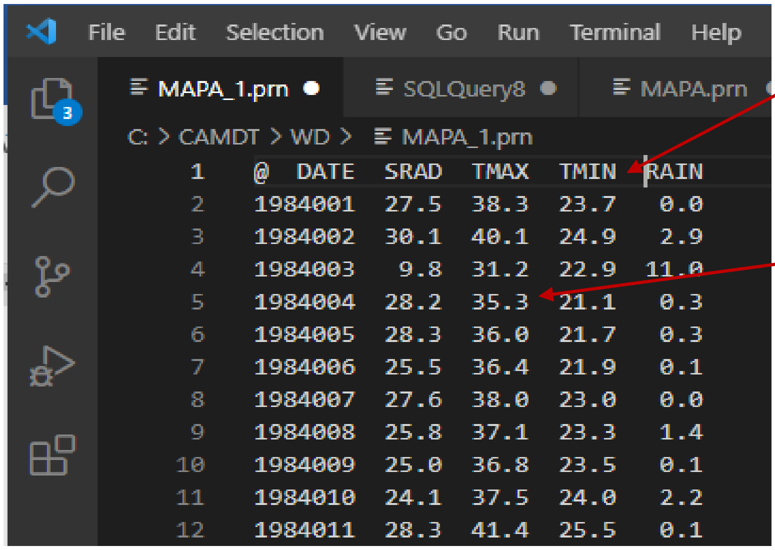
```
1984020  27.6    36.1    20.8     0.0
1984021  25.5    37.3    21.8     0.0
1984022  24.0    34.6    21.7     0.0
1984023  29.2    35.1    20.3     0.1
1984024  25.9    35.1    20.9     0.0
1984025  26.2    35.7    19.1     0.1
1984026    16.3    34.1    20.6     1.7
1984027    27.0    33.6    21.1     1.0
1984028    17.0    34.9    23.4     5.6
1984029    16.3    35.5    23.8     4.8
1984030    25.5    34.8    25.1     4.5
1984031    25.2    34.8    25.1    13.4
1984032    21.6    32.5    22.9     5.8
1984033    27.7    37.0    22.4     0.2
1984034    15.2    32.4    22.9     8.6
```

Fig. A.11.1.i.1 Sample of part of process to Align MAPA.PRN from Excel CSV, aligning the columns.

j. @▬▬DATE▬▬SRAD▬▬TMAX▬▬TMIN▬▬RAIN

▬▬ represent 2 spaces in between the columns

k. Remove underscores in the temperature column headers (T_MAX and T_MIN)
The fully aligned WTD data should look as below, Fig. A.11.1.k. :



```
@  DATE  SRAD  TMAX  TMIN  RAIN
1984001  27.5  38.3  23.7   0.0
1984002  30.1  40.1  24.9   2.9
1984003   9.8  31.2  22.9  11.0
1984004  28.2  35.3  21.1   0.3
1984005  28.3  36.0  21.7   0.3
1984006  25.5  36.4  21.9   0.1
1984007  27.6  38.0  23.0   0.0
1984008  25.8  37.1  23.3   1.4
1984009  25.0  36.8  23.5   0.1
1984010  24.1  37.5  24.0   2.2
1984011  28.3  41.4  25.5   0.1
```

2 spaces between column Headers

2 spaces between data columns

Fig. A.11.1.k. Sample of MS VS Code Editor aligned WTD file

l. After completing the alignment, save the file as MAPA.WTD

5. Repeat this formatting and alignment for all the Weather Centers in the Excel Workbook.

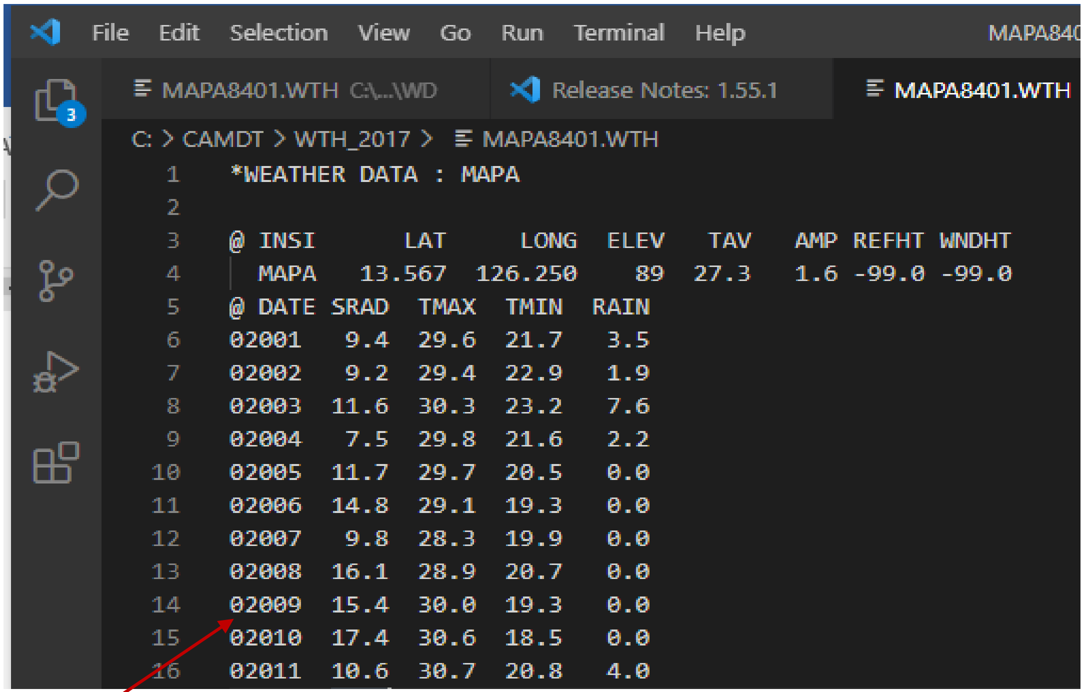
SECTION C. *.WTH YEARLY FILES

Each *.WTD file should be split into yearly *.WTH files equivalent to the number of years found in the *.WTD file, e.g. MAPA.WTD should be split into MAPA8401.WTH, MAPA8501.WTF, , , , MAPA1901.WTH.

First Observation
Year in *.WTD = 1984

Last Observation
Year in*.WTD = 2019

Each *.WTH File should be formatted the same way as the *.WTD file as done above but with the DATE data column shown as below as the final output, Fig. B.1.a. :


File
Edit
Selection
View
Go
Run
Terminal
Help
MAPA840
MAPA8401.WTH C:\...\WD
Release Notes: 1.55.1
MAPA8401.WTH
C: > CAMDT > WTH_2017 > MAPA8401.WTH
3

```
*WEATHER DATA : MAPA

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  MAPA   13.567  126.250    89  27.3   1.6 -99.0 -99.0
@ DATE SRAD  TMAX  TMIN  RAIN
02001   9.4  29.6  21.7   3.5
02002   9.2  29.4  22.9   1.9
02003  11.6  30.3  23.2   7.6
02004   7.5  29.8  21.6   2.2
02005  11.7  29.7  20.5   0.0
02006  14.8  29.1  19.3   0.0
02007   9.8  28.3  19.9   0.0
02008  16.1  28.9  20.7   0.0
02009  15.4  30.0  19.3   0.0
02010  17.4  30.6  18.5   0.0
02011  10.6  30.7  20.8   4.0
```

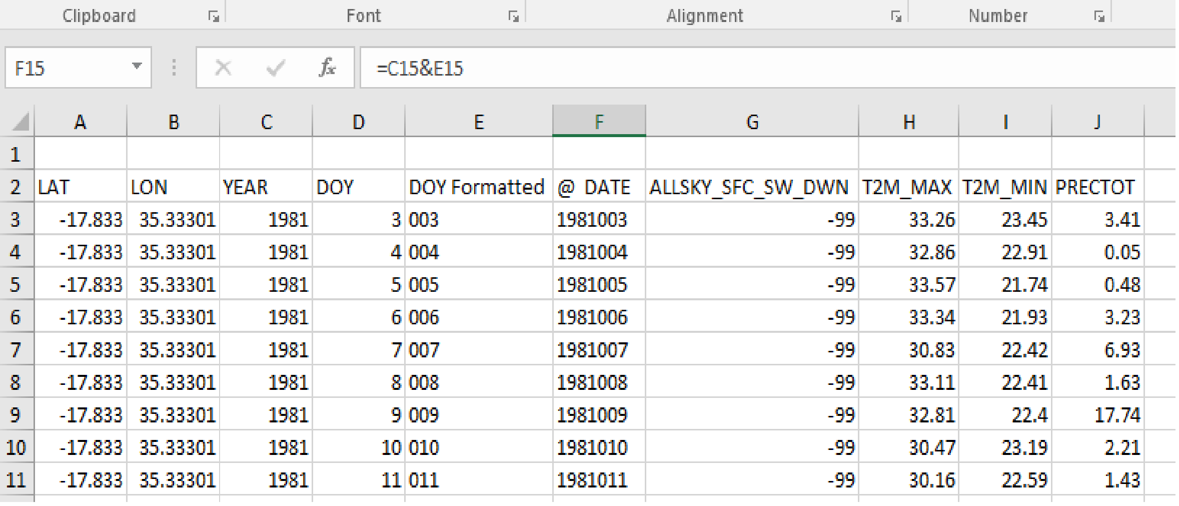
Fig. B.12.a. *Sample MAPA0201.WTH now Aligned file (Observation year = 2002)*

***Note: Weather data in this file is only illustration data*

Observation Year = 2002, Observation Day = 009 = 09 Jan

1 Feb = 02032,
31 Dec = 02365

*To create a *WTH file, start with the WTD worksheet for the desired Weather station as below,* Fig. B.12.b. *:*


Clipboard
Font
Alignment
Number

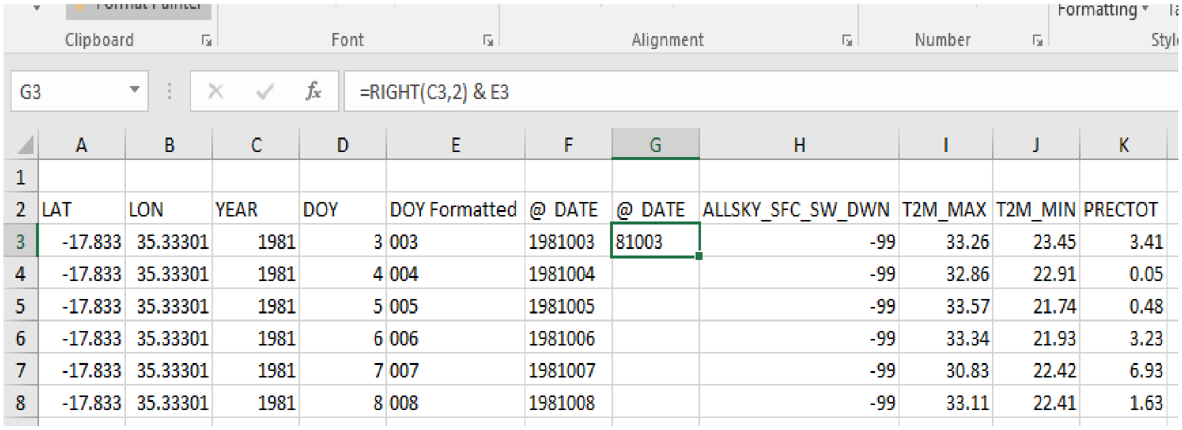
F15

=C15&E15

LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
-17.833	35.33301	1981	3	003	1981003	-99	33.26	23.45	3.41
-17.833	35.33301	1981	4	004	1981004	-99	32.86	22.91	0.05
-17.833	35.33301	1981	5	005	1981005	-99	33.57	21.74	0.48
-17.833	35.33301	1981	6	006	1981006	-99	33.34	21.93	3.23
-17.833	35.33301	1981	7	007	1981007	-99	30.83	22.42	6.93
-17.833	35.33301	1981	8	008	1981008	-99	33.11	22.41	1.63
-17.833	35.33301	1981	9	009	1981009	-99	32.81	22.4	17.74
-17.833	35.33301	1981	10	010	1981010	-99	30.47	23.19	2.21
-17.833	35.33301	1981	11	011	1981011	-99	30.16	22.59	1.43

Fig. B.12.b Sample of daily climatological data with re-formatted DOY and @ DATE, columns **E** and **F**.

1. Insert a Column between **F** and **G** and write Header @ DATE
2. Insert a formula in **G3** as shown below:

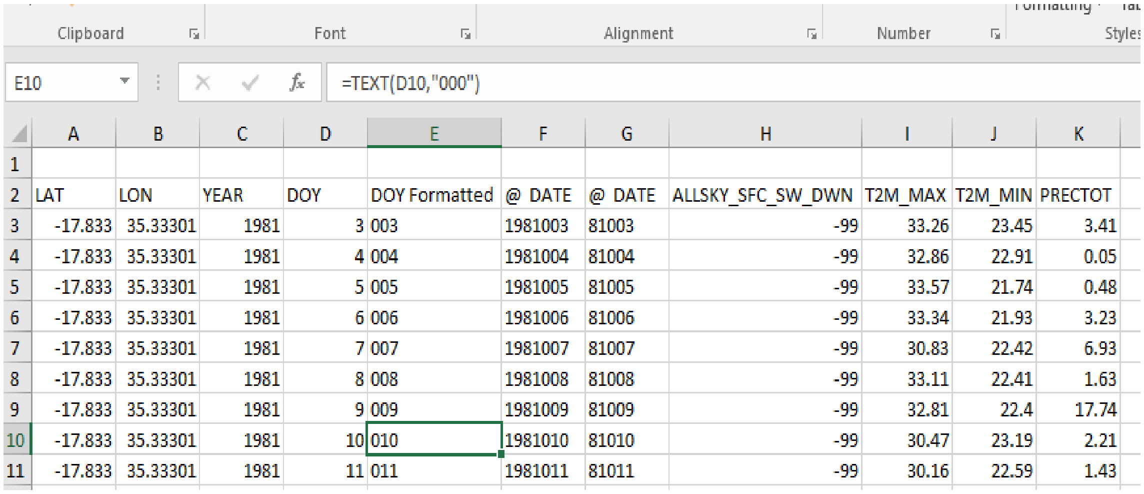


G3   =RIGHT(C3,2) & E3

	A	B	C	D	E	F	G	H	I	J	K
1											
2	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
3	-17.833	35.33301	1981	3	003	1981003	81003	-99	33.26	23.45	3.41
4	-17.833	35.33301	1981	4	004	1981004		-99	32.86	22.91	0.05
5	-17.833	35.33301	1981	5	005	1981005		-99	33.57	21.74	0.48
6	-17.833	35.33301	1981	6	006	1981006		-99	33.34	21.93	3.23
7	-17.833	35.33301	1981	7	007	1981007		-99	30.83	22.42	6.93
8	-17.833	35.33301	1981	8	008	1981008		-99	33.11	22.41	1.63

Fig. B.12.b.2 Sample of daily climatological data with new column @ DATE, column **G**.

3. Drag or copy the formula in **G3** all the way down to the last row as below:

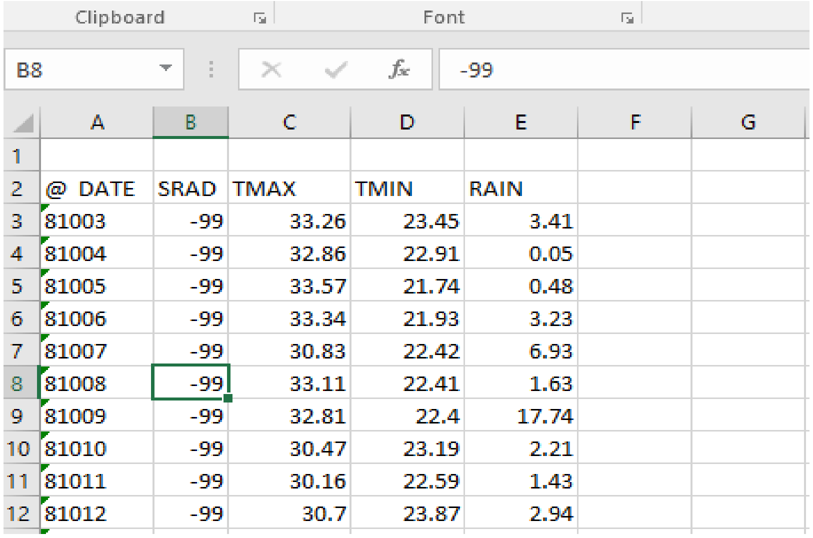


E10   =TEXT(D10,"000")

	A	B	C	D	E	F	G	H	I	J	K
1											
2	LAT	LON	YEAR	DOY	DOY Formatted	@ DATE	@ DATE	ALLSKY_SFC_SW_DWN	T2M_MAX	T2M_MIN	PRECTOT
3	-17.833	35.33301	1981	3	003	1981003	81003	-99	33.26	23.45	3.41
4	-17.833	35.33301	1981	4	004	1981004	81004	-99	32.86	22.91	0.05
5	-17.833	35.33301	1981	5	005	1981005	81005	-99	33.57	21.74	0.48
6	-17.833	35.33301	1981	6	006	1981006	81006	-99	33.34	21.93	3.23
7	-17.833	35.33301	1981	7	007	1981007	81007	-99	30.83	22.42	6.93
8	-17.833	35.33301	1981	8	008	1981008	81008	-99	33.11	22.41	1.63
9	-17.833	35.33301	1981	9	009	1981009	81009	-99	32.81	22.4	17.74
10	-17.833	35.33301	1981	10	010	1981010	81010	-99	30.47	23.19	2.21
11	-17.833	35.33301	1981	11	011	1981011	81011	-99	30.16	22.59	1.43

Fig. B.12.b.3 Sample of daily climatological data with new column @ DATE, dragged to cover all rows, note the formula (+TEXT(D10,”000”)

4. Now Copy Column **G** to Column **K** by highlighting on the Column names, copy the selected columns and paste into a new Excel Workbook as below. Rename the columns to SRAD, TMAX, TMIN and RAIN as below, Fig. B.12.b.4 :



	A	B	C	D	E	F	G
1							
2	@ DATE	SRAD	TMAX	TMIN	RAIN		
3	81003	-99	33.26	23.45	3.41		
4	81004	-99	32.86	22.91	0.05		
5	81005	-99	33.57	21.74	0.48		
6	81006	-99	33.34	21.93	3.23		
7	81007	-99	30.83	22.42	6.93		
8	81008	-99	33.11	22.41	1.63		
9	81009	-99	32.81	22.4	17.74		
10	81010	-99	30.47	23.19	2.21		
11	81011	-99	30.16	22.59	1.43		
12	81012	-99	30.7	23.87	2.94		

Fig. B.12.b.4 Sample of daily climatological data with missing SRAD.

N.B. Missing SRAD, i.e. -99 is to be replaced with interpolated/extrapolated from neighbouring days.

5. Save the above Excel sheet and Export to formatted *.WTH file using steps starting from SECTION A.8. to 12, Repeat this for each of the years in the *.WTD file.

CONCLUDING REMARK

The steps to make daily climatological data formats compatible with CAMDT/DSSAT have been described above, with the processes pertaining to the NASA data. It is important to ensure that the missing data are to be replaced through interpolation or extrapolation as the case may be. Due to the sensitivity of CAMDT/DSSAT to formats of the data to be ingested for running the models, the reformatting process will apply to all other sources of data as necessary. This is a living i.e. iterative process, so users are free to get in touch with authors for further clarifications as the needs arise.

REFERENCES

(IBSNAT, 1993; Tsuji, 1998; Uehara, 1998; Jones et al., 1998), International Benchmark Sites Network for Agrotechnology Transfer project

(Jones et al., 2001)CROPGRO, using a modular structure; (Jones and Kiniry, 1986), The CERES models for Maize (Ritchie and Otter, 1985), The CERES models for Wheat

(Hoogenboom et al., 1994a; Jones et al., 1998; Hoogenboom et al., 1999), DSSAT and development of compatible models for additional crops, such as potato, rice, dry beans, sunflower, and sugarcane

(Uehara, 1989; Jones et al., 1998), DSSAT modifications to improve accuracy

(Jones et al., 2001), CROPGRO, using a modular structure, This design was motivated to a large extent by the modular features of APSIM (McCown et al., 1996), but it uses the approach developed by van Kraalingen (1990, 1991, 1995), Kraalingen et al. (2003)

(Jones et al. (2001) and Porter et al. (2000), DSSAT-CSM structure using the modular approach

END OF USER GUIDE 1

USER GUIDE 2

RUNNING CAMDT GUI

Authors: Bradwell J Garanganga and Trymore Nyakutambwa

- Prepared by Eunjin Han[1] at IRI, Columbia University – (August, 2016)
- Adapted by Trymore Nyakutambwa[2] and Brad Garanganga[3] at digiSoft, Harare – (May 2021)

Acronyms

BN, NN, AN	Below Normal, Near Normal, Above Normal
CAMDT	Climate Agriculture Modelling and Decision Tool
DSSAT	Decision Support System for Agrotechnology Transfer
FORECAST model	A method of collecting **quantitative weather data** about the **current state of the atmosphere** at a given **location** and **time** and using mathematical modelling to project how the atmosphere will change at that location at a designated time
FResampler	The concept of 'conditional block sampling' of weather data conditioned on the probabilities of BN:NN:AN from the tercile forecast
GUI	Graphical User Interface
HINDCAST model	A way of testing a mathematical model at a single latitude and longitude point within a given timeframe, closely estimated inputs for past weather data are entered into the model to see how well the output matches the known results
IRI	International Research Institute for Climate and Society
NMHS	National Meteorological and Hydrological Services
PMW	Python Mega-Widgets, a python library for various graphical tools
PYTHON	A high level Software development language
SCF	Seasonal Climate Forecast
STOCHASTIC	Prediction/forecasting of Rainfall amount is characterized by rainfall intensity and rainfall frequency
WD	Working Directory housing CAMDT/DSSAT and Weather files

1. INTRODUCTION

Climate Information Services can also be used to assist NMHS and the Agricultural Sector to predict, plan and implement crop production using Seasonal Climate Forecasts and Hindcasts. This tool requires parameters supplied by both NMHS, for example seasonal Rainfall recordings, Maximum and Minimum Temperatures, Sun radiation, longitudes and latitudes for the homogeneous rainfall zones. Temporal Downscaling from other forecast centres is also required to validate the national forecasts. The Agricultural Sector will provide data for the homogeneous rainfall zones such as crop type and varieties, required farm inputs and their costs, farming seasons (prediction horizons), planting details, water management and fertilizer types, markets and selling prices.

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Two (2) temporal downscaling methods are available in CAMDT: ***Stochastic Disag*** and ***FResampler.***

- Non-parametric performs as the parametric method in downscaling probabilistic climate forecast.
- Non-parametric method is sensitive to data volume and sampling size.
- The parametric method is sensitive to data volume and type of rainfall information.
- Downscaling median not enough; downscaling distribution sampling points is needed.

i. Stochastic Disag (Parametric)

The conditional stochastic weather generator disaggregates monthly rainfall to daily weather sequences that preserve monthly rainfall statistics. Since a typical Seasonal Climate Forecast is provided for the coming three months e.g., JFM, additional steps are required before we can downscale the SCF:

a. Determine representative seasonal deviates (here, seasonal rainfall total) from quantiles of the given SCF probability curve, and
b. Derive monthly rainfall amounts from the seasonal deviates. The stochastic disaggregation method based on Hansen and Ines (2005). The stochastic weather generator simulates rainfall occurrence using a two-state second-order hybrid Markov model (Hansen and Mavromatis, 2001). A first-order chain is applied if the previous day is wet (e.g., a transition probability of P11, if wet day following a wet day), and a second-order chain is applied if the previous was dry (e.g., a transition probability of P101 or P001) (Stern and Coe, 1984, Wilks, 1999). If the Markov model determines a wet day, a rainfall amount is sampled from a hyper-exponential distribution. Rainfall amount can be characterized by rainfall intensity and rainfall frequency. See More >>>

ii. FResampler (Non-Parametric)

This is used to disaggregate a SCF to daily weather realizations. The FResampler1 is based on the concept of 'conditional block sampling' of weather data conditioned on the probabilities of BN:NN:AN from the tercile forecast. This method randomly samples a block of daily time-series of weather data for a target season from historical observations conditioned on those tercile probabilities. Sampling is done with replacement. FResampler1 preserves the covariance between rainfall and other weather variables, e.g., minimum and maximum temperature and solar radiation in a particular day.

The non-parametric resampling method does not require any assumptions on the distribution of rainfall amount (e.g., gamma distribution in Coe and Stern (1982), exponential in Todorovic and Woolhiser, 1975, Stern, 1982, lognormal in Swift and Schreuder (1981) or hyper-exponential distribution in Hansen and Ines (2005)). Thus, the parameters of a parametric model do not need to be estimated. This kind of non-parametric downscaling approach is preferred by some who are not comfortable with prior assumptions on the probability density functions or dependence of target variables (Lall and Sharma, 1996). In addition, resampling approaches do not necessarily consider precipitation as a main driving variable unlike other stochastic approaches which simulate rainfall occurrence (wet or dry day) independently and then other variables are simulated conditioned on wet/dry condition of the day (Rajagopalan and Lall, 1999). See More >>>

2. Running CAMDT in PYTHON

Climate Agriculture Modelling and Decision Tool (CAMDT) was developed at IRI in 2017 (Han and Ines: 2017). CAMDT is a computer desktop tool designed to guide decision-makers in adopting appropriate crop and water management practices that can improve crop yields given a climatic condition. It has been used with example for the Bicol region, Philippines. So the station used in the data ingestion is in the Bicol region. There will be need to make appropriate changes of the station where it be applied. The model works on Python platform. If a person is new in using Python, one will need to install Anaconda in order to avoid installing the modules separately. In consultation with the developers, some modifications to the CAMDT model were made in order to conduct the experiments with different cultivars grown if Southern Africa. The necessary steps required to install CAMDT are briefly discussed in the following section(s).

3. Steps to download and install CAMDT

There are few steps required to download and successfully run CAMDT

i. Open working folder git clone:
https://github.com/Agro-Climate/CAMDT.git

ii. If one is new to working with Python 3.8.x, one of the best ways to run CAMDT is to install Anaconda which helps you avoid installing all required modules separately. This can be downloaded from the following website: https://www.continuum.io/anaconda-overview OR install the python using the Python 3.8 Install package.

iii. If one is not conversant with graphs, install an older version of Anaconda, i.e. 4.4.x version.

iv. Please note that CAMDT uses **TkInter** (Python interface for GUI) and **PMW** widget to create graphical user-interface.

v. Use PIP (which installed together with PYTHON) to install PMW – Python Mega Widgets

Please note that Weather files (*.WTD and *.WTH) as discussed further in the section are GENERATED data, based on actual climatology. The climatological data required to initiate the running of CAMDT can be obtained from NASA climatological data set on website: https://power.larc.nasa.gov/data-access-viewer/.

vi. Users must input daily 30-year climatological data: (Solar Irradiance, Temperature max, Temperature max, Precipitation) for an observation station. It is convenient to use NASA data.

Note: option 3 is your data from NASA which you have converted to .WTH and refactored the required fields

vii. Use **Anaconda** to install other packages if they are not already installed:

- a) **Scipy**
- b) **numpy**
- c) **Matplotlib**
- d) **Pmw**

One can now test CAMDT by inputting the requisite climatological data. CAMDT is a weather generator used to drive Decision Support System for Agrotechnology Transfer (DSSAT). DSSAT was developed by J.W. Jones, in the USA and his co-workers, (Jones et al: 2003). DSSAT helps decision-makers by reducing the time and human resources required for analyzing complex alternative decisions (Tsuji et al., 1998). The latest version of the software is 4.75 (Hoogenboom et al: 2019). In order to run CAMDT, therefore, demands that you obtain open source DSSAT. This requires that you register with DSSAT Foundation to get access to the software. Once you have successfully downloaded and installed both CAMDT and DSSAT software on your computer, you will be able to conduct crop yield prediction experiments.

4. CAMDT Limitations

The 2017 edition of CAMDT is ONLY automated for and strictly tied to the Rice crop cultivars and was originally developed to model Rice production in the Philippines, mostly the PILI weather centre in the Bicol River Basin. Various CAMDT computer codes and the executables work well for the rice cultivars as per the original specifications for the Model. There is a need to make some changes to enable the model to have flexibility in simulating yields for other crop cultivars.

The CAMDT software was developed using the **FORTRAN** programming language and the **PYTHON** development platform, by IRI based at Columbia University. The **FORTRAN** software code is not free and is an intellectual property of IRI and its partners, whereas they have made the **PYTHON** based CAMDT code an Open Source software. Open Source means it is freely available on the public domain and has no Copyright or usage protection.

The **PYTHON** software code is responsible for reading a weather station's historical weather data (for y >= 30 years) and combine it using n realisations to generate an n^{th+1} predicted climatological data set for the predicted or targeted year(s) by using either the **Hindcast** or **Forecast model**. The more realisations (n *>= 30*) or observed number of years(y) we have, the more accurate our prediction (forecast) will be.

The **FORTRAN** software code reads the weather data sets (***RAIN***, Solar Radiation (***SRAD***) and Minimum and Maximum (T_{MIN}, T_{MAX}) temperatures generated by **PYTHON** and passes that data as input to the CROP YIELD prediction model for DSSAT.

The **FORTRAN** software code is hidden from the users since it is not Open Source. The CAMDT output data sets are visible to the user and are independent of the crop (RICE, MAIZE, SORGHUM, etc.) whose YIELD is to be predicted by DSSAT.

The challenge, therefore, is to automatically link the CAMDT output to the DSSAT input.
digiSoft Engineers did some analysis of the flow of the modelling data and introduced some key manual interventions to enable modelling of crops other than RICE.

User Guide 3 was prepared to overcome the limitations of CAMDT linking to DSSAT for other crops.

5. STEPS TO RUN CROP YIELD PREDICTION MODELS

This section of the user guide takes users through steps to model RICE; *User Guide 3* describes steps for other cereals/crops, requiring the user's manual intervention in order to achieve desired yields/outputs of the different crops.

I. CAMDT Folders Setup

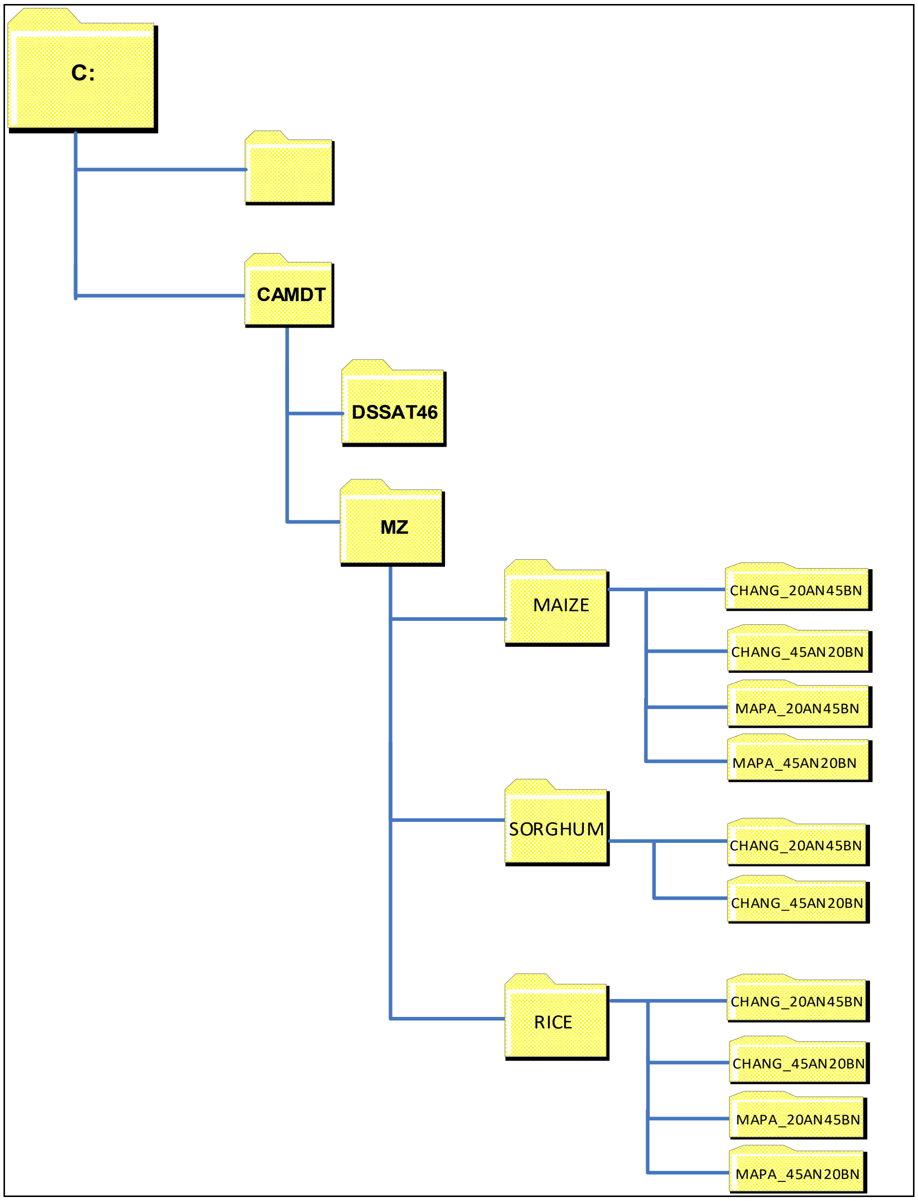
The folder tree in Figure 0 shows a sample weather station called STAT whose RICE directory has 2 subdirectories/folders (20AN-45BN & 45AN-20BN) for the two weather terciles 20% Above Normal – 45% Below Normal and 45% Above Normal – 20% Below Normal. These are the thresholds set to represent respectively, Below Normal and Above Normal Rainfall conditions as per seasonal climate (rainfall) forecasts.

All Weather station names in all weather files are referenced to by their 4-character abbreviations. E.g. MAPAI – MAPA, CHANGALANE – CHAN, BEITBRIDGE – BEIT.

a. Folder MZ in Figure 0 below represents the country with the weather stations under observation, in this case Mozambique
b. Yield Predictions for Three Cereals (MAIZE, RICE, and SORGHUM) are going to be modelled.
c. The next level of folders represent the Working folders (WD) where CAMDT will generate and store weather patterns for the two (2) terciles 20% and 45%. The naming convention of these two folders will follow the pattern:
    i. STAT_20AN45BN_WD - 20%AN / 45% BN and,
    ii. STAT_45AN20BN_WD - 45%AN / 20% BN where STAT is the weather station
    iii. CAMDT running files and Weather input files for Hindcast/Forecast are also stored in these folders

II. Weather Data Preparation

a. Before crop yield prediction modelling can be done, format data as described in User Guide 1:
   i. Download climatological data from the NASA website,
   ii. Use MS Excel to Extract and rearrange the data into columns required by CAMDT/DSSAT,
   iii. Format the data as strictly required for DSSAT/CAMDT input using MS Excel,
   iv. Split the data into annual daily weather using MS Excel and digiSoft MS VB Tools for Excel,
   v. Export the data into TEXT format using the MS Excel,
   vi. Refer to the ***digiSoft Data Formatting User Guide*** for steps (i) to (v) in this Section.


C:
CAMDT
DSSAT46
MZ
MAIZE
CHANG_20AN45BN
CHANG_45AN20BN
MAPA_20AN45BN
MAPA_45AN20BN
SORGHUM
CHANG_20AN45BN
CHANG_45AN20BN
RICE
CHANG_20AN45BN
CHANG_45AN20BN
MAPA_20AN45BN
MAPA_45AN20BN

<Figure 1> CAMDT working directory structure

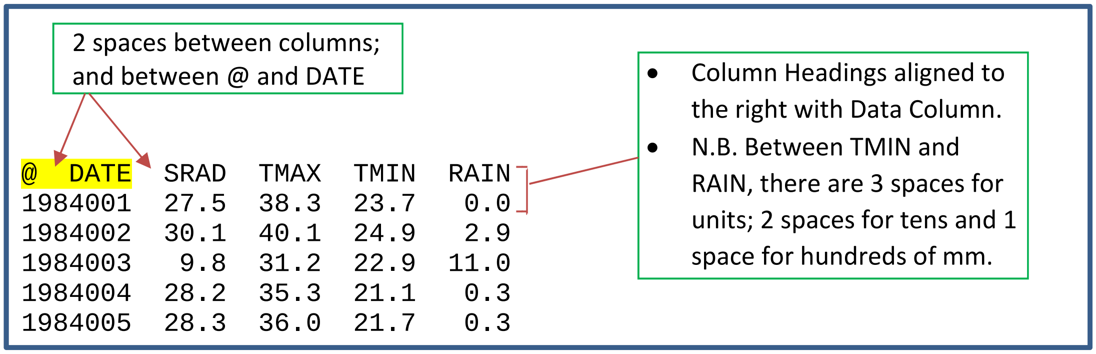
b. Copying Weather data to Working Directory (WD = Tercile folder like \STAT_20AN45BN_WD):

i. The Working Directory and CAMDT/DSSAT system files are setup with the assistance of the ***digiSoft CAMDT/DSSAT technical personnel***,

ii. Copy the STAT.WDT and STAT*.WTH files into the WD directory in readiness for the CAMDT/DSSAT Model Run. STAT represents the 1st four characters of the Weather station name and * represents the 2 digit year to be observed plus 01, e.g. STAT9801.WTH for year 1998.

iii. Check and ensure that the weather files follow the following formats:

STAT.WTD



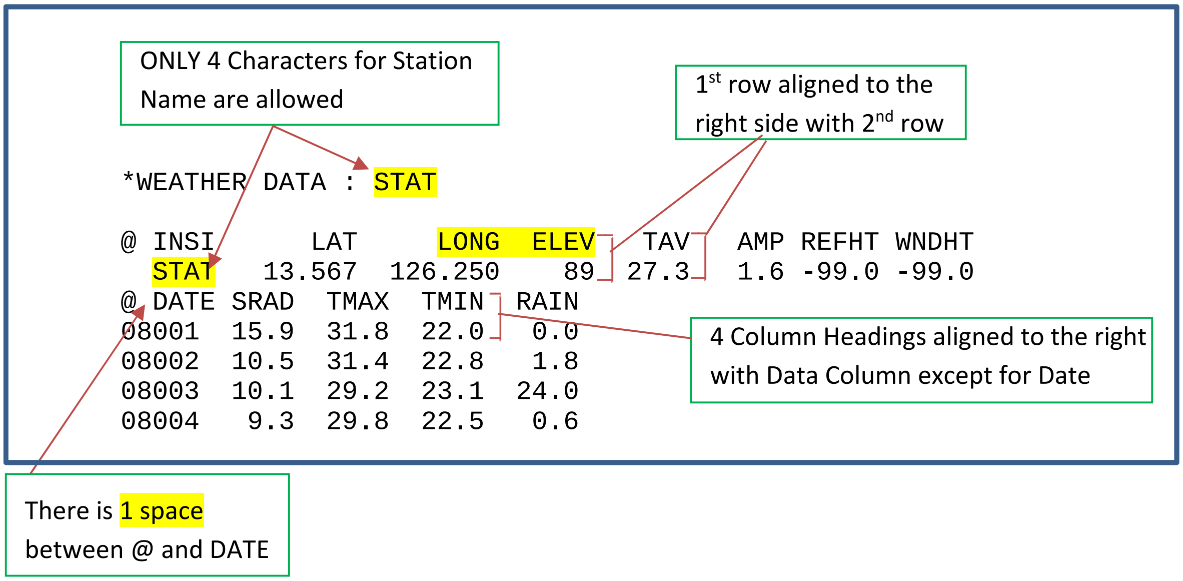
2 spaces between columns; and between @ and DATE

```
@  DATE  SRAD  TMAX  TMIN  RAIN
1984001  27.5  38.3  23.7   0.0
1984002  30.1  40.1  24.9   2.9
1984003   9.8  31.2  22.9  11.0
1984004  28.2  35.3  21.1   0.3
1984005  28.3  36.0  21.7   0.3
```

- Column Headings aligned to the right with Data Column.
- N.B. Between TMIN and RAIN, there are 3 spaces for units; 2 spaces for tens and 1 space for hundreds of mm.

<Figure 2> Global Weather Data formatted for CAMDT

STAT*.WTH



ONLY 4 Characters for Station Name are allowed

1st row aligned to the right side with 2nd row

```
*WEATHER DATA : STAT

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  STAT   13.567  126.250    89  27.3   1.6 -99.0 -99.0
@ DATE SRAD  TMAX  TMIN  RAIN
08001  15.9  31.8  22.0   0.0
08002  10.5  31.4  22.8   1.8
08003  10.1  29.2  23.1  24.0
08004   9.3  29.8  22.5   0.6
```

4 Column Headings aligned to the right with Data Column except for Date

There is 1 space between @ and DATE

<Figure 3> Yearly Weather Data formatted for CAMDT

III. Rice Automated Modelling vs Other Crops’ Manual Modelling

a) Rice yield prediction modelling will be run using the automated CAMDT GUI screen as explained in Section 5.iv below, since the original CAMDT edition is tied to Rice.

b) The modelling procedures for other crops follow user intervention steps as described in *User Guide 3*.

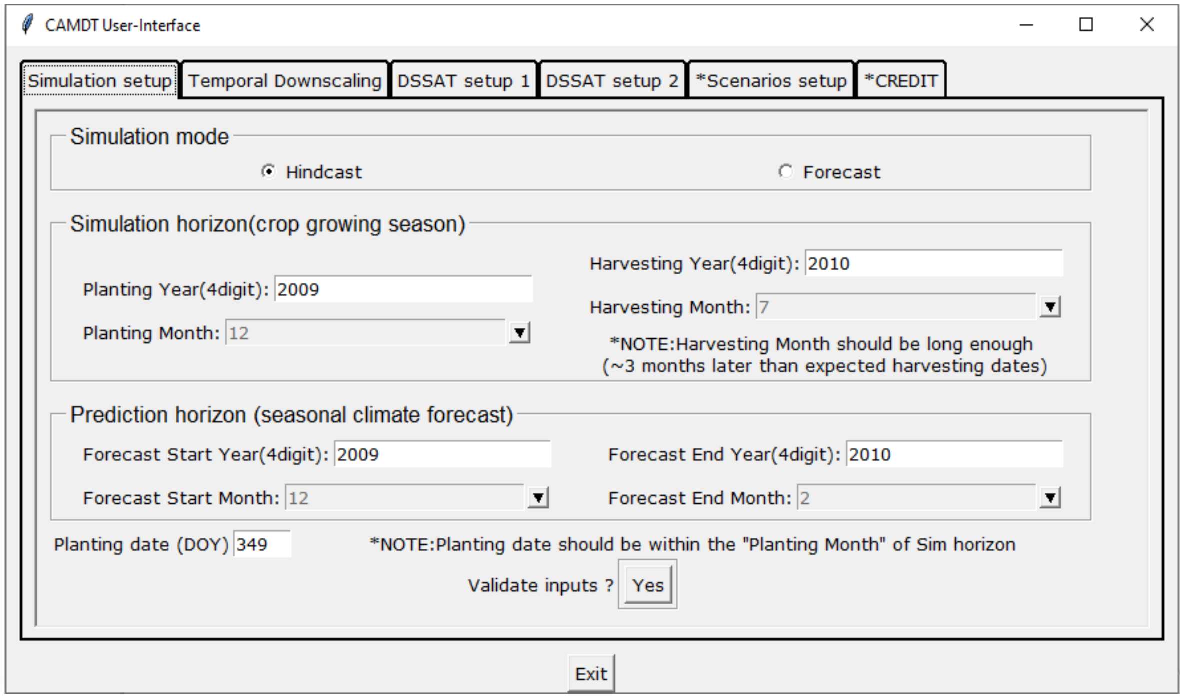
IV. Running Rice Crop Yield Simulation

a. **Method 1: Locate the CAMDT Working Directory or folder (WD) using MS Windows Explorer, e.g.**
   i. The folder should be similar to C:\CAMDT\MZ\RICE\STAT_20AN45BN_WD
   ii. Double-Click the Python file: "CAMDT_2017_0310.py".
   iii. The Python programme will run and display the GUI screen as in Figure 4 below.

b. **Method 2: Search for the MS Windows Command prompt and run as Administrator**
   i. Type: CD \ <Enter>
   ii. Type: CD CAMDT\WD <Enter>
   iii. Type: py CAMDT_2017_0310.py <Enter>
   iv. The Python programme will run and display the GUI screen as in Figure 4 below.
   where WD = \MZ\RICE\STAT_20AN45BN_WD

Adjust the size of the pop-up CAMDT-GUI window for full view as shown in Figure 4.

c. **Simulation setup**



Simulation mode
● Hindcast ○ Forecast

Simulation horizon(crop growing season)
Planting Year(4digit): 2009
Planting Month: 12
Harvesting Year(4digit): 2010
Harvesting Month: 7
*NOTE:Harvesting Month should be long enough (~3 months later than expected harvesting dates)

Prediction horizon (seasonal climate forecast)
Forecast Start Year(4digit): 2009
Forecast Start Month: 12
Forecast End Year(4digit): 2010
Forecast End Month: 2

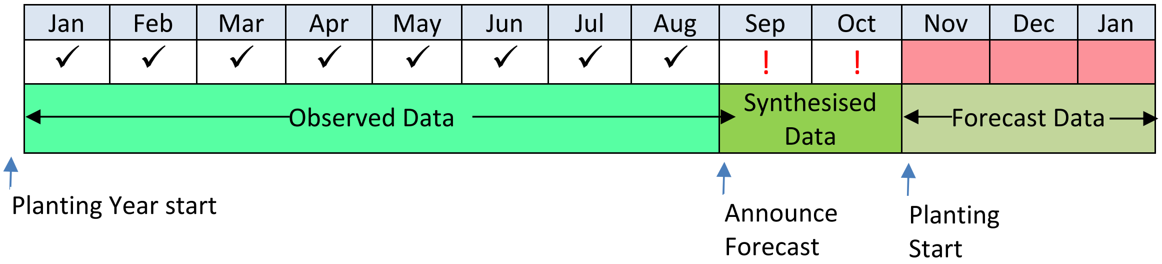
Planting date (DOY) 349
*NOTE:Planting date should be within the "Planting Month" of Sim horizon

<Figure 4.a.> Simulation horizon setup - HINDCAST

On the first page "Simulation setup", you can set up simulation mode and crop growing period. First, there are two simulation options: Hindcast and Forecast. The Hindcast mode can be used to run the crop simulation model (DSSAT) for past events (i.e., for the period when observed weather data are available).

d. Forecast for Upcoming planting season

Seasonal Climate Forecasts are done as part of the Regional Outlook Forums (RCOFs). These are downscaled to National Climate Outlooks (NCFs). In Southern Africa RCOFs/NCOFs are done in August/September ahead of the planting season October/November to March/April. The Outlooks themselves are in rolling three-monthly blocks thus OND, NDJ, DJF and JFM. Meantime, the CAMDT will require preparation of data files from 1 January of the planting year up to the end of the month preceding the planting month (which is usually November). Whereas daily climatological data are available up to August, there will be gaps in September and October to cover the forecast horizon (NDJ). In this case, there is need to construct day climatological data for September and October. This can be done by using expected patterns under Above-Normal (AN), Near-Normal (NN) or Below-Normal (BN) for the station as corresponding to the Outlook for OND and NDJ. So providing the ‘constructed’ data for September and October will enable CAMDT to run successfully. The details of this process are shown in the chart line, <Figure 4.b.> below:

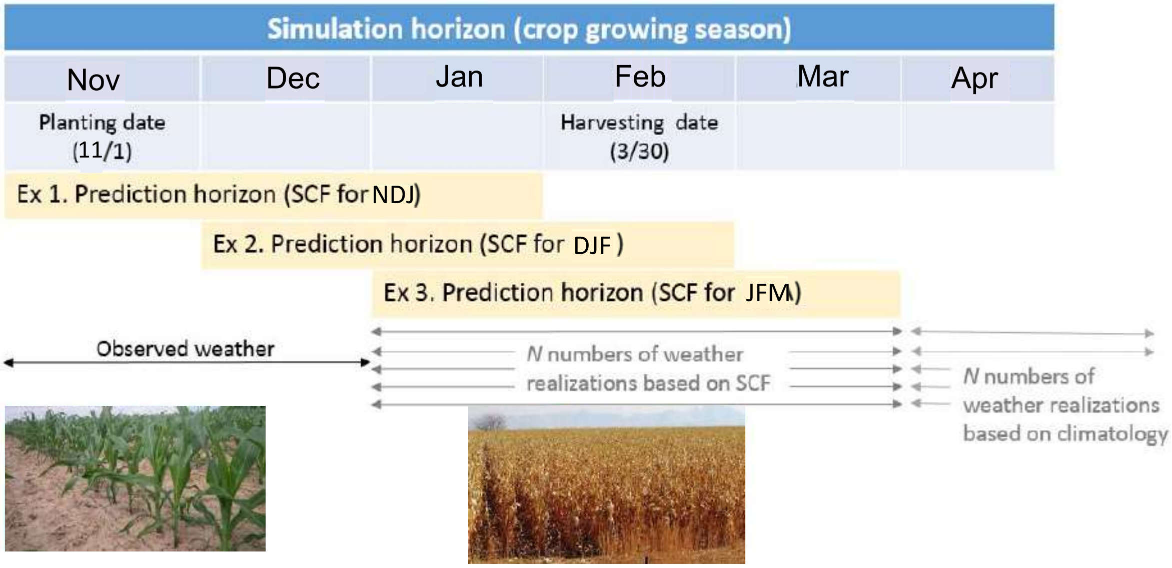


Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
✓	✓	✓	✓	✓	✓	✓	✓	!	!	🟥	🟥	🟥

<Figure 4.b.> Simulation horizon setup – FORECAST for Southern Africa

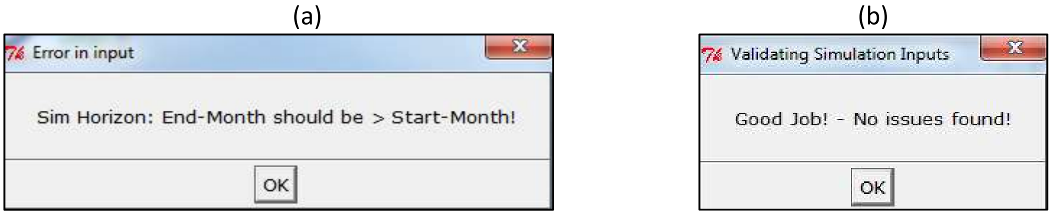
Next, *Simulation horizon (crop growing season)* section is to designate a crop growing period by typing/selecting a planting year/month and harvesting year/month. Note that if you type an invalid number for planting/harvesting year (i.e., not 4-digit number such as 209 instead of 2009), the Entry Field (blank box) would remain in red to indicate that there is an error in the format of your input. The user-defined planting month should include planting date. For example, in Figure 4, the planting DOY, 349(December 15 or 14 for leap year) corresponds to the planting month (December, 2009). Typical rice growing period in the Philippines is three months and thus approximate harvesting month would be March, 2010 in Figure 5. However, when we generate *N* weather realizations based on Seasonal Climate Forecast (SCF) (see Figure 5), 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 4 so that DSSAT can finish simulations even for extremely delayed growths. For instance, you can put harvest month as July, 2010 rather than actual harvesting month (e.g., March, 2010). If you put harvest month as March, 2010, DSSAT may generate error-message for some simulations when crop maturity is delayed to April.

Prediction horizon (seasonal climate forecast) section is to specify the period for which SCF is released. Typically IRI seasonal climate forecast is provided for a trimester with different lead time. However, in CAMDT the 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 5, the *prediction horizon* can be set for DJF or JFM or FMA depending on when you run the CAMDT. For instance, when you run the CAMDT on February 5th, 2010, you would 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 temporally downscaled *N* weather realizations will be used to run DSSAT for FMA season see <Figure 4.a.>. Weather conditions beyond the SCF (e.g., April in Figure 5) are generated based on climatology because no SCF information is available for this period.


Simulation horizon (crop growing season)
Nov
Dec
Jan
Feb
Mar
Apr
Planting date (11/1)
Harvesting date (3/30)
Ex 1. Prediction horizon (SCF for NDJ)
Ex 2. Prediction horizon (SCF for DJF)
Ex 3. Prediction horizon (SCF for JFM)
Observed weather
N numbers of weather realizations based on SCF
N numbers of weather realizations based on climatology

<Figure 5> (WE NEED to change the Simulation horizon to conditions that obtain in Southern Africa i.e. Nov, Dec, Jan, Feb, Mar and Apr)

Lastly, planting date should be provided in DOY (Day of Year) format. Again, this planting date should match with the planting month in the previous *Simulation horizon* section. If you want to check if all your 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 you put planting month and harvesting month as 2009/11 and 2009/7 respectively, you will get a pop-up error message in Figure 6(a). Once you fix the mistake in harvesting month 2009/7 to 2010/7, you will get a message shown in Figure 6(b).


(a)

Error in input

Sim Horizon: End-Month should be > Start-Month!

(b)

Validating Simulation Inputs

Good Job! - No issues found!

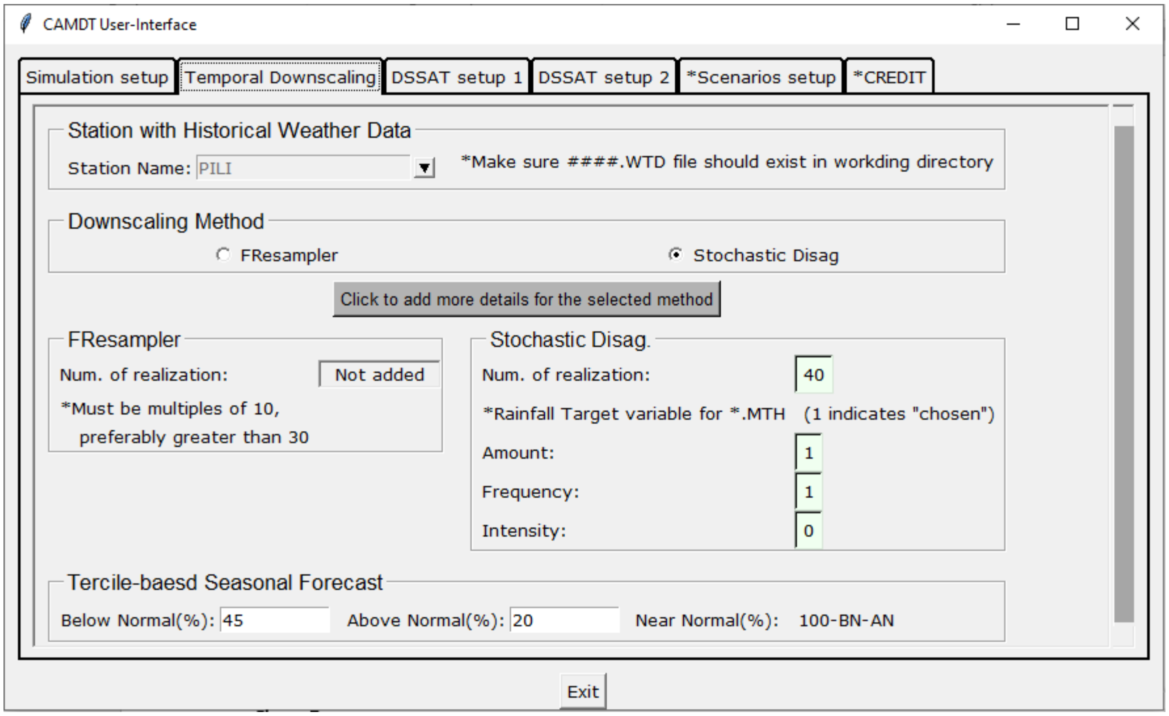
<Figure 6> Validating Simulation Horizon Input

a. Temporal Downscaling.

Most of the publically accessible seasonal climate forecasts (SCF) by Regional and National Climate Outlooks Forums (i.e. RCOFs or NCOFs) are released in the format of tercile probability: below-, near- and above-normal probability. 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 7.

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. The first step is to select a weather station 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 7). 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 7, you should have PILI.WTD file as shown in Figure 8. The *.WTD file has similar format to the DSSAT weather input file (*.WTH) shown in Figure 9.

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.


CAMDT User-Interface
Simulation setup
Temporal Downscaling
DSSAT setup 1
DSSAT setup 2
*Scenarios setup
*CREDIT
Click to add more details for the selected method
Exit

Station with Historical Weather Data

Station Name: PILI

*Make sure ####.WTD file should exist in workding directory

Downscaling Method

○ FResampler ● Stochastic Disag

FResampler

Num. of realization: Not added

*Must be multiples of 10,
preferably greater than 30

Stochastic Disag.

Num. of realization: 40

*Rainfall Target variable for *.MTH (1 indicates "chosen")

Amount: 1

Frequency: 1

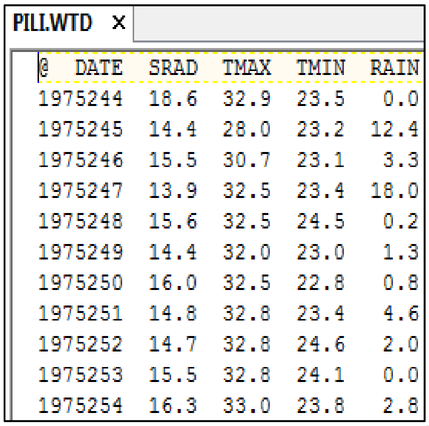
Intensity: 0

Tercile-baesd Seasonal Forecast

Below Normal(%): 45 Above Normal(%): 20 Near Normal(%): 100-BN-AN

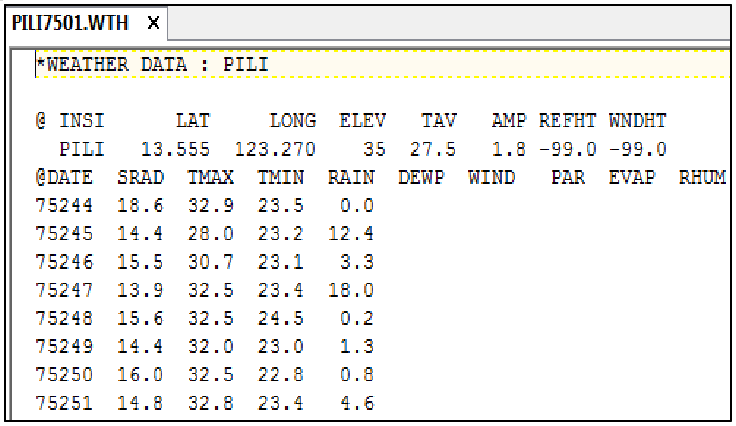
<Figure 7>

DSSAT does not allow any missing data, fill in the missing values before running CAMDT (*.WTD should not have any missing values such as -99). The *.WTD (temporal downscaling) and *.WTH files, should be in the main working directory (to be setup in Figure 23. In this exercise, PILI.WTD should be in the folder “~\WD”



```
@  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
```

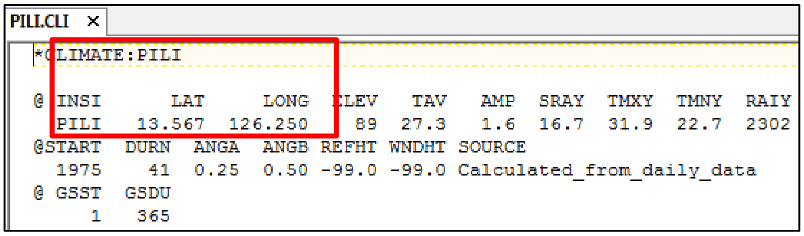
<Figure 8>



```
*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
```

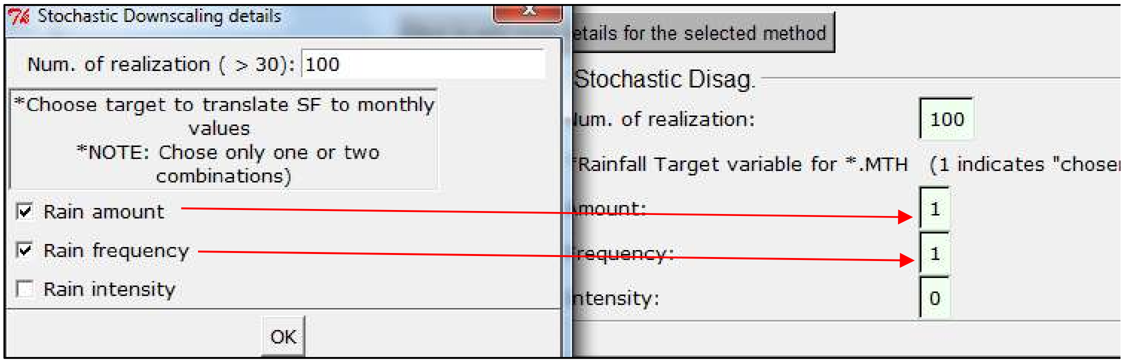
<Figure 9>

There are two temporal downscaling methods available in CAMDT: *Stochastic Disag* and *FResampler* method. The *Stochastic Disag* method is a conditional weather generator designed for the stochastic disaggregation of monthly rainfall into daily realizations. Model parameters of the *Stochastic Disag* are estimated by running *EstimatePrm.exe* with arguments *.CLI and *.WTD files. Command for running *EstimatePrm.exe* is hidden behind the CAMDT, but you 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 10 for the PILI station. The *.CLI file provides only geo-location of the weather station to the parameter estimation program. Therefore, the information within the red box in Figure 10 is only necessary. Next step for the parameter estimation is to determine monthly target information (again, *Stochastic Disag* basically generates daily weather realizations from monthly rainfall). You 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 you select the *Stochastic Disag* method and clicks the button “Click to add more details for the selected method” in Figure 7, a pop-up window appears so that you can select monthly targets (Figure 11 (a)). In addition, you 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 realization is 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 11(b).



```
*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 10>


(a)

(b)

Stochastic Downscaling details

Num. of realization (> 30): 100

*Choose target to translate SF to monthly values
*NOTE: Chose only one or two combinations)

☑ Rain amount
☑ Rain frequency
☐ Rain intensity

OK
etails for the selected method

Stochastic Disag.

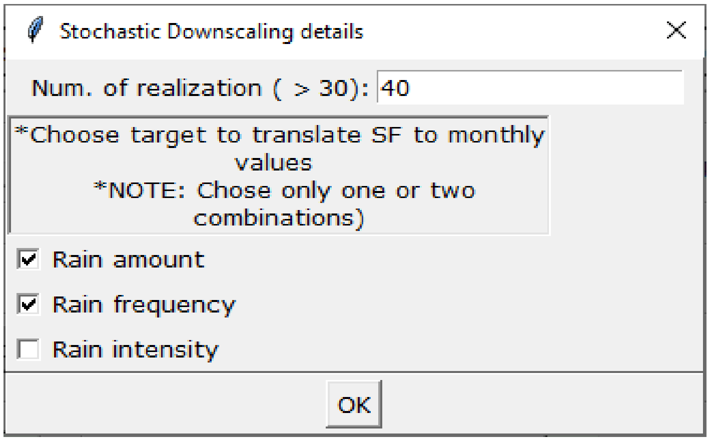
lum. of realization: 100

Rainfall Target variable for *.MTH (1 indicates "chose

mount: 1
requency: 1
ntensity: 0

<Figure 11>

The second downscaling method, *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 you select the *FResampler* method and clicks the button “Click to add more details for the selected method” in Figure 7, a simple pop-up window (Figure 14a) appears for you to determine number of realizations. Clicking “OK” copies the output to the bottom of the screen like in Figure 15 for the *Stochastic* method.



Num. of realization (> 30): 40

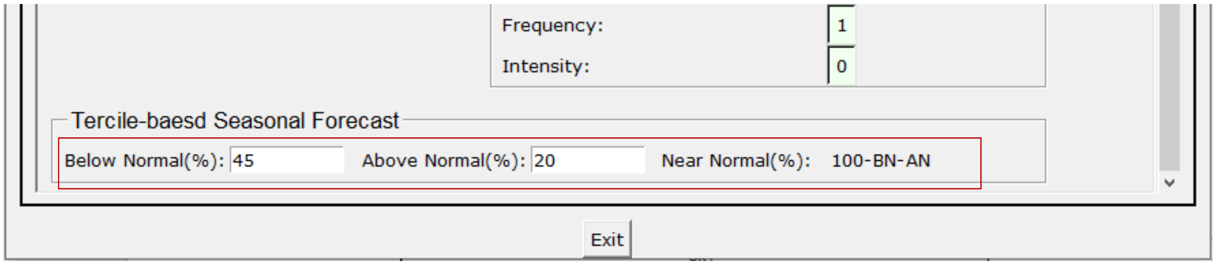
*Choose target to translate SF to monthly values
*NOTE: Chose only one or two combinations)

☑ Rain amount
☑ Rain frequency
☐ Rain intensity

<Figure 12>

Tercile-based SCF can be typed directly by a user into the bottom window to provide probabilities of Below Normal (BN) and Above Normal (AN), see Figure 13. The CAMDT extracts probabilities of BN, NN and AN from the chosen weather data in *.WTD. The chosen different monthly targets: one of the rainfall characteristics (rainfall amount, frequency, intensity), or combination of two characteristics (e.g., amount & frequency) can be selected by using the Check Boxes as shown on the bottom of the Temporal Downscaling screen as shown in Figure 12. Again, the input is copied to the main window (see Figure 11(b)).

If the *FResampler* method is selected, only the number of realisations is required when you click “Click to add details of the selected method” (Figure 14(a)). Clicking “OK” will copy the number of realisations to the main window (Figure 14(b)).



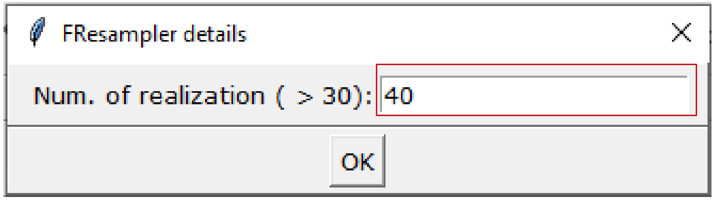
Frequency: 1
Intensity: 0

Tercile-baesd Seasonal Forecast

Below Normal(%): 45 Above Normal(%): 20 Near Normal(%): 100-BN-AN

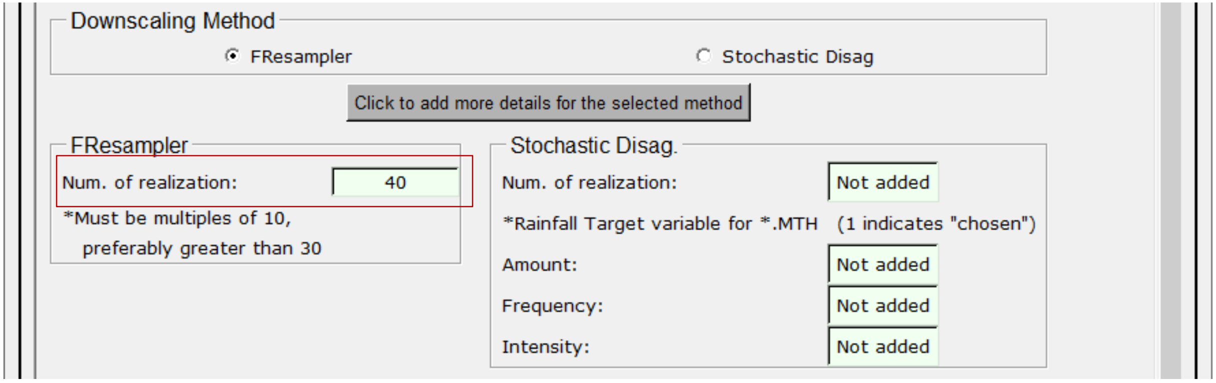
<Figure 13>

(a)



Num. of realization (> 30): 40

(b)



Downscaling Method

● FResampler ○ Stochastic Disag

FResampler

Num. of realization: 40

*Must be multiples of 10,
preferably greater than 30

Stochastic Disag.

Num. of realization: Not added

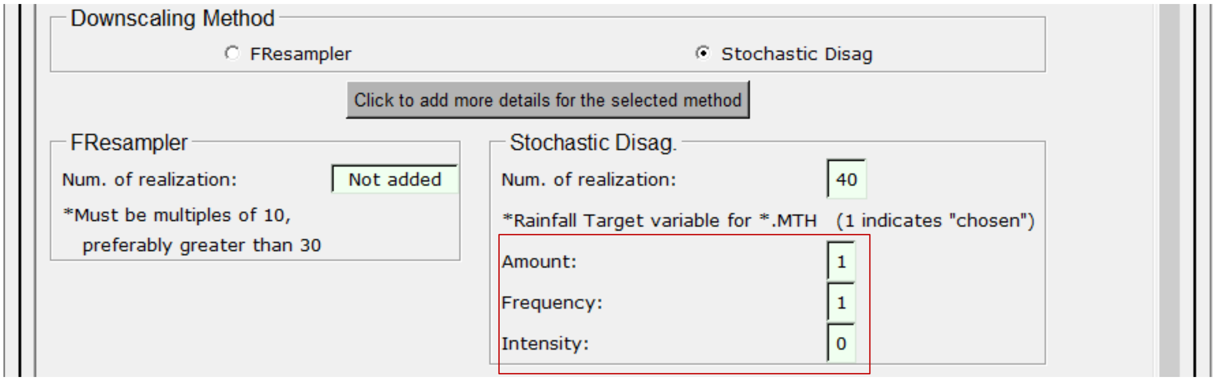
*Rainfall Target variable for *.MTH (1 indicates "chosen")

Amount: Not added

Frequency: Not added

Intensity: Not added

<Figure 14>



Downscaling Method

○ FResampler ● Stochastic Disag

FResampler

Num. of realization: Not added

*Must be multiples of 10,
preferably greater than 30

Stochastic Disag.

Num. of realization: 40

*Rainfall Target variable for *.MTH (1 indicates "chosen")

Amount: 1

Frequency: 1

Intensity: 0

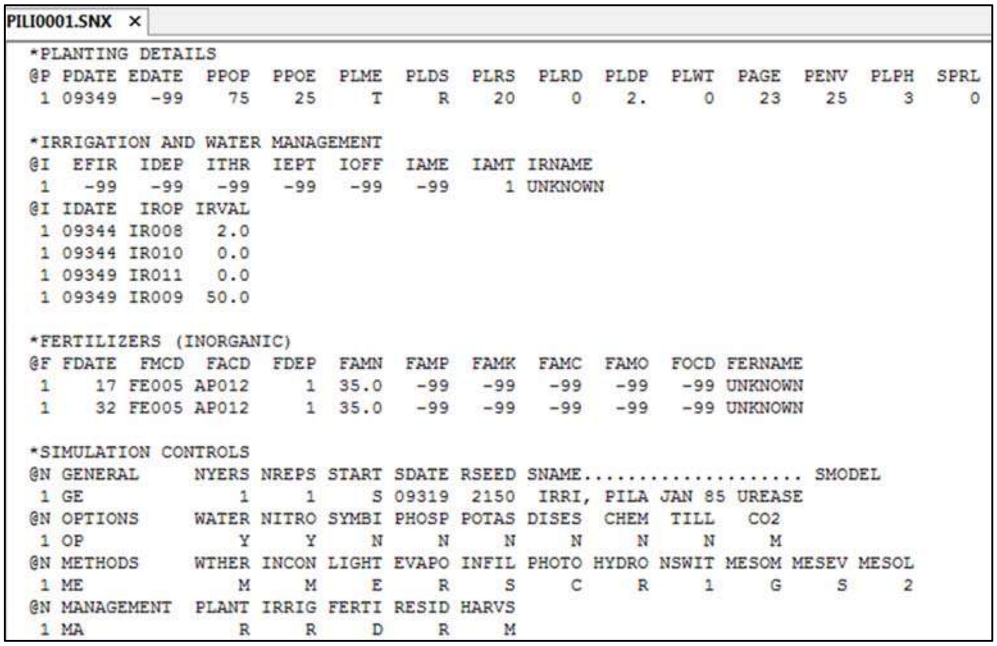
<Figure 15>

3) DSSAT Setup

Next step is to provide crop management inputs for DSSAT on “DSSAT setup 1” and “DSSAT setup 2” pages (Figure 17 and 19). 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 much options.

First, since the current version of CAMDT focus on rice, there are two planting methods available: dry seed or transplanting (Figure 17). Planting details can be typed in the next section where some default values are already given for guidance.

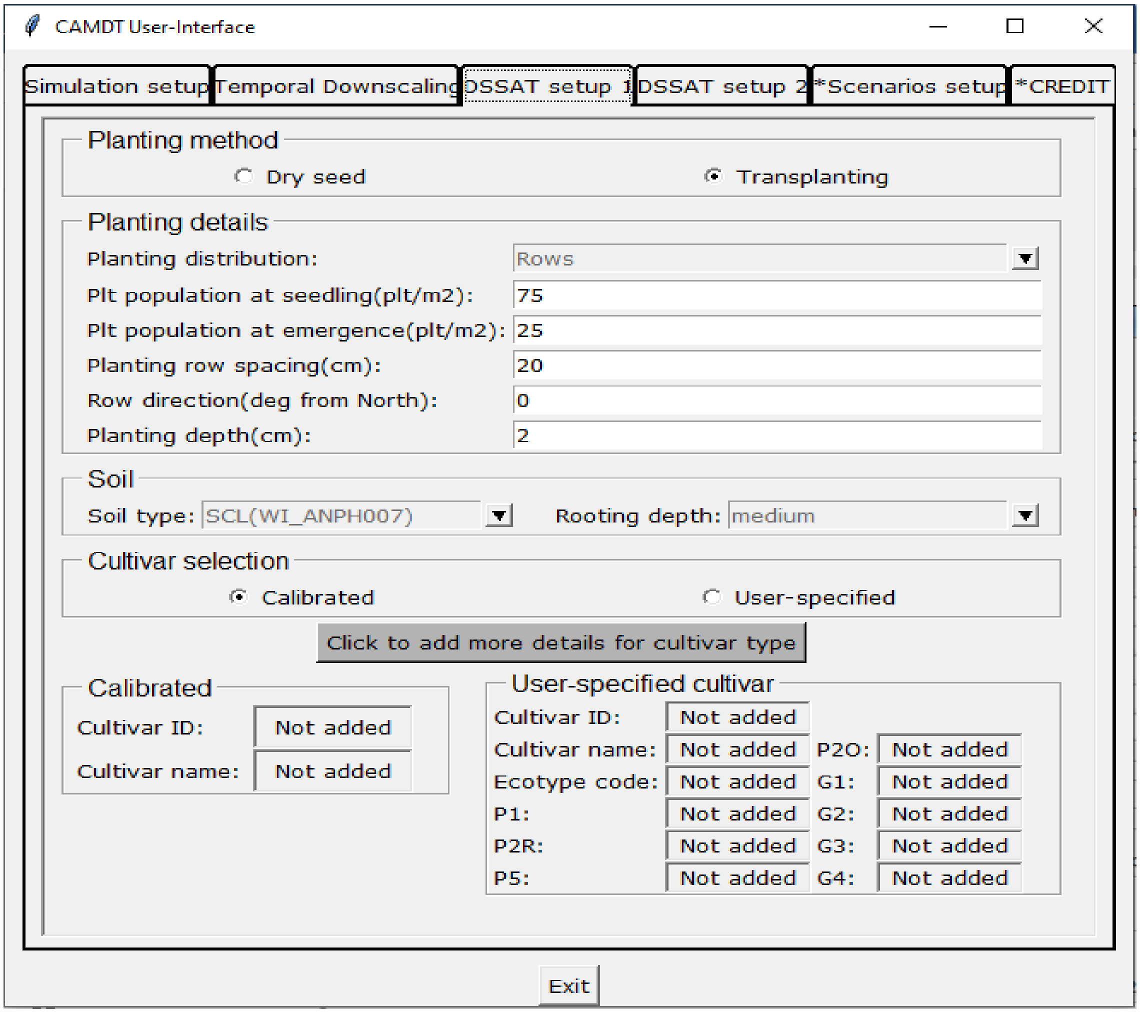
Soil physical or chemical characteristics are critical factors for crop growth. Due the unavailability of soil database from the Bicol region in the Philippines, a few soil profiles extracted from WISE (World Inventory of Soil Emission Potentials) soil database (WI.SOL) were added on CAMDT. More soil 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, you 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>



Planting method

○ Dry seed ● Transplanting

Planting details

Planting distribution: Rows

Plt population at seedling(plt/m2): 75

Plt population at emergence(plt/m2): 25

Planting row spacing(cm): 20

Row direction(deg from North): 0

Planting depth(cm): 2

Soil

Soil type: SCL(WI_ANPH007) Rooting depth: medium

Cultivar selection

● Calibrated ○ User-specified

Click to add more details for cultivar type

Calibrated

Cultivar ID: Not added

Cultivar name: Not added

User-specified cultivar

Cultivar ID: Not added

Cultivar name: Not added P2O: Not added

Ecotype code: Not added G1: Not added

P1: Not added G2: Not added

P2R: Not added G3: Not added

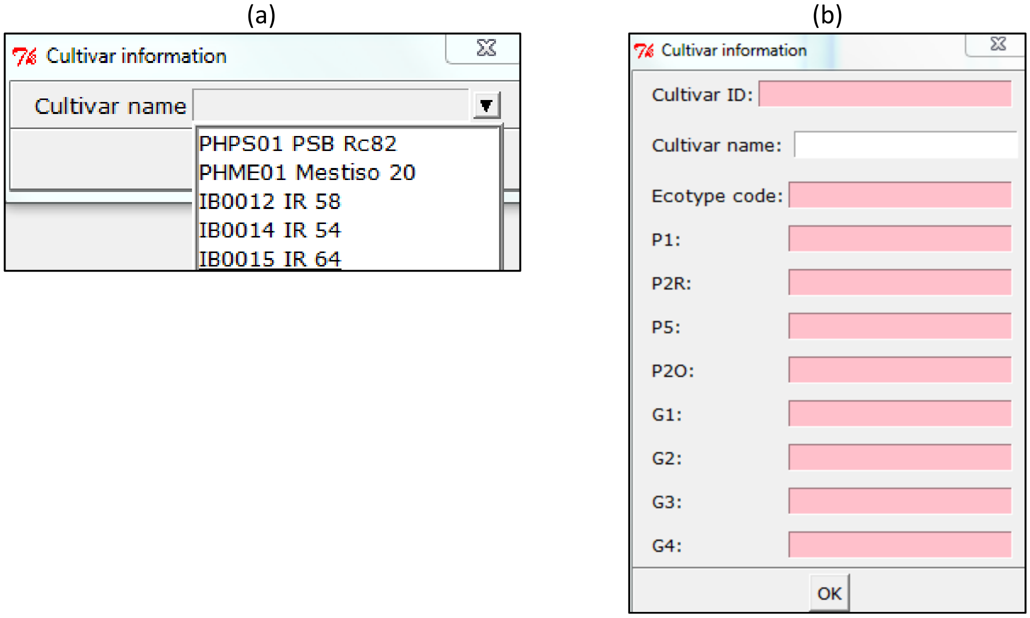
P5: Not added G4: Not added

<Figure 17>

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 4.6 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). In total, those five cultivars are available for DSSAT simulation in the current version of CAMTD (Figure 18(a)), but again additional cultivars from *RICER46.CUL* file can be easily added by modifying Python script of the CAMDT. If you want to simulate using the given cultivars, “Calibrated” option should be chosen under the “Cultivar selection” group (Figure 17). Once you click “Click to add more details for cultivar type” button, a new pop-up window appears for you to select a cultivar type as shown in Figure 16(a). In case you are an expert of DSSAT and has your own calibrated parameters for a certain cultivar, you 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 17. Then new coefficients can be directly typed on the new window (Figure 18(b)) and these coefficients will be written into *RICER46.CUL* file under the working directory.

<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.


(a)

Cultivar information

Cultivar name

PHPS01 PSB Rc82
PHME01 Mestiso 20
IB0012 IR 58
IB0014 IR 54
IB0015 IR 64

(b)

Cultivar information

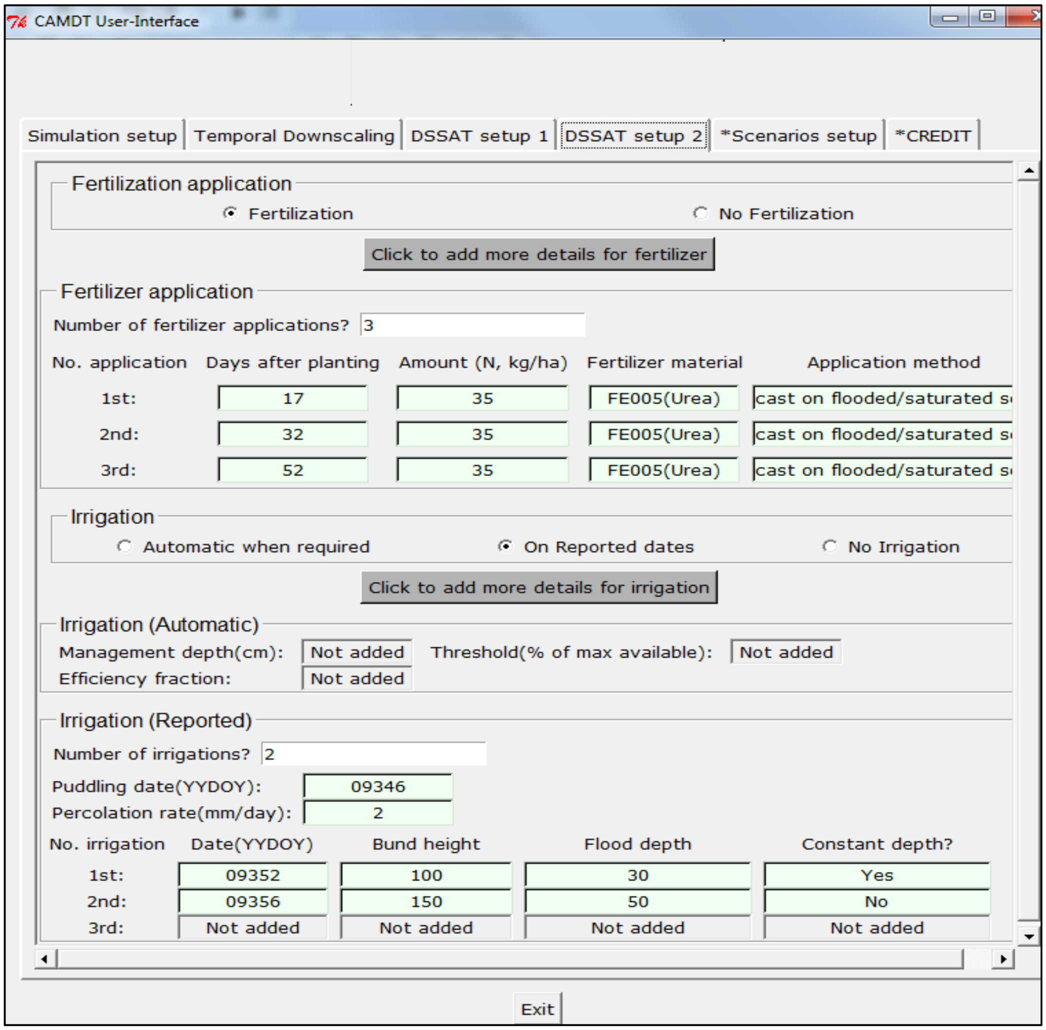
Cultivar ID:
Cultivar name:
Ecotype code:
P1:
P2R:
P5:
P2O:
G1:
G2:
G3:
G4:

<Figure 18> Cultivar Selection ((a)) and Inputting calibrated Cultivar ((b))

The “DSSAT setup 2” page in Figure 17 is to get user’s inputs for fertilizer and irrigation applications. First, you should select if fertilizer would be applied (by selecting “Fertilization” button) or not (by selecting “No Fertilization” button). If “Fertilization” was selected, you 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 three times. Figure 19 shows an example of how to fill out the Fertilizer Application section. Once you fill out the pop-up window, the inputs will be copied to the main window. Note that you also should type “number of fertilizer applications” on the blank box in the “Fertilizer application” group.

Next, an irrigation option need to be chosen. There are three options available: 1) Automatic when required, 2) On Reported dates, 3) No Irrigation. The first option, “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 21 are required when “Automatic when required” is selected on the main window in Figure 19.

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 19). For the rest of irrigation, you need to provide irrigation date, bund height, flood depth and if the flood depth would be constant or not. If you check “yes” to the question, “Constant flood depth?” (as shown in Figure 19, 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 you click “ok” button of the pop-up window, all the inputs you provided will be copied to the main window. Do not forget to type “Number of Irrigations” on the main window in Figure 19.


CAMDT User-Interface
Simulation setup
Temporal Downscaling
DSSAT setup 1
DSSAT setup 2
*Scenarios setup
*CREDIT
Click to add more details for fertilizer
Click to add more details for irrigation
Exit

Fertilization application

● Fertilization ○ No Fertilization

Fertilizer application

Number of fertilizer applications? 3

No. application	Days after planting	Amount (N, kg/ha)	Fertilizer material	Application method
1st:	17	35	FE005(Urea)	cast on flooded/saturated s
2nd:	32	35	FE005(Urea)	cast on flooded/saturated s
3rd:	52	35	FE005(Urea)	cast on flooded/saturated s

Irrigation

○ Automatic when required ● On Reported dates ○ No Irrigation

Irrigation (Automatic)

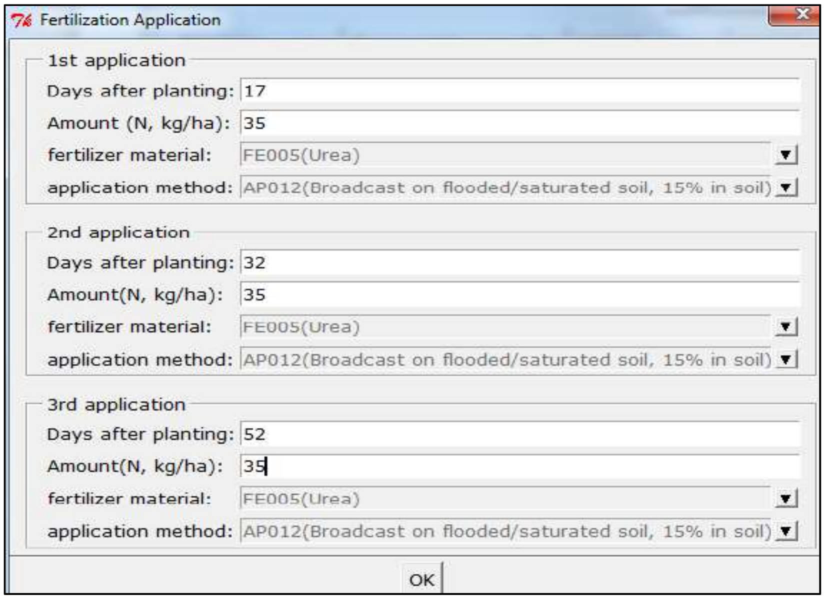
Management depth(cm): Not added
Threshold(% of max available): Not added
Efficiency fraction: Not added

Irrigation (Reported)

Number of irrigations? 2
Puddling date(YYDOY): 09346
Percolation rate(mm/day): 2

No. irrigation	Date(YYDOY)	Bund height	Flood depth	Constant depth?
1st:	09352	100	30	Yes
2nd:	09356	150	50	No
3rd:	Not added	Not added	Not added	Not added

<Figure 19> Fertiliser application and Water irrigation management for DSSAT ingestion


Fertilization Application
OK

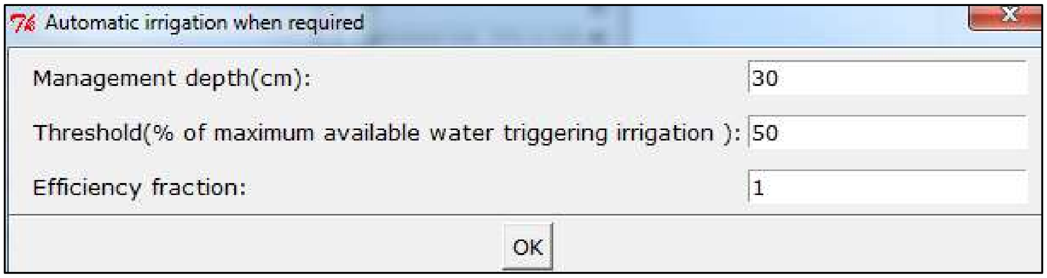
1st application
Days after planting: 17
Amount (N, kg/ha): 35
fertilizer material: FE005(Urea)
application method: AP012(Broadcast on flooded/saturated soil, 15% in soil)

2nd application
Days after planting: 32
Amount(N, kg/ha): 35
fertilizer material: FE005(Urea)
application method: AP012(Broadcast on flooded/saturated soil, 15% in soil)

3rd application
Days after planting: 52
Amount(N, kg/ha): 35
fertilizer material: FE005(Urea)
application method: AP012(Broadcast on flooded/saturated soil, 15% in soil)

<Figure 20>

dAMS
digiSoft AgroMeteorology Science



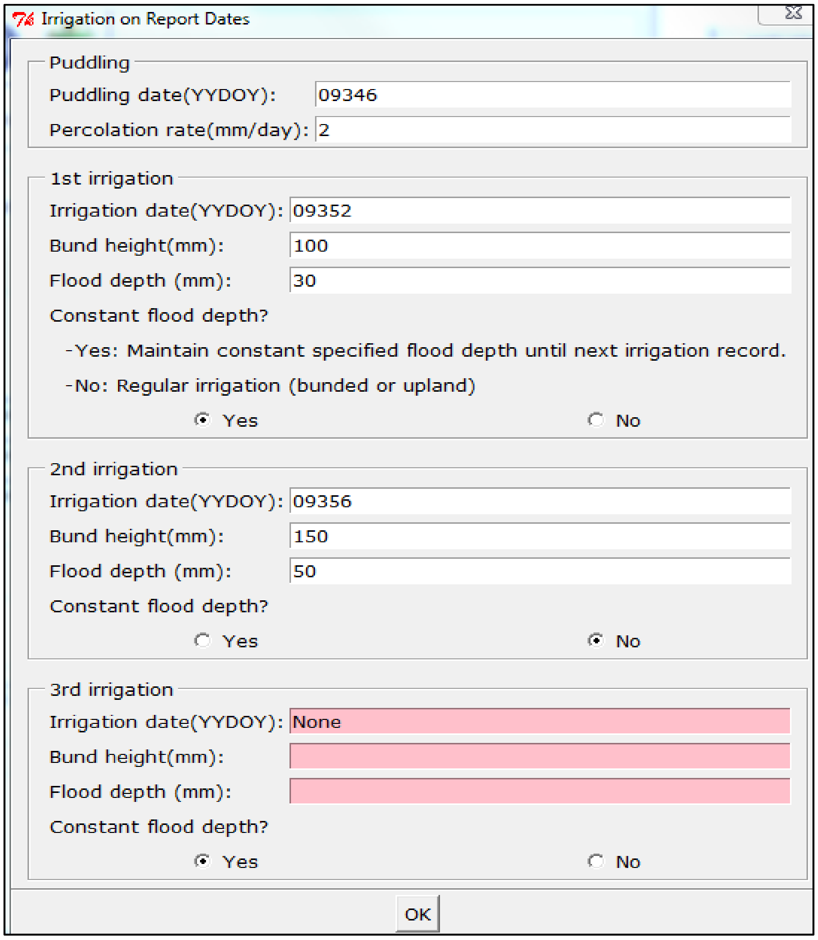
Automatic irrigation when required

Management depth(cm): 30

Threshold(% of maximum available water triggering irrigation): 50

Efficiency fraction: 1

<Figure 21>



Irrigation on Report Dates

Puddling

Puddling date(YYDOY): 09346

Percolation rate(mm/day): 2

1st irrigation

Irrigation date(YYDOY): 09352

Bund height(mm): 100

Flood depth (mm): 30

Constant flood depth?

-Yes: Maintain constant specified flood depth until next irrigation record.

-No: Regular irrigation (bunded or upland)

● Yes ○ No

2nd irrigation

Irrigation date(YYDOY): 09356

Bund height(mm): 150

Flood depth (mm): 50

Constant flood depth?

○ Yes ● No

3rd irrigation

Irrigation date(YYDOY): None

Bund height(mm):

Flood depth (mm):

Constant flood depth?

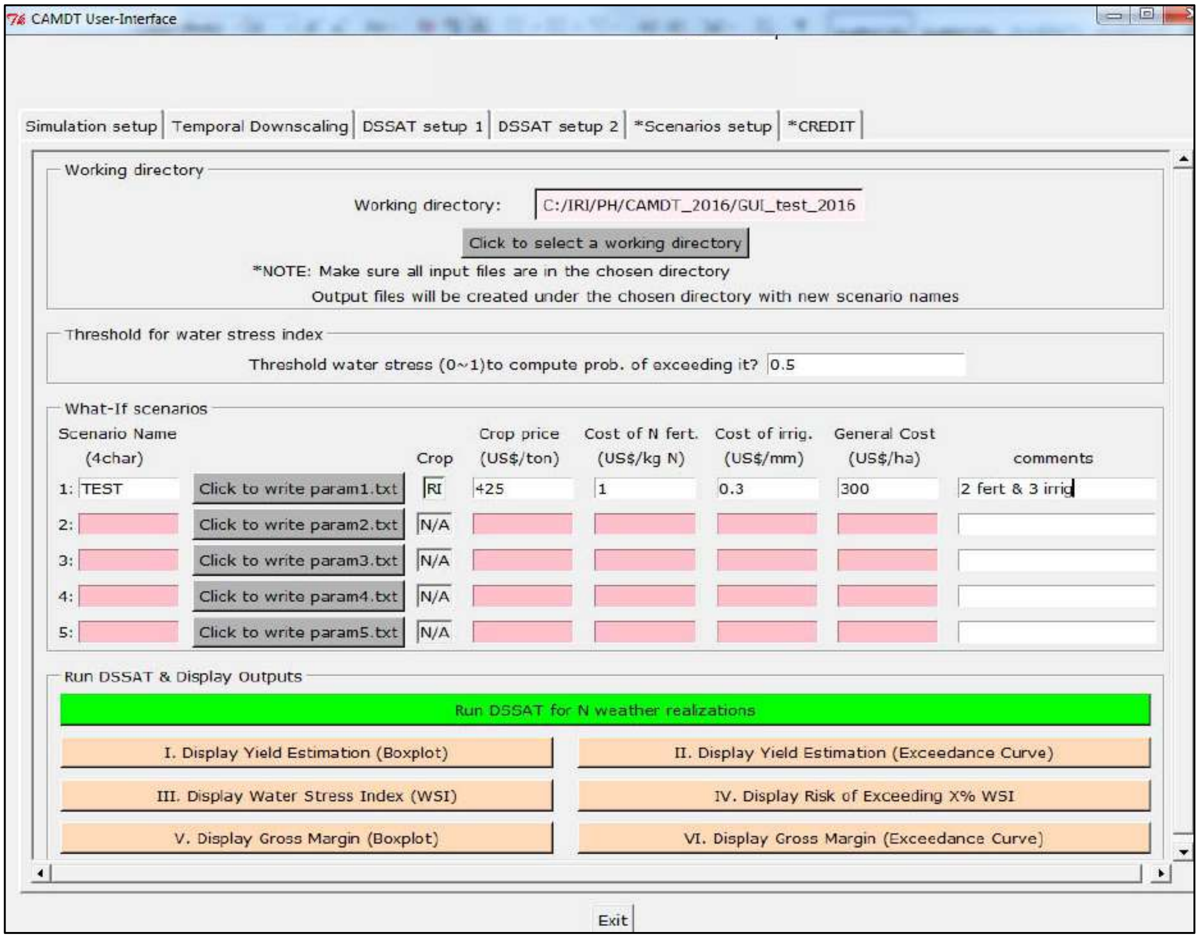
● Yes ○ No

<Figure 22>

4) Scenario Setup

Now we are ready to set up “what-if” scenario(s) and run DSSAT for the scenarios. On “Scenarios setup” page in Figure 23, first, you need 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 you click “Click to select a working directory” button, a new pop-up window will appear so that you can select a folder. 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.


CAMDT User-Interface
Simulation setup
Temporal Downscaling
DSSAT setup 1
DSSAT setup 2
*Scenarios setup
*CREDIT
Working directory
Click to select a working directory
Threshold for water stress index
What-If scenarios
Click to write param1.txt
Click to write param2.txt
Click to write param3.txt
Click to write param4.txt
Click to write param5.txt
Run DSSAT & Display Outputs
Run DSSAT for N weather realizations
I. Display Yield Estimation (Boxplot)
II. Display Yield Estimation (Exceedance Curve)
III. Display Water Stress Index (WSI)
IV. Display Risk of Exceeding X% WSI
V. Display Gross Margin (Boxplot)
VI. Display Gross Margin (Exceedance Curve)
Exit

Working directory: C:/IRI/PH/CAMDT_2016/GUI_test_2016

*NOTE: Make sure all input files are in the chosen directory
Output files will be created under the chosen directory with new scenario names

Threshold water stress (0~1)to compute prob. of exceeding it? 0.5

Scenario Name (4char)	Crop	Crop price (US$/ton)	Cost of N fert. (US$/kg N)	Cost of irrig. (US$/mm)	General Cost (US$/ha)	comments
1: TEST	RI	425	1	0.3	300	2 fert & 3 irrig
2:	N/A					
3:	N/A					
4:	N/A					
5:	N/A					

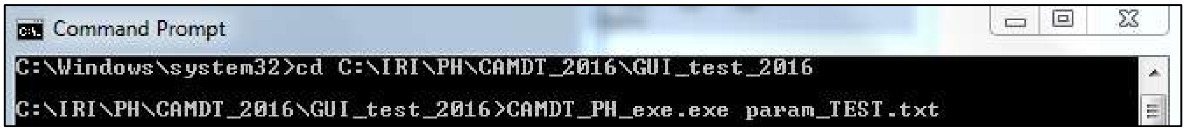
<Figure 23>

<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 (*DisAg*) 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
	dscsm046.exe	DSSAT 4.6 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	RICER046.CUL	contains genetic coefficients for rice growth simulation
	RICER046.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)

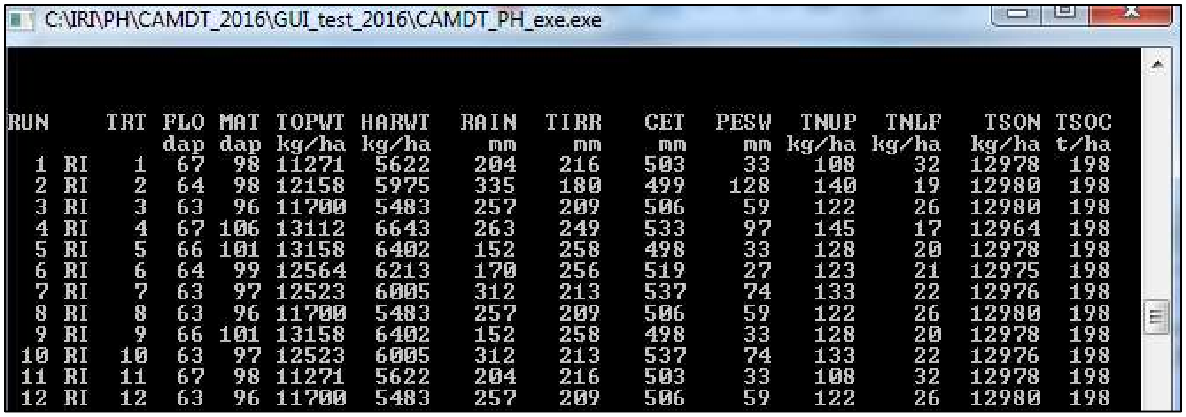
Next, you need to define threshold to compute water stress. Water stress (WS) is defined as (1 – ET_{act}/ET_{crop}), where ET_{crop} is potential daily root water uptake (demand of the atmosphere) and ET_{act} is actual transpiration due to soil moisture constraint. Therefore, WS=1 means the highest 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 you 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.

Now, let's move to the next box, "What-If scenarios" in Figure 23 to make a name of the scenario. **The scenario name should be exactly 4 characters** (any combination of letters and numbers are fine). Once you click the button "Click to write param1.txt" next to the scenario name box, "Crop" box will turn to green with "RI" (rice). Once you click the button "Click to write param1.txt", the CAMDT will create a text file, "param_####.txt" where #### is the scenario name you typed. This text file contains all information which you 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. You can run *CAMDT_PH_exe.exe* by typing a command line on your MS-Dos window as shown in Figure 24. Instead of doing this, however, you 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).



```
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
```

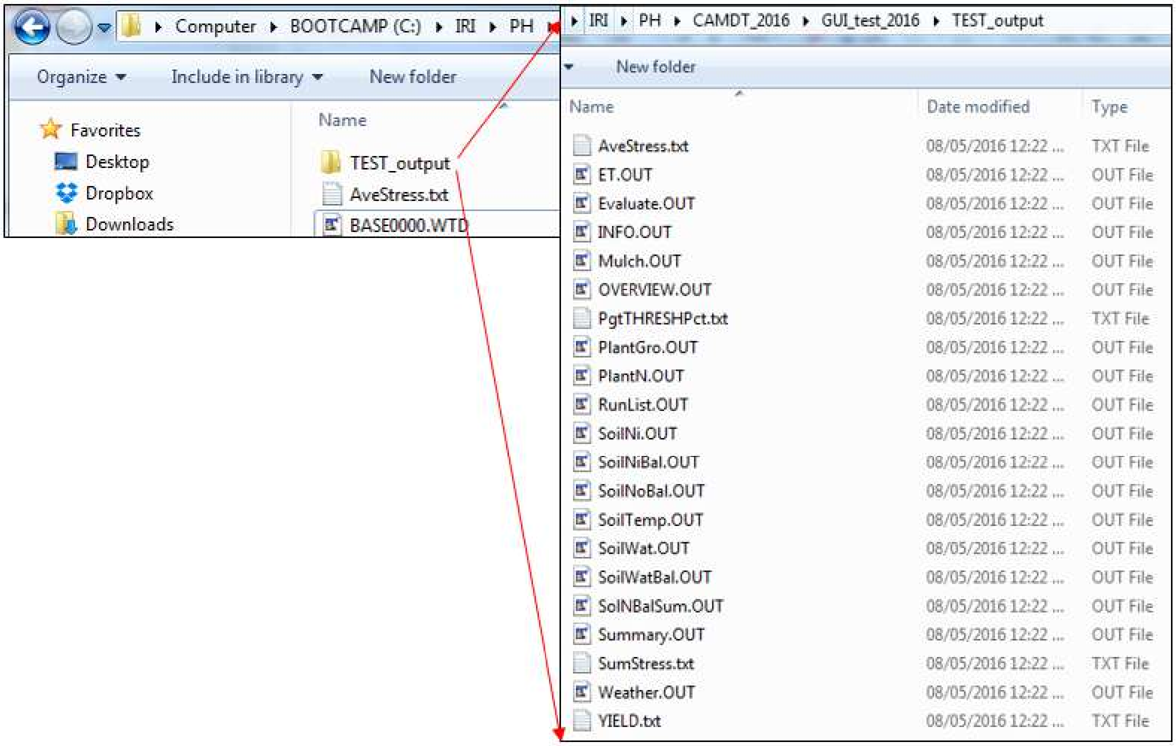
<Figure 24>



```
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>

Once all simulations ran successfully, you should be able to find a new folder “####_output” (in this exercise “TEST_output”) under your working directory as shown in Figure 26. The folder contains all the DSSTA 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.



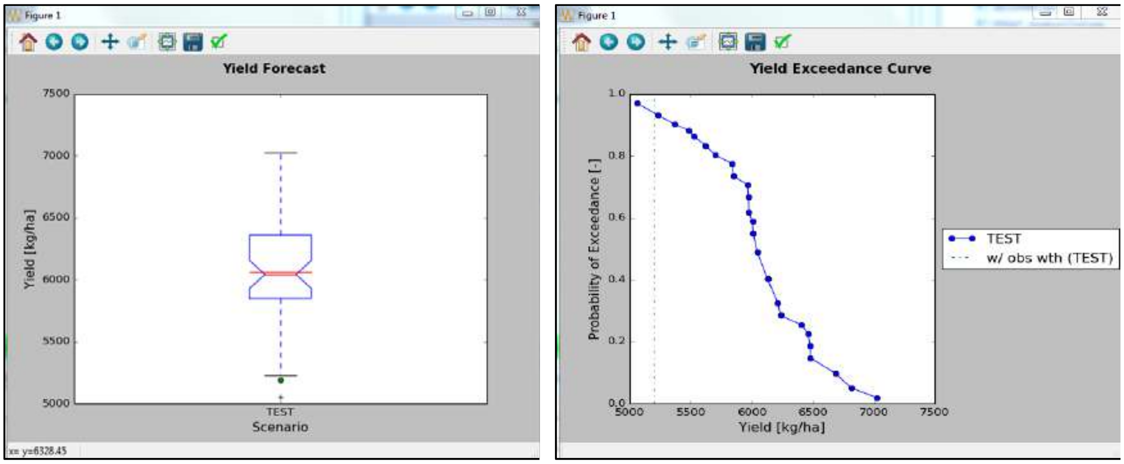
Name	Date modified	Type
AveStress.txt	08/05/2016 12:22 ...	TXT File
ET.OUT	08/05/2016 12:22 ...	OUT File
Evaluate.OUT	08/05/2016 12:22 ...	OUT File
INFO.OUT	08/05/2016 12:22 ...	OUT File
Mulch.OUT	08/05/2016 12:22 ...	OUT File
OVERVIEW.OUT	08/05/2016 12:22 ...	OUT File
PgtTHRESHPct.txt	08/05/2016 12:22 ...	TXT File
PlantGro.OUT	08/05/2016 12:22 ...	OUT File
PlantN.OUT	08/05/2016 12:22 ...	OUT File
RunList.OUT	08/05/2016 12:22 ...	OUT File
SoilNi.OUT	08/05/2016 12:22 ...	OUT File
SoilNiBal.OUT	08/05/2016 12:22 ...	OUT File
SoilNoBal.OUT	08/05/2016 12:22 ...	OUT File
SoilTemp.OUT	08/05/2016 12:22 ...	OUT File
SoilWat.OUT	08/05/2016 12:22 ...	OUT File
SoilWatBal.OUT	08/05/2016 12:22 ...	OUT File
SolNBalSum.OUT	08/05/2016 12:22 ...	OUT File
Summary.OUT	08/05/2016 12:22 ...	OUT File
SumStress.txt	08/05/2016 12:22 ...	TXT File
Weather.OUT	08/05/2016 12:22 ...	OUT File
YIELD.txt	08/05/2016 12:22 ...	TXT File

<Figure 26>

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 23. The first two buttons, “I. Display Yield Estimation (Boxplot)” and “II. Display Yield Estimation (Exceedance Curve)” are to display predicted yields in two different ways (using boxplot and exceedance curve). 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 indicates 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. In 2010, El Niño resulted in a drier weather in JFM and a drier SCF 39.73%BN, 39.2%NN, 20.45%AN was forecasted. Therefore the green dot show very low yield compared to the forecasted yields from climatology (20%AN, 35%NN, 45%BN we set in Figure 13).

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 × $(n + 1)^{-1}$, 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.

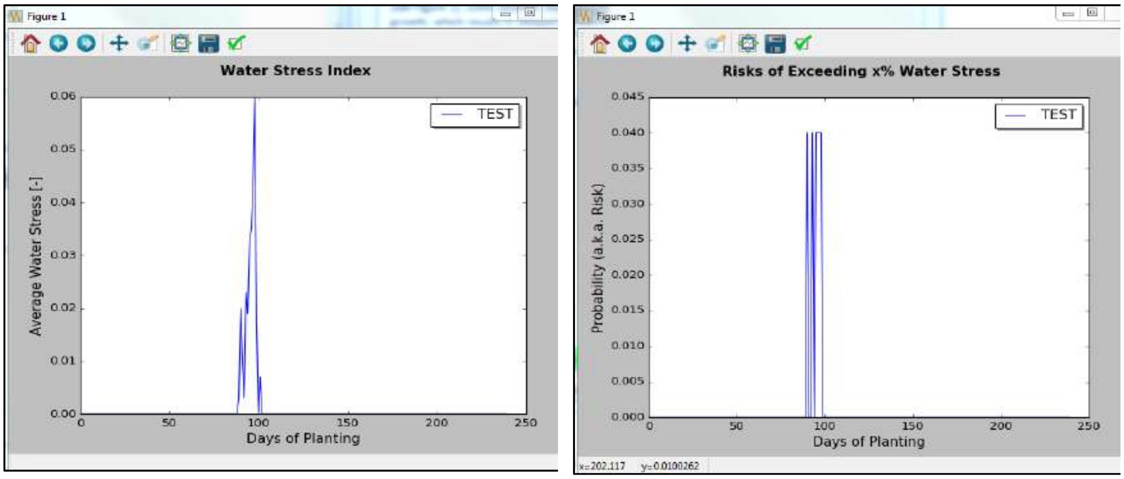
(a) (b)



<Figure 27>

Next two buttons, "III. Display Average Water Stress (WS)" and "IV. Display Risk of Exceeding X% WS" were 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 19), 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)).

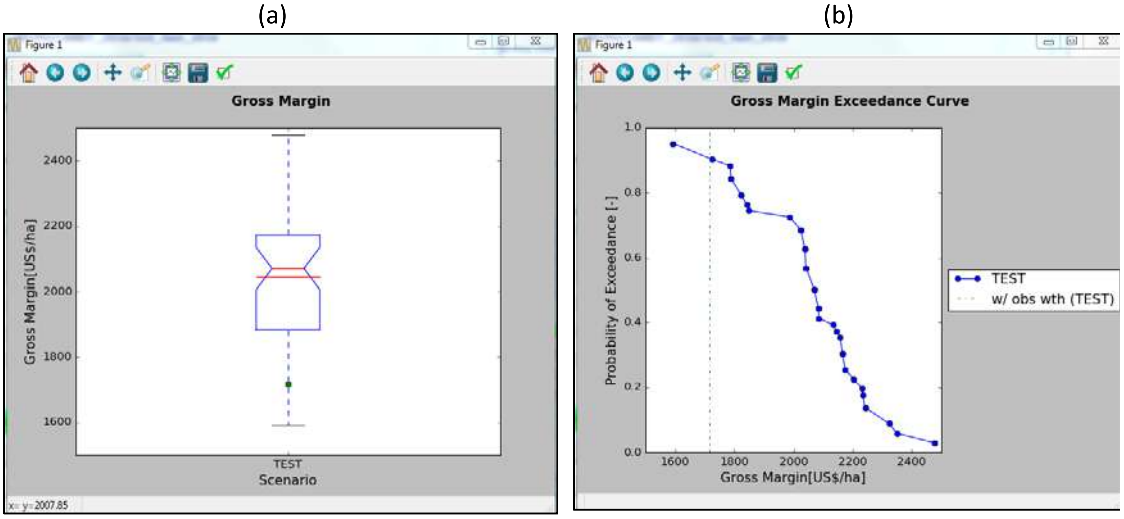
(a) (b)



<Figure 28>

Expected gross margins can be also 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.

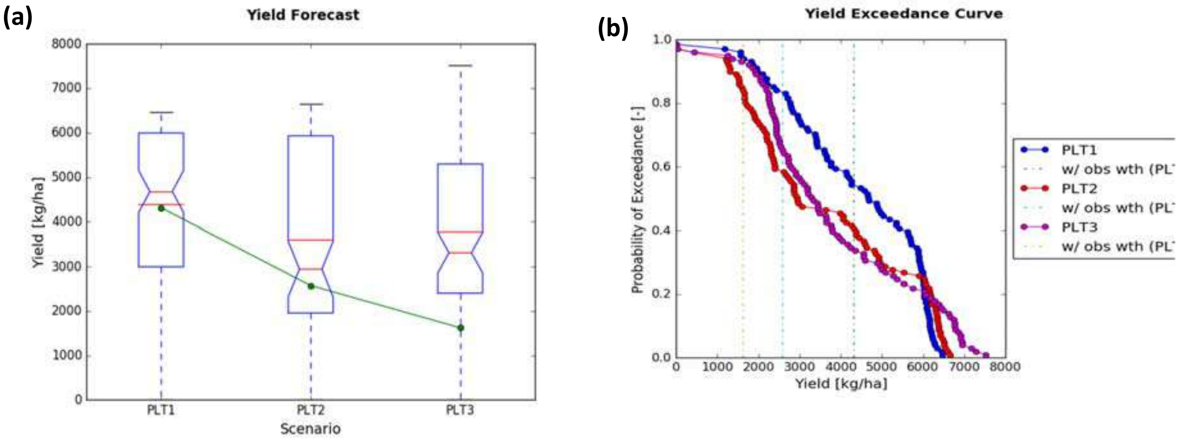
In this excise, we tried only one scenario. However, If you want to make another scenario (say by changing the planting date), you can simply go back to the page you want to make a change, make changes whatever you want and then type a new scenario name on the second line in Figure 23.



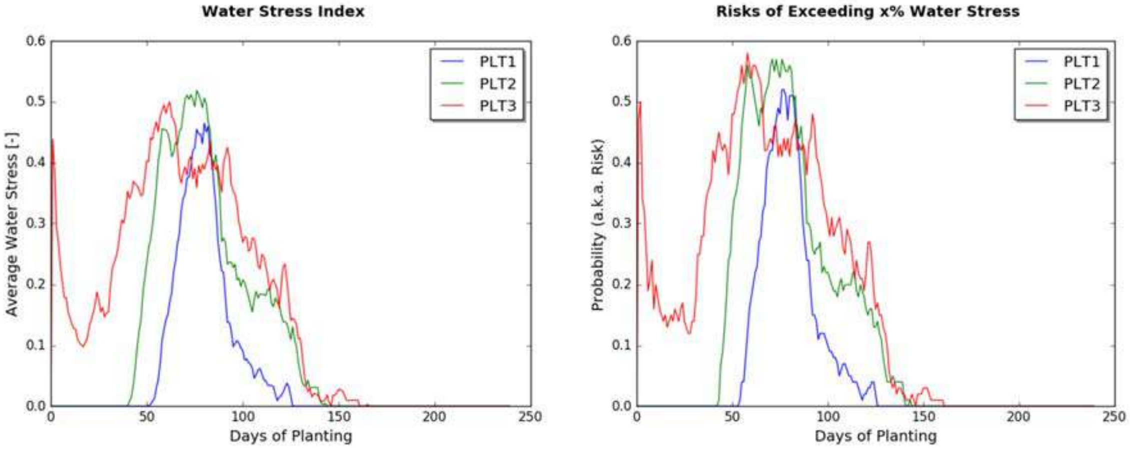
<Figure 29>

If you click “Click to write param2.txt” button, the newly updated information will be saved into another “param_####.txt” file. You can create up to 5 different scenarios for comparison. Example parameters file is: …WD\TEST_output\param_TEST.txt, where TEST is the scenario name entered by the user.

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



(c) **(d)**



<Figure 30>

References:

Han, E- J. and A. V. M. Ines (2017), Downscaling probabilistic seasonal climate forecasts for decision support in agriculture: A comparison of parametric and non-parametric approach. Climate Risk Management 18, 2017, Pages 51-65.

https://doi.org/10.1016/j.crm.2017.09.003 FEWSNET.

Hoogenboom, G., C. H. Porter, V. Shelia, K. J. Boote, U. Singh, J.W., White, L.A. Hunt, R. Ogoshi, J. I. Lizaso, J. Koo, S. Asseng, A. Singels, L. P. Moreno and J. W. Jones (2019), Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.7 (www.DSSAT.net). DSSAT Foundation, Gainesville, Florida, USA.

(https://www.ipcc-data.org/guidelines/pages/weather_generators.html)

Jones, J.W., G. Hoogenboom, C.H. Porter, K. J. Boote, W.D. Batchelor, L. A. Hunt, P. W. Wilkens, U. Singh, A. J. Gijsman, and J. T. Ritchie (2003), DSSAT Cropping System Model. European Journal of Agronomy 18:235-265.

Tsuji, G.Y., 1998. Network management and information dissemination for agrotechnology transfer. In: Tsuji, G.Y., Hoogenboom, G., Thornton, P.K. (Eds.), Understanding Options for Agricultural Production. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 367_/381

END OF USER GUIDE 2

USER GUIDE 3

RUNNING CAMDT/DSSAT CROP MODELLING FOR NON-RICE CEREALS

Authors: Bradwell J Garanganga, Trymore Nyakutambwa

Acronyms

CAMDT	Climate Agriculture Modelling and Decision Tool
DSSAT	Decision Support System for Agrotechnology Transfer
GUI	Graphical User Interface
IRI	International Research Institute for Climate and Society
MZCER046	DSSAT Maize Cultivar Code
NDJ	November, December, January season
RICER046	DSSAT Rice Cultivar Code
SGCER046	DSSAT Sorghum Cultivar Code
WD	Working Directory housing CAMDT/DSSAT and Weather files
WTD	File with daily Weather data aggregated over many years
WTH	File with one Year’s daily Weather data

1. INTRODUCTION

The 2017 edition of CAMDT is ONLY automated for and tied to the Rice crop and was originally developed to model Rice production in the Philippines, mostly the PILI weather centre in the Bicol river basin.

The CAMDT software was developed using the **FORTRAN** programming language and the **PYTHON** development platform, by IRI based at Columbia University. The **FORTRAN** software code is not free and is an intellectual property of IRI and its partners, whereas they have made the **PYTHON** based CAMDT code an Open Source software. Open Source means it is freely available on the public domain and has no Copyright or usage protection.

2. Rice Automated Modelling vs Other Crops’ Manual Modelling

a. Rice modelling is run using the automated CAMDT GUI screen as explained in Section 4 of User Guide 2, since the original CAMDT edition is strictly hard-coded for Rice.

b. Modelling procedures for other crops follow user intervention steps as described from Section 2 below.

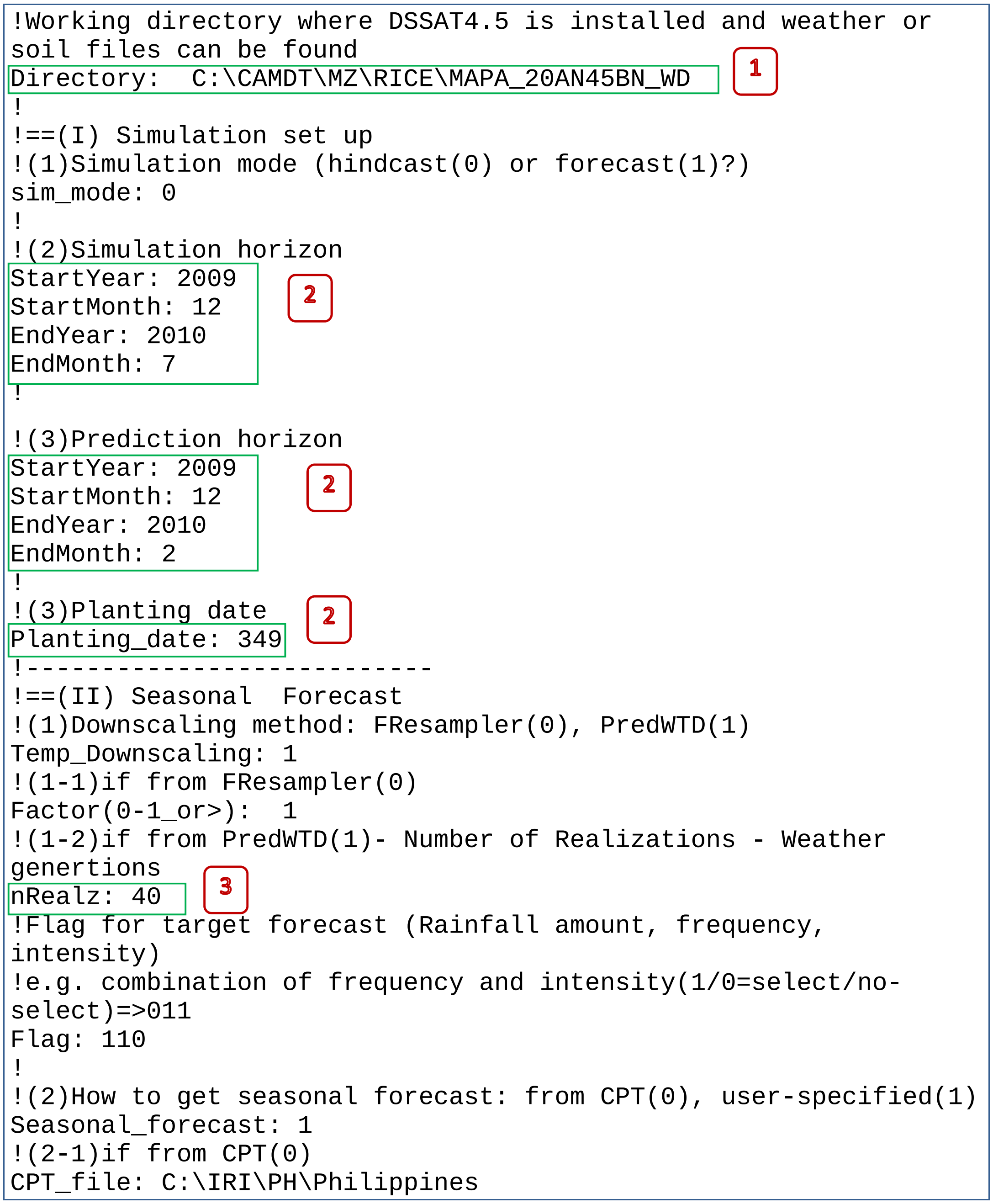
Note: Assume the initial RICE working directory is for the 20AN-45BN Tercile which is:
(...\RICE\MAPA_20AN45BN_WD

3. Running RICE Automated Dummy Model at CMD SHELL

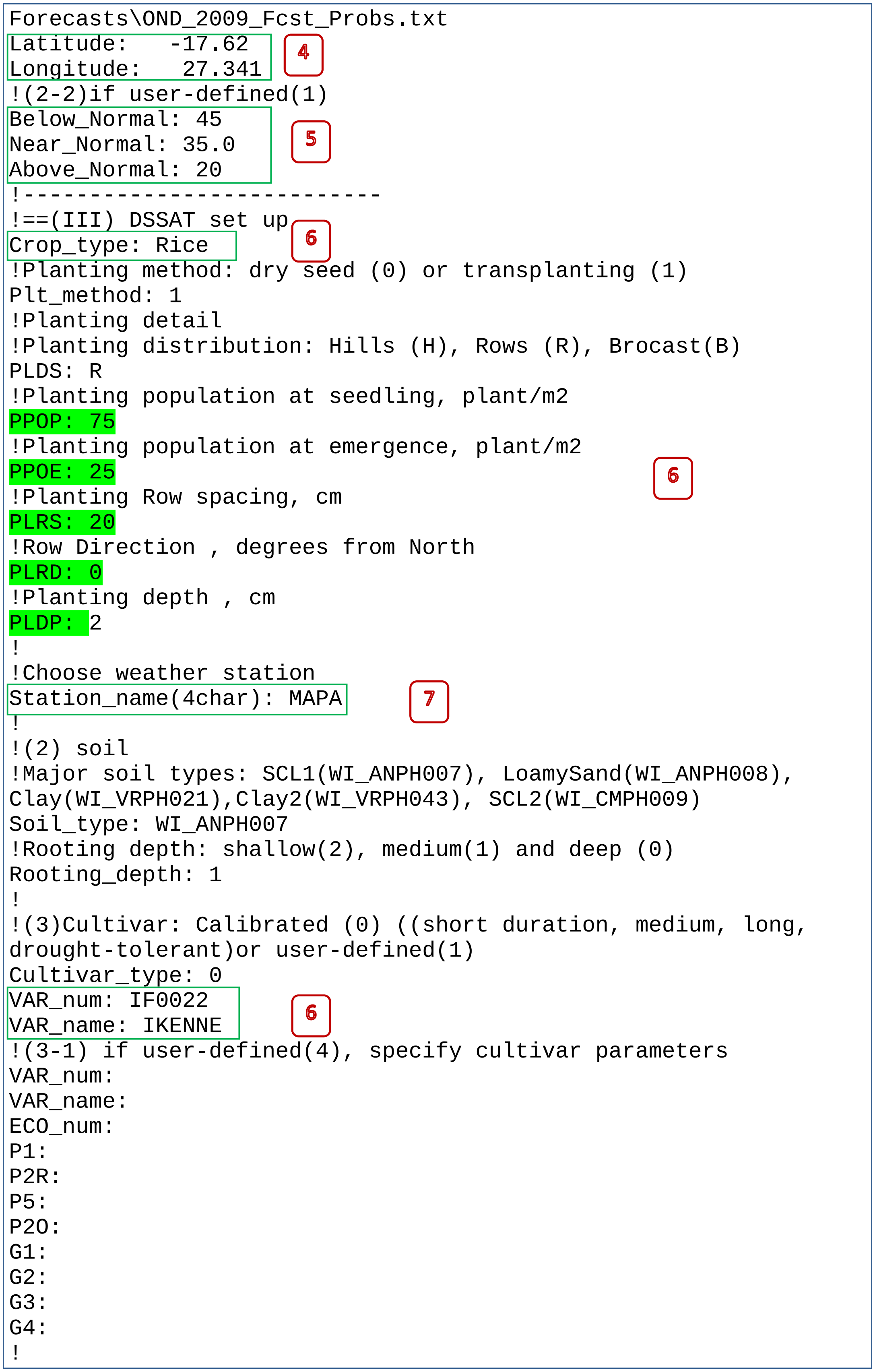
a) To start MAIZE crop simulation, Copy entire (...\RICE\MAPA_20AN45BN_WD) folder to new Working Dir (...\MAIZE\) folder usinf Windows Explorer

b) Open the file (...\MAIZE\MAPA_20AN45BN_WD\TEST_output\param_TEST.txt) using Notepad, where _WD designates your path to your new MAIZE working directory or folder. Parts of the parameters file that will be changed are enclosed in the green boxes as in <Figure 1> below:

<Figure 3> Sample CAMDT Parameters file



```
!Working directory where DSSAT4.5 is installed and weather or
soil files can be found
Directory:  C:\CAMDT\MZ\RICE\MAPA_20AN45BN_WD
!
!==(I) Simulation set up
!(1)Simulation mode (hindcast(0) or forecast(1)?)
sim_mode: 0
!
!(2)Simulation horizon
StartYear: 2009
StartMonth: 12
EndYear: 2010
EndMonth: 7
!

!(3)Prediction horizon
StartYear: 2009
StartMonth: 12
EndYear: 2010
EndMonth: 2
!
!(3)Planting date
Planting_date: 349
!----------------------------
!==(II) Seasonal  Forecast
!(1)Downscaling method: FResampler(0), PredWTD(1)
Temp_Downscaling: 1
!(1-1)if from FResampler(0)
Factor(0-1_or>):  1
!(1-2)if from PredWTD(1)- Number of Realizations - Weather
genertions
nRealz: 40
!Flag for target forecast (Rainfall amount, frequency,
intensity)
!e.g. combination of frequency and intensity(1/0=select/no-
select)=>011
Flag: 110
!
!(2)How to get seasonal forecast: from CPT(0), user-specified(1)
Seasonal_forecast: 1
!(2-1)if from CPT(0)
CPT_file: C:\IRI\PH\Philippines
```



```
Forecasts\OND_2009_Fcst_Probs.txt
Latitude:    -17.62
Longitude:    27.341
!(2-2)if user-defined(1)
Below_Normal: 45
Near_Normal: 35.0
Above_Normal: 20
!---------------------------
!==(III) DSSAT set up
Crop_type: Rice
!Planting method: dry seed (0) or transplanting (1)
Plt_method: 1
!Planting detail
!Planting distribution: Hills (H), Rows (R), Brocast(B)
PLDS: R
!Planting population at seedling, plant/m2
PPOP: 75
!Planting population at emergence, plant/m2
PPOE: 25
!Planting Row spacing, cm
PLRS: 20
!Row Direction , degrees from North
PLRD: 0
!Planting depth , cm
PLDP: 2
!
!Choose weather station
Station_name(4char): MAPA
!
!(2) soil
!Major soil types: SCL1(WI_ANPH007), LoamySand(WI_ANPH008),
Clay(WI_VRPH021),Clay2(WI_VRPH043), SCL2(WI_CMPH009)
Soil_type: WI_ANPH007
!Rooting depth: shallow(2), medium(1) and deep (0)
Rooting_depth: 1
!
!(3)Cultivar: Calibrated (0) ((short duration, medium, long,
drought-tolerant)or user-defined(1)
Cultivar_type: 0
VAR_num: IF0022
VAR_name: IKENNE
!(3-1) if user-defined(4), specify cultivar parameters
VAR_num:
VAR_name:
ECO_num:
P1:
P2R:
P5:
P2O:
G1:
G2:
G3:
G4:
!
```

```
!(4)Fertilizer: Yes(0), or No(1) -No automatic option
Fertilization: 1
!(4-1) if Yes, 'days after sawing',
'amount','material','applications'
Number_applications:
Fertilizer_1(days):
Fertilizer_1(amount):
Fertilizer_1(material):
Fertilizer_1(application):
Fertilizer_2(days):
Fertilizer_2(amount):
Fertilizer_2(material):
Fertilizer_2(application):
Fertilizer_3(days):
Fertilizer_3(amount):
Fertilizer_3(material):
Fertilizer_3(application):
!
!(5) Irrigation: Automatic when required(0),on reported dates
(2), no irrigation(3)
Irrigation_method: 3
!(5-1)if Automatic(0)
Management_depth(cm):
Threshold:
EndPoint:
Efficiency_Fraction:
End_of_Application:
Method:
Amount:
!(5-2)if Manual
Number_irrigation:
!(5-2-1) if transplanted
Puddling_date:
Puddling:
!whether transplanted or dry seeds
.
.
!---------------------------
!==(IV) Output analysis
WSI_threshold: 0.5
```

<Figure 3> Sample CAMDT Parameters file

c) Change TEST_output\param_TEST.txt file to reflect PATH of current desired Crop (MAIZE) 1
d) Leave params_TEST.txt file with all other RICE parameters and Save the file,
e) Switch to Command Prompt (type CMD <Enter>) at the windows Search box. Change into current crop …WD (e.g. MAIZE\MAPA_20AN45BN_WD) by typing:
CD C:\CAMDT\MZ\MAIZE\MAPA_20AN45BN_WD <Enter>

f) Run: CAMDT_PH.exe TEST_output\param_TEST.txt <Enter>
g) Allow shell command to run to the end and note (Successful termination, which ends by 'Cleaning current Working Directory'):

```
[      Cleaning current working directory...


  Processing completed...        ]

** Note: A set of tables with decimal numbers (NOT columns of -99) is displayed as the output
scrolls on the screen
```

<Figure 4> CAMDT Command Line successful termination message

h) Change …WD\TEST_output\param_TEST.txt to desired current crop, e.g. MAIZE using Notepad and save the changes:
   Crop_type: RICE --> MAIZE
   VAR_num: PHPS01 --> IF0022
   VAR_name: PSB Rc82 --> IKENNE

6

i) Run: CAMDT_PH.exe TEST_output\param_TEST.txt <Enter>
   with parameters set to current crop, e.g. MAIZE
   Shell command should report an error at the end:

```
[ Creating experiment file

   Creating base weather file: DSSBatch.V45

   Error in Cultivar entry.  Fix cultivar input file.

   File: RICER046.CUL   Line:   128   Error key: IPVAR

   Additional information may be available in WARNING.OUT file.

   Please press < ENTER > key to continue 99

   End of file reached, the word not matched, no meaning.

   ERROR, cannot open the file, SUMMARY.OUT

   forrtl: severe (606): unknown unit number

   Image           PC        Routine         Line       Source

   CAMDT_PH.exe      0042D719  Unknown            Unknown  Unknown  ]
```

<Figure 5> CAMDT Command Line Maize Cultivar Termination Message

j) Change MAIZE\MAPA_20AN45BN_WD\MAPA0001.SNX (all occurrences of RI --> MZ; that is RICE to MAIZE cultivar file selection), for SORGHUM change RI --> SG), see Figure 4 >>> below.

k) Run from current Working Directory at CMD SHELL:

```
DSCSM046.EXE MZCER046 B DSSBatch.V46 <Enter>
```

(to model MAIZE)

OR

```
DSCSM046.EXE SGCER046 B DSSBatch.V46 <Enter>
```

(to Model SORGHUM)

Maize Experiment file: MAIZE\MAPA_20AN45BN_WD\MAPA0001.SNX

```
*EXP.DETAILS: IRUP0001RI BAWP EXPERIMENTS

*GENERAL
@PEOPLE
-99
@ADDRESS
-99
@SITE
Bicol
@ PAREA  PRNO  PLEN  PLDR  PLSP  PLAY HAREA  HRNO  HLEN  HARM.........
    -99   -99   -99   -99   -99   -99   -99   -99   -99   -99

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
  11 0 0 Bicol_run1                 1  1  0  1  1  0  0  0  0  0  0  0  1
  21 0 0 Bicol_run1                 1  2  0  1  1  0  0  0  0  0  0  0  1
  31 0 0 Bicol_run1                 1  3  0  1  1  0  0  0  0  0  0  0  1
  41 0 0 Bicol_run1                 1  4  0  1  1  0  0  0  0  0  0  0  1
  51 0 0 Bicol_run1                 1  5  0  1  1  0  0  0  0  0  0  0  1
  61 0 0 Bicol_run1                 1  6  0  1  1  0  0  0  0  0  0  0  1
  71 0 0 Bicol_run1                 1  7  0  1  1  0  0  0  0  0  0  0  1
  81 0 0 Bicol_run1                 1  8  0  1  1  0  0  0  0  0  0  0  1
  91 0 0 Bicol_run1                 1  9  0  1  1  0  0  0  0  0  0  0  1
 101 0 0 Bicol_run1                 1 10  0  1  1  0  0  0  0  0  0  0  1
 111 0 0 Bicol_run1                 1 11  0  1  1  0  0  0  0  0  0  0  1
 121 0 0 Bicol_run1                 1 12  0  1  1  0  0  0  0  0  0  0  1
 131 0 0 Bicol_run1                 1 13  0  1  1  0  0  0  0  0  0  0  1
 141 0 0 Bicol_run1                 1 14  0  1  1  0  0  0  0  0  0  0  1

 381 0 0 Bicol_run1                 1 38  0  1  1  0  0  0  0  0  0  0  1
 391 0 0 Bicol_run1                 1 39  0  1  1  0  0  0  0  0  0  0  1
 401 0 0 Bicol_run1                 1 40  0  1  1  0  0  0  0  0  0  0  1
 411 0 0 Bicol_run1                 1 41  0  1  1  0  0  0  0  0  0  0  1
```

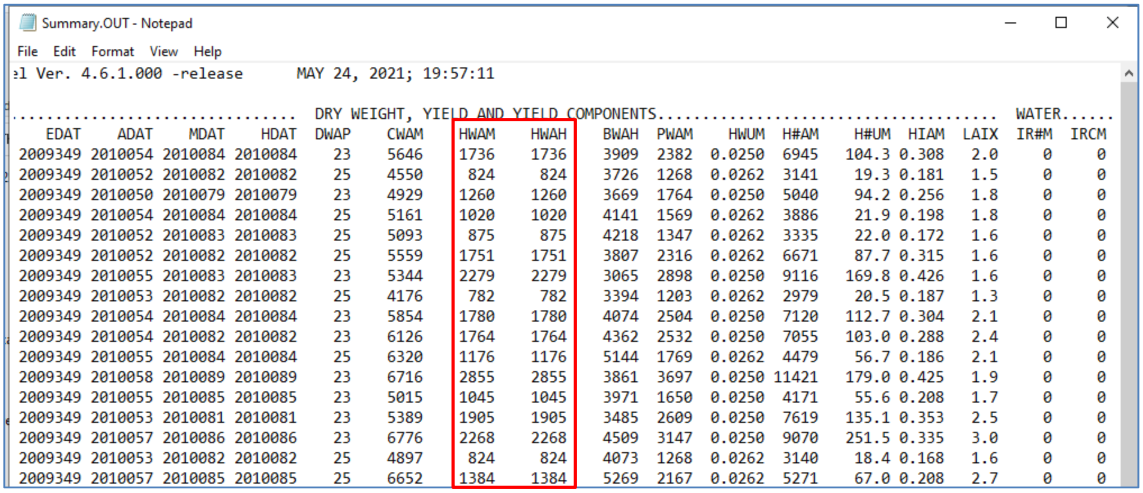
<Figure 6 > Maize Experiment file: MAIZE\MAPA_20AN45BN_WD\MAPA0001.SNX

Allow the program run to the end and DSSAT will produce:

MAIZE\MAPA_20AN45BN_WD\SUMMARY.OUT file with 2 identical columns (HWAM & HWAH) representing the Yield predicted by DSSAT.

HWAM - Harvest Weight At Maturity (measured in kg)

HWAH - Harvest Weight At Harvesting (measured in kg)



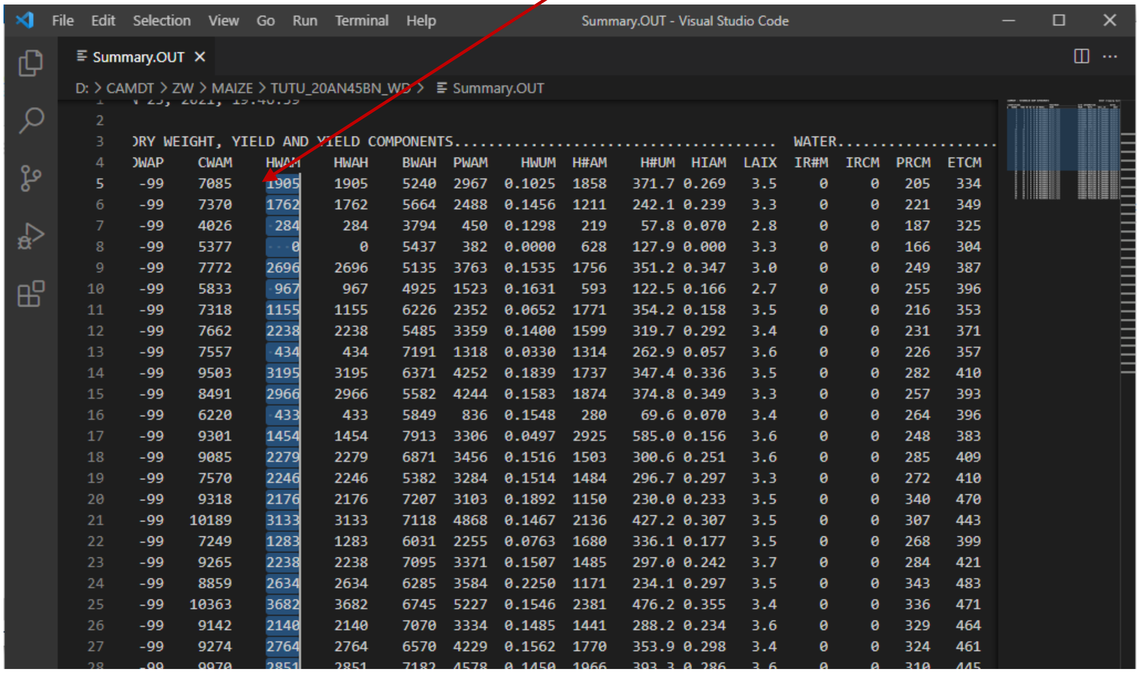
```
el Ver. 4.6.1.000 -release      MAY 24, 2021; 19:57:11

..............................  DRY WEIGHT, YIELD AND YIELD COMPONENTS..................................  WATER......
   EDAT    ADAT    MDAT    HDAT  DWAP   CWAM  HWAM   HWAH   BWAH  PWAM   HWUM  H#AM   H#UM  HIAM  LAIX  IR#M  IRCM
2009349 2010054 2010084 2010084    23   5646  1736   1736   3909  2382 0.0250  6945  104.3 0.308   2.0     0     0
2009349 2010052 2010082 2010082    25   4550   824    824   3726  1268 0.0262  3141   19.3 0.181   1.5     0     0
2009349 2010050 2010079 2010079    23   4929  1260   1260   3669  1764 0.0250  5040   94.2 0.256   1.8     0     0
2009349 2010054 2010084 2010084    25   5161  1020   1020   4141  1569 0.0262  3886   21.9 0.198   1.8     0     0
2009349 2010052 2010083 2010083    25   5093   875    875   4218  1347 0.0262  3335   22.0 0.172   1.6     0     0
2009349 2010052 2010082 2010082    25   5559  1751   1751   3807  2316 0.0262  6671   87.7 0.315   1.6     0     0
2009349 2010055 2010083 2010083    23   5344  2279   2279   3065  2898 0.0250  9116  169.8 0.426   1.6     0     0
2009349 2010053 2010082 2010082    25   4176   782    782   3394  1203 0.0262  2979   20.5 0.187   1.3     0     0
2009349 2010054 2010084 2010084    23   5854  1780   1780   4074  2504 0.0250  7120  112.7 0.304   2.1     0     0
2009349 2010054 2010082 2010082    23   6126  1764   1764   4362  2532 0.0250  7055  103.0 0.288   2.4     0     0
2009349 2010055 2010084 2010084    25   6320  1176   1176   5144  1769 0.0262  4479   56.7 0.186   2.1     0     0
2009349 2010058 2010089 2010089    23   6716  2855   2855   3861  3697 0.0250 11421  179.0 0.425   1.9     0     0
2009349 2010055 2010085 2010085    23   5015  1045   1045   3971  1650 0.0250  4171   55.6 0.208   1.7     0     0
2009349 2010053 2010081 2010081    23   5389  1905   1905   3485  2609 0.0250  7619  135.1 0.353   2.5     0     0
2009349 2010057 2010086 2010086    23   6776  2268   2268   4509  3147 0.0250  9070  251.5 0.335   3.0     0     0
2009349 2010053 2010082 2010082    25   4897   824    824   4073  1268 0.0262  3140   18.4 0.168   1.6     0     0
2009349 2010057 2010085 2010085    25   6652  1384   1384   5269  2167 0.0262  5271   67.0 0.208   2.7     0     0
```

<Figure 7> Summary.OUT showing Yield kg columns at Harvest

4. Use VS Code to Create a CAMDT Crop YIELD.txt file

Use VS Code to copy out one of the columns (HWAM or HWAH) and paste to a new file, save that file as ...WD\TEST_output\YIELD.txt

Place cursor here



File Edit Selection View Go Run Terminal Help
Summary.OUT - Visual Studio Code
Summary.OUT
D: > CAMDT > ZW > MAIZE > TUTU_20AN45BN_WD > Summary.OUT

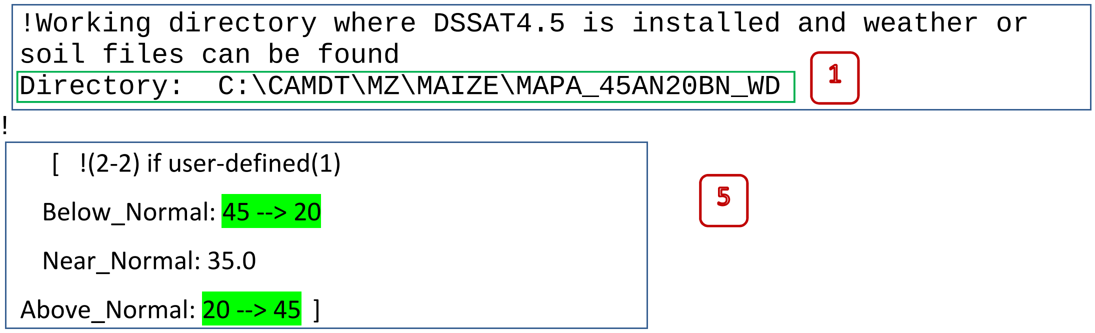
```

DRY WEIGHT, YIELD AND YIELD COMPONENTS..................................  WATER...................
DWAP    CWAM   HWAM    HWAH    BWAH  PWAM    HWUM  H#AM    H#UM  HIAM  LAIX  IR#M  IRCM  PRCM  ETCM
 -99    7085   1905    1905    5240  2967  0.1025  1858   371.7 0.269   3.5     0     0   205   334
 -99    7370   1762    1762    5664  2488  0.1456  1211   242.1 0.239   3.3     0     0   221   349
 -99    4026    284     284    3794   450  0.1298   219    57.8 0.070   2.8     0     0   187   325
 -99    5377      0       0    5437   382  0.0000   628   127.9 0.000   3.3     0     0   166   304
 -99    7772   2696    2696    5135  3763  0.1535  1756   351.2 0.347   3.0     0     0   249   387
 -99    5833    967     967    4925  1523  0.1631   593   122.5 0.166   2.7     0     0   255   396
 -99    7318   1155    1155    6226  2352  0.0652  1771   354.2 0.158   3.5     0     0   216   353
 -99    7662   2238    2238    5485  3359  0.1400  1599   319.7 0.292   3.4     0     0   231   371
 -99    7557    434     434    7191  1318  0.0330  1314   262.9 0.057   3.6     0     0   226   357
 -99    9503   3195    3195    6371  4252  0.1839  1737   347.4 0.336   3.5     0     0   282   410
 -99    8491   2966    2966    5582  4244  0.1583  1874   374.8 0.349   3.3     0     0   257   393
 -99    6220    433     433    5849   836  0.1548   280    69.6 0.070   3.4     0     0   264   396
 -99    9301   1454    1454    7913  3306  0.0497  2925   585.0 0.156   3.6     0     0   248   383
 -99    9085   2279    2279    6871  3456  0.1516  1503   300.6 0.251   3.6     0     0   285   409
 -99    7570   2246    2246    5382  3284  0.1514  1484   296.7 0.297   3.3     0     0   272   410
 -99    9318   2176    2176    7207  3103  0.1892  1150   230.0 0.233   3.5     0     0   340   470
 -99   10189   3133    3133    7118  4868  0.1467  2136   427.2 0.307   3.5     0     0   307   443
 -99    7249   1283    1283    6031  2255  0.0763  1680   336.1 0.177   3.5     0     0   268   399
 -99    9265   2238    2238    7095  3371  0.1507  1485   297.0 0.242   3.7     0     0   284   421
 -99    8859   2634    2634    6285  3584  0.2250  1171   234.1 0.297   3.5     0     0   343   483
 -99   10363   3682    3682    6745  5227  0.1546  2381   476.2 0.355   3.4     0     0   336   471
 -99    9142   2140    2140    7070  3334  0.1485  1441   288.2 0.234   3.6     0     0   329   464
 -99    9274   2764    2764    6570  4229  0.1562  1770   353.9 0.298   3.4     0     0   324   461
 -99    9970   2851    2851    7182  4578  0.1450  1966   393.3 0.286   3.6     0     0   310   445
```

<Figure 8> Copying DSSAT Crop Yield Output for Non-Rice Cereal

- i. Open the file …WD\Summary.OUT using MS VS Code (see Figure 6 above)
- ii. Place cursor just before 1st digit of 1st data row values, i.e. Row 5 of HWAH column
  If the 1st row has 3 digit figure, select the space before the 1st digit so that total characters selected are always 4.
- iii. Press Shift + Ctrl + Alt and press Right arrow (→) to select all 4 characters if the 1st figure
- iv. Whilst still pressing Shift + Ctrl + Alt, use down arrow (↓) to select all the figures of column HWAH
- v. Release keys and Press Ctrl + C to copy the selected column figures
- vi. Go to File --> New File and then Press Ctrl + V to paste the column values into a new file
- vii. Go to File --> Save As and Select the …WD\TEST_output folder and type the file name as YIELD, then press <Enter>
- viii. You now have the YIELD.txt file for current Crop (Maize, Sorghum, etc.) for 20AN-45BN

5. Running Crop Modelling for 45AN-20BN tercile

- a. Repeat from Section 2 to 3 above by Copying …\RICE\MAPA_45AN20BN_WD to …**MAIZE**\ folder for the same Weather station but ensure that params_TEST.txt is changed correctly to:



```
!Working directory where DSSAT4.5 is installed and weather or
soil files can be found
Directory:  C:\CAMDT\MZ\MAIZE\MAPA_45AN20BN_WD
!
   [  !(2-2) if user-defined(1)
  Below_Normal: 45 --> 20
  Near_Normal: 35.0
Above_Normal: 20 --> 45  ]
```

<Figure 9> Changing Tercile from 20AN45BN to 45AN20BN in parameters.txt file

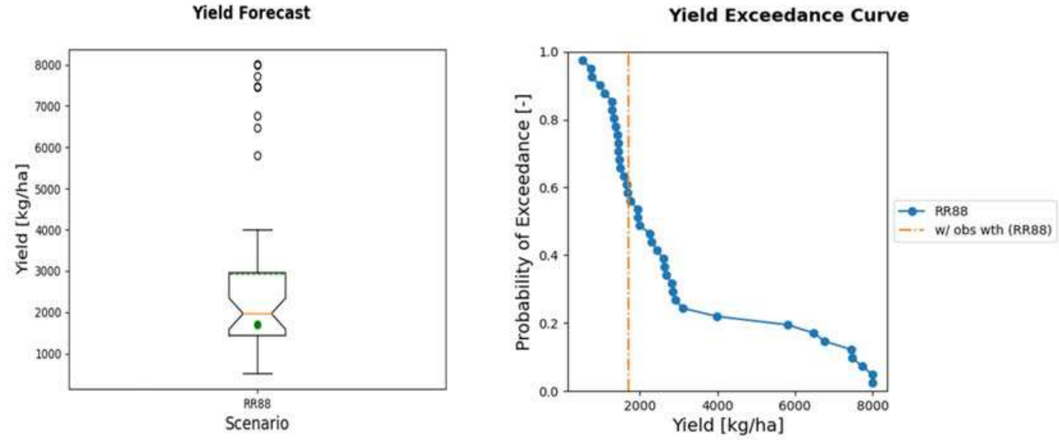
- b. Repeat from Section 2 to 4 above for the other crop (e.g. **SORGHUM**) but switching …WD to …\SORGHUM\MAP_20AN45BN_WD for the 20AN-45BN tercile

  AND

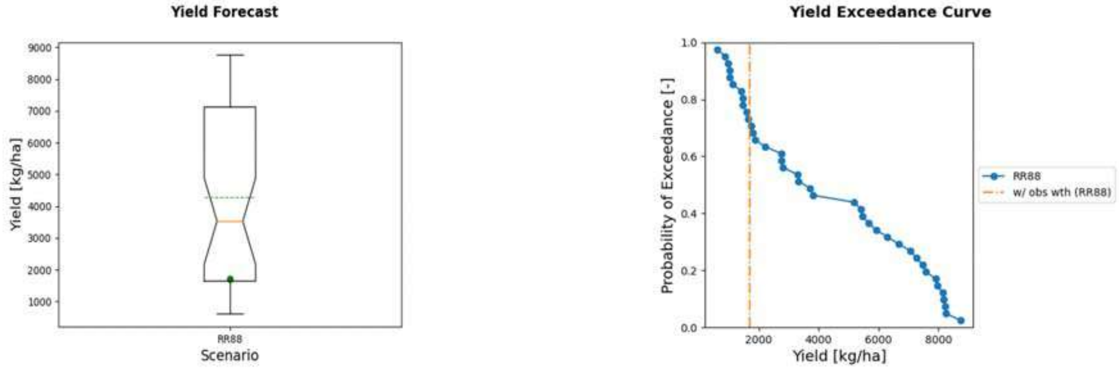
  …\SORGHUM\MAP_45AN20BN_WD for the 45AN-20BN tercile

6. Generate CAMDT Crop Yield Graphs

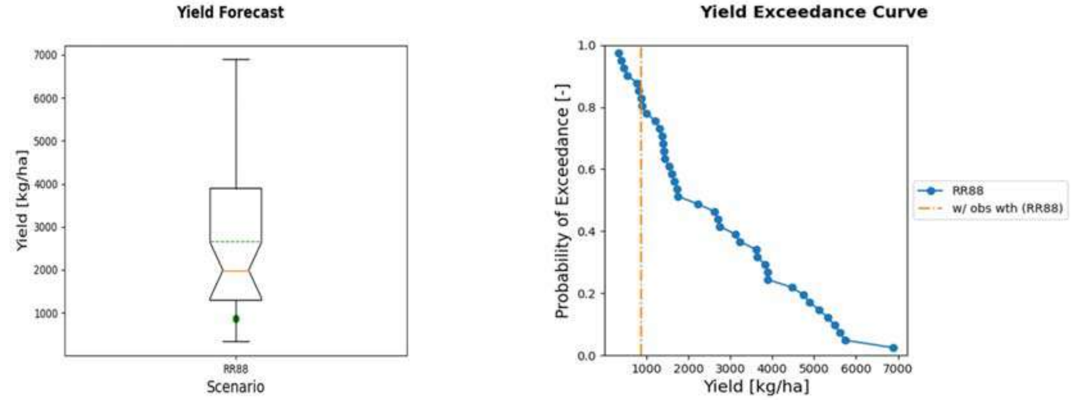
- a. Run <py CAMDT_2017_0310.py> from CMD SHELL Prompt in current …WD folder of desired crop and tercile or double-click CAMDT_2017_0310.py from Windows Explorer in current desired …WD folder.
- b. Setup/fill in simulation parameters to resemble those in current crop's parameter file: …WD\TEST_output\parameter_TEST.txt, fill in scenario (TEST fields and click on the scenario <Write button>)
- c. Don't click on the green Run DSSAT button
- d. Click the Boxplot button and save the graph in \MAIZE\MAPA_20AN45BN\Graphs\ folder
- e. Repeat the same (d.) for Exceedance curve)
- f. Repeat (b.) to (e.) in this section for \MAIZE\MAPA_45AN20BN\



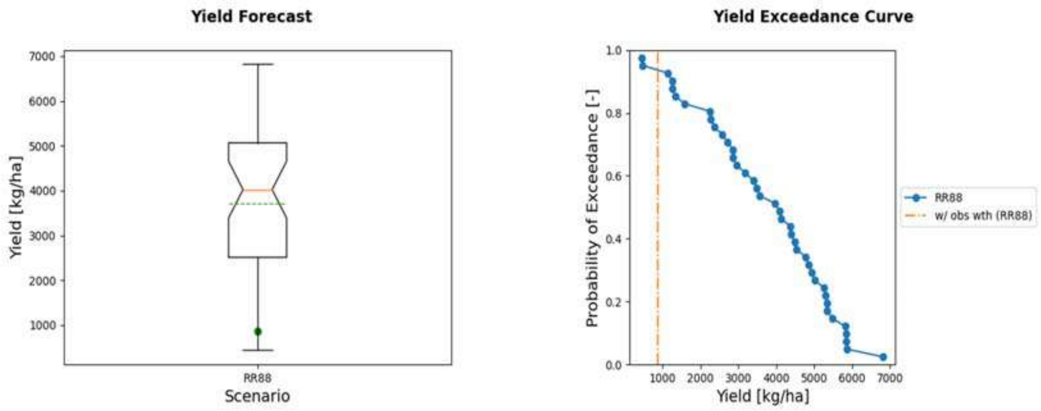
<Figure 10a> Mozambique MAPAI RICE Boxplot and Exceedance Curve at 20AN-45BN for JFM 2009-2010



<Figure 10b> Mozambique MAPAI RICE Boxplot and Exceedance Curve at 45AN-20BN for JFM 2009-2010



<Figure 10c> Mozambique MAPAI MAIZE Boxplot & Exceedance Curve at 20AN-45BN for JFM 2009-2010



<Figure 10d> Mozambique MAPAI MAIZE Boxplot & Exceedance Curve at 45AN-20BN for JFM 2009-2010

g. Repeat Section 5 above for the other crop (e.g. SORGHUM) but switching …WD to:
…\SORGHUM\MAP_20AN45BN_WD, for the 20AN45BN tercile

AND

…\SORGHUM\MAP_45AN20BN_WD, for the 45AN20BN tercile

and CULTIVAR from RICE to SORGHUM in param_TEST.txt for both terciles:

```
!Planting distribution: Hills (H), Rows (R), Broadcast (B)
PLDS: R
!Planting population at seedling, plant/m2
PPOP: 10
!Planting population at emergence, plant/m2
PPOE: 10
!Planting Row spacing, cm
PLRS: 70
!Row Direction , degrees from North
PLRD: 0
!Planting depth , cm
PLDP: 4
.
.
VAR_num: PHPS01 --> IB0055;
VAR_name: PSB Rc82 --> PIONEER 850

.
.
```

<Figure 11> Changing CULTIVAR details from RICE to SORGHUM, in parameter.txt file

END OF USER GUIDE 3