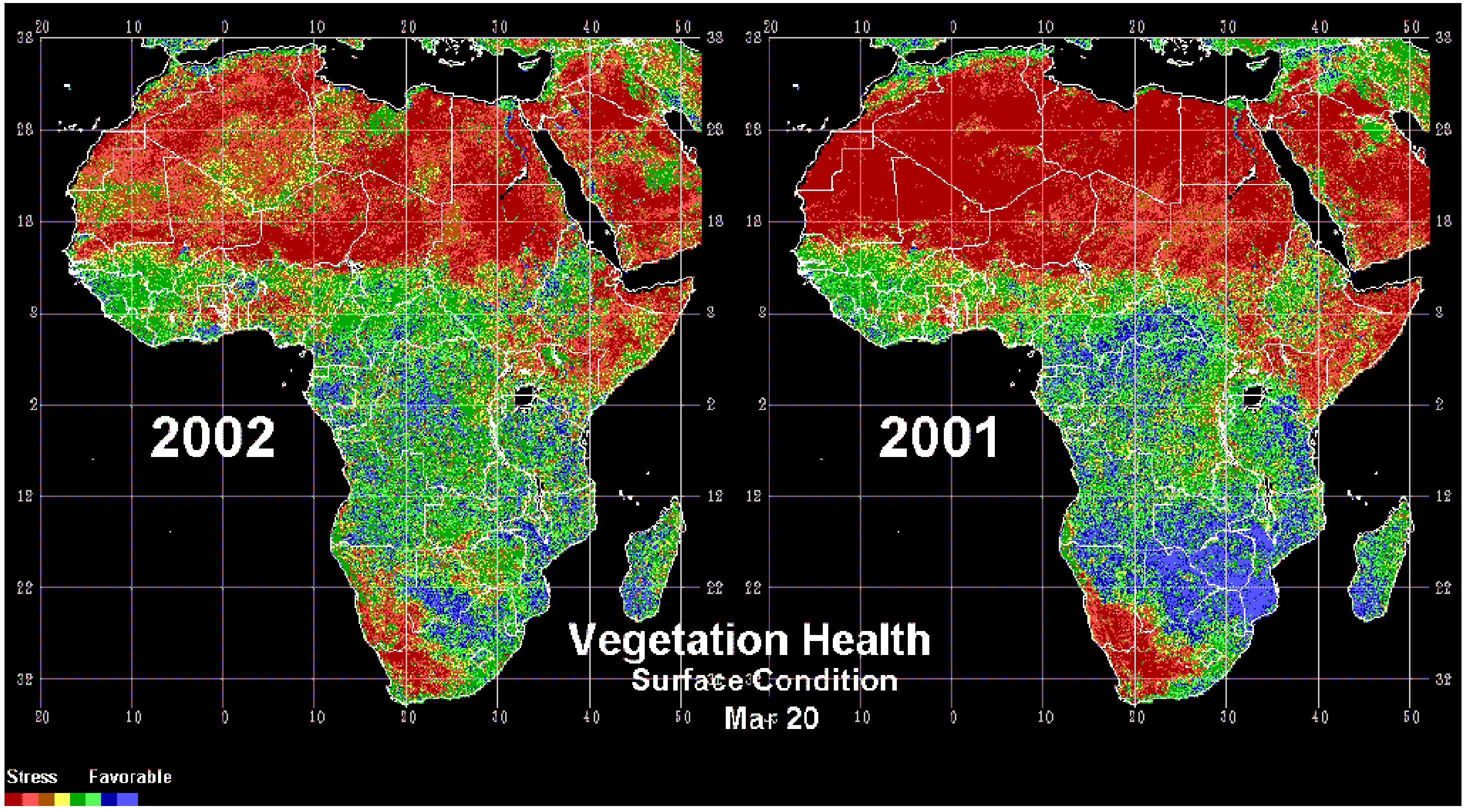
Experimental

	Value
Spatial scale of results	Season to decades
Time to conduct analysis	Site
Data needs	4 to 5
Skill or training required	1
Technological resources	4 to 5
Financial resources	4 to 5
Range for ranking: 1 (least amount) to 5 (most demanding).	

Examples: growth chambers, experimental fields.

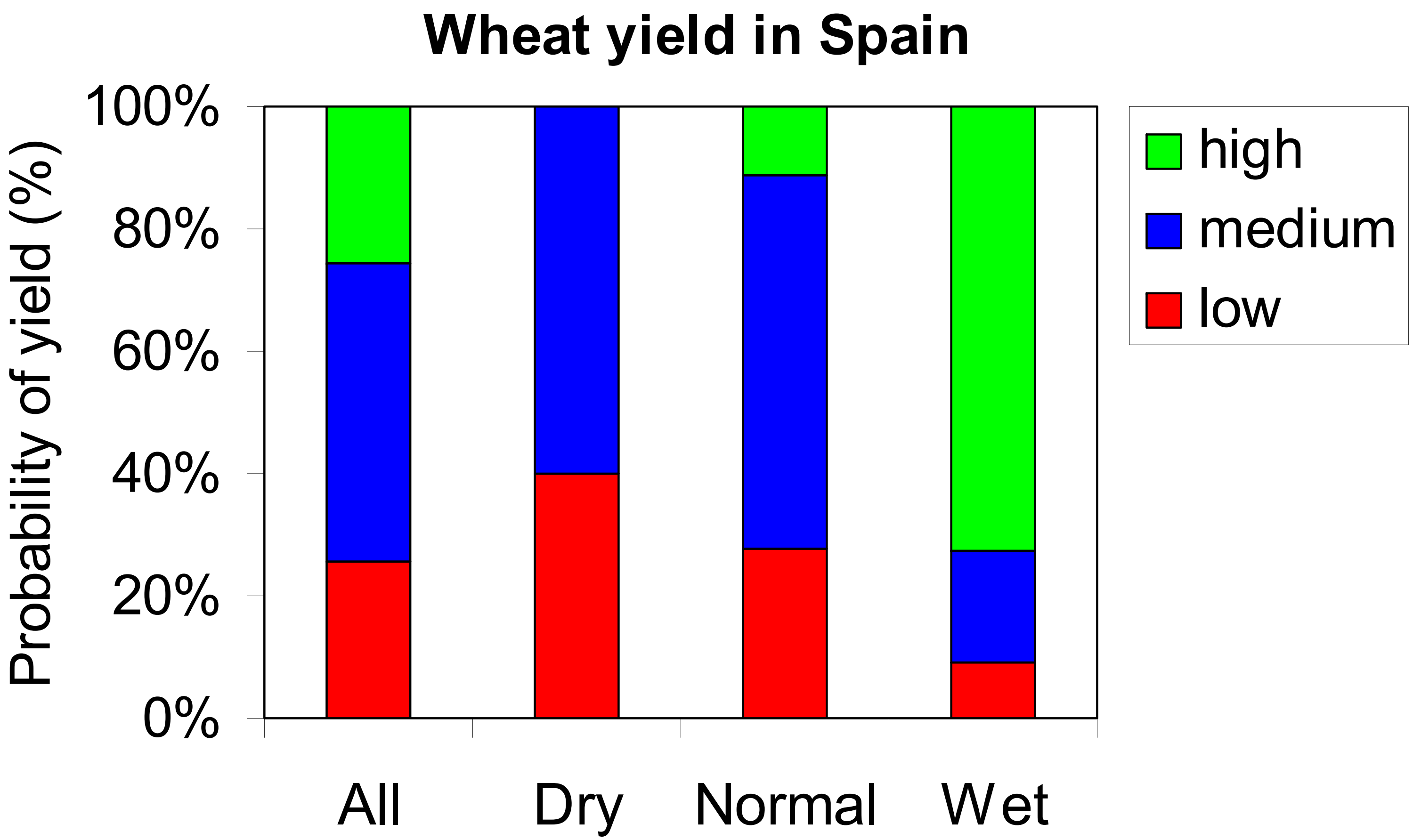
Analogues: Drought, Floods



Africa vegetation health (VT - index)
Vegetation health: **Red – stressed**, **Green – fair**, **Blue – favourable**

(Source: NOAA/NESDIS)

Analogues: Drought



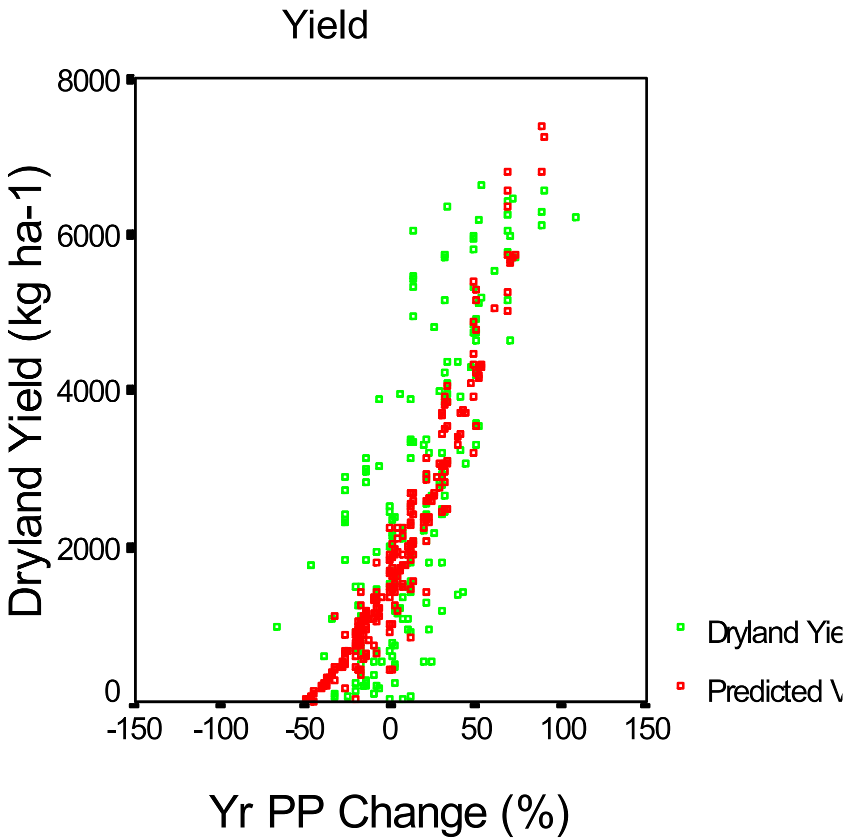
Analogues (space and time)

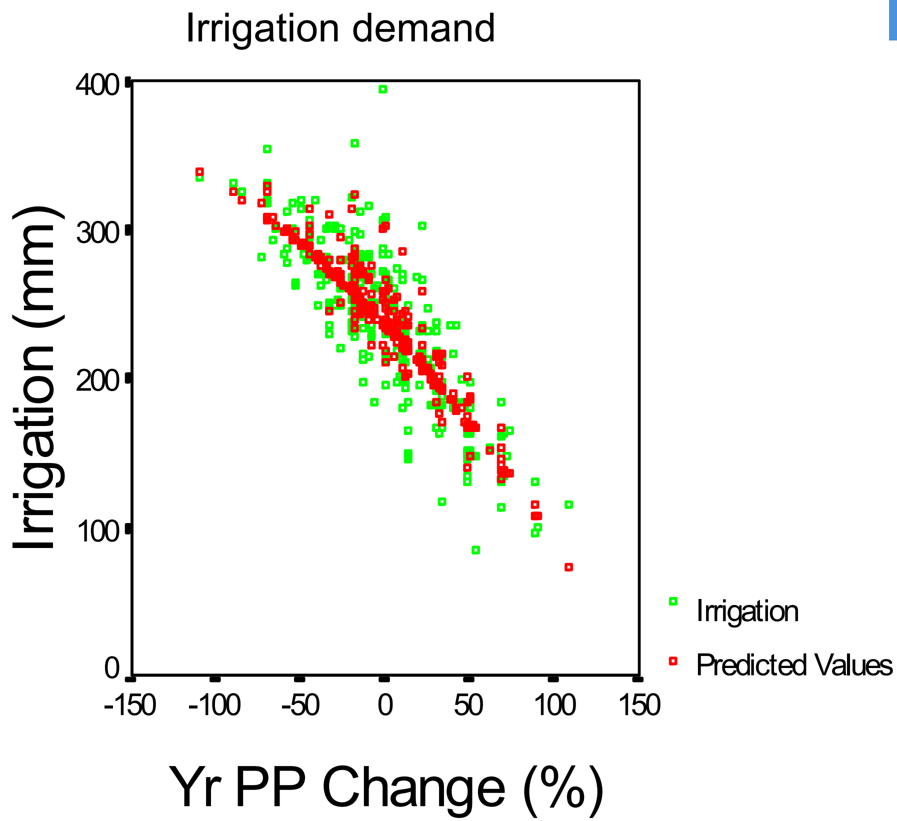
Example: existing climate in another area or in previous time

	Value
Spatial scale of results	Decades
Time to conduct analysis	Site to region
Data needs	1 to 2
Skill or training required	1 to 3
Technological resources	1 to 3
Financial resources	1 to 2
Range for ranking: 1 (least amount) to 5 (most demanding).	

Production Functions

Statistically-derived functions (Almeria – Wheat)





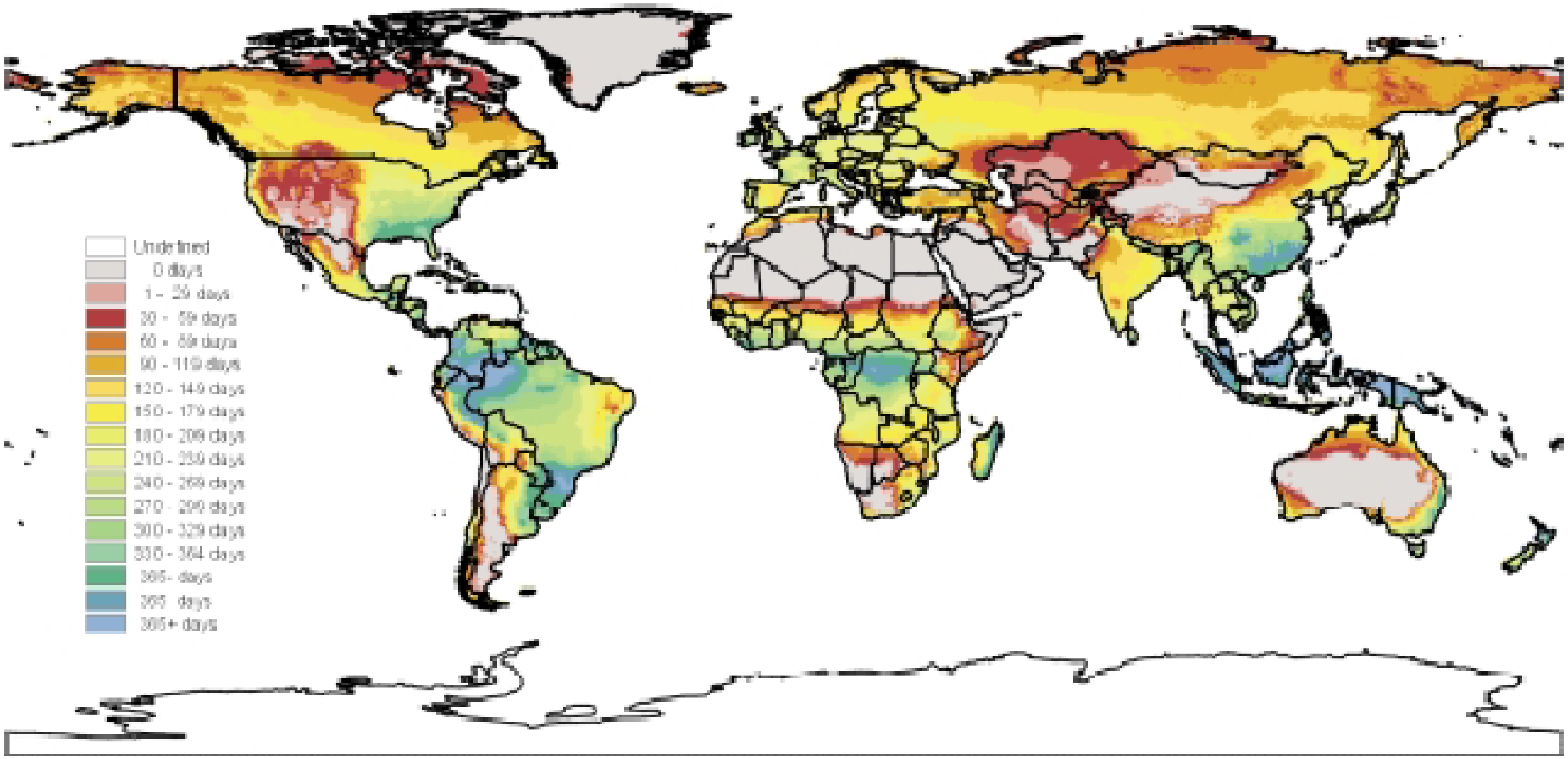
(Source: Iglesias et al., 1999)

Production Functions

Example: derived with empirical data.

	Value
Spatial scale of results	Season to decades
Time to conduct analysis	Site to globe
Data needs	2 to 4
Skill or training required	3 to 5
Technological resources	3 to 5
Financial resources	2 to 4
Range for ranking: 1 (least amount) to 5 (most demanding).	

Agroclimatic Indices



Length of the growing periods (reference climate, 1961–1990).

(IIASA-FAO, AEZ)

Agroclimatic Indices

	Value
Spatial scale of results	Season to decades
Time to conduct analysis	Site to globe
Data needs	1 to 3
Skill or training required	2 to 3
Technological resources	2 to 3
Financial resources	1 to 3
Range for ranking: 1 (least amount) to 5 (most demanding).	

Example: FAO, etc.

Crop Models

Based on

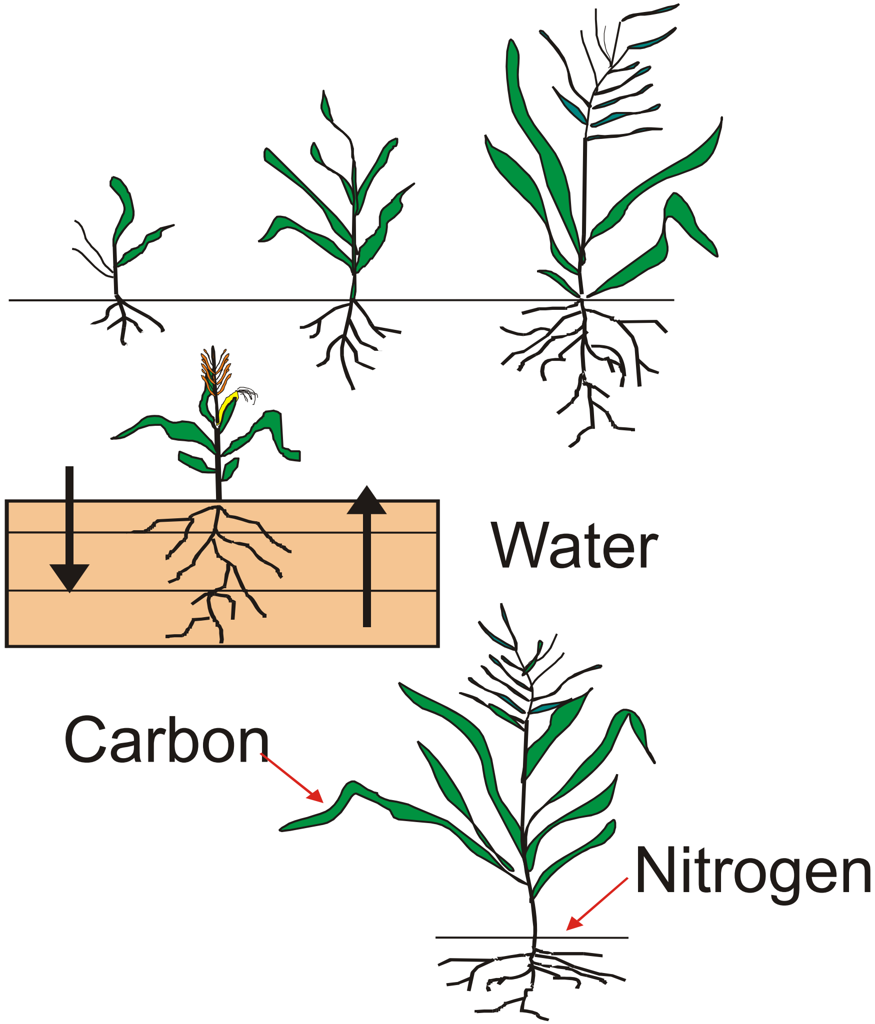
Understanding of plants, soil, weather, management

Calculate

Growth, yield, fertilizer & water requirements, etc

Require

Information (inputs): weather, management, etc



Models – Advantages

- Models are assisting tools; -stakeholder interaction is essential
- Models allow us to ask "what if" questions, the relative benefit of alternative management can be highlighted:
  a) Improve planning and decision-making
  b) Assist in applying lessons learned to policy issues
- Models permit integration across scales, sectors and users.

Models – Limitations

- Models need to be calibrated and validated to represent reality
- Models need data and technical expertise
- Models alone do not provide an answer; stakeholder interaction is essential.

Crop Models

	Value
Spatial scale of results	Daily to centuries
Time to conduct analysis	Site to region
Data needs	4 to 5
Skill or training required	5
Technological resources	4 to 5
Financial resources	4 to 5
Range for ranking: 1 (least amount) to 5 (most demanding).	

Examples: CROPWAT, CERES, SOYGRO, APSIM, WOFOST, etc.

Economic Models

- Consider both producers and consumers of agricultural goods (supply and demand)
- Economic measures of interest include:
  a) How do prices respond to production amounts?
  b) How is income maximized with different production and consumption opportunities?

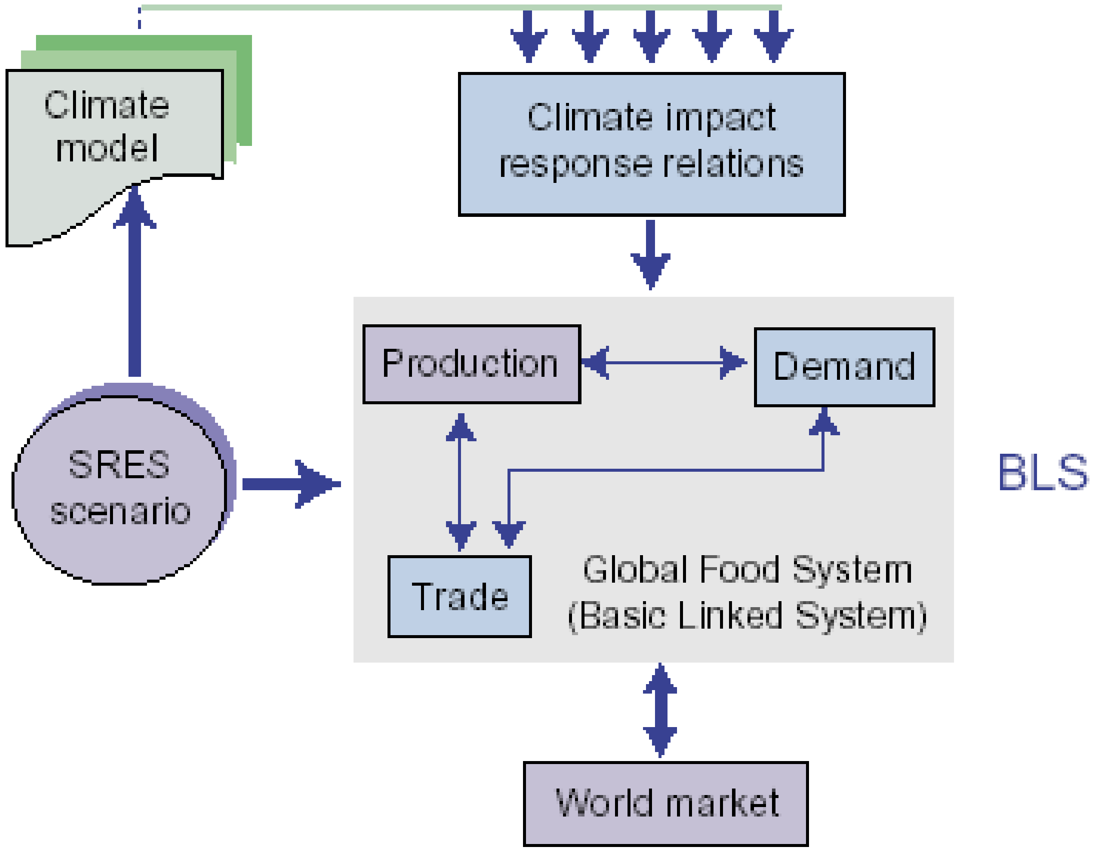
Economic Models (continued)

- Microeconomic: Farm
- Macroeconomic: Regional economies
- All: Crop yield is a primary input (demand is the other primary input)
- Economic models should be built bottom-up.

Farm Models – Differences

	Small holder farmer	**Commercial farmer**
Strategy of production	Stabilize food production	Maximize income
Risk	Malnutrition and migration	Debt and cessation of activity
Source of risk	Weather	Weather, markets and policies
Non-structural risk - avoidance mechanisms	Virtually nonexistent	Insurance, credit, legislation
Inputs and farm assets	Very low	Very significant
Price of food crops	Local for primary crops and partially global for industrial crops, with some interference by governments	Global with some interference of policies

Agricultural Trade Models



(Source: Parry et al., 1999)

Social Sciences Tools

- Surveys and interviews
- Allow the direct input of stakeholders (demand-driven science), provide expert judgement in a rigorous way.

Surveys and Interviews

- Development of adaptation options with stakeholders.

Surveys of Stakeholders: Example - Designing Adaptation Options

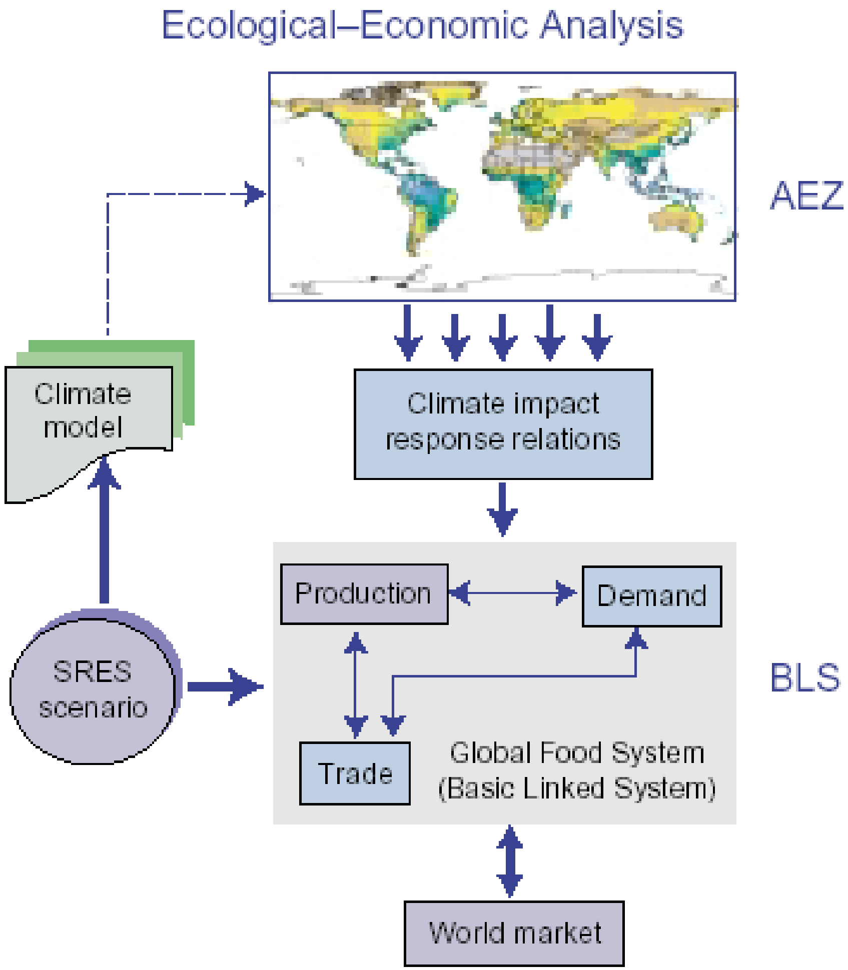
Stakeholder group (including women)	Adaptation Level 1	Adaptation Level 2	Adaptation Level 3
Small-holder farmers or farmers' groups	Tactical advice on changes in crop calendar and water needs	Management of risk in water availability (quantity and frequency)	Education on water-saving practices and changes in crop choices
Commercial farmers	Tactical advice on improving cash return for water and land units	Investment in irrigation technology; risk-sharing (e.g. insurance)	Private sector participation in development of agro-businesses
Resource Managers	Education on alternatives for land and water management	Integrated resource management for water and land	Alternatives for the use of natural resources and infrastructure

Economic and Social Tools

Examples: Farm, econometric, I/O, national economies, BLS, …

	Value
Spatial scale of results	Yearly to centuries
Time to conduct analysis	Site to region
Data needs	4 to 5
Skill or training required	5
Technological resources	4 to 5
Financial resources	4 to 5
Range for ranking: 1 (least amount) to 5 (most demanding).	

Integrators: Geographic Information Systems (GIS)



Integrators: GIS

Example: …. All possible applications ….

	Value
Spatial scale of results	Monthly to centuries
Time to conduct analysis	Region
Data needs	5
Skill or training required	5
Technological resources	5
Financial resources	5
Range for ranking: 1 (least amount) to 5 (most demanding).	

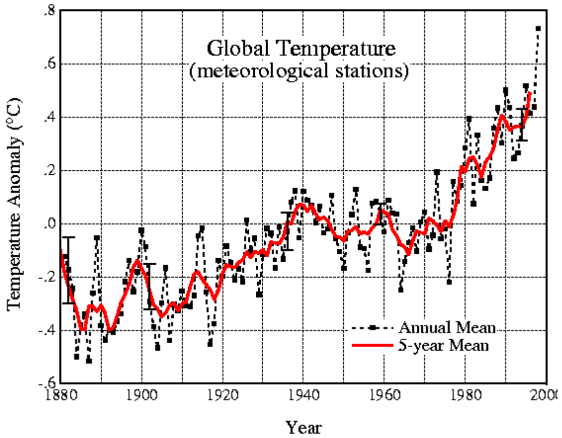
Conclusions

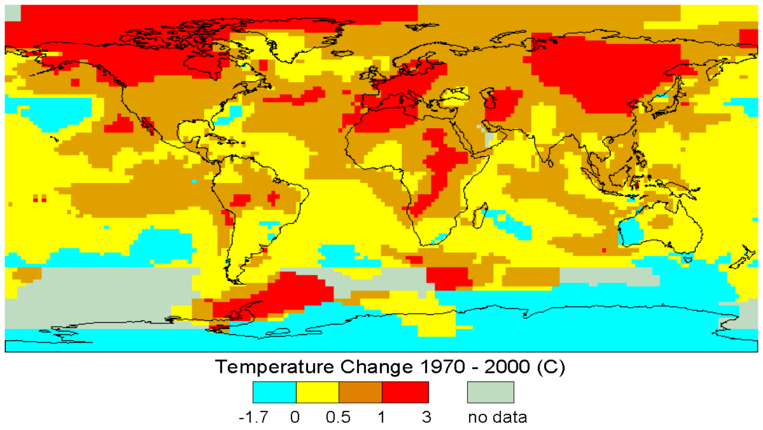
- The merits of each approach vary according to the level of impact being studied, and they may frequently be mutually supportive
- For example, simple agroclimatic indices often provide the necessary information on how crops respond to varying rainfall and temperature in wide geographical areas; crop-specific models are used to test alternative management that can in turn be used as a component for an economic model that analyses regional vulnerability or national adaptation strategies
- Therefore, a mix of approaches is often the most rewarding,

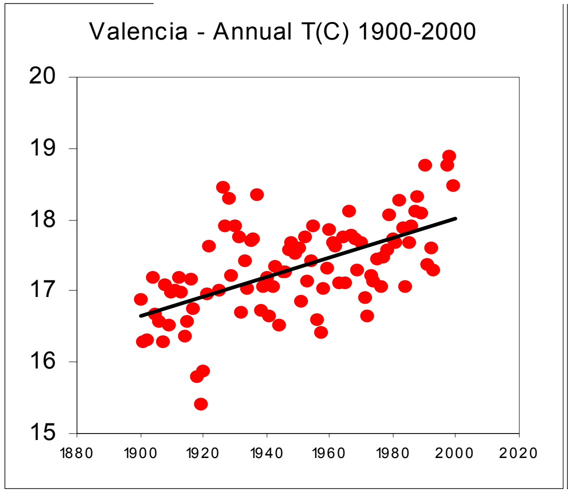
Datasets

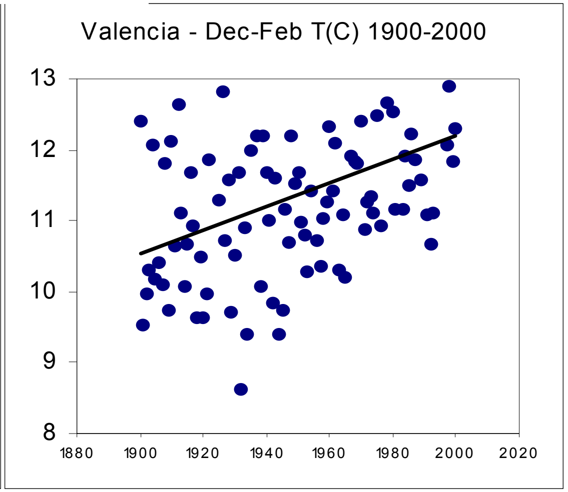
- Data are required data to define climatic, nonclimatic environmental, and socioe-conomic baselines and scenarios
- Data are limited
- Discussion on supporting databases and data sources

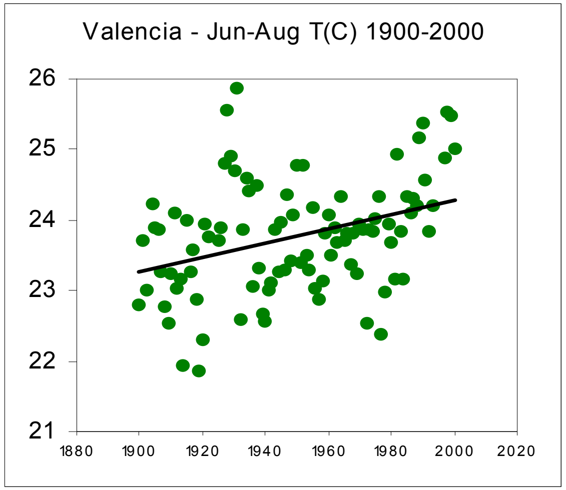
IPCC Working Group 1: “A Collective Picture of a Warming World”





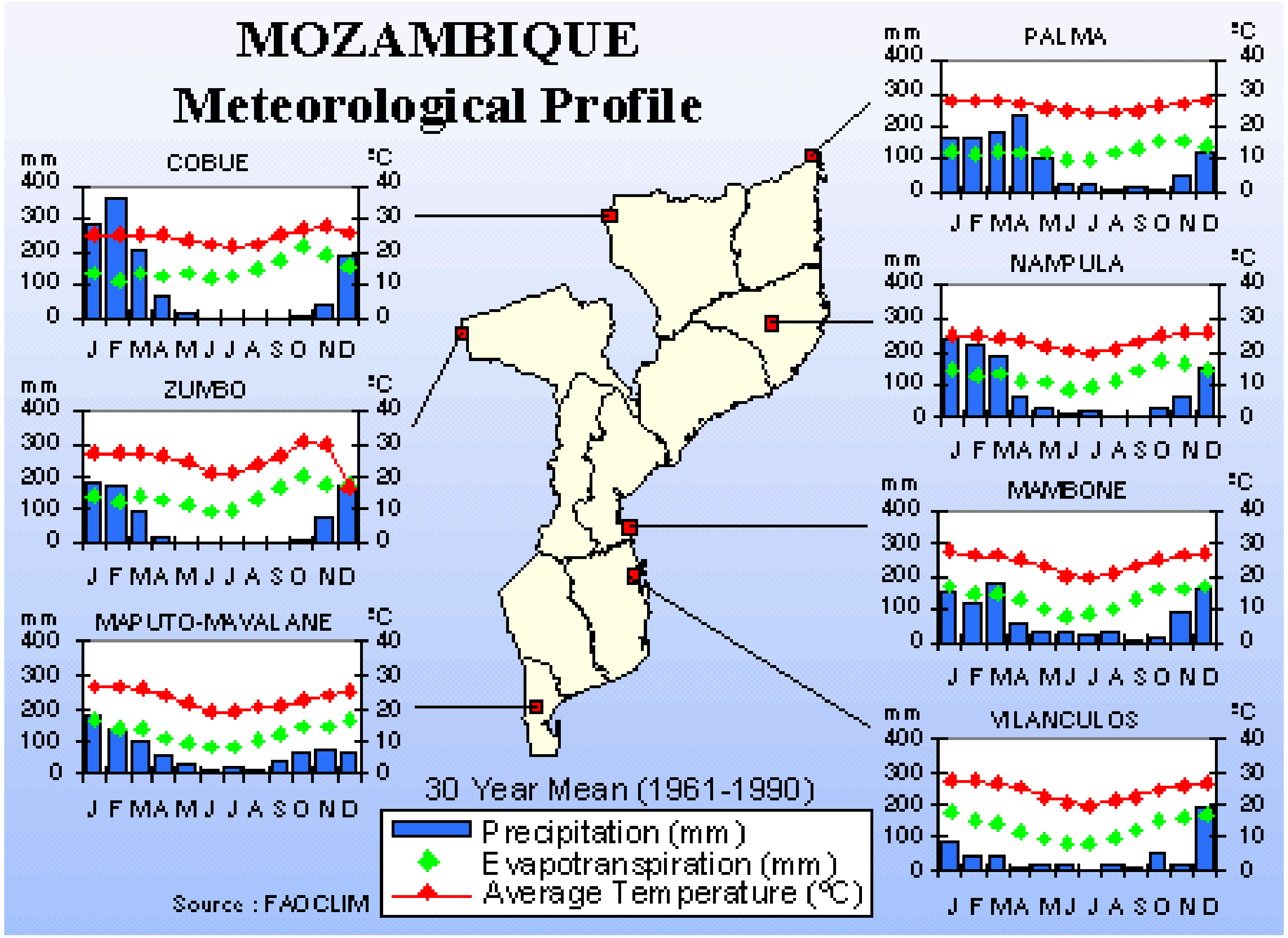






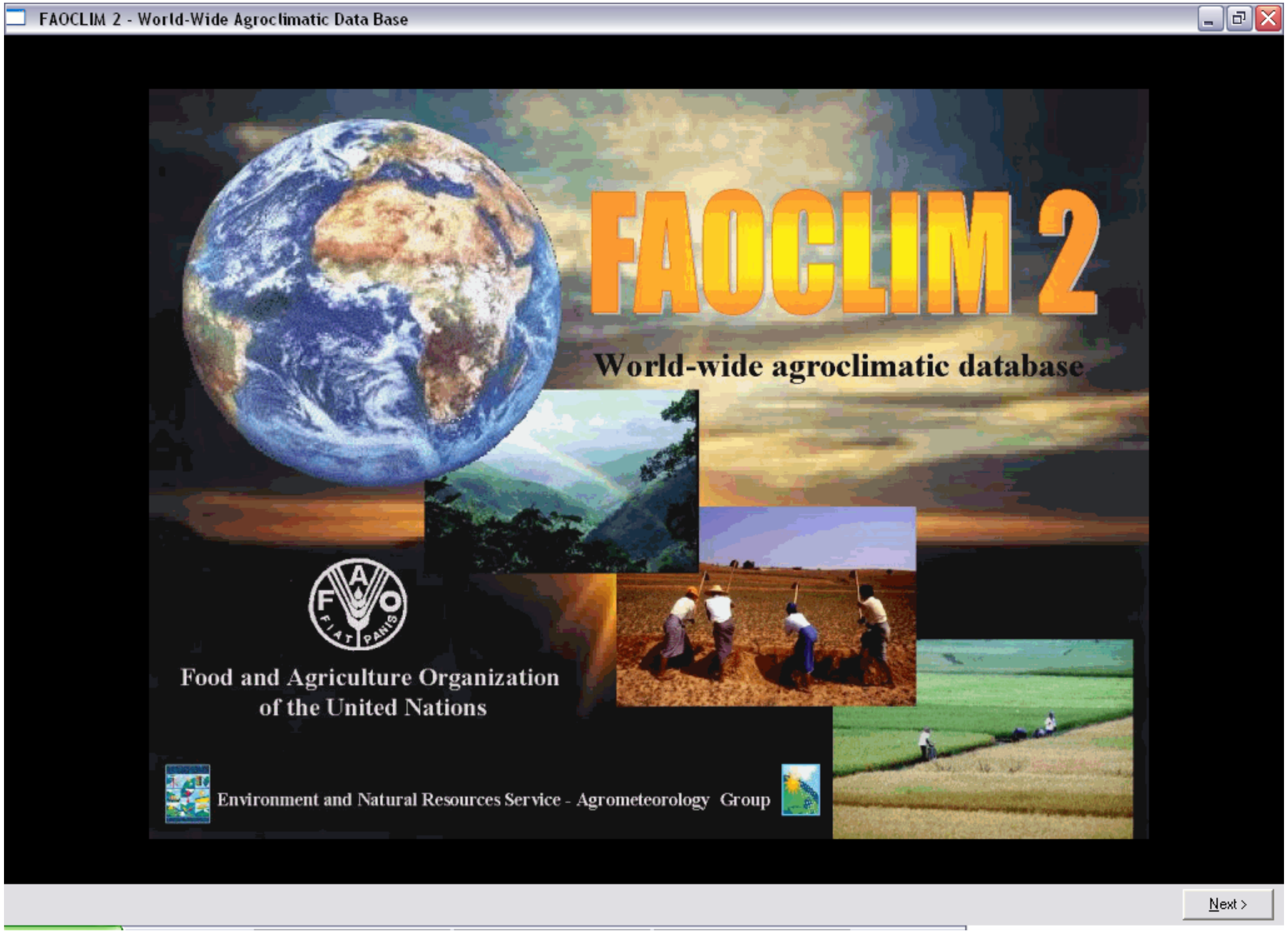
(Source of data: GISS/NASA)

Climate



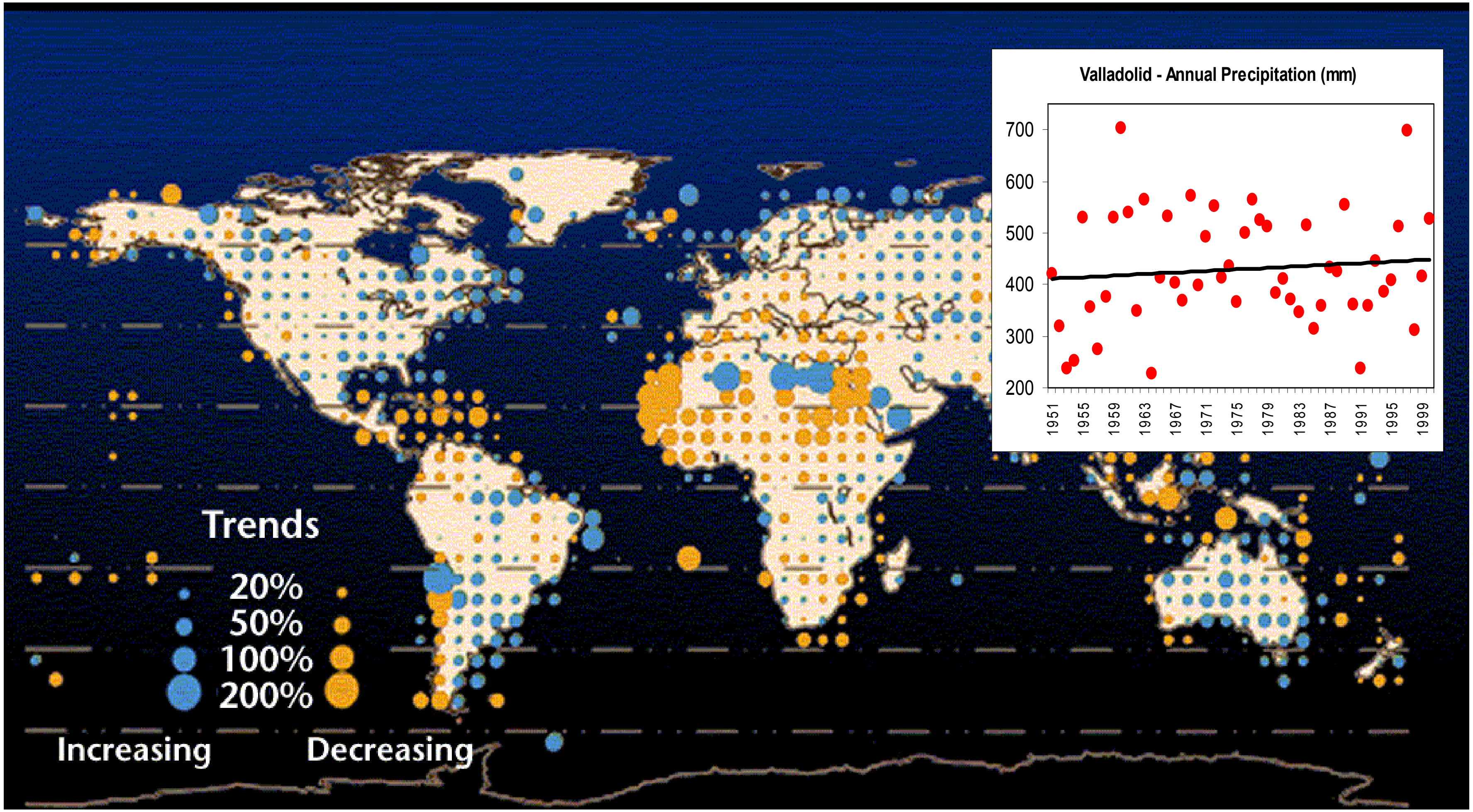
MOZAMBIQUE
Meteorological Profile
COBUE
ZUMBO
MAPUTO-MAVALANE
PALMA
NAMPULA
MAMBONE
VILANCULOS
mm
°C
J F M A M J J A S O N D
30 Year Mean (1961-1990)
Precipitation (mm)
Evapotranspiration (mm)
Average Temperature (°C)
Source : FAOCLIM

FAOCLIM



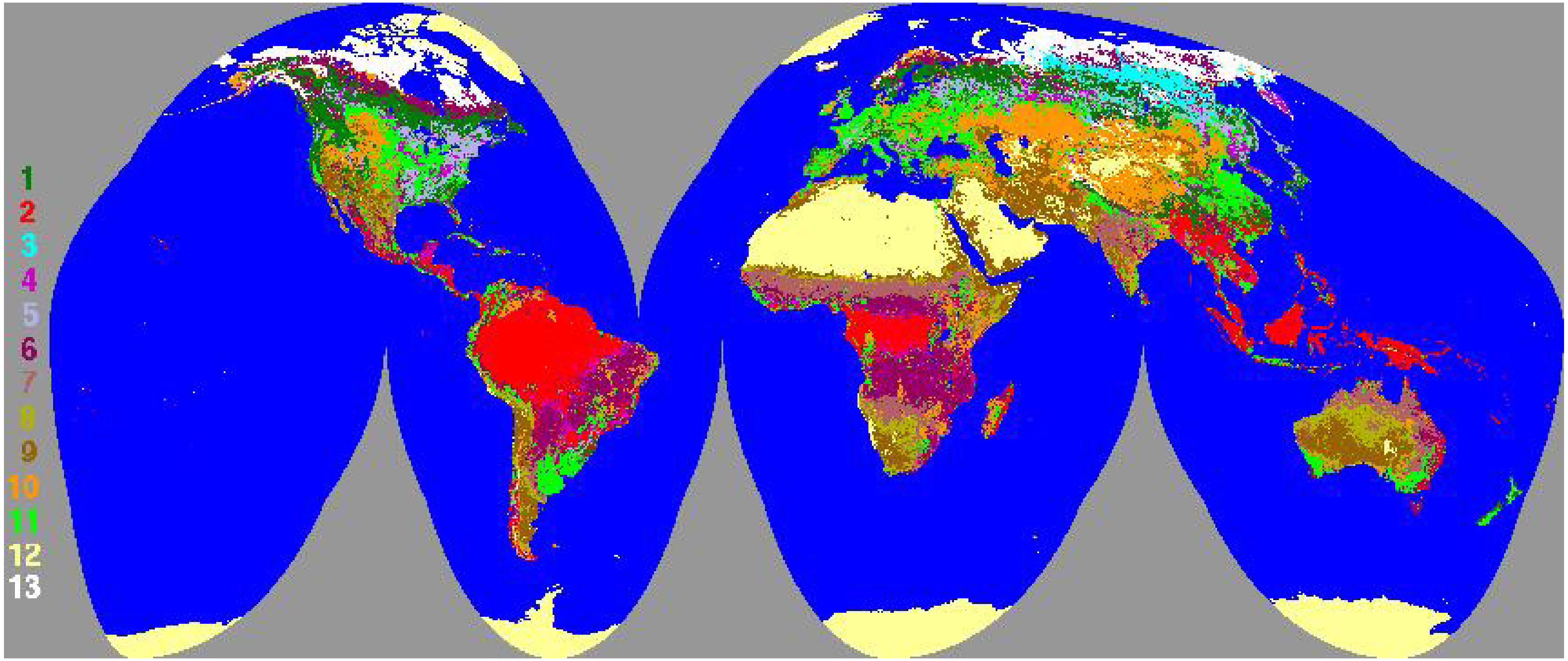
FAOCLIM 2 - World-Wide Agroclimatic Data Base
FAOCLIM 2
World-wide agroclimatic database
Food and Agriculture Organization
of the United Nations
Environment and Natural Resources Service - Agrometeorology Group
Next >

Annual Precipitation1901-1995



(Source: NOAA, NCDC)

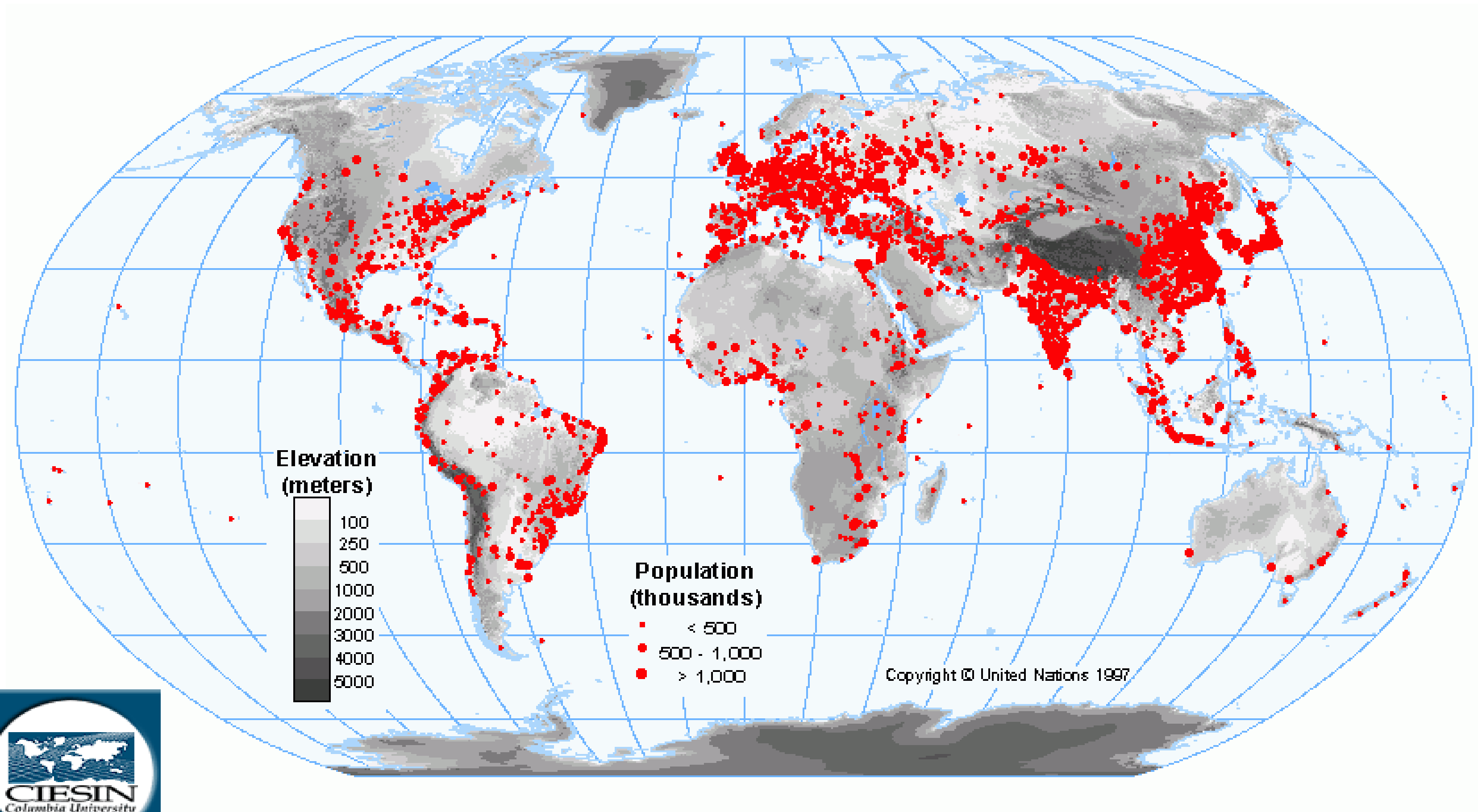
Global Land Cover Classification



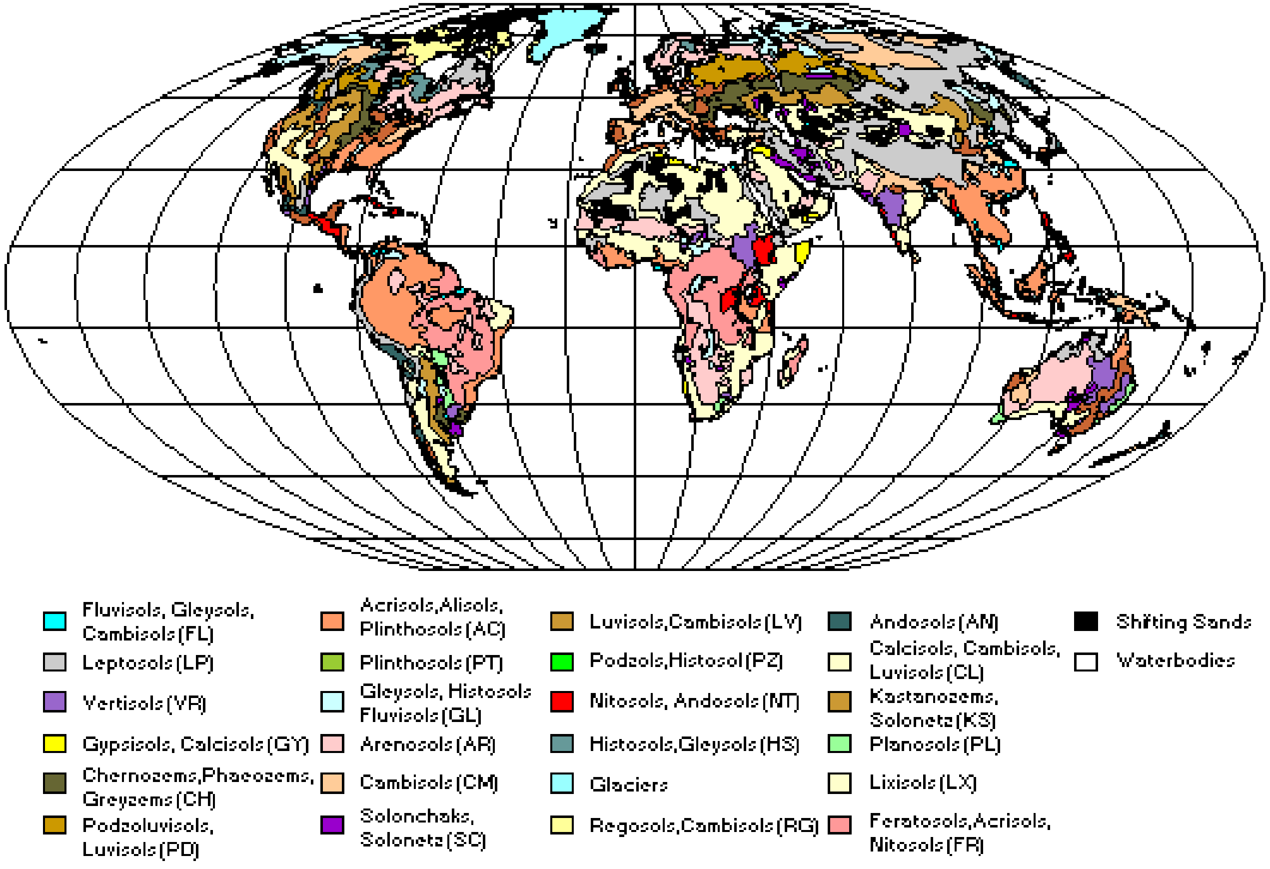
1: Evergreen needle leaf forests
2: Evergreen broad leaf forests
3: Deciduous needle leaf forests
4: Deciduous broad leaf forests
5: Mixed forests
6: Woodlands
7: Wooded grasslands/shrubs
8: Closed bushlands or shrublands
9: Open shrublands
10: Grasses
11: Croplands
12: Bare
13: Mosses and lichens

(Souce: De Fries et al., 1998)

Population

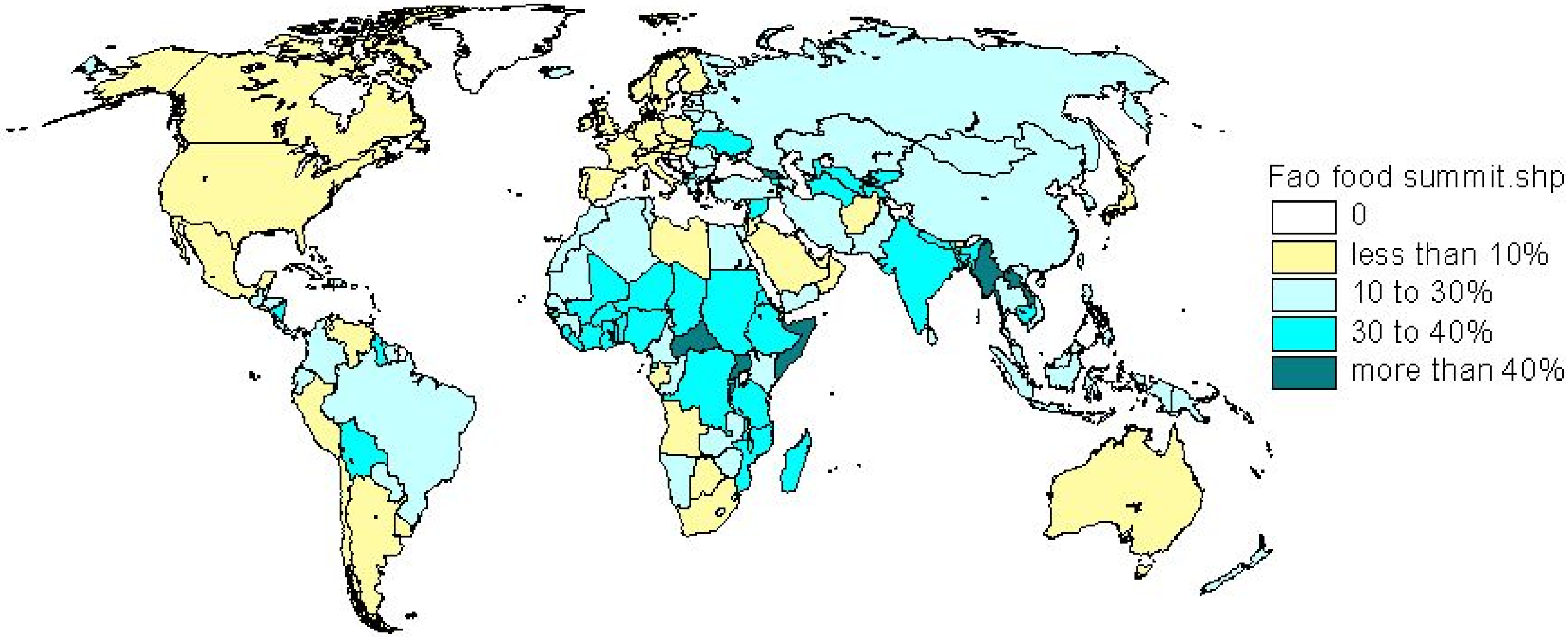

Elevation
(meters)
100
250
500
1000
2000
3000
4000
5000
Population
(thousands)
< 500
500 - 1,000
> 1,000
Copyright © United Nations 1997

Soils: FAO

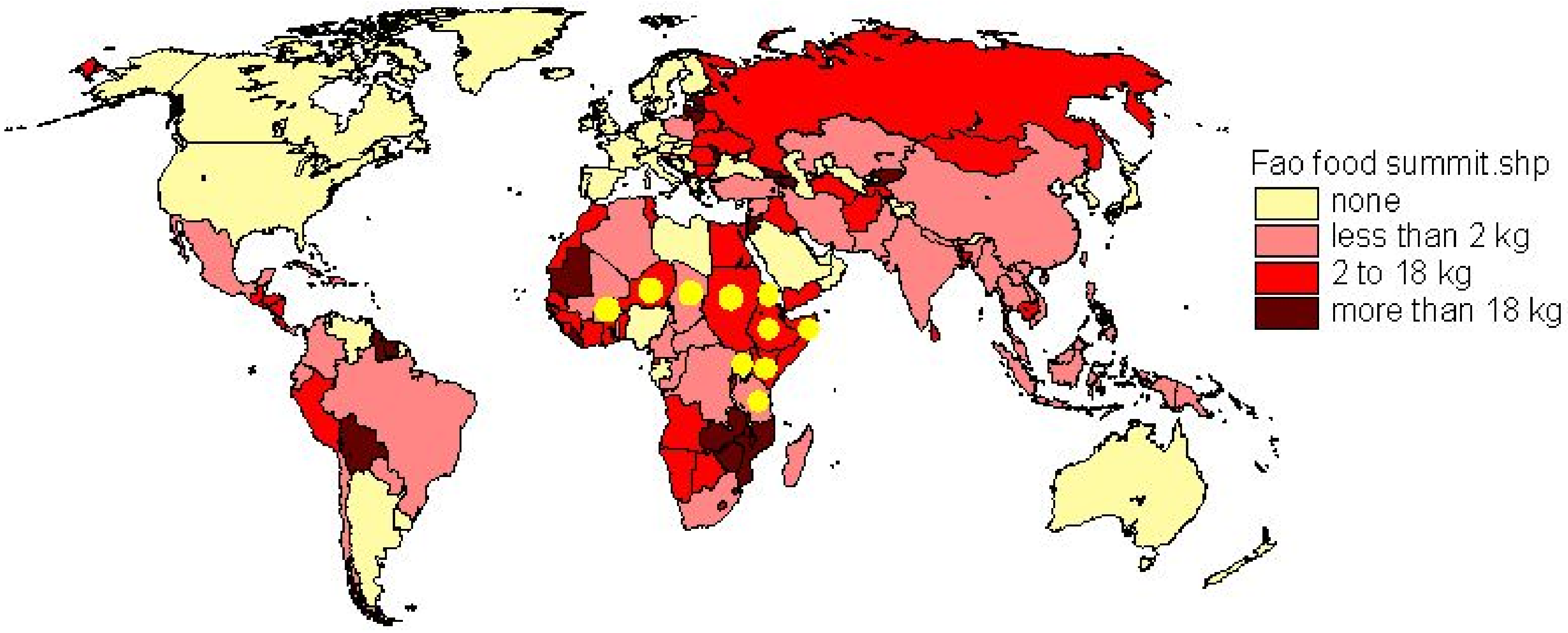

Fluvisols, Gleysols, Cambisols (FL)
Leptosols (LP)
Vertisols (VR)
Gypsisols, Calcisols (GY)
Chernozems, Phaeozems, Greyzems (CH)
Podzoluvisols, Luvisols (PD)
Acrisols, Alisols, Plinthosols (AC)
Plinthosols (PT)
Gleysols, Histosols Fluvisols (GL)
Arenosols (AR)
Cambisols (CM)
Solonchaks, Solonetz (SC)
Luvisols, Cambisols (LV)
Podzols, Histosol (PZ)
Nitosols, Andosols (NT)
Histosols, Gleysols (HS)
Glaciers
Regosols, Cambisols (RG)
Andosols (AN)
Calcisols, Cambisols, Luvisols (CL)
Kastanozems, Solonetz (KS)
Planosols (PL)
Lixisols (LX)
Ferralsols, Acrisols, Nitosols (FR)
Shifting Sands
Waterbodies

FAO and the World Bank

Agricultural GDP as share of total GDP



Food aid received from external sources 2000

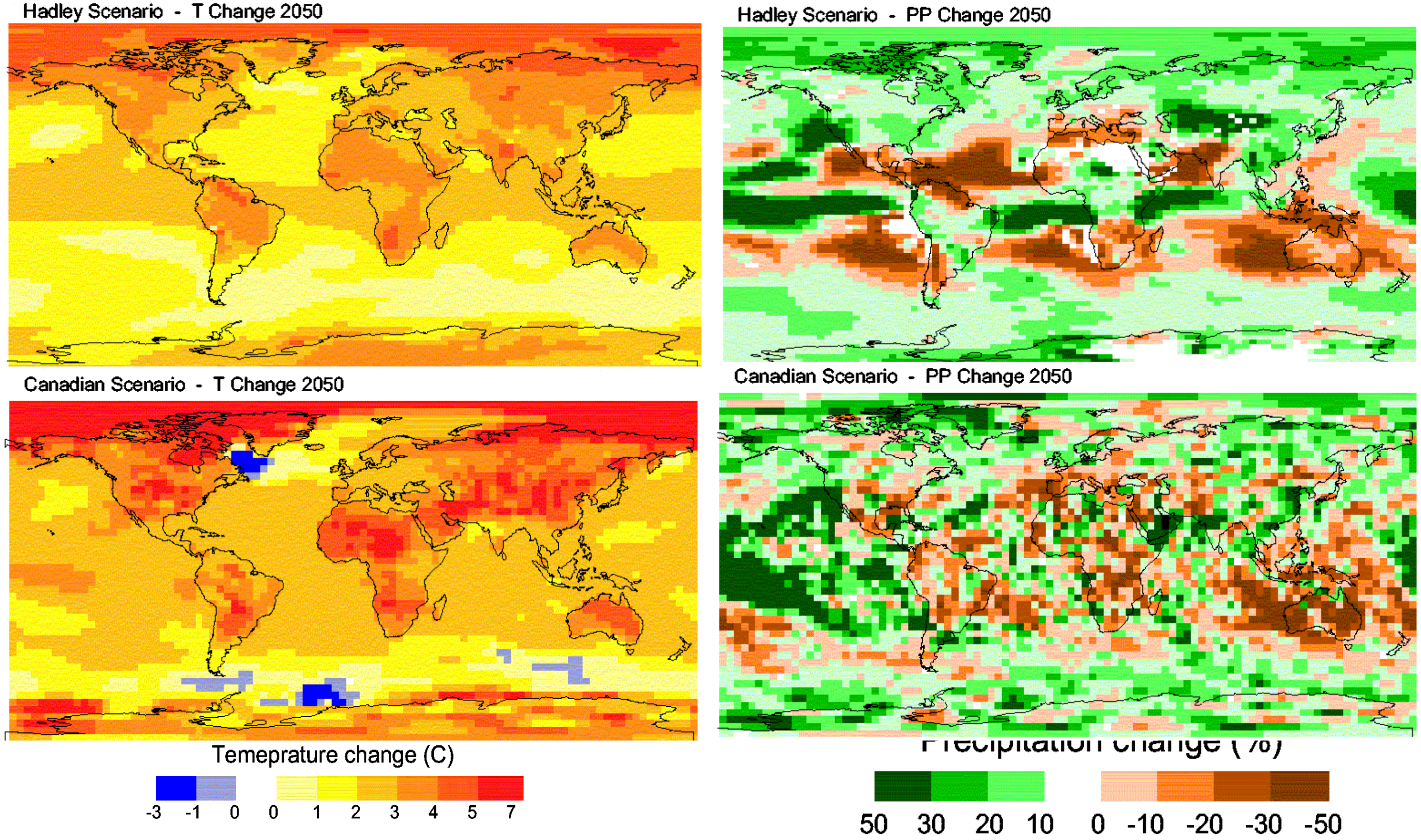


Countries facing exceptional food emergencies due to the drought August 2001

USGS, FEWS, USAID

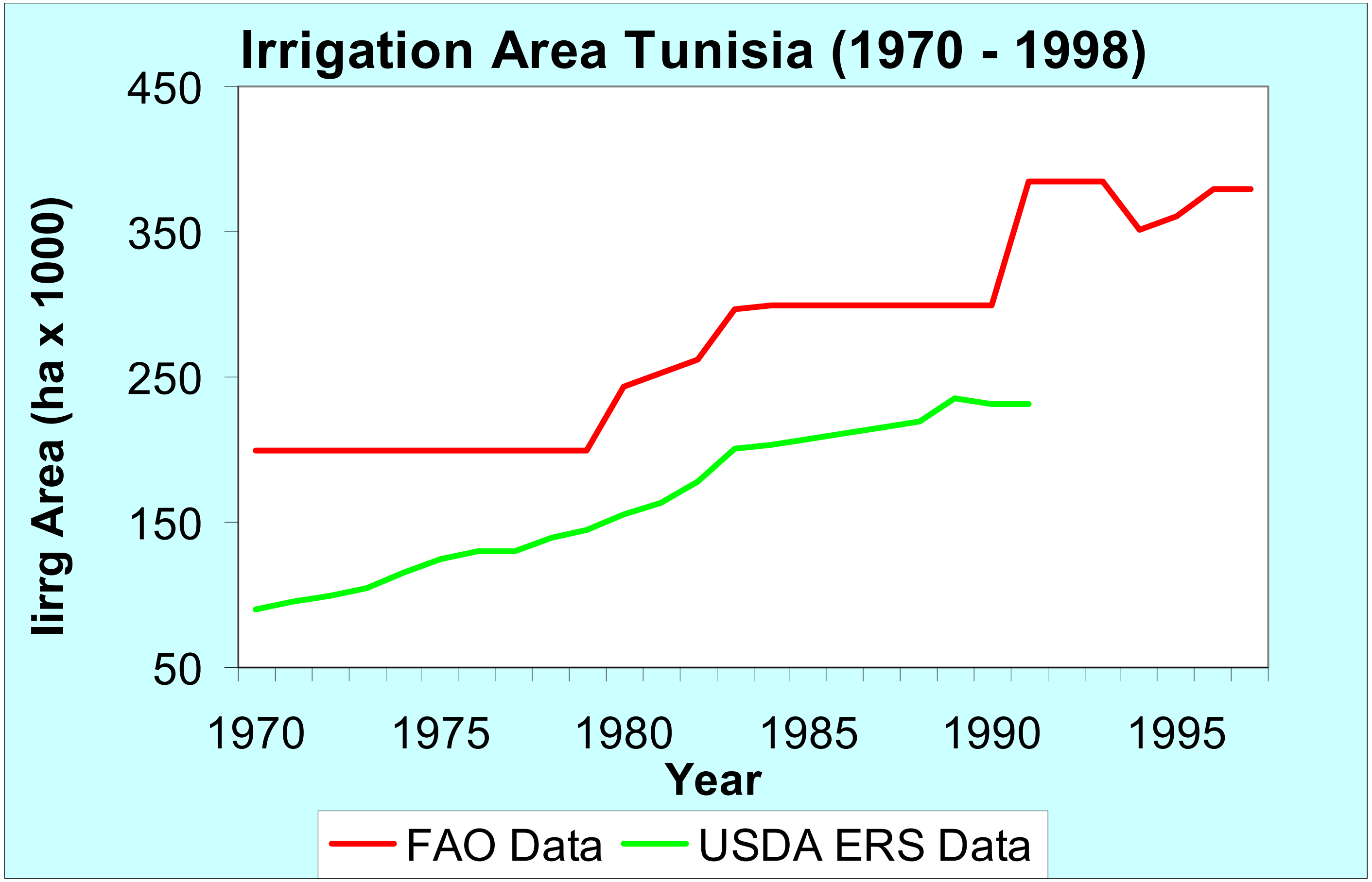
- FEWS NET in cooperation with USGS and US AID
  - Botswana – village flood watch
  - Carbon sequestration
  - Environmental monitoring and information system
  - Land cover performance
  - Madagascar conservation
  - Rift Valley fever
  - Sahel land use
  - Sustainable tree crops

Projected Change in Annual Temperature and Precipitation for the 2050s



The projected change in annual temperature and precipitation for the 2050s compared to the present day, for two genaral circulation models (GCMs)GCMs, when the climate models are driven with an increase in greenhouse gas concentrations defined by the IPCC "business-as-usual" scenario.

Data: Scales, Sources, Reliability



Practical Applications: Policy Questions

- What components of the farming system are particularly vulnerable and may thus require special attention?
- Can the water/irrigation systems meet the stress of changes in water supply/demand?
- Will climate significantly affect domestic agriculture?
- How can land use and land tenure aspects concerning poor people be taken into consideration?

Practical Applications: DSSAT

Question: What components of the farming system are particularly vulnerable, and may thus require crop models such as the Decision Support System for Agrotechnology Transfer (DSSAT)?

DSSAT
A Decision Support System for Agrotechnology Transfer

Decision Support System for Agrotechnology Transfer

ICASA
International Consortium for Agricultural Systems Applications

http://www.icasanet.org/

http://www.clac.edu.eg

Practical Applications: DSSAT

1. Overview and previous examples of previous use

2. Guided use of the model

Decision Support System for Agrotechnology Transfer (DSSAT)

Components	Description
Databases	Weather, soil, genetics, pests, experiments, economics
Models	Crop models (maize, wheat, rice, barley, sorghum, millet, soybean, peanut, dry bean, potato, cassava, etc.)
Supporting software	Graphics, weather, pests, soil, genetics, experiments, economics
Applications	Validation, sensitivity analysis, seasonal strategy, crop rotations

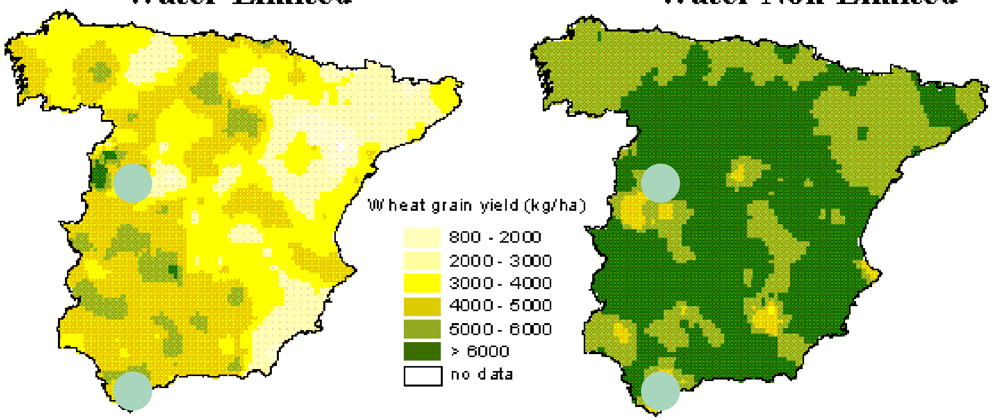
Input Requirements

- Weather: Daily precipitation, maximum and minimum temperatures, solar radiation
- Soil: Soil texture and soil water measurements
- Management: planting date, variety, row spacing, irrigation and nitrogen (N) fertilizer amounts and dates, if any
- Crop data: dates of anthesis and maturity, biomass and yield, measurements on growth and Leaf Area Index (LAI).

Crop Model Validation

Simulated Wheat Yield with the 1961-90 Climate

Water-Limited | **Water Non-Limited**



Site Validation	SEVILLA		ZAMORA	
	Obs	Sim	Obs	Sim
Planting (DOY)	325	325	305	305
Anthesis (DOY)	108	110	135	137
Phys. Maturity (DOY)	149	150	175	176
Rainfed Yield (kg ha-1)	6013	6769	6250	6821

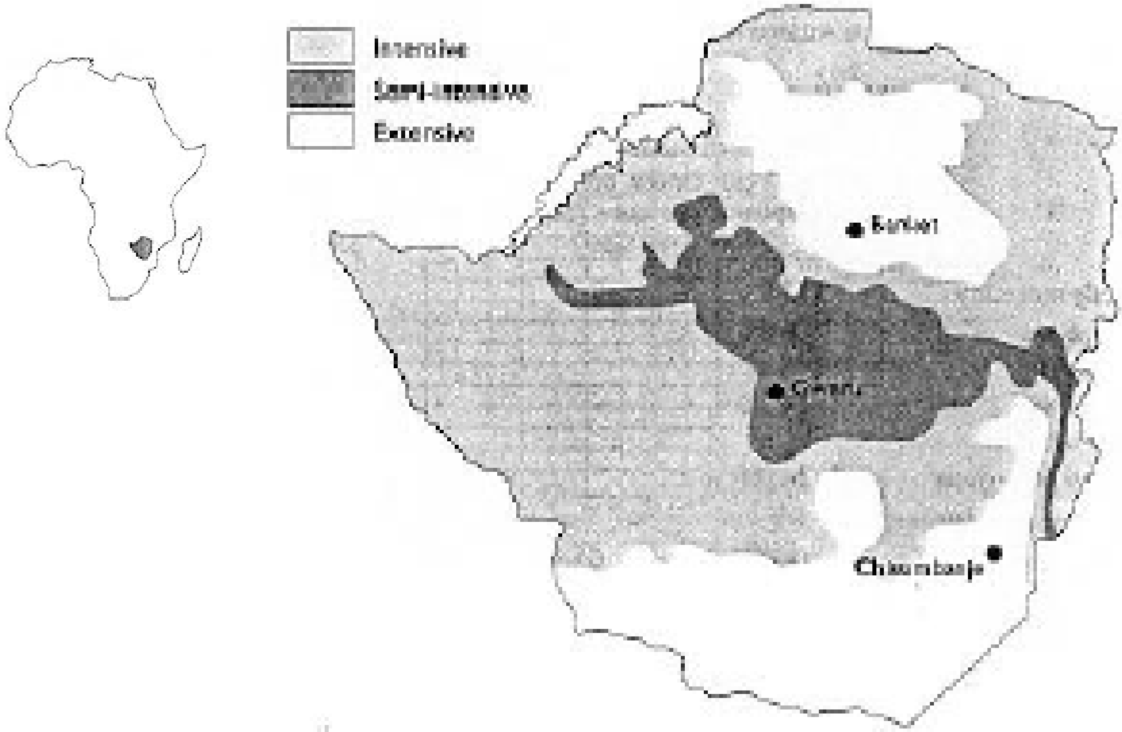
(Source: Iglesias et al., 1999)

Examples

- Can optimal management be an adaptation option for maize production in Zimbabwe?
- Can adaptation be achieved by optimizing crop varieties?
- Does the start of the rainy season affect maize yield in Kasungu, Central Malawi?

Can Optimal Management be an Adaptation Option for Maize Production in Zimbabwe?

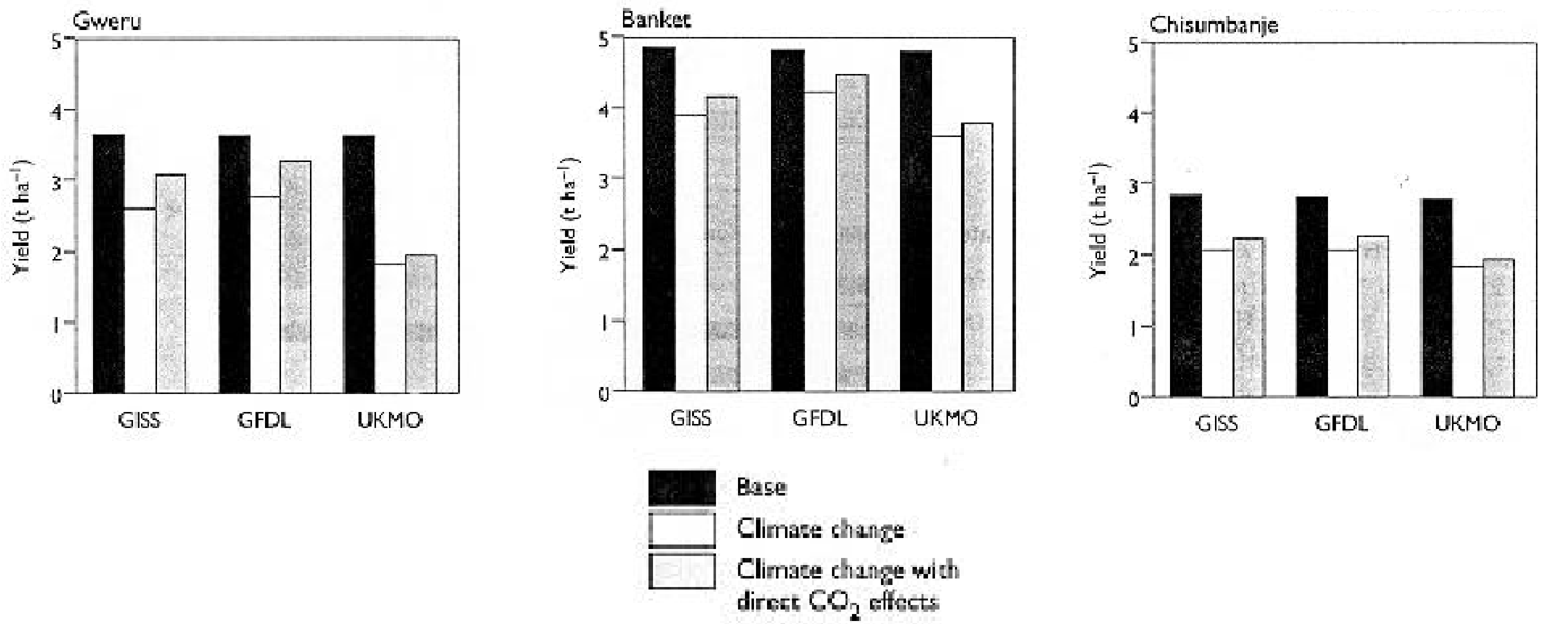
Agroclimatic zones



(Source: Muchena, 1994)

Impacts: Zimbabwe

Gueru | Banket | Chisumbanje

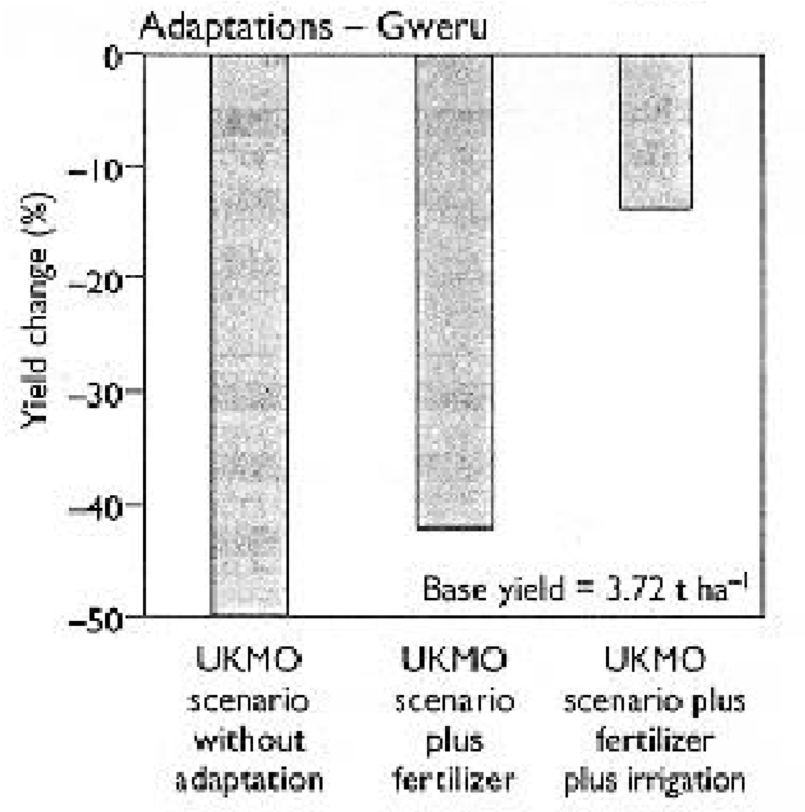


Impacts of climate change: CERES-Maize model

(Source: Muchena, 1994)

Adaptation: Zimbabwe

Adaptation strategies in Gueru: CERES-Maize model



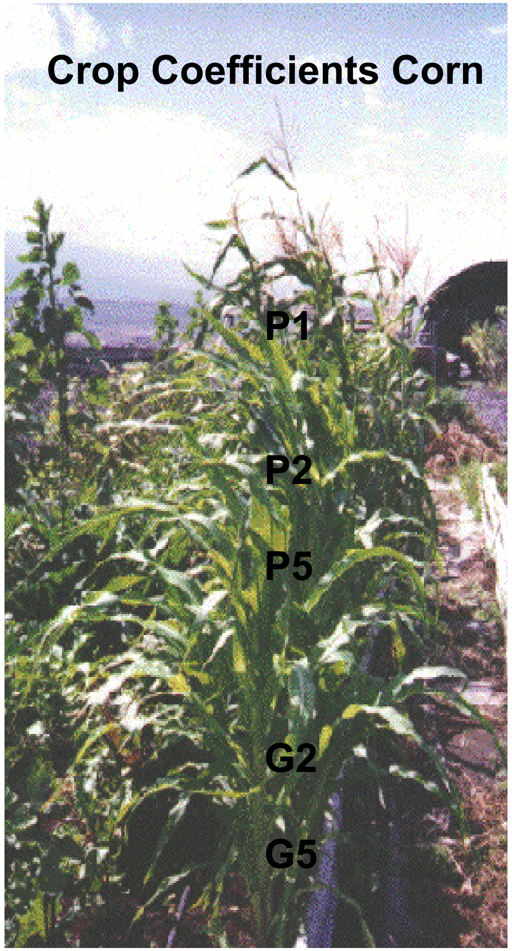
Increased inputs and improve management:

a) Fertilizer

b) Fertilizer and irrigation.

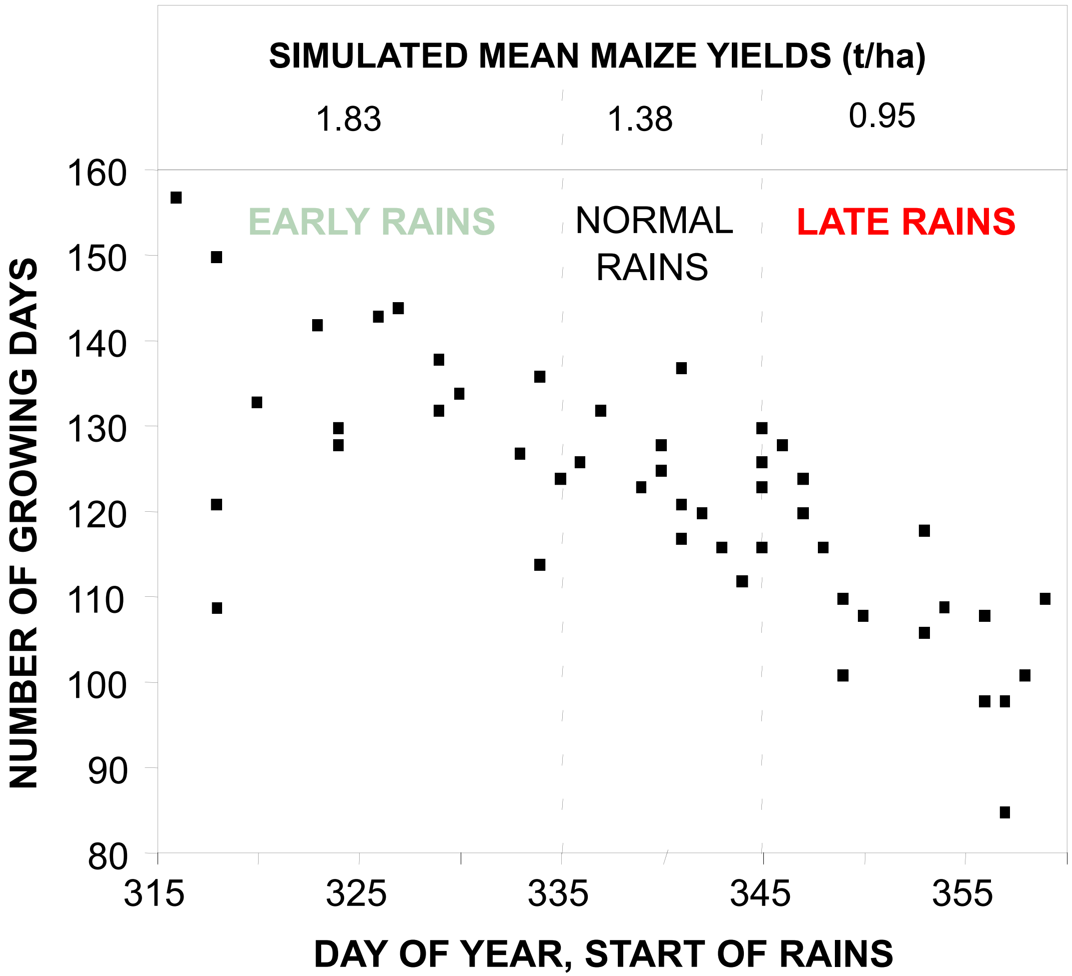
(Source: Muchena, 1994)

Can Adaptation be Achieved by Optimizing Crop Varieties?



- Juvenile phase (growing degree days base 8° C from emergence to end of the juvenile phase)
- Photoperiod sensitivity
- Grain filling duration (growing degree days base 8 from silking to physiological maturity)
- Potential kernel number
- Potential kernel weight (growth rate).

Does the Start of the Rainy Season Affect Maize Yield in Kasungu, Central Malawi?



Practical Applications: Worked Examples

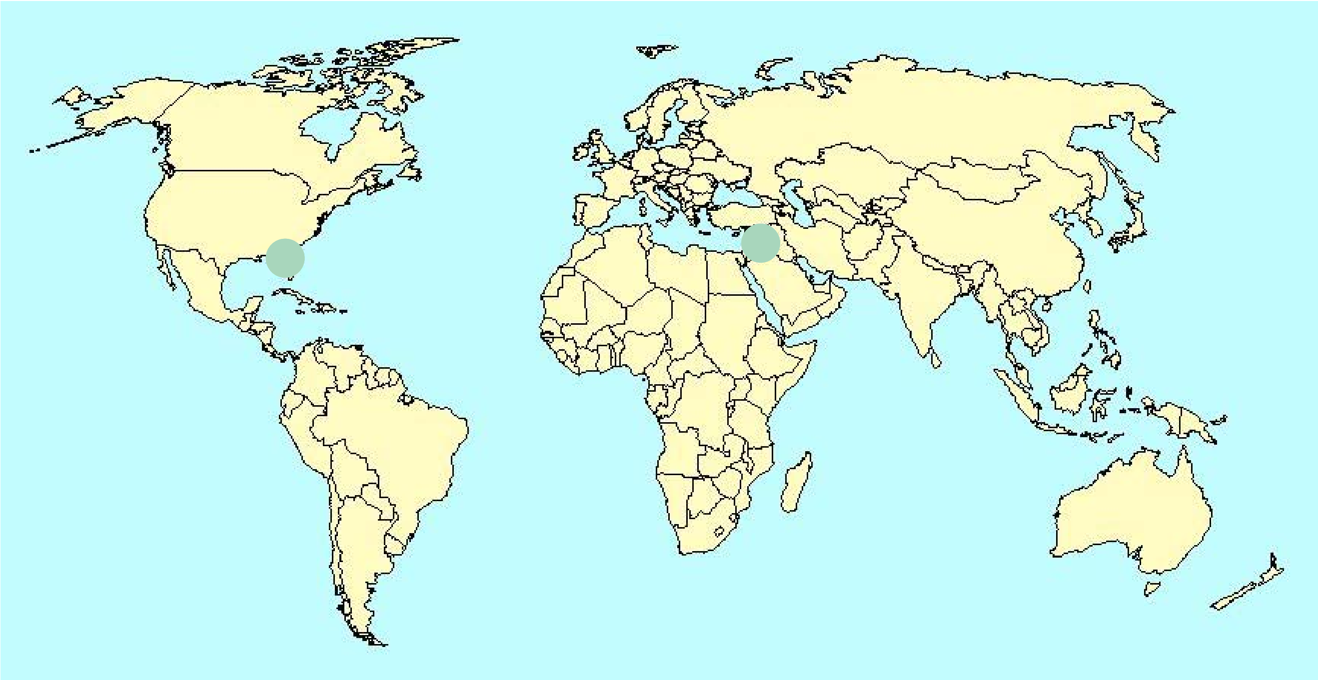
1. Effect of management (nitrogen and irrigation) in wet and dry sites (Florida, USA, and Syria)

2. Effect of climate change on wet and dry sites:

   a) Sensitivity analysis to changes in temperature and precipitation (thresholds) and CO_2 levels

3. Adaptation: changes in management to improve yield under climate change

Application 1. Management



- Objective: Getting started

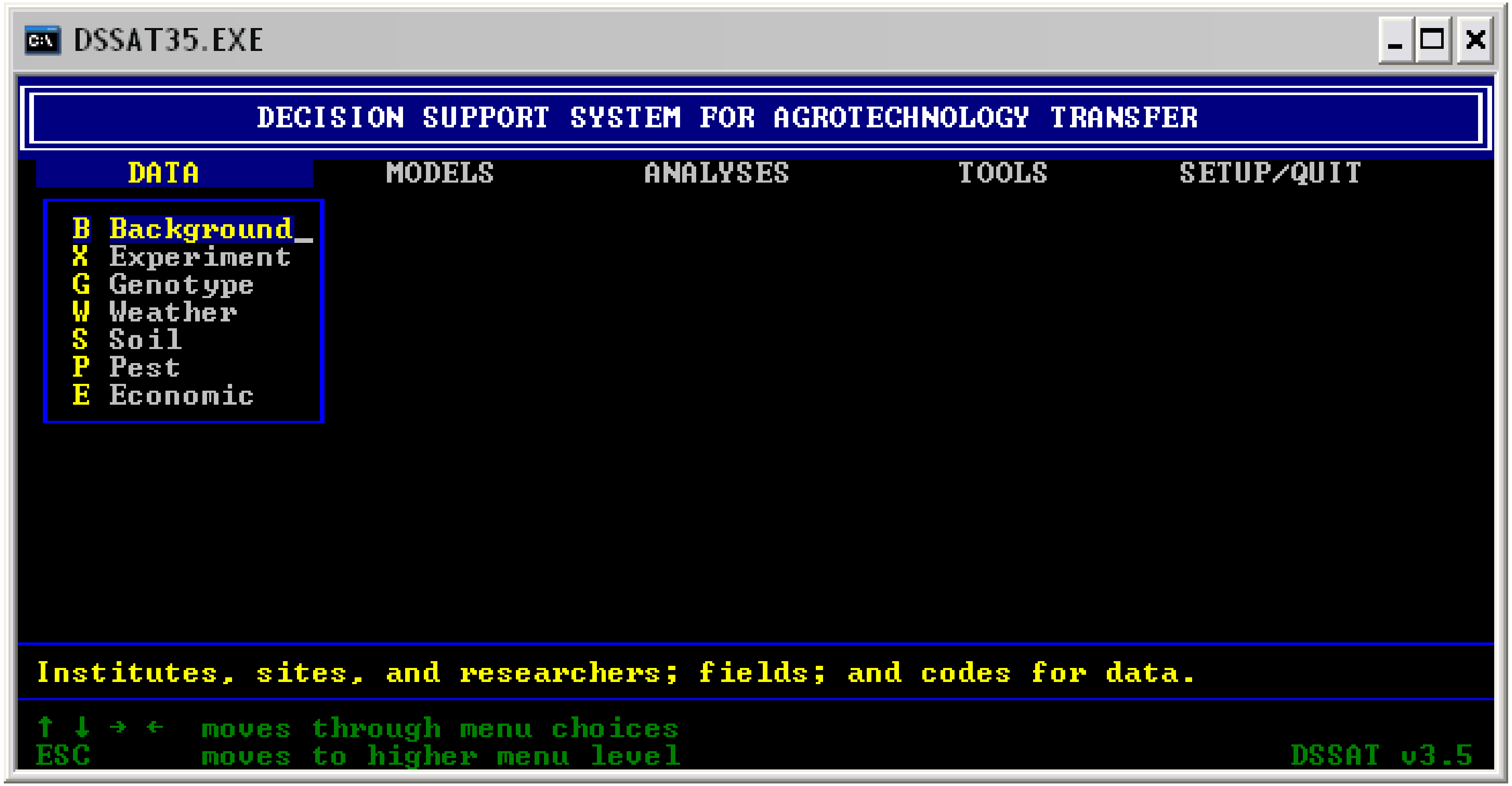
Weather

	Syria	Florida, USA
SR (MJ m^2 day^1)	19.3	16.5
T Max (° C)	23.0	27.4
T Min (° C)	8.5	14.5
Precipitation (mm)	276.4	1364.3
Rain days (num)	55.7	114.8

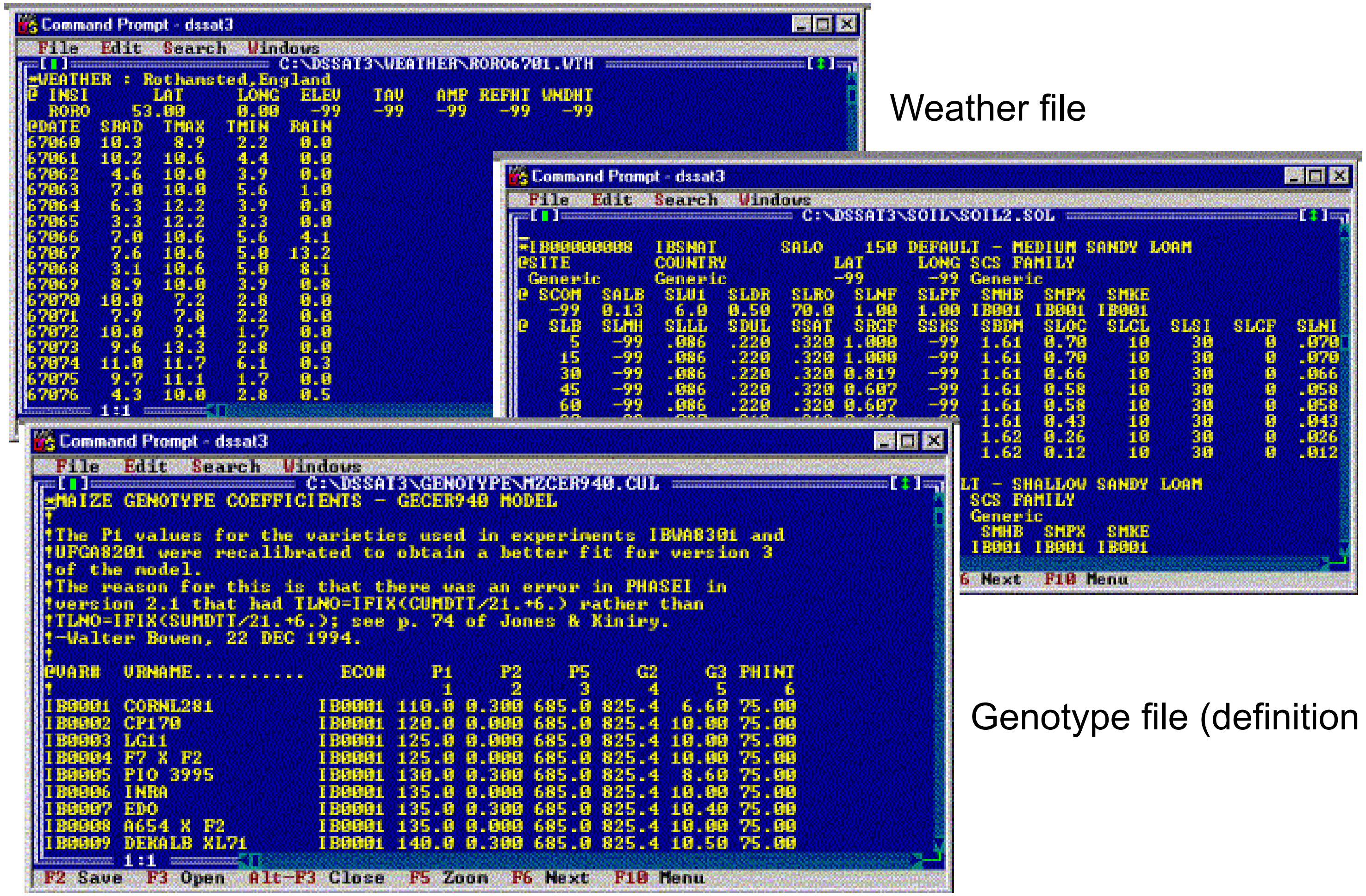
Input Files Needed

- Weather
- Soils
- Cultivars
- Management files (*.MZX files) description of the experiment.

Open DSSAT . . .


DSSAT35.EXE
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER
DATA
MODELS
ANALYSES
TOOLS
SETUP/QUIT
B Background
X Experiment
G Genotype
W Weather
S Soil
P Pest
E Economic
Institutes, sites, and researchers; fields; and codes for data.
↑ ↓ → ← moves through menu choices
ESC moves to higher menu level
DSSAT v3.5

Examine the Data Files . . .

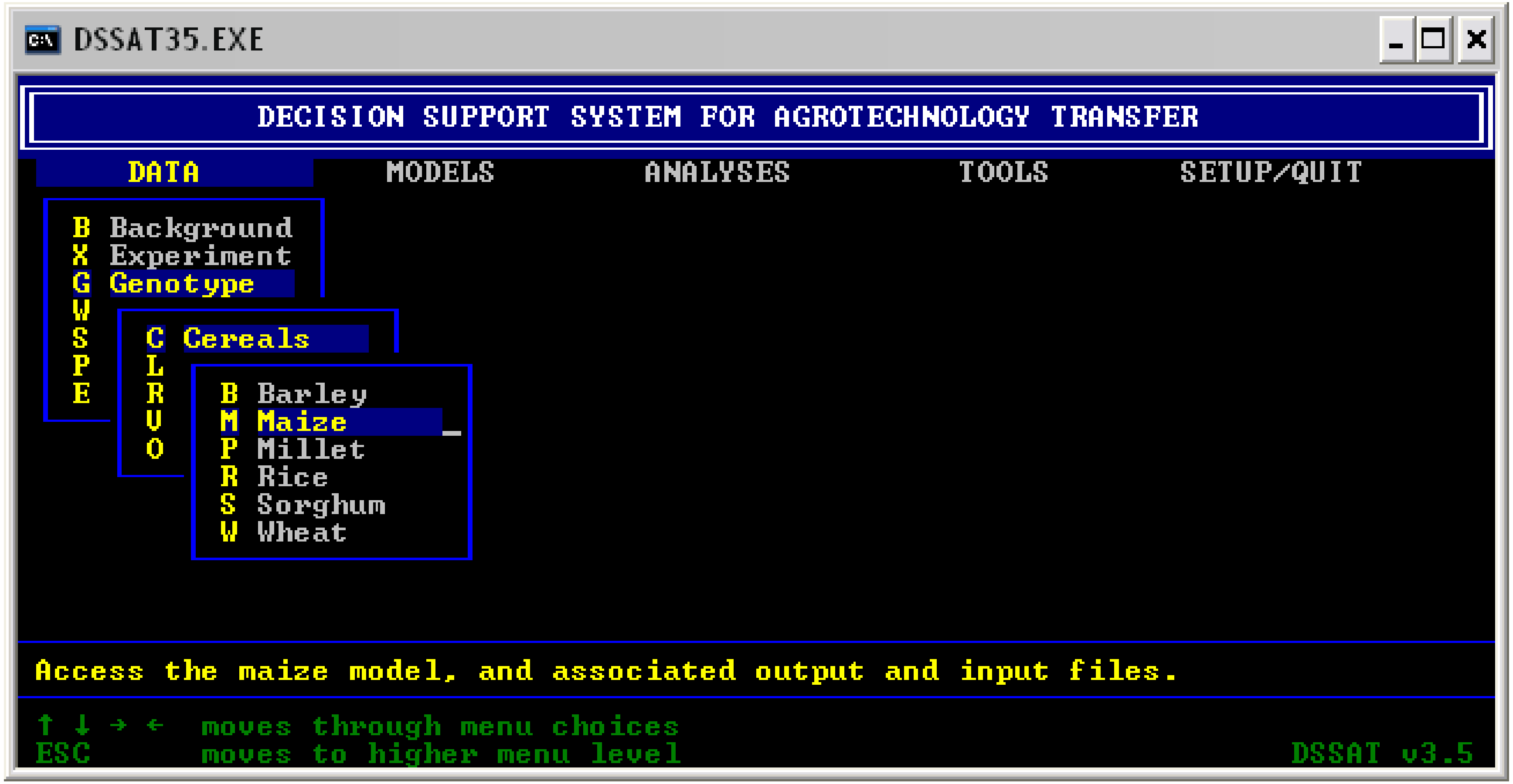


Weather file

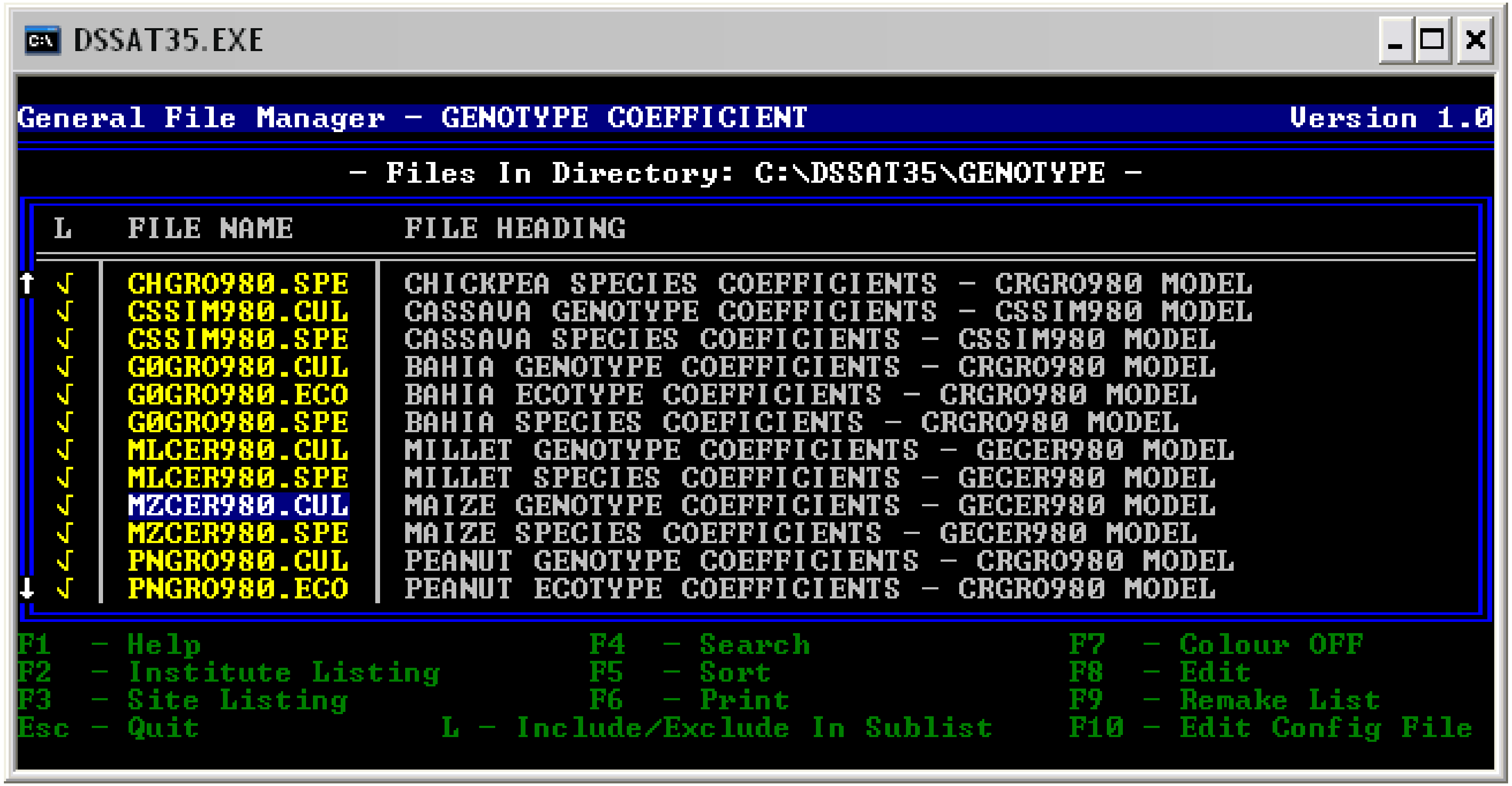
Soil file

Genotype file (definition of cultivars)

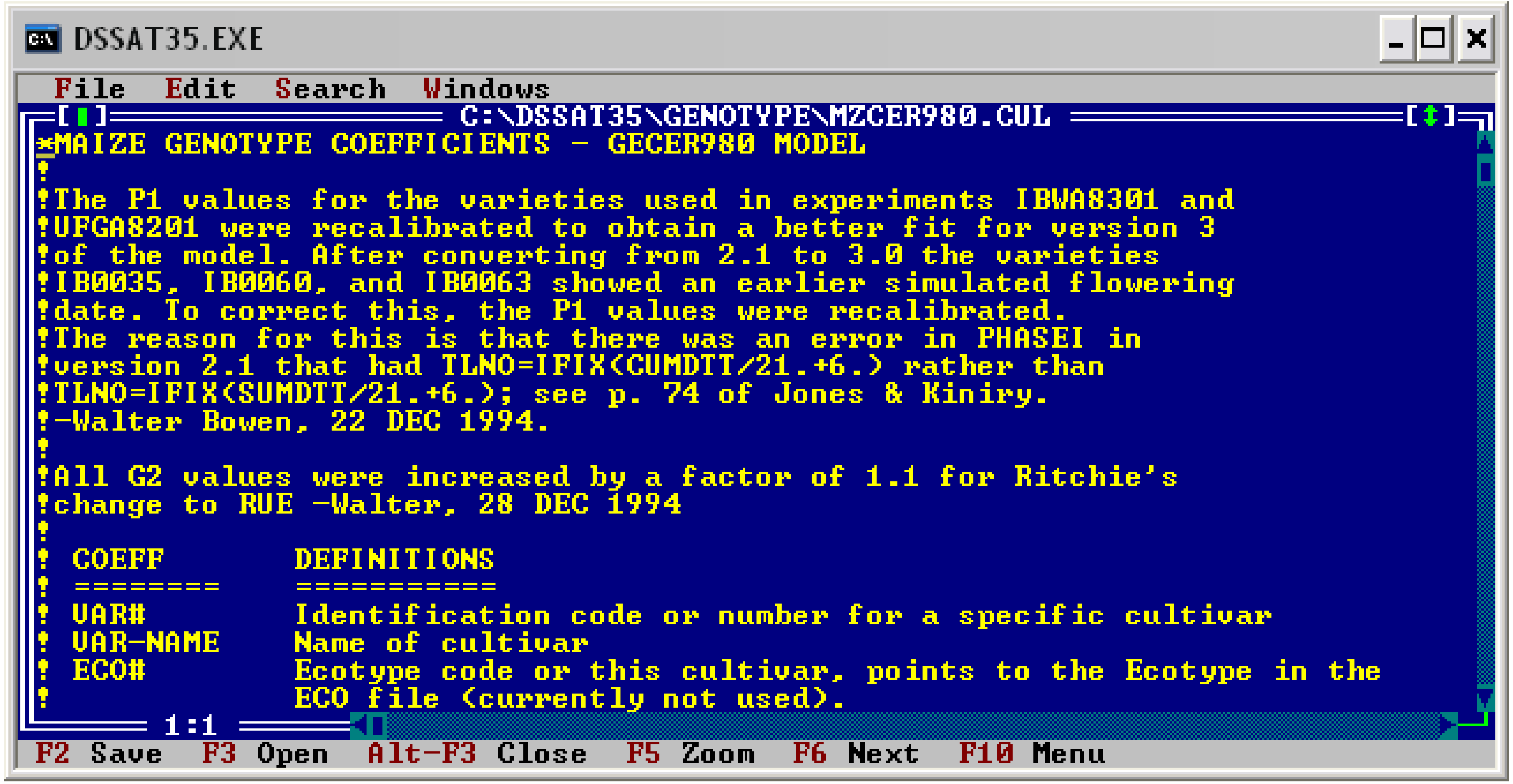
Location of the Cultivar File . . .



Select the Cultivar File . . .

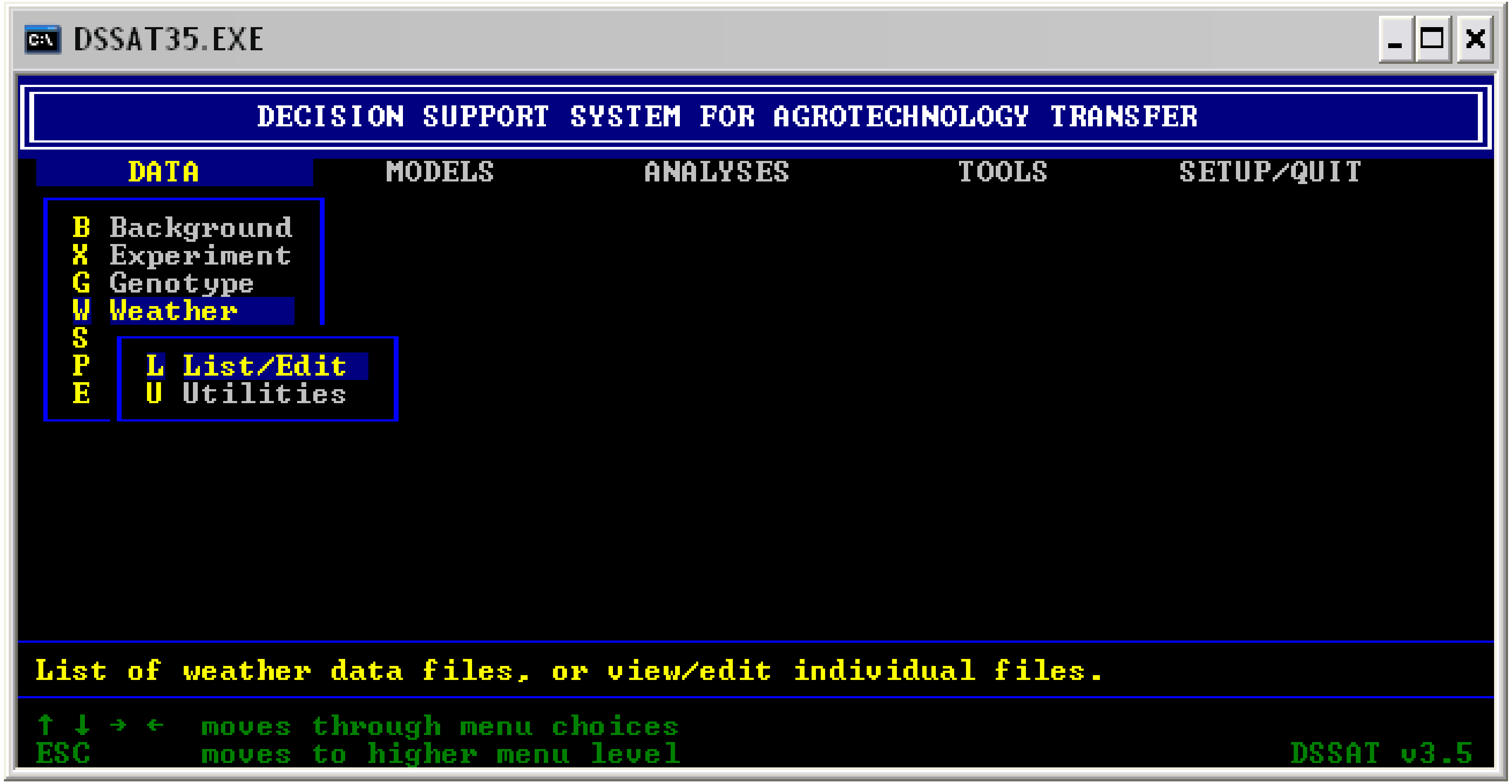


Examine the Cultivar File . . .



```
DSSAT35.EXE
 File  Edit  Search  Windows
[■]========== C:\DSSAT35\GENOTYPE\MZCER980.CUL ==========[↕]
*MAIZE GENOTYPE COEFFICIENTS - GECER980 MODEL
!
!The P1 values for the varieties used in experiments IBWA8301 and
!UFGA8201 were recalibrated to obtain a better fit for version 3
!of the model. After converting from 2.1 to 3.0 the varieties
!IB0035, IB0060, and IB0063 showed an earlier simulated flowering
!date. To correct this, the P1 values were recalibrated.
!The reason for this is that there was an error in PHASEI in
!version 2.1 that had TLNO=IFIX(CUMDTT/21.+6.) rather than
!TLNO=IFIX(SUMDTT/21.+6.); see p. 74 of Jones & Kiniry.
!-Walter Bowen, 22 DEC 1994.
!
!All G2 values were increased by a factor of 1.1 for Ritchie's
!change to RUE -Walter, 28 DEC 1994
!
! COEFF        DEFINITIONS
! ========     ===========
! VAR#         Identification code or number for a specific cultivar
! VAR-NAME     Name of cultivar
! ECO#         Ecotype code or this cultivar, points to the Ecotype in the
!              ECO file (currently not used).
====== 1:1 ======
F2 Save  F3 Open  Alt-F3 Close  F5 Zoom  F6 Next  F10 Menu
```

Location of the Weather File . . .



Selection of the Weather File . . .

DSSAT35.EXE

Weather File Manager (WFM) Version 1.0

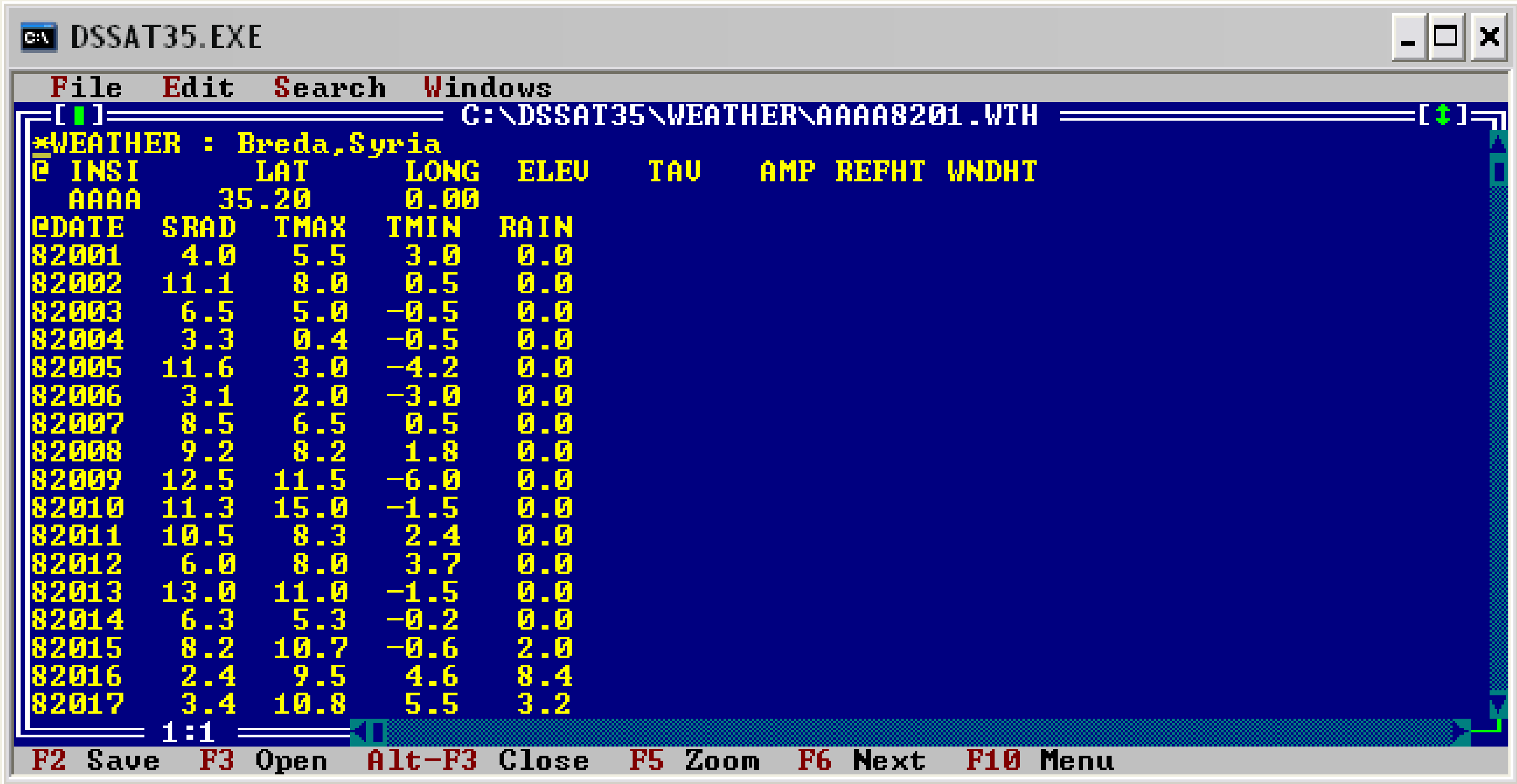
– Files In All Installed Directories –

FILENAME	SITE NAME	ZONE	YR	LAT	LONG	ELEV
AAAA8201.WTH	BREDA,SYRIA	XXX	-9	35.2	0.0	0
ALCL5601.WTH	CLANTON,AL	XXX	-9	32.5	-86.4	185
ALCL5701.WTH	CLANTON,AL	XXX	-9	32.5	-86.4	185
ALCL5801.WTH	CLANTON,AL	XXX	-9	32.5	-86.4	185
ALCL5901.WTH	CLANTON,AL	XXX	-9	32.5	-86.4	185
AUCB7001.WTH	AUCB	XXX	-9	-35.0	149.0	-99
AUCR.CLI	CROSSVILLE,ALABAMA,U	XXX	-9	34.3	-86.0	573
CCPA.CLI	PALMIRA,VALLE,COLOMB	XXX	-9	3.5	-76.3	965
CCPA7801.WTH	PALMIRA,VALLE,COLOMB	XXX	-9	3.5	-76.3	965
CCPA7901.WTH	PALMIRA,VALLE,COLOMB	XXX	-9	3.5	-76.3	965
CCPA8001.WTH	PALMIRA,VALLE,COLOMB	XXX	-9	3.5	-76.3	965
CCPA8101.WTH	PALMIRA,VALLE,COLOMB	XXX	-9	3.5	-76.3	965

F1 – Help F4 – Search F7 – Colour OFF
F2 – Institute Listing F5 – Sort F8 – Edit
F3 – Site Listing F6 – Print F9 – Remake List
Esc – Quit F10 – Working List

– File Location: C:\DSSAT35\WEATHER –

Examine the Weather File . . .



DSSAT35.EXE

File Edit Search Windows

C:\DSSAT35\WEATHER\AAAA8201.WTH

*WEATHER : Breda,Syria

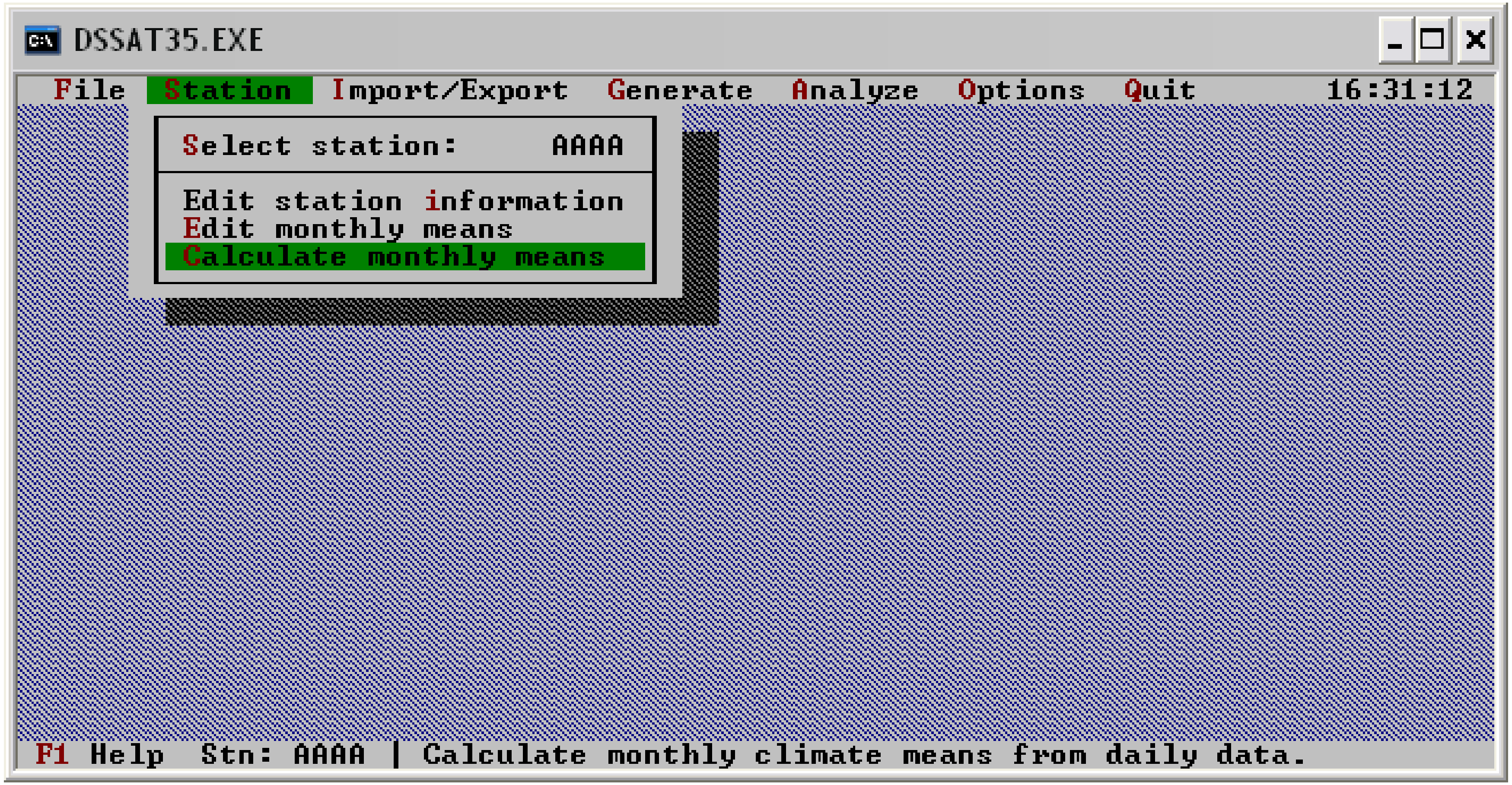
@ INSI	LAT	LONG	ELEV	TAV	AMP	REFHT	WNDHT
AAAA	35.20	0.00					

@DATE	SRAD	TMAX	TMIN	RAIN
82001	4.0	5.5	3.0	0.0
82002	11.1	8.0	0.5	0.0
82003	6.5	5.0	-0.5	0.0
82004	3.3	0.4	-0.5	0.0
82005	11.6	3.0	-4.2	0.0
82006	3.1	2.0	-3.0	0.0
82007	8.5	6.5	0.5	0.0
82008	9.2	8.2	1.8	0.0
82009	12.5	11.5	-6.0	0.0
82010	11.3	15.0	-1.5	0.0
82011	10.5	8.3	2.4	0.0
82012	6.0	8.0	3.7	0.0
82013	13.0	11.0	-1.5	0.0
82014	6.3	5.3	-0.2	0.0
82015	8.2	10.7	-0.6	2.0
82016	2.4	9.5	4.6	8.4
82017	3.4	10.8	5.5	3.2

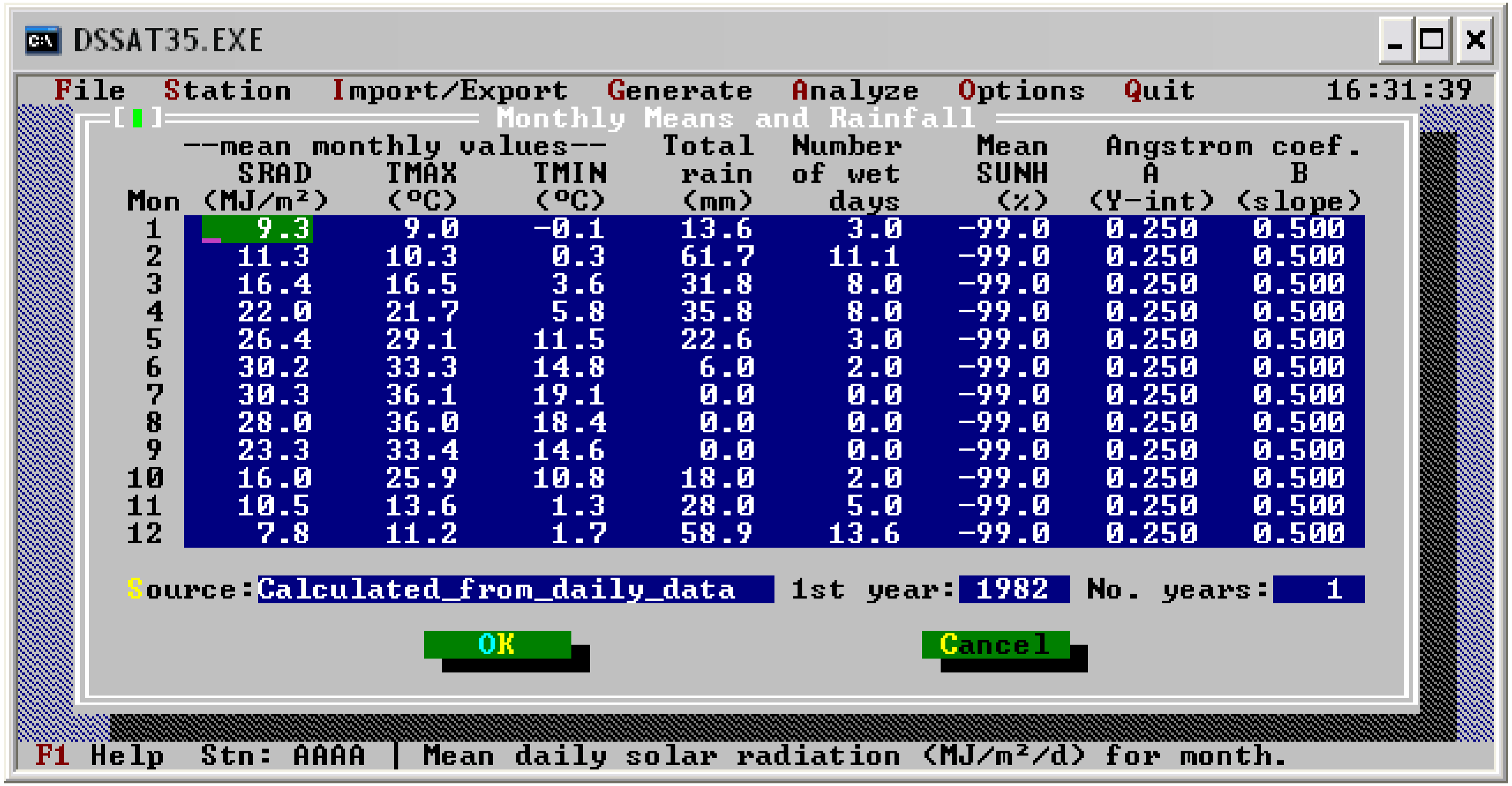
1:1

F2 Save F3 Open Alt-F3 Close F5 Zoom F6 Next F10 Menu

Calculate Monthly Means . . .



Calculate Monthly Means . . . (continued)



DSSAT35.EXE

File Station Import/Export Generate Analyze Options Quit 16:31:39

Monthly Means and Rainfall

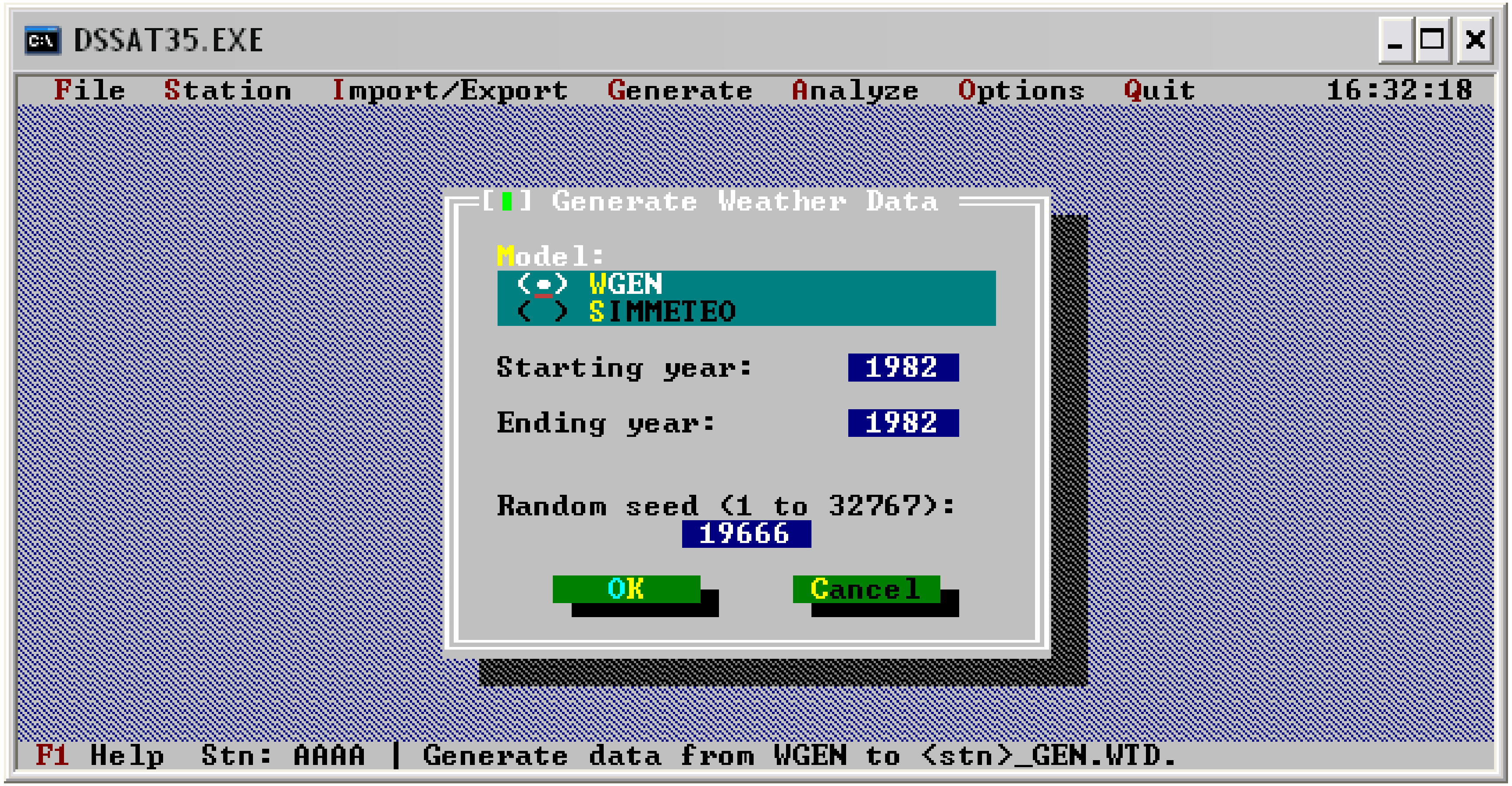
Mon	--mean monthly values-- SRAD (MJ/m²)	TMAX (ºC)	TMIN (ºC)	Total rain (mm)	Number of wet days	Mean SUNH (%)	Angstrom coef. A (Y-int)	B (slope)
1	9.3	9.0	-0.1	13.6	3.0	-99.0	0.250	0.500
2	11.3	10.3	0.3	61.7	11.1	-99.0	0.250	0.500
3	16.4	16.5	3.6	31.8	8.0	-99.0	0.250	0.500
4	22.0	21.7	5.8	35.8	8.0	-99.0	0.250	0.500
5	26.4	29.1	11.5	22.6	3.0	-99.0	0.250	0.500
6	30.2	33.3	14.8	6.0	2.0	-99.0	0.250	0.500
7	30.3	36.1	19.1	0.0	0.0	-99.0	0.250	0.500
8	28.0	36.0	18.4	0.0	0.0	-99.0	0.250	0.500
9	23.3	33.4	14.6	0.0	0.0	-99.0	0.250	0.500
10	16.0	25.9	10.8	18.0	2.0	-99.0	0.250	0.500
11	10.5	13.6	1.3	28.0	5.0	-99.0	0.250	0.500
12	7.8	11.2	1.7	58.9	13.6	-99.0	0.250	0.500

Source: Calculated_from_daily_data 1st year: 1982 No. years: 1

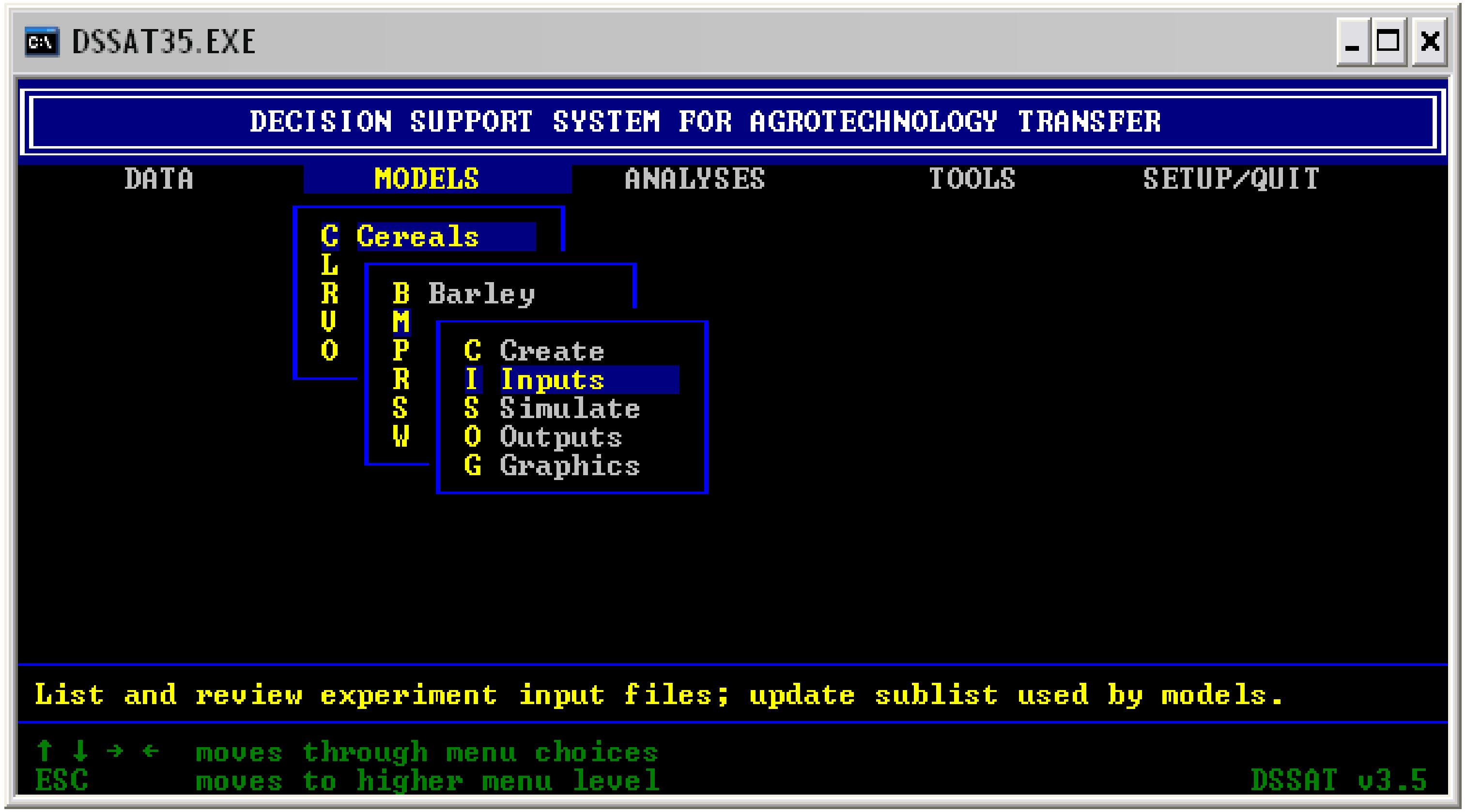
OK Cancel

F1 Help Stn: AAAA | Mean daily solar radiation (MJ/m²/d) for month.

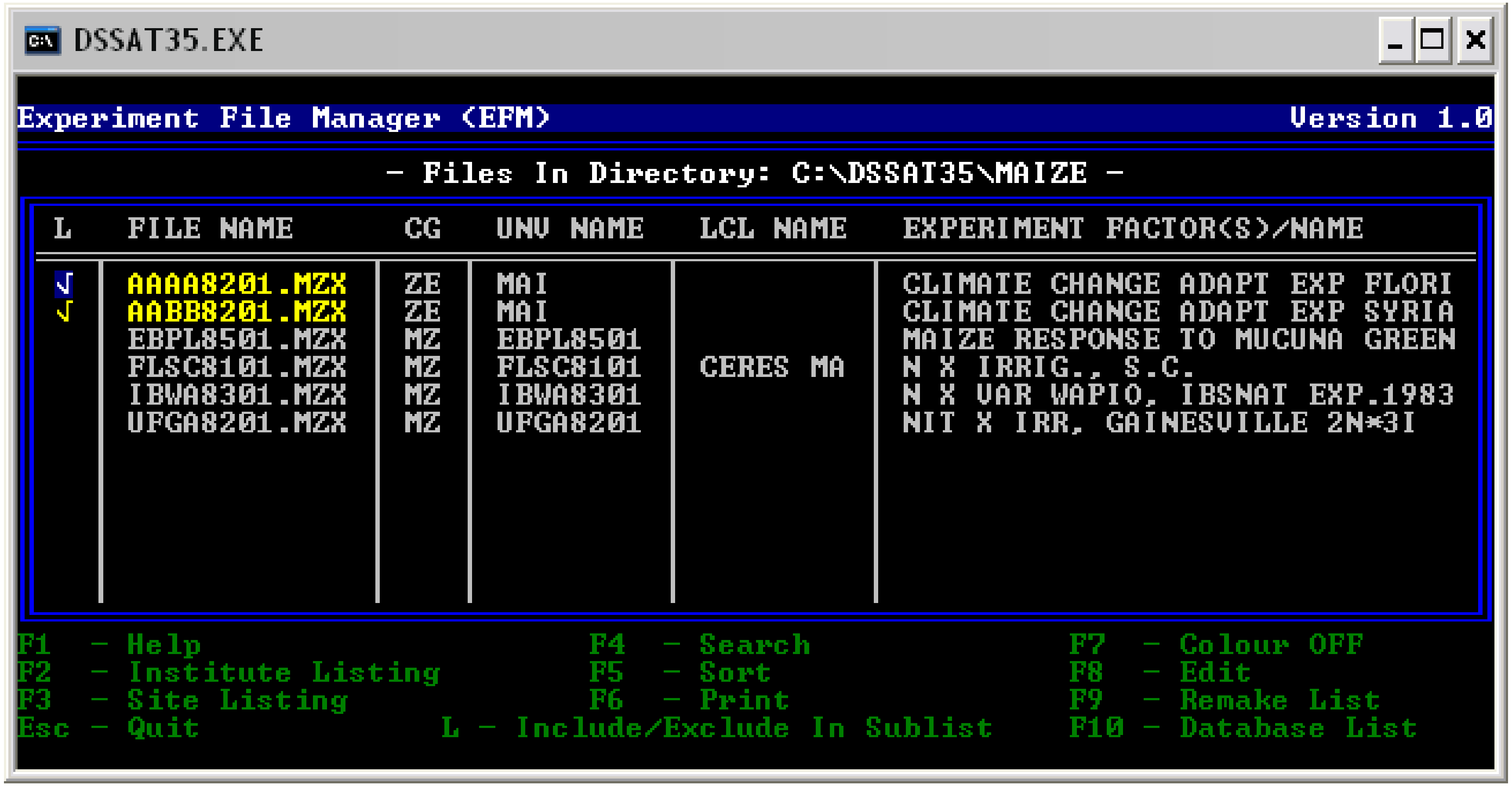
Program to Generate Weather Data . . .



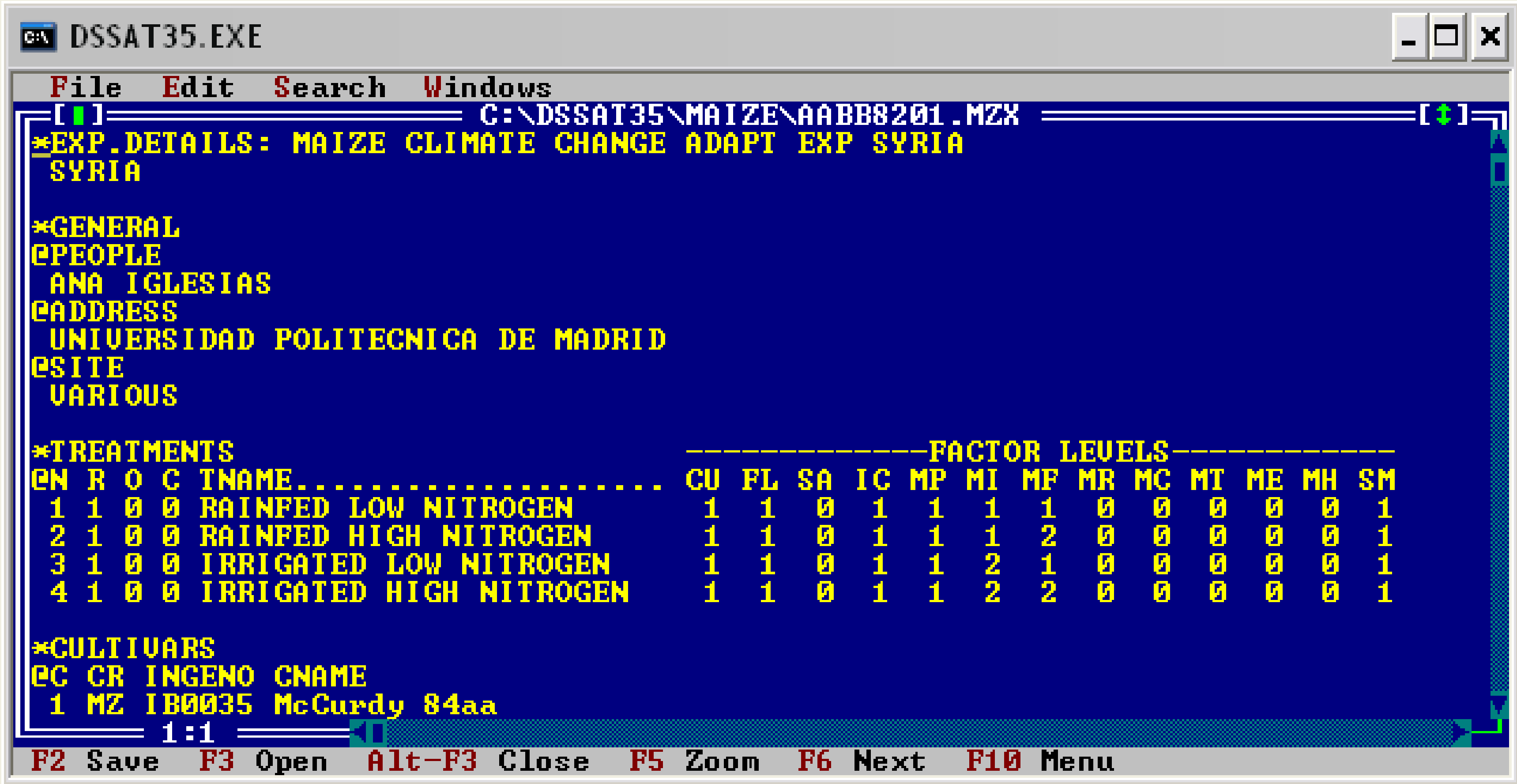
Location of the Input Experiment File . . .



Select the Experiment File . . .



Examine the Experiment File (Syria)



Examine the Experiment File (Florida)

```
DSSAT35.EXE
 File  Edit  Search  Windows
[■]════════════ C:\DSSAT35\MAIZE\AABB8201.MZX ════════════[↕]
*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0035 McCurdy 84aa

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX   SLDP ID_SOIL
 1 AAAA0002 AAAA     -99.0     0 DR000     0     0 00000 -99     180 IBMZ91001
@L ...........XCRD ...........YCRD .....ELEV .............AREA .SLEN .FLWR .SL
 1           0.00000         0.00000      0.00               0.0     0   0.0   0

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE  ICWD ICRES ICREN ICREP ICRIP ICRID
 1    MZ 82056   100     0  1.00  1.00 -99.0  1000  0.80  0.00   100    15
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086   1.5   0.6
 1    15 0.086   1.5   0.6
 1    30 0.086   1.5   0.6
 1    60 0.086   1.5   0.6
 1    90 0.076   0.6   0.6
 1   120 0.076   0.5   0.6
 1   150 0.130   0.5   0.6
      1:1
F2 Save  F3 Open  Alt-F3 Close  F5 Zoom  F6 Next  F10 Menu
```

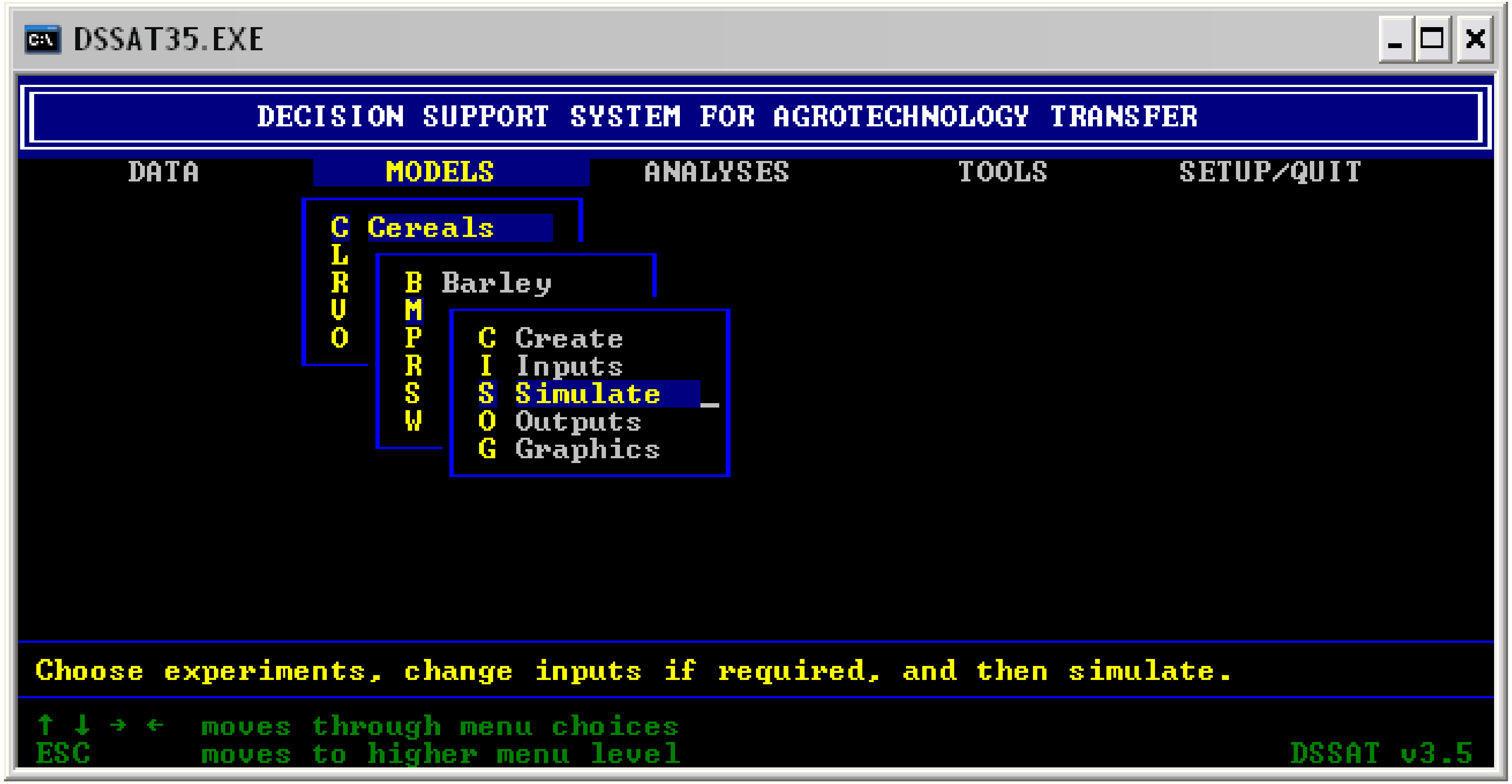
The Experiment File Can Also Be Using a Text Editor (Notepad)

PIOTMZ01.SNX - Notepad

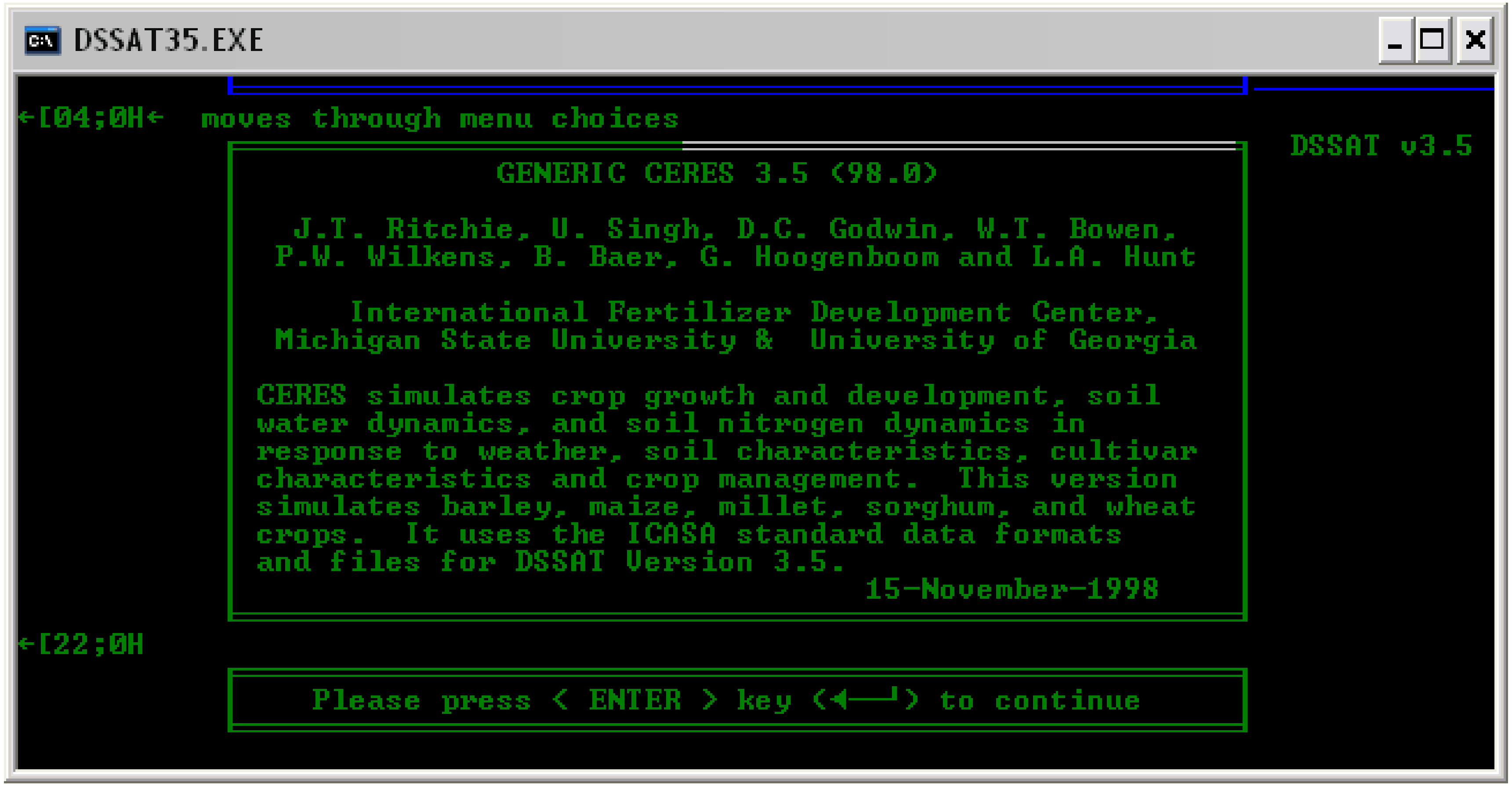
File Edit Search Help

```
*EXP.DETAILS: PIOTMZ01SN NEW PIO CULTIVAR TEST

*GENERAL
@PEOPLE
 A. IGLESIAS AND C. ROSENZWEIG
@ADDRESS
 NASA/GISS, USA
@SITE
 DES MOINES, IOWA
@NOTES
 NEW PIONNER PROJECT

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 DIA0 BASE MZ PL1          16  1  0  1  1  0  1  1  0  0  1  0  1
 2 1 0 0 DIA1 HC10 MZ PL1          16  2  0  1  1  0  1  1  0  0  2  0  1
 3 1 0 0 DIA2 HC20 MZ PL1          16  3  0  1  1  0  1  1  0  0  3  0  1
 4 1 0 0 DIA3 HC50 MZ PL1          16  4  0  1  1  0  1  1  0  0  4  0  1
 5 1 0 0 DIA4 CC10 MZ PL1          16  5  0  1  1  0  1  1  0  0  2  0  1
 6 1 0 0 DIA5 CC20 MZ PL1          16  6  0  1  1  0  1  1  0  0  3  0  1
 7 1 0 0 DIA6 CC50 MZ PL1          16  7  0  1  1  0  1  1  0  0  4  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0070 PIO3394
 2 MZ IB0012 PIO3382

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX   SLDP ID_SOIL
 1 DIA00001 DIA05101 -99       0 DR000     0     0 00000   -99     90 IBPI000990
 2 DIA10001 DIA15101 -99       0 DR000     0     0 00000   -99     90 IBPI000990
 3 DIA20001 DIA25101 -99       0 DR000     0     0 00000   -99     90 IBPI000990

*INITIAL CONDITIONS
@C    PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1     MZ 51120  1200   -99  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.262   0.5   4.6
 1    15 0.262   0.5   4.6
 1    30 0.262   0.5   4.4
 1    45 0.262   0.2   3.8
 1    60 0.262   0.2   3.8
 1    90 0.261   0.2   2.8
@C    PCR ICDAT  ICRT  ICND  ICRN  ICRE
```

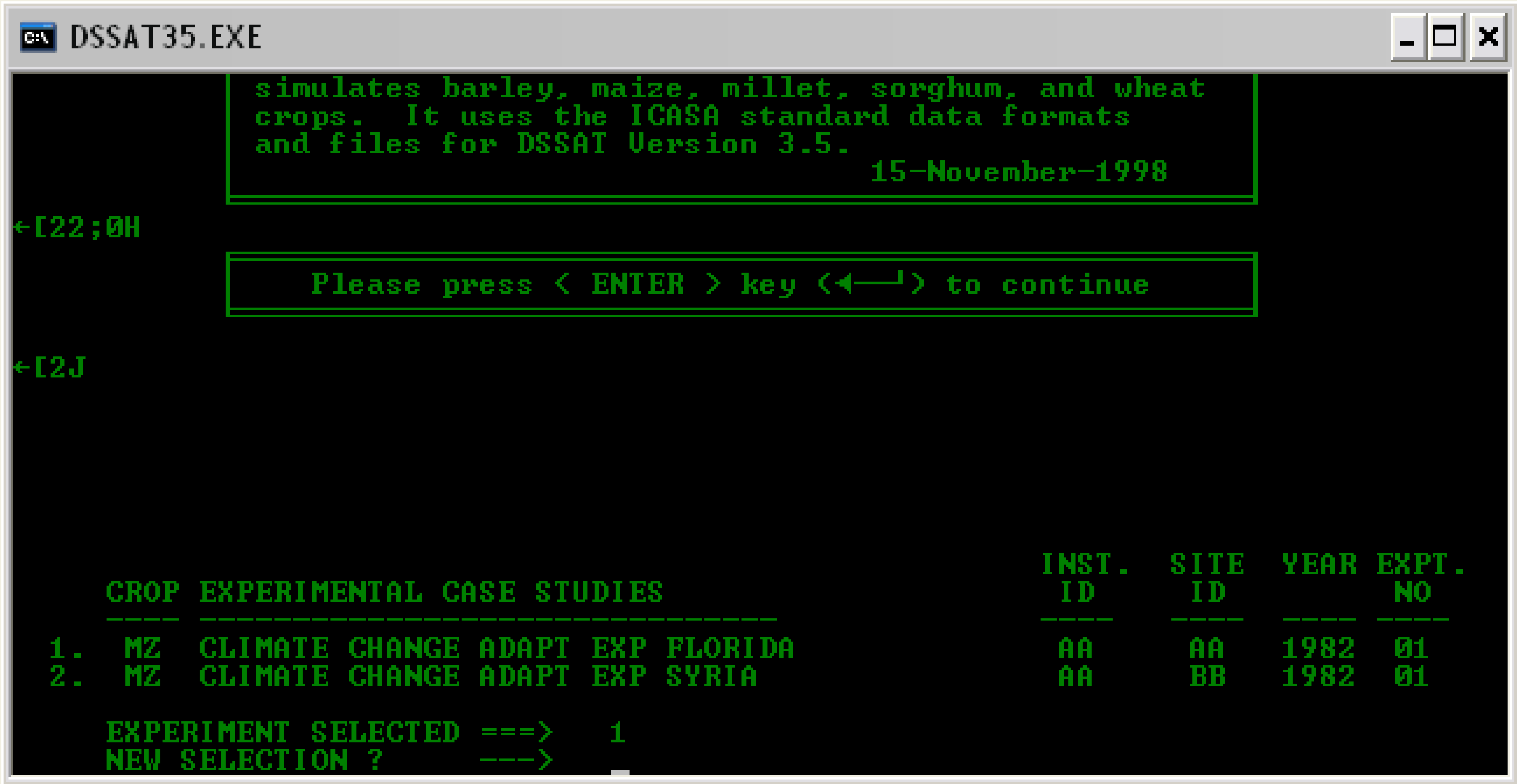
Start Simulation …



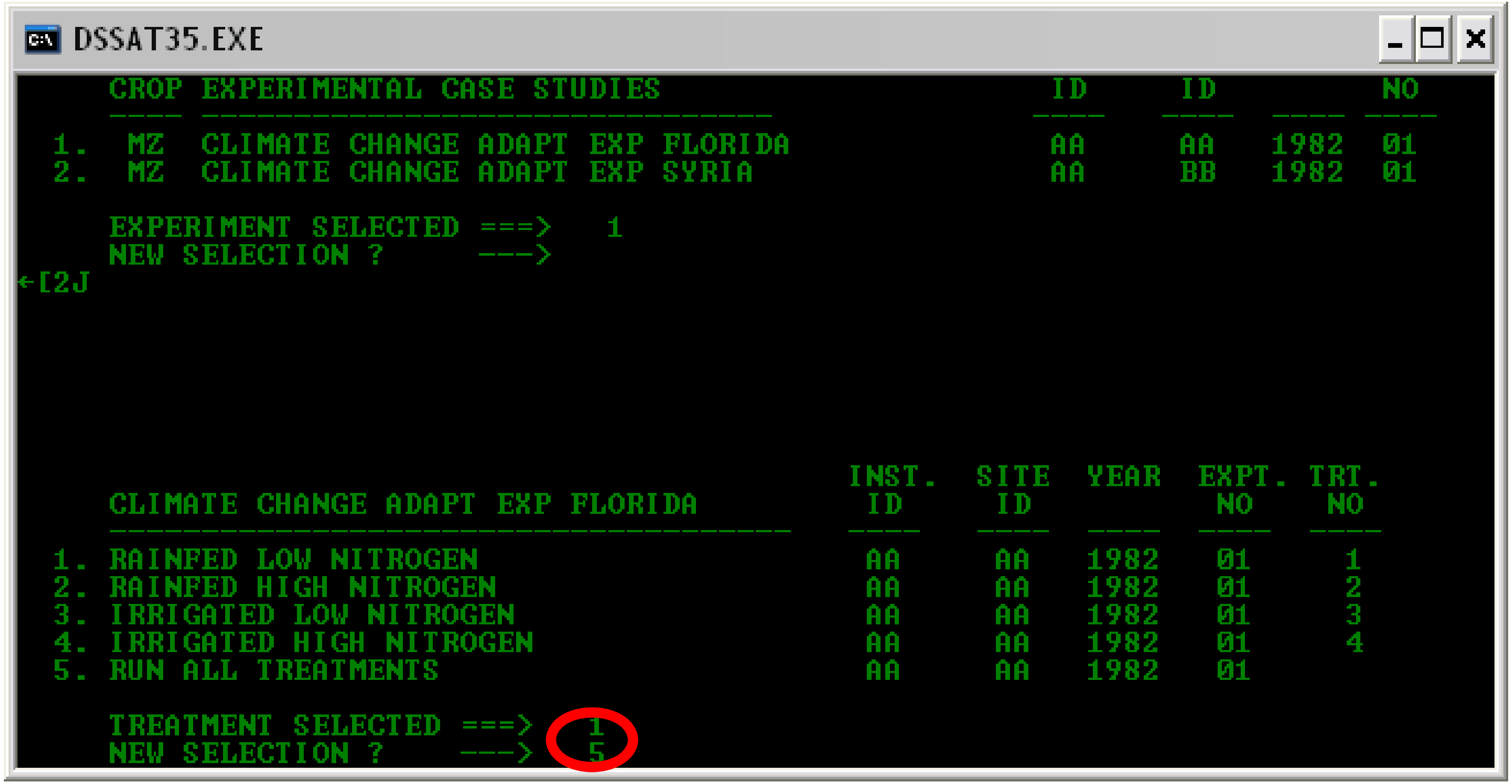
Running . . .


DSSAT35.EXE
←[04;0H← moves through menu choices
DSSAT v3.5
GENERIC CERES 3.5 (98.0)
J.T. Ritchie, U. Singh, D.C. Godwin, W.T. Bowen,
P.W. Wilkens, B. Baer, G. Hoogenboom and L.A. Hunt
International Fertilizer Development Center,
Michigan State University & University of Georgia
CERES simulates crop growth and development, soil
water dynamics, and soil nitrogen dynamics in
response to weather, soil characteristics, cultivar
characteristics and crop management. This version
simulates barley, maize, millet, sorghum, and wheat
crops. It uses the ICASA standard data formats
and files for DSSAT Version 3.5.
15-November-1998
←[22;0H
Please press < ENTER > key (←┘) to continue

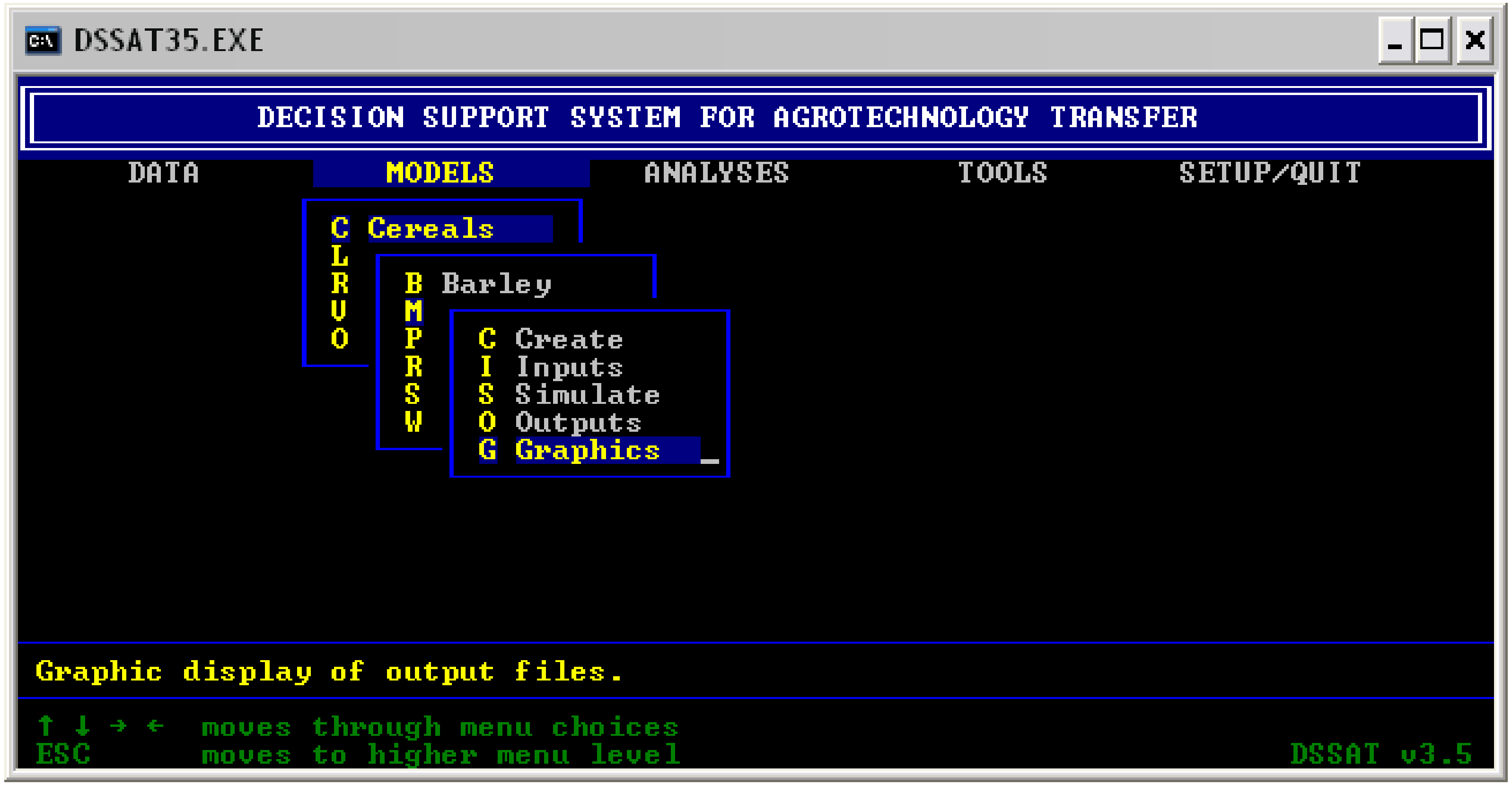
Select Experiment . . .



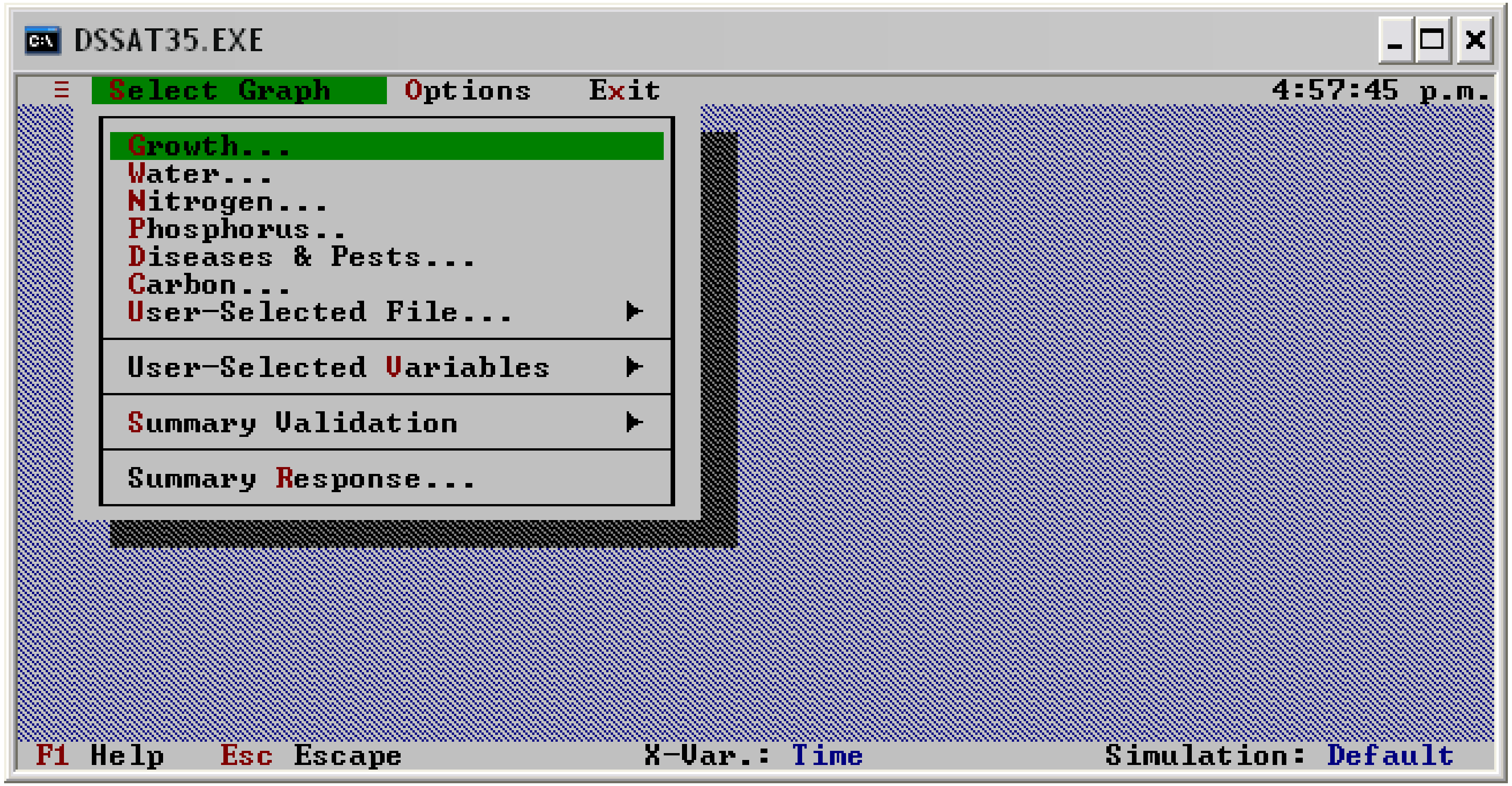
Select Treatment . . .



View the Results . . .



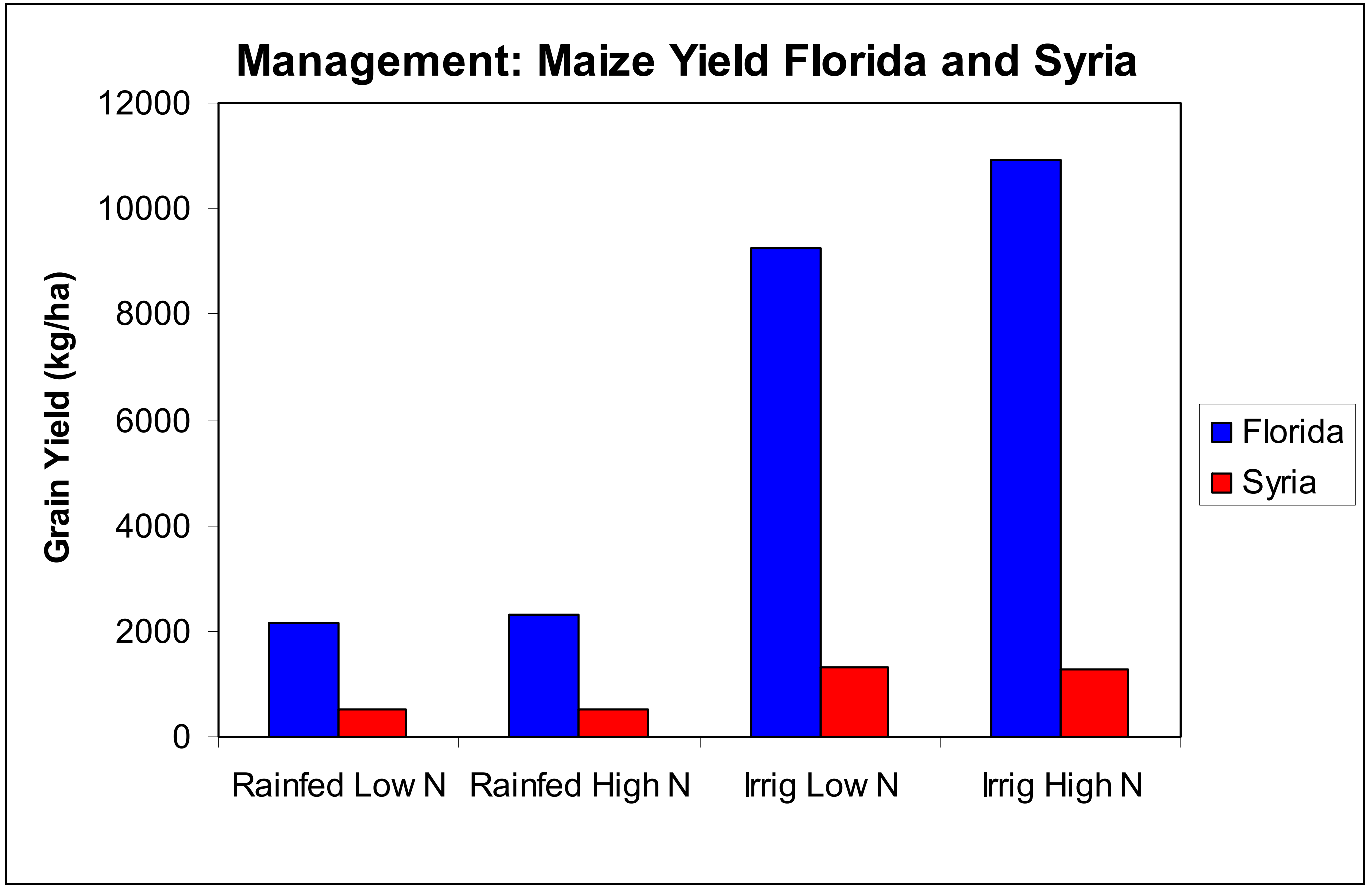
Select Option . . .



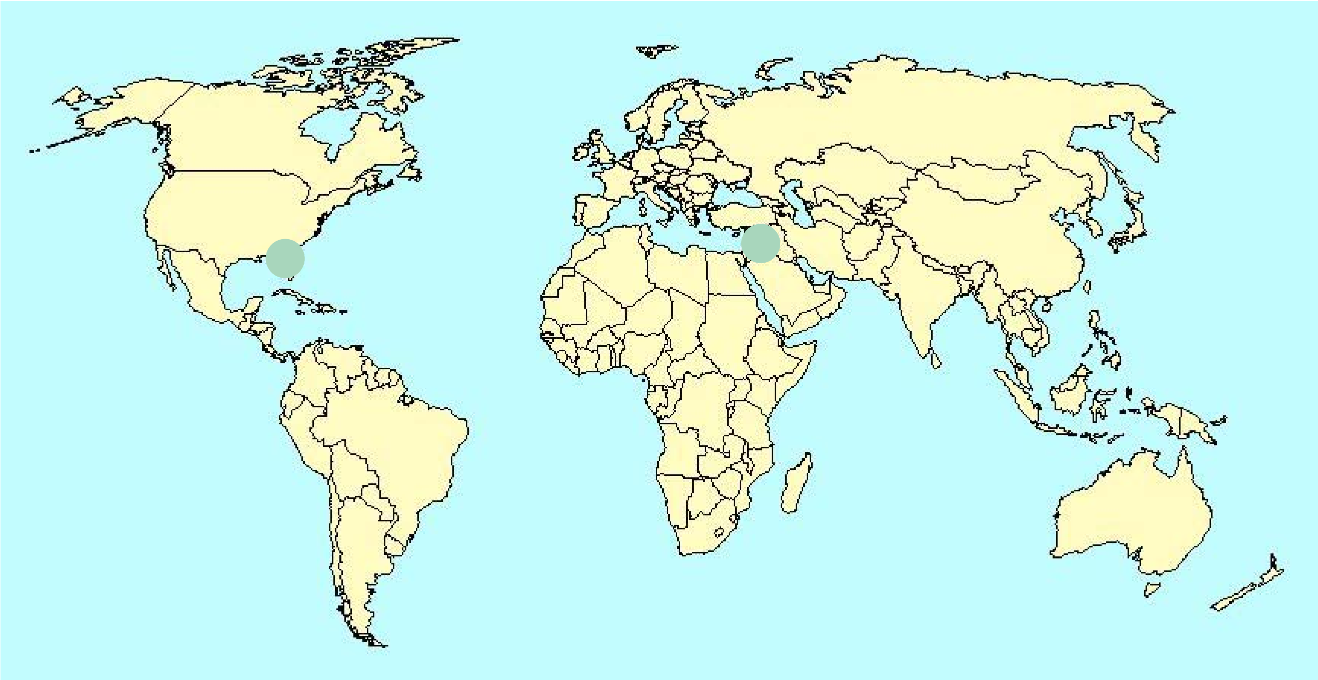
Retrieve Output Files for Analysis

- C:/DSSAT35/MAIZE/SUMMARY.OUT
- C:/DSSAT35/MAIZE/WATER.OUT
- C:/DSSAT35/MAIZE/OVERVIEW.OUT
- C:/DSSAT35/MAIZE/GROWTH.OUT
- C:/DSSAT35/MAIZE/NITROGEN.OUT
- These are DOS text files, can be imported into Excel

Analyse and Present Results

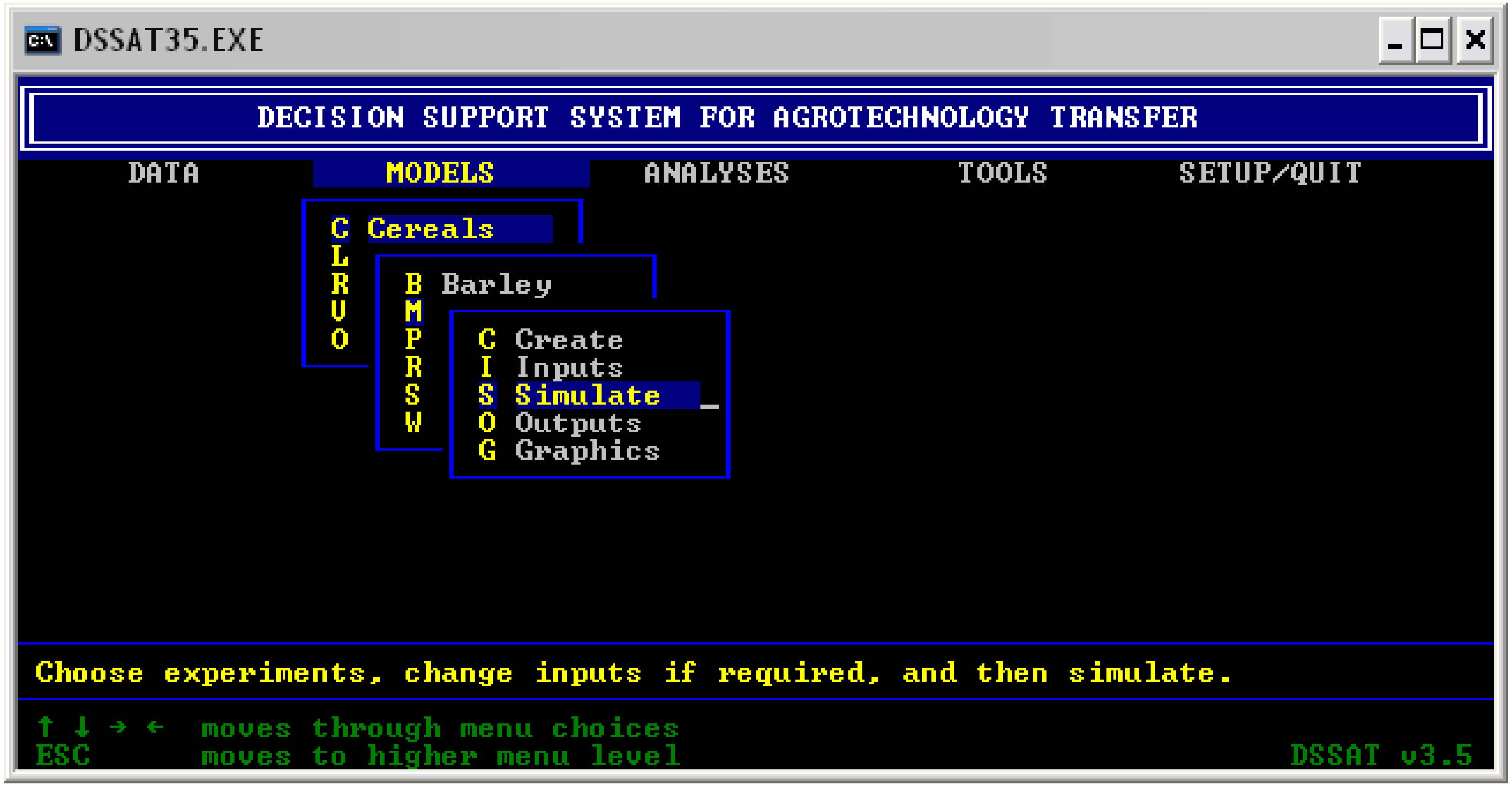


Application 2. Sensitivity to Climate

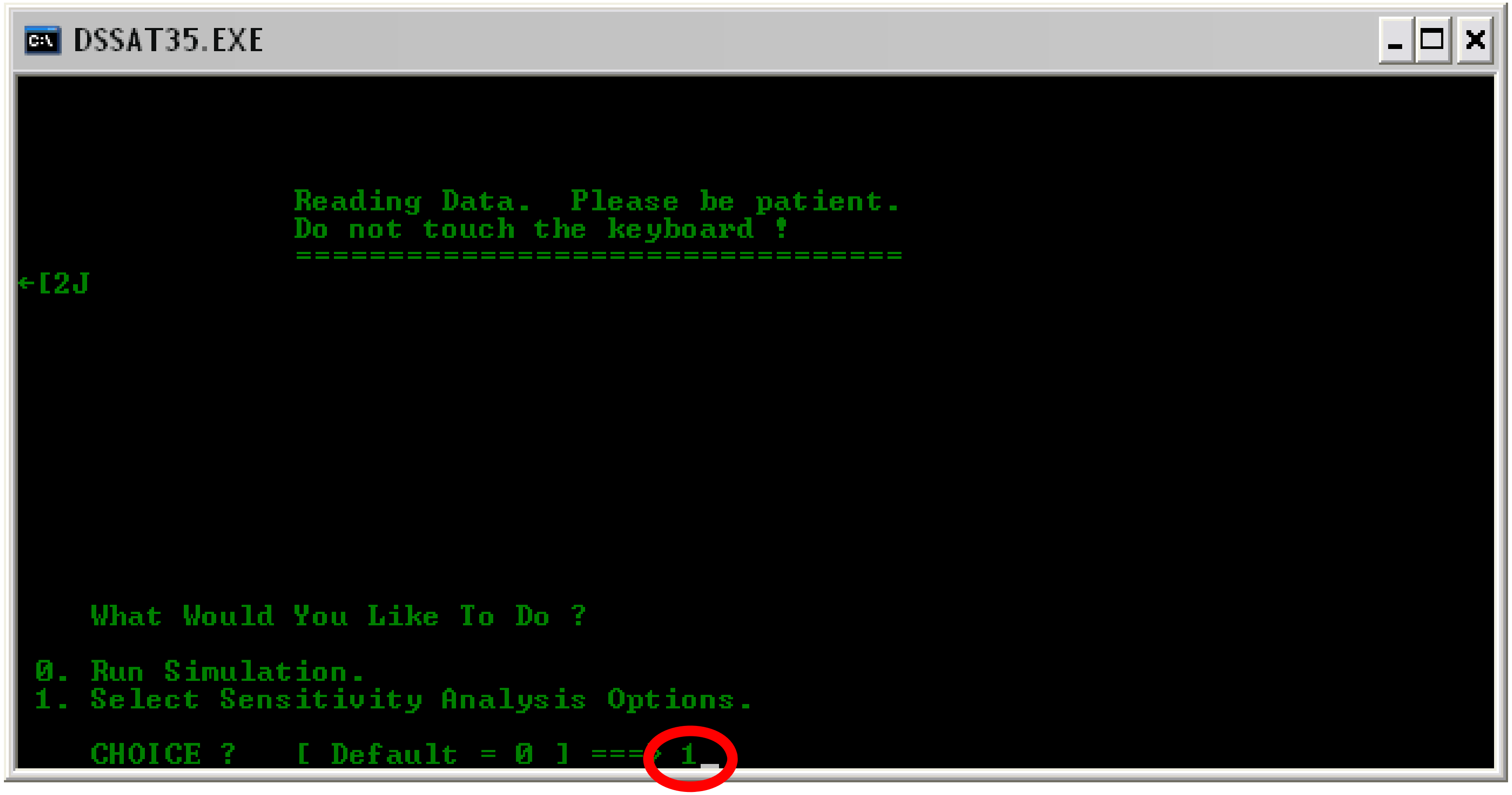


- Objective: Effect of weather modification

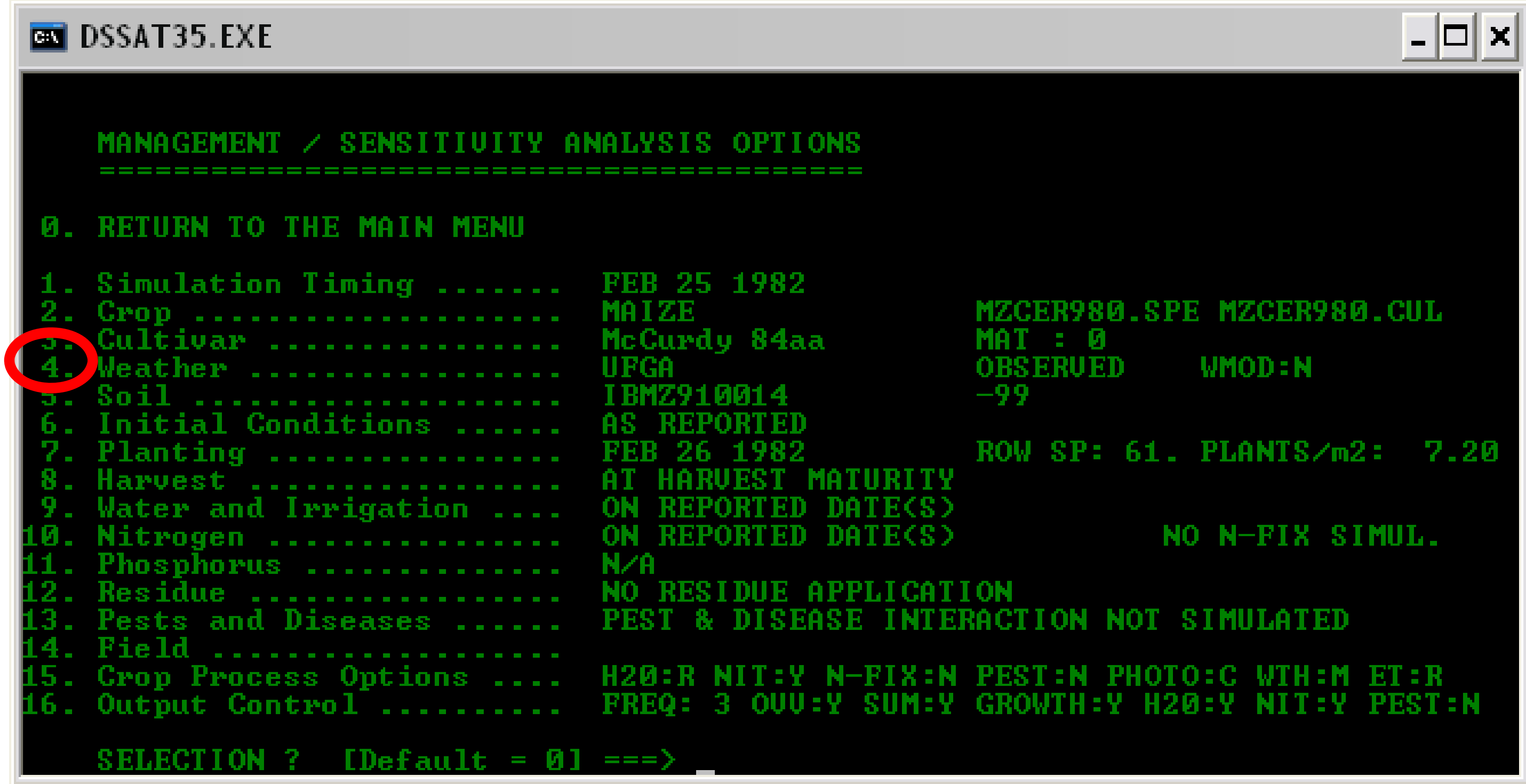
Start Simulation . . .



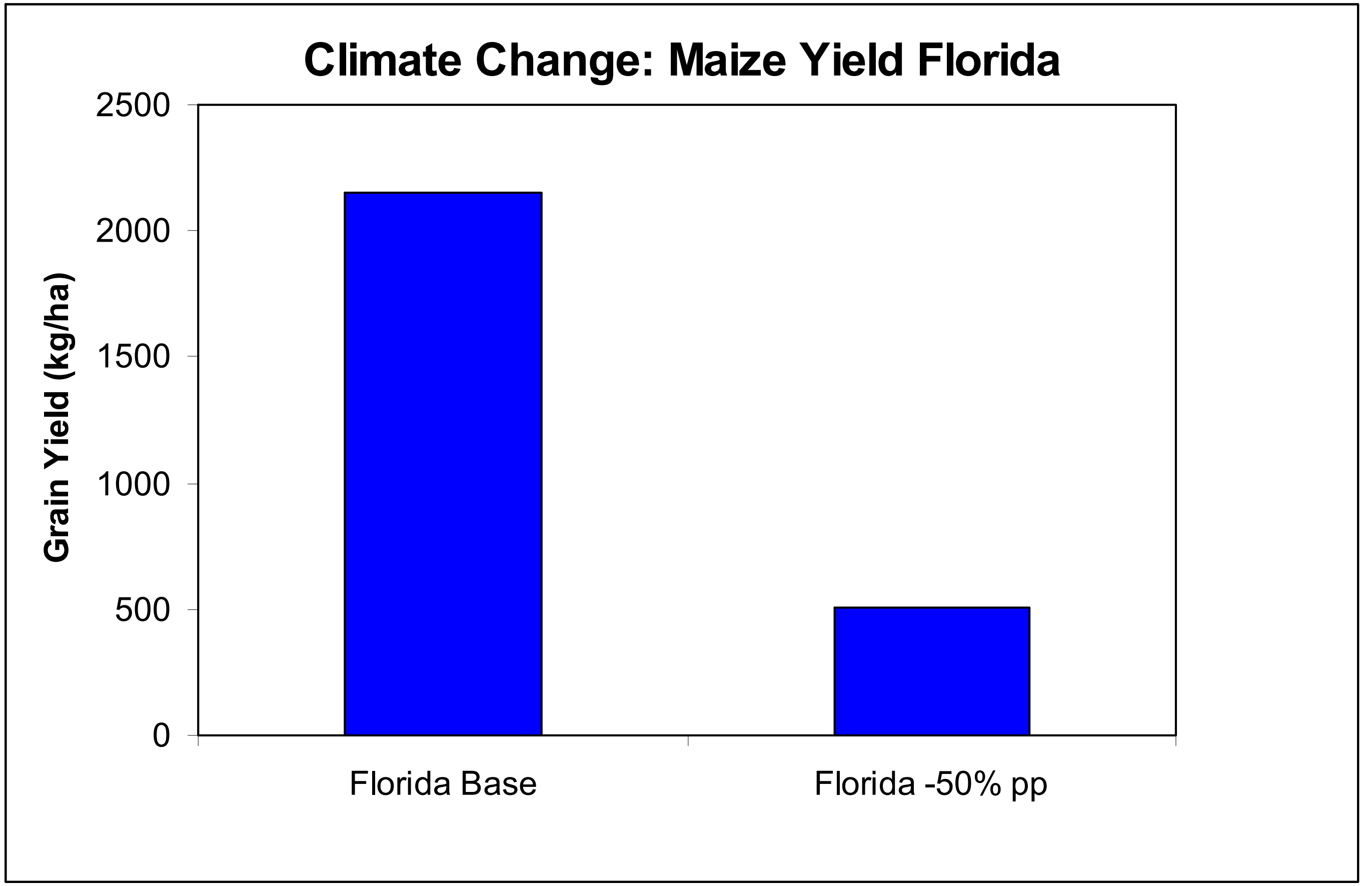
Sensitivity Analysis . . .



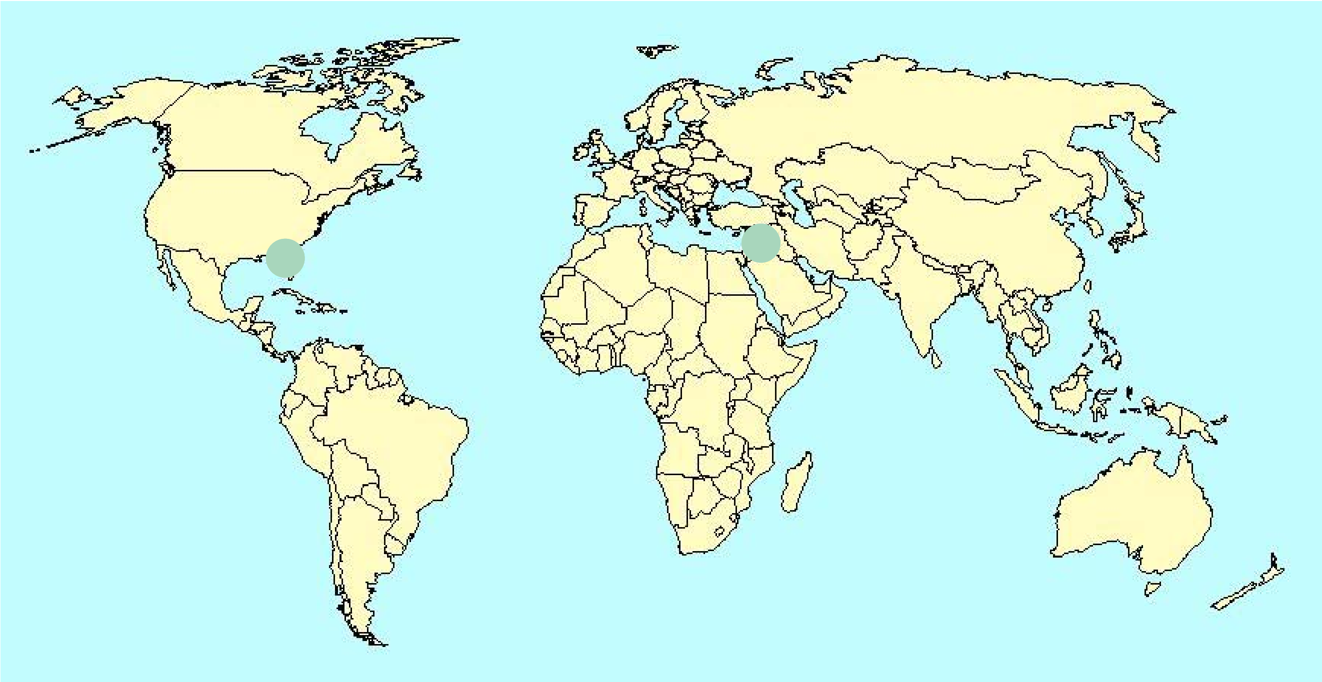
Select Option …



Analyze Results . . .



Application 3. Adaptation



- Objective: For advanced participants …

AGL

Water Resources, Development and Management Service
CROPWAT

CROPWAT is a decision support system for irrigation planning and management.

<http://www.clac.edu.eg>

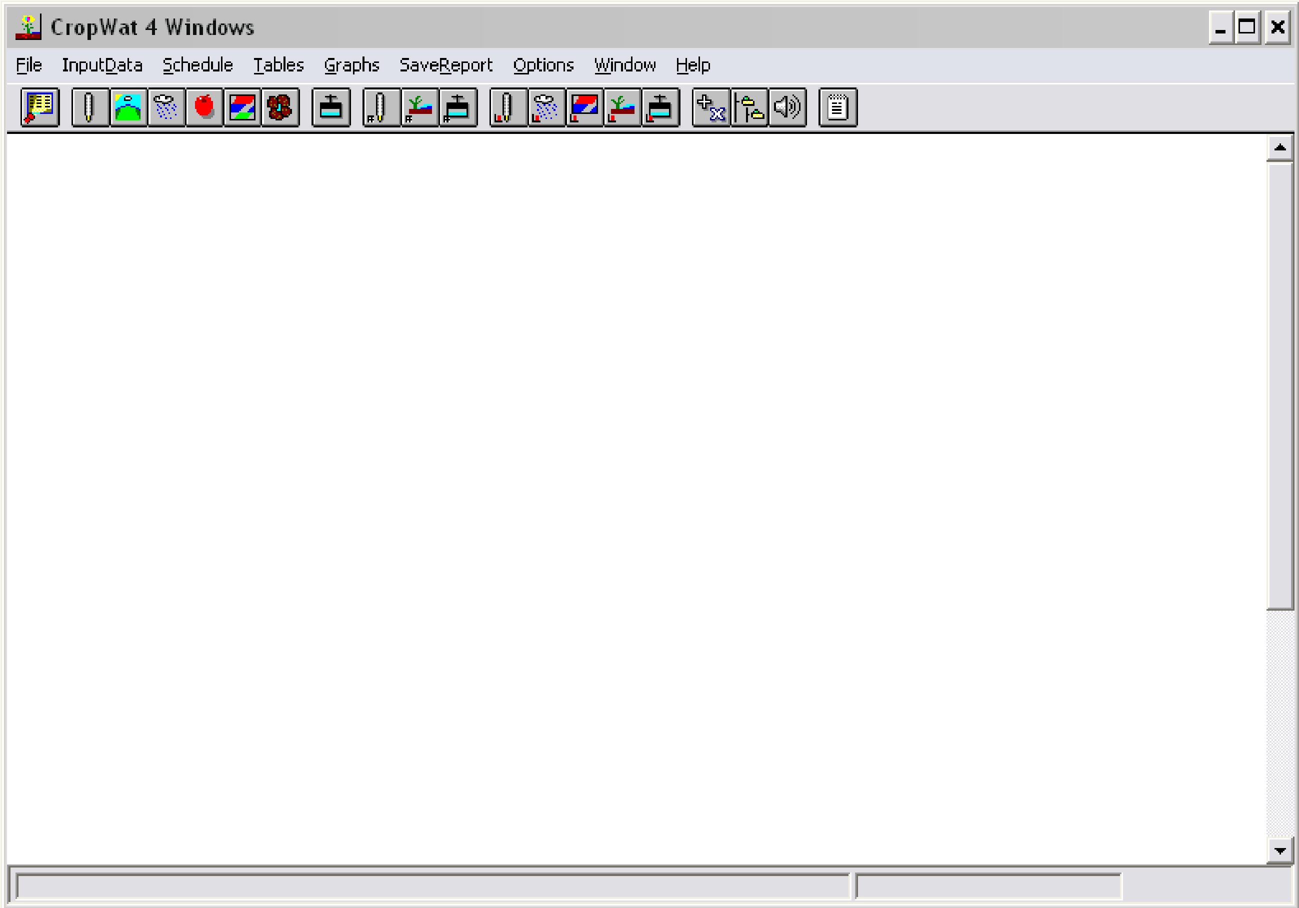
<http://www.fao.org/ag/agl/aglw/cropwat.htm>

Can the water/irrigation systems meet the stress of changes in water supply/demand?

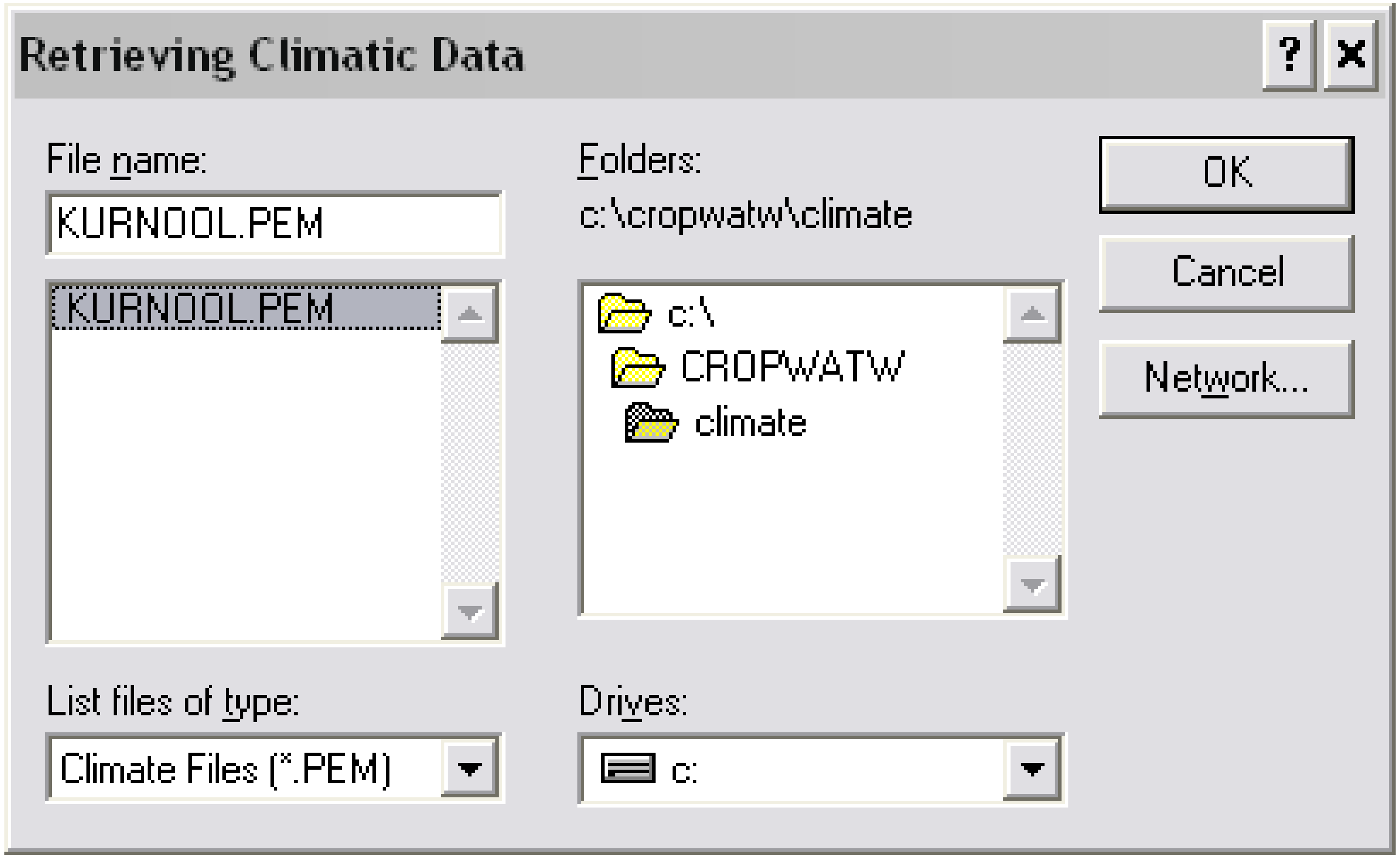
Worked Examples

1. Calculate ETo
2. Calculate crop water requirements
3. Calculate irrigation requirements for several crops in a farm

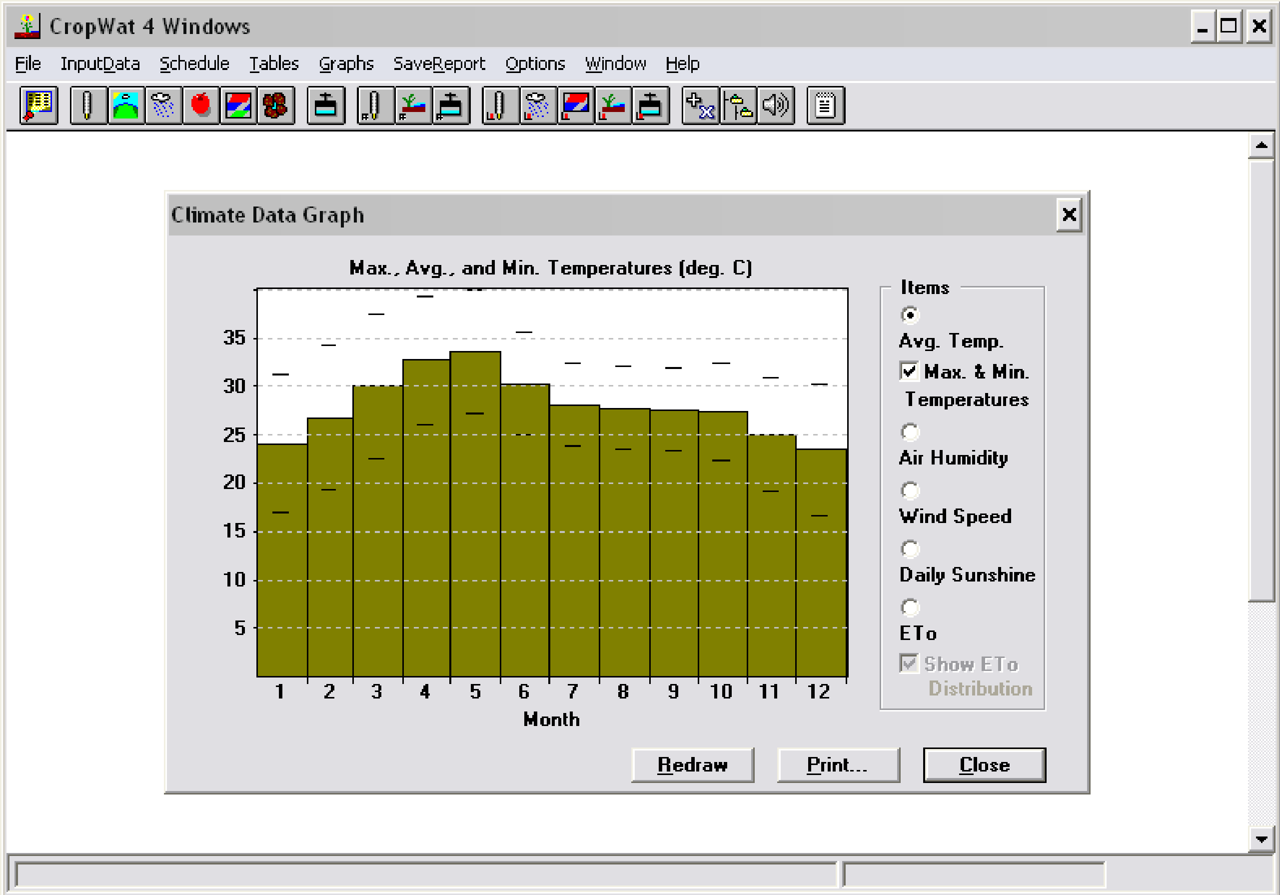
Start CROPWAT …



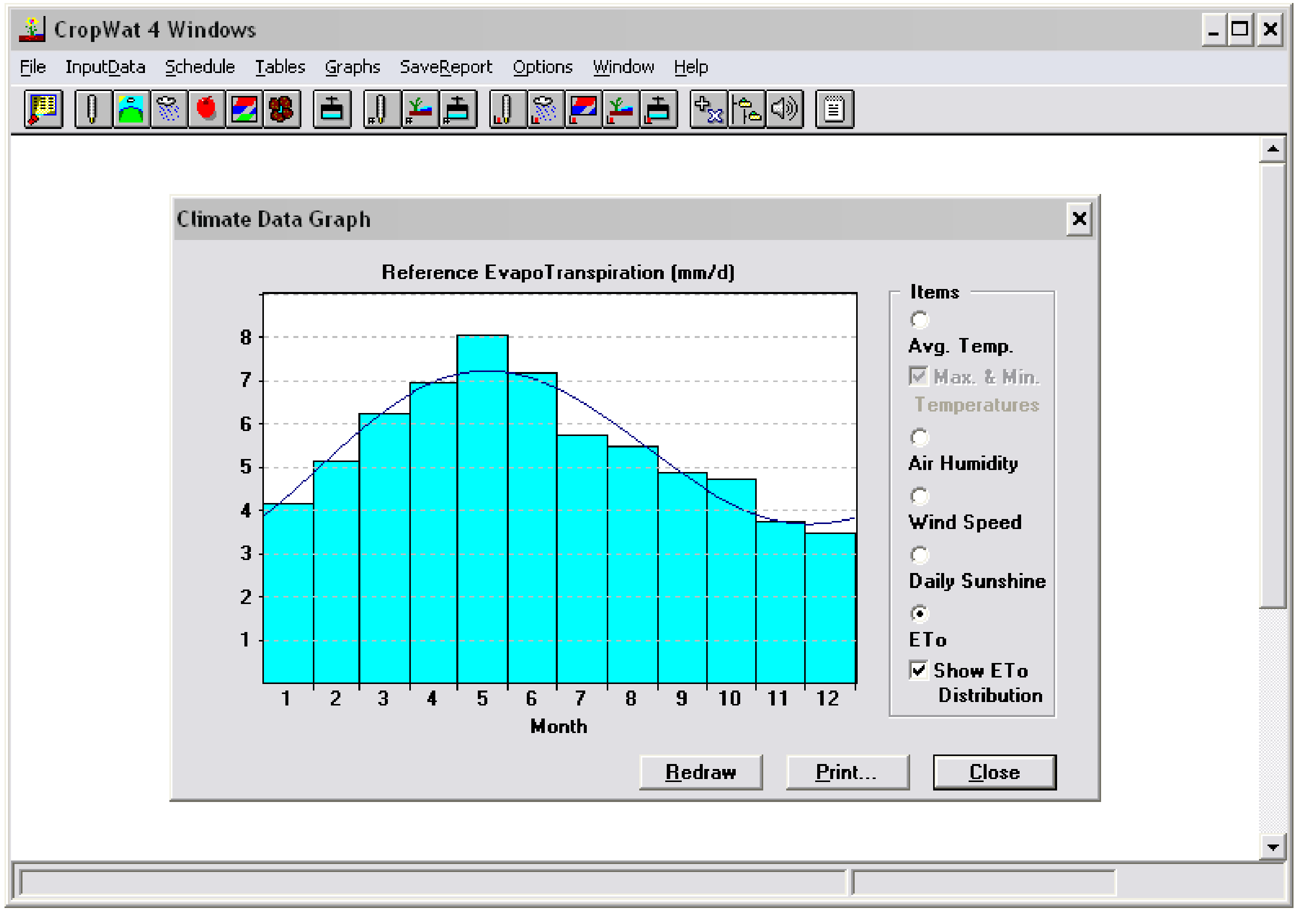
Retrieve Climate File . . .



Examine Temperature . . .

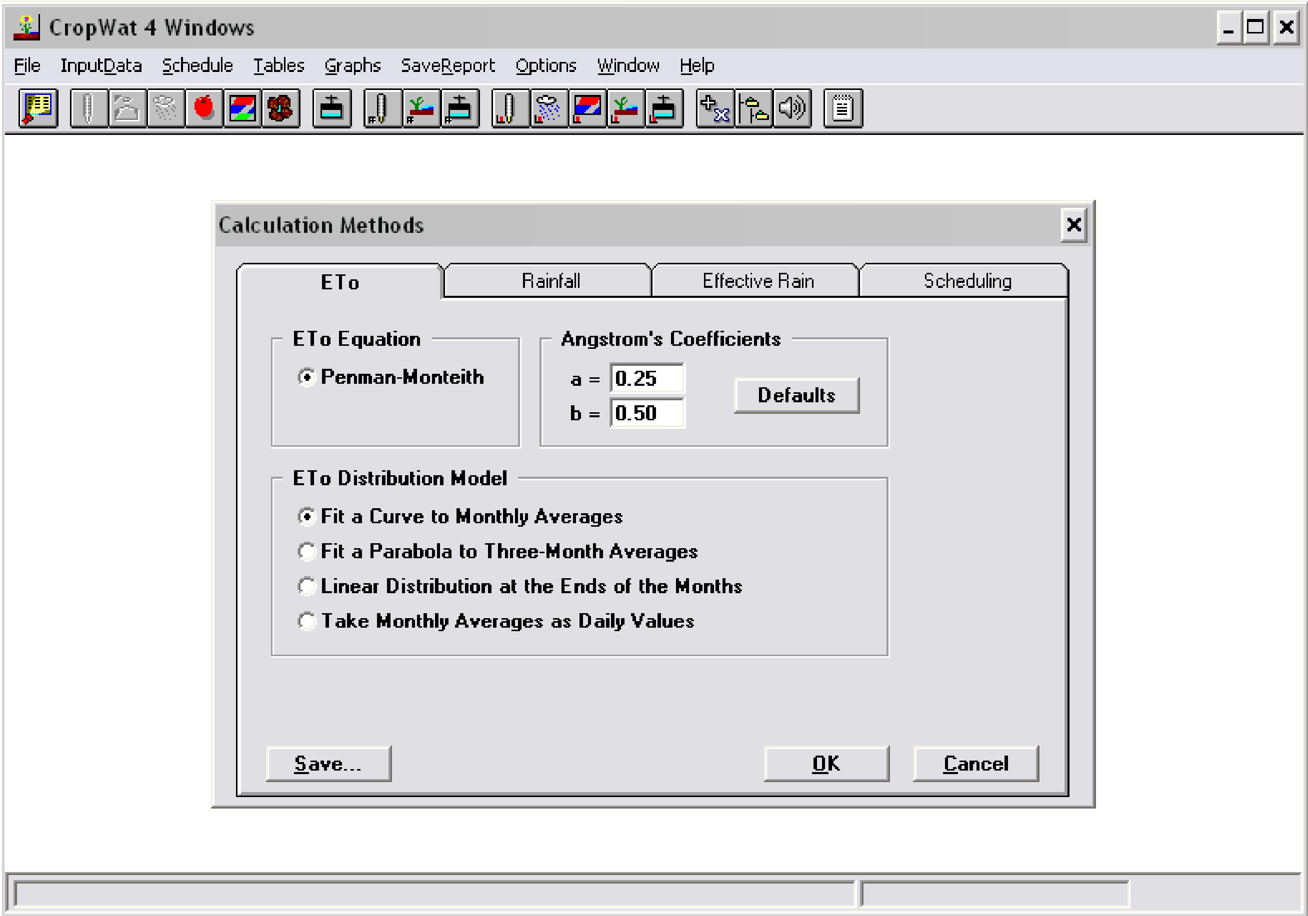


Examine ET0 . . .

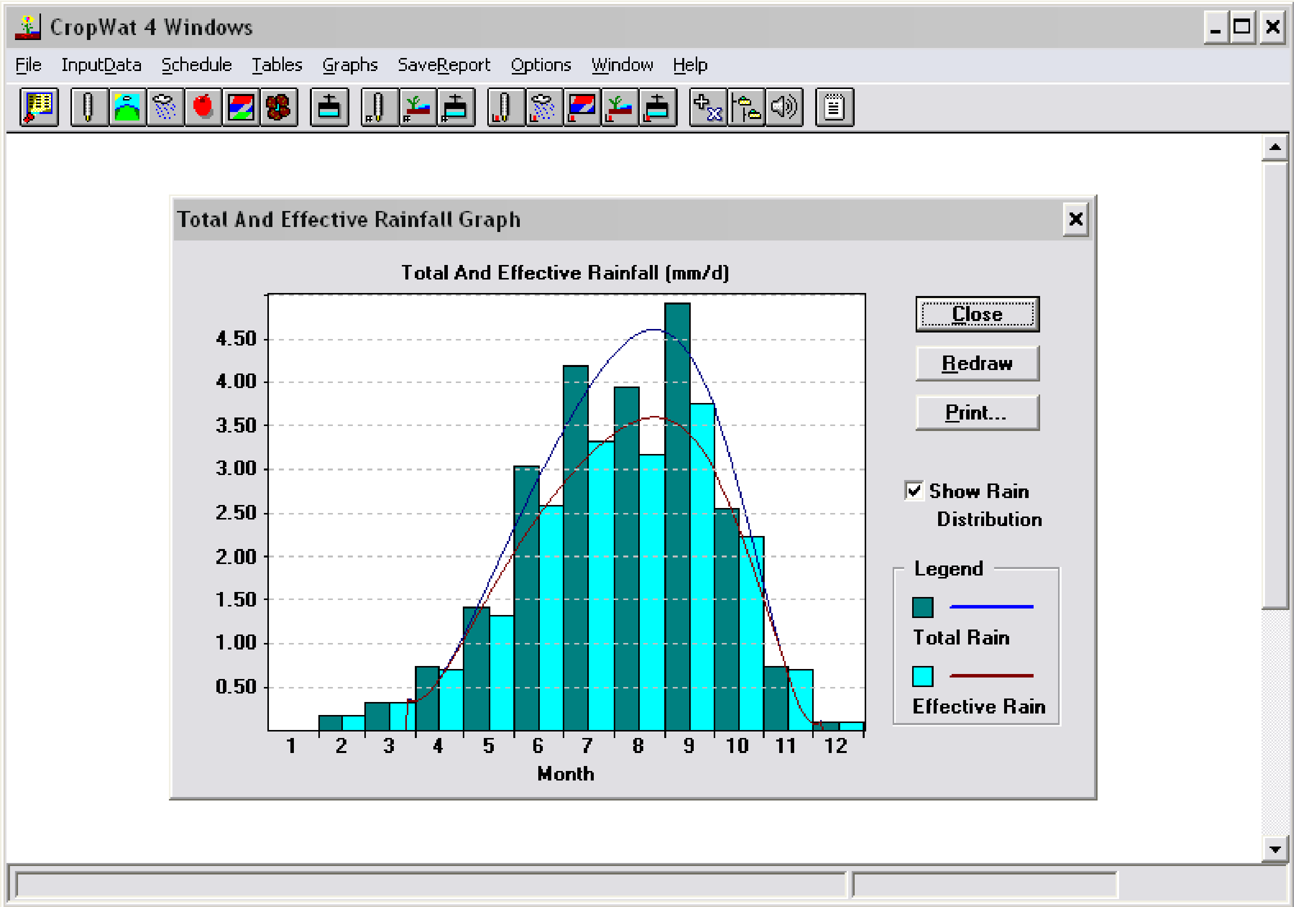


CropWat 4 Windows
File InputData Schedule Tables Graphs SaveReport Options Window Help
Climate Data Graph
Reference EvapoTranspiration (mm/d)
8
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10 11 12
Month
Items
Avg. Temp.
Max. & Min. Temperatures
Air Humidity
Wind Speed
Daily Sunshine
ETo
Show ETo Distribution
Redraw
Print...
Close

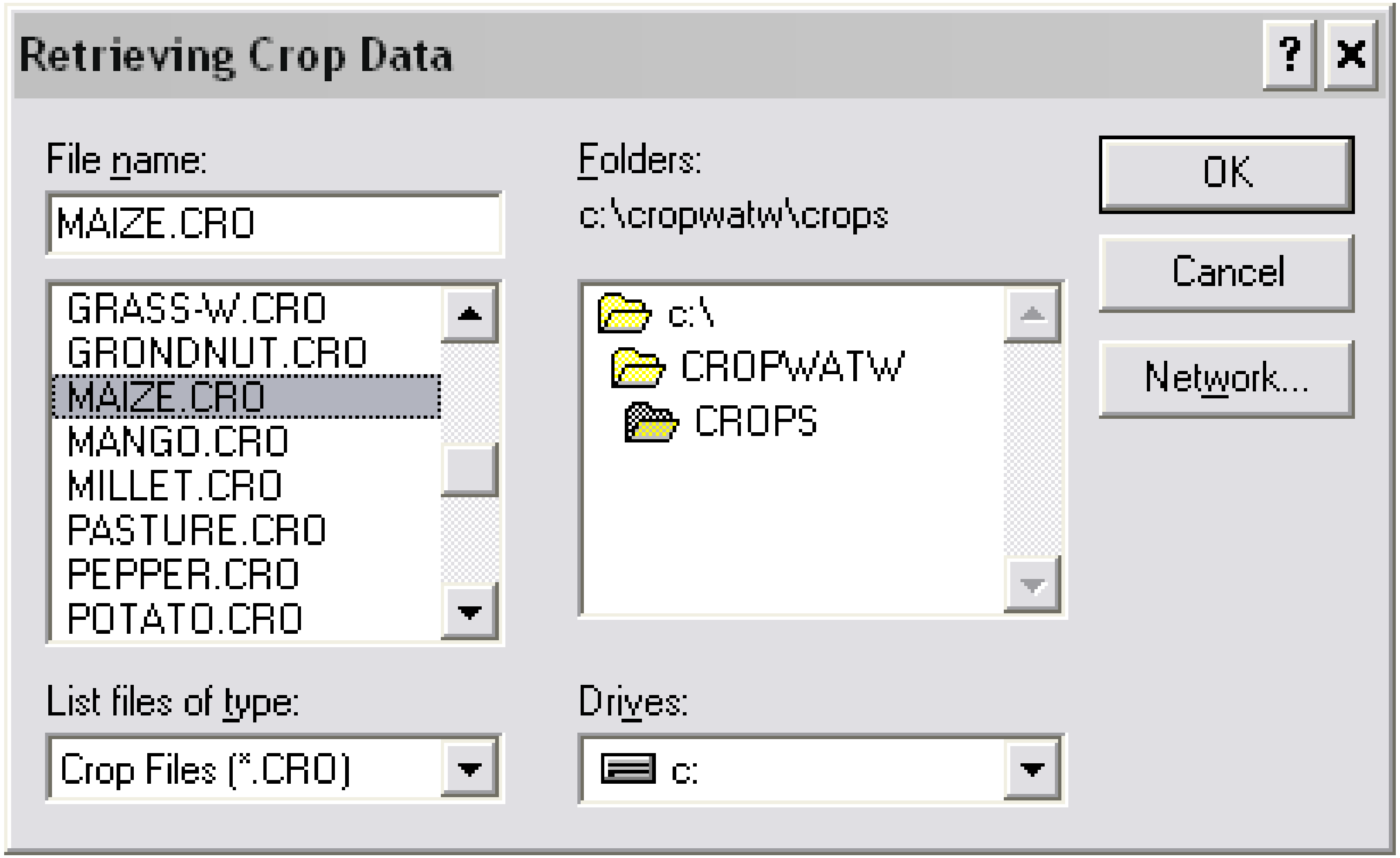
Calculate ET0 . . .



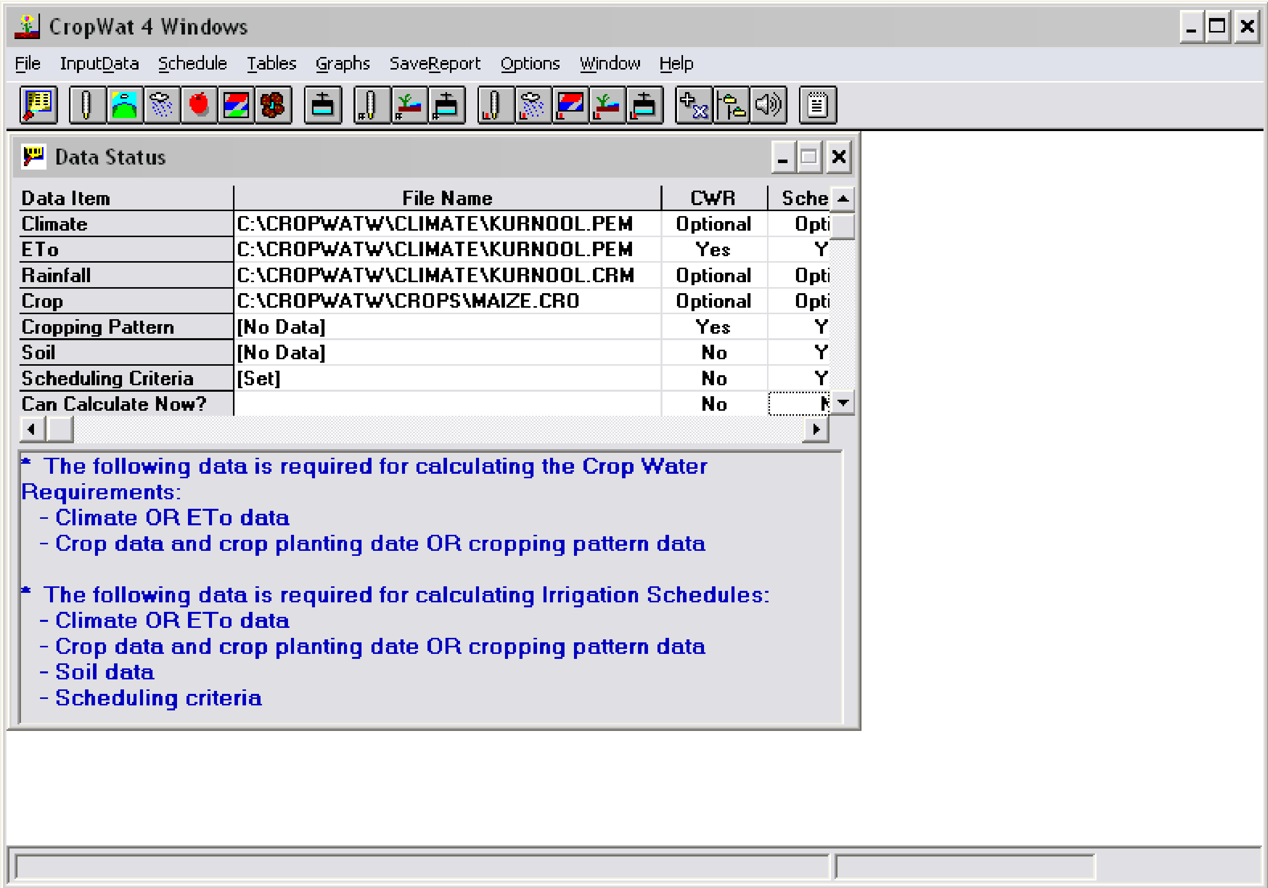
Examine Rainfall . . .



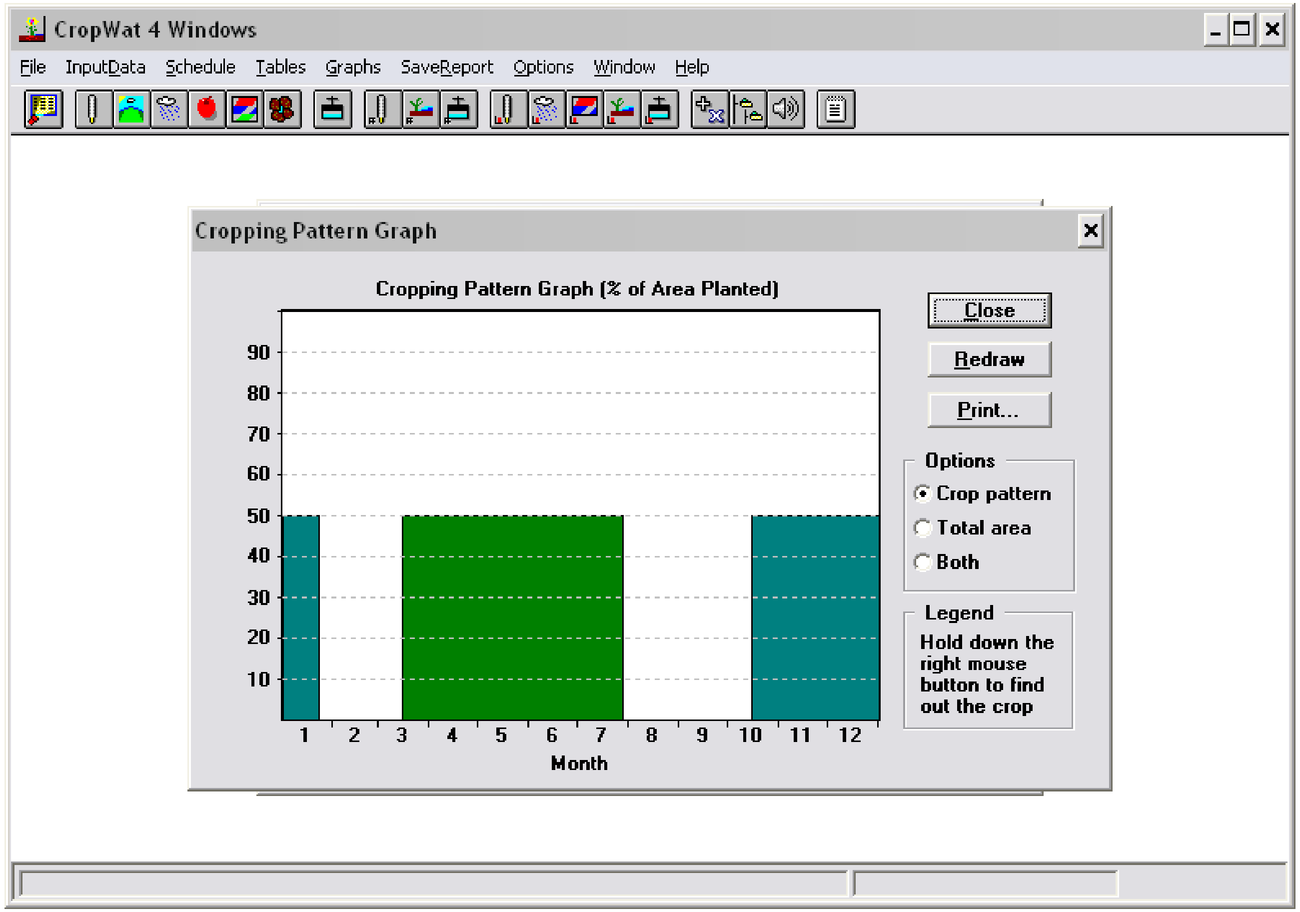
Retrieve Crop Parameters . . .



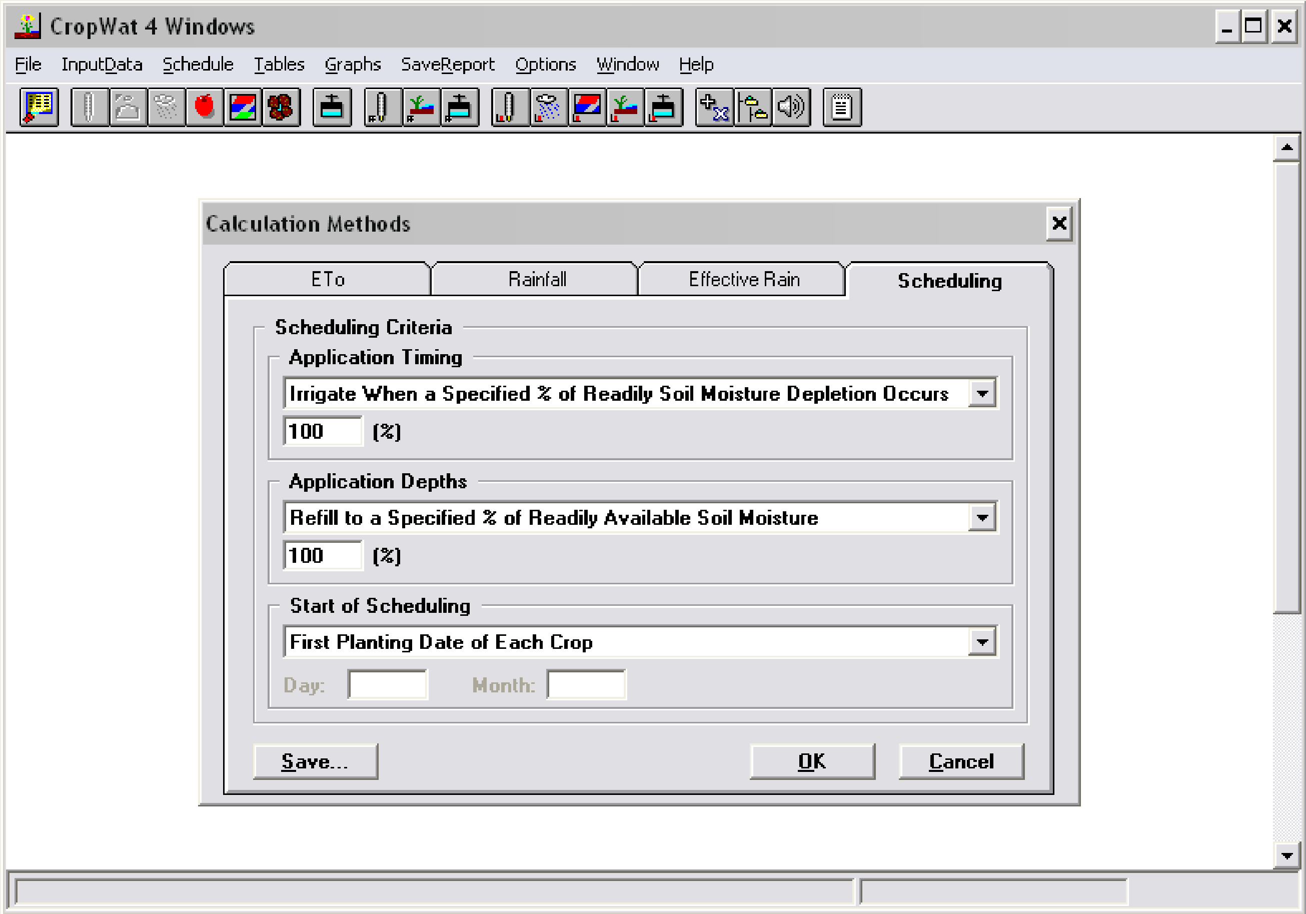
View Progress of Inputs . . .



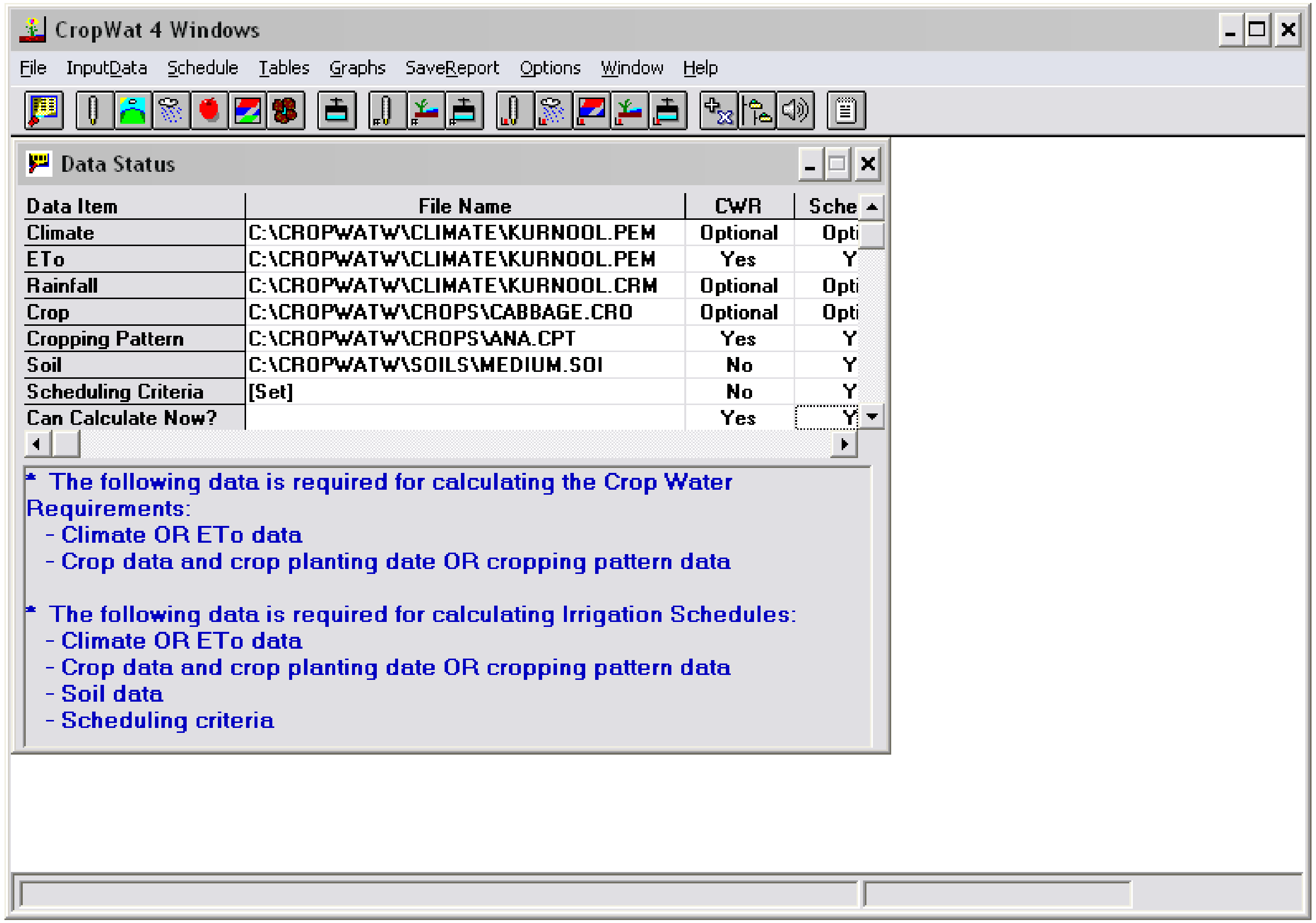
Define and View Crop Areas Selected . . .



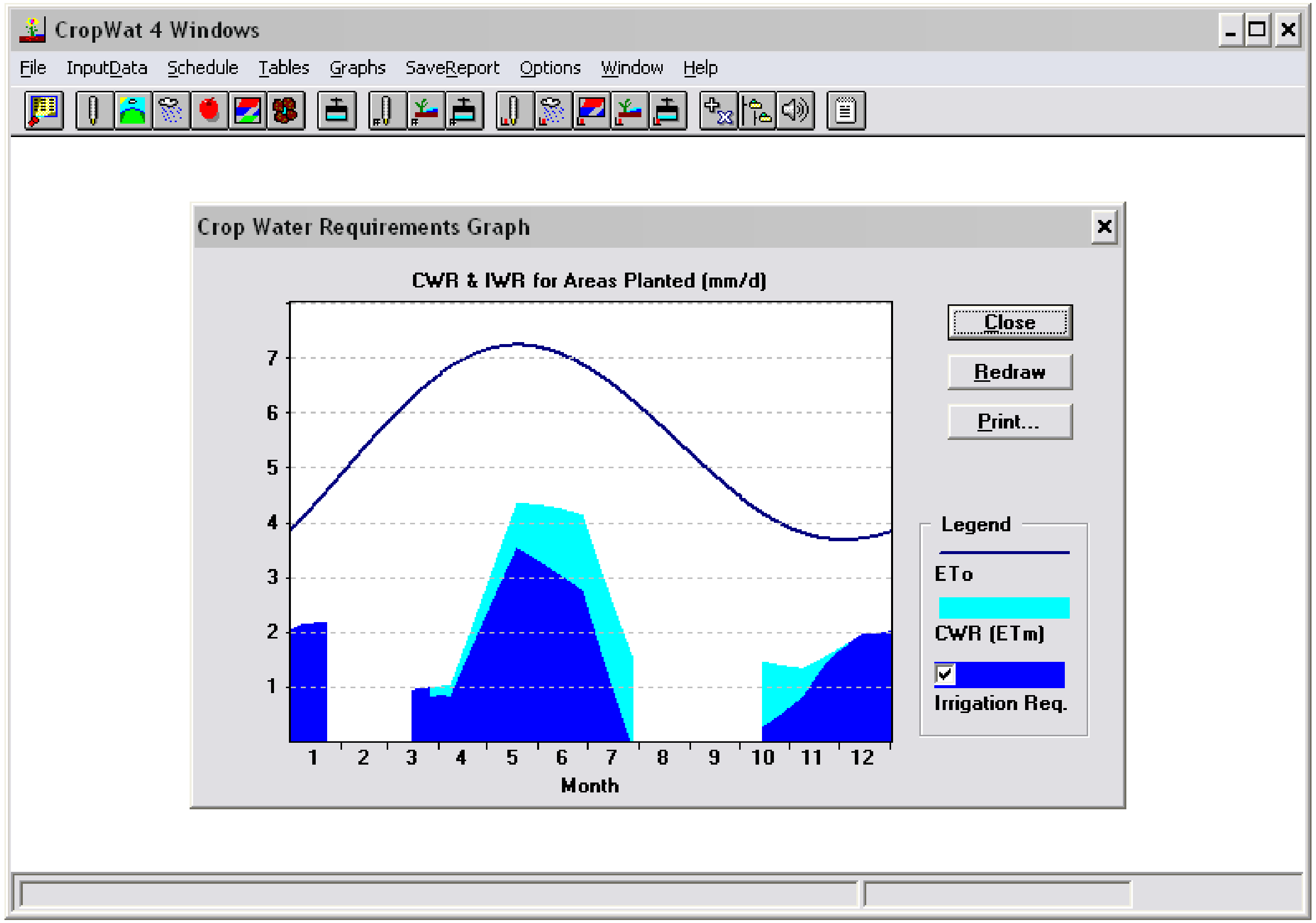
Define Irrigation Method . . .



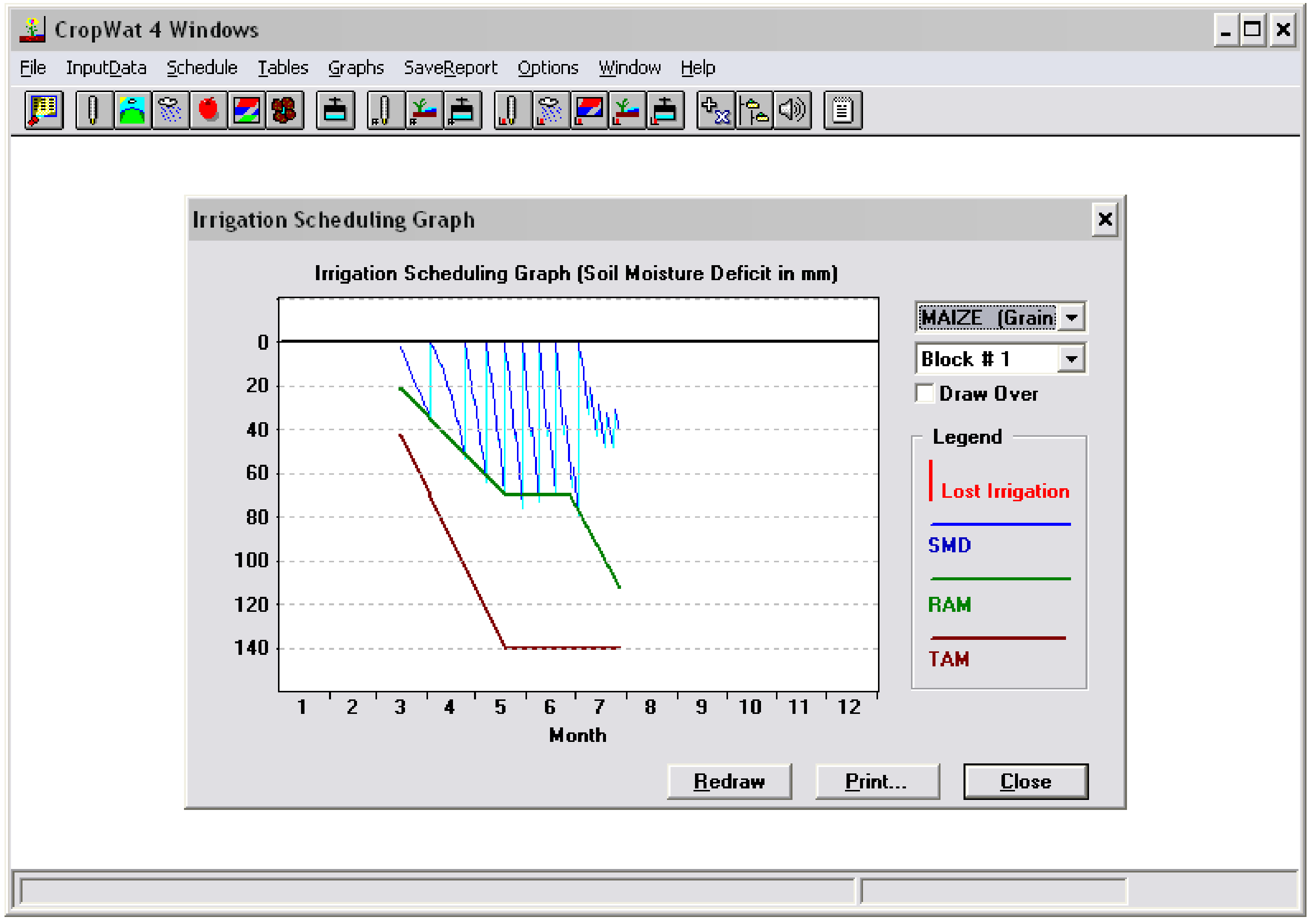
Input Data Completed . . .



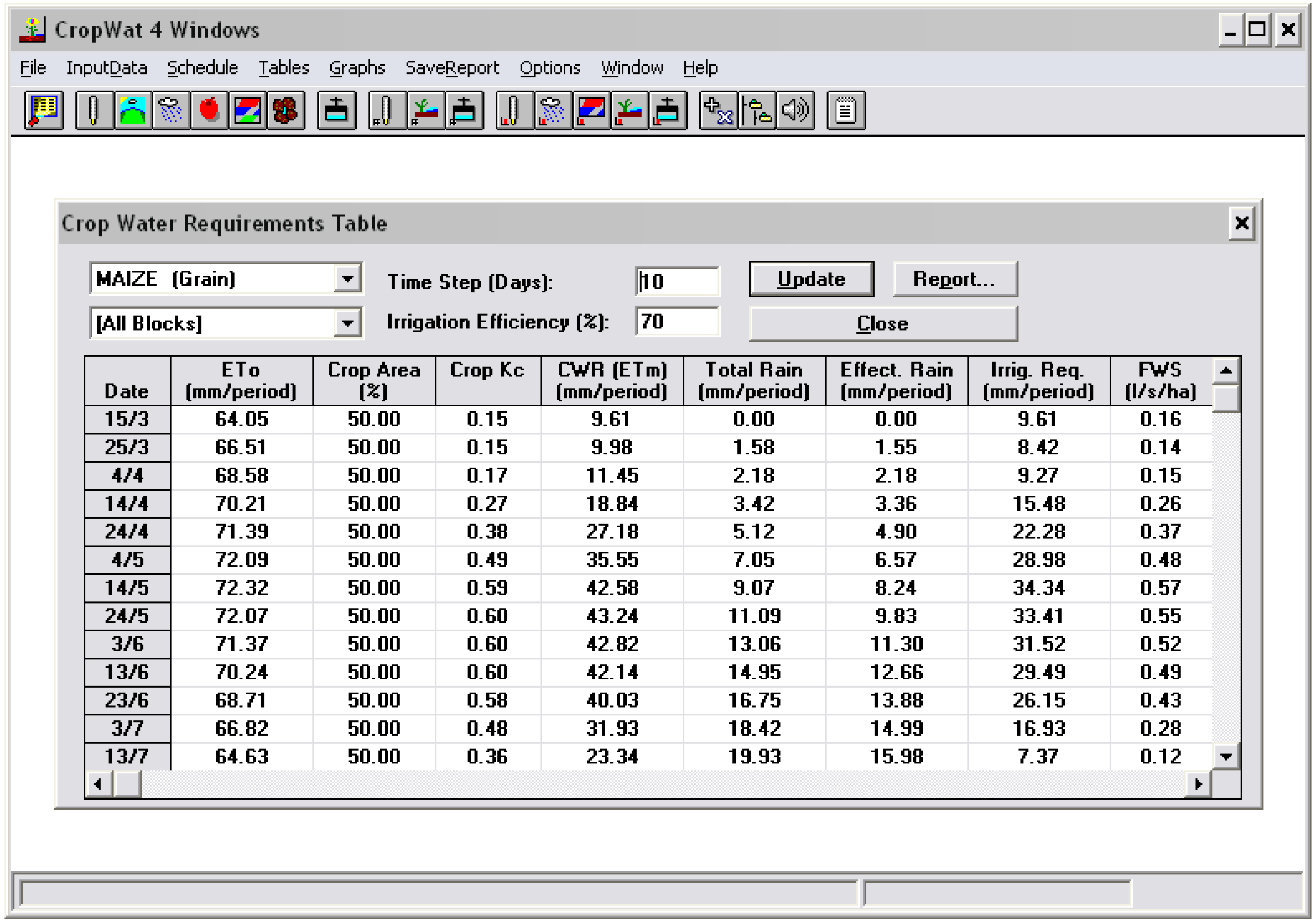
Calculate Irrigation Demand . . .



Calculate Irrigation Schedule . . .



View Results . . .



Date	ETo (mm/period)	Crop Area (%)	Crop Kc	CWR (ETm) (mm/period)	Total Rain (mm/period)	Effect. Rain (mm/period)	Irrig. Req. (mm/period)	FWS (l/s/ha)
15/3	64.05	50.00	0.15	9.61	0.00	0.00	9.61	0.16
25/3	66.51	50.00	0.15	9.98	1.58	1.55	8.42	0.14
4/4	68.58	50.00	0.17	11.45	2.18	2.18	9.27	0.15
14/4	70.21	50.00	0.27	18.84	3.42	3.36	15.48	0.26
24/4	71.39	50.00	0.38	27.18	5.12	4.90	22.28	0.37
4/5	72.09	50.00	0.49	35.55	7.05	6.57	28.98	0.48
14/5	72.32	50.00	0.59	42.58	9.07	8.24	34.34	0.57
24/5	72.07	50.00	0.60	43.24	11.09	9.83	33.41	0.55
3/6	71.37	50.00	0.60	42.82	13.06	11.30	31.52	0.52
13/6	70.24	50.00	0.60	42.14	14.95	12.66	29.49	0.49
23/6	68.71	50.00	0.58	40.03	16.75	13.88	26.15	0.43
3/7	66.82	50.00	0.48	31.93	18.42	14.99	16.93	0.28
13/7	64.63	50.00	0.36	23.34	19.93	15.98	7.37	0.12

Will climate significantly affect domestic agriculture? – model integration; GIS integration

Integration of Agriculture and Other Sectors

- The following discussion on how to integrate the V&A methods and tools into comprehensive assessments relevant to policy used these examples:

  a) Agriculture – land use, water use (Egypt)

  b) Agriculture – socio-economic issues (Mediterranean)

  c) Agriculture – water (Global)

Integrated Assessment in Egypt

Aim:

Analysis of no regret options for the future

Current vulnerability:

- Dependence on the Nile as the primary water source
- Large traditional agricultural base
- Long coastline already undergoing both intensifying development and erosion
- Problems derived from population increase
- Agriculture entirely based on irrigation (water from the Nile, and to lesser degree from groundwater)
- Soil conditions and water quality deteriorating

(Source: Strzepek et al., 1999)

Integrated Assessment in Egypt

- Methods:
  a) Scenario development
  b) Vulnerability evaluation using agronomic, economic, and water allocation models
- Results: Future vulnerability:
  a) Significant decreases in crop yield and agronomic water use efficiency

Adaptation: Limits of Current Technology

2002	Egypt	Morocco	Spain	Tunisia
Area (1000ha)	100,145	44,655	50,599	16,361
Population (1000)	70,507	30,072	40,977	9,728
Population 2030 (1000)	109,111	42,505	39,951	12,351
Population in agriculture (% of total)	35	35	7	24
Population in rural areas (% of total)	57	43	22	33
Population in rural areas 2030 (% of total)	46	29	15	22
Agricultural Area (% of total)	3	69	58	55
Irrigation area (% of agricultural)	100	4	12	4
Wheat Yield (kg/ha) (World = 2,678)	6,150	1,716	2,836	3,853
Agricultural Imports (million $)	3,688	1,740	12,953	1,022
Agricultural Exports (million$)	774	811	16,452	391
Fertiliser Consumption (kg/ha)	392	12	74	12
Crop Drought Insurance	No	No	Yes	No
Agricultural Subsidies	Low	Low	High	Low
Agriculture, value added (% of GDP)	17	14	4	12
GDP Per capita (US$) UN derived from purchasing power parity (PPP)	4,000	3,900	21,200	6,800

(Source: Data: FAOSTAT)

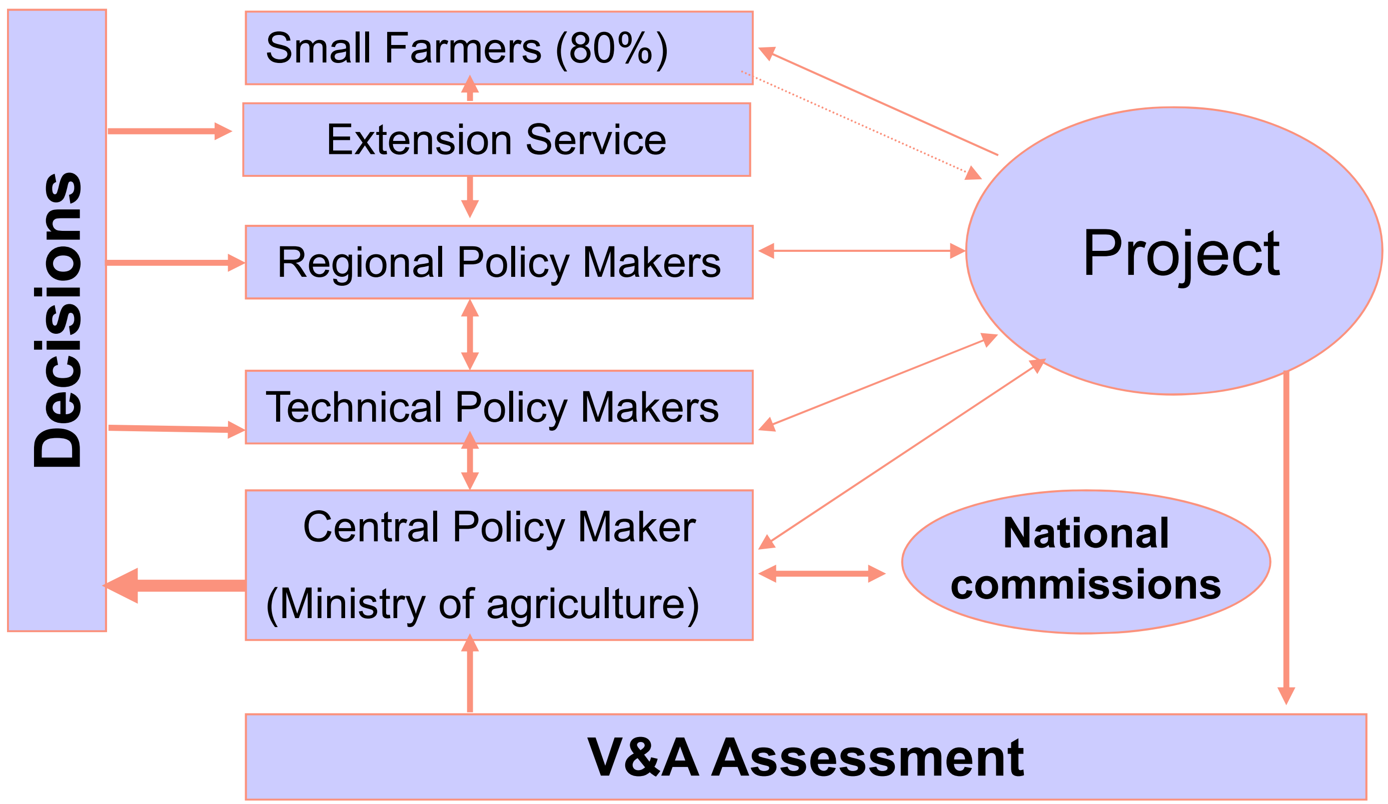
Adaptation

- On-farm adaptation: Use of alternative existing varieties and optimization of the timing of planting may improve yield levels or water use (no cost). In Egypt this is a very limited option.
- Essential changes in resource management (crops, water and land) would lead not only to adaptation to climate change but also to the overall improvement of the agricultural systems (no regret options).
- Explicit guidance to farmers regarding optimal crop

Socioeconomic Issues

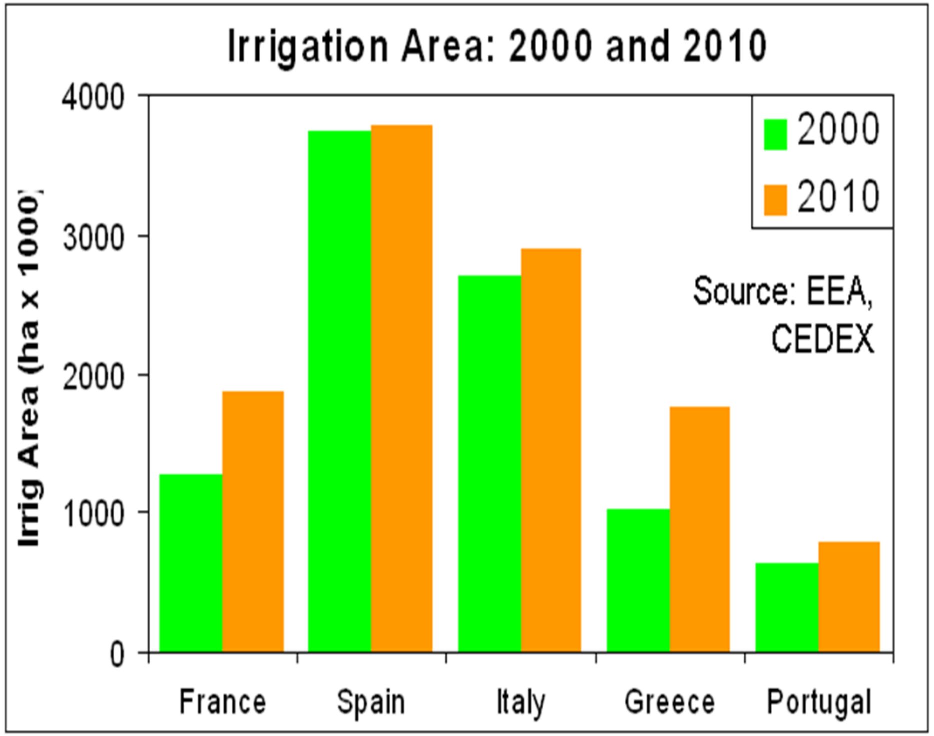
- Policy, stakeholders
- Technology.

Understanding the Stakeholder Linkages and Decision Process



Policy Decisions

- Adaptation is, in part, a political process, and information on options reflects different views about the long-term future of resources, economies, and societies.



(Source: Downing, 2001)

National Strategy on Water Management: Tunisia

Current and projected water demand (%)

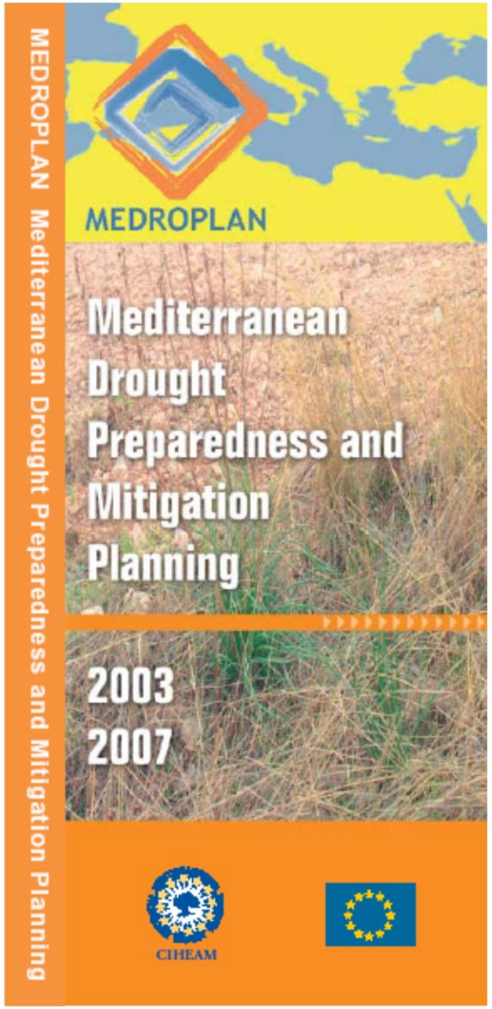
	1996	2030
Drinking	11.5	17.7
Irrigation	83.7	73.5
Tourism	0.7	1.5
Industrial	4.1	7.3

- Resources management:
  - Mobilization, storage (over 1,000 hill reservoirs in 10 years) and transfer of the resources
  - Use of the nonconventional resources: saline and wastewater for irrigation (95,400 and 7,600 ha)
  - Desalinization
- Demand management:
  - Water saving in irrigation (up to 60% government subsidies), industry, and other uses.

Crop Liberalization: Egypt

- The recent Egyptian policy of crop liberalization is giving farmers the possibility of adapting to more suitable crops in each area;
- As result of this policy, the area sown with cotton has sharply decreased in recent years while the cereal area has increased.

Drought Management in the Mediterranean

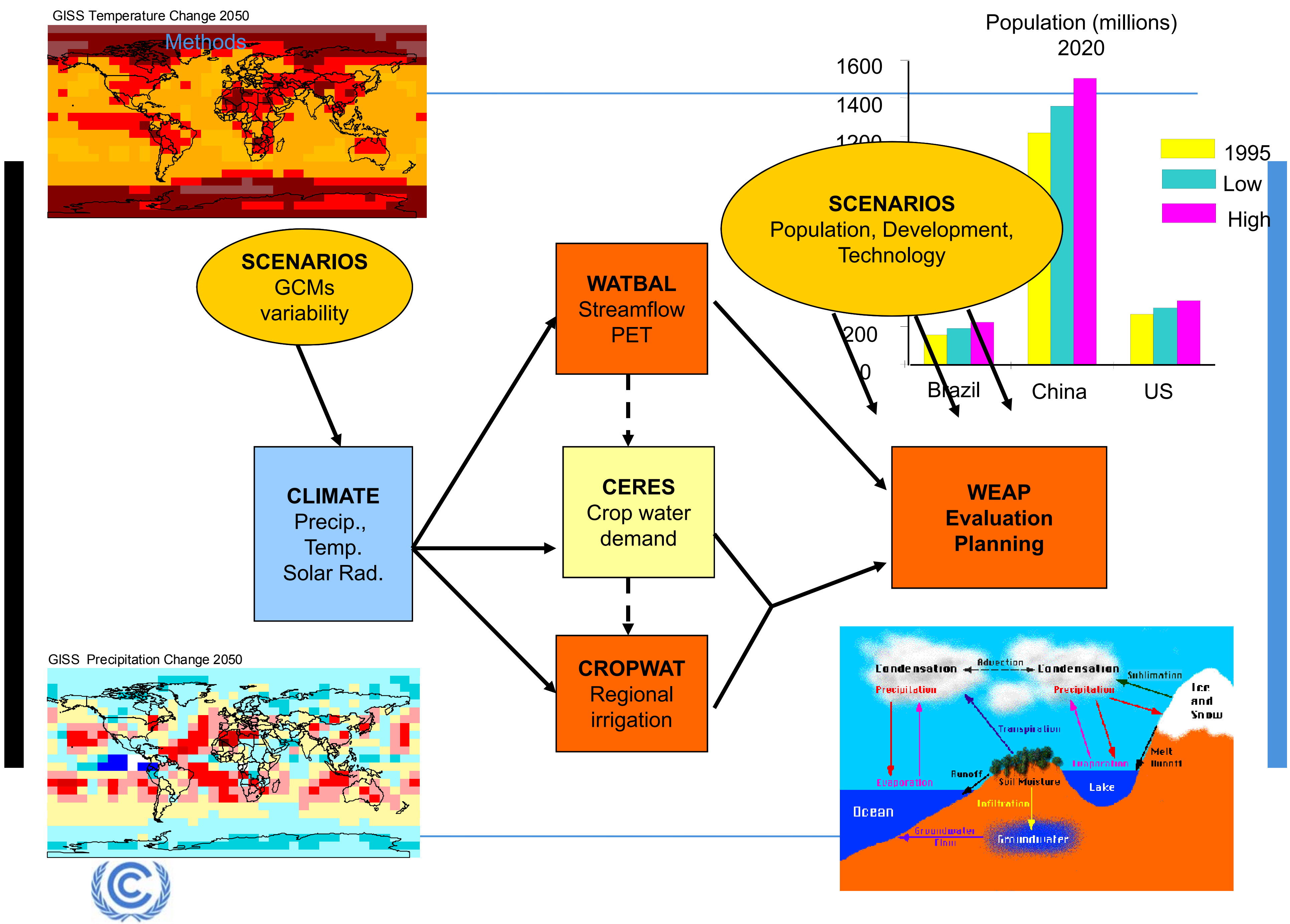


- Disaster management could be an effective adaptation option

- Decreasing drought vulnerability is a "win-win" adaptation option.

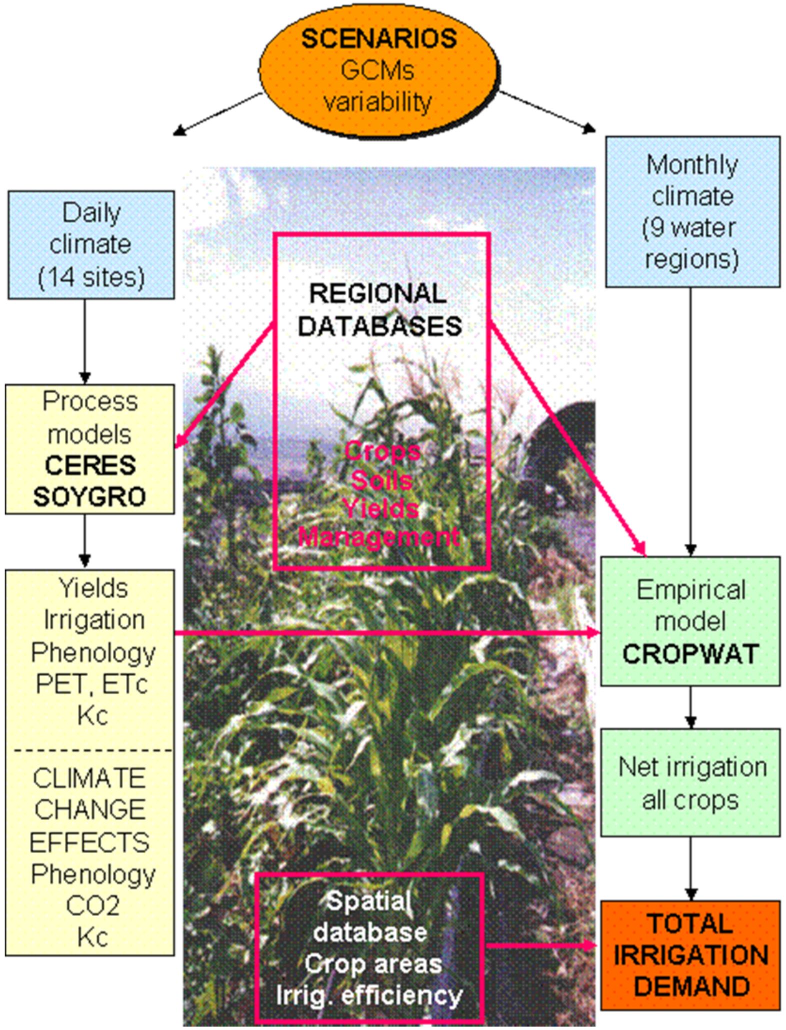
Water for Agriculture

- **WATER** is a fundamental requirement for agriculture. That requirement is certain to increase along with the growth of population and living standards, especially in view of the prospect of a warmer climate imposed by the enhanced greenhouse effect.



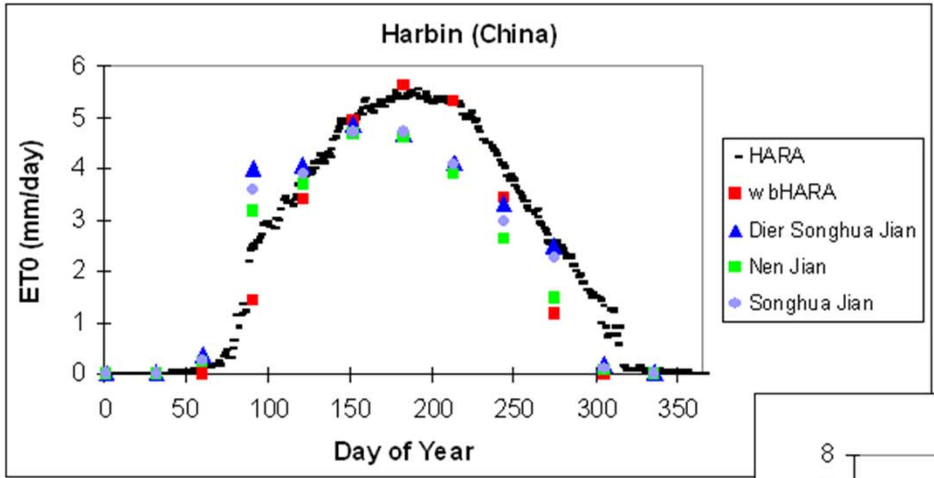
GISS Temperature Change 2050
Methods
Population (millions)
2020
1600
1400
200
0
Brazil
China
US
1995
Low
High
SCENARIOS
Population, Development, Technology
SCENARIOS
GCMs
variability
WATBAL
Streamflow
PET
CLIMATE
Precip.,
Temp.
Solar Rad.
CERES
Crop water
demand
WEAP
Evaluation
Planning
CROPWAT
Regional
irrigation
GISS Precipitation Change 2050
Condensation
Advection
Condensation
Sublimation
Precipitation
Precipitation
Ice and Snow
Transpiration
Evaporation
Runoff
Soil Moisture
Evaporation
Melt Runoff
Lake
Infiltration
Ocean
Groundwater Flow
Groundwater

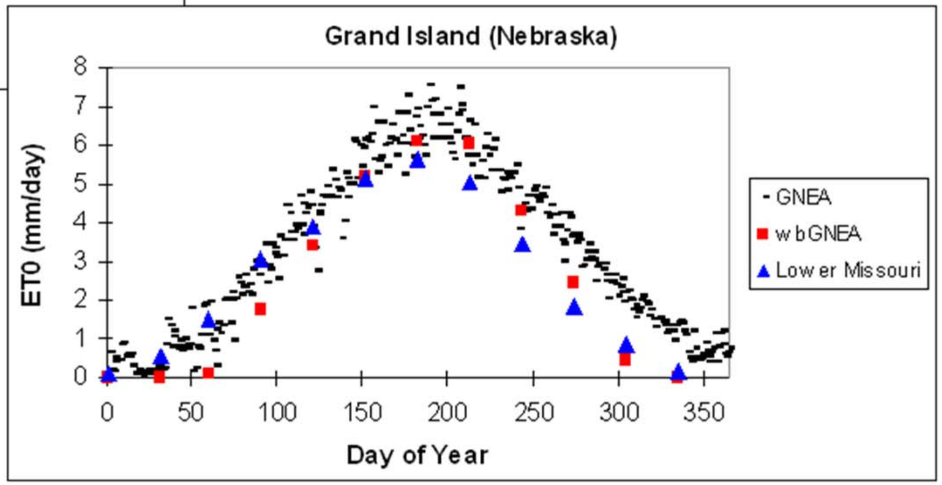
Methods



Crop yields, water demands and nitrogen leaching are estimated with process-based crop models (calibrated and validated). The ratios (Kc) between simulated and actual crop (ET) are used to estimate regional water demand with CROPWAT, and are then adjusted by a regional irrigation efficiency.

Working with Different Models: Consistency, Scales, Calibration





Projections Using the Suite of Models

- Changes in run-off, water demands, and water system reliability
- Actual changes in crop yield based on consistent projections of changes in water supply and demand
- Changes in environmental stress due to human use of water resources
- Changes in water quality.