School of Natural Resources and
Department of Agronomy & Horticulture

Methods on seasonal crop yield forecasting

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and

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There are 3 types of crop yield forecasts:

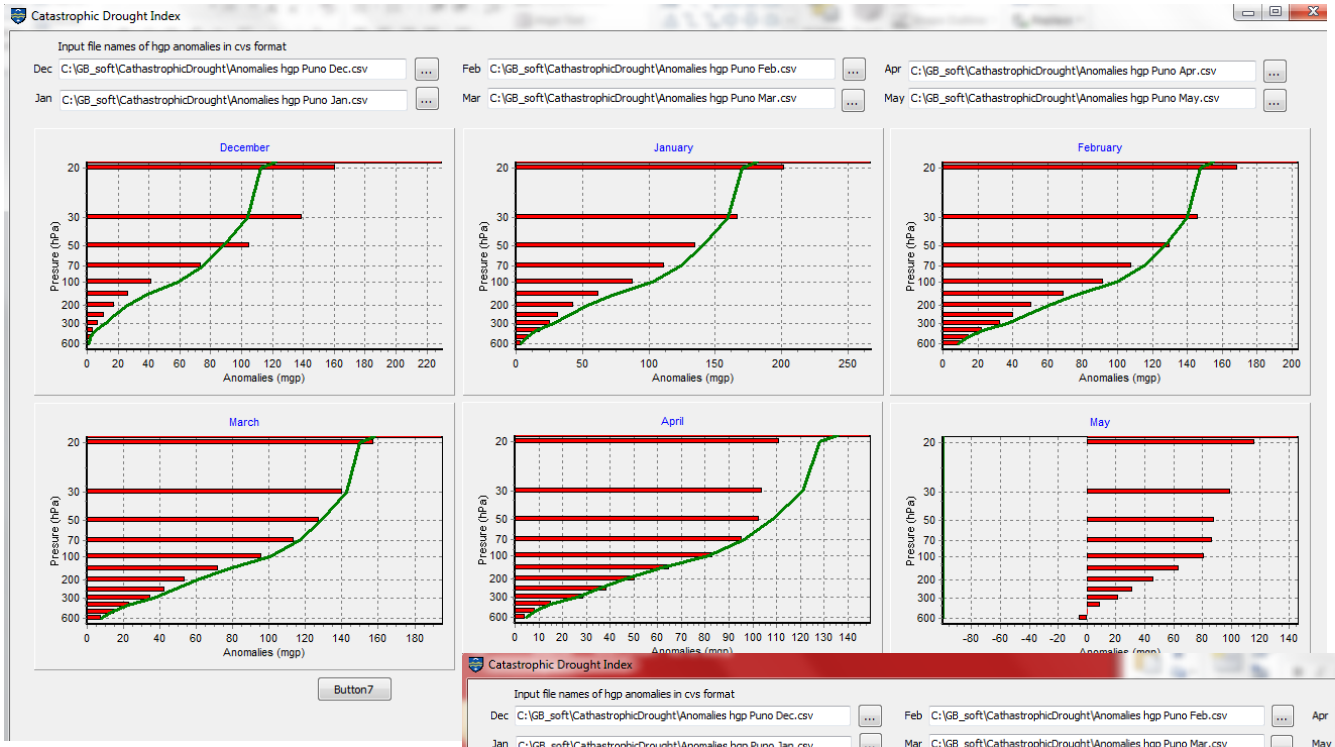
1. Boolean
2. Categorical
3. Continuous

1. Boolean

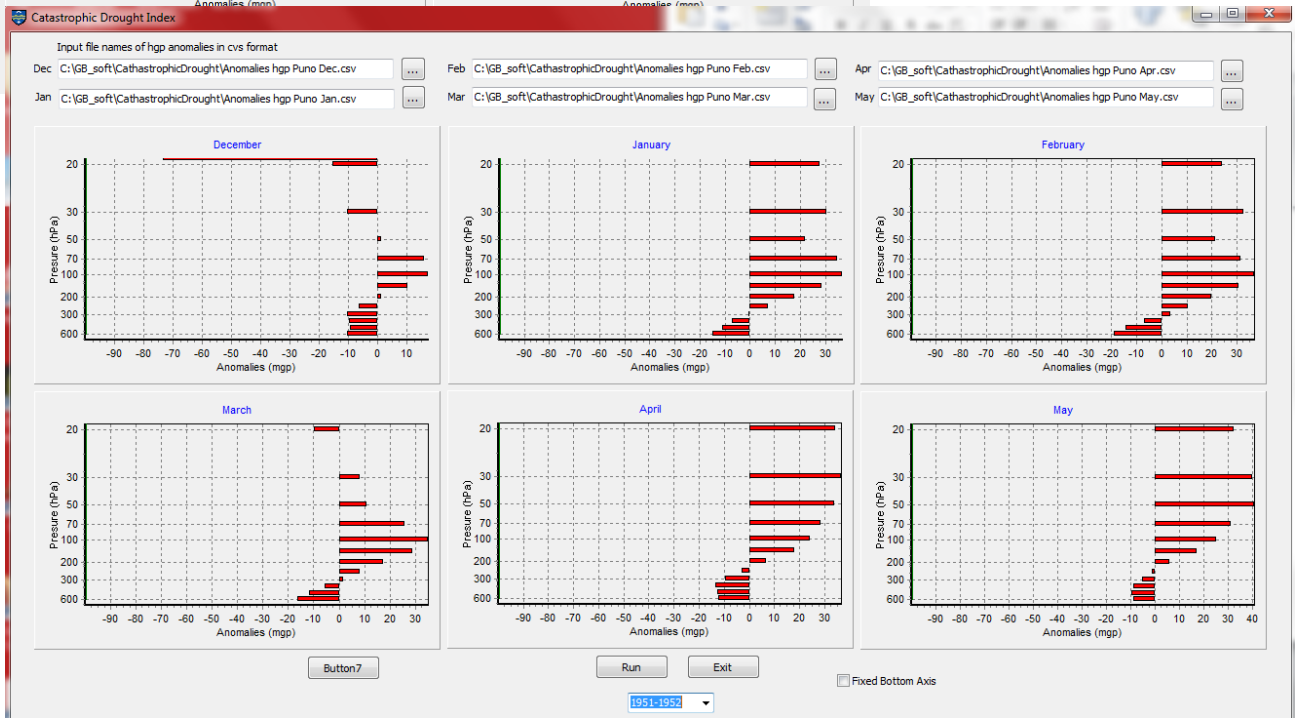
When the forecast look for knowing whether a threshold is crossed or not
Specially applied by Insurance Companies

Example:

Catastrophic Drought Index Insurance for Quinoa Producers in Peru



1982-83
Year of a
Catastrophic Drought



1952-53
Regular year

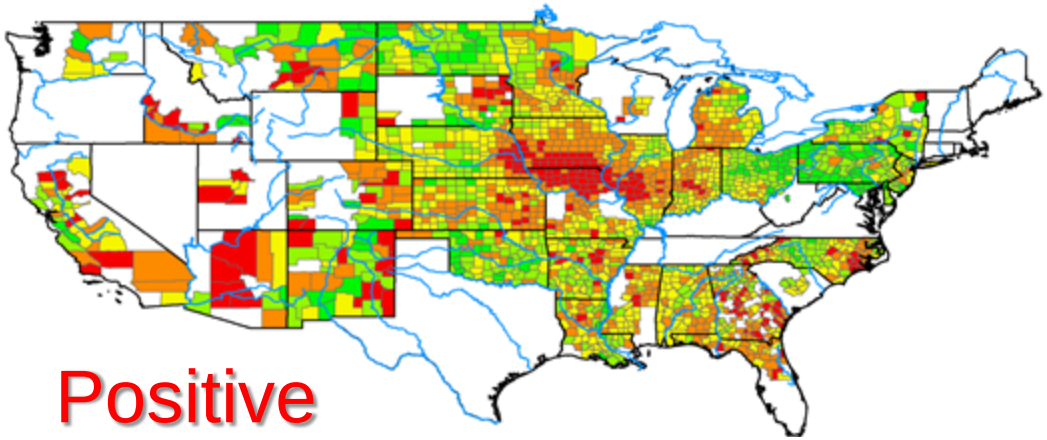
2. Categorical

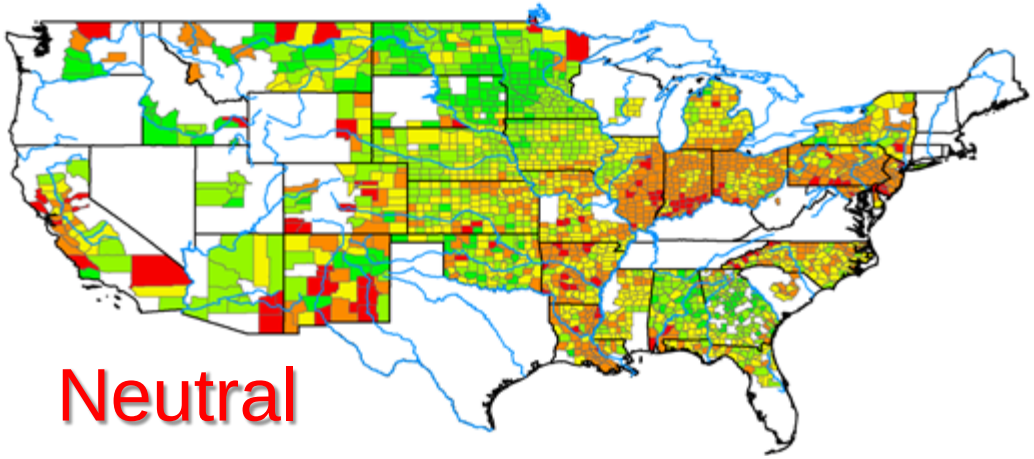
Based on the persistence of a teleconnection Index
The forecast look for knowing the statistical distribution of yields given a value of the index

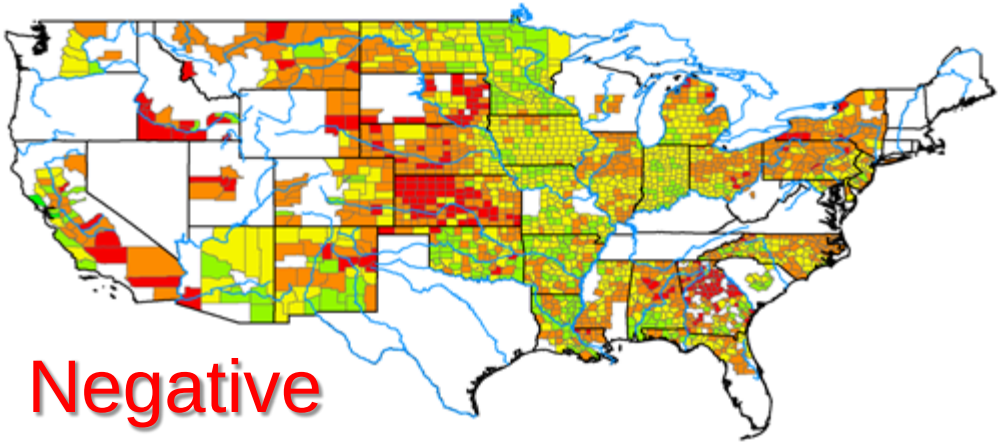
Example:

El Niño based forecasts

Oceanic Niño Index







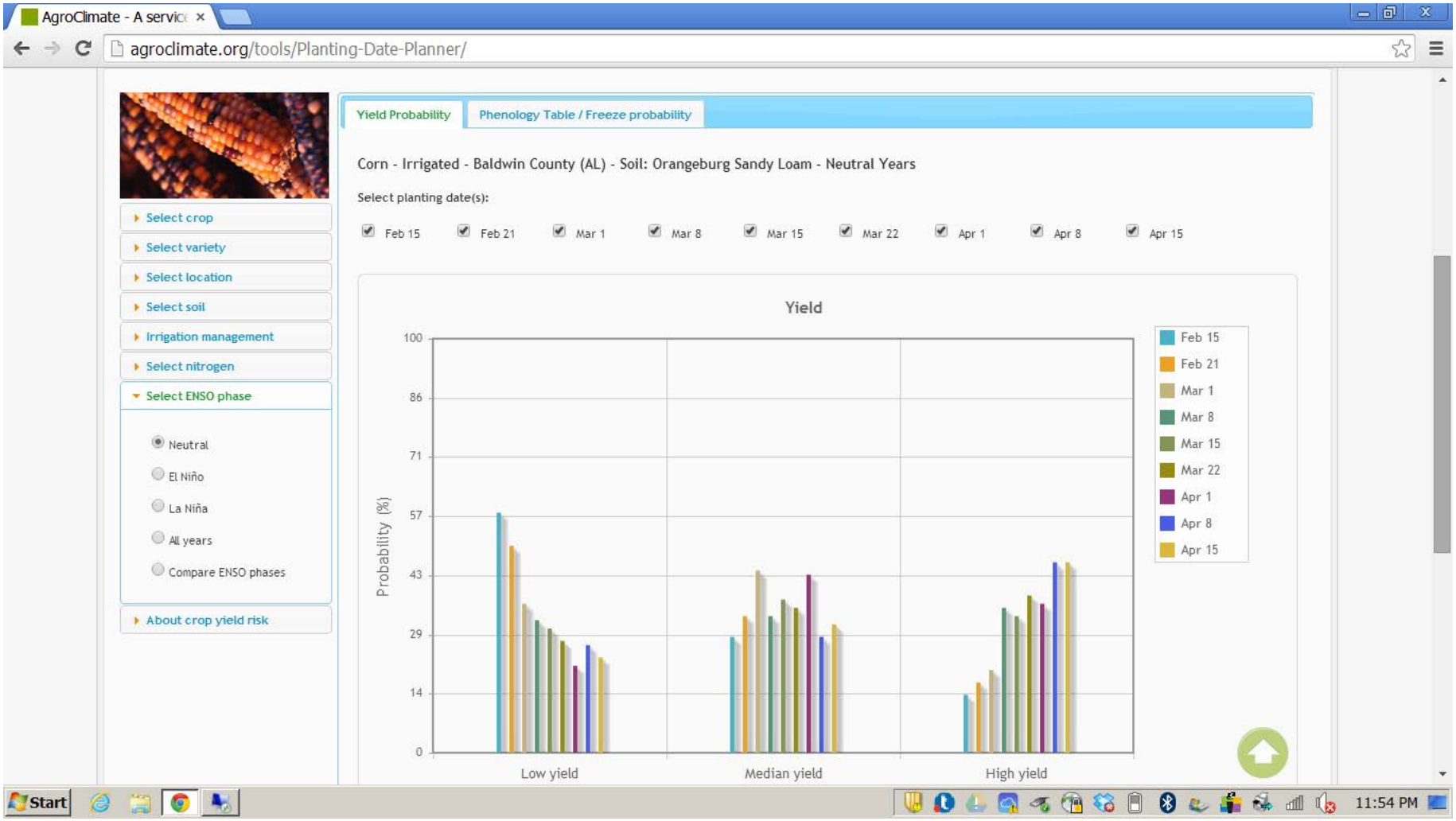
Corn

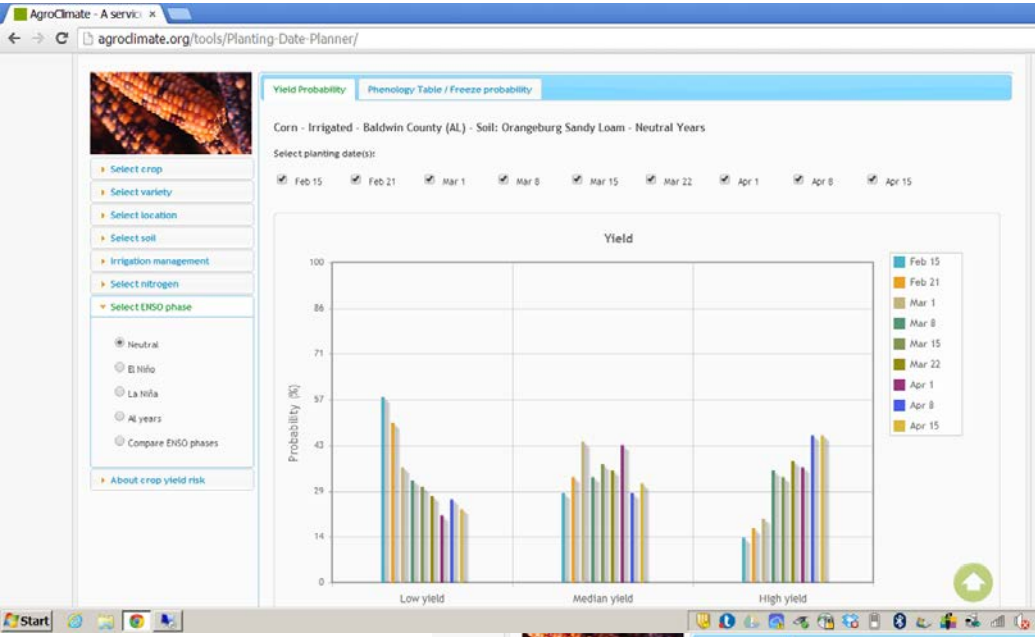
Yield

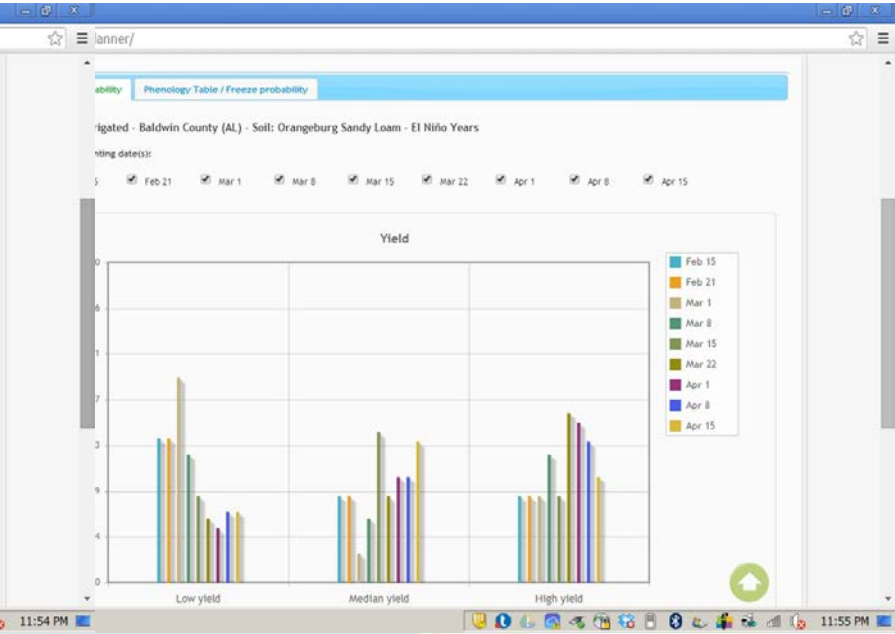
<< < = > >>

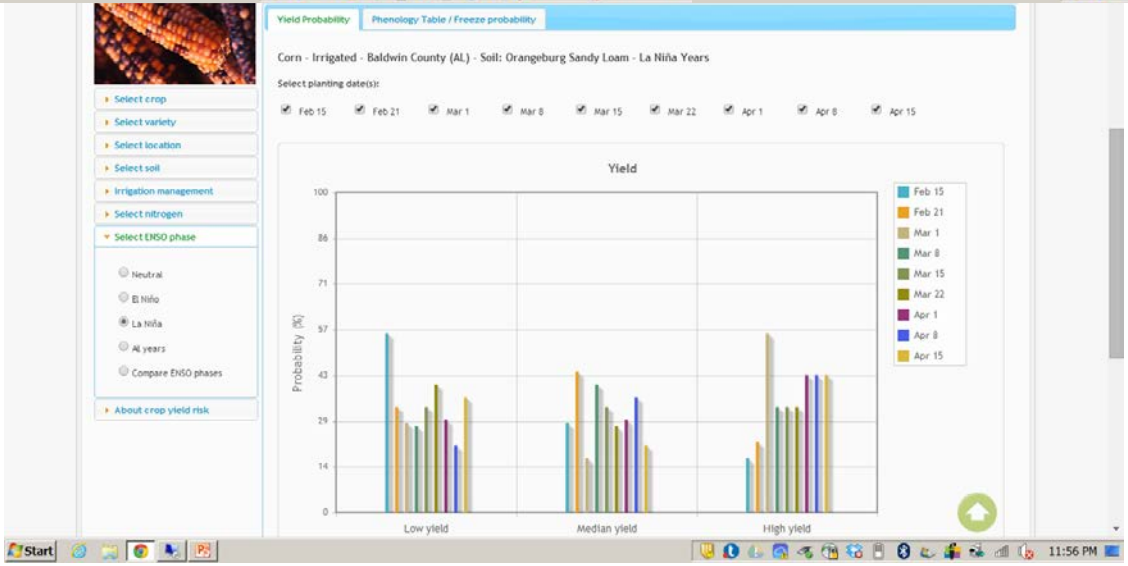
Categorical CropClimate Forecasting Tool

ENSO phases vs planting dates




AgroClimate - A servic
agroclimate.org/tools/Planting-Date-Planner/
Yield Probability
Phenology Table / Freeze probability
Corn - Irrigated - Baldwin County (AL) - Soil: Orangeburg Sandy Loam - Neutral Years
Select planting date(s):
Feb 15
Feb 21
Mar 1
Mar 8
Mar 15
Mar 22
Apr 1
Apr 8
Apr 15
Select crop
Select variety
Select location
Select soil
Irrigation management
Select nitrogen
Select ENSO phase
Neutral
El Niño
La Niña
All years
Compare ENSO phases
About crop yield risk
Yield
Probability (%)
100
86
71
57
43
29
14
0
Low yield
Median yield
High yield
Start
11:54 PM


Phenology Table / Freeze probability
Yield
Low yield
Median yield
High yield
11:55 PM


Yield Probability
Phenology Table / Freeze probability
Corn - Irrigated - Baldwin County (AL) - Soil: Orangeburg Sandy Loam - La Niña Years
Select planting date(s):
Feb 15
Feb 21
Mar 1
Mar 8
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Mar 22
Apr 1
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Apr 15
Select crop
Select variety
Select location
Select soil
Irrigation management
Select nitrogen
Select ENSO phase
Neutral
El Niño
La Niña
All years
Compare ENSO phases
About crop yield risk
Yield
Probability (%)
Low yield
Median yield
High yield
Start
11:56 PM

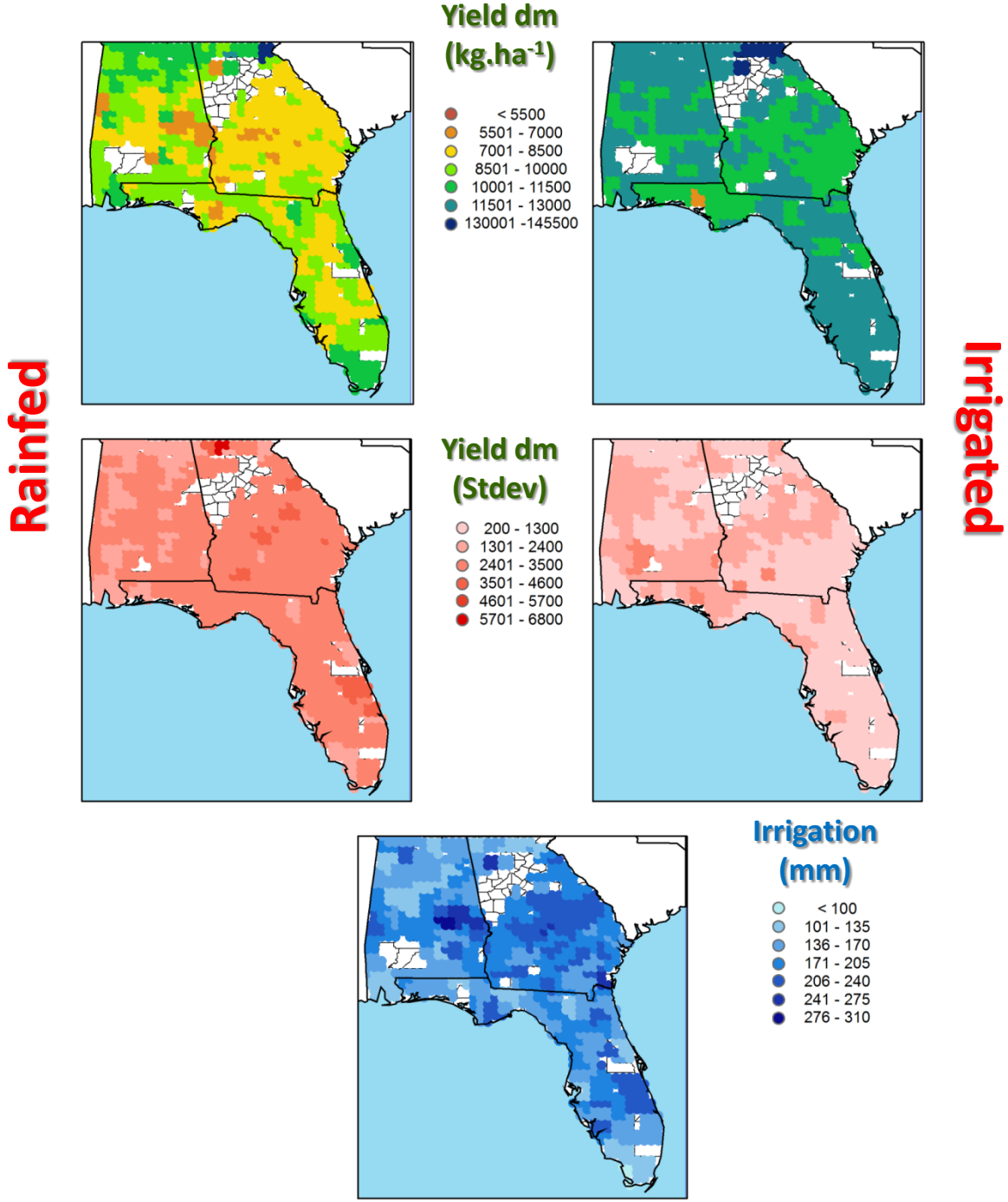
3. Continuous

Based on downscaled seasonal climate forecast from Global and/or Regional Climate model feeding dynamic crop models

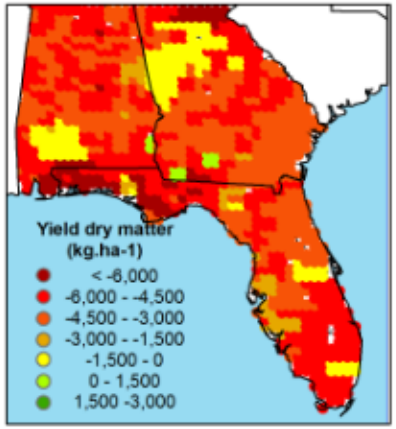
Example:

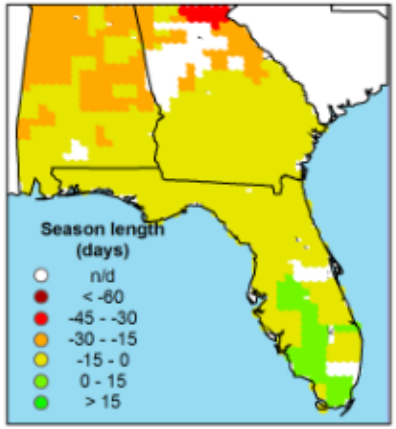
FSU Regional Spectral Model feeding the dynamic crop models
Decision Support System for Agrothecnology Transfer DSSAT

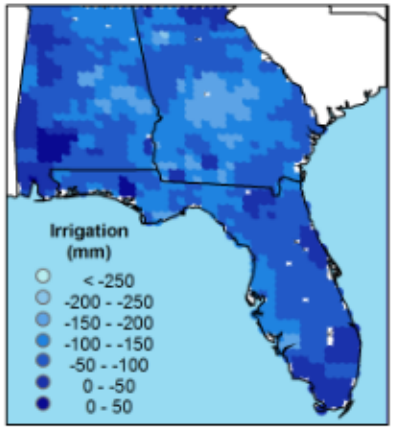
Simulated Corn using observed weather data (1961-2010)

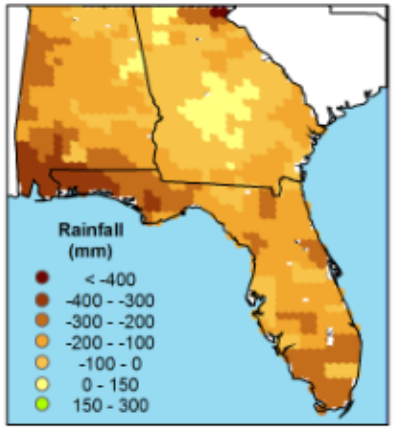


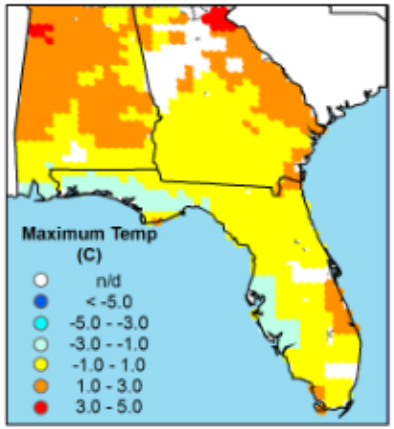
Changes on important parameters related to corn production (2011)

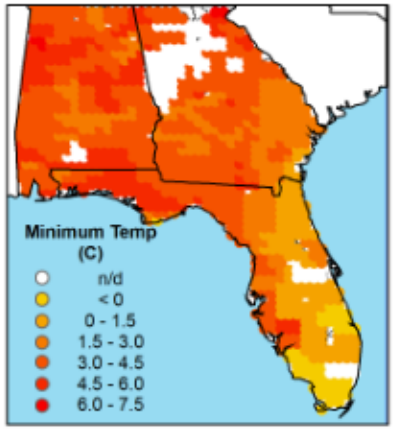


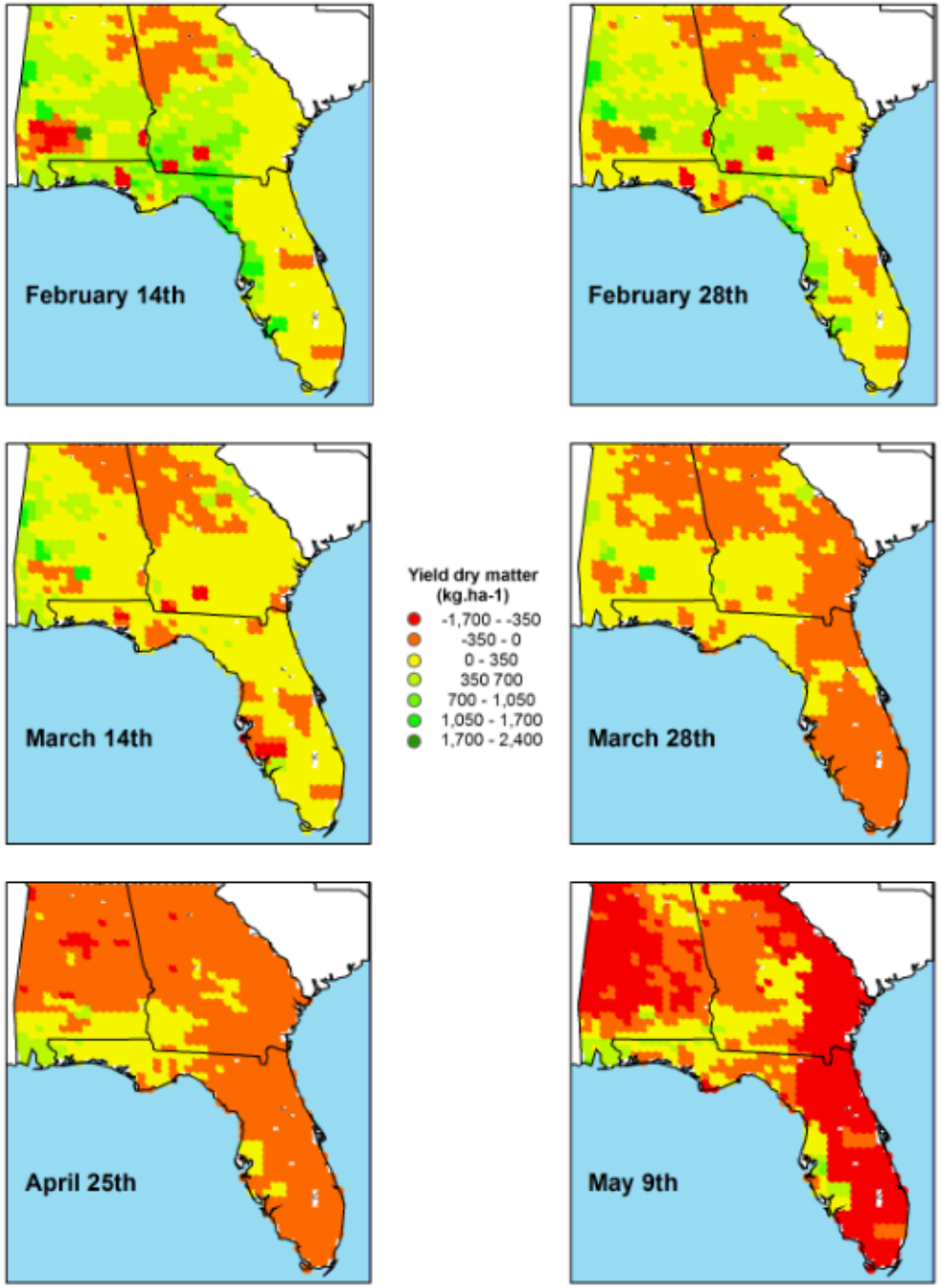




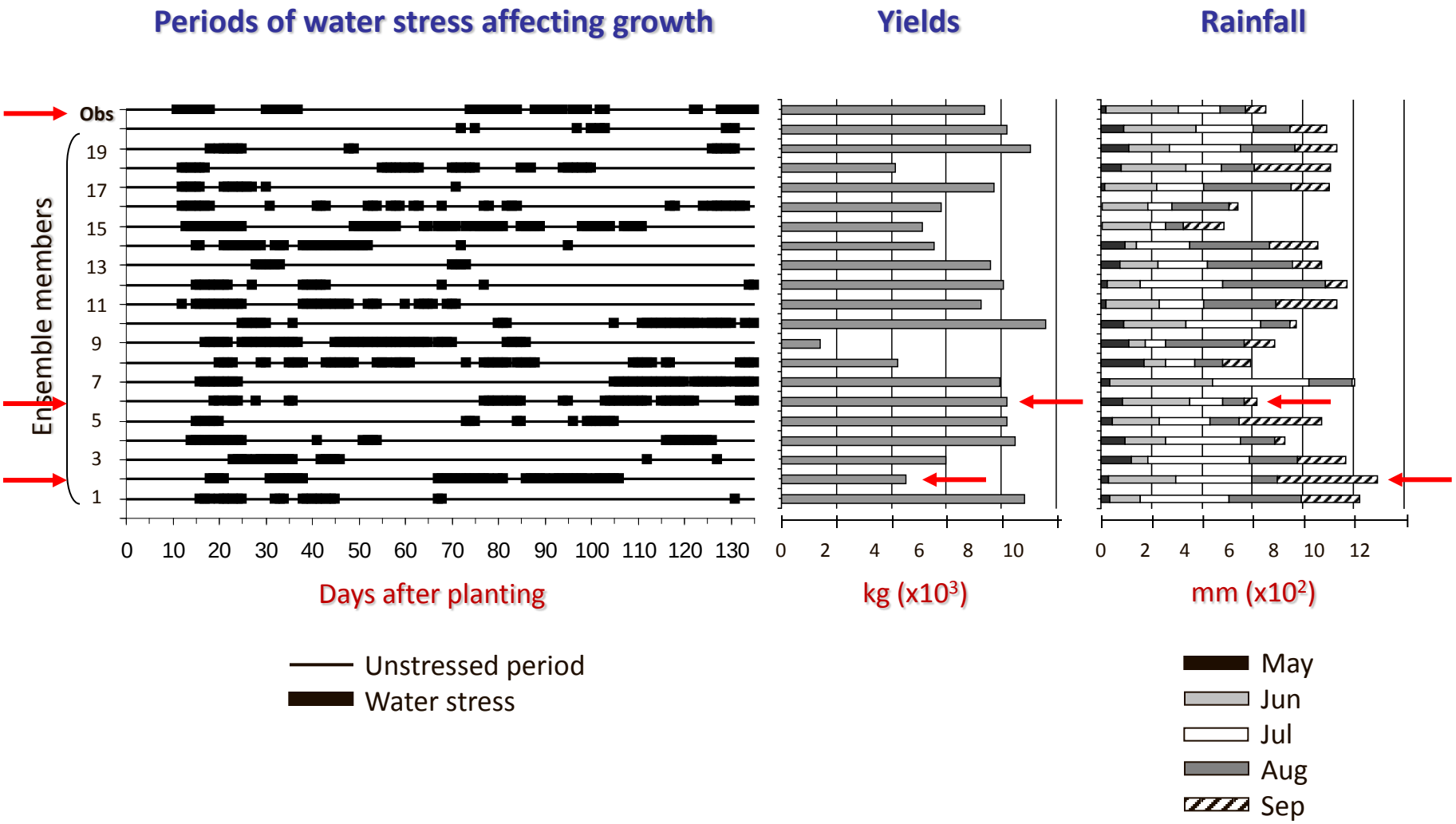




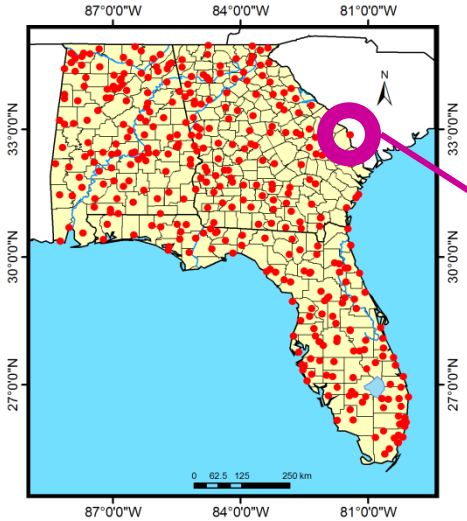




Adaptation: Changes on forecasted yields by moving planting dates (Current: April 11th)


Periods of water stress affecting growth
Yields
Rainfall
Obs
19
17
15
13
11
9
7
5
3
1
Ensemble members
0 10 20 30 40 50 60 70 80 90 100 110 120 130
Days after planting
0 2 4 6 8 10
kg (x10³)
0 2 4 6 8 10 12
mm (x10²)
Unstressed period
Water stress
May
Jun
Jul
Aug
Sep

Weather station network



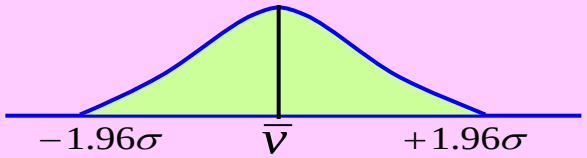
Historical record of daily values

- Rainfall
- Max temp
- Min temp

Parameter estimation

Weather Generator parameters

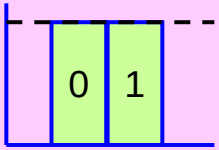
Temperature, Incoming solar radiation, Rainfall amount:



$$\hat{v} = \bar{v} \pm \sigma \times r$$

Rainfall events:

Two-state First-order Markov Chain



$$\hat{P}_{01} = \frac{\#\ of\ 1's\ following\ 0's}{Total\ \#\ of\ 0's}$$

$$\hat{P}_{11} = \frac{\#\ of\ 1's\ following\ 1's}{Total\ \#\ of\ 1's}$$

Geospatial Weather Generator (GiST)

Temporal downscaling

- Rainfall
- Max temp
- Min temp

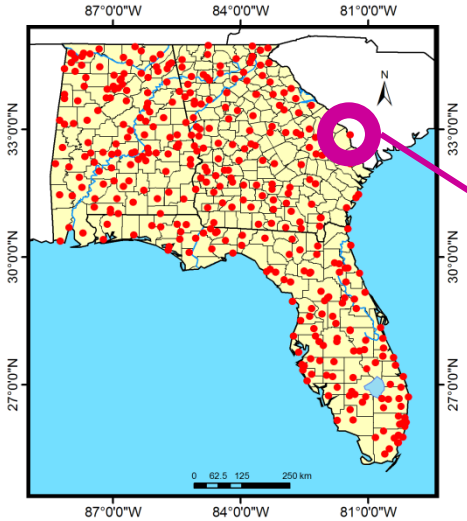
Ensemble of daily downscaled forecast for each weather station

GiST-wg: GeoSpatio and Temporal Weather Generator

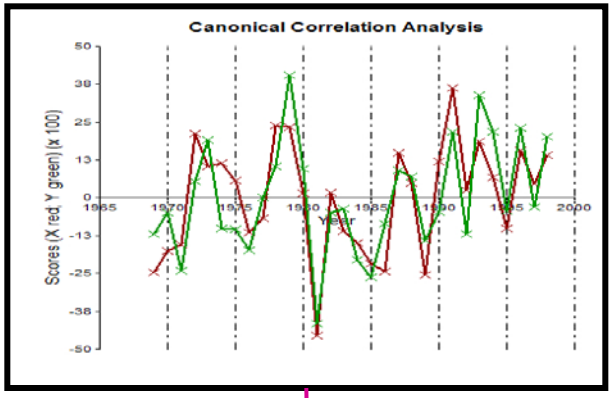
Stochastic Downscaling

http://agenviromodeling.com

Weather station network



Cross-validated monthly forecasts



Historical record of daily values

- Rainfall
- Max temp
- Min temp

Parameter estimation

Weather Generator parameters

Geospatial disaggregation

Cross-validated monthly forecast for each weather station

Parameter perturbation

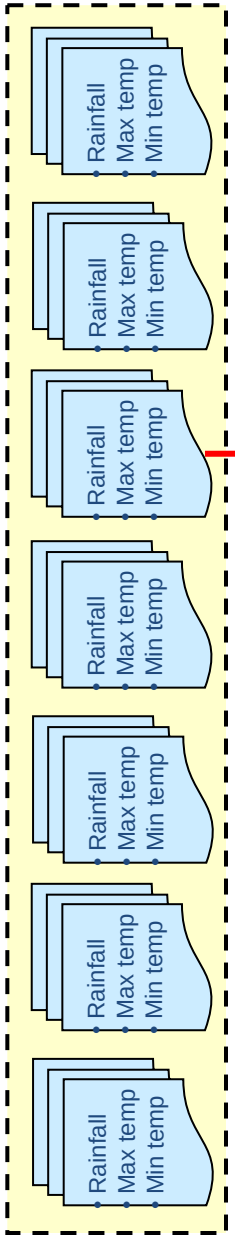
Geospatial Weather Generator (GiST)

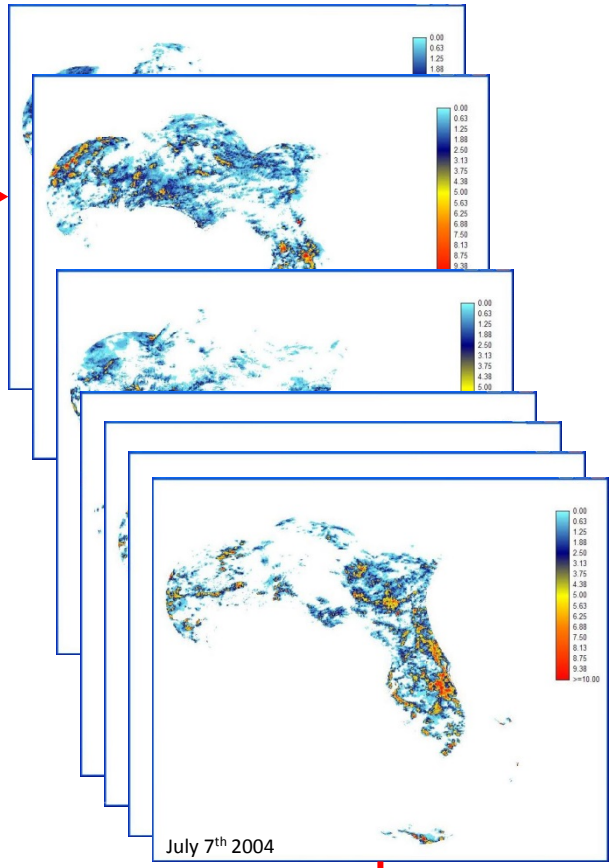
Temporal downscaling

- Rainfall
- Max temp
- Min temp

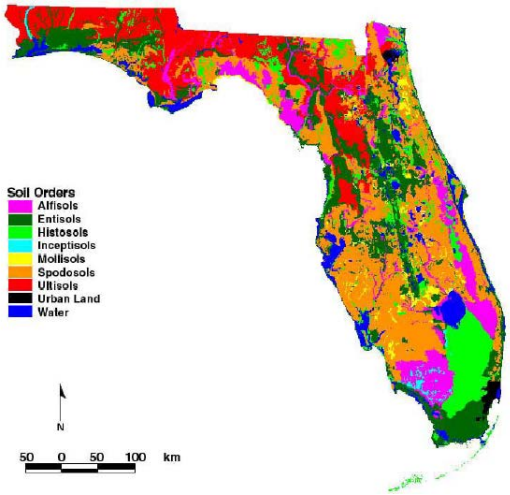
Ensemble of daily downscaled forecast for each weather station

Geospatial seasonal crop yield forecast





Soil data(*)



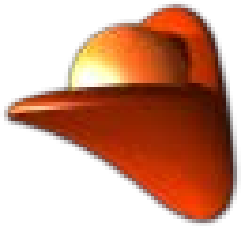
DSSAT
(GEM)

Crop management
real
&
alternatives

Spatio-temporal downscaled seasonal climate forecast

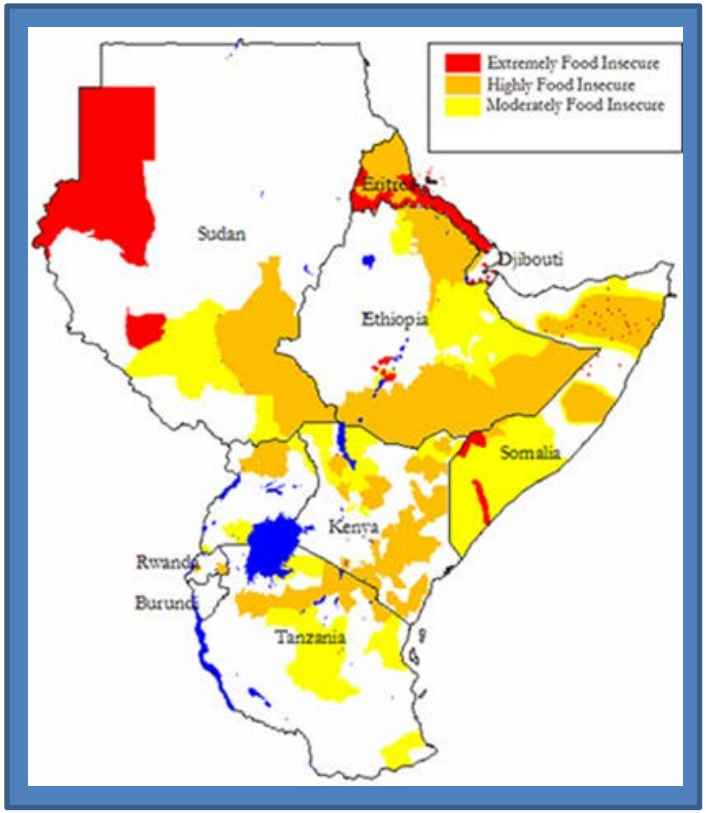
(*) Collins M.E. 2001. Soils in Florida. Soil and Water Science – research brief. SWS-01-1. Gainesville, FL.

GEM:
Geospatio Environmental Modeling



Study area (GHA)

- Countries involved in the study are: Ethiopia, Somalia, Eritrea, Djibouti, Kenya, Sudan, Tanzania, Uganda, Rwanda, Burundi.



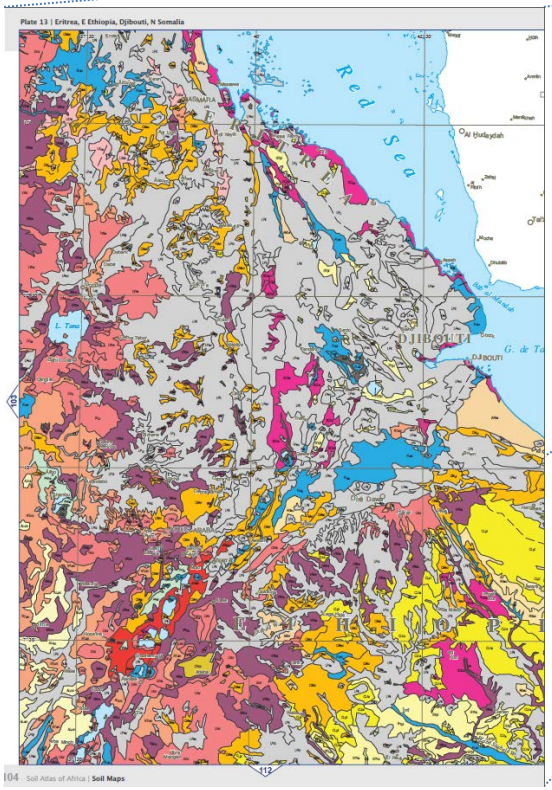
Study Area (countries and agricultural areas under risk)

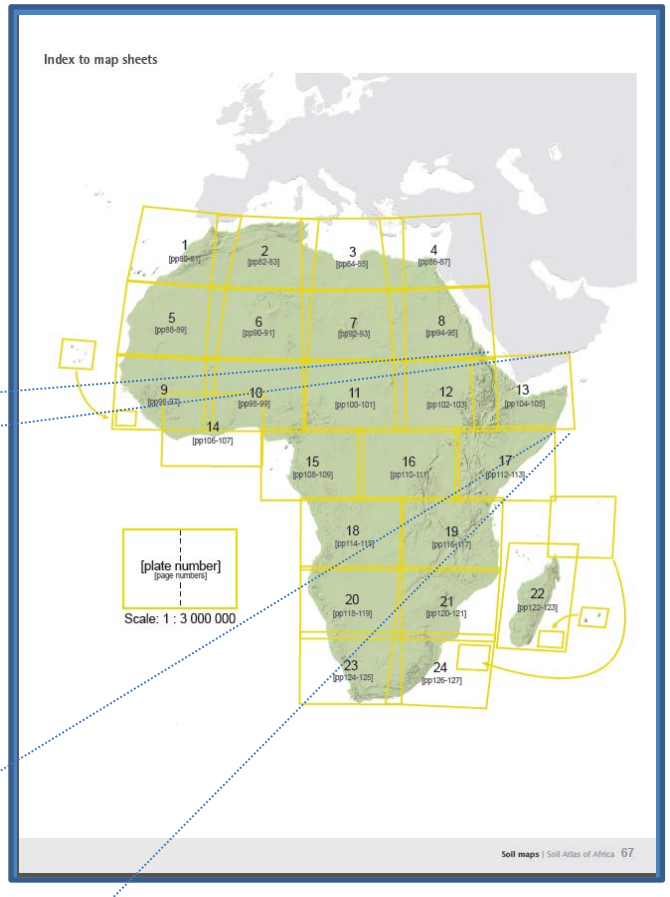
Source of soil data:

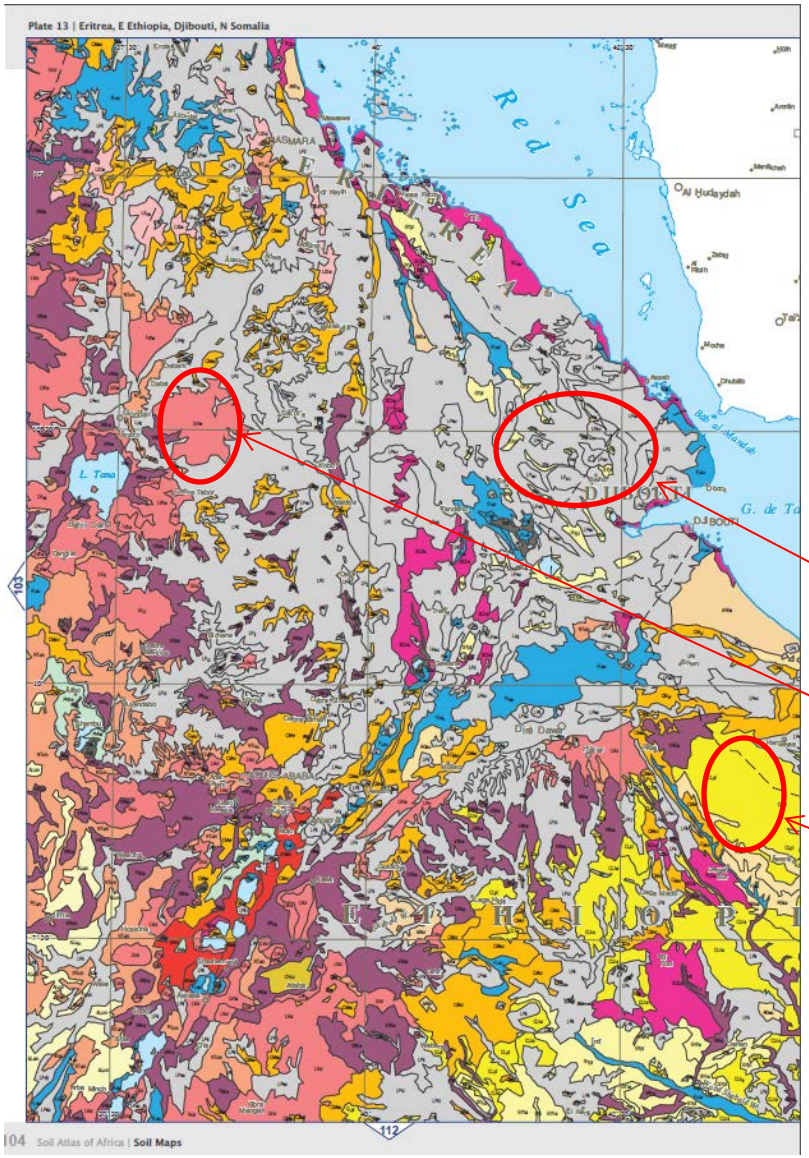
The Soil Atlas of Africa (Jones et al., 2013):

Soils maps derived from several projects covering African continent, such as the Harmonized World Soil Database, the Soil Geographical Database of Eurasia, and the FAO-UNESCO soil map of the World

- All Africa categorized in sectors, each of them shows a soil map sheet.







- At each soil map sheet, that included one or more countries, **soil groups** were identified;
- Once the soil group was identified, we proceed to look for the soil data.

Example:

Leptosols,

Solonchacks,

Calcisols

Source of soil data:

The reanalyzed soil database of the ISRIC-WISE 1.1 (Romero et al., 2012)

- Source of soil profile data from FAO, ISRIC, and USDA-NRCS; data from this source also found in the African Soil Information Service.

- 1272 soil profile description available for Africa;

- Advantage: soil profile data already in format to be used by DSSAT;

- Data includes detailed information for each soil layer required by the model :

- Soil depth
- Soil color and soil albedo (only for topsoil)
- Clay and silt fraction
- Hydraulic coefficients –wilting point, field capacity, saturation- estimated!
- Bulk density
- Soil organic C
- Total N concentration
- pH and CEC

Source of soil data:

- And additional information related to crop growth and development, such as soil fertility factor, mineralization factor, and root growth factor.

- **Example** of a soil profile description in specific format for DSSAT:

```
*WI_CMTZ062  WISE      LS     175 WISE DATABASE, SOIL TZ062
@SITE      COUNTRY        LAT     LONG   SCS Family
 -99         Tanzania     -4.217   33.183   Chromic Cambisol (CMx)
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
  BN      0.13   7.70   0.60 76.00  1.00   1.00  SA001 SA001  SA001
@  SLB  SLMH   SLLL   SDUL   SSAT SRGF  SSKS  SBDM  SLOC  SLCL   SLSI   SLCF  SLNI  SLHW  SLHB  SCEC  SADC
     20     Ap 0.031  0.127  0.399  0.82  17.64   1.50   0.61  7.00  11.00 -99.0  0.07   5.80  -99.0  3.20  -99.0
     40    Bw1 0.026  0.099  0.359  0.55  26.43   1.62   0.22 12.00   5.00 -99.0  0.04   5.50  -99.0  3.20  -99.0
     80    Bw2 0.215  0.299  0.358  0.30   0.26   1.62   0.19 19.00   8.00 -99.0  0.03   5.50  -99.0  4.50  -99.0
    175     BC 0.210  0.296  0.370  0.08   0.37   1.59   0.10 17.00  18.00 -99.0  0.02   5.80  -99.0  4.70  -99.0
```

Number of soil profile descriptions identified for each country.

Based on the soil map and the most dominant soils in each country, some soil profiles descriptions were selected from the Reanalyzed Soil Database of the ISRIC-WISE 1.1

Country	Number of soil profiles
Ethiopia	18
Eritrea	7
Uganda	9
Kenya	36
Tanzania	36
Sudan	24
Rwanda	5
Somalia	16
Burundi	8

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