Monthly Prediction of the Vegetation Condition: A case for Ethiopia

Getachew Berhan
Addis Ababa University, Ethiopia
getachewb1@yahoo.com

Tsegaye Tadesse
National Drought Mitigation Center
University of Nebraska-Lincoln, USA
ttadesse2@unl.edu

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Introduction

- Drought is one of the most important challenges facing the planet.
- Nearly 50% of the world's most populated areas are highly vulnerable to drought (UNEP, 2006).
- Frequent and severe droughts have become one of the most natural disasters in sub-Saharan Africa resulting in:
  - Serious economic crisis,
  - Social crisis,
  - Environmental crisis.
- About 180 million people in Africa live in drought-prone areas, and 50 million people are threatened with starvation in case of rain failure.

- We nee data to construct information
- Plenty of data sources these days
- When data increase-may hide pattern and to take action (hide relevant information)
- Information is the start-up to take action
- We need relevant information to take knowledge based decision.
- What is knowledge?

Introduction…

- Knowledge: a justified true belief, and it is created and organized by the flow of information (Nonaka , 1994).

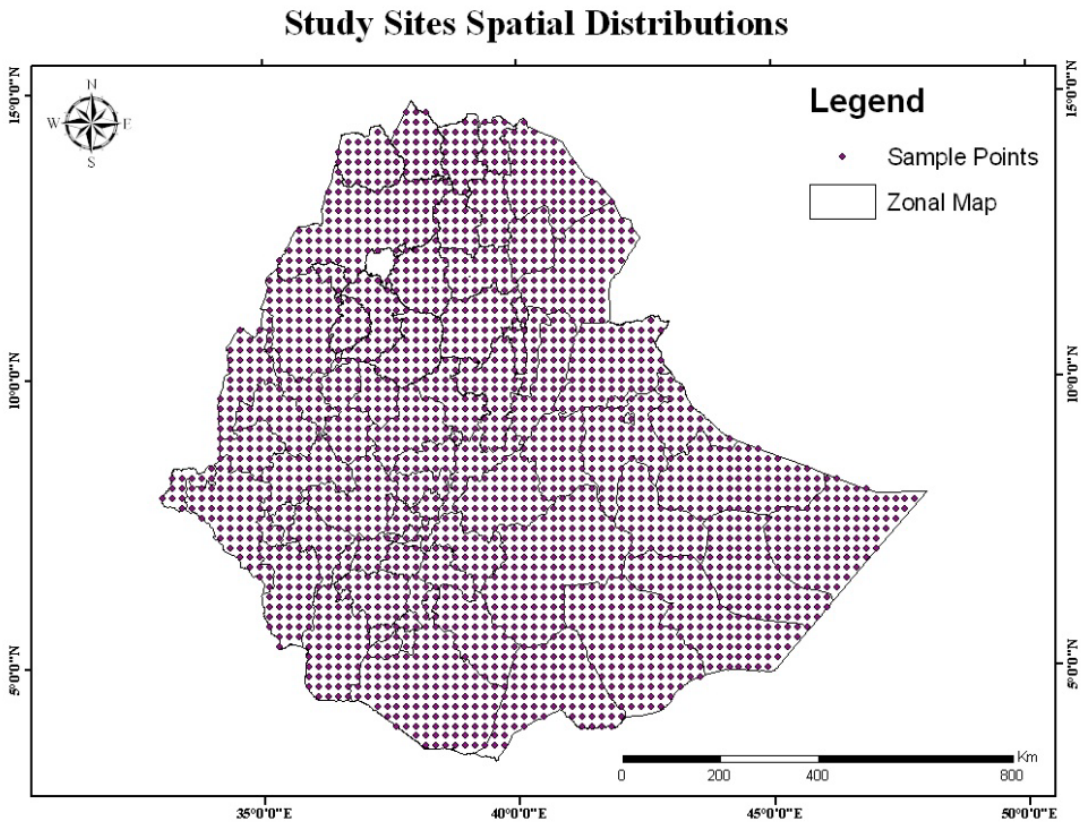
- This research is on explicit knowledge
  - With the patterns observed from data,
  - Where this pattern can easily be understood by humans and validated by test data with some degree of certainty (Han and Kamber, 2006).

Objective

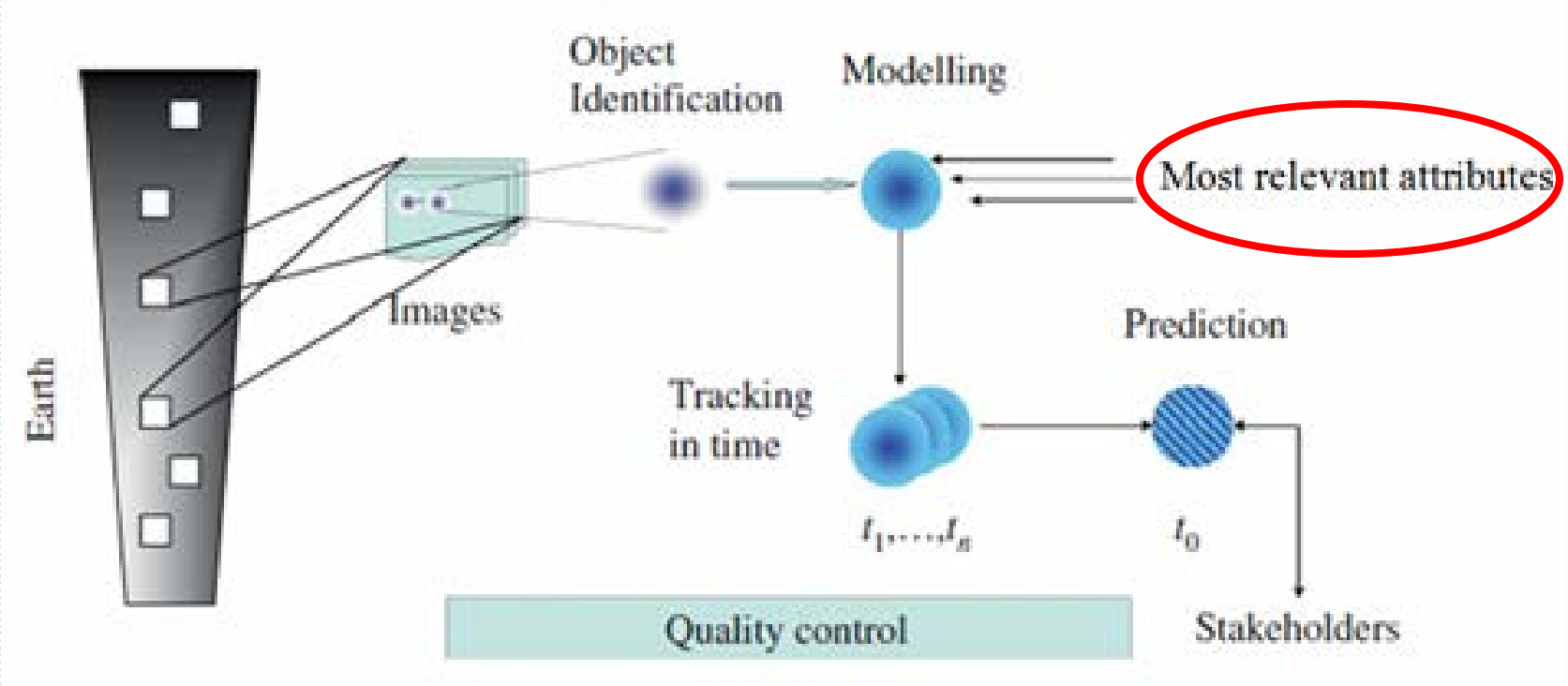
- The objective of this research is to develop a monthly drought monitoring approach using data mining and knowledge discovery from the database approach.

Materials and Methods

- Study Area and Sample Size
  - Covering the whole country Ethiopia, a total of 2812 sample points

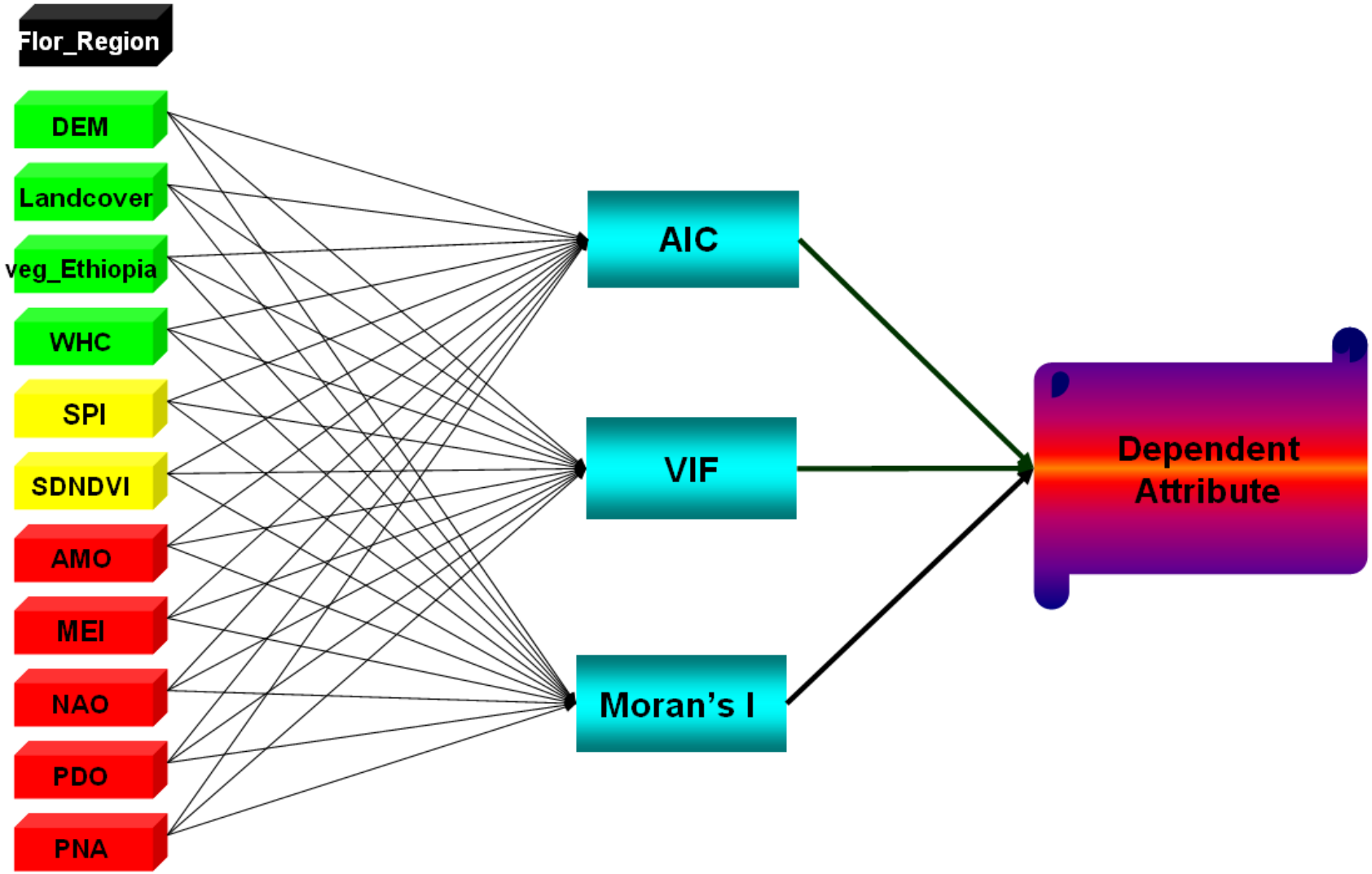


Research Framework



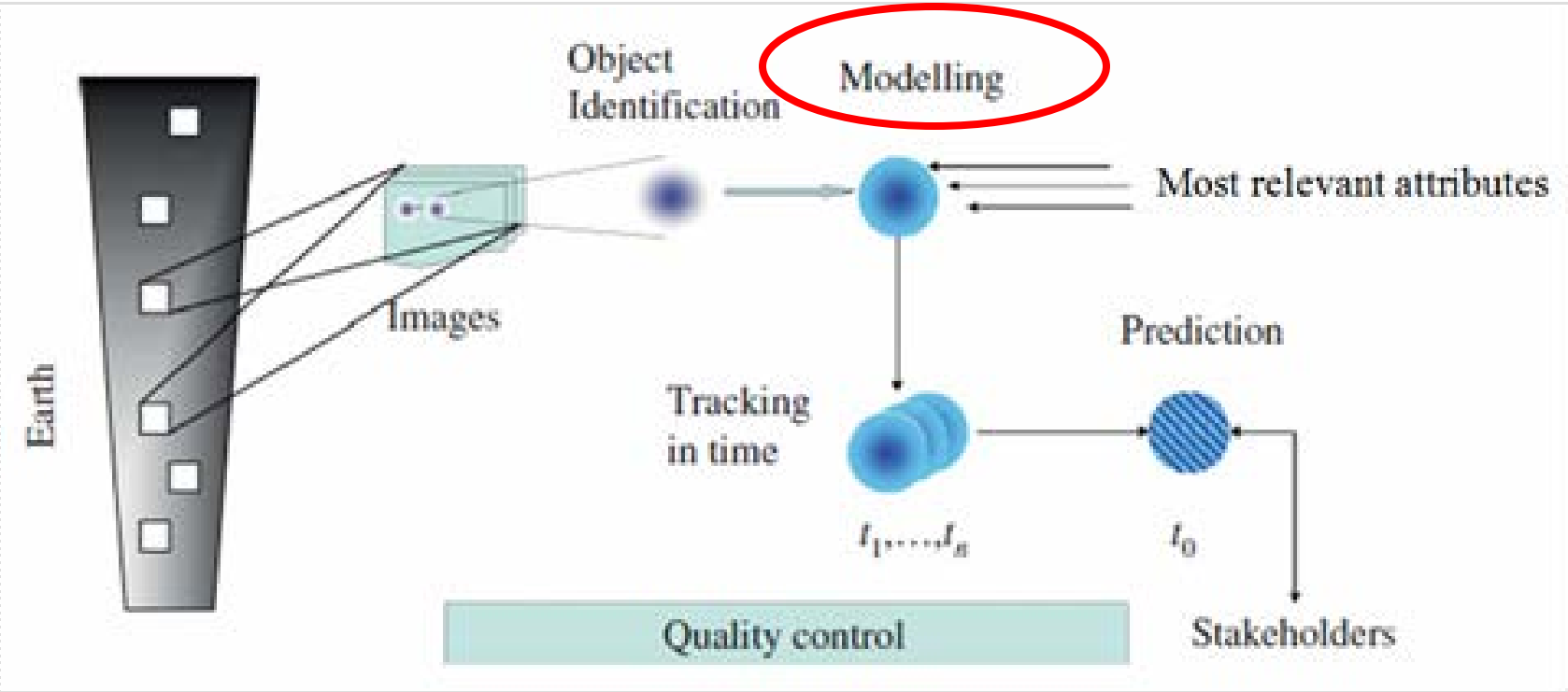
- Relevant Attributes Selection
  - Possible sources of qualitative evidence:
    - Archival records
    - Direct observation
  - Three criteria were used for selecting the attributes
    1. Relevance for agricultural drought
    2. Availability of the data for modeling (cost)
    3. Statistical criteria

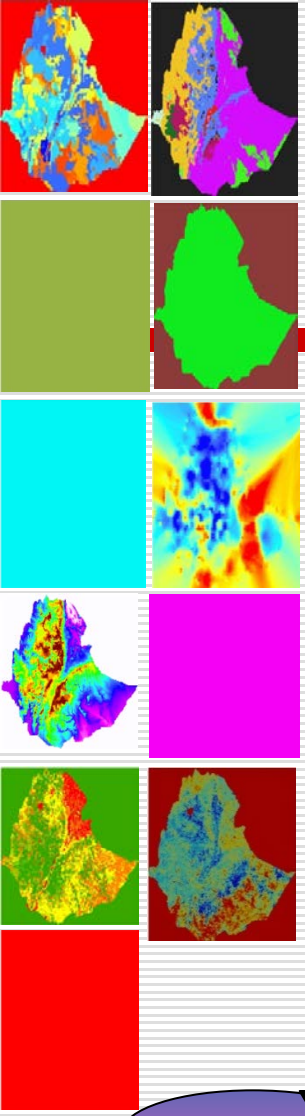
Materials and Methods. . .

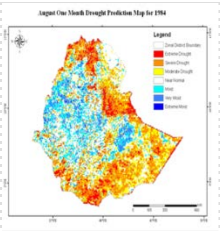


Selected Attribute (Acronyms)	Format	Source
SDNDVI	Raster	NOAA AVHRR
DEM	Raster	USGS
WHC	Raster	USGS
veg_Ethiopia	Vector	Ecodiv.org
Landcover	Raster	ESA
SPI_3month	Raster	IRI
PDO (Pacific Decadal Oscillation)	Point data	NOAA
AMO (Atlantic Multi-decadal Oscillation Index)	Point data	NOAA
NAO (North Atlantic Oscillation)	Point data	NOAA
PNA (Pacific North American Index)	Point data	NOAA
MEI (Multivariate ENSO Index)	Point data	NOAA

Modeling


Object
Identification
Modelling
Most relevant attributes
Earth
Images
Prediction
Tracking
in time
$t_1,\ldots,t_n$
t_0
Quality control
Stakeholders





Interpretation

Data Mining

Transformation

Preprocessing

Selection

Knowledge

Patterns

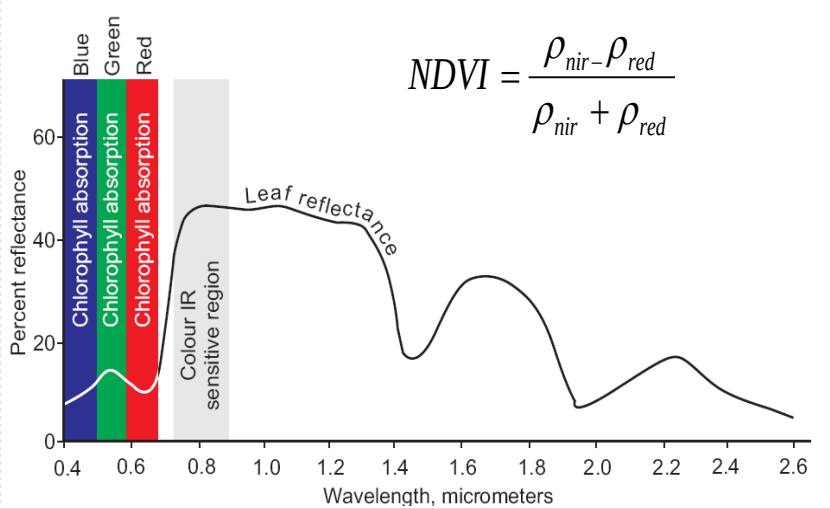
Transformed Data

Preprocessed Data

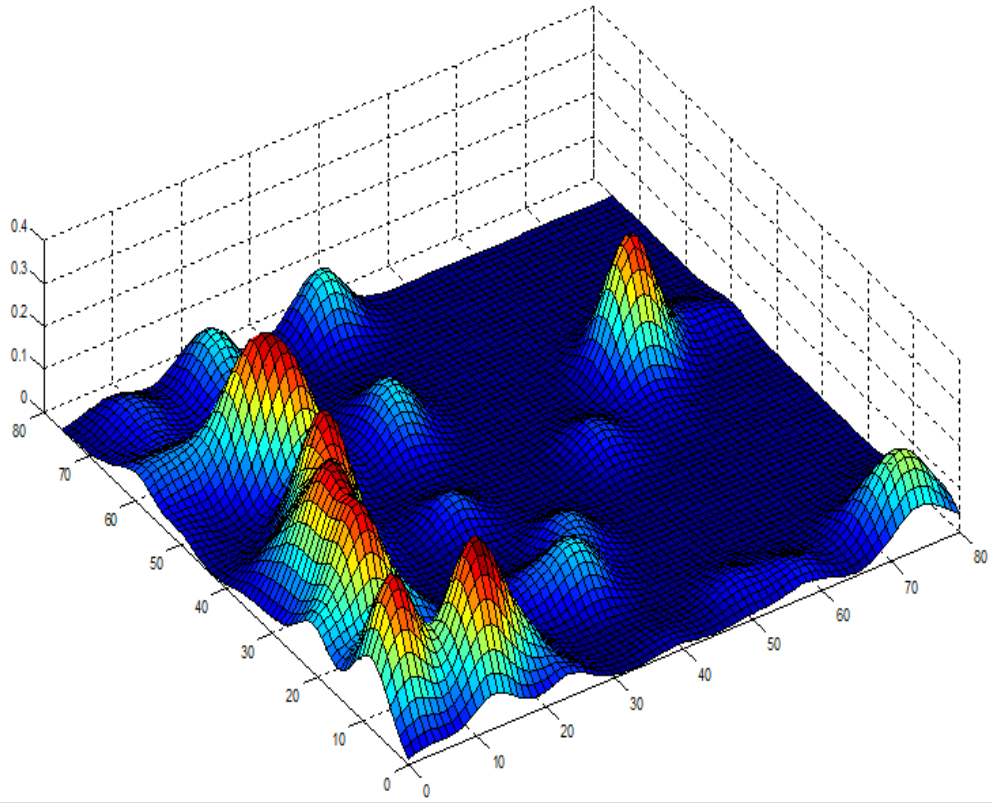
Target Data

Original Data

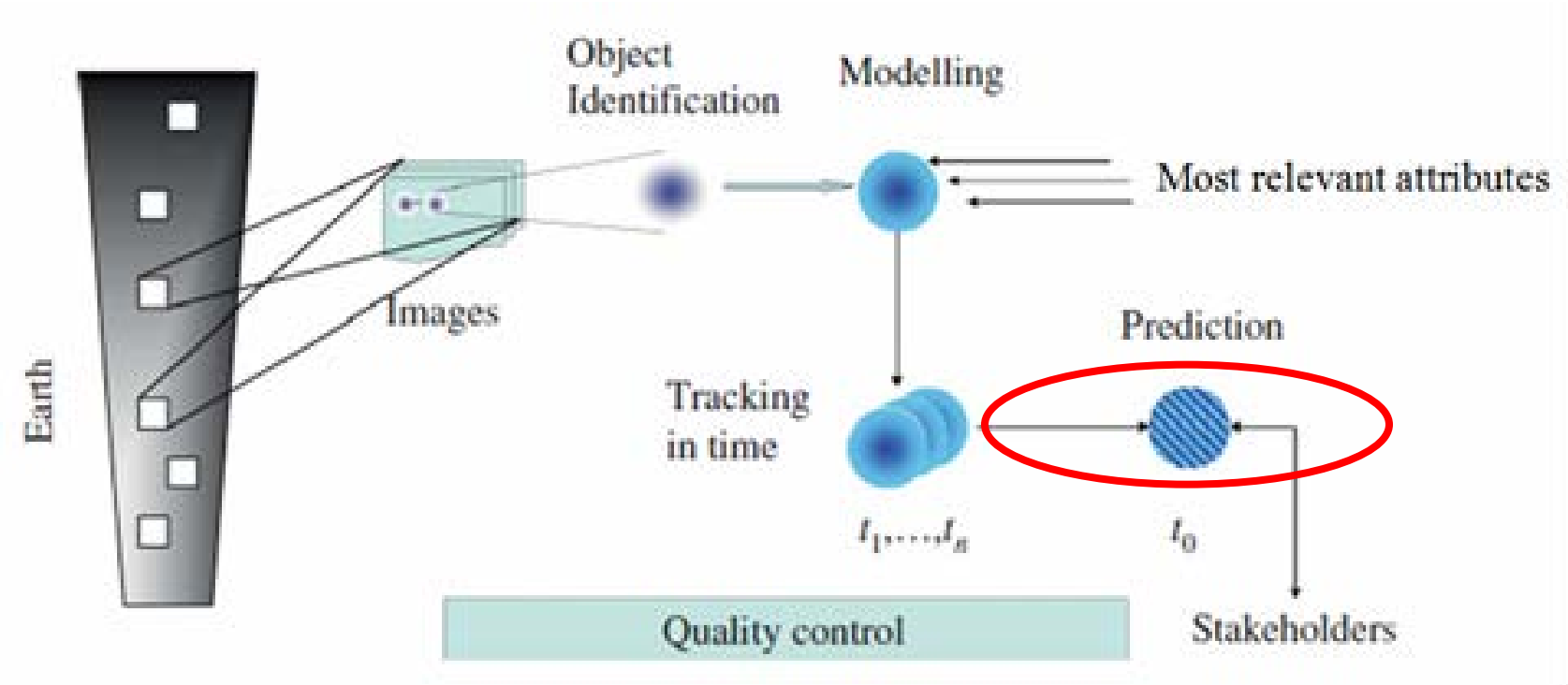
- Assumption = possible to model drought in space and time dimensions using its attributes
  - Dependent variable here is SDNDVI



$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}}$$



Materials and Methods. . .



- A 24 years of data (1983 – 2006) of the 11 key attributes were used for drought modeling experiment.
- The years 1983 – 2006 were used because complete dataset for all the 11 attributes were obtained in these time periods for the whole modeling exercise for developing the knowledge base.
- During the modeling experiment 10 – 30 rules were produced.

- From the experimental datasets, 80% were used for training and 20% for testing the models (*Gopal et al., 1999*).
- Using the 24 years historical datasets of the 11 attributes, a total of 10 models were developed for predicting drought in one to four month time lags for the growing season of June-October.

Regression Tree models

Rule 1: [124 cases, mean -59.0, range -251 to 163, est. err 62.0]

if

3 Month SPI <= -20

SDNDVI <= 0

Land cover in 14 (rain fed croplands), 20 (mosaic cropland (50-70%) / vegetation (grassland/shrub land/forest)

then

***DroughtObject** = 57.6 + 0.83 3 Month SPI - 0.023 DEM + 0.15 SDNDVI*

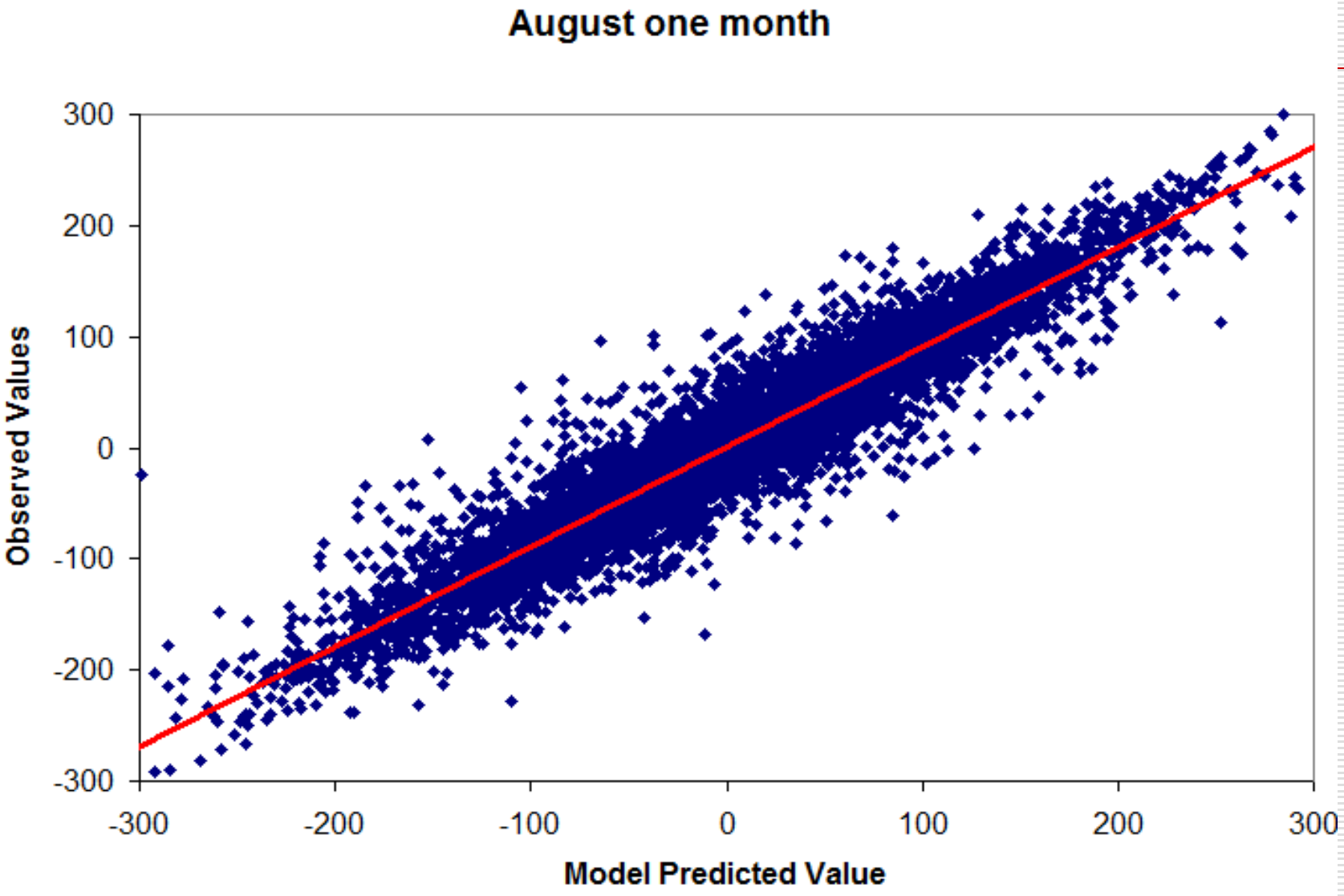
Results and Discussions

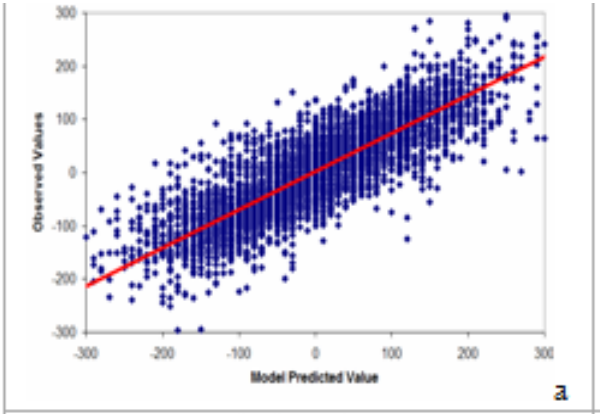
- Summary of validation results for June-October regression tree models

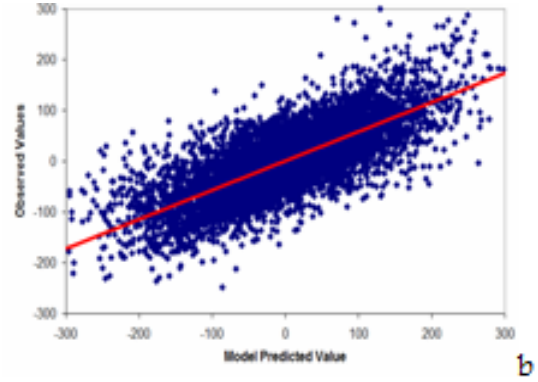
Months	Evaluation on test data		
	Average error	Relative error	Correlation coefficient
June one month	37.5	0.49	0.85
June two month	46.488	0.61	0.77
June three month	51.748	0.67	0.71
June four month	179.753	0.57	0.77
July one month	27.255	0.36	0.92
July two month	39.691	0.51	0.84
July three month	189.925	0.59	0.75
August one month	22.184	0.29	0.95
August two month	186.404	0.58	0.75
September one month	180.224	0.57	0.77

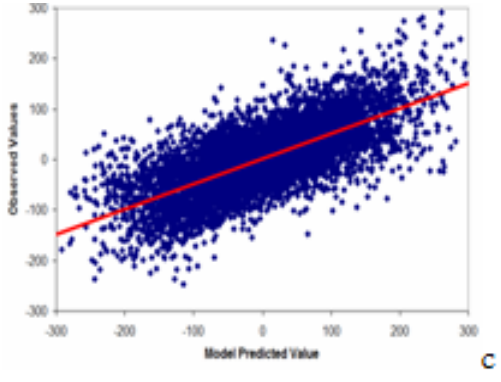
Lowest

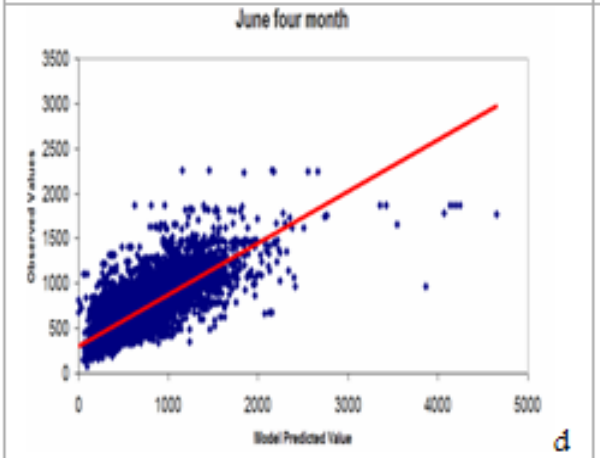
Highest

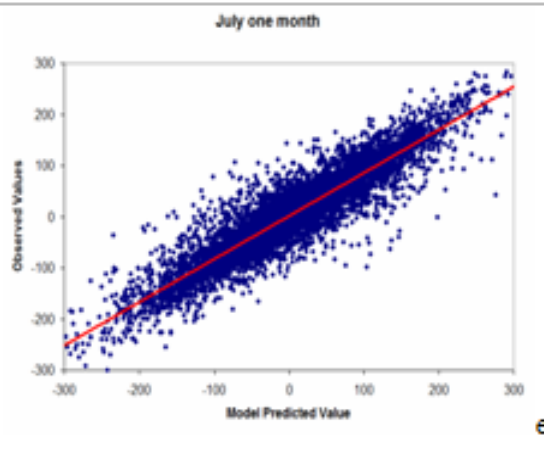

August one month
Observed Values
Model Predicted Value
300
200
100
0
-100
-200
-300
-300
-200
-100
0
100
200
300

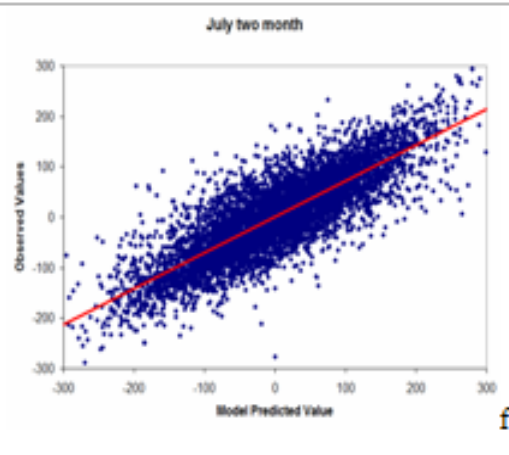

Observed Values
Model Predicted Value
a

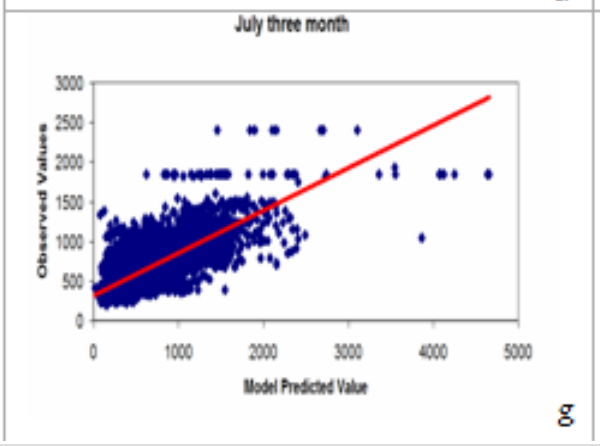

Observed Values
Model Predicted Value
b

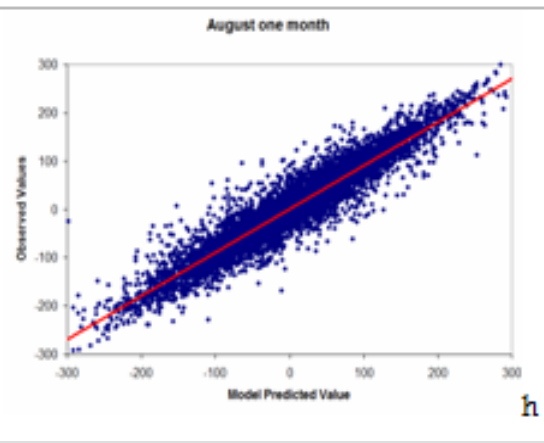

Observed Values
Model Predicted Value
c

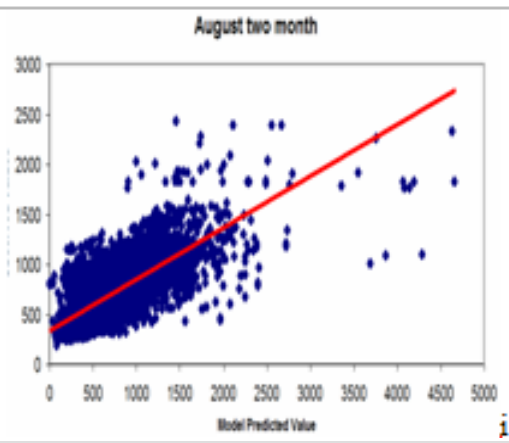

June four month
Observed Values
Model Predicted Value
d

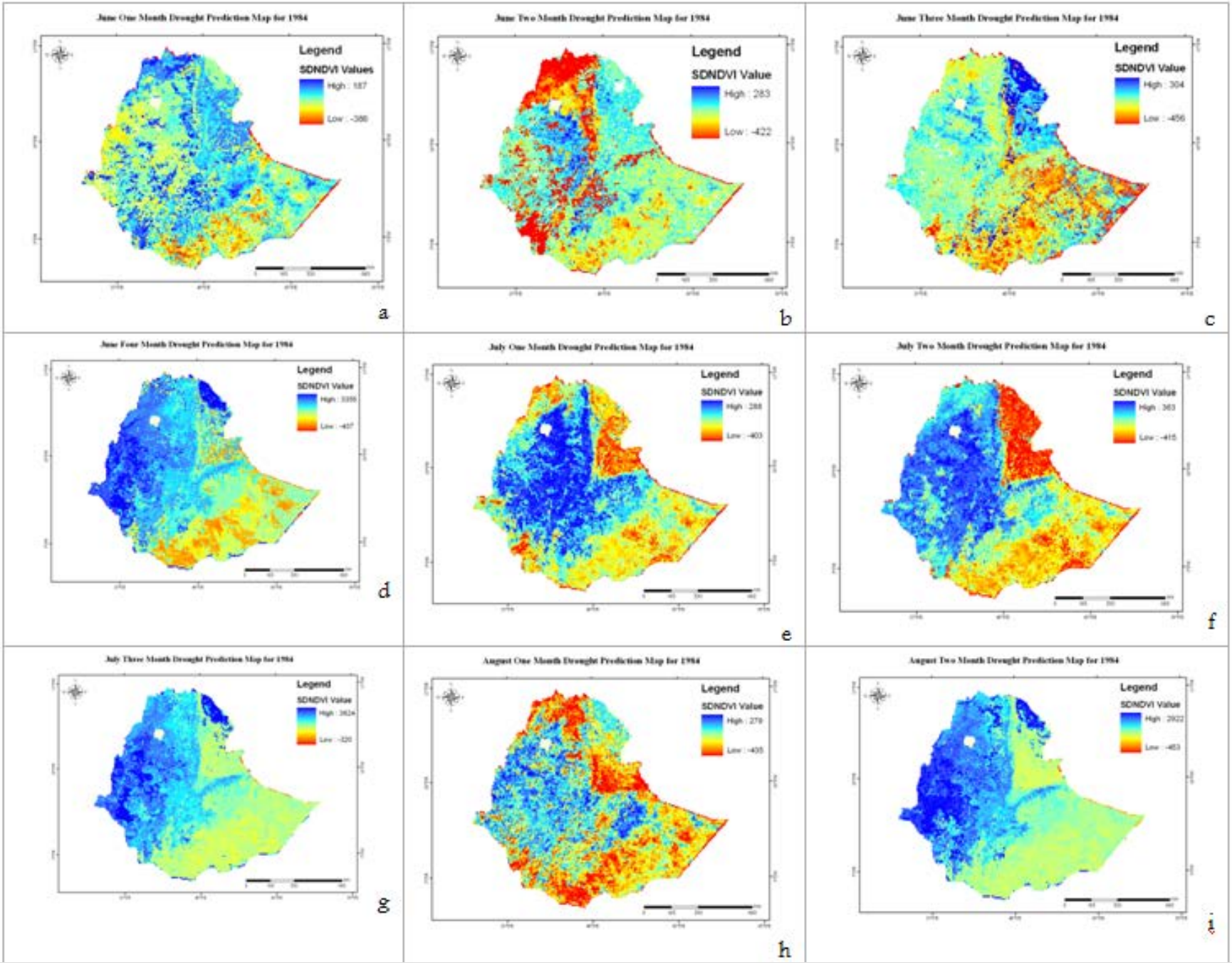

July one month
Observed Values
Model Predicted Value
e


July two month
Observed Values
Model Predicted Value
f


July three month
Observed Values
Model Predicted Value
g

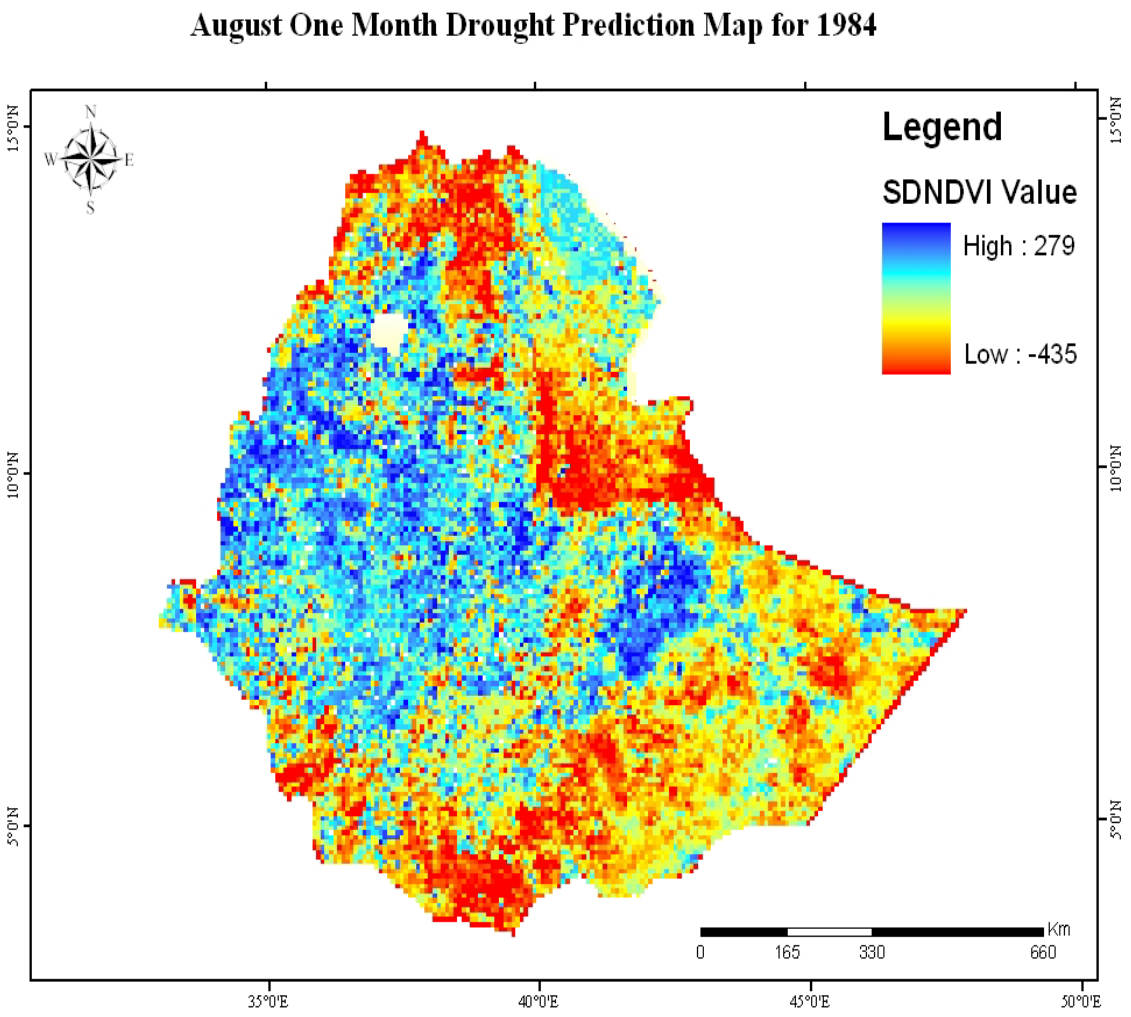

August one month
Observed Values
Model Predicted Value
h


August two month
Model Predicted Value
i

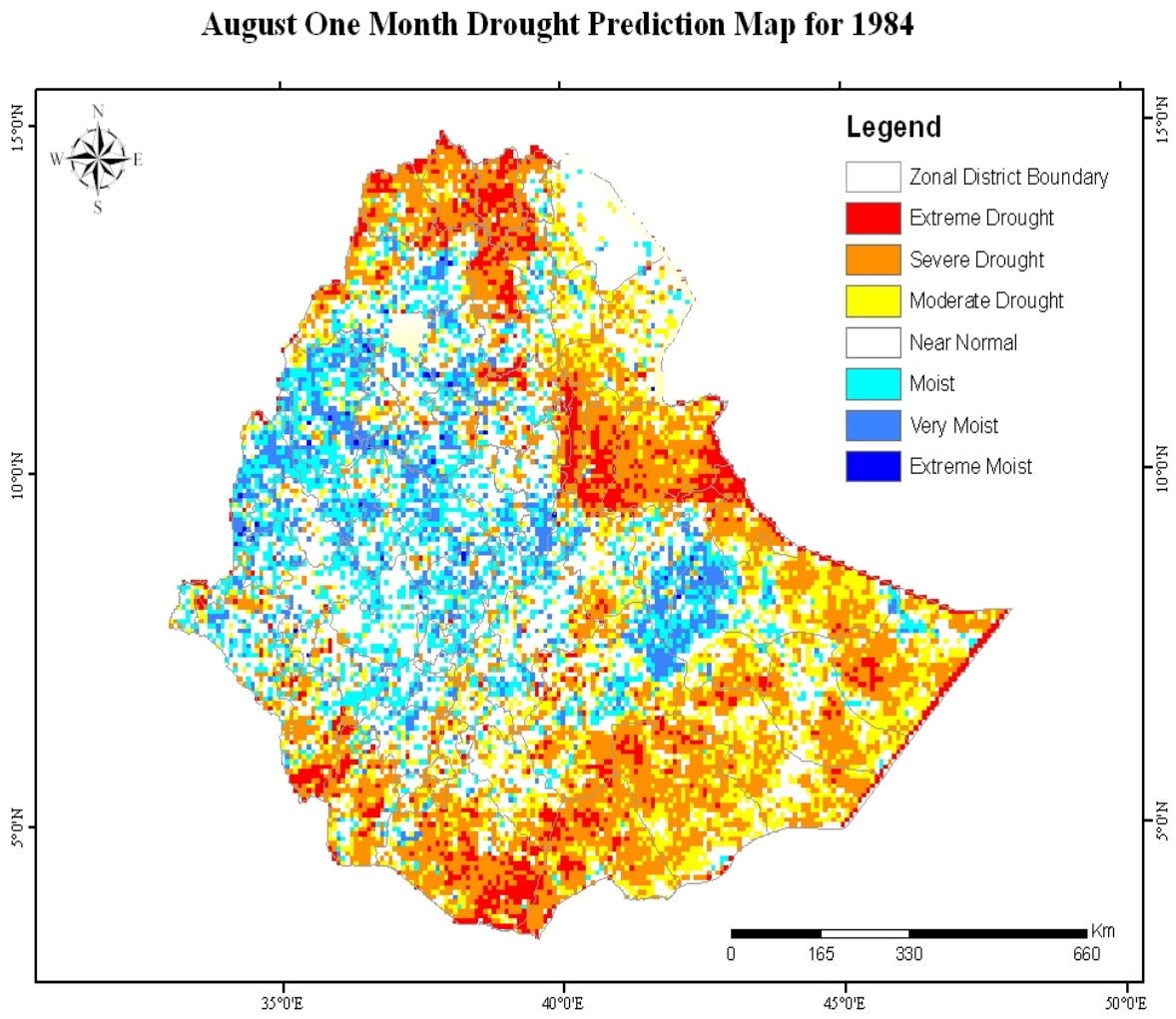

June One Month Drought Prediction Map for 1984
Legend
SDNDVI Values
High : 187
Low : -386
a
June Two Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 283
Low : -422
b
June Three Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 304
Low : -456
c
June Four Month Drought Prediction Map for 1984
Legend
SDNDVI Value
d
July One Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 288
Low : -403
e
July Two Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 363
Low : -415
f
July Three Month Drought Prediction Map for 1984
Legend
SDNDVI Value
g
August One Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 279
Low : -405
h
August Two Month Drought Prediction Map for 1984
Legend
SDNDVI Value
High : 2922
Low : -463
i

- Model Implementations
  - The pattern observed corresponds to the accuracy levels obtained
  - August one month prediction was the highest accuracy and also with best pattern.
  - As the prediction month length increase the pattern observed decreased

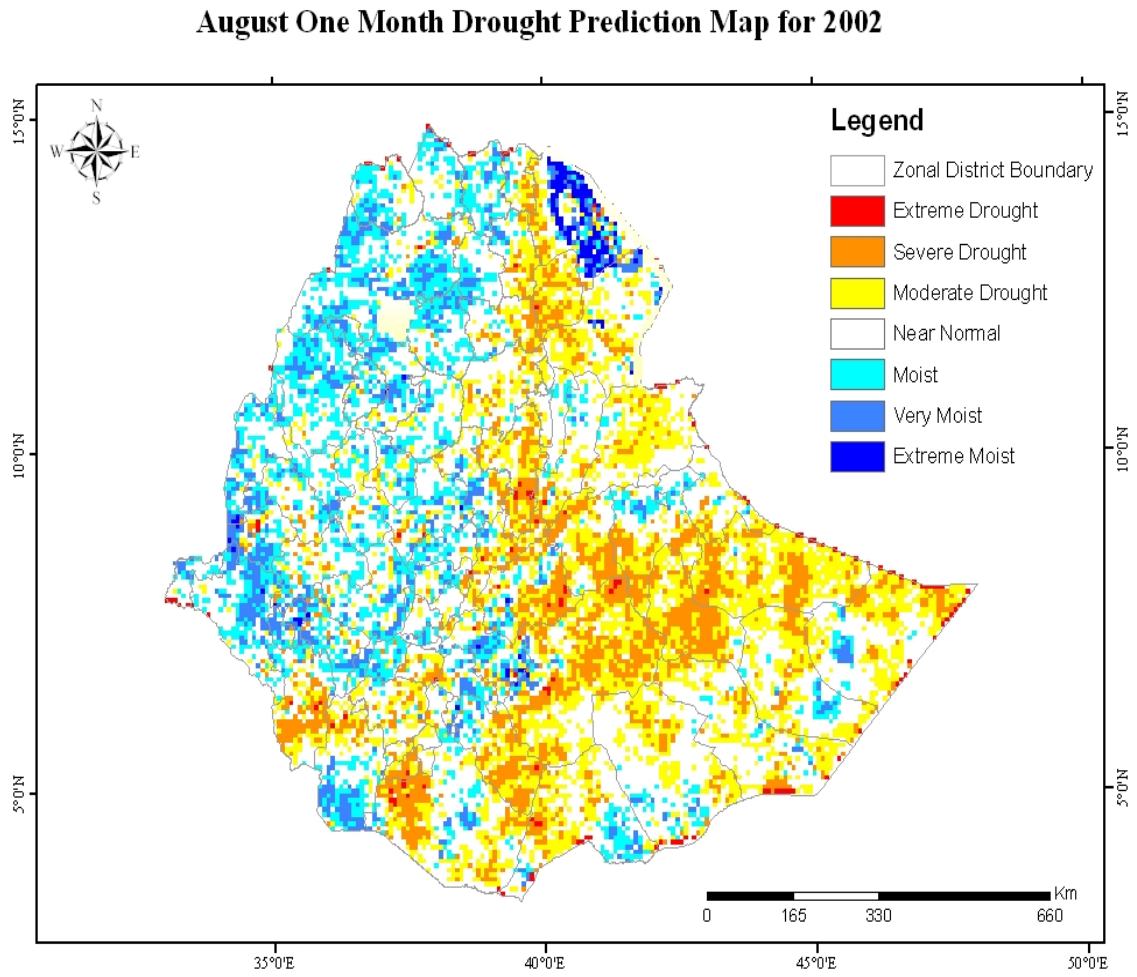
Results and Discussions. . .



Results and Discutions. . .



Results and Discussions. . .

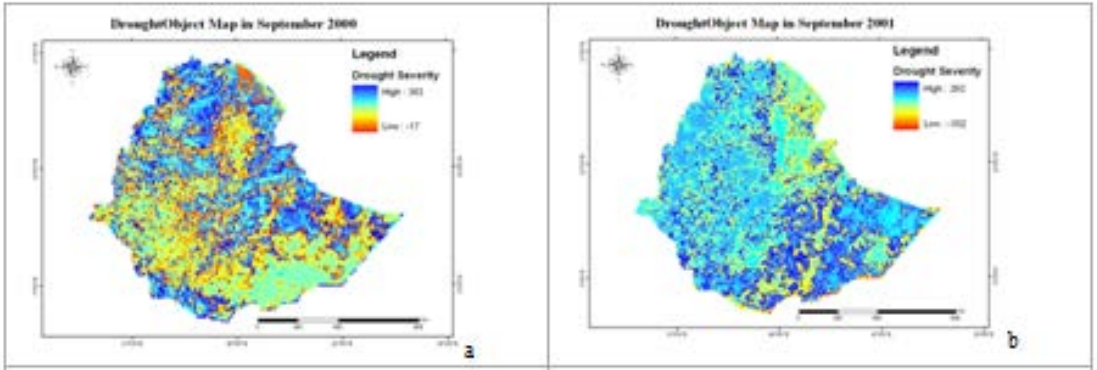


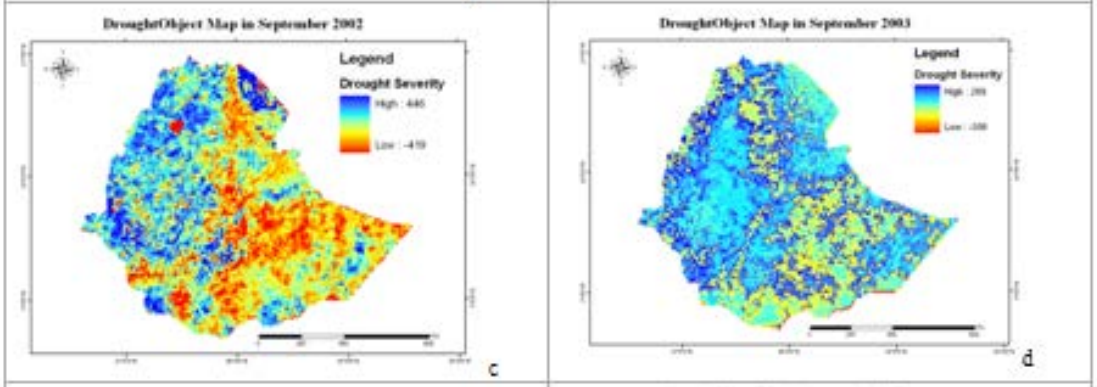
- The errors in the models are attributed to:
  - low spatial and temporal resolution of input datasets
  - Heterogeneous ecosystems of Ethiopia

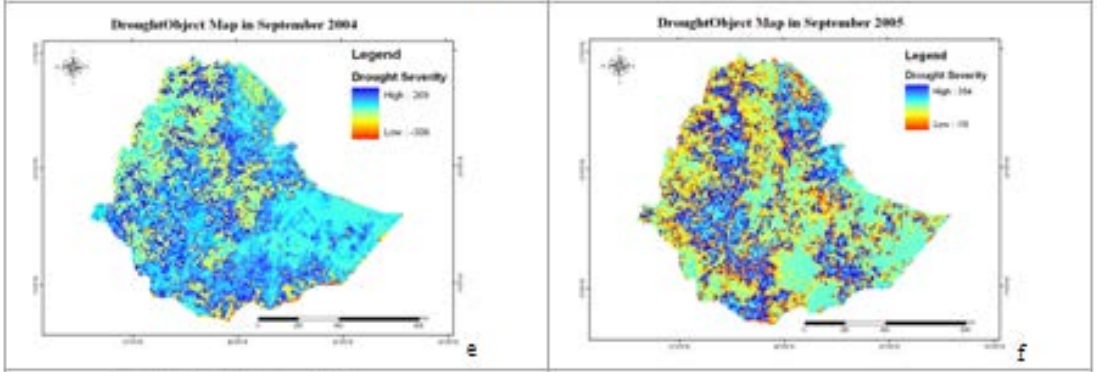
Model Evaluation

- Method
  - The model evaluation here was done in the context of "fitness for purpose".
  - The evaluation of the drought model product was done using the "Meher" season (long rainy season) yield data.
  - 41 "Meher" growing Zones were used for this evaluation.
  - Two criteria were used for selecting Zones:
    - Availability of data from 2000 – 2006 Meher season
    - Zones are in "Meher" crop growing districts

Results and Discussions. . .







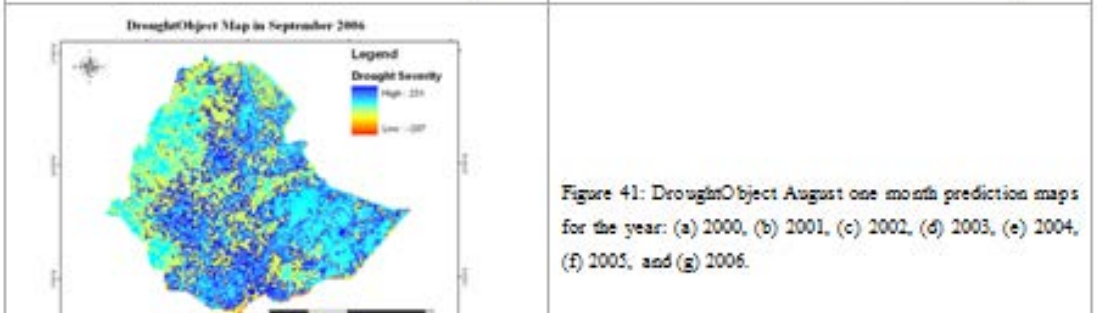
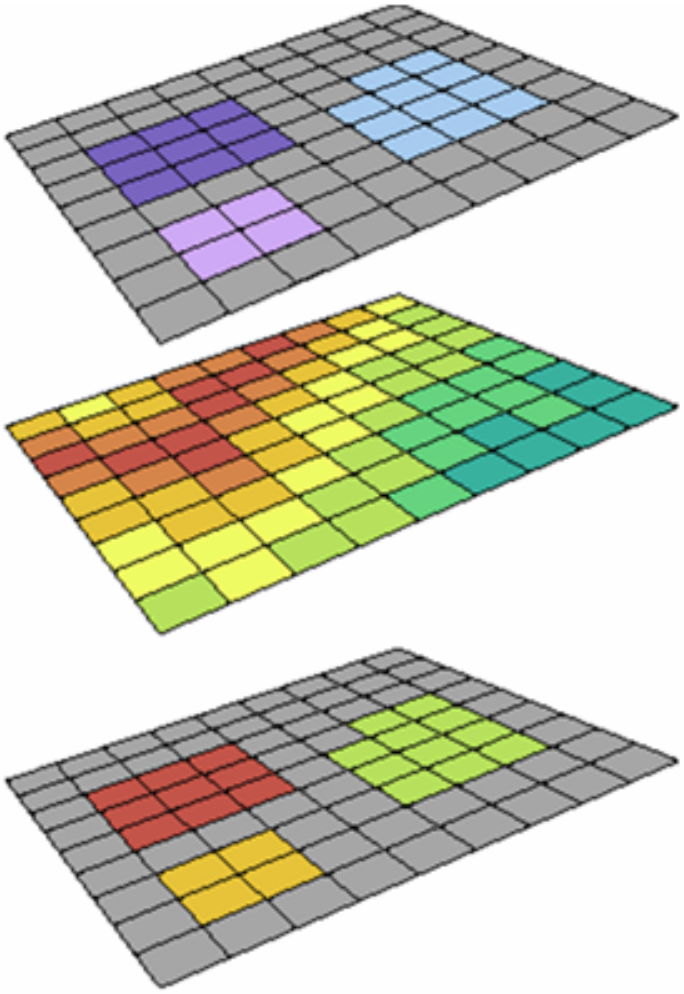


Figure 41: DroughtObject August one month prediction maps for the year: (a) 2000, (b) 2001, (c) 2002, (d) 2003, (e) 2004, (f) 2005, and (g) 2006.

Results and Discussions. . .

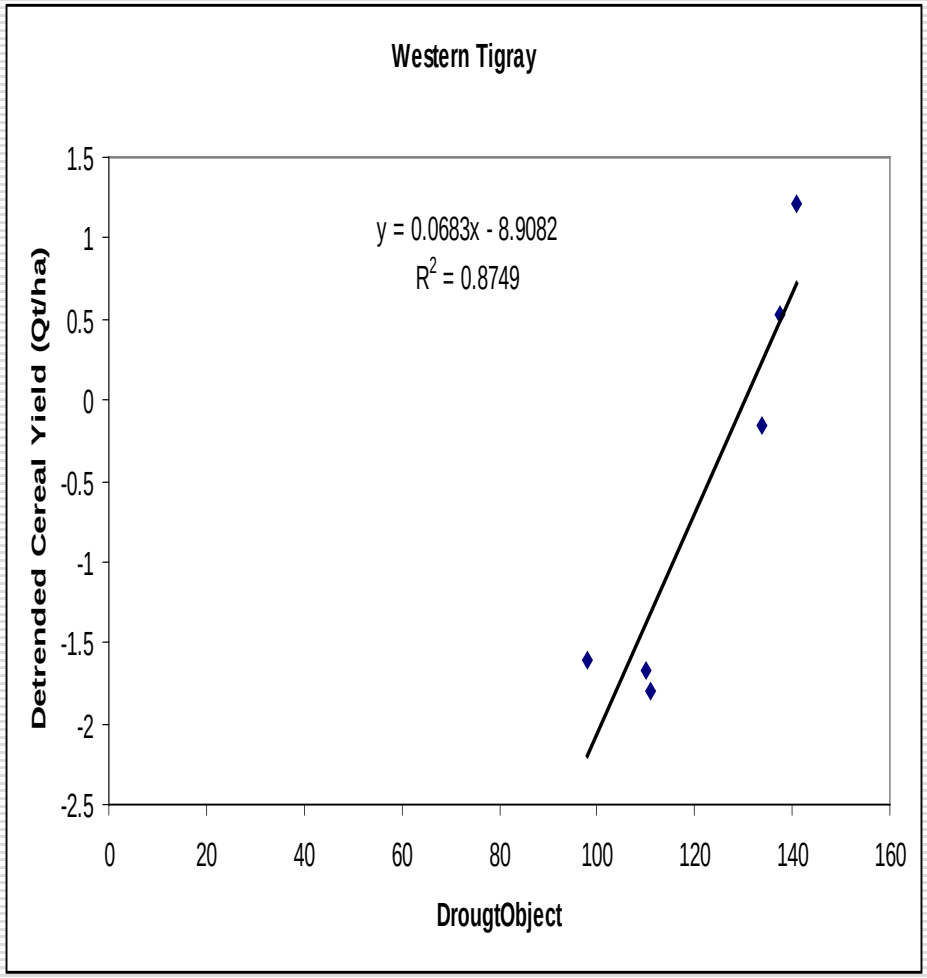


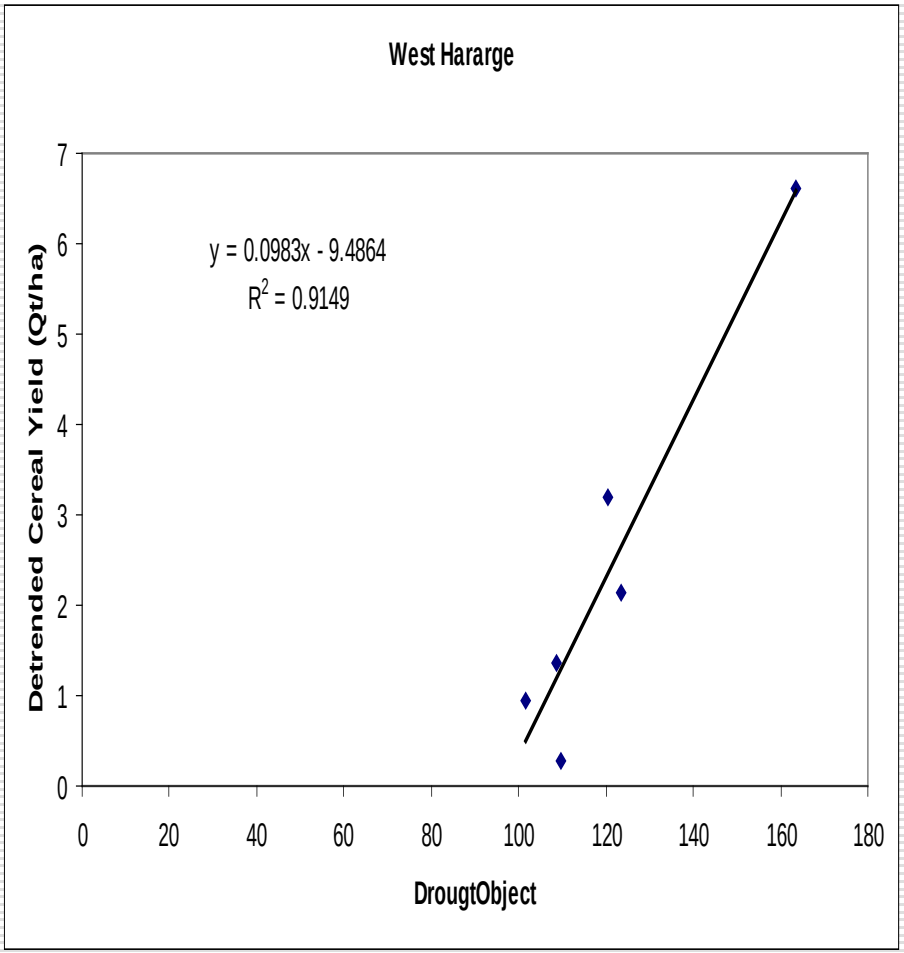
Zonal Map of Ethiopia

DroughtObject Image

Zonal Output Attributes From DroughtObject Image for each Zone

Results and Discussions. . .





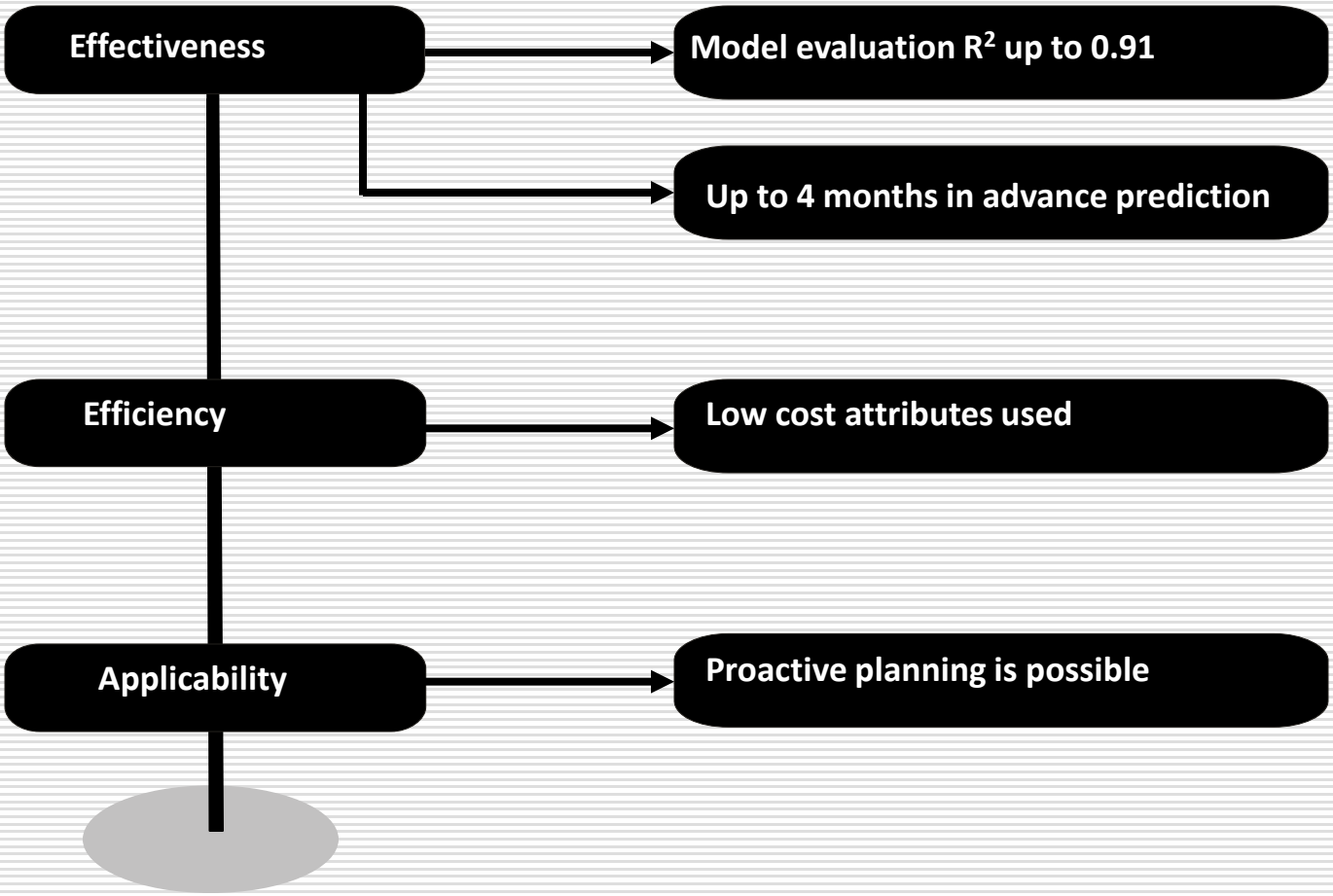
- The model evaluation showed the reliability of model products.
- The errors in correlating model output with yield data is mainly attributed to coarse administrative yield data.

6. Conclusions

- The research has shown that drought can be effectively identified and monitored using the developed.
  - The new system enables drought prediction better, faster and cheaper.
  - Compared to previous work, ten more weeks can be predicted in advance with the new approach (i.e. a total of 4 months in advance drought prediction is possible).
  - The problem of meteorological point data collection and analysis at coarse resolutions level were solved with this new approach and the coverage and time delay issues are addressed.
  - Decision makers at different levels can use the new system to plan proactively for potential food insecurity.
  - Drought planning can be made at risk-based drought management approach rather than a crisis-based approach.

Contributions

In terms of Metrics

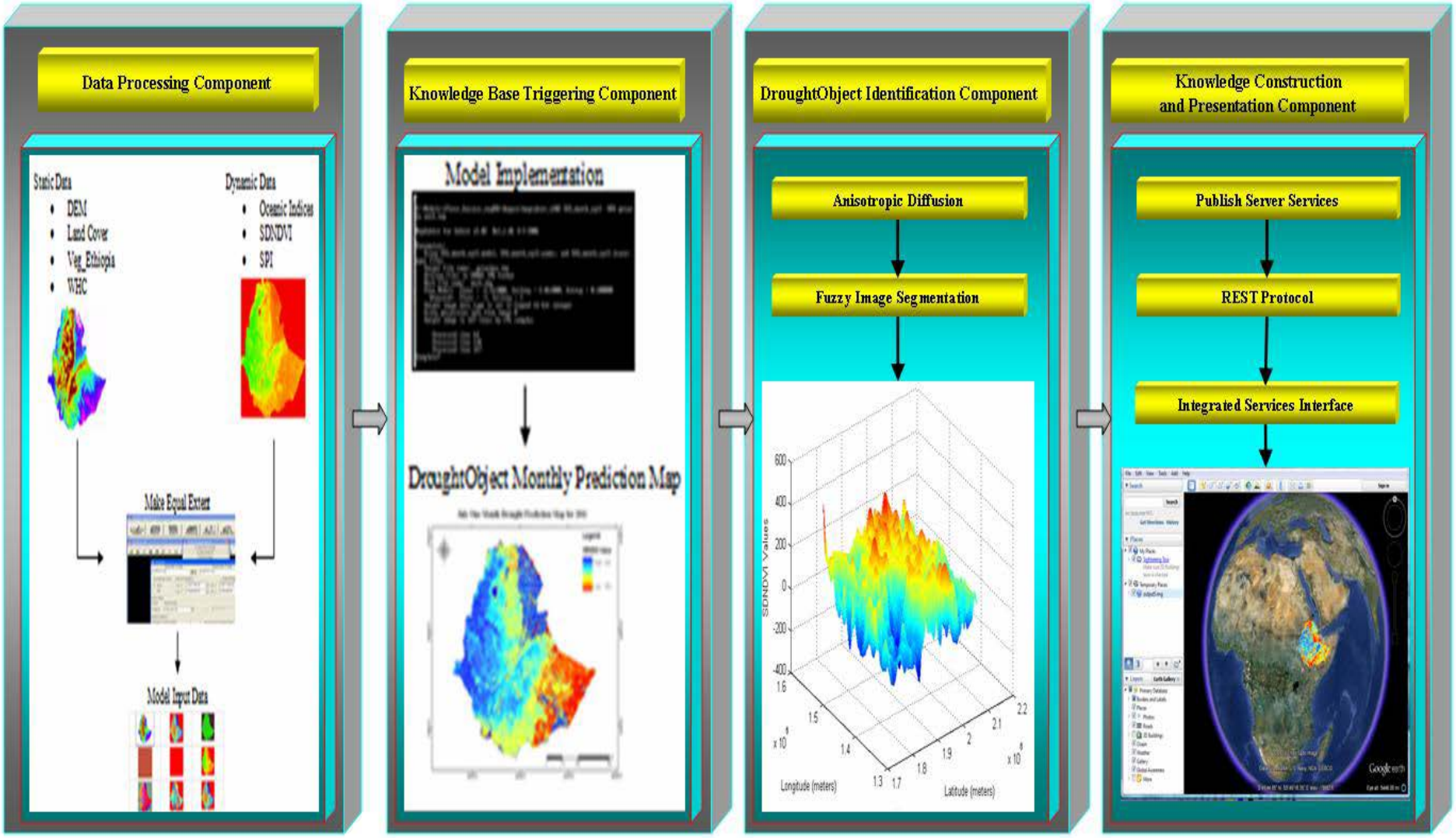


Future Research

- Three key future researches proposed

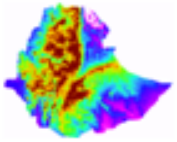
1. Design and develop *droughtOutlook* system
2. Develop database and Data warehouse system
3. Develop an Empirical Drought Early Warning and Agile Insurance System

Future Research – having the working system in place

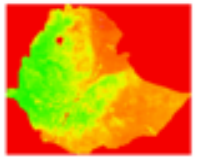


Future Research…

Static Data
- DEM
- Land Cover
- Veg_Ethiopia
- WHC

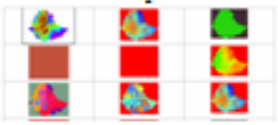


Dynamic Data
- Oceanic Indices
- SDNDVI
- SPI



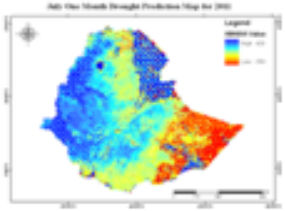
Make Equal Extent

Model Input Data

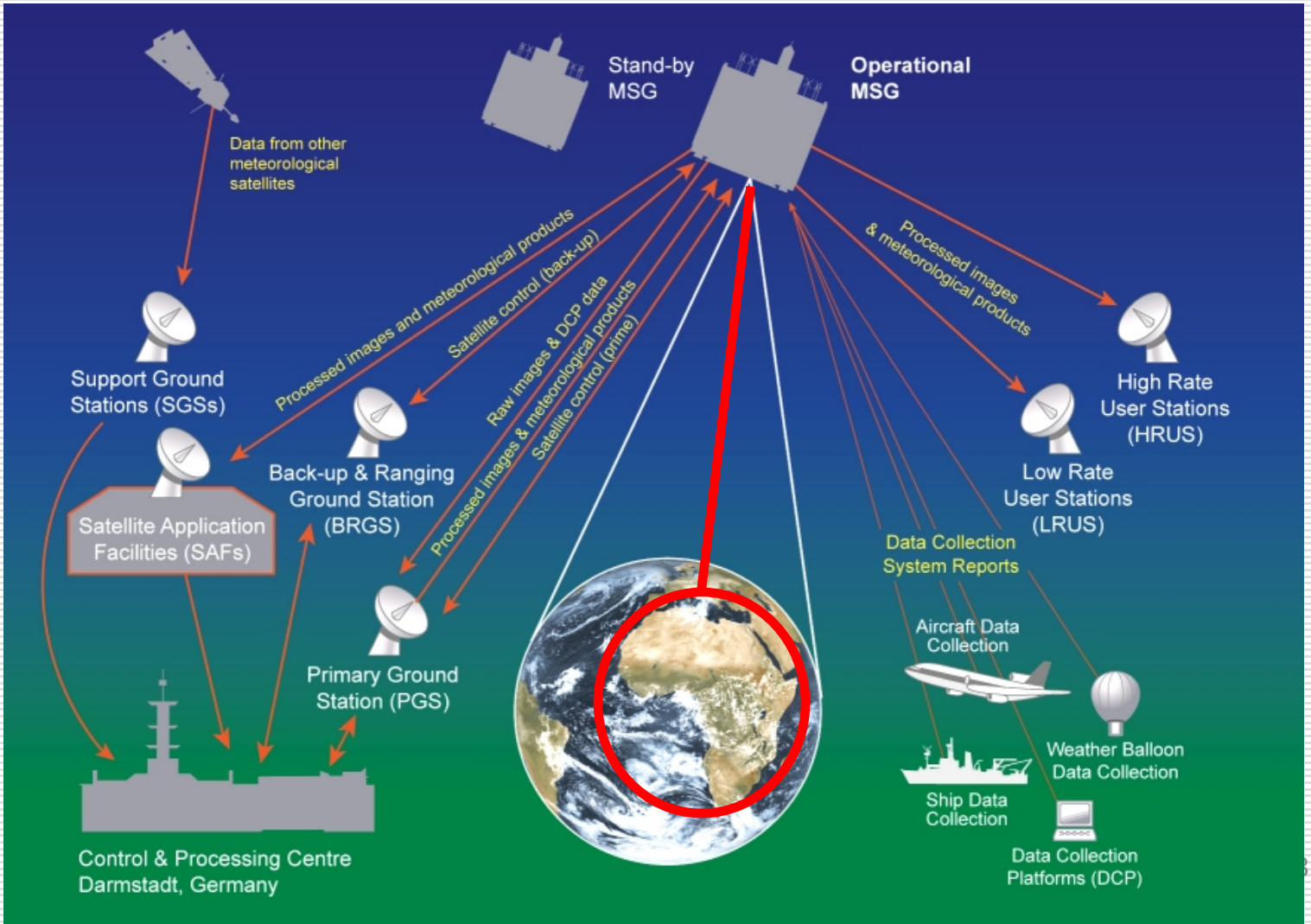


Model Implementation

2011 DroughtObject Monthly Prediction Map



The Big Picture




THANK YOU!