Climate Data observation, climate monitoring and long range forecast methods in Ethiopia

A paper presented at WMO Workshop on Climate Monitoring including the implementation of Climate Watch Systems in RA-I with focus on Eastern and Southern Africa

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By

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Outline

- Climate Data Observation
  - History of meteorological data observation in Ethiopia
  - Technologies and instruments used for observing meteorological data in Ethiopia
  - Stations distribution
  - Who is responsible for managing and transferring data in NMA?
- Climate monitoring
  - Climate bulletin
  - Other products
- Long range forecasting systems and methods
- Conclusions

History of Meteorological Data recording in Ethiopia

- The first meteorological stations were established in the 19th century by missionaries and explores
- In 1890 and 1896 weather stations were established at Adamitulu and Gambella by the Italians.
- During the five years (1936-1941) Italian invasion – 192 stations were established in Ethiopia
- Since 1951 for the purpose of flight operations 495 aeronautical and climate stations were established.
- After the establishment of NMSA (1980), the total number of stations have substantially increased to 1200; but later the number of stations dropped to 548.
- The total number of stations now raised to more than 1200

Technologies and instruments used for observing meteorological data in Ethiopia

- Manned Surface Observing Stations
  - Synoptic, Indicative, Ordinary and Precipitation station
- Automatic Observing Stations
- Upper Air Stations
  - Radiosonde and Pilot Balloon
- Satellite Data Receiving Stations
- Stations at the airport – mainly for air navigation
  - Sadis and AWOS
- Meteorological Radar

Pictorial view of surface stations

Surface stations types

Synoptic/class I stations collect >10 meteorological parameters.

Class III: collect only air temperature and rainfall

Class IV: collect only rainfall

Synoptic/Class I

Class III

Class IV

Meteorological elements recorded at Class IV stations

No.	Element	Unit	Time of observation
1	Rainfall	millimeters	09 LST
2	Maximum Temperature	^{o}C	18 LST
3	Minimum Temperature	^{o}C	09 LST

→ **Meteorological elements record at Class III stations**

No.	Element	Unit	Time of observation
1	Rainfall	millimeters	09 LST

→ **Meteorological elements record at Class IV stations**

Meteorological elements recorded at Class I stations

No	Element	Unit	Time of observation
1	Rainfall	millimeters	09 LST
2	Maximum Temperature	°C	18 LST
3	Minimum Temperature	°C	09 LST
4	Dry Bulb Temperature	°C	06, 09,12,15,18 LST
5	Wet bulb Temperature	°C	06, 09,12,15,18 LST
6	Relative Humidity	%	06, 09,12,15,18 LST
7	Sun shine duration	Hours	18 LST
8	Wind run at 2 meters	M/s or knots	06, 09,12,15,18 LST
9	Wind speed and Direction at 10 meters	M/s and degree	06, 09,12,15,18 LST
10	Cloud Amount	Oktas	06, 09,12,15,18 LST
11	Soil temperature at 10, 20, 30, 50 and 100 centimeters depth	°C	06, 09,12,15,18 LST
12	Pan Evaporation	millimeters	06, 09,12,15,18 LST
13	Pitche Evaporation	millimeters	06, 09,12,15,18 LST

Meteorological elements recorded at Class II stations in addition elements recorder at class I stations

No	Element	Unit	Time of observation
1	Grass minimum temperature	°C	00,03,06,09,12, 15,18,21 LST
2	Station level pressure	mb(hPa)	00,03,06,09,12, 15,18,21 LST
3	QNH (Sea level pressure)	mb(hPa)	00,03,06,09,12, 15,18,21 LST
4	Weather Present weather Past weather	In symbols	00,03,06,09,12, 15,18,21 LST
5	Cloud Low cloud amount Type of low cloud Type of medium cloud Type of high cloud	Oktas type	00,03,06,09,12, 15,18,21 LST
6	Height of low cloud	Kmts	00,03,06,09,12, 15,18,21 LST
7	Horizontal visibility	Kmts	00,03,06,09,12, 15,18,21 LST

Pictorial view Automatic Stations and Upper air stns

Upper Air obs.

AWOS

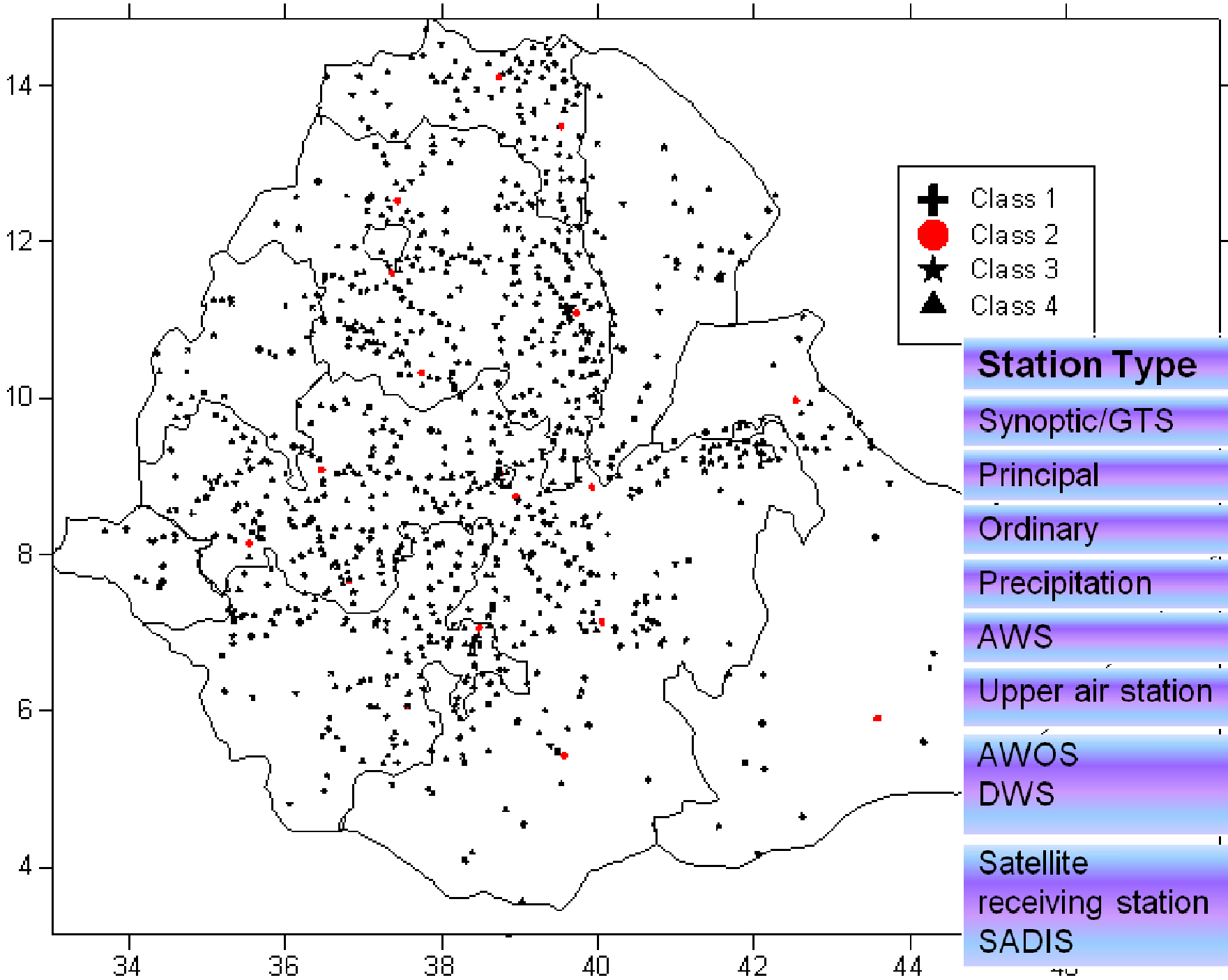
Meteorological elements recorded at AWS stations

- Each of the stations measure and transmit every 15minutes
  - Air temperature
  - Rainfall
  - Solar radiation
  - Relative humidity
  - Wind speed and wind Direction.
  - As per current setup, the station measures rainfall at the height of one meter above the ground
  - Air temperature at the height of 1.5 meters, anemometer and wind direction at the height of 2 meters.
  - The setting of all the sensors are inline with WMO recommended standards.

Images we receive at the Satellite data receiving station

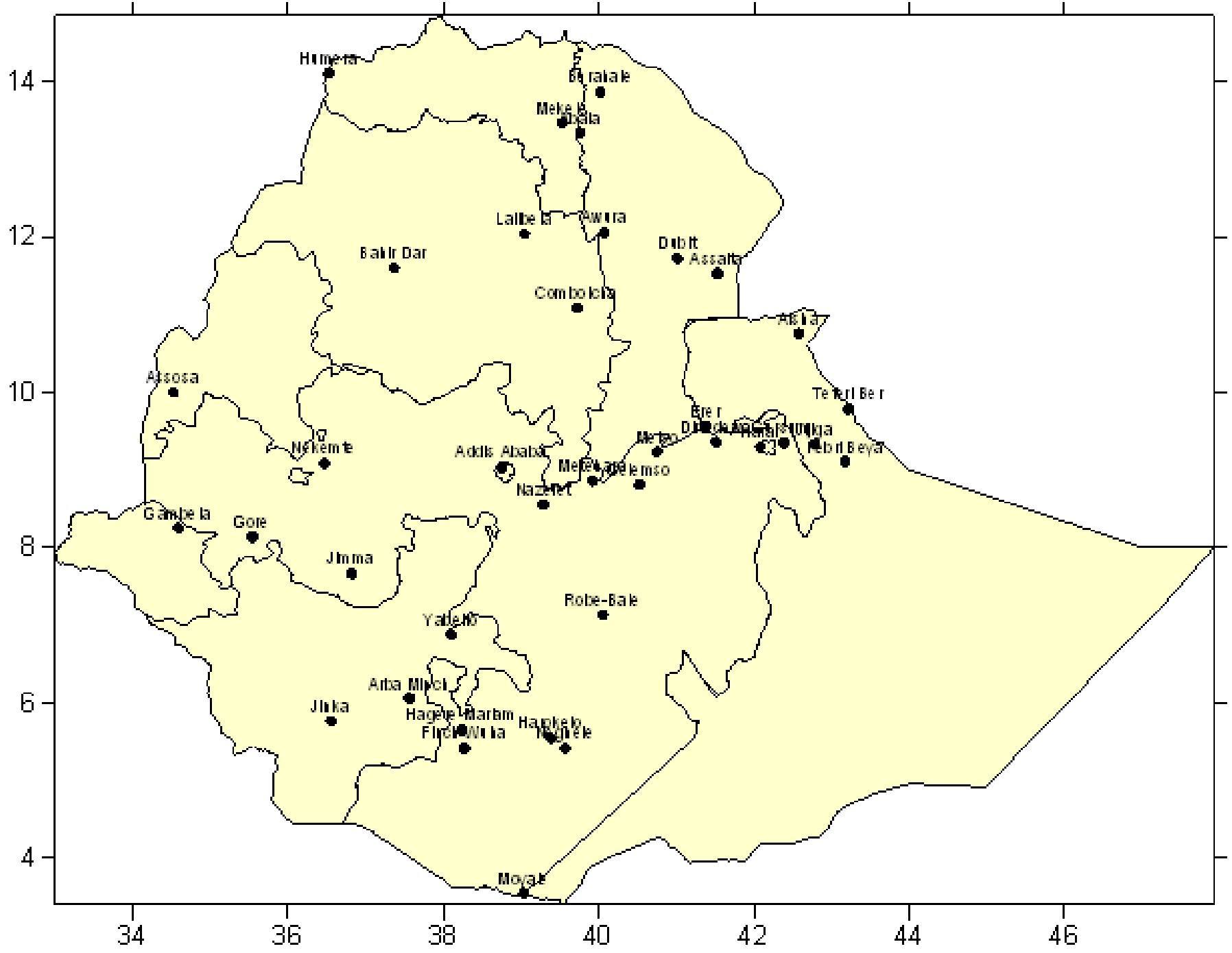
- Cloud pictures every 15 mintes
- Vegetation maps every dekad
- SWB every dekad
- NDWI every dekad
- Fire detection when there is on
- Phenology information – information about the crops from sowing up to harvest
- RFE – rainfall estimation from cold clod duration (the duration of a cloud at a given treshhold temperature.

Stations Distribution over Ethiopia as updated on December 2012

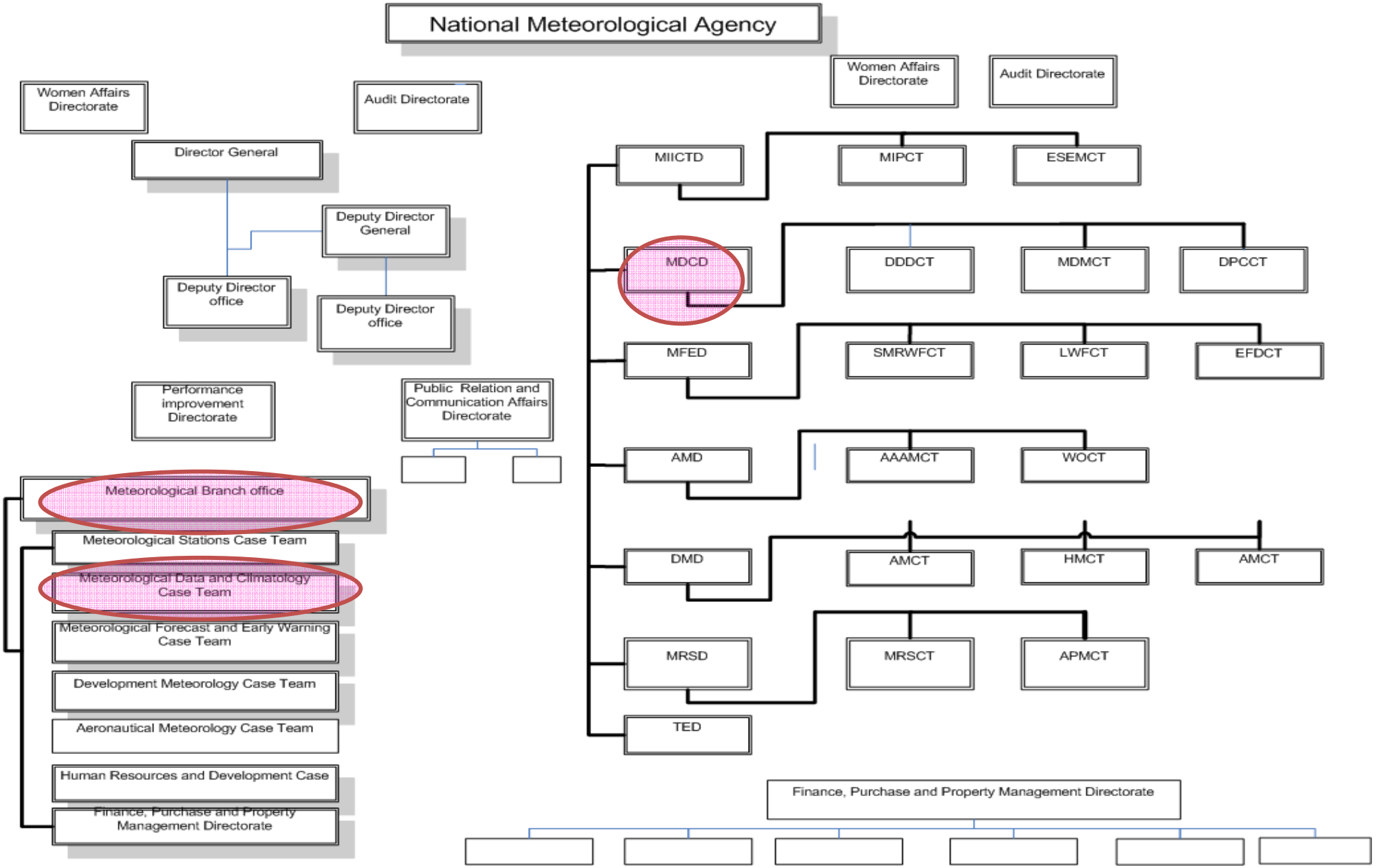


Station Type	No.
Synoptic/GTS	18
Principal	173
Ordinary	571
Precipitation	403
AWS	37
Upper air station	2
AWOS	4
DWS	4
Satellite receiving station	2
SADIS	1

Automatic surface stations distribution



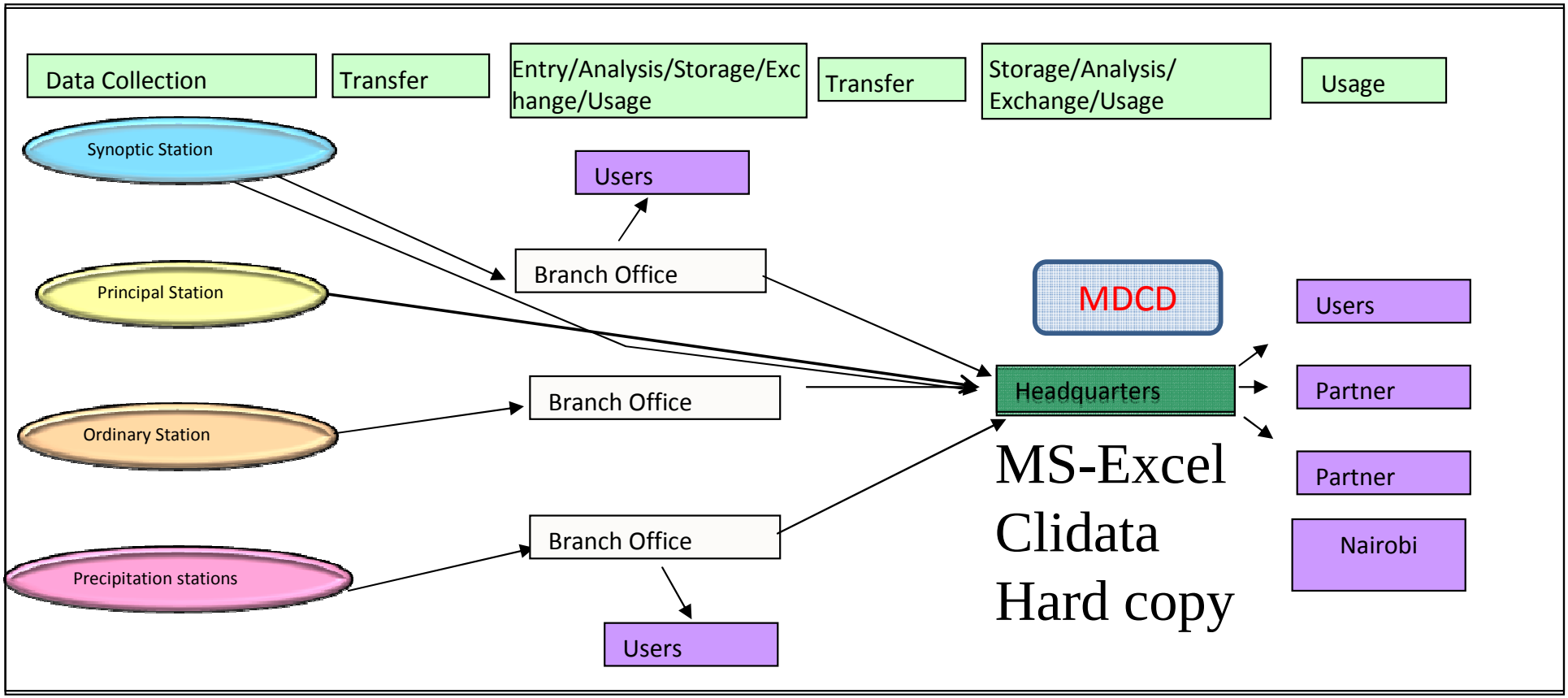
Who is responsible for managing and transferring data in NMA?



Roles of the Directorates

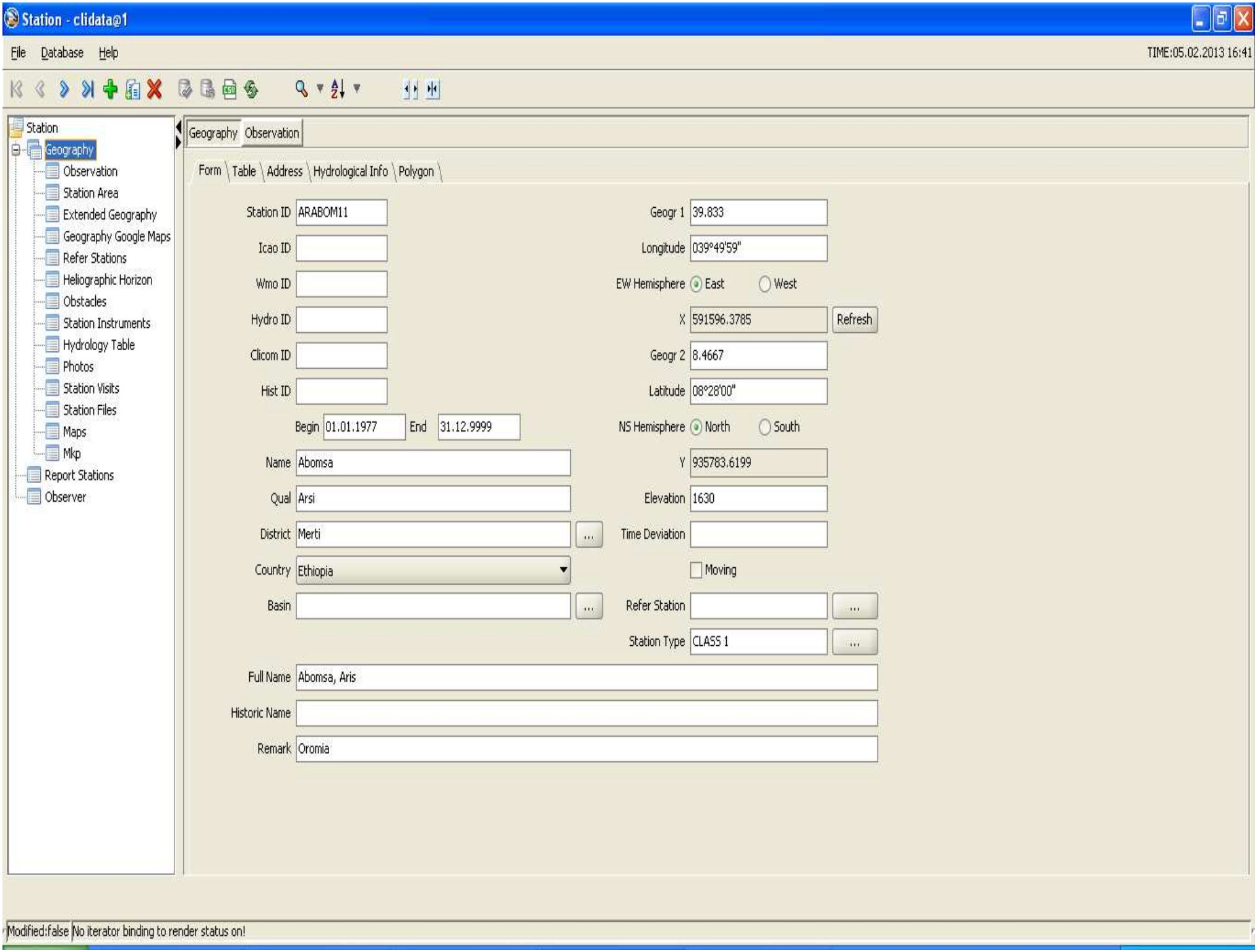
- Data Collection and Archiving
- Data Computerizations
- Data quality control
- Data Processing
- Data Management and Administration
- Data Delivery and Dissemination

Data Flow



- Branch offices manage stations found in their area of responsibility
- Data entered to a computer at the branch office sent to HQ by email, CD's or diskettes. Data delivered to users at regional level. Used for operational purpose. They manage, store and archive data. Hard copy data send by post to HQ.
- All Data from branch offices sent to HQ are managed, organized, processed and stored in computer archived in hard copy and delivered to users.


clidata@1 2012.05.10 14:06
File
Help
Stations
Metadata
Kef
Discoverer
ROM
Products
Administration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Help
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Station
Geography
Observation
Station Area
Extended Geography
Geography Google Maps
Refer Stations
Heliographic Horizon
Obstacles
Station Instruments
Hydrology Table
Photos
Station Visits
Station Files
Maps
Mkp
Report Stations
Observer
Geography
Observation
Form
Table
Address
Hydrological Info
Polygon
Station ID
ARABOM11
Icao ID
Wmo ID
Hydro ID
Clicom ID
Hist ID
Begin
01.01.1977
End
31.12.9999
Name
Abomsa
Qual
Arsi
District
Merti
Country
Ethiopia
Basin
Full Name
Abomsa, Aris
Historic Name
Remark
Oromia
Geogr 1
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Longitude
039°49'59"
EW Hemisphere
East
West
X
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Refresh
Geogr 2
8.4667
Latitude
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NS Hemisphere
North
South
Y
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Moving
Refer Station
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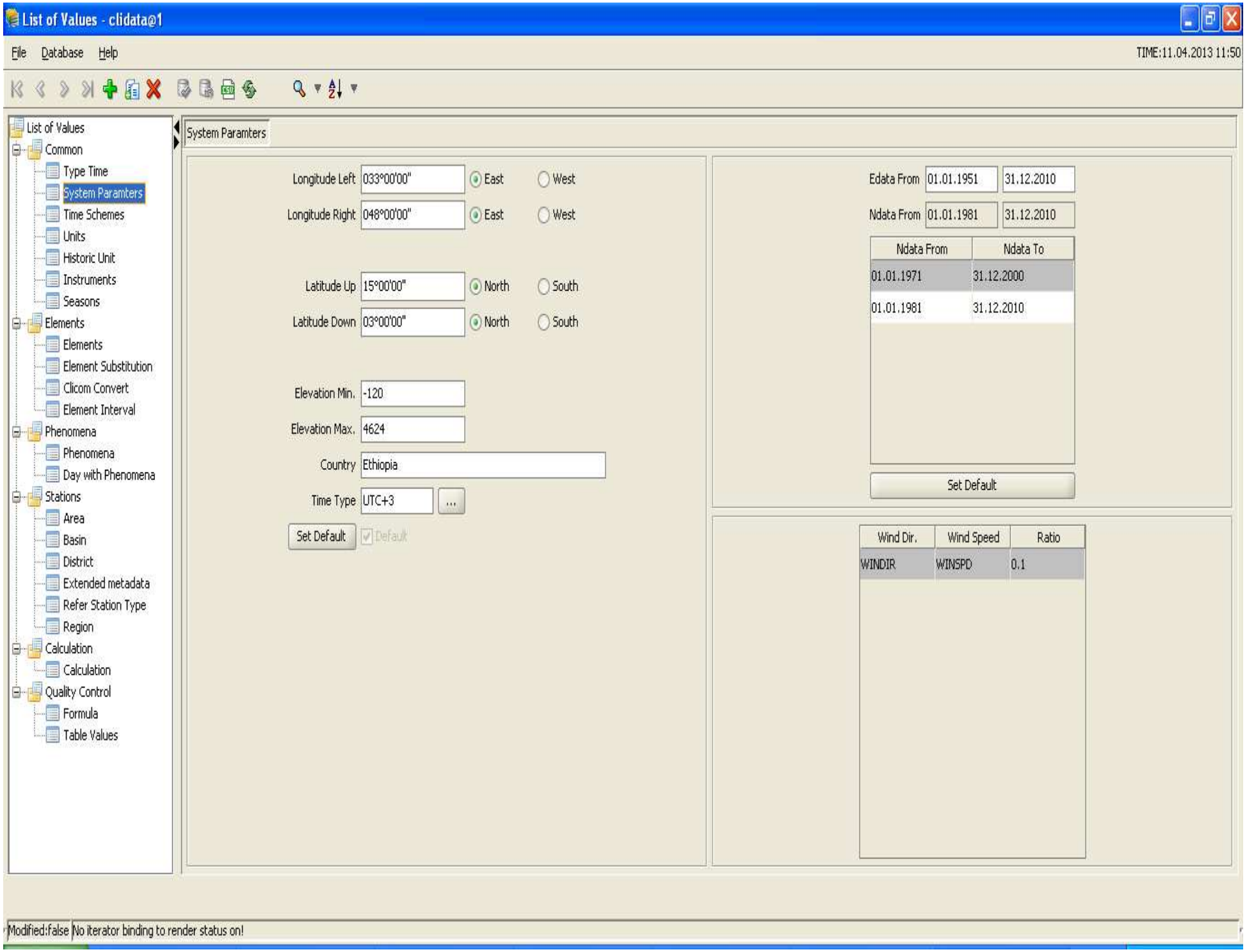
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Help
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Type Time
System Paramters
Time Schemes
Units
Historic Unit
Instruments
Seasons
Elements
Elements
Element Substitution
Clicom Convert
Element Interval
Phenomena
Phenomena
Day with Phenomena
Stations
Area
Basin
District
Extended metadata
Refer Station Type
Region
Calculation
Calculation
Quality Control
Formula
Table Values
System Paramters
Longitude Left
033°00'00"
East
West
Longitude Right
048°00'00"
East
West
Latitude Up
15°00'00"
North
South
Latitude Down
03°00'00"
North
South
Elevation Min.
-120
Elevation Max.
4624
Country
Ethiopia
Time Type
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...
Set Default
Default
Edata From
01.01.1951
31.12.2010
Ndata From
01.01.1981
31.12.2010
Ndata From
Ndata To
01.01.1971
31.12.2000
01.01.1981
31.12.2010
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Wind Dir.
Wind Speed
Ratio
WINDIR
WINSPD
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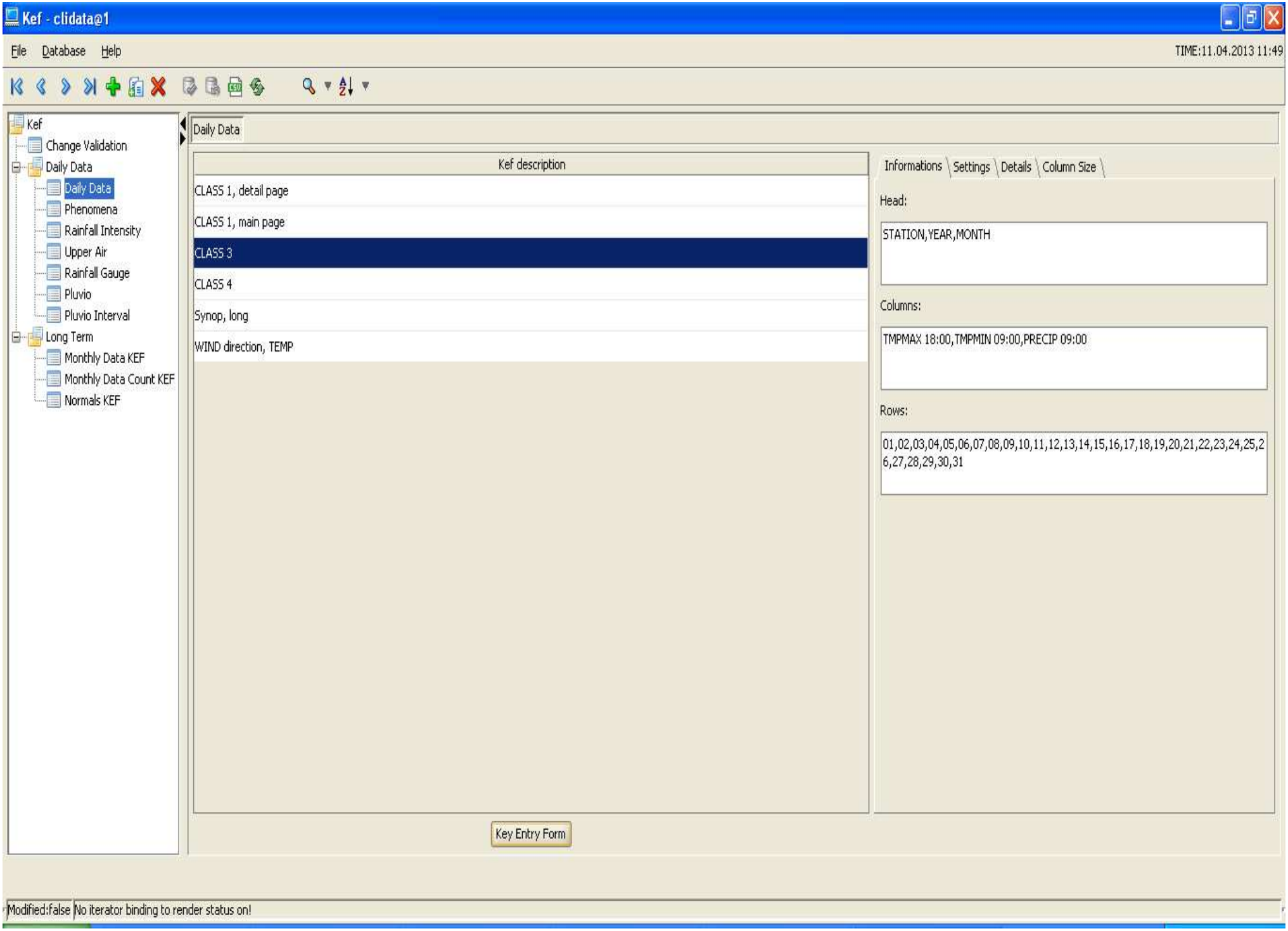
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Daily Data
Daily Data
Phenomena
Rainfall Intensity
Upper Air
Rainfall Gauge
Pluvio
Pluvio Interval
Long Term
Monthly Data KEF
Monthly Data Count KEF
Normals KEF
Daily Data
Kef description
CLASS 1, detail page
CLASS 1, main page
CLASS 3
CLASS 4
Synop, long
WIND direction, TEMP
Informations
Settings
Details
Column Size
Head:
STATION,YEAR,MONTH
Columns:
TMPMAX 18:00,TMPMIN 09:00,PRECIP 09:00
Rows:
01,02,03,04,05,06,07,08,09,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31
Key Entry Form
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No iterator binding to render status on!

KEF

Close

Zeros Y

STATION SHAKAK13 ...

YEAR 2008

MONTH 10

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07	26.5	16.8	0.0
08	27.0	17.2	0.0
09	26.5	15.4	0.0
10	26.0	15.8	0.0
11	25.5	16.6	0.0
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13	26.5	17.0	0.0
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17	27.0	15.6	0.0
18	26.5	16.4	0.0
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20	26.5	14.8	0.0
21	27.0	15.4	0.0
22	26.5	15.6	0.0
23	27.5	16.2	0.0
24	27.5	16.4	0.0
25	28.0	17.4	0.0

Oracle Discoverer - [Workbook1]

File Edit View Sheet Format Tools Graph Window Help

Arial 10

Page Items:

	Eg gh id	Eg el abbreviation	Year	Mdtype	Pktype	Mdfunction	Time	Regular	Valmon01	Valmon02	Valmon03	Valmon04	Valmon05	Valmon06	Valmon07	Valmon08	Valmon09	Valmon10	Valmon11	Valmon12
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4	GOYETN14	PRECIP	1998	0	0	MAX	09:00	N	.00	.00	14.70	4.30	60.70	20.80	40.10	33.60	18.50	30.60		.00
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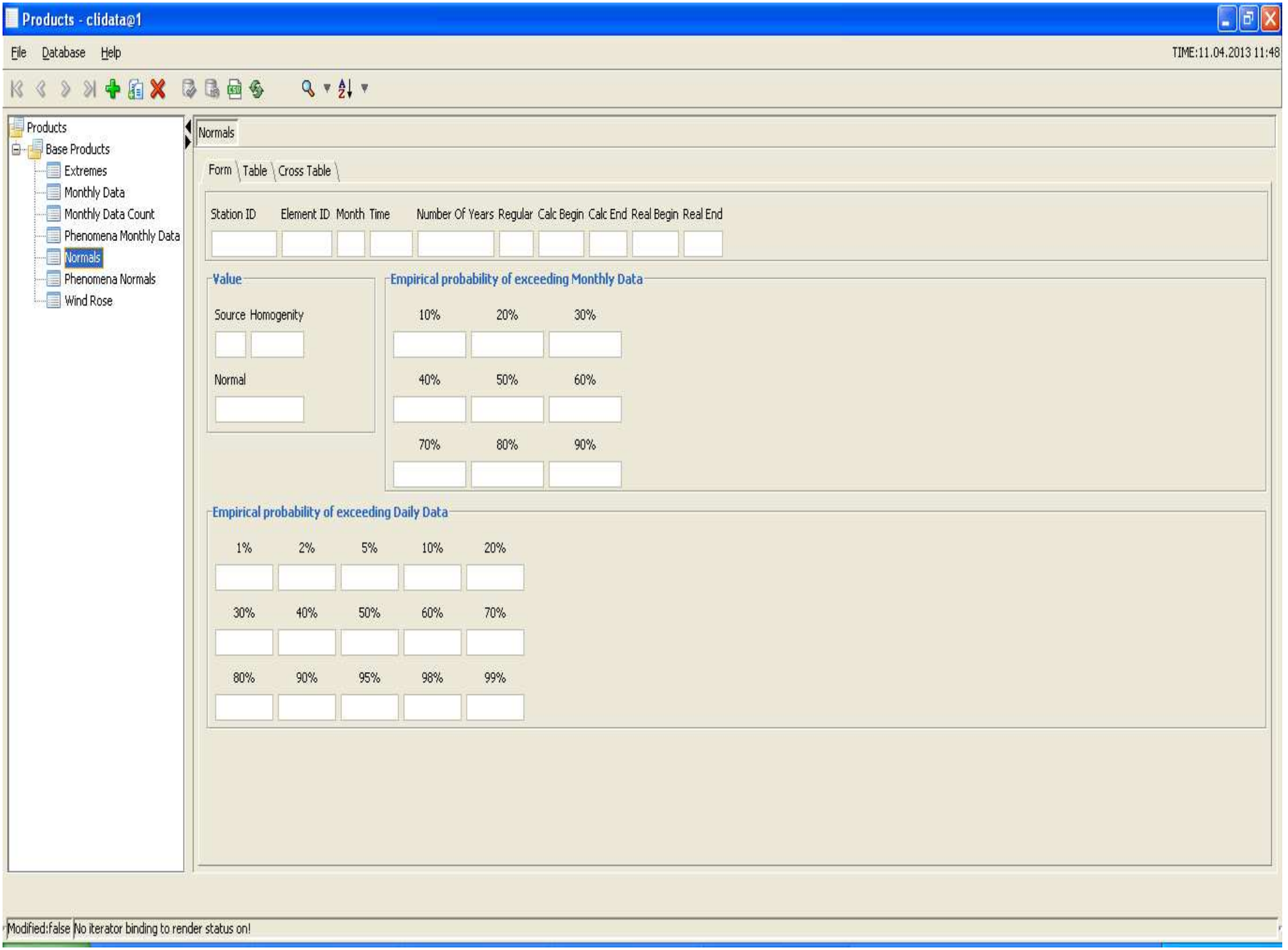
22	GOYETN14	PRECIP	1999	7	0	MAX	09:00	N		.00	.00	.90	.00	7.50	21.10	34.40	.00	26.10	.00	.00
23	GOYETN14	PRECIP	1999	7	0	SUM	09:00	N		.00	.00	.90	.00	14.80	43.40	54.20	.00	40.50	.00	.00
24	GOYETN14	PRECIP	1999	8	0	MIN	09:00	N		.00	.00	.00	.00	.00	.60	.00	.00	.00	.00	.00
25	GOYETN14	PRECIP	1999	8	0	MAX	09:00	N		.00	.00	.00	25.80	15.30	27.40	38.00	4.40	.00	.00	4.20
26	GOYETN14	PRECIP	1999	8	0	SUM	09:00	N		.00	.00	.00	42.80	39.20	52.80	69.50	6.60	.00	.00	6.90

Sheet 1

NUM


Products - clidata@1
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Help
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Products
Base Products
Extremes
Monthly Data
Monthly Data Count
Phenomena Monthly Data
Normals
Phenomena Normals
Wind Rose
Normals
Form
Table
Cross Table
Station ID
Element ID
Month
Time
Number Of Years
Regular
Calc Begin
Calc End
Real Begin
Real End
Value
Source
Homogenity
Normal
Empirical probability of exceeding Monthly Data
10%
20%
30%
40%
50%
60%
70%
80%
90%
Empirical probability of exceeding Daily Data
1%
2%
5%
10%
20%
30%
40%
50%
60%
70%
80%
90%
95%
98%
99%
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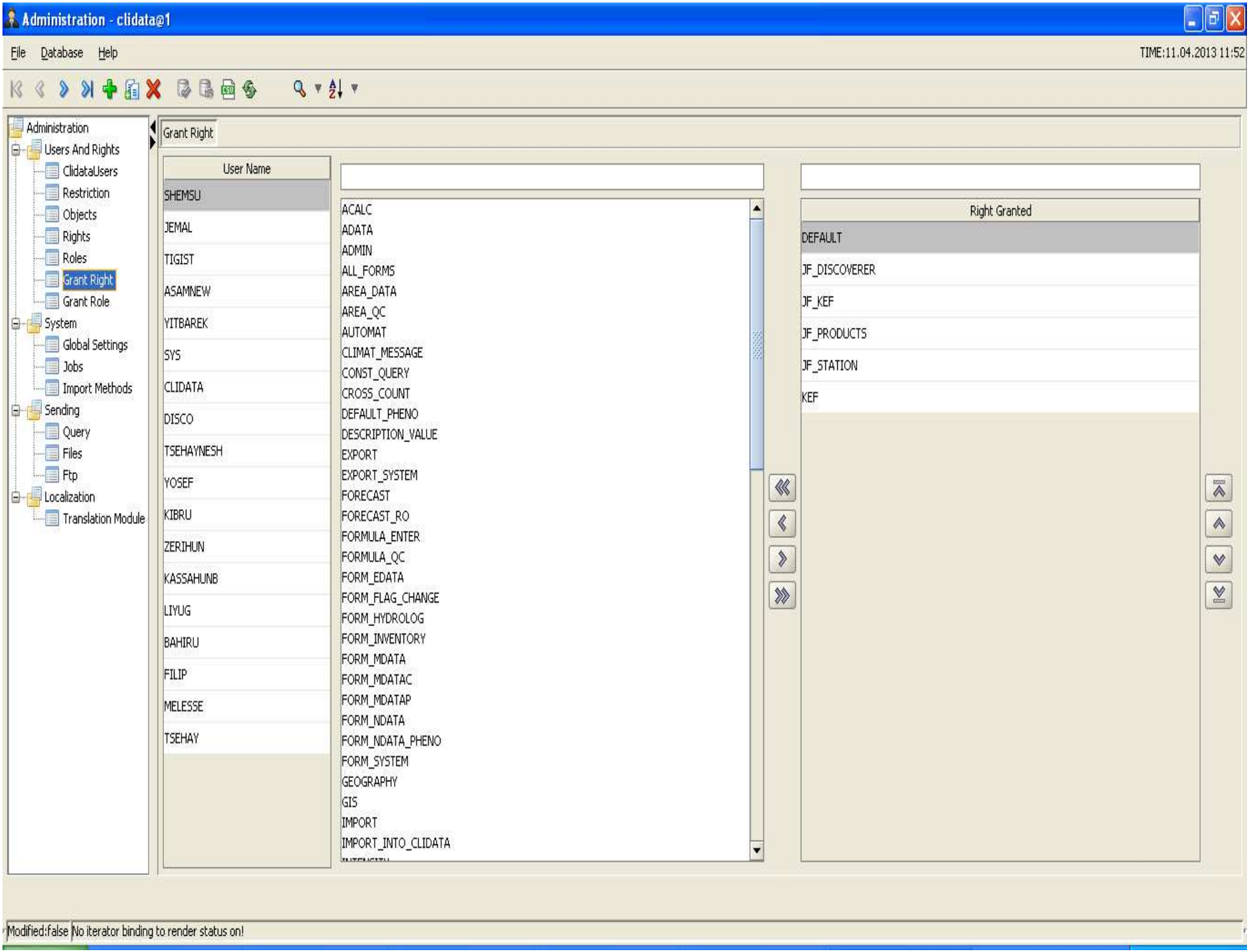
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Restriction
Objects
Rights
Roles
Grant Right
Grant Role
System
Global Settings
Jobs
Import Methods
Sending
Query
Files
Ftp
Localization
Translation Module
Grant Right
User Name
SHEMSU
JEMAL
TIGIST
ASAMNEW
YITBAREK
SYS
CLIDATA
DISCO
TSEHAYNESH
YOSEF
KIBRU
ZERIHUN
KASSAHUNB
LIYUG
BAHIRU
FILIP
MELESSE
TSEHAY
ACALC
ADATA
ADMIN
ALL_FORMS
AREA_DATA
AREA_QC
AUTOMAT
CLIMAT_MESSAGE
CONST_QUERY
CROSS_COUNT
DEFAULT_PHENO
DESCRIPTION_VALUE
EXPORT
EXPORT_SYSTEM
FORECAST
FORECAST_RO
FORMULA_ENTER
FORMULA_QC
FORM_EDATA
FORM_FLAG_CHANGE
FORM_HYDROLOG
FORM_INVENTORY
FORM_MDATA
FORM_MDATAC
FORM_MDATAP
FORM_NDATA
FORM_NDATA_PHENO
FORM_SYSTEM
GEOGRAPHY
GIS
IMPORT
IMPORT_INTO_CLIDATA
Right Granted
DEFAULT
JF_DISCOVERER
JF_KEF
JF_PRODUCTS
JF_STATION
KEF
Modified:false
No iterator binding to render status on!

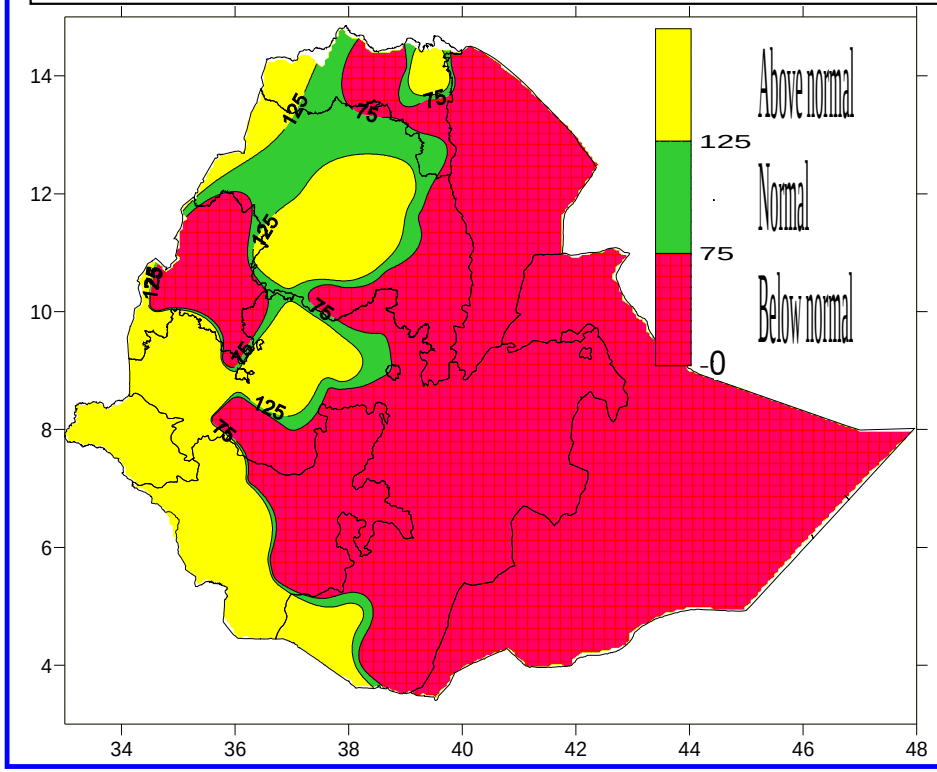
Climate Monitoring

HIGHLIGHTS

During January 2011, days remaind hot over Northeastern, Southeastern, Southern, central part of the country especially Somalia and Gambella region.

Particularly the extreme maximumTemperature values were as high as 37.5,36.5,35.6,37.5,35.2and42.5^{o}C over Gode,Metehara,Miesso,Pawe,Sawla and Gambela respectively. In general the monthly average temperature were above normal overmost part of the country except over border of northwestern,western,southwestern ,southern and some part of central Ethiopia.

On the other hand the monthly rainfall amount of this month less than 25mm except some pockets area of Northern Tigray ,Western, Southwestern and central part of the country. Among the stations which had better rainfall during this month are Adigrat, Ambo, Arjo,Chira, Gambella, Kachise,Nekemte and yabelo with a monthly total rainfall amount of 43.1,44.8,82.6,55.4,197.7,43.4,42.0 and 45.0mm respectively.

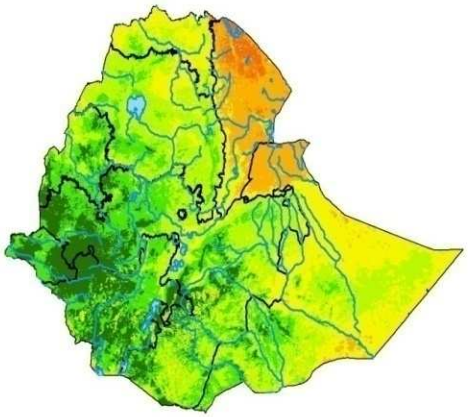


Percent of Normal Rainfall of January 2011

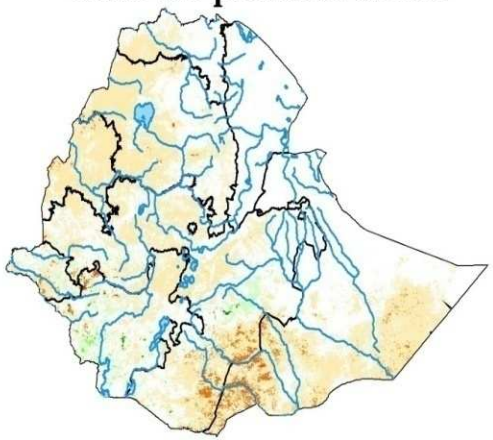
Contents of the climate bulletin

- It is issued at monthly, seasonal and annual time scales
- Monthly climate bulletins contains
  - Synoptic situations of the moth (e.g. Monthly climate bulletin of December 2001contains Synoptic situation of December 2001)
  - Tropical Oceanic and Atmospheric highlights
  - Weather (Extreme Temperature along with the date, record extreme temperature along with the date)
  - Rainfall – comparison b/n this month and last year same month rainfall record
  - Reports of heavy falls along with the date
  - Stations with more than or equal to 100 mm of rainfall during the month
  - New heaviest monthly rainfall recorded during the month
  - Rainfall maps
- Seasonal Climatology Bulletin
    - Same as monthly bulletin but referring to specific season (Belg, Bega or Kiremt)
- Annual Climatology Bulletin
    - Referring to specific year

10-Daily Synthesis NDVI for the 3rd Dekad of Nov. 2011



Difference from the previous dekad



Legend:

- High
- Moderate to High
- Moderate
- Low to Moderate
- Low
- Bare
- No Data

0 280 560 1,120 Kms.

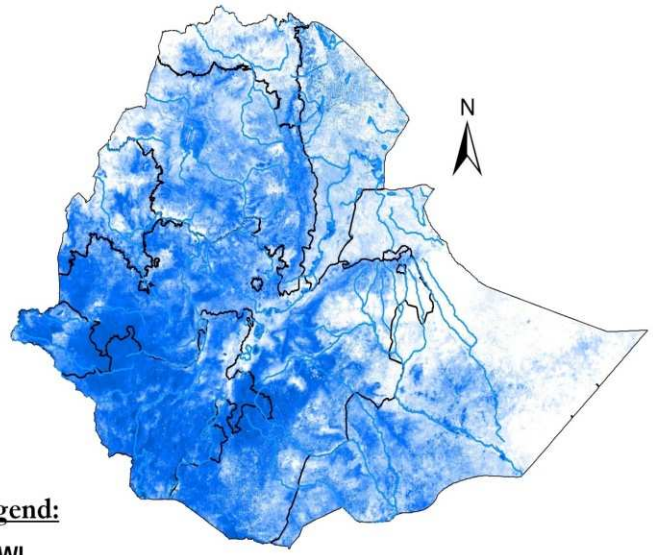
- Rivers
- Lakes
- Administrative Regions

SDRPU-DMDD

Legend:

- Large increase
- Moderate increase
- Slight increase
- No Change
- Slight decrease
- Moderate decrease
- Large decrease

Normalized Difference Water Index for the 3rd Dekad of Nov. 2011



Legend:

NDWI

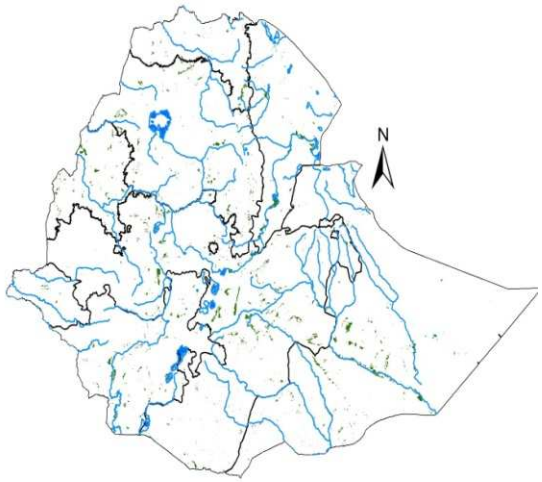
High

Low

0 185 370 740 Kms.

SDRPU-DMDD

Small Water Bodies for the 3rd Dekad of Nov. 2011



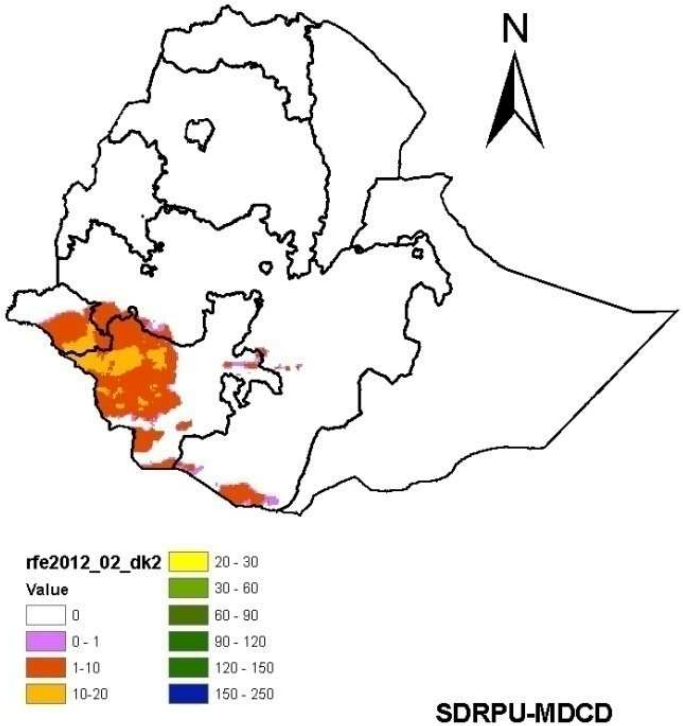
Legend:

0 170 340 680 Kms.

- SWB/Free Water
- (Humid) Vegetation
- SWB/Free Water with (Humid) Vegetation
- Rivers
- Adminisrative Regions

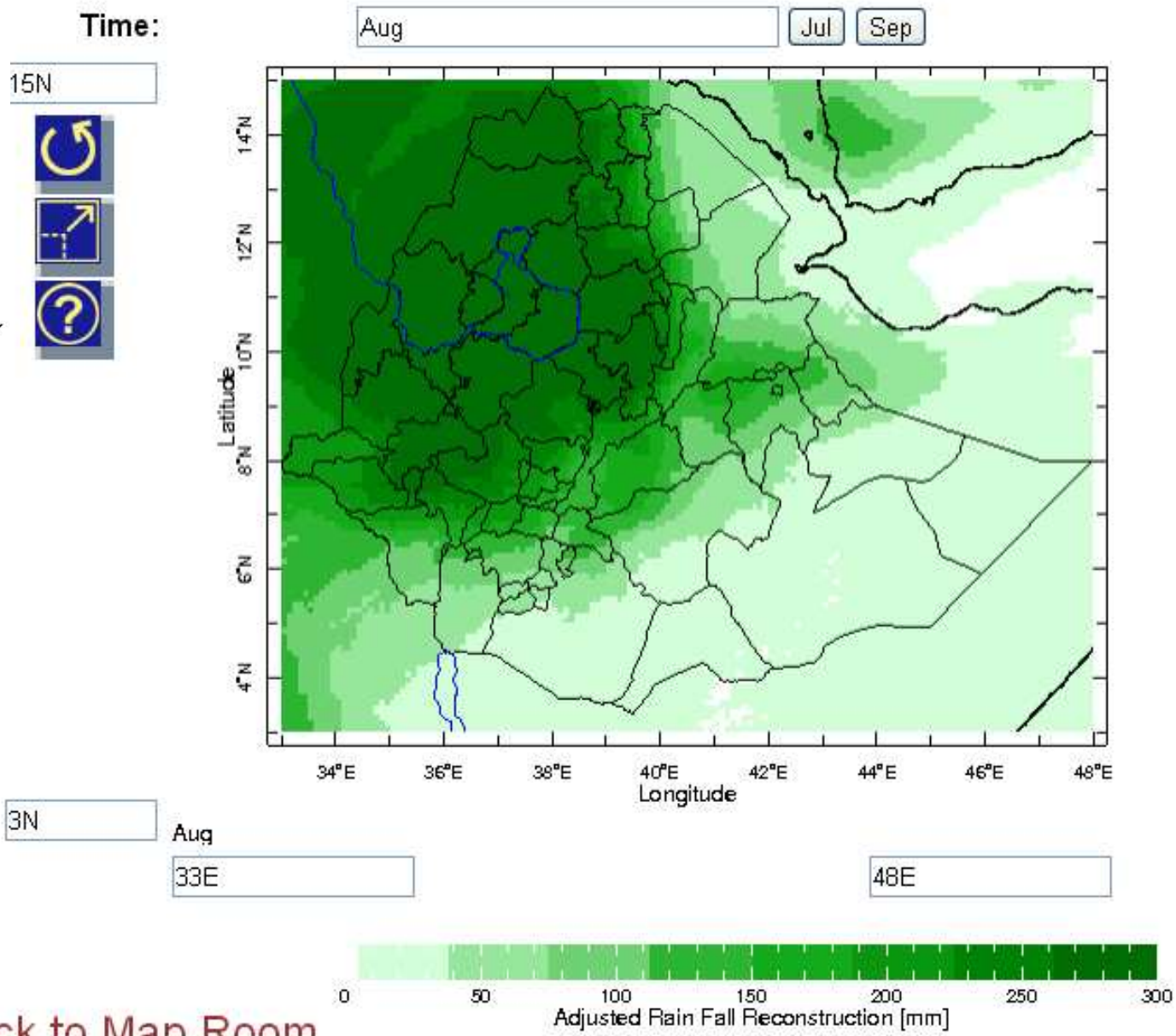
SDRPU-DMDD

Rainfall estimation from satellite data 2nd dekad of January 2012



SDRPU-MDCD

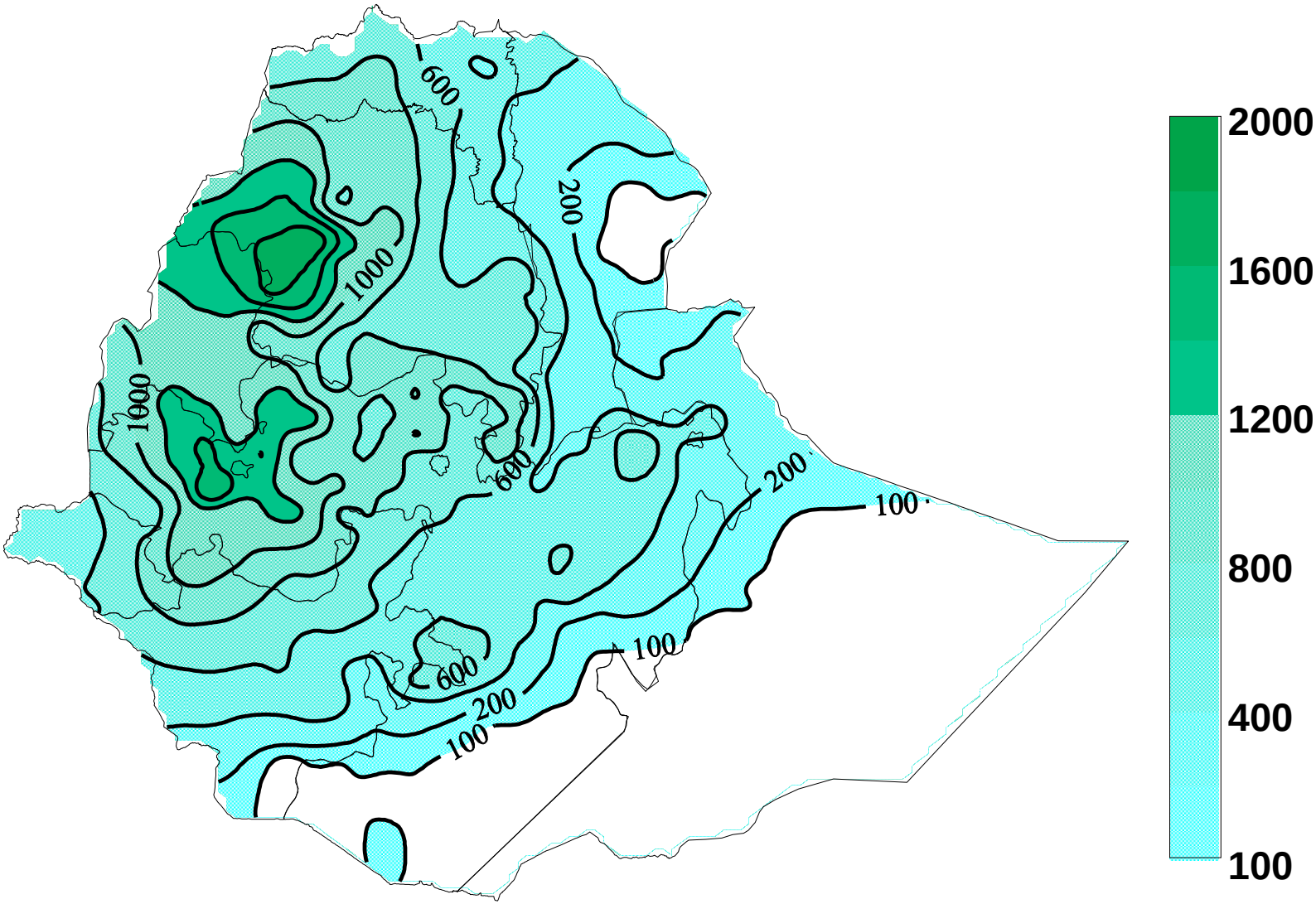
August mean rainfall (1983-2010) reconstructed from station observations and remote sensing proxies



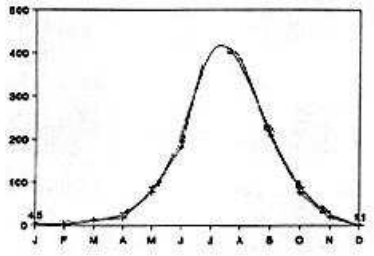
ıck to Map Room

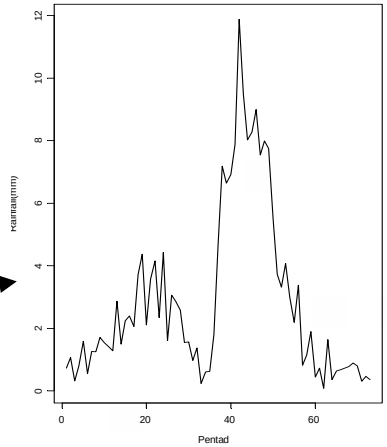
Click on map to get local information

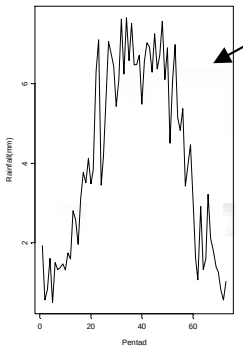
Spatial Distribution of Long-term Kiremt (June to Sep) rainfall (mm) constructed from stations observation data

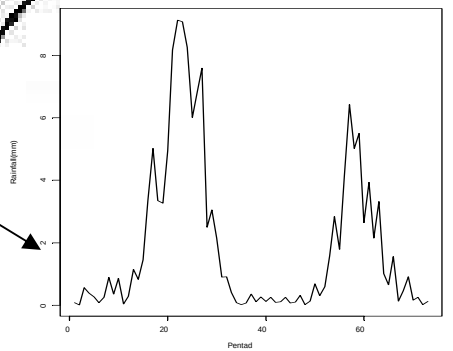


Map showing rainfall regimes in Ethiopia









Bahir Dar

Kombolcha

Jimma

Gode

b_3

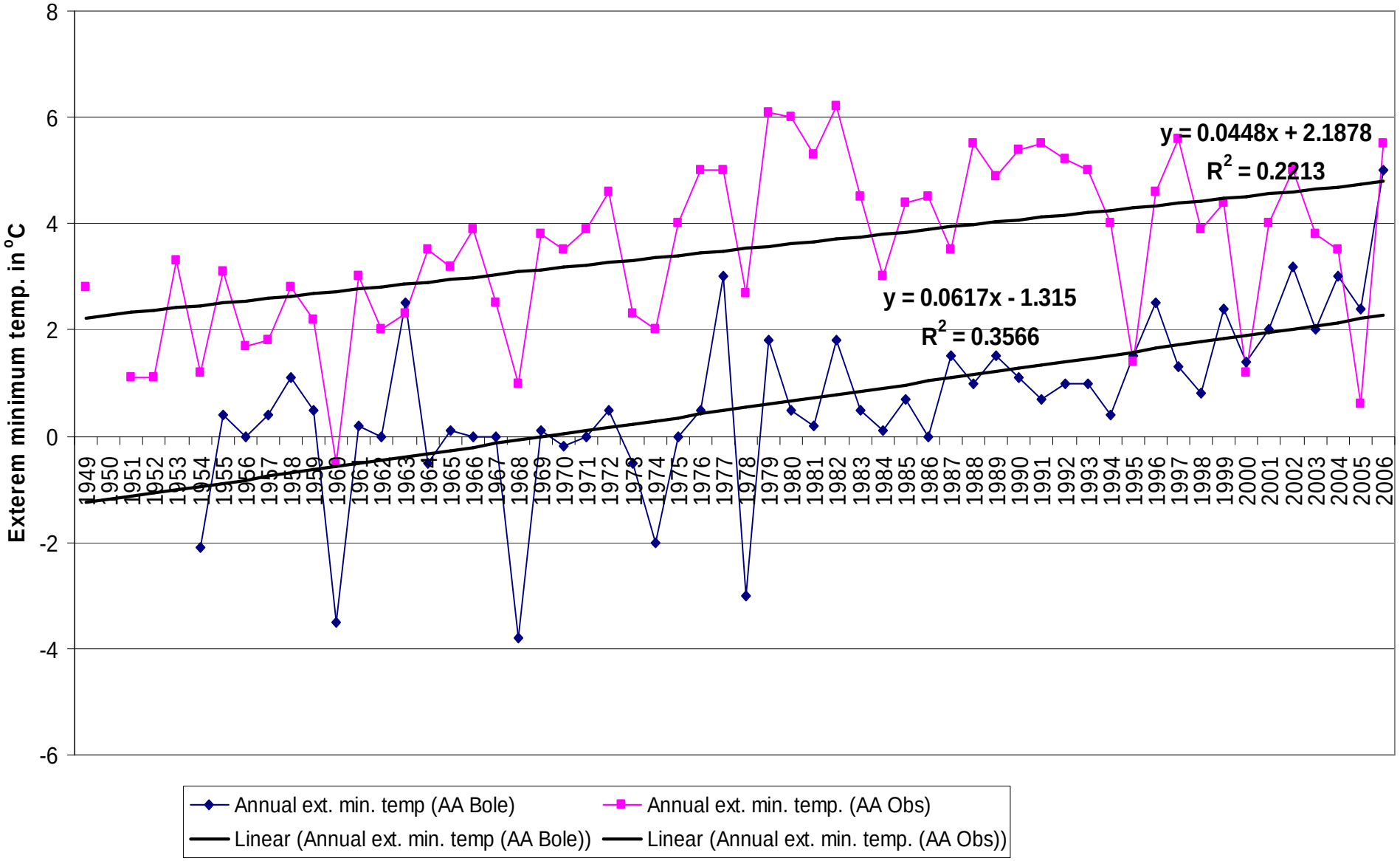
b_2

b_1

B

A

C


1949-2006 annual extreme minimum temperature over Addis Ababa Bole and Addis Ababa Observatory stations
Exterem minimum temp. in °C
8
6
4
2
0
-2
-4
-6
y = 0.0448x + 2.1878
R2 = 0.2213
y = 0.0617x - 1.315
R2 = 0.3566
1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Annual ext. min. temp (AA Bole)
Annual ext. min. temp. (AA Obs)
Linear (Annual ext. min. temp (AA Bole))
Linear (Annual ext. min. temp. (AA Obs))

THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF WATER RESOURCES
NATIONAL METEOROLOGICAL AGENCY

CLIMATE CHANGE TECHNOLOGY NEEDS ASSESSMENT REPORT OF ETHIOPIA

JUNE 2007
ADDIS ABABA
ETHIOPIA

Federal Democratic Republic of Ethiopia

Ministry of Water Resources

National Meteorological Services Agency

ጢስ አባይ (ጢስ ዒሳት) ፏፏቴ Tis Abay (Tis Issat) or Blue Nile Falls

Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC)

June 2001

Addis Ababa, Ethiopia

THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF WATER RESOURCES
NATIONAL METEOROLOGICAL AGENCY

CLIMATE CHANGE NATIONAL ADAPTATION PROGRAMME OF ACTION (NAPA) OF ETHIOPIA

JUNE 2007
ADDIS ABABA
ETHIOPIA

Long range forecasting systems and methods

Steps of seasonal prediction in Ethiopia

The National Meteorological Services Agency of Ethiopia issues seasonal climate outlook three times a year. The forecast is given at the beginning of *Kirmet*, *Bega* and *Belg* seasons. As you know *Kirmet* spans June to September, *Bega* spans October to January and *Belg* spans February to May.

Ways of selecting analogue years

•Plot Sea surface temperature anomalies (SSTA's) and Multivariate ENSO Index (MEI) of the 4 Niño regions (NIÑO1+2, NIÑO3, NIÑO3.4 and NIÑO4) from 1971 to current and observe the graphical trend.

•Perform partial correlation between the current year and all other years to get 20 similar years.

•Examine the SST forecast for the upcoming season. It could be El-Niño, La Niña or Neutral.

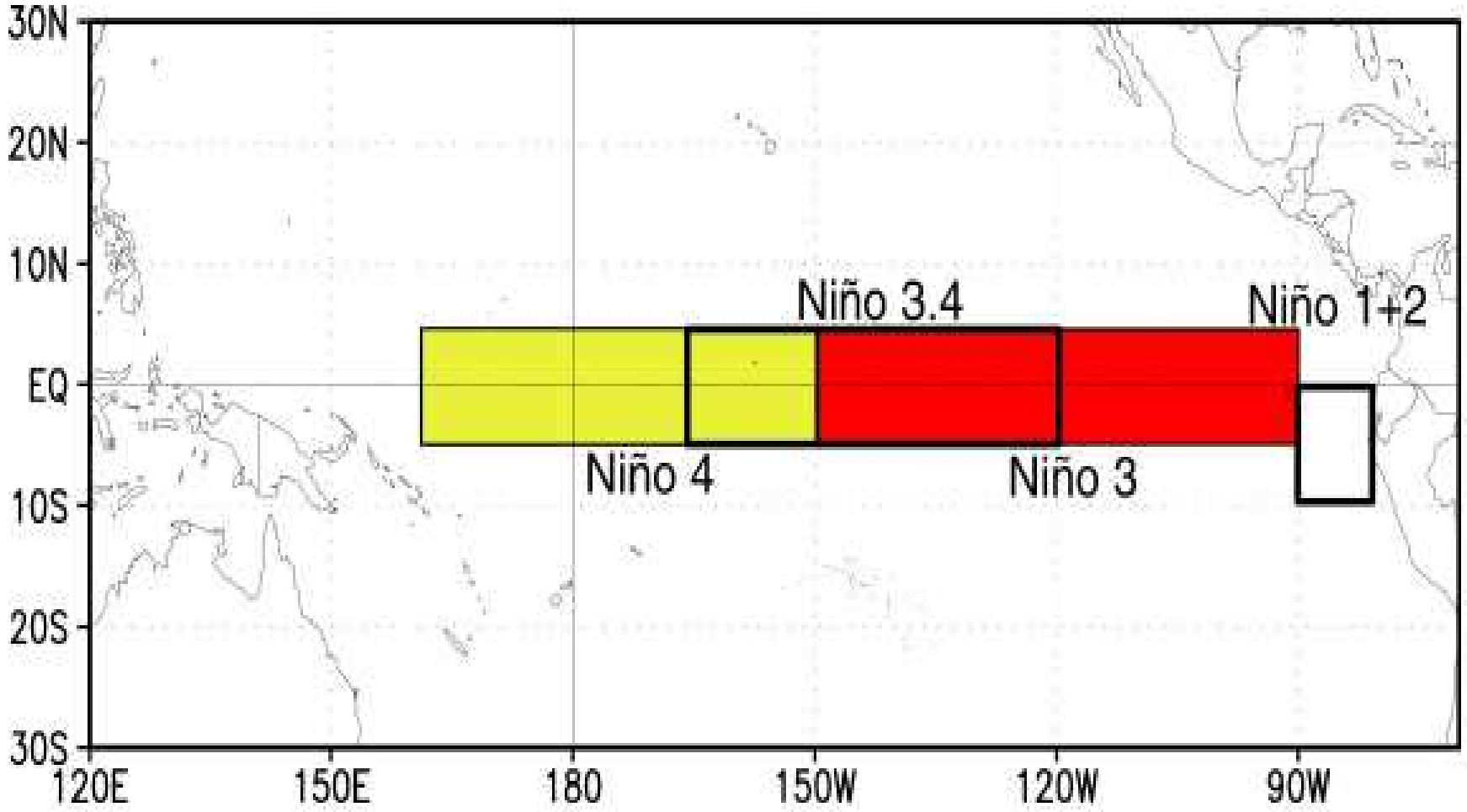
•Use this information to disregard years, which have got dissimilar SSTA pattern with the forecast given for the current year.

•Do correlation and look at the trend thoroughly and get 10 best similar years with the current year.

•Compare pre-seasonal months rainfall and temperature distribution of the selected years with current year. Also consider extreme cases (dry spells and heavy rain and etc) of pre-seasonal months, SST of India and Atlantic Oceans and weather system. Using these information one can select 5 or 3 analogue years.

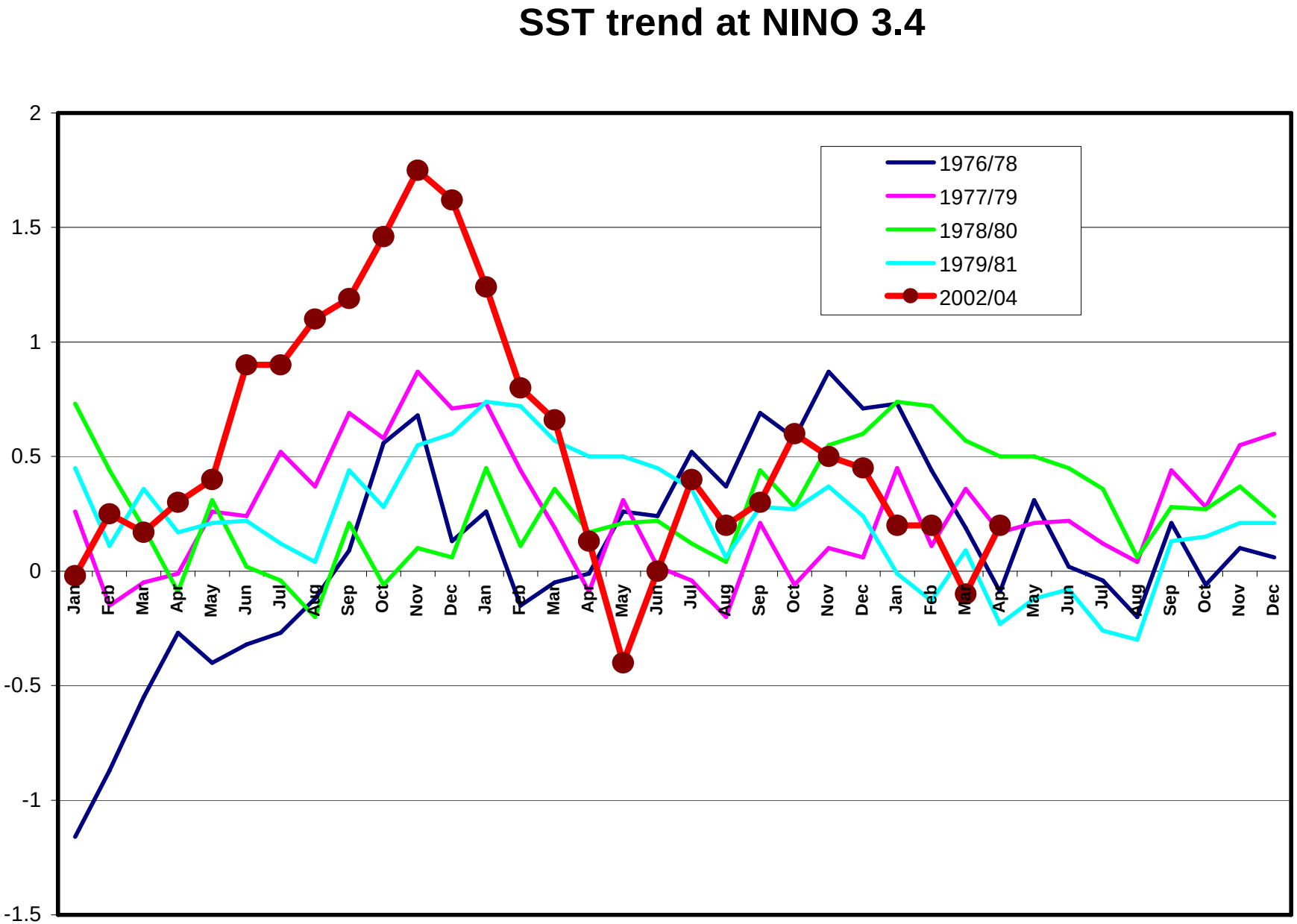
•In short, NMSA compares SSTA's and MEI between current year and previous years (starting from 1971) to find out first series of analogue years. And then use the regional situations such as sea surface temperature of neighboring oceans, pre-seasonal months rainfall patterns, weather systems and the like to refine the first selection.

Nino regions



Climate outlook for Kiremt 2004

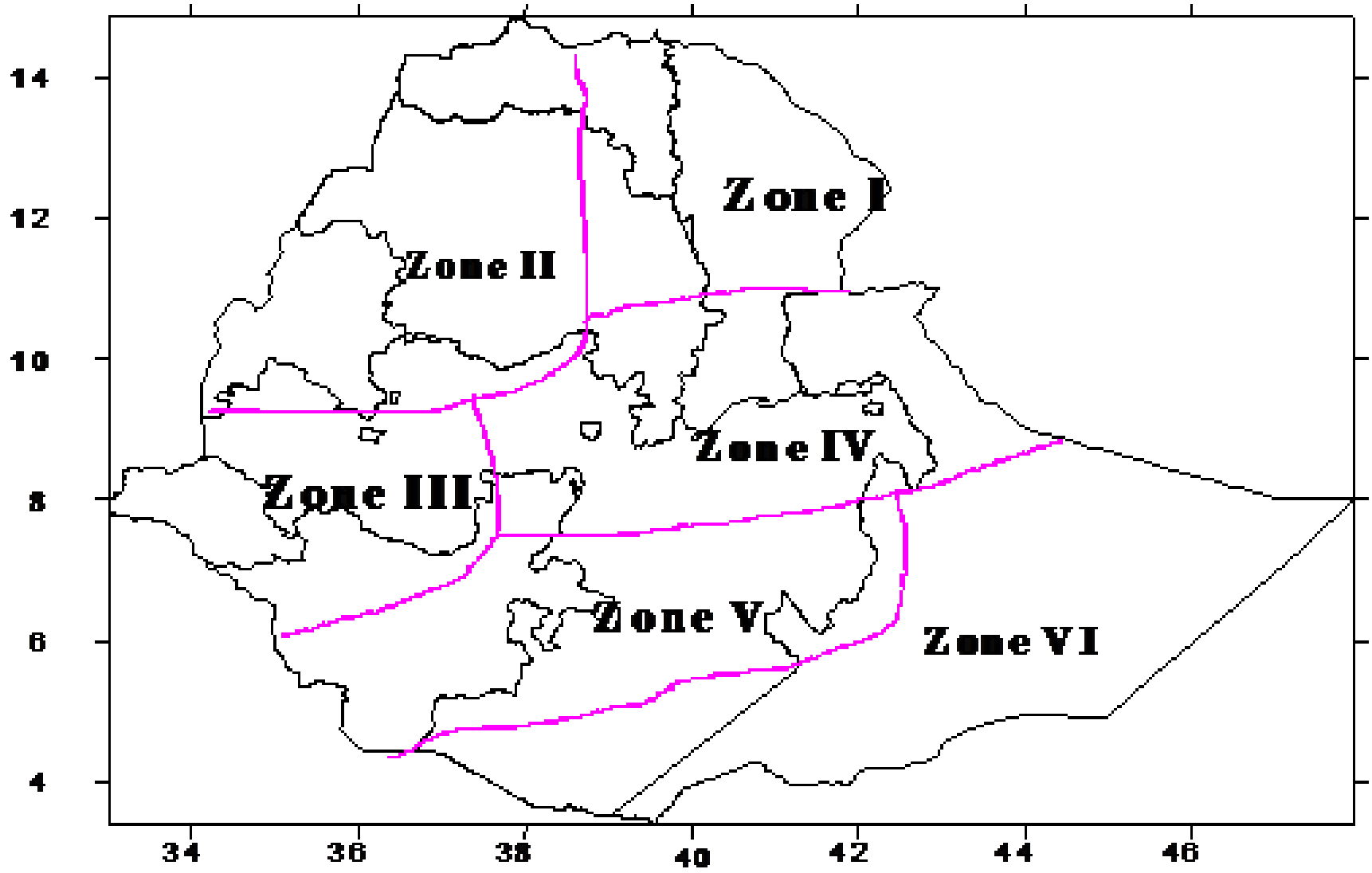
Selection of Analogue years



Ways of prediction

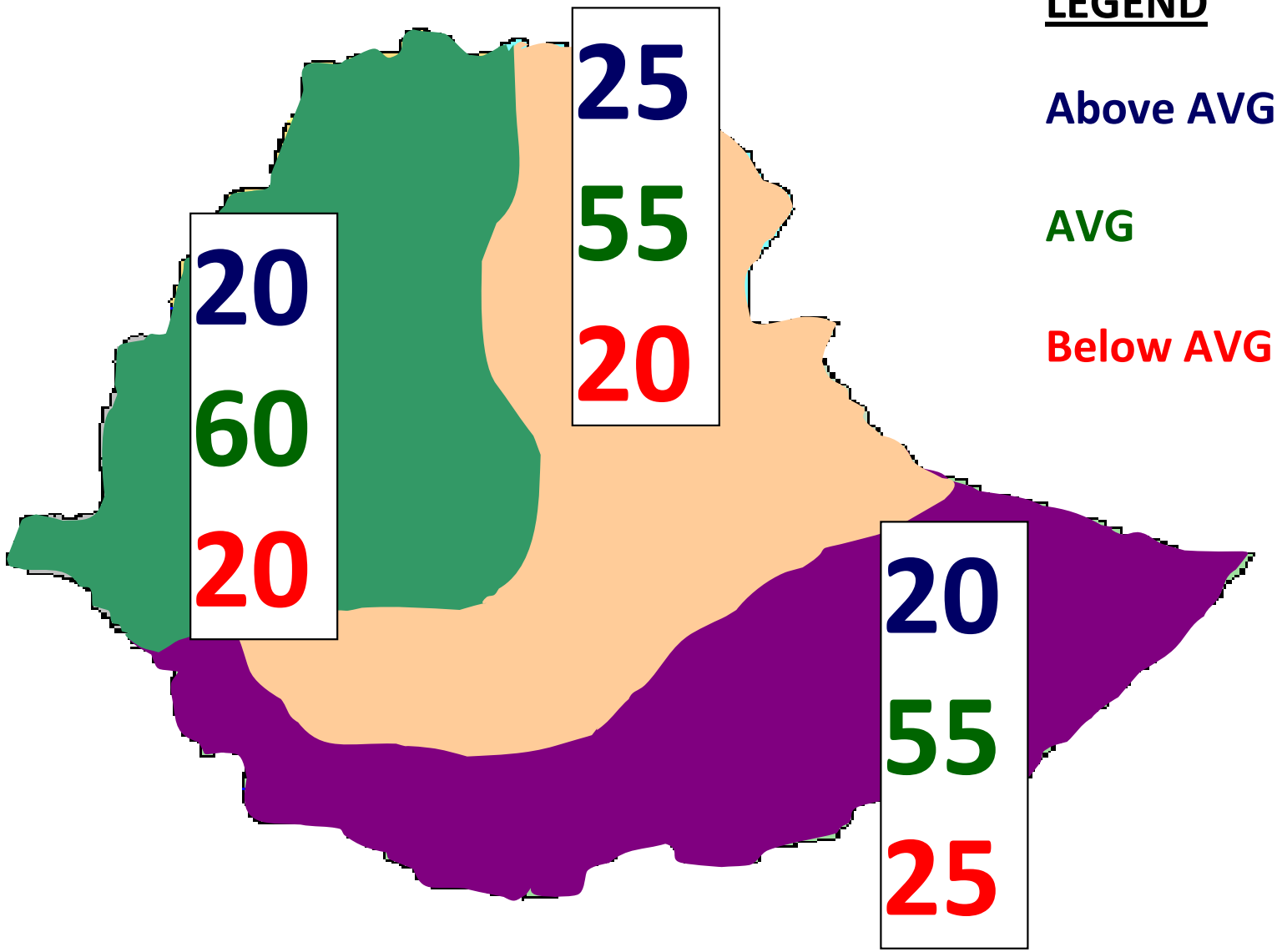
- After getting the analogue years, we classify the stations into homogenous rainfall zones. NMSA has adopted the method of principal component analysis to regionalize the country into homogenous rainfall zones. For your information this was done in Kenya, Nairobi. An example is depicted in Figure 2.
- Get the seasonal rainfall amount for each station.
- Get the deciles (<33% correspond to below normal, 33%-66%-normal and >66% -above normal).
- Count the number of stations with Above Normal (AN), Normal (N) and Below Normal (BN). And calculate the percentage of stations with AN, BN and N out of the total for each homogenous rainfall zone separately.
- Do step four for all analogue years, in particular for the best three analogue years.
- Calculate the average for the three selected analogue years. That will be the forecast.

Homogenous rainfall zones of Ethiopia during September to December



Typical Forecast

Climate outlook for Kiremt 2005



Specific issues related to climate monitoring and prediction in the region

- The rainfall in the region is highly variable specially during the short rainy season in Ethiopia. That means predicting it difficult compared to long rainy season.
- Not all data are computerized
- Failure of Data Base Systems at times
- Lack of trained manpower, fast Advancement of technology
- Network lines between head and branch offices not yet completed
- No well organized and documented metadata of stations and instruments
- Data Gaps and length
  - Most of the stations start recording in the 1970's and have lot's of gaps
  - Data gaps created due to many reasons
    - War outbreak, Absence of observers and leaving the organization with our prior notice Instruments breakdown and slow maintenance services
  - Acquiring modern instruments needs high budget and using them requires trained manpower.
  - Data demand and supply do not agree

User activities in support of Climate Risk management and early warning systems including Data bases and, preparedness and mitigation procedures

- Some users have installed AWS (E.g. WFP)
  - They get in return the AWS data and daily data on six parameters from 40 stations equiped with raidio.
  - They use the data for running Livelihood, Early Assessment and Protection (LEAP) software
- We are working with the Ethiopian Environmental Protection Agency in the areas of climate adaptation and mitigation
- We are also collaborating with the Disaster Risk Management and Food Security Sector (DRMFSS)

What is LEAP?

- **What is LEAP?** LEAP (Livelihood, Early Assessment and Protection) is the Government of Ethiopia (GOE) owned food security early warning tool embedded in the national risk management framework and linked to the US$ 160 million contingent fund. LEAP converts satellite and ground based agro-meteorological data into crop or rangeland production estimates and ultimately into livelihood protection requirements. It also quantifies the financial resources needed to scale up PSNP in case of a major drought.


Thank you for
Listening