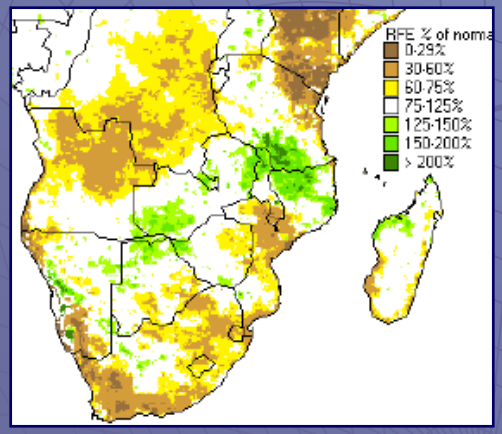
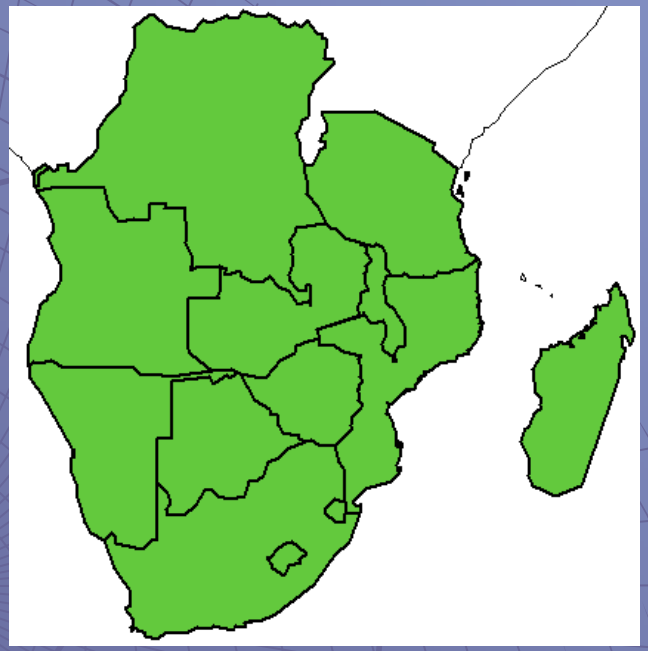
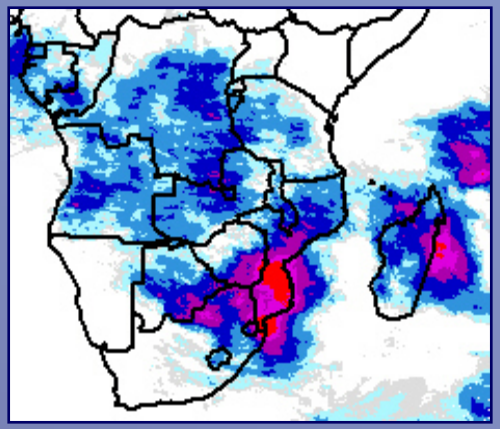
Operational Monitoring Using Remote Sensing in the SADC Region







Training Center

Southern African Development Community (SADC)
Regional Remote Sensing Unit (RRSU)
Gaborone, Botswana

U.S. Geological Survey
Center for Earth Resources Observation and Science (EROS)
Sioux Falls, South Dakota, USA

Applications of Coarse to High Resolution Satellite Imagery for Land Productivity Assessment & Management

Operational Monitoring using Remote Sensing in the SADC region

[B. Siwela, SADC RRSU]

Bamako , Mali

6 - 17 February, 2006

SADC Region - Background

Southern **A**frican **D**evelopment **C**ommunity

Prone to floods and droughts.

- 14 Member States.
- 200+ million people.
- Varied climate regions.
- Mostly uni-modal rainfall systems (bi-modal in the north).
- Varied cropping systems.
- Maize (corn) dominant crop
- Cassava and tubers important in the north.
- Rain fed agriculture – irrigation only significant in South Africa and Zimbabwe.

Main Objective of RRSU

- Strengthen national and regional capabilities in the area of Remote Sensing, Agrometeorology and GIS.
- Support early warning for food security and natural resources and disaster management.
- Principal contact institutions:
  - National Meteorological Services (NMSs).
  - National Early Warning Units (NEWUs).
  - National Disaster Management Units.

SADC RRSU and Cooperating Partners:

- The SADC Regional Remote Sensing Unit (RRSU) is situated within the Food, Agriculture and Natural Resources (FANR) Directorate at the SADC Secretariat, Gaborone, Botswana

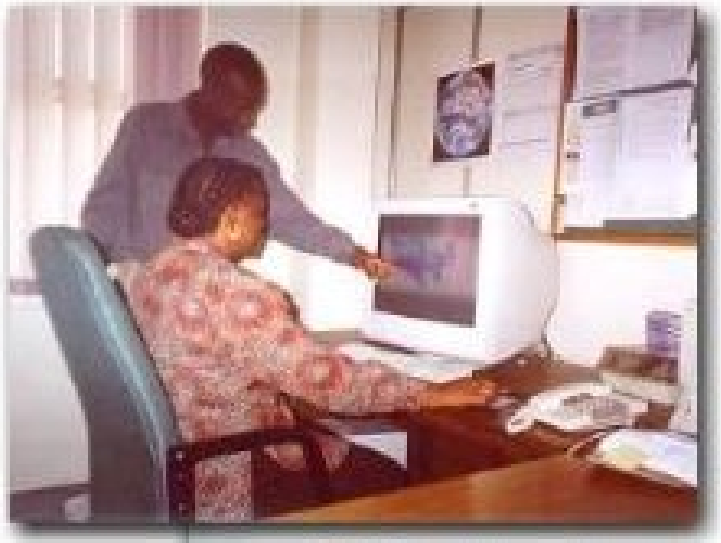
	• Technical support and training. • Emergency food assessments. • Supply of satellite data.
	• Technical support and training. • Vulnerability assessment activities. • Support to the Regional Disaster Management Strategy. • Supply of satellite data.

SADC RRSU: Operational Activities

- Training of agro-meteorologists in the use of satellite imagery products and GIS for early warning for food security.
- Monitoring crops, vegetation and weather developments during the crop growing period using satellite images and GIS techniques.
- Developing and maintaining database of satellite images, maps and associated data.

RRSU: Agromet & GIS Training

- Creating trained experts in RS and GIS applications.



- National staff seconded to RRSU
- Backstopping missions organized for on-the-job training in Member States.

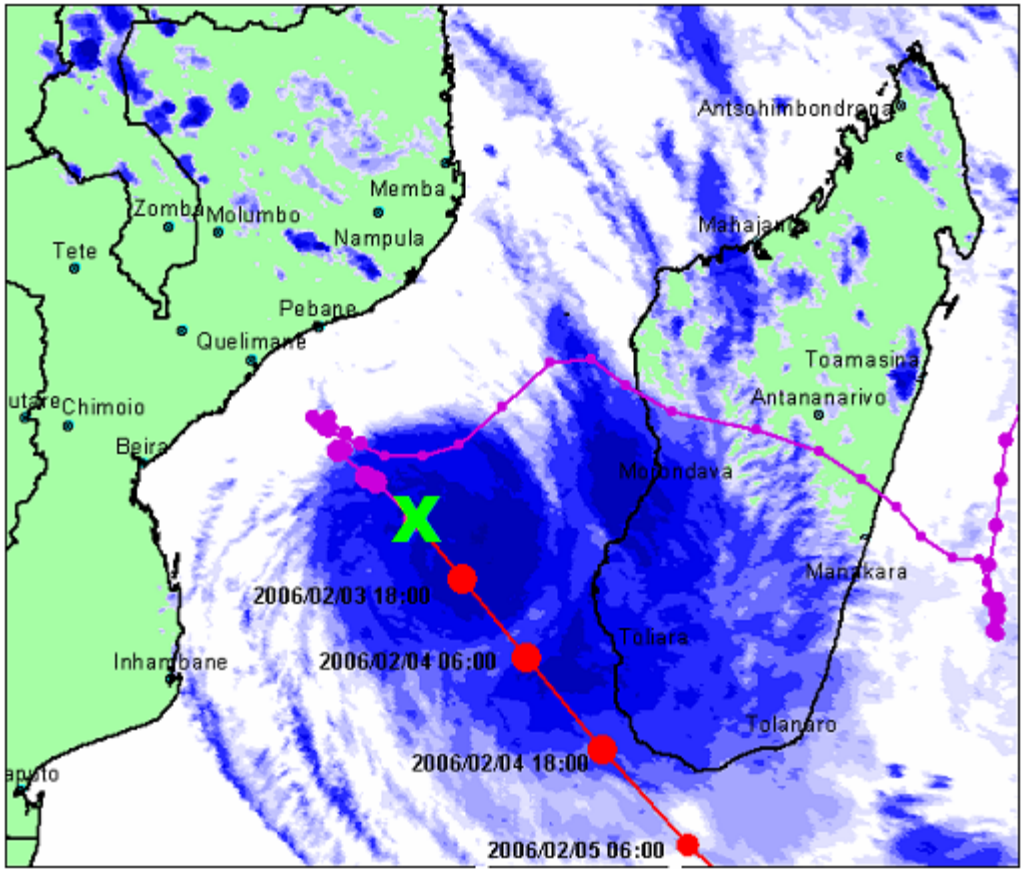
- Subject- or application-specific workshops conducted at national and regional levels.

Monitoring Rainfall Activity

- Cold Cloud Analysis using METEOSAT thermal infra-red images
- monitoring of major weather systems

Tropical Cyclone Boeletsi,
2 February 2006;

possible torrential rains for
southern Madagascar

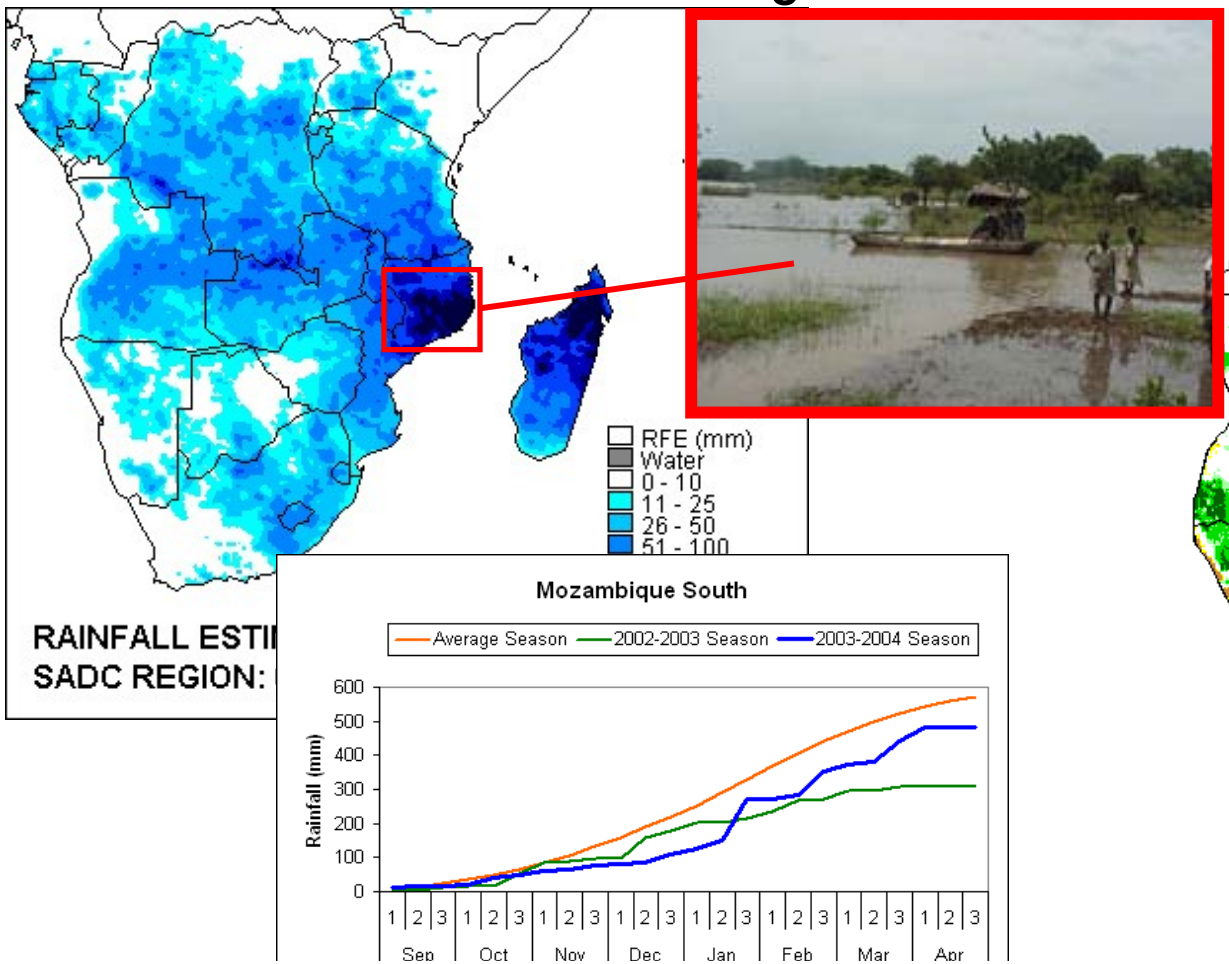


Monitoring Rainfall Activity

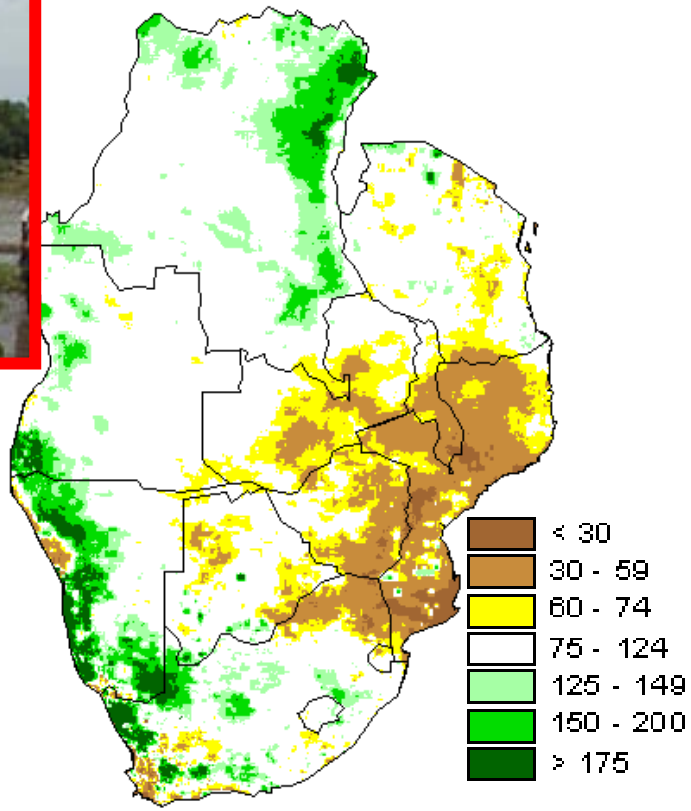
- Rainfall Estimates (RFE) are produced by NOAA Climate Prediction Center; disseminated by FEWSNET
- Based on combination of the following:
  - METEOSAT data used to composite a Cold Cloud Duration (CCD) layer for -38°C, a rainfall estimate is generated from the CCD using the GOES Precipitation Index (GPI). GPI = CCD x 3
  - WMO GTS rainfall data from approx. 1000 stations (not all stations used at any given time), and are taken as the true rainfall within 15-km radius of each station
  - Two satellite microwave instruments, SSM/I (Special Sensor Microwave/Imager) and the AMSU (Advanced Microwave Sounding Unit), which acquire data every 6 hours and every 12 hours respectively.

Monitoring Rainfall Activity

- Rainfall Estimate (RFE) images.
- Combine satellite images with rain gauge observations.
- RRSU receives RFE images from USGS – EROS Data Center.



Time series rainfall analysis



Percentage cumulative rainfall received

Rainfall Estimates (RFE) - Applications

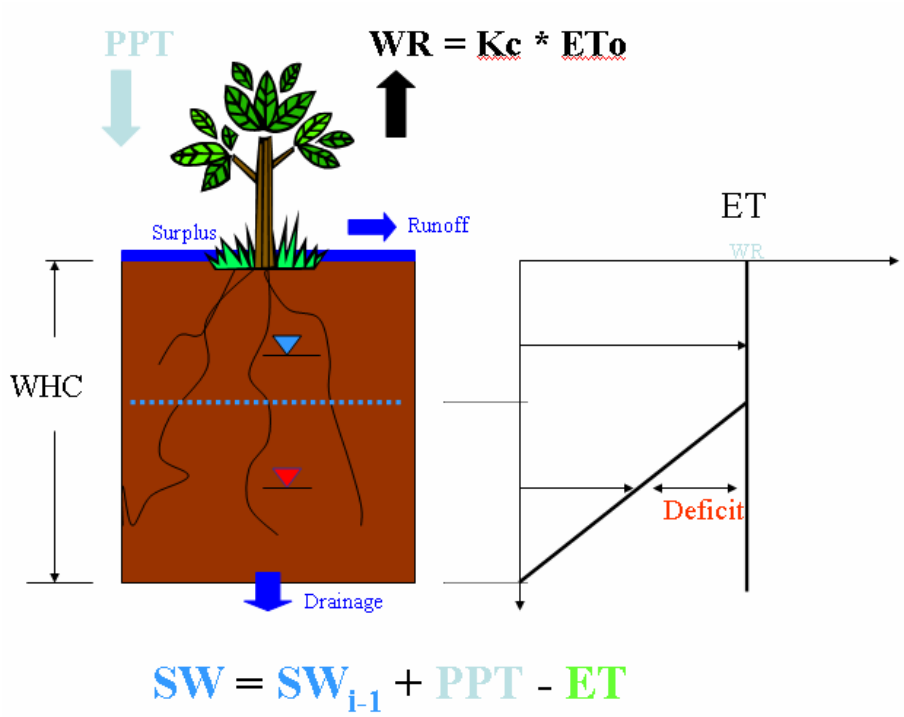
- RFE is used to drive a number of applications for season monitoring
- These include
  - Crop Water Requirements Satisfaction Index (WRSI)
  - Onset of Rains
  - Standardized Precipitation Index (SPI)
  - Quelea Bird breeding forecasts
  - Basin Excess Rainfall Maps
  - FEWS Stream Flow Model (SFM)

Water Requirements Satisfaction Index

- The Water Requirements Satisfaction Index (WRSI) is a crop specific water balance approach that models the effect of seasonal rainfall availability on potential crop yields.
- Two approaches are used in the SADC region – using satellite-based, distributed approach, and a ground-based point-specific approach
- The model is being used in several SADC countries to monitor crop water use with a view to yield forecasting and estimation. SADC RRSU is providing training
- Operational model run at USGS but modern modelling software now publicly available from FAO (AgrometShell) and USGS (GeoSpatial WRSI).

Water Requirements Satisfaction Index

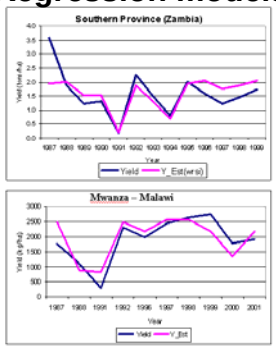
Crop Water Balance Modeling



Water Requirements Satisfaction Index (WRSI)

WRSI=100*AET/WR

Regression models

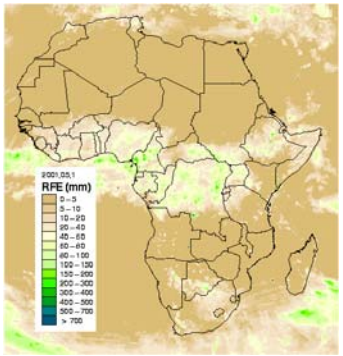


Yield Estimation

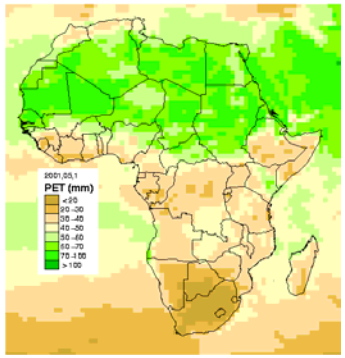
Water Requirements Satisfaction Index

WRSI = f (<u>ppt</u>, <u>pet</u>, <u>WHC</u>, <u>Crop Type</u>, SOS, EOS, LGP)

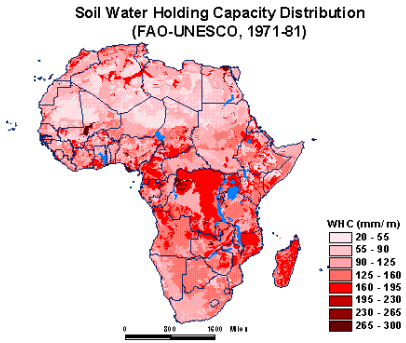
RFE (NOAA)



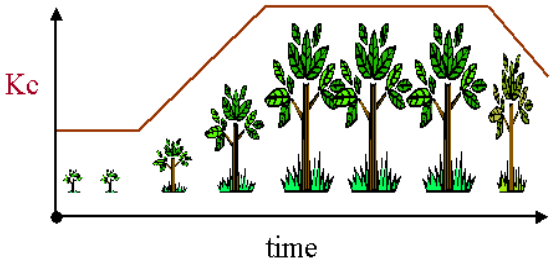
data from NOAA, generated at EDC



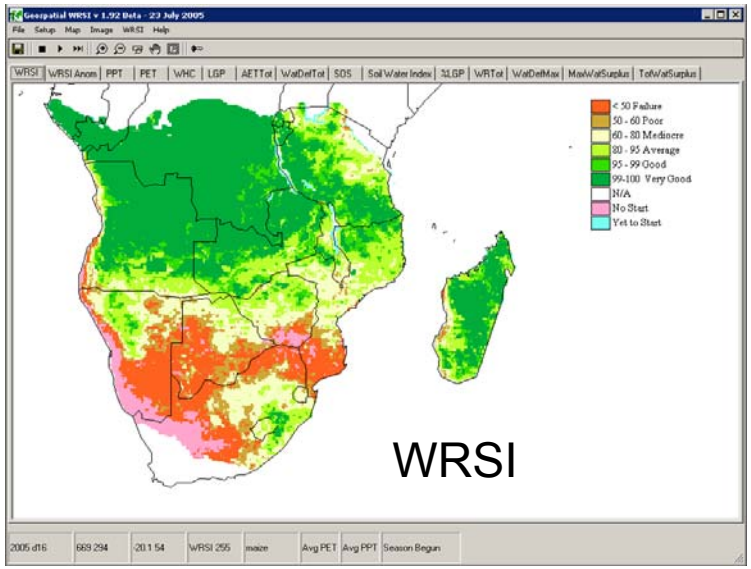
FAO soils map of the world

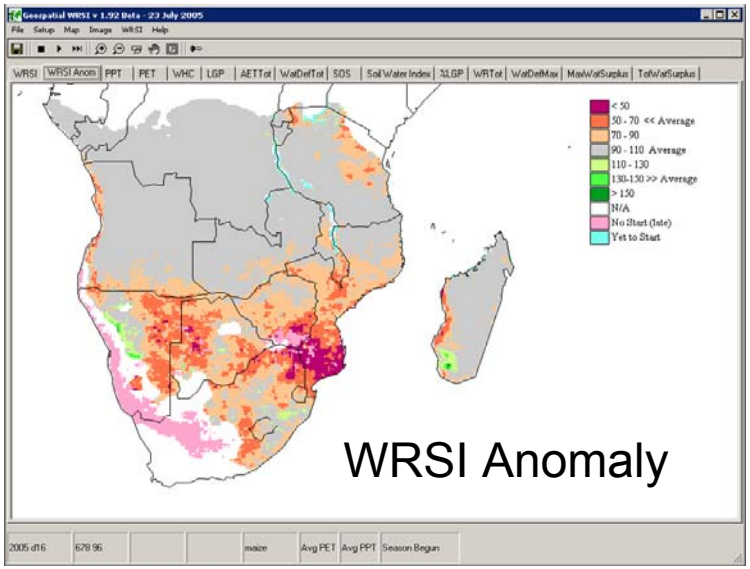


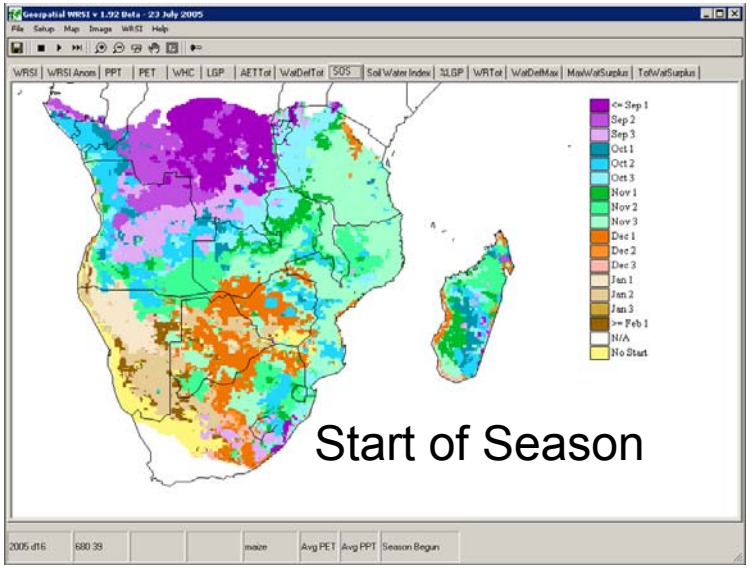
Kc (FAO)

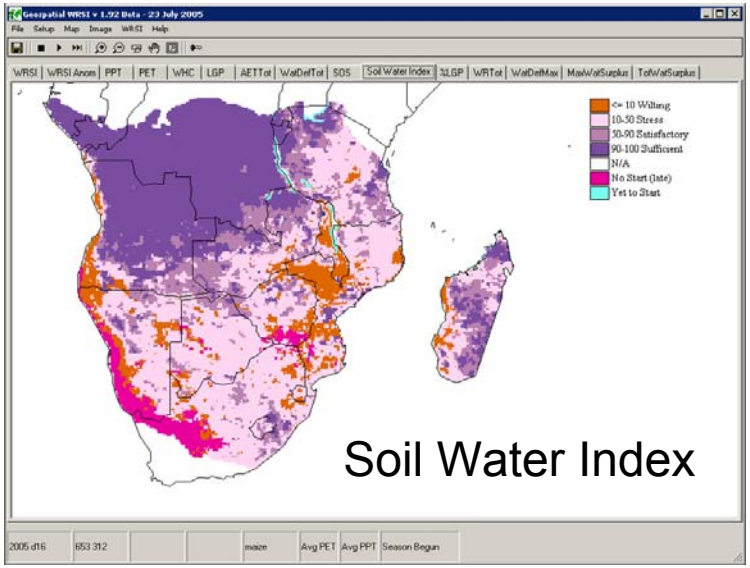


WRSI Water Balance - Products







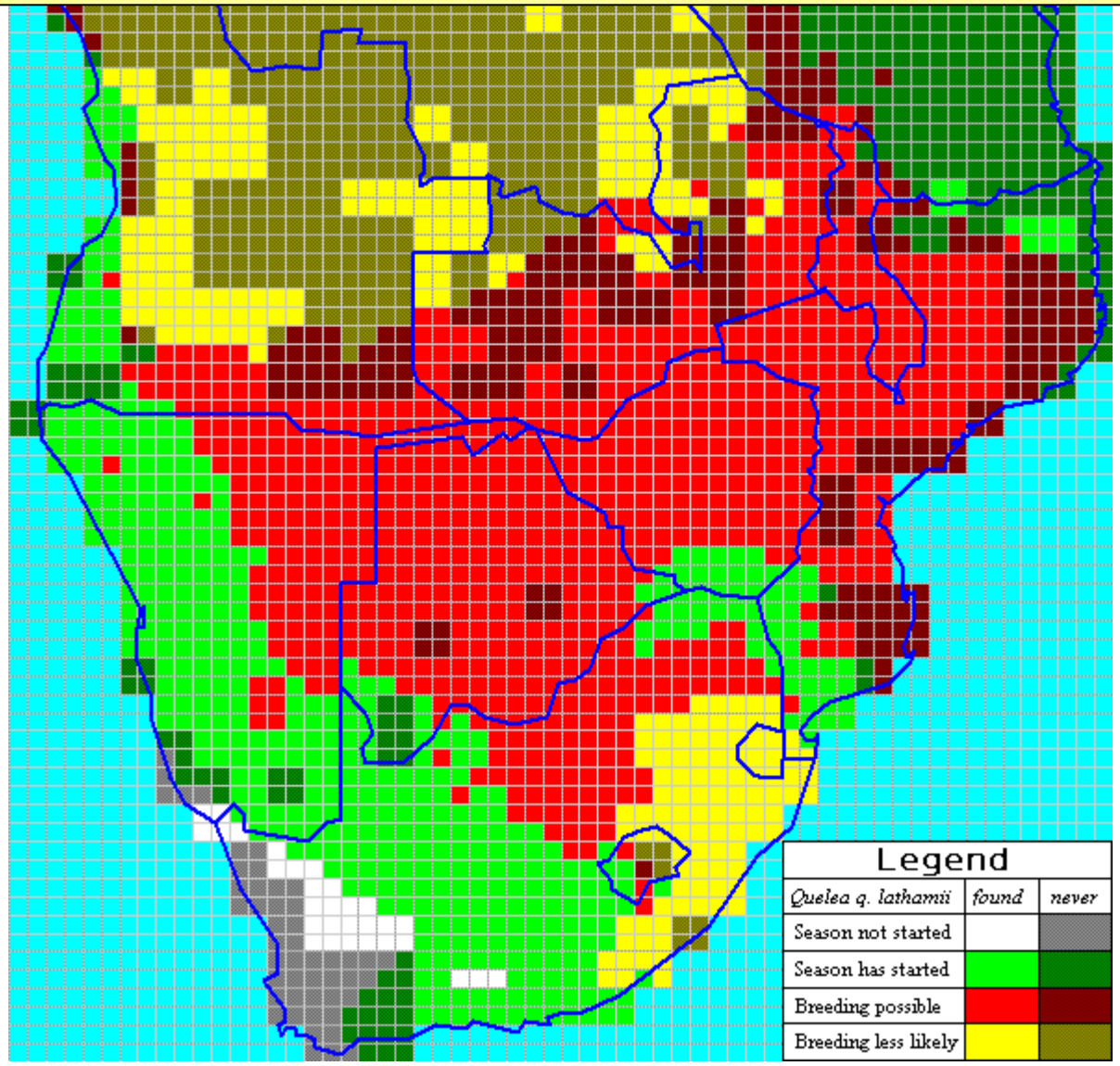


Quelea Bird Breeding forecasts

Model relationship between quelea bird breeding habits and rainfall patterns

These birds feed on various small grain crops (wheat, sorghum etc.)

Natural Resources Institute, UK
www.nri.org



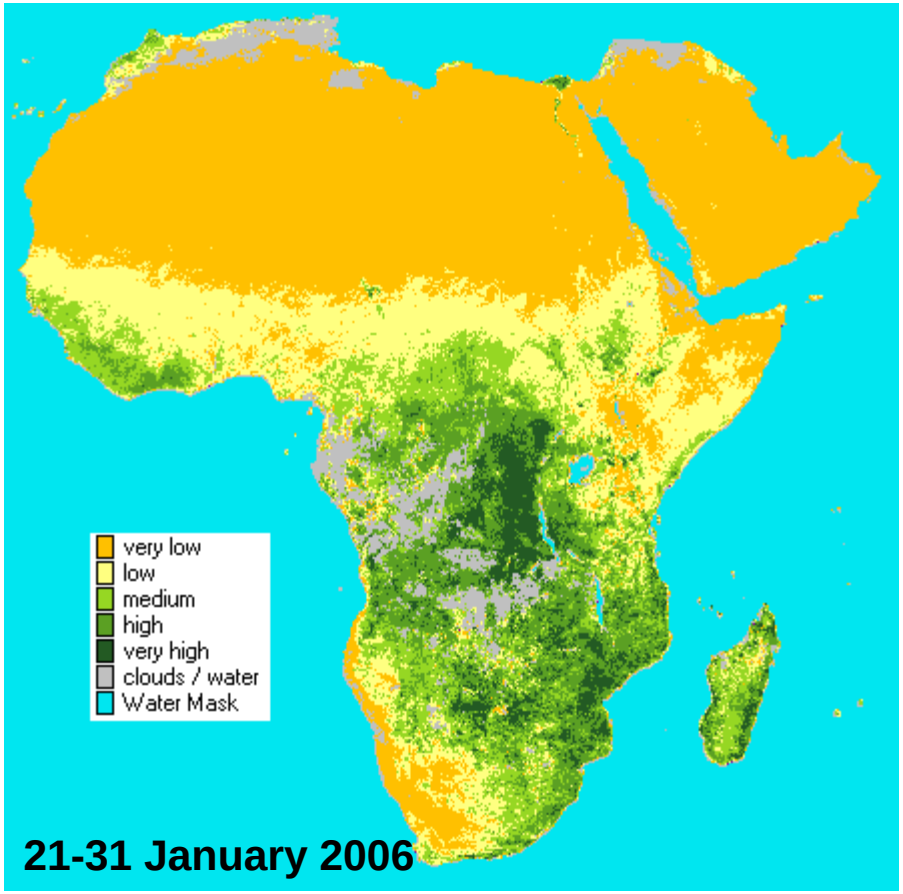
http://gisdata.usgs.net/sa_floods/files/region/quel/

Available NDVI datasets

Type	Resolution	Frequency	Source
NOAA AVHRR	1.1km, 8km	10 days	USGS/FEWSNET
SPOT VGT	1.1km	10 days	FAO-ARTEMIS
MODIS	250m, 500m	16 days	USGS
METEOSAT-8	3km		**Botswana Meteorological Department**

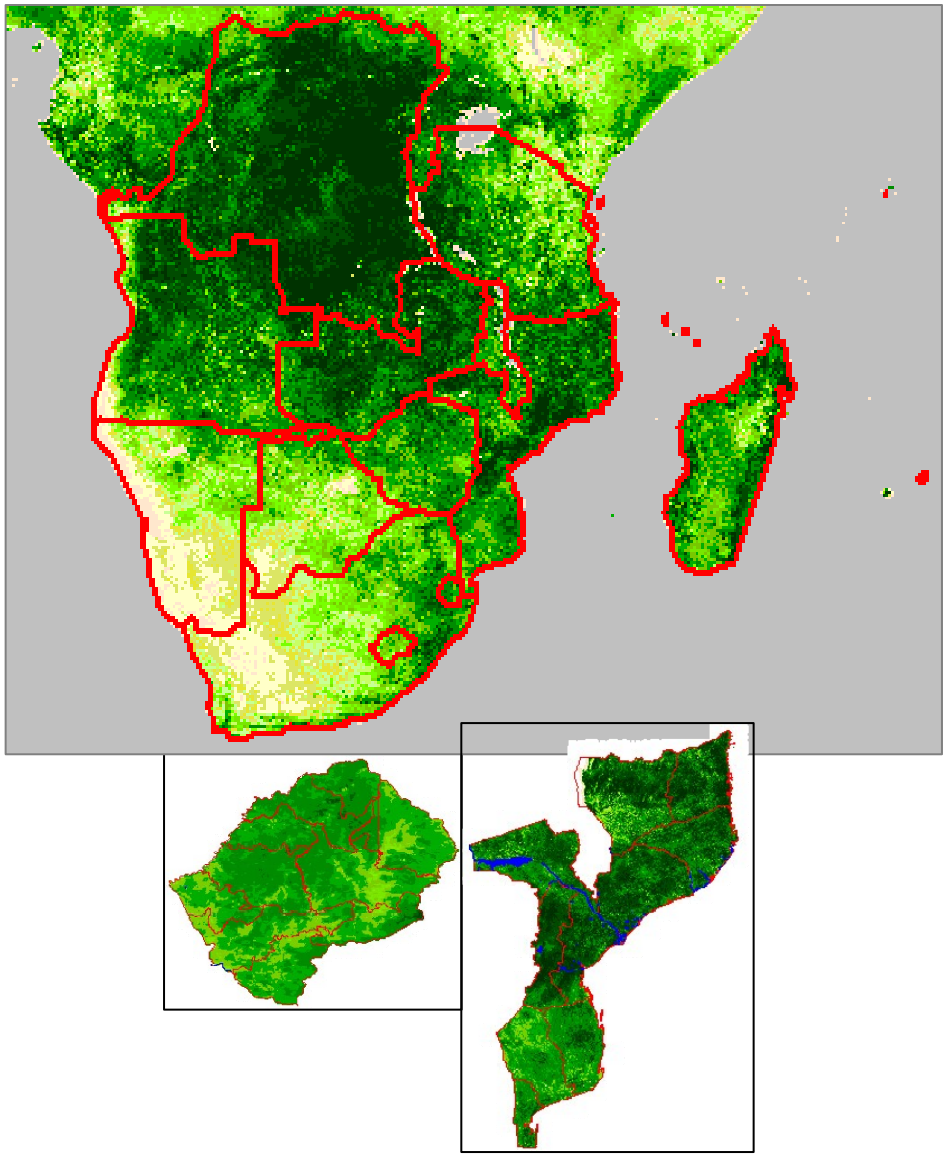
AVHRR NDVI

- GAC 8km
- USGS / FEWSNET
- 1982-current



SPOT VGT NDVI

- S-10 NDVI (MVC) from FAO ARTEMIS (via FTP)
- EumetCast distribution via METEOSAT-8 receivers, http://www.vgt4africa.org



METEOSAT-8 SEVIRI NDVI

- SEVIRI (Spinning Enhanced Visible and Infrared Imager) relevant channels:
  - VIS006, VIS008
  - IR108 , IR120 (thermal infrared) for cloud masking

Channel	Spectral Domain	λ_{cen}	λ_{range}
VIS006	Green - Red	0.635	0.56 - 0.71
VIS008	Infra-red	0.810	0.74 - 0.88
IR016	Short Wave IR	1.640	1.50 - 1.78

METEOSAT-8 SEVIRI CHANNELS

Basic + Airmass + Hi Res Vis Missions

Basic	Band (µm)	Airmass	Band (µm)
VIS 0.6	0.56 - 0.71	WV 6.2	5.35 - 7.15
VIS 0.8	0.74 - 0.88	WV 7.3	6.85 - 7.85
		IR 8.7	8.30 - 9.10
IR 1.6	1.50 - 1.78	O_3 9.7	9.38 - 9.94
IR 3.9	3.48 - 4.36	CO_2 13.4	12.40 - 14.40
IR 10.8	9.80 - 11.80	High Res VIS	1km Sampling
IR 12.0	11.00 - 13.00	HRV	0.6 - 0.9

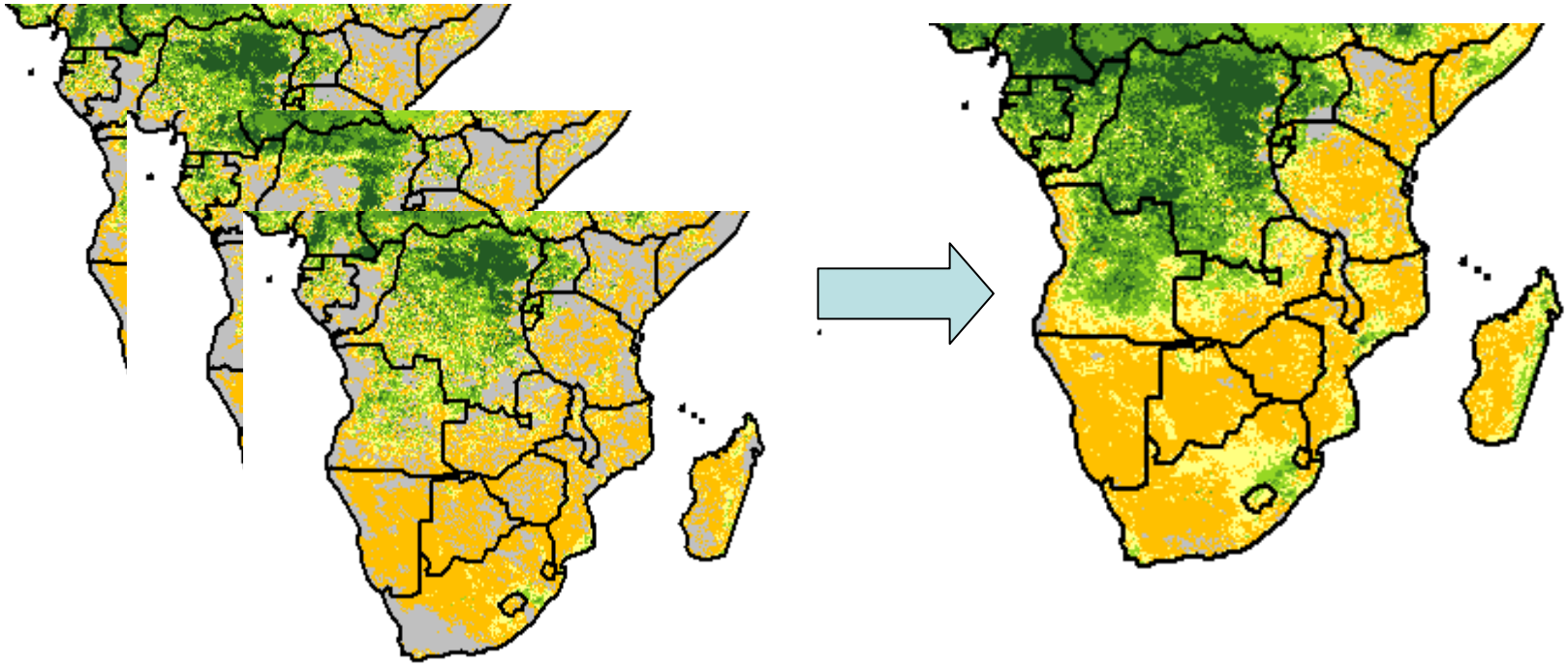
3 km data sampling intervals at sub satellite point, except HRV (1 km)

Images each 15 minutes

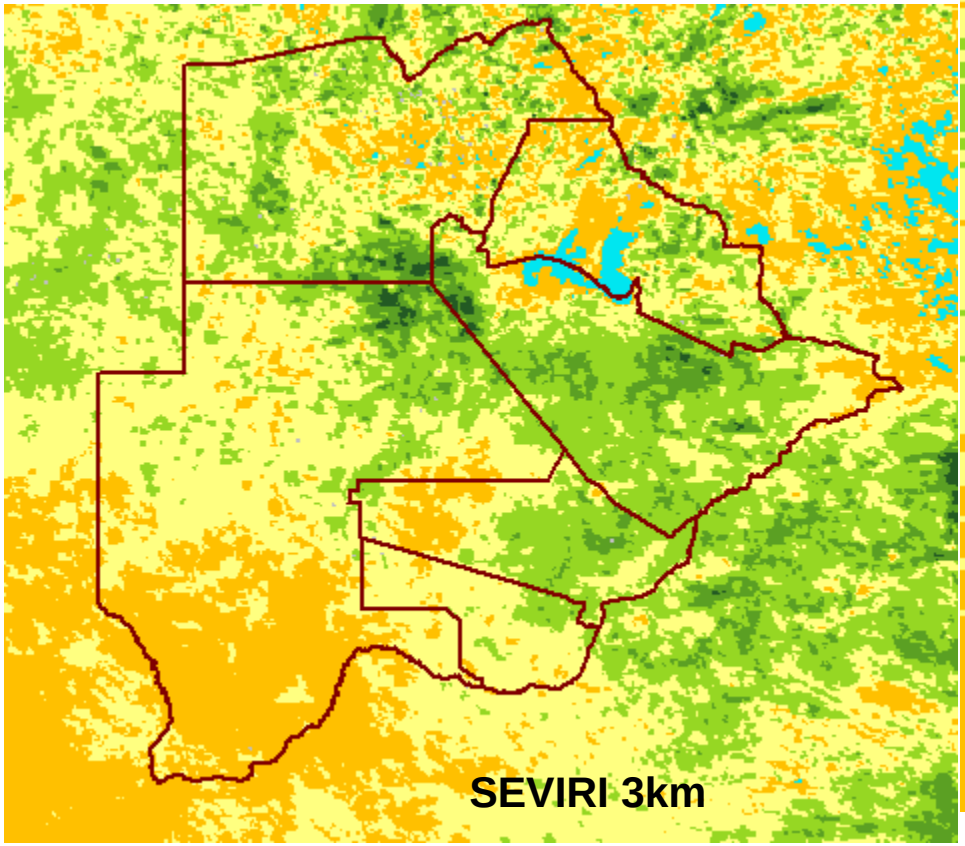
METEOSAT-8 SEVIRI NDVI

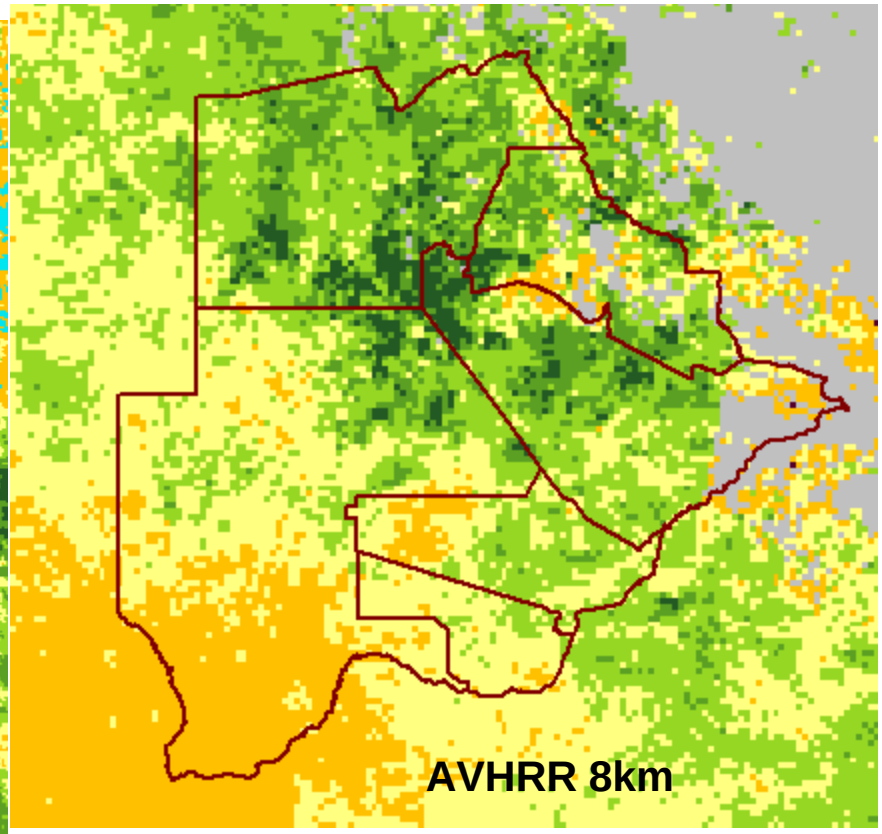
- NDVI = **(VIS008 – VIS006) / (VIS008 + VIS006)**
- **Valid NDVI values [0.0 … 0.5]**
- Difference between VIS008 and VIS006 gives good indication of vegetation density

	Day 1	Day 2	Day 3	Day 4	……..	Day N	MVC
1030	□	□	□	□	□	□	■
1130	□	□	□	□	□	□	■
1200	□	□	□	□	□	□	■
1230	□	□	□	□	□	□	■

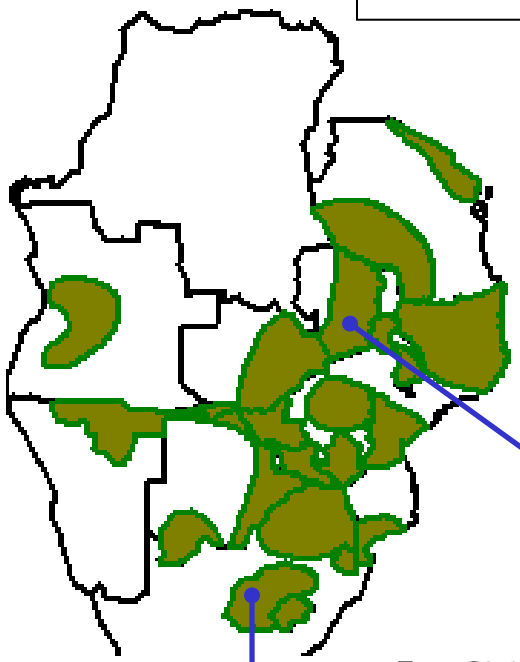


METEOSAT-8 SEVIRI NDVI

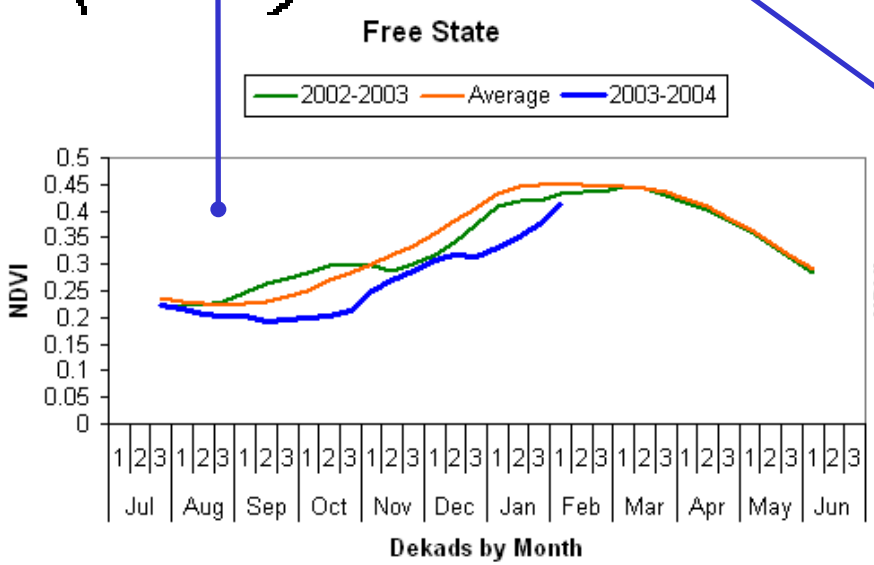


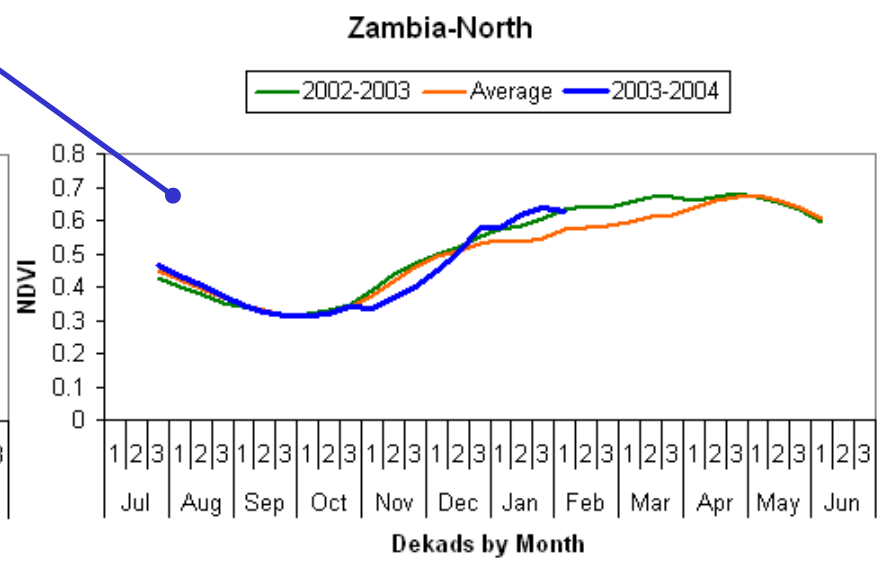


Time series NDVI



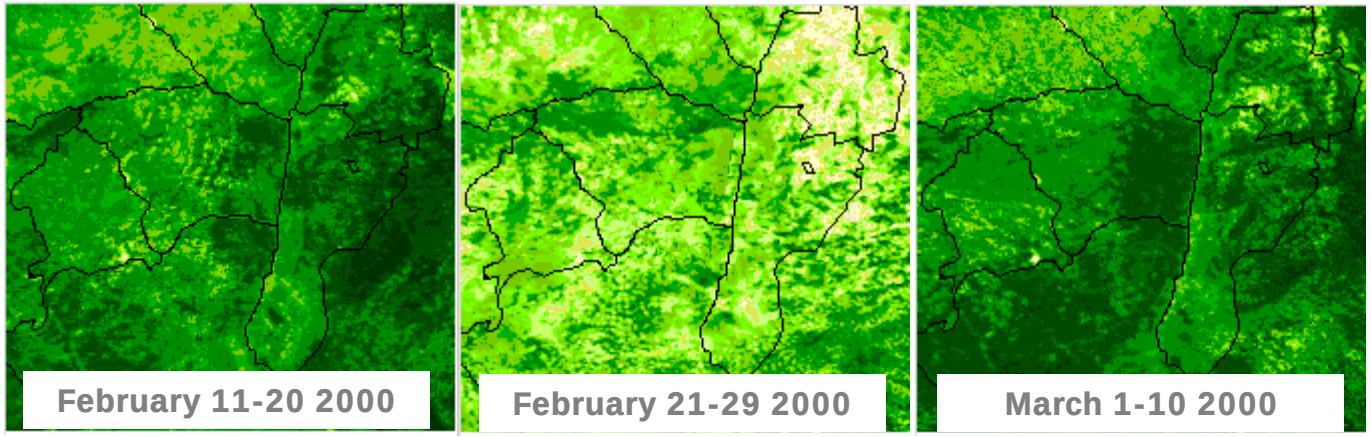
- Time series analysis done for visualizing seasonal trends in the major agricultural areas
- Comparison with average and other seasons





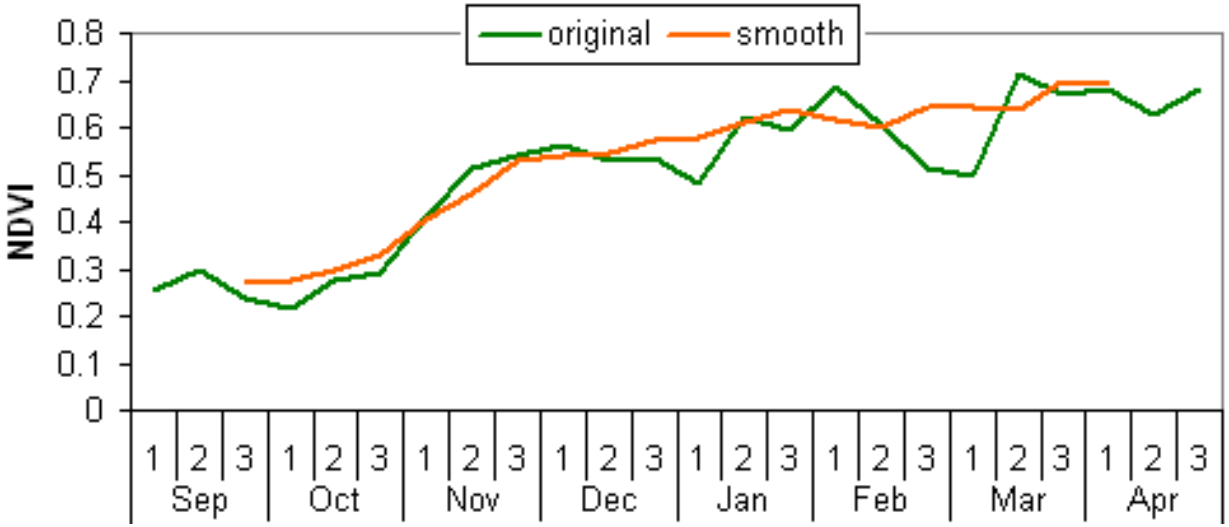
NDVI Time series

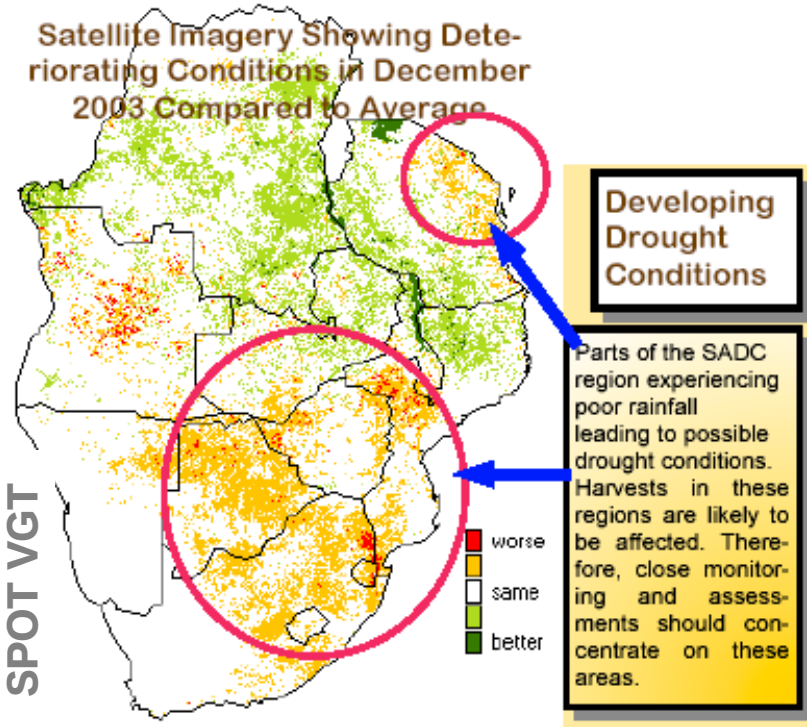
- NDVI trend series smoothing (Reed et al, 1999)

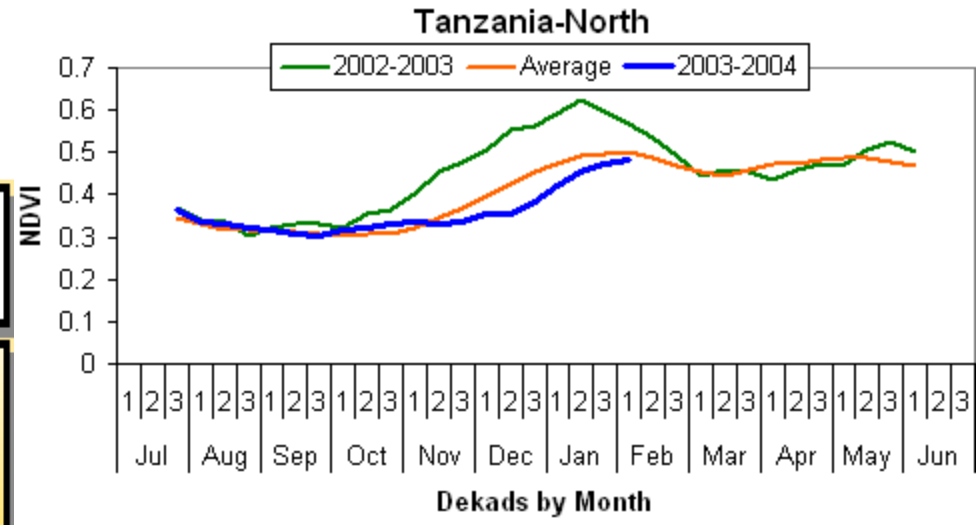


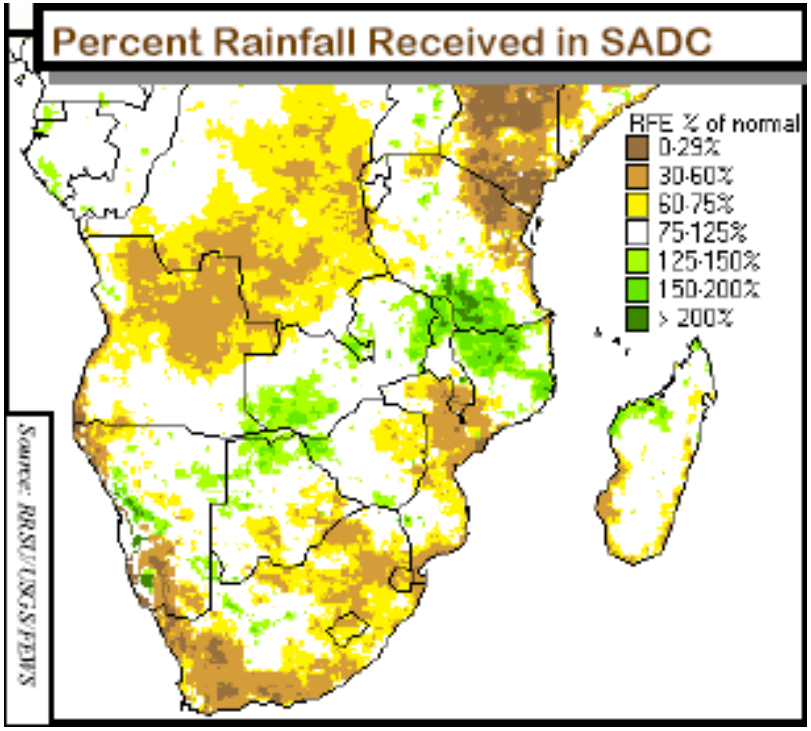
Weighted least squares approach to NDVI smoothing

5-dekad overlapping moving windows used



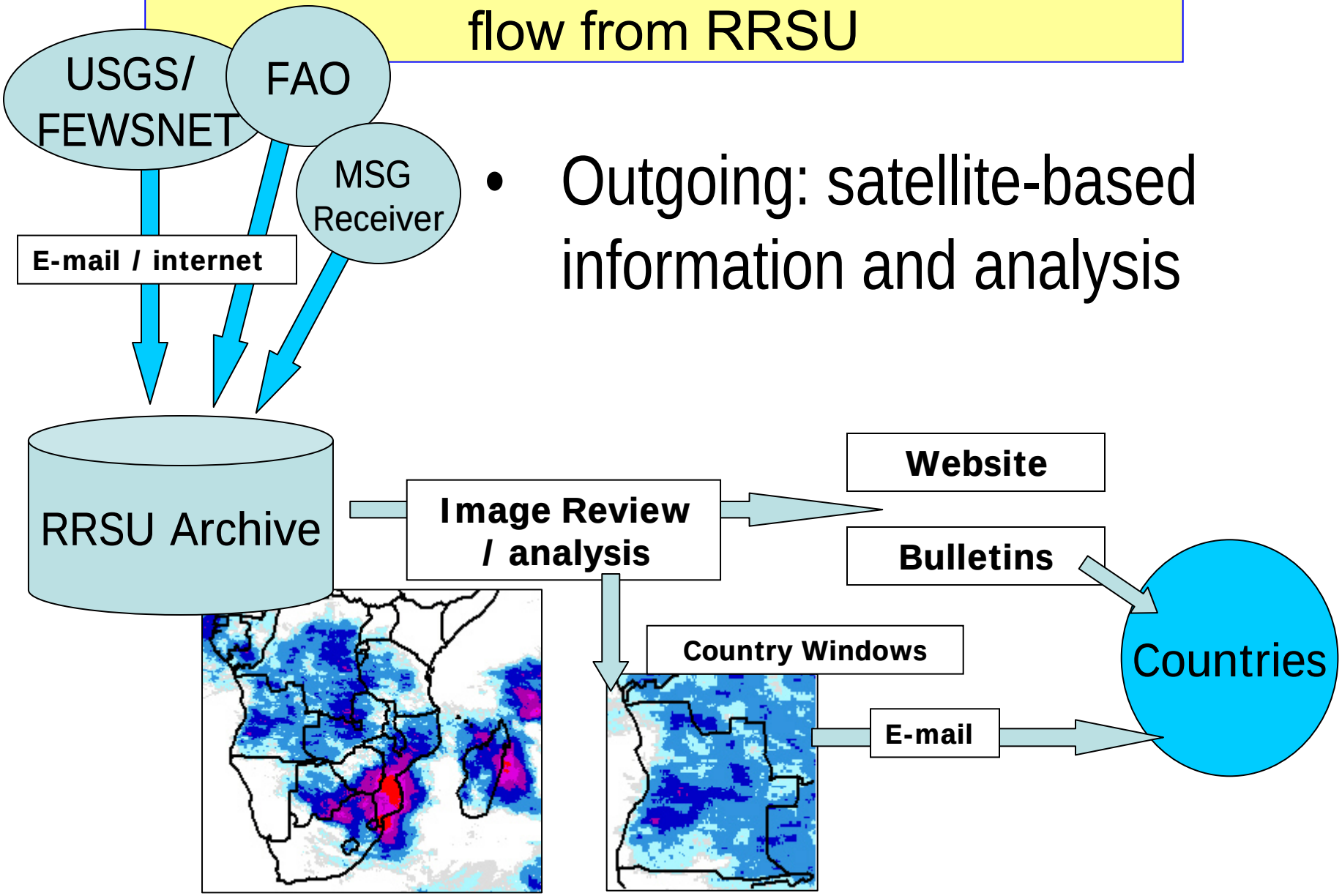






- 2003 drought in parts of southern Africa
- VGT S-10 NDVI used in SADC report to show extent of drought

SADC Region Early Warning Information flow from RRSU



- Outgoing: satellite-based information and analysis

Principal Datasets at the RRSU

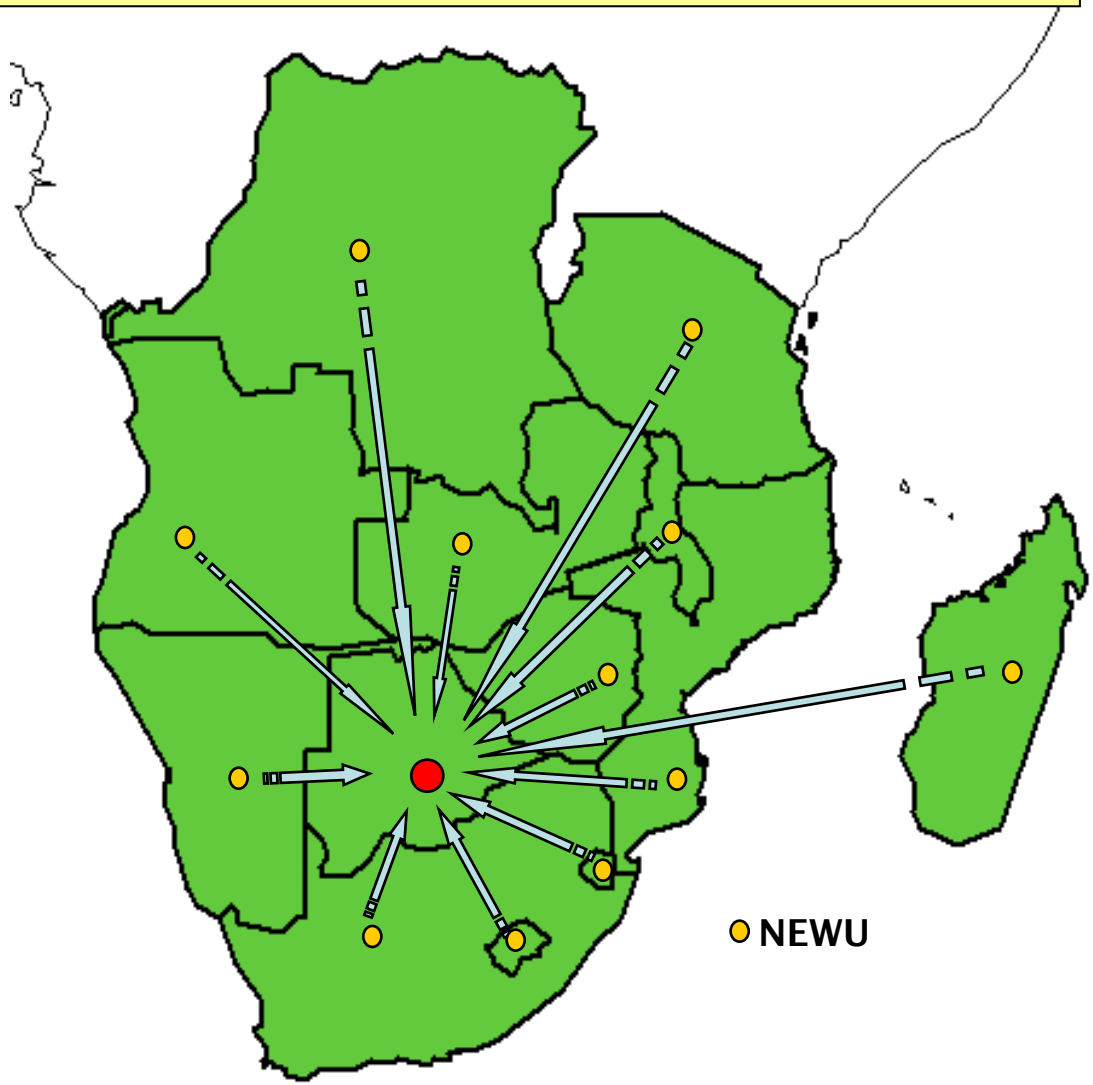
Imagery	Resolution	Main use(s)
METEOSAT	3 / 8 km	Monitoring rainfall, storms
Rainfall Estimates	8 km	Monitoring rainfall, floods
Water Requirements Satisfaction Index (WRSI)	8 km	Crop condition
NDVI (LAC/GAC)	1.1 km / 8 km	Monitoring crops, vegetation
SPOT-4 VGT	1.1 km	Monitoring crops, vegetation
MODIS	250 m	Monitoring crops, vegetation
LANDSAT	30 m	Land cover
ASTER	15 m	Land cover, terrain modelling, vegetation

+ Vector datasets [admin boundaries, transport, hydrological, etc]

+ Tabular data [climate data, crop statistics, etc]

SADC Region Early Warning Information flow

- Incoming: ground-based information and analysis
  - Rainfall data, crop stages, crop condition, hydro info, etc



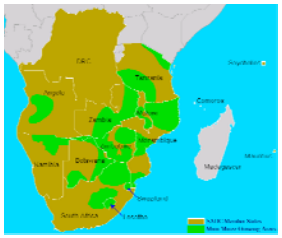
End-user Information Products

- A number of bulletins are produced to meet information requirements, including:
  - Regular agro-meteorological updates at 10-day and monthly intervals
  - Ad-hoc “Significant Weather Developments” (SWD) bulletins which aim to “ *provide timely highlights of developing weather patterns and their potential impacts to human lives and property*”
  - Other special bulletins to address current issues e.g. forecast interpretation; flood / drought alerts

Agromet Up-dates

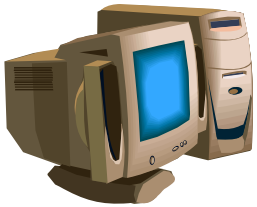
- Rainfall

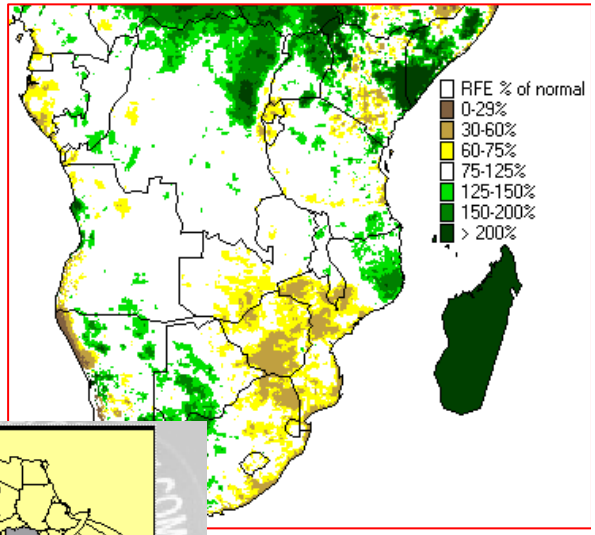
- Areas

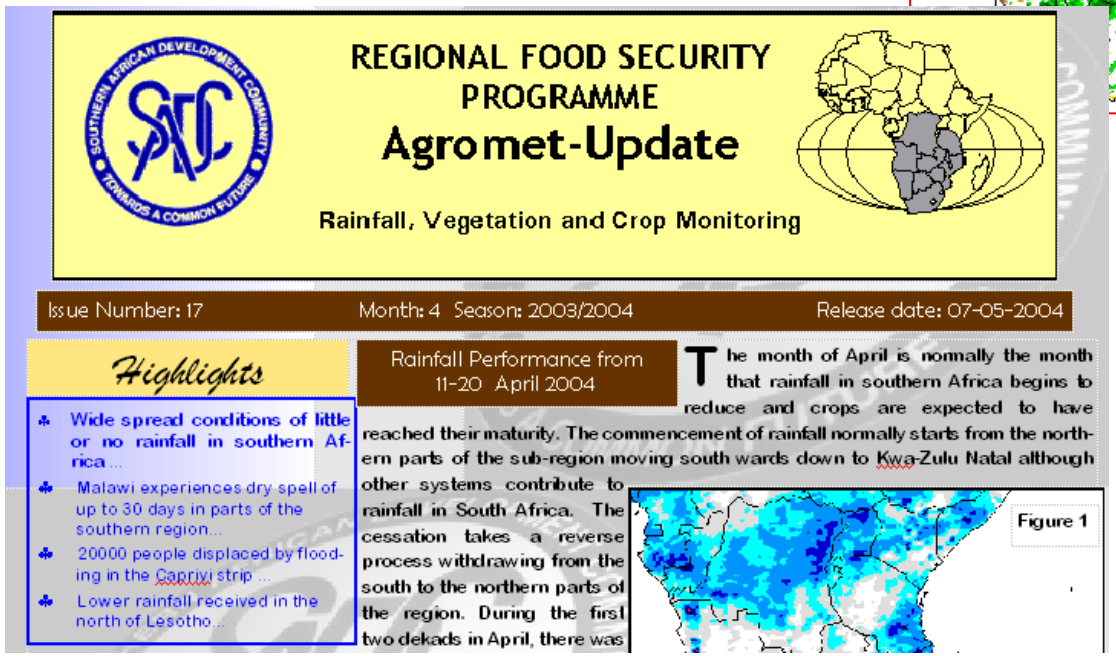


- Crops

- Models







REGIONAL FOOD SECURITY PROGRAMME

Agromet-Update

Rainfall, Vegetation and Crop Monitoring

Issue Number: 17 | Month: 4 Season: 2003/2004 | Release date: 07-05-2004

Highlights

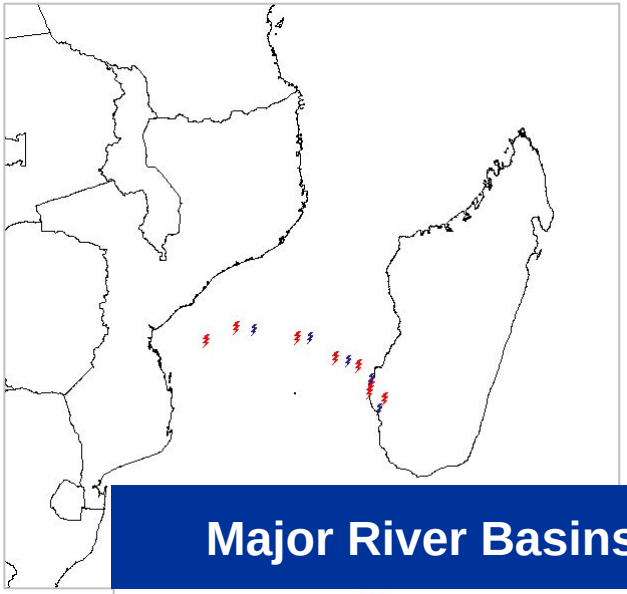
- Wide spread conditions of little or no rainfall in southern Africa ...
- Malawi experiences dry spell of up to 30 days in parts of the southern region...
- 20000 people displaced by flooding in the Capriyi strip ...
- Lower rainfall received in the north of Lesotho...

Rainfall Performance from 11-20 April 2004

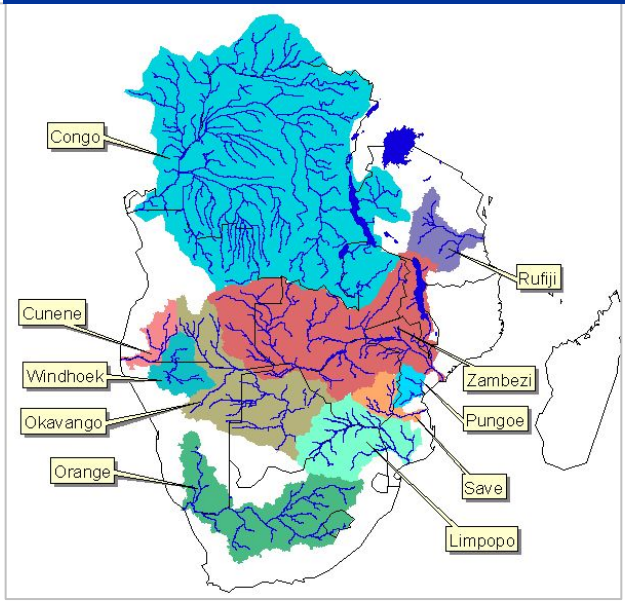
The month of April is normally the month that rainfall in southern Africa begins to reduce and crops are expected to have reached their maturity. The commencement of rainfall normally starts from the northern parts of the sub-region moving south wards down to Kwa-Zulu Natal although other systems contribute to rainfall in South Africa. The cessation takes a reverse process withdrawing from the south to the northern parts of the region. During the first two dekads in April, there was

Figure 1

Forecast Cyclone Tracks



Major River Basins



REGIONAL REMOTE SENSING UNIT

Significant Weather Developments

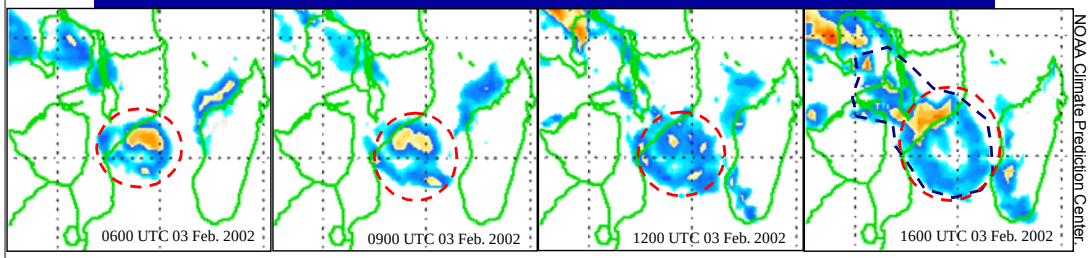
Release date: 4 February 2002 : 1200 UTC

TROPICAL DISTURBANCE IN MOZAMBIQUE CHANNEL

A *tropical disturbance* has formed in the Mozambique Channel. The chance of the disturbance developing into a cyclone is currently fair. Due to the disturbance, heavy rains may be expected in central Mozambique, Malawi, eastern Zambia and northeastern Zimbabwe.

A tropical disturbance has developed in the Mozambique Channel. Satellite infrared images (see figures below) show a region of convection developing from off the central coast of Mozambique into the Channel. Winds are estimated at between 37 and 46 km/hr. The potential for the development of a significant cyclone are currently fair.

Infrared images showing progression of disturbance in Mozambique Channel



NOAA Climate Prediction Center

Heavy Rainfall Prospects

Cloud bands associated with the tropical disturbance, coupled with moisture influxes into the southern fringes of the rain-bearing Inter-Tropical Convergence Zone (ITCZ) may bring heavy rains to central Mozambique, Malawi, eastern Zambia and northeastern Zimbabwe.

Terminology Note

A *tropical disturbance* or zone of disturbed weather is an area of low pressure relative to the surrounding region. Its associated cloud masses are usually not well organized as compared to an actual cyclone.

The Regional Remote Sensing Unit will keep you updated on any significant development regarding the tropical disturbance.

The Significant Weather Developments bulletin is intended to provide timely highlights of developing weather patterns that might pose a threat to human lives and property. While efforts have been made to ensure accuracy of this report, country specific requirements should be addressed to the National Meteorological Services. The RRSU and FEWSNET produce a situational Regional Flood Watch during the rainy season.

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Thank You