

# **Agro-ecological zoning and water availability in East and Central Africa – geoinformatics based maps and models for regional scale planning and management**

ASARECA Technical workshop on priority  
setting 05-09 May 2003, Entebbe, Uganda

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ICRAF - World Agroforestry Centre



**Temperature**

**Precipitation**

**Evapotranspiration**

**Length of growing season**

**Farming system**

**Soil type, fertility and erosion**

**Hydrology**

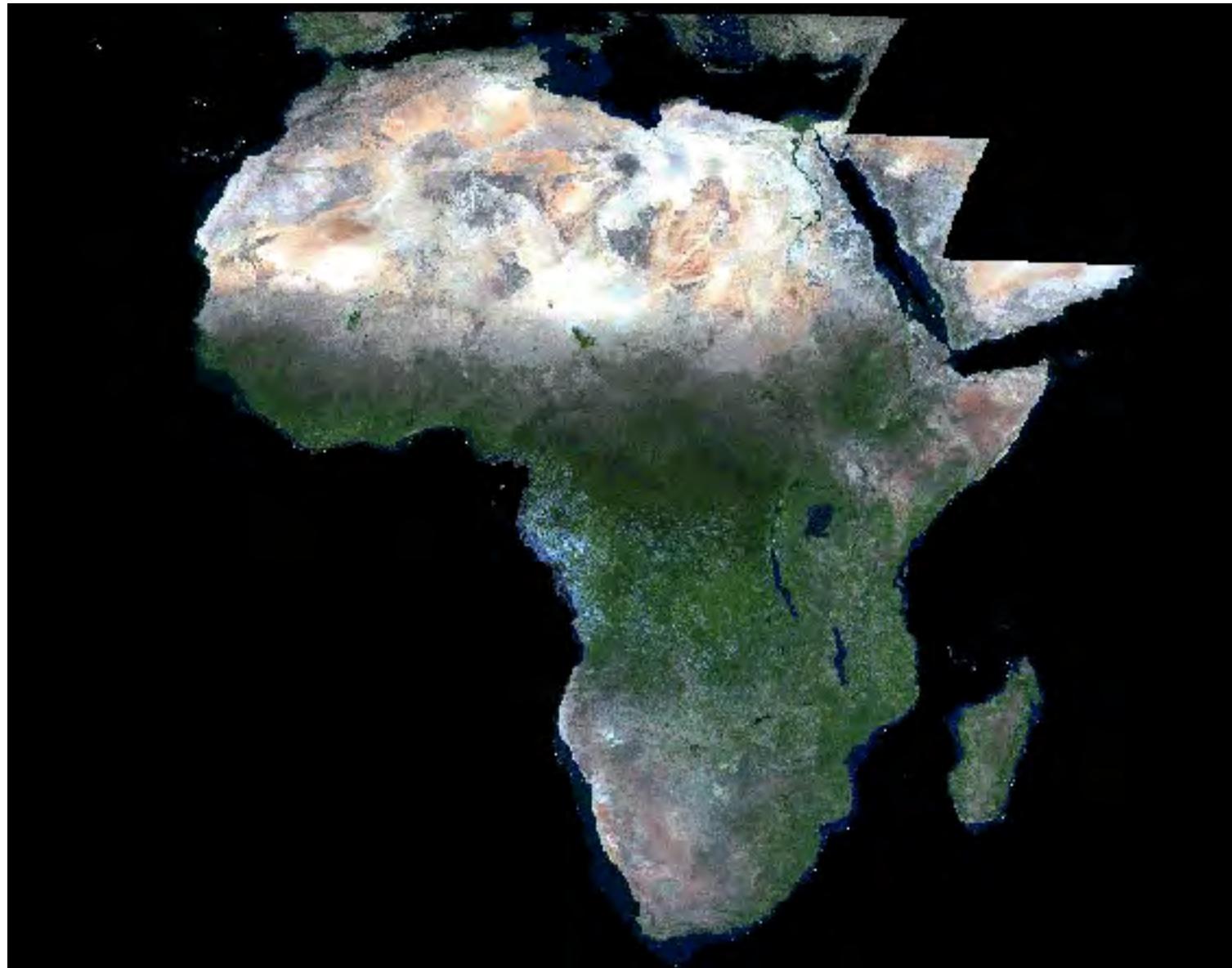
**Land use/cover**

**+ Infrastructure (market and market access)**

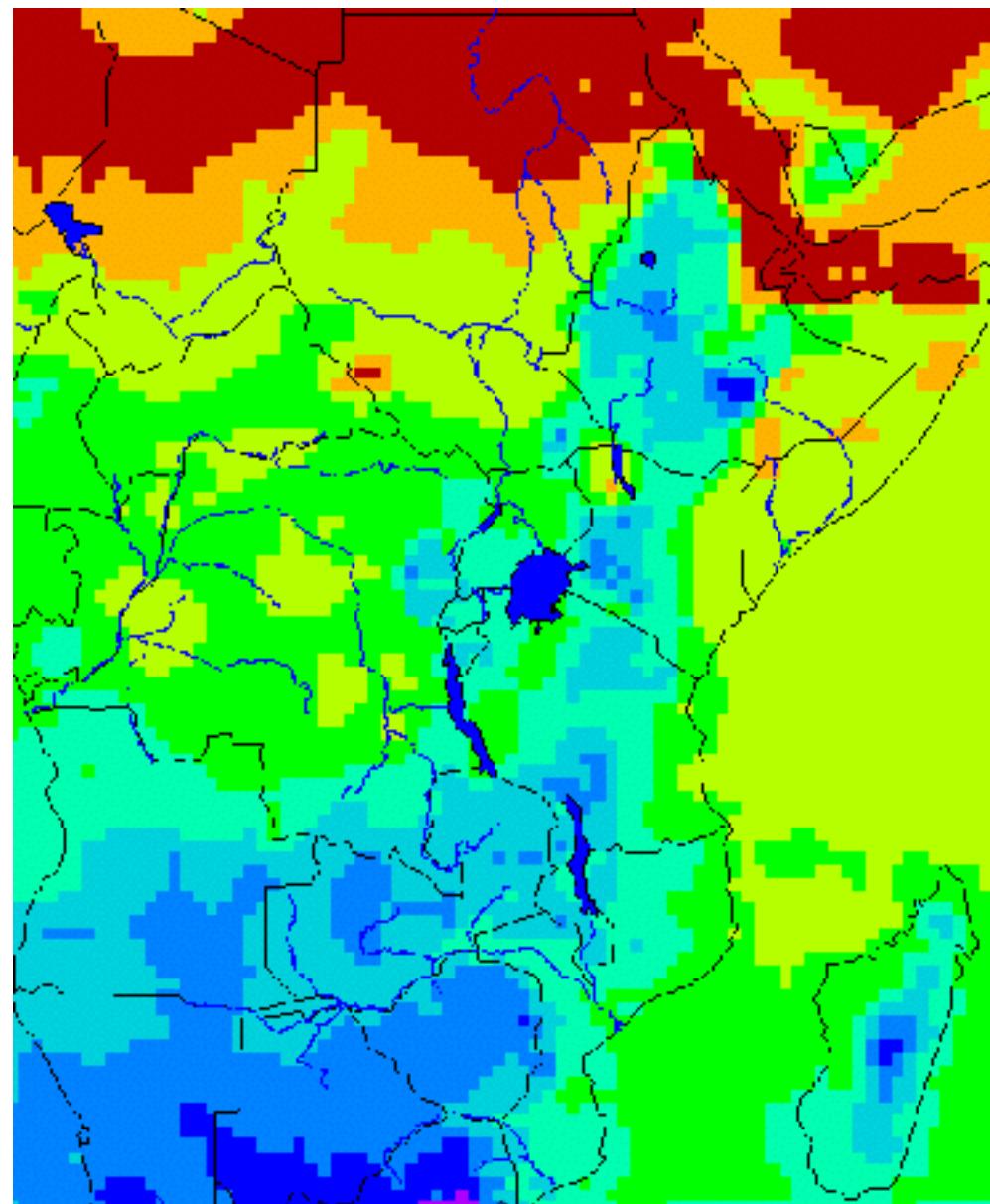
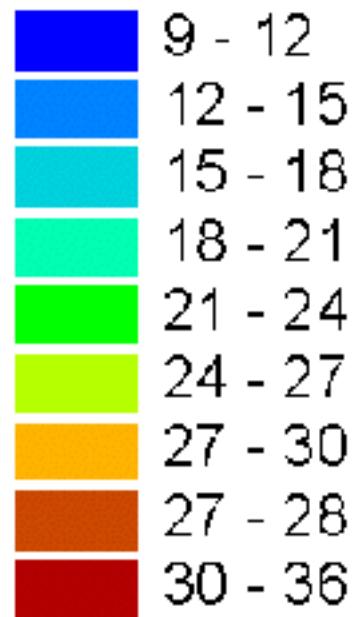
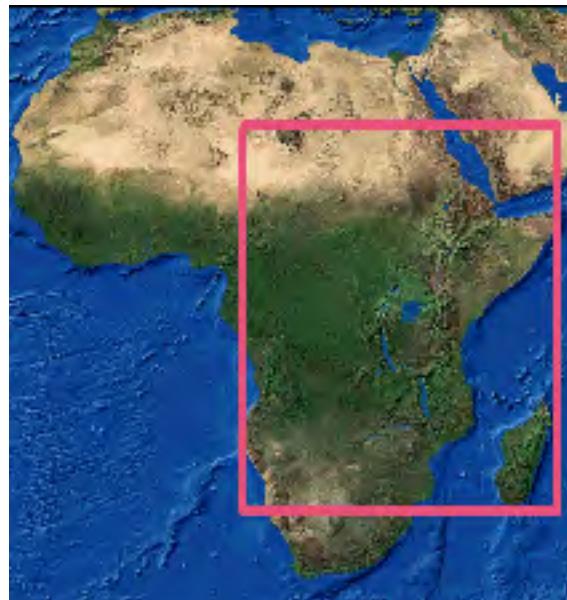
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**AGROECOLOGICAL ZONING**

# Africa's dynamic environment



# Temperature data



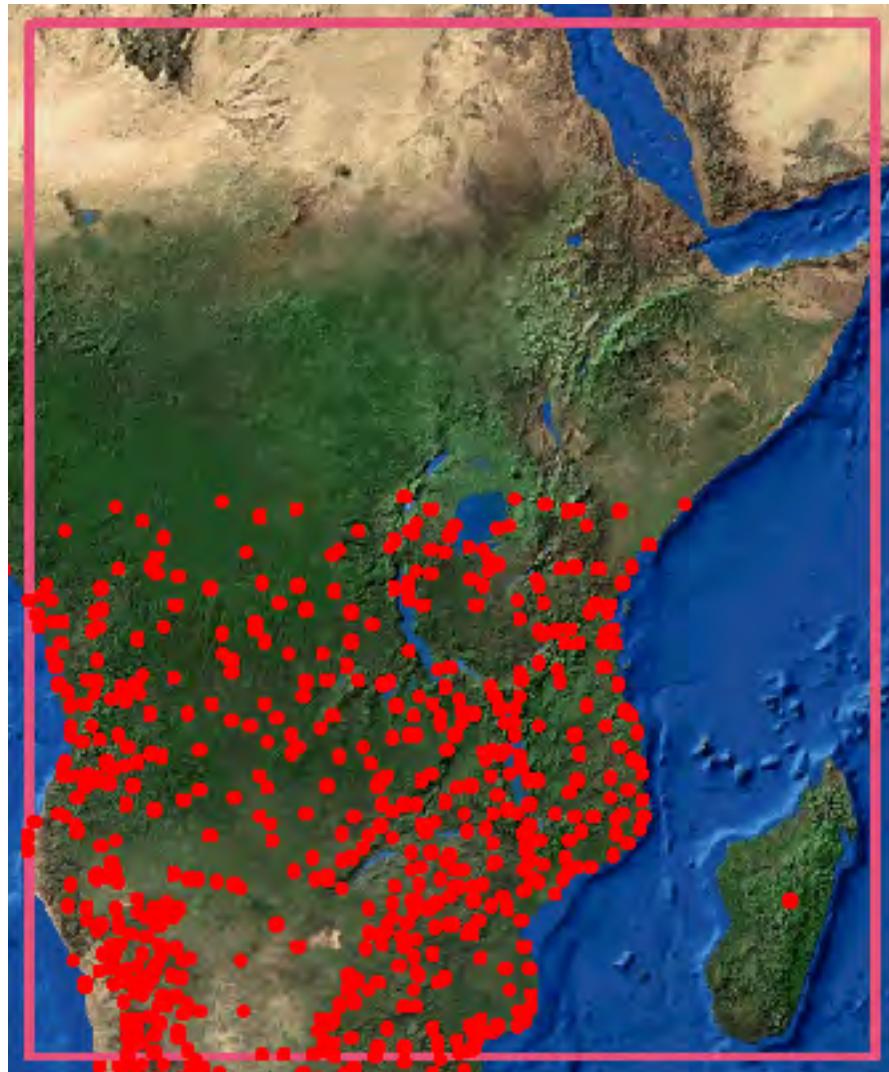
# Temperature data

Available data (i.e. data that is already captured)

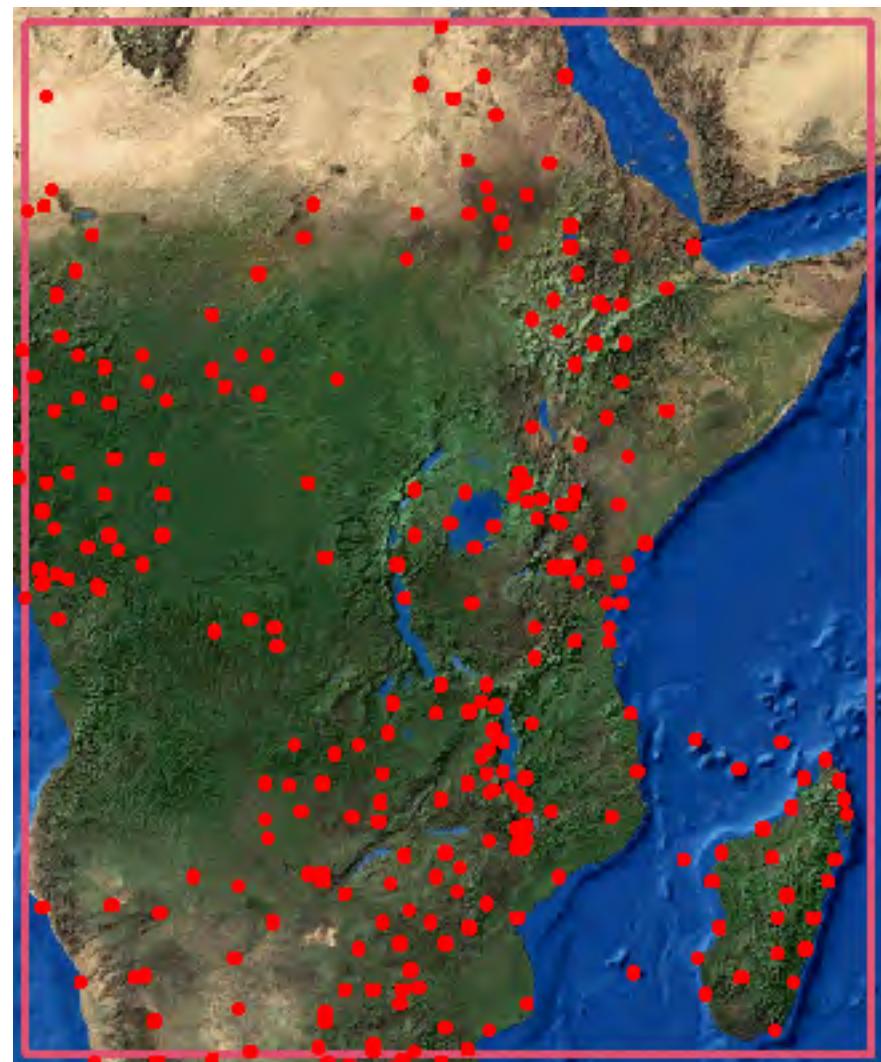
- ✓ Monthly Climate station data going back more than 100 years
- ✓ Daily climate station data from around 1977
- ✓ Ground temperature estimations from Remote Sensing (TERRA MODIS from 2000)
- ✓ Climate statistics map (50 km resolution – the one you saw!)

# Temperature data

Monthly data (S. equator)



Daily data (freely available)

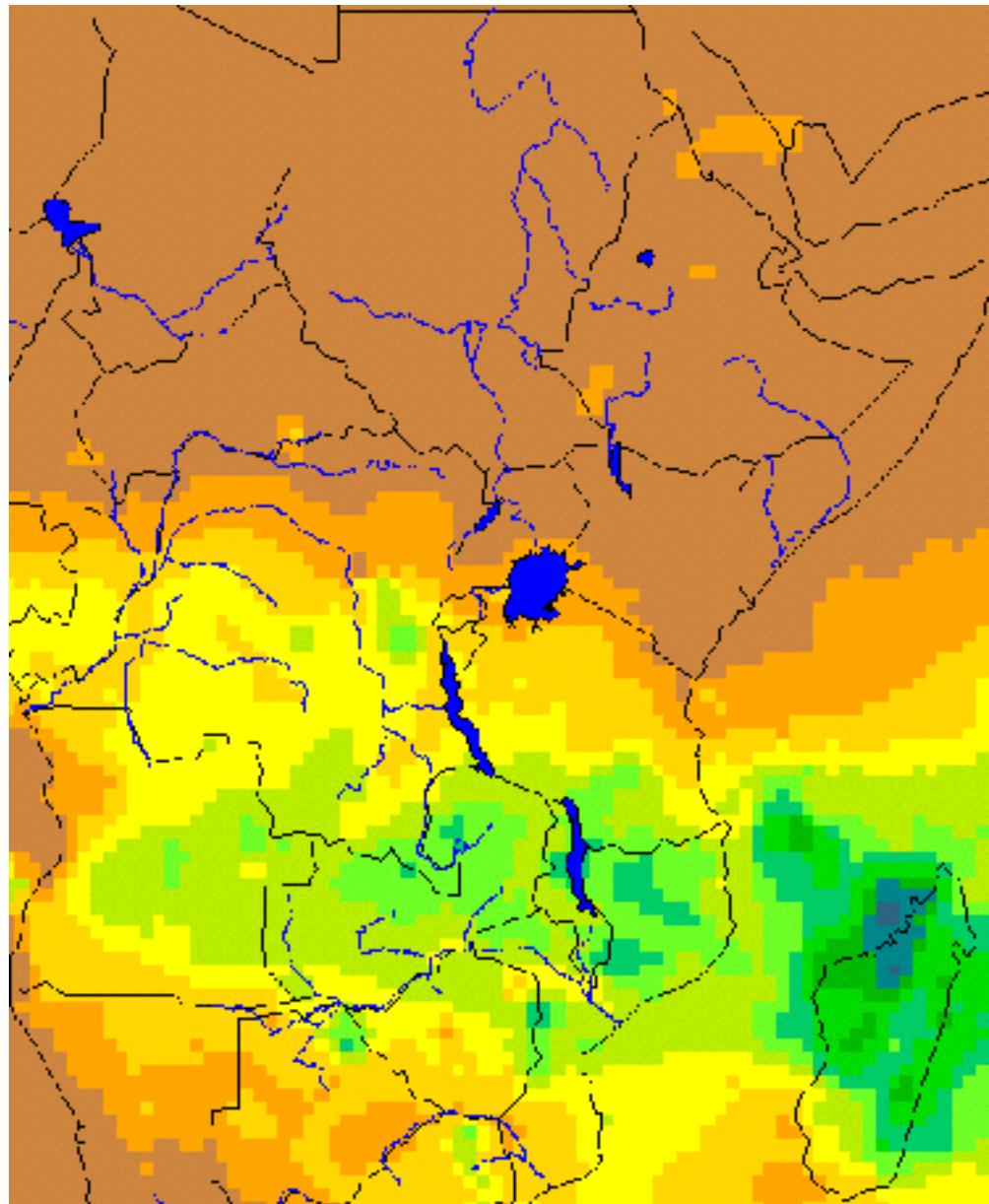
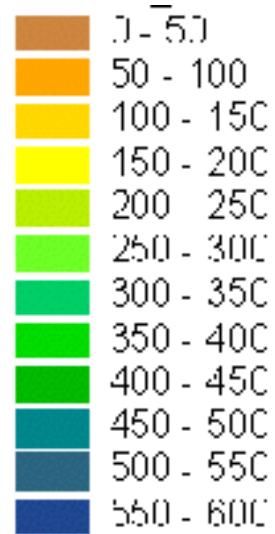
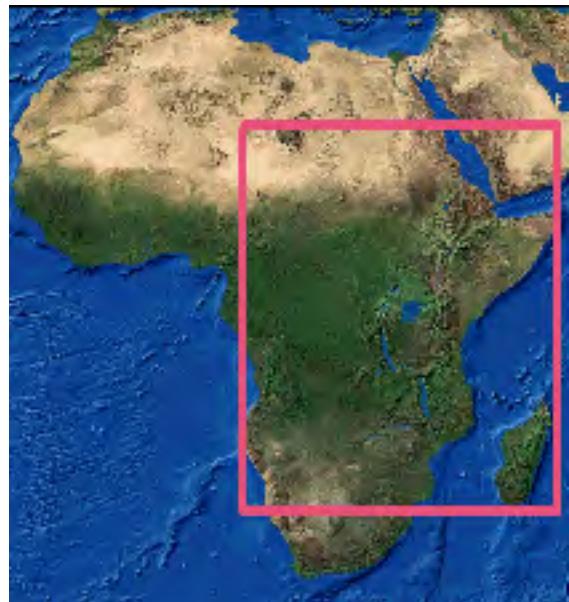


# Temperature data

Can be improved by:

- Including more ground stations
- Making use of Digital Elevation Models for geostatistical interpolations (e.g. sunny and shady side of mountains)
- Making use of Remote Sensing Data

# Rainfall data



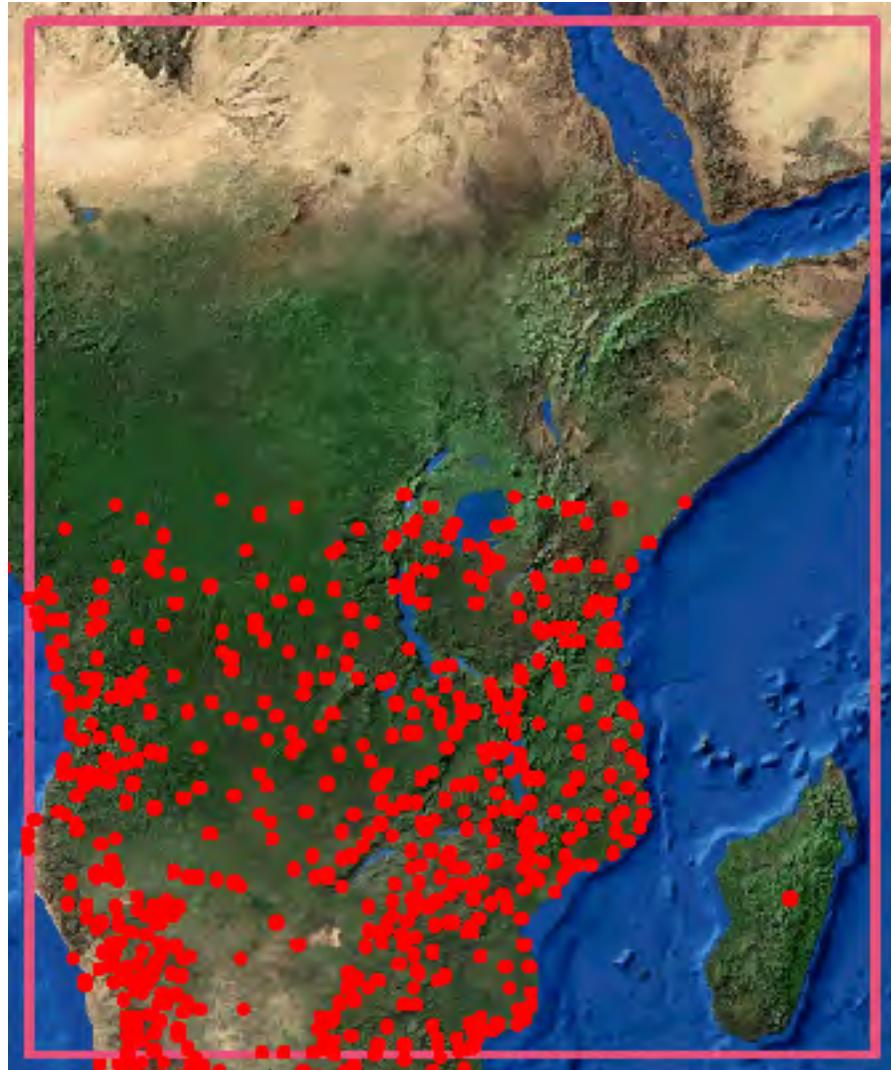
# Rainfall data

## Available data

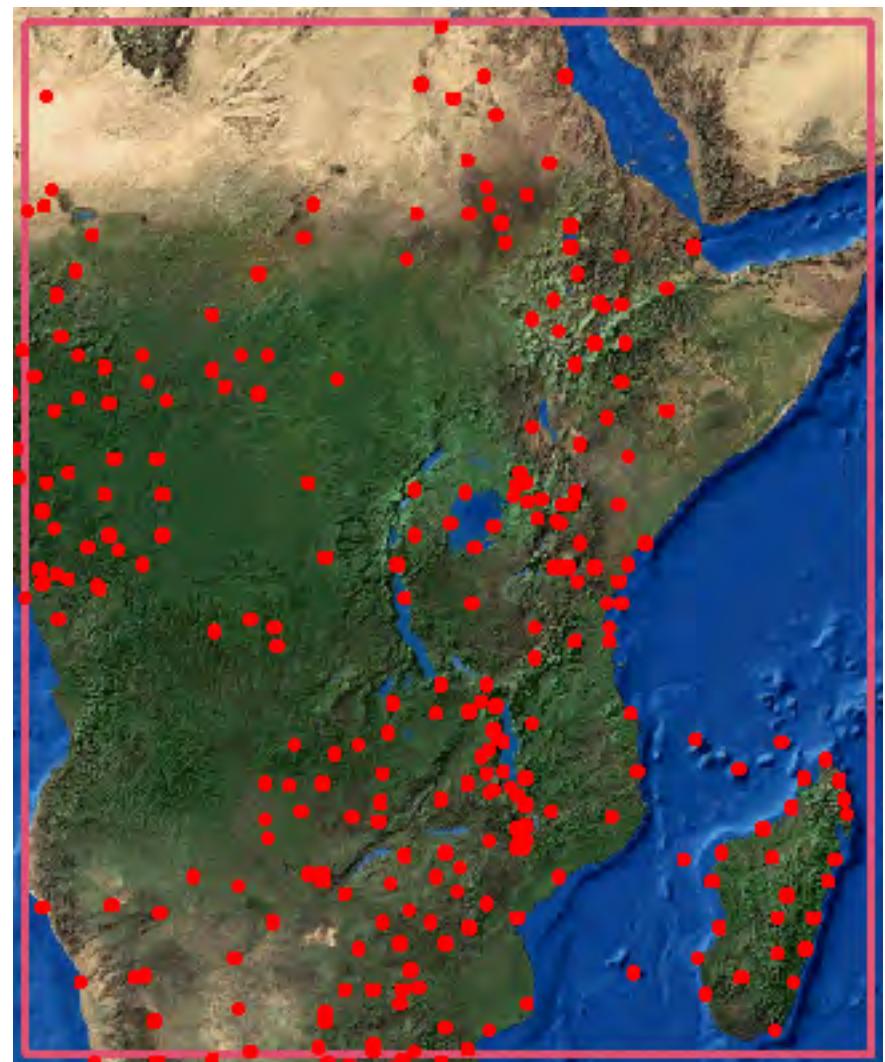
- ✓ Monthly Climate station data going back more than 100 years
- ✓ Daily climate station data from around 1977
- ✓ Rainfall estimates from METEOSAT and ground based data, 10day composites May 1995 to present (8 km resolution)
- ✓ Rainfall estimates from METEOSAT and ground based data, daily data 1998 To present (8 km resolution)
- ✓ Climate statistics map (50 km resolution – the one you saw!)

# Rainfall data

Monthly data (S. equator)



Daily data (freely available)



# Rainfall data

Can be improved by:

- Including more ground stations
- Making use of Digital Elevation Models (elevation and aspects as independent variables) in geostatistical interpolations
- Using NOAA-AVHRR vegetation index as a proxy for rainfall over dry areas with poor data coverage (goes back to 1982)

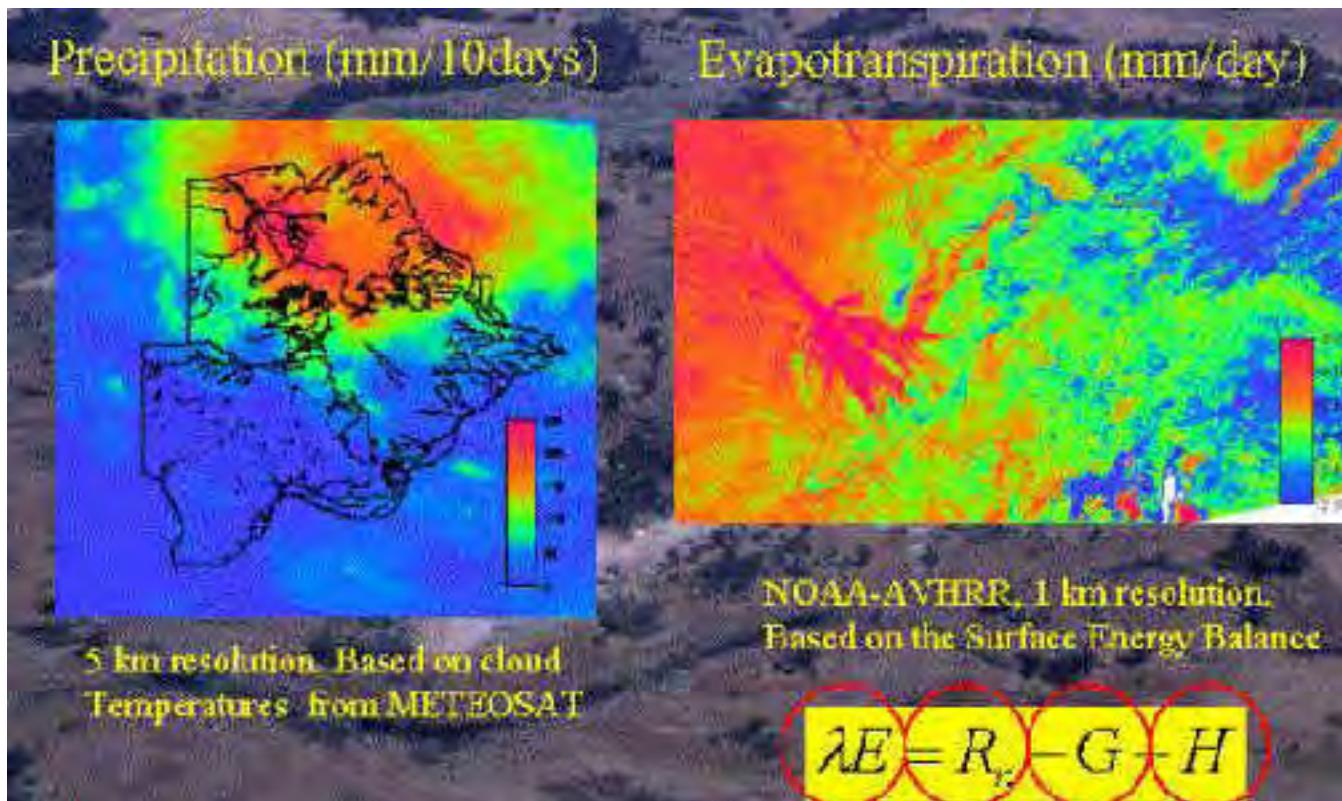
# Evapotranspiration data

Available data

- ✓ Scattered pan type evapotranspiration field data
- ✓ Evapotranspiration estimates from NOAA-AVHRR and ground based data, daily values from 1996 to present (8 km resolution)

# Evapotranspiration data

## Remote sensing for estimating spatial distribution of precipitation and evapotranspiration



# Evapotranspiration data

Can be improved by:

Combining Remote sensing data with field data for accurate point measurements of surface energy balance (evapotranspiration)



**Net radiometre**



**Microclimate station**

# Length of growing season

Available data

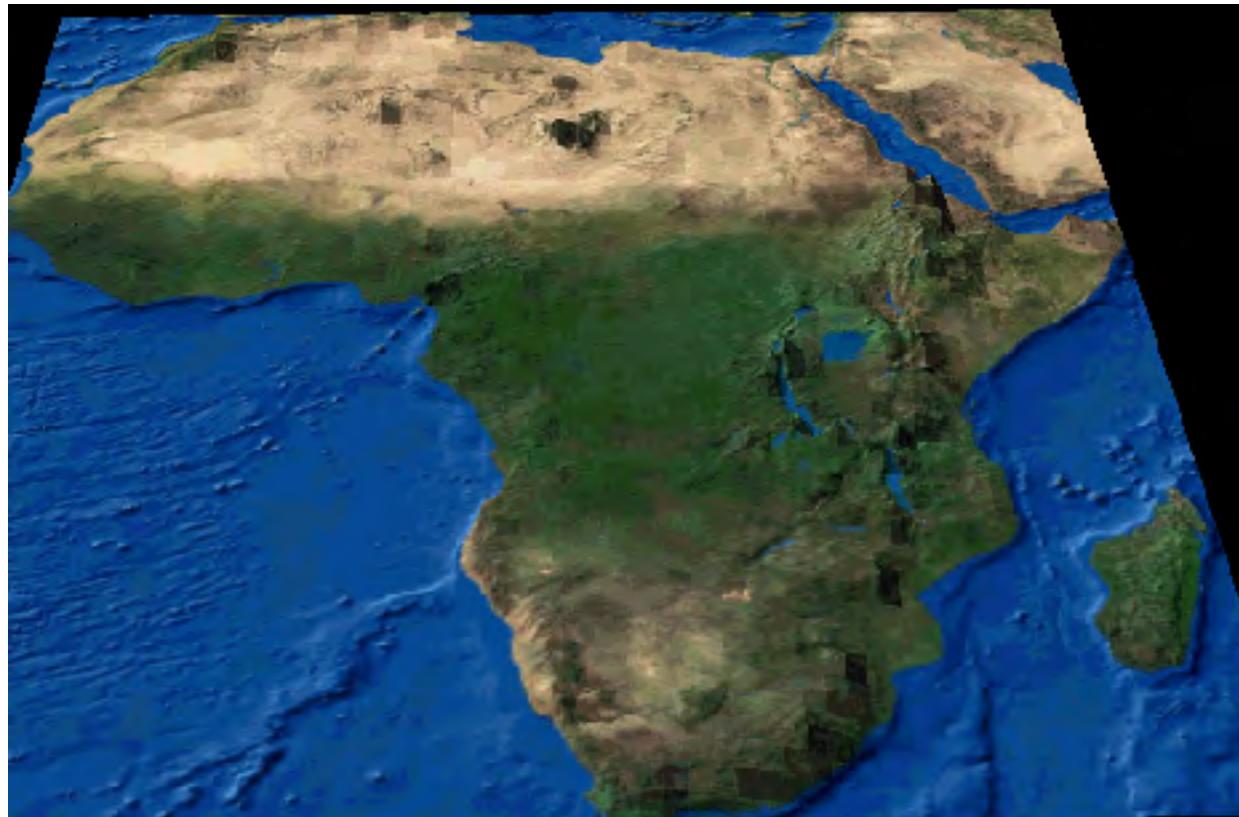
Temperature

Precipitation

Evapotranspiration...

...and

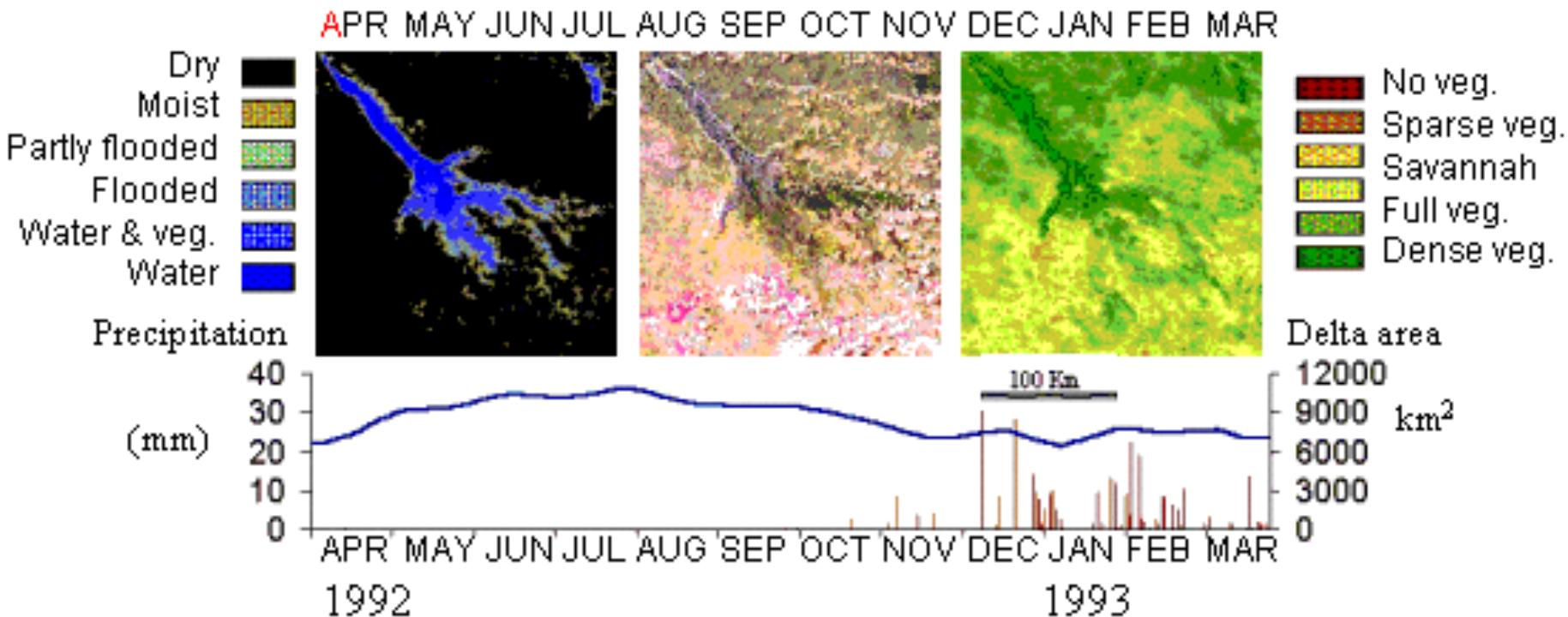
Insolation  
(computed  
from DEM)

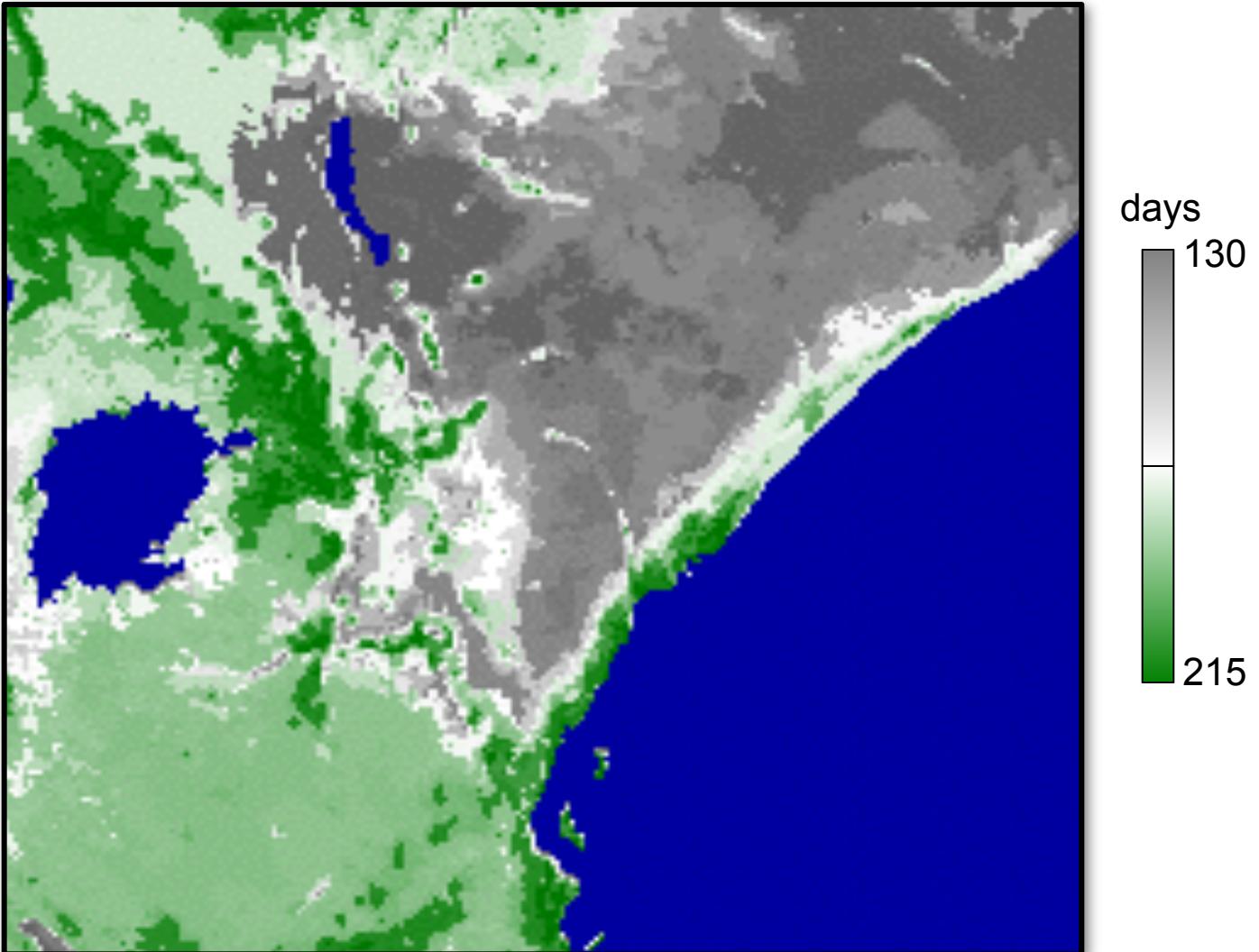


# Length of growing season

Can be improved by:

- Vegetation dynamic maps for Remote Sensing (NOAA-AVHRR and TERRA-MODIS)





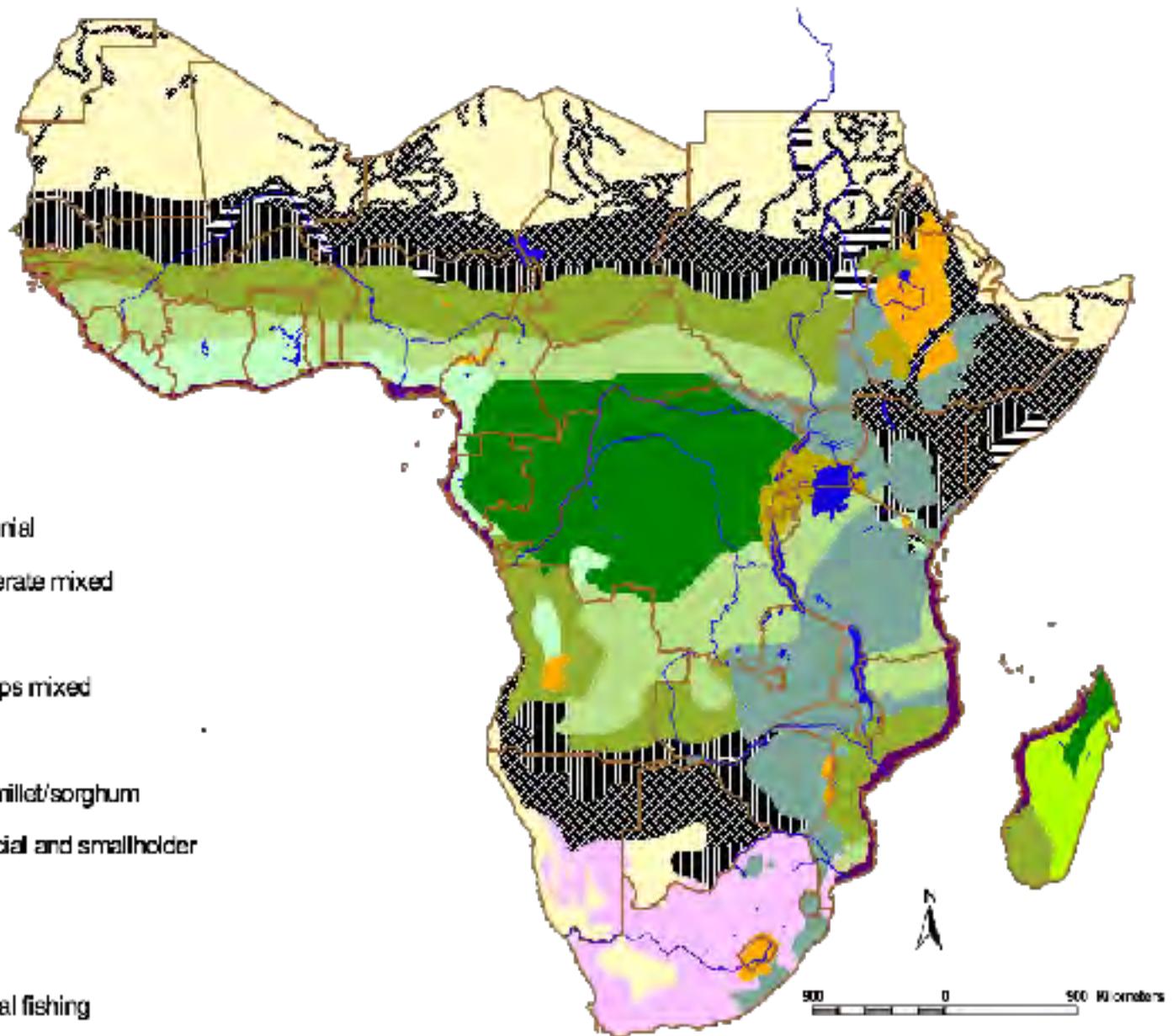
Estimated lengths of the photosynthetically active period in Kenya  
from long-term (1982-97) Advanced Very High Resolution Radiometer  
(AVHRR) data.

# Farming systems

- Major rivers
- Major Lakes
- National Boundaries

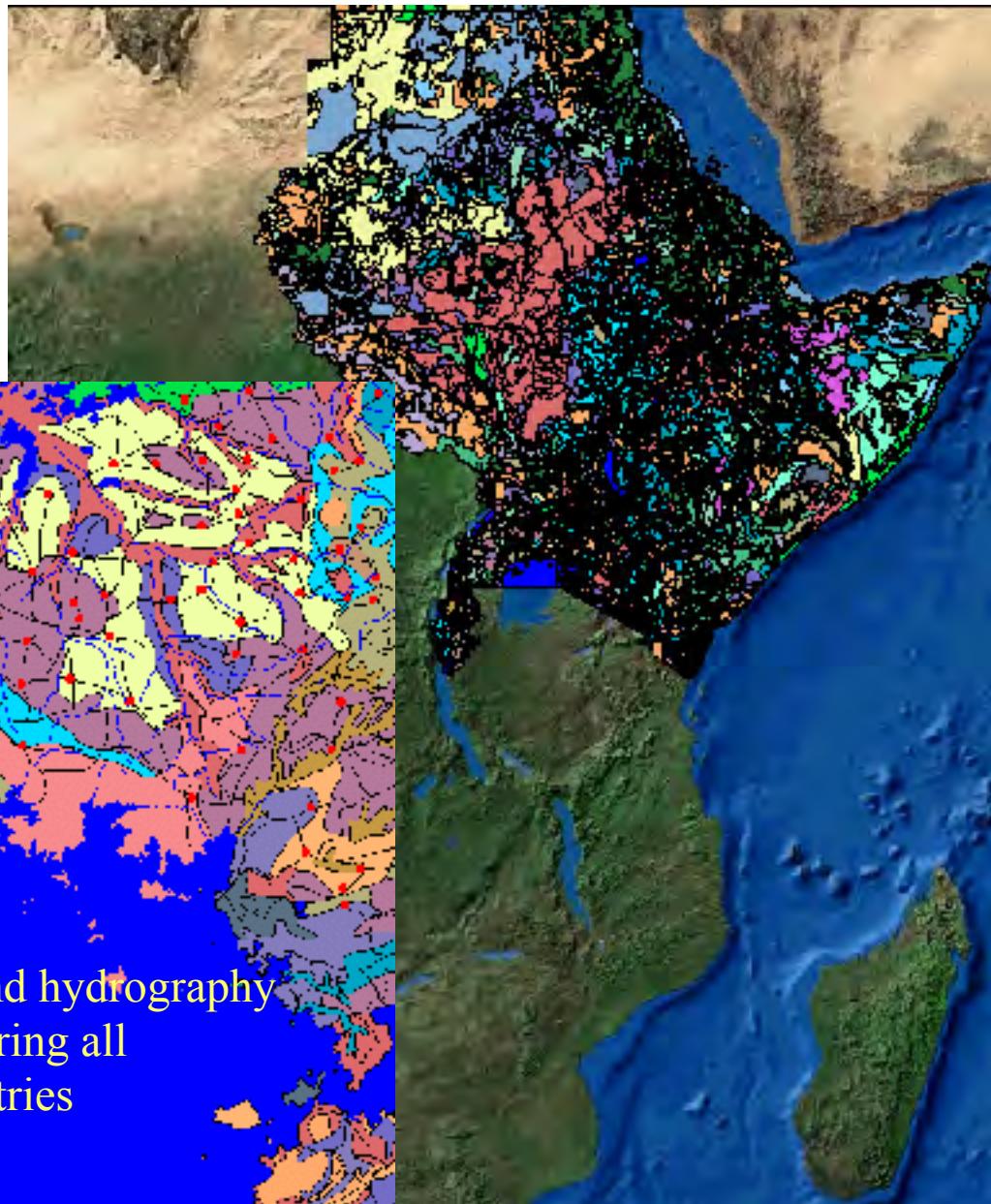
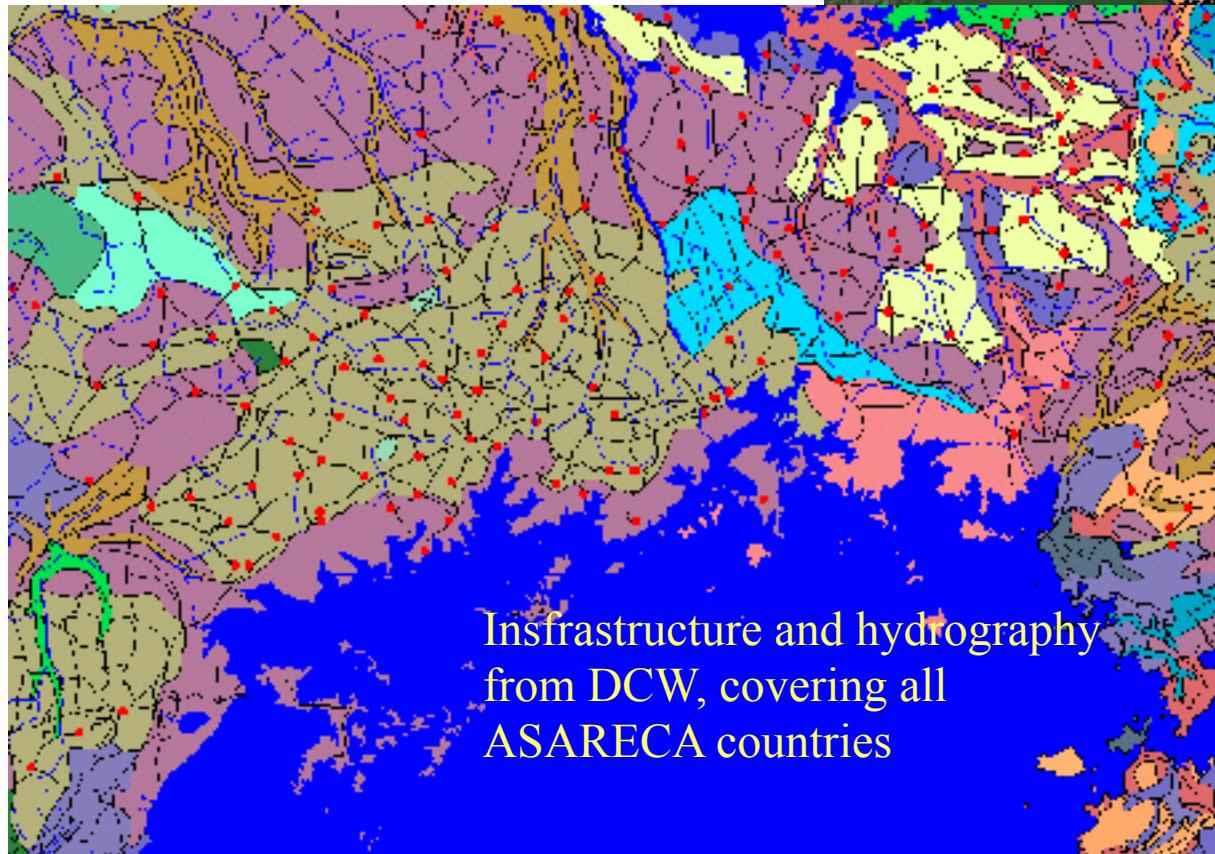
## Major Farming Systems

- 1. Irrigation
- 2. Tree crop
- 3. Forest based
- 4. Rice-tree crop
- 5. Highland perennial
- 6. Highland temperate mixed
- 7. Root crops
- 8. Cereal-root crops mixed
- 9. Maize mixed
- 11. Agro-pastoral millet/sorghum
- 10. Large commercial and smallholder
- 12. Pastoral
- 13. Sparse (arid)
- 14. Coastal artisanal fishing



# Soil type, fertility and erosion

FAO Soil map



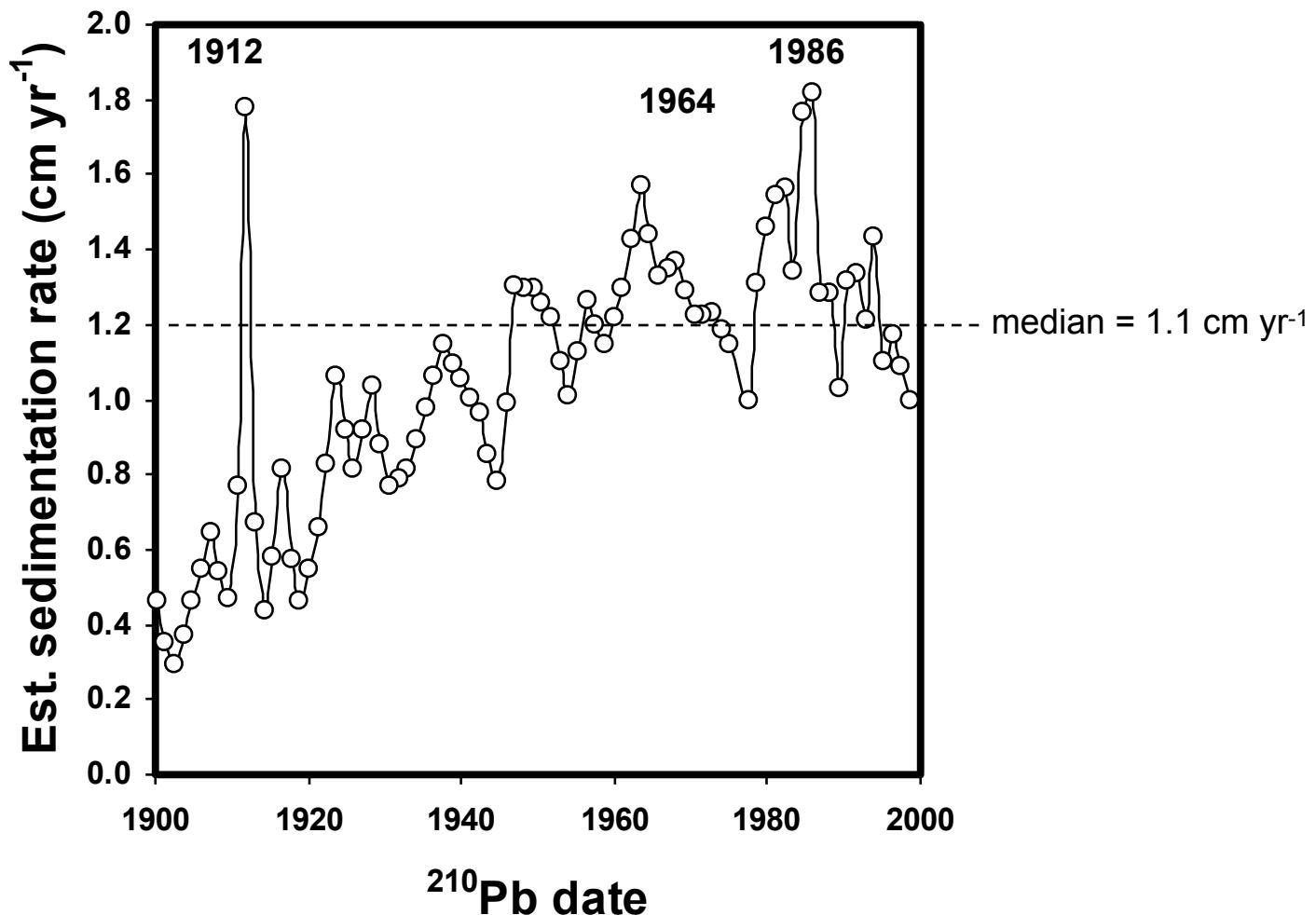
# **Soil type, fertility and erosion**

## Available data

- ✓ FAO soil map and derivates incl. soil depth (1: 1 million)
- ✓ Geological map (partial coverage - SADC countries and Ethiopia) (1: 1 million)
- ✓ Country specific more large scale maps
- ✓ Soil profile and sample data, and other baseline data

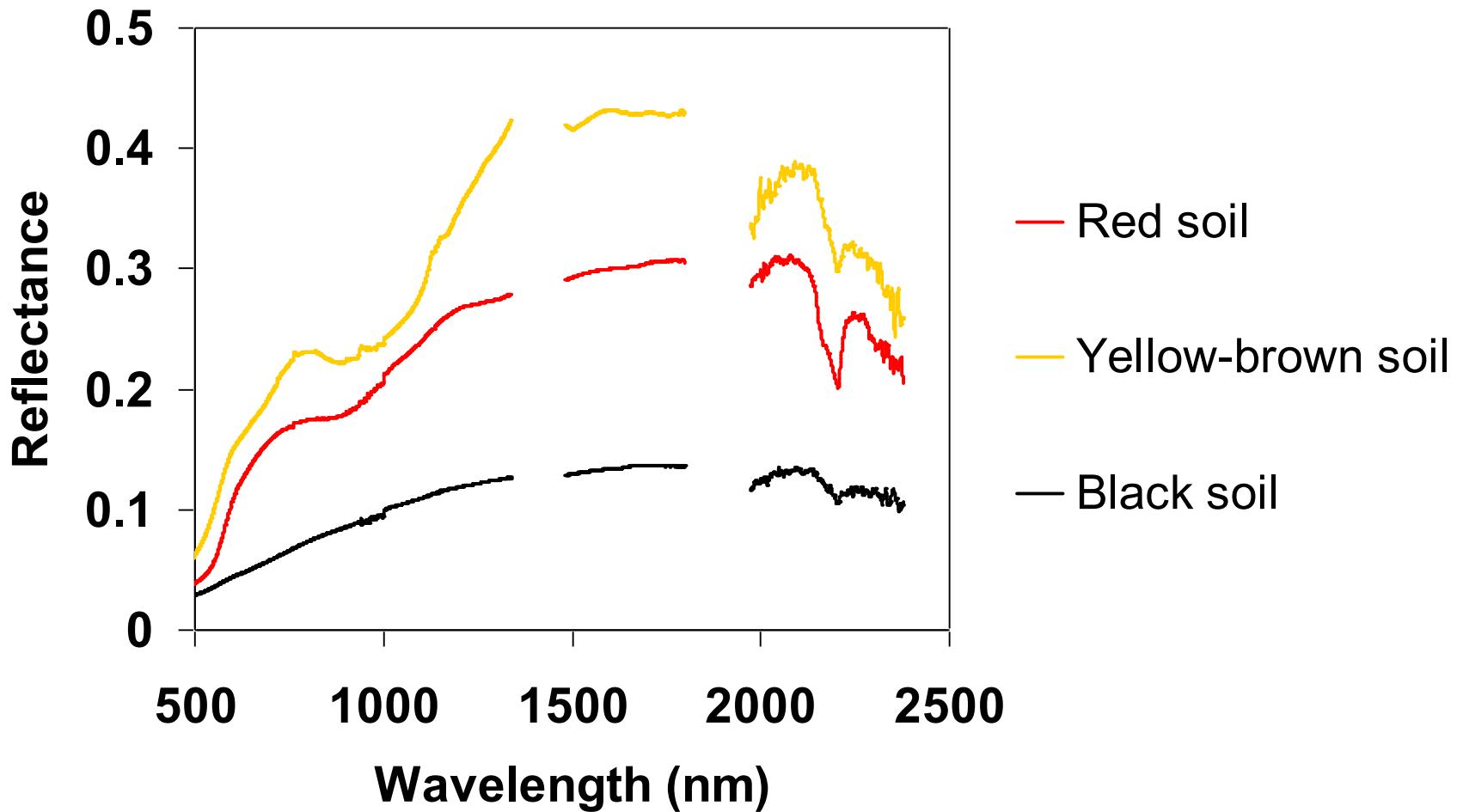
# Soil type, fertility and erosion

## Probable changes in sedimentation rates in the Nyando River Basin over the last 100 years



# Soil type, fertility and erosion

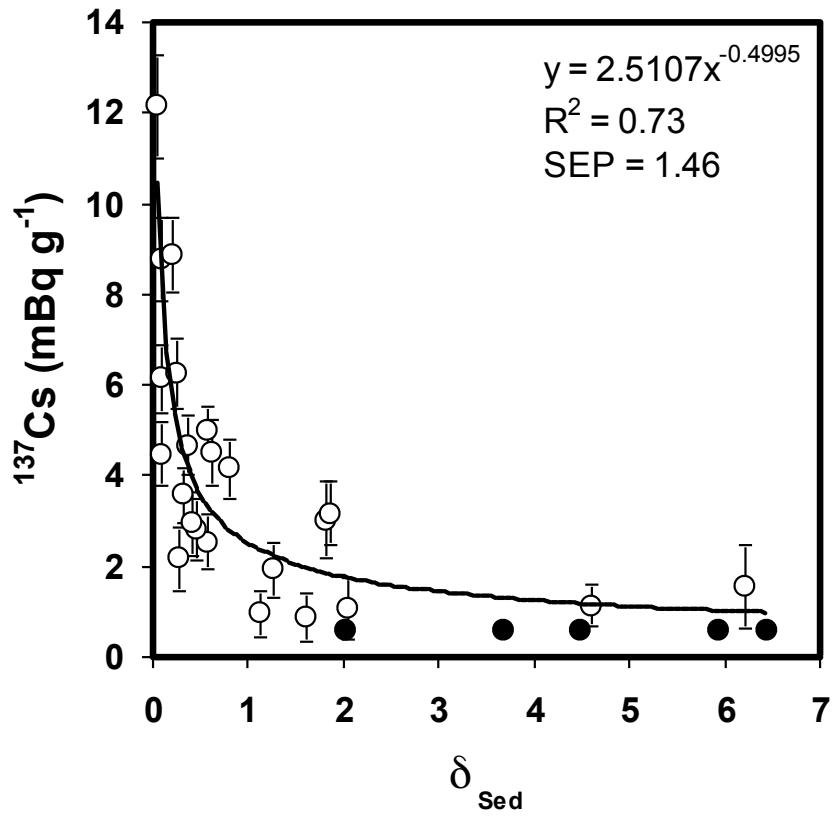
## Field spectrometry - Western Kenya Soils



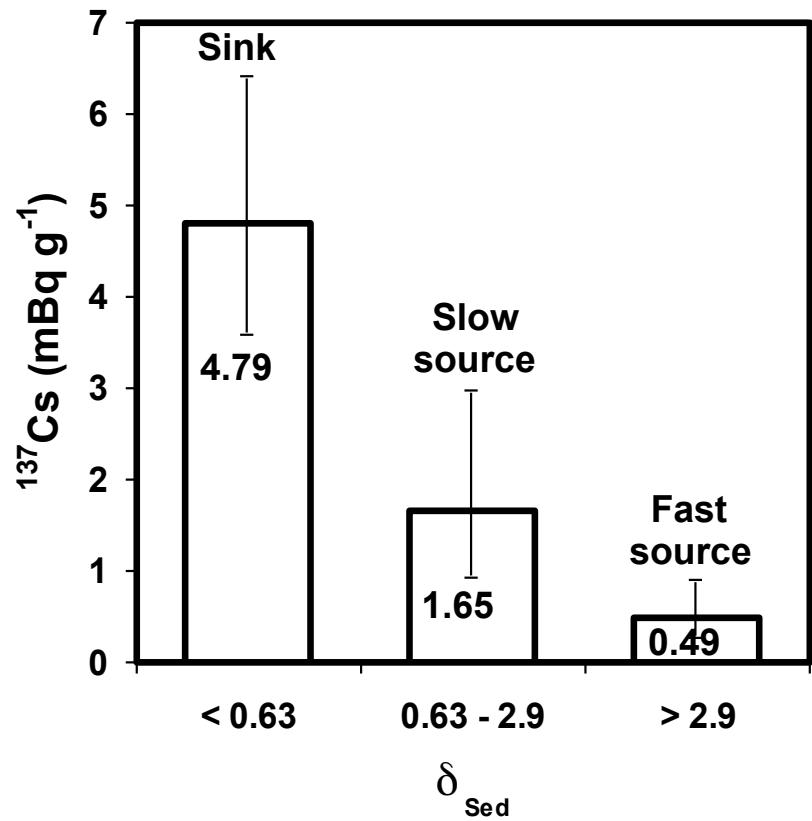
# Soil type, fertility and erosion

## Relationship between sediment-standardized reflectance ( $\delta_{\text{Sed}}$ ) and $^{137}\text{Cs}$ inventories of soils

Power function

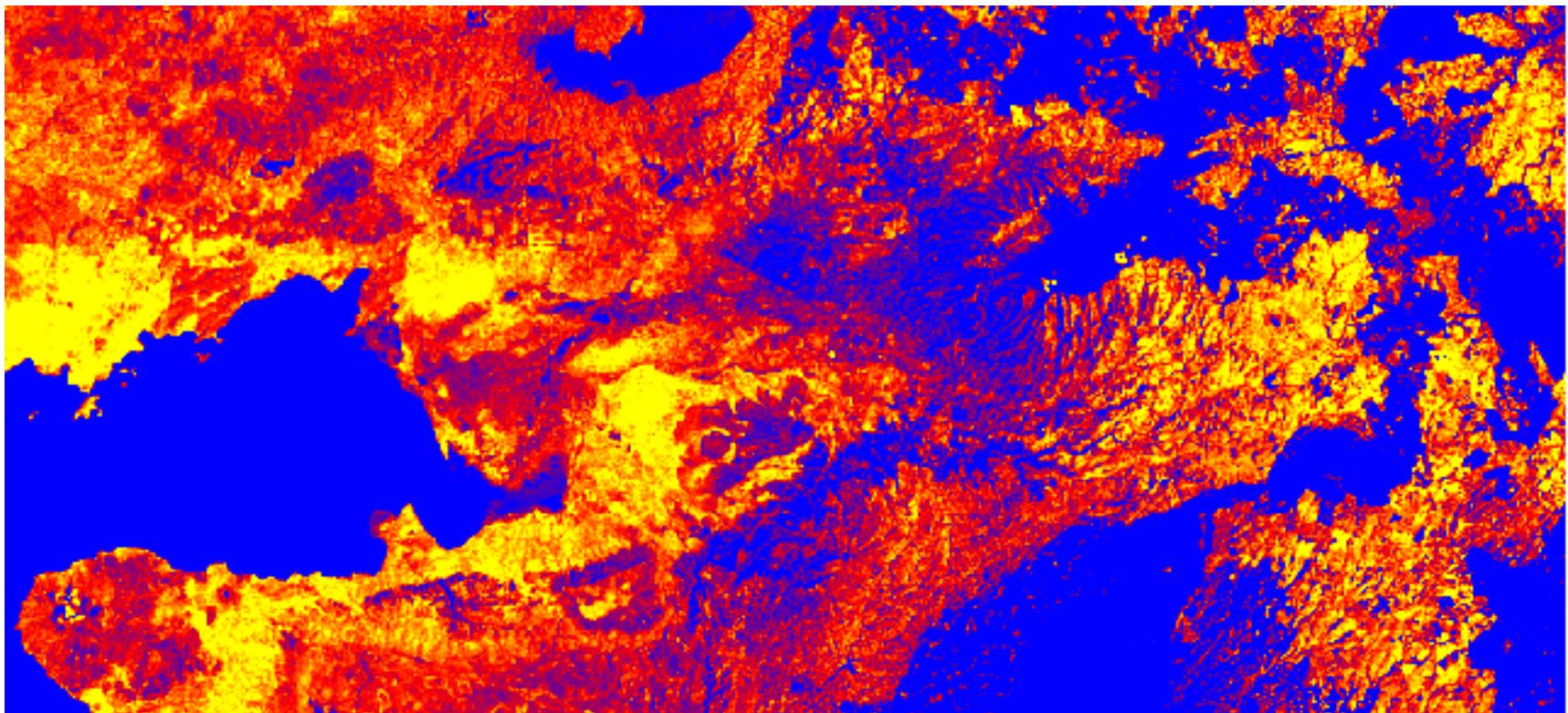


Erosion Phase Interpretation



# Soil type, fertility and erosion

Soil fertility and erosion can be mapped from spectral soil properties derived from Remote Sensing data



**Indicative distribution of sediment source potential in the Nyando River Basin.**  
(Interpretation based on Landsat ETM+ satellite image, Feb. 2000)

# **Soil type, fertility and erosion**

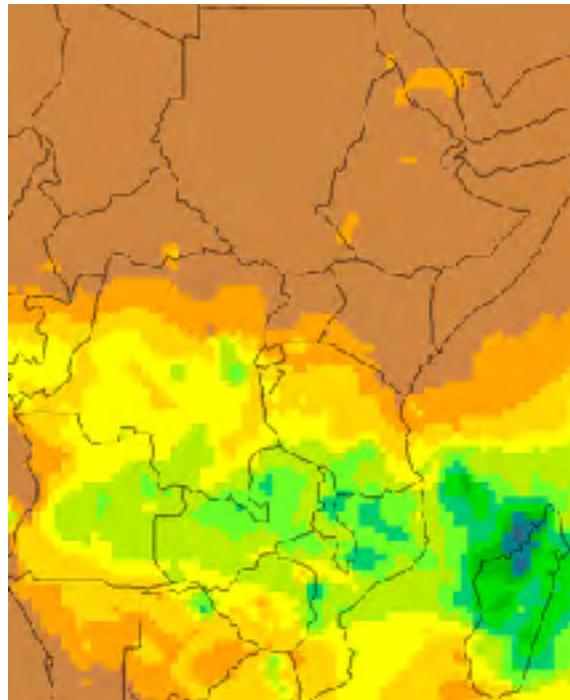
Can be improved by:

- Making use of archived soil profiles (new methods for scanning can be used for effective fertility analysis)
- Assembly and quality control of soil samples and other baseline data
- Erosion-transport-sedimentation surveys (incl. community based erosion pits)
- Ground surveys and Remote Sensing for mapping Soil Fertility from soil reflectance properties (EO-1 Hyperion, Landsat ETM, TERRA MODIS)

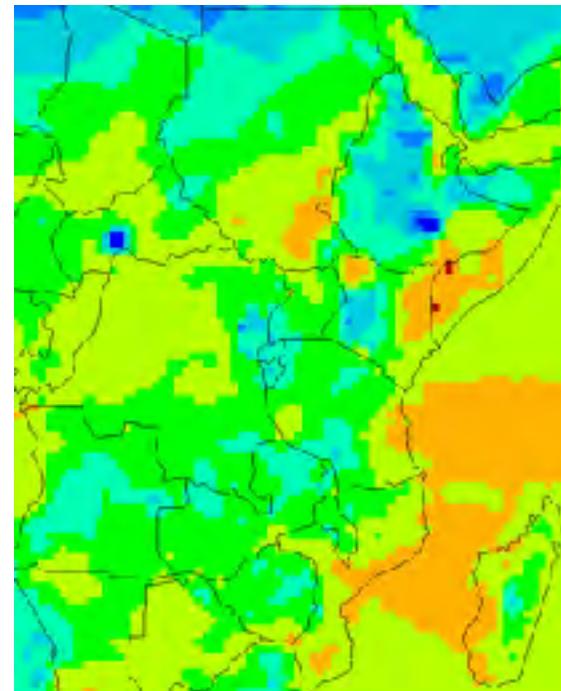
# Hydrology

Vertical water balance

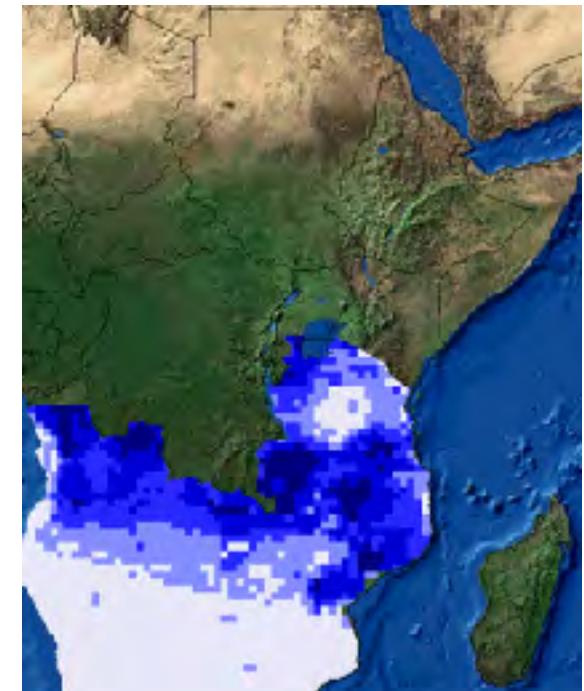
Rainfall



- Evapotranspiration =

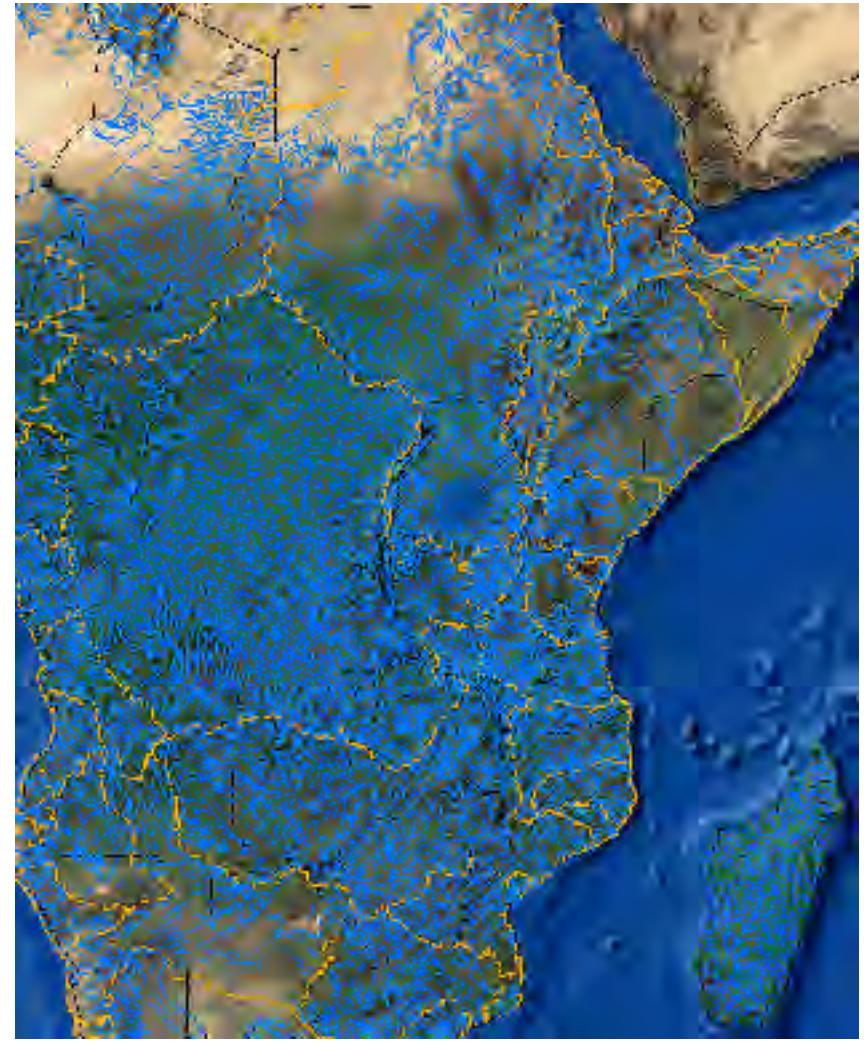


Net recharge



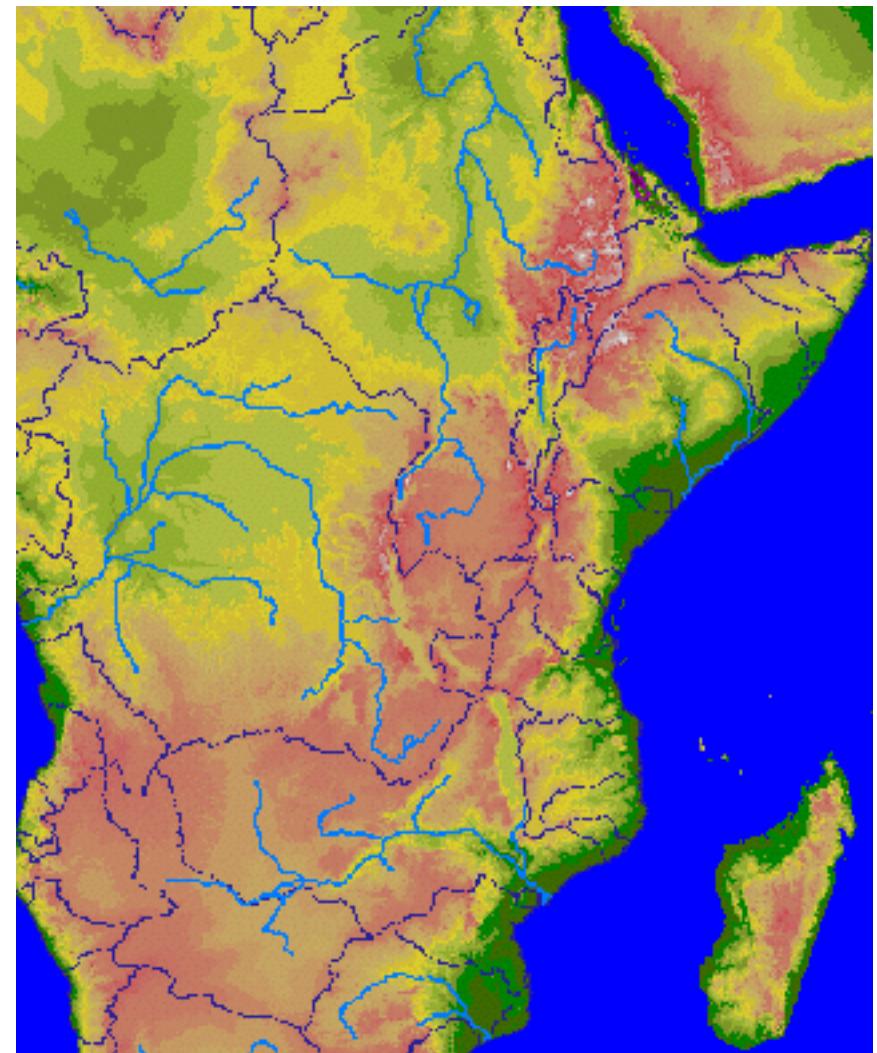
# Hydrology

Runoff in basins, forming a lot of small streams ...



# Hydrology

... forming large rivers. But the DEM is too poor for modeling.



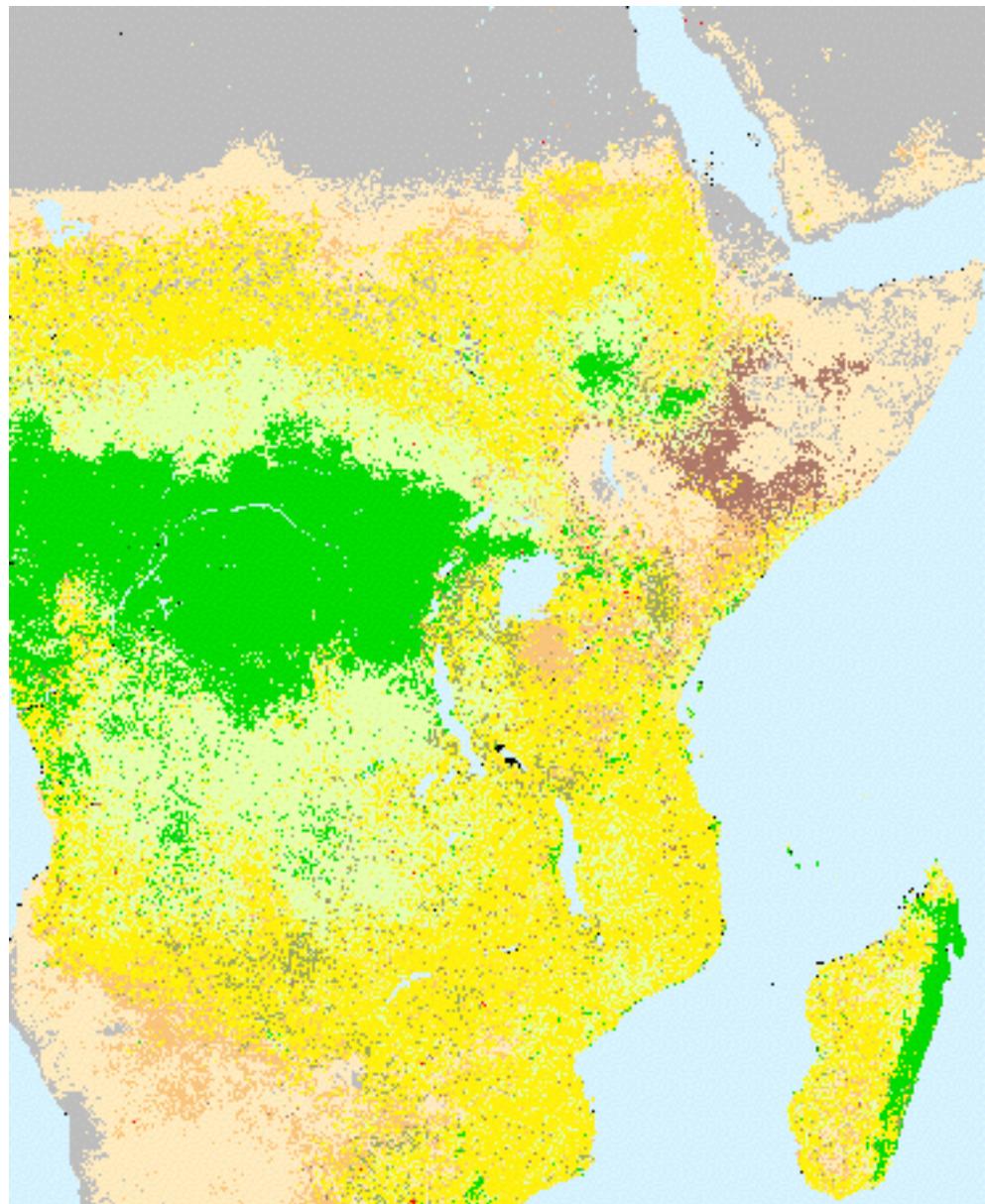
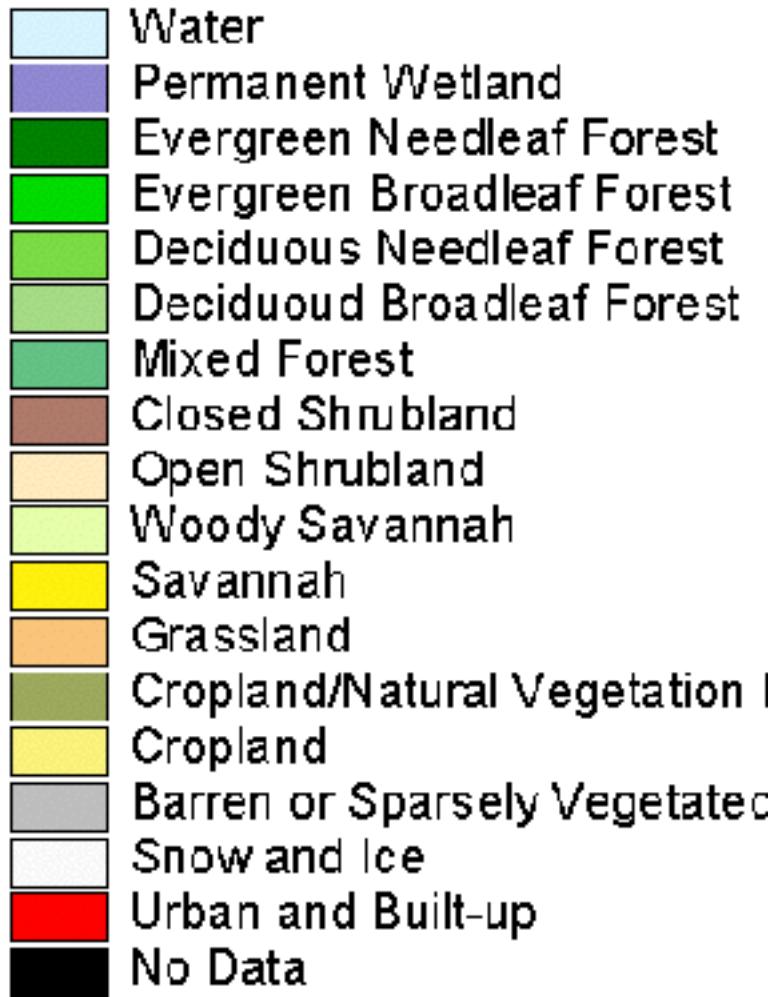
# Hydrology

Can be improved by:

- Assembly and quality control of runoff records
- New DEM derived from Remote Sensing (SRTM, or stereo pairs of TERRA-ASTER Images)
- Better estimates of precipitation and evapotranspiration
- Better estimates of soil hydraulic properties (incl infiltration capacity)

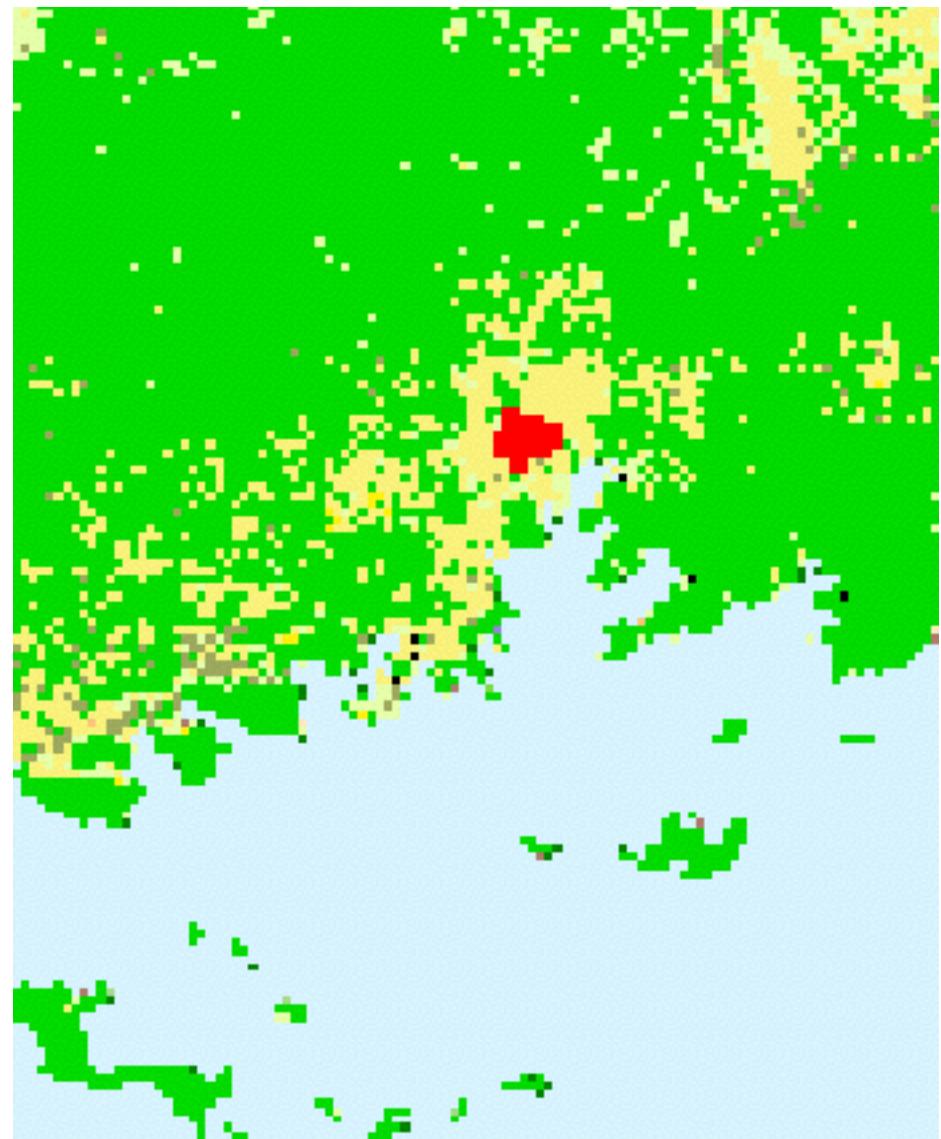
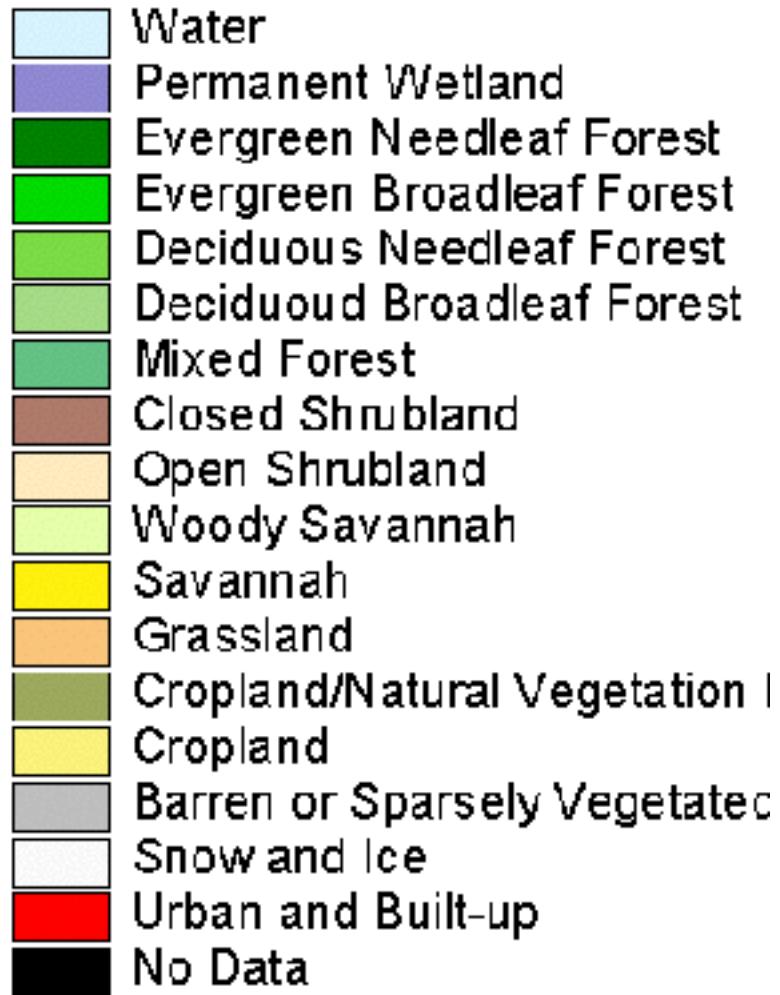
# Land use/cover

TERRA MODIS by NASA



# Land use/cover

## Detail over Entebbe



# **Land use/cover**

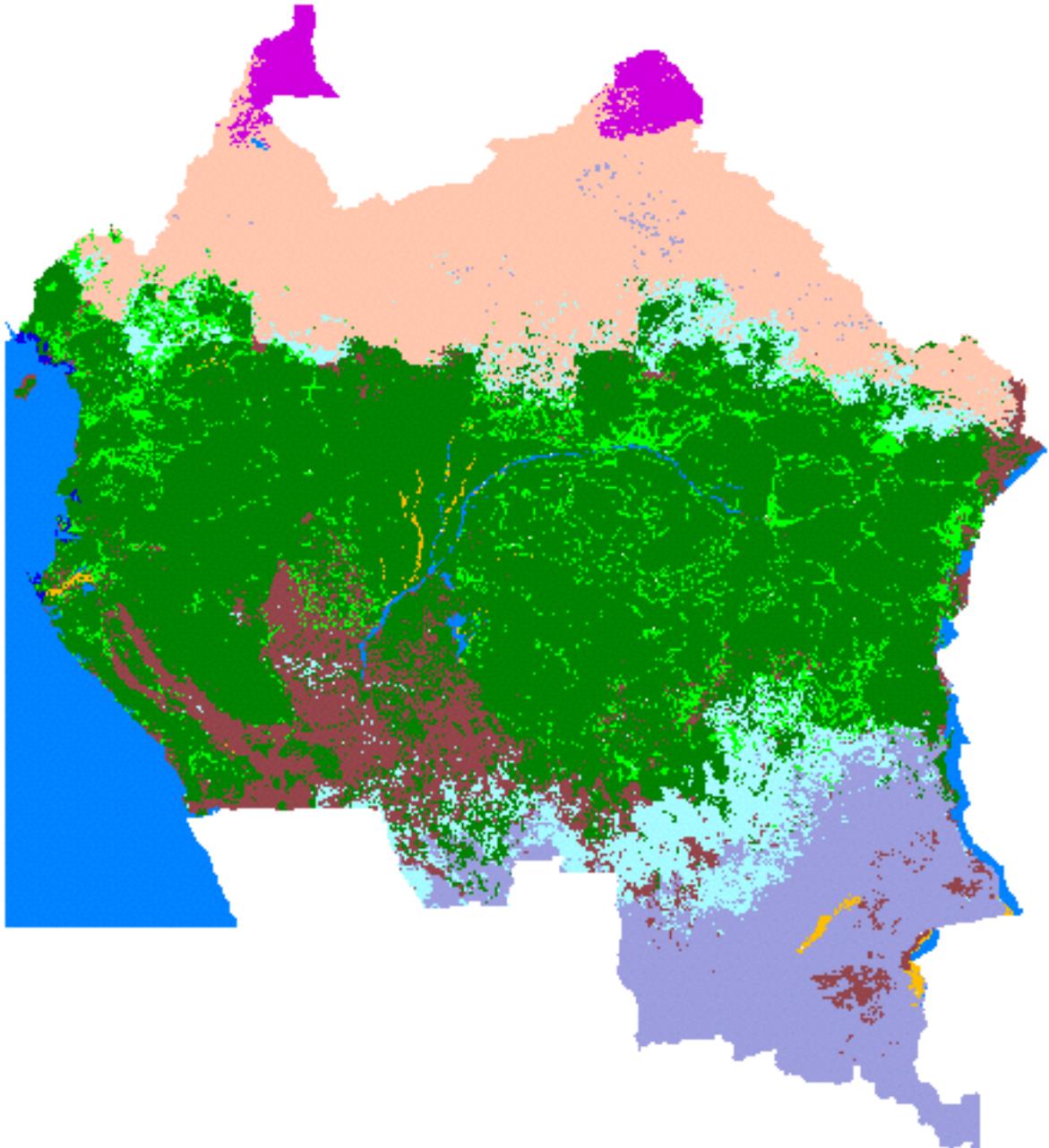
## Available data

- ✓ Global land cover classification from NOAA-AVHRR (1993)
- ✓ Global land cover classification from TERRA-MODIS (2000/01)
- ✓ Global tree cover from TERRA MODIS (2000)
- ✓ FAO Africover (not completed for all ASARECA countries)
- ✓ More detailed maps over selected regions
- ✓ Country specific datasets, including biomass projects in several countries

# Land use/cover

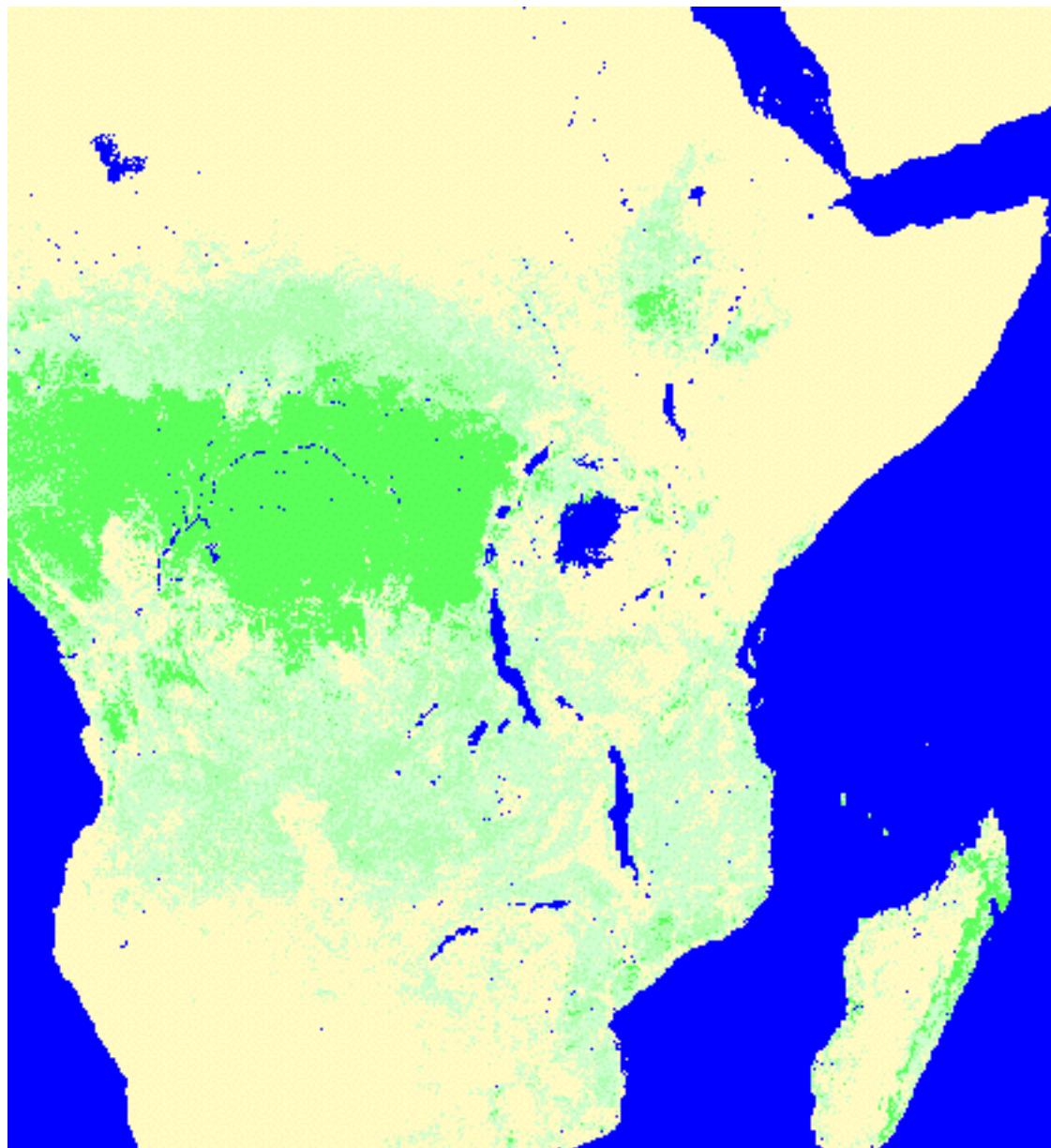
CARPE  
Vegetation map

- [Dark Green] Dense moist forest
- [Green] Secondary forest
- [Light Blue] Forest/ savanna mosaic
- [Purple] Woodland
- [Orange] Woodland & tree savanna
- [Brown] Grasslands
- [Dark Blue] Mangroves
- [Yellow] Swamp grassland
- [Magenta] Shrubs and steppe
- [Light Blue] Water
- [Dark Blue] Ocean



# Land use/cover

TERRA MODIS  
tree cover  
(annual update)



# **Land use/cover**

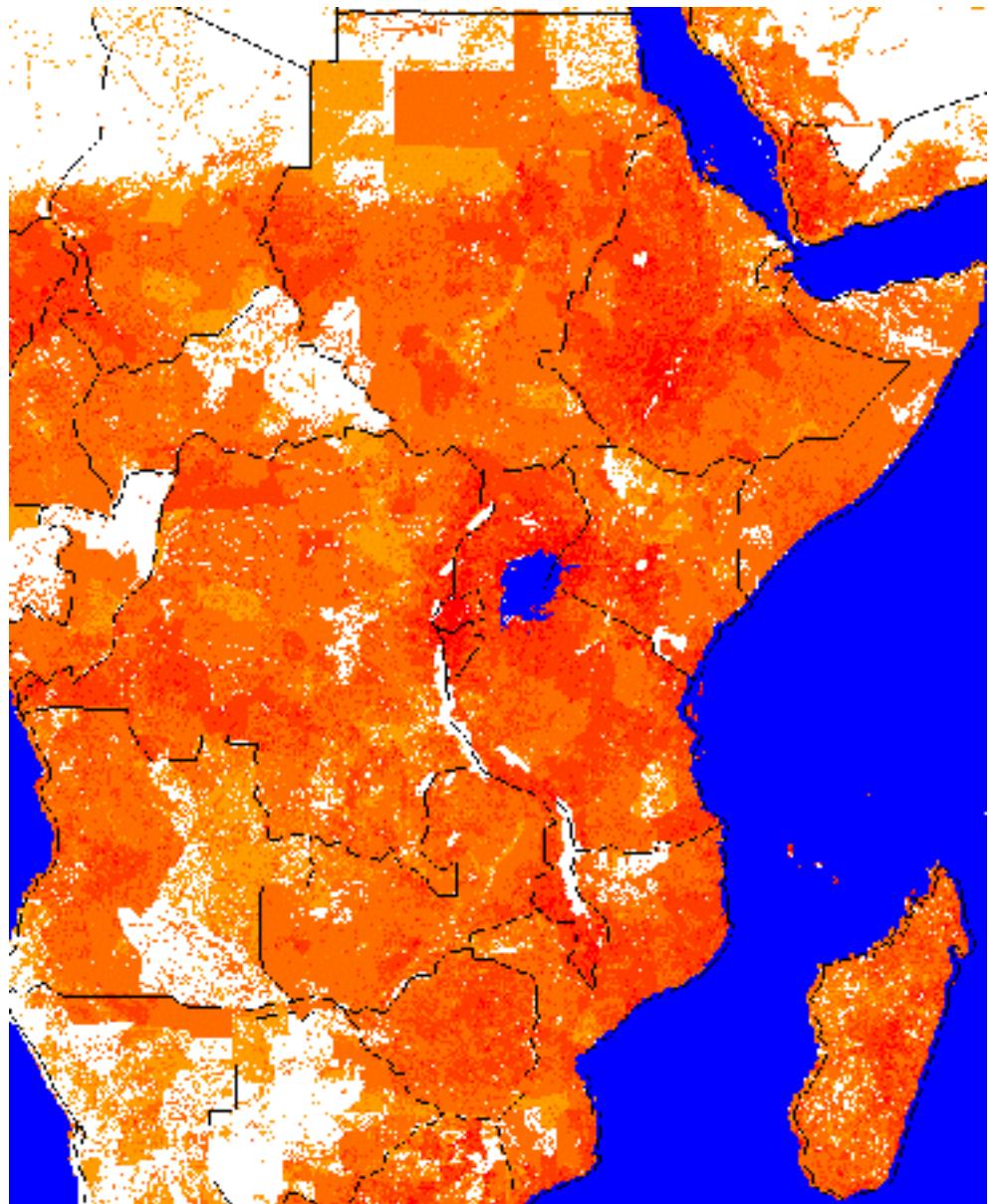
Can be improved by:

- Existing maps
- Remote Sensing snapshots (Landsat (E)TM) and timeseries (NOAA-AVHRR, TERRA\_MODIS) combined with GIS data (soil, climate, elevation, slope, aspect, infrastructure). I.e. certain crops only exists in narrow ranges of temperature and soils etc.

# Population and socio-economic data

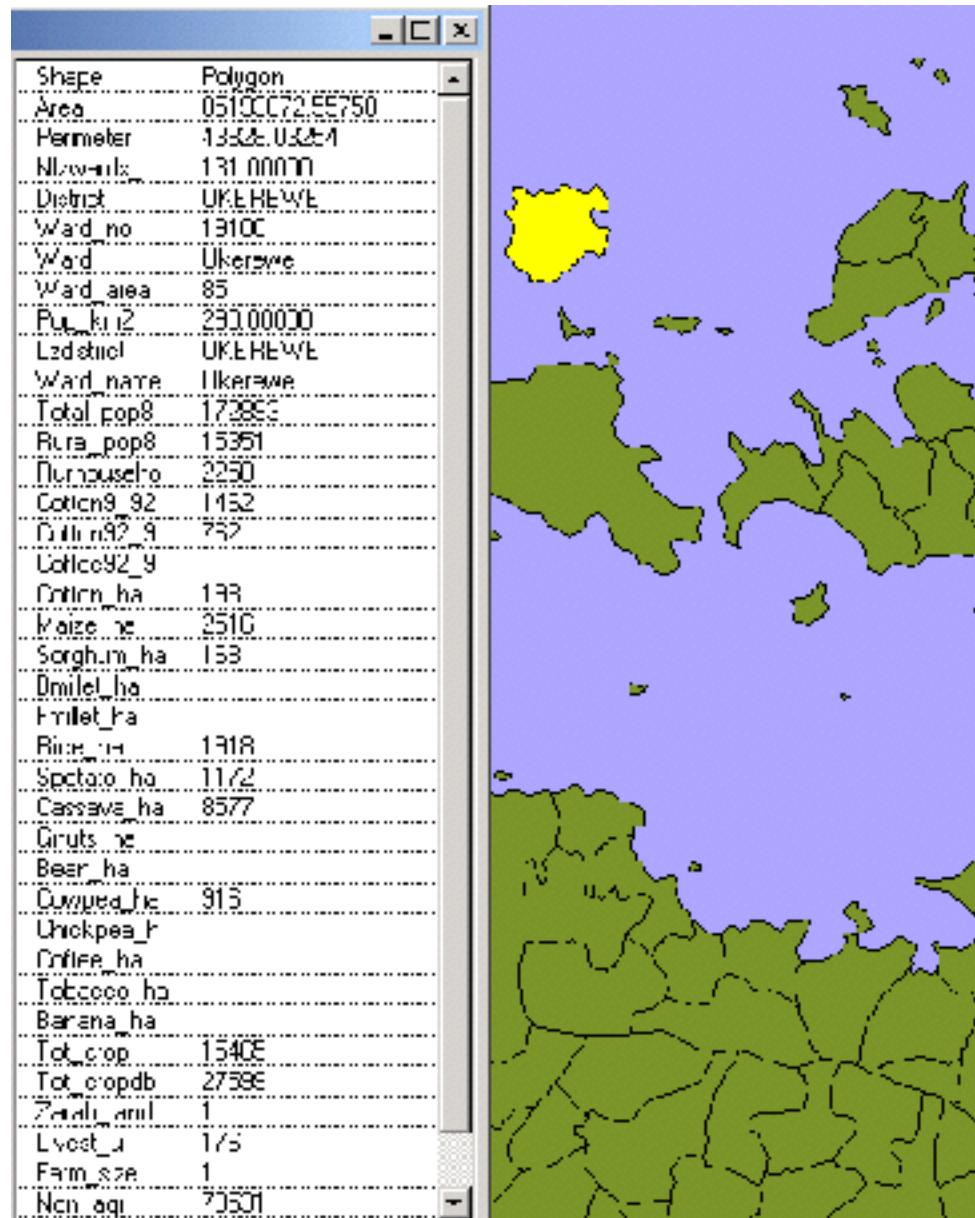
Available

- ✓ Estimations of population densities going back to the 1960s
- ✓ FAO
- ✓ CIESIN
- ✓ LANDSCAN (shown)
- ✓ Socio-economic data down to ward level (varying between countries)



# Population and socio-economic data

Socio-economic data down to ward level in some countries.



# **Population and socio-economic data**

Can be improved by:

- Census
- Assembly and quality control of official data
- Very High resolution Remote Sensing techniques
- Statistical methods for distributing lumped data to spatial datasets (e.g. of land cover, population etc)

# Remote Sensing data

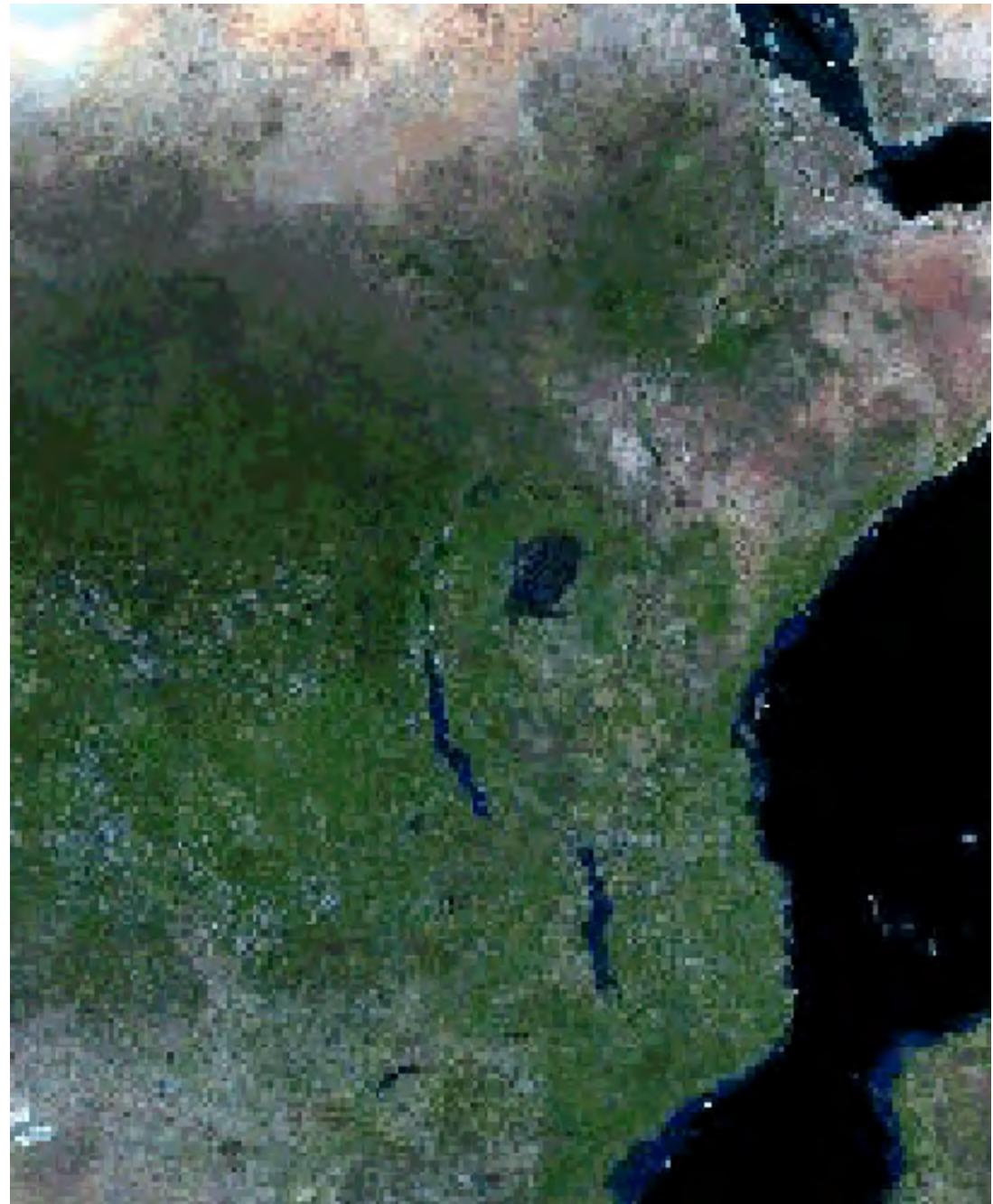
## Available data

- ✓ 1 full coverage Landsat ETM (30 m resolution) (2000)
- ✓ 1 full coverage Landsat TM (30 m resolution) (1980-2000)
- ✓ 6 full coverages TERRA MODIS composite scenes (500 m resolution) (2000/01) (the animation you saw)
- ✓ 93 full coverage NOAA-AVHRR composites (1 km resolution) (1993/96)
- ✓ 2 partial coverage (Lake Victoria, White Nile and Congo basin) JERS radar composite scenes (100 m resolution) (1996/97)

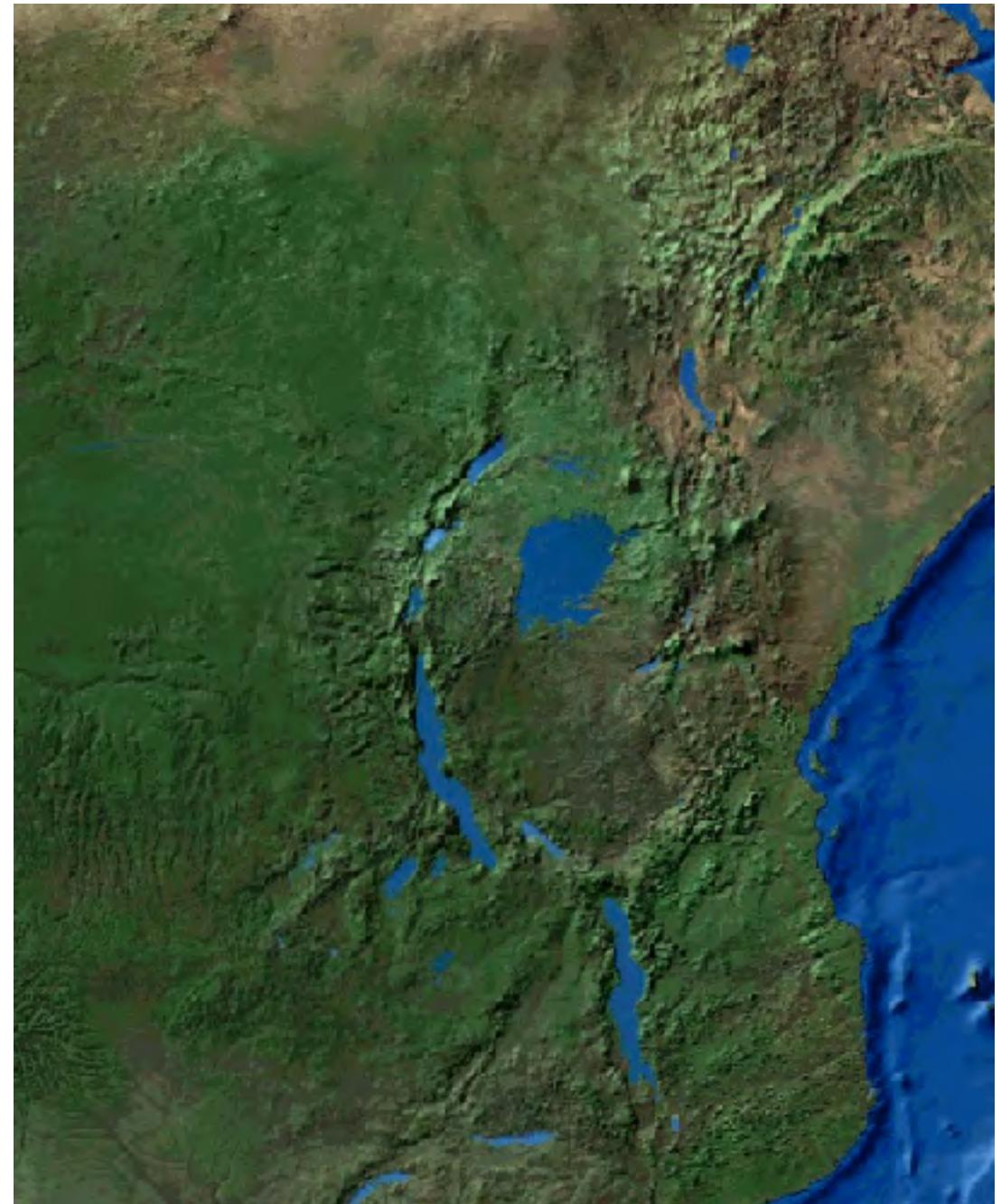
# Remote Sensing: TERRA MODIS



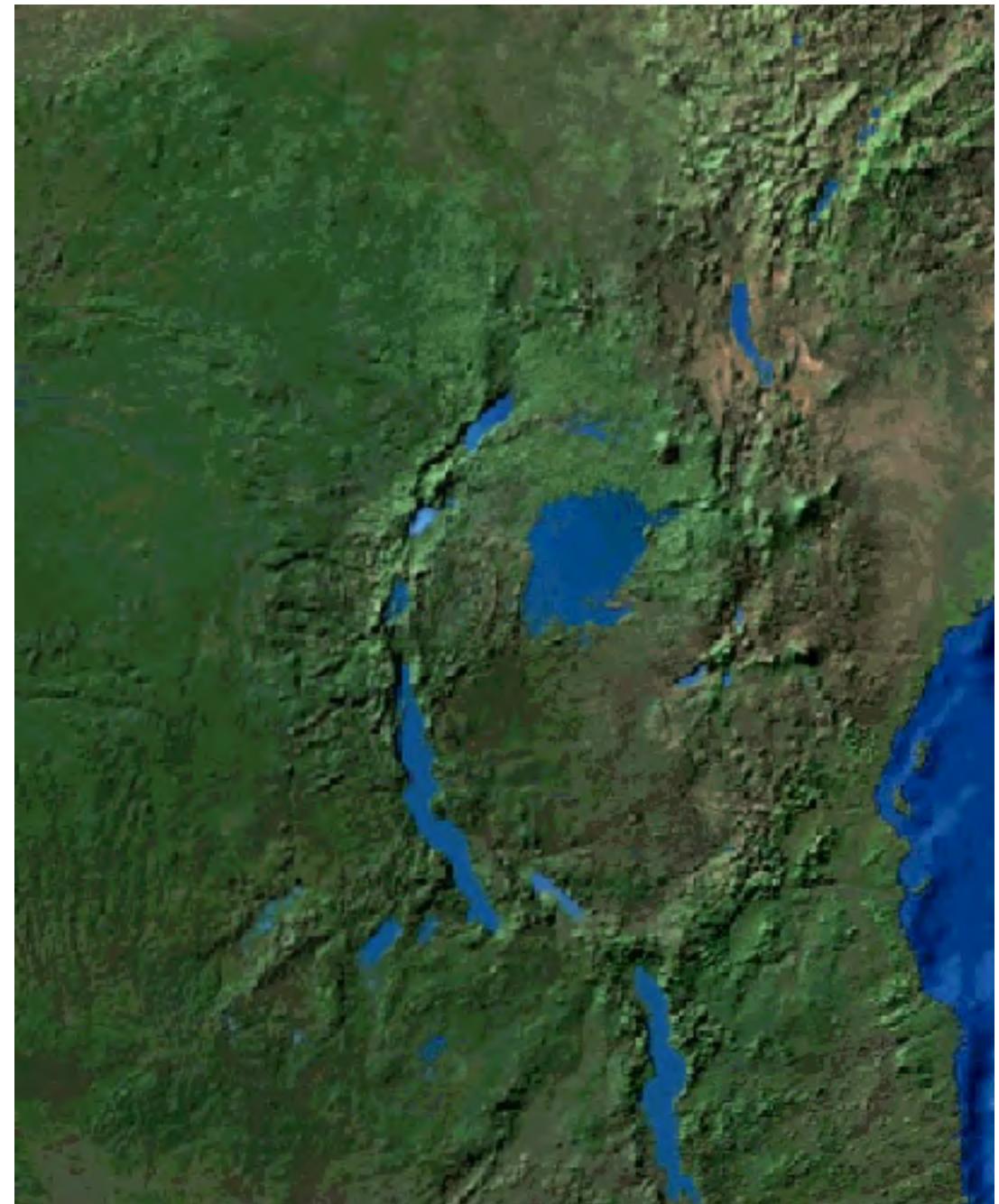
# Remote Sensing: TERRA MODIS



# Remote Sensing: NOAA AVHRR



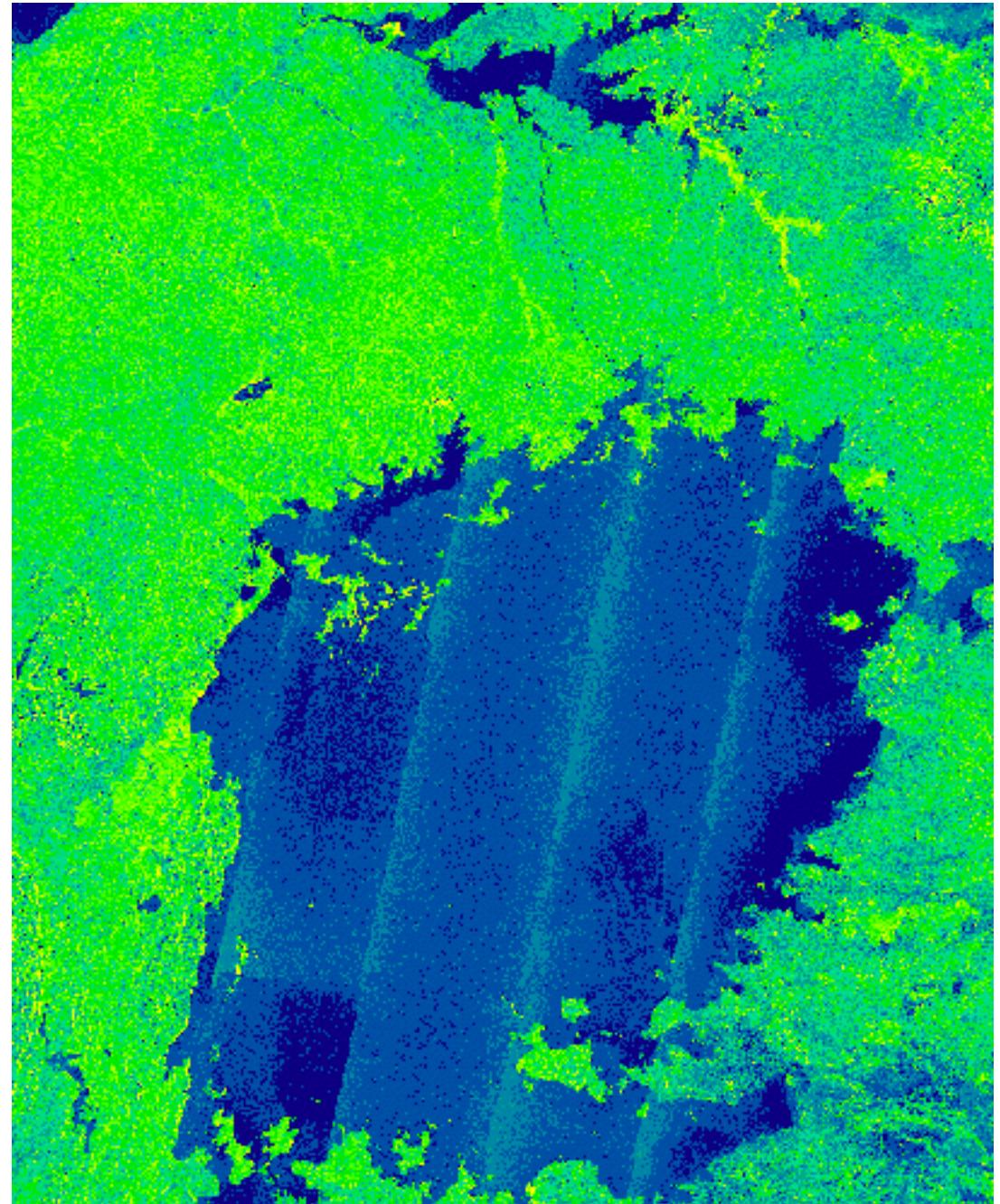
# Remote Sensing: NOAA AVHRR



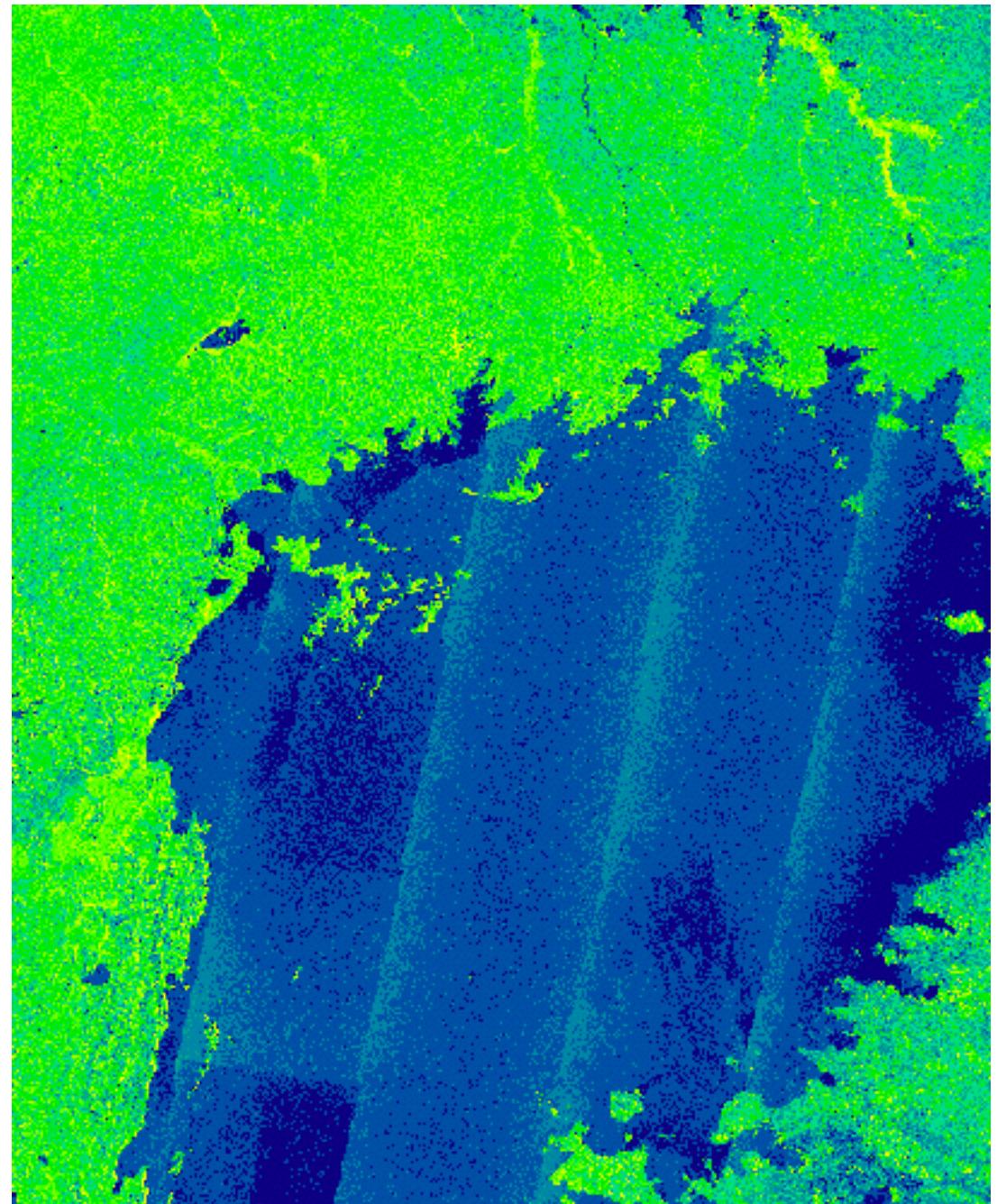
Remote Sensing:

JERS SAR

“Sees” through clouds

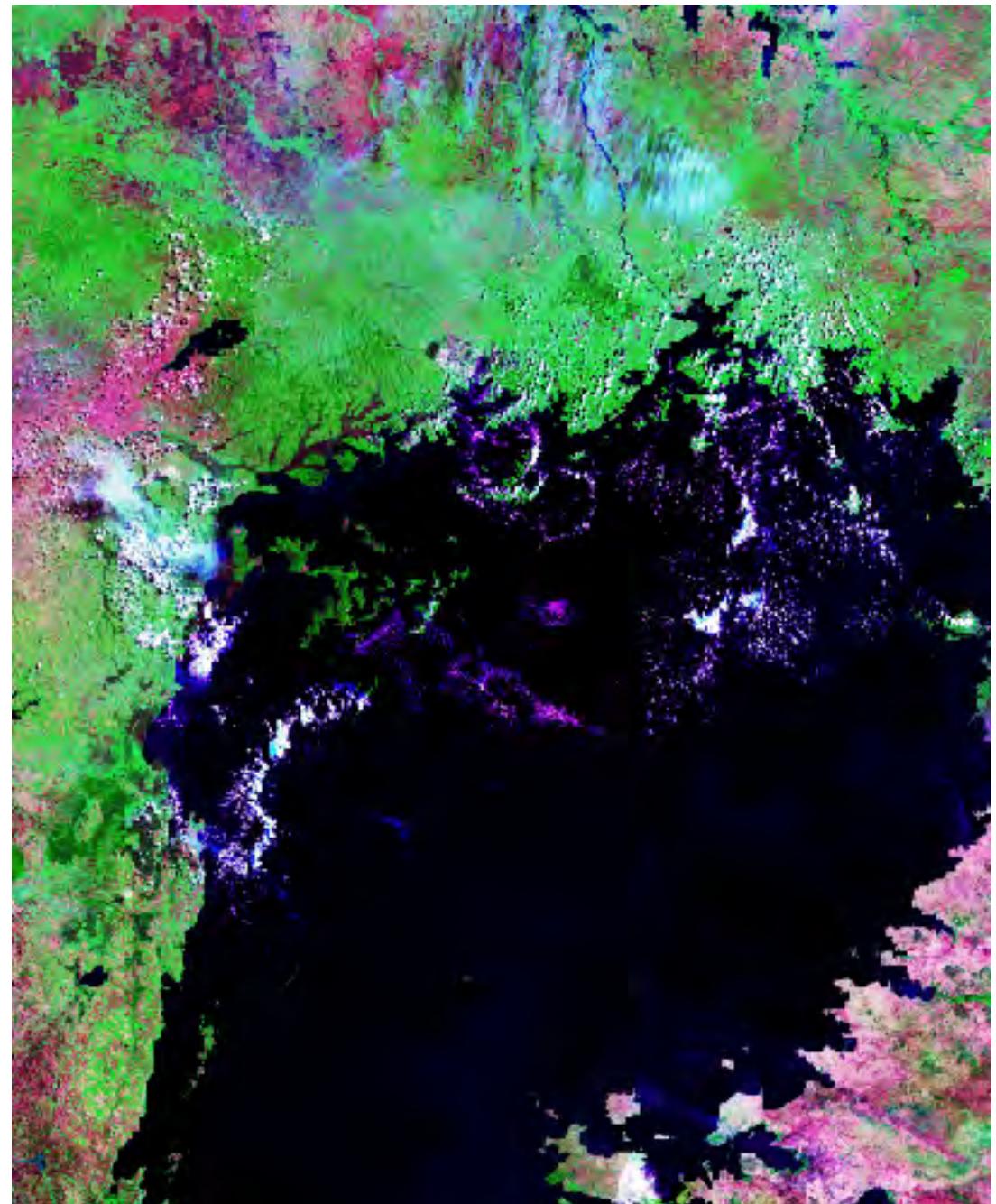


# Remote Sensing: JERS SAR

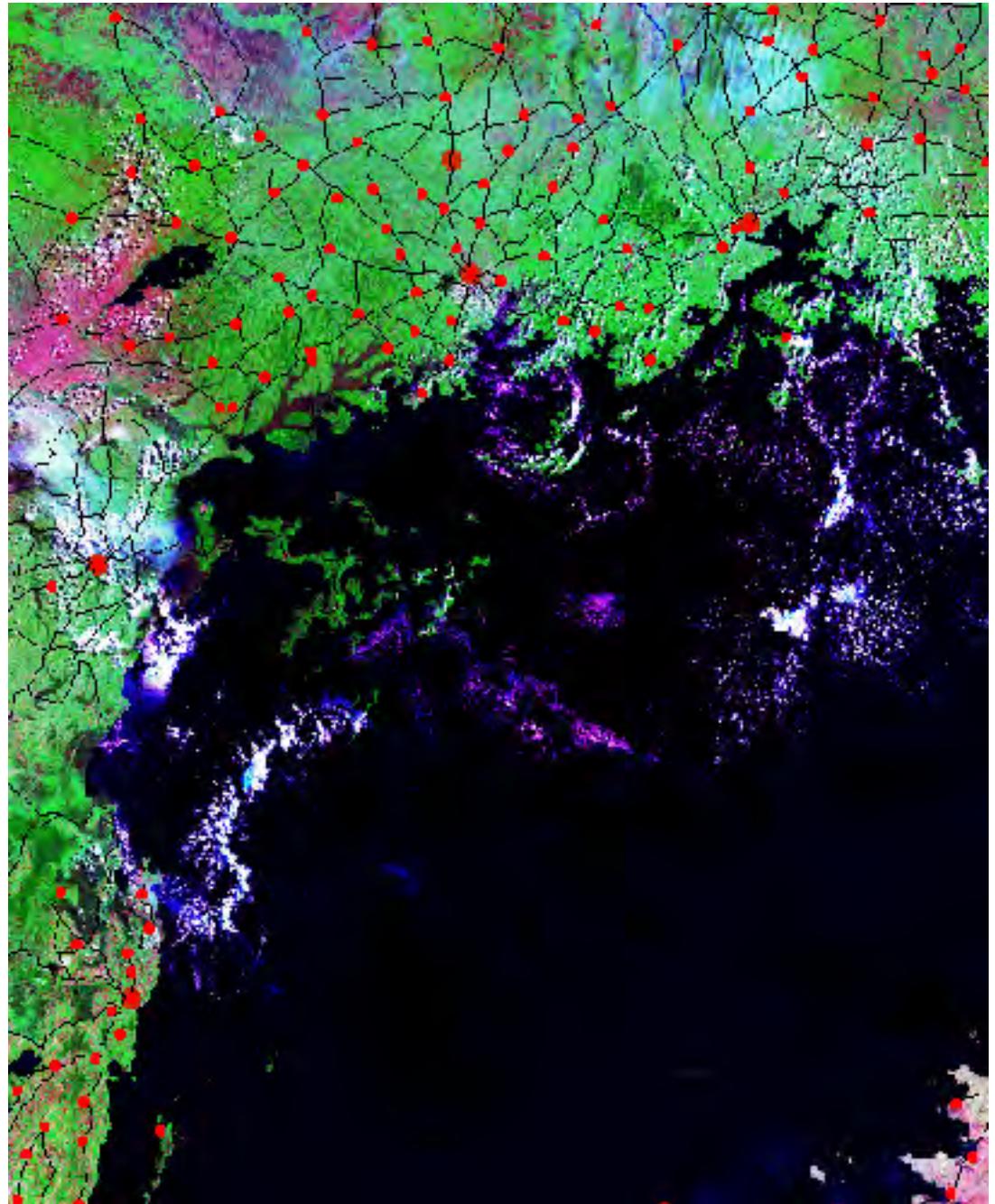


# Remote Sensing:

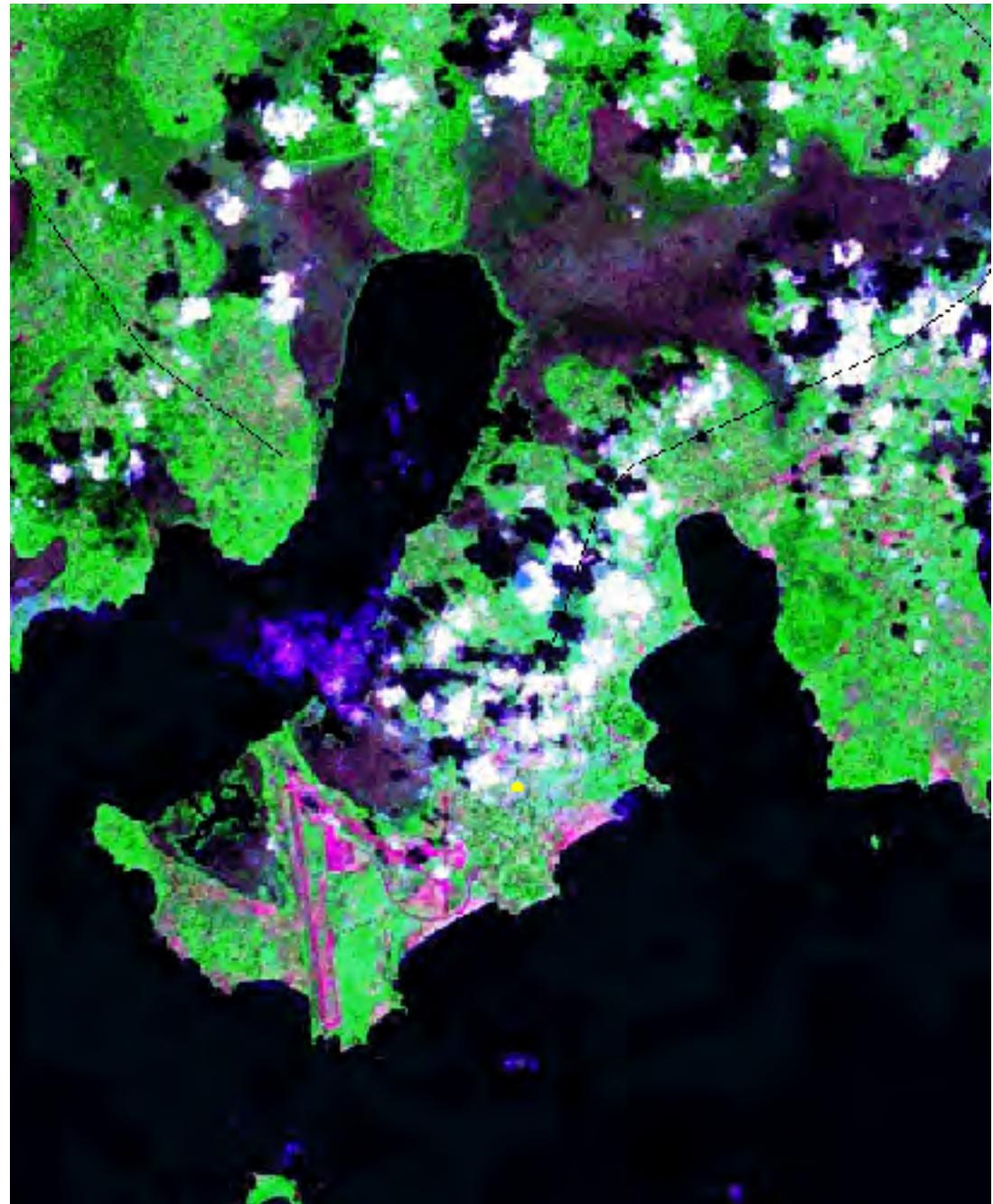
## Landsat TM



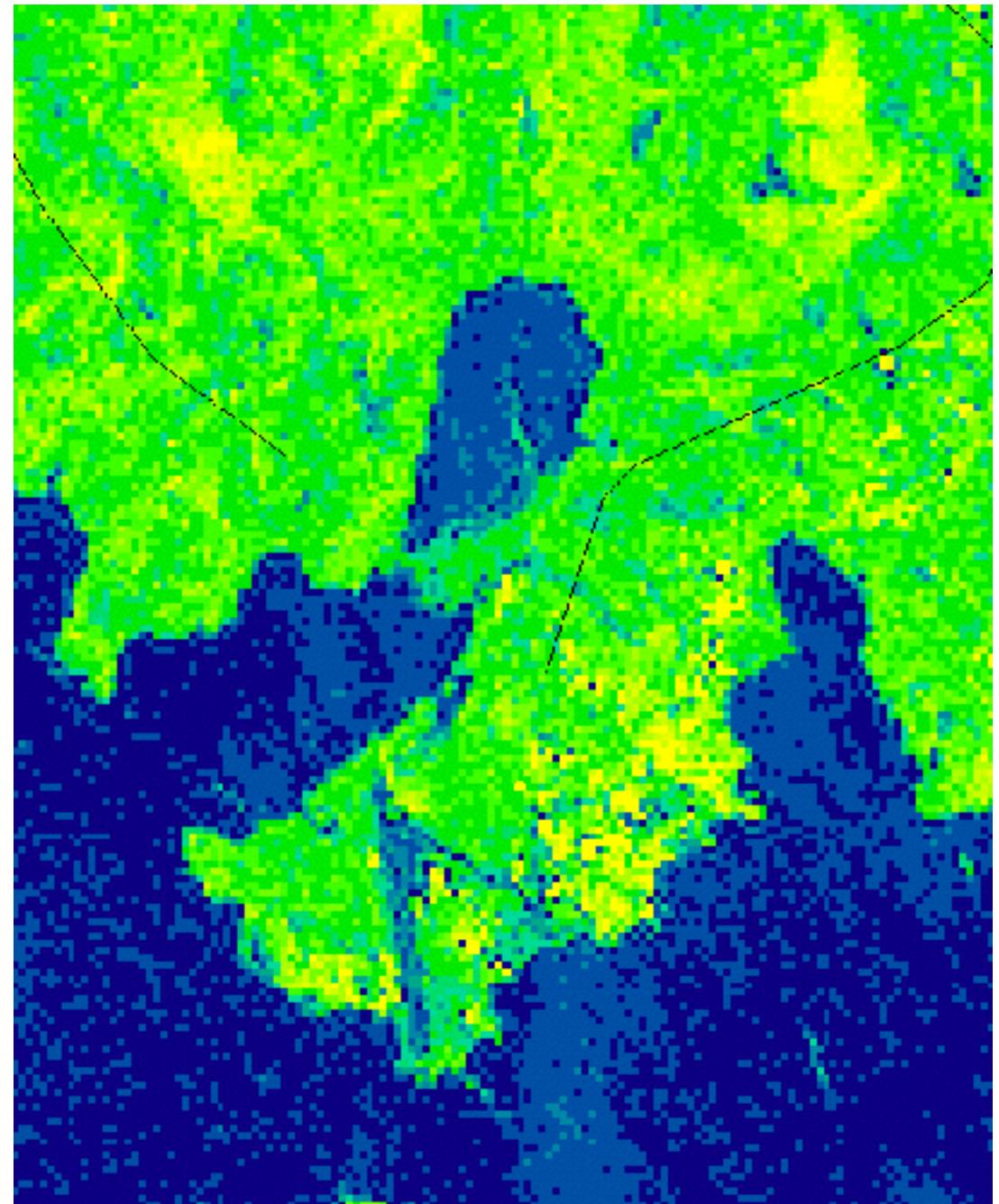
Remote Sensing:  
Landsat TM  
Infrastructure from DCW  
(for all ASARECA  
countries)



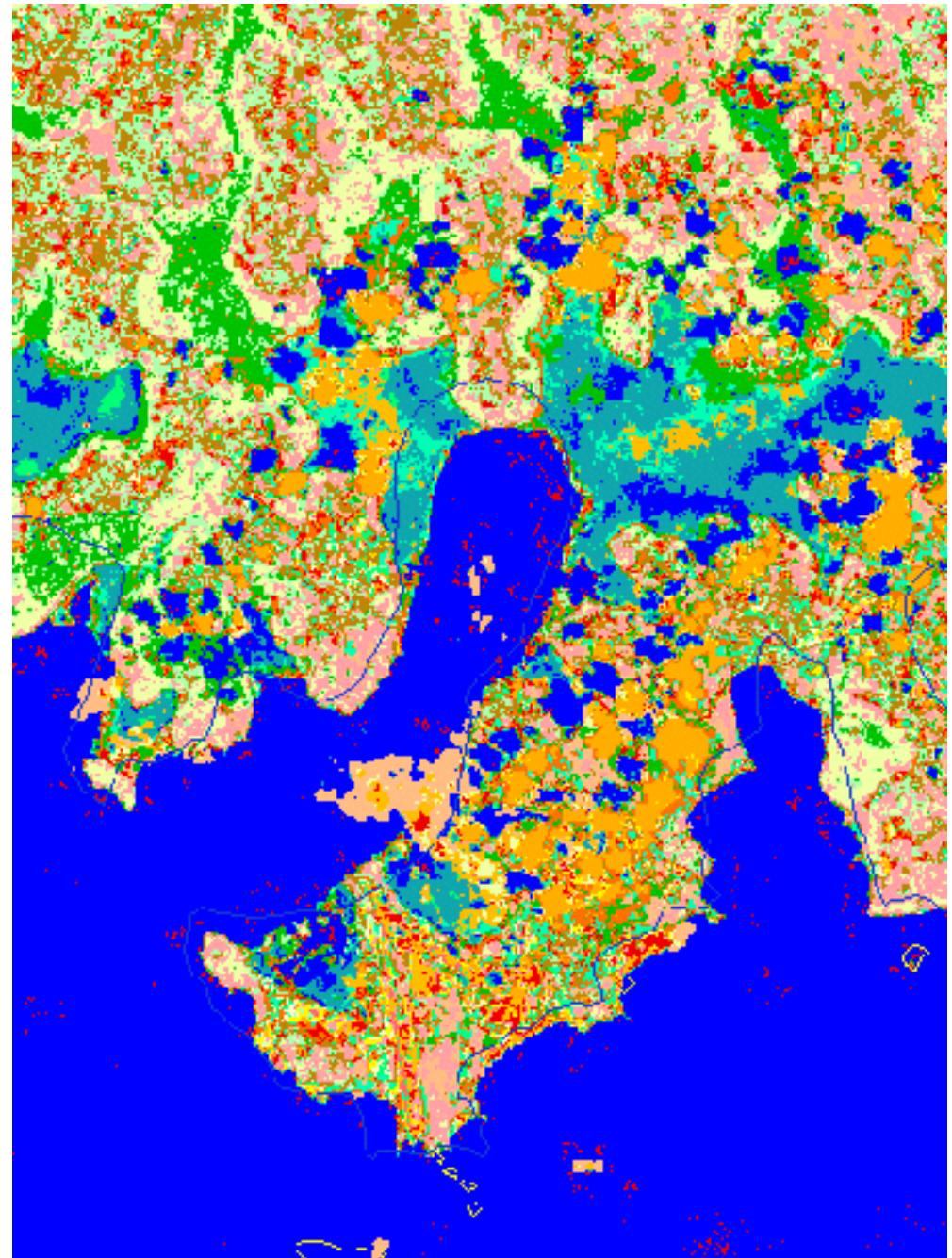
Remote Sensing:  
Landsat TM  
Entebbe airport



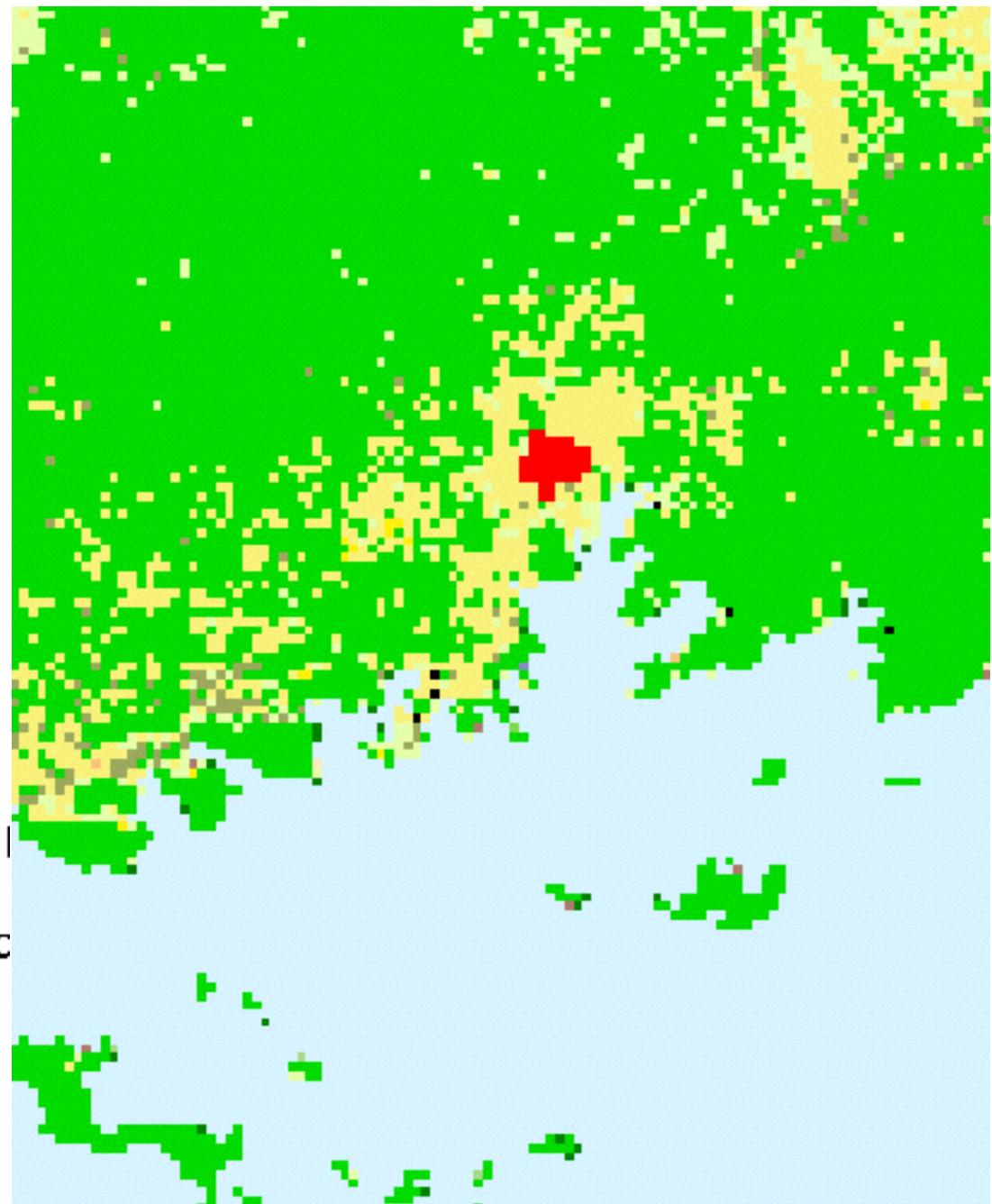
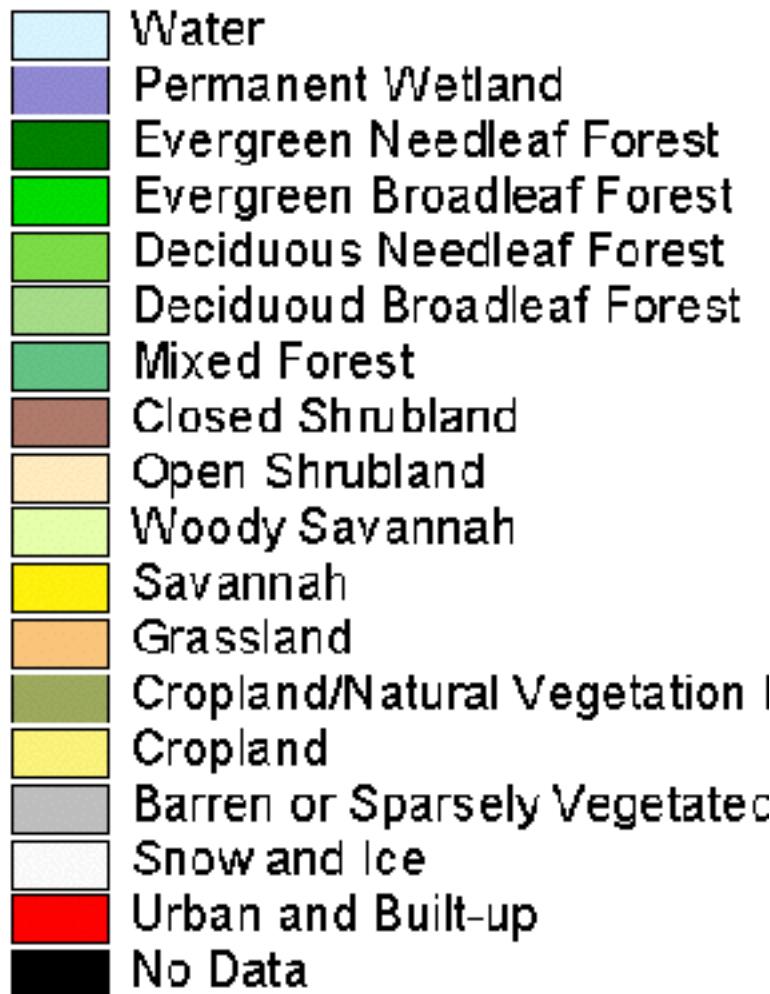
Remote Sensing:  
JERS SAR  
Entebbe airport



Remote Sensing:  
Landsat TM  
Classification (uncoded)  
The ‘water’ on land is  
from cloud shadows.

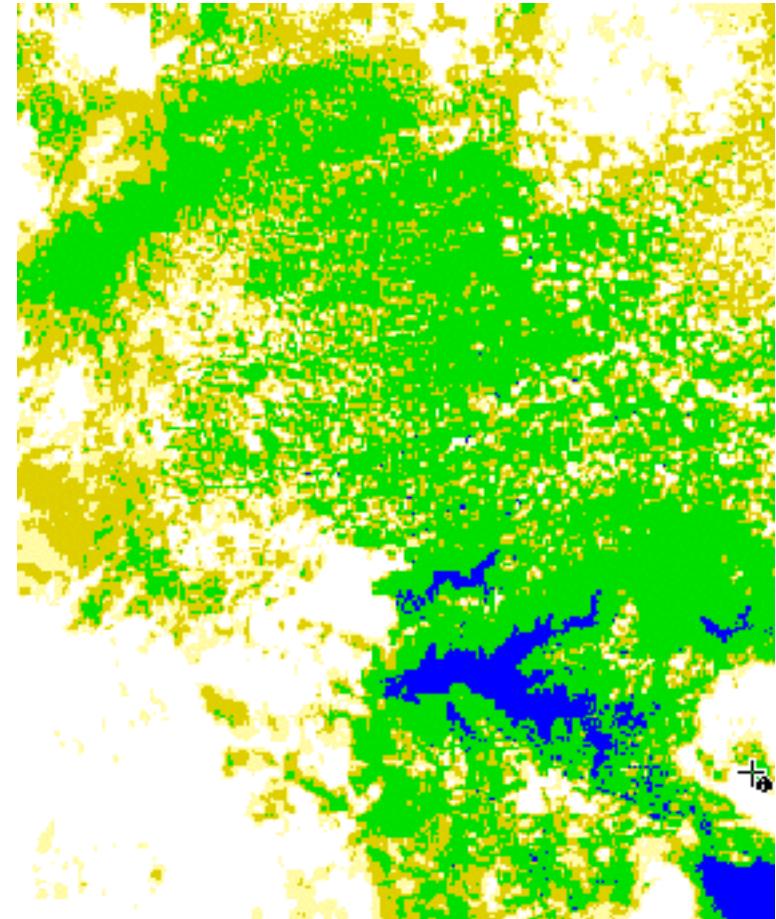
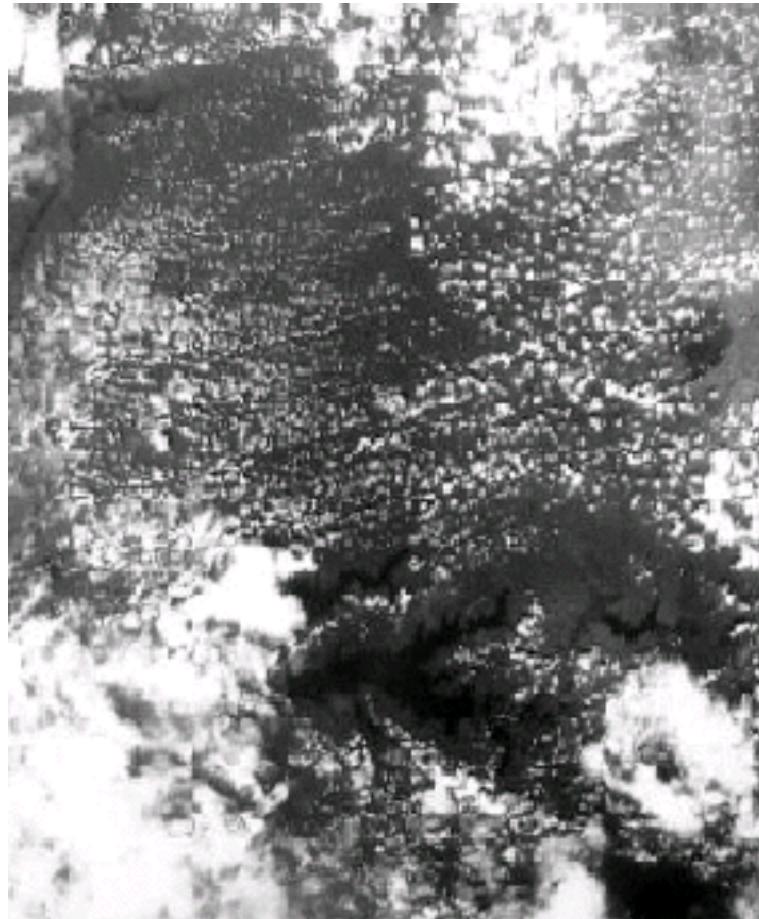


# TERRA Landcover



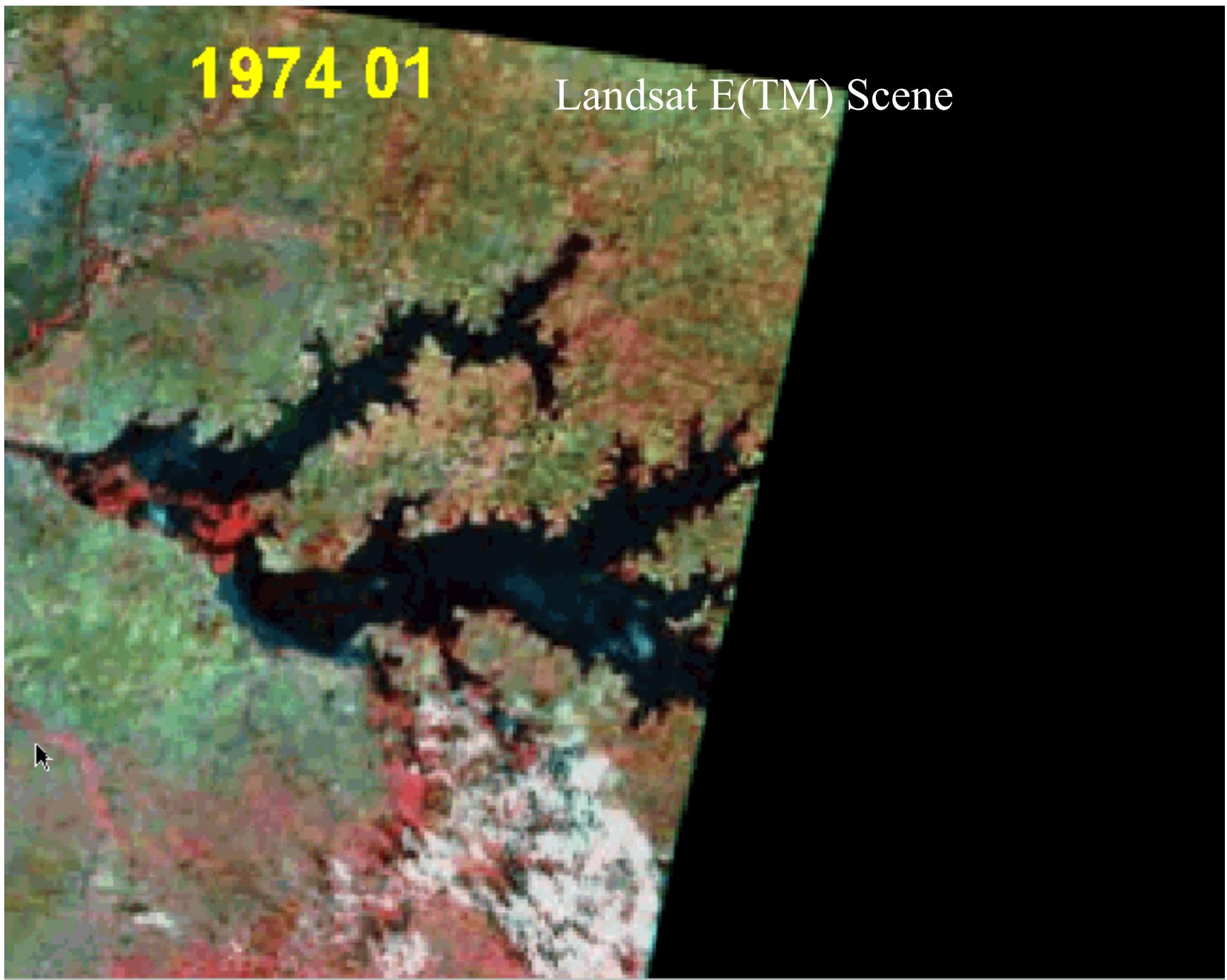
# Lake Kyoga, Uganda – example of change studies from remote sensing

Lake Kyoga from CORONA 1963-10-29



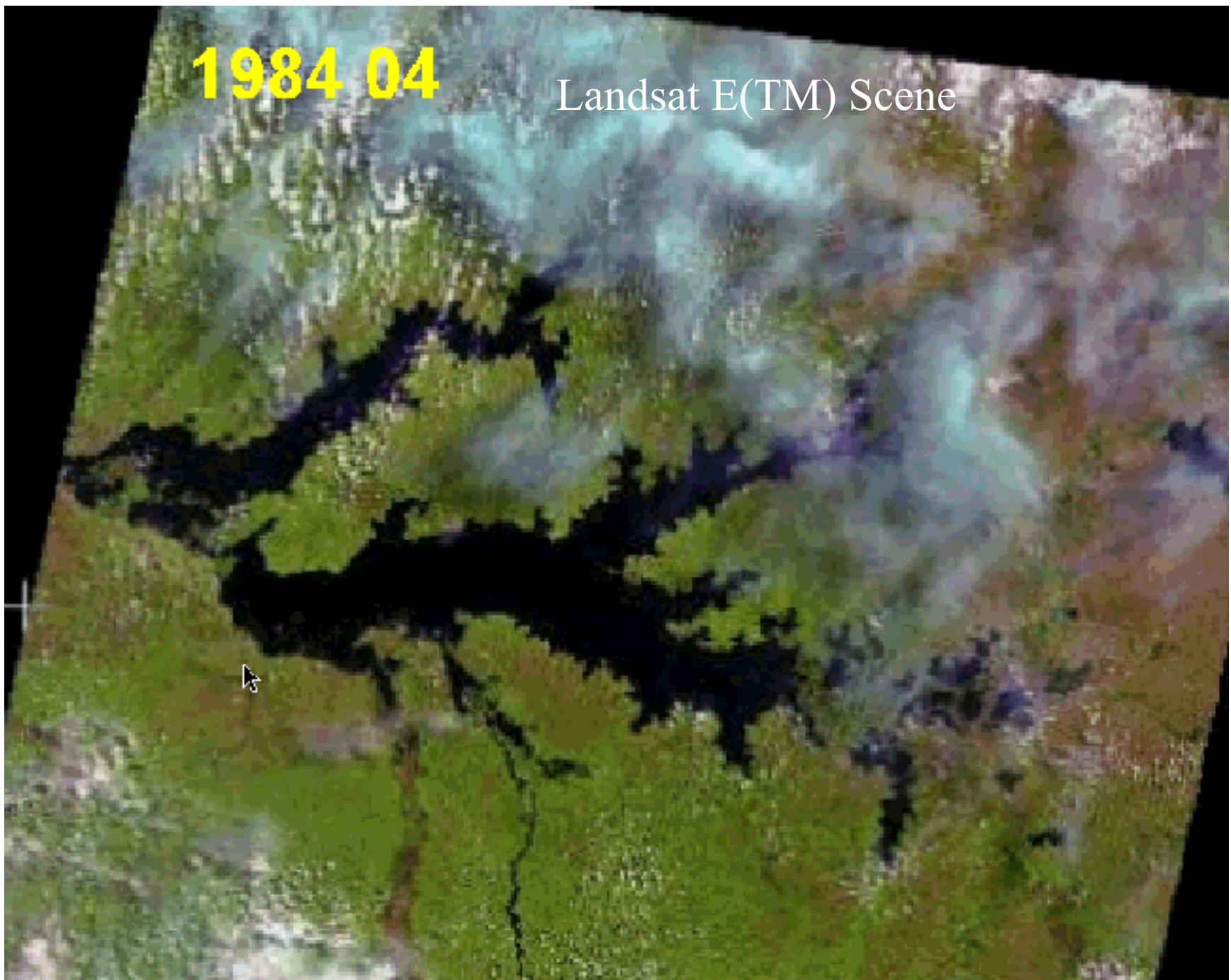
**1974 01**

Landsat E(TM) Scene



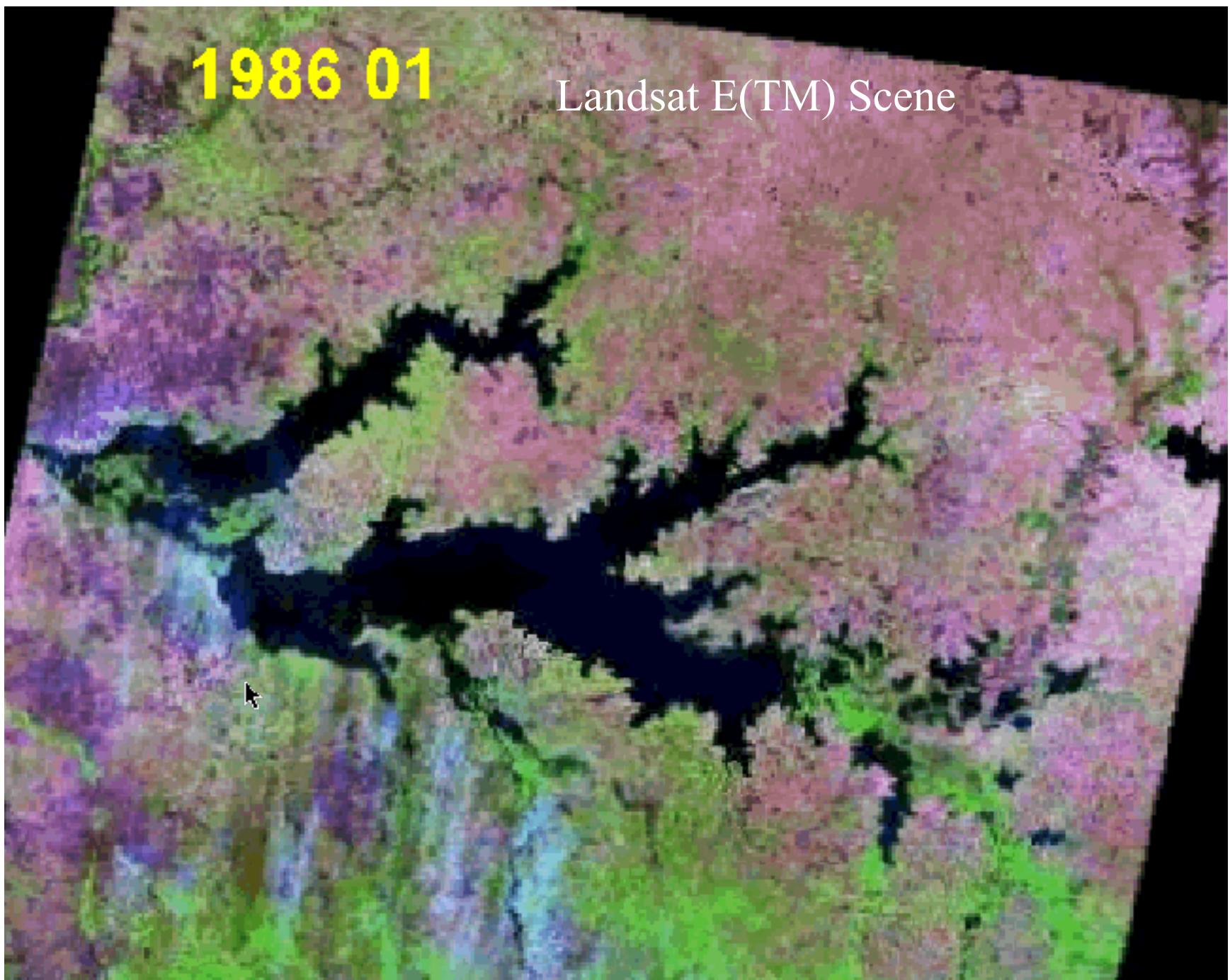
**1984 04**

Landsat E(TM) Scene



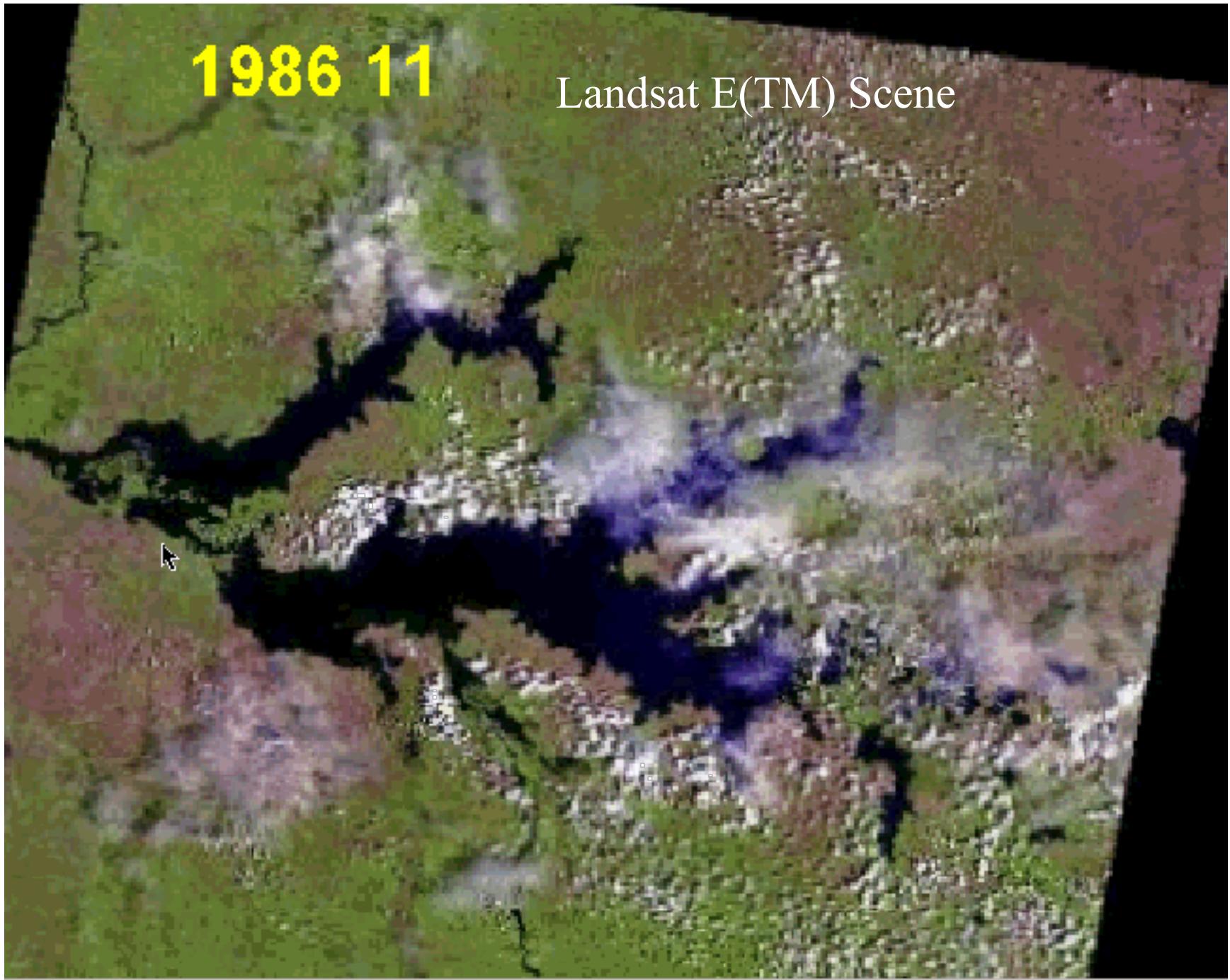
**1986 01**

Landsat E(TM) Scene



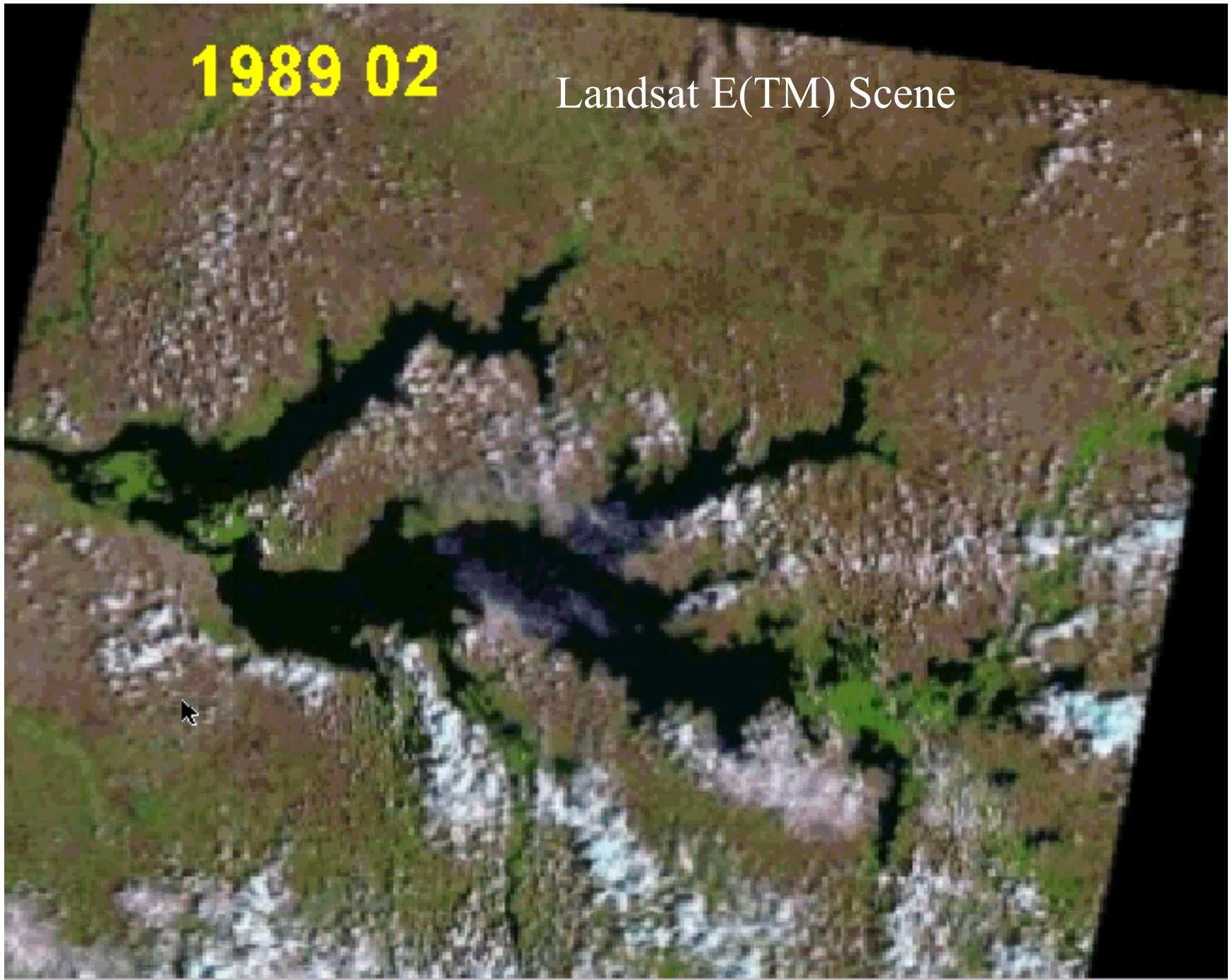
**1986 11**

Landsat E(TM) Scene



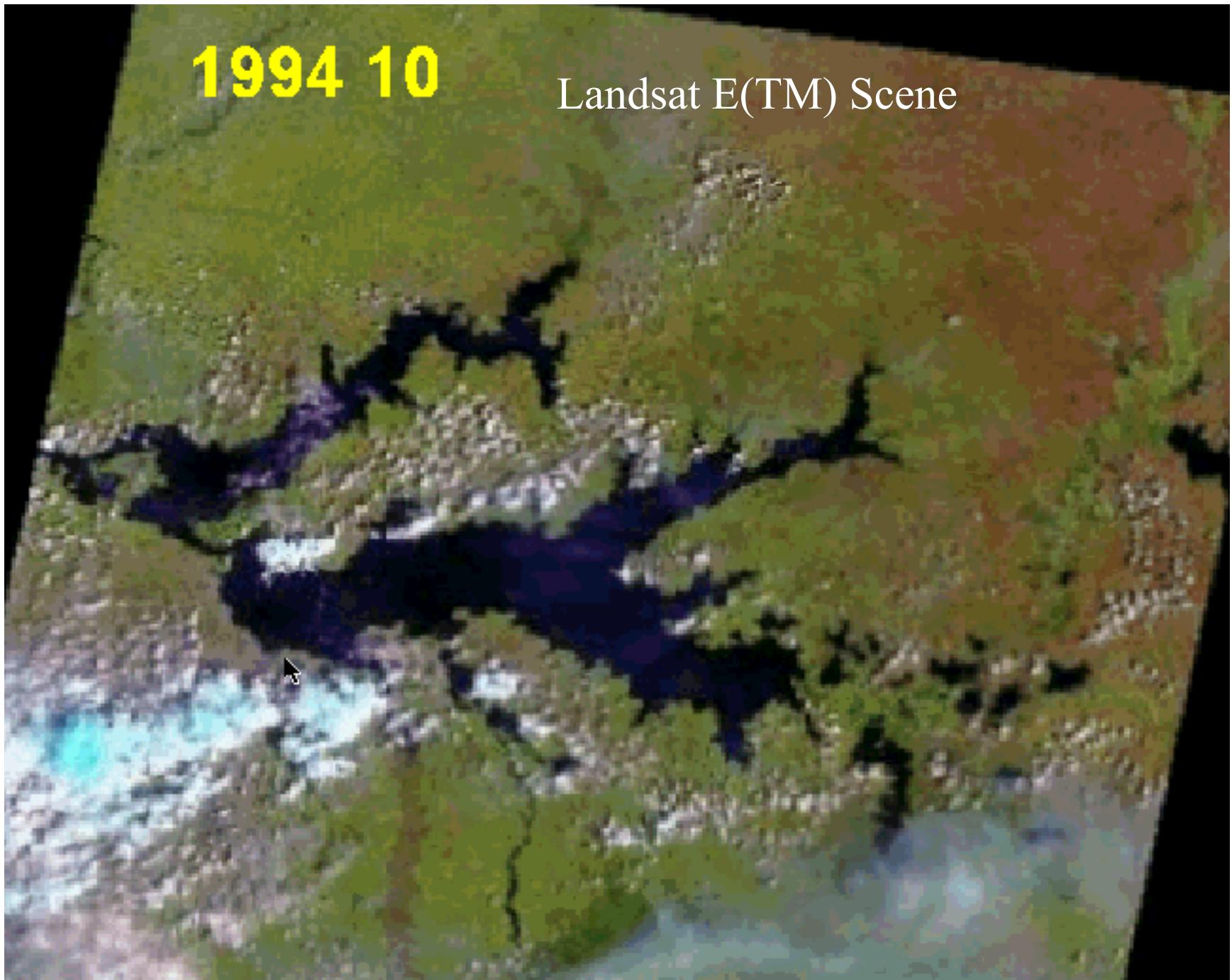
**1989 02**

Landsat E(TM) Scene



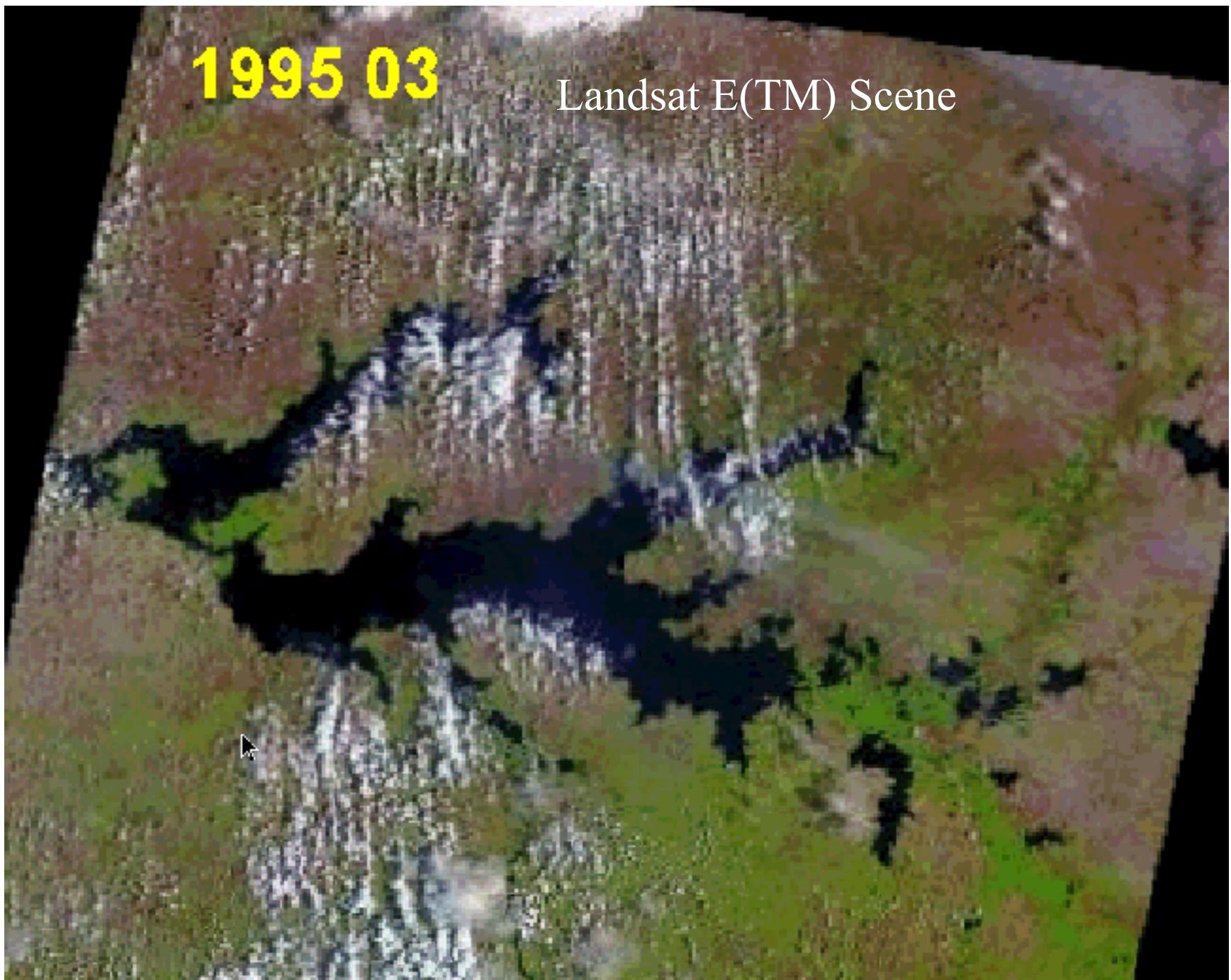
**1994 10**

Landsat E(TM) Scene



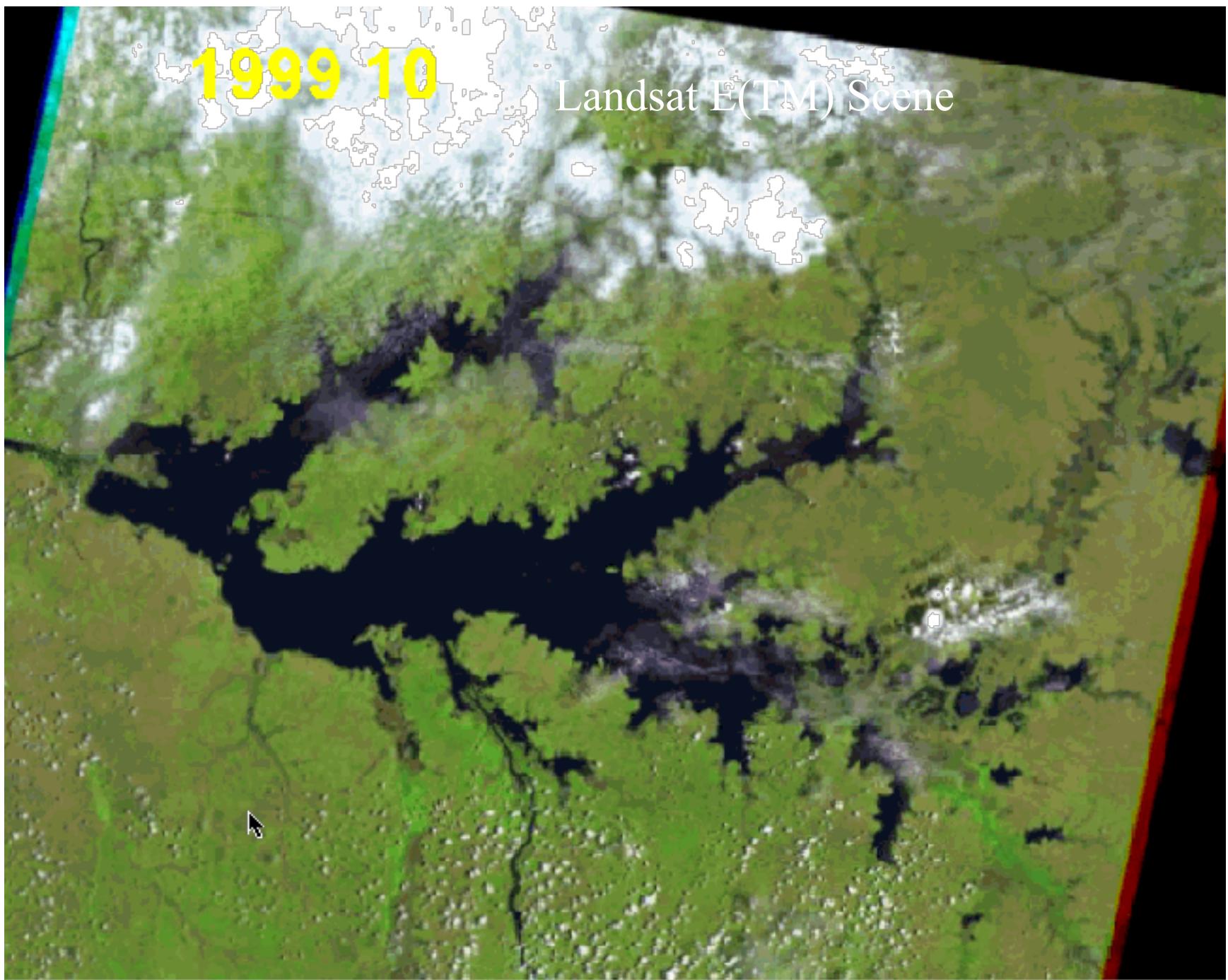
**1995 03**

Landsat E(TM) Scene



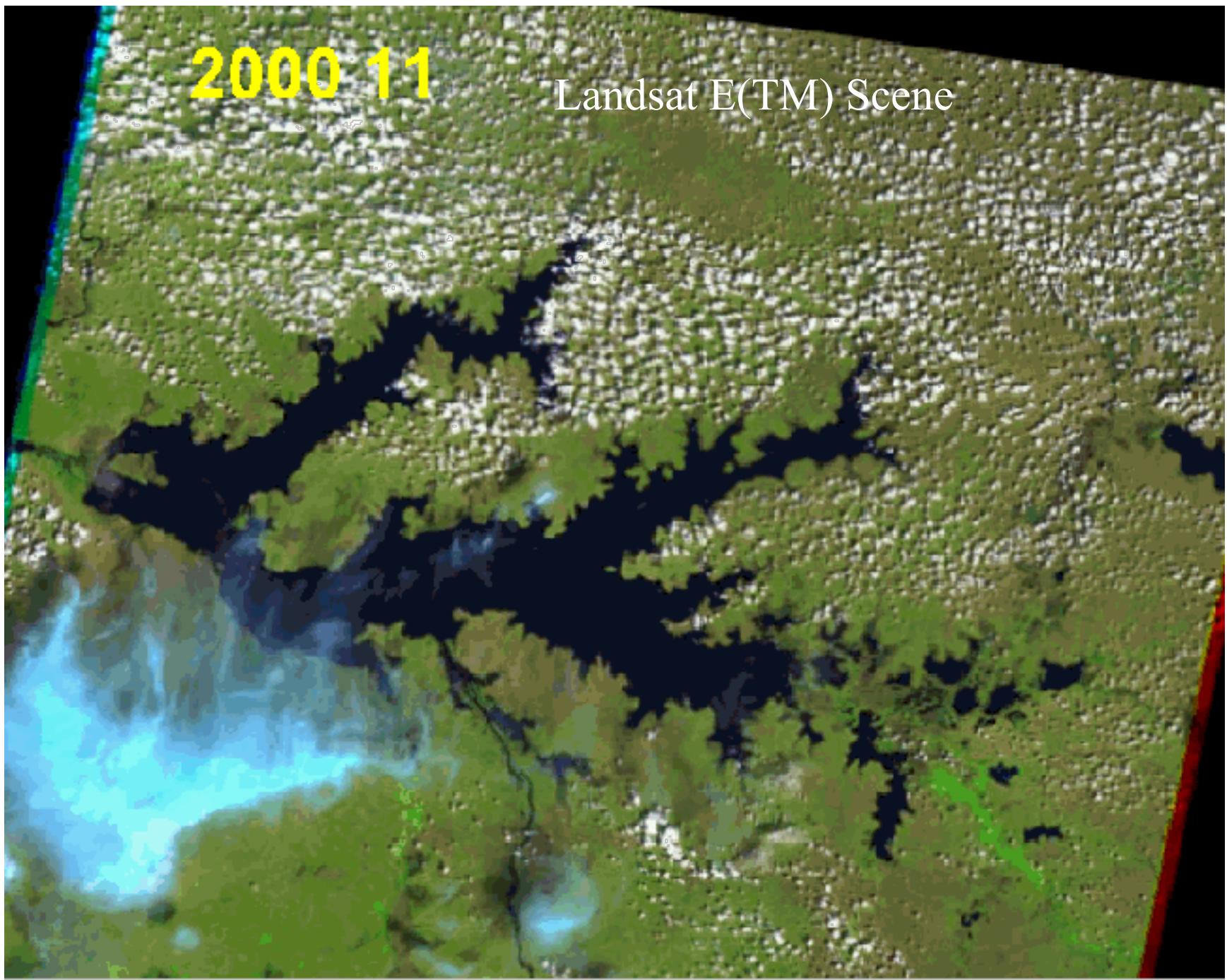
1999 10

Landsat E(TM) Scene



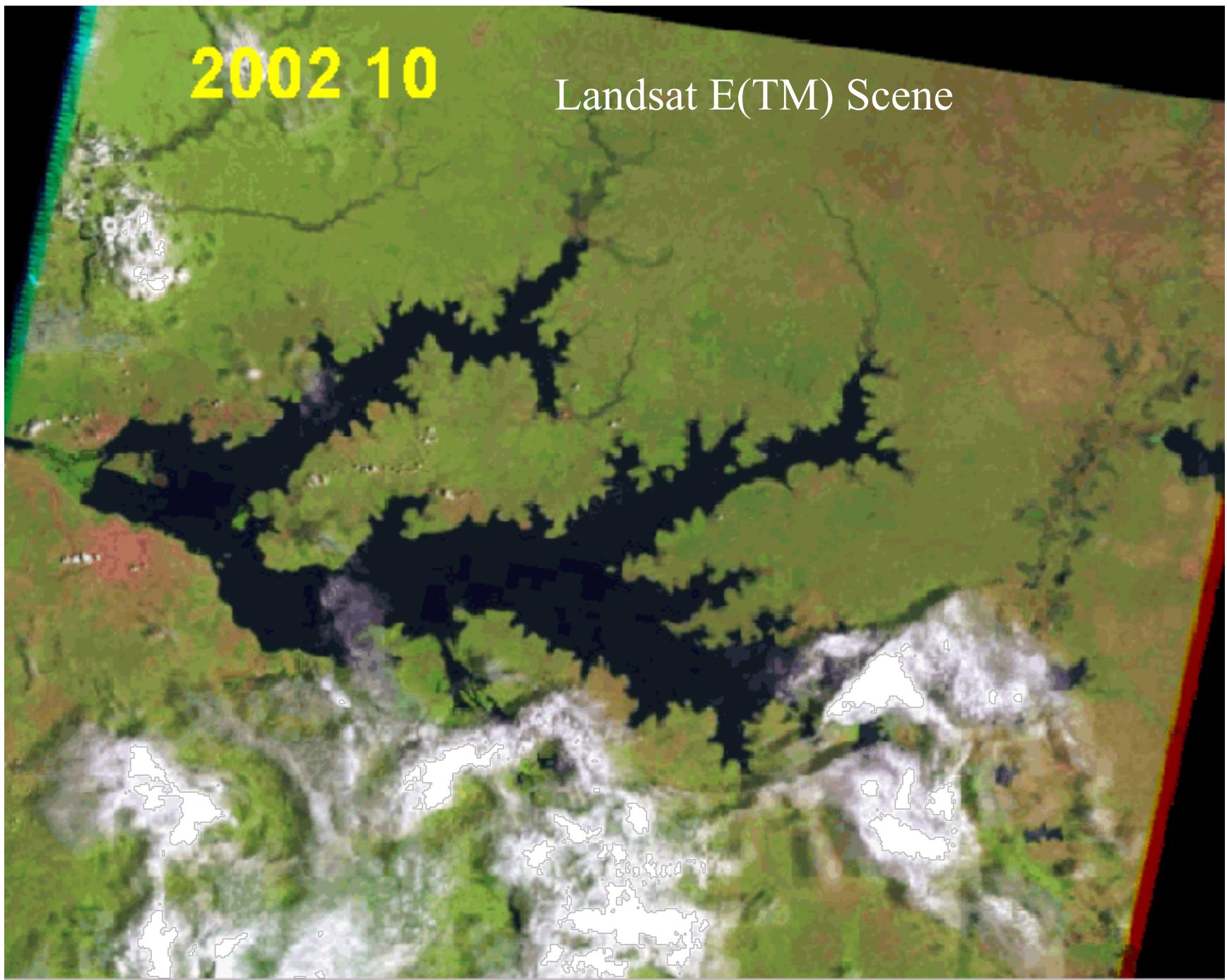
**2000 11**

Landsat E(TM) Scene



**2002 10**

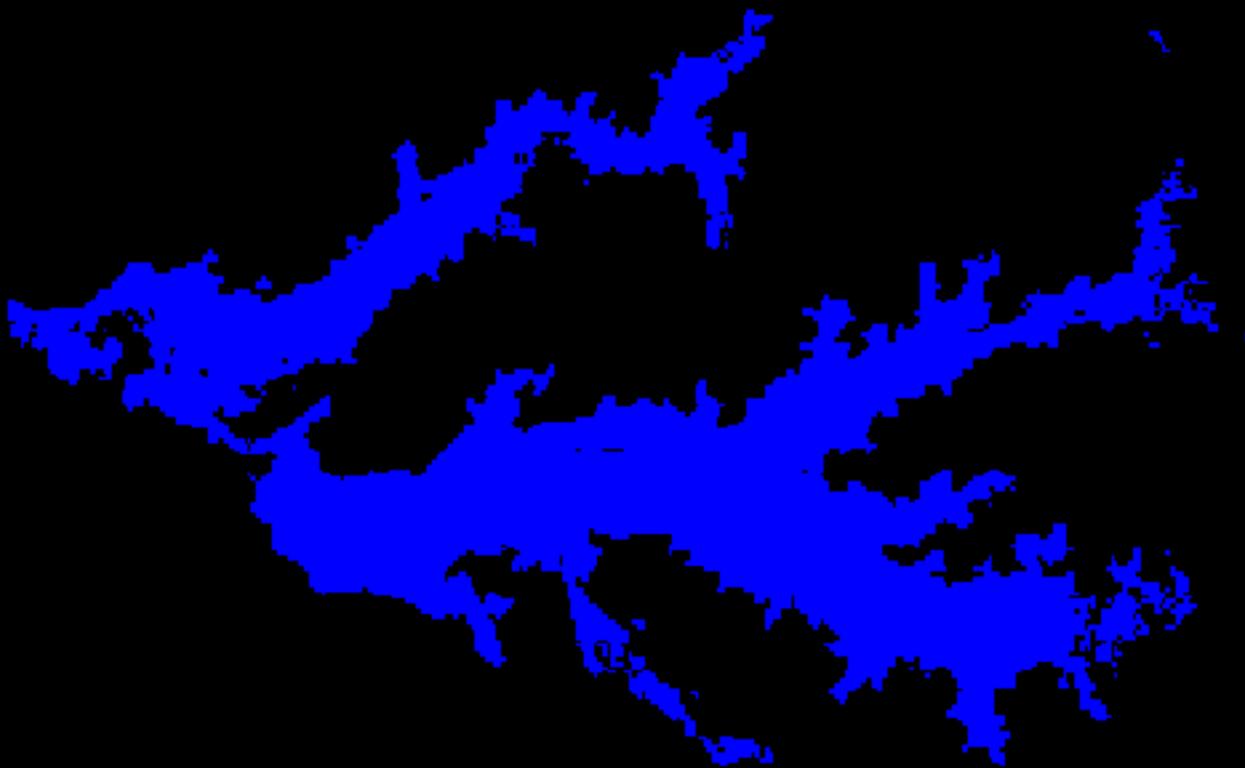
Landsat E(TM) Scene



**1984**

## Lake Kyoga

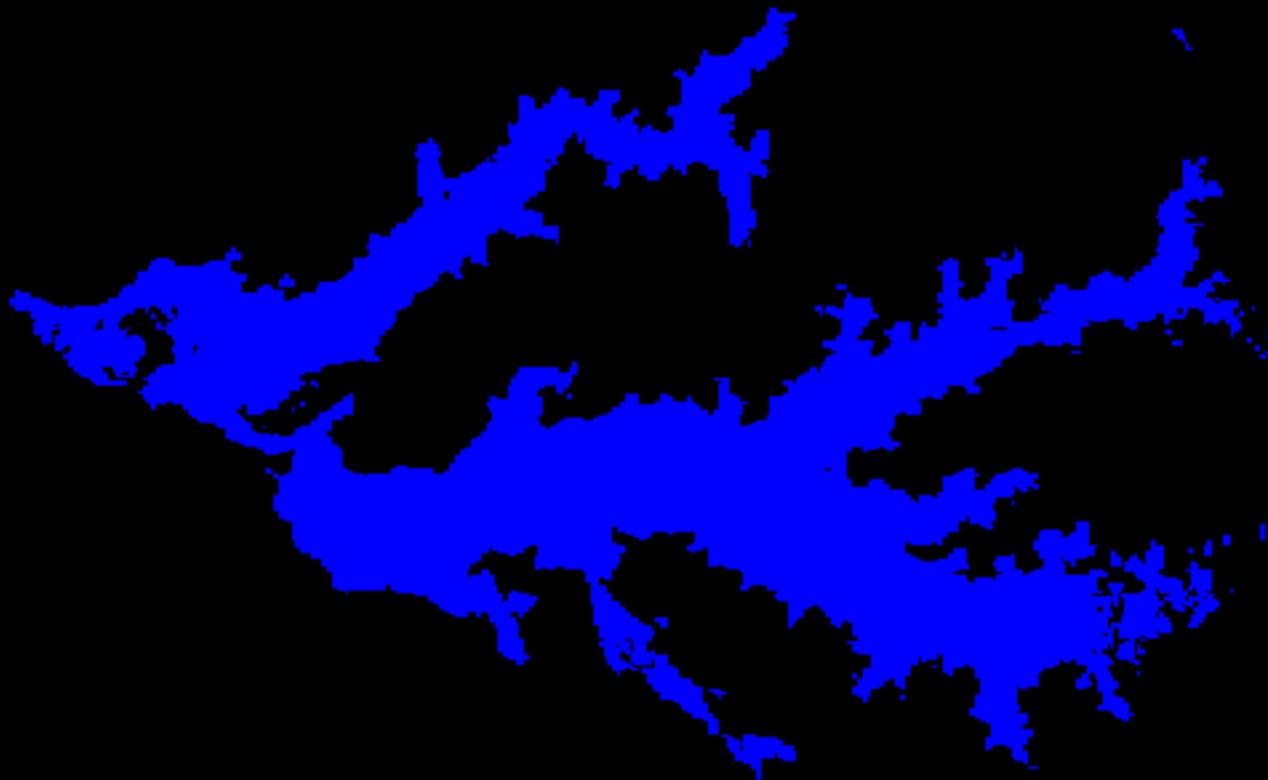
- Water area classified from  
Landsat E(TM) Scene



**1995**

## Lake Kyoga

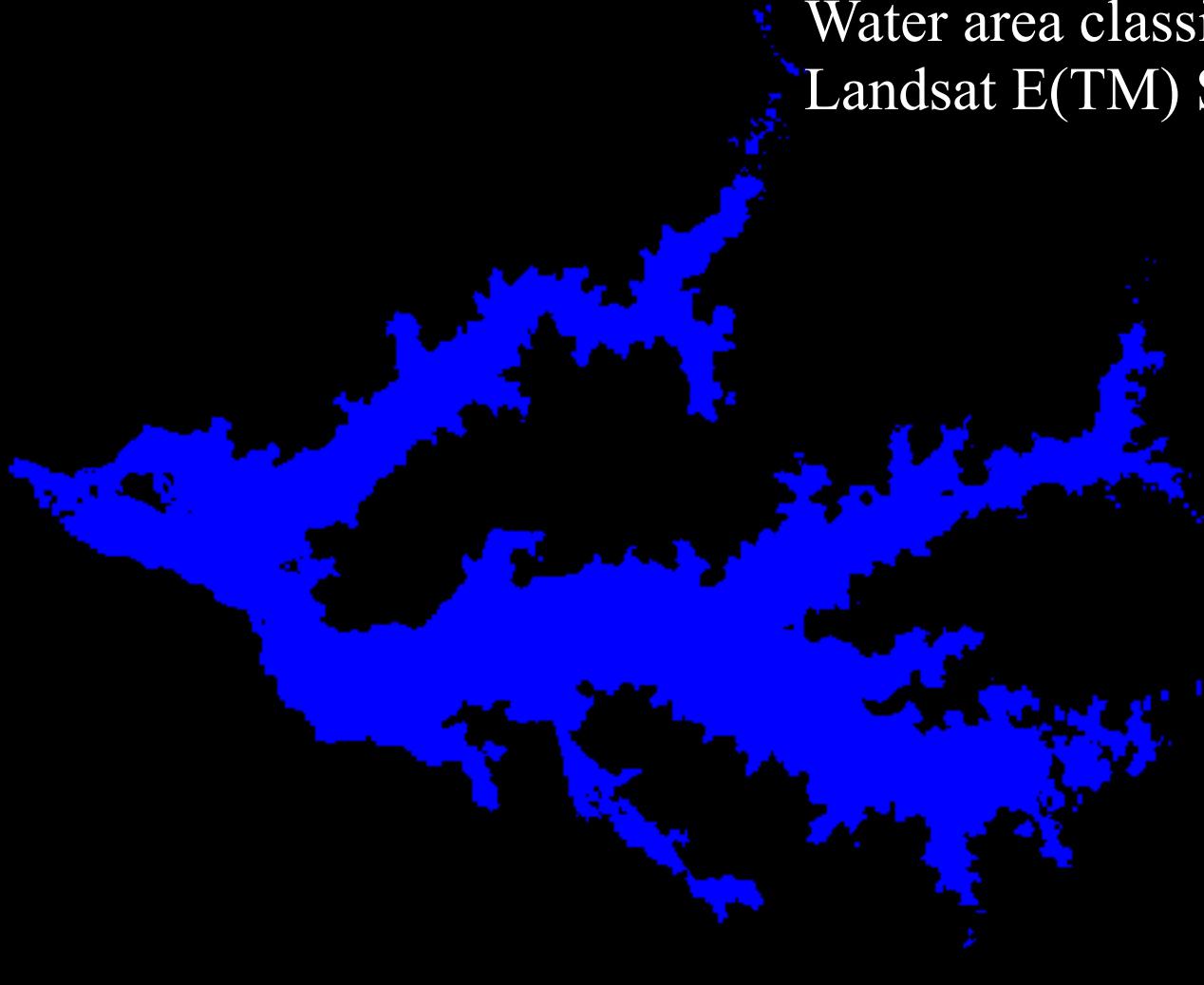
- Water area classified from Landsat E(TM) Scene



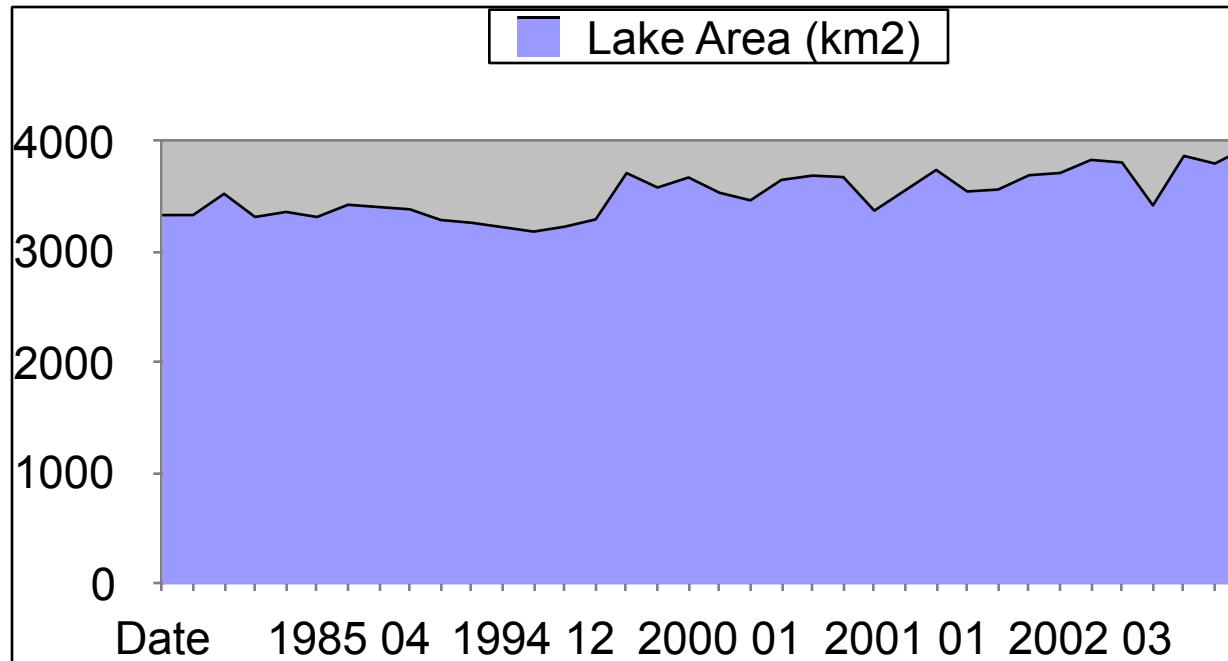
**2001**

## Lake Kyoga

Water area classified from  
Landsat E(TM) Scene



## Lake Kyoga – change in water area 1984 to 2002



# **Software and dissemination**

All that you have seen is based on free data

Almost all data is covering all ASARECA countries

All that you have seen can be done using freeware

All can hence be disseminated as maps and CDs

The graphical possibilities can be used to create learning tools for everyone; from the local farmer to the university student.

# Agro-ecological zoning and water availability in East and Central Africa

## A project proposal

### Work flow and cost estimations excl. overhead (USD)

- 1 Basemap acquisition (100,000) (can be done as ‘stand alone’)
- 2 Soil Fertility index mapping (375,000).
- 3 Field site selection, map/model evaluation and updating (240,000).
- 4 Basemap dissemination, consencus building and mapping harmonisation (380,000).
- 5 Water yield and runoff modeling (55,000).
- 6 Agro-ecological zone mapping (55,000).
- 7 Dissemination and learning tool development (130, 000)

The following maps would come out of the project:

- Land use/cover, scale 1: 500 000
- Vegetation, scale 1:500 000
- Topography, scale 1: 500 000
- Rainfall distribution, scale 1: 500 000
- Temperature distribution, scale 1: 500 000
- Evapotranspiration, scale 1: 500 000
- Water balance (runoff), scale 1: 500 000
- Length of growing period, scale 1: 500 000
- Soil fertility, scale 1: 500 000
- Agro-ecological zoning, scale 1: 500 000