University of Reading

TAMSAT

National Centre for Earth Observation

NATURAL ENVIRONMENT RESEARCH COUNCIL

Operational Drought Risk Assessment using Satellite based Observations and *in situ* Measurements: Africa

Dr Elena Tarnavsky

4th SALGEE Workshop, 1-3 Sep 2015 Matera, Italy

Drought Risk Monitoring: Motivation

Meteorological Drought
(rainfall deficit, increased ET, dry spells)

Hydrological Drought
(water supply shortage)

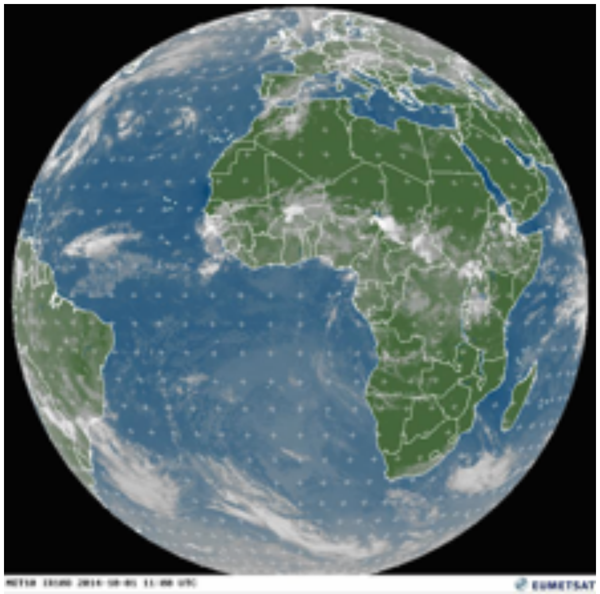
Agricultural Drought
(soil water deficit, crop-yield shortfall)

- Since the 1980s, in Africa (sparse ground observation network) the TAMSAT approach has been used for operational rainfall estimation in drought monitoring and food security contexts

Rainfall Deficit Monitoring: Requirements

- Rainfall occurrence
- Rainfall amount
- Available in (near) real time
- Long-term record
- Temporally consistent
- Spatially-contiguous (e.g. continental Africa)
- High spatial resolution
- Accurate in space and time
- Estimate of reliability/skill
- Easily accessible format
- Free of charge (incl. for commercial applications)
- Transparent methodology

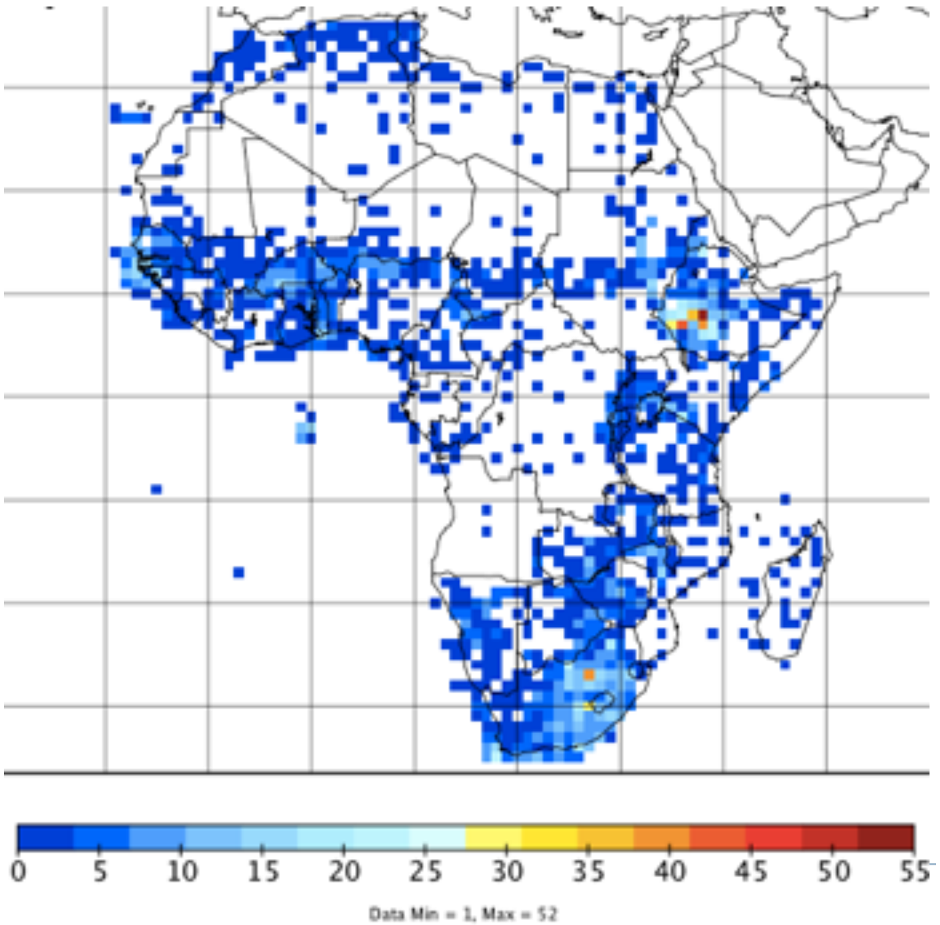
TAMSAT Rainfall Estimation Approach



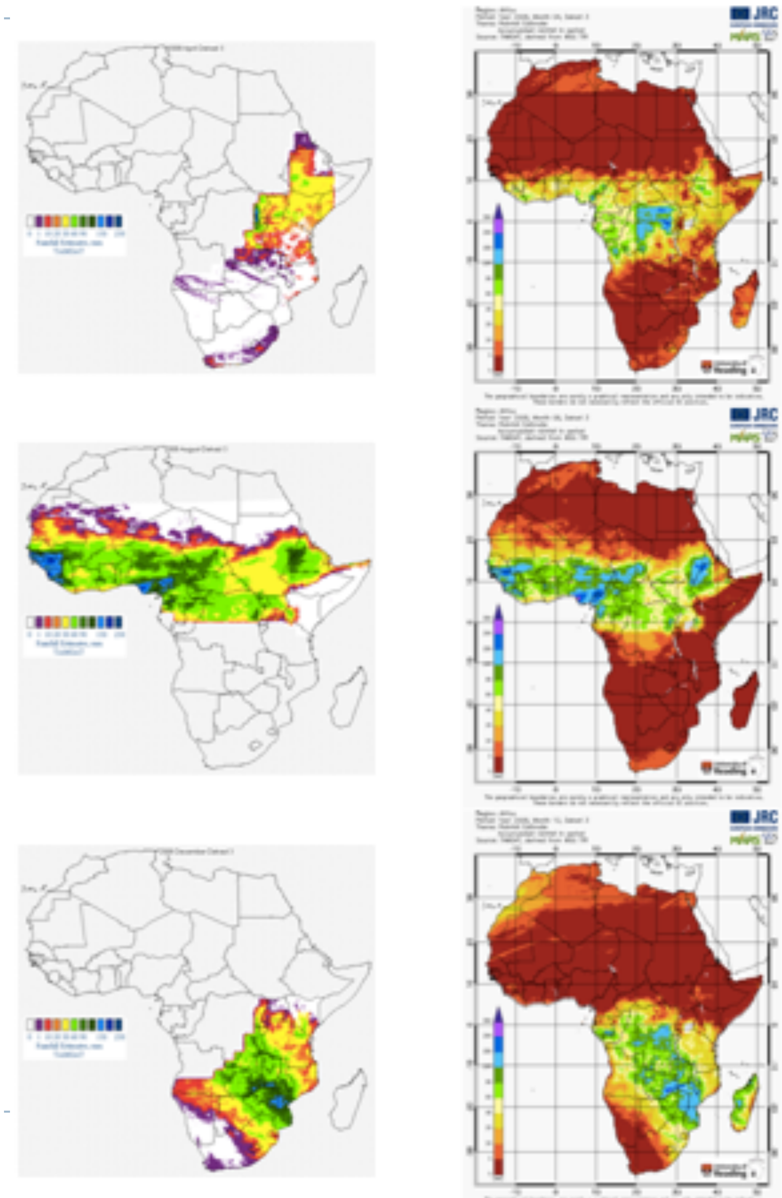
- Data Input: Meteosat TIR (10.8μm) imagery, **15 min sampling frequency**
- Calculate **Cold Cloud Duration (CCD)** that is the length of time cloud top is colder than threshold temperature T_t for each pixel
- Estimate rainfall amount as **Rainfall [mm] = a_0 + a_1 CCD [hrs]** with **T_t, a_0, a_1 calibrated against historic gauge observations**
- **Local temporally consistent / climatological (1983-2010) calibration**: parameters vary in space (regions) & time (months), pan-African coverage

TAMSAT pan-African Rainfall Estimation

TAMSAT rain gauge archive
for **spatially contiguous**
and **temporally consistent**
monthly calibrations (**1983-2010**)

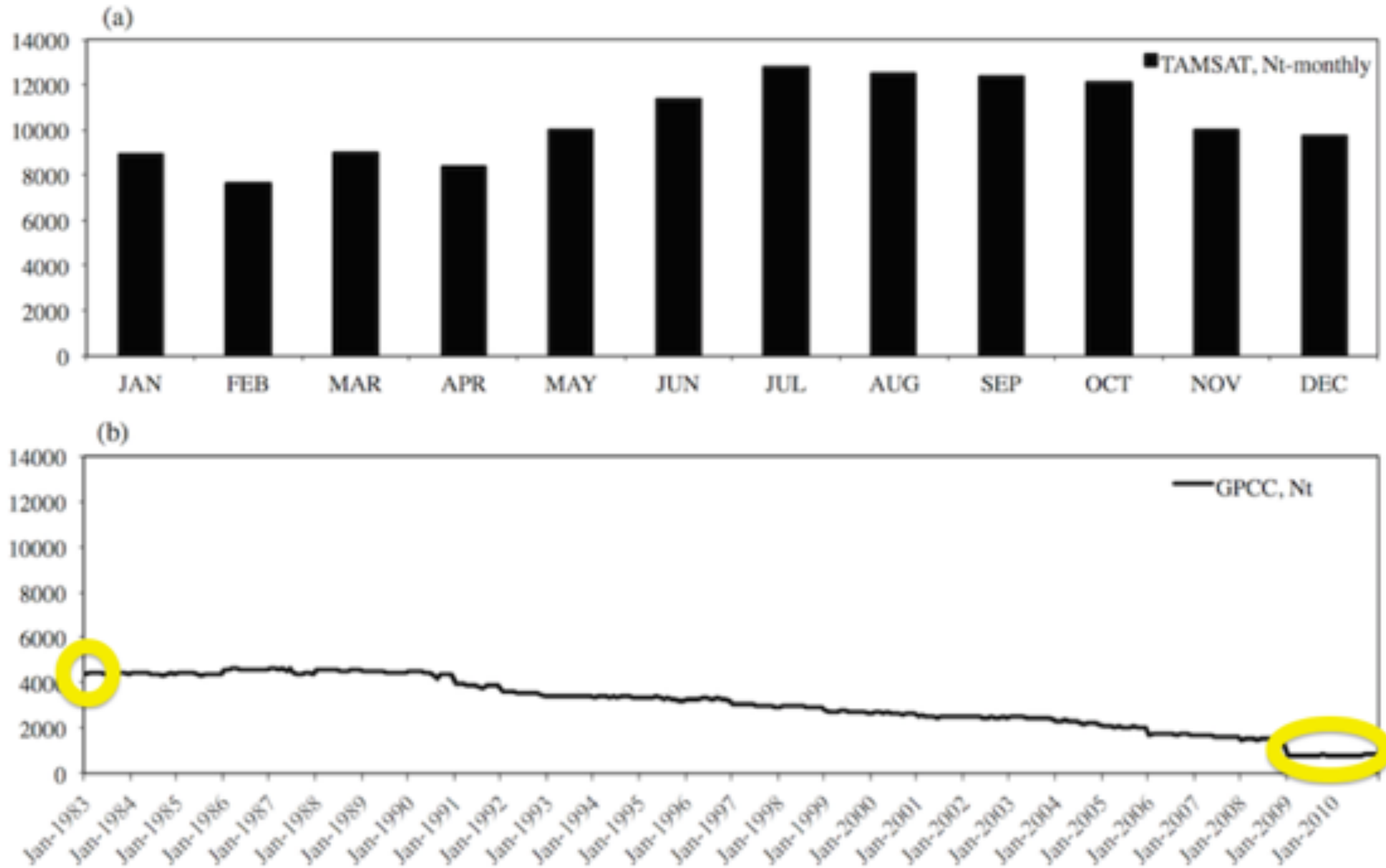


Legend: number of gauges within 0.5-deg grid cell



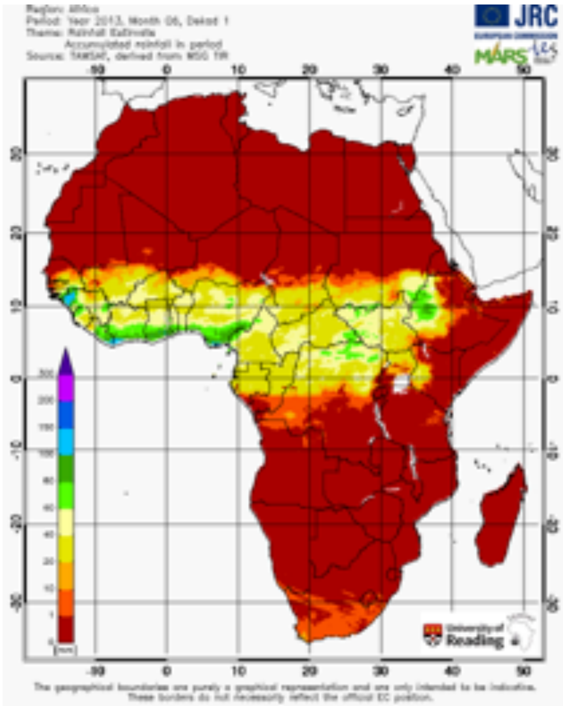
Temporally-consistent remote sensing data

TARCAT v2.0 - Calibration parameters based on 28-years climatology of *in situ* observations, i.e. not susceptible to bias due to varying gauge data input over time (Tarnavsky et al. 2014)

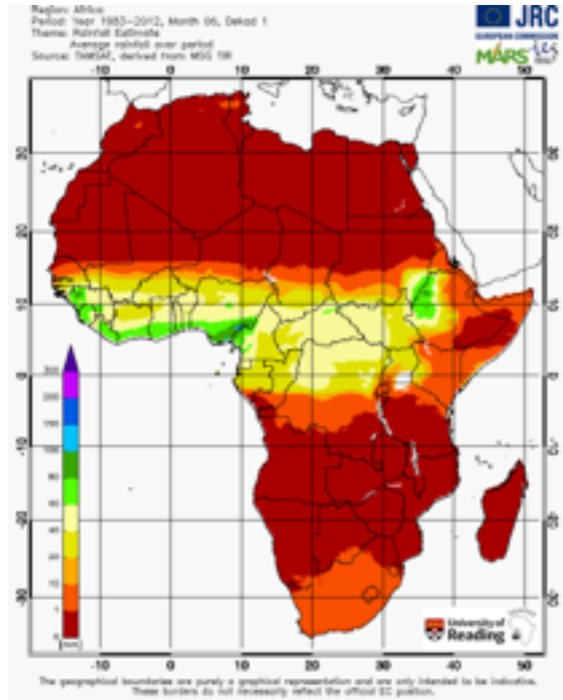


TAMSAT Operational Rainfall Products

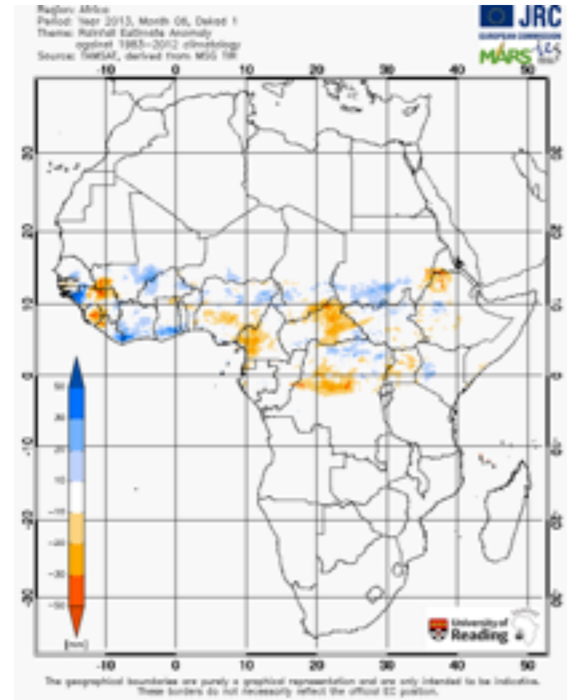
Disseminated via GEONETCast and publicly available through TAMSAT's web site



Total rainfall (1983-present):
- Dekadal (10-daily) & daily
- Monthly
- Seasonal

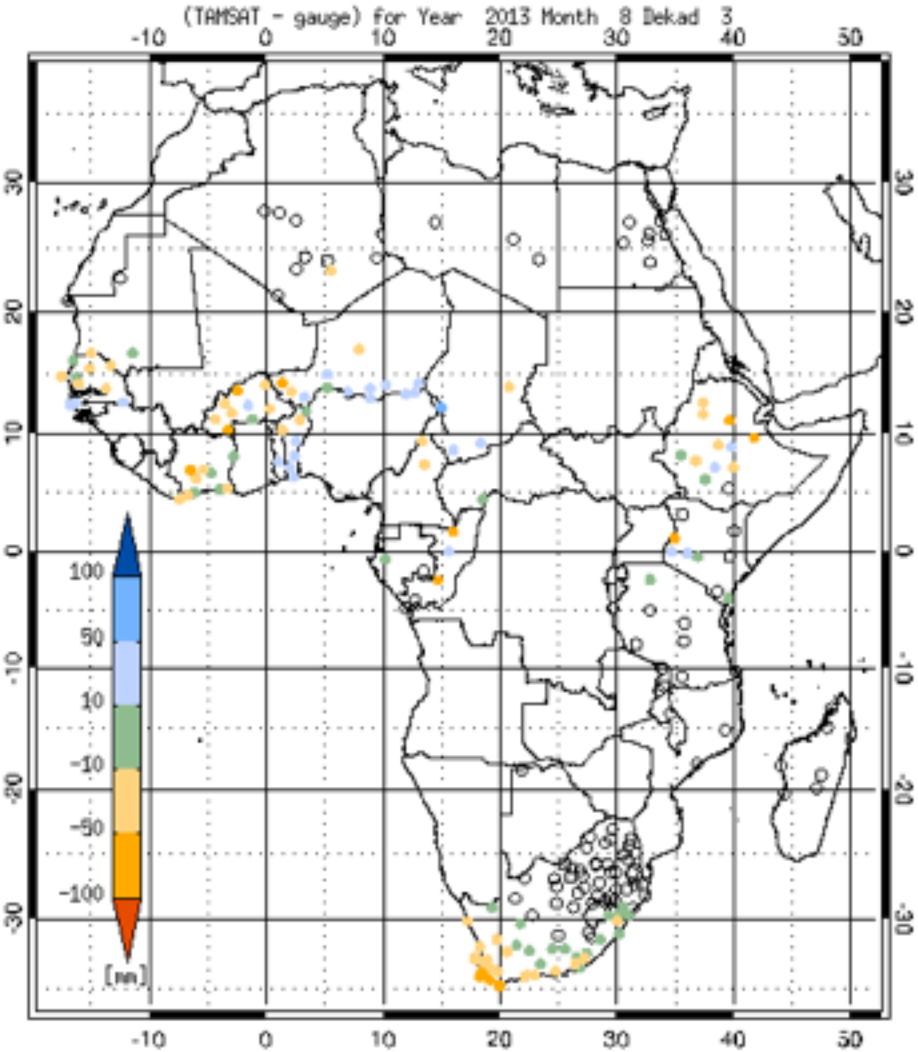


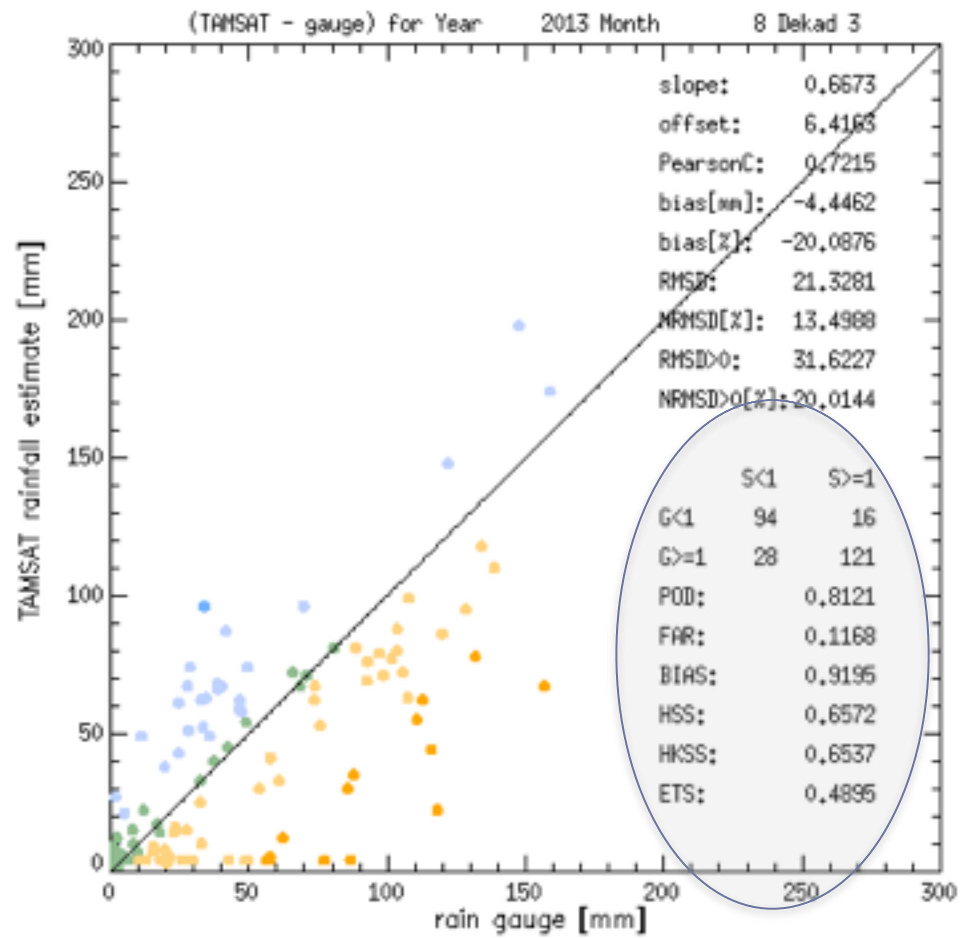
30-year Climatology (1983-2012):
- Dekadal (10-daily)
- Monthly
- Seasonal

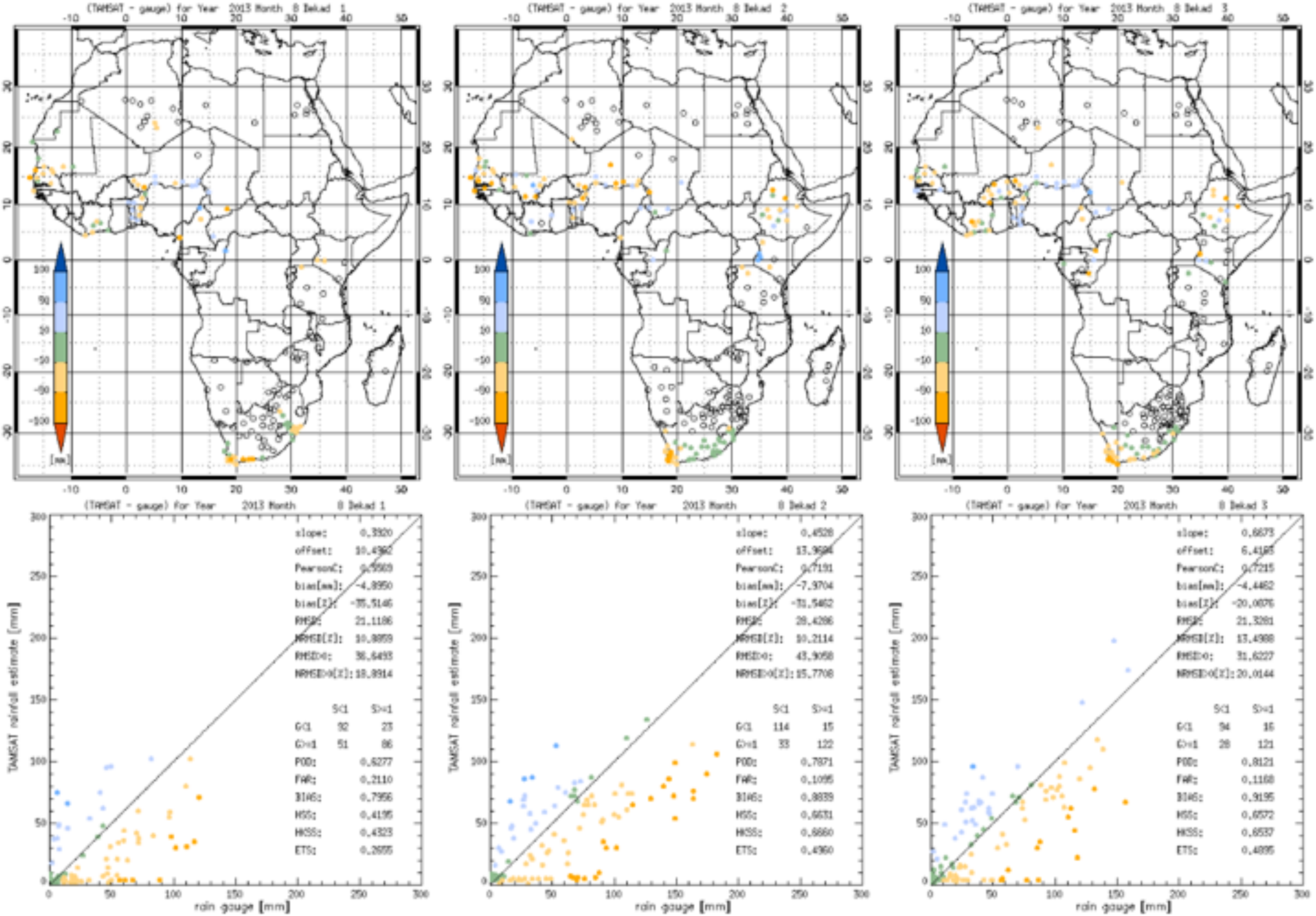


Rainfall anomaly (1983-present):
- Dekadal (10-daily)
- Monthly
- Seasonal

TAMSAT Operational Validation






(TAMSAT - gauge) for Year 2013 Month 8 Dekad 1
(TAMSAT - gauge) for Year 2013 Month 8 Dekad 2
(TAMSAT - gauge) for Year 2013 Month 8 Dekad 3
[mm]
slope: 0.3920
offset: 10.4362
PearsonC: 0.5563
bias[mm]: -4.8950
bias[%]: -35.5146
RMSD: 21.1186
NRMSD[%]: 10.8859
RMSD>0: 38.6493
NRMSD>0[%]: 18.8914
S<1 S>=1
G<1 92 23
G>=1 51 86
POD: 0.6277
FAR: 0.2110
BIAS: 0.7956
HSS: 0.4195
HKSS: 0.4323
ETS: 0.2655
slope: 0.4528
offset: 13.9694
PearsonC: 0.7131
bias[mm]: -7.9704
bias[%]: -31.5462
RMSD: 28.4286
NRMSD[%]: 10.2114
RMSD>0: 43.9058
NRMSD>0[%]: 15.7708
S<1 S>=1
G<1 114 15
G>=1 33 122
POD: 0.7871
FAR: 0.1095
BIAS: 0.8839
HSS: 0.6631
HKSS: 0.6660
ETS: 0.4960
slope: 0.6673
offset: 6.4193
PearsonC: 0.7215
bias[mm]: -4.4462
bias[%]: -20.0876
RMSD: 21.3281
NRMSD[%]: 13.4988
RMSD>0: 31.6227
NRMSD>0[%]: 20.0144
S<1 S>=1
G<1 94 16
G>=1 28 121
POD: 0.8121
FAR: 0.1168
BIAS: 0.9195
HSS: 0.6572
HKSS: 0.6537
ETS: 0.4895
TAMSAT rainfall estimate [mm]
rain gauge [mm]

Summary

- Fundamental differences between point-based rainfall observations at gauges and area-based rainfall estimates from satellite data
  - Perfect agreement is not to be expected
  - Even with perfect skill scores, both gauge and satellite data still have errors

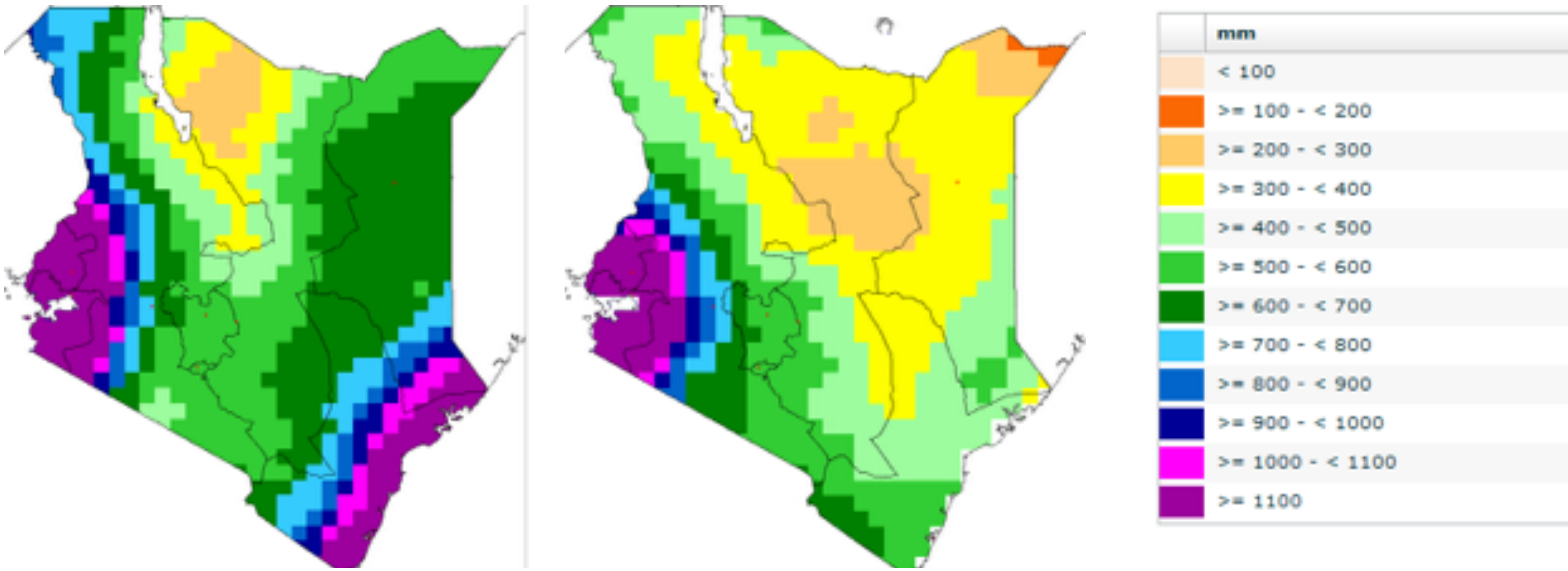
- Important to use validation methods/statistics that capture application/user - specific information - **different levels of validation**:
  - Validation **against observations**: gauges, radar, other satellite-based rainfall products —> probability statistics, summary statistics, etc.
  - Validation **for specific applications/users**: inter-comparisons with similar products (over common space and time scales)
    —> performance metrics/diagnostic statistics/reliability measures
    (e.g. drought monitoring, index insurance)
    —> verification of derived products against independent observations
    (e.g. anomalies, seasonal totals, forecast terciles)
    —> through modelling simulations
    (e.g. soil moisture, crop yield)
    —> acceptable error/error tolerance

Operational * Validation *

- Verification = Are we building the product right?
- Validation = Are we building the right product?

Applications: rainfall product comparison

Average annual rainfall sum (1989-2012): Kenya at 0.25° x 0.25° lat-lon grid

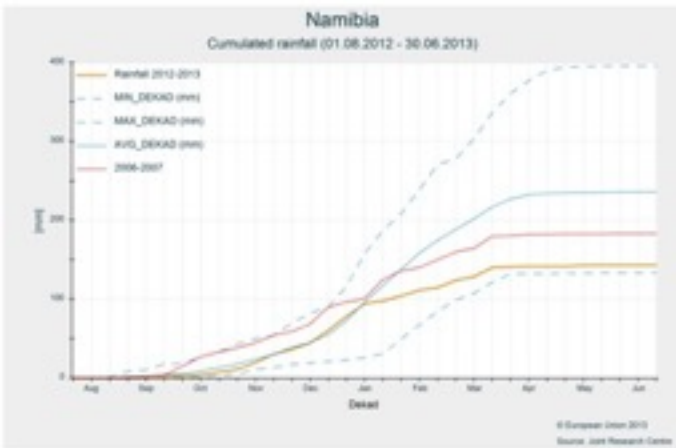


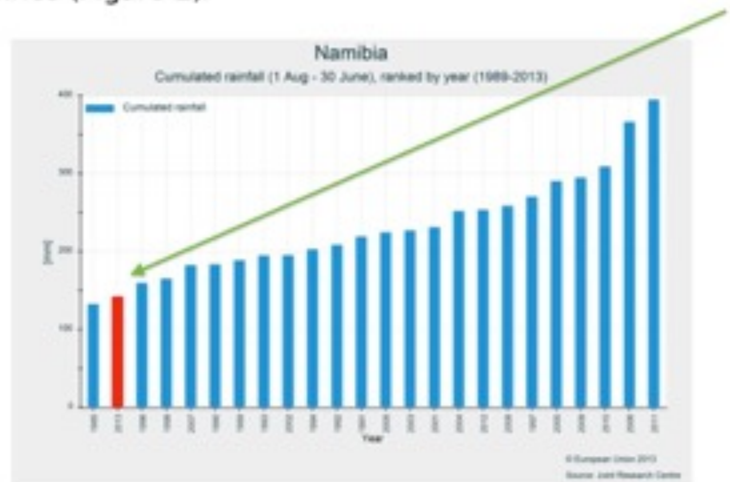
ECMWF
ERA-Interim
(1989-2010)

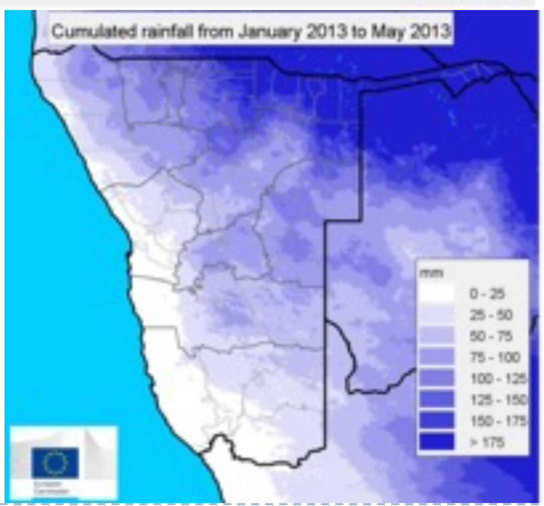
TAMSAT
TARCAT v2.0

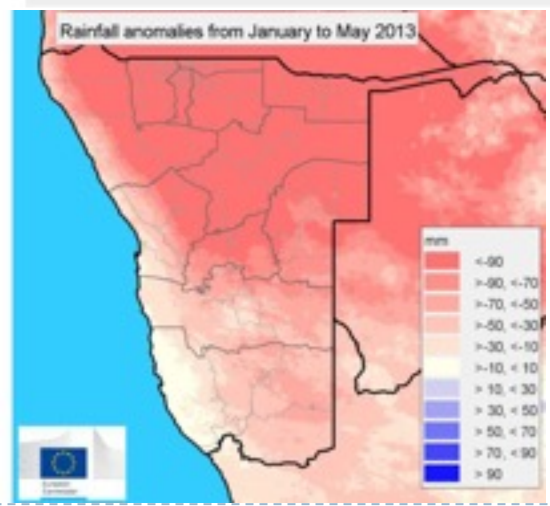
Applications: drought monitoring bulletins

The summer season in Namibia (September 2012 - May 2013) has been the second driest of the last 25 years. Considering Namibia in its entirety, it can be seen that there was average rainfall until late December 2012, but there has been very little rain since (Figure 2).









JRC
EUROPEAN COMMISSION
MARS ies

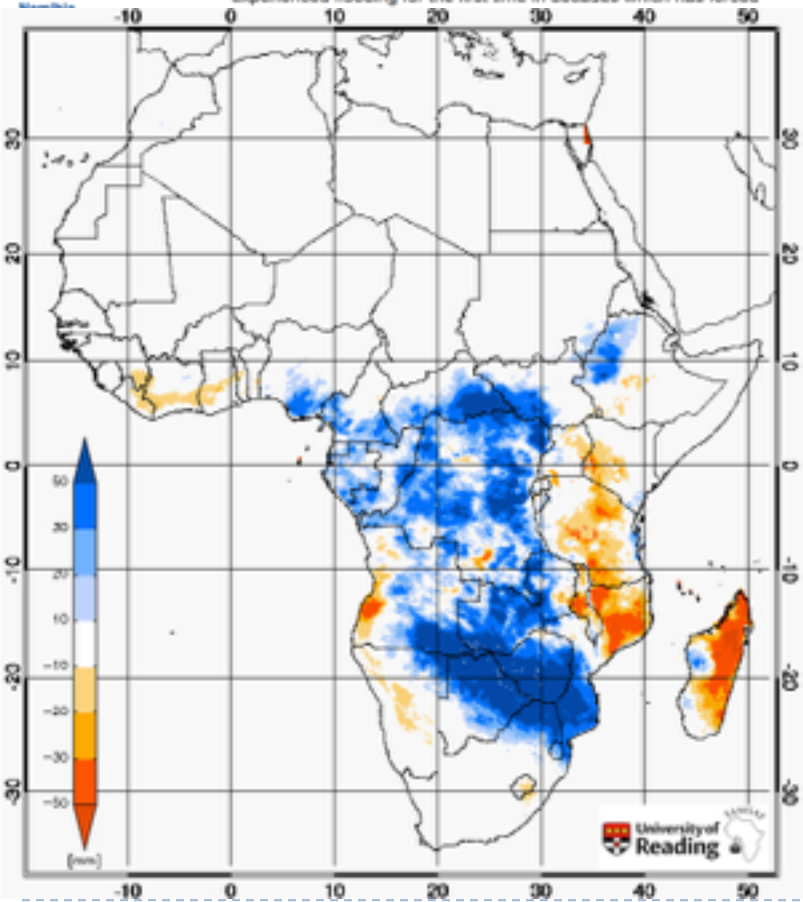
Applications: flood detection

Namibia: Heavy Rains Flood Villages

BY GEORGE SANZILA, 17 MARCH 2014

RELATED TOPICS

Makolonga/Linyanti — Following heavy rainfall in the Zambezi Region the two constituencies of Sibbinda and Linyanti have experienced flooding for the first time in decades which has forced



Data: Dekadal RFE anomaly

Start date: 1st dek' Jan 2013

End date: 2nd dek' Jun 2014

Area bounds: Region Rectangular Pixel

Region: Namibia

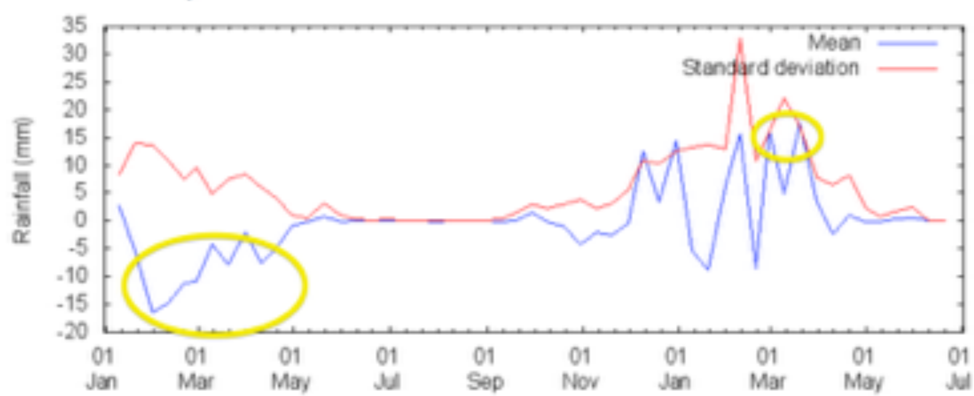
Plot: Mean & standard deviation

Y-axis (optional): min max

Alter current selection Add new selection

Submit time series

Time series plot



Applications: decision-support platforms

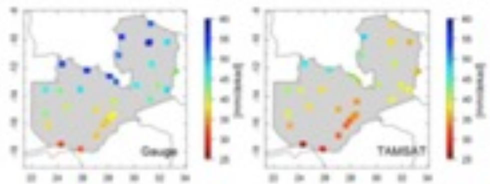
- TAMSAT is one of many other rainfall products and used alongside products on other environmental variables

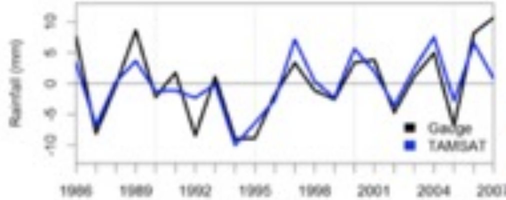
SPIRITS
Institute for Environment and Sustainability

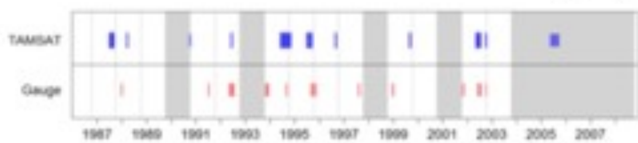
SPIRITS

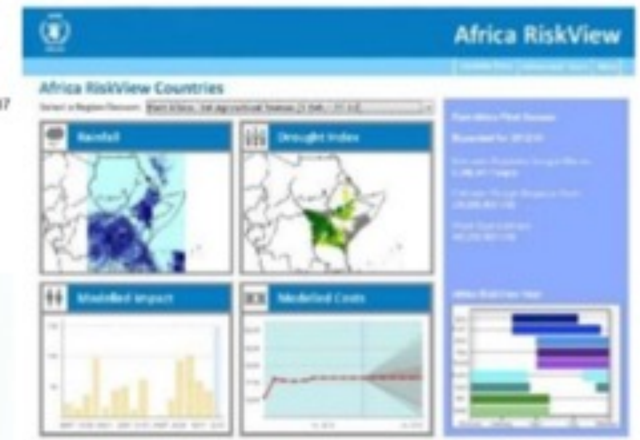
SPIRITS is an integrated and flexible **free software** environment for analyzing satellite derived **image time series** in **crop and vegetation monitoring**. With this toolbox, you can process and examine time series of low and medium resolution sensors such as SPOT-Vegetation and MODIS-Terra/Aqua. It can be used to perform and to automatize many spatial and temporal processing steps on time series and to extract spatially aggregated statistics. Vegetation indices and their anomalies can be rapidly mapped and statistics can be plotted and interpreted in seasonal graphs to be shared with analysts and decision makers.

Applications: weather index insurance



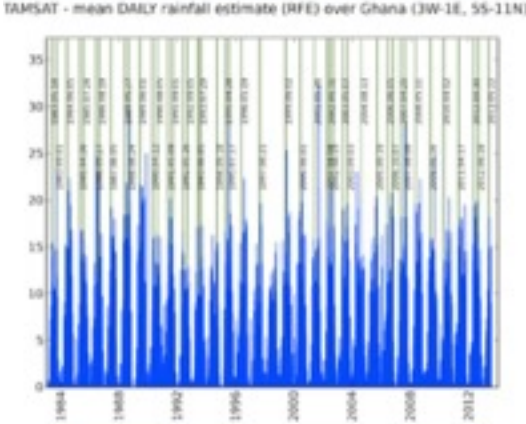


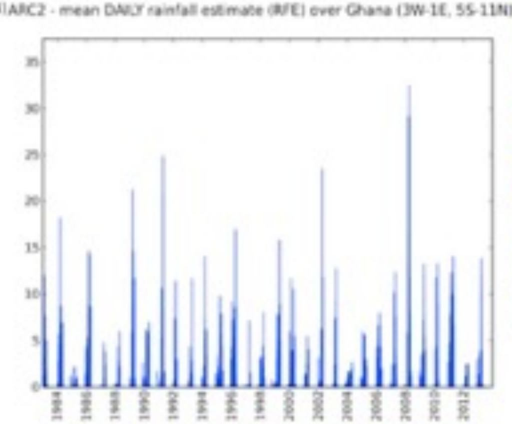




Start of season (SOS)

- Rain > 25 mm over 5 consecutive days
- Day 1 + 2 more days of the 5 days are wet (rain > 1 mm)
- For the next 30 days, no more than 7 days are dry





Applications: risk transfer

- Water Requirements Satisfaction Index (WRSI) approach (by FAO, in operational use by FEWS NET, Africa Risk Capacity, etc)
- WRSI sensitivity analysis to different rainfall driving datasets:
  - NOAA CPCP ARC2
  - CHIRPS
  - TAMSAT

  e.g. correlation with observed production

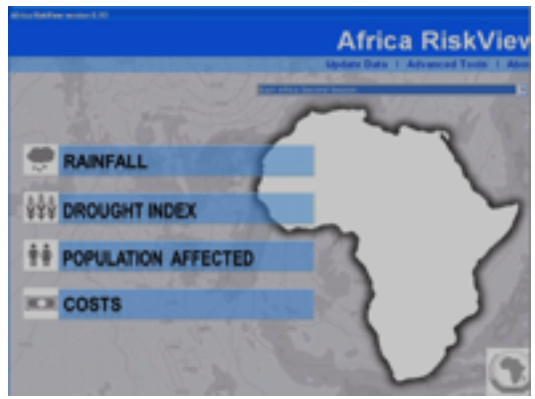
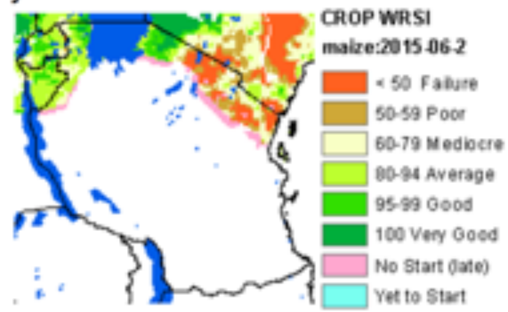


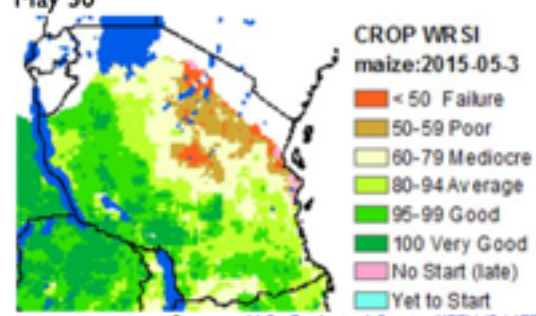
Figure 1. Crop Water Requirement Satisfaction Index (WRSI) in the northern bimodal maize-growing areas, *Masika* as of June 20



Source: U.S. Geological Service/FEWS NET

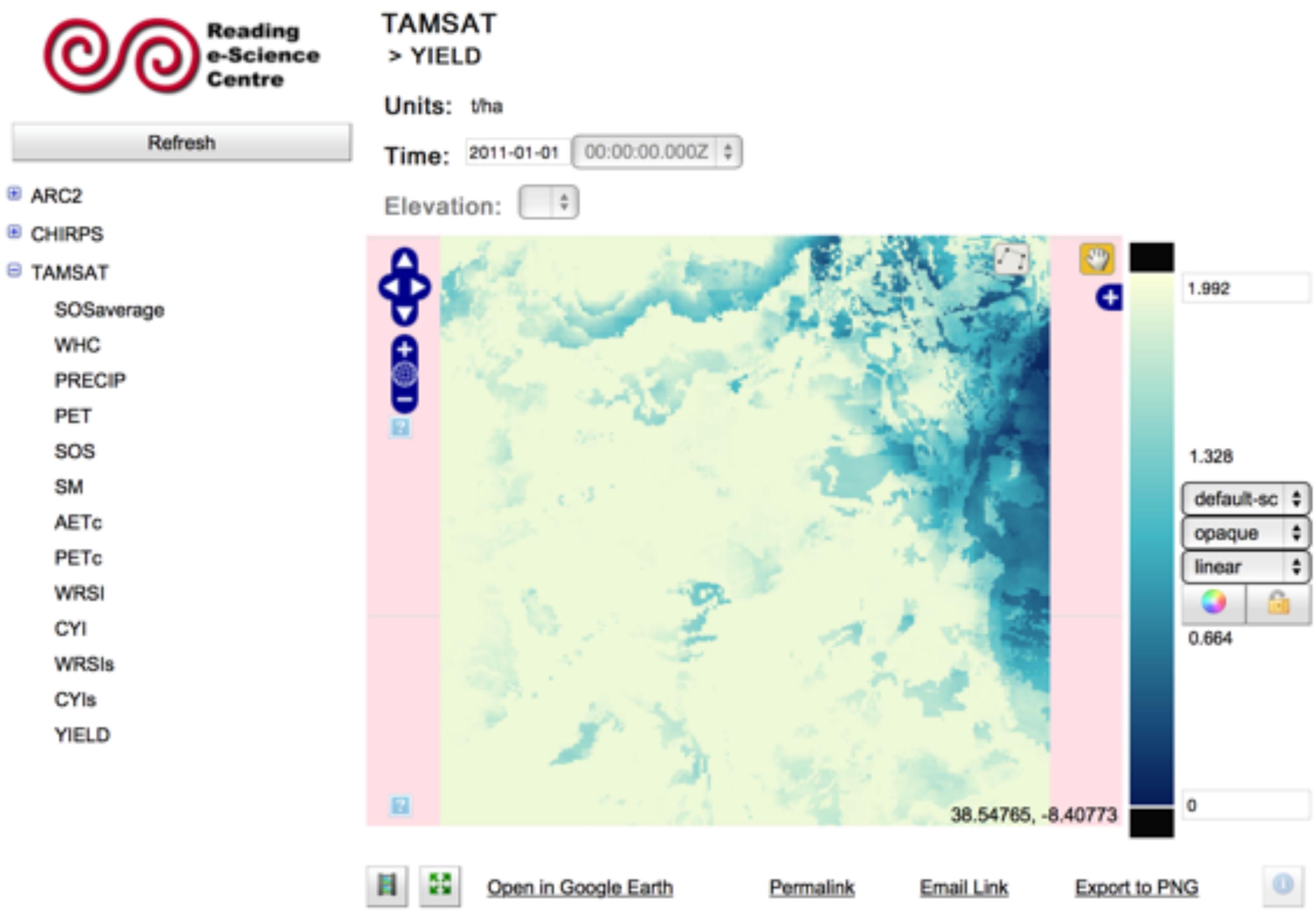
- Motivation for drought risk monitoring:
  - Recurrence intervals & spatial patterns —> (re)insurance index structure
  - Anticipating the onset of drought —> humanitarian intervention, policy implications
  - Understanding the factors driving drought —> attribution & trajectories:
    - Other variables (SM, ET, LST, VHP, etc.)
    - Dynamic inter-comparison/evaluation tools

Figure 2. Crop Water Requirement Satisfaction Index (WRSI) in the southern unimodal maize-growing areas, *Msimu* as of May 30



Source: U.S. Geological Service/FEWS NET

Applications: web-based visualisation




Thank you!
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