UNITED NATIONS
Office for Outer Space Affairs

Universidade Federal de Santa Maria
SEDES SAPIENTIÆ
1960

UN-SPIDER/ZFL Virtual Expert Meeting for Southern Africa
"Space-based Solutions for Disaster Risk Management and Emergency”

UN-SPIDER Recommended Practices for Drought Monitoring and Flood Mapping

Brazil Regional Support Office
Silvia Pardi Lacruz

Agenda

- Drought indices
- Recommended Practice: Drought monitoring using the Standard Vegetation Index (SVI)
- Case study:
  - Multitemporal analysis of drought in Mozambique

- Introduction to the use of radar imaging for flood mapping
- Recommended practice on radar-based flood mapping
- Case study:
  - Floods on March 2019 in the Beira region of Mozambique

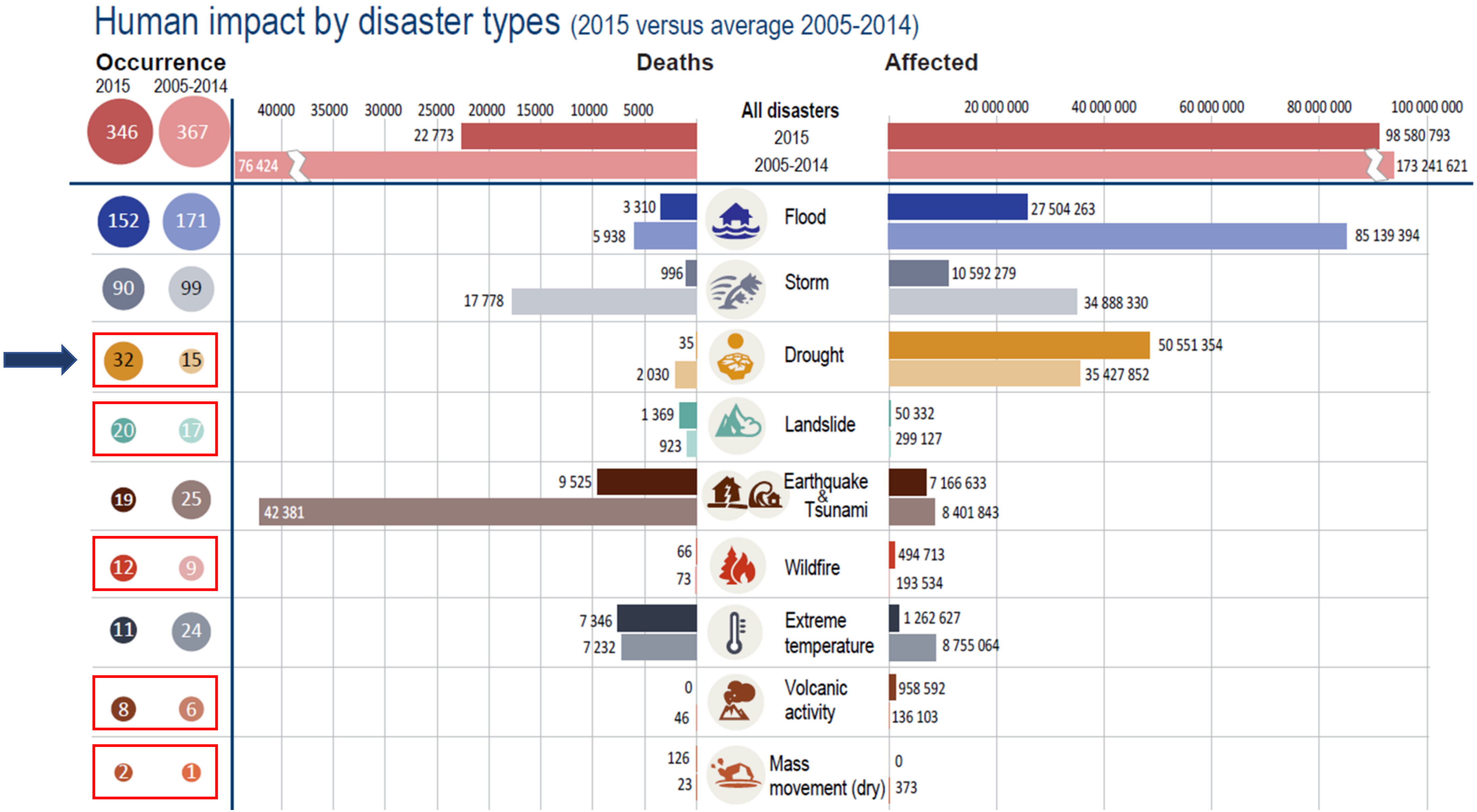
Drought

Drought

- Drought is the most complex but least understood of all natural disasters, affecting more people than other disaster.
    - Southern Africa suffered probably the worst drought in several decades and perhaps a century. According to the International Federation of Red Cross and Red Crescent (IFRC), at least 11 million people facing food shortages. Grain production was down 30% across the region.
    - In 2000, the Western U.S. entered the beginning of what scientists call a megadrought — the second worst in 1,200 years — triggered by a combination of a natural dry cycle and human-caused climate change.

Drought

- Drought differs from other natural disasters in three aspects:
  - duration and evolution (onset and end of drought – difficult to determine)
  - drought impacts spread over a larger geographical area
  - absence of a precise and universally accepted definition



http://www.emdat.be/publications

Drought Indices

- Since the beginning of the 20th century, drought indices have been developed using as input data precipitation, temperature, soil moisture and water availability.

- Indices are used to provide quantitative assessment of the severity, location, timing and duration of drought events.

- Limitation: obtaining data that represented the entire area covered by the phenomenon, whether due to the difficulty of obtaining a dense mesh of information or the extension of the areas affected by the drought.

Drought Indices

Indices	Drought type
Percent of Normal Precipitation - PNP Deciles - D Normalized Precipitation Index - NPI Supply-Demand Drought Index - SDDI National Rainfall Index - RI Palmer Drought Severity Index - PDSI	Meteorological drought
Crop Moisture Index - CMI Crop-Specific Drought Index - CEDI Surface Water Supply Index - SWSI Dependable Rains - DR Dry Conditions and Excessive Moisture Index - DM	Agricultural drought
Palmer Hydrological Drought Index - PHDI Surface Moisture Drought Index - SMDI Reclamation Drought Index - RDI Keetch-Byram Drought Index - KBDI	Hydrological drought
Standardized Precipitation Index - SPI	Socioeconomic drought

Use of Remote Sensing for Drought

- Drought is hardly directly detected in an Earth observation satellite image; it is usually identified through indexes or products.

- Changes in vegetation cover detected by remote sensing in the spatial and temporal domain have been used as indicators of drought.

- Using orbital Earth observation sensors, it is possible to develop and adapt techniques to identify, monitor and quantify drought, and thus better understand characteristics such as severity, event onset and spatial extent.

Drought Indices

A comparative study of NOAA–AVHRR derived drought indices using change vector analysis.
Bayarjargal et al., 2006.
Remote Sensing of Environment, 105 (2006)
p. 9 – 22.

The NOAA–AVHRR images-derived and meteorological-measured drought-indices

Drought indices	Formula*	Source and reference
(1) Normalized Difference Vegetation Index (NDVI)	$NDVI_{ijk} = \frac{(NIR_{ijk} - R_{ijk})}{(NIR_{ijk} + R_{ijk})}$	Ji & Peters, 2003; Tucker, 1979; Tucker & Choudhury, 1987
(2) Anomaly of Normalized Difference Vegetation Index (NDVIA)	$NDVIA_{ijk} = \overline{NDVI}_{ij} - NDVI_{ijk}$	Anyamba et al., 2001
(3) Standardized Vegetation Index (SVI)	$SVI_{ijk} = \frac{(NDVI_{ijk} - \overline{NDVI}_{ij})}{\sigma NDVI_{ij}}$	Liu & Negron-Juarez, 2001; Peters et al., 2002
(4) Vegetation Condition Index (VCI)	$VCI_{ijk} \frac{(NDVI_{ijk} - NDVI_{i,min})}{(NDVI_{i,max} - NDVI_{i,min})}$	Kogan, 1990, 1995, 1997, 2000
(5) Temperature Condition Index (TCI)	$TCI_{ijk} = \frac{(BT_{i,max} - BT_{ijk})}{(BT_{i,max} - BT_{i,min})}$	Kogan, 1995, 1997, 2000
(6) Vegetation Health Index (VH)	$VH_{ijk} = 0.5^{*} VCI_{ijk} + 0.5^{*} TCI_{ijk}$	Kogan, 1997, 2000, Kogan et al., 2004
(7) Ratio between LST and NDVI (LST/NDVI)	$LST_{ijk}/NDVI_{ijk}$	Karnieli & Dall'Olmo, 2003; Lambin & Ehrlich, 1996; McVicar & Bierwirth, 2001
(8) Drought Severity Index (DSI)	$DSI_{ijk} = \Delta LST_{ijk} - \Delta ANDVI_{ijk}$; $\Delta LST_{ijk} = (\overline{LST}_{ij} - LST_{ijk})/\sigma LST_{ij}$ $\Delta NDVI_{ijk} = (\overline{NDVI}_{ij} - NDVI_{ijk})/\sigma NDVI_{ij}$	Bayarjargal et al., 2000
(9) Palmer Drought Severity Index (PDSI)	$PDSI_{ijk} = PDSI_{ik}\{j-1+ \left[\frac{Z_{ijk}}{3} + 0.103^{*} PDSI_{ij-1k}\right]\}$	Dai et al., 2004; Palmer, 1965; National Drought Mitigation Center, 2003

*NIR_{ijk} and R_{ijk} — reflectance values at the near-infrared (channel 2) and red (channel 1) wavelengths of NOAA–AVHRR, respectively, for pixel i during month j for year k. Note that j can be also referred to 8-day (e.g. MODIS data), 10-day (e.g. PAL AVHRR), 14-day (1 km AVHRR), 16-day (1 km MODIS), depending on the time intervals of data sets.
$NDVI_{ijk}$ — monthly NDVI for pixel i in month j for year k.
$\overline{NDVI}_{ij}$ — multiyear average NDVI for pixel i in month j.
$\sigma NDVI_{ij}$ — standard deviation of NDVI for pixel i in month j.
$NDVI_{i,min}$ and $NDVI_{i,max}$ — multiyear minimum and maximum NDVI, respectively, for pixel i.
BT_{ijk} — brightness temperature at channel 4 for pixel i in month j for year k.
$BT_{i,min}$ and $BT_{i,max}$ — multiyear minimum and maximum brightness temperature, respectively, for pixel i.
LST_{ijk} — land surface temperature for pixel i in month j for year k.
$\overline{LST}_{ij}$ — multiyear average LST for pixel i in month j.
σLST_{ij} — standard deviation of LST for pixel i in month j.
$PDSI_{ijk}$ and $PDSI_{ij-1k}$ — monthly PDSI for pixel i for year k in a current month j and previous month $j-1$.
Z_{ijk} — monthly moisture status for pixel i in month j for year k.

UN-SPIDER Recommended Practice for Drought Monitoring

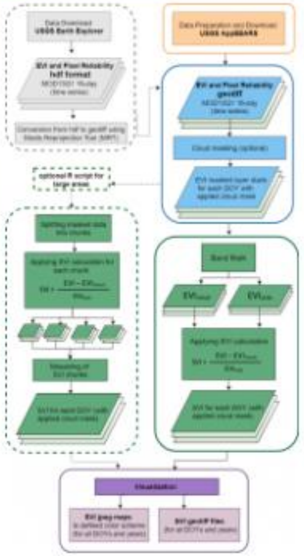
UNITED NATIONS
Office for Outer Space Affairs
UN-SPIDER KNOWLEDGE PORTAL
Space-based information for Disaster Management and Emergency Response

English ~~Español~~ Français

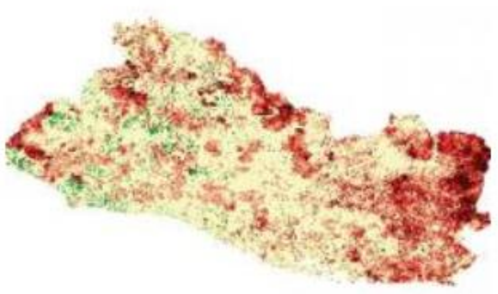
Search...

Home | Space Application | Risks & Disasters | Links & Resources | Advisory Support | Network | Projects | News & Events | About Us

Flowchart



Recommended Practice: Drought monitoring using the Standard Vegetation Index (SVI)



Drought monitoring is an important component in drought early warning systems. This practice shows how to monitor the impacts of meteorological drought on natural vegetation using MODIS optical satellite imagery. The practice has been developed in the context of the SEWS-D project. It is similar to the practice developed by the Iranian Space Agency but it proposes the use of a different index (SVI instead of VCI). The practice was developed by the Universidad Federal de Santa Maria (UFSM) in Brasil. (The above image shows the standard vegetation index based on EVI for El Salvador on 28 July 2014.)

Recommended by:

Universidade Federal de Santa Maria

Related Practices

Recommended Practice: Drought monitoring using the Vegetation Condition Index (VCI)

UN-SPIDER Recommended Practice for Drought Monitoring

Step by Step: Drought monitoring using the Standard Vegetation Index (SVI)

Share this page

Share 2

Twitter

Share

Back to overview

In Detail

Data Access:

The step-by-step procedure for drought monitoring using the Standard Vegetation Index (SVI) is available to follow using R-Studio and Python. These two methods were developed to give the user flexibility to choose which of the open source tools is more practical and convenient.

Please click on the icons below to see the corresponding step-by-step procedure.

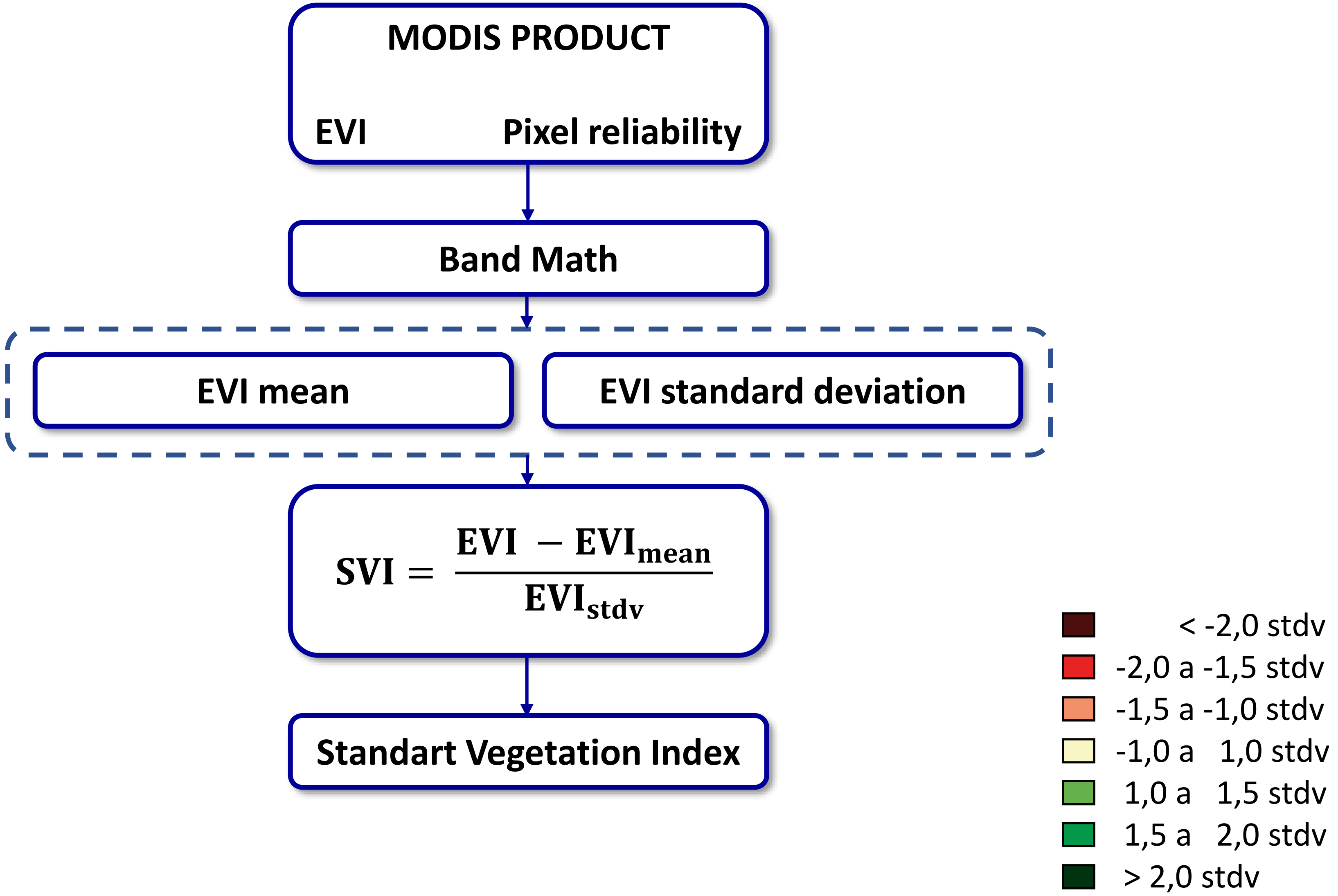
R

python™

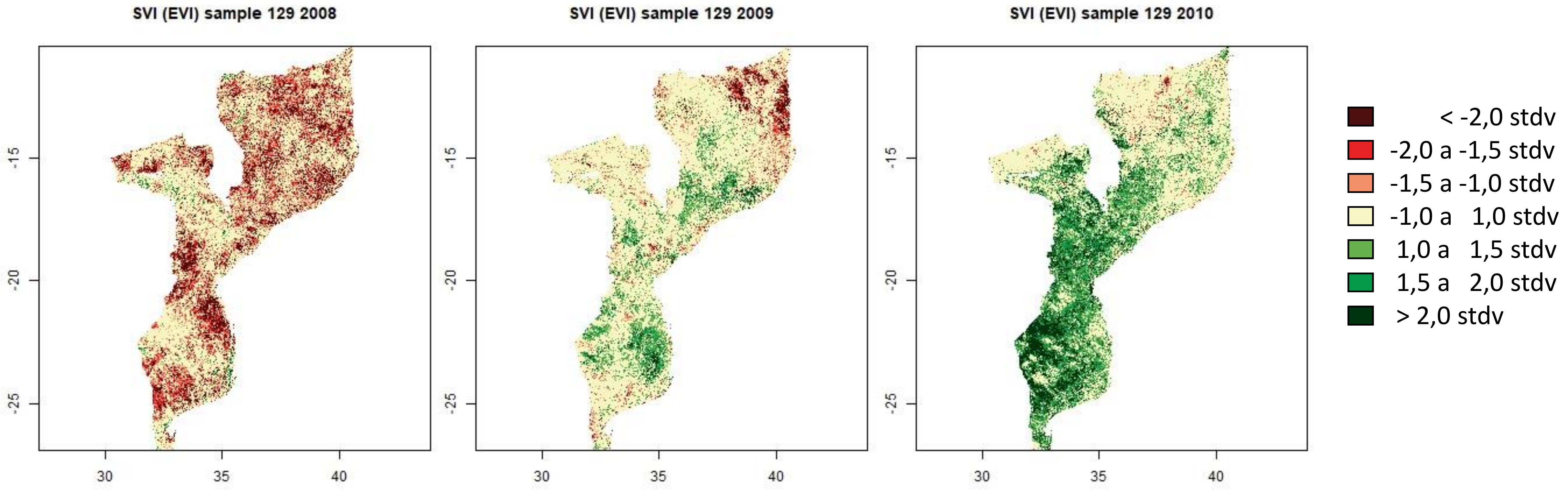
R Script for large areas

Google Earth Engine

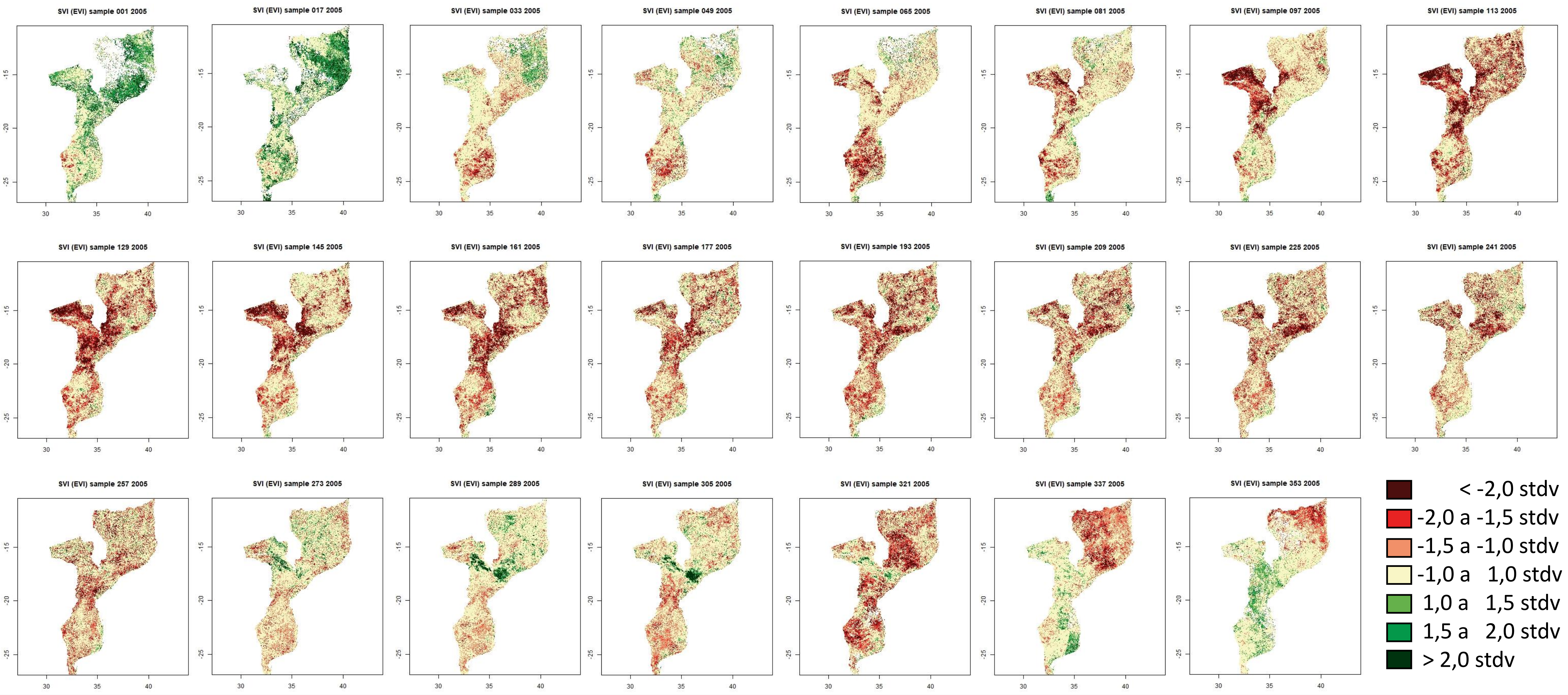
UN-SPIDER Recommended Practice for Drought Monitoring



Multitemporal analysis of drought in Mozambique

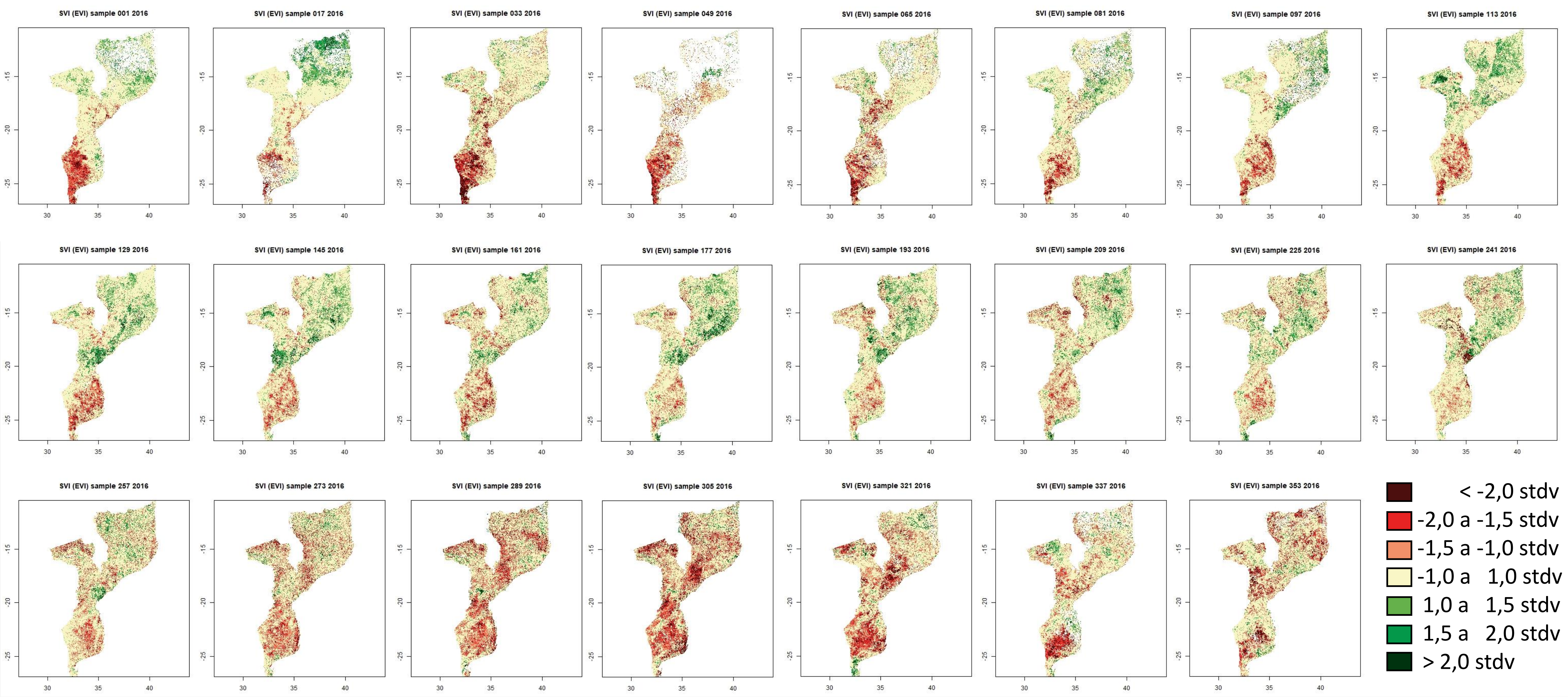


Multitemporal Analysis of Drought in Mozambique - 2005

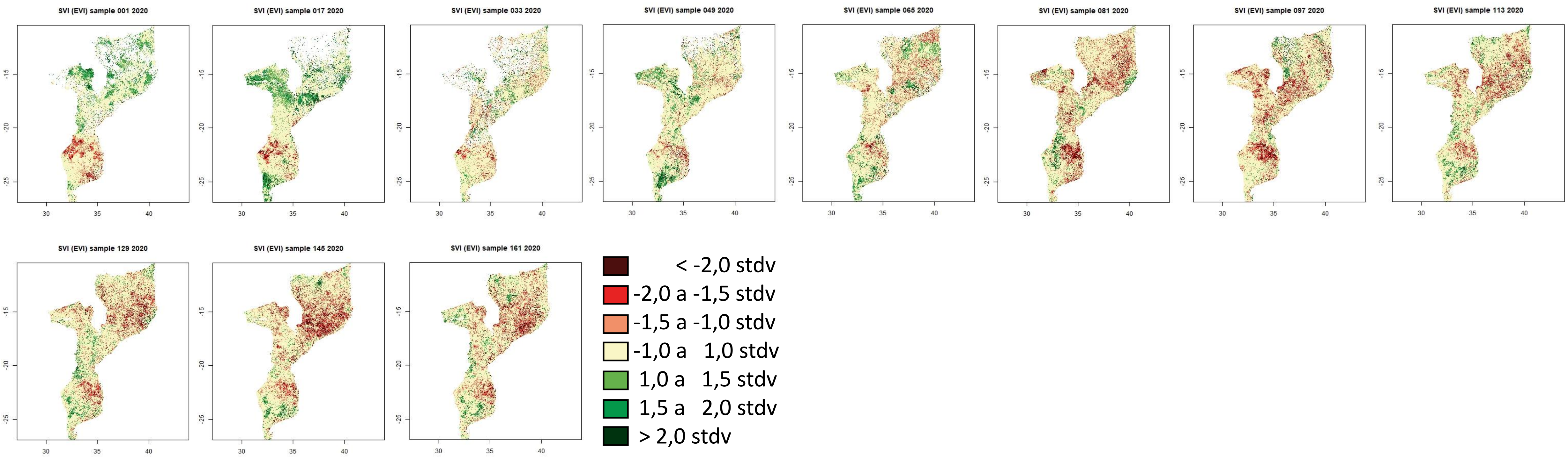


Multitemporal Analysis of Drought in Mozambique - 2008

Multitemporal Analysis of Drought in Mozambique - 2016



Multitemporal analysis of drought in Mozambique - 2020



Recommendations

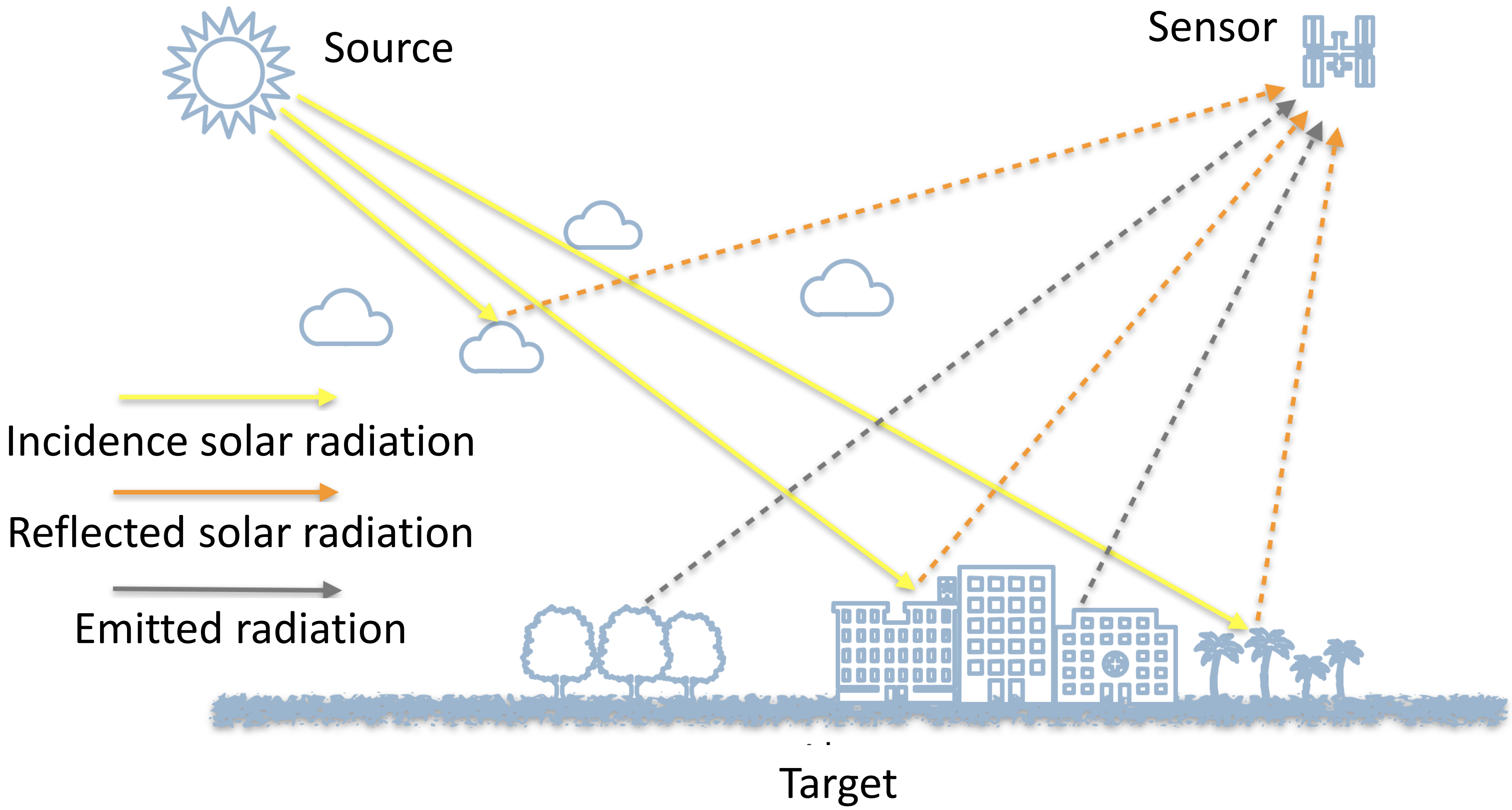
- Validate the practice for each country or region.
- Build a drought databank.
- Relate the information to land use and cover maps and soil types.
- Integrate emergency and disaster information with drought maps.

Flood

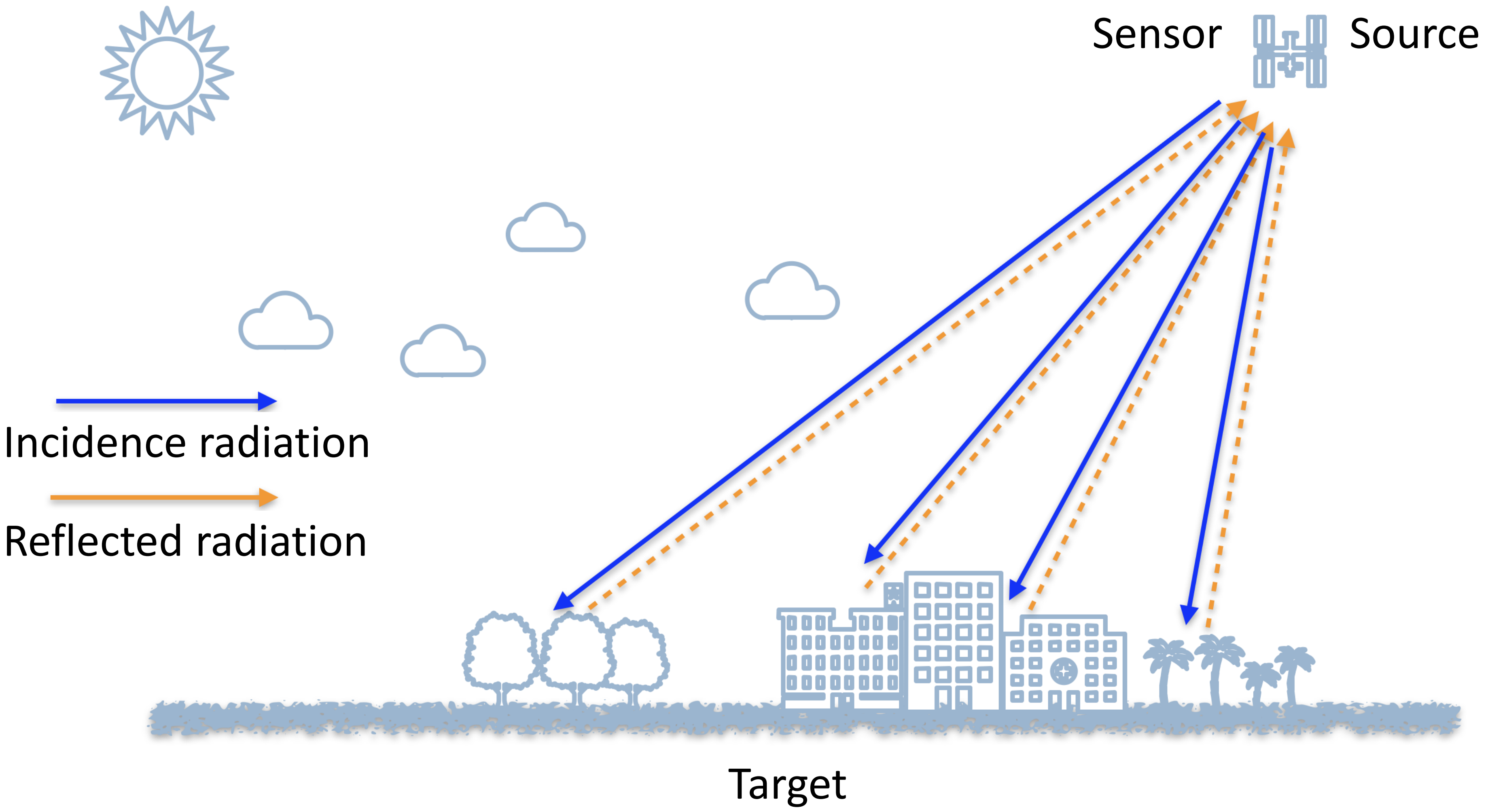
Using Radar Images for Flood Mapping

- RADAR principles
  - SAR
  - Resolution and angle of incidence
  - Frequency band and polarization (HH, HV, VV, VH)
- Image characteristics
  - Shadow
  - Foreshorting and layover distortion
  - Speckle
- Backscattering

Using Radar Images for Flood Mapping

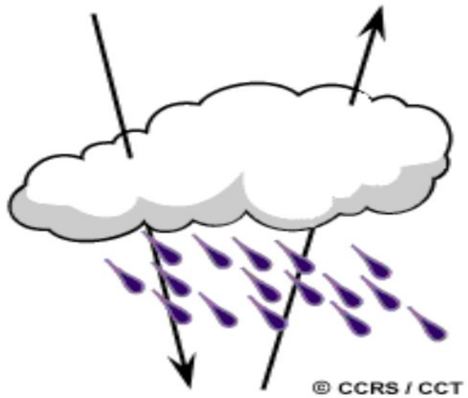


Using Radar Images for Flood Mapping



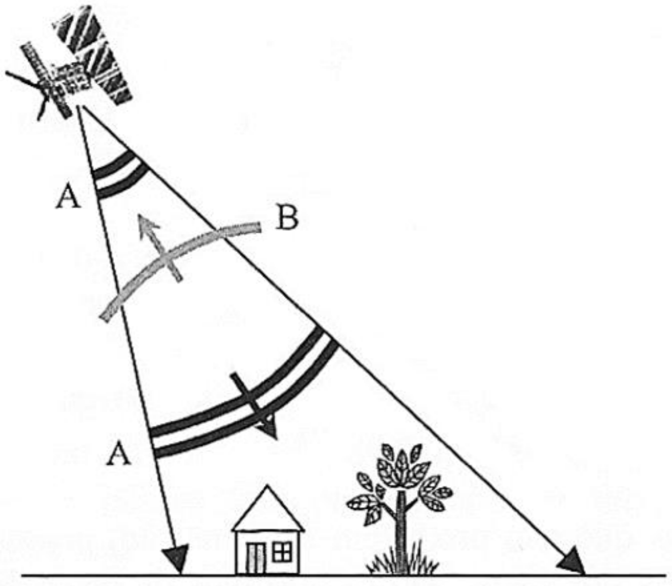
Using Radar Images for Flood Mapping

- Radar images
- Different wavelength characterists comparing to optical images
  - SAR (1cm – 1m) - longest wavelengths when comparing to optical images: visible (0,4µm – 0,7µm), near-infrared (0,7µm – 1,3µm), mid-wave infrared (1,3µm – 8µm), far-infrared or thermal-infrared (8µm – 14µm).

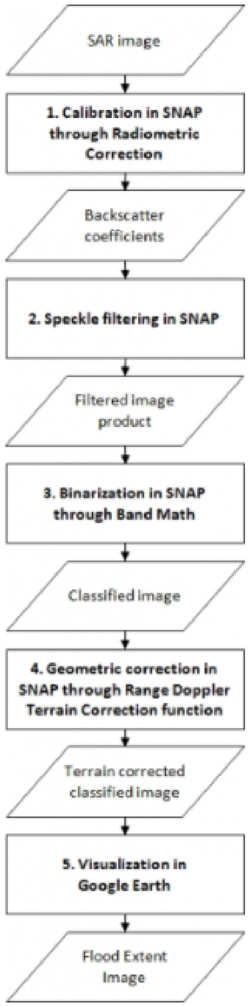


Using Radar Images for Flood Mapping

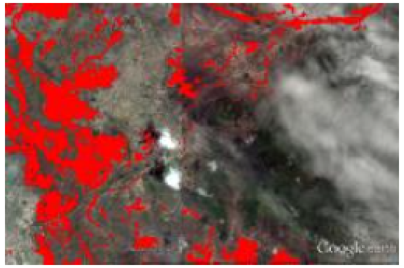
- Radar remote sensing
- Active sensors have its own source of light or illumination. In particular, it actively sends a pulse and measures the backscatter reflected to the sensor. Therefore, images can be acquired day and night, completely independent of solar illumination.



Flowchart



Recommended Practice: Radar-based Flood Mapping



The UN-SPIDER Recommended Practice on radar-based flood mapping explains the use of Synthetic Aperture Radar (SAR) satellite imagery for flood mapping. The practice shows the use of the European Space Agency's (ESA) SNAP software for pre-processing and processing of SAR imagery using a threshold method for deriving the flood extent. Google Earth is used to visualize the results of the image processing. This practice was developed by the Space Research Institute NASU-SSAU, Ukraine, a UN-SPIDER Regional Support Office. This practice can be applied globally and has been used successfully for floods in Australia, Africa and Asia.

Step by Step | **In Detail**

Objective:

The objective of this practice is to determine the extent of flooded areas. The use of SAR satellite imagery for flood extent mapping constitutes a viable solution to process images quickly, providing near real-time flooding information to relief agencies. Moreover, flood extent information can be used for damage assessment and risk management creating scenarios showing potential population, economic activities and the environment at potential risk from flooding,

Disaster type:

Flood

Disaster Cycle Phase:

Recovery & Reconstruction   Relief & Response

Recommended by:

Related Practices

Recommended Practice: Flood Hazard Mapping

Related data

Sentinel 1 - SAR Dataset (ESA)

view all

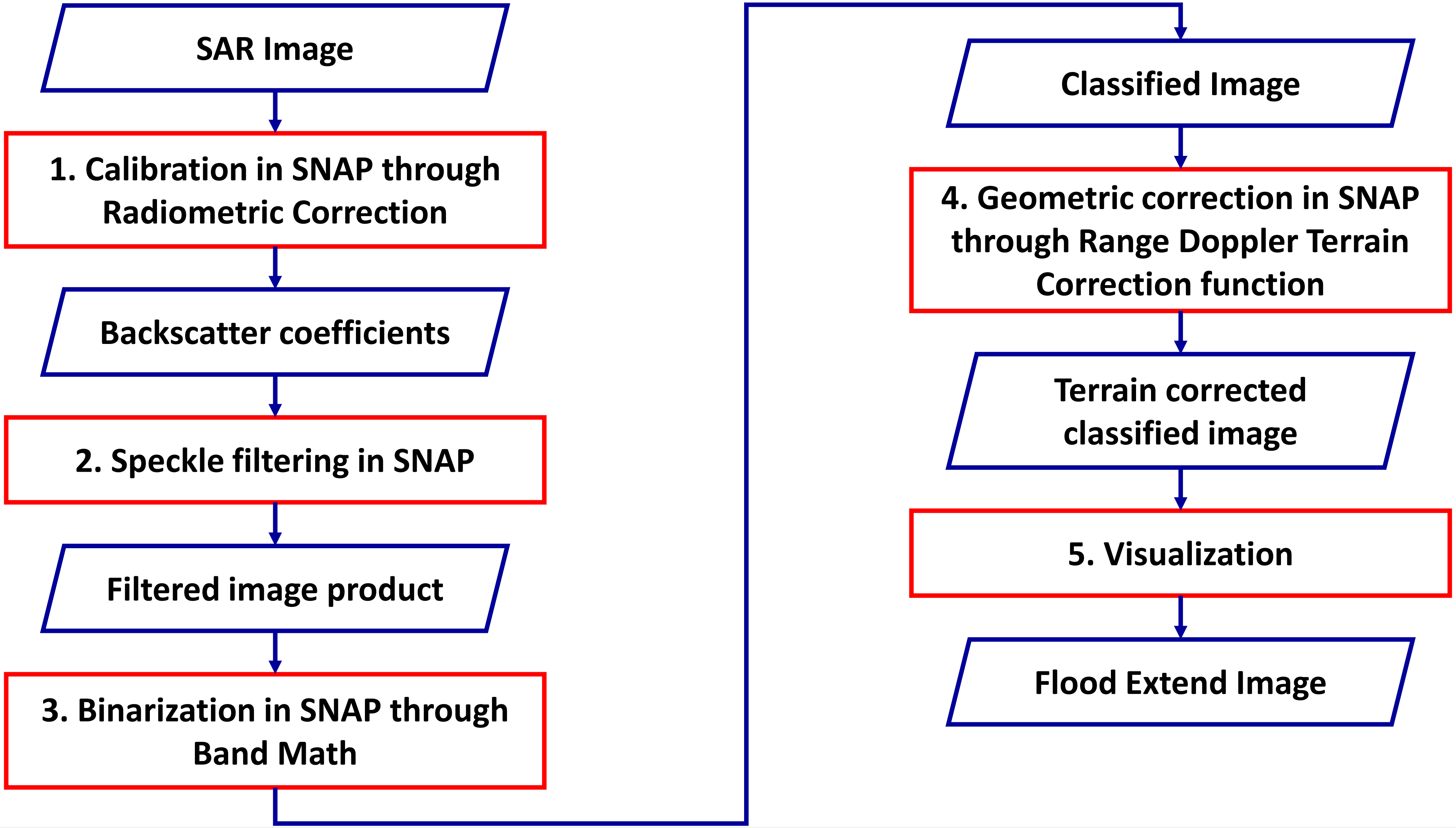
Related Software

Google Earth Pro
Sentinel Application Platform (SNAP)
Python

view all

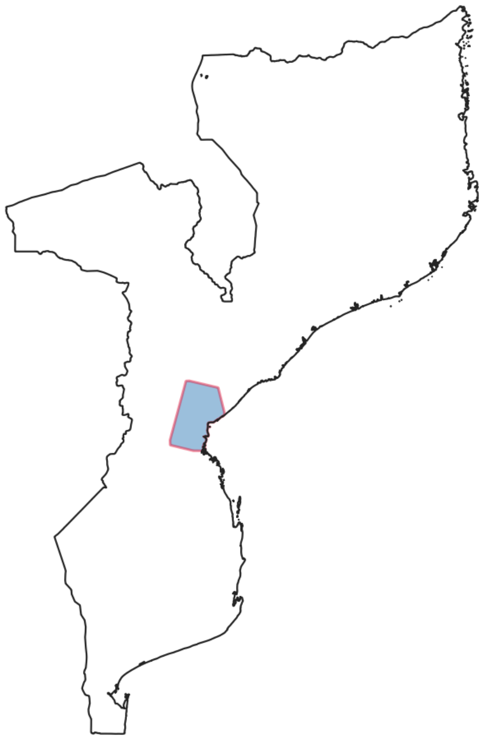
Share this page

Recommended Practice: Radar-based Flood Mapping



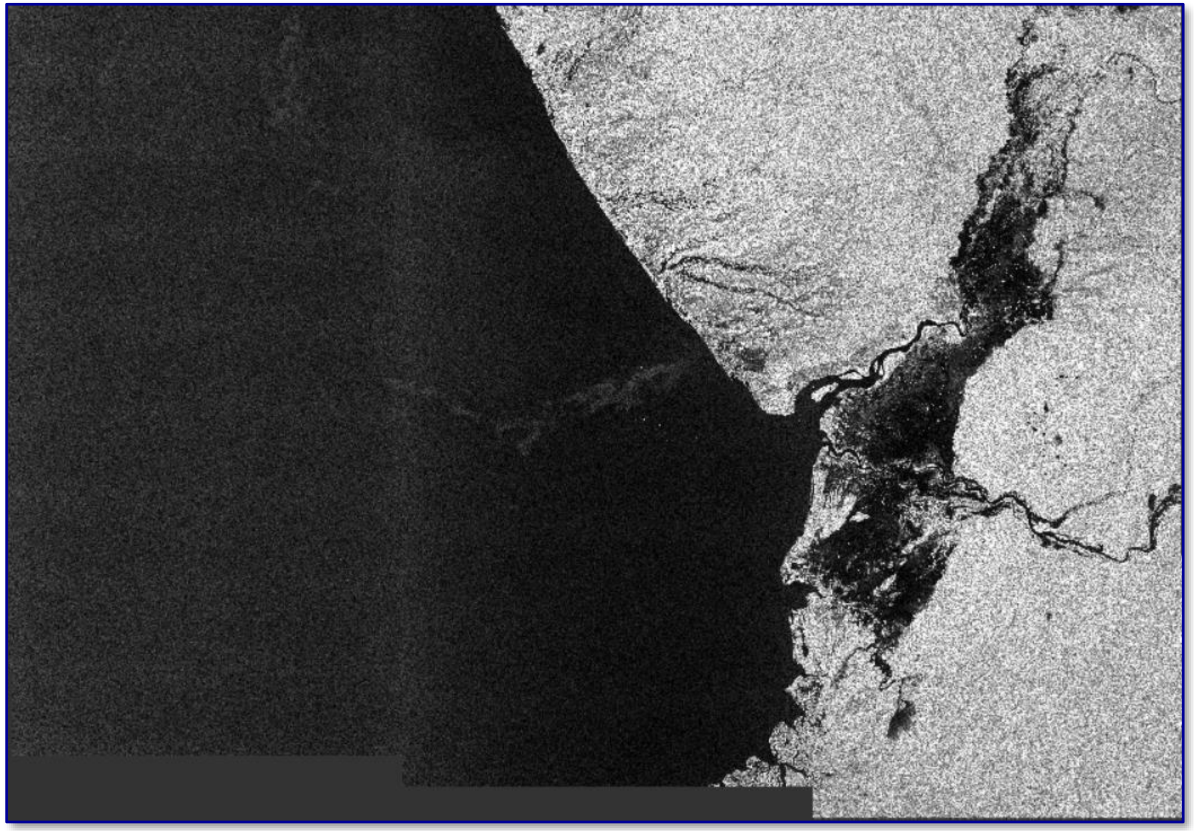
Case Study

- Tropical Cyclone Idai brought torrential rain and flash flooding to parts of Mozambique.
- Over 100 people were killed and 500,000 were affected.
- The flooding damaged power supplies and communications, and also affected water supplies.
- ~ 5000 properties were submerged and large cropland destroyed.
- The city of Beira were particularly affected by the storm.
- Reports indicate that the flood waters in Mozambique reach 6 metres in some areas.

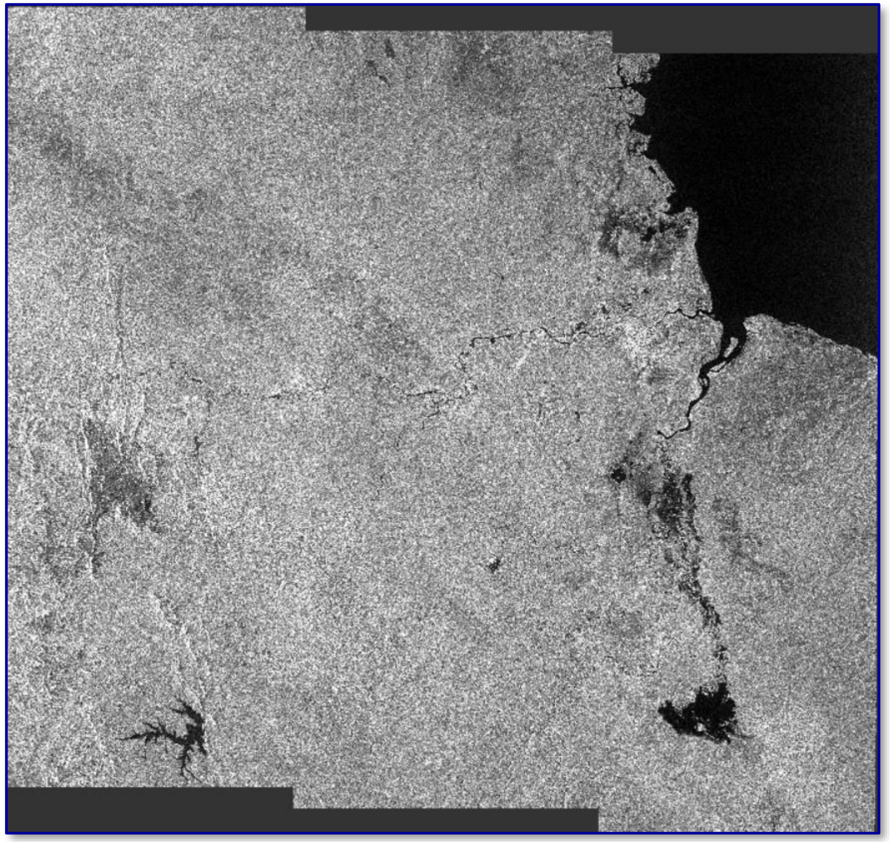


https://disasterscharter.org/es/web/guest/activations/-/article/cyclone-in-mozambique-activation-598-

Case Study

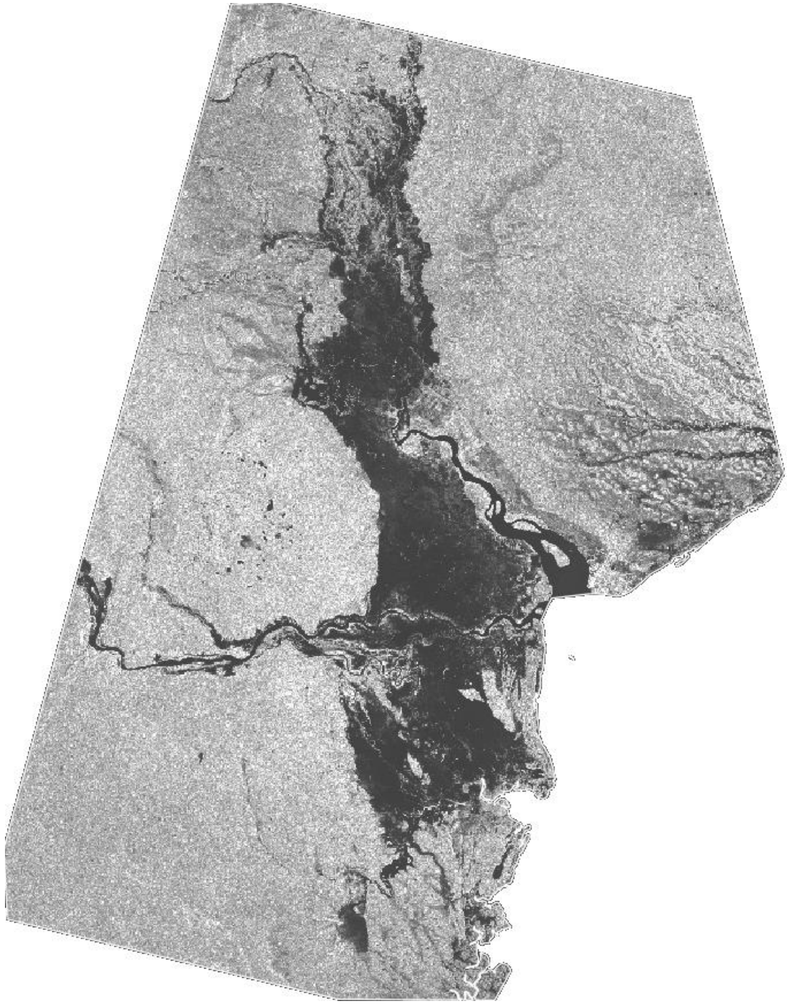


Sentinel-1 image 20 March 2019

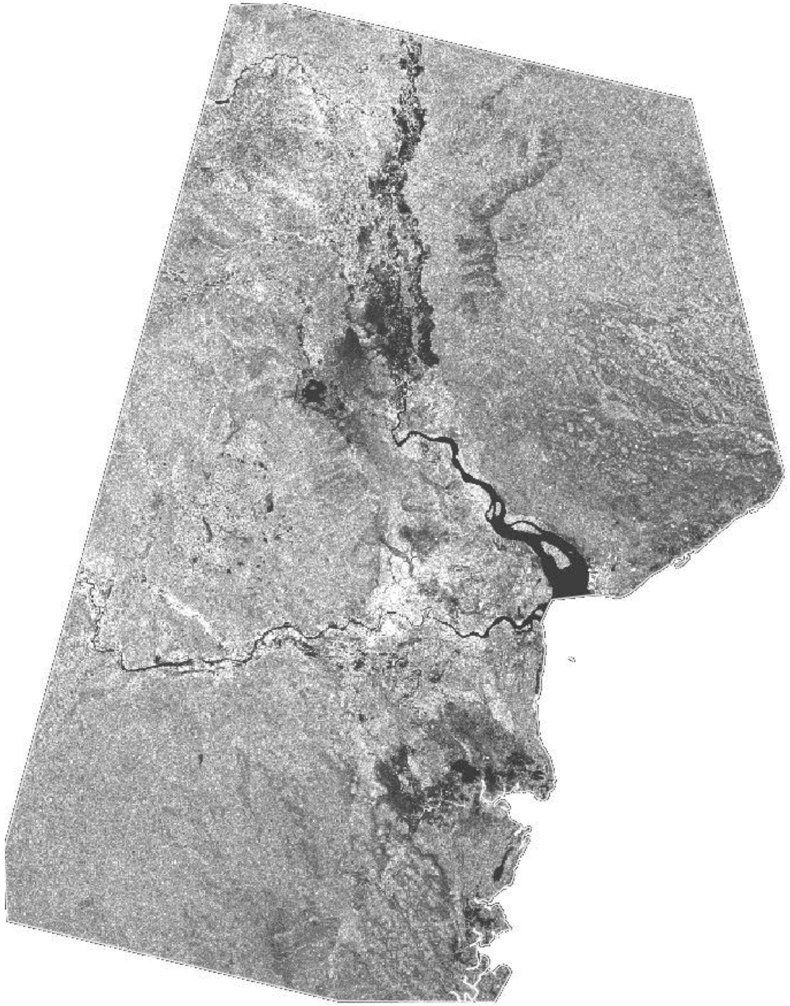


Sentinel-1 image 31 March 2019

Case Study

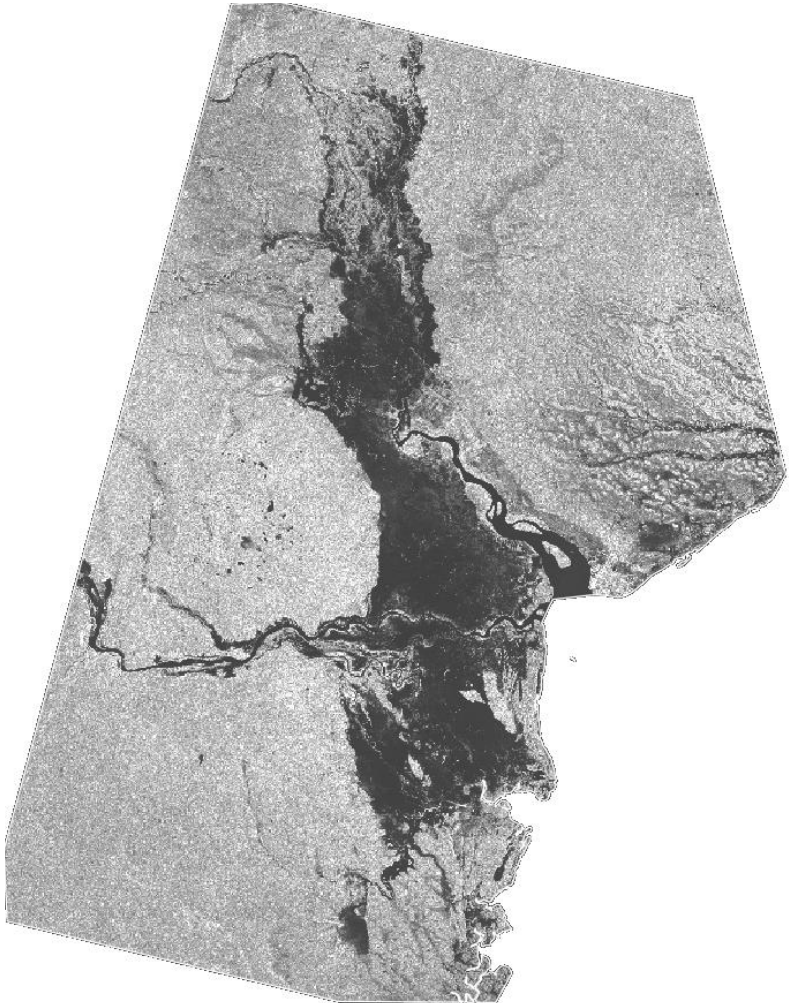


Sentinel-1 image 20 March 2019

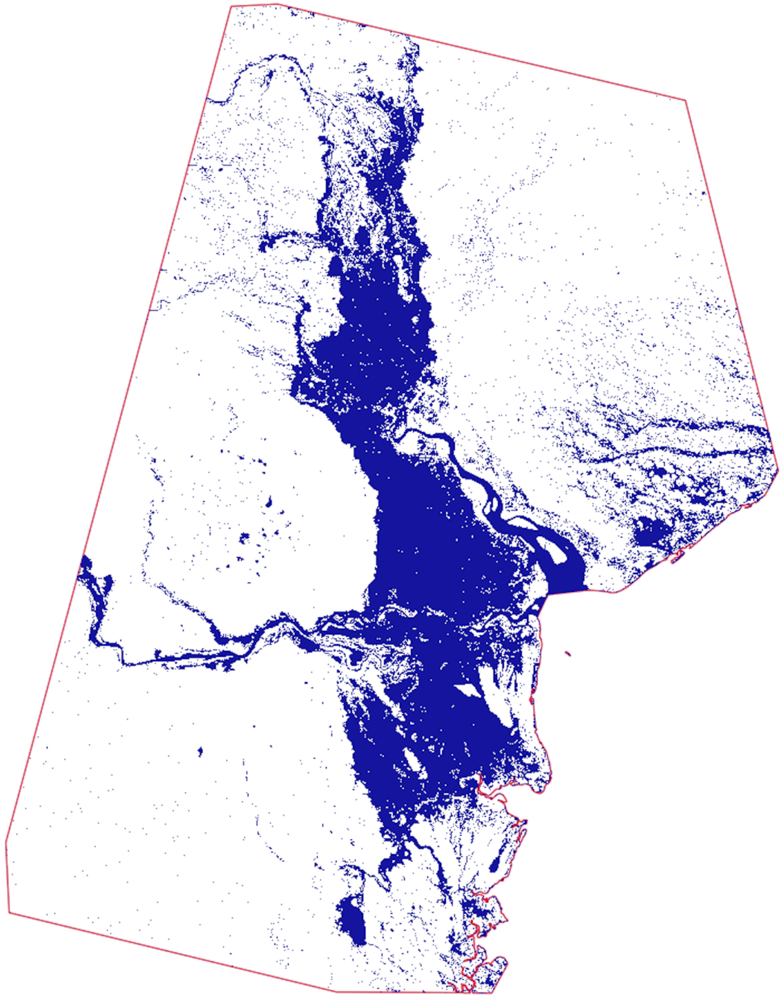


Sentinel-1 image 31 March 2019

Case Study

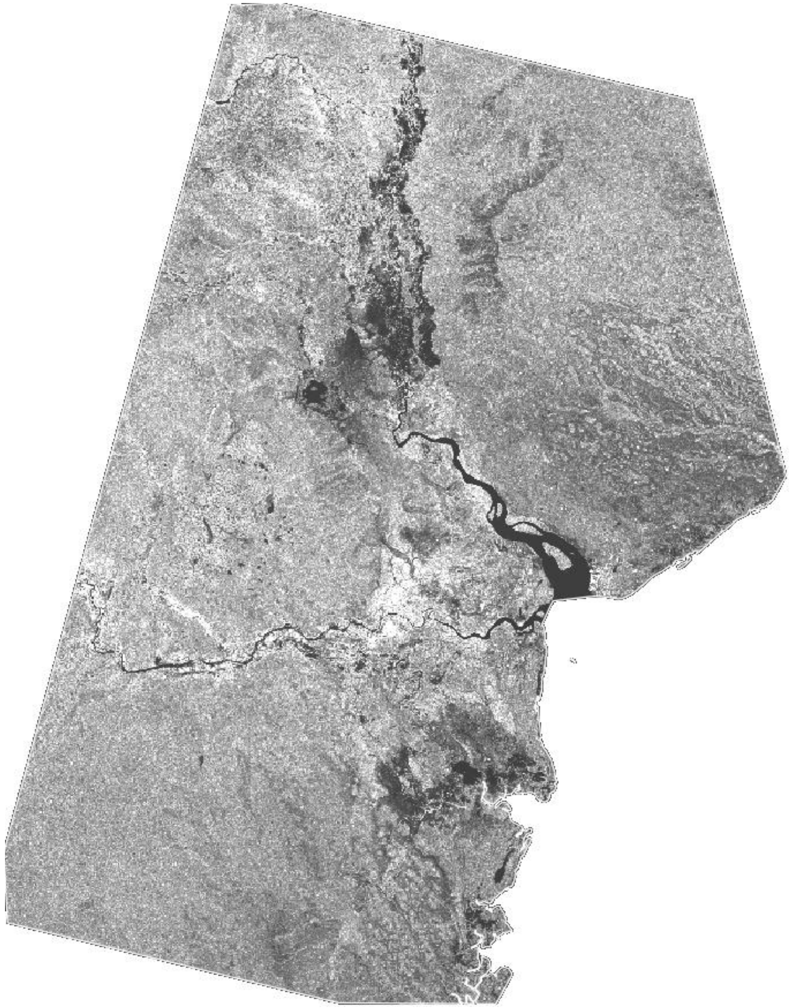


Sentinel-1 image 20 March 2019

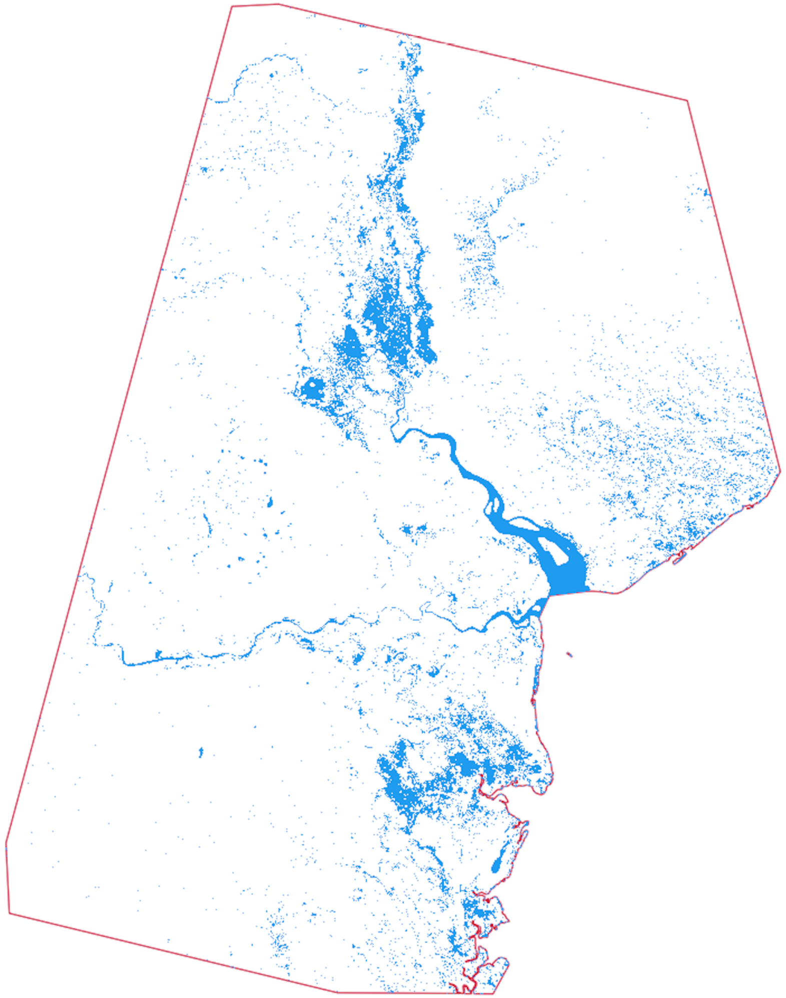


Flood mask 20 March 2019

Case Study

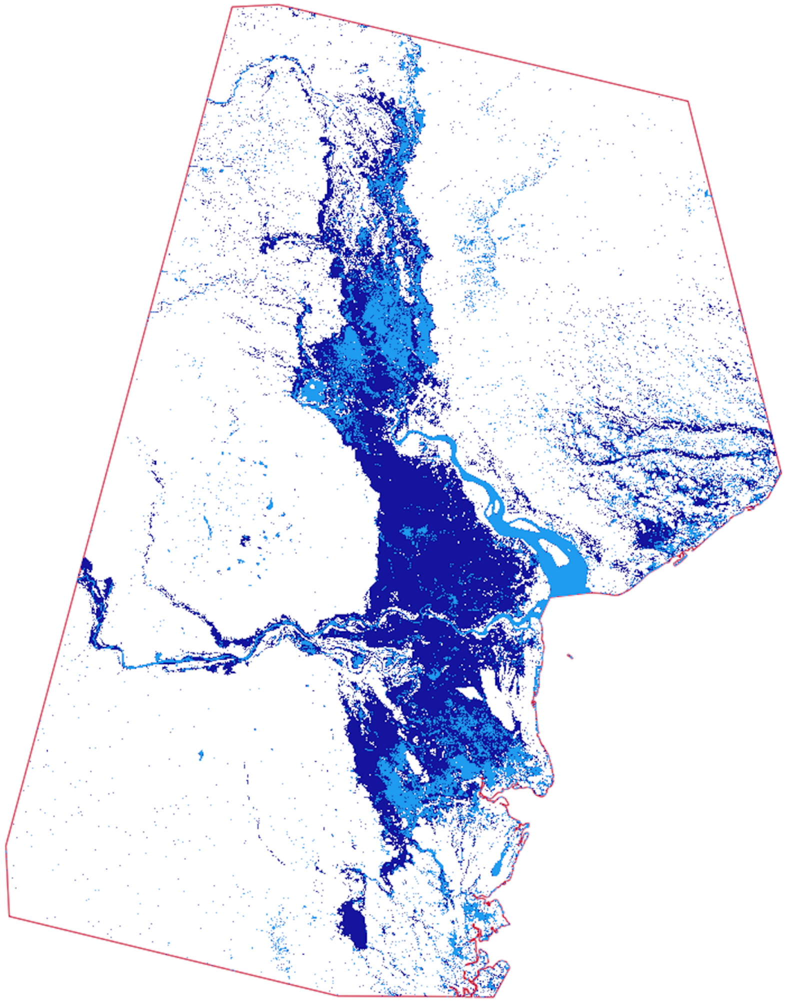


Sentinel-1 image 31 March 2019

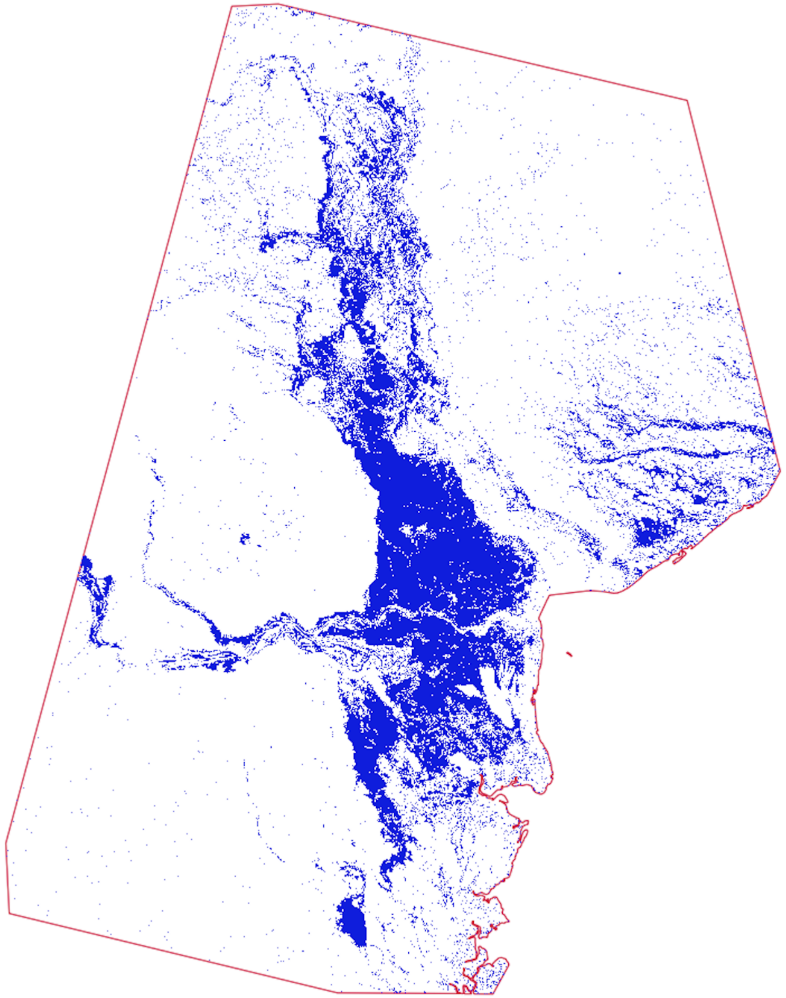


Flood mask 31 March 2019

Case Study

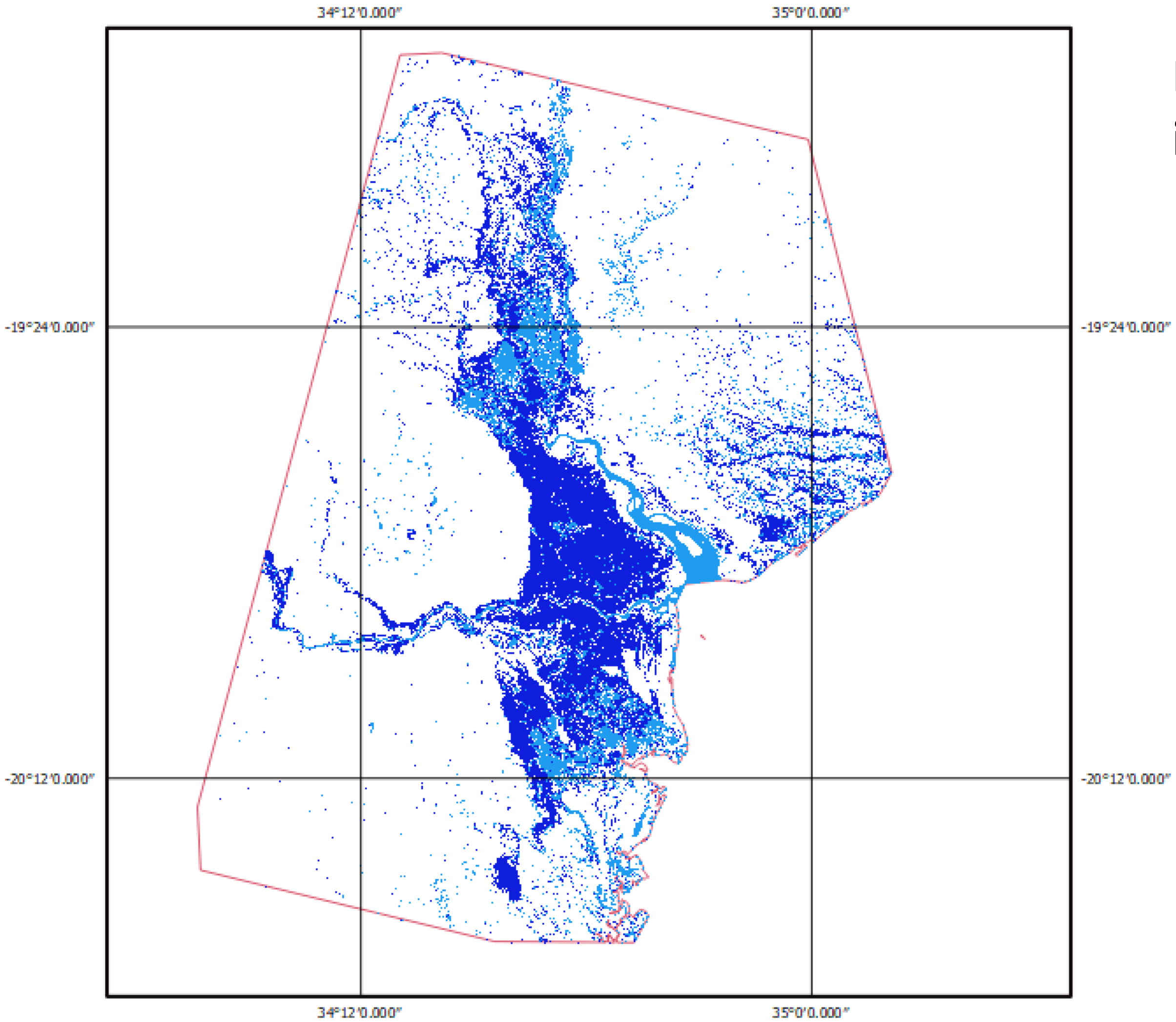


Flood mask

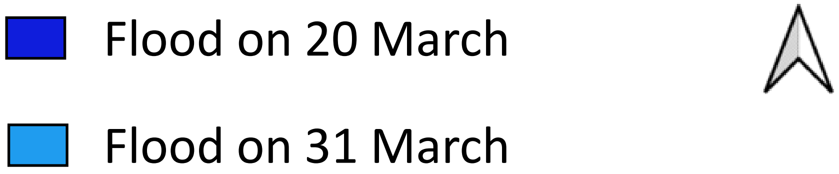


Flood mask 20 March 2019

Case Study



Extension of floods on 20 and 31 March 2019 in the Beira region of Mozambique



Date	Area (ha)
20 March 2019	311,898
31 March 2019	101,259
Period	**210,639**

Thank you!

Silvia Pardi Lacruz
spardilacruz@gmail.com