V Convención Científica Internacional UCLV 2025

Advancements in Earth Observation for Water Resources Monitoring and Management in Africa

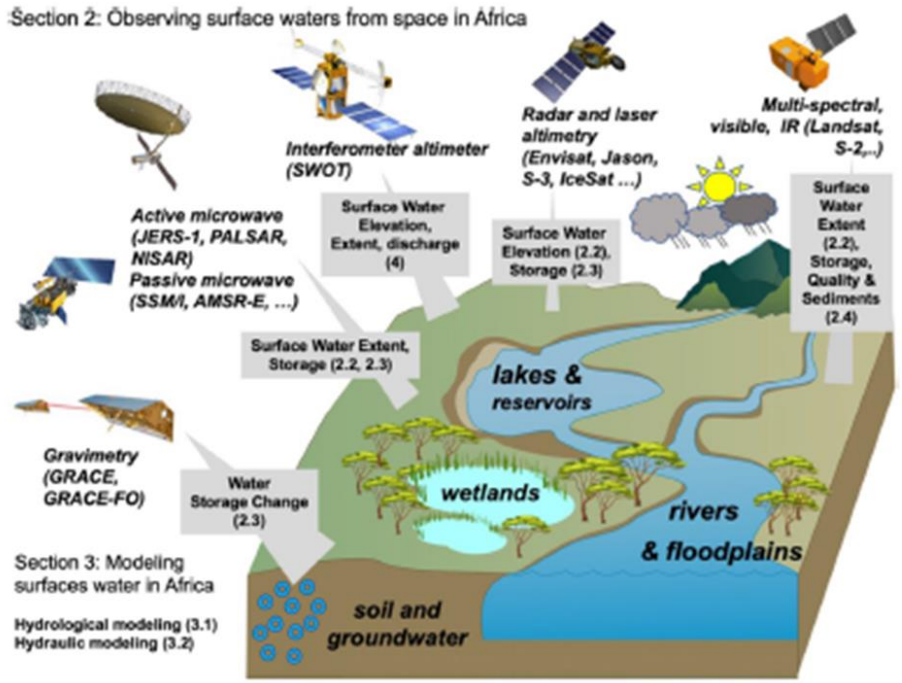
DIGIWATER

Timothy Dube

University of the Western Cape, Cape Town, South Africa

Outline

- Hydrology of Africa
- Threats to Water Resources
- Overview EO Application Challenges in Africa
- Opportunities for Water Resources Applicatio
- Take Home Messages

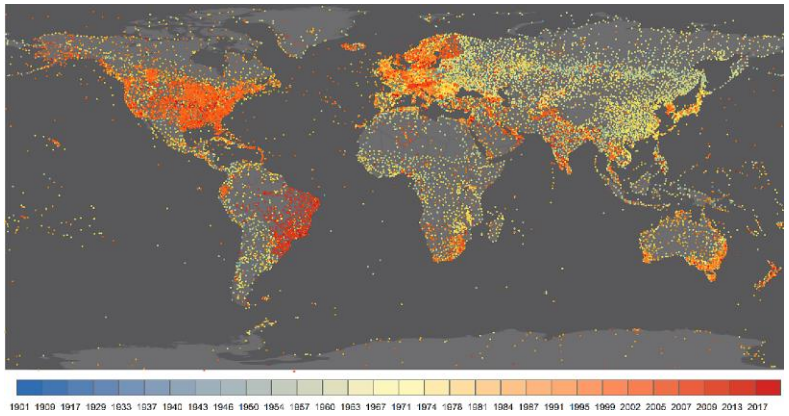


Hydrology of Africa & its relevance

- In Africa water resources are essential - terrestrial life, ecosystems, biodiversity, & human society and economic activities
- Despite their importance,
  - freshwater storage & flux,
  - their spatial distribution and variability, remain poorly understood in many regions –
  - hinders the development of sustainable water resource management strategies.
- African continent has the rapid growing population, freshwater systems are diverse and significant, including the Nile and Congo rivers, and large lakes like Victoria, Tanganyika, and Malawi but currently under threat.

Traditional Water Resources Monitoring & Management Challenges in Africa

- Limited ground-based monitoring infrastructure
- Data quality issues, including inconsistencies and inaccuracies
- Rapid changes in climate patterns affecting water availability
- Insufficient funding for monitoring initiatives
- Lack of coordination among monitoring agencies & stakeholders
- Inadequate data coverage in remote areas



EO Data for Water Resources Applications in Africa

- Over the years, RS applications WRM have undergone significant advancements
- Transitioning from traditional methods to advanced satellite systems became attractive for water-related studies
- Evident in the in the increase in the number of RS and WRM studies

Journal of Hydrology 623 (2023) 129738

Contents lists available at ScienceDirect

Journal of Hydrology

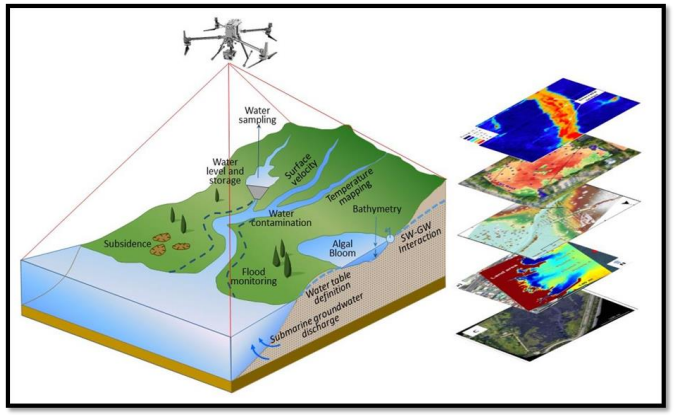
journal homepage: www.elsevier.com/locate/jhydrol

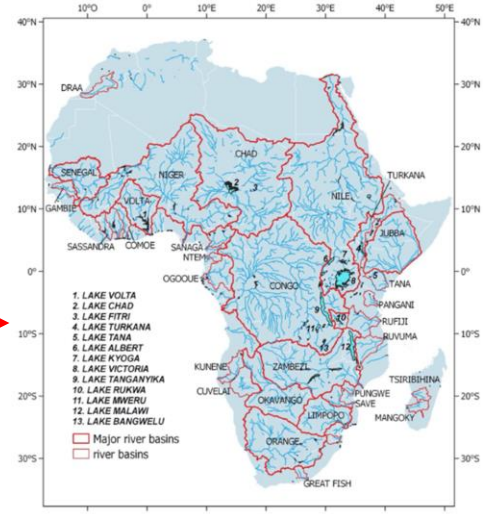
Review papers

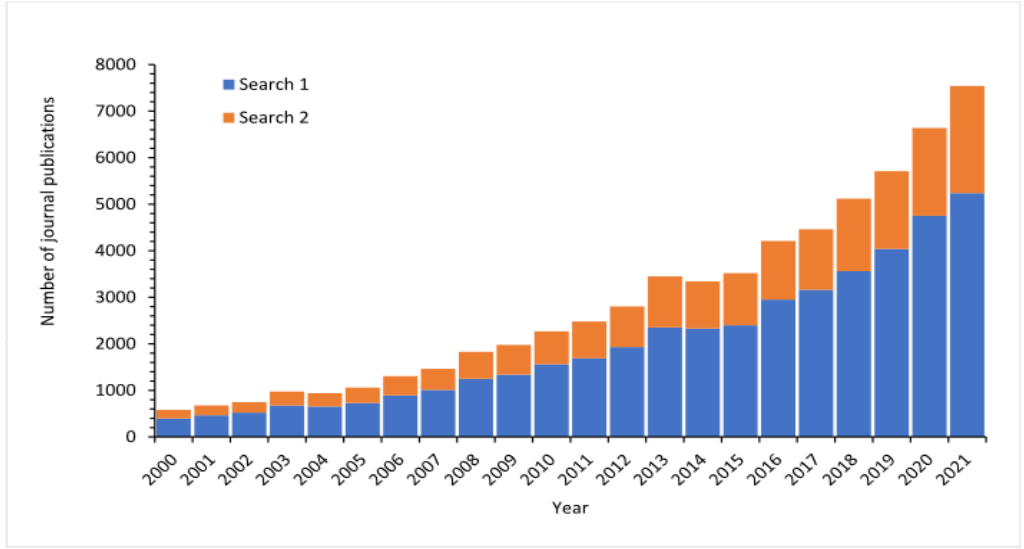
Advancements in earth observation for water resources monitoring and management in Africa: A comprehensive review

Timothy Dube [a], Dylan Seaton [a,*], Cletah Shoko [b], Cheikh Mbow [c]

[a] Institute of Water Studies, Department of Earth Sciences, The University of the Western Cape, Private Bag X17, Bellville 7535, South Africa
[b] Division of Geography, School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg 2050, South Africa
[c] Centre De Suivi Ecologique (CSE), Rue Léon Gontran Damas, Fann Résidence, Dakar, BP: 15 532 Dakar-Fann, Senegal

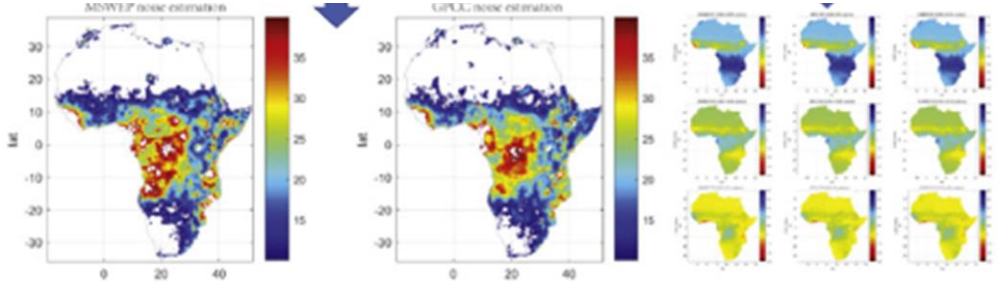






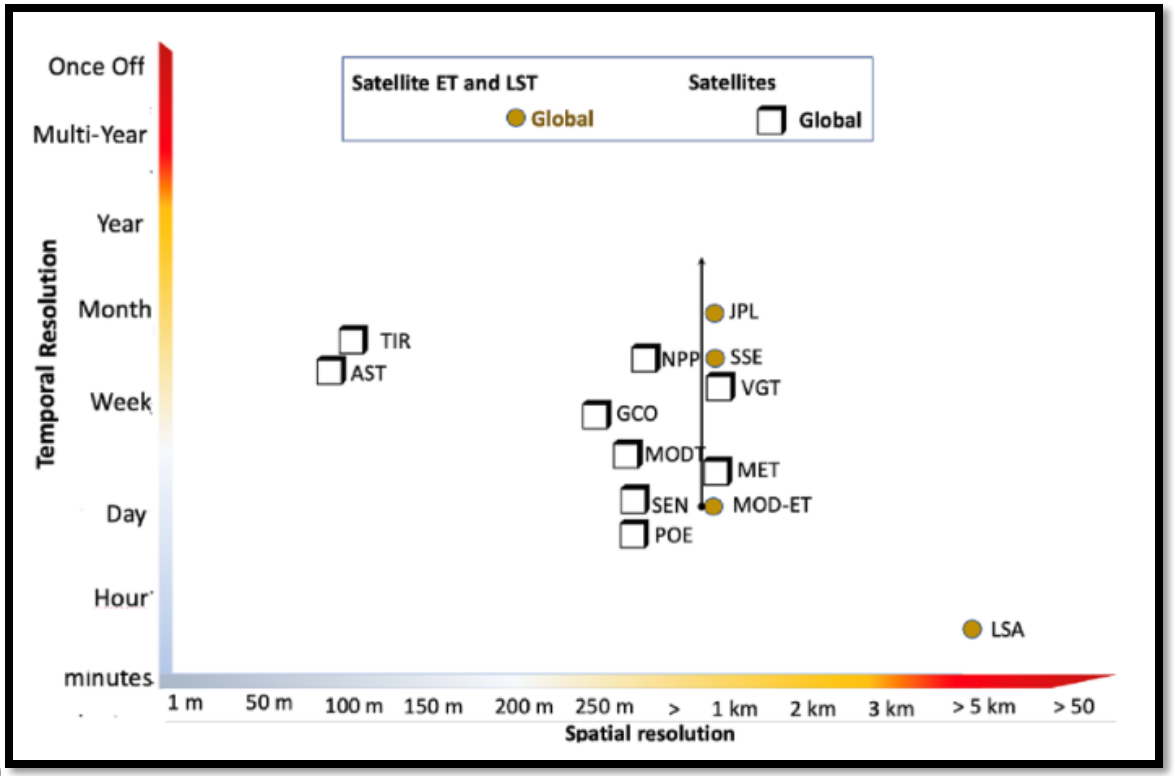
EO Data for Rainfall Estimation

- Satellite-derived estimates helped overcome the limitations of in-situ gauging stations, many of which suffer from maintenance issues when they are available
- Satellite data provide near real-time rainfall observations with enhanced spatial distribution and higher temporal frequency
- Various rainfall estimation products have been applied:
  - Tropical Rainfall Measuring Mission (TRMM)
  - Precipitation Estimation (PERSIANN)
  - Climate Prediction Center-Morphing (CMORPH)
  - Global Satellite Mapping of Precipitation(GSMAP) & MSG.



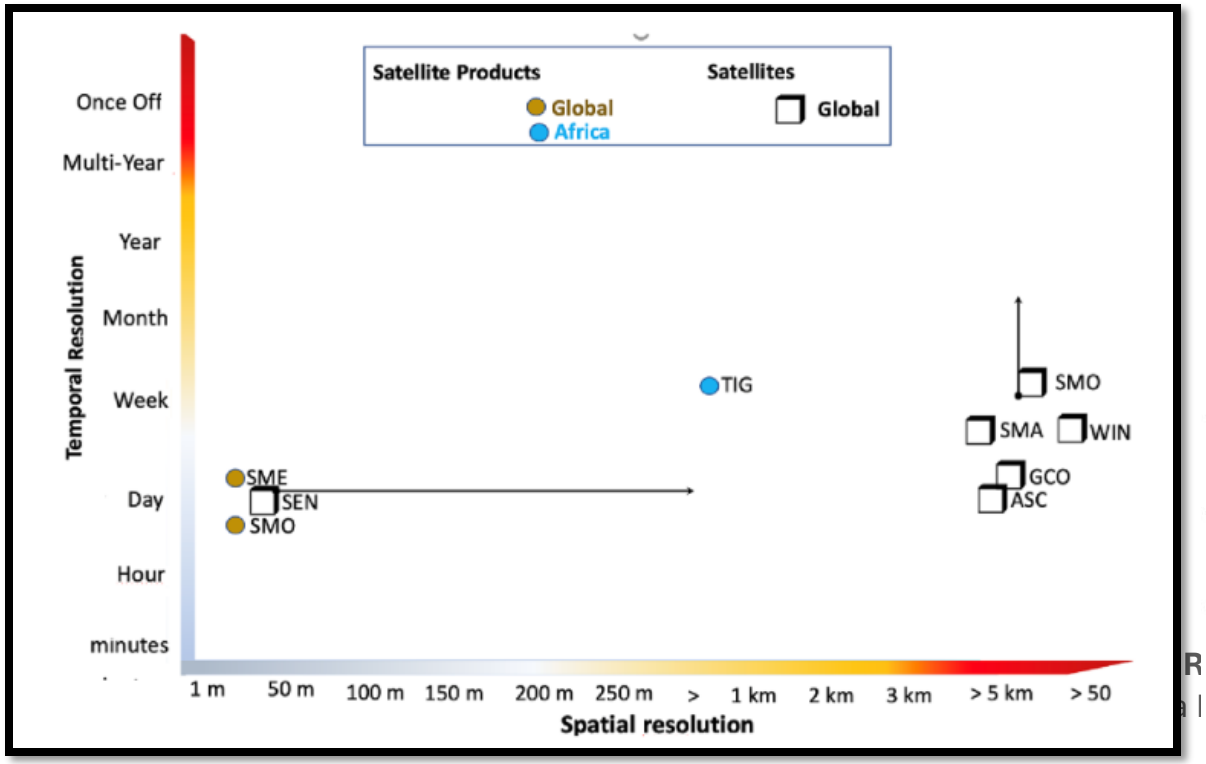
EO Data for ET Estimation

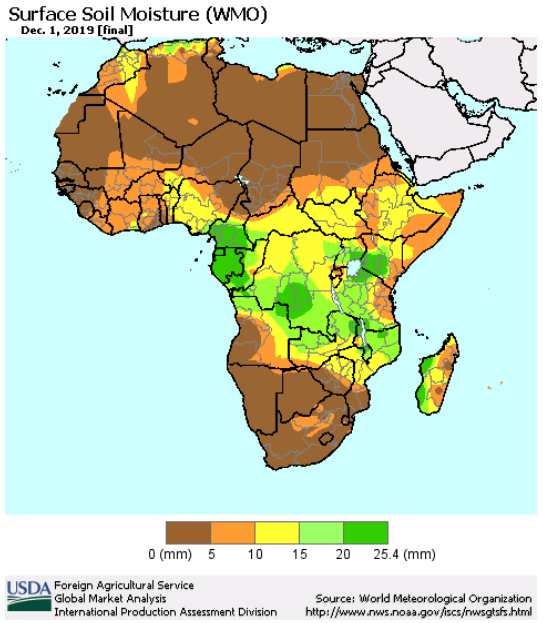
- Satellite-based products yielded a wealth of ET-related data, and such products include:
  - Advanced Very High-Resolution Radiometer (AVHRR)
  - Moderate Resolution Imaging Spectrometer (MODIS)
  - Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER)
  - Landsat's thermal infra-red (TIR) sensors

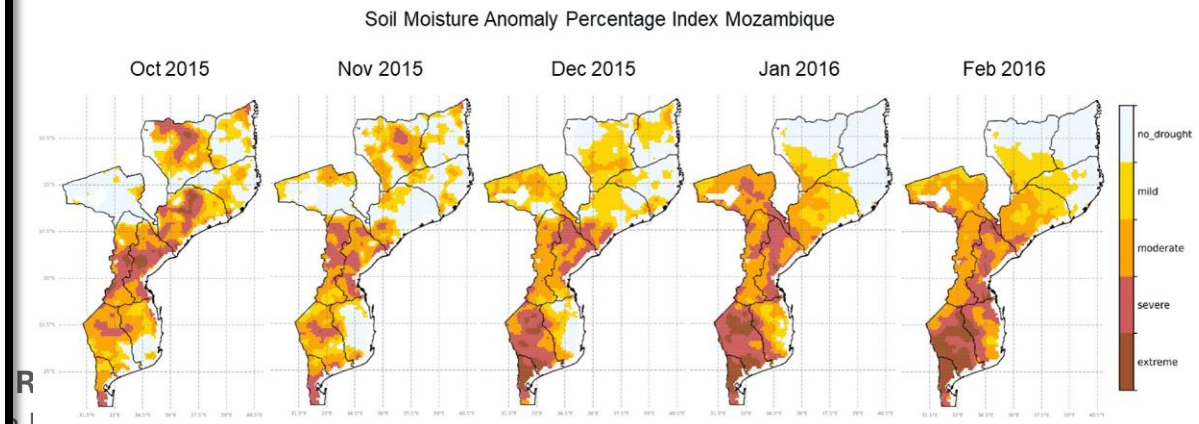


EO Data for Soil Moisture Analysis

- Regional to global scale soil moisture applications
- Drought prone regions like the horn of Africa
- Spatial resolution too coarse for small scale applications
- Limited validation data

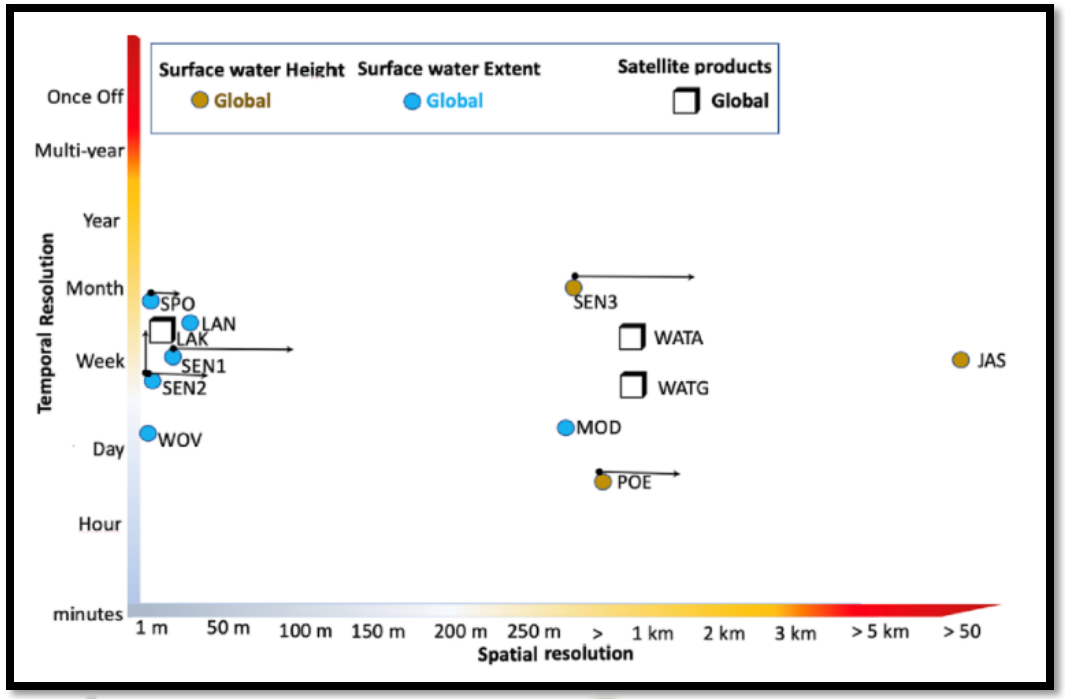


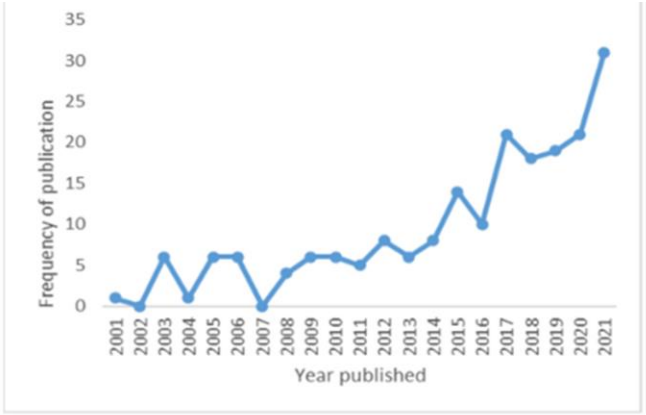


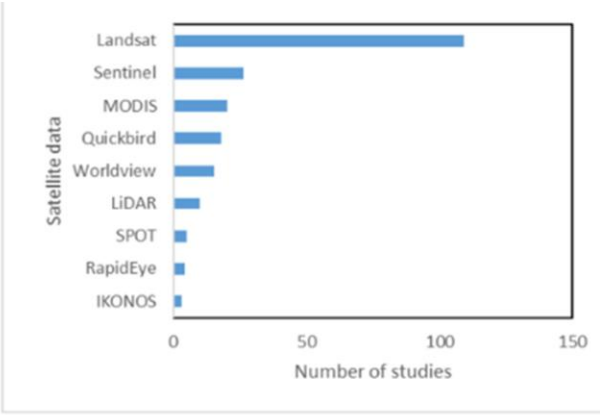


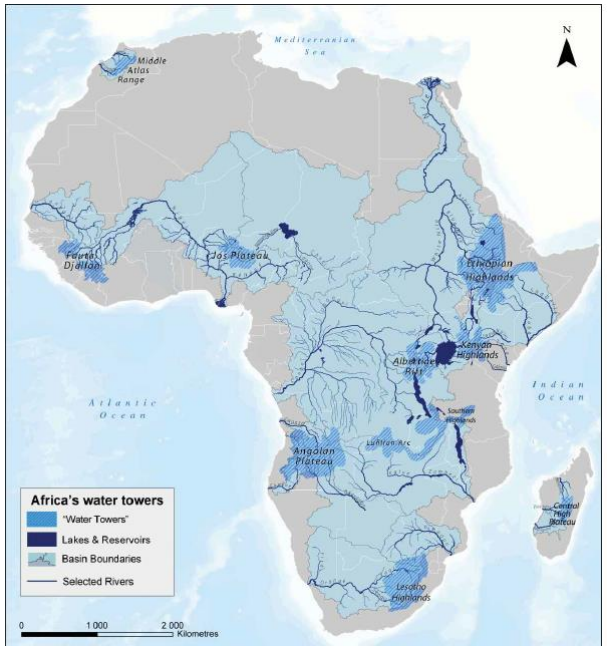
EO Data for Surface Water Monitoring

- EO has been extensively used for delineation & monitoring inland surface water bodies, either through radar or optical sensors.









EO Applications in Crop Water-use assessment

ISPRS Journal of Photogrammetry and Remote Sensing 204 (2023) 117–130

Contents lists available at ScienceDirect

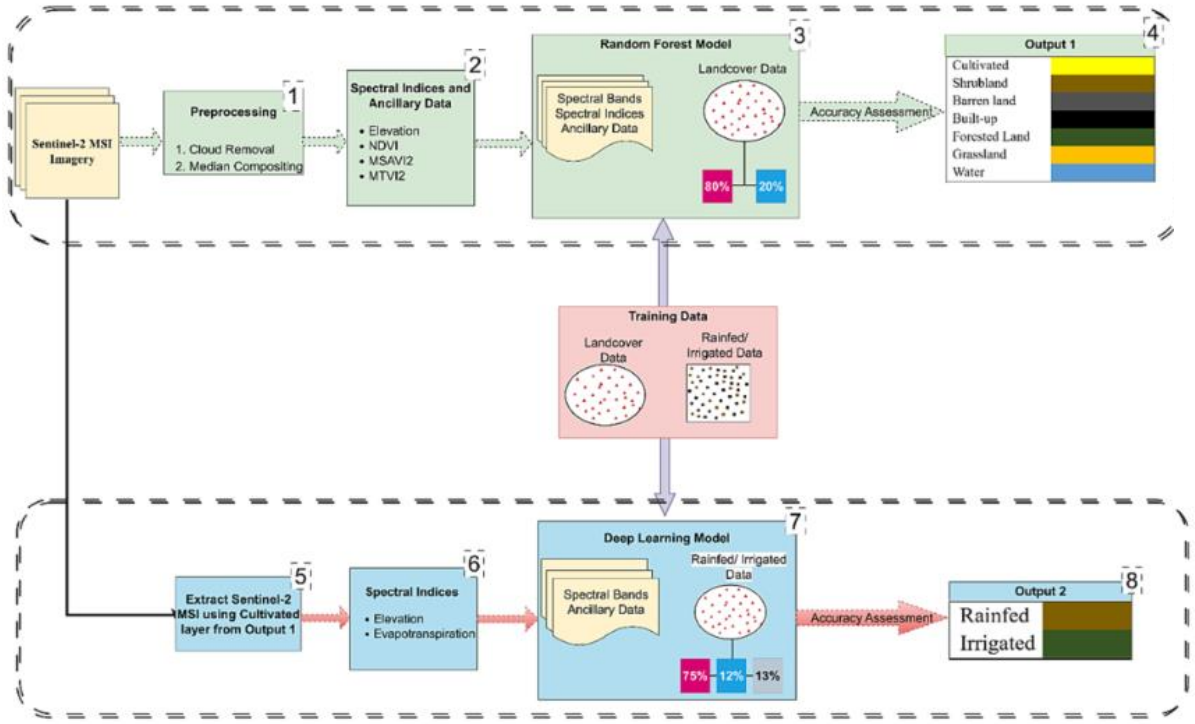
ISPRS Journal of Photogrammetry and Remote Sensing

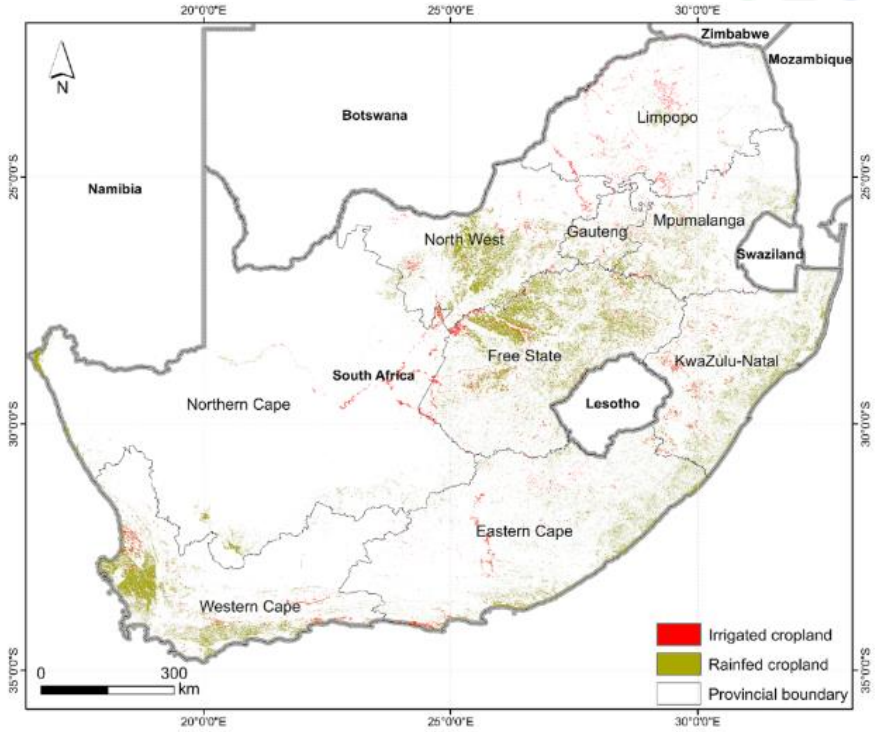
journal homepage: www.elsevier.com/locate/isprsjprs

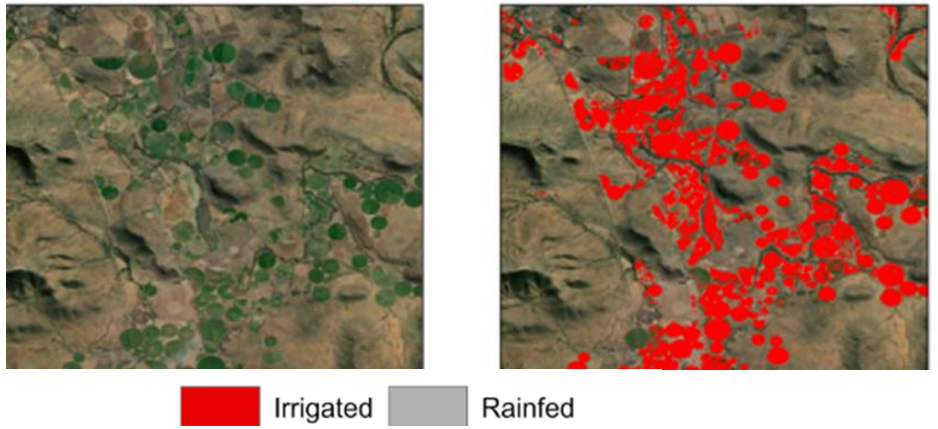
Fine-scale characterization of irrigated and rainfed croplands at national scale using multi-source data, random forest, and deep learning algorithms

Kudzai S. Mpakairi [a], Timothy Dube [a], Mbulisi Sibanda [b], Onisimo Mutanga [c]

[a] Institute of Water Studies, Department of Earth Sciences, University of the Western Cape, Bellville, Cape Town, South Africa
[b] Department of Geography, Environmental Studies and Tourism, Faculty of Arts and Humanities, University of the Western Cape, Bellville, Cape Town, South Africa
[c] Discipline of Geography and Environmental Science, School of Agricultural Earth and Environmental Sciences, University of KwaZulu-Natal, Scottsville, Pietermaritzburg, South Africa







Drought Applications

GEOMATICS, NATURAL HAZARDS AND RISK
2022, VOL. 13, NO. 1, 1342–1365
https://doi.org/10.1080/19475705.2022.2072774

Taylor & Francis
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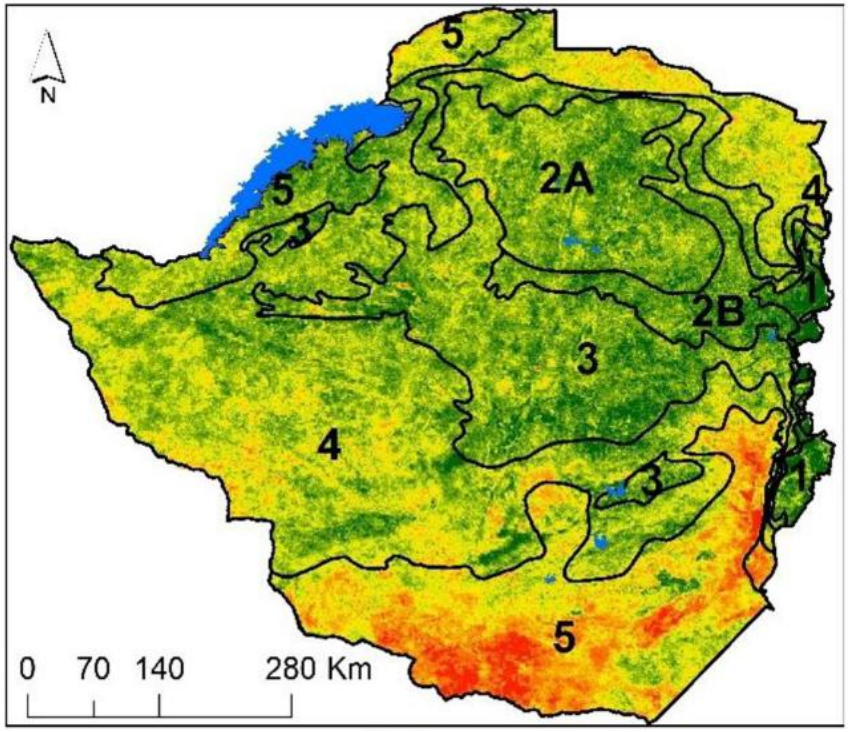
Fine-scale multi-temporal and spatial analysis of agricultural drought in agro-ecological regions of Zimbabwe

Alice Sharara[a], Munyaradzi Davis Shekede[a], Isaiah Gwitira[a], Mhosisi Masocha[a] and Timothy Dube[b]

[a]Department of Geography Geospatial Sciences and Earth Observation, Faculty of Science, University of Zimbabwe, Harare, Zimbabwe; [b]Institute of Water Studies, Department of Earth Sciences, the University of the Western Cape, Bellville, South Africa



Invasive Species Mapping & Water-Use Estimation

GISCIENCE & REMOTE SENSING
2021, VOL. 58, NO. 4, 483–500
https://doi.org/10.1080/15481603.2021.1903281

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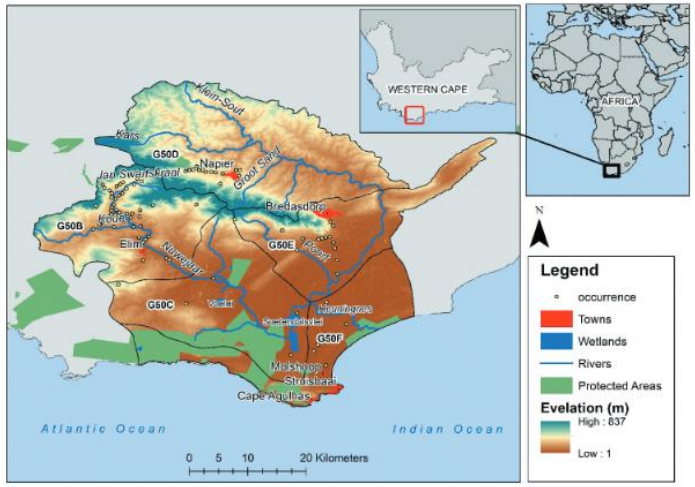
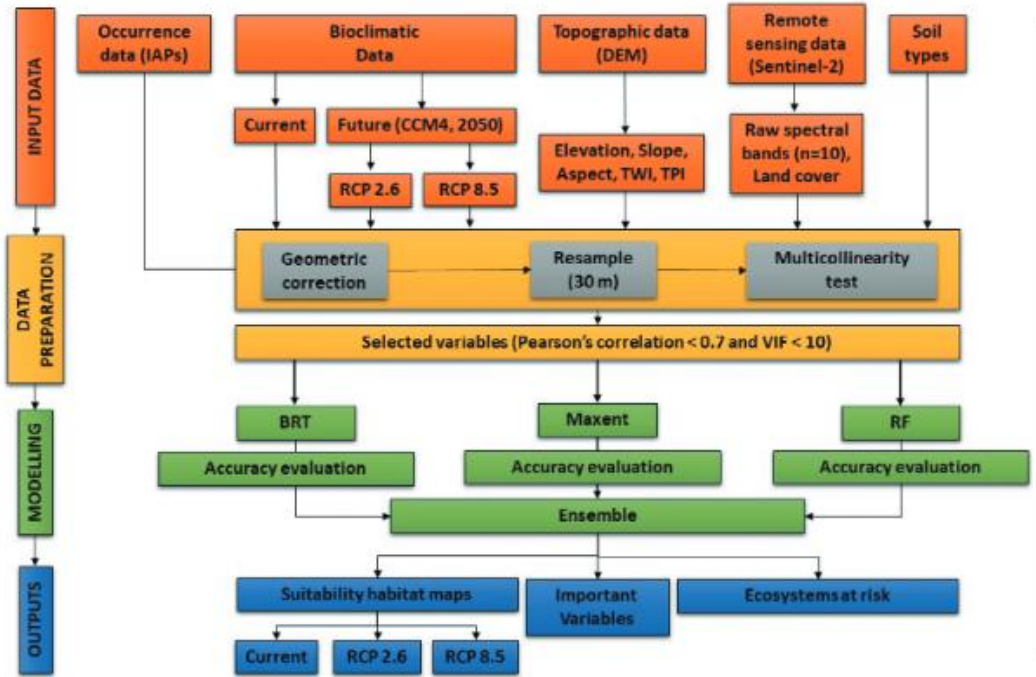
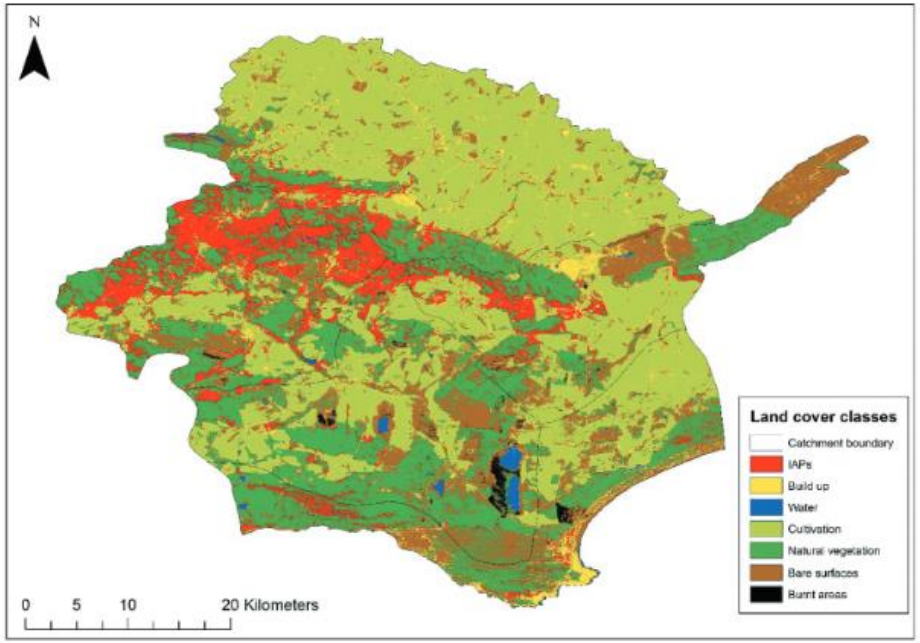
Modeling the geographic spread and proliferation of invasive alien plants (IAPs) into new ecosystems using multi-source data and multiple predictive models in the Heuningnes catchment, South Africa

Bhongolethu Mtengwana[a], Timothy Dube[a], Bester Tawona Mudereri[a,b] and Cletah Shoko[c]

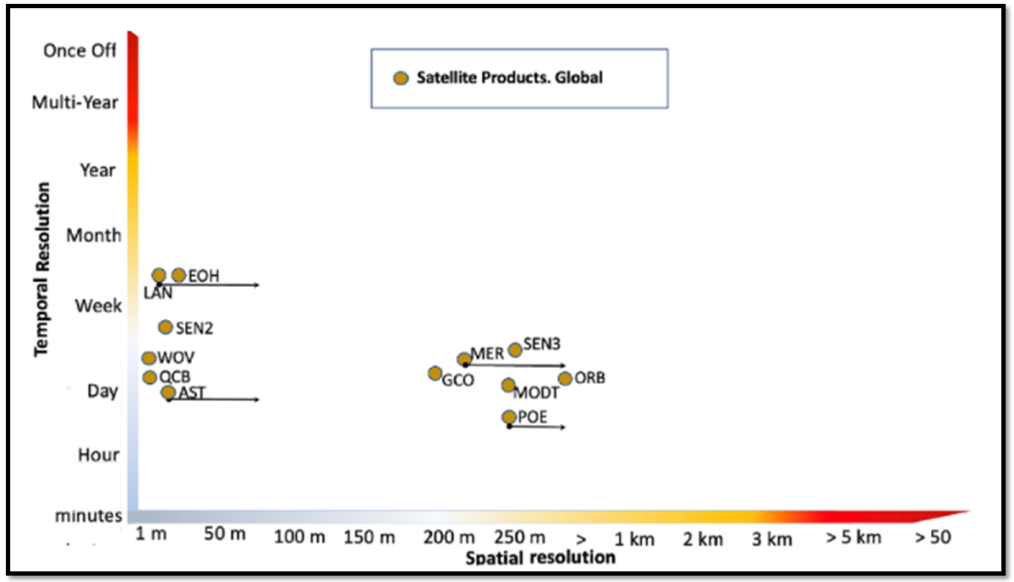
[a]Department of Earth Sciences, University of the Western Cape, Bellville, South Africa; [b]Department of Animal and Wildlife Science, Midlands State University, Gweru, Zimbabwe; [c]Division of Geography, School of Geography, Archaeology and Environmental Studies, University of Witwatersrand, Johannesburg, South Africa







EO Data for Water Quality Monitoring



Contents lists available at ScienceDirect

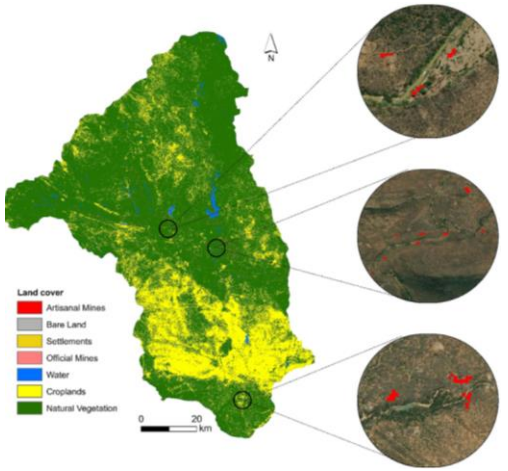
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Assessment of land use and land cover, water nutrient and metal concentration related to illegal mining activities in an Austral semi–arid river system: A remote sensing and multivariate analysis approach

Thandekile Dube [a,*], Timothy Dube [a], Tatenda Dalu [b,*], Siyamthanda Gxokwe [a], Thomas Marambanyika [c]

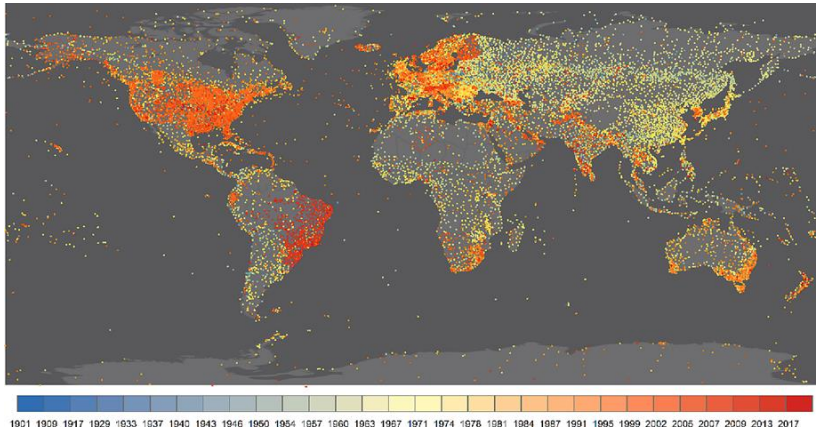
[a] Institute for Water Studies, Department of Earth Science, University of the Western Cape, Bellville 7535, South Africa
[b] Aquatic Systems Research Group, School of Biology and Environmental Sciences, University of Mpumalanga, Nelspruit 1200, South Africa
[c] Department of Geography, Environmental Sustainability and Resilience Building, Midlands State University, Gweru, Zimbabwe

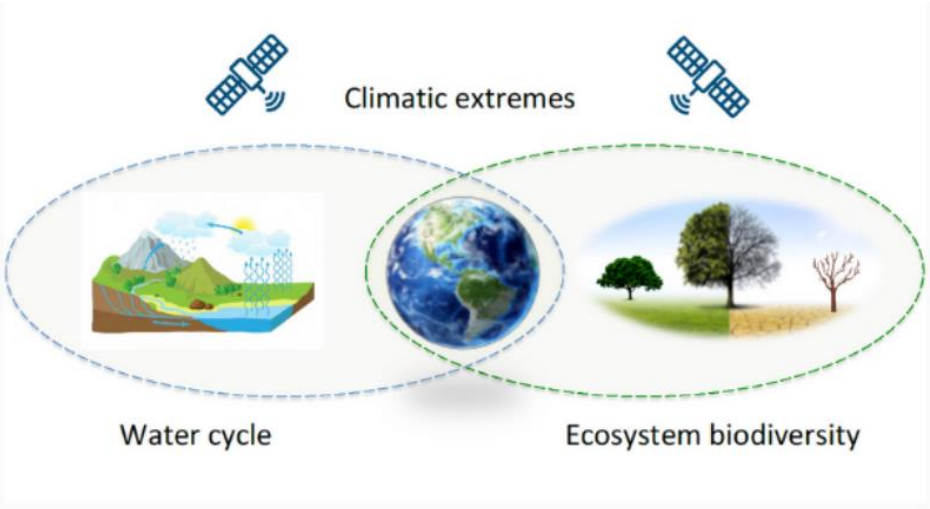


DIGIWATER: Building Resilient Water Futures
Cayo Santa María, Cuba. October 20-24, 2025

EO Applications Challenges in Africa

- Internet connectivity to access data
- Limited in-situ monitoring resources to validate EO data
- Inadequate high performance systems for big data analytics
- Limited skills and capacity in EO and geospatial analytics
- Limited financial research support government.
- Lack of data sharing





Take Home Message

- Availability of sensors and observations, along with analytical models, has contributed to monitoring water resources at various scales.
- EO data offers critical solutions by providing a comprehensive view of the continent's water resources, aiding in decision-making processes.
- EO data facilitates informed decision-making, targeted interventions, and building resilience to water-related challenges.
- The availability & accessibility of hydrological data for monitoring and assessing water resources have been partially improved across Africa through the adoption of satellite data.

Take home message

- International remote sensing initiatives, North-South research collaborations, and projects has contributed to the research progress.
- Prominent satellite data series e.g. Landsat, MSG, MODIS, CHIRPS, TRMM and GRACE have played significant roles in African hydrological research.
- Limited and malfunctioning in-situ hydrological monitoring networks in Africa have affected the accurate calibration and validation of remotely sensed hydrological models.
- The lack of high-resolution spatial and temporal data hampered accurate monitoring of hydrological processes at smaller scales.
- Despite the widespread use of rainfall satellite products, validation attempts over Africa, particularly in western and southern regions, have been limited.
- Future research should focus on multi-source data integration, assimilation, big data analytics and machine learning techniques to address complex hydrological research questions at various scales

Muchas gracias...! Thank you....!