

MAPPING ZAMBIA'S MEAN ANNUAL RAINFALL USING SATELLITE DATA

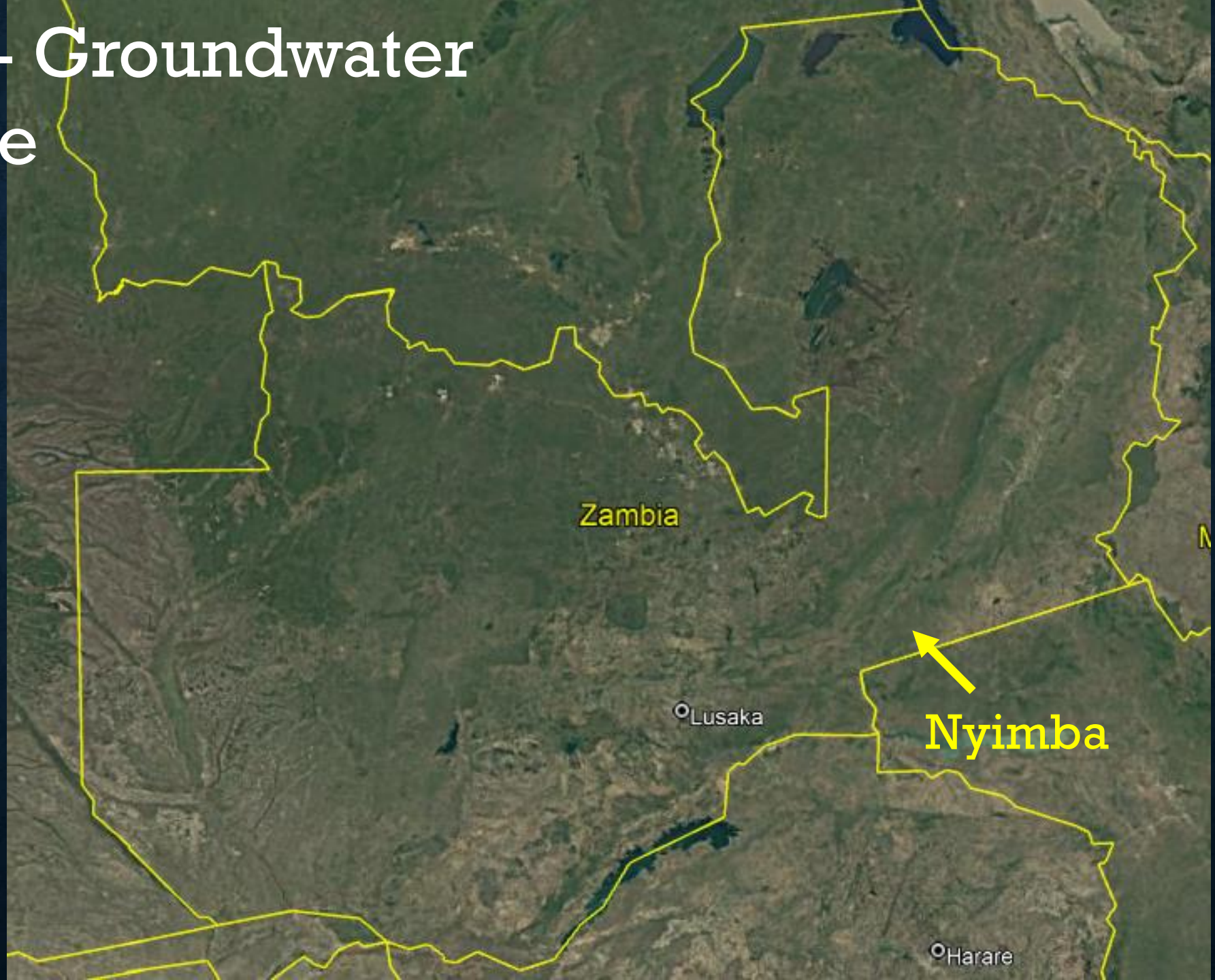
Arthur Chapman

18 June 2025

OVERVIEW

- The project
- Data source – scarcity -> Satellite
- Data formats – Software for data manipulation
- QGIS – Import – Add as a raster layer
- Data extraction for modelling purposes
- Interpretation - land cover effects on mean annual rainfall
- Pro's and con's of satellite data for rainfall estimation + alternative satellite sources

Zambia - Groundwater Recharge



THE PROJECT

- Funder – Climate Technology Centre and Network (CTCN), United Nations Environment Programme (UNEP)



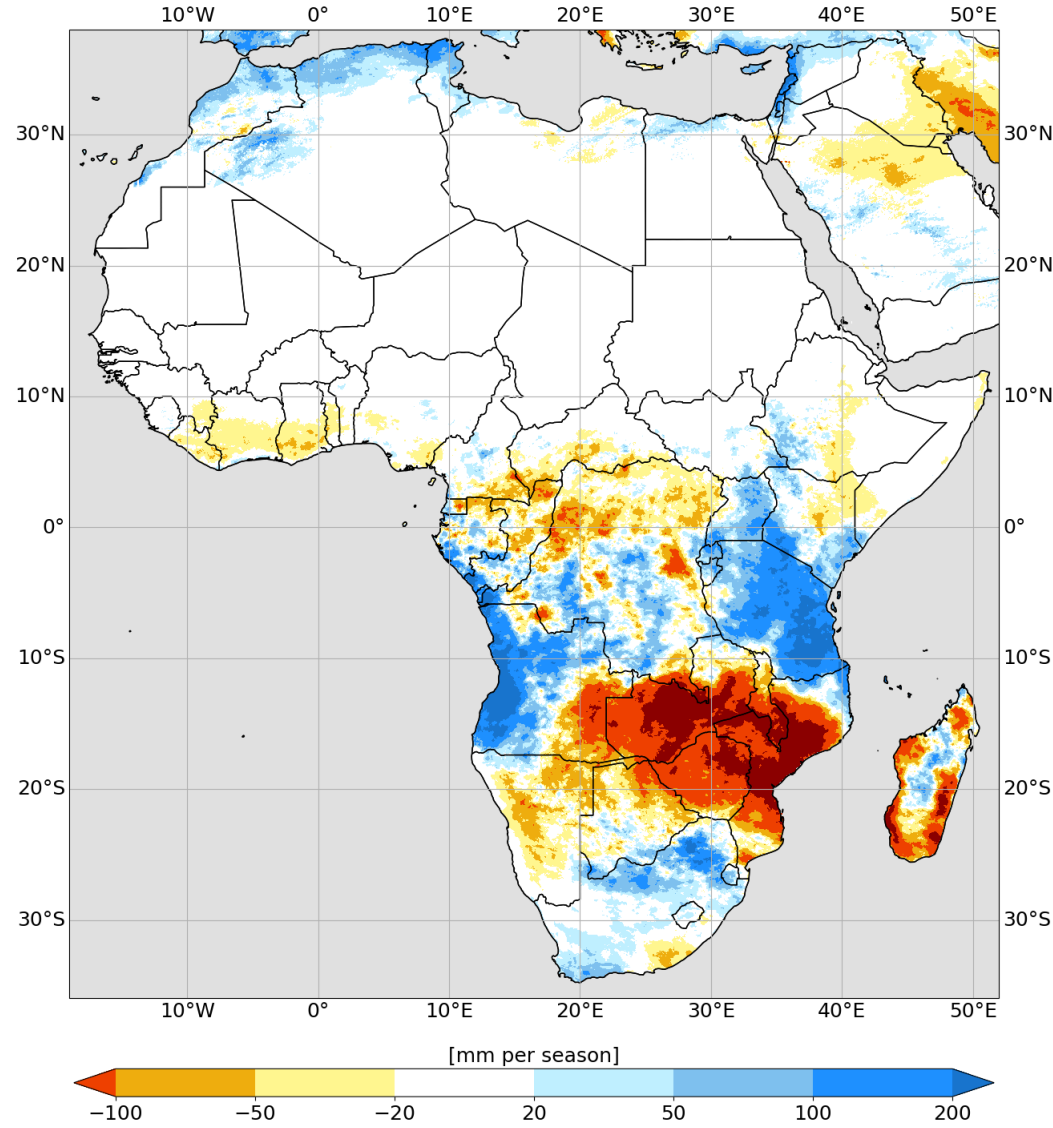
- Project Lead & Contractor – Oneworld Sustainable Investments (OneWorld), Cape Town



TROPICAL APPLICATIONS METEOROLOGICAL SATELLITE (TAMSAT)

- 30-year climatology specifically for Africa (U. Reading, UK)
- Satellite + ground-based gauge data
- Satellite sensor – Meteosat TIR camera
- Data resolution: $0.0375^\circ \times 0.0375^\circ$ (~ 4km grid nodes)
- Temporal resolution: daily, pentadal (5-day), decadal, **monthly**, seasonal timescales (**but no long-term estimates**)
- Format: netCDF

Period: Year 2024, Month 12-02
Theme: Rainfall Anomaly Estimate (against 1983-2012 climatology)
Source: TAMSAT, derived from Meteosat TIR



El Niño

2023-2024 DJF rainfall
anomaly estimate
(against 1983-2021
climatology)

NETCDF

- NetCDF (network Common Data Form)
- Array-oriented (grids) 4D geoscience data model (eg GCMs)
 - 3D spatial rep + time - hierarchical or nested
- Self-describing
- Format cannot be read as flat text files or manipulated as such – special software
 - Metadata can be read with special viewer codes

NETCDF CLIMATE OPERATORS (NCO)

- Objective: Long-term mean annual rainfall
- Transform: Mean monthly to long-term annual mean
- NCO - A suite of command-line programs to interact with NetCDF files
- Linux package for scriptable operations
- Extract data chunks from “hyperslabs” + mathematical operations

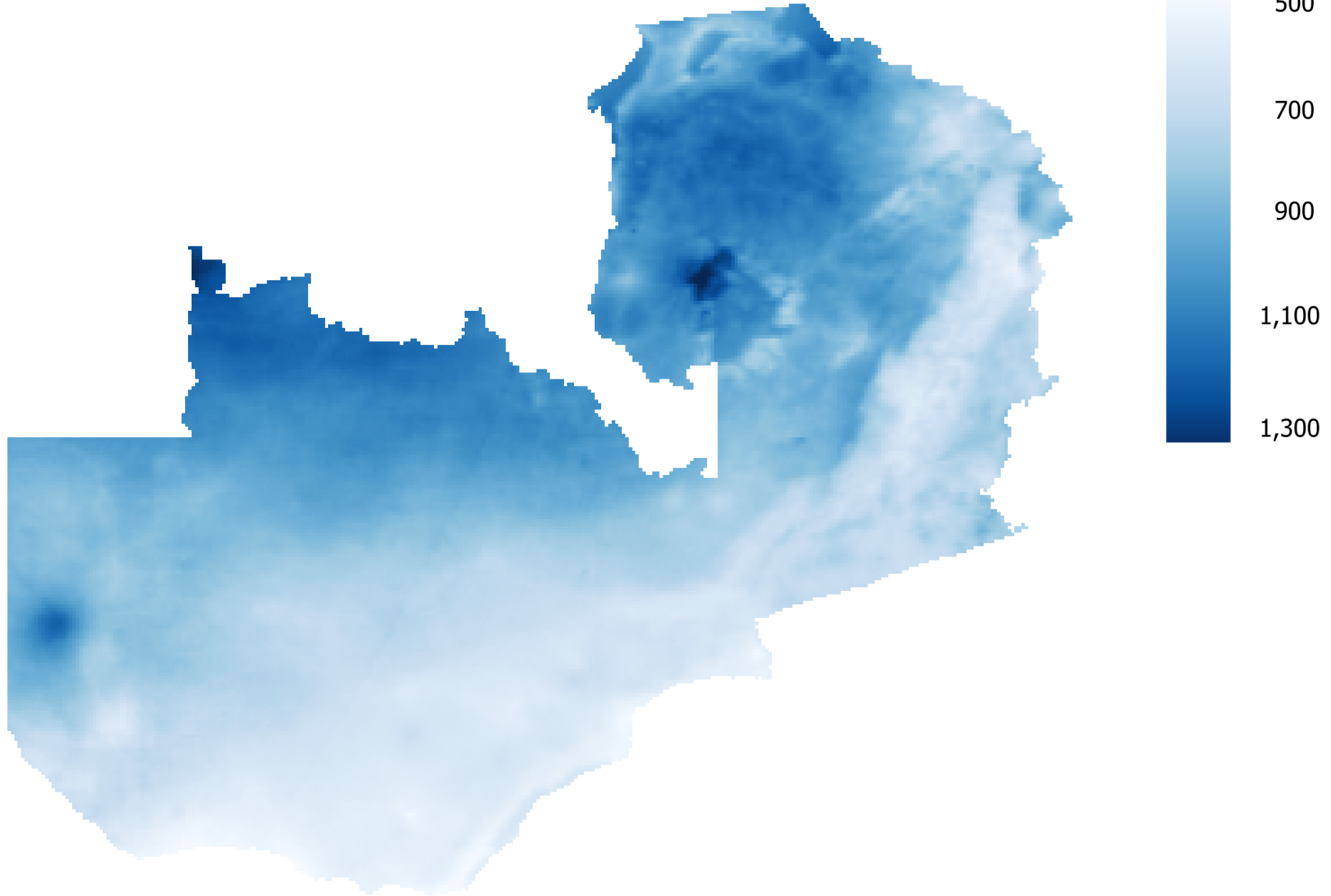
MAPPING THE MEAN ANNUAL RAINFALL

- QGIS – Add as a raster layer
- Also ArcGIS Pro

POINT SOURCE MAP EXTRACTION

- The groundwater recharge model uses a point-source value for annual rainfall - tabular data
- Conversion of NetCDF to CSV file
- R application (Hafen, K; 2019) “OpenSourceOptions”
 - Raster package for R

Rainfall (mm)





Topography
and land use
/ cover
influence
rainfall



L. Mweru

L. Mweru Wantipa

L. Tanganyika

Kawambwa

Kasama

Tunduma

Chitipa

Mt

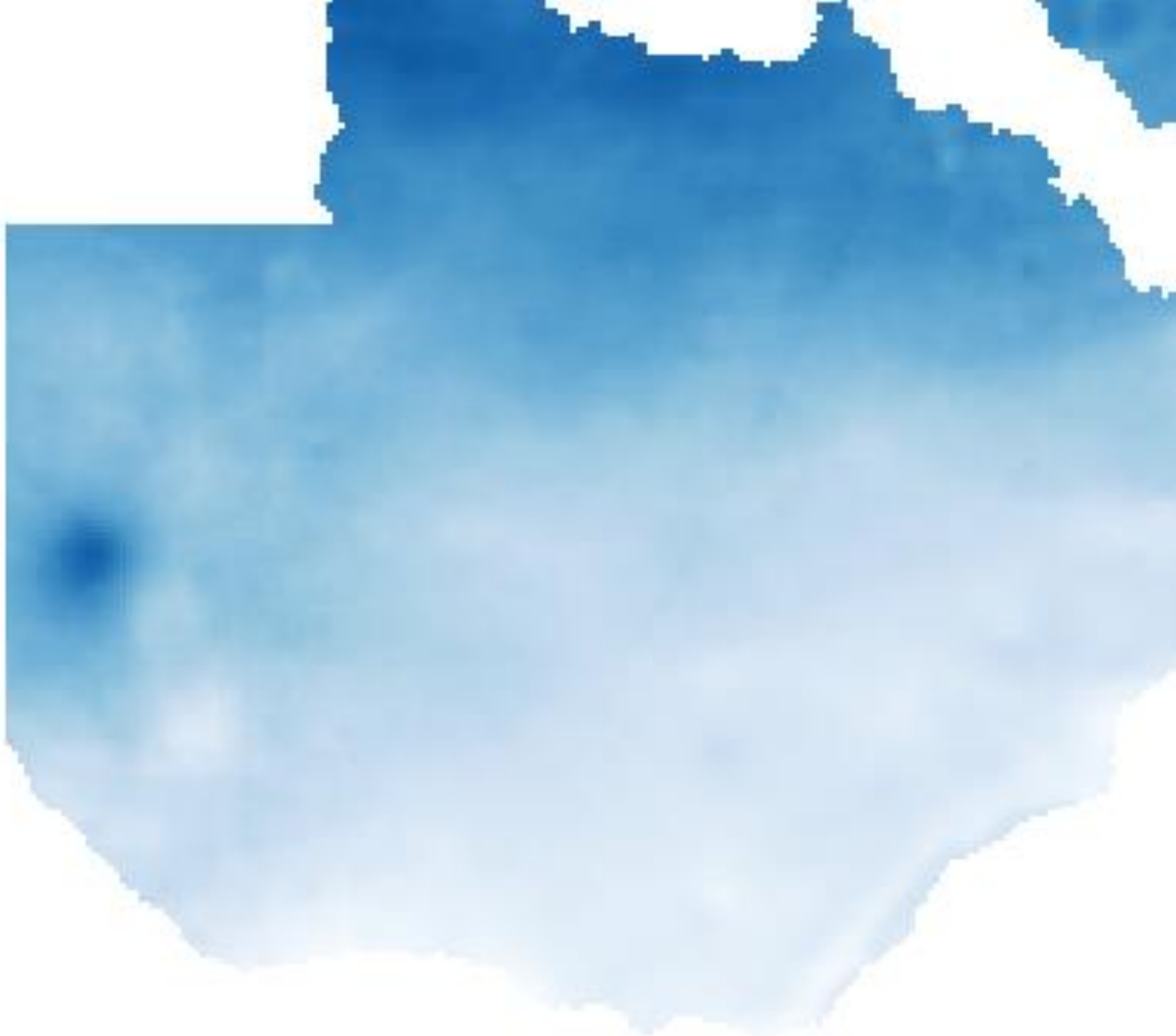
mbashi

L. Bangwaelu

Kitwe

Ndola

Image Landsat / Copernicus



Land use influences are not captured well in low rainfall areas



Zambia

Kafue National Park

Kalabo

Barotse
floodplain

Image Landsat / Copernicus

HOW GOOD ARE SPP?

- Limited accuracy for short-term events – 1-day rain or extreme events
- Better during the wet season than the dry season
- Lower accuracy in arid regions
- Accuracy is impaired over mountainous regions or with highly varied topography

OTHER SPP

- CHIRPS
- MSWEP
- PERSIANN-CDR
- IMERG
- GPM-SM2RAIN
- Others

OTHER USES FOR SATELLITE PRECIPITATION PRODUCTS

- SPP discriminates spatial changes in rainfall that a sparse rain gauge network cannot – modelling
- Apply in data-scarce areas
- Drought tracking
- Crop simulation and prediction
- Evaluating long-term trends

<<<<<<<<<<<<<