Modelling the Resilience of Ecosystem Service Provision in African Landscapes

This project is part of the Oppenheimer Programme in African Landscape Systems (OPALS)

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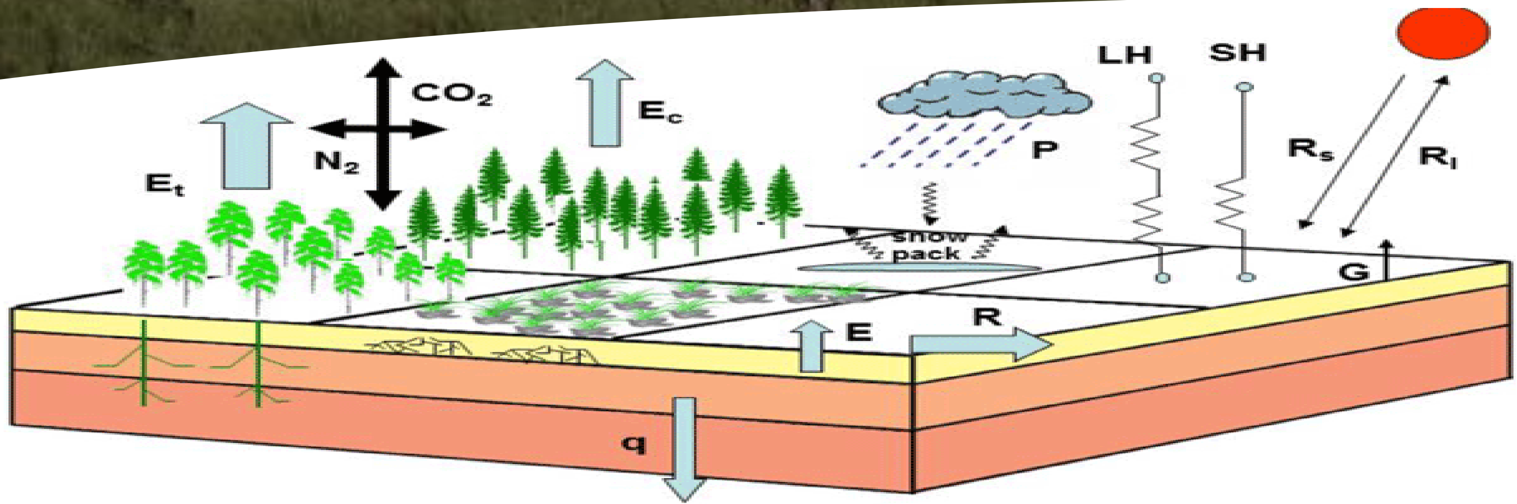

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A quick introduction

- African ecosystems play a significant role in the lives of people living in Africa by providing a range of goods and services (Chapman et al., 2022*).

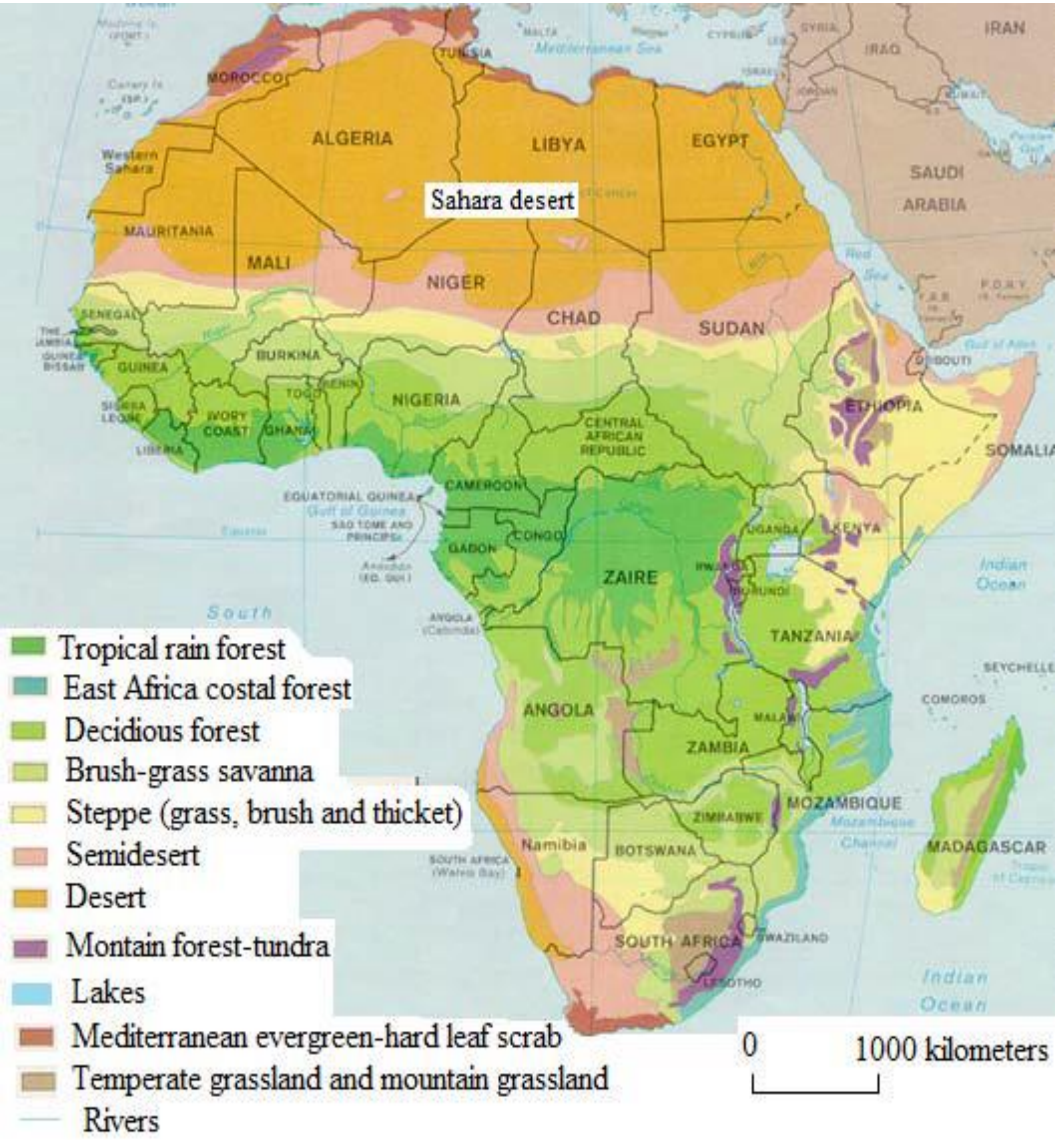
Ecosystem services

"*The benefits that humans obtain from ecosystems*"

The Millennium Ecosystem Assessment (MA), (2005)*

Cultural	Regulating	Provisioning	Supporting
• Religious, educational, recreational, aesthetics, heritage	• Water purification, erosion control, climate regulation, flood regulation, pollination	• Food, fibre, fresh water, fuel wood, genetic resources	• Primary production, Habitat provision, nutrient cycling, Water cycling, soil formation

Ecosystem service classification



Map of ecosystems in Africa (Ambelu, 2009)*

*Ambelu, B. A. 2009. Biological monitoring based on macroinvertebrates for decision support of water management in Ethiopia. PhD thesis, Ghent University, Gent, Belgium.
*Chapman, C. A., Abernathy, K., Chapman, L. J., Downs, C., Effiom, E. O., Gogarten, J. F., Golooba, M., Kalbitzer, U., Lawes, M. J., Mekonnen, A., Omeja, P., Razafindratsima, O., Sheil, D., Tabor, G. M., Tumwesigye, C., & Sarkar, D. (2022). The future of sub-Saharan Africa's biodiversity in the face of climate and societal change. *Frontiers in Ecology and Evolution*, *10*, 790552
*Millennium Ecosystem Assessment (Program) (Ed.). (2005). *Ecosystems and human well-being: Synthesis*. Island Press.

Project aim

- To improve the value of modelling frameworks for informing better decisions in Africa, through better understanding of African landscape dynamics in the Joint UK Land Environment Simulator (JULES) Land Surface Model.

Engagement with stakeholders

Collaboration with other researchers and data collection

Model evaluation using observations

Parameterization of PFTs

Scenario modelling with improved model

Expected impact / contributions

Improved knowledge on African ecosystems service provision and their response to changing climate.

Improve observational constraint in Africa by working with collaborators to collate new and existing datasets on African ecosystems.

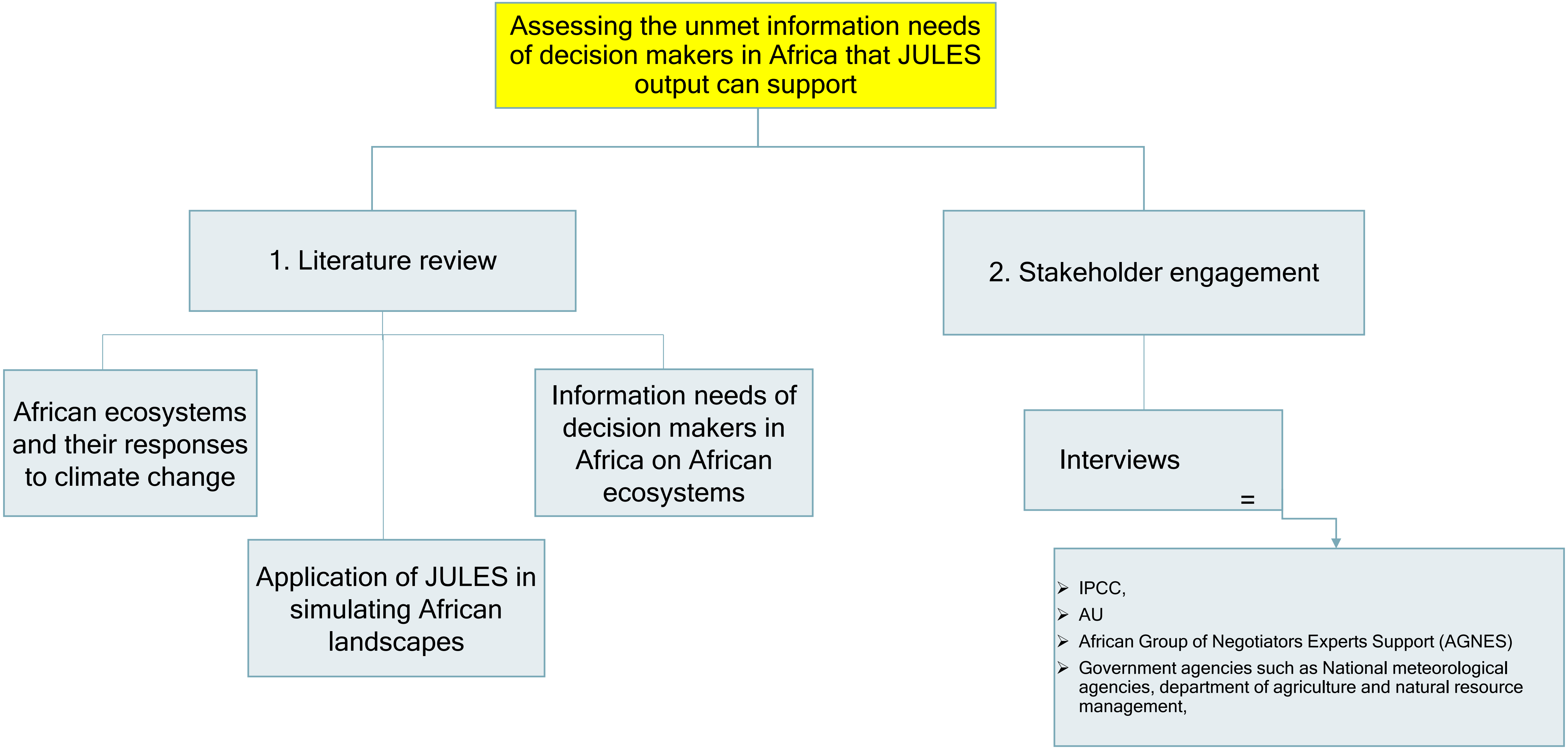
Improve the accuracy of JULES in simulating African landscapes and its relevance to decision makers to inform better decision making for environmental sustainability.

Improved representation of African landscapes in land surface models.

Reliable data useful for future predictions and thereby improving the value of model predictions in Africa.

What I will be doing

CHAPTER 1



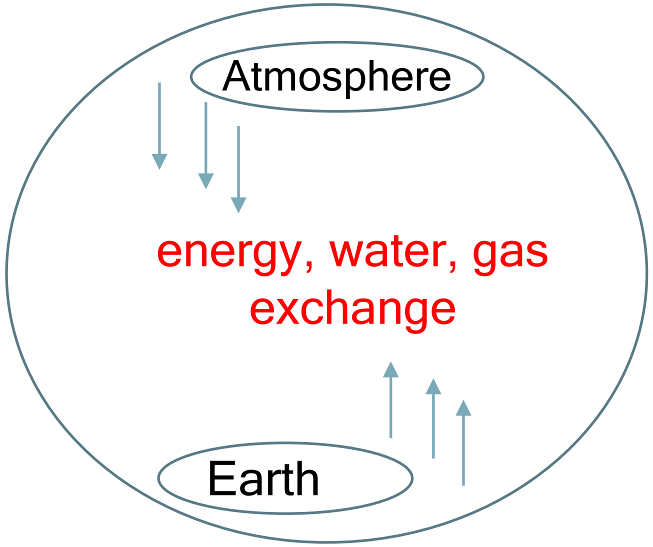
CHAPTER 2

Model evaluation

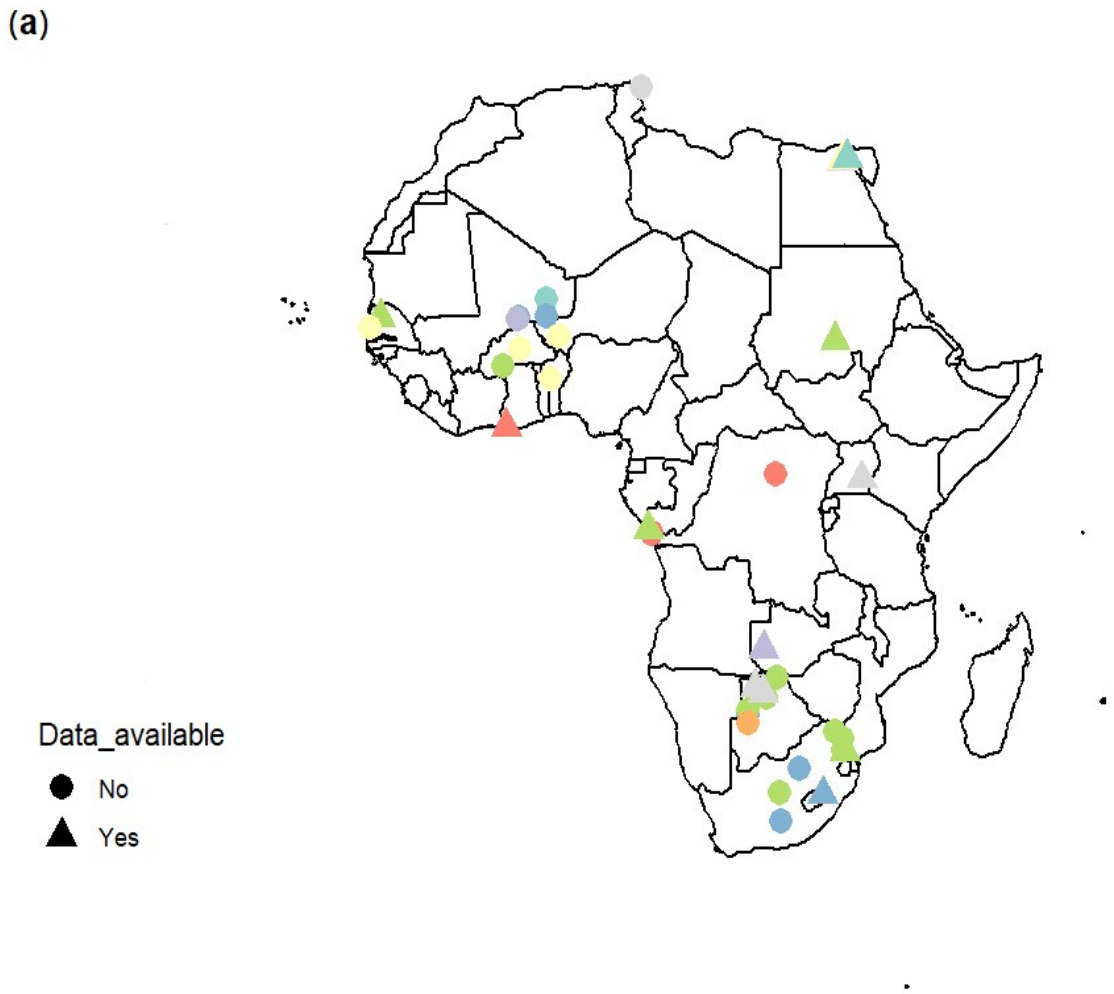
1. Site level evaluation using measurement from flux tower sites in Africa

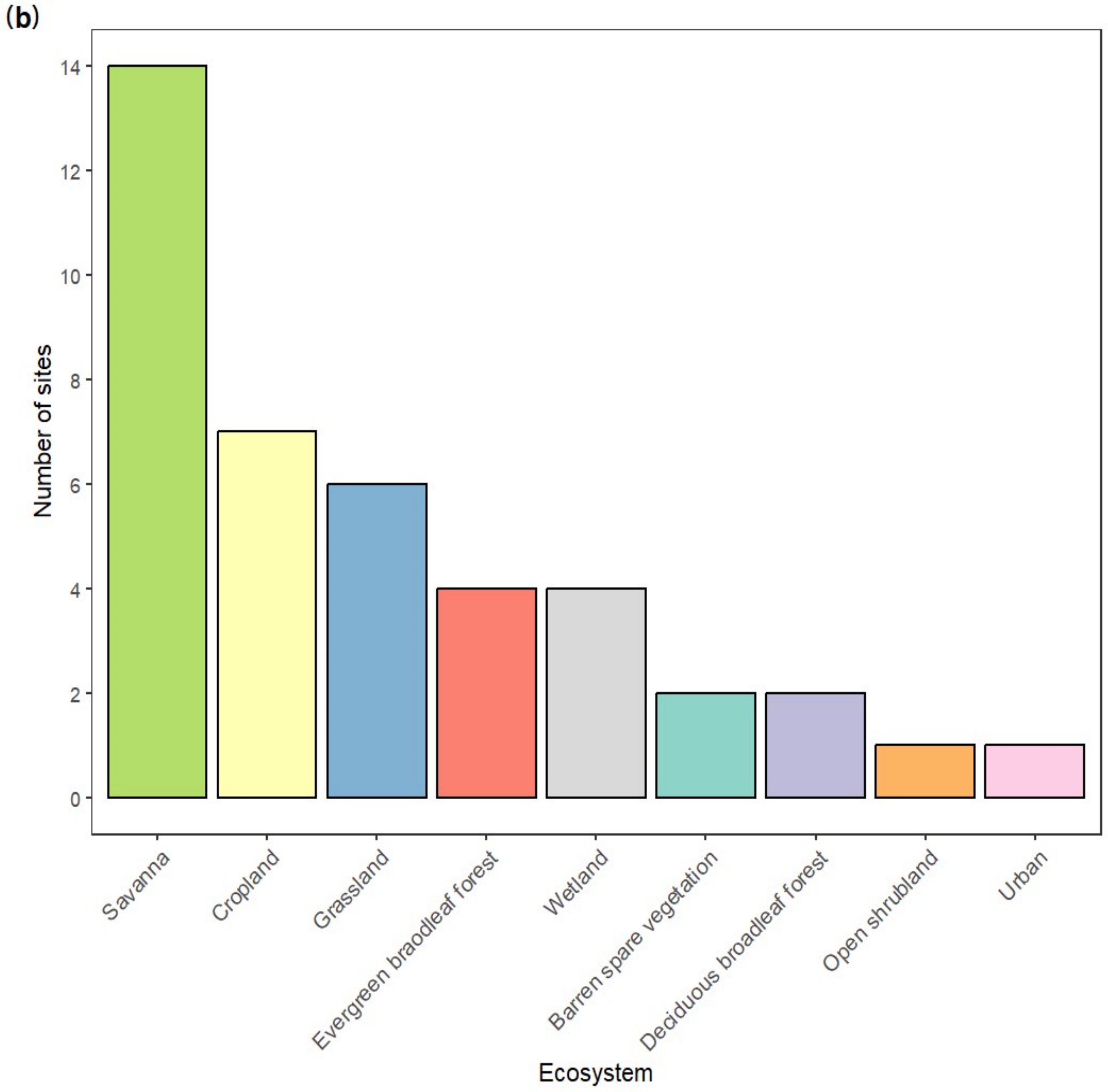
Variables → **GPP**
LAI
ET
LE
H

The flux tower at the Maputaland site, South Africa



The flux tower at the Demokeya site, Senegal





Known flux tower sites identified across Africa

(a) Map of Africa showing the location of flux tower sites identified, with colour coding according to their ecosystem type based on the International Geosphere-Biosphere Programme (IGBP) classification;

(b) Distribution of ecosystems amongst identified flux tower sites in Africa

2. Continental scale evaluation of JULES using MODIS satellite data

- MODIS GPP product PMLv2 (Zhang et al., 2019*),
- and the LAI product (Myneni et al., 2002*)

*Myneni, R. B., Hoffman, S., Knyazikhin, Y., Privette, J. L., Glassy, J., Tian, Y., Wang, Y., Song, X., Zhang, Y., Smith, G. R., Lotsch, A., Friedl, M., Morisette, J. T., Votava, P., Nemani, R. R., & Running, S. W. (2002). Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data. *Remote Sensing of Environment*, *83*(1-2), 214-231. https://doi.org/10.1016/S0034-4257(02)00074-3
*Zhang, Y., Kong, D., Gan, R., Chiew, F. H. S., McVicar, T. R., Zhang, Q., & Yang, Y. (2019). Coupled estimation of 500 m and 8-day resolution global evapotranspiration and gross primary production in 2002-2017. *Remote Sensing of Environment*, *222*, 165-182. https://doi.org/10.1016/j.rse.2018.12.031

3. Ecosystem manipulation experiments

Ecosystem manipulation experiments are designed to simulate scenarios to understand and predict the impact of natural and anthropogenic pressures on the ecosystems and how these ecosystems respond to future change.

Research paper

Short- and long-term responses of photosynthetic capacity to temperature in four boreal tree species in a free-air warming and rainfall manipulation experiment

Raimundo Bermudez[1,3], Artur Stefanski[1], Rebecca A. Montgomery[1] and Peter B. Reich[1,2]

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Ecosystem productivity and CO_2 exchange response to the interaction of livestock grazing and rainfall manipulation in a Kenyan savanna

Joseph O. Ondier[a,*], Daniel O. Okach[a], John C. Onyango[a], Dennis O. Otieno[b]

[a] Department of Botany, Maseno University, Private Bag, Maseno, Kenya
[b] School of Biological and Physical Sciences, Jaramogi Oginga Odinga University of Science and Technology, Kenya

Ecology, 95(1), 2014, pp. 98–109

Interactive effects of grazing, drought, and fire on grassland plant communities in North America and South Africa

Sally E. Koerner[1] and Scott L. Collins

Department of Biology, MSC03-2020, University of New Mexico, Albuquerque, New Mexico 87131 USA

Ecology, 94(5), 2013, pp. 1155–1164

Influence of competition and rainfall manipulation on the growth responses of savanna trees and grasses

Edmund C. February,[1,3] Steven I. Higgins,[2] William J. Bond,[1] and Louise Swemmer[1,4]

[1]*Department of Biological Sciences, University of Cape Town, Private bag, Rondebosch 7701 South Africa*
[2]*Institut für Physische Geographie, Johann Wolfgang Goethe-Universität Frankfurt am Main, Altenhöferallee 1, 60438 Frankfurt am Main, Germany*

Plant, Cell and Environment (2008) **31**, 1038–1050 doi: 10.1111/j.1365-3040.2008.01815.x

Seasonal differences in photosynthesis between the C_3 and C_4 subspecies of *Alloteropsis semialata* are offset by frost and drought

DOUGLAS G. IBRAHIM[1], MATTHEW E. GILBERT[2], BRAD S. RIPLEY[2] & COLIN P. OSBORNE[1]

Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK and [2]Botany Department, Rhodes University, P.O. Box 94, Grahamstown 6140, South Africa

Research

New Phytologist

Diverse functional responses to drought in a Mediterranean-type shrubland in South Africa

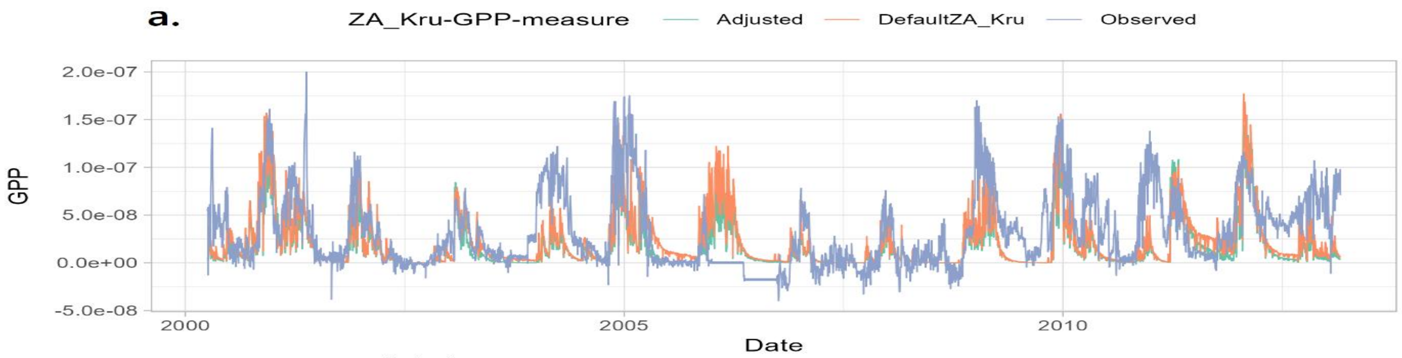
A. G. West[1,2], T. E. Dawson[2], E. C. February[1], G. F. Midgley[3], W. J. Bond[1] and T. L. Aston[1]

[1]Botany Department, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa; [2]Department of Integrative Biology, University of California, Berkeley, Berkeley, CA 94720, USA; [3]Climate Change and Bioadaptation, South African National Biodiversity Institute, Rhodes Drive, P/bag x7, Kirstenbosch 7735, South Africa

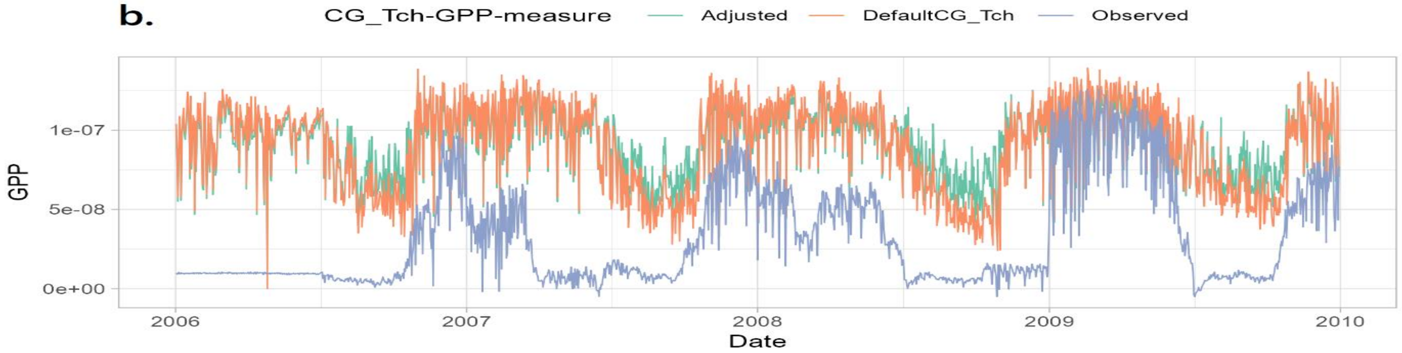
Summary

Preliminary results running JULES vn7.1

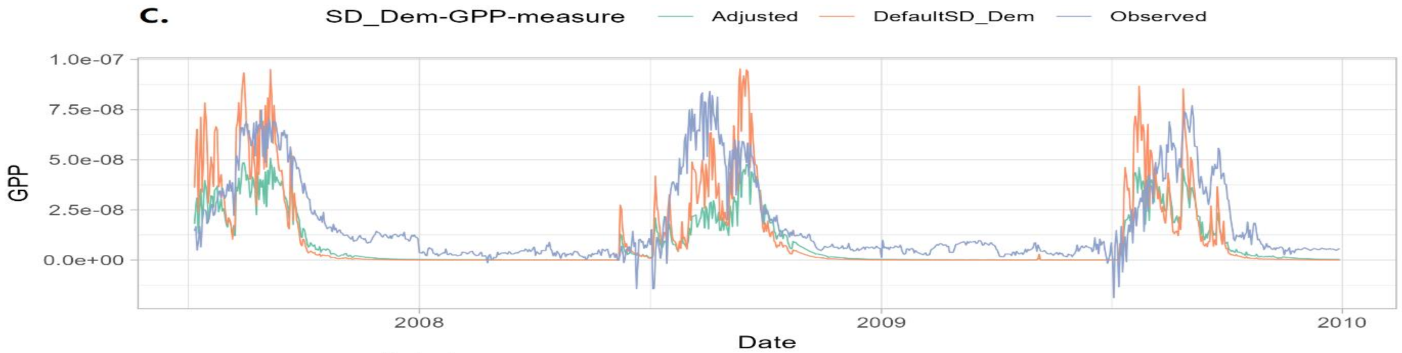
GPP Modelled vs Observed



	label	mse	rmse	cor
1	DefaultZA_Kru	1.182153e-15	3.438245e-08	0.5472407
2	Adjusted	1.250777e-15	3.536632e-08	0.5606299



	label	mse	rmse	cor
1	DefaultCG_Tch	4.328261e-15	6.578952e-08	0.4510471
2	Adjusted	4.477462e-15	6.691384e-08	0.3776455



	label	mse	rmse	cor
1	DefaultSD_Dem	2.590100e-16	1.609379e-08	0.7472274
2	Adjusted	2.459813e-16	1.568379e-08	0.8109508

Comparison of Gross Primary Productivity (GPP) Simulations in Savanna Ecosystems: Default and Adjusted Configurations in JULES for Selected African Flux Tower Sites

CHAPTER 3

Parameterization of PFTs of African landscapes in JULES

- Dataset – from TRY Database
- Preliminary analysis of plant traits in TRY database to assess the available plant types and traits relevant to Africa landscape

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Parameters	Description
Alpha	Quantum efficiency of photosynthesis (mol CO_2 (mol PAR photons) $^{-1}$
knl	Rate of decay of N through the canopy
g_leaf_0	Minimum turnover rate for leaves (360 d)$^{-1}$
dqcrit	Critical humidity deficit (kg H2O per kg air)
f0	Ci=Ca when dq = 0
g_grow	Rate of leaf growth (360 d)$^{-1}$
lai_max	Maximum leaf area index
nmass	Top leaf N content (kgN per kgLeaf)
rootd_ft	Parameter for decay of root functioning with depth (m)
tleaf_of	Temperature below which leaves are dropped (K)
tlow	Lower temperature parameter for photosynthesis (°C)
tupp	Upper temperature parameter for photosynthesis (°C)
vsl	Regression slope between Vcmax and Narea (µmolCO_2 gN^{-1} s^{-1})
Vcmax	The maximum rate of carboxylation of Rubisco
LMA	Leaf mass per unit area
lai_min	Minimum leaf area index

CHAPTER 4

Scenario modelling

- The improved JULES will be used to run simulations of African ecosystems under different scenarios such as climate change, and land use change.

- The findings from engagement with stakeholders will help in shaping the choice of scenario modelling to be undertaken at this stage.

Thanks for listening!

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