Earth Observation of forage type (woody, herbaceous) to support climate resilience and disaster risk financing in African Pastoral Communities

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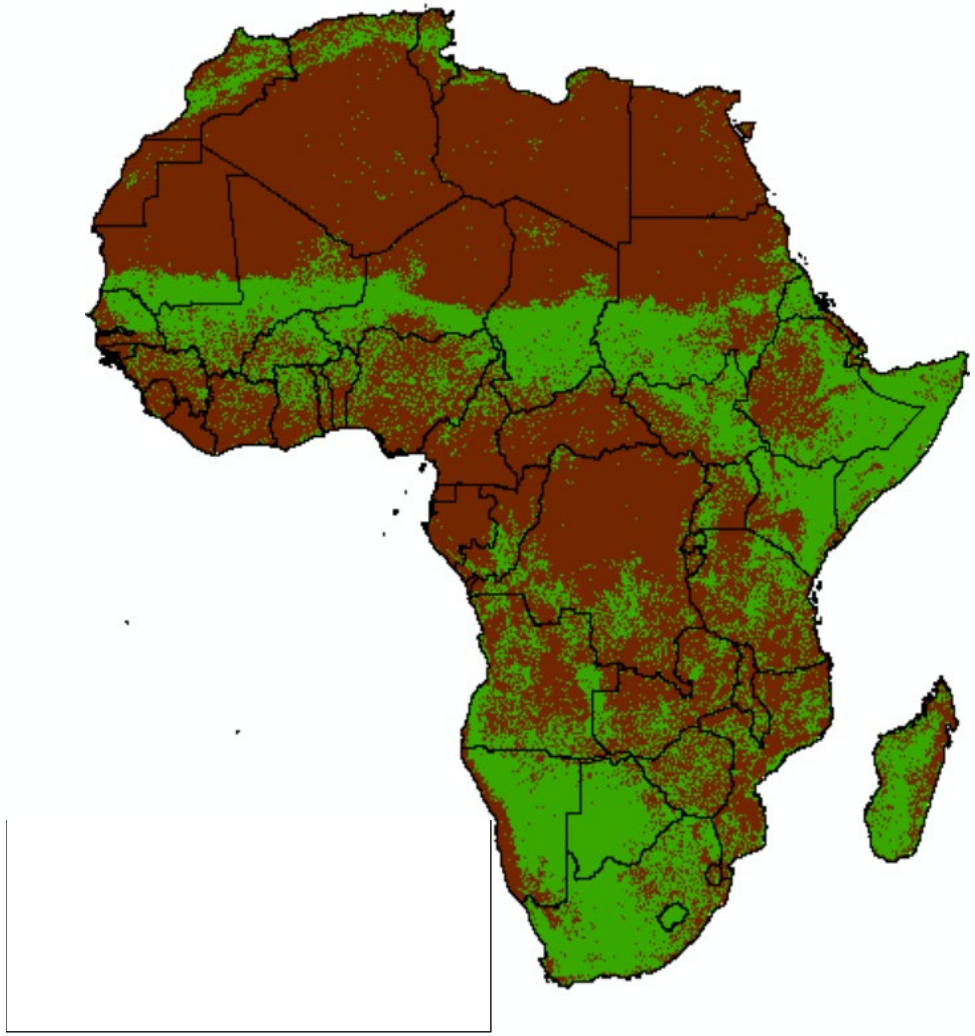
African grazing systems

- Found in semi-arid regions
- Low and erratic rainfall
- Low but significant human populations
  - Pastoral and agro-pastoral
- Political and Economic Marginalization
  - Perceived low resource base
  - Governments favor agricultural research and development assistance in agricultural areas
  - Pastoralist households often highly vulnerable to wealth depletion during drought and other disruptions (following loss of livestock)



Challenges for Pastoralist Livelihoods in East Africa (Kenya)

- Recurrent droughts

- Conflict

Climate related challenges in drylands

- Low, erratic rainfall, recurrent droughts
- Lack of wild forage and failure of forage crops
- Weight loss and mortality of livestock
- Collapse of market prices for livestock
- Malnutrition and starvation

Conflict

- Droughts exacerbate conflict
- Human-wildlife
- Inter-communal

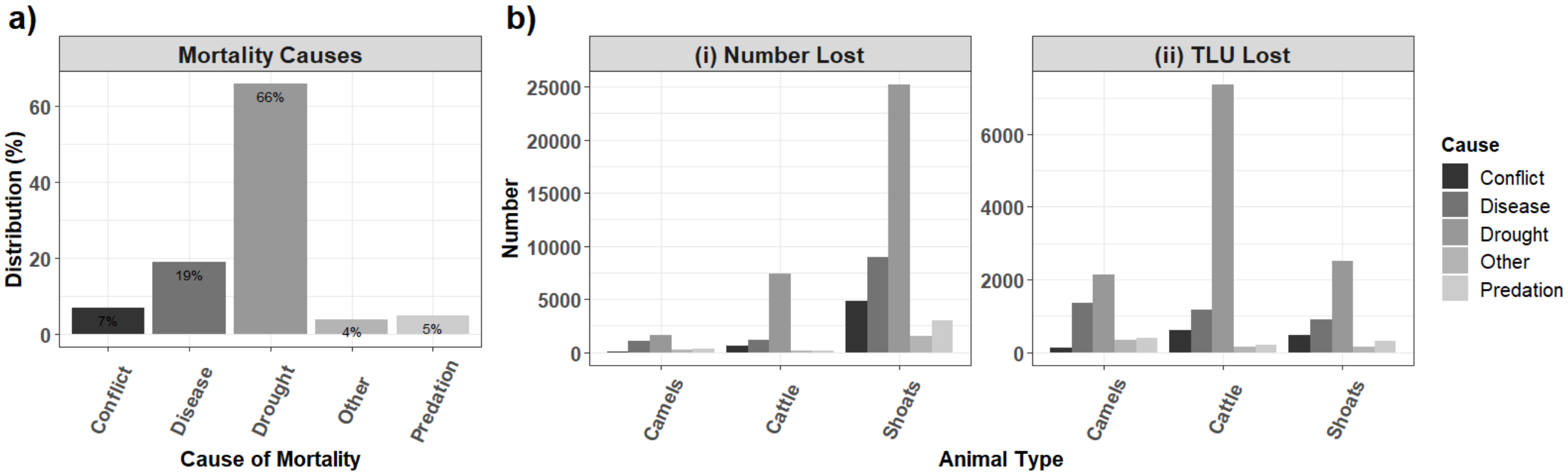
Challenges for Pastoralist Livelihoods in East Africa (Kenya)

- Land degradation, loss of native woody cover, increase in invasive species

Environmental change

- Land degradation (herbaceous cover)
- Loss of forage trees
- Increase in non-palatable invasive shrubs

Challenges for Pastoralist Livelihoods in East Africa (Kenya)



Livestock mortality causes, and livestock types affected in Marsabit county, Kenya (2008-2021).
(a) causes of livestock losses as a percent of total across all livestock types
(b) livestock losses for each type expressed in (i) number of animals lost and (ii) tropical livestock units lost

1 tropical livestock unit (TLU) is equivalent to ~1 cow by weight
Shoat = sheep & goats

Kahiu et al 2024 | https://doi.org/10.1038/s41598-024-62893-4

How do we address drought challenges?

- Traditional drought coping mechanisms and aid programs ineffective
- Drought risk financing tools
  - Minimize drought impacts
  - Reduce the risk of food insecurity
  - Stimulate markets
  - Empower local communities

13 million facing severe hunger as drought grips Horn of Africa

Feb 23, 2022

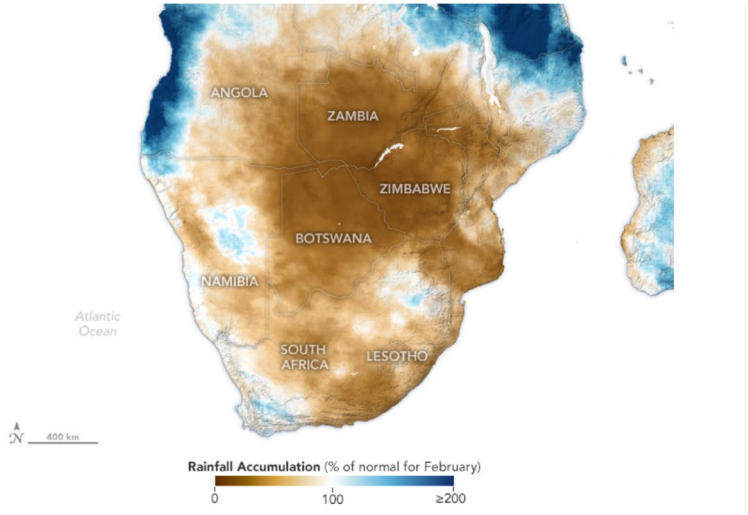
BY FRENCH PRESS AGENCY - AFP | NAIROBI | FEB 23, 2022 - 10:23 AM GMT+3 |

EO-based index provides that opportunity

"**Index-Based Insurance** – an innovative insurance approach that pays out benefits based on a **pre-determined index** for loss of assets and investments, resulting from weather and catastrophic events. The index measures deviations from normal (e.g., rainfall, temperature, earthquake magnitude, wind speed, crop yield, or livestock mortality rates)."

International Finance Corporation

Severe Drought in Southern Africa



Livestock insurance for pastoral resilience

Index-Based Livestock Insurance (IBLI)

https://zep-re.com/drive-project/about-drive/; https://ibli.ilri.org/

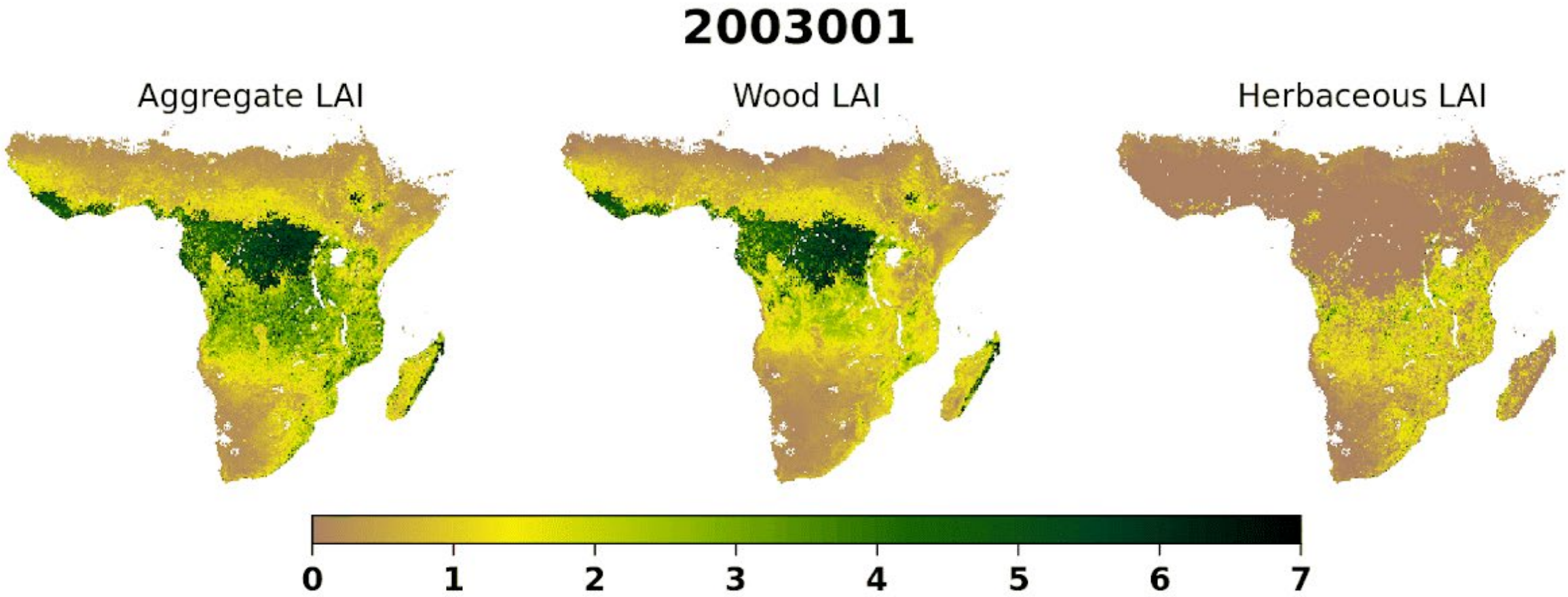
- Operational in parts of Kenya, Ethiopia & Somalia
- Supported by:
  - National Governments In Horn of Africa
  - International Livestock Research Institute (ILRI)
  - The World Bank
- Implemented by:
  - ZEP-RE (Horn of Africa coordinator)
  - *Financial Services for Climate Resilience* ($179M)
- Approach:
  - Premiums per TLU paid commercially by pastoralists and/or via GOV subsidies
  - Index: uses MODIS NDVI time series and anomalies
  - Payouts triggered when NDVI falls below threshold values
- Future plans:
  - Expansion to additional counties in Kenya and Horn of Africa
  - Initial planning for expansion to West Africa


IBLI Kenya Flickr

Enhancing EO Inputs to Index-Based Livestock Insurance

- Aggregate greenness provides insufficient detail
- Separation of woody and herbaceous forage using partitioned leaf area index (LAI)
- See poster board #60 for analysis of impacts of
  - *Prosopis* encroachment
  - Land degradation

Operationalizing Partitioned LAI Data for IBLI

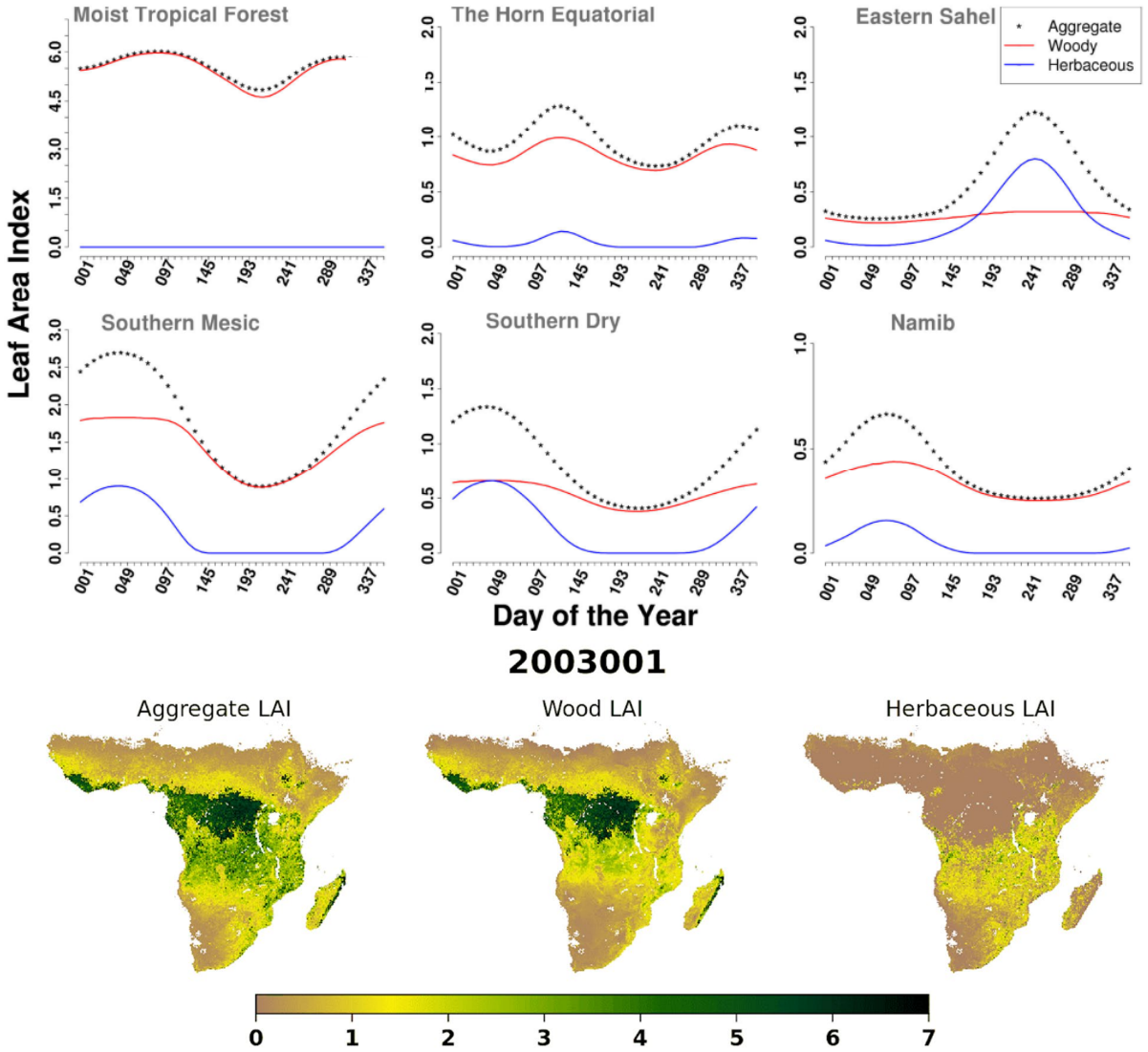


- 8-day woody and herbaceous LAI retrievals (**Kahiu & Hanan, 2018 | DOI: 10.1002/2017JG004105**)
- Archival MODIS data (2003-2023) available for SSA
- VIIRS now available for future operational products

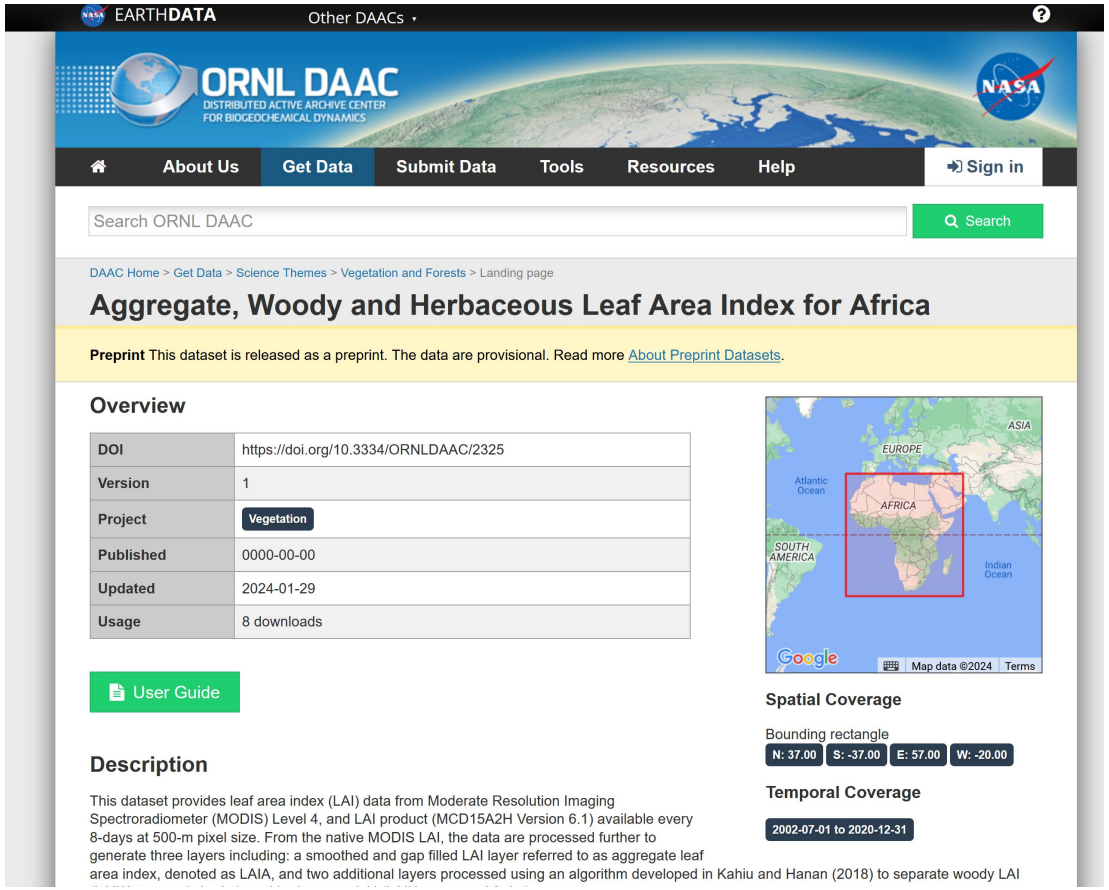
Operationalizing Partitioned LAI Data for IBLI

Distinct forage production profiles among biomes

Related to differences in tree cover, tree size, seasonality
(sampled pixels from six regions)



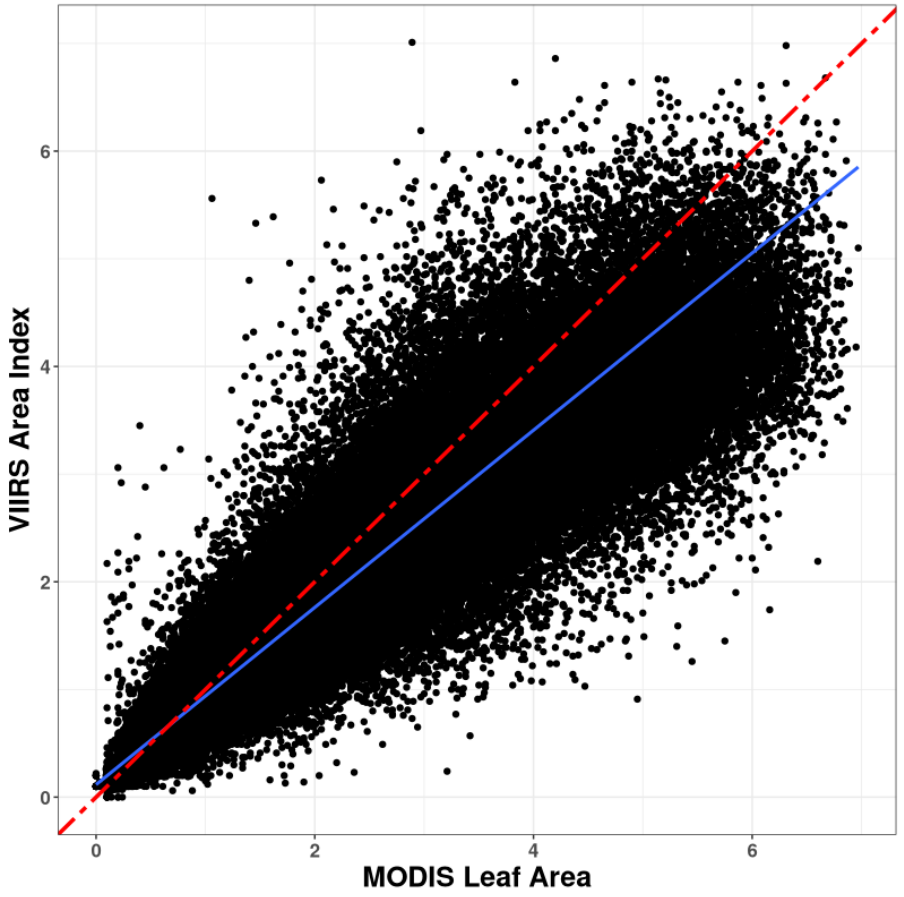
Archival Data Available at Oak Ridge DAAC

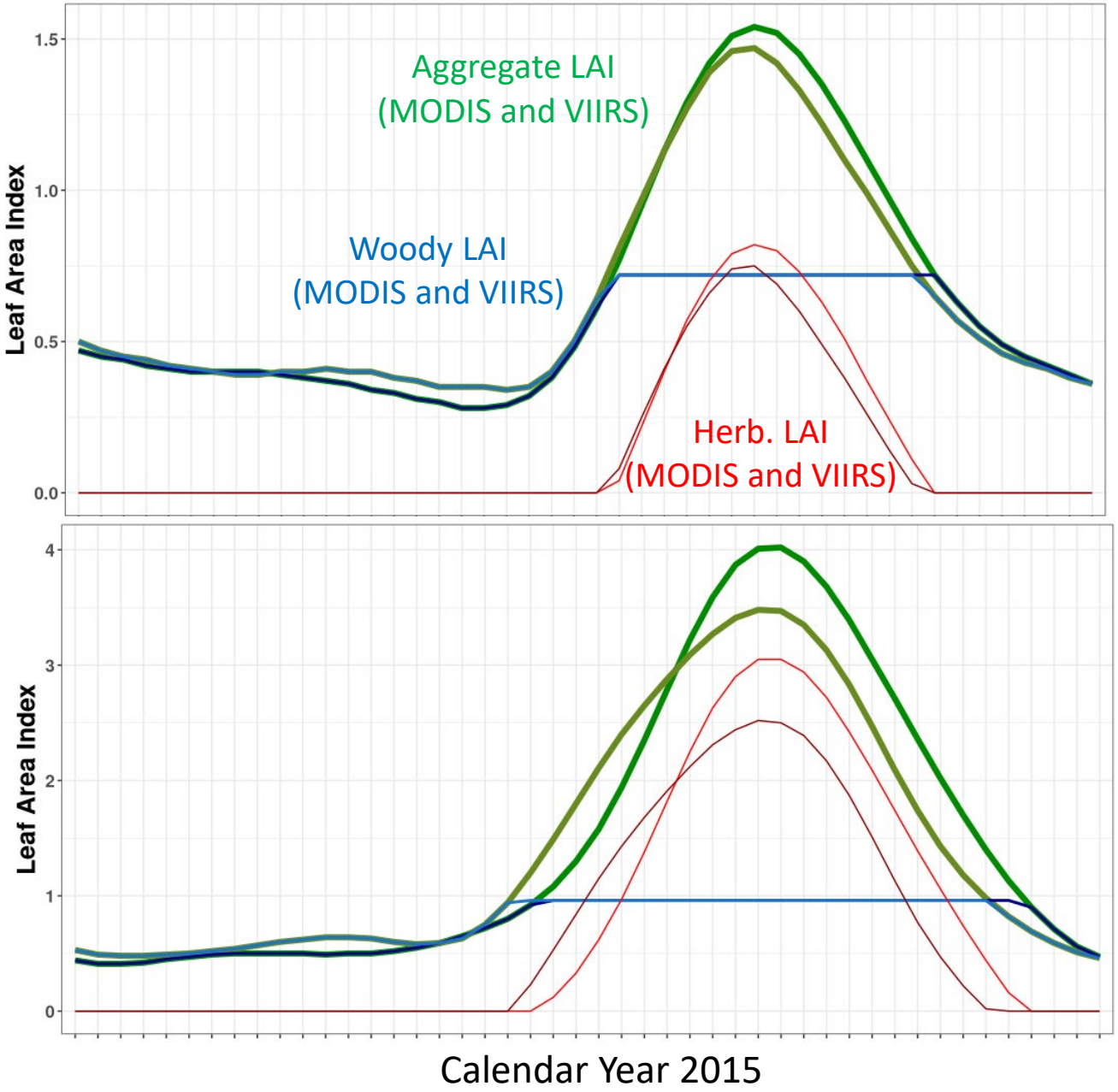


https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2325

Operationalizing Partitioned LAI Data for IBLI

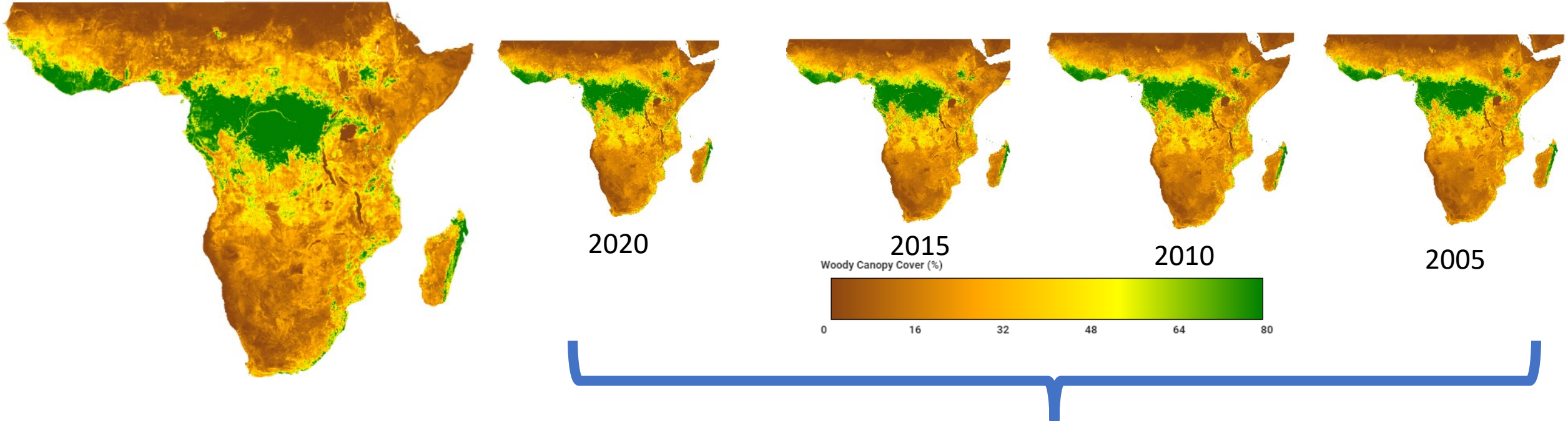
- Transition from MODIS to VIIRS
- Inter-sensor calibration to extend time series





Operationalizing Partitioned LAI Data for IBLI

❖LAI partitioning method is dependent on accurate woody canopy cover data



2022 woody cover @40m

Derived from Sentinel 1 GRD SAR backscatter & Sentinel 2 reflectance)

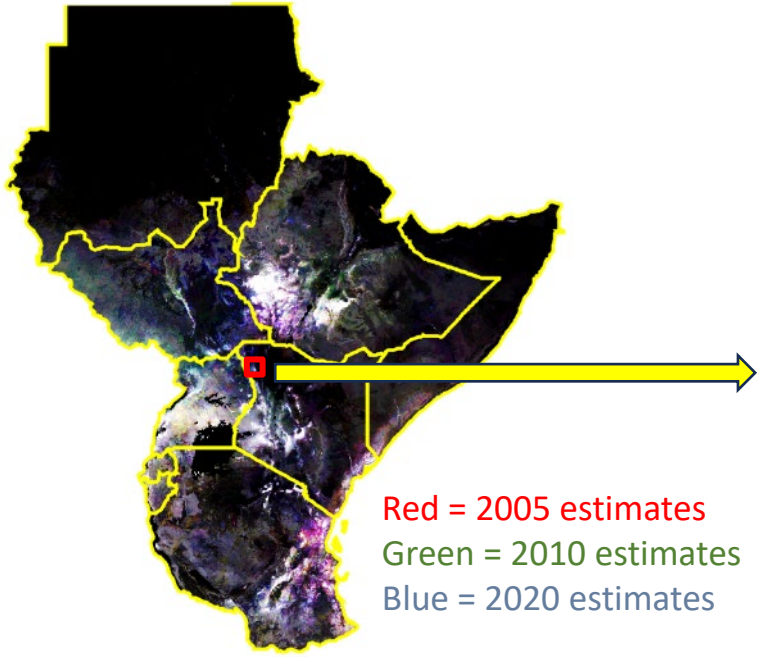
2005-2020 Epochal woody cover estimates @ 500 m

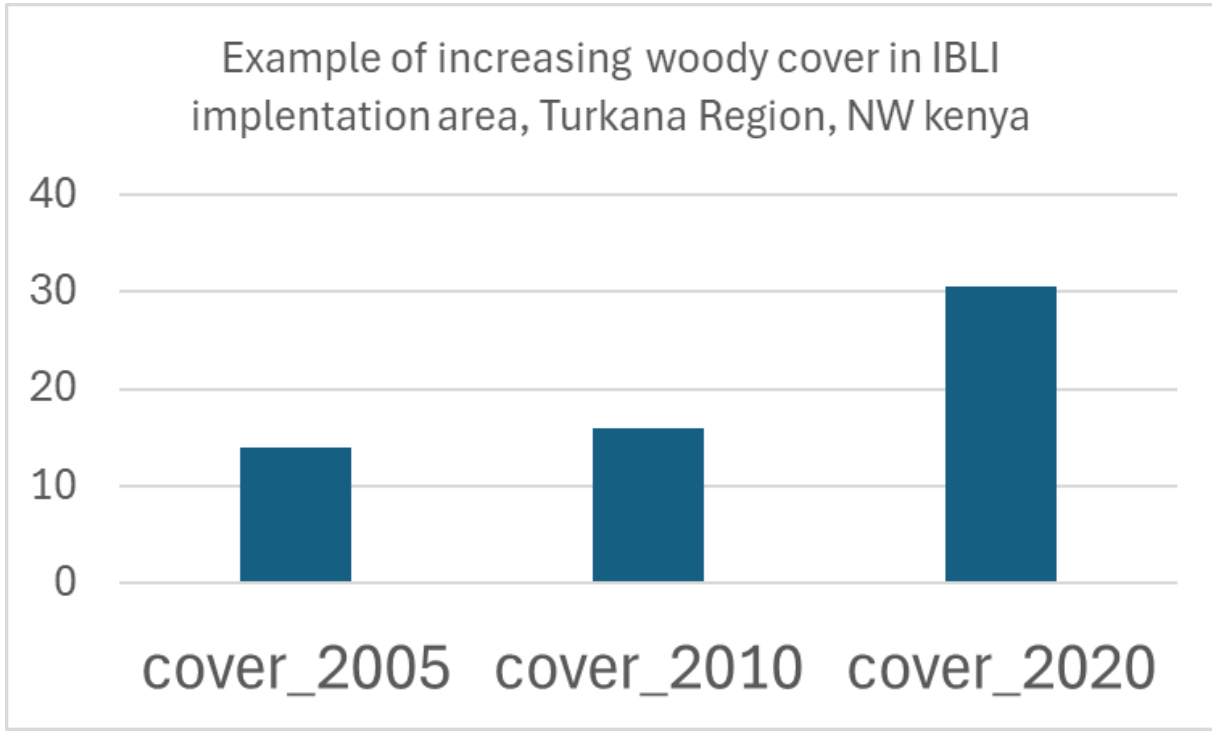
Based on MODIS NBAR reflectance and ALOS PALSAR annual SAR backscatter, for normalizing partitioned leaf area index for historical changes in woody conditions

Operationalizing Partitioned LAI Data for IBLI

❖LAI partitioning method is dependent on accurate woody canopy cover data

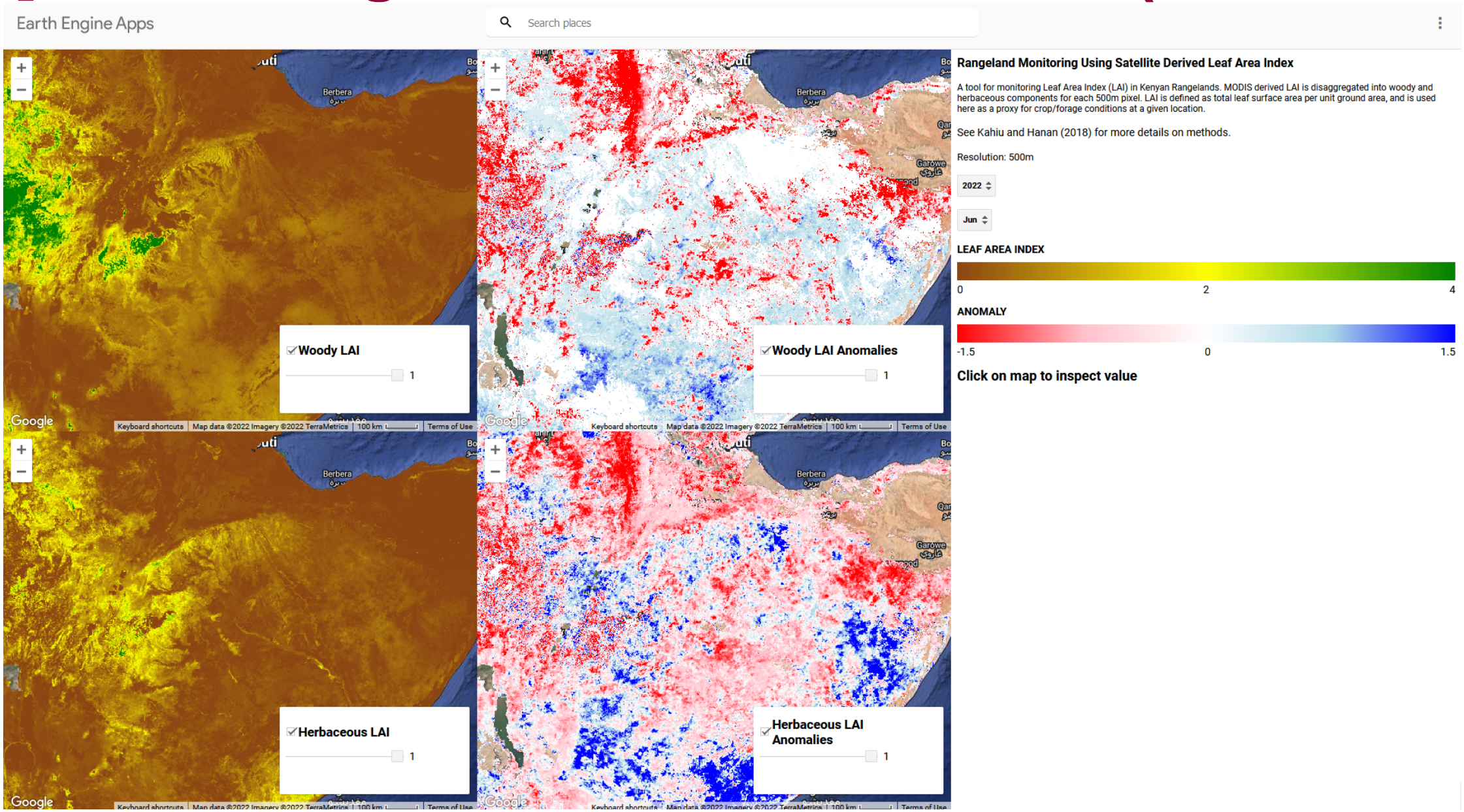
RGB composite showing epochal woody canopy cover changes (2005-2020) for Horn of Africa.





Blueish-green indicates areas with increasing woody cover, while red indicates areas with decreasing cover

Operationalizing Partitioned LAI Data for IBLI (2022 anomalies)



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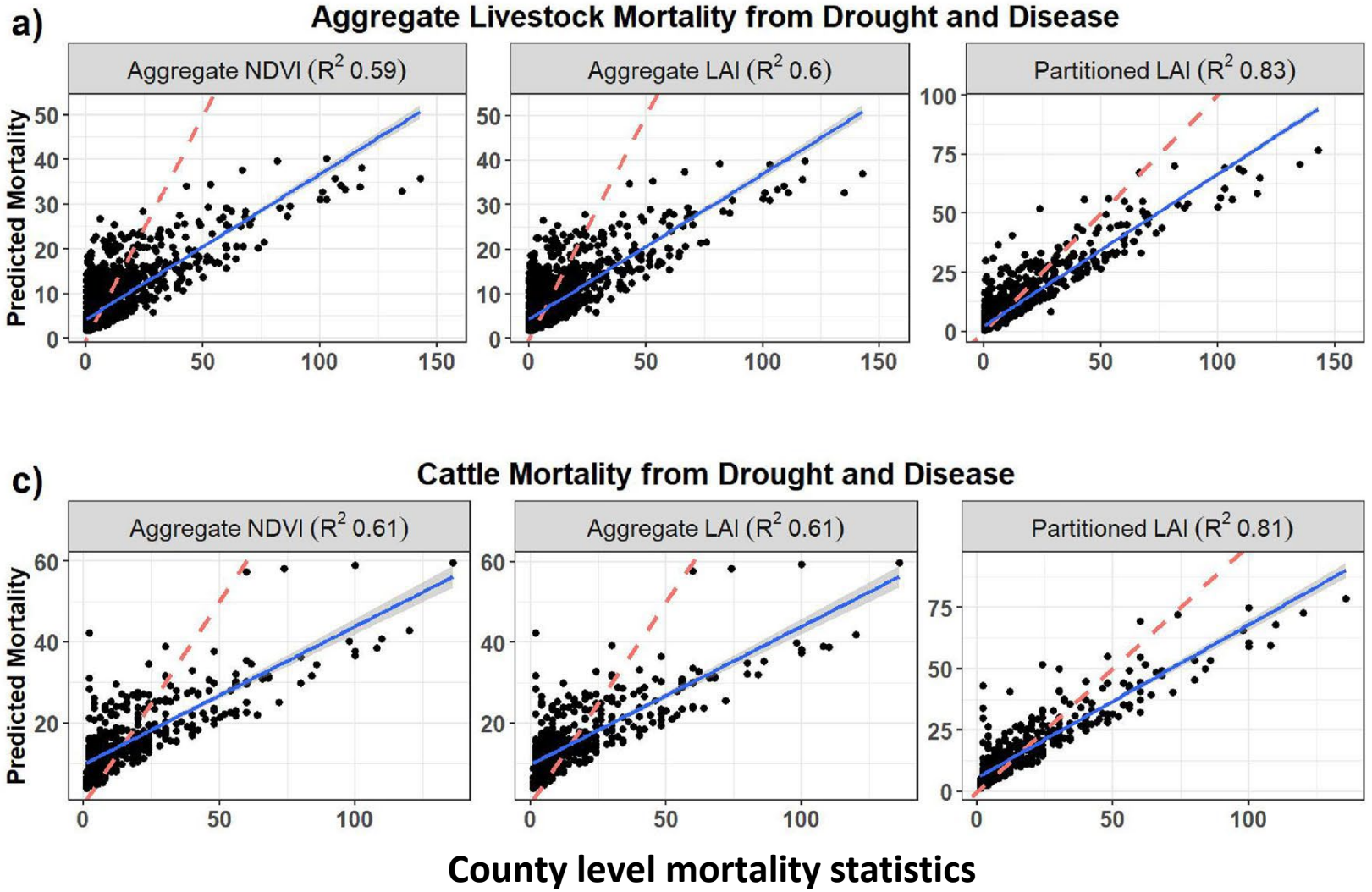
Operationalizing… for IBLI… and why it matters!



Partitioned LAI recognizes distinct foraging strategies of grazers versus browsers

- Partitioned LAI models outperform aggregate NDVI and LAI models
- Use of partitioned LAI has potential to improve IBLI product design
- Revise anomaly calculations
  - Cattle - LAI_H is most influential
  - Camels - LAI_W
  - Sheep and goat models combine both
- Respond to landscape changes
  - Shrub encroachment
  - Loss of herbaceous cover
  - **See Poster # 60**

Kahiu et al 2024 | DOI: 10.1038/s41598-024-62893-4

Leveraging browse and grazing forage estimates to optimize index-based livestock insurance

Earth Observation of forage type (woody or herbaceous) to support climate resilience and disaster risk financing in African Pastoral Communities

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New Mexico State University, United States of America

African pastoral communities are profoundly vulnerable to climate change and drought, which pose severe risks to their livelihoods dependent on livestock and nomadic herding practices. Index-based livestock insurance (IBLI) initiatives aim to mitigate the financial impact of these risks by compensating pastoralists for livestock losses based on predetermined indices. In this study, we explore and demonstrate opportunities to leverage Earth Observation data for advancing IBLI implementation in African pastoral communities. Existing IBLI risk assessment models primarily utilize simple greenness indices (such as the Normalized Difference Vegetation Index or NDVI), which may inadequately represent the variegated forage types present in natural grazing lands. We propose a refined approach by partitioning satellite leaf area index data for 20+ years into herbaceous and woody leaf components, to mirror the distinct grazing and browsing habits of different livestock. We also derive and showcase more accurate historical (multi-epochal) woody vegetation maps for African drylands, derived using combined SAR/Optical satellite data, which is a precursor to our methods for partitioning leaf area index into different forage types. Finally, through a comparative analysis using historical livestock mortality data from Northern Kenya, we showcase how partitioned leaf area index outperforms traditional NDVI-based assessments in predicting livestock mortality, demonstrated by lower root mean squared error and higher R^2 values. This research underscores the potential of utilizing detailed satellite-derived forage data to reduce basis risk and enhance the precision of IBLI assessment, fostering more resilient pastoral communities.