Modelling savanna vegetation structure using Synthetic Aperture Radar and spaceborne lidar:
A case study in Kruger National Park, South Africa

Marco Wolsza[1], Sandra MacFadyen[2,3], Jussi Baade[4], Tercia Strydom[5], Christiane Schmullius[1]

[1]Department for Earth Observation, Friedrich Schiller University Jena, Germany
[2]Mathematical Biosciences Lab, Stellenbosch University, South Africa
[3]National Institute for Theoretical and Computational Sciences (NITheCS), Stellenbosch, South Africa
[4]Department of Geography, Friedrich Schiller University Jena, Germany
[5]Scientific Services, South African National Parks (SANParks), Skukuza, South Africa

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Data: Spaceborne lidar

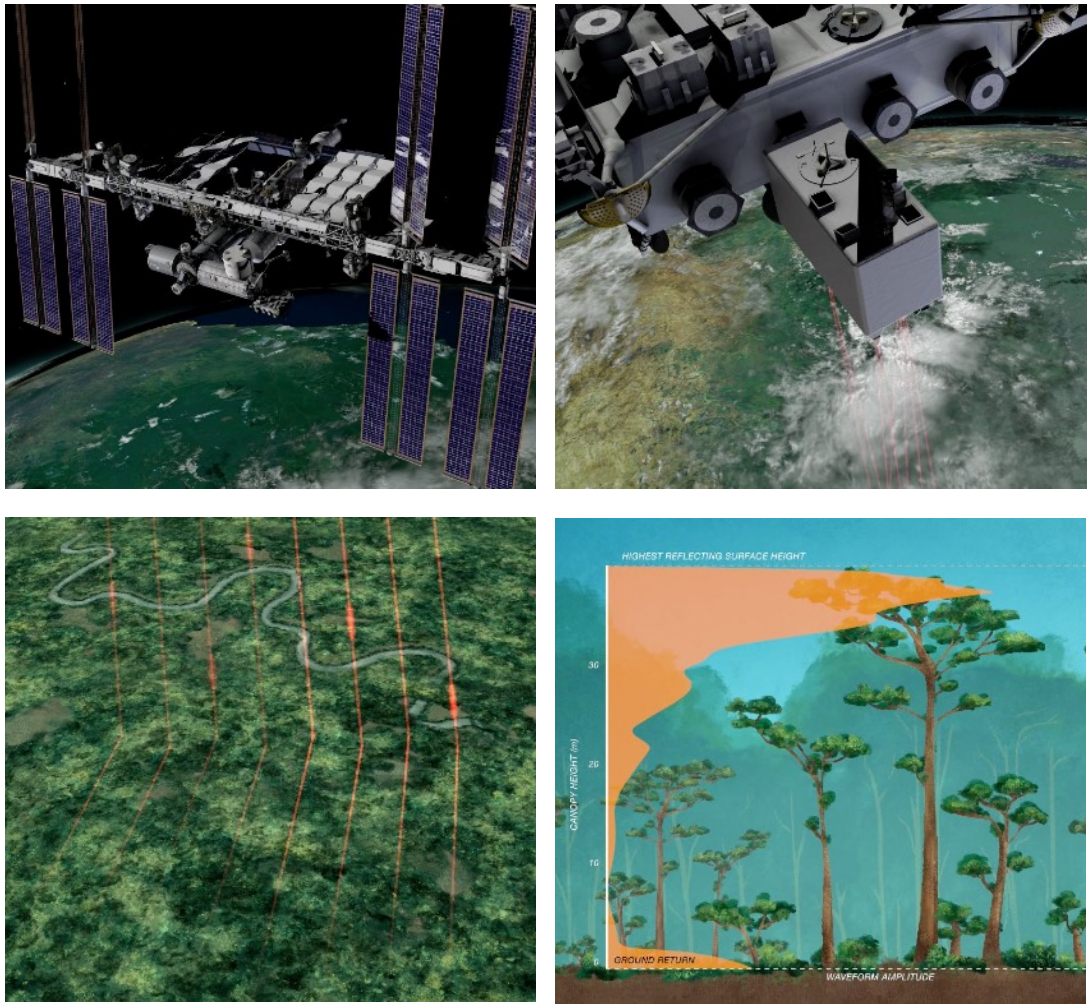

Fig 1: Overview of GEDI instrument operation. Adapted from: NASA's Goddard Space Flight Center (2018), GEDI Media Resources, https://svs.gsfc.nasa.gov/13090.

- Global Ecosystem Dynamics Investigation (GEDI)
- Instrument attached to the ISS
- Hopefully continues to collect data until 2030

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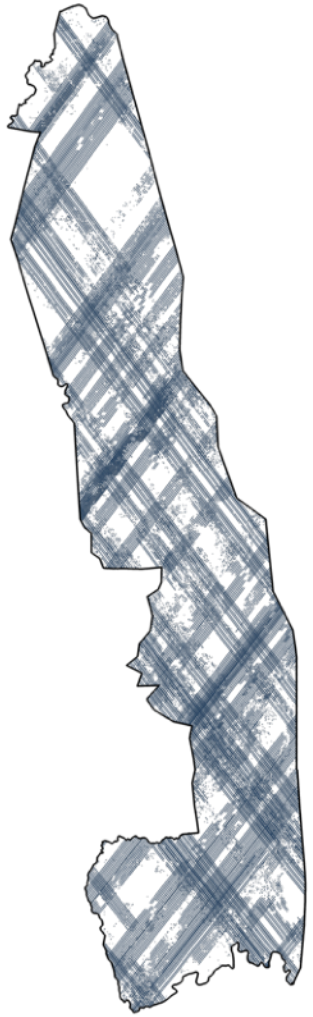

Fig 2: Spatial distribution of ~478k GEDI footprints acquired during leaf-on periods between 2019-12 – 2023-04 and overview of selected vegetation structure metrics.

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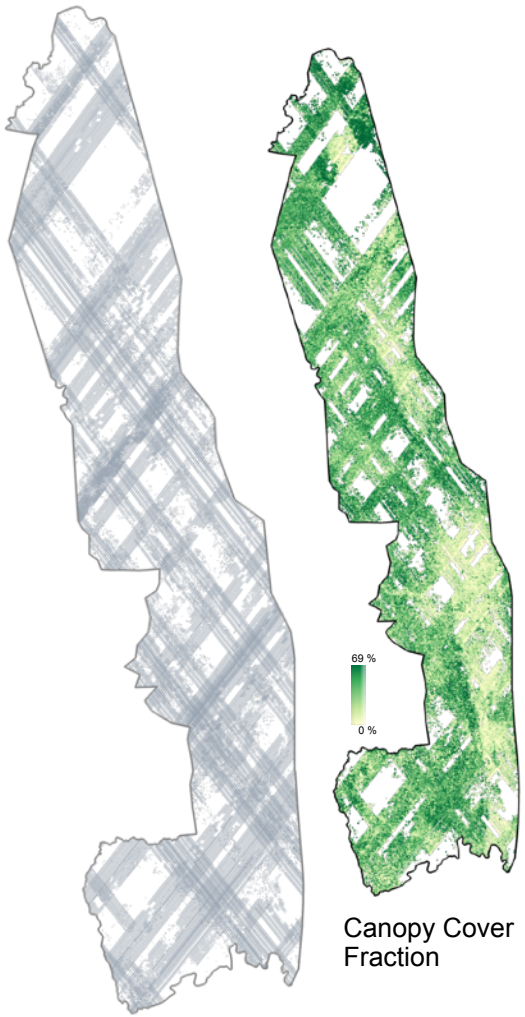

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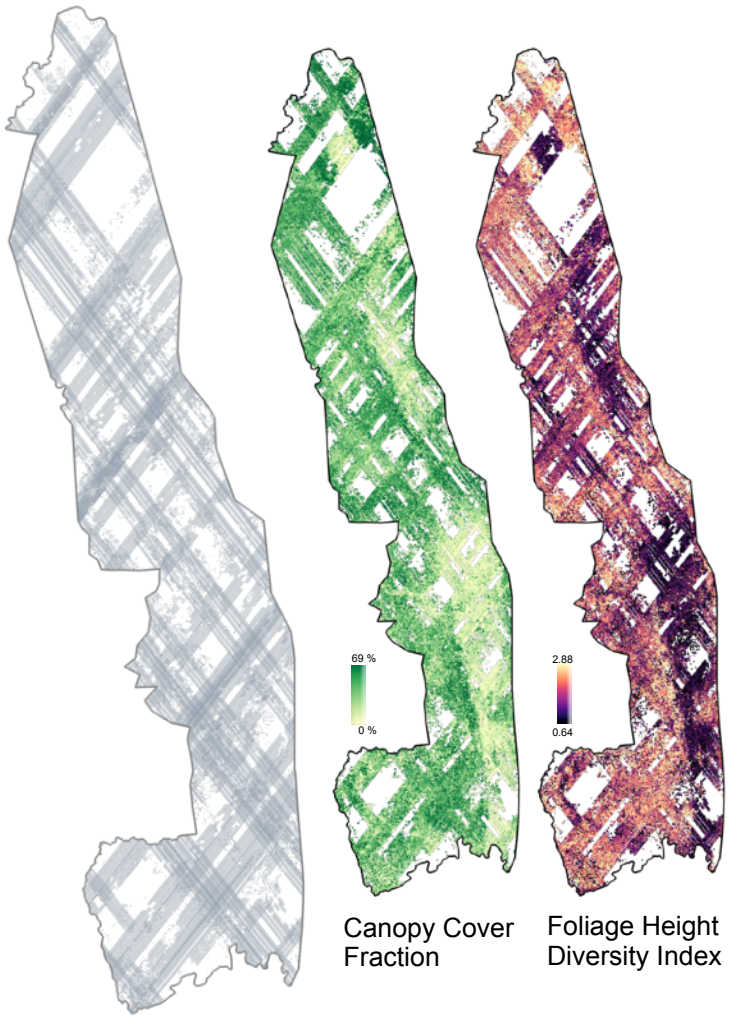

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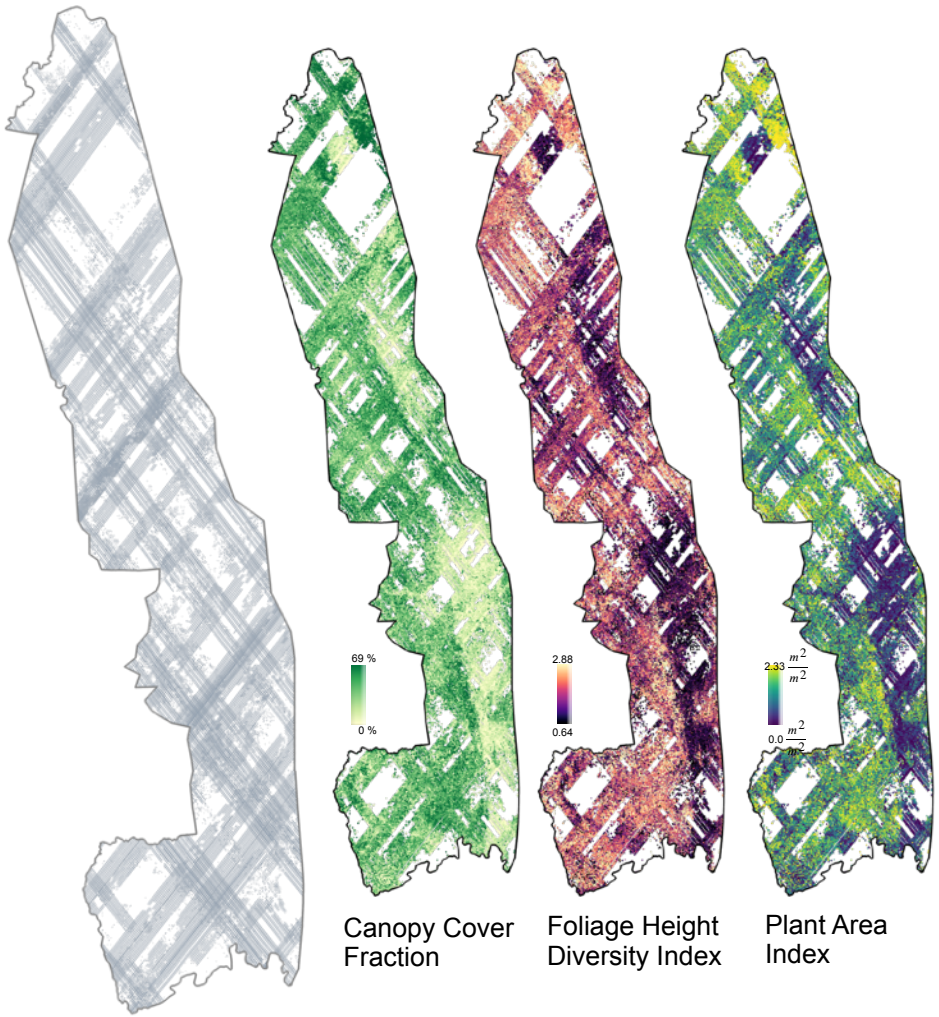

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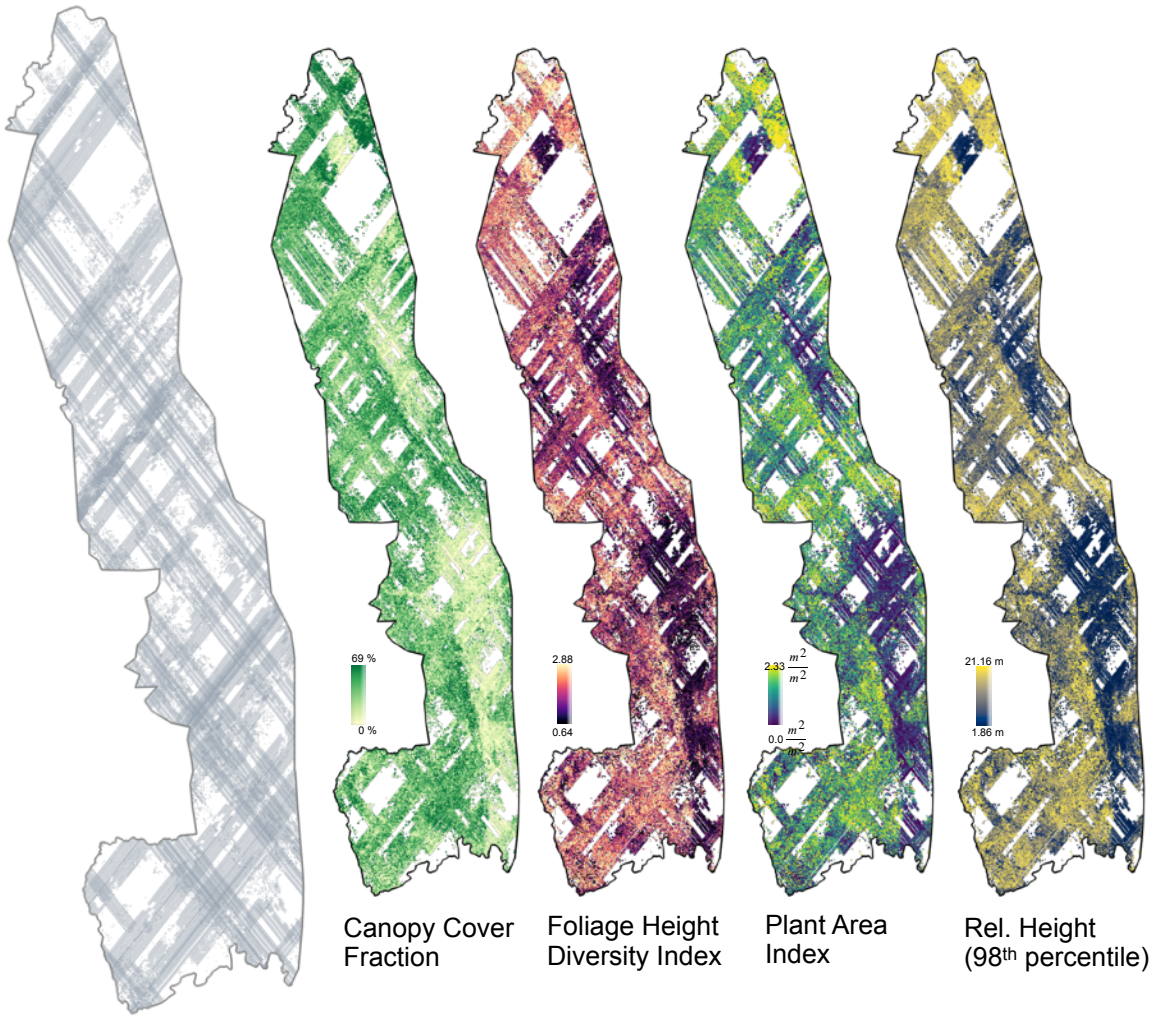

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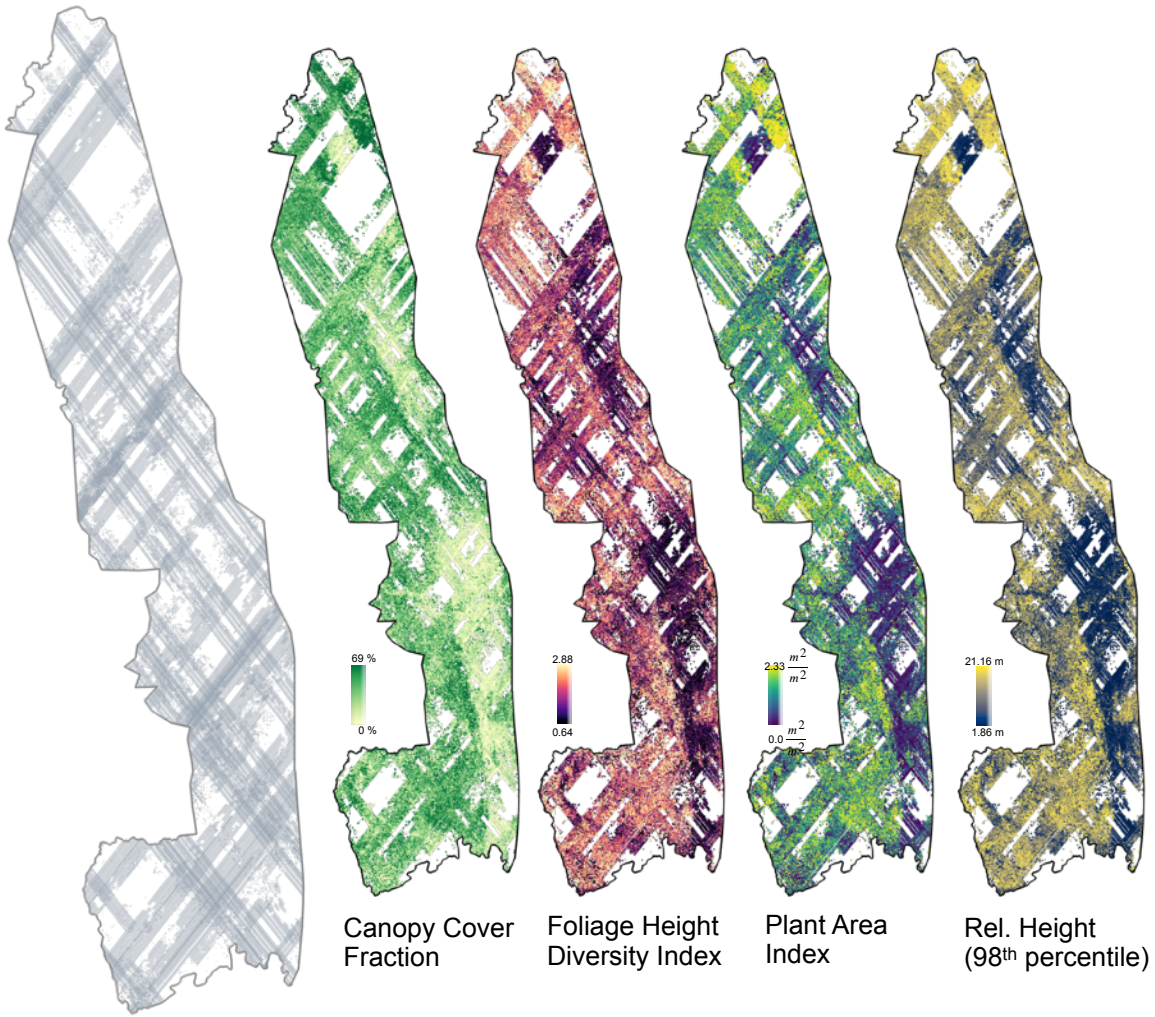

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- Vegetation structure metrics calculated from waveforms
- **Higher accuracy during leaf-on conditions** for canopy height measurements in savanna ecosystems (Li et al., 2023)

Data: Synthetic Aperture Radar (SAR)

Fig 3: Copernicus Sentinel-1 LRW VH-pol dry season composite (Jul-Sept, 2018-2023). Contains data from Digital Earth Africa (2024a).

Fig 4: Sensitivity of SAR measurements to forest structure and penetration into the canopy at different wavelengths. Adapted from Saatchi et al. (2019).

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- Backscatter intensity = Energy returned from ground object
  - Influenced by physical and dielectric properties
- **Higher sensitivity during leaf-off conditions** to woody vegetation structure in savanna ecosystems (Mathieu et al., 2013; Urbazaev et al., 2015; Main et al., 2016)

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- Open-source, reproducible framework to create wall-to-wall maps of vegetation structure metrics for savanna ecosystems

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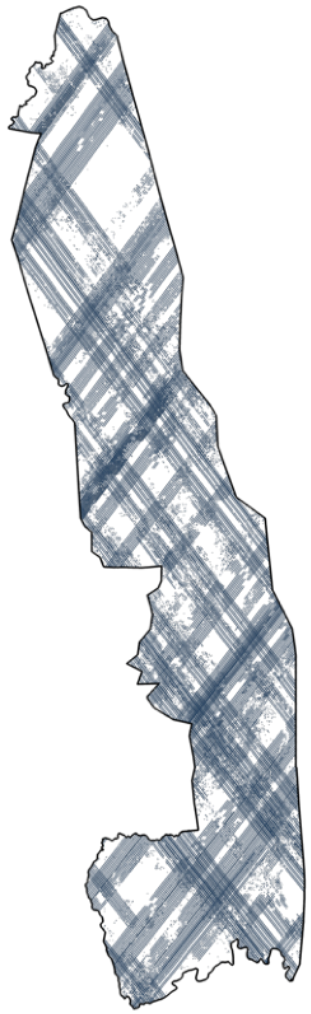
- But first… How to address spatiotemporal challenges?
  - How to determine **leaf-on** condition of individual GEDI shots?
  - When is the “best” subsequent **leaf-off** period?
  - What if there was a **fire** in-between?
  - How to account for interannual variability of **precipitation** patterns?

Methods: Addressing challenges



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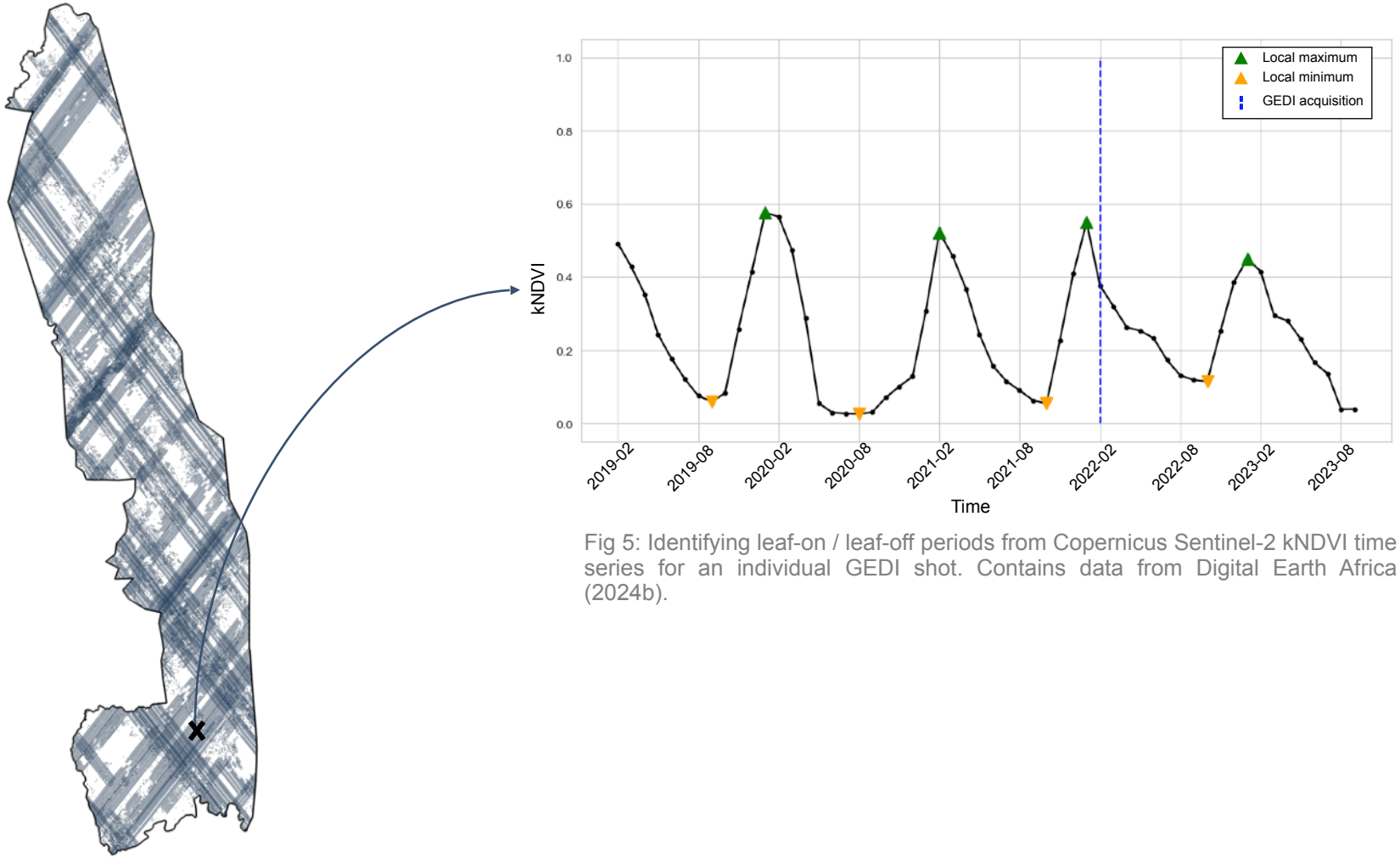

Fig 5: Identifying leaf-on / leaf-off periods from Copernicus Sentinel-2 kNDVI time series for an individual GEDI shot. Contains data from Digital Earth Africa (2024b).

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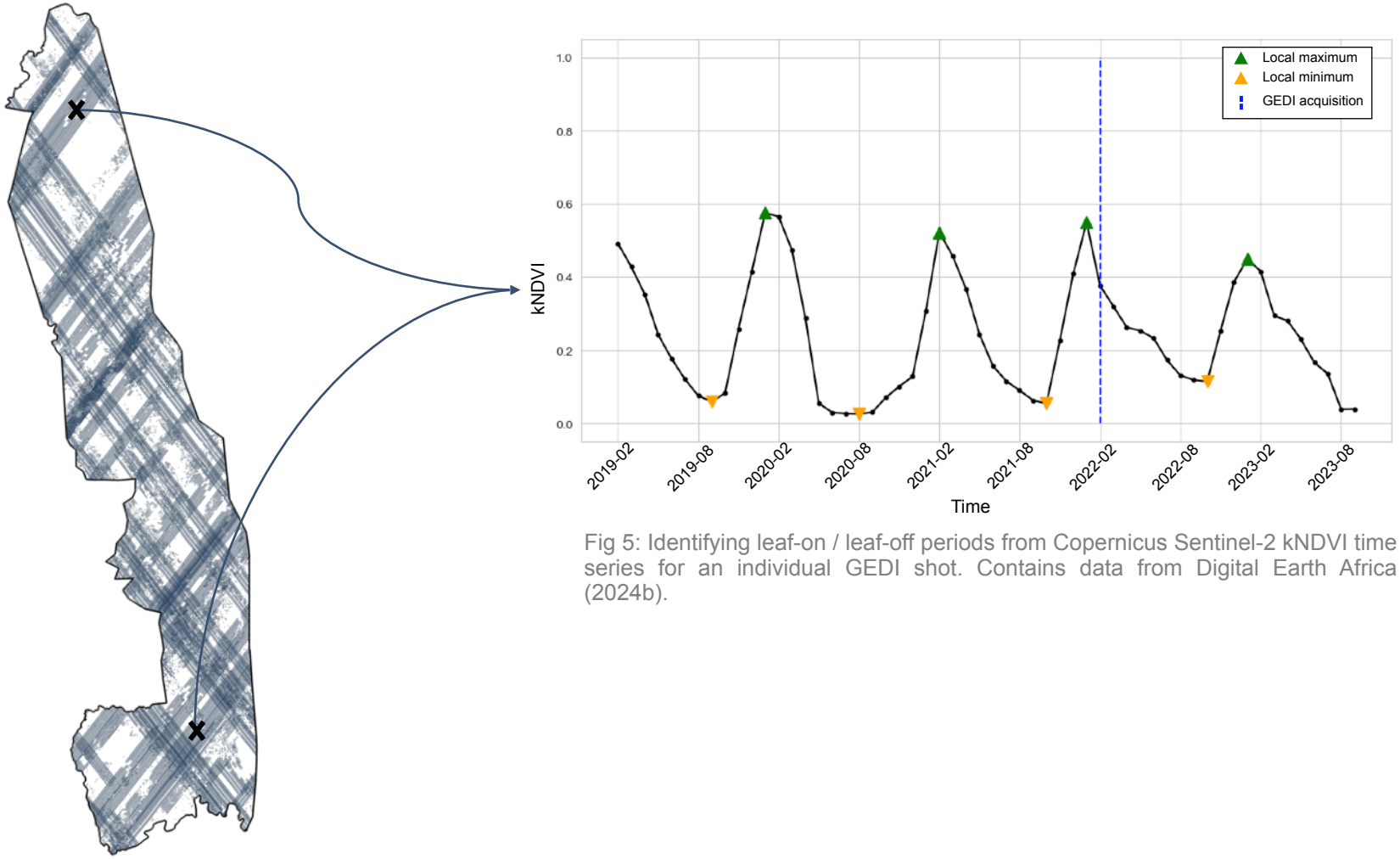

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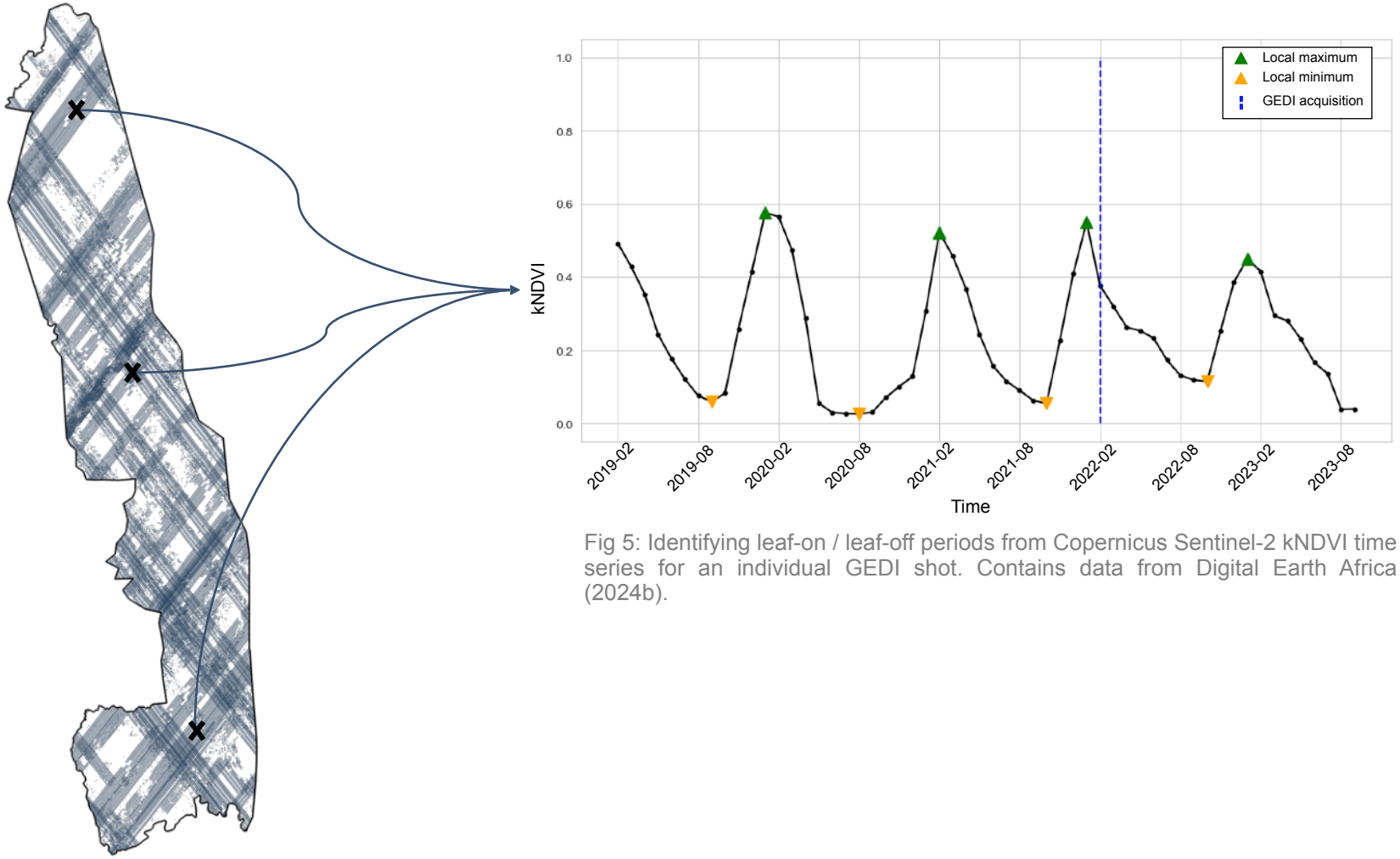

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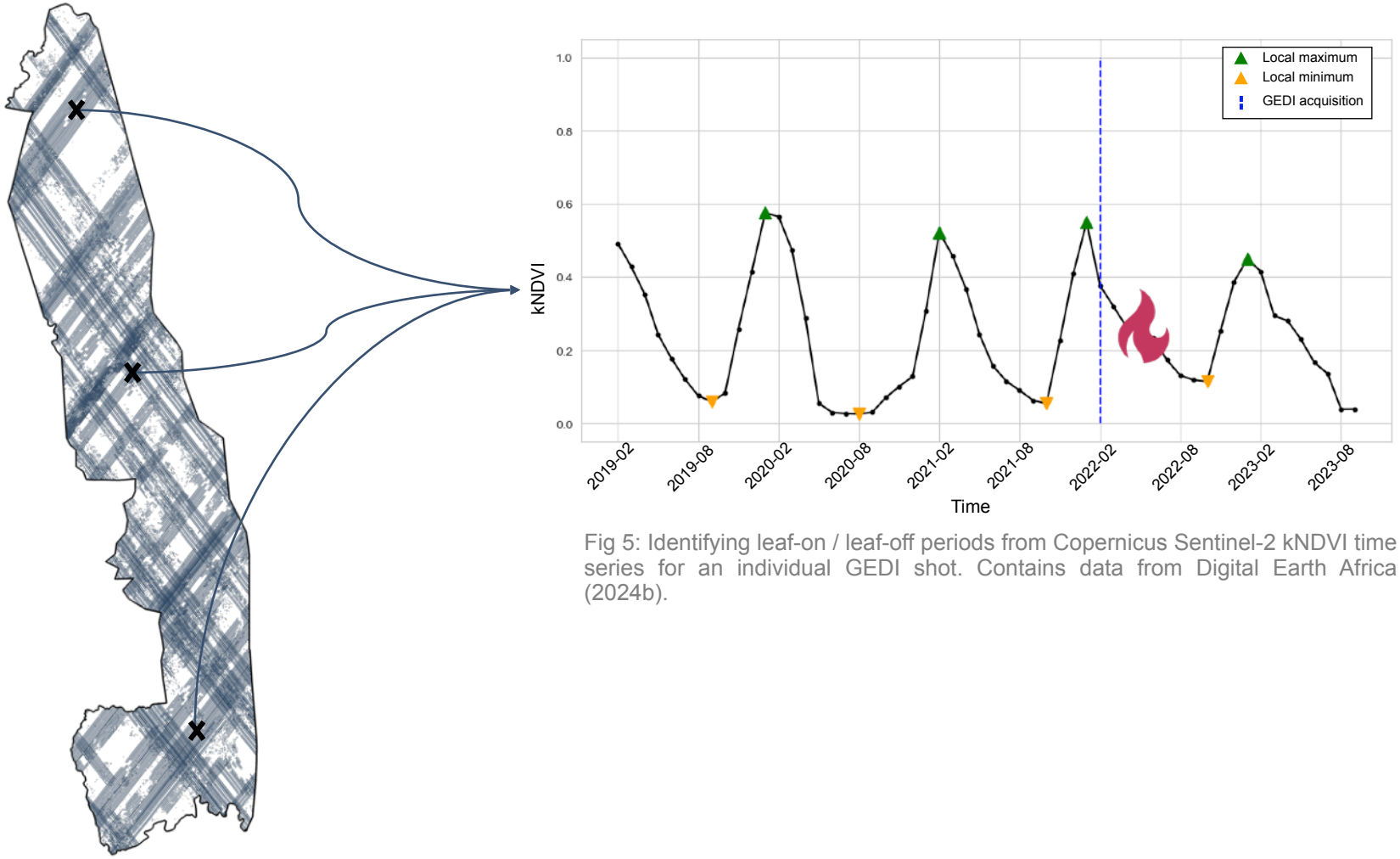

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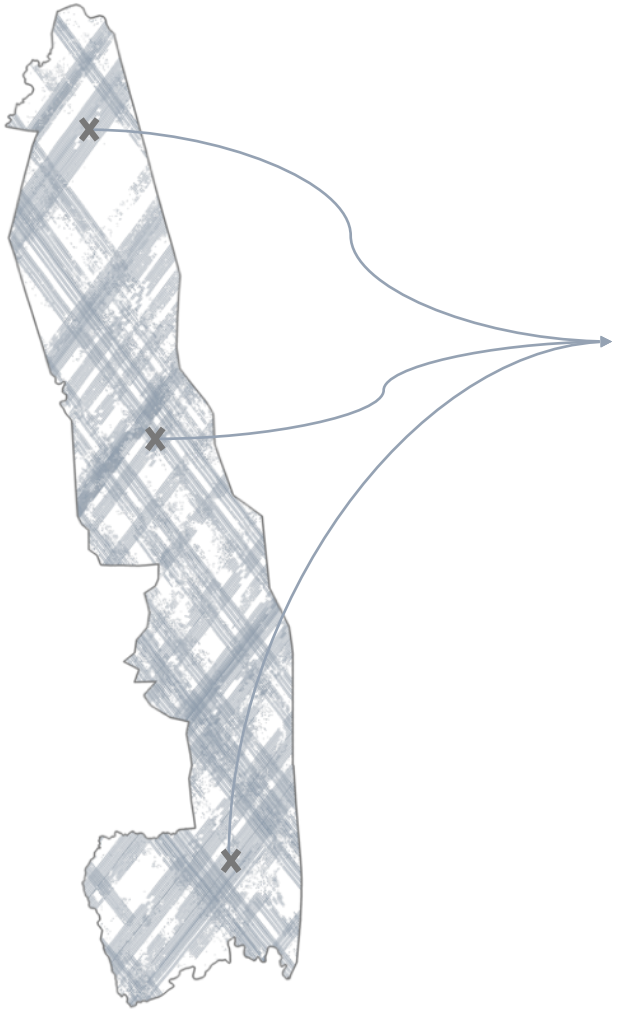

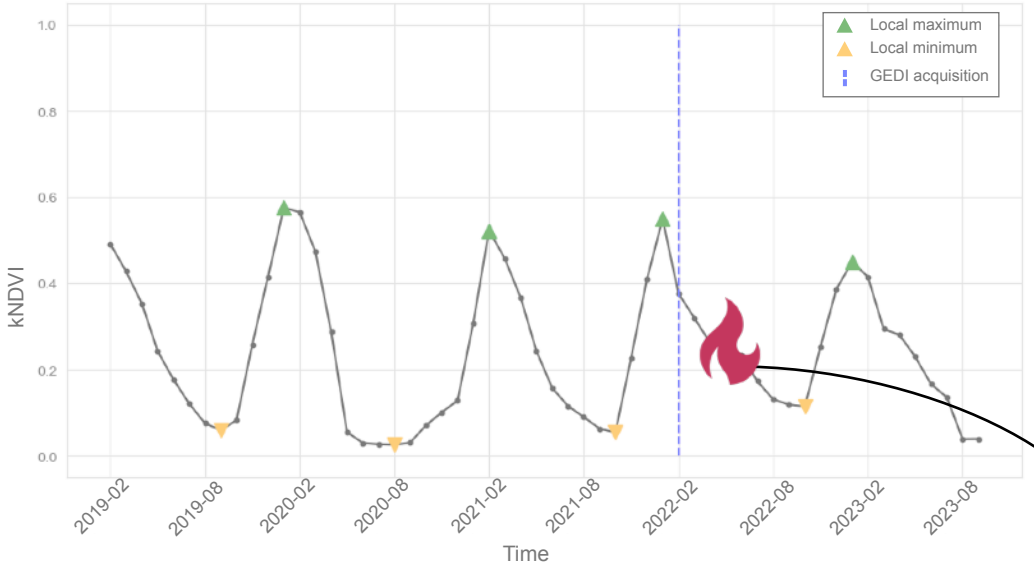

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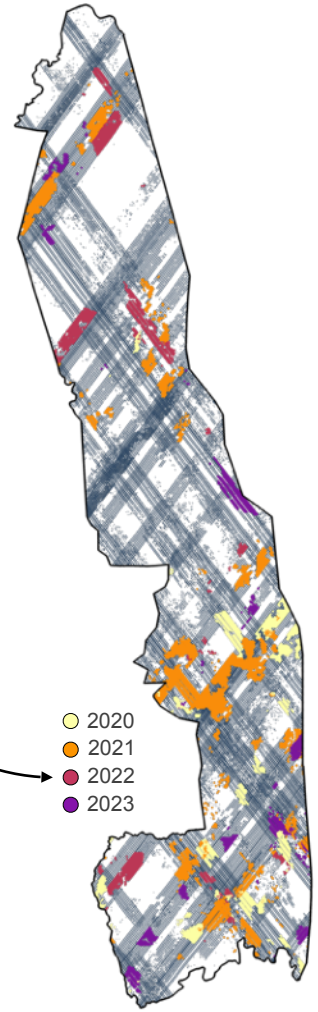

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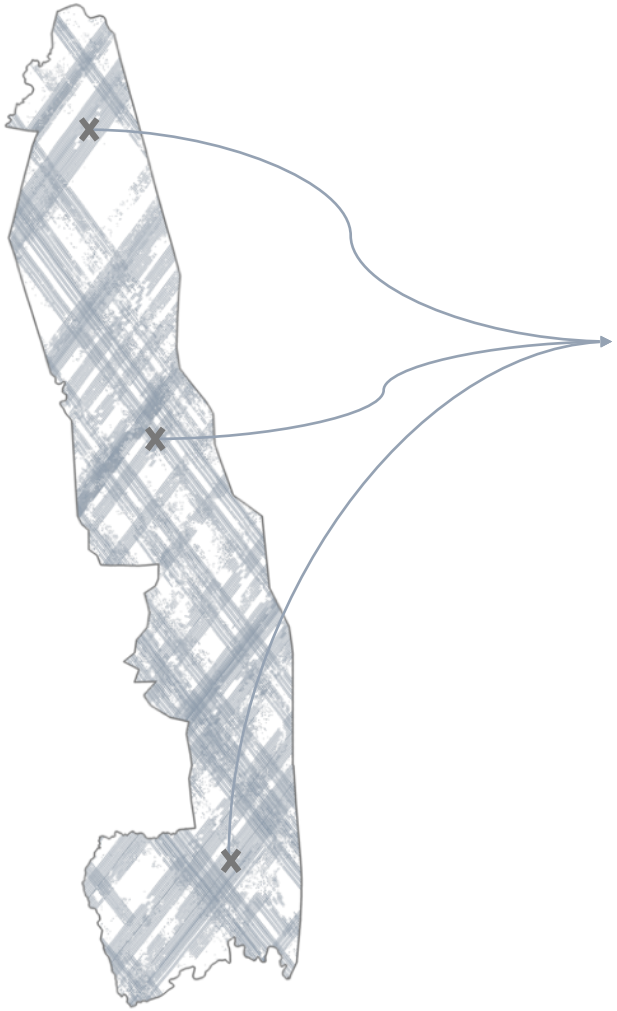

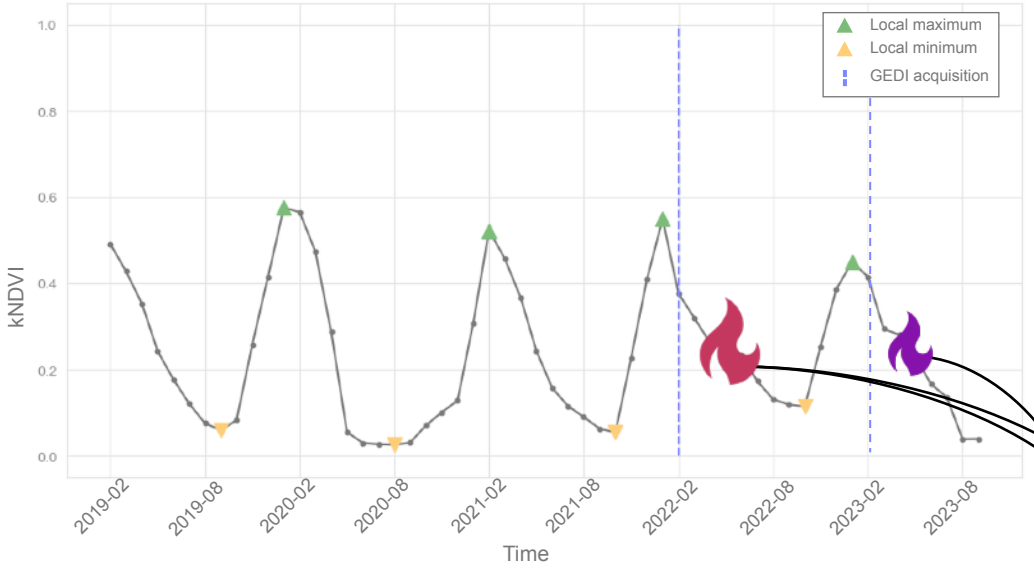

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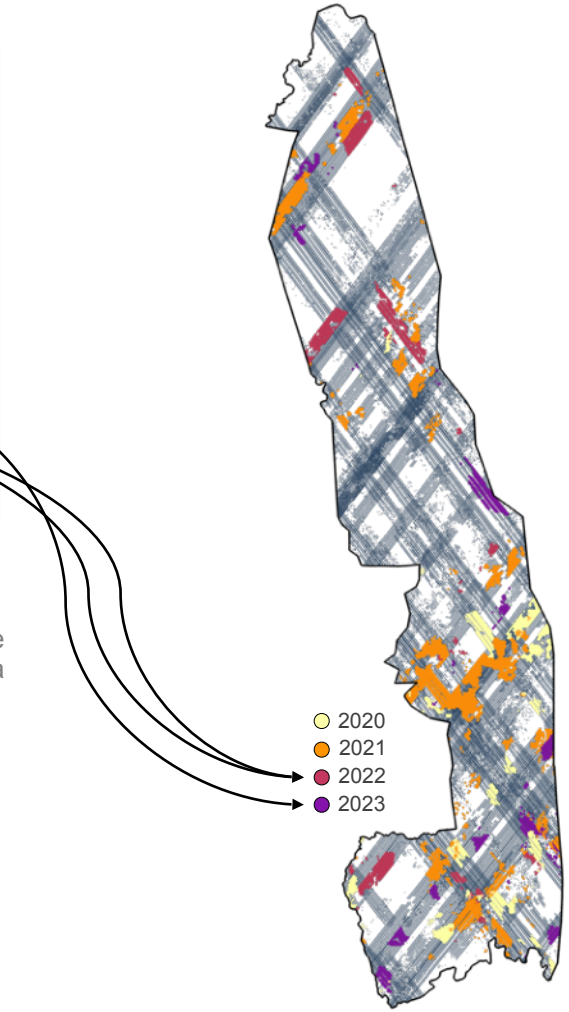

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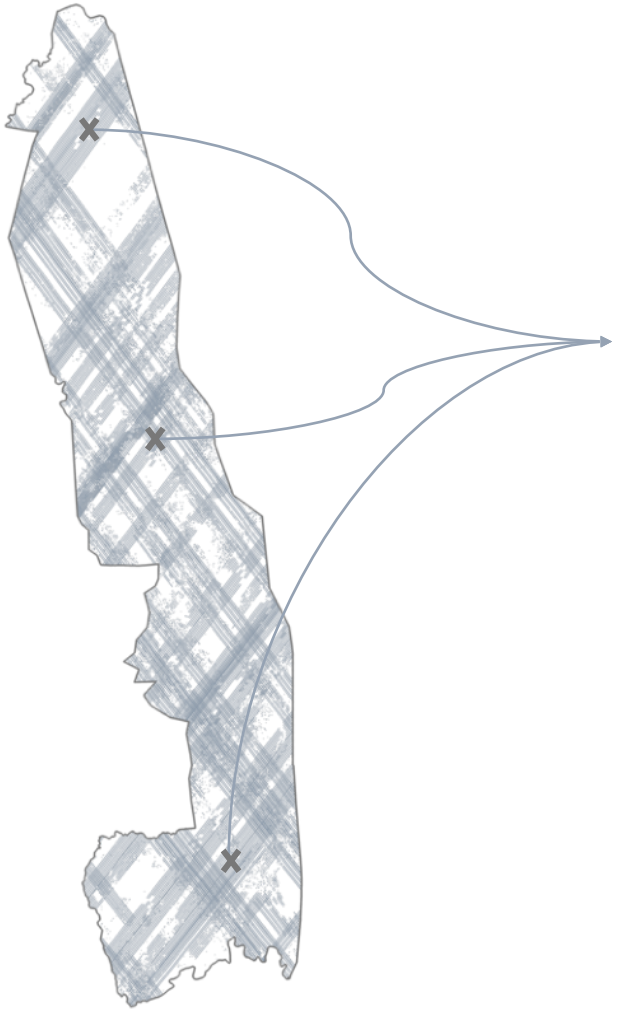

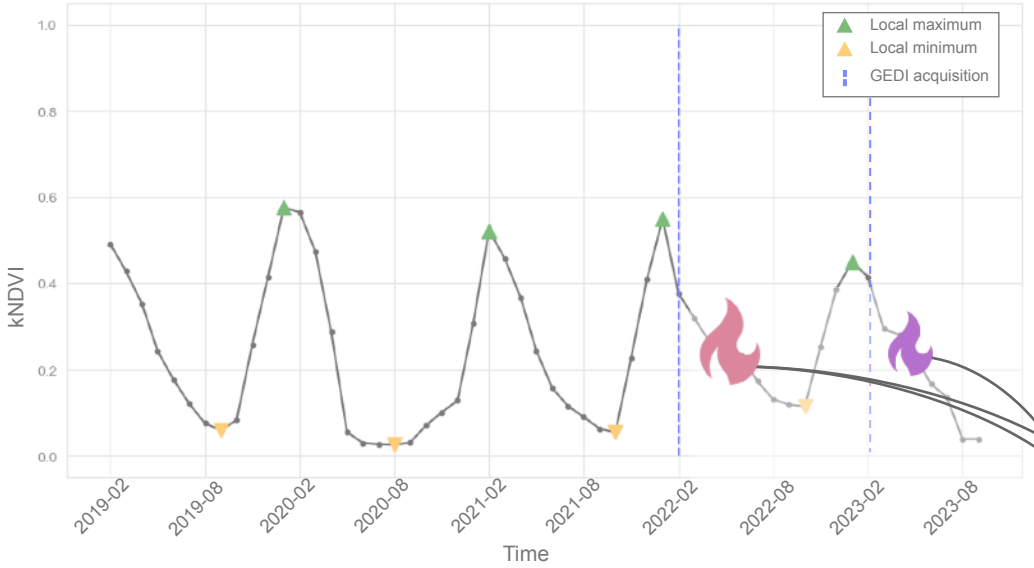

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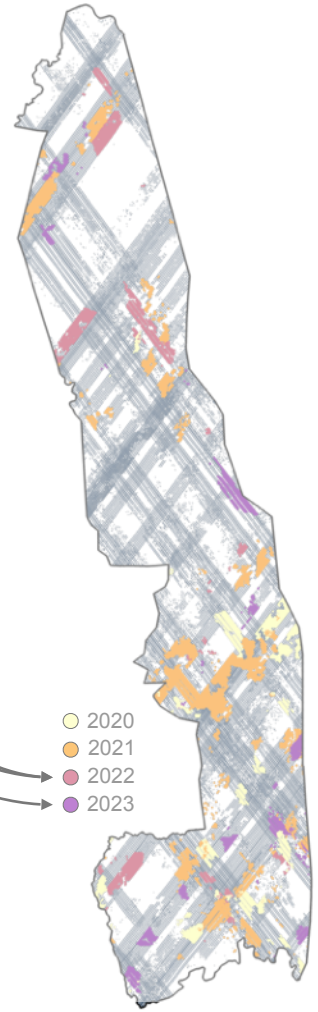

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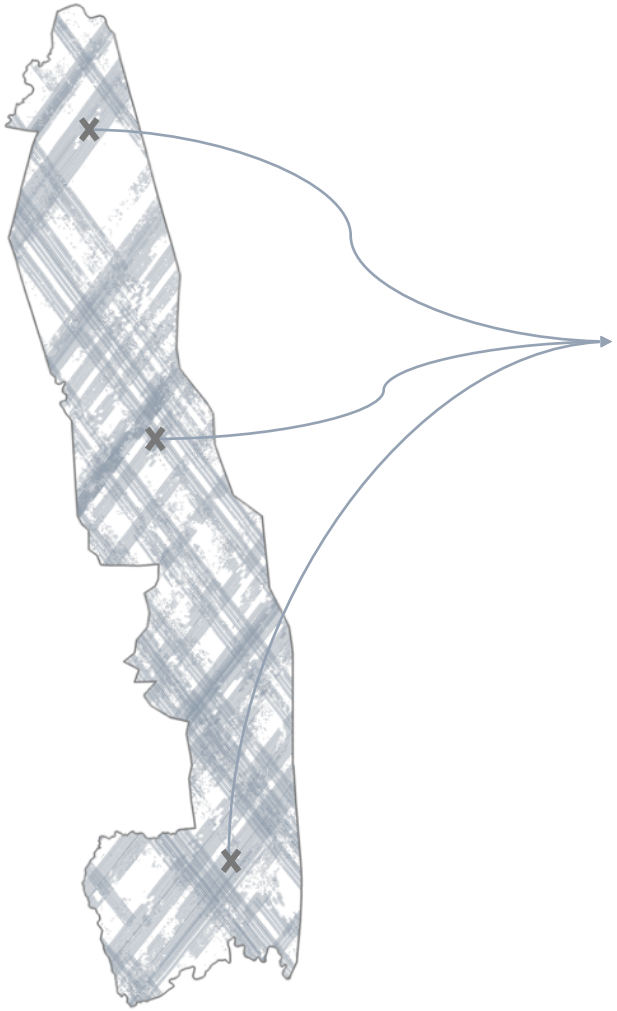

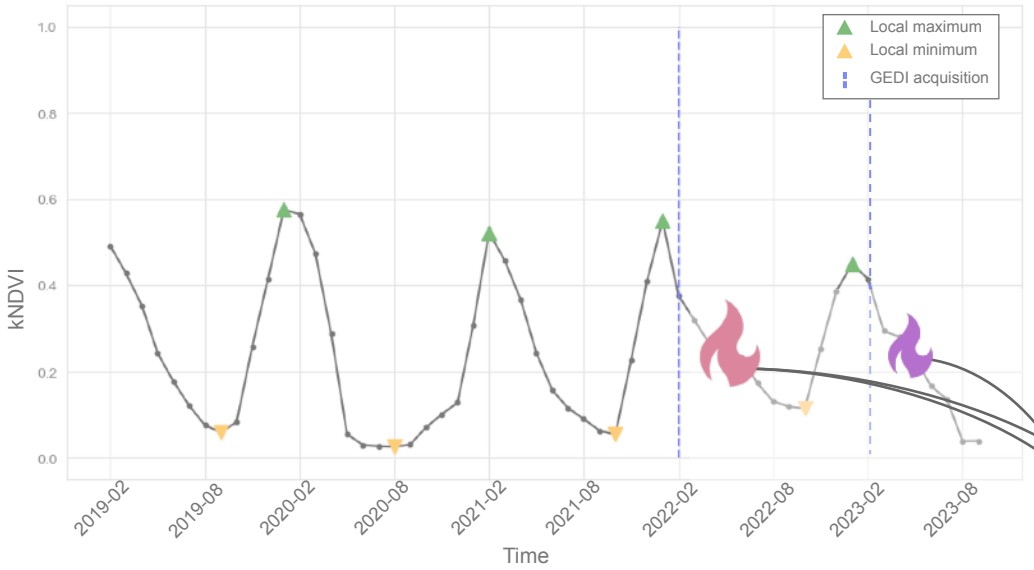

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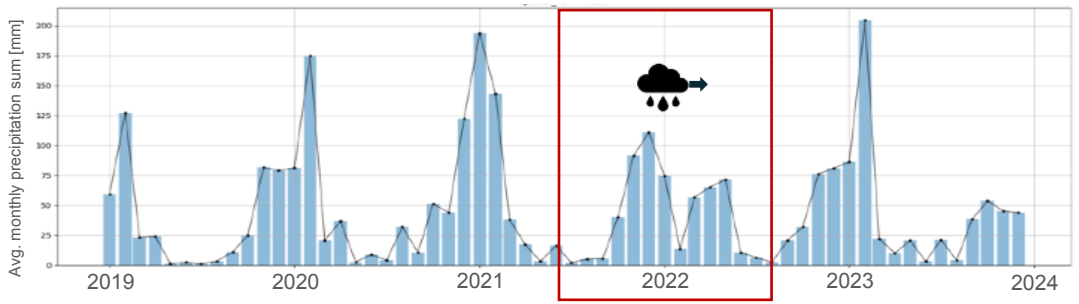
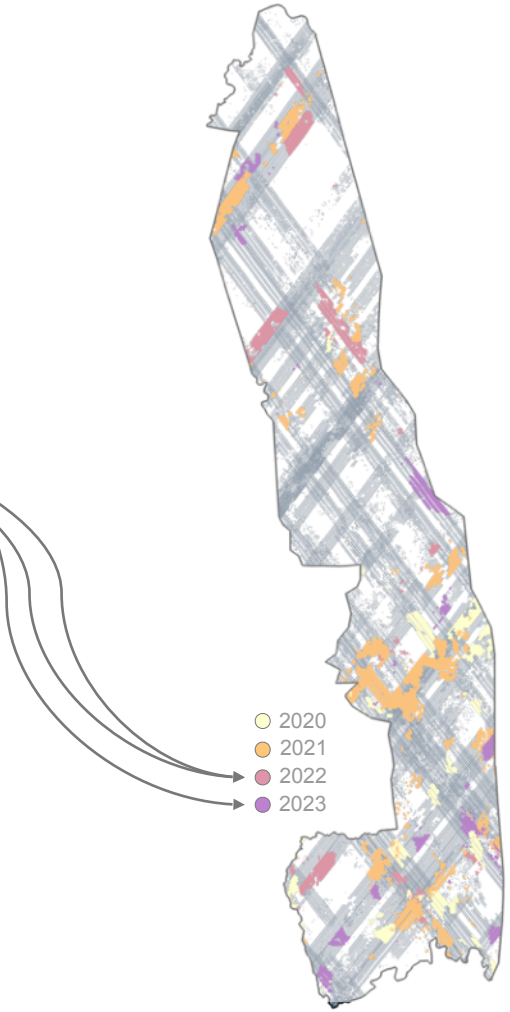


Fig 7: MSWEP V2 (Beck et al., 2019) monthly precipitation sum, average of all pixels intersecting with Kruger National Park.



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  - Predicting VH backscatter using GEDI metrics
  - Per year cross-validation
  - Different sample sets

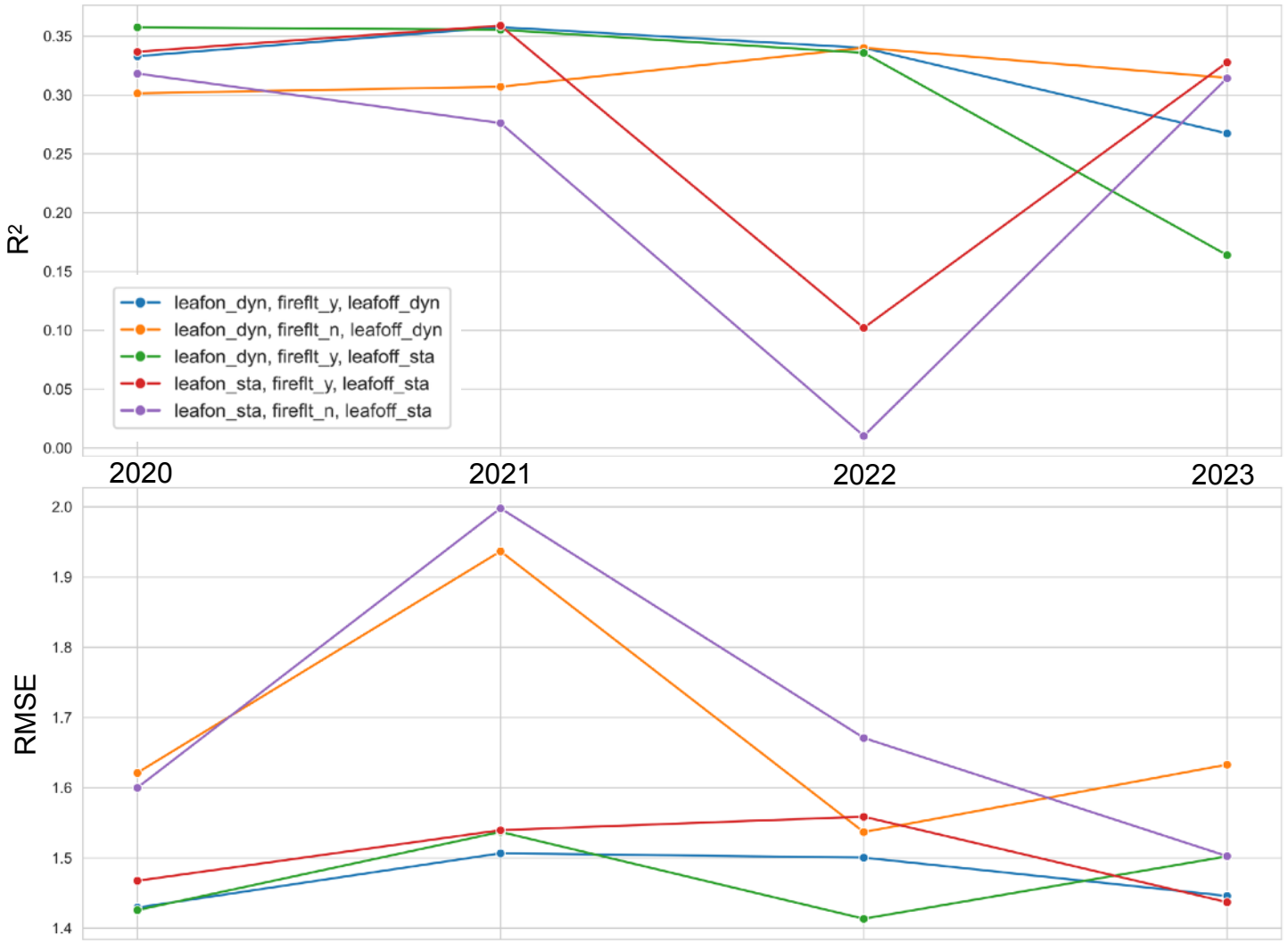

Fig 8: Results of Random Forest Regression models showing variability of R^2 and RMSE per year depending on input sample set. Sample set with dynamic windows and additional fire filtering (blue line) performs best.

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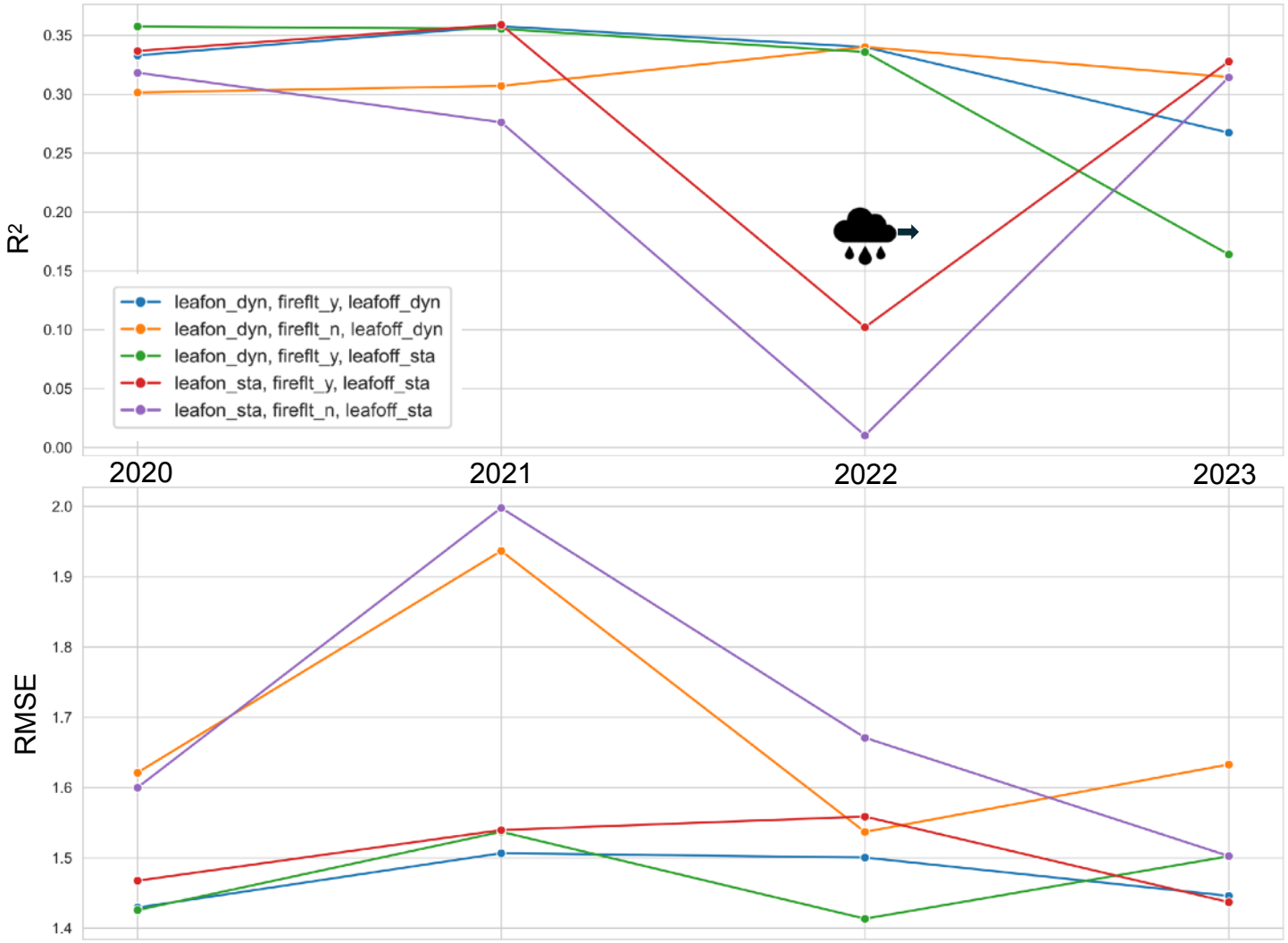
  - Dynamic windows = stable model performance



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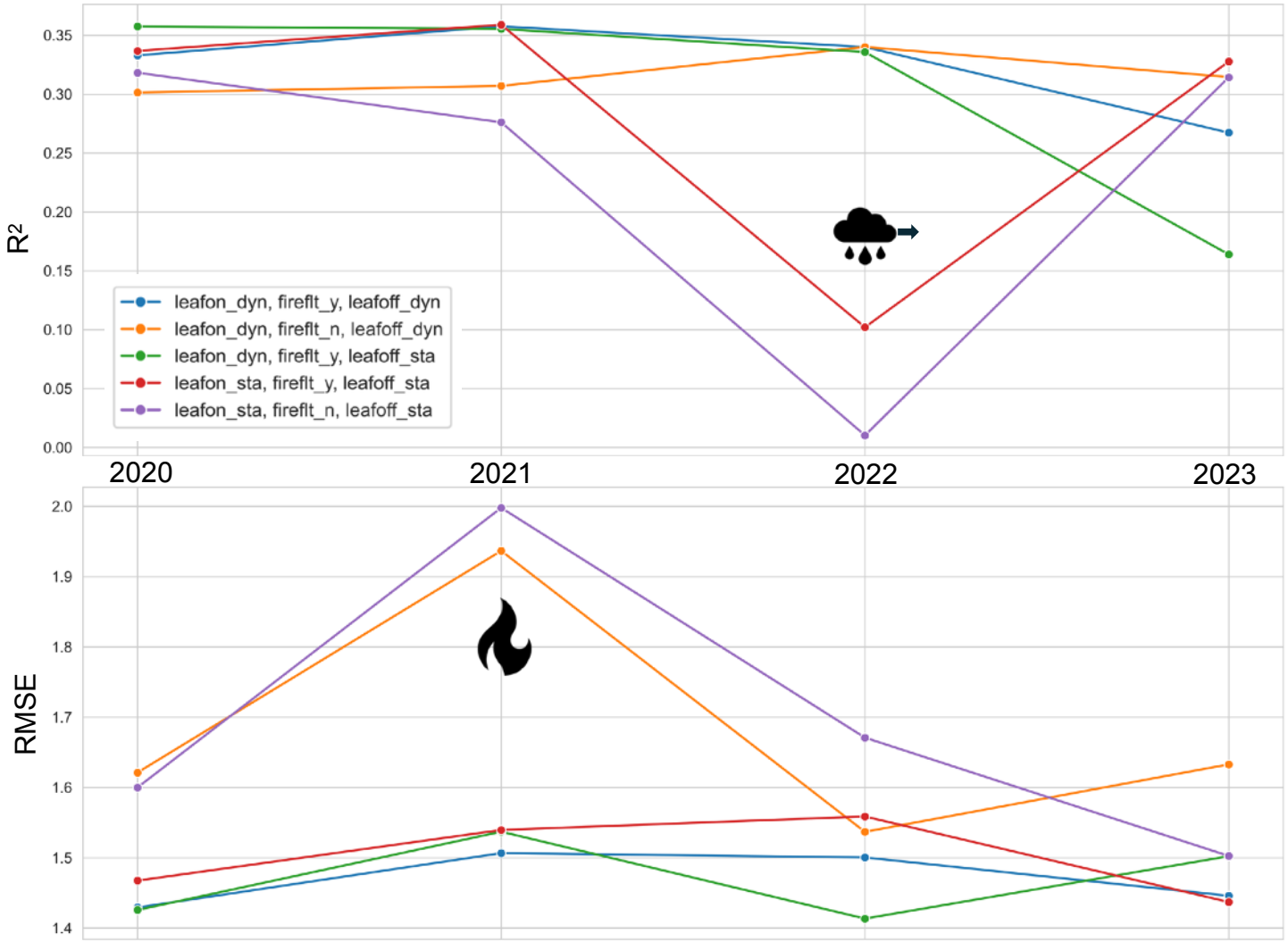

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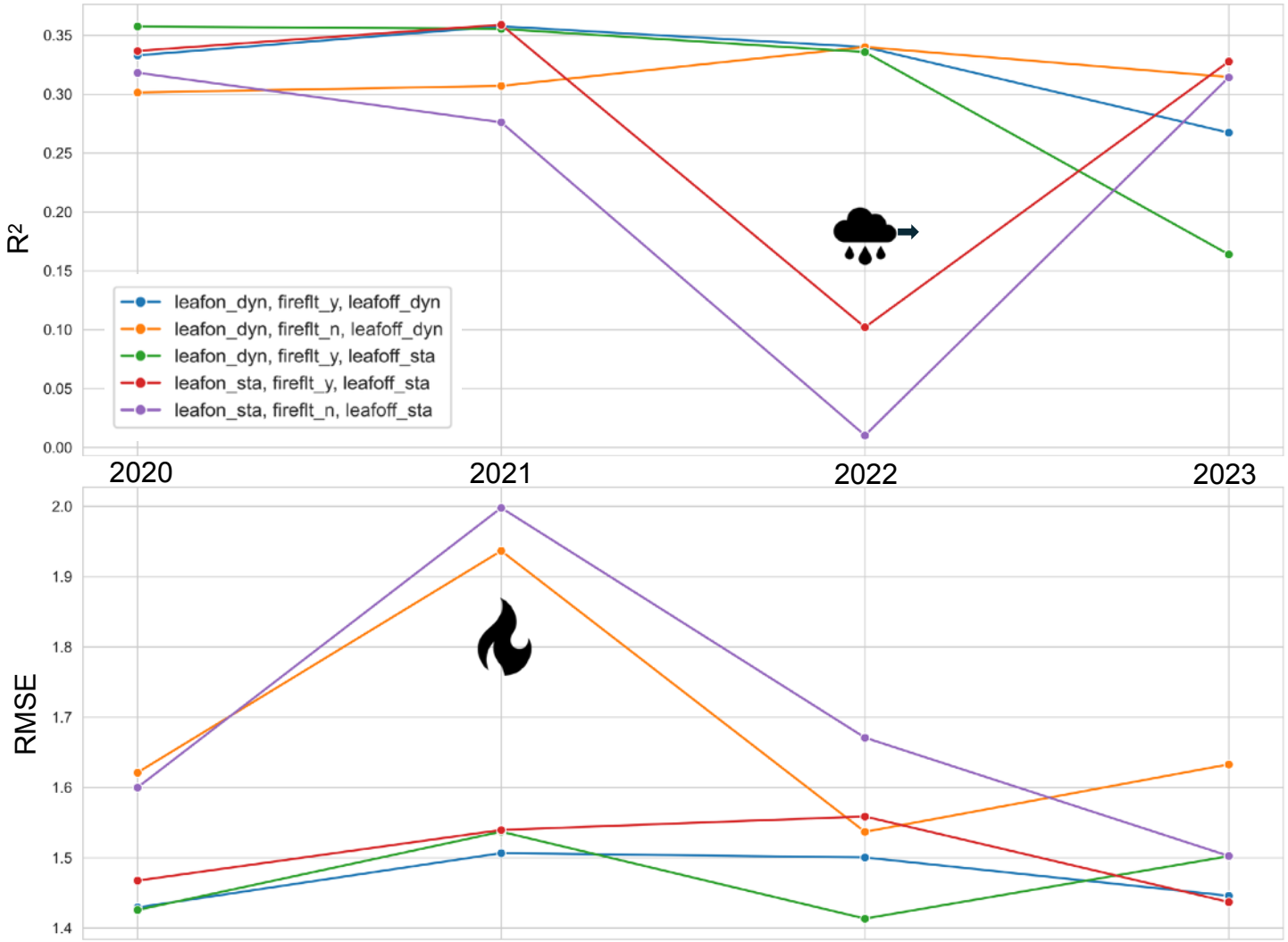

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References

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Thank you for your attention!

@maawoo