# Abstract in Manuscript:

During the 2024 B-Cubed Hackathon, we extended the R package "`rasterdiv`" by incorporating Time-Weighted Dynamic Time Warping (TWDTW) to the package’s pre-existing `paRao()` function for the calculation of parametric Rao’s Quadratic Diversity (Rao’s Q) index. This expands the user’s ability to biodiversity trends when using time series of Earth Observations. Biodiversity indices like Shannon’s H do not consider spatio-temporal dynamics, and others (e.g. Rao’s Q) only incorporate geographic distance between observations, often leaving phenological variation overlooked.

Through integrating TWDTW into the `paRao()` function, users can assess different facets of an ecosystem’s biodiversity by incorporating phenological differences among its plant communities. This is also valuable to distinguish between natural habitats that follow a seasonal phenological trend and artificial land cover types, which may lack phenological changes. Previous studies have also found that the time weighting ability of TWDTW enables the discernment of different floral community types which could otherwise be misclassified as the same with traditional Dynamic Time Warping (DTW).

To evaluate the efficacy of TWDTW within the `paRao()` function, we compared the ability of TWDTW Rao’s Q index against other biodiversity indices at classifying the different plant communities in a disturbed grassland in Calabria, Italy. Our study used a Planet Phenological Index (PPI) time series from the Sentinel-2 satellite network. The results indicated that accounting for phenological cycles can filter out artefacts and better distinguish habitats with differing plant species diversity. This improves the ability to assess ecosystem changes through space and time, providing a more comprehensive understanding of biodiversity dynamics, and the ability to gauge the resilience of different vegetation patches.

We conclude that the inclusion of plant phenology in biodiversity assessment is necessary, and that our modifications to `paRao()` will be valuable to facilitate the accurate detection and description of ecosystem trends in response to our changing environment.

# ChatGPT’s Draft Abstract:

In this study, we extend the R package "rasterdiv" by incorporating Time-Weighted Dynamic Time Warping (TWDTW) to enhance biodiversity assessment through remote sensing. Biodiversity indices traditionally focus on spatial components, often neglecting temporal dynamics crucial for ecosystem analysis. By integrating TWDTW, we enable the calculation of Rao’s Quadratic Diversity index (Rao’s Q) over time-series data, thus capturing phenological variations.

Our method leverages the TWDTW algorithm to account for temporal shifts in vegetation phenology, improving the resolution of biodiversity indices from satellite imagery. This is particularly valuable in distinguishing between natural habitats and artificial land cover types, which lack temporal phenological changes. The implementation within "rasterdiv" uses the "twtwd" function from the TWDTW R package, enabling robust phenological analysis across multiple temporal snapshots.

We applied our extended Rao’s Q index to multiband remote sensing data from a disturbed grassland, demonstrating its efficacy in reflecting ecosystem diversity. Our findings indicate that accounting for phenological cycles can filter out artifacts and better classify floral communities. This approach enhances the ability to monitor ecosystem health and resilience, providing a more comprehensive understanding of biodiversity dynamics.

The study underscores the importance of incorporating temporal dimensions in biodiversity indices, offering a significant improvement over static spatial analyses. Our contributions provide a valuable tool for environmental informatics, aiding in the accurate detection and description of ecosystem trends in response to environmental changes.