

BioSpace25 - Biodiversity insight from Space
10 - 14 February 2025 | ESA-ESRIN | Frascati - Italy



Spatiotemporal patterns of Amazonian canopy mortality revealed by remote sensing time series

Introduction



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- Recent studies suggests that the Amazon has gone from a carbon sink to a carbon source [1][2][3]
- Risk of nonlinear changes not well understood and could result in significant ecosystem and biodiversity loss.



Image credit: Pablo Sánchez Martínez

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[1] Gatti, L.V. *et al.* (2021) *Nature*.
[2] Basso, L. S *et al.* (2023). *ACP*.
[3] Harris *et al.* (2021) *Nature*.

- The AmazonSOS project [4]:
 - Consortium of Brazilian and UK researchers
 - Aim: Investigate the combined risk of climate change and deforestation to the integrity of Amazonian forests
- Why large canopy trees:
 - Easier to 'see'
 - Largest 1% of trees contain 50% of the biomass [5]
 - Little is known about what causes large tree mortality [6]
 - Large trees could be at an increased risk under climate change.



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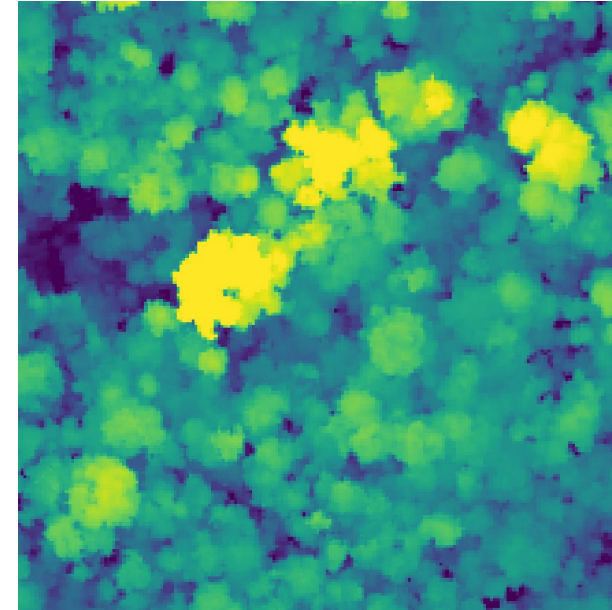
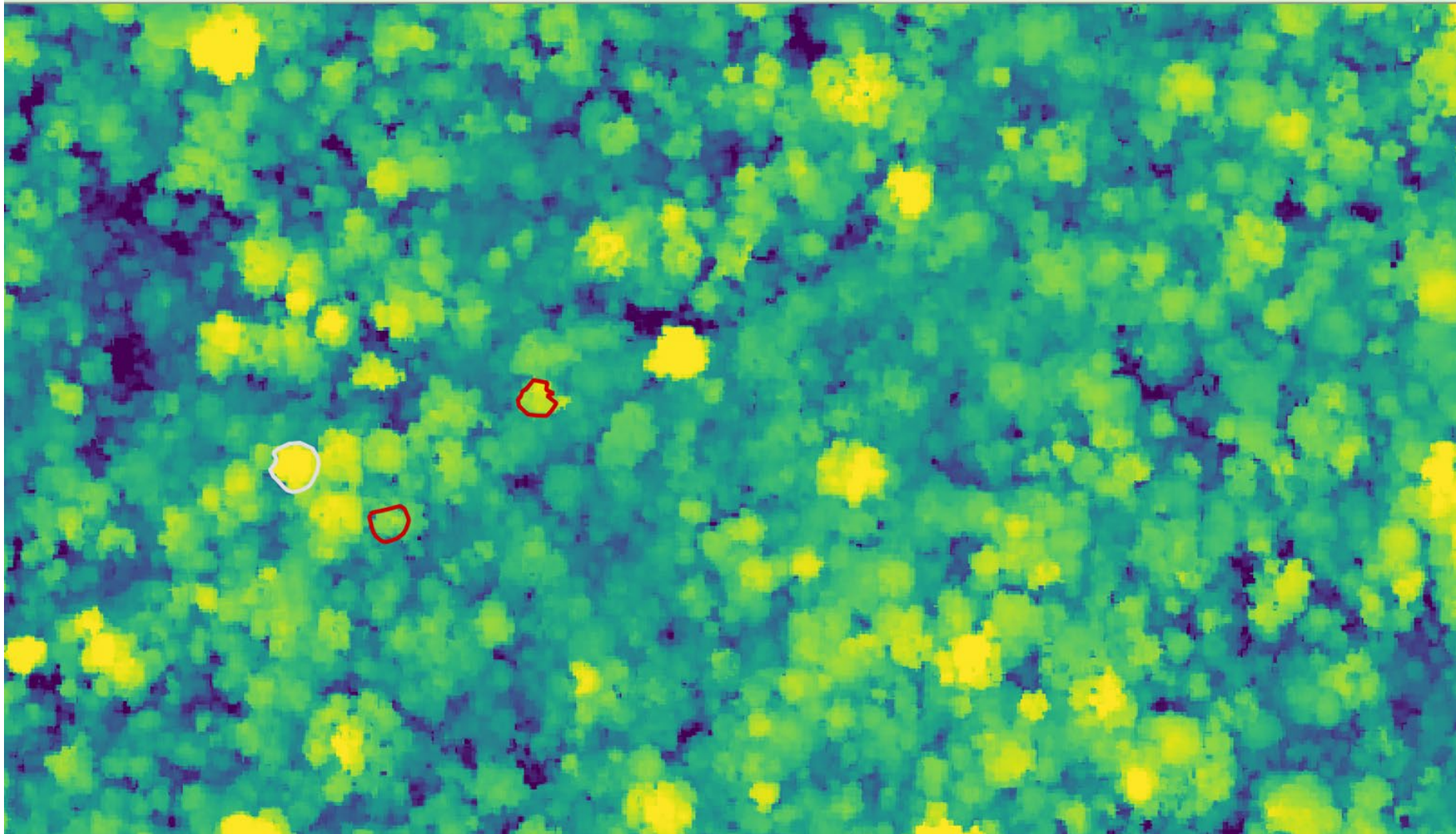
Natural
Environment
Research Council

[4] <https://csfl.ed.ac.uk/amazon-sos-nerc-large-grant-award-scientists-university-edinburgh>

[5] Lutz, J.A. et al. (2018). Glob. Ecol. Biogeogr.

[6] Gora E.M, and Esquivel-Muelbert A. (2021). Nat Plants.

Creating a large tree mortality database



dos-Santos, M.N., M.M. Keller, and D.C. Morton. 2019. LiDAR Surveys over Selected Forest Research Sites, Brazilian Amazon, 2008-2018. ORNL DAAC, Oak Ridge, Tennessee, USA.
<https://doi.org/10.3334/ORNLDAAC/1644>



Modes of death (simplified)



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Standing dead



Uprooted



Broken



These images were created with the assistance of DALL·E 2 5



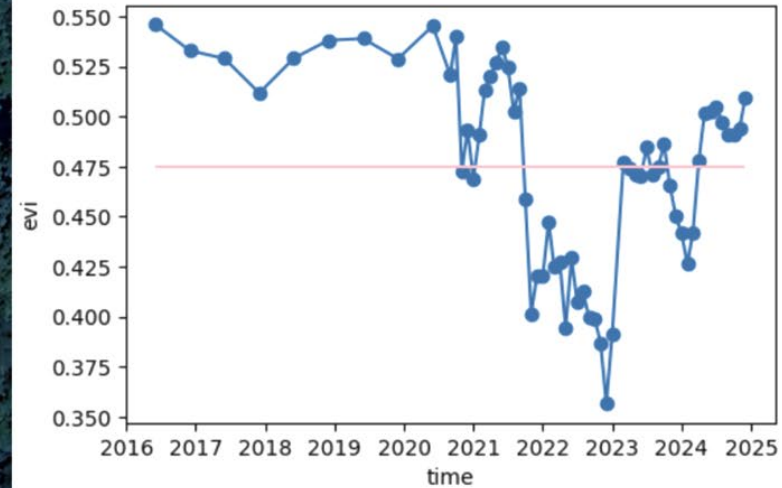
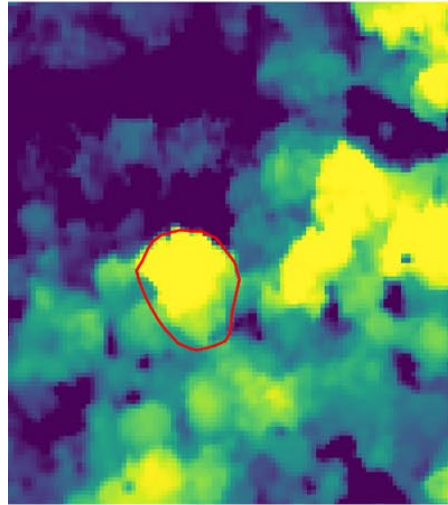
Creating a large tree mortality database



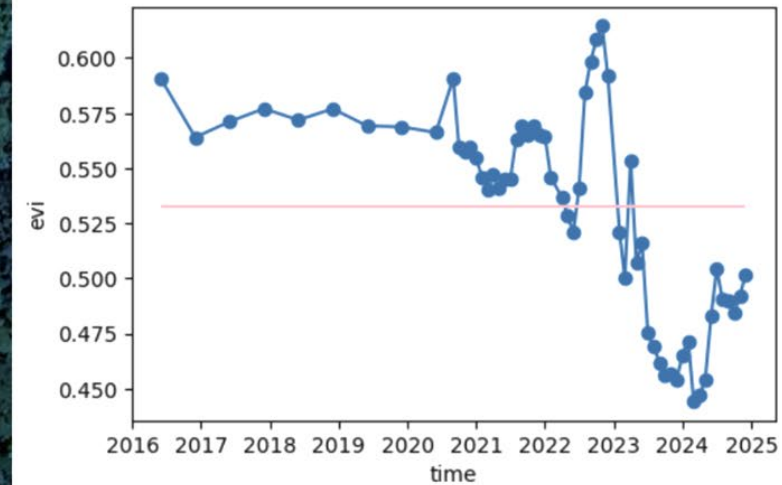
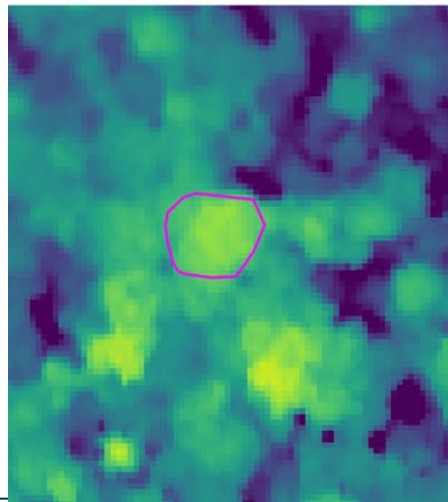
ALS canopy height
(2017)

High resolution imagery
(2024)

Planet NICFI EVI time series



Broken / Uprooted



Standing

~1500
annotated
events

Image data: Google maps
(2024)

Time series data ©2015-
2025 Planet Labs
Inc., made available
under the NICFI program



Detecting canopy mortality



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(BASELINE) Algorithm based on 2 hypothesis:



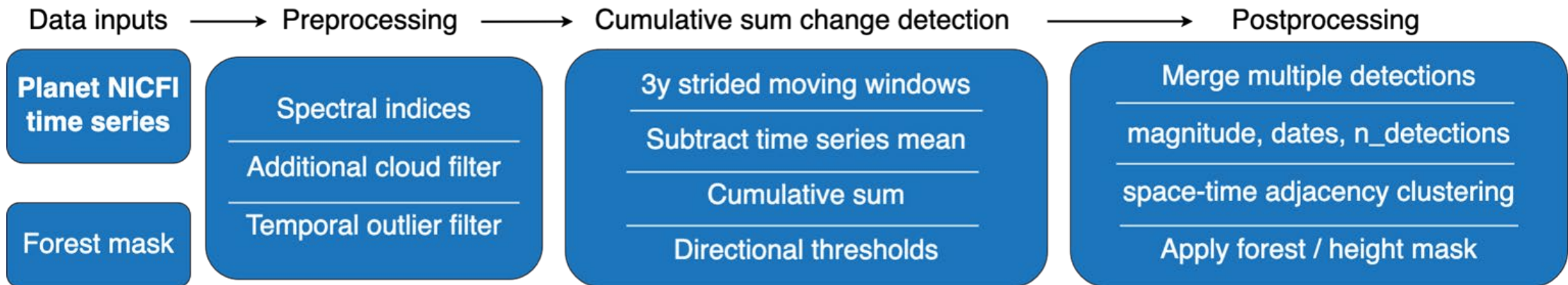
Decrease in VIs

Increase in red reflectance



Decrease in VIs

decrease in red reflectance

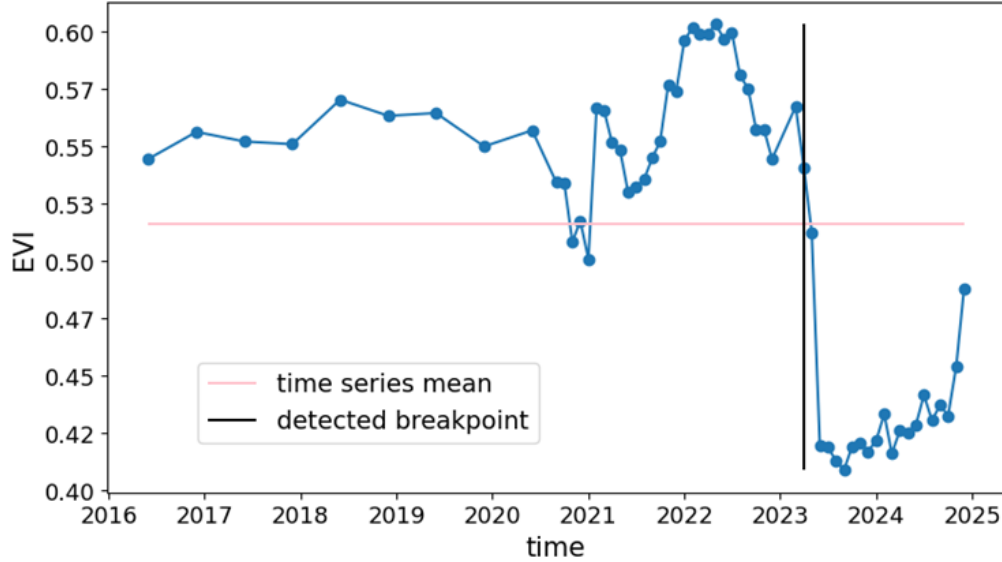


Detecting canopy mortality

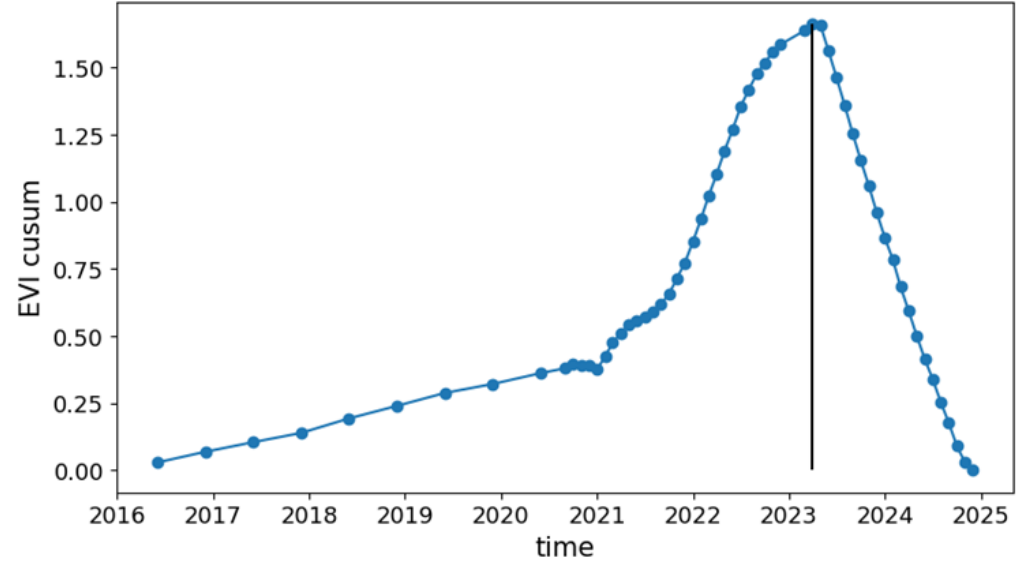


BAS

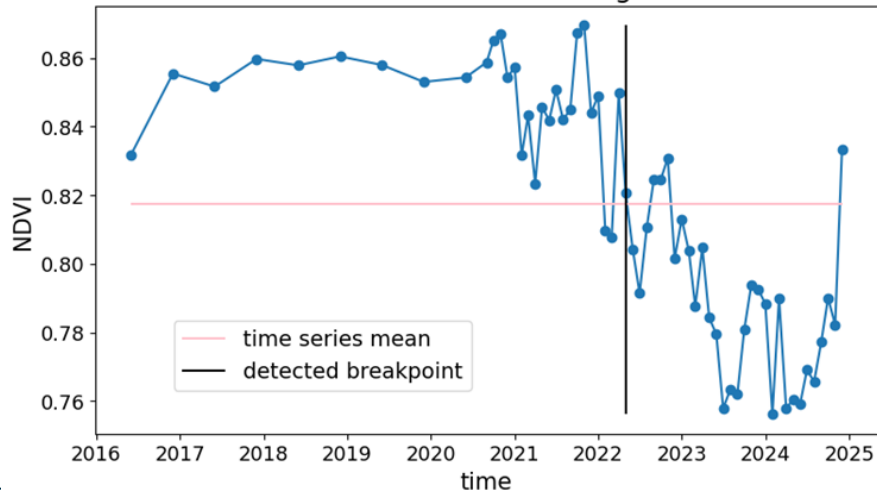
EVI time series for a broken / uprooted tree



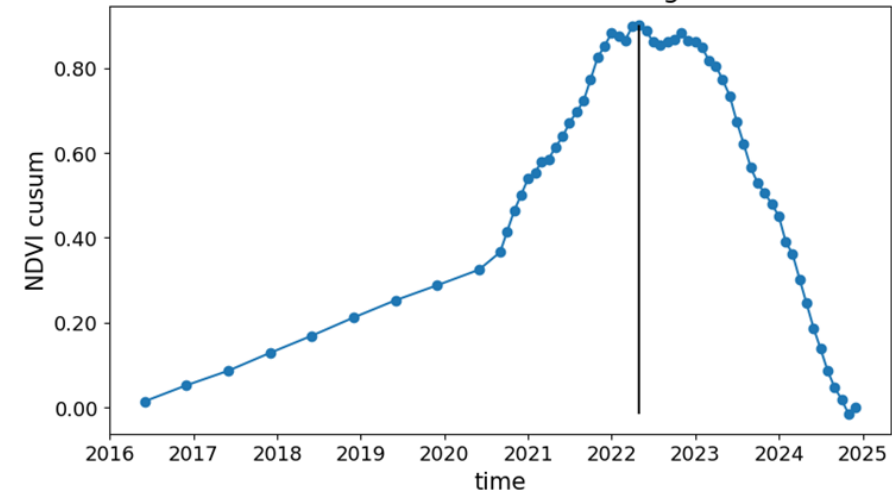
EVI cumulative sum for a broken / uprooted tree



NDVI time series for a standing dead tree



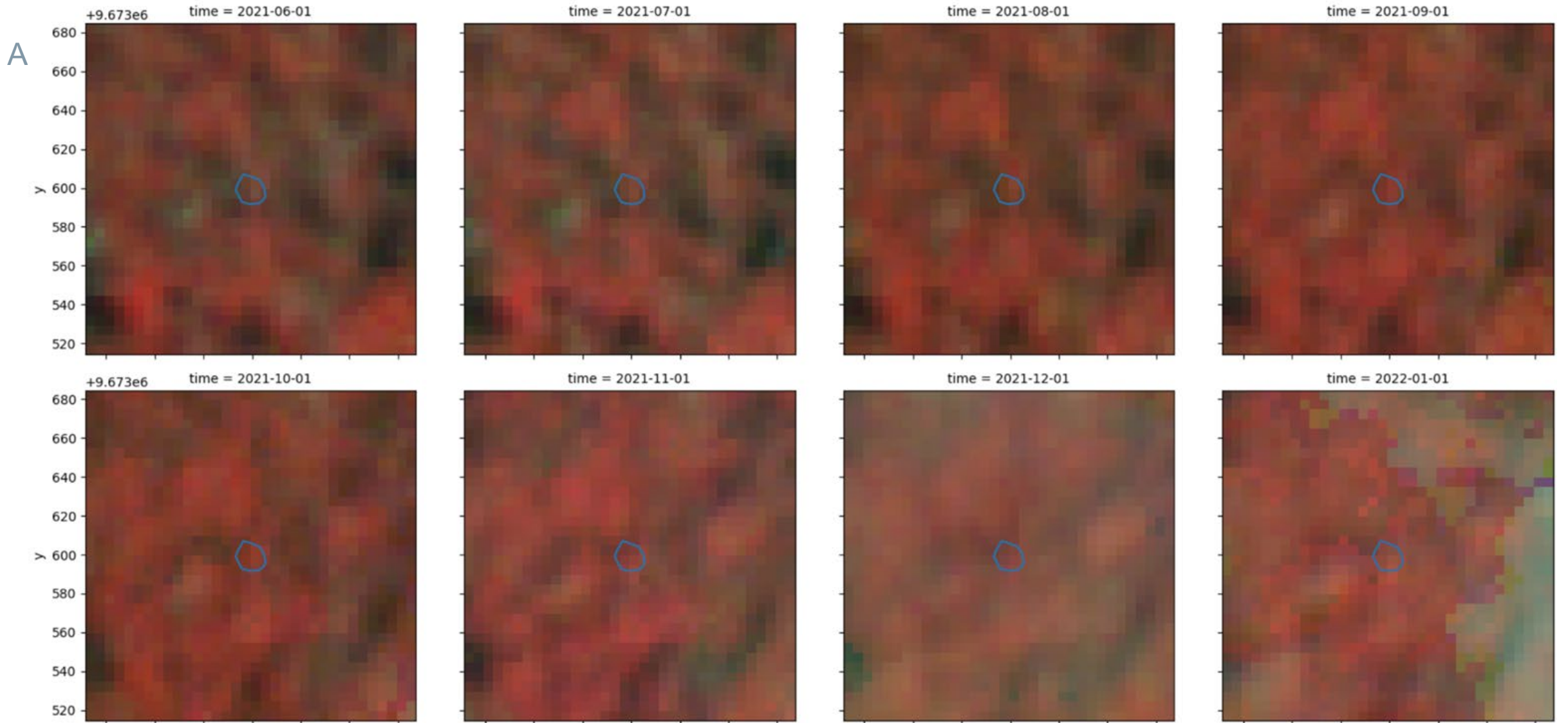
NDVI cumulative sum for a standing dead tree



Canopy tree mortality in NICFI data



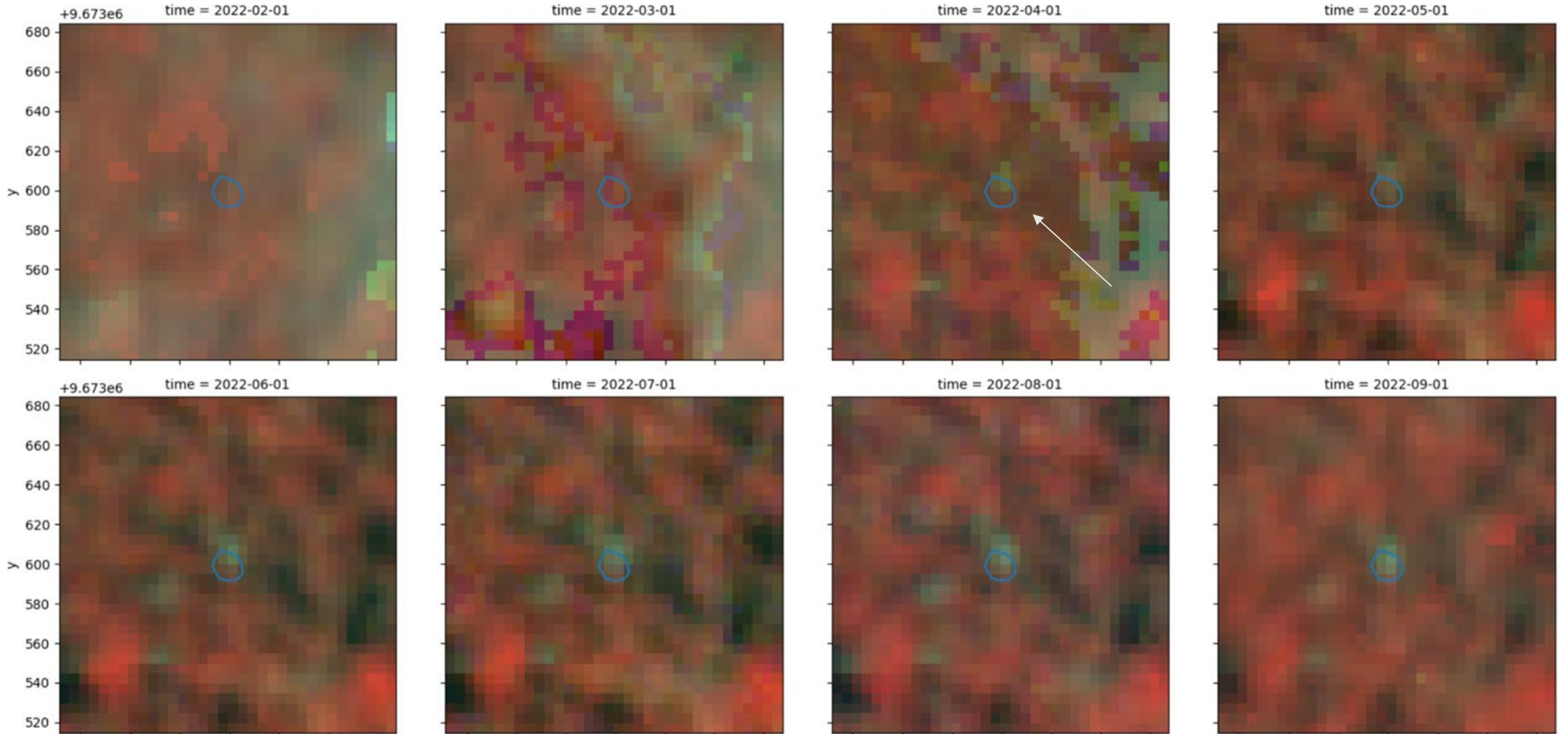
Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Canopy tree mortality in NICFI data



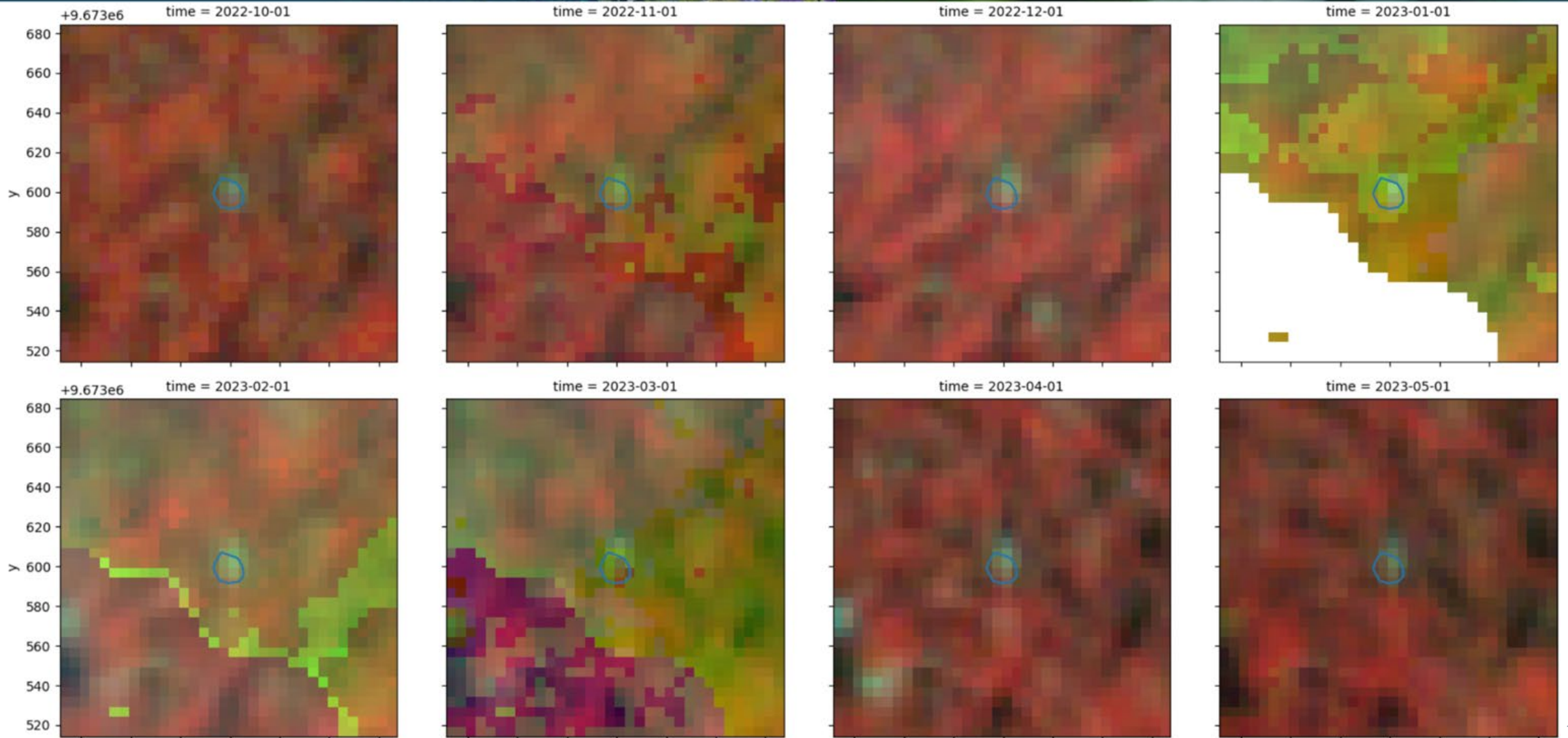
Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Canopy tree mortality in NICFI data



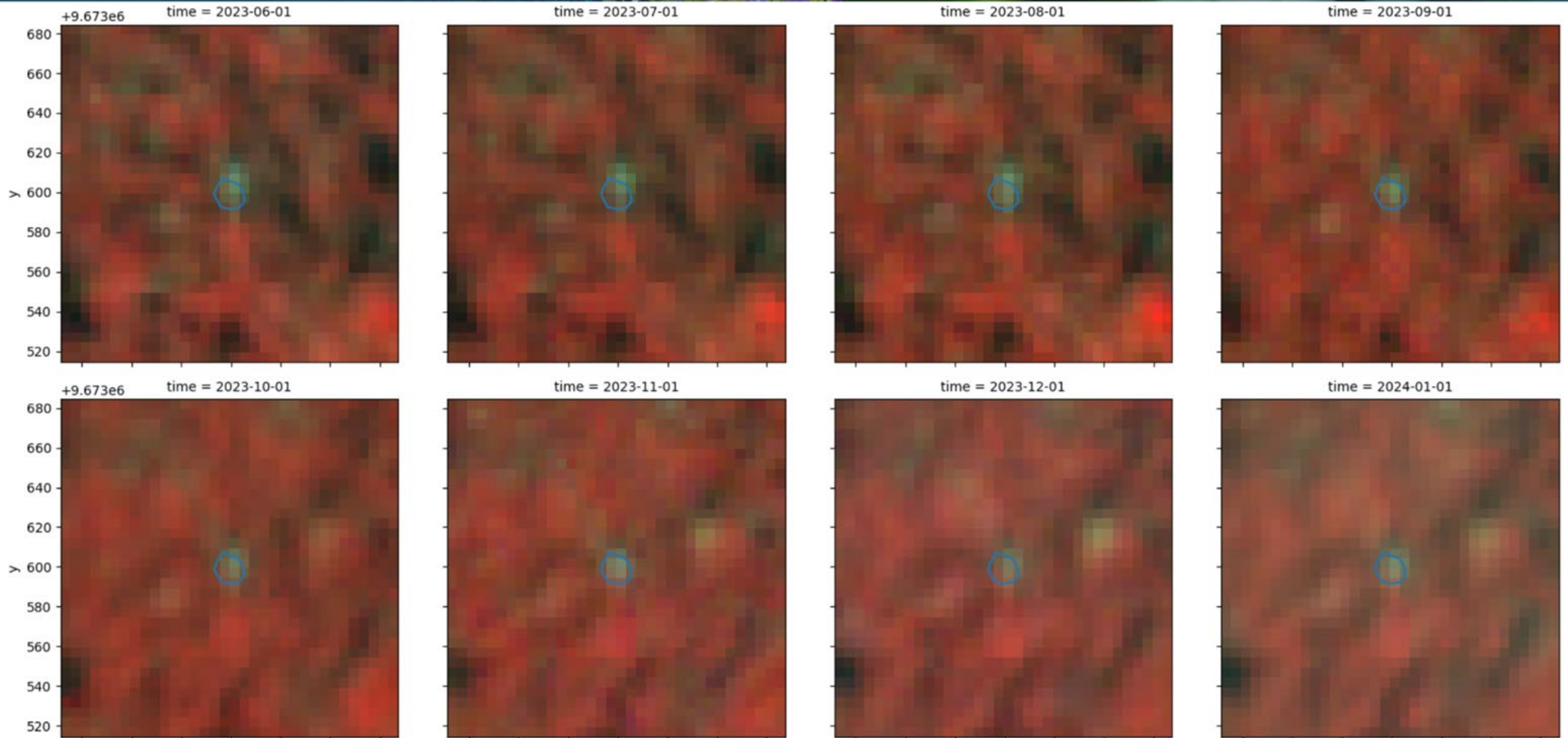
Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Canopy tree mortality in NICFI data



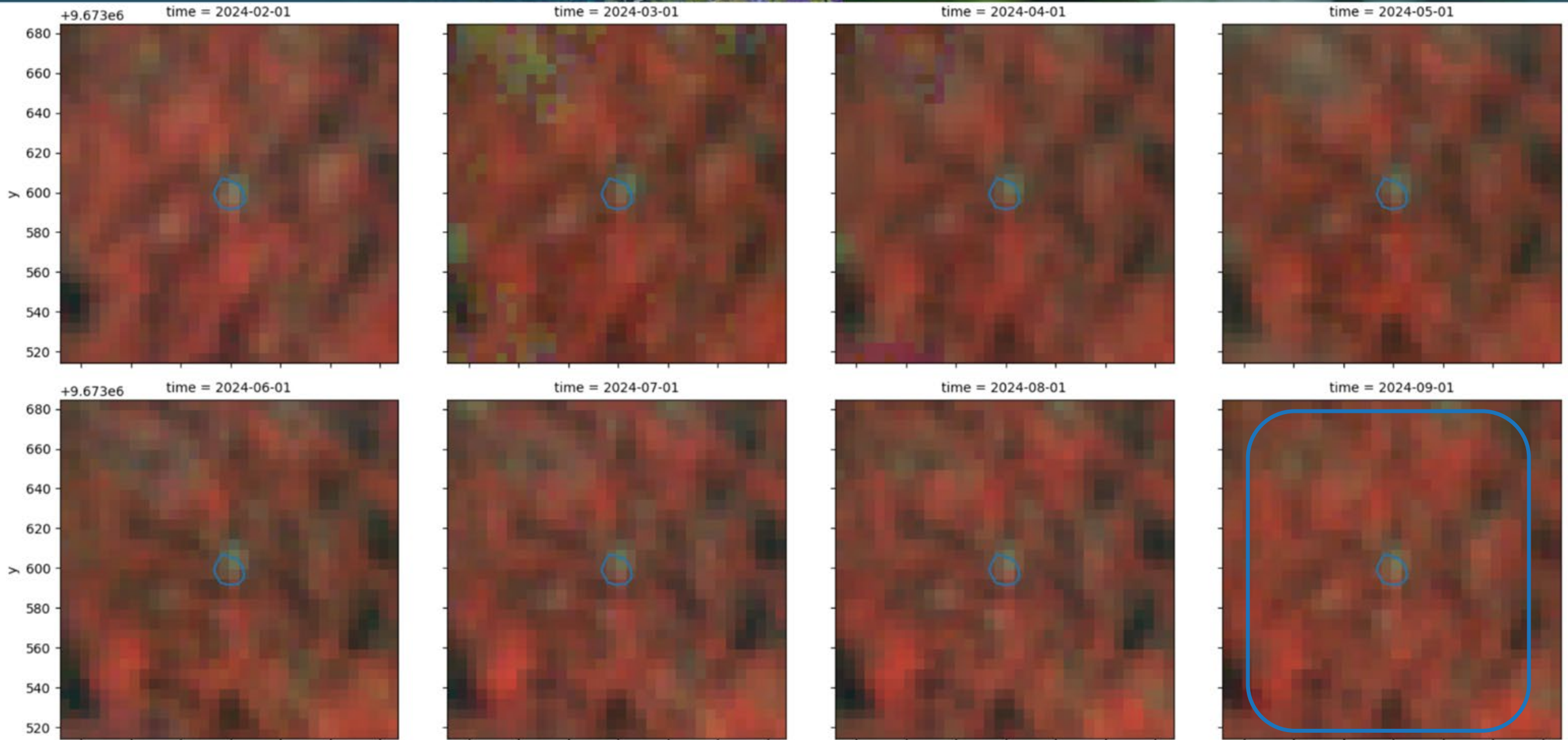
Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Canopy tree mortality in NICFI data



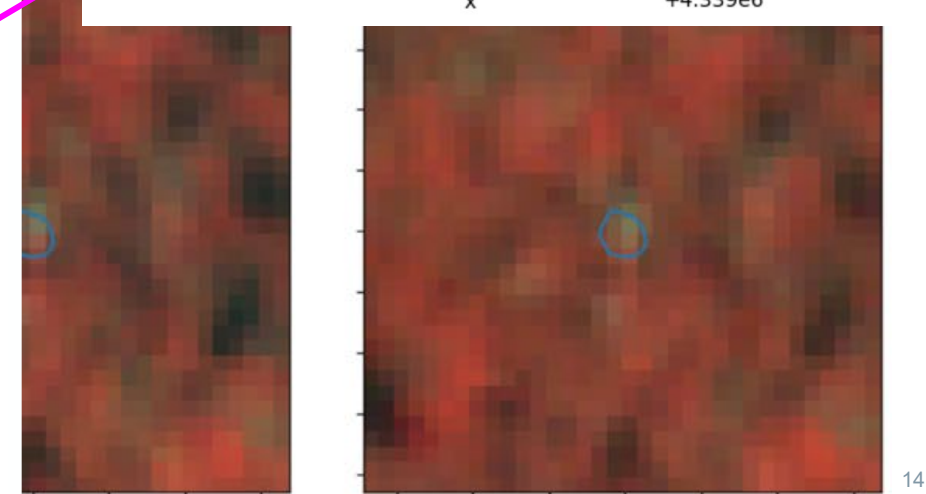
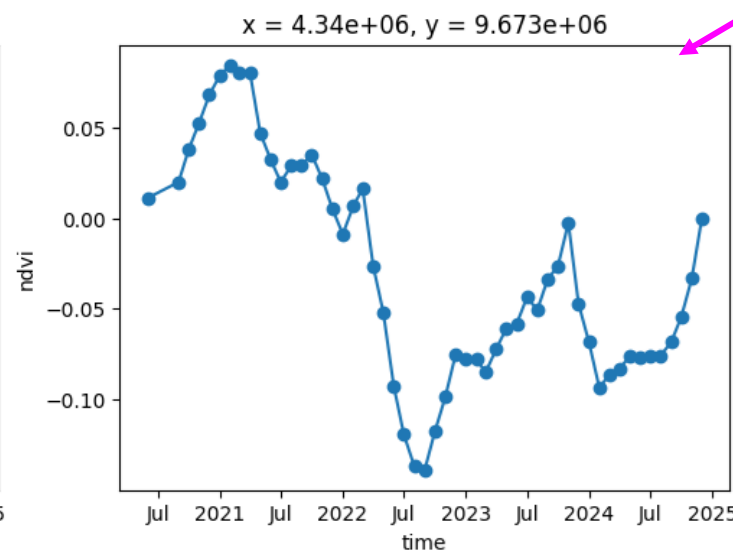
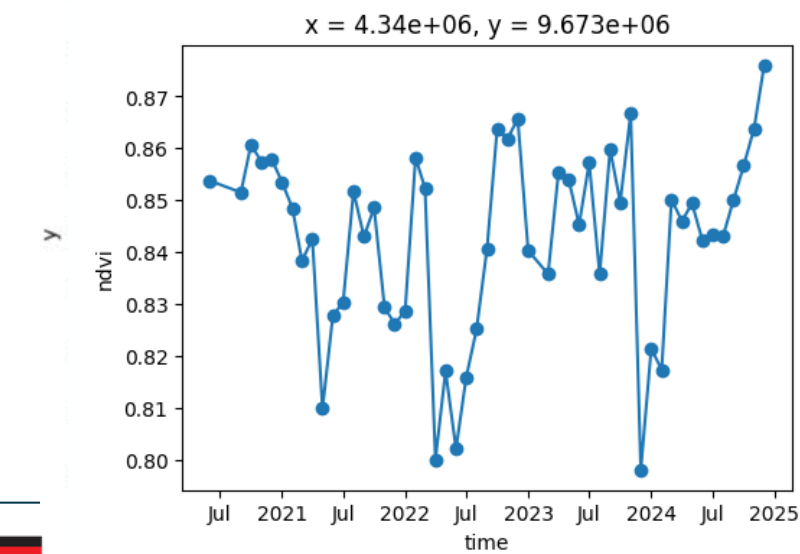
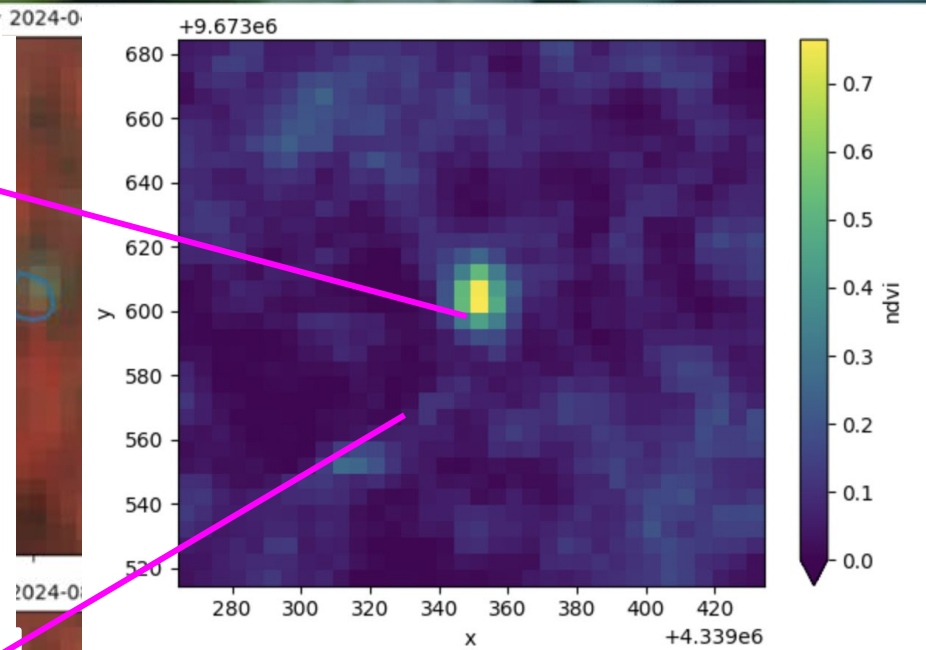
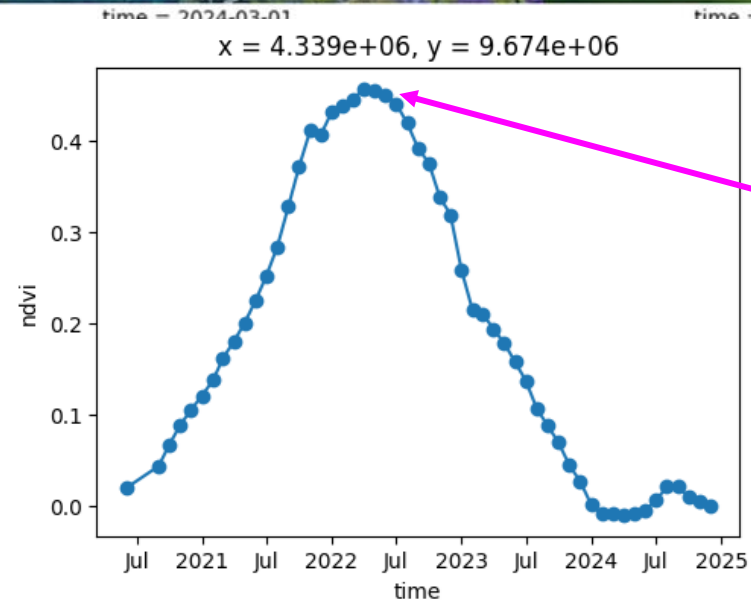
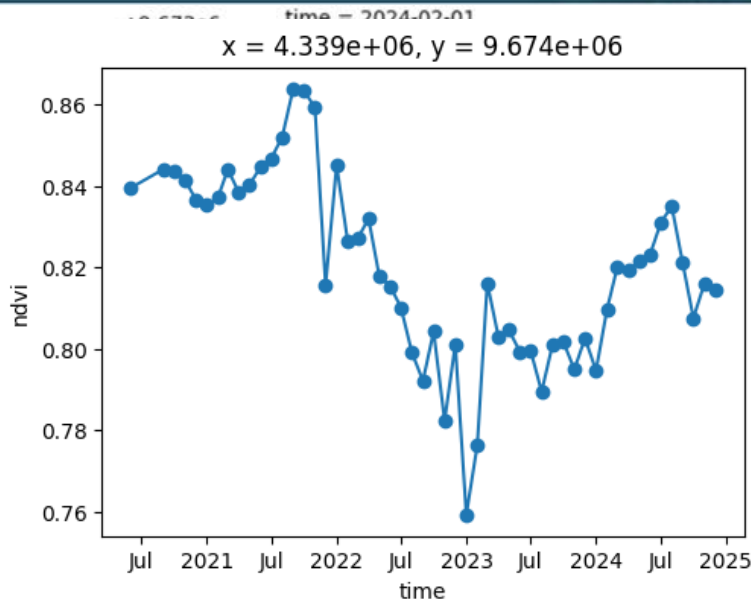
Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Canopy tree mortality in NICFI data



Image data ©2015-2025 Planet Labs Inc., made available under the NICFI program



Results



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Image data: Google maps (2023)

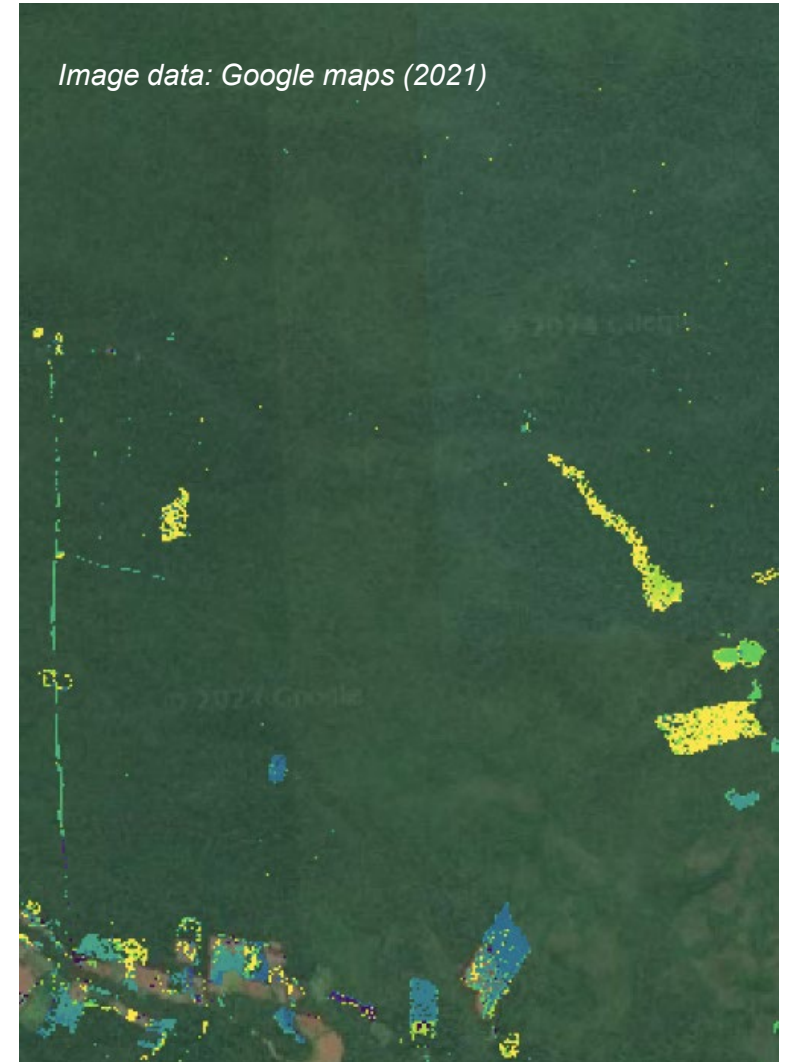
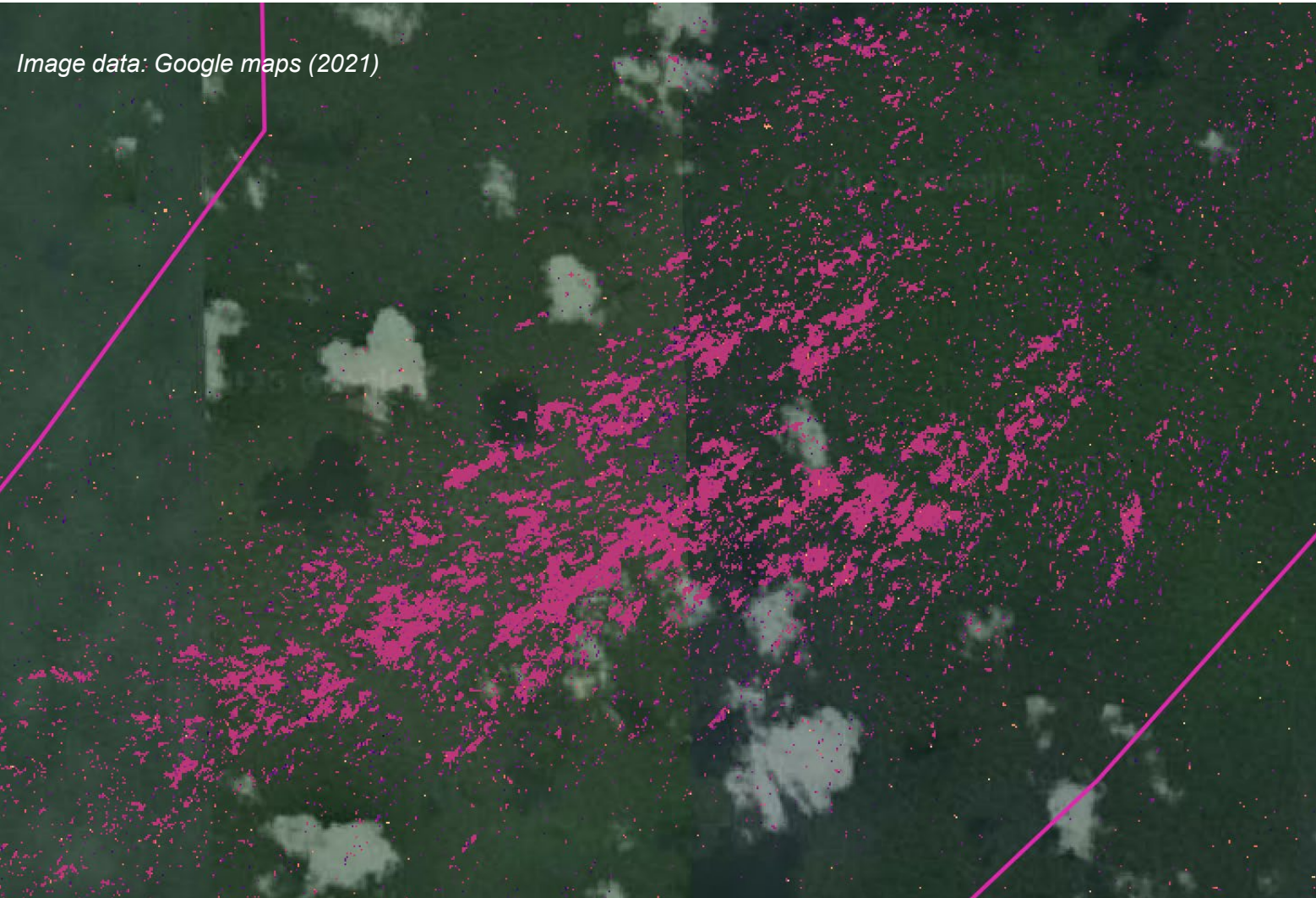


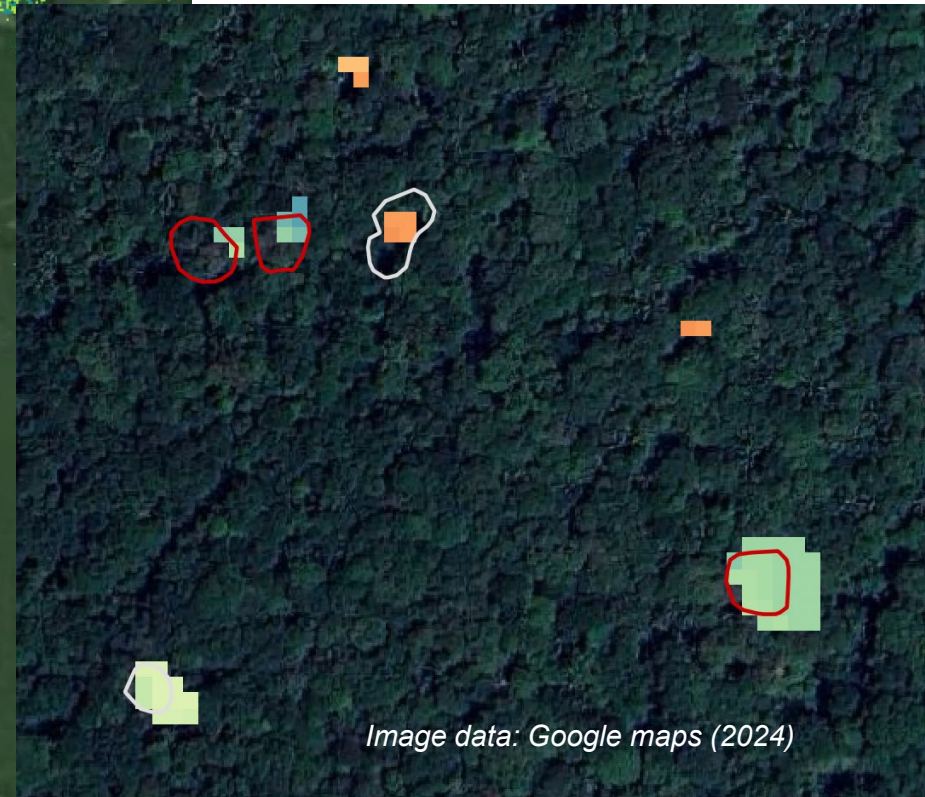
Results



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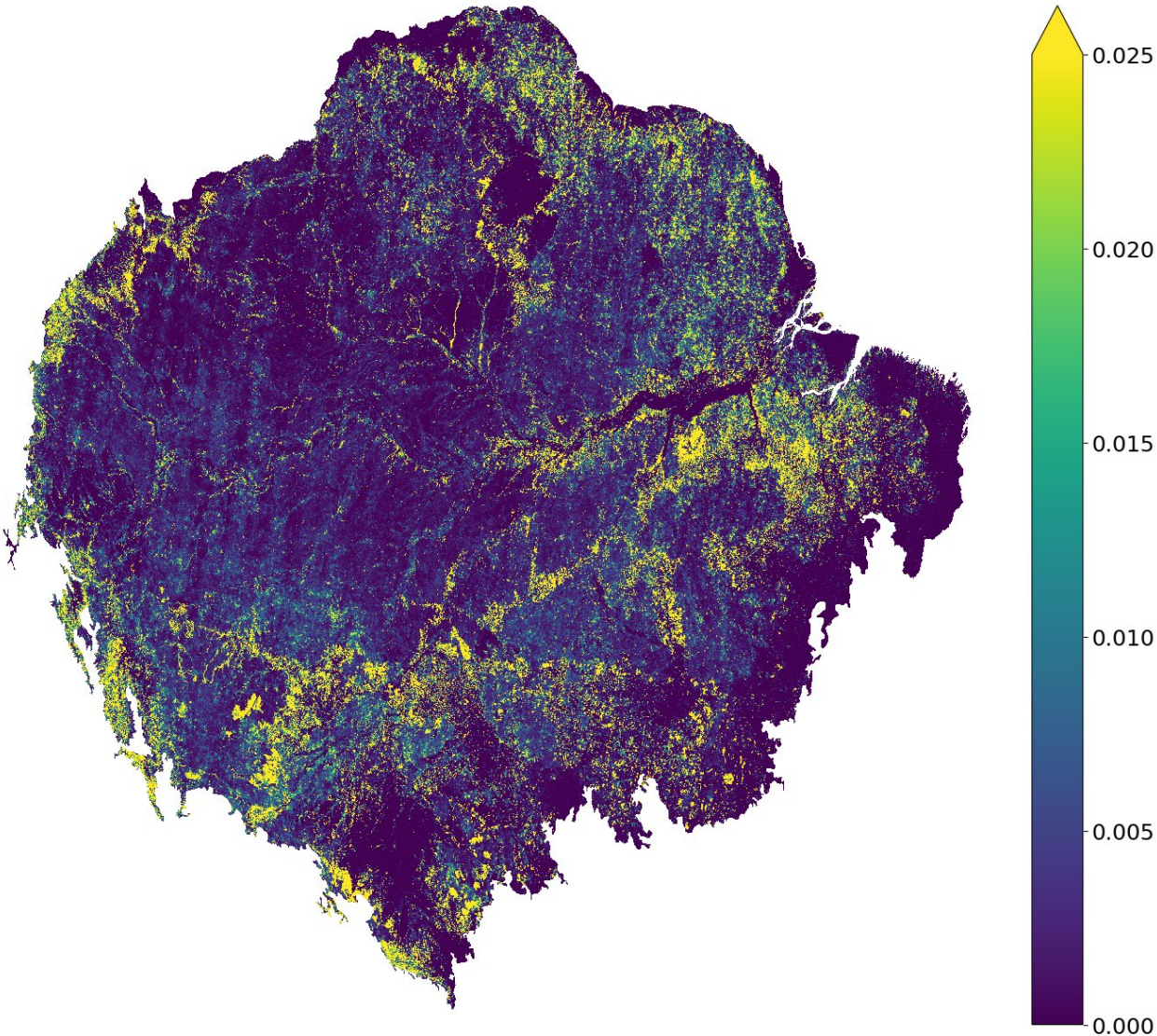




Canopy mortality map



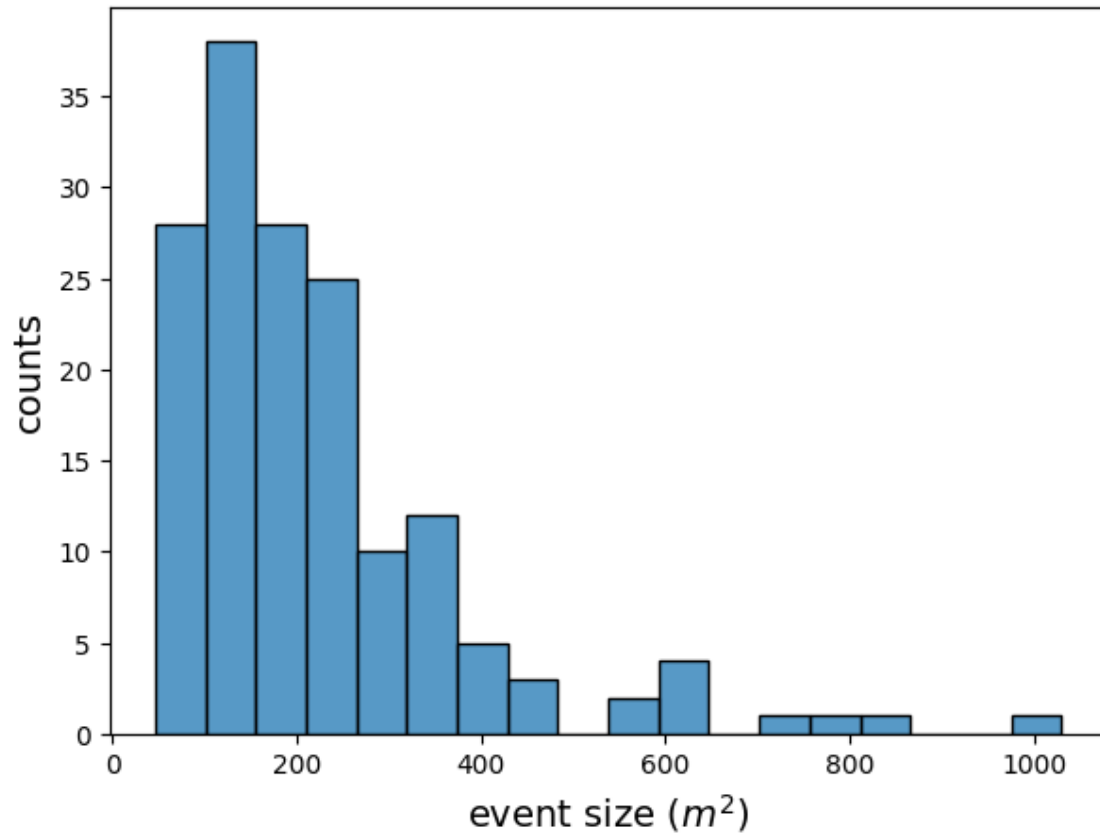
Proportion of 5m pixels with a mortality indicator detection in a 1km² grid.



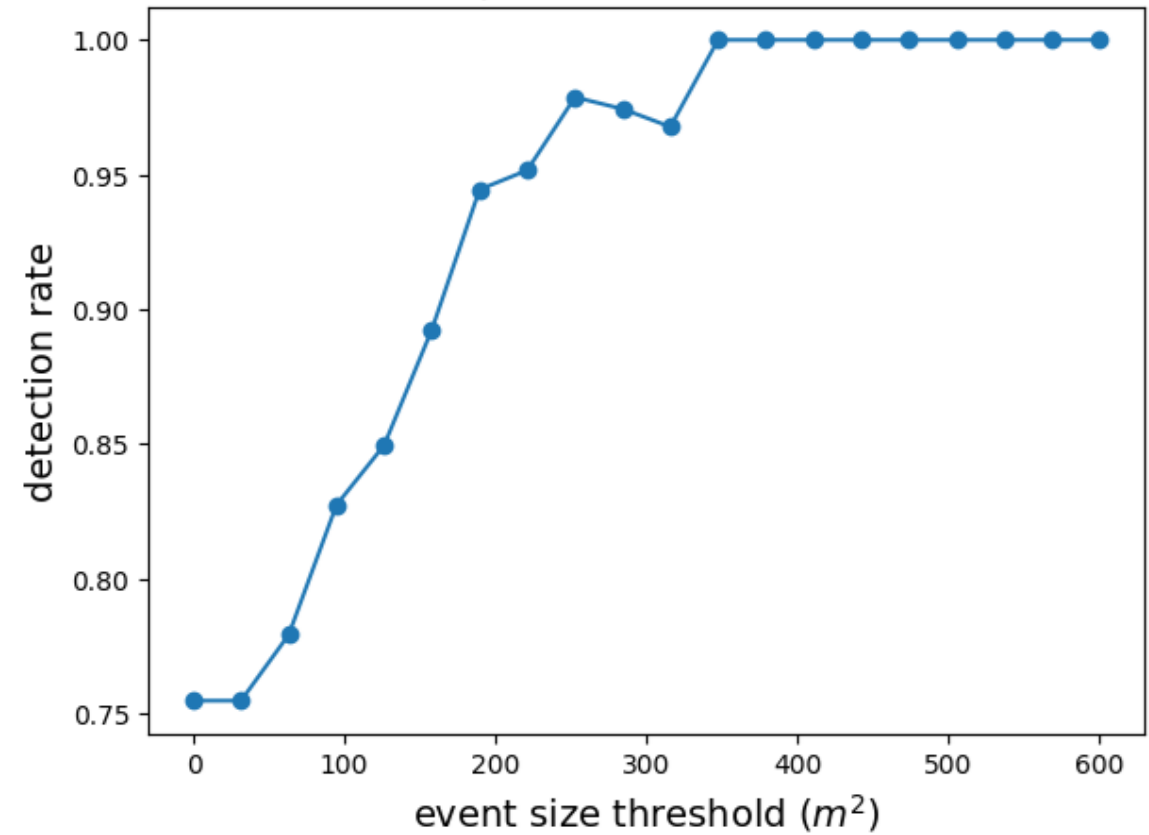
(Very) Preliminary validation



event size distribution in Ducke



size-dependent detection rate



- Algorithmic and data pipeline improvements
 - Enhance quality masking
 - Change-in-slope methods
- Full validation with ALS, photogrammetry, and field data products
- Geographic performance assessment
- Generate products according to user's requirements (e.g. modellers)
- Decompose modes of death and causality attribution

Results

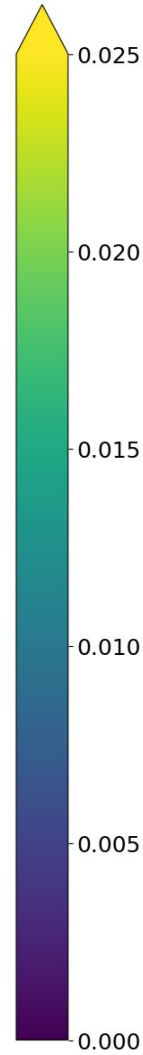
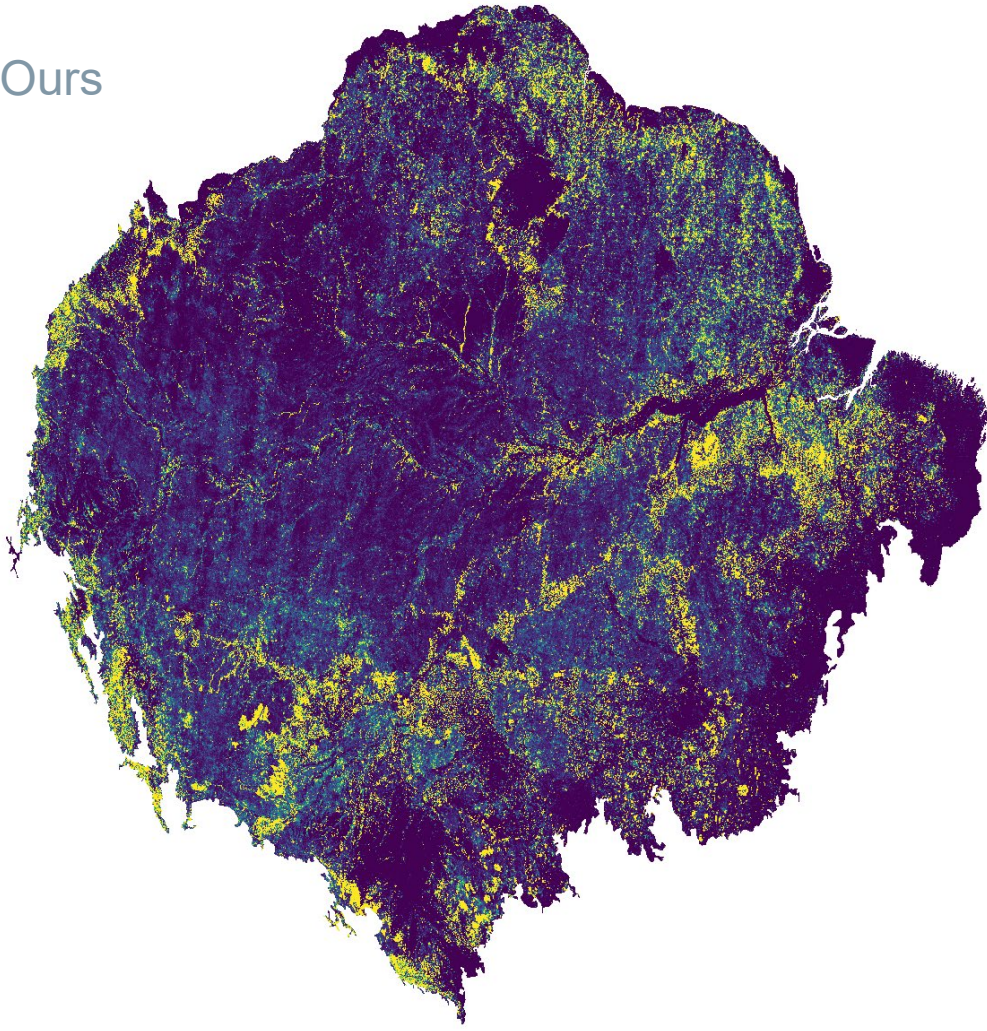


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