



Impact of Amazon Deforestation on ASCAT Backscatter



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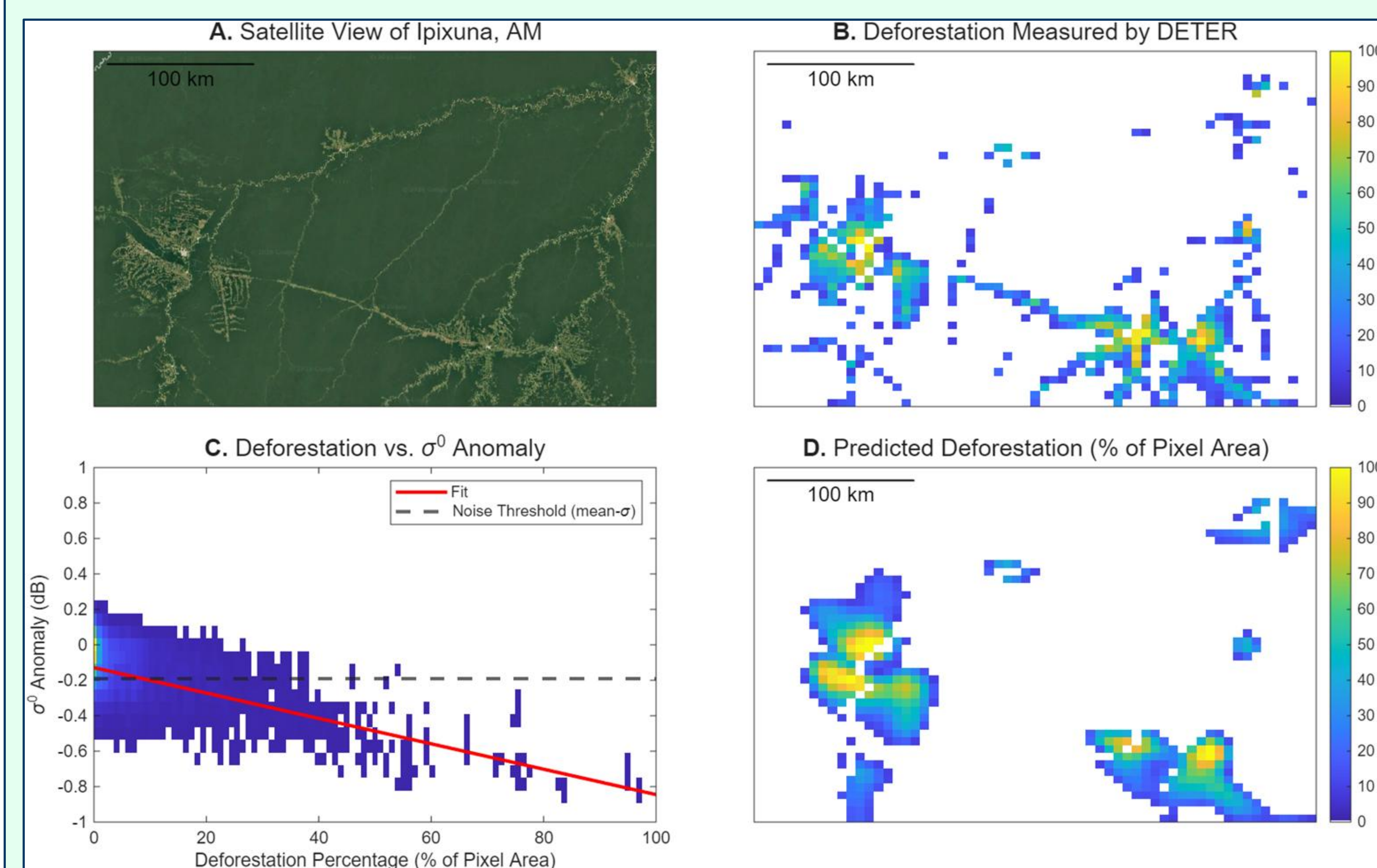
Abstract

The Amazon rainforest is a well-established reference for the calibration of scatterometer sensors¹. Its equatorial location and stable, largely isotropic scattering characteristics make it useful for a wide variety of sensors. However, the Amazon is under increasing threat from both natural and human-driven landscape degradation. Scatterometer research efforts may benefit from a self-contained method of identifying disturbances in Amazon calibration areas. This methodology provides a quantitative approach for identifying and measuring Amazon deforestation using solely enhanced-resolution C-band σ^0 data.

Methodology

Deforestation areas from PRODES and DETER, the complementary monitoring programs maintained by the Brazilian National Institute for Space Research (INPE), are compared to ASCAT UHR backscatter data over the Amazon basin. To account for seasonal variation and other sources of variation in backscatter, undisturbed reference zones are established near known pockets of deforestation. These reference zones are established in each of the Köppen climate zones present in the Amazon basin: tropical rainforest (Af), tropical monsoon (Am), and tropical savanna (Aw).

The σ^0 anomaly value is calculated each month for all known deforested pixels. Then a linear regression is formed and applied to ASCAT UHR data to predict deforestation concentration and distribution. The predicted distribution and total area of deforestation are compared to real-world data to validate estimates and evaluate spatial correlation.



The study area surrounding Ipixuna, Amazonas (A) includes both large- and small-scale deforestation features (B). When compared to nearby protected jungle, deforested pixels show a marked decrease in backscatter value (C). Though substantially smoothed from ground truth data, large areas of deforestation are observable using this predictive method (D), effectively creating “hotspots” around major deforestation. The prediction above comes within 7.3% of actual deforestation area and has a correlation of 0.759 to in situ data.

Results

Predictions in the reference zones show significant correlation to measured deforestation, especially surrounding urban development and agriculture. At a small scale, the impact of deforestation on ASCAT backscatter data is not readily apparent, likely due to the coarse nominal resolution of the sensor.

The strength of correlation between predicted and actual deforestation is shown by 2D cross-correlation coefficients. Predictions for monsoon (Am) and savanna (Aw) climate zones are strongest at 0.833 and 0.632, respectively. Rainforest climates (Af) exhibit a weaker correlation under the same methodology, as low as 0.557.

Area estimates follow a similar trend, predicting within 4.5% of actual deforestation area in the savanna reference zone and 15.3% in the savanna. Again, the rainforest region exhibits the weakest predictive ability, with an overestimate of 24.2%.

When the reference zone prediction model is applied to their corresponding climate zone, the reliability of predictions decreases substantially, likely due to local climatic variations.

The ability to highlight deforestation is influenced by proximity to bodies of water and by time of year. The presence of rivers or lakes within a pixel decreases its brightness substantially, causing the regression to predict significant deforestation. To counteract this effect, a mask is used to disregard pixels with water in them. Additionally, there is a measurable difference in behavior between the wet and dry season. The baseline brightness of reference areas decreases and the decrease from deforestation is greater during the dry season, necessitating separation between data from each season. This is due to both increased rainfall and flooding during the wet season.

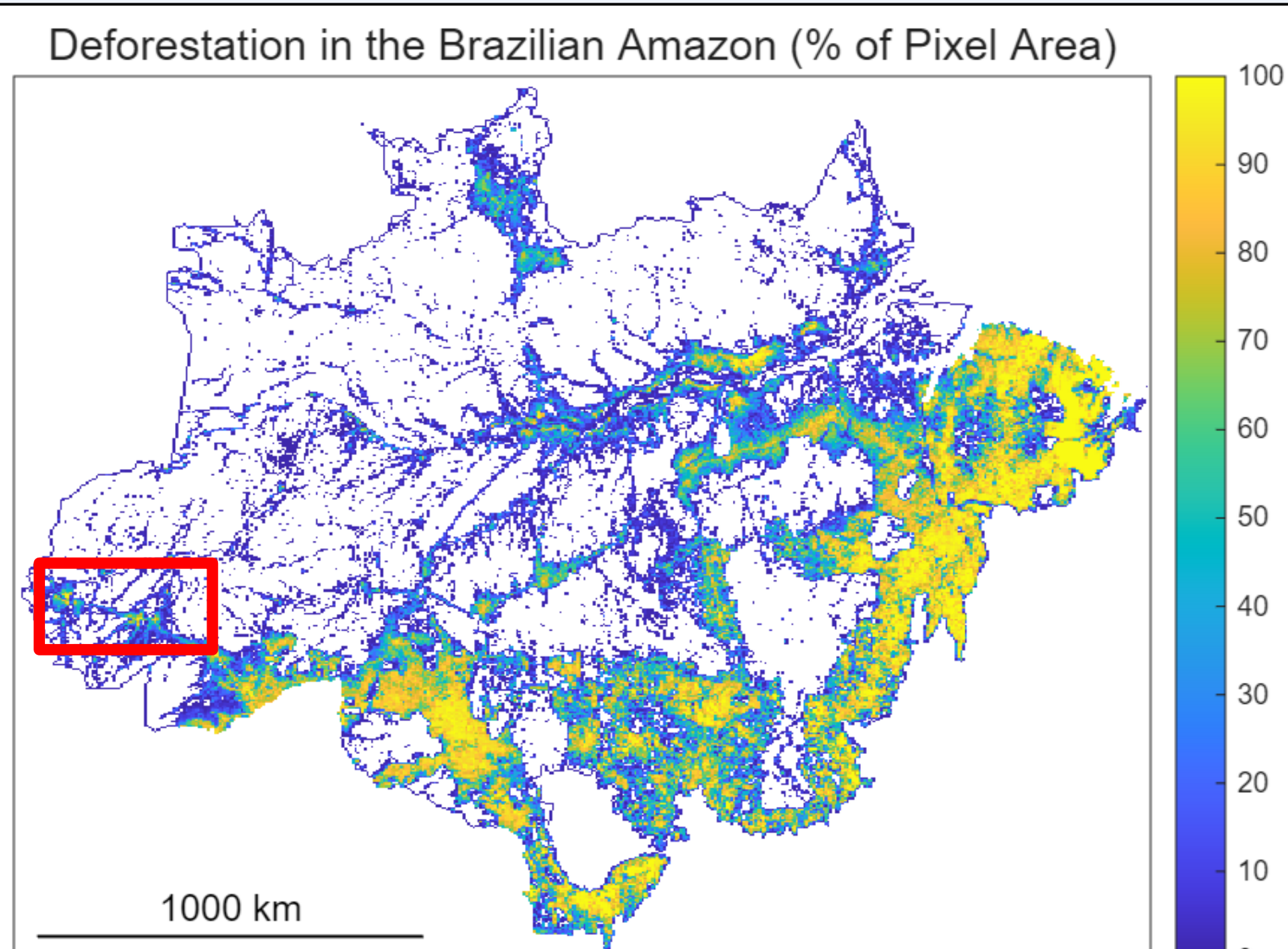
Conclusion

While it is certainly not the first attempt at measuring deforestation, this methodology is unique for relying solely on microwave scatterometer data to do so. With a rough knowledge of climate and hydrography, the location and amount of deforestation can be predicted with reasonable confidence without relying on optical imagery. The results may also be used for detection purposes to quickly highlight probable pockets of disturbance in a calibration area that may require reevaluation.

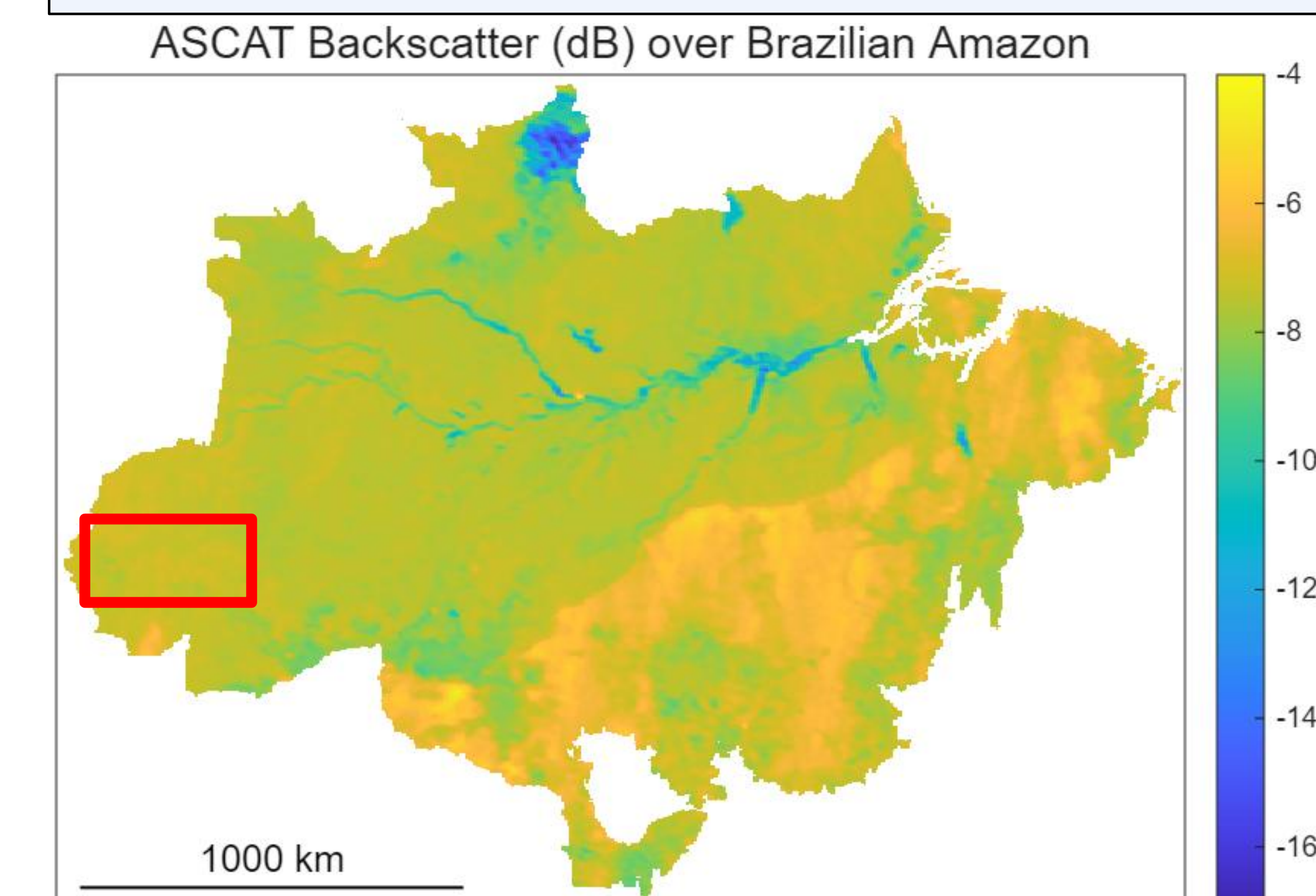
Because it requires minimal input data beyond high-resolution σ^0 measurements, this approach can be applied to similar tropical regions of the world. While detailed records of land use over several decades exist for the Amazon rainforest, efforts to track other rainforests and savannas stand to benefit from scatterometer-based vegetation mapping. With targeted analysis, maps of deforestation in the Congo, Indonesia, and Madagascar may also be augmented using available C-band scatterometer data.

Changes in vegetation can also be measured over time using a series of backscatter measurements. This represents a novel application of scatterometer data that extends existing landscape classification capabilities to the problem of deforestation, opening the possibility of mapping tropical deforestation over the span of available ERS and ASCAT data.

1. Long, David G., and Gary B. Skouson. "Calibration of spaceborne scatterometers using the Amazon tropical rainforest." *Microwave Instrumentation for Remote Sensing of the Earth*. Vol. 1935. SPIE, 1993.
2. Shimabukuro, Yosio Edemir, et al. "The Brazilian Amazon monitoring program: PRODES and DETER projects." *Global forest monitoring from earth observation*. Vol. 2012. Boca Raton, FL: CRC Press, 2012. 153-169.



Accumulated deforestation up to July 2023 within INPE Amazon boundaries. Study area highlighted in red.



Brazilian Amazon rainforest C-band σ^0 measurements at 40° incidence angle taken July 2023. The red rectangle highlights the study region in the figure above.