Idai damage assessment from the Sentinel-1 radar satellite

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About Idai

- In the Southern Hemisphere Idai ranks as the second-deadliest tropical cyclone on record.
- On 14 March, Idai reached its peak intensity, with maximum sustained winds of 195 km/h (120 mph)
- On 15 March, Idai made landfall near Beira, Mozambique
- Total damages across Mozambique, Zimbabwe, Madagascar, and Malawi is estimated to $2.2 billion (2019)
- Idai caused severe flooding in Madagascar, Mozambique, Malawi, and Zimbabwe, killed at least 1,303 people + affected more than 3 million others.

from https://en.wikipedia.org/wiki/Cyclone_Idai

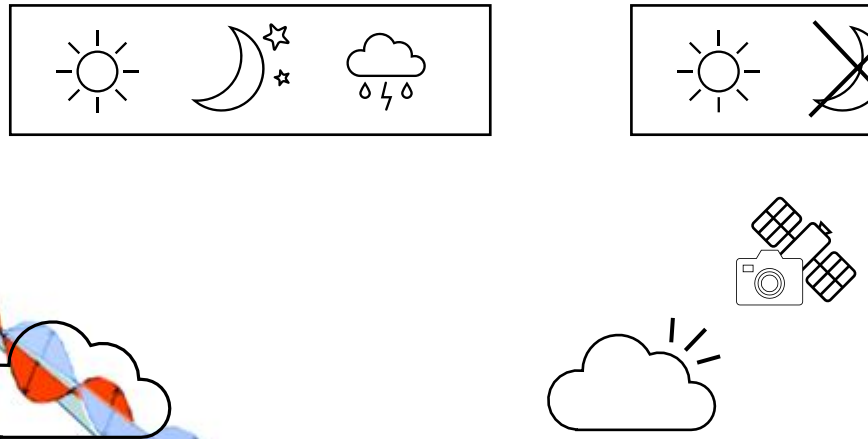
Goal

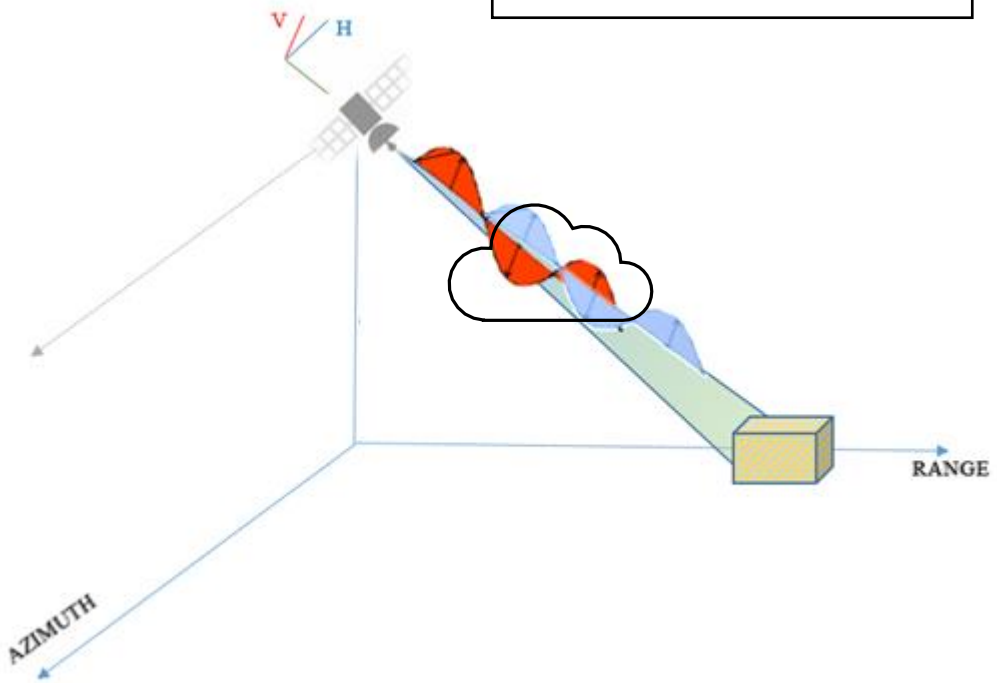
- Investigate the potential of Radar Satellite data in urban cyclone damage assessment. *Data source: ESA's Sentinel-1 Synthetic Aperture Radar (SAR) satellite.*
- Make damage assessment faster with automized image analysis.

- Manual analyzed satellite image-based damage assessment maps were not available of the full city until 3 weeks after the cyclone impact.
- How does radar damage assessment compare to manual assessments.

Satellites Images from Radar vs. Camera

Radar **Camera**





- Radar can
  - look through clouds
  - Record in all weather, day and night.
- Camera has,
  - Typical higher resolution
  - Visually easy to interpret

Illustration from: *https://www.capellaspace.com/sar-101-an-introduction-to-synthetic-aperture-radar/*

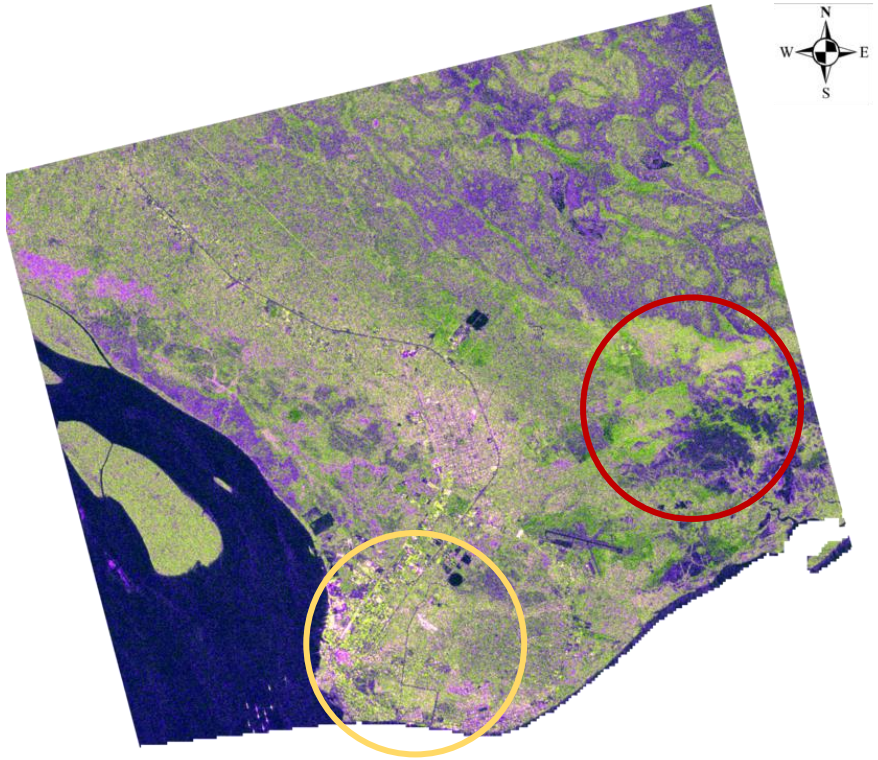
Satellites Images from Radar vs. Camera

Radar **Camera**

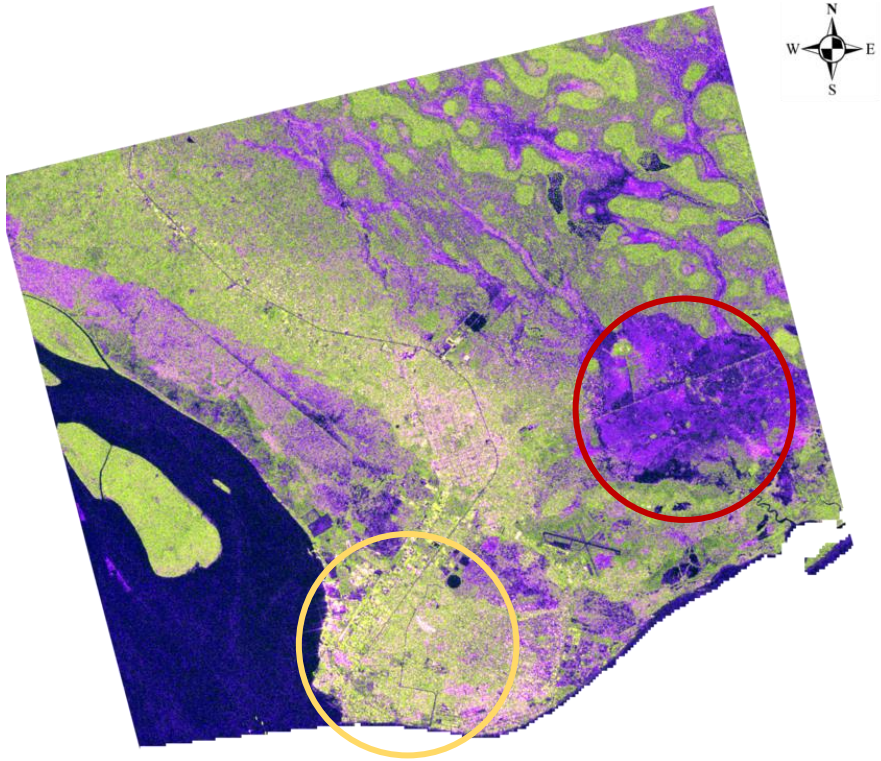
Radar images of Idai

Artificial Color Radar images of Beira, MZ

Before Idai



After Idai



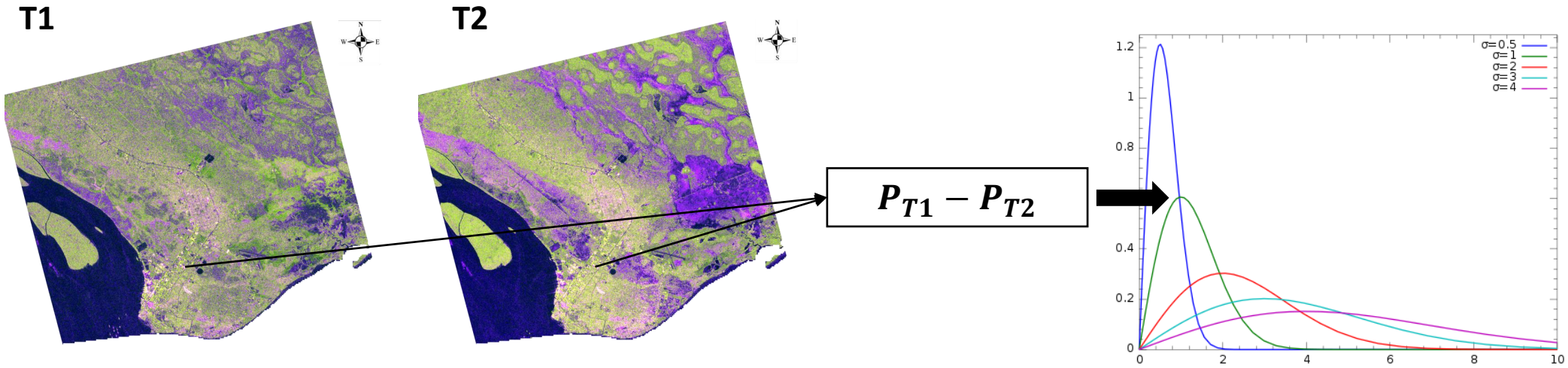
Flooding is very easy to see in Radar images.

Urban areas are complex to interpret in Radar images.

Method: Change Detection over Time

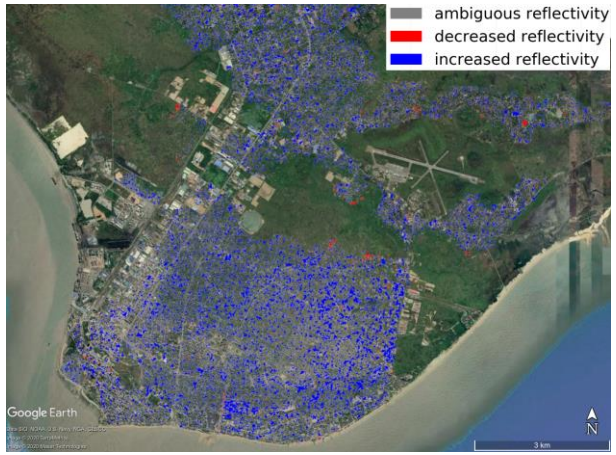
$$P{-}2\rho \ln Q \leq z \simeq P\chi^2(p^2) \leq z + \omega_2[P\chi^2(p^2+4) \leq z - P\chi^2(p^2) \leq z],$$

Conradsen, K.; Nielsen, A.A.; Schou, J.; Skriver, H. A test statistic in the complex Wishart distribution and its application to change detection in polarimetric SAR data. *IEEE Trans. Geosci. Remote Sens.* **2003**, *41*, 4–19.

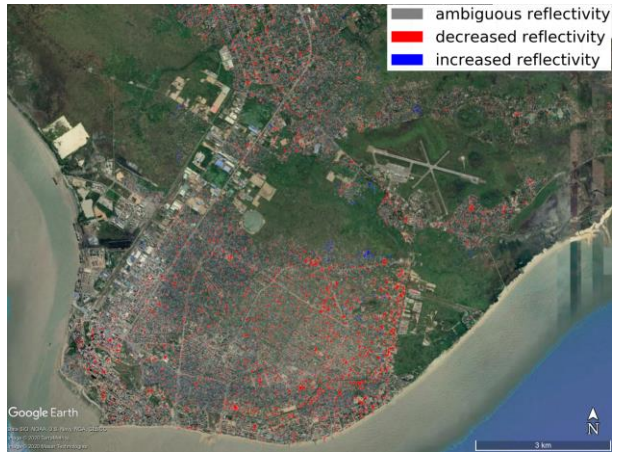


Results – Change Maps

02 Mar–14 Mar



14 Mar–20 Mar

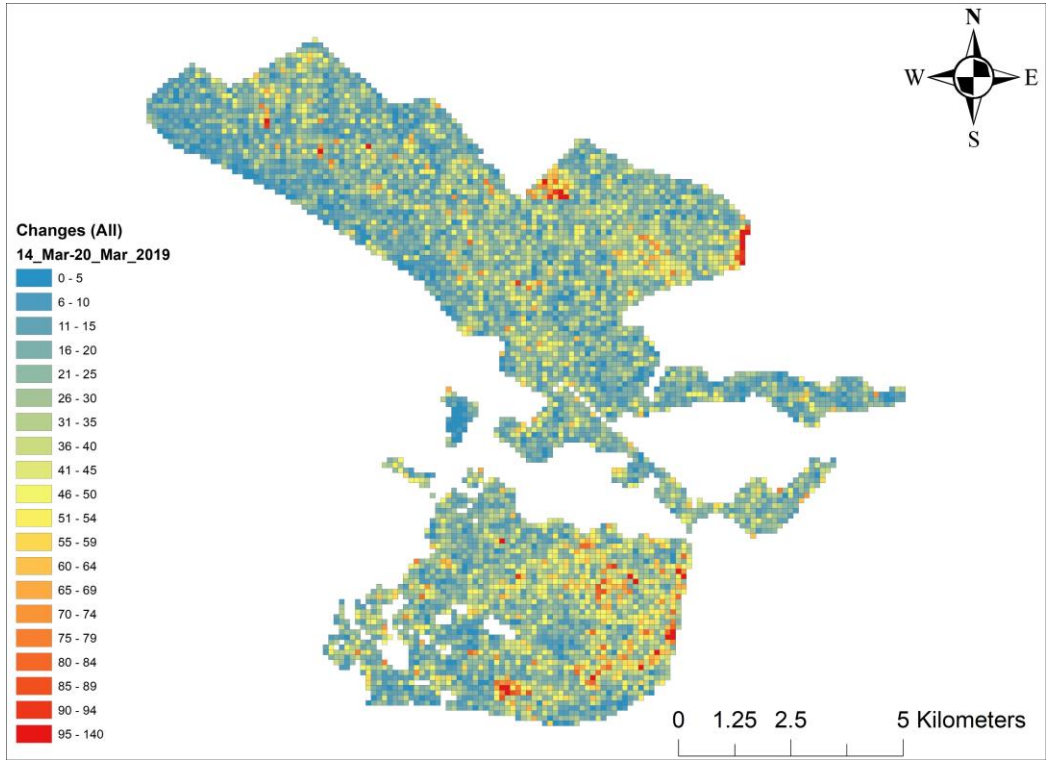


20 Mar–26 Mar

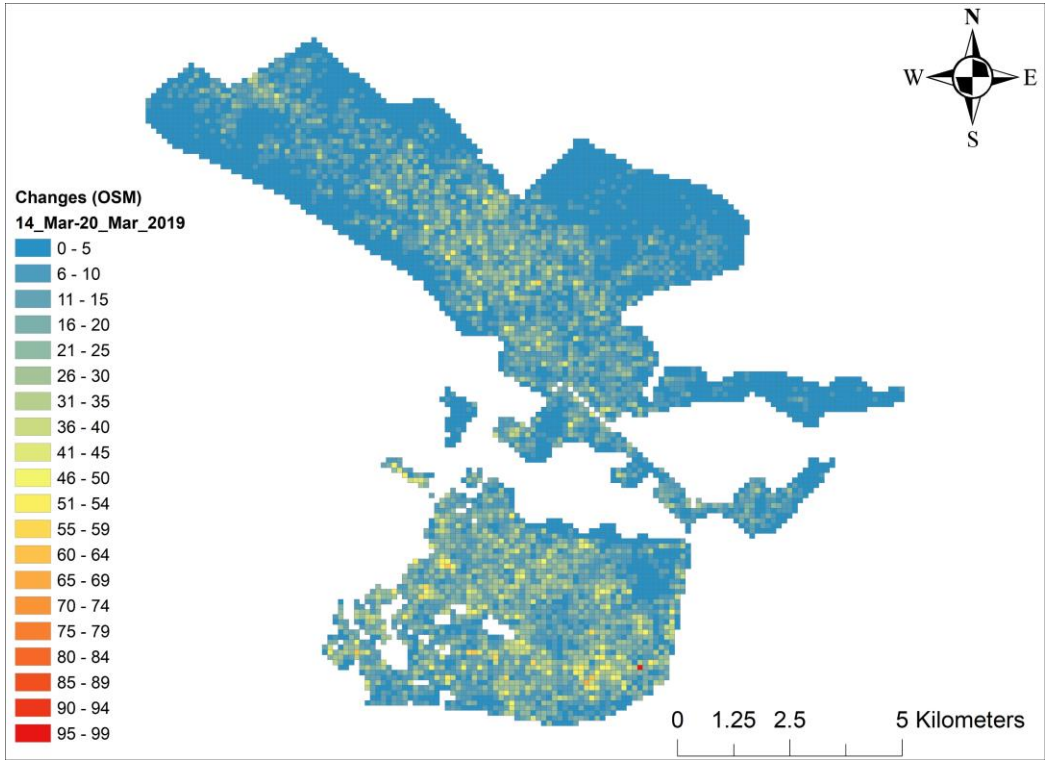
26 Mar–01 Apr

Results – Count of damages

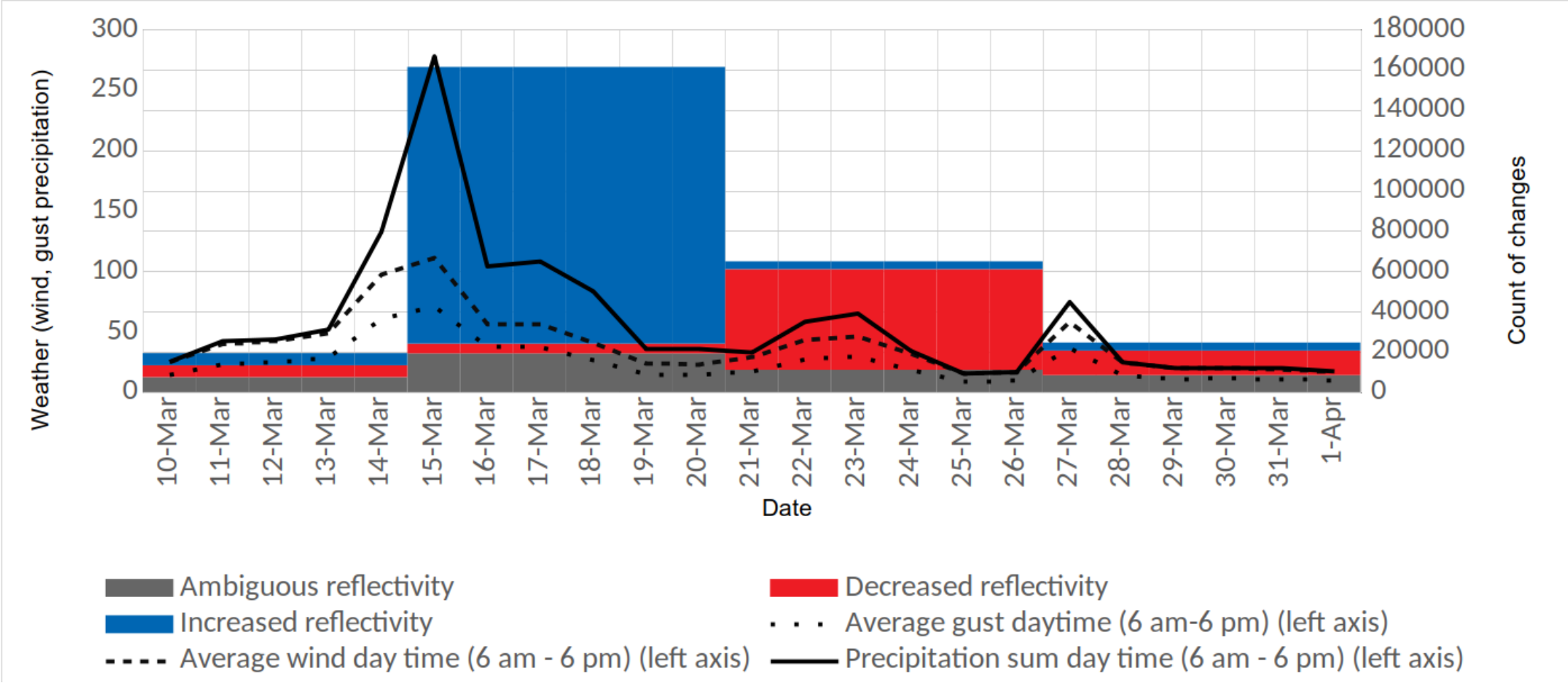
Changes unfiltered



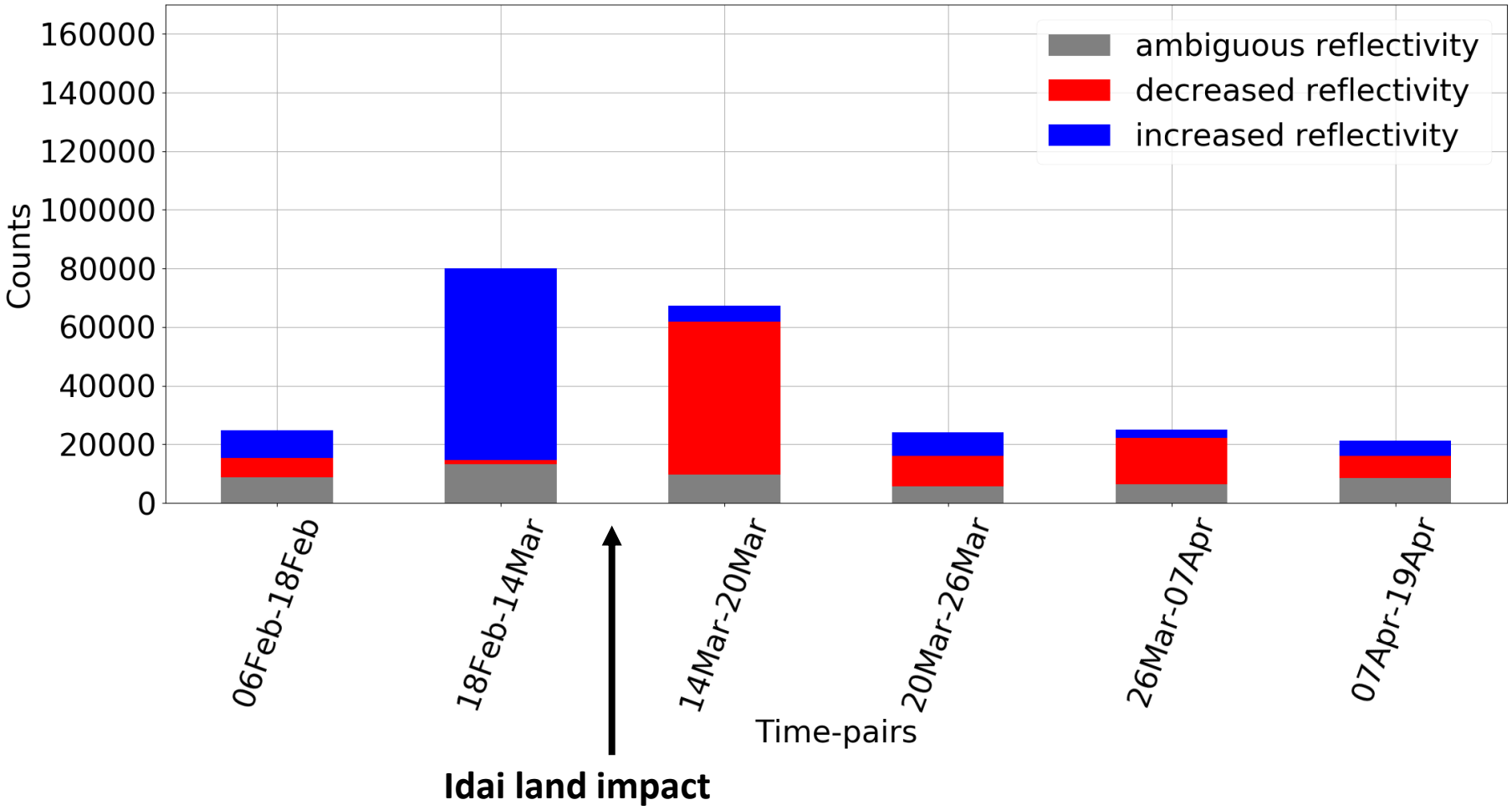
Changes filtered by OpenStreetMap building footprints



Results: Comparing with weather data



Results: Satellite 2



Comparison with Auxiliary data

	Manual Tags	*Changes*	Poverty	Dist. to Coast	Construction Density
Manual tags	1.00	0.55	0.20	-0.02	0.71
Changes		1.00	0.41	-0.30	0.76
Poverty			1.00	-0.51	0.54
Dist. to coast				1.00	-0.33
Construction density					1.00

Manual Tags – UNOSAT manual tagged house damages from satellite images.
Changes – Change detections with the radar data.
Poverty – PMT score from previous study, **Fisker, Peter, and David Malmgren-Hansen. "Using Satellite Data to Guide Urban Poverty Reduction."**
Dist. to coast – Measured with ArcGIS
Construction density – From previous study.

Conclusion

- Can deliver very fast overview of cyclone impact
- Aux. data on location of houses is necessary to focus changes on house damages.
- An automatic way of extracting updated building footprints can improve method compared to OSM data.
- Use assessment based on Radar images for sampling of aerial images after cyclone impacts

- With better data on house type and locations assessment can be focused on Schools, hospitals and critical infrastructure.

Thank you!

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