AN INITIATIVE OF
THE NETHERLANDS
RED CROSS

AUTOMATED DAMAGE ASSESSMENT

Jacopo Margutti, Data Scientist, PhD

ML for Earth System Modelling and Analytics workshop 03-04 May 2021

OUTLINE

WHY AUTOMATED DAMAGE ASSESSMENT

HOW WE DO IT

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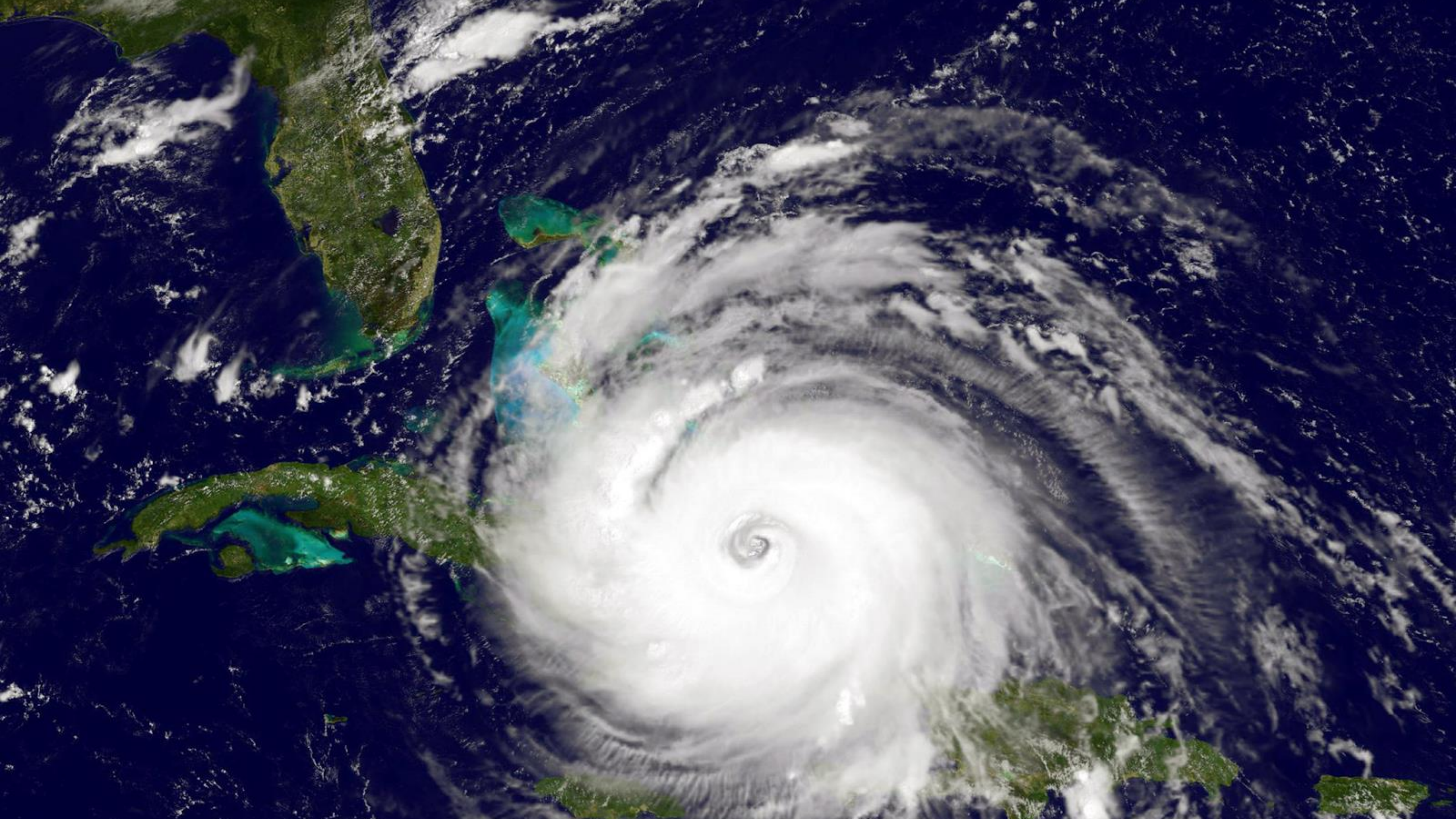
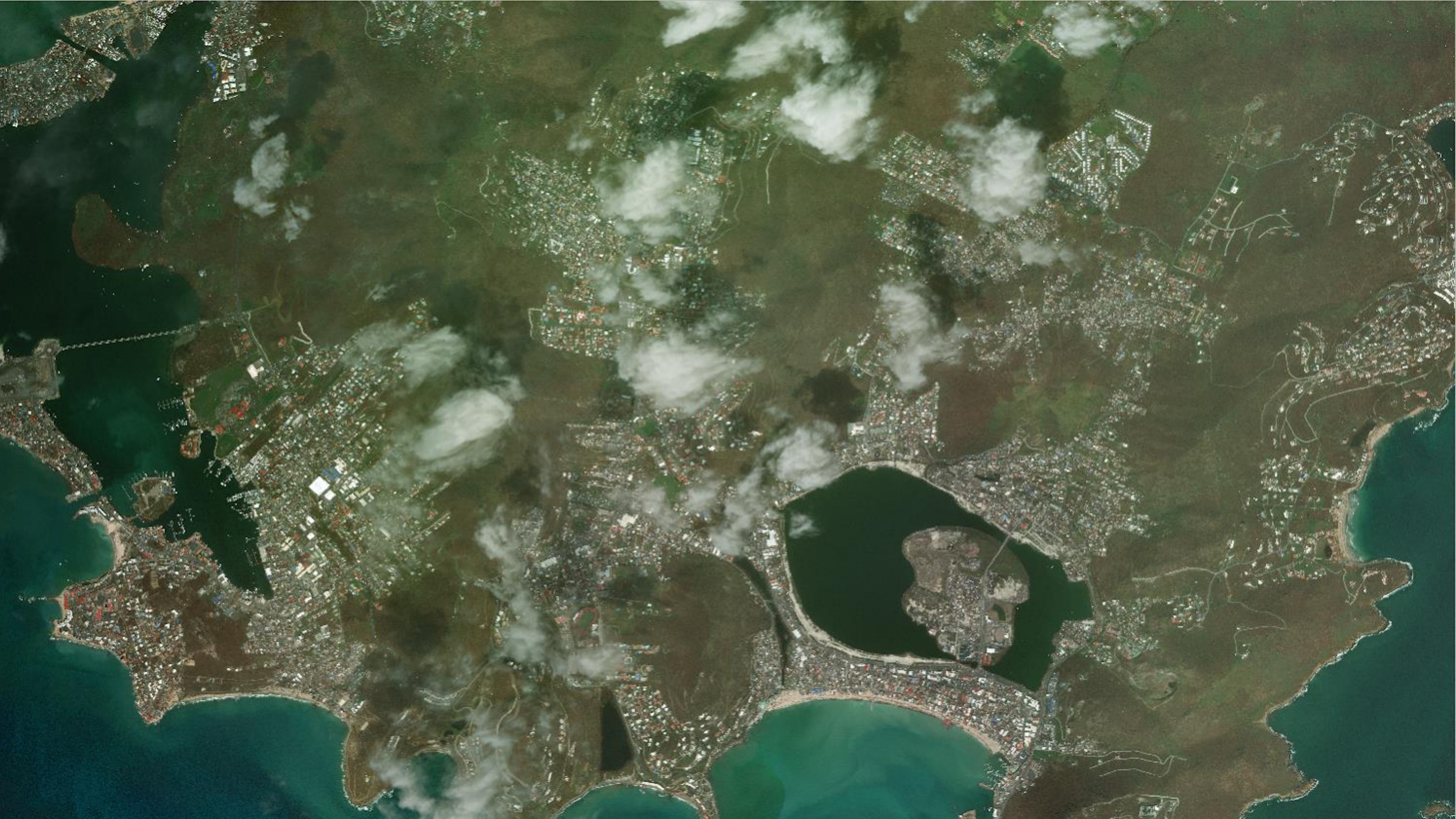



AFTER IRMA:
DRONE IMAGERY
SOURCE: 510
BLUE AREAS TARPAULINE
510
Red Cross St. Maarten
JuxtaposeJS



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WHY AUTOMATION

Emergency responders *immediately* need to know:

- **WHERE** are the people in need
- **HOW BAD** is the situation → the scale of the damage

How can we do it?

- By going to the field and surveying

  → often impossible, takes weeks/months for large areas

- By manually checking satellite imagery

  → too slow if affected area is large

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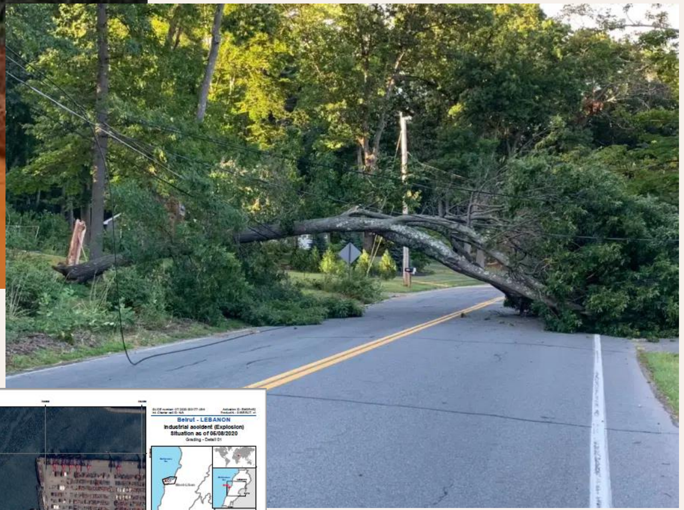

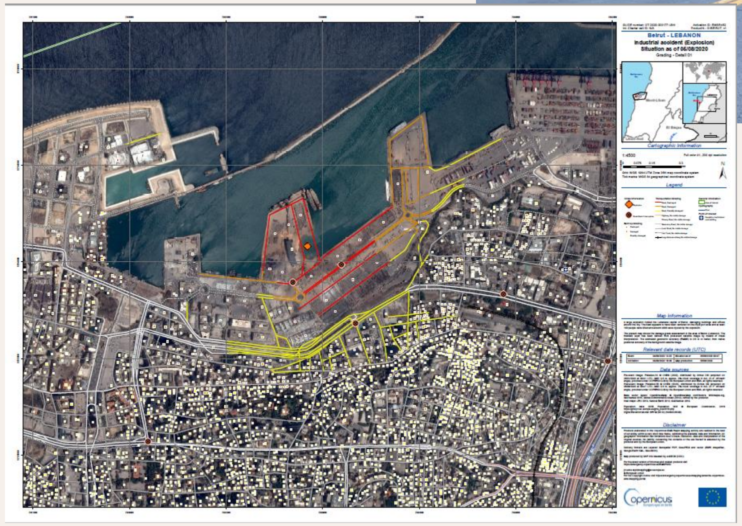

WHY AUTOMATION

Automation is about **speed** and **availability**

Mapping:

- one machine: 1,000 km2/h *
- HOT OSM (many humans): < 100 km2/h **

Damage Assessment (on satellite images):

- one machine: 10,000 buildings/h *
- UNOSAT: < 100 buildings/h/person ***

* Azure's NC24: 24 vCPUs, 224 GB RAM, 4x NVIDIA K80 GPUs, 3.60 USD/hour
** https://doi.org/10.1080/22797254.2018.1460567
*** https://www.mdpi.com/2072-4292/12/17/2839

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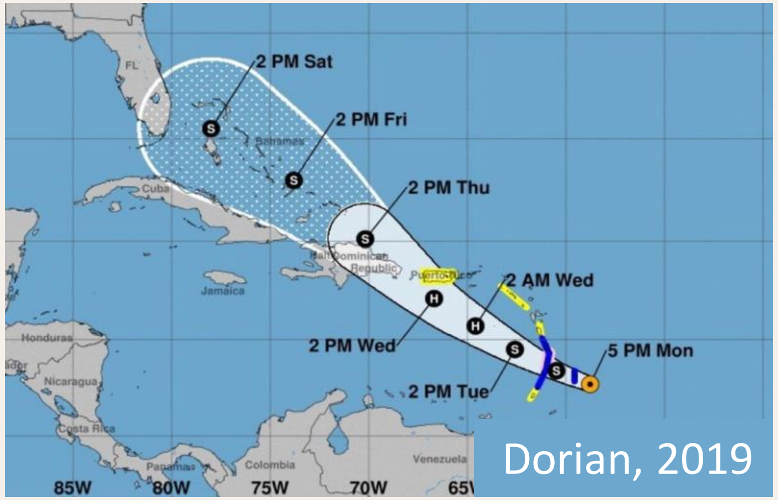

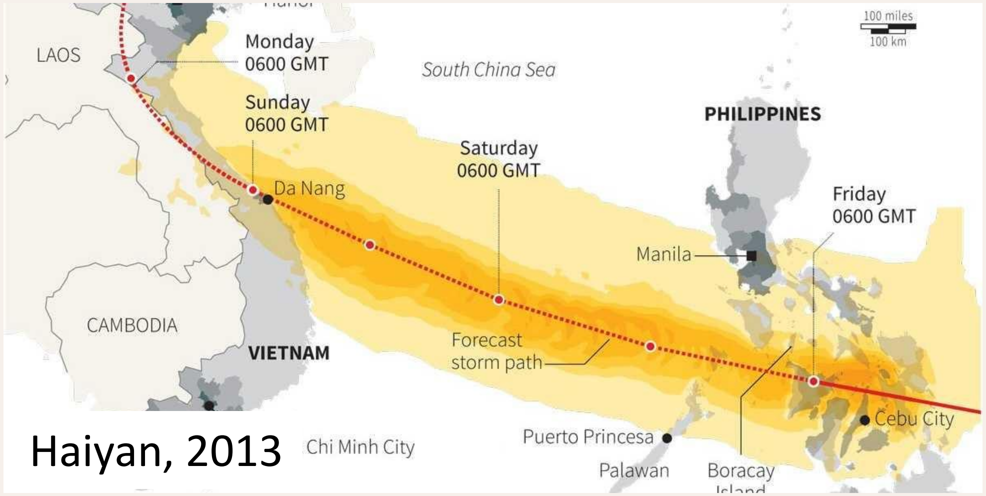

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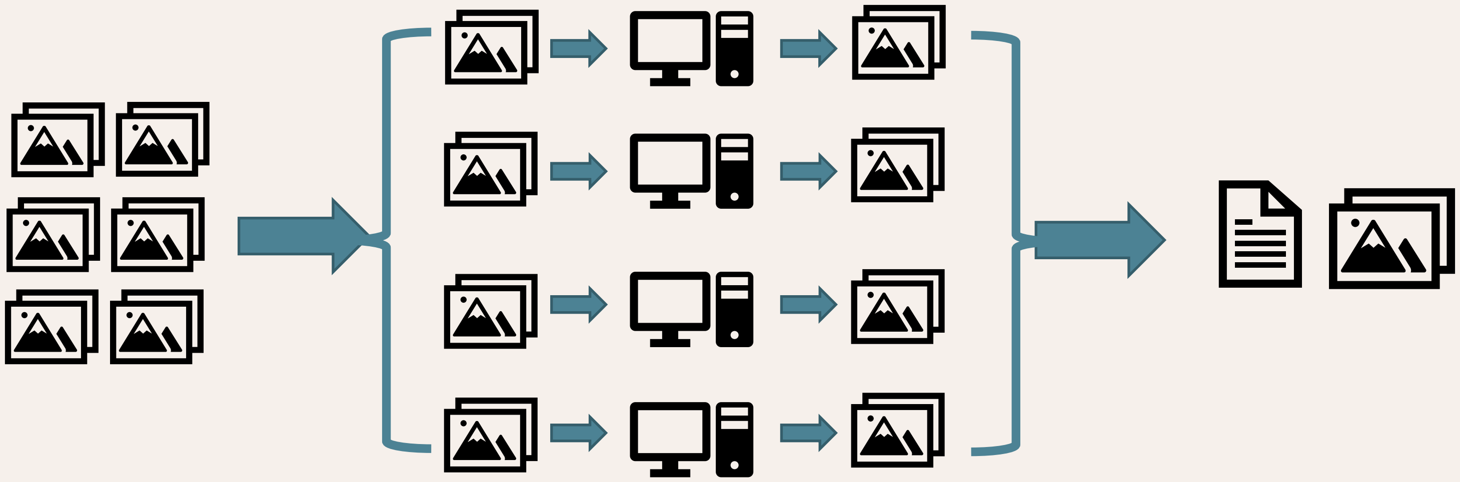
WHY AUTOMATION

- Machines can also work in parallel → will go **as fast as you can pay for**



github.com/rodekruis/ada-azure-batch

- Example: mapping + damage on ~12,000 km2* on Azure with 26 x NC12 VMs):

  completed in 1.2 h for 24 EUR

* Super typhoon mangkhut, Philippines, 2018

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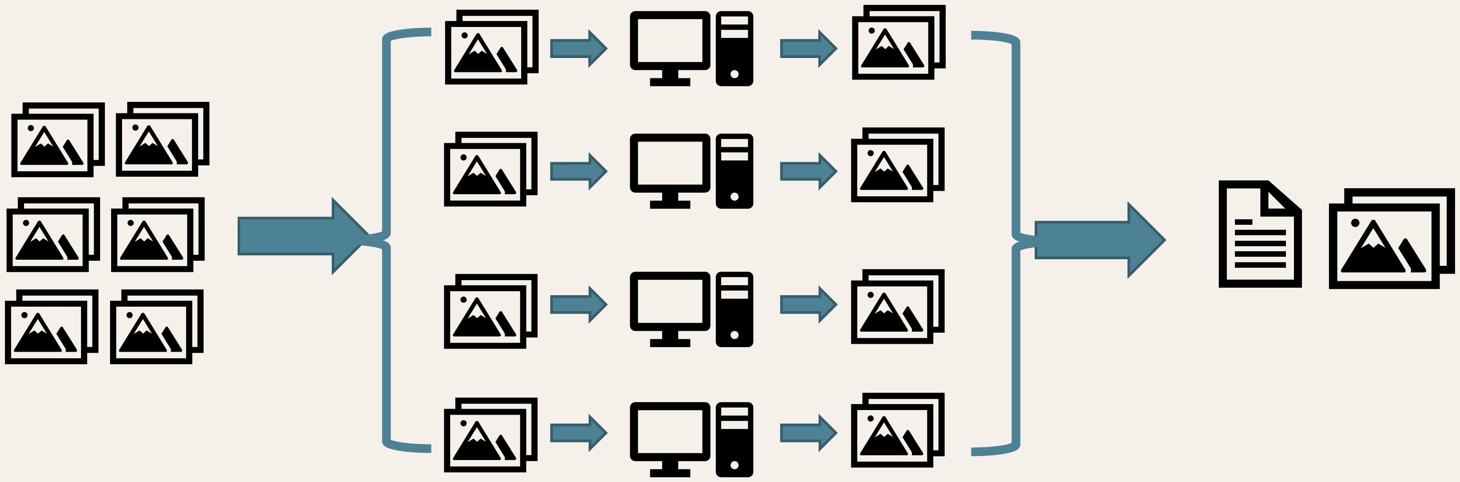

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HOW WE DO AUTOMATED DAMAGE ASSESSMENT

STEP 1: **BUILDING DETECTION**

input: satellite image (RGB, <= 0.5 m/pixel)

output: building locations (vector)

source: Bing Maps (fully automated) or manual input

HOW WE DO AUTOMATED DAMAGE ASSESSMENT

STEP 2: **BUILDING DAMAGE CLASSIFICATION**

1. satellite images, pre- and post-disaster (RGB, 0.5 m/pixel)
2. building locations (vector)

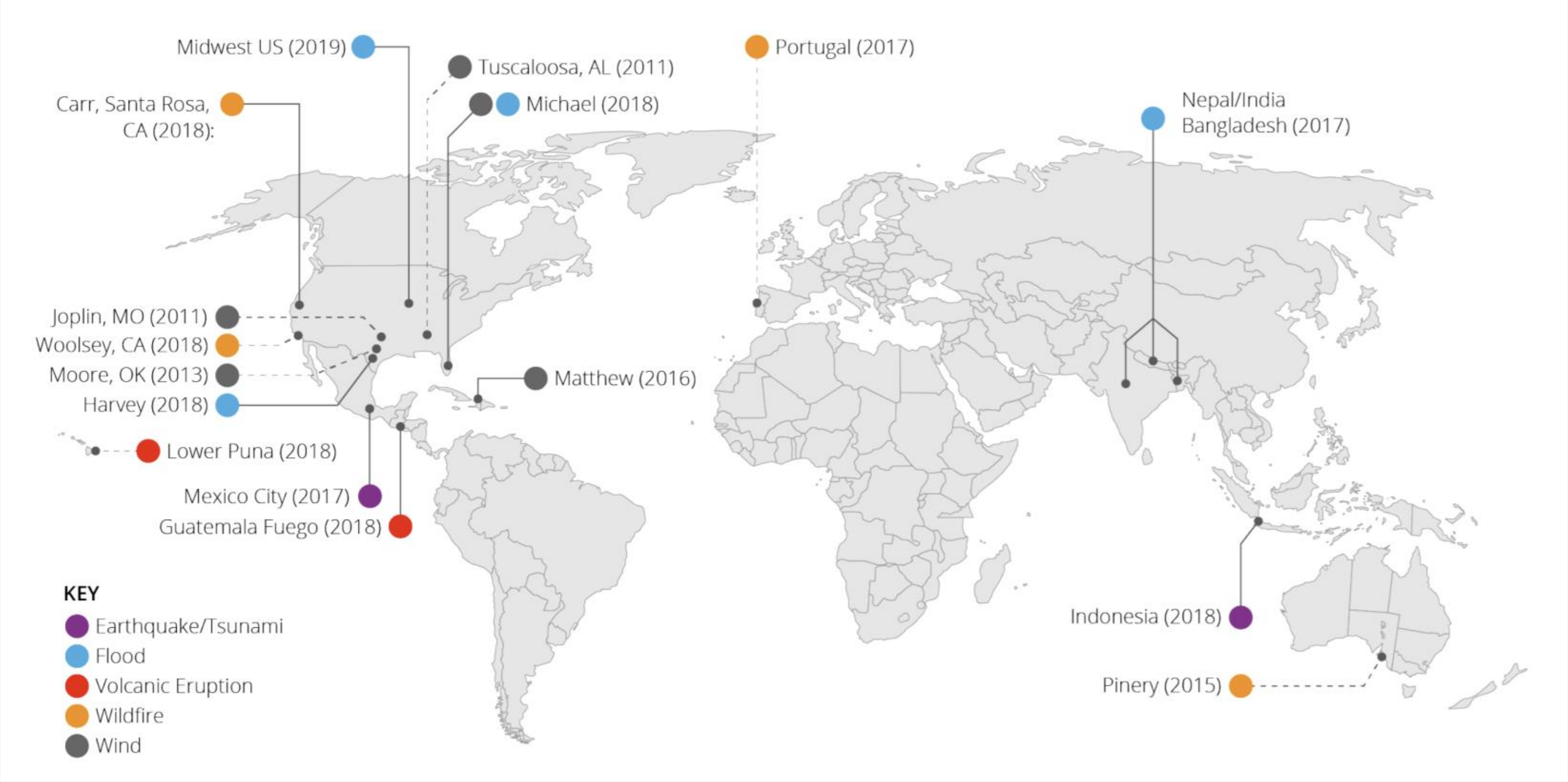
output: building damage (vector), 4 classes

source(s): Maxar Open Data or manual input

TRAINING DATA

Training data: **xBD dataset** (arXiv:1911.09296)

850k buildings, 45k km2, 4 continents, 19 disasters

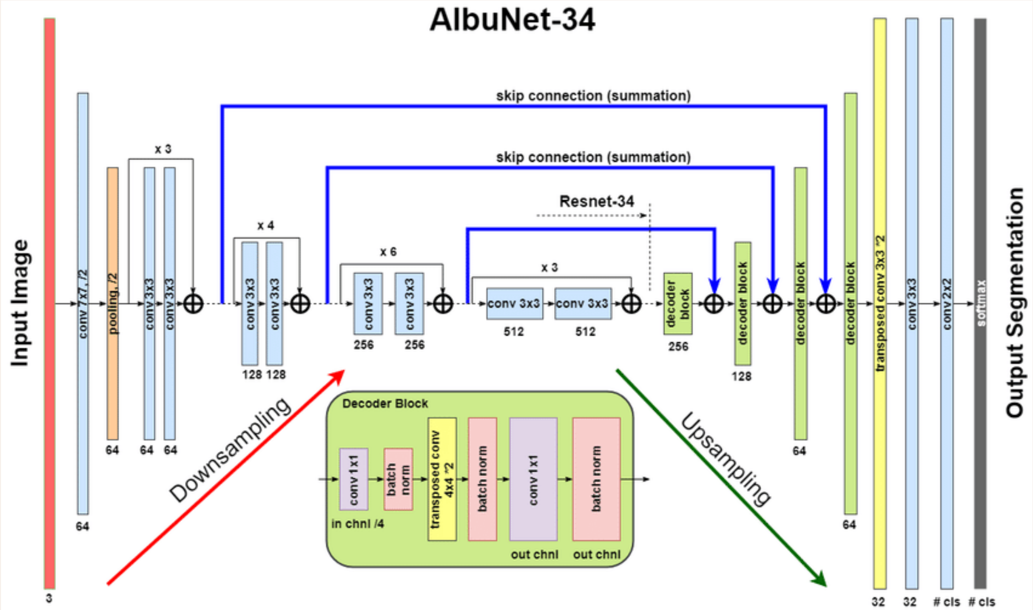


arXiv:1911.09296

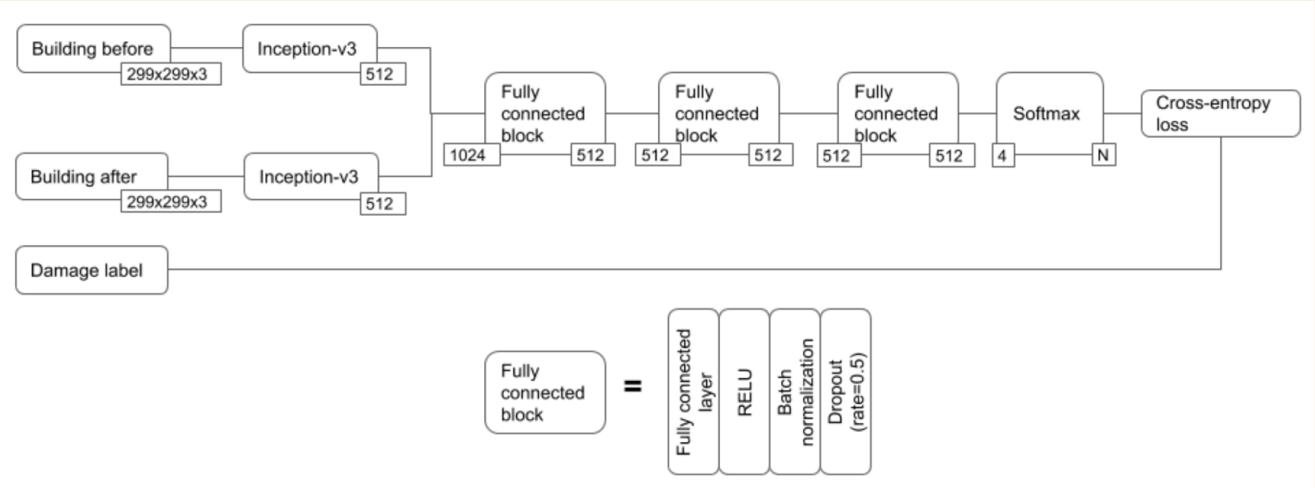
MODELS

Model **architectures**:

- Building detection (segmentation): U-Net with ResNet encoder (a.k.a. AlbuNet)
- Building damage classification: pseudo-siamese Net



arXiv:1804.08024v1



doi:10.3390/rs12172839

PERFORMANCE

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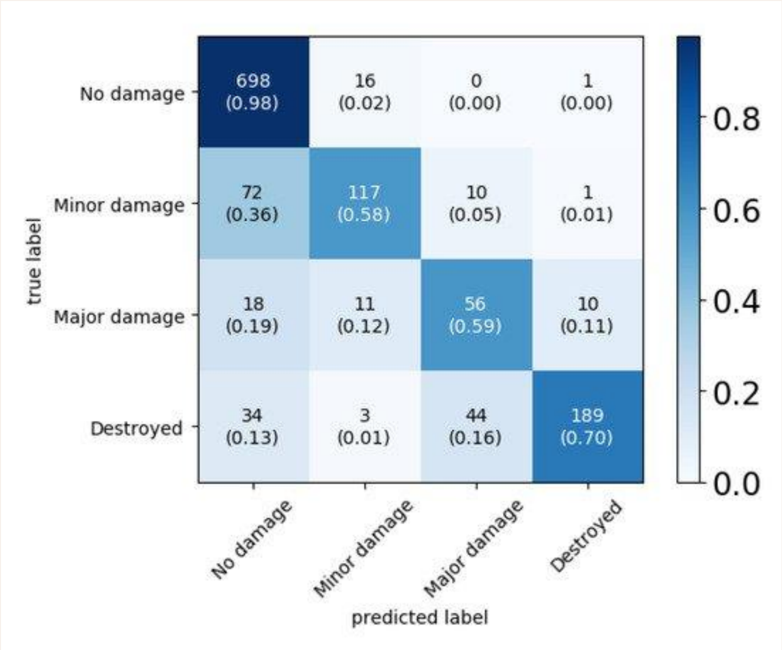
PERFORMANCE

Key **performance** indicators:

- Building detection (segmentation): IoU 0.71, MCC 0.68
- Building damage classification, Macro F1 (4 classes): 0.59-0.79



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Additional observations (doi:10.3390/rs12172839) :

- Little (<10%) effect on performance of
    - world region (continent)
    - damage type (water, wind, etc.)
    - image parameters (off-nadir angle, panchromatic resolution, etc.)
- Performance strongly influenced by **which specific disaster** models are trained and tested on

CONCLUSIONS

- **Automated Mapping and Damage Assessment** can be useful tools in Emergency Response
  - Faster and more often available than current methods

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- **Automated Mapping and Damage Assessment** can be useful tools in Emergency Response
  - Faster and more often available than current methods
- Model performance tested on a number of disasters in different world areas
  - Good enough for first estimates, more work to be done
- Models and framework are **fully open source**, so that the community can use & improve them
  - Automated mapping: https://github.com/rodekruis/automated-building-detection
  - Automated Damage Assessment: https://github.com/rodekruis/caladrius

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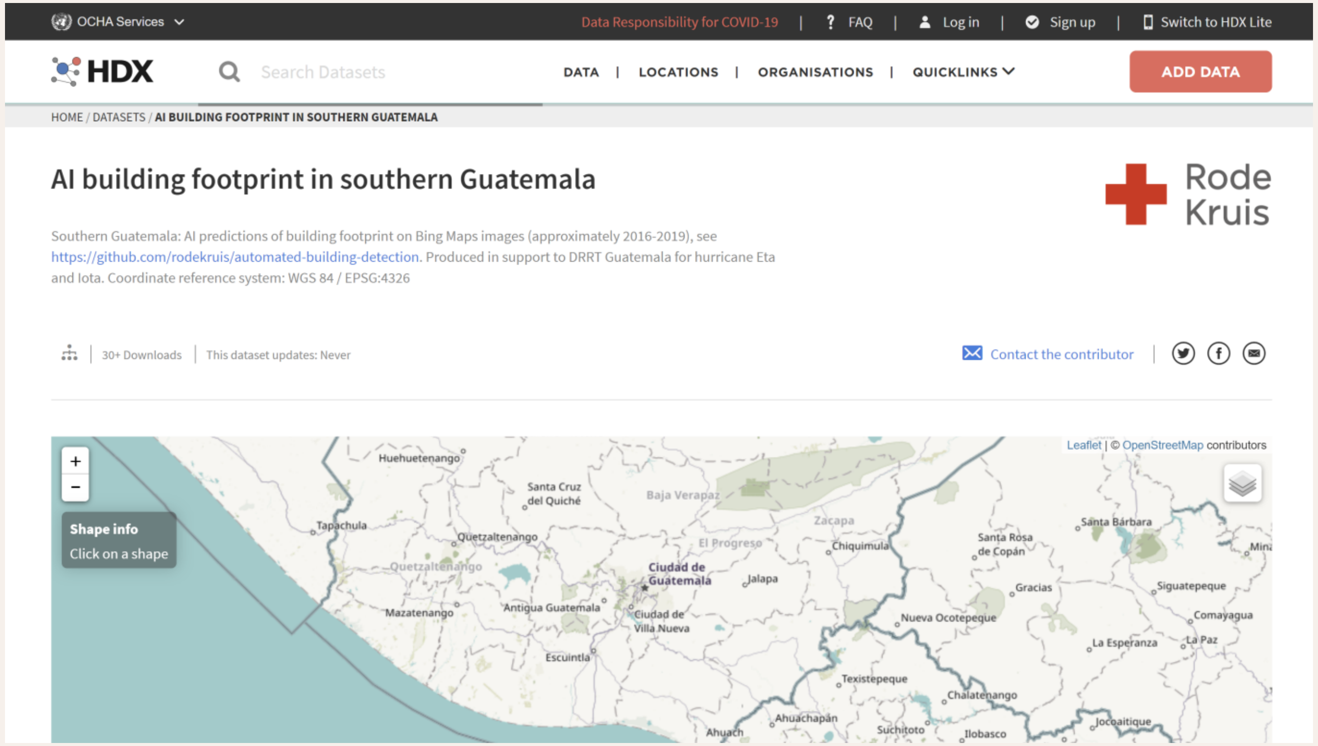
REAL USE CASES

- Automated Mapping:
  - Typhoon Goni, Philippines 2020
  - Hurricane Eta and Iota, Guatemala 2020
  - Flash Floods, Zimbabwe 2020
- Damage Assessment:
  - Explosion, Beirut 2020



https://data.humdata.org/organization/netherlands-red-cross

THANK YOU!

contact: jmargutti@redcross.nl