Satellite Data for Disaster Risk Finance

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FOR 5 POINTS

$30K

4994

Presentation Overview

Introduction → Value of Satellite Data → Sources of Satellite Data/Imagery → New Technology – Drones, Machine Learning, etc. → Real world Example → Group exercise

Why care ████████ ORF?

Good Plan████

The Right Tradeoffs in ███ugh Situations

Examples in the DRF Context

How to increase the *speed, predictability, and transparency* of disaster response?

How to ensure that money reaches the people *who need it the most, when* they need it the most?

Google

Sentinel/ICEYE

Bahamas

Sentinel/ICEYE
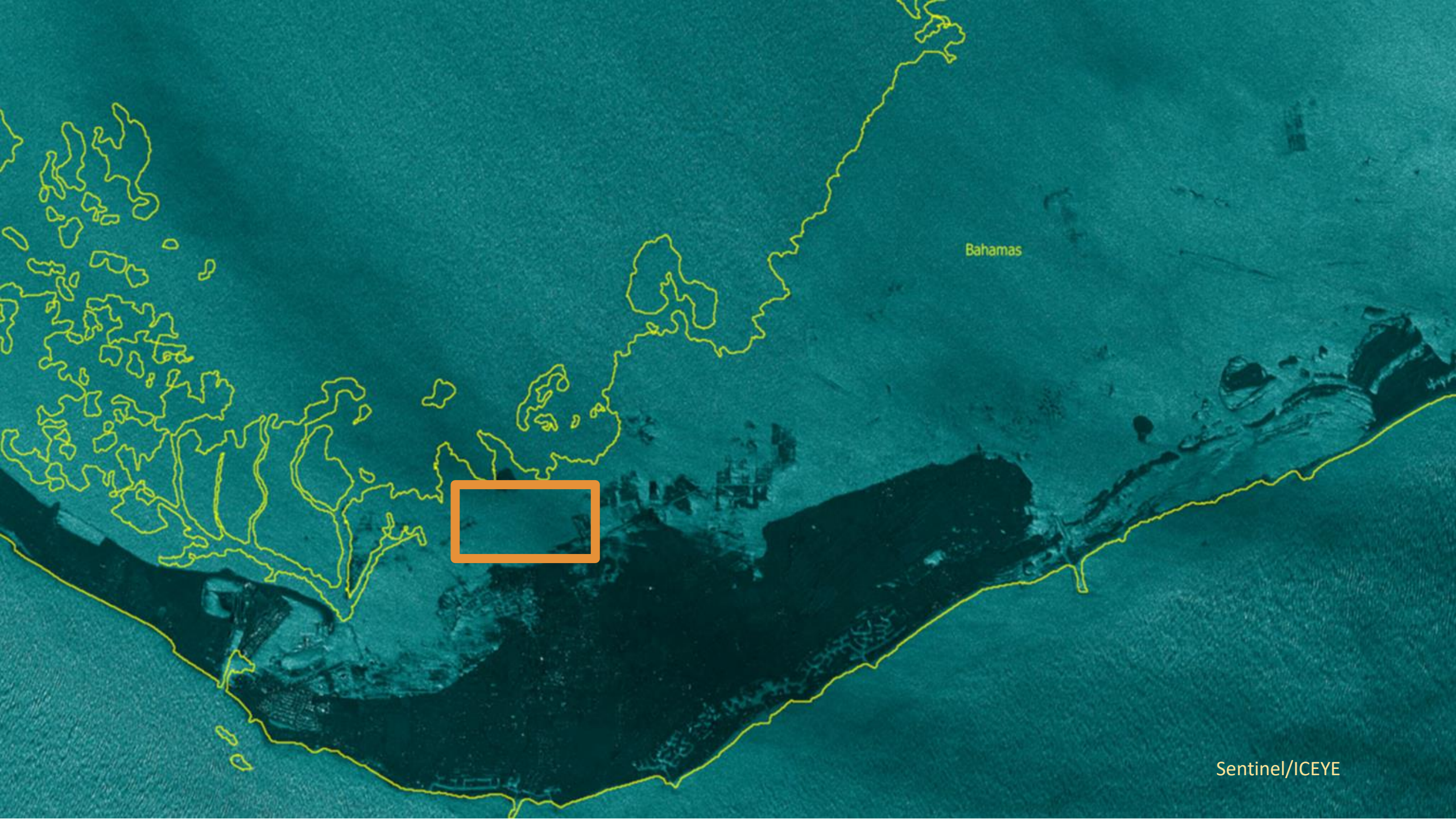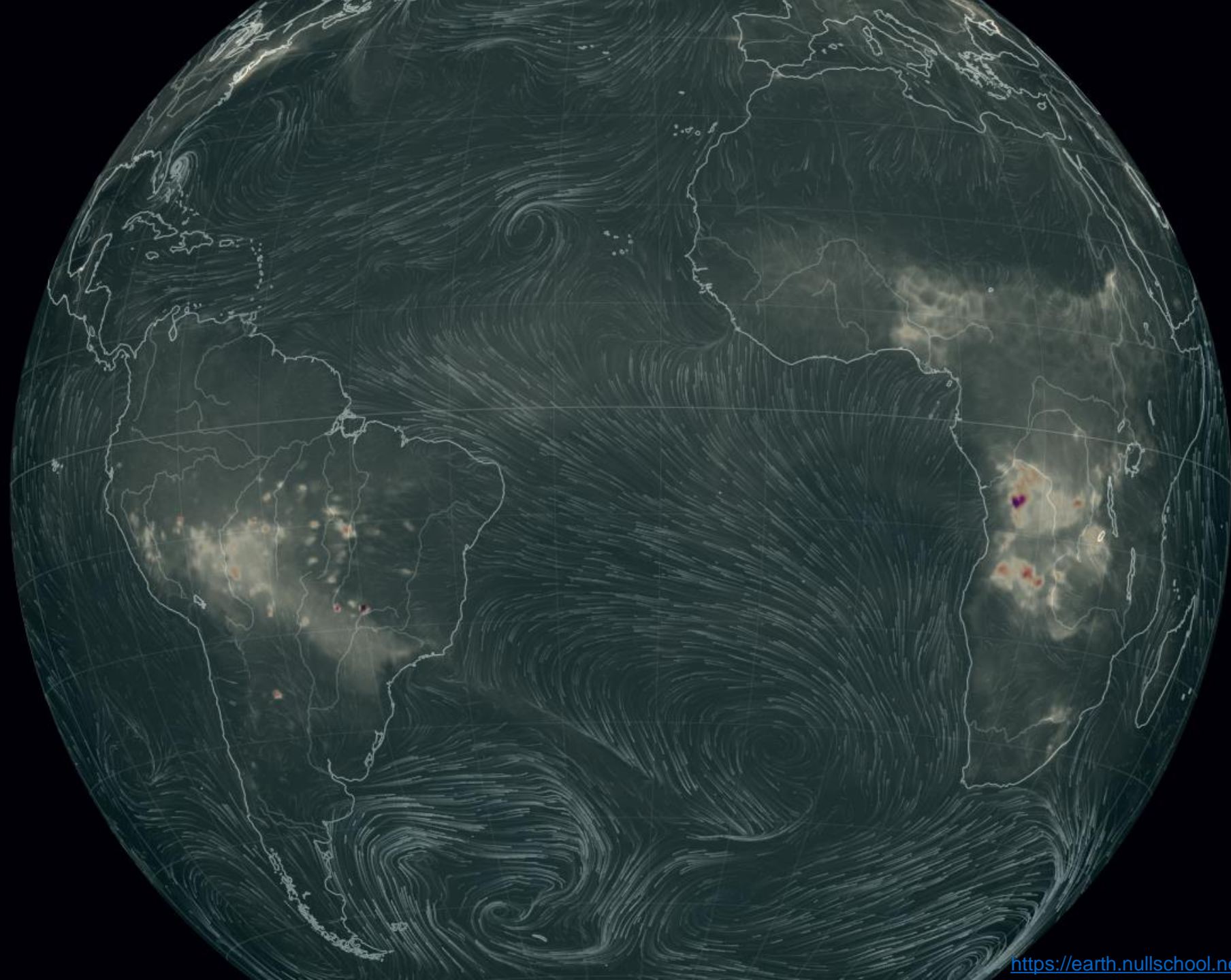
Introduction to Satellite Data - Types

Limiting Factors and Trade-offs

For 1000 POINTS!

SPATIAL RESOLUTION
The size of one pixel on the ground

25cm US Legal Limit

(d) 250m

(d) 250m

(b) 10m

(c) 30m

1cm is possible in principle!
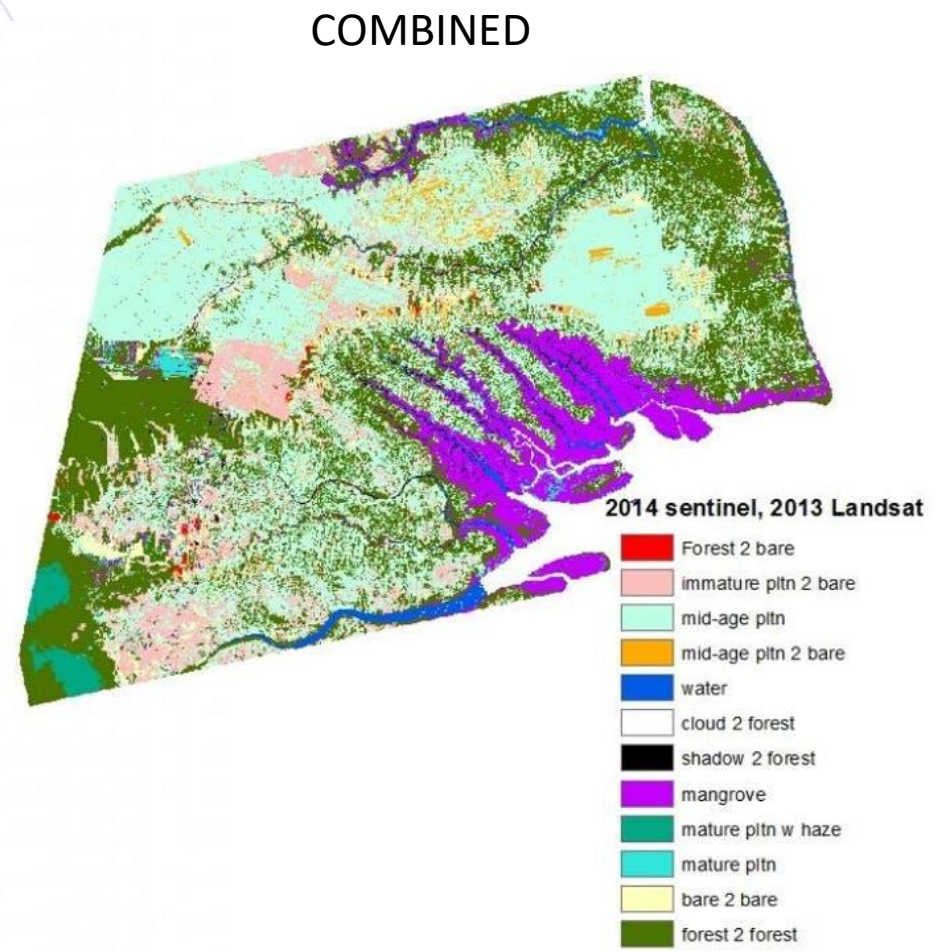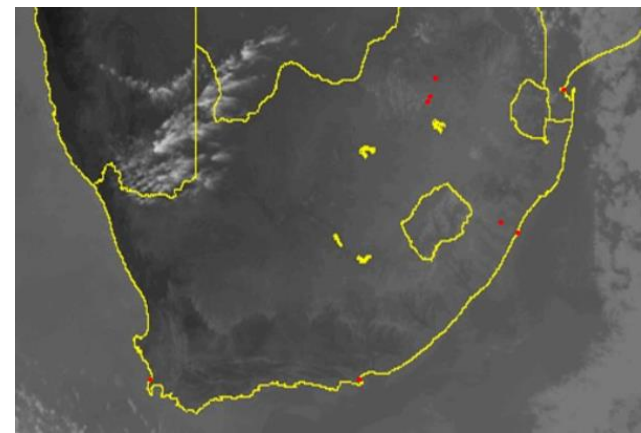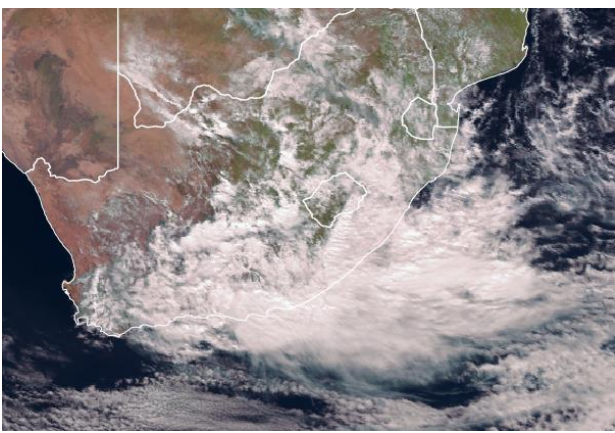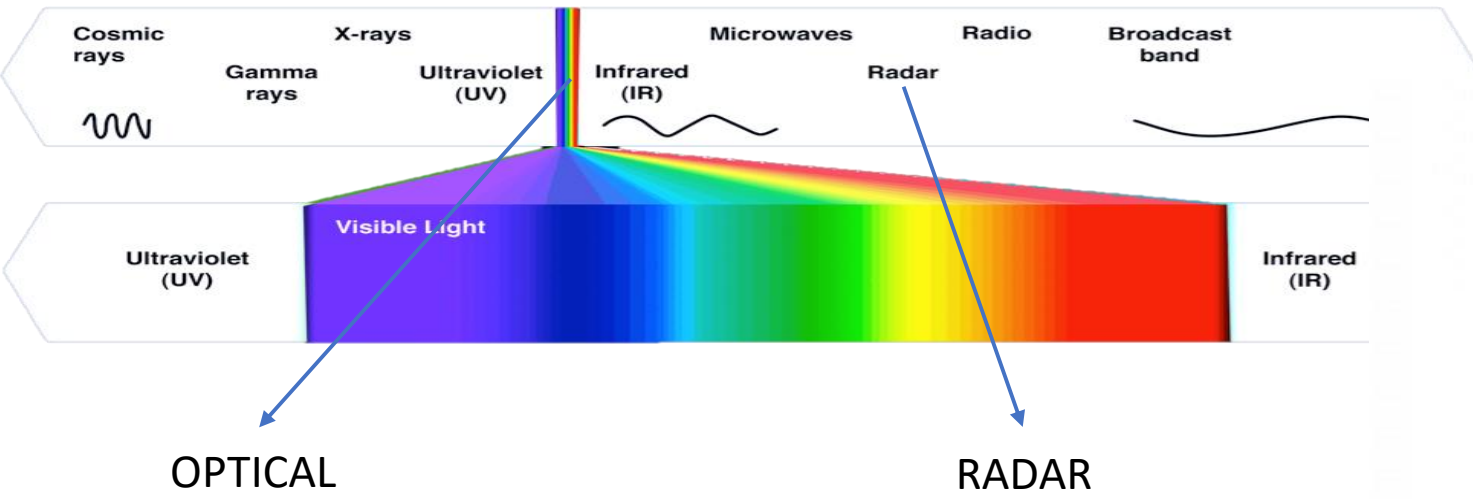
Limiting Factors and Trade-offs
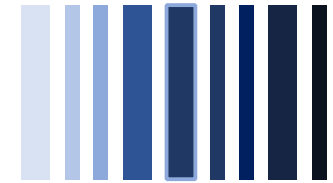
SPATIAL RESOLUTION
The size of one pixel on the ground

TEMPORAL RESOLUTION
How often data of the same area is collected

SPECTRAL RESOLUTION
Dimension and number of specific wavelength intervals

RADIOMETRIC RESOLUTION
how many grey levels are measured between pure black and pure white

THESE USUALLY FIGHT AGAINST EACH OTHER
WHY? **10 POINTS**

Orbital Altitudes of many significant satellites of earth

Scale: 1 Pixel = 10 Km / 6.2 mi

2000 Km / 1243.7 mi

Earth Radius 6378 Km / 3963 mi

0 km / mi - Sea Level.
37.6 km / 23.4 mi - Self Propelled Jet Aircraft Flight Ceiling (Record Set in 1977).
215 km / 133.6 mi - Sputnik-1 The first artificial satellite of earth.
340 km / 211.3 mi - International Space Station.
390 km / 242.3 mi - Former Russian Space Station MIR.
595 km / 369.7 mi - Hubble Space Telescope.

[700 - 1700 km] - Polar Orbiting Satellites.
[435 - 1056 mi]

35,786 km
Geosynchronous (GEO) and Geostationary (GSO) Satellites
Geosynchronous satellites orbit the Earth at the same rate that the
Earth rotates. Thus they remain stationary over a single line of longitude.
A geostationary satellite will remain in a fixed location as observed
from the earths surface, allowing a satellite dish to be aligned to them.
This particular altitude marks the border between the MEO and
HEO Zones.

20,350 km
GPS (Global Positioning System) Satellites
These Satellites are on a Semi-synchronous Orbit (SSO)
meaning that they orbit the earth in exactly 12 hours (twice per day).

LEO Zone
(Low Earth Orbit)

MEO Zone
(Medium Earth Orbit)
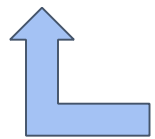
HEO Zone
(High Earth Orbit)

2000 Km / 1243.7 mi

600 - 800 km / 372.8 - 497.1 mi - Sun-synchronous Satellites
These satellites orbit the Earth in near exact polar orbits north to south.
They cross the equator multiple times per day and each time they are at the same angle
with respect to the sun. Satellites on these types of orbits are particularly useful
for capturing images of the Earth's surface or images of the sun.

Scale: 1 Pixel = 100 Km / 62.1 mi

20000 Km / 12437.4 mi

MEO Zone
(Medium Earth Orbit)

HEO Zone
(High Earth Orbit)

LEO Zone
(Low Earth Orbit)

384,000 km
The Moon

Days:

0 1 2 3 4 5 6

Example - The Copernicus Sentinel-2
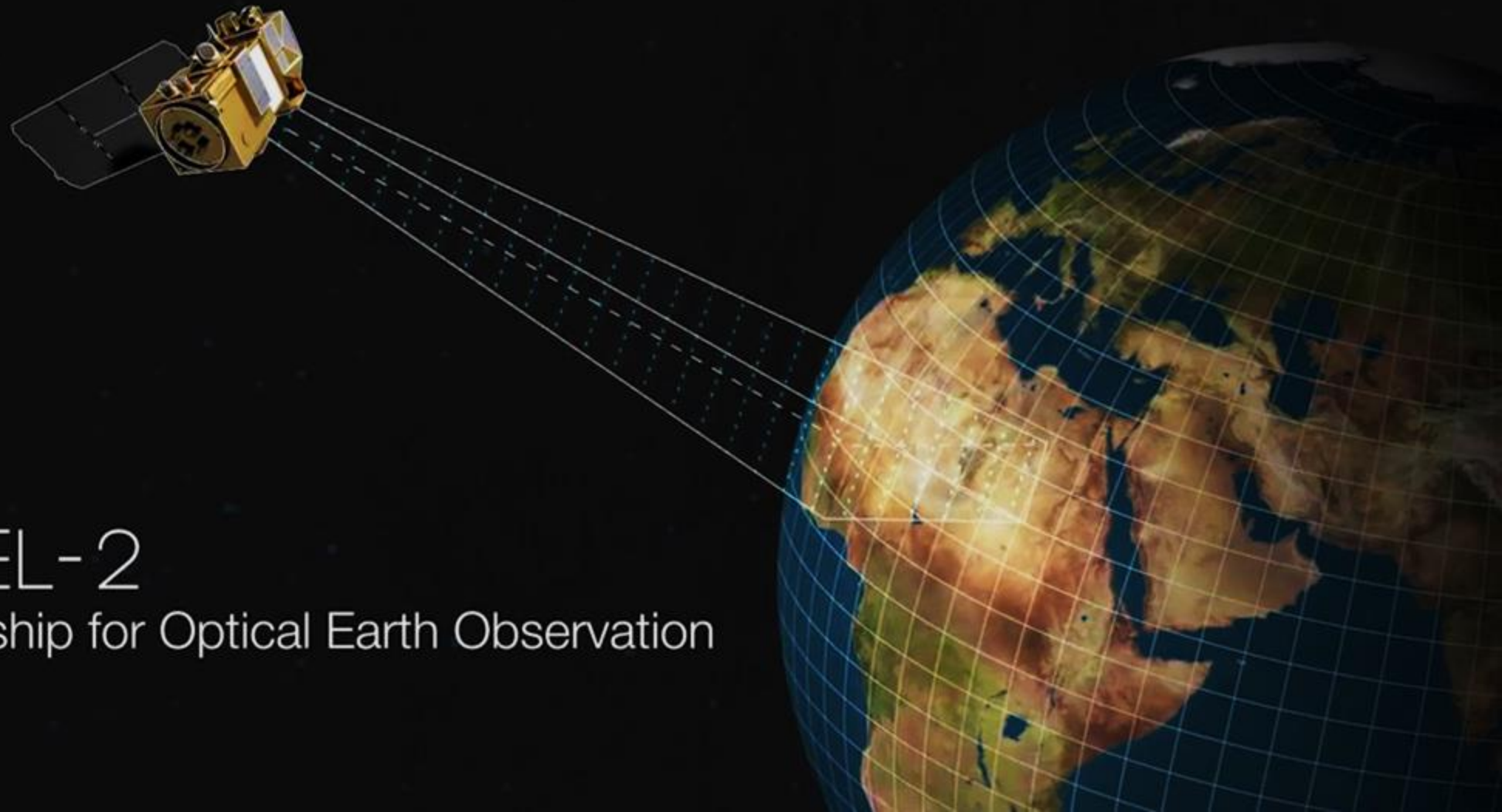
SENTINEL-2
Europe's flagship for Optical Earth Observation
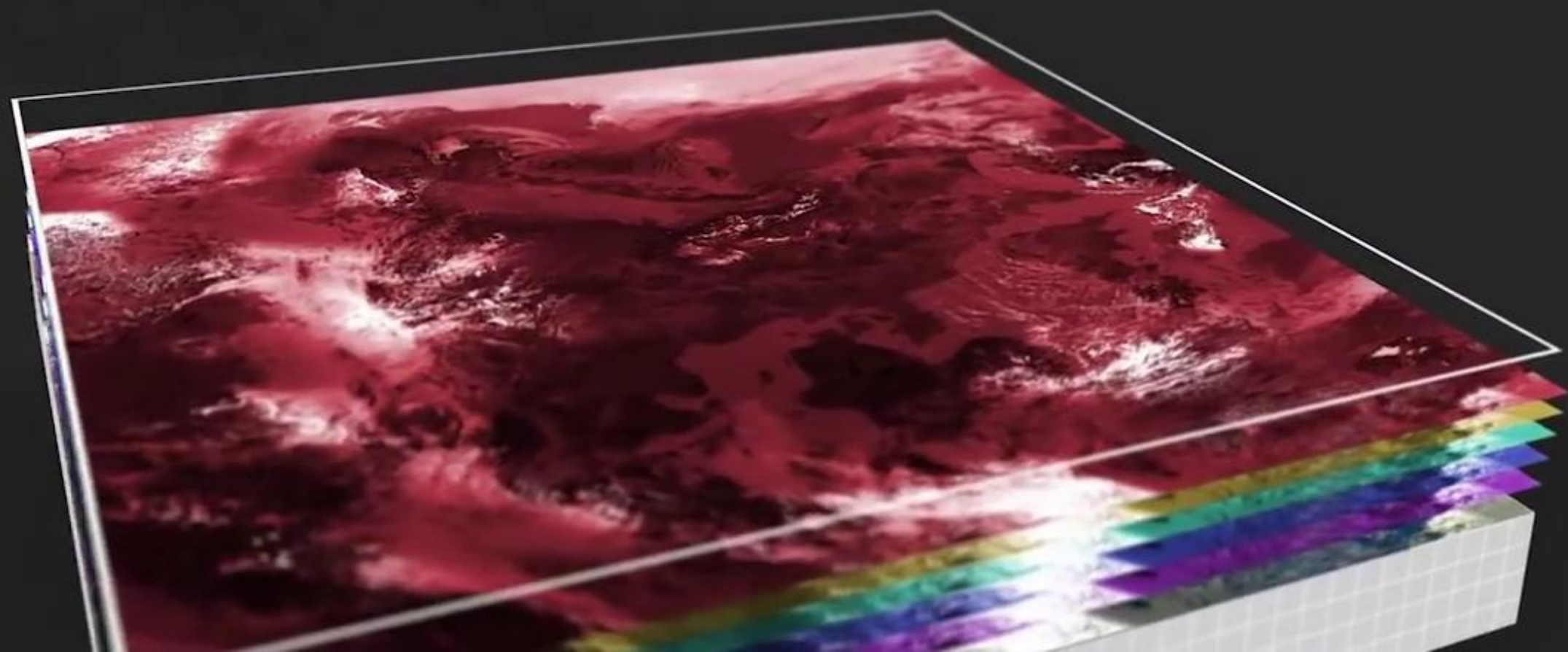
ESA-DEVELOPED EARTH OBSERVATION MISSIONS

2010

2015

2020

2025

2030

Proba-1
GOCE
SMOS
CryoSat
Swarm
Proba-V

Meteosat 10 (MSG)
MetOp-B
Meteosat 11 (MSG)

Sentinel-1A
Sentinel-2A
Sentinel-1B
Sentinel-2B
Sentinel-3A
Sentinel-3B
Sentinel-5p
Seosat
Aeolus
Sentinel-6A
Sentinel-2C
Sentinel-1C
EarthCARE
Sentinel-3C
Biomass
Sentinel-1D
Sentinel-2D
Sentinel-3D
FLEX
Sentinel-6B

MetOp-C
Sentinel-5A
MetOp-SG-A1
MetOp-SG-B1
MTG-I
Sentinel-4A
MTG-S1
MTG-I2

Sentinel-5B
MetOp-SG-A2
MTG-I3
Sentinel-4B
MTG-S2
MetOp-SG-B2

Science | esa — European Space Agency

Copernicus | European Commission

Meteorology | EUMETSAT

www.esa.int

European Space Agency

Value of Satellite Data in DRM

What Types of Disasters Would Benefit From Satellite Data For DRF?

5 POINTS PER EXAMPLE!

Value of Satellite Data in DRM

Cyclones ▶

Earthquakes ▶

Fires ▶

Floods ▶

Snow and Ice ▶

Ocean Waves ▶

Oil spills ▶

Volcanoes ▶

Landslides ▶

Other ▶

https://disasterscharter.org
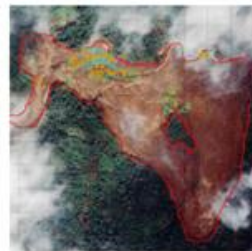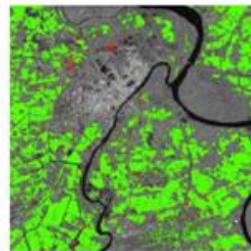
Value of Satellite Data in DRM

- Often available globally
- Provides objective information
- Often captures what is going on better than models
- Short time lags (some data available in less than 2 hrs after the satellite overpass)
- Ability to combine multiple data sources

How about night time satellite data?

What can we do with night time satellite photos?

10 POINTS

Value of Satellite Data in DRF – Example

- Link night time light observations (= impacts on power grids) after major cyclones or floods to displacement or to show economic growth areas

Sources of Satellite Data/Imagery

EXAMPLES
European Space Agency (ESA) will provide free and open access to a range of data types
NASA – Specifically the Advanced Rapid Imaging and Analysis (ARIA) team at NASA's Jet Propulsion Laboratory
JAXA - Japan Aerospace Exploration Agency - Advanced Land Observing Satellite DAICHI (ALOS
Private companies such as: Fusion Space Technologies, ICEYE, GaoJing, ImageSat International, Deimos Imaging Inc, and BlackSky Global, CubeSpace, etc

More - https://en.wikipedia.org/wiki/List_of_Earth_observation_satellites

DETAIL				
Satellite ▼	Open Data ▼	Spatial resolution (m) ▼	Revisit rate (days) ▼	Cost ($ per km²) ▼
Airbus Pléiades	No	0.5	1	13
Airbus SPOT 6/7	No	1.5	1	5.15
DigitalGlobe IKONOS	No	0.82	3	n/a
DigitalGlobe WV1	No	0.5	1.7	n/a
DigitalGlobe WV2	No	0.46	1.1	17.5
DigitalGlobe WV3	No	0.31	1	32
DigitalGlobe WV4	No	0.31	1	n/a
EU Sentinel 2	Yes	10	5	0
NASA MODIS	Yes	500	1	0
NASA/USGS LandSat 1-3	Yes	60	18	0
NASA/USGS LandSat 4-5	Yes	30	16	0
NASA/USGS LandSat 7-8	Yes	15	16	0
Planet Labs PlanetScope	No	3	0.25	n/a
Planet Labs RapidEye	No	5	5.5	1.28
Planet Labs SkySat	No	0.72	1	n/a
UrtheCast Deimos-1	No	22	3	n/a
UrtheCast Deimos-2	No	0.75	2	n/a
UrtheCast Iris	No	1	15	n/a
UrtheCast Theia	No	5	15	n/a

New Technology
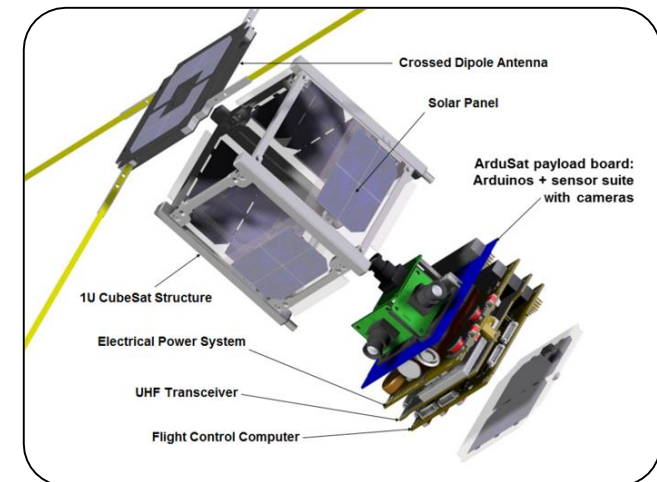
Algorithms for Enriching

Raw data doesn't always answer the important questions.

Often one needs models, or algorithms, to add value to the raw data. Increasing role for Artificial Intelligence (AI)

H. Rapanoel, B.Bassett, J. Petzer et al
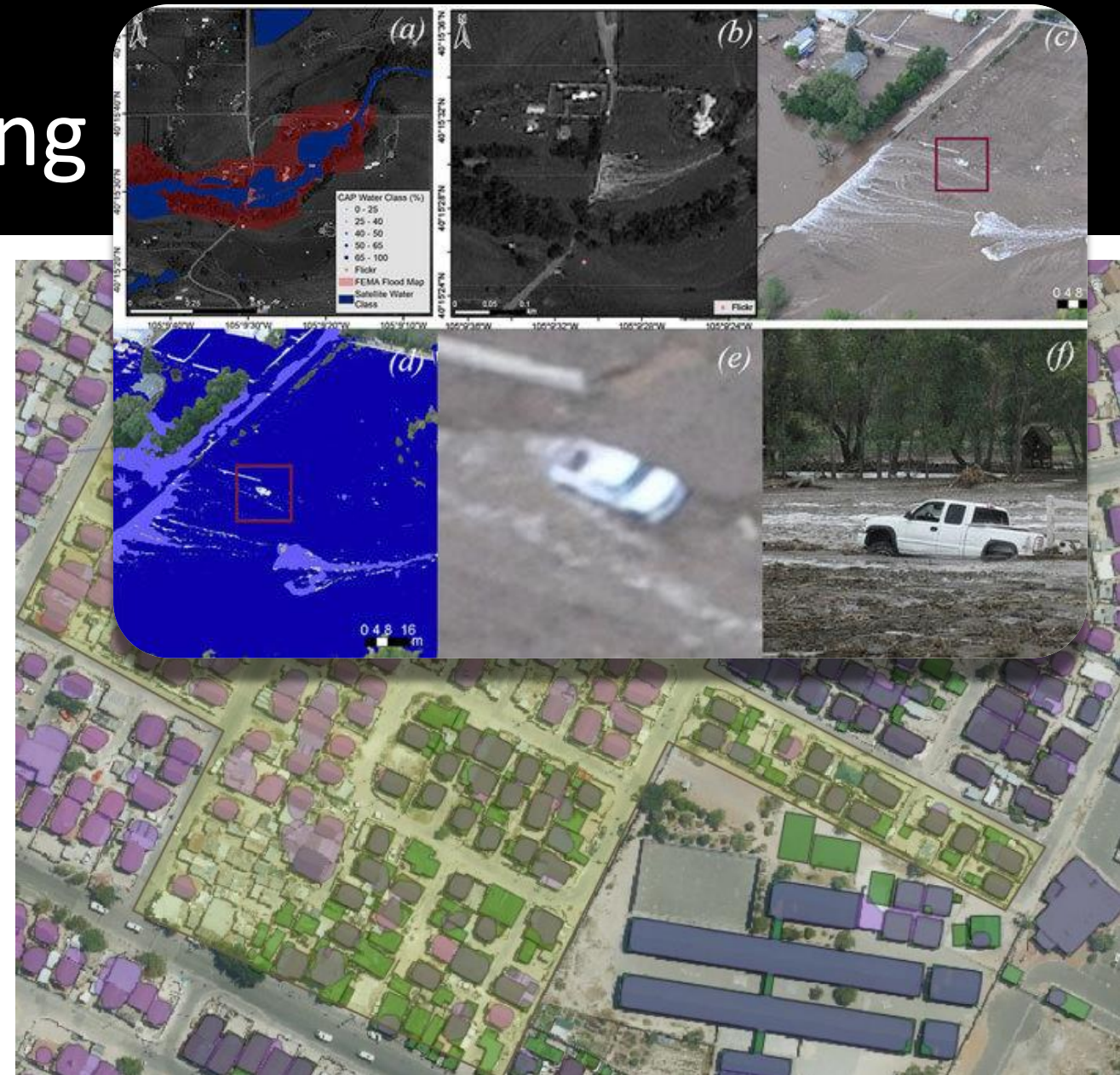
Group Discussion

Advantages, disadvantages and consequences of satellite data for DRF

EVENT – Cyclone Idai – 14 March 2019
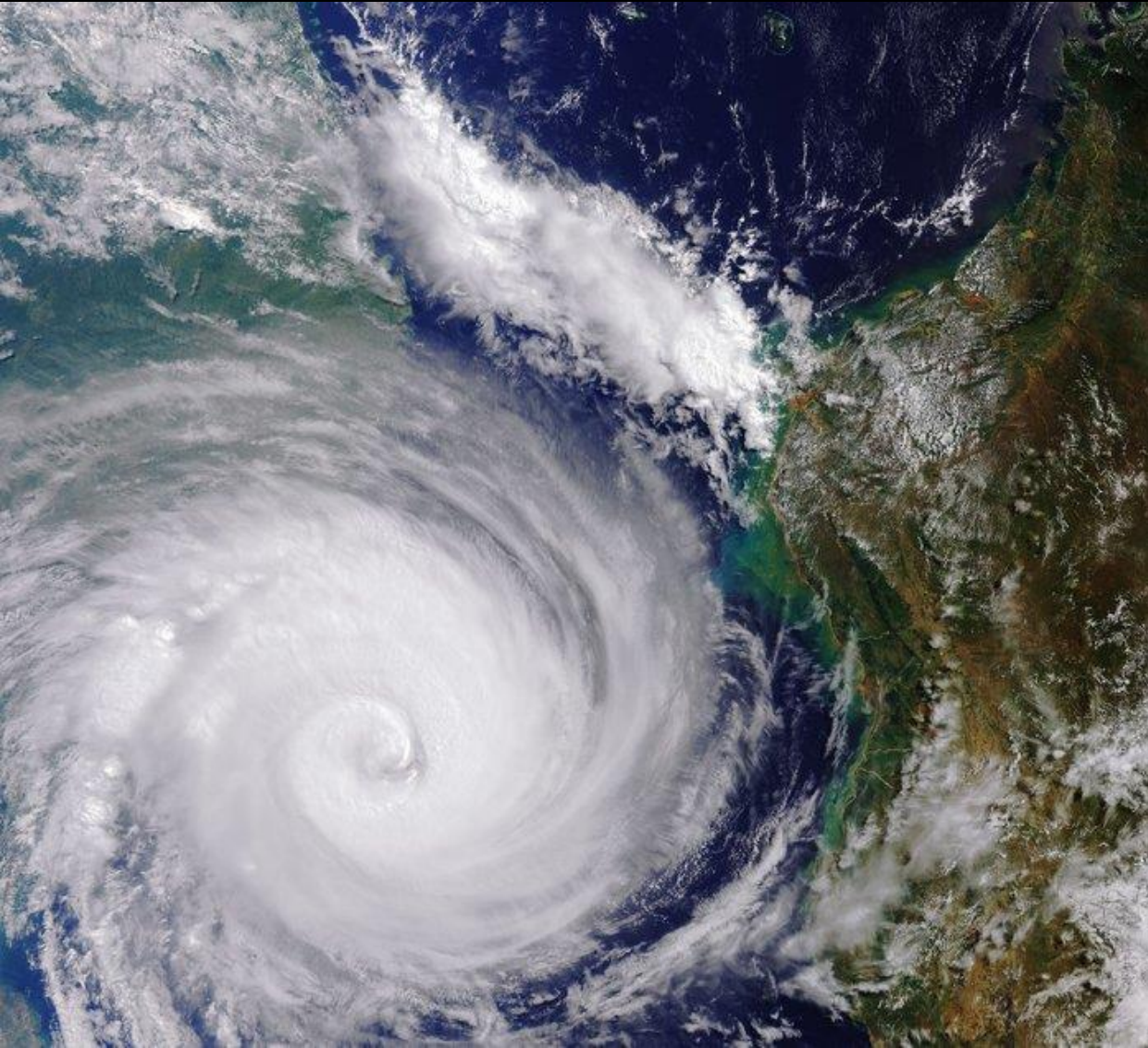
- Idai originated from a tropical depression on 4 March

- Copernicus Sentinel-3 mission shows Cyclone Idai west of Madagascar and heading for Mozambique, Zimbabwe and Malawi

- Width of the storm is around 800–1000 km

- Winds of up to 105mph (170km/h)

- Expected to make landfall 16 March as a Category 4 Tropical Storm

International Disaster Management Cycle

Using satellite data to better analyse and understand the **DRF** implications in each step of the **DRM Cycle**

EVENT

Response

Recovery

Mitigation
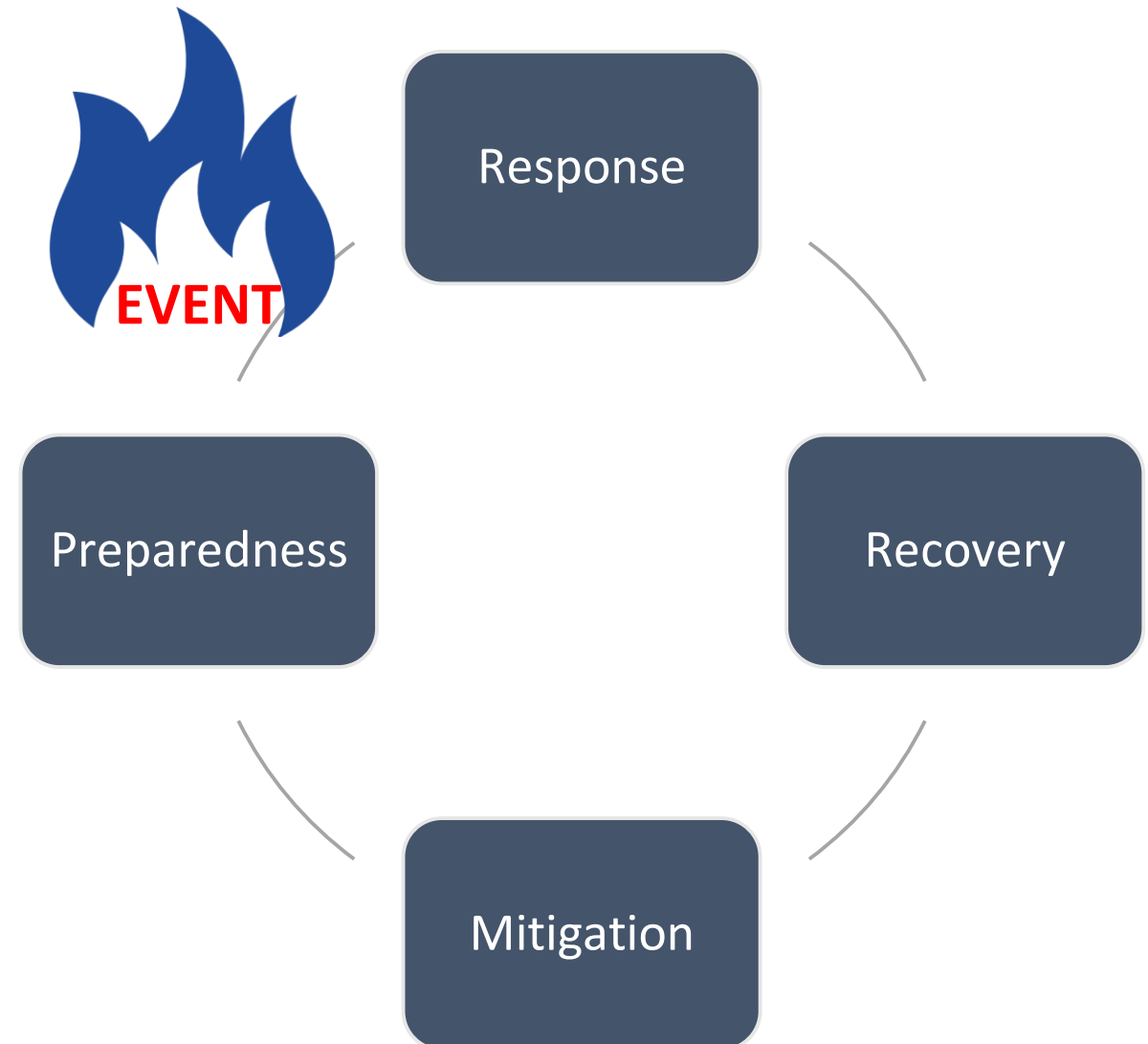
Preparedness

Path of the Storm

PREPAREDNESS
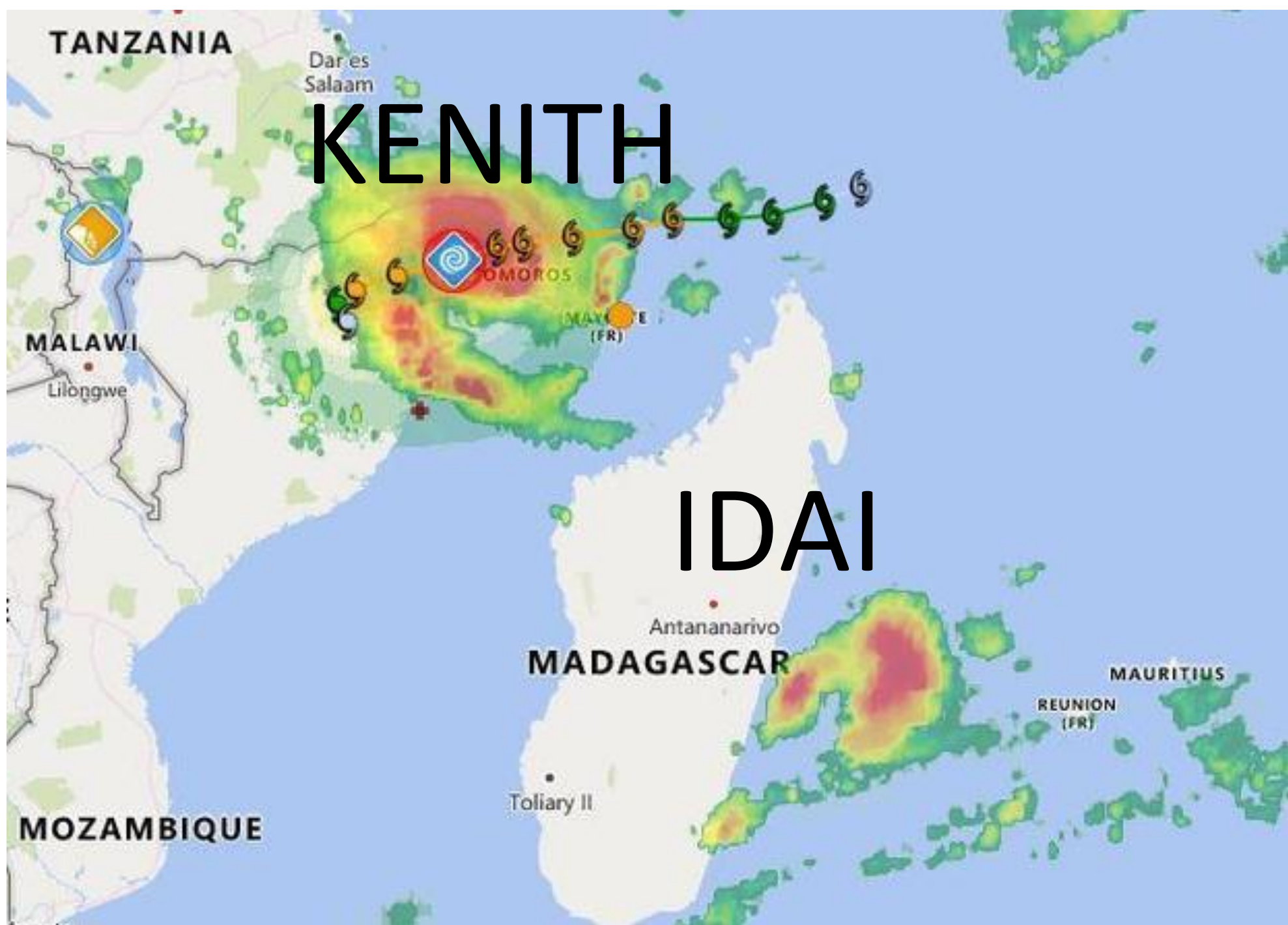
Potential Response

1. Declare State of Emergency
2. Apply via International Charter on Space and Disasters
3. Receive updated satellite data and analysis
4. Provide data and analysis to authorities on the ground to see:
   - How Much Funding is needed
   - What is the affected area (Hazard Mapping)
   - How can you reach the affected area
   - Who are affected
   - How do we evacuate
   - How is the situation changing over time

RECOVERY

2019-03-18 ICEYE-X2

2019-03-19 Sentinel-1

2019-03-20 Sentinel-1

2019-03-23 ALOS-2
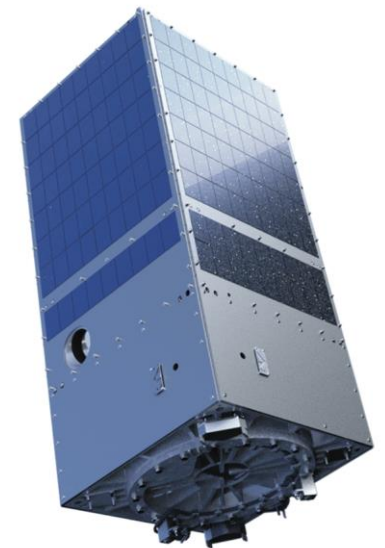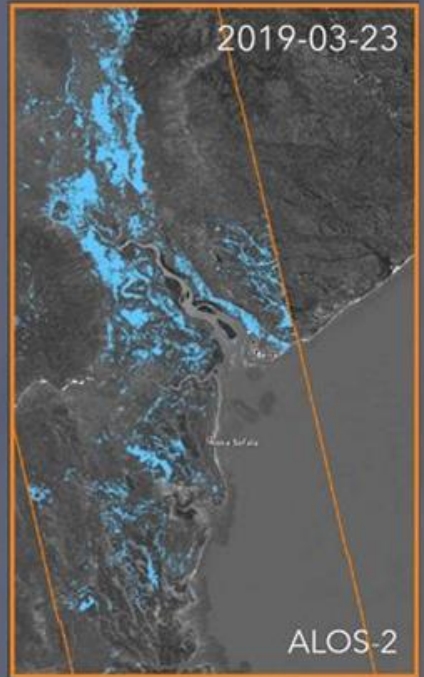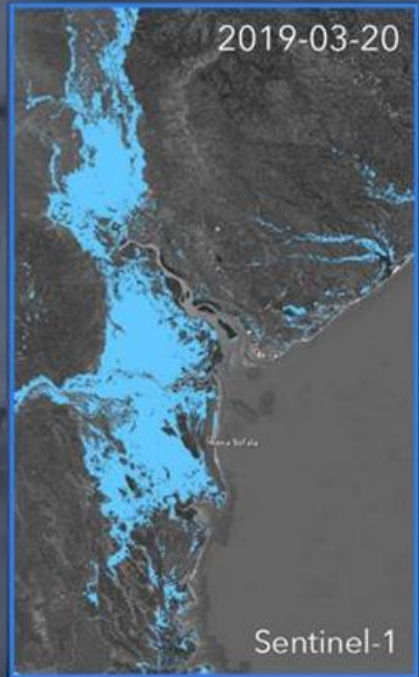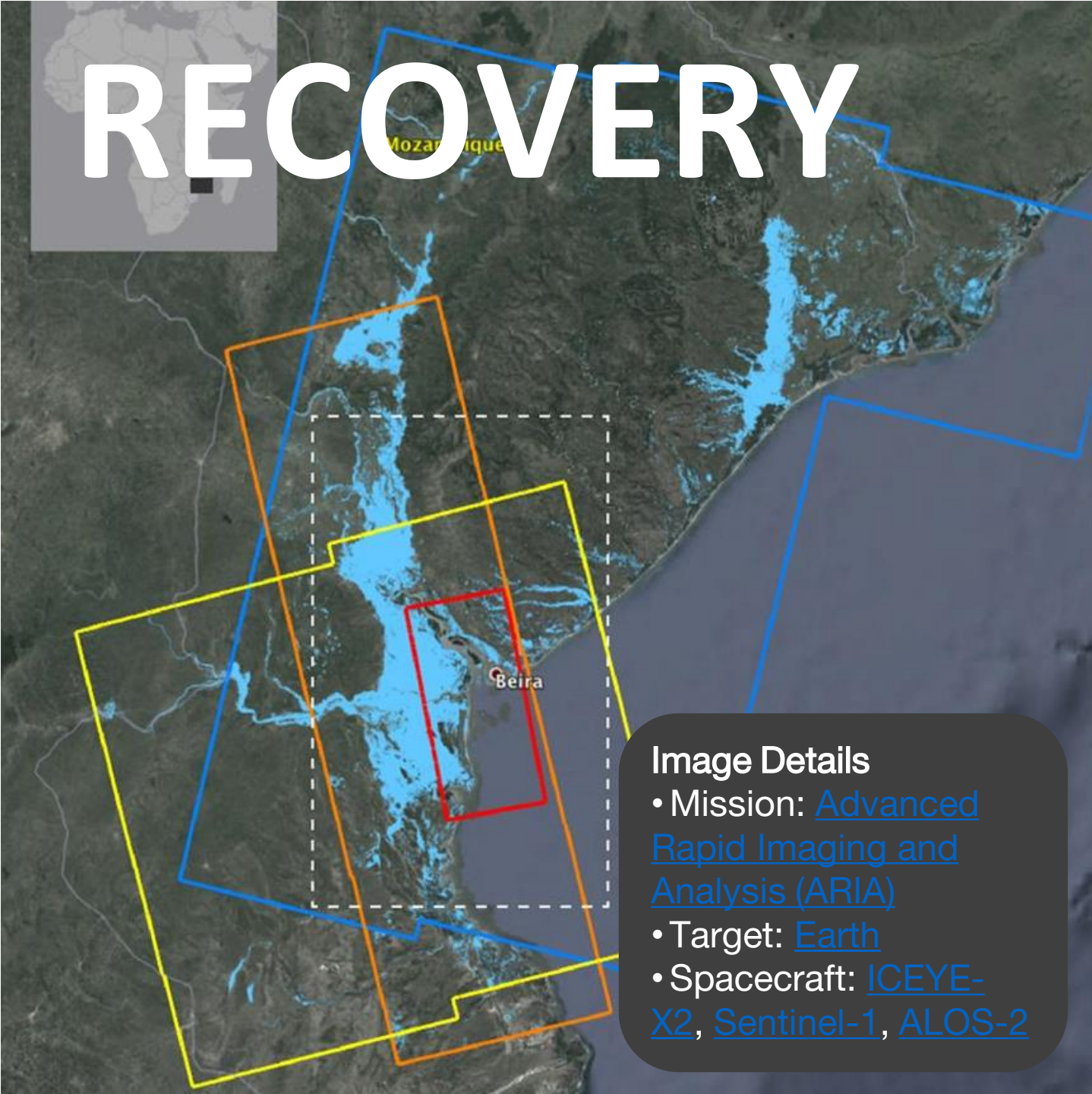
Image Details
• Mission: Advanced Rapid Imaging and Analysis (ARIA)
• Target: Earth
• Spacecraft: ICEYE-X2, Sentinel-1, ALOS-2

Potential Recovery Strategy

1. Review satellite data to find areas for temporary housing, fresh water, safe areas, etc

2. Overview activities aimed at restoring the lives of affected people and the infrastructure that supports them

Drone and Arial Imagery

Pungwe River

Dondo

Beira

Buzi River

N

25 km

Cartographic Information

1:55000

Full color ISO A1, low resolution (100 dpi)

Grid: WGS 1984 UTM Zone 36S map coordinate system
Tick marks: WGS 84 geographical coordinate system

Legend

Crisis Information
Flooded Area
Previous Flooded Area

General Information
Area of Interest

Image Metadata
Image Footprint

Placenames
0 Placename

Built-Up Area
Built-Up Area

Transportation
Airfield runway
Primary Road
Local Road
Dirt Track
Long-distance railway
Airfield runway

Hydrography
Coastline
Area
Stream
Lake
Land Subject to Inundation
River

Facilities
Chemical plant construction and heavy industrial plant

Physiography & Land use - Land Cover
Features available in vector data

Map Information

Tropical Cyclone IDAI made landfall during the night of 14 March at 23:30 UTC close to Beira City in central Mozambique. On 15 March at 00:00 UTC, its centre was located approximately 75 km north-west of the centre of Beira, with maximum sustained winds up to 167 km/h. Heavy rainfall, strong winds and storm surge effected the coastal area of the Beira region, in particular Beira. The JRC estimated a maximum storm surge at height of 2.5 m in the area.

Heavy rainfall, strong winds and severe flood damage have been forecast across several districts in the provinces of Zambezia, Sofala, Manica, Tete and Inhambane and eastern Zimbabwe.

The present map shows the flood in the area of Beira (Mozambique). The thematic layer has been derived from post-event satellite image using a semi-automatic approach. The estimated geometric accuracy is 5 m CE90 or better, from native positional accuracy of the background satellite image.

Relevant date records

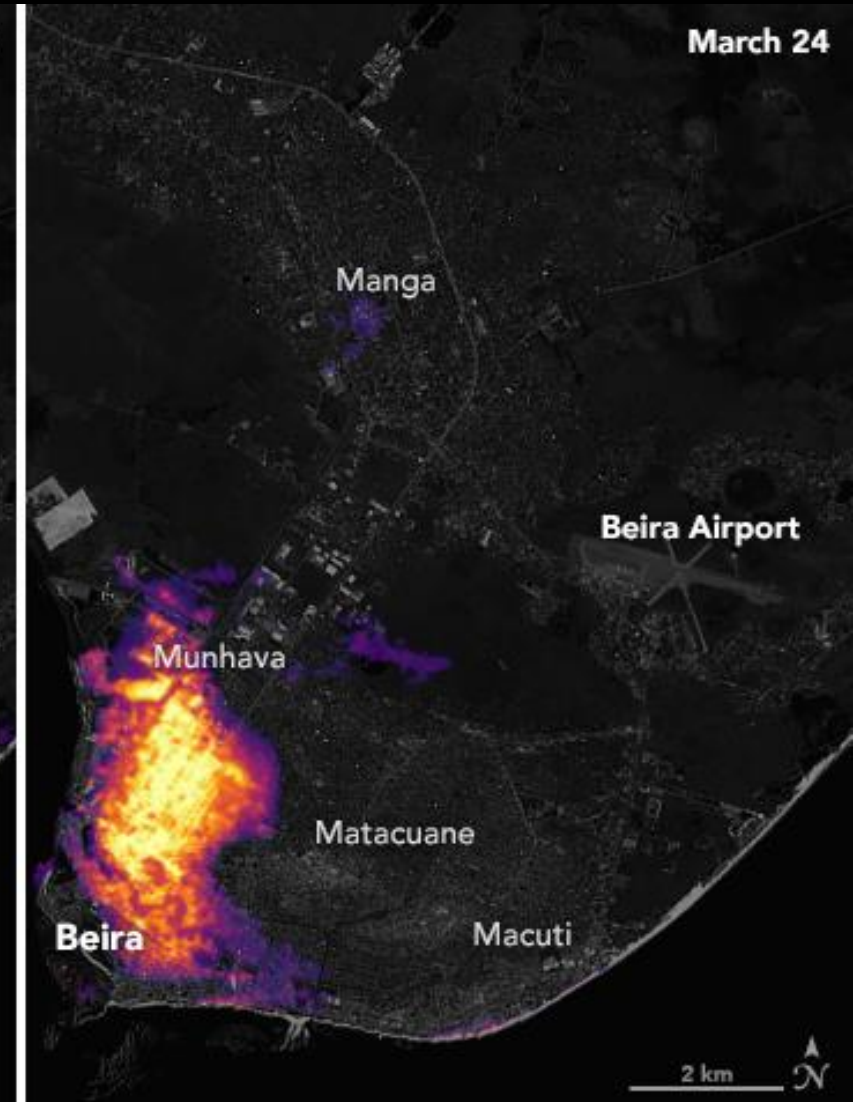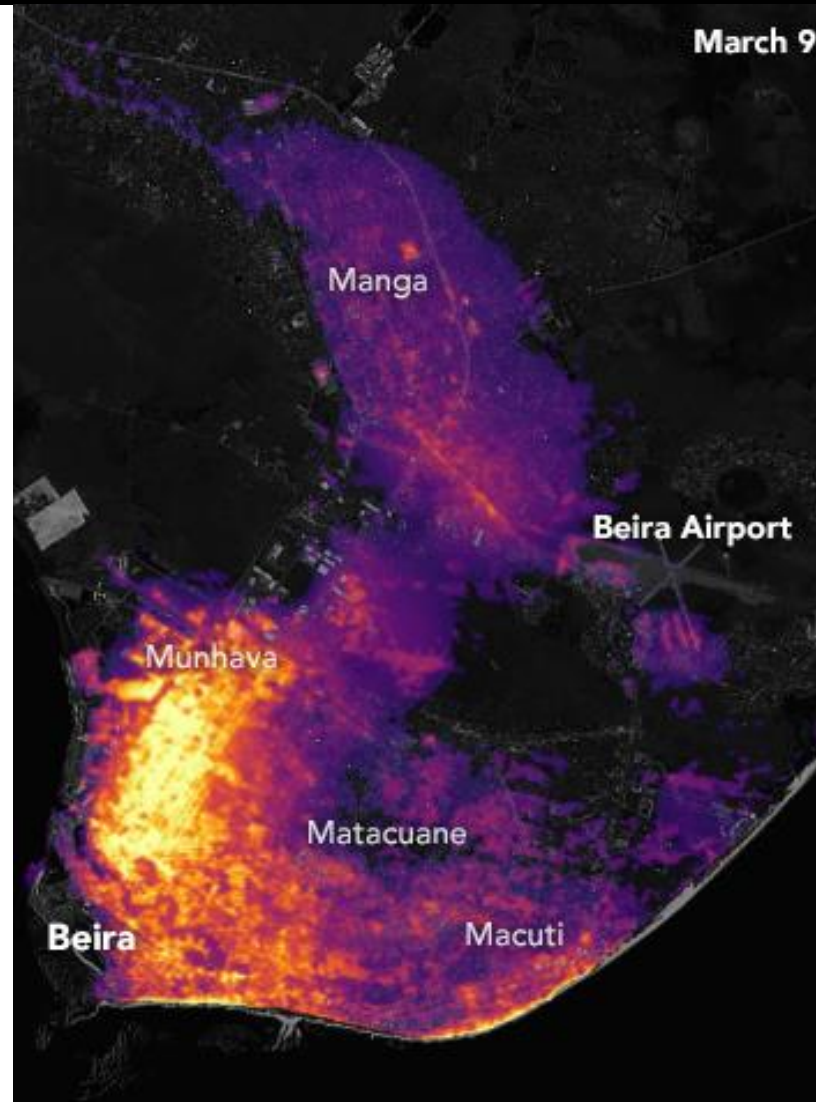| Event			
Event	15/03/2019	Situation as of	19/03/2019
Acquisition	15/03/2019	Map production	19/03/2019

Data Sources

Pre-event image: Sentinel 2D (2019) acquired on 02/2/2019 at 07:32 UTC, GSD 10 m approx. 0% cloud coverage in AoI, provided under COPERNICUS by the European Union and ESA.

Post-event image: COSMO-SkyMed © AGI (2019), distributed by e-GEOS S.p.A. (acquired on 16/03/2019 at 4:41 UTC, GSD 2.5 m), provided under COPERNICUS by the European Union and ESA, all rights reserved.

Sentinel- A/B (2019), acquired on 16/03/2019 at 16:14 UTC, GSD 60 m) provided under COPERNICUS by the European Union and ESA.

Base vector layers: OpenStreetMap © OpenStreetMap contributors www.openstreetmap.org Coordinates 20°S, is held by the producer.
Inset image: JRC 2019 Natural Earth 2012, GeoNames 2013.

Population data: GHS Population Grid © European Commission, 2016 http://data.europa.eu/89h/jrc-ghsl_ghs_pop_gpw4_globe_r2015a. Digital Elevation Model: SRTM (90 m) USGS/NASA/NGA.

Disclaimer

Products elaborated in this Copernicus EMS Rapid Mapping activity are realized to the best of our ability, within a very short time frame, optimizing the available data and information. All geographic information has limitations due to scale, resolution, date and interpretation of the original sources. No liability concerning the contents or the use hereof is assumed by the producer and by the European Union.

Please be aware that the thematic accuracy on satellite is lower in urban and forested areas due to inherent limitations of the SAR analysis technique.

Map produced by GAF AG released by e-GEOS.

For the latest version of this map and related products visit: http://emergency.copernicus.eu/EMSR348

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Copernicus
Europe's eyes on Earth

Example: Satellite-derived night-time light observations

- Monitor displacement via satellite-derived observations of night-time lights

- Spatial extent of power outages can serve as a proxy for disaster impacts

- Estimations of people affected or the coordination of rapid response teams.

Potential Mitigation Strategy

1. Post event review of disaster
   - Eliminate or reduce the probability of disaster occurrence
   - SET UP TRIGGERS FOR FUNDS
   - Review and update building codes; vulnerability analyses updates; zoning and land use management; building use regulations and safety codes; preventive health care; and public education
2. Ease access to quality updated satellite data
3. Update national and regional development planning
4. Potentially set up programs to better collect, exploit, analyse and integrating satellite and drone data

Potential Preparedness Strategy

1. Ensure satisfactory level of readiness to respond to any emergency situation through programs that strengthen the technical and managerial capacity of governments, organizations, and communities

2. Early warning alerts – ALSO FOR FINANCING

3. Ongoing satellite trend analysis

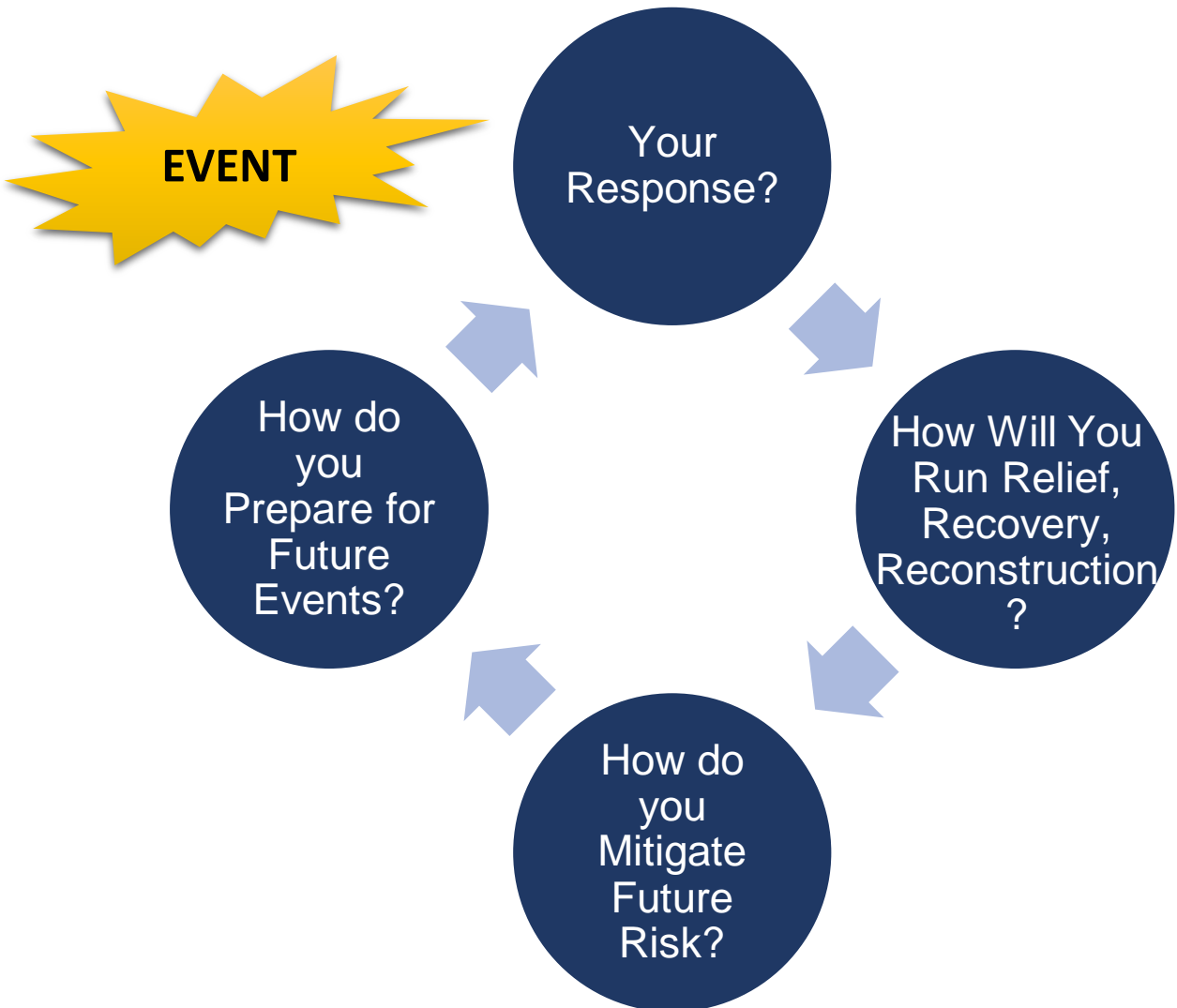4. Machine learning predictive and classification models

Devastating Impact

- Idai caused severe **flooding** in Madagascar, Mozambique, Malawi, and Zimbabwe
- Idai ranks as the second-deadliest tropical cyclone on record (**1300+ fatalities**)
- Hundreds of thousands of people in urgent need of assistance
- A **cholera** outbreak ensued in the storm's wake, with more than 4,000 confirmed cases and seven fatalities by 10 April.
- Over **1,9 million people** still affected by related **drought** and damage to agricultural land

Costliest tropical cyclone in the South-West Indian Ocean basin

Total damages at least **$2.2+ billion**

Group Discussion – 15 Minutes

EVENT

Your Response?

How Will You Run Relief, Recovery, Reconstruction?

How do you Mitigate Future Risk?

How do you Prepare for Future Events?

Choose Hypothetical Disaster in Your Region

Design a DRF Strategy using the DRM Cycle and Satellite Data

Bonus points for best strategies!

Design a DRF Strategy using the DRM Cycle and Satellite Data

1. What Disaster are you preparing for and why?

How Will you use Satellite Data to:

2. RESPOND (Financing, Planning, Timing, etc.)
3. RECOVER (Analysis, Unlocking Funds, etc.)
4. MITIGATE (Planning, Strategies, etc.))
5. PREPARE (Alerts, Financing etc.)

THANK YOU!