

International Collaborations concerning Satellite EO for Natural Hazards and Disaster Response

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→ THE EUROPEAN SPACE AGENCY

Satellite EO & Disaster Risk Management (DRM)

- **Emergency Response,**
 - Rapid Crisis Mapping & Damage Assessment
 - Situation Mapping
 - **Prevention, Preparedness, Recovery, Reconstruction**
 - Detailed Damage Mapping
 - Risks Assessment (Floods, Fires, Geo-Hazards)
 - **All phases**
 - Reference Mapping
 - Digital Elevation and Digital Terrain models,
 - LU/LC cover Mapping
 - Asset Mapping
- DRM : not just emergency response
- Some EO services available **Globally,** Operational/Pre-operational



Operational EO capabilities for Disaster Response:



- The **International Charter Space & Major Disasters**; scope: global
- The **Copernicus Emergency Management Service (CEMS)**; scope: global
- The **UN Satellite Mapping Centre (UNITAR/UNOSAT)**; scope: global
- **Sentinel Asia** (ADRC, JAXA); scope: Asia Pacific Region

Operational EO capabilities for Disaster Response:

- Many programmes and projects, national & international, looking at EO based services for Disaster Risk Resilience in particular Risk Assessment (hydromet, geohazards)
- Innovation: Digital Twin on Extreme Events (observing, modelling, simulating)

Disasters: the International Charter 'Space & Major Disasters'



- An **International agreement among 17 Space Agencies** focused on **supporting** the immediate response phase and services of national **disaster management** centres and the International Humanitarian community (e.g. UN)
- **A unified system of space data acquisition and delivery** for disaster response **at no cost to the user** and on a best effort basis
- **Data delivery** to civil protection agencies, emergency & rescue services including the International Humanitarian Community
- **Universal Access:** nationally mandated users from countries worldwide may apply, provided base criteria are met
- **107 Authorized Users** in **97 countries**
- Operational **24/7** via an on-duty-operator
- **1002 activations in 145 countries** since inception in 2000



Seamless access to data from 270+ satellites



The International Charter in numbers



1035
Activations



146
Countries



270
Satellites



17
Member
Agencies



107
Authorized Users from 97 countries



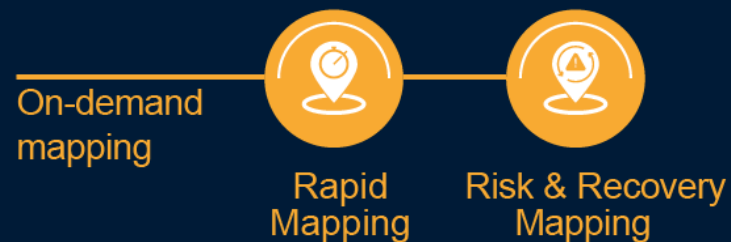
Copernicus Emergency Management Service (CEMS)



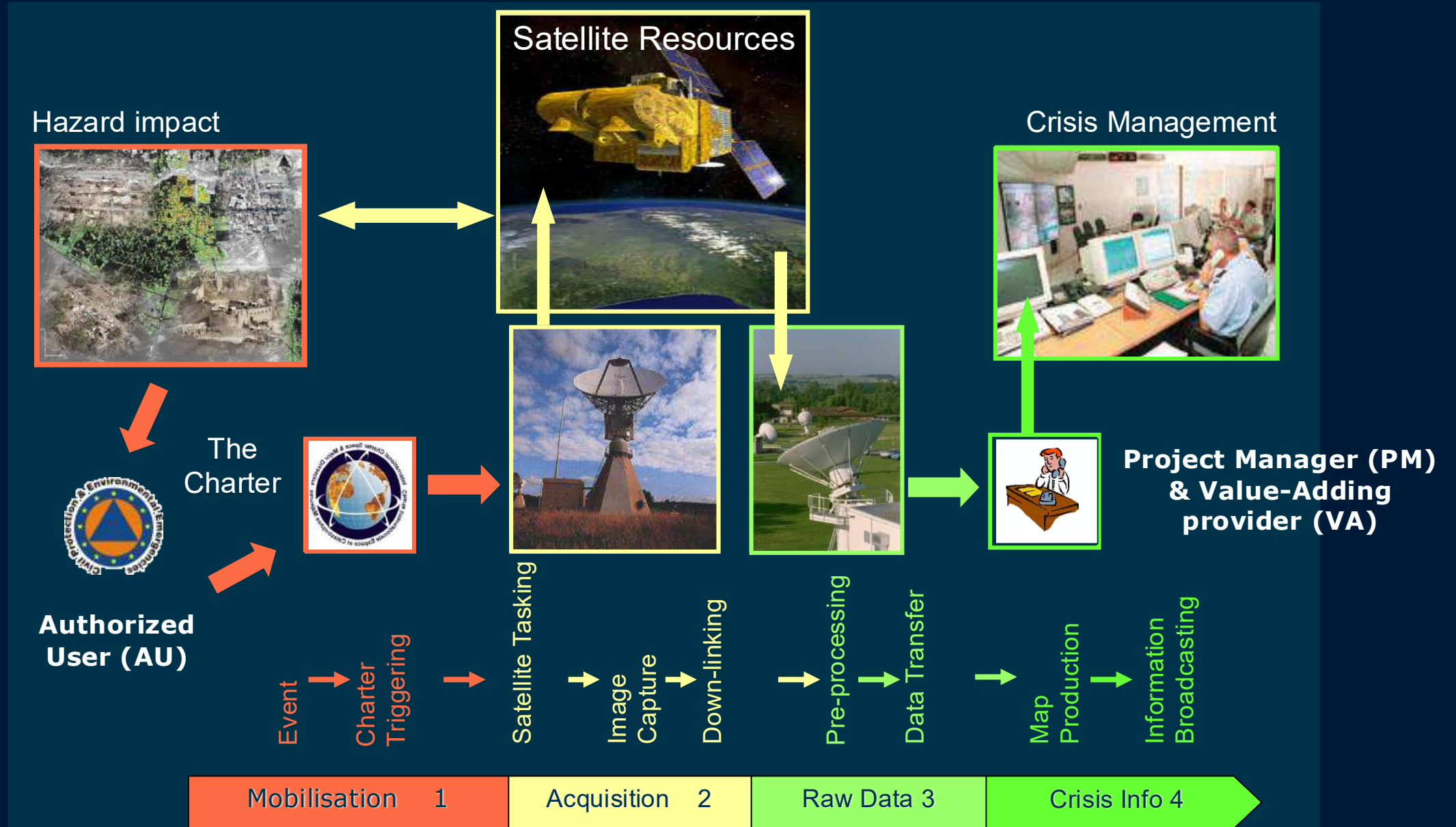
The **CEMS is operational since 2012** and uses satellite imagery and other geospatial data to provide a free of charge mapping service in cases of natural disasters, human-made emergency situations and humanitarian crises worldwide

CEMS services covering different parts of the DRM cycle:

- ✓ CEMS On-Demand Mapping includes **Rapid Mapping** and **Risk and Recovery Mapping**. These are both EO based services.
- ✓ **CEMS and the Charter collaborate** concerning events where the two services are activated. This can be for CEMS activations for Rapid Mapping or Risk and Recovery Mapping.
- ✓ **Exposure Mapping** service; the goal is the periodic production of global geospatial information on human settlements in the form of built-up area grids.
- ✓ **Early Warning and Monitoring** (and alert e.g. GLOFAS): preparatory measures as well as emergency response to predicted and ongoing major events at global scale



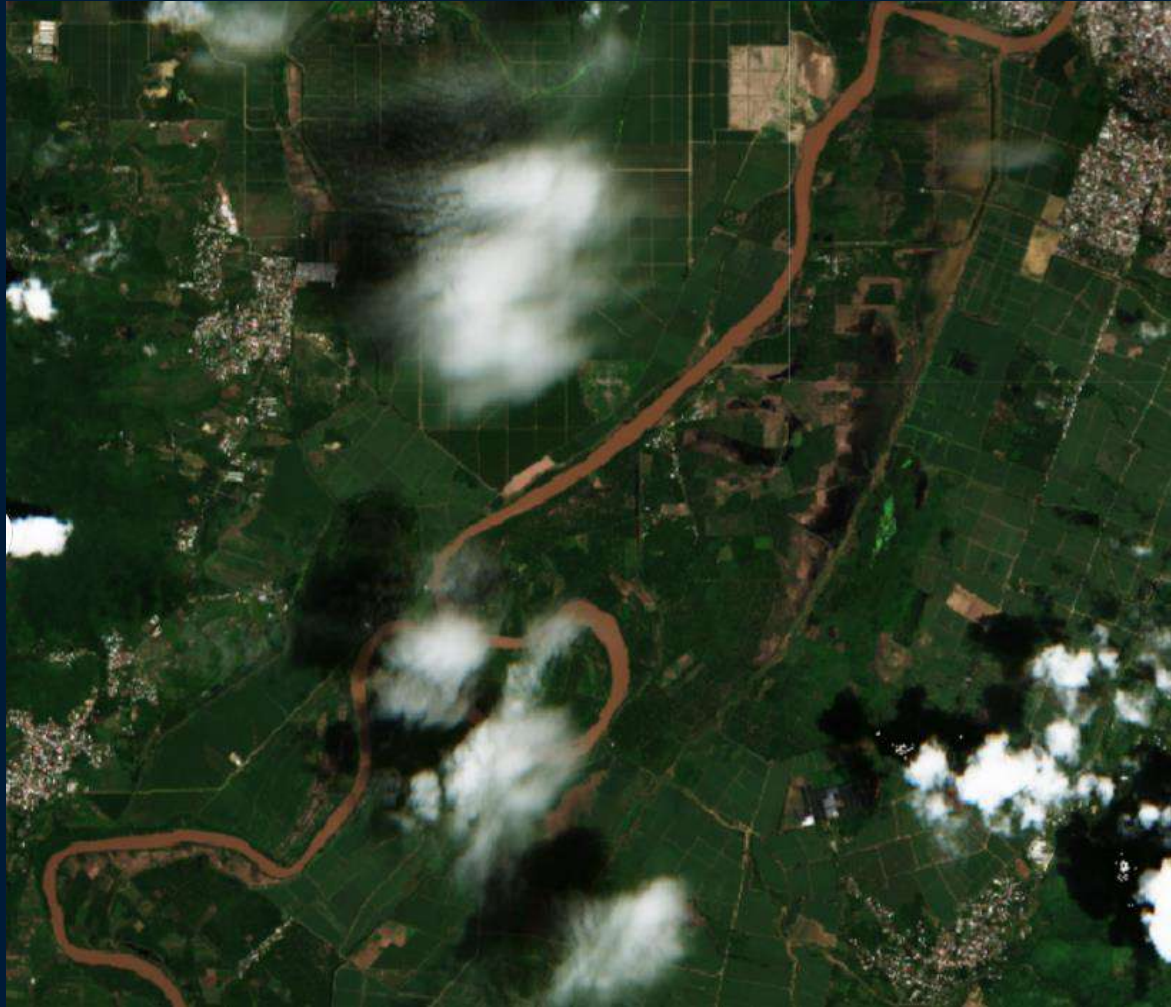
The International Charter operational scheme:



Activation 778: Flood in Honduras

On-line visualization of imagery on the Charter Mapper

Pre-event S2 Image (Sept 13th, 2022)



Post-event S2 Image (Sept 28th, 2022)





ACTIVATION 894

Hurricane Beryl in Jamaica

2 July 2024

AU/CB: **UNITAR**
PM: **UNITAR**
VA: **NOAA**

PM: **UNOSAT**
ECO: **CONAE**

VAPs uploaded: **11**

Services used in the Charter Mapper:

PAN-SHARP
HASARD
SAR-Change
STACK

Data Provided:

AMAZONIA-1: 1	CBERS-4A: 6
SENTINEL-1: 24	SENTINEL-2: 43
GF-1: 16	PNEO: 22
ICEYE: 2	KOMPSAT-5: 136
LANDSAT-8/9: 17	KhalifaSAT: 5
TerraSAR-X: 3	PLEIADES: 47
PLANETSCOPE: 20	US-VHR: 416
RCM: 15	SAOCOM-1: 6

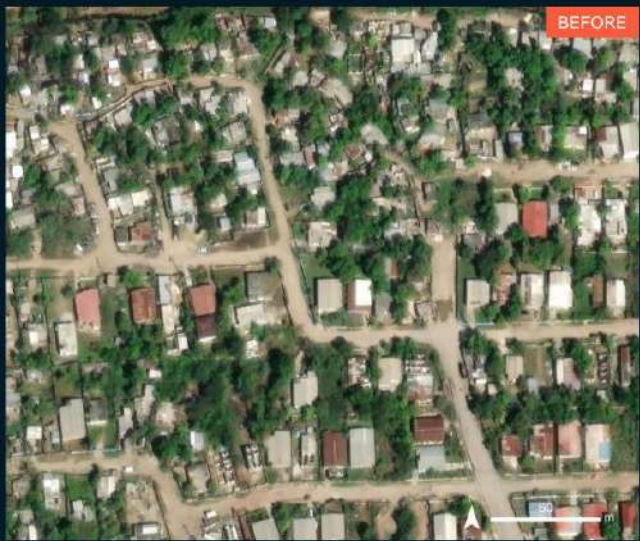
- **Right:** Potentially damaged structures observed in Saint Andrew Parish, Kingston Parish and Saint Catherine Parishes, Jamaica as of 04 July 2024.
- **Left:** Flooded areas, inundated roads and potentially affected structures observed in Saint Andrew Parish as of 04 July 2024.

Copyright: Includes Pleiades Neo material © Airbus DS (2024)
Maps produced by UNITAR / UNOSAT

AOI 4 : New Haven, Saint Andrew Parish, Jamaica

Standing floodwater and affected roads

Image center:
76°51'19"W
18°15'5"N



BEFORE



AFTER

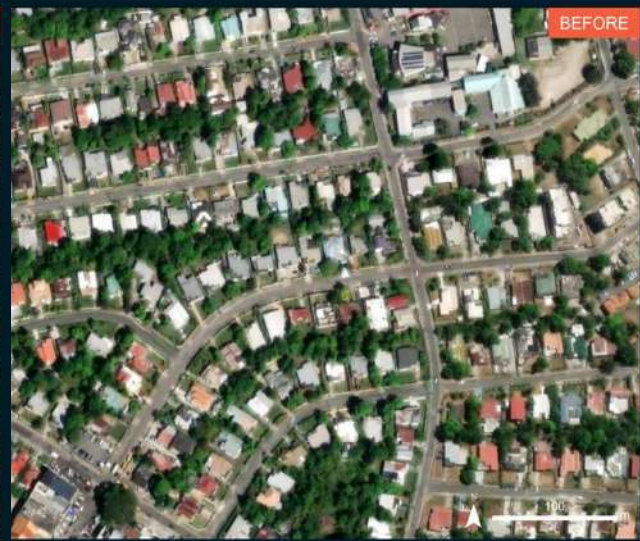
Pleiades NEO / 4 July 2024

WorldView-2 / 17 March 2023

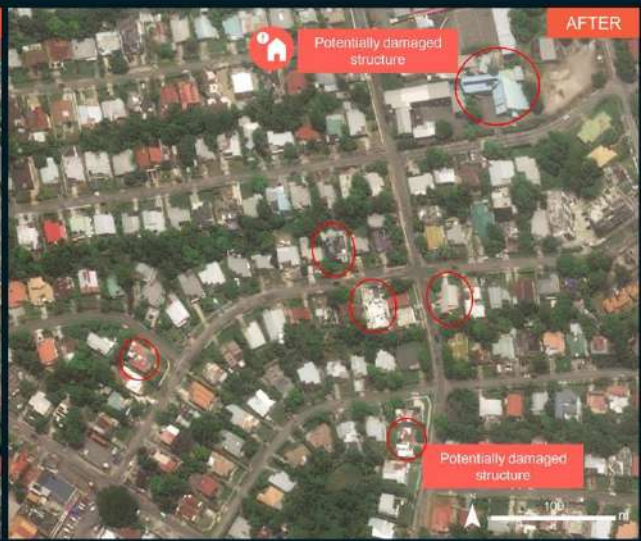
AOI 2 : Meadowbrook, Saint Andrew Parish, Jamaica

Potentially damaged structures

Image center:
76°48'52"W
18°2'48"N



BEFORE



AFTER

Pleiades NEO / 4 July 2024

WorldView-2 / 17 March 2023

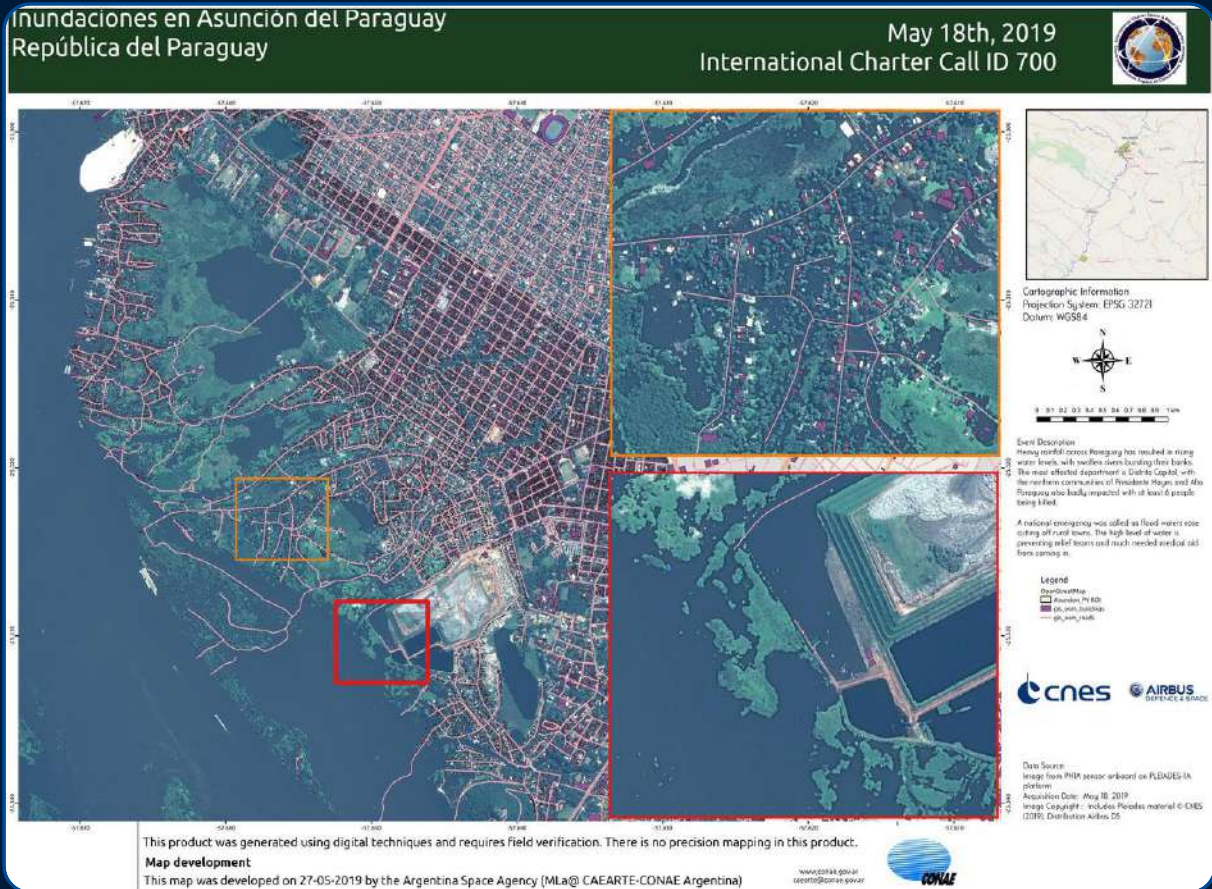


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Feedback from the Authorised User of Paraguay



Paraguay's Secretaria de Emergencia Nacional (SEN) became an Authorized User in 2018. It activated the Charter in 2019 in response to flooding (Image below: Map based on Pleiades data.).



SEN Managers

« all the help and support in our first call from Paraguay, all the information you provided us, is and will be, very useful to help our people that is our main goal »



The International Charter contributes to the **Sendai Framework** for Disaster Risk Reduction Focus on **Disaster Response**

Natural events

- Earthquakes
- Fires
- Floods
- Ice jams
- Landslides
- Tsunamis
- Ocean storms
- Volcanic eruptions



Man-made events

- Oil spills
- Industrial accidents

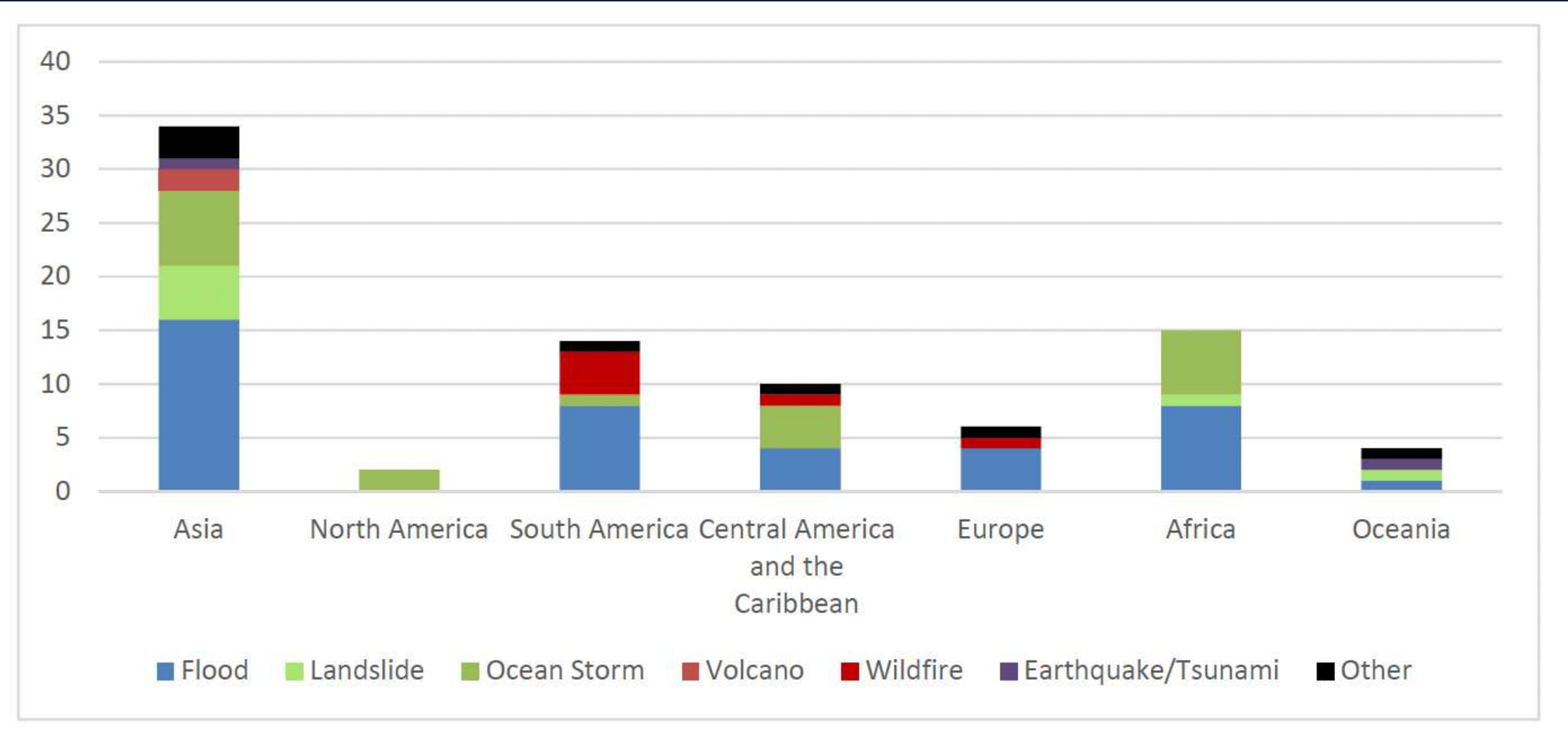


Excluded:

- Conflicts
- Slow-onset events (e.g. Drought)



Types of hazards, situation in 2024



X Emergencies falling out of Charter scope:

Complex emergencies, humanitarian/rescue actions not linked to a specific disaster

❌ Emergencies with doubtful/no benefit from space assets, examples

- Routine epidemiological outbreaks
- Dynamics of the disaster (e.g. some flash flood) too fast (not enough time to task satellites)
- Size of the disaster is not compatible with the resolution of the available satellites.

X Calls beyond emergency period

A Charter call occurring **more than 10 days** after the actual crisis start could be rejected.

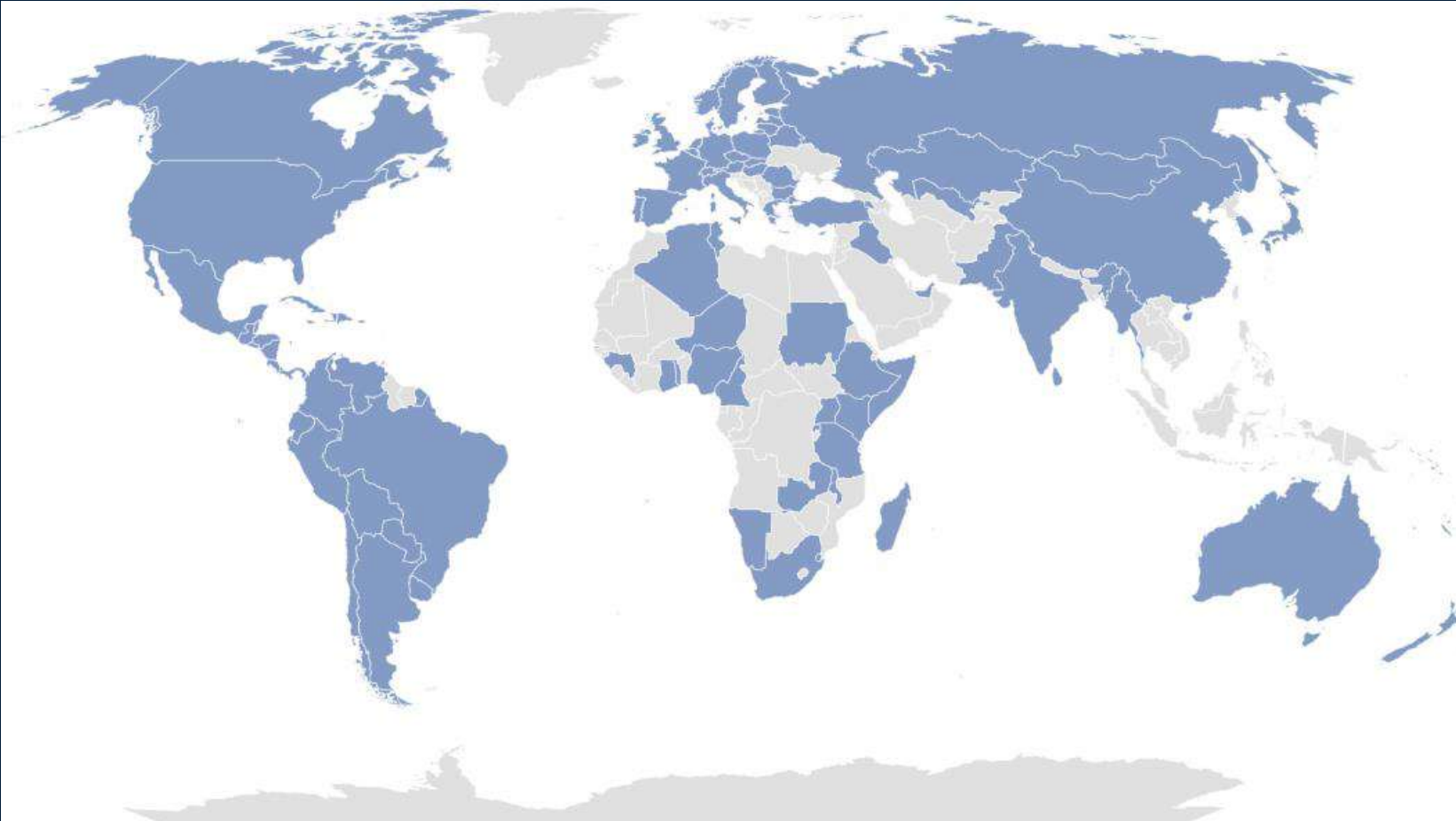
The Charter reserves the right to reject/cancel an activation.

Charter Member Agencies



Authorized Users & Universal Access

Direct access to **nationally mandated** Disaster Risk Management (DRM) organizations in 97 countries, the EU, UN agencies, and the International Red Cross and Red Crescent



Map of **countries with direct access** to the Charter (Blue)

- 107 organizations in 96 countries have direct access to the Charter
- 56 of these organizations have been granted Authorized User status through the *Universal Access* initiative

Key Interfaces in the Charter



- **Authorized User:** The organization who has the right to submit requests and be recipients of Charter results.*
e.g. National Director of the National System of Emergencies (SINAE), Uruguay
- **End User:** An organization which asks the AU to trigger the Charter on its behalf (could be of another Country). It is expected that the end user will use the products during the emergency response phase.
- e.g. Fire and Rescue Force of Uruguay

**In some cases, Authorized Users are not recipient of the Charter results and only submit requests on behalf of an end user. In other cases the Authorized and End Users are identical.*

Collaboration with the UN



UNOOSA / UN-SPIDER:

- **Charter Cooperating Body since 2004**, UNOOSA is, granted the privilege to act as gateway for requests submission on behalf of UN users related to humanitarian actions and to promote the Charter.
- **Since 2018, UNOOSA can trigger the Charter** on behalf of national disaster management authorities in countries that are not yet Charter Authorised Users.



ESA staff plus Terradue and ACRI-ST led a 3-day training in July 2023 including the ESA Charter Mapper Organized by UNOOSA, UN-SPIDER, The University of Bonn, and The German Space Agency (DLR)

UNITAR/UNOSAT:

- **Since 2009**, granted the privilege to act as gateway for requests submission on behalf of UN users.
- **Since 2017**, UNOSAT can trigger the Charter on behalf of national Red Cross or Red Crescent users.



Technical Meeting concerning the use of the Charter Mapper to generate VA products Organized by LIST and ESA with UNOSAT



Evolution of space technology to better support DRM:



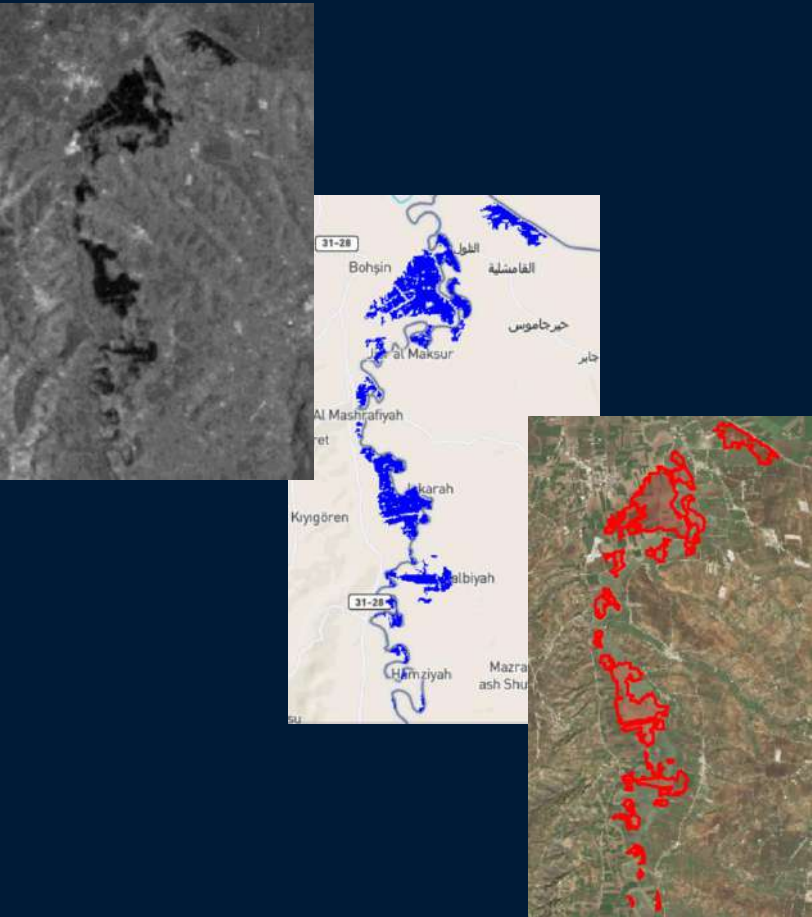
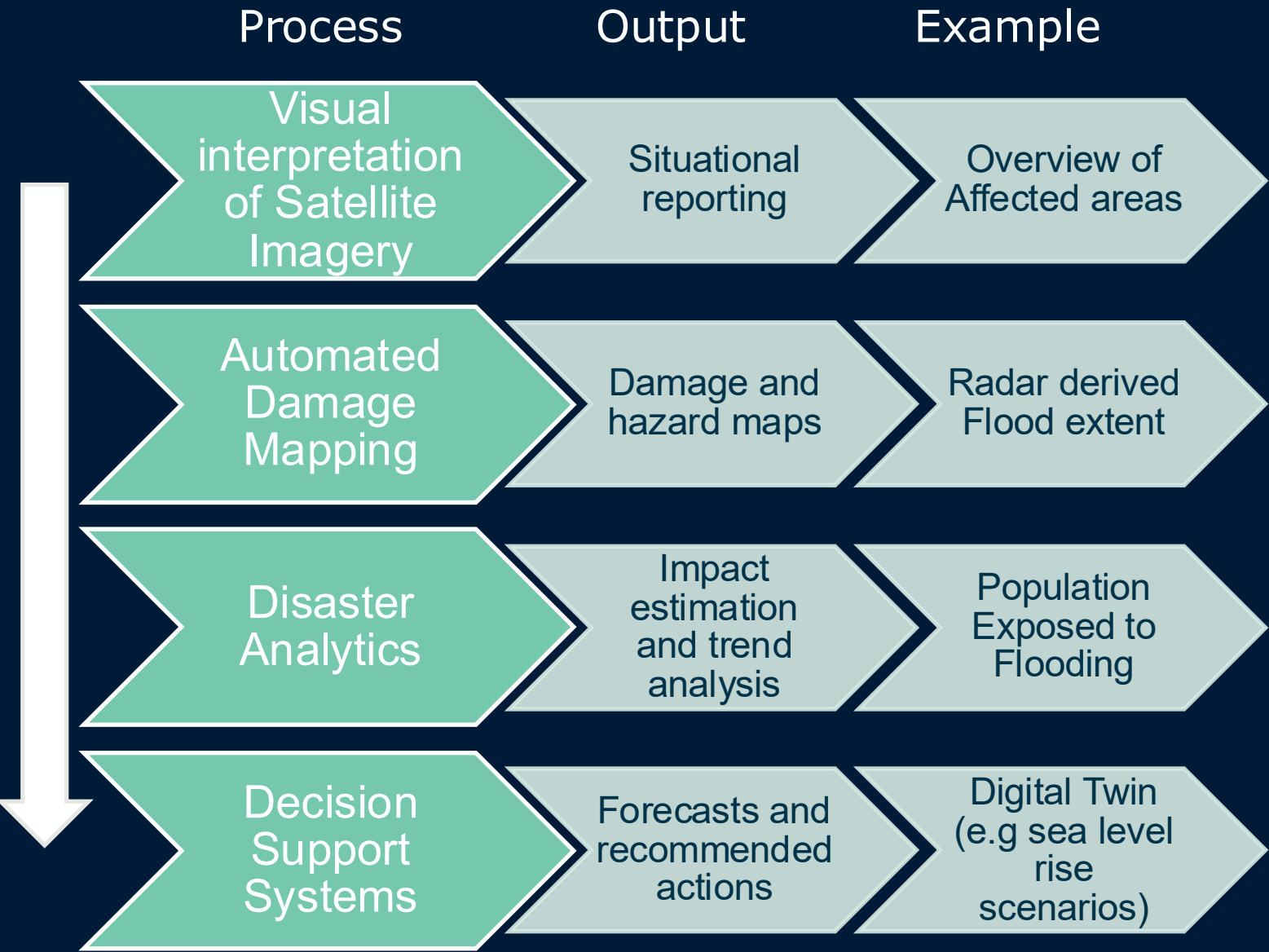
Overall EO for Disaster response has evolved from an availability problem to a usability problem.

Critical challenges currently affecting the Humanitarian Aid community (UN Crisis, Humanitarian Reset).

Areas of technical improvements:

- Increase **timeliness** with more EO missions (current)
- Increase **timeliness with new EO missions** (designed for NRT data delivery)
- Reduce **processing time** (by operating services on-line and with automated Value Adding service chains)
- Reduce **cost** (on-line platforms)
- Improve **accuracy & reliability** (portability of VA services)

Current information retrieval techniques/automation

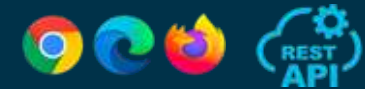


SAR image -> Processing result -> Vector analytics



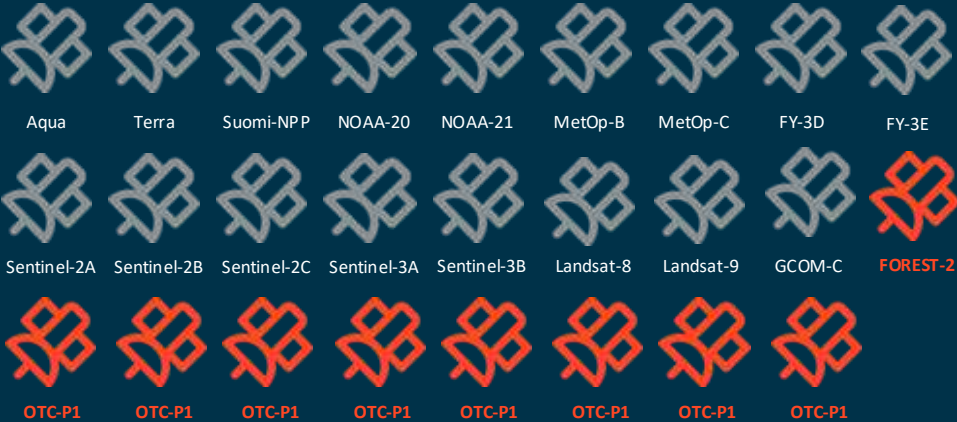
New EO missions : example with OroraTech

Continuous Active Fire Product



Live

LEO



GEO



Aggregation of Over 30+ Satellites for Global Monitoring

-  3rd party missions 2020-2026
-  OroraTech's Constellation (OTC-P1) from 2026

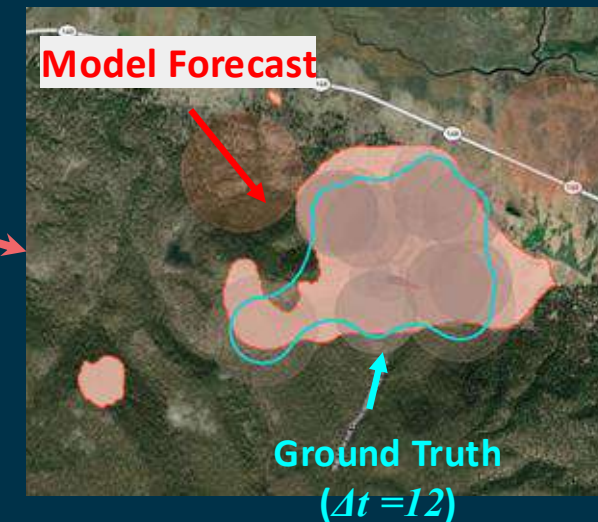
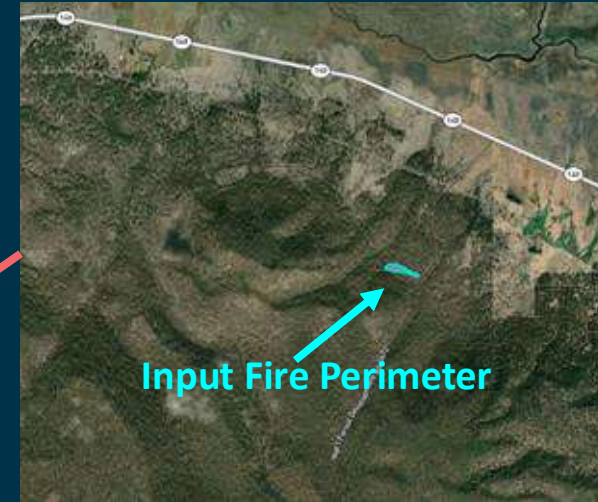
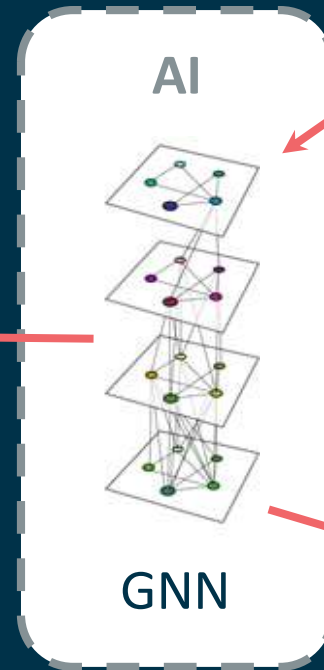
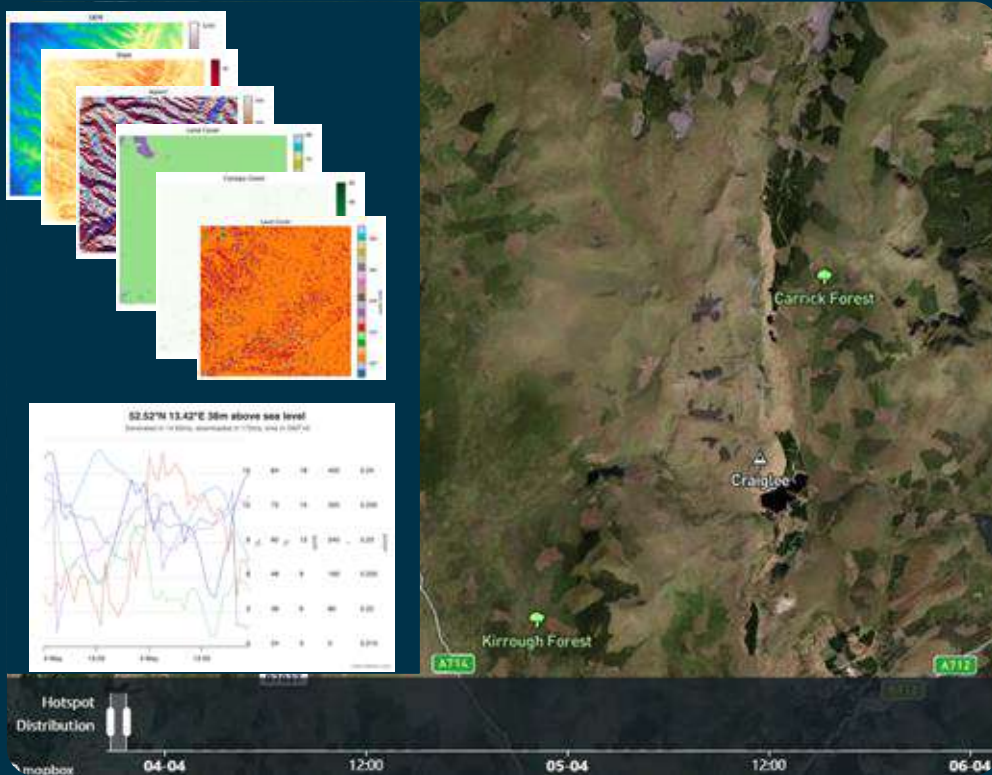
OroraTech



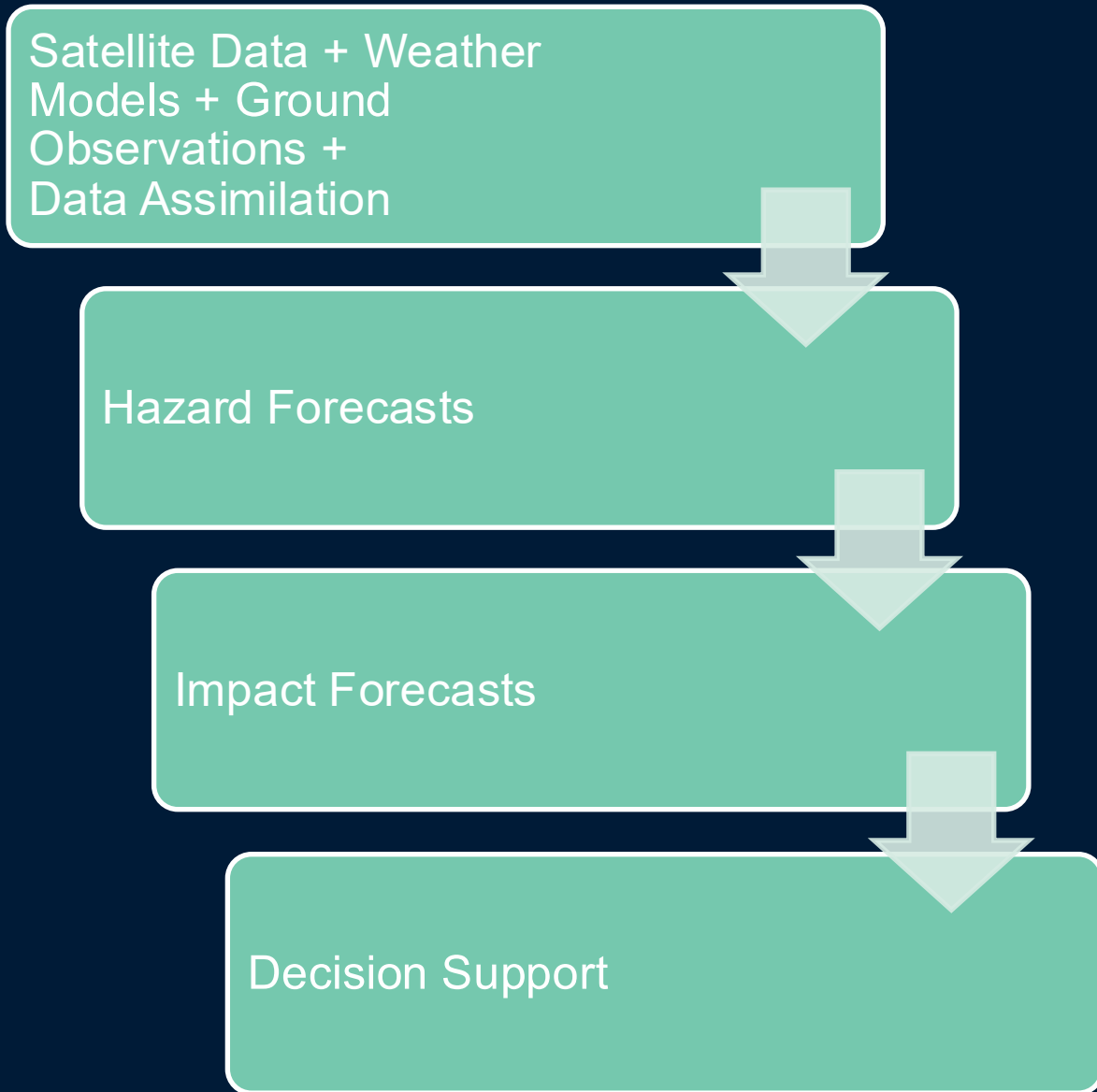
Using AI & EO for predicting Fire Spread (FIRE-AID)

Spatio-temporal Graph Neural Network

Learning Fire Behavior from observed fire propagation data



Integrating EO Data with Models



New systems move from mapping what has happened to simulating what could happen in what-if scenarios; primarily for risk mitigation; also relevant for impact forecasting purposes.

Digital Twins are Virtual representations of specific Earth systems which can be continuously updated using observations and models to be used to predict a disaster outcome given a future scenario.

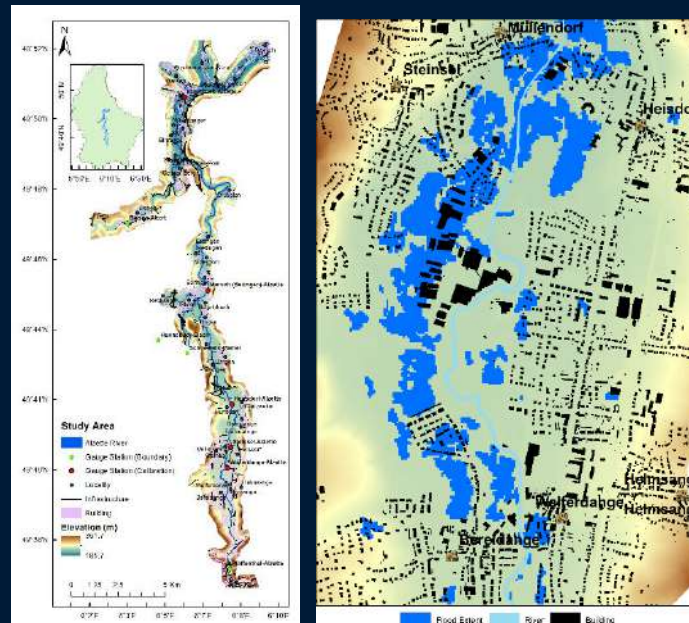


Objective

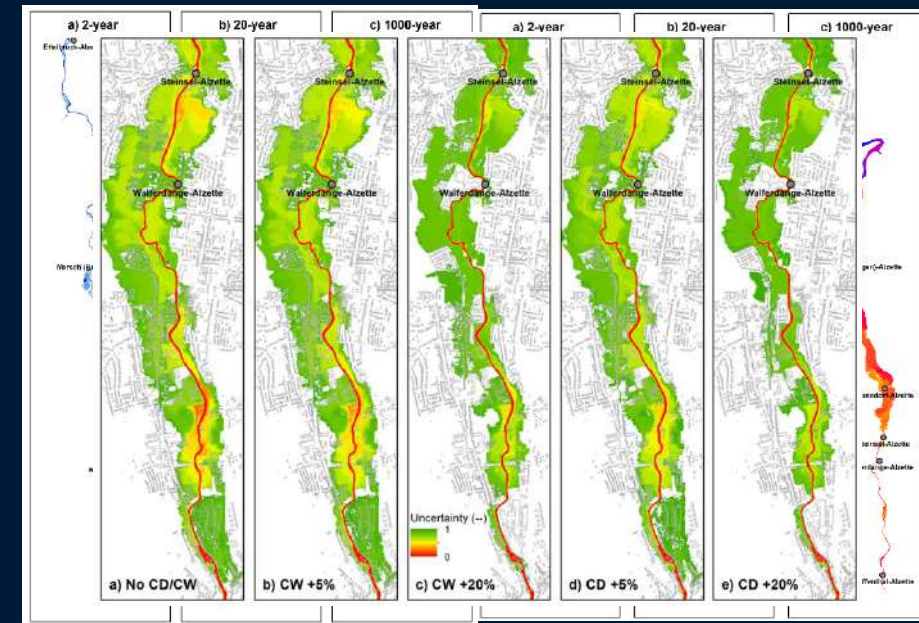
- ## Study Area

-
- ```
graph TD
 EOData((EO Data)) --> SoilMoisture[Soil Moisture]
 EOData --> CITYWATCH[CITYWATCH]
 EOData --> HASARD[HASARD]
 CITYWATCH --> BuildingMaps[Building Maps]
 HASARD --> FloodExtentMaps[Flood Extent Maps]
 SoilMoisture --> RainfallRunoff[Rainfall-runoff Model (SUPERFLEX)]
 BuildingMaps --> HydraulicModel[Hydraulic Model (LISFLOOD-FP)]
 FloodExtentMaps --> HydraulicModel
 RCMs[Regional Climate Models (RCMs)] --> RainfallRunoff
 RainfallRunoff --> HydraulicModel
 RainfallRunoff --> ReturnPeriods[Return Periods]
 GaugeStations((Gauge Stations)) --> RainfallRunoff
 GaugeStations --> HydraulicModel
 RiverGeometry((River Geometry)) --> HydraulicModel
 RiverGeometry --> RiverConveyance[River Conveyance]
 RCPs[RCPs] --> WhatIfScenarios[What-if Scenarios]
 ReturnPeriods --> WhatIfScenarios
 RiverConveyance --> WhatIfScenarios
 RCMs --> WhatIfScenarios
 WhatIfScenarios --> ScenarioMaps[Scenario Maps]
 ScenarioMaps --> ImpactAssessment[Impact Assessment Model]
 ImpactAssessment --> HazardMaps[Hazard Maps]
 HazardMaps --> FinalOutput[]
```

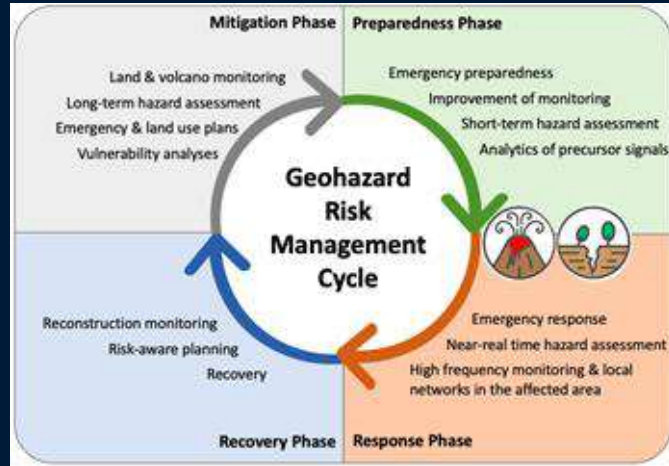
## LISFLOOD-FP hydraulic model (zoomed-in over urban area)



## Climate Change & "What-if" Scenarios



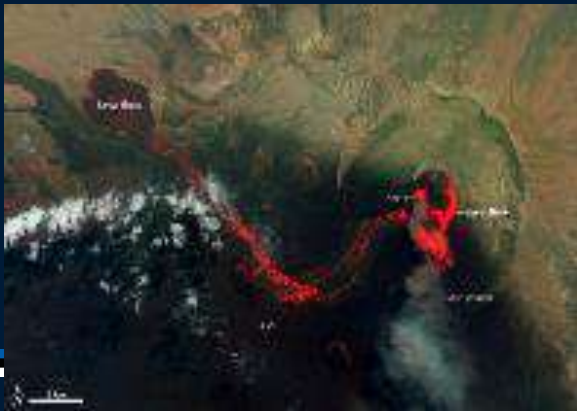
# A Digital Twin on EO & Geohazards:



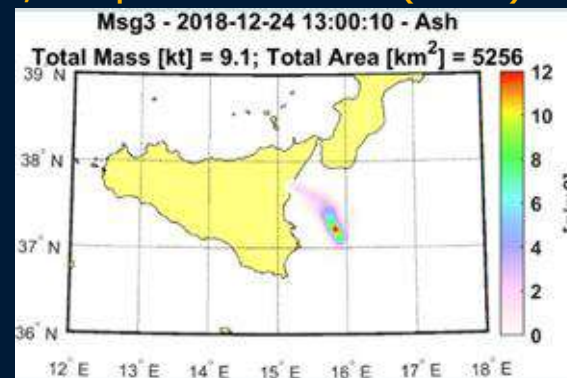
The Geohazard DTC led by INGV (IT) is addressing strategies to mitigate the geohazard risk associated to **volcanic & seismic phenomena**, using EO data and modelling.

## EO-derived products are effective in monitoring and operational applications

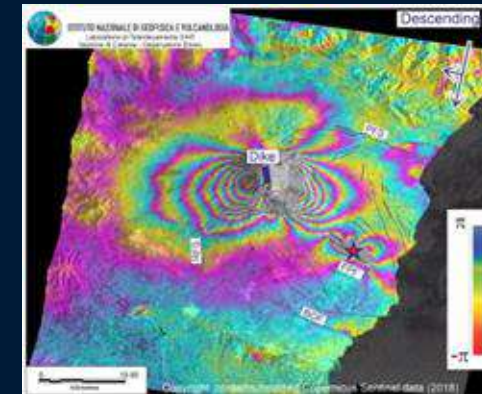
Thermal imaging of active lava domes and lava flows



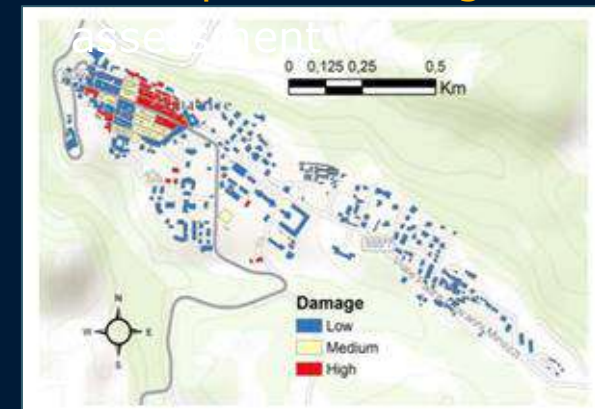
Volcanic ash and gas clouds detection & retrieval, sulphur dioxide (SO<sub>2</sub>) flux rates



Ground deformation mapping



Earthquake Damage



# Take home message

- Earth observation is **evolving from providing snapshots of events toward delivering actionable intelligence** that supports decision-making before, during, and after disasters.
- The future value of EO lies not only in **observing hazards, but in continuously updating predictive models** with near-real-time observations
- Future disaster management systems may move from mapping what has happened to simulating what could happen and identifying the **most effective options concerning risk mitigation**.
- Note that this evolution is not replacing rapid mapping services but augmenting them with predictive and impact-based capabilities



# Thank you

[www.esa.int](http://www.esa.int)