

United Nations Workshop on Space-based Technologies for Disaster Risk Reduction

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# **Analysis of the activations of the selected satellite-based emergency mapping mechanisms**



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# Outline

- CEU and PhD research project
- Satellite-based emergency mapping (SEM) mechanisms
- Coverage of the SEM mechanisms
- Activations of the SEM mechanisms
- Network visualization
- Bipartite network projection
- Conclusions and next steps

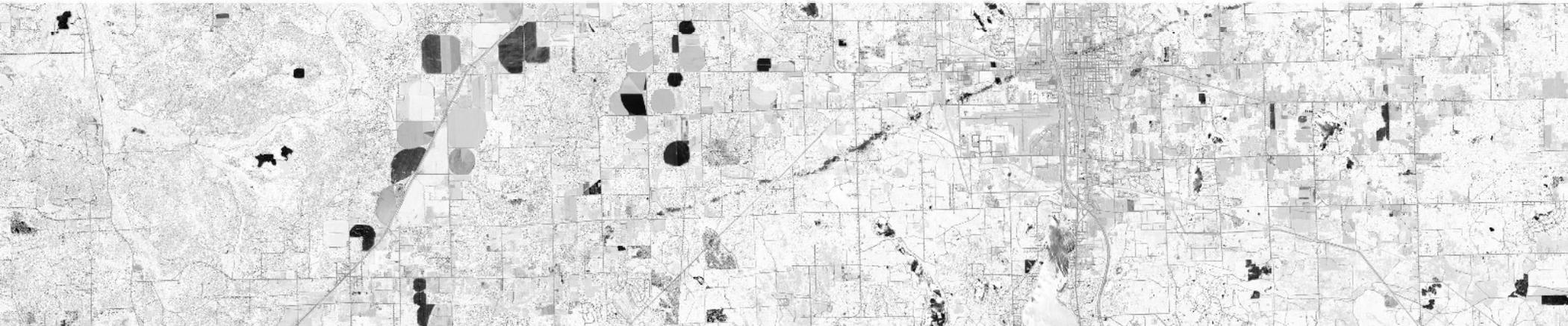


# Central European University

Environmental Systems Laboratory

# Problem

A mismatch between the availability / potential benefits of modern space-based technologies and their practical application.



## **Global implementation mechanisms**

- International frameworks for disaster risk reduction and management
- Satellite-based emergency mapping (SEM) mechanisms
- Global capacity building initiatives – UN-SPIDER

# Satellite-based emergency mapping mechanisms

Over the past 20 years, scientists and disaster responders have increasingly used satellite-based Earth observations for global rapid assessment of disaster situations. There is a number of international mechanisms providing space-based information for disaster response:

- International Charter “Space and Major Disasters” (active since 2000)
- Sentinel Asia (since 2007)
- Copernicus Emergency Management Service (since 2012, plus its previous phase - since 2005)
- UNITAR Operational Satellite Applications Programme (UNOSAT) (since 2003)



## Selected SEM mechanisms

Datasets of activations of the 3 selected satellite-based emergency mapping (SEM) mechanisms for the 2000-2020 period:

- **International Charter “Space and Major Disasters”** (692 activations)
- **Copernicus Emergency Management Service** (447 activations)
- **Sentinel Asia** (342 activations)





## What is the Charter?

- An International agreement among participating Agencies to provide space-based data and information in support of response efforts during emergencies caused by major disasters.
- The Charter brings together efficient space-based technologies to support disaster management.
- The Charter's capacities can be activated through a single access point which is available 24 hours, seven days a week.

Space agencies contribute through:

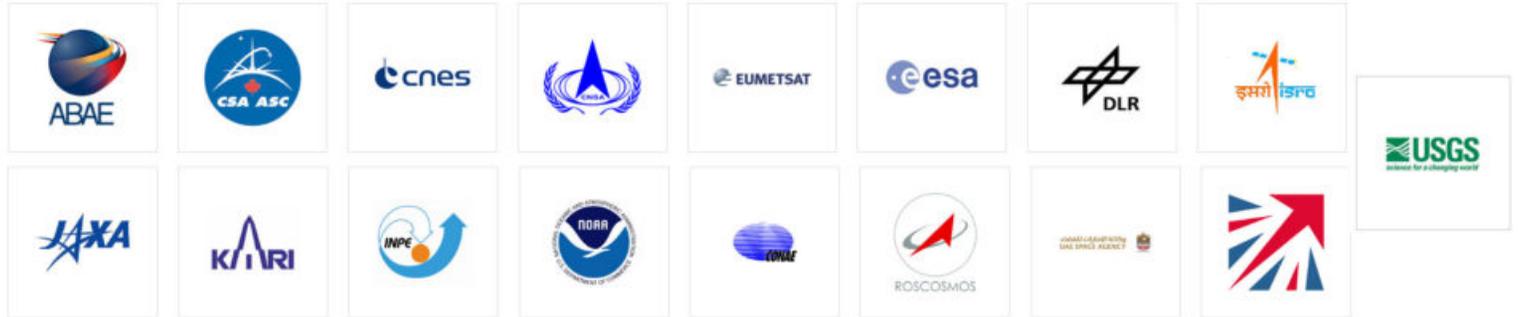
- **Priority satellite tasking**
- Archive Retrievals
- Organization of map production

**No cost for  
the User!**

<https://disasterscharter.org/web/guest/home>

# Composition of the Charter

## CHARTER MEMBERS



## CHARTER PARTNERS



## AUTHORIZED USERS

# What is Copernicus?

## European Union Earth Observation and Monitoring Programme



Atmosphere



Marine



Land



Climate Change



Security



Emergency

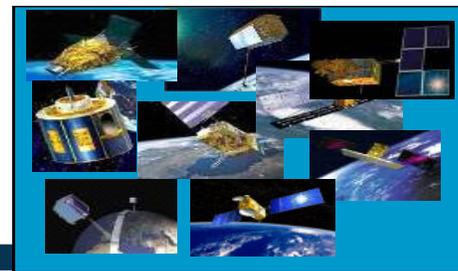


Sentinels

6 services use Earth Observation data to deliver  
...



...added-value products



Contributing missions

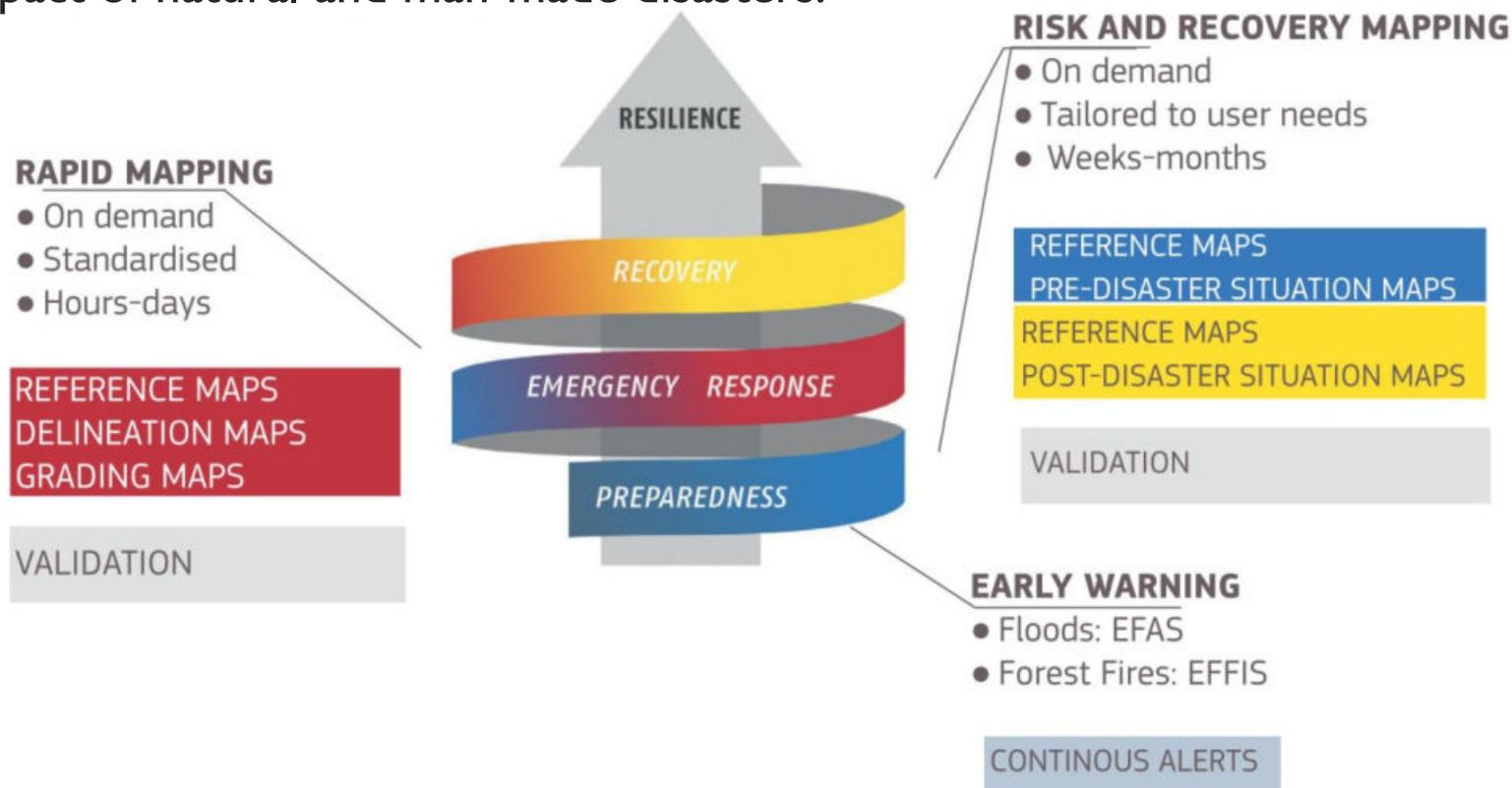


in-situ

# Copernicus Emergency Management Service (EMS) overview

Supports all phases of the disaster management cycle (during, before, after):

- Warnings & risk assessments for floods and forest fires.
- Information on the impact of natural and man-made disasters.



<https://emergency.copernicus.eu/>

## What is Sentinel Asia?

Sentinel Asia is a voluntary initiative by a collaboration between **space agencies** and **disaster management agencies**, applying remote sensing and Web-GIS technologies to assist disaster management in the Asia-Pacific region (only natural disasters).

In Oct 2005, at the 12th Session of the Asia-Pacific Regional Space Agency Forum (APRSAF), the plan to initiate the pilot project was approved.

In Feb 2006, Joint Project Team (JPT) was organized and Sentinel Asia has started.



<https://sentinel-asia.org/#>



Members – 112 organizations in total:

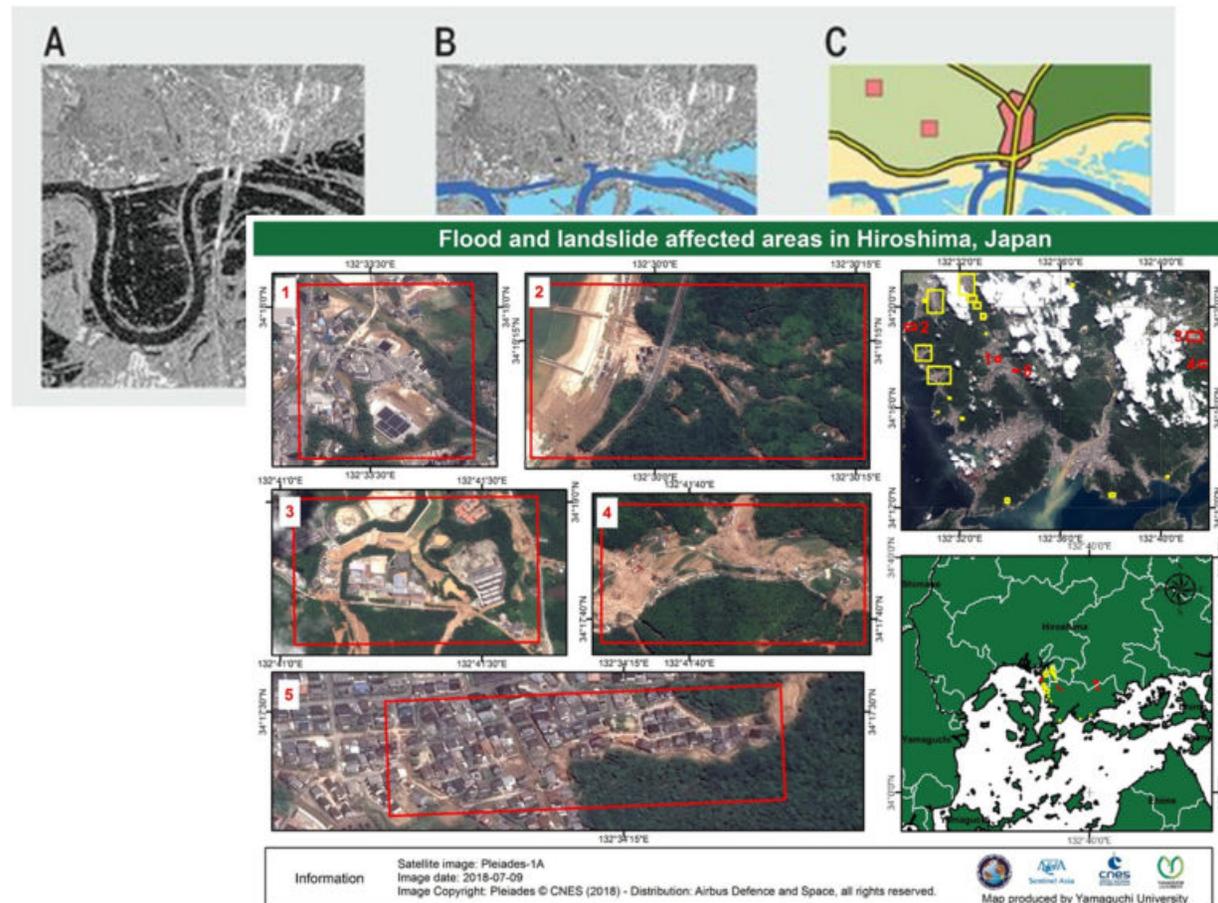
- 95 organizations from 29 countries & regions
  - 17 international organizations
- + Asian Disaster Reduction Center (ADRC) member countries

Different types of members:

- Data Provider Node (DPN)
- Data Analysis Node (DAN)



# Satellite-based emergency mapping mechanisms



The only bodies authorized to **directly** request the Charter to be activated are the **Authorized Users - AUs** (typically civil protection agencies, governmental relief organizations, or other authorities with a mandate related to disaster management)

In dark blue – countries with direct access to the Charter as of February 2022

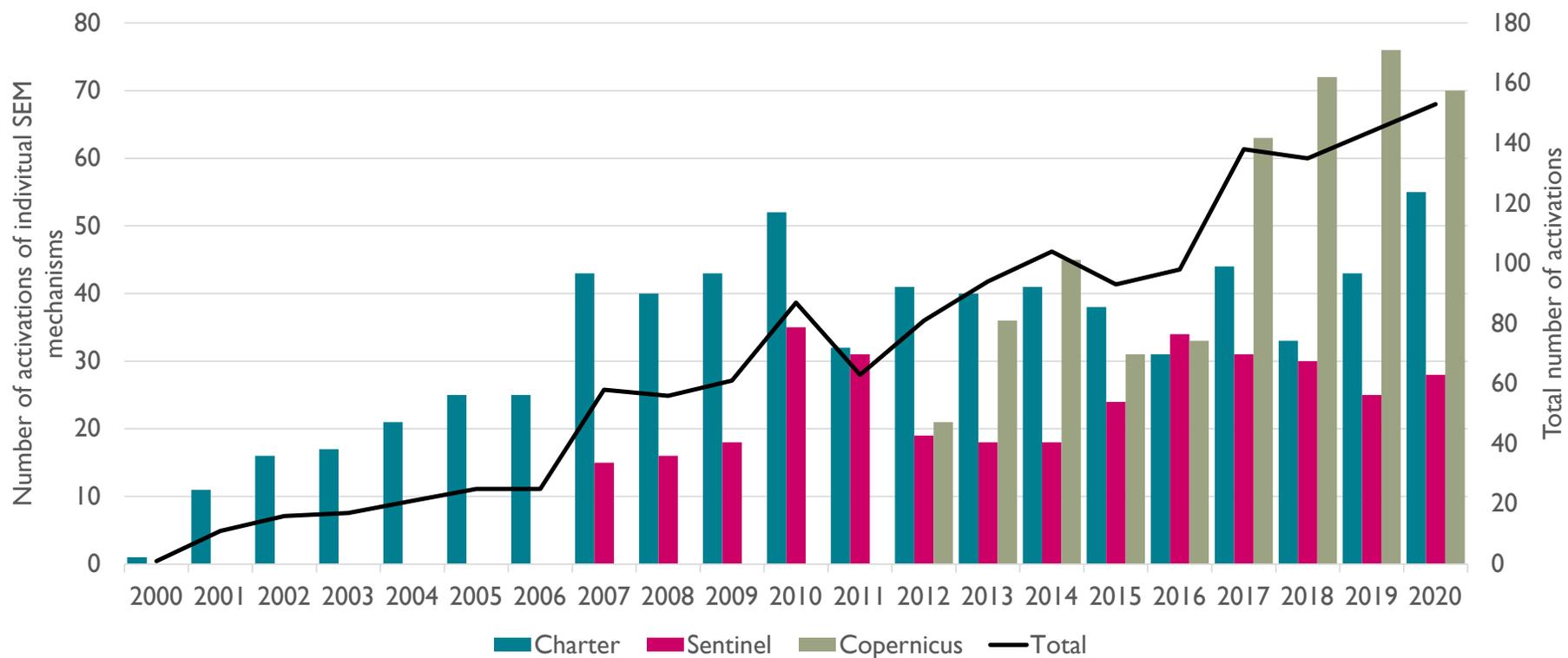




## **Gaps in direct access to the selected SEM mechanisms**

- 93 countries and territories currently have direct access to at least one of the three initiatives.
- This leaves a significant number of countries in Africa, as well as many in the Middle East, Pacific, Central America and the Caribbean, and Western Balkan not being directly involved in such initiatives.
- Such gaps still can be covered by indirect access, as well as by the United Nations mapping initiatives.

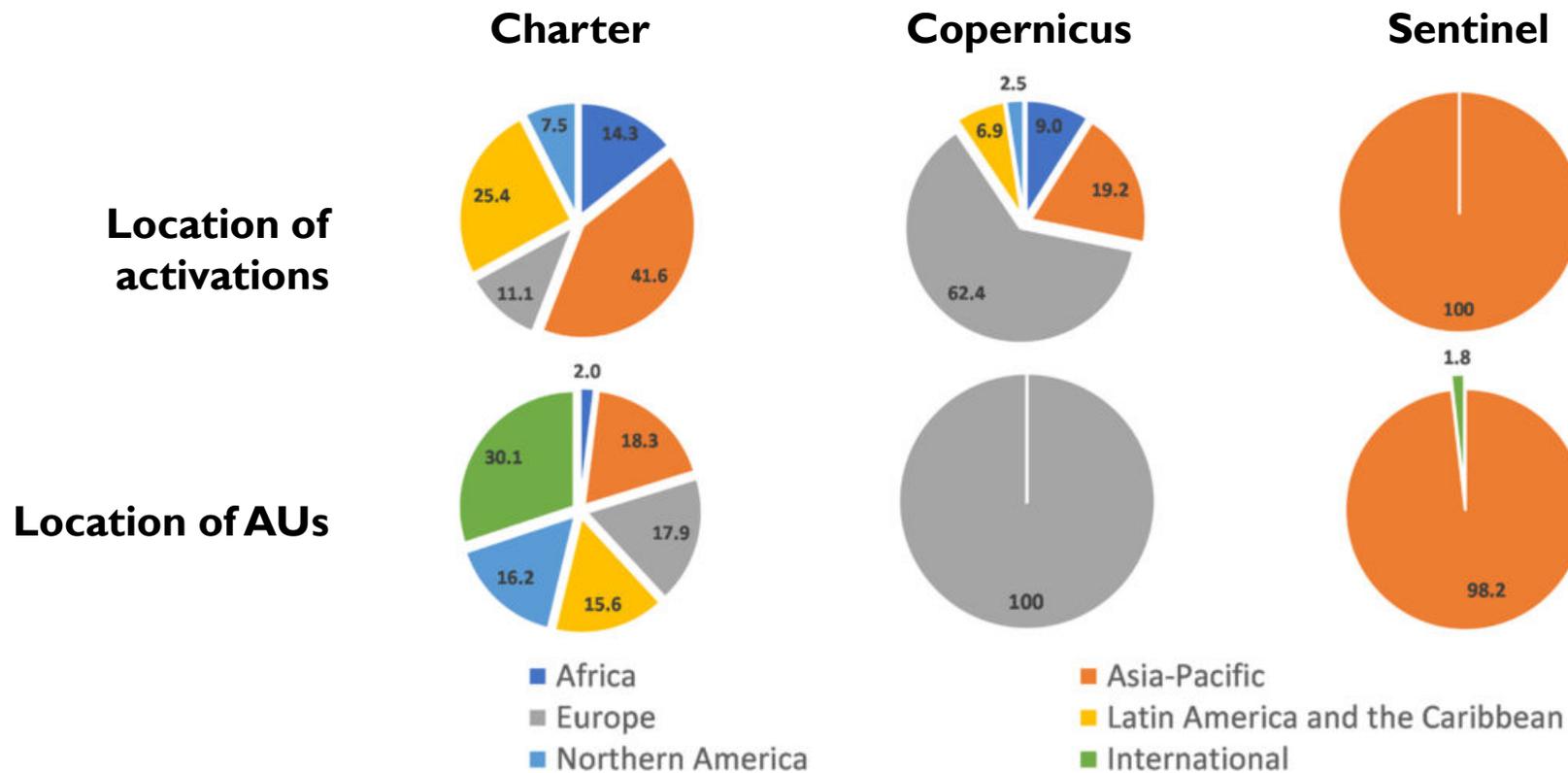
# Number of activations per year of different SEM mechanisms for 2000-2020

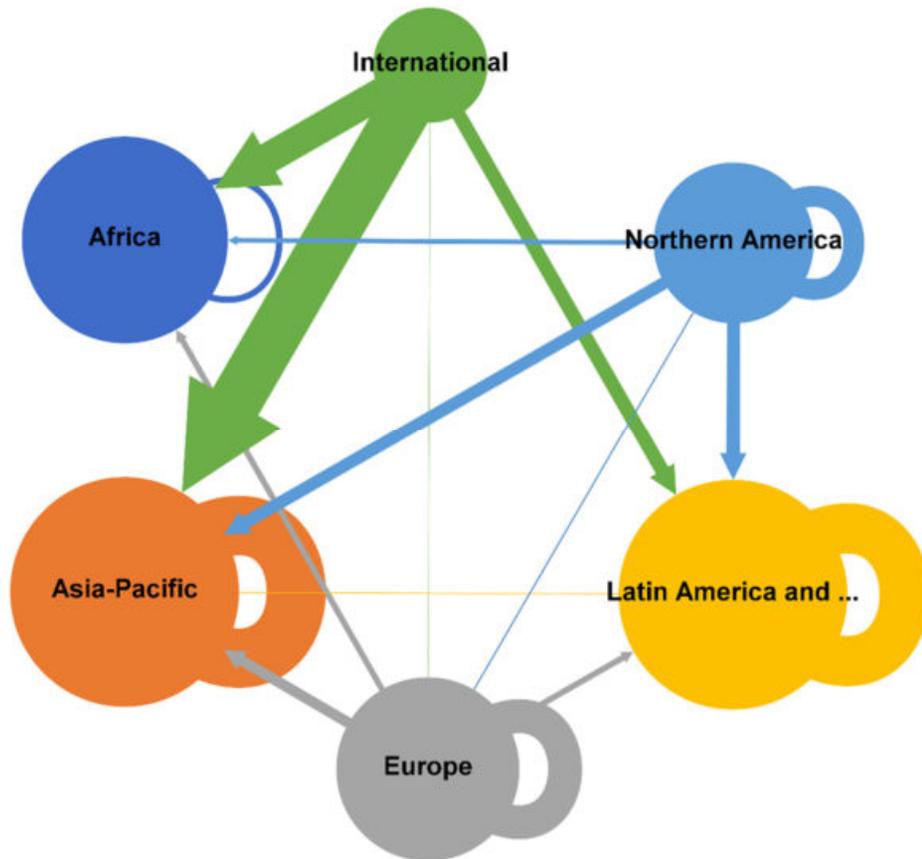


## The share of most common types of disasters, based on all activations

	SEM mechanism		
Disaster type	Charter	Copernicus EMS	Sentinel Asia
Flood	41.8	37.6	50.3
Storm	15.2	15.2	12.6
Earthquake	9.5	5.6	12.9
Wildfire	7.4	26.4	2.3
Other	2.6	10.3	2.3

# Location of activations and Authorized Users (AUs), by geographic region (share, %)





## International Disasters Charter activations by geographic regions

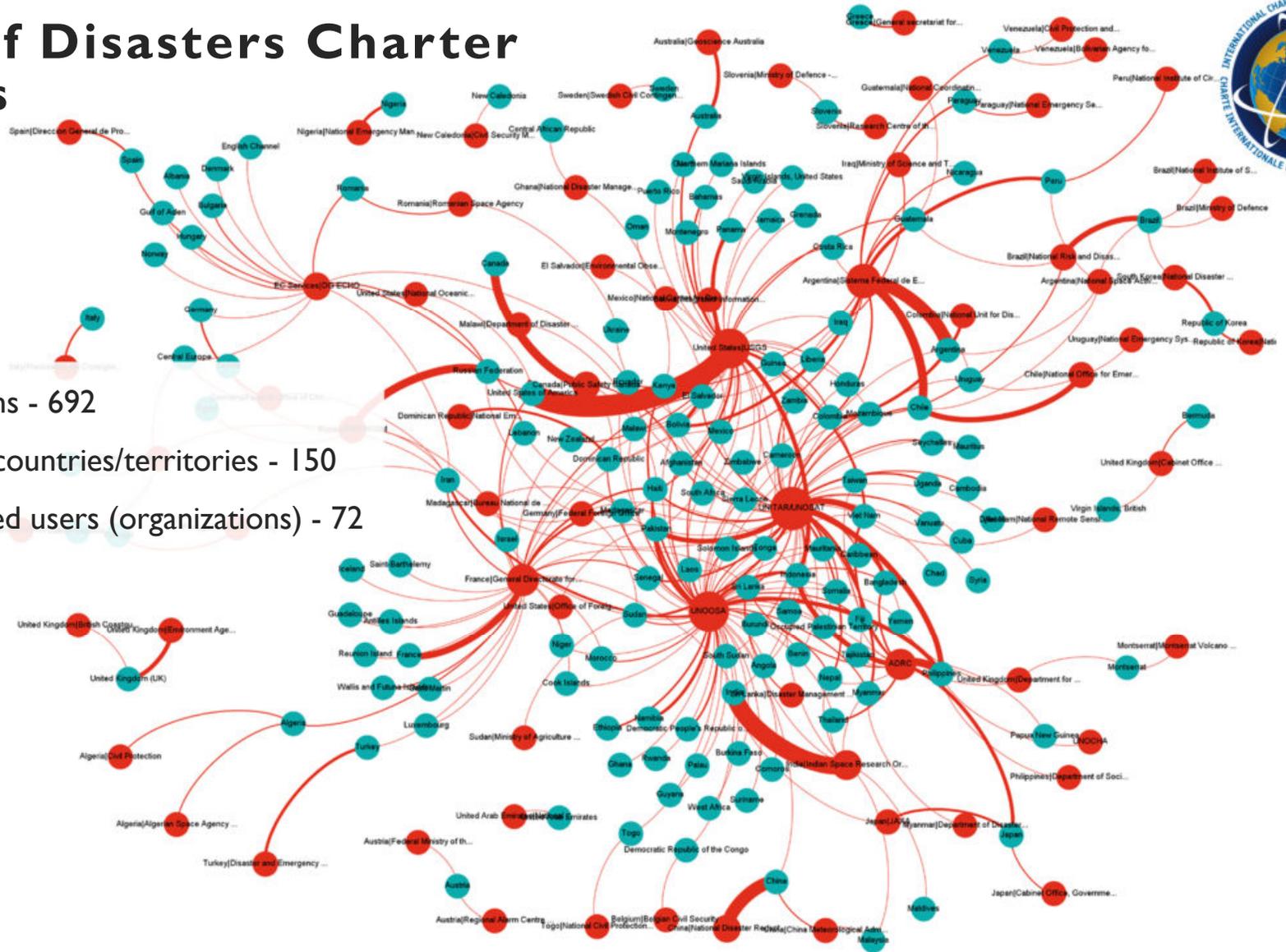
Three different types of “behavior” among geographic regions:

- Europe and Northern America
- Asia-Pacific and Latin America and the Caribbean
- Africa



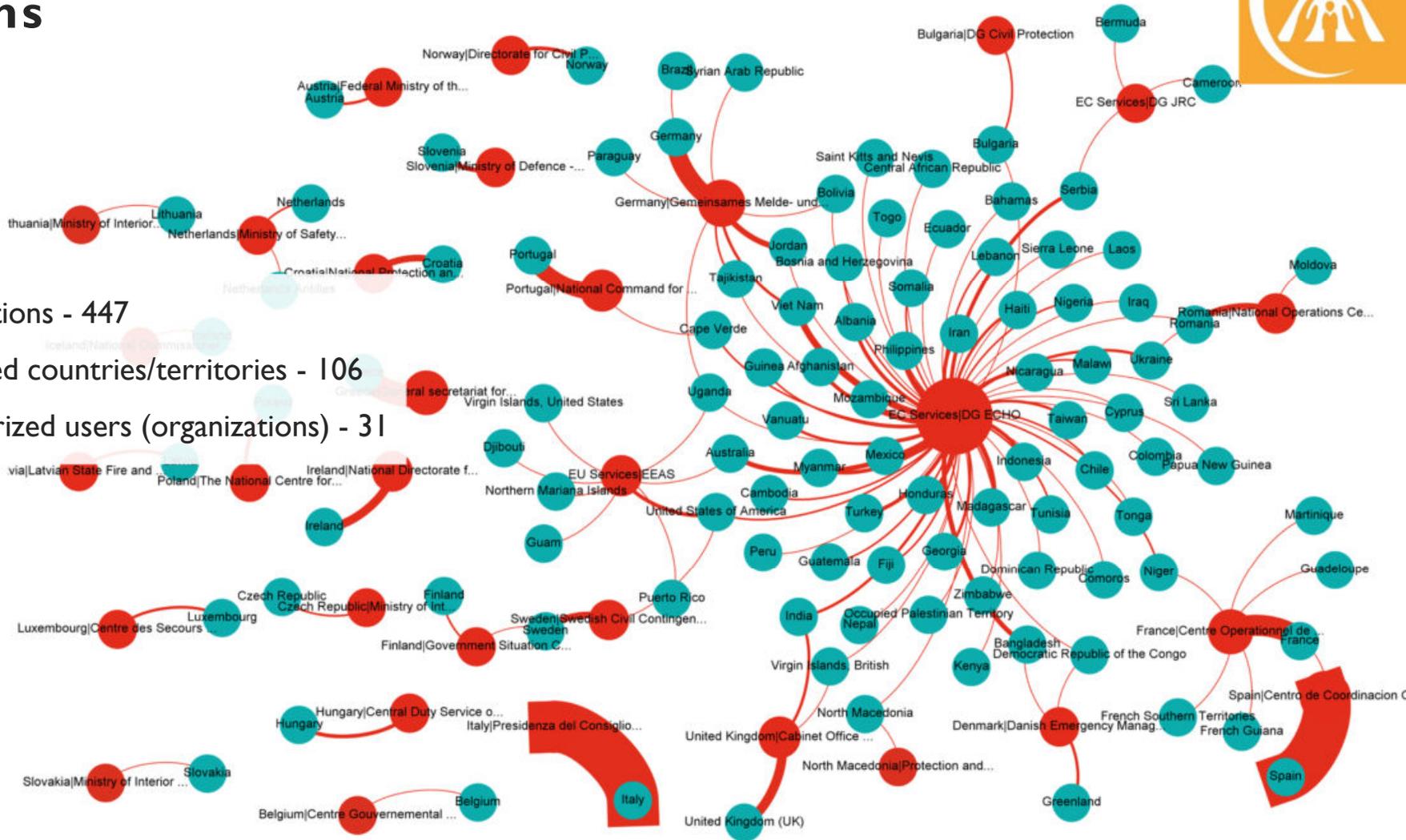
**Networks**

# Network of Disasters Charter activations



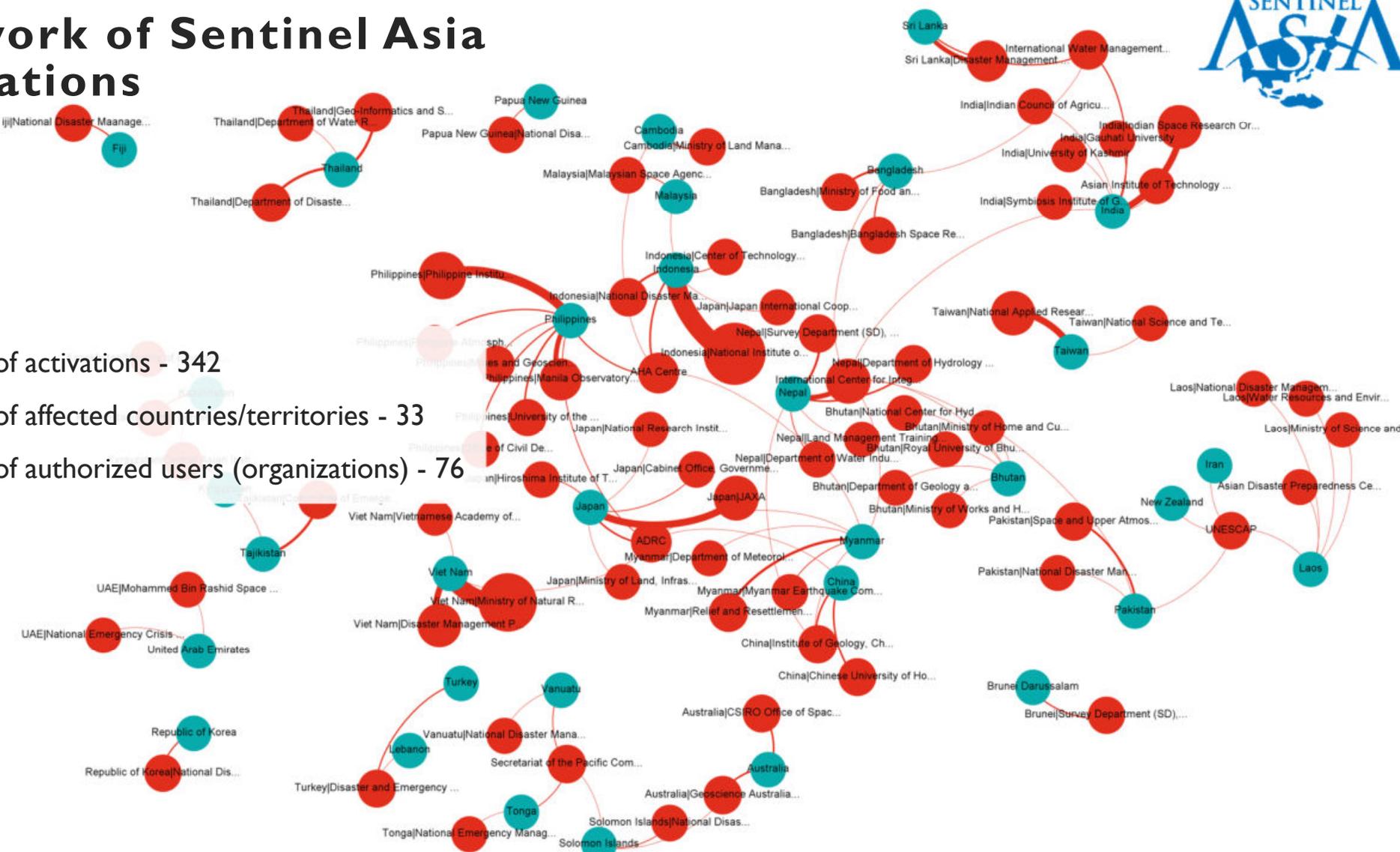
- Number of activations - 692
- Number of affected countries/territories - 150
- Number of authorized users (organizations) - 72

# Network of Copernicus EMS activations



- Number of activations - 447
- Number of affected countries/territories - 106
- Number of authorized users (organizations) - 31

# Network of Sentinel Asia activations



- Number of activations - 342
- Number of affected countries/territories - 33
- Number of authorized users (organizations) - 76

## Most affected (largest number of activations)

<b>Charter</b>	<b>Number of activations</b>	<b>Copernicus EMS</b>	<b>Number of activations</b>	<b>Sentinel Asia</b>	<b>Number of activations</b>
USA	37	Italy	54	Indonesia	56
India	31	Spain	50	Viet Nam	55
Philippines	31	Greece	24	Philippines	48
Chile	27	France	23	Japan	26
Indonesia	26	Germany	19	India	25
China	24	Portugal	17	Nepal	24
Argentina	23	United Kingdom	10	Taiwan	16
Viet Nam	20	Viet Nam	10	Sri Lanka	13
Russia	18	Ireland	9	Myanmar	13
Pakistan	17	Sweden	8	Thailand	13

## Most active organizations

Charter	Number of activations	Copernicus EMS	Number of activations	Sentinel Asia	Number of activations
UNITAR-UNOSAT	124	DG ECHO (EC Services)	150	LAPAN (Indonesia)	45
UNOOSA	104	Presidenza del Consiglio dei Ministri - Dipartimento della Protezione Civile - Centro Situazioni (Italy)	54	MONRE (Viet Nam)	39
USGS (USA)	102	CECOP (Spain)	51	PHIVOLCS (Philippines)	20
SIFEM-DNPC (Argentina)	66	BBK (Germany)	35	ICIMOD	16
DGSCGC (France)	49	COGIC (France)	27	JAXA (Japan)	16
ADRC	44	General secretariat for Civil protection - Directorate for Emergency Planning and Response (Greece)	24	ISRO (India)	15
ISRO (India)	35	National Command for Relief Operations - National Authority for Civil Protection (Portugal)	18	NARL (Taiwan)	15

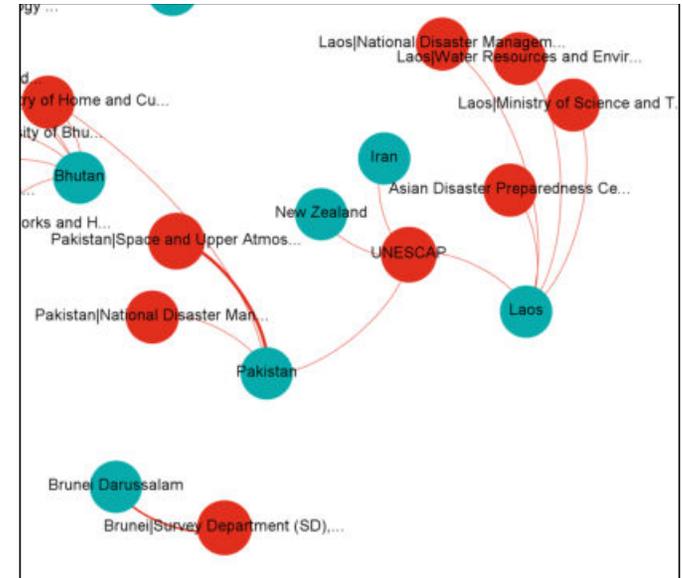
## Most important links (highest number of activations) between countries and organizations

Charter			Copernicus EMS			Sentinel Asia		
Organization (AU)	Country	Number of activations	Organization (AU)	Country	Number of activations	Organization (AU)	Country	Number of activations
USGS (USA)	USA	34	Presidenza del Consiglio dei Ministri - Dipartimento della Protezione Civile - Centro Situazioni (Italy)	Italy	54	LAPAN (Indonesia)	Indonesia	44
ISRO (India)	India	28	CECOP (Spain)	Spain	50	MONRE (Viet Nam)	Viet Nam	39
NDRCC (China)	China	21	General secretariat for Civil protection - Directorate for Emergency Planning and Response (Greece)	Greece	24	PHIVOLCS (Philippines)	Philippines	20
SIFEM-DNPC (Argentina)	Argentina	21	DGSCGC (France)	France	22	JAXA (Japan)	Japan	16
SIFEM-DNPC (Argentina)	Chile	14	BBK (Germany)	Germany	19	ISRO (India)	India	15
Public Safety Canada	Canada	14	National Command for Relief Operations - National Authority for Civil Protection (Portugal)	Portugal	17	NARL (Taiwan)	Taiwan	15
EMERCOM (Russia)	Russia	13	Cabinet Office - Civil Contingencies Secretariat (United Kingdom)	United Kingdom	10	DMPTC (Viet Nam)	Viet Nam	14
ADRC	Philippines	13	National Directorate for Fire and Emergency Management (Ireland)	Ireland	9	ICIMOD	Nepal	11
DGSCGC (France)	France	11	National Protection and Rescue Directorate in the Civil Protection Sector (Croatia)	Croatia	7	Manila Observatory (Philippines)	Philippines	11
UNITAR-UNOSAT	Viet Nam	10	DG ECHO (EC Services)	Viet Nam	7	Disaster Management Centre (Sri Lanka)	Sri Lanka	10

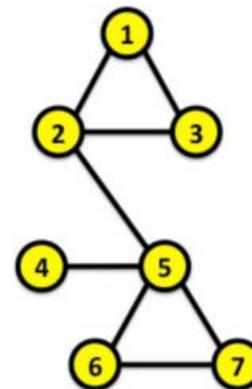
## Bipartite network projection

Bipartite graphs have two node sets  $U, V$  and edges in  $E$  that only connect nodes from opposite sets.

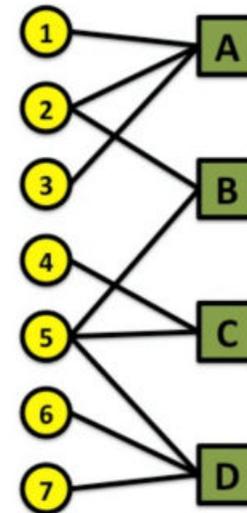
Bipartite graphs can be projected – transformed from a two-mode network (that includes the nodes of two types) into a one-mode network (representing one specific type of the nodes).



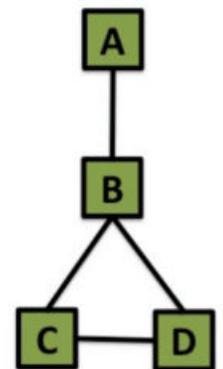
Projection U



U V

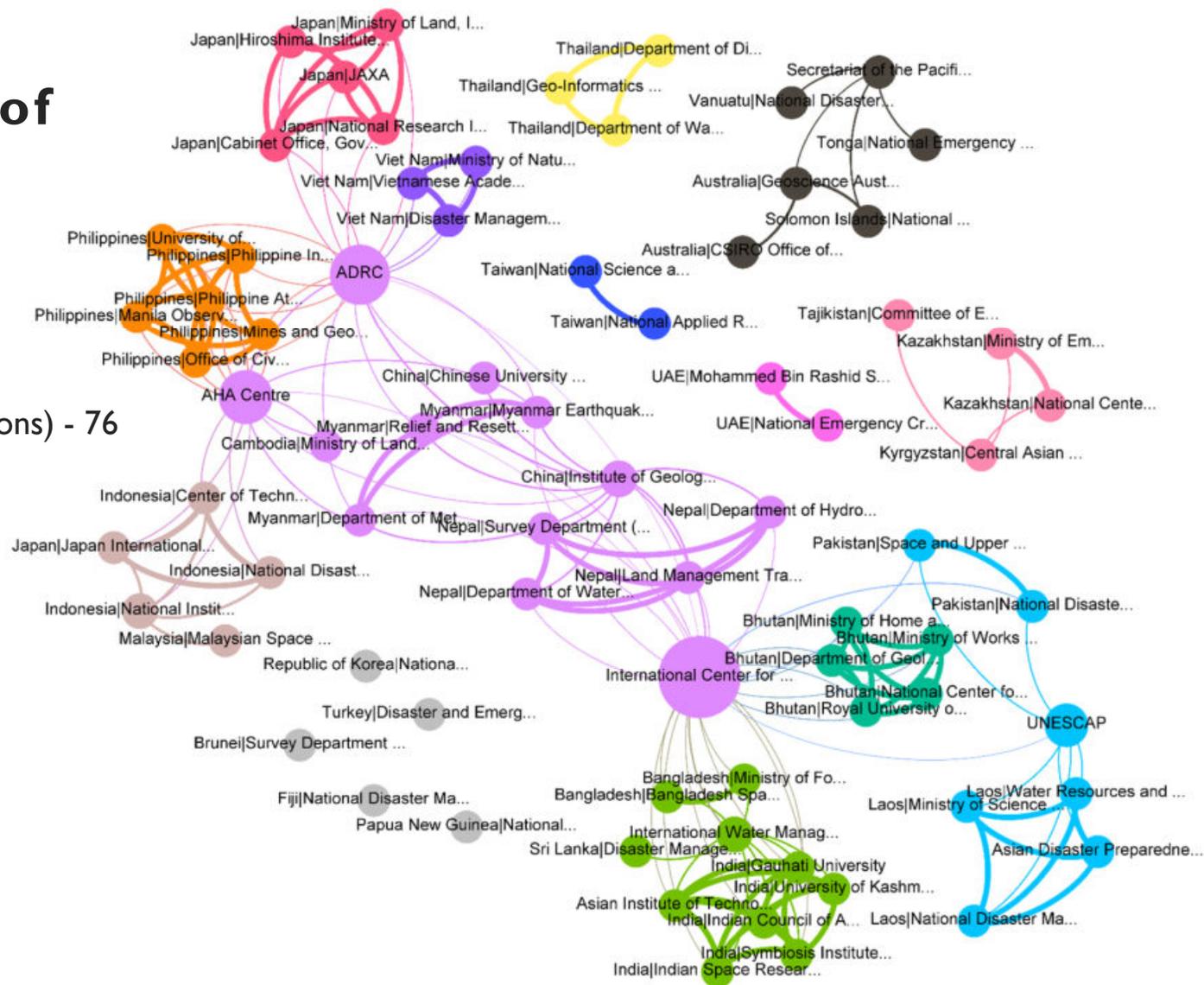


Projection V



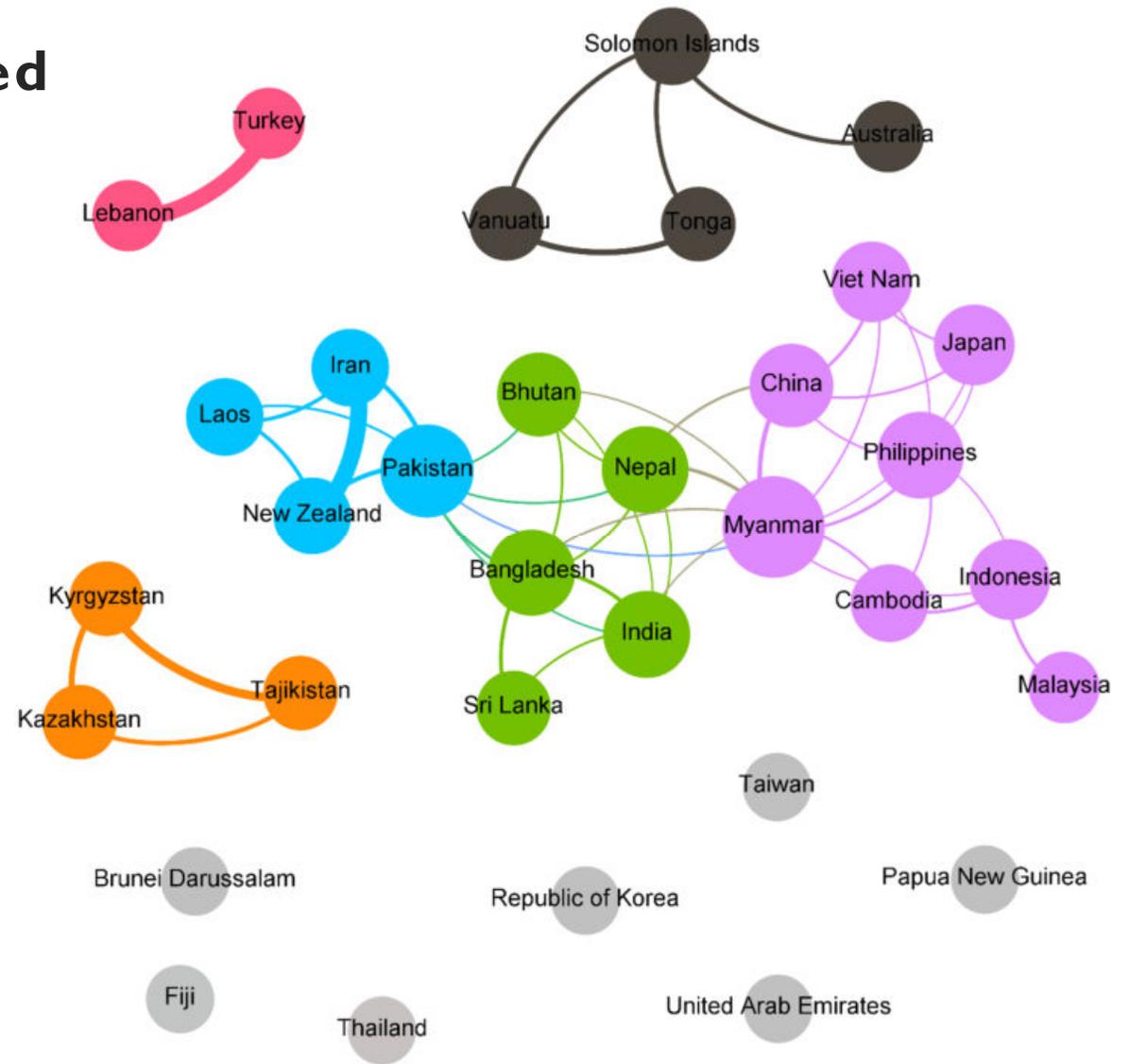
# Sentinel's overlap weighted projection of organizations

- Number of authorized users (organizations) - 76

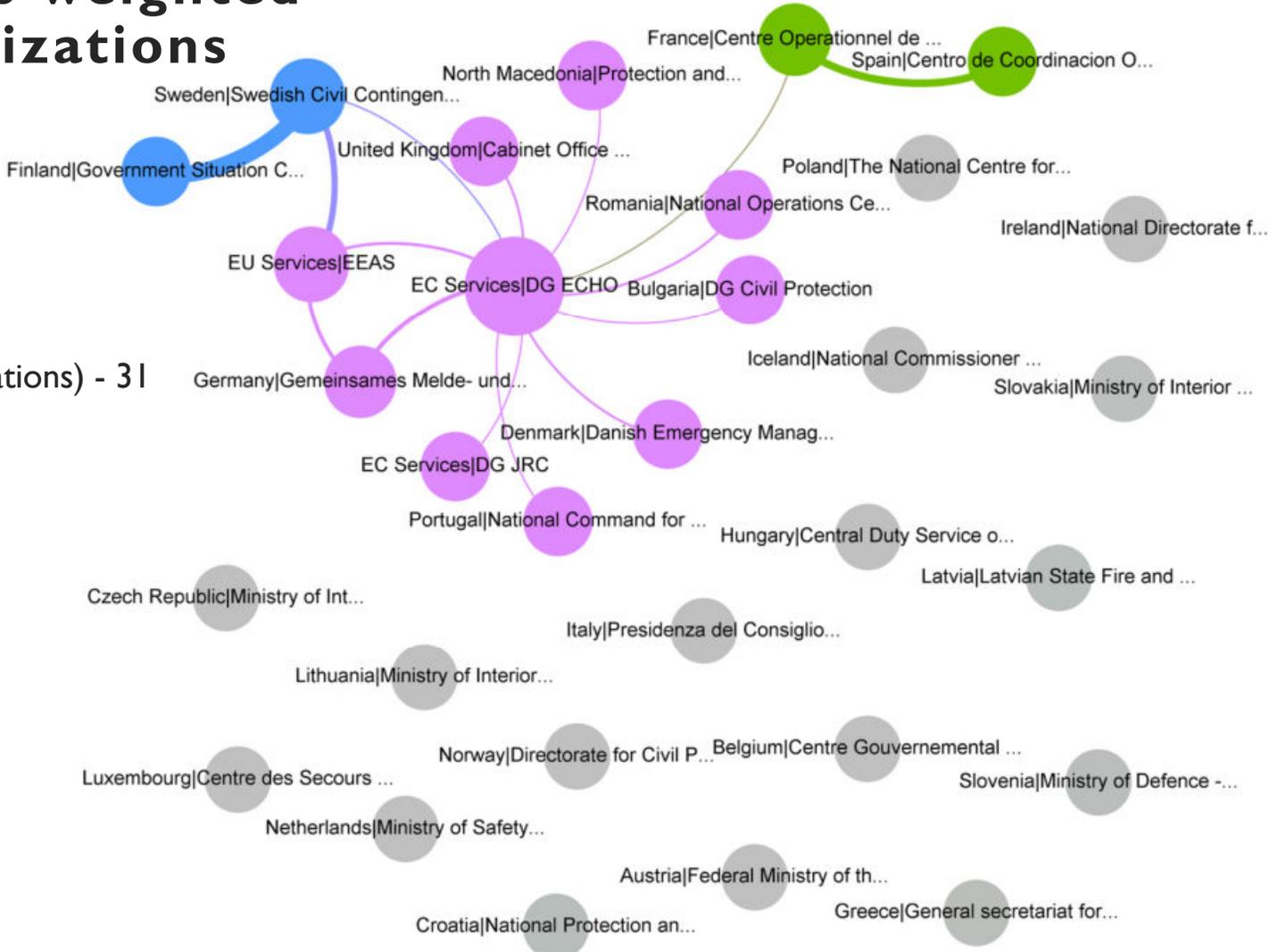


# Sentinel's overlap weighted projection of countries

- Number of affected countries/territories - 33



# Copernicus' overlap weighted projection of organizations

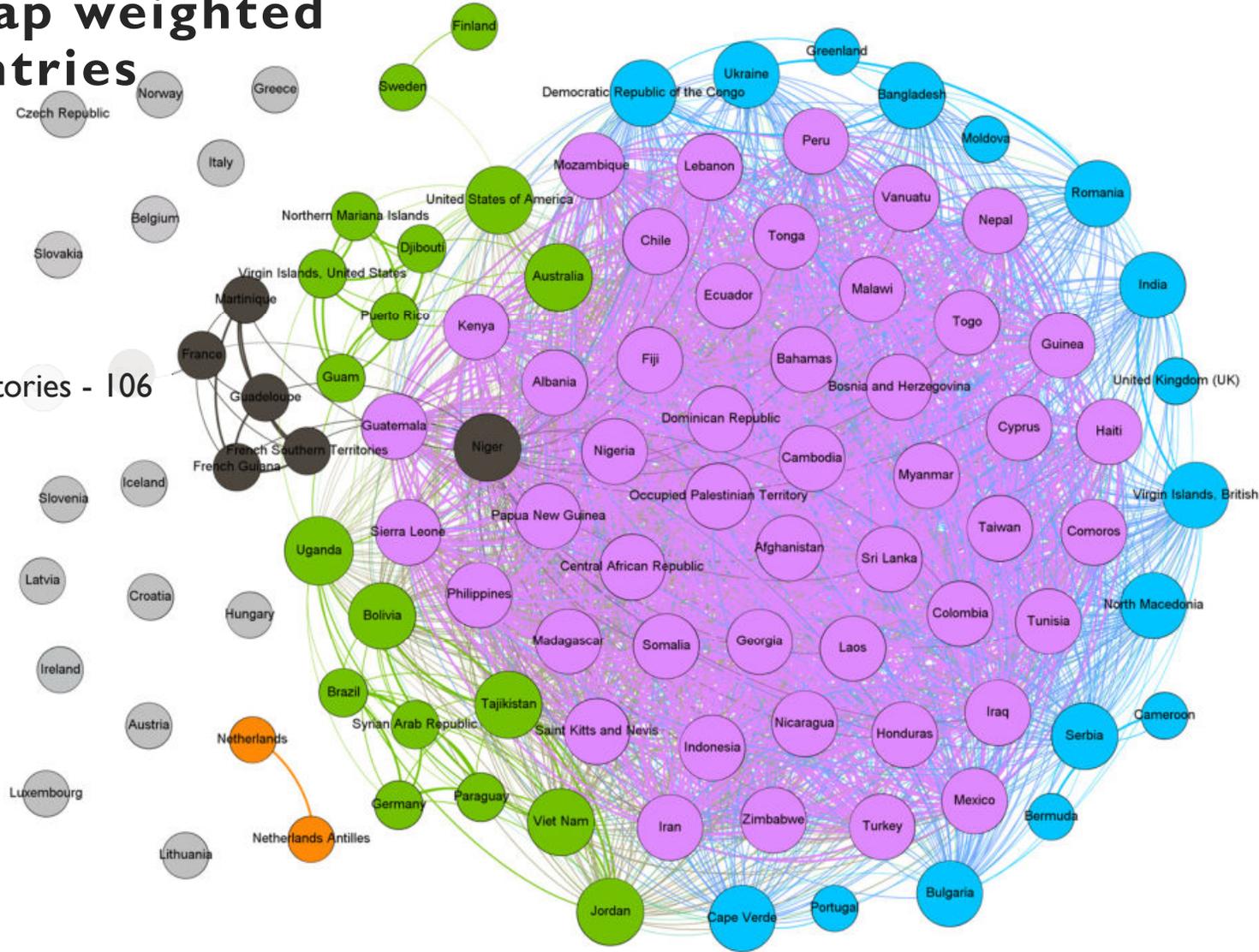


- Number of authorized users (organizations) - 31

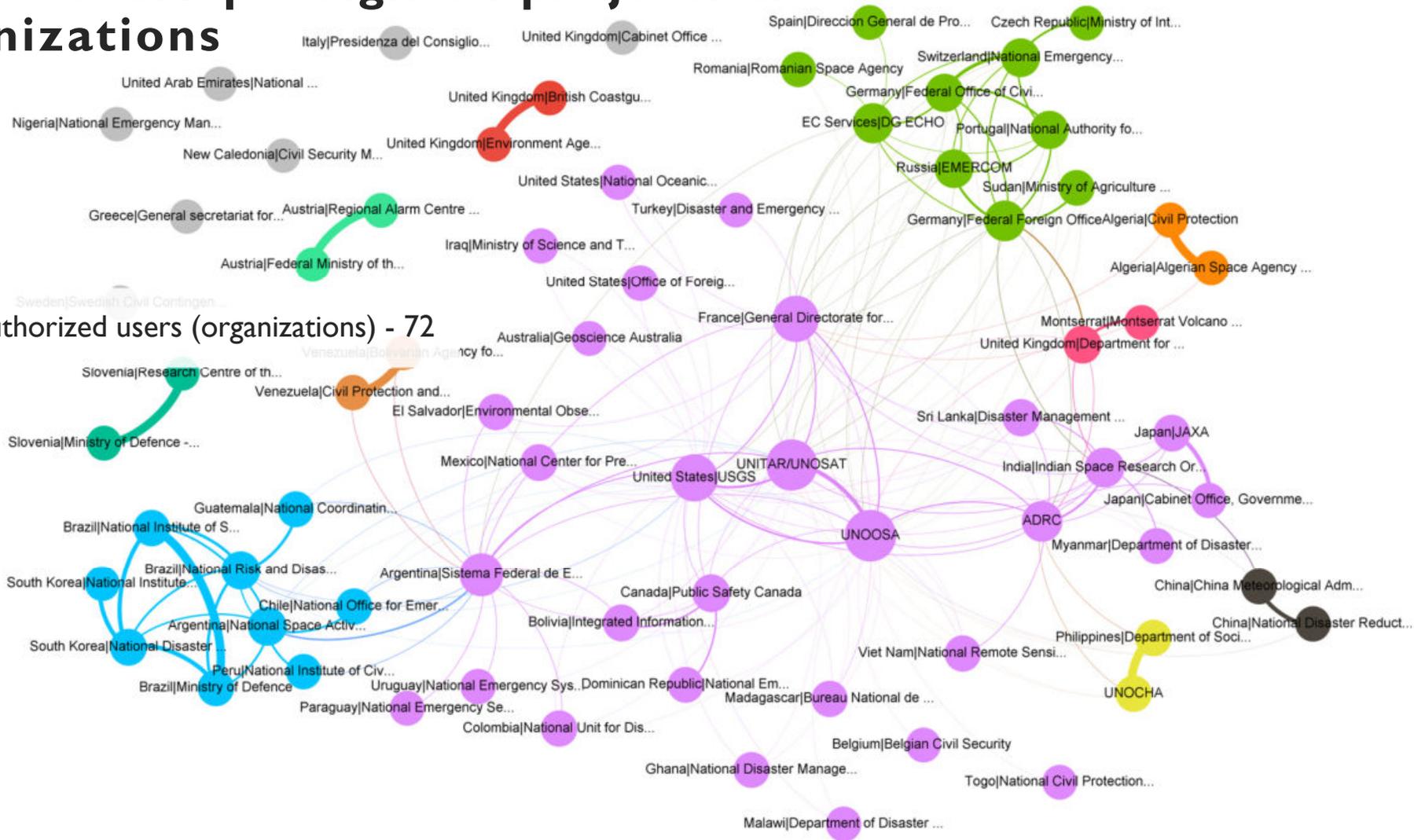


# Copernicus' overlap weighted projection of countries

- Number of affected countries/territories - 106



# Charter's overlap weighted projection of organizations

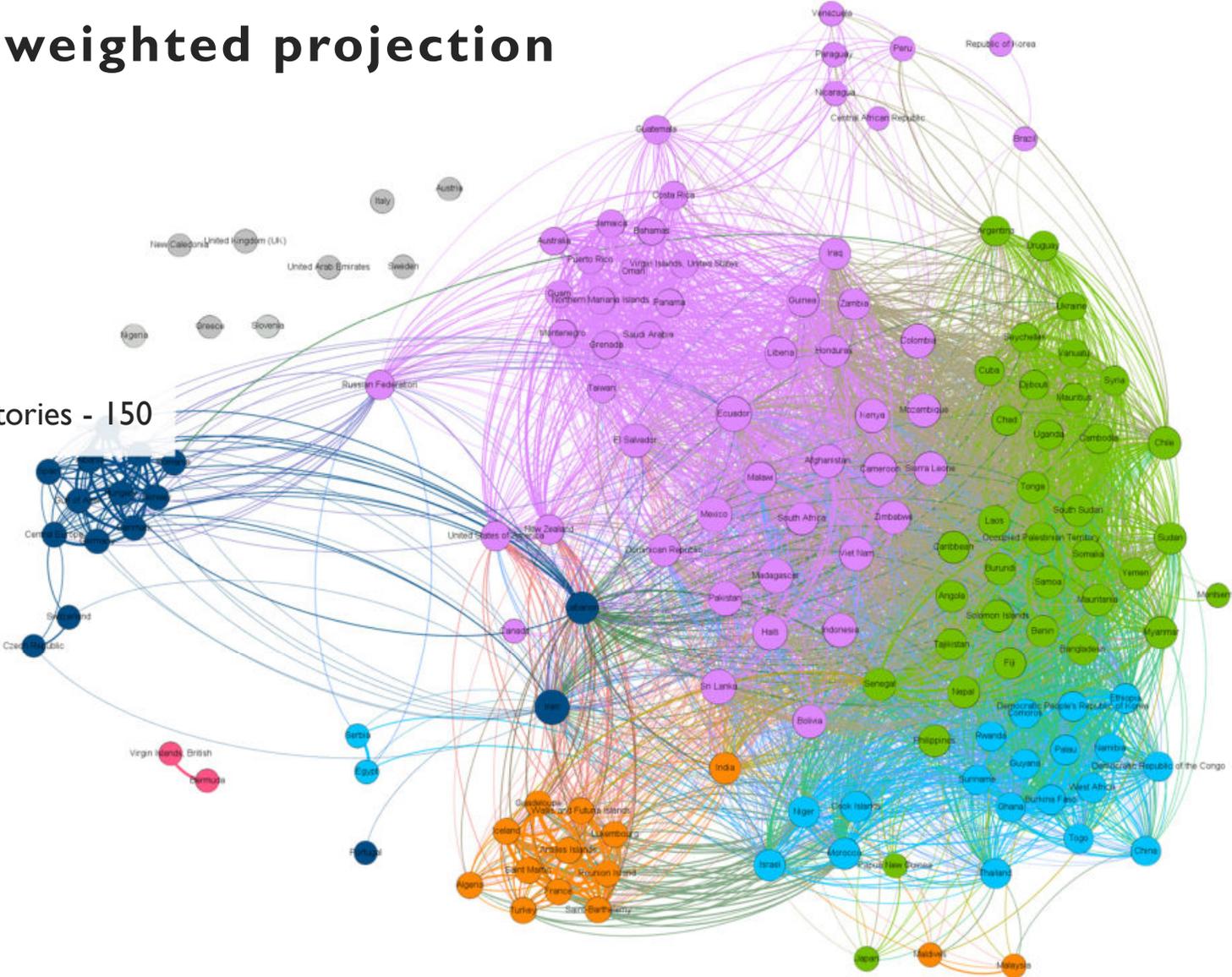


- Number of authorized users (organizations) - 72



# Charter's overlap weighted projection of countries

- Number of affected countries/territories - 150



## Challenges of the satellite-based emergency mapping field

- Three selected SEM mechanisms cannot fully demonstrate the level of complexity of the overall global system, which consists of many more similar mechanisms. Such a large network with a huge number of participants inevitably faces communication issues. This might lead to a question of whether countries already covered by Sentinel Asia should actually aim at joining the Charter as well. In the case of countries from other regions without similar regional SEM mechanisms, direct access to initiative seems more clearly advisable.
- SEM mechanisms, apart from Copernicus EMS, seem to be reaching their maximum capacity of activations per year. At the same time, existing SEM mechanisms can get overwhelmed if there are too many disasters happening at the same time. This problem might be addressed through efficient coordination among different mechanisms, making sure to avoid the situation when all initiatives focus on the same large event and overlook other disasters that might be happening at the same time (maybe less severe, but still significant).
- The disaster management field already experienced an important paradigm shift - from addressing the consequences of emergencies (disaster management) to focusing on mitigation of and adaptation to potential risks (disaster risk reduction). Even though most initiatives do mention the possibility of pre-disaster assessments, in reality, it rarely happens (the only significant exception being the special European Copernicus “Risk and Recovery Mapping” service). So far slow-onset disasters, like droughts and epidemics, are also being mainly disregarded by the existing SEM mechanisms.

## Next steps

- To potentially have a more comprehensive overview of the situation and more clearly defined gaps, activations of some **other mechanisms** could be considered as well, in a way following the example of the Voigt et al. (2016) study.
- A portfolio of the **Copernicus’s “Risk and Recovery Mapping” service** can be explored as well, including network visualization.
- A **joint network of activations** coming from different mechanisms could also be developed and explored.
- Conducted network analysis of the SEM mechanisms could potentially be expanded and deepened further, **exploring the topology of the developed graphs** and positions of their elements. A more detailed investigation of the **potential reasons** behind connections between countries supported through indirect activations (on behalf of other countries or organizations) can be conducted.



THANK YOU

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Records of the International Charter "Space and Major Disasters" activations for the countries which were both visited by UNOOSA with advisory missions and have direct access to the SEM mechanism as of 2020

	Direct access to Charter since	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
India	2001	X		O	O	O		O			O	X	O	O	O	O,X	O		O	O	O
Nigeria	2005										O	O	O								
Turkey	2005			X						O	O	O				O					
China	2007					X		O	O		O		O	O	O	O	O	O	O		
Malawi	2014									X						O,X					
Dominican Republic	2015			X	X			X							X		O	O			
Chile	2015							X	X	X	X	X		X	X	O		O		O	
Colombia	2015				X			O,X	X	O	X	X				X		O			O
Guatemala	2016					X					X		X			X			O		X
El-Salvador	2016	X				X				X		X									O
Sri Lanka	2017				X		X		X						X		X	X	O		O
Myanmar	2017				X				X		X			X		X					O
Ecuador	2017	X							X				X				X				
Sudan	2018				X		X							X	X		X			X	O,X
Madagascar	2018							X			X		X	X		X		X			O
Peru	2018							X		X	X		X	X	X			X		O	
Ghana	2019											X									
Tunisia	2019																				
Togo	2020								X												O
Ethiopia	2020					X	X														
Haiti	2020				X				X		X		X				X	X			

Years when at least one activation of the Charter took place are indicated in the corresponding cell: if activation was requested by own Authorized User (AU) of the affected country, it is marked with "O"; if activation was requested on behalf of the affected country by international organization or another state, it is indicated as "X". Shaded areas represent the years when each country had direct access to the mechanism (had officially registered an AU).

REVIEW

# Global trends in satellite-based emergency mapping

Stefan Voigt,<sup>1\*</sup> Fabio Giulio-Tonolo,<sup>2</sup> Josh Lyons,<sup>3</sup> Jan Kučera,<sup>4</sup> Brenda Jones,<sup>5</sup> Tobias Schneiderhan,<sup>1</sup> Gabriel Platzeck,<sup>6</sup> Kazuya Kaku,<sup>7</sup> Manzul Kumar Hazarika,<sup>8</sup> Lorant Czarán,<sup>9</sup> Suju Li,<sup>10</sup> Wendi Pedersen,<sup>11</sup> Godstime Kadiri James,<sup>12</sup> Catherine Proy,<sup>13</sup> Denis Macharia Muthike,<sup>14</sup> Jerome Bequignon,<sup>15</sup> Debarati Guha-Sapir<sup>16</sup>

Over the past 15 years, scientists and disaster responders have increasingly used satellite-based Earth observations for global rapid assessment of disaster situations. We review global trends in satellite rapid response and emergency mapping from 2000 to 2014, analyzing more than 1000 incidents in which satellite monitoring was used for assessing major disaster situations. We provide a synthesis of spatial patterns and temporal trends in global satellite emergency mapping efforts and show that satellite-based emergency mapping is most intensively deployed in Asia and Europe and follows well the geographic, physical, and temporal distributions of global natural disasters. We present an outlook on the future use of Earth observation technology for disaster response and mitigation by putting past and current developments into context and perspective.

**D**isaster responders and the humanitarian community increasingly use Earth Observation (EO) satellite systems to assess the impact of and to plan and coordinate emergency response activities after major natural

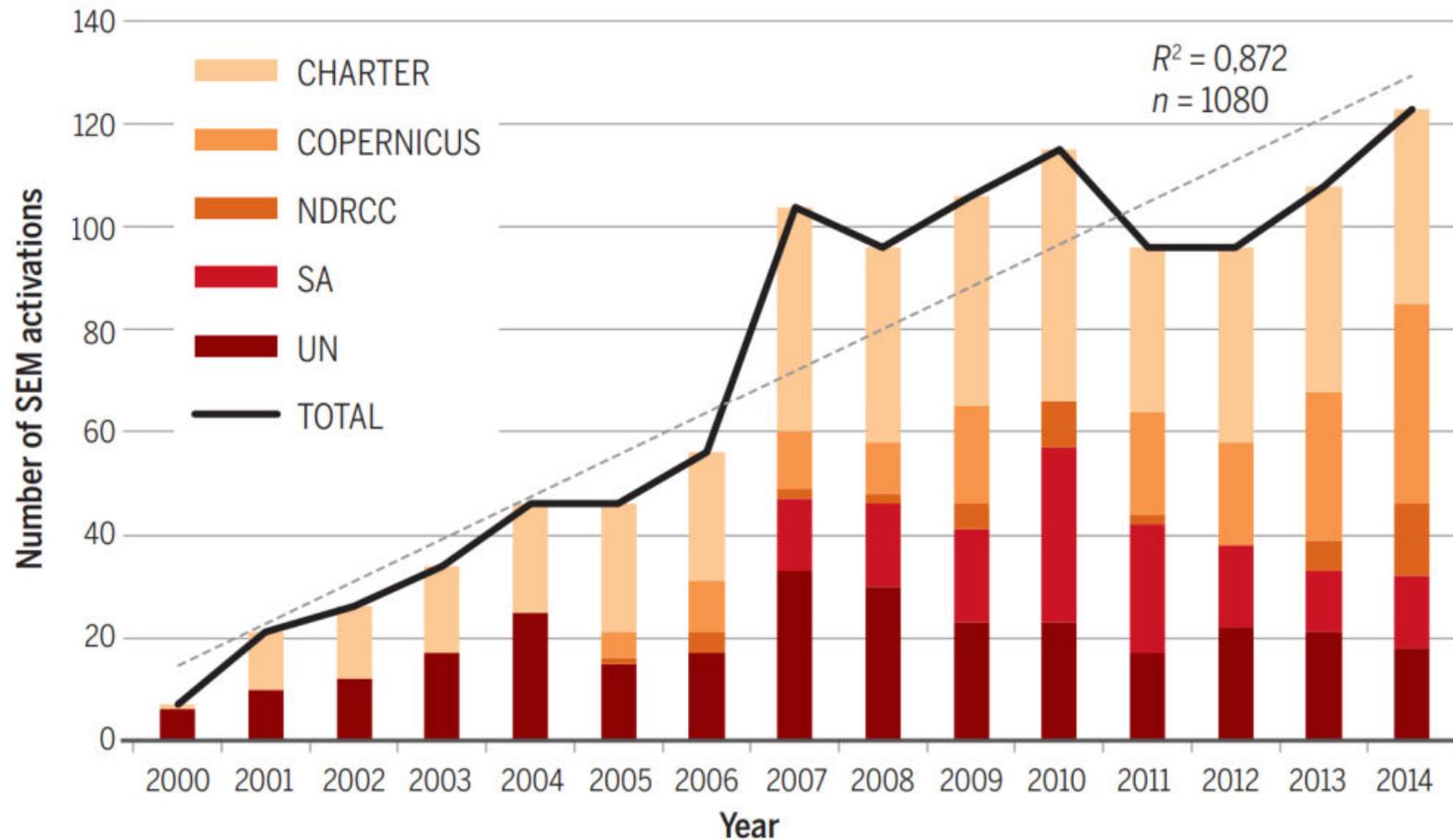
and recovery programs (2–4). The ultimate goal of SEM is to improve disaster relief effectiveness and thus to help reduce suffering and fatalities before, during, and after a disaster event occurs. We focus our Review on the response phase in

further expanding the EO constellations and ease of use of satellite data. The provision of quantities of raw satellite data to the disaster response community has no operational value. Being time sensitive in its relevance to immediate disaster mitigation, the data need to be quickly processed, analyzed, and transformed by disaster sensing professionals (6) into intuitive and understandable information products such as maps and reports; these can then directly be used in disaster emergency management operations (7, 8).

In reviewing global SEM responses of the past 15 years, five major events stand out, given their influence on the development of the international SEM community: (i) After the Indian Ocean Tsunami in 2004 (7), widespread international SEM cooperation and response coordination became necessary owing to the scale of the event, the size of the impacted region, and the number of countries affected. During the disaster, satellite monitoring played an important role by providing a global view of the situation on the ground and helping people to understand the magnitude of devastation caused by the tsunami. (ii) The Wenchuan earthquake in 2008 (9) mobilized an unprecedented number of programmed satellites and acquired satellite imagery for a single disaster event. Analysis and mapping of the disaster was mainly organized by the National Disaster Reduction Centre of China (NDRCC) and resulted in the generation of numerous satellite products. During this event, it became clear that satellite imagery alone could not suffice to assess

Voigt, Stefan, *et al.* 2016. Global trends in satellite-based emergency mapping. *Science* 353.6296: 247-252. <https://science.sciencemag.org/content/353/6296/247>

# Global trends in satellite-based emergency mapping



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