Report by IOC/UNESCO TOWS-WG Ad-hoc Team on Meteotsunami
February 2023

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The purpose of this report is to:

a) Review current global status and advise on gaps related to MT monitoring and warning systems.

b) Identify guidelines for Standard Operating Procedure (SOP) development to monitor and warn for MTs.

c) Review relationships and coordination required between Tsunami Service Providers/National Tsunami Warning Centers and Regional/National Meteorological Services activities to monitor and warn for MTs

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Key Takeaways:

- At present, **all operational meteotsunamis (MT) are addressed within the standing procedures of National or Regional meteorological services, usually anomalous tides, storm surges or other coastal flooding phenomena.**

- Meteotsunami (MT) occurrence is common along virtually all coastlines. **Only infrequently does MT pose a significant risk to life and property** and this is typically in areas with particularly strong MT forcing characteristics such as the **Balearic Islands region of the Mediterranean sea**. In these cases specific MT Early Warning Systems (EWS) have been developed that rely heavily on identifying the meteorological parameters necessary for MT development through NWP schemes.

- Outside of dedicated MT EWS', MT procedures are inconsistent and present risks. The **Global Tsunami Warning System can play a supporting role in terms of making direct tsunami detection**, though even when a tsunami is detected by the network, this will not typically be sufficient to fully characterize the tsunami wave field and support precise coastal impact forecasts.

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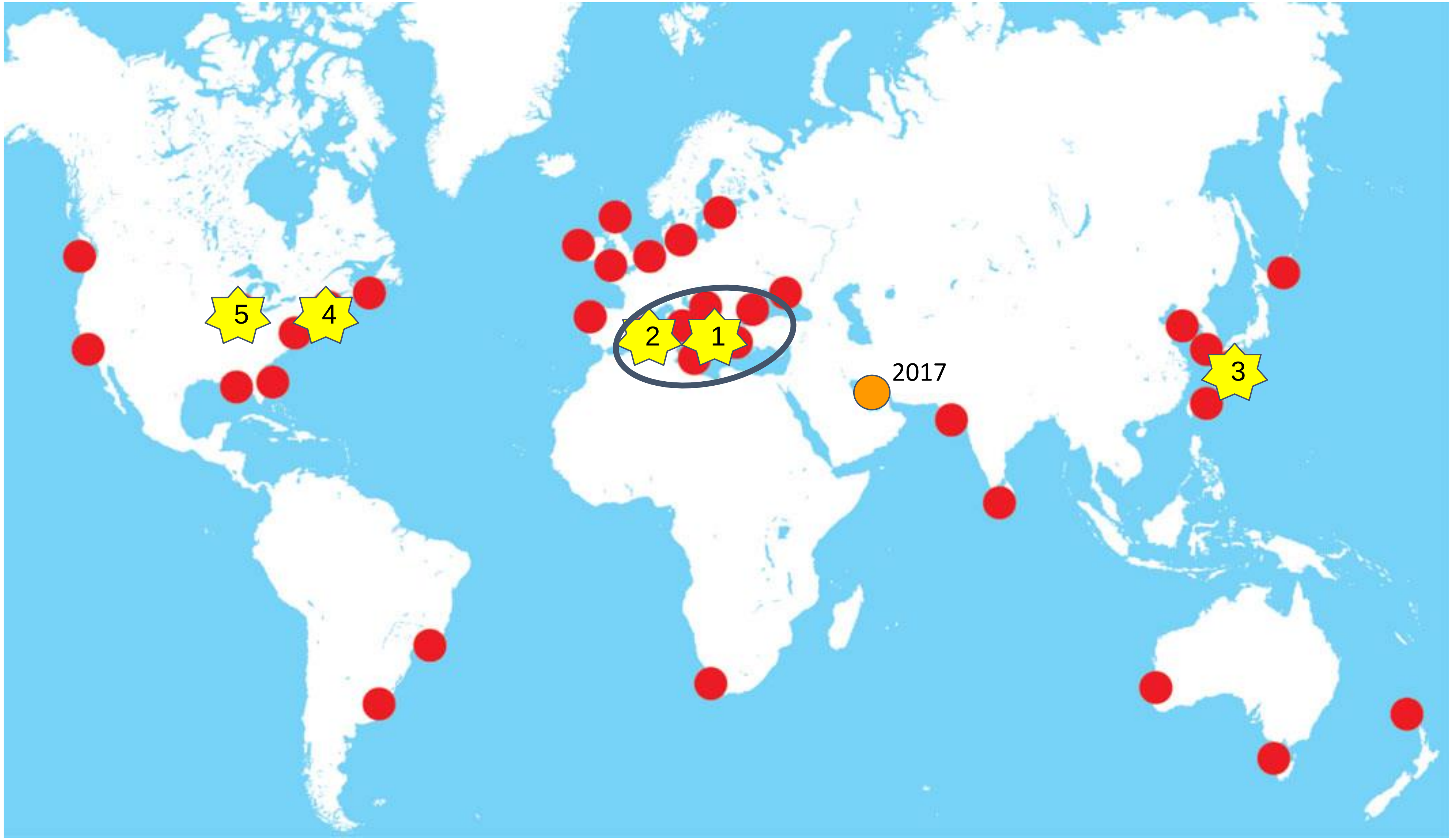
Key Takeaways cont):

- A **future unified system** in which a combination of **direct tsunami detection** from the ever-expanding global tsunami sensing network and **NWP-based MT forecasts** is considered worthwhile.

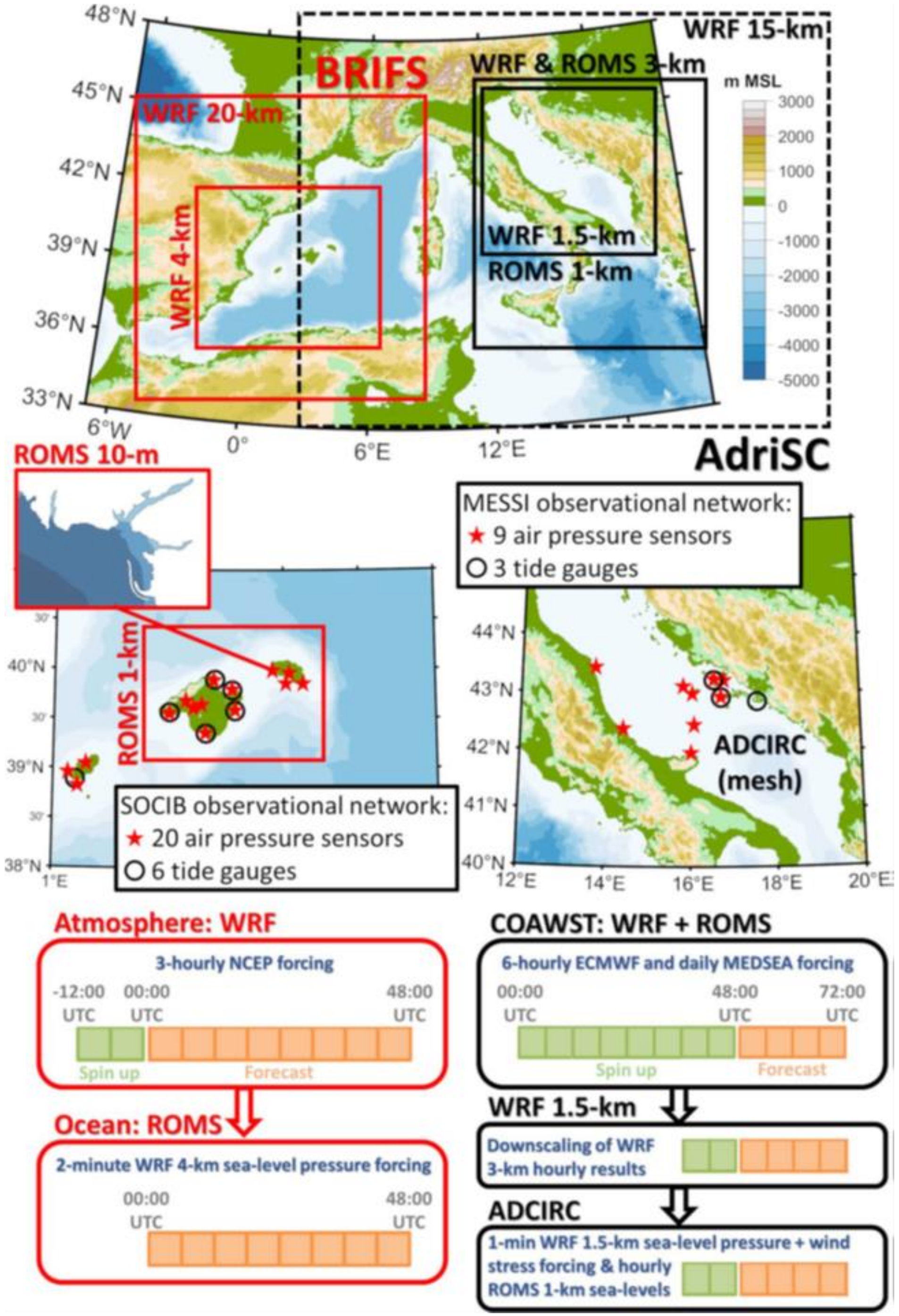
- MT only form under a narrow range of parameters related to water depth and the translational speed of the source disturbance. **Local understanding of the MT threat posed to a given coastline is critical** to ensuring the phenomena is addressed through Met services.

Significant MT Occurrences (reported as of 2015)



Mediterranean MT System

Existing meteotsunami monitoring and forecasting systems in the Mediterranean Sea: BRIFS (in red) associated with the SOCIB observational network in the Balearic Islands and AdriSC forecast system (in black) associated with the MESSI observational network in the Adriatic Sea (after Vilibić et al., 2021)



Mediterranean MT System: Tendency for overprediction

Verification of meteotsunami forecast issued by the AEMET experimental rissaga prediction service between 2003 and 2006 (after Jansà and Ramis, 2021).

Verification –through a contingency table- of a sample (2003-2006) of the rissaga prediction service established in 1985 at the Spanish National Meteorological Service

Rissaga	Observed amplitude (when amplitude >= 30 cm)			
Forecast amplitude	30-75 cm	75-150 cm	> 150 cm	total
No forecast (< 30 cm)	4	1	1	6
30-75 cm	2	1	1	4
75-150 cm	9	11	4	24
> 150 cm	1	2	1	4
Total	16	15	7	38

Under-prediction

Correct prediction

Over-prediction

When rissaga (>30 cm) is observed:
Rissaga was not forecast: 16%
Rissaga was forecast: 84%

MT Alerting

Dedicated Systems:

1. *Balearic Islands*
2. *Adriatic Sea*
3. *S. Korean Peninsula*

Key Attributes:

- *High resolution NWP*
- *Met sensing networks*
- *Depth constrained ocean model coupling*
- *Deterministic, Probabilistic…or *qualitative**

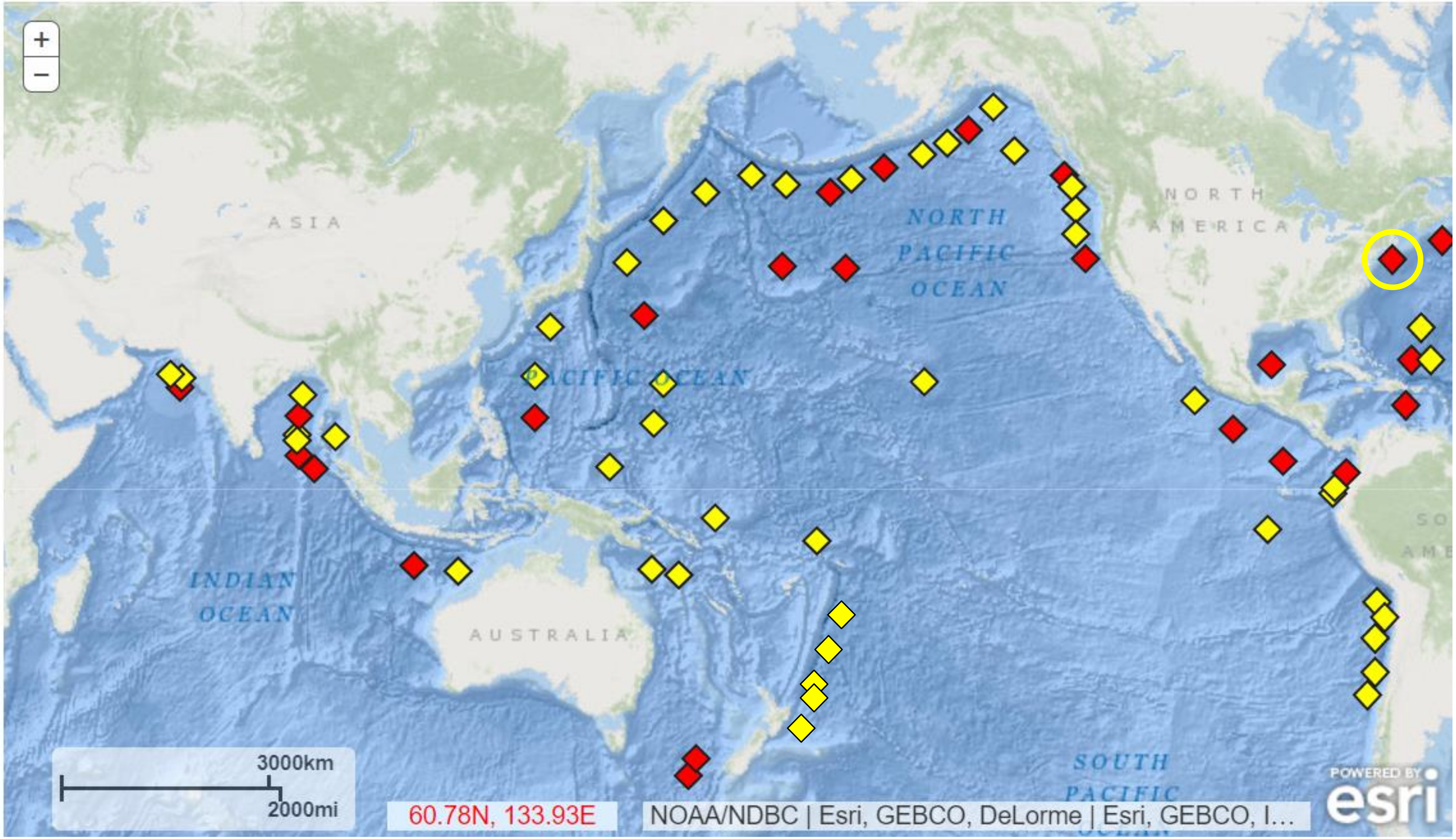
Q: *Is there a role for GTWS/TSP/NTWCs in MT?*

Generized Systems:

All other met services areas address MT as "lesser included" component of coastal flooding eg:

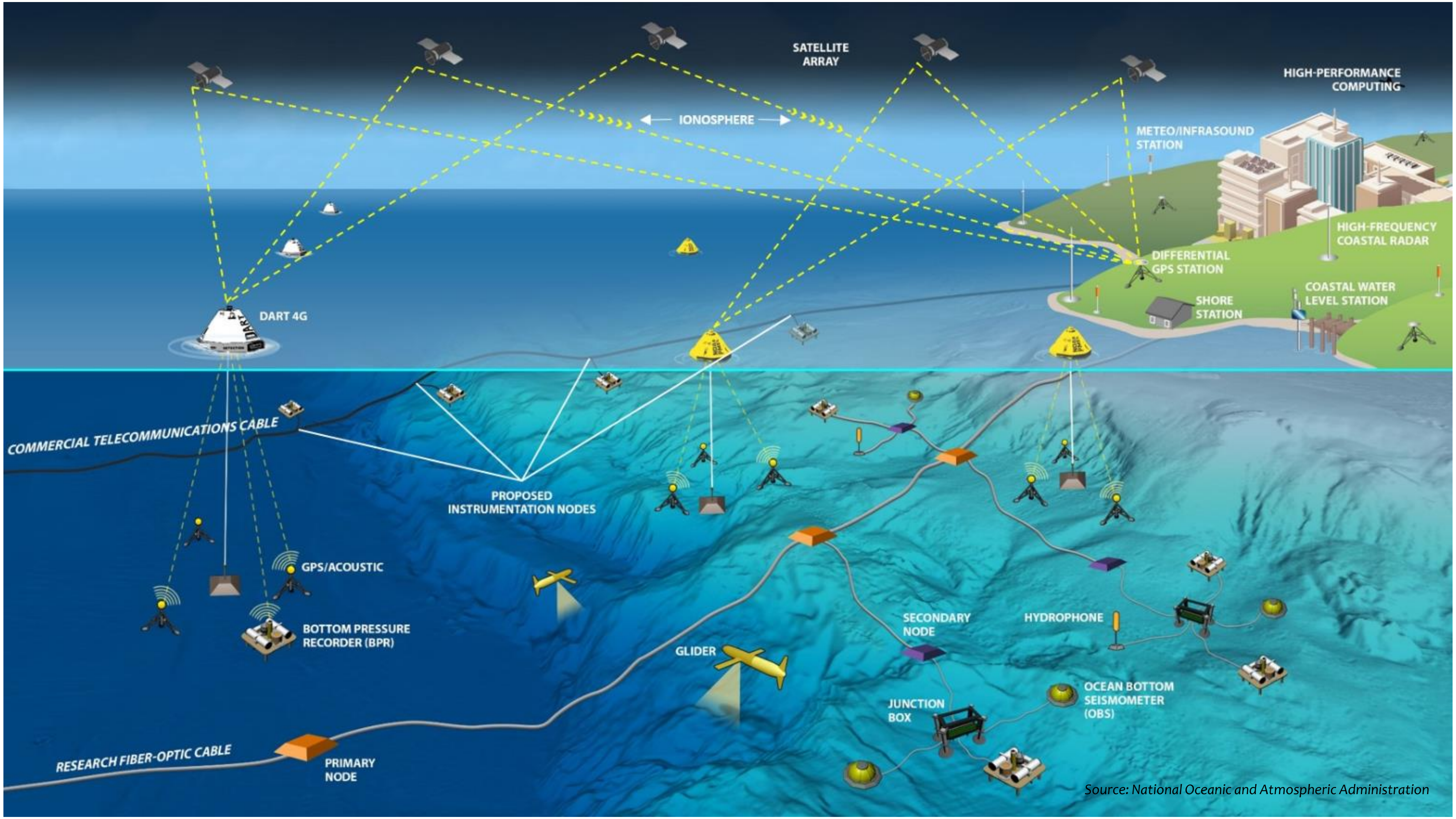
- seiche
- anomalous tides
- MT

Can GTWS be used for MT?   Yes…and no



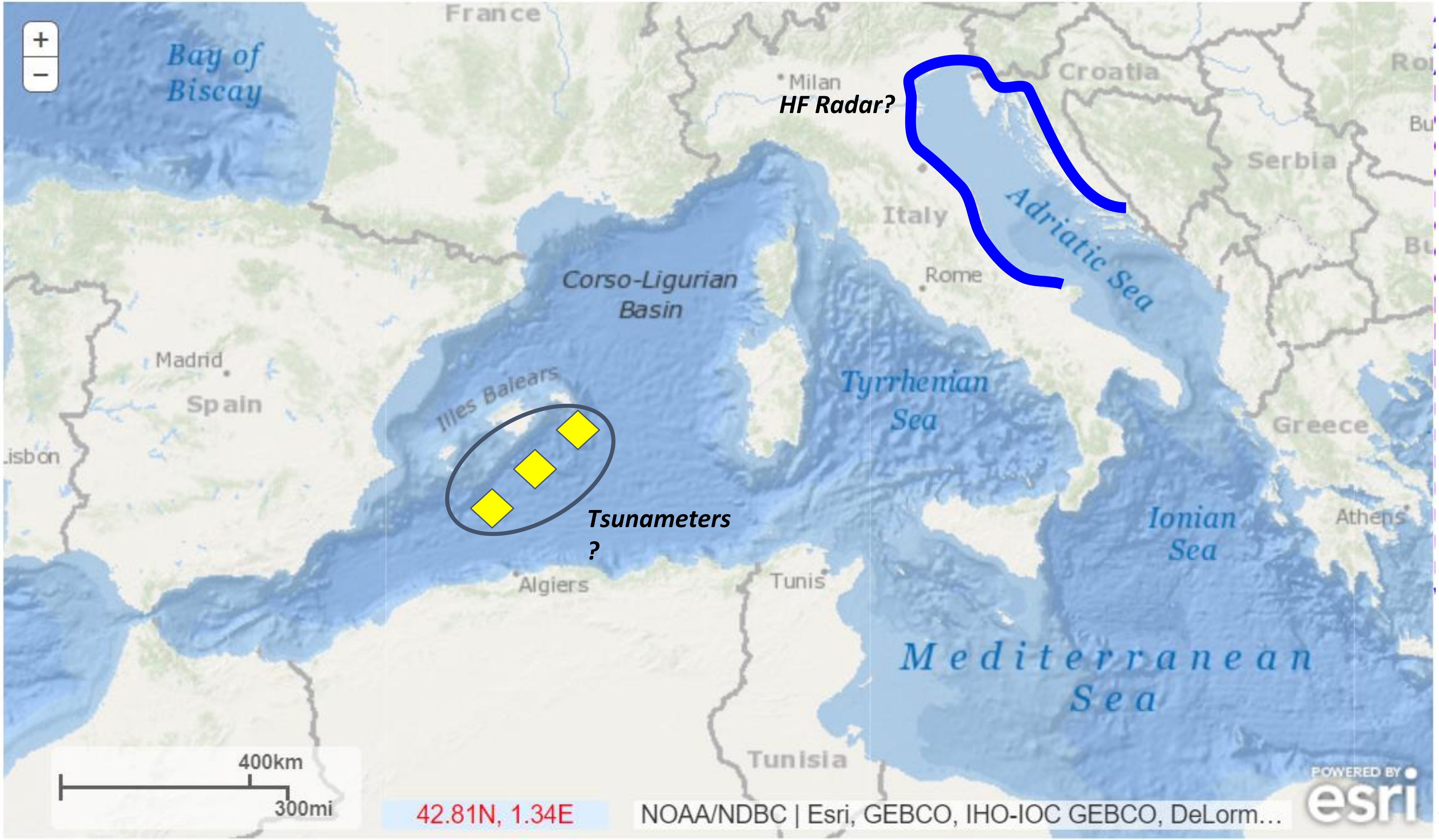
Rethinking Ocean Observations:

Reducing Uncertainty in Global Tsunami Forecasts



Source: National Oceanic and Atmospheric Administration

Could the GTWS be used for MT?   Possibly



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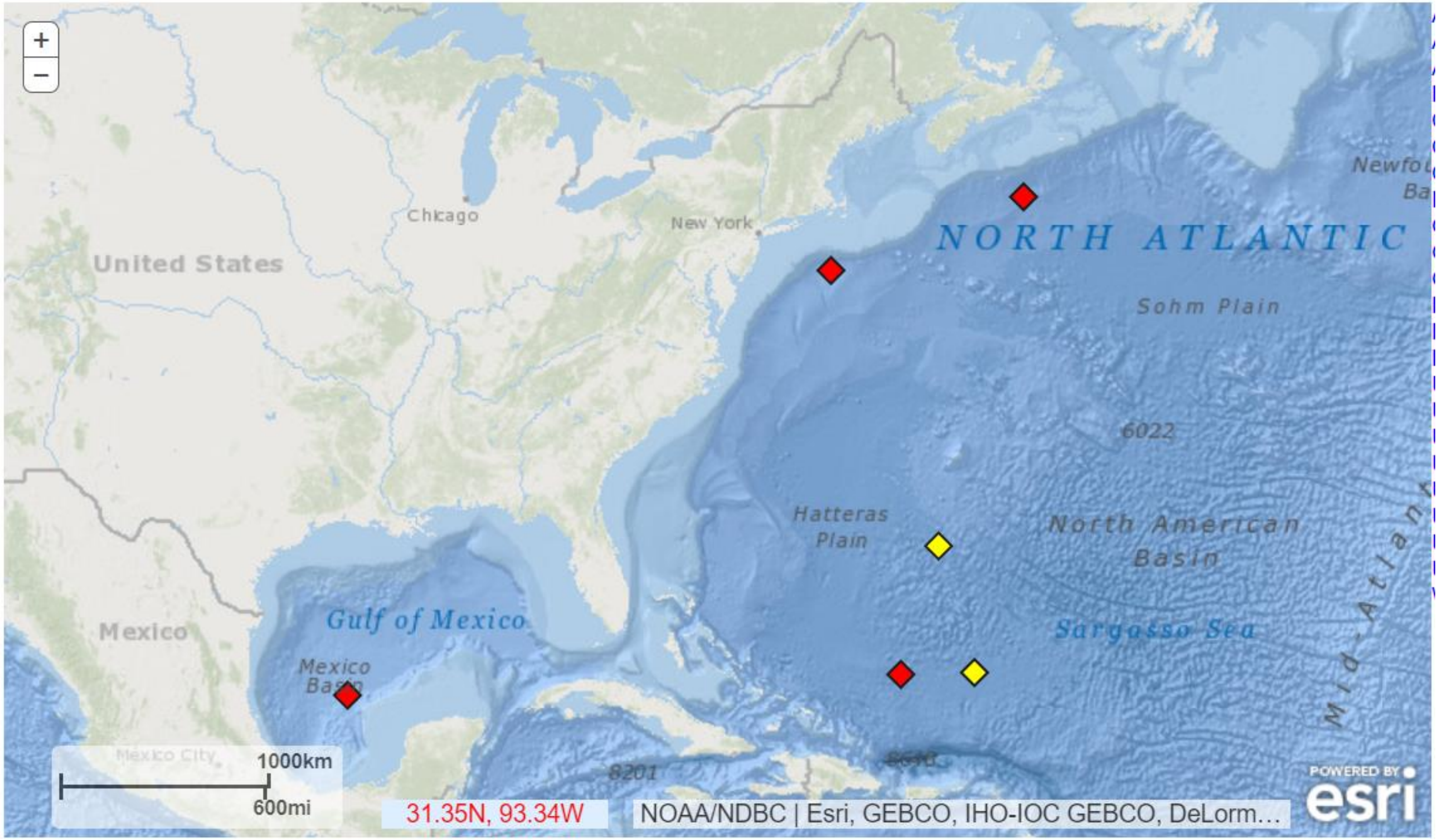

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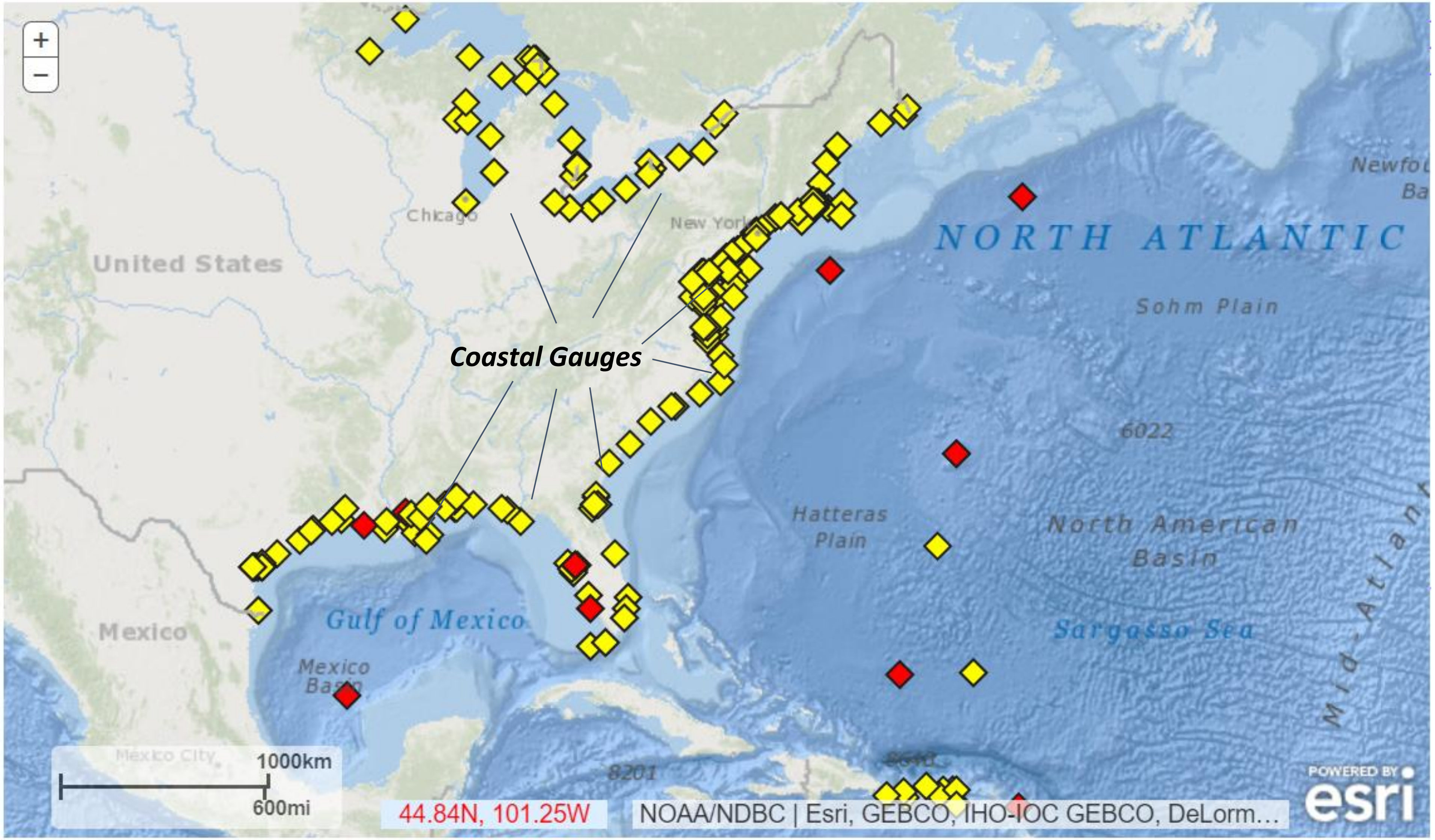

General Standard Operating Procedure Guidance

(i) **<u>Understanding risk</u>**. Member states prone to MT impact should conduct detailed risk assessments to include:

1. Identify areas prone to MT development;
2. Identify types of weather disturbances can create MT in risk-prone areas, and what the seasonal variation is;
3. Determine the range of impact that can be expected from MT, particularly if this an evacuation hazard or a more limited marine impact and;
4. Identify and exercise the the primary mitigation measures available to address these risks.

(ii) **<u>Available Detection networks</u>**: Identify instruments available that can detect MT within area of responsibility including:

1. Meteorological sensors that can identify precursor disturbances
2. Tsunameters that can provide positive detection of MT once formed,
3. Coastal water-level gauges that can verify MT arrival in coastal locations and validate forecasts
4. HF radar that can identify tsunami current velocities in coastal areas (Lipa et al., 2014).

General Standard Operating Procedure Guidance

(iii) **Triggering considerations.** Ensure tsunami detection instruments are tuned to alarm or trigger upon detecting tsunamis. Some guidelines include:

1. Tsunameters trigger on >3cm detection (deep water)
2. Coastal gauges trigger upon tsunami detection (phase filter)
3. Coastal radars (if available) trigger upon tsunami detection (orbital velocity)

(iv) **Communications.** States with at-risk coastal areas should pay careful attention to communications status. This includes ensuring

1. Communications established between detection instruments and warning service support offices (internationally and nationally) and that
2. Regular testing of communications paths, and redundancies identified and conducted

Future Unified System?

Finding: *"Immediate improvement of the existing MT warning can be achieved by unifying the generalized and targeted approach for the meteotsunami warning"*

Goal: Combine NWP-based coupled models with direct, high-density, targeted tsunami observations

Pro:

- Reduced false alarms and more accurate forecasts in MT-prone regions
- Comprehensive MT cuing and forecasts in all other zones

Con:

- Potentially high cost v. risk
- Human capital intensive

Who would oversee such a system? WMO? IOC? Both? Neither?

Ad-hoc Team Recommendations

1. **Joint WMO/IOC coordination on MT alerting**. MT currently is addressed by national or regional Met services offices, but usually in the context of storm surge or anomalous coastal flooding events. It has become clear that a comprehensive dialogue between the IOC and WMO is necessary to ensure full exchange of information in support of a robust international alerting standard.

1. **MT consideration in GTWS instrumentation strategy**. Tsunami detection and measurement capabilities are rapidly improving and this is expected to accelerate under the UN Ocean Decade. It is now possible to consider non-seismic tsunami sources in the global instrumentation strategy, including volcanoes and MT, among others. Input from national and regional met services offices would be particularly useful as the GTWS considers a new generation of tsunami detection and measurement networks

1. **Establish Framework for a Unified MT Global System.** Combining the direct tsunami detection capability of the GTWS with the NWP-based algorithms tuned to MT prediction could deliver significant advances in global capability at minimal cost. It is recommended that the ad-hoc team continue to explore this possibility through 2023 including WMO-namd expert representatives.

1. **Comprehensive hazard assessment**. It is recommended that the ad-hoc team conduct a global MT hazard assessment, providing to all MS an expert document of the existence of MT risks on their coasts.

TOWS WG Recommendation (DRAFT)

The Group decided to continue the Ad Hoc Team on Meteotsunamis to finalise its report, **recommends** that WMO experts be engaged to assist in this task, and **also acknowledges** that WMO requests the WMO-IOC Joint Collaborative Board to discuss tsunami related issues with respect to meteo-tsunami, to clarify the roles and responsibilities for the WMO and UNESCO-IOC, and how best to strengthen collaboration for supporting Member States.