United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

What do we know and need to know to warn for tsunamis generated by non-seismic and complex sources?

Achieving a ***Source Agnostic*** Tsunami Detection, Forecast and Warning System—Stakeholder requirements and international framework drivers

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UN Ocean Decade Tsunami Programme Science Committee
April 7, 2022

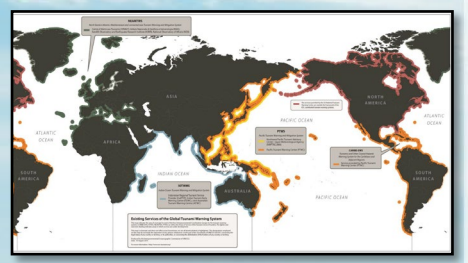
Acknowledgements: Mike Angove

Question: What do at-risk populations need out of tsunami alerts?

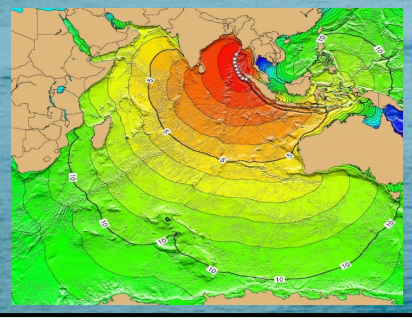
- Timely: Alerts are issued in sufficient time for Emergency Managers and the public to take appropriate actions to preserve life and property.
- Relevant: The alerts and the associated actions must correspond to the actual threat.
- Accurate: Overestimating the threat can strain the usually limited emergency management resources available at short notice and cause ancillary safety concerns. Underestimating the threat—or worse, not anticipating any threat at all—can have obvious catastrophic consequences.

Consistently delivering alerts with these attributes is a significant challenge for the Global Tsunami Warning System, given reliance on high-uncertainty proxy relationships.

How do Global Tsunami Warning Systems Work ?



IOC Tsunami Warning and Mitigation Systems

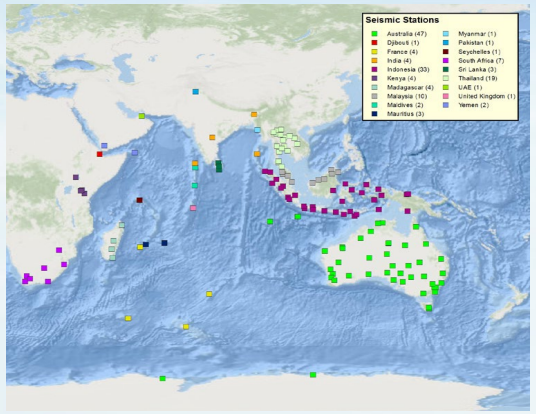


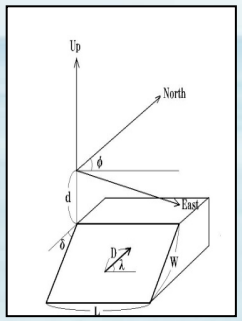
Tsunami Travel / Response Times

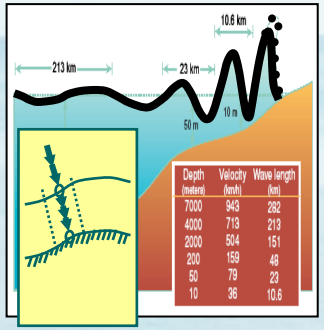
Dec 26, 2004 Indian Ocean, EQ M 9.1

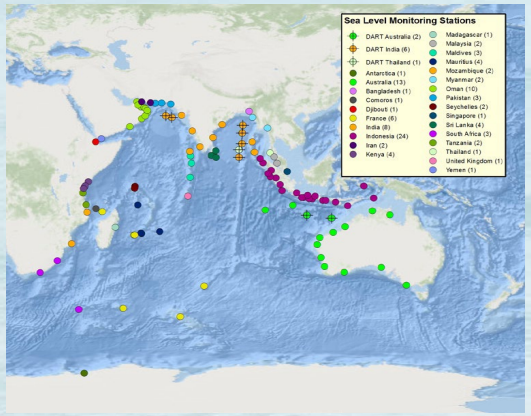
15 min to Indonesia with wave heights of more than 30 m

11 hours to cover whole Indian Ocean









Seismological Data

Model Results

Sea level Data

Threat Information

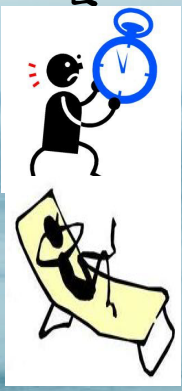
Warning Status

NTWC -1

NTWC -2

NTWC-n

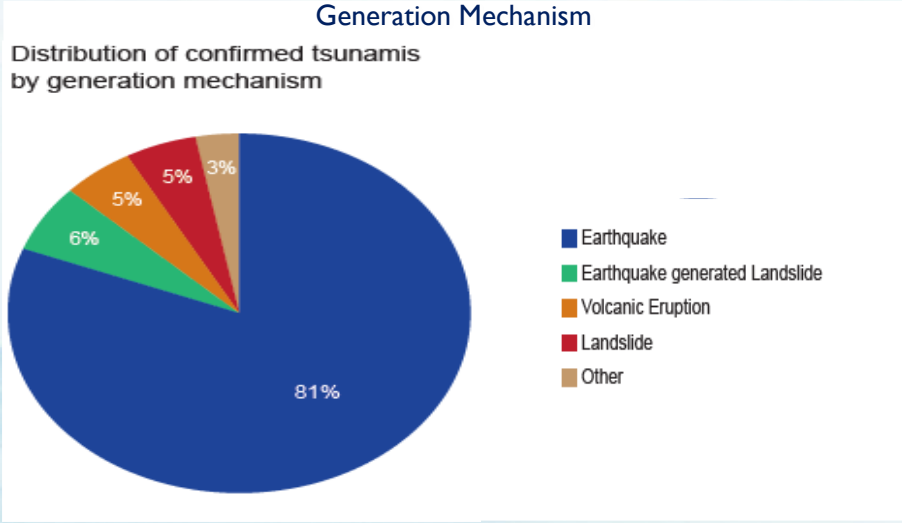
Warnings
NDMO
LDMO
Media
Public

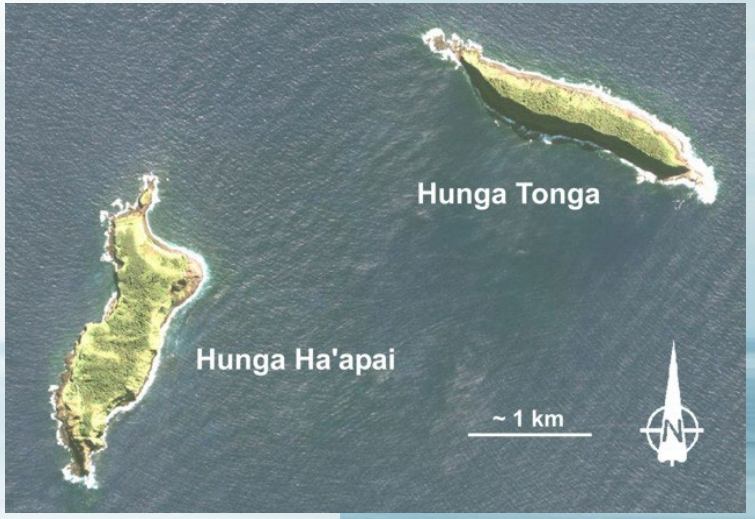


GTS
SMA
FAX
Email
Web

TV
Radio
SMS
Email
Web
SIRENS

This challenge is greatly amplified when considering tsunamis generated without seismic cues





- First indicators often come too late to take evasive action
- Observing systems not tuned to support forecasts for non-seismic sources—even when early detections are made
- Warning Centers not all conditioned to anticipating or responding to non-seismic source tsunamis

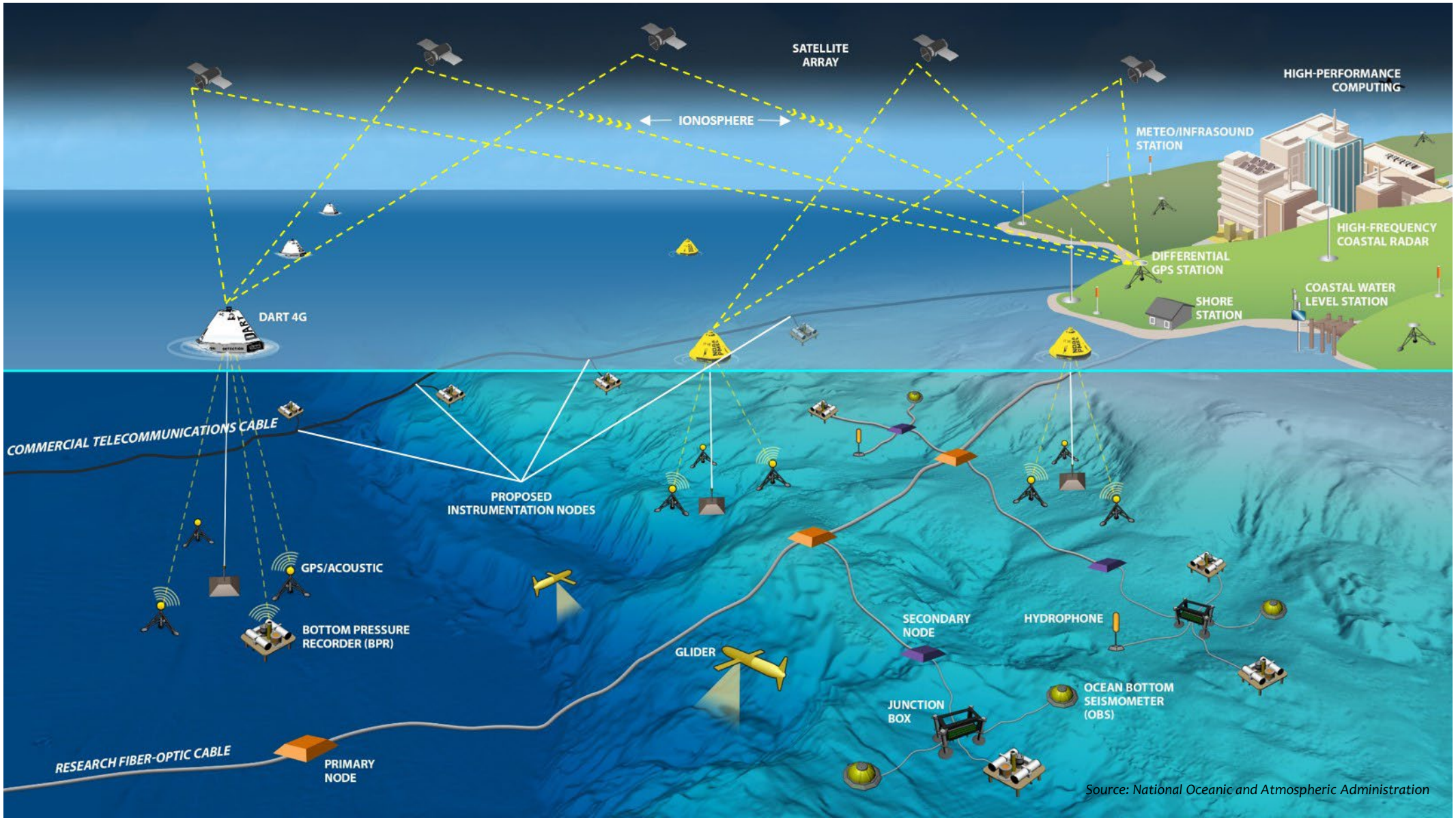
This requires a fundamentally different approach to solving the problem

Opportunity: By shifting focus toward *direct tsunami detection and measurement* we will improve Timeliness, Relevance and Accuracy of *all* Tsunamis

- Tsunamigenic processes—even those associated with earthquakes—are complex and difficult to accurately simulate in real-time.
- In contrast the tsunami **wavefield** is detectable and measureable—with the right instruments and techniques—and propagates deterministically in open water.
- Focusing effort on improving direct tsunami detection and measurement will allow that Global Tsunami Warning System to address all tsunamis independent of source.
- **RESULT**: ***EM Decisions informed by accuracy and precision, rather than broad uncertainties.***

Rethinking Ocean Observations:

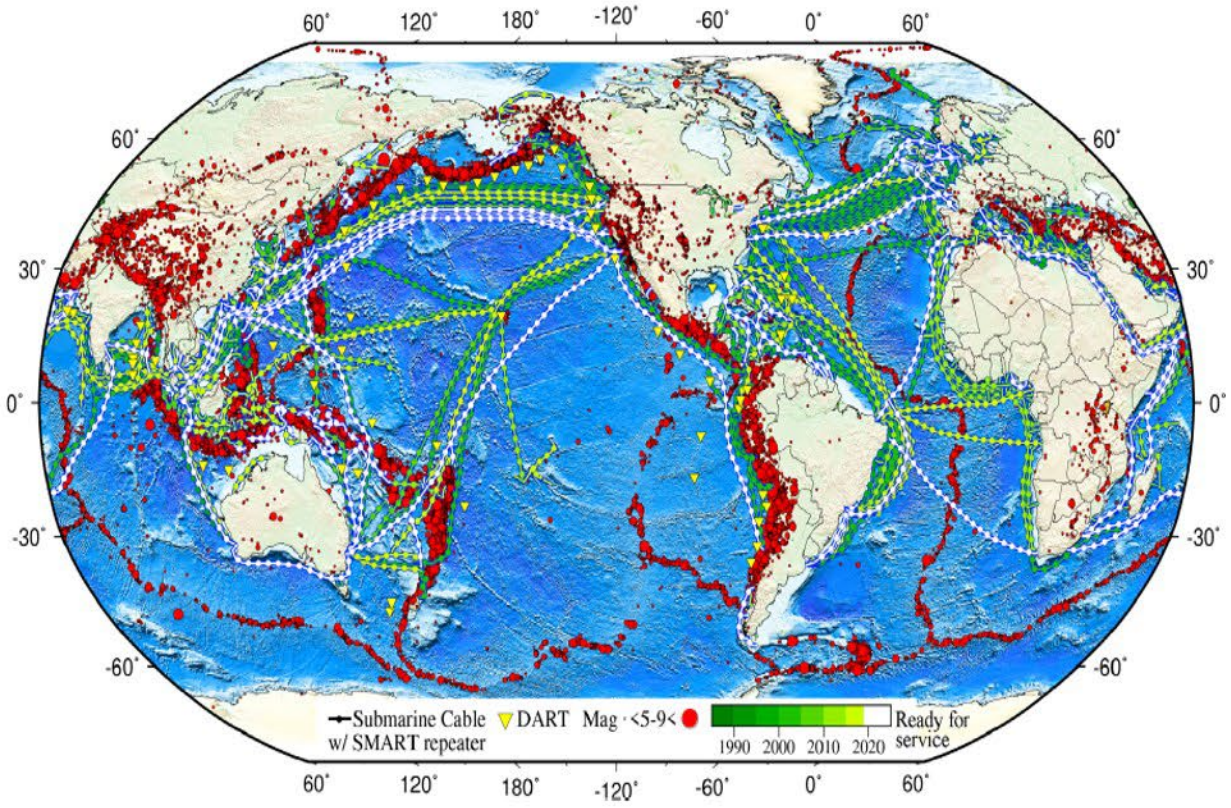
Reducing Uncertainty in Global Tsunami Forecasts



Source: National Oceanic and Atmospheric Administration

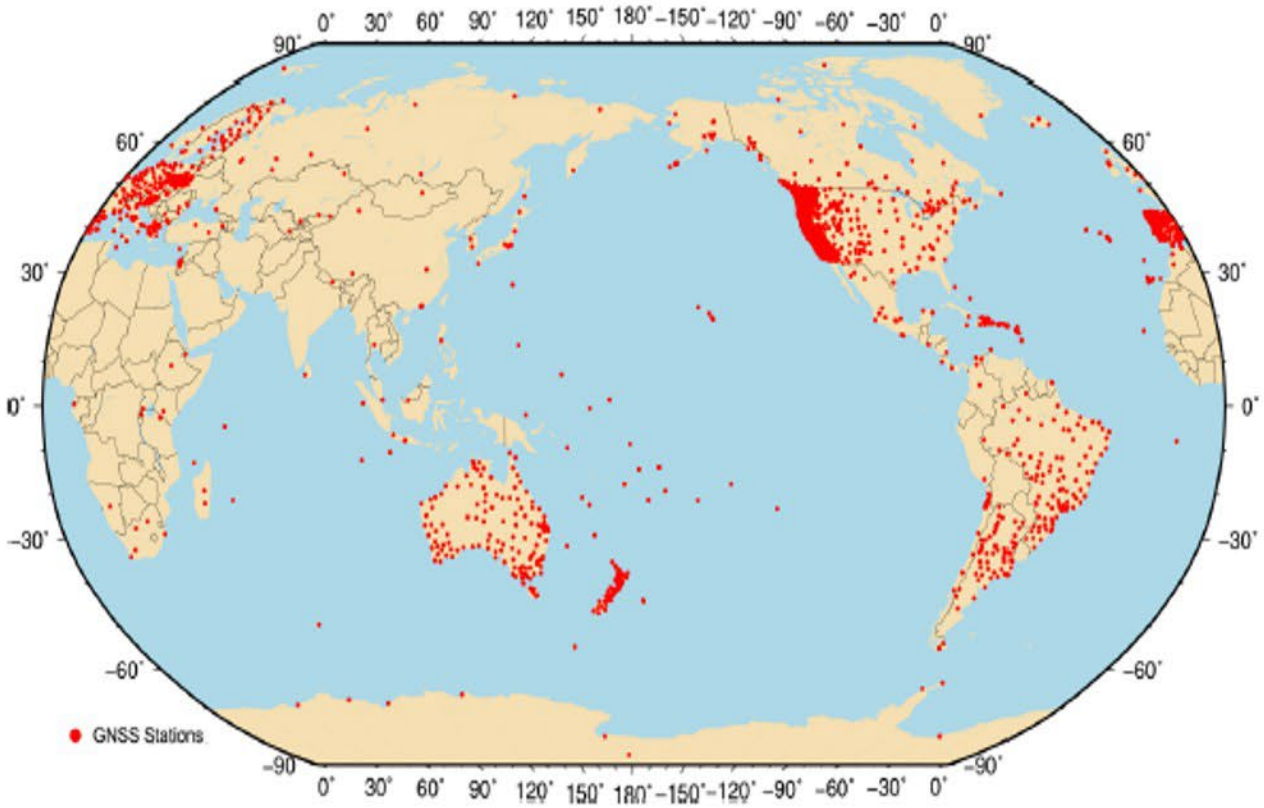
NEW POTENTIAL SOURCES OF OBSERVATIONS FOR TSUNAMI WARNING SYSTEMS

Locations and magnitudes of historical seismic events (red), DART tsunami buoys (yellow triangles) and current (green) and planned (white) submarine cables,. SMART repeaters shown every 300 km



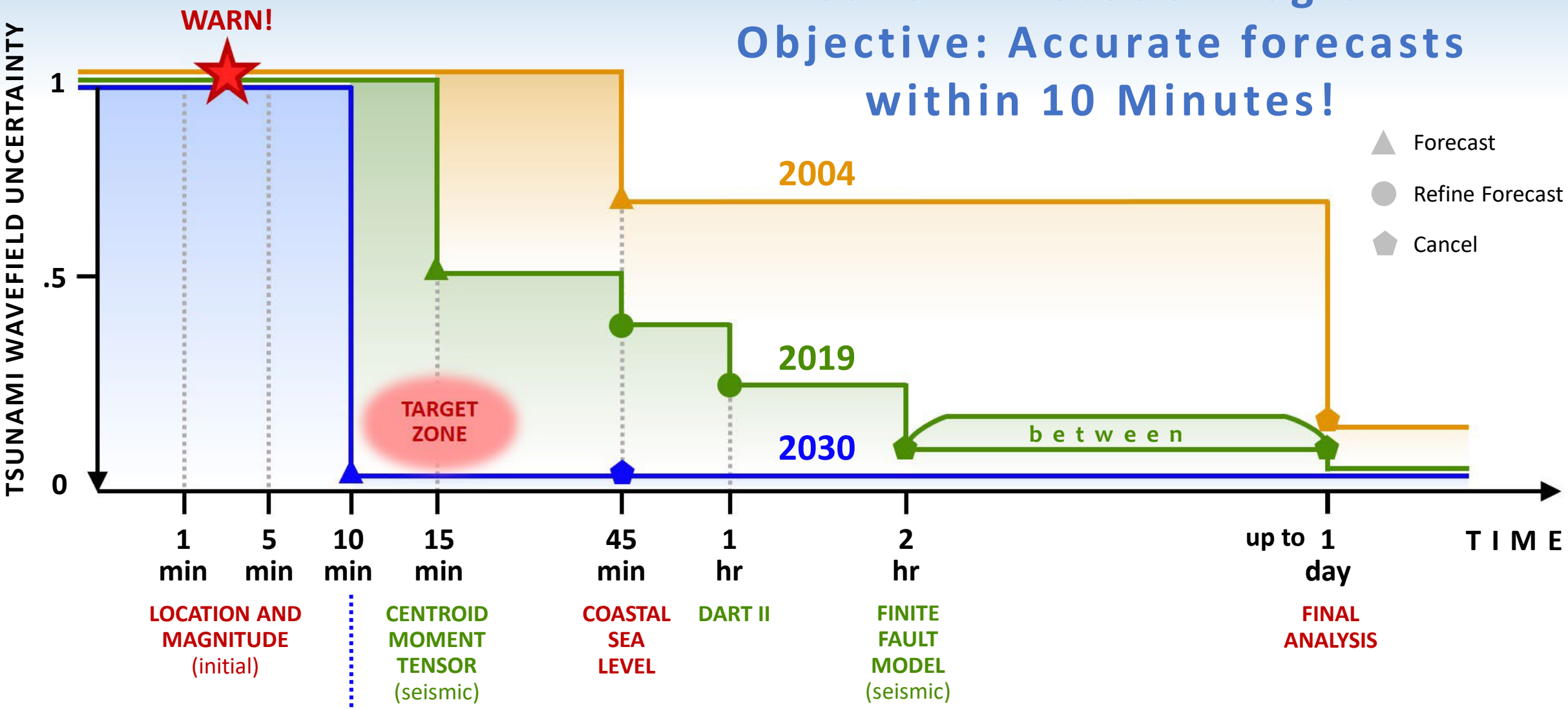
Angove, M . et. al, 2019

The location of 2,260 real-time GNSS stations from public networks around the world



Pacific Northwest Geodetic Array/Central Washington University

Tsunami Decade Program
Objective: Accurate forecasts within 10 Minutes!



- Centroid Moment Tensor (GNSS)/Finite Fault Model (GNSS)
- Full Bottom Pressure (Tsunameters and Cables)
- In-situ Accelerometers
- More…

Data Availability 2004—2030

Angove et. all, 2019

Summary: Tsunamis can be caused by many sources:

- Undersea Earthquakes
- Landslides
- Volcanic Eruption
- Weather disturbances
- Impact
- etc

But…they all have one thing in common: a propagating wave field that can be detected, measured and forecast given the right observing strategy and techniques. The UN Tsunami Decade Program will endeavor to advance these technologies and techniques in support of the Safe Ocean Pillar of the UN Decade of Ocean Science