CLIMATE-RESILIENT DAMS AND
HYDROPOWER INFRASTRUCTURE
INTEGRATING
ENVIRONMENTAL SUSTAINABILITY
IN PLANNING AND DEVELOPMENT

Dams and Earthquakes:
Structural Health Monitoring for Engineering & Safety

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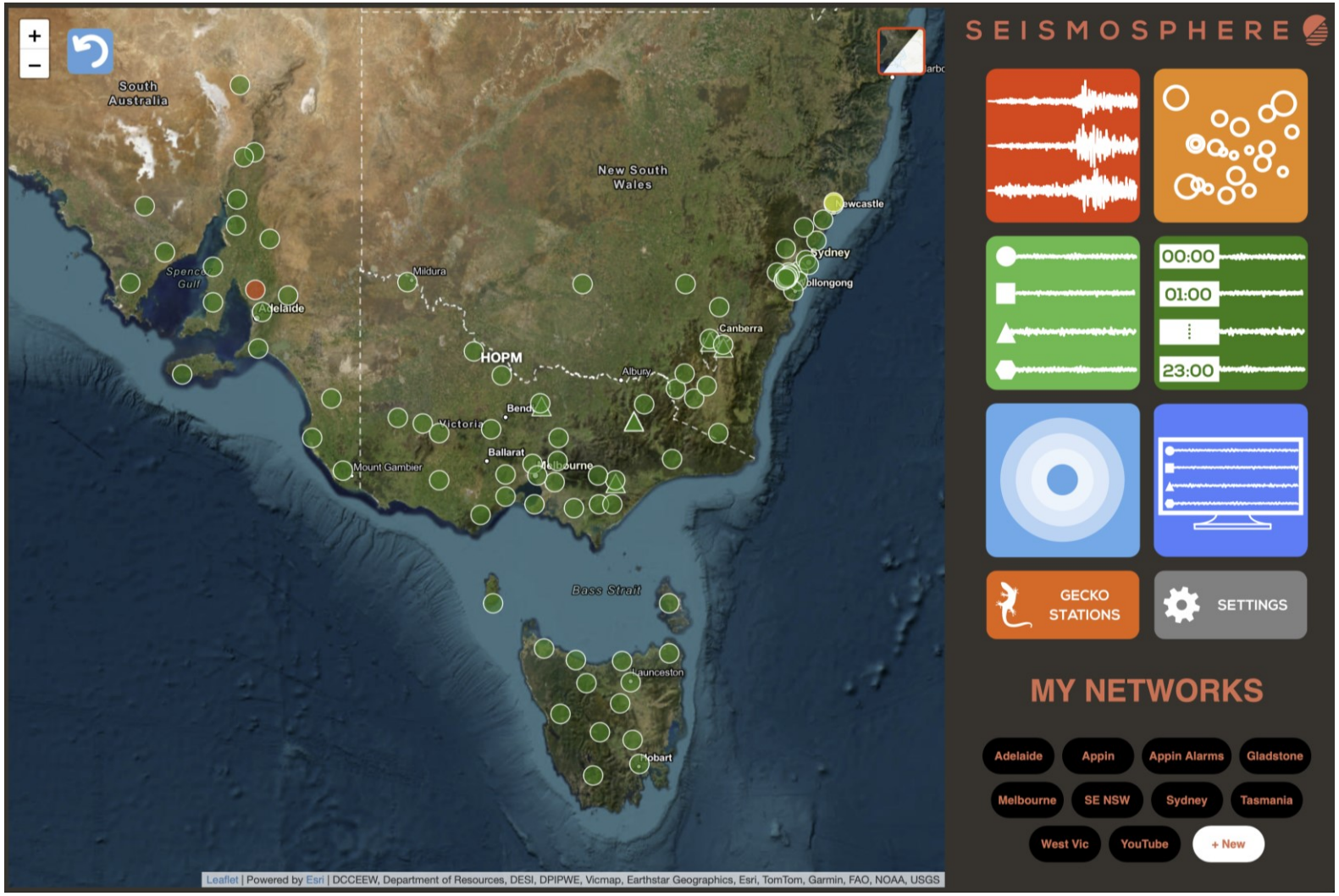
Seismology Research Centre

- Earthquake observatory based in Melbourne, Australia
- 24/7 earthquake monitoring and notifications
- Monitoring 40 large dams for ANCOLD member authorities
- Providing earthquake alarm actions for 700 individual water industry assets



Why undertake structural monitoring?

- Measure response of dams, buildings, bridges, pipelines, etc. to earthquakes, blasts & other vibration events
- **Before** an earthquake
  - Determine natural frequency of structure
  - Monitor response to minor earthquakes
- **During** a major earthquake
  - Alarm generation for occupants & emergency management
  - Record dynamic response of structure
- **After** a major event
  - Look for changes in natural frequency
  - Compare actual performance to modelled design

Natural Period

- Taller structures = longer periods

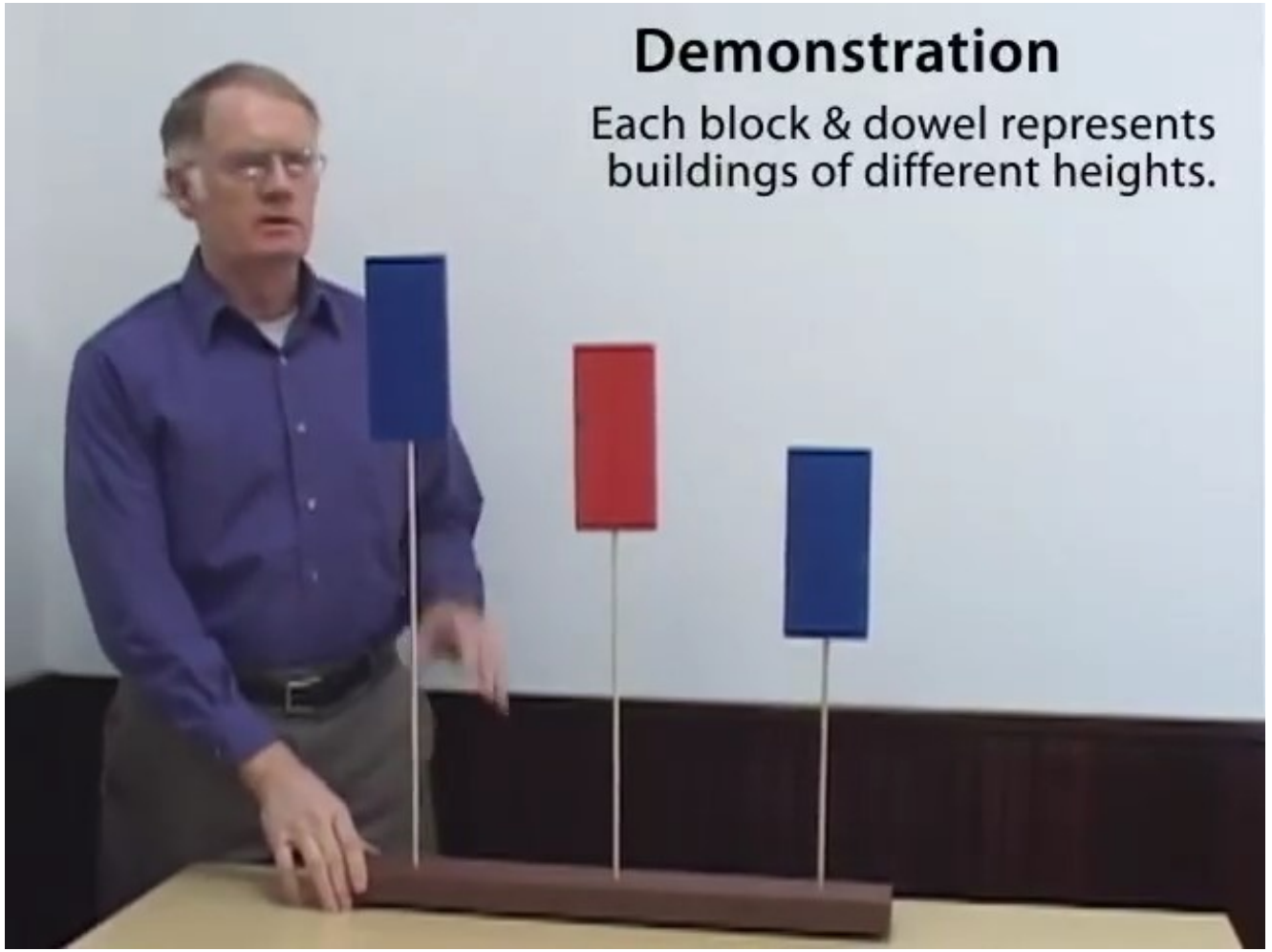
  e.g. 30m+ high; 1 to 10 second period resonance

- Small structures = higher frequency

  e.g. <30m high; resonate at 1Hz to 30Hz

- If a structure is shaken at its natural frequency, the shaking is amplified

Natural Period Demonstration

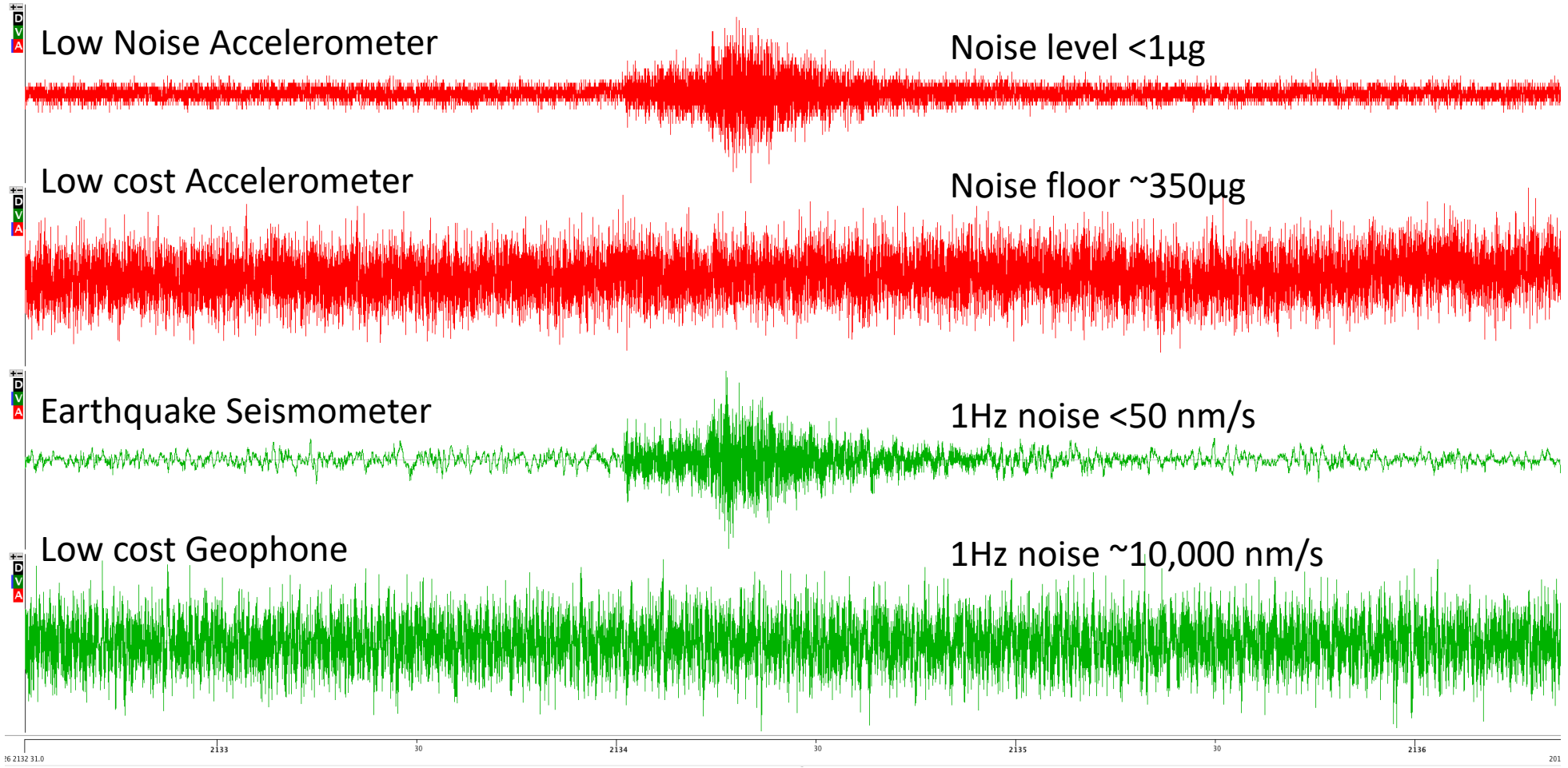


Earthquake Resonance

Measuring Natural Frequency

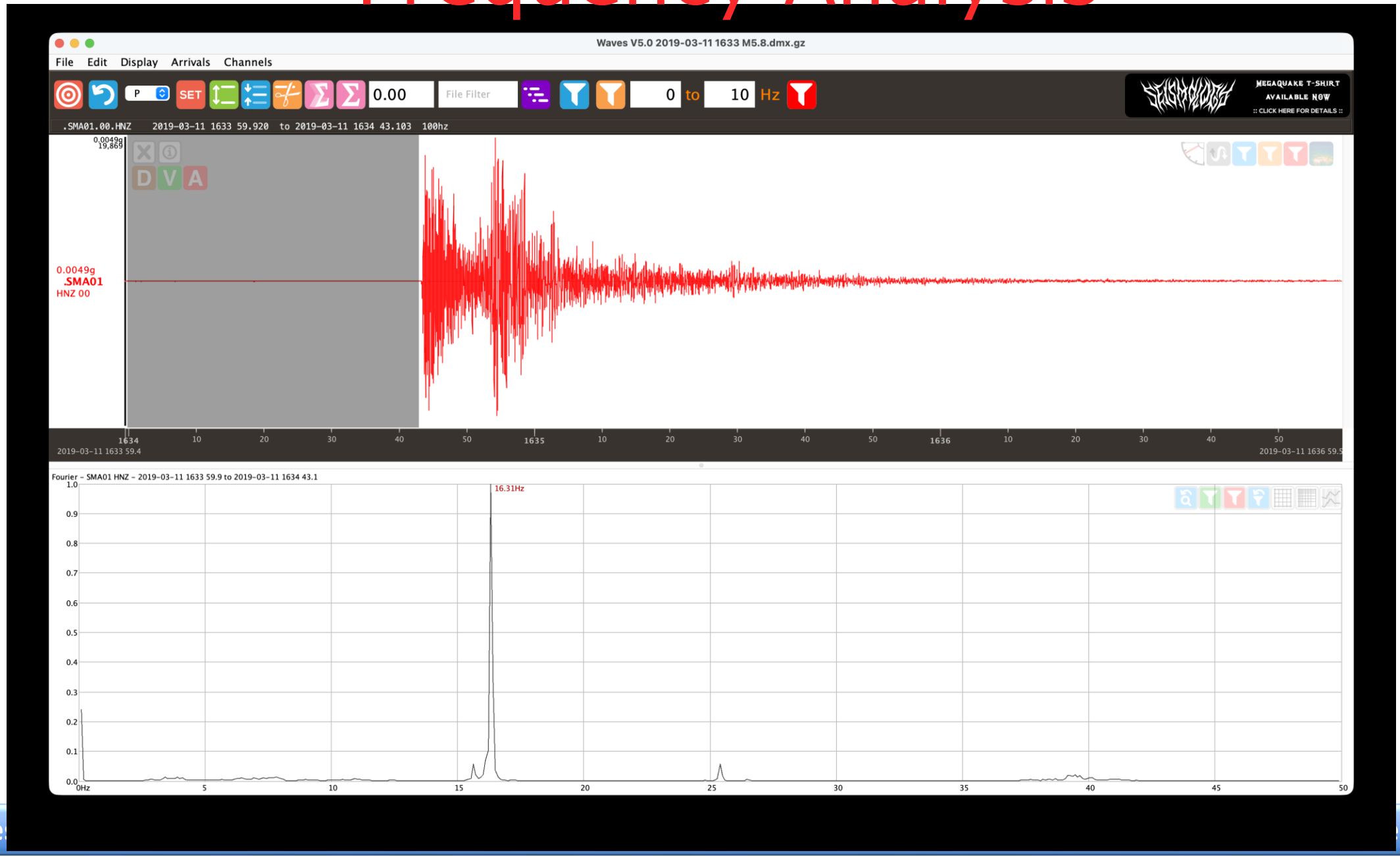
- Need to detect very low amplitude, low frequency motion
- ☐ Cannot use low cost accelerometers - too noisy
- ☐ No cheap geophones - not sensitive to low frequencies
- ☐ Usually recorded with a velocity seismometer
- ☐ Modern low-noise accelerometers can now be used
- Excitation sources: weather, population activity, natural earth resonance

Sensor Quality & Noise



Magnitude 1.8 at 115km range

Frequency Analysis



Instruments in Dams

Where to Locate Instruments in Dams

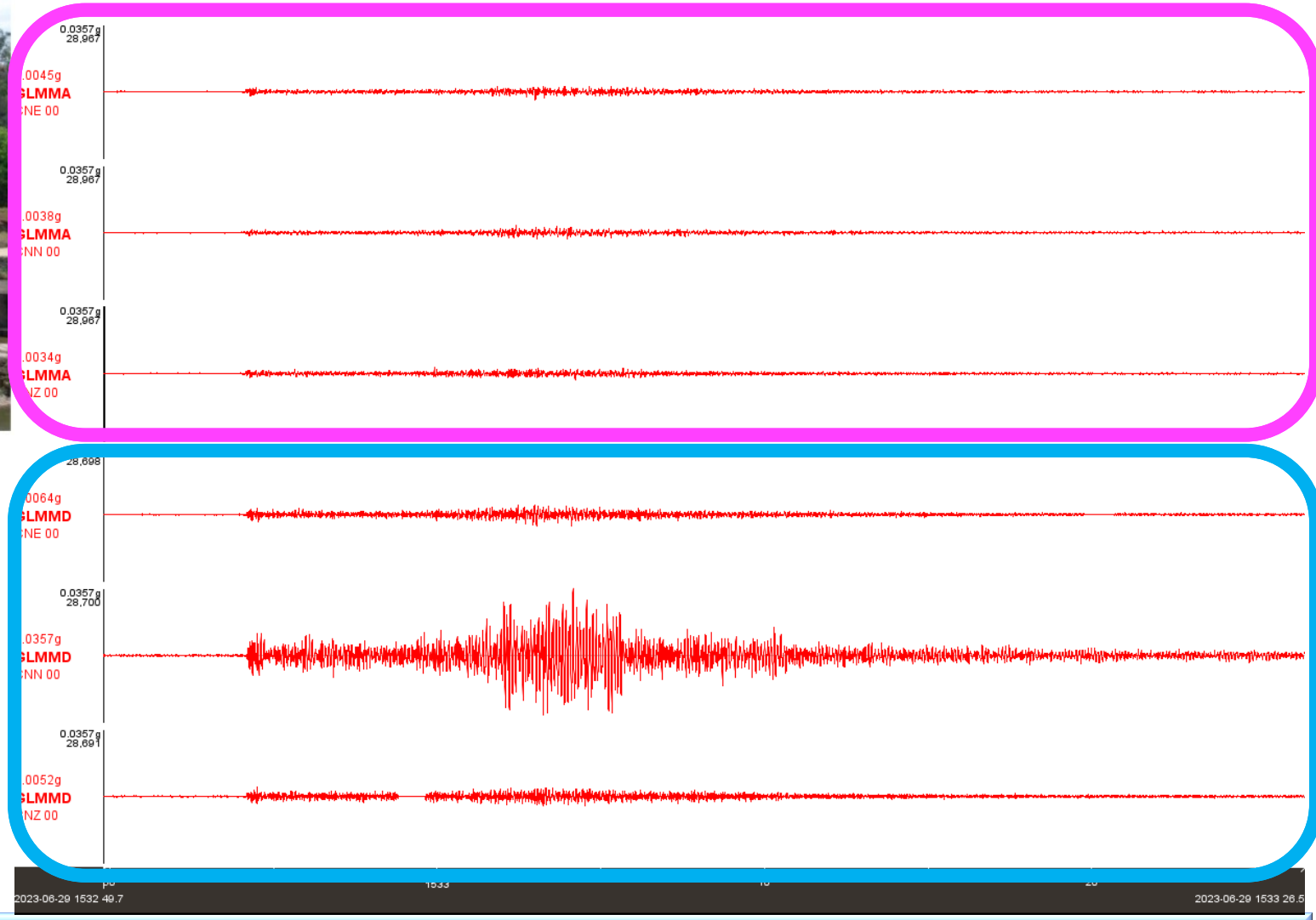
Priority of installation location:

- **1st unit:** **middle of crest**
  (likely to have greatest amplification)
- **2nd unit:** **toe of dam**
  (preferably on bedrock)
- **3rd unit:** **free field bedrock with 2km of dam**
  (act as input motion reference)
- **4th/5th:** **on abutments**
  (relative motion of crest, feedback)
- **6+ units:** **throughout the structure of the dam**
  (in galleries at different levels)

The more sensors are throughout the dam, the better an idea the engineers can have about how the dam responds to earthquakes

Bedrock vs Crest

Magnitude 4.7 earthquake, 60km from dam

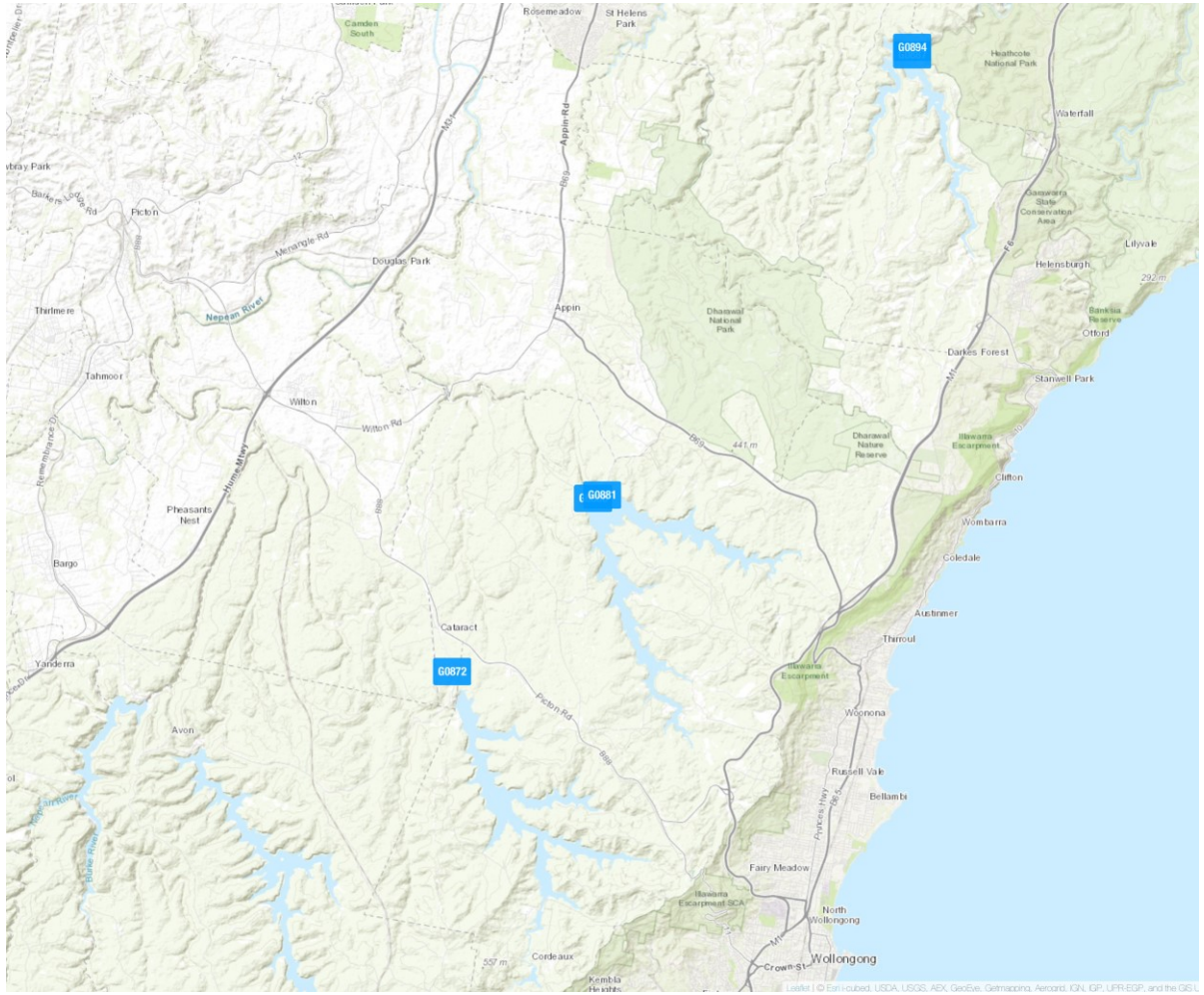


Motion Along Dam Wall

Upstream-Downstream

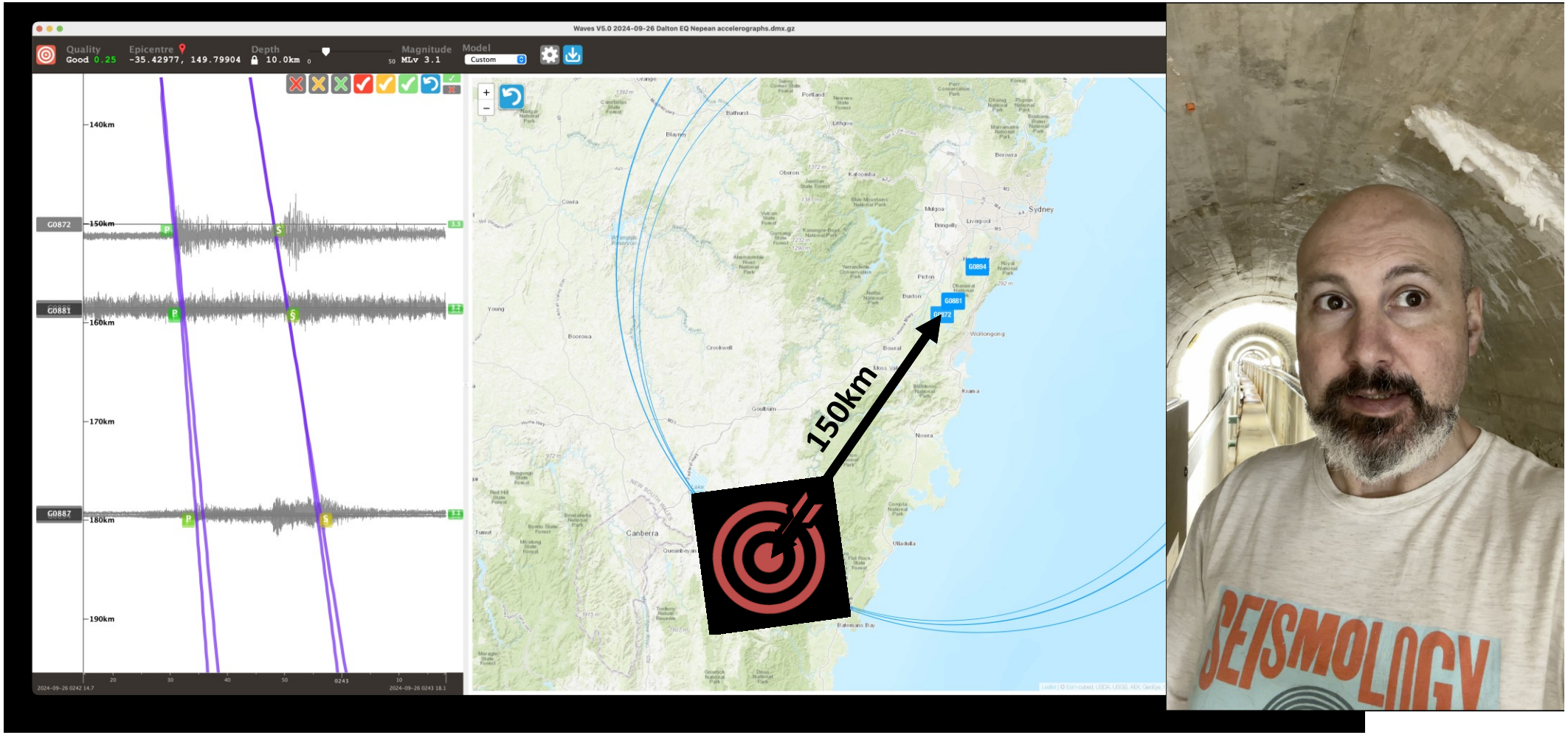
Vertical

2024 Nepean Dams Project



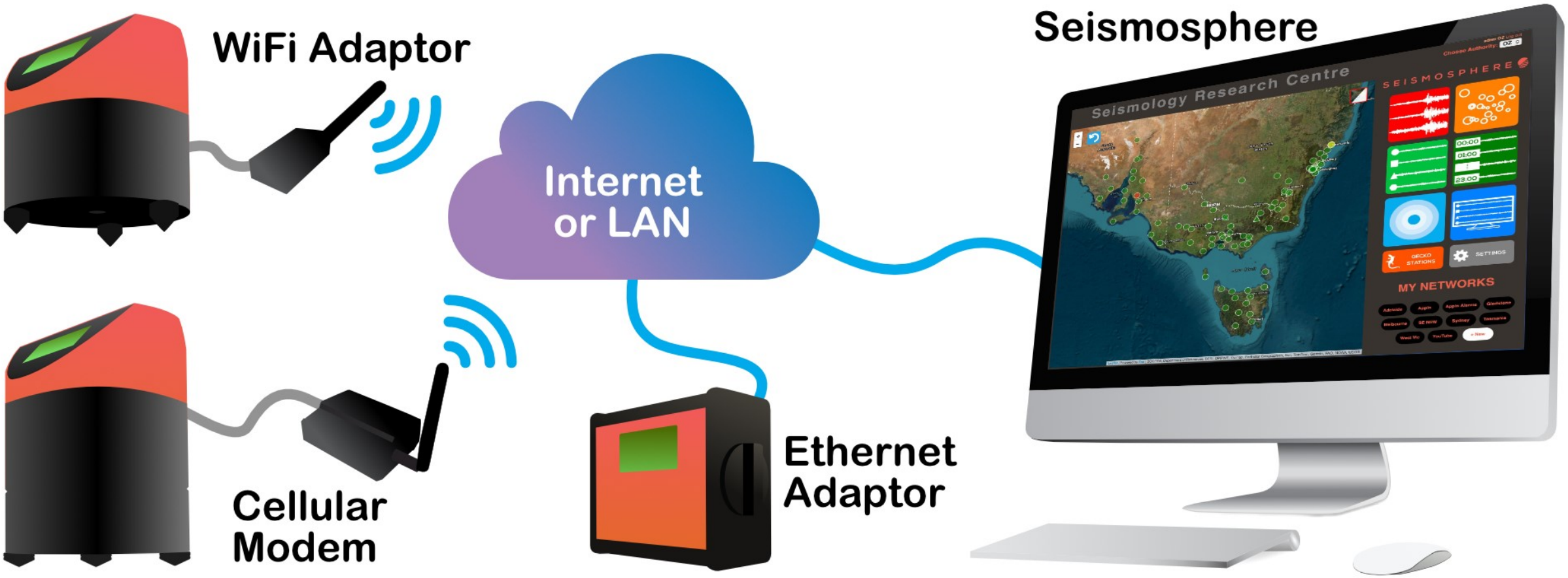
Climate-Resilient Dams and Hydropower Infrastructure: Integrating Environmental Sustainability in Planning and Development

Magnitude 3.1 earthquake during installation!

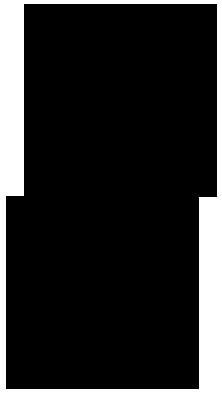


Sample Project – 5 sensors per dam

Data Telemetry

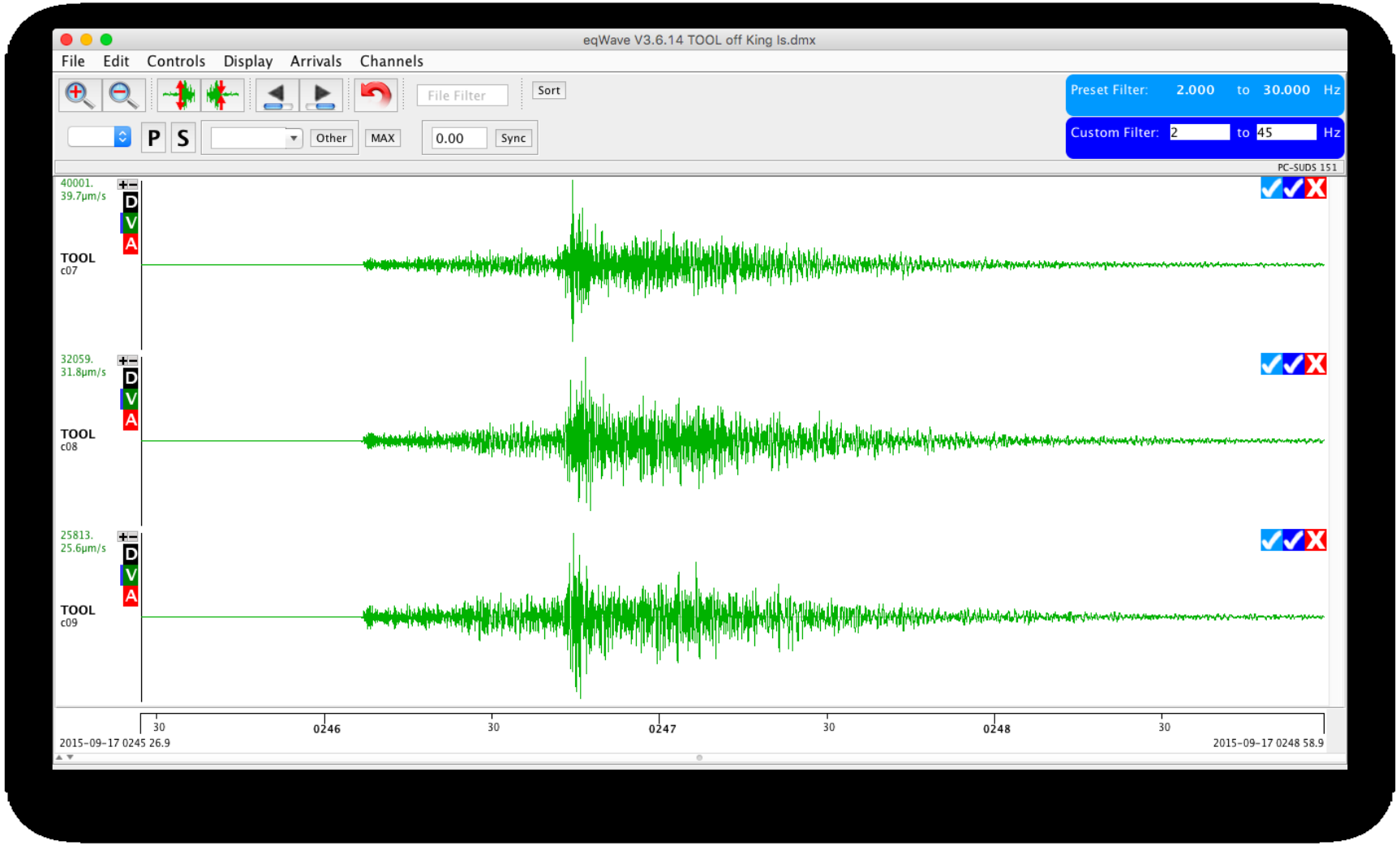


Remote Centralised Data Management

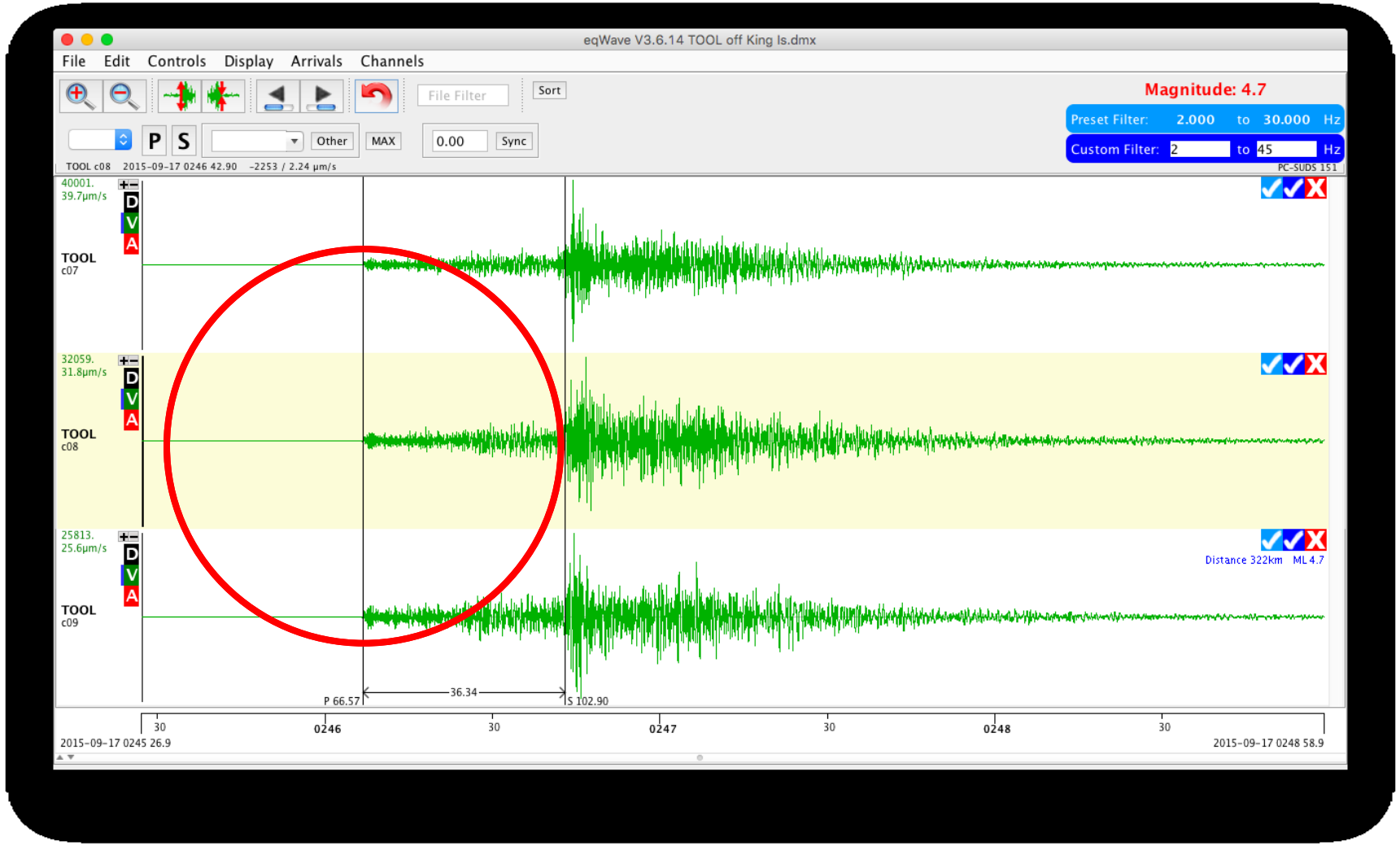


- Realtime data telemetry
- Automatic earthquake alerts
- Seismic instrument network health monitoring
- Rapidly accessible data for engineering analysis
- Reduce asset survey time after a major earthquake
- Help to prioritise emergency services
- Read-only access for stakeholders
- Universal accessibility via web browsers

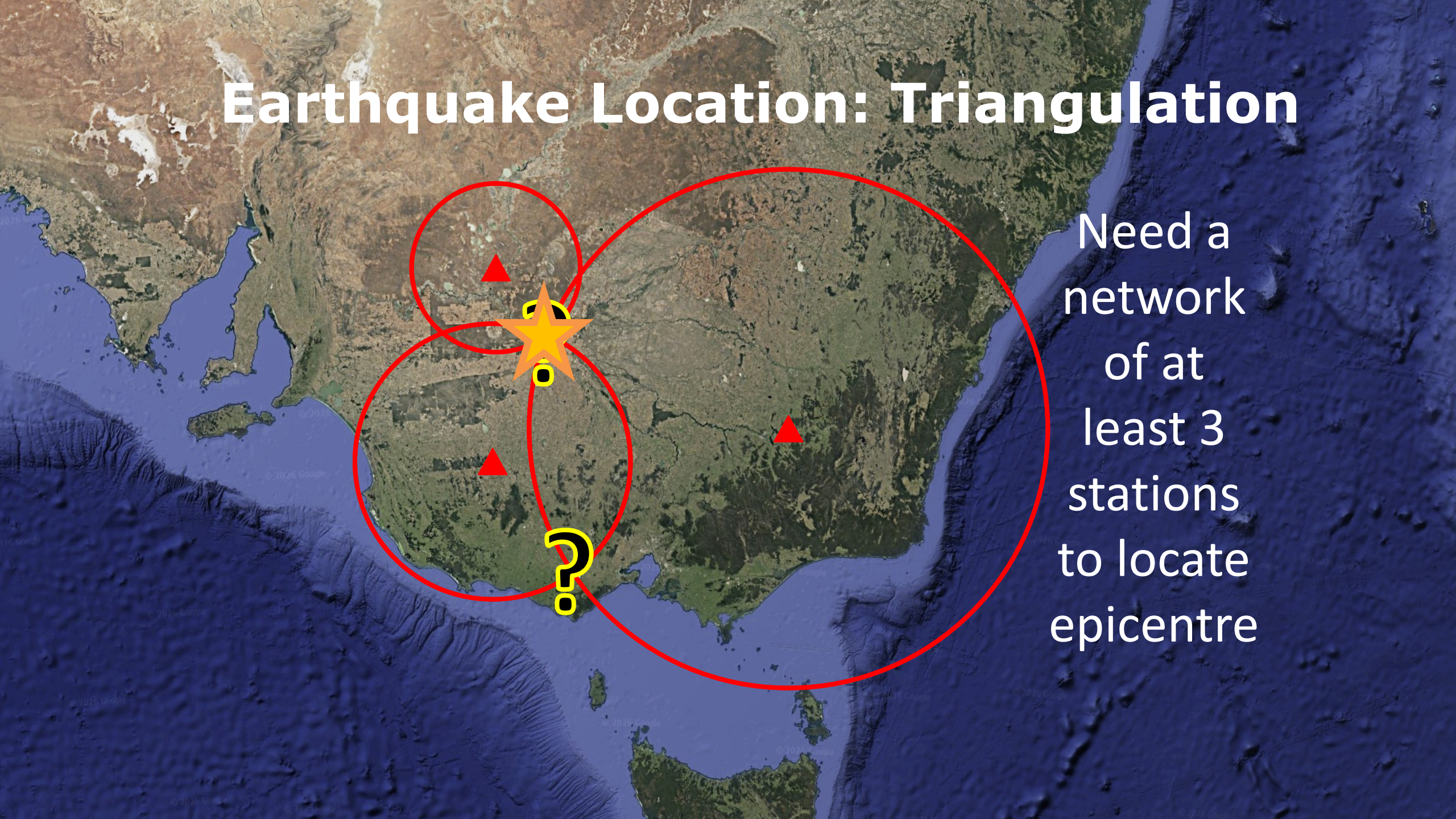
How is earthquake location determined?



P & S wave arrival time difference = distance.
Peak amplitude at distance = magnitude.

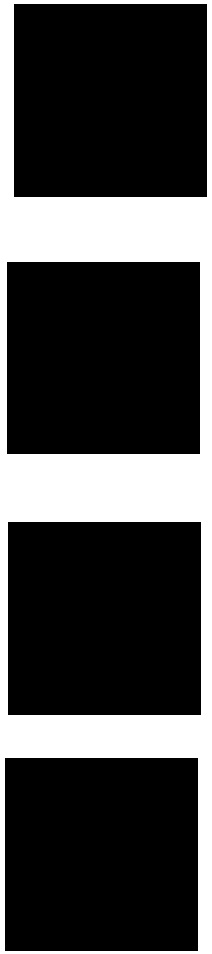


Earthquake Location: Triangulation



Need a network of at least 3 stations to locate epicentre

Summary



- Structural health & performance monitoring requires **continuous** waveform data to be recorded **before**, **during** & **after** major earthquakes
- **Low-noise, high-sensitivity accelerographs** required for amplitude and frequency sensitivity for engineering analysis
- **Realtime telemetry** required for automatic earthquake alerts
- **Centralised data collection** and analysis is critical for effective emergency response


Thank You