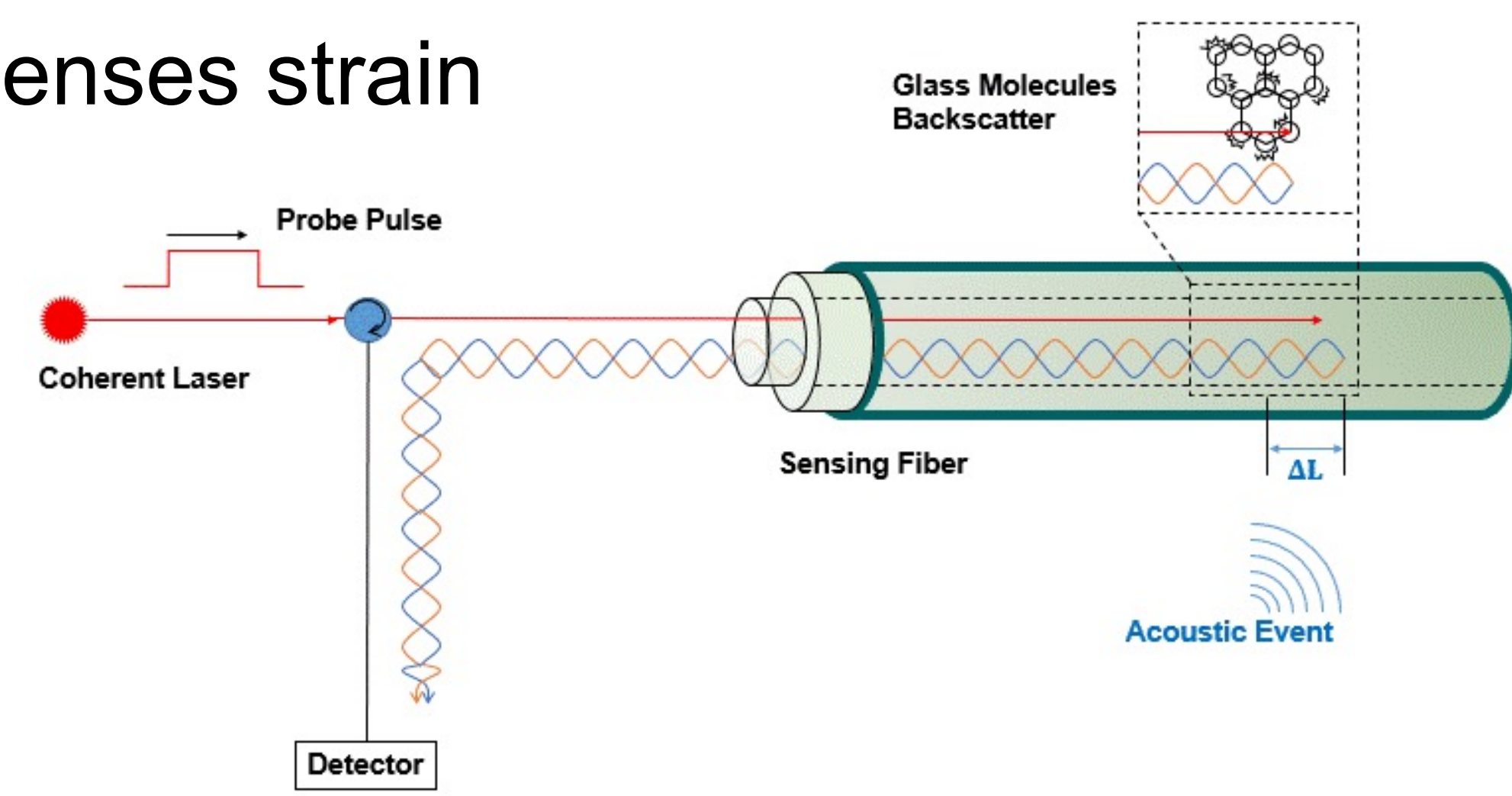
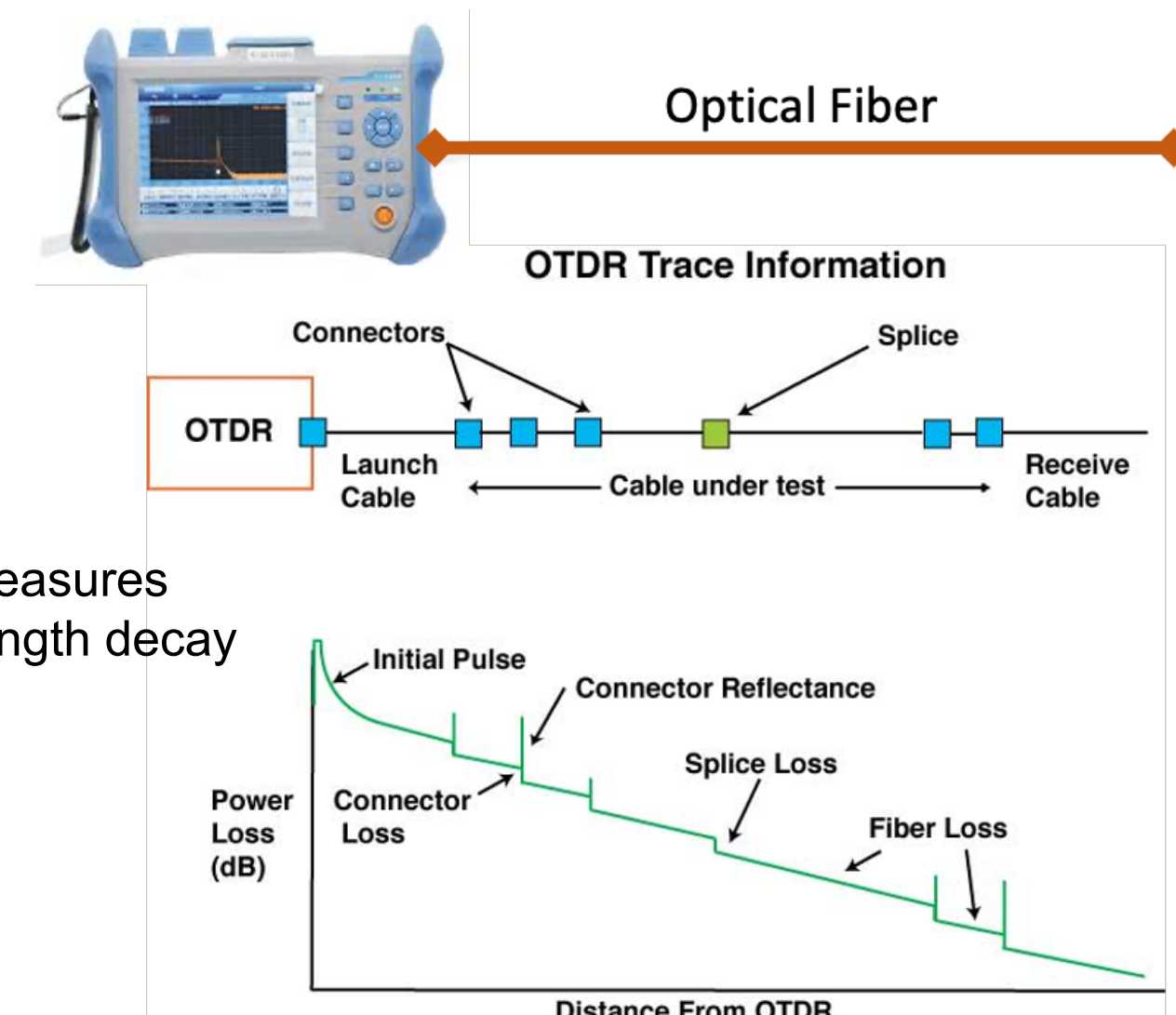


## Fiber Optic Strain Sensing

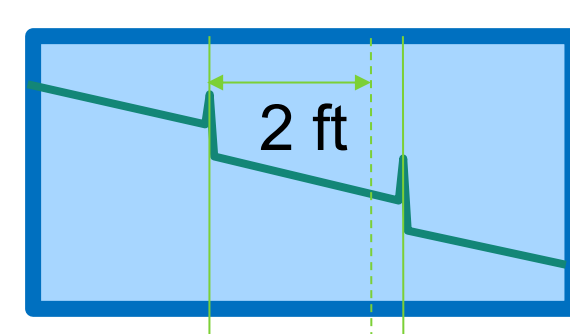
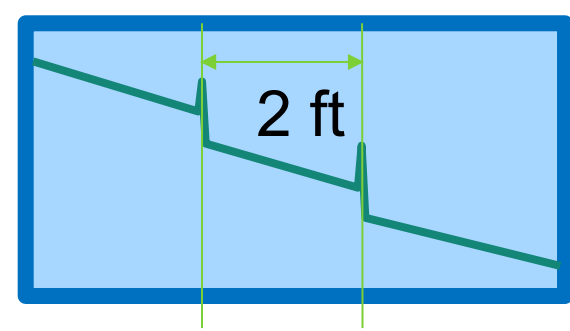
### How fiber senses strain



The OTDR measures reflection strength decay with distance



Two connectors



When fiber is stretched ...

... distance between Imperfections changes

- Distributed Strain Sensing with Optical Time Domain Reflectometers
  - The OTDR is routinely used for communications fiber testing
  - Acquires a "trace" where reflections represent defects along fibers with lengths from 1-100 km
  - If the fiber is stretched, the time between defects will increase
  - Time Strain is defined as the change in travel time between defects when repeated measurements are made
  - Time Strain Inversion algorithms can be used to monitor strain as small as  $10^{-4}$  at 1 cm to 10 m resolution
  - Off the shelf OTDR's can acquire traces at 1 to 60 second intervals

# MoMacMo, Limited

## Geophysics for the greater good

- Climate change and geohazards
- Fiber optic strain monitoring
- Landslides, pipelines, volcanos
- Monitoring and prediction

www.momacmo.org

## Distributed Acoustic Sensing (DAS)

**The Mt. Meager DAS Experiment**

Sara Klaasen<sup>ETH</sup>, Andreas Fichtner<sup>ETH</sup>, Jan Dettmer<sup>U. Calgary</sup>

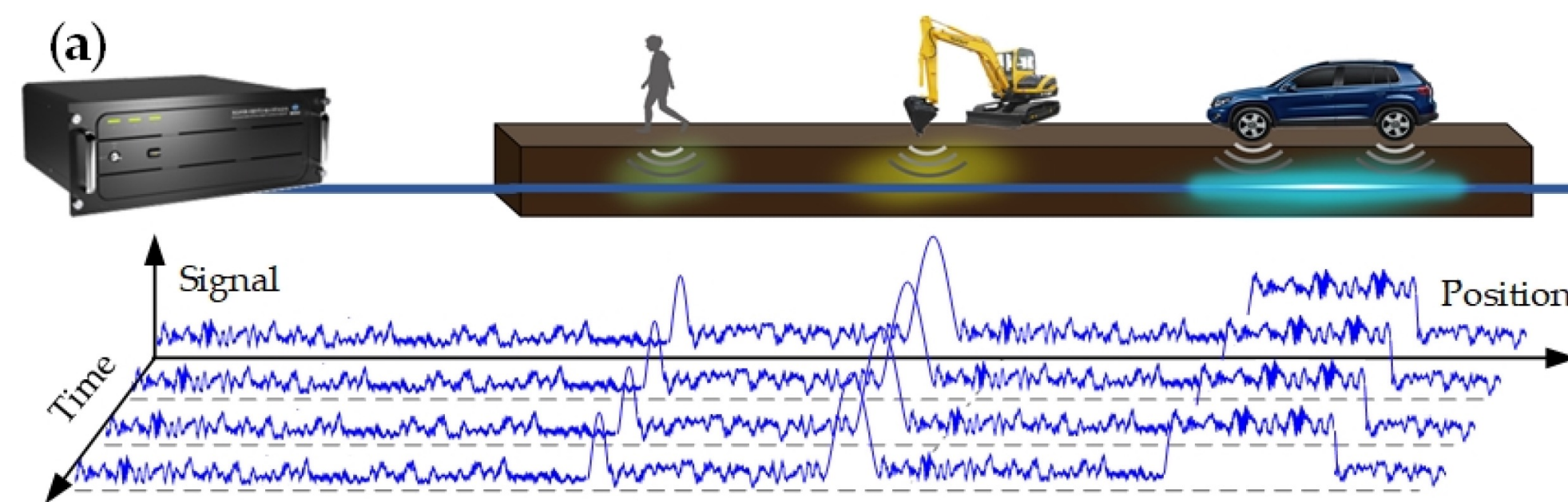
**Mt. Meager**

- Active volcano in the Garibaldi range
- High geothermal potential
- Massive landslides [50 Mio m<sup>3</sup> in 2010]

**DAS Experiment**

- 3 km cable along Meager ridge at 2100 a.s.l.
- Sep.-Oct. 2019

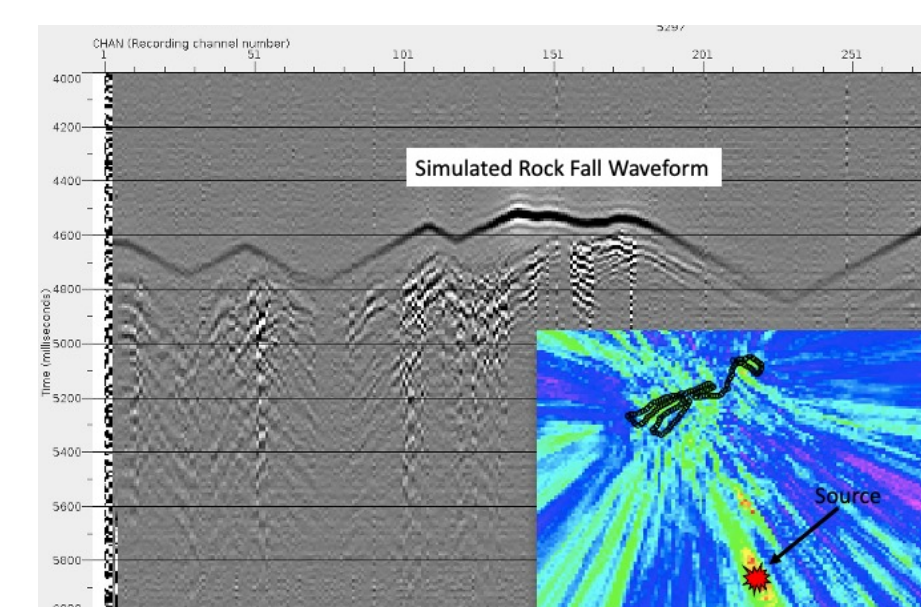
### DAS Vibration Monitoring



### Rockfall Detection with Distributed Acoustic Sensing

- DAS detects broad-band differential strain on fibers
- Rockfalls generate energetic surface waves in the 5-50 Hz range
- DAS detects these events crossing the fiber
- We use interferometry to provide rockfall energy density maps

#### Rockfall Interferometry



**Mt Meager DAS Cable Layout**

Glacier (K-N)  
Ridge (A-J)

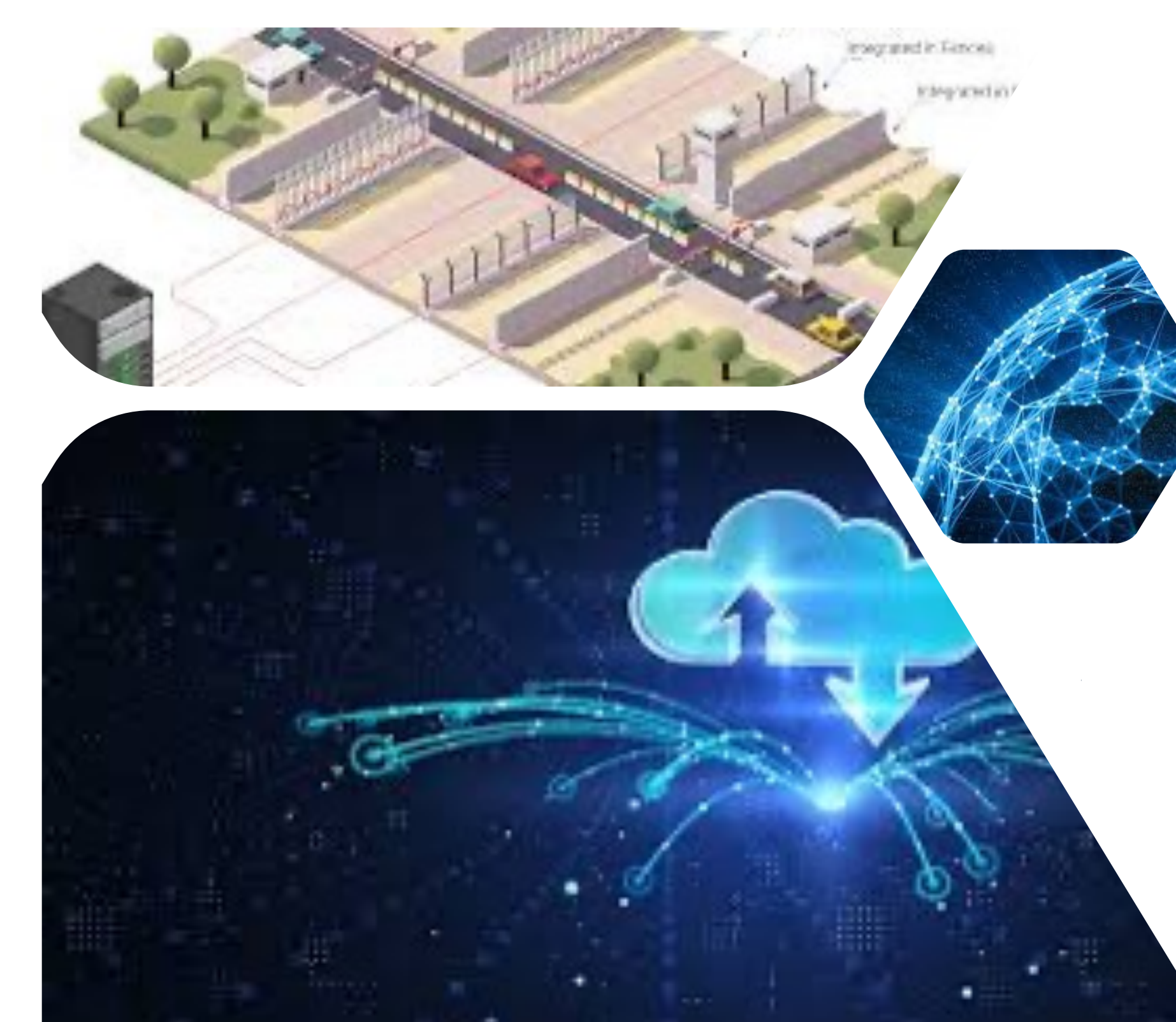
Low Frequency Strain

- Zero to 1 Hz
- Temp induced
- Warm = expansion
- Cold = contraction
- One UTC day
- Sunrise on glacier
- Wind on ridge

## MoMacMo Vision: Global Strain Monitoring

### A Global "Internet of Things" (IoT)

- Low cost sensors
- Monitoring on active internet fibers
- Cellular and LoRaWAN networks



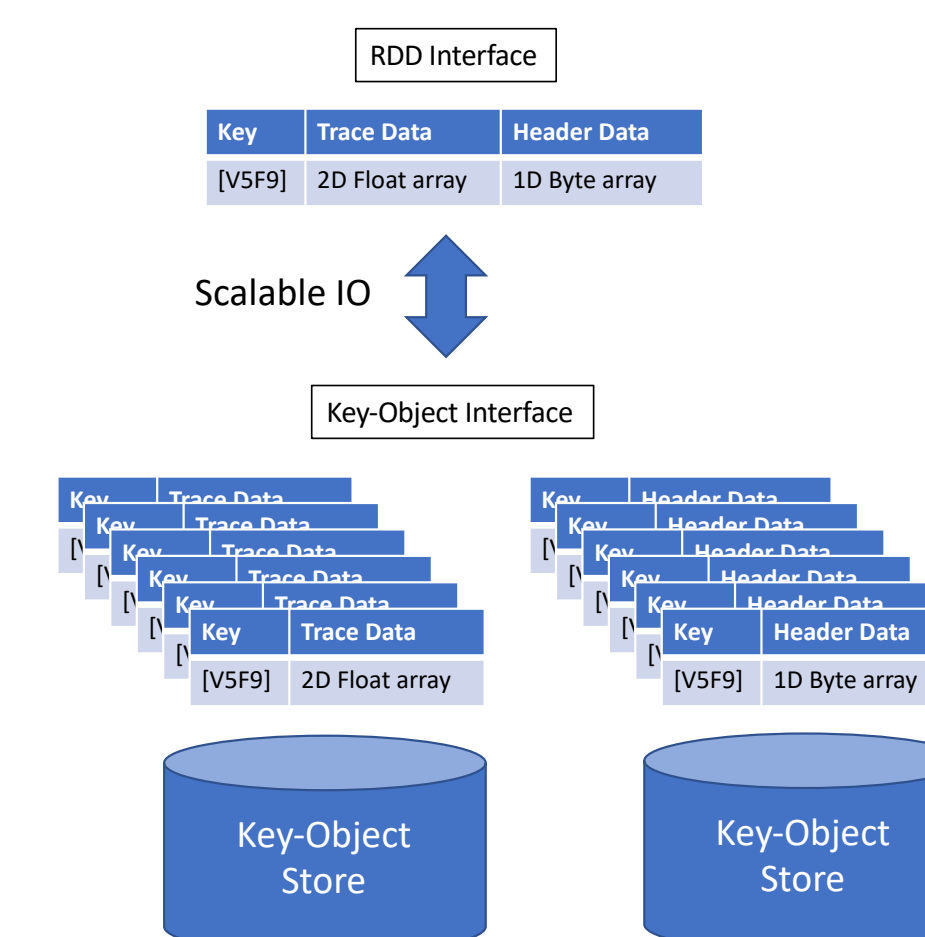
#### Geologic Hazard Monitoring and Prediction

- Earthquakes
- Volcanic eruptions
- Landslides
- Glacial outburst
- Subsidence
- Pipeline Leaks



#### All in the Cloud

- IoT frameworks
- Cloud storage
- Machine learning
- Real time analysis
- Predictions and alarms



# Fiber Strain Monitoring for Environmental Geophysics

Chuck Mosher, Sanjay Sood, Rob Ferguson

