Build an AI-powered platform for early detection of earthquake precursors using seismic waveform analysis, anomaly detection, and geospatial imaging. Integrated Hugging Face models, USGS open data, and a real-time alerting dashboard for scientific and emergency use.

Built an AI-powered earthquake precursor detection platform using Hugging Face, USGS seismic data, and InSAR imagery. Designed a real-time risk scoring dashboard with waveform anomaly detection and automated event summarization, enabling focused early warning insights for geoscience and emergency management use.

## **🌍 Project Name: *QuakeCast – AI-Powered Earthquake Pattern Detection & Early Risk Forecasting***

### **🚀 What It Does**

**QuakeCast** is an AI-powered platform that analyzes seismic data, satellite imagery, and historical patterns to **detect potential foreshocks, anomalies, and stress signatures**—and predict **short-term earthquake risks** in tectonically active regions.

It does **not** predict exact earthquakes (no AI can currently), but provides **real-time anomaly detection and risk-level indicators** to help scientists, civil authorities, and planners monitor early warning signals and allocate attention to high-risk zones.

### **🌐 Real-World Problem It Solves**

Earthquake prediction remains one of the grand challenges in geoscience. While precise forecasting is not yet possible, early detection of **precursor anomalies** (like low-frequency tremor, gas emissions, or stress migration) using machine learning can help inform **early alerts and focused monitoring**, potentially saving lives and resources.

### **🤖 Key Hugging Face Tasks Used**

| **Task** | **Use in QuakeCast** |
| --- | --- |
| **Time Series Classification** (custom/transfer learning) | Classify seismic signal types (tremor, foreshock, background) |
| **Anomaly Detection (custom)** | Flag deviations from normal waveform or stress signal patterns |
| **Text Summarization & Generation** | Auto-summarize regional seismic bulletins or generate risk reports |
| **Image Classification** | Analyze InSAR satellite imagery or seismic spectrograms |
| **Graph Machine Learning** | Model fault line stress propagation via graph networks (optional advanced feature) |

### 🛠️ **Tech Stack**

| **Compnent** | **Technology** |
| --- | --- |
| Backend | Python, FastAPI |
| ML | PyTorch, Hugging Face Transformers, Scikit-learn |
| Data | USGS Earthquake Catalog, IRIS waveform data, Sentinel-1 InSAR |
| Frontend | React or Angular, D3.js for seismic visualizations |
| Storage | PostgreSQL/PostGIS or TimescaleDB (for seismic data) |
| Hosting | Vercel (frontend), Render/AWS (backend), Docker |

### 📈 **Example Features**

* Upload or stream waveform data → classify for tremor/foreshock patterns
* Analyze historical earthquake sequences using sliding time windows
* Display risk heatmaps for a region over time
* Input InSAR image → detect ground deformation using Hugging Face models
* Auto-generate a daily seismic summary for a region

### Portfolio Demo:

* Visual dashboard with risk indicators and animated seismic maps
* Side-by-side comparison of predicted vs. actual earthquake events
* Optional email/SMS alerts (via Twilio) for risk threshold exceedance

### Roadmap Summary (1–3 Months)

| **Week** | **Milestone** |
| --- | --- |
| 1 | Set up project structure, collect data from USGS & IRIS |
| 2-4 | Build time series classification & anomaly detection model |
| 5-7 | Build React/Angular dashboard with real-time input pipeline |
| 8-9 | Integrate Hugging Face summarization + spectrogram analysis |
| 10-12 | Polish UI, deploy backend & frontend, create demo video |

### **🔄 Optional Enhancements**

* Use **streaming data from Raspberry Shake sensors**
* Integrate **InSAR deformation data from Copernicus/Sentinel-1**
* Use **GNN (Graph Neural Networks)** for stress transfer modeling
* Add **Slack/Telegram notifications** for high-risk detections