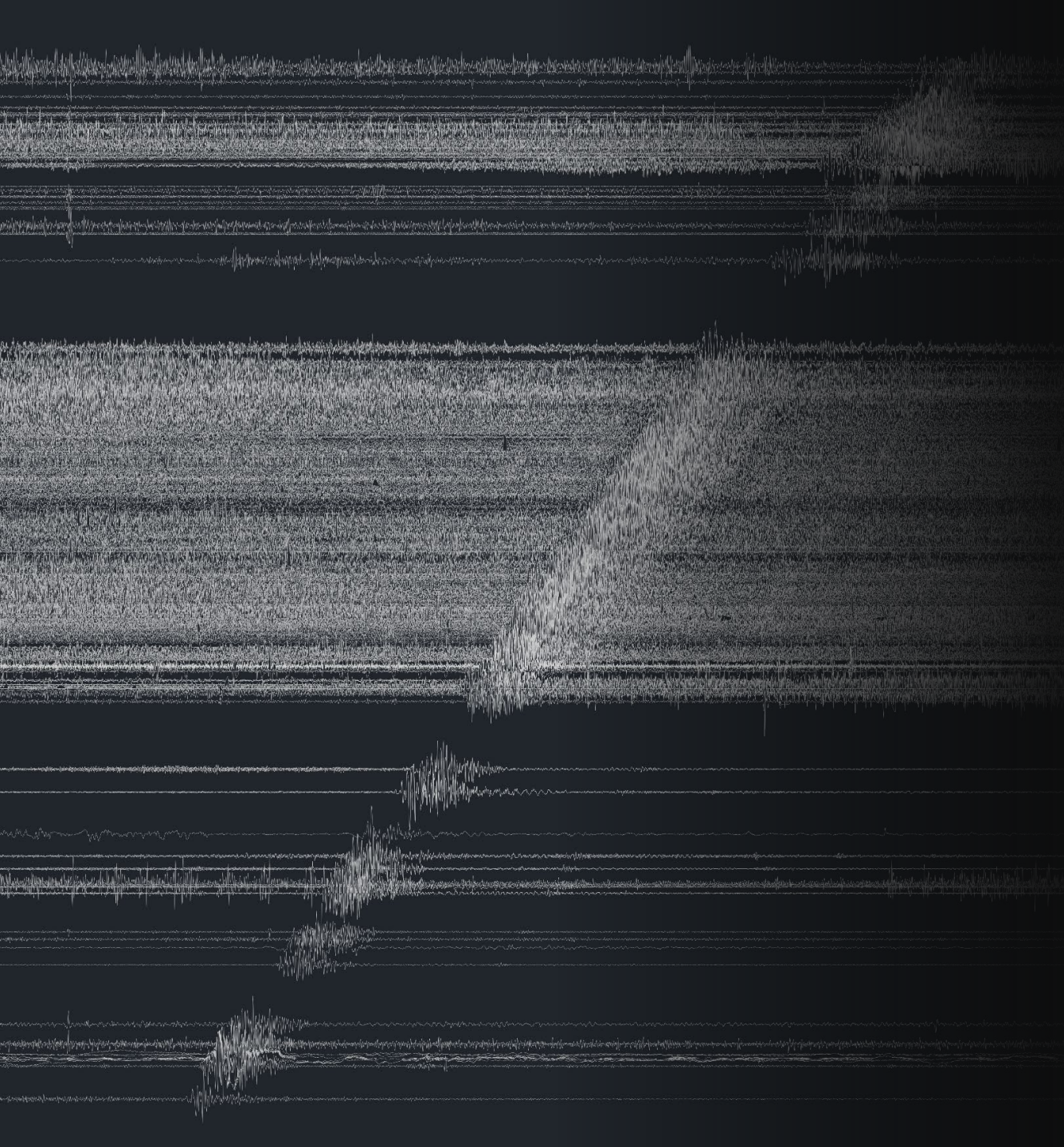
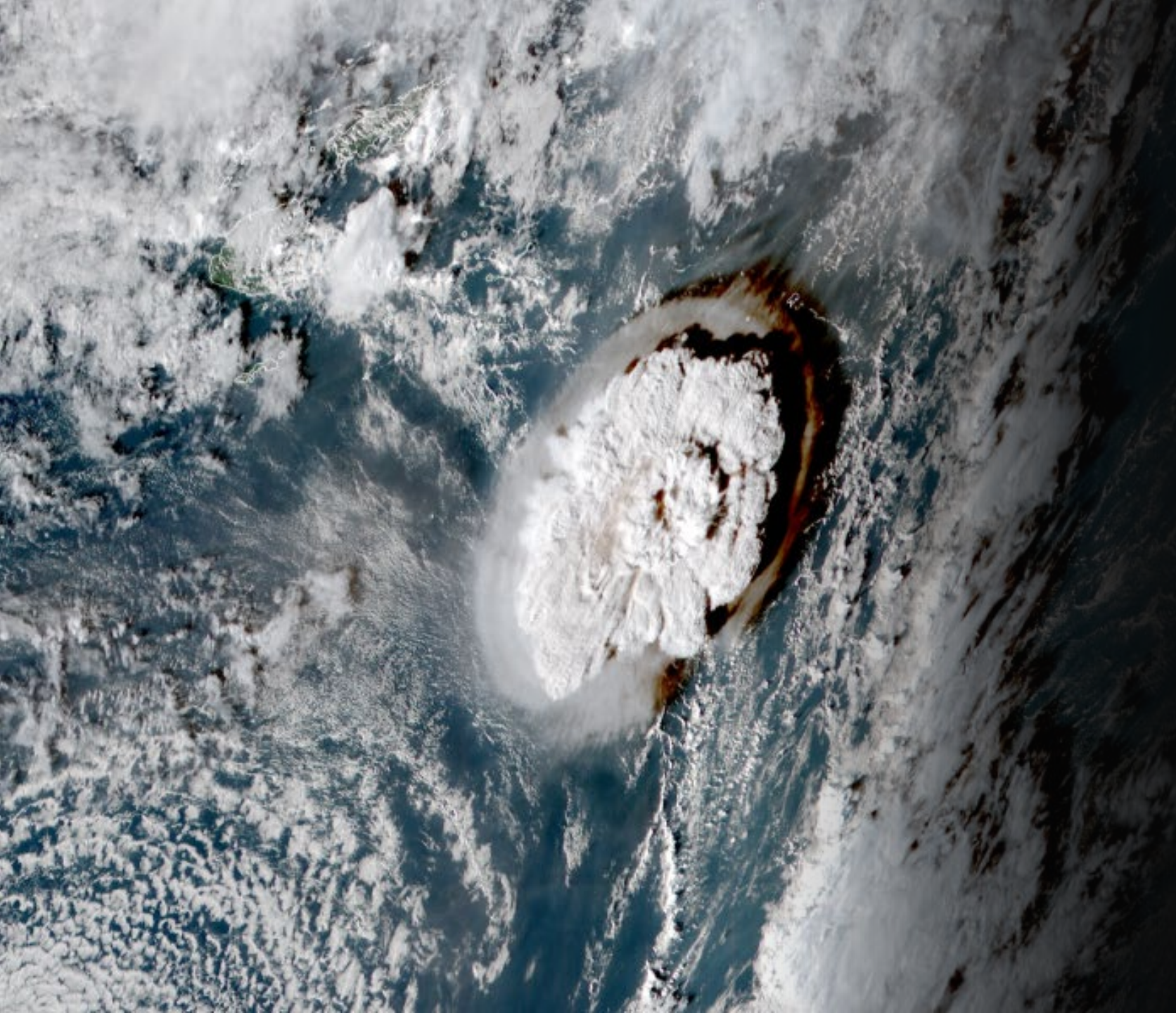


Using **Open Source** to observe a volcanic eruption on a **global scale** in **near real time**

Felix Eckel | Milton Garces | Meritxell Colet

C | A | U
Christian-Albrechts-Universität zu Kiel
Mathematisch-Naturwissenschaftliche Fakultät

ISLA



It was Saturday, the 15th January 2022. Hunga Tonga-Hunga Ha'apai volcano just had a very big eruption.

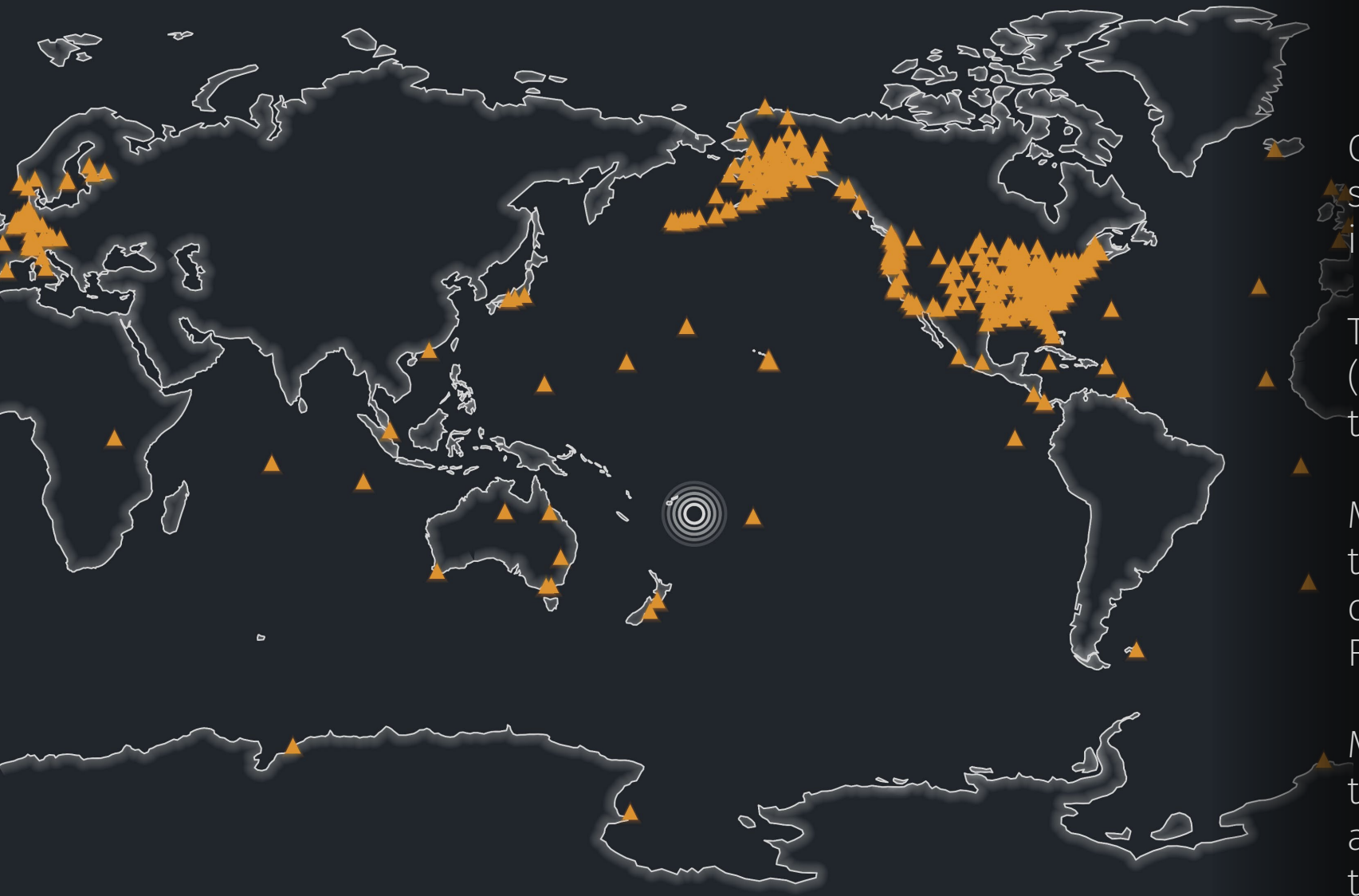
First satellite images showed massive concentric waves propagating from the eruption site.

Almost like an earthquake in the atmosphere.

These slides show how to use Open Access data and perfom Big Data processing to quickly visualize this event based on the atmospheric wave fields.

Himawari-8 satellite
JPA – CIRA/RAMMB

DATA SET



available infrasound stations

One type of instrument that is sensible for these wave fields is an infrasound microphone.

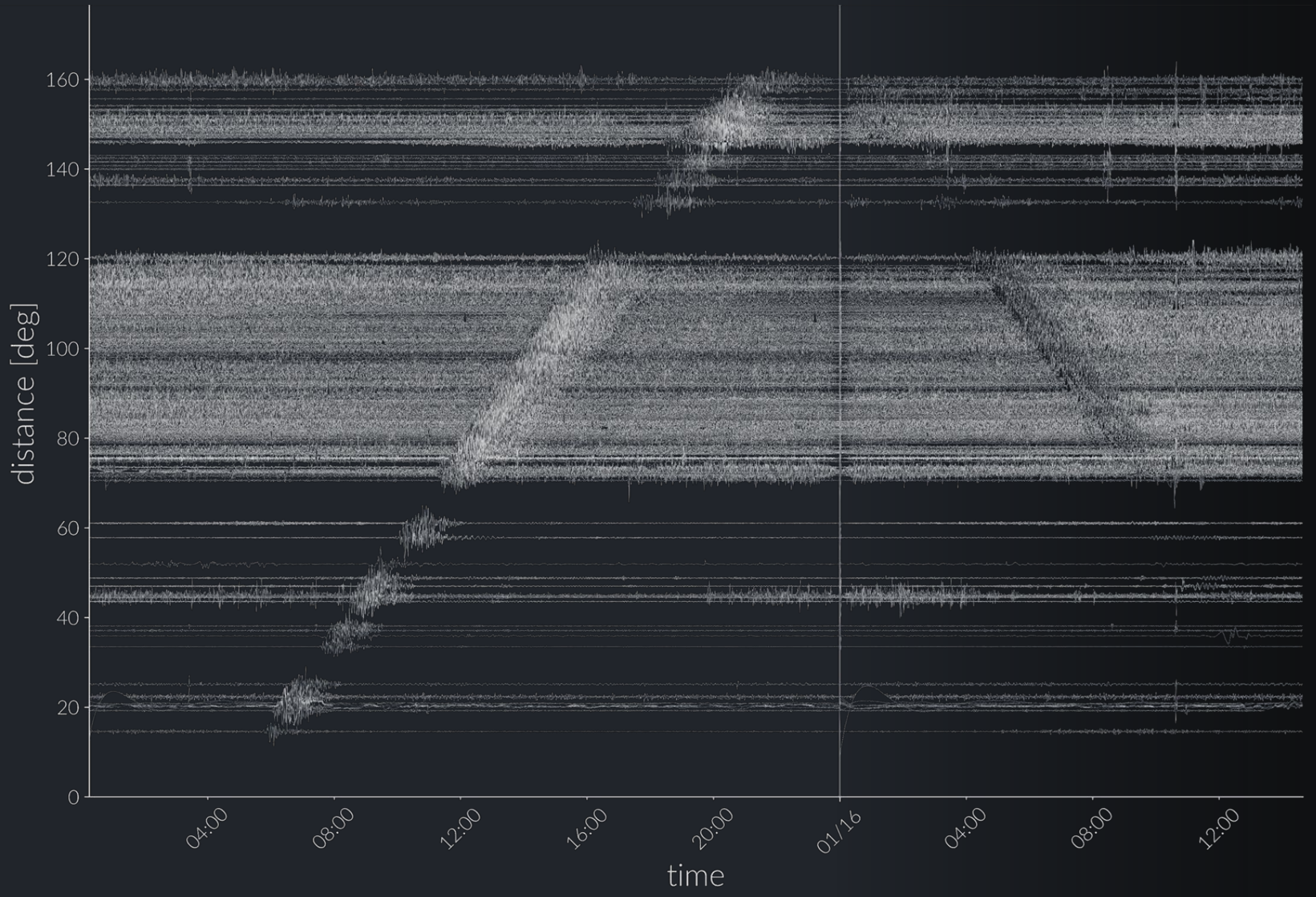
The International Monitoring System (IMS) operates a global network of these sensors.

Multiple other institutions have their own networks, like the community science project Raspyshake.

Many of these sites (yellow triangles) provide Open Data Access and can be requested by common toolboxes like *obspy*, an Open Source package for python.

INFRASOUND **SECTION**

all available waveforms



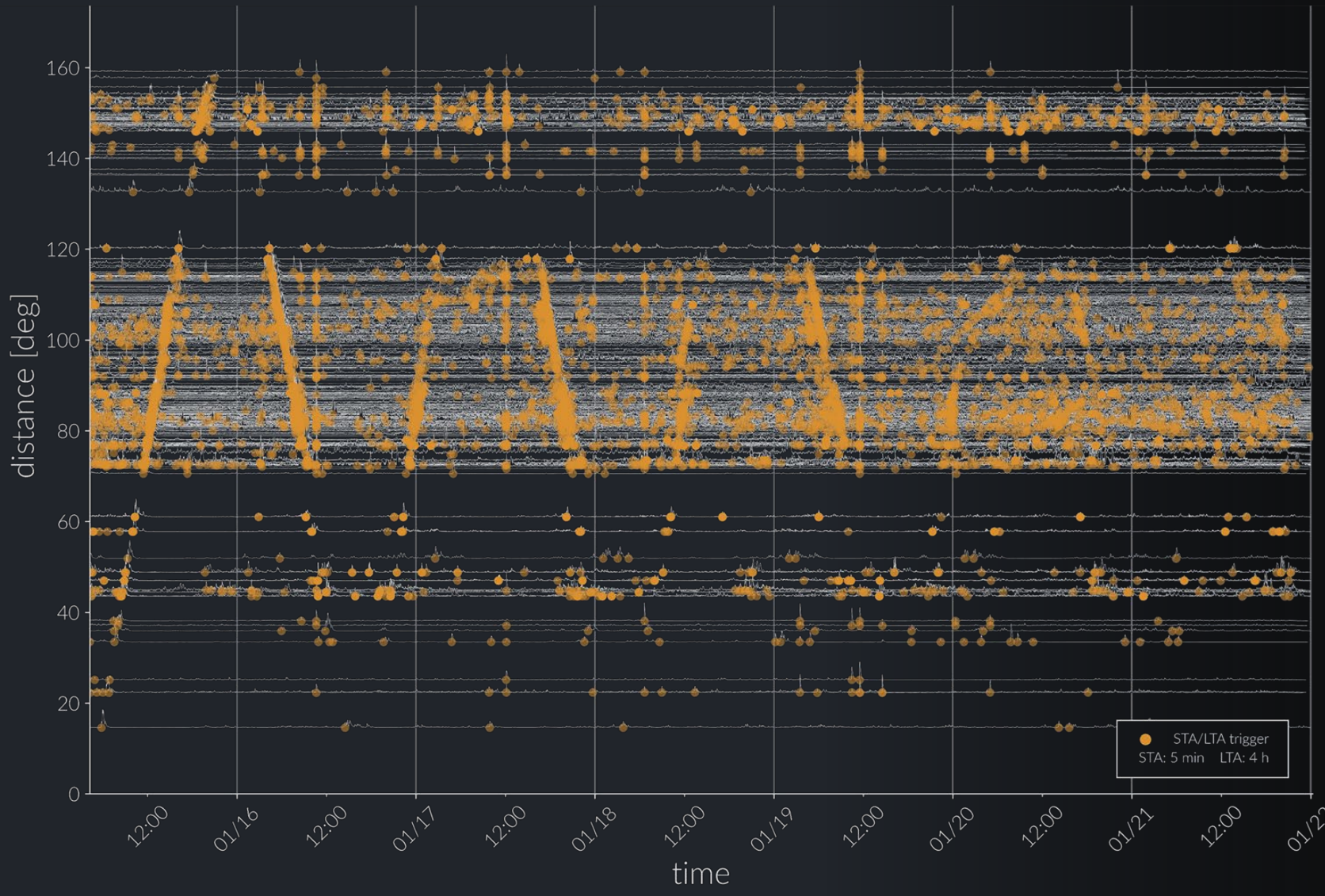
The downloaded waveforms can be order with respect to the (angular) distance to the event and plotted.

The pattern that emerges shows the propagating Lamb wave – an atmospheric pressure wave – that travels around the globe and back on the other side.

The data for this event was requested on Sunday evening. Since no manual outlier detection or similar time-consuming processing steps were performed, the processing of the data is quick.

INFRASOUND **SECTION**

STA/LTA with automatic trigger

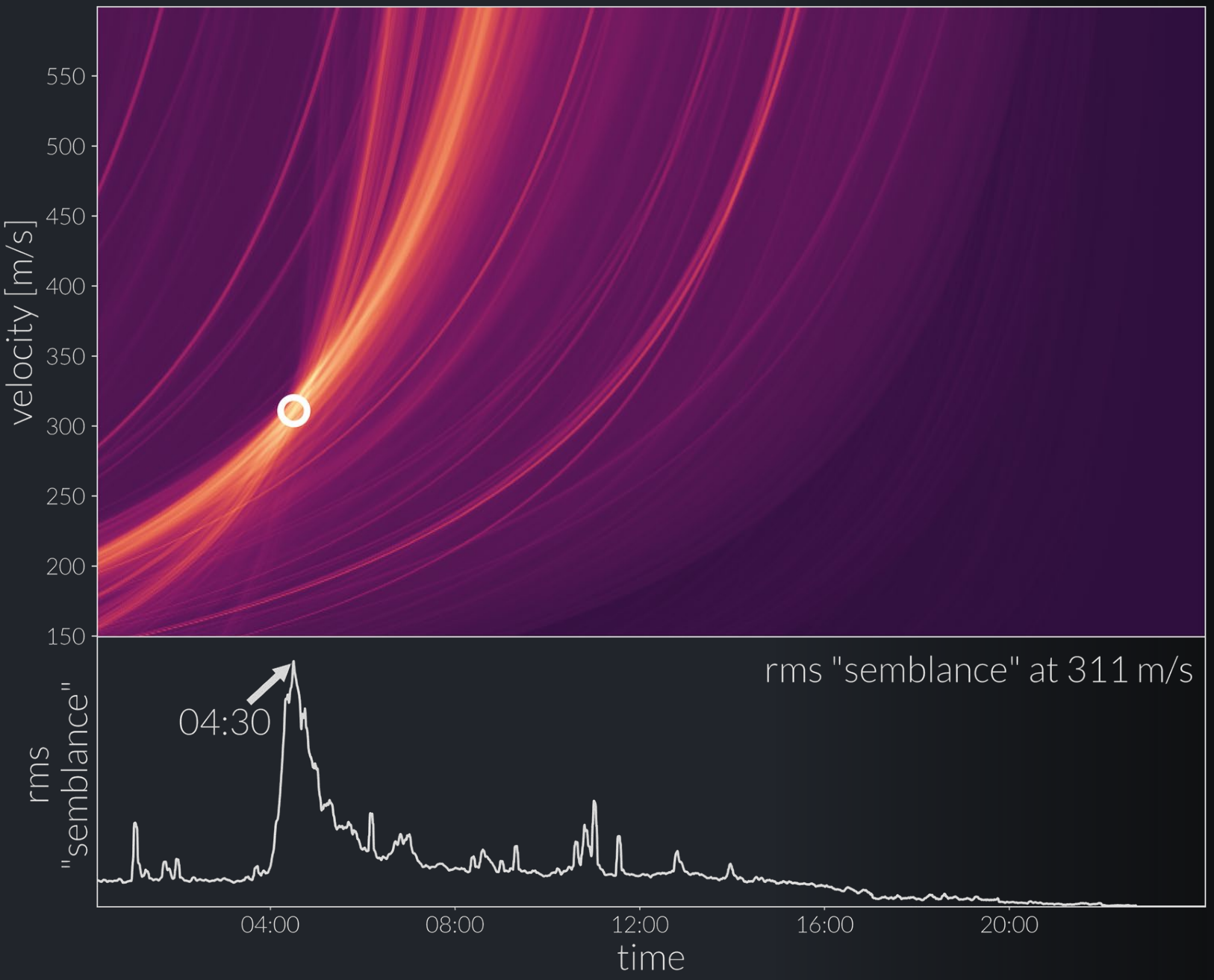


The section from Sunday indicated that the Lamb wave was still propagating.

Further data was downloaded for the week after the eruption.

Since the raw waveforms are too noisy to identify the signal, the STA/LTA characteristic function was computed (short time averag / long time average).

A sensitive automatic trigger indicates spikes in the characteristic function and reveals the Lamb wave that can be followed for almost 7 days.



ORIGIN **TIME**

by semblance analysis

With the waveform both the origin time as well as the travel velocity of the Lamb wave can be calculated via semblance analysis.

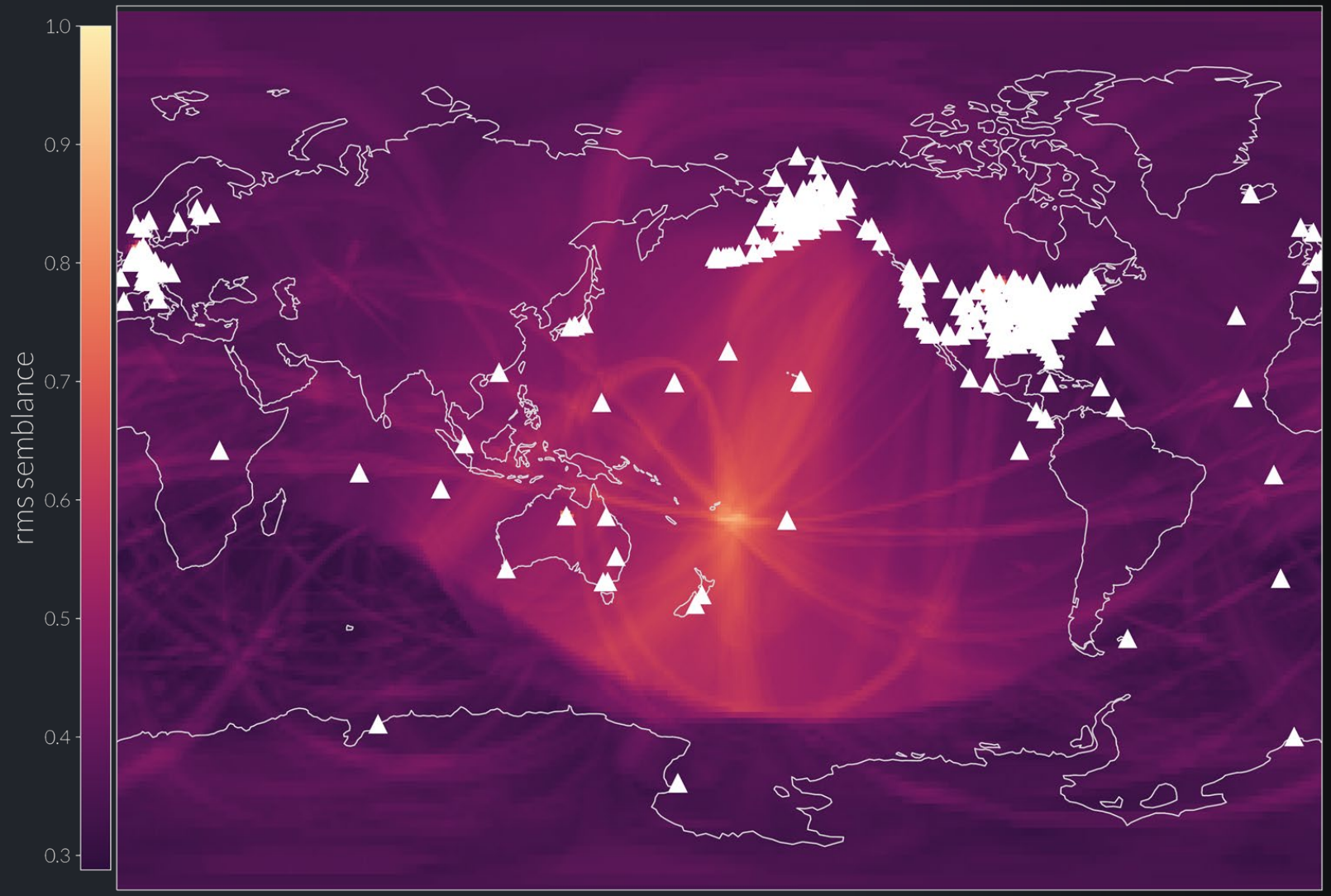
For this the root-mean-square (basically a moving average of the waveform) is time corrected for many assumed travel velocities (y-axis). All corrected waveforms are stacked.

For the correct velocity the stacked trace shows a maximum. This is the case for ~310 m/s.

The origin time can be read from the selected semblance trace.

PLACE OF **ORIGIN**

by semblance analysis

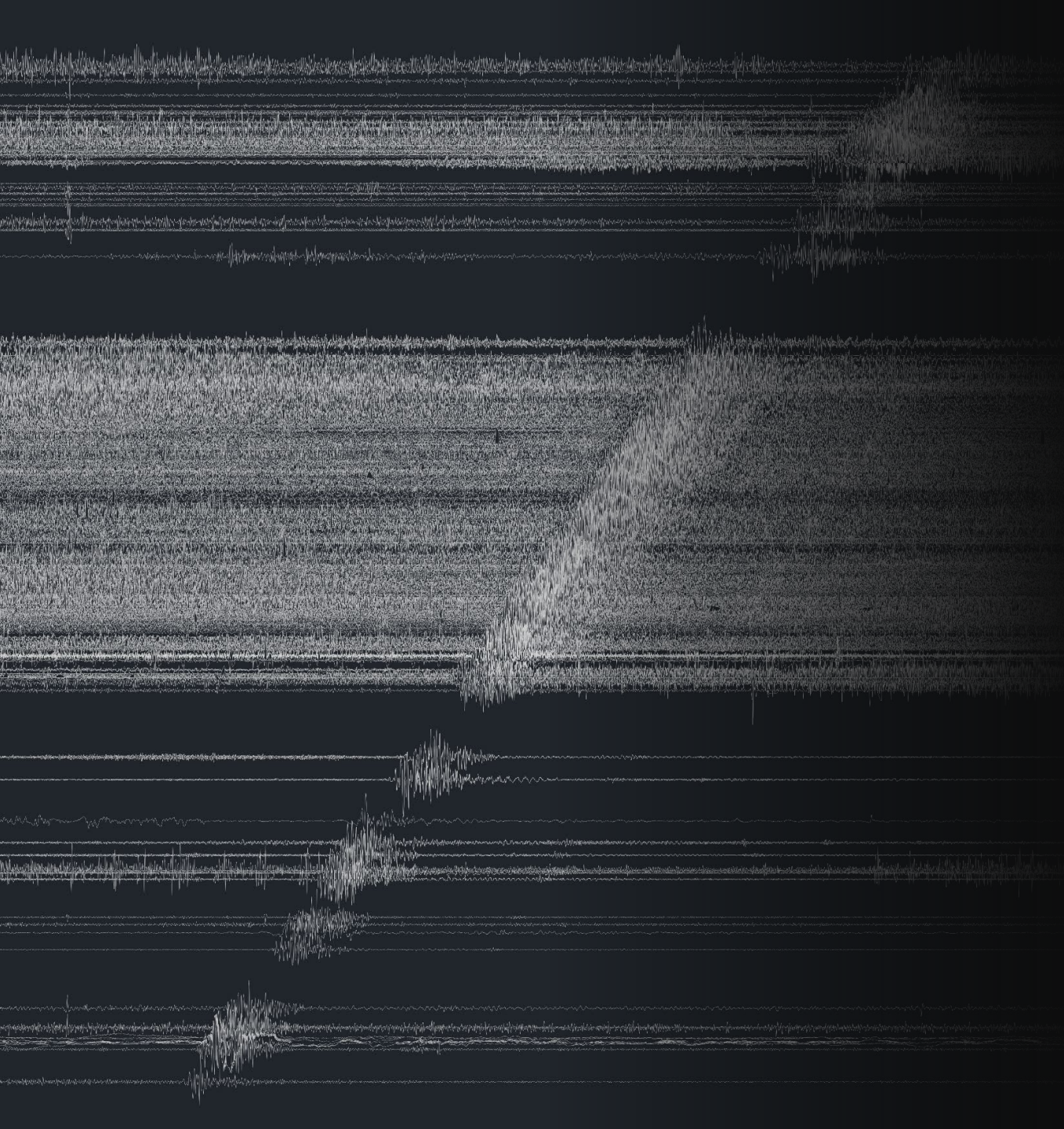


The same semblance approach can be performed to estimate the place of origin for the event.

With the assumed velocity of 310 m/s all traces are time corrected for any location in a 1x1 degree grid.

Again, at the correct location the time corrected traces interfere positively and yield a semblance spike.

The actual place of origin can be determined with an error of 1 degree.



Using **Open Source** to observe a volcanic eruption on a **global scale** in **near real time**

With Open Data access to a global network of receivers it is very easy and fast to request data.

Processing the data set as a whole might increase the noise level in the analysis but enables near real-time results.

Methods that are used on earthquakes in seismology can be easily adapted to wave fields that travel the atmosphere.

Felix Eckel

felix.eckel@ifg.uni-kiel.de

@FelixEckel