Analysis of time delay data and clock drift in a network of seismic monitors

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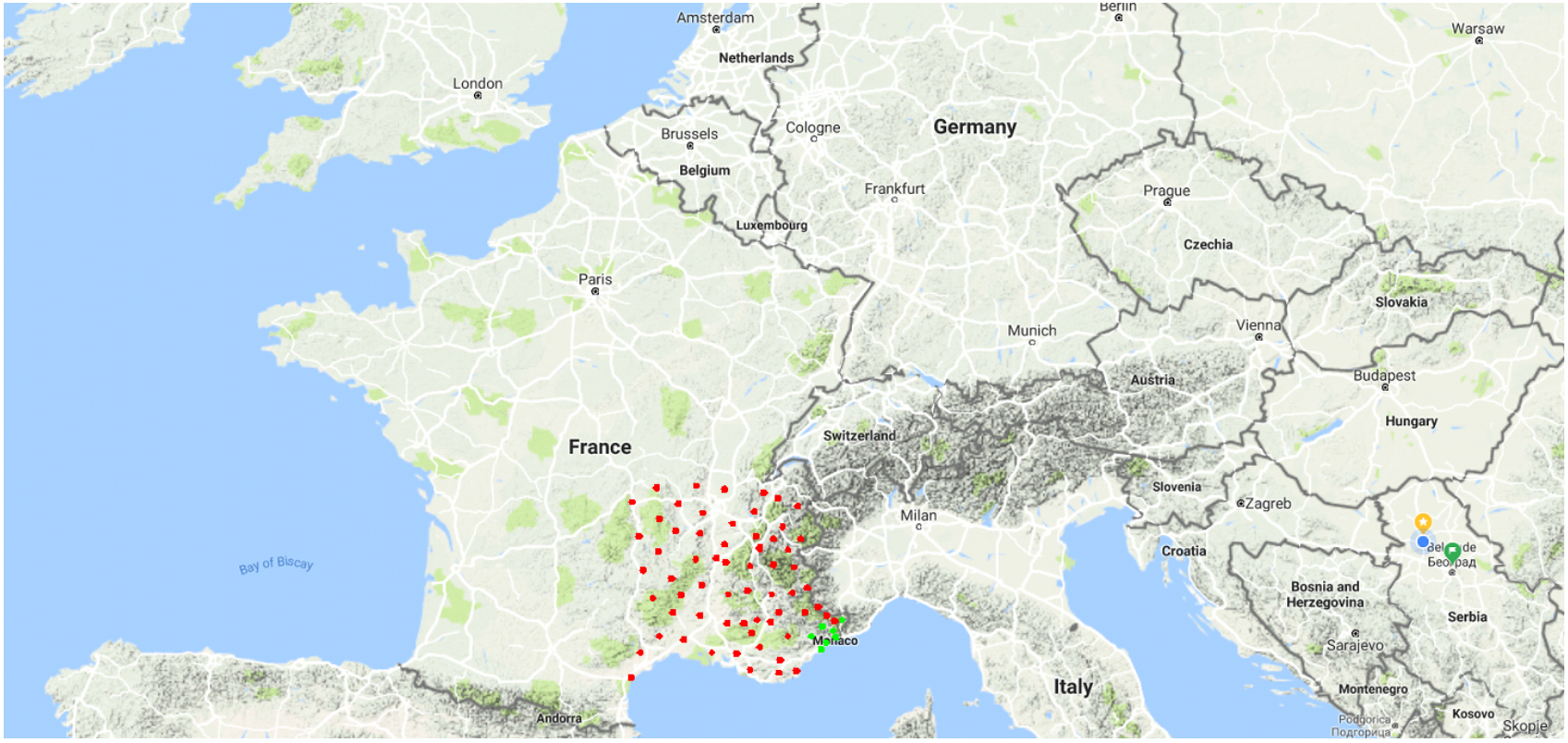
ECMI Modelling Week, 21 July 2018

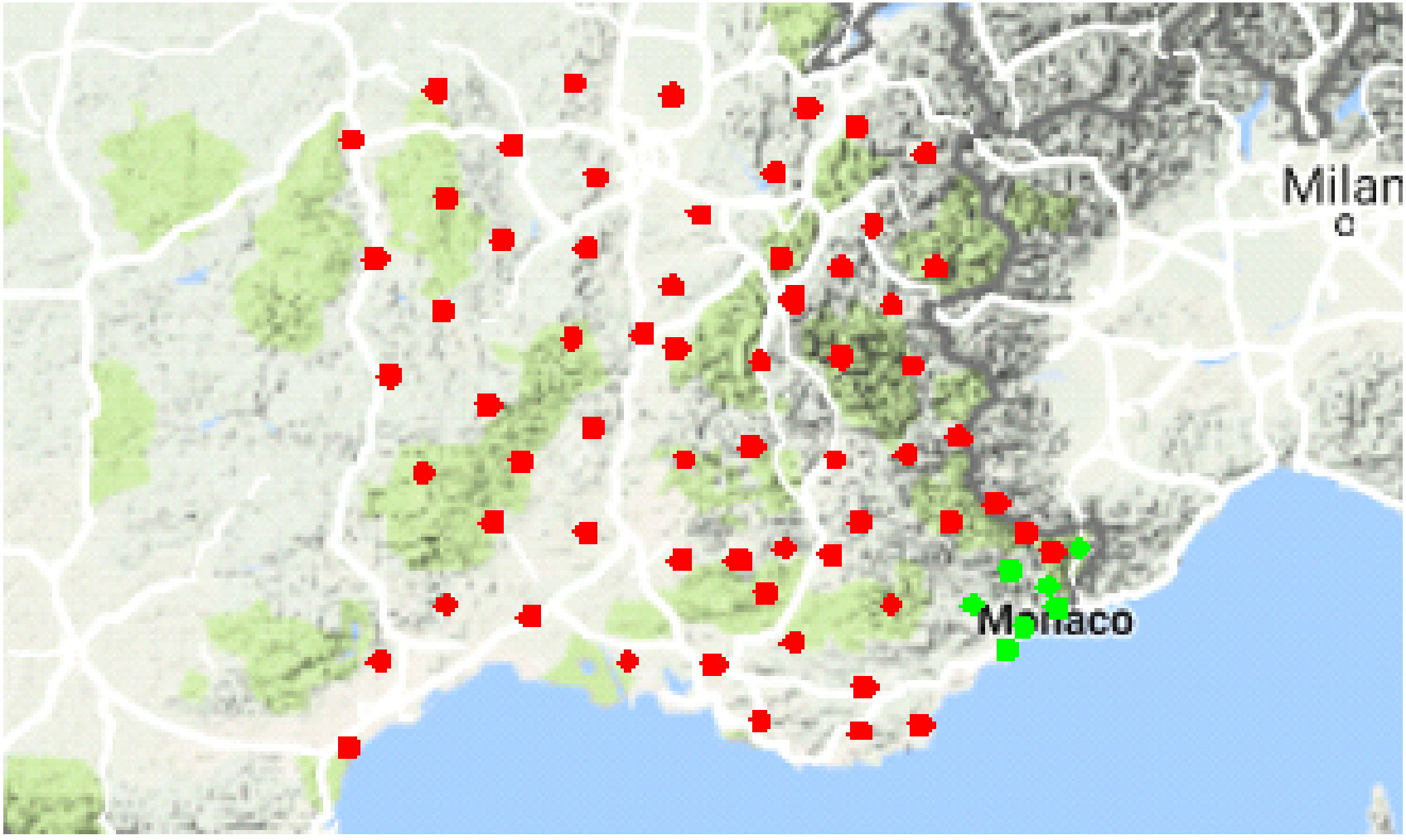
Problem statement

- Seismic monitoring is used to study the behaviour and composition of the underground floor
- Continuous synchronization to the Global Positioning System for accurate timing is not possible
- The instruments' clocks deviate in time causing lack of accuracy in the measurements
- A reliable method to correct for the time deviation is required
- Real data collected from a network of seismic monitors over time is analyzed
- The problem is to discern the time drift of the clock in each monitor from noise and actual data

The network of seismic monitors

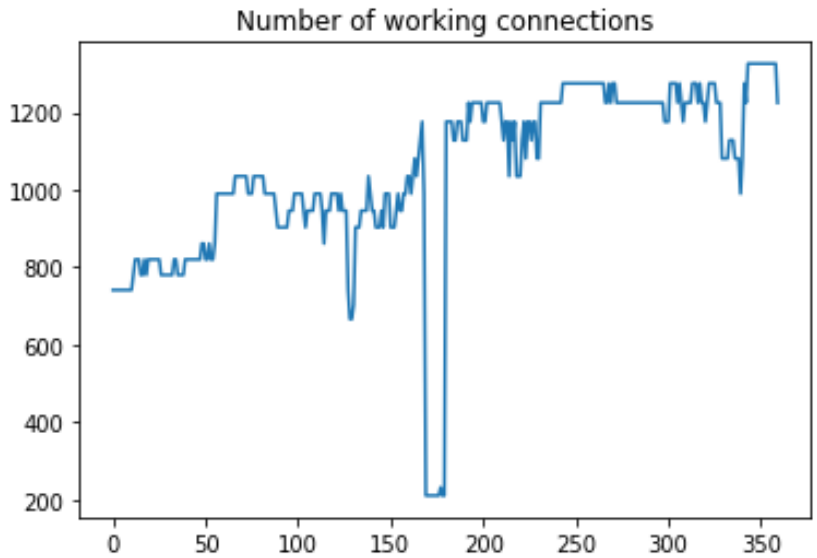


The network of seismic monitors



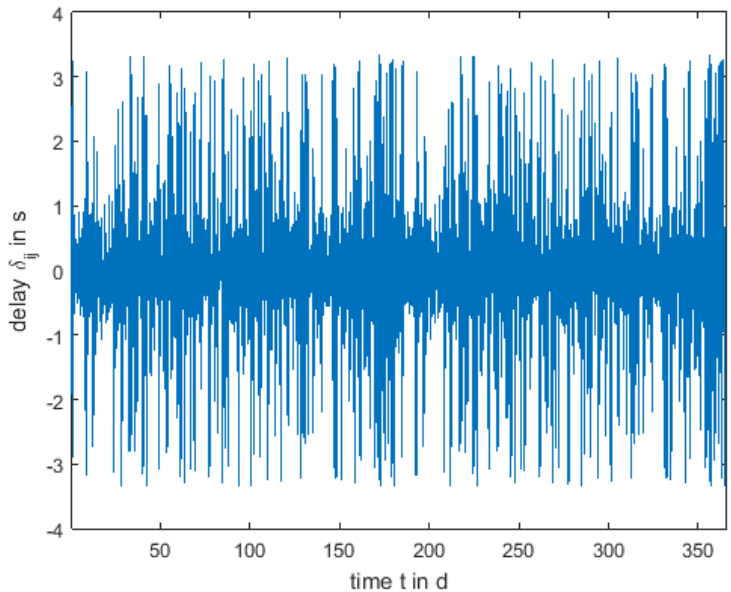
Numbers of working stations and connections to stations during one year

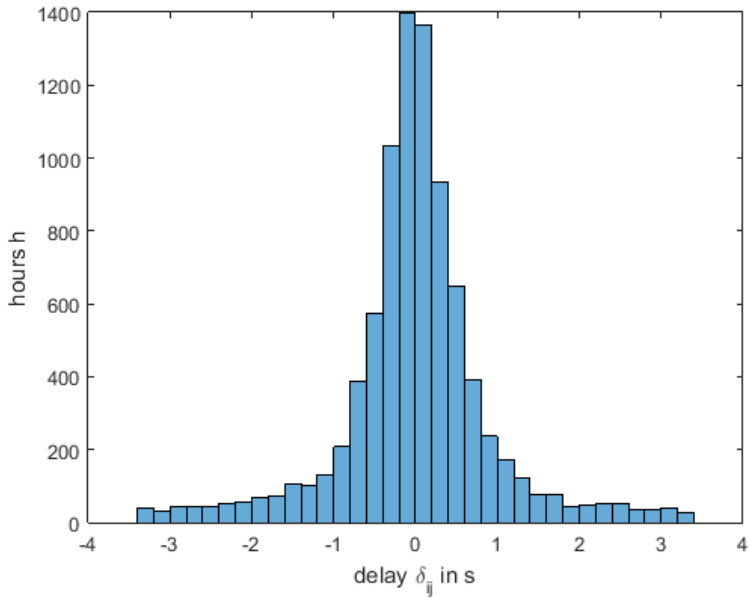
- The network consists of 73 seismic monitors
- Not all monitors work at all times
- If two monitors are working simultaneously, they are connected
- Connections are undirected



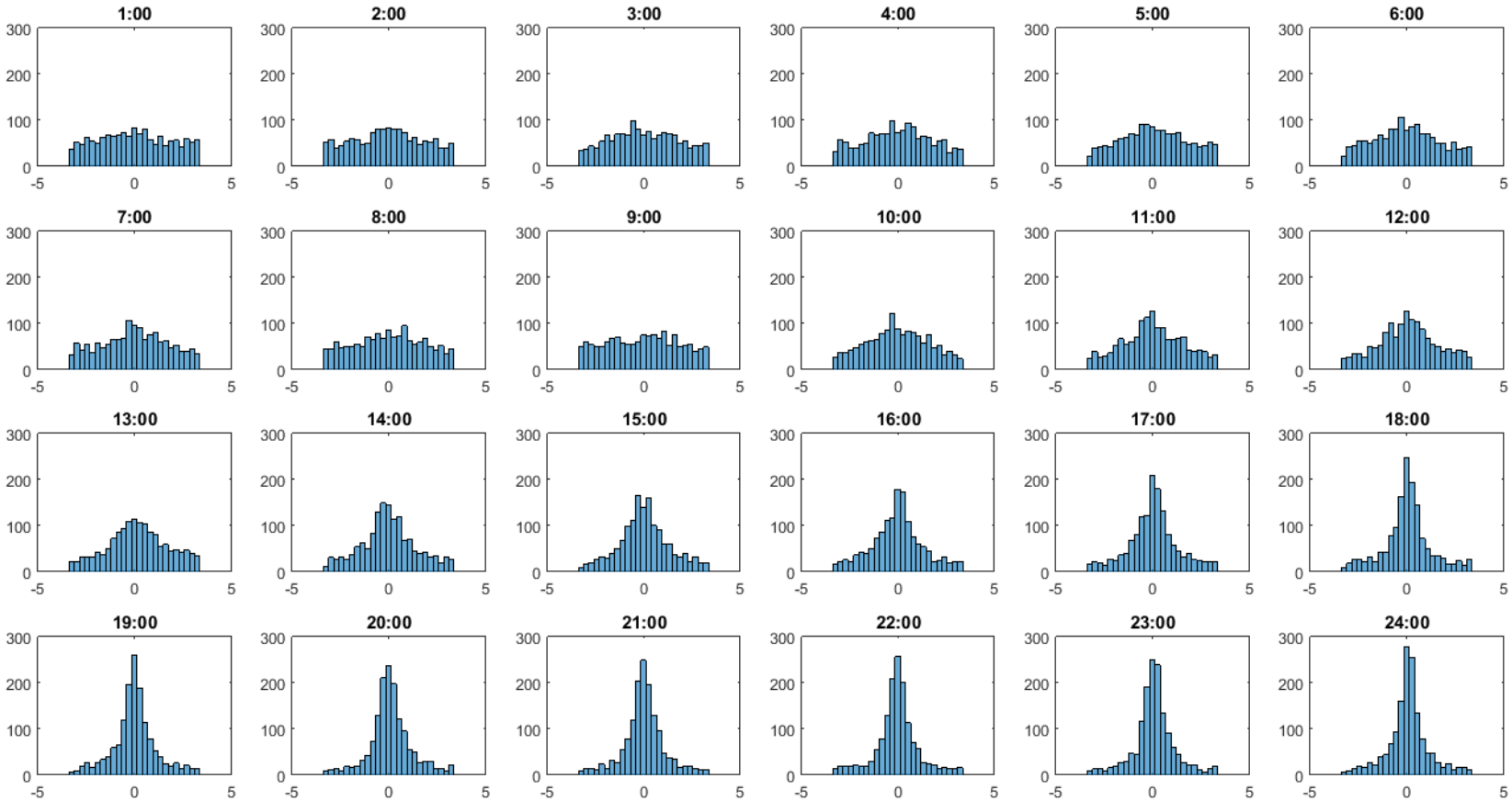
Time-delay signal characteristics

- Data recorded in one second intervals
- Time-delay cross-correlation in one-hour intervals
- Tracing time-delays recorded by one station over a year
- Time delays are computed in both directions (from A $\rightarrow$ B and B $\rightarrow$ A) and are opposite numbers

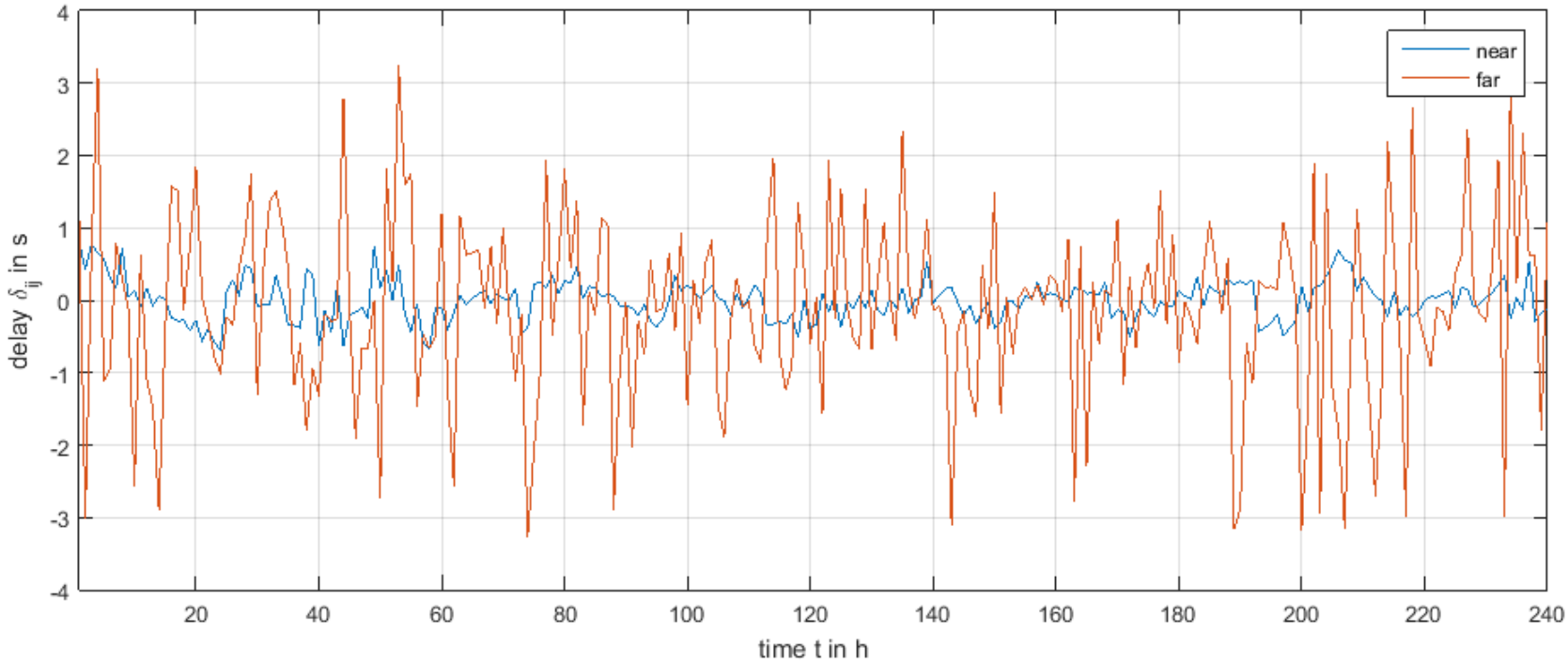




Histograms showing time delays recorded by all active stations over 24 hours



Comparison of time delay of the furthest and the closest station pairs



- Time delays are smaller between stations which are close to each other
- The non-linear trace of the data is thought to be caused by the station's non-ideal clock (clock drift)

Clock drift and errors in the data

Graph approach to model the data

Signal denoising

Exctracting clock drift from noise

Results

Conclusion