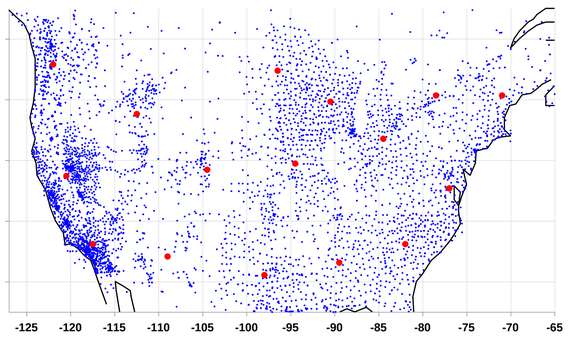
Maps of coherence of GPS noise in the USA, 2013-2017

Alexey Lyubushin, Institute of Physics of the Earth, Russian Academy of Sciences, Moscow

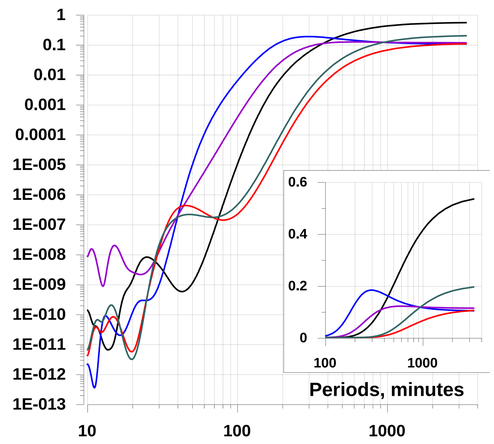
General Assembly 2018 of the European Geosciences Union, Vienna, Austria, 08-13 April 2018
Session E4.1/NP4.3/AS5.13/CL5.18/ESSI2.3/GD10.6/HS3.7/NH11.14/SM7.03 , "Big data and machine learning in geosciences“



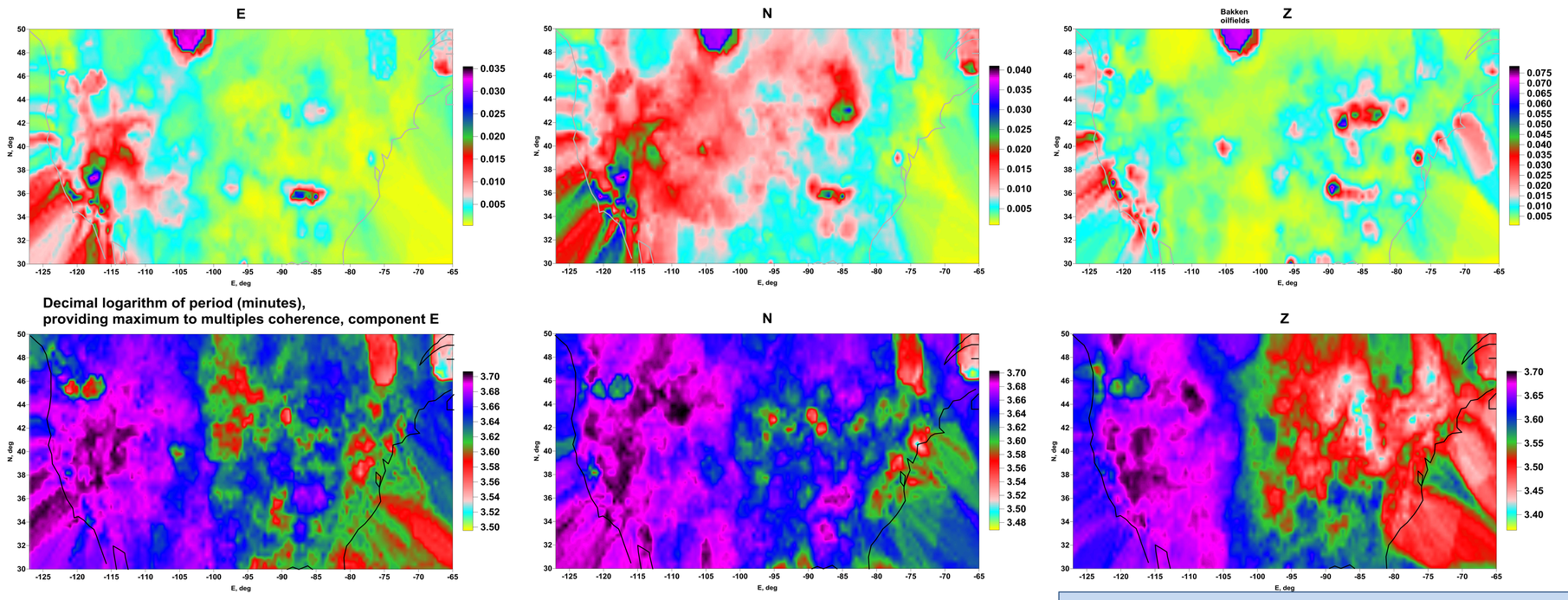
Network of 4930 GPS stations in the USA, observations 28.02.2013– 31.12.2017, Δt = 5 minutes, source: ftp://gneiss.nbmg.unr.edu/rapids_5min/kenv/ (Nevada Geodetic Lab)

Red points present positions of 16 reference points for which multiple coherence functions were estimated within moving time window of the length 5 days with mutual shift 1 day from 10 nearest operable GPS stations. Positions of reference points were found as centers of clusters by using of *k*-means clustering procedure for cloud of GPS stations positions.

For all estimates of multiple coherence functions their maximum values with respect to frequencies were found and values of periods corresponding to these maximums were found as well.

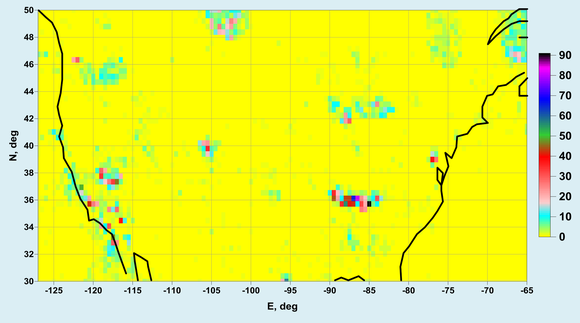


Examples of several multiple coherence functions for different reference points estimated within time windows of the length 5 days (1440 samples with 5 minutes sampling step) from 10 nearest operable GPS stations for vertical component using vector autoregression model of 5th order.

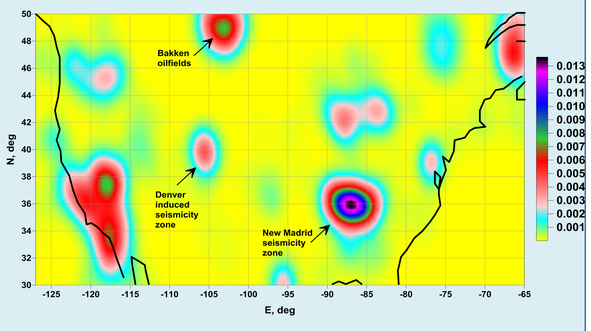


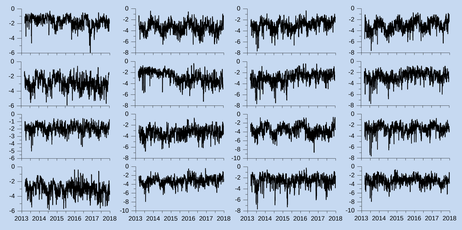
Averaged maps of maximums of multiple coherence functions. Let's take regular grid of the size 125×50 nodes which cover the rectangular domain (127°W, 65°W) and (30°N, 50°N). Each node of this regular grid will be regarded as reference point for which the sequence of multiple coherence functions will be estimated from 10 nearest operable stations within moving time window of the length 5 days with mutual shift 1 day. Thus, each time window presents some "elementary" map of spatial distribution of maximums of multiple coherence functions for 3 components of GPS signals. Let's average all elementary maps from all time windows. This operation provides average maps of multiple coherence maximums.

Map of numbers of hits of maximum values (taking with respect to nodes of the regular grid) of multiple coherence functions maximums (taking with respect to frequencies) to the nodes of regular grid of the size 125X50 for all time windows of the length 5 days and for all 3 components of GPS signals. Yellow means that no maximums correspond to the node. Black means the node that is the most frequent for maximum.

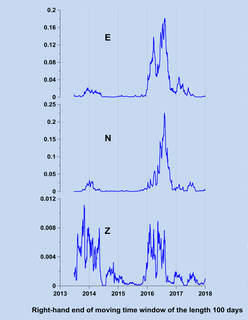


Estimate of 2D probability distribution function of numbers of hits of maximums of multiple coherence to the nodes of regular grid.
Gaussian kernel function with radius 1 degree was used.





Graphics of maximum values of logarithm of multiple coherence functions for vertical (Z) component for each of 16 reference points. Similar graphics for other (E and N) components.



Graphics of multiple correlation coefficients for 16-dimensional time series of logarithms of maximal multiple coherence functions for 16 reference points

Conclusion

The map of most frequent positions of frequency-dependent maximum of multiple coherence of GPS noise extracts several "spots of noise coherence" among which there are regions in California, New Madrid seismic zone, Bakken shale oilfields, Denver zone of induced seismicity. Time-dependent analysis of multiple correlations between coherence measures from the vicinity of 16 reference points extracts essential maximum during time interval from mid-2015 up to mid-2016. Maps of logarithm of periods providing maximum to multiple coherence measure from 10 nearest operable GPS stations give additional information about spatial peculiarities of coherence distribution. In particular such map for logarithm of periods reflects differences between mountain and plain parts of the region.