Discharge response to rainfall in the Ruzzo springs system in the Gran Sasso d'Italia aquifer: preliminary results by applying cross-correlation analysis

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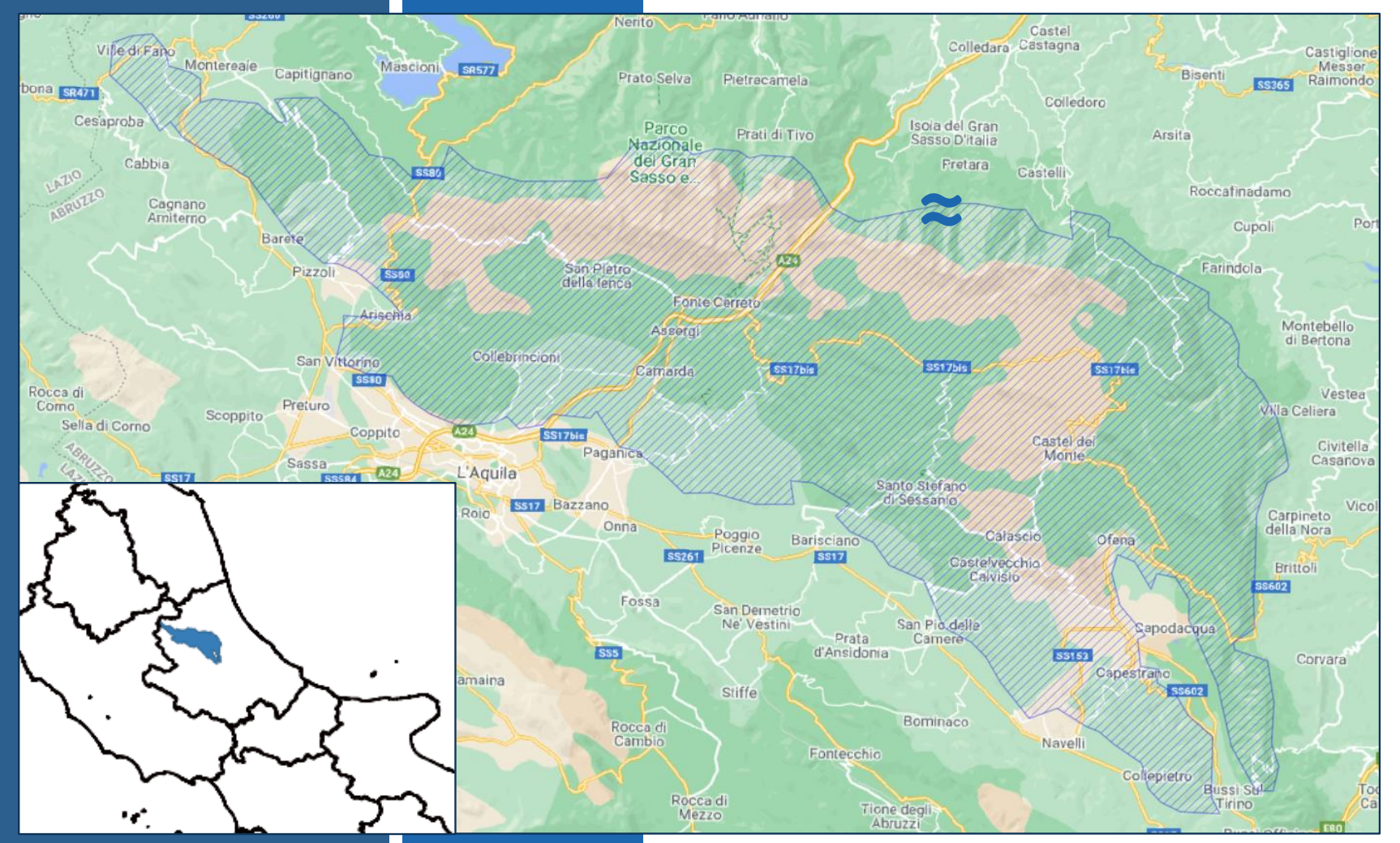
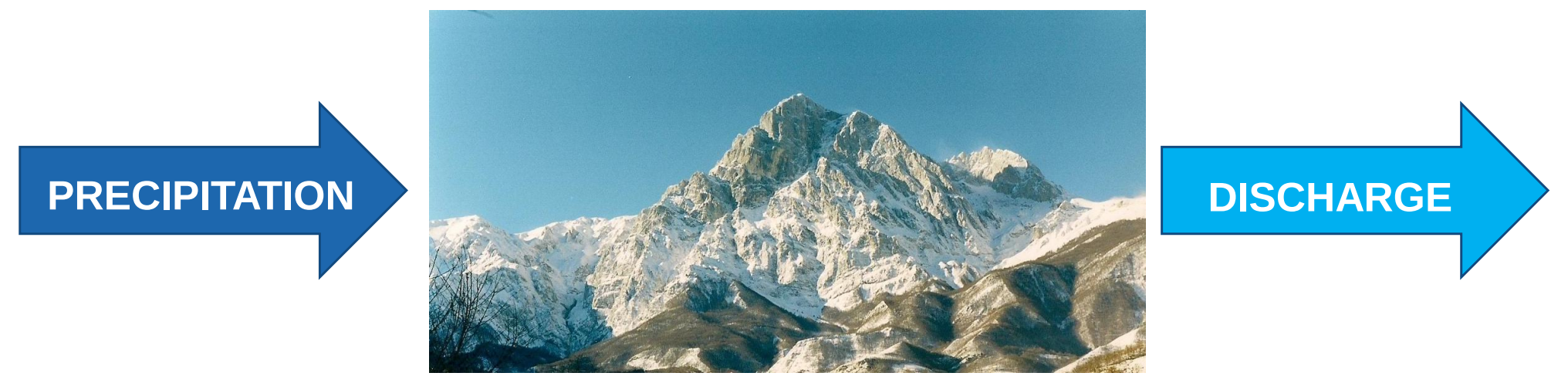
INTRODUCTION





PRECIPITATION

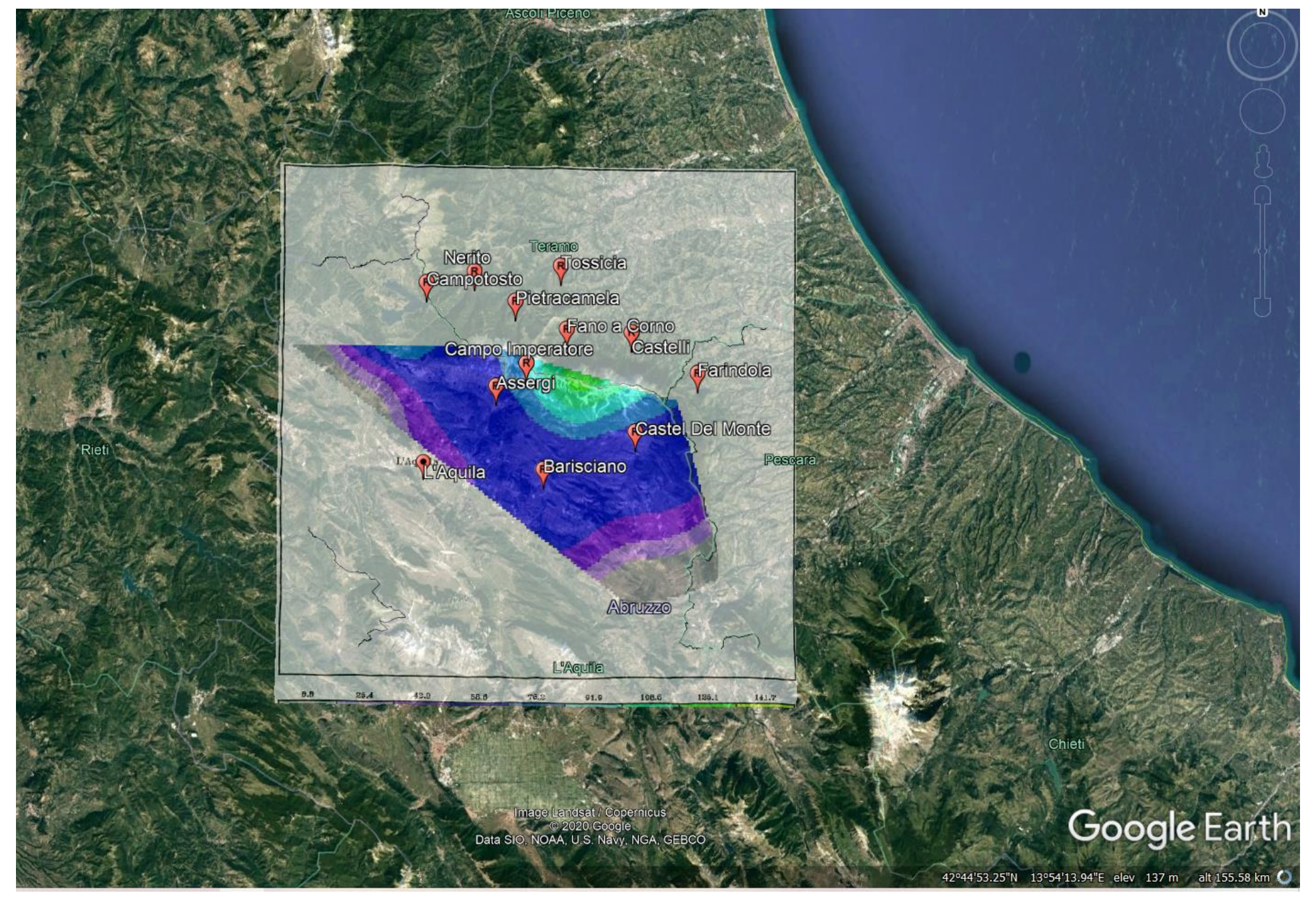
DISCHARGE

The Ruzzo system is composed by different springs ranging from 925 to 1620 m a.s.l., in the Northern boundary of the Gran Sasso aquifer. The estimated mean annual discharge is 0.69 m³/s. They are mainly fed by the Corno Grande and Campo Imperatore sub-units [1,2,3].

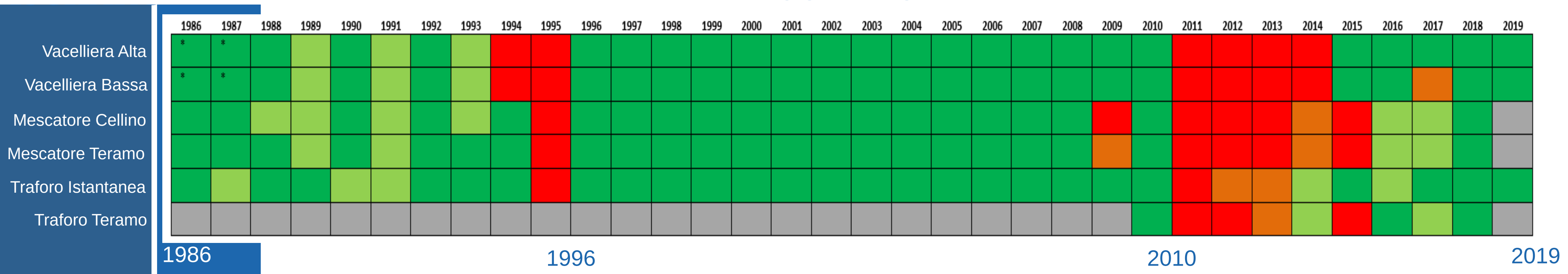
DATASET

Signal analysis requires continuous series of data. Interpolation algorithms may be used to fill in possible holes, but their application should be confined to isolated no-data. Therefore, **it is vital to ensure the continuity of observations**, to better assess climatic behaviour in a non-stationary system.

PRECIPITATION



DISCHARGE



🟩 All data available 🟩 1-3 months missed 🟨 4-11 months missed 🟥 All months missed ⬜ Observations not yet recorded

The more are the hydrological variables to correlate, the less is the overlapping period

METHODS

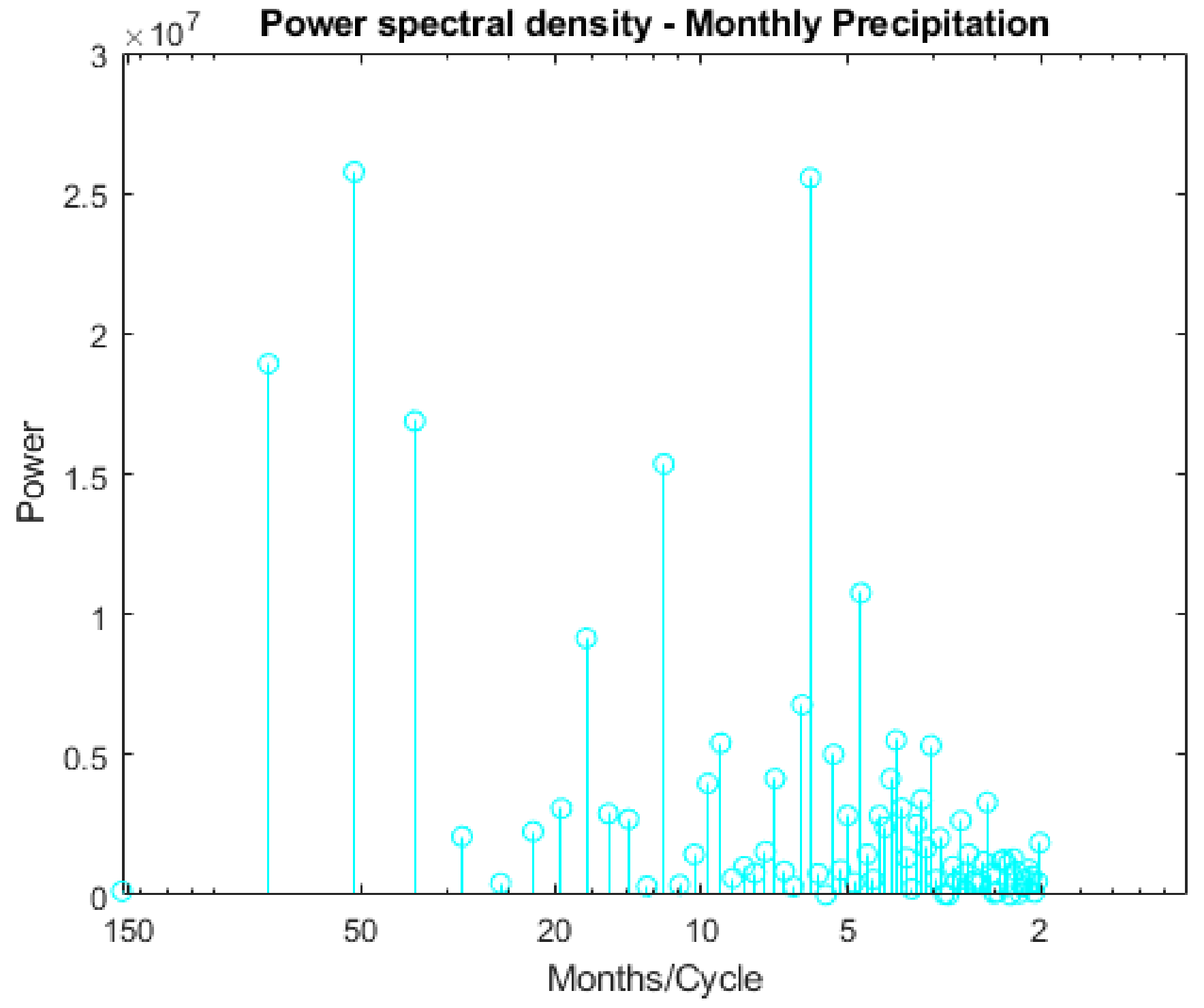
Fourier transform: : decomposes a signal function represented in a time domain (timeseries) into its characteristic sinusoidal components in the complex field (amplitudes, phases and frequencies.). The absolute value of the transform is the original frequency value of the original timeseries, while the complex argument represent the phase offset of predominant sinusoidal functions that compose the signal. Useful for stationary signals, with many limitation for natural signals[4].

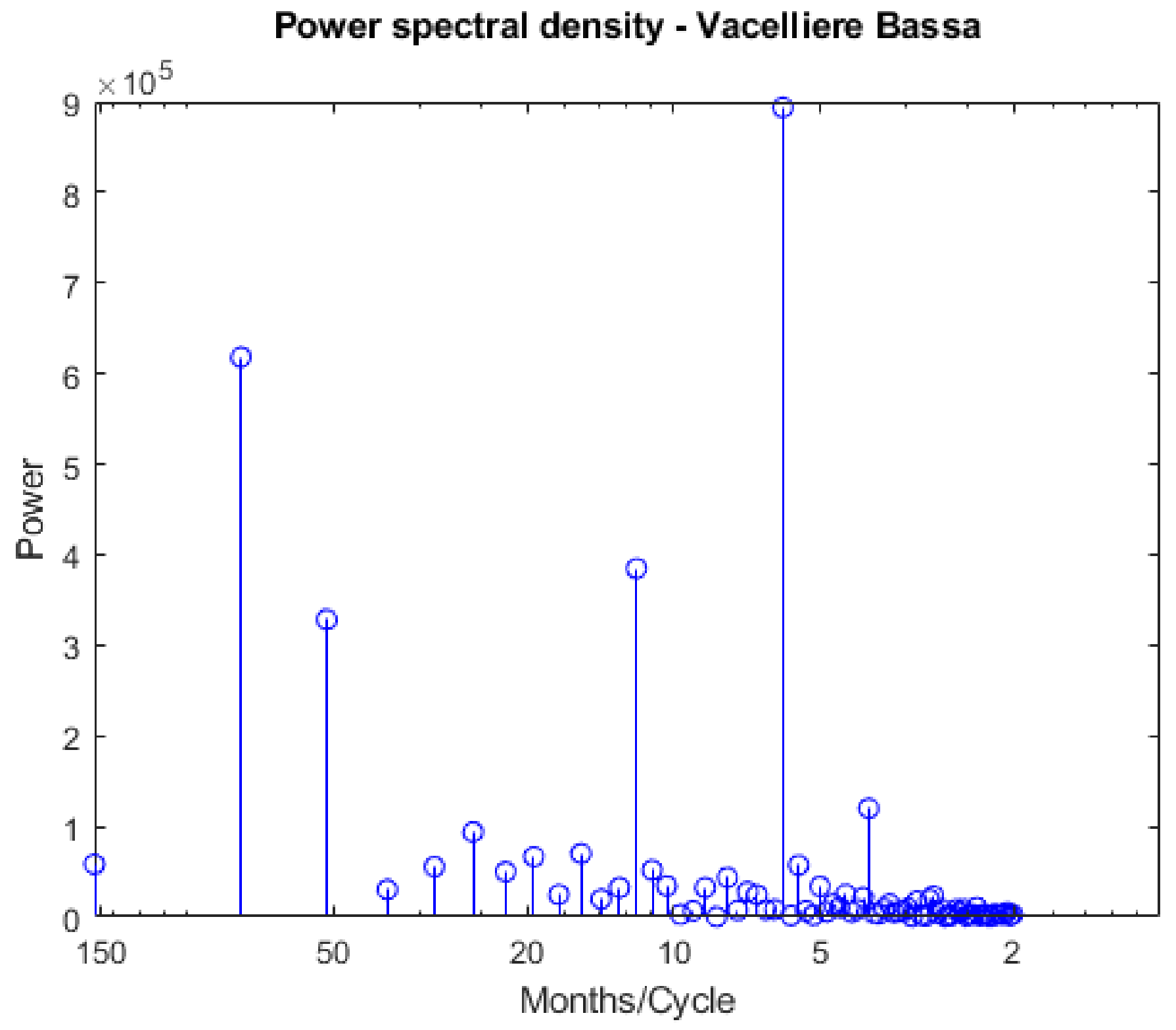
Empirical mode decomposition: decomposes a signal x(t) into intrinsic **mode** functions (IMFs) and residual in an iterative process. Ita is an empirical, direct and adaptive method to analyse non –linear trends [5]

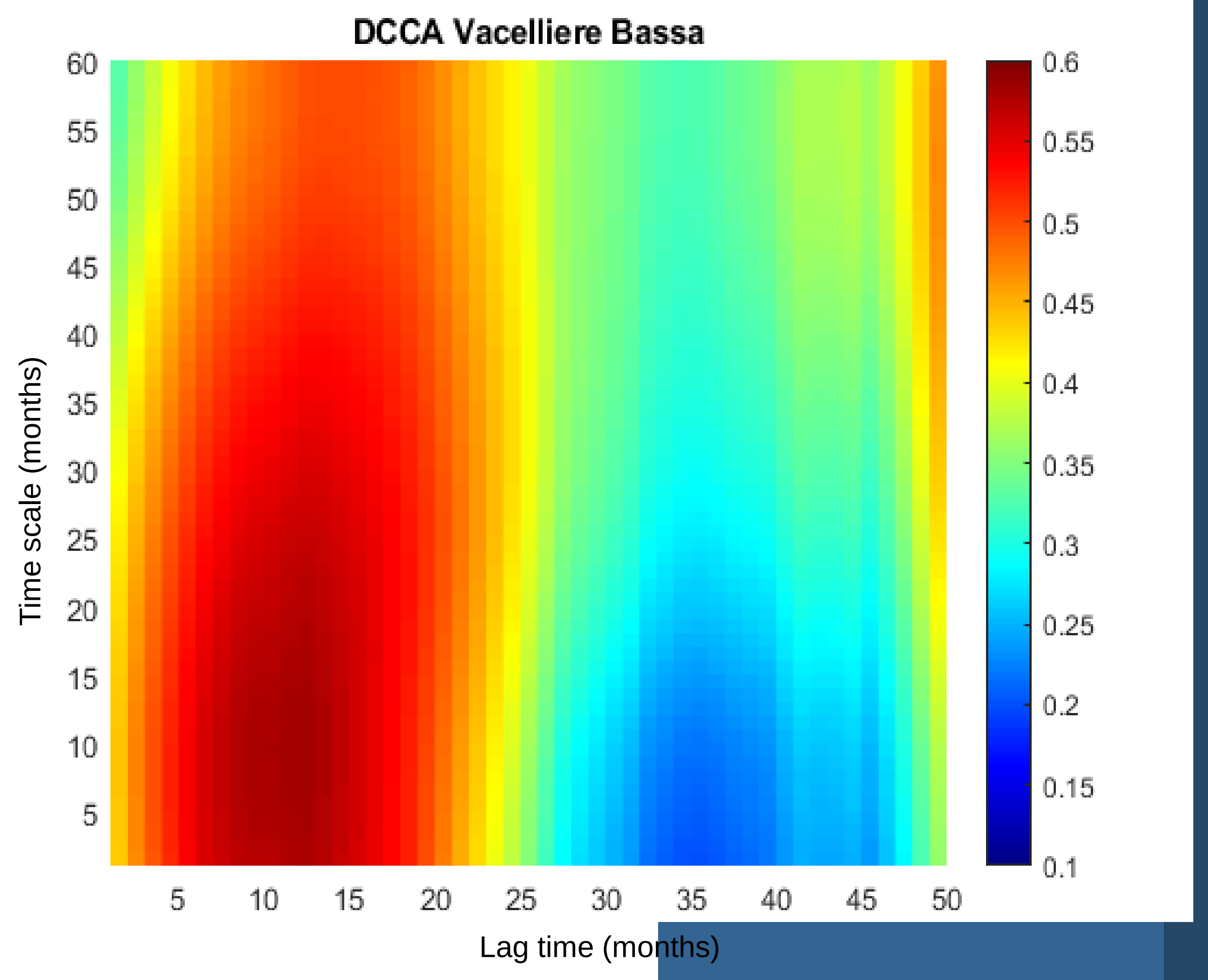
Detrended cross correlation: This method is designed to investigate power-law cross correlations between different simultaneously recorded time series in the presence of nonstationarity [6].

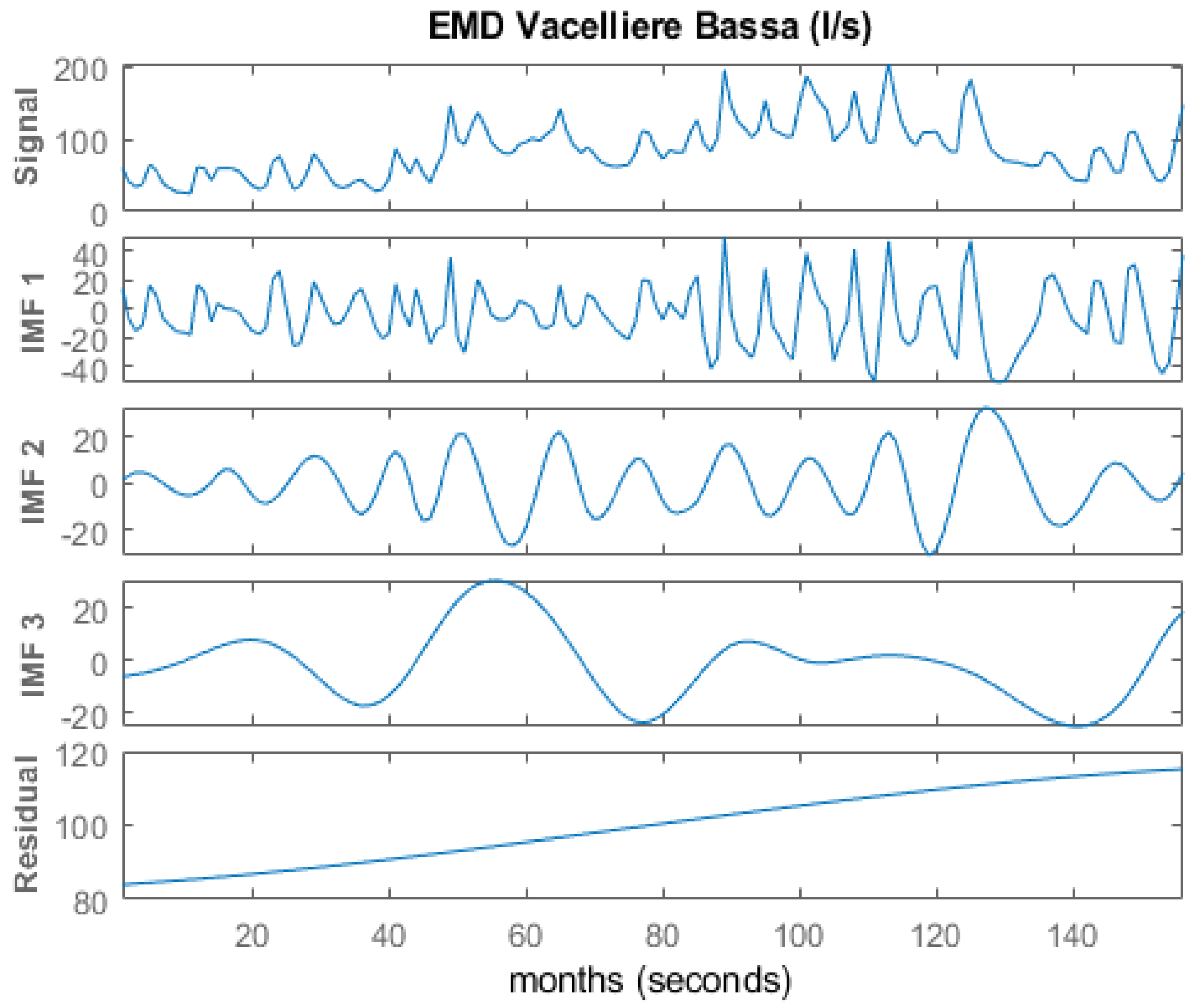
Detrended Partial Cross Correlation: applicable in a complex system where more than one variable affect the signal behaviour. It allows to estimate a third-variable influence on the correlation between two variables. Also, the Temporal evolution of such influences can be estimated [7].

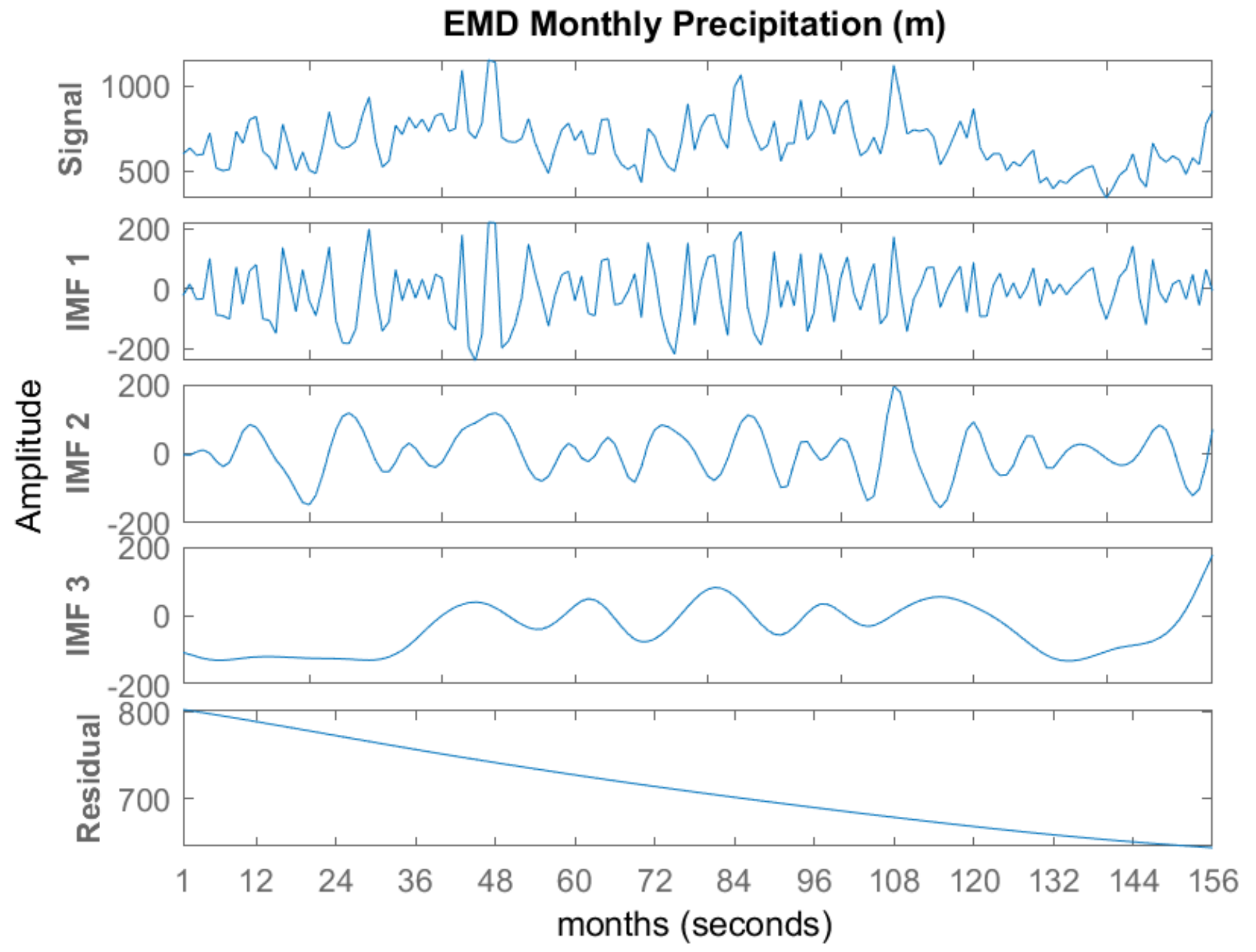
RESULTS











Fourier transform computes dominant frequencies considering the signal as stationary. Complex, non-stationary signals may be decomposed in modl functions where frequency and amplitude are not fixed quantities in the time. Correlation with two non-stationary variables (i.e. discharge and precipitation) may occur at different time –scales and with lag-times that are not fixed, but falls into a «window» of lag times. This is particularly evident if more than a variable influences the signal.

	IMF1	IMF2	IMF3	IMF4
VACELLIERE BASSA				
Central frequency (cycles, months)	0.167	0.078	0.025	0.006
Central period (months)	6	12.9	39.4	156.4
VACELLIERE ALTA				
Central frequency (cycles, months)	0.142	0.059	0.025	0.014
Central period (months)	7.1	17.1	39.5	74.0
TRAFORO ISTANTANEA				
Central frequency (cycles, months)	0.132	0.077	0.013	0.012
Central period (months)	7.6	13.0	73.0	83.4
MESCATORE TERAMO				
Central frequency (cycles, months)	0.174	0.088	0.032	0.012
Central period (months)	5.7	13.4	32.1	103.5
MESCATORE CELLINO				
Central frequency (cycles, months)	0.188	0.080	0.039	0.012
Central period (months)	5.3	11.3	31.1	80.5
PRECIPITATION				
Central frequency (cycles, months)	0.186	0.1093	0.0318	0.0132
Central period (months)	5.3	9.1	31.4	76.0
NAO				
Central frequency (cycles, months)	0.182	0.130	0.055	0.0167
Central period (months)	5.5	7.7	18.3	60.0

	F1	F2	F3
VACELLIERE BASSA			
Central frequency (cycles, months)	0.17	0.084	0.019
Central period (months)	6	12.9	52.6
VACELLIERE ALTA			
Central frequency (cycles, months)	0.17	0.084	0.013
Central period (months)	6	12.9	76.9
TRAFORO ISTANTANEA			
Central frequency (cycles, months)	0.084	0.021	0.014
Central period (months)	12.9	47.6	71.4
MESCATORE TERAMO			
Central frequency (cycles, months)	0.17	0.084	0.013
Central period (months)	6	12.9	76.9
MESCATORE CELLINO			
Central frequency (cycles, months)	0.17	0.084	
Central period (months)	6	12.9	
PRECIPITATION			
Central frequency (cycles, months)	0.17	0.02	0.012
Central period (months)	6	50.0	83.3
NAO			
Central frequency (cycles, months)	0.18	0.084	0.032
Central period (months)	5.6	12.9	31.3

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