Detecting Trends in Drini River Basin

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Abstract

The present study aims to analyze the river flow of Drini River, situated in northern Albania, using the data from this watershed.
The objective of the study is to investigate whether there is any support for increases in river floods in observational data. Flood trend studies tend to focus in the annual maximum flood series, which means that in years with many high flows only one flood event per year will be selected, and in years with no large flows at all, a relatively low flow will be selected.
In the present study it is used a Peak-Over- Threshold approach (POT), selecting all floods above a certain threshold that occur in an entire flow record, provided that the floods extracted can be regarded as independent. This means that in one particular year several floods may be recorded, whereas in another year no floods may be recorded. Thus the use of POT series also allows an estimate of the trend in the frequency of floods, rather just their magnitude, by calculating the number of POTs that occur each year and investigating the trend in this series. The data to be use are these of maximum monthly river flow in Drini river basin and are selected to be free of human influence (as much as it is possible).
The method used to estimate whether there is a significant positive or negative trend in flood magnitude and frequency is the linear regression. By this method a regression line fits to the series and the slope describes whether the trend is strong or not. The null hypothesis is that the slope of the line is zero.
However, the linear regression method requires the assumption of normal distribution and is very sensitive to outliers in the data; by ranking the observation and applying the non-parametric Mann – Kendall test, a more robust measure of trend is obtained.

Key words: flood, water regime, peak over treshold

General feature

The Drini River, as the biggest river in Albania, has been always important even from the hydrometric point of view.
The climate variation does impact the water flow, but human influence cannot be ignored, especially in Drini watershed where there are three hydropower station with there respective reservoirs.
In this study the data used are of some hydrometric station having a long time record and free of human influence which means no effect from Hydropower Stations or reservoir, etc.
Yet, to date, there is little concrete evidence of climate – induced change for river flood-records. There are problems with strong natural variability and with data availability and quality. The search for weak changes in time series of hydrological data, which are subject to strong natural variability, is a difficult task, and use of adequate data and of good quality methodology is essential.
However, it is very difficult to identify trends in hydrological data, for several reasons. Records tend to be short, and in Drini River many data reflect a long history of human intervention. Variability over time in hydrological behavior is very high, and detection of any signal is difficult. Finally, land-use and other changes are continuing in the catchment, with effects that may outweigh any climatic trends. Even if a trend is identified, it may be difficult to attribute it to global warming because of other changes that are continuing in the catchment. Lack of data, which cover all the basin and consistent data analysis, makes it impossible to obtain a representative picture of recent patterns and trends in hydrological behavior. Monitoring stations (hydrological and meteorological) are continuing to be closed. Reconstructions of long records, is needed to understand the characteristics of natural decadal-scale variability in stream flow.

Flow distribution during the time

Different studies show cycles with different continuity from 2-3 year to 100 year (Shehu.B.) The water flow differs from year to year under the influence of climatic factors and mainly atmospheric precipitation and air temperature.
Other factors, except human influence, have a slow influence, coming after the climatic changes. So from all factors, the climatic one is the most changeable. Climatic changes influence directly in water resources regime and step by step, the changes in flora, relief etc. In natural conditions, the hydrologic regime needs century, and the soil and relief much more than this. But, under the human influence these rhythms change a lot in increasing direction.
To characterize the water flow fluctuation, during the years, you must have a very long data series. In our case the conclusions are not definitive.
Analyzing the fluctuation of the river flow during the years, we can detach a slight orderliness (Figure 1). After the 1954 it is observed a gradual growth of the curve and such growth is more evident in the hydrological year 1963 that continue up to the end of 1966 and after that with some small fluctuation it is a diminishing tendency. So the period up to 1970, in general is a wet period, including years with more values greater than the multiannual mean.

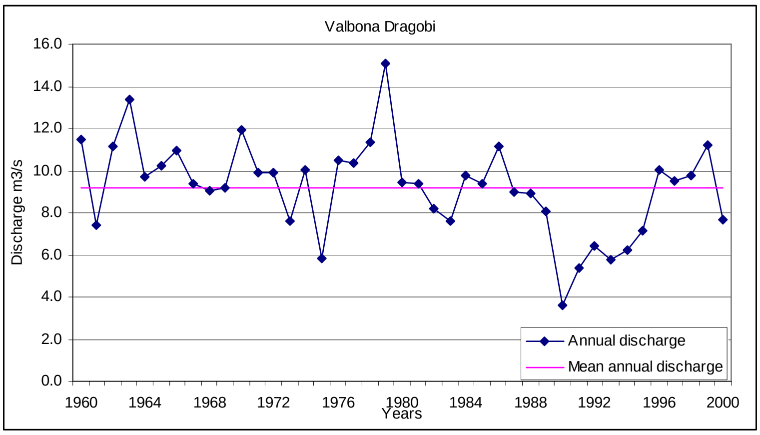


Figure.1 Fluctuation of the river flow during the years

Up to 1980 there are cycles with low water and cycles with high waters. So this is a typical hydrologic periodicity always with a positive tendency. After the 1980 there are regular consecutive cycles with high and low water but now the tendency is a negative one. In this period the number of years with low water is greater, that means there are more consecutive years with low water (more than three) so the dry period is more extended than before the 1980 (Figure 2). In these graphics the discharges are calculated as the moving average values.
Taking in consideration the result of the precipitation analyses, it is evident that the river flow process, follow the precipitation process during this period.

Trend in observed stream flow

Change in a series can occur in numerous ways: gradually (a trend), abruptly (a step change) or in a more complex form and may affect the mean, median, variance autocorrelation or almost any other aspect of the data.
A number of floods in Europe, as well as in our country too, during the past decade have provoked the question of whether they are an effect of a changing climate or not. But in some areas at risk from flooding, the threat of inundation had sometimes also been aggravated by man.
Whether floods are increasing ore not has therefore become an even more acute issue to study.
The objective of the study is to investigate whether there is any support for increases in river floods in observational data. Trend analyzes requires long records to distinguish trend from climate variability preferably in excess of about 50 years (Kundzewicz and Robson, 2000).
In our efforts to detect change in river flow due to climatic change we have to keep present the difference between variability and climatic change because: a-*Climate variability can cause apparent trend.* Climate variability can easily give rise to apparent trend when records are short—these are trends that would be expected to disappear once more data had been collected. Because of climate variability, records of 30 years or less are almost certainly too short; at least 50 years of record is necessary for climate change detection.

b-Climate variability obscures other changes. Because climate variability is typically large, it can effectively obscure any underlying changes due either to climate change or to urbanization.

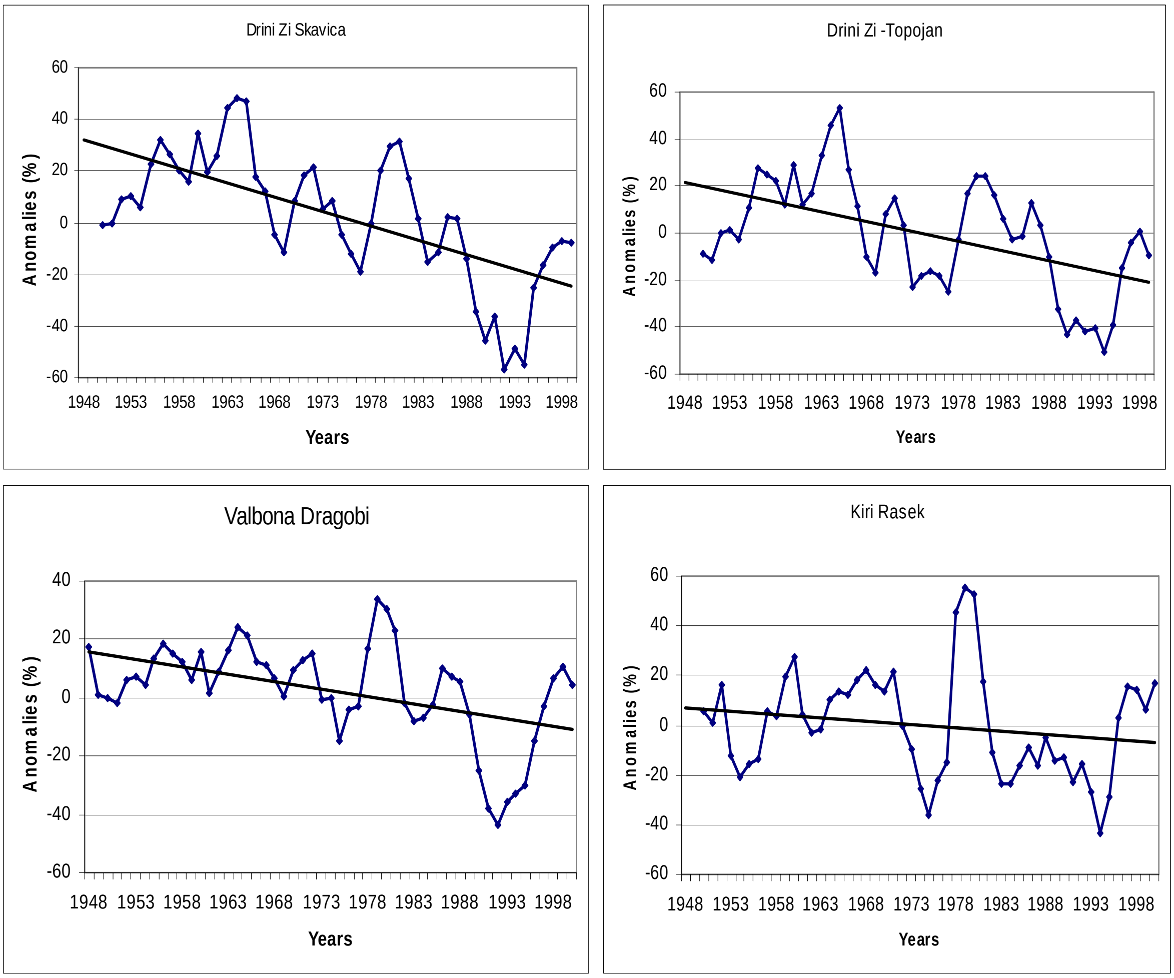


Figure 2 Yearly anomalies of some station in Drini River basin

The best way to improve understanding of change is to gather as much information as possible, using, e.g. information about changes in the catchment (land-use change, etc.) and about data collection methods.

The main factor influencing the water balance over space and time, are precipitation. Hydrological variability over time in a catchment is influenced by variations in precipitation over daily, seasonal, annual, and decadal time scales. Flood frequency is affected by changes in the year-to-year variability in precipitation and by changes in short-term rainfall properties (such as storm rainfall intensity). The frequency of low or drought flows is affected primarily by changes in the seasonal distribution of precipitation, year-to-year variability, and the occurrence of prolonged droughts.

In general, the patterns found are consistent with those identified for precipitation: Runoff tends to increase where precipitation has increased and decrease where it has fallen over the past few years.

Trend analyses of river floods and low flow

The issue of detecting climate change signature in river flow data is very complex because the process of river flow is the integrated result of several factors, such as precipitation inputs, catchement storage and evaporation losses but also the river training measures taken over time and the morphological processes changing the river conveyance (Pinter et al., 2003).

From the world experience there are some global, continental, regional scale studies of trends in river flow using monthly, seasonal or annual flow data. Studies using daily mean data are fewer. Some other authors use annual maximum daily mean river flows (Douglas et al., 2000).

Flood trend studies tend to focus in the annual maximum flood series, which means that in years with many high flows only one flood event per year will be selected, and in years with no large flows at all, a relatively low flow will be selected

In the present study we decided to adapt (Robson and Reed, 1999) a more representative way of describing the occurrence of floods using a Peak-Over-Threshold approach (POT). This selects all floods above a certain threshold that occur in an entire flow record, provided that the floods extracted can be regarded as independent. This means that in one particular year several floods may be recorded, whereas in another year no floods may be recorded.

Thus the use of POT series also allows an estimate of the trend in the frequency of floods, rather just their magnitude, by calculating the number of POTs that occur each year and investigating the trend in this series. The data to be use are these of maximum monthly river flow in Drini river basin and are selected to be free of human influence.

Five different indices were used to describe the characteristics of floods. The first is the annual maximum daily river flow (Ann.Max). In flood-rich year the annual maximum series will only include of the large floods, whereas in flood-poor years a small river flow will be selected that may not necessarily be a flood at all.

Two POT indices describing flood magnitude were use: the POT 1 Magnitude (POT 1 Mag.) and POT 2 magnitude (POT 2 Mag.) As the threshold for the POT1 Mag. the smallest annual flood for the whole period was selected. For the POT 2 Mag. the mean of the maximum annual series was selected.

The frequency of flood events can be described by counting the number of POT's occurring in each year. Two such flood frequency indices were used: POT 1 Frequency (POT 1 Freq) and POT 2 frequency (POT 2 Freq.).

The first series (Ann.Max) describe the magnitude and frequency of the most extreme floods, whereas POT 1 and POT 2 series characterize the behavior also of the more moderately sized floods.

Because the drought tend to be longer lasting than floods, data of lower temporal resolution than daily are more likely to be sufficient for low flow studies than they are for flood events. The monthly minimum discharges for detecting trends in the Drini catchemnt area are used. One low flow indice was used to describe the lower flow spectrum, the series of 30 day (Min. 30-day) minimal river flow.

Result and discussion

Detection of trends in long time series is an important scientific issue. It is necessary if we are to establish the true effect of climate change in our hydrological systems, and it is fundamental for planning of future water resources and flood protection. Studies of trend detection are also of importance because of our need to understand the changes of the "natural" word. In view of the many dramatic recent floods, detection of trends in long time series of flood data is of paramount scientific and practical importance.

Different studies found out that flood risk in some basins can be expected to rise in winter, whereas at the same time summer drought may become more severe.

The hypothesis that climate change will cause increases in frequency and severity of extreme hydrological events has resulted in growing recent interest in change detection in flow data.

Finding a significant change in time series of river flow data by statistical testing is not difficult if a change results from a major human intervention in the river regime, such as, for instance, dam construction. It is far more difficult to find a gradual change, related to climatic impact, in the behavior of the extremes of flow amidst natural variability.

Flood risk may have grown due to a range of land-use changes (deforestation, urbanization, reduction of wetlands etc.), which induce land-cover changes, hence of hydrological systems

Flood risk may have grown due to considerable changes in socio-economics systems, such as economic development of flood-prone areas, with a general increase in population and wealth, which lead to increasing exposure and exacerbated flood losses.

It is difficult to find a gradual change, related to climatic impact, in the behavior of the extremes of flow amidst natural variability.

The method used to estimate whether there is a significant positive or negative trend in flood magnitude and frequency is the linear regression. By this method a regression line fits to the series and the slope describes whether the trend is strong or not. The null hypothesis is that the slope of the line is zero.

However, the linear regression method requires the assumption of normal distribution and is very sensitive to outliers in the data; by ranking the observation and applying the non-parametric Mann – Kendall test, a more robust measure of trend is obtained.

The results of the trends analyzes are presented in two ways: plots of the entire index series (Fig.3) and fitted regression lines for each station and indexes and the slope of the trends is shown in Table 1. In the Figure 3 there are some of the graphical result.

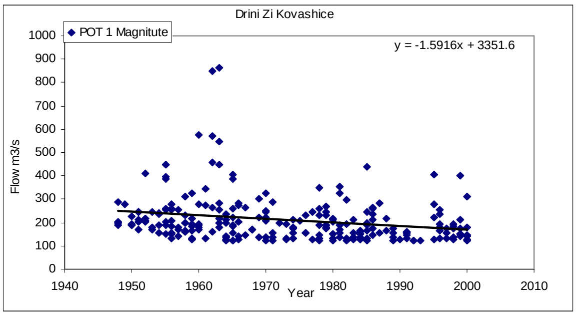
Table 1 Slopes of the trends

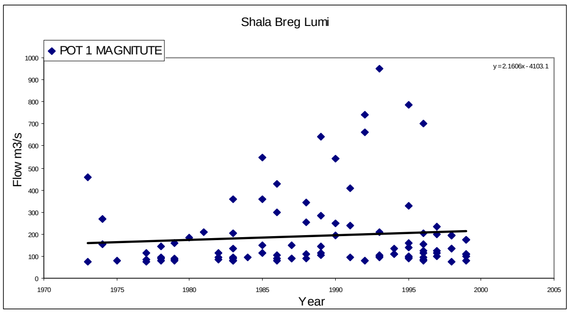
Station	Flood Magnitute Ann. Max	POT1mag.	POT2 mag.	Flood Frequency POT1Freq.	POT 2 Freq.
Murra-Muhurr	0.79	0.45	0.64	0.038	0.053
Kiri Rasek	-2.82	-2.1	-1.59	0.02	-0.0094
Valbona Dragb.	-.55	0.19	-1.6	-0.05	0.011
Shala Breg	11.7	2.16	1.65	0.16	0.17
Drini Zi Kovash.	-3.0	-1.6	-0.11	-0.016	-0.05
Drini Zi Skavice	-5.11	-3.1	-1.85	-0.066	-0.059

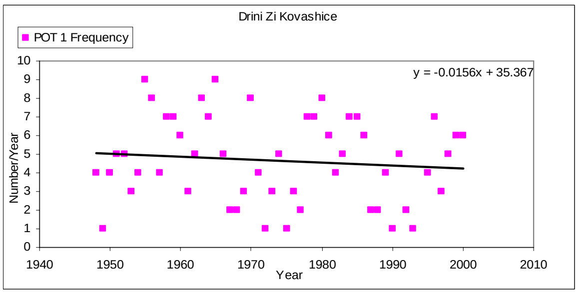
For the flood index series (magnitude and frequency) the stations of Drini Zi River shows negative trend and the station in the branches show negative or positive trends sometimes differing either from the threshold selected. Table 1 and Figure 3.

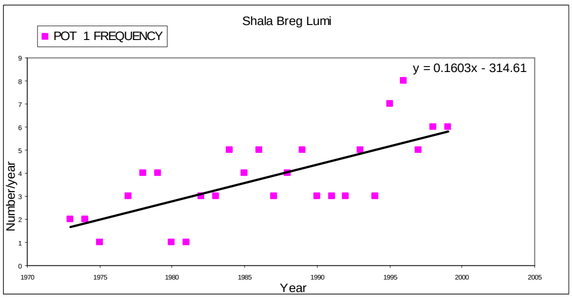
Drini River is the most human influenced river in the Albanian territory. From its spring in Ohrid lake the flow is controlled and even before it surpass Albanian border there is another reservoir constructed time before.

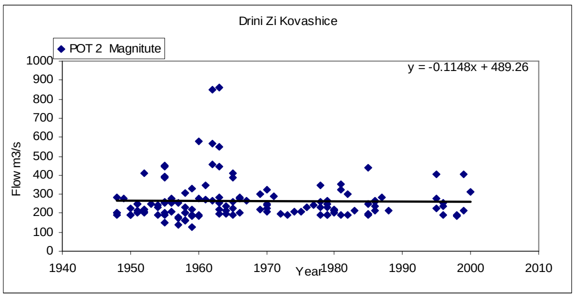
A reservoir's capacity to store the incoming flood flows and slowly release the water over time generally means that low flows are augmented and flood flows are mitigated downstream of the reservoirs (Vorosmarty *et al*., 1997). However if there is a change in the river flow regime due to reservoirs construction in the catchment's, this is mask changes in the hydrological cycle due to climate change. But in the same time it is evident that, if there is any climate change impacts on river flow regime it would be a recent phenomenon, and that statistical test for trend are not able to detect changes which have not lasted long, or are weak (Radziejewski and Kundzewics, 2004) .

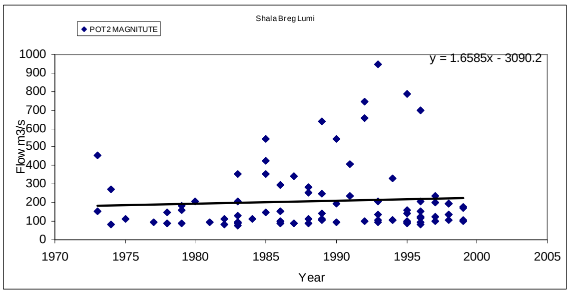

Drini Zi Kovashice
POT 1 Magnitute
y = -1.5916x + 3351.6
Flow m3/s
Year

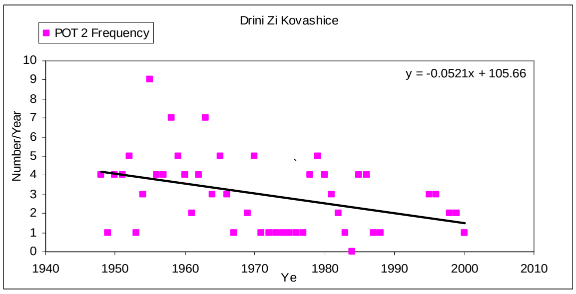

Shala Breg Lumi
POT 1 MAGNITUTE
Flow m3/s
Year

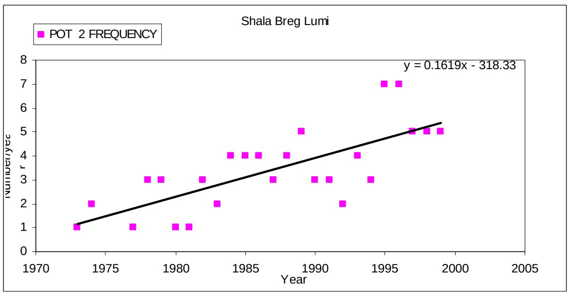

Drini Zi Kovashice
POT 1 Frequency
y = -0.0156x + 35.367
Number/Year
Year

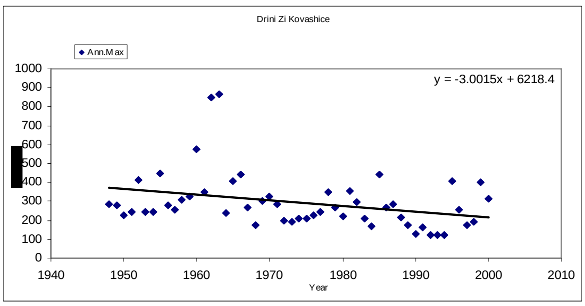

Shala Breg Lumi
POT 1 FREQUENCY
y = 0.1603x - 314.61
Number/year
Year

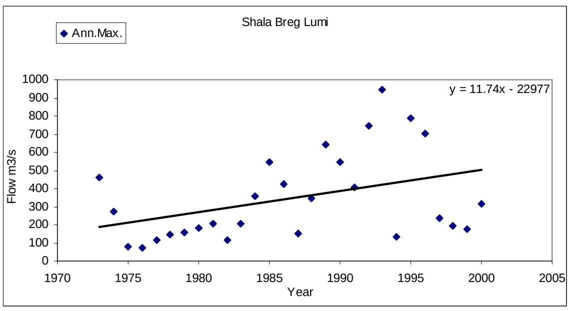

Drini Zi Kovashice
POT 2 Magnitude
y = -0.1148x + 489.26
Flow m3/s
Year


POT2 MAGNITUTE
y = 1.6585x - 3090.2
Flow m3/s
Year


Drini Zi Kovashice
POT 2 Frequency
y = -0.0521x + 105.66
Number/Year
Ye


Shala Breg Lumi
POT 2 FREQUENCY
y = 0.1619x - 318.33
Year


Drini Zi Kovashice
Ann.Max
y = -3.0015x + 6218.4
Year


Shala Breg Lumi
Ann.Max.
y = 11.74x - 22977
Flow m3/s
Year

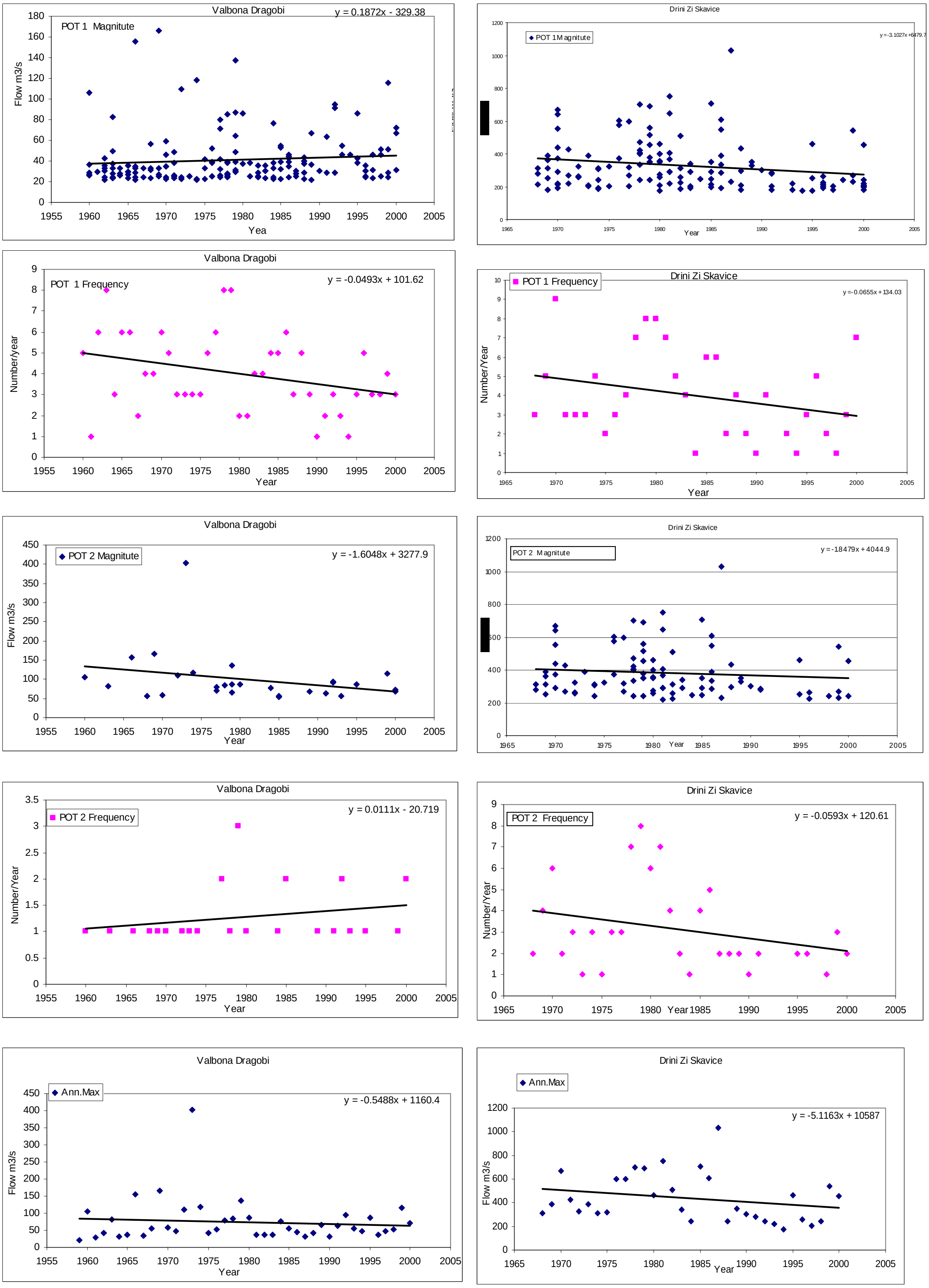


Figure 3. Time series of the five different flow index series and fitted linear regressions.

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