European Geosciences Union General Assembly 2016
Vienna | Austria | 17–22 April 2016

Session 7.4 Change in Climate, Hydrology and Society

Global investigation of Hurst-Kolmogorov behaviour in river runoff

Markonis Y, Nasika C, Moustakis Y, Markopoulos A, Dimitriadis P and Koutsoyiannis D, National Technical University of Athens, Greece (contact: imarkonis@itia.ntua.gr)

abstract

Long-term persistence or Hurst-Kolmogorov behaviour (HK) is a well-studied property of river discharge. Here, we use a large dataset (GRDC international archive), which counts over 1000 records above 60 years, 450 of which are also above 100 years, to examine the dependence structure in annual time scale. We estimate the Hurst coefficient *H*, for record lengths between 60 and 208 years, and investigate the sample size effect on the estimation (in subsets of 60-80, 80-100, 100-120 and above 120 years). We further extend our investigation by exploring the roles of catchment size, runoff mean values, elevation of gauge (above sea level), location (zonal: tropical, mid-latitude, high-latitude) to *H* determination. Finally, we determine if there are any links between *H* in the streamflow and the regional precipitation.

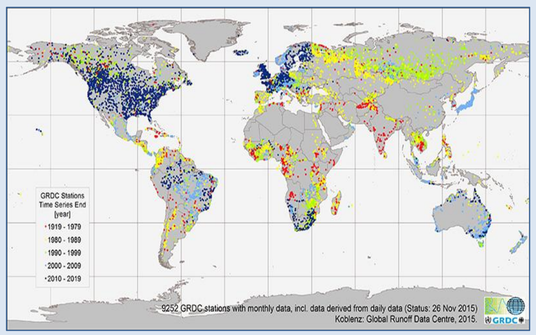
Acknowledgement: This research is conducted within the frame of the undergraduate course "Stochastic Methods in Water Resources" of the National Technical University of Athens (NTUA).

raw data

4070 rivers with 9252 stations from 160 countries over the world from 1806 to 2015 with mean sample size of 49 years and mean record length of 58 years summing up to 389 567 years of measurements

Global Runoff Data Centre

raw dataset



Source: Global Runoff Data Centre, 2015 GRDC

1

Record length > 20 years
Missing values < 10%
Qn sample size > 60 years
St. d. threshold (0.5 x σ in 20-year moving window – falsely rejects 5% of time series with H > 0.8)

data set #1

2278 rivers with 3127 stations from 82 countries over the world from 1806 to 2015 with mean sample size of 59 years and summing up to 192 111 years of measurements and 11 797 15-year blocks

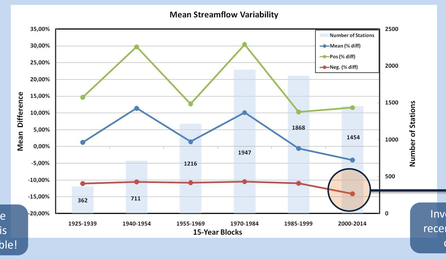
Record length > 60 years
Missing values < 33%

data set #2

924 rivers with 1311 stations from 49 countries over the world from 1806 to 2015 with mean sample size of 75 years and mean record length of 84 years summing up to 111 588 years of measurements

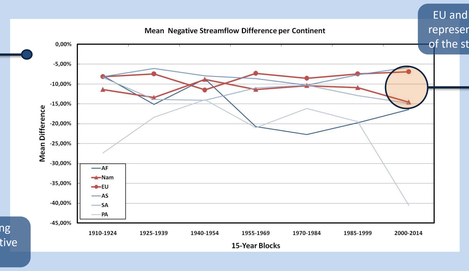
streamflow change in 15-year intervals

2

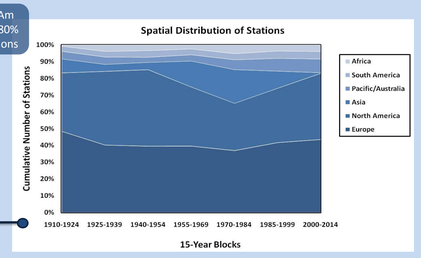


Negative change is rather stable!

Investigating recent negative change

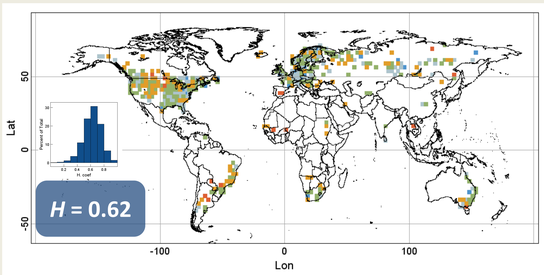


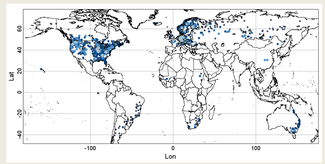
EU and NAm represent 80% of the stations



long-term persistence in global streamflow

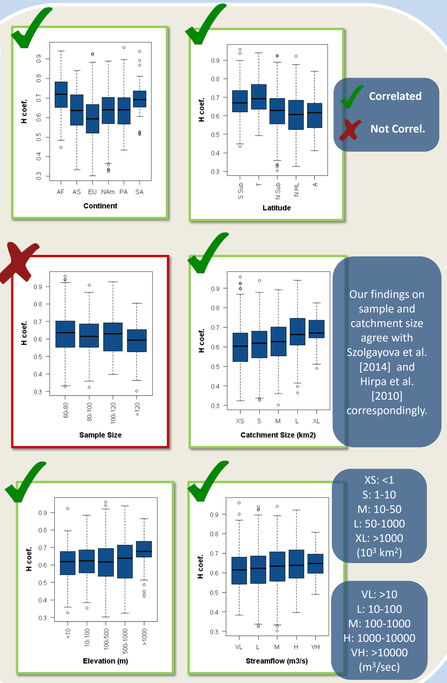
3





Map of the *H* values presented at a 2.5 x 2.5 grid (on the left). Warmer colors depict higher values of *H* (0.1 classes).
Map of the original locations of the stations used for the estimation of *H* (above) and their record length (cycle size; 60-80, 80-100, 100-120 and >120).

4



Correlated

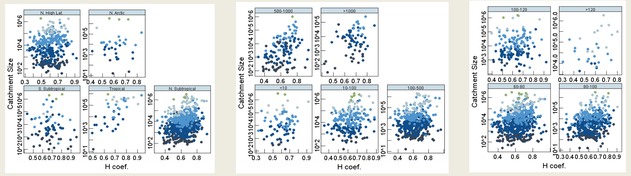
Not Correl.

Our findings on sample and catchment size agree with Szolgayova et al. [2014] and Hirpa et al. [2010] correspondingly.

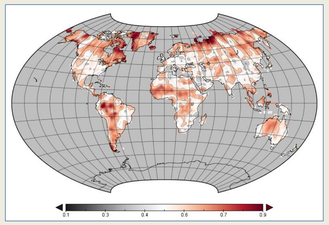
XS: <1
S: 1-10
M: 10-50
L: 50-1000
XL: >1000
(10^3 km^2)

VL: >10
L: 10-100
M: 100-1000
H: 1000-10000
VH: >10000
(m^3/sec)

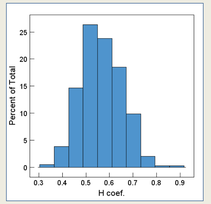
5

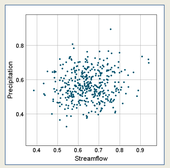


6

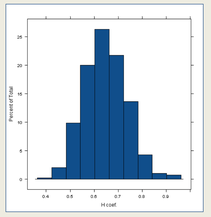


Global spatial variability of *H* coefficient, estimated from CRU TS3.22 dataset (2.5° × 2.5° res. grid from 1901 to 2013 at annual scale). Source: Markonis and Koutsoyiannis 2016.





H of precipitation follows a similar distribution in the same grid boxes with a smaller mean (0.57). However it is not correlate with the corresponding values of *H* for the stream flow.



methods

1. Data preparation
2. Determination of observed change
3. *H* estimation: LSSD method (Climacogram, Koutsoyiannis 2002)
4. Exploration of streamflow/ catchment features effect to *H*
5. Investigation of independency between variables affecting *H*
6. Correlation between streamflow and precipitation

conclusions

1. High quality original dataset. Not demanding preparation of data.
2. Stable negative changes (≃ −10%). Strong decrease in the last 15 years (N. & S. America, Australia).
3. *H* follows a normal distribution, with $\mu = 0.62$ and $\sigma = 0.13$.
4. Catchment size, latitude and elevation are weakly linked to *H*. Record length is not.
5. *H* increases with catchment size above 50×10^3 km^2 and elevation above 1000 m.
6. *H* is higher in the tropical zone (*H*≃0.70) similarly to precipitation. However they are not correlated.

References

Hirpa, Feyera A., Mekonnen Gebremichael, and Thomas M. Over. "River flow fluctuation analysis: Effect of watershed area." *Water Resources Research* 46.12 (2010).

Koutsoyiannis, Demetris. "The Hurst phenomenon and fractional Gaussian noise made easy." *Hydrological Sciences Journal* 47.4 (2002): 573-595.

Markonis Y. and D. Koutsoyiannis, Scale-dependence of persistence in precipitation records, *Nature Climate Change*, 6 (4), 399-401. 2016.

Szolgayová, E., et al. "Factors influencing long range dependence in streamflow of European rivers." *Hydrological Processes* 28.4 (2014): 1573-1586.