Floods: risk trend, climate change effect, and future challenges

Increasing risk at global level

Water is crucial for life, and traditionally humans have inhabited places near to rivers in order to have availability of such important source. Water is not only necessary to survive, but also is crucial for many human activities, such as energy production, food production, etc. In the past century, global population has increased (from 1.6 billion in 1900 to 6.9 billion in 2010) and many have moved in cities (10% population lived in cities in 1900 and more than 50% lived in cities in 2010). Today to be close to water, due to the technological improvements, is not that necessary anymore, but still 800 million people are living without any improvement for the water supply and safety, mainly due to the lack of investments, war, and political will. On the other hand, for the people which have access to clean and fresh water the proximity to the water source (lakes or rivers) is still of importance due to cultural, aesthetic, and others reasons [1]. Anyway, to live near water sources is not always a positive aspect, it can, in fact, also increase the risk in case of flooding events. Recently, Ceola *et al.* [2] has used nightlight images from satellite to investigate the proximity of urban areas to rivers, the related flood risk, and the evolution in time. Such innovative approach allows to find an average increasing proximity of population and economical activities of 1.2% each year (data analysis from 1992 to 2012). Also, from the study emerge a higher increasing trend in the developing counties, meanwhile developed countries like Europe have a slightly positive trend and North American even a negative trend. Thus, the risk is increasing in the developing country in which people are moving near water sources [2]. Also, a problem related to the developed countries is that not always the population density is overlapping the water availability, and such situation create a pressure on the water source, and such pressure it is expected to grow due to climate change [1]. Nowadays, around half of the global population lives within 3 Km from water source and 90% within 10 Km, and also the more close to the rivers the higher the population density becomes, with an average of 150 person/Km^2 within 2 Km from fresh water bodies to 50-60 person/Km^2 in areas distant 25 Km from water sources, although such relation is more clear for the people living in rural areas, meanwhile in urban areas such decrease is less intense due to the water transportation infrastructures [1]. All that information reveals an increasing risk, both due to the increase vulnerability and exposure at global level.

Floods in Europe, Climate Change effects

Due to the large amounts of vulnerable sites such as the millions of industries on the European's countries, and the large amount of water availability and presence of rivers, Europe has a strong interest to study and control the evolution of floods and the possible impacts of climate change on them. Using data collected in the past decades, large database has been provided to researchers which have try to establish the influence of the changing climate on such potentially catastrophic events. In particular, three main factors are expected to change in relation to a warming climate: magnitude, frequency, and timing [3]. The establish of magnitude change has found anyway no scientific evidence, also due to the presence in Europe of infrastructures able to stop, for now, drastic floods. On the contrary, the

time shifting of extreme events has change across all Europe, as shown in Figure 1, waring from -65 to +45 days in the past five decades (1960s to 2010s) due to several factors based on the region of influence [3]. At the same time, anyway, the discharged amount of water during the year by flood events event has changed in all over Europe based on the same database, revealing three different behaviours [4]:

- North-West Europe: increase discharge up to 12%, due mainly to the increased autumn and winter rainfall;

- South Europe: decreased precipitation and an increase of evaporation haved led to a decrease of discharged water in the flood events;

- North-East Europe: decrease of the discharge in flood events due to warmer temperatures which decrease the snow coverage and the consequent water discharge during the melting season.

This data refer to the annual discharged amount, which do not necessary means a decrease magnitude of events, which actually seems to be increased in the last years also due to the higher capacity of the warmer atmosphere to stock water in form of humidity [4]. On the other hands, the total amount discharged can be related to the availability of water in the region, which means an increased risk of periods with poor water supply in south and north-east Europe.

Conclusions

The studies reported had proof how close to water humans live and how such precious source is driving the world population distribution. Especially for the developing countries is important to design the new cities in order mitigate the possible effects of floods events. Although, also developed countries need to assess and mitigate the problem, also due to a higher vulnerability in terms of economic potential loses (which are in fact increased in the last years) [4].

Climate change is expected to change the water cycle at global level, due to a warming climate, and thus to change magnitude, frequency, and timing of river flood [3]. In Europe, thanks to a large time-period data set available, new discoveries has been produced, revealing the necessity of a re-thinking the territory in order to assess future events. However, both in European and in a global scale, more work needs to be done, implementing lack on data and to produce models able to predict in a more accurate way the space and time evolution of such phenomena. At the same time, the study of water cycle modifications due to climate change could be crucial since, as shown, water play a key role for the human activities. Possibly, such studies, should applying a multidisciplinary approach which could lead to more holistic results for such complex processes.

Andrea Facchin

Bibliography

[1] M. Kummu, H. de Moel, P. J. Ward, and O. Varis, "How close do we live to water? a global analysis of population distance to freshwater bodies," *PLoS One*, vol. 6, no. 6, 2011, doi: 10.1371/journal.pone.0020578.

[2] S. Ceola, F. Laio, and A. Montanari, "Satellite nighttime lights reveal increasing human exposure to floods worldwide," *Geophys. Res. Lett.*, vol. 41, no. 20, pp. 7184–7190, 2014, doi: 10.1002/2014GL061859.

[3] G. Blöschl *et al.*, "Changing climate shifts timing of European floods," *Science (80-.).*, vol. 590, no. August, pp. 588–590, 2017.

[4] G. Blöschl *et al.*, "Changing climate both increases and decreases European river floods," *Nature*, vol. 573, no. 7772, pp. 108–111, 2019, doi: 10.1038/s41586-019-1495-6.

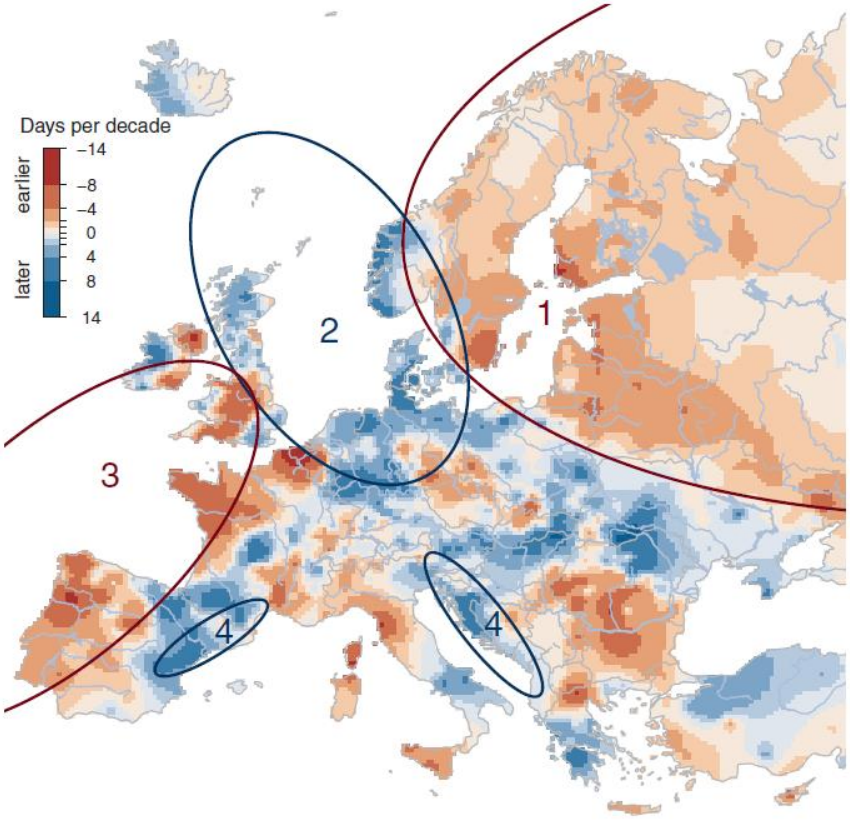

Figure 1. Bloschl et al, Science 2017