**Explorer’s Questions**

1. How big is the Rhine catchment (km2)?

**185,000 km2**

1. If it rained for one full day over the whole catchment area at 5mm/hour and all the precipitated water ended up in the river, how much would be the increase in the average river runoff? 66 Runoff, discharge, streamflow are terms that in most cases are used with the same meaning. Write a script that performs the calculation.

**avg\_runoff\_change in a file question2-3assign1.R**

1. (Optional) How much time does a rain drop falling at Alpine Rhine need to reach the ocean? Write a script that performs the calculation.

**time\_to\_sea** **in a file question2-3assign1.R**

1. **In the study of study of Middelkoop et al. (2001):**
2. Which other hydroclimatic changes reported in the article and not discussed above?

*“shift of the hydrological regime in the entire Rhine basin”*

1. Can you detect three assumptions made by Middelkoop et al. (2001)?

*1. In the Alpine area, higher temperatures will reduce the amount of snow accumulation during winter. This results in higher winter discharge, and lower summer*

*discharge. In addition, winter precipitation increases, while precipitation may*

*decrease in some summer months. Higher temperatures will intensify evapotranspiration, particularly during summer. On an annual basis, this increase is larger*

*than the precipitation increase, resulting in a reduction of annual runoff.*

*2. In the German Middle Mountains, the investigated catchments demonstrate only*

*a minor seasonal shift in river flow. The changes in runoff are controlled by the*

*balance between increased precipitation on the one hand, and increased evapotranspiration rates due to higher temperatures on the other hand.*

*Peak flows resulting from heavy rainfall and convective thunderstorms, however, are expected to increase.*

*3. In the lowland area, increased winter precipitation will cause higher winter discharge and winter peak flows.*

1. Why Middelkoop and his colleagues made this study? Why is it important? For example, the reason for searching for a way to the Orient was that Ottoman Empire monopolized the trade routes across Asia.

**This study is made due to many reasons. They are all listed in the study. Briefly the reasons are:**

**-winter sports in Alps**

**-flood defense**

**-inland navigation**

**-hydropower generation**

**-water availability for industry, agriculture and domestic use**

**-floodplain development**

1. Are there other studies that have a similar analysis over Rhine, or a similar hypothesis in other regions? (hint: use google scholar or web of science/scopus).

**Statistical trend analysis of annual maximum discharges of the**

**Rhine and Meuse rivers**

**F.L.M. Diermanse, J.C.J. Kwadijk, J.V.L. Beckers\* and J.I. Crebas**

1. Is there any evidence in the news about low or high flow events of Rhine since 2000?

**https://dredgingandports.com/news/2019/billions-lost-due-to-rhine-traffic-decline-during-low-water/**