

Water and Climate example exam – with brief elaboration

Sea level rise (30p)

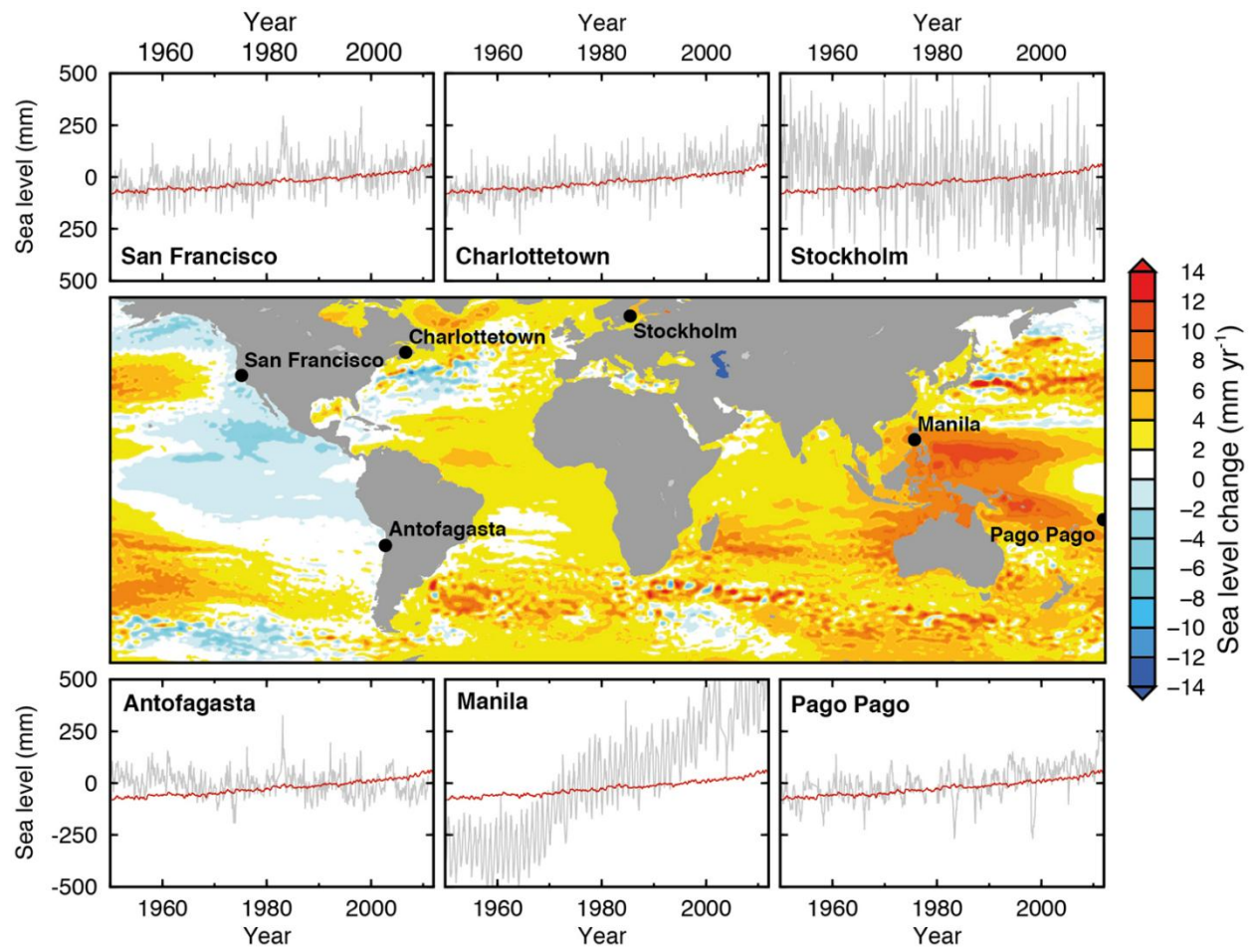


Figure 1. Observed sea level for different location and the average global trend

1. **(9p)** Study figure 1.

- a. Provide one possible reason for the year to year variations in observed local sea level, explain your answer.

Number of storms varies each year. Storm cause a surge, can be up to several meters, that influence the annual average SL at a location

- b. Provide 3 reasons for differences in the trends between the stations

Regional differences in sea level may be caused by eg intensification of wind (eg trade winds in the pacific; variations in ocean circulations, density (temp, salt) that influence regionally SL. Or can be due to local subsidence (an effect of relative SLR)

- c. What might be a reason for negative trends in sea level trend in some stations (eg Stockholm).

Effect of relative SLR. This can be negative due to a rise of the land. This happens eg in NW EU still due to the rebounding of the earth crust after the disappearance of the icesheets. May also be caused by vulcanism

Sea-level rise

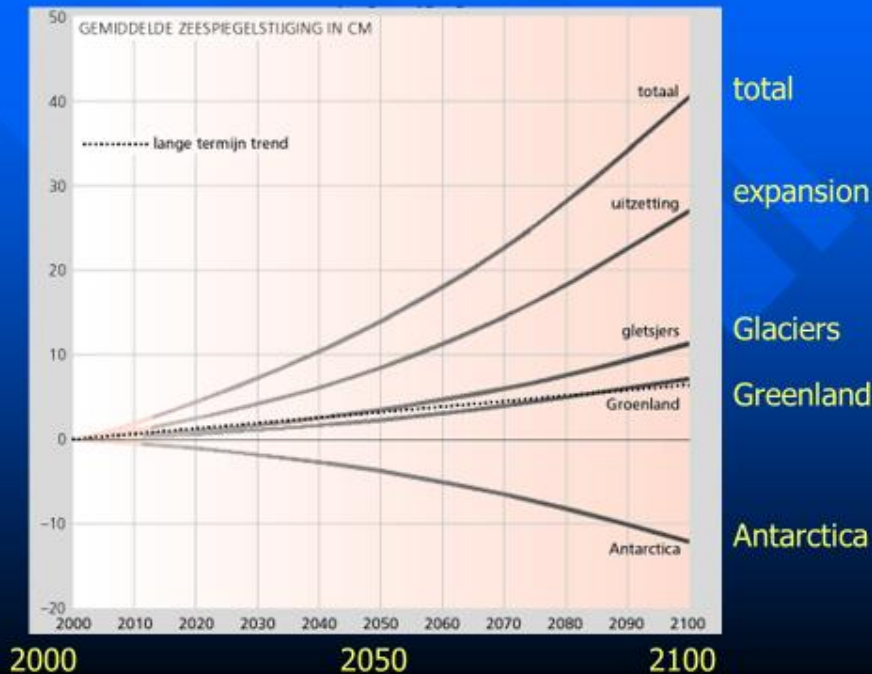


Figure 2. Contribution for (future) sea level rise (published around 2000)

2. **(12p)** Study figure 2. This figure was published around the year 2000 and shows the (future) contributions to global sea level rise according to mean estimated based on the scientific knowledge in that period
 - a. Elaborate for 3 processes what the physical mechanisms are, explaining how they contribute to global sea level rise;

Expansion is due to the warming of the atmosphere, which warms the upper layers of the ocean which penetrates slowly into the deeper layers. Warming water means that the volume increases. Glaciers (Mountains): due to the warming of the atmosphere more melt than accumulation. the mass balance of the glaciers becomes negative, Net they shrink and mass (water) is added to the oceans via the rivers; Greenland, more or less the same as Mountain glaciers; Antarctica does not melt but land ice flows directly into the ocean.
 - b. Currently the assessments on both the contributions of each of the processes as well as on the total potential rise for **2050** is different. What are the main differences in contributions, and what is the difference in potential rise.

Contribution of Greenland (melt) and mountain glaciers is currently estimated to be larger than the contribution of the thermal expansion. Antarctica is positively contributing. High end scenarios for 2050 are higher than the one shown here
 - c. Explain the physical mechanisms of the “low probability, high impact” sea level rise scenarios for **2100** and later by the IPCC.

These scenarios are associated with the very uncertain but may be fast response of the ice flow from Antarctica. If the floating ice sheets around Antarctica would break up

more fast, the land ice from Antarctica will start to flow faster as water will flow between the bedrock and the ice, decreasing the resistance. In relatively short time (unknown how fast) large parts of Antarctica will disintegrate and massive volumes of ice will flow into the oceans, leading to SLR of many meters.

- d. Provide a physical explanation for the assumed negative contribution of Antarctica to the global sea level rise that were common around 2000 (Fig 2).

Response of an icecap is a mass balance. Currently Antarctica is very cold ($< -20^{\circ}\text{C}$) with little precipitation. Warming of the atmosphere would increase the amount of water in the atmosphere leading to more precipitation on Antarctica while there will be not be more snowmelt. That would cause a positive mass balance, meaning that water is taken from the ocean and is stored on Antarctica having a negative effect on the SLR globally.

- 3. **(9p)** Projections for sea level rise can be made (a.o.) by
 - a. extrapolation of the observed trend,
estimating sand nourishment volumes for the coming years. For the next 10 years this is probably the most reliable estimate
 - b. studying the geological sea level record and :
to assess the relation between CC and sea levels for the very long term, use this to illustrate the very serious consequences and raise awareness for the urgency of mitigating CC. These responses are beyond the capability of the climate/ocean/ice models due to the very long term response (eg limited by computational capacity and knowledge on the response of the icesheets)
 - c. by using output of Climate models as input in ice sheet and glacier models and calculate their response over time.
Provides projections for the decadal to century scale, relevant for design of infrastructure with long life times. Extrapolation is not able to incorporate this and the geological record is not appropriate because eg 100yrs is extremely short.

For each approach provide a specific example where the use of results of that approach would be appropriate in decision making in water, flood or environmental management. Obviously, this should yield 3 different examples. Justify your answer.

Adaptation to climate change (40p)

1. **(5p)** In adaptation literature often the terms Resilience and Robustness appear. What is the difference between these terms and to illustrate your answer provide an example for both a resilient and a robust measure.

Resilience is the ability to recover from extreme events and impacts without long term harm while possibly accepting considerable impacts in the meantime, eg plant mangroves as flood defense as they have the ability of self-recovery after an extreme event. Robustness refers to the ability to endure such changes without adapting. Eg build strong and high embankments to avoid flooding

2. **(5p)** Explain what is meant by the term Adaptation Tipping Point in a DAPP (Dynamic Adaptive Policy Pathway) approach to plan for adaptation.

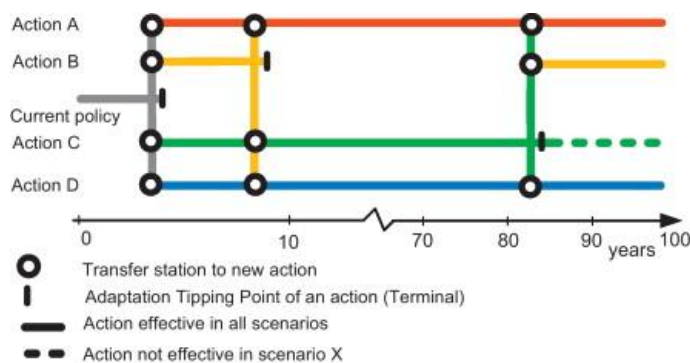
Point where climate / SL has changed that much that we cannot achieve our policy targets anymore

3. **(10p)** In adaption planning of a water resources system one can start (a) with greenhouse gas emission scenarios or (b) with a proposed policy for the functionality of the water resources system. For both approaches, sketch the planning process consisting of a series of steps that need to be taken to define adaptive measures.

(a) Make assumptions (eg on socio economic development, faster or slower CC) ; Predict the outcomes of these assumptions (eg change of flood risk); take actions (eg design an embankment for these new conditions). (b) Propose the policy, identify the vulnerability for changes in boundary conditions, assess possible actions to decrease the vulnerability

4. **(20p)** According to all climate scenarios heavy rainfall will increase in The Netherlands. There are however large differences between the scenarios. Some suggest that the increase will change rapidly and a lot. Others suggest that the changes will be more slowly and moderate. The changes differ between +10 and +80% in intensity . The government of The Netherlands seeks for an adaptive planning approach for a urban areas to avoid damage due to pluvial flooding. Assume that the current system is at its upper limit and any extra rainfall will result in unacceptable damage. Also assume that only the following 3 options for adaptation are available:

- Increase green areas in cities (can handle 30% extra rainfall intensity),
- Replacing the storm water drainage system by wider sewage pipes, canals and stronger pumps (can handle 50% extra rainfall intensity),
- Improve the rainfall forecast to operate the current storage reservoirs (can handle 10% extra rainfall intensity).



Adaptation Pathways Map

Path actions	Relative Costs	Target effects	Side effects
1	+++	+	0
2	+++++	0	0
3	+++	0	0
4	+++	0	0
5	0	0	-
6	++++	0	-
7	+++	0	-
8	+	+	- - -
9	++	+	- - -

Scorecard pathways

- a. Draw a pathway map to support adaptive planning in for this example where you put on the horizontal axis the change in rainfall intensity (5p)
- b. Shortly explain the rationale behind the sequence of decisions according your map, continuing along an action line or switching (5p)
 should be a plausible storyline (eg start with small measures, postpone the more expensive and difficult ones as you are not sure on the speed of the change (eg first improve the forecasts, last the sewer system)
- c. Explain what information or analysis you would use to replace the rainfall intensity into time on the axis in the pathways map (5p).
 Run different climate scenarios and determine from them what the first date is that critical values are exceeded. As the system is at its upper limit any extra rainfall needs to be managed with the options we have. So we need to know when 10% extra is reached, when 30%, when 40% etc.
- d. Mention three indicators that would you consider to put on a score card to show additional consequences (5p).
 eg Costs, space, co-benefits, complexity for implementation.

Climate and water scenarios (30p)

1. **(5p)** Provide 3 purposes of defining a Baseline climatology for developing water scenarios.
 To define the reference for comparison of a certain variable, calibrate models, describe the current conditions
2. **(10p)** Very often the basis for scenarios development are two axes (for example the delta scenarios or the SPS or the KNMI climate scenarios). What is important to consider when defining these axes.
 Should be relevant as drivers for what we want to study, should be independent to each other, should be drivers that bear a considerable uncertainty
3. **(5p)** Water scenarios can be created by the direct method and the delta method. Explain the difference between the two approaches.
 Direct method hydrological models use the raw output data on variables such as P and T as input. Delta method uses the differences between the variables for the control/baseline output and the scenario output often averaged over a month. The differences are used to perturb observed precip and T series. These perturbed series are used as model input
4. **(10p)** Global climate models describe the full hydrological cycle, so including soil, and groundwater. Nevertheless their direct output is rarely used for water resources management or flood management. Why is that so? Provide 2 reasons.
 Poor skill on precipitation amounts and variability, scale too coarse for decision making