Deltares

Water system recovery after two consecutive years of extreme drought

Janneke Pouwels

Perry de Louw

Dimmie Hendriks

Joachim Hunink

01-05-2020

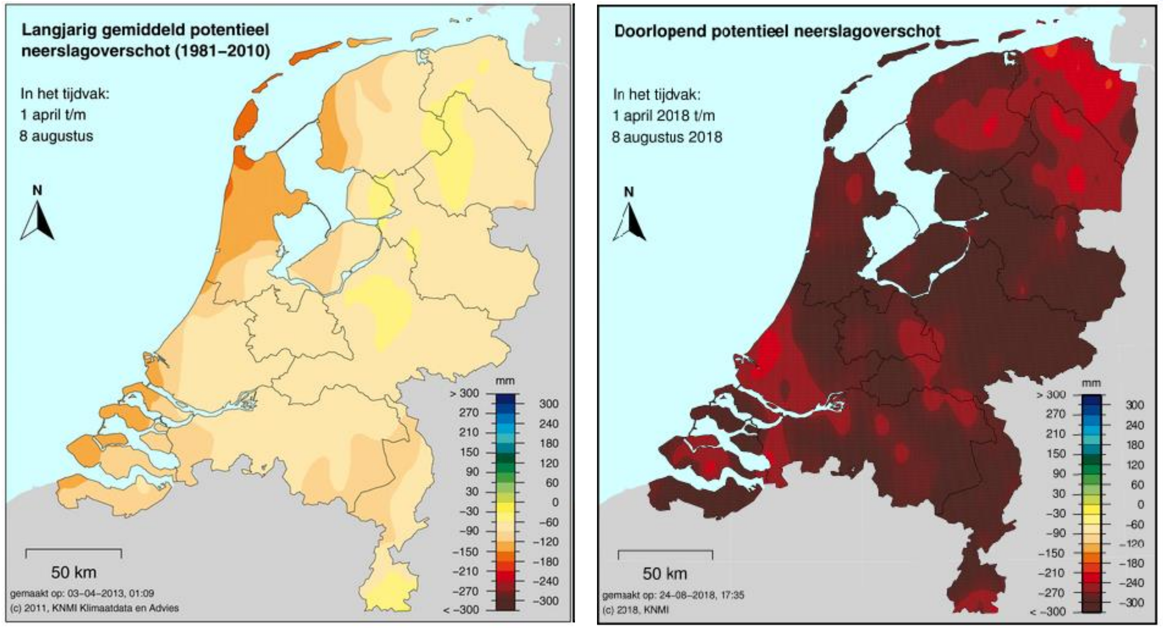
Table of contents

- Introduction
- Method
  - Modeling drought on national scale
  - Hydrological model LHM
- Results
  - Timeseries of quick and slow responding areas
  - Stream discharge during dry years
  - Spatial variation of recovery
- Conclusions

Deltares

Introduction - Past years drought in the Netherlands

- In the Netherlands 2018 was an extremely dry year with a high precipitation deficit (see figures).
- The extreme low rainfall amount, in combination with above average high potential evaporation rates, caused a precipitation deficit of 300 mm in the growing season, which is normally less than 100 mm.
- This 2018 drought caused over 1 billion euros of economic damage to different sectors (e.g. agriculture, nature, industry, shipping, infrastructure and buildings).
- Damage was due to extreme low groundwater levels and large soil moisture deficits. Many streams stopped flowing since groundwater levels were too low to feed the streams.

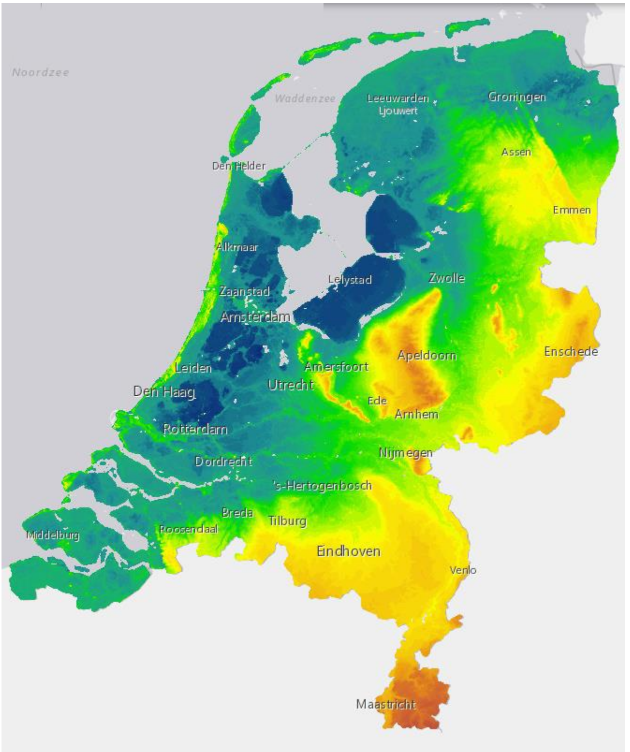


Maps show potential precipitation surplus 1 April-8 Augustus. Left: longyearly average, right: the year 2018.
Source: Koninklijk Nederlands Meteologisch Instituut (KNMI)

Introduction - Past years drought in the Netherlands

- In 2019, the spatial variability of precipitation in the Netherlands was high.
- The low lying western part of the Netherlands had only a small precipitation deficit of a few tens of millimeters.
- The high sandy areas in south and east of the Netherlands had an extremely large precipitation deficit of more than 240 mm.
- For the higher sandy areas this was the second dry year in a row, therefore the following question arose:

What is the effect of two consecutive dry years on the water system and how fast may it recover?



Height map of the Netherlands, with the high sandy areas in the south and the east. Source: AHN (ahn.nl)

Method – Modeling drought on national scale

Model used

- integrated nationwide groundwater and surface water model (LHM-model)
- See next slide for information on the model

Modeled years

- Start with warm state
- Modeling 2 consecutive extremely dry years
- After 2 dry years: 10 years with average precipitation and evaporation patterns

Modelled years: 2x dry year, 10x average year

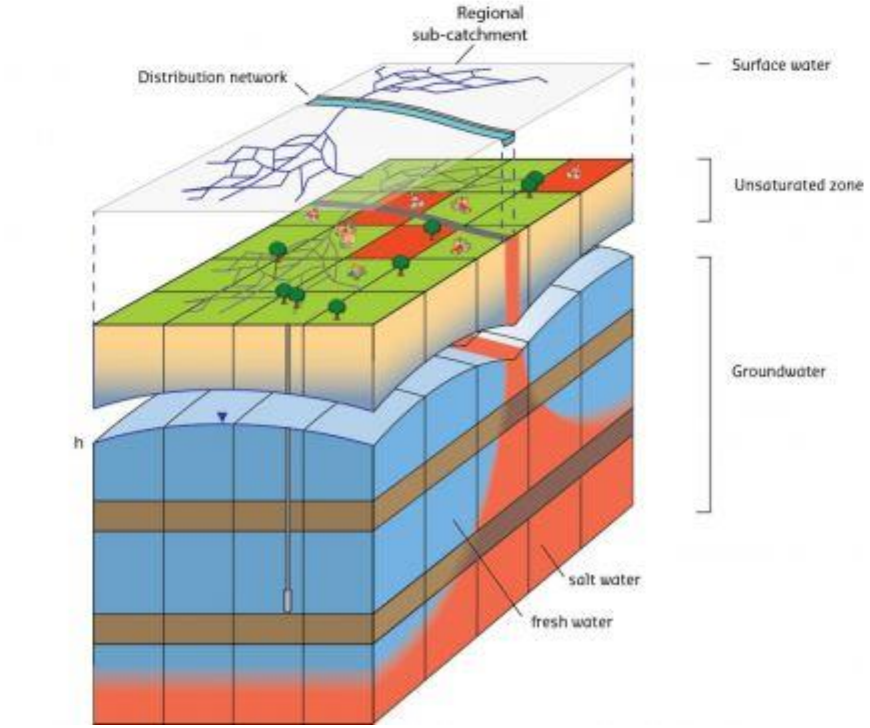
Modeled area

- Whole Netherlands

Method – Hydrological model LHM

- LHM is a hydrological model containing the whole of the Netherlands
- It is an integrated model with the following hydrological components:
  - Saturated zone (groundwater)
  - Unsaturated zone
  - Regional surface water
  - Nationwide surface water

- LHM is used for different purposes, for example:
  - To analyse effects of climate change to Dutch water system;
  - During droughts to advice on the nationwide water distribution;
  - To analyse effects of possible measures in the water system.

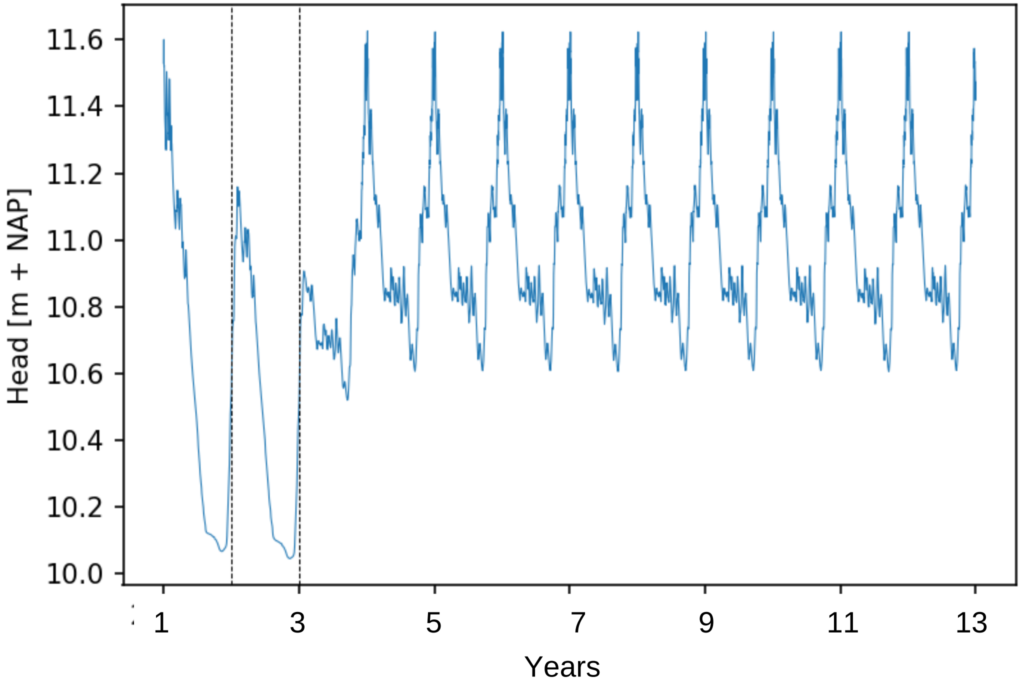


Schematic overview of the LHM-model (nhi.nu)

Results – Timeseries in quick responding area

- Location of timeseries: Relative low location in the sandy areas of the Netherlands.
- Low groundwater heads in first dry year.
- No full recovery of groundwater heads in the winters after the 1st and 2nd dry year.
- First normal year still has lower groundwater heads.
- Groundwater on this location fully recovered after one normal year.

Phreatic head – location with relative high groundwater heads



Modeled phreatic head at a location with high groundwater heads. Year 1 and 2 are the dry years, year 3-12 are the normal years.

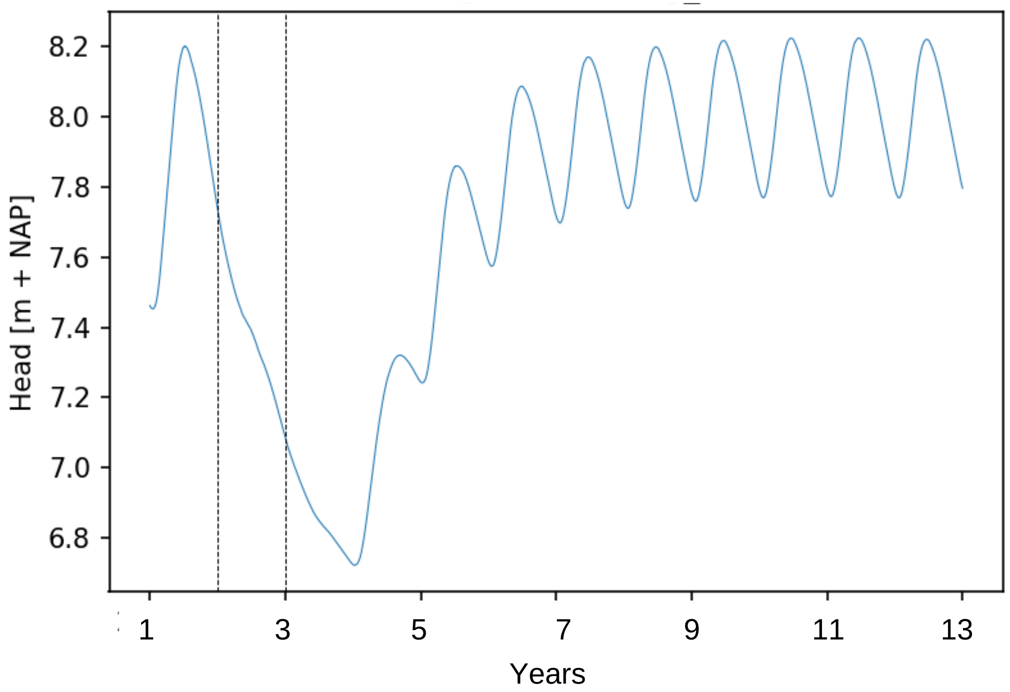
Dry | Dry | Average | Average | Average | Average | Average | Average | Average | Average | Average | Average

Modelled years: 2x dry year, 10x average year

Results – Timeseries in slow responding area

- Location of timeseries: Relative high location in the sandy areas of the Netherlands.
- Still high groundwater heads in first dry year. So no immediate response on dry conditions.
- Groundwater levels begin to drop at the end of the first year.
- Dropping of groundwater levels stops at the end of the first recovery year.
- Recovery of groundwater heads goes slowly, it takes around 5 years to recover.

Phreatic head – location with relative low groundwater heads



Modeled phreatic head at a location with low groundwater heads. Year 1 and 2 are the dry years, year 3-12 are the normal years.

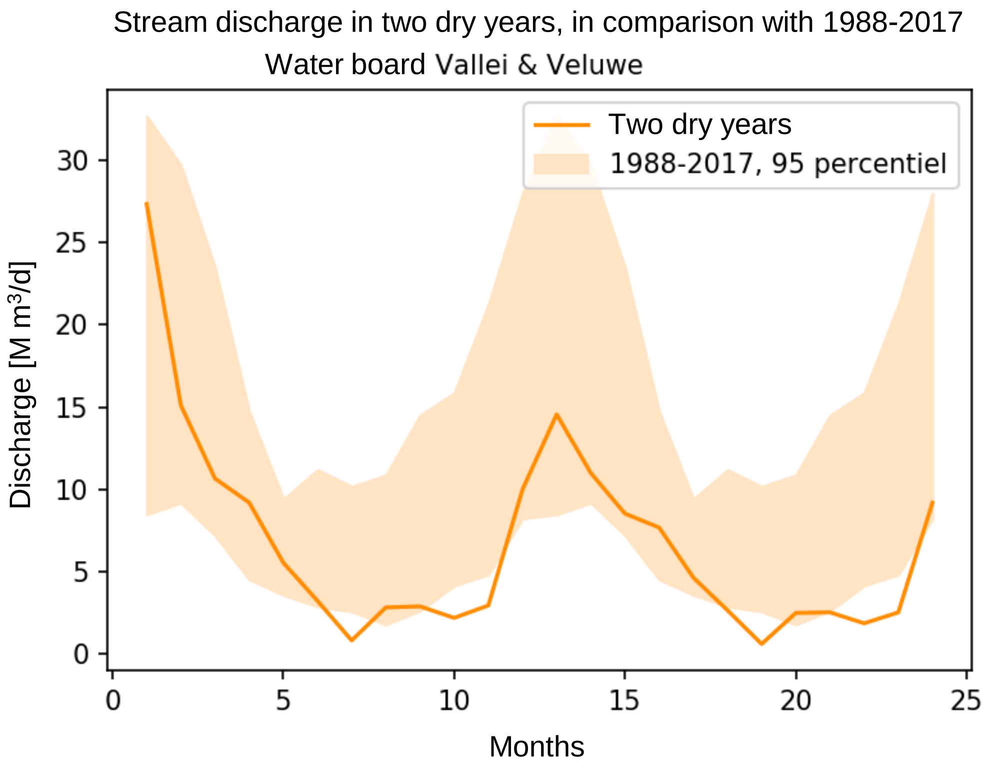
Dry | Dry | Average | Average | Average | Average | Average | Average | Average | Average | Average | Average

Modelled years: 2x dry year, 10x average year

Deltares

Results – Stream discharge during dry years

- Location of timeseries: relative hilly sandy area
- Stream discharge drops in first dry year below the 95-percentile
- No full recovery of stream discharge in the winter between the two dry years
- Stream discharge in second dry year lower than in first dry year.



Modeled stream discharge of the two dry years, compared with the longyearly average (1988-2017) stream discharge.

Dry | Dry | Average | Average | Average | Average | Average | Average | Average | Average | Average | Average

Modelled years: 2x dry year, 10x average year

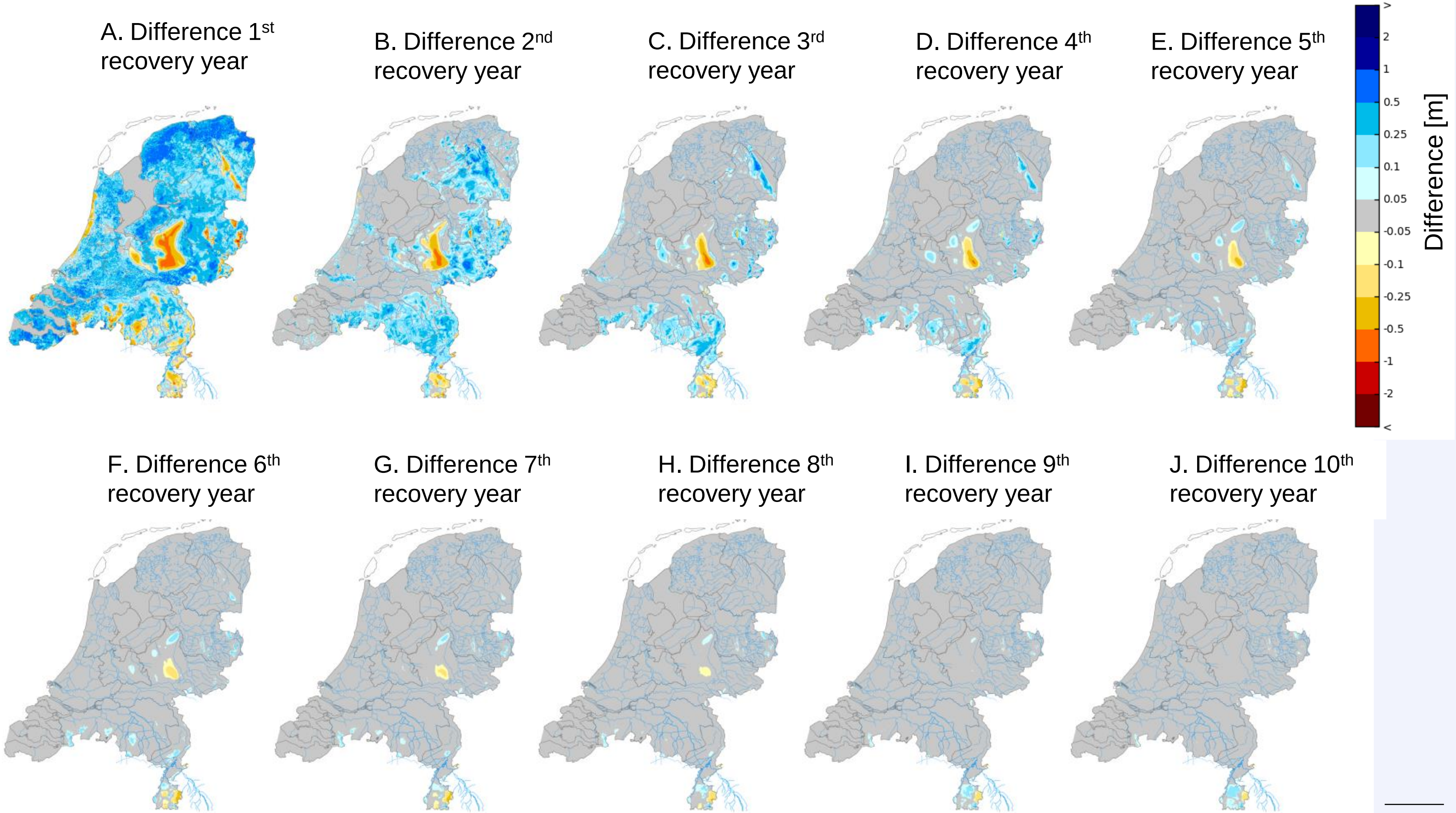
Deltares

Results – spatial variation of recovery

- In the first recovery year, groundwater levels rises in most areas. Yet in the relative high areas, the groundwater level still drops (fig. A)
- In the relative high areas, recovery of groundwater heads starts after one ‘average’ year.
- In the low-lying western part of the Netherlands, groundwater heads are fully recovered after one ‘average’ year.
- In the relative high areas, groundwater heads are fully recovered after 3-8 years.

Difference in summer groundwater heads with previous year

Blue: higher groundwater levels, red: lower groundwater levels



Modelled years: 2x dry year, 10x average year

Deltares

Conclusions

The model results showed:

- For the higher sandy areas, groundwater levels and stream discharges were even lower in the second than in the first dry year.
- There is a large spatial variation in groundwater level recovery. In the first recovery year groundwater levels increased for most of the area, except for the higher-lying sandy areas lacking any surface waters (ditches and streams), like the largest Dutch forest area, the Veluwe.
- For the central part of the Veluwe, this dropping continues until the seventh recovery year.
- Two consecutive dry years have a large impact on the water system, and full recovery of groundwater levels and stream discharges may take 2 to 4 years in most of the sandy areas, yet the recovery of the highest parts may take up to 7 to 8 years.

Contact

janneke.pouwels@deltares.nl