

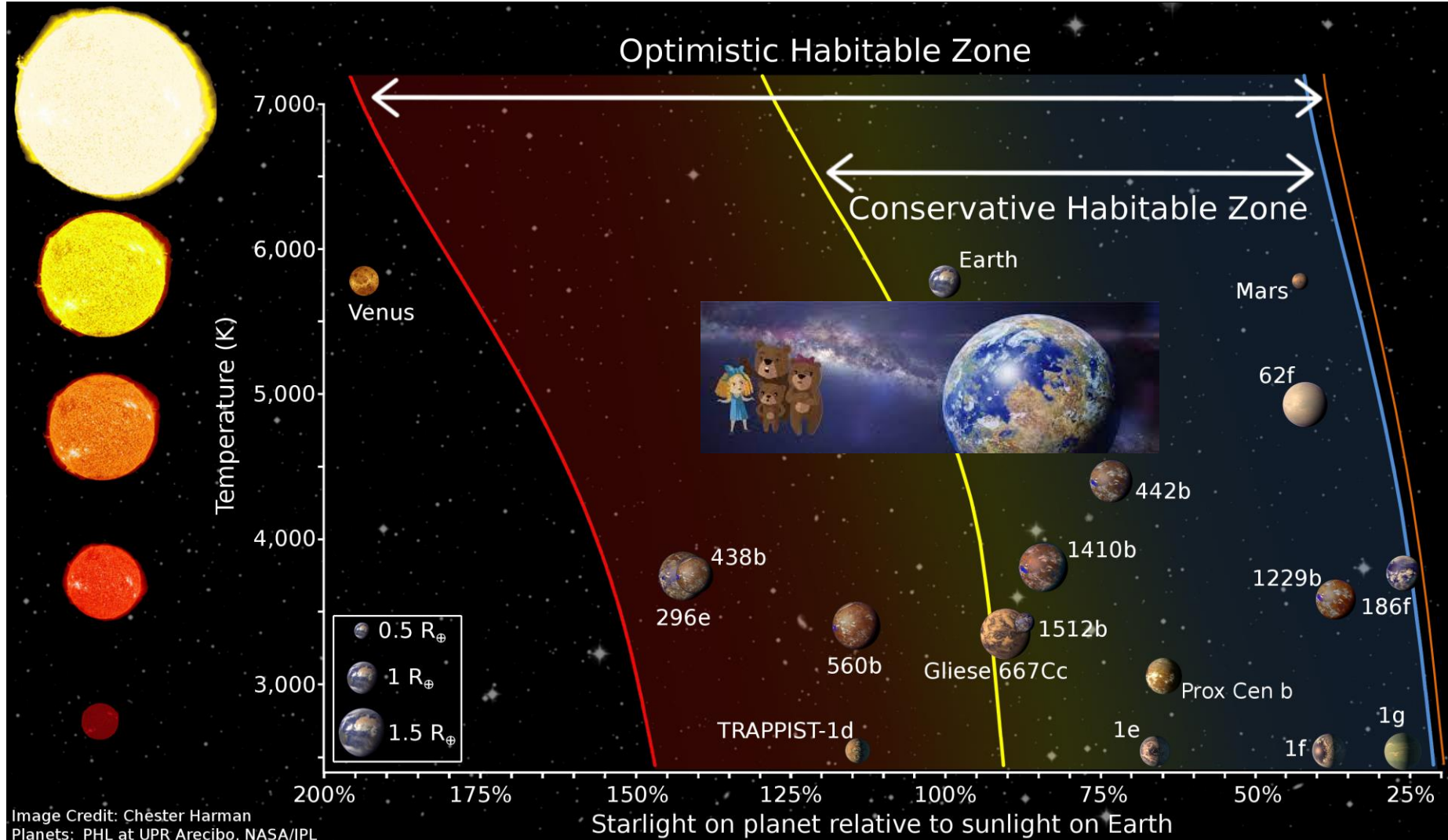
Goudlokje en de drie dijken (Van normeren naar risicobenadering)

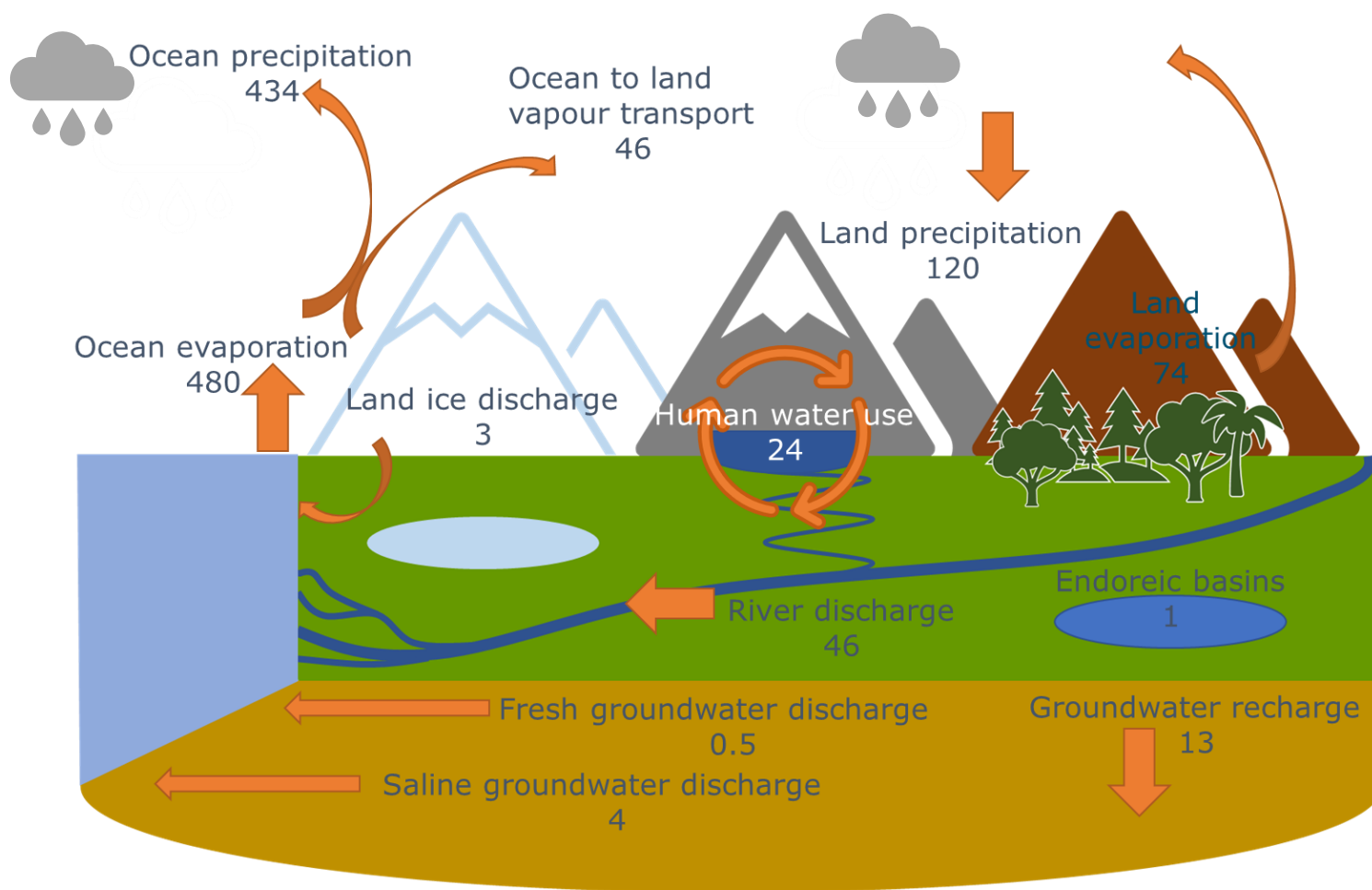
Hydrologie en Omgevingshydraulica

13 Juni, Martine van der Ploeg



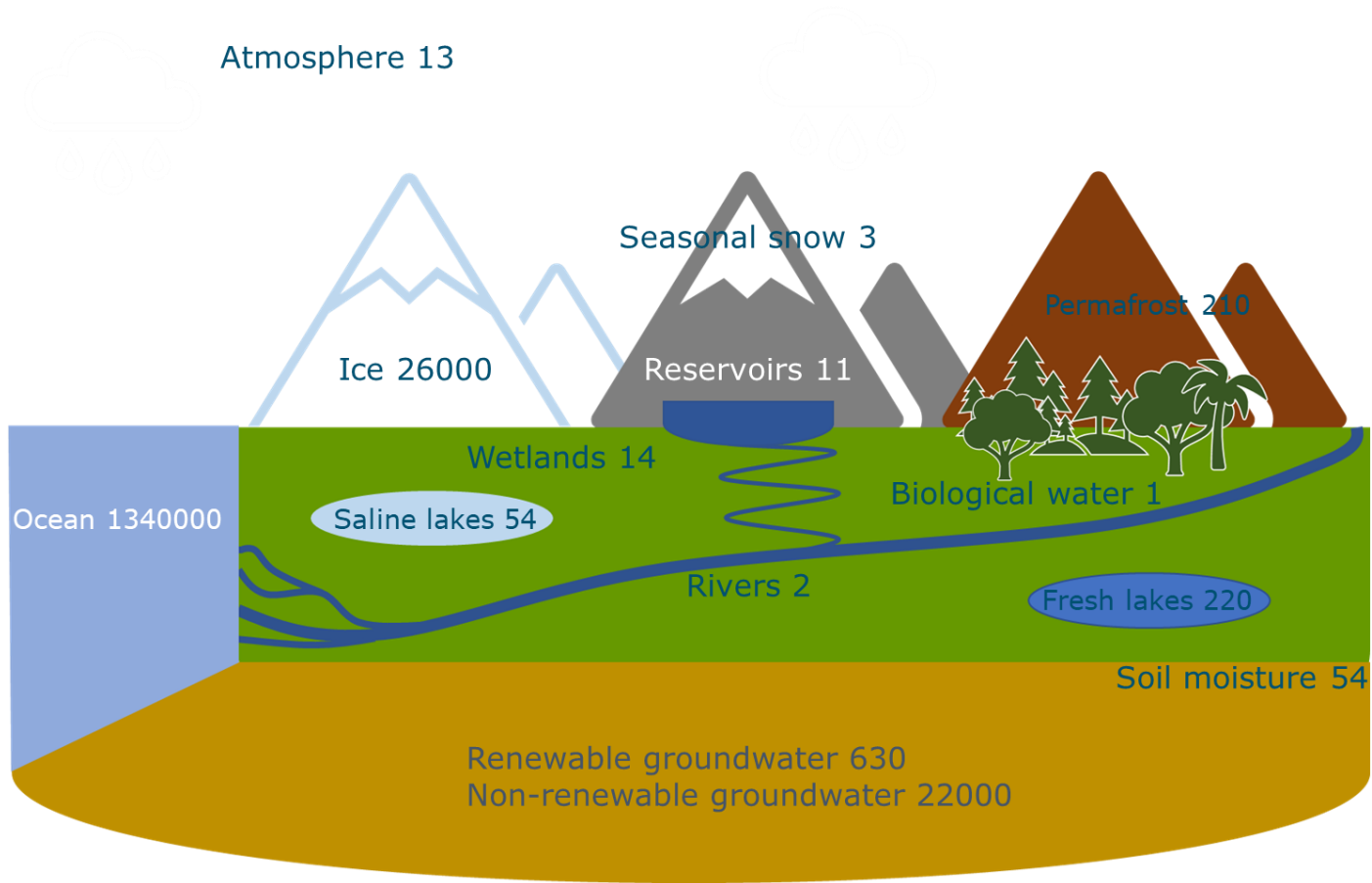






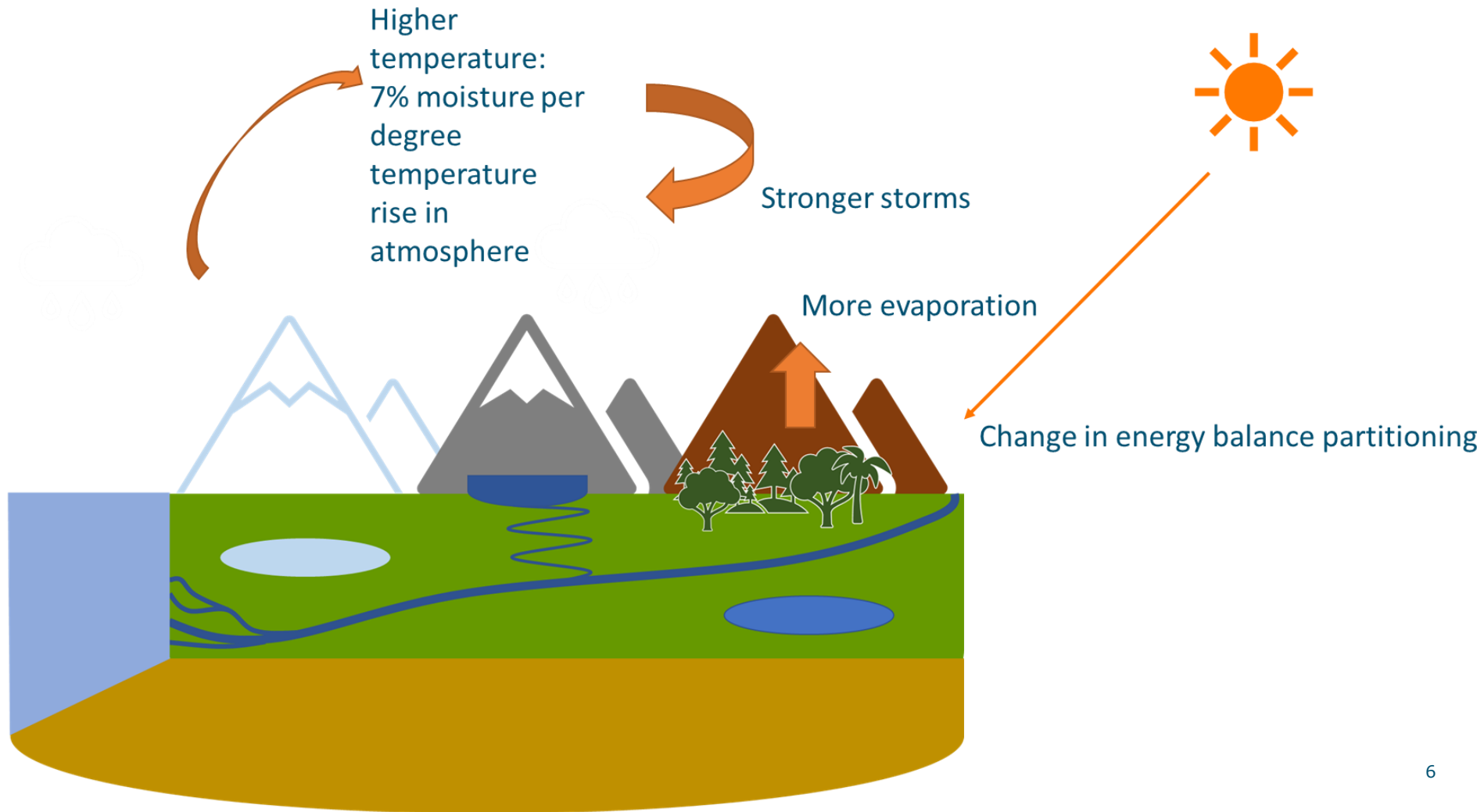
Hydrological cycle – fluxes ($10^3 \text{ km}^3 \text{ year}^{-1}$)

based on Allan et al. 2020/IPCC 2022



Hydrological cycle – storage (10^3 km^3)

based on Allan et al. 2020/IPCC 2022





Extreme heat in North America, Europe and China in July 2023 made much more likely by climate change

Following a record hot June, large areas of the US and Mexico, Southern Europe and China experienced extreme heat in July 2023, breaking many local high temperature records.

Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change



From the 12th to the 15th of July, heavy rainfall associated with cut-off low-pressure system “Bernd” led to severe flooding particularly in the German states North Rhine-Westphalia and Rhineland-Palatinate, as well as in Luxembourg, and along the river Meuse and some of its tributaries in Belgium and the Netherlands.

23 August, 2021 | **EXTREME RAINFALL** | **EUROPE**

High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely



Western Central Europe, North America, China, and other parts of the Northern Hemisphere faced water shortages, extreme heat, and soil moisture drought conditions throughout the summer of 2022

05 October, 2022 | **DROUGHT** | **EUROPE, NORTH AMERICA, NORTHERN ASIA**

Limited net role for climate change in heavy spring rainfall in Emilia-Romagna



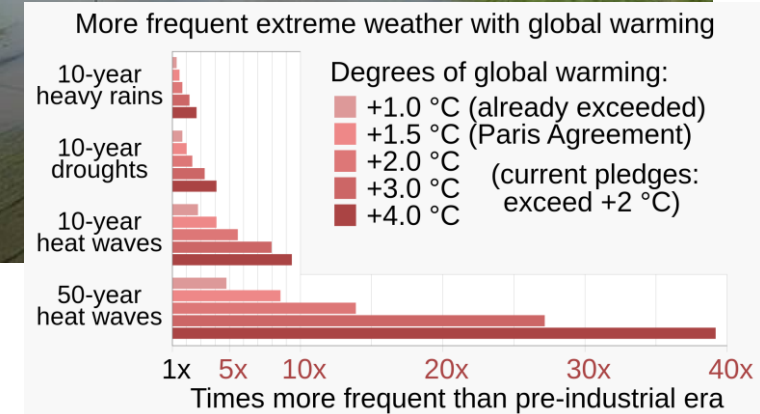
During May 2023, the North Italian region of Emilia-Romagna, particularly the provinces of Bologna, Ravenna, Forli-Cesena, Rimini, experienced severe flooding, following three separate heavy rainfall events on the 2nd, 10th, and 16th of May.

31 May, 2023 | **EXTREME RAINFALL** |

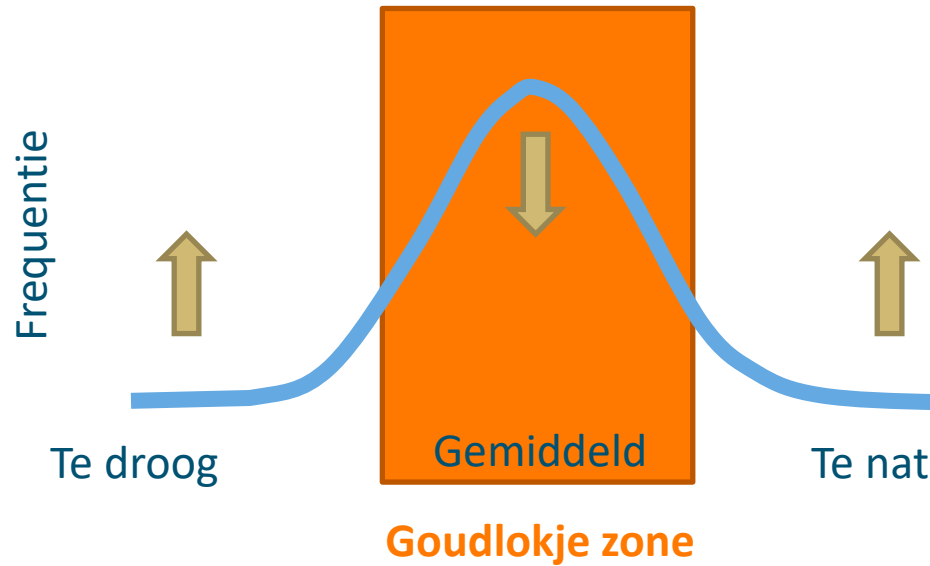
Verwachter veranderingen in de water cyclus



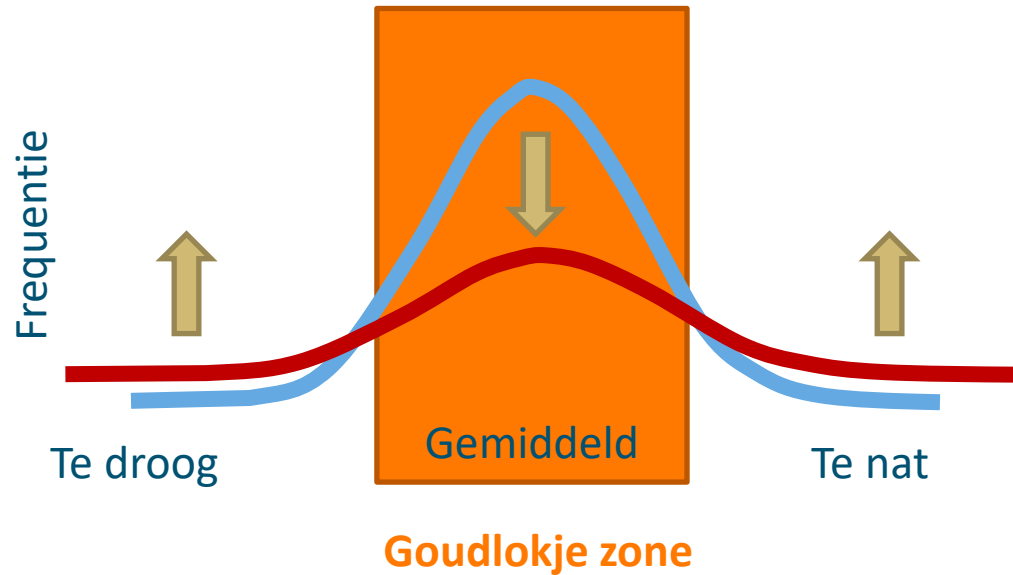
Te Brake, 2011



De water cyclus en de Goudlokje zone



De water cyclus en de Goudlokje zone

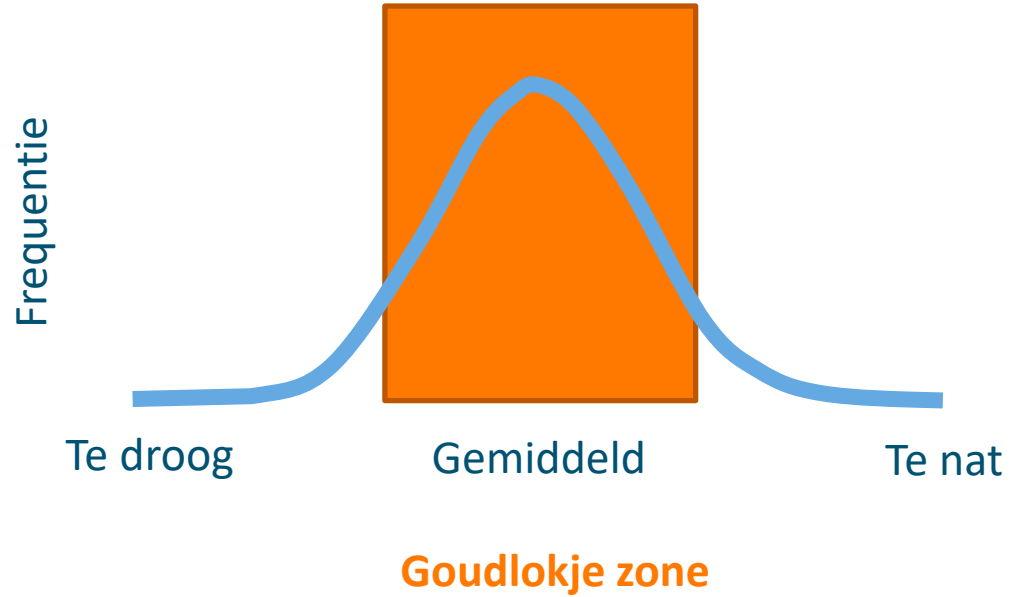
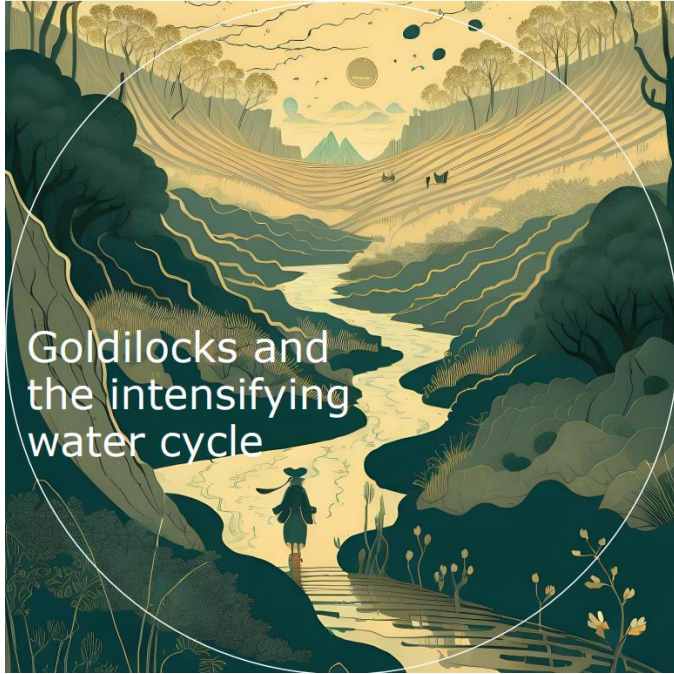


Impact op dijken

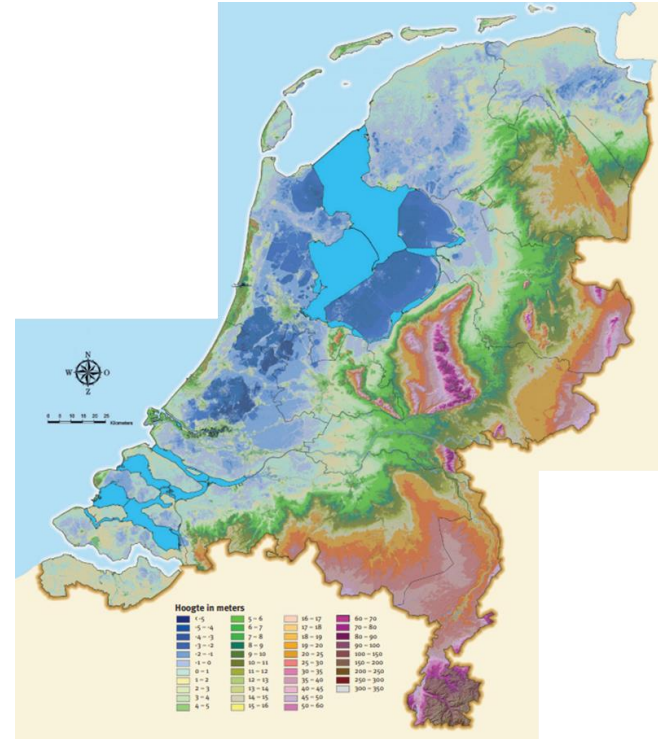
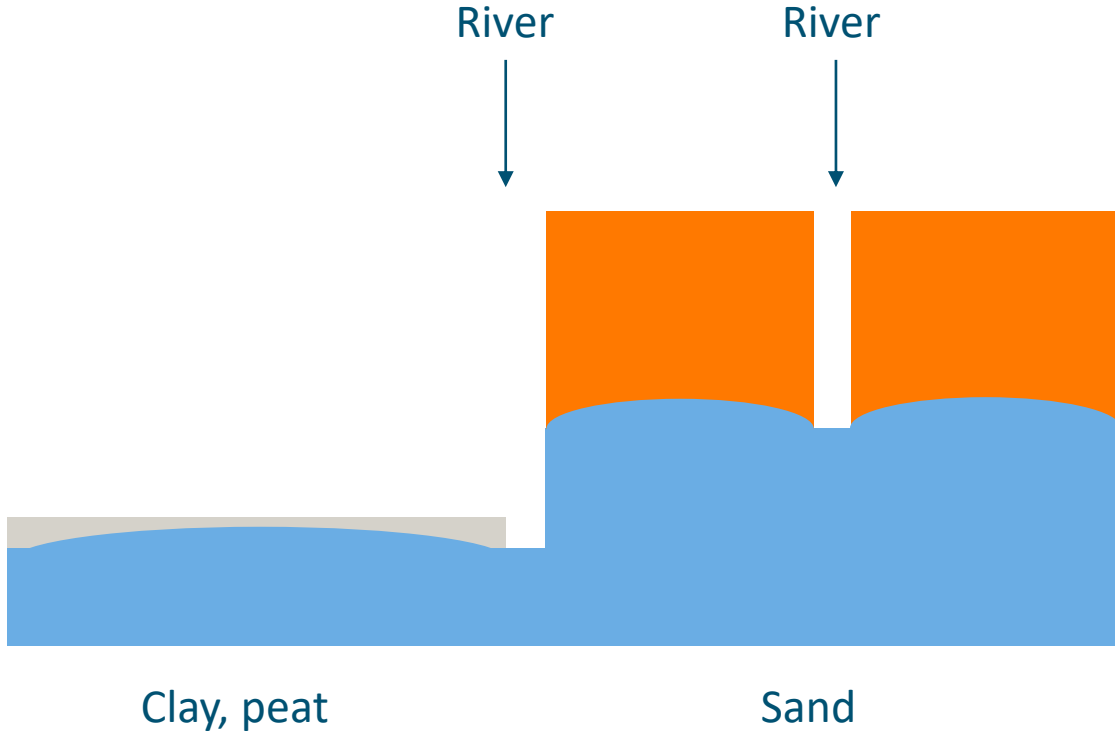


Waterkering
Van Ommerpolder
in 2018

Niek Bosma
Wetterskip Fryslan



Balans in Nederland is een uitdaging

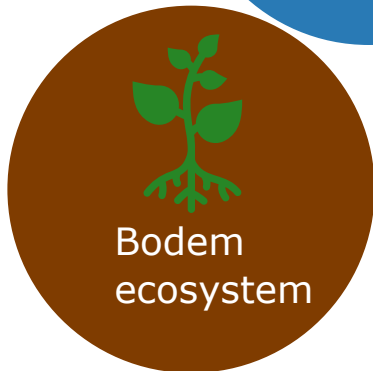
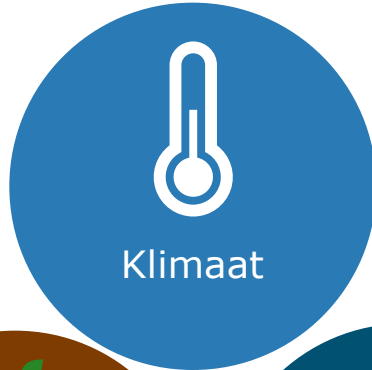


Biofysische landschaps interacties en wereldwijde klimaatverandering

Biofysische interacties

Biofysisch en maatschappij

Benadering



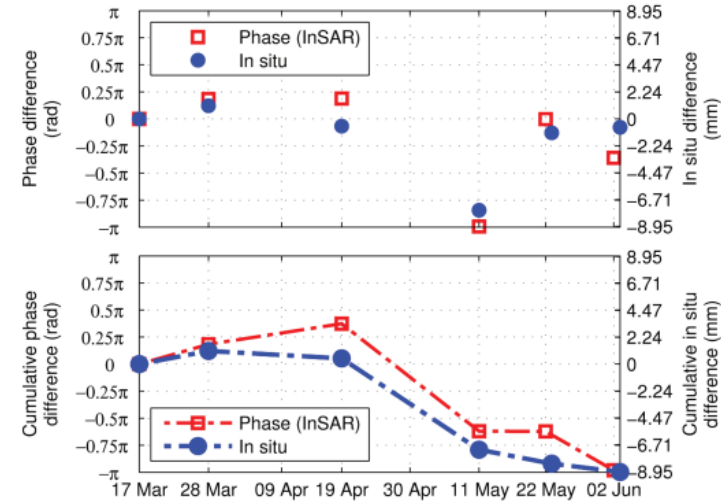
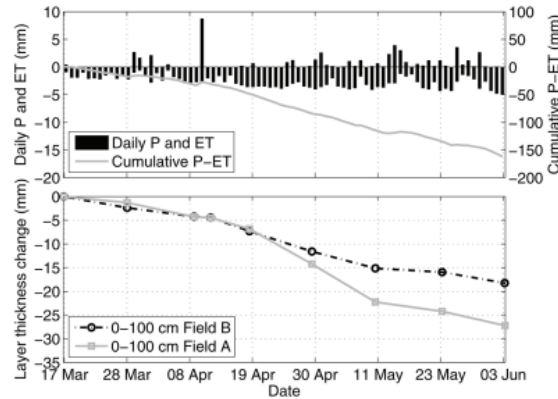
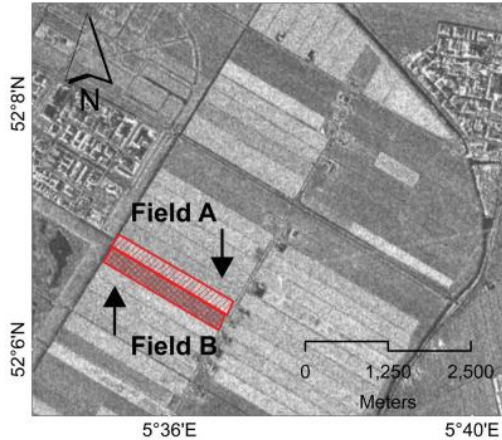
Experimenteel veld & laboratorium

Computer modellen

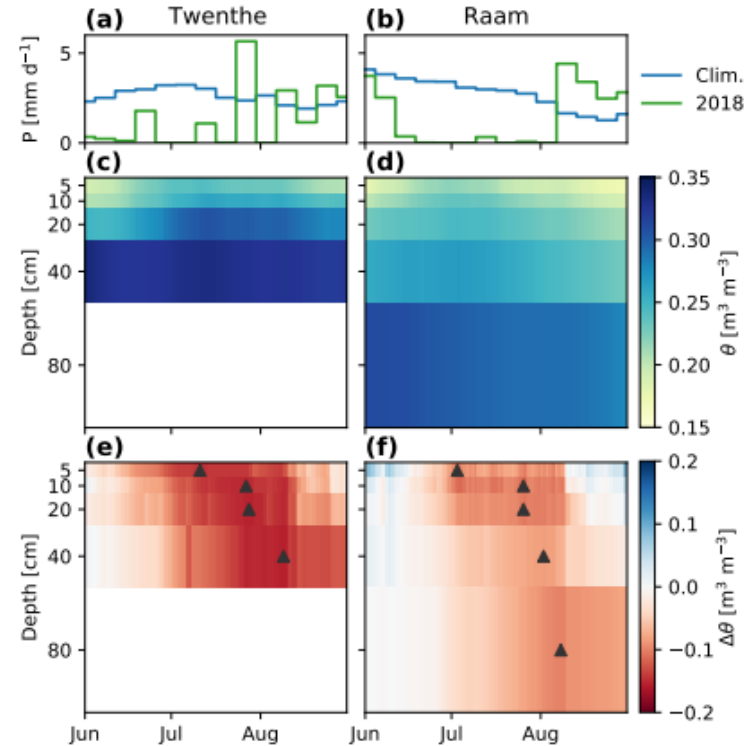
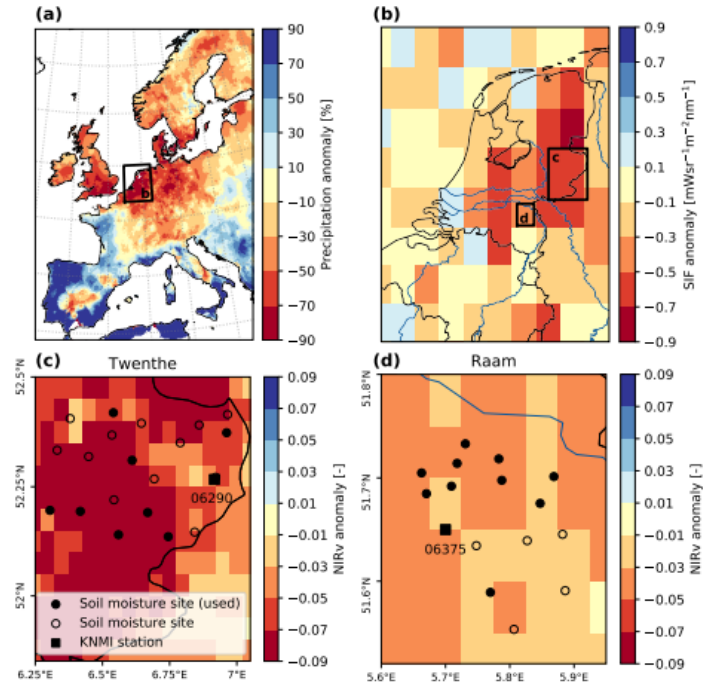
Remote sensing, monitoring

Droogte in observaties

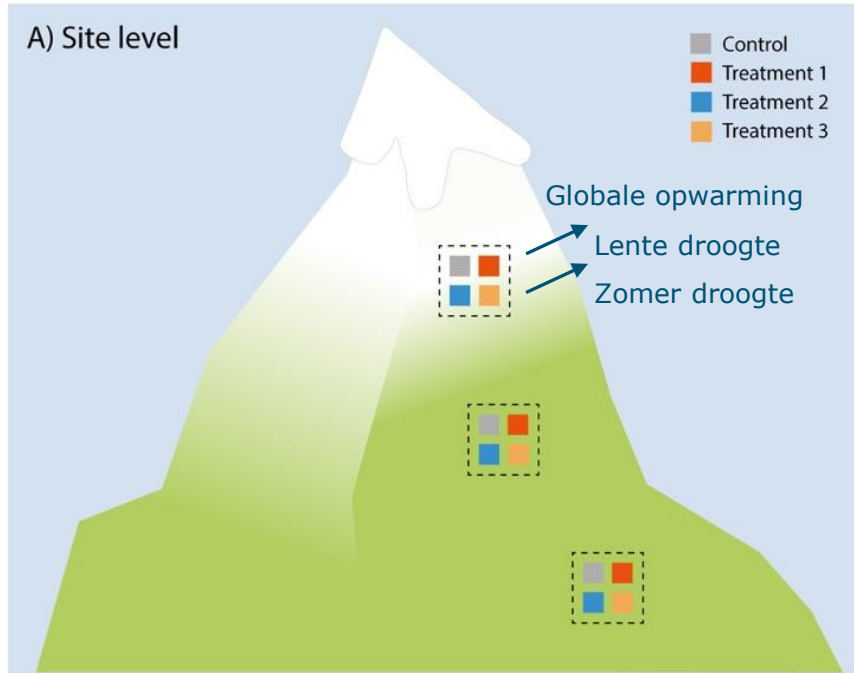
2011 spring drought



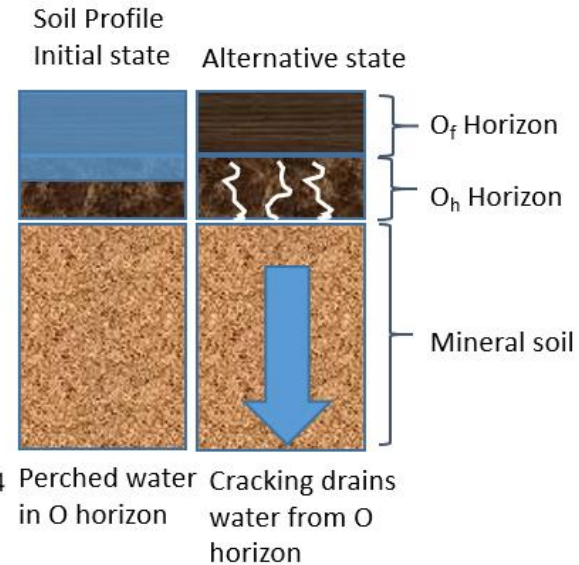
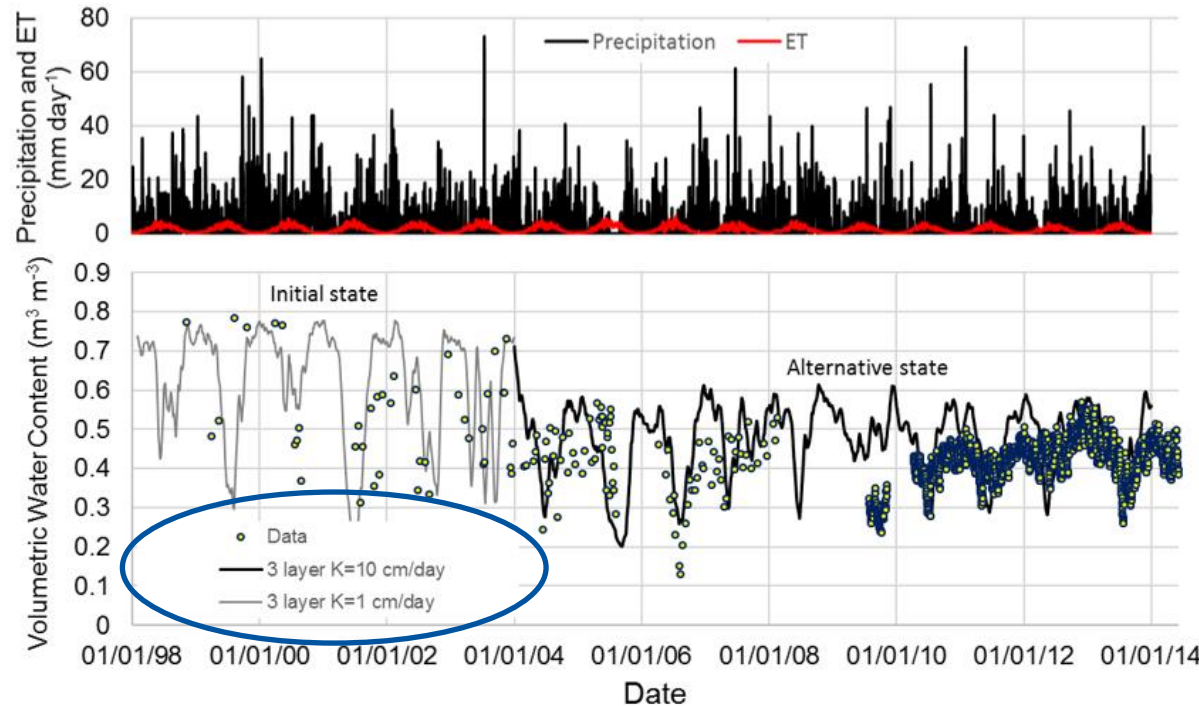
Zomer droogte in 2018



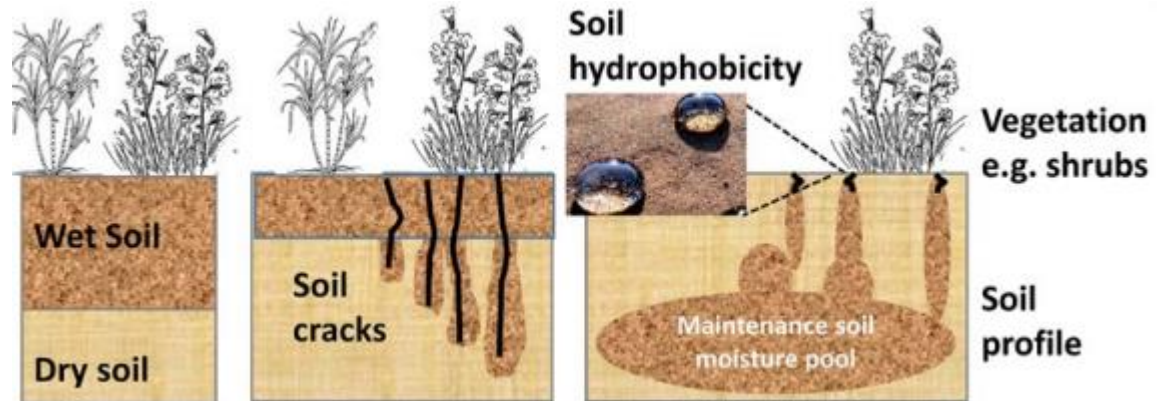
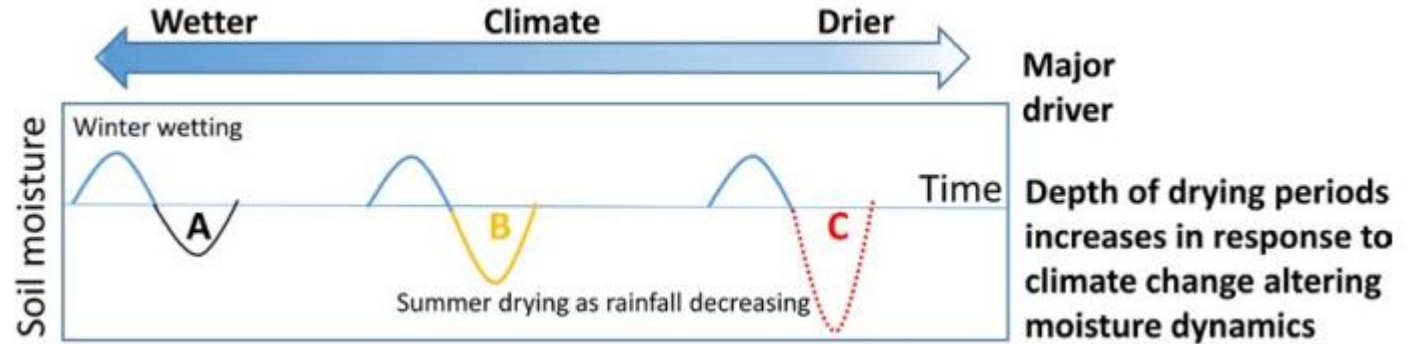
Klimaat manipulatie experimenten



Toen het echt heel droog werd...



Impact van veranderingen in nat-droogte cycli



Structuurvorming: fysisch

Klei krimp/zwel gedrag gerelateerd aan bodemvocht

$R=3$; isotrope krimp

$R(\theta)$; niet-isotrope krimp

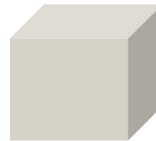
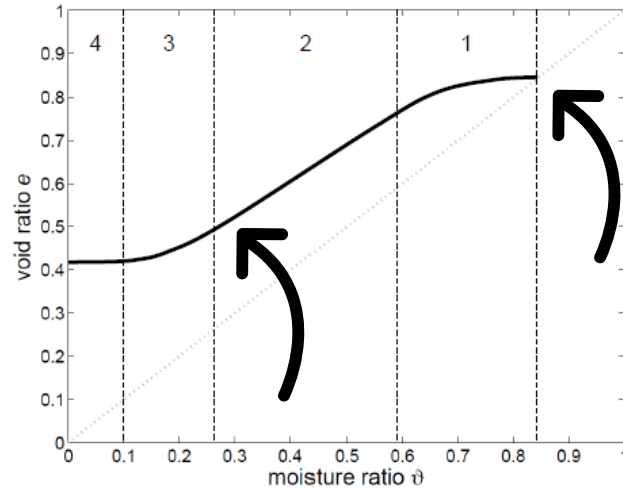
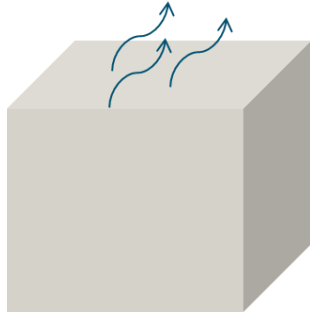
$1 < R < 3$ verticale krimp, geen scheuren

$R > 3$ wel scheuren

$$\Delta V = \left[1 - \left(1 - \frac{\Delta z}{z} \right)^{r_s} \right] z$$



Krimpfasen



1. Structurele krimp
2. Basis krimp
3. Rest krimp
4. Geen krimp

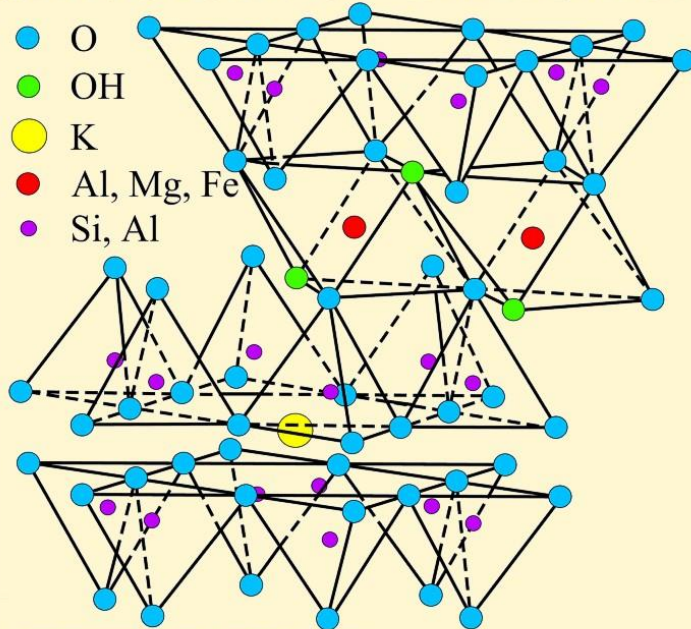
Kleimineralogie

- Massa % kleimineralen in de lutumfractie ($<2\ \mu\text{m}$; zonder humus en CaCO_3)

	kaolinet	illiet	vermiculiet	smectiet	chloriet
Rivierklei Rijn	5 - 10	35 - 40	10 - 20	10 - 15	5 - 10
Zeeklei zoet Zuid Holland	5 - 10	35 - 40	10 - 20	10 - 15	5 - 10
Zeeklei Friesland/Groningen	5 - 10	30 - 40	< 5	30 - 40	< 5

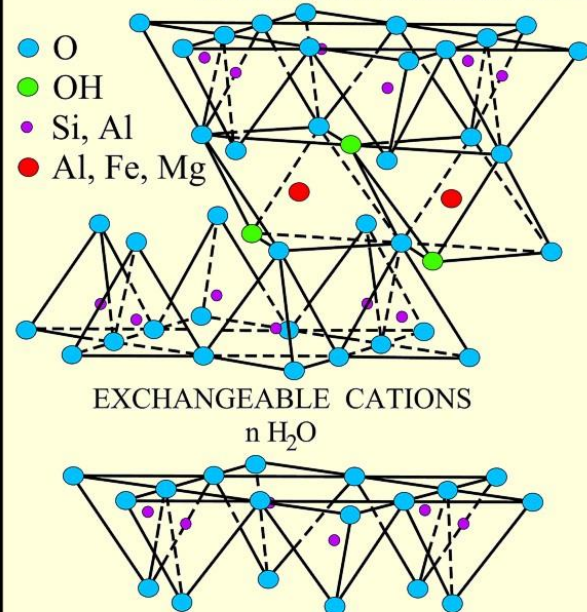
- Vermiculiet en smectiet zijn zwellende/krimpene kleimineralen
 - In Friesland/Groningen is $\sim 35\%$ van de klei zwellend/krimpene

STRUCTURE OF ILLITE/MICA



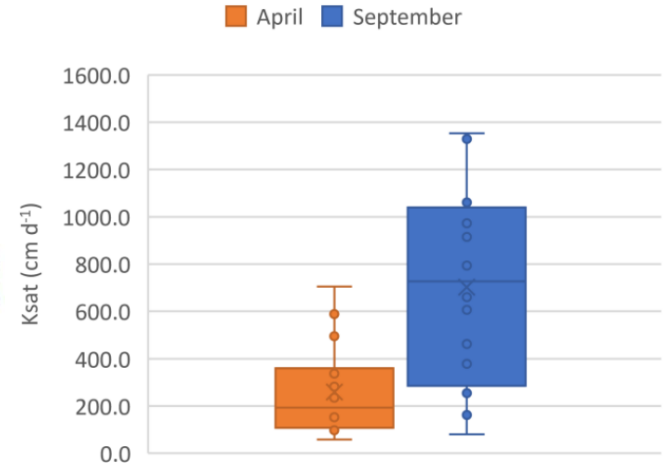
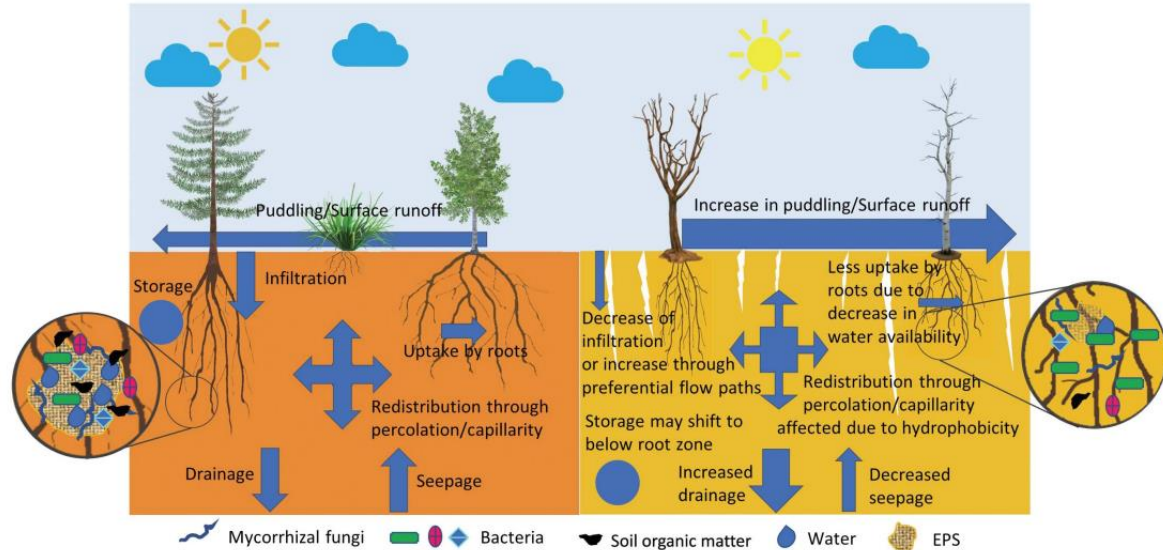
MODIFIED FROM GRIM (1962)

STRUCTURE OF MONTMORILLONITE



MODIFIED FROM GRIM (1962)

Impact droogte verdeling neerslag/infiltratie



Coban et al., DOI: 10.1126/science.abe0725

Gras op dekzand, Wageningen
Voor en na zomer droogte in 2022

We bevorderen fundamenteel begrip en voorspelling van hydrologische processen in rivieren, aquifers en delta's om het waterbeheer te ondersteunen.

atmospheric moisture
over ocean

transport of moisture
from ocean to land

precipitation over land

precipitation
over ocean

ocean
evaporation

ocean
circulation

ocean
mixed zone

ocean
deep water zone

groundwater
discharge to ocean

lakes
saline

evapotranspiration

wetlands
fresh

rivers

municipal
water use

industrial
water use

streamflow
to ocean

groundwater

soil moisture

grazing
water use

agricultural
water use

reservoirs

snowpack

snowmelt

ice sheets
and glaciers

precipitation over land

permafrost

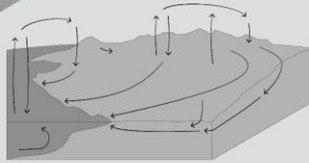
groundwater
recharge

groundwater

Novel modelling approaches and
uncertainty in hydrology

USGS

General
overview of
how water
moves



Dank voor jullie aandacht!

Martine.vanderPloeg@wur.nl

