Chesapeake Hypoxia Analysis and Modeling Program (CHAMP)
June 23-25, 2021

Potential impacts of climate change on nitrogen loading to the Chesapeake Bay under the high (RCP8.5) climate warming scenario: Results from a process-based modeling study (DLEM)

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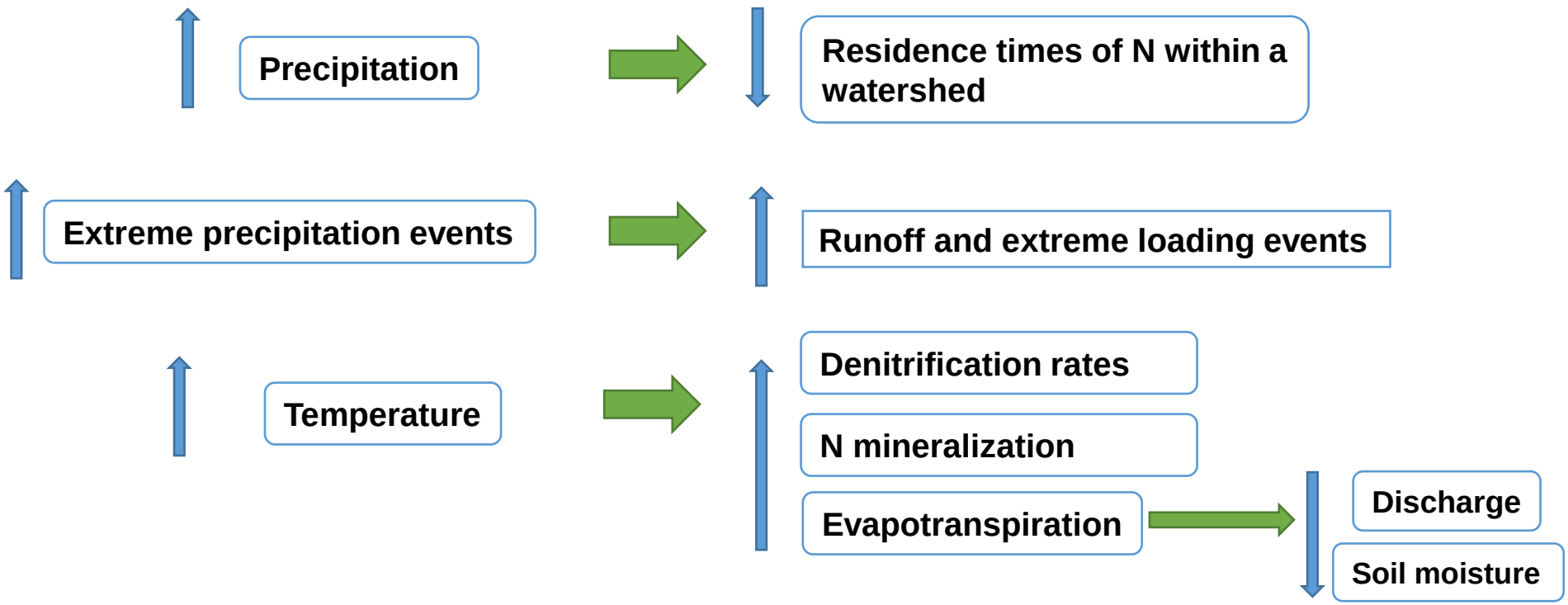
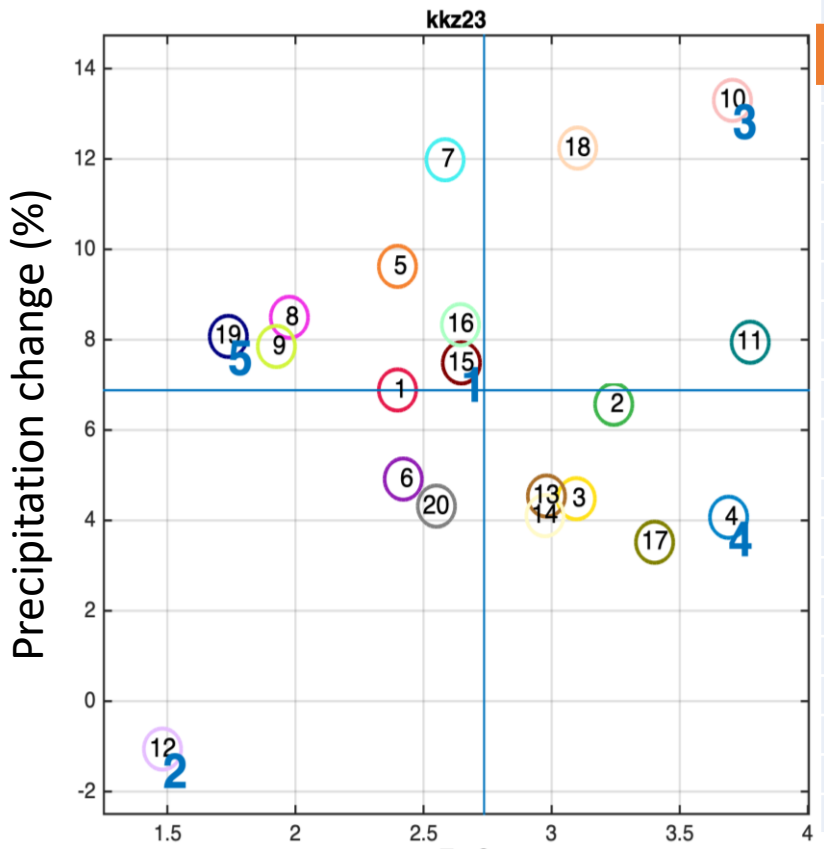
Introduction — The impacts of climate on N & water cycles



Chesapeake Bay Watershed

Climate data — GCM ranks



KKZ Rank	Model ID	Model Nama	Model origin
1	m15	IPSL-CM5B-LR	France
2	m12	inmcm4	Russia
3	m10	HadGEM2-CC365	UK
4	m4	CanESM2	Canada
5	m19	MRI-CGCM3	Japan
6	m07	CSIRO-Mk3-6-0	Australia
7	m11	HadGEM2-ES365	UK
8	m14	IPSL-CM5A-MR	France
9	m02	bcc-csm1-1-m	China
10	m06	CNRM-CM5	France
11	m18	MIROC-ESM-CHEM	Japan
12	m05	CCSM4	USA – NCAR
13	m17	MIROC-ESM	Japan
14	m01	bcc-csm1-1	China
15	m08	GFDL-ESM2G	USA
16	m20	NorESM1-M	Norway
17	m16	MIROC5	Japan
18	m03	BNU-ESM	China
19	m09	GFDL-ESM2M	USA
20	m13	IPSL-CM5A-LR	France

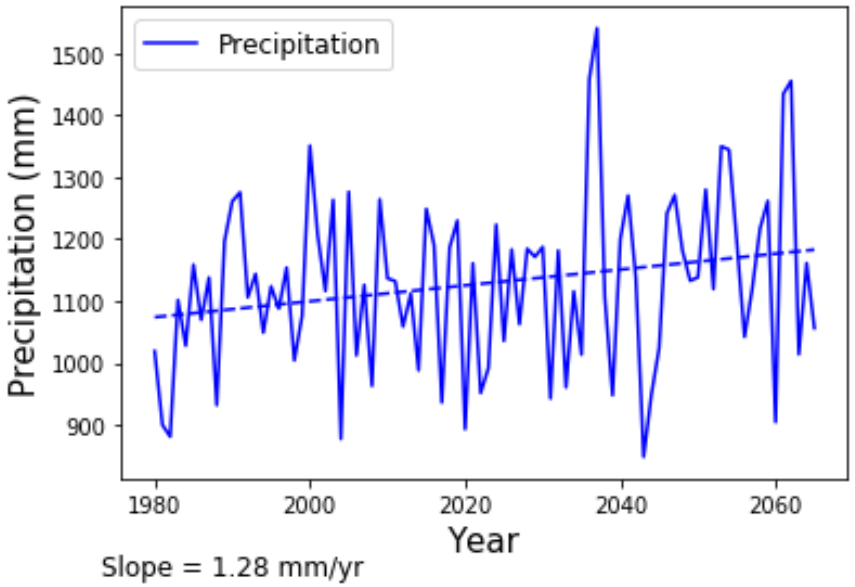
RCP8.5

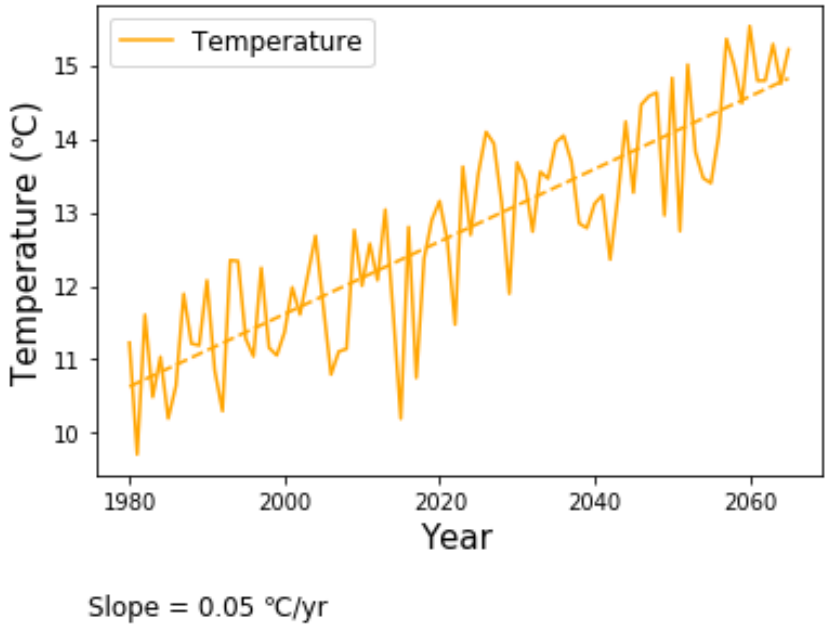
From Maria Herrmann and Raymond Najjar

Climate data — Interannual variation

15 IPSL-CM5B-LR (France)

Based on daily data during 1980-2065

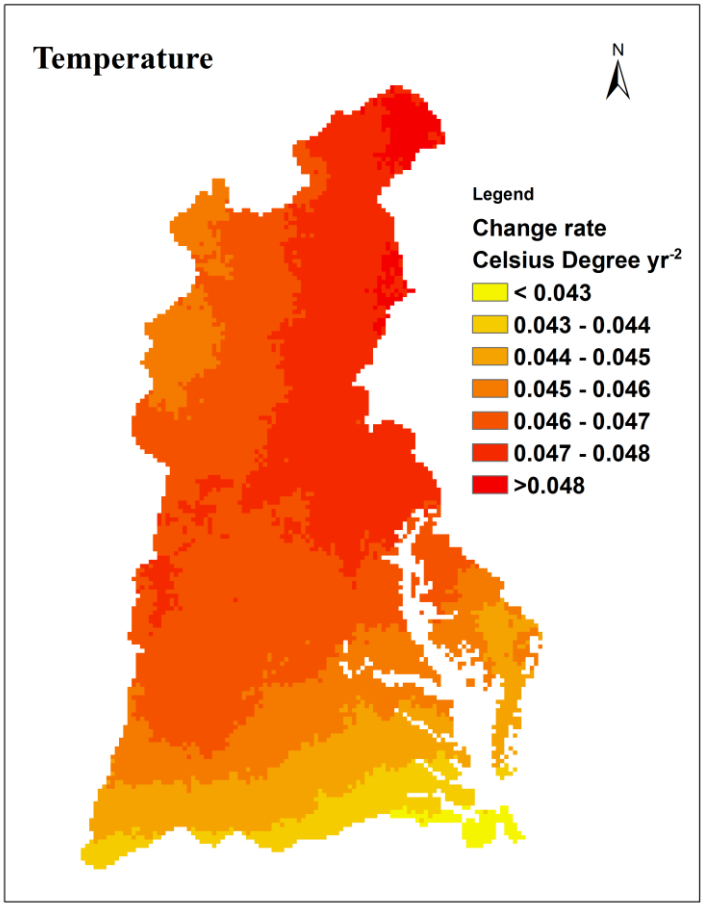


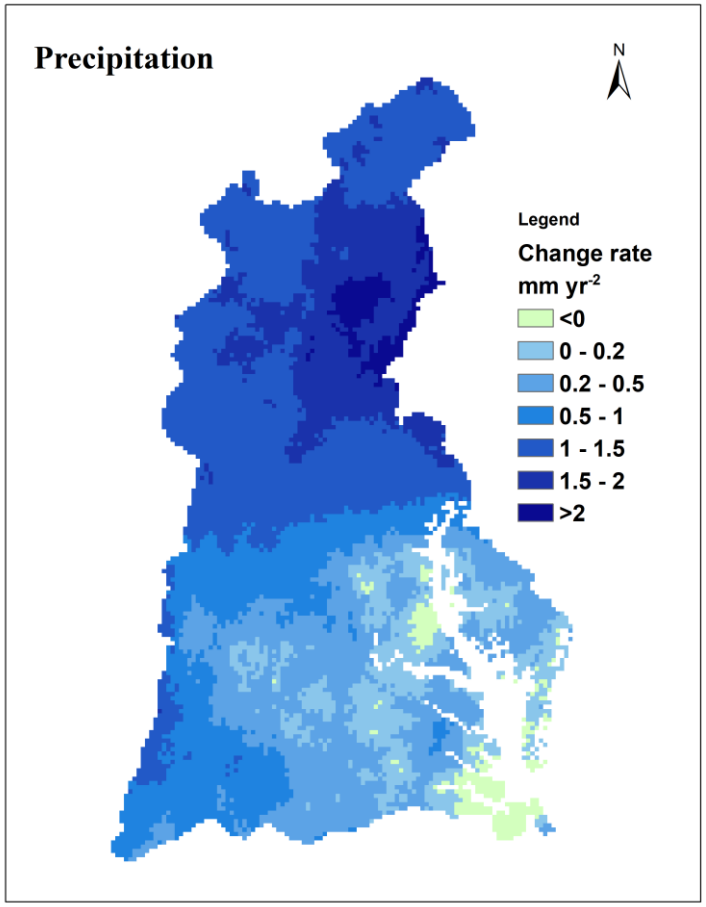


Precipitation and temperature at odds in terms of their impact on N yield

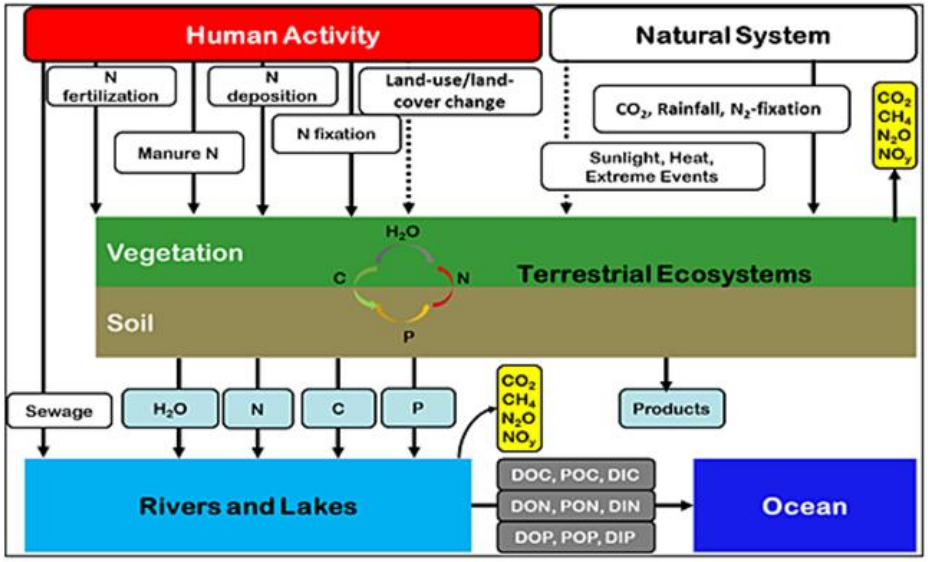
Climate data — Spatial patterns of change rates

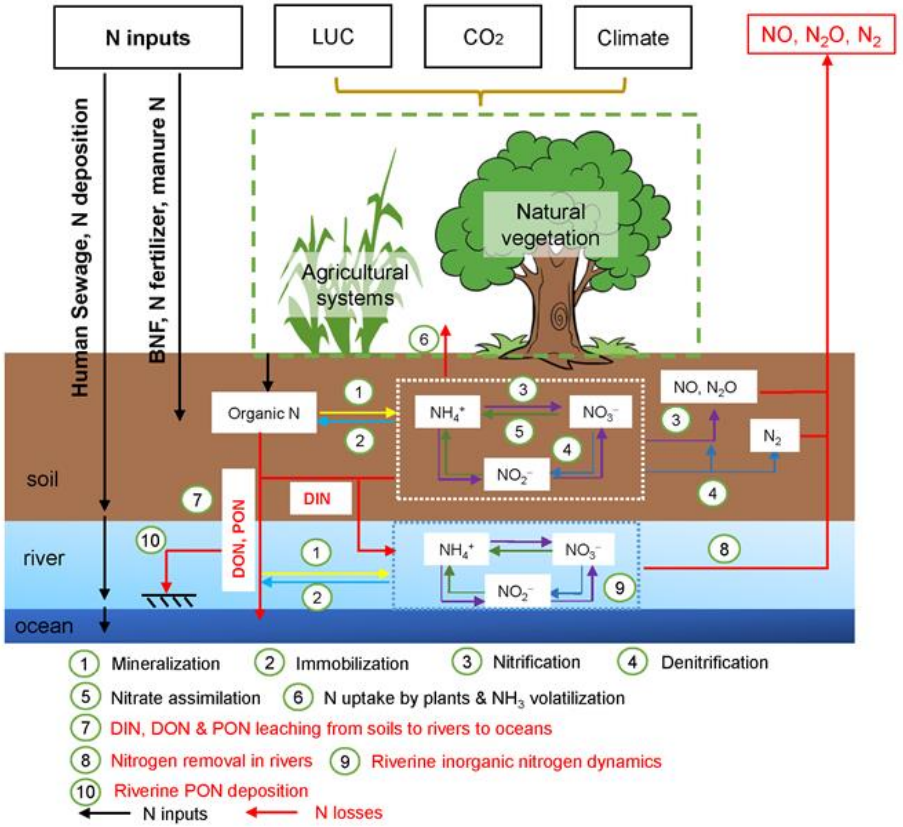
Annual change rates of temperature and precipitation during 1980-2065





Model — DLEM


Human Activity
Natural System
N fertilization
N deposition
Land-use/land-cover change
Manure N
N fixation
CO_2, Rainfall, N_2-fixation
Sunlight, Heat, Extreme Events
CO_2 CH_4 N_2O NO_y
Vegetation
Soil
Terrestrial Ecosystems
H_2O
C
N
P
Sewage
H_2O
N
C
P
CO_2 CH_4 N_2O NO_y
Products
Rivers and Lakes
DOC, POC, DIC
DON, PON, DIN
DOP, POP, DIP
Ocean

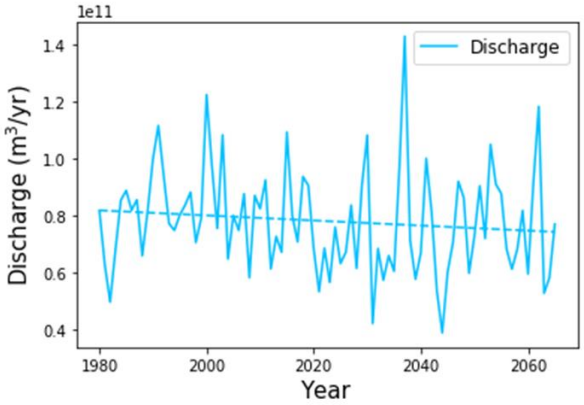

N inputs
LUC
CO_2
Climate
NO, N_2O, N_2
Human Sewage, N deposition
BNF, N fertilizer, manure N
Agricultural systems
Natural vegetation
soil
river
ocean
Organic N
NH_4^+
NO_3^-
NO_2^-
NO, N_2O
N_2
DIN
DON, PON
1 Mineralization
2 Immobilization
3 Nitrification
4 Denitrification
5 Nitrate assimilation
6 N uptake by plants & NH_3 volatilization
7 DIN, DON & PON leaching from soils to rivers to oceans
8 Nitrogen removal in rivers
9 Riverine inorganic nitrogen dynamics
10 Riverine PON deposition
N inputs
N losses

Model — Simulation experiment

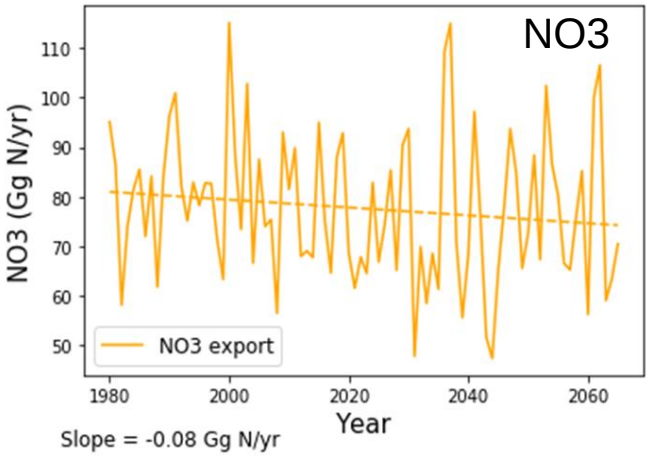
Experiments	Climate	CO_2	atm. N deposition	N manure	Land-use	N fertilizer	Sewage
Historical run and spin up	1900-1980	1900-1980	1900-1980	1900-1980	1900-1980	1900-1980	1900-1980
Analysis Period	1981-2065	1980	1980	1980	1980	1980	1980

Results — Interannual variations of discharge & N loading

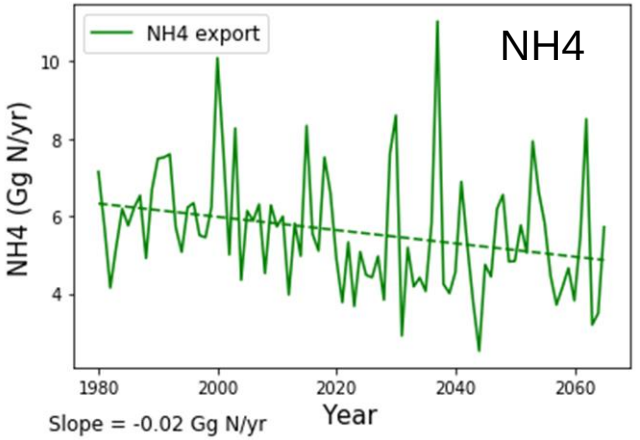
Discharge



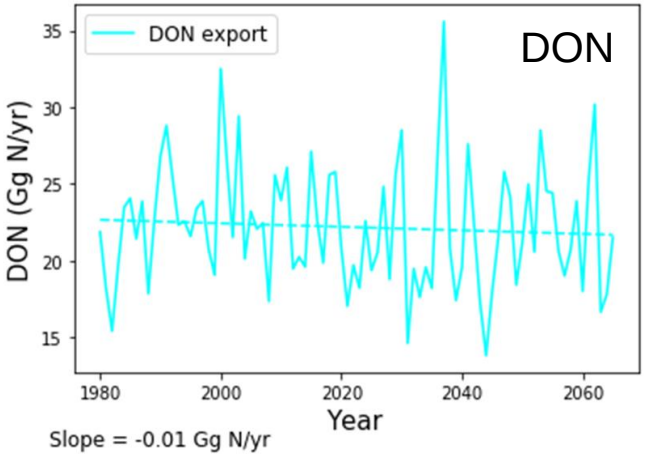
Slope = -88941389.69 m³/yr



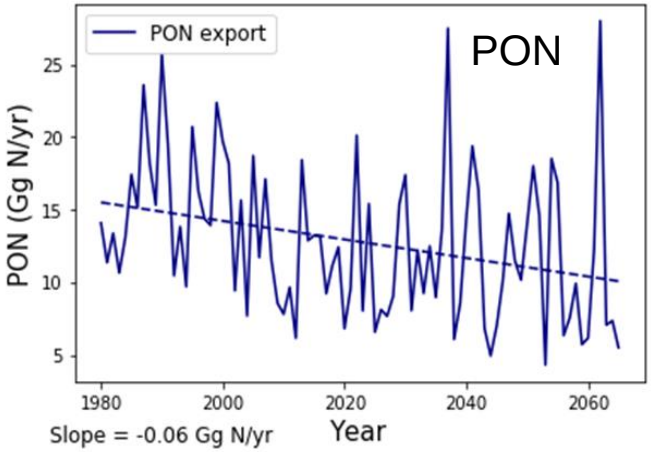
Slope = -0.08 Gg N/yr



Slope = -0.02 Gg N/yr

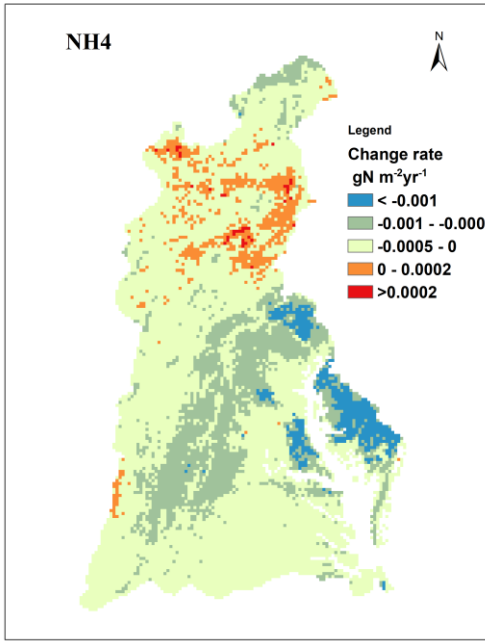


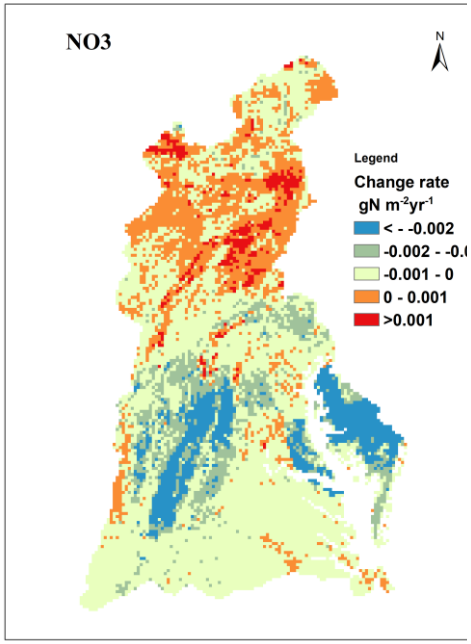
Slope = -0.01 Gg N/yr

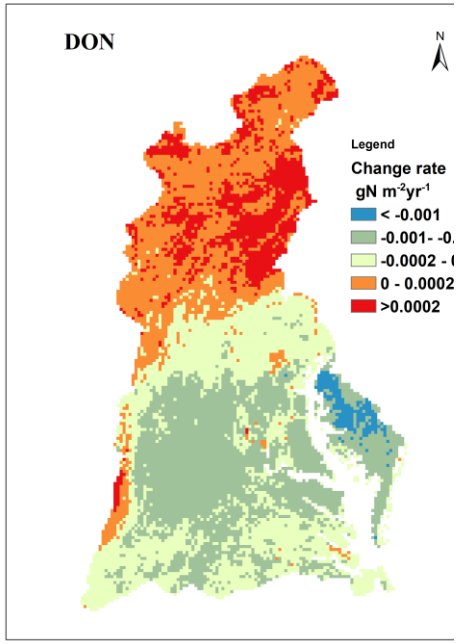


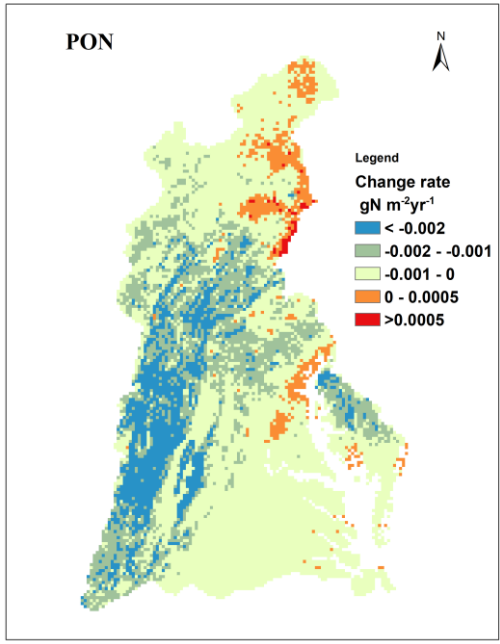
Slope = -0.06 Gg N/yr

Results — Spatial patterns of change rates in N loading

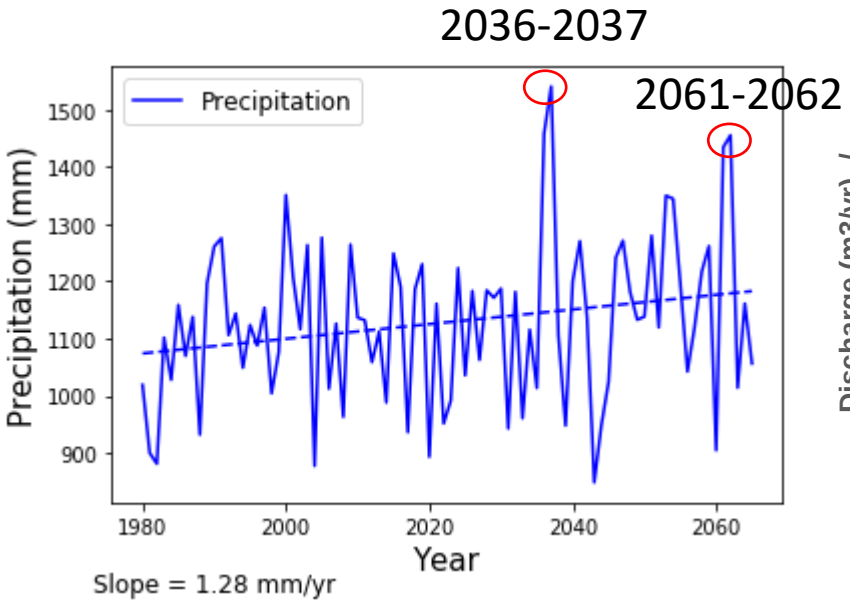


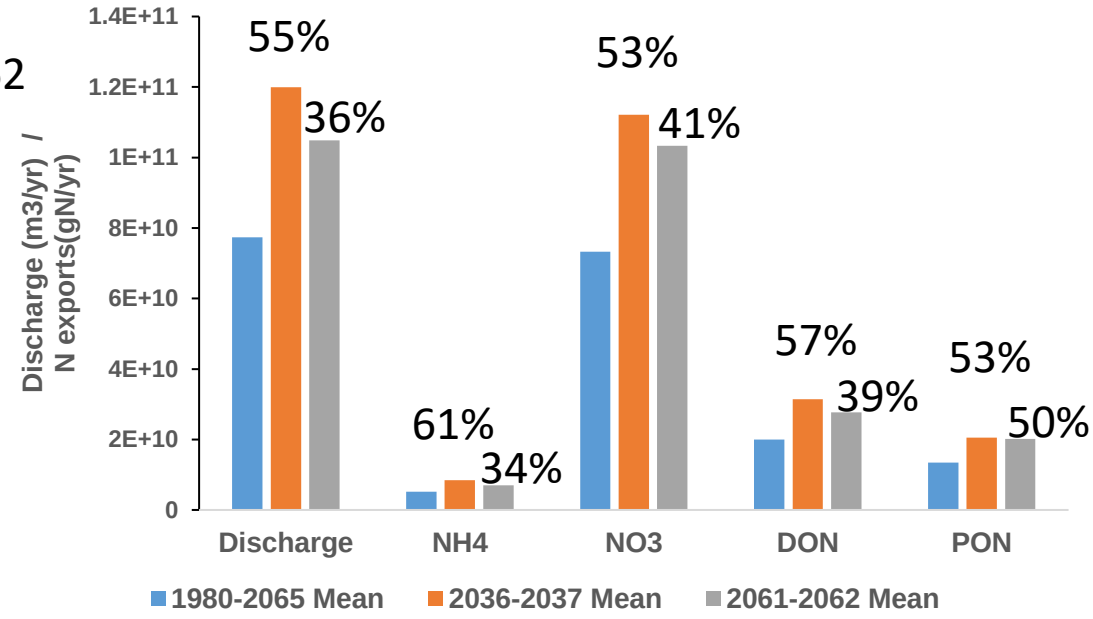






Results — Extreme events





Continuous run with daily MACA VS Delta approach

Difference:

(1) The climate data are developed by different methods

Delta approach: historical climate = observed climate,
future climate = observed climate data + monthly delta.

Continuous run: both historical and future climate data are directly derived from GCM daily data.

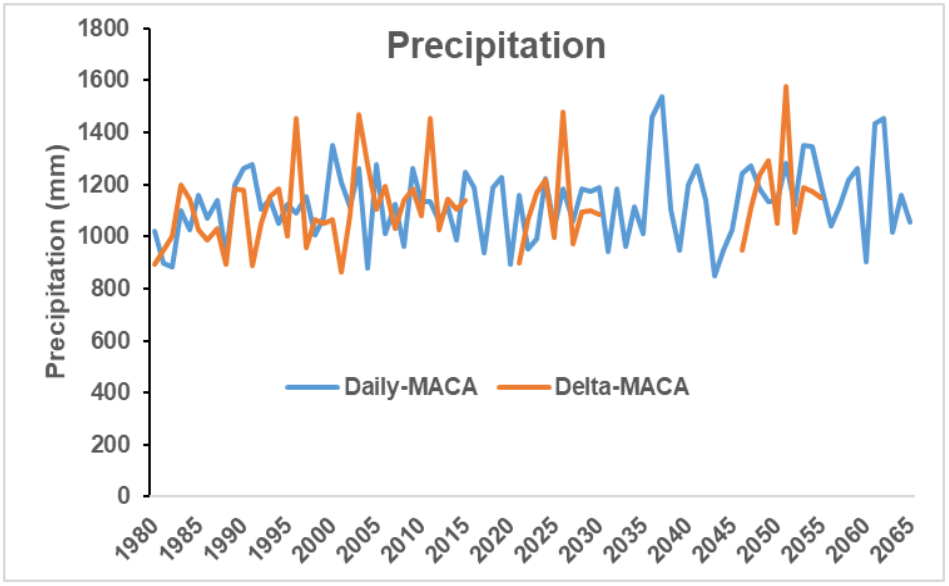
(2) Model simulation methods

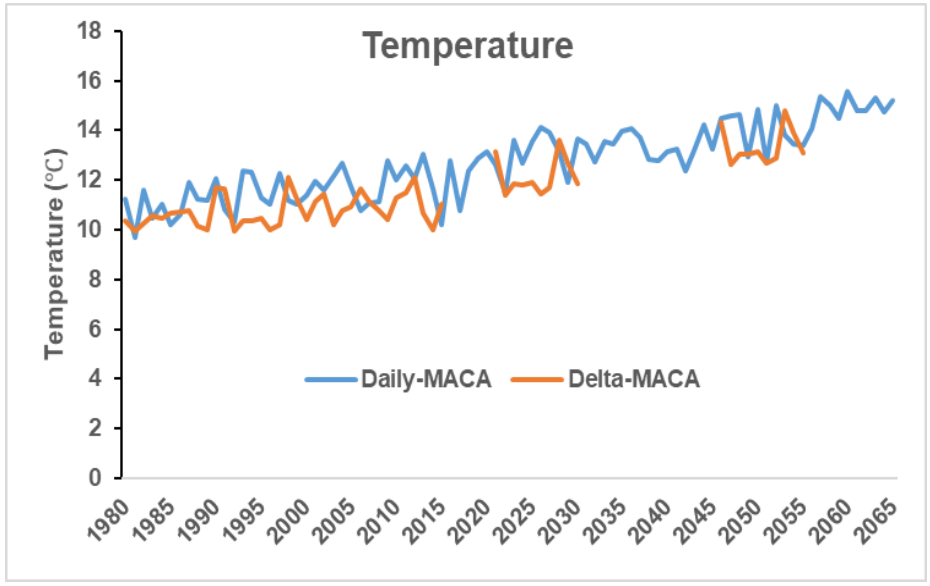
Delta approach: 1991-2000, 2021-2025, 2046-2055.

Continuous run: 1981-2065

Continuous run with daily MACA VS Delta approach

15 IPSL-CM5B-LR (France)





Summary

- Simulated results show substantial year–to-year variations in N loading in response to projected climate change (RCP8.5)
- Extreme precipitation events in the future may largely amplify the nutrient loading from CBW.
- Increasing temperature would enhance the evapotranspiration and further decrease discharge and N loading even though precipitation also may increase in CBW.
- Daily climate data can capture the inter-annual variations of precipitation, especially the peak values, compared with Delta approach.
- Future Plan: Simulations based on more daily MACA GCMs and uncertainties analysis.

Acknowledgements

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Thanks for your attention!

Q&A