Green Central Asia

Enhancing environment, climate and water resilience

Water availability modelling under climate change

Dr. Iulii Didovets, Dr. Anastasia Lobanova
didovets@pik-potsdam.de

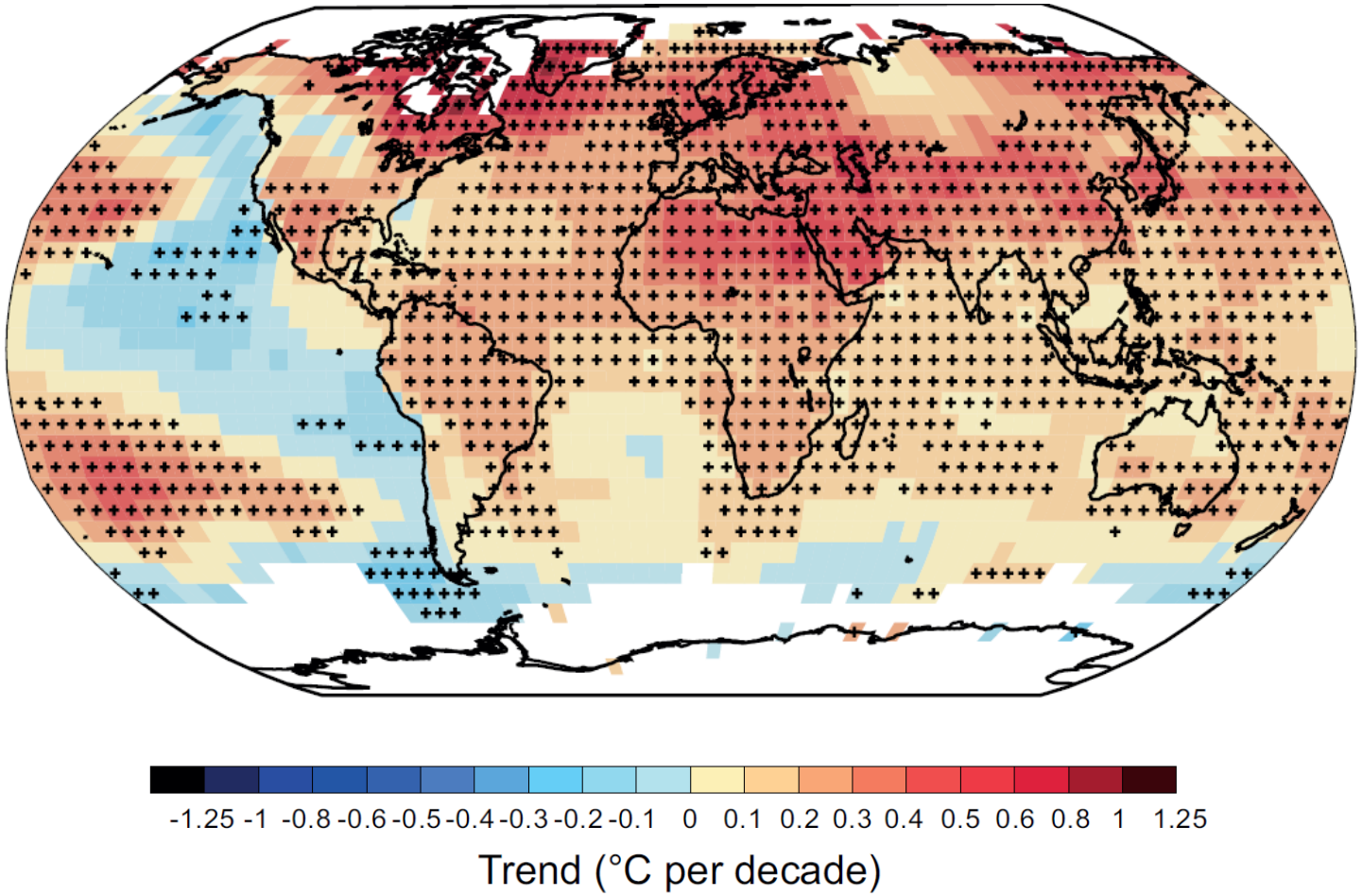
Tashkent Water Security Lectures
10-11 December, 2020
ONLINE

01 | What is going on with our climate?

-

Global and regional trends

Trend in temperature - °C per decade



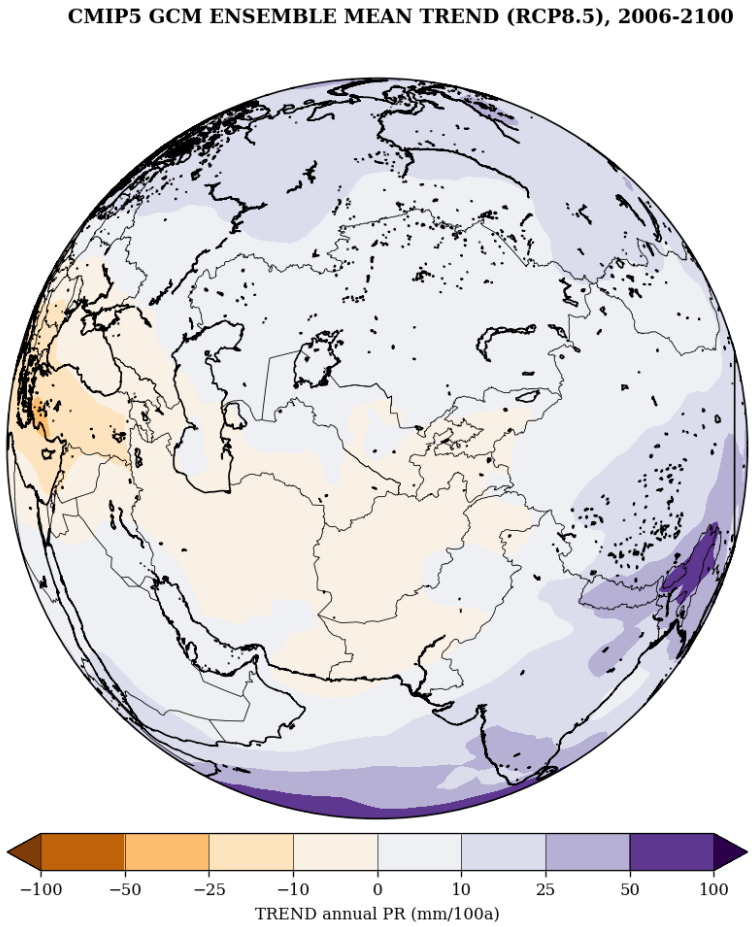
- Overall warming between 1.75 °C to 2.5 °C
- Number of cold days decreased
- Number of hot days increased between 1951-2010

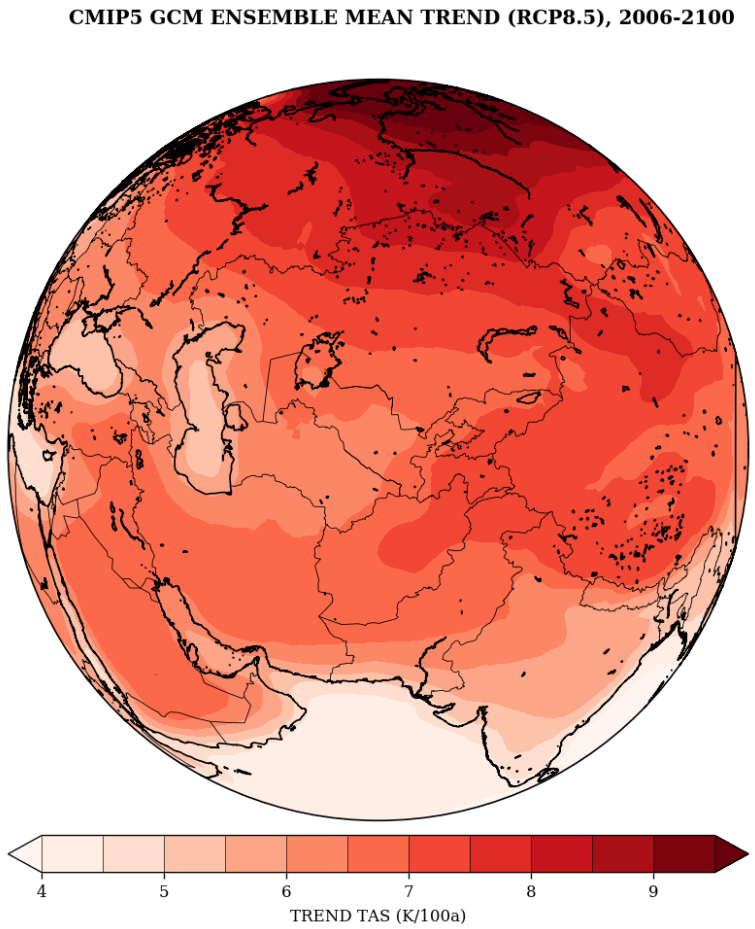
Source: IPCC AR5

Green Central Asia

Temperature and Precipitation projections

Projections of temperature and precipitation, obtained from CMIP5 simulations for the region Central Asia





Faster warming trends in the region than global average values

Source: own elaboration PIK

Green Central Asia

02 | Water in Central Asia

-

Brief facts

Water resources in Central Asia

- Water scarce region with strong dependence on water resources
- Most rivers are fed by snow and ice melt in the high mountains and don’t drain into the ocean but into endorheic lakes, Amu Darya and Syr Darya into the Aral Sea
- Majority of glaciers in the region are losing mass since 1960

Green Central Asia

Importance of water resources in Central Asia

GDP from Agriculture

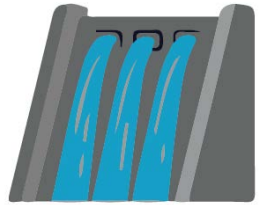
20-22%

(except for Kazakhstan - 5%)

Irrigated land

90%

Turkmenistan
Usbekistan



Share of energy from HPP

85%

Kyrgyzstan

98%

Tajikistan

63%

Afghanistan

Source: World Bank Development Indices

Green Central Asia

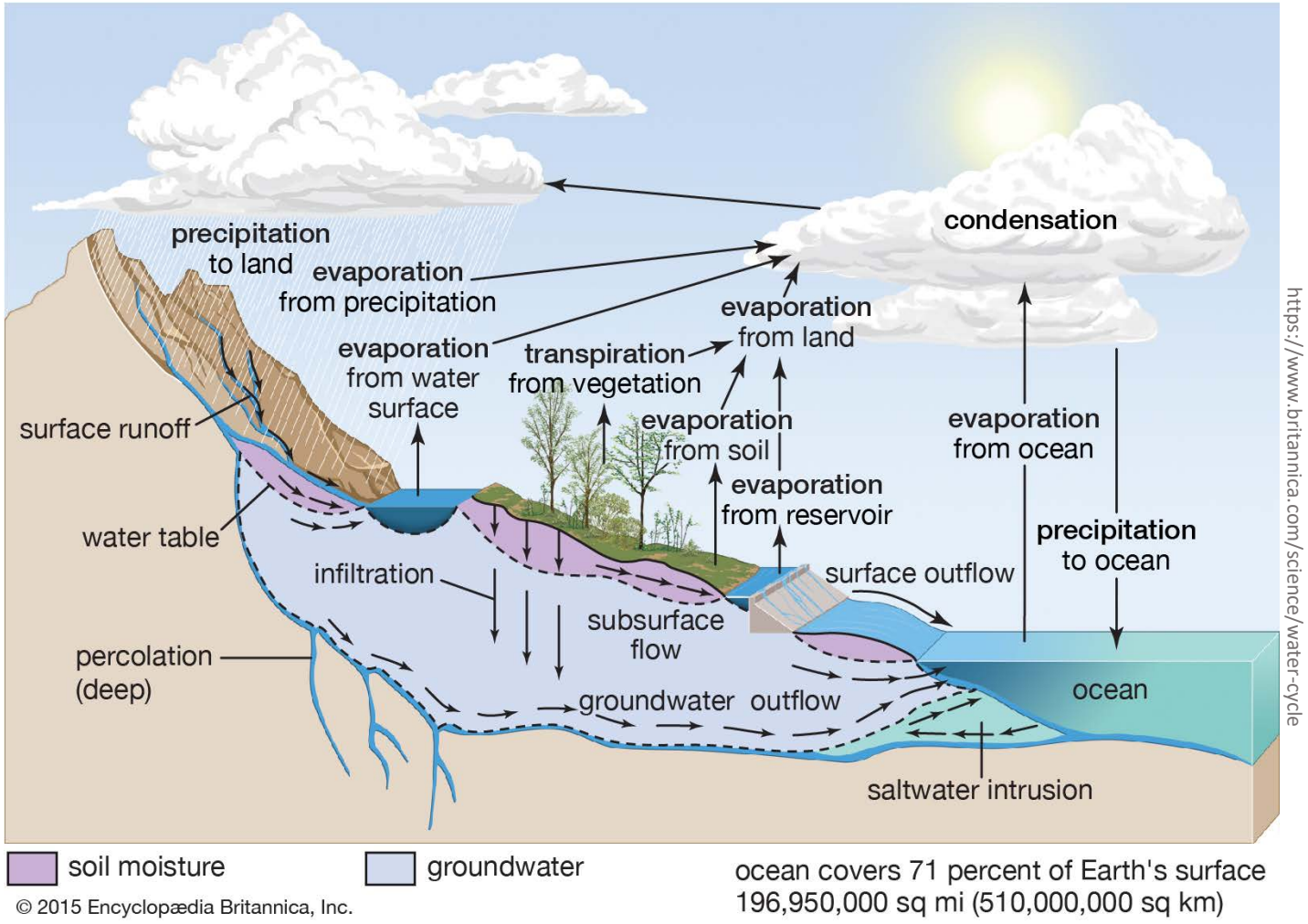
03 | Modelling

-

General scheme

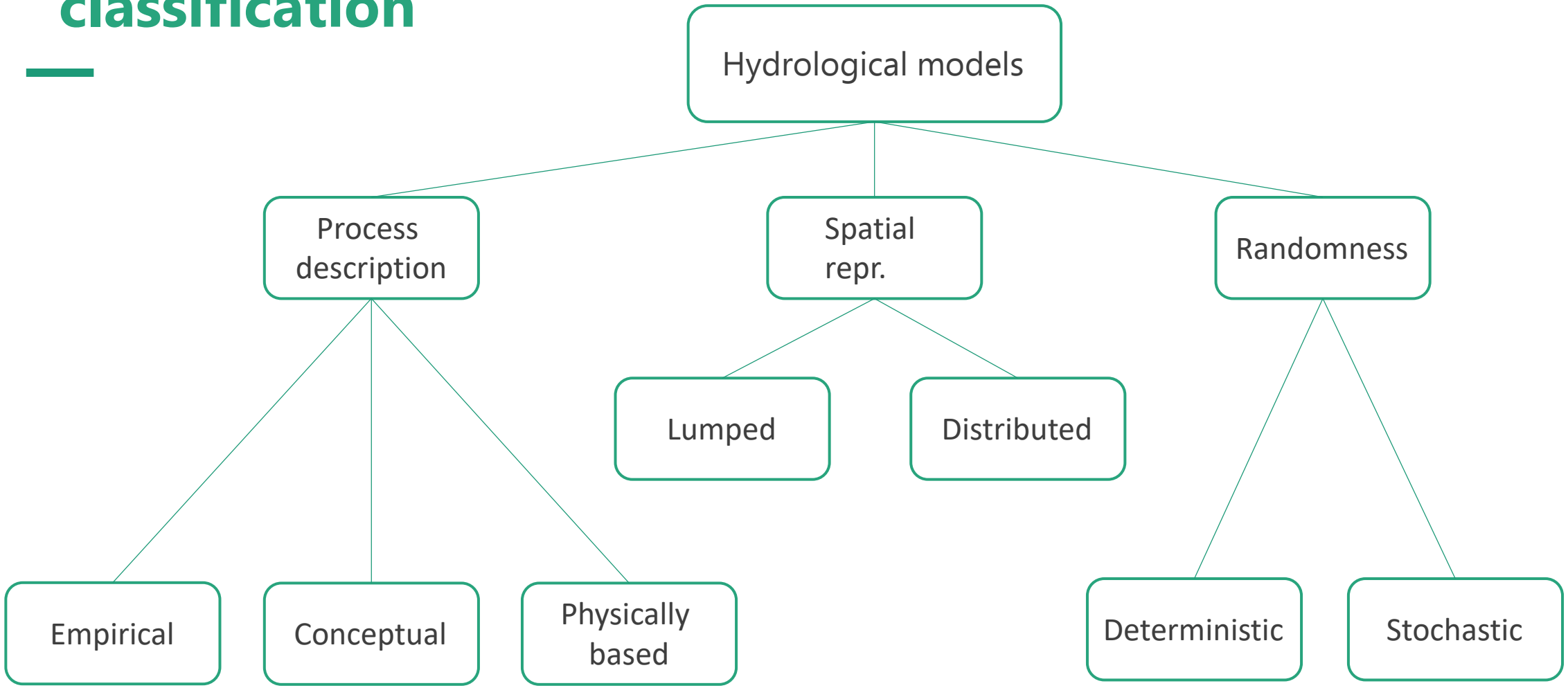
A hydrologic model is

- simplified, conceptual representation of the hydrological cycle
- simplification of a real-world system that helps in understanding, predicting and managing water resources



Green Central Asia

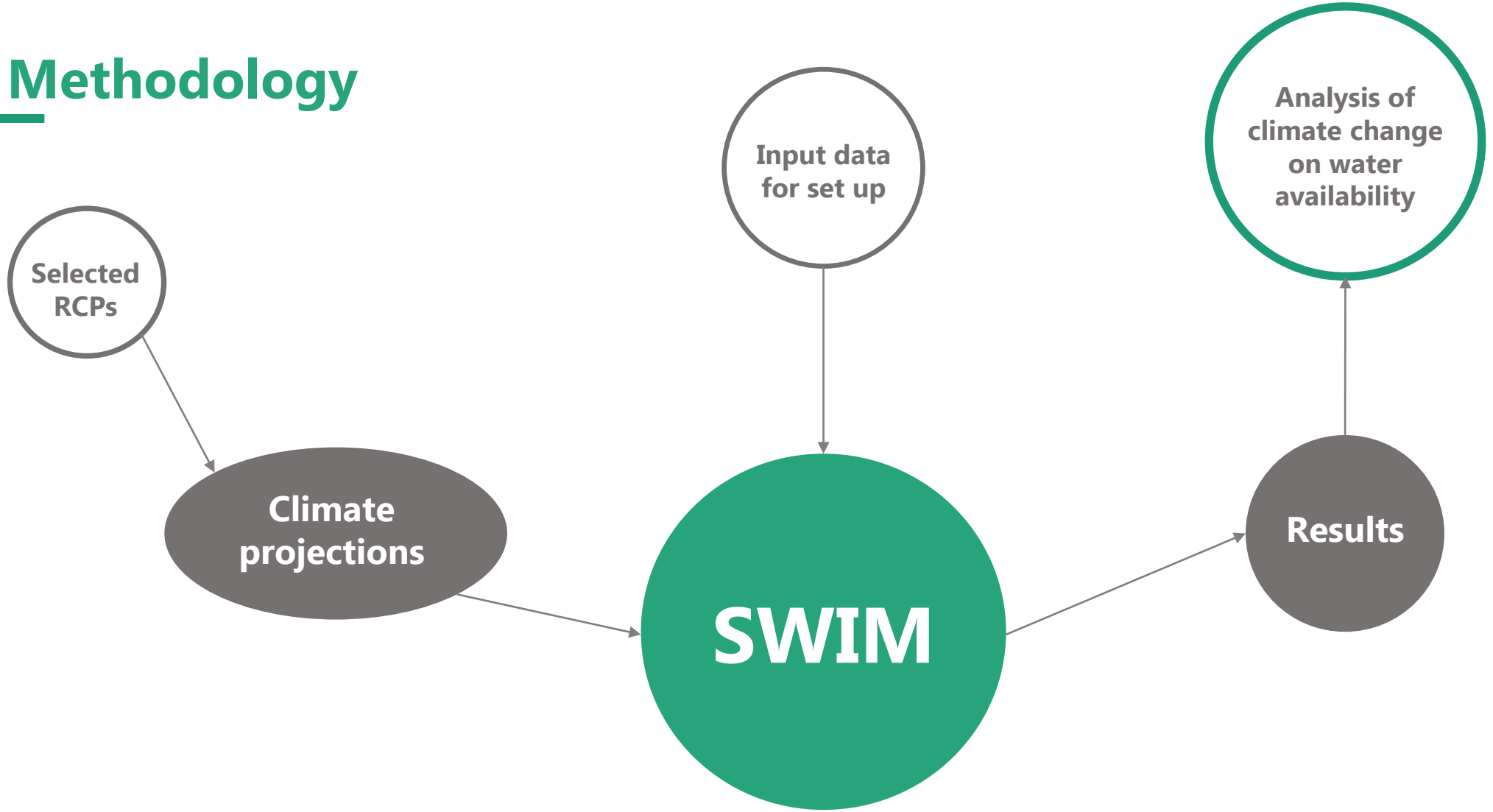
Model classification



Green Central Asia

Source: Nguyen Hong Quang 2016

Methodology

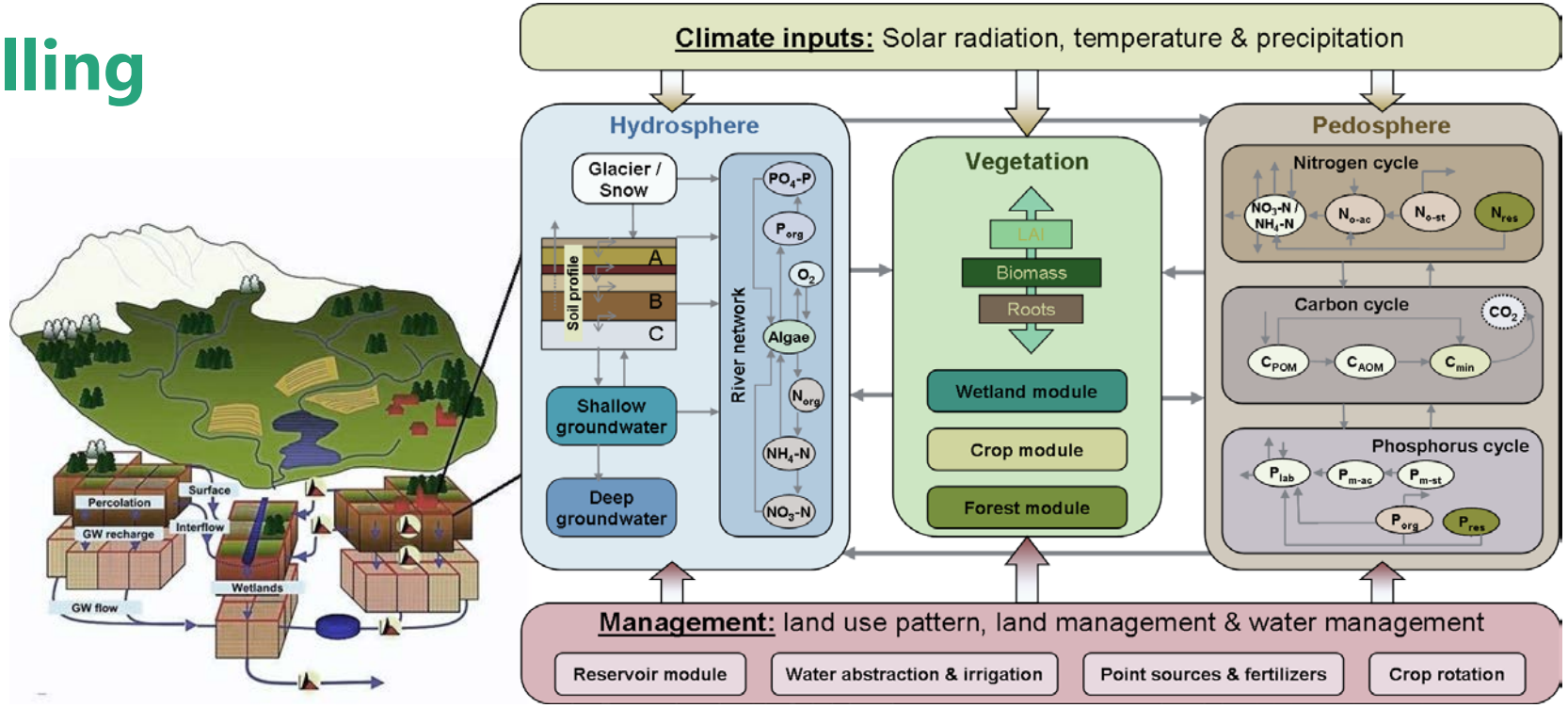


Green Central Asia

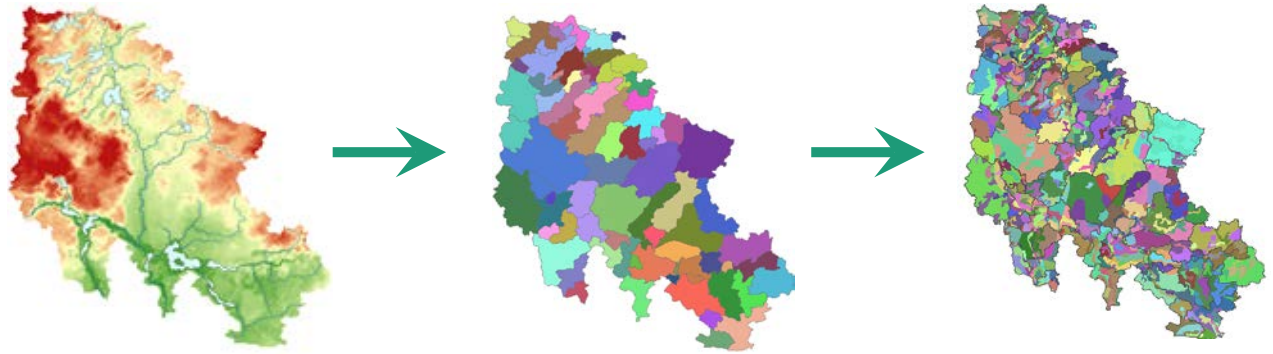
Hydrological modelling

SWIM
Soil and Water Integrated Model

- Eco-hydrological process-based semi – distributed model
- Discharge, crop growth, sediment and nutrients flow at the daily time step
- Additional modules – reservoir operation, irrigation, wetlands, glaciers



Catchment scale → Subbasin scale → Hydrotope level



Input data for hydrological modelling

Climate data

Reanalysis

- WATCH Era40 (www.eu-watch.org)
- WFDEI
- WFDE5
- GPCC (dwd.de/EN/ourservices/gpcc/gpcc.html)

Observations

- ECA&D (ecad.eu)
- Local data
- National data

Land Use

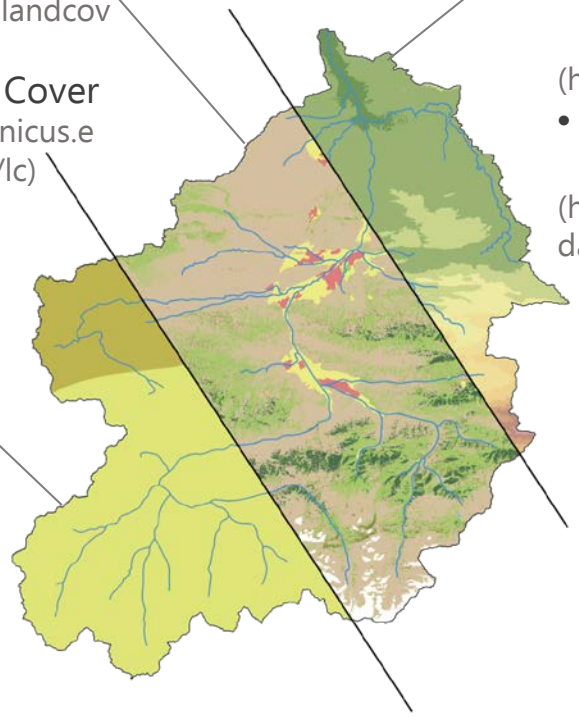
- GlobeLand30 (http://www.globallandcover.com/)
- Global Land Cover (https://land.copernicus.eu/global/products/lc)

Digital Elevation Model

- Shuttle Radar Topography Mission (SRTM) (http://srtm.csi.cgiar.org/)
- ASTER Global Elevation Data (https://portal.opentopography.org/datasets)

Soil data

- HWSD (www.fao.org)



(Isfara River basin)

Discharge

- GRDC Database (bafg.de)
- The Global River Discharge Database (rivdis.sr.unh.edu)
- ORNL DAAC (daac.ornl.gov/RIVDIS/guides/rivdis_guide.html)
- Center for Sustainability and the Global Environment (nelson.wisc.edu/sage/data-and-models/riverdata/)

Green Central Asia

SWIM output data

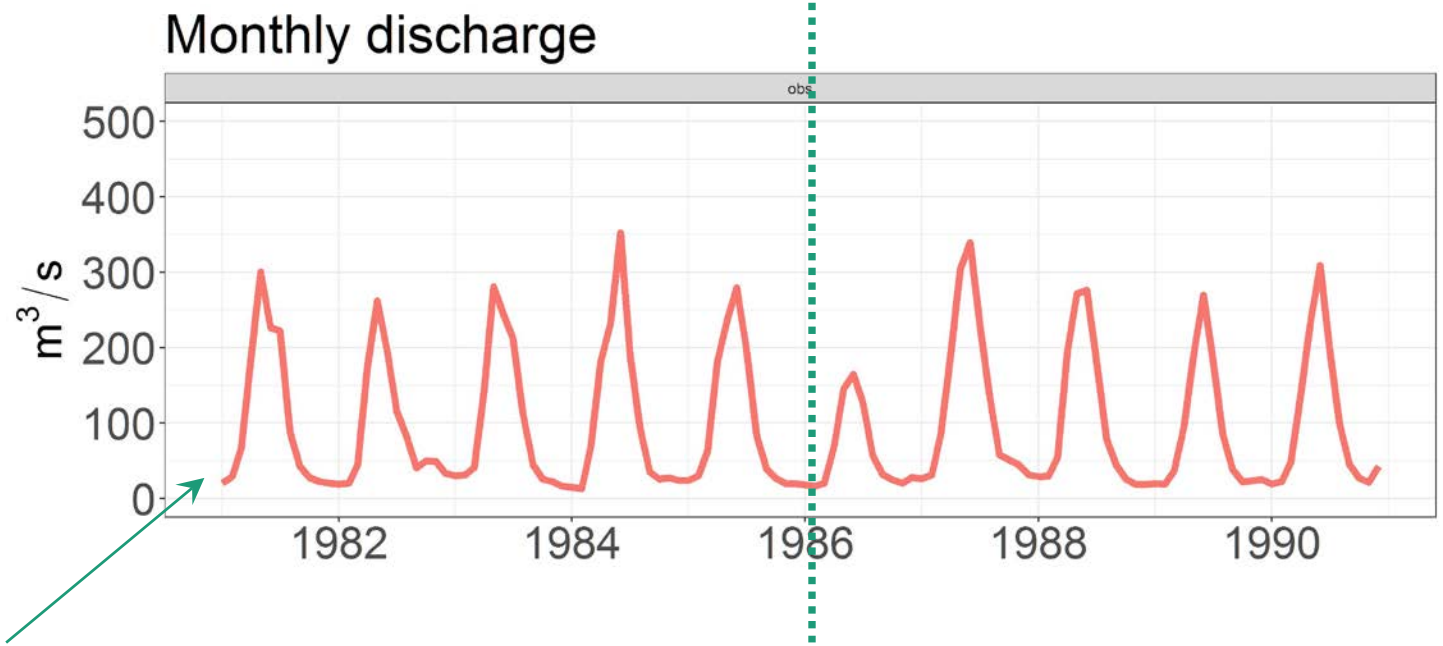
- Water discharge ($m^3\ s^{-1}$)
- Nutrient concentrations ($mg\ L^{-1}$) and loads ($kg\ d^{-1}$),
- Crop yield ($t\ ha^{-1}$)
- GIS-Outputs of water and nutrient cycle components on maps

Green Central Asia

Model calibration and validation

Calibration period

Validation period



*warming up the model before calibration for several years

Other components:

Evapotranspiration

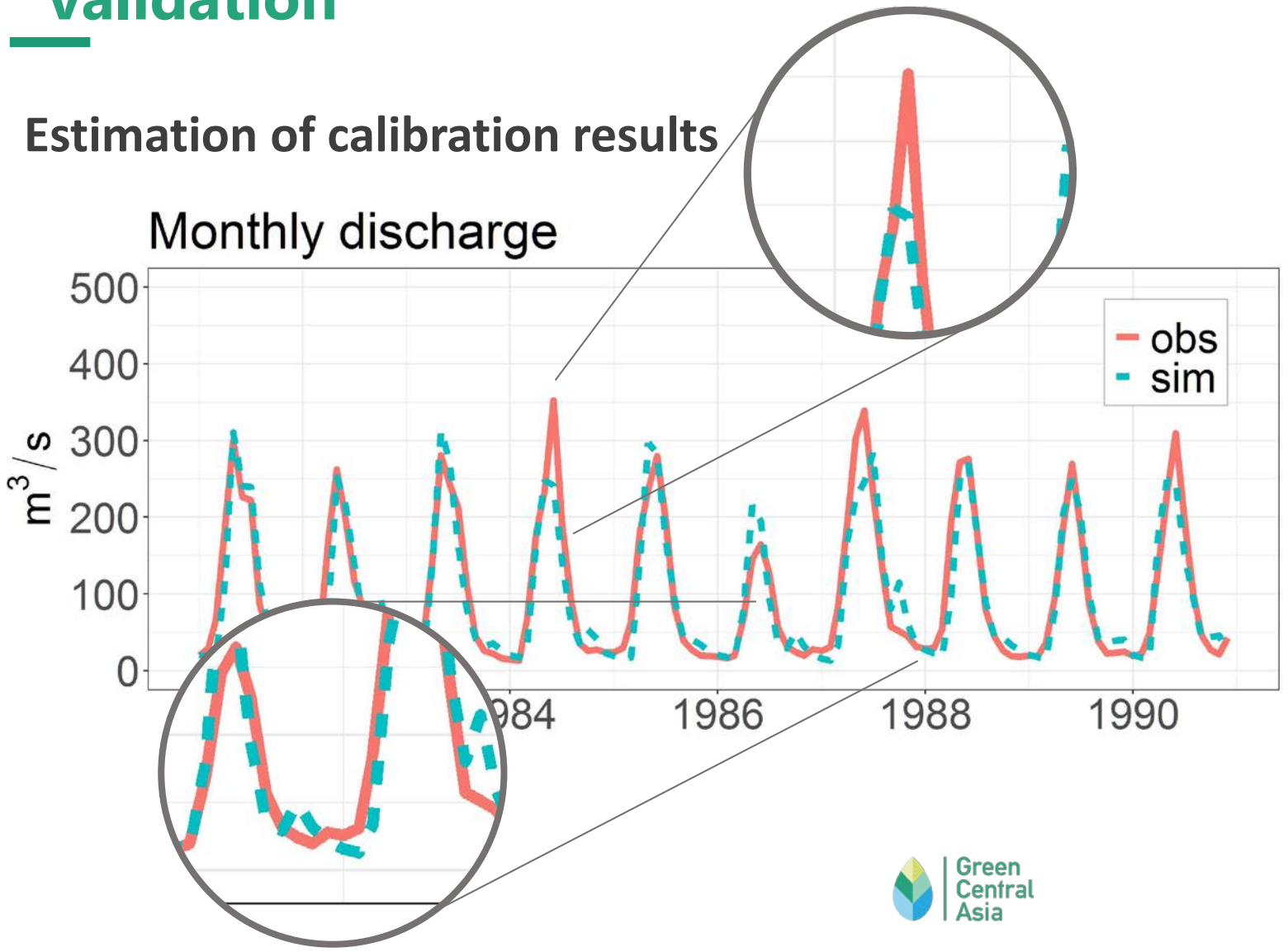
Snow cover

Etc.

Green Central Asia

Model calibration and validation

Estimation of calibration results



Nash-Sutcliffe efficiency (NSE)

efficiency can range from $-\infty$ to 1. An efficiency of 1 ($E = 1$) corresponds to a perfect match

$$\frac{\sum_{t=1}^{N}\left(Q_{s,t}-Q_{o,t}\right)^2}{\sum_{t=1}^{N}\left(Q_{o,t}-\overline{Q}_o\right)^2}$$

Percent bias (PBIAS)

can range from $-\infty$ to $+\infty$, 0 is a perfect fit

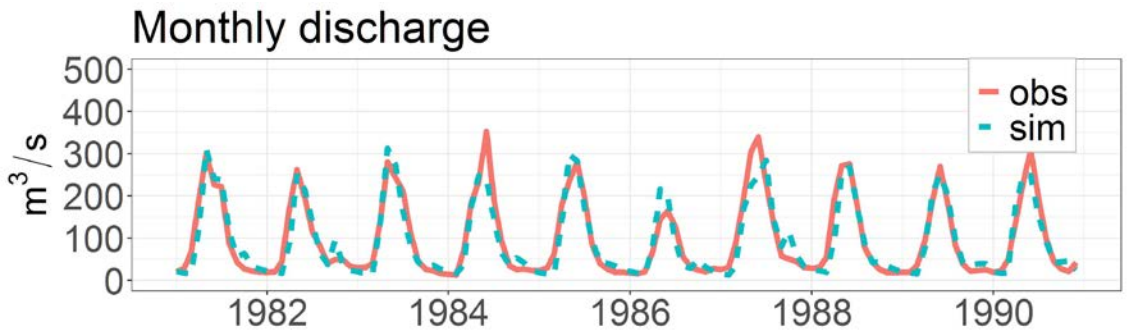
$$\frac{\sum_{t=1}^{N}(Q_{s,t}-Q_{o,t})}{\sum_{t=1}^{N}Q_{o,t}} * 100$$

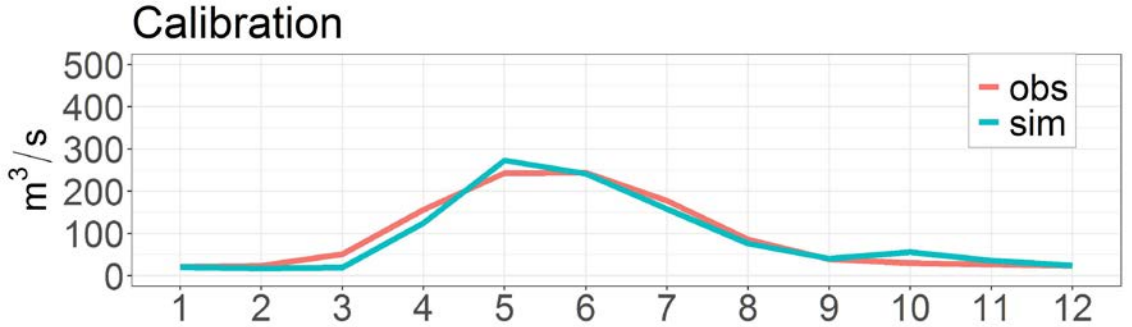
Green Central Asia

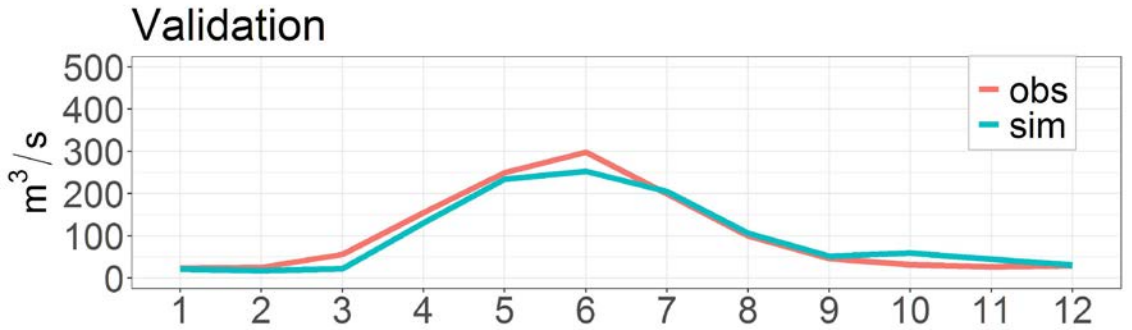
Model calibration and validation

Kafirnigan River

Modelled area – 3216 km2
Gauge – Chinor
Mean annual T – 5.3 C
Annual P – 677 mm
Min elev – 896 m
Max elev – 4368 m

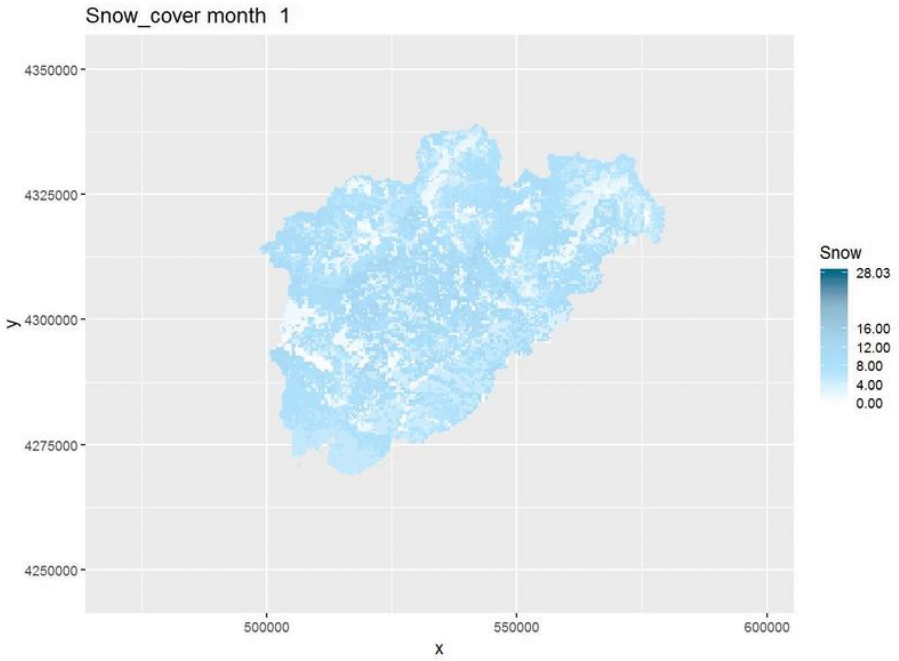






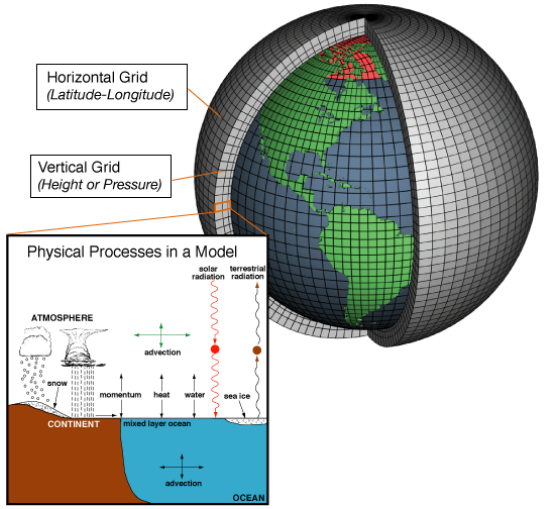
Green Central Asia

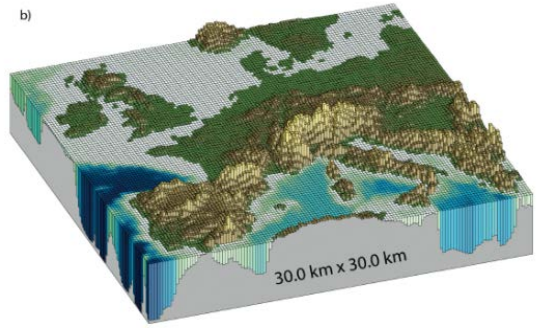
Model calibration and validation (snow representation)



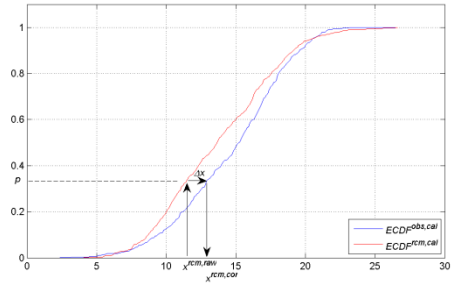
Green Central Asia

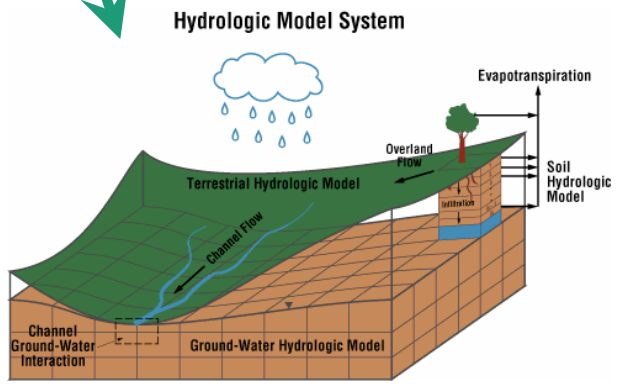
Climate projections





source: IPCC AR5 (2013)

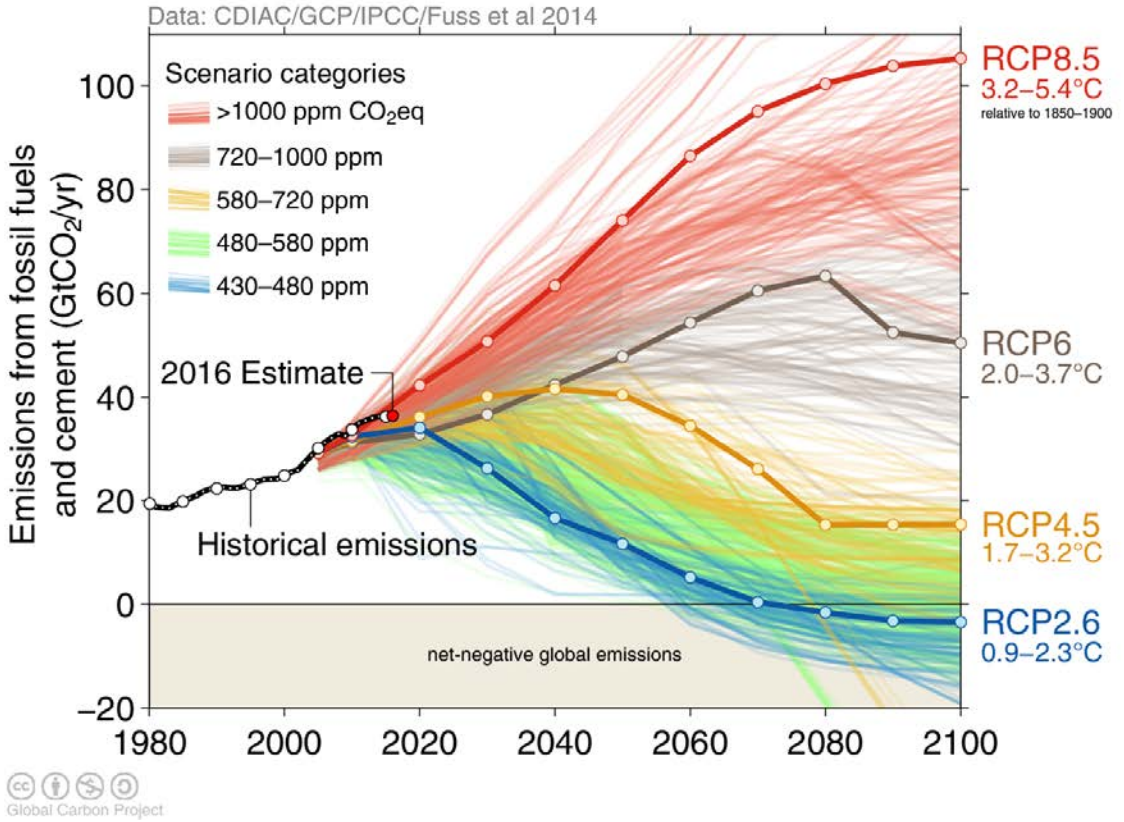




Green Central Asia

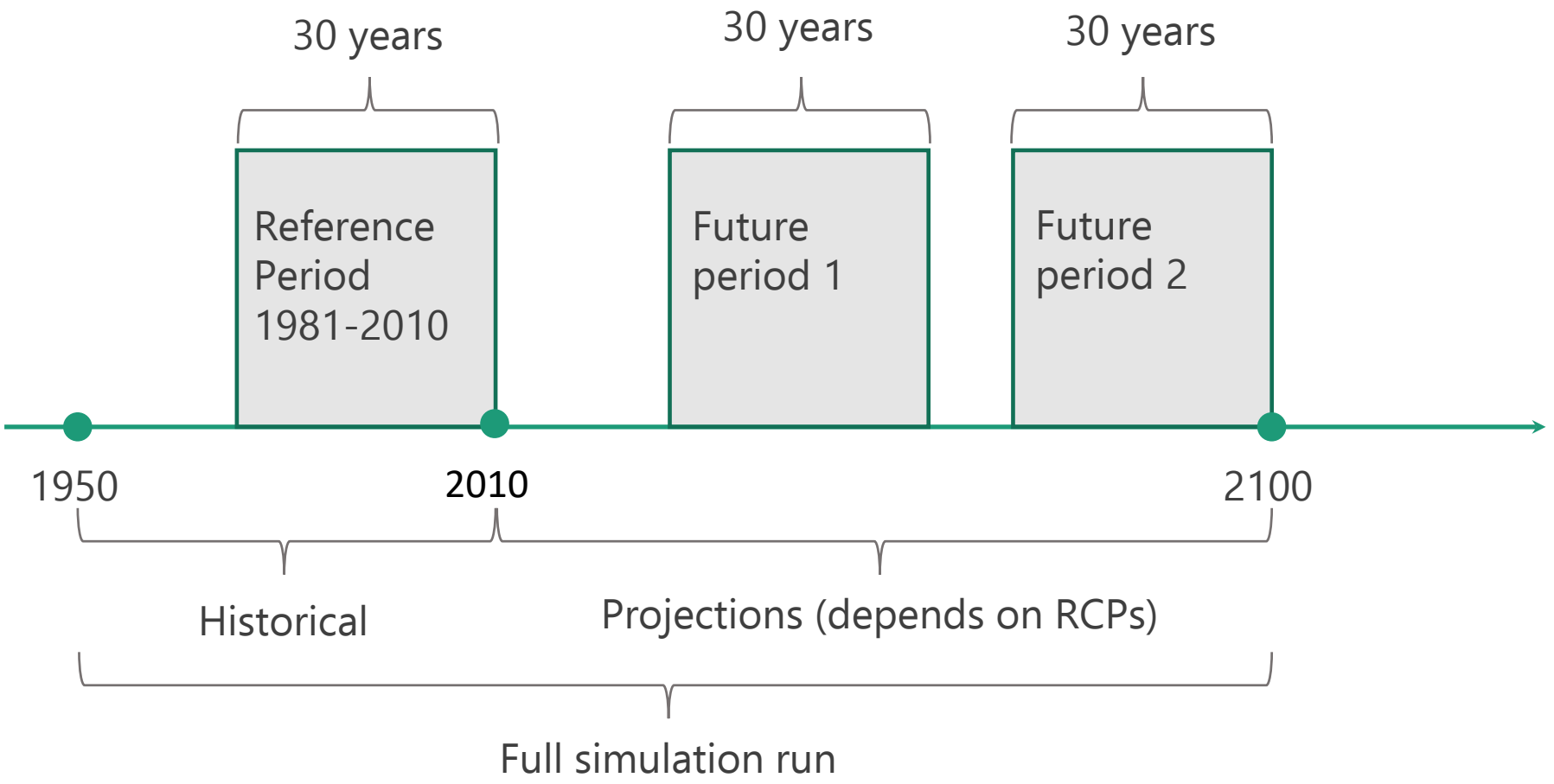
Climate projections

RCP Representative Concentration Pathways:



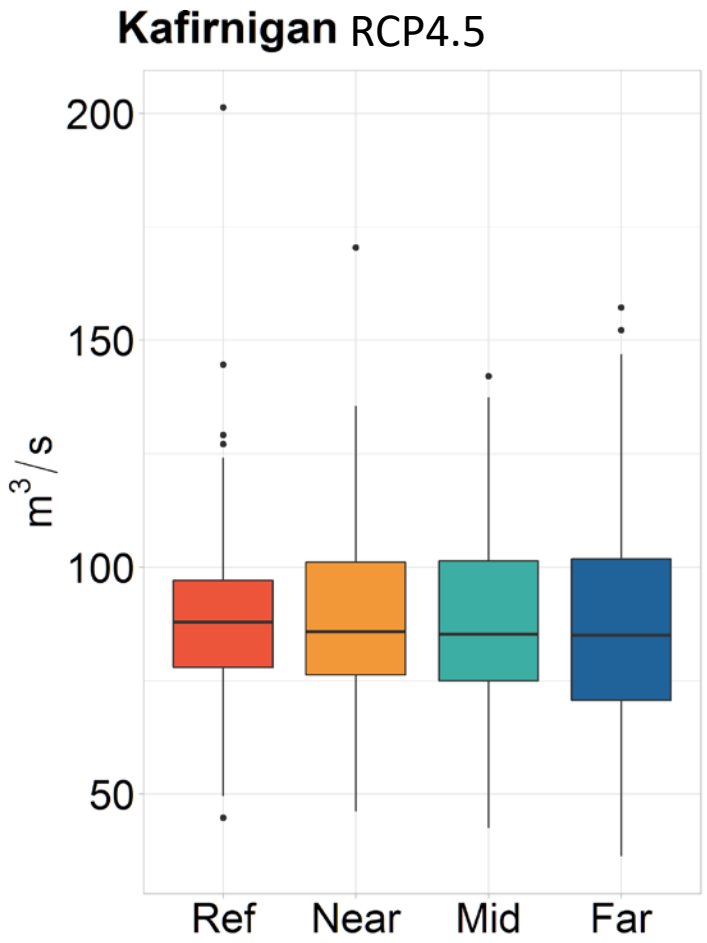
Green Central Asia

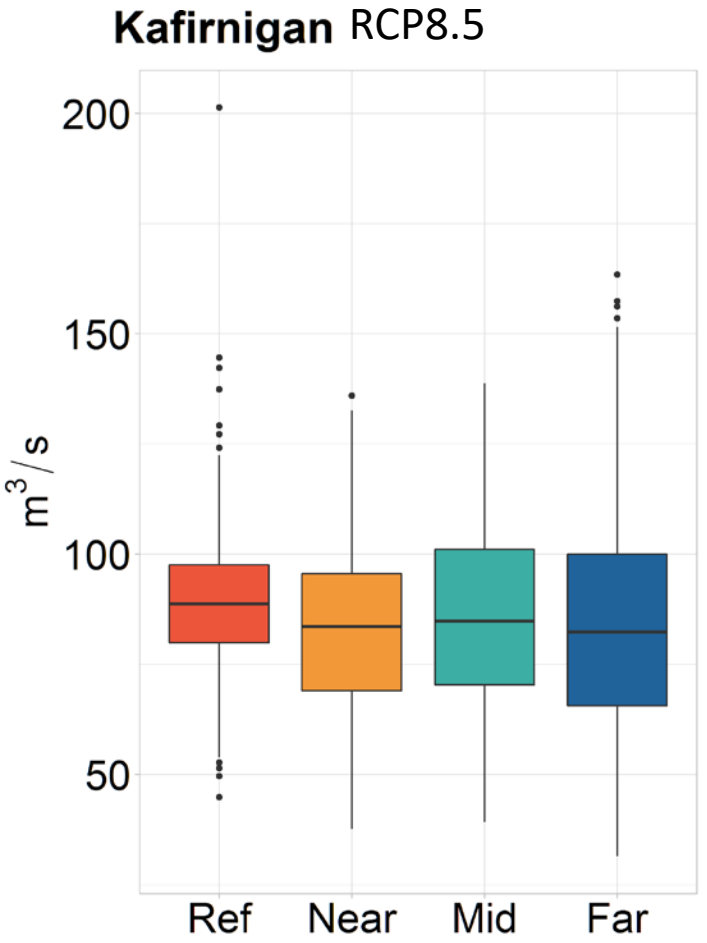
Climate change impact analysis



Green Central Asia

Changes in annual dynamics

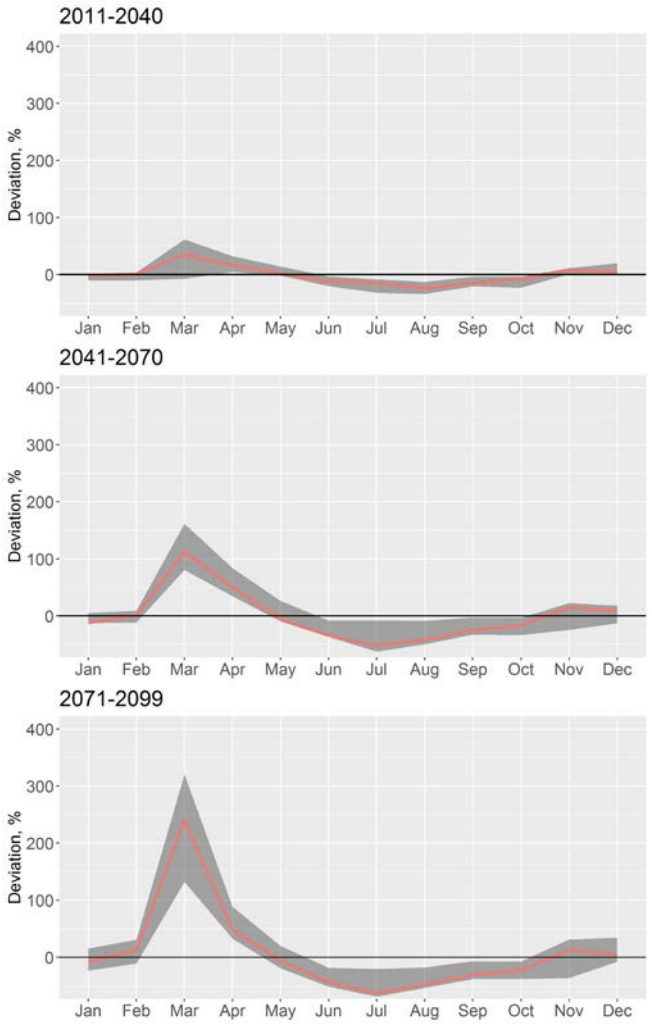




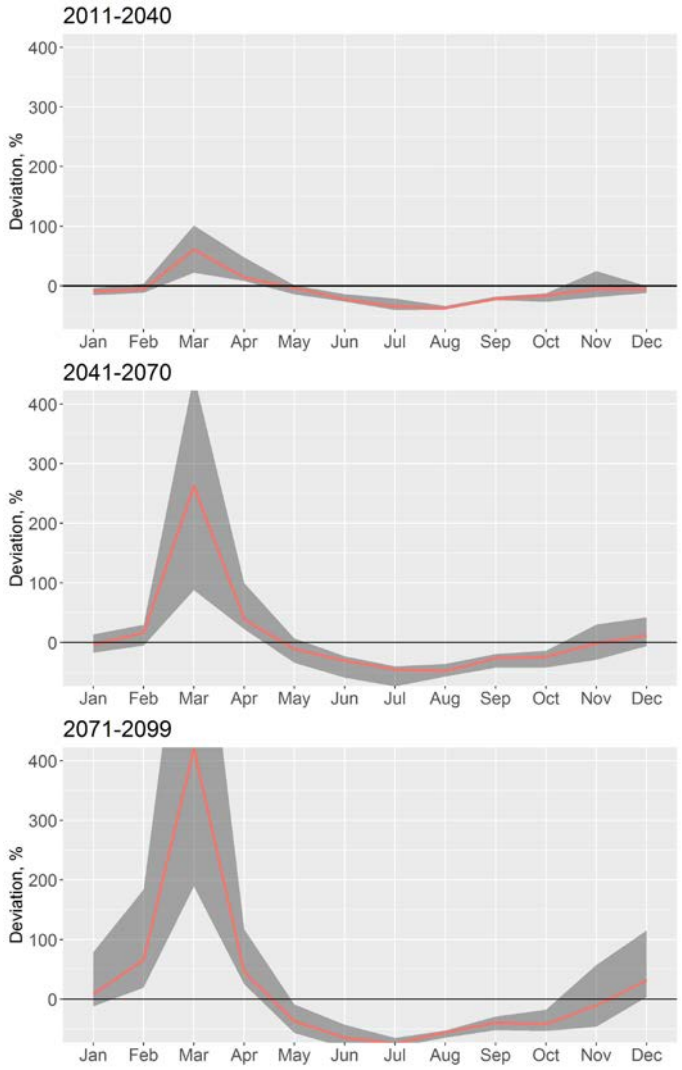
Green Central Asia

Seasonal changes

RCP4.5

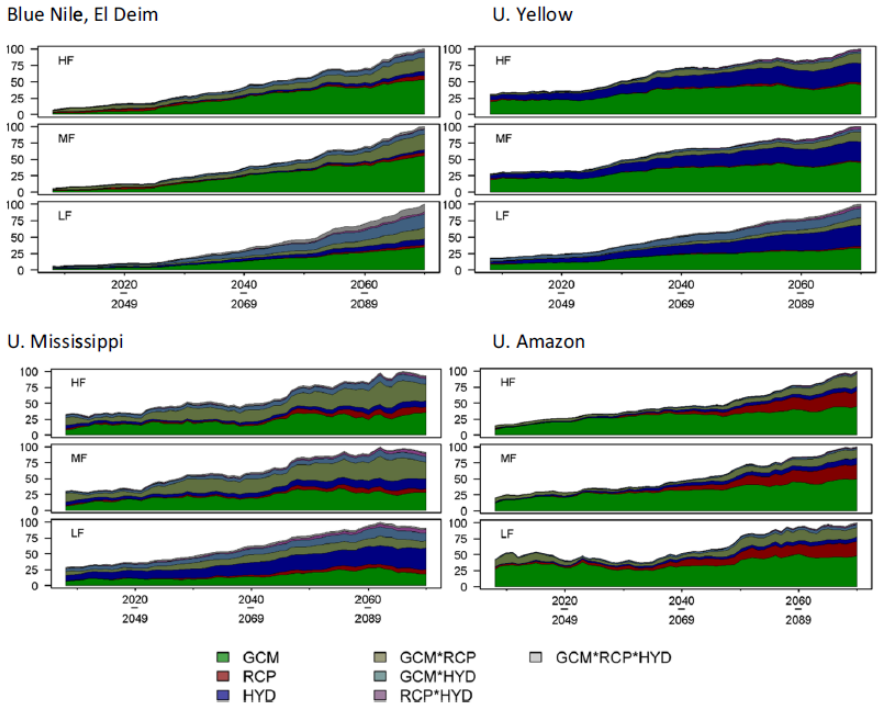


RCP8.5

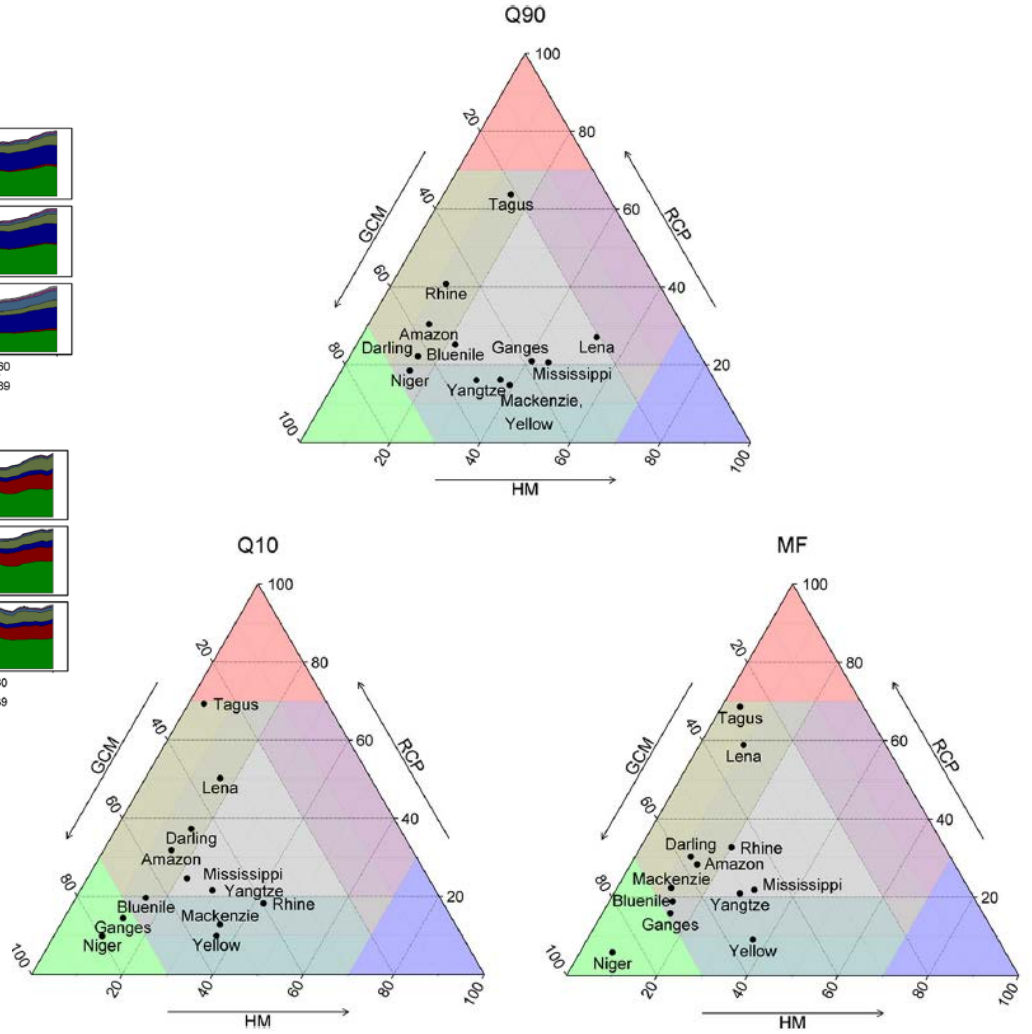


Green Central Asia

Uncertainty



Vetter et al. 2016, Climatic Change



PIK activities within Green Central Asia

WATER

- Water resources availability
- Hydropower potential
- Testing of the seasonal water availability

Green Central Asia
Enhancing environment, climate and water resilience

RESEARCH

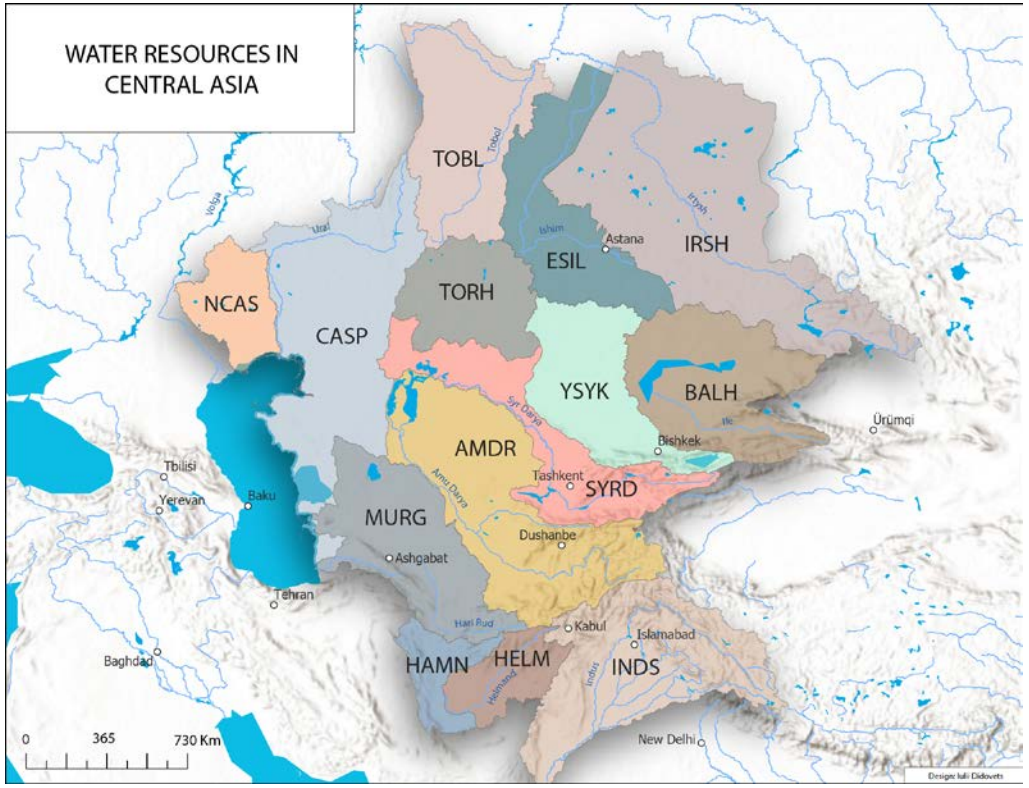
CAPACITY BUILDING

Climate

Water

Agriculture

Security



Green Central Asia

Thank you!

Dr. Iulii Didovets
didovets@pik-potsdam.de