Effect of modelling scale on the assessment of climate change impact on river runoff – a case study for the Narew (Poland)

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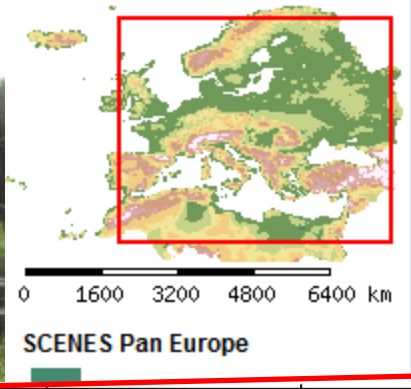
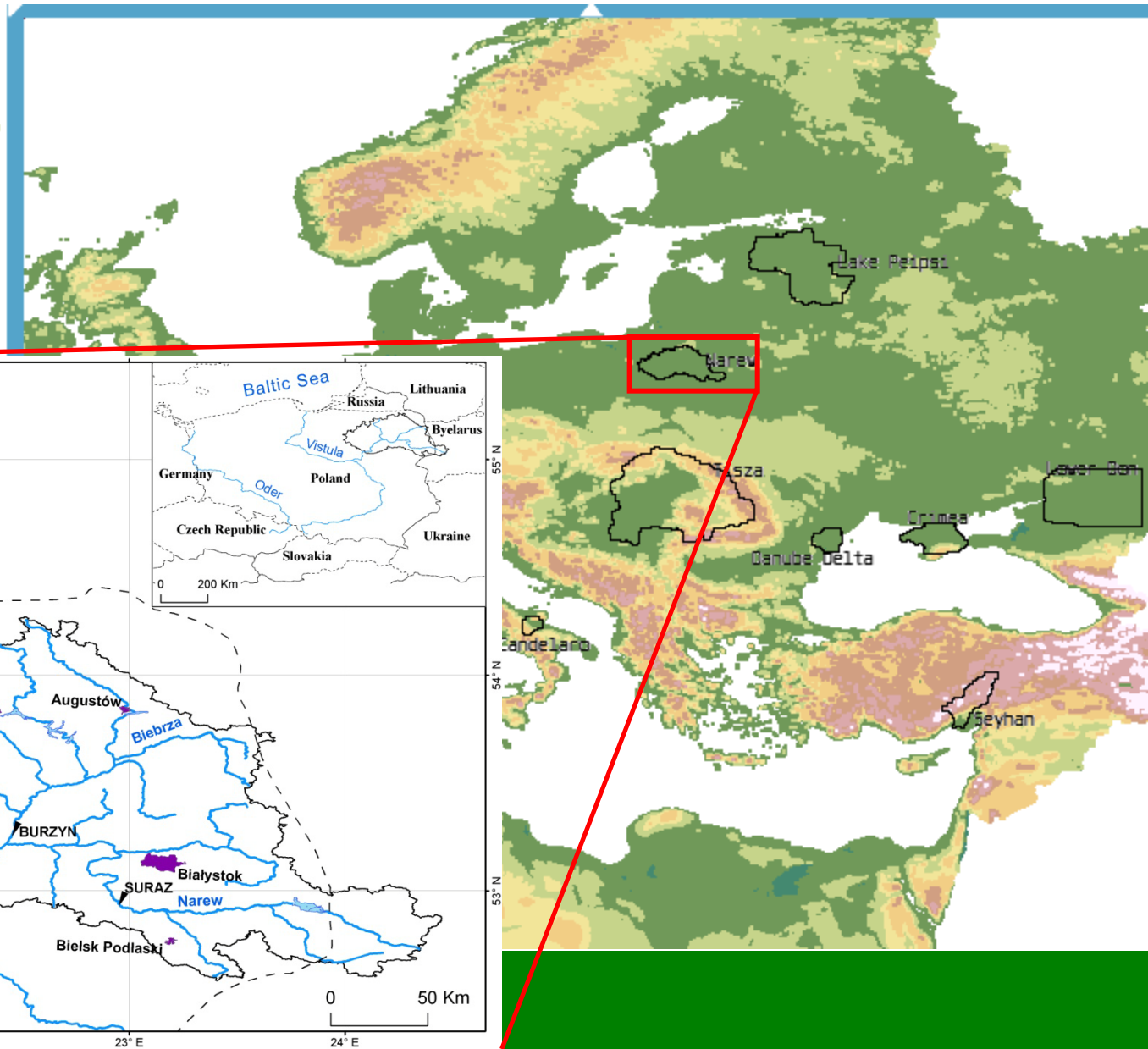
Background


0 1600 3200 4800 6400 km
SCENES Pan Europe


Lake Peipsi
Narew
Dniester
Lower Don
Crimea
Danube Delta
Candelaro
Ceyhan

Flow gauges
Country borders
Lakes
Cities with pop. above 25,000
Rivers
Narew River Basin
Baltic Sea
Russia
Lithuania
Byelarus
Vistula
Germany
Oder
Poland
Czech Republic
Ukraine
Slovakia
0 200 Km
Ełk
Augustów
Biebrza
Szczytno
Pisa
BURZYN
Łomża
Białystok
Narew
Ostrołęka
SURAZ
ZAMBSKI
Bielsk Podlaski
Bug
Vistula
Lake Zegrzyńskie
0 50 Km
21° E
22° E
23° E
24° E
55° N
54° N
53° N

Objective

- To investigate the effect of using a global or a catchment model on the assessment of climate change (CC) impact on river runoff
  - Global vs. catchment = WaterGAP vs. SWAT
  - CC impact: SRES A2 GCMs: IPSL-CM4 & MIROC3.2 for 2050s
  - Impact on runoff analysed at three levels:
    - Mean annual runoff
    - High and low monthly runoff (Q10 & Q90)
    - Seasonal cycle
- **Not the model competition!**

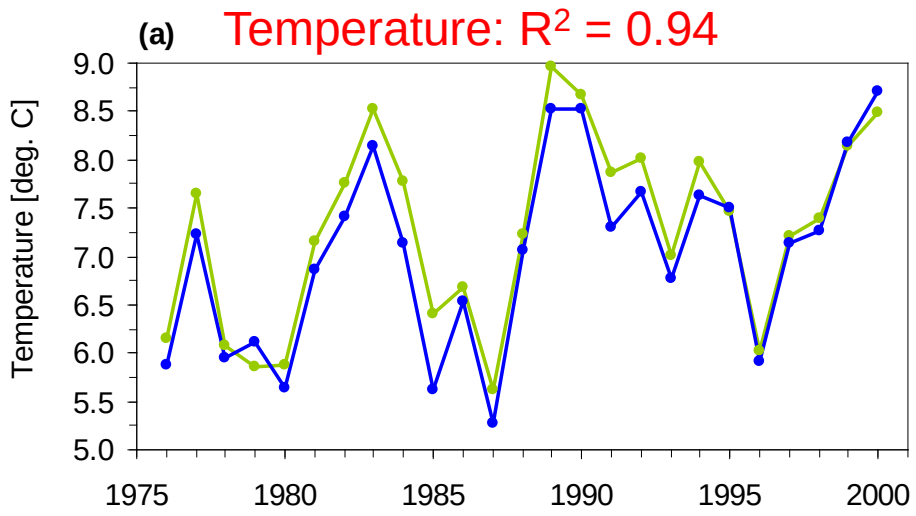
Modelling approaches

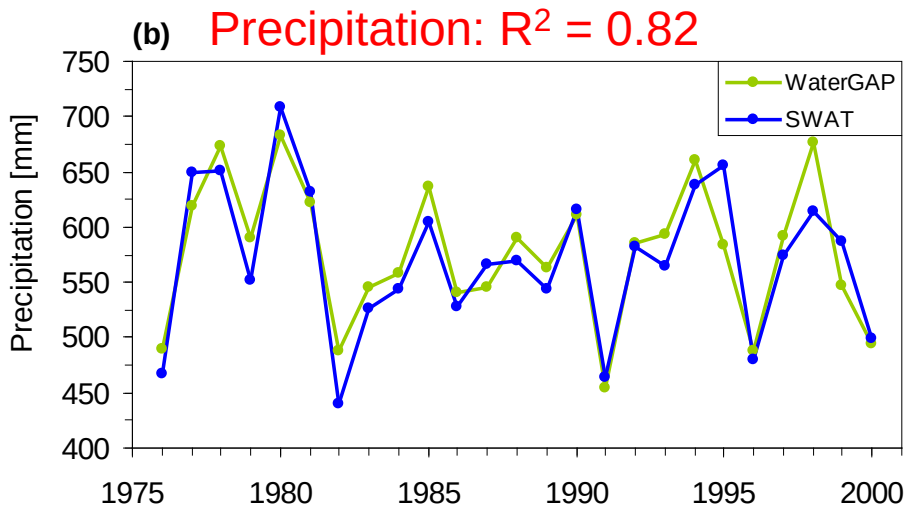
Aspect	SWAT	WaterGAP
Basic unit	Hydrologic Response Unit	5' by 5' grid cell
Potential ET	Penman-Monteith	Priestley-Taylor
Actual ET	Evaporation from canopy & soil + sublimation + plant water uptake	Evaporation from canopy & vegetated soil + sublimation
Snowmelt	Degree-day method	
Surface runoff	Modified SCS curve number method	HBV method
Redistribution in soil	Storage routing method between up to 10 soil layers	No redistribution, one soil layer
Soil water content	Variation between absolute zero and saturation	Variation between the wilting point and field capacity
Groundwater storage	Two groundwater storages (shallow unconfined and deep confined)	One groundwater storage
Baseflow	Recession constant method	Linear storage equation
Flood routing	Variable storage coefficient method	Linear storage equation

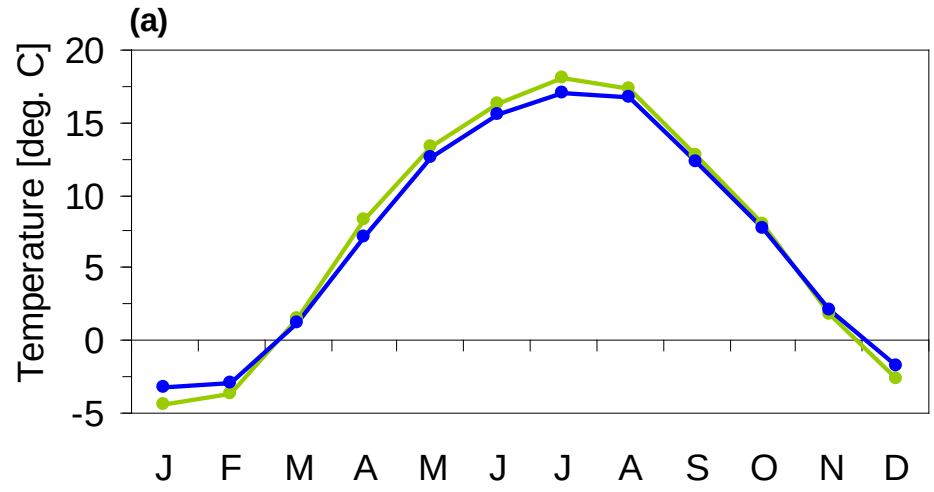
Modelling setup

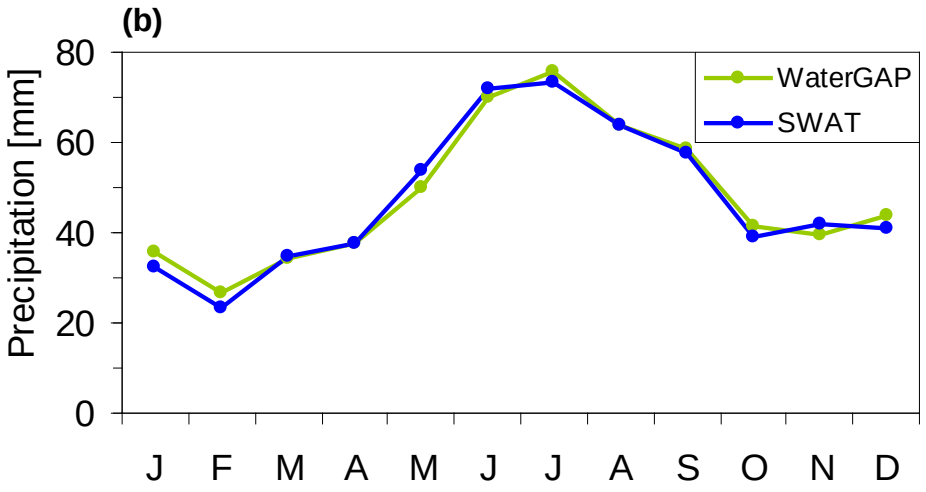
SWAT: 151 sub-basins, 1131 HRUs
WaterGAP: 531 cells

Climatic input analysis for the baseline (1976-2000)

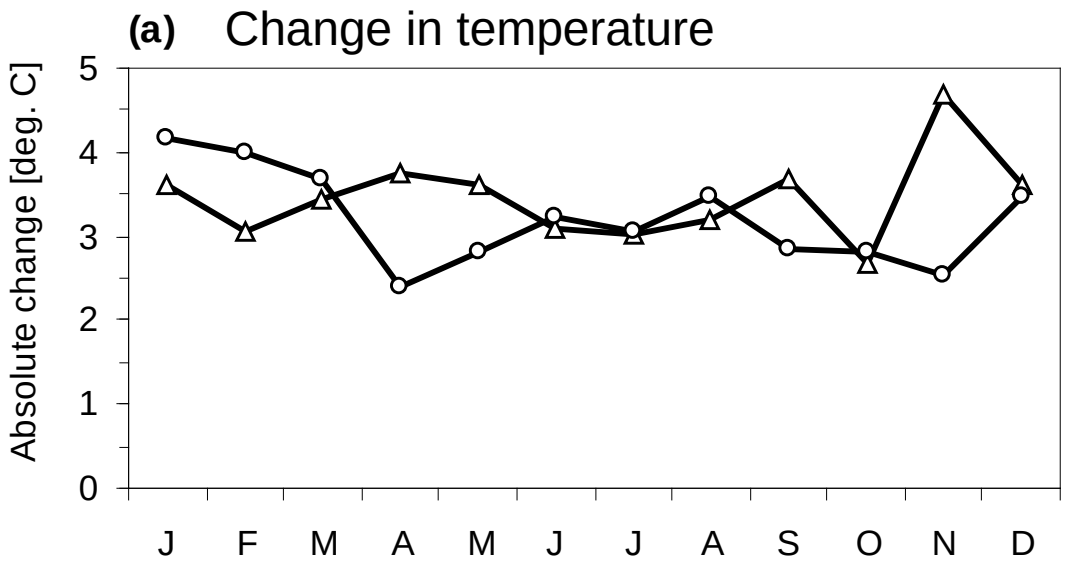




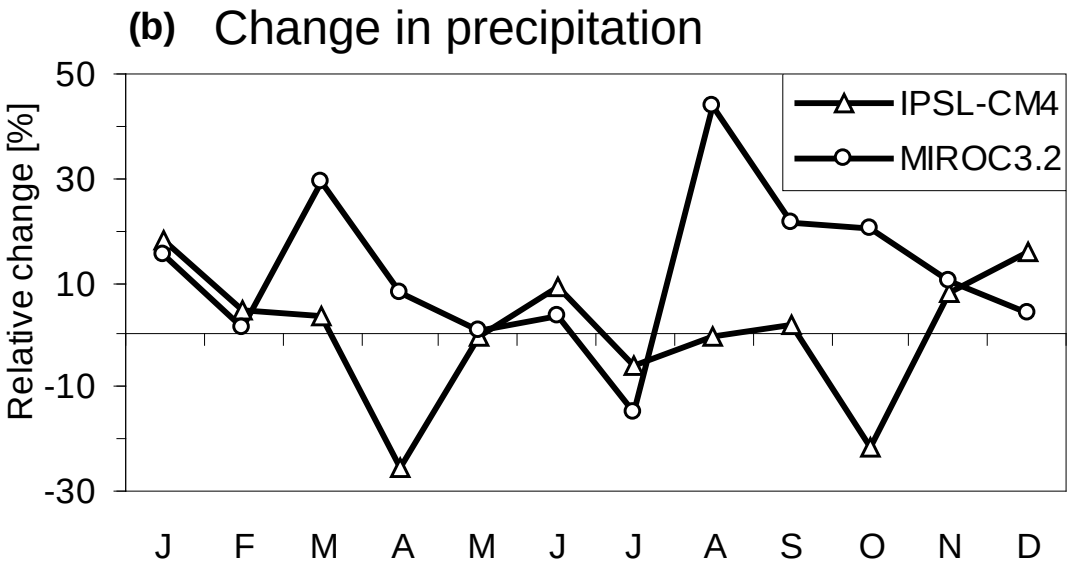




Projections for 2050s



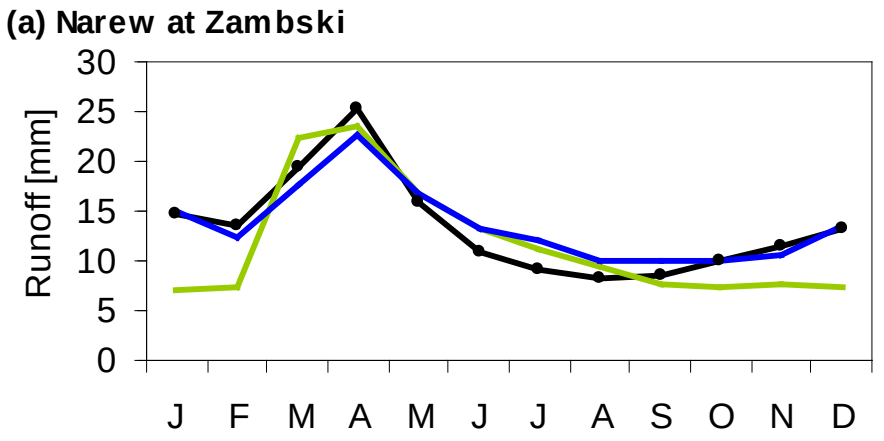
Mean annual change:
IPSL-CM4: 3.5 ˚C
MIROC3.2: 3.2 ˚C

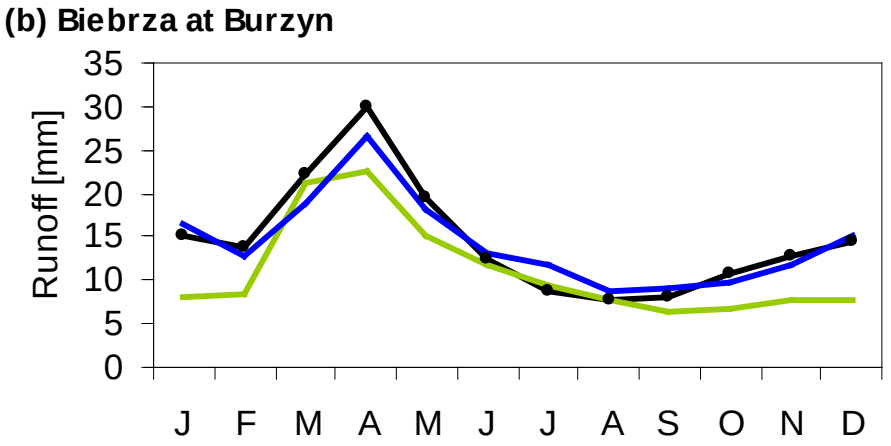


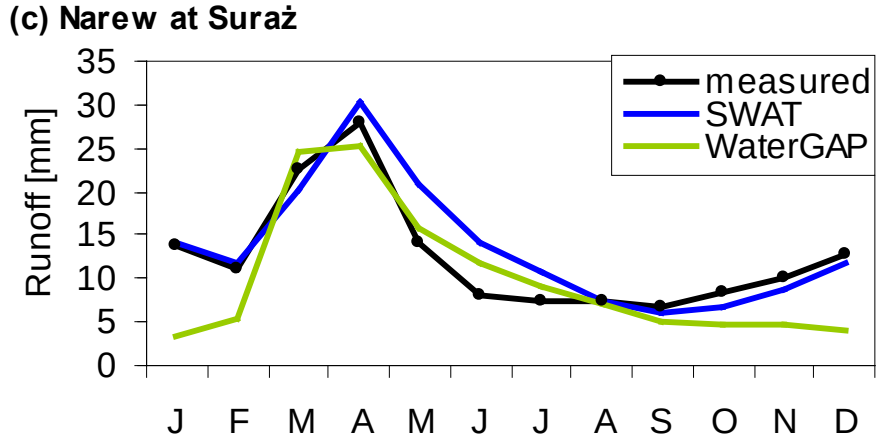
Mean annual change:
IPSL-CM4: 1%
MIROC3.2: 11%

Baseline simulated & measured runoff

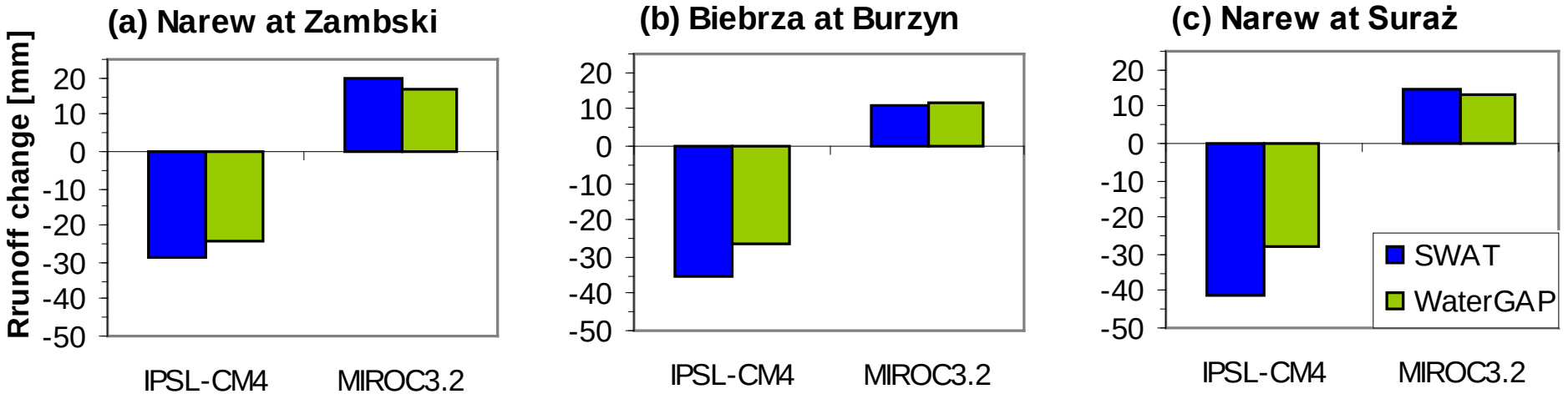
- Underestimation of mean runoff by 12-24% in WaterGAP
- Low runoff period lasts until Feb. in WaterGAP
- Overall - acceptable





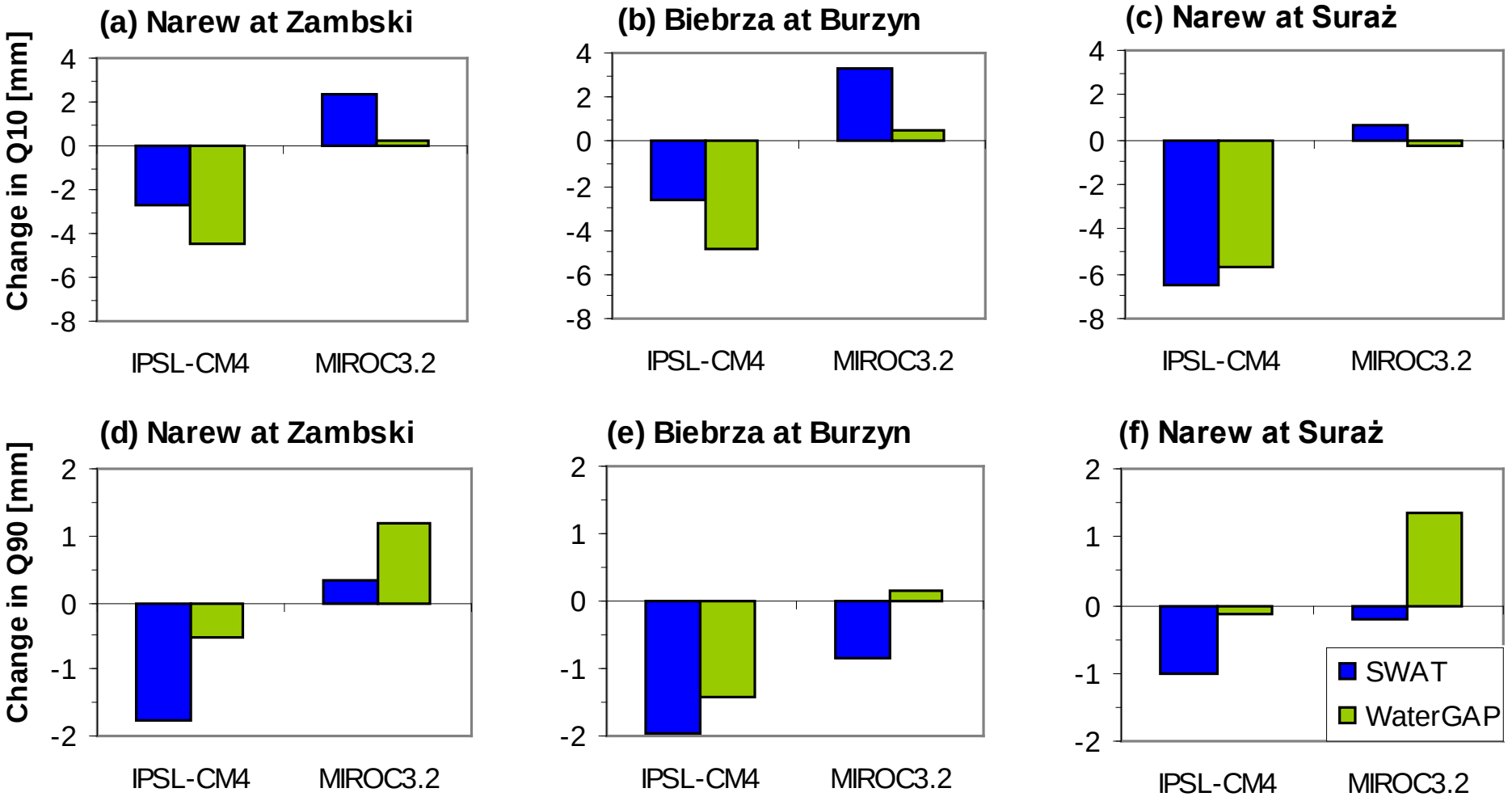


Change in mean annual runoff

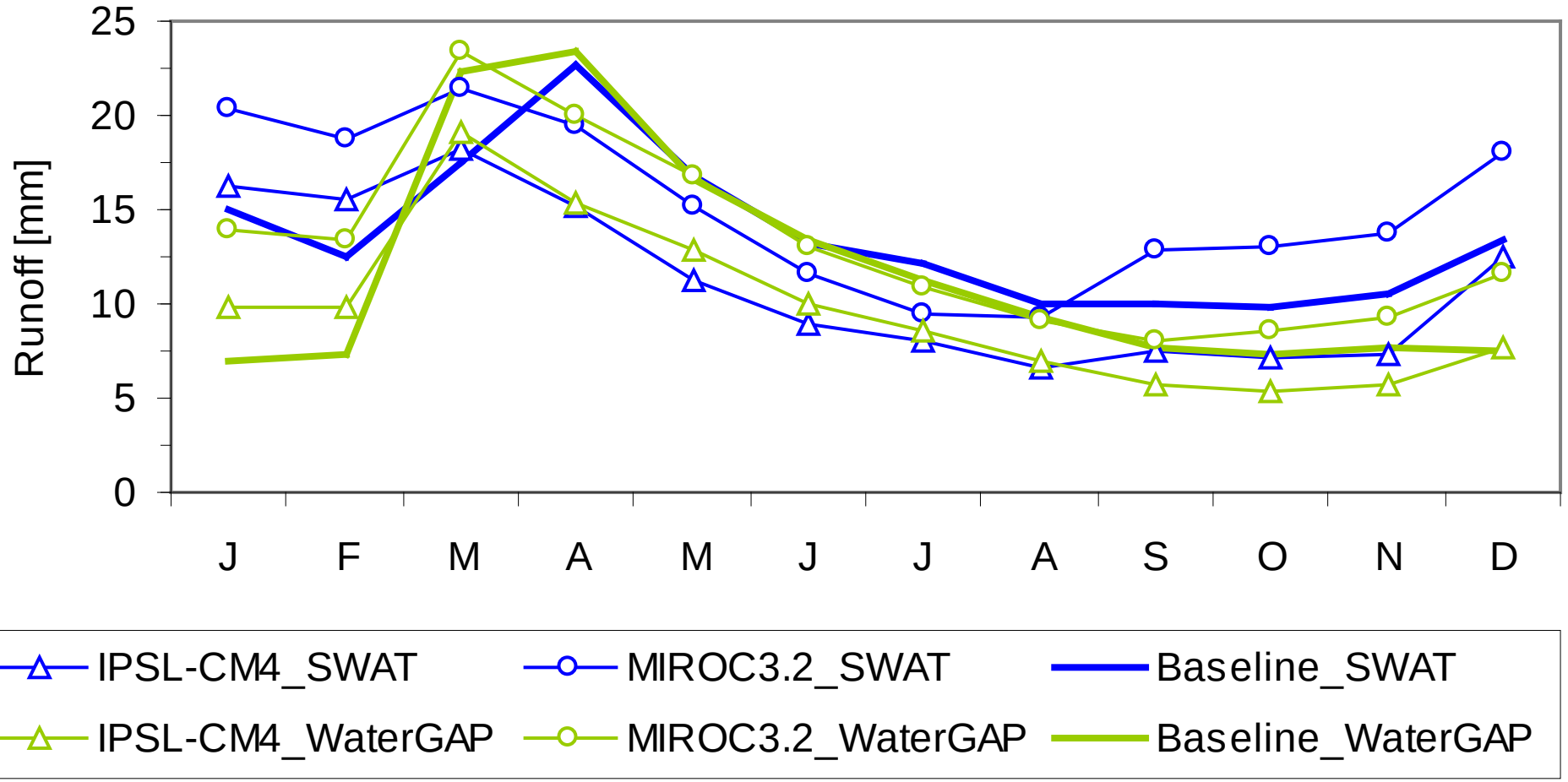


- Consistency between SWAT and WaterGAP
- Inconsistency between the climate models

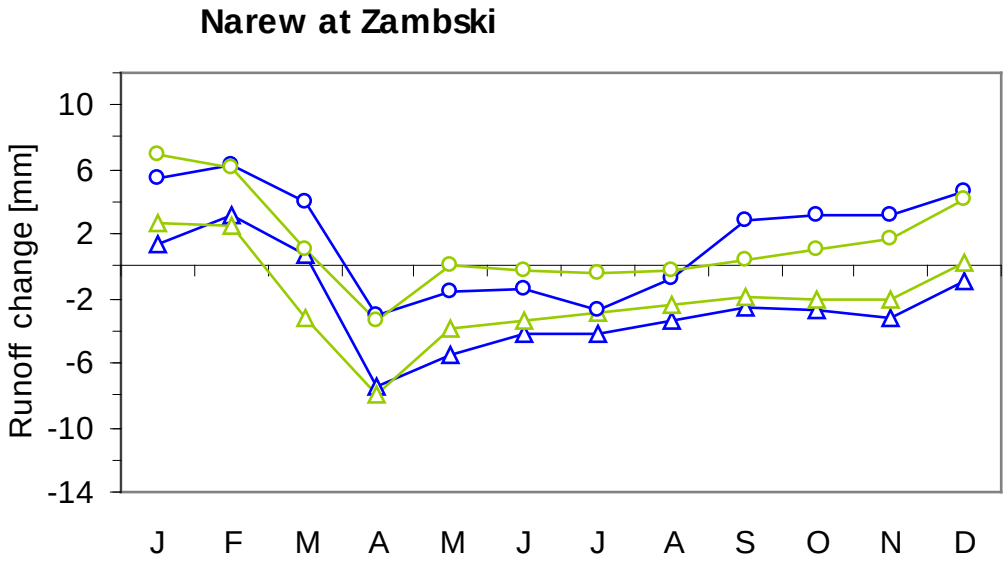
Change in monthly Q10 (high runoff) and Q90 (low runoff)

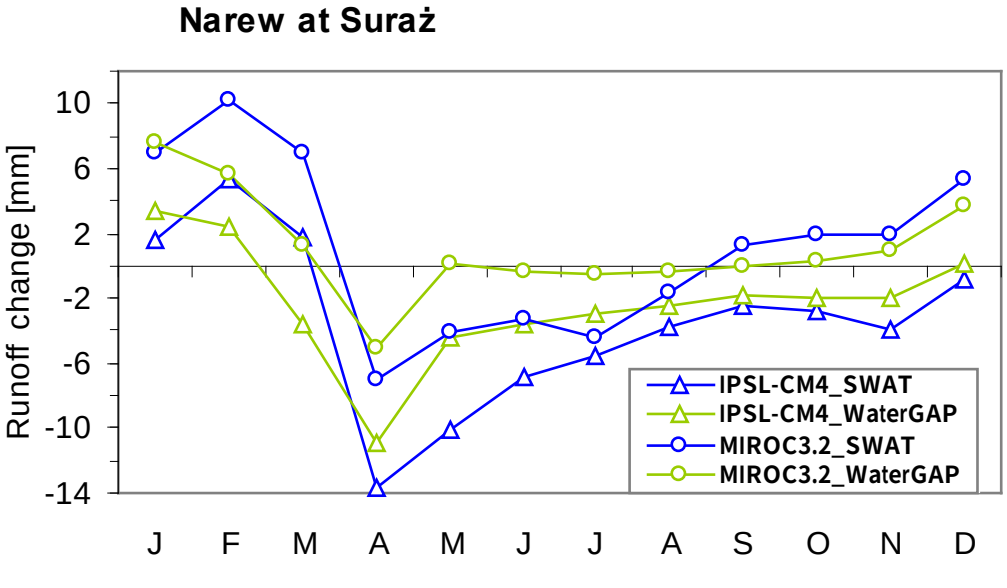


Changes in seasonal cycle (monthly runoff)



Absolute changes in mean monthly runoff





- Direction of change ☑
- Magnitude of change ~
- Higher sensitivity to climate change impulse of SWAT
- Larger impacts and larger inconsistency in smaller catchments

Conclusions & Outlook

- Simple indicators, qualitatative assessment => good agreement
- When to use a global model, when to use a catchment model?
- Uncertainty due to climate models much larger than due to hydrological models (in this region)
- Impact on environmental flows?

Thank you!