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Abteilung Hydrologie und Wasserwirtschaft

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Leibniz-Institute of Freshwater Ecology and Inland Fisheries

Streamflow-based evaluation of climate model sub-selection methods

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Glance projects

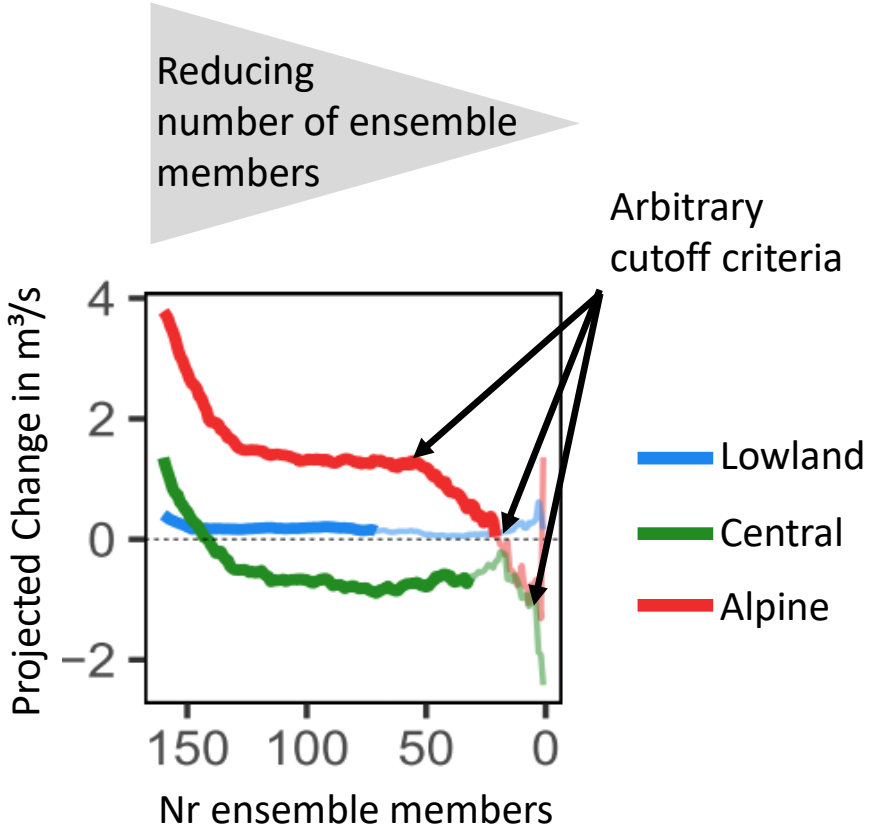
global change effects on river ecosystems

Bundesministerium für Bildung und Forschung

ISIMIP Workshop, 12.01.2021, Latest Results Session

The climate change ensemble selection problem

Projected average streamflow change in three German catchments



Kiesel et al. (2019) Ecol. Eng.

Sub-selection methods to deal with the ensemble problem

Sub-selection methods (discussed by *Eyring et al. 2019, Nat Clim Chang***)**

- democracy/full ensemble (Dem) (e.g. *IPCC 2013*)
- diversity of Global Circulation Models (DivG)
- diversity of Regional Climate Models (DivR)

} (*Abramowitz et al. 2019, Earth Syst Dynam*)

- trading off information content and redundancy (MIMR) (*Pechlivanidis et al. 2018, WRR*)
- best performing climate depiction (bCl) (*Ruane and McDermid 2017, Earth Perspectives*)
- best performing variable of interest (bSf) (*Kiesel et al. 2019, Ecol Eng*)
- climate model weighing (sWGT) (*Knutti et al. 2017, Geophys Res Lett*)
- reliability ensemble average (REA) (*Tebaldi and Knutti 2007, Phil Trans R Soc A*)

Motivation

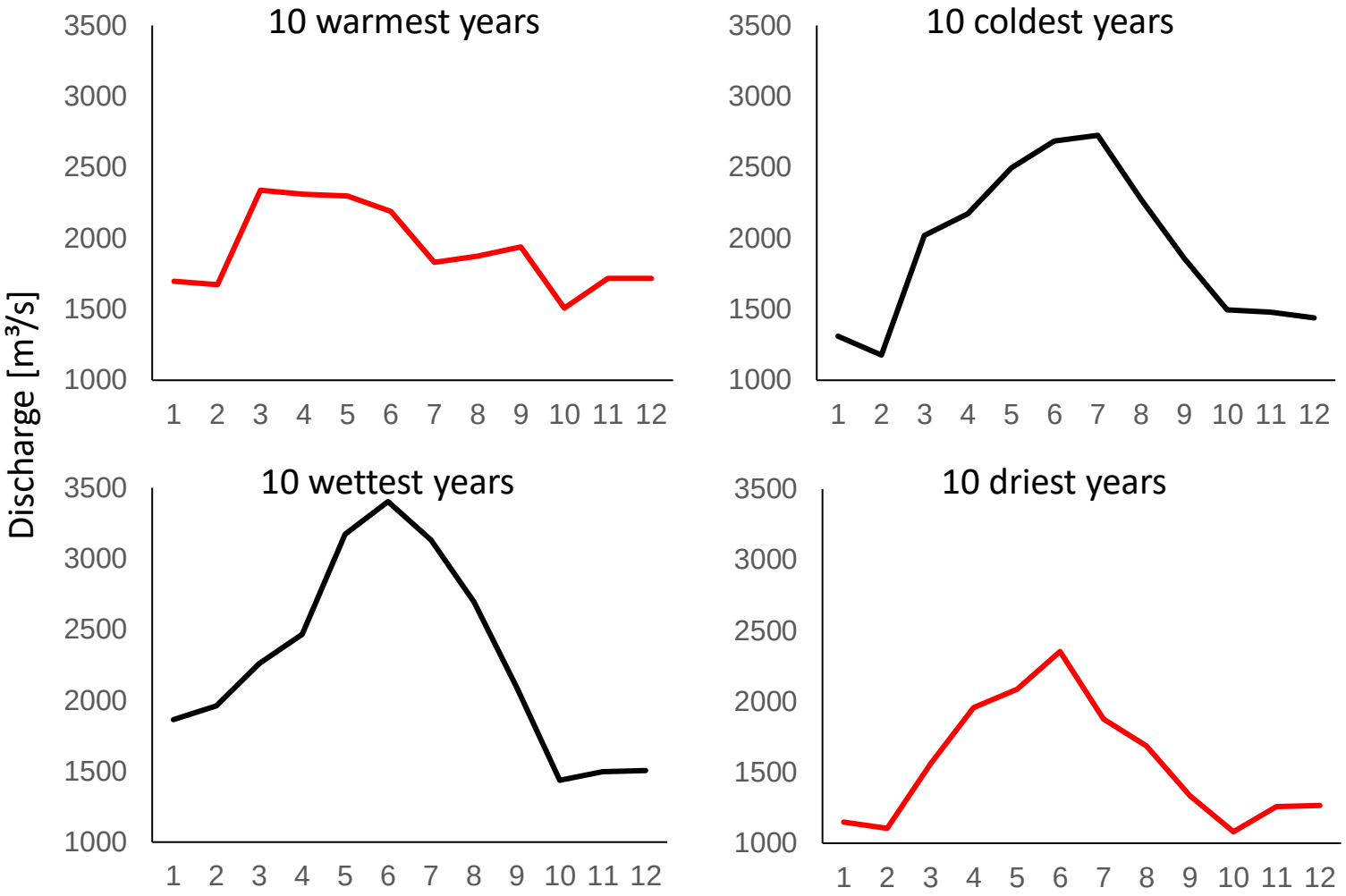
- **Is there a way to validate which of these sub-selection methods is “best”?**

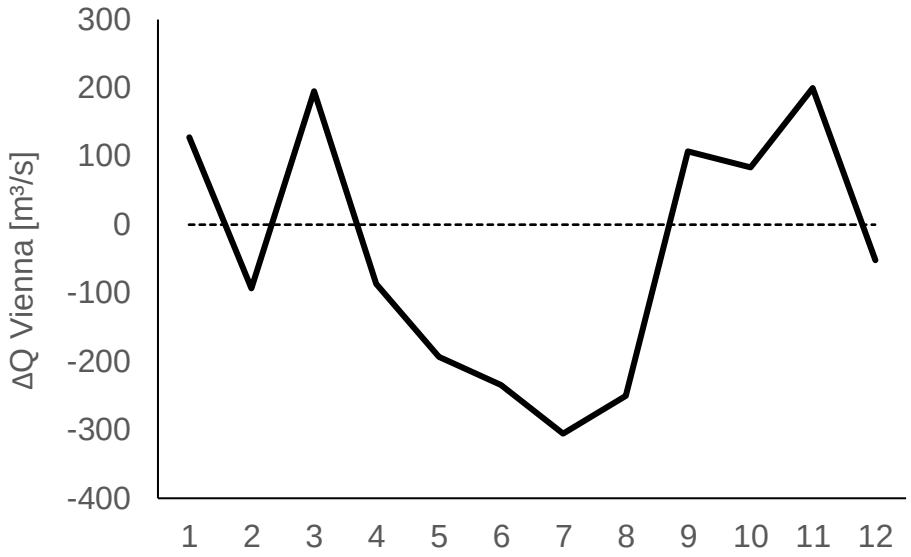
Approach

- Climate models are applied to predict the change from present to future
- We don‘t know the future…but we know the past impact of climate change (*Blöschl et al. 2017, Science*)
- Models that can’t predict past climate change are less well suited to predict an aggravated, future change

Danube: Temporal dependence discharge seasonality

Observed Discharge: Danube at Vienna (1901-2007)





Warmer, drier climate -> less pronounced seasonality
(*Kling et al. 2012, J Hydrol*)

➡ **Evaluate which model ensemble can depict impacts of the warming climate best**

Climate model sub-selection assessment - Methodology

Hindcasted climate change data

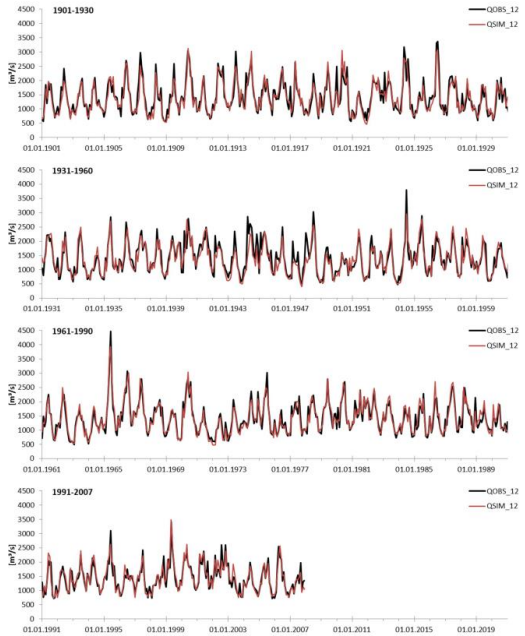
www.cordex.org

16 combinations of GCM + RCM (RCP8.5)

Linear Scaling bias correction (1960-1990)

Jacob et al. 2014, Reg Env Change
Stanzel et al. 2018, J Hydrol

COSERO Model Upper Danube

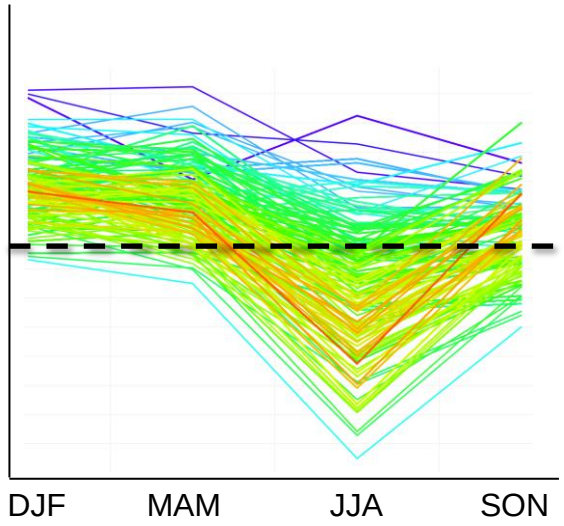


High-performance hydrological model (>100 yr)

5-step evaluation (*Krysanova et al. 2018*)

Kling et al. 2012, J Hydrol

Hindcasted seasonality (1960-1989 vs 1990-2015)



For 16 GCM-RCM

All possible medians

Kiesel et al. 2020, Clim Change

Evaluation

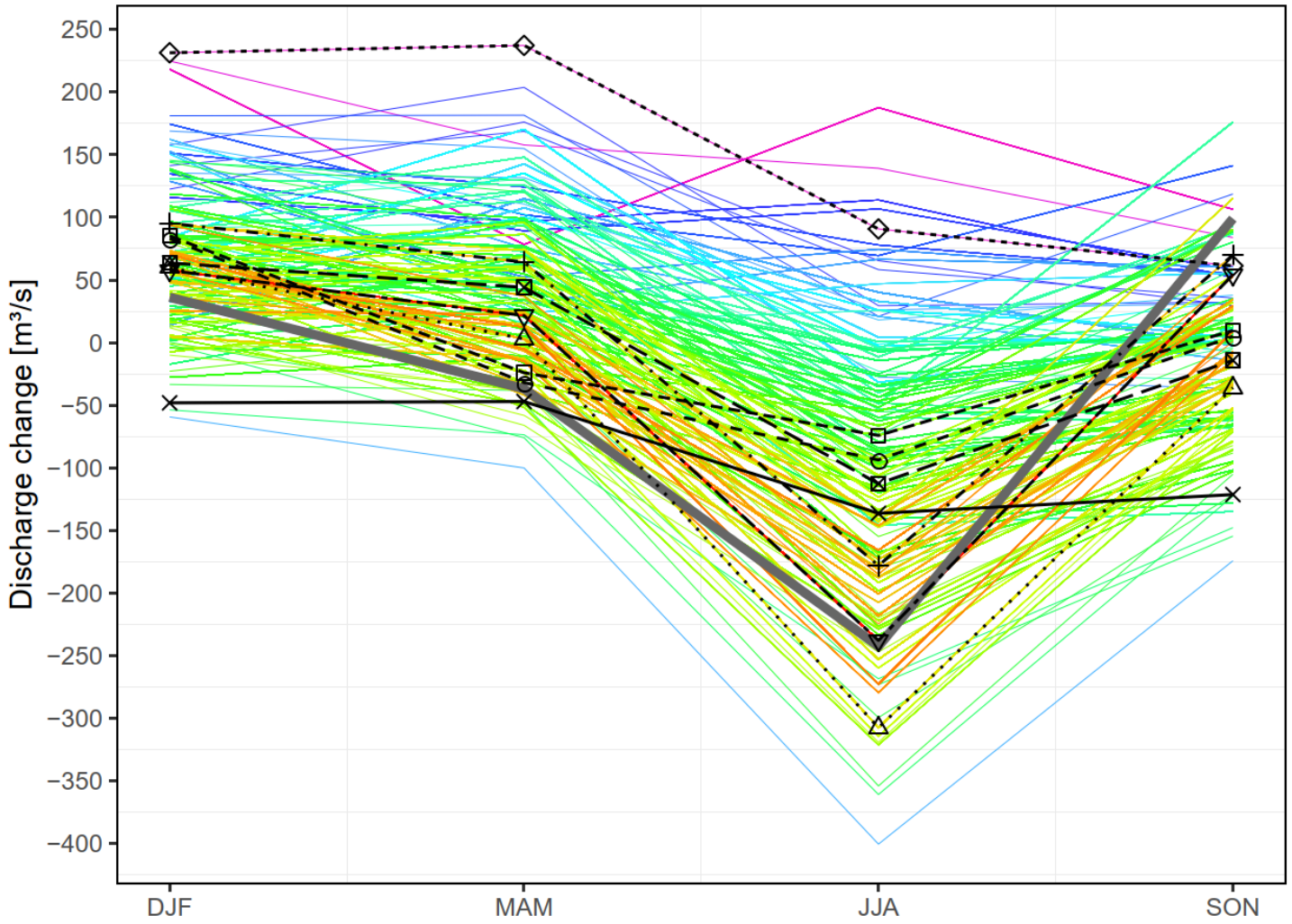
- bCl
- bSf
- Dem
- DivG
- DivR
- MIMR
- REA
- sWgt

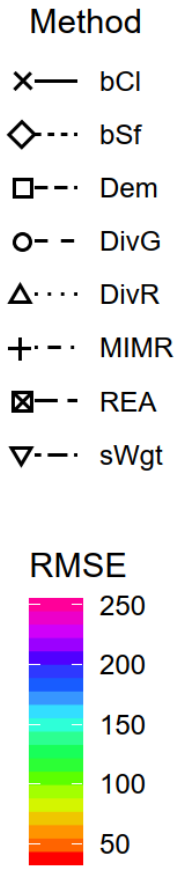
Median selection

RMSE against observed change

Kiesel et al. 2020, Clim Change

Climate Models: Agreement with observed sign of change

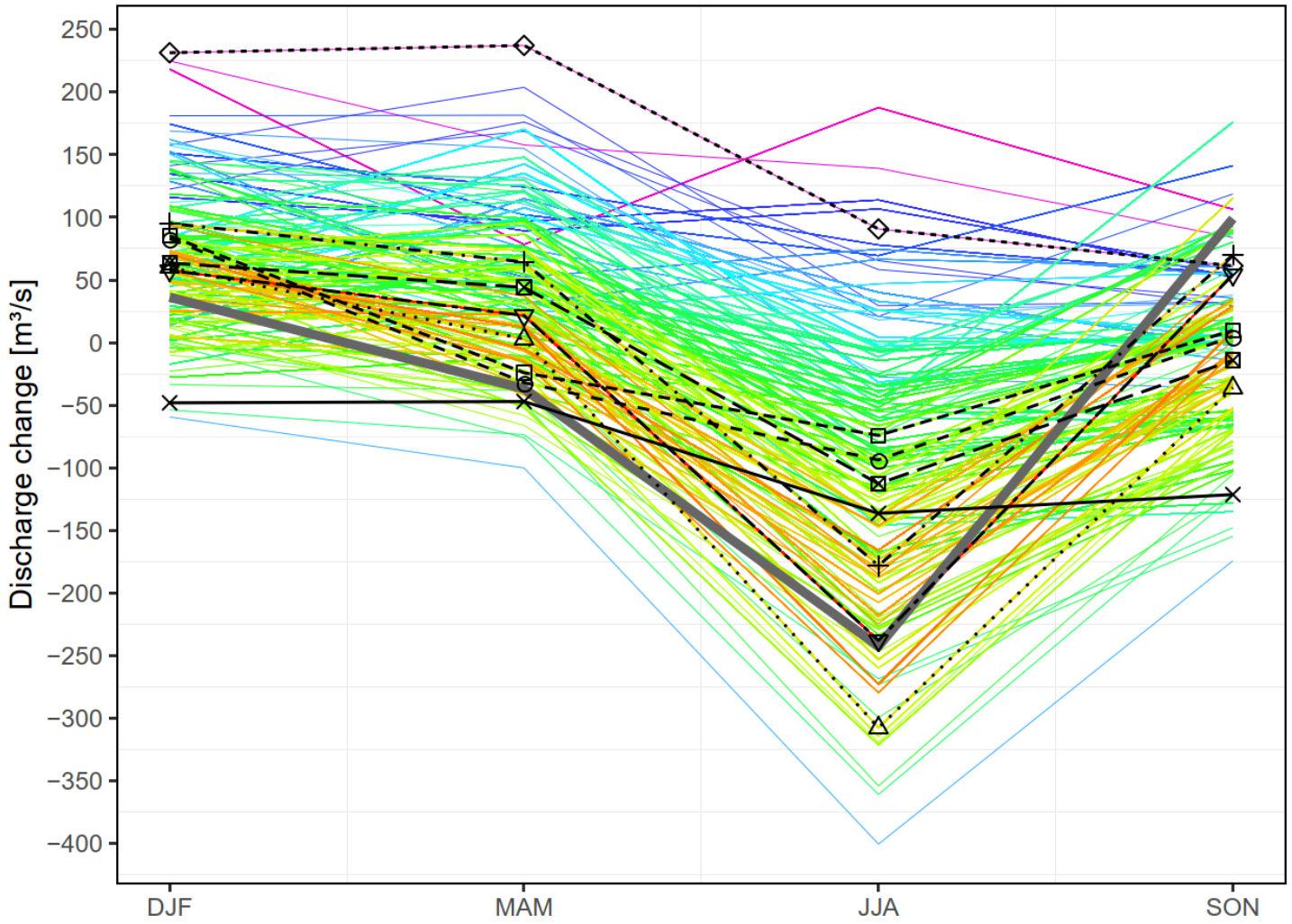


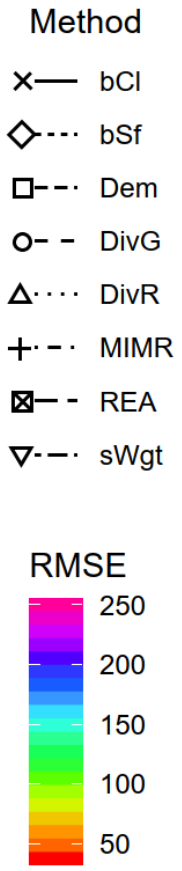


GCM	RCM	Method	RMSE	Rank
KNMI-RACMO	ICHEC	**sWgt**	38	1
-	-	**MIMR**	68	2
CLMcom-CCLM	MOHC	**DivR**	78	3
DMI-HIRHAM	**ICHEC**	**DivG**	**91**	**4**
CLMcom-CCLM	CNRM		94	5
MPI-REMO	MPIr1		95	6
-	-	**REA**	96	7
-	**-**	**Dem**	**99**	**8**
KNMI-RACMO	**MOHC**		**107**	**9**
SMHI-RCA	ICHEC		117	10
CLMcom-CCLM	ICHEC	**bCl**	130	11
SMHI-RCA	MPI		141	12
IPSL-WRF	IPSL		142	13
CLMcom-CCLM	MPI		157	14
SMHI-RCA	CNRM		157	15
SMHI-RCA	MOHC		168	16
CNRM-ALADIN	CNRM		169	17
MPI-REMO	MPIr2	**bSf**	238	18
SMHI-RCA	IPSL		241	19

Correct reproduction of direction of change in all seasons

Sub-selection methods: Agreement with observed change





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Best RMSE
Worst RMSE

Conclusions

- Splitting historic observations into a reference and evaluation period can be beneficial to assess historic climate change impact
- Wide range of performance differences between sub-selection methods indicates that the selection matters
- Methods maintaining and maximizing diversity and information content clearly outperformed methods that reproduce historical climate or streamflow best
- To yield more robust conclusions, we suggest to test the proposed methods using multiple hydrological models in multiple basins located under a strong hydro-climatic gradient

Thank you!

Kiesel J, Stanzel P, Kling H, Fohrer N, Jähnig S, Pechlivanidis I. 2020. Streamflow-based evaluation of climate model sub-selection methods. Climatic Change, https://doi.org/10.1007/s10584-020-02854-8. In: Krysanova V, Hattermann FF, Kundzewicz ZW. 2020. How evaluation of hydrological models influences results of climate impact assessment—an editorial.