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High-resolution climate forcing data & sensitivity experiments

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- Advancements in Downscaling Algorithms Beyond Temperature and Precipitation for the CHELSA Dataset
- High-resolution climate forcing sensitivity experiments (TG 1.7)
 - Overview & first results





CHELSA – W5E5 variables in ISIMIP

shortname	description	CF Standard Name	levels	frequency
tas tasmax	daily-mean near-surface (2 meter) air temperature daily-maximum near-surface (2 meter) air temperature	air temperature air temperature	surface surface	day day
tasmin	daily-minimum near-surface (2 meter) air temperature	air temperature	surface	day
rsds	total downwelling shortwave solar radiation	surface downwelling shortwave flux in air	surface	day
pr	daily precipitation flux (liquid and solid)	precipitation flux	surface	day







Philipp Brun



Brun, P., Zimmermann, N.E., Hari, C., Pellisier, L., Karger, D.N. (2022) Global climate-related predictors at kilometer resolution for the past and future, Earth System Science Data 14, 5573–5603 https://doi.org/10.5194/essd-14-5573-2022



CHELSA – variables

shortname	description	CF Standard Name	levels
tas	daily-mean near-surface (2 meter) air temperature	air temperature	surface
tasmax	daily-maximum near-surface (2 meter) air temperature	air temperature	surface
tasmin	daily-minimum near-surface (2 meter) air temperature	air temperature	surface
rsds	total downwelling shortwave solar radiation	surface downwelling shortwave flux in air	surface
rlds	total downwelling longwave solar radiation	surface downwelling longwave flux in air	surface
hurs	daily-mean near-surface (2 meter) relative humidity	relative humidity	surface
pr	daily precipitation flux (liquid and solid)	precipitation flux	surface
ps	daily mean near-surface (2 meter) air pressure	surface air pressure	surface
clt	surface total cloud area fraction	cloud area fraction	surface
tz	near surface temperature lapse rate	-	surface
sfcWind	daily-mean 10m wind speed	wind speed	surface



Where are we going with this?

- Monthly versions are online
- Daily version is in production (delayed due to CDS server switch)
- R package to access data on gitlabext.wsl.ch (beta version)
- Aim is: to produce a comprehensive dataset for 1940-today
- No CMIP planned yet (storage and compute problems)

High-resolution climate forcing sensitivity experiments

Adohris - Advantages of downscaling climate to high resolution for climate change impact studies





Which results are already in?



SIMSTRAT at 32 ISIMIP regional lakes: 30", 90", 300", 1800" MITgcm at lake Kinneret: 30", 90", 300"

→ Evaluated based on observed temperature profiles



5 point-scale models at 4 PROFOUND sites: 30", 90", 300", 1800"
→ Evaluated based on in-situ carbon & water fluxes, stand-data



CWATm at Bhima basin: 30", 90", 300", 1800"
GR4J across Norway: 30", 90", 300", 1800"
SWAT model at 4 river basins around lake Kinneret: 90", 300", 1800"
SWIM model at Zeravshan catchment (10300km²): 300", 1800"
→ Evaluated based on river discharge and water storage

Simulation location across sectors and models



What's to come?



First results – lakes, water and forest sector

S		0.27	0 27 (-0 001)	0.27 (-0.002)	0.27 (-0.002)
e	SIMSTRAT	0.21	0.21 (0.001)	0.21 (0.002)	0.21 (0.002)
a	MITacm		0.25 (0.0)	0.24 (-0.009)	0.24 (-0.01)
-	Wingen				
	SWAT	0.77	0.74 (-0.038)	0.73 (-0.044)	0.73 (-0.044)
Water	CWatM GR4J	2.49	2.4 (-0.092)	2.38 (-0.107)	2.39 (-0.105)
		1.16	1.1 (-0.059)	1.15 (-0.016)	1.1 (-0.06)
	SWIM	0.38	0.31 (-0.067)		
	3D-CMCC	0.78	0.75 (-0.026)	0.76 (-0.02)	0.73 (-0.047)
rest	3PGHydro 3PGN-BW	1.04	1.01 (-0.031)	1.03 (-0.009)	0.96 (-0.077)
		0.78	0.75 (-0.032)	0.76 (-0.019)	0.73 (-0.048)
R	4C	0.71	0.69 (-0.014)	0.69 (-0.016)	0.69 (-0.021)
	BBGCMuSo	0.7	0.69 (-0.011)	0.7 (0.005)	0.7 (-0.003)
		60km	10km	3km	1km
		-0.10	-0.08 -0.06	-0.04 -0.02	0.00

-0.08 -0.06 -0.04 ΔNRMSE

60km 1km: Forcing improvement == simulation improvement



Global Historical Climatology Network daily (GHCNd)

60km ► 1km: Effect of topography



△ NRMSE (60km - 1km)

60km ▶ 10km vs. 3km ▶ 1km





Acknowledgements















POTSDAM INSTITUTE FOR **CLIMATE IMPACT RESEARCH**







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Karger, D.N., Lange, S., Hari, C., Reyer, C.O.P., Conrad, O., Zimmermann, N.E., Frieler, K. (in press) CHELSA-W5E5: Daily 1 km meteorological forcing data for climate impact studies. *Earth System Science Data*. https://doi.org/10.5194/essd-2022-367

Comparison with GHCN-D

- Correlation usually higher for the highres data, except for rsds
- tasmax and tasmin have various shifts in bias (stations?)
- rsds has lower bias in the highres data





Karger, D.N., Lange, S., Hari, C., Reyer, C.O.P., Conrad, O., Zimmermann, N.E., Frieler, K. (in press) CHELSA-W5E5: Daily 1 km meteorological forcing data for climate impact studies. *Earth System Science Data*. <u>https://doi.org/10.5194/essd-2022-367</u>

High-resolution climate forcing data What is available for ISIMIP3?



Coarse resolution



Daily
 minim

- Daily precipitation, solar radiation, minimum/maximum/mean temperature
- 30" / 90" / 300" / 1800"
- Historical period (1979 2016)
- Download via ISIMIP data portal (<u>https://data.isimip.org/search/query/chelsa/</u>)



What about the forcing data? GHCN data analysis – example ISIMIP lake



High-resolution climate forcing data

Absolute differences between coarse (W5E5 0.5°) and high-resolution (30arcsec) CHELSA data

Mean Daily Precipitation



Minimum Daily 2m Air-Temperature

Mean Daily 2m Air-Temperature



Maximum Daily 2m Air-Temperature



Downwelling Shortwave Solar Radiation





Karger, D.N., Lange, S., Hari, C., Reyer, C.O.P., Conrad, O., Zimmermann, N.E., Frieler, K. (in press) CHELSA-W5E5: Daily 1 km meteorological forcing data for climate impact studies. *Earth System Science Data*. <u>https://doi.org/10.5194/essd-2022-367</u>

Comparison to other high resolution products





- Better representation of orographic rain effects
- >100 x faster than a numerical model, but not a complete representation of all processes
- Avoids problems of pure statistical interpolations based on stations

Karger, D.N., Wilson, A.M., Mahony, C., Zimmermann, N.E., Jetz, W. (2021) Global daily 1km land surface precipitation based on cloud cover-informed downscaling. *Scientific Data.* doi.org/10.1038/s41597-021-01084-6