

Supporting Information for

OpenBench: a land models evaluation system

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Table S1. Dataset for crop-related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download Link
GDHY	Crop yield	0.5°/Yearly	1981-2016	Global	Iizumi and Sakai (2020)	https://doi.pangaea.de/10.1594/PANGAEA.909132
SPAM	Crop yield	0.5°/Yearly	2000, 2010, 2020	Global	Yu et al. (2020)	https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/SWPE-NT
Grogan2022	Crop yield	0.083333°/Yearly	2010	Global	Grogan et al. (2022)	https://doi.org/10.7910/DVN/XGGJAV
Wit2022	Crop development stage, Total above ground production, Total weight storage organs	0.1°/Monthly	1999-2023	Global	Wit (2022)	DOI: 10.24381/cds.b2f6f9f6
Monfreda2008	Production, Yield, Harvested area, Harvested area	0.1°/Yearly	2000	Global	Monfreda et al. (2008)	http://www.earthstat.org/harvested-area-yield-175-crops/
GIWUED	Water use	0.25°/Monthly	2011-2018	Global	Zhang et al. (2022a)	https://doi.org/10.11888/hydro.tpd.271220
GGMSEUD	Water use	0.5°/Monthly	1971-2010	Global	Huang et al. (2018)	https://zenodo.org/records/1209296
ChinaCropPhen1km	Crop phenology	1km/Yearly	2000-2019	China	Luo et al. (2020)	https://doi.org/10.6084/m9.figshare.8313530
GCPE	Crop phenology	0.5°/Yearly	2020	Global	Mori et al. (2023)	https://doi.org/10.2480/agromet.D-23-00004
CROPGRIDS	Harvested and Crop (physical) area	0.05°/Yearly	2020	Global	Tang et al. (2024a)	https://figshare.com/articles/dataset/CROPGRIDS/22491997
AgERA5	Crop forcing	0.1°/Daily	1979-2023	Global	Copernicus Climate Change Service (2019)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-agrometeorological-indicators?tab=overview

15 **Table S2.** Dataset for urban-related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download Link
Urban-PLUMBER	Atmospheric forcing, Flux measurement	Station/Hourly	2003-2020	Global	Harris et al. (2020b); Lipson et al. (2024)	https://doi.org/10.5281/zenodo.7104984
ERA5-HEAT	Heat index	0.25°/Hourly	1940-2023	Global	Di Napoli et al. (2021)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/derived-utci-historical?tab=overview
UEHNL	Urban extention	1km/Yearly	1992-2020	Global	Zhao et al. (2022)	https://doi.org/10.6084/m9.figshare.16602224.v1
GSDLST	Surface temperature	1km/Daily	2003-2020	Global	Zhang et al. (2022b)	https://doi.org/10.25380/iastate.c.5078492
CHIRTS	Max and Min temperature	0.05°/Daily	1983-2016	Quasi-global	Verdin et al. (2020)3/24/2025 10:55:00 AM	https://www.chc.ucsb.edu/data/chirtsdaily
MCD43A3	Albedo	500m/16-daily	2000-2024	Global	Schaaf and Wang (2015)	https://doi.org/10.5067/MODIS/MCD43A3.006
ETMonitor	Evapotranspiration	0.5°/Monthly	2001-2019	Global	Zheng et al. (2022)	DOI: 10.12237/casearth.6253cdde819aec49731a4bc2
AH4GUC	Anthropogenic heat flux	1km/Hourly	2010	Global	Varquez et al. (2021)	https://figshare.com/articles/dataset/Global_1-km_present_and_future_hourly_anthropogenic_heat_flux/12612458/6
DONG_AHE	Anthropogenic heat flux	1km/Hourly	2013	Global	Dong et al. (2017)	http://www-old.ide.titech.ac.jp/~kandalab/ja/news/2016/AHE_release_20161212_files/AHE_release_20161212.htm
China_AHE	Anthropogenic heat flux	500m/Yearly	2000-2016	Global	Wang et al. (2020)	https://data.tpdc.ac.cn/en/data/637e99a1-be38-4a9f-8af9-a8600e13d568
PF-AHF	Anthropogenic heat flux	1km/Yearly	1970-2050	Global	Jin et al. (2019)	https://doi.org/10.6084/m9.figshare.c.4182824.v1
Qian2024	Anthropogenic heat flux	500m/Yearly, Month and Hourly	-	China	Qian et al. (2024)	https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/VIJFPK
MODIST	Surface temperature	1km/Daily	2003-2020	Global	Zhang et al. (2022b)	https://iastate.figshare.com/collections/A_global_seamless_1_km_resolution_daily_land_surface_temperature_dataset_2003_2020_/5078492

TRIMS	Surface temperature	1km/Daily	2000-2022	Global	Tang et al. (2024b)	https://doi.org/10.11888/Meteoro.tpd.271252
SVCM-SP	Air temperature	1km/Daily	2003-2020	Global	Zhang et al. (2022c)	https://doi.org/10.25380/iastate.c.6005185

Table S3. Dataset for dam, river, and Lake -related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download Link
ResOpsUS	Inflow, Outflow, Water storage and Water depth	Station/Daily	1930-2020	US	Steyaert et al. (2022)	https://doi.org/10.5281/zenodo.5893641
ReaLSAT	Surface area variations	Vector/Monthly	1984-2020	Global	Khandelwal et al. (2022)	https://doi.org/10.5281/zenodo.4118463
G-REALM	Water depth	Vector/10-daily	1992-2023	Global	The Global Reservoir and Lake Monitor	https://ipad.fas.usda.gov/cropexplorer/global_reservoir/
GLAST	Lake surface water temperature	Vector/Daily	1981-2020	Global	Tong et al. (2023)	https://zenodo.org/record/8322038
HydroWeb_2.0	Water depth for lake and river	Station/Monthly	1992-2021	Global	Santos Da Silva et al. (2010)	https://www.theia-land.fr/en/product/water-levels-of-rivers-and-lakes-hydroweb/
GRDC-RSEG	Discharge	Station/Monthly	1980-2020	Global	Elmi et al. (2024)	https://doi.org/10.18419/darus-3558
HydroSat	Surface water extent, Water level, River discharge and Water storage anomaly	Station/Monthly	Various	Global	Elmi and Tourian (2023)	https://hydrosat.gis.uni-stuttgart.de/php/index.php
Dai2021	Discharge	Station/Monthly	1950-2018	Global	Dai (2021)	https://rda.ucar.edu/datasets/d551000/
GSIM	Discharge	Station/Monthly	1806-2016	Global	Do et al. (2018)	https://doi.pangaea.de/10.1594/PANGAEA.887477
GSHA	Discharge	Station/Monthly	1806-2021	Global	Yin et al. (2024)	https://zenodo.org/records/10433905
CAMELS	Discharge	Station/Monthly	1980-2015	Global	Addor et al. (2017)	https://gdex.ucar.edu/dataset/camels.html
CAMELS-Chem	Atmospheric and Stream water chemistry data	Station/Monthly	1980-2018	US	Sterle et al. (2024)	https://www.hydroshare.org/resource/841f5e85085c423f889ac809c1bed4ac/
Caravan	Discharge	Station/Daily	Various	Global	Kratzert et al. (2023)	https://doi.org/10.5281/zenodo.7540792; https://github.com/kratzert/Cara

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GRDC	Discharge	Station/ Daily- Monthly	1806- 2023	Global	The Global Runoff Data Centre (2022)	https://portal.grdc.bafg.de/applications/public.html?publicuser=PublicUser
GIEMS_v2	Inundation	0.25°/M onthly	1990- 2020	Global	Prigent et al. (2020)	https://catalogue.ceda.ac.uk/uuid/1d01d0efb6c24c218489605b5aa44cf5/
Glofas4.0	Discharge	0.05°/Da ily	1980- 2023	Global	Harrigan et al. (2020)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/cems-glofas-historical?tab=form
GRADES-hydroDL	Discharge	Station/ Daily	1980- 2023	Global	Lin et al. (2019); Yang et al. (2023)	https://www.reachhydro.org/home/records/grades-hydrodl
China_Major_River	Discharge	Station/ Monthly	1950- 2023	China	Wei et al. (In preperation)	-
Reservoir_area_storage_in_China	Inundated areas and Water storage dynamics	Vector/ Monthly	2017- 2021	China	Chen et al. (2024)	https://doi.pangaea.de/10.1594/PANGAEA.961148
GCOS	Lake surface water temperature	0.05°/Da ily	1995- 2023	Global	Copernicus Climate Change Service Climate Data Store (2020)	DOI: 10.24381/cds.d36187ac
HYDAT	Discharge, Water levels and Sediment concentrations	Station/ Daily	Various	Canada	-	https://collaboration.cmc.ec.gc.ca/cmc/hydrometrics/www/

Table S4. Dataset for water cycle-related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download Link
ILAMB	Various	0.5°/Monthly	Various	Global	Collier et al. (2018)	https://www.ilamb.org/ILAMB-Data/DATA/
ISMN	Soil Moisture	Station/Daily	Various	Global	Varquez et al. (2021)	https://ismn.earth/en/dataviewer/
PLUMBER2	Various	Station/Hourly	Various	Global	Ukkola et al. (2022)	https://researchdata.edu.au/plumber2-forcing-evaluation-surface-models/1656048
GSSM1km	Soil Moisture	1km/Daily	2000- 2020	Global	Han et al. (2023)	https://doi.org/10.6084/m9.figshare.21806457.v2
LORA	Total runoff	0.5°/Monthly	1980- 2012	Global	Hobeichi et al. (2019)	https://geonetwork.nci.org.au/geonetwork/srv/eng/catalog.search#/metadat

a/f9617_9854_8096_5291						
GRUN-ensemble	Total runoff	0.5°/Monthly	1902-2019	Global	Ghiggi et al. (2021)	https://doi.org/10.6084/m9.figshare.12794075.v1
GRAiCE	TWSC	0.5°/Monthly	1984-2021	Global	Palazzoli et al. (2025)	https://doi.org/10.5281/zenodo.10953658
GRACE-REC	TWSC	0.5°/Daily	1979-2019	Global	Humphrey and Gudmundsson (2019)	https://doi.org/10.6084/m9.figshare.7670849.v3
GRACE-SeDA	TWSC	0.5°/Monthly	2002-2022	Global	Gou and Soja (2024)	https://www.research-collection.ethz.ch/handle/20.500.11850/648738
GlobSnow_v3	Snow water equivalent	0.25°/Daily	1979-2018	Northern Hemisphere	Luo et al. (2021)	https://www.globsnow.info/swe/archive_v3.0/
SnowEx23	Various	Various	2016-2023	US	-	https://nsidc.org/data/snowex/data
NH-SWE	Snow water equivalent	Station /Daily	1950-2022	Northern Hemisphere	Fontrodona-Bach et al. (2023)	https://doi.org/10.5281/zenodo.7515603
ERA5-Land	Various	0.1°/Hourly	1950-2024	Global	Muñoz-Sabater et al. (2021)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=overview
Xu2024	Total evaporation	0.1°/Daily	1950-2022	Global	Xu et al. (2024)	https://zenodo.org/records/10906128
X-BASE	Total evaporation, transpiration	0.05°/Hourly	2001-2020	Global	Nelson et al. (2024)	https://meta.icos-cp.eu/collections/zfwf1Ak2I7OlziGDTX8Xl6_T
FLUXCOM	Total evaporation	0.5°/Daily	1950-2016	Global	Jung et al. (2019)	https://www.fluxcom.org/EF-Products/
GLEAM4.2a	Various	0.1°/Daily	1980-2023	Global	Miralles et al. (in review)	https://www.gleam.eu/#downloads
NEON	Total evaporation, Transpiration	Station/Hourly	2019-2023	United States	Zahn and Bou-Zeid (2024)	https://zenodo.org/records/12191876

GLEAM_hybrid	Total evaporation, Transpiration	Station/Daily	Various	Global	Koppa et al. (2022)	https://doi.org/10.5281/zenodo.5886608
Li2024	Transpiration	0.1°/Daily	2000-2020	Global	Li et al. (2024)	https://doi.org/10.6084/m9.figshare.24320866.v1
CNRDv1.0	Total runoff	0.25°/Monthly	1961-2018	China	Gou et al. (2021)	https://figshare.com/articles/dataset/CNRDv1_0/13185410
GRFR	Total runoff	0.05/3-hourly	1980-2019	Global	Yang et al. (2021)	https://www.reachhydro.org/home/records/grfr
GRFR_025	Total runoff	0.05°/3-hourly	1980-2019	Global	Yang et al. (2021)	https://www.reachhydro.org/home/records/grfr
GRAD-ES	Total runoff	0.25°/Daily	1979-2013	Global	Lin et al. (2019);Yang et al. (2019)	https://www.reachhydro.org/home/records/grades
Lian2022	Canopy interception	0.5°/Monthly	2000-2020	Global	Lian et al. (2022)	https://doi.org/10.5281/zenodo.7309030
SMC11.0	Soil moisture	1km/Daily	2000-2022	China	Shangguan Wei (2024)	https://data.tpdac.cn/en/data/49b22de9-5d85-44f2-a7d5-a1ccd17086d2
SMAPL3	Soil moisture	0.5°/Monthly	2016-2020	Global	Oneill et al. (2023)	https://nsidc.org/data/spl3smp/versions/9
SMAPL4	Various	0.5°/Daily	2016-2024	Global	Reichle et al. (2022)	https://nsidc.org/data/spl4smgp/versions/7#anchor-documentation

Table S5. Dataset for Ecosystem and Carbon Cycle -related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download Link
ILAMB	Various	0.5°/Monthly	Various	Global	Collier et al. (2018)	https://www.ilamb.org/ILAMB-Data/DATA/
GIMMS_LAI4g	LAI	0.5°/Monthly	1982-2020	Global	Cao et al. (2023)	https://doi.org/10.5281/zenodo.7649107
Lin2023	LAI	500m/8-daily	2000-2023	Global	Lin et al. (2023)	http://globalchange.bnu.edu.cn/research/laiv061#download
Yuan2011	LAI	Station/Monthly	Various	Global	Yuan et al. (2011)	-
X-BASE	GPP and NEE	0.05/Hourly	2001-2020	Global	Nelson et al. (2024)	https://meta.icos-cp.eu/collections/zfwf1Ak2I7OlziGDTX8XI6_T

FLUXCOM	GPP and NEE	0.5°/Daily	1950-2016	Global	Jung et al. (2019)	https://www.fluxcom.org/EF-Products/
Zheng2020	GPP	0.05°/8-daily	1982-2017	Global	Zheng et al. (2020)	https://doi.org/10.6084/m9.figshare.8942336.v3
Zhang2017	GPP	500m/8-daily	2000-2016	Global	Zhang et al. (2017)	https://doi.org/10.6084/m9.figshare.c.3789814.v1
Soilgridv2	Soil organic carbon	0.25°(remaped)/Constant	-	Global	Poggio et al. (2021)	https://www.isric.org/explore/using-soilgrids-interface
PLUMBER2	Various	Station/Hourly	Various	Global	Ukkola et al. (2022)	https://researchdata.edu.au/plumber2-forcing-evaluation-surface-models/1656048
CEDA	Burn area, Above-ground biomass	1km/Monthly, 1km/Yearly	1982-2018, 2001-2017 and 2019; 2010 and 2015-2021	Global	Chuvieco et al. (2018, 2020); Santoro and Cartus (2024); Van Der Velde et al. (2024)	https://data.ceda.ac.uk/neodc/esacci/biomass/data/agb/maps/v5.01/netcdf ; https://data.ceda.ac.uk/neodc/esacci/fire/data/burned_area
Huang2021	Above-ground biomass, Root biomass	1km/Yearly	-	Global	Huang et al. (2021)	https://doi.org/10.6084/m9.figshare.12199637.v1
Xu2021	Above-ground biomass	0.1°/Yearly	2000-2019	Global	Xu et al. (2021)	https://zenodo.org/records/4161694
GFED5	Burn area	0.25°/Monthly	1997-2020	Global	Chen et al. (2023)	https://zenodo.org/records/7668424
Liu2024	Fraction of ground covered by green vegetatio	250m/Yearly	2000-2021	Global	Liu et al. (2024)	https://zenodo.org/records/10589730

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FLUXNET-CH4	methane	Station/Hourly	Various	Global	Delwiche et al. (2021)	https://fluxnet.org/data/fluxnet-ch4-community-product/

Table S6. Dataset for Radiation and Energy Cycle -related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download link
ILAMB	Various	0.5°/Monthly	Various	Global	Collier et al. (2018)	https://www.ilamb.org/ILAMB-Data/DATA/
GLEAM v4.2a	Sensible heat	0.1°/Daily	1980-2023	Global	Miralles et al. (in review)	https://www.gleam.eu/#downloads
ERA5-Land	Various	0.1°/Hourly	1950-2024	Global	Muñoz-Sabater et al. (2021)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=overview
PLUMBER 2	Various	Station/Hourly	Various	Global	Ukkola et al. (2022)	https://researchdata.edu.au/plumber2-forcing-evaluation-surface-models/1656048
CLARA_A VHR	Various	0.25°/Monthly	1979-2020	Global	Copernicus Climate Change Service (2021)	https://doi.org/10.24381/cds.85a8f66e
CERES_EBAF_Ed4.2	Various	1°/Monthly	2000-2024	Global	Kato et al. (2018); Loeb et al. (2018)	https://ceres.larc.nasa.gov/data/
Xu2022	Net radiation	0.05°/Daily	1981-2019	Global	Xu et al. (2022)	https://doi.org/10.5281/zenodo.5546316
GEBA	Various	Station/Monthly	1902-2022	Global	Wild et al. (2017)	https://geba.ethz.ch/
HOMTS	Land surface temperature	0.25°/Daily	1960-2017	China	D. Wang et al. (2021, 2023)	https://doi.org/10.1002/joc.7959
SMAPL4	Various	0.1°/3-hourly	2016-2024	Global	Reichle et al. (2022)	https://nsidc.org/data/spl4smgp/versions/7
FLUXCOM	Various	0.5°/Daily	1980-2014	Global	Jung et al. (2019)	https://www.fluxcom.org/EF-Products/
CARE	Surface downward longwave radiation	0.25°/Hourly	2000-2020	Global	Letu et al. (2023); Wang and Wang (2022)	http://www.slrss.cn/care_zh/cp/sjxz/
CLARA_3	Various	0.25°/Monthly	1979-2024	Global	Karlsson et al. (2023)	https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=CLARA_AVHRR_V003

25 **Table S7.** Dataset for Forcing -related references available for OpenBench

Dataset	Items	Resolution	Period	Region	Reference	Download link
ILAMB	Various	0.5°/Monthly	Various	Global	Collier et al. (2018)	https://www.ilamb.org/ILAMB-Data/DATA/
MSWX	Various	0.1°/3-hourly	1979-2021	Global	Beck et al. (2022)	https://www.gloh2o.org/mswx/
MSWEPv2.8	Precipitation	0.1°/3-hourly	1979-2020	Global	Beck et al. (2019)	https://www.gloh2o.org/mswep/
CRU TS v4.08	Various	0.5°/Monthly	1901-2023	Global	Harris et al. (2020a)	https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.08/
CERES_EBAF_Ed4.2	Various	1°/Monthly	2000-2024	Global	Kato et al. (2018); Loeb et al. (2018)	https://ceres.larc.nasa.gov/data/
GPCP	Precipitation	0.5°/Daily and Monthly	1983-2020	Global	Huffman et al. (2023)	https://doi.org/10.5067/MEASURES/GPCP/DATA305; https://doi.org/10.5067/MEASURES/GPCP/DATA304
CLARA_3	Various	0.25°/Monthly	1979-2024	Global	Karlsson et al. (2023)	https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=CLARA_AVHRR_V003
CN051	Precipitation, Air temperature	0.5°/Daily and Monthly	1961-2021	China	Xu et al. (2009)	-
ERA5-Land	Various	0.1°/ Hourly	1950-2024	Global	Muñoz-Sabater et al. (2021)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=overview

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