River forcing data overview.

Version: 1.0
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Date: 21.10.2024

This document summarizes the data processing for each group of rivers and model variables during different periods spanning January 1950 to September 2024.

Raw data sources:

- In-situ measurements for Danube, Dnepr, and Dnestr (monthly resolution, starting in 1947, 1818, 1881)
- Daily discharge values for the Danube since 2020
- EFAS: Data is used from 1992 on. 6 hourly temporal resolution but resample to monthly. (https://ewds.climate.copernicus.eu/datasets/efas-historical?tab=overview)
- Ludwig/SESAME water discharge csv sheets (yearly resolution, 1960-2000). Also contains average climatology (distribution across months) for each river, though not used. We do not use rivers from the data sheet which have not been attributed a name and probably modeled values.
- Ludwig/SESAME nutrient discharge csv sheets (yearly resolution, 1960-2000)
- TNMN Database oxygen data for ukrainian stations of the Danube (1997-2021)
- Danube temperature file (1984-2018, monthly resolution), for different branches of Danube stuary

River forcing product specification:

- Gridded Files of monthly resolution (time,lat,lon). Horizontal resolution according to model setups (2.5 and 15km)
- Spans timer period January 1950 - September 2024.
- One file for physical and one for biogeochemical variables. Biogeochemical variables come as fluxes in mmol/s).
- Note that fluxes for the Danube are distributed across 3 (15km setup) and 5 (2.5km setup) river mouths, and the Dnepr across 1 and 2 river mouths. The Bug values are added on top of the dnepr values given our model resolution

Waterflux

	1950-1960	**1960-1991**	**1992-2019**	**2020-2024**
Danube	In-situ file	In-situ file	In-situ file	Daily discharge file averaged to monthly, used since January 2020.
Dnepr	In-situ file	In-situ file	In-situ file	In-situ file, EFAS since 2022*****
Dnestr	In-situ file	In-situ file	In-situ file	In-situ file, EFAS since 2023*****
Other rivers*	1960-1969 climatology	Ludwig/SESAME discharge values, modulated across months using EFAS mean from 1992-2000.******	EFAS	EFAS
Inguri	1992-2000 EFAS climatology	1992-2000 EFAS climatology	EFAS	EFAS

- ***** *EFAS values debiased wrt to in-situ data (adjustment of mean, in-situ is considered more reliable. Adjustment important to avoid jumps at transition between datasets)*
- ****** *Ludwig/Sesame debiasted wrt to EFAS data (adjustment of mean, EFAS is considered more reliable).*

Other rivers include:
Bug, Sakarya, Filyos, Kizil Irmak, Yesilirmak, Rioni, Cockroach, Kodori, Bzyb.
The Inguri is treated separately because it is not named in the Ludwig/SESAME csv sheets

Salinity: Using a constant value of 2 for all rivers.
Runoff depth: 9 meters (depth level 13) for all rivers

Nutrients (Nitrate, Phosphate and Silica)

	1950-1959	**1960-1999**	**2000-2024**
All rivers (except Inguri)	Ludwig/Sesame mean for period 1960-1969. Values modulated across months using monthly water discharge (see above). For Danube, Dnepr and Dnestr, where monthly water discharge data is available the monthly distribution will vary, for the rest it will be repetitive.	Yearly Ludwig/SESAME values modulated across months using monthly water discharge (see above). For all rivers except Danube, Dnepr and Dnestr this distribution is repetitive.	Extrapolation of Ludwig values using water discharge and coefficients from a linear regression between (our) yearly discharge values and Ludwig/Sesame nutrient values for period 1960-2000.
Inguri	1960-1969 climatology	Monthly water flux multiplied with linear regression parameters from Rioni	Water flux multiplied with linear regression parameters from Rioni

(Nitrate, Phosphate and Silica) distribution across related variables

- Nitrate (NO3) is 100% NO3 from Ludwig/Sesame file.
- Ammonium (NHS) is 10% of the Nitrate flux
- Dissolved Nitrogen (DNL and DNS) is one third of NO3+NHS (distributed 50-50 across DNL and DNS)
- Dissolved Carbon (DCL and CS) is Dissolved Nitrogen times 10.
- Silica is distributed 90% to SIO and 10% to SID.

Temperature

	1950-1983	**1984-2018**	**2019-2024**
Danube (data for different branches available)	In-situ data climatology (1984-1993)	In-situ data	In-situ data climatology (2010-2018)
Dnestr, Dnepr (and Bug)	Danube In-situ data climatology (1984-1993), Tulcea branch	Danube in-situ data, Tulcea branch	Danube In-situ data climatology (2010-2018), Tulcea branch
Rest	-999 (sea surface temp.)	-999 (sea surface temp.)	-999 (sea surface temp.)

Oxygen:
From the Ukrainian danube station data, we compute an average Dissolved Oxygen concentration seasonality, and apply that to all rivers equally.

Other biogeochemical tracers:

- Monthly water flux is multiplied with fixed concentrations (mmol/m3, factors are the same for all rivers).
  'POC': 100, 'PON': 10, 'CFL': 0.01, 'CEM': 0.01, 'CDI': 0.01, 'NFL': 0.01, 'NEM': 0.01, 'NDI': 0.01, 'MIC': 0.001, 'MES': 0.001, 'BAC': 0.1, 'SMI': 25, 'AGG': 82661000, 'GEL': 0, 'NOC': 0, 'DIC': 3000, 'TA': 3083

- The values are mainly very small and will thus only have a minimal impact on model, except for BAC,DIC,TA, POC and PON (SMI and AGG currently disabled in simulations) where significant concentrations are assumed.

Setting PON to 10, corresponds to about 26kt/year for the danube, about 10% or less of DIN (~300-600kt). We also assume to have 10 times the amount of POC compared to PON.
The DIC concentrations 3000 value comes from black values in the GEMS-GLORI database, and corresponds to ~36mg/l
(https://doi.pangaea.de/10.1594/PANGAEA.804574)

- The variable CHA (excess negative charge) is computed as Total Alkalinity - Ammonium - Nitrate - Phosphate