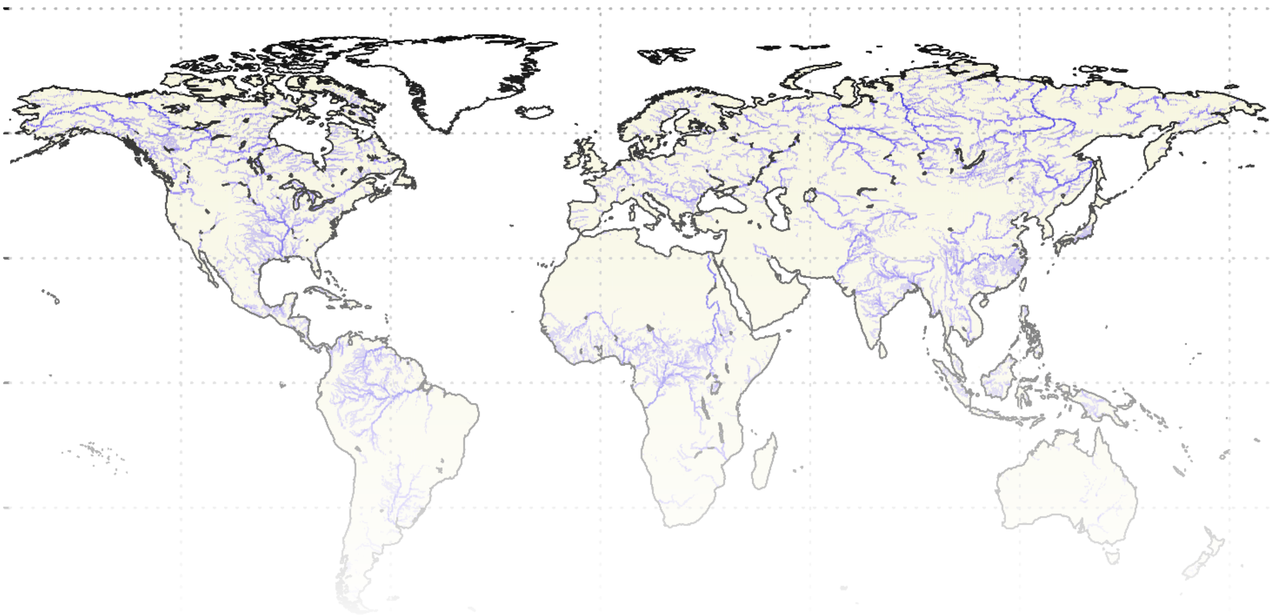

TODAY'S EARTH - *Global*

Land surface simulation by JAXA and UTokyo

Product Description Document

Last Revised Aug. 2nd, 2023

Today's Earth Developers Group

JAXA Japan Aerospace Exploration Agency
EORC
東京大学生産技術研究所
Institute of Industrial Science, The University of Tokyo

Revision History

Revision	Major Changes	Author
2018-03-31	NC	K. Hibino K. Yamamoto
2019-11-27	- System name changed from YEE(Yesterday's Earth at EORC) to TE(Today's Earth) - Correction of the statistics - Update member list	K. Yamamoto
2019-03-29	- Update introduction, Table 1, and member list	K. Yamamoto
2019-08-19	- Update variable list	K. Yamamoto
2020-03-09	- Update variable list	K. Yamamoto
2020-12-16	- Renew and revise in conjunction with the web page renewal - Publish of the Japanese version	K. Yamamoto
2023-08-02	- Add the TE-Global NEXRA Description - Add the revision history	K. Yamamoto W. Ma

TABLE OF CONTENTS

1. Introduction

"Today's Earth" (hereafter called "TE") is JAXA's terrestrial hydrological simulation system. The system derives land surface states/fluxes and river conditions from numerical calculations based on the satellite observation and atmospheric reanalysis. Today's Earth - Global" (hereafter called "TE-Global") enables us to access those data globally. We aim to build and evaluate a long-term, unified land surface hydrological dataset and provide information that contribute to floods, droughts, and other water related disasters.

The TE developers group consists of the researchers in Japan Aerospace Exploration Agency (JAXA) Earth Observation Research Center (EORC), The University of Tokyo (UT), and Remote Sensing Technology Center of Japan (RESTEC). Detailed member list is attached as the Appendix II.

1.1. Specification of TE-Global

The TE system consists of land surface model MATSIRO (Minimal Advanced Treatments of Surface Interaction and Runoff, Takata et al., 2003) version5 (Nitta et al., 2014) and river routing model CaMa-Flood (Catchment-based Macro-scale Floodplain, Yamazaki et al., 2011).

Figure 1 shows the schematic of TE-Global system. By giving forcing of surface meteorological parameters, MATSIRO simulates the water and energy interactions between a land surface with a vegetation canopy and atmosphere. The surface runoff and baseflow were calculated independently using Horton flow and the advanced application in TOPMODEL (Beven et al., 1984), respectively. Based on the calculated runoff amount, CaMa-Flood enables hydrodynamic simulation with floodplain on a global scale. The model solves the local inertial equation (Bates et al., 2010), considering a rectangular river channel and trapezium flood plain storage, and represents flood plain dynamics assuming that the elevation profile of the floodplain monotonically increases in each pixel.

TE not only visualizes and provides data on these geophysical quantities but also translates them into user-friendly risk indicators, such as return periods (i.e., the frequency at which an event occurs, approximately once every x years), and standardized deviation (i.e., a measure of how rare an event is compared to the climatological normal).

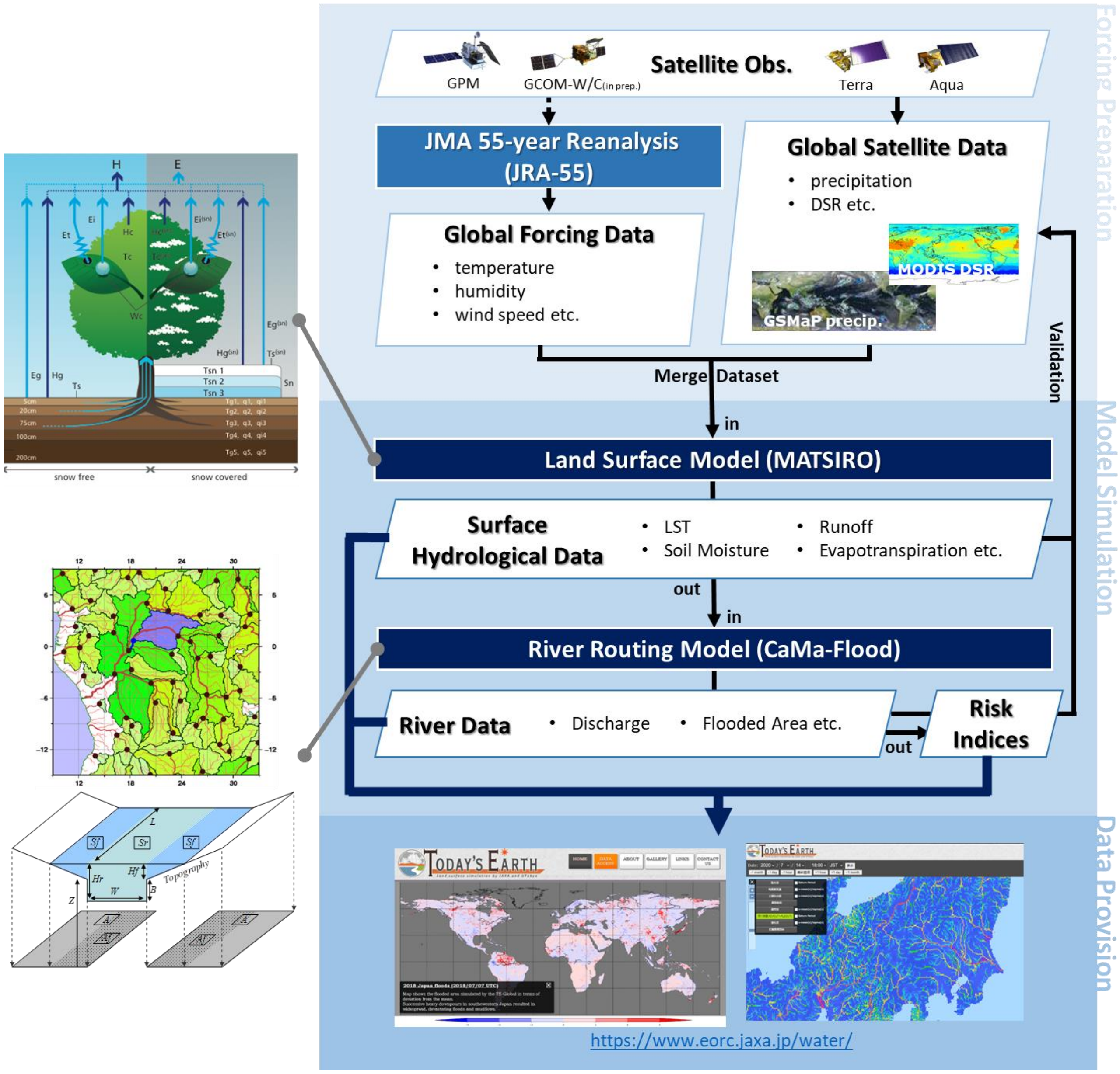

Figure 1. Schematic figure of TE-Global system.

1.2. Product Type

The TE-Global product can be categorized into four types based on the atmospheric forcing data used in the simulation. A concise summary of their characteristics is presented in Table 1.

Table 1. Basic characteristics of the TE-Global data.

		TE-Global			TE-Global NEXRA
		JRA-55 ver.	GSMaP ver.	MODIS ver.	
Format		NetCDF			
Latitude Extent		-90° to 90°			
Longitude Extent		0° to 360°			
Spatial Resolution		0.5° for MATSIRO output variables, 0.25° for CaMa-Flood output variables			
Temporal Resolution		3-hourly, daily, monthly			
Temporal Coverage		1958-present	2001-present	2003-present	2019-present
Dimensions		720 (lon) x 360 (lat) for the MATSIRO output variables, 1440 (lon) x 720 (lat) for CaMa-Flood output variables			
Origins (1st grid center)		(0.25°E, 89.75°S) for MATSIRO output variables (0.125°E, 89.875°S) for CaMa-Flood output variables			
Ensemble member		1			128
Forcing Data*1	rainfall	J	G(J)*3	J	N
	snowfall	J	J	J	N
	eastward wind	J	J	J	N
	northward wind	J	J	J	N
	surface air temperature	J	J	J	N
	specific humidity	J	J	J	N
	surface shortwave radiation (downward)	J	J	M	N
	surface longwave radiation (downward)	J	J	J	N
	surface air pressure	J	J	J	N
Data distribution Latency*2		About 3.5 days	About 5 days	About 20 days	About 1~5 days

1. J: JMA JRA-55 – the Japanese 55-year Reanalysis (Kobayashi et al., 2015)
   G: Global Satellite Mapping of Precipitation (GSMaP_MVK v6) (Kubota et al., 2007)
   M: Terra/Aqua MODIS Global Solar Radiation Product V811 (obtained from JASMES system)
   N: NICAM-LETKF JAXA Research Analysis, NEXRA. (Kotsuki et al., 2017a)
2. These are depending on the timing of data availability of forcing data, and it is unstable especially for TE-Global NEXRA.
3. Since GSMaP provides rainfall rate of 60N-60S region, JRA-55 rainfall is utilized in higher latitude area. For spatial continuity with GSMaP, JRA-55 rainfall less than 0.01mm/h are eliminated for this experiment.

1.2.1. Deterministic simulation product (TE-Global)

JRA-55 ver. is a product that utilizes only the Japan Meteorological Agency (JMS) JRA-55 – the Japanese 55-year Reanalysis dataset - as input for the TE-Global simulation. It is effective for assessing long-term water circulation. Among the JRA-55 input variables, those using GSMaP (Global Satellite Mapping of Precipitation) for rainfall are called GSMaP ver. and those using MODIS (Terra/Aqua MODIS Global Solar Radiation Product) for downward shortwave radiation are called MODIS ver. Although the temporal coverage is short since the data provision started when satellite observation data became available, we are aiming for more accurate simulation of the land surface water circulation by using actual satellite observation data.

1.2.2. Ensemble simulation product (TE-Global NEXRA)

Ensemble simulation is the process of creating ensemble members (multiple potential states of the Earth) by combining errors present in both observations and numerical models, and simulate from each of these states. By computing the average of simulation results from each ensemble member, the reduction of errors compared to a single-member simulation can be expected, and it becomes possible to estimate the reliability of the simulation from the variability among the members.

NEXRA (NICAM-LETKF JAXA Research Analysis) was applied for constructing an ensemble simulation system. NEXRA is a unique weather data assimilation system, that assimilates GSMaP global precipitation as observational data. It is known that the assimilation of precipitation data may improve the analyzed precipitation but generally degrades other atmospheric variables. However, the NEXRA can assimilate not "precipitation" itself, but "the likelihood of its precipitation based on the past precipitation frequency distribution", results in improving the accuracy of the atmospheric variables (Kotsuki et al., 2017a). Currently 128 atmospheric ensemble members are used for the TE-Global simulation and mean, sigma, 25%tile, 75%tile, min, max and their return period data is distributed.

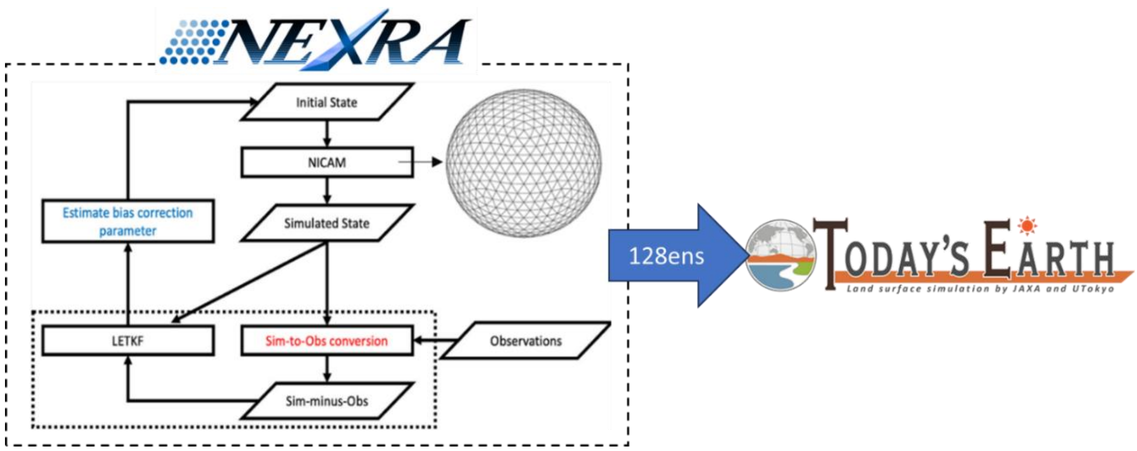

Figure 2. Schematic figure of the TE-Global NEXRA

2. Data Organization

2.1. File Naming Convention

The naming conventions for the provided data files are shown below：

➤ **TE-Global GSMaP, JRA55 and MODIS ver.:**

$$\mathrm{YEE2\_}\underbrace{\mathrm{AAAAAA}}_{\textcircled{1}}\_\underbrace{\mathit{itemname}}_{\textcircled{2}}\_\underbrace{\mathrm{Hyyyymm}}_{\textcircled{3}}\_\mathrm{GLB}\underbrace{\mathrm{XXX}}_{\textcircled{4}}\mathrm{.nc}$$

① Experiment Name (6 characters）
e.g.) “JRA-55” for TE-Global JRA-55 ver.
“GMVK03” for TE-Global GSMaP ver.
“MSWR08” for TE-Global MODIS ver.

② Item Name (See “3. Data Contents”)

③ Date & Time (UTC)
e.g.) “M202001” for monthly data of Jan. 2020.

④ Horizontal Resolution (3 digits)
e.g.) “050” for 0.5 deg lat./lon.
“025” for 0.25 deg lat./lon.

➤ **TE-Global NEXRA:**

$$\mathrm{TE\text{-}GLB}\underbrace{\mathrm{XXX}}_{\textcircled{4}}\_\underbrace{\mathrm{AAA}}_{\textcircled{1}}\_\underbrace{\mathrm{Hyyyymm}}_{\textcircled{3}}\_\underbrace{\mathit{itemname}}_{\textcircled{2}}\mathrm{.nc}$$

① Experiment Name (3 characters）
e.g.) “NEX” for TE-Global NEXRA

② Item Name (See “3. Data Contents”)

③ Date & Time (UTC)
e.g.) “M202001” for monthly data of Jan. 2020.

④ Horizontal Resolution (3 digits)
e.g.) “30M” for 30minutes (0.5 deg) lat./lon.
“15M” for 15minutes (0.25 deg) lat./lon.

2.2. File Format and Structure

All TE-Global data files are in NetCDF format, which is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. More information can be found here: https://www.unidata.ucar.edu/software/netcdf/docs/.

3. Data Contents

All the physical quantities provided by Today's Earth are summarized in Table 2. The "✓" in the "Fig" column indicate variables that are visualized as .png figures and the "✓" in the "Tile" column indicate variables that are visualized in the tile map page, respectively. Note that TE-NEXRA Global does not provide .png figure currently.

Table 2. Hydrological variables distributed in the Today's Earth

Model/ Category		Variables*		Item Name	Unit	Fig	Tile
Forcing		rainfall	tavg	GPRCT	$kg/m^2/s$	✓	✓
		snowfall	tavg	GSNWL	$kg/m^2/s$	✓	-
		eastward wind (10m)[*8]	tavg	GDU	m/s	-	-
		northward wind (10m)[*8]	tavg	GDV	m/s	-	-
		surface air temperature (2m)	tavg	GDT	K	✓	✓
		specific humidity (2m)	tavg	GDQ	kg/kg	✓	-
		surface shortwave radiation (downward)	tavg	SSRD	W/m^2	✓	-
		surface longwave radiation (downward)	tavg	SLRD	W/m^2	-	-
		surface air pressure[*8]	tavg	GDPS	hPa	-	-
MATSIRO	Water balance (State)	soil moisture (at each level) [Z1-Z6][*1]	tavg	GLW	m/m	✓[Z1]	✓[Z1]
		soil moisture (total volume)	tavg	GLWtot	kg/m^2	✓	-
		canopy water	tavg	GLWC	m	-	-
		snow amount	tavg	GLSNW	kg/m^2	✓	✓
	Water balance (Flux)	snow melt	tavg	SNMLT	$kg/m^2/s$	-	-
		snow freeze	tavg	SNFRZ	$kg/m^2/s$	-	-
		snow sublimation	tavg	SNSUB	$kg/m^2/s$	-	-
		ice melt	tavg	ICEMLT	$kg/m^2/s$	-	-
		ice sublimation	tavg	ICESUB	$kg/m^2/s$	-	-
		snow & ice sublimation	tavg	SSUB	$kg/m^2/s$	-	-
		transpiration	tavg	ETFLX	$kg/m^2/s$	✓	-
		canopy evaporation	tavg	EIFLX	$kg/m^2/s$	✓	-
		canopy sublimation	tavg	EISUB	$kg/m^2/s$	-	-
		soil evaporation	tavg	EBFLX	$kg/m^2/s$	✓	-
		soil sublimation	tavg	EBSUB	$kg/m^2/s$	-	-
		total runoff (total) [W1-W2][*2]	tavg	RUNOFF	$kg/m^2/s$	✓	-
		base runoff	tavg	RUNOFFB	$kg/m^2/s$	✓	-
		surface runoff	tavg	SRUNOF	$kg/m^2/s$	✓	-
		runoff (lake & land) [W1-W2][*2]	tavg	RUNOFFA	$kg/m^2/s$	-	-
	Heat balance (State)	soil temperature [Z1-Z6][*1]	tavg	GLG	K	✓	-
		snow temperature [L1-L3][*3]	tavg	GLTSN	K	✓	-
		land skin temperature [C1-C2][*4]	tavg	GLTS	K	✓	-
		canopy temperature [C1-C2][*4]	tavg	GLTC	K	✓	-
	Heat balance (Flux)	soil heat flux	tavg	GFLUXS	W/m^2	✓	-
		snow surface heat flux	tavg	SNFLXS	W/m^2	✓	-
		ground heat flux in total	tavg	GFLXTL	W/m^2	-	-
		surface shortwave radiation (upward)	tavg	SSRU	W/m^2	-	-
		surface longwave radiation (upward)	tavg	SLRU	W/m^2	-	-
		sensible heat flux	tavg	SENS	W/m^2	✓	-
		latent heat flux	tavg	LTNT	W/m^2	✓	-
		latent heat flux (evaporation)	tavg	EVAP	W/m^2	-	✓
	Others	snow covered fraction	tavg	SNRAT	-	✓	-
		albedo	tavg	ALB	-	-	-
		snow albedo [A1-A3][*5]	tavg	GLASN	-	-	-

		soil potential [Z1-Z6][*1]	tavg	GPSI	Pa	-	-
		dust density in snow [L1-L3][*3]	tavg	CDSTM	ppmw	-	-
		water flux atmosphere to land	tavg	WA2L	m/s	-	-
		water flux land to river	tavg	WL2R	m/s	-	-
		soil ice (at each level) [Z1-Z6][*1]	tavg	GLFRS	m/m	✓	-
		soil ice (total volume)	tavg	GLFRStot	kg/m²	✓	-
		land water	tavg	WLND	m	-	-
		inland water sinkbudget	tavg	BUDIND	kg/m²/s	-	-
		distributed water sinkbudget	tavg	RBUDIND	kg/m²/s	-	-
		ground water input	tavg	WINPT	kg/m²/s	-	-
		lake sh	tavg	SHLK	cm	-	-
		lake surface temperature	tavg	TSIL	℃	-	-
CaMa-Flood		river discharge	tavg	RIVOUT	m³/s	-	-
		river water storage	inst	RIVSTO	m³	-	-
		river water depth	inst	RIVDPH	m	✓[*6]	-
		river flow velocity	tavg	RIVVEL	m/s	-	-
		floodplain flow (discharge)	tavg	FLDOUT	m³/s	-	-
		floodplain water storage	inst	FLDSTO	m³	-	-
		floodplain water depth	inst	FLDDPH	m	✓[*6]	✓
		downscaled floodplain water depth[*7]	inst	FLDDPH	m		✓
		flood area	inst	FLDARE	m²	-	-
		flood fraction[*9]	inst	FLDFRC	-	✓[*6]	✓
		downscaled flood fraction[*7*9]	inst	FLDFRC	-	-	✓
		water surface elevation	inst	SFCELV	m	-	-
		total discharge (RIVOUT + FLDOUT)[*8]	tavg	OUTFLW	m³/s	✓[*6]	✓
		total storage (RIVSTO + FLDSTO)[*8]	tavg	STORGE	m³	-	-
Statistics		return period of rainfall[*7]	-	RPGPRCT	year	✓	✓
		return period of river water depth[*7]	-	RPRIVDPH	year	✓[*6]	✓
		downscaled return period of river water depth[*7]	-	RPRIVDPH	year	-	✓
		return period of total discharge[*7]	-	RPOUTFLW	year	✓[*6]	✓
		downscaled return period of total discharge[*7]	-	RPOUTFLW	year	-	✓

* For original model output data (hourly or 3-hourly data), “tavg” are forward time averaged variables, “inst” are instantaneous variables at a time on the file name + temporal resolution.

1. Z1-Z6 represents the soil layers, the depth (m) of which is Z1: 0 - 0.05, Z2: 0.05 - 0.25, Z3: 0.25 - 1, Z4: 1 - 2, Z5: 2 - 4, and Z6: 4 - 14.
2. W1 and W2 represent the values regarding water and ice, respectively.
3. L1-L3 represents the snow layers. The number of the effective layers and their depth are variable. See Takata et al. (2003) for more details.
4. C1 and C2 represent the outputs for snow-free canopy and snow-covered canopy, respectively.
5. A1, A2 and A3 represent the snow albedo of visible, near-infrared and infrared area, respectively.
6. River width is displayed with enhancement depending on its catchment size in .png figures.
7. Only provided in TE-Japan.
   - Downscaled product: downscaled from 1/60 deg. to 1/240 deg. along with the unit catchment defined in the CaMa-Flood model.
   - Return period calculated from the statistical distribution of TE-Japan's simulation results for the period 2007-2020.
8. Only provided in TE-Global. Regarding wind speed, TE-Japan provides the absolute value of the synthesized wind speed for both eastward and northward directions as GDU.
9. TE-Japan updated to FLDFRC with permanent water removed from 2020/09/02, TE-Global updated to FLDFRC with permanent water removed from 2022/01/01.

Note:

- TE-Global tends to have underestimation bias for its base runoff. Users are advised to check whether quality is sufficient for their applications when these data are used.

- Currently we have an error in unit description for GLW and GLWC netCDF header and figure information. Please refer to the table above for correct information.

4. Terms of Use

This terms of use is the same as that shown in the TE-Global website https://www.eorc.jaxa.jp/water/term.html?1

Today's Earth (hereinafter referred to as "the Service") provides the terrestrial hydrological simulation data by the Japan Aerospace Exploration Agency (JAXA) Earth Observation Research Center (EORC) and institute of Industrial Science, The University of Tokyo, in free of charge (only for research, education and public purposes).

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- Statistic and analysis of data use
- Questionnaire surveys to users for improvement of the Service
- Response to inquiries from users

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4.11. Contact Information

If there are any concerns or questions about the Service, please contact us by sending mail to:

Z-watercnt@ml.jaxa.jp

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Appendix I: Member List of TE Developers Group

Latest member list is at:
https://www.eorc.jaxa.jp/water/contact_us.html