GFDL-ESM2G (CMIP5)

Climate Model Report Card

GLISA
A NOAA RISA TEAM

Model Name: Geophysical Fluid Dynamics Laboratory Earth System Model version 2G

Developers: National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL)

Data Portal: https://cera-www.dkrz.de, https://esgf-node.llnl.gov

Spatial Resolution: 2.02° x 2.50°

Temporal Resolution: 3 hr, daily, monthly

Historical Run(s): 1861-2005

Future Scenario(s): RCP2.6, RCP4.5, RCP6.0, RCP8.5

Future Time Period(s): 2006-2100

LAKE COMPONENT

Name: Lake model within Land Model, version 3 (LM3)

Reference: [1]Milly, P. C., Malyshev, S. L., Shevliakova, E., Dunne, K. A., Findell, K. L., Gleeson, T., ... & Swenson, S. (2014). An enhanced model of land water and energy for global hydrologic and earth-system studies. *Journal of Hydrometeorology, 15*(5), 1739-1761.

Description: Lake temperature calculations follow Henderson-Sellers (1985) and Hostetler & Bartlein (1990), accounting for vertical heat transfer within a column by eddy diffusion and convective mixing. Lakes and lake ice receive water from melting snowpack above lake ice, precipitation, and river inflows. Soil beneath the lakes is impermeable but receives geothermal heat flux. Lakes are defined by USGS's Global Land Cover Characteristics database under "IGBP Water Bodies."[1]

Vertical Layers | Depths: The documentation cites that "lakes are characterized by changing depth," but the study discretizes it into 20 dynamic layers with a maximum depth of 50m. It is unclear to GLISA if this is the same set-up used in CMIP5.[1]

Vertical Mixing (y/n): Yes

Horizontal Mixing (y/n): Yes, a variable K_l is added to Henderson-Sellers (1985)'s and Hostetler & Bartlein (1990)'s work to account for three-dimensional mixing in large, deep lakes, and the LM3 documentation specifies horizontal lake calculations are performed at a different time-step than vertical lake calculations.[1]

Lake Ice: Lakes have vertical profiles that consist of water and ice, with ice always above liquid water.[1]

ATMOSPHERE COMPONENT

Name: Atmospheric Model, version 2 (AM2)

Reference: [2]Anderson, J. L., Balaji, V., Broccoli, A. J., Cooke, W. F., Delworth, T. L., Dixon, K. W., ... & Wyman, B. L. (2005). The GFDL Global Atmospheric Model Development Team: The new GFDL global atmosphere and land model AM2/LM2: Evaluation with prescribed SST simulations. *Journal of Climate, 17*, 4641-4673.

Physical Parameterizations: Shortwave radiation (Freidenreich & Ramaswamy, 1999), longwave radiation (Schwarzkopf & Ramaswamy, 1999), moist convection (Moorthi & Suarez, 1992), with deep convection modification of (Tokioka et al., 1988), cloud microphysics (Rotstayn, 1997; Rotstayn et al., 2000), turbulence and convective boundary layers (Lock et al., 2000)[2]

Chemistry: Ozone profiles follow Fortuin & Kelder (1998) with observations from 1989-1991. Shortwave radiation work accounts for the absorption of H_2O, CO_2, O_3, and O_2, and longwave radiation work accounts for H_2O, CO_2, O_3, N_2O, CH_4, and 4 halocarbons. Sulfate, black and organic carbon, dust, and sea salt are considered.[2]

LAND COMPONENT

Name: Land Model, version 3 (LM3)

Reference: [1]Milly, P. C., Malyshev, S. L., Shevliakova, E., Dunne, K. A., Findell, K. L., Gleeson, T., ... & Swenson, S. (2014). An enhanced model of land water and energy for global hydrologic and earth-system studies. *Journal of Hydrometeorology, 15*(5), 1739-1761.

 # Land Cover Types: 3 land covers types (soil, lake, or glacier), and 5 soil vegetation types (C3 grass, C4 grass, temperate deciduous tree, tropical tree, or cold evergreen tree).[1]

 # Soil Layers: 20 layers (+5 for snow) with a total depth of 10m

Soil Moisture: Water flux at the surface is calculated by adding rainfall, snowmelt, the canopy interception store and subtracting evaporation.[1]

Runoff: Rainfall that cannot enter the soil column because it is too saturated with no available macropores present becomes surface runoff. Runoff is then combined with nearby water flowing into a upstream river and lake, if present. LM3 uses a TOPMODEL approach.[1]

Sub-Grid Lakes (y/n): Yes, gridcells are made up of many tiles, where tiles are either 100% lake, glacier, or soil.[1]

Carbon Fluxes: Carbon and vegetation dynamics follow Shevliakova et al. (2009), where carbon is tracked in leaves, fine roots, heartwood, sapwood, and labile and is affected by weather, climate, atmospheric CO_2 concentration, soil state, and disturbances (anthropogenic and natural).[1] While the models only differ in ocean components, "the ESM2G model produces a more realistic carbon accumulation in vegetation pools" than ESM2M."[3]

Land Use Change: Each grid cell is defined by a combination of four land-use types: undisturbed lands, croplands, pastures, and lands previously used in agriculture or harvested.[3] LM3 is largely based on LM3V (Shevliakova et al., 2009) and the LaD model (Milly & Shmakin, 2002), where the former is designed to address land use and land management changes. In LM3's documentation, the spin-up period neglected land use change while the historical phase used land use scenarios of Hurtt et al. (2011)[1], but it is unclear to GLISA if this is the same set-up used in CMIP5.[1]

Groundwater: Groundwater is all water below the "water table" (which has a depth of 10m), and is steady-state with uniform recharge. A zero water flux and a constant geothermal heat flux are given at the bottom of the soil-bedrock layers.[1]

Additional References

[3]Dunne, J. P., John, J. G., Shevliakova, E., Stouffer, R. J., Krasting, J. P., Malyshev, S. L., ... & Zadeh, N. (2013). GFDL's ESM2 Global Coupled Climate–Carbon Earth System Models. Part II: Carbon System Formulation and Baseline Simulation Characteristics, *Journal of Climate, 26*(7), 2247-2267.