TaiESM1 (CMIP6)

Climate Model Report Card

Model Name: Taiwan Earth System Model

Developers: Research Center for Environmental Changes, Academia Sinica, Taiwan (AS-RCEC)

Data Portal: https://www.wdc-climate.de/ui/q?general_key_ss=TaiESM1

Spatial Resolution: 0.9° x 1.25°

Temporal Resolution: monthly, daily, 3-hour

Time Periods: Historical: 1850–2014; Future: up to 2100

Scenario(s): SSP1-2.26 SSP2-4.5, SSP3-7.0 SSP5-8.5

Reference: Lee, W.-L., Wang, Y.-C., Shiu, C.-J., Tsai, I., Tu, C.-Y., Lan, Y.-Y., Chen, J.-P., Pan, H.-L., and Hsu, H.-H.: Taiwan Earth System Model Version 1: description and evaluation of mean state, Geosci. Model Dev., 13, 3887–3904, https://doi.org/10.5194/gmd-13-3887-2020, 2020.

LAKE COMPONENT

Name: Lake Model within NCAR's Community Land Model, version 4 (CLM4)

Reference: Oleson et al., 2010

Description: The lake model is from Zeng et al. (2002), which is based on various one-dimensional models that vertically solve the thermal diffusion equation for 10 layers of water and ice. Each grid cell is assigned a percentage of lake, wetland, glacier, urban, and soil, where lake percentages are from Cogley's (1991) 1.0° x 1.0° perennial freshwater lake data.[2]

Coupled to atmosphere: Yes

1D/3D/Other: 1D

 # Layers: 10 layers with a maximum depth of 50m [2]

Lake Ice Model Description: The 10 layers can be water or ice, and frozen lake albedos are based on sea ice values from NCAR LSM (Bonan, 1996). [2]

ATMOSPHERE COMPONENT

Name: Community Atmosphere Model version 5.3 (CAM5)

Reference: Lee et al., 2020

Resolution: 0.9x1.25 degree; 288 x 192 longitude/latitude; 30 levels; top level ~2 hPa [1]

Physical Parameterizations: The dynamic core is Finite-Volume (Lin, 2004), radiative fluxes and heating rates are determined using the Rapid Radiative Transfer Model for GCMs (Iacono et al., 2008), shallow convection and moist turbulence schemes (Park & Bretherton 2009, Bretherton & Park 2009), a two-moment cloud microphysics scheme is used (Morrison & Gettelmen, 2008). Modified trigger functions for deep convection (Y.-C. Wang et al., 2015) and a new cloud macrophysics scheme (Shiu et al., 2020). [1]

Chemistry: Statistical-Numerical Aerosol Parameterization (SNAP; Chen et al., 2013) is used in TaiESM1. SNAP is a bulk parameterization and the modal approach (Seigneur et al., 1986; Whitby and McMurry, 1997) is adopted to describe the particle size distribution. Three-moment aerosol scheme (Chen et al., 2013). [1]

LAND COMPONENT

Name: Community Land Model, version 4 (CLM4)

Reference: Oleson et al., 2010

 # Land Cover Types: 5 land cover types (soil, wetland, lake, urban, glacier) and 16 vegetation plant function types (PFTs), where each grid cell can contain multiple surface types and up to 4 PFTs. [2]

 # Soil Layers: 15 ground layers (+up to 5 for snow), where the upper 10 (0m to 3.8m) are hydrologically active soil layers and the lower 5 are bedrock layers (3.8m to 42m) for a total depth of 42m. [2,3]

Soil Moisture: Vertical moisture between the 10 hydrologically active soil layers is governed infiltration, surface and sub-surface runoff, gradient division, gravity, canopy transpiration, and groundwater interactions. [2]

Runoff: Surface runoff consists of Dunne runoff (overland-flow from saturation excess) and Hortonian runoff (infiltration excess). A TOPMODEL-based runoff model called SIMTOP, described by Niu et al. (2005), is used for runoff parameterization. [3]

Sub-Grid Lakes: Grid cells can be assigned a percentage of lake, wetland, glacier, and soil, with lake percentages from Cogley's (1991) 1.0° x 1.0° perennial freshwater lake data. [2]

Land Use Change: CLM4 includes transient land cover and land use change (LCLUC) with 0.5° resolute data from Hurtt et al. (2006) that describes changes in land cover from 1850-2005 between crop, pasture, primary vegetation, and secondary vegetation classes. [2,3]

Groundwater Description: There's an unconfined aquifer below the 10 soil layers. [3]

References

1. Lee, W.-L., Wang, Y.-C., Shiu, C.-J., Tsai, I., Tu, C.-Y., Lan, Y.-Y., Chen, J.-P., Pan, H.-L., and Hsu, H.-H.: Taiwan Earth System Model Version 1: description and evaluation of mean state, Geosci. Model Dev., 13, 3887–3904, https://doi.org/10.5194/gmd-13-3887-2020, 2020.

2. Oleson, K. W., Dai, Y., Bonan, G., Bosilovich, M., Dickinson, R., Dirmeyer, P., ... & Zeng, X. (2010). Technical description of version 4.0 of the Community Land Model (CLM). Tech. Note NCAR/TN-478+STR.

3. Lawrence, D. M., Oleson, K. W., Flanner, M. G., Thornton, P. E., Swenson, S. C., Lawrence, P. J., ... & Slater, A. G. (2011). Parameterization improvements and functional and structural advances in version 4 of the Community Land Model. Journal of Advances in Modeling Earth Systems, 3(1).