BCC-CSM1.1m (CMIP5)

Climate Model Report Card

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Model Name: Beijing Climate Center Climate System Model version 1.1, moderate resolution (BCC-CSM1.1m)

Developer: Beijing Climate Center (BCC) of China's Meteorological Administration (CMA)

Data Portal: https://cera-www.dkrz.de

Spatial Resolution: 1.12° x 1.13°

Temporal Resolution: 3 hr, daily, monthly

Historical Run(s): 1850-2012 (daily, monthly), 1960-2007 (3 hr)

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

Future Time Period(s): 2006-2100 (daily, monthly), 2026-2100 (3 hr)

LAKE COMPONENT

Name: Lake model within the BCC-ACIM1.0, largely based on the lake model in NCAR's Community Land Model (CLM) version 3

Reference: [1]Oleson, K. W., Dai, Y., Bonan, G., Bosilovich, M., Dickinson, R., Dirmeyer, P., ... & Zeng, X. (2004). Technical description of the community land model (CLM). *Tech. Note NCAR/TN-461+STR.*

Description: CLM3's 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 in CLM3 is assigned a percentage of lake, wetland, glacier, and soil, where lake percentages are from Cogley's (1991) 1.0° x 1.0° perennial freshwater lake data. Snow cover above lakes is greatly simplified and soil beneath lakes is not considered.[1] The lake scheme was greatly improved for BCC-AVIM2.0 for CMIP6 and Qui et al. (2020) found that the surface temperatures of the Great Lakes are underestimated by as much as 6-8°C in this version.[2]

Vertical Layers | Depths: 10 layers for a maximum depth of 50m

Vertical Mixing (y/n): Yes

Horizontal Mixing (y/n): No

Lake Ice: The 10 layers can be water or ice,[2] and frozen lake albedos are based on sea ice values from NCAR LSM (Bonan, 1996).[1] Lake ice calculations and physics are greatly improved in BCC-AVIM2.0 and CLM4.[2,3]

ATMOSPHERE COMPONENT

Name: BCC-AGCM2.2, largely based on NCAR CAM3

Reference: [4]Wu, T., Yu, R., Zhang, F., Wang, Z., Dong, M., Wang, L., ... & Li, L. (2010). The Beijing Climate Center atmospheric general circulation model: description and its performance for the present-day climate. *Climate dynamics, 34*(1), 123.

Physical Parameterizations: Deep cumulus convections scheme (Wu, 2012), shallow/mid-tropospheric moist convection scheme (Hack, 1994), modified (Rasch & Kristjansson, 1998) stratiform precipitation (cloud microphysics) scheme (Zhang et al., 2003), cloud macrophysics (Collins et al., 2004), gravity wave drag (Mcfarlane, 1987), radiative transfer scheme from CAM3 (Collins et al., 2004), boundary layer parameterization (Holtslag & Boville, 1993)[4,5]

Chemistry: There are prescribed aerosols, no atmospheric chemistry, and a global carbon budget without spatial distribution.[5] There is an ozone chemistry scheme from Cionni et al. (2011).

LAND COMPONENT

Name: Atmosphere-Vegetation Interaction Model version 1 (BCC-AVIM1.0) based on NCAR's Community Land Model (CLM) version 3

Reference: [6]Ji, J. (1995). A climate-vegetation interaction model: Simulating physical and biological processes at the surface. *Journal of Biogeography, 22*(2/3), 445-451.

 # Land Cover Types: 4 surface types (soil, wetland, lake, glacier) and 15 vegetation plant function types (PFTs), where each grid cell can contain multiple surface types and up to 4 PFTs.[7] .Full PFT list in Oleson et al. (2004).

 # Soil Layers: 10 layers (+up to 5 for snow) for a total depth of 3.44m

Soil Moisture: Soil moisture and temperature are governed by the heat and water transfer equations involving vertical transport between layers by means of "infiltration, surface and sub-surface runoff, gradient diffusion, gravity, and root extraction through canopy transpiration."[1,6] Soil water flux is calculated with Darcy's Law.[1]

Runoff: Rainfall that reaches the ground becomes runoff when the upper soil layer is saturated.[6] CLM3 uses a conceptual form of TOPMODEL for runoff parameterization.[1]

Sub-Grid Lakes (y/n): Yes. 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.[1]

Carbon Fluxes: BCC-AVIM1.0 has a terrestrial carbon cycle that uses a series of biochemical and physiological processes such as photosynthesis vegetation respiration, and the release of CO_2 into the atmosphere through soil respiration.[6,7]

Land Use Change: Wu et al. (2019) cites a "variable crop planting area" for a land use change scheme for BCC-AVIM1.0,[5] although Avav et al. (2013) cites no land use change for BCC-CSM1-1m in CMIP5.[8] BCC-AVIM2.0 for CMIP6 was upgraded to explicitly involve land use and land cover changes with deforestation.[5]

Groundwater: Undocumented

Additional References

[2]Qiu, B., Huang, A., Shi, X., Dai, Y., Wei, N., Guo, W., ... & Ling, X. (2020). Implementation and evaluation of an improved lake scheme in Beijing Climate Center Atmosphere-Vegetation Interaction Model. *Journal of Geophysical Research: Atmospheres, 125*(9), e2019JD031272.

[3]Subin, Z. M., Riley, W. J., & Mironov, D. (2012). An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1. *Journal of Advances in Modeling Earth Systems, 4*(1).

[5]Wu, T., Lu, Y., Fang, Y., Xin, X., Li, L., Li, W., ... & Liu, X. (2019). The Beijing Climate Center climate system model (BCC-CSM): The main progress from CMIP5 to CMIP6. *Geoscientific Model Development, 12*(4), 1573-1600.

[7]Wu, T., Song, L., Li, W., Wang, Z., Zhang, H., Xin, X., ... & Zhou, M. (2014). An overview of BCC climate system model development and application for climate change studies. *Journal of Meteorological Research, 28*(1), 34-56.

[8]Anav, A., Friedlingstein, P., Kidston, M., Bopp, L., Ciais, P., Cox, P., ... & Zhu, Z. (2013). Evaluating the land and ocean components of the global carbon cycle in the CMIP5 earth system models. *Journal of Climate, 26*(18), 6801-6843.