UQAM-CRCM5 (NA-CORDEX)

GLISA
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Climate Model Report Card

Model Name: Fifth-generation Canadian Regional Climate Model

Institution: Center for Regional Climate Study and Simulation (ESCER centre) of University of Quebec in Montreal (UQAM) in collaboration with Environment and Climate Change Canada (ECCC)

Data Portal: www.earthsystemgrid.org

Spatial Resolution: 0.11° grid (ERA-Interim only), 0.22° grid, 0.44° grid, available data interpolated to common half (0.44°), quarter (0.22°), and eighth (0.11°) degree lat-lon grids

Simulation Timestep: 5 min (0.11°), 10 min (0.22°), 20 min (0.44°)

LAKE COMPONENT

Name: Freshwater Lake model (FLake)

Reference: [1]Mironov, D. V. (2005). Parameterization of lakes in numerical weather prediction. Part 1: Description of a lake model. *German Weather Service, Offenbach am Main, Germany.*

Description: Freshwater 1-D lake model with an ice component capable of predicting vertical temperature structure and mixing conditions in lakes of various depths on time scales from a few hours to many years.[1] FLake performs best for shallow lakes (<40m) and has limited applicability to deep lakes.[2]

Vertical Layers | Depths: 2 vertical layers (a mixed layer with uniform temperature and an underlying thermocline extending to the bottom of the lake).[1] Lake depths are from the database of Kourzeneva (2010), but a "virtual" maximum lake depth of 40-60m is recommended instead of the actual lake depth for FLake. A maximum lake depth of 60m was used for the Great Lakes.[2,3]

Vertical Mixing (y/n): Yes

Horizontal Mixing (y/n): No

Lake Ice: Ice and snow depths are developed using a simple two-layer thermodynamic model. The concept of self-similarity of the temperature-depth curve is used to describe the temperature structure of the ice and snow cover[1]. However, the snow-module it is not activated and instead, snow above the lake-ice is implicitly accounted for by varying the ice albedo and thermal conductivity of ice. It does not allow for partial ice coverage, meaning lake grid cells are either entirely ice-covered or ice-free.[2]

ATMOSPHERE COMPONENT

Name: Global Environment Multiscale (GEM) model, version 3.3 with a local-area model (LAM) configuration

Reference: [4]Côté, J., Gravel, S., Méthot, A., Patoine, A., Roch, M., & Staniforth, A. (1998). The operational CMC–MRB global environmental multiscale (GEM) model. Part I: Design considerations and formulation. *Monthly Weather Review, 126*(6), 1373–1395.

Physical Parameterizations: Deep convection (Kain & Fritsch, 1990), shallow convection following the Kuo-transient (1965) scheme, large-scale condensation (Sundqvist et al., 1989), correlated-K longwave and shortwave radiation schemes (Li & Barker, 2005), gravity-wave drag (McFarlane, 1987), orographic blocking (Zadra et al., 2003), planetary boundary layer (Delage, 1997)[4]

Chemistry: Hernandez-Diaz et al. (2013) cites that aerosols are not implemented in this version of GEM[5], although https://na-cordex.org/rcm-characteristics cites uniform ozone and the netCDF metadata cites forcing from greenhouse gases (CO_2, CH_4, N_2O, CFC-11, and effective CFC-12).

Output Data Temporal Resolution: daily, monthly, seasonally, annually

GCM Driver(s): CanESM2, MPI-ESM-LR, MPI-ESM-MR, GEMatm-Can, GEMatm-MPI

Reanalysis Driver: ERA-Interim

Historical Run(s): 1979-2014 (ERA-Interim, 0.11° and 0.22°), 1979-2012 (ERA-Interim, 0.44°), 1950-2005 (CanESM2, GEMatm-Can), 1949-2005 (remaining GCM drivers)

Future Scenario(s): RCP4.5 (CanESM2, MPI-ESM-LR), RCP8.5 (all GCM drivers)

Future Time Period(s): 2006-2100

LAND COMPONENT

Name: Canadian Land Surface Scheme (CLASS), version 3.5+

Reference: [6]Verseghy, D. L. (2011). CLASS-The Canadian land surface scheme (Version 3.5), *Tech. rep.*, Climate Research Division, Science and Technology Branch, Environment Canada.

 # Land Cover Types: 5 surface types (ocean, ice sheet, urban, lake, or CLASS land surface type), 4 land surface sub-areas (bare soil, vegetation over soil, snow over bare soil, and vegetation over snow) and 4 vegetation types (needleleaf trees, broadleaf trees, crops, grass; plus urban and bare soil)[6]

 # Soil Layers: CLASS default: 3 layers with a depth of 4.1m, but versions 3.2 and up support options where the third layer can be replaced with many thinner layers, and/or the bottom of the soil profile may be extended.[6] UQAM-CRCM5 used 26 for a depth of 60m.[3]

Soil Moisture: Fluxes between soil layers is calculated using Darcy's Law.[7] Mein & Larson's (1973) method is used to calculate infiltration in the upper soil layer.[6]

Runoff: When the surface infiltration capacity is exceeded, water ponds on the surface until the surface retention capacity (varies with land cover) is reached, and the overflow then becomes surface runoff. Total runoff comes from the deep soil column's water drainage (sub-surface runoff) and surface runoff.[5,6]

Sub-Grid Lakes (y/n): Yes, there is a mosaic configuration that allows for multiple surface types within each grid cell (either CLASS land surface type, ocean, ice sheets, urban, or lake) and calculations are performed over each sub-grid.[3,6] The USGS database was used for vegetation and lake fractions. Lake fractions are better adjusted in OURANOS-CRCM5 to represent the Great Lakes. (https://na-cordex.org/rcm-characteristics)

Carbon Fluxes: Undocumented

Land Use Change: Undocumented

Groundwater: Undocumented

Additional References

[2]Martynov, A., Sushama, L., Laprise, R., Winger, K., & Dugas, B. (2012). Interactive lakes in the Canadian Regional Climate Model, version 5: the role of lakes in the regional climate of North America. *Tellus A: Dynamic Meteorology and Oceanography, 64*(1), 16226.

[3]Martynov, A., Laprise, R., Sushama, L., Winger, K., Šeparović, L., & Dugas, B. (2013). Reanalysis-driven climate simulation over CORDEX North America domain using the Canadian Regional Climate Model, version 5: model performance evaluation. *Climate Dynamics, 41*(11), 2973-3005.

[5]Hernández-Díaz, L., Laprise, R., Sushama, L., Martynov, A., Winger, K., & Dugas, B. (2013). Climate simulation over CORDEX Africa domain using the fifth-generation Canadian Regional Climate Model (CRCM5). *Climate Dynamics, 40*(5-6), 1415–1433.

[7]Music, B., Frigon, A., Slivitzky, M., Musy, A., Caya, D., & Roy, R. (2009). Runoff modelling within the Canadian Regional Climate Model (CRCM): analysis over the Quebec/Labrador watersheds. *IAHS publication, 333*, 183.