

# RegCM4 (NA-CORDEX)

## Climate Model Report Card

**Model Name:** Regional Climate Model 4

**Institution(s):** National Center for Atmospheric Research (MPI-ESM-LR) and Iowa State University (HadGEM2-ES, GFDL-ESM2M)

**Data Portal:** [www.earthsystemgrid.org](http://www.earthsystemgrid.org)

**Simulation Timestep:** 50s (25km), 100s (50km)

**Spatial Resolution:** 25km grid (approx. 0.22°), 50km grid (approx. 0.44°), available data interpolated to common half (0.44°) and quarter (0.22°) degree lat-lon grids

**Output Data Temporal Resolution:** 1-hr (pr only), 3-hr (pr only), daily, monthly, seasonally, annually

## LAKE COMPONENT

**Name:** 1D energy-balance lake model

**Reference(s):** <sup>1</sup>Hostetler, S. W., & Bartelin, P. J. (1990). Simulation of lake evaporation with application to modeling lake-level variations at Harney-Malheur Lake, Oregon. *Water Resour. Res.*, 26, 2603-2612.

<sup>2</sup>Hostetler, S. W., Bates, G. T., & Giorgi, F. (1993). Interactive coupling of a lake thermal model with a regional climate model. *J Geophys Res.*, 98(D3): 5045-5057.

**Description:** The model accounts for vertical heat transfer within a column (1 meter vertical resolution) by eddy diffusion and convective mixing<sup>1,2</sup>

**Vertical Layers | Depths:** Spatially explicit lake depths are assigned using bathymetry data for each grid cell<sup>3</sup>

**Vertical Mixing (y/n):** Yes

**Horizontal Mixing (y/n):** No

**Lake Ice:** The partial ice cover scheme of Patterson & Hamblin (1988) is used to calculate the surface energy and heat and moisture exchanges.<sup>2</sup> This ice scheme allows partial ice coverage within grid cells, where a fraction of the grid cell remains water until 10cm of ice can form, which is then when the entire cell becomes ice.<sup>4</sup> Some studies (Notaro, 2013; Bennington, 2014) cite that RegCM4 only allows grid cells to be ice-free or 100% ice-covered,<sup>3,5</sup> and it is unclear to GLISA if this was the case for NA-CORDEX simulations. Snow can form above lake ice.<sup>3</sup>

## ATMOSPHERE COMPONENT

**Name:** Hydrostatic version of Pennsylvania State University (PSU)-National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5)

**Reference:** <sup>6</sup>Grell, G., Dudhia, J., & Stauffer, D. R. (1994). Description of the fifth generation Penn State/NCAR Mesoscale Model (MM5). *NCAR Tech. Rep. TN-3981STR*, 121 pp.

**Physical Parameterizations:** A large-scale precipitation scheme (Pal et al., 2000), a multiple cumulus convection Grell scheme (Anthes, 1977; Grell, 1993; Emanuel, 1991; Emanuel & Zivkovic-Rothman, 1999) with a new "mixed scheme" from Grell+Emanuel, boundary layer scheme (Holtslag, 1990), longwave and shortwave radiation scheme (Kiehl et al., 1996)<sup>6</sup>

**Chemistry:** Dust and aerosol emission parameterizations following Laurent et al. (2008) and Alfaro & Gomes (2001). The radiation scheme used (Kiehl et al., 1996) accounts for O<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, O<sub>2</sub>, and CFCs.<sup>6,7</sup> <https://na-cordex.org/rcm-characteristics> cites no uniform aerosols for RegCM4's CORDEX runs.

**GCM Driver(s):** HadGEM2-ES, GFDL-ESM2M, MPI-ESM-LR

**Reanalysis Driver:** ERA-Interim

**Historical Run(s):** 1979-2014 (ERA-Interim), 1949-2005 (MPI-ESM-LR), 1950-2005 (HadGEM2-ES, GFDL-ESM2M)

**Future Scenario(s):** RCP8.5

**Future Time Period(s):** 2006-2100 (MPI-ESM-LR, 22° grid), 2006-2099 (HadGEM2-ES, GFDL-ESM2M, and MPI-ESM-LR, 44° grid)

## LAND COMPONENT

**Name:** The Biosphere-Atmosphere Transfer Scheme (BATS)

**Reference:** <sup>8</sup>Dickinson, R. E., Henderson-Sellers, A., & Kennedy, P. J. (1993). Biosphere-Atmosphere Transfer Scheme (BATS) version 1e as coupled to the NCAR Community Climate Model. *NCAR Tech. Note NCAR/TN-3871STR*.

**# Land Cover Types:** 20 vegetation types and 12 soil types<sup>8</sup>

**# Soil Layers:** 3 (+1 for snow), with an upper layer thickness of 0.1m, a soil rooting layer with varying thickness of 1 to 2m, based on vegetation cover and/or land use, and a third deep soil layer 3m thick<sup>8</sup>

**Soil Moisture:** Soil infiltration in BATS is written as a residual of the surface water balance equation, which is calculated from precipitation, excess water dripping from canopy, surface runoff, and evaporation.<sup>9</sup>

**Runoff:** BATS contains a simple surface runoff parameterization,<sup>4</sup> but was "not intended for local cite application, but was guided by the requirement that in a GCM, it should, on the average, give a similar amount of surface runoff as is observed"<sup>9</sup>

**Sub-Grid Lakes (y/n):** No. Elguindi et al. (2014) and Giorgi et al. (2012) cite that a sub-grid configuration of BATS (Giorgi, 2003) can be used in RegCM4,<sup>7,10</sup> but <https://na-cordex.org/rcm-characteristics> cites that it wasn't for NA-CORDEX.

**Carbon Fluxes:** Undocumented

**Land Use Change:** Undocumented

**Groundwater:** The BATS documentation doesn't include groundwater calculations, although Yang & Dickinson (1996) cite that groundwater accumulates from the gravitational drainage of soil water.<sup>9</sup>

### Additional References

<sup>3</sup>Notaro, M., Zarrin, A., Vavrus, S., & Bennington, V. (2013). Simulation of heavy lake-effect snowstorms across the Great Lakes basin by RegCM4: Synoptic climatology and variability. *Monthly Weather Review*, 141(6), 1990-2014.

<sup>4</sup>Patterson, J. C., & Hamblin, P. F. (1988). Thermal simulation of a lake with winter ice cover. *Limnology and Oceanography*, 33(3), 323-338.

<sup>5</sup>Bennington, V., Notaro, M., & Holman, K. D. (2014). Improving climate sensitivity of deep lakes within a regional climate model and its impact on simulated climate. *Journal of Climate*, 27(8), 2886-2911.

<sup>7</sup>Giorgi, F., Coppola, E., Solmon, F., Mariotti, L., Sylla, M. B., Bi, X., ... & Brankovic, C. (2012). RegCM4: model description and preliminary tests over multiple CORDEX domains. *Climate Research*, 52, 7-29.

<sup>9</sup>Yang, Z. L., & Dickinson, R. E. (1996). Description of the Biosphere-Atmosphere Transfer Scheme (BATS) for the Soil Moisture Workshop and evaluation of its performance. *Global and Planetary Change*, 13(1-4), 117-134.

<sup>10</sup>Elguindi, N., Bi, X., Giorgi, F., Nagarajan, B., Pal, J., Solmon, F., ... & Giuliani, G. (2014). Regional climate model RegCM: reference manual version 4.5. *Abdus Salam ICTP, Trieste*, 33.