

# Cloud processes simulated by the Canadian Regional Climate Model along a cross-section in the Pacific Ocean

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In this study, the 4<sup>th</sup> generation of the Canadian Regional Climate Model (CRCM) has been integrated over the Pacific Ocean in the context of the GCSS (GEWEX Cloud System Study) Pacific Cross-section Intercomparison (GPCI), which is an international project to evaluate and improve the representation of cloud and precipitation processes in weather and climate prediction models.

The CRCM was run at 180-km resolution over the Pacific Ocean with 115x75 grid points in the polar stereographic projection (Fig.1). Instantaneous model results are output every 3 hours for the periods of June-July-August (JJA) 1998. Seasonal mean results simulated by the CRCM are analyzed and compared with different observations and reanalysis data along a cross-section in the Pacific Ocean, which extends from the stratocumulus regions off the coast of California, across the shallow cumulus areas in the central Pacific Ocean, down to the deep convection regions of the ITCZ.

A number of modifications have been introduced in the model physics in order to improve the simulation of the cloud properties in the CRCM. The modifications are briefly summarized as:

1. A switch has been added to turn off the shallow convection once the deep convection had been detected on the same grid point.
2. A temperature perturbation based on the mean relative humidity in the mixing layer has been added in the trigger function of shallow convection; and the free convective vertical velocity scale been used in the cloud

base mass flux closure of the shallow convection.

3. In the deep convection, cloud radius and the minimum cloud-depth threshold have been updated according to Kain (2004) rather than remaining constants. A dilute updraft ascent has been used to calculate convective available potential energy (CAPE) in the closure, which provides a more accurate calculation in convection rainfall and mass flux.

4. The calculation of the eddy diffusivities has been upgraded based on the scheme from the ECMWF; the entrainment at the top of boundary layer has been considered based on Grenier and Bretherton (2001).

5. The large-scale cloud fraction has been diagnosed following Xu and Randall (1996).

6. The evaporation of the falling larger scale precipitation has also been considered.

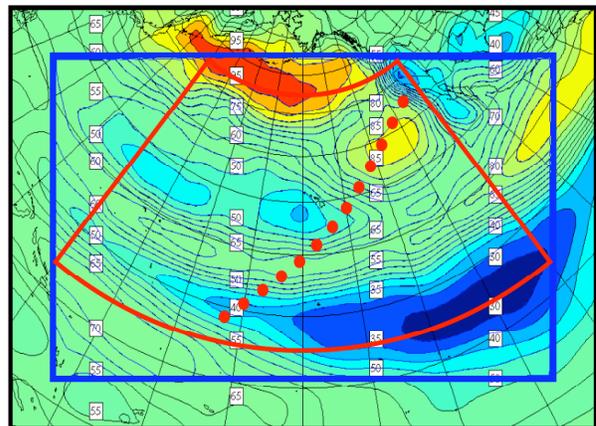


Fig.1. CRCM computational domain in the polar stereographic projection. The blue line is the sponge zone of the model; the dotted line indicates the location of the cross-section; the solid red line represent the 2-dimensional common area required by the GPCI. The contours are observed seasonal mean cloud cover from ISCCP for JJA 1998.

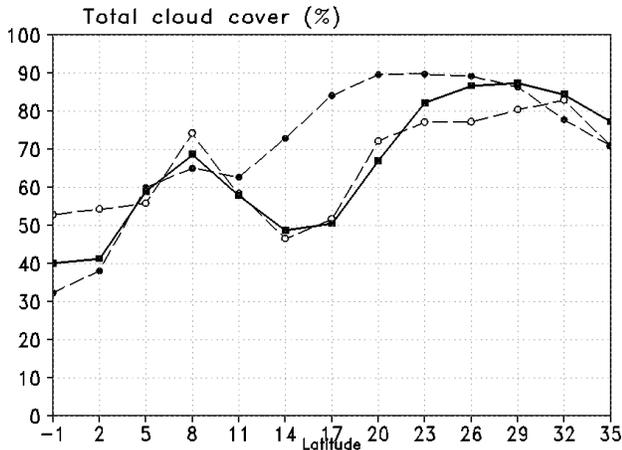


Fig.2. Seasonal mean total cloud cover simulated by the modified CRCM (dashed line with circles), the original CRCM (dashed line with dots) and the observation from ISCCP (solid line) along the GPCI cross-section for the period of JJA 1998.

Comparison results show that these modifications have a significant beneficial influence on the CRCM simulation. Great improvements have been found in the simulated total cloud cover over the shallow convective region (Fig. 2) while comparing with the observation from the International Satellite Cloud Climatology Project (ISCCP). Some improvement in the fields of simulated vertical structure of the relative humidity (Fig. 3), cloud distribution and vertical velocity have also been noticed while comparing with the ERA40 reanalysis.

**References:**

Grenier, H., and C. S. Bretherton, 2001: A moist PBL parameterization for large-scale models and its application to subtropical cloud-topped marine boundary layers. *Mon. Wea. Rev.*, **129**, 357–377.

Kain, J. S., 2004: The Kain–Fritsch convective parameterization: An update. *J. Appl. Meteor.*, **43**, 170–181.

Xu, K.-M. and D. A. Randall, 1996: A semiempirical cloudiness parameterization for use in climate models. *J. Atmos. Sci.*, **53**, 3084-3102.

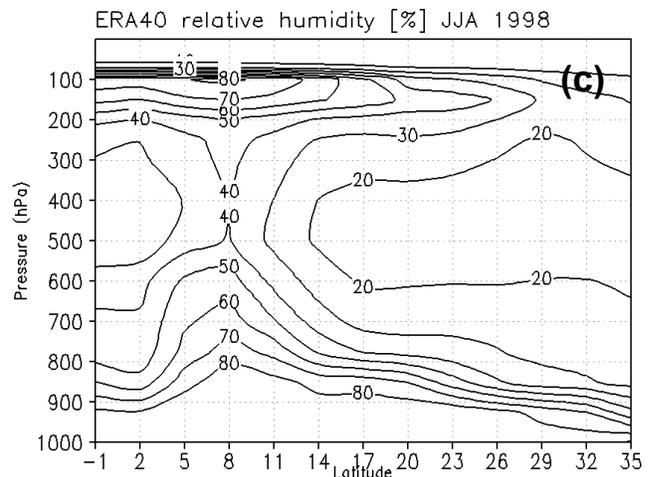
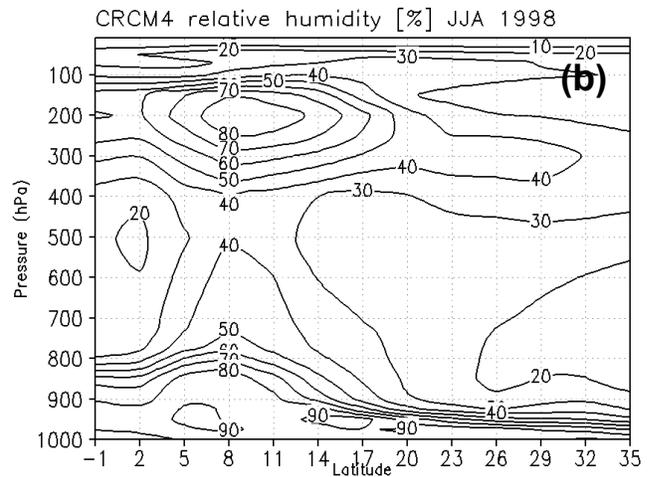
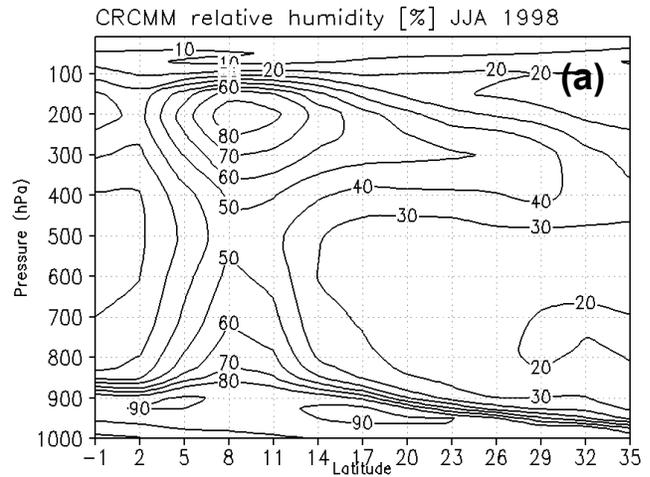


Fig.3. Vertical structures of the seasonal mean relative humidity simulated by (a) the modified CRCM, (b) the original CRCM, and (c) the ERA40 reanalysis along the GPCI cross-section.