IRS2012-332
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Radiative impacts of representing cloud horizontal variability by cloud type with the McICA methodology in the climate model GEM

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In climate models, whether they are global or regional, large-scale or meso-scale, cloud processes and their interactions with radiation are a primary source of uncertainty. This is due to the range of spatio-temporal scales involved in cloud processes and difficulties in correctly representing inhomogeneous subgrid-scale processes. Tuning of parameters is often used to reduce radiative biases that arise, in part, due to assumptions about cloud vertical overlap and horizontal inhomogeneity which can lead to compensating biases and simulated clouds or precipitation that potentially disagree with observations.

The Monte Carlo Independent Column Approximation (McICA, Barker et al., 2002) is a method in which the radiative transfer is computed by random sampling of possible cloud states produced by a stochastic cloud generator (SCG, Räisänen et al., 2004) as opposed to including cloud structure within the radiative transfer solution. By its nature, McICA produces unbiased radiative fluxes and heating rates with respect to the independent column approximation (ICA) although it produces random errors. The SCG is used to randomly generate subcolumns of the possible cloud field (respecting the mean fields provided by the microphysics scheme and assumed cloud structure) for each spectral integration point. Since the radiative transfer works on each subcolumn independently the radiative transfer scheme can be simplified and allows a highly flexible description of the subgrid-scale cloud structure within the cloud generator. This method is currently used in several climate and numerical weather prediction (NWP) models.

For the Global Environmental Multi-scale (GEM) model (used as a climate and NWP meso-scale model), the McICA method and the SCG have been implemented with a first-order differentiation between the three cloud types produced by the model: stratiform; deep; and shallow convective clouds. Our goal is to have the SCG take into account characteristics of these three clouds types, namely vertical overlap and horizontal variability of cloud water, and examine the radiative impacts of this differentiation.

The SCG was altered to account for three simultaneously occurring cloud types using parameters derived from surface and satellite observations made at high spatial and temporal resolutions. The new SCG and McICA were implemented in GEM and simulated cloud and radiative fields were compared to surface and satellite-based observational datasets.

This presentation will focus on the comparison between the modelled radiative fluxes at surface and top-of-atmosphere and observations from ARM surface sites and satellites. The different parameters of the SCG will be compared based on their radiative impacts.

Barker, H. W., R. Pincus, and J.-J. Morcrette (2002), The Monte Carlo independent column approximation: Application within large-scale models. in Proceedings of the GCSS-ARM Workshop on the Representation of Cloud Systems in Large-Scale Models, May 2002, Kananaskis, AB, Canada. (Available upon request from the Environment Canada Library, call number QC 175.25.S8 B37 2002).
Räisänen, P., H. W. Barker, M. Khairoutdinov, J. Li, and D. A. Randall (2004), Stochastic generation of subgrid-scale cloudy columns for largescale models. Quart. J. Roy. Meteor. Soc., 130: 2047– 2067.