Comparison of the Cloud-Radiation Interaction between GEM and ARM-SGP Observations

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Introduction

Microphysical processes play a key role in controlling the liquid and ice water content of simulated clouds and, as a result, are important controls on the interaction of clouds with both solar and terrestrial radiation. Due to their extreme complexity, processes controlling the cloud-radiation interaction are highly parameterized in present-day climate models. Here, we evaluate the cloud-radiation interaction as simulated by the new Canadian Regional Climate Model, based on the limited area version of GEM (Global Environmental Multi-scale Model, [1]). We evaluate the simulated co-variability of downwelling shortwave (SWD) and longwave (LWD) radiation at the surface as a function of liquid water path (LWP) and integrated water vapor (IWV).

Model and Observations

Observations comes from the ARM (http://www.archive.arm.gov) Southern Great Plains (SGP) site, at the central facility (CF-1). Data streams used for this model evaluation are the *improved MicroWave Radiometer RETrievals of cloud liquid water and precipitable water vapor* (MWRRET) with LWP and IWV derived from the 2-channel microwave radiometer and the *surface RADiation measurement (BEFLUX input) Quality Control testing* (QCRADBEFLUX1LONG) which provides observed downwelling SWD and LWD radiation at the surface.

GEM uses a prognostic total cloud water variable, with a Sundqvist-type, bulk-microphysics scheme. GEM-LAM was integrated for the period 1998-2004 over a domain centered on the ARM-SGP site CF-1 (37°N, 97 °W). The integration used ECMWF reanalysis as lateral boundary conditions, prescribed SSTs and employed a horizontal resolution of $\sim$ 42 km. Time series of model results were extracted from the grid-point closest to the ARM-SGP site.

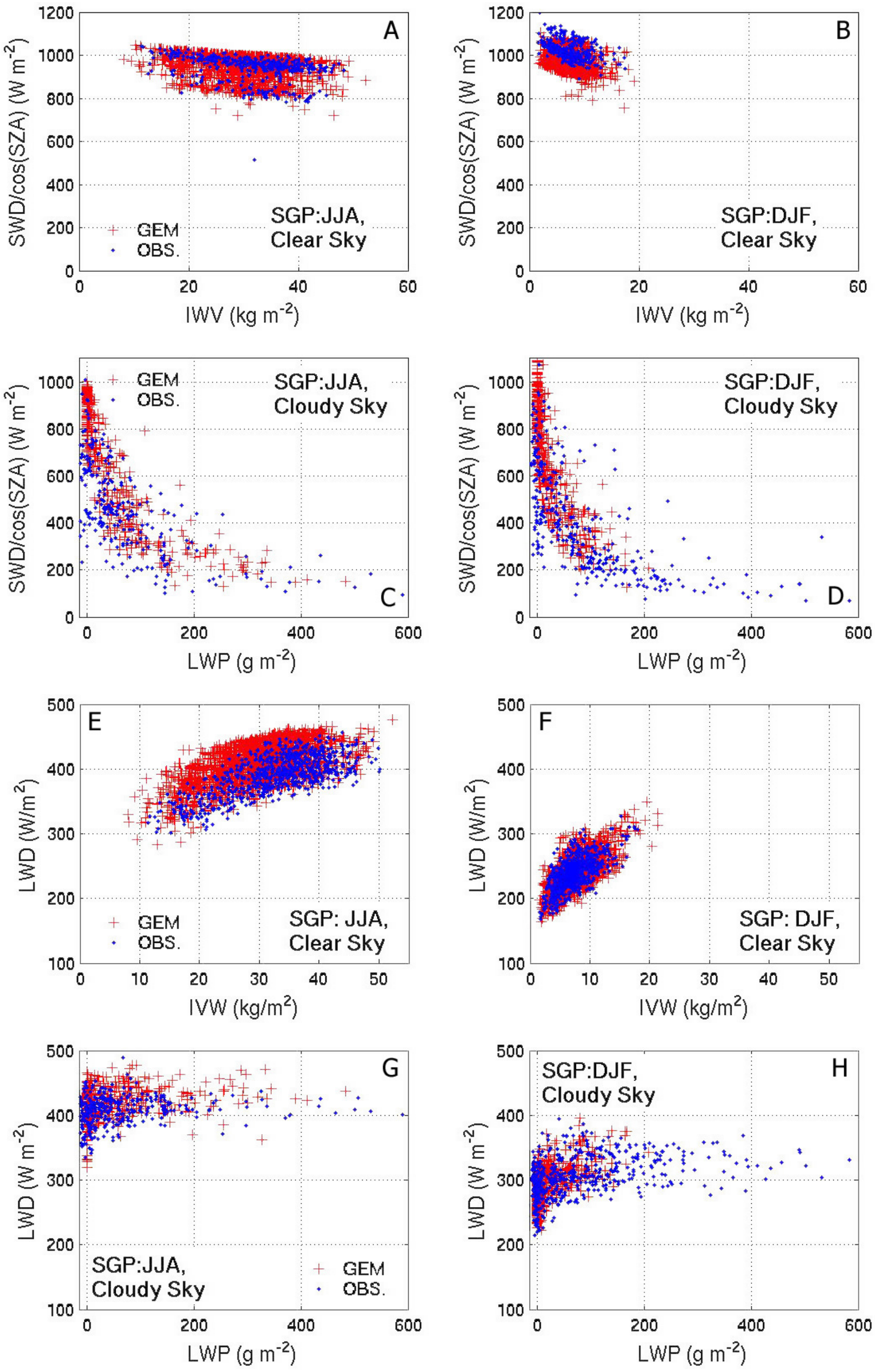
Both observations and model are averaged over 3 h periods for the entire 7 years. The MWR cannot operate when its teflon window is wet. For this reason, all precipitation events greater than 0.25 mm/3h are removed from the data-set of LWP and IWV for both observations and model.

Results

In this section, we present the summer (JJA) and winter (DJF) co-variability graphs. Observations are in blue and model is in red. In order to isolate the IWV effect on downwelling radiation, only clear sky conditions (cloud fraction $\leq$10 %) are used for the SWD-IWV and LWD-IWV co-variability. Similarly, only cloudy sky conditions (cloud fraction $\geq$90 %) are used for SWD-LWP and LWD-LWP co-variability.

In the following figures (A-D), SWD is divided by the cosine of the local solar zenith angle (SZA). Shown are only values for SZA below 65° for figures A-B and for SZA below 85° for figures C-D.

Figures A and B show the interaction between SWD and IWV for JJA and DJF respectively. GEM reproduces well this interaction during the summer but has a negative bias during the winter. In other words, GEM underestimates downwelling SWD at surface for a given amount of IWV compared to observations. Figures C and D depict the interaction between SWD and LWP for JJA and DJF respectively. They show that the model reproduces fairly well the observed interaction between LWP and SWD except for an overestimation in SWD for low amount of LWP during the summer.



Figures E and F show the interaction between LWD and IWV for JJA and DJF respectively. The model reproduces well the observed interaction except for a positive bias during the summer, result of a warm temperature bias during that season at this particular site. For the LWD-LWP interaction, figures G and H show that the cloud emissivity is saturated through the LWP range of observations. GEM reproduces well this interaction except for the same positive bias in the summer season as shown by figure E.

Conclusions

From these results, we conclude that GEM reproduces fairly well the cloud-radiation interaction at the SGP site except for the negative bias in winter for the SWD-IWV interaction. Without the warm temperature bias in the summer season, GEM would better reproduce the atmospheric water LWD emissivity. Furthermore, it shows that an error in simulated LWP would lead to an incorrect simulated SWD radiation at the surface but would not have an impact on the simulated LWD radiation at the surface.

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References

[1] Côté J., et al., 1998. The operational CMC-MRB global environmental multi-scale (GEM) model. Part I: Design considerations and formulation. Mon. Weather Rev.: 126, 1373-1395.