An Evaluation of Five WRF-ARW Microphysics Schemes Using Synthetic GOES Imagery for an Atmospheric River Event Affecting the California Coast

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INTRODUCTION

Significant precipitation events in California during the winter season are often caused by land-falling "atmospheric rivers" associated with extra-tropical cyclones from the Pacific Ocean. When an atmospheric river makes landfall on the coast of California (Fig. 1), the northwest to southeast orientation of the high terrain enhances forcing on the low-level flow in the warm sector of approaching extra-tropical cyclones. As a result, sustained precipitation is enhanced and modified by the complex terrain.

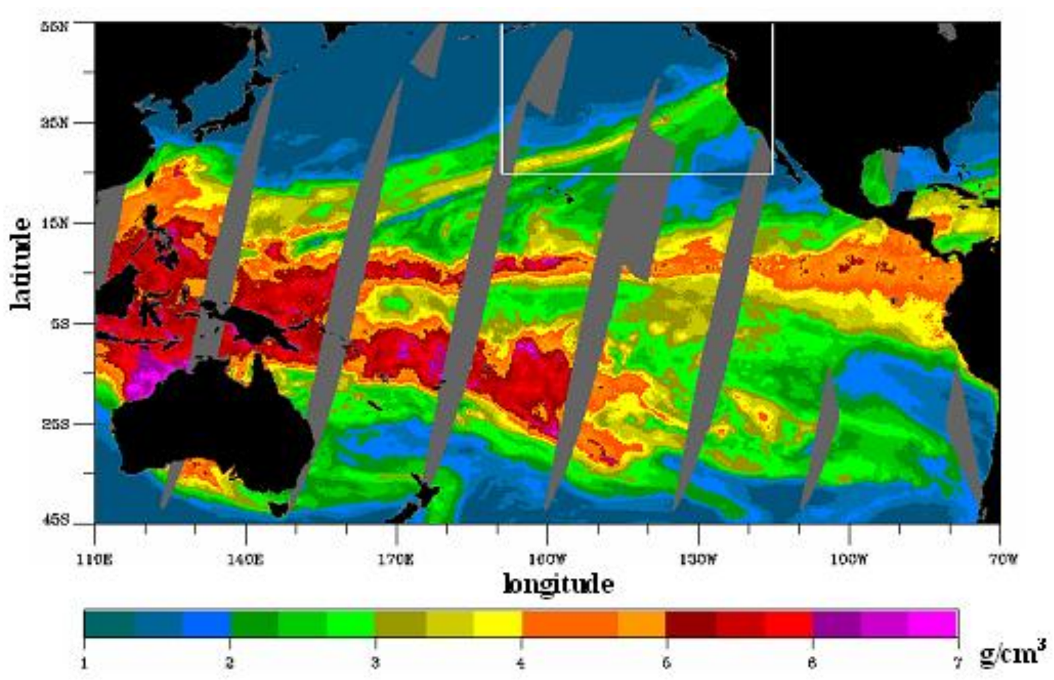


Figure 1. SSM/I image of atmospheric river that occurred on Dec. 30 2005.

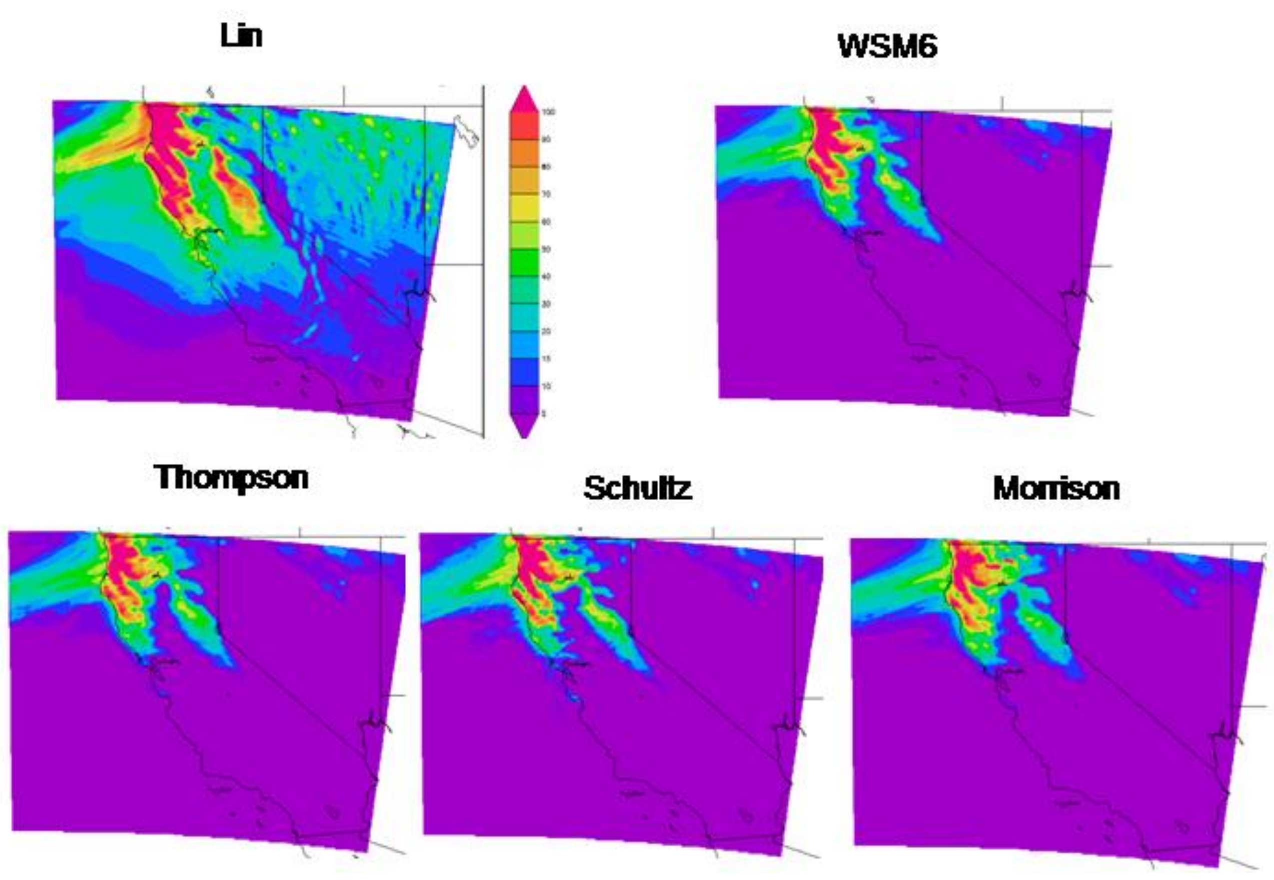
For this type of event, previous studies have shown strong sensitivity of simulated precipitation amounts to the choice of microphysical schemes used in numerical models for weather prediction. The main focus of the present study is to assess differences in performance of various microphysics within WRF by using a new approach involving synthetic satellite imagery. Basically, simulated brightness temperatures from model runs using various microphysics are compared to observations from channel 4 (10.7 micrometers) of GOES-10.

For this purpose an atmospheric river event that occurred on 30 December 2005 was simulated. The 24-hour-long WRF-ARW simulations starting at 12 UTC, with 15-min output were performed over nested domain (with 20- and 4-km grid spacing, respectively) and using five different microphysical schemes (Lin, WSM6, Thompson, Schultz, and 2-moment Morrison). Synthetic imagery was created and scenes from the simulations were statistically compared with observations using a histogram-based technique.

RESULTS

Firstly, accumulated precipitation simulated by the five different model configurations were compared. The results from all simulations were generally similar results with an exception for the model run using Lin microphysics. This run was characterized by both larger precipitation coverage and heavier amounts compared to all other solutions (Fig. 2).

Figure 2. 12-hour precipitation accumulations simulated by model runs using Lin, WSM6, Thompson, Schultz, and 2-moment Morrison microphysics. amounts valid at 31 December 2005 at 00 UTC.



Secondly, brightness temperatures simulated by various model configurations were compared to observations from GOES-10. The results indicated very different solutions for various model configurations (Fig. 3). The model run using Lin microphysics resulted in an almost constant field of 210 K.

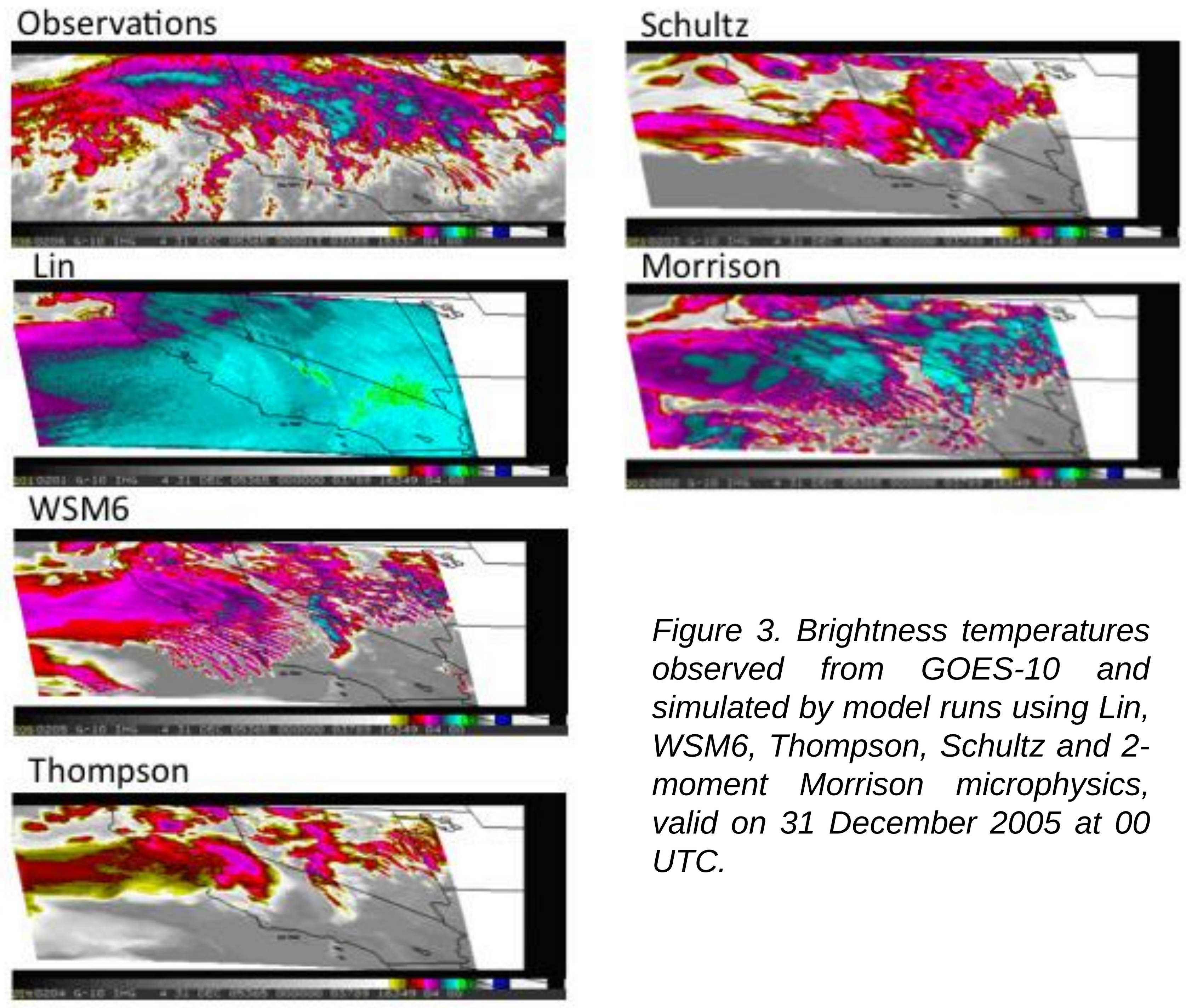


Figure 3. Brightness temperatures observed from GOES-10 and simulated by model runs using Lin, WSM6, Thompson, Schultz and 2-moment Morrison microphysics, valid on 31 December 2005 at 00 UTC.

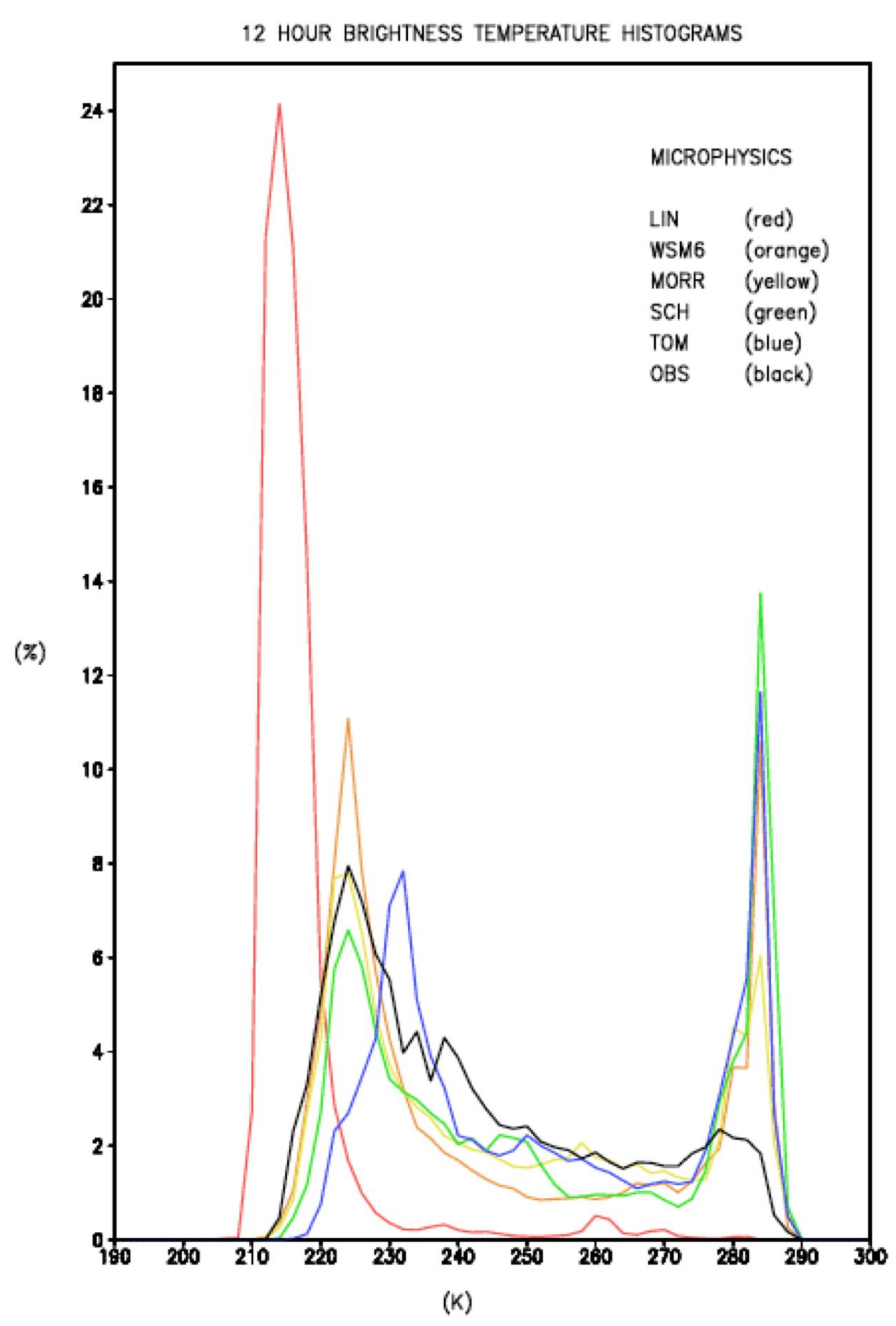
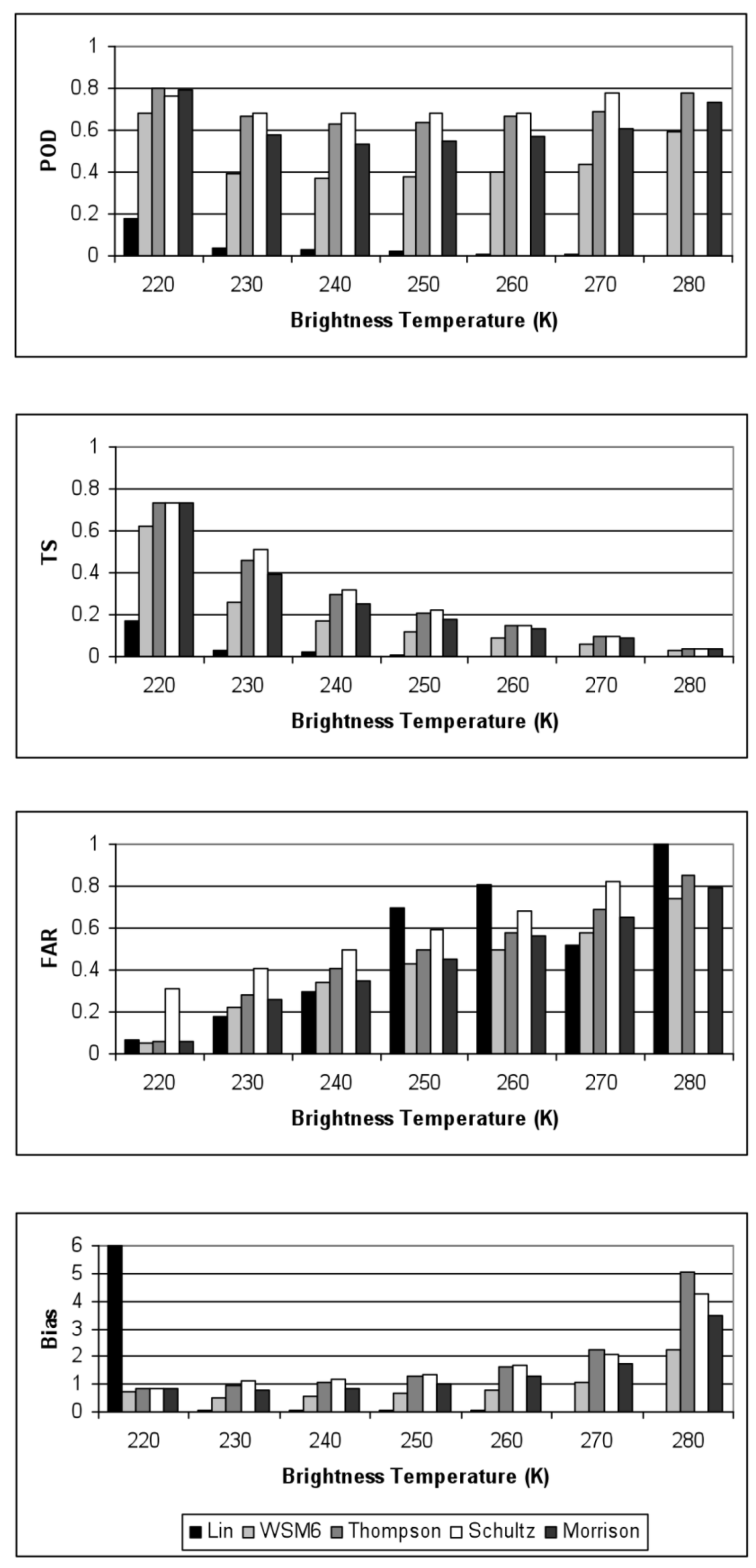


Figure 4. Probability of occurrence histograms for observed GOES-10 brightness temperatures (K) and synthetic brightness temperatures (K) simulated by model runs using Lin, WSM6, Thompson, Schultz and Morrison microphysical algorithms valid on 31 December 2005 at 0000 UTC (12-hour forecasts).

Figure 5. Calculation of a) POD, b) TS, c) FAR and d) Bias for 12-hour brightness temperature forecasts, valid at 00 UTC 30 December 2005, for the five different model solutions.



SUMMARY

Overall, the results in the present study indicate that synthetic satellite imagery can potentially be very useful as a model performance evaluation tool.

Using synthetic satellite data as a validation tool might allow model errors to be more easily identified.

Synthetic satellite imagery should be very useful for better understanding and improvement of existing microphysical schemes in addition to the identification of errors in cloud generation.

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