THE HEATED CONDENSATION FRAMEWORK AS A CONVECTIVE TRIGGER IN THE NCEP CLIMATE FORECAST SYSTEM VERSION 2

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INTRODUCTION

Recent advancements in high performance computing represent an exciting opportunity for global climate model development, pushing the limits of representing clouds and convection in a global atmospheric model. As a consequence, atmospheric moist convection can now be represented in sophisticated schemes such as global cloud-resolving models and super parameterization schemes. However, regardless of the strategy used to represent atmospheric moist convection in climate models, most schemes still require the representation of processes that control the initiation of convection. Such processes are commonly known as convective trigger functions, which specify a criterion or a set of criteria that have to be satisfied in order for a parameterized convection to initiate.

In a recent paper, Bombardi et al. (2015) modified the convective triggering mechanism of the deep convection scheme of the National Centers for Environmental Prediction (NCEP) atmosphere-ocean global coupled model (AOGCM), the Climate Forecast System version 2 (CFSv2). An additional criterion called the ***Heated Condensation Framework (HCF) (Tawfik and Dirmeyer 2014)*** was added to the original trigger function in the Simplified Arakawa-Schubert (SAS) convective scheme. This modification resulted in improvements in the CFSv2 representation of the Indian summer monsoon as well as the monsoon onset timing

OBJECTIVE

In this work, we present a follow-up on Bombardi et al. (2015) using an updated version of the convective trigger function in SAS. ***Our hypothesis is that the CFSv2 precipitation biases can be reduced by improving the timing of convection through the improvement of the convective trigger function.***

THE HCF TRIGGER

The HCF was developed by Tawfik and Dirmeyer (2014). The HCF was designed to represent the atmospheric background state with respect to convection using standard profiles of temperature and specific humidity.

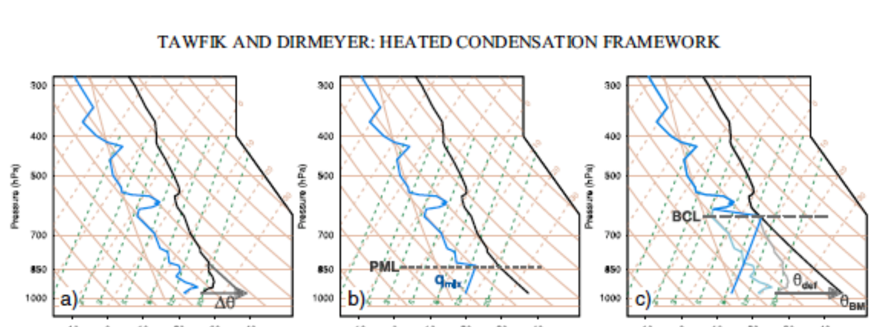

*Figure 1 – SkewT-LogP diagram of temperature (black) and dew point (blue) illustrating the steps to calculating the conditions for triggering convection. **From Tawfik and Dirmeyer (2014)***

MODEL AND EXPERIMENTS

Table 1 summarizes the experiments carried out with the CFSv2. Four ensemble members were generated for each set of experiments for each year from 1998 to 2010, totaling 156 short-run members and 156 seasonal members. Since the motivation is to improve prediction of the Indian monsoon, seasonal runs were initialized before the onset of the summer Indian monsoon in the first days of April (1 through 4). Seasonal runs were integrated for 7 months and data were saved with daily temporal resolution. Short runs were initialized in the peak of the summer Indian monsoon in mid July (14 through 17). The short runs were integrated for approximately 2 weeks with data saved at 3-hourly temporal resolution, making it possible to study the diurnal cycle of precipitation.

Table 1 – Configuration of experiments

Experiment Name	Type	Deep Convection	Shallow Convection	Trigger Function	Convective Cloud Base
CTRL	Short (~2 weeks) Seasonal (7 months)	New SAS	SAS based	Original (pressure difference)	LFC
HCFv2	Short (~2 weeks) Seasonal (7 months)	New SAS	SAS based	HCFv2	LFC
HCFv2_BCL	Short (~2 weeks) Seasonal (7 months)	New SAS	SAS based	HCFv2	BCL

HCF APPLIED TO DYNAMO SOUNDINGS

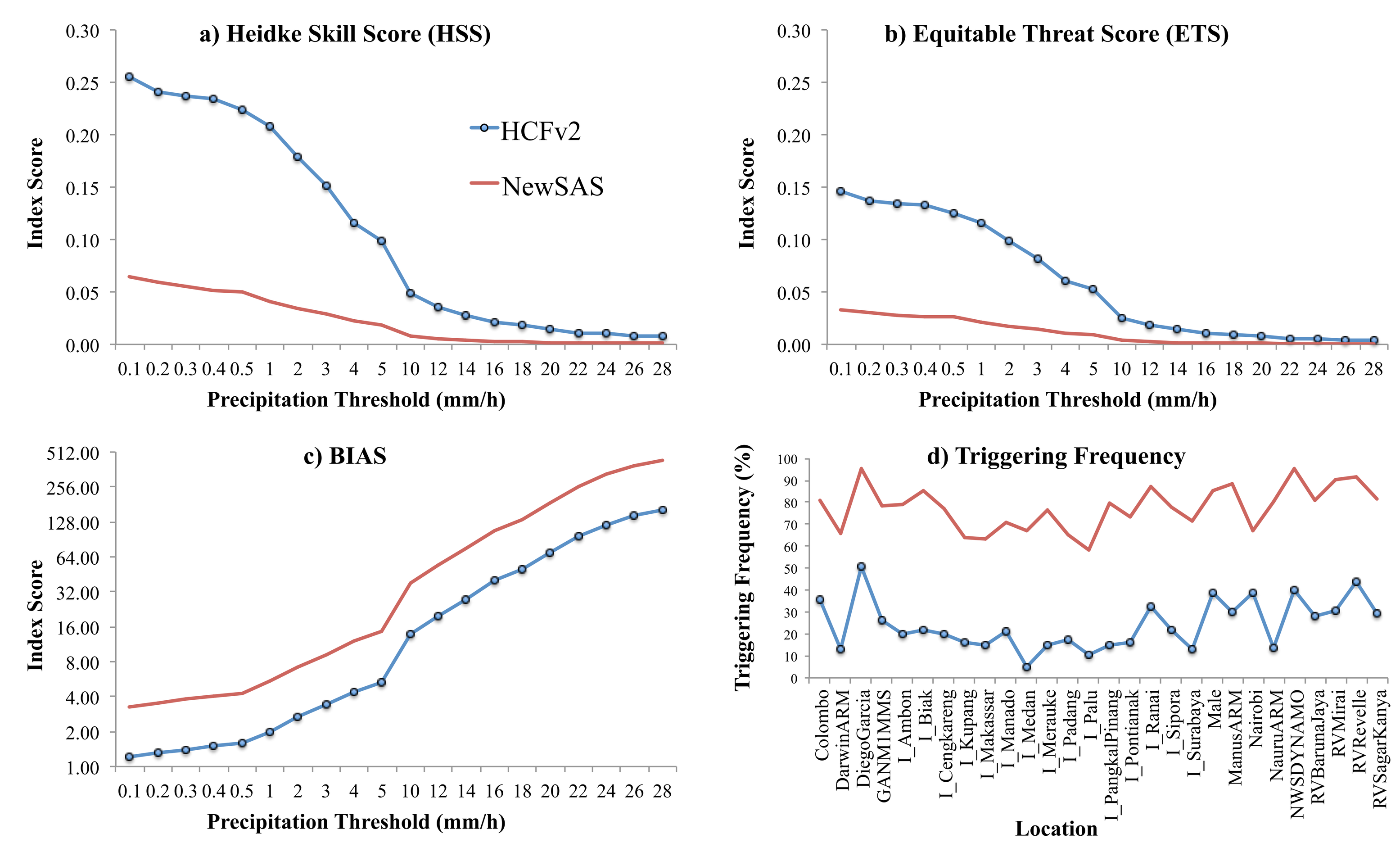

Figure 2 – Comparison between the HCF trigger and the original triggering mechanisms shown by a) the Heidke Skill Score; b) the Equitable Threat Score; c) the Bias; and d) the triggering frequency for each sounding release location.

DIURNAL CYCLE OF PRECIPITATION

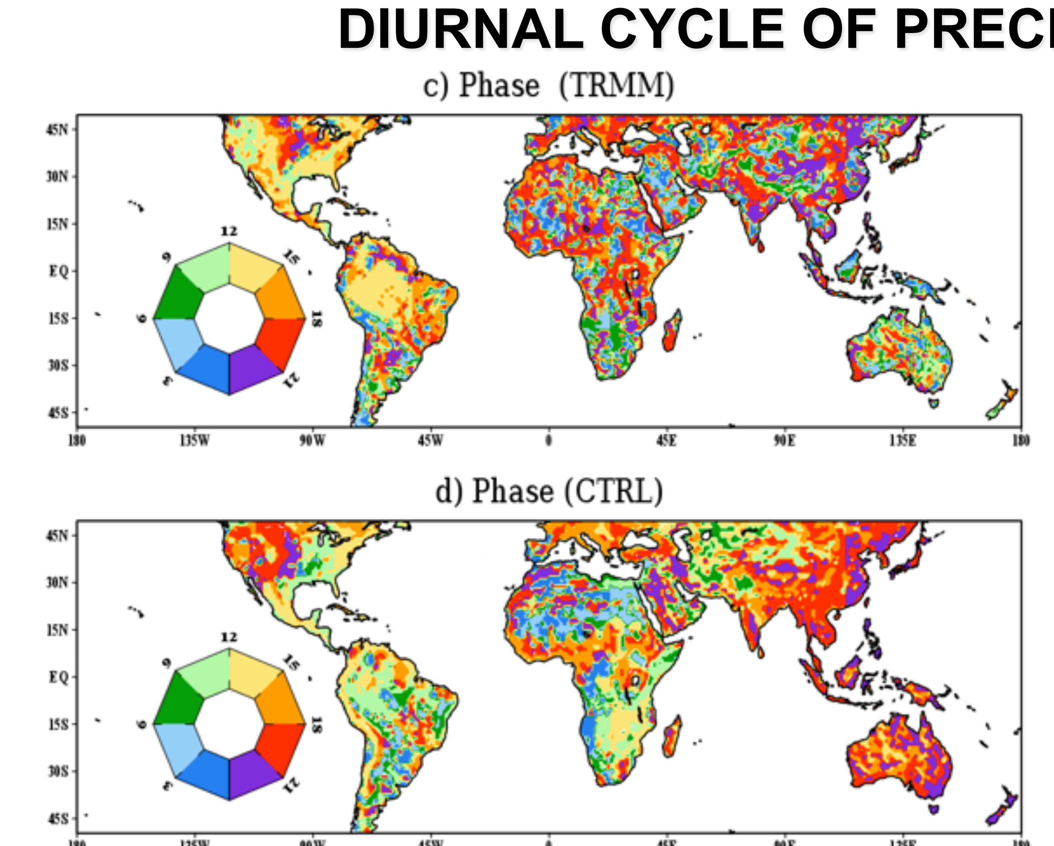

Figure 3 – Phase (LST) of the observed (TRMM) and simulated (CTRL) diurnal cycle of precipitation during the second half of July, which are the first 2 weeks of simulation in the short runs.

The phase is not very well represented by the CFSv2 (Fig. 2), a common problem in atmospheric models.

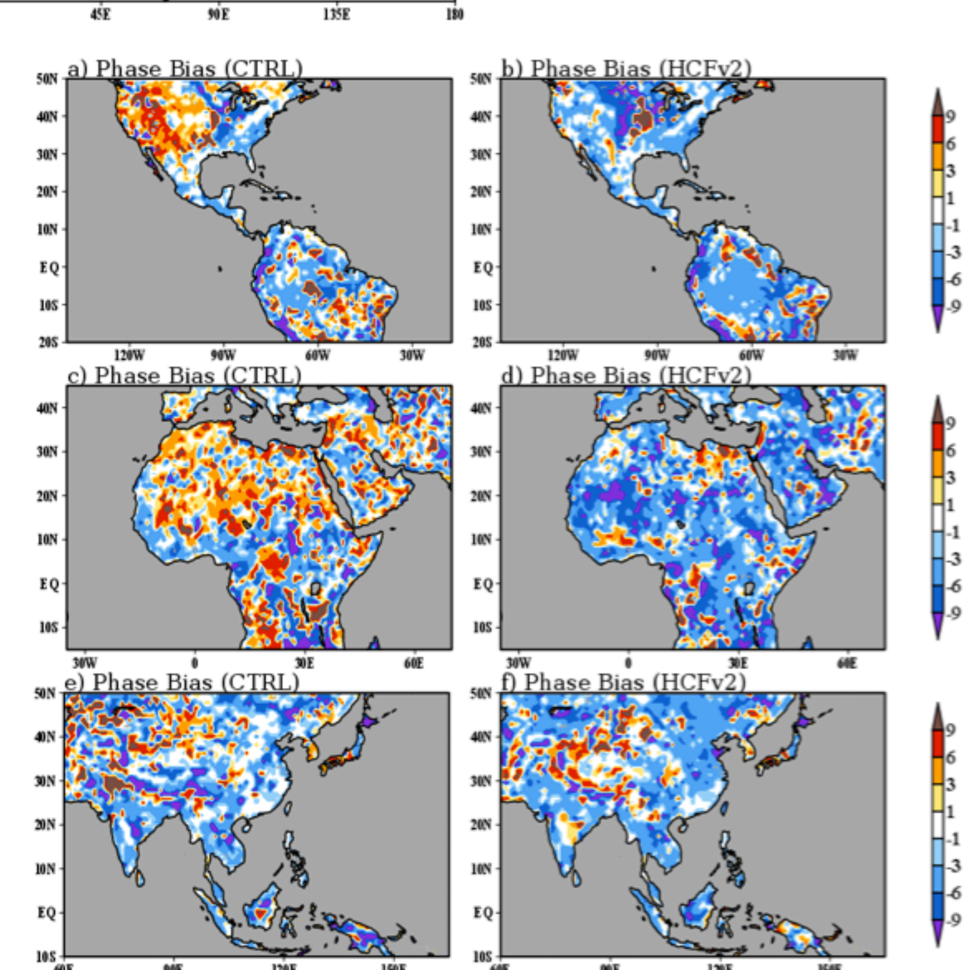

Figure 4 – Bias of the phase of the diurnal cycle of precipitation from CTRL (left) and HCFv2 (right). Negative values indicate that the maximum of the diurnal cycle occurs earlier in HCFv2 than in CTRL.

The most pronounced differences are found over North and South America (Fig. 4a,b) and Africa (Fig. 4c,d). The HCFv2 shows ***improvement over most of the western and southern United States*** and ***detriment over the Great Plains in the United States*** (Fig. 4a,b)

SEASONAL SIMULATIONS

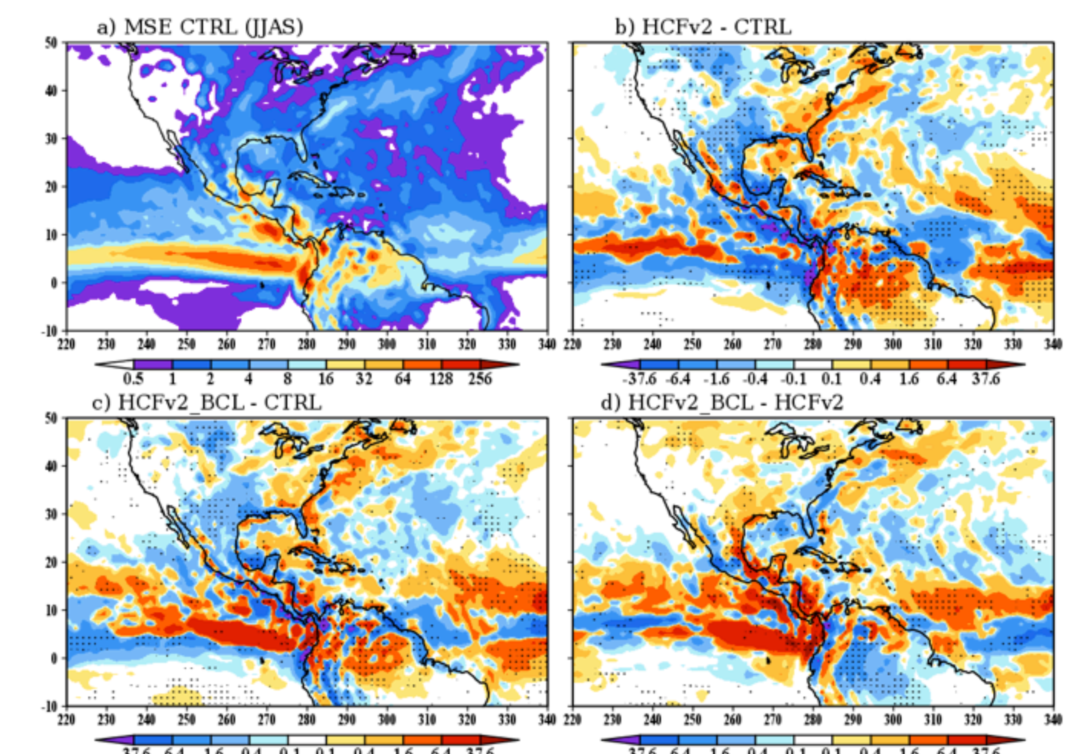

Figure 5 – JJAS precipitation MSE [(mm/day)²] for the a) CTRL experiment. The difference between JJAS precipitation MSE between b) HCFv2 and CTRL; c) HCFv2_BCL and CTRL; and d) HCFv2_BCL and HCFv2. The stapling indicates regions where the MSE difference is statistically significant at 5% level according to the Wilcoxon signed-rank test.

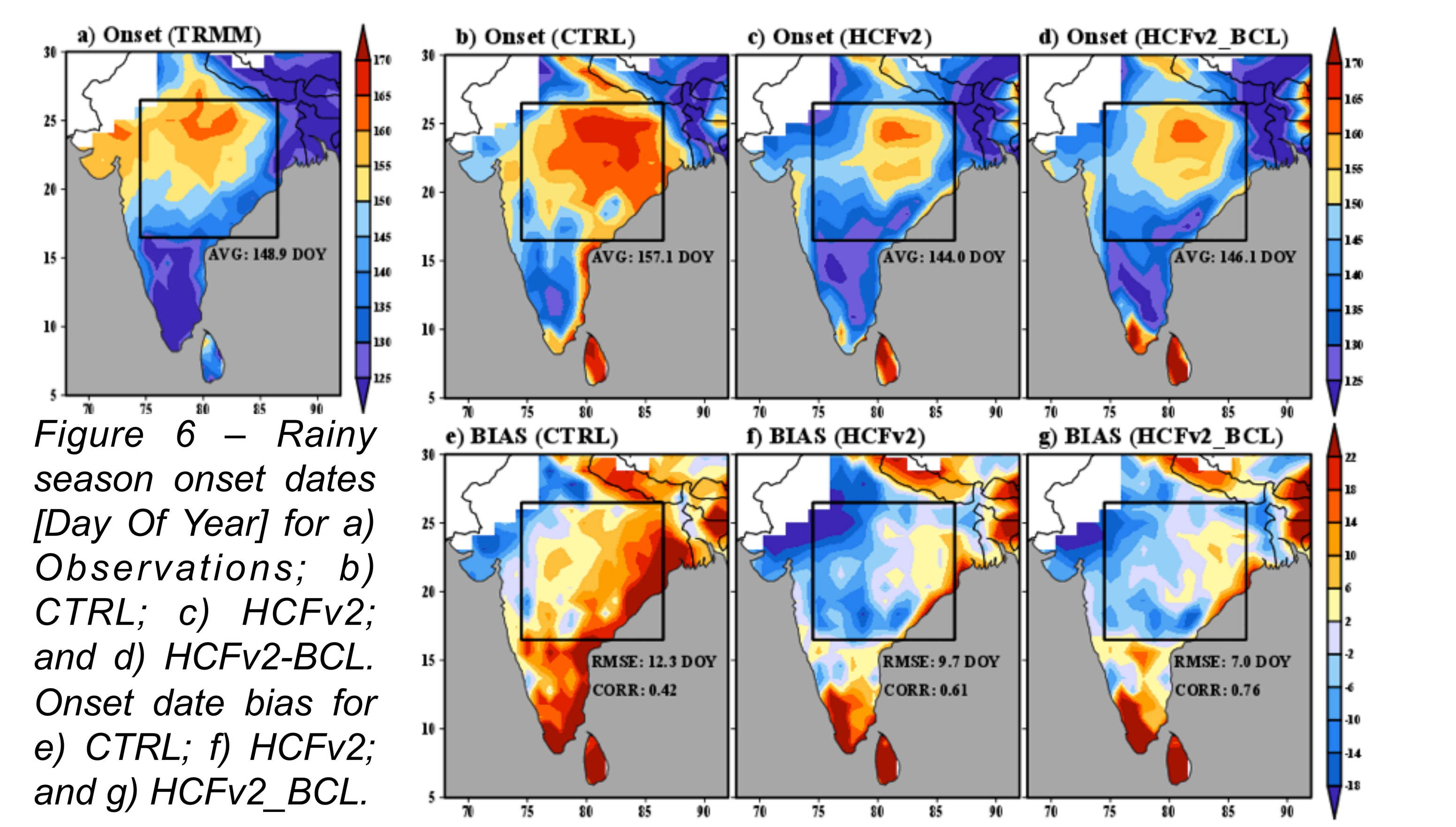

Figure 6 – Rainy season onset dates [Day Of Year] for a) Observations; b) CTRL; c) HCFv2; and d) HCFv2-BCL. Onset date bias for e) CTRL; f) HCFv2; and g) HCFv2_BCL.

CONCLUSIONS

The observational analysis shows that the HCF trigger better captures the frequency of convective triggering, whereas the original SAS trigger initiates convection too often. When implemented in the CFSv2, the new trigger improves the phase of the diurnal cycle of precipitation over the western and southern United States. The seasonal simulations show that the HCF trigger improves the intensity of summer precipitation over most of North America and over the Indian subcontinent. In addition, the new trigger improves the representation of the monsoon onset date over India.

Acknowledgements

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