Sensitivity of the surface parameters in CReSS for weather simulations over the arid and semi-arid regions

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To conduct forecast and/or hindcast simulations for rain enhancement research over the United Arab Emirates (UAE), we need an accurate and reliable numerical model to simulate clouds formation and precipitation development over the desert areas. The main purpose of this study is to check the performance of Cloud Resolving Storm Simulator (CReSS: Tsuboki and Sakakibara, 2007) model and validate and improve the numerical model for weather simulations over the UAE.
Land surface temperature plays an important role in reproducing clouds and precipitation, especially over the desert areas. In spite of importance of land surface temperature, CReSS had not been validated in terms of land surface temperature in detail and it recently turned out that CReSS experiments underestimate the land surface temperature during not only daytime but also nighttime.
To investigate the major parameters to influence the land surface temperature, sensitivity test was performed for the time duration from 0600 UTC 09th to 0600 UTC 12th September 2015 and compared with Aqua/Moderate Resolution Imaging Spectroradiometer (MODIS) data. The parameters related to land surface processes, which were investigated in this study, were thermal diffusivity, thermal capacity, evapotranspiration efficiency, roughness length, soil temperature in the deepest layer, emissivity on surface, number of soil and sea layers, and thickness of each soil layer.
The sensitivity experiments showed that the increase of land surface temperature in the daytime resulted from smaller thermal diffusivity, thermal capacity, evapotranspiration efficiency, roughness length, emissivity of land surface and larger soil temperature in the deepest layer, number of soil layers and thickness of soil layers. On the other hand, the increase of land surface temperature in the nighttime resulted from smaller evapotranspiration efficiency, emissivity of land surface and larger thermal diffusivity, thermal capacity, soil temperature in the deepest layer, number of soil layers, thickness of soil layers.
On the basis of sensitivity experiment, numerical experiments were performed to optimize the parameters in trial and error manner. To increase the land surface temperature during both daytime and nighttime, diverse parameters were tuned, including soil temperature at the deepest layer, evapotranspiration efficiency, and so on. The difference of domain-averaged land surface temperatures between Aqua/MODIS observation and CReSS simulation decreased from 13 K in the experiments with default values of the parameters (CTL) to 1 K in the experiment with optimized values of the parameters (OPT) in the daytime (1400 LST 10 September 2015). The difference in the nighttime (0200 LST 11 September 2015) also decrease from 3 K in CTL to 1 K in OPT experiments (see Figure. 1).
CReSS CTL experiments with 5 km horizontal resolution showed an improvement in reproducing the convective clouds over the desert areas to some extent, but still significantly underestimated such convective clouds. To examine a grid size dependency of the reproducibility of clouds and precipitation over the desert areas, CReSS OPT experiment with 1km horizontal resolution was performed. The model well reproduced convective precipitation over the mountain area and also over northwestern coastal and inland desert areas, which was not well reproduced by CReSS OPT with 5km horizontal resolution.

Keywords: Cloud Resolving Storm Simulator (CReSS), Land surface temperature, United Arab Emirates (UAE)

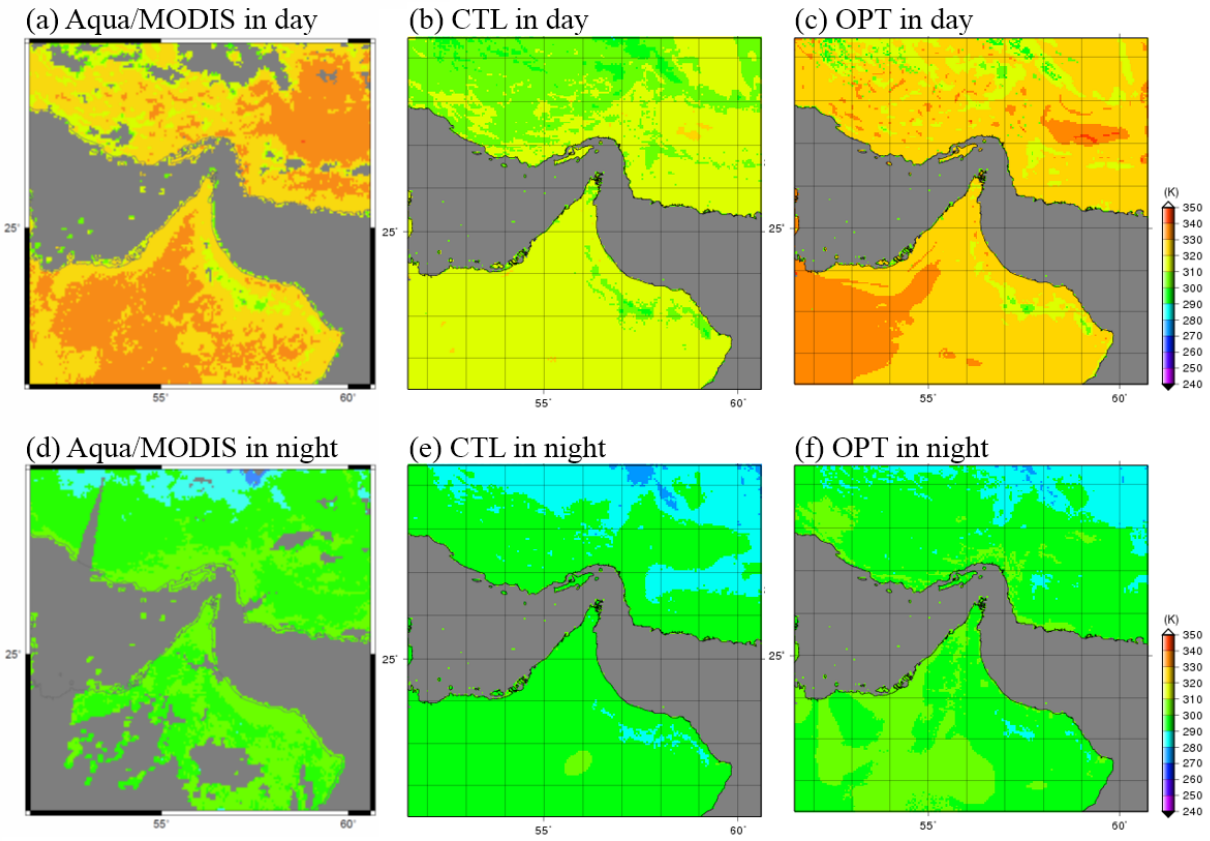

Figure 1. The distribution of land surface temperature by (a) Aqua/MODIS, (b) CReSS CTL, (c) CReSS OPT in 1400 LST 10 September 2015 and (d) Aqua/MODIS, (e) CReSS CTL, (f) CReSS OPT in 0200 LST 11 September 2015.