# IMPACT OF LAND SURFACE MODELS ON PRECIPITATION FORECASTING IN WRF WEATHER MODEL: APPLICATION TO NILWALA RIVER BASIN IN SRI LANKA

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## Introduction

Accurate prediction of weather is of great importance in today's world since adverse weather conditions such as torrential rainfalls could cause serious negative impacts on activities of humans in many ways. Weather modeling is a branch of atmospheric modeling in which weather parameters such as precipitation, wind velocity, temperature etc., are predicted. An atmospheric model is generally based on laws of thermodynamics and fluid dynamics. Numerical weather modeling samples the state of the fluid at a given time and uses the equations of fluid dynamics and thermodynamics to estimate the state of the fluid at some time in the future.

Weather models could be further classified into two distinct groups, namely global weather models and regional weather models. Among many weather prediction models WRF 3.0 (Weather Research and Forecasting Version 3.0) model is one of the most popular regional weather models used for research and operational purposes. As in any weather model WRF contains a number of different physics options to take the effects of weather influential processes into account. These physics options could be varied in calibrating the model so that the most effective set of physics options is selected before the model is executed for any operational purpose.

In the case WRF model the land surface model, which is one of the model physics components, plays a vital role. This is because the interactions between the land surface and the atmosphere (land-atmosphere processes) are modeled using the land surface model. The basic elements of land-atmosphere interactions are the exchanges of moisture and energy between the two systems. In WRF model used in this study, there are several land surface options available. Namely, Noah land surface model, 5-layer Thermal diffusion model (default land surface model option in WRF) and Rapid Update Cycle (RUC) Model.

The objective of this study is to check the impacts of various land surface models on rainfall predictions generated by WRF, on its application to the Nilwala river basin in Southern Sri Lanka. The area of the river basin is approximately 1,073 $km^2$. It lies mainly in the Matara district within the latitudes 5° 55' - 6° 13' and longitudes 80° 25'- 80° 38'.

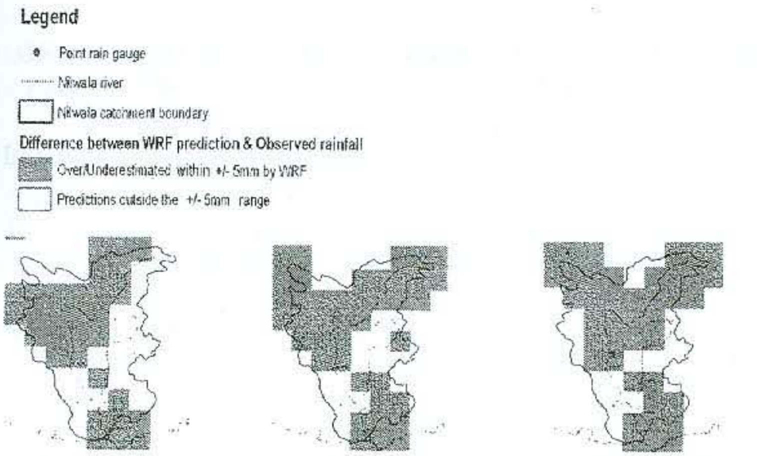
## Methodology

WRF model was applied to the Nilwala river basin with different land surface models keeping all other factors such as domain configuration, domain size, and other physics options etc., unchanged. Ferrier microphysics scheme was employed with Rapid Radiative Transfer Model long wave radiation scheme, Dudhia short wave radiation scheme, Monin-Obukhov surface layer, Kain-Fritsch cumulus scheme and Yonsei University boundary layer scheme as other physics options of WRF. Initial and lateral boundary conditions were obtained from the Global Forecast System (GFS) for initiating the WRF model (Awad et al, 2007). GFS Model, which is run by National Center for Environmental Prediction (NCEP), is initialized using observed data from radiosondes weather satellites and surface weather observations. For the analysis two global data sets were downloaded from the GFS on 09/12/2008 and 19/03/2009. In the present study, 45/15/5 km (1800x1800 km/645x 645 km/245x245km) domain configuration was tested with the above three land surface models for a forecast time of 24 h. The land surface schemes employed in the study were 5 layer thermal diffusion model, Noah land surface model and RUC in WRF. Land surface schemes were applied to the 1st, 2nd and 3rd domains in all the model runs. Model accuracy was monitored by comparing the model predictions with observed point rainfalls, obtained from the Department of Meteorology, for the rain gauging stations at Mapalana, Kekanadura, Thihagoda, Thelijjawila, Goluwatta, and Mawarella. Since the output of WRF is spatially distributed and the field observed rainfalls are in point format, these point rainfalls were spatially distributed on 5 km x 5 km horizontal grid for comparison purposes with the predictions. For checking the accuracy of model predictions difference between WRF prediction and observed precipitation (spatially distributed) were plotted over the watershed. The 0 – 5 mm over/under predictions were considered as acceptable forecasts. Area inside the basin in which the predictions were within the above specified +/-5 mm range was expressed as a % of the total area of the basin (Correctly Predicted Area %, CPA). This was taken as the measure of success of predictions. Figure 1 and Figure 2 show the difference between WRF prediction and observed rainfalls on 10/12/2008 and 20/03/2009, respectively. Table 1 gives CPA% for each land surface model.

**Results**

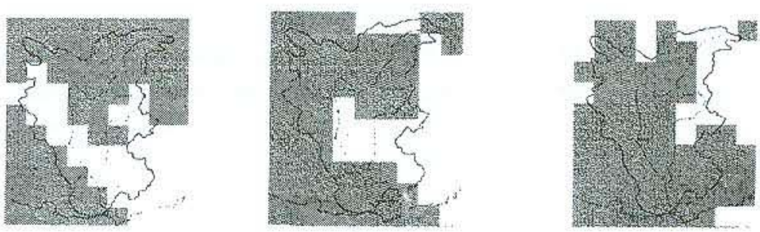
**Table 1. CPA % for various cumulus schemes**

| Rain event on 10/12/2008 | | Rain event on 20/03/2009 | |
|---|---|---|---|
| Land Surface model | CPA % | Land Surface model | CPA % |
| Noah | 50 | Noah | 61 |
| Thermal diffusion | 63 | Thermal diffusion | 82 |
| Rapid Update Cycle | 71 | Rapid Update Cycle | 74 |




(a)Noah (b) RUC (c) Thermal diffusion

**Figure 1. Difference between WRF prediction and observed rainfalls on 10/12/2008**



(a)Noah (b) RUC (c) Thermal diffusion

**Figure 2. Difference between WRF prediction & Observed rainfalls on 20/03/2009**

## Conclusions

According to the above results for the two rain events over the Nilwala basin RUC land surface model has responded with equally good CPA's of 71% and 74%. The thermal diffusion model too has produced good results with CPA's of 63% and 82% on 10/12/2008 and 20/03/2009, respectively. Both rain events have shown dependence on different land surface models but for the same land surface model, similar CPA% have been observed. The ability of RUC land surface model in rainfall forecasting over the Nilwala basin was further proven with a CPA value of 88% which was produced for the rain event on 06/04/2009, as the test was carried out following the same procedure.

## Acknowledgement

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## References

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