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Utilization of high resolution short range weather forecast for agro advisory services

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ABSTRACT

Agriculture is heavily weather dependent in India. The economy of the country is largely synchronized to the success of agriculture every year, as it contributes nearly 25% to gross domestic product (GDP). Farming community, planners and line department people always look forward to the accurate forecast from the weather men for decision making process in the event of natural disturbances. The district level agro advisories provided by IMD using medium range forecast (3-10 days) are good but covering large area. The advent of mesoscale model (Mesoscale Model (MM5) & *Weather Research and Forecasting* (WRF) etc) with high resolution (available at 9×9 sq km or below) enable the weathermen to give forecasts at village level and also location specific. This requires verification before value addition to it. Mesoscale model forecast data at 9×9 sq km grid have been generated by Department of meteorology and oceanography, Andhra University was collected for verification over Andhra Padesh.The verification skill scores, ratio scores, correlation coefficient and RMSE have been analyzed. Majority of the stations are showing good correlation for maximum and minimum temperature and relative humidity, where as rainfall forecast have desirable skill scores for most of the stations.

Key words : MM5, WRF, short range weather forcast agro advisory services.

The influence of weather elements on crop prospect is so high in tropical countries like India. The weather-induced variability of crop production is more than 10 per cent and it may go as high as 50 per cent. So, weather should be taken as one of the input for agricultural planning as well as operations in various facets of agricultural production (Verma 1998). Hence, farming community needs to be advised in time by custom-tailored weather forecasts to initiate suitable measures to minimize the losses and as well to increase the production. In order to cater the needs of peasants, India Meteorological Department has started to issue district-wise weather forecast for five days from monsoon 2008. However, to improve the accuracy of forecast meso scale modeling will give the much-needed boost and many research organizations and universities have initiated to give mesoscale (MM5) forecast on experimental basis in our country. For instance, institutes like National Centre for Medium Range Weather Forecasting (NCMRWF), Indian Institute of Delhi & Kharagpur, Indian Institute Tropical Meteorology (IITM-Pune), Centre for Mathematical Modelling and Computer Simulation(C-MMACS) Bangalore, Indian Air Force (IAF) and Indira Gandhi Centre for Atomic Research (IGCAR-Kalpakkam) have already started to run real-time basis for forecasting mesoscale weather systems (Rajagopal and Iyengar, 2002; Mohanty *et al.*, 2004; Sandeep *et al.*, 2006; Vaidya, 2007; Goswami and Patra, Srinivas *et al.*, 2006). Further, assessing the quality and skills, identifying the relative strengths and weaknesses of the forecasts are very important for operationalisation at ground level. NCMRWF, the countries premium organization in simulating MESOSCALE models carried out a diagnostic verification of the forecast generated through Perfect Prog Method (PPM) based equations using T-80 model output. In order to provide insight into the basic characteristics of the forecast, a detailed verification of the temperature forecast has been done. The examination of the conditional distribution p(x/ f) shows that the maximum temperature forecasts are relatively unbiased whereas the minimum temperature forecasts are slightly biased and need improvement of the model (Maini, *et al* 2003). The present paper elucidates high resolution (mandal-wise) mesoscale model forecast and its verification, which has been done at Central Research Institute for Dry land Agriculture (CRIDA), Hyderabad in collaboration with Andhra University, Vishakapatnam.

MATERIALS AND METHODS

MM5 Modeling – Overview

The PSU/NCAR mesoscale model is a limited-area, nonhydrostatic or hydrostatic terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. It has been developed at Penn State and NCAR as a community mesoscale model and is continuously being improved by contributions from users at several universities and government laboratories.

The Fifth-Generation NCAR / Penn State Mesoscale

Table 1: Correlation co-efficient and RMSE between observed and forecasted weather parameters at selected stations over Andhra Pradesh

Station Name	Maximum Temp		Minimum Temp		Relative Humidity	
	r	RMSE	r	RMSE	r	RMSE
Adilabad	0.95	9.8	0.82	2.5	0.93	57.8
Anantapur	0.53	13.5	0.52	2.9	0.84	41.5
Bapatla	0.82	6.0	0.76	5.1	0.18	17.5
Bhadrachalam	0.97	9.3	0.89	3.0	0.79	29.2
Hakimpet AP	0.98	10.9	0.78	5.4	0.90	37.4
Hanamakonda	0.98	11.2	0.44	6.2	0.80	28.5
Hyderabad AP	0.89	17.0	0.85	4.4	0.44	51.4
Kakinada	0.34	9.4	0.75	1.9	0.24	26.6
Kalingapatnam	0.27	9.7	0.26	4.9	0.50	26.9
Kavali	0.36	9.9	0.30	3.4	0.19	13.9
Khammam	0.96	8.0	0.94	4.5	0.45	33.5
Kurnool	0.97	12.5	0.88	2.1	0.40	38.9
Machilipatnam	0.53	10.0	0.26	3.5	0.48	20.9
Mahabubnagar	0.98	16.0	0.92	2.9	0.82	71.6
Medak	0.96	10.8	0.81	2.3	0.87	33.7
Nalgonda	1.00	2.1	0.98	2.4	0.83	32.3
Nandigama	0.92	10.9	0.77	6.8	0.86	10.1
Nandyal	0.94	9.2	0.21	9.6	0.57	40.0
Narsapur	0.98	7.7	0.67	3.2	0.96	22.6
Nellore	0.14	9.2	0.02	2.4	0.23	19.7
Nizamabad	0.95	14.7	0.91	2.6	0.95	31.5
Ongole	0.56	10.9	0.46	3.7	0.46	20.2
Ramagundam	0.99	13.4	0.92	3.3	0.89	39.2
Tirupathi AP	0.62	15.5	0.69	3.5	0.22	47.0
Tuni	0.01	7.3	0.42	3.3	0.47	39.5
Vijayawada AP	0.92	8.7	0.72	4.0	0.50	24.0
Visakhapatnam	0.88	5.6	0.19	3.7	0.66	32.9

r – Correlation Coefficient RMSE – Root Mean Square Error

Model (MM5) is the latest in its series that developed from a mesoscale model used by Anthes at Penn State in the early 70's and it was later documented by Anthes and Warner (1978). Since that time, it has undergone many changes designed to broaden its usage. These include (i) a multiple-nest capability, (ii) nonhydrostatic dynamics, which allows the model to be used at a few-kilometer scale, (iii) multitasking capability on shared- and distributed-memory machines, (iv) a four-dimensional data-assimilation capability, and (v) more physics options.

MM5 is a regional model and requires initial condition as well as lateral boundary condition to run. To produce lateral boundary condition for a model run, one needs gridded data to cover the entire time period that the model is integrated over.

Weather data: Observation and Forecast

Three days sliding forecast generated using the MM5 model for Andhra Pradesh region for different weather parameters (Rainfall, temperature, relative humidity and wind speed and direction) were obtained from the Department of Meteorology and Oceanography, Andhra University, Vishakapatnam. Daily-observed temperature (maximum & minimum) data was collected for 29 IMD stations located in Andhra Pradesh . The daily rainfall of 1128 mandals was collected from Department of Economics and Statistics, Government of Andhra Pradesh to compare the forecast and observed data through spatial analysis using GIS technique.

Utilization of high resolution model for AAS

Agriculture decision making exclusively depends on weather. Farmers always look forward to have a precise weather forecast from the forecasting agencies. So far, medium range forecast has restricted to district level. This blanket forecast for the districts are not helpful in decision making at the block/village level. The advent of numerical weather prediction (NWP) forecasting tools like MM5 and WRF models which provides short range sliding weather forecast

Table 2: Ratio score and HK score between observed and forecasted rainfall at selected stations over Andhra Pradesh

Station name	Ratio Score (Percentage of correct forecast)	Hanssen and Kuipers Score (HK score)
Adilabad	86.6	0.75
Ananthapur	82.3	0.81
Visakhapatnam	94.4	0.94
Vijaywada ap	75.0	0.73
Tirupathi ap	50.0	0.13
Rentachintala	75.0	0.73
Ramagundam	68.7	0.67
Ongole	75.0	0.71
Nizamabad	75.0	0.71
Nellore	56.2	0.53
Narsapur	64.7	0.63
Nandigama	81.2	0.80
Medak	66.6	0.64
Mahabubnagar	80.0	0.79
Machilipatnam	75.0	0.73
Kurnool	75.0	0.69
Khammam	81.2	0.80
Kalingapatnam	81.2	0.80
Kakinada	80.0	0.79
Hyderabad AP	62.5	0.60
Hanamkonda	75.0	0.73
Hakimpet AP	75.0	0.73

with high accuracy levels and high resolution (9 X 9 sq km) capacity is most helpful in making decision for day to day to agricultural operations. . In order to achieve the correctness of the forecast at micro level requires verification of the same with the observed data. This, further helps in model sensitivity analysis for modifying the parameterization schemes to improve the accuracy of the model forecast.

Verification of the forecast

The scores used for verification of rainfall forecast are ratio score and Hanssen and Kuipers (H.K) skill score. The ratio score (RS) measures the percentage of correct forecasts out of total forecasts issued. The Hanssen and Kuipers' discriminate (HK) is the ratio of economic saving over climatology.

If the H.K Score is closer to 1 then the forecasts are the best and when the H.K Score is near 0 or less than 0 then the forecasts are bad. In the case of maximum and minimum temperatures, relative humidity, the correlation coefficient and RMSE values are calculated for verification of the forecast. RMSE is frequently used measure of the differences between the values predicted by a model and the values actually observed. It is a good measure of the accuracy of forecast.

RESULTS AND DISCUSSION

The verification of weather forecast is more important fact before issuing value added agro advisories. For verification analysis skill scores, ratio scores, correlation coefficient and RMSE have been computed and furnished in Table 1 and 2. Majority of the stations are showing good correlation coefficients and RMSE ranges for maximum temperature (0.6-0.9 & 2.0-17.0), minimum temperature (0.5-0.9 & 1.9-9.6) and relative humidity (0.5-0.9& 10-57). High correlations were found for maximum and minimum temperatures. However, low correlation values are found for the stations, which are located near the coast (Table.1). Further sensitivity analysis is required to get the insight for the low correlation coefficients.

From the Table 2, the forecast skills scores are more stable and sustainable almost. The range of ratio scores observed is in between 50% - 94%. Hanssen and Kuipers

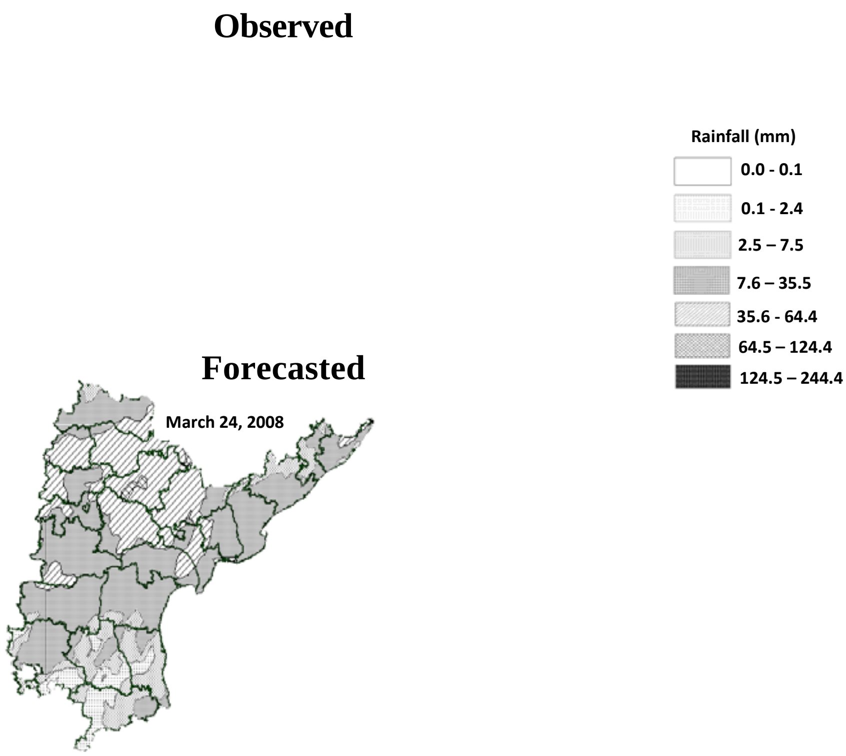

Fig. 1: Comparison of observed and forecasted rainfall data over Andhra Pradesh during March 23-25, 2008

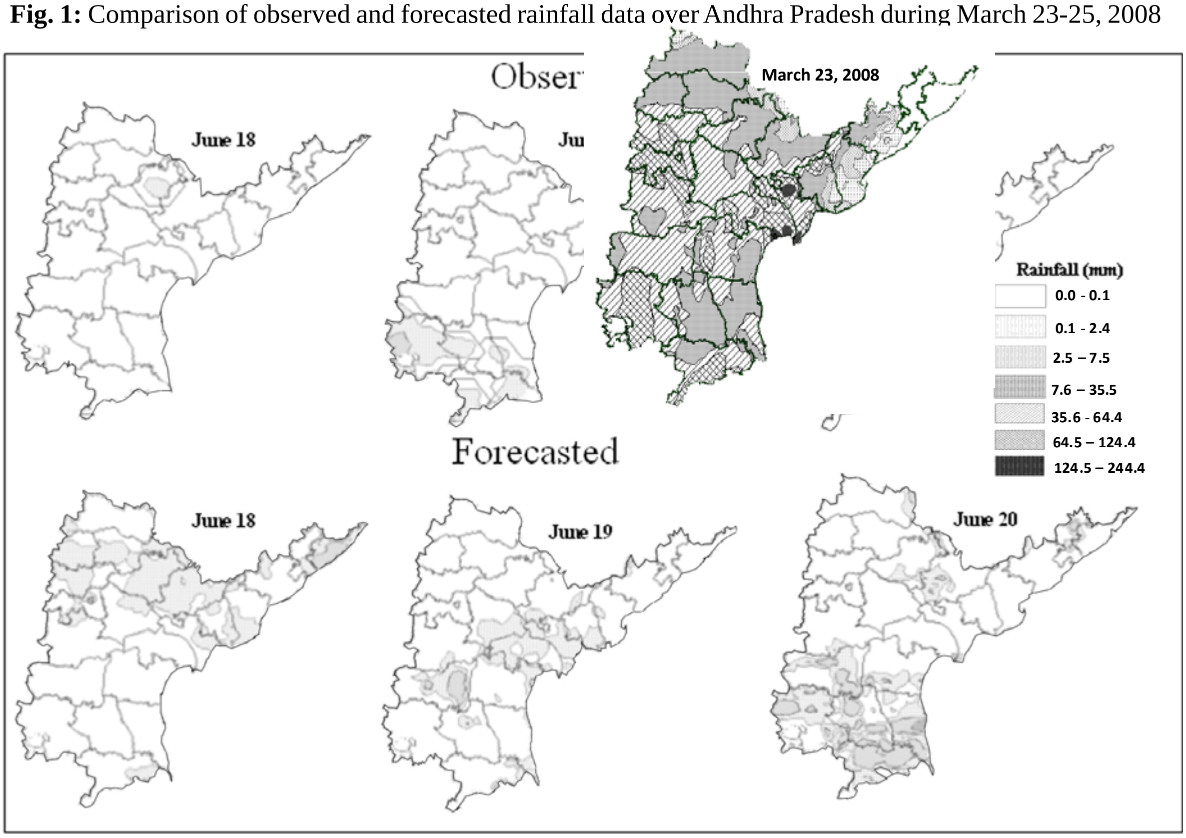

Fig. 2: Comparison of observed and forecasted rainfall data over Andhra Pradesh during June 18-20, 2008

(H.K) skill score ranges are in between 0.6-0.9. It was found that very few stations are showing low skill scores.

The spatial analysis of precipitation parameter was analyzed using GIS. The simulated and observed rainfall data are comparable except at some locations, where the model predicted some area with overestimate and some areas with low estimate (Fig.1.) However, the forecast can able to predict the rainfall events well and have the good potential for AAS units. Two case studies were taken and verified to assess the location specific performance of model prediction.

Case study 1 – Heavy rainfall event

Heavy rainfall event occurred during March 23 – 25, 2008. This period is coinciding with the harvesting of rabi crops in Andhra Pradesh. Due to this untimely rain, crop damage was noticed. Mesoscale model has predicted the heavy rainfall pattern correctly. Moderate (7.6 –35.5 mm) and rather heavy rainfall (35.6-64.5mm) intensity prediction was good on March 23, 2008. Further improvement was observed on the second day forecast (March 24, 2008) for rainfall (Fig.1). Moderate rainfall conditions predicted by model were very good. Third day forecast (March 25, 2008) was not as good as first and second day forecast. However, the model could able to predict the event with accuracy but failed in predicting the amount of heavy rainfall (125 -250 mm) in some locations during first and second day of the forecast. The model requires further improvement in predicting higher amounts of rainfall.

Case study 2 – Dry spell condition

In Andhra Pradesh, generally onset of southwest monsoon takes place during second week of June along with good rainfall. For this case study we considered a dry spell event during June 18-20, 2008 (Fig.2). Since, this is the important period to start field operations and sowings. The model has predicted no rainfall conditions well at most of the location. The Day-1 forecast of very light rain fall conditions matched with observed rainfall data whereas no rainfall predicted on Day -2 is well matched with observed data, except a few locations. Moderate rainfall conditions predicted by the model in third day forecast were slightly deviating with observed rainfall conditions.

CONCLUSION

The results from the mesoscale model forecast are encouraging. Nonetheless, the model prediction is good enough to forecast the weather parameters with varying accuracy levels. The accuracy of forecast requires further improvement in the model parameters. It was observed from the above study and considering the importance of the forecast at micro level, the high-resolution model has the good potential for issuing weather based agro advisories and crop management.

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