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Assessment of rainfall trends at micro and macro level in Andhra Pradesh

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ABSTRACT

Climate change scenarios generated using GCM models are mostly based on grid data for the entire country or for a given state. Most international organizations use this data in generating the scenarios for India. An attempt has been made to make a comparison of rainfall trends based on 1° X 1° grid data and data collected from a dense network of 1128 raingauge stations in Andhra Pradesh. No decreasing trend is noticed over the entire state with grid data. However, a clear decreasing trend in annual rainfall is found in the tract consisting of Medak, Nalgonda, Krishna, East and West Godavari districts from block level data. On the contrary, increasing trend is noticed with grid data in these districts. In Prakasam district, declining trend in many blocks with block level data was noticed, but increasing trend is seen with grid data. Like-wise in Rayalaseema (Anantapur, Cuddapah, and Chittor) some blocks are showing increasing or decreasing trend with block level while with grid data, no significant trend was observed.

Key words: Rainfall trends, grid data, block data, Andhra Pradesh

The reliance on climatic data is increasing as their role in planning and climatic prediction expands. This raises the priority of understanding spatial and temporal variability. Many of the GCM's models use complex land surface processes. It is important to understand the variability on a block (sub-grid) level before the effects of heterogeneous nature of land surfaces effects on grid-scale model estimates can be specified (Bougeault, *et al*., 1991). An understanding of the spatial variability and its timely use can also lead improved real time data bases. Ashraf *et al.,* (1997) and Hubbard (1994) reported that the density of meteorological stations required to detect spatial variations depends on weather variable of interest. A 60 km spacing is required to explain 90% of the variation between sites of Nebraska for maximum daily air temperature. For minimum temperature, relative humidity, solar radiation and PET that spacing reduces to 30 km, and for wind speed and precipitation, spacing of 10 and 5 km are required, respectively. Based on 306 uniformly distributed stations Mooley and Parthasarathy (1984), Parthasarathy *et al.* (1993) and Parthasarathy et al. (1994) constructed all India rainfall series. They have also used area weighted method to calculate all India rainfall using data of the 306 districts outside the hilly regions like Jammu and Kashmir, Himachal Pradesh, Hills of west Uttar Pradesh, Sikkim and Arunachal Pradesh, Bay Islands and Arabian Sea Island. Presently this time series is updated by the Indian Institute of Tropical Meteorology, Pune (www.tropmet.res.in) and this rainfall time series was extensively used by many researchers. The rainfall trends and scenarios are generally worked out based on the IMD grid data for the entire country or for a given state. Most International organizations also use this data for developing the scenarios for India. Work done at CRIDA indicate that using block level long term data for building such scenarios can give more accurate results and capture the micro level trend (CRIDA, 2009). Following is the comparative statement of using IMD grid data and the block level long term data collected from the Directorate of Economics and Statistics, Govt. of Andhra Pradesh. IMD is providing current and past weather data (Observed or grid data) for operational and research purpose. At present, IMD has a wide network of rain gauge (458), surface observatories (559 – one in each district) and upper air observatories like radiosonde (39), pilot balloons (62), RS/RW observatories (39) and Doppler Weather Radars (5) across the country to provide reasonable weather forecast. However, this network may not be adequate to provide weather based agro advisories at micro level, say block/mandal level. On the other hand, in addition to IMD, State Government Organisation like Directorate of Economics and Statistics is also having a network of rain gauge / weather stations in their respective states. Growing awareness on the climate change and its effects compel one to question the reliability of projections based on the 1° X 1° grid data. With this background, an attempt has been made to make a comparison of rainfall trends based on 1° X 1° grid data and data collected from a dense network of raingauge stations in Andhra Pradesh.

MATERIALS AND METHODS

The data utilized in this study comes from two sources viz., mandal level (1128 mandals) daily rainfall from Directorate of Economics and Statistics, Govt. of Andhra Pradesh, for the period of 1971 – 2007 and the distribution of rainguage stations is presented in Fig 1. Another data source is IMD grid data of daily rainfall at a resolution of 1° X 1° for the period from 1951 – 2007 (24 grid points as depicted in Fig

2.). Though the data beyond 2007 is available at mandal level, IMD grid data is not available beyond 2007. To maintain uniformity, the length of data is restricted to 37 years (1971-2007). Mandal and grid-wise annual rainfall data was arrived by summing the daily rainfall data. Then, Mann-Kendall trend test to detect any significant increasing and declining tendency in annual rainfall was carried out by using Toolkit software V1.02 (CRC for Catchment Hydrology, Australia, 2005). Based on the trend results, thematic maps have been prepared using GIS tool.

RESULTS AND DISCUSSION

The data points of IMD representing Andhra Pradesh State are 24 grid points whereas block level data is able to represent 1128 locations. The former is covering around 111 x 111 km for each point but later covers about 10-30 km only. In the grid data, there is no point available to represent the Medak district and some points are commonly representing the two districts like Srikakulam / Vizianagaram and Nalgonda / Warangal. In general, annual rainfall is not showing significant increasing / decreasing trend in major parts of the State in both the cases (Fig. 3). Numerically, 865 mandals showed non significant trend, 88 mandals increasing trend and declining tendency in 129 mandals with mandal level data source. In the case of grid rainfall data source, increasing trend is seen in eight grid points and in remaining 16 grid points non significant trend is noticed (Fig 4). Interestingly, no declining trend in annual rainfall is observed in any part of the State with this data source. This clearly explains that rainfall variability / trend studies for small scale may not be done as the grid data itself derived from interpolation of many rain gauge stations around the grid point. More over extrapolation of trend results of a particular grid point for the entire total district or for entire 111 X 111 km area may lead to erroneous interpretation as rainfall is highly variable spatially even within same agro-climatic zone / district.

Decreasing trend in annual rainfall is found in the tracts consisting of Medak, Nalgonda, Krishna, East and West Godavari districts from mandal level data whereas increasing trend is noticed with grid data. The case of Medak district is very peculiar. As 1° X 1° grid data source not representing this district, it is very difficult to interpolate / extrapolate the result, as in the case of other district which has at least one grid point. Almost half-of-the mandals in Medak district showed declining trend in annual rainfall with mandal level data gives apparent indication about vulnerability of the district in terms of declining rainfall trends. This scenario is apparently missing in the grid level trends.

In Prakasam district, declining trend in number of mandals, but increasing tendency is seen with grid data. Like-wise in southern Andhra Pradesh (Anantapur, Cuddapah, Nellore and Chittor) and north coastal Andhra Pradesh (Visakhapatnam, Srikakulam and Vizianagaram) some mandals are showing either increasing or decreasing trend from mandal data. In the case of grid data, no significant trend is observed. After comparing the results from both the data sources, it seems grid data is not of much use to study the rainfall trends / variability at localised scale say mandal / block level and the mandal level data would give better and reliable information for policy makers, planners and researchers.

Long term trends of Indian monsoon rainfall for the country as a whole as well as for smaller regions have been studied by several researchers. Most of the studies are based on the rainfall series constructed by Parthasarathy *et al*. (1994). They observed that the monsoon rainfall is without any trend and mainly random in nature over a long period of time, particularly on the all India time scale (Mooley and Parthasarathy, 1984). But on the spatial scale, existence of trends was noticed by Parthasarathy (1984) and Rupa Kumar *et al*. (1992). Parthasarathy (1984) found an increasing trend in the monsoon rainfall for Telangana sub-division. Deriving from the network of 306 stations and for the period 1871-1984, Rupa Kumar *et al*. (1992) identified the areas having decreasing and increasing trends of monsoon rainfall. They observed a significantly increasing trend to a tune of 10 to 20% of the normal over northern parts of Andhra Pradesh.

Guhathakurta and Rajeevan (2006) constructed a homogenous rainfall series using a network of 1476 raingauge stations whose distribution is presented in Fig 6. The spatial distribution of their network in the region, where the present study is carried out is also not homogenous as more than 70 per cent of the stations considered lie only on the east coast. They observed significant increasing trends in Rayalaseema and Coastal A.P. They have also analysed the contribution of each of major rain producing month's in annual rainfall and examined whether there is any significant change in their contribution. Their analysis showed that July and August contribution to the annual rainfall is increasing for the three regions of the A.P. state. Whereas, the June contribution is decreasing in Telangana region and September's contribution is decreasing in Rayalaseema and coastal A.P. regions.

The per cent geographical area under increasing or decreasing trends or no significant trend in annual rainfall using block level data in different districts of Andhra Pradesh is presented in Table 1. Increasing trend was noticed in more than 25 per cent area of Kurnool ditrict. Increasing trends inthe range of 15 to 20 per cent of area was observed in Ananthapur, East Godavari, Guntur, Khamman, Krishna,

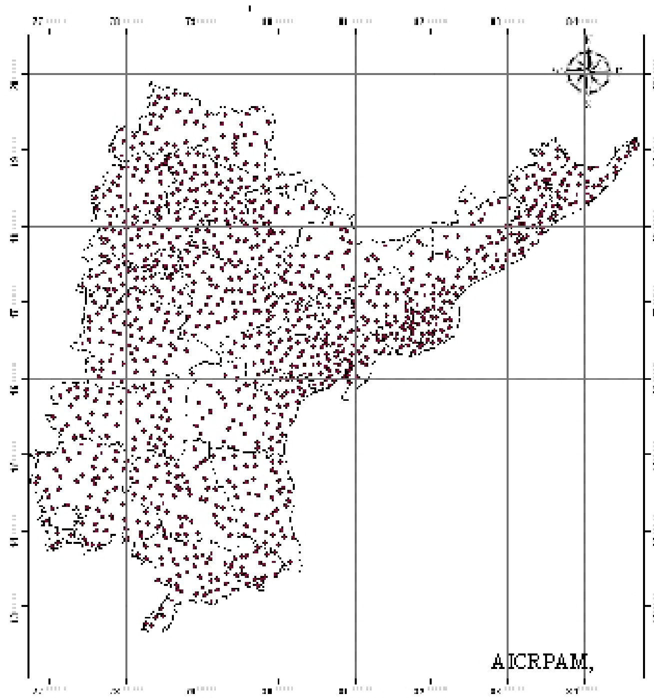

Fig. 1: Location map of 1128 raingauge stations in Andhra Pradesh

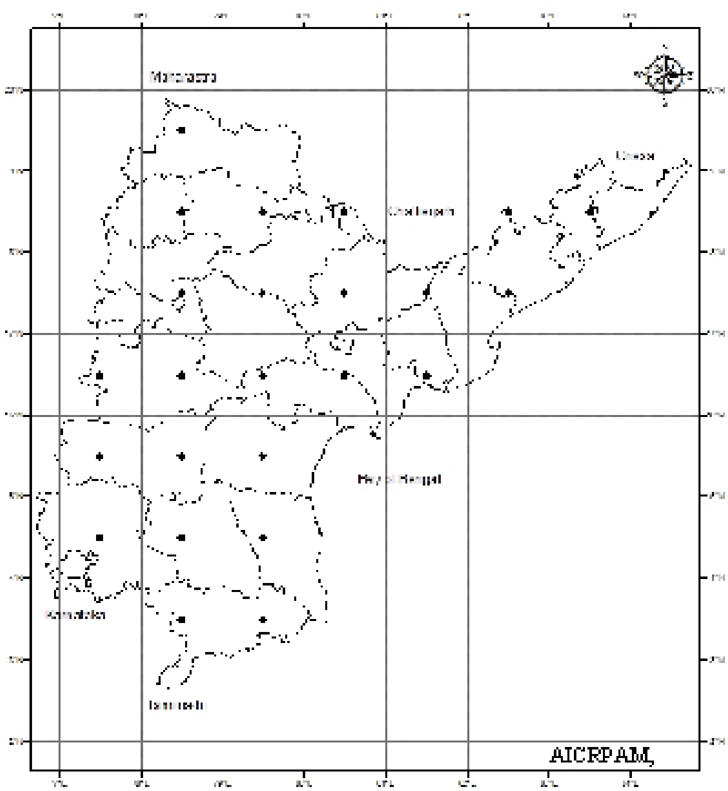

Fig. 2: Location map of IMD grid points on 1° x 1° scale in Andhra Pradesh

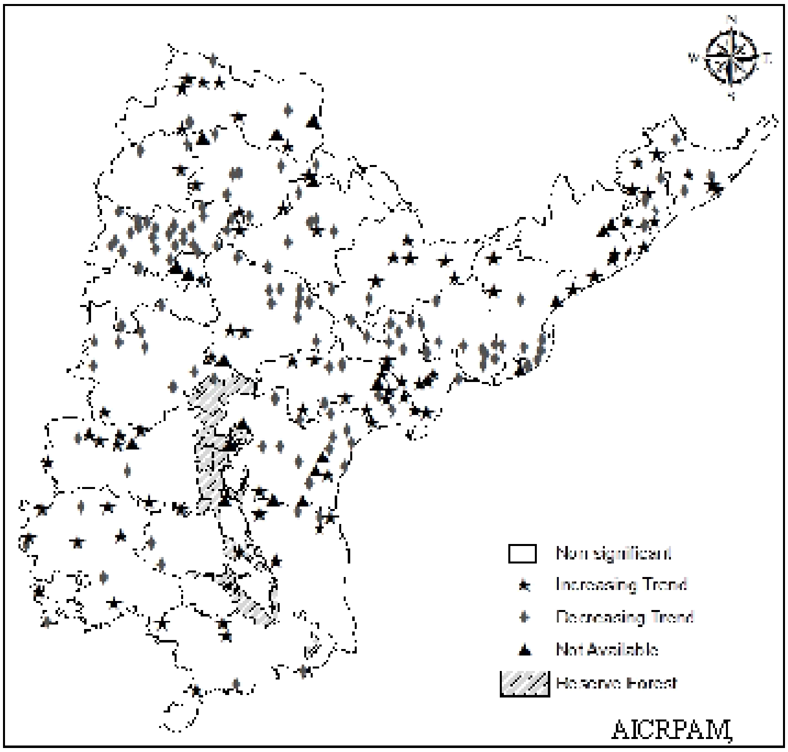

Fig. 3: Annual rainfall trends using mandal level data (1971 – 2007)

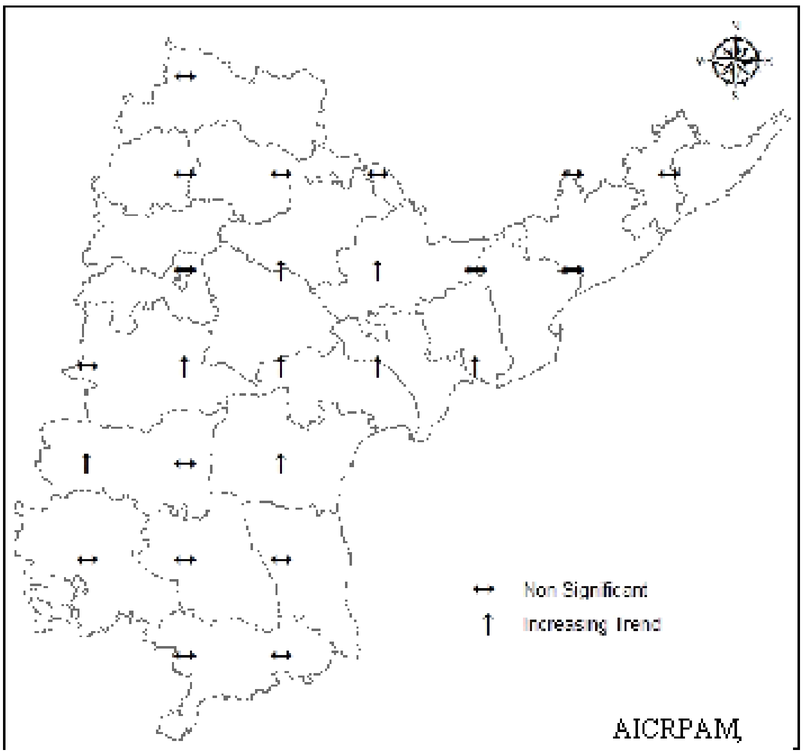

Fig. 4: Annual rainfall trends using IMD gridded data (1971 – 2007)

Table 1: Per cent area under increasing/decreasing trend in annual rainfall in different districts of Andhra Pradesh based on block level data

District	Total Geographical Area of District (Acres)	Increasing at 99% Significant	Increasing at 95% Significant	Increasing at 90% Significant	Decreasing at 99% Significant	Decreasing at 95% Significant	Decreasing at 90% Significant	No Significant Trend	Not Available
Adilabad	3447417	Nil	1%	7%	Nil	Nil	Nil	91%	Nil
Anantapur	4024417	10%	5%	3%	Nil	Nil	Nil	81%	Nil
Chittoor	3116714	Nil	4%	4%	Nil	Nil	2%	90%	Nil
Cuddapah	3171945	2%	4%	3%	Nil	Nil	Nil	91%	Nil
East Godavari	2280711	10%	1%	6%	Nil	Nil	Nil	84%	Nil
Guntur	2250910	5%	6%	6%	Nil	5%	Nil	78%	Nil
Hyderabad	36378	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Karimnagar	2427396	Nil	5%	5%	1%	4%	Nil	85%	Nil
Khammam	3352217	9%	2%	4%	Nil	Nil	Nil	85%	Nil
Krishna	1852116	5%	7%	4%	Nil	Nil	2%	82%	Nil
Kurnool	3684690	6%	14%	6%	Nil	3%	Nil	71%	Nil
Mahabubnagar	3882951	Nil	2%	7%	Nil	4%	Nil	87%	Nil
Medak	1988944	Nil	Nil	Nil	14%	17%	5%	65%	Nil
Nalgonda	3034113	4%	Nil	Nil	3%	4%	5%	80%	4%
Nellore	2772851	3%	2%	5%	Nil	Nil	Nil	89%	Nil
Nizamabad	1657969	Nil	Nil	Nil	Nil	Nil	2%	98%	Nil
Prakasham	3655788	10%	3%	5%	1%	1%	Nil	76%	4%
Ranga Reddy	1584109	3%	Nil	10%	Nil	4%	Nil	83%	Nil
Srikakulam	1257898	Nil	3%	Nil	Nil	5%	Nil	93%	Nil
Visakhapatnam	2396860	4%	1%	4%	1%	Nil	Nil	88%	Nil
Vizianagaram	1288026	15%	Nil	Nil	9%	3%	Nil	74%	Nil
Warangal	2679450	Nil	2%	6%	Nil	4%	5%	80%	3%
West Godavari	1606901	Nil	Nil	2%	Nil	1%	2%	95%	Nil

Table 2: Trend scenario from the grid data in different districts

Trend scenario	Name of the districts
Increasing trend	Khammam, Prakasam, West Godavari, Nalgonda, Warangal, Guntur
Decreasing trend	--
No trend	Adilabad, Nizamabad, Karimnagar, Srikakulam, Vizianagaram, Rangareddy, East Godavari, Visakhapatnam, Nellore, Kadapa, Ananathapur, Chittor
Partly increasing/partly decresing	Mahaboob Nagar, Kurnool, Krishna

Prakasam and Vizianagaram district. Likewise decreasing trend was noticed in about 35 per cent area of Medak ditrict. In Vizianagaram and Nalgonda district in about 12 per cent area the decreasing trend was noticed. However, the rainfall trends derived from grid data does not indicate the per cent area of each district showing any increasing or decreasing trend. The trend scenario in different districts derived from the grid level data is presented in Table 2.

The trends observed from the block level data of the present study are in contradiction to the earlier trend analyses of Rupa Kumar *et al.* (1992) and Guhathakurta and Rajeevan (2006). In both the earlier studies, significant increasing trends were reported, whereas the trend analysis of the present investigation using block level data indicated the non-existence of any significant trend over major (84%) geographical area of Andhra Pradesh.

After comparing the results in the present investigation from both the data sources, it appears that there are severe limitations in using grid data for scenario or trend analysis and often it can give opposite results. Wherever available it is advisable to use data available from local sources collected from closely located weather stations.

CONCLUSION

The data points representing Andhra Pradesh State, when IMD source used is only 24 grid points whereas mandal level data source able to represent overwhelmingly by 1128 mandals. The former is covering around 111 km for each point but later covers about 10-30 km only. In the grid data, there is no point available to represent the Medak district and some points are commonly representing the two districts like Srikakulam / Vizianagaram and Nalgonda / Warangal. With grid data no decreasing trend is noticed over the entire state. However, a clear decreasing trend in annual rainfall is found in the tract consisting of Medak, Nalgonda, Krishna, East and West Godavari districts from block level data. On the contrary, increasing trend is noticed with grid data in these districts. In Prakasam district, declining trend in many blocks with block level data was noticed, but increasing trend is seen with grid data. Like-wise in Rayalaseema (Anantapur, Cuddapah and Chittor) some blocks are showing increasing or decreasing trend with block level while with grid data, no significant trend was observed. Wherever available it is advisable to use data available from local sources collected from closely located weather stations.

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