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Trend Analysis of Temperature over New South Wales

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ABSTRACT

The study has primary objective is to study trends in monthly mean maximum temperature in New South Wales (NSW) over 46 years periods from 1966 to 2011, for this purpose, non-parametric rank based Mann Kendall's tau test were employed. The study explore that increasing trends all over the state dominates over negative trends, all 288 stations are analyzed out of which all stations shows trends (positive and negative trends), 51.04 percent of stations shows significant positive trends at 99% level of significance, while only 7 percent of the stations shows decreasing trends (not significant). Maximum number of significant increasing trends are recorded in the month of September (24), while maximum number of decreasing trends are in month of August (8), though they are not significant, these declining trends are observed mostly in northern part of NSW over Western slopes, Tablelands and coastal strip climate zone. Minimum number of significantly increasing trends where observed in months of February, May, July and December, i.e. only two stations, whereas no station showed significant decreasing trends at any level of significance. Seasonal variability is also evident from the study, for instance, December, January and February, have least number of significant trends, while maximum number of trends were observed in early winter season i.e. May, June and July. The study does not aim to explore possible factors affecting temperature trends in NSW.

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INTRODUCTION

It has been reported in many studies that the climate is changing is due to the both climatic and anthropogenic activities, precisely those activities which are hazardous or can change the chemistry of climate. Climate change is evident by many events from increasing greenhouse gas, extreme events with increased frequency and intensity, variation in temperature globally and locally, and precipitation and hydrological cycle (Durdu, 2010).

Deforestation, industrialization, and most importantly burning of fossil fuel are the main factors, which effect most in changing greenhouse gases (UNFCCC, 2007). Increasing Concentration of greenhouse gases is one of the major factor among other factors, which causes increase in temperature (Scavia *et al*., 2002). It has been reported by the intergovernmental panel (IPCC) that mean surface temperature is increased approximately about $0.56\,℃ \ to\ 0.92℃$ from 1906 to 2000, which is more than the previous report of IPCC (IPCC, 2001, 2007). These changes may lead to an unexpected and uncertain climatic pattern, as the temperature increased everywhere in the world, some region likely to have less rainfall, therefore these regions may lack availability of fresh water, while some regions may experience more precipitation and storms, which may threaten life of the people in case of extreme flooding (IPCC, 2007).

Numerous studies have been conducted to emphasize on the fact that global warming is related to surface temperature, and to quantify the extent of variability and its influence over different space and terrain. Many studies have shown that this variability is mostly vary from one climatic region to another, however most studies agreed on that it is rising. For example, temperature patterns in Nepal after 1977 is rising with an up slope from 0.03 ℃ to 0.12 ℃ each year (Shrestha *et al*., 1999), Egypt is also experiencing increasing trend from 1941-2000 (Domroes *et al*., 2005). Many studies have shown positive or increasing trends in different parts of the

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world, however this variability is maximum in winter season (Lund *et al*., 2001; Fan and Wang, 2011). For example, in Switzerland, Rebetez (2007) reported that maximum increasing trend in temperature was observed during winter for period 1975 to 2004.

Collins (2000), reported that Australia's mean temperature has increased approximately 0.8 ℃ since 1910, and showed sharp increase after 1950, maximum warming being observed in 1998, while 1990s and 1980s were being the warmest year. Especially, southern part of Western Australia and Queensland experienced most of this variability, while some declining trend was observed in southern Queensland and New South Wales (NSW) (Suppiah *et al*. 2001). Plummer *et al*. (1999) reported that extreme events have been associated with these increasing temperature since 1957 to 1996, while decreased in frequency and intensity of extreme cool events was observed. Stone *et al*. (1996) also reported that increasing trend of temperature is associated also with the reduced frost frequency and its duration. This study is focused on quantifying which regions has significant trends using Mann-Kendall rank correlation test over New South Wales (NSW) in mean temperature time series. This study does not aim to analyze factors that influenced increasing or decreasing trends, however this study is important in a way that it will pave the way for understanding station wise temperature variability and hydrological data.

Study Area:

New South Wales (NSW) is an Australian state bounded by Queensland to the north, Victoria to the south and South Australia to the west, and from Tasman Sea to the east. NSW is in the temperate zone, with generally mild climate, but northwest region and southern Tableland region have higher and cold temperatures respectively. NSW is divided into four climate zones (see Fig. 1); the coastal strip, the climatic conditions of coastal strip is determined by the hot water of the Tasman Sea, which keep the region cool and cause increase rainfall, second climate zone is the highlands, this is a mountainous region which extend up to northern part of NSW with 1500 meters high peaks, whereas maximum peak at Mount Kosciuszko is about 2228 meters high, these peaks increases from east to west or away from the coastal plain, however from west of division its slope gradually descends onto the Western plain, therefore snowfalls happened over the region called Tablelands. Third zone is Western Slopes, here rainfall and snowfalls is decreased as the altitude decreased, since temperature rises with the decreased in altitude and decreased as the height increased. Another zone which differ from other part of NSW is the flatter part of the country to the west, this zone has hot summer, with decreased in rainfall below up to 200mm.

NSW climate is very diverse and variable, since 1950 to 1980 annual temperature was increased by 0.1oC per decades, and since 1990 it raised up to 0.5 ℃ per decade. While 2007 is the warmest year. From 1997 to 2008, all years are hotter than average value of mean temperature, no such increased have ever recorded in the history. It has been well established fact that increasing greenhouse concentration, together with enhanced relative humidity are expected to increase warmer nights in the north east coast of the region.

Data Description and Methodology:

Mean maximum monthly temperature data were used in this analysis from 24 stations located in NSW (see Table. 1) for period of 46 years (1966-2011). Data were obtained from Australian metrological department (site www.bom.gov.au). Trends in these 24 stations were analyzed using rank based Mann Kendall's tau test, this test is effective for detecting and analyzing trends between hydrological and metrological indices. This test does not depend on original data values since it depends only on the rank that is why if there are any missing values then the results would not be affected, another advantage of using Kendall's tau test over other method is that, it also works well even if there are gaps in the data (Lemaitre, 2002; Chaouche *et al*., 2010). Chaouche (2010) showed hypothesis of Kendall's tau only depends on the monotonic change but not on the gap or break in the time series. Several studies have shown that Kendall's tau test is much more powerful than the student t test or Bootstrap when the data is not normally distributed, however Kendall's tau become less efficient when data is normally distributed (Önöz and Bayazit, 2003; Yue and Pilon, 2004). The formal null and alternative hypothesis are defined as

H_0: no correlation exist between two variables if $\tau = 0$; and

H_1: correlation exist between two variables if $\tau \neq 0$, where τ is defined mathematically as

$$\tau = \frac{2*S}{n(n-1)},$$

,

Where S is the difference between concordant and discordant pairs. These two hypothesis are being tested at 99% level of significance. Here for any station if $Z_\tau > Z_{\frac{\alpha}{2}}$, then given station has positive trend and if $-Z_\tau < -Z_{\frac{\alpha}{2}}$, then station has negative trend.

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RESULTS AND DISCUSSION

Analysis of trends using non parametric Mann Kendall tau test clearly provides evidence that majority of station showed an increasing trends, these trends are tested on 99% significance level, however, there are some stations which showed a decreasing trends, particularly in stations located in eastern coastal regions and western plains, although these trends are not significant at 99% level of significance (see fig 2(a-I)), these two climate regions showed decreasing trends might be because of increasing number of rainfall days, since Tasman Sea is in the vicinity of the region, therefore it causes rainfall increase in coastal strip climate zone. However, maximum increasing trends for most of the months is observed, for instance in September all stations showed significantly positive trends.

Table 2 presents overall result of the analysis, according to our analysis 288 stations were tested and all of stations have increasing trends, 147 (51.04%) of stations have significant increasing trends at 99% level, no station has significant negative trend in any month. Maximum variability is greatest in September, while August has maximum number of decreasing trends (see fig. 2(h)), these decreasing trends occur in northern part of NSW climate zones i.e. Tablelands and western slopes, while Western plains showed increasing trends though not significant at 99% level of significant. Maximum number of significant increasing trends are observed in early winter season, which is related with less winter rainfall and streamflow, while lowest number of significant trends were observed in summer only 24 stations. Although this seems quite ambiguous that summer rainfall and temperature are increasing, it should be further investigated that either this variability is due to increased rainfall or any other factor, however increasing trends in temperature are part of global variability.

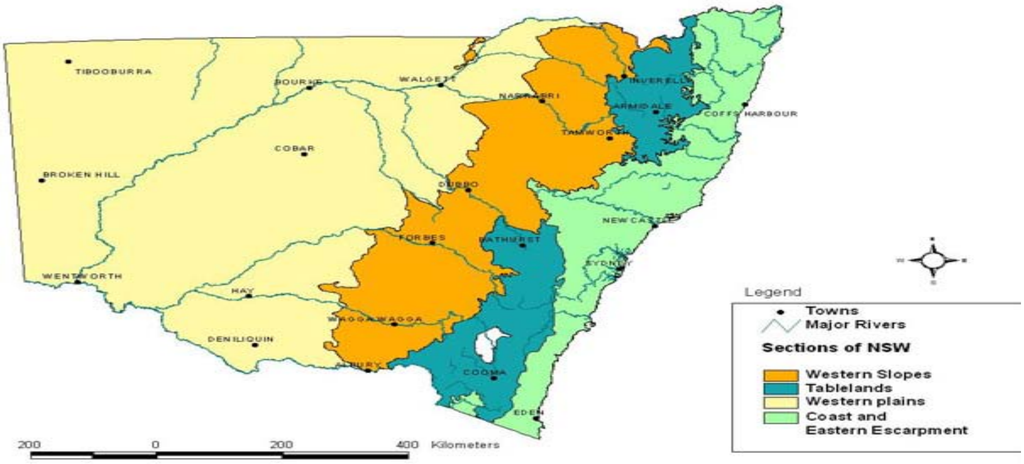

Fig. 1: Australian Climate zones

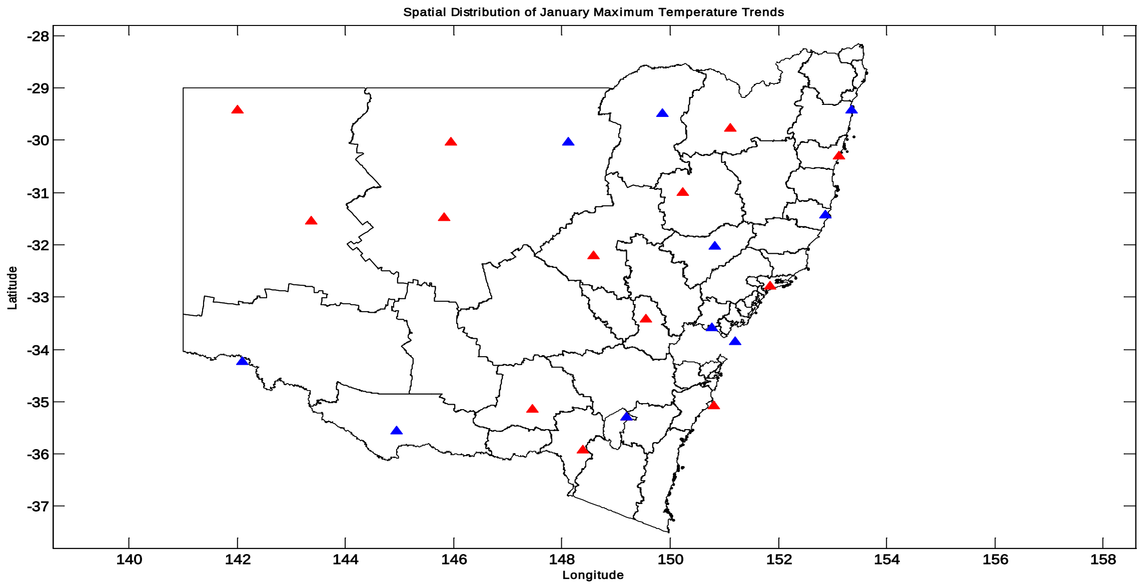

Fig. 2(a): Spatial Distribution trends in monthly maximum temperature for January where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

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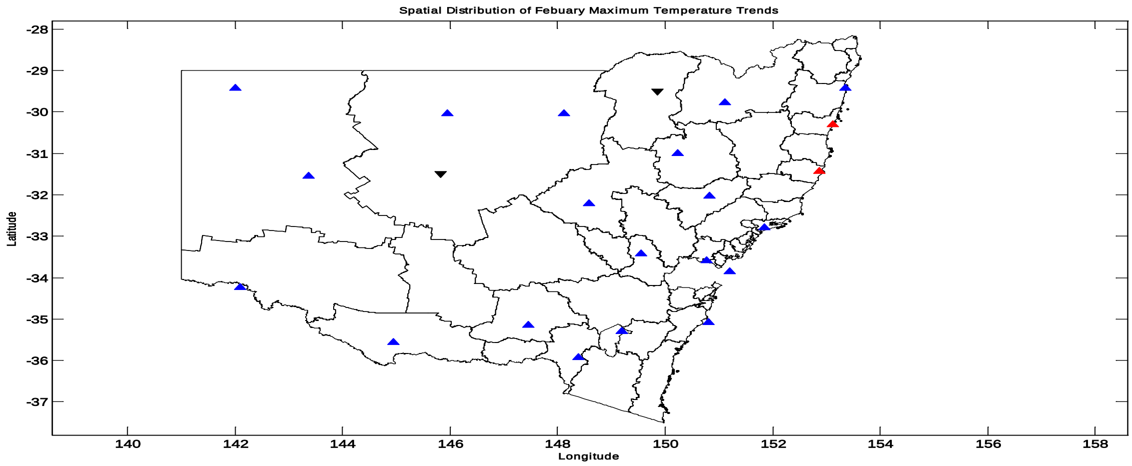

Fig. 2(b): Spatial Distribution trends in monthly maximum temperature for February where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

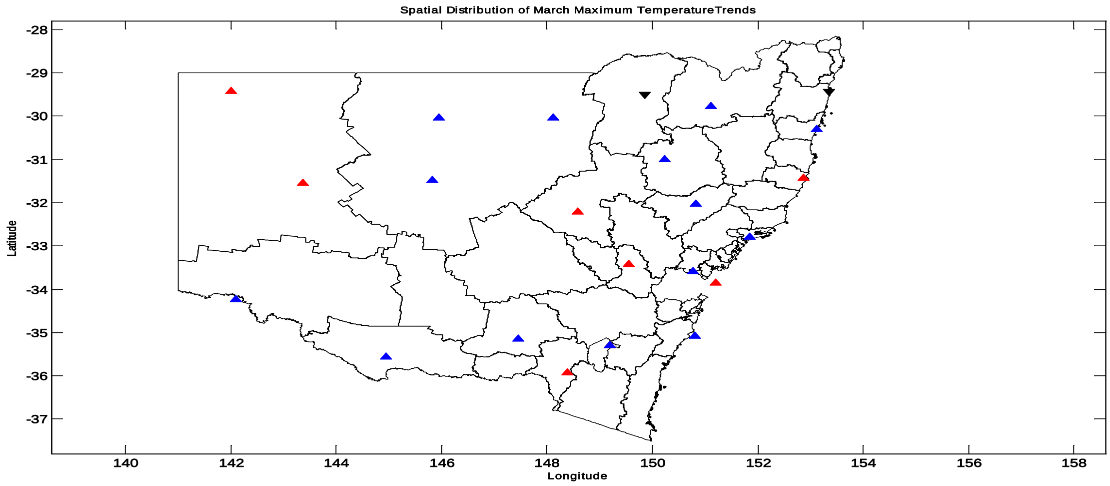

Fig. 2(c): Spatial Distribution trends in monthly maximum temperature for March where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

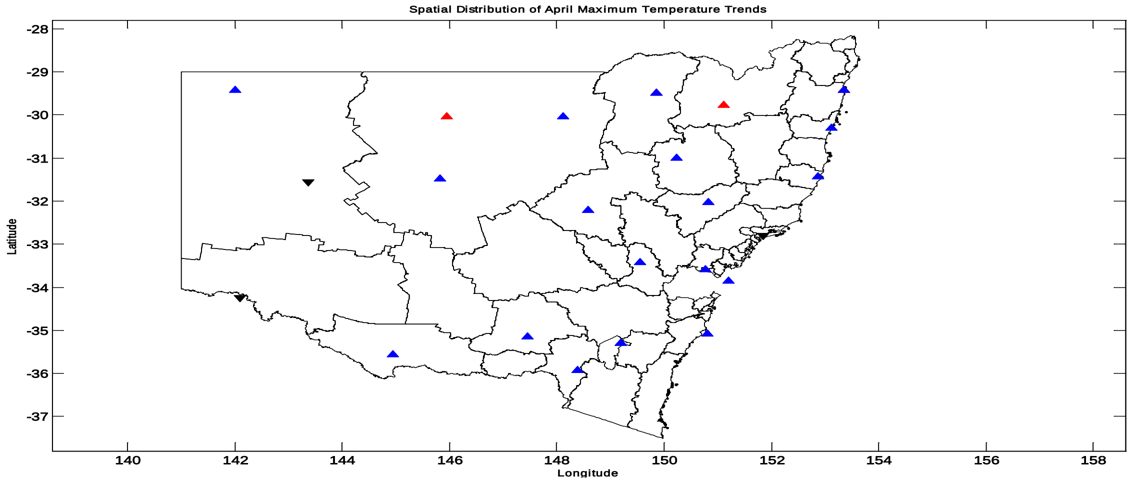

Fig. 2(d): Spatial Distribution trends in monthly maximum temperature for April where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

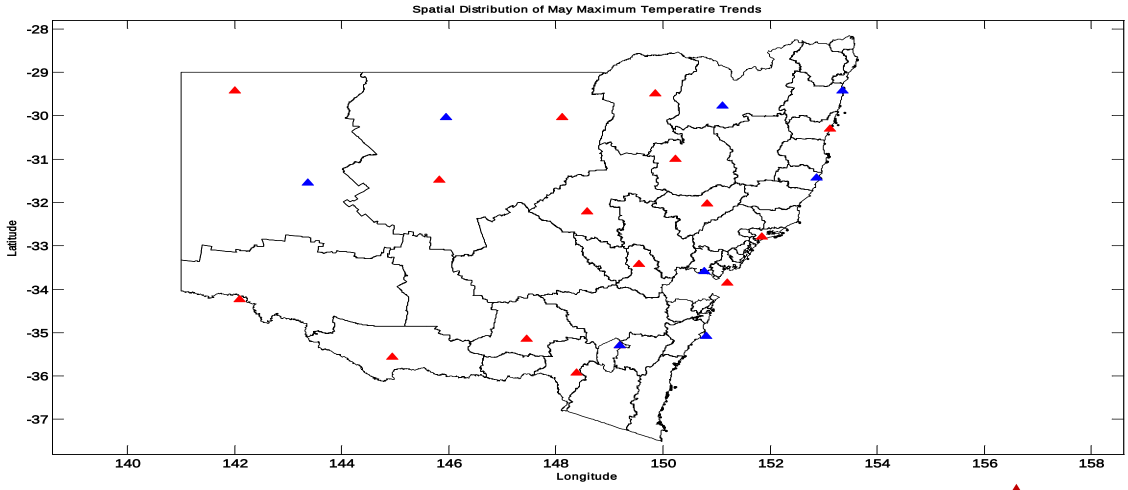

Fig. 2(e): Spatial Distribution trends in monthly maximum temperature for May where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

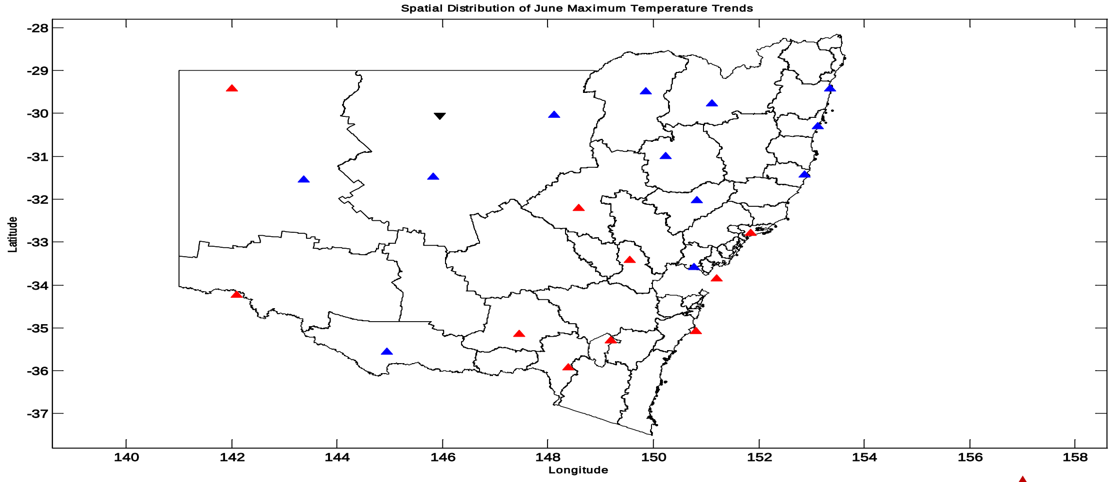

Fig. 2(f): Spatial Distribution trends in monthly maximum temperature for June where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

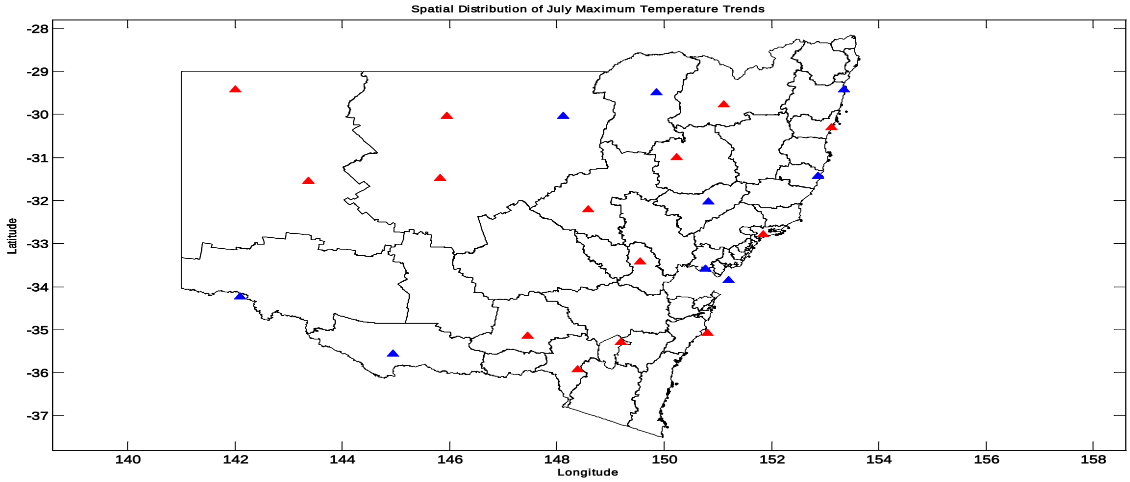

Fig. 2(g): Spatial Distribution trends in monthly maximum temperature for July where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

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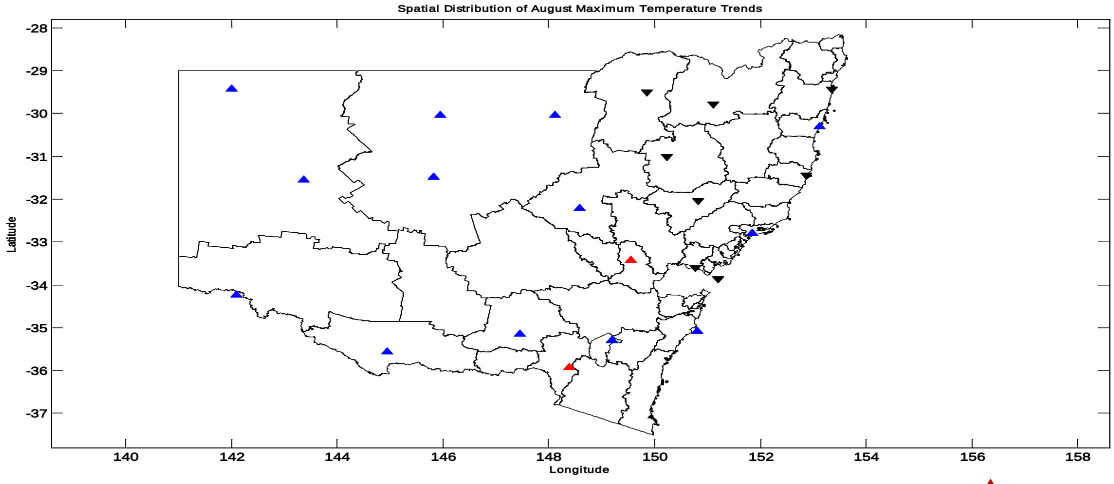

Fig. 2(h): Spatial Distribution trends in monthly maximum temperature for August where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

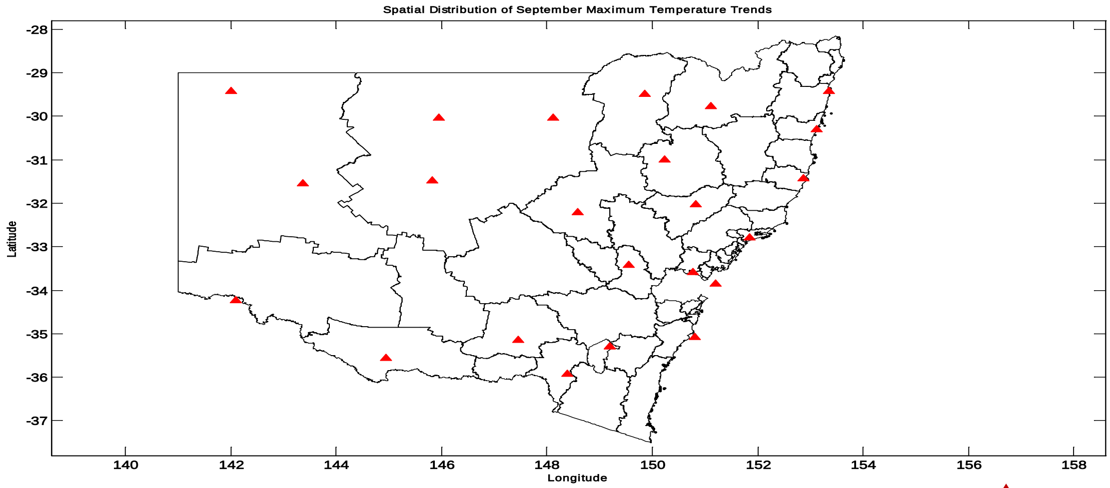

Fig. 2(I): Spatial Distribution trends in monthly maximum temperature for September where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

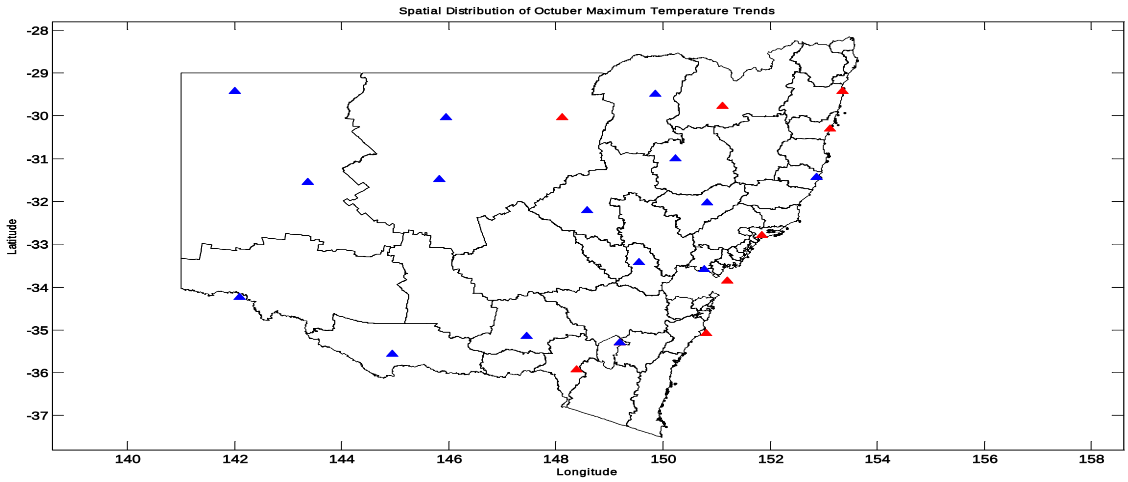

Fig. 2(J): Spatial Distribution trends in monthly maximum temperature for October where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

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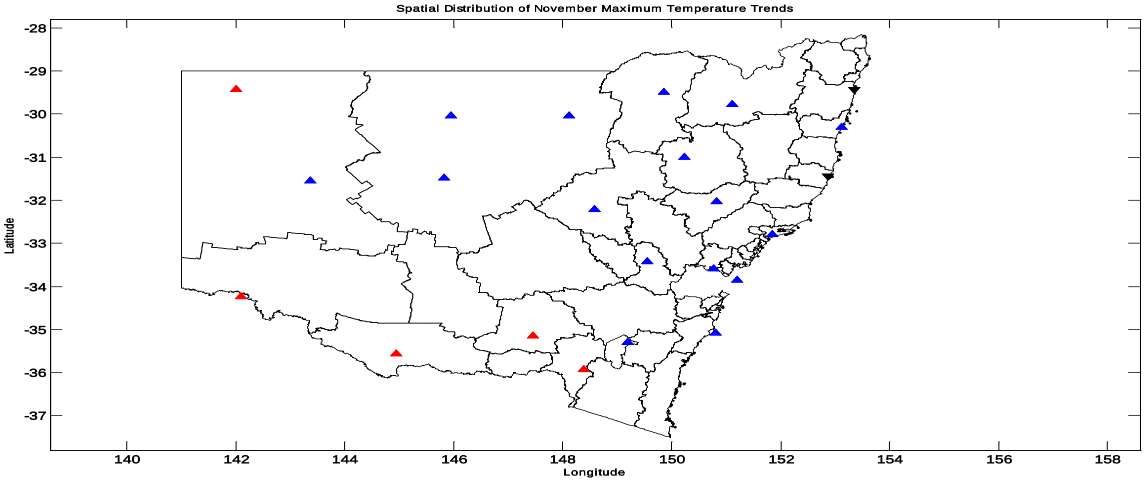

Fig. 2(K): Spatial Distribution trends in monthly maximum temperature for November where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

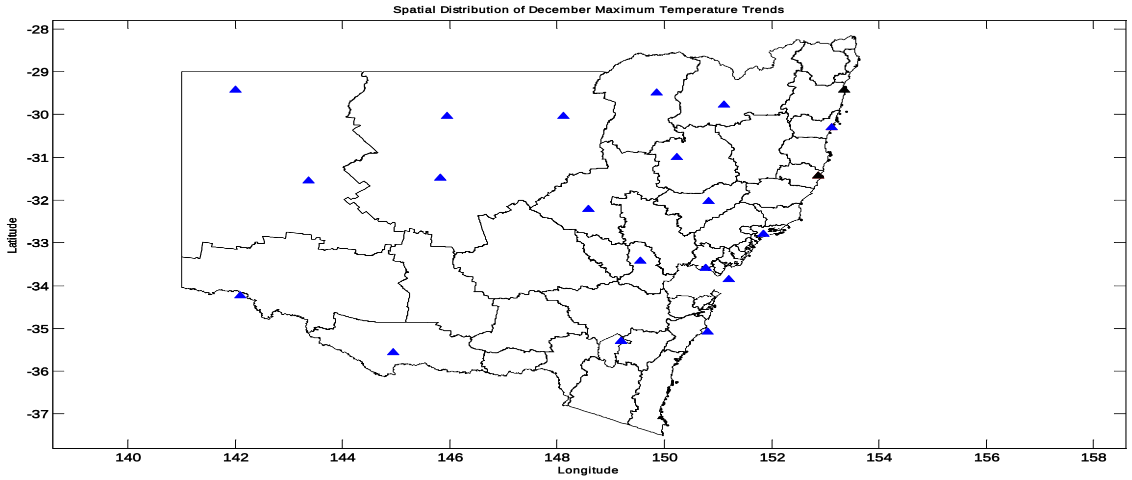

Fig. 2(l): Spatial Distribution trends in monthly maximum temperature for December where (▲) represents significant increasing trend, (▲) Non-significant increasing trend, (▼) non-significant decreasing trend.

Table 1: Location of stations, along with their station id, latitude and longitude.

Station NAME	STATION ID	LATITUDE	LONGITUDE
Tibbburra	46037	-29.43	142.01
Wilcannia	46043	-31.56	143.37
Cobar MO	48027	-31.48	145.83
Walgetta	48245	-30.04	145.95
Moree comprison	52088	-30.04	148.12
Inverell comparison	53115	-29.49	149.85
Gunnedah Resource centre	55024	-31.01	150.24
Inverell	56242	-29.78	151.11
Yamba	58012	-29.43	153.36
Coffs harbour MO	59040	-30.31	153.12
Port Macquaire Airport	60139	-31.43	152.87
Williamtown Raaf	61078	-32.79	151.84
Scone	61363	-32.03	150.83
Bathurst Agriculture Station	63005	33.43	149.56
Dubbo	65070	-32.22	148.58
Richmond	66062	-33.86	151.21
Nowra Rain Air Station	67105	-33.6	150.78
Canberra airport	68072	-35.3	149.2
Point perpendicular	68151	-35.09	150.8
Canberra	70351	-35.31	149.2
Wagga Wagga	72150	-35.16	147.46

Cabramurra	72161	-35.94	148.38
Hay (Miller street)	74258	-35.56	144.95
Deniliquin	76031	-34.24	142.09

Table 2: Summary of selected station results of New South Wales.

Months	No. of Station tested	No. with decreasing trends	Number wi significant decreasing trends	Number with increasing trends	Number with significant increasing trends	Number o significant trends	Percent with significant trends	No trends
January	24	0	0	10	14	14	58.88	0
February	24	02	0	20	2	2	8.33	0
March	24	02	0	14	8	8	33.33	0
April	24	03	0	19	02	02	8.33	0
May	24	0	0	08	16	16	66.66	0
June	24	01	0	12	11	11	45.83	0
July	24	00	0	10	14	14	58.33	0
August	24	08	0	14	02	02	8.33	0
September	24	0	0	00	24	24	100	0
October	24	0	0	15	09	09	37.5	0
November	24	02	0	18	04	04	16.66	0
December	24	02	0	20	02	02	8.33	0
TOTAL	288	20	0	121	147	147	51.05	0

Conclusion:

The study reveals that NSW mean monthly maximum temperature is in positive phase almost in all month and stations, the increasing trend might result in a declined in rainfall and streamflow, as it reduced evaporation and ground water level. It has been documented that till 2050 evaporation would significantly increase, which consequently, results in reduction of summer rainfall. The aim of the study is to present statistics and to analyze which regions of the state have significant positive or negative trends, however impact of variability and factors which cause or enhanced this variability are not the question of this study.

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REFERENCES

Collins, D., 2000. Annual temperature summary: Australia records warmest decade. Climate Change Newsl., 12: 6.

Chaouche, K., L. Neppel, C. Dieulin, N. Pujol, B. Ladouche, E. Martin, D. Salas, Y. Caballero, 2010. Analyses of precipitation, temperature and evapotranspiration in a French Mediterranean region in the context of climate change. Comptes Rendus Geoscience, 342(3): 234-243.

Durdu, Ö.F., 2010. Effects of climate change on water resources of the Büyük Menderes River Basin, western Turkey. Turk. J. Agric. For., 34(4): 319-332.

Fan, X.-H., M.-B. Wang, 2011. Change trends of air temperature and precipitation over Shanxi Province, China. Theoretical and Applied Climatology, 103(3-4): 519-531.

IPCC, 2001. Climate change 2001: the third IPCC scientific assessment. In: J.J. McCarthy, O. F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds). Intergovernmental Panel on Climate change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC. 2007. Climate change 2007: the fourth IPCC scientific assessment. In:. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Lemaitre, F., 2002. Recensement des tests de de´ tection de tendances ou de ruptures adapte´s a` l’analyse de stationnarite´ des re´gimes de crues en France. Travail de fin d’e´ tude. ENTPE, Cemagref Lyon, p: 94.

Lund, R., L. Seymour, K. Kafadar, 2001. Temperature trends in the United States. Environmetrics, 12(7): 673-690.

Önöz, B., M. Bayazit, 2003. The power of statistical tests for trend detection. Turkish Journal of Engineering & Environmental Sciences, 27(4): 247.

Plummer, N., M.J. Salinger, N. Nicholls, 1999. Changes in climatic extremes over the Australian region and New Zealand during the twentieth century. Climatic Change, 42: 183-202.

Rebetez, M., M. Reinhard, 2007. Monthly air temperature trends in Switzerland 1901-2000 and 1975-2004. Theoretical and Applied Climatology, 91(1-4): 27-34. Rebetez, M., Reinhard, 2007. Monthly air temperature trends in Switzerland 1901-2000 and 1975-2004. Theoretical and Applied Climatology, 91(1-4): 27-34.

Journal of Applied Science and Agriculture, 8(5) October 2013, Pages: 673-681

Shrestha A.B., C.P. Wake, P.A. Mayewski, J.E. Dibb, 1999. Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971–94. Journal of Climate, 12(9): 2775-2786.

Scavia, D., 2002. Climate change impacts on U. S. coastal and marine ecosystems. Estuaries, 25(2): 149-164.

Stone, R., N. Nicholls & G. Hammer, 1996. Frost in northeast Australia: Trends and influences of phases of the southern oscillation. J. Climate, 9: 1896-909.

Suppiah, R., D. Collins & P. Della-Marta, 2001. Observed Changes in Australian Climate [Internet document]. CSIRO Division of Atmospheric Research, Aspendale, Victoria. Available from: http://www.dar.csiro.au/publications/Suppiah_2001a.pdf

UNFCCC, 2007. Climate change: Impacts, vulnerabilities and adaptation in developing countries. UNFCCC Secretariat. Bonn, Germany. http://unfccc.int/resource/docs/publications/impacts.pdf.

Yue, S., P. Pilon, 2004. A comparison of the power of the t test, Mann-Kendall and bootstrap tests for trend detection. Hydrological Sciences Journal, 49(1): 21-37.