Variation of Convective Parameters over Srinagar

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ABSTRACT

In tropics, convection plays an important role in precipitation. Srinagar, being located in tropical / extra tropical zone, the rainfall is not purely convective but it is modified by rugged terrain and local factors. In the present study, the effect of convection on precipitation over Srinagar has been observed from the study that mean convective available potential energy (CAPE) is positively correlated in winter (December to February), Monsoon (June to September), post-monsoon (November to December) seasons while negatively correlated in pre-monsoon (March to May) season with mean value of rainfall during last 21 years (1986-2006). The deviations of convective inhibition energy (CINE) in pre-monsoon and monsoon seasons are more variable than other seasons. The inter-annual variations of CAPE have shown that the values of CAPE at 12 UTC are higher than its values at 00 UTC for all the years except the year 1992, while the values CINE at 12 UTC slightly more than values of CINE at 00 UTC in most cases. The inter - annual variations of CAPE and CINE at 00 UTC and 12 UTC show that at 00 UTC positive buoyancy favours the convection but at 12 UTC shallow cumuli inhibits the convection.

Key words : *convective available potential energy, convective inhibition energy and synoptic scale systems.*

1. Introduction

Convective available potential energy (CAPE) modulates the convective environment of the mid-latitude meso-scale /synoptic scale weather phenomena. Because convection occurs when conditional instability is released, i. e., when boundary layer parcels are lifted by some mechanism so as to reach the level of free convection (LFC). Large values of CAPE indicates that the near-ground atmosphere is relatively warm and/or moist while upper levels are relatively cool. These meso-scale weather phenomena are reflected by the occurrence of moderate to heavy rainfall / snowfall on some days, succeeding and preceding the days with comparatively less rainfall / snowfall depending on the availability of moisture. In Kashmir valley, the precipitation comes mainly in the form of snow during winter, which is associated with mid-latitude eastward moving systems or troughs in westerlies. Keeping this in mind a statistical analysis of CAPE and Convective inhibition energy (CINE) of last 21 years (1986 - 2006) for Srinagar has been made. The inter-annual and seasonal variations have also been examined. Srivastava and Sinha Ray **(1999)**[1] explained role of CAPE and CINE during April over India, because in most part of the country thunderstorm and duststorm activities are more prominent during this time.

Further, Williams and Renno **(1993)**[2] have shown that isolated heavy rainfall on any isolated day results not only from a higher value of CAPE, rather it results from the combined effect of a high positive value of CAPE and low negative value of CINE. It has been shown that CAPE plays an important role in mesoscale convective systems (Moncrieff and Miller, **1976)**[3]**,** especially in the tropical atmosphere (Bhat et. al, **1996)**[4]**.** In cases, when level of neutral buoyancy (LNB) is not clearly found the study has been made up to 200 hPa (Dutta and De, **1999)**[5]. The value of CAPE was sensitive to the upper level buoyancy force and the location of level of neutral buoyancy (LNB), which is one of the main controllers of deep / shallow convection over the area.

2. Data and Methodology

The upper air radiosonde data used in the study have been taken from meteorological observatory, Srinagar. The value of CAPE in J/Kg has been calculated using the formula

$$CAPE = \int_{Z_{LFC}}^{Z_{LNB}} \frac{g(T_{VP} - T_{VE})}{T_{VE}} dz = \int_{P_{LFC}}^{P_{LNB}} \frac{-R(T_{VP} - T_{VE})}{T_{VE}} dp \quad (1)$$

Where,

T_{VE} = Virtual temperature of the environment at pressure level p.

T_{VP} = Virtual temperature at pressure level p of an air parcel following pseudo adiabat through surface wet bulb temperature.

P_{LFC} = Pressure at the level of free convection (LFC)

P_{LNB} = Pressure at the level of neutral buoyancy (LNB)

Z_{LFC} = Height of the LFC, and,

Z_{LNB} = Height of the LNB.

The convectively generated maximum updraft (W_{max}) is calculated using the formula given by Williams and Reno, 1993 :

$$W_{max} = \sqrt{2 \times CAPE} \quad (2)$$

The value of convective inhibition energy (CINE) in J/Kg has been calculated using the formula of William and Renno (1993) as shown below :

$$CINE = \int_{Z_{LFC}}^{Z_{llfc}} \frac{g(T_{VP} - T_{VE})}{T_{VE}} dz = \int_{P_{SFC}}^{P_{lfc}} \frac{-R(T_{VP} - T_{VE})}{P} C \quad (3)$$

Where, Z_{SFC}, Z_{LFC} are the height of the surface and LFC respectively above mean sea level and P_{SFC}, P_{LFC} are the pressures at the surface and at LFC respectively.

3. Results and discussions

The seasonal and inter-annual variations of CAPE and CINE at 00 UTC and 12 UTC at Srinagar for the last 21 years have been analysed. The results are graphically shown in Figures (1-8). The seasons are classified as winter (December-February), pre-monsoon (March -May), monsoon (July -September) and post-monsoon (November-December). The annual and monthly means of CAPE and CINE at 00 UTC and 12 UTC are derived from daily radiosonde data. It has been found that the mean annual CAPE values are negatively correlated (-0.49) with the mean annual rainfall values for pre-monsoon season while having slightly positive 0.15, 0.18 and 0.07 for winter, monsoon and post-monsoon seasons respectively. The possible reason of this type of resemblance can be given as most of the rainfall occurs, in almost all the seasons, due to mid-latitude eastward moving systems and the moisture trapping in the Kashmir valley is modified by other local factors e. g. orientation of terrains. The catabatic / anabatic flow, nocturnal cooling and other local factors significantly modifies the rainfall pattern and convection regime or in turn the value of instability of the atmosphere via CAPE and CINE exchange. The values of CAPE at 12 UTC are higher then 00 UTC values and their difference are more (512.89 J/Kg) for the year 2002 (Figs. 1-2). In the year 1992 the value of CAPE at 00 UTC is higher than 12 UTC. Similarly, the difference of CINE values at 12 UTC and 00 UTC (Figs. 3-4) shows that the positive differences slightly outnumber the negative differences. The departures of CAPE and CINE from its 21 years mean values for all the years are shown graphically in Figs. (5-8). The variation in the values of CAPE is more in monsoon season in comparison to the other seasons during the period 1986 - 2006 (Figs. 5 - 6) due to breakup of deep convection. It may be due to presence of large number of shallow cumuli with bases at the LCL and is more susceptible in mixing of dry environmental air, which decreases the buoyancy or convective up-thrust parameter. Figs. 7 and 8 show the deviations of CINE from 21 years mean at 00 UTC and 12 UTC for the period 1986 - 2006. These Figs. show that pre-monsoon and monsoon season variations are more prominent than the winter and post-monsoon seasons. This may be due to the fact that less moisture content in the atmosphere with different slope and orientations of the relief's inhibit the convection. In this case the surrounding air is less buoyant and unable to release the moist air up to the level of free convection and prevents the convective development of clouds. A case study of the west to eastward moving synoptic scale systems (Western Disturbances) for the months of January and February, 2006 have been made to analyze the state of convection over the area. It has been observed that the maximum updraft is not linearly correlated with CAPE values but cappy inversions and entailment of dry air prevents the deep convection and the system is not intensified as it should be. In other words, the convection or precipitation is modified by local effects and rugged terrains. The computed parameters are given in the table 1. From the table 1 it is clear that during the month of January 00 UTC CAPE values exceed 200 J/Kg on two occasions whereas at 12 UTC the values remain between 0 - 50 J / Kg. Maximum value of CAPE was attained at 12 UTC in February month and it was 1100.57 J / Kg.

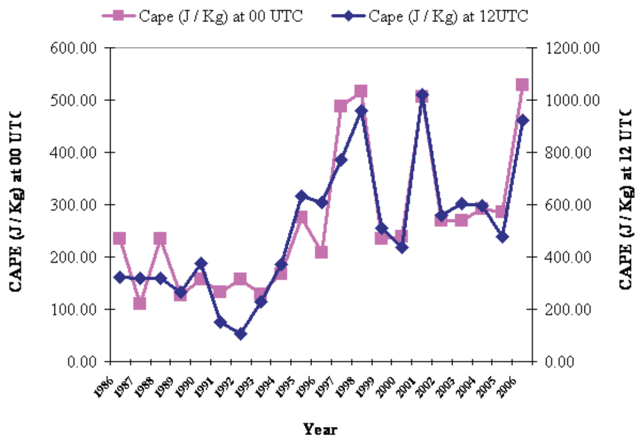

Fig. 1 : Inter-annual variation of CAPE at Srinagar during the period 1986-2006

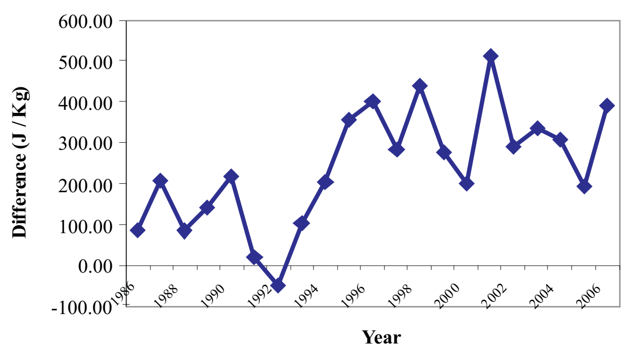

Fig. 2 : Difference between CAPE values at 12 UTC and 00 UTC (CAPE (12 UTC) - CAPE (00 UTC)) at Srinagar during the period 1986-2006

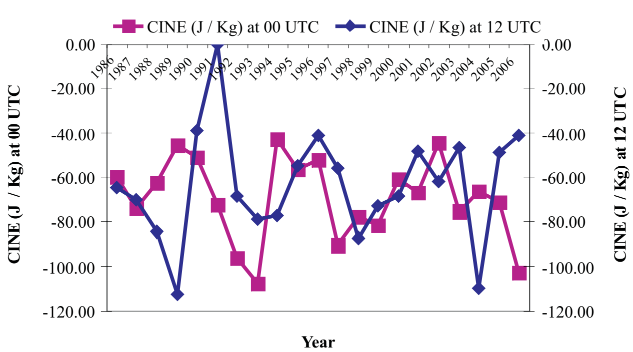

Fig. 3 : Inter-annual variation of CINE at Srinagar during the period 1986-2006

Table 2 shows the values of mean, standard deviation (SD) and coefficient of variation (CV) of CAPE for 00 UTC and 12 UTC. The mean, SD and CV at 00 UTC are found to be 74.76 J/Kg, 99.86 J/kg and 1.34 respectively for the month of January and 10.03 J/Kg, 16.31 J/Kg and 1.63 at 12 UTC respectively. Similarly the mean, SD and CV for February at 00 UTC are found to be 69.40 J / Kg, 65.67 J / kg and 0.95 respectively and 248.28 J/Kg, 364.03 J/Kg and 1.47 respectively at 12UTC.

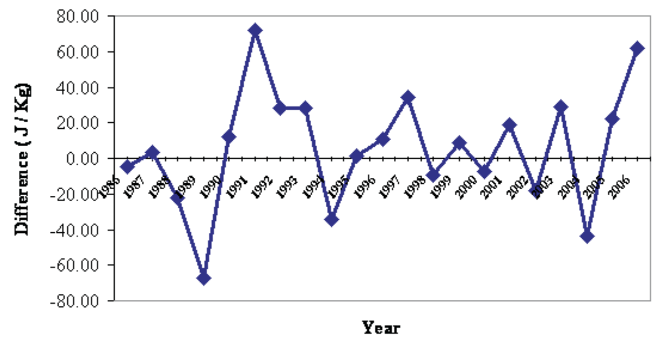

Fig. 4 : Difference between CINE values at 12 UTC and 00 UTC (CINE (12 UTC) - CINE (00 UTC)) at Srinagar during the period 1986-2006

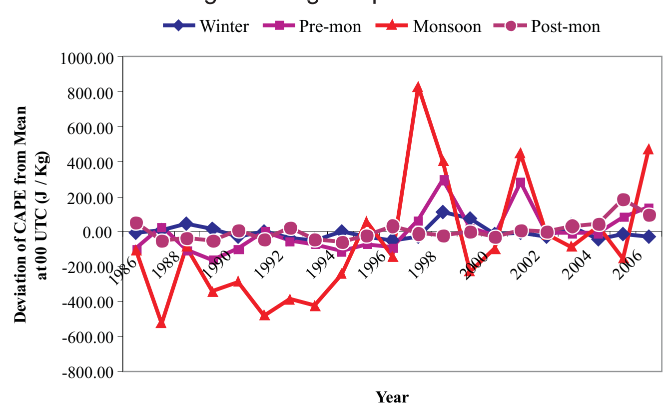

Fig. 5 : Seasonal deviation of CAPE (00 UTC) from mean at Srinagar during the period 1986-2006

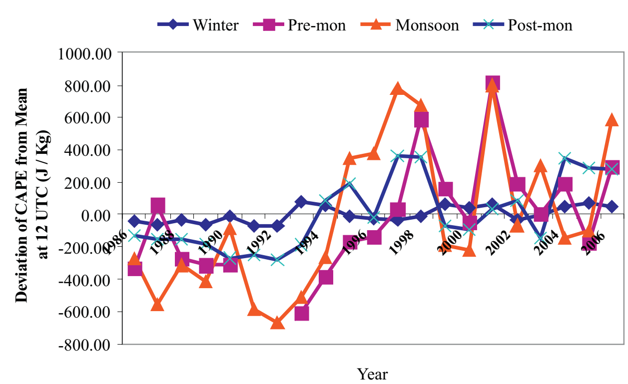

Fig. 6 : Seasonal deviation of CAPE (12 UTC) from mean at Srinagar during the period 1986-2006

It has been found that highest CAPE value is associated with the more moisture and which possibly is an indicator of more rainfall / snowfall over the area. The actual values of snowfall recorded on 18th, 19th 20th are 12, 60 and 24 cm respectively. This agrees fairly well with the CAPE values during that time.

Convectively generated maximum updraft have been computed from CAPE values for each case and given in table 2. Based on the monthly averaged values of convectively generated maximum updraft, the mean, SD and CV at 00 UTC for January, 2006 are found to be 8.95 m / sec, 8.78 m / sec and 0.98 respectively and at 12 UTC their values are 2.96 m

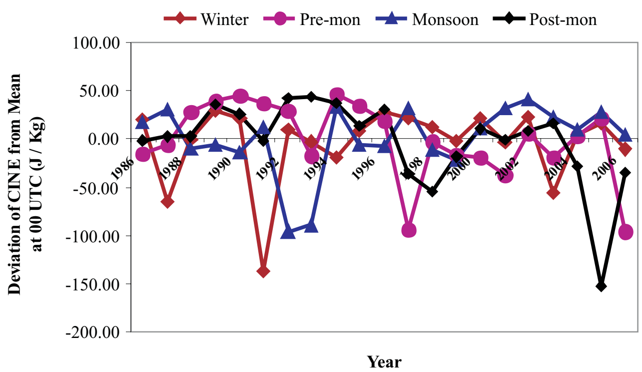

Fig. 7 : Seasonal deviation of CINE (00 UTC) from mean at Srinagar during the period 1986-2006

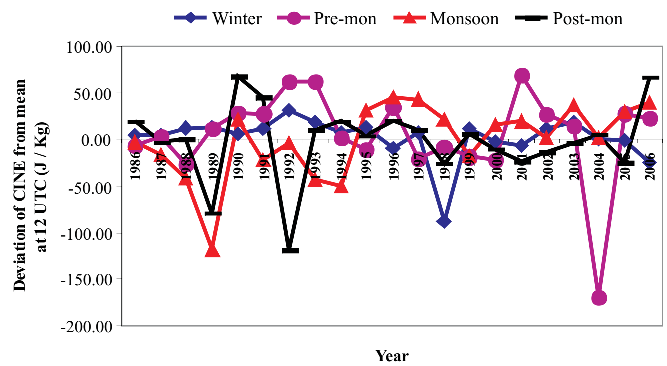

Fig. 8 : Seasonal deviation of CAPE (12 UTC) from mean at Srinagar during the period 1986-2006

Table 1

Computed Thermodynamic Parameters over Srinagar

Month	Date	CAPE J/Kg (00Z)	CAPE J/Kg (12Z)	CINE J/Kg (00Z)	CINE J/Kg (12Z)
	02-Jan-06	68.82	0.00	0.00	0.00
	03-Jan-06	52.30	0.00	0.00	0.00
	07-Jan-06	5.72	17.96	-0.21	0.00
	17-Jan-06	150.56	0.00	-6.25	0.00
	19-Jan-06	0.24	4.02	-1.02	0.00
	21-Jan-06	267.79	-	-36.44	-
	22-Jan-06	-	47.95	-	-1.19
	23-Jan-06	200	18.39	-15.72	-83.39
	30-Jan-06	1.20	12.00	-0.22	0.00
	31-Jan-06	1.01	-	-1.94	-
February	01-Feb-06	-	48.68	-	-206.87
	02-Feb-06	-	280.9	-	-27.60
	13-Feb-06	26.88	-	- 410.97	-
	18-Feb-06	-	2.31	-	0.00
	19-Feb-06	-	45.35	-	-251.7
	20-Feb-06	-	1100.57	-	-118.07
	21-Feb-06	43.25	-	-281.5	-
	22-Feb-06	0.85	549.59	-638.94	-100.69
	23-Feb-06	-	21.71	-	-216.24
	25-Feb-06	156.00	-	0.00	-
	27-Feb-06	-	74.45	-	-32.67
	28-Feb-06	120.00	111	0.00	-116.86

- : Data not available

TABLE 2

Statistics of CAPE, CINE and Convectively Generated Maximum Updraft (Wx) over Srinagar

Parameter	**Month**											
	January 2006				**February 2006**				**January 2006**		**February 2006**	
	CAPE J/Kg (00Z)	CAPE J/Kg (12Z)	CINE J/Kg (00Z)	CINE J/Kg (12Z)	CAPE J/Kg (00Z)	CAPE J/Kg (12Z)	CINE J/Kg (00Z)	CINE J/Kg (12Z)	Wx 00 UTC	Wx 12 UTC	Wx 00 UTC	Wx 12 UTC
Mean	74.76	10.03	-6.18	-8.46	69.40	248.3	-266	-71.0	8.95	2.96	4.26	13.25
S. D.	99.86	16.31	12.22	29.43	65.67	364.1	274.8	135.7	8.78	3.55	6.58	14.65
C. V.	1.34	1.63	-1.98	-3.48	0.95	1.47	-1.03	-1.91	0.98	1.20	1.55	1.11

/ sec, 3.55 m / sec and 1.20 respectively. Similarly the mean, SD and CV for February, 2006 at 00 UTC are found to be 4.26 m / sec, 6.58 m / sec and 1.55 respectively and at 12 UTC the values 13.25 m / sec, 14.65 m / sec and 1.11 respectively. Higher value of the up thrust parameter enhances convective build up of the system.

4. Conclusions

The following conclusions may be drawn from the above study :

(i) The mean annual values of CAPE are found to be negatively correlated (-0.49) with the mean annual rainfall values for pre-monsoon season while slightly positive 0.15, 0.18 and 0.07 for winter, monsoon and post-monsoon seasons respectively.

(ii) The inter - annual variations of CAPE and CINE at 00 UTC and 12 UTC show that at 00 UTC positive buoyancy favours the convection in most cases but at 12 UTC shallow cumuli (often called neutrally buoyant fossils) inhibits the convection.

(iii) The case study over Srinagar has shown that the increasing value of CAPE is an indication of sudden increase in moisture which is associated with the passage of Western disturbance and it can further be utilized for the prediction of winter rainfall / snowfall in any model development.

(iv) The mean value of CAPE has been found to be more at 12UTC in February, 2006 in comparison to the value at 00 UTC but in January, 2006 the mean value of CAPE at 00 UTC is higher than 12 UTC value.

(v) The Mean value of CINE has been found more at 12 UTC in February, 2006 than its value at 00 UTC but in January, 2006 the mean value of CAPE at 00 UTC value is higher than 12 UTC value.

(iv) Atmosphere in the lower tropospheric levels over the area was quite convectively unstable, this fact is very well inferred from convectively generated up thrust.

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