Temporal Variation Features of Convective Available Potential Energy derived from a Ground-based Microwave Radiometer before and after Artificially Triggered Lightning Events*

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Abstract: Convective available potential energy (CAPE) has been widely used in convective weather diagnosis and forecasting. A ground-based microwave radiometer has been installed at a field experiment site during the May-July in 2016 and 2017 and worked at two modes, the meteorological observation mode for atmospheric temperature and humidity profiles at a 4-minute temporal resolution, and the lightning observation mode for artificially rocket-triggered lightning brightness temperatures when a thunder storm cloud is proper for artificial triggering operation. This paper makes use of the atmospheric temperature and humidity profile data obtained before and after artificially triggered lightning event to calculate CAPE once every 4 minutes. The CAPE data for 15 rocket-triggered lightning events have been collected and the temporal variation features of CAPE before and after rocket-triggered lightning events have been analyzed. The preliminary results show that in most cases the CAPE before rocket-triggered lightning event shows an increasing trend to a maximum and then decreases quickly until the radiometer is commanded to go to its lightning observation mode, which implies that a thunder storm is coming up, and that the average of CAPE over an hour before rocket-triggered lightning event is usually larger than that after rocket-triggered lightning event, which implies that the thunder storm has passed away.

Key words: convective available potential energy; ground-based microwave radiometer; artificially-triggered lightning; temporal variation analysis

1. Method

It is well known that

$$CAPE = g\int_{Z_{LFC}}^{Z_{EL}} \left(\frac{T_{vp} - T_{ve}}{T_{ve}}\right) dZ \qquad (1)$$

where Z_{LFC} is the height of the free convection level, Z_{EL} is the height of the equilibrium level, T_{vp} is the virtual temperature of a specific air parcel, and T_{ve} is the virtual temperature of the environment. CAPE is effectively the positive buoyancy of an air parcel and is an indicator of atmospheric instability, which makes it very valuable in predicting severe weather.

The virtual temperature profiles used for CAPE computation are from the temperature and humidity profiles retrieved from atmospheric brightness temperatures at 22 frequencies in 22-60GHz band observed with a ground-based microwave radiometer installed at Guangzhou Field Experiment Site for Lightning Research and Test (GFESL).

2. Results and Summary

Of the 15 artificially rocket-triggered lightning events observed in 2016 and 2017 in Guangdong, China, 6 are given in Fig. 1 to show the time series of CAPE available for this study.

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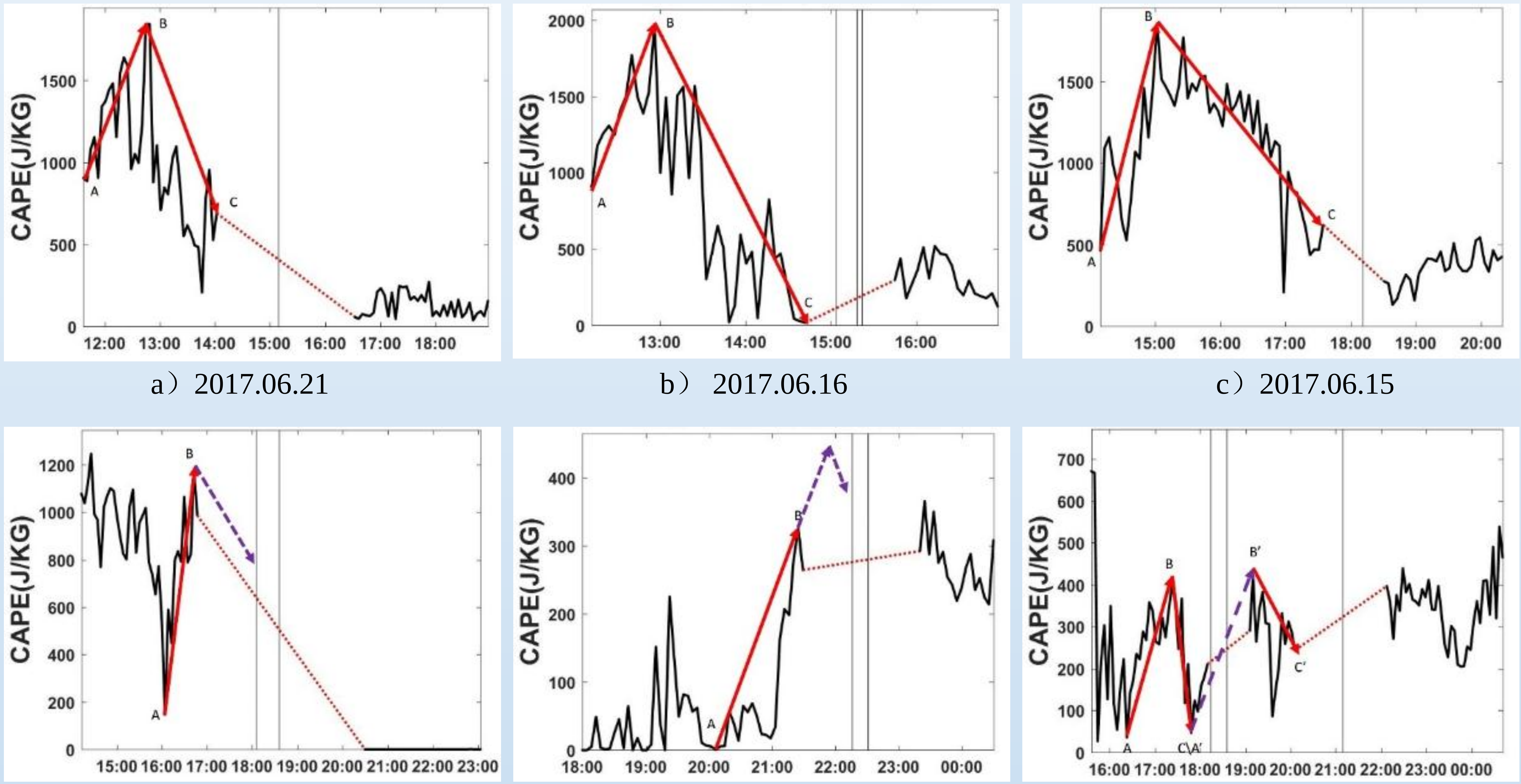
The statistics for the temporal variation features of CAPE are given in Tables 1 and 2. One can see the following.

1) In most cases, CAPE time series has a feature of first rise up and then move down before artificially rocket-triggered lightning events.

2) Average over the 15 events shows the range of increase is 652.1 J/kg and the range of decrease is 752.1 J/kg. And the rate of increase is 11.2 J/kg/min and the rate of decrease is 9.5 J/kg/min.

3) In most cases, CAPE value after rocket-triggering is obviously less than before rocket-triggering. CAPE



a）2017.06.21 b） 2017.06.16 c）2017.06.15

d）2016.06.14 e）2017.06.02 f）2016.06.13

Fig. 1 **Time series of CAPE for the 6 cases. As shown, CAPE increases from “A” until to “B” and then decreases until “C” before the period for Artificially Triggering Lightning begins and the radiometer starts lightning observation mode.**

Table 1 Statistics for the temporal variation features of CAPE before artificially rocket-triggered lightning events

Event	Date	CAPE at A (J/kg)	CAPE at B (J/kg)	CAPE at C (J/kg)	range of increase (J/kg)	range of decrease (J/kg)	rate of increase (J/kg/min)	rate of decrease (J/kg/min)
1	2016.06.09	468.9	1118.4	131.6	649.5	986.8	3.2	11.0
2	2016.06.11	322.4	1112.4	28.3	790.0	1084.1	6.2	7.9
3	2016.06.13	35.6	398.6	46.6	363.0	352.0	6.1	13.5
4	2016.06.13	46.6	422.0	243.4	375.4	178.6	4.6	3.5
5	2016.06.14	146.0	1181.3	----	1035.3	----	27.2	----
6	2016.06.15	355.1	866.5	749.4	511.4	117.1	4.6	2.8
7	2017.06.02	0.5	325.5	----	325.0	----	4.2	----
8	2017.06.12	787.3	1681.2	74.6	893.9	1606.6	22.4	8.5
9	2017.06.15	464.5	1852.5	621.2	1388.0	1231.3	26.2	8.1
10	2017.06.15	132.8	543.7	425.4	410.9	118.3	5.1	5.6
11	2017.06.16	907.2	1971.4	17.0	1064.2	1954.4	24.2	18.4
12	2017.06.16	177.3	519.0	123.5	341.7	395.5	16.3	9.0
13	2017.06.21	886.5	1843.5	690.6	957.0	1152.9	14.1	15.8
14	2017.07.08	231.3	445.3	204.0	214.0	241.3	1.7	12.1
15	2017.07.10	1125.6	1588.5	1230.4	462.9	358.1	2.8	6.8
	Minimum	0.5	325.5	17.0	214.0	117.1	1.7	2.8
	Maximum	1125.6	1971.4	1230.4	1388.0	1954.4	27.2	18.4
	Average	405.8	1058.0	352.8	652.1	752.1	11.2	9.5

Table 2 The CAPE values averaged over one hour before artificially rocket-triggered lightning events as compared with those after artificially rocket-triggered lightning events

Event	CAPE from 1-hour average before rocket-triggering event （J/kg）	CAPE from 1-hour average after rocket-triggering event （J/kg）	Deference （J/kg）
1	556.0	304.1	251.9
2	264.0	60.6	203.5
3	230.7	278.8	-48.2
4	278.8	370.0	-91.2
5	744.0	0.0	744.0
6	712.1	0.0	712.1
7	119.3	272.4	-153.0
8	256.0	203.4	52.6
9	779.1	304.1	475.0
10	411.7	9.5	402.1
11	342.0	342.9	-0.9
12	310.9	35.3	275.6
13	701.2	137.9	563.3
14	316.3	58.9	257.4
15	1002.2	618.8	383.4
Minimum	119.3	0.0	119.3
Maximum	1002.2	618.8	383.4
Average	468.3	199.8	268.5

average over one hour before rocket-triggering event is 468.3 J/kg while the average over one hour after rocket-triggering event is only 199.8 J/kg.

The last word is that the temporal variation features of CAPE revealed above are just the features associated with the life cycle of thunder storms, rather than dominated by rocket-triggering.

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