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Surface ozone concentration variation under thunderclouds

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Abstract

Investigations of variations of surface ozone concentration under a thundercloud during its development and disintegration processes are carried out in village Ruispiri (Telavi region). On the basis of great deal of statistical material reduction of surface ozone concentration during development of thunderclouds and its violent increase during disintegration of thunderclouds were determined. The obtained results enable to use surface ozone concentration as an indicator of vertical flows in the surface air layer under thunderclouds.

1. Introduction

1.1. During developing of a convective cloud an ascending air flow is observed under its basis and a descending one – in its peripheries. As the cloud reaches the state of thunderstorm both the ascending and descending air flows start to act. In the disintegration stage of the cloud a descending air flow dominates in its basis. Creation of descending air flows in the basis of the cloud reduces the intensity of the descending air flow in its peripheries. When the cloud disintegrates the descending air flow in its basis is intensive and in the peripheries it is weakened or completely terminated. Due to circulation the air masses are moved off the cloud at some distance that depends on the height and capacity of the cloud. In case, when a thundercloud breaks, the tropopause some stratospheric air descends onto its peripheries. On the other hand, in a convective cloud, even in its developing stage, a process of charge division begins. Therefore, some low intensity discharges are observed among the drops that create ozone [1]. Some part of the ozone originated within a cloud during the cloud developing stage is transported by the ascending air flows and circulation to the cloud peripheries, and the other part accumulates in the water drops. The higher and larger the cloud is, the further the ozone is moved off the cloud. As a convective cloud is charged the electric field created by it on the ground surface will cause origination of charge flows from different sharp surfaces.

1.2. The latter creates ozone [2]. Due to dependence on the electric field tension direction the ozone concentration created by means of discharges from pointed surfaces above ground will have different intensities. In the initial stage the ascending air flow feeding the cloud transports the ozone originated from pointed surfaces as well as the ozone that has moved off the surface air cloud peripheries. Due to the above reasons in its initial developing stage the reduction of the surface ozone concentration under the basis of the convective cloud and its growth in the peripheries must be observed. After beginning of thunderstorm discharges the cloud passes to disintegration stage. By this time there appear precipitations with different intensities under it that refer to the beginning of activities of the descending air flow. During a torrential downpour descending air flows transport the ozone below the cloud. Besides, if the temperature in the surface air layer is high the rain drops start to evaporate and the ozone accumulated in the drops is emanated. Due to these processes the ozone concentration in the surface air layer is to violently increase. For checking the above supposition we carried out an independent investigation according to a large statistical database.

2. Results of measurements

During a thunderstorm process we evaluated the surface ozone concentration by the following expression: $\Delta\rho = \rho c_{fw}$, where ρ is an average value of the surface ozone concentration per hour, ρc_{fw} is the corresponding hourly value of the averaged surface ozone concentration in a fair weather, $\Delta\rho$ is an averaged hourly deviation of the surface ozone concentration from the one that in a fair weather during the given process at a corresponding time.

During the continuous surface ozone concentration measurements its violent reduction in the initial development stage and growth while the disintegration process of the thundercloud were often observed. There is an example below (Fig. 1). On July 11, 1974 at 18:00 over village Ruispiri a thundercloud started to develop and during the diurnal variation of the surface ozone concentration its reduction was observed. The disintegration of the thundercloud that started at 20:00 was followed by abrupt growth of the surface ozone concentration. During the development of the convective cloud the surface ozone concentration decreased by 10% below its initial value, but it increased by 90% after disintegration of the cloud. The figure also shows that violent increase of the surface ozone concentration advances the origination of thunderstorm by 4 hours. The table shows 63 cases of variations of surface ozone concentration under thunderclouds for village Ruispiri. All the 63 cases state that during a thundercloud development process the ascending air flow decreases surface ozone concentration and the descending air flow increases it in the thundercloud disintegration stage. During thunderstorm process the surface ozone concentration decreases by 32% at average rate, besides the maximum decrease is 78% and the minimum – 6%, and during the thundercloud disintegration the surface ozone concentration increases by 72% at average rate, here the maximum increase is 166% and the minimum – 7%. The table also shows average, maximal and minimal values of the surface ozone concentration (ρ) in the development and disintegration stages of the cloud. As in the figure, during a thunderstorm process the surface ozone concentration at average rate decreases from 55mkg/m^3 to 37 mkg/m^3, and during the thundercloud disintegration process it increases from 38mkg/m^3 to 56 mkg/m^3. The maximum values of the surface ozone concentration observed during the cloud growth and disintegration processes are equal to 67 mkg/m^3 and 97 mkg/m^3, and the minimum – 5 mkg/m^3 and 20 mkg/m^3 correspondingly.

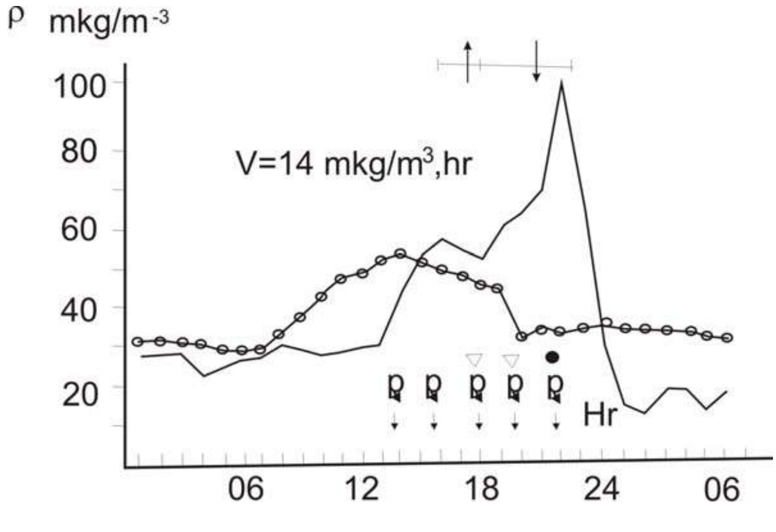

Fig. 1. Surface ozone concentration variation under thunderclouds in 11.07.1974 in Ruispiri village (•); R - thunderstorm; X – thunderstorm with rain; • - rain; X - torrential downpour; X - ascending air flow; X - descending air flow; X - average diurnal variation of surface ozone concentration; V - surface ozone concentration growth velocity; **r** - time period from the beginning of surface ozone concentration growth till the first thunderstorm.

Table of surface ozone concentration variation under thunderclouds

Stages of the thundercloud	Number of cases	Number of cases when $\Delta\rho$			$\Delta\rho$ mkg/m^3			ρ mkg/m^3					
								Average		Max		Min	
		> 0	< 0	= 0	Ave	Max	Min	Start	Finish	Start	Finish	Start	Finish
Development	63	0	63 100%	0	-18 32%	-38 78%	-2 6%	55	37	92	67	15	5
Disintegration	63	63 100%	0	0	18 72%	43 166%	4 7%	38	56	67	97	5	20

3. Conclusion

The above obtained results enable us to conclude that surface ozone concentration may be successfully used as an indicator of vertical flows in the surface air layer below a thundercloud. Especially, during a thundercloud development stage a reduced surface ozone concentration and ascending air flow are observed below it, and in its disintegration stage – increased surface ozone concentration and descending air flow.

References

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Изменение концентрации приземного озона под грозовыми облаками

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Резюме

В с. Руиспири (Восточная Грузия) проведено исследование изменении концентрации приземного озона (КПО) под грозовыми облаками во время их развития и распада. На основе большого статистического материала установлены уменьшение КПО под грозовыми облаками при их развитии и резкий рост при распаде грозового облака. Получунные результаты дают возможность использовать КПО, как индикатор вертикальных потоков в приземных воздушных слоях под грозовыми облаками.

მიწისპირა ოზონის კონცენტრაციის ცვალებადობა ელჭექის ღრუბლის ქვემოთ

ჯუმბერ თ. ხარჩილავა

რეზიუმე

სოფელ რუისპირში (თელავის რ-ნი) ჩატარებულია მიწისპირა ოზონის კონცენტრაციის (მოკ) ცვალებადობის გამოკვლევა ელჭექის ღრუბლის ქვემოთ მისი განვითარებისა და დაშლის პერიოდისათვის. იდი სტატისტიკური მასალის საფუძველზე დადგენილ იქნა მოკ-ის შემცირება ელჭექის ღრუბლის განვითარებისას და მკვეთრი ზრდა ელჭექის ღრუბლის დაშლისას. მიღებული შედეგები საშუალებას იძლევა მოკ –ი გამოვიყენოთ როგორც ვერტიკალური ნაკადების ინდიკატორი ჰაერის მიწისპირა ფენაში ელჭექის ღრუბლის ქვემოთ.