積雨雲高度雙型式之研究

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摘 要

本文之前部，係提出一：準一次元，有時序，無降水之積雨雲模式。本模式含一氣源及三區。固定半徑之核心區含雲之主上升氣流。環形週邊區含雲之外圍不活躍部份。環境區爲距雲較遠之廣大範圍。此三區卽構成一底部敞開之對流單元。底部以下爲氣源區，但此氣源區係以一氣源替代。氣源係假設位於雲底之下，地面之上某高度，而以等率放射一定性質之氣源空氣。如氣源空氣之性質甚佳且放射率亦高，亦卽高強度氣源，則氣源之上可望有雲之形成。經由百種以上，不同情況之敏感度測驗，已發現在一特定之大氣中，氣源強度有兩個關鍵值。如氣源強度低於低關鍵值，無雲可生成。高於高關鍵值，則將產生一深積雨雲。無深積雨雲能吸取低層大氣中之潛能而能自行發展至一相當高度。當氣源強度介於高低關鍵值之間時，卽產生甚淺之積雨雲；此淺雲係完全由氣源支持。此兩關鍵值均甚小且甚爲接近。因其甚小，故在實際大氣中極有可能存在。因其甚爲接近，故氣源上所生之雲將發展爲高雲，或停留爲淺雲與氣源強度變化之關係極爲敏感；尤其是當氣源強度變化於高低關鍵值之上下時。此測驗之結果——高低關鍵值之發現——具有一深切之含意，卽所生成之雲，要就是深而高之雲，要就是淺雲，不會僅發展至中等高度而停止（除非另有其他因素使其爲此，如逆溫層之存在）。本文後部卽推證如果有許多氣源同時存在於一廣大面積時，而此等氣源之強度均不同，有大於高關鍵值者，亦有低於低關鍵值者，卽將有許多雲生成，根據本研究之結果，就空間而言，此等雲將只有兩種型態。卽：要就是發展很高的雲，要就是不發展的低雲；卽使是氣源強度有弱有強也有中等，成很均勻的分佈。如在一小面積僅有數氣源存在，例如，日出後，由於山坡加熱而在山頂上形成的氣源，而其強度已超過低關鍵值，却未超過高關鍵值時，則氣源上所生成之雲將爲低淺的雲，當太陽升高而山坡加熱過程愈來愈強時，氣源強度卽隨之加強。當加強至超過高關鍵值時，所生成之雲卽驟然發展至甚高之高度，當氣源強度從低於低關鍵值增強至高於高關鍵值時，此過渡時期雲頂高度之增加卽顯示一不連續現象。亦卽是在此之前均爲低淺雲，其後則均爲深高雲。雲高度之分佈，就時間言，卽顯出雙型態。運用此等結果，卽可解釋在海洋上的積雨雲，何以有空間上的雙型態分佈。陸地上，尤其是山頂上的雲，何以有時間上的雙型態分佈。本文中，同時亦曾試圖澄清形成深高雲及淺低雲的條件。

A Quasi-one-Dimensional, Time-Dependent and Non-Precipitating Cumulus Model : on the Bimodal Distribution of Cumulus Cloud Height

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ABSTRACT

A quasi-one-dimensional, time-dependent and mon-precipitating cumulus cloud model is presented. The model has a source and three regions. A core region of constant radius houses the main updraft of a cloud. An annulus immediate environmental region houses the outer inactive part. A far environmental region represents the vast environment in which the cloud activity is embedded. These three regions constitute a convective cell but with an open bottom. Below the bottom is the source layer which is replaced by a circular source located directly beneath the core region, below the cloud base and above the ground. The source emits the source air of specified properties at a constant rate. If the properties of the source air is good enough and the rate of emission is high enough, namely, a high source strength, clouds are expected to be produced, through a sensitivity test composed of more than one hundred cases of different source strengths, we have discovered that there exists two critical values of the source strength for a given atmosphere. If the source strength is below the lower critical value, no cloud can form. If it is above the upper critical value, a deep cumulus cloud is produced. This deep cumulus is able to draw upon the latent energy stored in the lower atmosphere in addition to the source supply; therefore, it is able to develop spontaneously to a great height. If the source strength is inbetween, a shallow plume cloud is produced. This shallow plume cloud is solely supported by the source. These two critical values are both very small and close to each other. The smallness, $0.35 \sim 0.7 ms^{-1}$, malses this result more realistic. The closeness indicates that, in reality, whether a cloud shall develop to a deep or a shallow one is extremely sensitive to the source strength, when the source strength is near to its critical values. An important implication of the existence of two critical source strength is that a cloud produced can only be a shallow one or a deep one. None can be of intermidiate height unless there are other factors present, such as an inversion. When there are many sources in a wide area and their strengths vary from sub-lower-critical to super-upper-critical, many clouds shall be produced. According to our results, the spectrum of these clouds should be bimodal with respect to space . That is, there are only the very large and very small clouds present, even if the spectral distribution of the source strengths is even. When there are a few sources formed over mountain peaks due to the upper level heating

process after sunrise, a series of clouds may be formed. In the early morning, the source strength is sub-lower critical, no cloud can be formed. When the heating process gets stronger and stronger, the source strength shall increase. After the source strength exceeds the lower critical value, shallow plume clouds shall be formed. When the source strength exceeds the upper critical value, deep cumulus clouds shall be formed. At the time of the transition of the source strength from the sub- to super-upper critical value, there will be a discontinuity in the cloud top height namely, before this time, the clouds formed are shallow ones and after, deep ones. This shows a sudden increase of the heights of the cloud tops at this time, the spectral distribution of the clouds, therefore, is bimodal with respect to time. Applying these results, we have offered some plausible explanations to the bimodal distribution of the final height of the cloud tops with respect to time, as observed over mountain peaks, and that with respect to space as observed over oceans. Also, we have attempted to clarify the conditions for the formation of the shallow and deep cumulus clouds.