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Optical lightning detector for Jovian orbiter: *OLD*

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Abstract

Recent observational and theoretical studies suggest that thunderstorms, i.e., strong moist convective clouds in Jupiter's atmosphere are very important not only as an essential ingredient of meteorology of Jupiter but also as a potentially very useful "probe" of the water abundance of the deep atmosphere, which is crucial to constrain the behavior of volatiles in early solar system. Therefore, every opportunity and methods should be pursued to observe Jupiter's convective clouds. Lightning observation with properly designed device shall greatly enhance the value of the observation of convective clouds onboard JGO.

Convective clouds is the key of mechanism for large structures

Jupiter's atmosphere exhibits distinct banded structure. Optically bright, anti-cyclonic shear regions are called "zones", whereas optically dark region with cyclonic shear are called "belt". There have been two confronting idea about the origin of the belt/zone structure: the "shallow theory" and "deep theory".

Based on detailed analysis of cloud motions by Galileo orbiter (figure above), Gierasch et al. (2000) proposed that the thunderstorms can produce the small scale eddies and ultimately drive the belt/zone structure. Moreover, the belt zone structure helps the development of thunderstorms in the belt region in accordance with observation; the belt/zone structure and thunderstorms may be in a "symbiotic" relation. This framework is a refined version of "shallow origin" theory, but, although it is a very fantastic idea, quantitative verification remains to be done

Moist convection as a probe of deep atmosphere composition

Most recent numerical modeling (Sugiyama et al, 2008) can calculate all three types of cloud, i.e., H2O, NH3, and, NH4SH. Our group is concentrated on very long-term integration of two-dimensional model, aiming at the understandings of the statistical properties of convective clouds and the average structure of the atmosphere which are established as the "radiative-convective equilibrium" (Nakajima et al, 2000). One of our most important findings is the existence of distinct, quasi-periodic temporal variation of the convective cloud activity; "explosion" of cloud activity extending all over the computational domain occurs separated by "quiet" period of order of 10 days. Still surprising finding is that the period of the "active/break" cycle is roughly proportional to the amount of condensable component in the sub-cloud layer. This strong correspondence between the deep volatile abundance and temporal variability of cloud convection implies a new method to "probe" the deep atmosphere.

JGO is the ideal vehicle

According to the observation by Voyager and Galileo, lightning activity is more active at high latitudes than at lower latitudes. Whether this distribution is persistent or not becomes an important clue for estimating how deep the belt/zone structure extends. JGO with other equipments especially for atmospheric spectral imaging is the ideal platform for *OLD*. Comparing quantitative lightning activity with ambient cloud motion and variations of estimated cloud height would result in significant progress of our understandings.