Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM29-09 Room:304 Time:May 21 16:15-16:30

Whole atmosphere-ionosphere coupled model (GAIA) for space weather research

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Space near the Earth, called geospace, is a highly complex system, consisting of the solar wind, the magnetosphere, the ionosphere, and the neutral atmosphere. Those regions have different physical characteristics with different temporal and spatial scales. In particular, the magnetosphere, the ionosphere, and the neutral atmosphere are strongly coupled with each other, and interaction between the regions is nonlinear and extremely complicated. Even within each region, there are strong interactions between physical processes with different temporal and spatial scales. The geospace environment significantly varies as electromagnetic energy and particles from the sun vary. Furthermore, recent observations have revealed that atmospheric waves generated in the lower atmosphere and variations of the lower and middle atmosphere significantly influence the thermosphere and the ionosphere. In order to quantitatively understand such a complicated system, it is necessary to model the entire geospace region self-consistently. We have developed an atmosphere-ionosphere coupled model, which includes the whole neutral atmosphere and the ionosphere. The model is called GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy). Some unsolved phenomena in the upper atmosphere have been already reproduced and studied. The model will be a useful tool for space weather research and forecast. We will report some recent results using GAIA, such as (1) upper atmosphere variation during the annular solar eclipse on May 21, 2012, (2) effects of lower atmospheric phenomena on the ionosphere, and (3) ionospheric variation associated with magnetic storms including effects of disturbances from the lower atmosphere. We will also report our future plans for the development of GAIA.

Keywords: atmosphere, ionosphere, coupling, model, simulation, space weather