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Global Change of the Thermosphere Caused by High-latitude Energy Inputs (Extended Abstract)

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The energy originated from the solar wind is continuously poured into the high-latitude thermosphere. The aurorae and geomagnetic disturbances are known as its manifestation. This energy sometimes causes global scale changes of wind, temperature and composition in the thermosphere as well as the solar Extreme Ultra Violet (EUV) radiation. This thermospheric response to the high-latitude energy inputs has been studied by using numerical models. Results from numerical simulations show that strong circulation can be set up and the traveling atmospheric disturbances (TADs) are also generated in the high-latitude thermosphere during geomagnetic disturbed periods. TADs propagate to middle- and low-latitude regions and cause wind and temperature variation. It is found that heating/cooling due to adiabatic expansion/compression plays a preeminent role to cause temperature variation during TADs passing.

Temperature variation estimated from an empirical model (MSISE 90)

We can overview the temperature variation at various conditions using an empirical model, for example, MSISE90 [Hedin, 1991]. Figure 1 shows zonal mean temperature at solar minimum and geomagnetic quiet condition and temperature differences from the solar minimum and geomagnetic quiet condition. Above 250 km altitude, the temperature difference between two cases of the solar maximum (F10.7=200) and the solar minimum (F10.7=70) is 400-500 K. It is more than 50% of temperature at solar minimum (~800 K). During a period of geomagnetic disturbance, the temperature difference from a geomagnetic quiet condition becomes about 400 K at high-latitude and about 100 K at middle- and low-latitude above 250 km.

Temperature variation caused by TADs estimated from numerical simulations

It is well known that the Traveling Atmospheric Disturbances (TADs) cause temperature, wind and composition changes in the global thermosphere. Pröless [1982, 1993] showed that large scale TADs propagating from high- to low-latitude cause composition change in the thermosphere. Furthermore, several numerical simulations revealed the feature of large scale TADs [*e.g.* Millward *et al.*, 1993; Balthazor and Moffet, 1999]. Fujiwara *et al.* [1996] showed that the upper thermospheric temperature (at about 260 km) was enhanced about 100 K at high-latitude and 20-40 K at middle- and low-latitude during or after the enhancement of auroral energy injection lasting for 1 hour. These disturbances were caused by TADs generated at high-latitude and the TADs contributed to heating/cooling through the process of compression or expansion of the air. The disturbances are almost recovered after the passage of the TADs. To

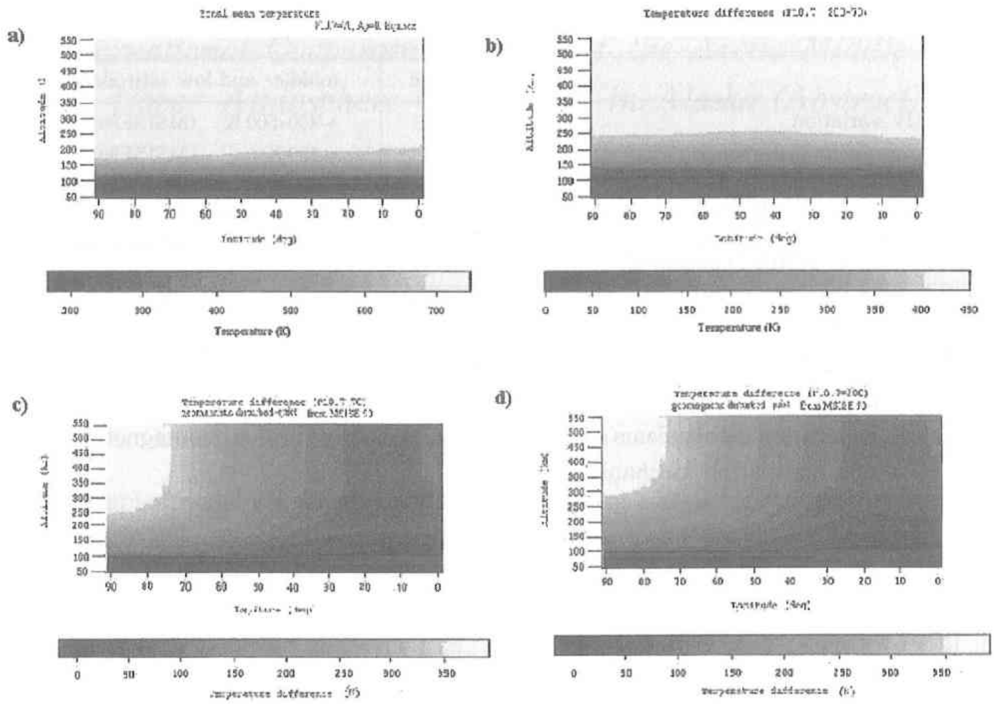

Fig. 1. a) Zonal mean temperature at solar minimum (F10.7=70) and geomagnetic quiet (Ap=0) condition. b) Temperature difference between the conditions of solar maximum (F10.7=200) and solar minimum (F10.7=70) during geomagnetic quiet period. c) Temperature difference between geomagnetic disturbed (Ap=100) and quiet (Ap=0) periods at solar minimum (F10.7=70). d) Same as c) except for at solar maximum (F10.7=200).

set up new wind and temperature fields, more energy should be continuously poured into the thermosphere. For example, enhancement of auroral energy injection lasting for 12 hours into high-latitude can cause temperature enhancement of about 400 K at high-latitude and 100-150 K at middle- and low-latitude. The long lasting energy injection can drive strong winds in the whole thermosphere. Such strong winds advect the heat and then, the temperature and wind enhancement region is extended globally. The time scale of the propagation of TADs from high- to low-latitude is about 3-4 hours and the time scale for setting up new wind field and/or advecting the heat from high- to low-latitude seems about 10 hours.

Summary and Future study

The thermospheric thermal structure is strongly affected by two types of energy inputs from the Sun; the solar Extreme Ultra Violet (EUV) radiation and the energy due to the solar wind (auroral energy). The changes of these energy inputs cause the global temperature variation in the thermosphere. The amplitudes of the temperature variation above 250 km are summarized as follows (Table 1).

The auroral energy injected into the high-latitude thermosphere sometimes exceeds the solar EUV that is the main heat source in the thermosphere and causes the global change of the

Table 1. Amplitudes of temperature variation caused by changes of EUV radiation and high-latitude auroral energy injection.

	high-latitude	middle- and low-latitude	
EUV variation	~400-500 K	~400-500 K	(MSISE90)
geomagnetic disturbance	~350-400 K	~100 K	(MSISE90)
short-lasting geomagnetic disturbance (TADs passage)	~100 K	~20-40 K	(Simulation)
long-lasting geomagnetic disturbance (TADs+circulation)	~400 K	~100-150 K	(Simulation)

thermosphere. TADs and the thermospheric circulation are quite important for producing the disturbances. In order to understand the thermospheric changes, we should investigate more details abut 1) generation mechanisms of wind and TADs during various geomagnetic conditions, 2) propagation and dissipation mechanisms of TADs.

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