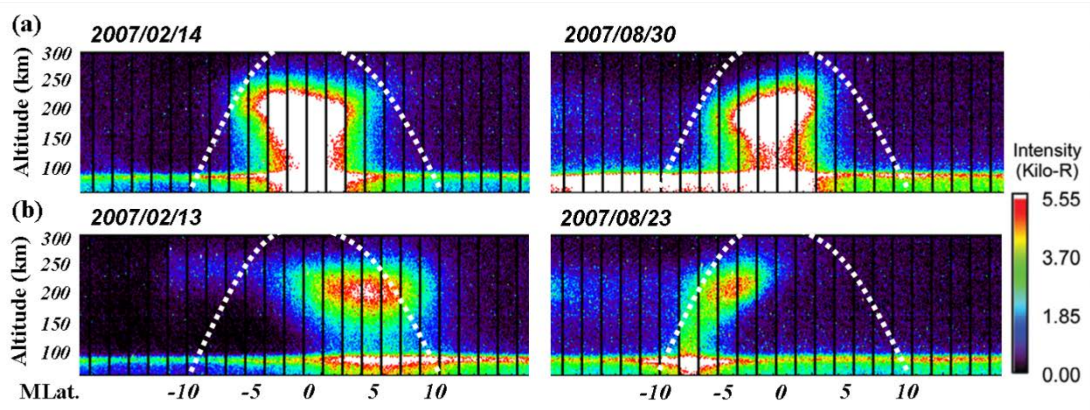
Supplement

I. Observation data

Observations have found cases that are consistent with our simulation results regarding the influence of the neutral wind. Figure S1 shows four cases observed by ISUAL in the Asian region at 23:00 local time during the two months considered in our studies: two cases in February shown on the left side and two cases in August shown on the right side. Figure S1(a) features nightglow patterns that agree with simulation results under the condition of no wind or weak wind while Fig. S1(b) would correspond to simulation results for the normal wind condition. We can see from Fig. S1(a) that a bright spot of nightglow was observed at the geomagnetic equator during both months. As the volume emission rate, according to Eq. (4), is proportional to the O^+ density, the observations were supportive of the simulation results of density variations in Fig. 1(a). Similarly, the two cases in Fig. S1(b), which featured nightglow bright spots in the winter hemisphere, suggested that the density variations shown in Fig. 1(b) are realistic.



(Figure S1) Four observation cases by ISUAL in February 2007 and August 2007 (the same periods as shown in Fig. 1).

II. Chemical process

Photo-Chemical Reaction: $\frac{\partial n}{\partial t} + \vec{\nabla} \cdot (n\vec{v}) = P - L$

n: density,
P: production rate

L: Loss rate

$$O_2 + O^+ \xrightarrow{r} O_2^+ + O \qquad \text{-----①}$$

$$O_2^+ + e^- \xrightarrow{\alpha^*} O(^1D, ^1S) + O(^3P) \qquad \text{-----②}$$

Where r and α^* are rate coefficients of Reactions ① and ② respectively.

Consider the P and L of $O_2^+ : P_{O_2^+} = r[O_2][O^+], L_{O_2^+} = \alpha^*[O_2^+][e^-]$

Steady State: $\dfrac{d[O_2^+]}{dt} = 0 = P_{O_2^+} - L_{O_2^+} = r[O_2][O^+] - \alpha^*[O_2^+][e^-]$

$$\Rightarrow [O_2^+] = \frac{r[O_2][O^+]}{\alpha^*[e^-]} \qquad \text{-----③}$$

From ② $\Rightarrow P_{O(^1D)} = \mu_D \alpha^*[O_2^+][e^-]$ -----④

μ_D is the quantum yield

Substitute ③ into ④ $\Rightarrow P_{O(^1D)} = \mu_D\, r[O_2][O^+]$

Triple state but just 2 red lines because J=2 to J=0 is not allow (from selection rule of quantum mechanism).

$$O(^1D) \xrightarrow{A_{1D}} O(^3P) + h\nu_{6300}$$

$$O(^1D) \xrightarrow{A_{2D}} O(^3P) + h\nu_{6364}$$

If $O(^1D)$ undergoes collisions with neutral particles, it will lose energy, named Quenching Reaction.

$$O(^1D) + N_2 \xrightarrow{K_1} O + N_2$$

$$O(^1D) + O_2 \xrightarrow{K_2} O + O_2$$

$$O(^1D) + O \xrightarrow{K_3} O + O$$

$$\Rightarrow L_{O(^1D)} = \{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}\}[O(^1D)]$$

Steady state: $\frac{d[O(^1D)]}{dt} = 0 = P_{O(^1D)} - L_{O(^1D)}$

$$\Rightarrow \mu_D\, r[O_2][O^+] = \{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}\}[O(^1D)]$$

$$\Rightarrow [O(^1D)] = \frac{\mu_D\, r[O_2][O^+]}{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}}$$

Volume Emission Rate of 630.0nm:

$$I_{6300} \equiv [h\,\nu_{6300}] = A_{1D}[O(^1D)]$$

$$I_{6300} = \frac{A_{1D}\,\mu_{1D}\, r[O_2][O^+]}{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}}$$