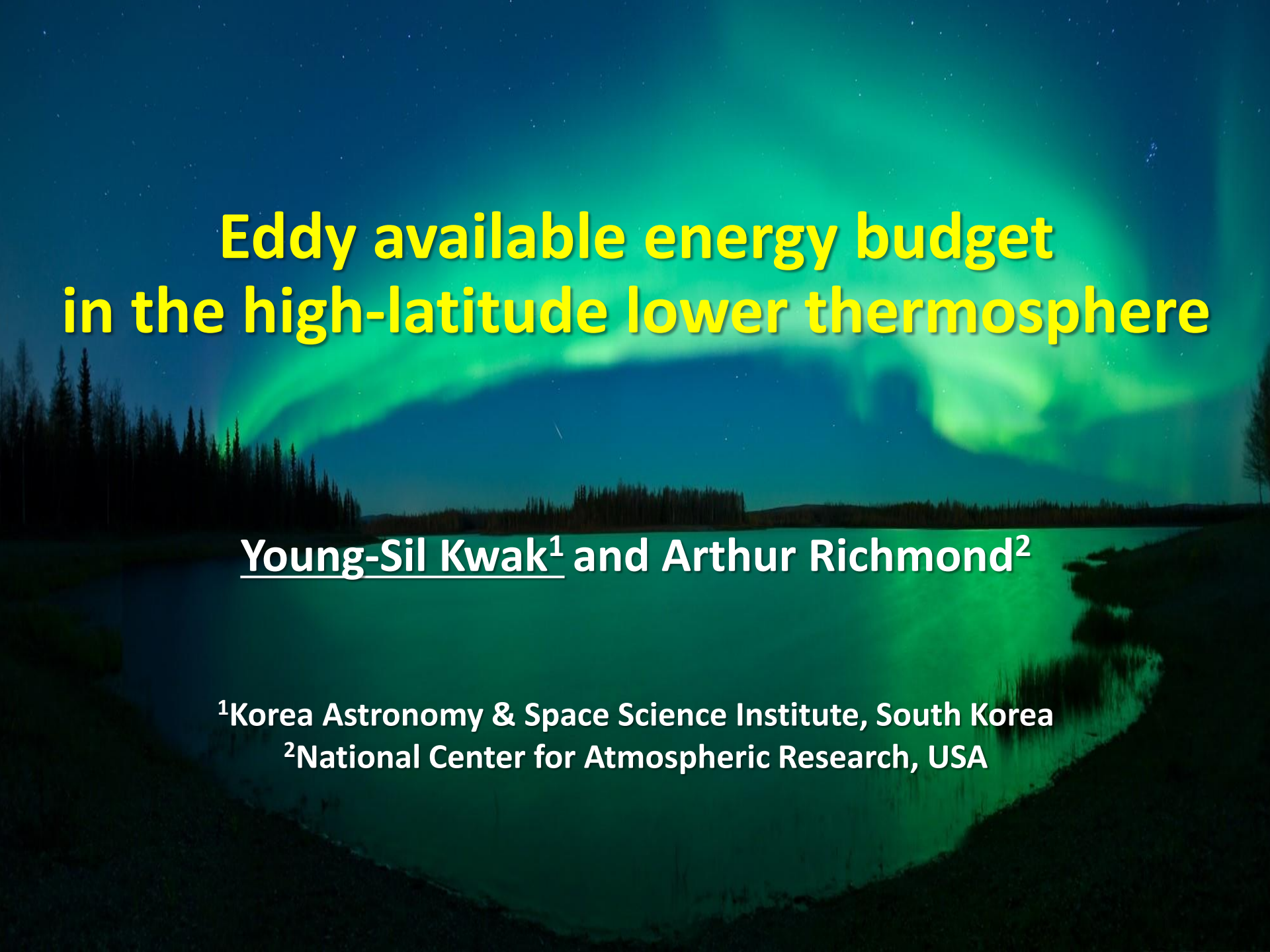


Eddy available energy budget in the high-latitude lower thermosphere

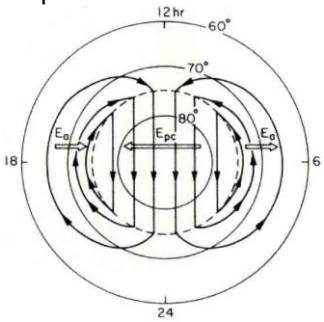
Young-Sil Kwak[1] and Arthur Richmond[2]

[1]Korea Astronomy & Space Science Institute, South Korea
[2]National Center for Atmospheric Research, USA

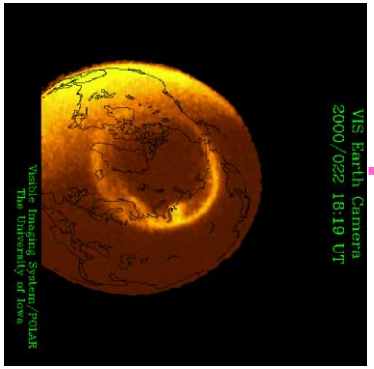
I-T Processes in the High Latitude

Ionosphere

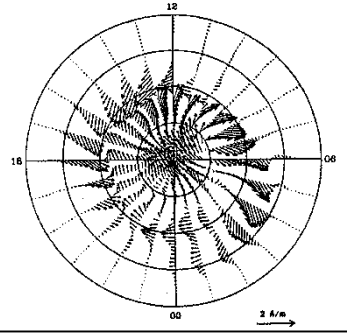
Ionospheric E-Filed & Convection



Auroral Particle Precipitation



Ionospheric Current



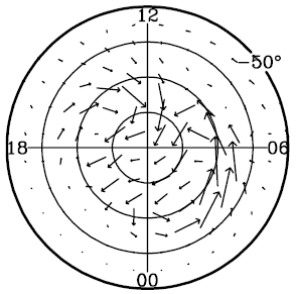
Ion-drag acceleration

auroral heating

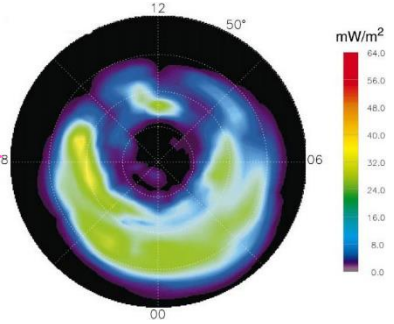
Joule heating

Thermosphere

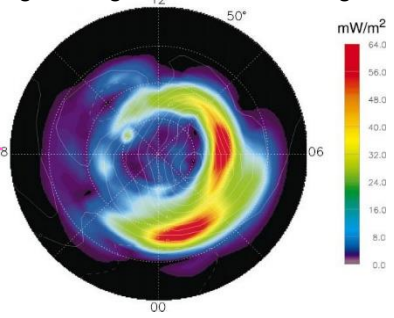
Ion Drag



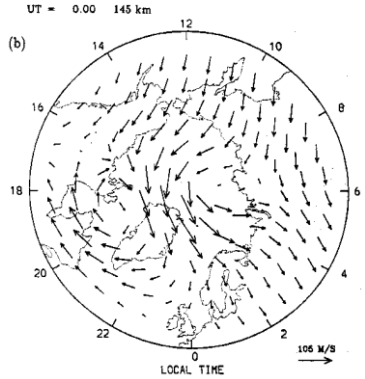
Auroral Electron Energy Flux



Height-Integrated Joule Heating Rate



High-latitude Thermospheric Winds



Studies on physical mechanisms controlling high-latitude lower thermospheric winds

- ***Walterscheid & Brinkman* [2003], and references therein**
  Analyses of high-latitude thermospheric wind dynamics based on theoretical and numerical models

- ***Kwak & Richmond* [2007]**
  Analyses of the momentum forces acting on the high-latitude lower thermospheric wind system below 170 km, using NCAR TIE-GCM

- ***Kwak, Richmond, & Roble* [2007]**
  Study on the dependence of the high-latitude lower thermospheric momentum forcing on the IMF direction

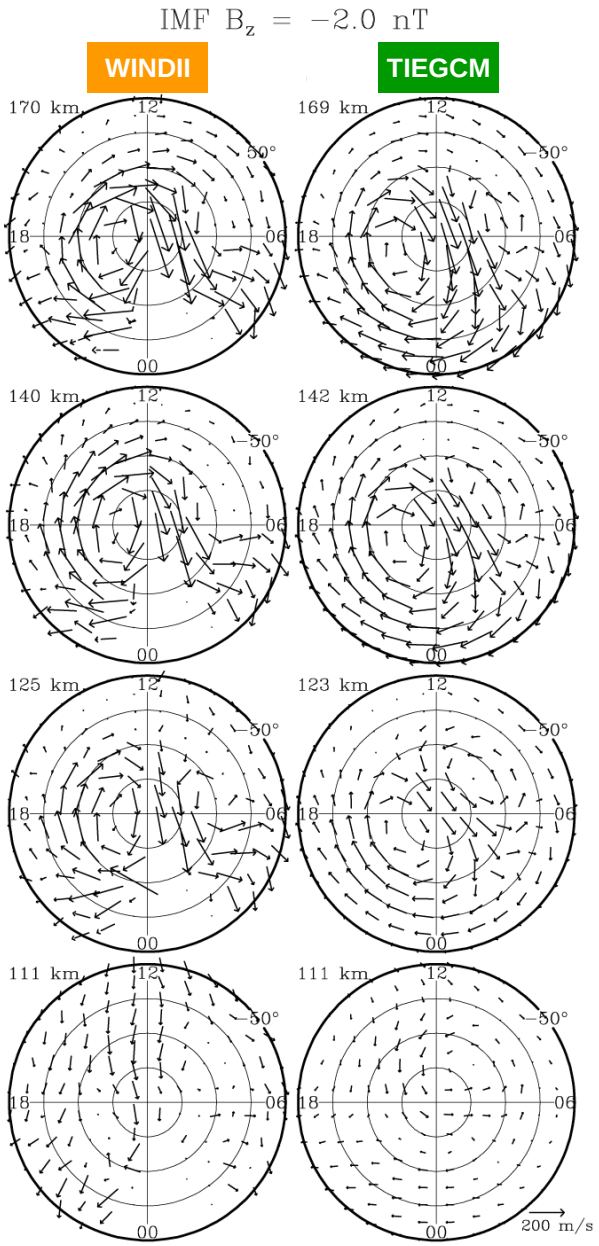
- ***Kwak & Richmond* [2014]**
  Systematic analyses of the horizontal divergence and the vertical component of vorticity for the high-latitude lower thermospheric wind field

- ***Kwak & Richmond* [2017]**
  Study on the relative contributions of momentum forcing and heating to high-latitude lower thermospheric winds

Thermospheric Winds in the High Latitude

WINDII: **Wind** Imaging
Interferometer
on the UARS

TIEGCM: **T**hermosphere
Ionosphere
Electrodynamics
General
Circulation
Model



Only part of the energy of the thermospheric gas ➡ is available for driving dynamics

[*Kwak and Richmond*, 2007]

Eddy Available Energy

Eddy Available Energy (EAE)

= Eddy Kinetic Energy (EKE)

+ Eddy Available Potential Energy (EAPE)

We evaluate the budgets of EAE production, transport, and loss under steady-state forcing of the high-latitude lower thermosphere by using NCAR TIE-GCM.

Eddy Available Energy Budget (1)

Eddy Available Energy (EAE) = Eddy Kinetic Energy (EKE, $\varepsilon_k = \frac{\vec{v}^2}{2}$ **)**

+ Eddy Available Potential Energy (EAPE, $\varepsilon_p \equiv \frac{\xi' - \xi_r \ln(\xi/\xi_r)}{\kappa_r \zeta}$ **)**

Eddy Kinetic Energy Budget

$$\frac{\partial \varepsilon_k}{\partial t} = -\nabla \cdot \left[\vec{v}(\varepsilon_k + \Phi')\right] - e^z \frac{\partial}{\partial z}\left[e^{-z} w(\varepsilon_k + \Phi') + \frac{g}{p_0}\vec{v}\cdot\vec{\tau}\right] + w\xi' + \frac{\vec{\tau}}{\rho H}\cdot\frac{\partial \vec{v}}{\partial z} + \vec{v}\cdot\lambda\cdot(\vec{v}_E - \vec{v})$$

viscous dissipation

Horizontal flux convergence

vertical flux convergence

conversion from ε_p

Ion-drag generation or dissipation

Eddy Available Energy Budget (2)

Eddy Available Energy (EAE) = Eddy Kinetic Energy (EKE, $\varepsilon_k = \frac{\vec{v}^2}{2}$ **)**

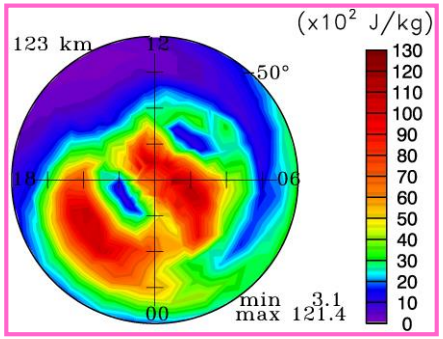
+ Eddy Available Potential Energy (EAPE, $\varepsilon_p \equiv \frac{\xi' - \xi_r \ln(\xi/\xi_r)}{\kappa_r \zeta}$ **)**

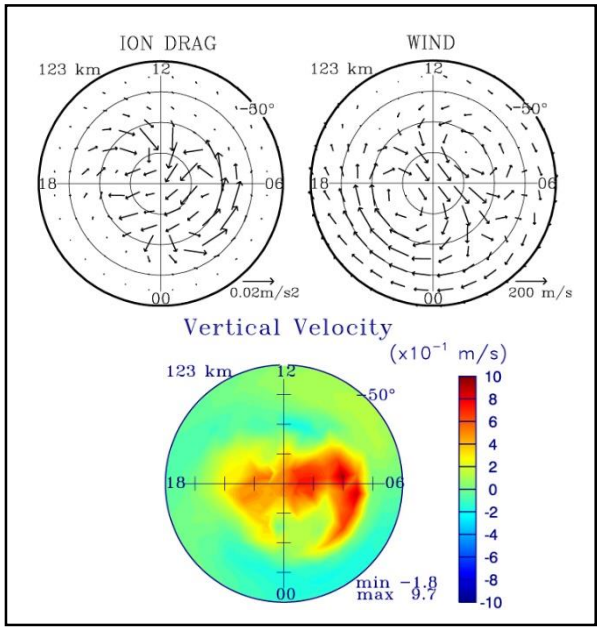
Eddy Available Potential Energy Budget

$$\frac{\partial \varepsilon_p}{\partial t} = -\vec{v}\cdot\nabla\varepsilon_p - w\frac{\partial \varepsilon_p}{\partial z} - w\xi' + \frac{\kappa\xi'}{\kappa_r\zeta\xi}\left[Q - \xi\frac{D\kappa^{-1}}{Dt}\right] + w\left[\varepsilon_p \frac{d}{dz}\ln\left(\frac{\xi_r}{\kappa_r\zeta}\right) - \frac{\kappa'\xi'}{\kappa_r\zeta}\right]$$

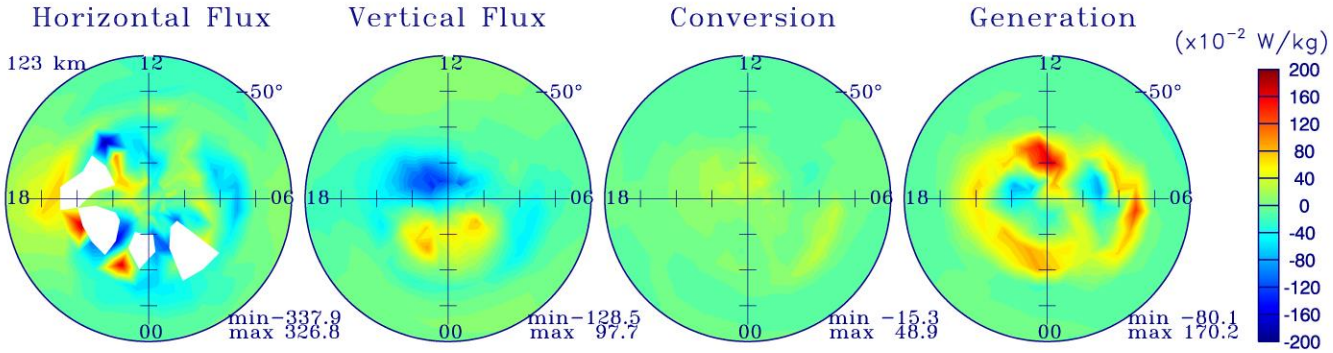
advection — conversion to ε_k — generation — small term

Eddy Kinetic Energy





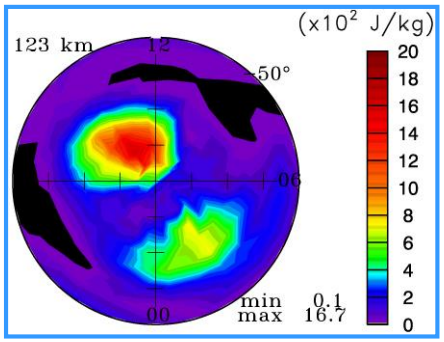
Eddy Kinetic Energy Budget

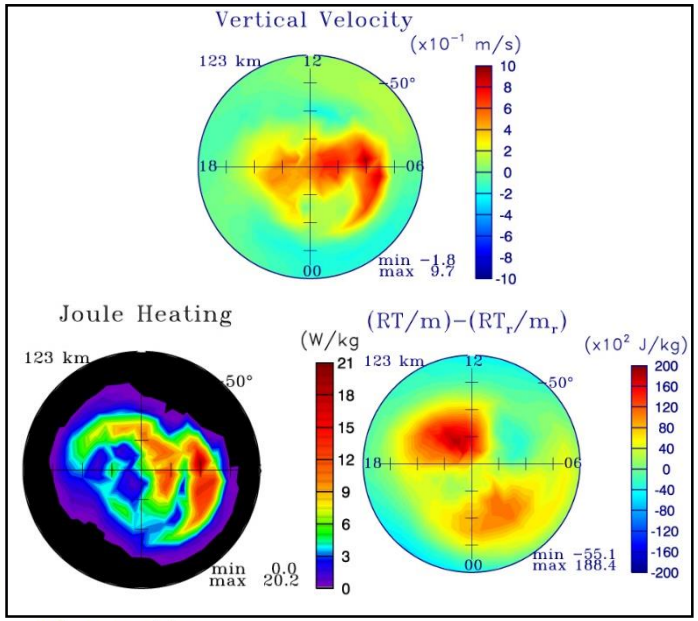


In the high-latitude thermosphere, Eddy Kinetic Energy

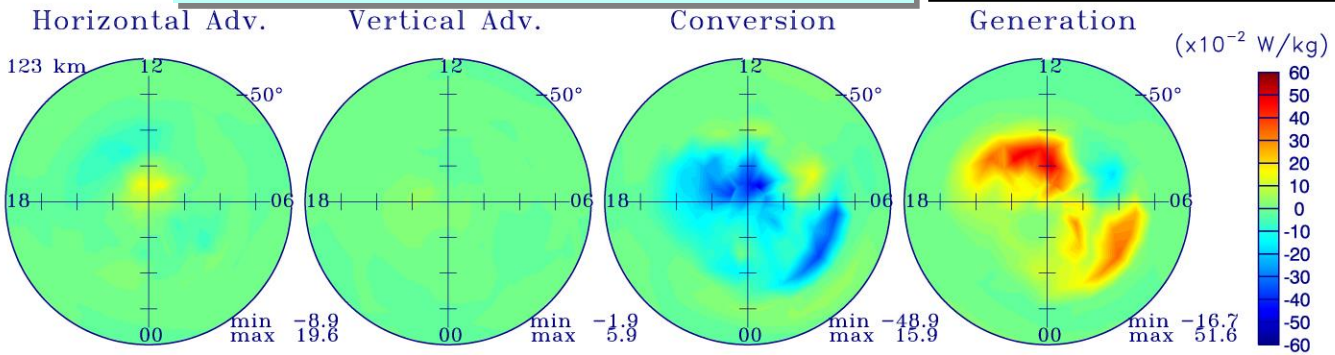
- is generated primarily where the ion-drag force associated with plasma convection accelerates the neutral gas.
- is destroyed primarily where the ion-drag force opposes the wind.

Eddy Available Potential Energy





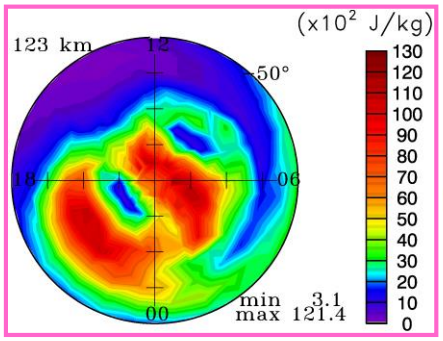
Eddy Available Potential Energy Budget

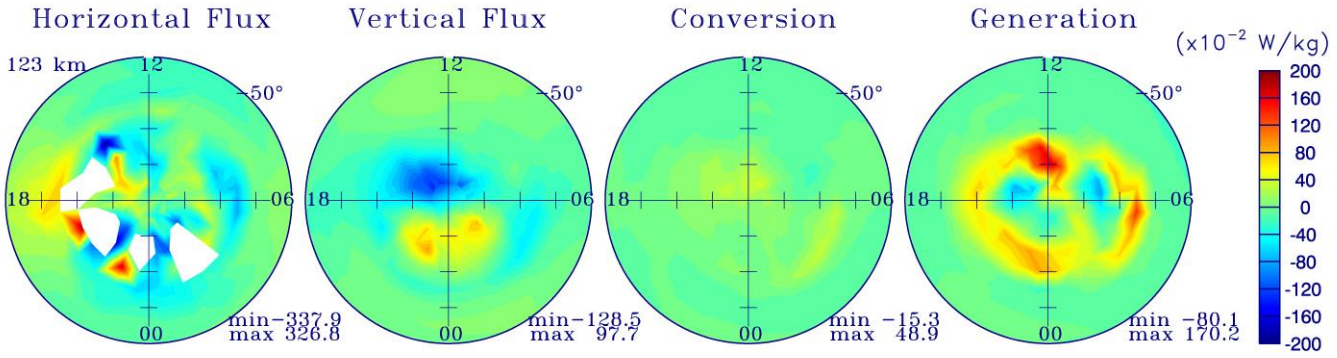


In the high-latitude thermosphere, Eddy Available Potential Energy
- is generated primarily where Joule heat is deposited in regions of elevated temperatures.

Eddy Kinetic Energy Budget

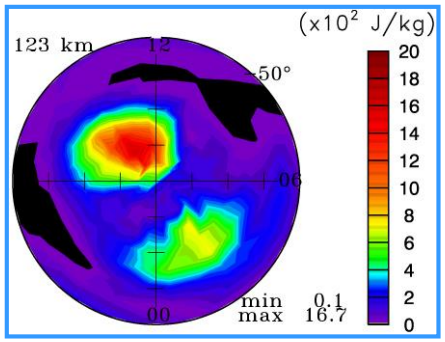
Eddy Kinetic Energy

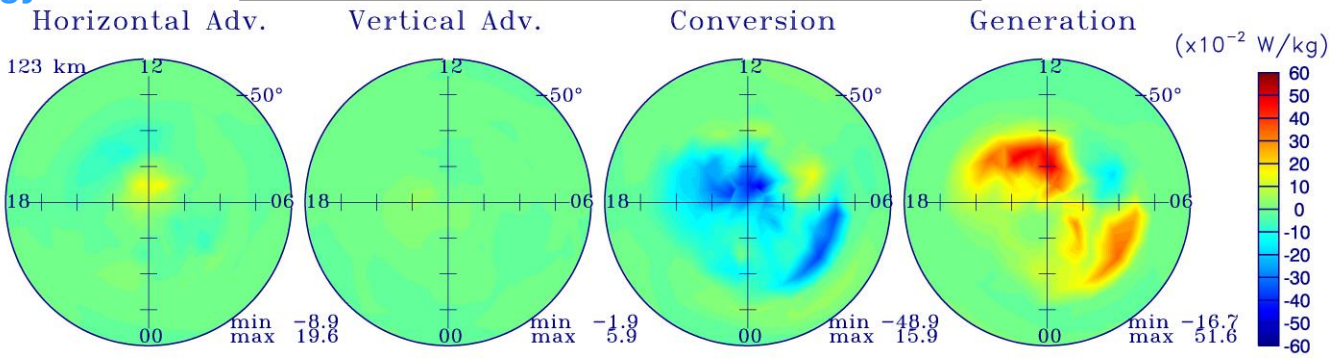




Eddy Available Potential Energy Budget

Eddy Available Potential Energy





- In the high-latitude thermosphere, drag from convecting ions is generally more important than Joule heating for generating dynamical energy, although Joule heating can play a more significant role for impulsive forcing;
- transport of eddy available energy significantly affects the budget;
- energy conversion between kinetic and available-potential forms constitutes an important part of their budgets.


Thanks for your attention!