Estimate of energy deposition by Alfvén waves in the IT

O. P. Verkhoglyadova, X. Meng, A.J. Mannucci (1), R. McGranaghan (1, 2)

[1]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA;*
[2]*University Corporation for Atmospheric Research (UCAR), Boulder, USA*

- Recent ground-based and spacecraft observations indicate the importance of dynamic ionospheric response to external driving, and the existence of transient and multi-scale plasma features in the high-latitude IT (Huang and Burke, 2004; Semeter et al., 2010; Lyons et al., 2016; Huang et al., 2016; McGranaghan et al., 2017+)

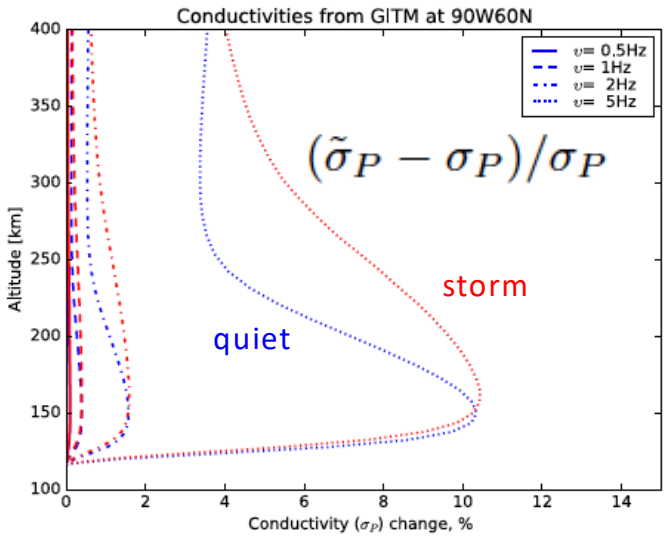
- ULF/Alfvén waves are important contribution to electromagnetic energy flow from the magnetosphere to the high-latitude ionosphere during geomagnetically active periods (Keiling et al., 2003; Lotko, 2004, 2007; Chaston et al., 2005; Hatch et al., 2016; Miles et al., 2018; Pakhotin et al., 2018+)

The relative efficiencies of Alfvén wave dissipation during quiet-time and storm

$$\langle \frac{\partial W}{\partial t} \rangle_T = \tilde{\sigma}_P \langle |E_\perp|^2 \rangle_T \qquad \tilde{\sigma}_P = \epsilon_0 \sum_\alpha \frac{\nu_\alpha \omega_{p\alpha}^2 (q_\alpha^2 + 2\omega^2)}{q_\alpha^4 + 4\omega^2 \nu_\alpha^2}, \quad \tilde{\sigma}_{||} = \epsilon_0 \sum_\alpha \frac{\nu_\alpha \omega_{p\alpha}^2}{\omega^2 + \nu_\alpha^2},$$
$$q_\alpha^2 = \nu_\alpha^2 - \omega^2 + \omega_{c\alpha}^2.$$

GITM modeling of the
13-14 October 2016 storm

Changes in the Pedersen conductivity due to waves at 60° lat and 12LT



$$\kappa = \frac{Q_w}{Q_s} = \frac{\tilde{\sigma}_P}{\sigma_P} \cdot \frac{\langle |E_{\perp w}|^2 \rangle_T}{|E_{\perp s}|^2} \approx 1.1 \cdot \frac{\langle |E_{\perp w}|^2 \rangle_T}{|E_{\perp s}|^2}$$

$E_{\perp s}$ quasi-static field

Table 1. Horizontal electric field estimations from GITM at 60° latitude.

Time	Quiet time value, mV/m	Storm time value, mV/m
12 LT (18 UT)	0.25 (11 Oct.)	46 (13 Oct.)
20 LT (06 UT)	0.60 (12 Oct.)	30 (14 Oct.)

$E_{\perp w} \sim 20 - 40\ mV/m$ Alfvén wave field

Alfvén wave contribution to storm energy deposition as compared to static Joule heating:

$\kappa \approx 30\ \%$

Conclusions

- An analytical expression for energy deposition by propagating Alfvén waves in the collisional ionosphere-thermosphere is derived.
- The relative efficiency of energy deposition rate of Alfvén wave (up to 5Hz in. frequency) to static field is estimated to be ~10% at high latitudes and below 250 km altitude.
- We show that Alfvén wave energy deposition can reach about 30% of the value of static Joule heating during a strong storm.
- **This effect carries important implications for ionospheric dynamics, especially for density enhancement in the daytime cusp, heating in the vicinity of auroral arcs and ion outflow.**

Verkhoglyadova et al, JGR, 2018; https://doi.org/10.1029/2017JA025097.