IMPACT OF TSUNAMI-DRIVEN GRAVITY WAVES ON THE IONOSPHERE

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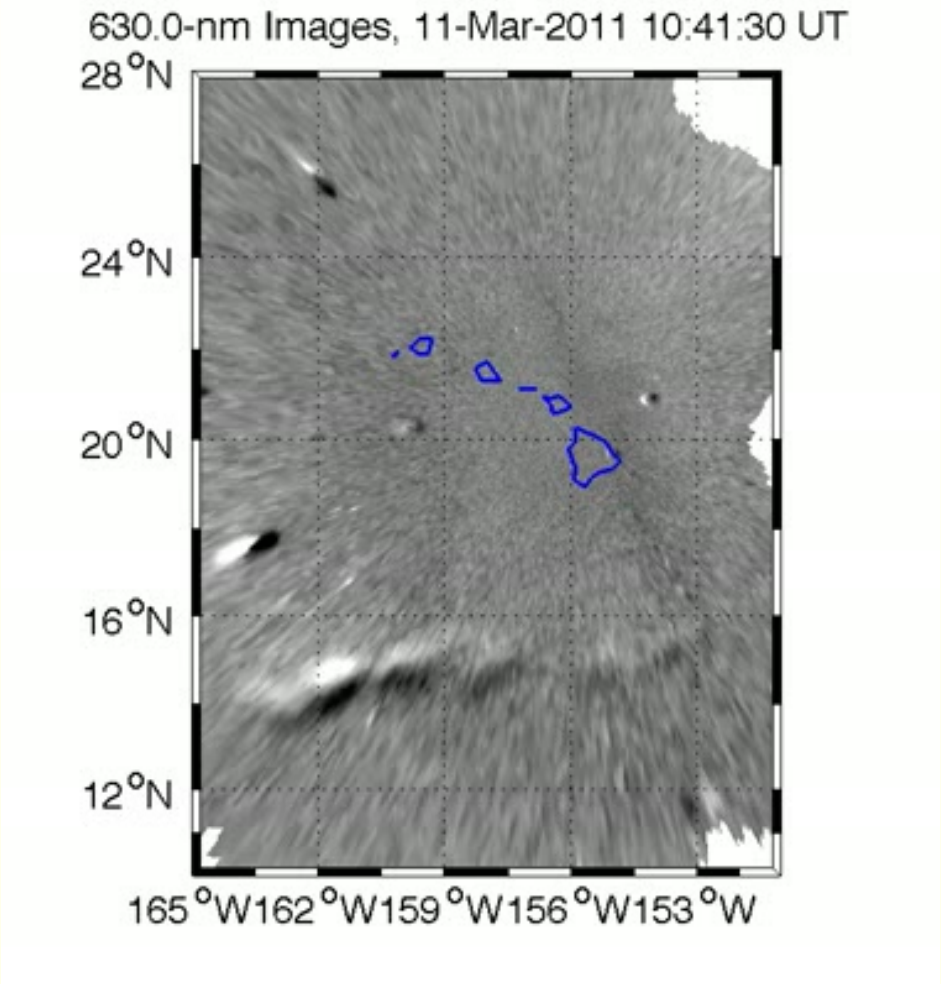
ATMOSPHERIC WAVE EFFECTS ON THE IONOSPHERE

- large-scale seismic disturbances (e.g., tsunamis, earthquakes, volcanoes, UNEs) can generate low-frequency atmospheric infrasonic/gravity waves
- these waves intensify as they propagate to high-altitudes ($\gtrsim$ 100 km) and can disturb the ionosphere by altering its plasma density, temperature, and/or current system
- these disturbances can be observed by variations in the total electron content (TEC) using the global positioning system (GPS), radars, and ground-based imaging (630.0 nm emissions)

OBSERVATIONS: 630.0 nm EMISSIONS

Makela et al., *GRL*, 2013



PLASMA DYNAMICS

- ion continuity

$$\frac{\partial n_i}{\partial t} + \nabla \cdot (n_i \mathbf{V}_i) = P_i - L_i n_i \tag{1}$$

- ion velocity

$$\frac{\partial \mathbf{V}_i}{\partial t} + \mathbf{V}_i \cdot \nabla \mathbf{V}_i = -\frac{1}{\rho_i} \nabla \mathbf{P}_i + \frac{e}{m_i} \mathbf{E} + \frac{e}{m_i c} \mathbf{V}_i \times \mathbf{B} + \mathbf{g}$$

$$-\nu_{in} (\mathbf{V}_i - \mathbf{V_n}) - \sum_j \nu_{ij} (\mathbf{V}_i - \mathbf{V}_j) \tag{2}$$

- electric field

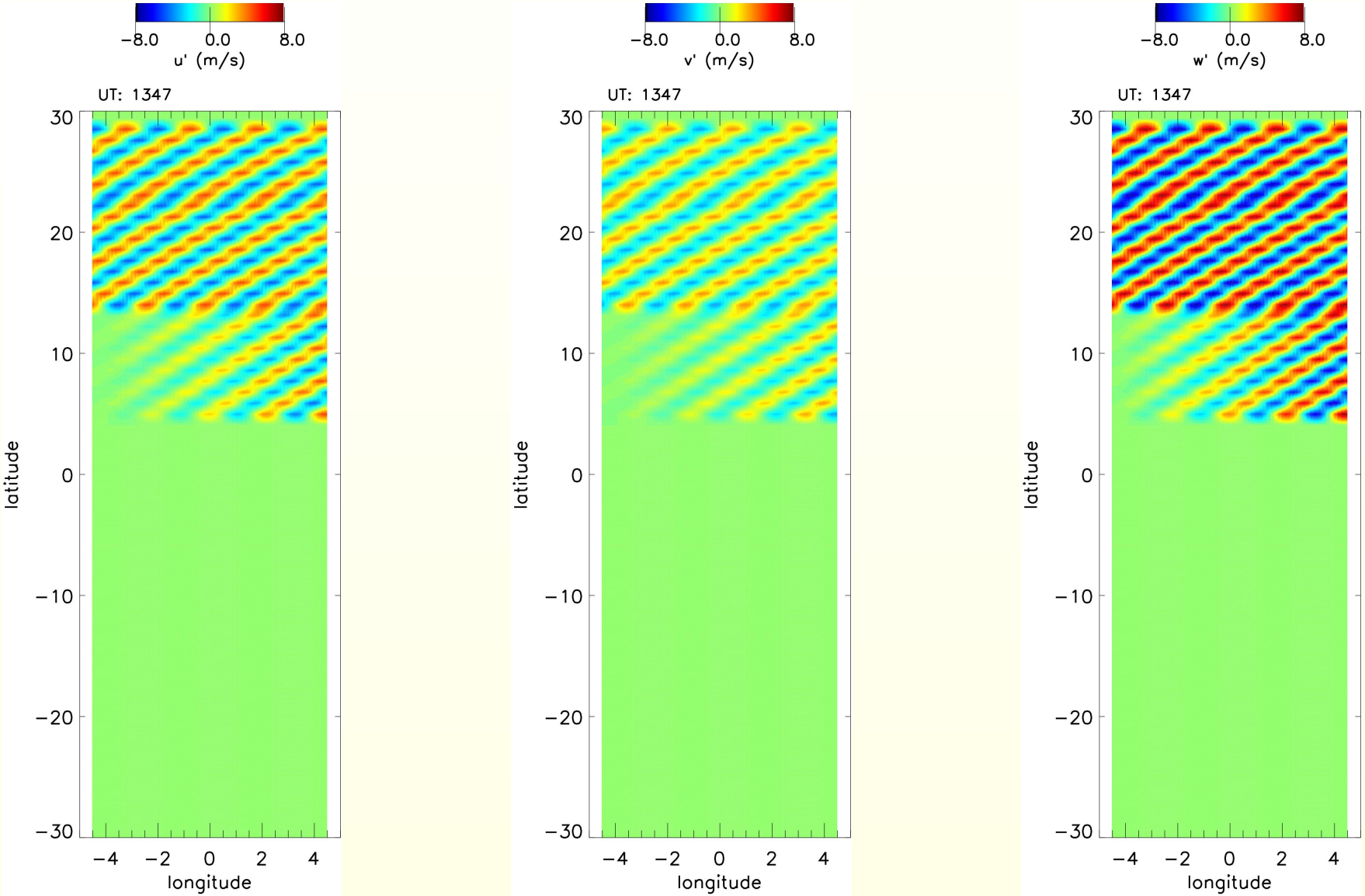
$$\nabla \cdot \mathbf{\Sigma} \nabla \Phi = S(J_{\|}, V_n, ...) \tag{3}$$

$$\mathbf{E} = -\nabla \Phi$$

TSUNAMI-DRIVEN GRAVITY WAVES

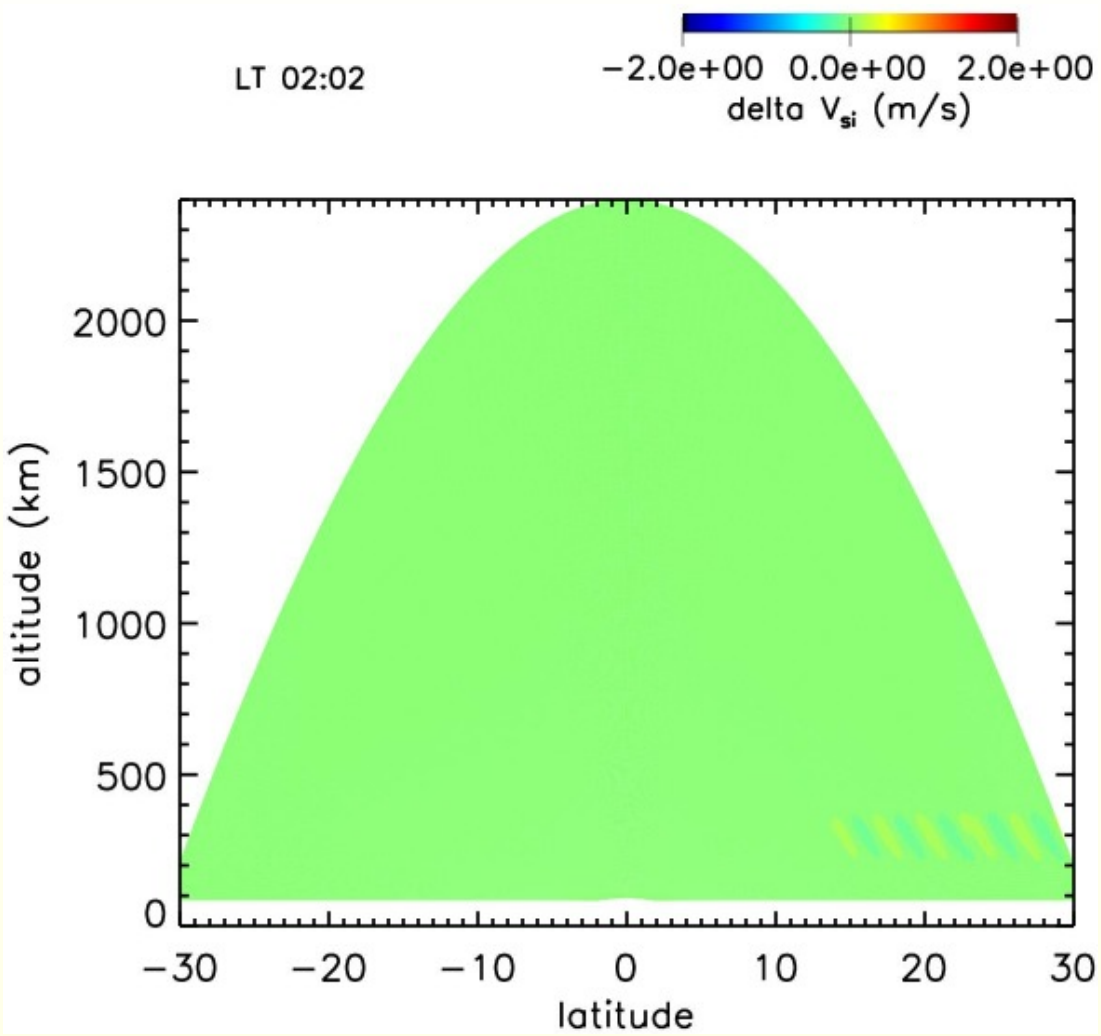
11 march 2011 tsunami

zonal, meridional, vertical wind perturbations at 294 km



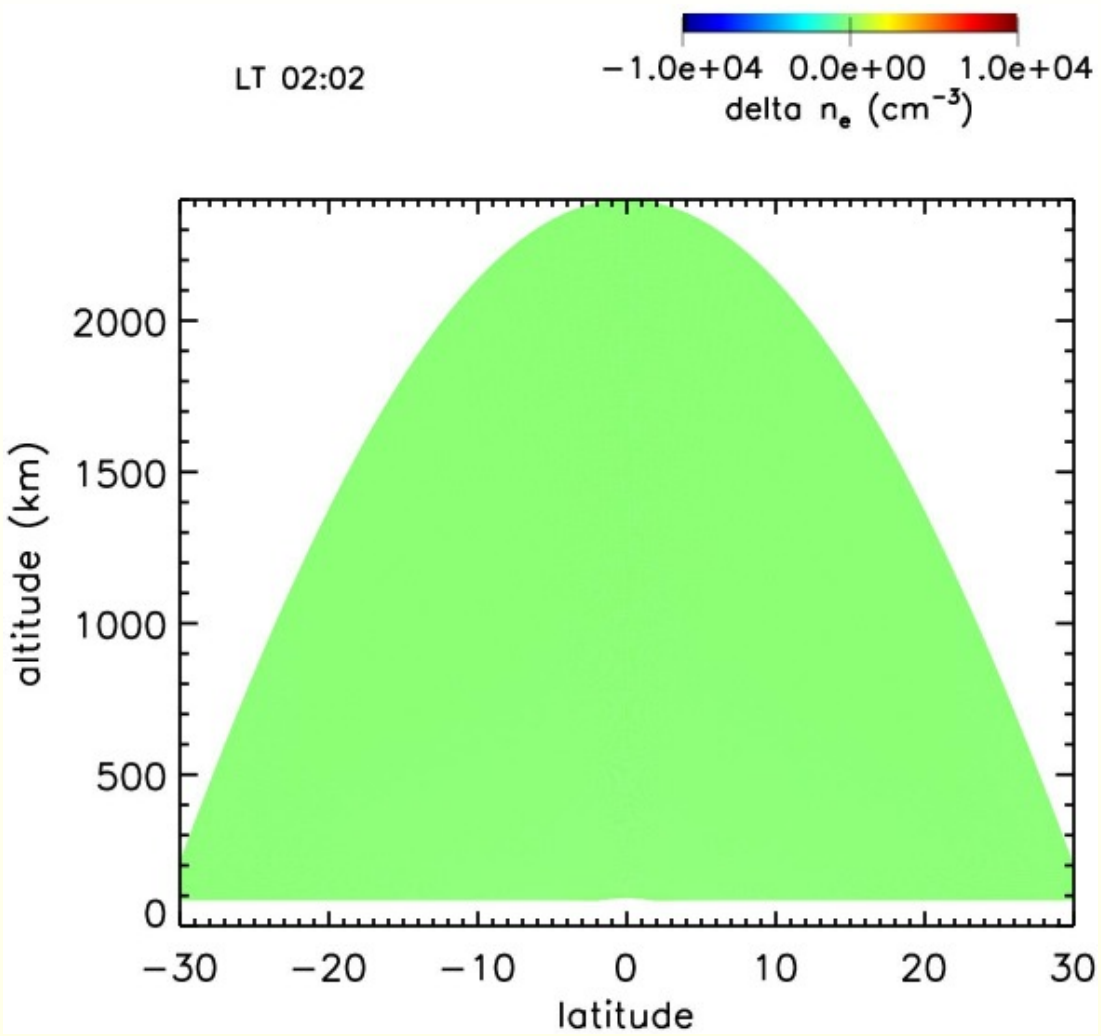
O^+ PARALLEL VELOCITY

difference: waves - nowaves



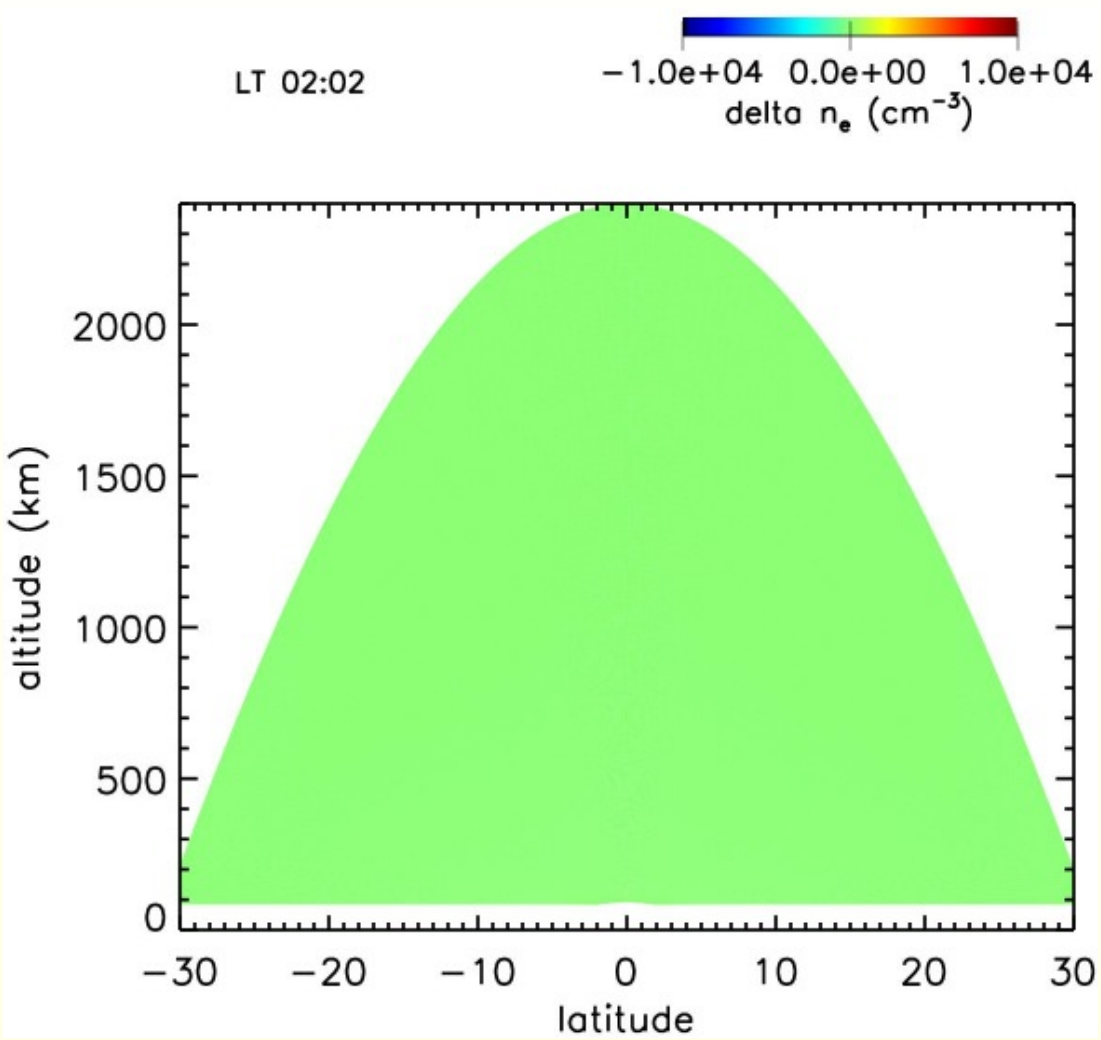
ELECTRON DENSITY

difference: waves - nowaves



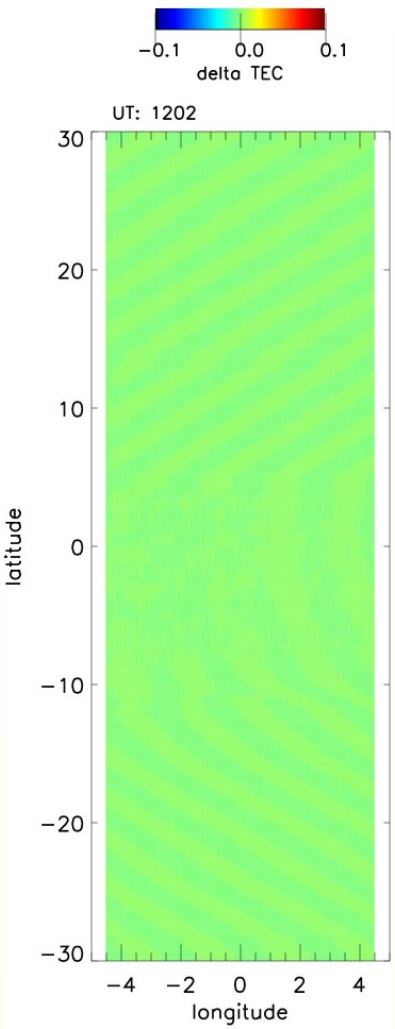
ELECTRON DENSITY: NO $E \times B$

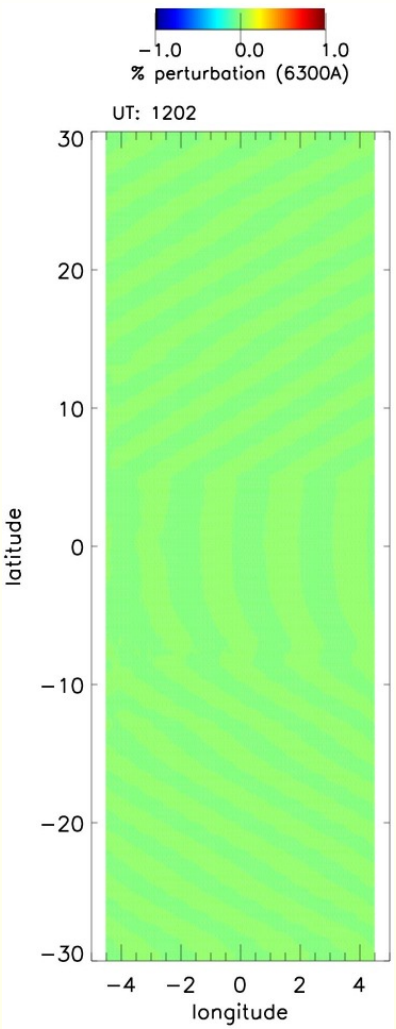
difference: waves - nowaves



TEC/630.0 nm EMISIONS

difference: waves - nowaves (consistent with observations [Makela et al., *GRL*, 2013])





SUMMARY

preliminary study of impact of tsunami driven gravity waves on the ionosphere

- impact on ionosphere
  - electron density (few percent of background)
  - parallel velocity ($\lesssim$ 10s m/s)
  - TEC ($\lesssim 0.1$ TECU)
  - 630.0 nm emissions (few percent of background)
  - sensitive to $\mathbf{k} \cdot \mathbf{B}$
- parallel motion dominates (associated with $\nu_{in} V_n$ term) over E $\times$ B motion (weak conjugate effect)
- plans
  - improved gravity wave model (e.g., waveform spreading, attenuation, 3D simulation data (Fritts/Laughman GATS))
  - investigate geophysical conditions (solar min vs solar max), longitudinal effects
  - ultimately couple atmospheric waves into global, high-resolution SAMI3