Intermediate and transisitonal scale structure in midlaitude E_s layers

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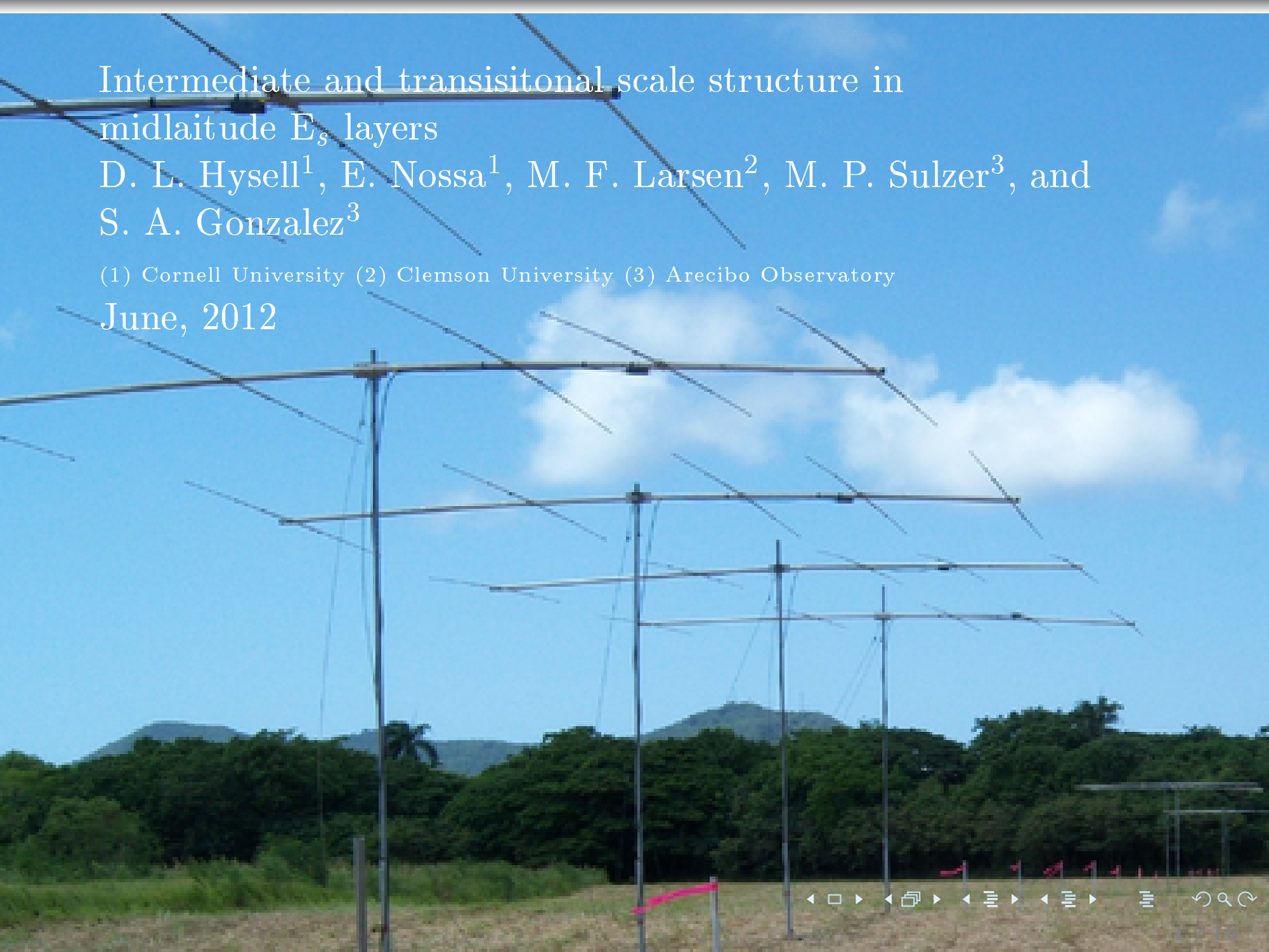
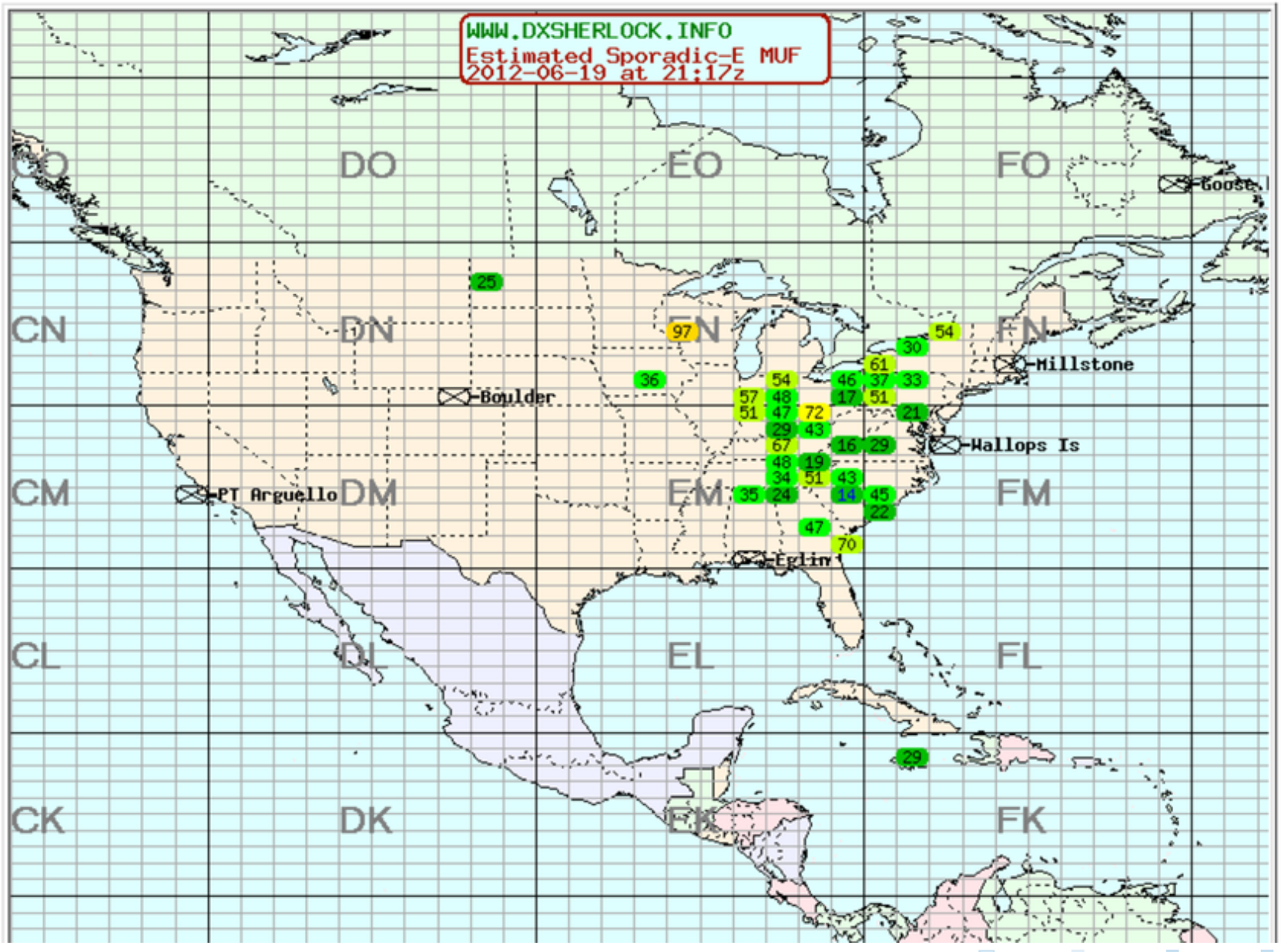
June, 2012



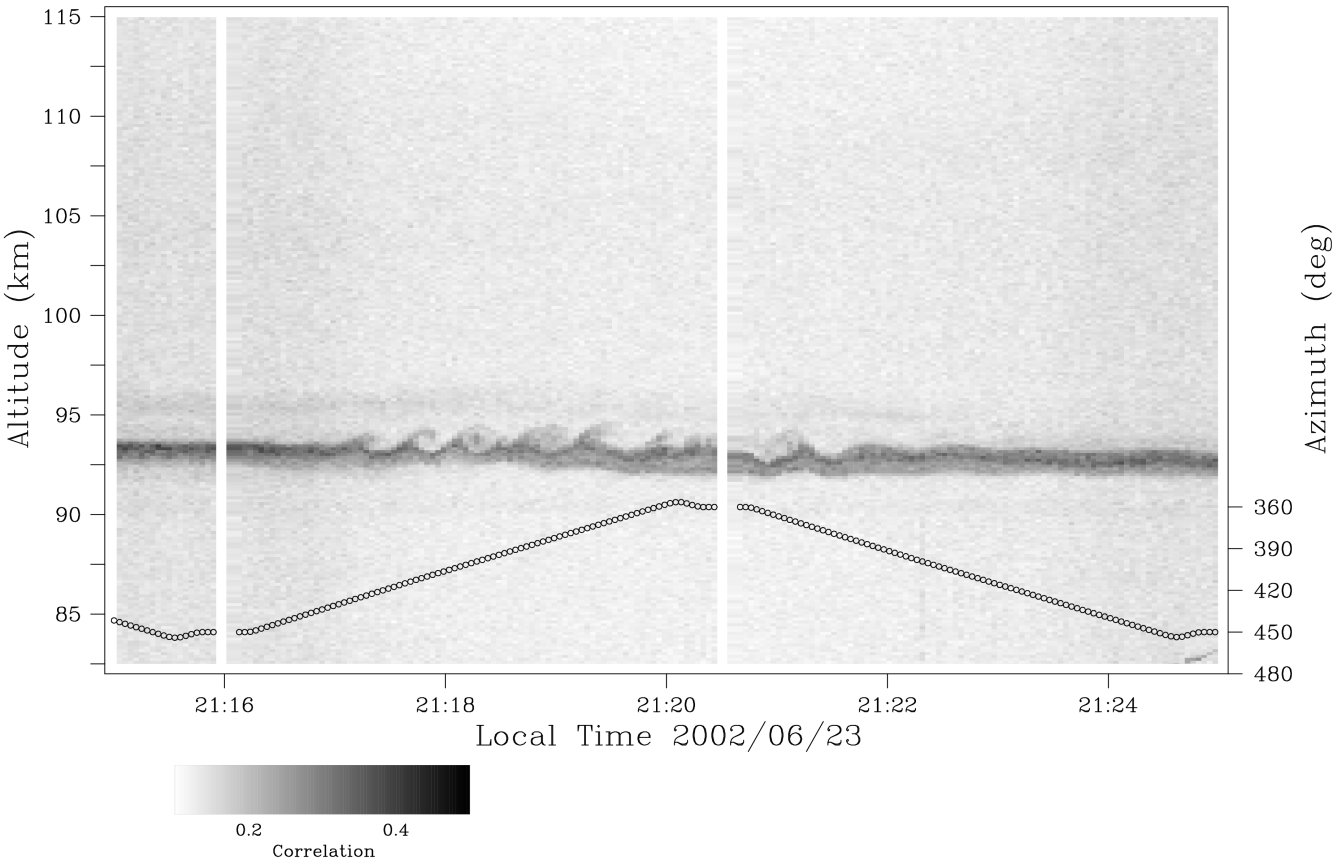
some definitions

scale	size	feature
large	100's km	layers
intermediate	10's km	rolls
transitional	few km	primary plasma waves
small	few m	secondary plasma waves

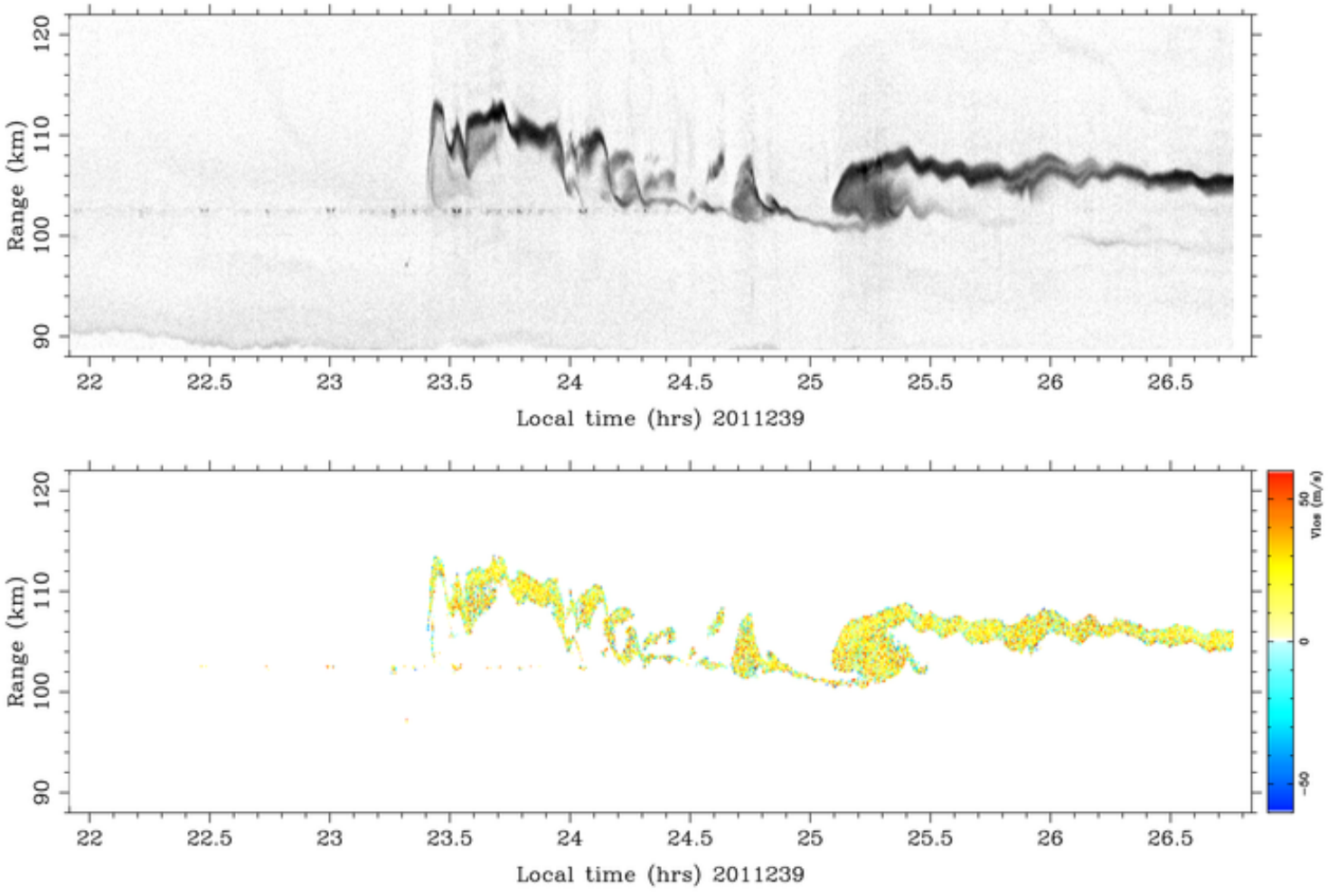
large scales



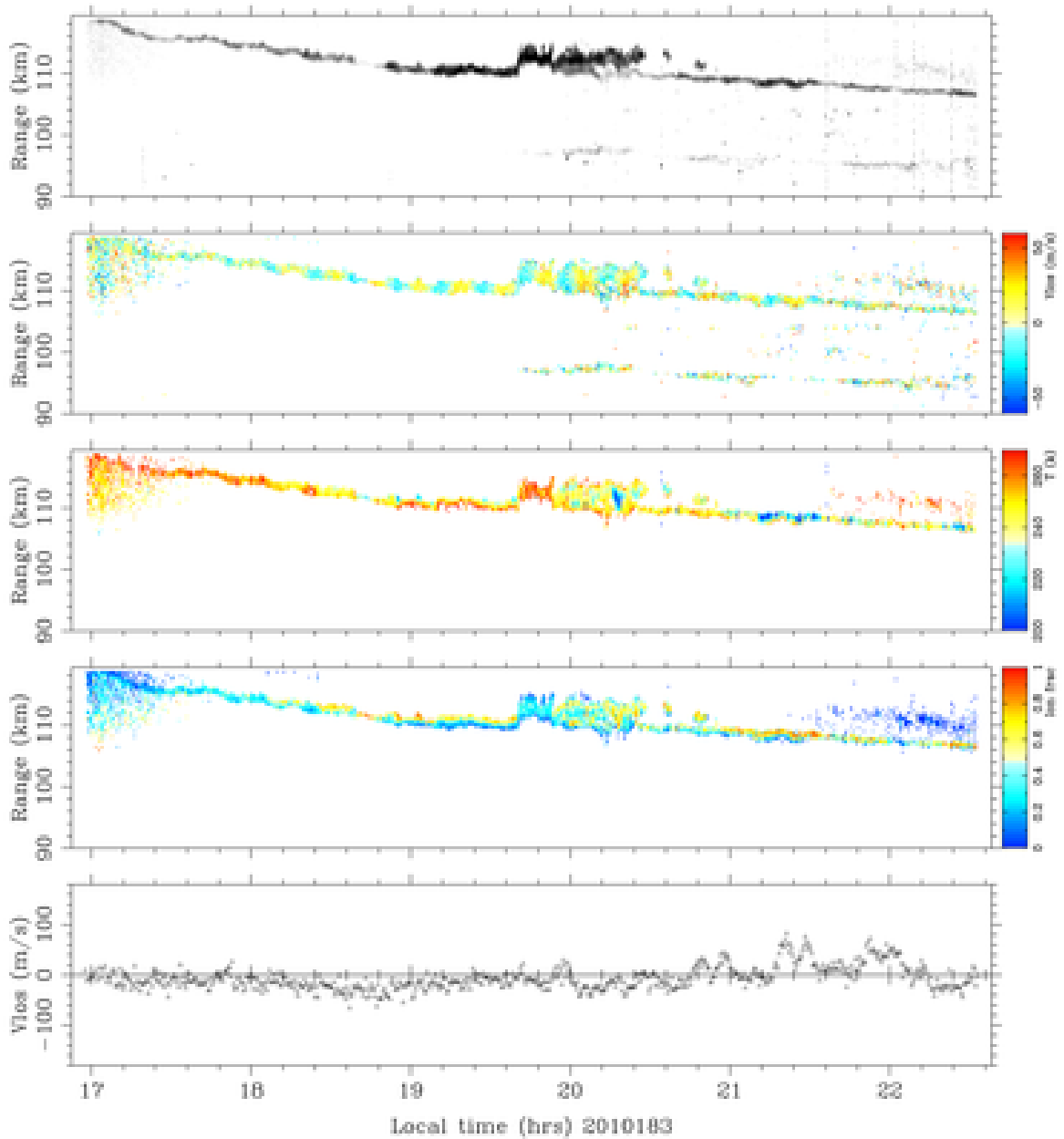
intermediate scales



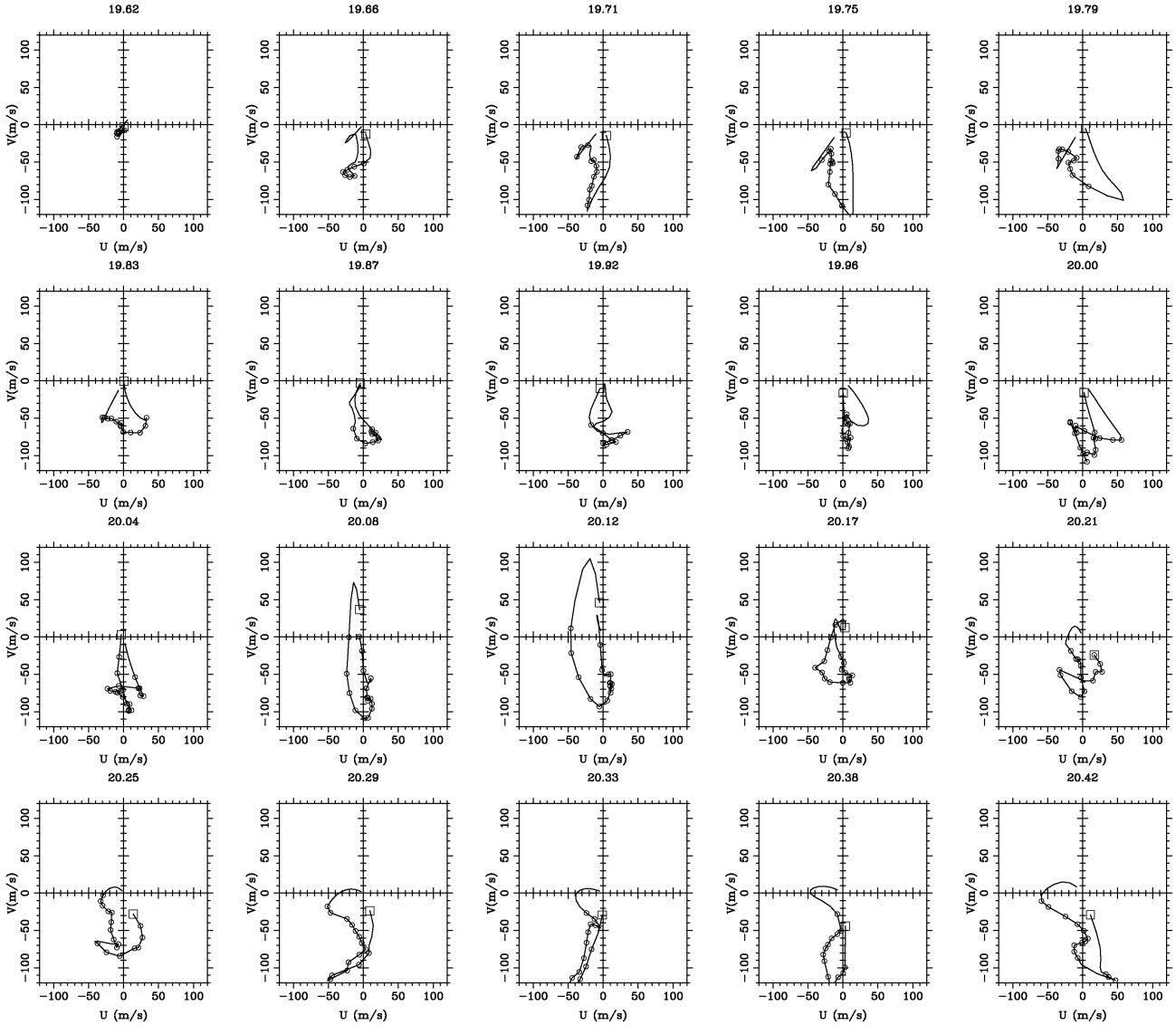
intermediate scales



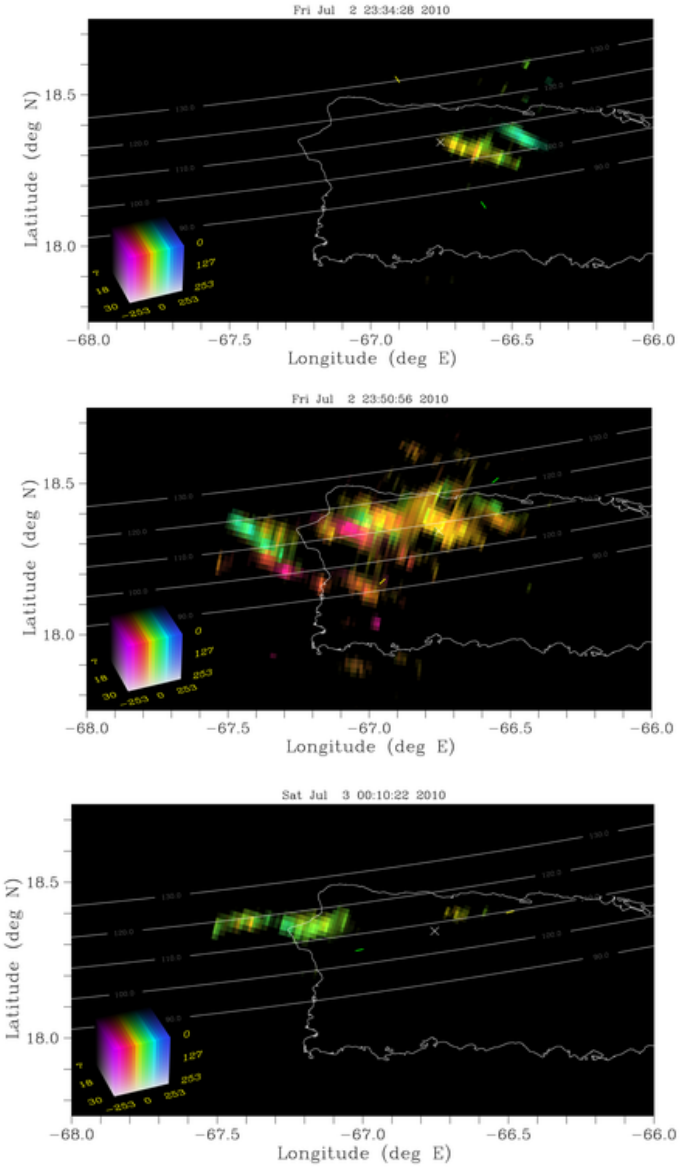
intermediate scales



neutral wind hodograms



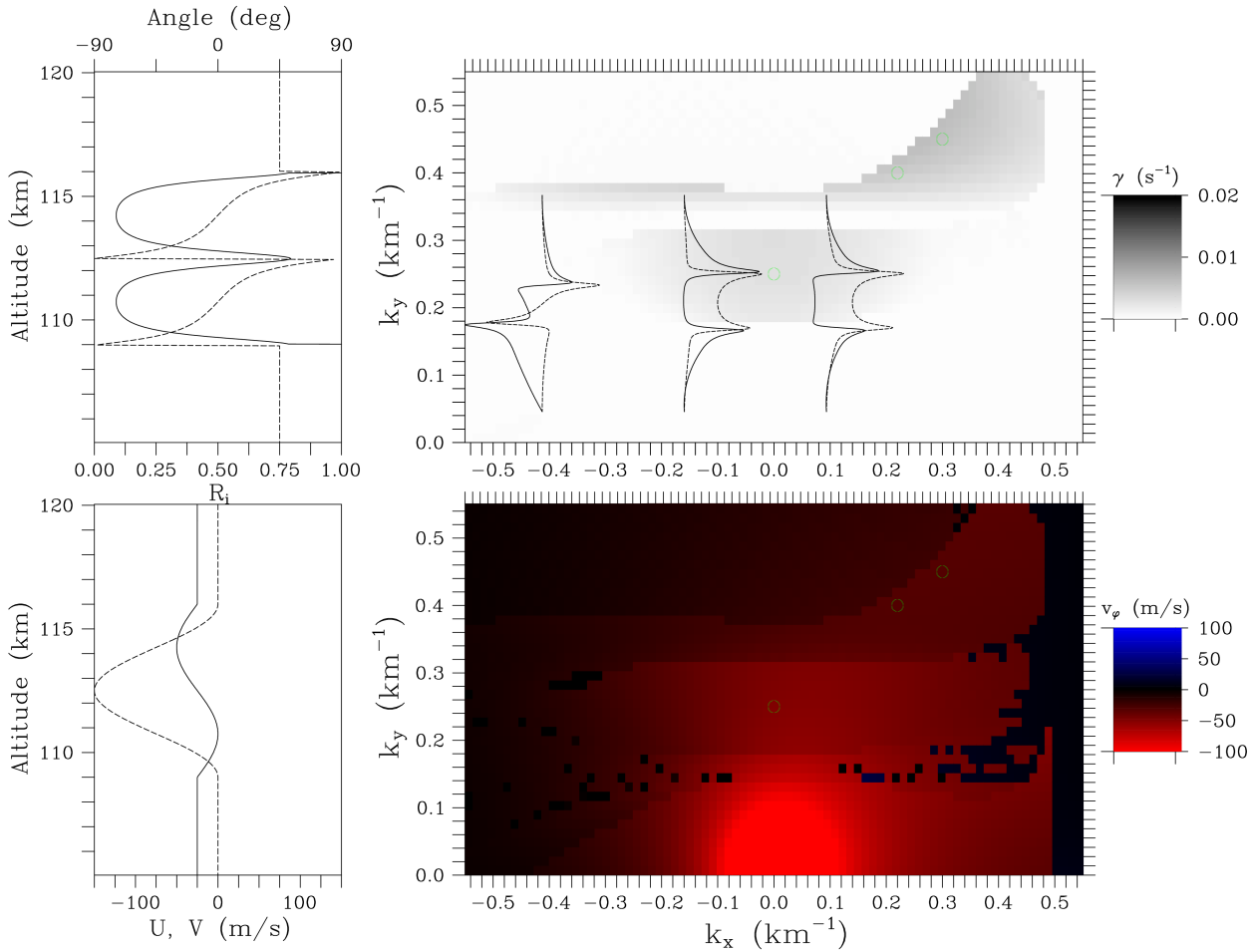
coherent scatter picture



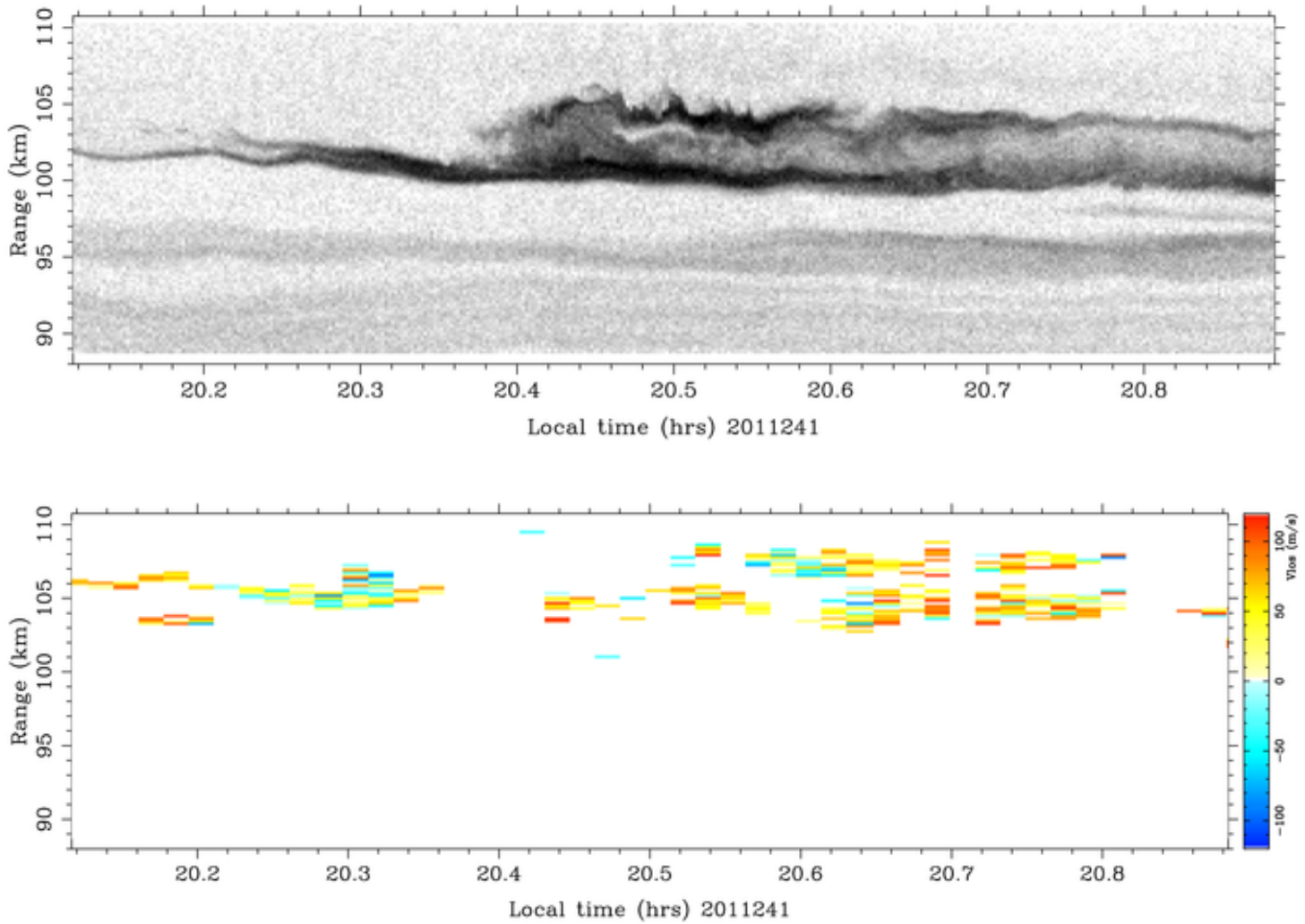
$$\psi'' + \left(\frac{N^2}{W^2} - \frac{W''}{W} - k^2 \right) \psi = 0$$

$$W \equiv (k_x U + k_y V - w)/k$$

eigenvalue problem



transitional scales



parallel wavenumbers

$$\frac{\partial n}{\partial t} + \underbrace{\mathbf{v}_e \cdot \nabla_\perp n}_{\text{ExB, gd}} + \underbrace{n \nabla_\perp \cdot \mathbf{v}_e}_{\text{FB}} = 0, \quad k_{||} = 0$$

$$= k_{||}^2 n_\circ |\mu_{e||}| \phi$$

$$\phi = \frac{i k_\perp (\mu_x E_\circ - \mu_\perp E_p) - D_\perp k_\perp^2 - D_{||} k_{||}^2}{\mu_\perp k_\perp^2 + \mu_{||} k_{||}^2 - i k_{||} \mu_{||} / L} \frac{n}{n_\circ}$$

$$\lambda_\perp (\text{max growth}) = 4\pi L \sqrt{\psi}$$

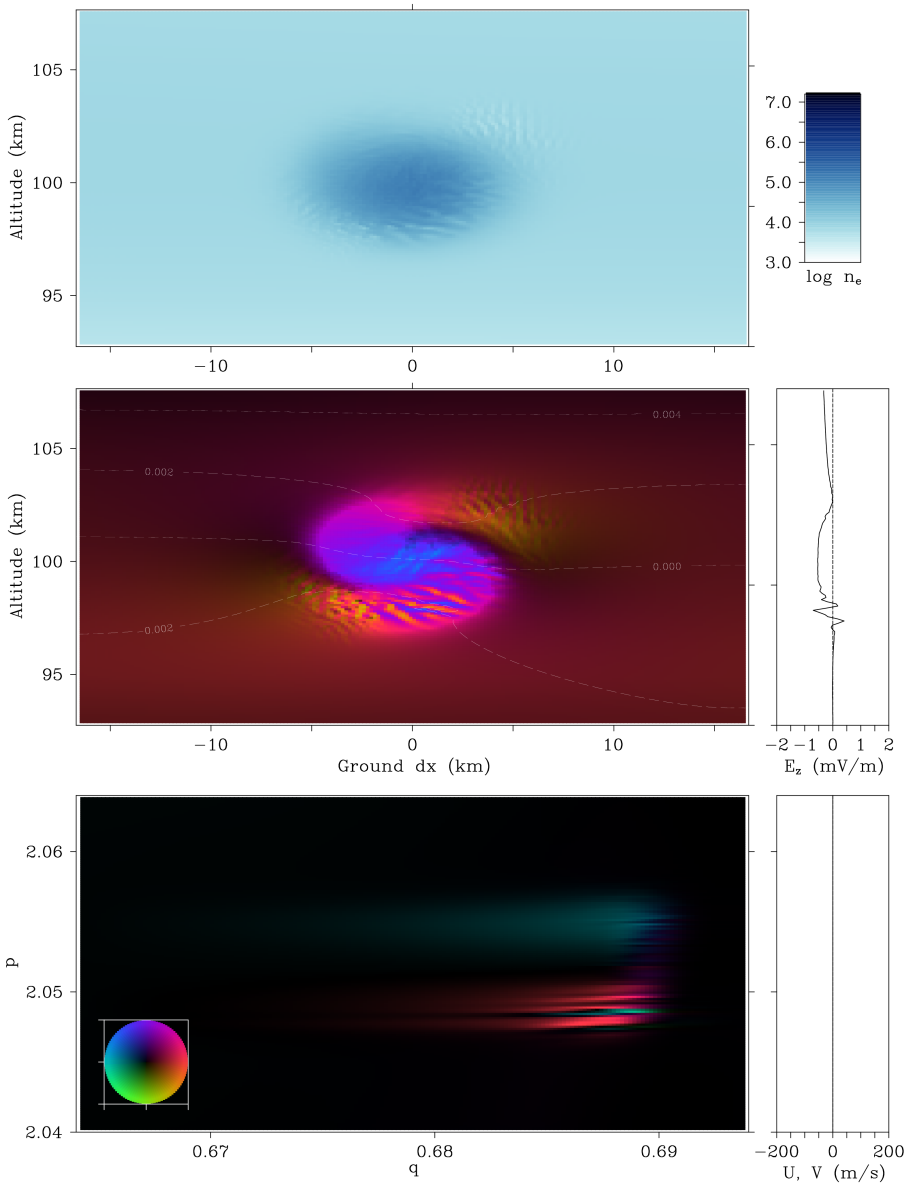
$$\gamma \propto k_\perp \mu_{i\perp} E$$

$$\begin{aligned}
\omega_r &= \frac{3}{4}\mu_{\perp i}\mathbf{k}_\perp \cdot \mathbf{E}_\circ + \left(\frac{1}{4}\mu_{\perp i}\frac{\mu_\times}{\mu_\perp} - \mu_{\times i}\right)(\mathbf{k}_\perp \times \mathbf{E}_\circ)\cdot \hat{b} \\
&\quad -\frac{1}{4}\frac{\mu_{\perp i}}{\mu_\perp}\left(k_\perp^2 D_\perp + k_{||}^2 D_{||}\right) \\
\gamma &= \frac{1}{4}\mu_{\perp i}\left[-\mathbf{k}_\perp \cdot \mathbf{E}_\circ + \frac{\mu_\times}{\mu_\perp}(\mathbf{k}_\perp \times \mathbf{E}_\circ)\cdot \hat{b}\right] - D_{\perp a}k_\perp^2 - D_{||a}k_{||}^2
\end{aligned}$$

given

$$\begin{aligned}
\mu_\perp k_\perp^2 &= \mu_{||} k_{||}^2 \\
k_{||} L &= 1/2
\end{aligned}$$

3D numerical simulation



intermediate, transitional, and small scales

- *E*-region coherent scatter occurrence modulated by MSTIDs
- *E*-layer rolls unaffected by MSTIDs
- Most likely coupling via field-aligned currents, current closure

summary

- Roll-like deformations in E_s layers consistent with neutral dynamic instability.
- Kilometer-scale waves in the layers consistent with collisional drift-wave instability.
- The roll-like deformations are prone to produce large polarization electric fields which drive the drift waves, particularly when some (but not too much) current is allowed to close through the E region.