Imaging of Sporadic *E* Layers with the Poker Flat Incoherent Scatter Radar

Outline

- E_s formation theory (background)
  - Electric field driver at high latitudes
  - Simple 1-D model
- Diffusion (w/ examples)
- Advection/evolution of layers (examples)
- Summary

Theory

Continuity and steady-state ion momentum equations, single ionization, quasi-neutrality

$$\frac{\partial n_j}{\partial t} = -\nabla \cdot (n_j \vec{v_j}) + (P_j - L_j)$$

0

$$\frac{\partial n_e}{\partial t} = -\nabla \cdot (n_e \vec{v_e}) + (P_e - L_e)$$

0

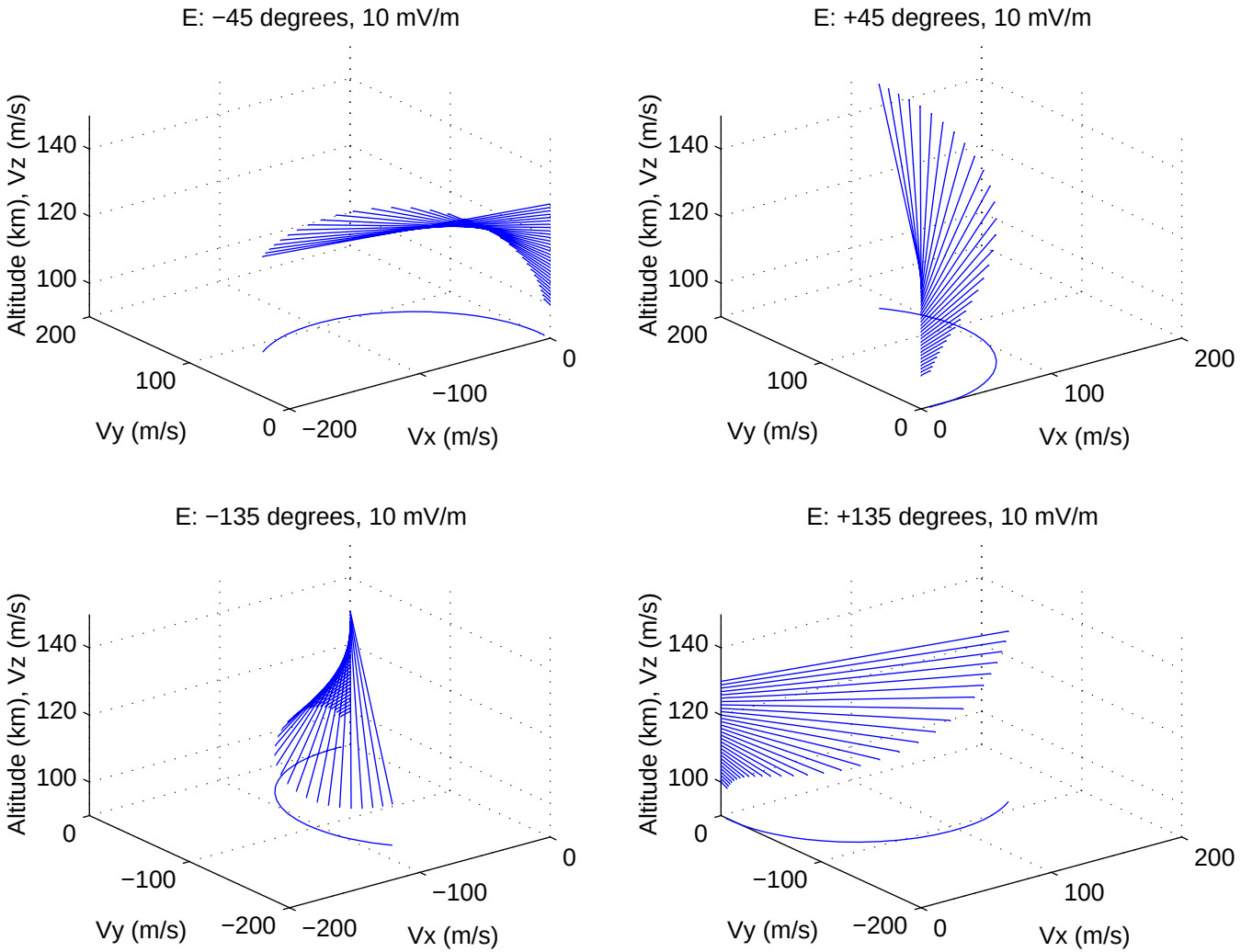
$$\sum_j n_j \approx n_e$$

$$0 = -\nabla p_j + n_j m_j \vec{g} + n_j q_e \left(\vec{E} + \vec{v_j} \times \vec{B} \right)$$

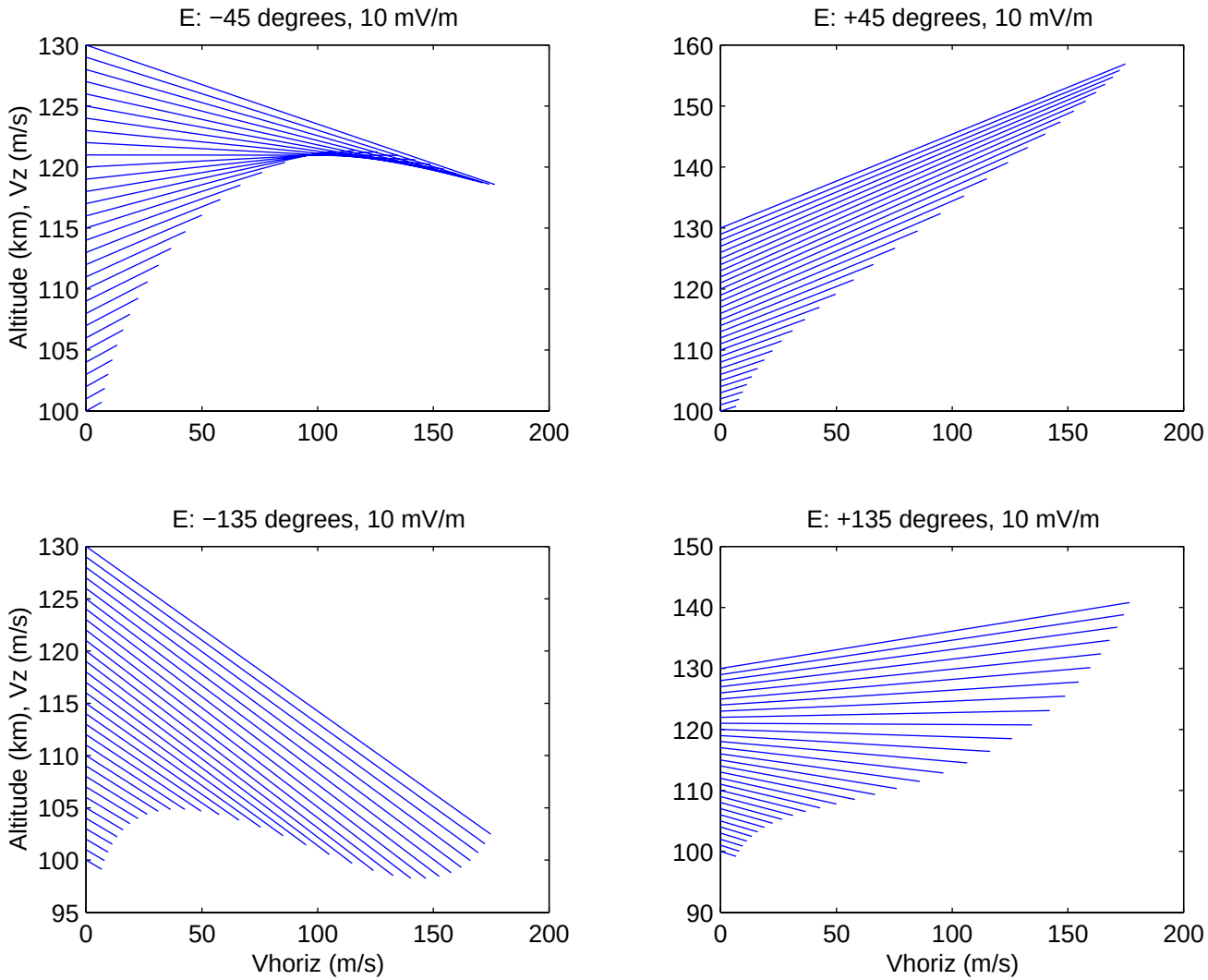
$$-n_j m_j \nu_{jn} \left[\vec{v_j} - \vec{u} + K \left(\frac{\nabla n_j}{n_j} - \frac{\nabla n_n}{n_n} \right) \right]$$

Nygren et at. (1984), Bristow and Watkins (1991), Kirkwood and von Zahn(1991)

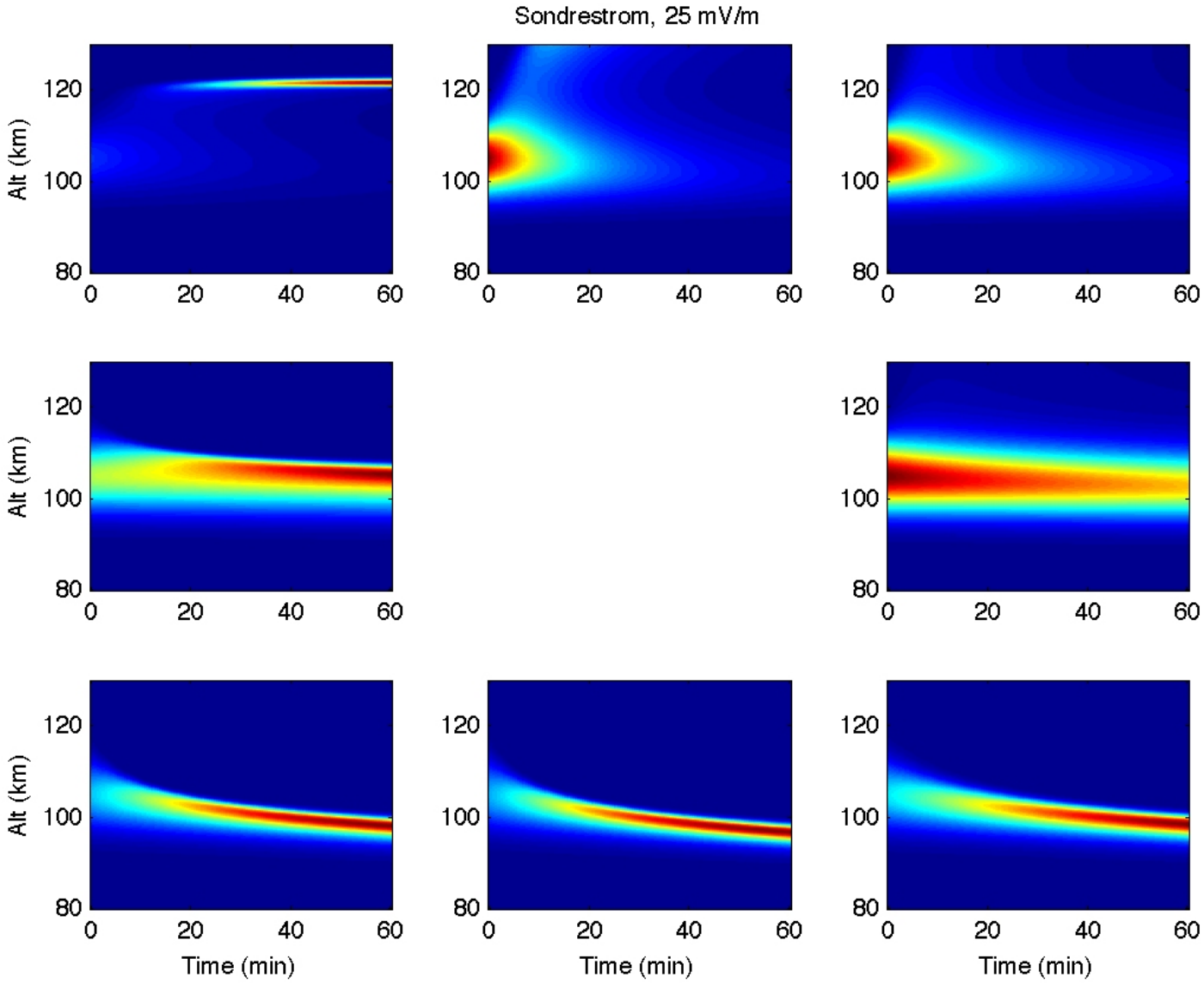
Ion Velocities



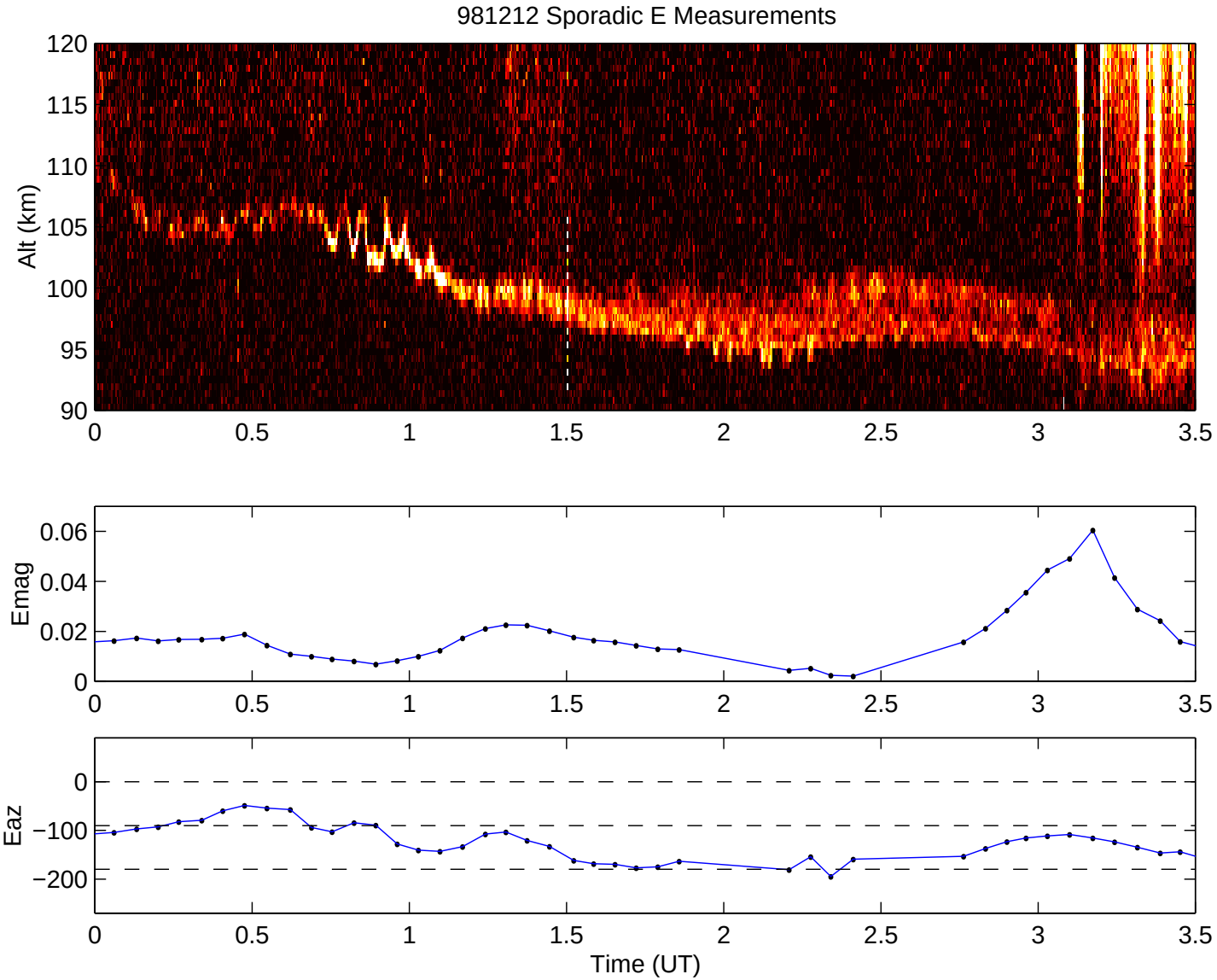
Ion Velocities



E_s Formation via E Fields



Simulation of Sondrestrom E_s



Eddy Diffusion

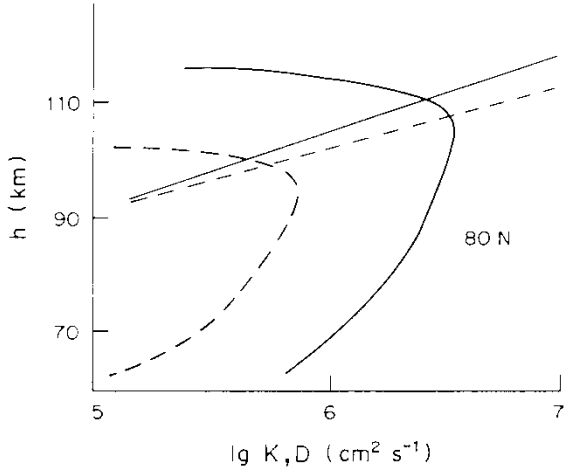


Fig. 8. Eddy (thick lines) and molecular (thin lines) diffusion coefficients for summer (dashed lines) and winter (solid lines) at high latitudes.

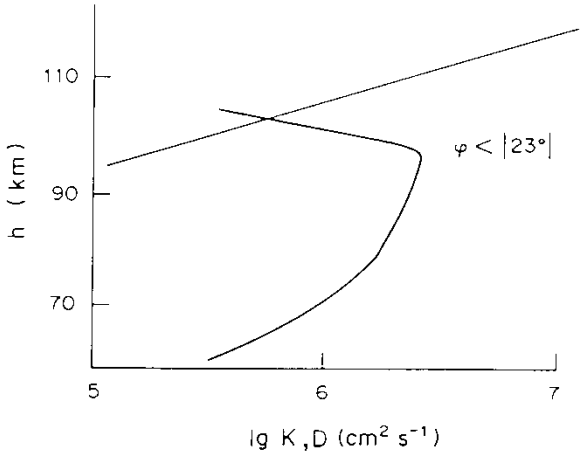


Fig. 10. Eddy (thick line) and molecular (thin line) diffusion coefficients at low latitudes.

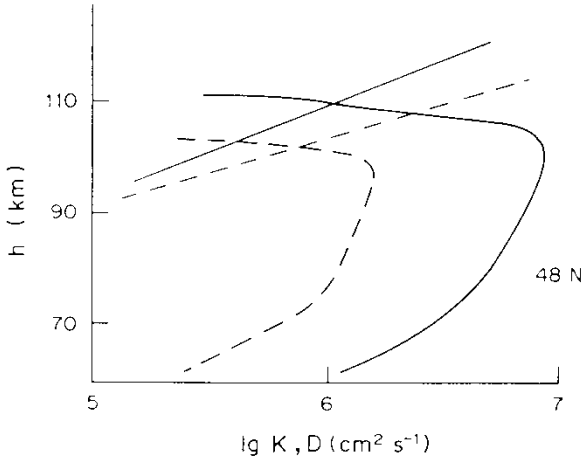
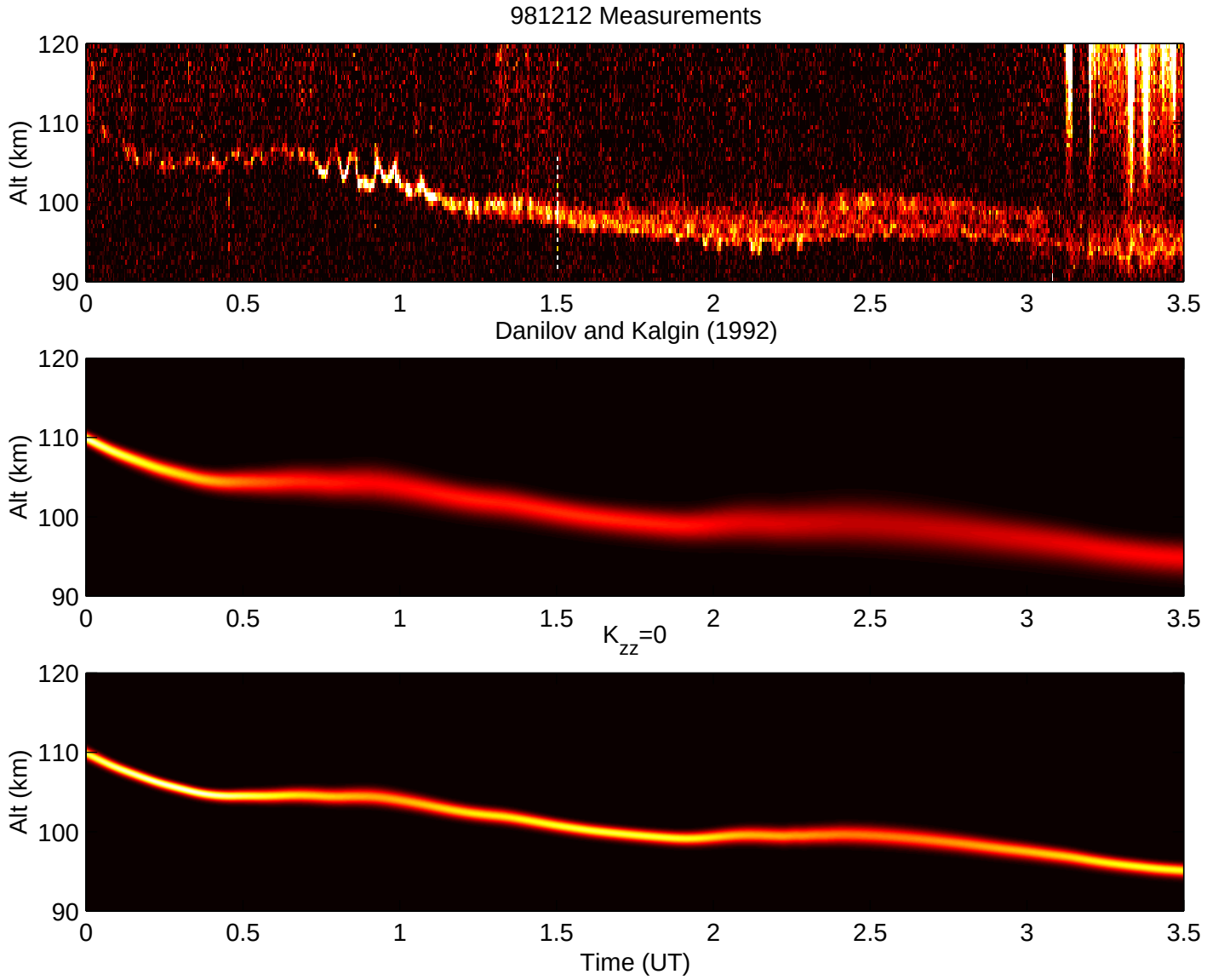
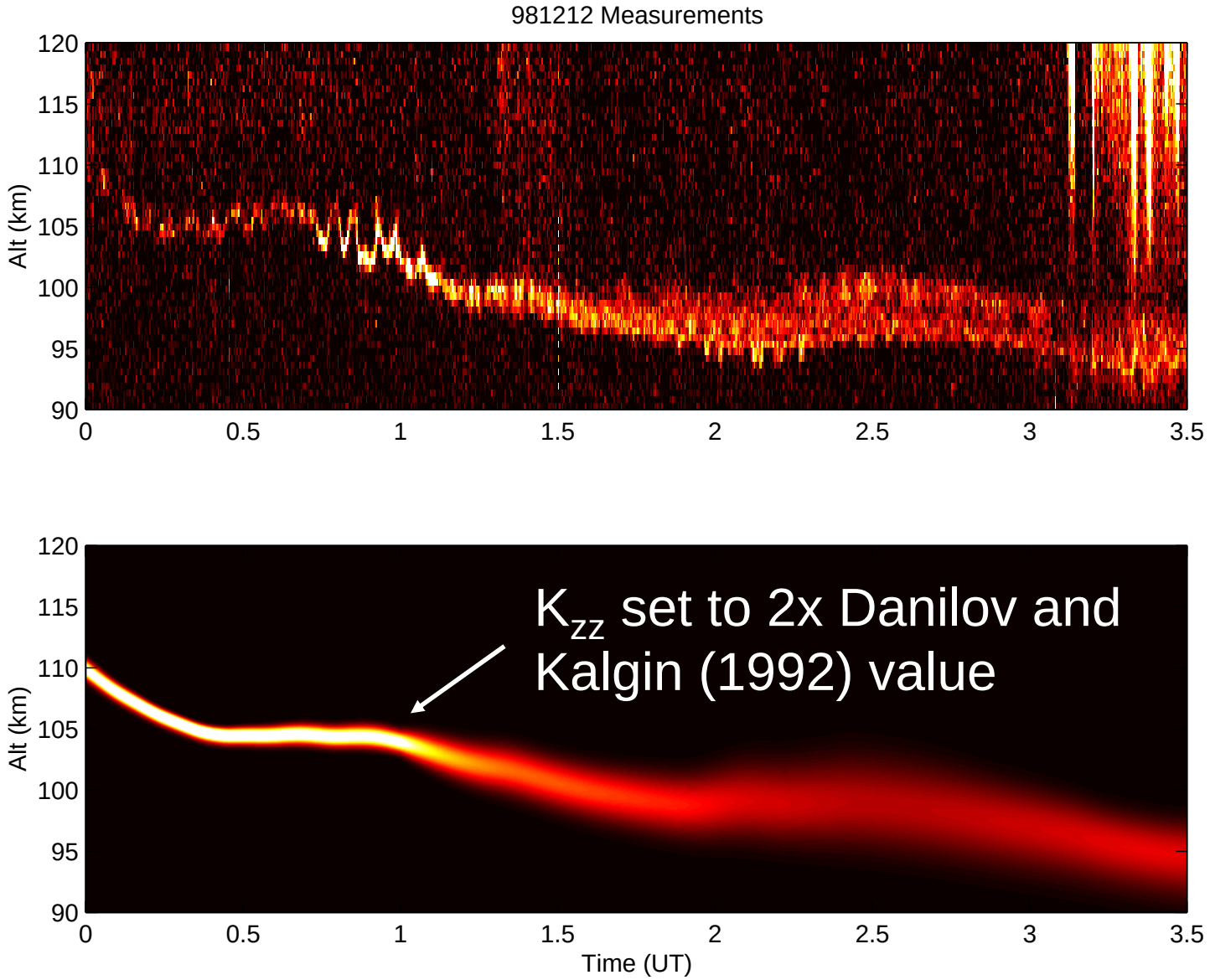


Fig. 9. Eddy (thick lines) and molecular (thin lines) diffusion coefficients for summer (dashed lines) and winter (solid lines) at middle latitudes.

Simulation of Sondrestrom E_s



Simulation of Sondrestrom E_s



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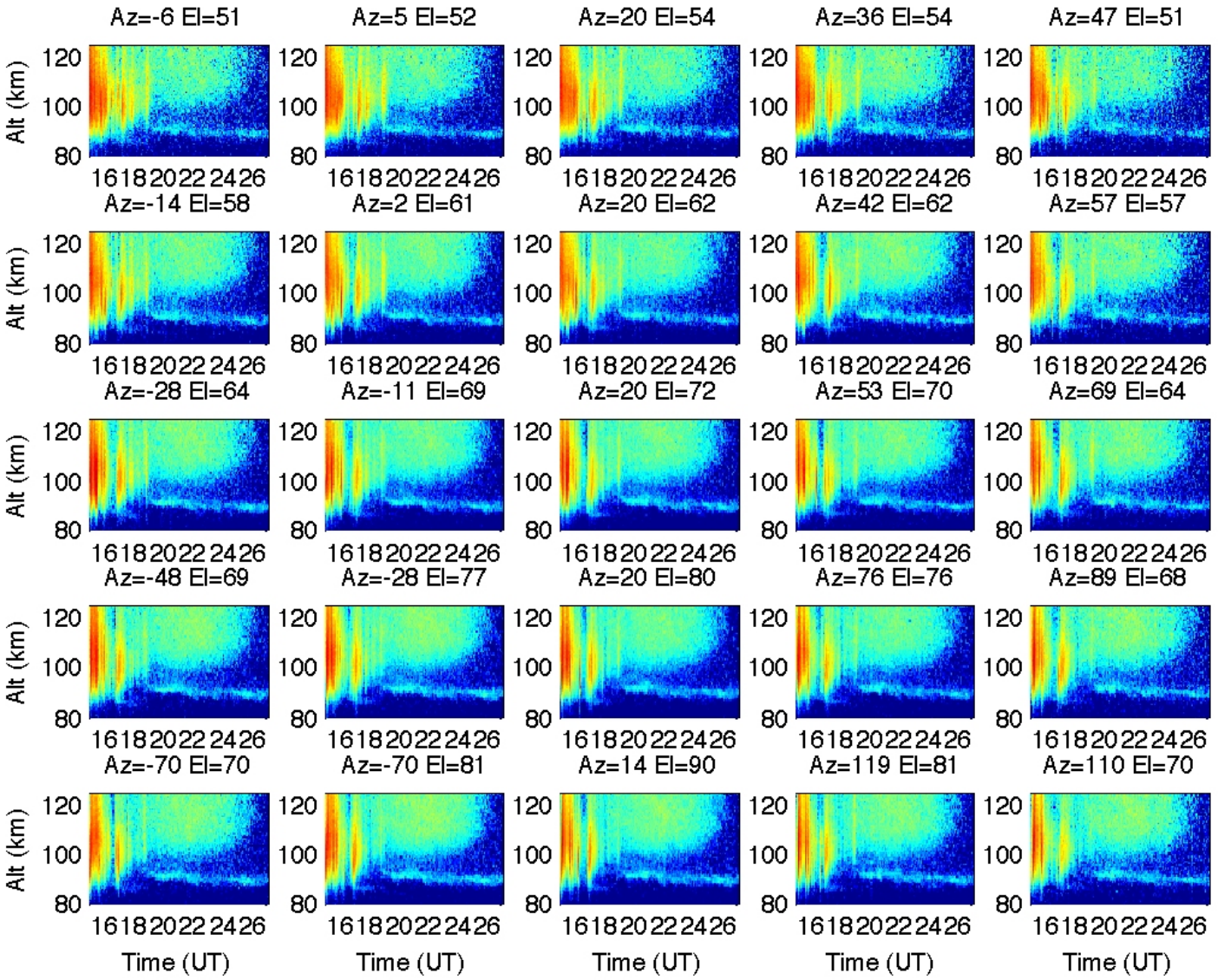

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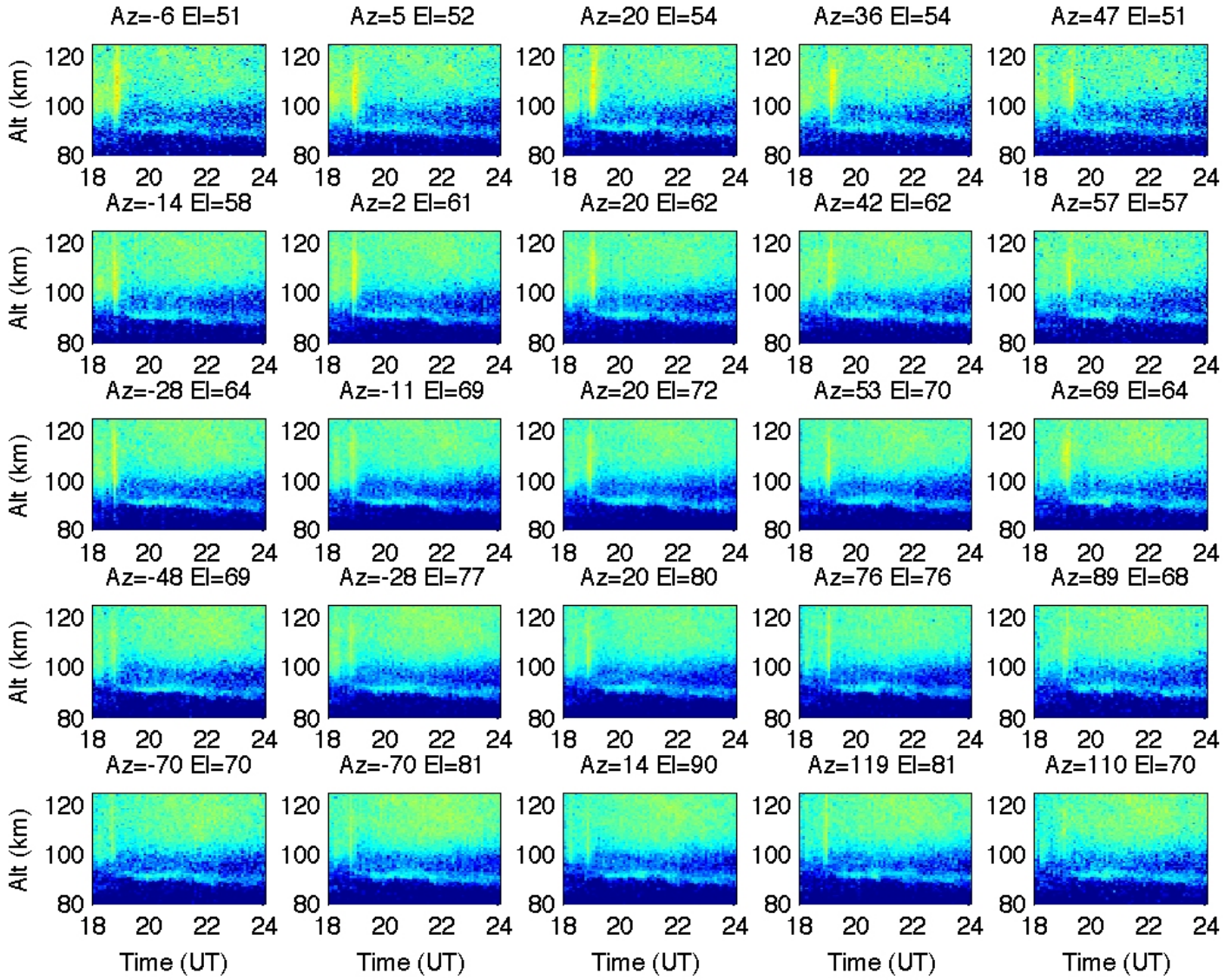

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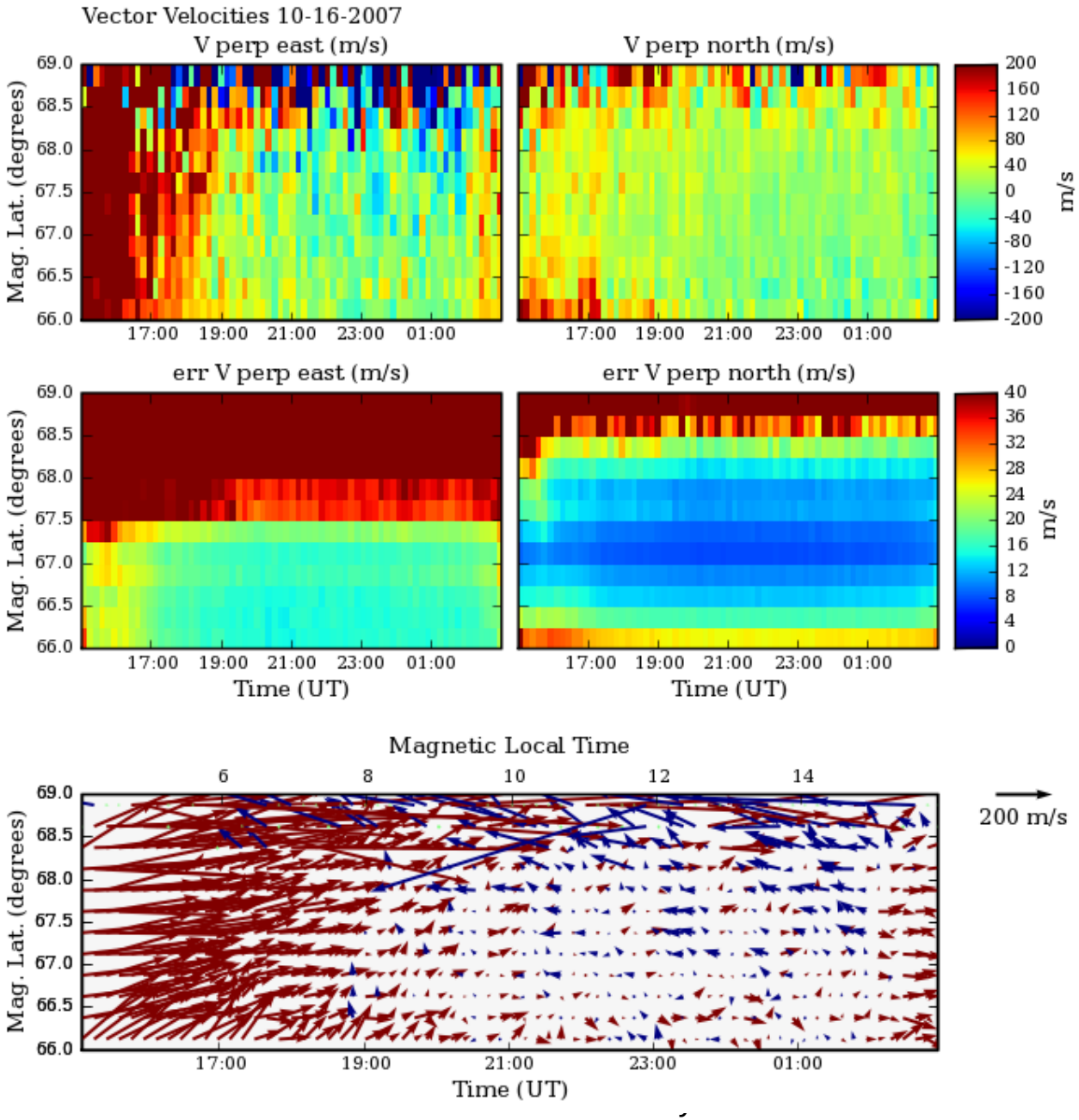
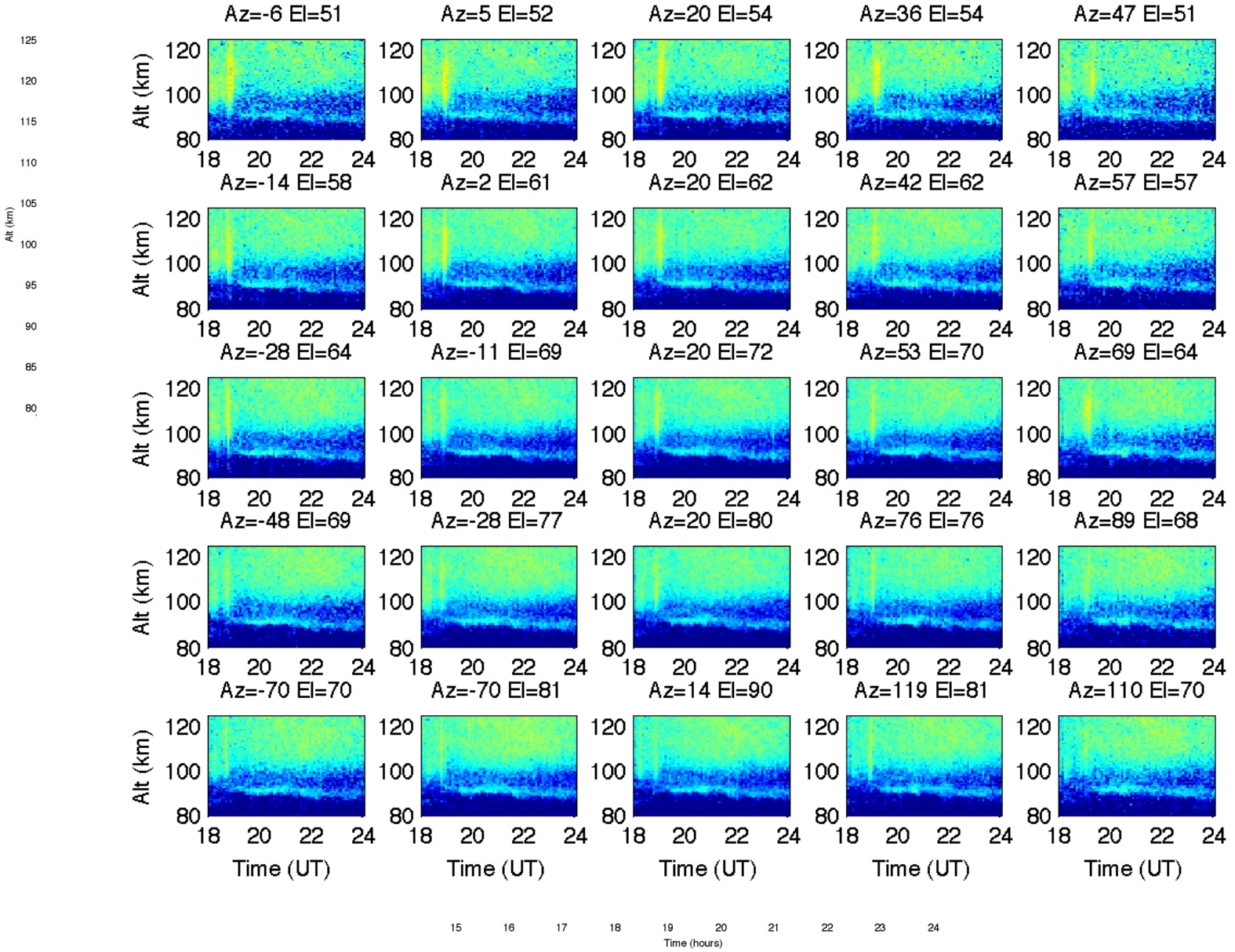


Simulations of *E* Dynamics



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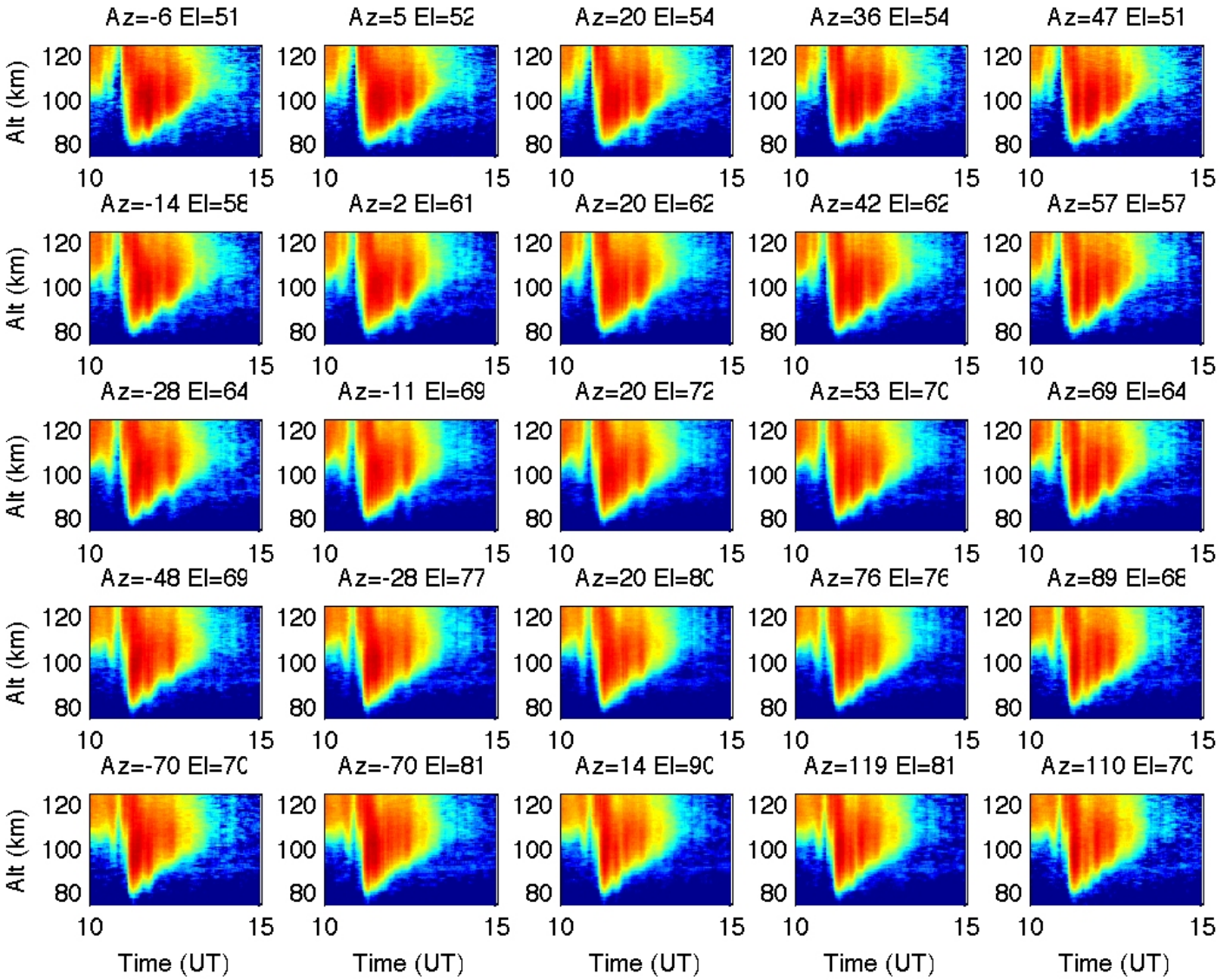
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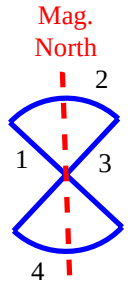
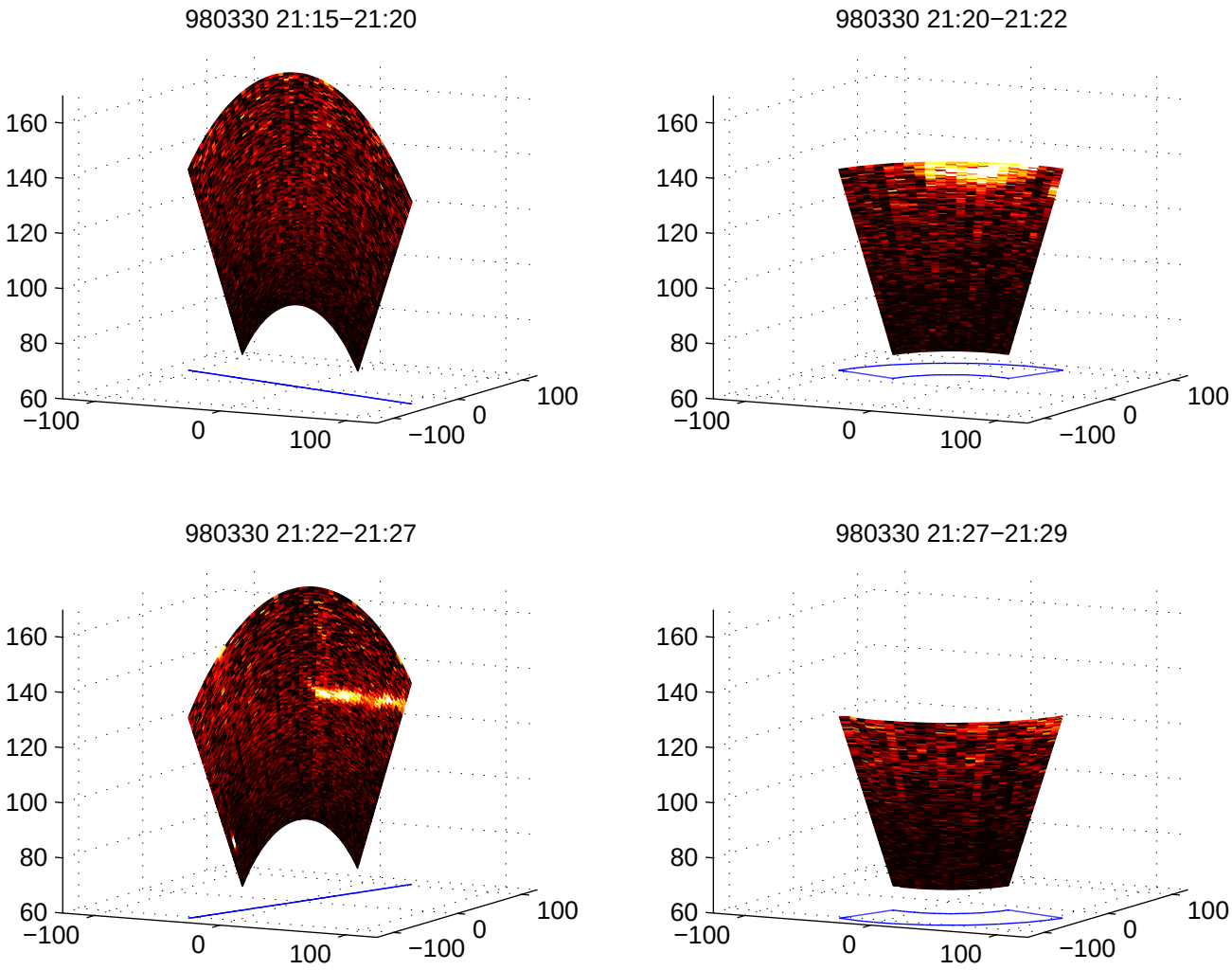
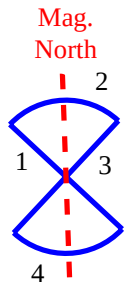
Az=42 El=62
Az=57 El=57
Az=-28 El=64
Az=-11 El=69
Az=20 El=72
Az=53 El=70
Az=69 El=64
Az=-48 El=69
Az=-28 El=77
Az=20 El=80
Az=76 El=76
Az=89 El=68
Az=-70 El=70
Az=-70 El=81
Az=14 El=90
Az=119 El=81
Az=110 El=70
Alt (km)
120
100
80
10
15
Time (UT)

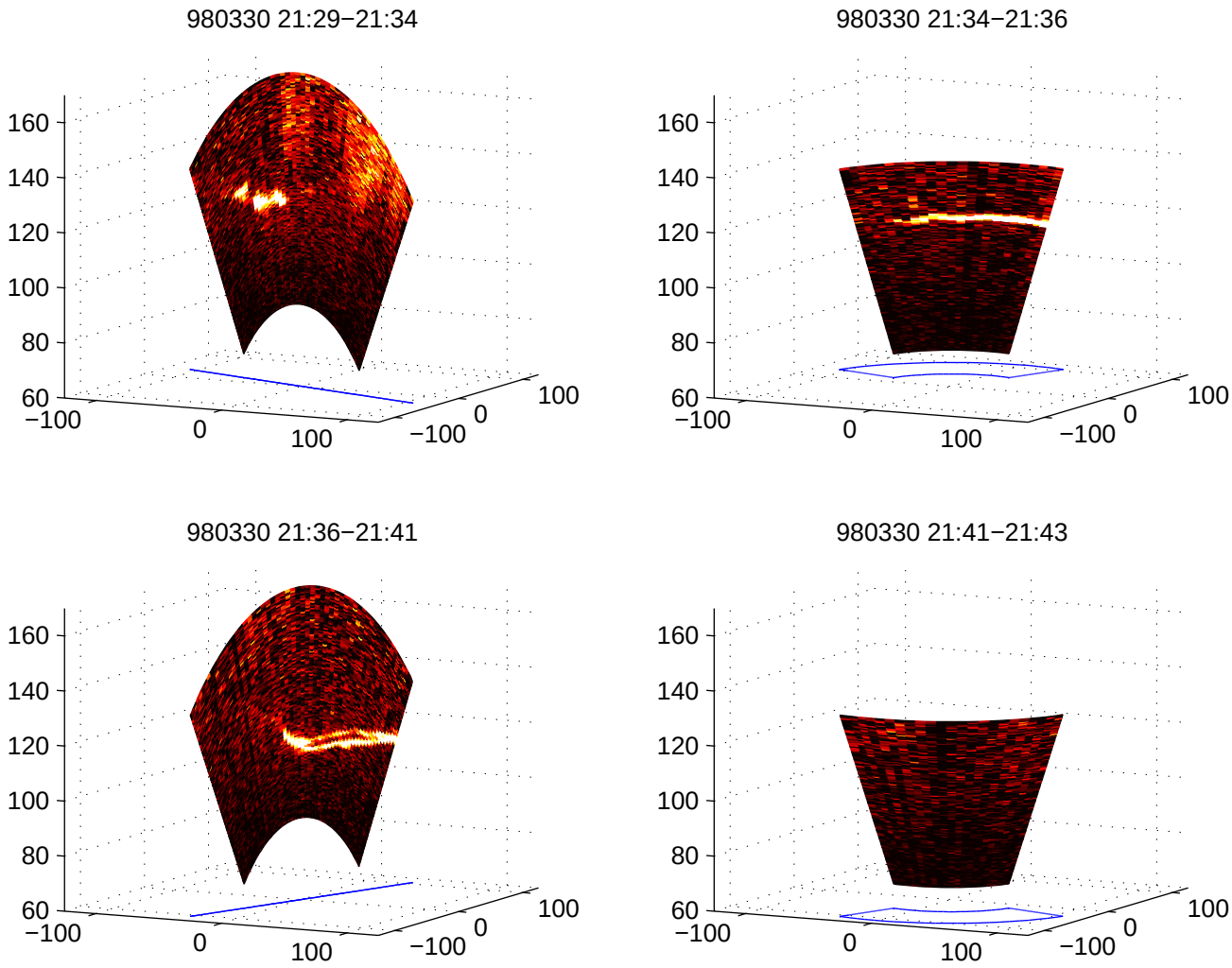
Sondrestrom E_s





Sondrestrom E_s





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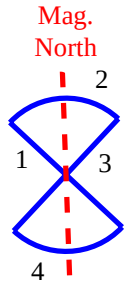
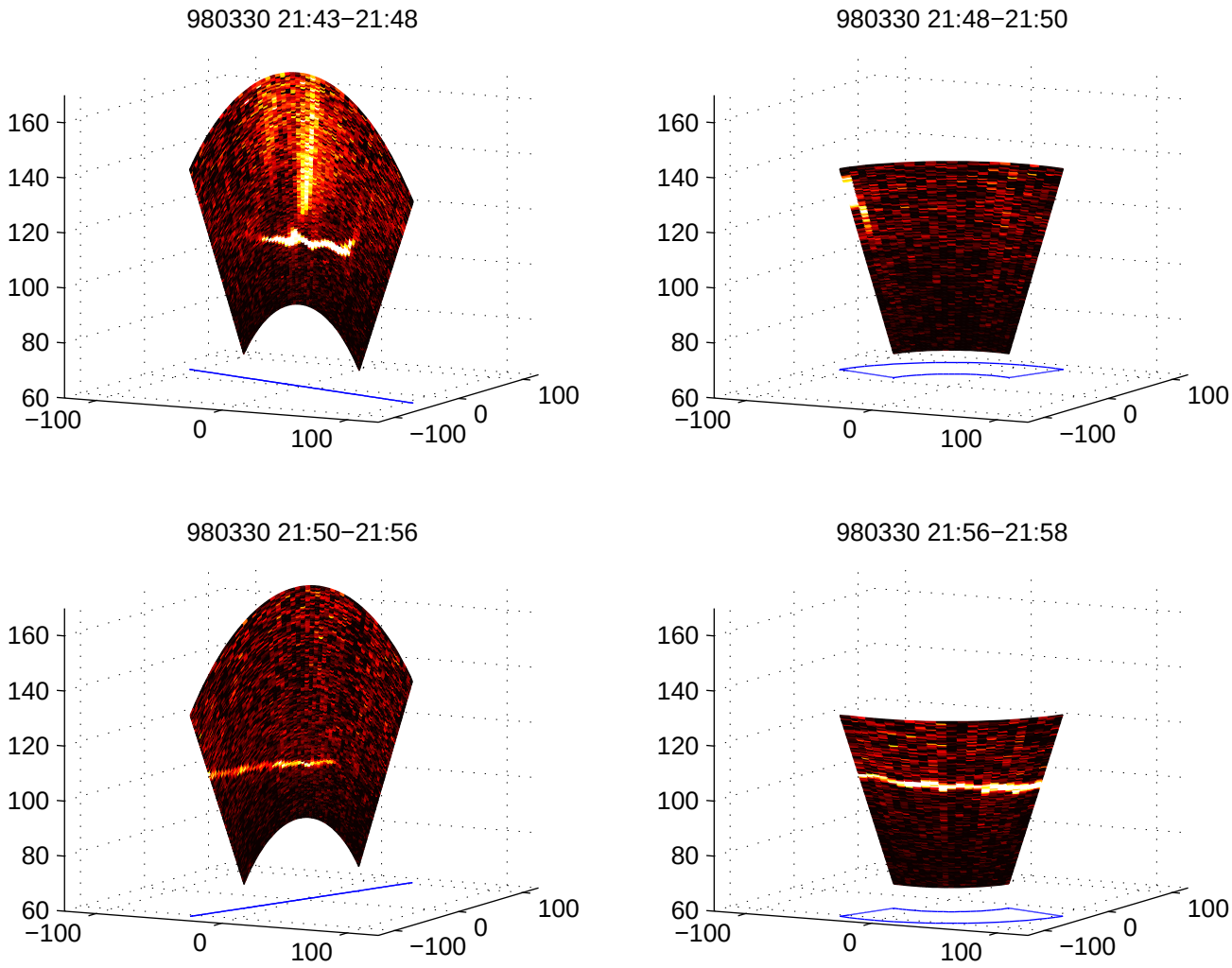
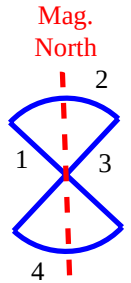
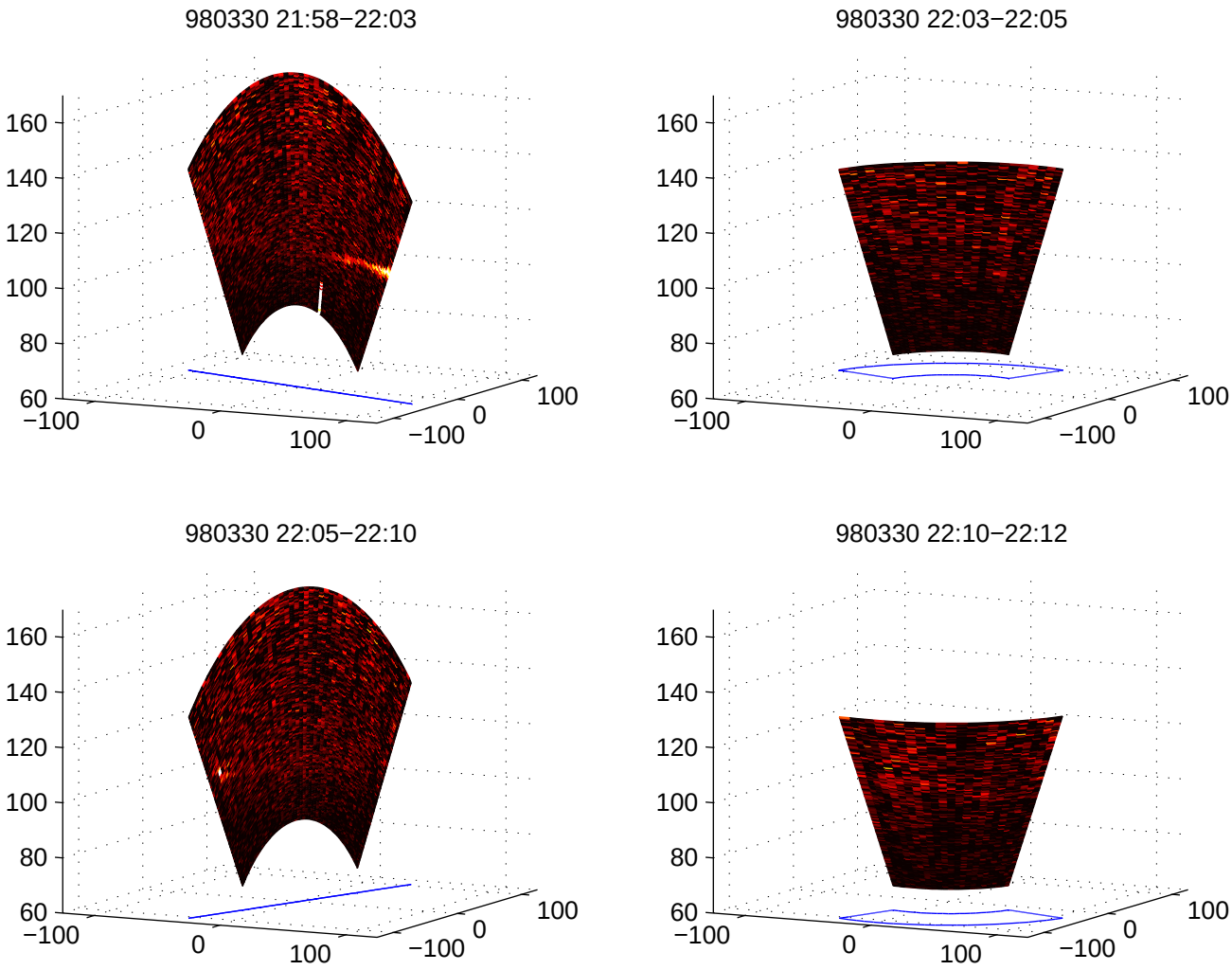




Sondrestrom E_s





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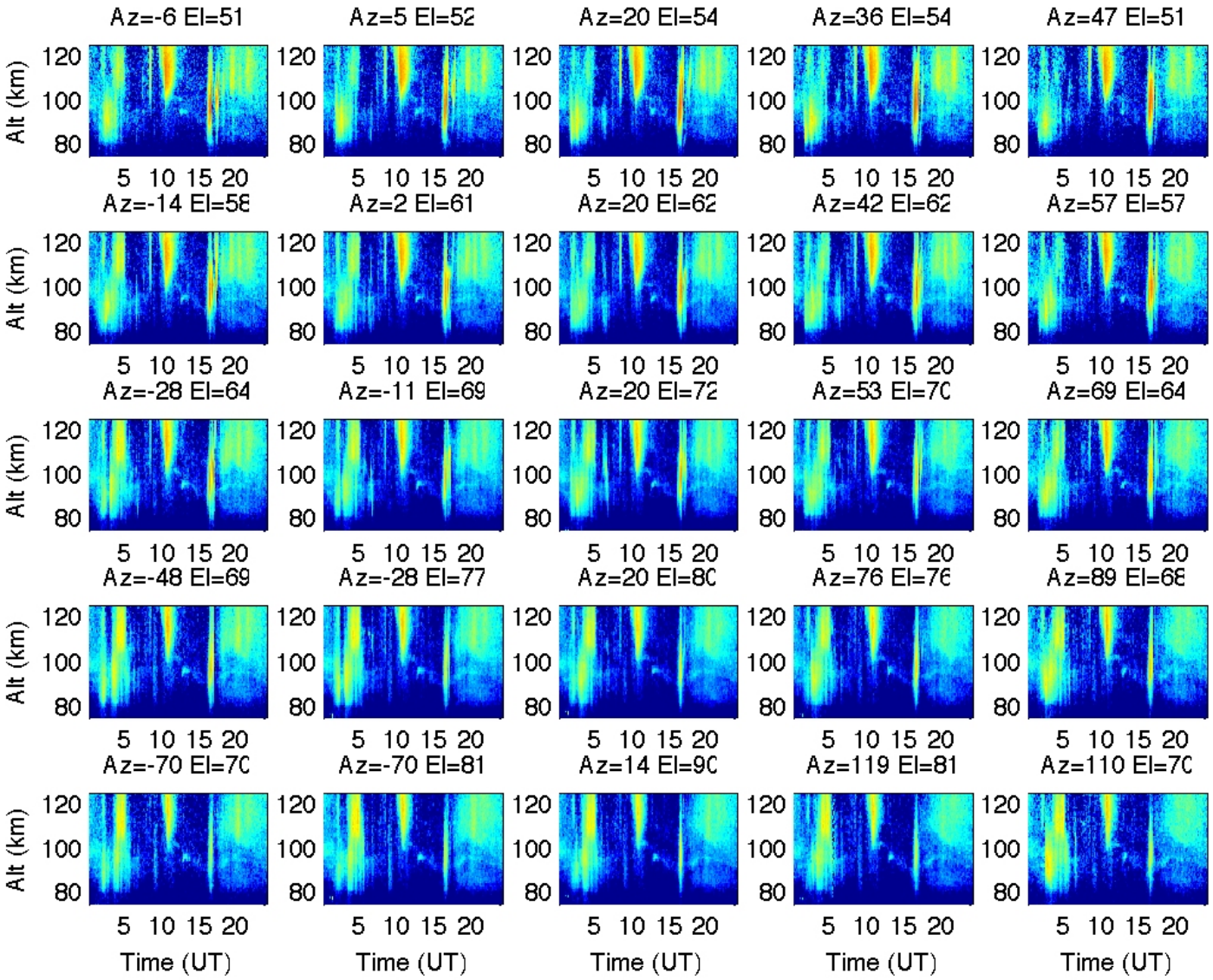

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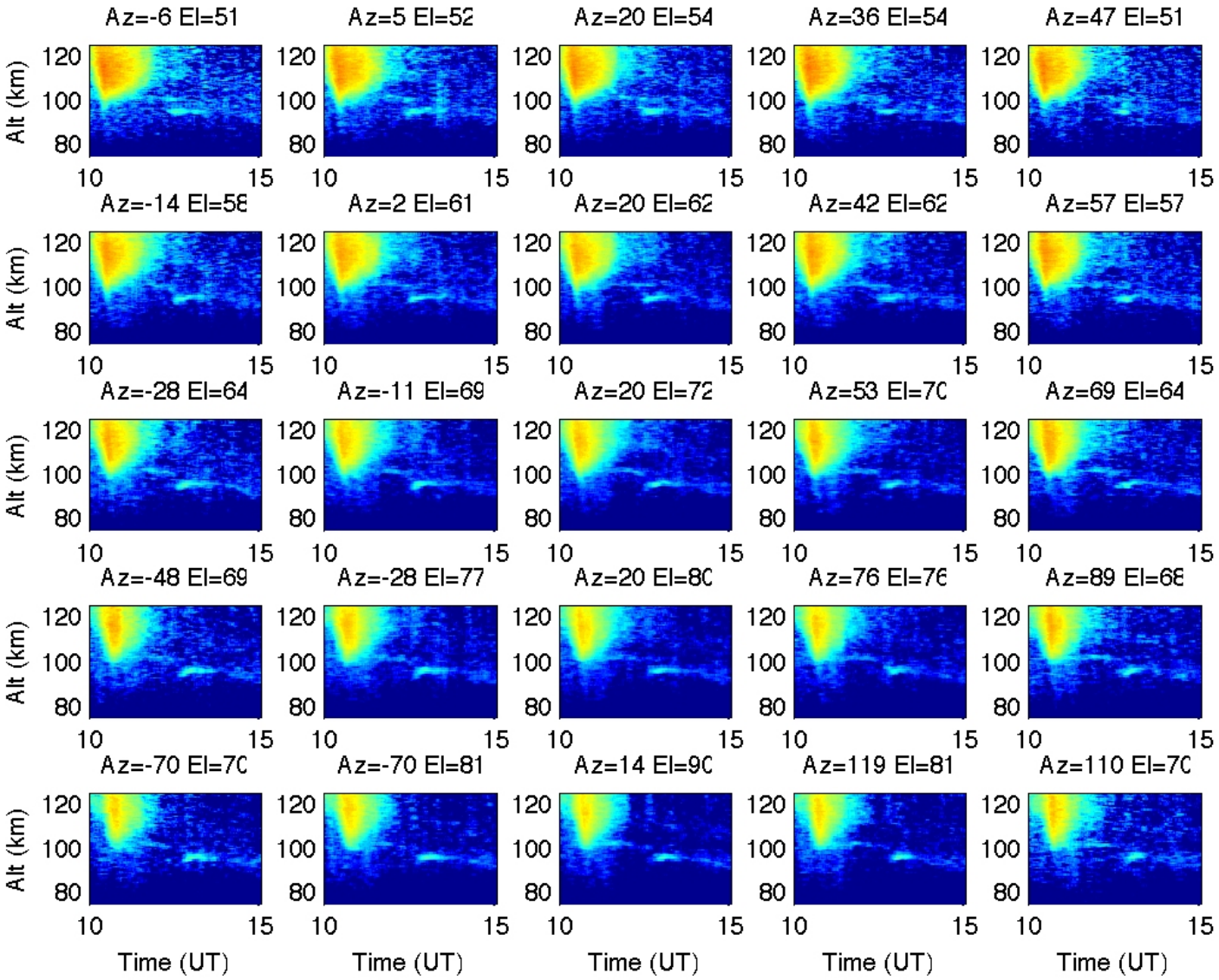

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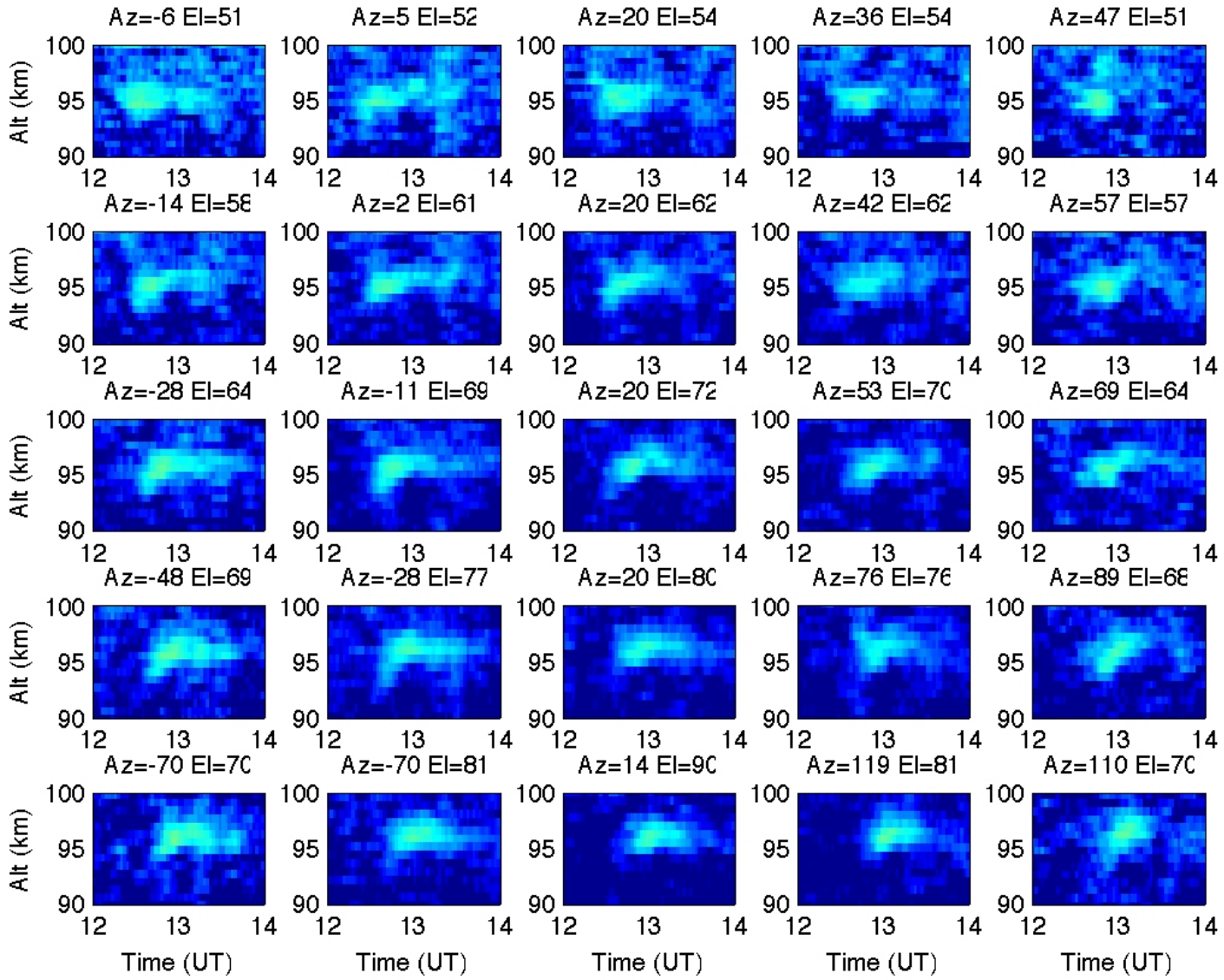

Summary

- One dimensional simulations appear able to describe many of the features of the metallic ion sporadic *E* observations at high latitudes.
- The addition of eddy diffusion is sometimes necessary to explain the temporal evolution of horizontally homogeneous layers. At other times eddy diffusion is apparently not present. This may represent a new way to estimate this difficult-to-measure quantity.
- Three dimensional measurements of the advection and evolution of sporadic *E* layers reveal complicated behavior. This is not completely unexpected, given that the ion motion is largely horizontal. Understanding that behavior will undoubtedly require three dimensional simulations.
- Similarly, these measurements promise a way to test theories about the source of the horizontal structure in sporadic *E* ionization.