Trapped Waves in a Slowly Evolving Flow.

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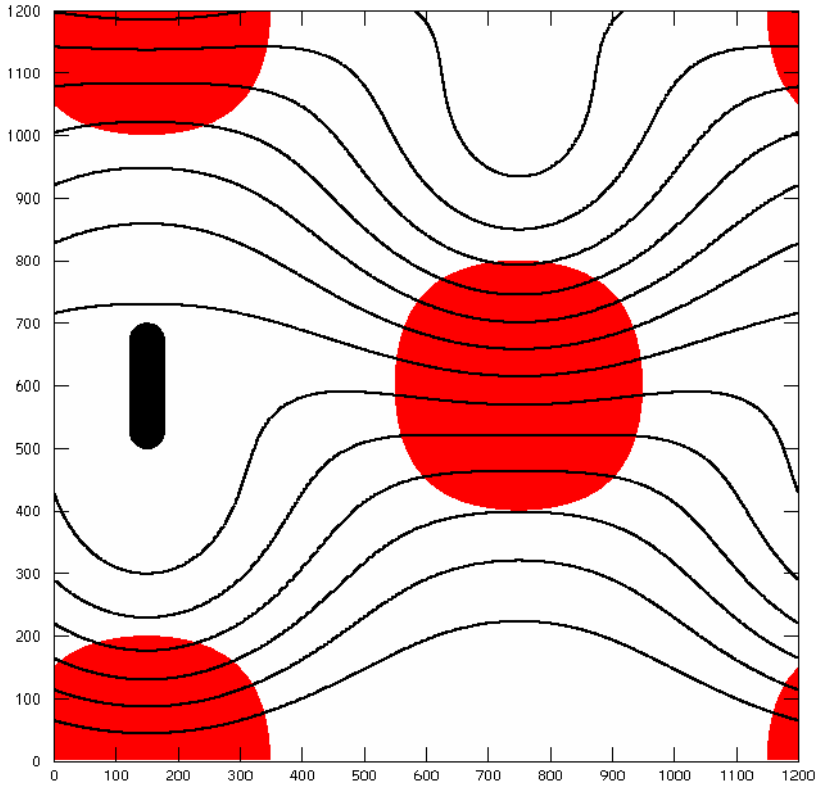
Large Scale Jet



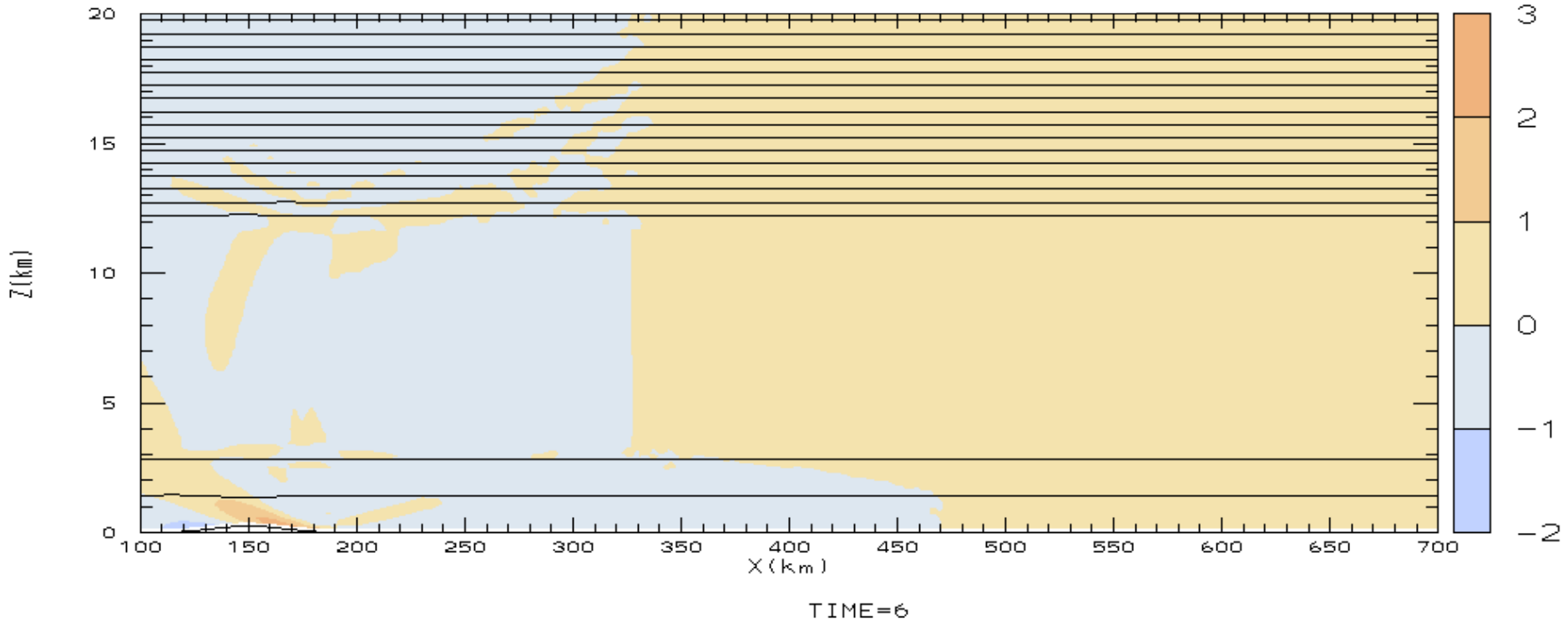
Mean u = 10 m s^{-1}

Red fill: u > 15

No initial cross-mtn flow

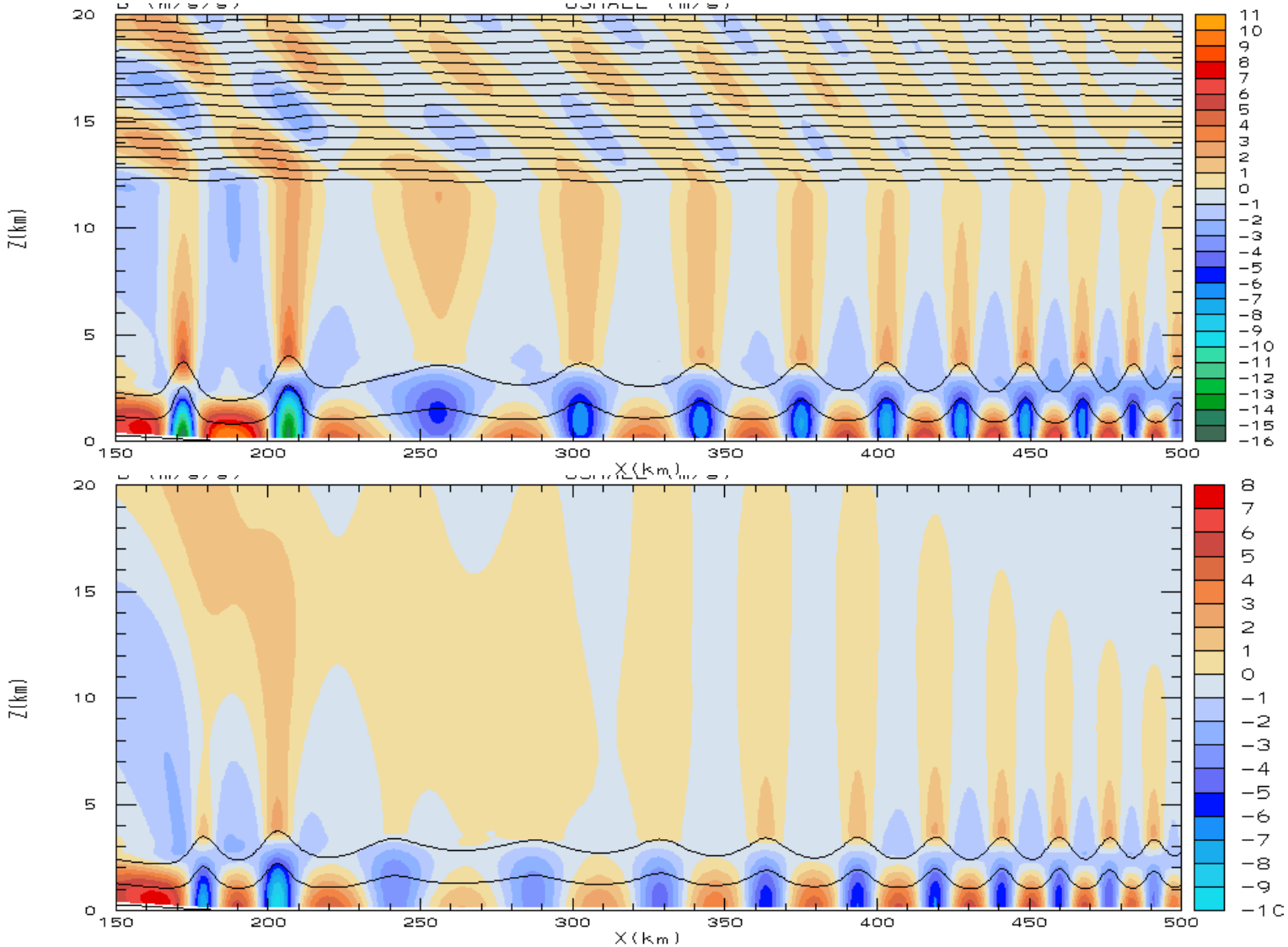
Pattern translates to east with a period of 33.5 hours.

25 Hours in the Life of Trapped Waves



Isentropes and mesoscale u (m s^{-1})

Stratospheric leakage is unimportant



Ray tracing explains the un-trapping

Using the dispersion relation for 2D 2-layer trapped waves along the centerline:

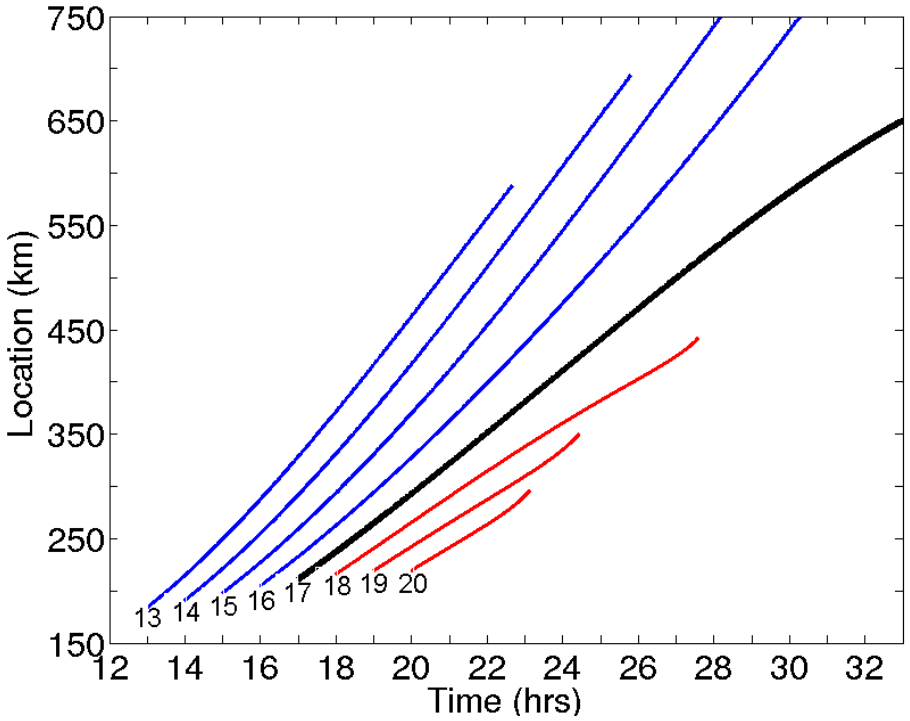
$$\frac{D_g}{Dt}\omega = k\frac{\partial U}{\partial t} \qquad \frac{D_g}{Dt}k = -k\frac{\partial U}{\partial x}$$

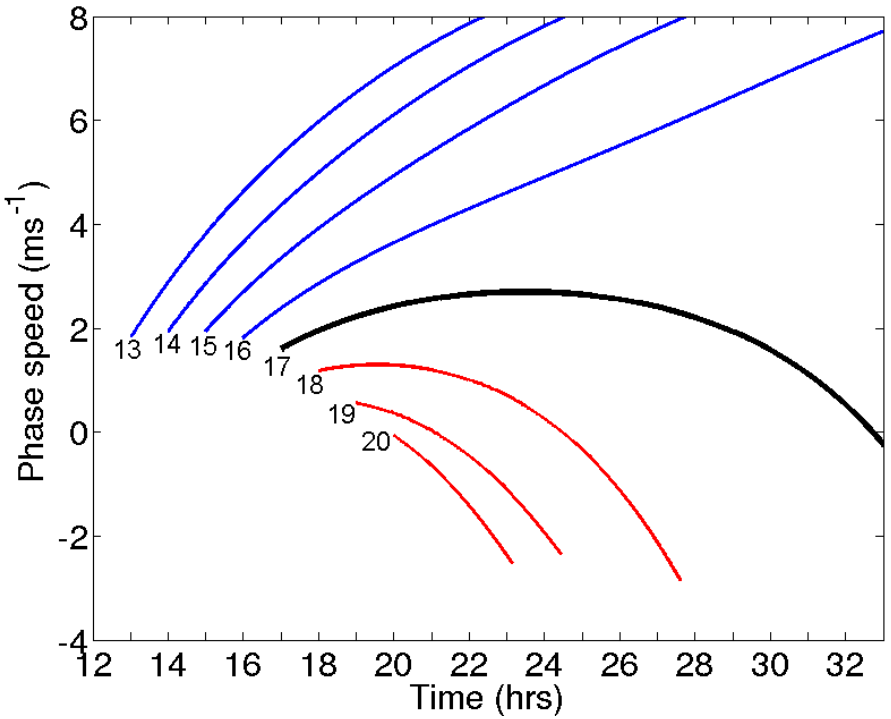
For the intrinsic frequency and intrinsic group velocity

$$\tilde{\omega} = \omega - Uk, \quad \tilde{c}_g = c_g - U$$

$$\frac{D_g}{Dt}\tilde{\omega} = -\tilde{c}_g k\frac{\partial U}{\partial x}$$

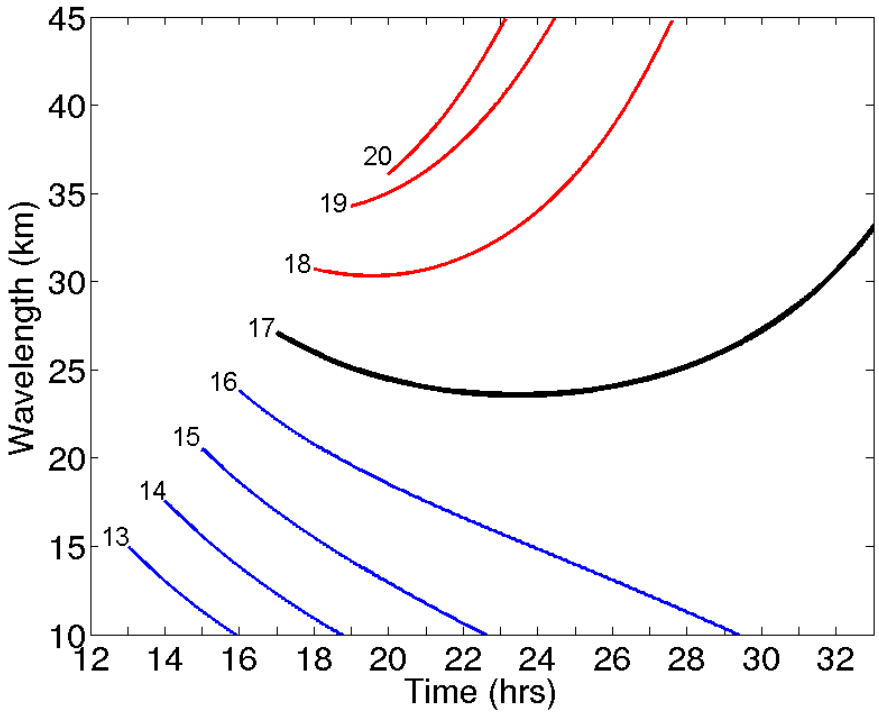
x-position and phase speeds for crests launched between hours 13 & 20

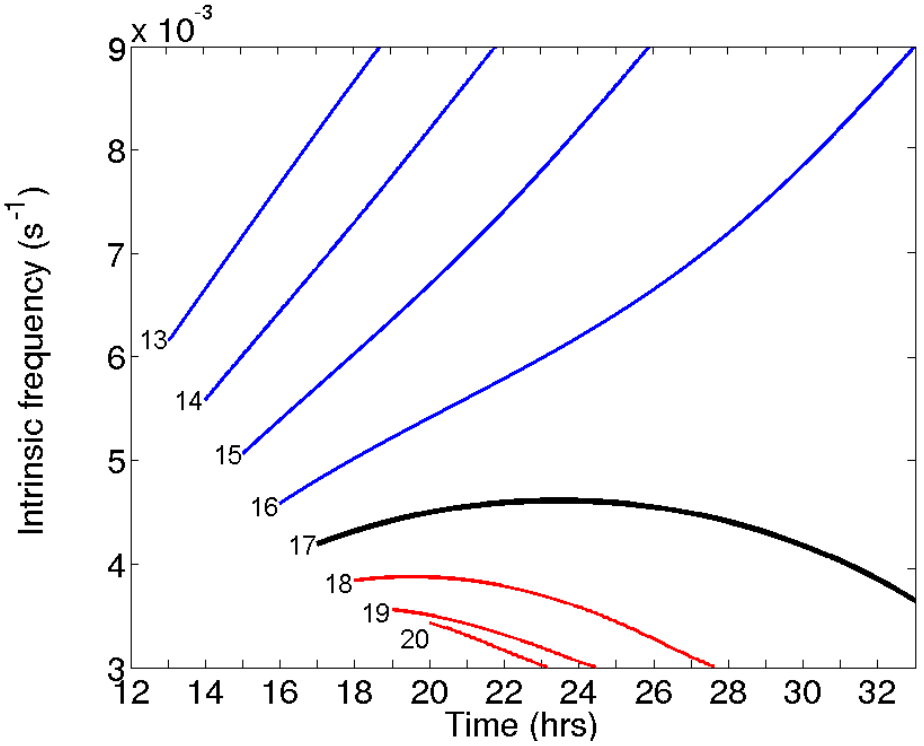




$U_{\max}$ at hour 16.75

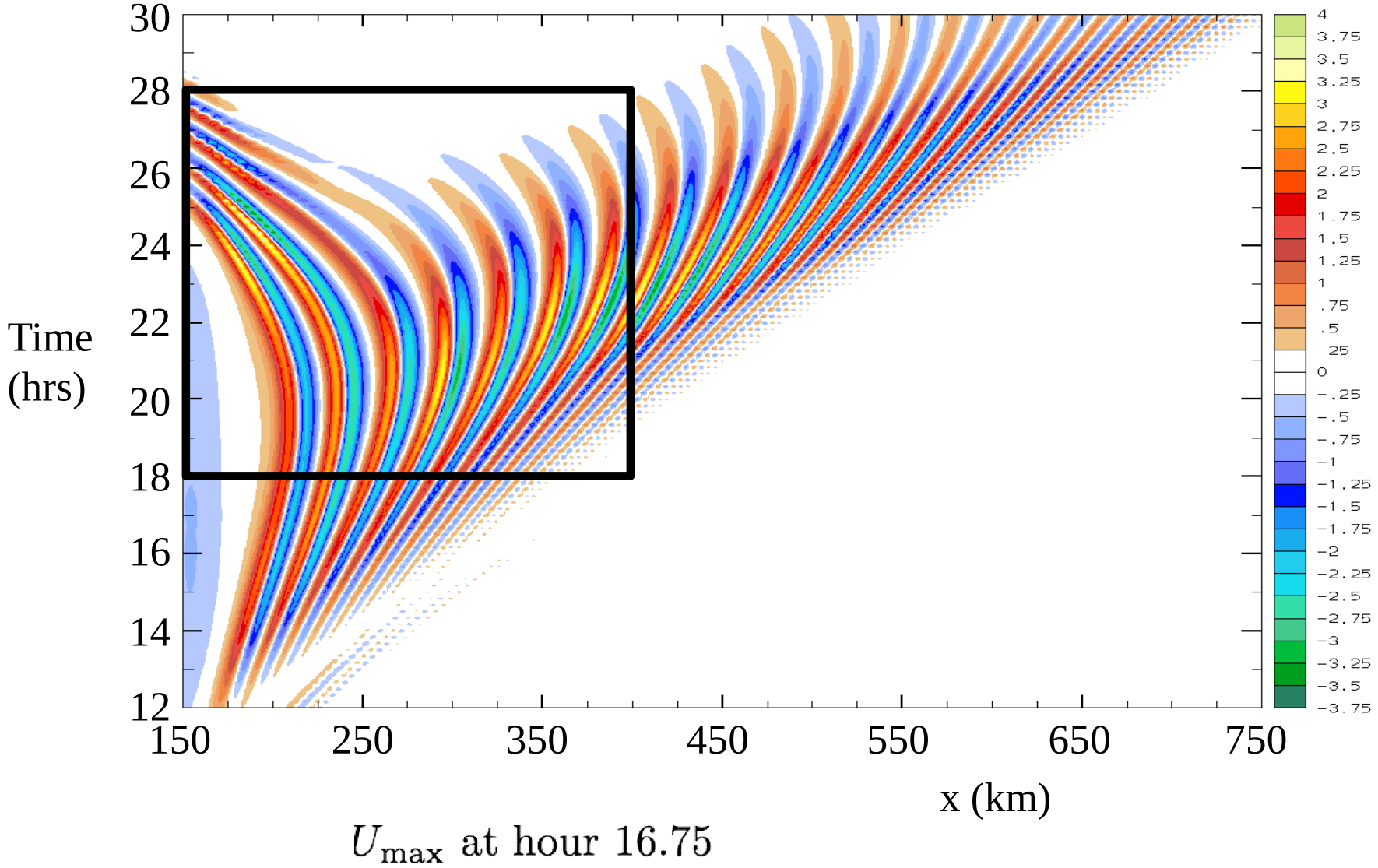
Wavelength and intrinsic frequency for crests launched between hours 13 & 20





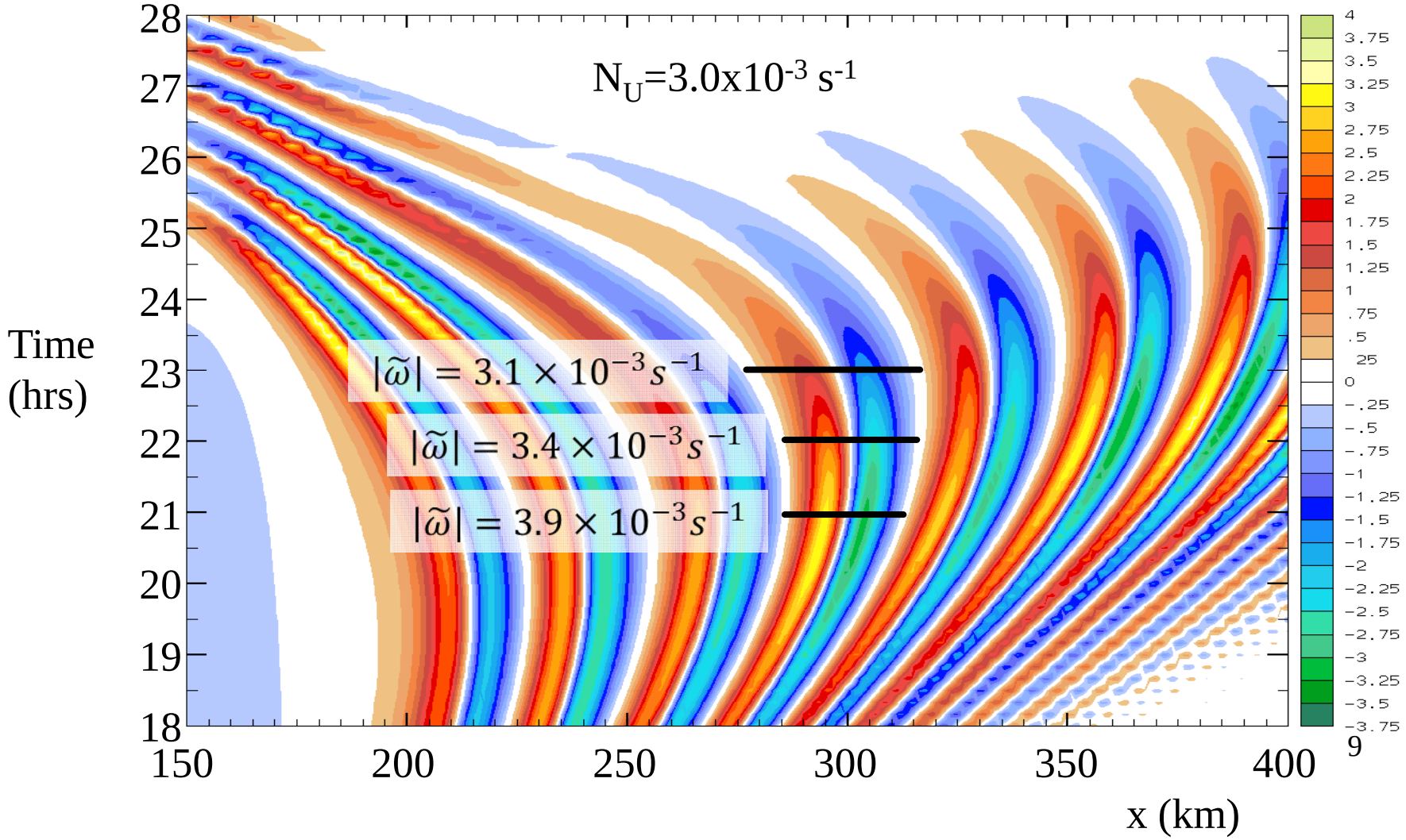
$U_{\max}$ at hour 16.75

w at the elevation of the interface



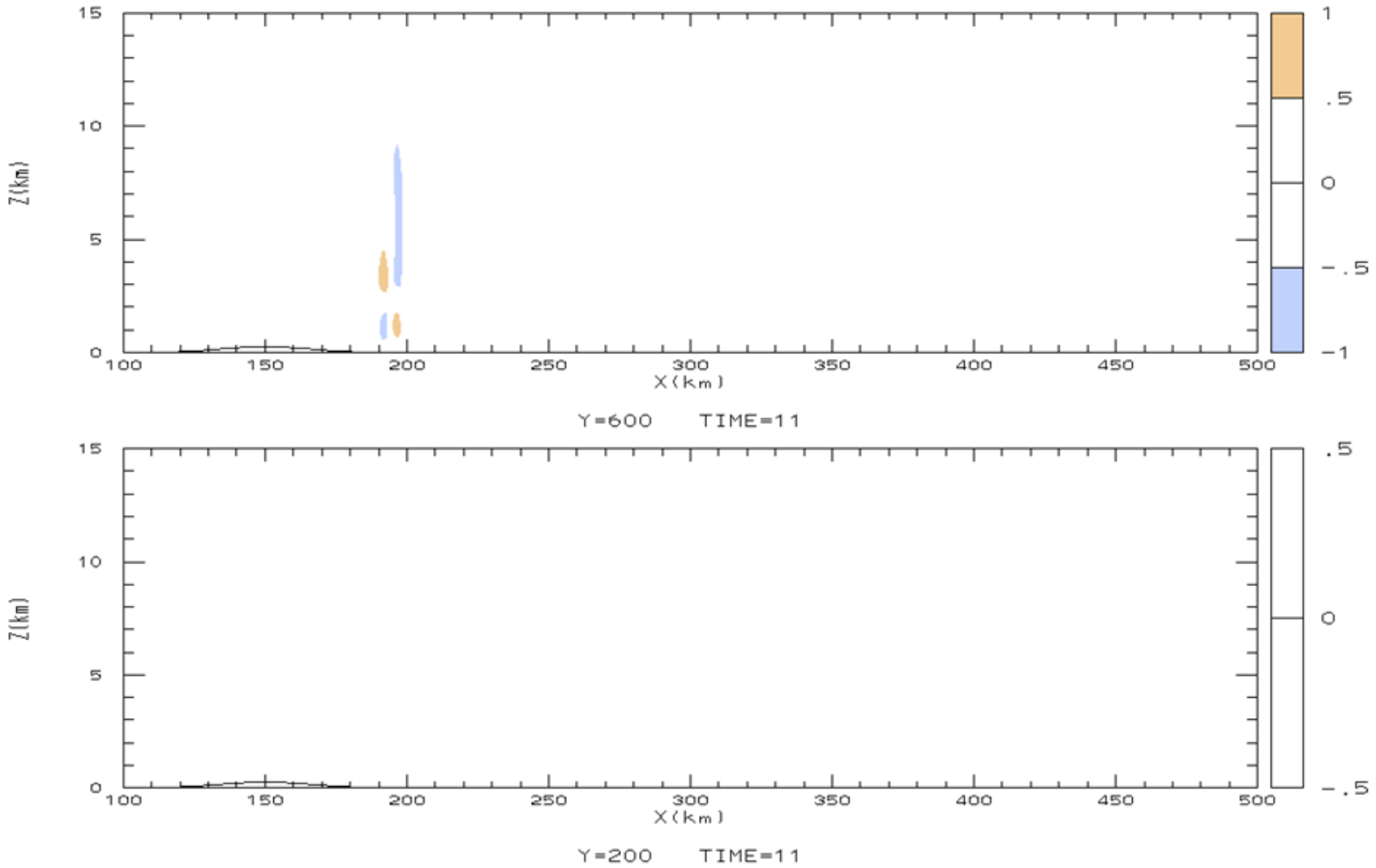
$U_{\max}$ at hour 16.75

Details of the wave untrapping



w (m s^{-1}) at z =3 km

Influence of Large-Scale Horizontal Structure



Conservation of Wave Action

Wave energy density for 2D Boussinesq internal gravity

$$\mathcal{E} = \frac{\rho_0}{2}\left(\overline{u'^2} + \overline{w'^2} + \frac{\overline{b'^2}}{N^2}\right)$$

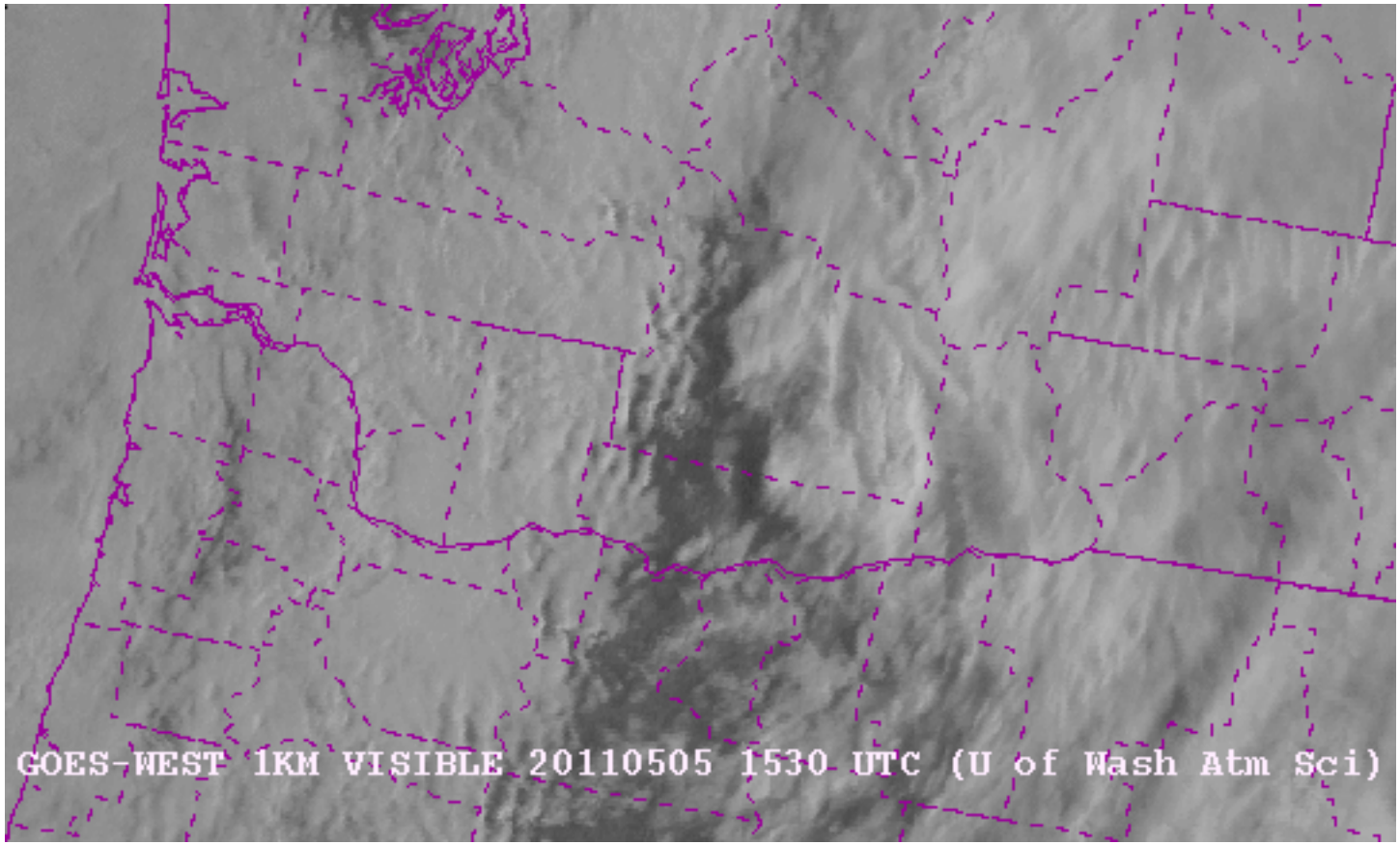
Wave action density

$$\mathcal{A} = \mathcal{E}/\tilde{\omega}$$

Conservation of wave action

$$\frac{\partial \mathcal{A}}{\partial t} + \nabla \cdot (\mathcal{A}\mathbf{c}_g) = 0$$

Lee of Cascades: 5 May 2011



Conclusions

- Horizontal variations in the synoptic-scale flow can dramatically influence trapped-lee waves
  - Waves tend to un-trap in the jet entrance region
  - Wave energy density may change dramatically to conserve wave action
- No un-trapping from horizontally homogenous deceleration