

# Mountain wave-induced turbulence: “lower turbulent zones” revisited

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Vanda Grubišić<sup>1,2</sup>

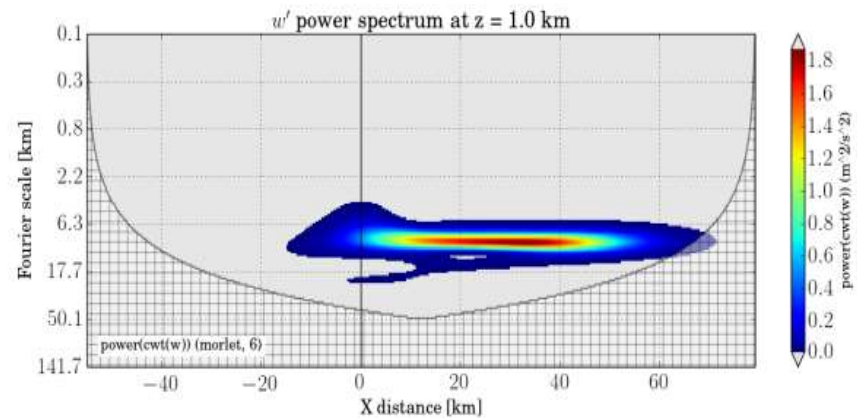
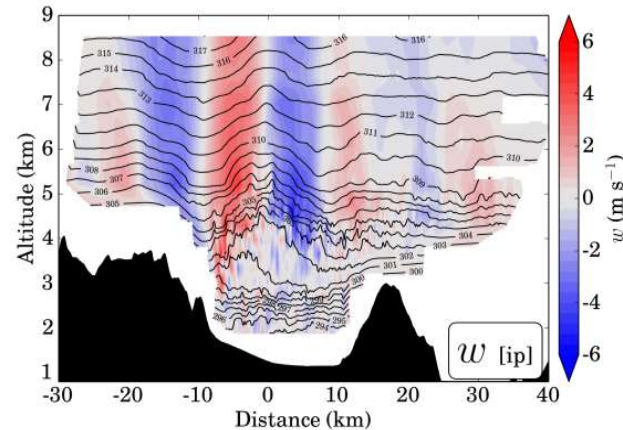
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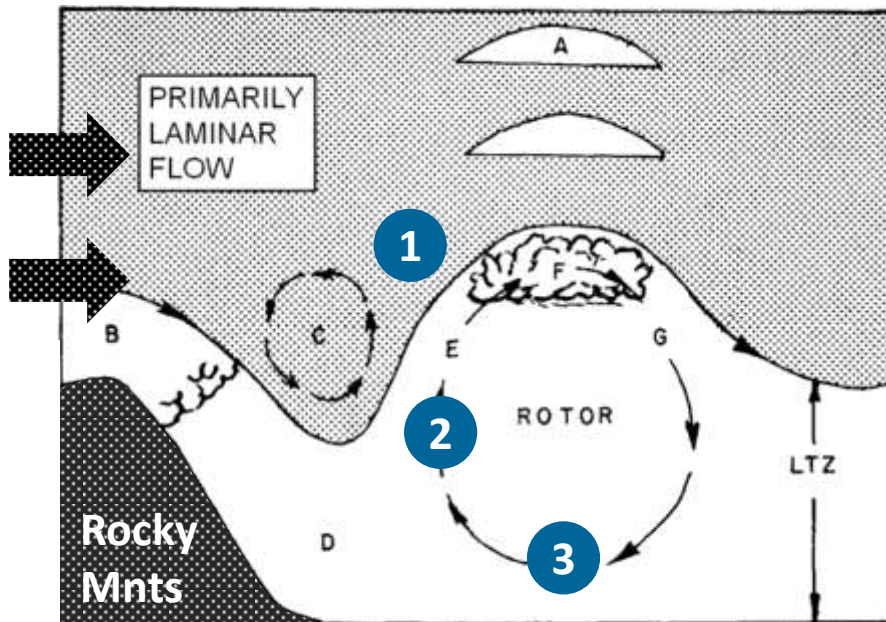


## TWO PARTS

- Mountain wave-induced turbulence
- Wavelet diagnostics of wave energy flux



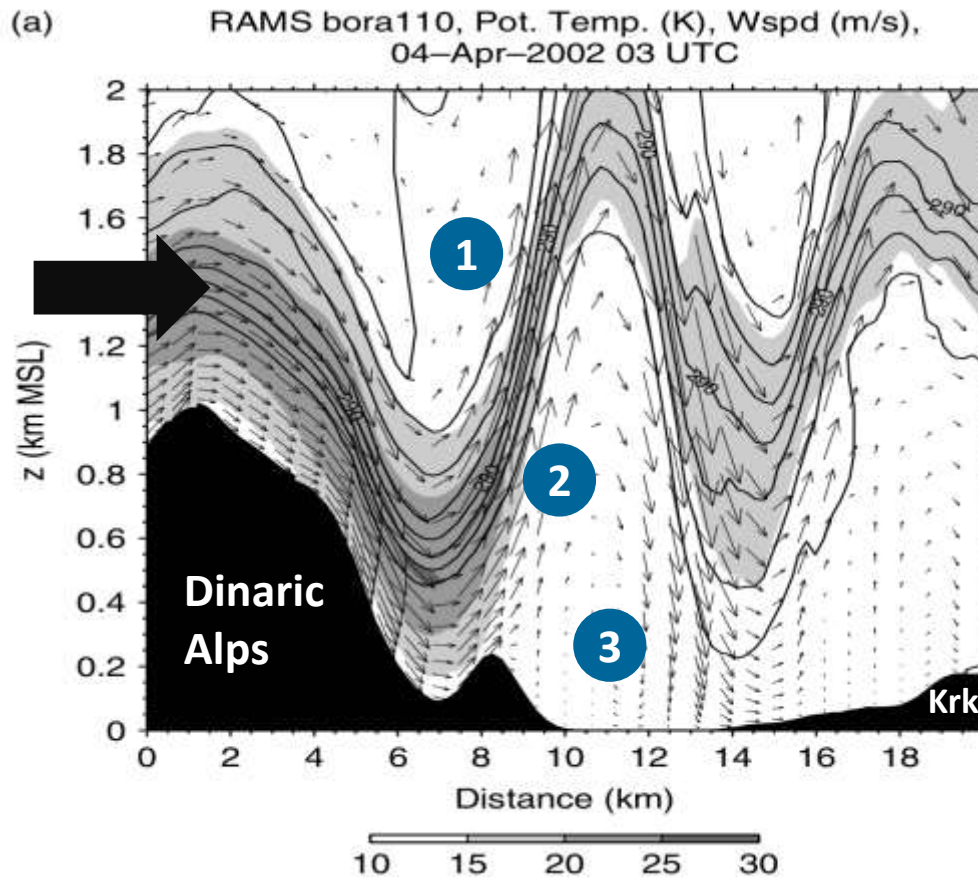
## Lester and Fingerhut, 1974: “Lower Turbulent Zones Associated with Mountain Lee Waves”



### Low-level turbulence in the lee of mountain ranges

- 1 mountain waves
- 2 rotor formation
- 3 severe turbulence

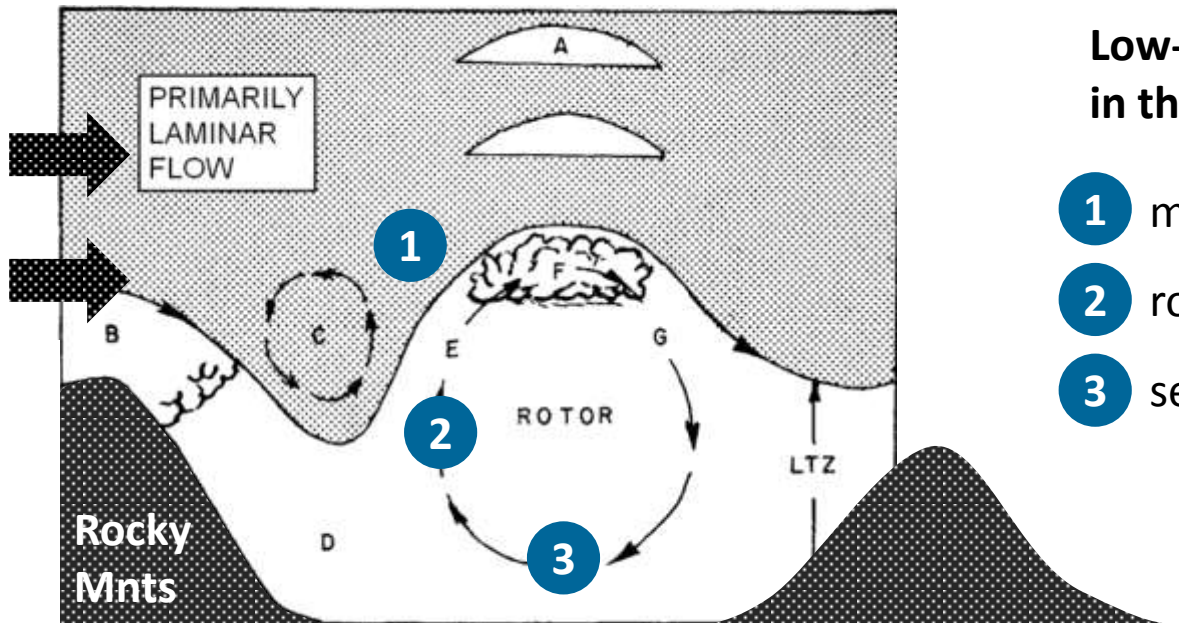
## Dinaric Alps – Bora



**4 April 2002, Krk**  
Gohm et al. (2008)

- 1** mountain waves
- 2** rotor formation
- 3** severe turbulence

## Lester and Fingerhut, 1974: “Lower Turbulent Zones Associated with Mountain Lee Waves”



**Low-level turbulence  
in the lee of mountain ranges**

- 1** mountain waves
- 2** rotor formation
- 3** severe turbulence

**More complex topography:  
Extensions to the original  
model of the LTZ?**

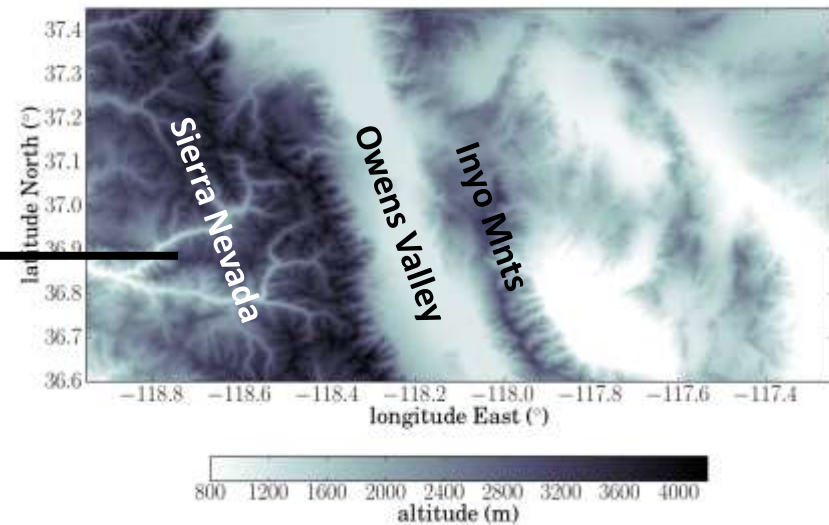
## Terrain-induced Rotor Experiment (T-REX)

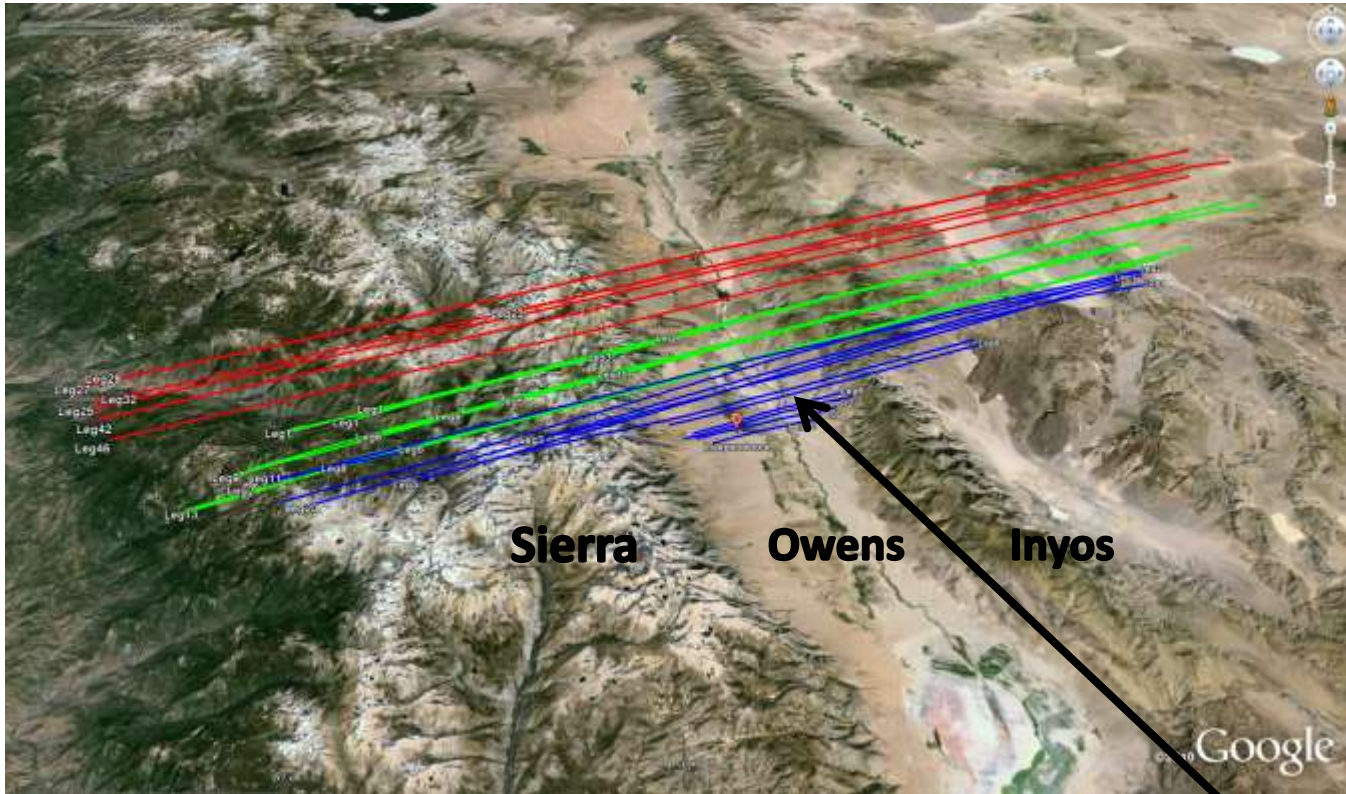
March-April 2006

Mountain waves and rotors



### Sierra Nevada, Owens Valley





**NCAR G-V**



**NCAS BAe-146**



**UW King Air**

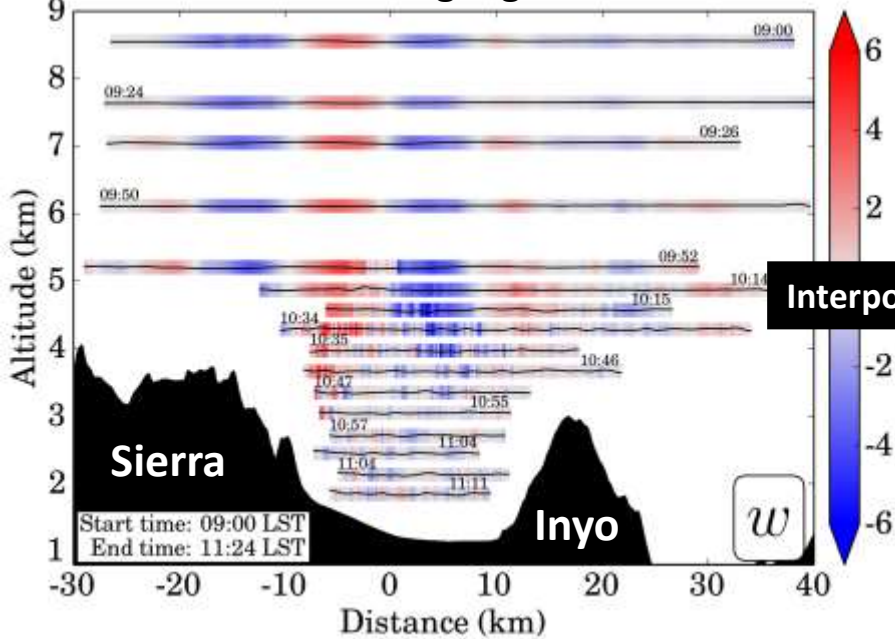


## King Air cross sections

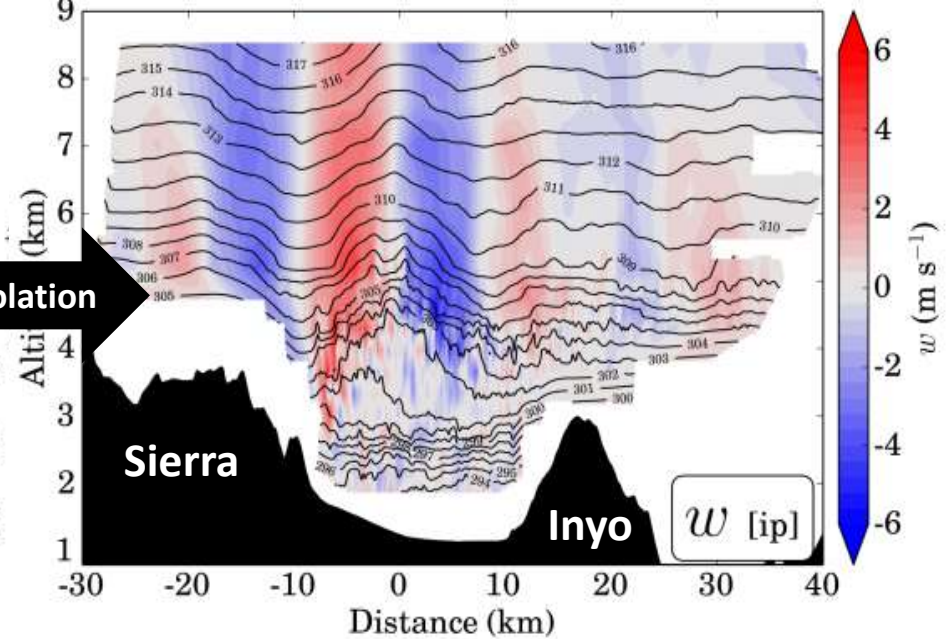
$u, v, w, \theta, \text{EDR}$



T-REX IOP 1, morning flight



Interpolation



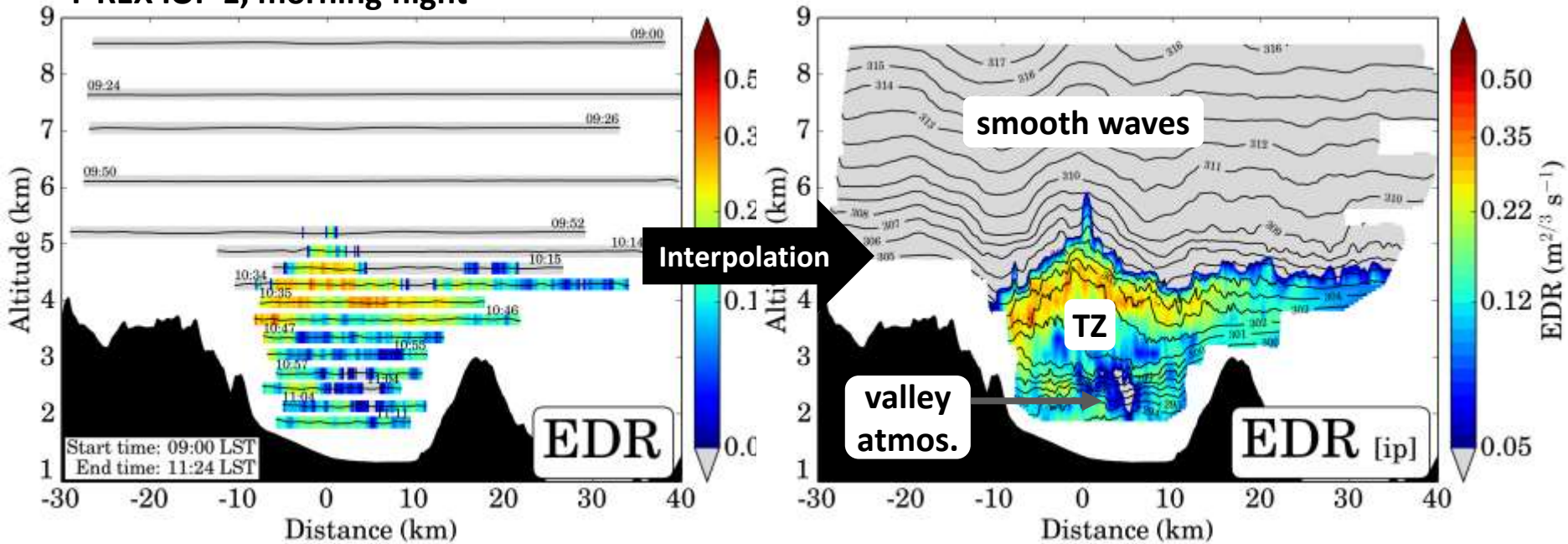


## King Air cross sections

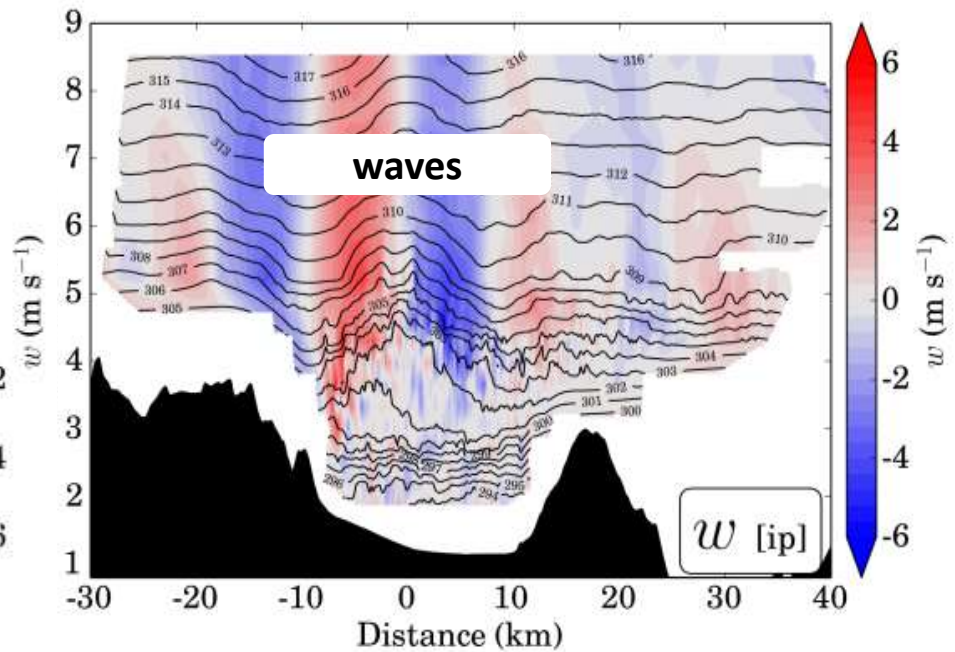
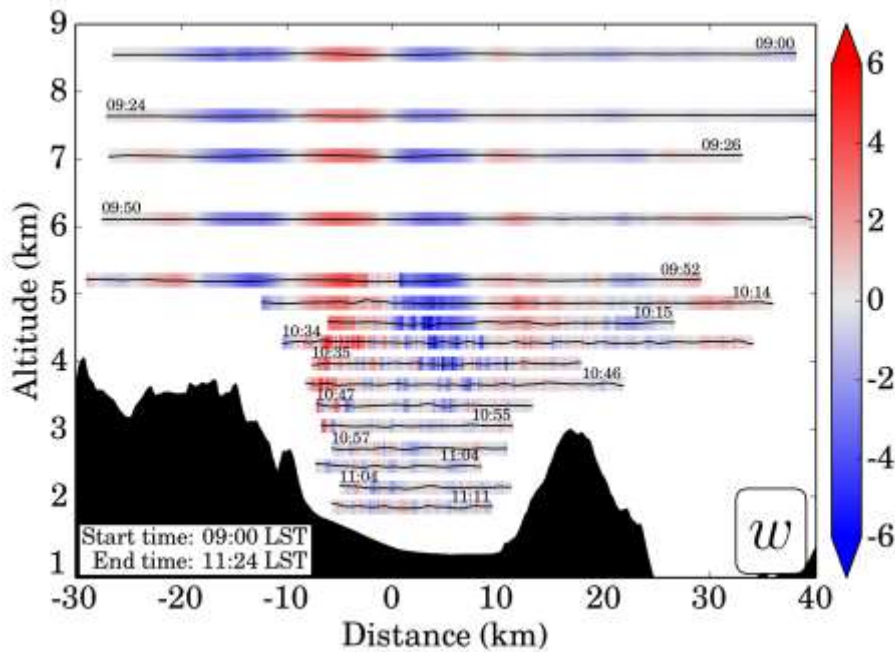
$u, v, w, \theta, \text{EDR}$



T-REX IOP 1, morning flight



EDR ... eddy-dissipation rate



**Linear theory:**

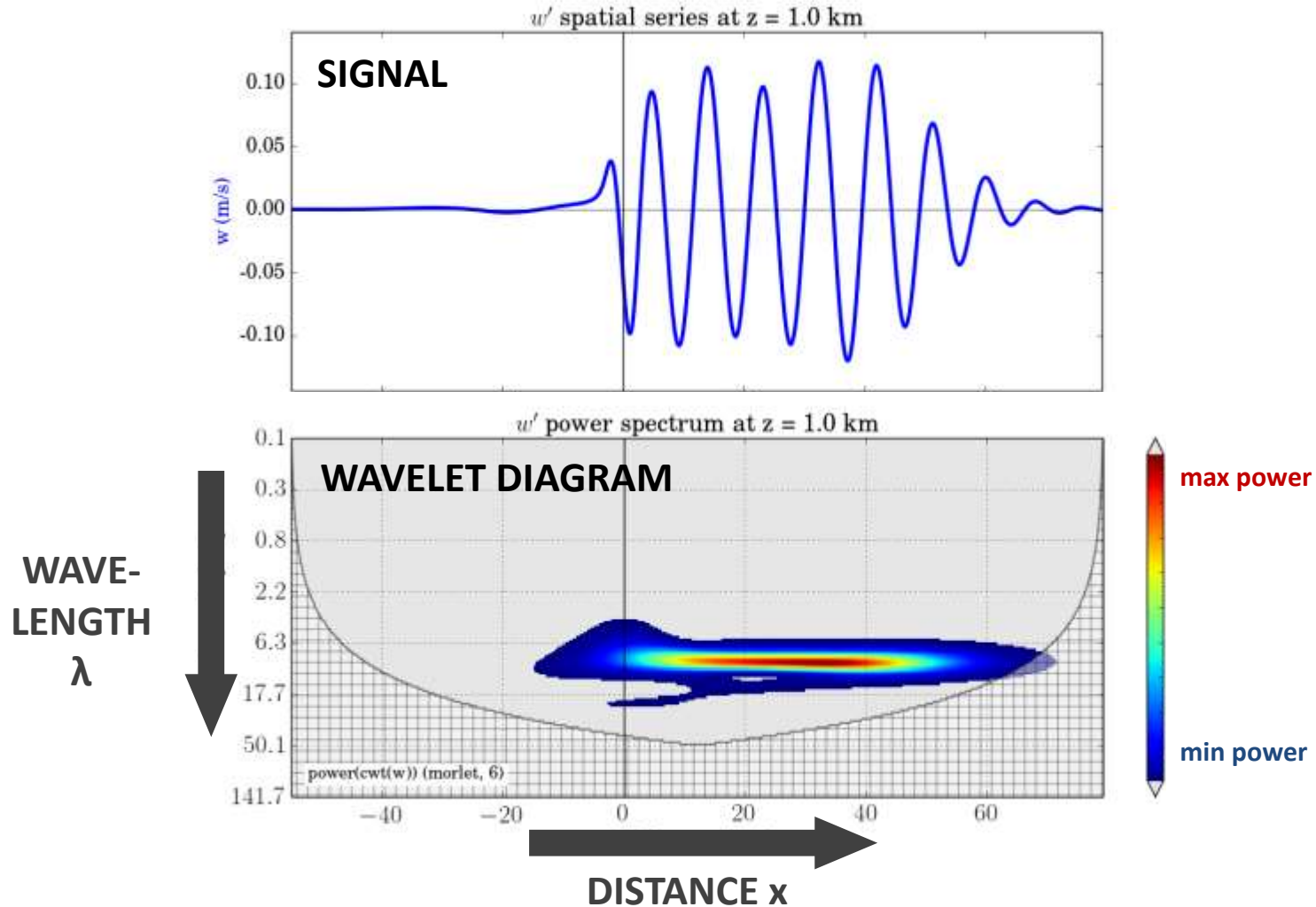
$$EF = \int p' w' dx$$

... vertical flux of energy

**EF > 0** ... **upward**-propagating  
mountain wave

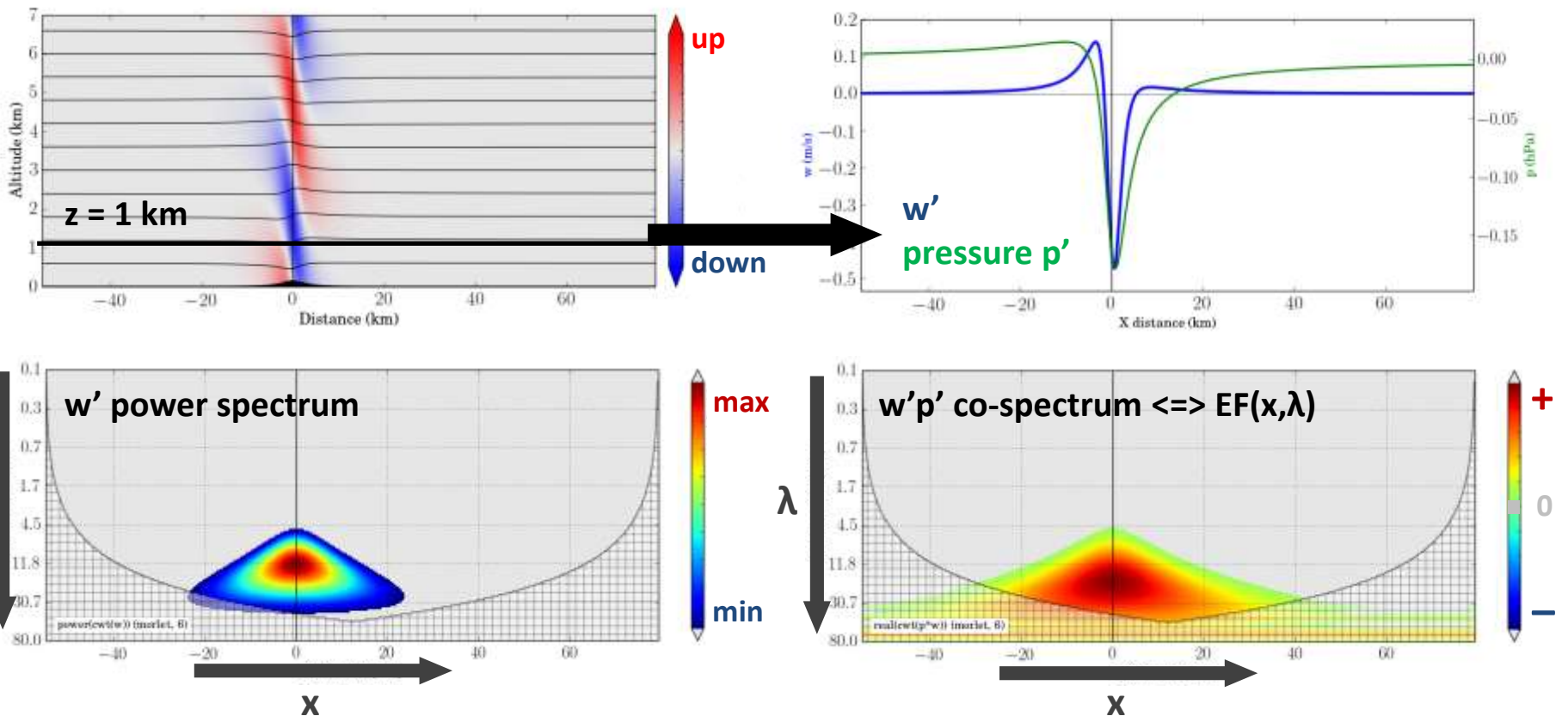
**EF = 0** ... trapped-lee wave

## Wavelet analysis



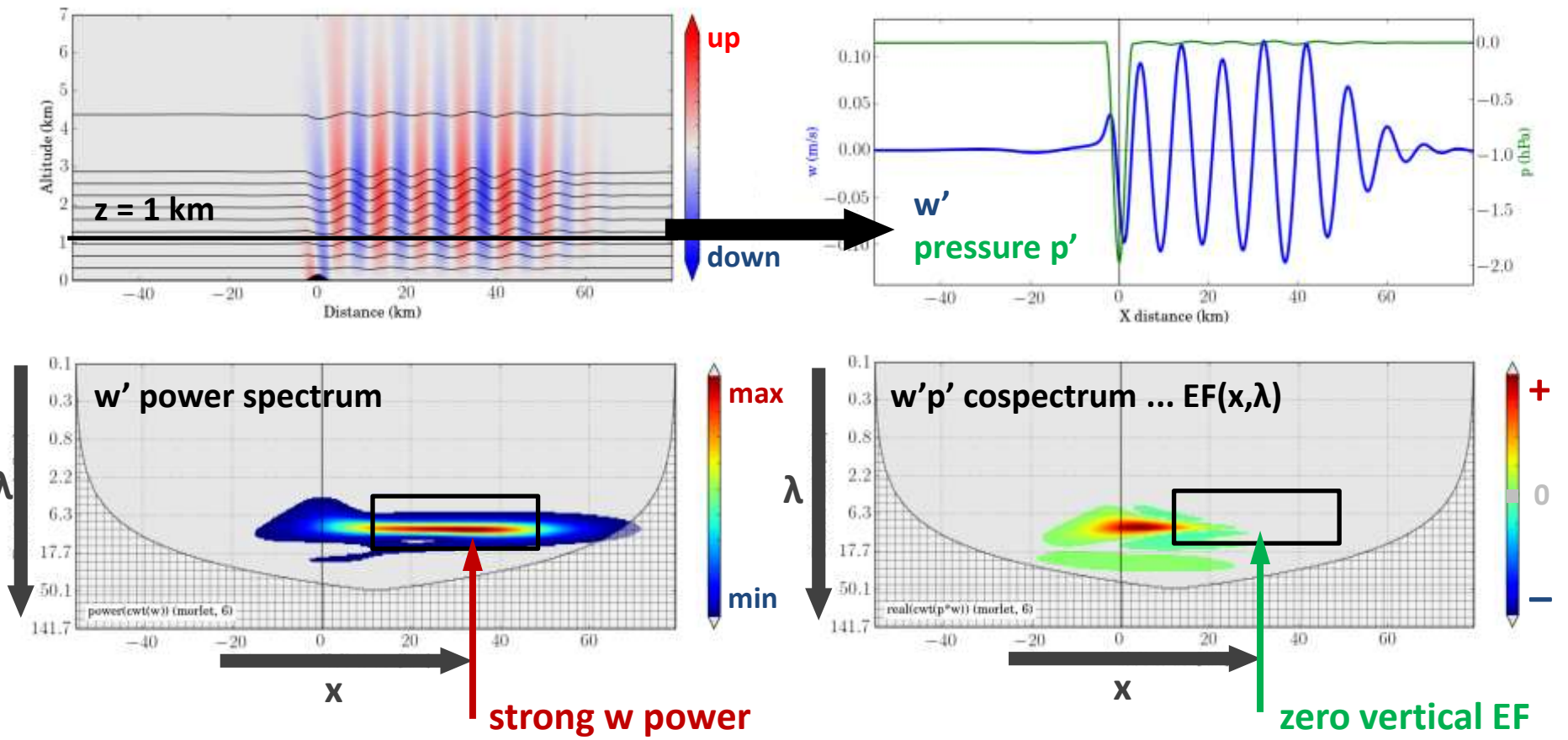
## Energy flux and wavelet diagnostics (Woods and Smith (2010))

### Linear, hydrostatic mountain wave: Queney (1948) solution

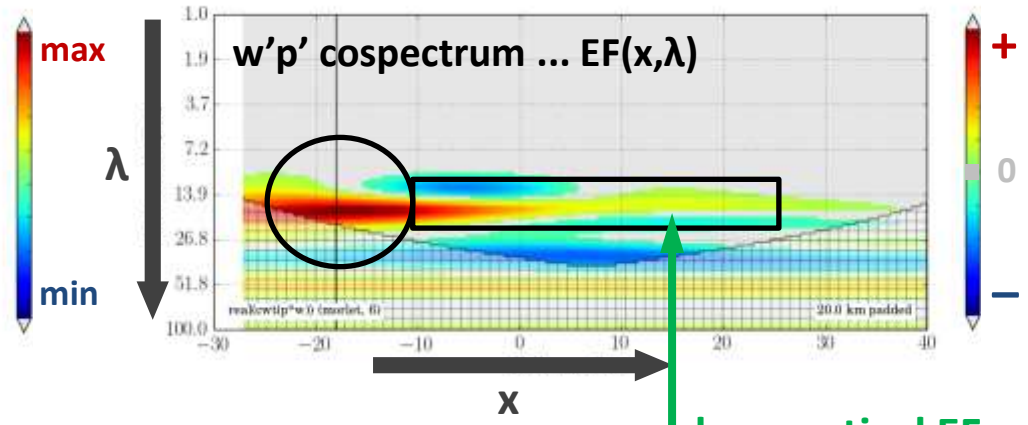
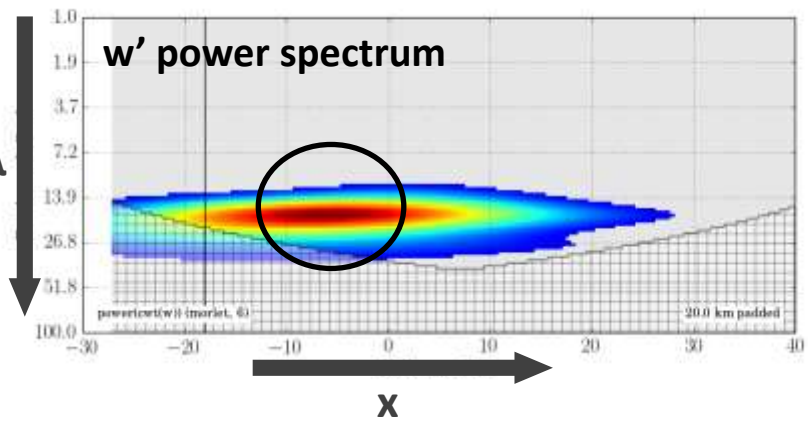
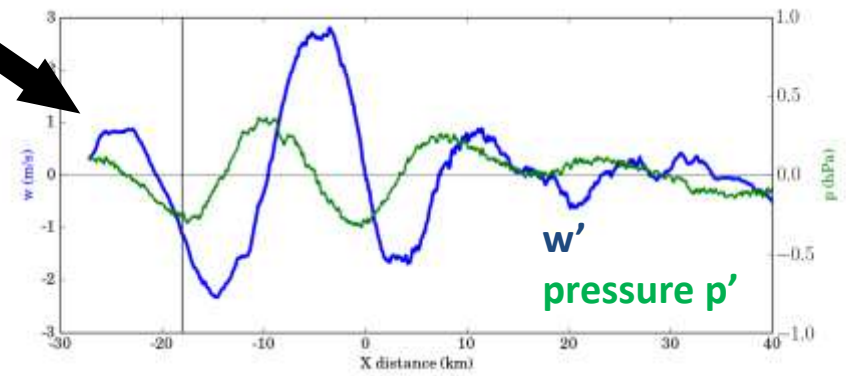
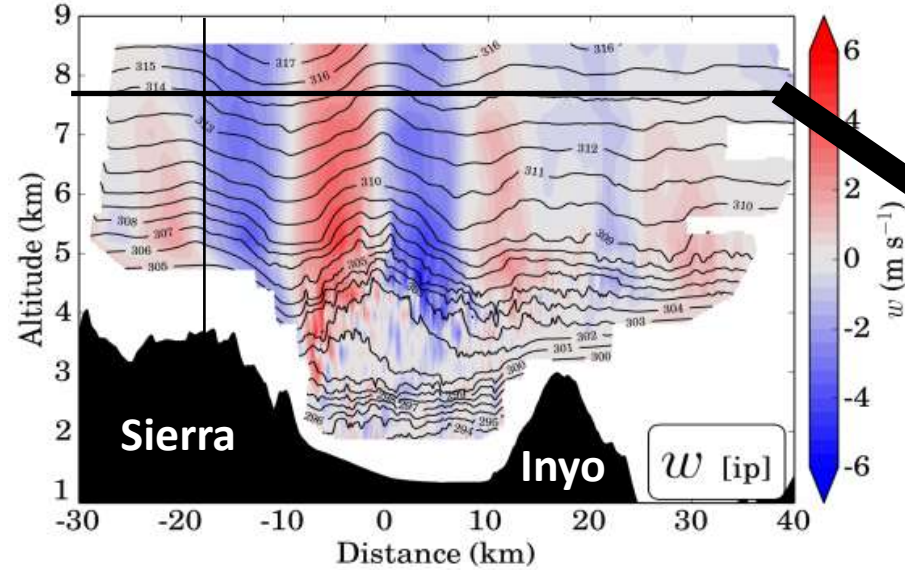


## Energy flux and wavelet diagnostics (Woods and Smith (2010))

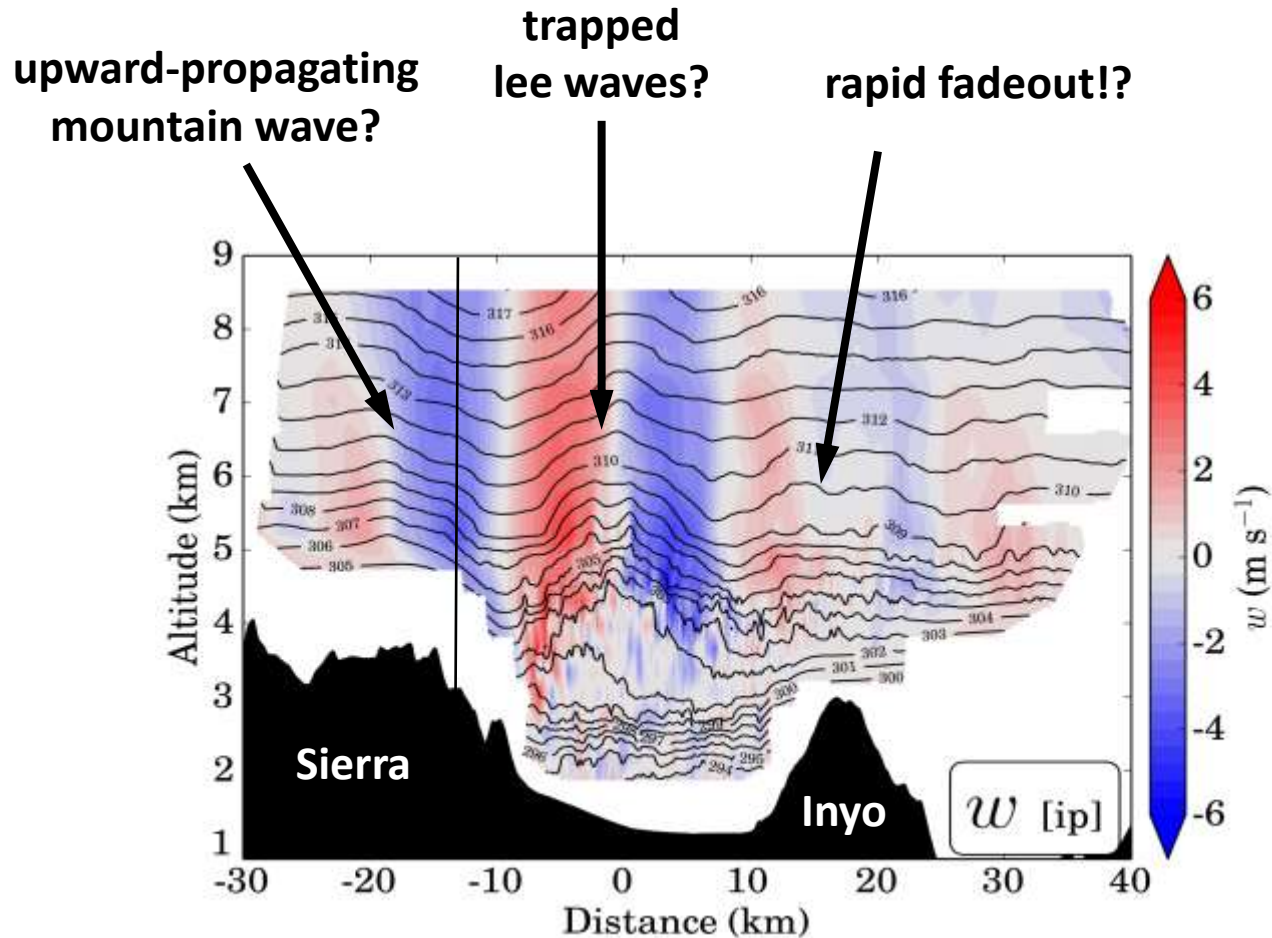
Trapped lee waves in a two-layer atmosphere: numerical simulation



## Real wave field during T-REX IOP 1

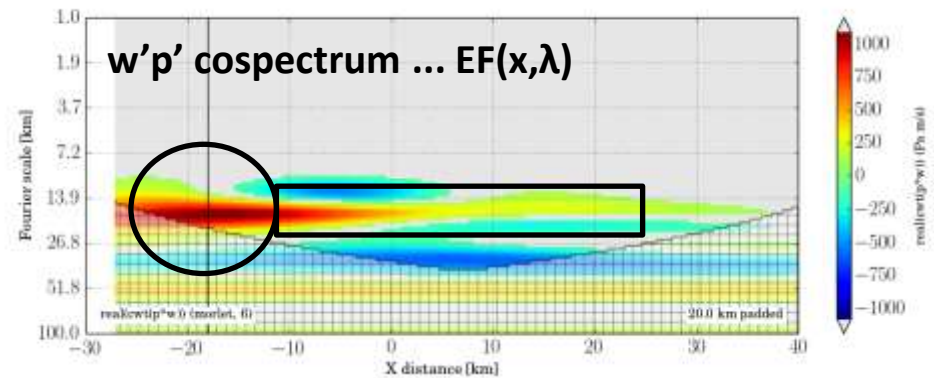
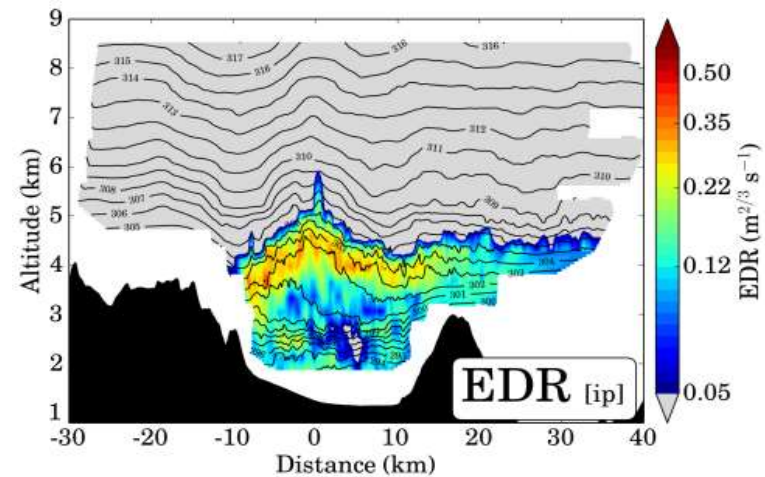


## Real wave field during T-REX IOP 1



## TWO PARTS

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- **Wave diagnostics:**
  - How far can we get with **linear theory**?
  - **What phase relationships** between  $w$ ,  $p$ ,  $u$ ,  $\theta$  to expect beyond?
  - **How to measure fluxes** of energy and momentum?

**Thank you for your attention!**

