T-REX EOPs: Valley winds and sensitivity to synoptic conditions

Juerg Schmidli, Gregory Poulos

Earth Observing Laboratory
National Center for Atmospheric Research

T-REX Data Workshop

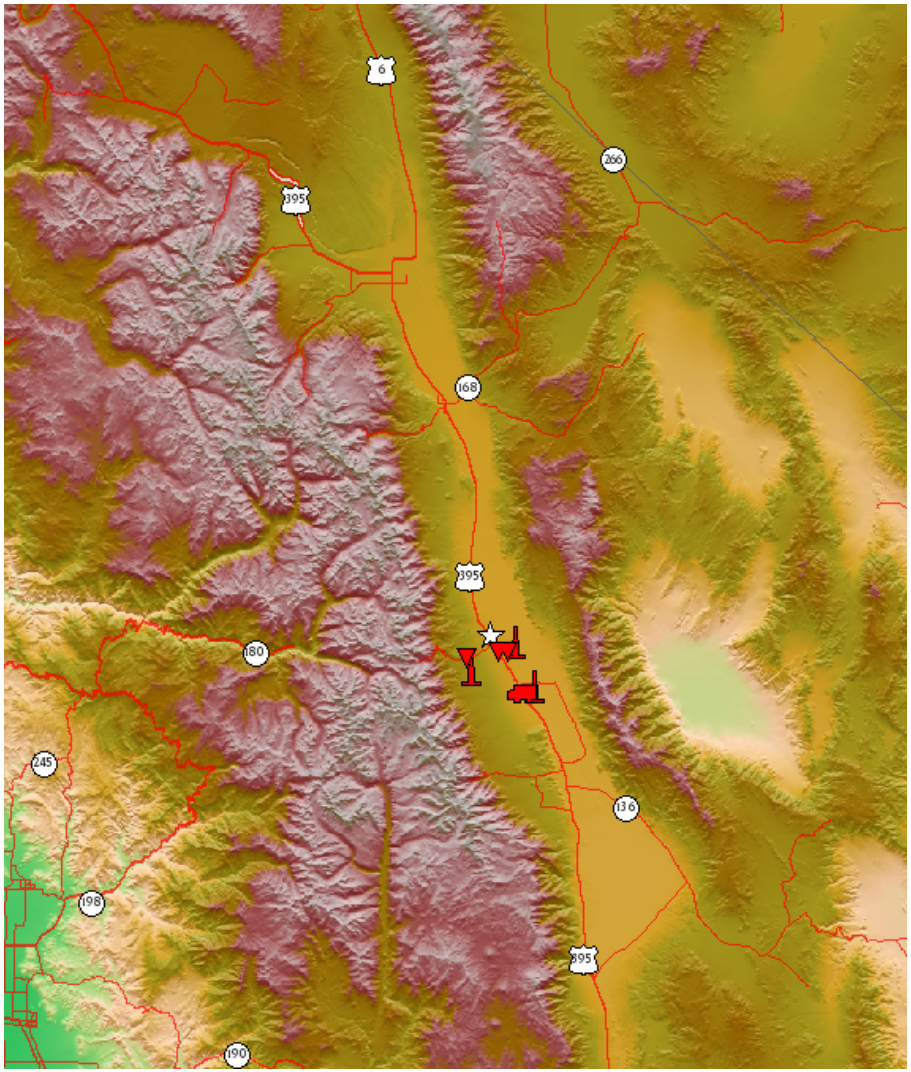
Acknowledgements
W. Brown, and the T-REX teams

Overview of T-REX EOPs

EOP	Date	$u(5.5\ \mathrm{km})$	Nighttime valley flow
1	22-23 Mar	12 @ 250	up-valley flow; shallow down-valley
2	29-30 Mar	20 @ 270	three layer structure
3	18-19 Apr	5 @ 340	most classical conditions
4	28-29 Apr	9 @ 315	moderate down-valley jet
5	29-30 Apr	10 @ 280	strong down-valley jet

- Goal: Explain the observed evolution of the valley wind and its case-to-case variability
- Today: Compare EOP 2 and EOP 5

Topography of Owens Valley and Instrumentation



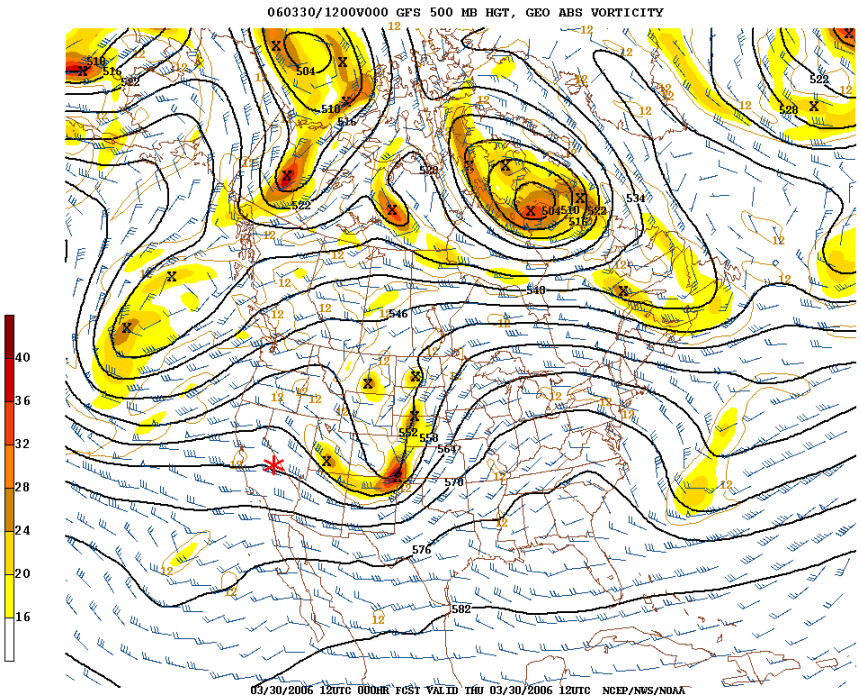
- Sierra Nevadas (3500-4000 m)
- Inyo Mnts (2400-3000 m) and White Mnts (3500-4000 m)
- 150 km long, 15-30 km wide, 1.5-3 km deep

- ISFF flux towers
- ISS wind profilers (MISS)
- Radiosonde from Independence

Synoptic situation

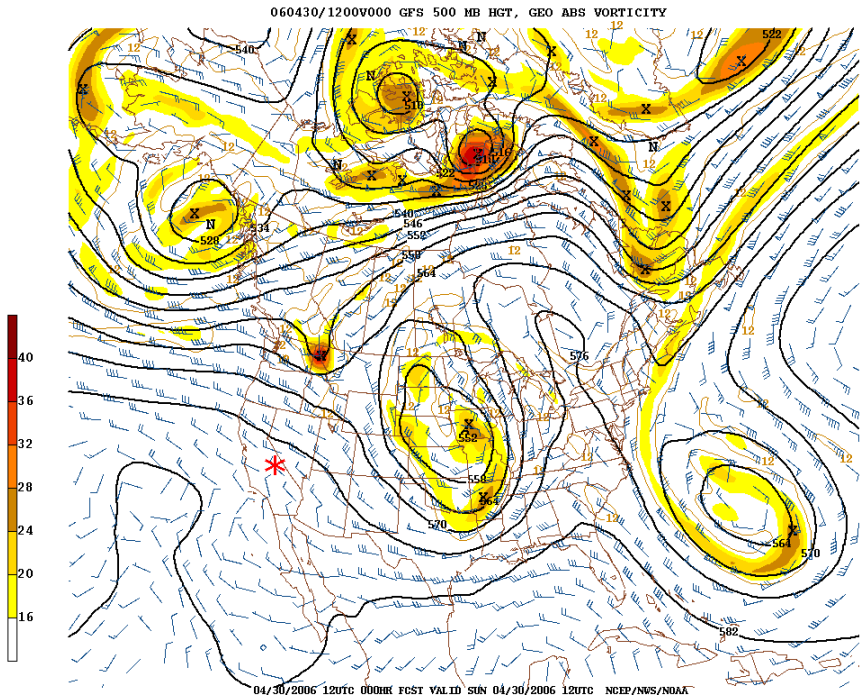
GFS 500 hPa 12 UTC (4 am)

EOP 2



$u(5.5\ \mathrm{km})$: 20 @ 270°

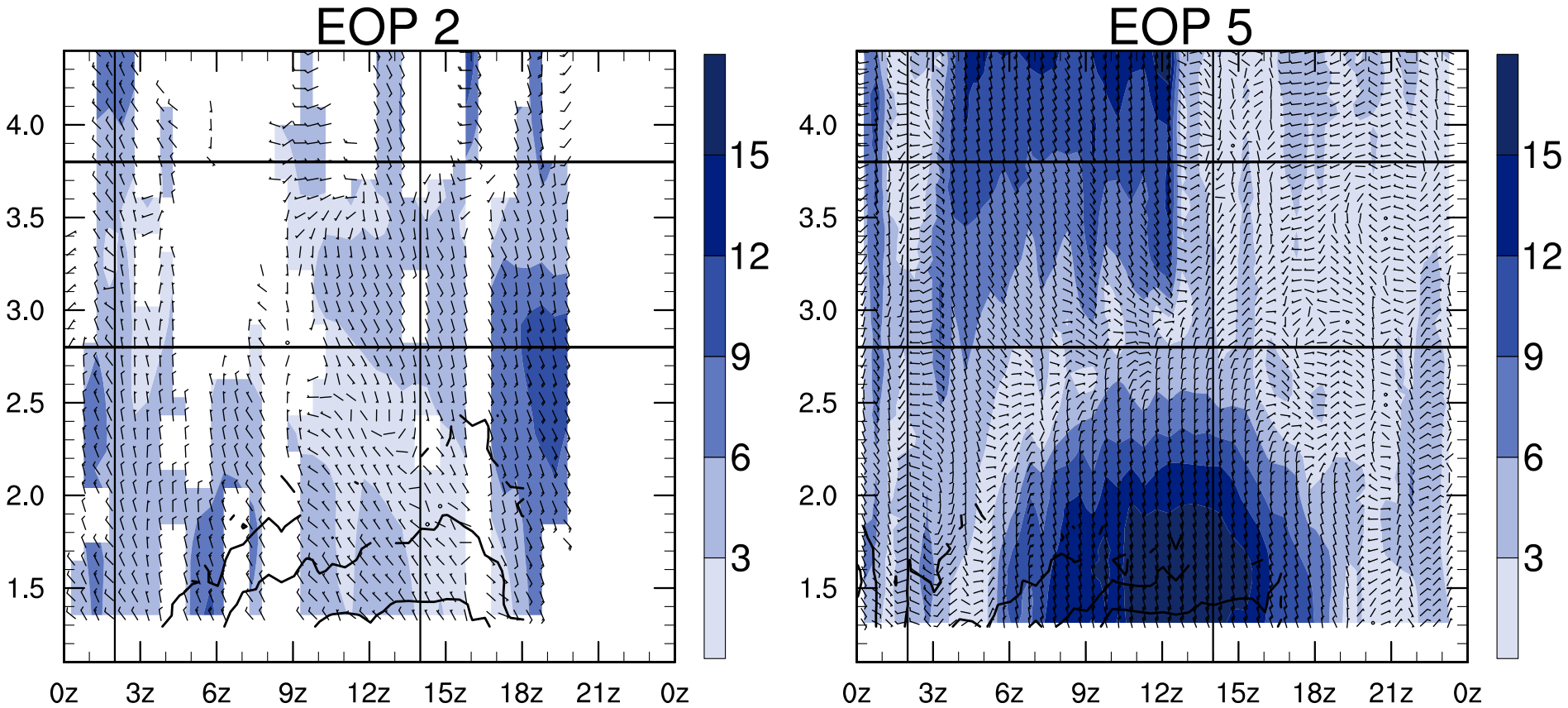
EOP 5



$u(5.5\ \mathrm{km})$: 10 @ 280°

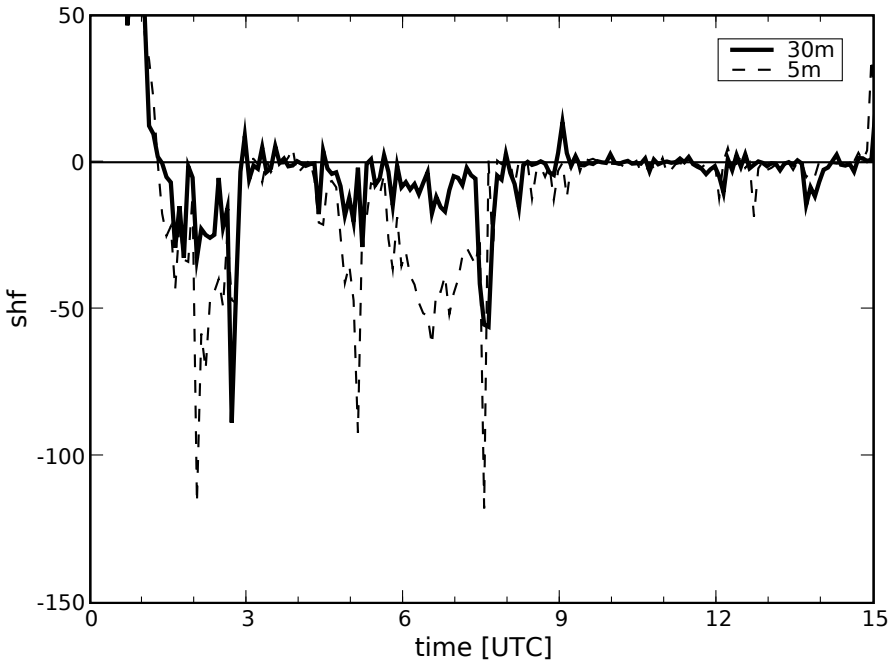
Time-height plot of wind and θ at MISS site

θ contour is 2.5 K



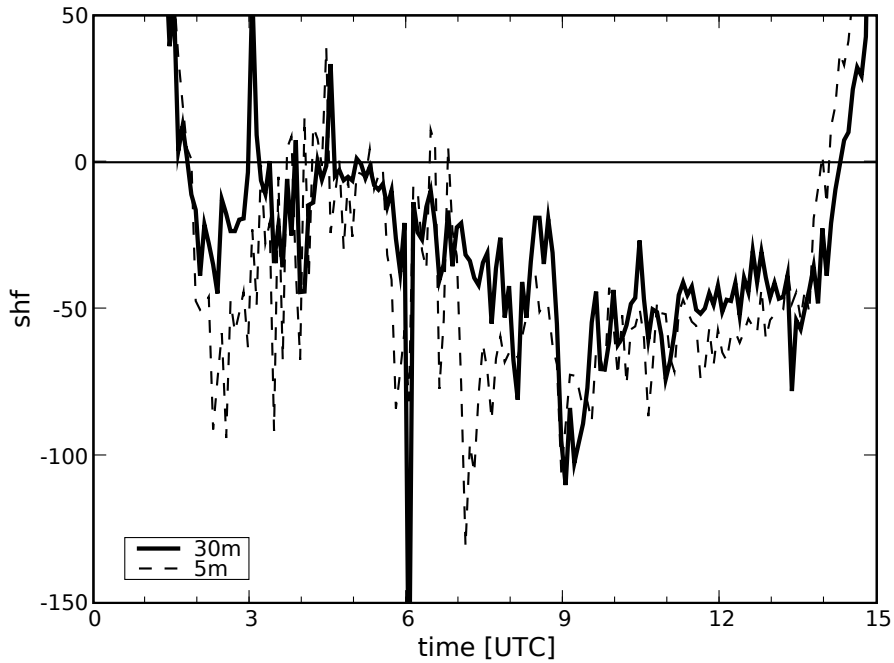
Turbulent heat flux *H* at ISFF central

EOP 2



weak and intermittent
($\overline{H} = -14\ \mathrm{W/m^2}$)

EOP 5



strong and continuous
($\overline{H} = -51\ \mathrm{W/m^2}$)

Simulation Setup and Analysis

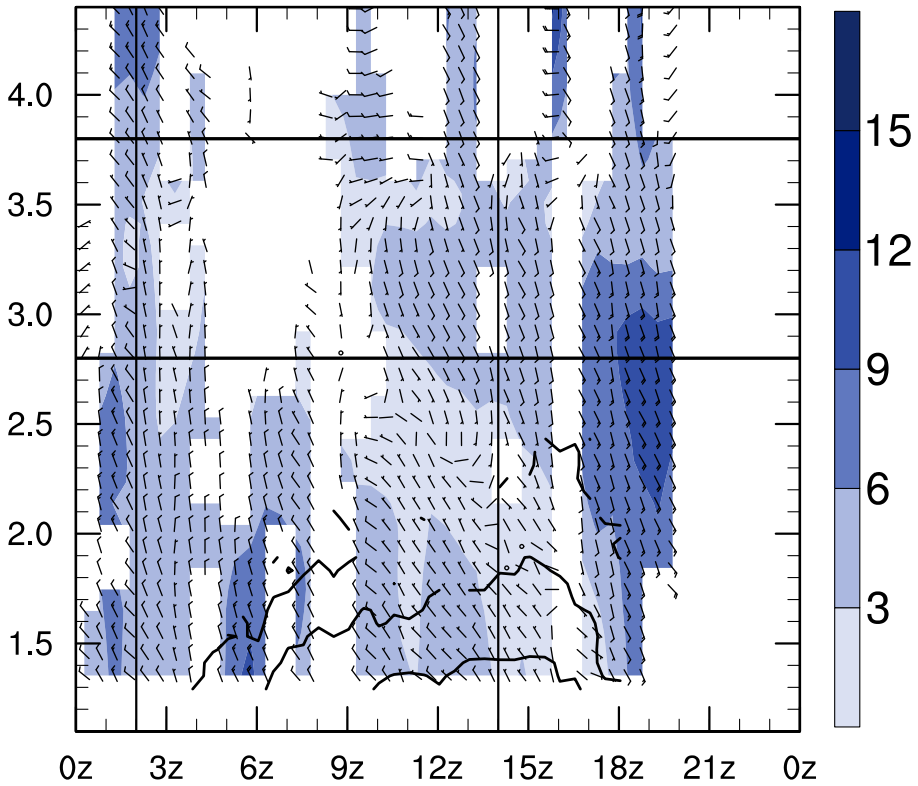
- ARPS in LES mode (1.5 TKE)
- forced by 6 h NAM analyses; one-way nesting
- 4 nested grids (9km, 3km, 1km, 350m)
- integrated for 36 h starting at 12 UTC (4 am)
  (11 h spin-up)

Analysis undertaken so far

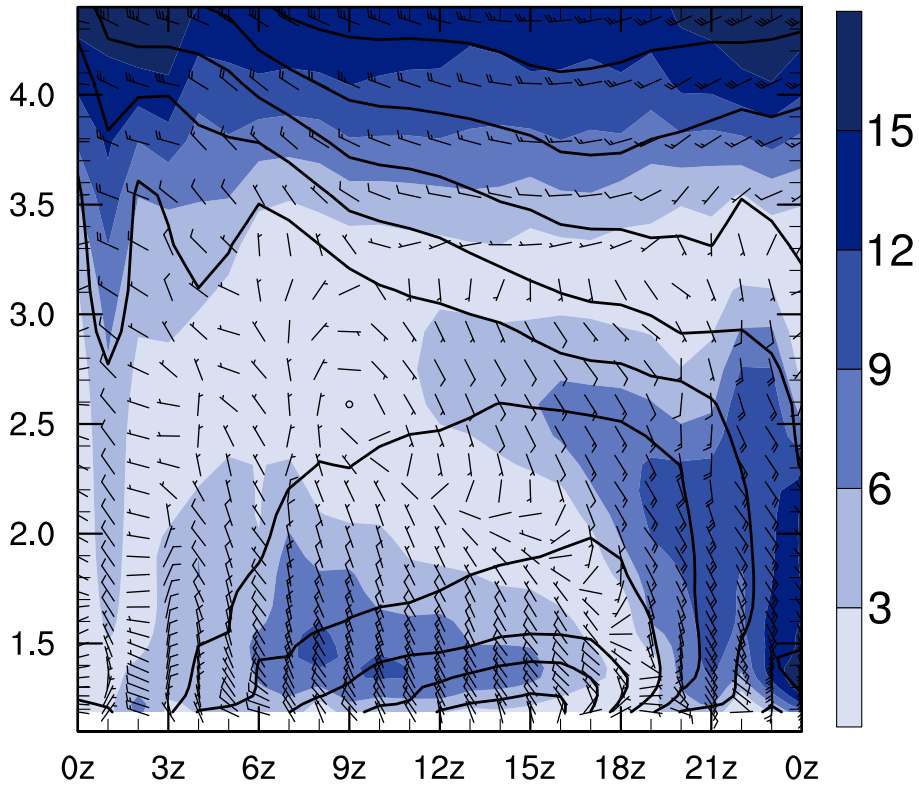
- compared with wind profiler, RASS, radiosonde, flux towers
- radiation and surface energy budgets
- calculated momentum and heat budgets; TAFs

Comparison with MISS: EOP 2

Time-height plot of wind and potential temperature



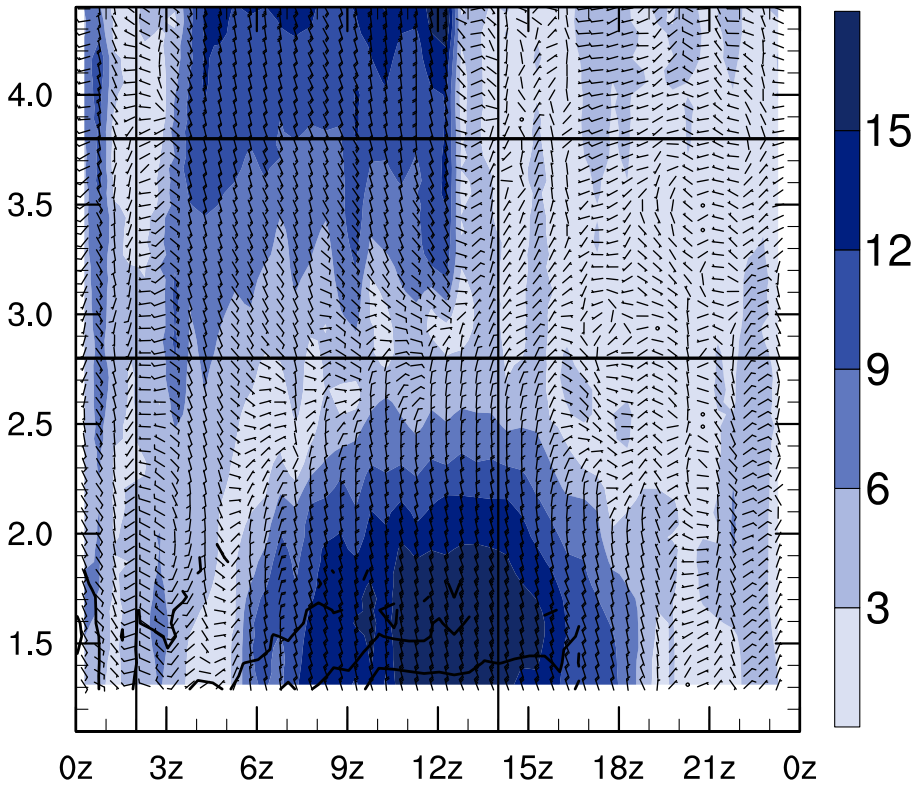
MISS



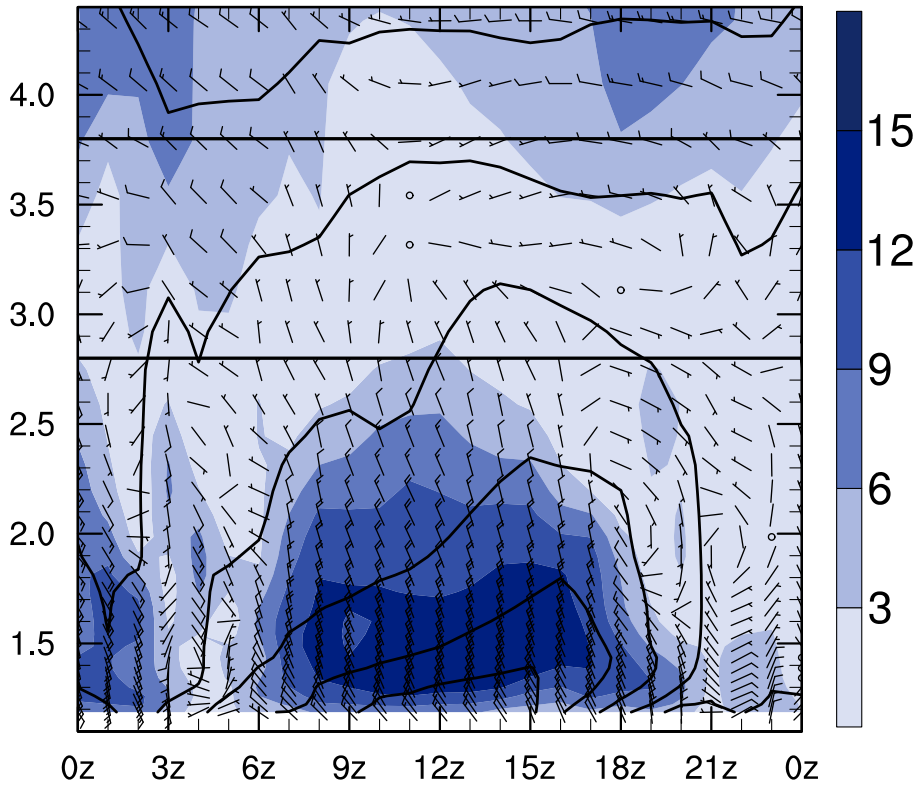
ARPS 1 km

Comparison with MISS: EOP 5

Time-height plot of wind and potential temperature



MISS



ARPS 1 km

Momentum equation for the along-valley wind

Along-valley acceleration (e.g. Mahrt 1982)

$$\frac{Du}{Dt} = \underbrace{-\frac{1}{\rho_0}\frac{\partial p_{\mathrm{ref}}}{\partial x} - \frac{g}{\theta_0}\frac{\partial(\overline{\theta}h)}{\partial x}}_{-\frac{1}{\rho_0}\frac{\partial p}{\partial x}} - F_x$$

where $\overline{\theta}$ is the (vertically integrated) potential temperature deficit

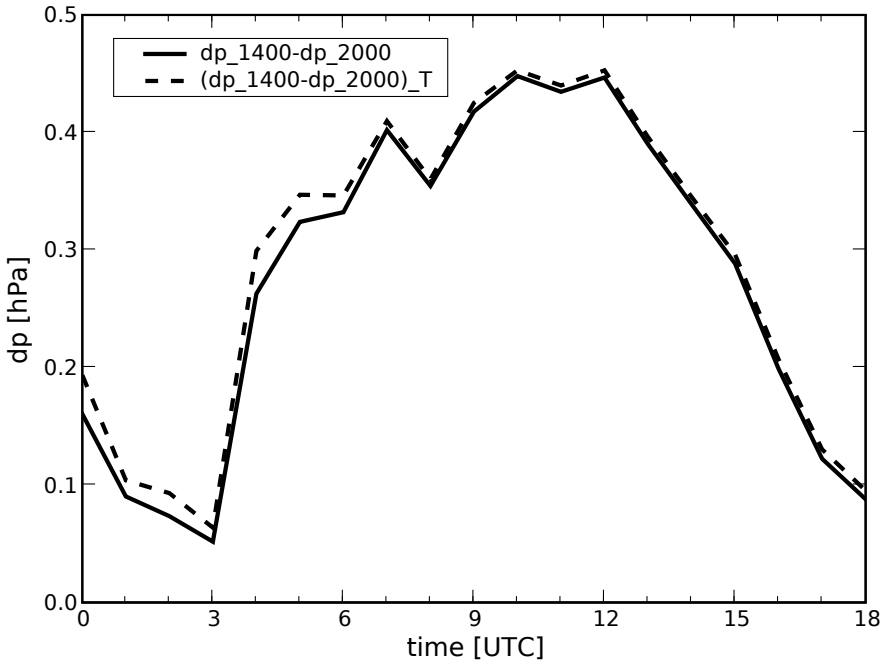
$$\overline{\theta} = \frac{1}{h}\int_z^{z_{ref}} \theta' \, dz'$$

and $h = z_{ref} - z$

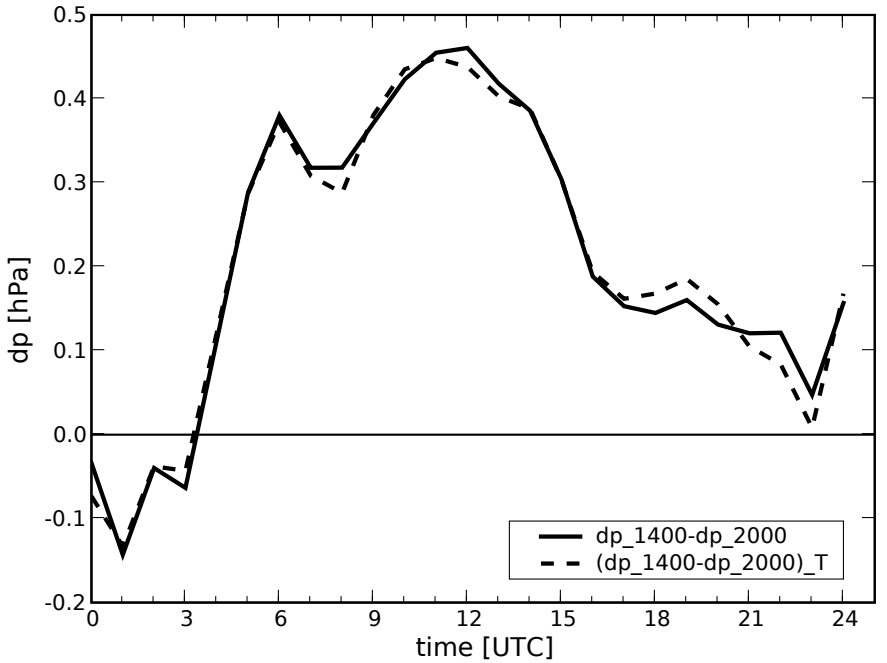
Along-valley forcing: Thermal wind term at 1400 m

$z_{ref} = 2000$ m; Difference between Lone Pine (south) and Bishop (north)

EOP 2



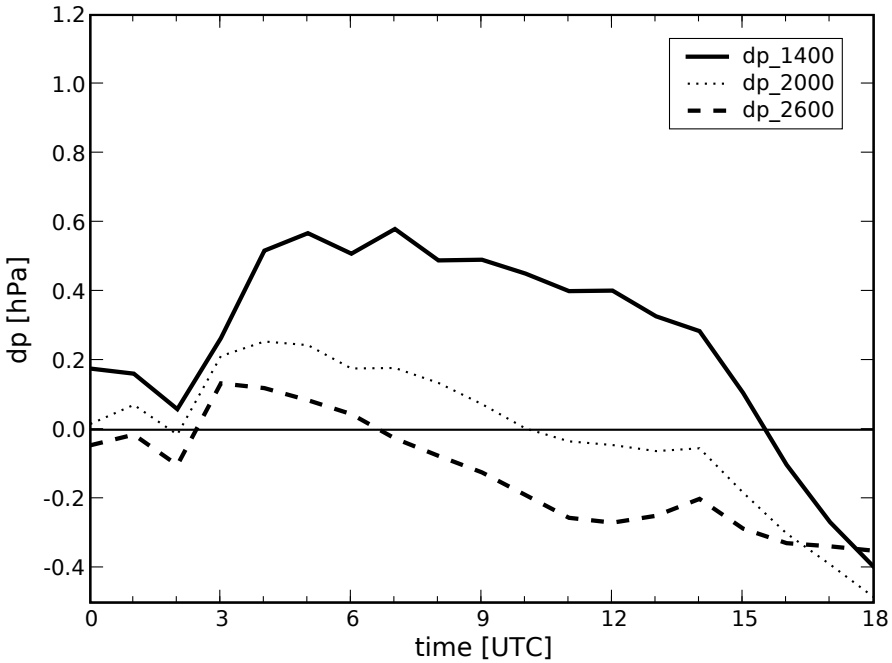
EOP 5



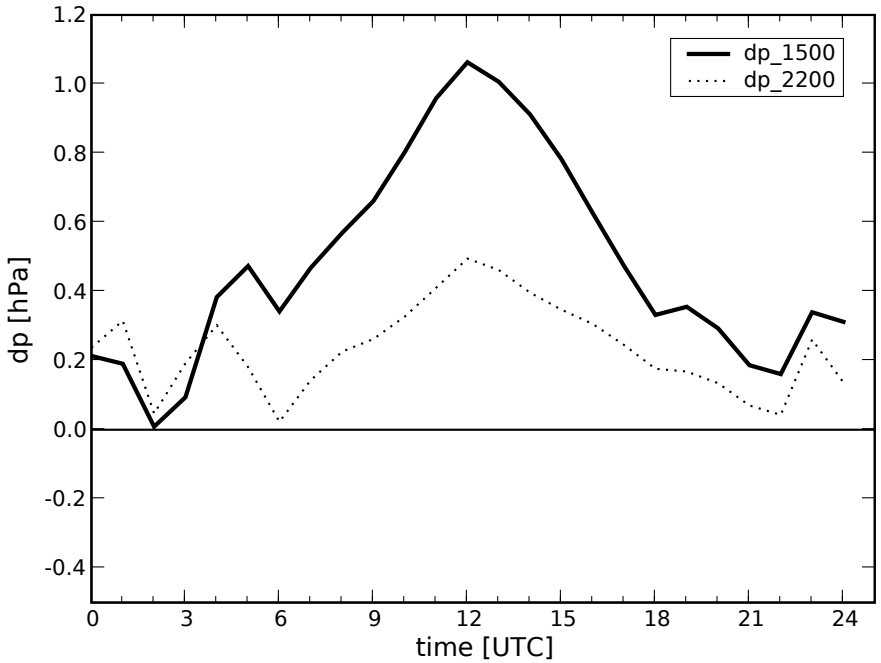
Along-valley forcing: Low- and upper-level PG

between Lone Pine (south) and Bishop (north)

EOP 2

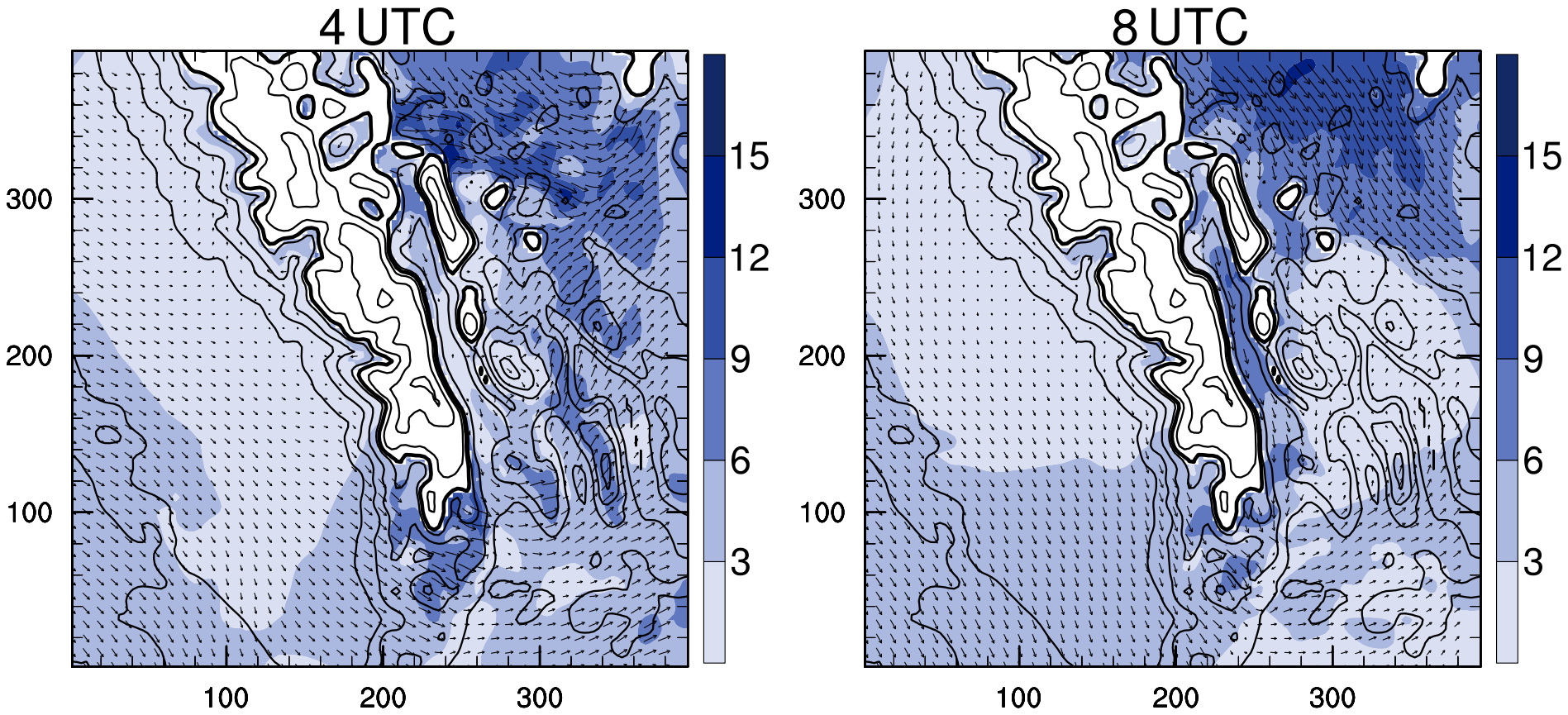


EOP 5



EOP 5: Large-scale forcing

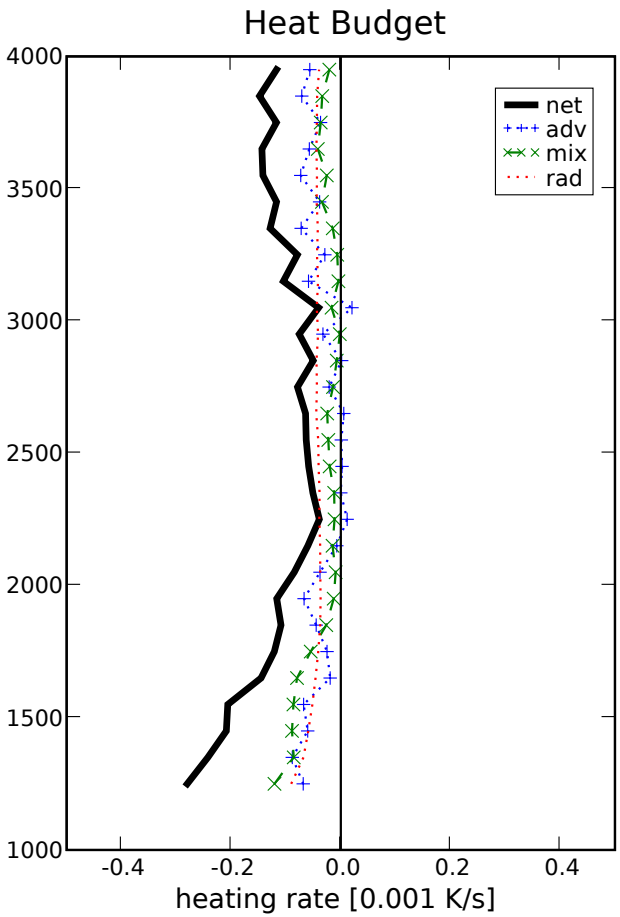
Wind at 2200 m MSL; 3 km domain



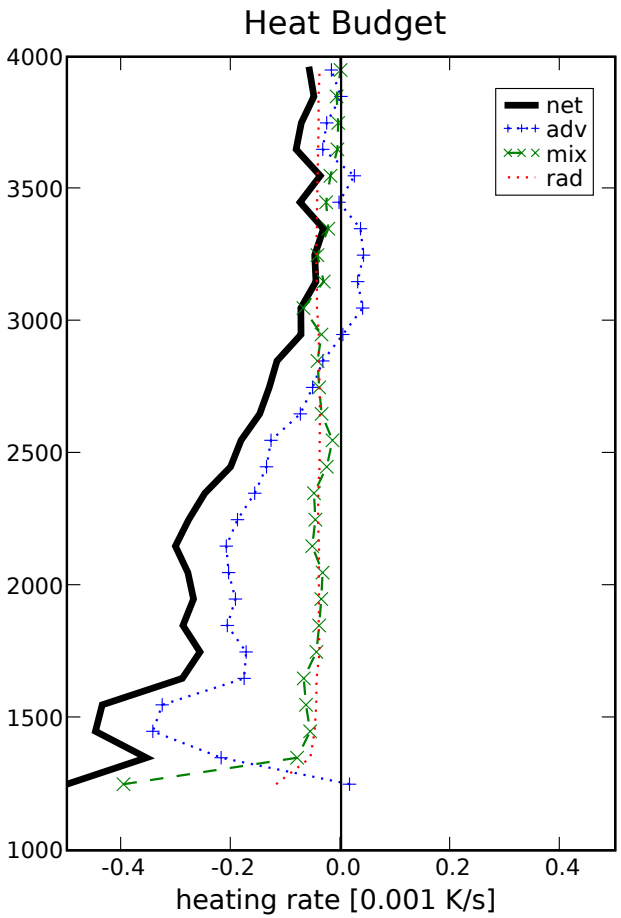
EOP 5: Heat budget components

Time: 5z

South (near ISFF south)



North (near Big Pine)



Conclusions

- All five EOPs have been simulated successfully using ARPS; investigate physical mechanisms leading to observed evolution
- Owens Valley wind system is very susceptible to synoptic influences. Specific geometry (wide; open to north and east above 2200-2500 m)
- EOP 2: upper-level PG opposes low-level thermal forcing $\Rightarrow$ three layer structure
- EOP 5: upper-level PG enhances low-level thermal forcing $\Rightarrow$ strong downvalley wind

Conclusions

- All five EOPs have been simulated successfully using ARPS; investigate physical mechanisms leading to observed evolution
- Owens Valley wind system is very susceptible to synoptic influences. Specific geometry (wide; open to north and east above 2200-2500 m)
- EOP 2: upper-level PG opposes low-level thermal forcing
  $\Rightarrow$ three layer structure
- EOP 5: upper-level PG enhances low-level thermal forcing
  $\Rightarrow$ strong downvalley wind

Conclusions

- All five EOPs have been simulated successfully using ARPS; investigate physical mechanisms leading to observed evolution
- Owens Valley wind system is very susceptible to synoptic influences. Specific geometry (wide; open to north and east above 2200-2500 m)
- EOP 2: upper-level PG opposes low-level thermal forcing
  $\Rightarrow$ three layer structure
- EOP 5: upper-level PG enhances low-level thermal forcing
  $\Rightarrow$ strong downvalley wind

Conclusions

- All five EOPs have been simulated successfully using ARPS; investigate physical mechanisms leading to observed evolution
- Owens Valley wind system is very susceptible to synoptic influences. Specific geometry (wide; open to north and east above 2200-2500 m)
- EOP 2: upper-level PG opposes low-level thermal forcing
  $\Rightarrow$ three layer structure
- EOP 5: upper-level PG enhances low-level thermal forcing
  $\Rightarrow$ strong downvalley wind