Southern California 'Sundowner' Events: Simulation Studies

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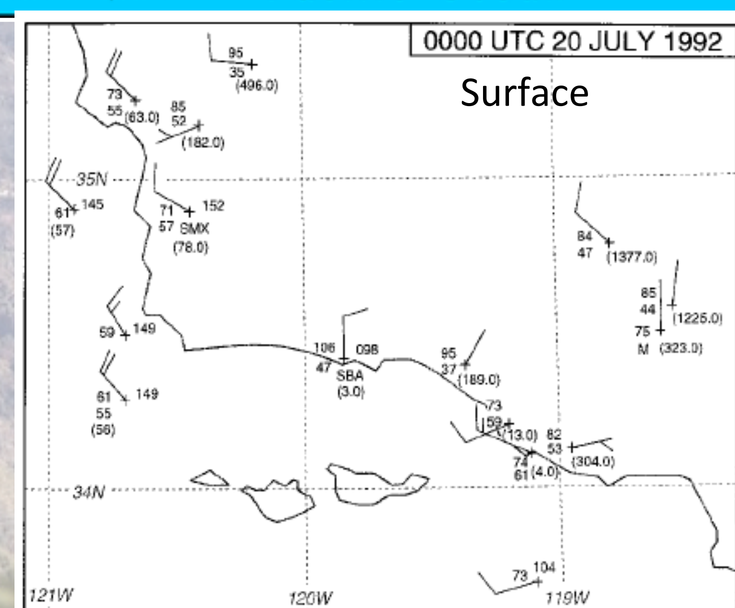
Sundowner Winds

- Local heating/wind events confined in/near Santa Barbara
- T rises of 10-25°C in a few hrs
- High winds up to 25-35 m/s may or may not occur
- Often associated with wildfires
- 1859 Sundowner in Goleta
  - Temperature 133°F (56° C); US record maximum temperature until 1913
  - Heating occurred in a matter of minutes w/ gusty NW winds



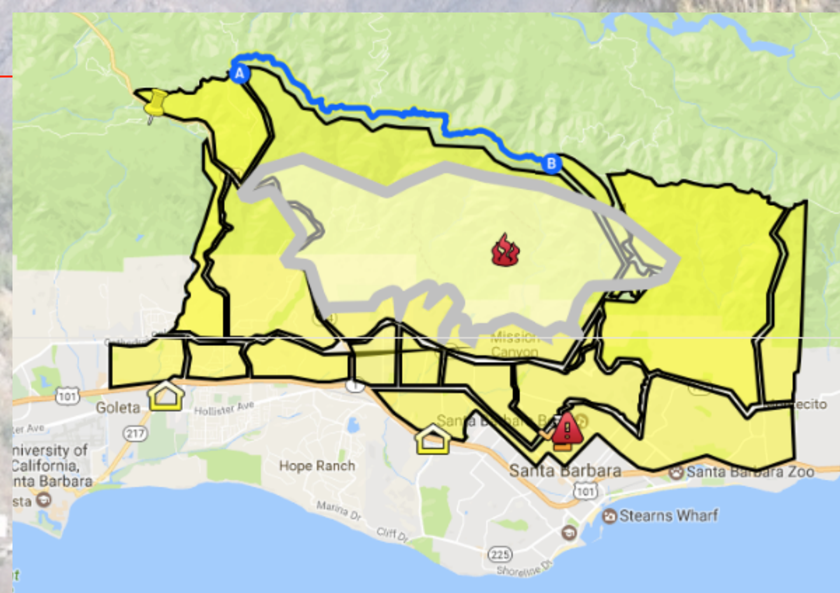
Cases Shown Today

19 July 1992

- Studied by Blier (1998). Maximum T difference between SBA and SMX was 19.4^{o}C at 00 UTC 20 July.

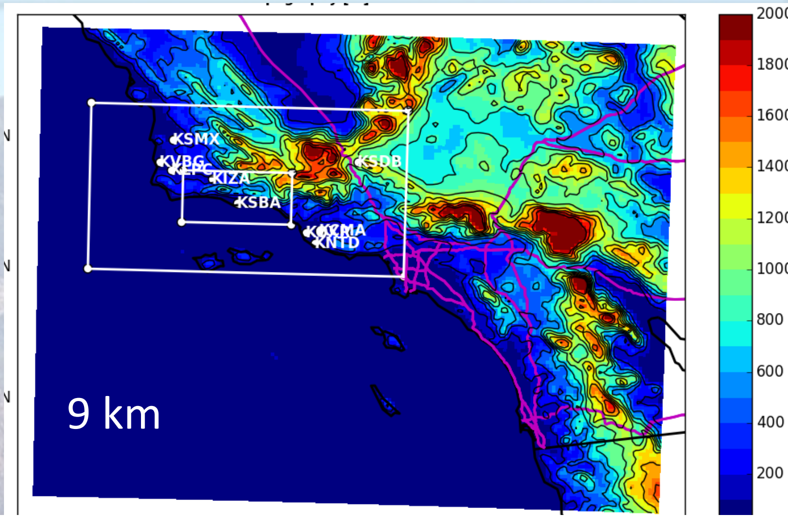
Jesusita Fire, 6-7 May 2009

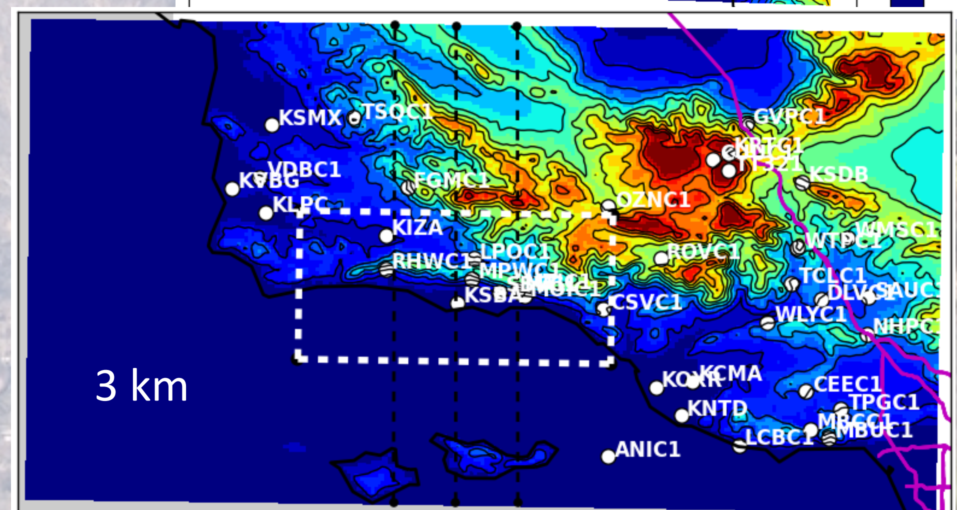
- Simulation covers from 00 UTC 6 May – 06 UTC 7 May. Fire was sparked by human activities (weed wacker) but NW Sundowner winds > 25 m/s beginning mid-PM contributed to fire spread

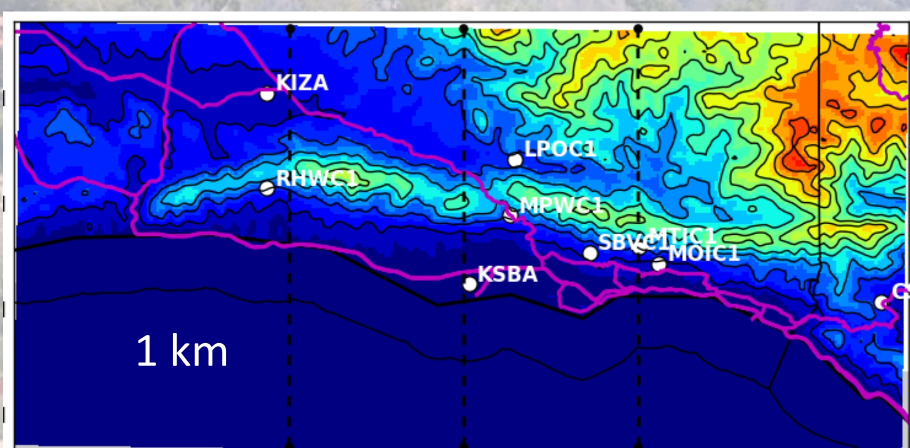


Small Domain Configuration

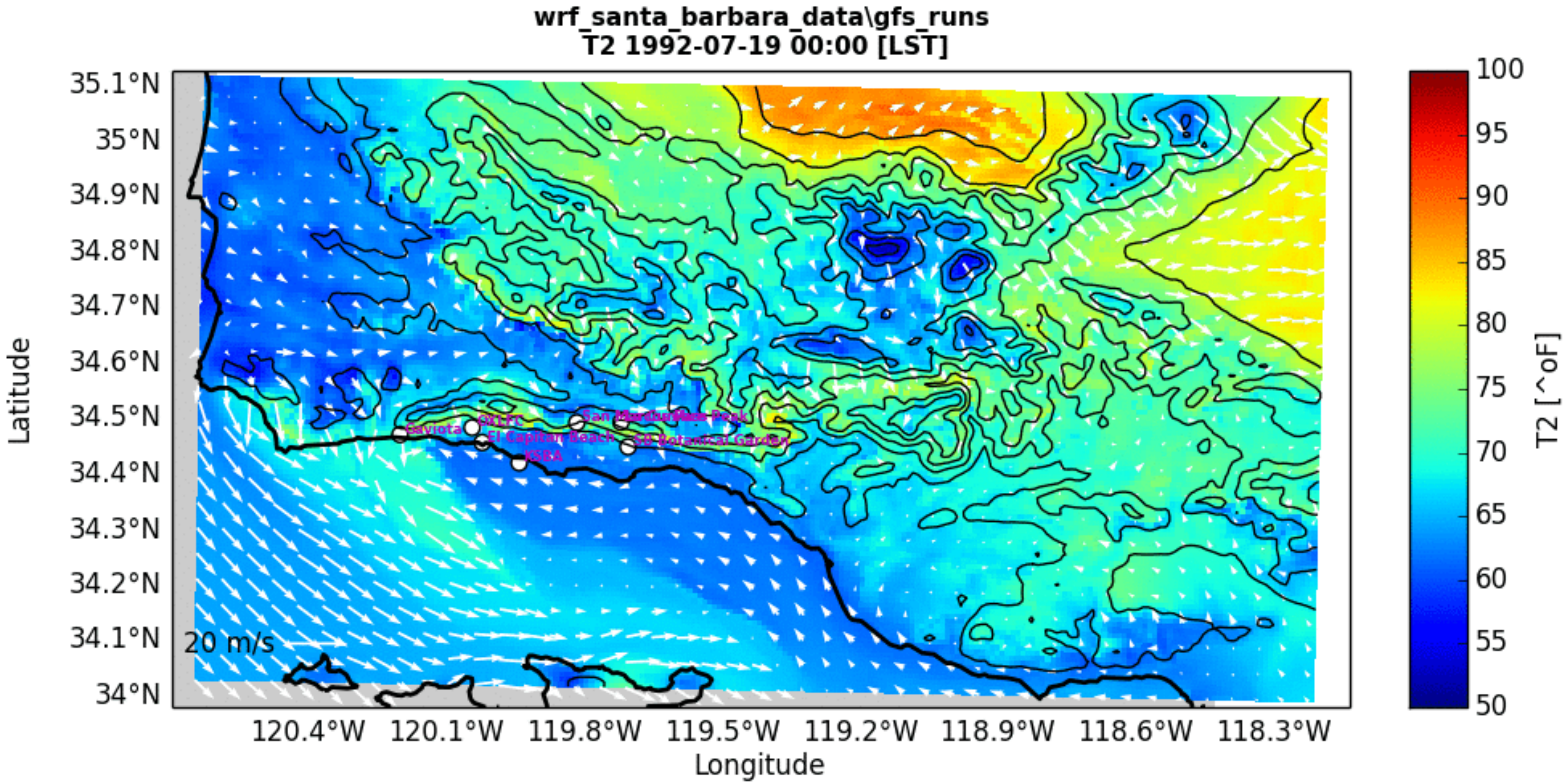
- ✓ WRF3.6.1 : *27/9/3/1 km, 50 levs*
- ✓ *GFS or FNL initialization*
- ✓ Ferrier microphysics;
- ✓ RRTMG longwave and shortwave
- ✓ Unified NOAH land surface scheme
- ✓ *Kain/Fritsch cumulus*
- ✓ YSU PBL/Janjic Eta surface layer
- ✓ *Vertical velocity damping*
- ✓ *Diffusion: Full w/2-D deformation*







19 July 1992 (Blier 1998) Sundowner Case



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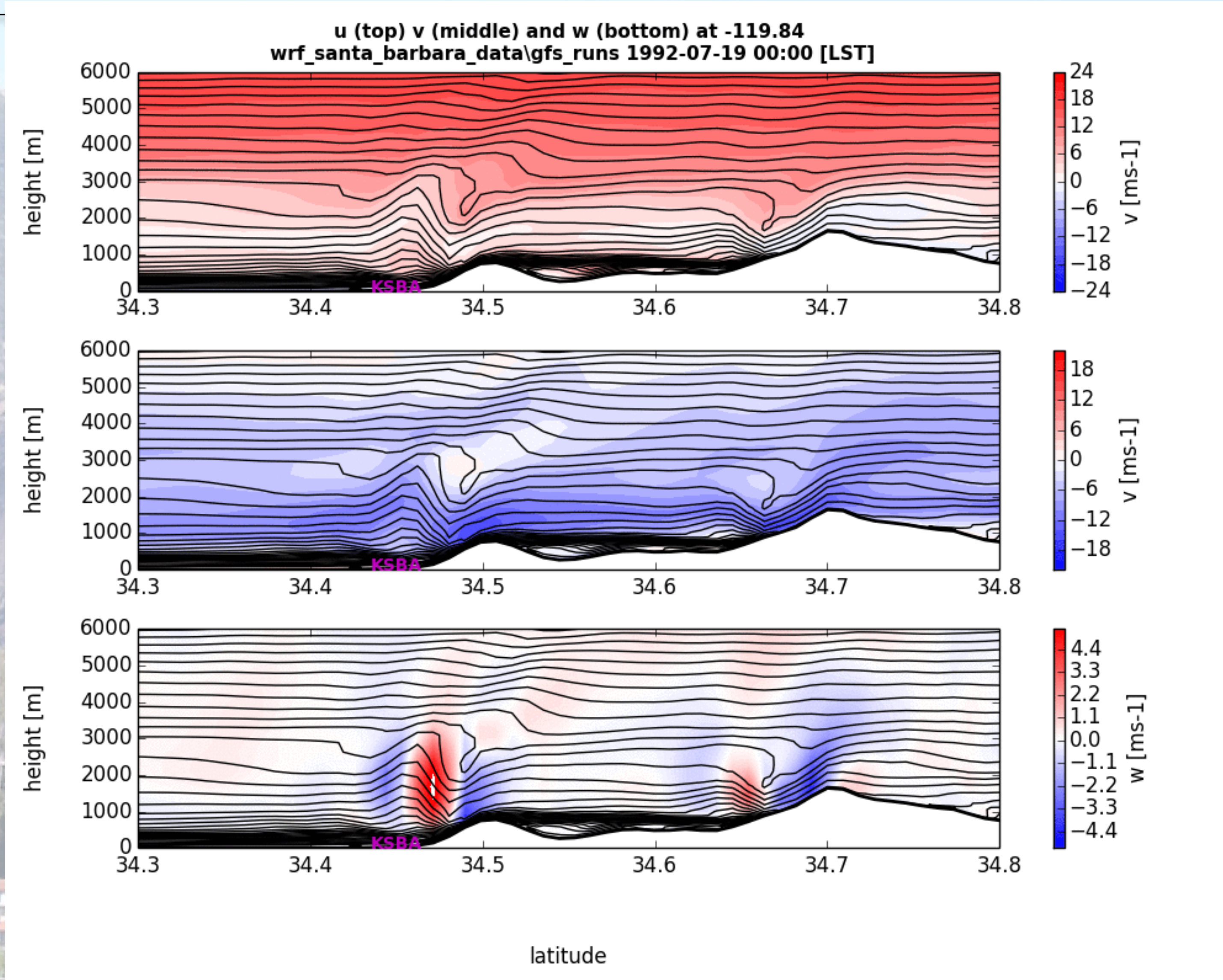
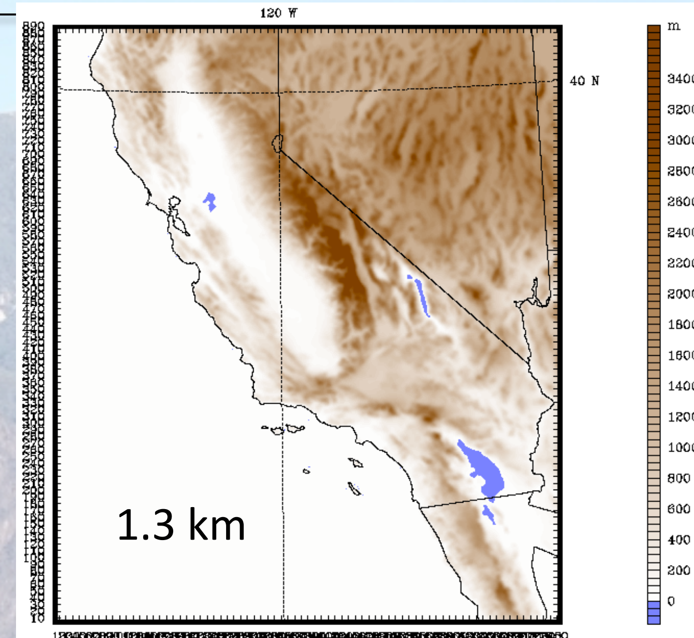
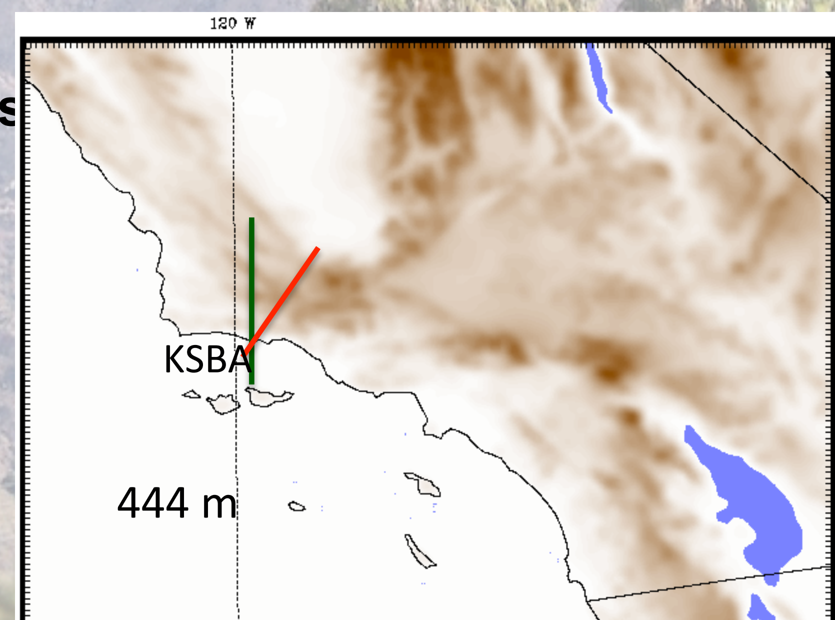


- Upstream: weaker/stronger/weaker upstream of both ranges but especially Santa Ynez
- IGW generation with evidence of vertical propagation and nonlinear effects, including possible hydraulic jumps, breaking waves, etc.

Large Domain Configuration

- ✓ **WRF3.6.1: 4/1.33/0.444 km, 75 levels**
- ✓ **NAM Operational Analysis Initialization**
- ✓ **Slope and topography shading effects**
- ✓ **No cumulus scheme**
- ✓ **MYJ PBL/ Janjic Eta surface layer**
- ✓ **Diffusion: Simple along model levels constant diffusion coefficients**



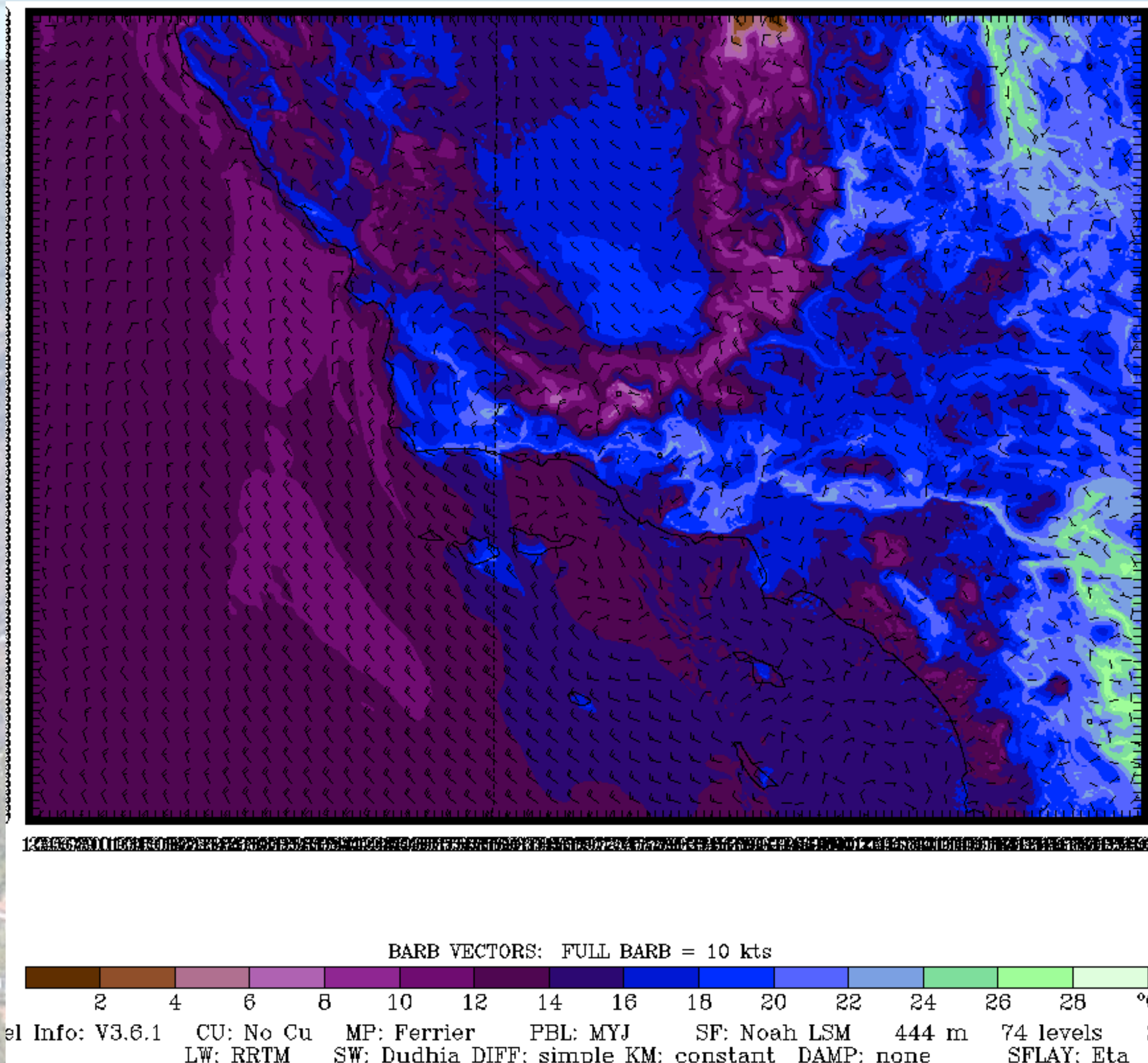


Jesusita Surface T/winds 15-23 UTC 6 May

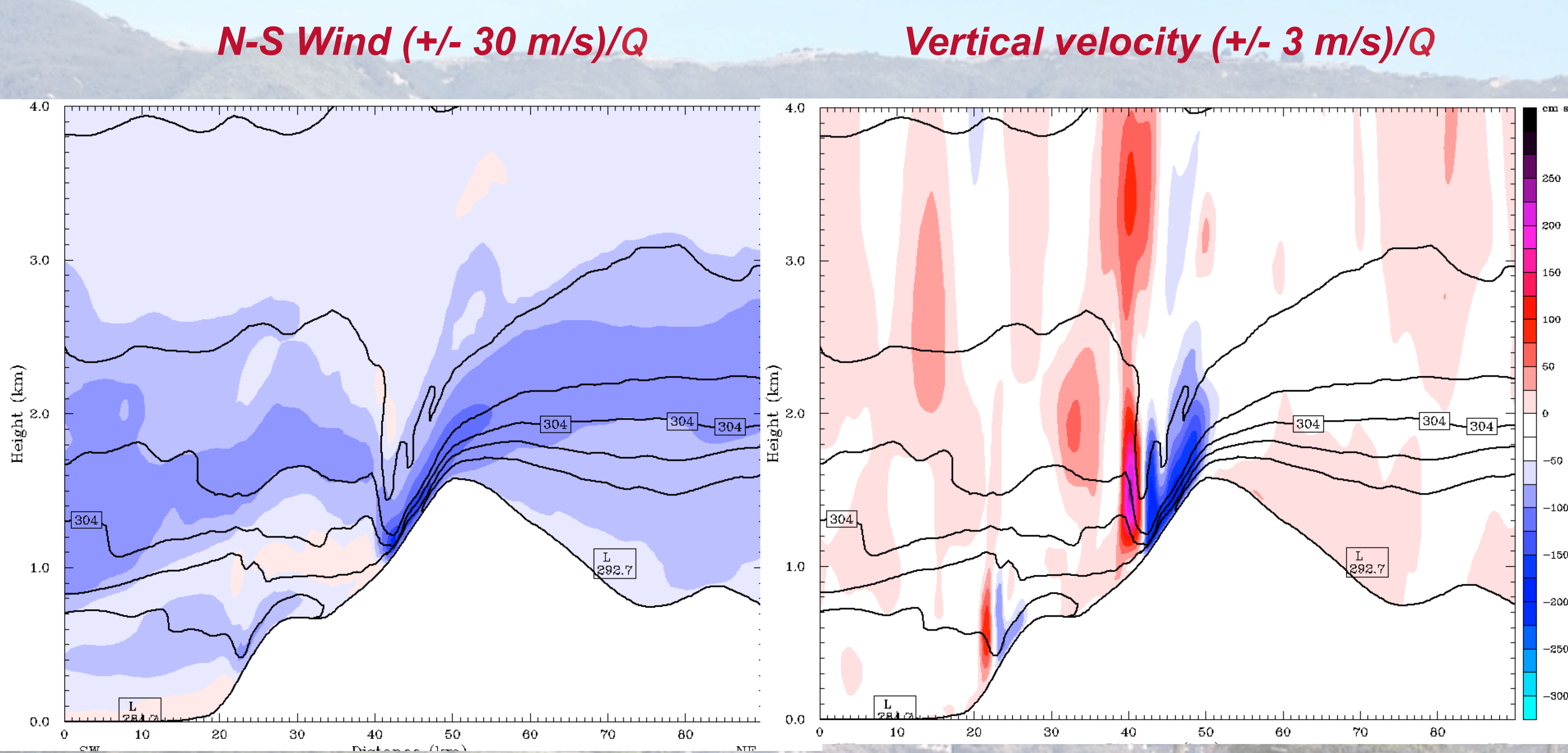
2m T(°C)

10m winds (barbs)

444m Grid



Jesusita Cross Sections 15 UTC 5/6 to 04 UTC 5/7



- Upstream: weak stability capped by stable layer and then another weakly stable layer
- Similar to 1992 case with suggestion of nonlinear IGW dynamics but with clear and persistent hydraulic jump
- Hydraulic jump propagates downslope and reforms/repropagates over time
- Intermittent weak solenoids; suggestion of vertical GW propagation later in PM.

Summary of Baseline Results

- Large scale upper ridge over Pacific w/generally SW-NW 500 hPa flow during event (often ~zonal) and NW-NE flow at 700 hPa

- Upstream stability/shear favors IGW dynamics and nonlinear effects, including hydraulic jumps which propagate down Santa Ynez range.

- IGWs (sometimes trapped) force much of the strong, gusty downslope winds.

- Weak solenoidal circulations that help modulate downslope and provide intermittency during the event at some locations.

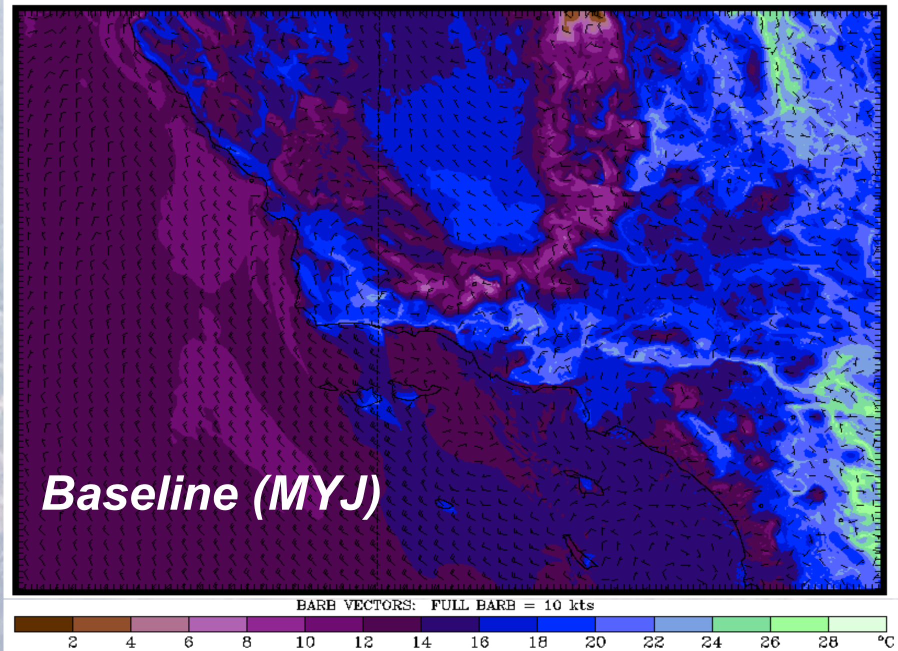
- Marine layer has difficult time re-establishing at coast.

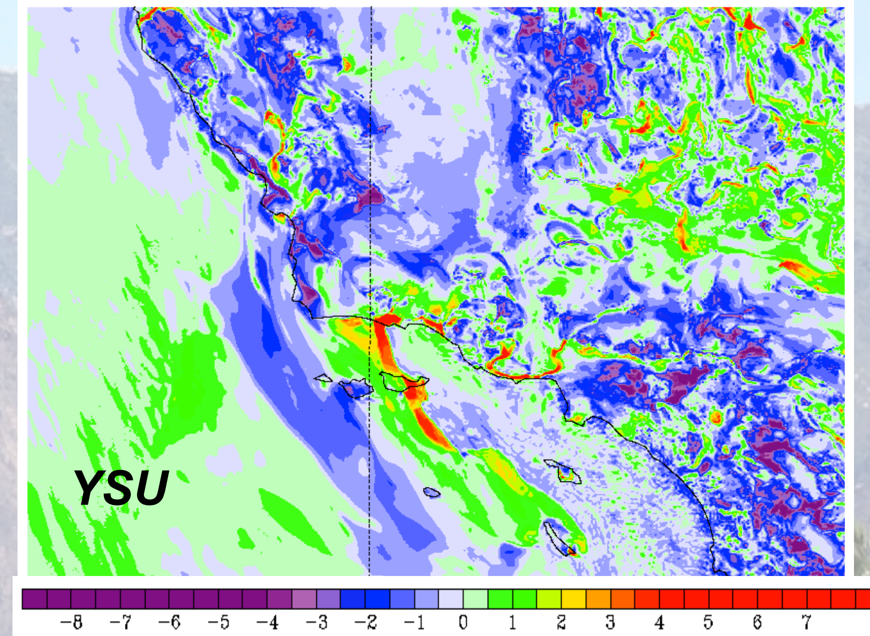
Sensitivity Studies: Jesusita Case

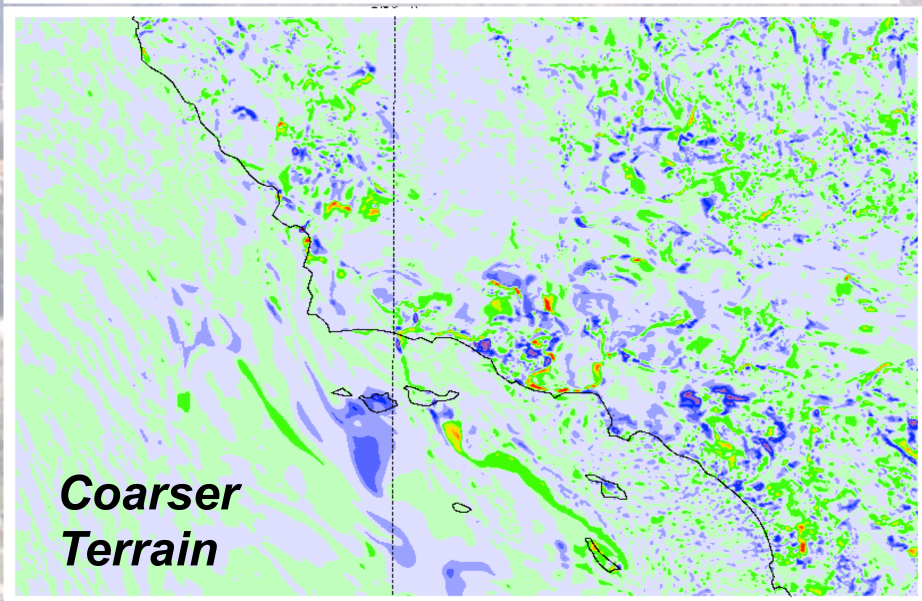
- Evaluate best configuration for operational forecasts
- Planetary Boundary and Land Surface Scheme
  - Baseline: Mellor-Yamada-Janjic (MYJ) PBL + Unified NOAH LSM
  - YSU PBL (Hong et al. 2006; Hong and Kim 2008)
  - Mellor-Yamada-Nakanishi-Niino (MYNN/2; Nakanishi and Niino 2004;2006)
  - TEMF (Angevine et al. 2010)
  - RUC Land surface scheme (Smirnova et al 1997,2000, 2015)
- Ocean Physics and Terrain
  - Simple Mixed Layer Ocean Model (Pollard, Rhines, Thompson 1972)
  - Terrain Degradation
    - Replace 30-second terrain with 2-minute terrain
- Data Assimilation
  - Nudging FDDA
  - 6 hr 3DVAR Cycling

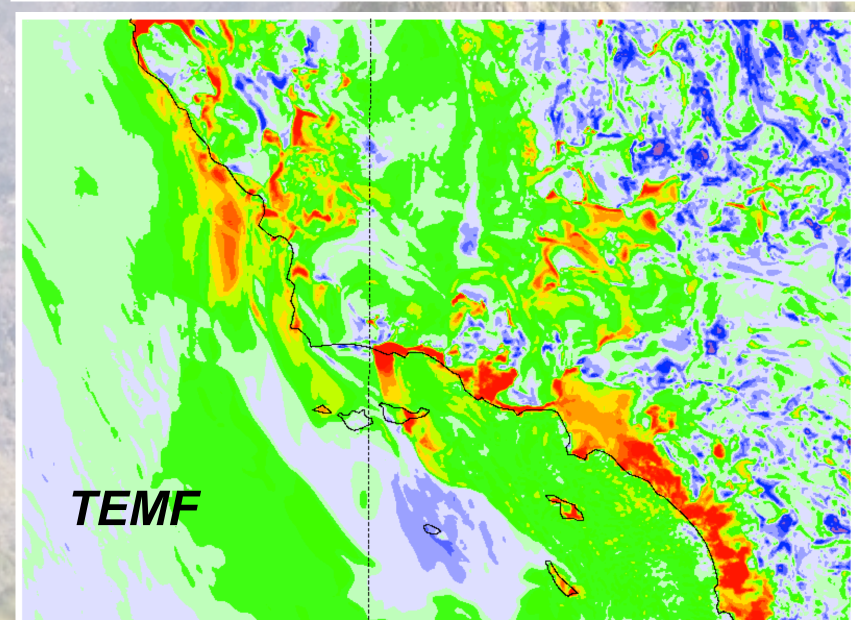
Results: Jesusita Case: 15UTC 5/6/09 Difference Maps

Surface Temperature (oC); Warm colors=> Warmer than Baseline



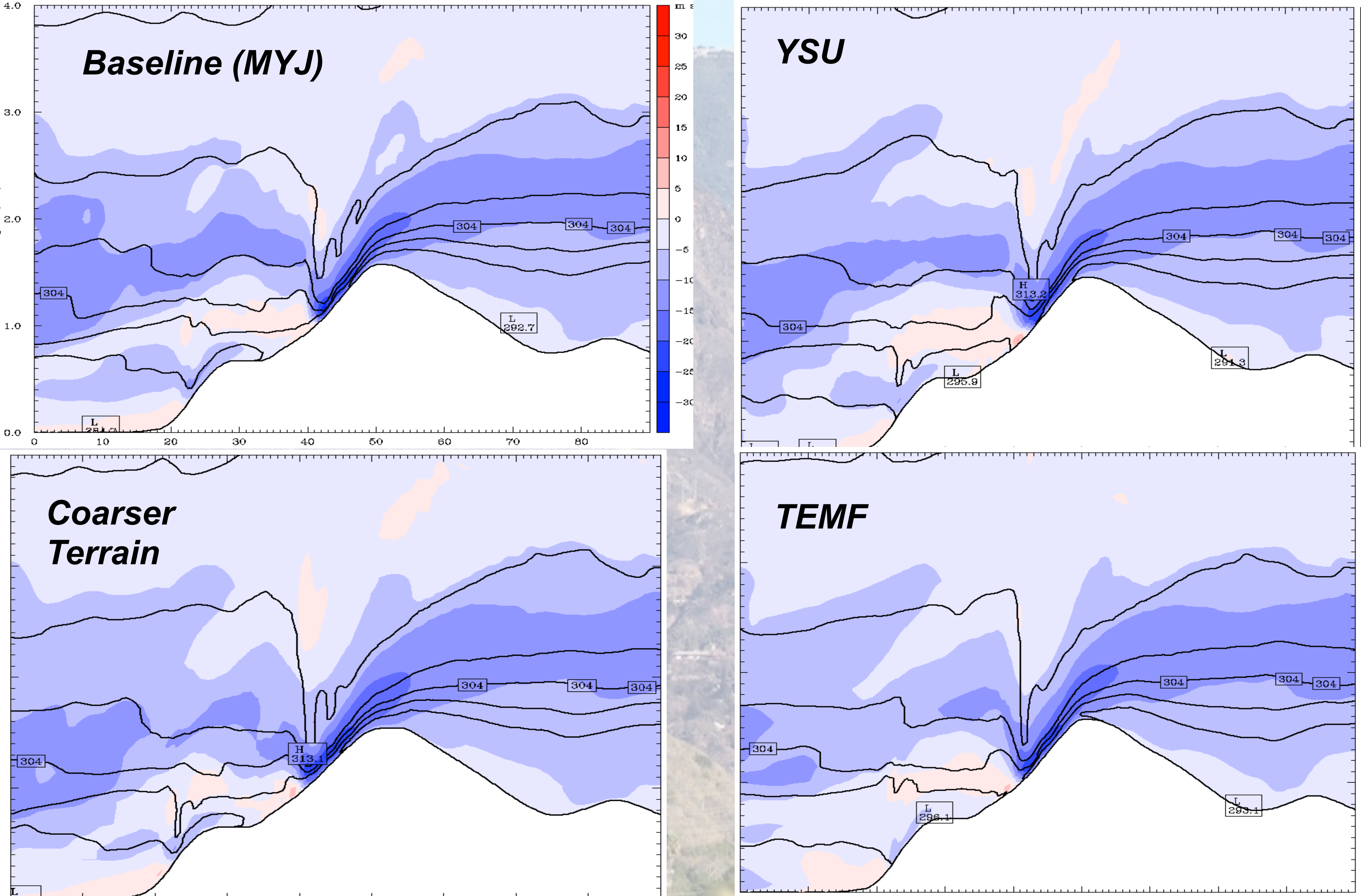






Results: Jesusita Case: 15UTC 5/6/09 Cross Sections

N-S Wind (+/- 30 m/s)/Q



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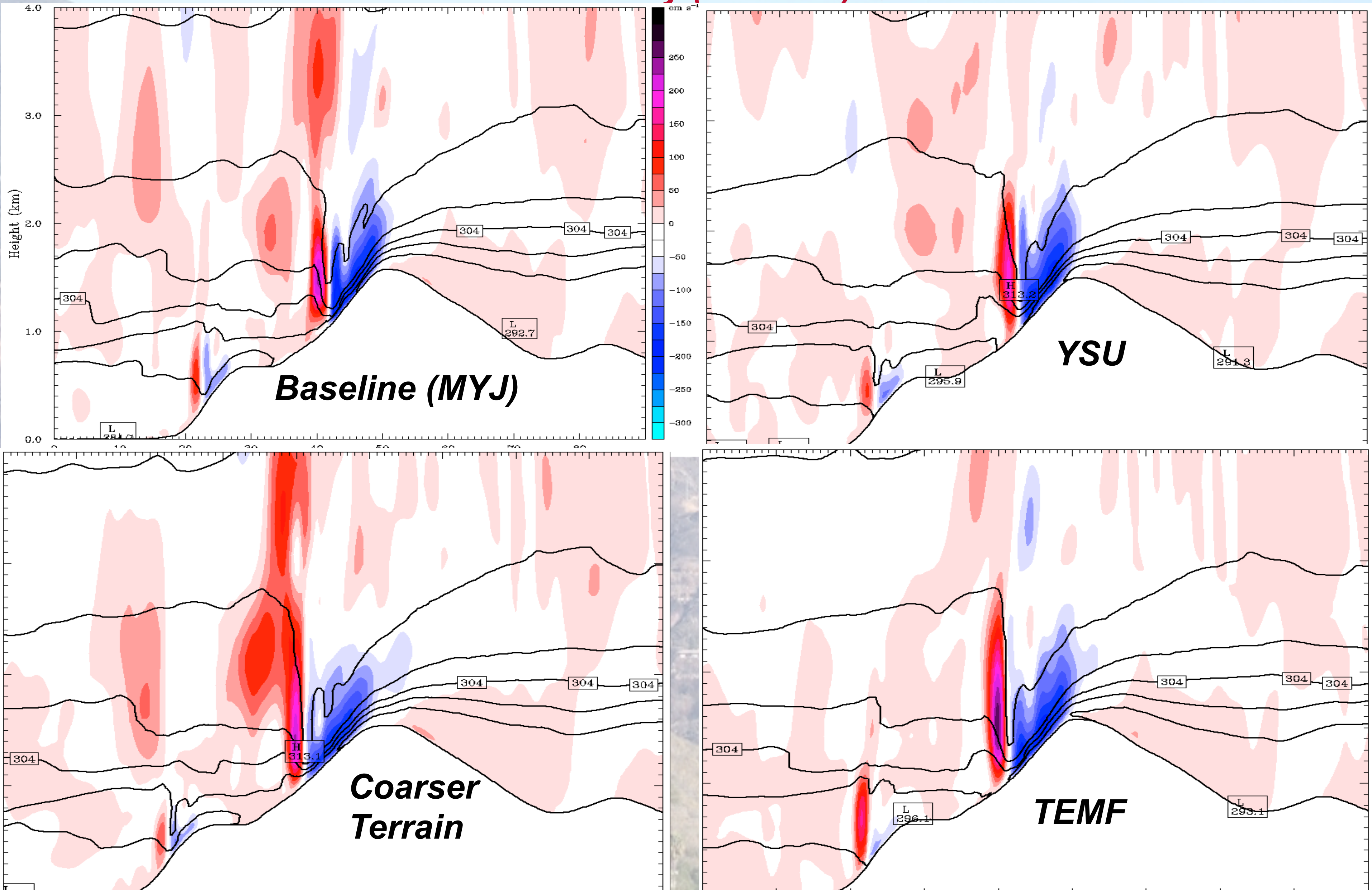
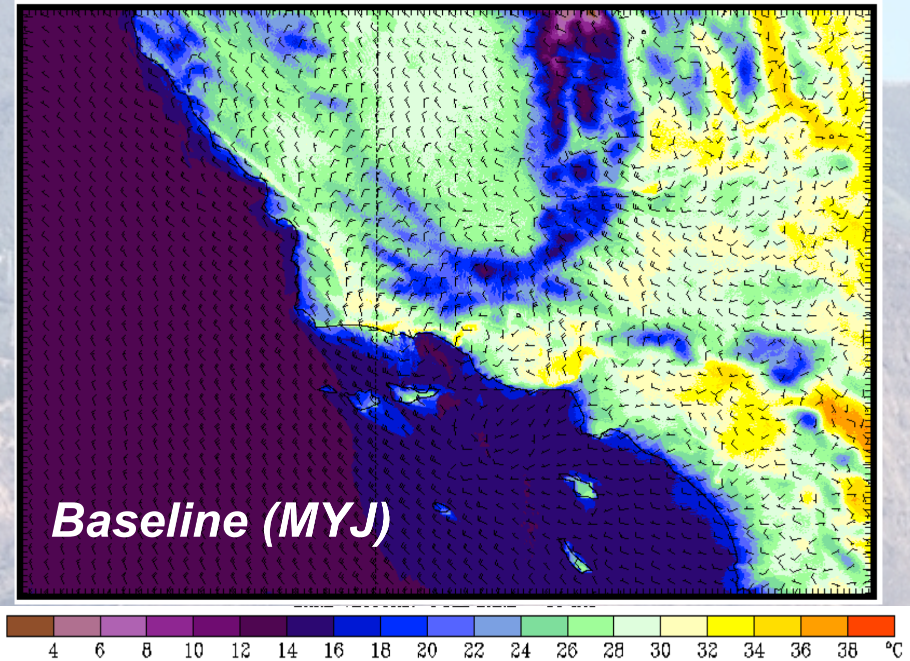
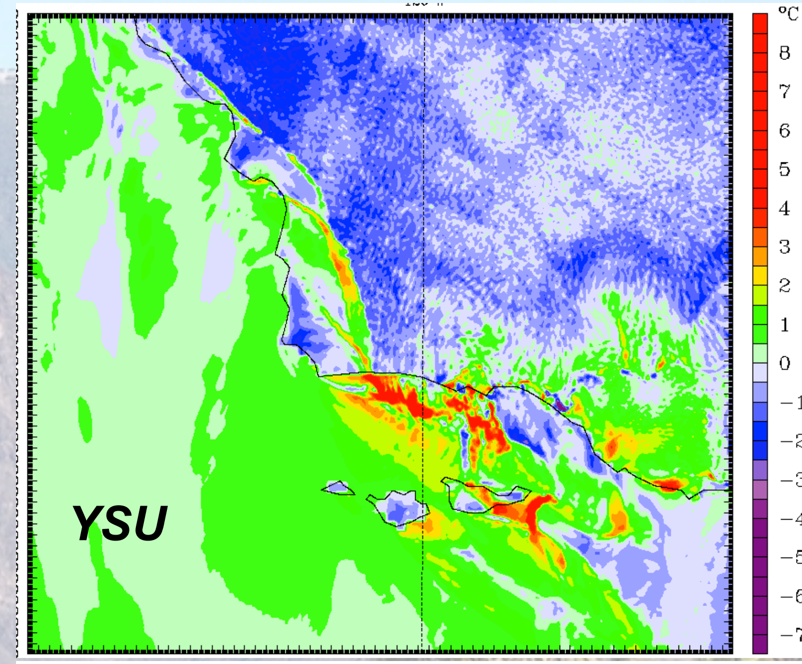
Vertical velocity (+/- 3 m/s)/Q

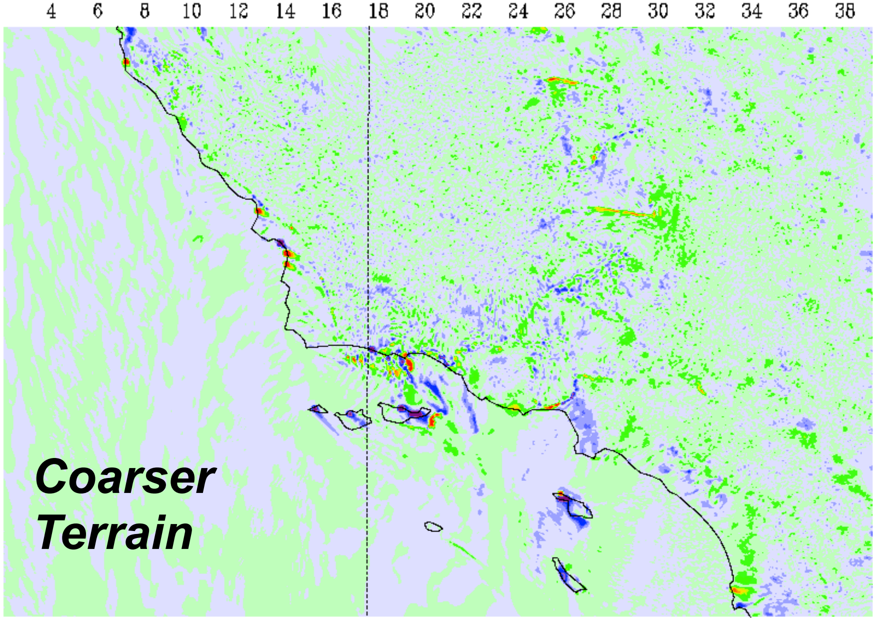


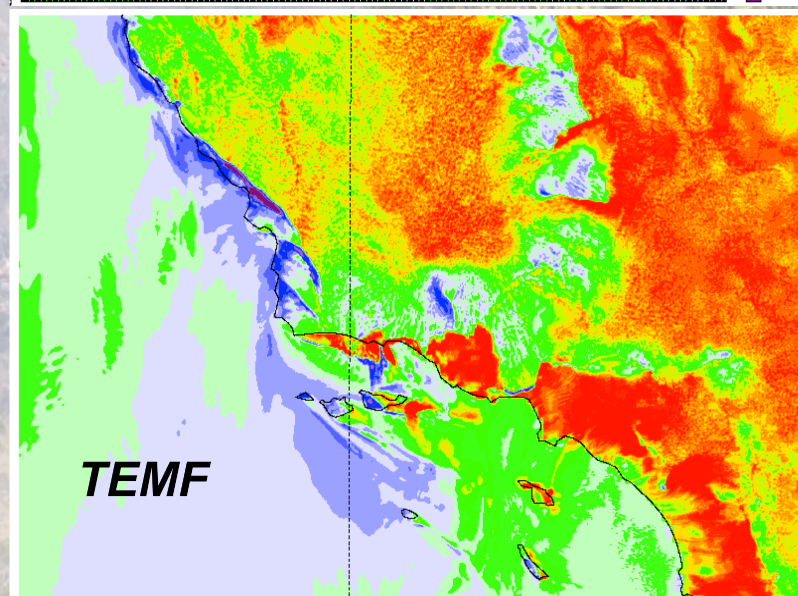
Results: Jesusita Case: 21UTC 5/6/09 Difference Maps

Surface Temperature (oC); Warm colors=> Warmer than Baseline









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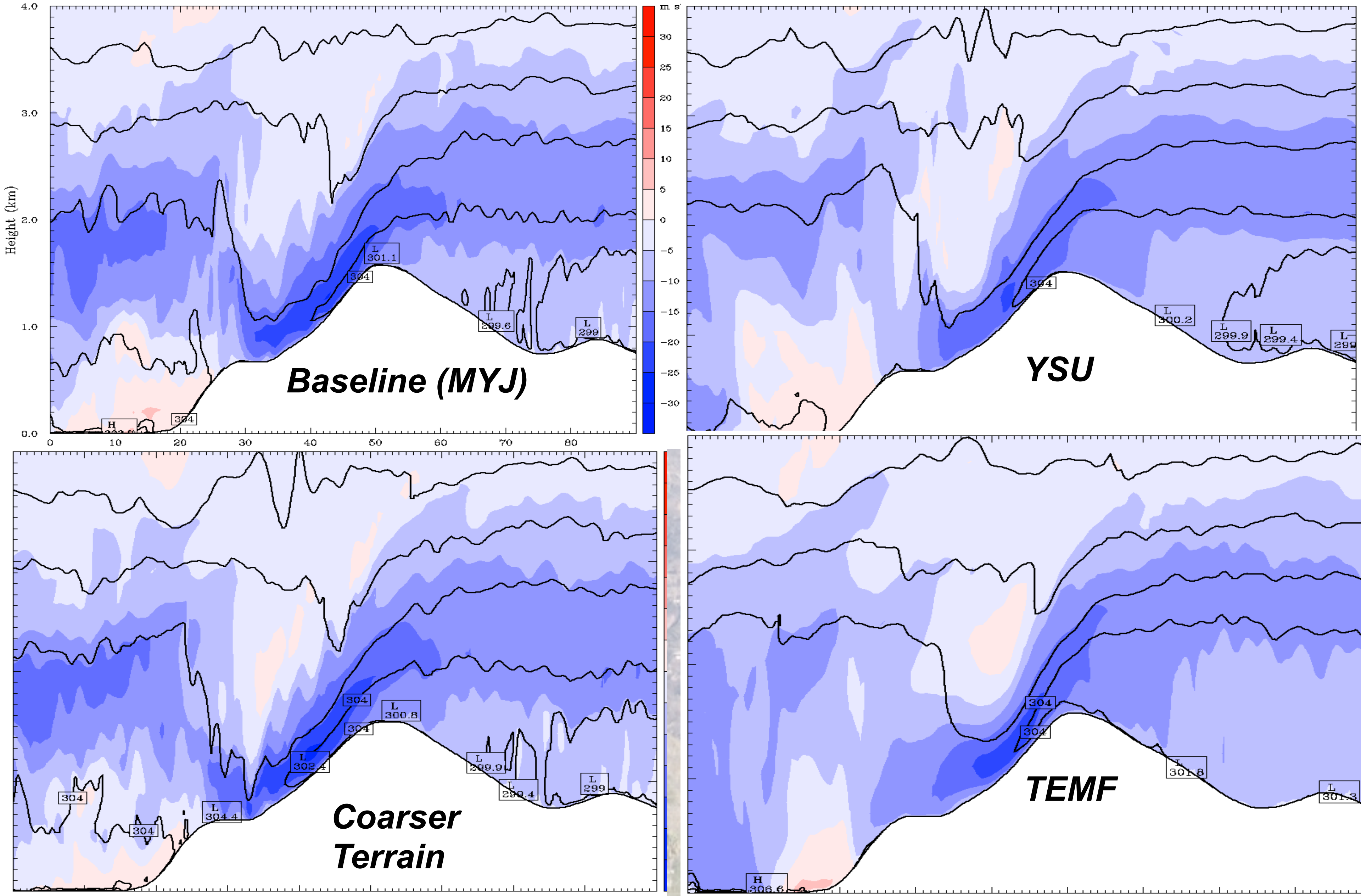
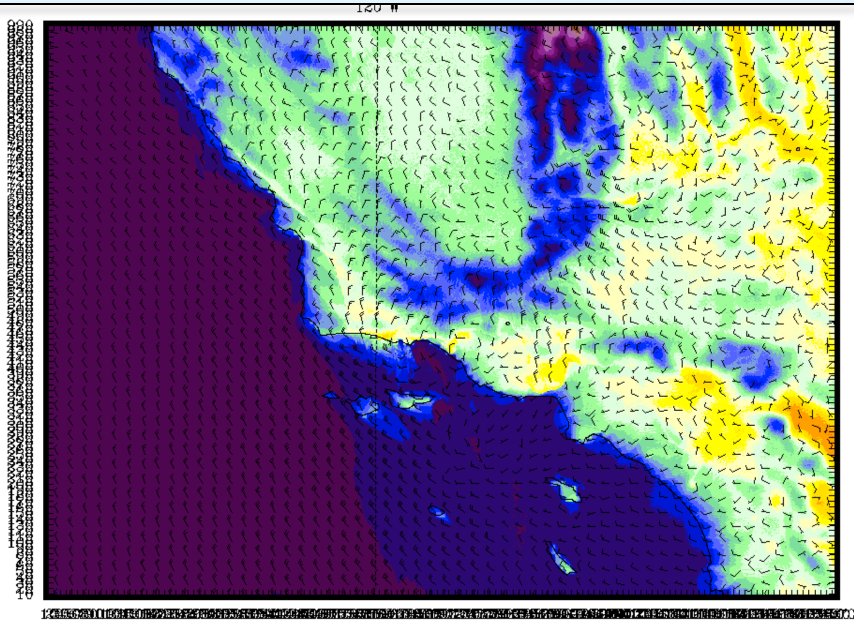
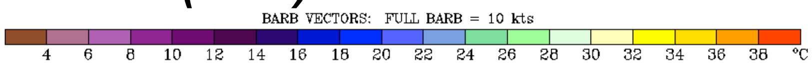
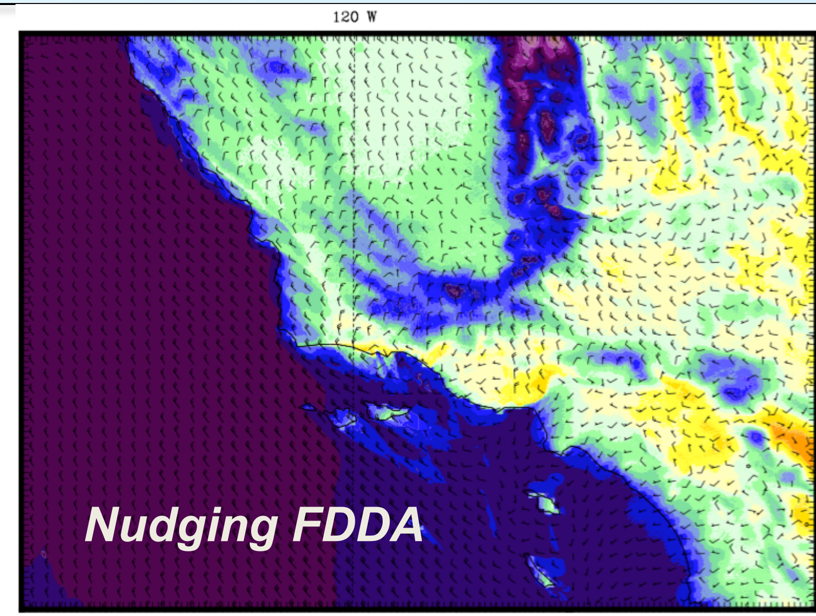


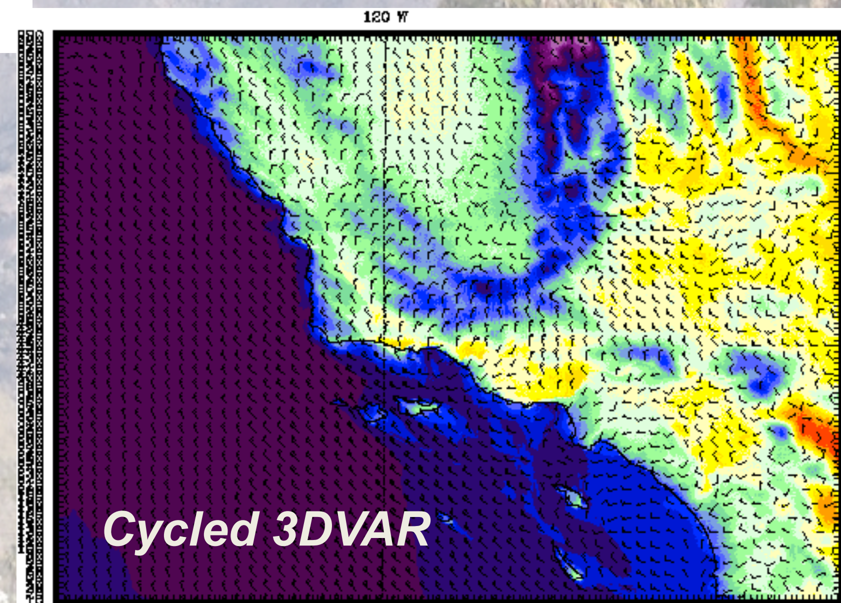
Jesusita Case: 21UTC 5/6/09 Cycled 3DVar v. Baseline



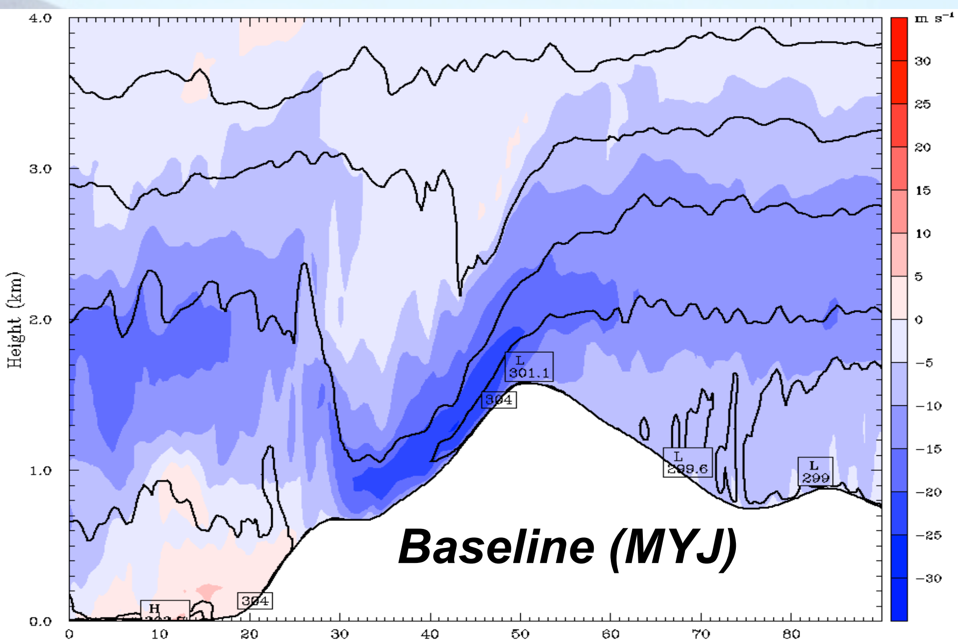
Baseline (MYJ)

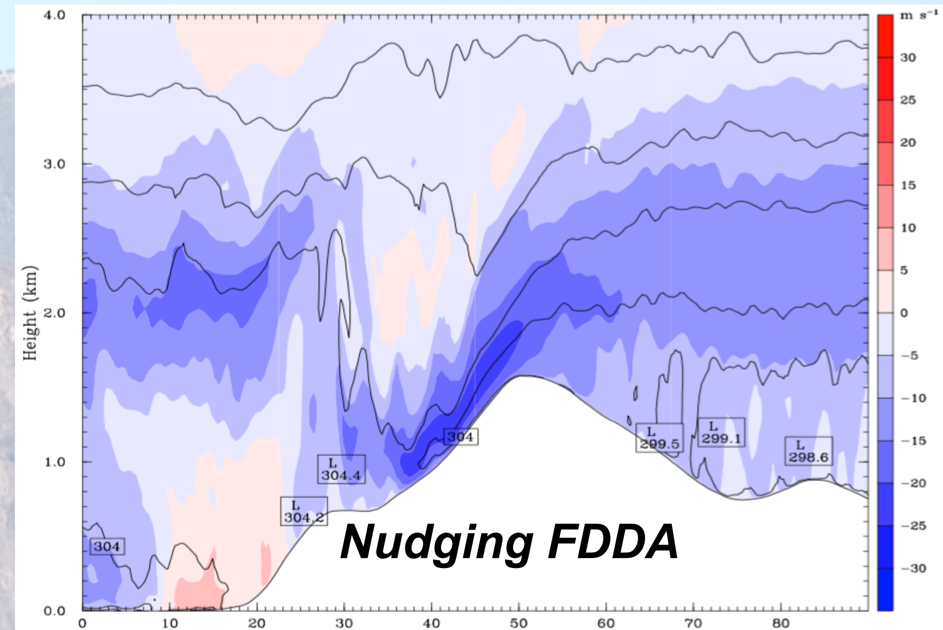


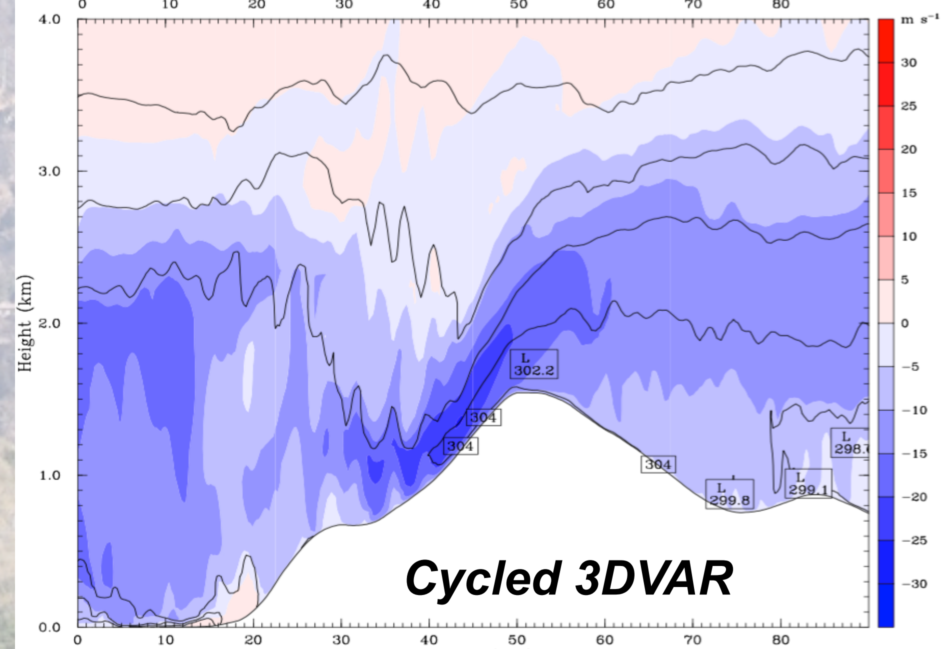




Jesusita Case: 21UTC 5/6/09 Cycled 3DVar v. Baseline







Closing Comments

- Differences in PBL/surface layer, terrain and ocean mixing mostly represent modulating influences and do not fundamentally change the dynamics.
  - Meso-g scale shifts in location and timing of extreme T/winds.
  - Important from fire-weather perspective w/r/t advance staging of resources.
- TEMF shows the largest differences in thermal signatures
  - Tends to produce deeper well-mixed structures and resists formation of absolute instabilities upstream.
  - Validation (not shown) mixed.
- Larger scale Cycled 3D-Var provides slightly better forecasts but no major changes to basic dynamics.
- Is a mesoscale ensemble the best short term answer? Or mesoscale DA? Or both? Part of future work.

Questions? (photo from 2016 Sherpa Fire)