Early Wind Forecasting Results from the 1.5 km WRF-ARW in Extreme Southwestern California
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Introduction
Wind flow into Southern California interacting with rugged terrain results in very complex wind patterns. To examine these winds, NWS San Diego utilizes a 1.5 km nest inside of our 3.7 km local WRF-EMS ARW. It has helped in both analyzing and predicting the strength, location, onset, and cessation of a variety of phenomena driven by local wind flows as seen in the following cases.

Sea Breeze/Upvalley Flow Case

Fig. 1. The image on the left is the 15 hour forecast 1.5 km WRF-EMS ARW surface winds (green barbs), wind speed (shading), and surface observations valid at 2100 UTC 12 August 2013. The leading edge of the sea breeze front is indicated (blue line with barbs) and is seen quite well in the shading. Note the calm winds at Palm Springs (yellow METAR observation). Two hours later (at 2300 UTC 12 August 2013) the image on the right shows the sea breeze front has passed Palm Springs based on the model forecast and the observation, with gusts to 18 knots.

Convergence Pattern Schematics and Convection Case

Fig. 2. Idealized schematic patterns for dominant offshore flow (left) and dominant onshore flow (right). The arrows are low-level cross-barrier (or gap) wind components. The thin dashed lines are convergence lines generated on/near mountain ridges, and the thick solid lines are convergence “arcs” downwind of passes and canyons. The thick dashed lines are the “Modified Elsinore Convergence Zone” (left) and the “Standard Elsinore Convergence Zone” (right). The legend is in thousands of feet MSL.

Convergence patterns can affect convection location and strength (fig. 2). In the following case study (a deep offshore flow case), convergence develops west of the mountain crests and below canyons and passes. The model reflects this pattern. East winds at the stations on the mountain crests in the satellite imagery in fig. 3 shows convergence, displaced to the leeside (western) slopes. Weak 700-500 mb winds also help generate an offshore flow surface convergence pattern (convergence is seen via the tight gradients in the black isotachs where velocities approach zero). The westerly sea breeze flow eventually nudges the convergence boundaries eastward during the afternoon, moving past the mountain crest. The dashed ridgeline convergence zones (fig. 2 and 3) near the mountains, (possibly beginning an event displaced off the mountain crest on the lee side), typically develops convection before the arcs downwind of the passes during very moist and unstable days, but convection may be confined to the ridgelines on relatively dry days when the LCL/LFC is high and mid-level relative humidity is rather modest. The 2200 UTC image (lower left image in fig. 3) shows convergence lines associated with the crest of the mountains and the convergence arcs associated with the gap flows. They have been displaced to the east (typical afternoon movement). Enhanced convection (especially near Warner Springs in the north in fig. 3), develops on the convergence lines as they move eastward.

Mountain Wave Case at Burns Canyon

On 30 January 2014 during strong onshore flow, a strong mountain wave and rotor hit Burns Canyon (BCNC1) gusting to over 80 mph (fig. 4 and 5). The 1200 UTC 30 January 2014 KNXN sounding shows a stable layer (inversion) near 5,000 feet MSL and 10,000 feet MSL, with moderate-strong westerly flow. The observations in fig. 5 show southeasterly rotor winds in blue text, which brackets the much stronger, westerly wind phase of the event (red text). The model forecasted a wave surfacing very close to the sensor at 1700 UTC, and the wave and strong west winds arrived at 1700 UTC. So in this case, the surface strong west winds were still a bit west of Burns Canyon in the model when the winds actually surfaced. The 10 hour forecast indicated 40-50 knot sustained winds at Burns Canyon (fig. 5, lower left), similar to the 45-55 mph winds seen in the observation data during the peak of the windstorm.

Summary and Conclusions
The 1.5 km resolution data has allowed us to take a closer look at several local phenomena and implement the findings operationally (Special thanks to Brian D’Agostino and Steven Vanderburg for their support on this project). We see that it can accurately forecast the sea breeze (at least in this case) in the Palm Springs area. For the mountain wave case, it captured the rotor flow at Burns Canyon and was close on the timing of the surface wave. The model also seems to have a good idea on the locations of convergence boundaries. We can now have more confidence in the model wind patterns for timing and intensity, from mountain waves to sea breezes, as well as for convergence zones.