Simulation of California extreme heat and its large scale meteorological pattern by CCSM4

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1. Introduction

How well does CCSM4 reproduce the pattern associated with extreme hottest days for the California Central Valley (CV)?

Grotjahn and Faure (2008) identified Large Scale Meteorological Patterns (**LSMPs**) associated with extreme CV heat. Grotjahn (2011) used portions of selected LSMPs to predict extreme CV heat.

CCSM4 simulations of key LSMP parts and daily surface maximum temperatures in the CV region are analyzed

2. JJAS Data

"**NDRA2**"= NCEP/DOE AMIP-II reanalyses 12 GMT daily data at 2.5x2.5 resolution. To match Grotjahn (2011) 1979-1998.

Corresponding historical CCSM4 from b40.20th.track1.1deg.012 daily data regridded to 2.5x2.5 for circ. index

3. Synoptics

Hottest days when subsidence inversion strong & low & sea breeze blocked by SLP gradient due to hot T anomaly being centered near coast

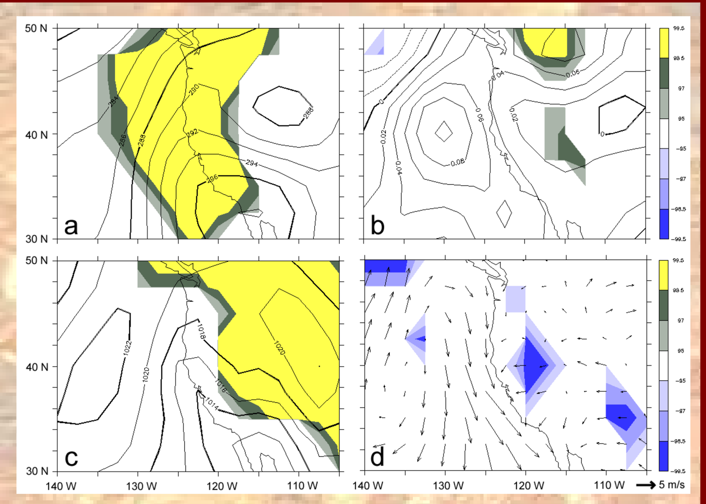
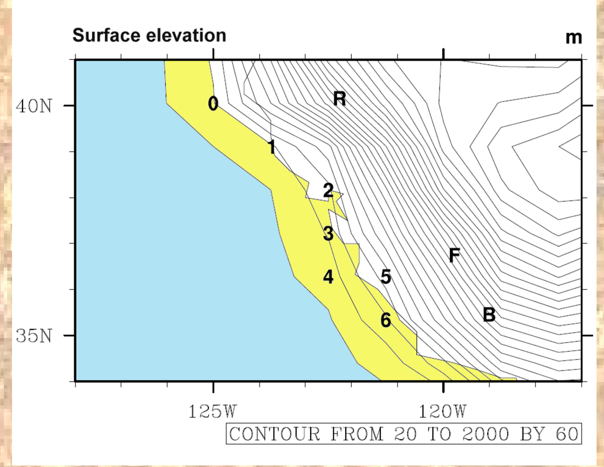


Figure 1. 4-panel chart: 850mbT, 700mb ω, SLP, sfc wind (u shaded). Shading top 1.5%.

4. CCSM surface values

1. CV not resolved by model; CCSM4 has broad topographic slope. Various CCSM4 grid points tested to 'represent' CV. (Fig. 2a)
2. Various choices have drawbacks fitting CV surface max T. Points near R, F, and B have good pdf, (fig. 2b) but elevations too high & on slope; pts 1, 2, & 5 elevs. like CV but land fraction 50-85% & pdf very different (Fig. 2b)
3. Need proxy (=CI) for CV surface max T.



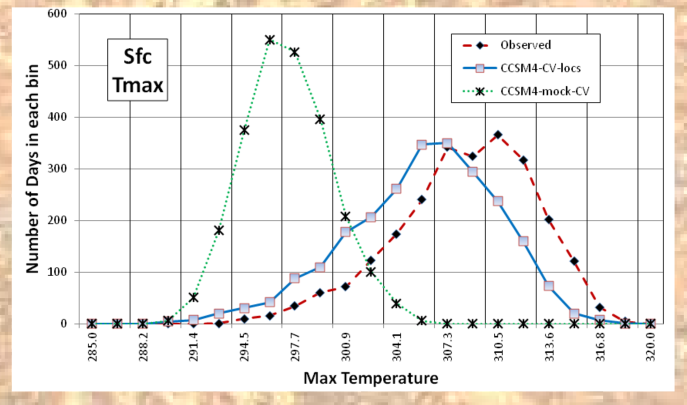


Figure 2. Top: a.) Candidate points (numbered) and locations of CV stations (R=KRBL, F=KFAT, B=KBFL) Bottom: b.) daily max temperature histograms (observed and 2 choices of CCSM points).

5. Circulation index (CI) calculation

1. Project 850 hPa daily T anomalies and 700 hPa v anomalies on parts of respective target ensemble mean patterns (in Fig. 3a,b) to obtain daily circulation index (CI) as in Grotjahn (2011). Ensemble dates chosen from hottest 1% of surface max T values
2. High CI implies hot surface max T values
3. CI calculated for NDRA2 & CCSM4 data

6. large scale patterns

1. Ensemble means for NDRA2 shown in fig. 3a, b.
2. Even using pts 1, 2, & 5, the ensemble means for CCSM similar to observed but: i) weaker (fig 3c,d) and ii) peak T anomaly is onshore.

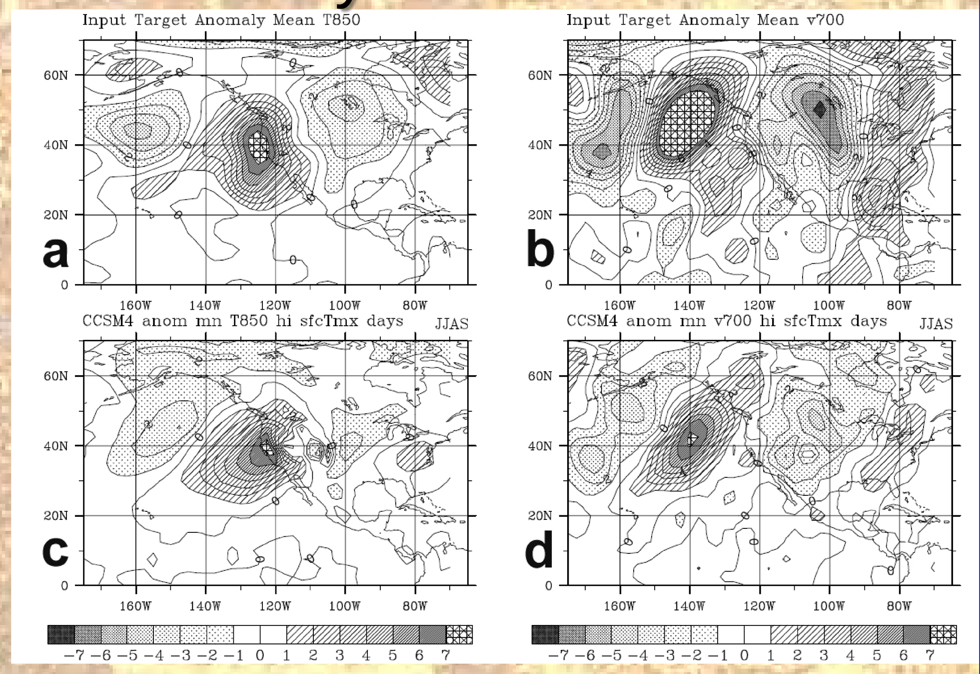


Figure 2. Ensemble mean fields. 850mbT anomaly: a) in NDRA2:, c) in CCSM4. 700mb v: b) in NDRA2, d) in CCSM4. CCSM4 based on extreme surface max T values at grid pts 1, 2, 5

7. circulation index comparisons

1. CI histograms for CCSM & NDRA2 shown in fig 4. Observed surface max T is '3-stn'.
2. CCSM : narrower range. (0.75 Std. Dev. vs 0.91) opposite skew & too few highest CI
3. CCSM durations of high CI are OK (fig. 5)
4. CI has much less relation to surface max T in CCSM4, especially if using pts 1, 2, & 5 (fig. 6c) (pts near R, F, B better; fig. 6b)

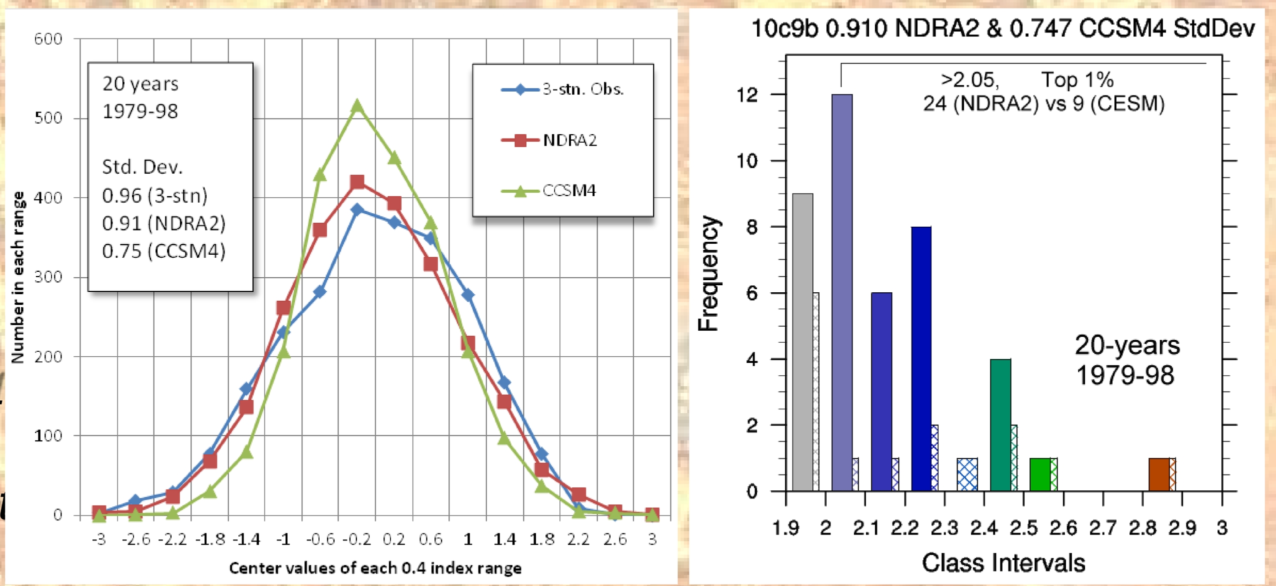


Figure 4. Left, full range histograms; CCSM too little variation & reversed skew. Right, top 1% of NDRA2 (solid) compared to CESM1 (hatched) coefficients of hottest days upper air pattern index. Larger index = hotter day; CCSM has too few (9 vs 24 dates)

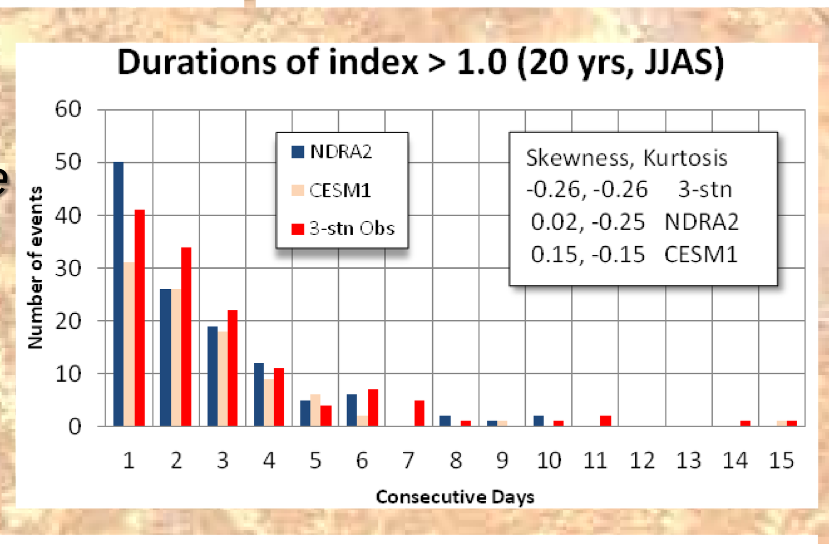
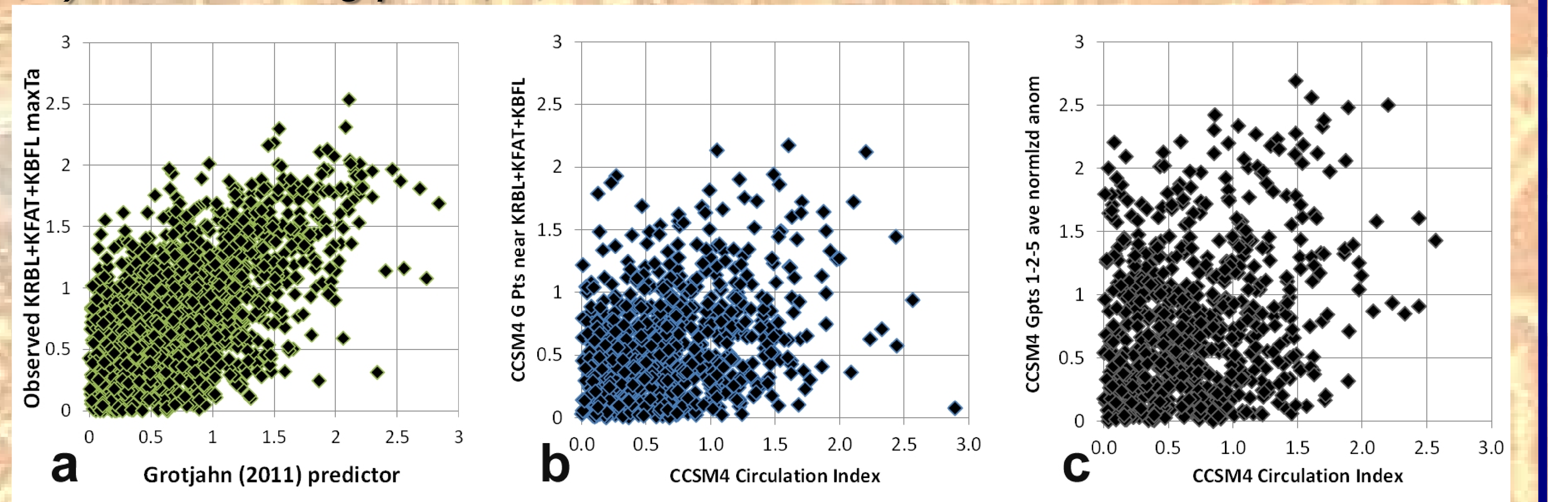


Figure 5. Duration above threshold of 1 standard dev..

Figure 6. CI versus surface max T: a) observed, b) CCSM data with pts near R, F, B, c) CCSM using pts 1, 2, & 5.



8. Conclusions

1. Unresolved topography clouds analysis of model surface data; implies need to use a CI type of proxy instead of direct use of surface data.
2. Large scale extreme heat pattern is too weak in CCSM. CCSM would not generate the hottest days adequately or often enough.
3. With rescaling: the high tail of CCSM data and durations of the hotter days can be made similar to observed results, but not low tail. (Model even worse at missing trough passages: cool days)

9. Acknowledgment & References

Thanks to Gary Strand for identifying the CCSM data.

Grotjahn, R (2011) Identifying Extreme Hottest Days from Large Scale Upper Air Data: a Pilot Scheme to find California Central Valley Summertime Maximum Surface Temperatures. *Climate Dynamics* DOI : 10.1007/s00382-011-0999-z

Grotjahn, R. and Faure, G. (2008) Composite Maps of Extraordinary Weather Events in the Sacramento California, Region. *Weather and Forecasting*. 23:313-335.