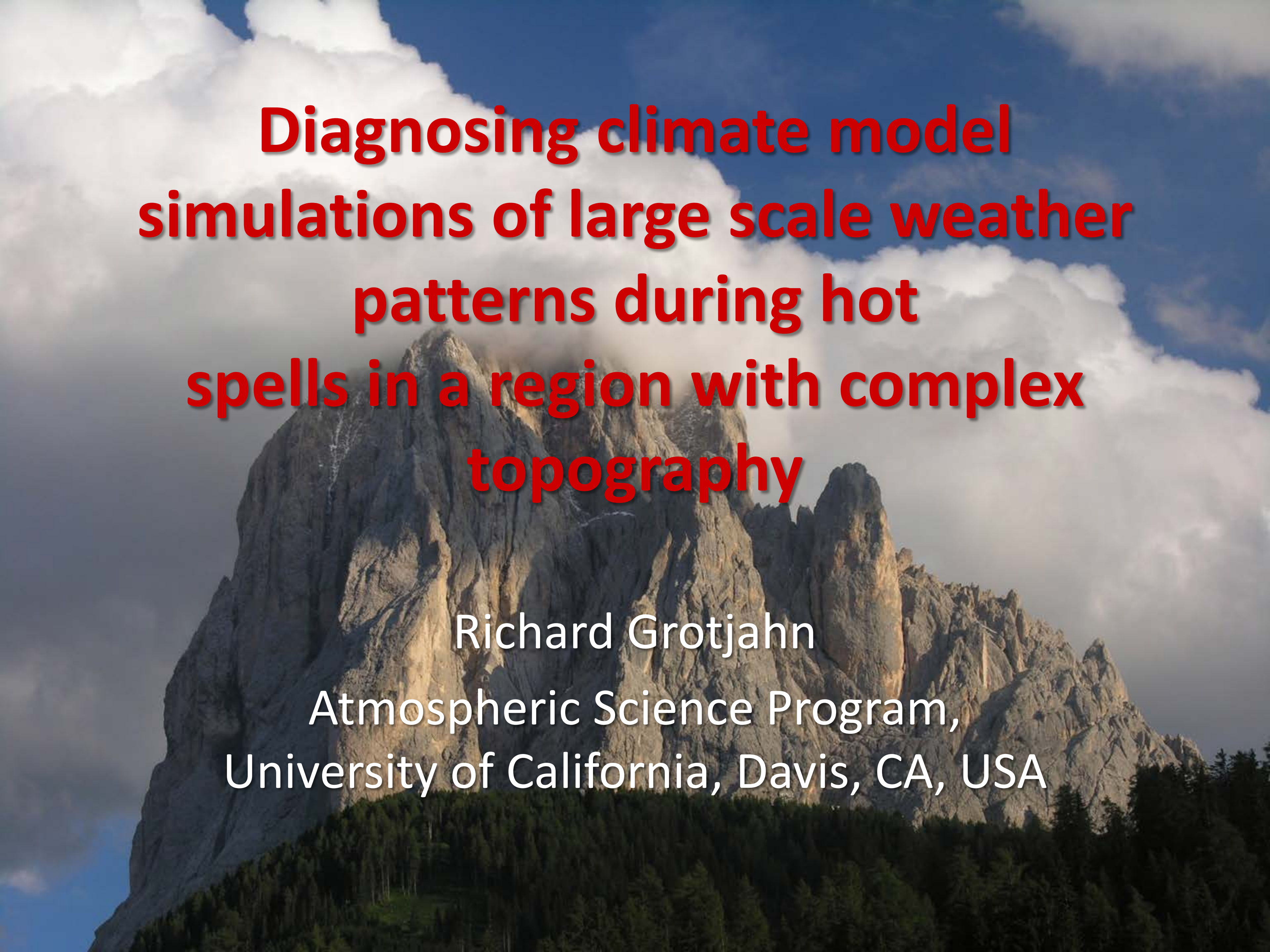

Diagnosing climate model simulations of large scale weather patterns during hot spells in a region with complex topography

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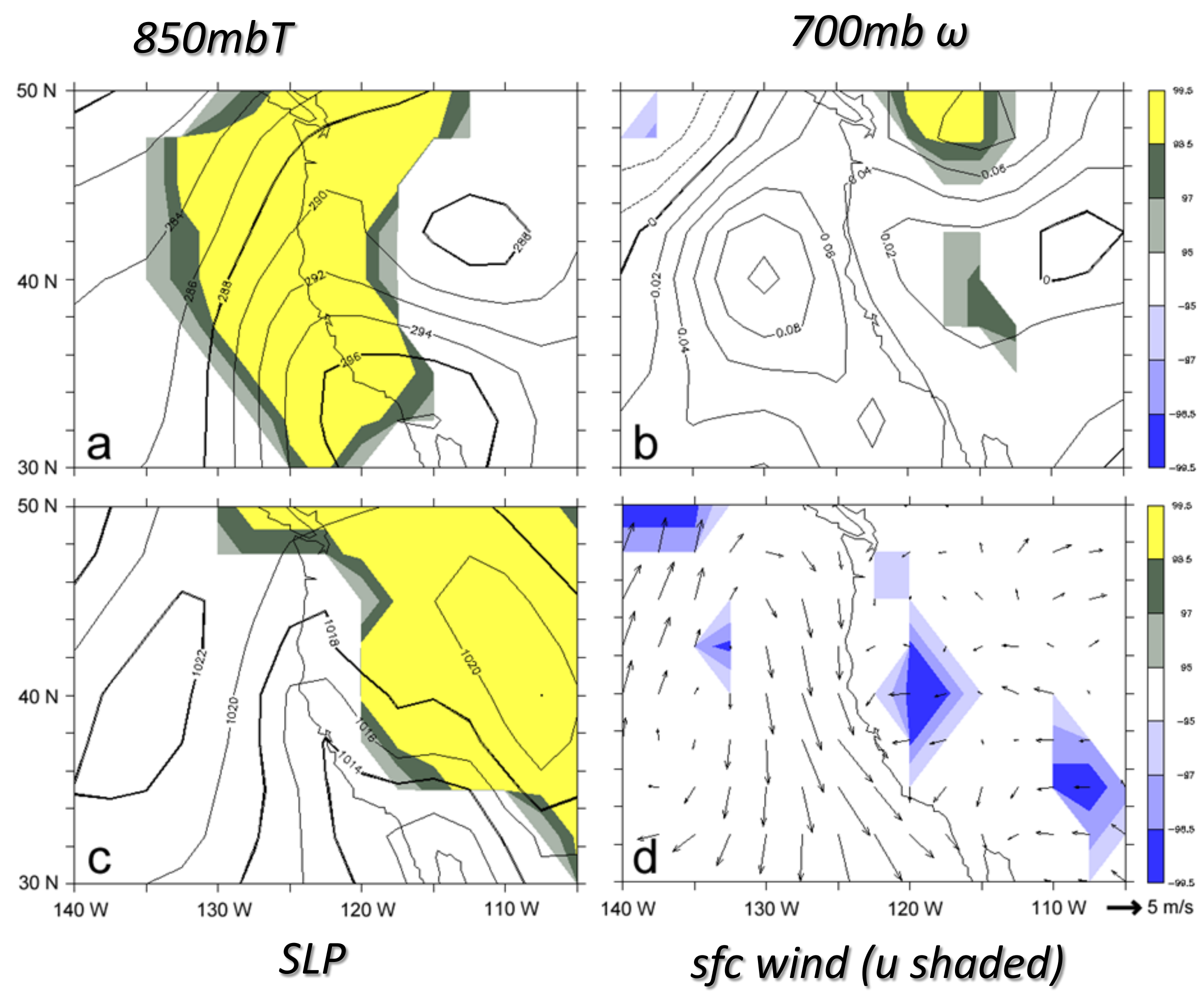
Introduction

- How well does a climate model simulate hot spells?
- This question is answered by how well a model simulates the larger scale 'weather' associated with extreme hot spells.
- Extreme hot spells affecting California are chosen because the large scale weather pattern associated with hot spells is well known and because the regional topographic variations are difficult to capture in a global climate model

Synoptics

- Hottest days when:
- Large scale sinking
- Subsidence inversion strong & unusually low
- T_a centered at/off shore so thermal low creates SLP gradient to block sea breeze

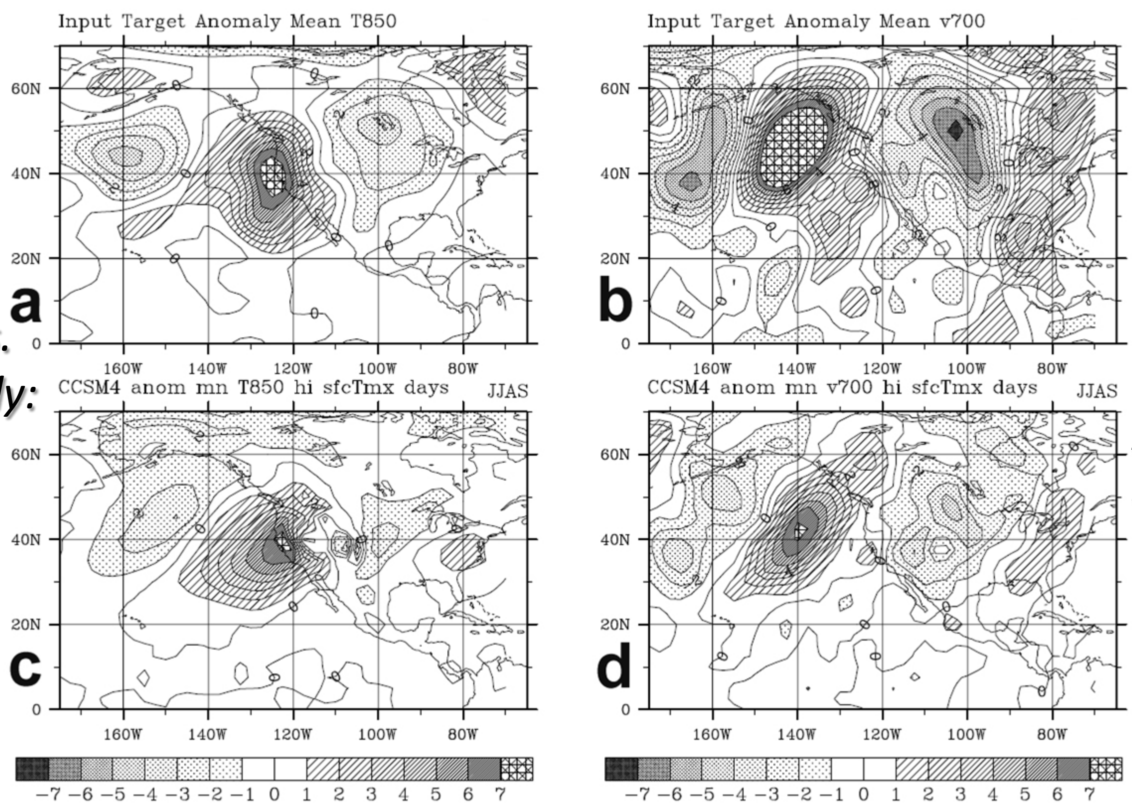


Shading: highest/lowest 1.5%

LSMPs comparison

1. Ensemble means for NDRA2 shown in figs a & b.
2. Ensemble means for NCAR's CCSM4 (figs c & d) similar to observed but: i) weaker, ii) shorter wavelength, iii) peak T anomaly is onshore, not off shore.
3. Generally the patterns are similar – validating method.

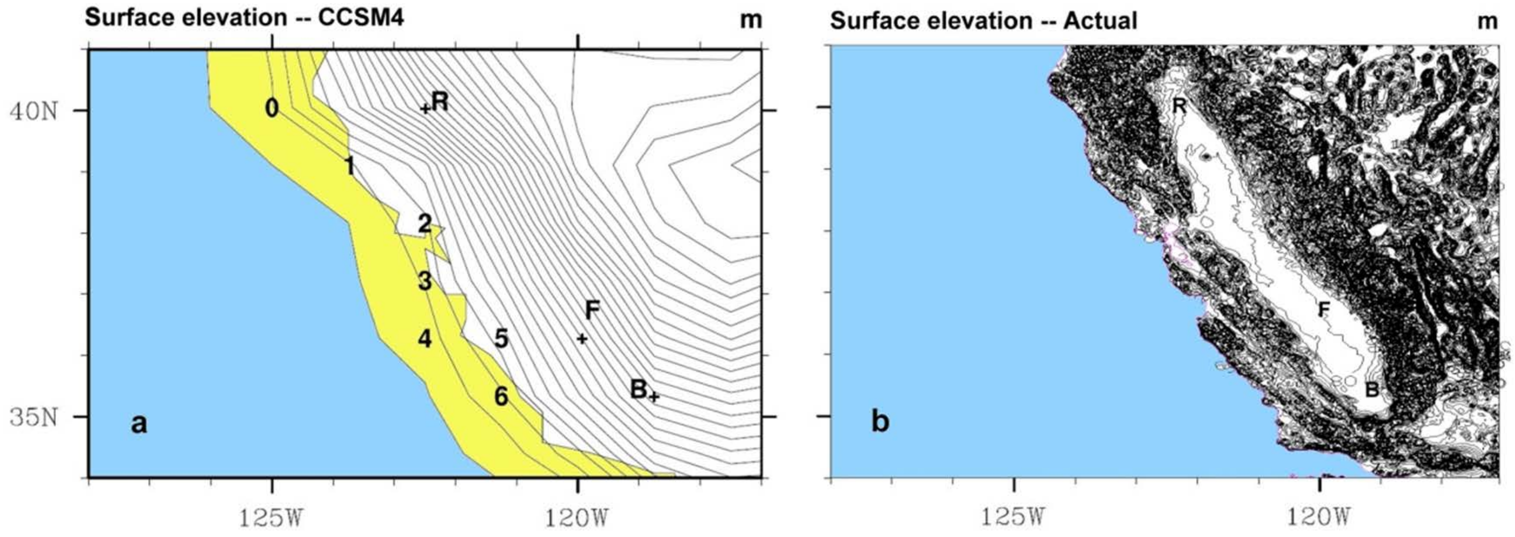
Ensemble means. 850mb T anomaly: a) in NDRA2:, c) in CCSM4.



Ensemble means. 700mb V anomaly: b) in NDRA2, d) in CCSM4.

Need proxy for CV max surface T_a

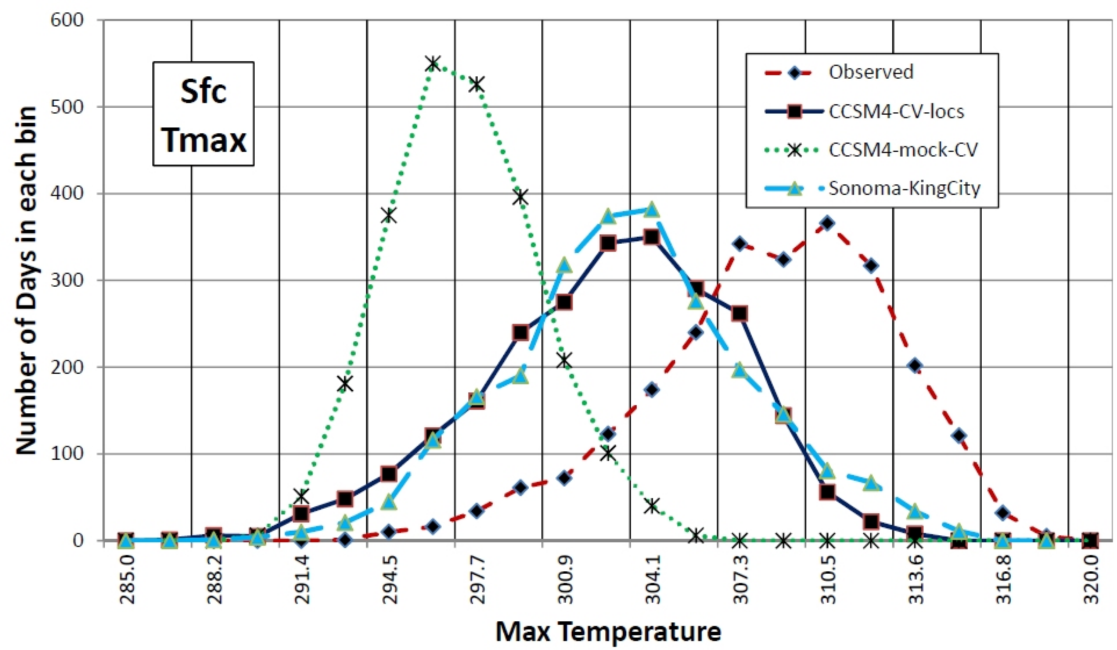
- CCSM4 does not resolve CV topography; model has broad slope instead.
- However, the LSMPs in the model can be viewed as input for statistical or RCM downscaling, so LSMPs make an obvious proxy.

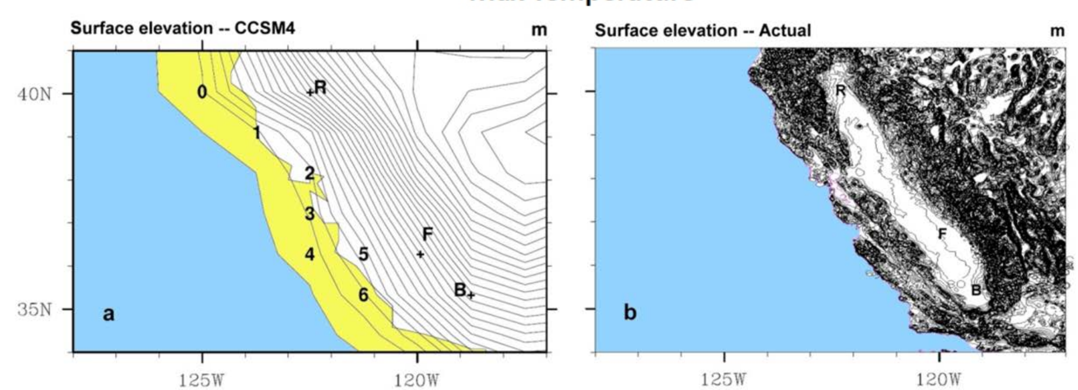


Topography a.)CCSM4 (1.1deg) and actual. Same scale and contour interval (60m).

Summer surface max T_a in model

1. Figure: want model to be like observed red dashed line. Model is like black or green lines.
2. Max T where CV is (black is model) poor match of observed (too cool, wrong skew, etc.)
3. Model values on ‘sloping’ CV (black solid) mimic observed distribution of coastal stations (blue dashed). Model coastal values (green dots) are poor match





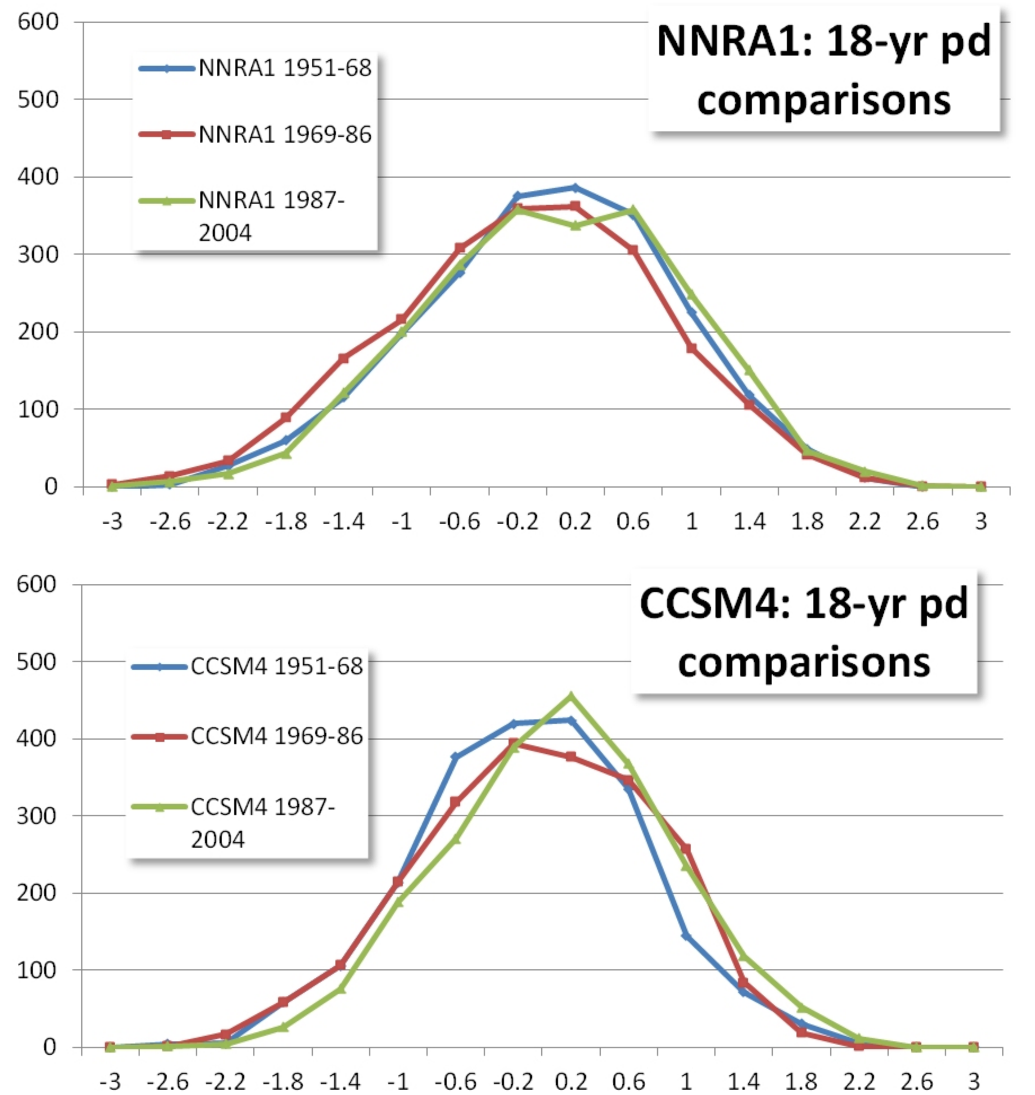
Points used in histograms above. CCCSM4 ‘sloping’ CV most like actual coastal stations.

Circulation index (CI) calculation

1. Project 850 hPa daily T anomalies and 700 hPa v anomalies on parts of respective target ensemble mean patterns (fig. 3a,b) to obtain daily circulation index (CI) as in Grotjahn (2011). Ensemble dates are hottest 1% of surface max T values (1979-88 period)
2. High CI implies hot surface max T_a values
3. CI calculated for NNRA1 & model data
4. Intended for max extremes, all CI and Sfc T_a are correlated (r=0.84)

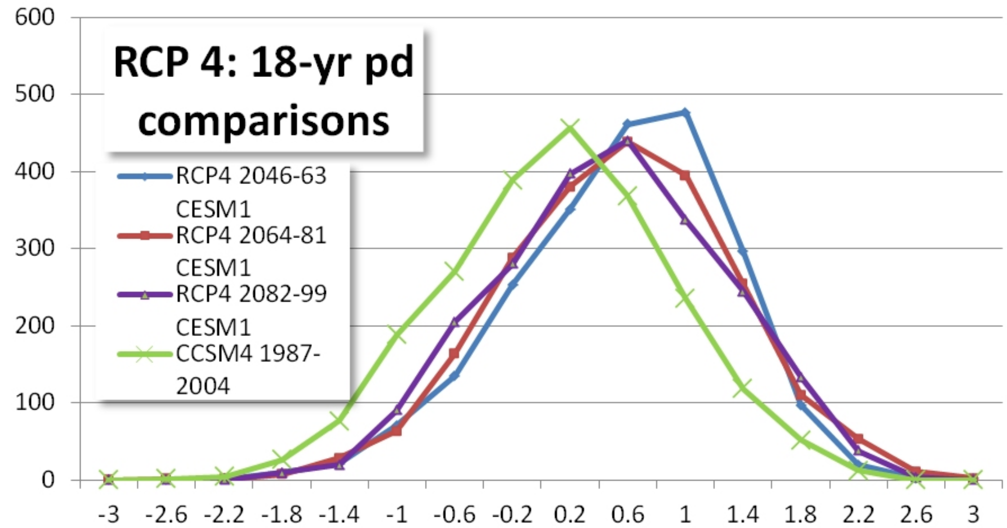
LSMP-based CI: historical climate

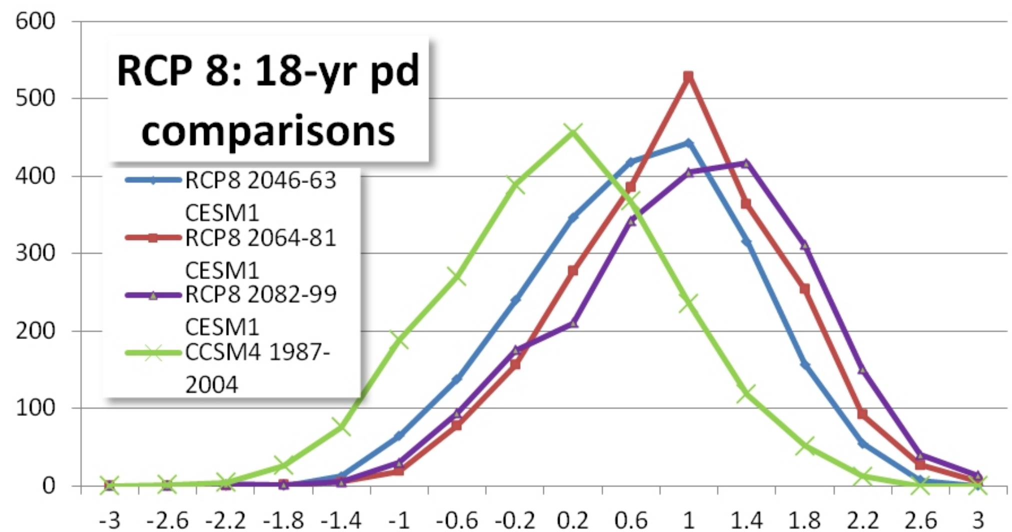
1. Historical CCSM4: range, standard deviation (0.75 Std. Dev. vs 0.91) & skew all smaller than NNRA1. (fig. 4)
2. Historical CCSM4: too few of highest CI
3. Historical CCSM skew 33% < NNRA1 skew
4. Surface station no trend (not shown), no trend in NNRA1, but historical CCSM4 has trend.
5. Inter-decade variation: Standard deviation varies by +/- 2-7%



LSMP-based CI: future scenarios

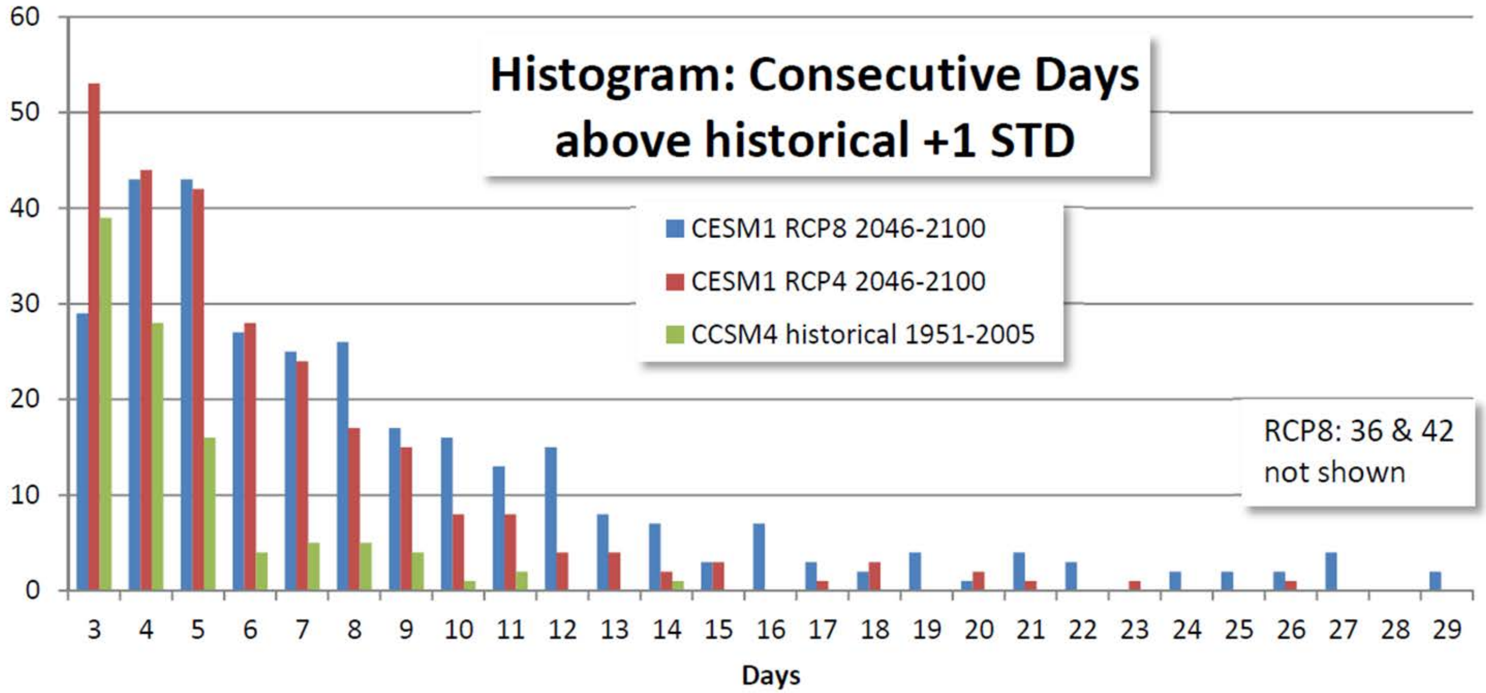
1. RCP 8.5 shifts median by 1 std. dev. (NNRA1 basis). RCP4.5 shift half that.
2. RCP cases: range increases as max values increase more than mins.
3. Model PDFs: RCP cases skew increases doubles historical period values. CESM RCP 4.5 is 25% > NNRA1.
4. RCP4.5 trend unclear and interdecadal variation comparable. RCP8.5 trend exceeds inter-decade variation.





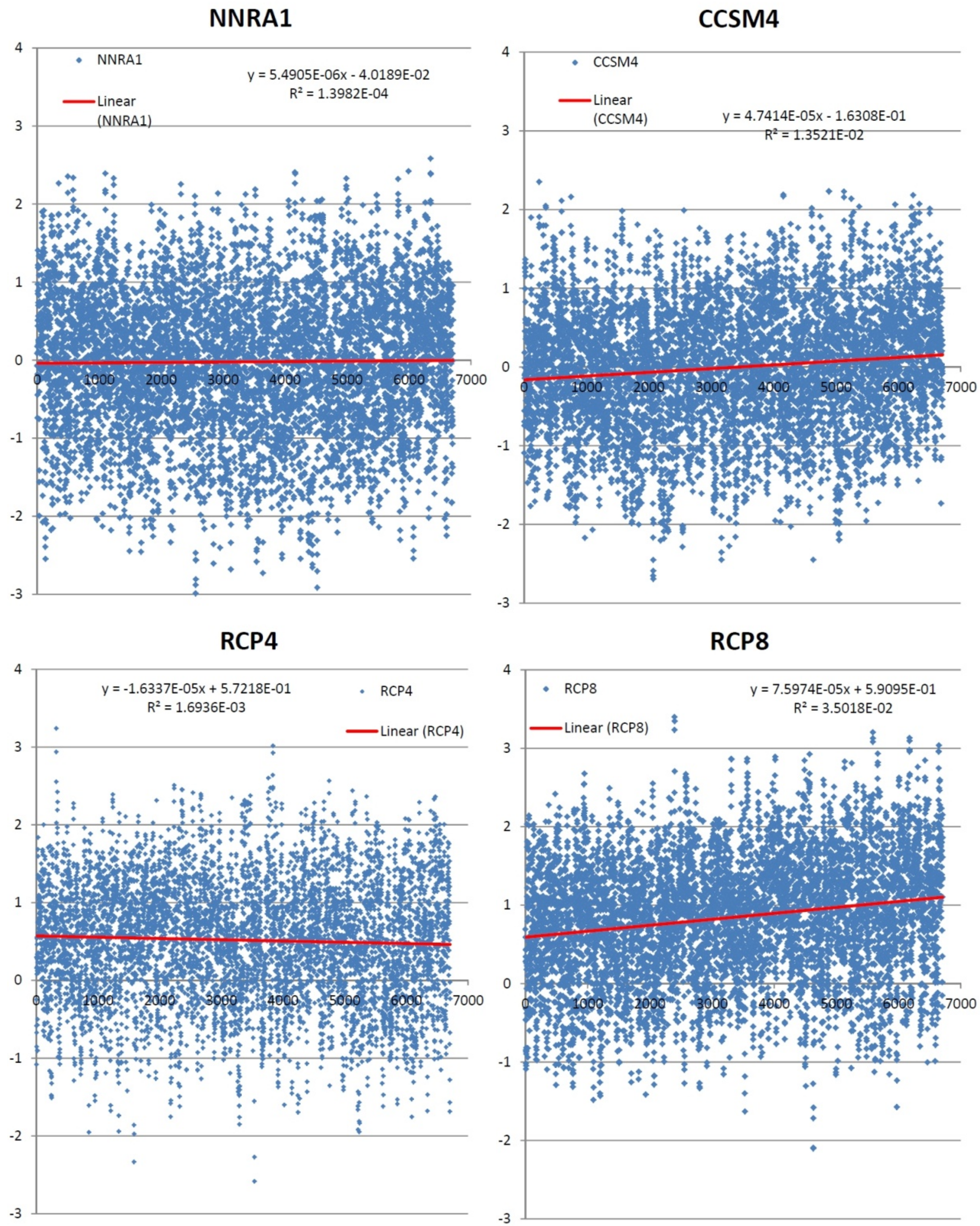
Durations of extreme high values

1. Large increases in durations above 1 std. dev. (1979-88 basis) due to shifts of medians. (fig.5)
2. 20-yr return values increase ~25% (2.2 → 2.8 (RCP4); → 3.1 std. dev. ~40% (RCP8)



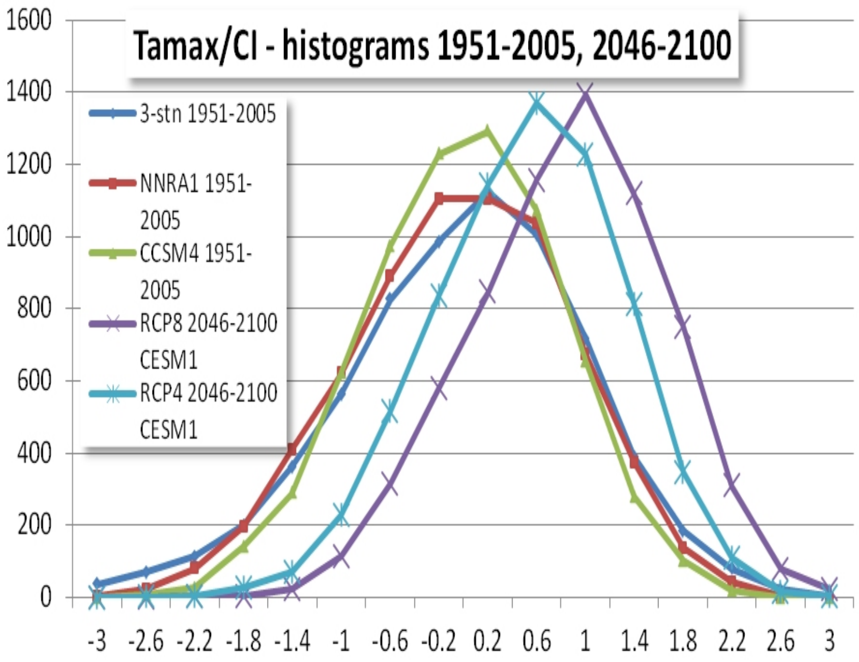
Visible Concerns

- 1951-2005:
  - CCSM4 has trend (NNRA1 and surface obs do not)
  - CCSM4 less scatter
  - CCSM4 mid-period dip in extremes (NNRA1 less clear)
- 2046-2100 (CESM1):
  - RCP8 strong trend, including max extremes
  - RCP8 less scatter than RCP4
  - RCP4 has weak, **negative** trend?!



Conclusions

1. CV unresolved so use LSMPs-based index as proxy for surface max temperatures.
2. Model LSMPs similar to reanalysis-based LSMPs but too weak in CCSM. CCSM would not generate the hottest days adequately or often enough in historical runs, BUT model has trend not found in reanalysis (or sfc obs)
3. In RCP scenarios, mean shifts (0.5 – 1. std. dev.); skew doubles as min shifts less than max. Durations above 1 std. dev. increase greatly.
4. Return values (RV) increase greatly. In both RCP cases 20year RVs exceed historical asymptote, i.e. unprecedented values.
5. RCP cases have mixture of trends. For RCP8 trend exceeds inter-decadal variability.



Acknowledgment/References

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- **References:**

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

- **Thanks for listening.**