Temperature Extremes and Associated Meteorological Patterns in the NARCCAP Hindcast Experiment

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I. Introduction

Motivation: Changes in temperature extremes due to anthropogenic climate change are expected to have severe negative impacts on society. It is therefore crucial to quantify how extremes are manifested and how well key mechanisms associated with these events are simulated in current generation regional climate models (RCMs).

Project Goal: Evaluate the ability of a suite of RCM hindcast experiments to simulate temperature extremes and their associated large-scale meteorological patterns (LSMPs).

Data: 6 NARCCAP hindcast experiments; NCEP North American Regional Reanalysis (NARR) and NASA Modern Era-Retrospective Analysis for Research and Applications (MERRA). All regridded to (0.5°x0.5°) for 1980-2003. NARR and MERRA comparison is presented to estimate observational uncertainty.

II. PDF Evaluation

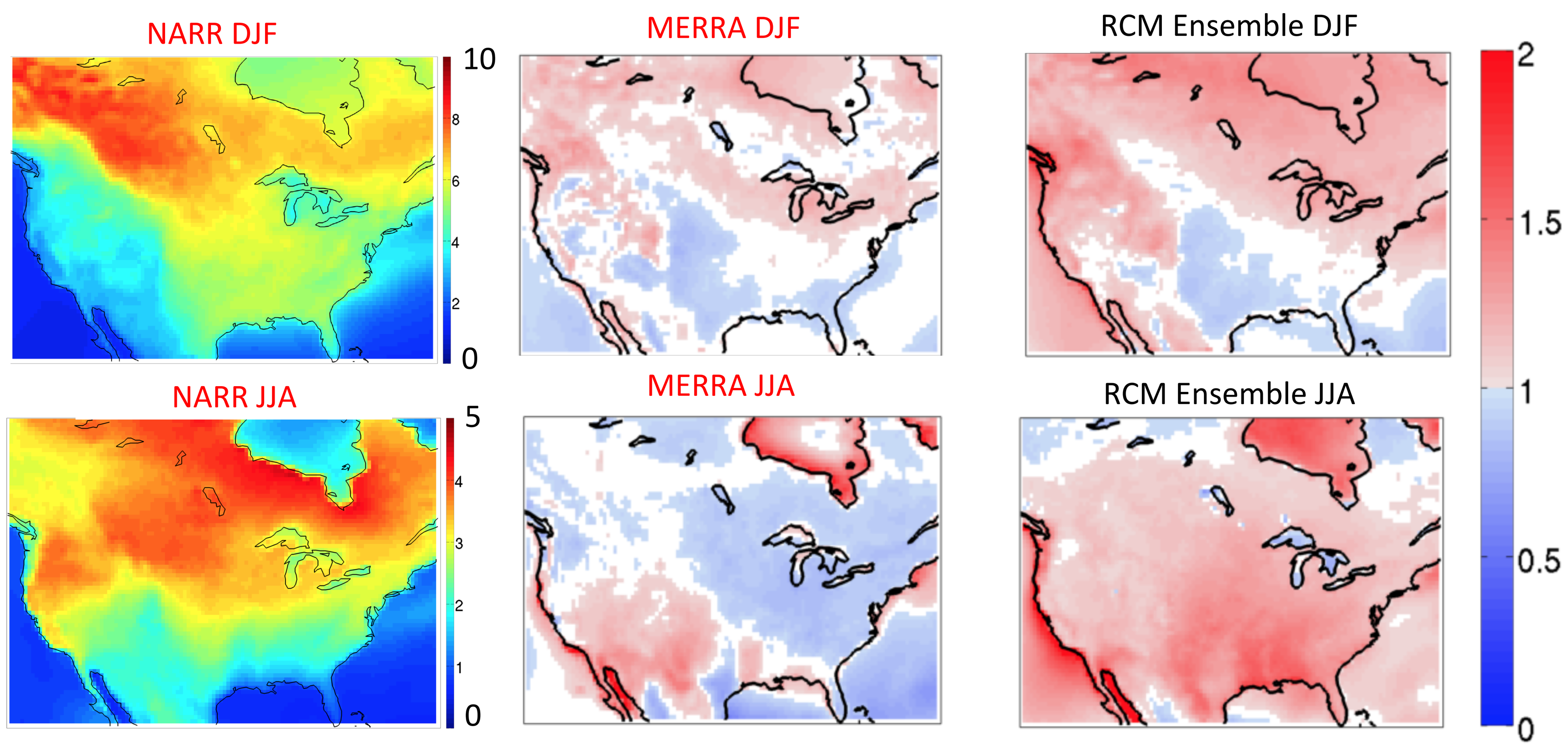

Fig 1. (Left) Standard deviation of daily surface temperature anomalies for NARR. (Center) Ratio of MERRA standard deviation to NARR standard deviation. (Right) Ratio of the 6-RCM ensemble standard deviation to NARR standard deviation.

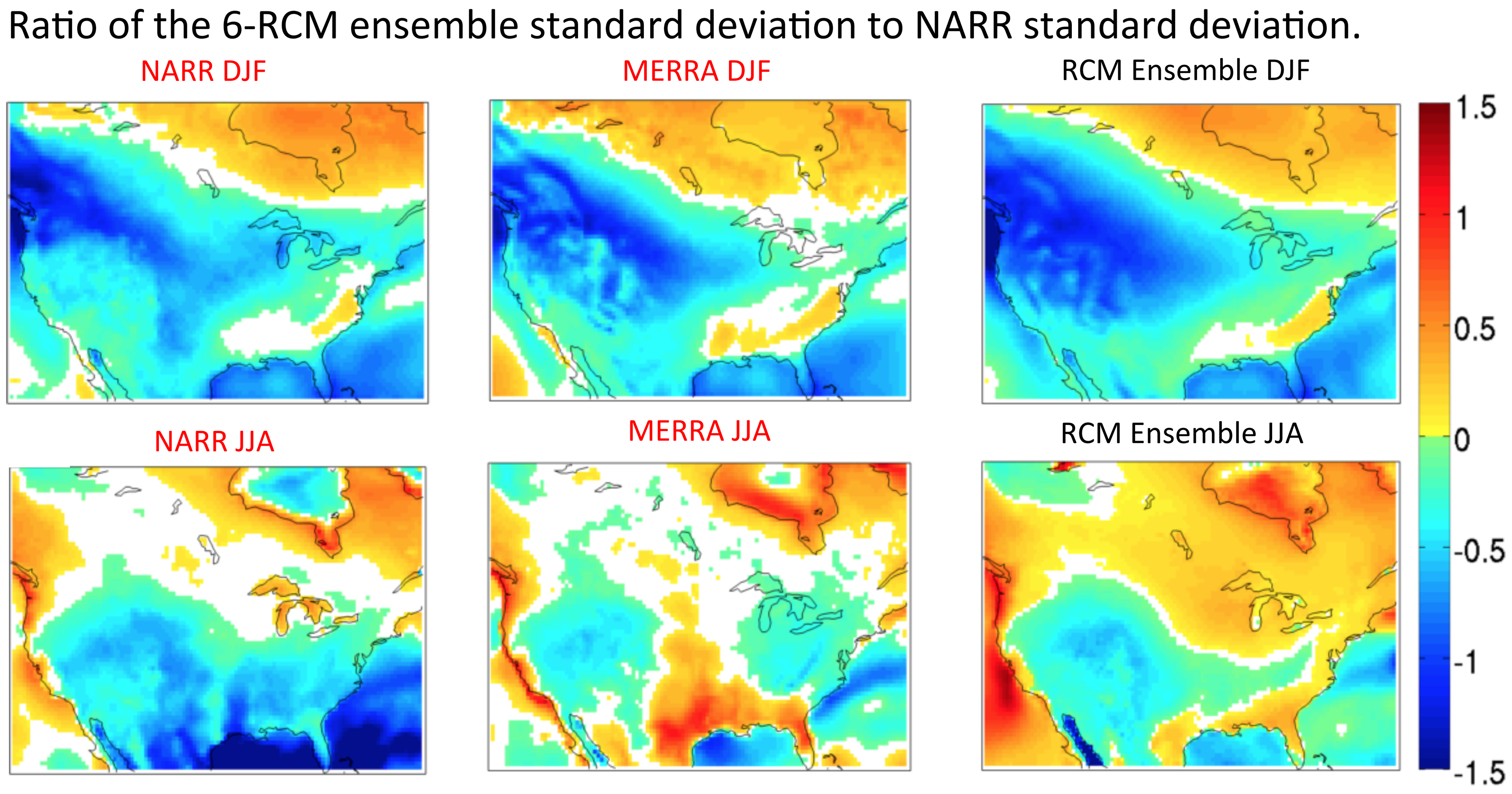

Fig. 2. (Left) Skewness of NARR, (center) skewness of MERRA, (right) skewness of the multi-RCM ensemble. Non-shaded grid cells are not significant at the 10% level.

- **RCM ensemble generally has higher variance than NARR, obs. uncertainty is low.**
- **DJF skewness has good agreement while JJA has strong disagreement (and high obs. uncertainty), especially along Gulf of Mexico coast.**
- **Future projections of extremes should be interpreted with caution in much of the domain in JJA where skewness uncertainty is large.**

- **K-means clustering is used to put NARR DJF probability distribution functions (PDF)s into 4 "basis" categories.**
- **K=4 clusters was found to be optimal in this case for defining clusters that are easy to interpret physically.**

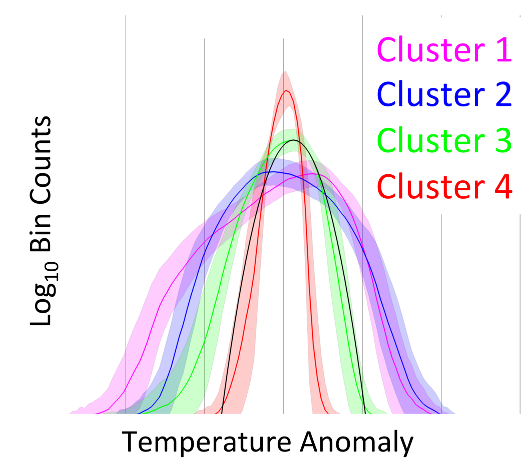

Fig. 3. NARR DJF basis PDFs and +/- 1 standard dev.

- **Clusters primarily reflect variance**
- **Northward expansion of cluster 1 in RCMs reflects positive variance bias there.**

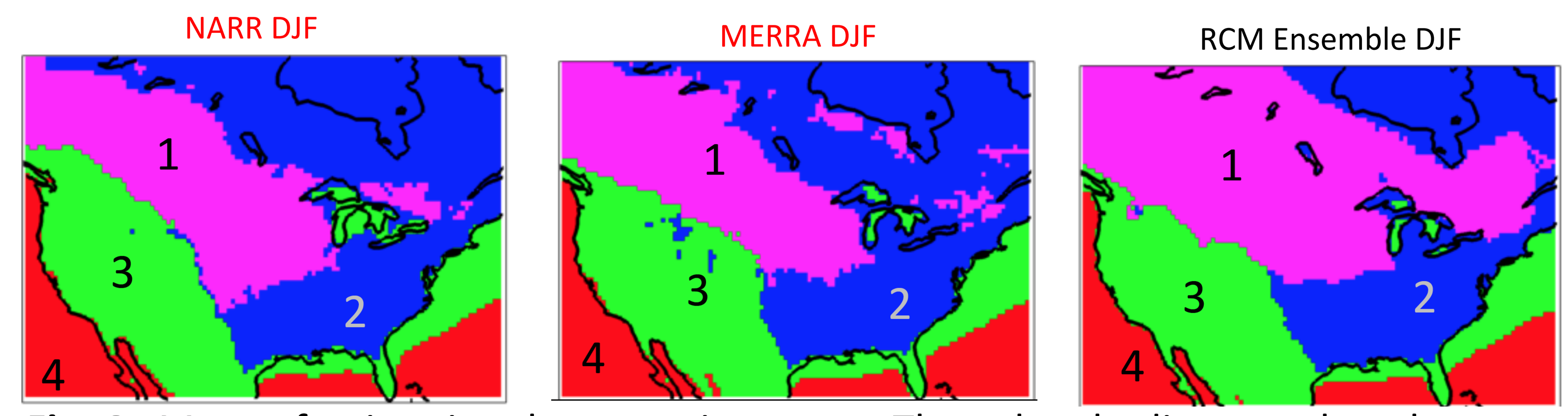

Fig. 4. Maps of pointwise cluster assignments. The color shading matches the PDF colors in Fig. 3. RCM cluster assignments match the basis PDF that has the smallest RMS difference from the RCM PDF.

III. Large-Scale Meteorological Patterns Examples

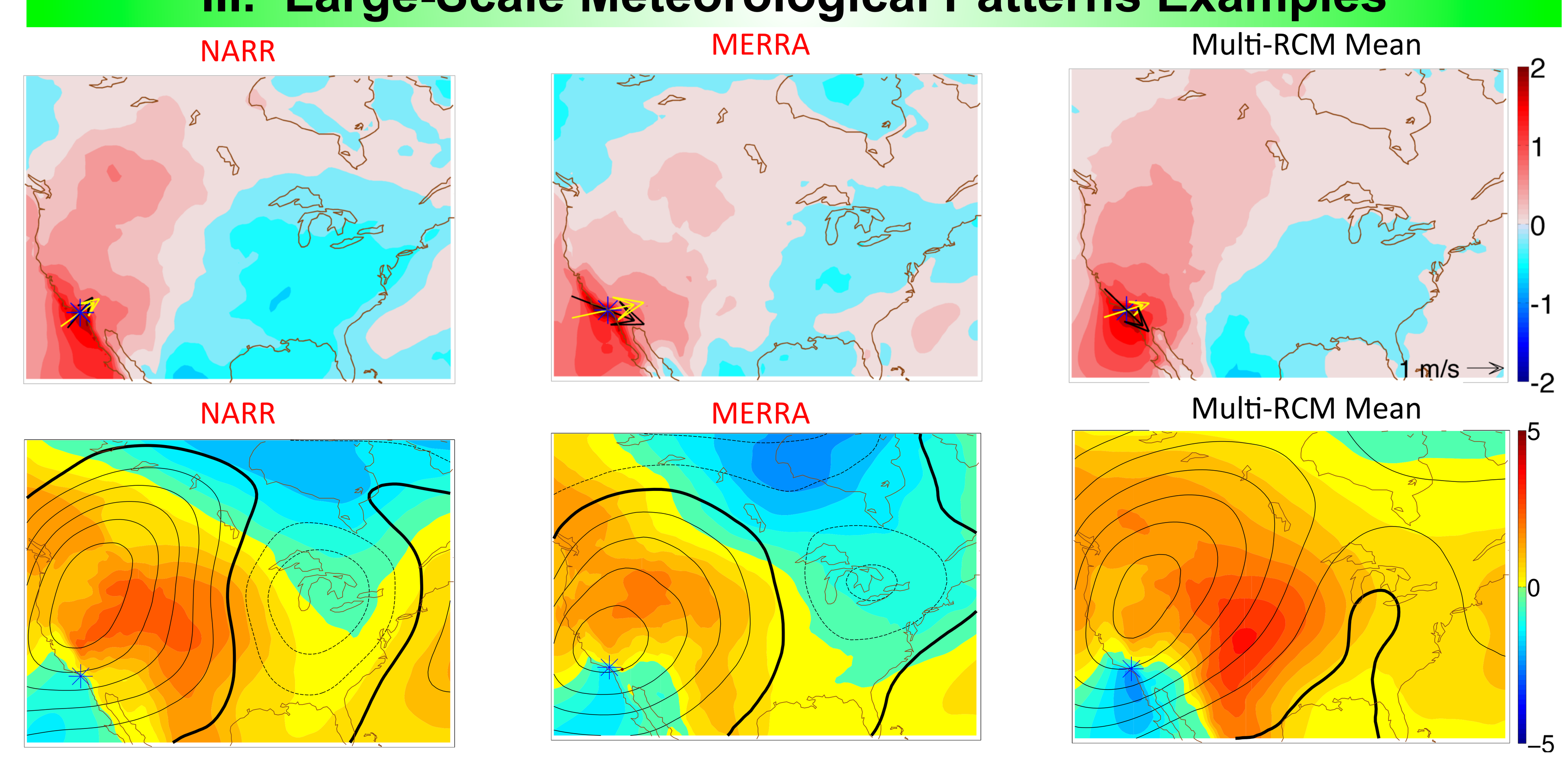

Fig 5. (Top) Composites of normalized temperature anomalies (units of standard deviation) for the warmest 5% of JJA days at Los Angeles gridpoint (blue *). Black wind vector is the composite surface wind and the yellow is climatology. (Bottom) Composites of sea level pressure (shaded, in mb) and 500 hPa geopotential height (contoured every 10 meters, dashed=neg, solid=pos) anomalies for the same days.

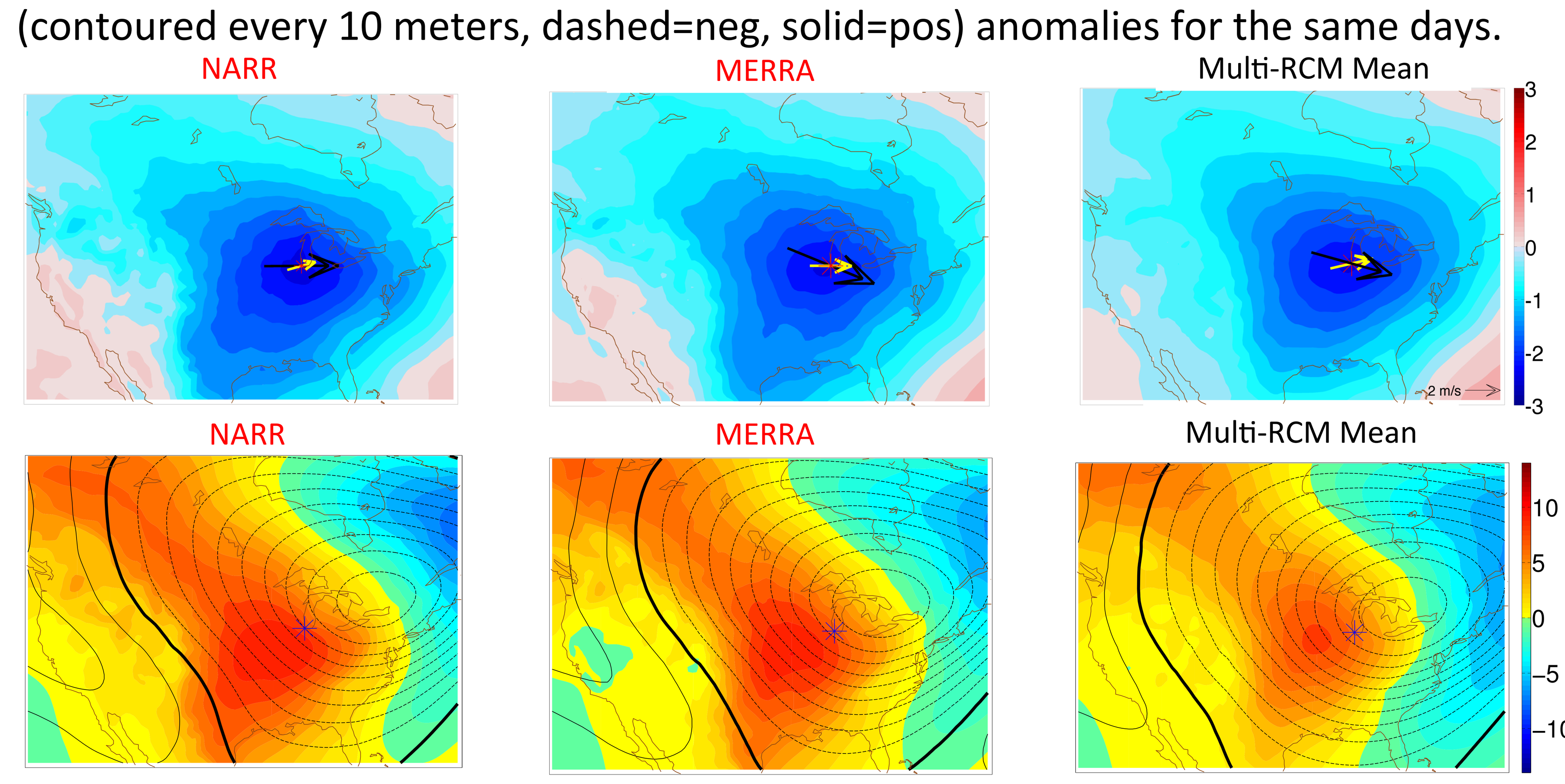

Fig 6. Same as Fig. 5 except for Chicago DJF cold days and with 20 m H500 contours.

- **LA has long warm tail and complex topography, LSMPs show disagreement.**
- **Chicago has long cold tail, and strong RCM-reanalysis agreement. Patterns and surface winds are similar.**

IV. Conclusions

- Models often capture variance and skewness well in DJF with substantial disagreement and high observational uncertainty for JJA skewness.
- Large-scale meteorological patterns associated with extremes are simulated well in most cases especially away from sub-gridscale topographical and coastal features, consistent with Loikith and Broccoli (2012).
- Results suggest the model ensemble mean is well-suited for simulating future temperature extremes with some notable exceptions in JJA.

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