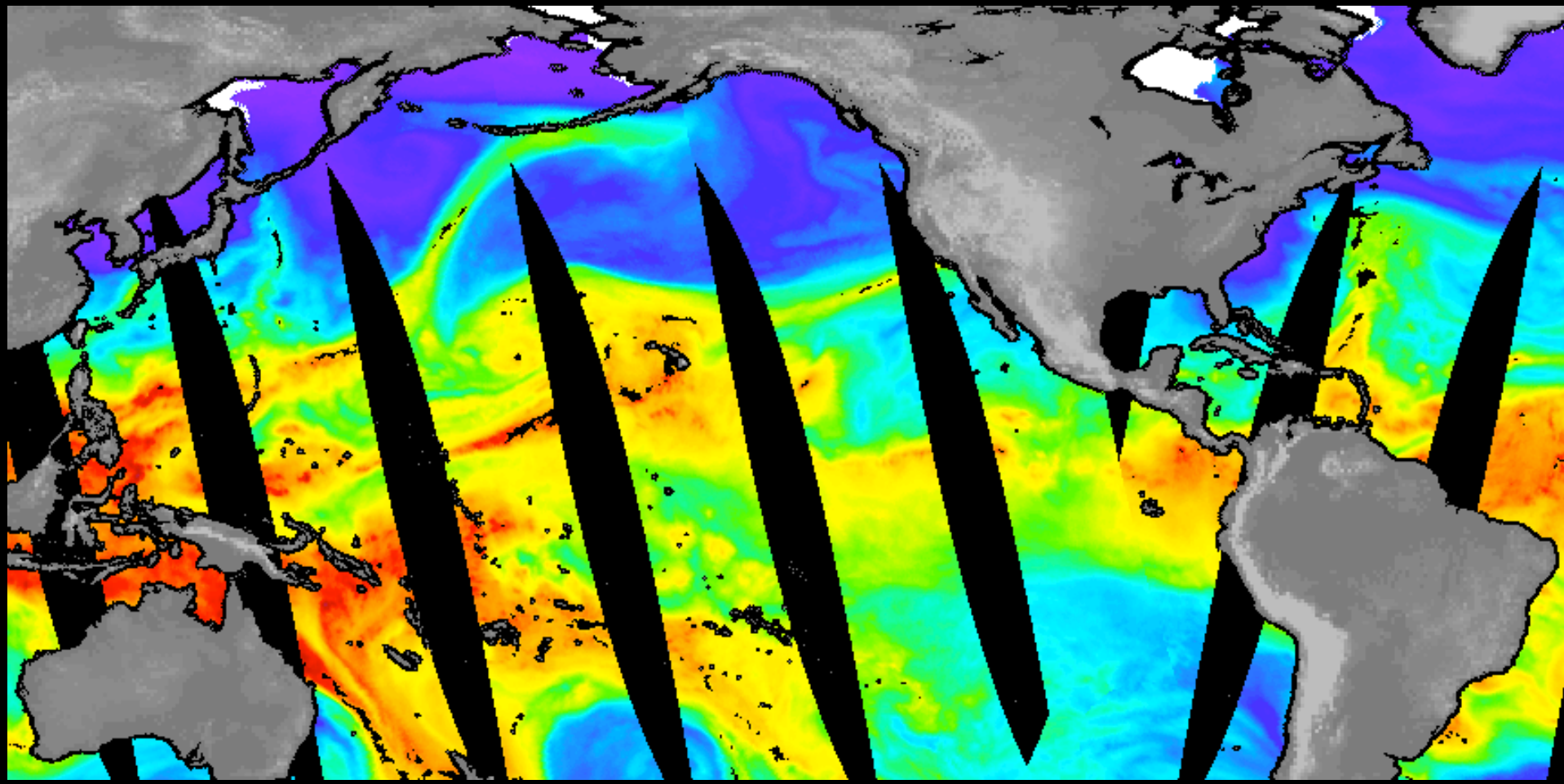
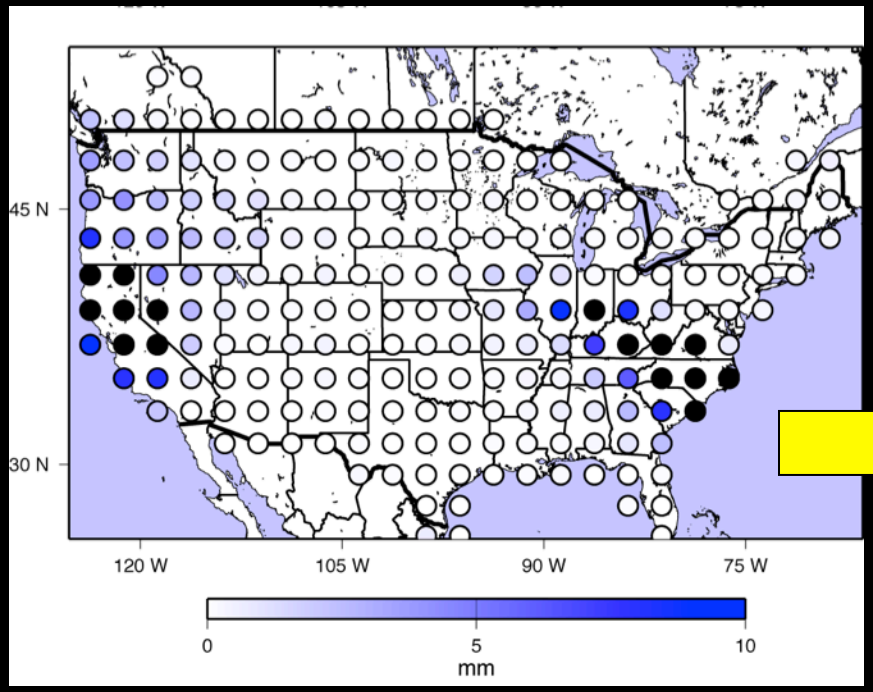
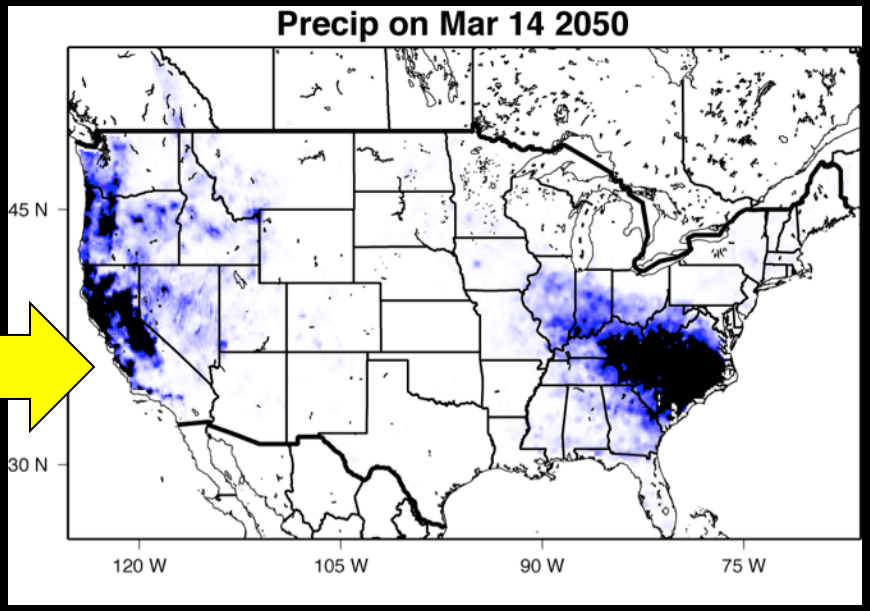




One day in the 21st Century...



Water-resources adaptations call for better downscaling and understanding of extreme precipitation events.

Special requirements:

- Extremes, not means!
- Long enough or numerous enough realizations to support frequency analysis of rare events
- Adequate representations of extreme-event meteorological processes & results

Evaluations/planning for extremes under climate change typically want:

High temporal resolution High spatial resolution High precip resolution

Needs:

1. Long-enough or numerous-enough series for extreme-event statistics
2. High spatial resolutions in ways that capture extremes
3. Realistic storm mechanisms/processes

Strategies:

1. Vulnerability (threshold) analysis, with historical examples & scenarios
2. Storm-condition focuses
3. High-resolution simulations/downscaling
4. Statistical downscaling

1. History- or scenario-based Vulnerability Analyses

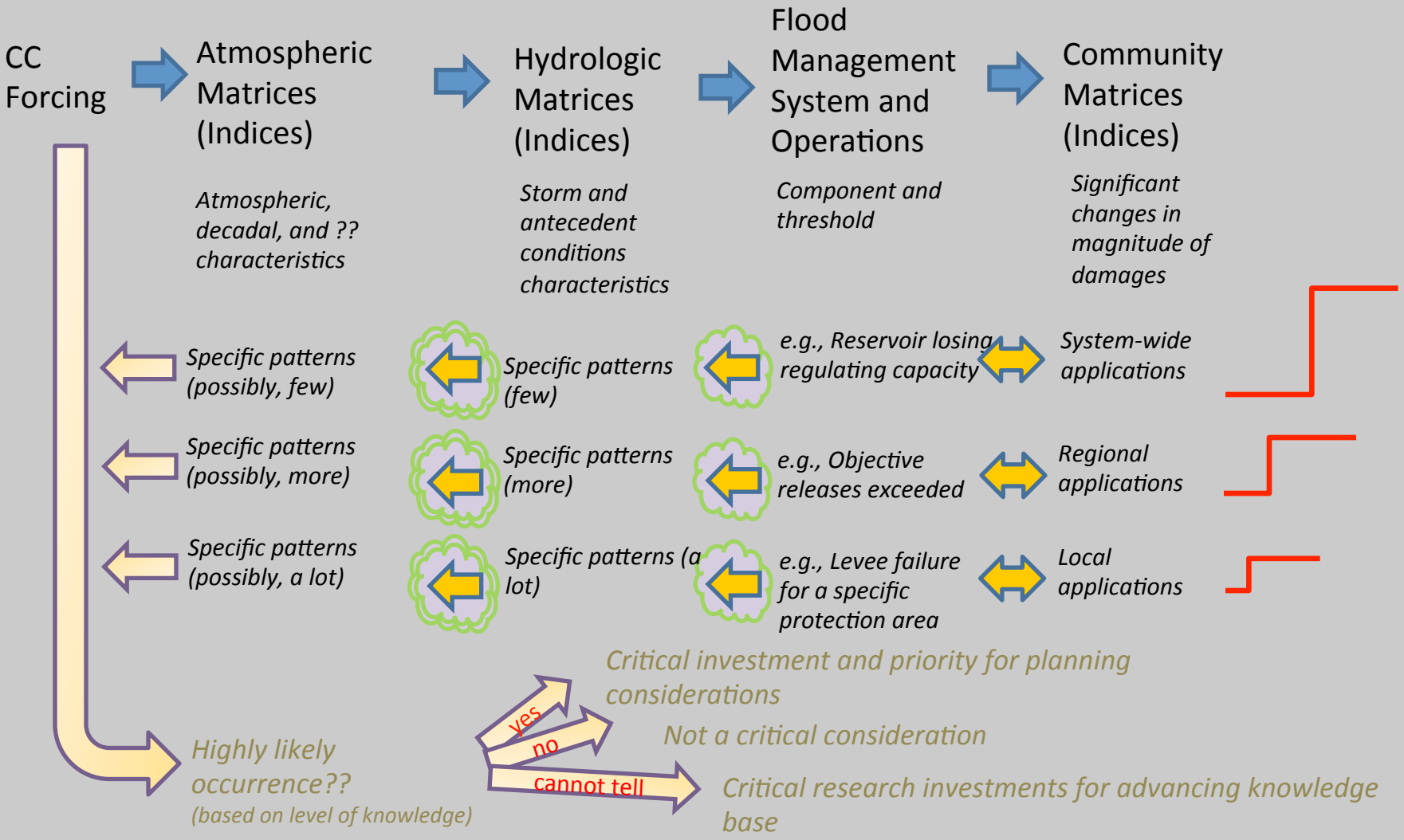
- **Using existing data & resource/mgmt models, map critical vulnerabilities of a city's stormwater management systems**

- **The question to climate analysts becomes "How likely are these breaking points to be reached in available climate-change projections & by common sense?"**

- *Uses most-realistic, highest-res data*
- *"Simply" expands beyond standard design-storm methods*

- *Infinite range of possibilities to be explored?*
- *Minimal connections to specific clim-chg projections*

Threshold Analysis Approach for CVFPP with Climate Change Considerations



ARkStorm Severe Storm Scenario

2. Severe-Storm Condition Evaluations

- **Focus on the specific storm types that challenge the stormwater systems most *(describing them in large-scale meteorological terms rather than "just" by intense simulated precip)***

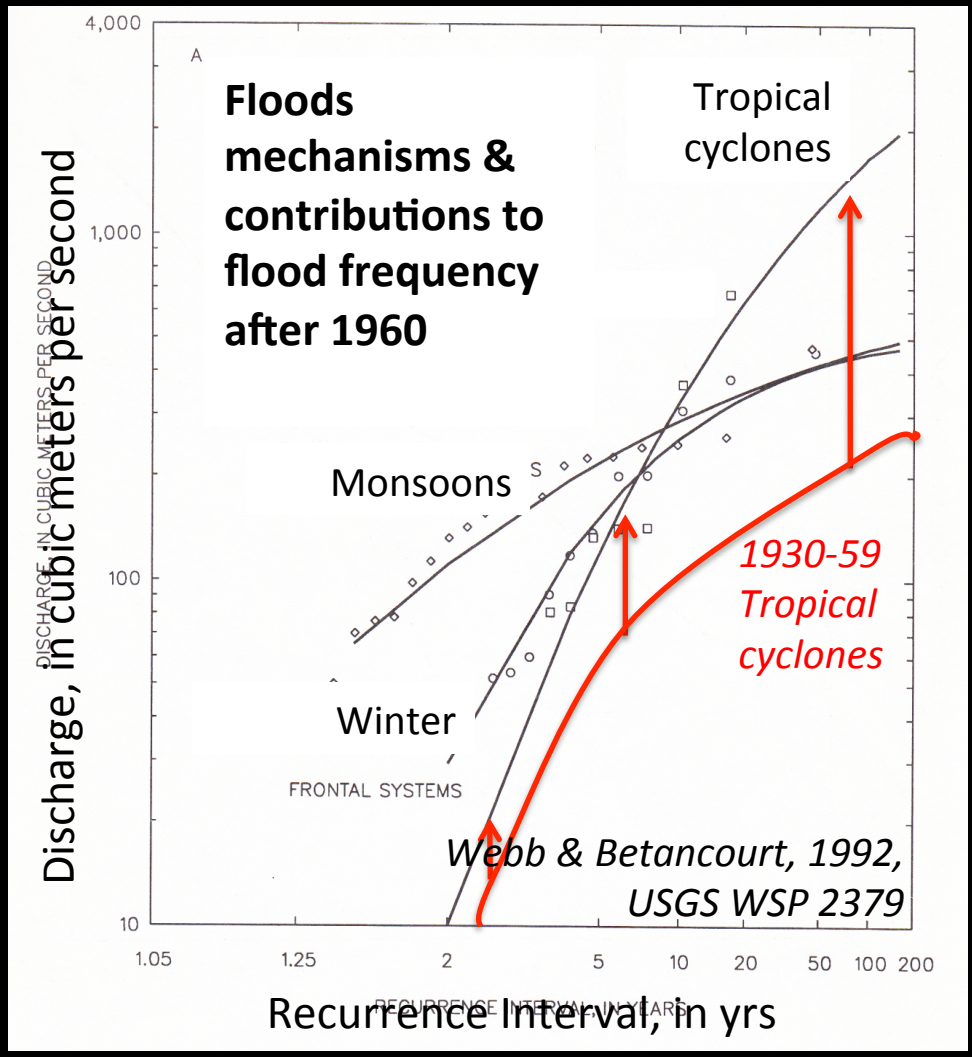
- **The question to climate analysts becomes "What sort of changes are projected in frequency & intensity of these storm types?"**

- *Focuses on best aspects of GCMs (general circulation models)*
- *Natural extension of historical vulnerability analyses*
- *Reduces range of possibilities to be explored*
- *Direct connections to specific clim-chg projections, without undue belief in uncertain details (i.e., specific precip amounts)*

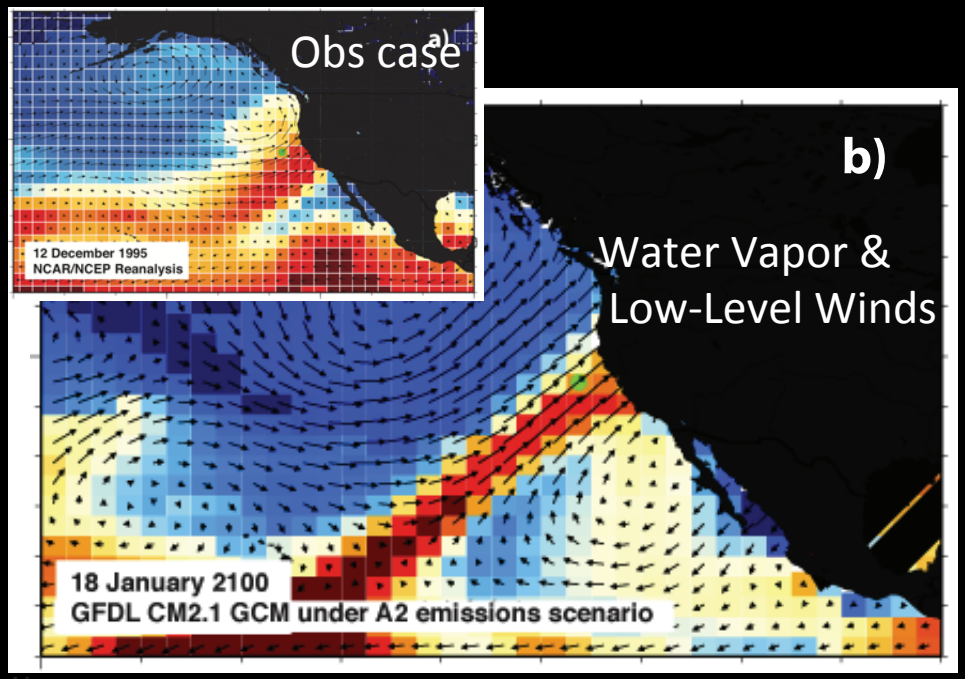
CHANGES IN EXTREME-EVENT MECHANISMS MAY BECOME VISIBLE LONG BEFORE CHANGES IN OVERALL EXTREMES ARE RECOGNIZED

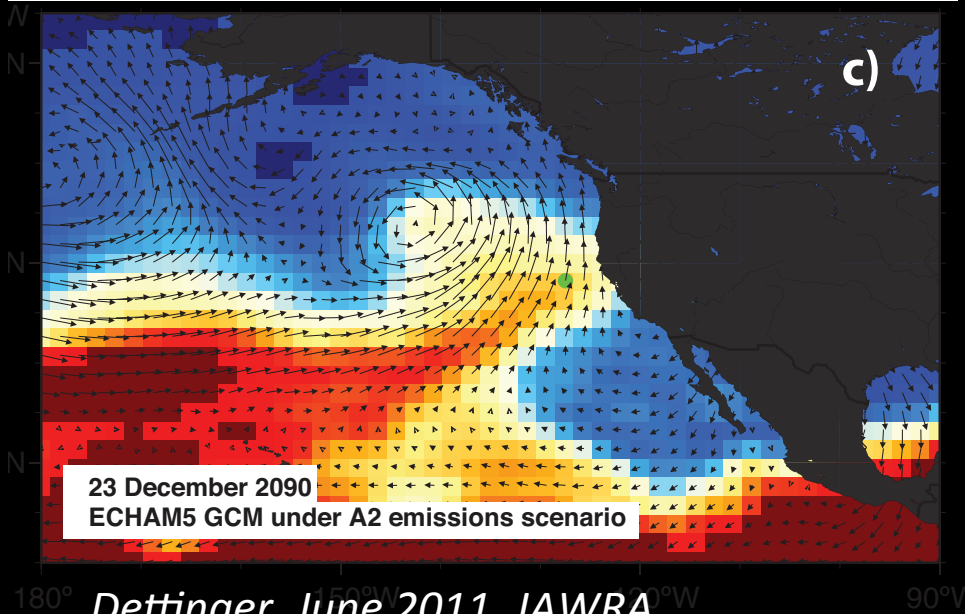
- Early warning of changes
- GCM-informed sensitivity analyses of vulnerabilities to potential storm changes
- Buying time until projected/downscaled extreme precipitation values are more trusted

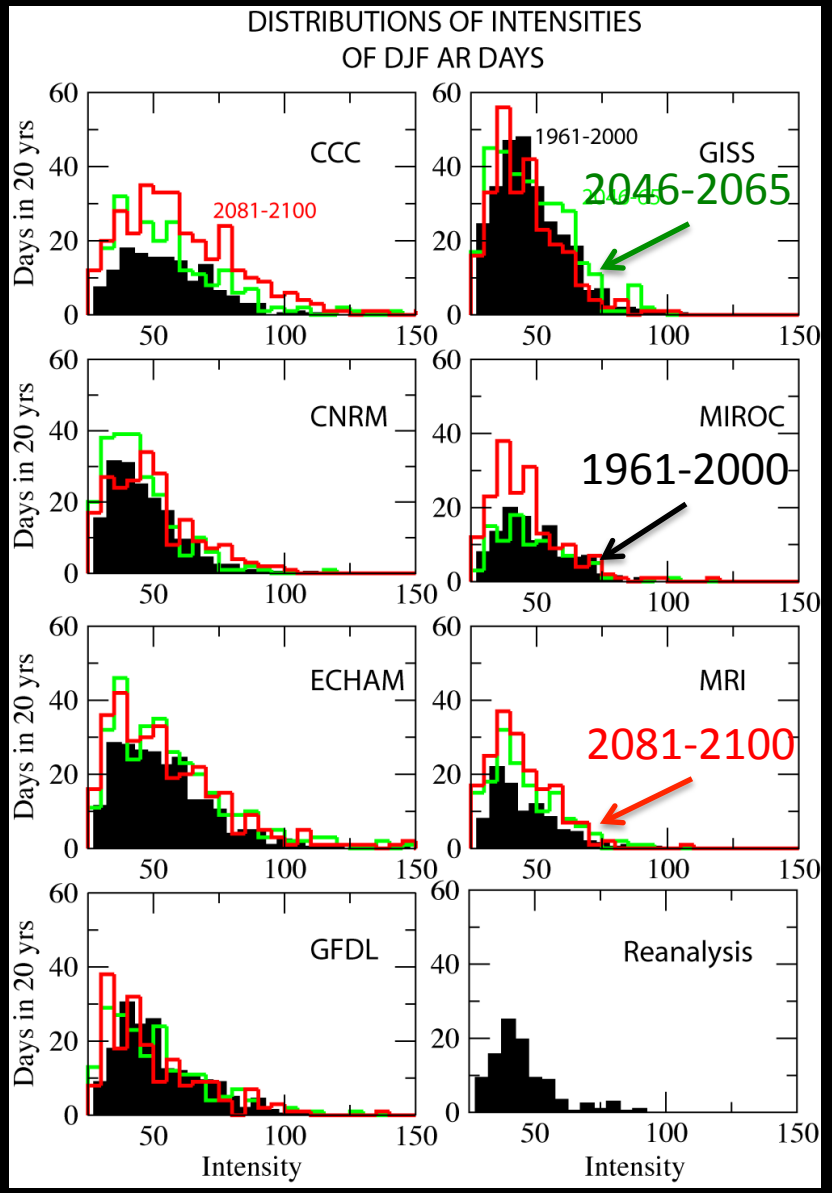
Flood frequency analyses of the Santa Cruz R, Tucson, AZ



"Semi-quantitative characterization" of a particular category of West Coast extreme storm events: Atmospheric Rivers in IPCC AR4 projections



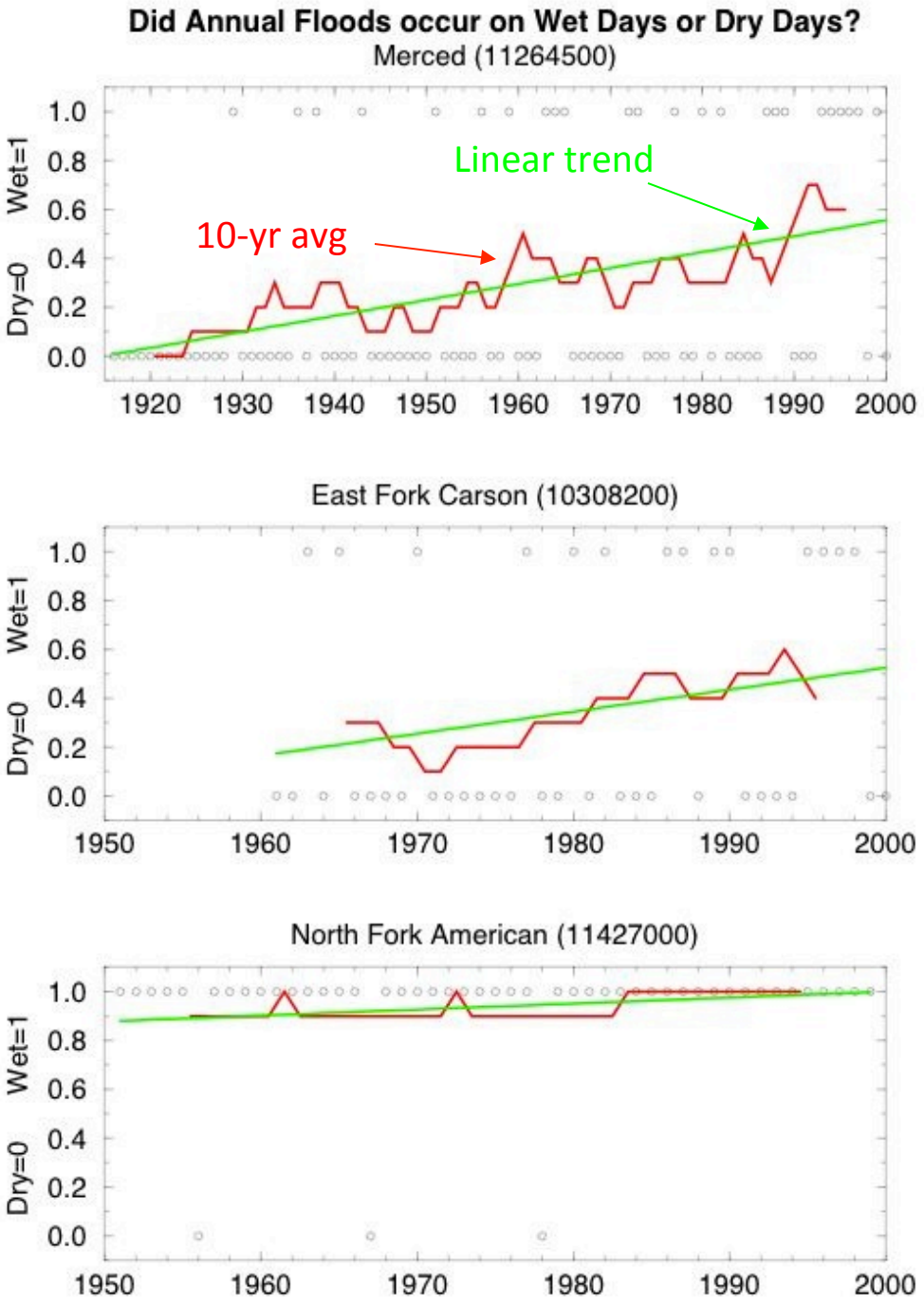




Dettinger, June 2011, JAWRA

Observations:

Have annual-peak flows become more precipitation-driven (rain- or rain-on-snow fed) than heat-driven (snowmelt-fed) in recent decades?



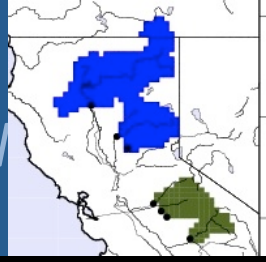
3. High-resolution Simulations and Downscaling

- **Continue along the developing path of "dynamical downscaling," using advances in that field as they emerge**

- **The question to climate analysts becomes "What precipitation extremes are projected at finest scales obtainable?"**

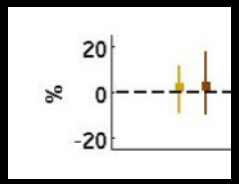
- *Provides detailed examples of extremes that might be faced*
- *Support may be necessary to ensure focus on extremes focus (most focus remains on average changes)*
- *Direct connections to specific clim-chg projections*
- *Technology still developing & expensive*
- *Short RCM simulations provide little basis for freq-analysis of rare extremes*

Projected floods in Sierra Nevada *(Das et al*



16 GCMs, A2 emissions

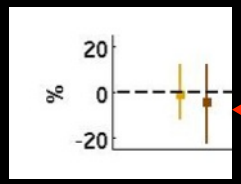
Northern Sierra Nevada



Change in mean annual flow

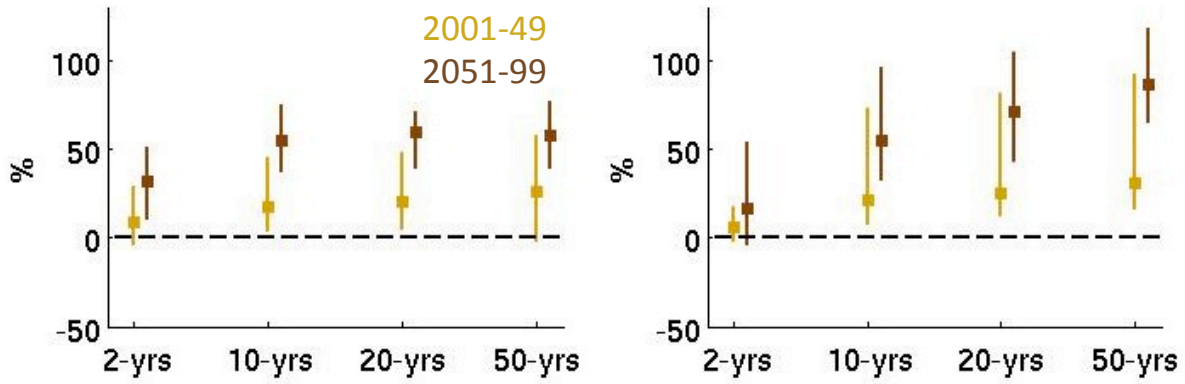
Southern Sierra Nevada

Change in mean annual flow



Drier avg

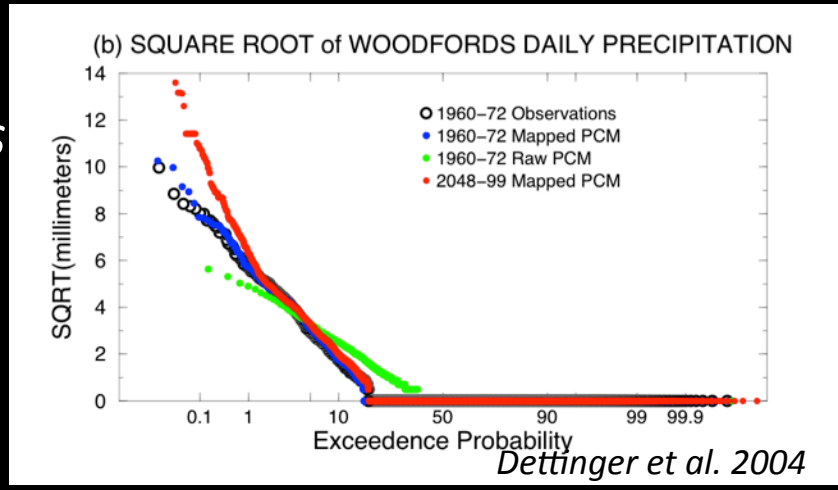
Change in flood flows with various return periods



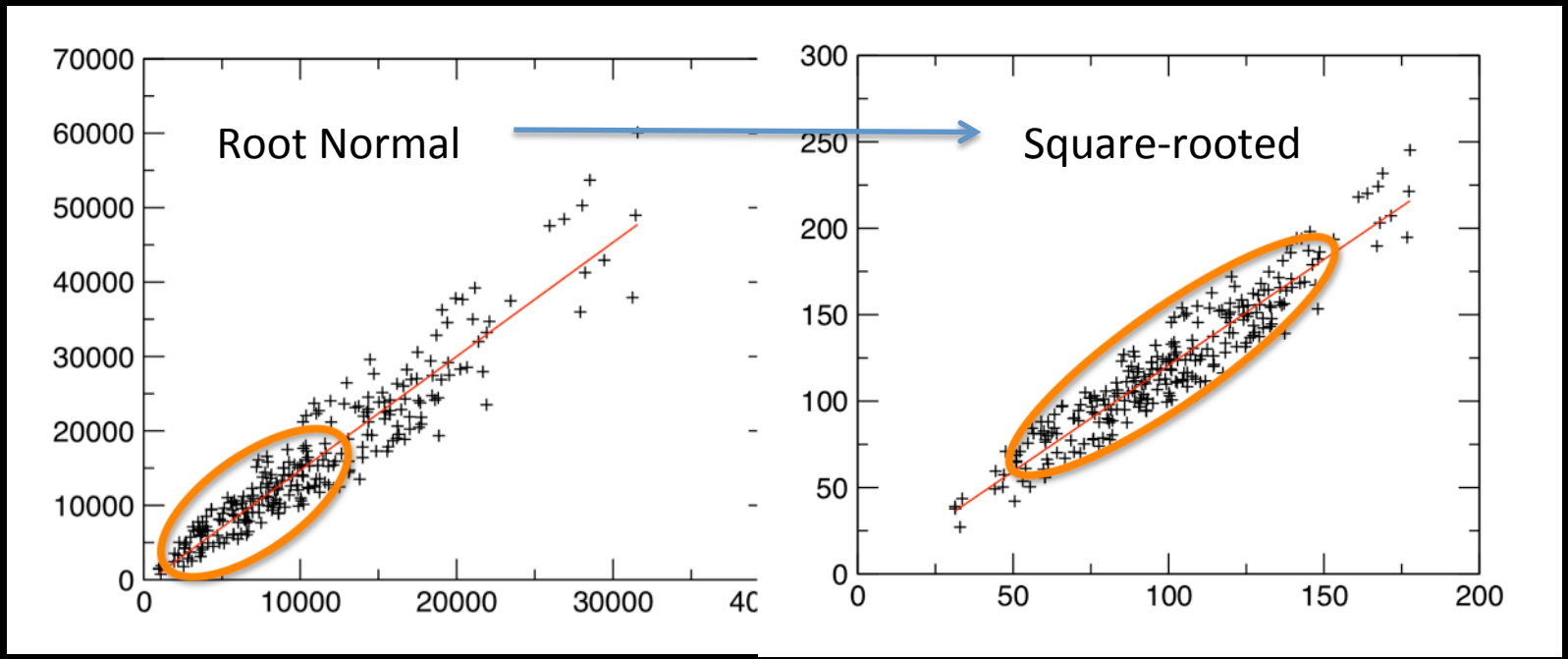
4. Statistical downscaling

- *Many advantages (speed, bias correction, …) as well as disadvantages*
- *Full-distribution bias corrections?*

- *Revisit/revalidate/redesign statistical dscaling with extreme, rare events as focus (figures are just simple illustrn of how this might look)*



Dettinger et al. 2004



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