Statistical Downscaling for the State of California

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US Geological Survey, La Jolla, CA

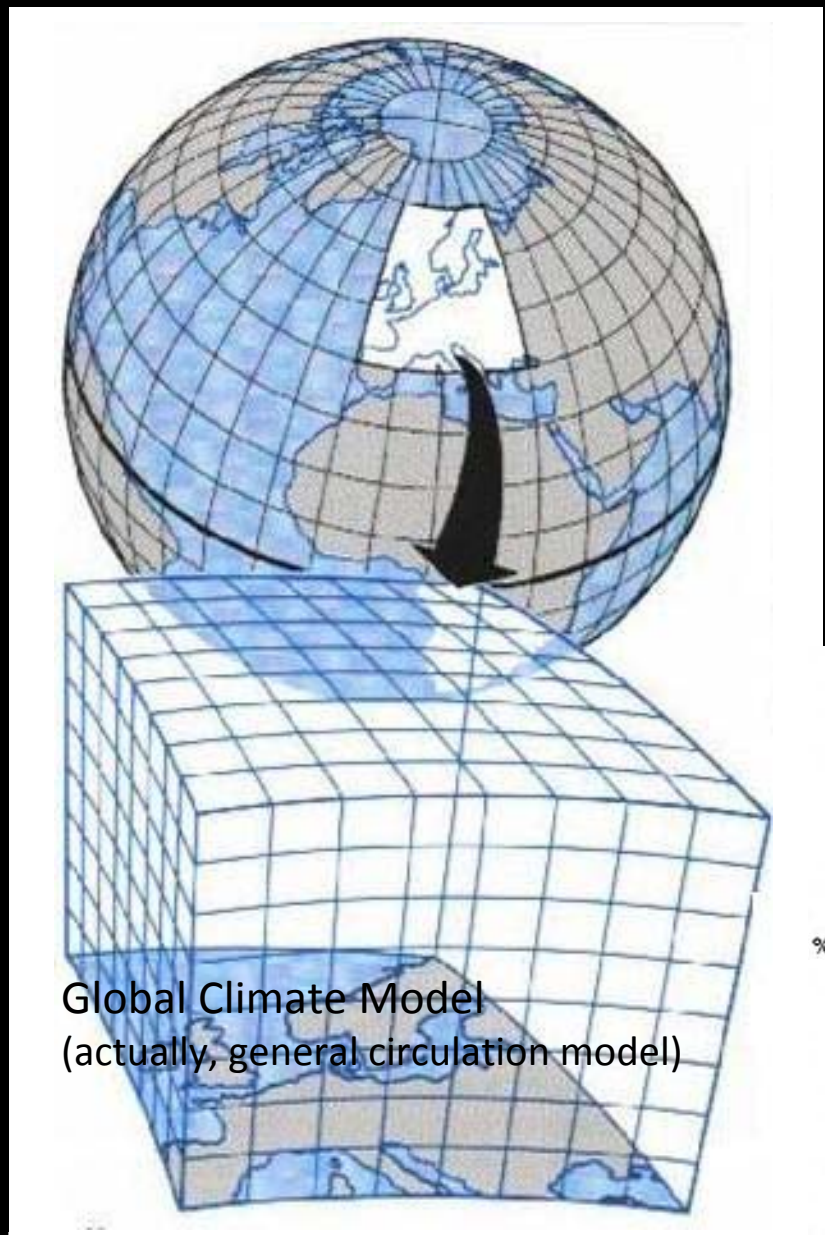
CDFG/USGS/USFWS Downscaling Workshop,
CSU Sacramento, Nov 3, 2010

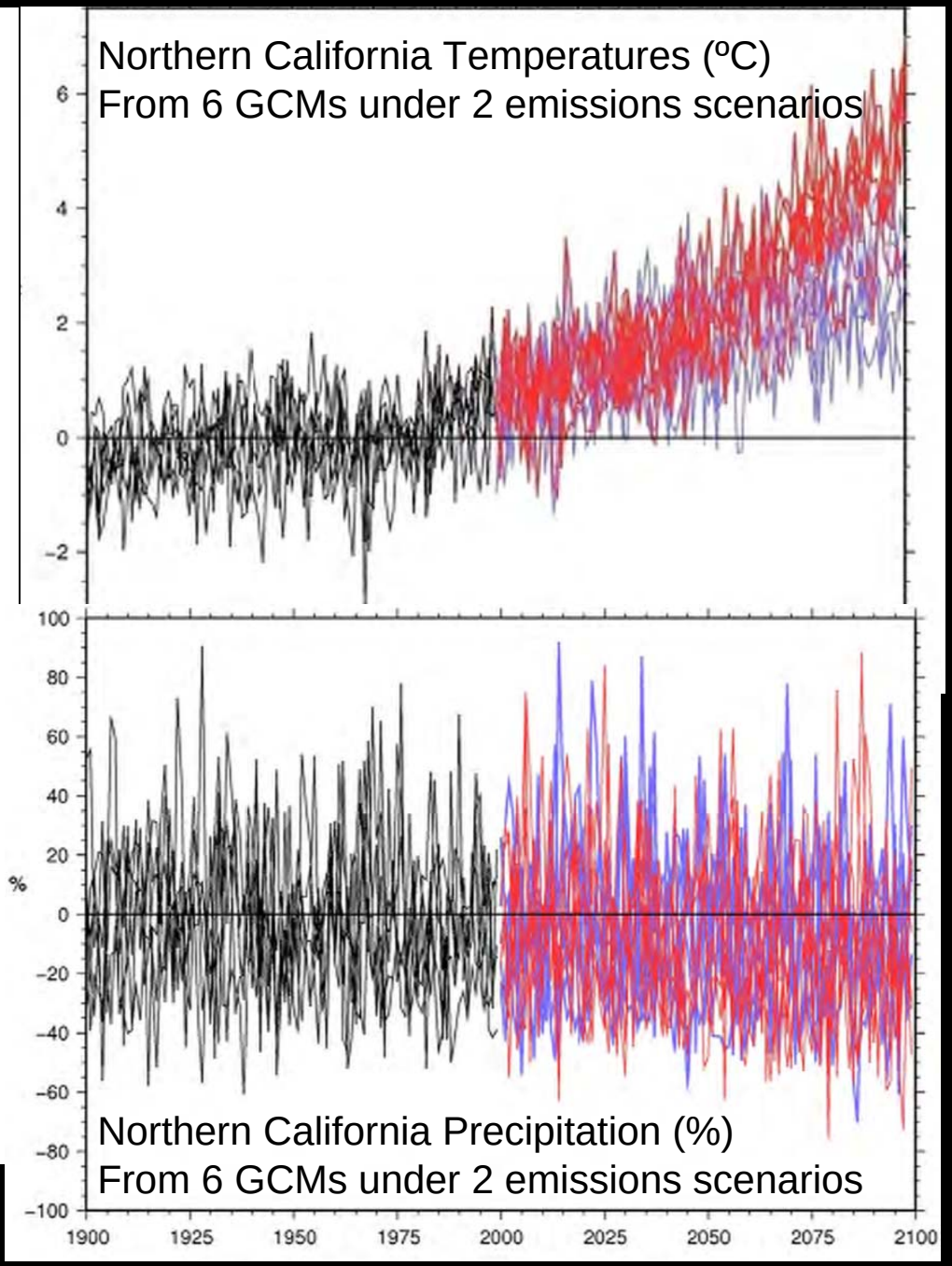
USGS

Scripps Institution of Oceanography

CEC's California Climate Change Center

NOAA OGP's California Applications Program

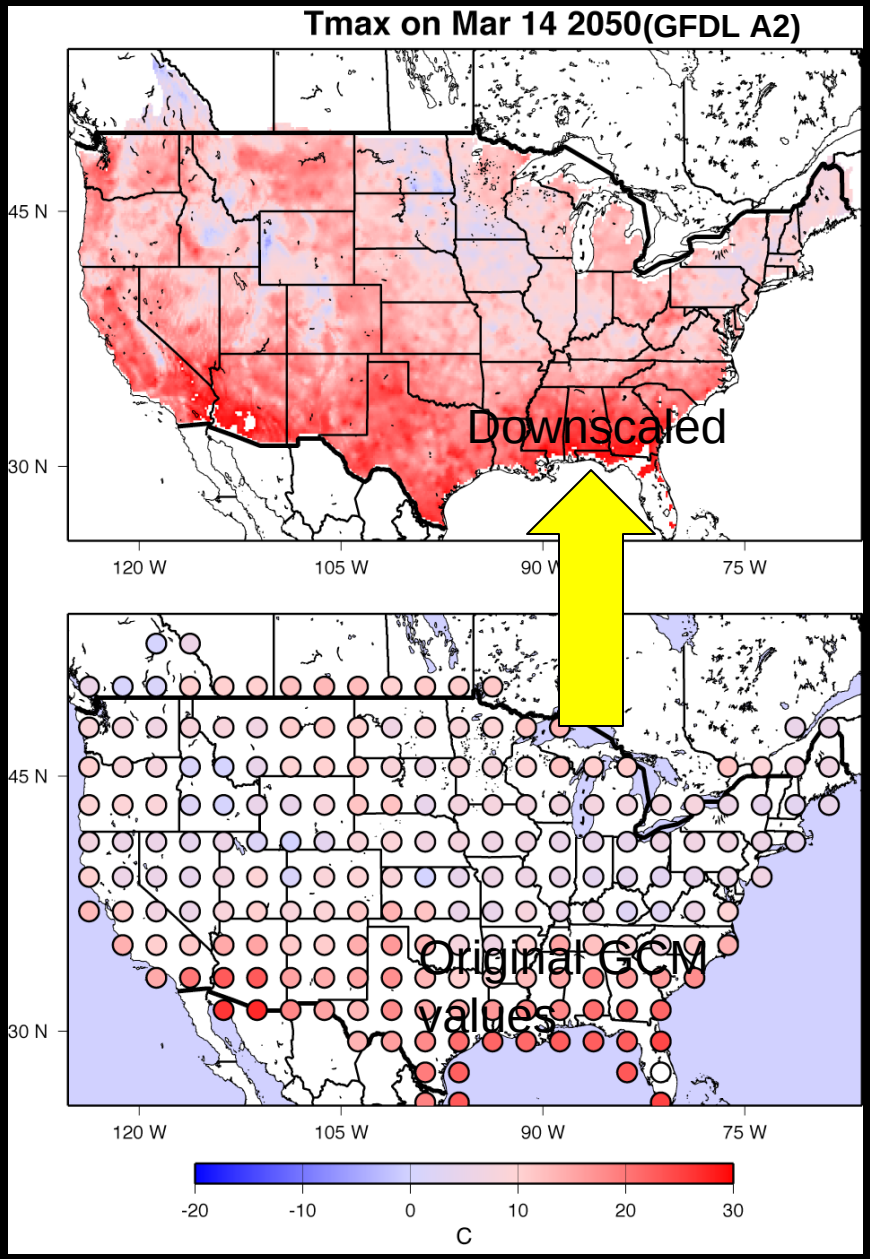


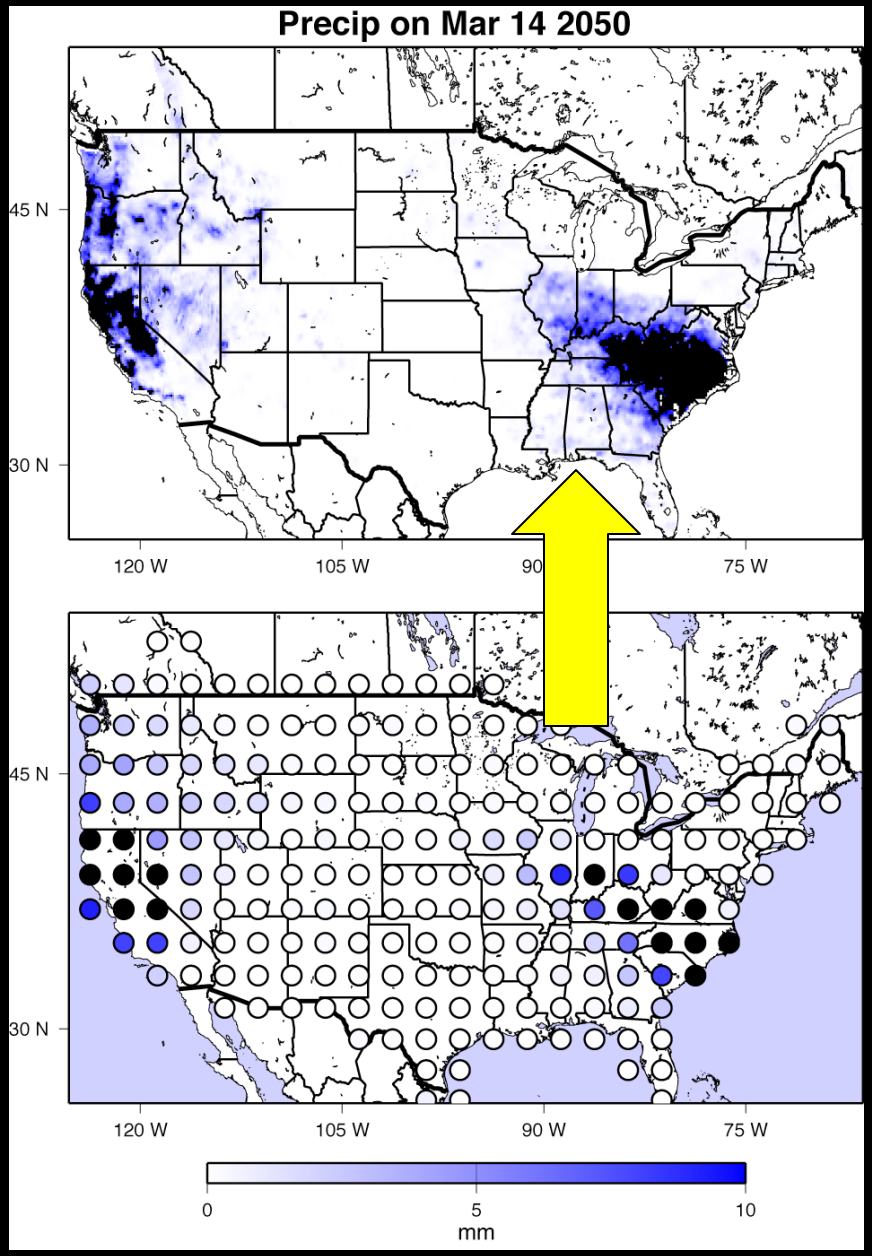


USGS

Cayan et al 2009

THE DOWNSCALING PROBLEM: One day in the 21st Century...





Downscaling options:

Statistical

- δT and %P rescaling
- Synthetic statistical
- Deterministic statistical

Dynamical simulation

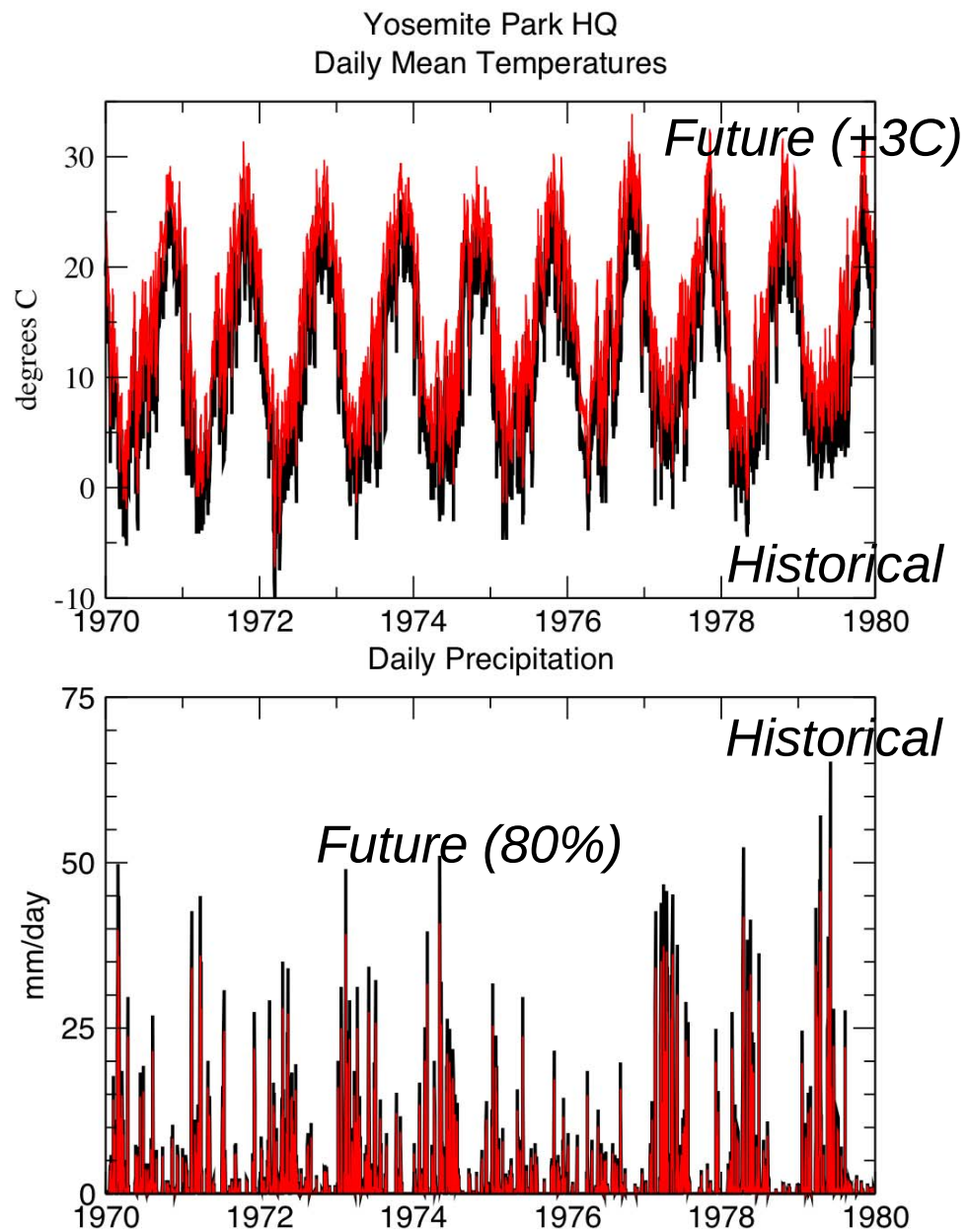
dT and %P re-scalings

ADD projected mean temperature changes to a historical record

Multiply historical record by projected mean precipitation (as fraction of historical)

↑ Easy, maintains realistic variability, know exactly what changed

↓ No new variability or extremes, not realistic, minimal use of GCM



Synthetic statistical scenarios

$$\mathrm{Prob}(O_i) = \alpha_o + \alpha_{oi-1}\, O_{i-1} + \alpha_{sh} SH_i + \alpha_u U_i + \alpha_h H_i$$

$$R_i = \exp(\beta + \beta_{sh} SH_i + \beta_u U_i + \beta_h H_i + \varepsilon)$$

$$TMAX_i = \delta_0 + \delta_{TMAXi-1} TMAX_{i-1} + \delta_{SH} SH_i + \delta_U U_i + \delta_h H_i + \zeta_i$$

$$TMIN_i = \gamma_0 + \gamma_{TMINi-1} TMIN_{i-1} + \gamma_{SH} SH_i + \gamma_u U_i + \gamma_h H_i + \xi_i$$

With O = occurrence of precipitation
SH = humidity
U = wind speed
H = geopotential height
R = wet-day precipitation amount
TMAX and TMIN = daily maximum & minimum temperatures

e.g., Wilby et al., 2001

Synthetic statistical scenarios

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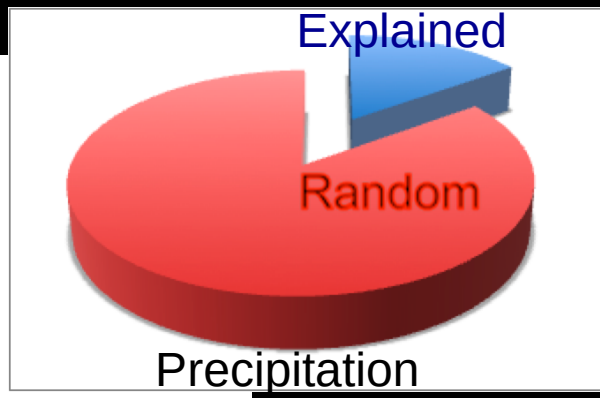
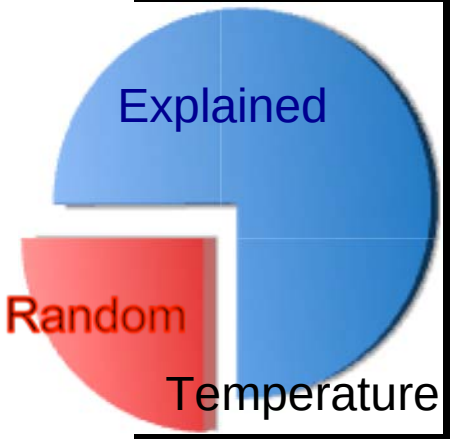


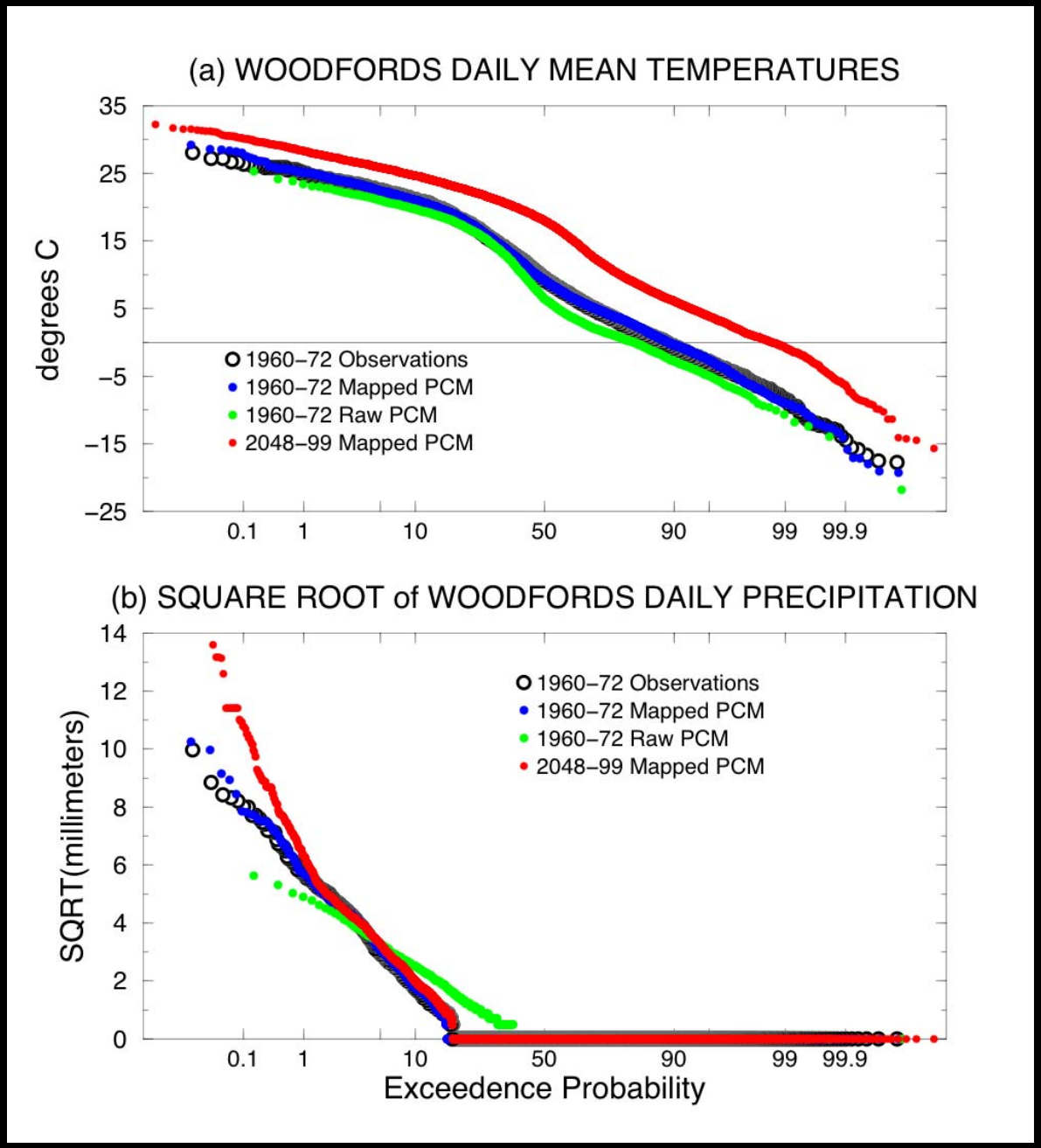


Deterministic statistical

Local bias-correction example

(Dettinger et al, 2004 Clim Chg)

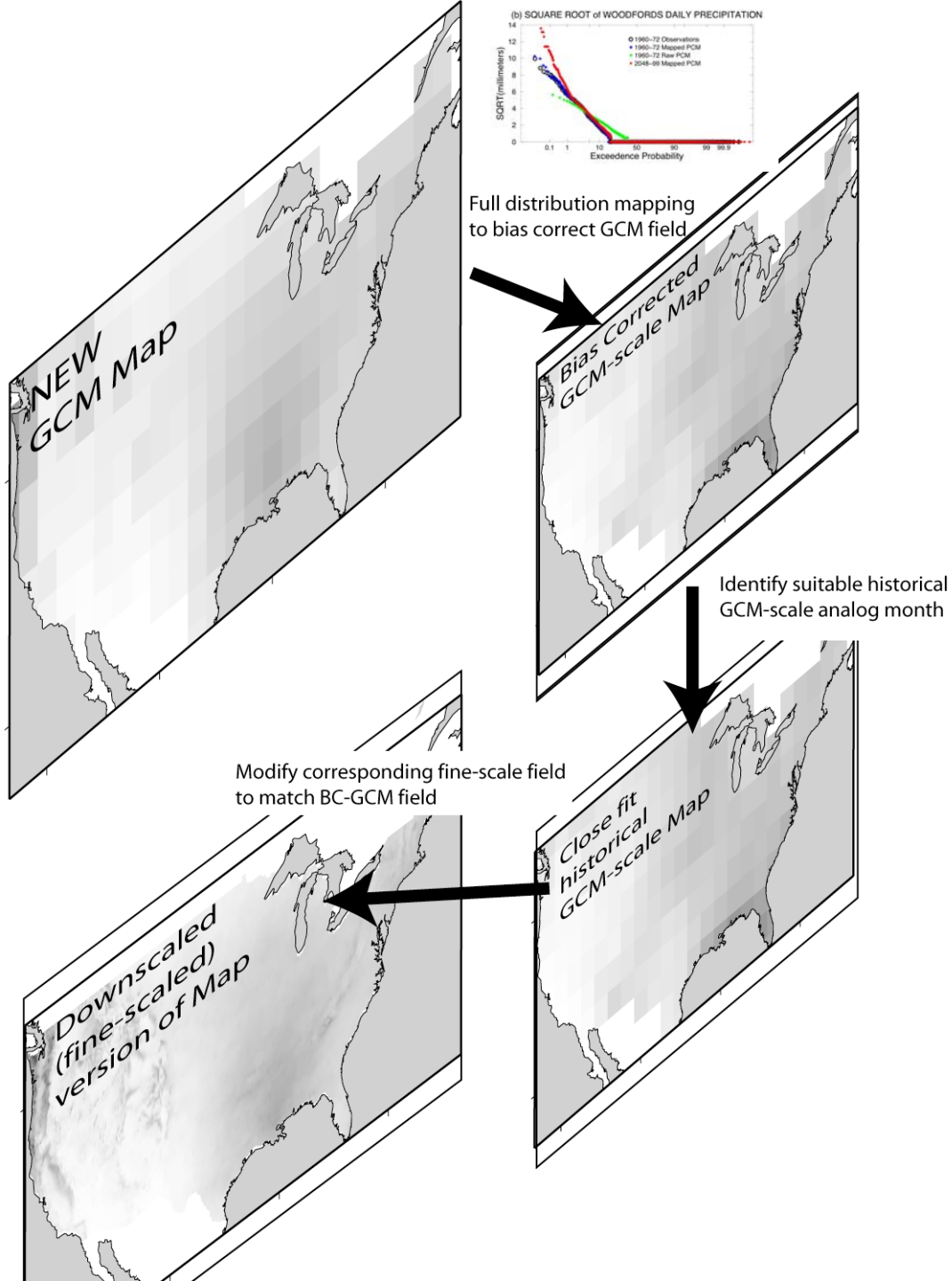
Map GCM variables into historical distribution of variables, maintaining ranks from GCM but absolute values from historical records



Deterministic Statistical

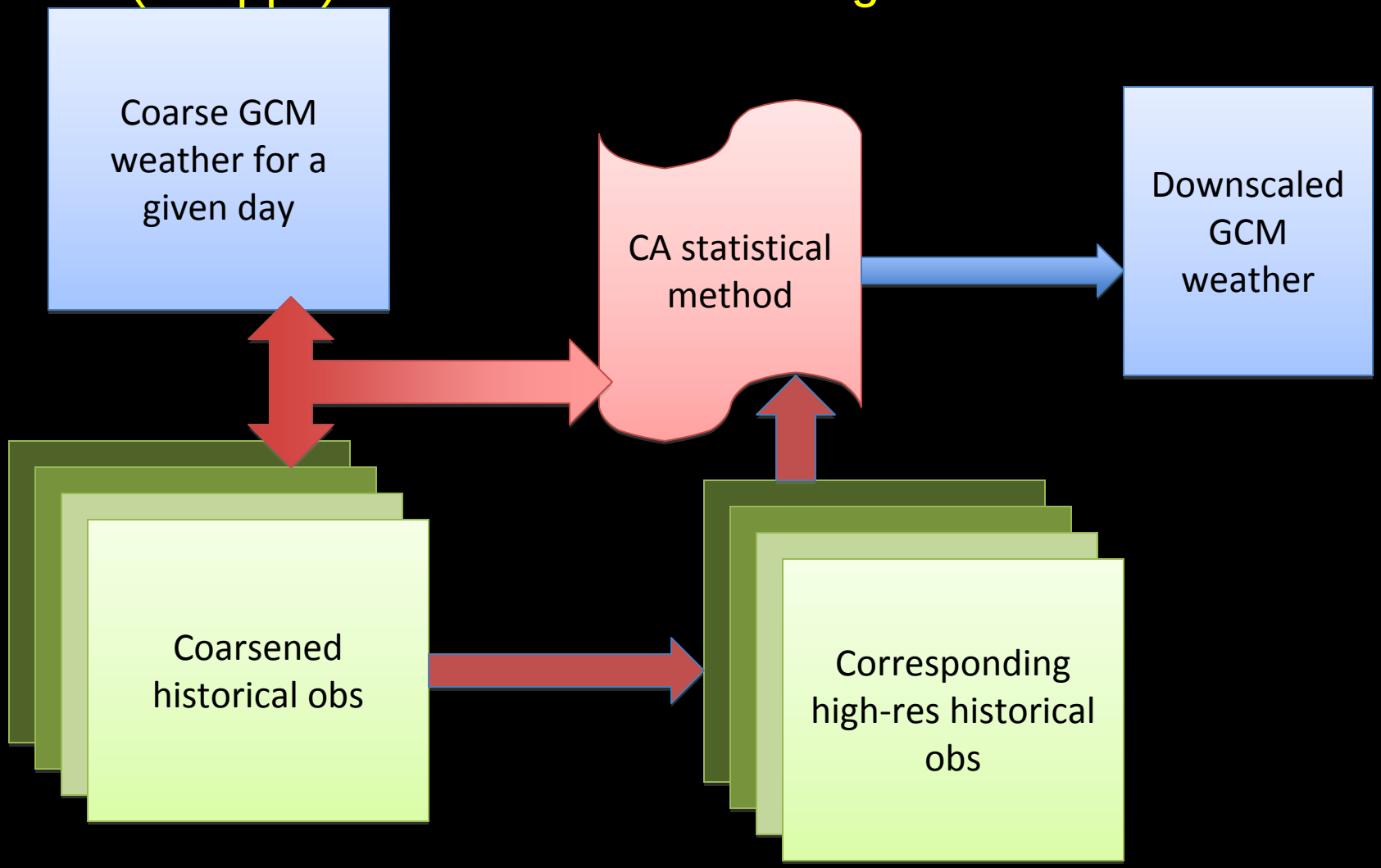
BCSD
(Ed Maurer & U Wash)

Bias-Correction
Spatial Disaggregation Method
(e.g., Maurer et al., HESS, 2010)



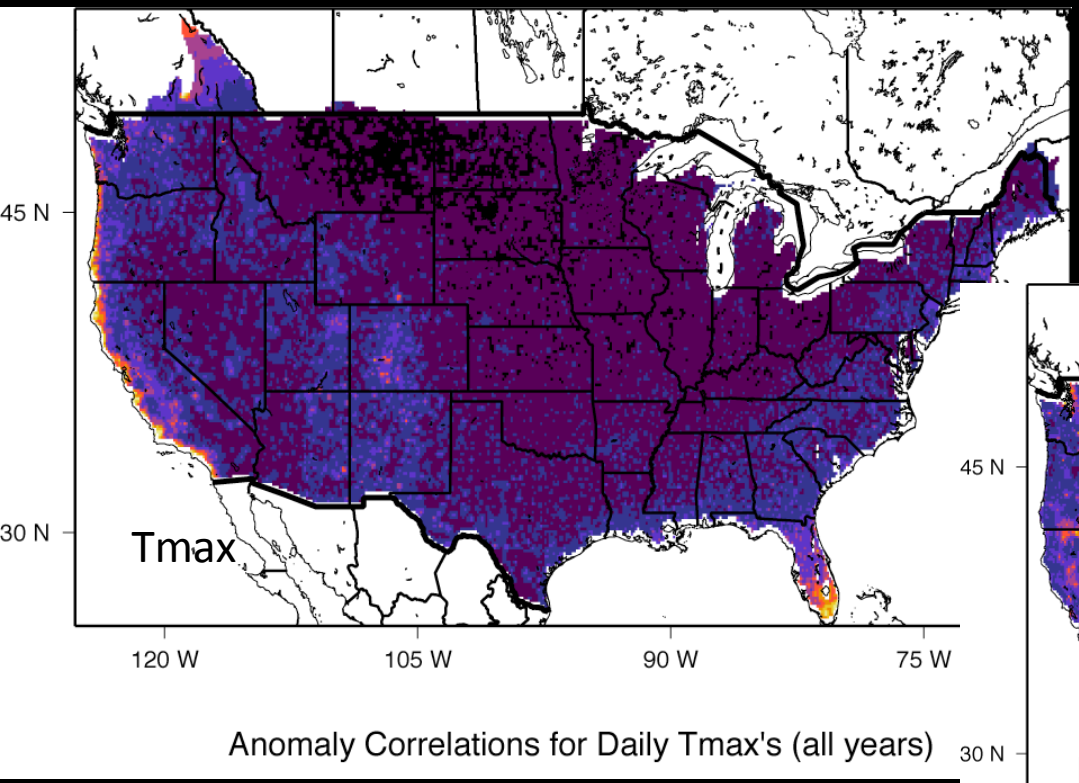
Deterministic statistical

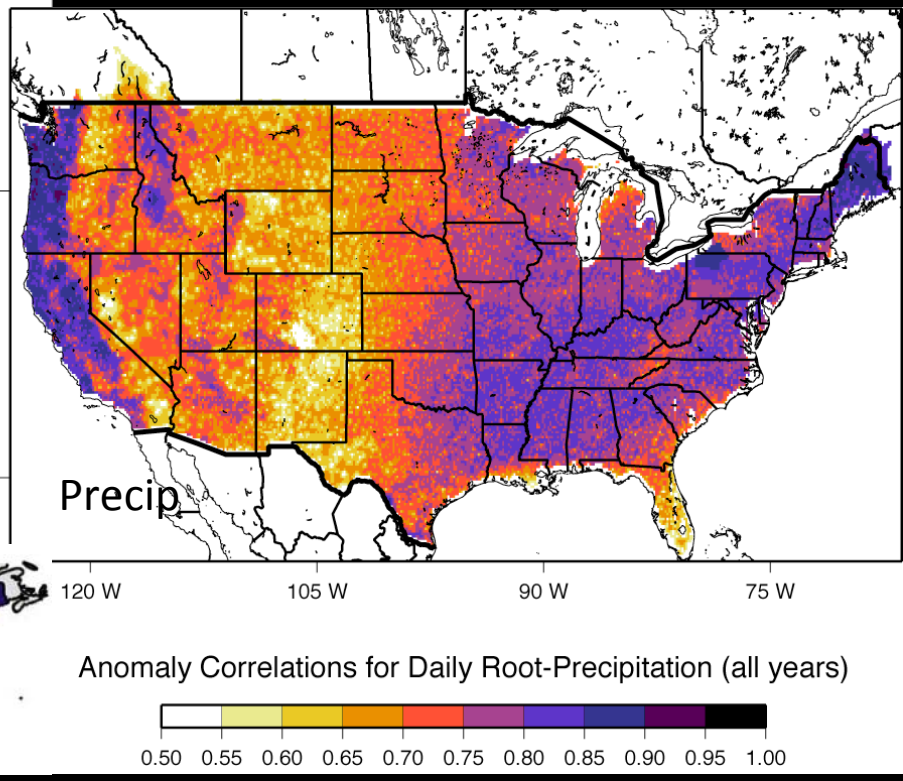
CA (Scripps) → Constructed Analogs



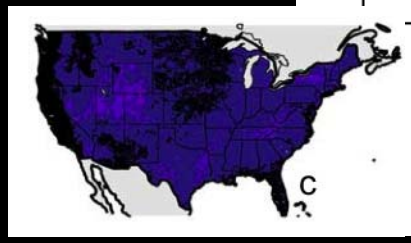
HIDALGO et al 2008:
http://www.energy.ca.gov/2007publications/CEC-500-2007-123/CEC-500-2007-123.PDF

Skill of downscaling as indicated by application of method to historical OBSERVATIONS





Precip Skill at monthly average scale



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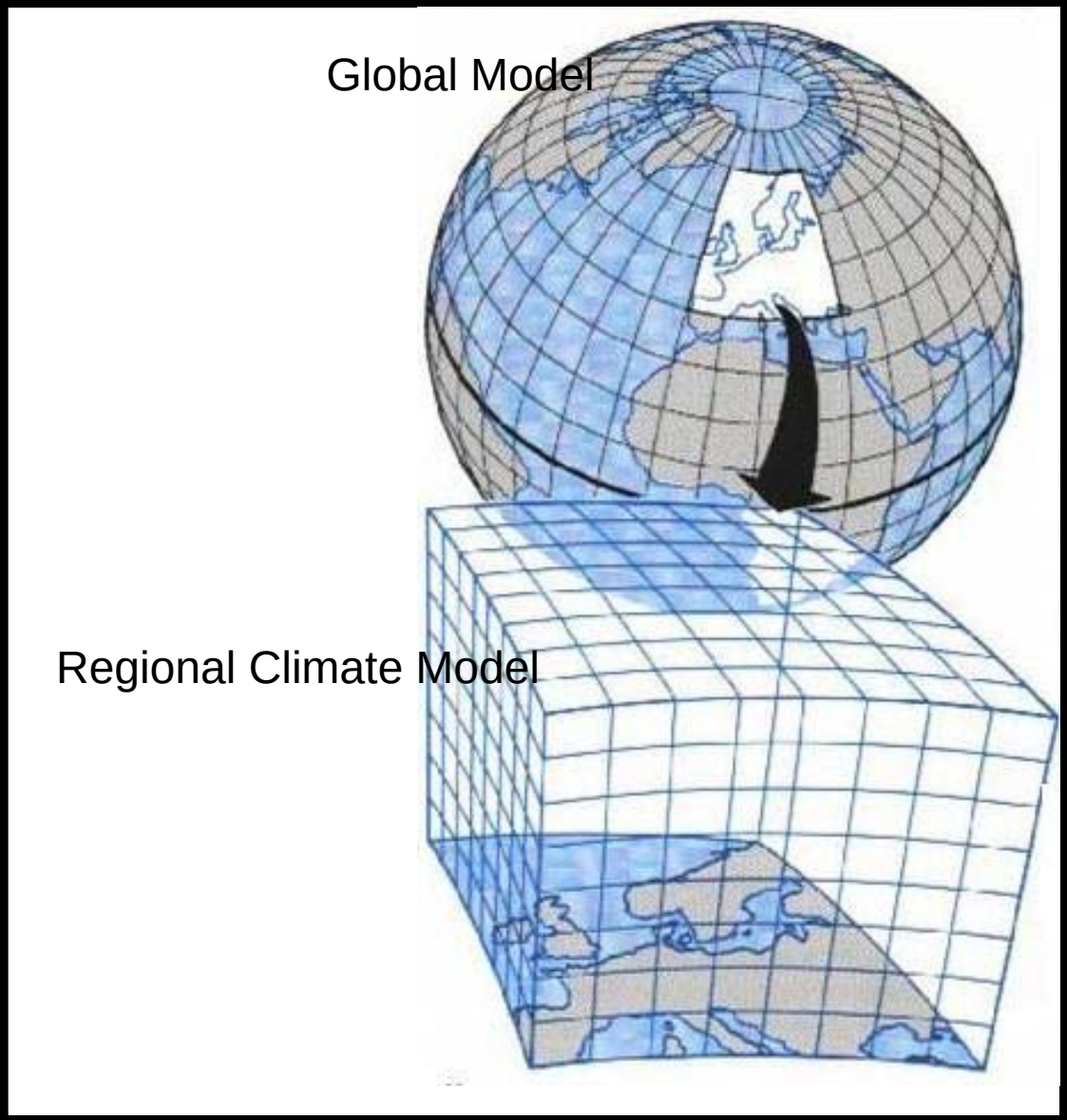
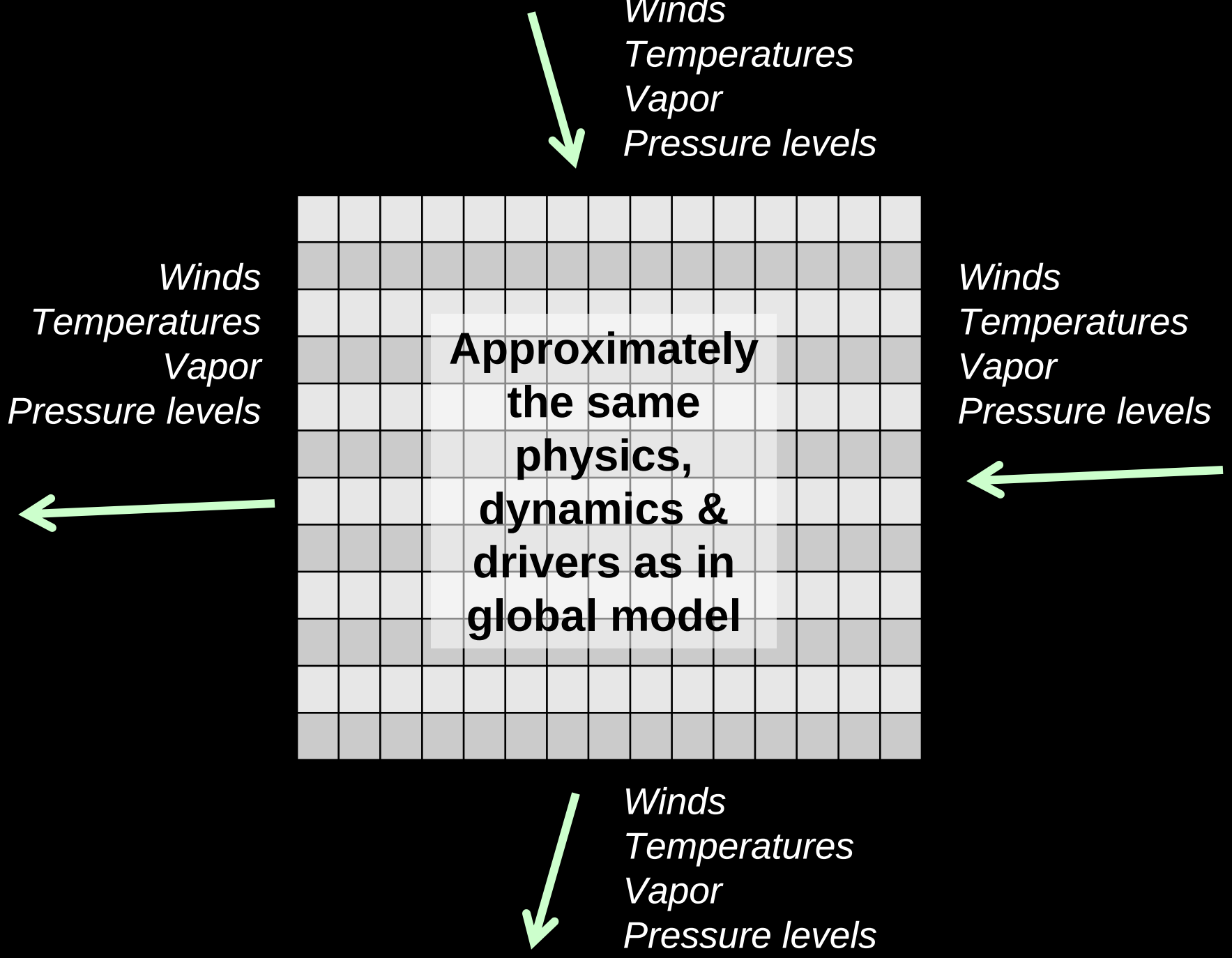
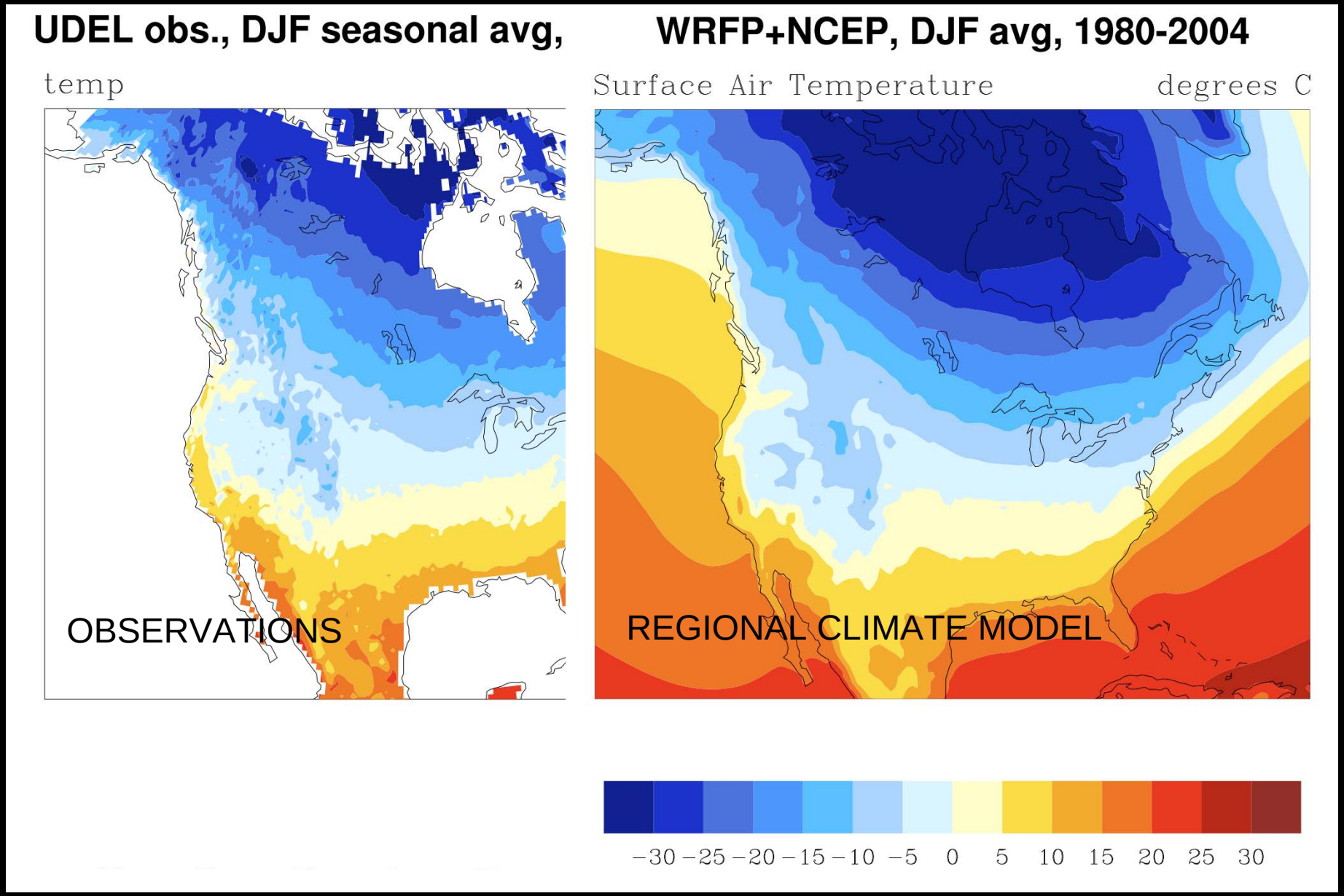
Dynamical simulation for downscaling



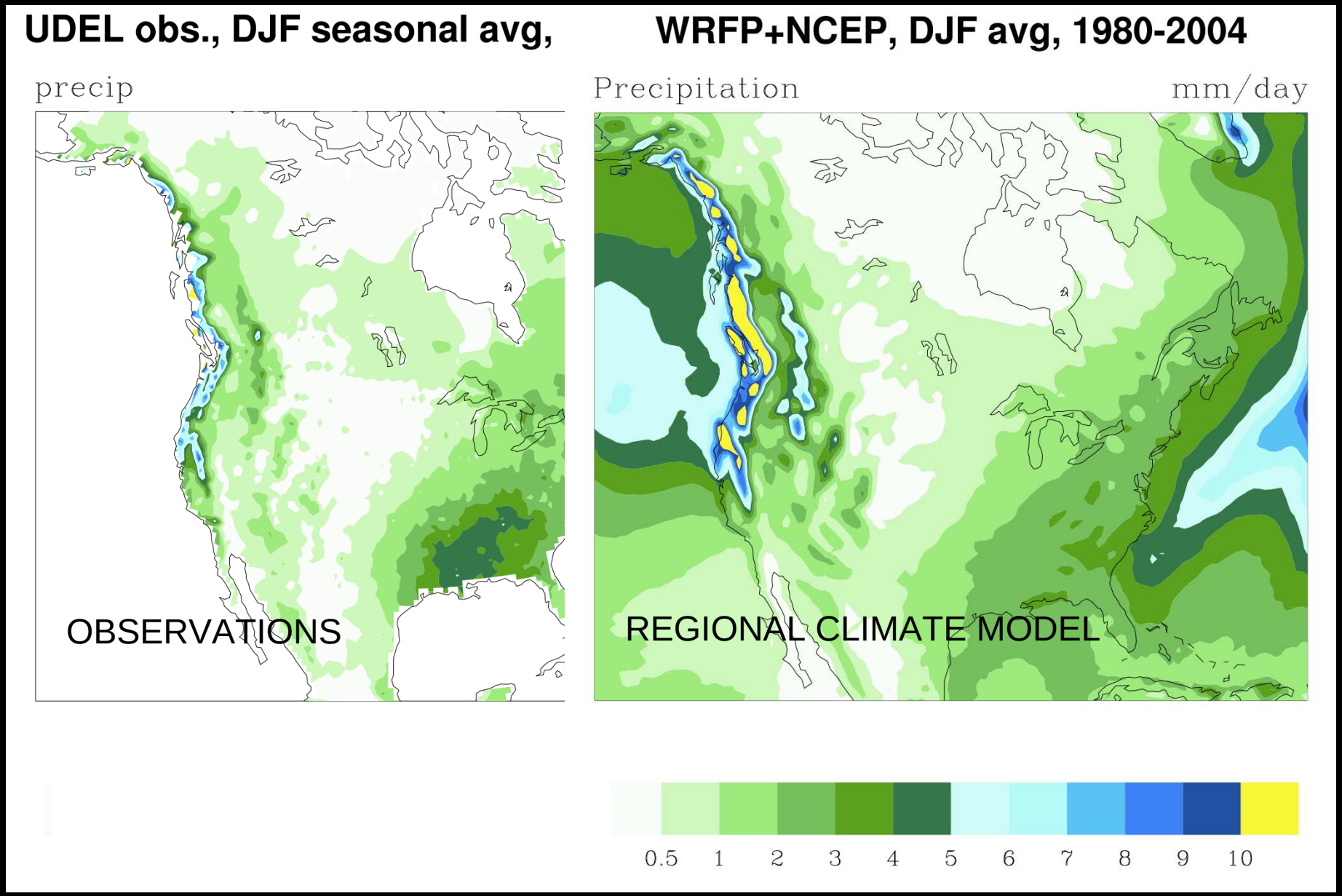

Winds
Temperatures
Vapor
Pressure levels
Winds
Temperatures
Vapor
Pressure levels
Winds
Temperatures
Vapor
Pressure levels
Approximately the same physics, dynamics & drivers as in global model
Winds
Temperatures
Vapor
Pressure levels

Comparison of Dynamically Downscaled Temperatures to Obs



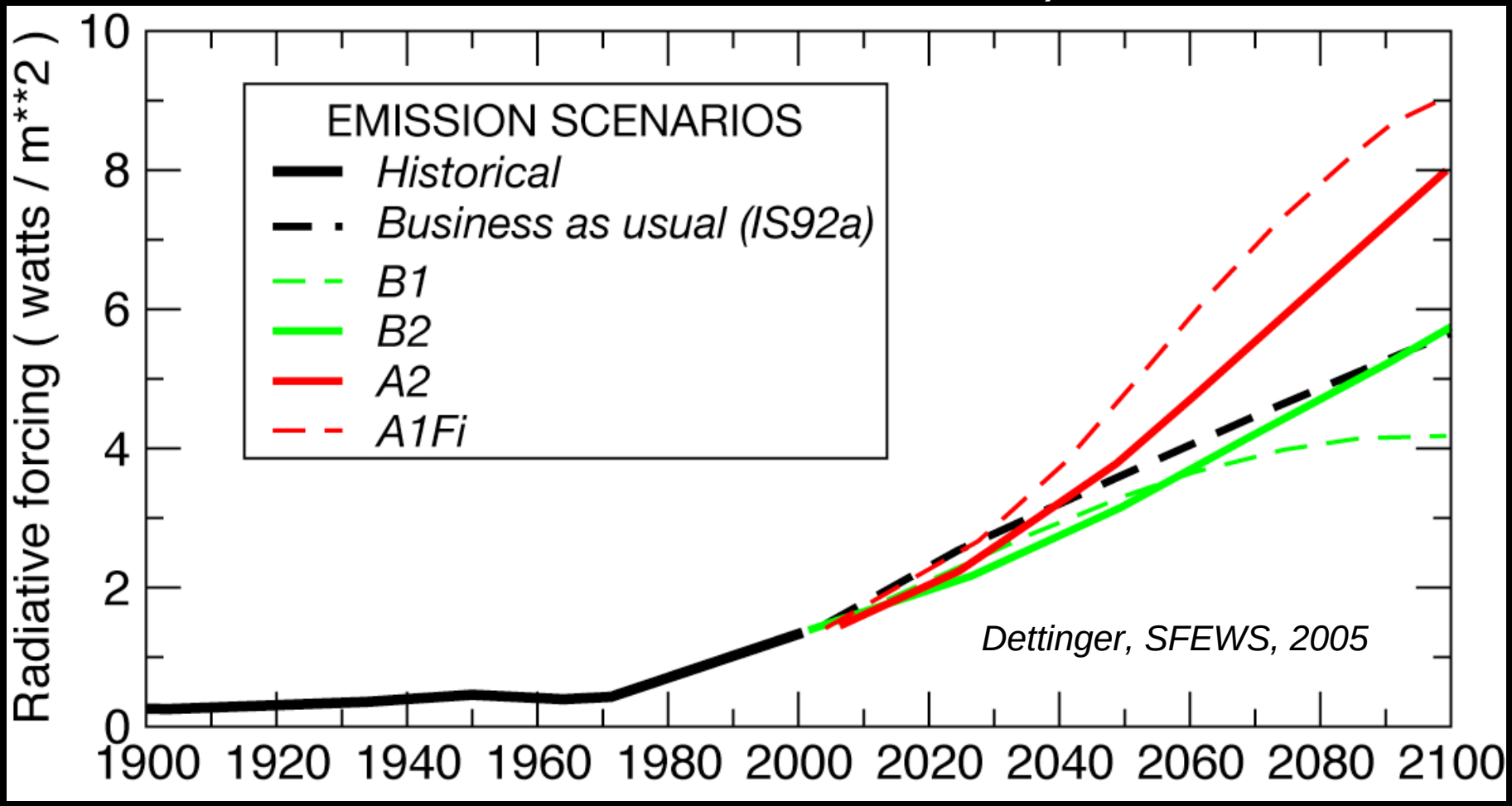
http://www.narccap.ucar.edu/results/ncep-results.html

Comparison of Dynamically Downscaled Precipitation to Obs



http://www.narccap.ucar.edu/results/ncep-results.html (30-yr projections, 50 km grids)

These are the kinds of radiative forcings from scenarios that we all have been evaluating impacts from in recent years (so called, Special Report on Emissions Scenarios, 2000, or SRES scenarios)



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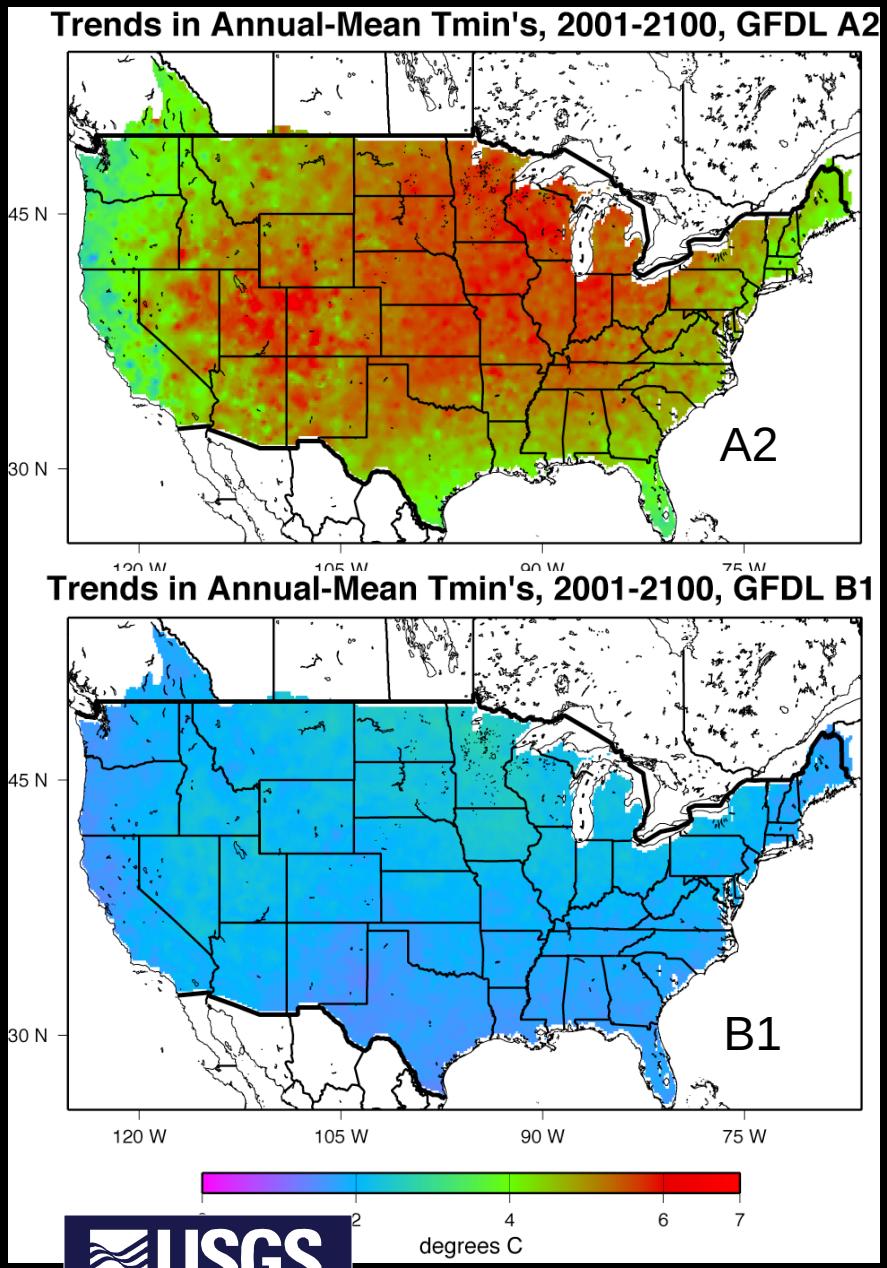
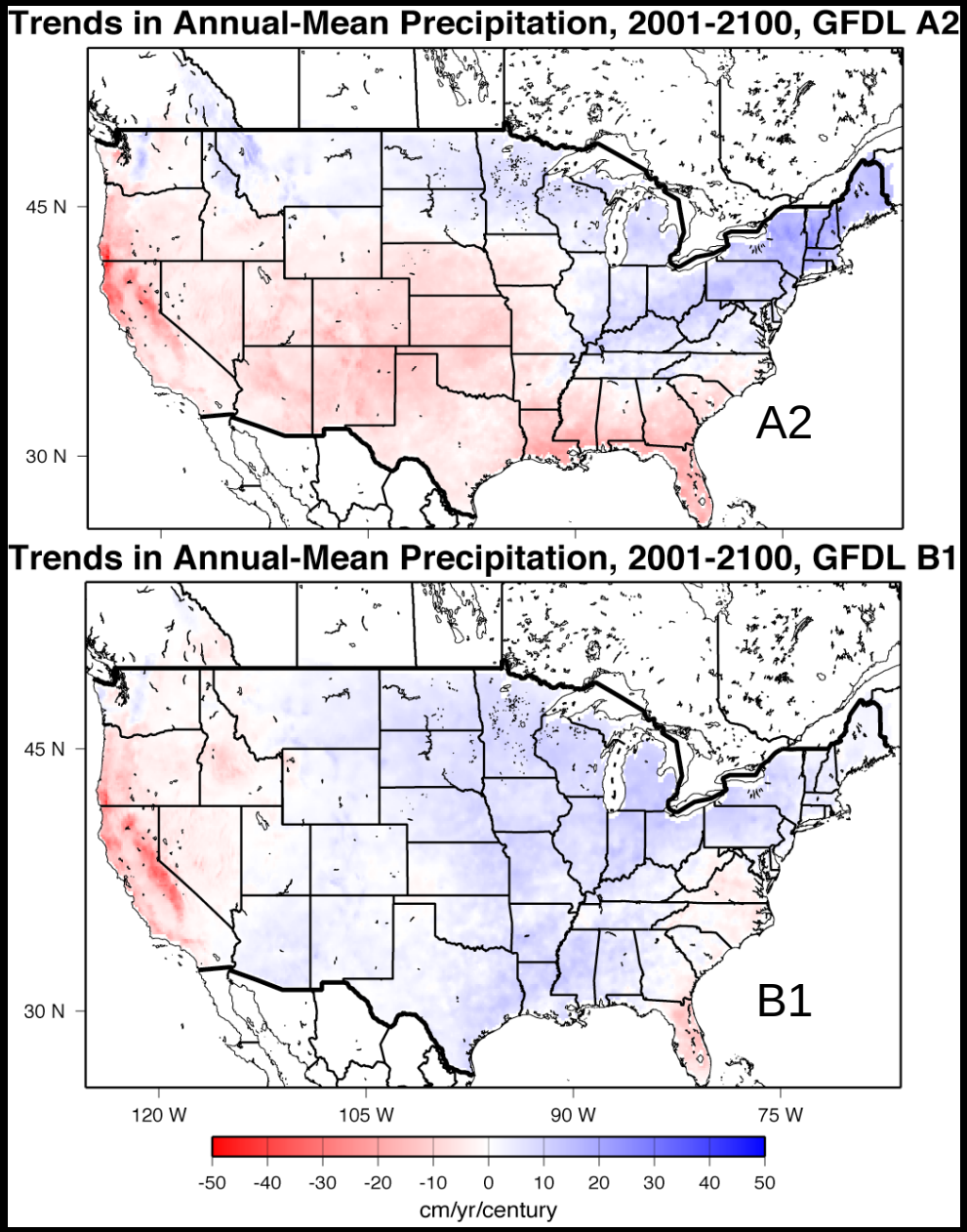
Downscaled GFDL Trends, 2001-2100

A2 Tmin Trends

B1 Tmin Trends





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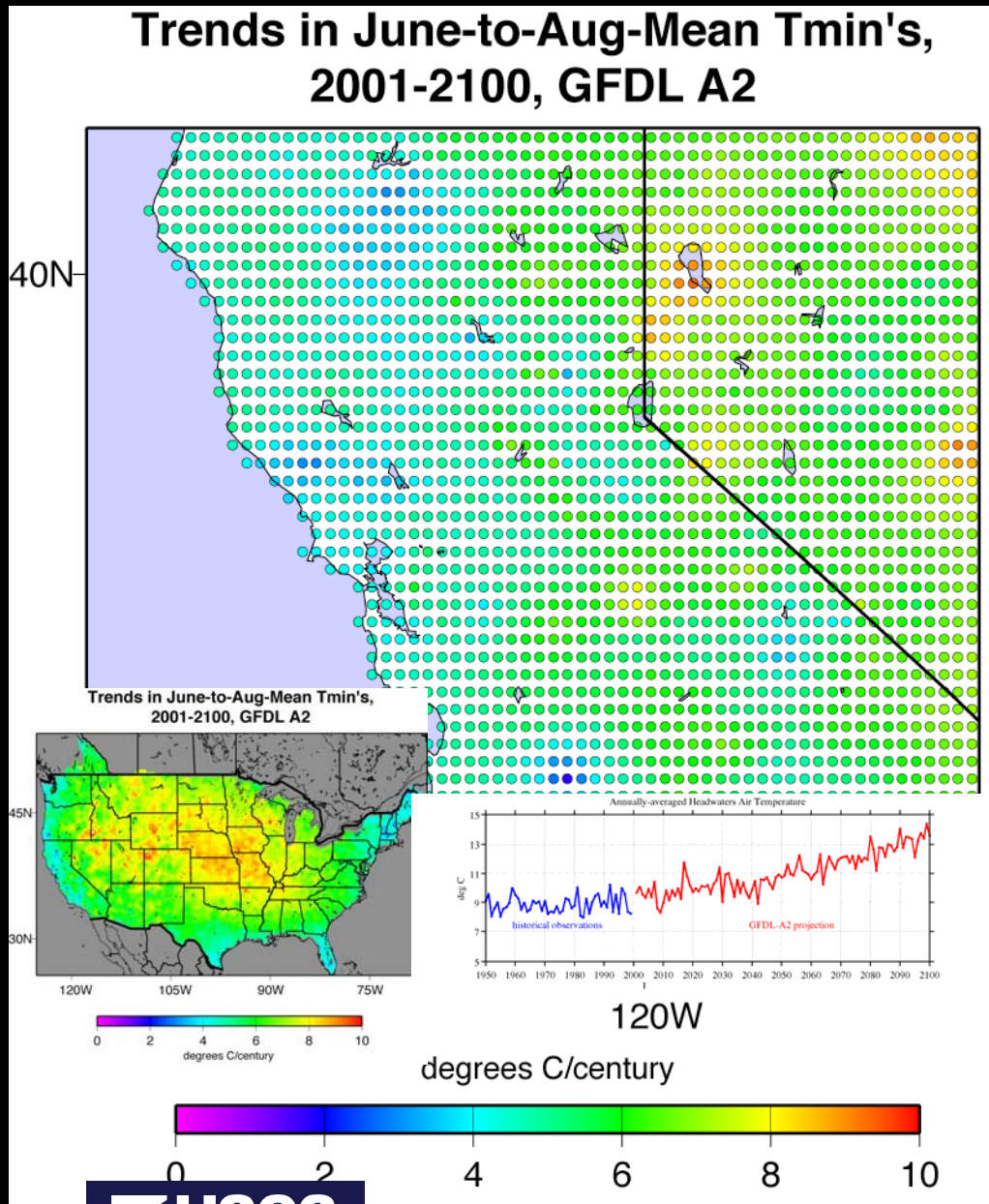

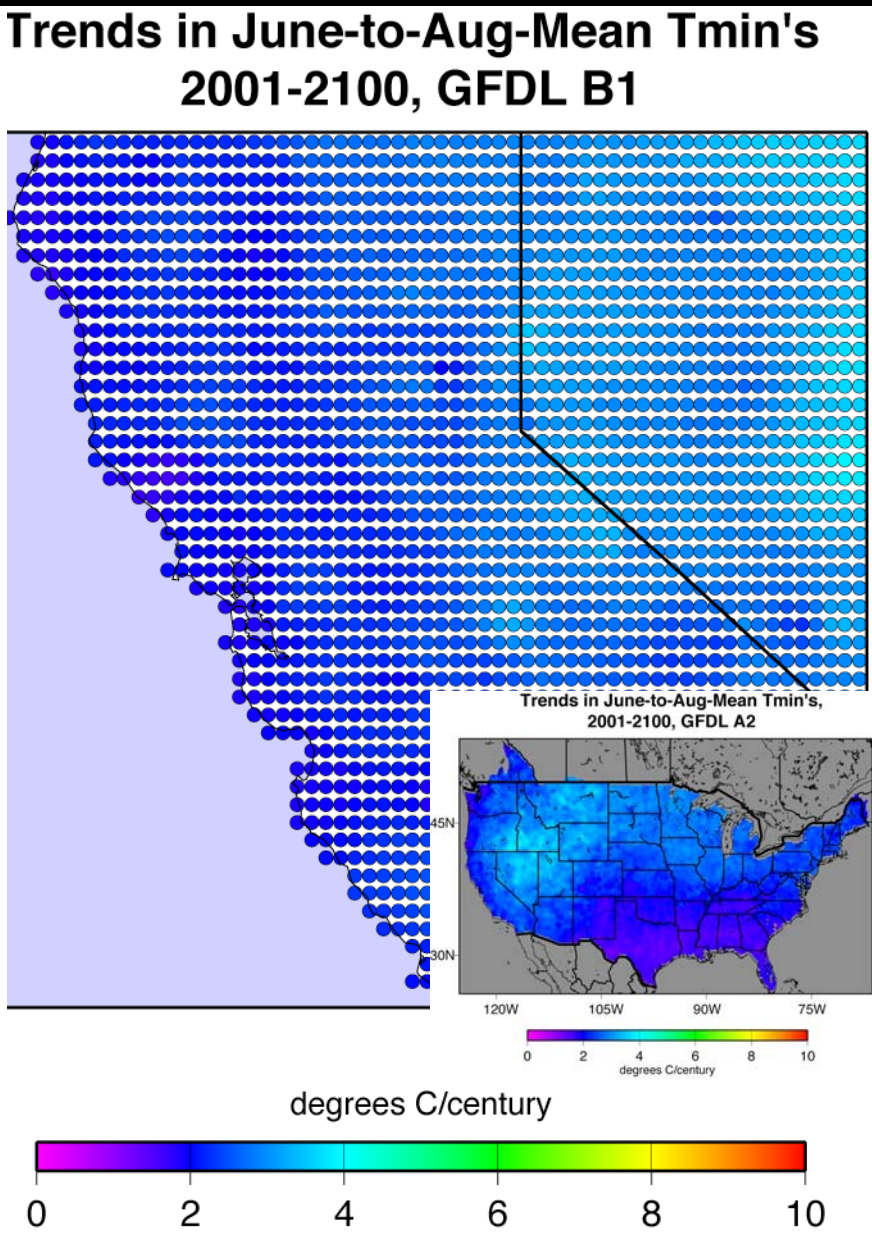

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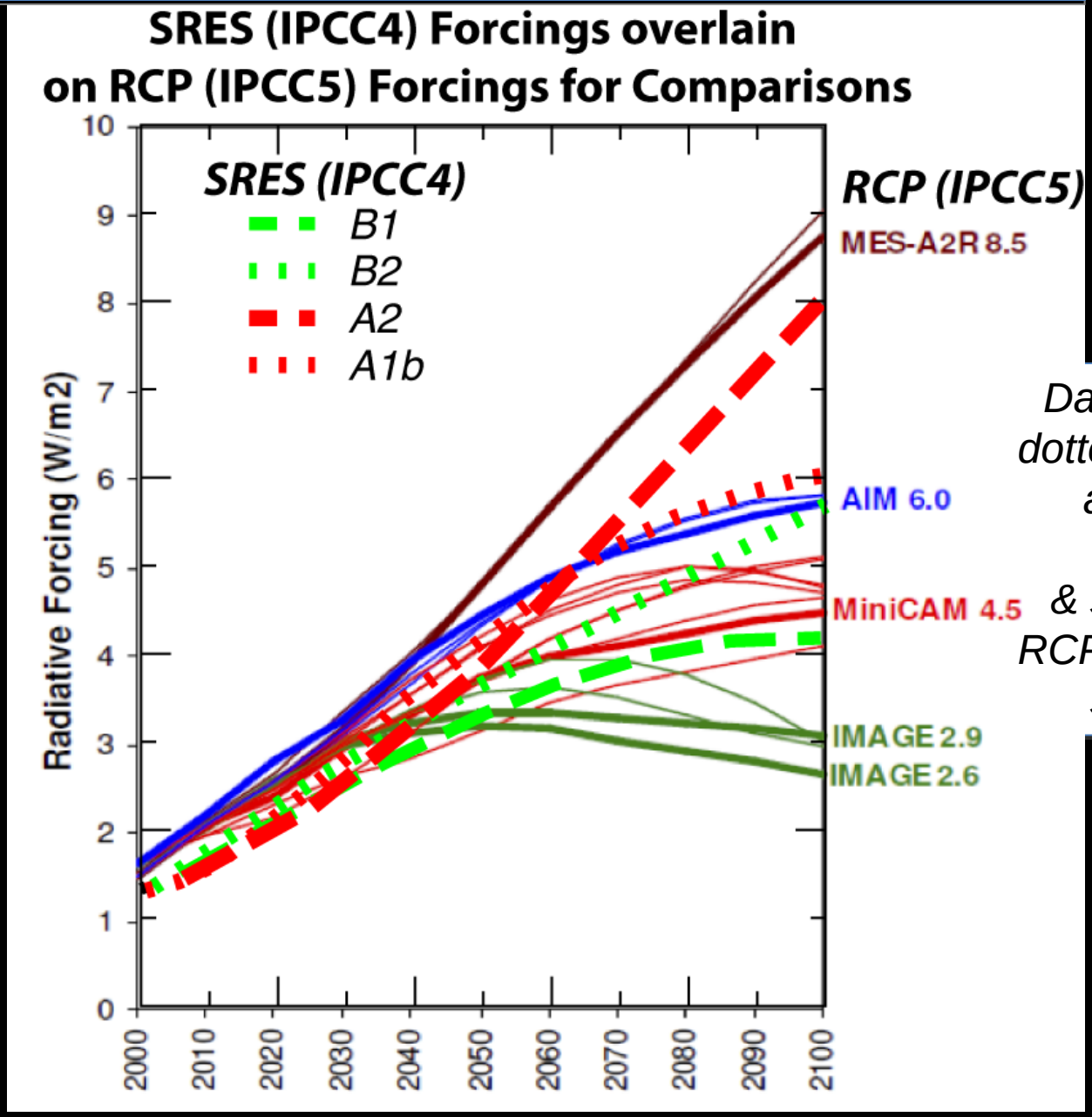
http://cascade.wr.usgs.gov/data/Task1-climate/

IPCC4 SRES scenarios vs. IPCC AR5 Representative Concentration Pathway (RCP) exemplars

Notice that RCP8.5 is more extreme than A2 and by end of century more like A1Fi (see slide #1)

A1b "approximates" RCP6.0

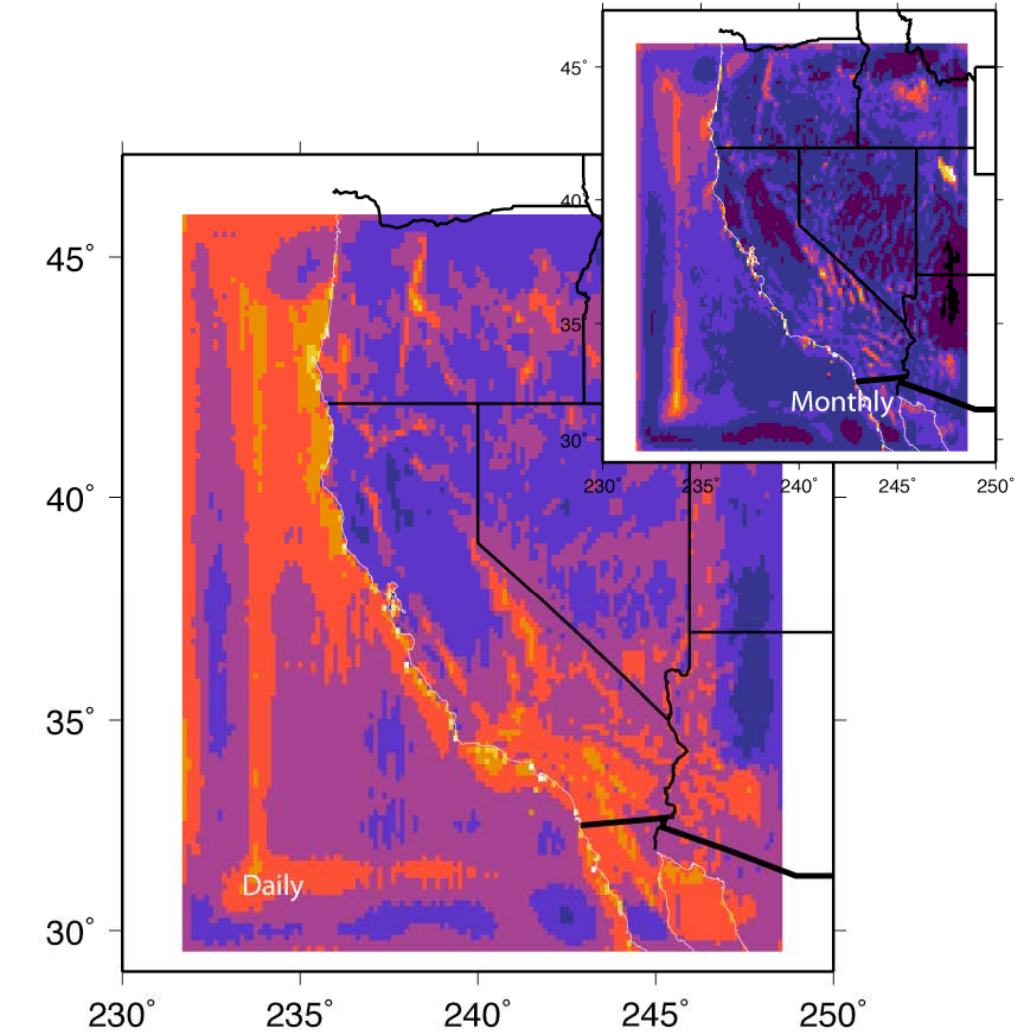
B1 "approximates" RCP4.5 at this global-aggregated scale.



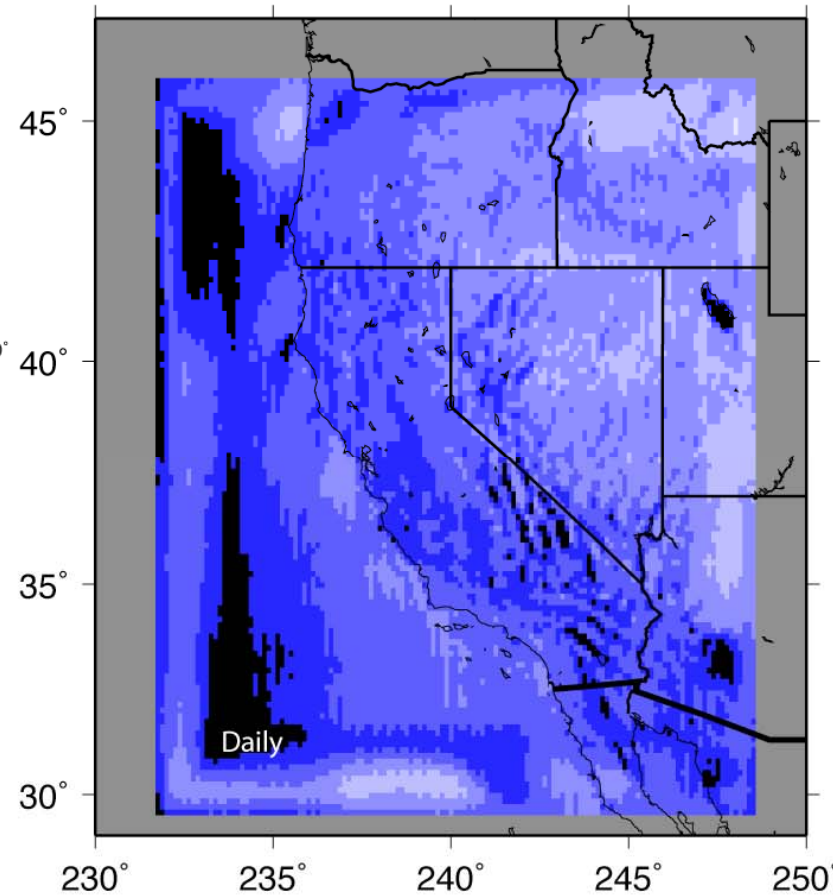
Dashed and dotted curves are SRES (IPCC4) & solids are RCP (IPCC5) scenarios

- Emission levels matter! And new AR5 scenarios are on their way.
- Statistical vs dynamical downscaling options
- Phil Duffy will be laying out available downscaled scenarios.
- We at Scripps have been providing many of the d'scaled scenarios for California's Climate Action Team and other State assessment activities in recent years.
- NOTE: Other variables (radiation, winds, etc) can be downscaled; overall modest changes, excepting humidities and longwave radiation

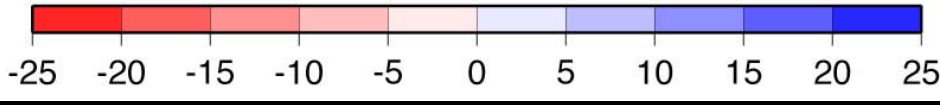
GOODNESS OF FIT OF DOWNSCALED HISTORICAL (1950-99) CARD10 SHORTWAVE FLUXES



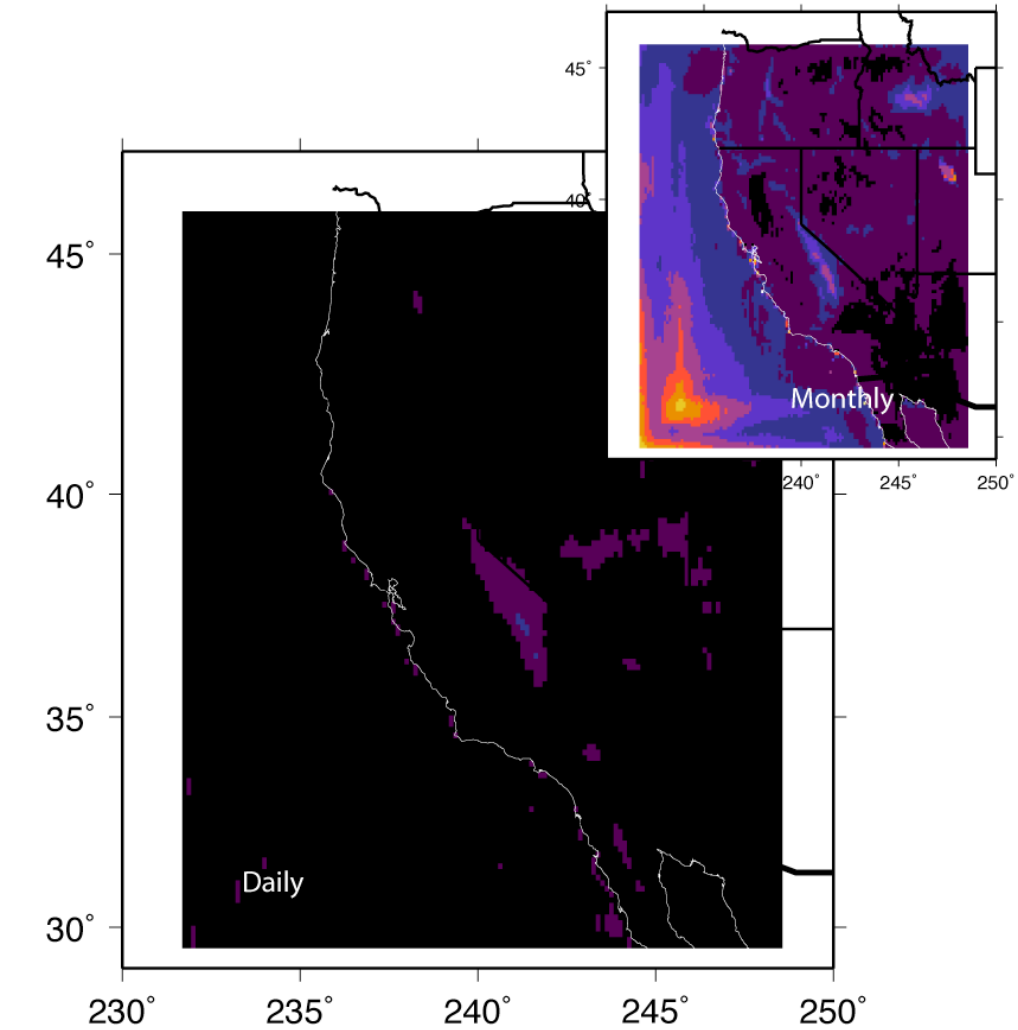
Anomaly Correlations for Daily Shortwave Flux (all years)
Downscaled Coarsened CARD10 Values



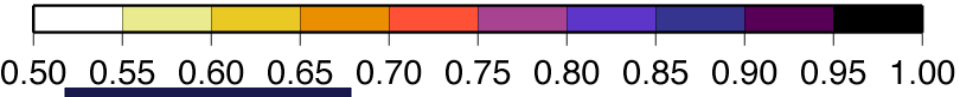
Anomaly StDevs for Daily Short Wave Fluxes (all years)
Downscaled difference from CARD10 (in percent of original)

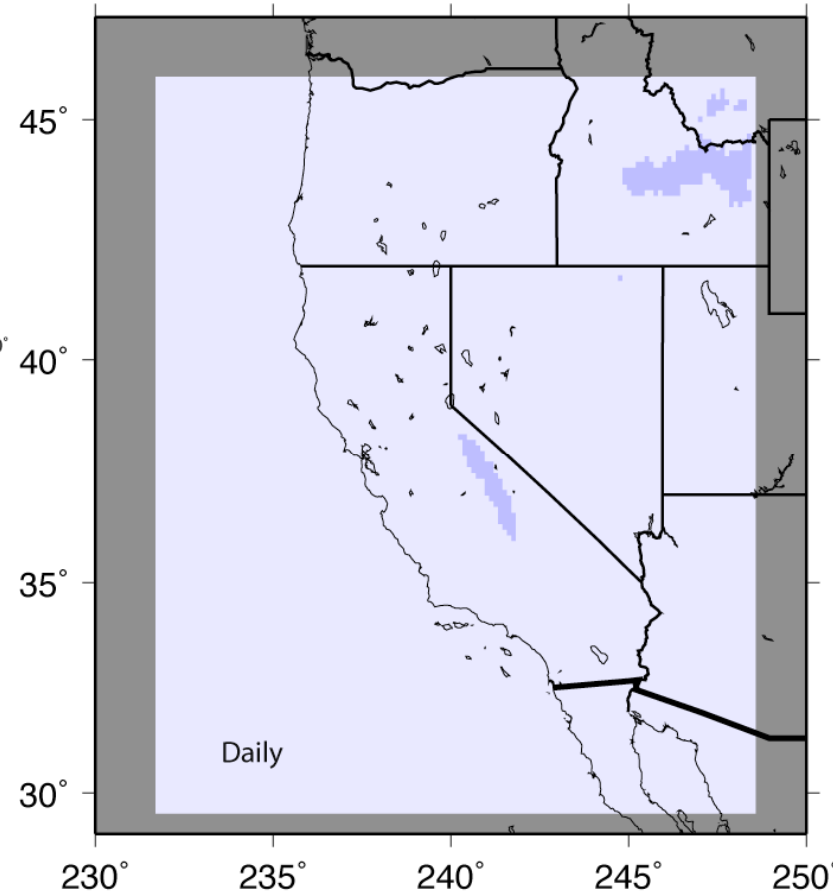


GOODNESS OF FIT OF DOWNSCALED HISTORICAL (1950-99) CARD10 LONGWAVE FLUXES

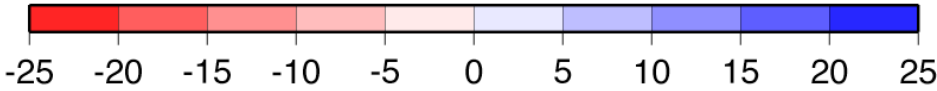


Anomaly Correlations for Daily Longwave Flux (all years)
Downscaled Coarsened CARD10 Values





Anomaly StDevs for Daily Longwave Fluxes (all years)
Downscaled difference from CARD10 (in percent of original)



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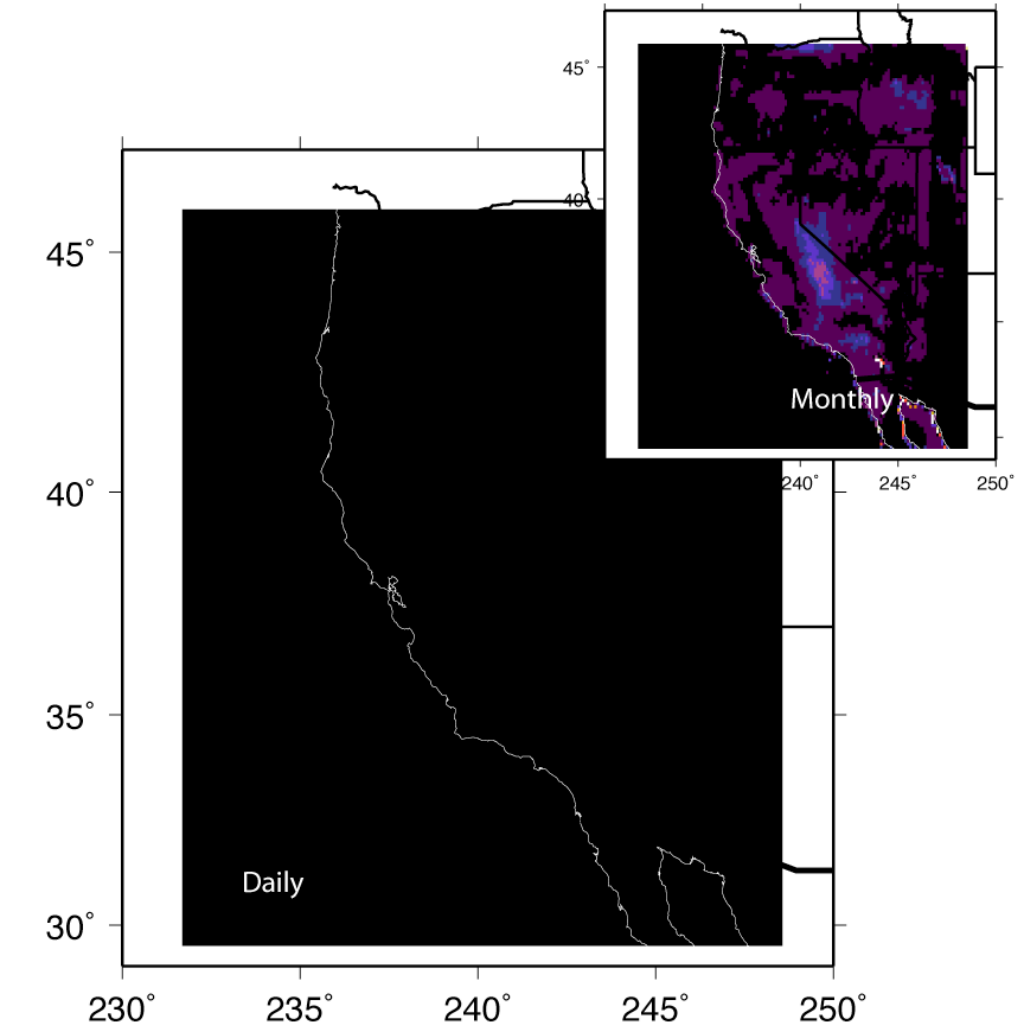
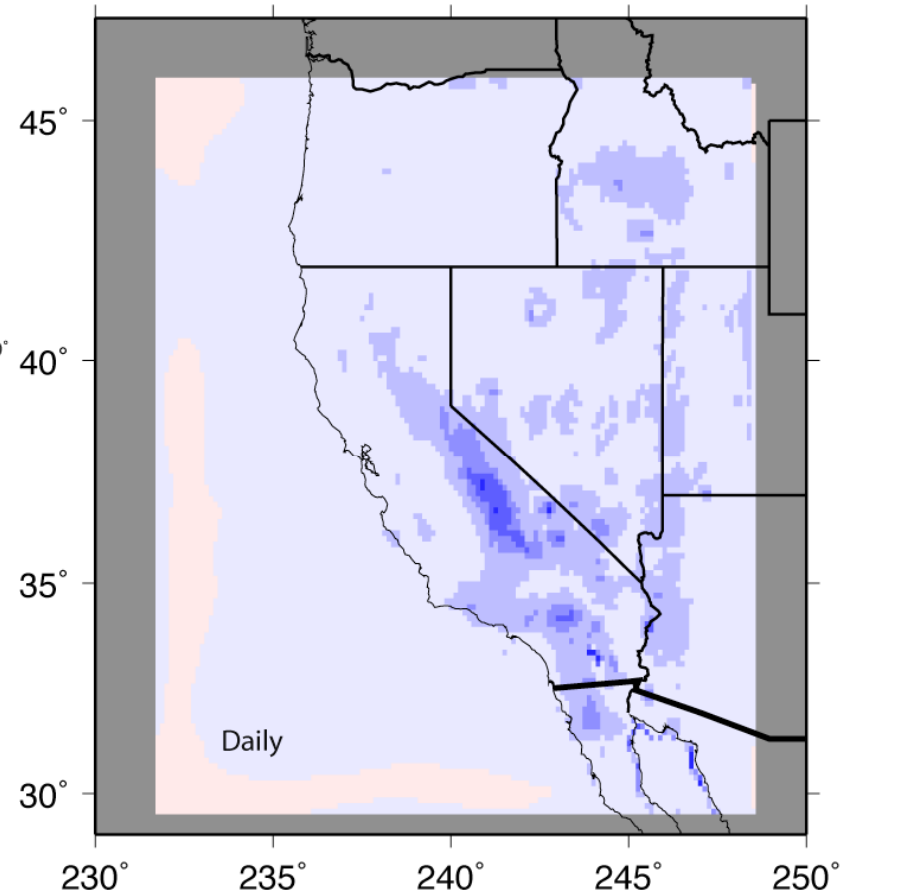
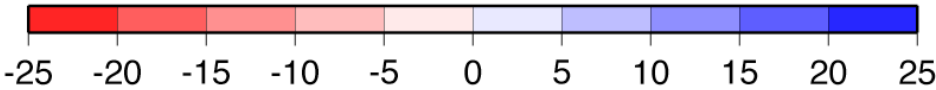
GOODNESS OF FIT OF DOWNSCALED HISTORICAL (1950-99) CARD10 SPECIFIC HUMIDITY



Anomaly Correlations for Daily Specific Humidity (all years)
Downscaled Coarsened CARD10 Values



Anomaly StDevs for Daily Specific Humidities (all years)
Downscaled difference from CARD10 (in percent of original)