Climate Scenarios with High Spatial Resolution

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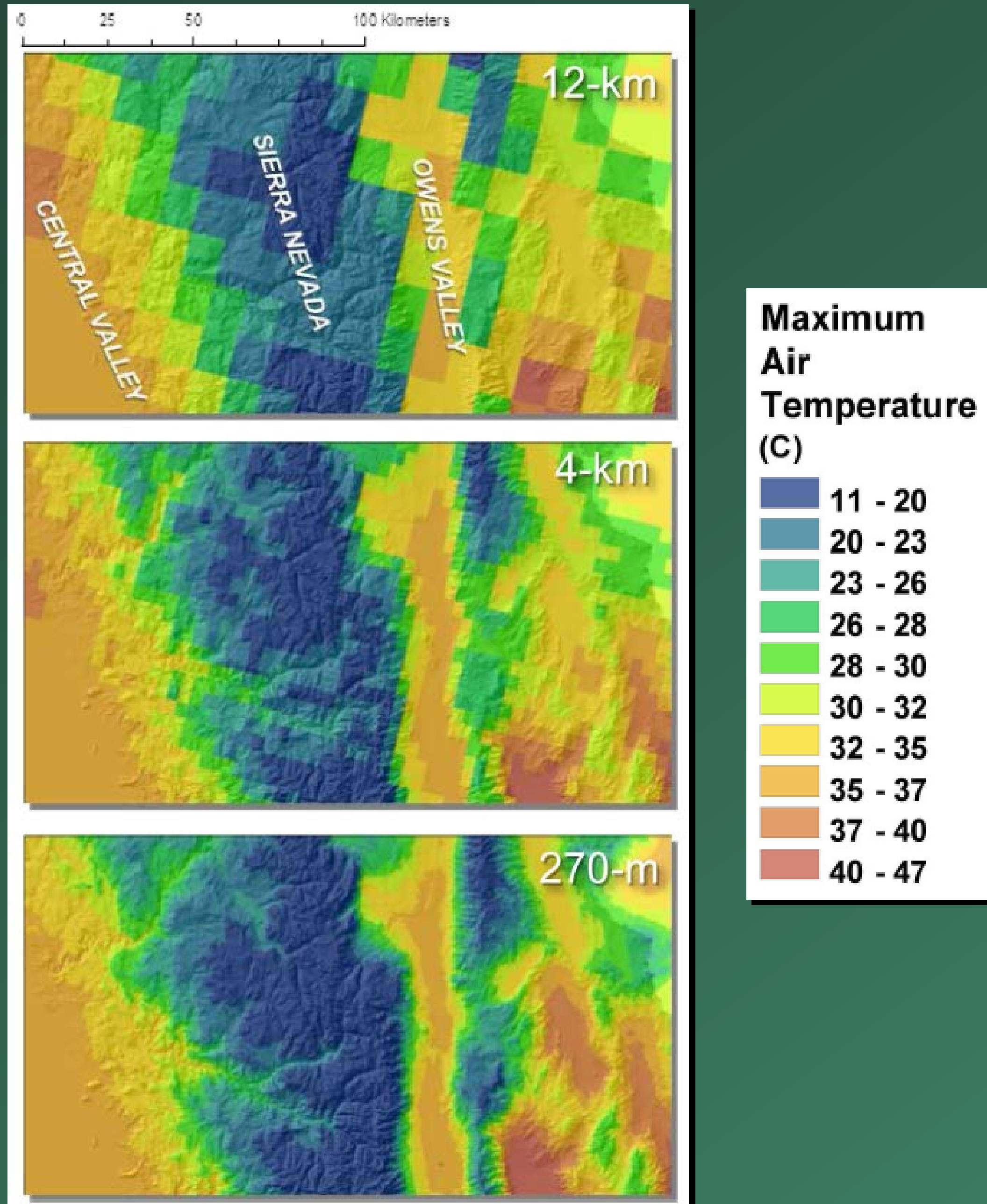
Selecting Climate Scenarios for the California Energy Sector
Staff Workshop February 27, 2015

Rationale

- How fine a scale is useful?
- What are the applications?
- What are the methods?
- How can we preserve extremes?
- Next steps and refinements


0
25
50
100 Kilometers
12-km
SIERRA NEVADA
OWENS VALLEY
CENTRAL VALLEY
4-km
270-m
Maximum Air Temperature (C)
11 - 20
20 - 23
23 - 26
26 - 28
28 - 30
30 - 32
32 - 35
35 - 37
37 - 40
40 - 47

Varying research interests

Gradient Inverse Distance Squared (GIDS) approach to fine resolution downscaling

For every month, for every grid cell, an equation is developed to downscale from 12-km to 4-km on the basis of:

$$Z = \left[\sum_{i=1}^{N} \frac{Z_i + (X - X_i) \times C_x + (Y - Y_i) \times C_y + (E - E_i) \times C_e}{d_i^2} \right] \Big/ \left[\sum_{i=1}^{N} \frac{1}{d_i^2} \right]$$

(Nalder and Wein, 1998)

Z = climate variable of interest, precipitation or air temperature at 4-km grid cell
Z_i = climate variable at 12-km grid cell i
X = easting
Y = northing
E = elevation
N = number of 12-km grid cells in the specified search radius
d_i = distance from 4-km site to 12-km cell (no less than 12-km, provides nugget)
C_x, C_y, C_e = regression coefficients for easting, northing, and elevation

Monthly Basin Characterization Model Climate and Hydrology

- CA BCM Published, hosted, 18 futures
- Great Basin BCM complete, in prep for hosting, 12 futures
- Upper Colorado BCM, Complete. historical
- Pacific NW, downscaled historical climate
- Lower Colorado, historical climate, soils
- North Central states, downscaled historical climate

Recharge 1981-2010

(mm/year)

- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- 350 - 400

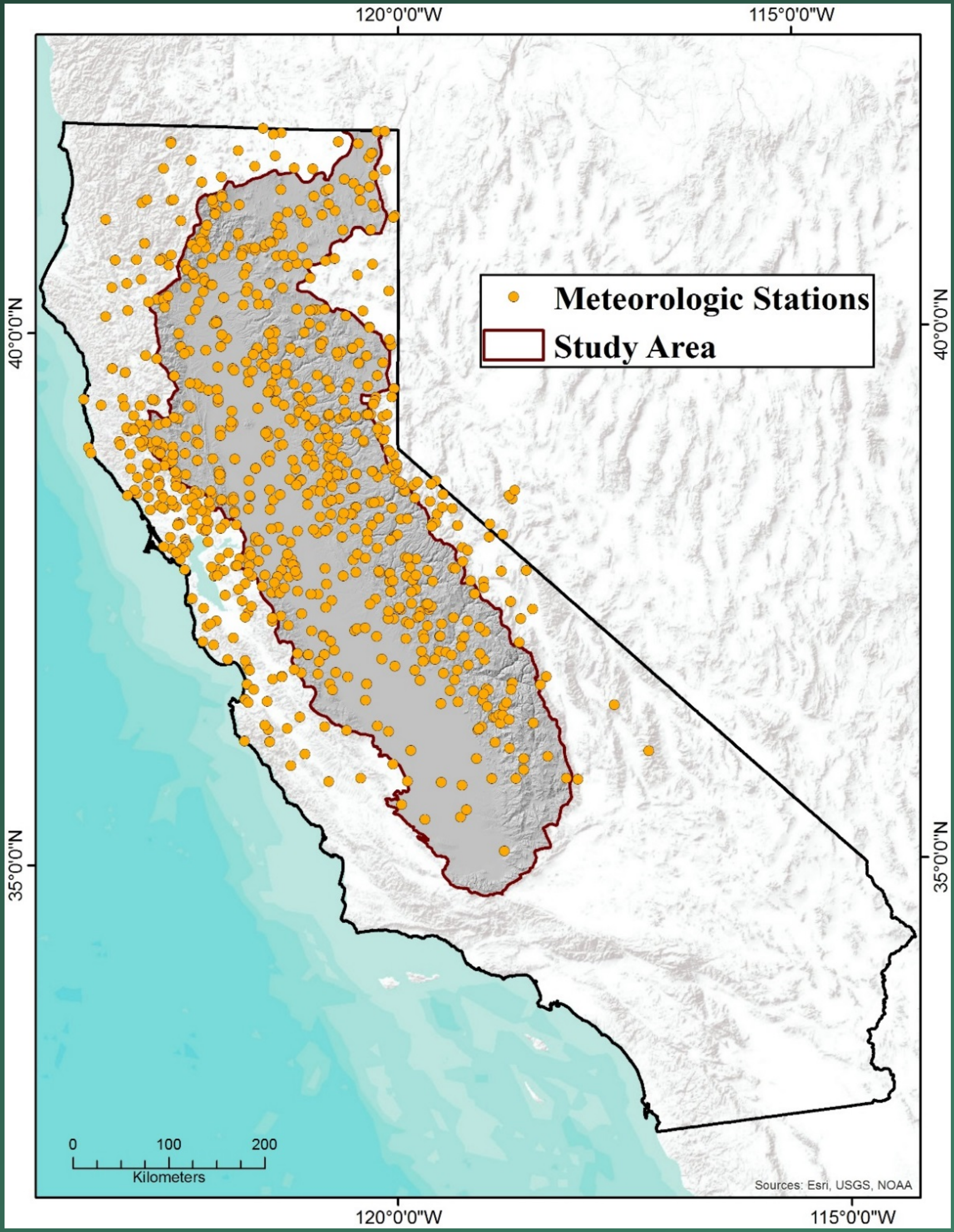
Futures completed and available

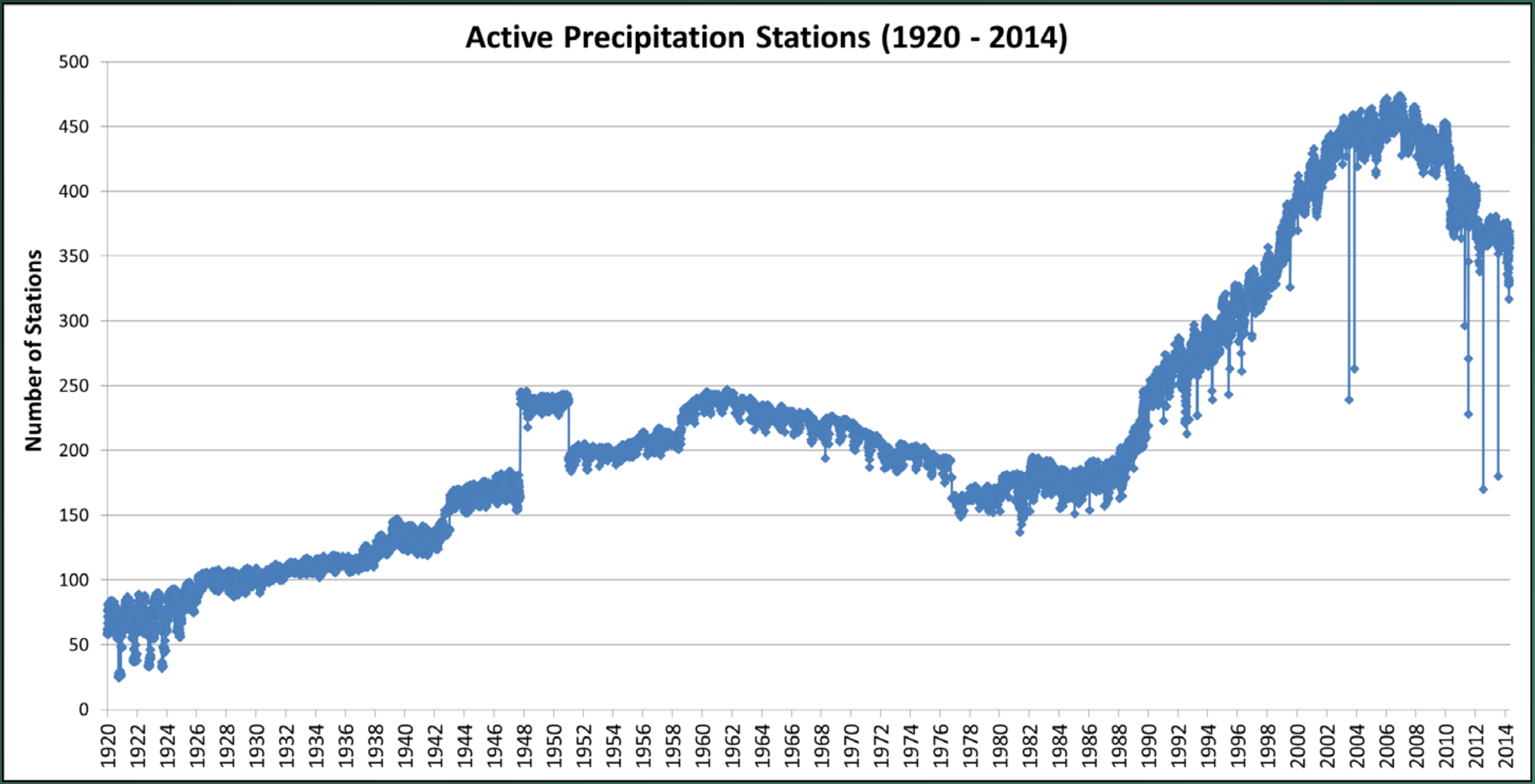
Fine-Scale Applications throughout West

- Changes in tree diameter and density: McIntyre et al. 2015 Proc. Nat. Acad. Sciences.
- Targeting climate diversity for conservation: Heller et al. 2015 Ecosphere
- Recruitment patterns of high elevation pines: Millar et al., 2015 PACLIM
- Adapting California's ecosystems: Chornesky et al., BioScience
- Severity and distribution of Aspen die-off: Anderegg et al., 2015 Nature GeoScience
- Threats to California Rangelands: Byrd et al. 2015 Landscape Ecology
- Magnitude and patterns of hydrologic change in CA: Thorne et al., 2015 Ecosphere
- Geographic range limits of Pinus Coulteri: Chardon et al. 2014 Ecography
- Climatic stress and forest fire severity western US: van Mantgem et al., 2013 Ecology Letters
- Climate-related tree mortality: Das et al., 2013 PLoS ONE
- Snow dependent habitat for wolverines: Curtis et al. 2014 PLoS ONE
- Downscaling for fine-scale applications: Flint and Flint 2012 Ecological Processes
- Conservation of vegetation in urban environment: Beltran et al., 2013 Geographical Info Sci
- Fens as indicatprs of recharge: Drexler et al. 2013 Journal of Hydrology
- Forest mortality in whitebark pine: Millar et al 2012 Can J Forest Research
- Uncertainty in dynamic population models: Conlisk et al 2013 Global Change Biology
- Conjunctive water use in the Central Valley: Hanson et al. 2012 Water Resources Research
- Assisted colonization strategies: Regan et al. 2011 Global Change Biology
- Species distributions under different scales: Franklin et al. 2012 Global Change Biology
- Oak genetics and resilience for adaptation: Sork et al. 2011 Molecular Ecology
- Case studies for water supply: Flint et al 2012 USGS SIR

Application to Daily Climate Grids

- How fine a scale is useful?
- What are the applications?
- What are the methods?
- How can we preserve extremes?
- Next steps and refinements


120°0'0"W
115°0'0"W
40°0'0"N
35°0'0"N
Meteorologic Stations
Study Area
0
100
200
Kilometers
Sources: Esri, USGS, NOAA
120°0'0"W
115°0'0"W


Active Precipitation Stations (1920 - 2014)
Number of Stations
0
50
100
150
200
250
300
350
400
450
500
1920
1922
1924
1926
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

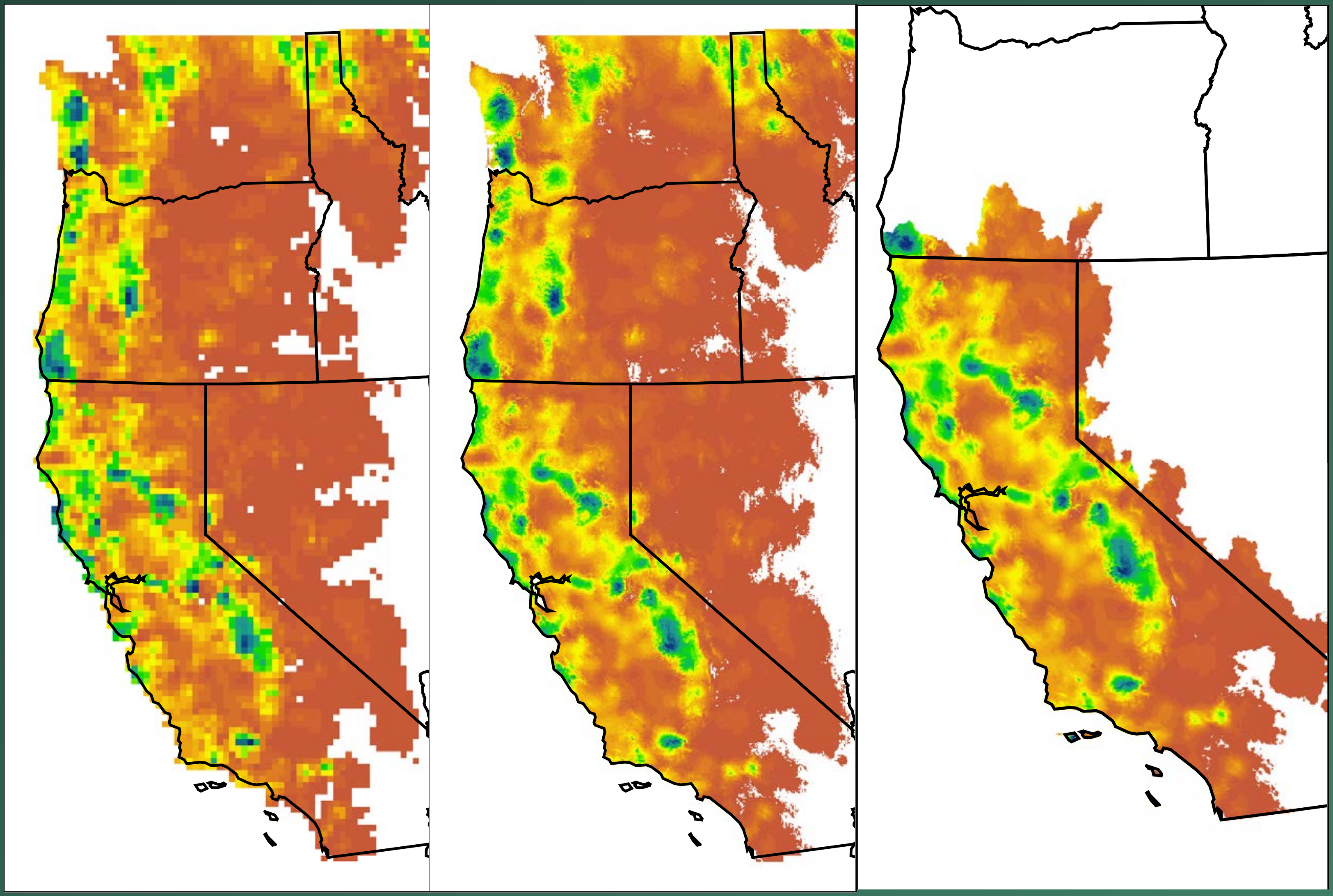
Comparisons with Daily Station Data and Gridded Datasets

(2001-2010, 172 stations, CIMIS, COOP, RAWS)

	Mean Absolute Error (MAE)						
	MetGrid	VIC		DayMet		PRISM	
	270-m	270-m	12-km	270-m	1-km	270-m	4-km
Precipitation (mm)	1.1	1.9	2.0	1.3	1.3	1.6	1.6
Minimum Temperature (°C)	1.2	2.6	2.7	2.6	2.6	2.0	2.0
Maximum Temperature (°C)	1.8	2.6	3.0	2.6	4.1	4.2	4.2

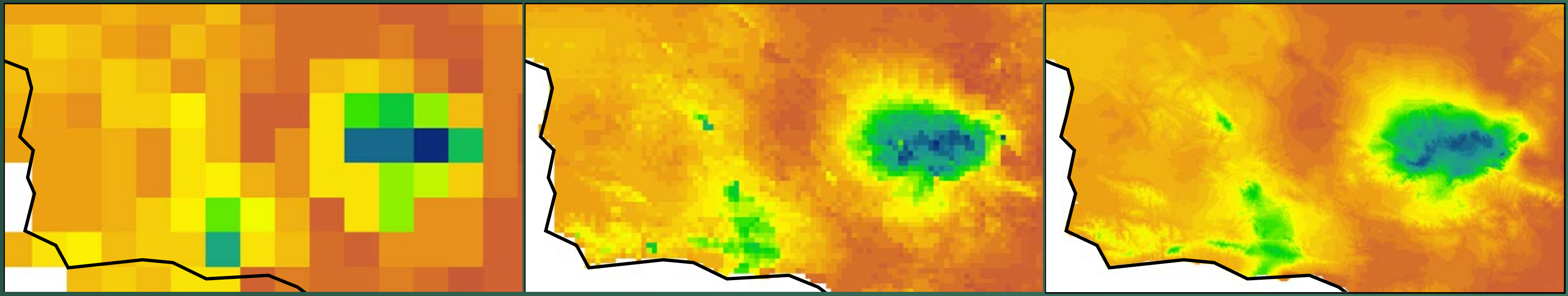
- Each gridded dataset evaluated at native resolution and downscaled to 270-m
- Absolute error of MetGrid at 270-m is lower than all other methods
- Downscaling from the native resolution improves estimate in most cases

LOCA Precipitation Grid Downscaled

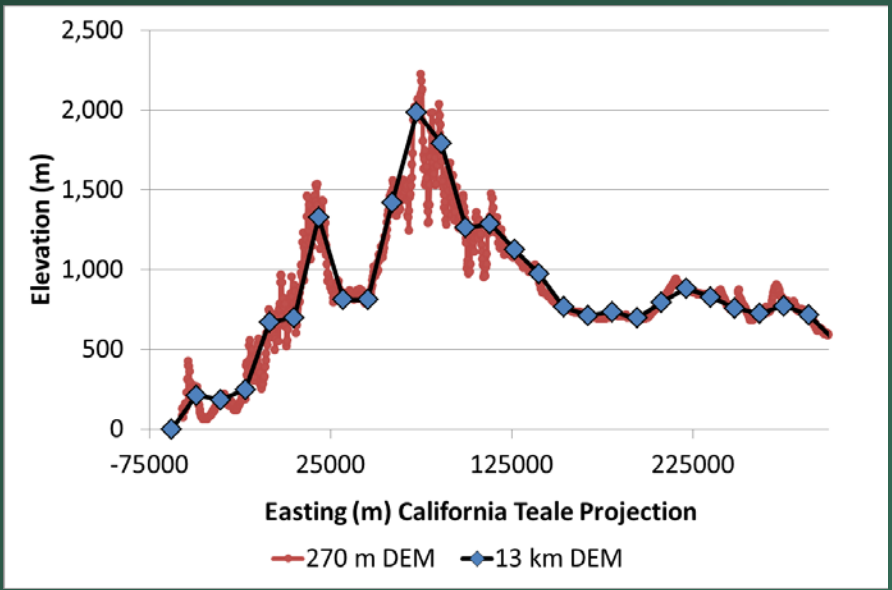


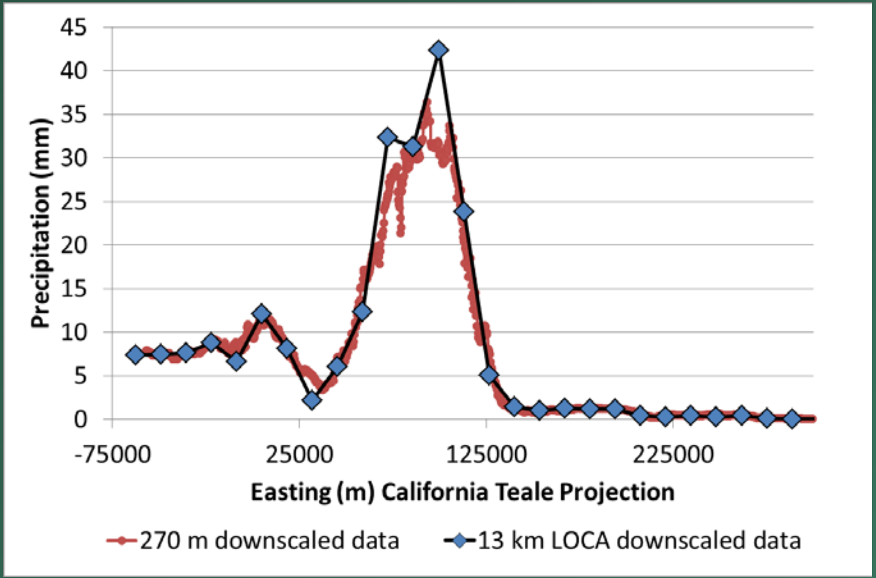
13 km   2 km   270 m

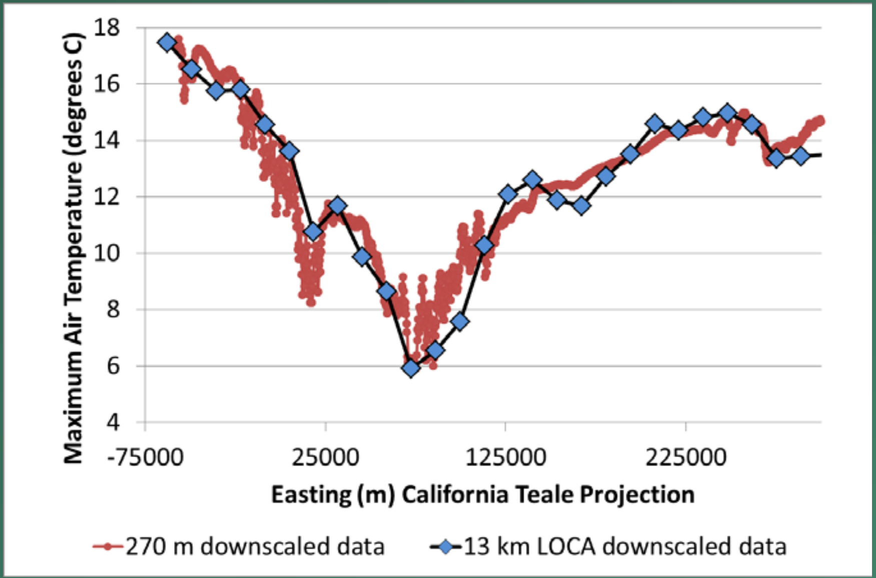
LOCA Precipitation Grid Downscaled



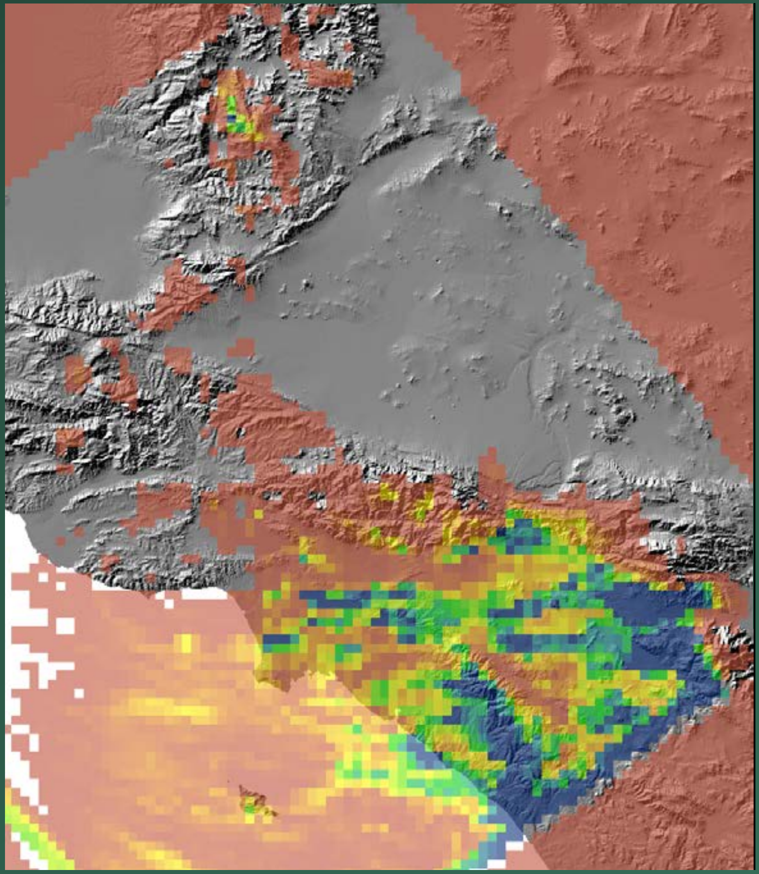
13 km　　2 km　　270 m

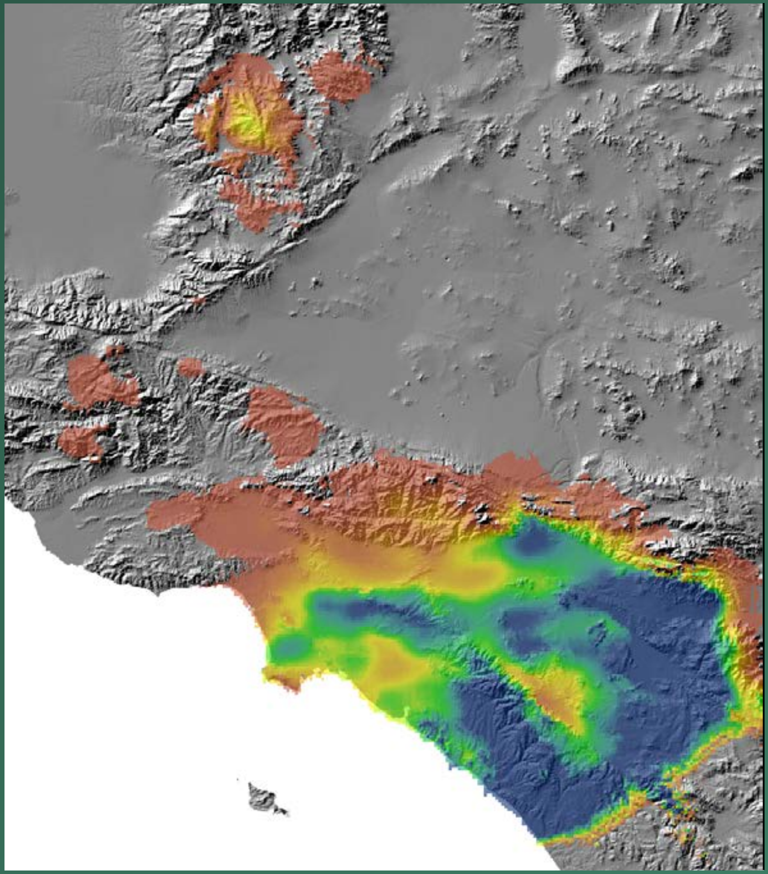

2,500
2,000
1,500
1,000
500
0
Elevation (m)
-75000
25000
125000
225000
Easting (m) California Teale Projection
270 m DEM
13 km DEM


45
40
35
30
25
20
15
10
5
0
Precipitation (mm)
-75000
25000
125000
225000
Easting (m) California Teale Projection
270 m downscaled data
13 km LOCA downscaled data


18
16
14
12
10
8
6
4
Maximum Air Temperature (degrees C)
-75000
25000
125000
225000
Easting (m) California Teale Projection
270 m downscaled data
13 km LOCA downscaled data

Downscaling Dynamical Regional Models





Summary

- Why fine scale?
  - Reseachers want it to describe field data for a range of climatic and hydrologic applications
- Does it work?
  - We've shown it to either improve gridded data to match measured data or not change it
  - Doesn't take away the big picture but drapes it on landscape
- Future plans for daily projections?
  - Being done for Sac Valley (CASCaDE II), can be done for State of California