An analysis of spatial trends within past to present climate trajectories in the Greater Yellowstone Ecosystem

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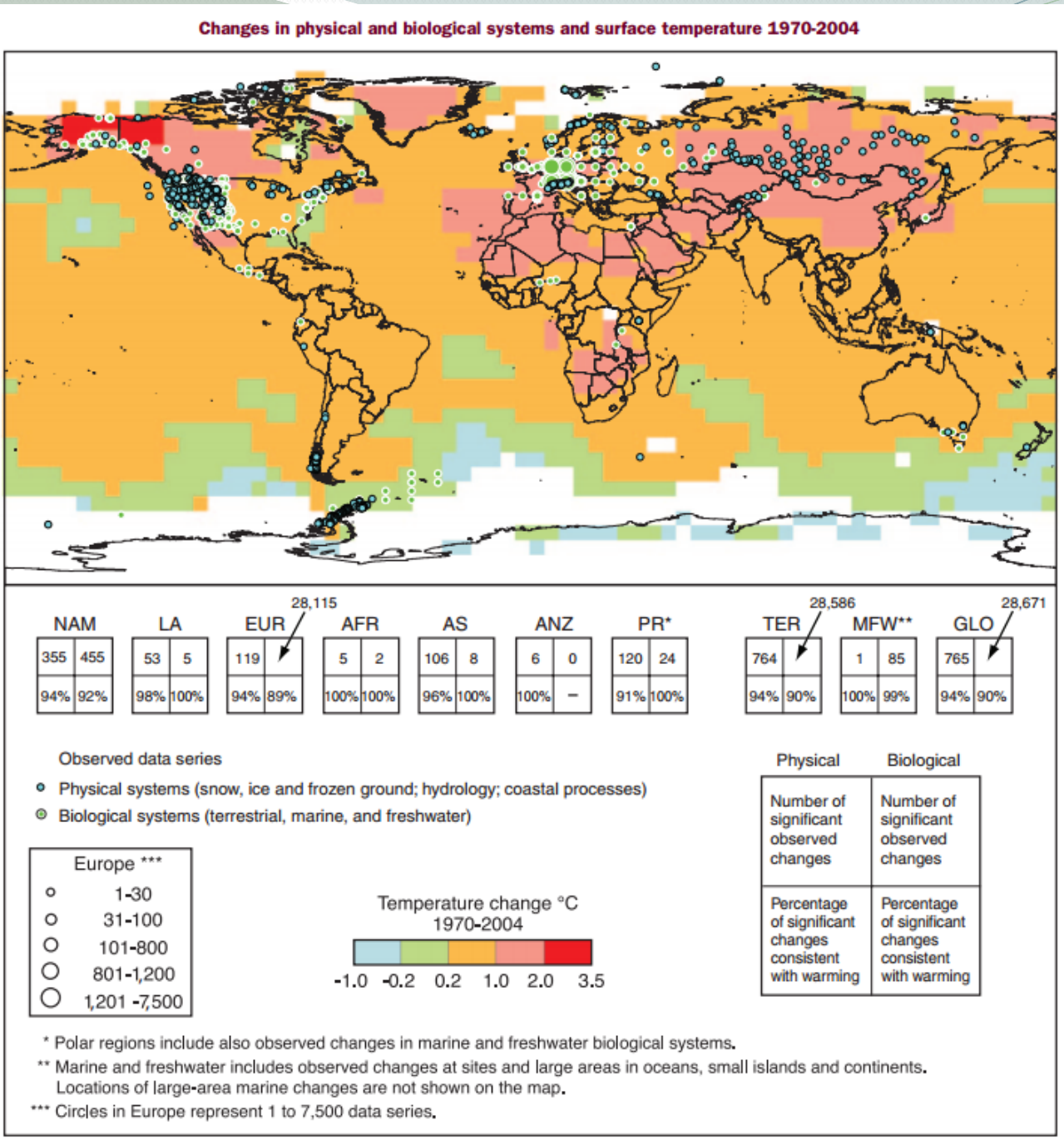
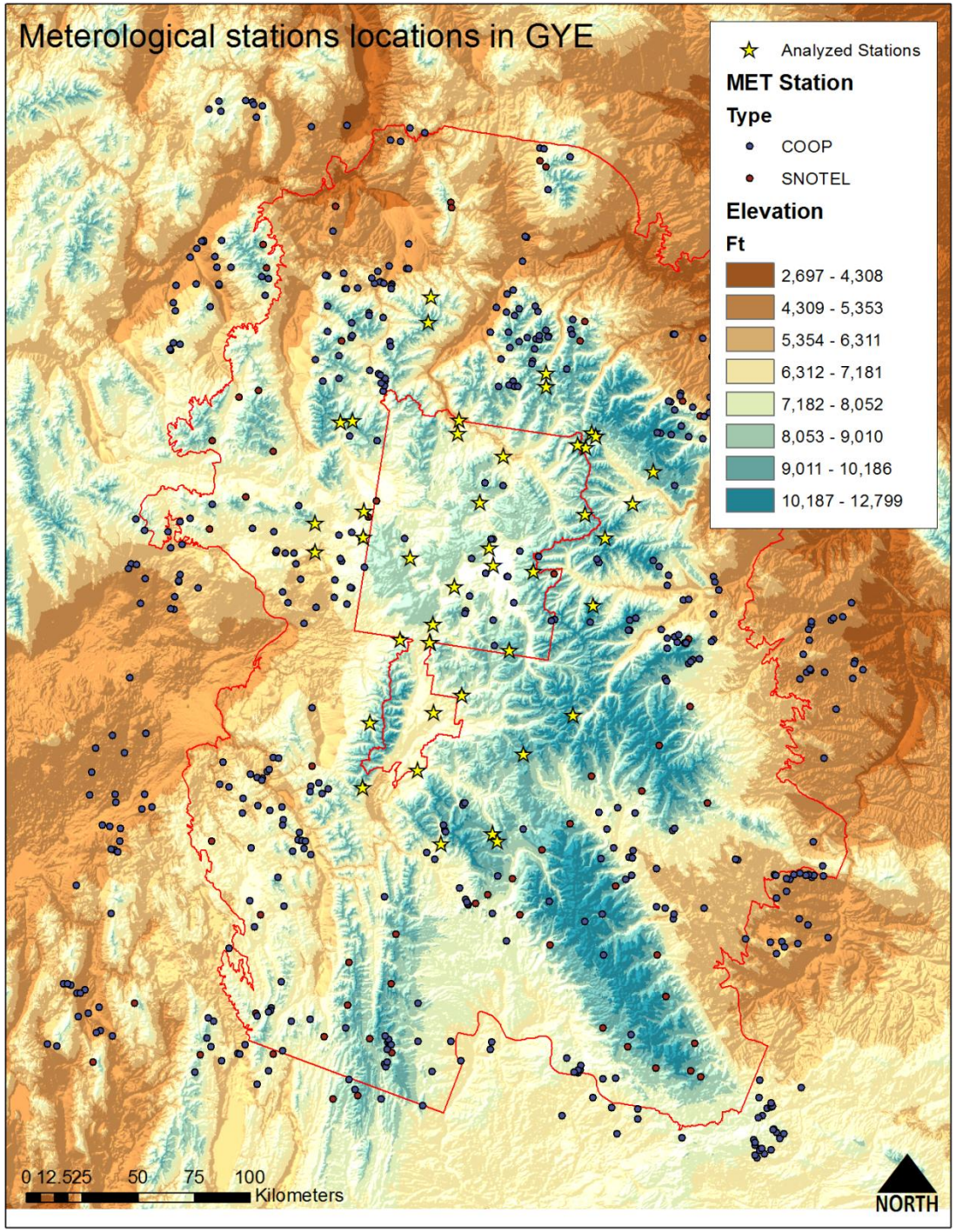
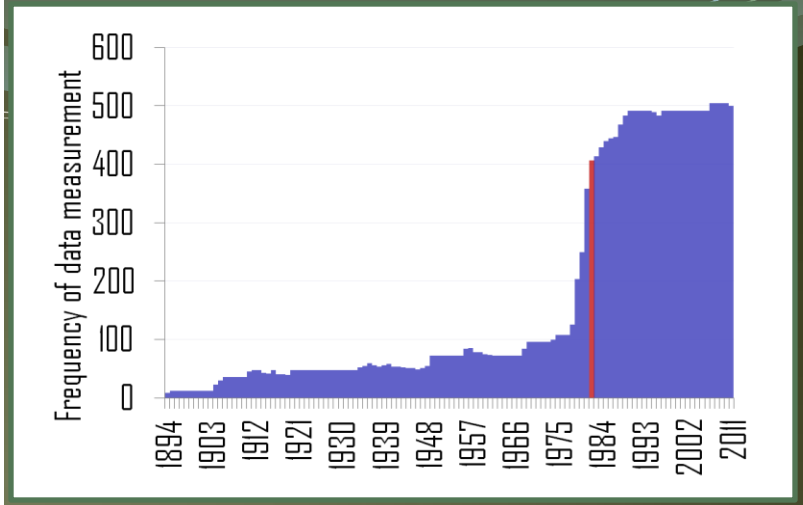
- Present day recorded changes in temperature at a global scale are not homogeneous across the landscape



IPCC 2007

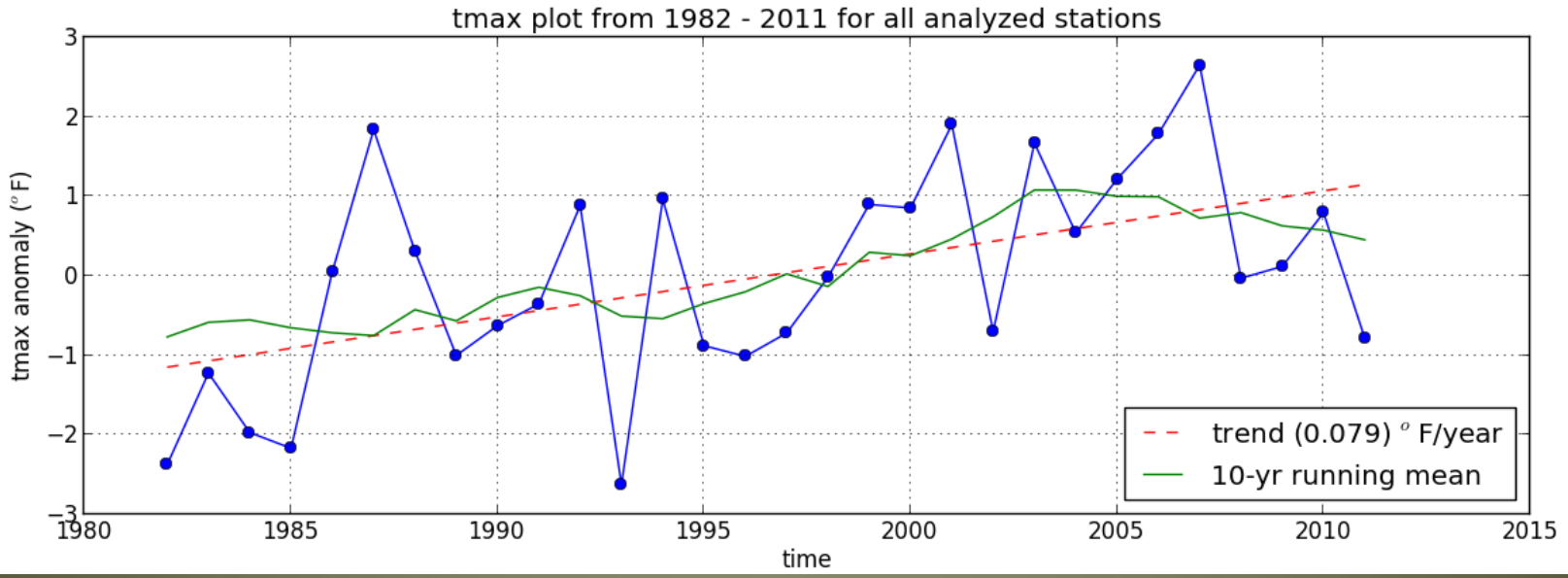


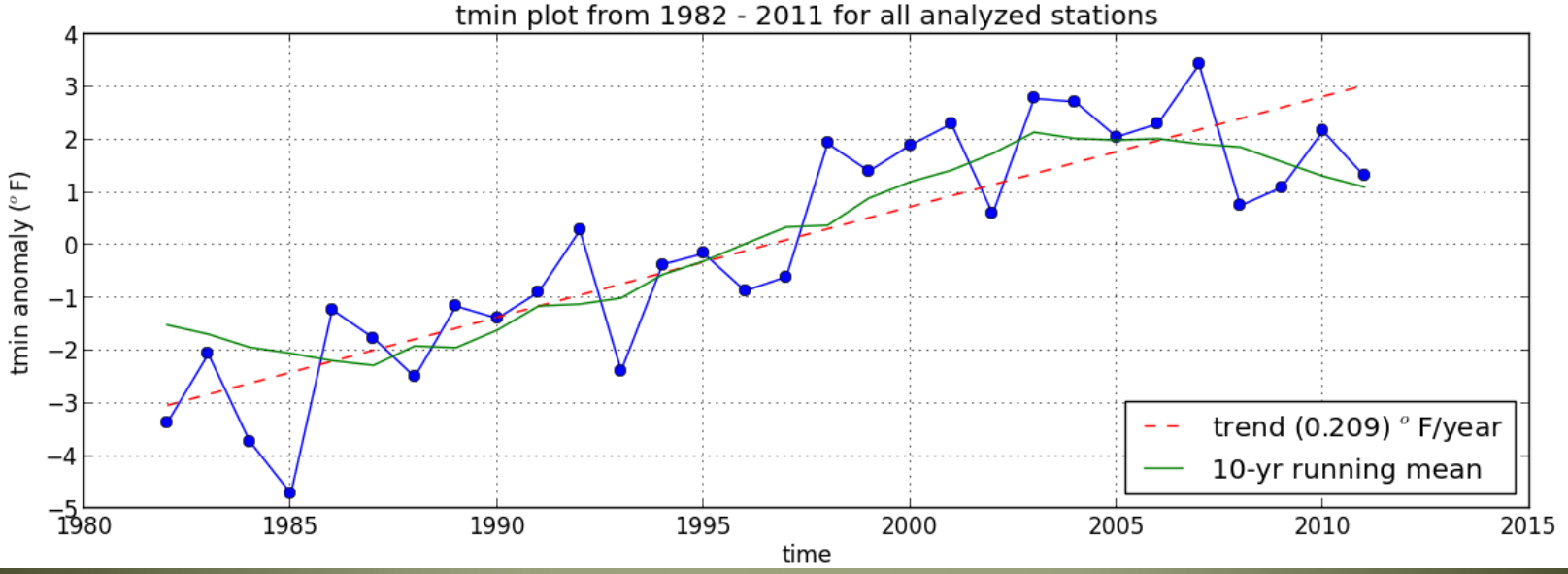


- ~700 observation locations in the GYE from 1894-2011

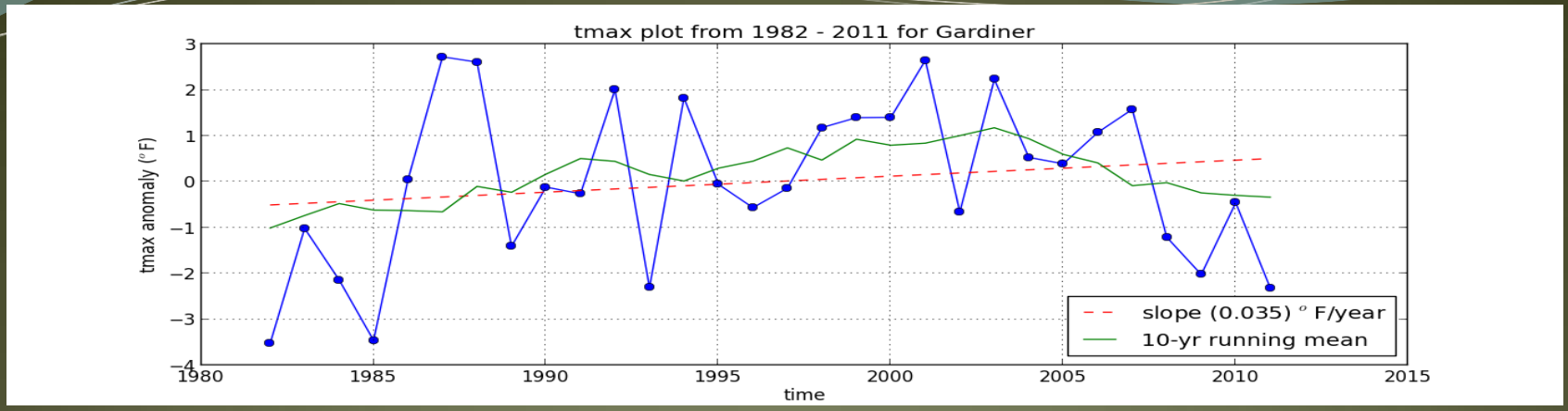
- Selection of 42 stations for analysis in an elevation gradient of 5280-9865 ft

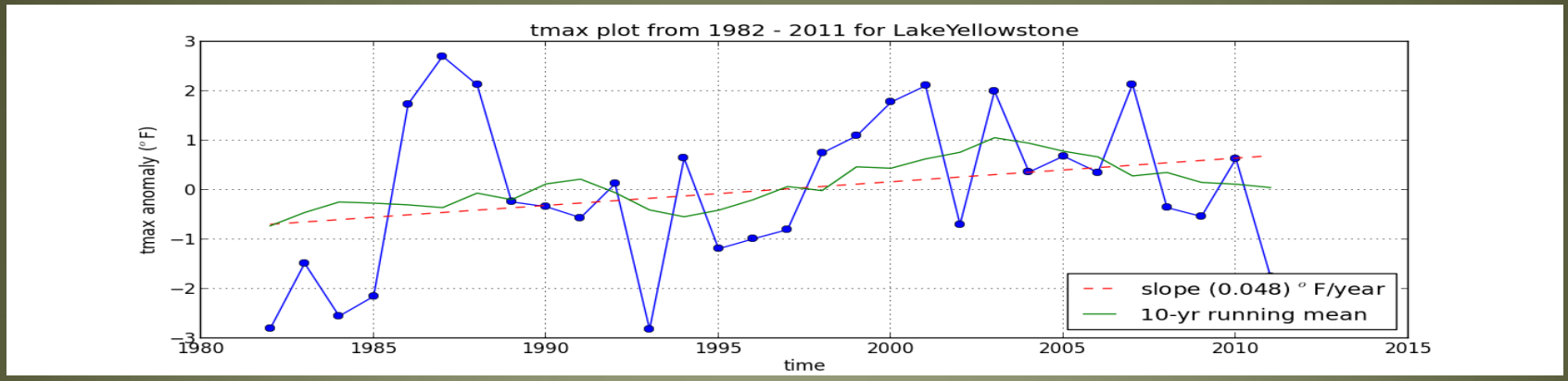
Significant trends in minimum and maximum temperature changes across GYE

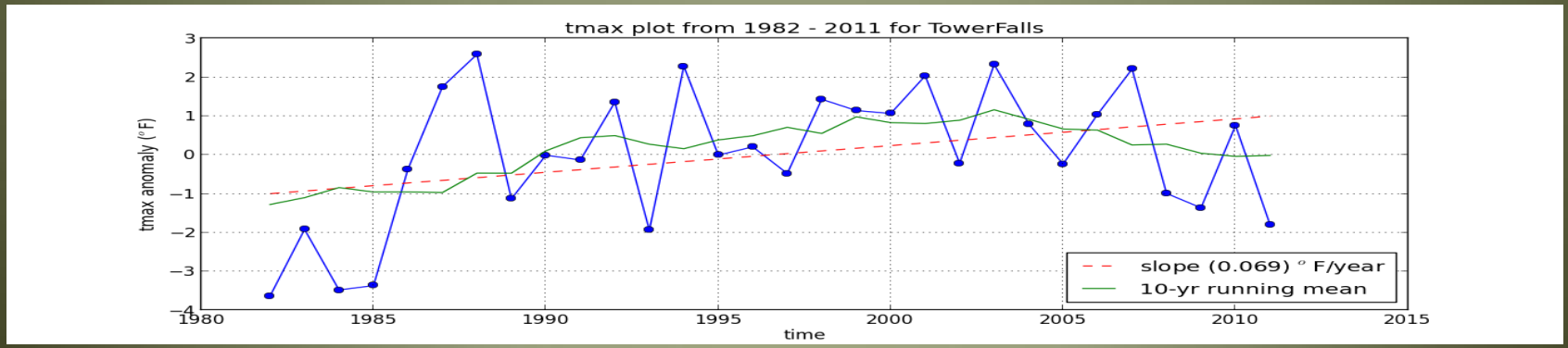




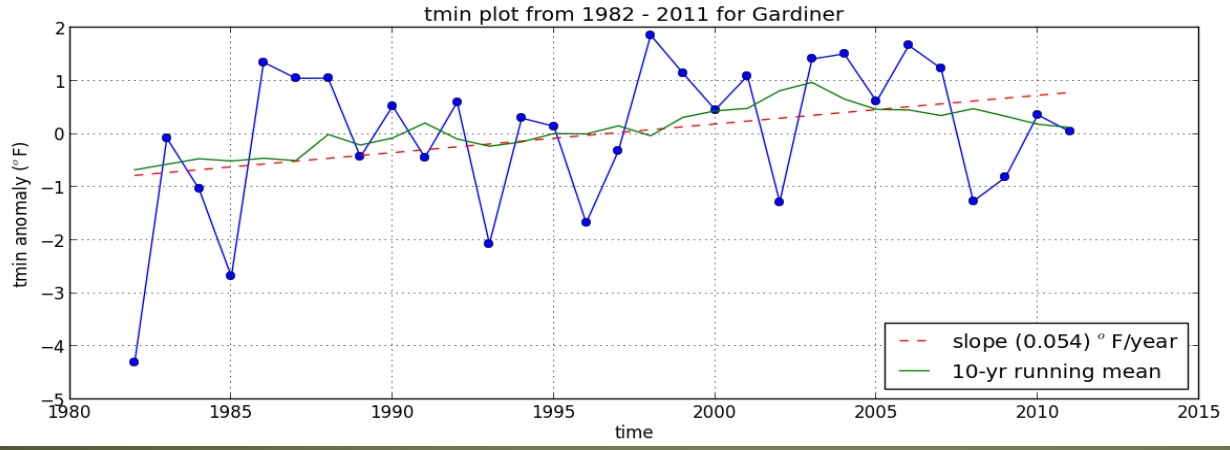
Maximum temperature rates of change with time are do not display a significant trend ubiquitously across GYE

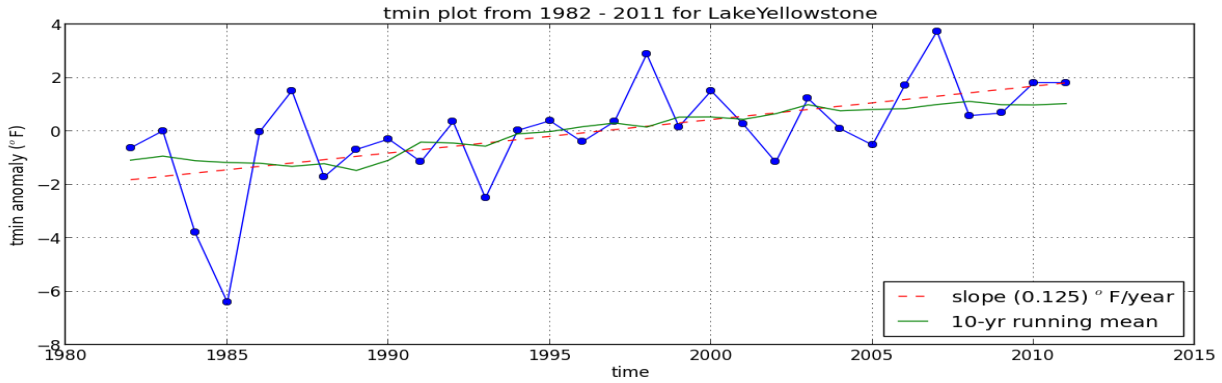


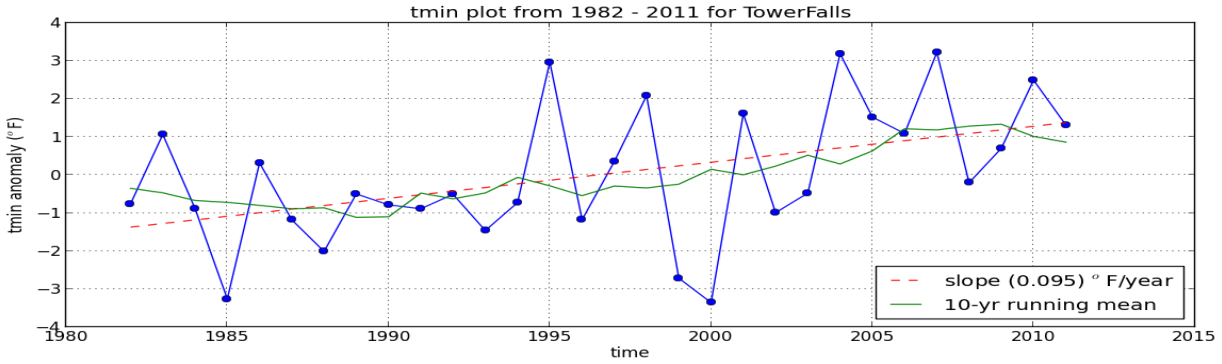




Minimum temperature rates of change with time display a significant trend

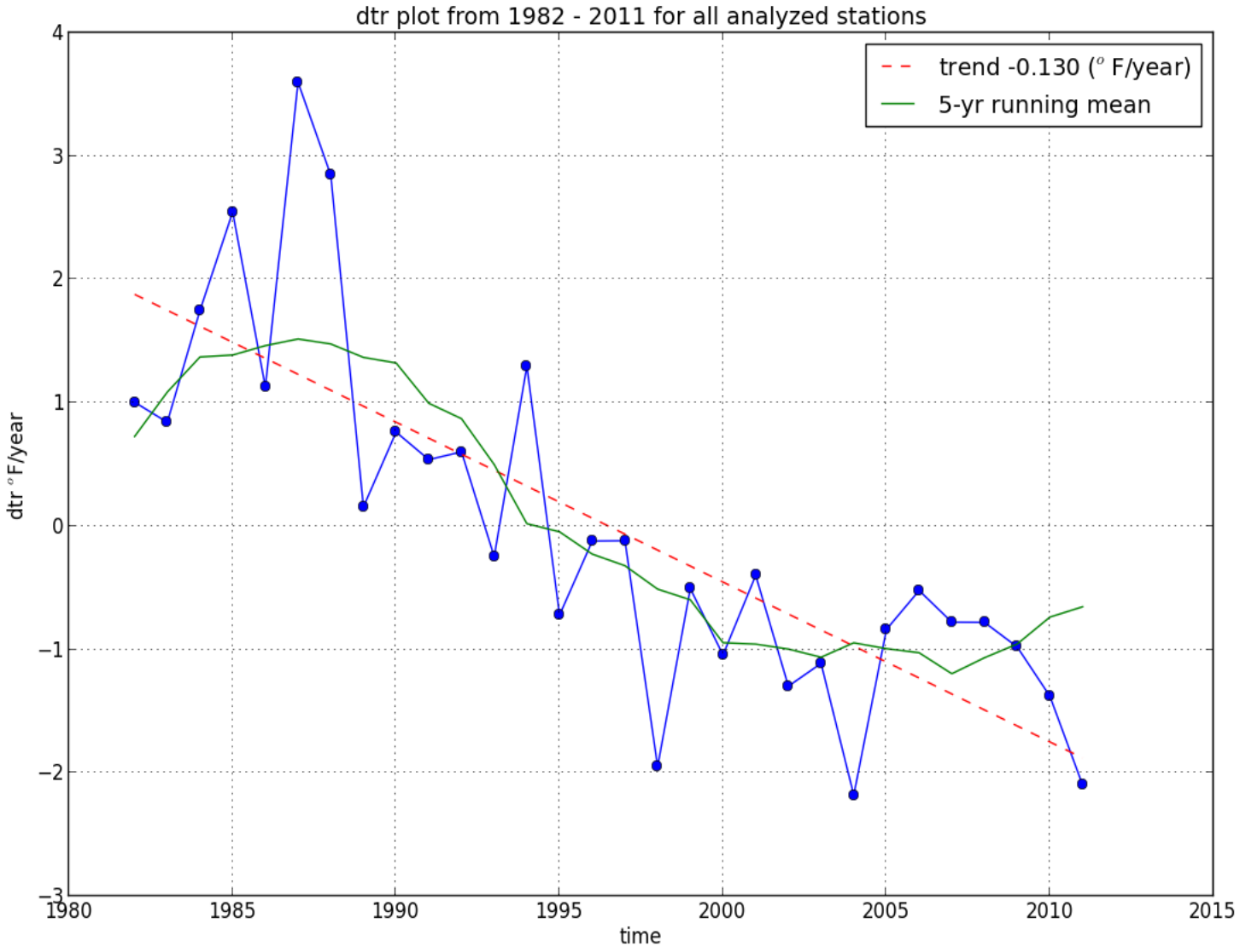






GYE experiencing milder winter lows

Significant diurnal temperature range contraction signal

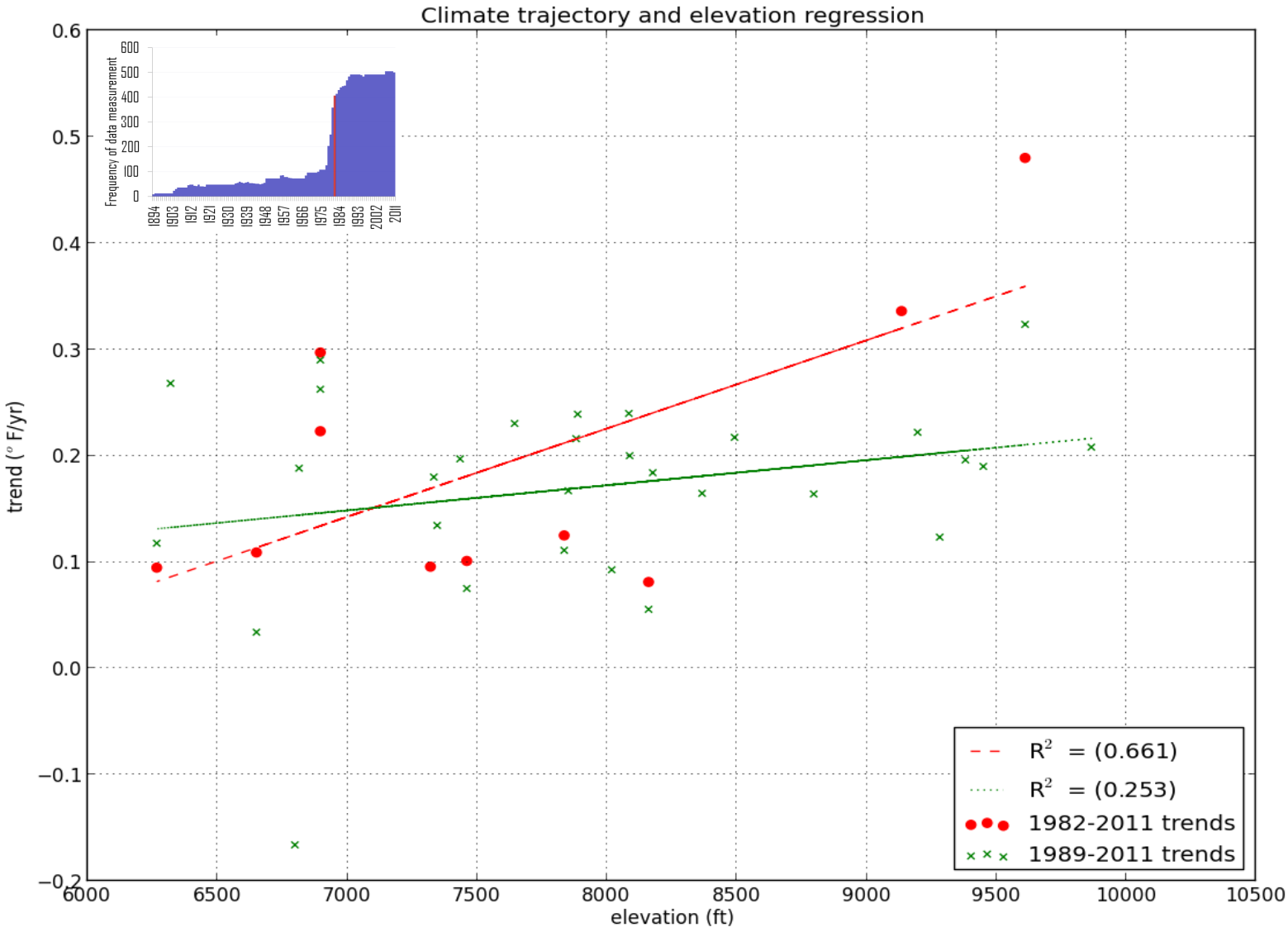


$R^2 = 0.634$, p-value = 1.44×10^{-7}

Minimum temperature rates of change display association with elevation

Station	Trend	R-sq	p-value	Elevation
Cooke City	0.10	0.36	4.73E-04	7460
Darwin Ranch	0.08	0.28	2.74E-03	8160
Fisher Creek	0.34	0.74	2.03E-09	9134
Gardiner	0.05	0.11	7.07E-02	5280
Jackson	0.11	0.20	1.21E-02	6650
Lake Yellowstone	0.13	0.33	9.77E-04	7835
Lick Creek	0.30	0.80	6.16E-11	6896
Moran Junction	-0.06	0.10	9.35E-02	6798
Old Faithful	0.10	0.32	1.10E-03	7320
Snake River	0.22	0.48	6.45E-05	6896
Togwotee	0.48	0.70	1.05E-08	9610
Tower Falls	0.09	0.22	9.46E-03	6266
YNP Mammoth	0.04	0.06	1.91E-01	6300

Significant positive correlation between minimum temperature trend and elevation



-- Slope: 0.016 (deg F/year/ 1000ft)

PRISM interpolation for regional climate assessment

-weighted regression of elevation

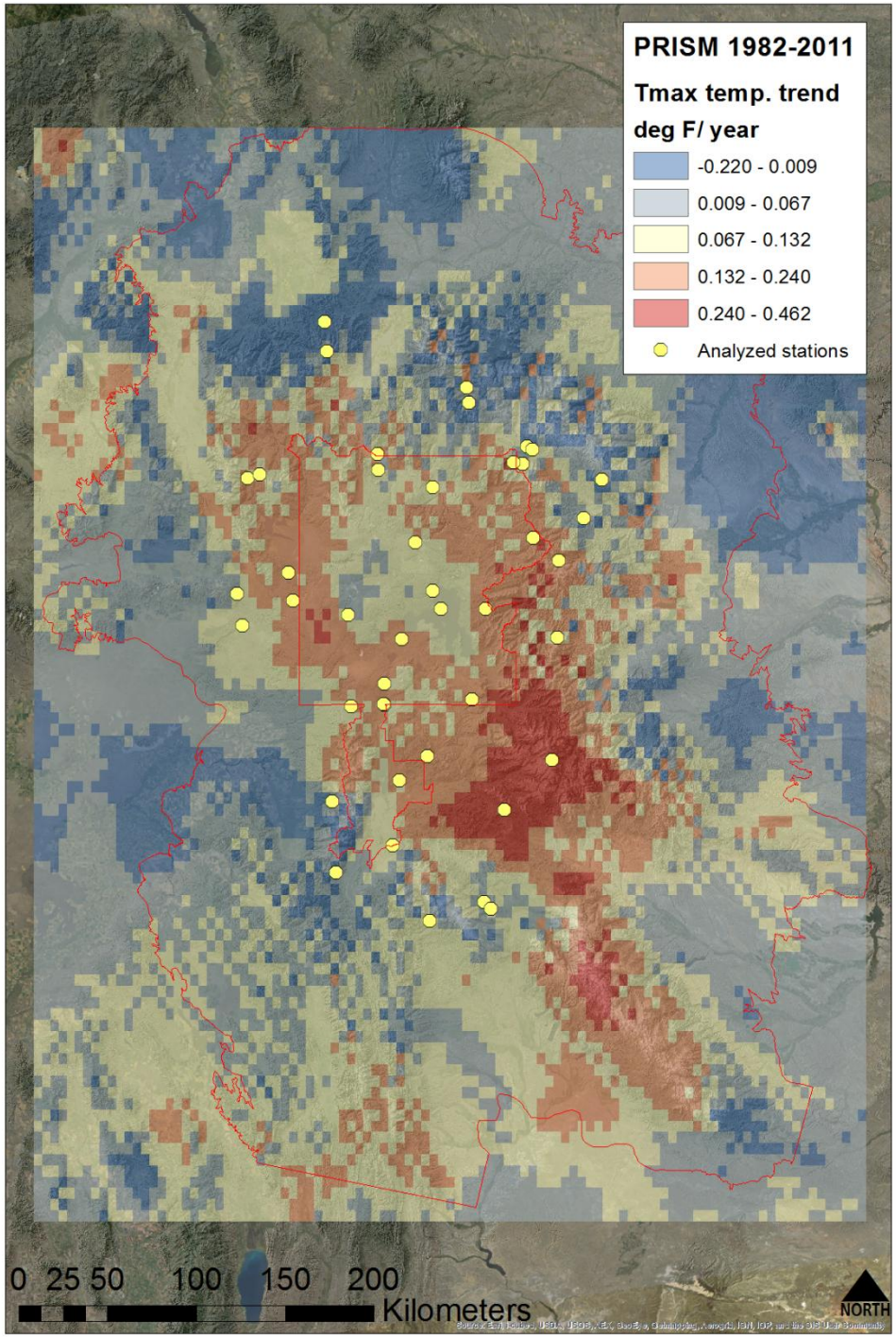
-weighting factors include:

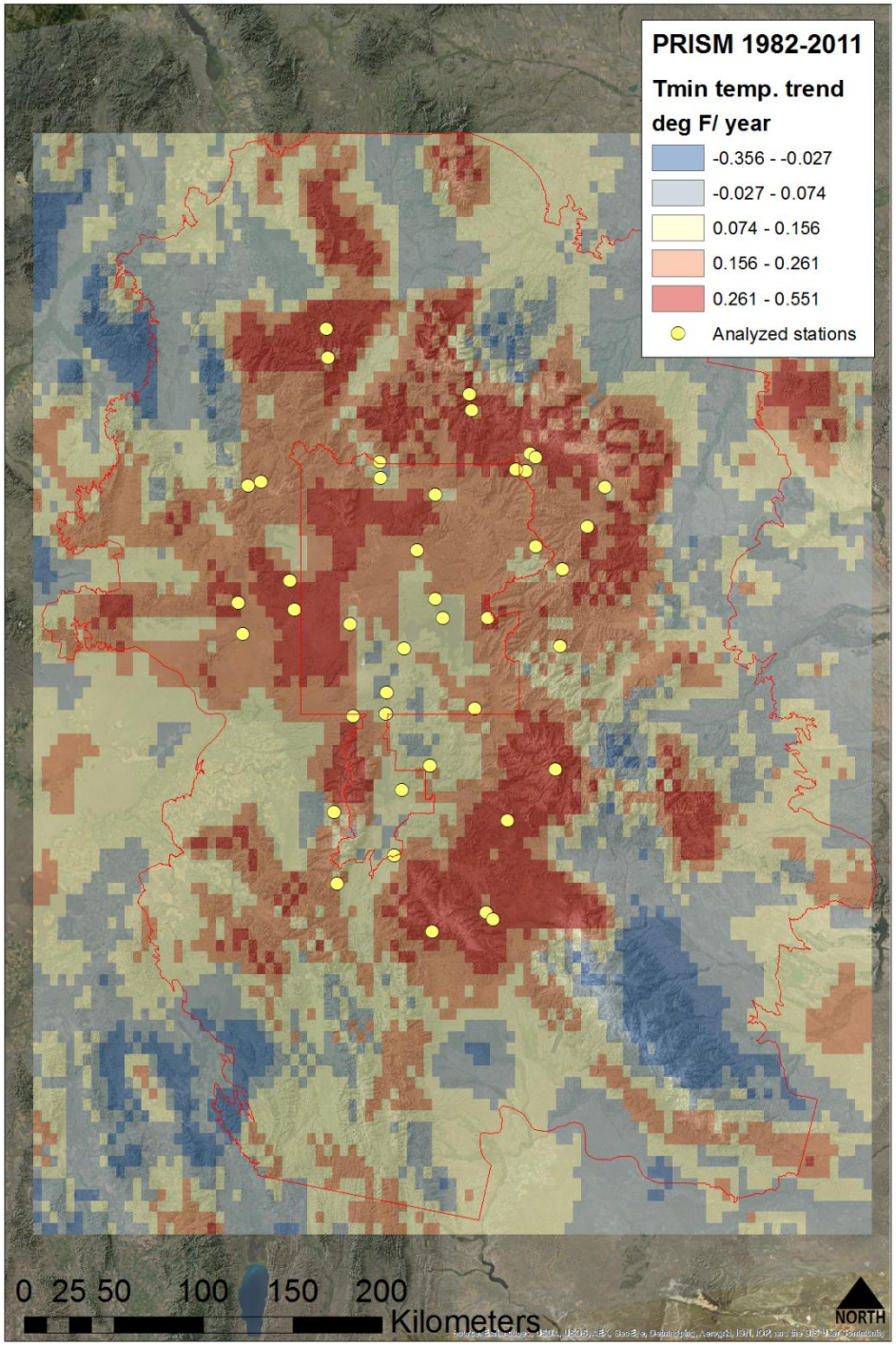
*station spacing

*terrain induced climate transition areas (rain shadow)

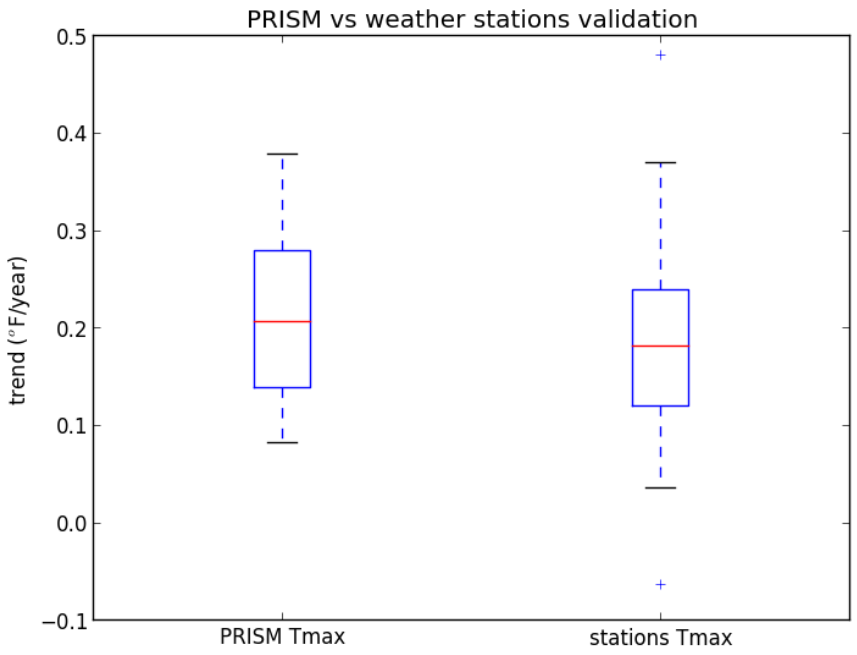
*cold air drainage (inversion areas)

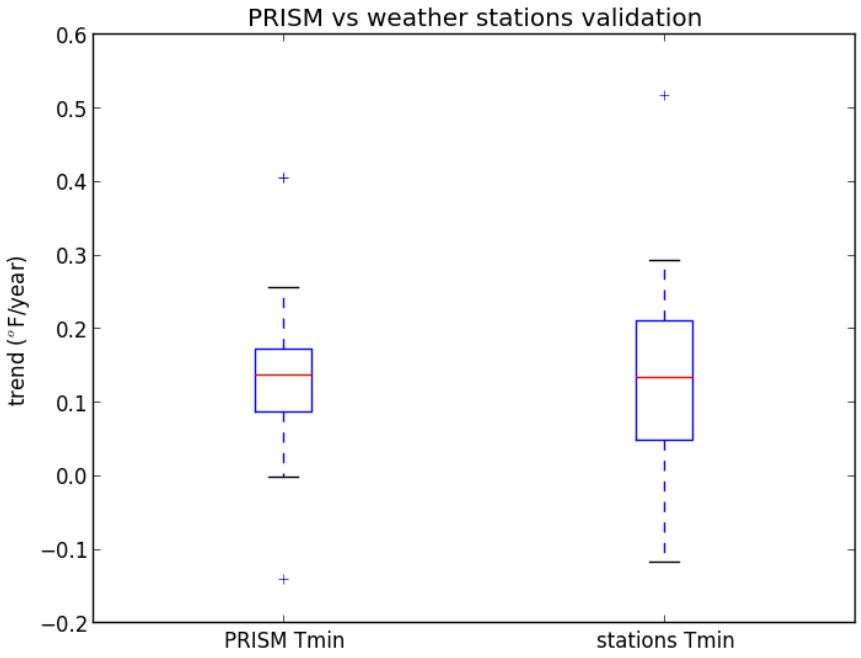
* coastal zone


PRISM 1982-2011
Tmax temp. trend
deg F/ year
-0.220 - 0.009
0.009 - 0.067
0.067 - 0.132
0.132 - 0.240
0.240 - 0.462
Analyzed stations
0 25 50 100 150 200
Kilometers
NORTH

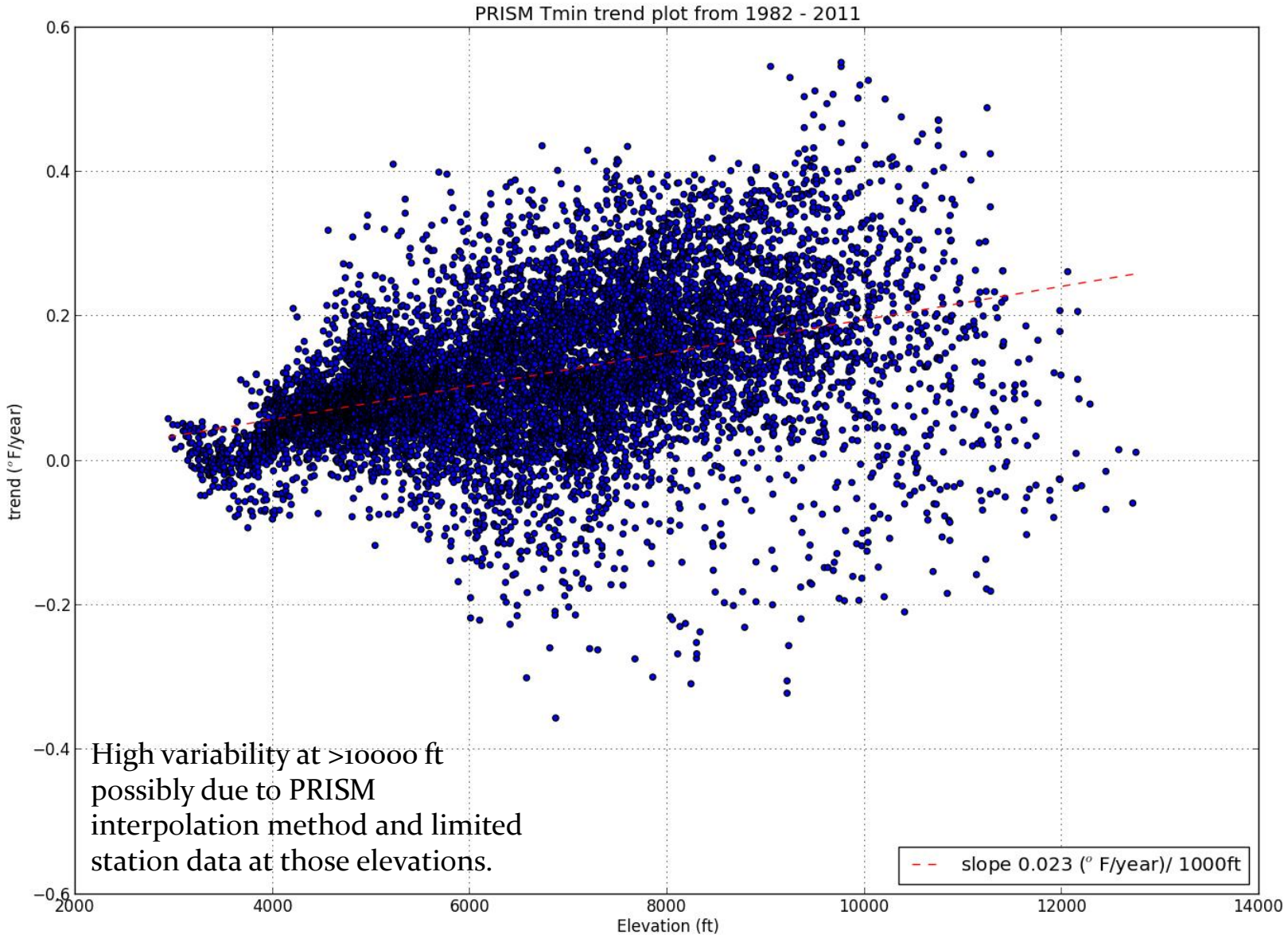

PRISM 1982-2011
Tmin temp. trend
deg F/ year
-0.356 - -0.027
-0.027 - 0.074
0.074 - 0.156
0.156 - 0.261
0.261 - 0.551
Analyzed stations
0 25 50 100 150 200
Kilometers
NORTH

PRISM displays filtering of variation for minimum temperature trends across GYE





-No significant difference in mean trends



High variability at >10000 ft possibly due to PRISM interpolation method and limited station data at those elevations.

Implications and future research

-Greater Yellowstone Ecosystem experiencing a diurnal temperature range contraction from 1982-2011 (Easterling et al 1997)

-Greatest increases of temperature trends occurring in the sub-alpine/alpine mountain regions

-Consistent with findings in Europe and Asia (Diaz and Bradley 1997)

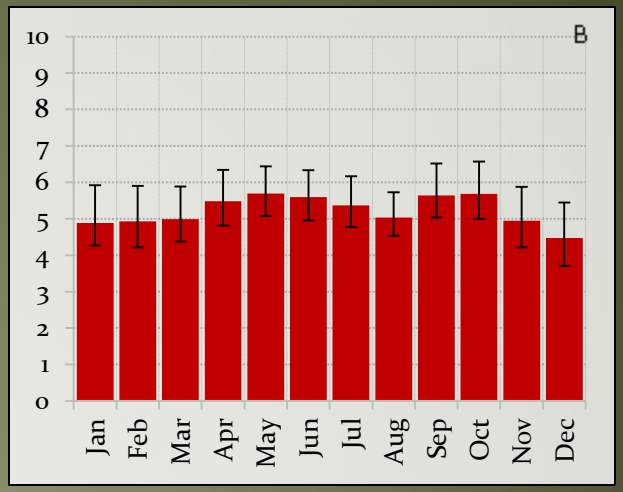
Implications and future research

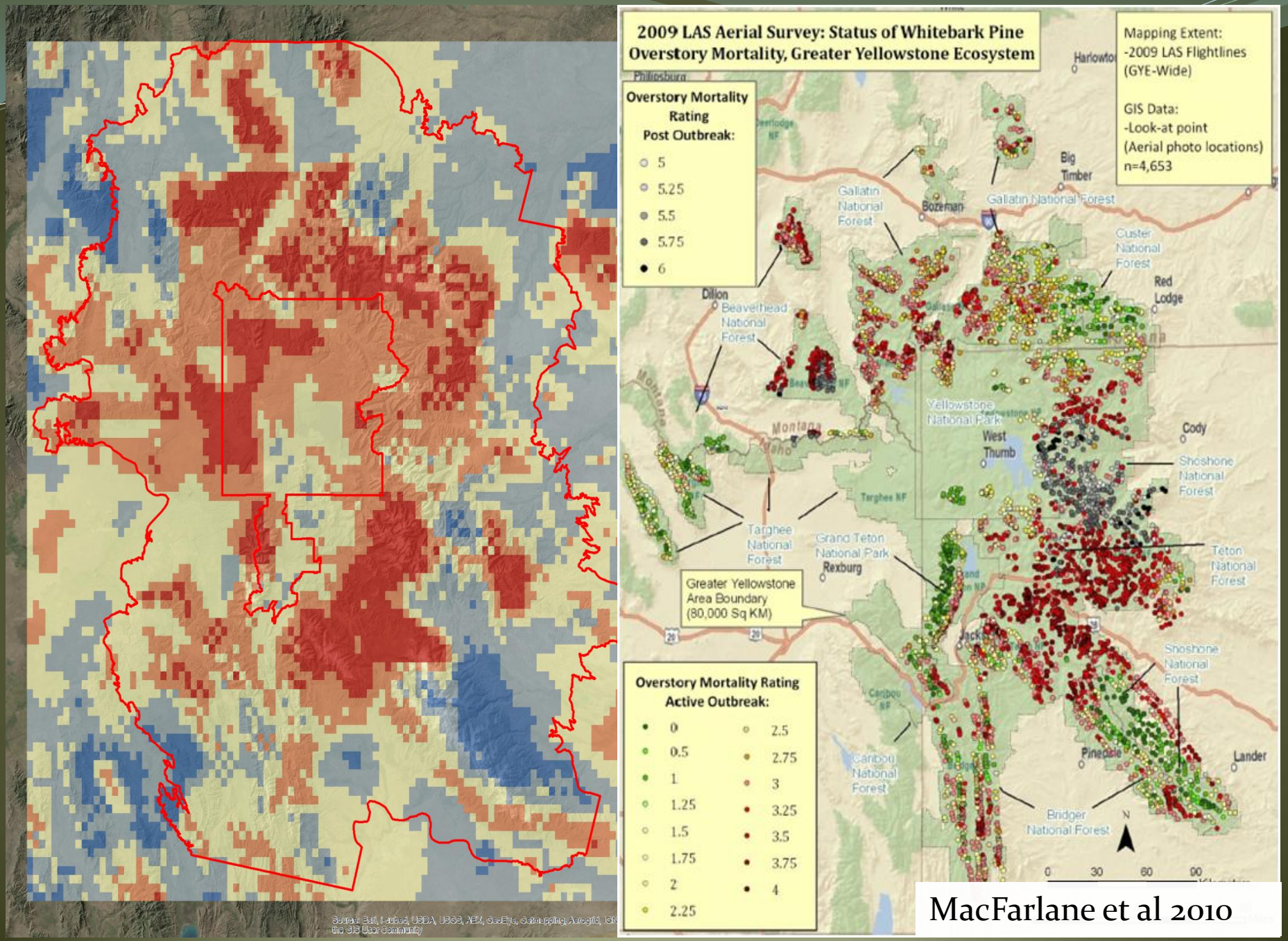
-Potential mechanisms include:

cloudiness, humidity, land cover changes, and increased atmospheric CO_2 levels

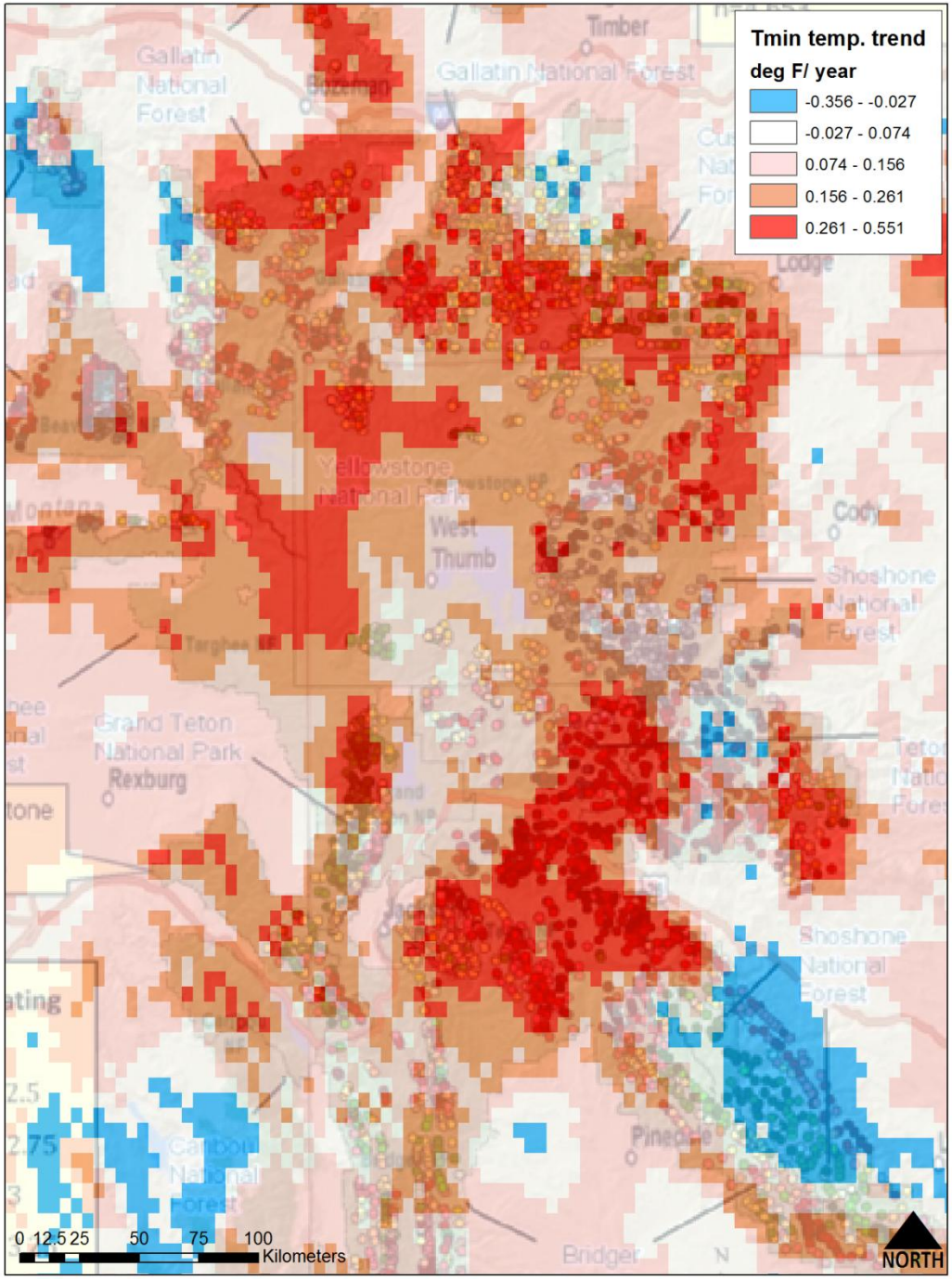
-Likely the number of days where average temperature cross the zero ^0C freeze/thaw isotherm (days of snowmelt) (Pederson 2010)

-Increased of snowmelt positive feedback, reduces albedo





MacFarlane et al 2010



Preliminary analysis display strong association of mortality with minimum temperature trends.

Implications

-Temperature trends imply increased exposure of climatic change for alpine species such as whitebark pine.

-Variation in snow melt timing, results in changes of water resource availability and phenological response periods.

-Climate/ecosystem forecast model application has high potential for active management of climate change.

Future research

-Analysis of daily snow depth/snow water equivalent measurements at meterological stations over 30 year period.

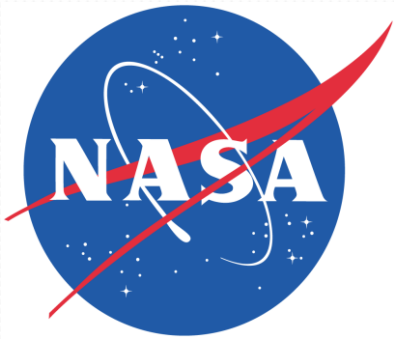
-Investigate remote sensed albedo products (MODIS/MISR) and measure monthly values in alpine zones.

-Overlay analysis of current whitebark pine distribution for multiple life stages.

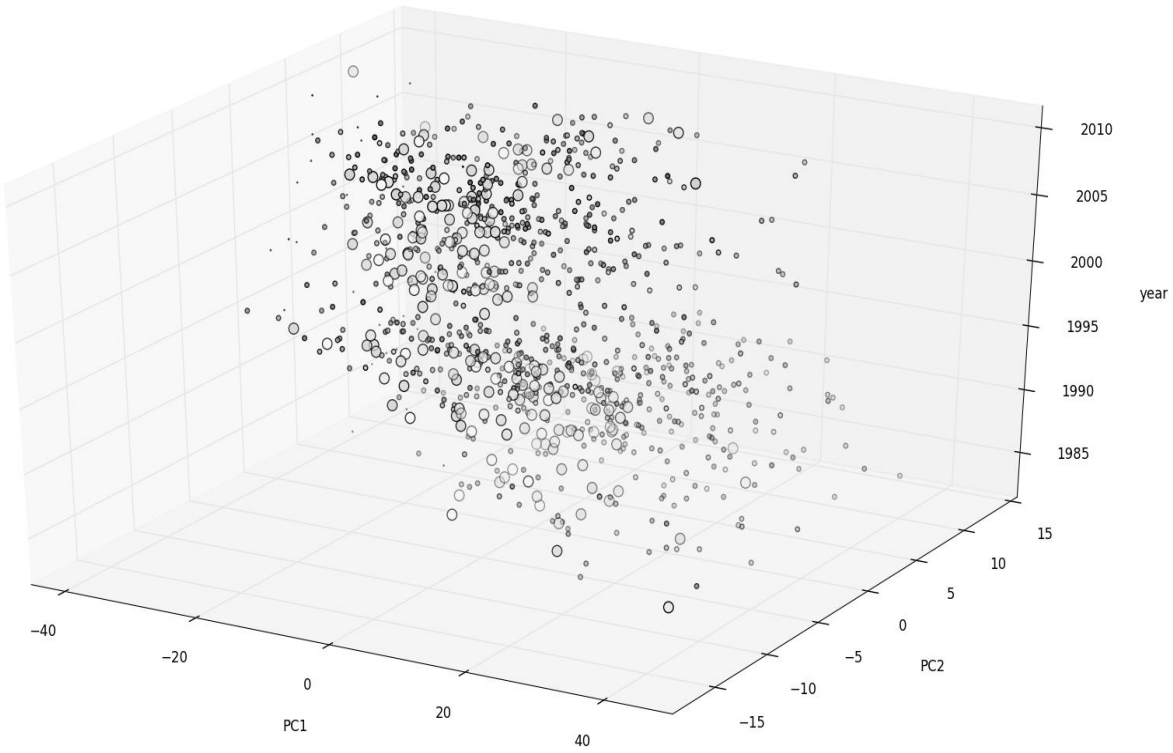
-Use NASA TOPS forecast model and predict change across the GYE.

Questions?

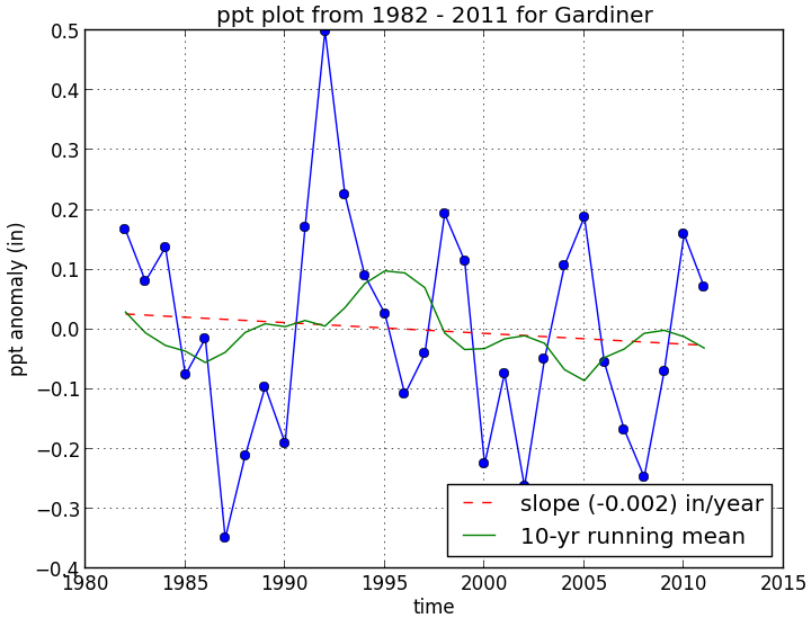
Appreciation of support

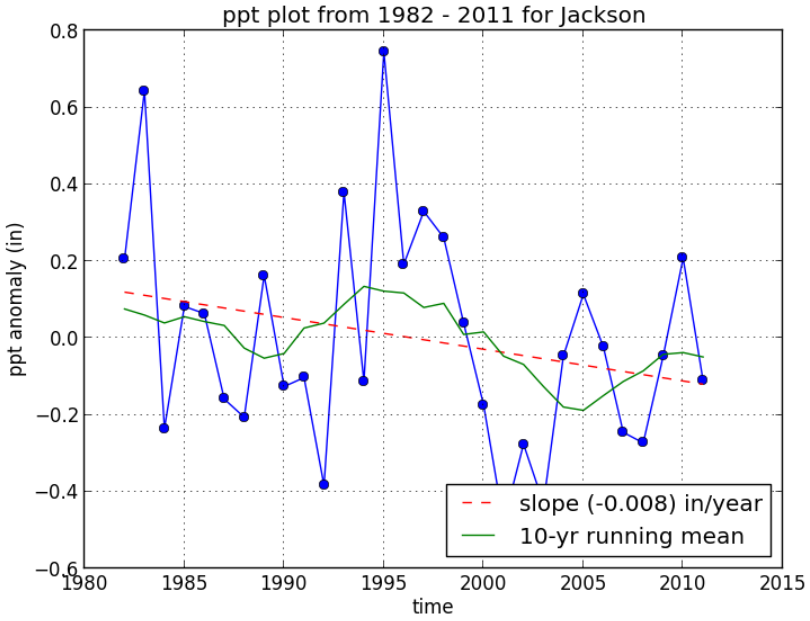


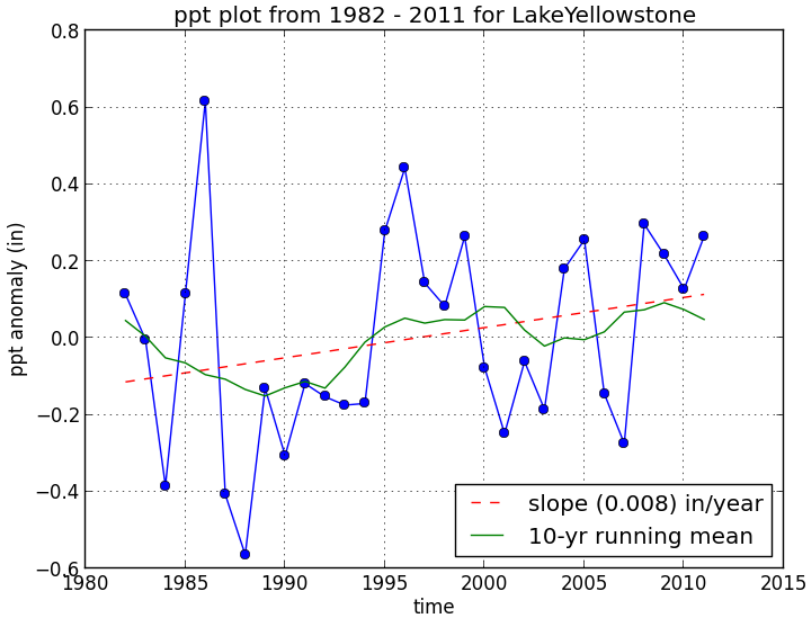
Principal component analysis display clustering of minimum temperature trends with elevation gradient

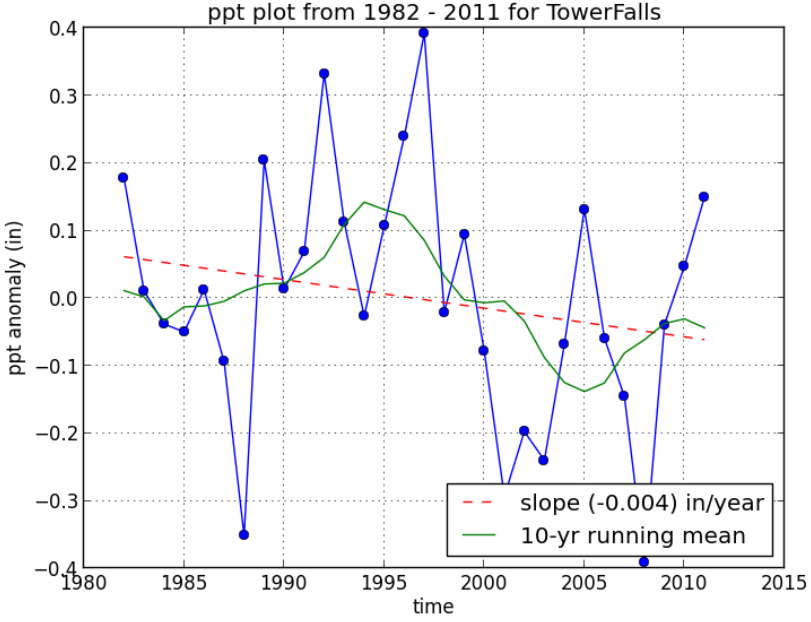


No significant trend in precipitation









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