Analysis of the Water Temperature at San Francisco Bay 2003 to 2013

Abstract

Climate change is occurring all over the globe effecting nations and environments. This study focus on the San Francisco Bay and the temperature of Its water. Like-seasons were compared year after year to capture any anomalies that occurred. Acquisition of satellite imagery and buoy data were combined, then an analysis was performed to see if the bay's water has been increasing due to the effects of climate change.

Method

Satellite Imagery was used from LandSAT8 for remote sensing analysis. Temperature data is within band 6 from the satellite imagery used to perform the statistics.

Temperature data retrieved from National Oceanic Data Center, a branch of NOAA, of the past 11 years.

The equations below were used to calculate the change in water temperatures

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{calmax} - Q_{calmin}}\right)(Q_{cal} - Q_{calmin}) + LMIN_\lambda$$

$L_\lambda =$ Spectral radiance at the sensor's aperture [W/(m² sr μm)]
$Q_{cal} =$ Quantized calibrated pixel value [DN]
$Q_{calmin} =$ Minimum quantized calibrated pixel value corresponding to $LMIN_\lambda$ [DN]
$Q_{calmax} =$ Maximum quantized calibrated pixel value corresponding to $LMAX_\lambda$ [DN]
$LMIN_\lambda =$ Spectral at-sensor radiance that is scaled to Q_{calmin} [W/(m² sr μm)]
$LMAX_\lambda =$ Spectral at-sensor radiance that is scaled to Q_{calmax} [W/(m² sr μm)]
$G_{rescale} =$ Band-specific rescaling gain factor [(W/(m² sr μm))/DN]
$B_{rescale} =$ Band-specific rescaling bias factor [W/(m² sr μm)]

$$T = \frac{K2}{\ln\left(\frac{K1}{L_\lambda} + 1\right)}$$

$K1 =$ Calibration constant 1 [W/(m² sr μm)]
$L_\lambda =$ Spectral radiance at the sensor's aperture [W/(m² sr μm)]
$\ln =$ Natural logarithm

$T =$ Effective at-sensor brightness temperature [K]
$K2 =$ Calibration constant 2 [K]

⬤ = Location of buoys

Image: example of a sensor buoy
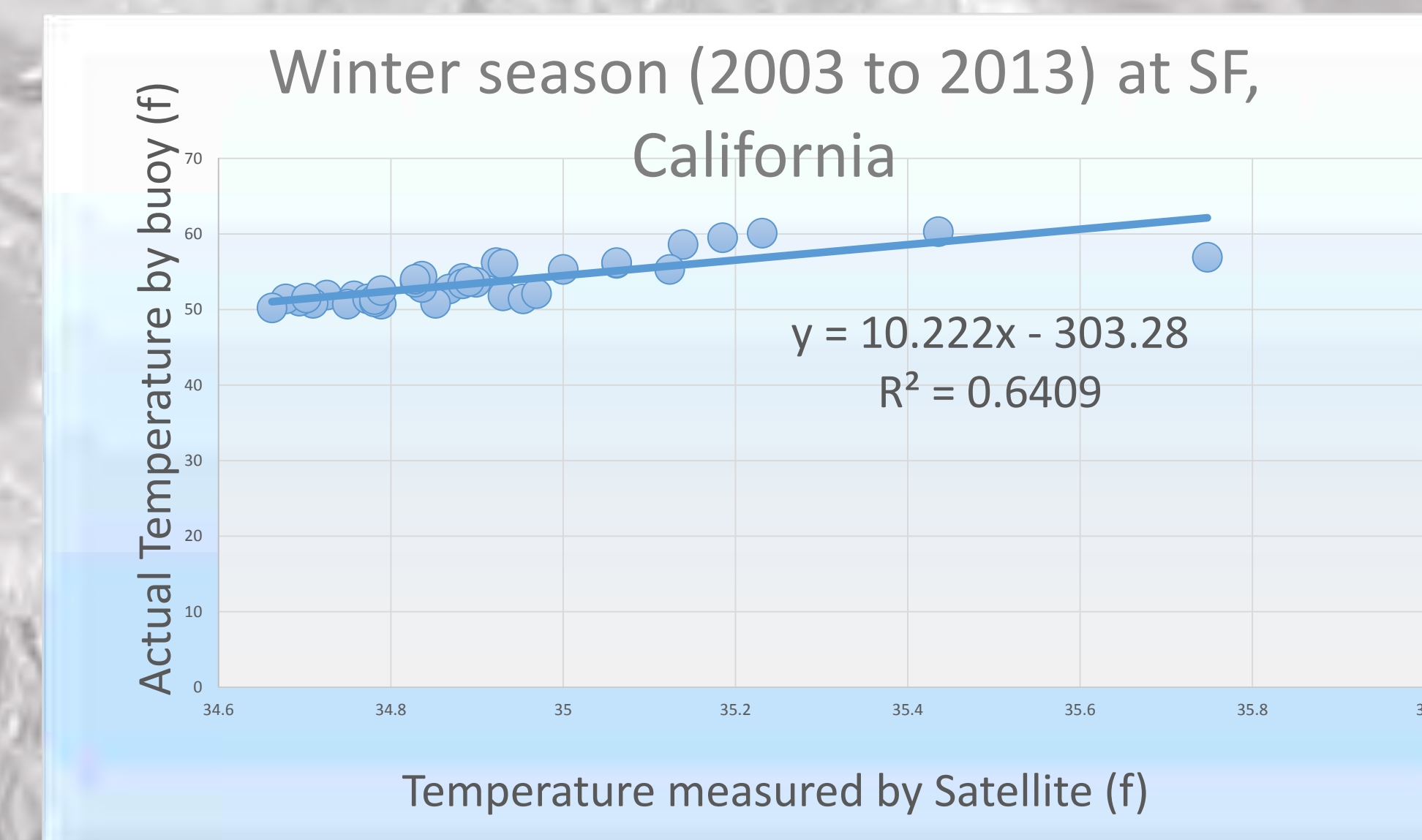
Results

Figure 1: Winter water temperatures have increased since 2003
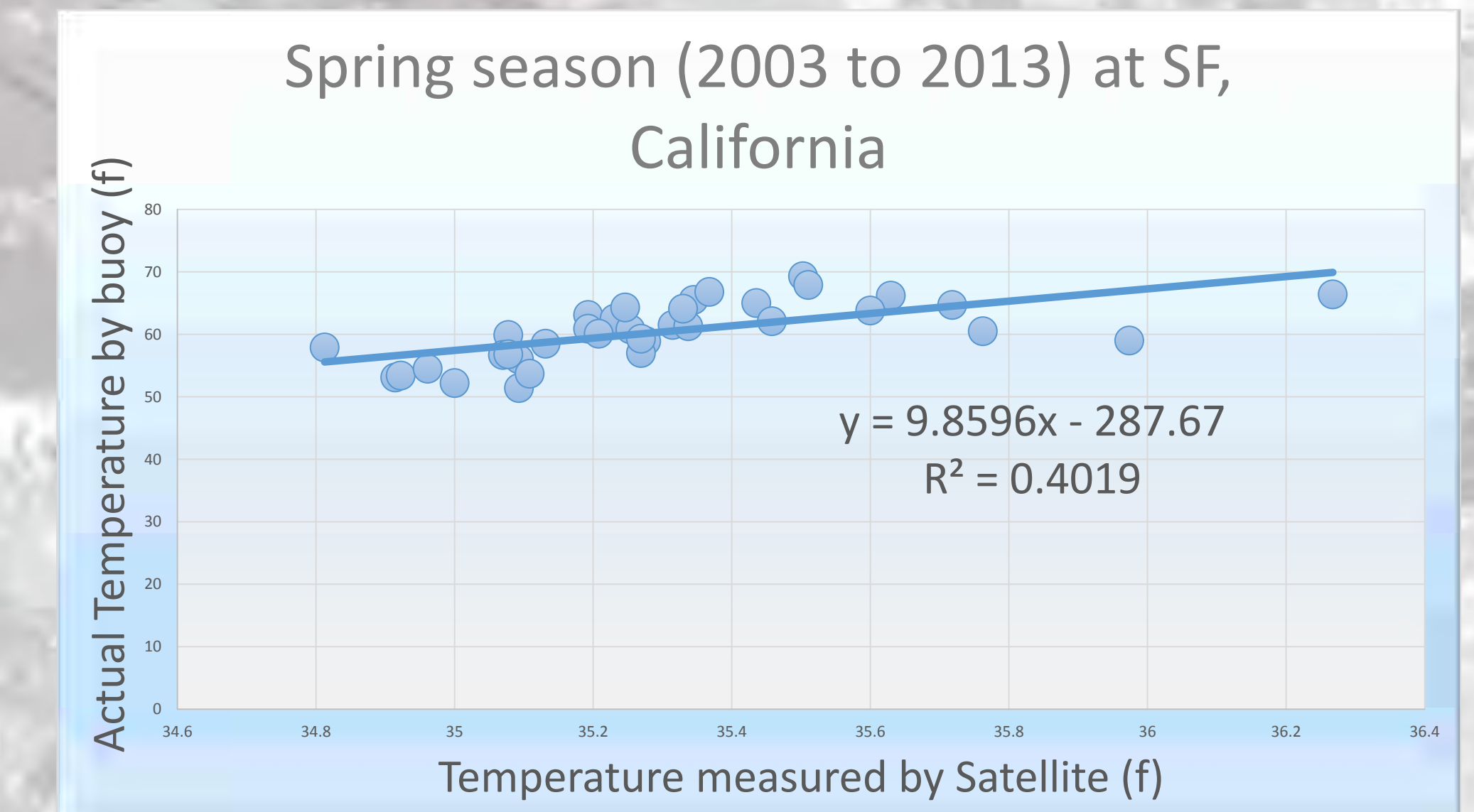

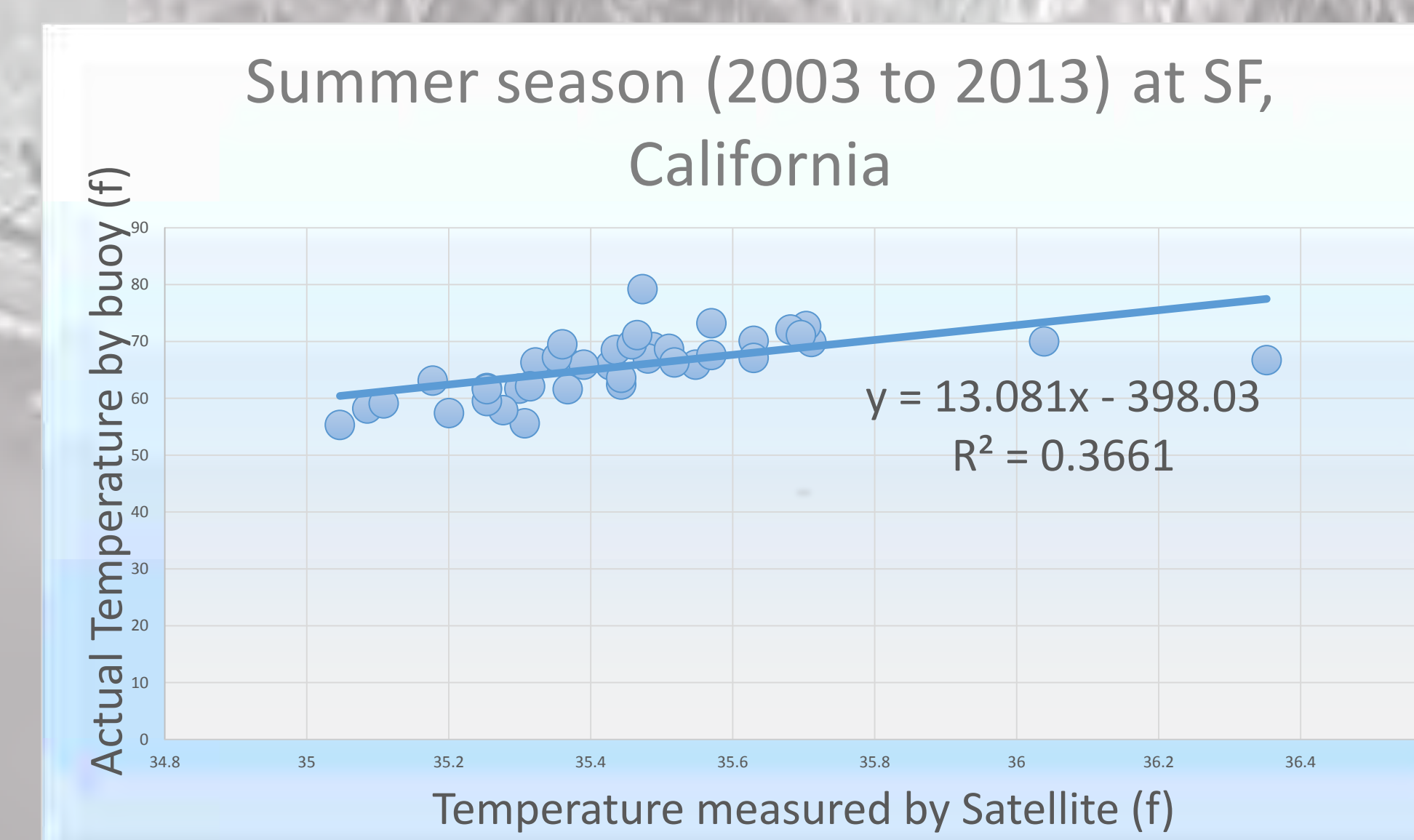Figure 2: Spring water temperatures have increased since 2003

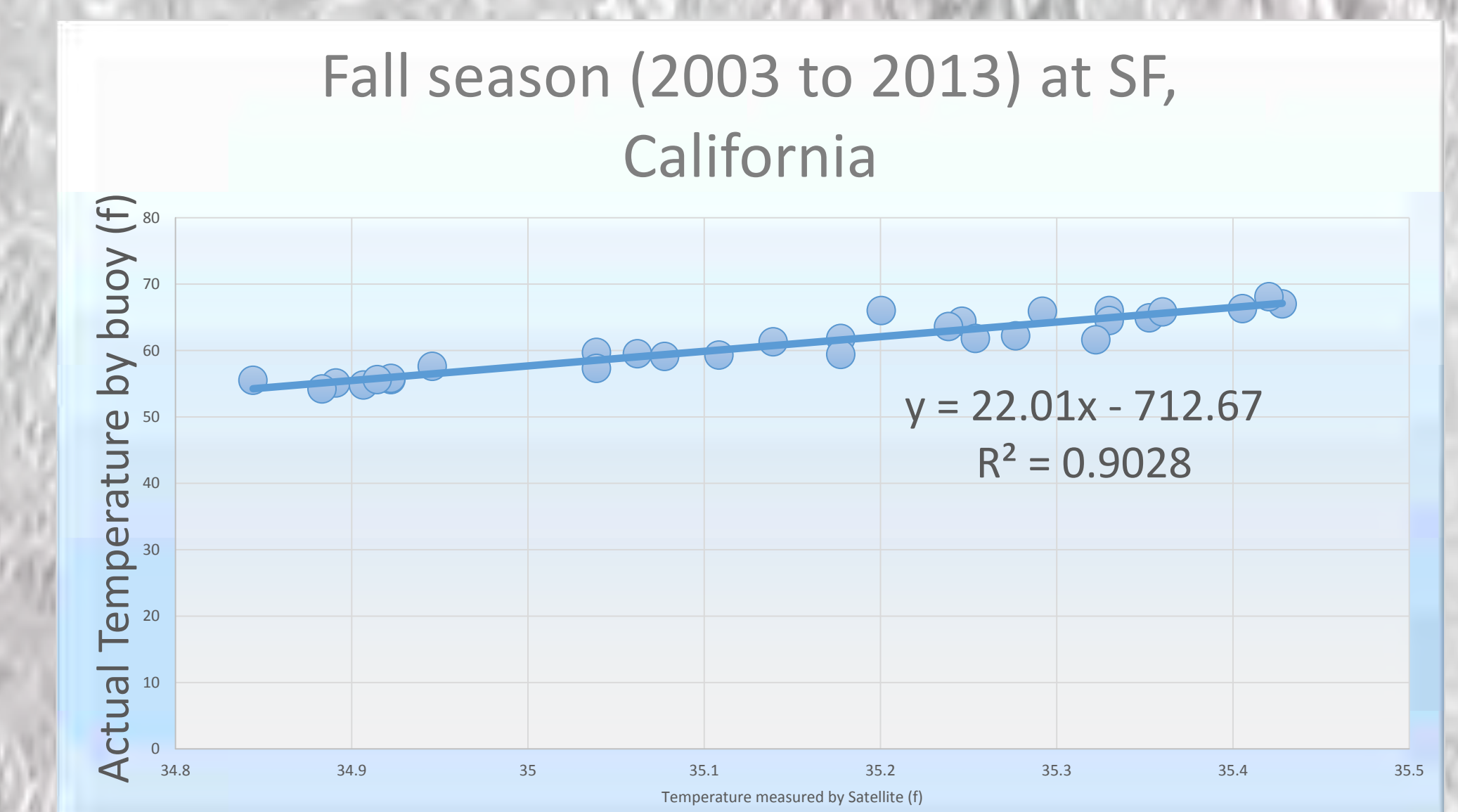Figure 3: Summer water temperatures have increased since 2003

Figure 4: Fall water temperatures have increased since 2003

Discussion

After the data was gathered and analyzed, the results revealed **all 4 seasons** show a rate of **increase in water temperature** year after year. Water temperature data is restricted to the past 18 years, however, and studying climate change effects requires more information. Whether it is anthropogenic or not needs further research.

Ihab Abujarad, Josh Emmons | 18 Mar 2014 | Sources: National Oceanic Data Center, USGS GloVis