Using Satellite Remotely Sensed Data to Understand of the Responses of Terrestrial Water and Ecosystems to the Recent California Drought

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Introduction

- Over the past decade, California went through a severe drought under a significant warming. Drought is a deficiency in precipitation over an extended period of time causing adverse impacts on the ecosystem.
- Understanding the trends in snow cover, stream flow, and ecosystem in response to drought is important for the communities to best prepare for the upcoming changes in water resources and ecosystems

Objectives:

- To understand how terrestrial water interacts with different ecosystems during a period of drought

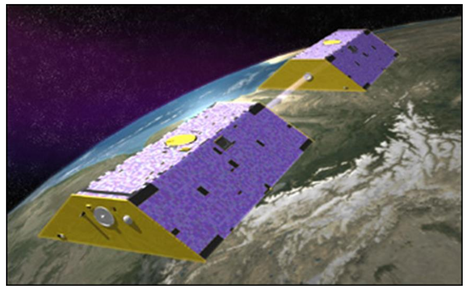

Figure 1: Gravity Recovery and Climate Experiment (GRACE) Mission, the twin satellites measuring the change in terrestrial water storage (TWS) across Earth.

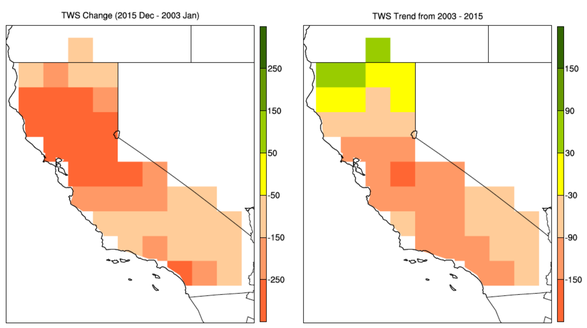

Figure 2 (Left) TWS Change (in mm) from 2003 Jan – 2015 Dec.; (Right) TWS Trend from 2003 – 2015 detected by GRACE

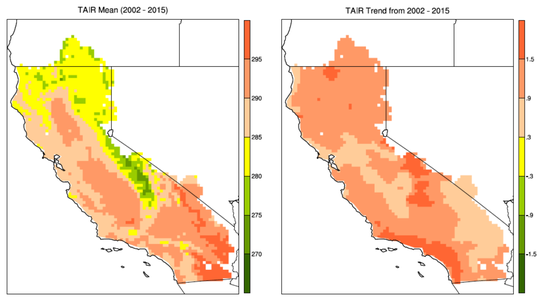

Figure 3: (Left) Air temperature mean (in Kelvin) from 2002 – 2015 and (Right) its trend from 2002 – 2015

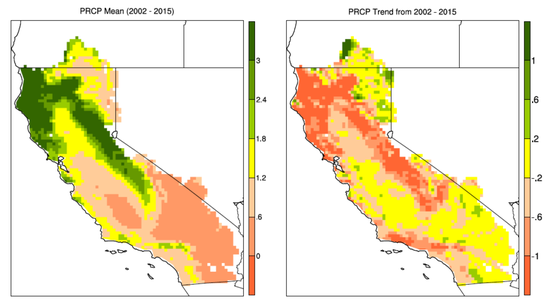

Figure 4: (Left) Precipitation mean (in mm) from 2002 – 2015 and (Right) its trend from 2002 – 2015

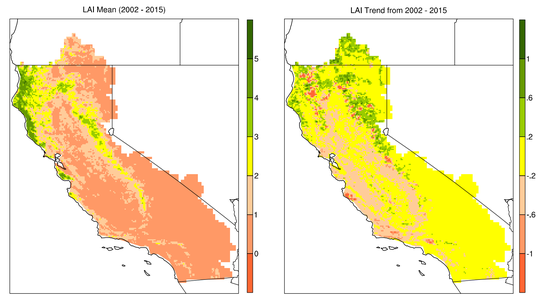

Figure 5: (Left) Leaf Area Index (LAI; in m^2/m^2) mean from 2002 – 2015 and (Right) its trend from 2002 – 2015

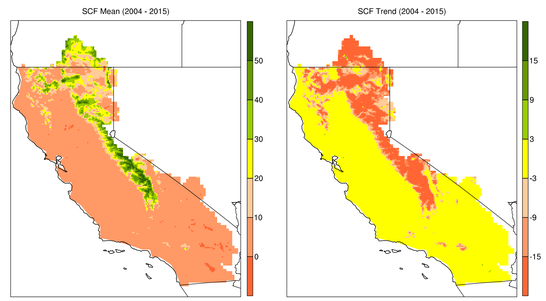

Figure 6: (Left) Snow Cover Fraction (SCF; %) mean from 2004 – 2015 and (Right) its trend from 2004 – 2015

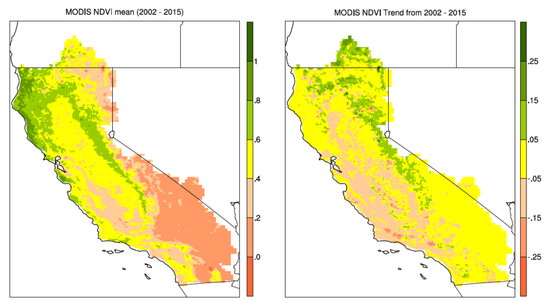

Figure 7: (Left) Normalized Difference Vegetation Index (NDVI; unitless) mean from 2002 – 2015 and (Right) its trend from 2002 – 2015

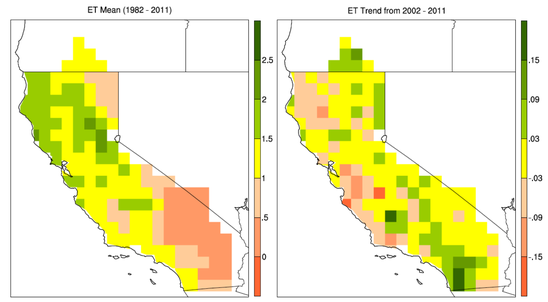

Figure 8: (Left) Evapotranspiration (ET; mm/day) mean from 1982 – 2011 and (Right) its trend from 2002 – 2011.

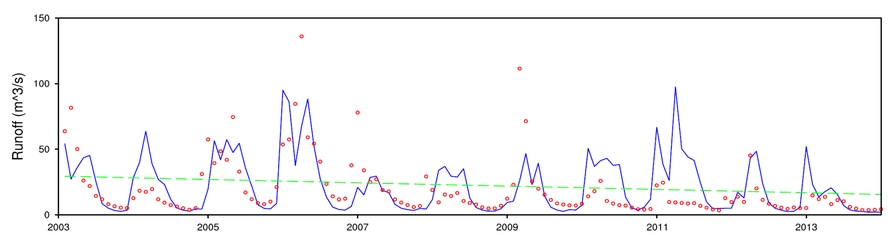

Figure 9: Monthly river streamflow (in mm/month) and its declining trend from 2003-2013

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Methods

- Data from different satellites (e.g. LAI) and reanalysis (precipitation, etc.)
- Using the National Center for Atmospheric Research (NCR) Command Language (NCL) code to analyze the collected data
- NCL code to plot the time series and spatial variations of long-term mean values and trends

Results

From 2002-2015, there were

- Decreasing trends in precipitation and river runoff, as well as increasing trend in temperature
- Little Increasing trends in LAI and NDVI in the forest ecosystem over mountainous regions and very little decreasing trend in many desert areas
- Decreasing trend in terrestrial water storage (TWS)
- Decreasing trend in snow cover over the mountainous forest ecosystem

Conclusions and Implications

- The drought was caused by a lack of precipitation and increase of temperature over many areas
- The LAI and NDVI increasing trends in the mountains are possibly caused by the elevated CO_2 that facilitates photosynthesis despite less snow water.
- The decreasing TWS trend in the Central Valley may be caused by groundwater pumping for irrigation, resulting in a less-than-expected decreasing trend in LAI and NDVI.
- Patches of died-off in the forests detected by the MODIS satellites are due possibly to the “hot” drought.

Acknowledgements:

The 2017 STEM Teacher and Researcher Program and this project have been made possible through support from Chevron (www.chevron.com), the National Marine Sanctuary Foundation (www.marinesanctuary.org), the California State University Office of the Chancellor, and California Polytechnic State University, in partnership with Biosphere 2, University of Arizona, and NASA MAP Project (80NSSC17K0352).