

Challenges for Projecting Future Climate Change Impacts on Water Resources in Hawai'i



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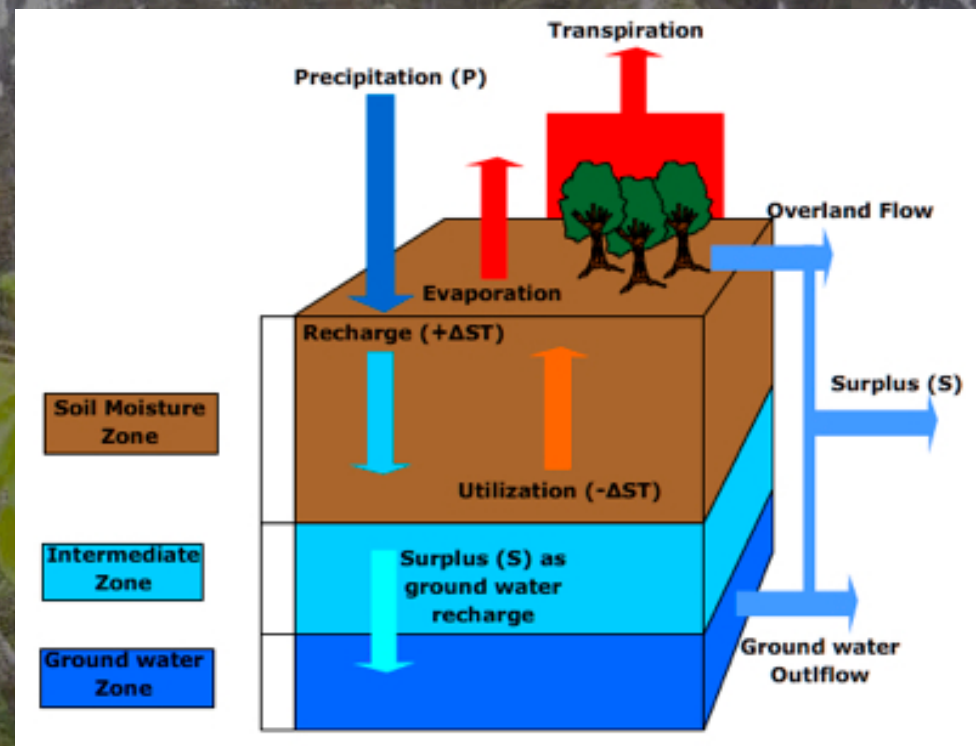
APEC Climate Symposium
East-West Center
19 October 2011

Sponsors of this research

Pacific Island Climate Change Cooperative
Hawai'i Commission on Water Resource Management
US Army Corps of Engineers—Honolulu District
National Oceanic and Atmospheric Administration
National Science Foundation EPSCoR Program
Pacific Island Ecosystems Research Center, USGS

Climate Influences on Water Resources

- Precipitation
 - Rainfall
 - Cloud water (fog) interception
- Evapotranspiration
- Sea level



PDO

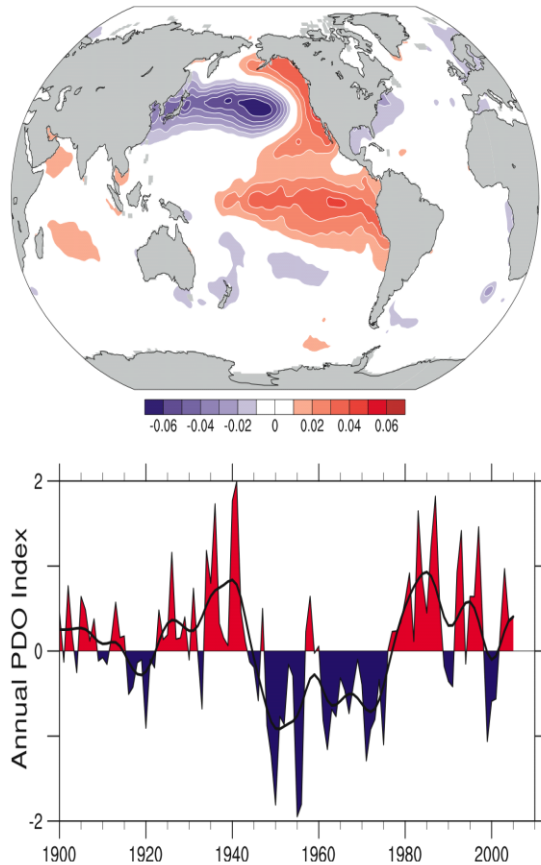


Figure 3.28

ENSO

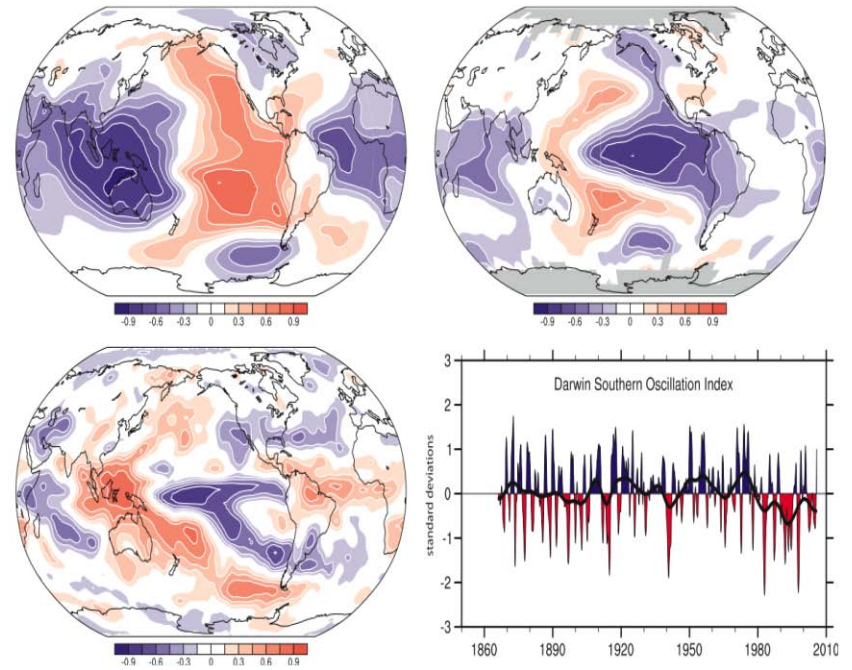
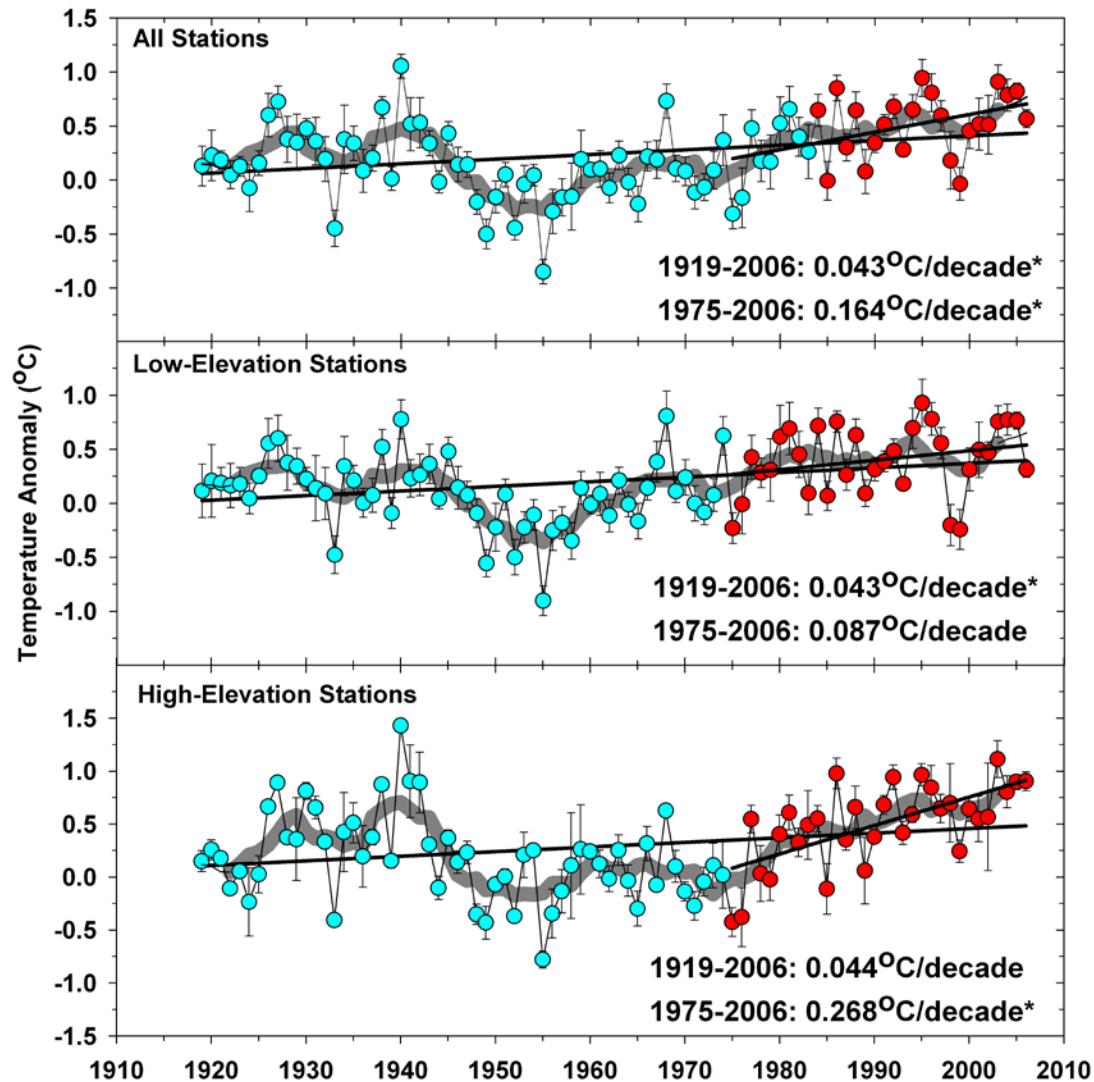


Figure 3.27

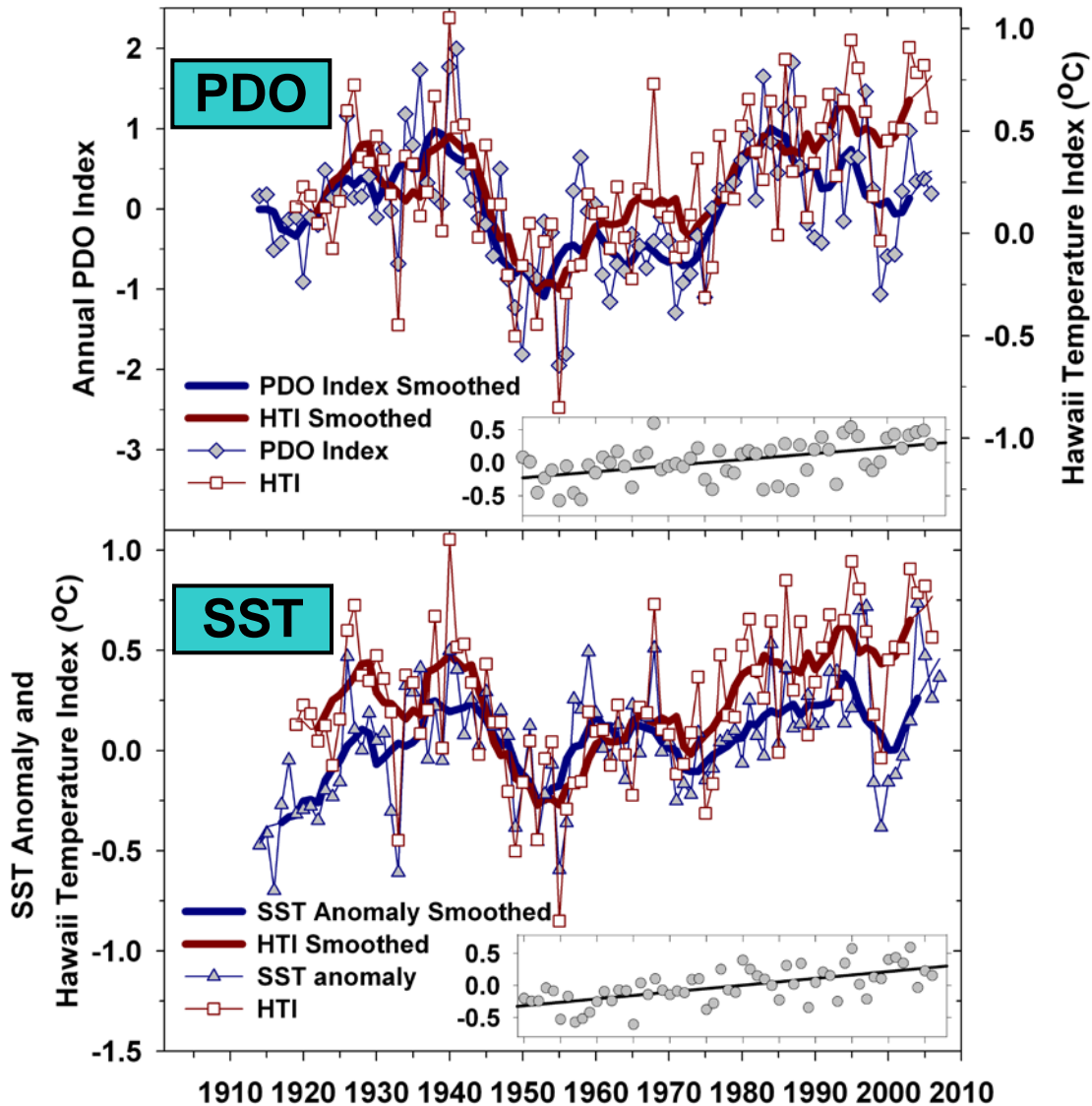
AR4, IPCC (2007); also see Mantua et al. (1997), Power et al. (1999), and Trenberth and Caron (2000)

Hawai 'i Temperature Index



Giambelluca, T.W., Diaz, H.F., and Luke, M.S.A. 2008. Secular temperature changes in Hawai 'i. *Geophysical Research Letters* 35, L12702, doi:10.1029/2008GL034377.

HTI—PDO—SST



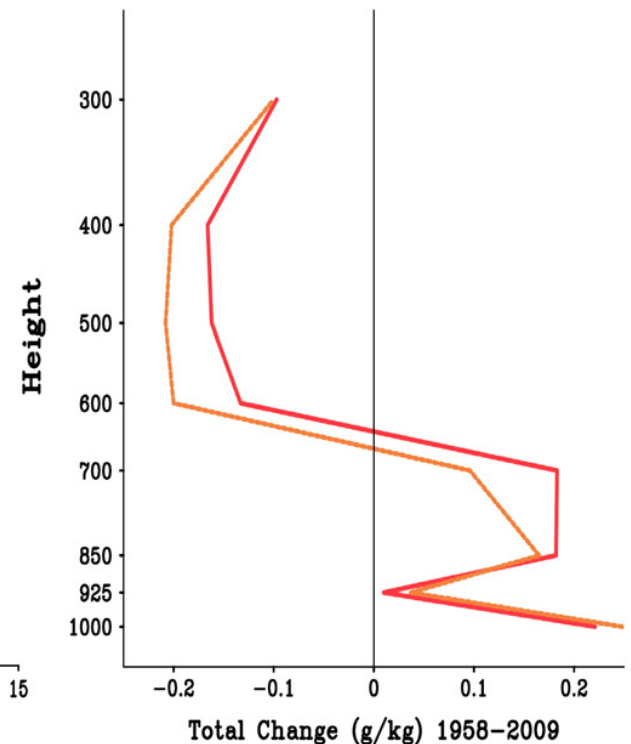
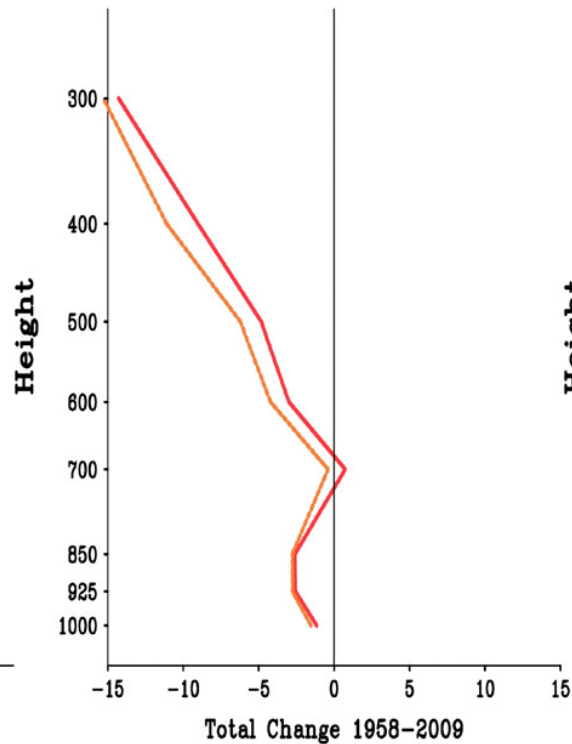
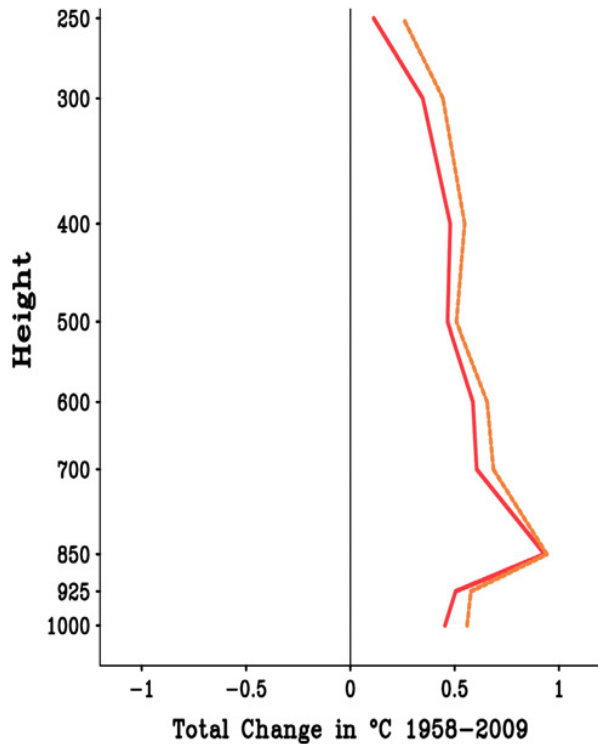
Giambelluca, T.W., Diaz, H.F., and Luke, M.S.A. 2008. Secular temperature changes in Hawai'i. *Geophysical Research Letters* 35, L12702, doi:10.1029/2008GL034377.

Changes in Vertical Profiles

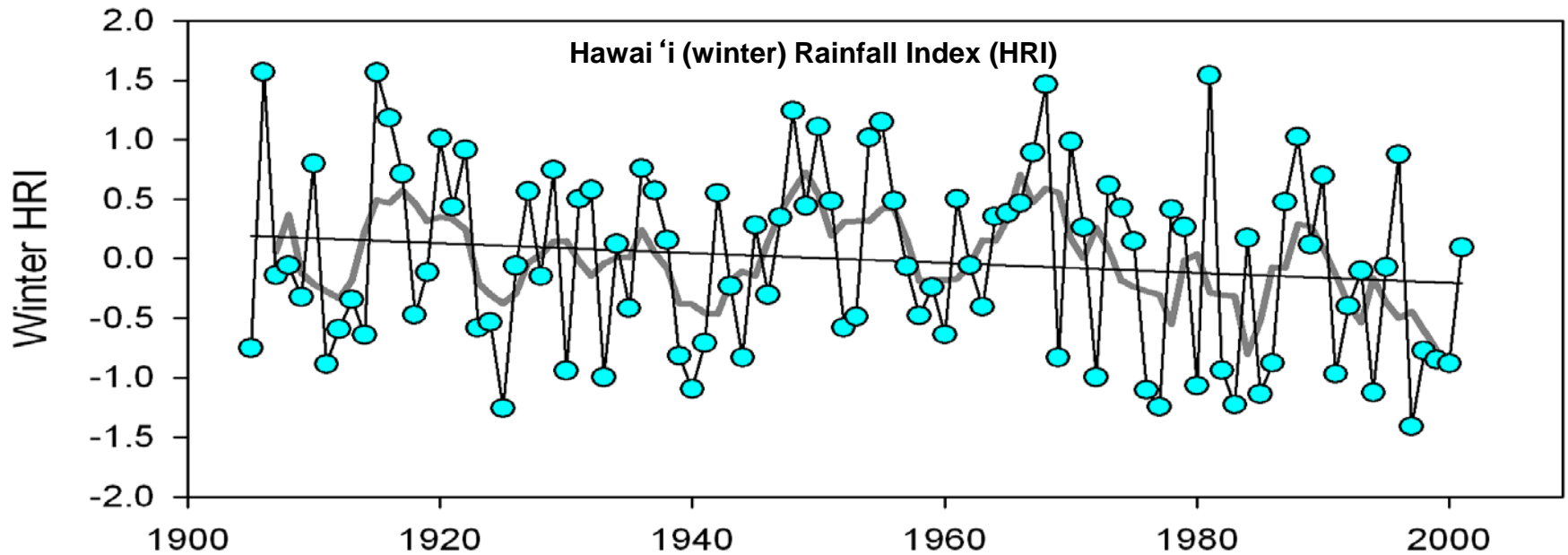
Hawaii Annual Temperature Trend
19°N–23°N; 161°W–154°W

Hawaii Annual Relative Humidity Trend
19°N–23°N; 161°W–154°W

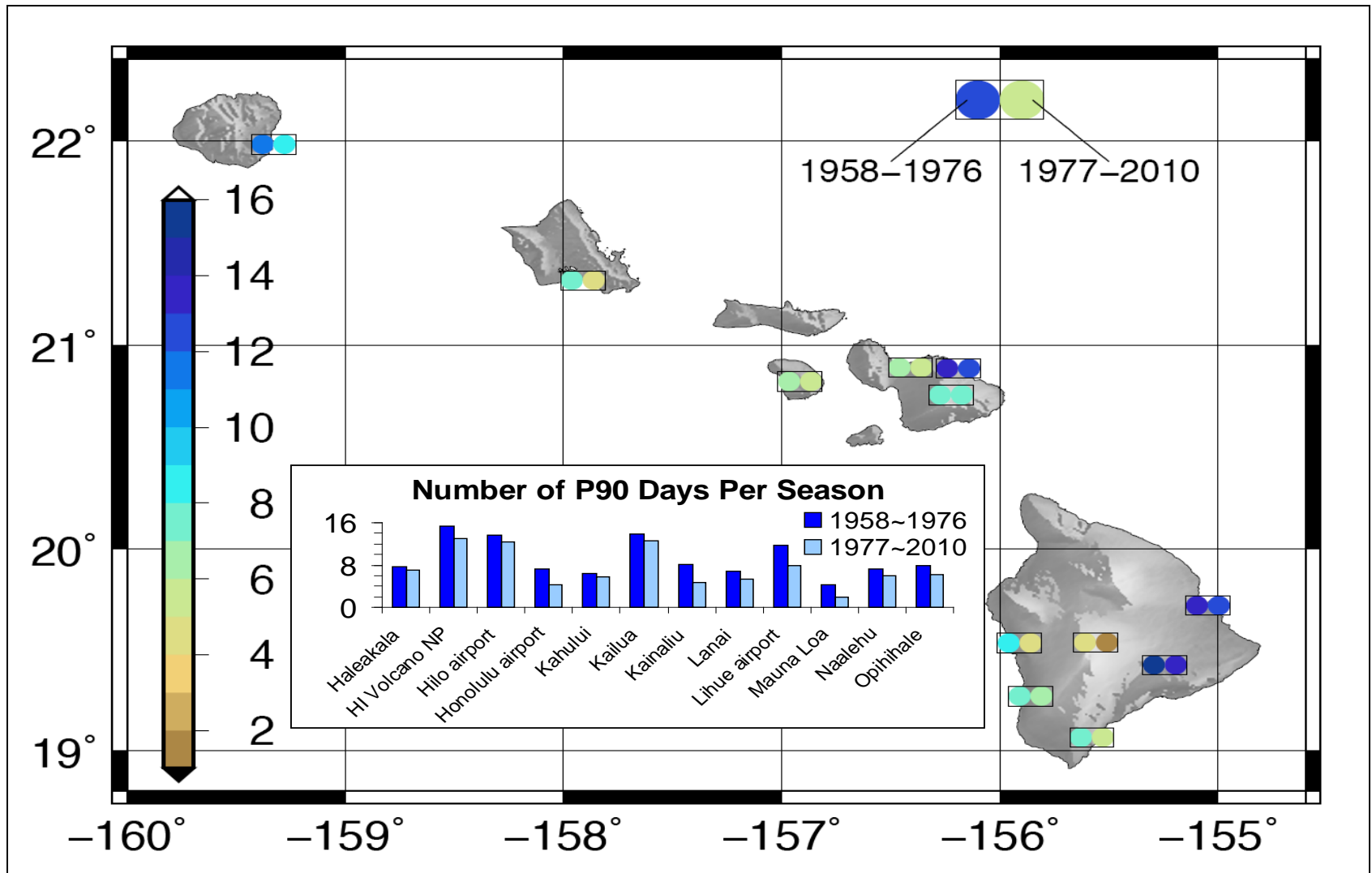
Hawaii Annual Specific Humidity Trend
19°N–23°N; 161°W–154°W



Hawai 'i Rainfall: Evidence of Long-Term Decrease



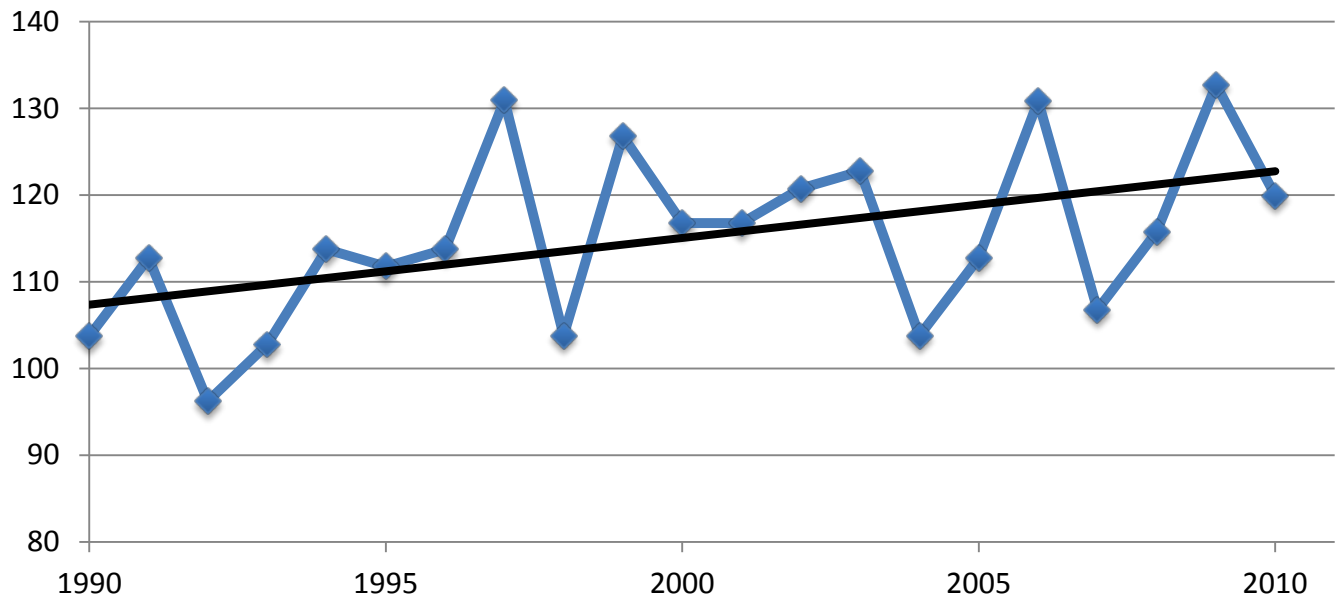
Decline in Heavy Rainfall Frequency



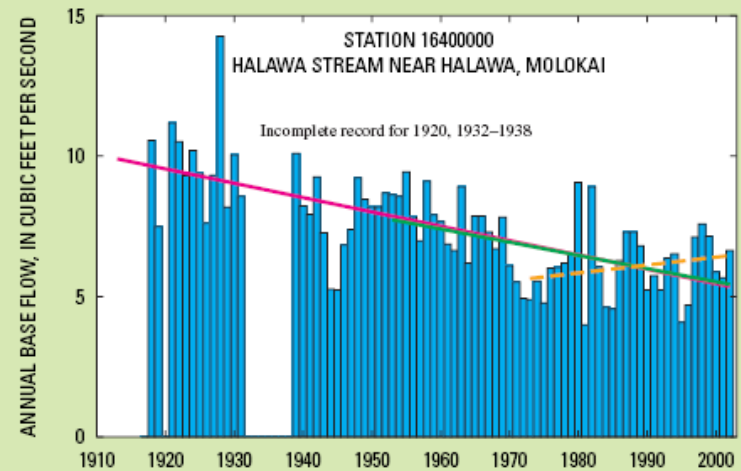
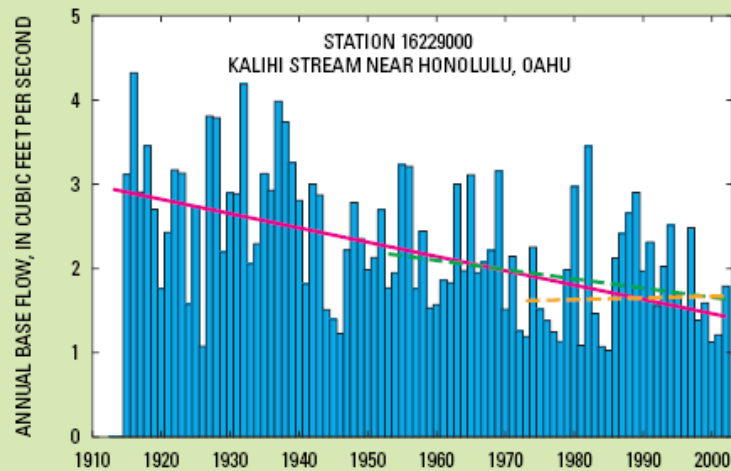
Giambelluca, T.W., Takahashi, M., Elison Timm, O., and Diaz, H.F. 2010. Projections of future changes in heavy rainfall frequency in Hawai'i using a statistical downscaling approach. American Geophysical Union Fall Meeting, San Francisco, December, 2010.

At High Elevations: Dry Days Becoming More Common

Number of Zero Rain Days per Dry Season
HaleNet Station 151



Stream Base Flow Also in Decline



TRENDS IN ANNUAL MEAN BASE FLOW SELECTED LONG-TERM-TREND STATIONS

EXPLANATION

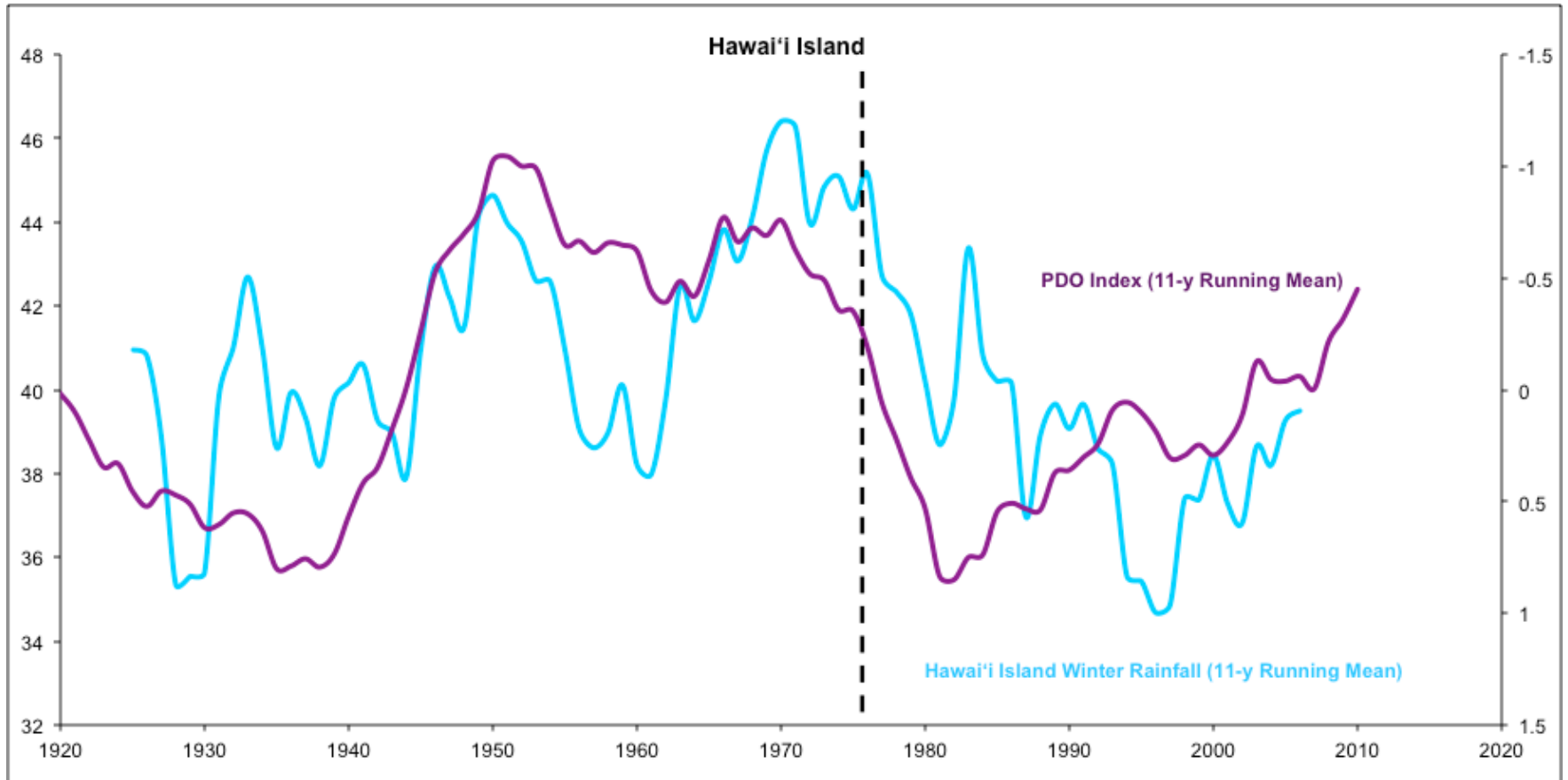
TREND LINE (KENDALL-THEIL ROBUST LINE)--Dashed line indicates statistically nonsignificant trend

— 1913-2002

— 1953-2002

— 1973-2002

Hawaiian Rainfall and the PDO

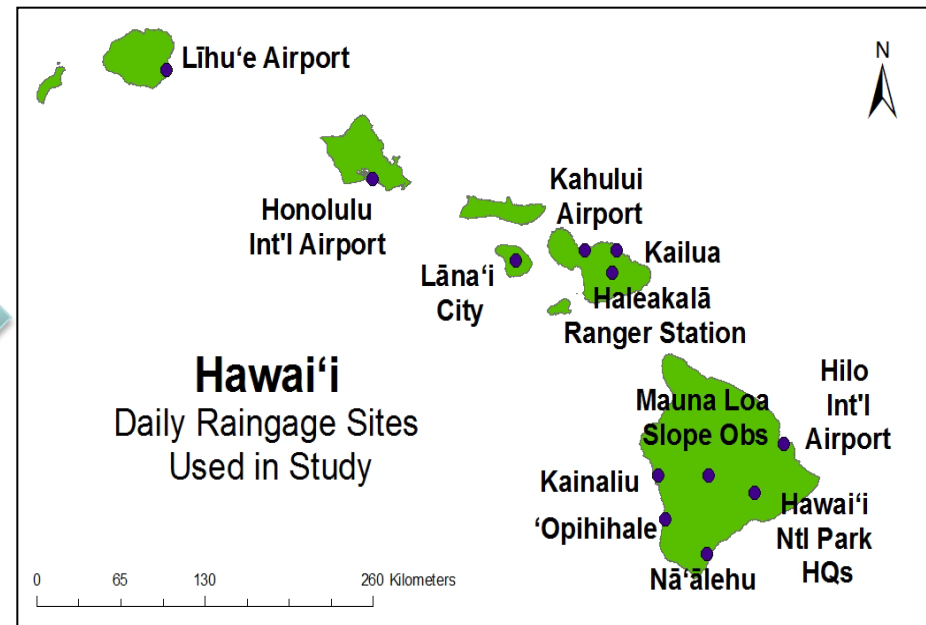
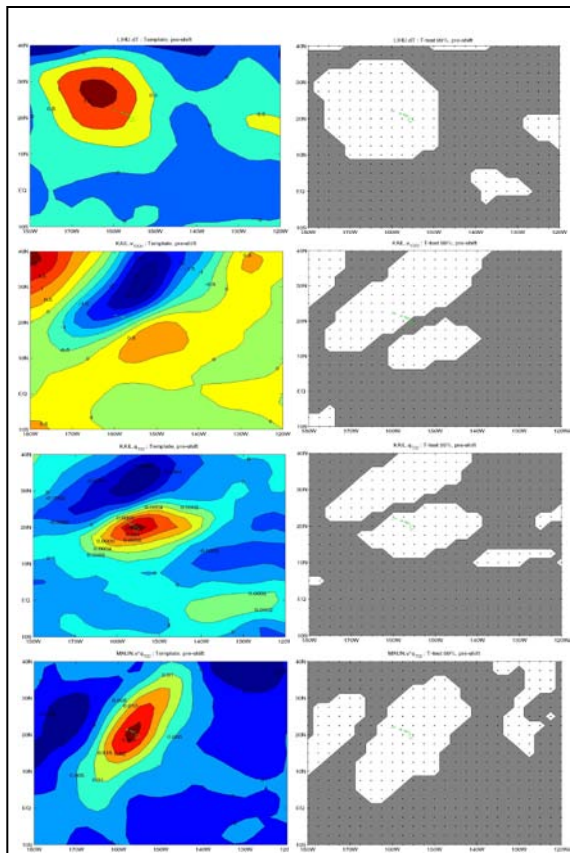


Projecting Rainfall Change Using Statistical Downscaling

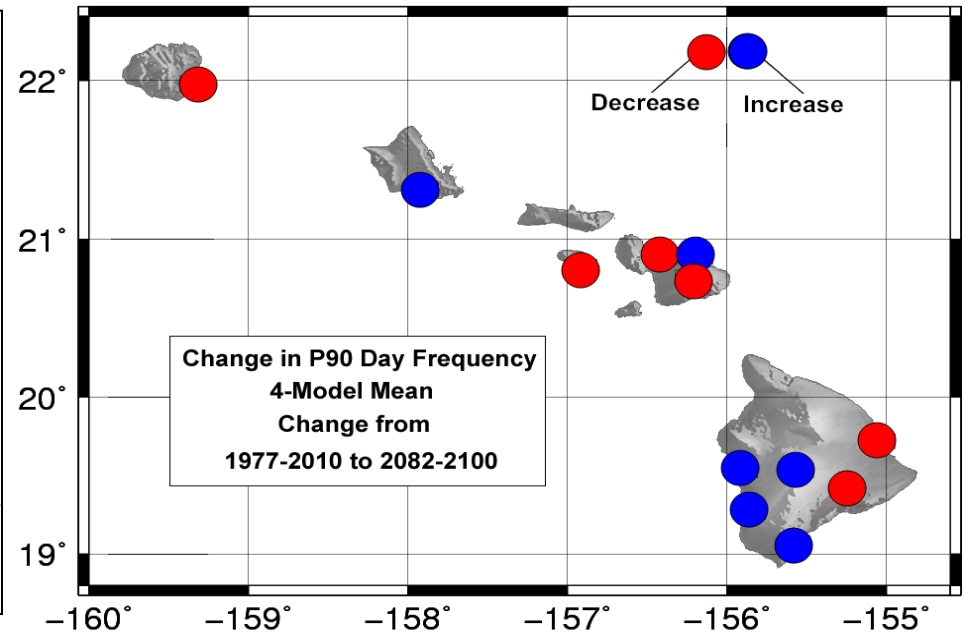
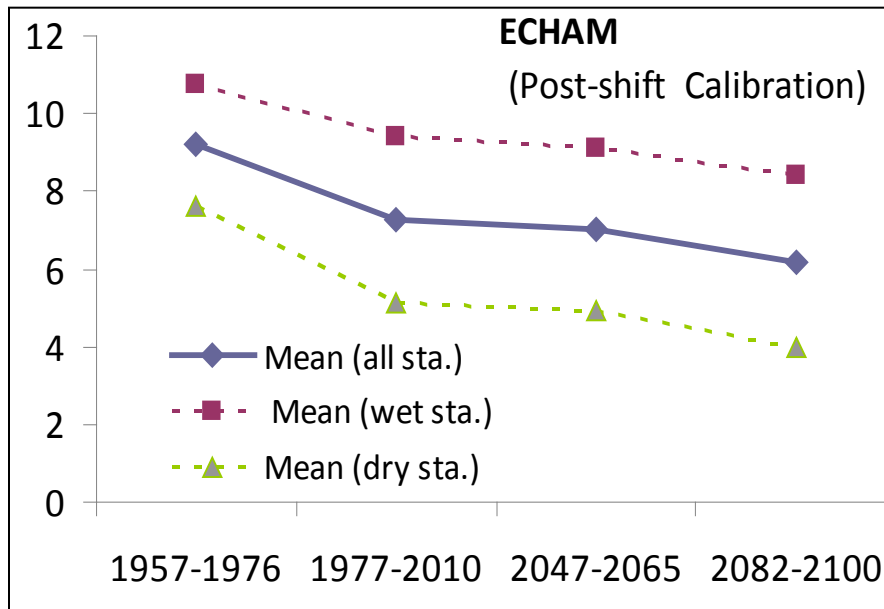
Large Scale Circulation



Point Rainfall



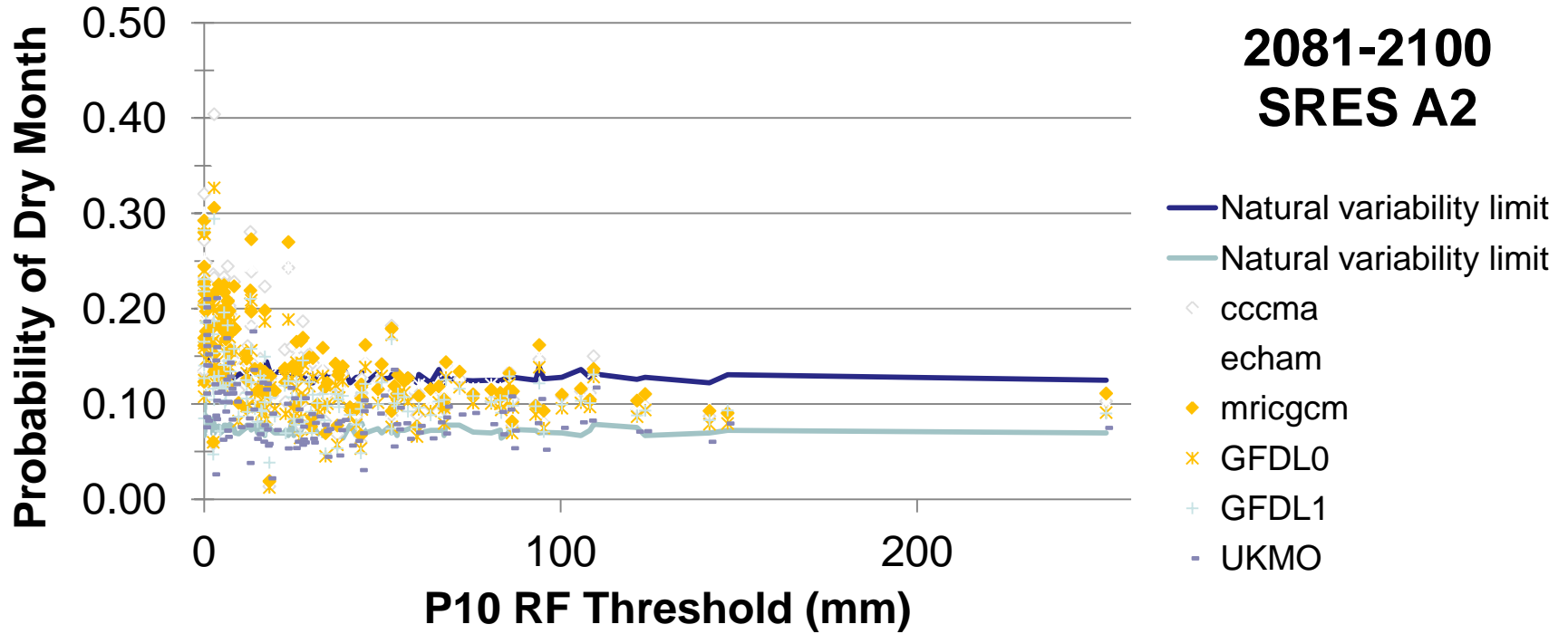
Projecting Heavy Rainfall Frequency



Projecting Drought Frequency

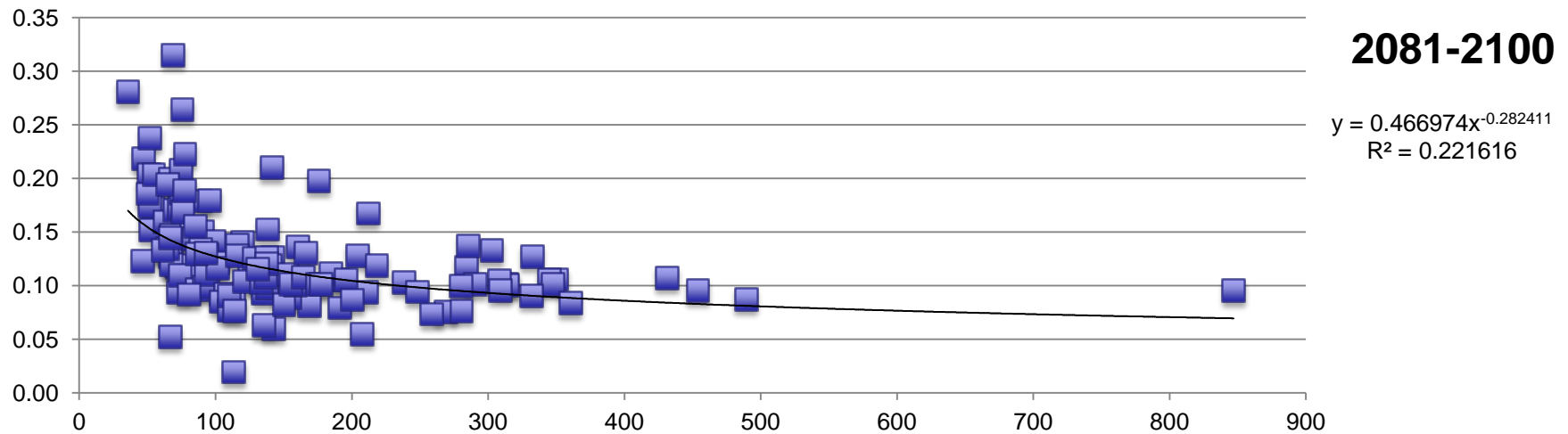
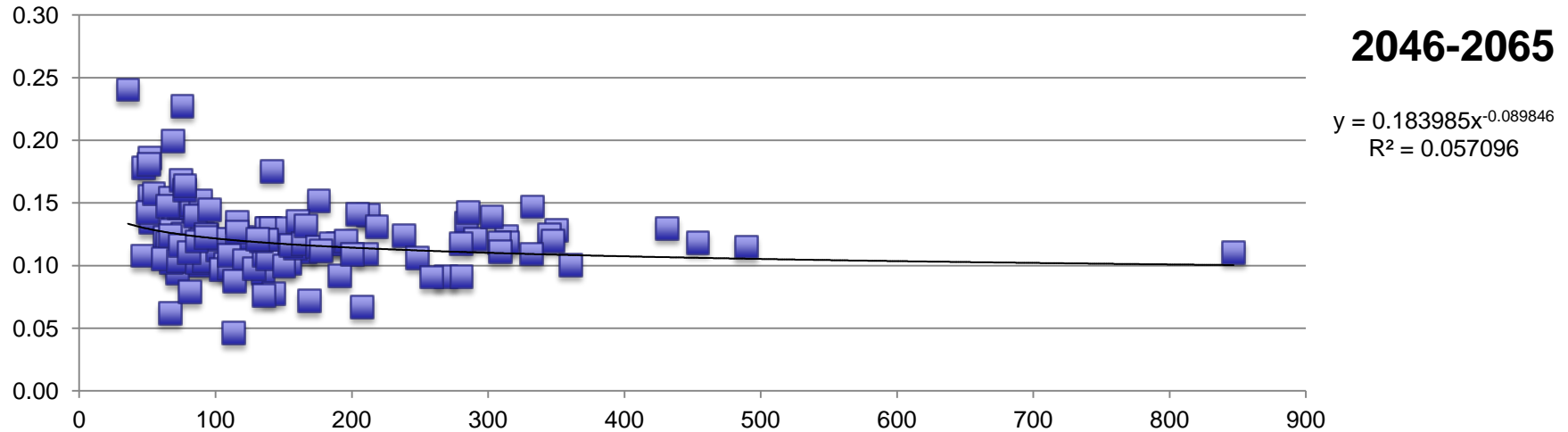
- 7 independent spatially-dependent variables
 - dT , gph_{500hPa} , q_{700hPa} , v_{700hPa} , q^*v_{700hPa} , q^*U_{700hPa} , $v_{1000hPa}$
- Composites developed to get templates
- Projection index quantifies pattern similarity
- 1st principal component used—condenses independent variables into a single time series
- Projected for 131 monthly raingage stations
- Focus on wet season: November-April

Projecting Drought Frequency



Projecting Drought Frequency

6-model ensemble



Rainfall Atlas of Hawai'i

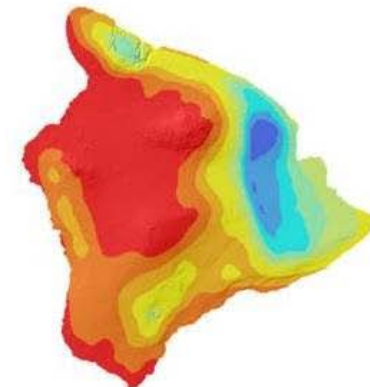
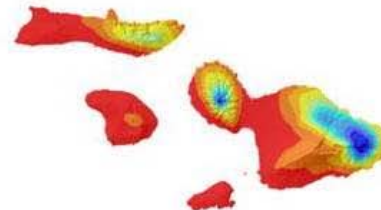
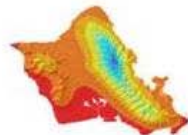
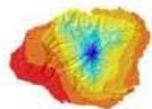
Geography Department - University of Hawai'i at Mānoa



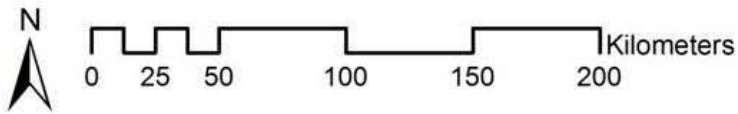
[HOME](#) [INTERACTIVE MAP](#) [DOWNLOADS](#) [HISTORY](#) [METHODS](#) [RAINFALL](#) [ACKNOWLEDGMENTS](#) [PEOPLE](#)

Mean Annual Rainfall State of Hawai'i

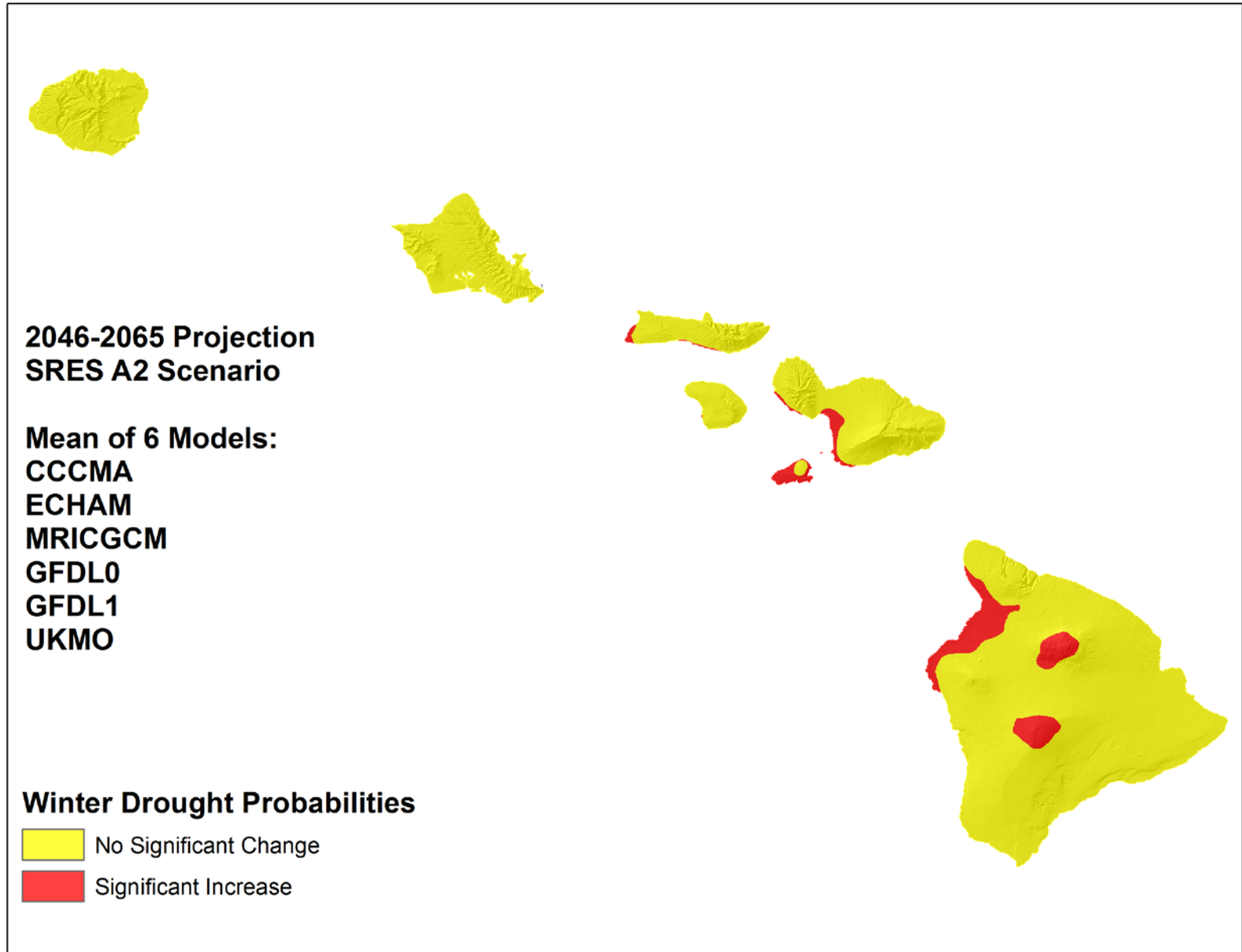
2011 Rainfall Atlas of Hawai'i
Department of Geography, University of Hawai'i at Mānoa



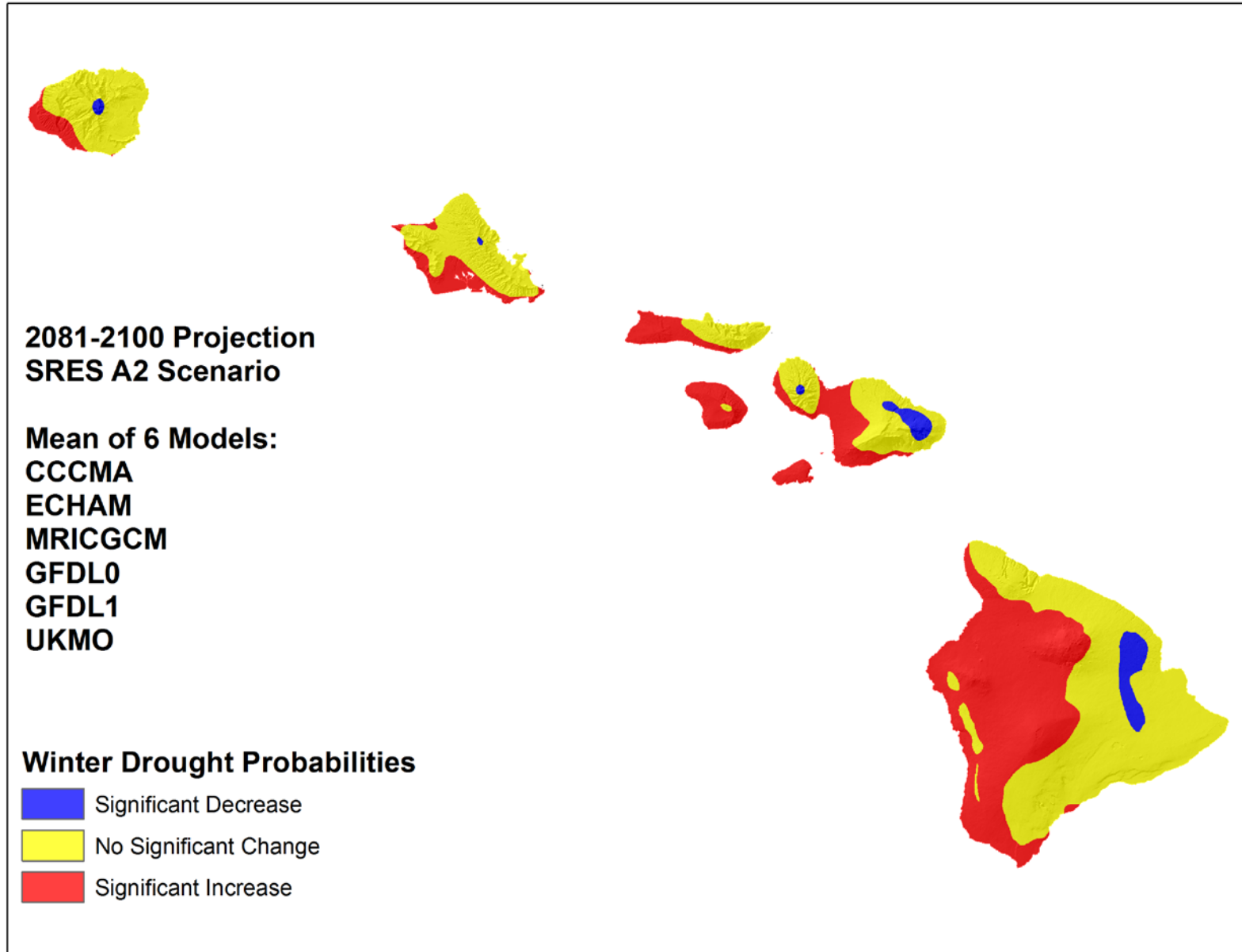
Annual Rainfall (mm)



Preliminary Projection Results



Preliminary Projection Results



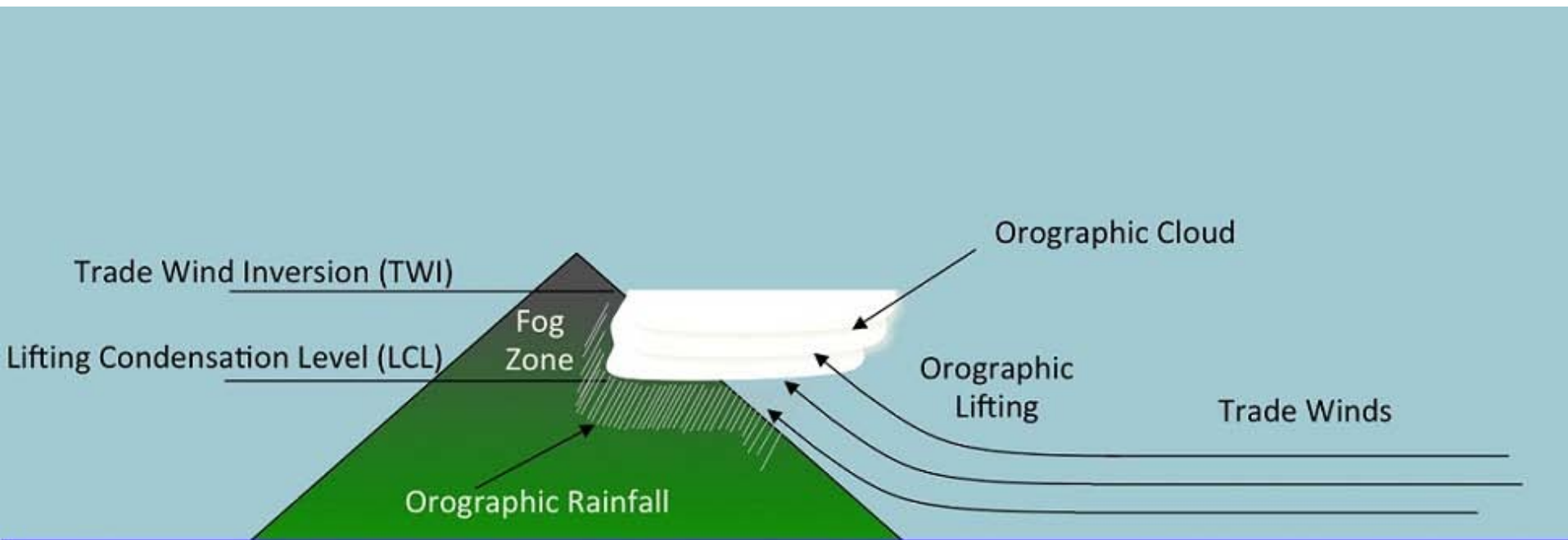
Future Changes Affecting Water: Warmer and Drier

- **High Confidence:**
 - Increasing temperatures
 - Increasing sea level
- **Less Certain:**
 - Lower mean rainfall?
 - Fewer heavy rainfall events?
 - More frequent drought events?
 - Higher rates of evaporation?
 - Reduced streamflow?
 - Reduced groundwater recharge?

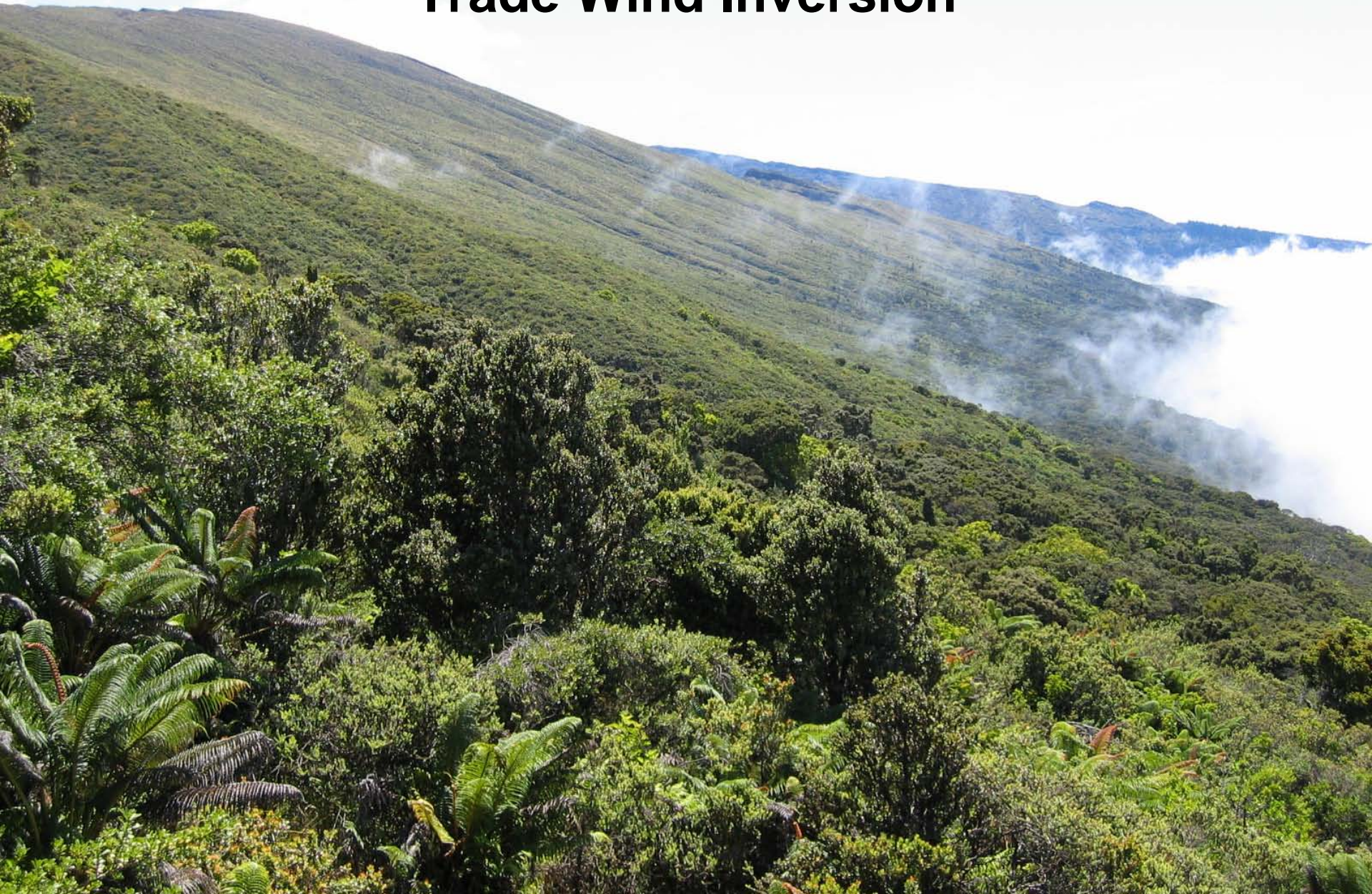


Thank You

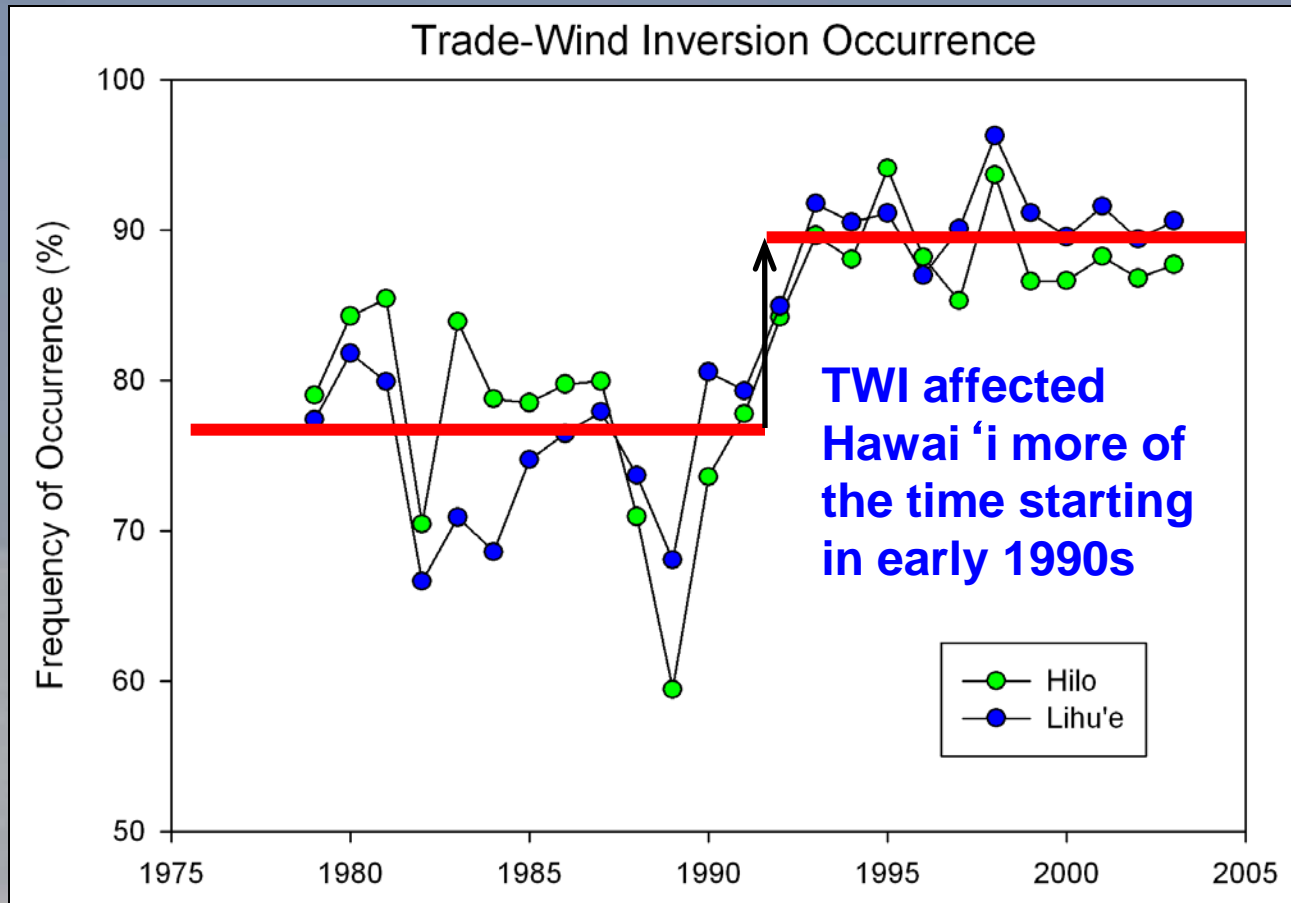
The Orographic Cloud



Trade Wind Inversion



TWI Trends



Cao et al. (2007)

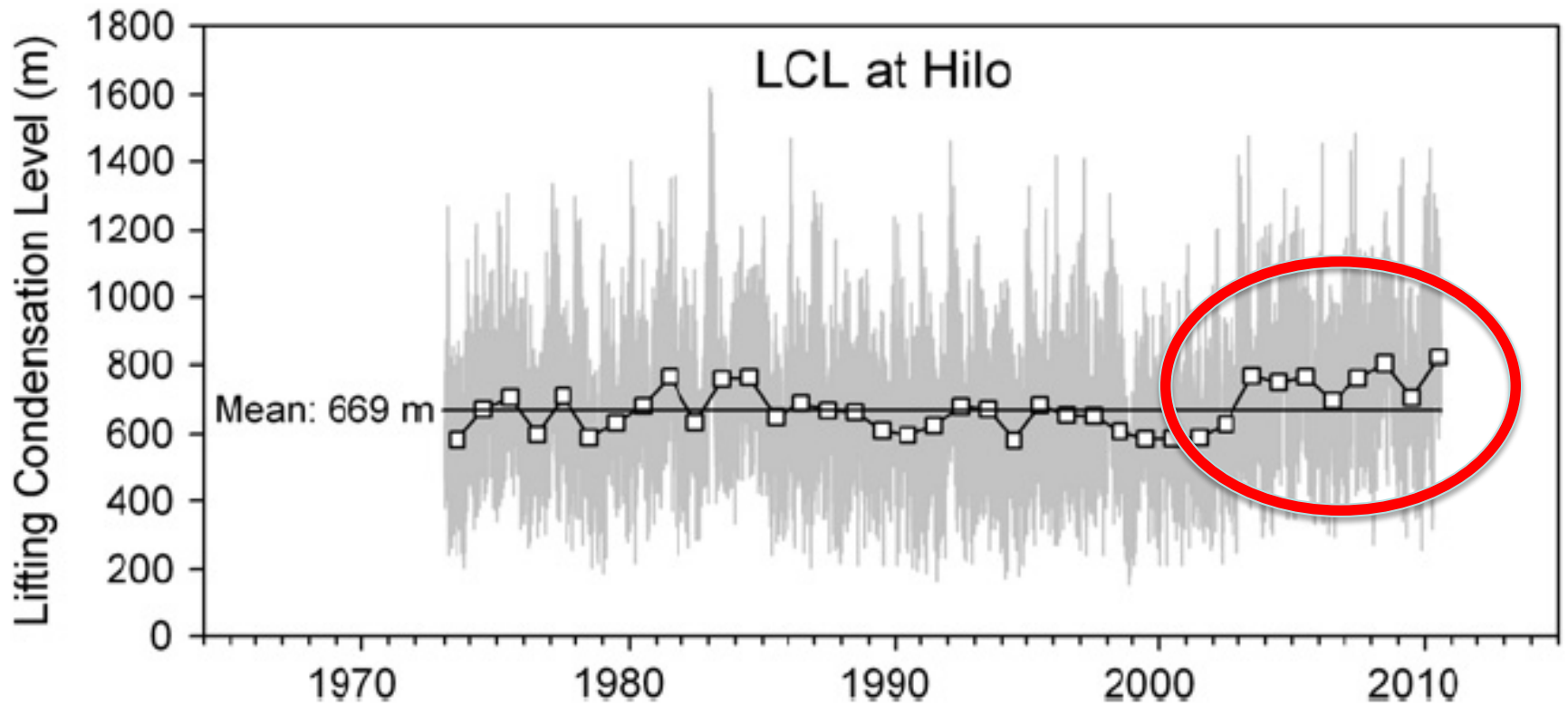
TWI Trends

TWI also appears to be moving lower in elevation

Source: Cao et al. (2007)

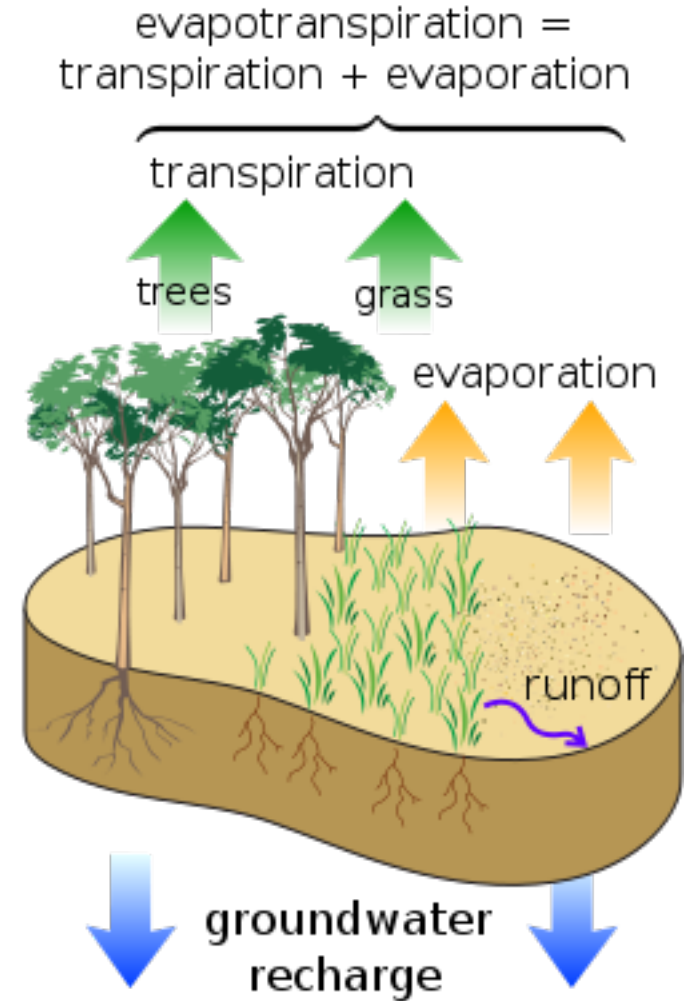


Change in Lifting Condensation Level



Climate Change Influences on Evapotranspiration

- **Moisture Availability**
- **Potential ET**
 - **Solar radiation (cloud cover)**
 - **Humidity**
 - **Temperature**
 - **Wind**



Lower Rainfall → Greater Solar Radiation

