Poster #35

The Northern Oscillation Index as a Predictor of Precipitation and Storm Surge in California and the Southern Coastal Pacific Northwest

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SUMMARY

We show that over California and the southern portion of the Pacific Northwest region, the Northern Oscillation Index (NOI) is a reliable predictor of storm likelihood, and therefore a predictor of seasonal precipitation totals, likelihood of extremely intense precipitation, and likelihood of extreme storm surge height.

We show that NOI variability can be used to characterize this region's water resources and flooding risk. We use monthly NOI as a predictor in two separate statistical models:

i) Statistical model of extreme daily precipitation at the location of NASA Ames Research Center in South S.F. Bay (the Moffett Field rain gage). Two predictors are used: NOI and HUS (specific humidity at 850 hPa atmospheric level).
ii) Statistical model of extreme storm surge height in South San Francisco Bay. Two predictors are used: the NOI and the SOI (Southern Oscillation Index).

Each of these models is applied to the S.F. Bay region and trained with Reanalysis values of the predictors (NOI, HUS, SOI). Using projected values of NOI, HUS and SOI from several CMIP5 global climate models, the two models give projections of future distributions of extreme daily precipitation, and extreme water height in South San Francisco Bay. These projections are useful in planning of water resources and flood protection infrastructure, including stormwater systems and levees.

THE NORTHERN OSCILLATION INDEX (NOI)

The NOI, introduced by Schwing et al. (2003), is defined as the difference between sea level pressure anomalies at two locations: a) the climatological mean North Pacific High (35°N, 130°W), and b) the climatological low near Darwin, Australia (10°S, 130°E): the two centers of action of the North Pacific Hadley-Walker circulation (Figure 1).

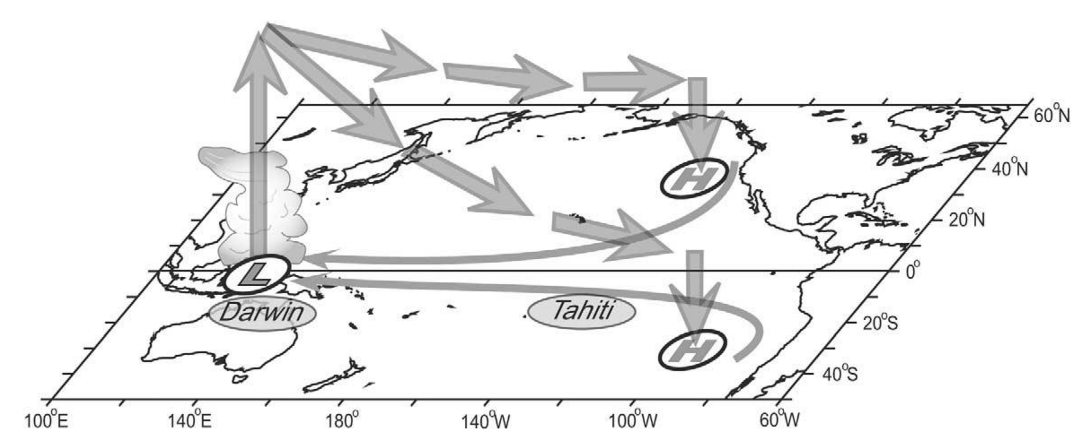

Figure 1: A schematic illustration of the mean Hadley-Walker circulation in the Pacific region, showing its North Pacific and South Pacific branches.
Figure reproduced from Schwing et al. (2002).

The NOI is less widely known than the indices traditionally associated with the El Niño Southern Oscillation (ENSO) phenomenon, such as the NINO indices, the Southern Oscillation Index (SOI) and the Multivariate ENSO Index (MEI). While teleconnections cause strong correlations between NOI and those indices, the information contained in NOI is specific to the North Pacific branch of the Hadley-Walker circulation.

WESTERN PRECIPITATION IS MORE HIGHLY CORRELATED WITH NOI THAN SOI

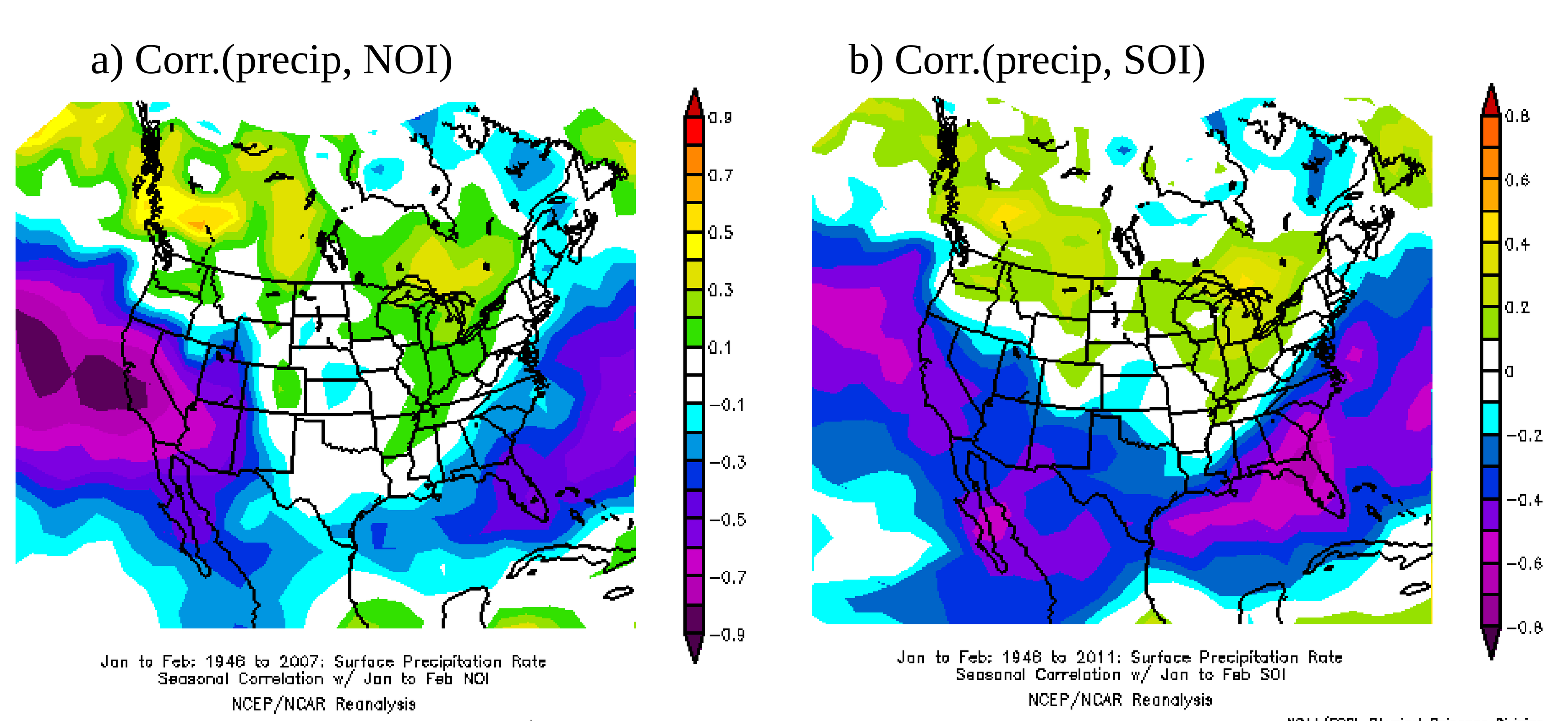

Figure 2: The linear correlation between Jan-Feb precipitation total and NOI (left panel) is stronger than 0.7 over much of California, and approaches 0.9 south of S.F. Bay. The correlation with SOI (right panel) is weaker than 0.5 over California.

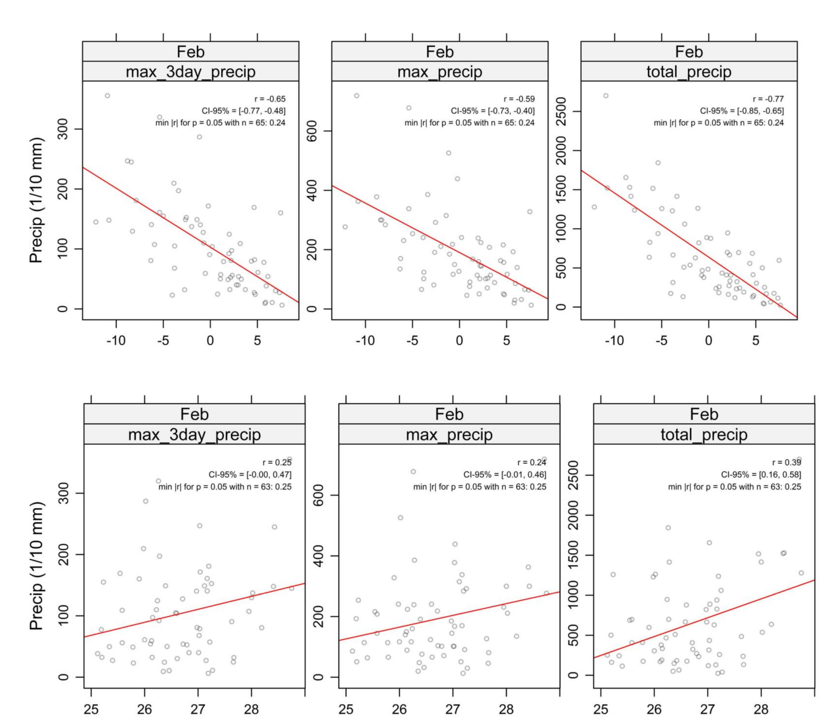

Figure 3: February precipitation indices plotted against monthly NOI (top) and NINO3.4 (bottom), for the Moffett Field gage.

i) STATISTICAL MODEL OF EXTREME PRECIPITATION

We fit a generalized extreme value distribution (GEV) to the daily precipitation from the Moffett Field gage (1948-2013), situated in NASA Ames Research Center. Each of the winter months (Oct.-May.) was treated separately. The parameters of the GEV were treated as linear functions of the (Reanalysis) monthly values of NOI and HUS (daily specific humidity at 850 hPa level) and the linear parameters were fitted. Similar work was carried out e.g. by Zhang et al. (2010) using SOI and other indices. We use NOI as a predictor for the first time.

Using GCM projections for NOI and HUS, our GEV-based model of extreme precipitation indicates more important changes in HUS than NOI. Projected future increases in extreme precipitation are primarily due to rises in humidity, and secondarily due to changes in atmospheric circulation as expressed by NOI (Figure 4).

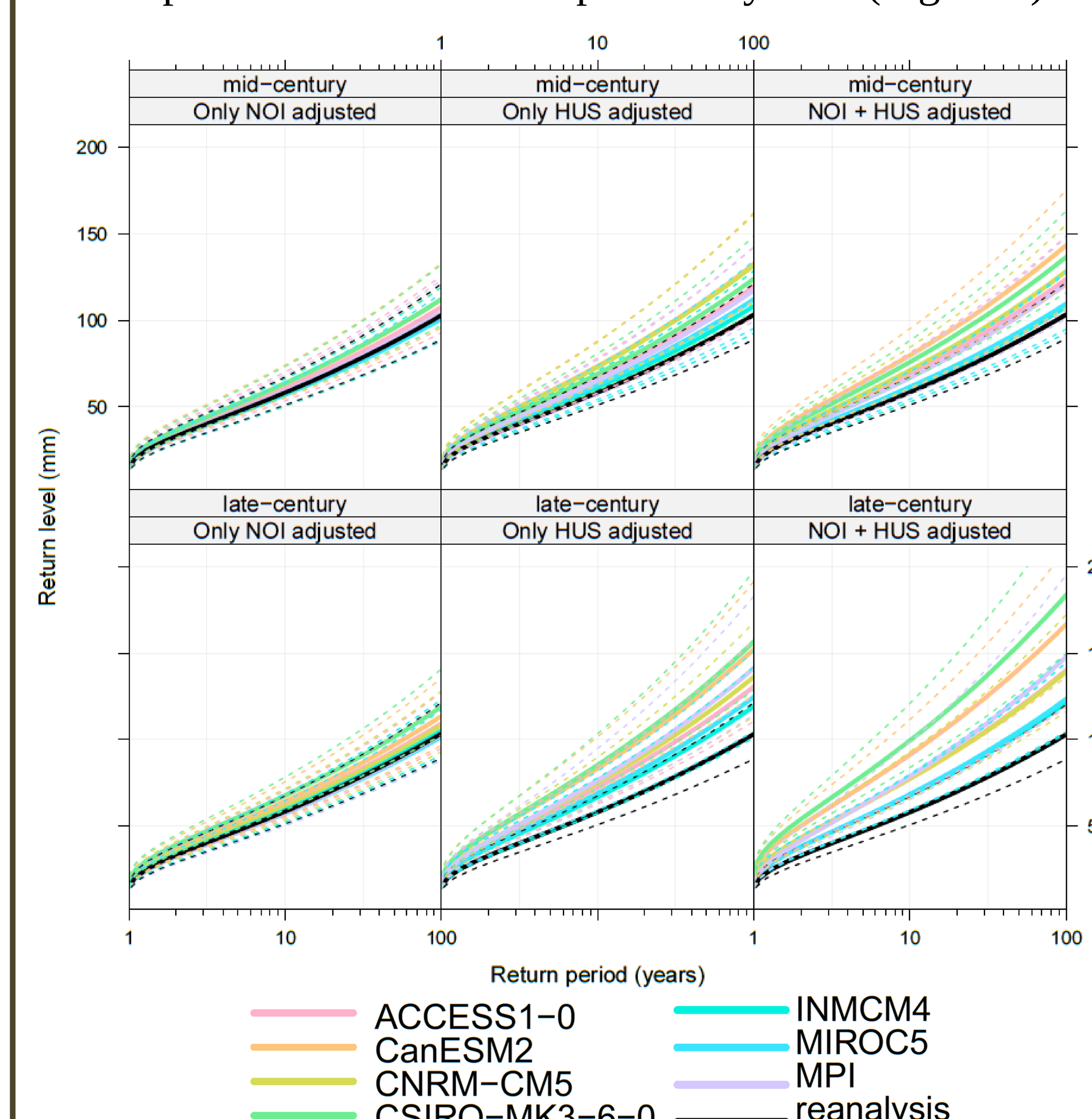

Figure 4: Predictive return levels for individual GCMs for the mid- and late-21st century. Solid lines are posterior medians and dotted lines span the 25th and 75th percentiles.

References

Schwing FB, Murphree T, Green PM (2002) The Northern Oscillation Index (NOI): a new climate index for the northeast Pacific. *Progress Oceanography* 53: 115-139.

Zhang X, Wang J, Ziers FW, Groisman PY (2010) The influence of large scale climate variability on winter maximum daily precipitation over North America. *J Climate* 23 (11): 2902-2915.

ii) STATISTICAL MODEL OF EXTREME WATER HEIGHT IN SOUTH S.F. BAY

We fit a generalized extreme value distribution (GEV) to the daily time series of non-tidal residuals, treating the GEV parameters as functions of monthly NOI and SOI, the former being the stronger predictor.

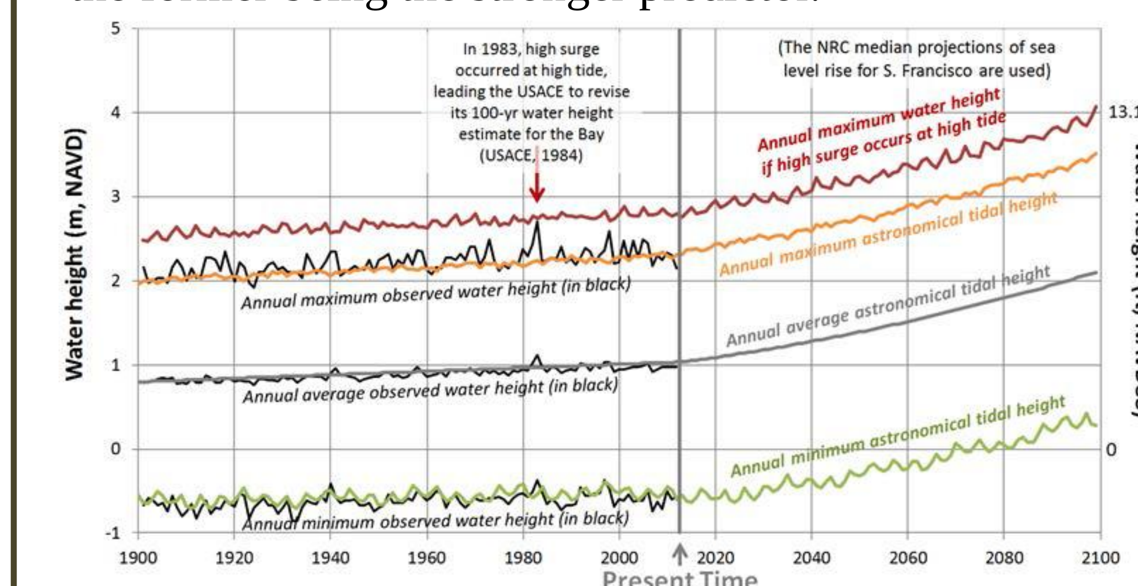

Figure 5: Historical and projected water height at S.F. Golden Gage Bridge, assuming 95 cm (3.12 ft) of sea level rise from year 2000 to 2100. The annual values plotted were derived from hourly data from NOAA for the S.F. tidal gage (#9414290). The value used for "high surge" varies for each of the 12 months and corresponds to the 99.99th empirical percentile for that month. The red line represents total water height if this high surge were to occur in the same hour as the annual maximum water height of the astronomical tide.

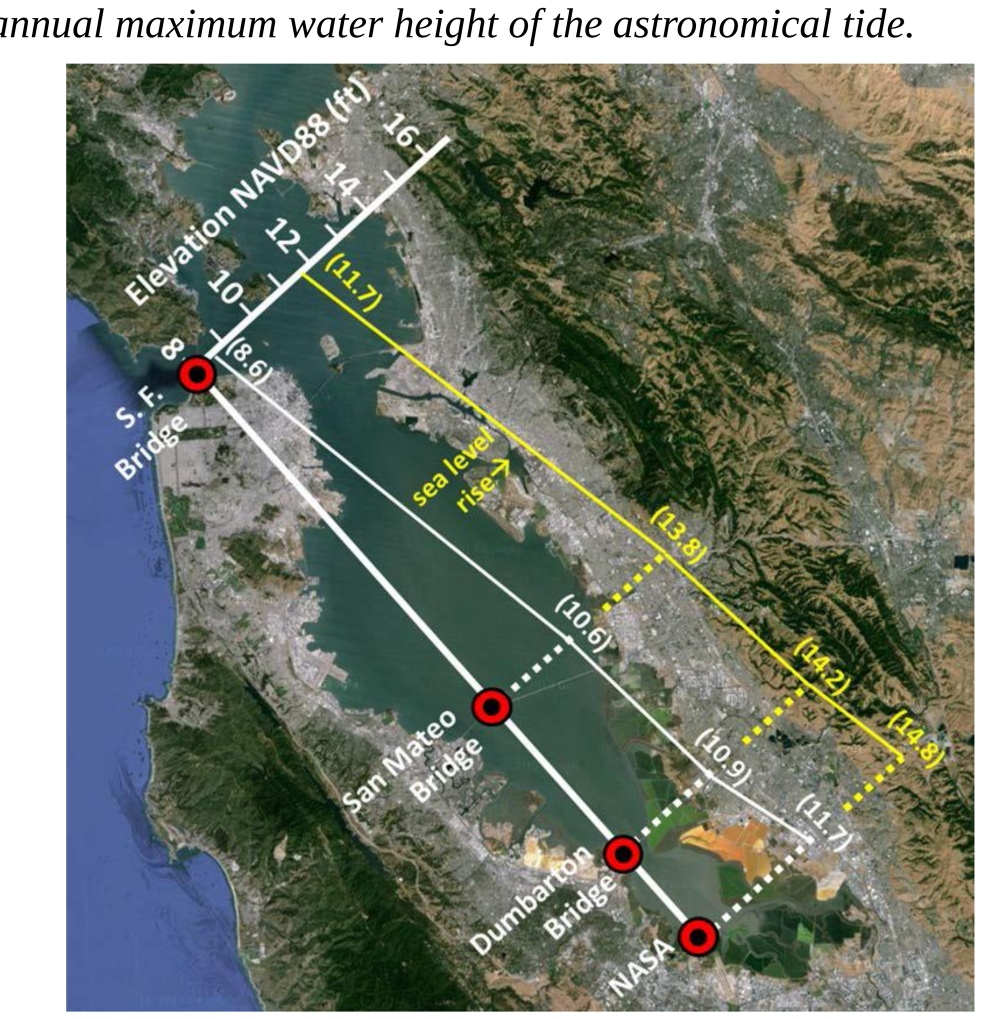

Figure 6: Estimated 100-year return period values of maximum water height at the Golden Gate Bridge, and three South Bay locations. The white line represents the present time, and the yellow line represents the end of this century (year 2100) with a sea level rise of 95 cm (3.12 ft), corresponding to the medium estimate by NRC (2012). Results are preliminary. We use the simplifying assumption of no future changes in hydrodynamics of the Bay.