PACIFIC REGION INTEGRATED CLIMATOLOTY INFORMATION PRODUCTS (PRICIP)

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1. INTRODUCTION

Coastal storms, and the strong winds, heavy rains, and high seas that accompany them, pose a threat to the lives and livelihoods of the peoples of the Pacific.

- In September 1992 the island of Kauai in Hawaii was hit by Hurricane Iniki. The estimate of the physical damage from Hurricane Iniki was $2.5 billion.
- Super Typhoon Pongsona struck the island of Guam on December 8, 2002. With over $700 million in damages, Super Typhoon Pongsona was reportedly the most costly disaster in the entire U.S. during the year 2002.
- In American Samoa, the heaviest rainfall in nearly 20 years occurred during May 18–20, 2003. The territory had 10–15 inches of rainfall, most of it in 2–3 hours. Four people were killed by mudslides, one person was seriously injured, and three people were rescued from two homes that were buried by a mudslide.
- On June 18-19, 2003, waves generated by an extra-tropical cyclone in New Zealand and a storm southeast of Tahiti reached the south shore of Oahu. These waves came just after a spring tide. During this event 3 people were injured, 350 swimmers and surfers were rescued, and 600 more were assisted by lifeguards.
- On January 3 to 5, 2004, Cyclone Heta caused significant damage and 2 fatalities as its path crossed Wallis and Futuna, Samoa, American Samoa, Tonga, Niue, and the Cook Islands. Being the only island directly in Heta's path, Niue was devastated.
- Between Meena's formation on February 3 and Rae's dissipation on March 6, 2005 five tropical cyclones swept through the Cook Islands. The combined effects of the five weeks of fury made it the worst storm season experienced by the islands, with damages estimated at US$25 million
- March 2006 brought almost 40 days of heavy rains to the main Hawaiian Islands. This led to flooding and landslides, a deadly dam break in northern Kauai, and a sewage spill in Honolulu's Waikiki district.

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Unquestionably, there is a need to provide communities and businesses, as well as government agencies and the scientific community better information to manage coastal storm-related risks. The NOAA National Climatic Data Center (NCDC) Integrated Data and Environmental Applications (IDEA) Center's Pacific Region Integrated Climatology Information Products (PRICIP) project is working to address this need. PRICIP is focused on improving our understanding of patterns and trends of storm frequency and intensity - "storminess"- within the Pacific region. PRICIP is exploring how extreme events are expressed within and between three thematic areas: *heavy rains*, *strong winds*, and *high seas*. PRICIP is developing a suite of extremes climatology-related data and information products that can be used by emergency managers, mitigation planners, government agencies and decision-makers in key sectors including water and natural resource management, agriculture and fisheries, transportation and communication, and recreation and tourism.

2. THE PRICIP INTEGRATING ARCHITECTURE

PRICIP was initiated via an Expert Teams Project Planning Workshop held in San Francisco on June 20-21, 2006. The nearly 30 participants consisted of recognized agency and university-based experts in the area of climate-related processes that govern storminess and its expression in the Pacific region. Among the outcomes at the workshop was a call to: continue the Strong Winds, Heavy Rains, and High Seas theme teams activated at the PRICIP workshop; develop theme-specific work plans that lead to the creation of theme-related product suites; and form a Program Integration Team and a Product Development Team to support the definition and development of an integrated storminess product for a priority geographic area or areas.

A key outcome subsequent to the June 2006 meeting was the formulation of what is referred to as the "PRICIP Integrating Architecture" (Figure 1.) This conceptual framework represents a basic construct for defining the elements of interest and delineating the relationships among and between them. The concepts embodied in it and how it can be applied are described further in Marra et al, (2007).

Most relevant here is a distinction between *targeted information products*, which are representative of a more advanced level of data analysis and integration, and *derived data products*, representative of a more basic level of data collection and analysis. These concepts formed the basis for discussion at the first formal Program Integration Team meeting (PIT) in

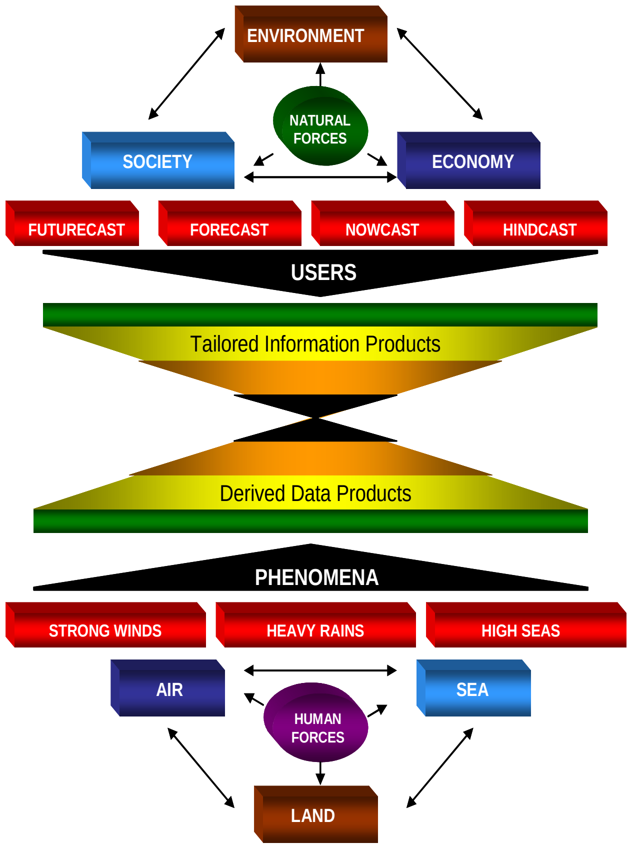

Figure 1. The PRICIP Integrating Architecture. *This figure depicts the basic construct for defining the elements of PRICP. At the top is the social system and the combination of factors within it that drive end-user product and service requirements in terms of content, format, timing, and delivery. At the bottom is the physical system and the combination of factors within it that, through their interaction, generate the different storminess-related phenomena. At the center of the figure are the connections between the social and physical systems. Depicted as an hourglass, it represents the transition from derived data, through the development of applied data products and decision-support tools, to the production of a tailored information suite applicable to a wide range of users, and the iterative, two-way interactions among producers and users that leads to the creation of these data and information products.*

December of 2006. This led to the development of a detailed work plan in March of 2007 that identified the build-out of a broad suite derived data products and the creation of a discrete tailored information product as initial tasks to be completed under the auspices of PRICIP.

3. TARGETED INFORMATION PRODUCTS – HISTORICAL EVENT ANATOMIES

Historical storm *event anatomies* have been identified as the initial PRICIP targeted information product. These event anatomies include a summary of sector-specific socioeconomic impacts associated with a particular extreme event, as well as its historic context climatologically. The intent is to convey the impacts associated with extreme events and the causes of them in way that enable users to easily understand them. The event anatomies are also intended to familiarize users with in-situ and remotely sensed products typically employed to track and forecast weather and climate.

The event anatomies are web enabled using a standards-based, vendor-neutral and open-source enterprise portal and portlet architecture that, by design, provides personalization, single sign on, content aggregation from different sources while also being a web server for the presentation layer of the information systems. A portal may have, therefore, feature sophisticated personalization features to provide customized content to users (whereby portal home pages may have different set of portlets that render content that is most relevant to an user or business situation). This portal and portlet architecture also lends itself to distributed, modular content development, whereby multiple agencies, institutions, and organizations can serve as content providers. The National Aeronautics and Space Administration (NASA) and the United States Geological Survery (USGS), as well as several NOAA line offices have developed event anatomy content modules for example.

The Hurricane Iniki event anatomy has been developed to illustrate prototypical content and to demonstrate how such content will be served (Figure 2). It can be viewed at http://www.pricip.org/ea.php. It is intended to provide a means to solicit input from the PRICIP Product Development Team and others prior to proceeding further towards completion of other event anatomies. To date content has been developed for seven extreme events in addition to Hurricane Iniki (i.e., Typhoon Chata'an and Super Typhoon Pongsona in the western North Pacific; Hurricane Heta and Hurricanes Meena, Nancy, Olaf and Percy in the central South Pacific; and Extreme Tides and Extra-Tropical Storm Surf in the central North Pacific). However, this content remains to be web-enabled.

Figure 2. Screen-grab of the Hurricane Iniki Event Anatomy Event Page.

4. DERIVED DATA PRODUCTS – INTERANNUAL AND ANNUAL PATTERNS AND TRENDS IN EXTREME EVENT INTENSITY AND FREQUENCY

Theme-specific data integration and product development teams were formed to create a broad suite of derived data products. These teams include representatives from NOAA's National Climatic Data Center (NCDC), Center for Operational Products and Services (CO-OPS), Coastal Services Center (CSC), and the National Weather Service (NWS), as well as the University of Hawai`i, University of Alaska, University of Guam, and Oregon State University. Sources of information include NOAA's Integrated Surface Hourly (ISH) mean sea level pressure and wind speed data; the Global Historical Climate Network (GHCN) precipitation dataset; the National Water Level Observing Network (NWLON) tide gauge records; the National Data Buoy Center (NDBC) wave buoy records; the U.S. Army Corps of Engineers' Coastal Data Information (CDIP) buoy data, and other data.

A guiding principle in the initial work plan was to provide for the continuation of individual investigator's efforts, such that each investigator would conduct the analyses and create the data products they were most familiar with. Looking at the same information in different ways, they would build upon each others work to create a more complete picture of patterns and trends of storminess in the Pacific. Examples of the results of these efforts are shown in Figures 3, 4, 5, and 6. They represent part of a set of strong winds, heavy rains, and high seas derived data and product sets being served via a Google map-based query tool as part of the initial PRICIP build out (http://www.pricip.org/ddp.php). This tool enables easy access to basic information about individual stationa/systems as well as specific PRICIP products and accompanying data sets. It also provides links to station and data/product metadata.

5. LESSONS LEARNED AND THE WAY FORWARD

The bulk of the work described above was carried out during 2007 and early 2008. Many of PRICIP's initial objectives have been met. Interesting and important scientific and technical discoveries have also resulted from this first round of product development. However, during the PIT meeting in October 2007, through subsequent PIT meetings in April and December of 2008, and from Product Development Team input during this time it became apparent that refinement of the work plan and the efforts it embodied were warranted prior to the launching of PRICIP as a formal NOAA website.

Among the changes currently being made is greater attention to delineation of key elements of regional and/or sub-regional extremes climatologies, or *event types* in the form of regional overviews, or *process signatures*. For example, in the central North Pacific phenomena associated with so-called high seas (i.e., elevated water levels at the shoreline) include:

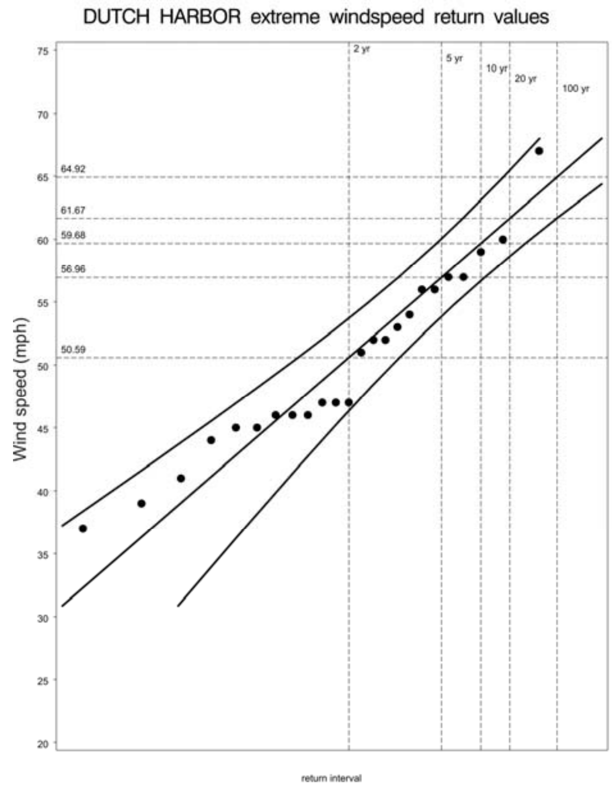

Figure 3. Annual Exceedance Probability Curve for Extreme Winds at Dutch Harbor, Alaska. This work was conducted for PRICIP by Dr. David Atkinson and his colleagues at the University of Alaska, Fairbanks.

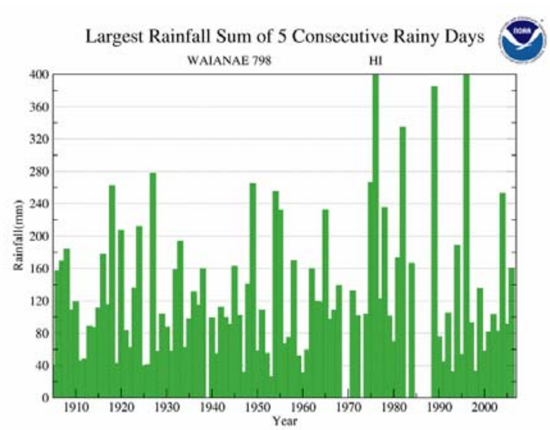

Figure 4. Inter-annual Variation in Sum of Five Consecutive Rainy Days at Waianae on the island of Oahu, Hawaii. This work was carried out for PRICIP by Dr. David Levinson and Michael Kruk at the NOAA NCDC.

tropical storms; extra-tropical storms in the northern and southern hemisphere; and the arrival of mesoscale eddies in conjunction with the occurrence of high winter tides. When strong winds and heavy rains are added to

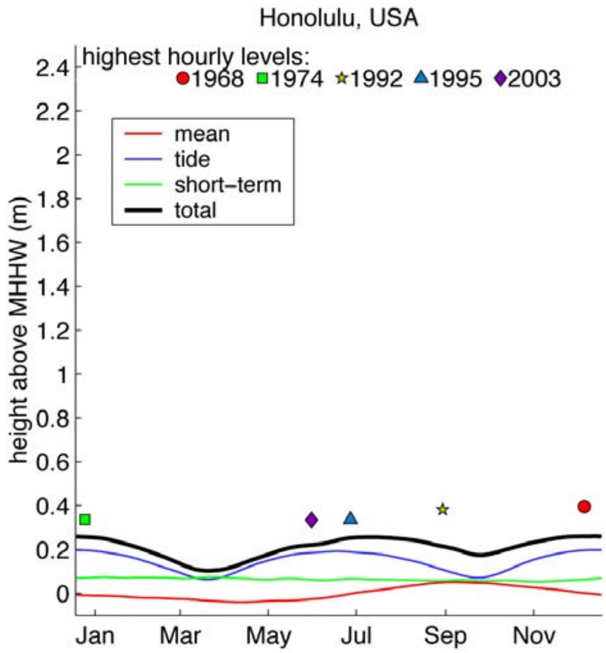

Figure 5. Annual Variance in Extreme Sea Levels at the Honolulu Harbor Sea Level Station. This daily variance stack was developed by Dr. Mark Merrifield and his colleagues at the University of Hawaii Sea Level Center. For more information see Merrifield et al.., 2007.

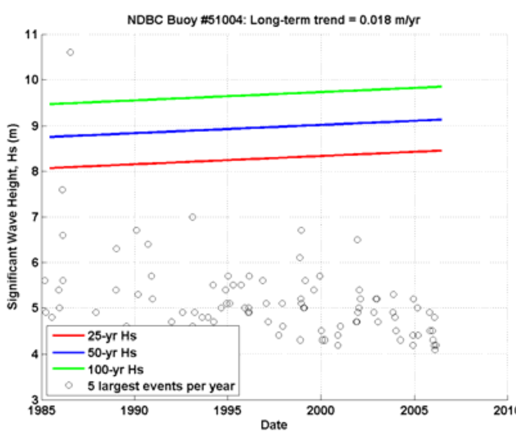

Figure 6. Inter-annual Variation in Extreme Water Levels and Trend of Return Periods at NDBC Buoy #51004 Southeast of Hawaii. This work was carried out by Dr. Peter Ruggiero and his colleagues at Oregon State University. For more information see Komar et al., 2008.

this, the set of phenomena associated with extreme events in the central North Pacific includes: local *Kona* storms; frontal systems and upper level lows; and tradewinds and accompanying rain and waves.

Attention is also being given to the formulation of a set of indicators and related products that are more closely tied to extreme event types and, as such, are both more precise in nature more fully integrated across themes. Recognition that Kona storms, for example are a phenomena of interest suggest that inter-annual variations of seasonal rainfall totals (intensity, frequency, trends, etc.) over periods of 30 days and 3 days should be examined. This is because these storms tend to occur during the winter months and are associated with both short-duration intense rainfall events and extended periods of intermittent but heavy rains. Correspondingly, inter-annual variations of seasonal variations (in extreme winds, waves, and water levels) also need to be examined for linkages to each other and to other types of extreme events. In turn, their relationship to variations in climate indices (e.g., ENSO), to variations in storm track intensity, frequency and location, etc. also needs to be explored.

Greater attention is also being given to the broader issues of integration and coherence within and between themes. On a general level this includes a common "look and feel" in the way in which products are presented. On a more specific level this includes considerations such as consistent, if not uniform data treatment and analysis protocols. This entails establishing data homogeneity and continuity requirements (e.g., minimum record lengths, maximum data gaps, common definitions of events and event thresholds, etc.), as well as considerations related to stationarity. It also encompasses the application of shared analytical techniques, for the calculation of exceedance probabilities and confidence intervals for example. Finally, the appropriateness of particular parameters is also relevant in this regard (e.g., the use of means versus maxima values, of observed versus residual values, etc.). Addressing these issues and, as a result, achieving some agreed upon degree of standardization will act as means of quality control. It will enhance product compatibility and comparability on a spatial and temporal basis. It will serve as a guide not only for members of the PRICIP team, but others that might be interested in developing derived data products for PRICIP.

With such guidance in hand, the intent over the coming months is to target the northern and central north Pacific, which includes Alaska, the Pacific Northwest, and Hawaii, as initial priority areas with respect to the creation of derived data products. Work will be carried out throughout the Pacific Region including the US West Coast as well as American Flag and US Affiliated Pacific Island jurisdictions as resources permit.

In this way, PRICIP will begin to address the need to provide decision makers in the Pacific Islands with high quality science-based information that enables them to understand, anticipate, and adapt to risks associated with extreme events in light of a changing climate. Further, it will serve as a path finding activity towards to the development of a national comprehensive coastal climatology program.

6. REFERENCES

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