Title: Weather Research Forecast Model runs for Hawaii

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Introduction

Climate change will lead to major changes in regional climates around the world. The Hawaiian islands have very variable climates, with some windward mountain regions receiving large amounts of rainfall (X m), while leeward areas receive substantially less (0.X m). Changes in rainfall have the potential to dramatically change local ecosystems and hydrology. With increased warming, even the same rainfall amounts will lead to drier ecosystems, through increased evapotranspiration. Changes to wind could lead to different levels of drying. Changes to moisture content could lead to different levels of fog interception.

There are two main methods of downscaling: statistical and dynamical. Statistical downscaling assumes that patterns and processes from the present will still hold into the future. In contrast, dynamic downscaling explicitly models the physical processes, and therefore can capture changes that may not be intuitive from a simple statistical downscaling.

In order to provide a dynamically downscaled model, XXXX ran model runs for the Hawaiian islands in 20XX. A subset of these results were made available via the USGS server at YYYY. The full 3D data set is housed at the University of Hawaii Manoa. Unfortunately, these data sets have proven difficult for individuals to use, due to the high resolution (hourly), due to challenges with extracting the data (there is a missing day, and the data are in GMT, not Hawaii local time), and due to some strong biases in the future predictions made by the model (i.e. some areas in the present-day simulation severely underestimate rainfall).

To address these concerns, we created a daily data set for temperature, rainfall, wind, XXXX, and fog interception. Data were interpolated using a simple Inverse Distance Weighting to be on the same scale as the Hawaii Rainfall Atlas dataset. We also calculated a simple bias-correction for the future scenarios. Data were processed into R format, and Geotiff format, for ease of use. We hope this data set is useful to provide GIS users with a dynamically-downscaled data set for Hawaii.

Methods

*WRF Methods*

We are using the output of the WRF model. The original WRF model runs were performed by <NAME>. However, a summary of the methods used is appropriate here. <ADD WRF MODELING SUMMARY, INFO ABOUT DOMAINS, INFO ABOUT SETTINGS>

*General methods 2D Data Set*

Hourly data were downloaded from <LINK> from data housed at the USGS server. Data were converted to Hawaii local time by dropping the first 10 hours from the simulation, and interpolating the last 10 hours, using the values from the second-to-last day in order to preserve any long-term trends and local synoptic conditions. January 1, 1996 was missing from the simulation run, and this day’s data was also interpolated (method varied by variable type, see variable-specific processing below). Data were aggregated to daily amounts in a variable-specific manner (see below). Monthly and annual aggregates were also generated, and monthly and annual climatologies were generated based on data from the entire time period. For the two future time periods, bias-corrected climatologies were generated by dividing the present-day observations from present day WRF model run (see variable processing below), then multiplying separately by each of the future climate scenarios. (i.e. if the WRF present run had half the rainfall of the present-day observations, future WRF scenario outputs would be multiplied by 2 to correct for the underestimation in the WRF model. For variable-specific reference products, please see the variable-specific information below. Data products were multiplied by 100 and then rounded to be integers, in order to reduce the file size of the resulting data files.

*General methods 3D Data Set*

*Rainfall-specific methods*

Comparison to Hawaii Rainfall Atlas (citation for rainfall atlas)

*Temperature-specific methods*

*Wind-specific methods*

*Fog-interception methods*

*<ADD FOR OTHER VARIABLES>*

# Results

## Rainfall

Mean climatology over estimated rainfall in some areas, while underestimating rainfall in other areas when compared to the Hawaii Rainfall Atlas analysis project (Figure R1). These patterns were similar to those seen in monthly climatologies (Figures R2 – R5). The annual (Fig. RS1) and monthly patterns (Fig. RS2) were not driven by any one individual year or month. Histograms for selected (Figs. RS3) and random (Figs. RS4) locations <say something once these histograms are made>. Minimum and maximum values were within the realm of plausibility (Table R1).

#\*\*# Add comparison of present to future

**Table R1.** Minimum, 2.5, 25, 50, 75, 97.5% and maximum values for WRF model outputs and Hawaii Rainfall atlas for four Hawaiian Islands.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Kauai | Oahu | Maui | Hawaii |
| Minimum |  |  |  |  |
| 2.5% |  |  |  |  |
| 25% |  |  |  |  |
| 50% |  |  |  |  |
| 75% |  |  |  |  |
| 97.5% |  |  |  |  |
| Maximum |  |  |  |  |

#\*\*# Needs to be by Island – will need more figures.

**Fig. R1.** Rainfall patterns for the annual climatology from the Weather Research Forecast Model (a) and from the Hawaii Rainfall Atlas project (b), and the difference (WRF – Atlas) between the two (c).

**Fig. R2.** Rainfall patterns for January (a – c), February (d – f) and March (g – i) from the Weather Research Forecast Model (a,d,g) and from the Hawaii Rainfall Atlas project (b,e,h), and the difference (WRF – Atlas) between the two (c,f,i).

**Fig. R3.** Rainfall patterns for April (a – c), May (d – f) and June (g – i) from the Weather Research Forecast Model (a,d,g) and from the Hawaii Rainfall Atlas project (b,e,h), and the difference (WRF – Atlas) between the two (c,f,i).

**Fig. R4.** Rainfall patterns for July (a – c), August (d – f) and September (g – i) from the Weather Research Forecast Model (a,d,g) and from the Hawaii Rainfall Atlas project (b,e,h), and the difference (WRF – Atlas) between the two (c,f,i).

**Fig. R5.** Rainfall patterns for October (a – c), November (d – f) and December (g – i) from the Weather Research Forecast Model (a,d,g) and from the Hawaii Rainfall Atlas project (b,e,h), and the difference (WRF – Atlas) between the two (c,f,i).

**Rainfall Supplements**

**Fig. RS1.** (supplement) Rainfall patterns for the WRF model and the Rainfall atlas by year.

**Fig. RS2.** (supplement) Rainfall patterns for the WRF model and the Rainfall atlas by month

**Fig. RS3.** Histograms across the entire time period for five selected points

**Fig. RS4.** Histograms across the entire time period for five random points (stratified to have one point in the ocean, and the remaining four points on land).

## Temperature

## Case Studies

Case Study 1: Some significant rainfall event? – look at rainfall accumulation over a series of days with rain gauge data, rainfall atlas data, and HI WRF data.

*Wind Speed*

*Fog Interception*

Discussion

Conclusions

Literature Cited