Motivation: Ground station data are scarce in most of Panama, like most sites in the tropics. We often want to estimate climate variables for a site for analyses. Many reanalysis datasets are currently available that have values for different site and time periods… but are they any good? which are best?

Which are best for spatial estimation? for temporal estimation and gap-filling?

Objectives

* evaluate how well global climate reanalysis datasets () capture spatial and temporal variation in climate in Panama

Ground sites

* core STRI sites (5-7)
  + BCI Lutz tower + clearing
  + Agua Salud - Celestino
  + Galeta
  + Parque Metropolitano
  + Sherman / San Lorenzo
  + Culebra (from 2010)
  + BCI AVA (from 2011? with a gap)
* potential additional STRI sites (2)
  + (Bocas del Toro) – but outside central Panama
  + (Fortuna) – but outside central Panama and montane
* defunct STRI site
  + (San Blas) – but outside central Panama and stopped recording > 20 years ago, never cleaned up or looked at by Steve
* ACP met stations (~9 current; 13 listed but not all current)
  + Need better metadata on ACP station locations in terms of shading of the sensors, exposure, etc.
  + first step – check on google earth what the site looks like
  + second step – try to obtain photos of the sites or even visit the sites to assess conditions
* ACP precipitation only stations

Analyses/figures/tables

* What climate reanalysis datasets to use? What years do they span, and what temporal resolution data are available?
  + CHELSA 1.2,
  + CHELSA 2.1,
  + TERRA,
  + PBCOR
  + Worldclim
* Which variables and where
  + Spatial variation:
    - Rainfall –all ACP and STRI stations
    - Solar radiation – STRI and ACP met
      * ok as long as sensor is above the top of the canopy, which it should always be at the STRI sites, but maybe not at the ACP sites.
      * these sensors are very liable to drift, so each record needs to be checked for drift before proceeding.
    - Temperature, windspeed
      * these will be very sensitive to the exact positioning of the sensors – are there trees shading the sensor, are they next to a building… above canopy or not, on a tower
  + Temporal variation:
    - STRI station data for temperature, humidity, solar radiation…
* Spatial variation (only variables available at many stations – so ACP + STRI data)
  + Response variables: mean annual precipitation, Jan-April precipitation, possibly individual months (in SI)
  + Points: individual sites
  + Table with one row per comparison, and statistics for the match to ground data: Pearson r2, RMSE, mean absolute error, random error, slopes and intercepts of linear regression
  + Figures:
    - scatterplots, one panel per reanalysis dataset, 1 figure per climate variable
    - maps showing estimates from a given climate reanalysis dataset with circles overlaid for magnitudes of errors, one panel per reanalysis dataset, 1 figure per climate variable
  + Potential analysis of what explains spatial pattern in errors – e.g., elevation (optional)
* Temporal variation on BCI (Lutz)
  + Temporal resolution of the analysis: daily, monthly, annual
  + Climate variables to look at
    - Daily maximum temperature
      * Steve Paton notes that these were not recorded by the electronic sensors until later years; previously just recording hourly averages and the manual max/min thermometers which are
    - Daily minimum temperature
    - Daily rainfall
    - Daily solar radiation
    - what other variables are in the BCI met data since at least year 2000?
  + Table with one row per comparison (climate variable, reanalysis dataset), and fit statistics
  + Figures…. how to represent this? Scatterplots with trendlines (supsmu)? Time series of the variables and their deviations… at monthly scale?

Possible additions

* Use ACP weather radar data as an alternative ground dataset
* Spatial variation analysis of MCWD (problem – requires a PET model for every ground rainfall site)
* Temporal variation at additional STRI met station sites
* Write a Shiny app that would let people examine relationships of interest for the variables of interest.

Notes – change prelimin results to show fitted linear model, RMSE for each.

updated August 30, 2022

**Overall objectives**

* (maybe) Document spatiotemporal patterns of climate variation across Panama
* Determine the best approach to estimating rainfall and other climate variables at sites and times in Panama for which we don’t have ground data.
  + Evaluate different global gridded climatologies against observed data for Panama
  + Evaluate different spatial and spatiotemporal interpolation/modeling approaches based solely on ground data (evaluate using spatial cross-validation)

Ground datasets

* STRI met stations – download from Figshare
* ACP met station rainfall data
* ACP weather radar – archived for the last few years, and KC Cushman has done some preliminary analyses on this.
* Satellite climate data? (but this goes into the reanalysis datasets, right?)

Variables included

Reanalysis datasets

* CHELSA 1.2 and 2.1
  + Climatologies: averages for 1981-2010 by month.
  + Daily data: every day of every month of every year for 1981-2010.
* TERRA?
* PBCOR for CHELSA 1.2 and perhaps others
* <https://www.nature.com/articles/s41597-021-01084-6>
* WORLDCLIM? maybe…

**To Do**

* Add the STRI met stations to the ground dataset – use fixed download links from Figshare as far as possible.
* Add computation of other measures of fit (see Larjavaara & Muller-Landau), including bias (mean error), RMSE, and so forth. And code to way to produces of fit statistics, and run these for annual precip, Jan-April precip, each month’s precip x the different satellite climatologies.

mean error

total error

random error

* Add code for alternative global climatologies: CHELSA 1.2, TERRA, etc.
* Look into methods for interpolating among the ground stations as an alternative.
* CHELSA 2.1 daily data – shouldn’t there be data for every day of every year? seems to be only days of 1980 available. Try to find a help file, check out download tools.
* Download the available daily and monthly CHELSA 2.1 precipitation and PET data, and extract region of interest, etc.
* Code for calculating MCWD from daily rainfall data. Check Condit et al. 2013 supplemental methods for details.
  + Where to get PET?
    - Either daily values calculated from monthly CHELSA, or
    - BCI ground-measured PET.
    - or a fixed value…. e.g., 100 mm/month
    - Penman-M equation?
* Email KC Cushman regarding the ACP radar data – another potential source of ground-based rainfall observations.
* Lit search – other papers like this for other areas of the world, or especially the tropics?
  + What has been done? (how novel would this be)
  + How have people done the comparisons? (spatial patterns compared? temporal patterns compared? What measures of fit?)

updated September 12, 2022

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