**Supplemental Materials**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Forcing dataset** | **Resolution (degrees)** | **Resolution (km)** | **Time period** | **Native format** | **Citation** |
| CHELSA 1.2 | Reanalysis dataset: ERA interim | 0.0083333 | ~1 | 1979-2013 | Climatology, monthly timeseries | (Karger et al., 2018) |
| CHELSA 2.1 | Reanalysis dataset: ERA5 | 0.0083333 | ~1 | 1981-2010 | Climatology, monthly timeseries | (Karger et al., 2018) |
| CHELSA EarthEnv | Reanalysis dataset: ERA5 | 0.0083333 | ~1 | 2003-2016 | Daily timeseries | (Karger et al., 2021b) |
| CHELSA W5E5 | Reanalysis dataset:  WFDE5 | 0.0083333 | ~1 | 1979-2016 | Daily timeseries | (Karger et al., 2021a) |
| CHIRPS v2  (Merged dataset) | Satellite products: TMPA  Observational dataset:  GTS | 0.05 | ~5.5 | 1981-2022 | Monthly timeseries | (Funk et al., 2014) |
| CHPclim v.1.0 | Observational dataset:  GHCN & FAO.  Assisted with satellites | 0.05 | ~5.5 | 1980-2009\* | Climatologies | (Funk et al., 2015) |
| TERRA | Spatially interpolated dataset:  WorldClim V2  Reanalysis dataset: JRA-55 | 0.04166667 | ~5 | 1981-2010 | Climatology, monthly timeseries | (Abatzoglou et al., 2018) |
| WorldClim V2  (Spatially interpolated dataset) | Observational dataset: WMO & FAO | 0.0083333 | ~1 | 1970-2000 | Climatologies | (Fick and Hijmans, 2017) |
| PBCORCHELSA 1.2 | ERA interim & USGS, GRDC, etc. | 0.0083333 | ~1§ | 1979-2013 | Climatologies | (Karger et al., 2018; Beck et al., 2020) |
| PBCOR CHPclim | GHCN & FAO & USGS, GRDC, etc. | 0.05 | ~5.5 | 1980-2009\* | Climatologies | (Funk et al., 2015; Beck et al., 2020) |
| PBCOR WorldClim | WMO & FAO & USGS, GRDC, etc. | 0.0083333 | ~1§ | 1970-2000 | Climatologies | (Fick and Hijmans, 2017; Beck et al., 2020) |
| CMORPH-CRT | Satellites:Meteosat-5, Meteosat-7, GOES-8, GOES-10, GMS-5,NOAA polar satellites, DMSP, TRMM  Observational dataset: CPC | 0.08 | ~8.5 | 1998-2022 | Climatologies and timeseries | (Joyce et al., 2004) |
| ERA5-Land | Satellites: AQUA, GPM, NOAA-18/19, etc.  In situ observations: WMO WIS | 0.1 | ~12 | 1950-2021 | Climatologies and timeseries | (Muñoz-Sabater et al., 2021; Copernicus Climate Change Service, 2019) |
| SM2rain | Satellites: MetOp ASCAT SM, AMSR-E SM, SMOS.  Reanalysis dataset:  TRMM-3B42RT | 0.1 | ~12 | 2007-2021 | Monthly timeseries | (Brocca et al., 2014) |
| GPM/IMERG | Precipitation-relevant satellite passive microwave (PMW) constellation, GMI sensor from GPM satellite. | 0.1 | ~12 | 2000-2021 | Climatology  And timeseries | (Precipitation Processing System (PPS) At NASA GSFC, 2019) |
| GPCP | Satellites: DMSP, GOES, GMS, Meteosat.  Observational dataset: GPCC for1986 onwards. | 2.5 | ~250 | 1979-2021 | Timeseries | (Adler et al., 2003) |
| GPCC | Observational datasets:  NMHSs via WMO | 0.5 | ~60 | 1891-2020 | Monthly timeseries | (Schneider et al., 2014) |
| GHCNd | Observational datasets: Integrated Surface dataset(Global) | NA | NA | 1959-2022 | Daily timeseries | (Menne et al., 2012) |
| CRU ts4.06 | Observational datasets: CLIMAT messages(WMO), MCDW(NOAA) | 0.5 | ~60 | 1901-2021 | Monthly timeseries | (Harris et al., 2020) |
| CRU-JRA | Reanalysis dataset:  JRA-55  Observational dataset: CRU 4.06 | 0.5 | ~60 | 1901-2021 | Climatology  And timeseries | (Harris et al., 2019) |
| JRA-55 | Satellites: GMS, METSTAT,etc. | 0.5626 | ~60 | 1957-2022 | Timeseries | (Kobayashi et al., 2015) |
| MERRA-2 | Satellites: GOES, AQUA, Meteosat, ASCAT, etc. | 0.667, 0.5 | ~60 | 1980-2022 | Timeseries | (Gelaro et al., 2017) |
| WFDE5 | Reanalysis dataset:  ERA-5 | 0.5 | ~60 | 1979-2018 | Daily timeseries | (Cucchi et al., 2020) |
| PERSIANN-CDR | Satellites: GEO satellites (NOAA ISCCP) | 0.25 | ~30 | 1983-2022 | Timeseries | (Sorooshian et al., 2014) |
| CPC | CPC Global Unified Gauge-Based Analysis of Daily Precipitation | NA | NA | 1991-2010 | Timeseries per station | (NOAA PSL,2008) |
| TRMM/GPM | Precipitation-relevant satellite passive microwave (PMW) constellation, GMI sensor from GPM satellite. | 0.25 | ~30 | 1997-2019 | Timeseries | (Precipitation Processing System (PPS) At NASA GSFC, 2018) |

Supplemental 1. can be the complete datasets.xlsx table for now, but eventually needs to also include a column for the citation, the complete dataset reference, and the complete reference for a methods description paper.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Site | Source | Latitude | Longitude | Analysis |
| ALHAJUELA | ACP | 9.206388889 | -79.620556 | Climatology |
| BALBOAFAA | ACP | 8.968888889 | -79.549444 | Climatology |
| BALBOAHTS | ACP | 8.959444444 | -79.554167 | Climatology |
| CANDELARIA | ACP | 9.382777778 | -79.516389 | Climatology |
| CANO | ACP | 9.076388889 | -79.822778 | Climatology |
| CANONES | ACP | 8.948888889 | -80.0625 | Climatology |
| CHICO | ACP | 9.263611111 | -79.509722 | Climatology |
| CHORRO | ACP | 8.975555556 | -79.990278 | Climatology |
| CIENTO | ACP | 9.297777778 | -79.728056 | Climatology |
| CRISTOBAL | ACP | 9.35 | -79.9 | Climatology |
| DIABLO | ACP | 8.965555556 | -79.573333 | Climatology |
| EMPIREHILL | ACP | 9.058055556 | -79.664722 | Climatology |
| ESCANDALOSA | ACP | 9.423611111 | -79.578333 | Climatology |
| GALETASTRI | STRI | 9.40275 | -79.86083 | Climatology |
| GATUN | ACP | 9.268333333 | -79.920556 | Climatology |
| HODGESHILL | ACP | 9.044166667 | 79.6513889 | Climatology |
| HUMEDAD | ACP | 9.048333333 | -80.039167 | Climatology |
| MONTELIRIO | ACP | 9.241111111 | -79.853333 | Climatology |
| RAICES | ACP | 9.091944444 | -79.987778 | Climatology |
| SALAMANCA | ACP | 9.304444444 | -79.583333 | Climatology |
| SANTAROSA | ACP | 9.185833333 | -79.654167 | Climatology |
| ZANGUENGA | ACP | 8.968611111 | -79.867778 | Climatology |
| AGUACLARA | ACP | 9.364444444 | -79.706111 | Climatology, Seasonality, Interannual. |
| BCI | ACP | 9.165277778 | -79.836389 | Climatology, Seasonality, Interannual. |
| BCICLEAR | STRI | 9.163114 | -79.838233 | Climatology, Seasonality, Interannual. |
| CASCADAS | ACP | 9.081388889 | -79.68 | Climatology, Seasonality, Interannual. |
| GAMBOA | ACP | 9.112222222 | -79.693889 | Climatology, Seasonality, Interannual. |
| GUACHA | ACP | 9.176944444 | -79.938889 | Climatology, Seasonality, Interannual. |
| PEDROMIGUEL | ACP | 9.022777778 | -79.617222 | Climatology, Seasonality, Interannual. |
| PELUCA | ACP | 9.38 | -79.561111 | Climatology, Seasonality, Interannual. |
| SANMIGUEL | ACP | 9.42 | -79.504167 | Climatology, Seasonality, Interannual. |
| BCIELECT | STRI | 9.163114 | -79.838233 | Climatology. |
| AVA | STRI | 9.1566 | -79.84828 | Not used |
| BOCAS | STRI | 9.350827 | -82.257943 | Not used |
| CELESTINO | STRI | 9.21142 | -79.72656 | Not used |
| FORTUNA | STRI | 8.7216333 | -82.237528 | Not used |
| PCULEBRA | STRI | 8.9107694 | -79.528914 | Not used |
| PNM | STRI | 8.994875 | -79.543117 | Not used |
| SANBLAS | STRI | 9.552572 | -78.952256 | Not used |
| SHERMAN | STRI | 9.280975 | -79.974519 | Not used |
| AGUABUENA | ACP | 9.127777778 | -79.598611 | Not used |
| AGUASALUD | ACP | 9.224444444 | -79.760278 | Not used |
| AMADOR | ACP | 8.916666667 | -79.534722 | Not used |
| ARCASONIA | ACP | 9.193333333 | -79.515 | Not used |
| BALBOADOCKS | ACP | 8.95 | -79.566667 | Not used |
| BARBACOA | ACP | 9.120277778 | -79.797222 | Not used |
| BATATILLA | ACP | 8.916944444 | 80.5008333 | Not used |
| BATEALES | ACP | 8.725 | 80.5663889 | Not used |
| BOCATUCUE | ACP | 8.753166667 | 80.3279 | Not used |
| CANOQUEBRADO | ACP | 9.004722222 | -79.826111 | Not used |
| CANOA | ACP | 8.885833333 | 80.5572222 | Not used |
| CERROCAMA | ACP | 9.026666667 | -79.905833 | Not used |
| CERROCOCOLI | ACP | 8.990267 | -79.59175 | Not used |
| CHAGRECITO | ACP | 9.394722222 | -79.305556 | Not used |
| CHAMON | ACP | 9.341944444 | -79.318333 | Not used |
| CHICOCABERCERA | ACP | 9.35 | -79.463611 | Not used |
| CHISNA | ACP | 8.788055556 | 80.4783333 | Not used |
| COCLENORTE | ACP | 9.073484 | -80.572365 | Not used |
| COCOLI326 | ACP | 8.9825 | -79.593611 | Not used |
| COCOSOLO | ACP | 9.366666667 | 79.8833333 | Not used |
| COROZAL | ACP | 8.979444444 | -79.575 | Not used |
| DOSBOCAS | ACP | 9.4525 | -79.431111 | Not used |
| ESPERANZA | ACP | 9.409722222 | -79.352222 | Not used |
| FRAILE | ACP | 8.800466667 | 80.5344167 | Not used |
| FRIJOLITO | ACP | 9.218888889 | -79.716111 | Not used |
| FTS | ACP | 9.281031 | -79.974518 | Not used |
| GALETA | ACP | 9.402742 | -79.860837 | Not used |
| GASPARILLAL | ACP | 8.862777778 | -80.015556 | Not used |
| GATUNWEST | ACP | 9.263055556 | -79.929167 | Not used |
| GOLDHILL | ACP | 9.051111111 | -79.655 | Not used |
| GUARUMAL | ACP | 9.204333333 | -79.525667 | Not used |
| INDIOCHORROS | ACP | 8.761666667 | 80.1266667 | Not used |
| INDIOESTE | ACP | 9.204978 | -79.518029 | Not used |
| ISLABRUJA | ACP | 9.210833333 | -79.917222 | Not used |
| JAGUA | ACP | 8.737222222 | -80.047222 | Not used |
| LIMONBAY | ACP | 9.355555556 | -79.914722 | Not used |
| LIMPIO | ACP | 9.328055556 | 79.4686111 | Not used |
| LOMAGRANDE | ACP | 8.866666667 | 80.45 | Not used |
| LOSDARIELES | ACP | 8.824166667 | -80.287778 | Not used |
| LOSHULES | ACP | 8.905277778 | -80.260278 | Not used |
| MARIAS | ACP | 8.883333333 | 80.22125 | Not used |
| MIRAFLORES | ACP | 9.014166667 | -79.61 | Not used |
| NUEVABORINQUEN | ACP | 8.986388889 | -79.598333 | Not used |
| NUEVOSANJUAN | ACP | NA | NA | Not used |
| NUEVOVIGÃA | ACP | 9.261783333 | 79.5899833 | Not used |
| PALMARAZO | ACP | 8.7336 | -80.6544 | Not used |
| PUNTABOHIO | ACP | 9.184166667 | -79.856111 | Not used |
| PUNTAFRIJOLES | ACP | 9.16 | -79.806111 | Not used |
| RANCHERIA | ACP | 8.744166667 | 80.4844444 | Not used |
| RIOPIEDRAS | ACP | 9.281944444 | -79.398056 | Not used |
| RIOPIEDRAS | ACP | 8.986388889 | 79.5983333 | Not used |
| RIOPIEDRASARRIBA | ACP | 9.281944444 | -79.398056 | Not used |
| SANPEDRO | ACP | 8.733333333 | 80.2238889 | Not used |
| SANTACLARA | ACP | 9.032666667 | -79.751833 | Not used |
| SANVICENTE | ACP | 8.885783 | -80.417233 | Not used |
| TRANQUILLA | ACP | 9.25 | -79.566667 | Not used |
| URACILLO | ACP | 8.975833333 | 80.175 | Not used |
| VALLECENTRALGATUN | ACP | 9.375833333 | -79.638611 | Not used |
| VICTORVALDEZ | ACP | 9.006666667 | -79.619167 | Not used |
| VISTAMARES | ACP | 9.234444444 | -79.401389 | Not used |

Supplemental table 2. All sites considered in the study and type of analysis employed.

Supplemental figures

Chart, scatter chart

Description automatically generated

Figure 5. Seasonality of all datasets, shapes binned each 4 months and 1 color per dataset.

Supplemental table or text

Gridded climate products rely on ground observations for calibration and validation. Thus, gridded product will approximate values better at sampled sites. We have tried to gather information about the stations in Panama that have been included in the production of the precipitation datasets. The time expands depend on the date of data acquisition. WMO does not list any MET station from Panama, WMO provides normal for GPCC and GPCP. NMHSs through WMO provides with climate normals for GPCC which is used in the production of the CHELSA algorithms. NMHSs datasets redirects to Hidromet Panama which displays the ETESA stations and have not been included in this study. GHCN dataset used by CHPclim and CHIRPS lists 7 stations for Panama, out of which we can confirm two stations with code PMW00010701 and PMW00010716 are included in our analysis under the code name BALBOAFAA and BALBOAHTS.

Table 1. Stations from Panama in GHCNd dataset

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| CODE | Latitude | Longitude | Elevation | Name |
| PM000105001 | 8.9100 | -80.5500 | 170.0 | BOCA DEL TOABRE |
| PM000128005 | 7.6300 | -80.6100 | 180.0 | LA MESA DE MACARACAS |
| PM000132001 | 8.5300 | -81.0600 | 1000.0 | EL PALMAR |
| PM000148001 | 9.1000 | -79.0800 | 30.0 | CHEPO |
| PMW00010701 | 8.9667 | -79.5500 | 9.1 | BALBOA ALBROOK |
| PMW00010705 | 8.9167 | -79.6000 | 10.1 | HOWARD |
| PMW00010715 | 9.3667 | -79.9000 | 4.3 | COCO SOLO |
| PMW00010716 | 8.9333 | -79.5667 | 13.1 | BALBOA |
| PMW00010718 | 8.9167 | -79.6000 | 16.2 | FT KOBBE |
| PMW00010719 | 9.3667 | -79.9500 | 9.1 | FT SHERMAN |

References

Joyce, R. J., Janowiak, J. E., Arkin, P. A., & Xie, P. (2004). CMORPH: A Method that Produces Global Precipitation Estimates from Passive Microwave and Infrared Data at High Spatial and Temporal Resolution. *Journal of Hydrometeorology*, *5*(3), 487–503. https://doi.org/10.1175/1525-7541(2004)005<0487:CAMTPG>2.0.CO;2

Brocca, L., Ciabatta, L., Massari, C., Moramarco, T., Hahn, S., Hasenauer, S., Kidd, R., Dorigo, W., Wagner, W., & Levizzani, V. (2014). Soil as a natural rain gauge: Estimating global rainfall from satellite soil moisture data: Using the soil as a natural raingauge. *Journal of Geophysical Research: Atmospheres*, *119*(9), 5128–5141. <https://doi.org/10.1002/2014JD021489>

Berrisford, P., Dee, P., Poli, P., Brugge, R., Fielding, M., & Fuentes, M. (2011). *The ERA-Interim archive Version 2.0* (No. 2.0; ERA Report Series).

Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., & Thépaut, J.-N. (2021). ERA5-Land: a state-of-the-art global reanalysis dataset for land applications. *Earth System Science Data*, *13*(9), 4349–4383. <https://doi.org/10.5194/essd-13-4349-2021>

Copernicus Climate Change Service. (2019). *ERA5-Land hourly data from 2001 to present*. ECMWF. <https://doi.org/10.24381/CDS.E2161BAC>

Precipitation Processing System (PPS) At NASA GSFC. (2019). *GPM IMERG Final Precipitation L3 Half Hourly 0.1 degree x 0.1 degree V06*. NASA Goddard Earth Sciences Data and Information Services Center. https://doi.org/10.5067/GPM/IMERG/3B-HH/06

Adler, R. F., Huffman, G. J., Chang, A., Ferraro, R., Xie, P.-P., Janowiak, J., Rudolf, B., Schneider, U., Curtis, S., Bolvin, D., Gruber, A., Susskind, J., Arkin, P., & Nelkin, E. (2003). The Version-2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present). *Journal of Hydrometeorology*, *4*(6), 1147–1167. [https://doi.org/10.1175/1525-7541(2003)004<1147:TVGPCP>2.0.CO;2](https://doi.org/10.1175/1525-7541(2003)004%3c1147:TVGPCP%3e2.0.CO;2)

Schneider, U., Becker, A., Finger, P., Meyer-Christoffer, A., Ziese, M., & Rudolf, B. (2014). GPCC’s new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. *Theoretical and Applied Climatology*, *115*(1–2), 15–40. <https://doi.org/10.1007/s00704-013-0860-x>

Menne, M. J., Durre, I., Vose, R. S., Gleason, B. E., & Houston, T. G. (2012). An Overview of the Global Historical Climatology Network-Daily Database. *Journal of Atmospheric and Oceanic Technology*, *29*(7), 897–910. https://doi.org/10.1175/JTECH-D-11-00103.1

Harris, I., Osborn, T. J., Jones, P., & Lister, D. (2020). Version 4 of the CRU TS monthly high-resolution gridded multivariate climate dataset. *Scientific Data*, *7*(1), 109. <https://doi.org/10.1038/s41597-020-0453-3>

University of East Anglia Climatic Research Unit; Harris, I.C. (2019): CRU JRA: Collection of CRU JRA forcing datasets of gridded land surface blend of Climatic Research Unit (CRU) and Japanese reanalysis (JRA) data.. Centre for Environmental Data Analysis, *date of citation*. <http://catalogue.ceda.ac.uk/uuid/863a47a6d8414b6982e1396c69a9efe8>

Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., Randles, C. A., Darmenov, A., Bosilovich, M. G., Reichle, R., Wargan, K., Coy, L., Cullather, R., Draper, C., Akella, S., Buchard, V., Conaty, A., Da Silva, A. M., Gu, W., … Zhao, B. (2017). The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). *Journal of Climate*, *30*(14), 5419–5454. <https://doi.org/10.1175/JCLI-D-16-0758.1>

Cucchi, M., Weedon, G. P., Amici, A., Bellouin, N., Lange, S., Müller Schmied, H., Hersbach, H., & Buontempo, C. (2020). WFDE5: bias-adjusted ERA5 reanalysis data for impact studies. *Earth System Science Data*, *12*(3), 2097–2120. https://doi.org/10.5194/essd-12-2097-2020

Sorooshian, S., Hsu, K., Braithwaite, D., Ashouri, H., & NOAA CDR Program. (2014). *NOAA Climate Data Record (CDR) of Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN-CDR), Version 1 Revision 1*. NOAA National Climatic Data Center. https://doi.org/10.7289/V51V5BWQ

Kobayashi, S., Ota, Y., Harada, Y., Ebita, A., Moriya, M., Onoda, H., Onogi, K., Kamahori, H., Kobayashi, C., Endo, H., Miyaoka, K., & Takahashi, K. (2015). The JRA-55 Reanalysis: General Specifications and Basic Characteristics. *Journal of the Meteorological Society of Japan. Ser. II*, *93*(1), 5–48. <https://doi.org/10.2151/jmsj.2015-001>

*CPC Global Unified Gauge-Based Analysis of Daily Precipitation: NOAA Physical Sciences Laboratory CPC Global Unified Gauge-Based Analysis of Daily Precipitation*. (2008). Retrieved March 6, 2023, from https://psl.noaa.gov/data/gridded/data.cpc.globalprecip.html

Precipitation Processing System (PPS) At NASA GSFC. (2018). *TRMM (TMPA) Rainfall Estimate L3 3 hour 0.25 degree x 0.25 degree V7* [Data set]. NASA Goddard Earth Sciences Data and Information Services Center. <https://doi.org/10.5067/TRMM/TMPA/3H/7>