Overview of the Latin American and Caribbean Flood and Drought Monitor (LACFDM)

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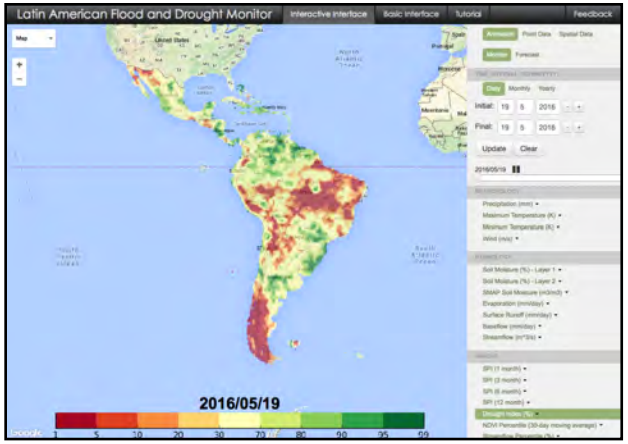
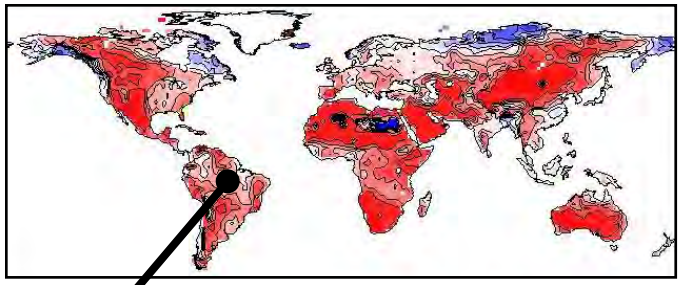
Princeton University

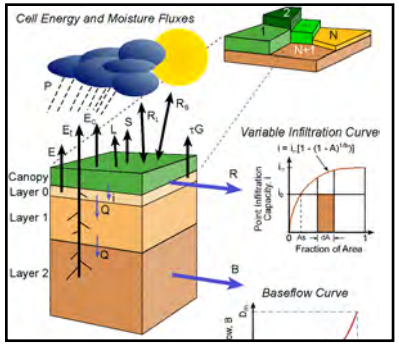
International Training: 'Application of Satellite Remote Sensing to Support Water Resources Management in Latin America and the Caribbean' –
Foz de Iguazú, Brazil, 13 - 20 July 2016



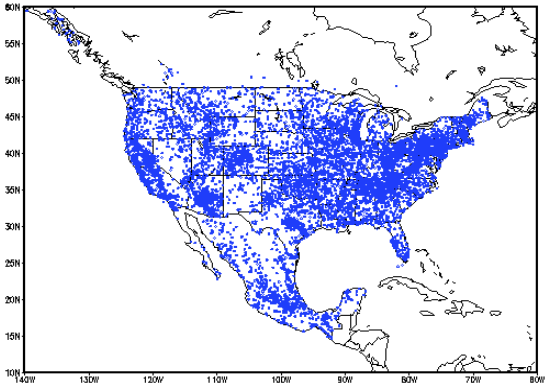
Data and Tools for Flood/Drought Monitoring and Prediction



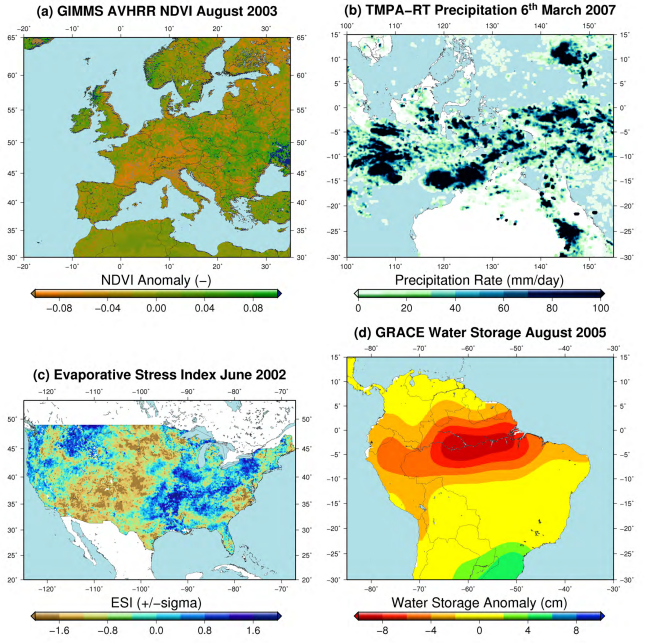
Hydrological Modeling



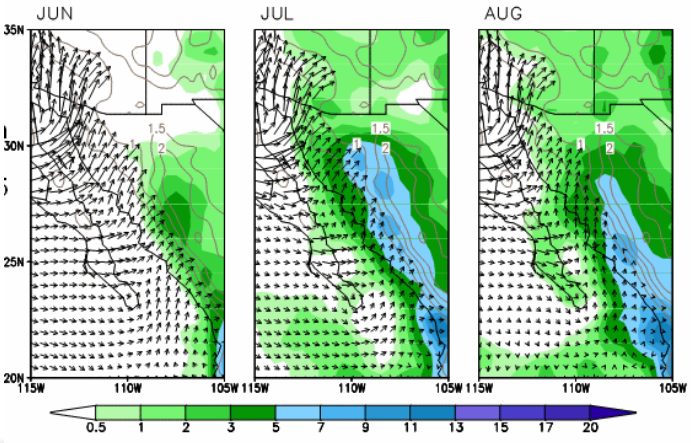
Ground Observations



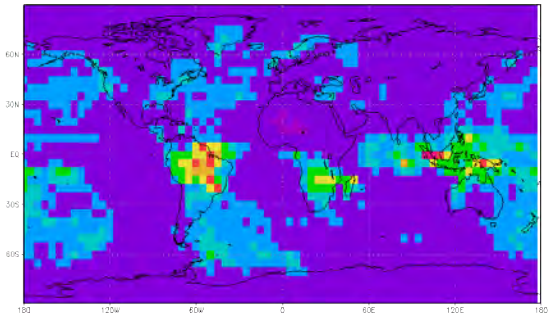
Satellite Remote Sensing



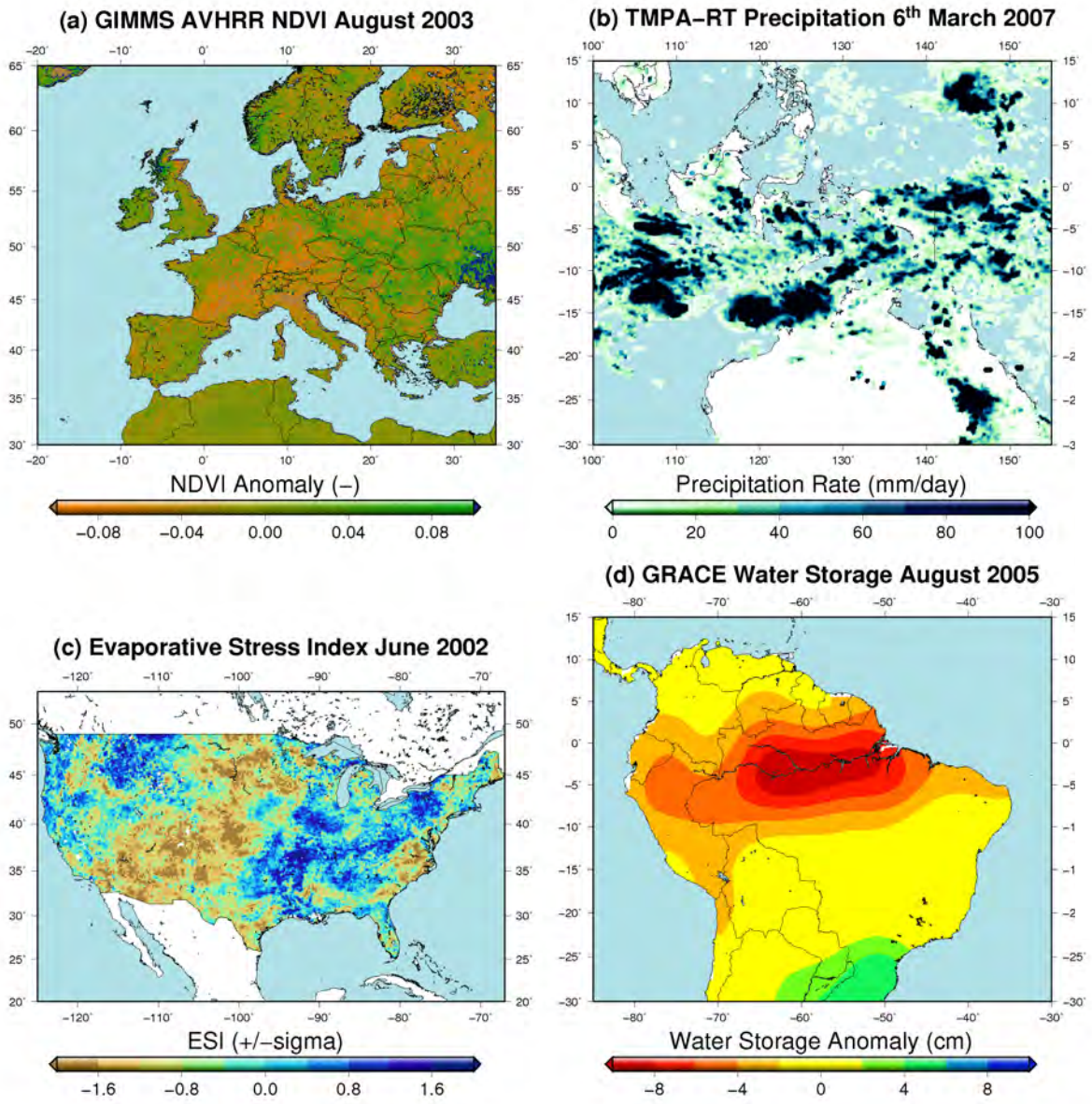
Reanalysis



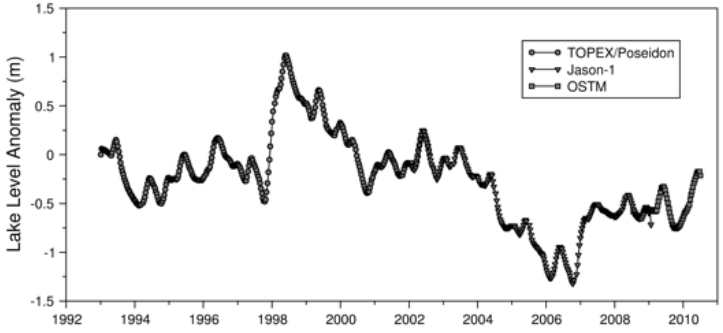
Regional/Global Climate Models, Statistical Prediction



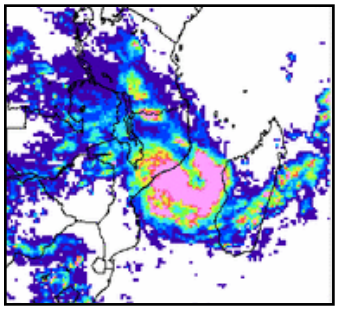
Observing the Water Cycle: Remote Sensing



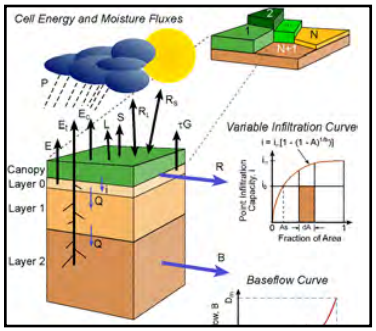
Satellite Altimetry of Large Water Bodies

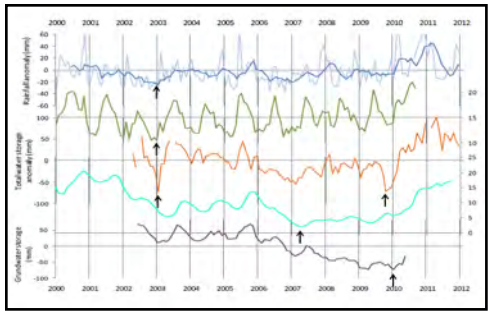


Putting it all together: Hydrological Monitoring/Forecasting Systems



Real-time Weather

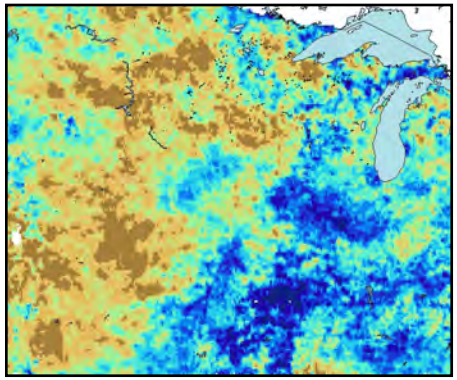




Land surface (hydrology) models

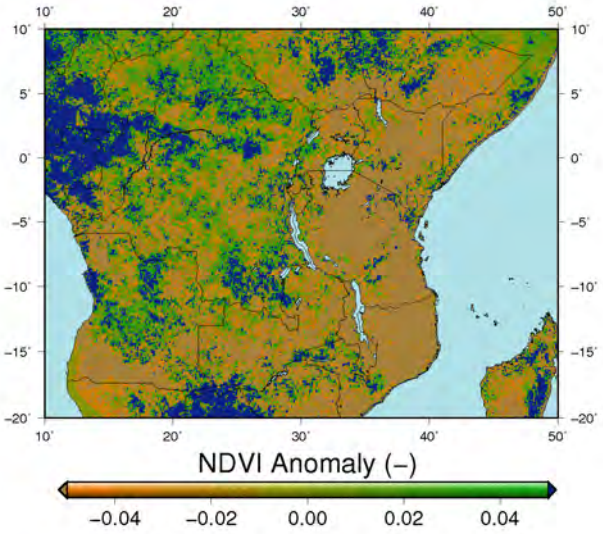
Initial Conditions

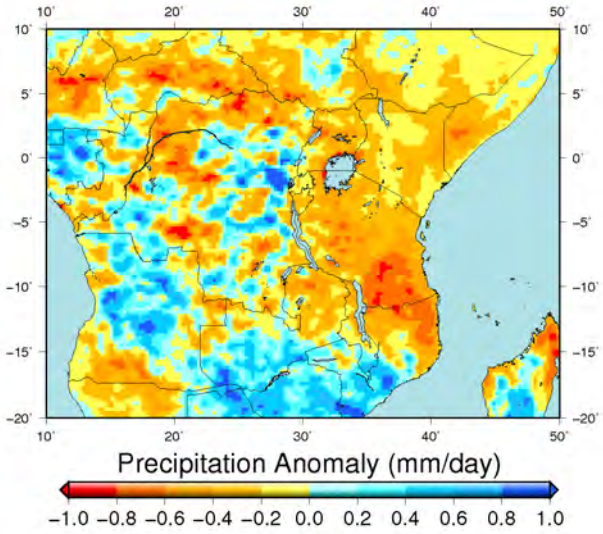
Hydrological Variables, Streamflow, Drought Indices

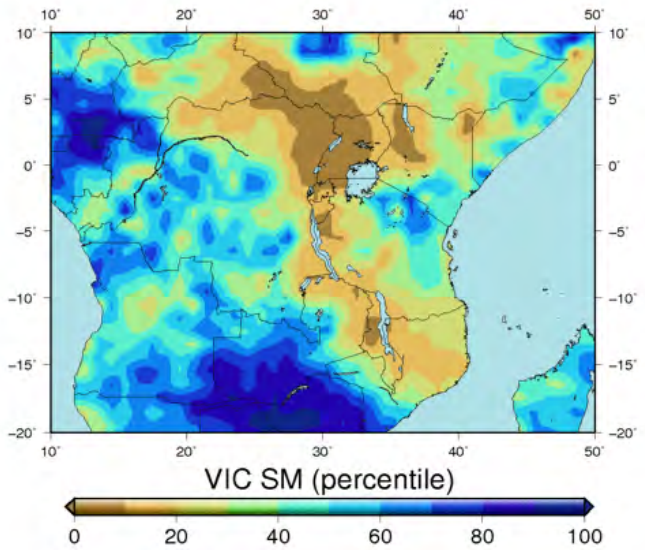


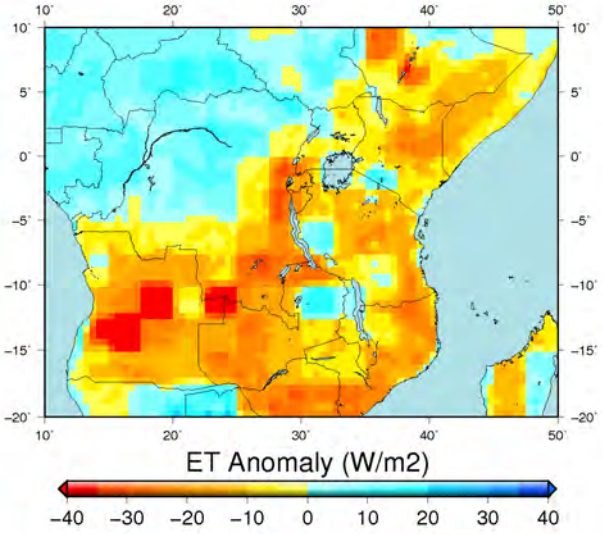
Management/Mitigation

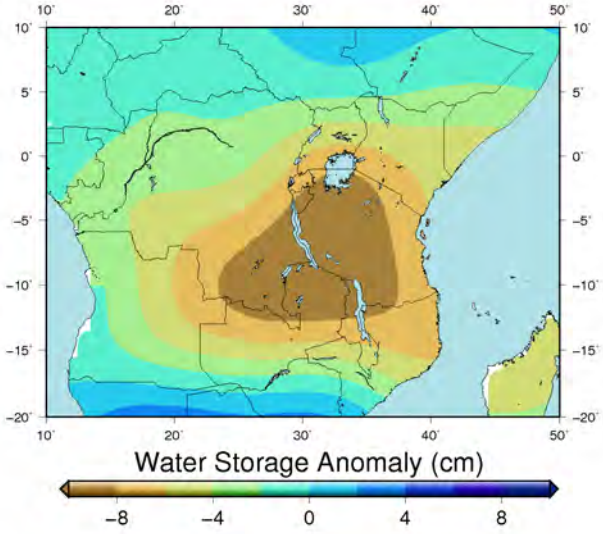
Multi-Sensor View of Single Drought Event

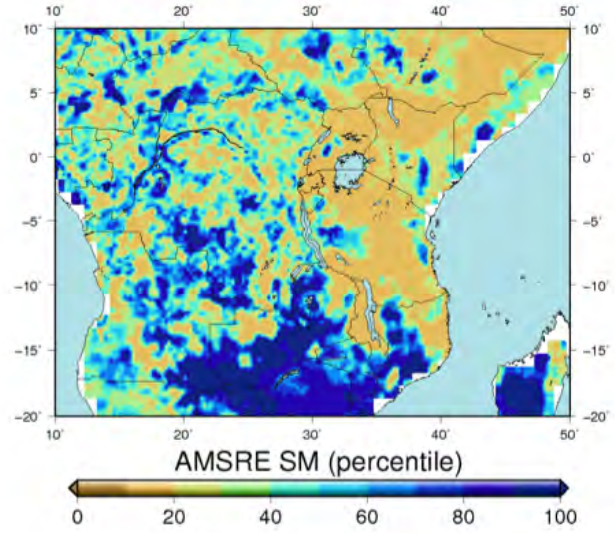


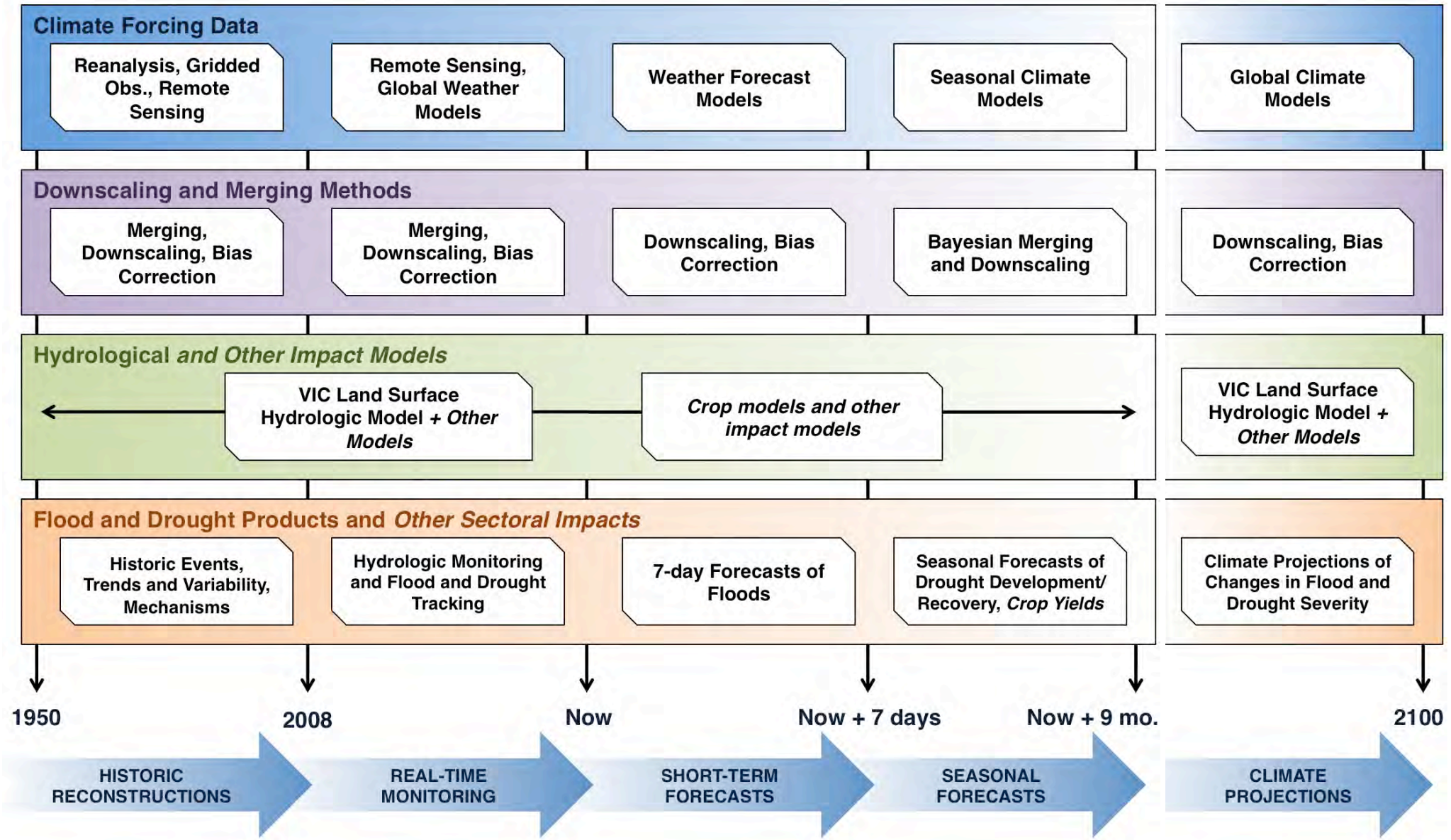












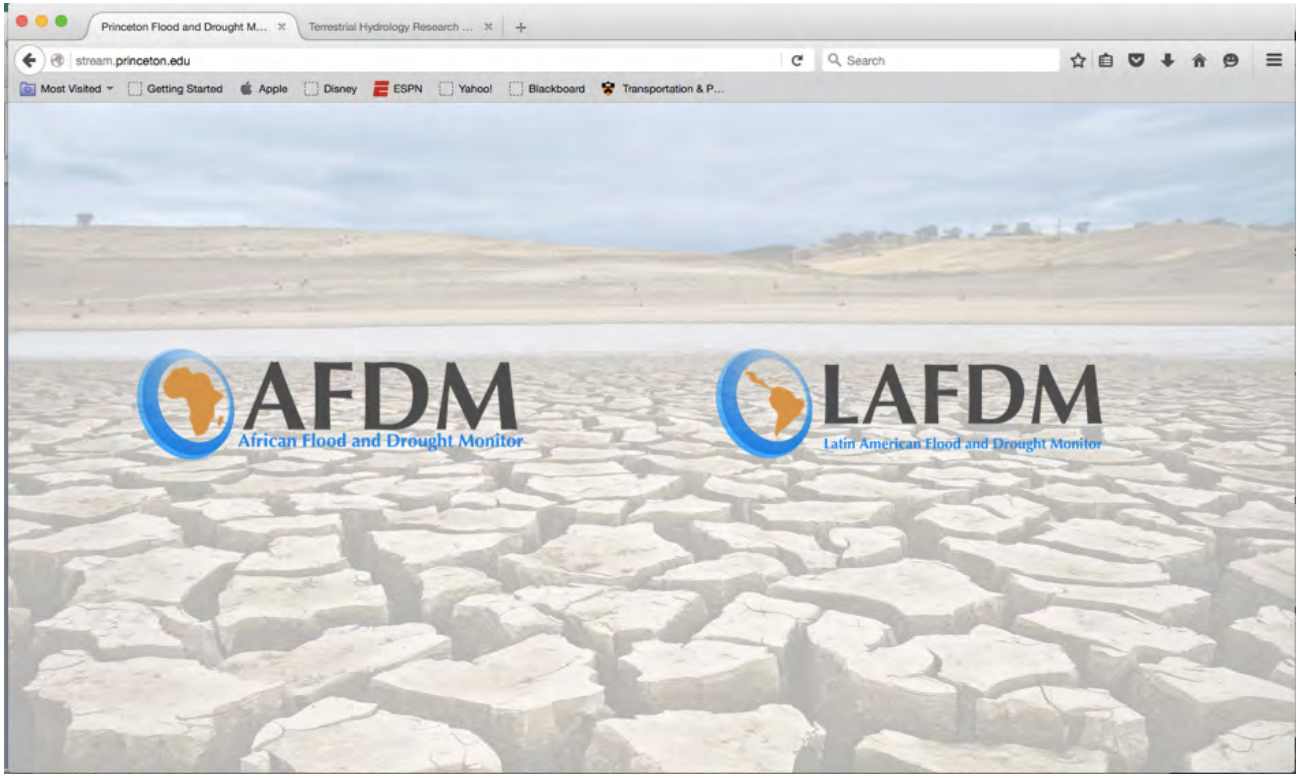
Sheffield, J., et al., 2014; A drought monitoring and forecasting system for sub-Sahara African water resources and food security. *Bull. Am. Met. Soc.*, June

Development of a global monitoring capability

The Flood and Drought Monitor: Web Interface

Main Portal for Flood and Drought Monitors

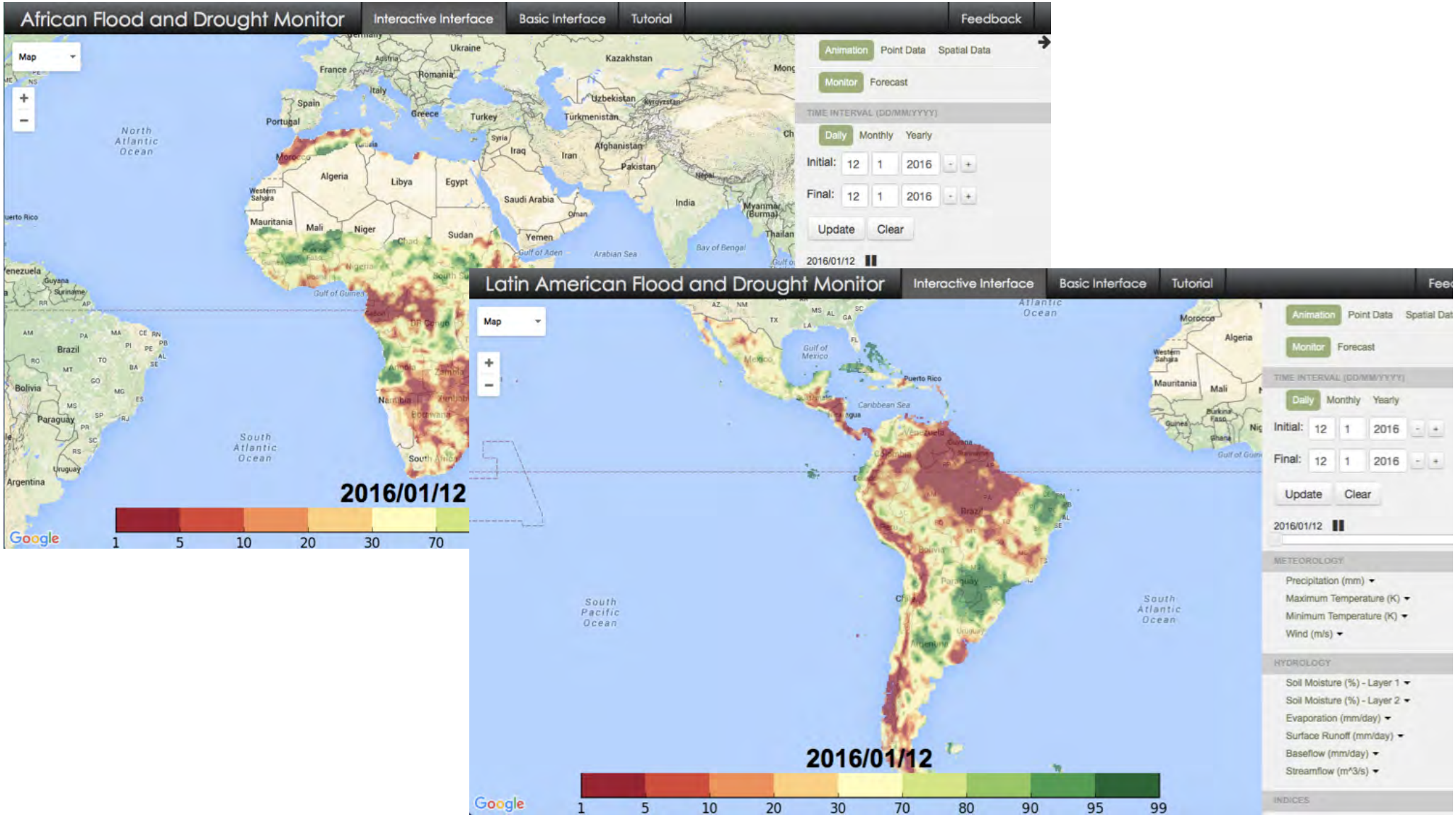
http://stream.princeton.edu



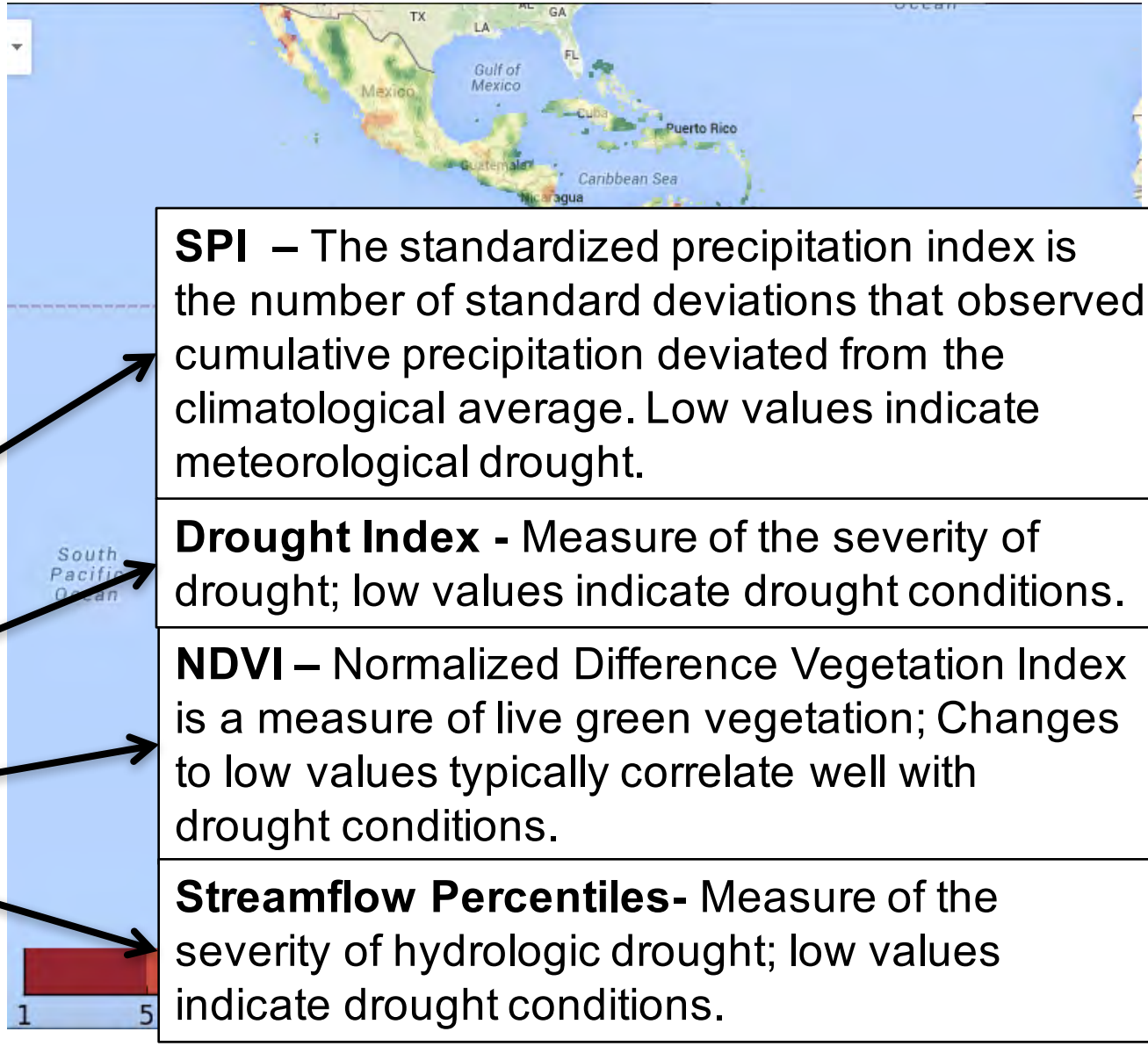
Available in English, French, Spanish, Arabic, Mandarin, and Portuguese (only for LAFDM)

Main Portal for the Latin American Monitor

Web Interfaces



Water Cycle Products and Indices



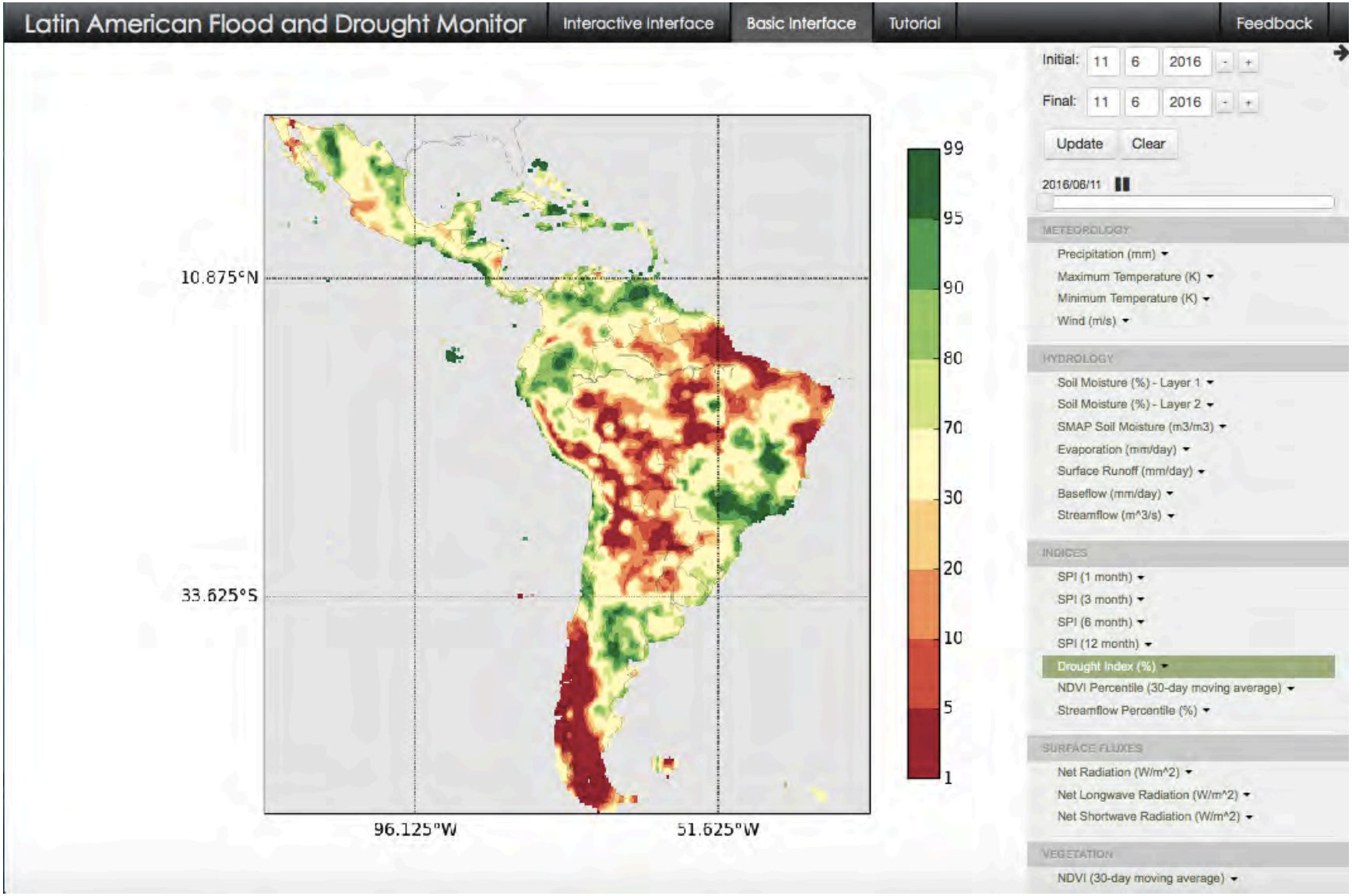
SPI – The standardized precipitation index is the number of standard deviations that observed cumulative precipitation deviated from the climatological average. Low values indicate meteorological drought.

Drought Index - Measure of the severity of drought; low values indicate drought conditions.

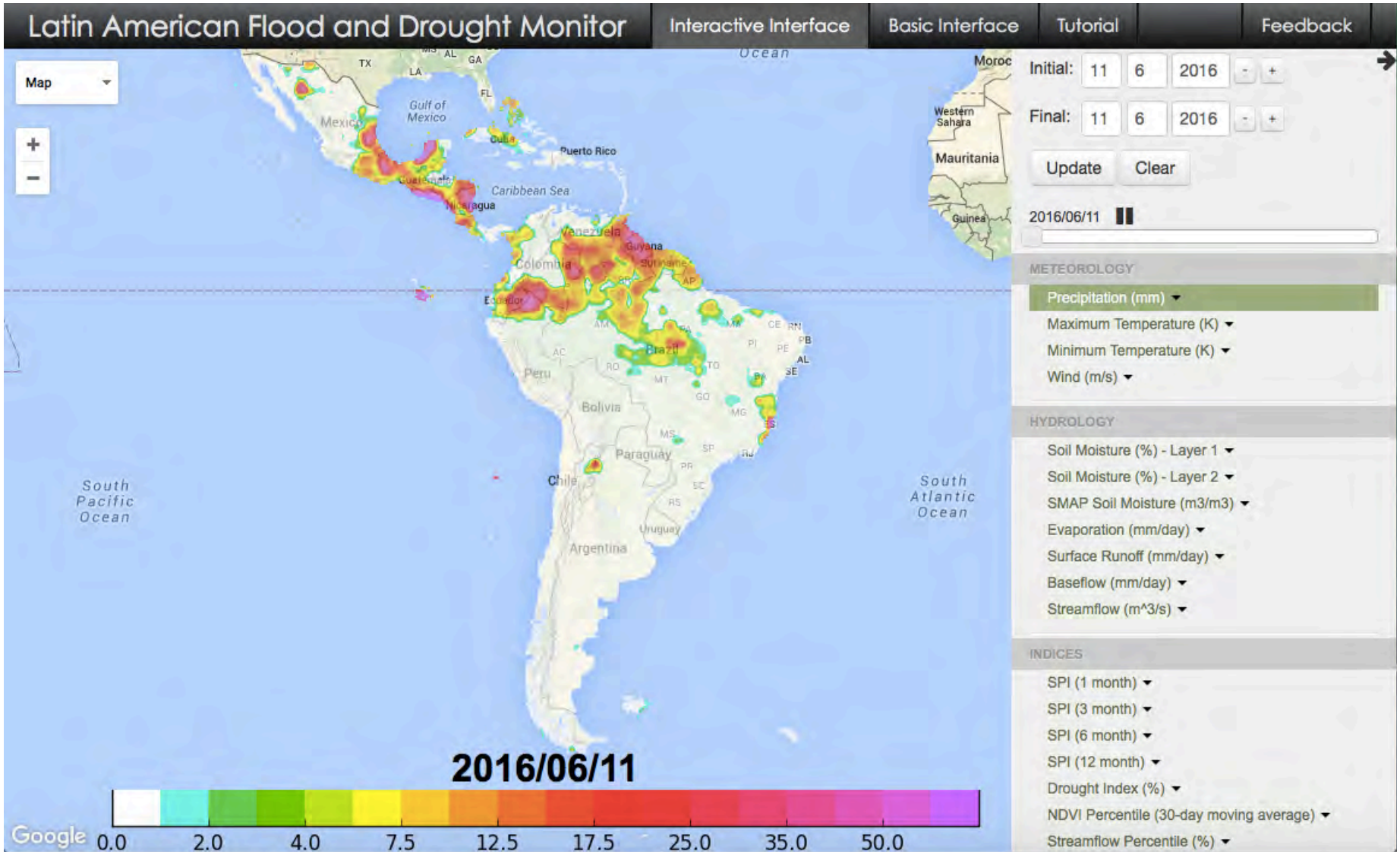
NDVI – Normalized Difference Vegetation Index is a measure of live green vegetation; Changes to low values typically correlate well with drought conditions.

Streamflow Percentiles- Measure of the severity of hydrologic drought; low values indicate drought conditions.

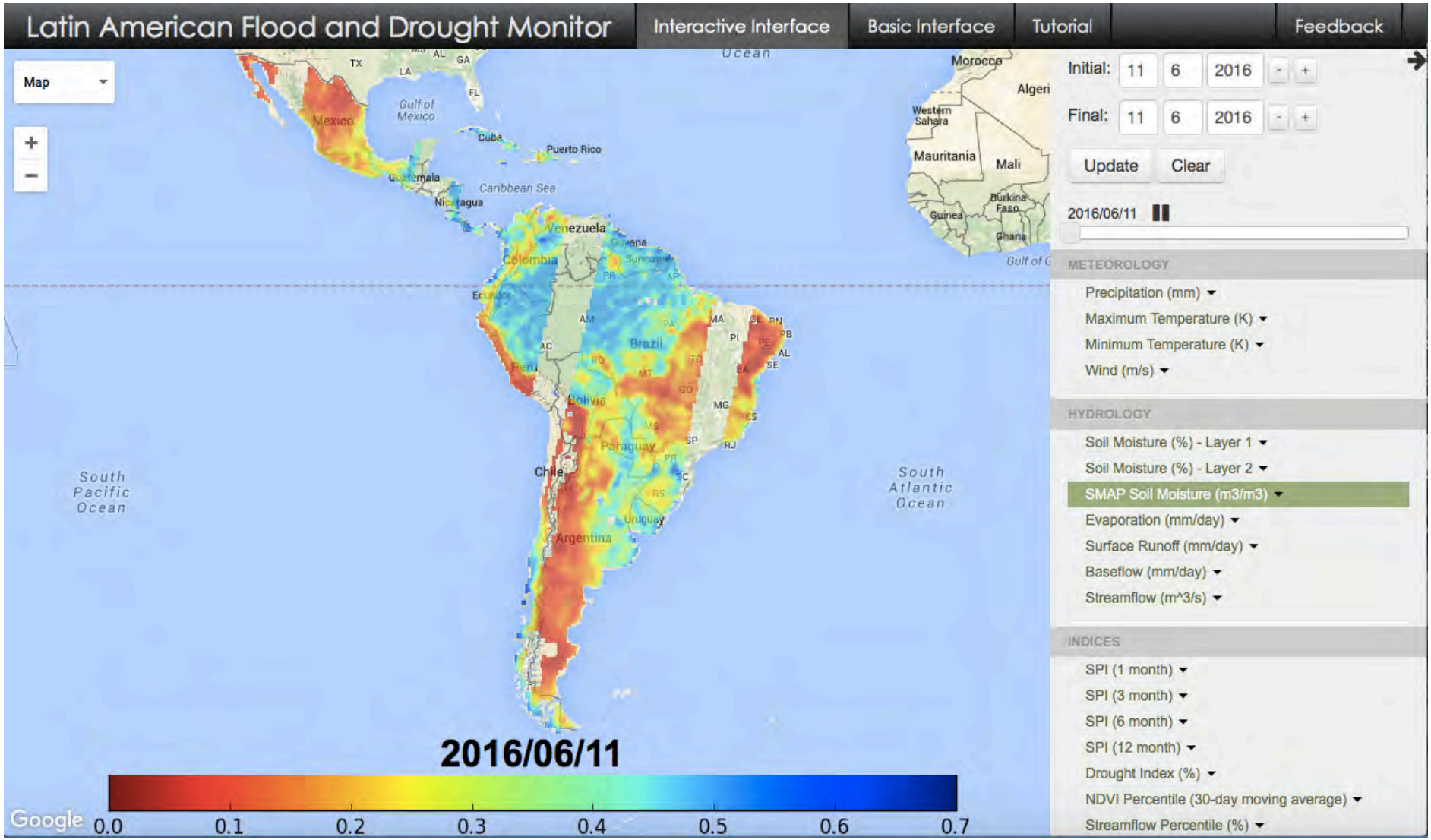
Basic Interface



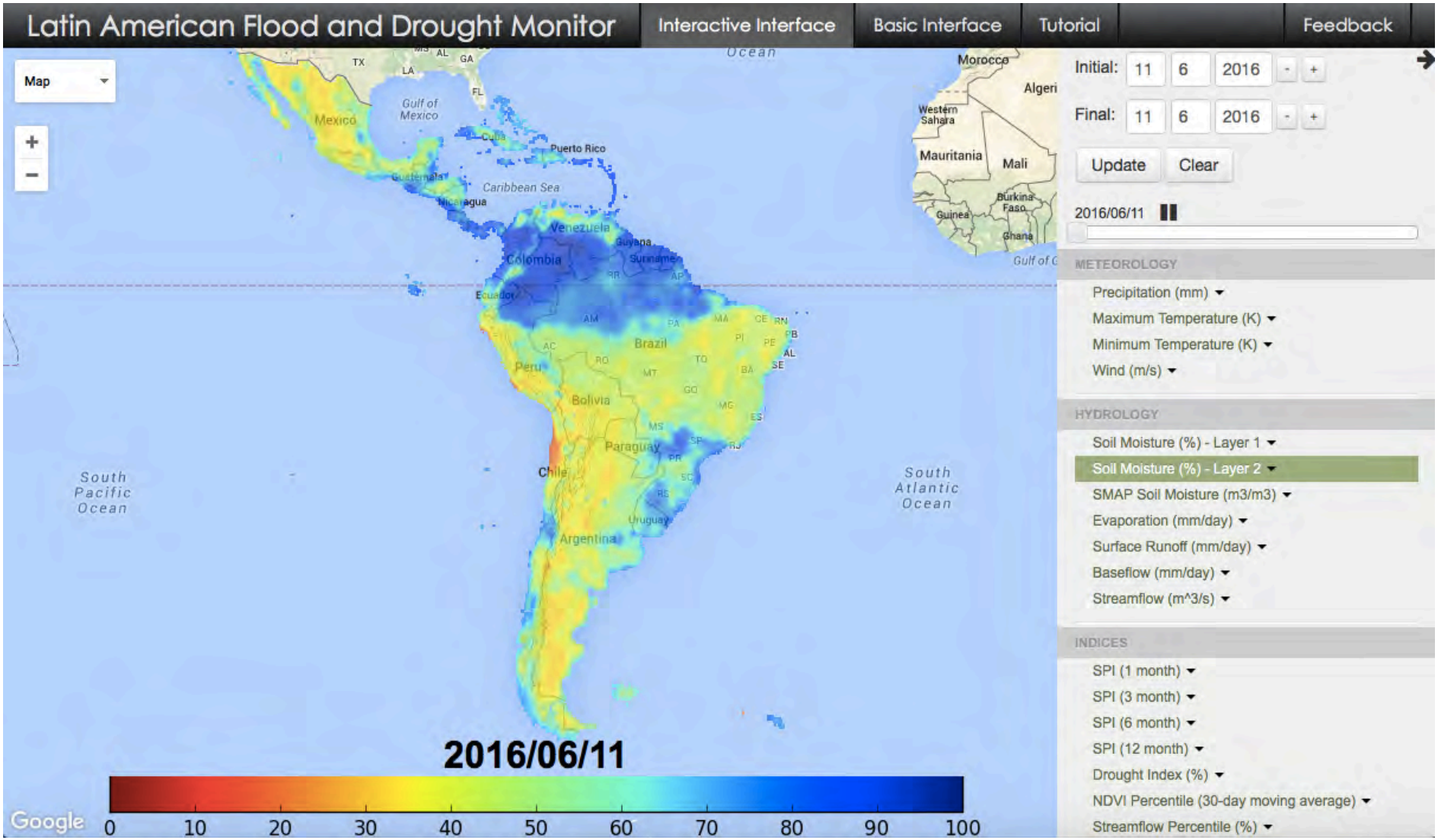
Interface: Precipitation



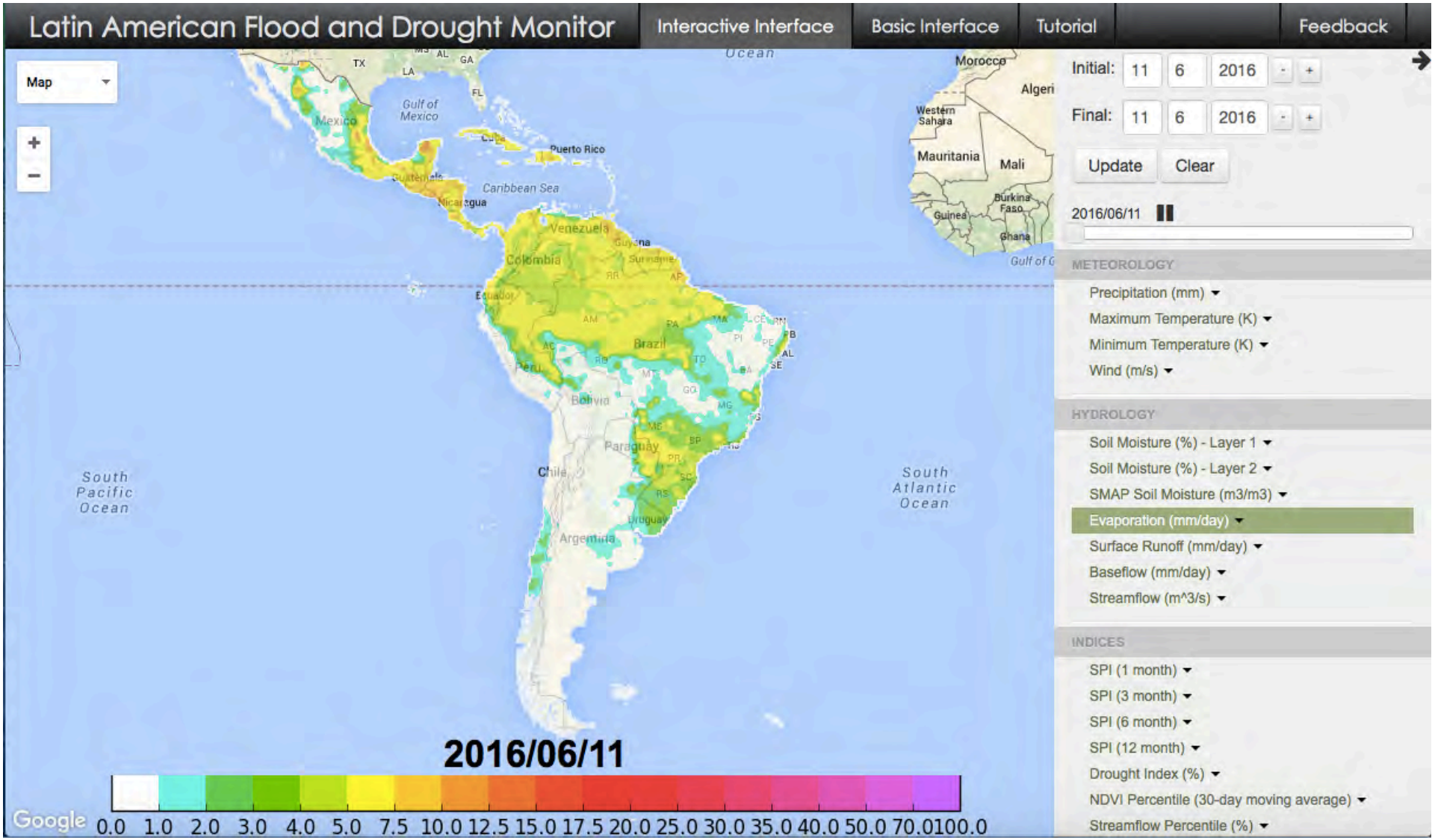
Interface: Soil Moisture (Remote Sensing)



Interface: Soil Moisture (modeled)



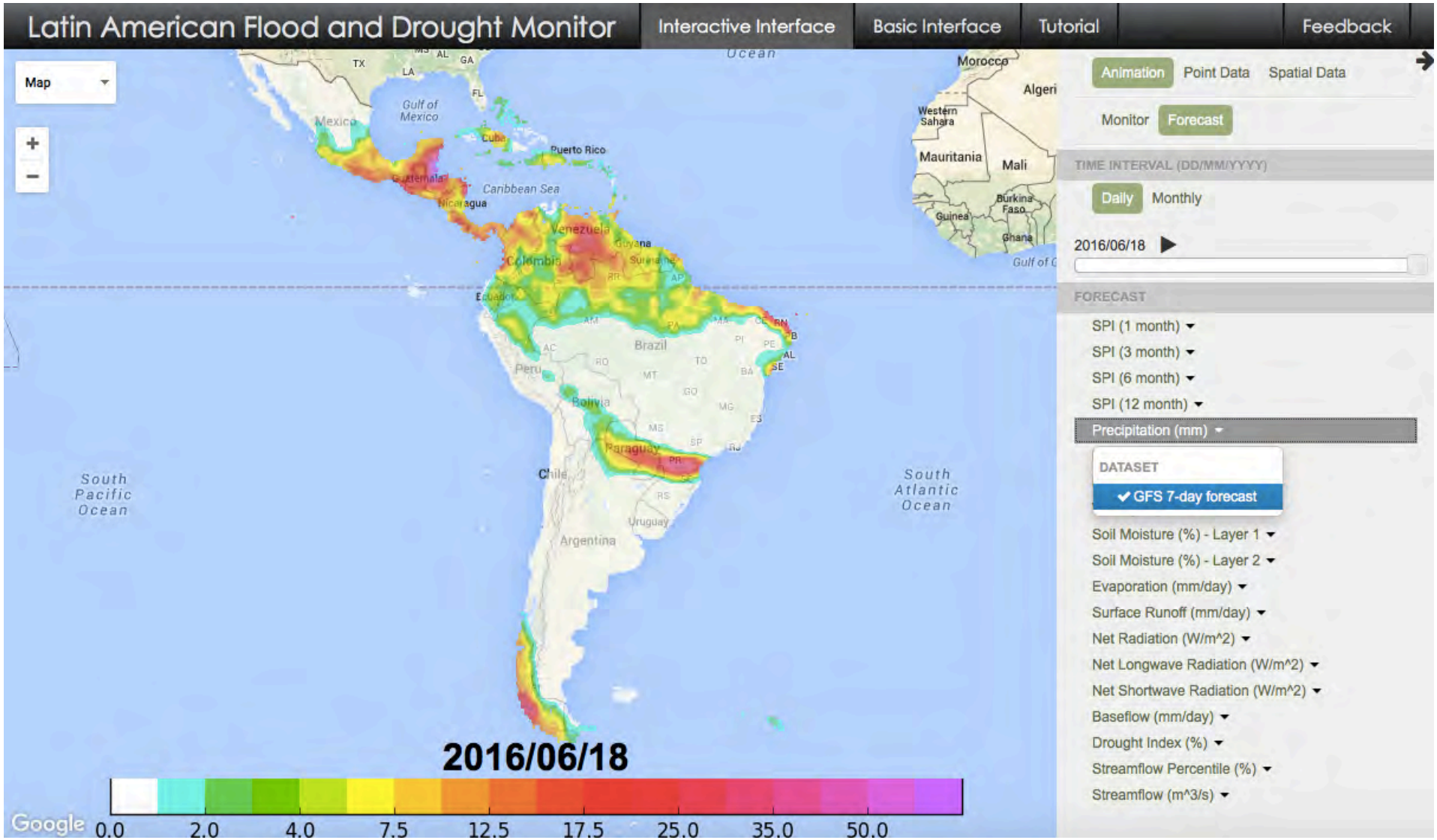
Interface: Evapotranspiration



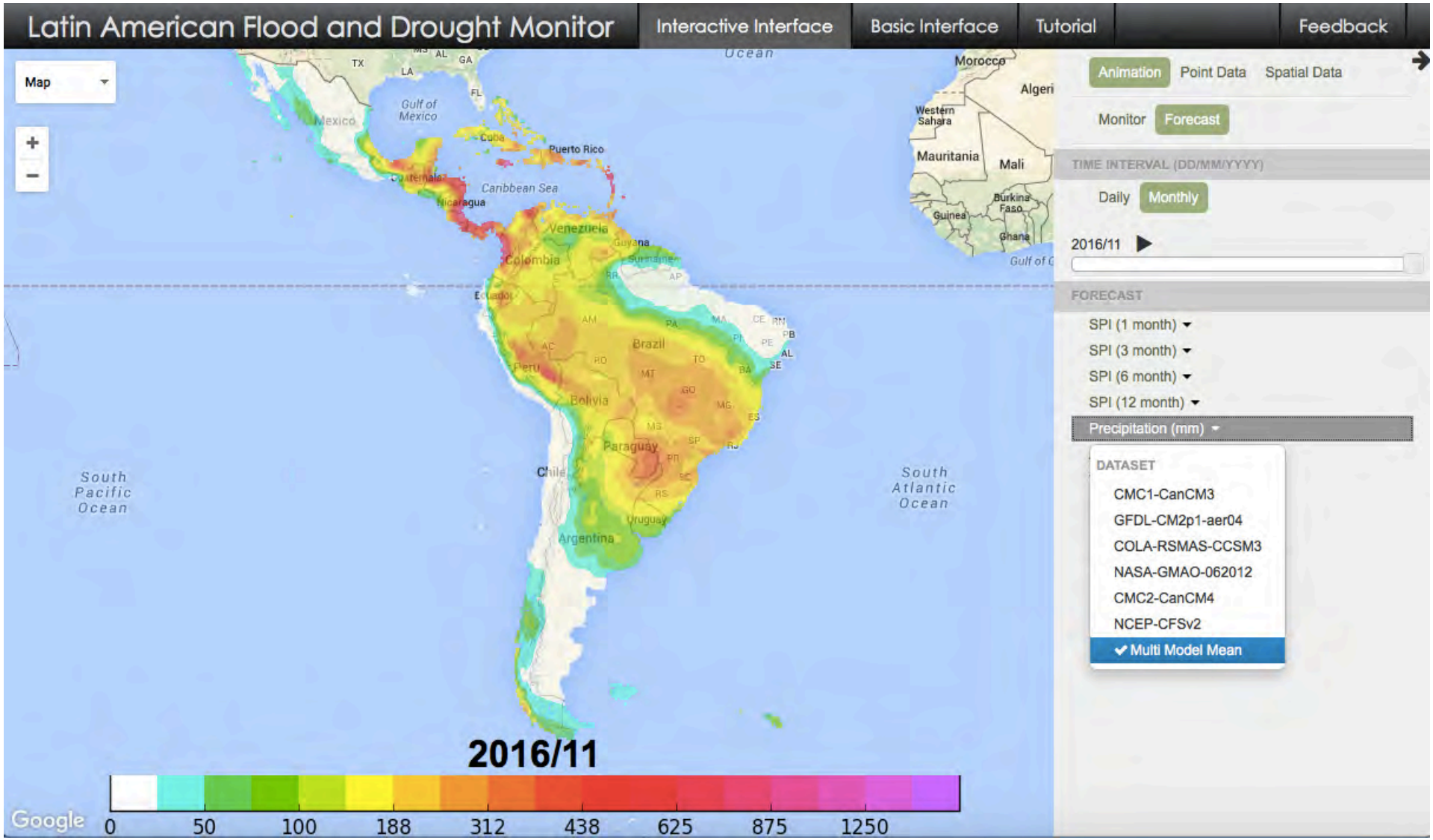
Interface: NDVI (Remote Sensing)

NDVI – Normalized Difference Vegetation Index is a measure of live green vegetation; Changes to low values typically correlate well with drought conditions.

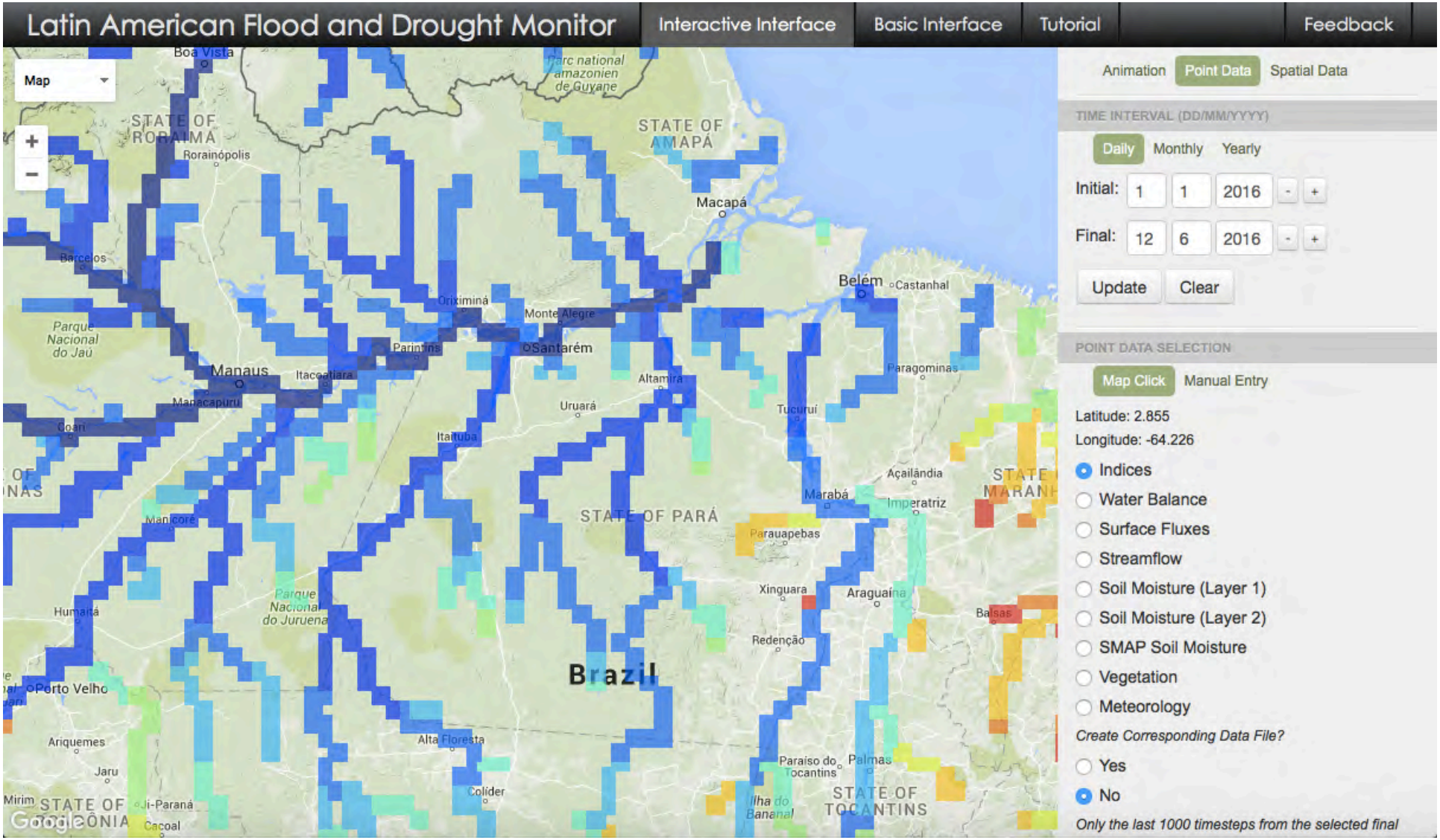
Interface: 7-day Forecast



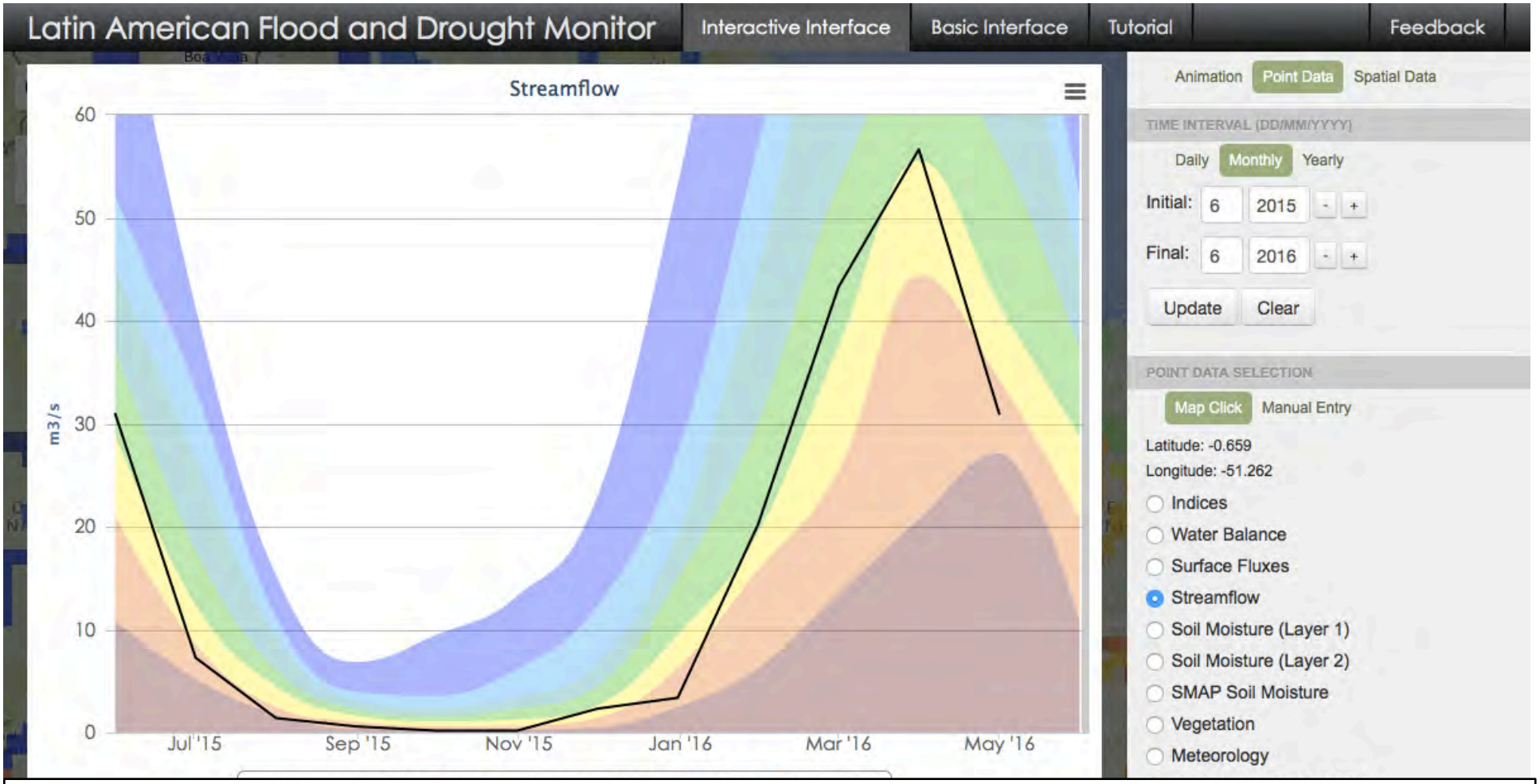
Interface: Seasonal Forecast



Point Data: Map Selection

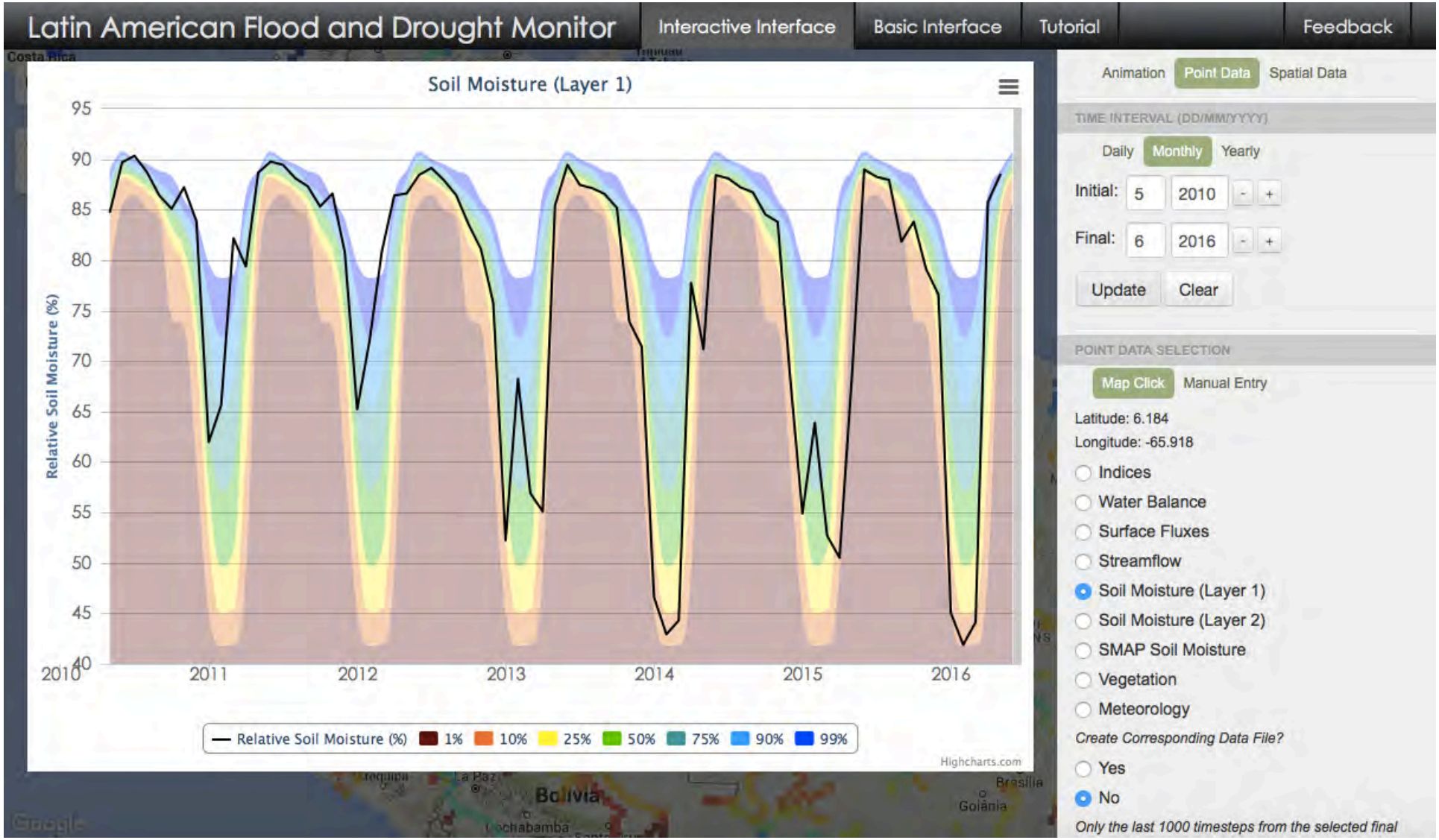


Point Data: Streamflow (Amazon River)

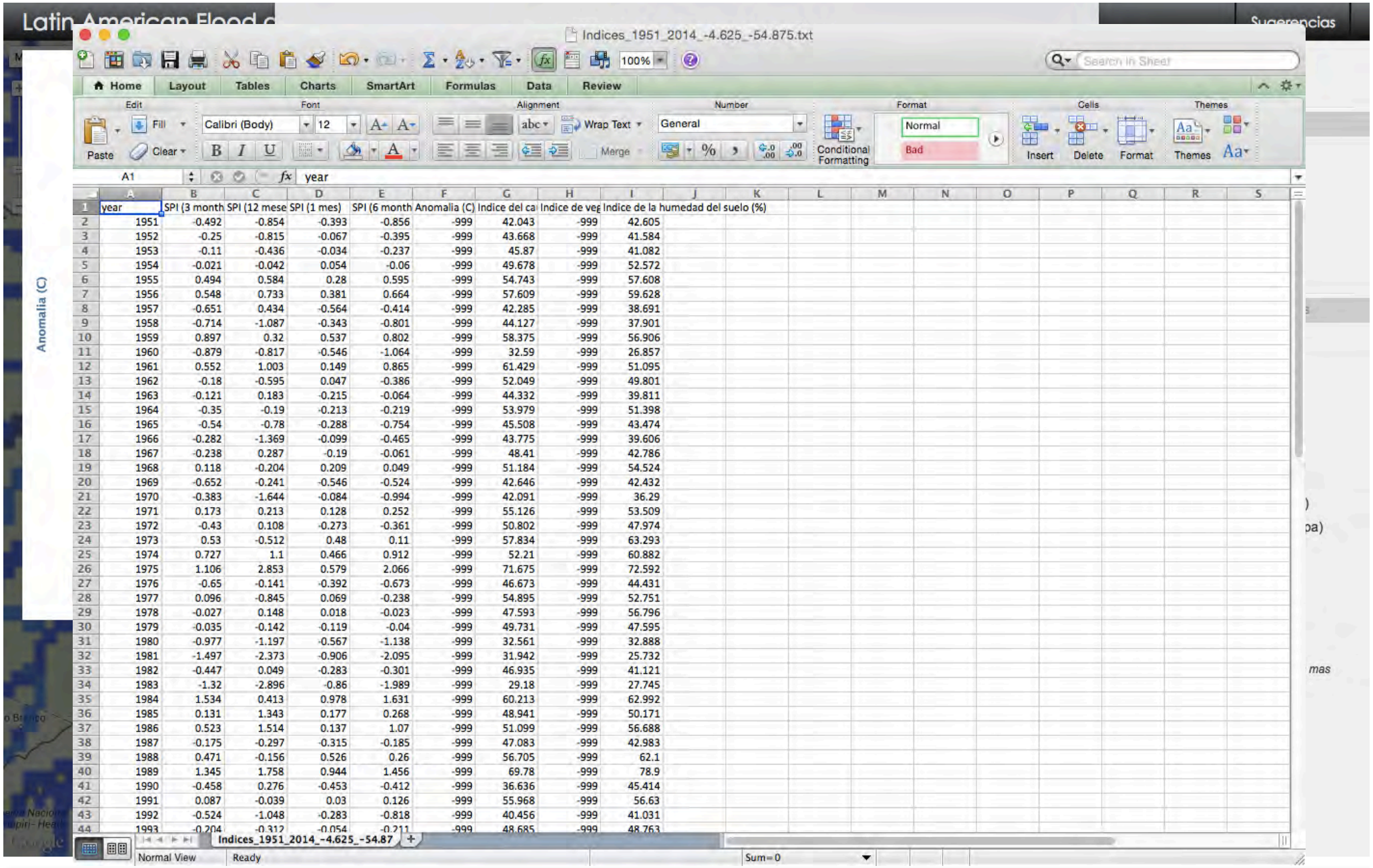


Streamflow Percentiles- Measure of the severity of hydrologic drought; low values indicate drought conditions.

Point Data: Soil Moisture (Venezuela)

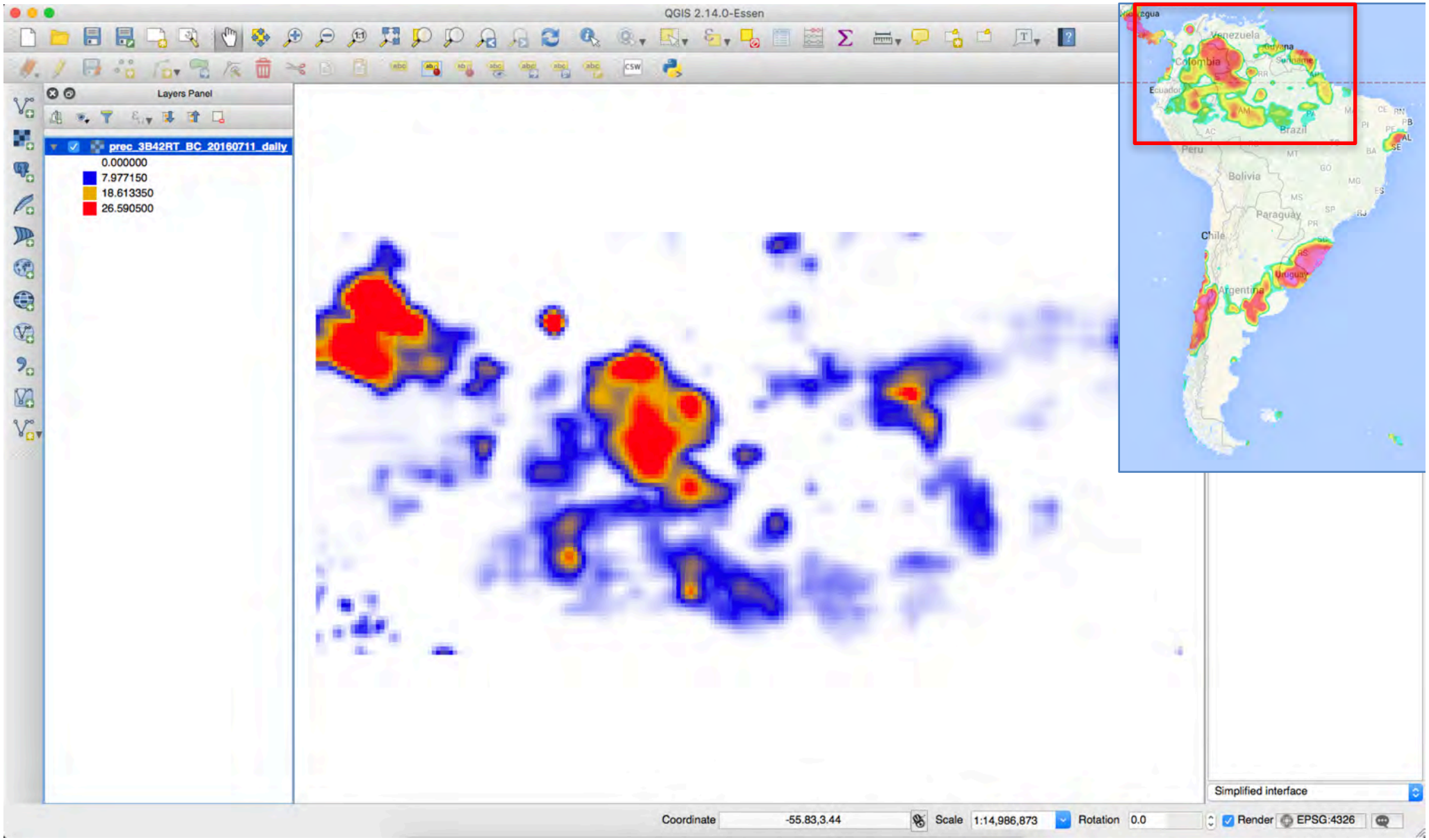


Point Data: Download

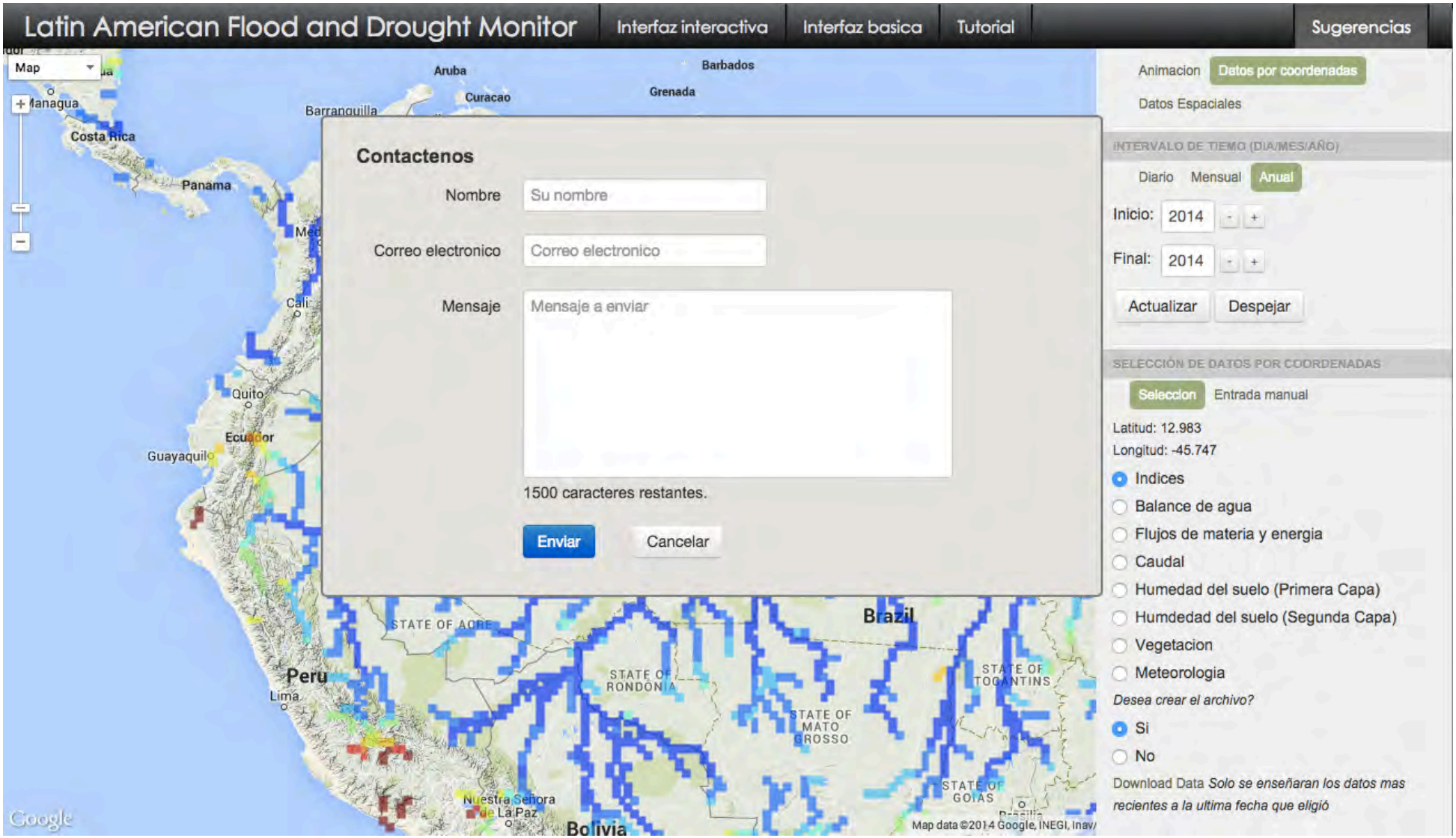


year	SPI (3 month	SPI (12 mese	SPI (1 mes)	SPI (6 month	Anomalia (C)	Indice del ca	Indice de veg	Indice de la humedad del suelo (%)
1951	-0.492	-0.854	-0.393	-0.856	-999	42.043	-999	42.605
1952	-0.25	-0.815	-0.067	-0.395	-999	43.668	-999	41.584
1953	-0.11	-0.436	-0.034	-0.237	-999	45.87	-999	41.082
1954	-0.021	-0.042	0.054	-0.06	-999	49.678	-999	52.572
1955	0.494	0.584	0.28	0.595	-999	54.743	-999	57.608
1956	0.548	0.733	0.381	0.664	-999	57.609	-999	59.628
1957	-0.651	0.434	-0.564	-0.414	-999	42.285	-999	38.691
1958	-0.714	-1.087	-0.343	-0.801	-999	44.127	-999	37.901
1959	0.897	0.32	0.537	0.802	-999	58.375	-999	56.906
1960	-0.879	-0.817	-0.546	-1.064	-999	32.59	-999	26.857
1961	0.552	1.003	0.149	0.865	-999	61.429	-999	51.095
1962	-0.18	-0.595	0.047	-0.386	-999	52.049	-999	49.801
1963	-0.121	0.183	-0.215	-0.064	-999	44.332	-999	39.811
1964	-0.35	-0.19	-0.213	-0.219	-999	53.979	-999	51.398
1965	-0.54	-0.78	-0.288	-0.754	-999	45.508	-999	43.474
1966	-0.282	-1.369	-0.099	-0.465	-999	43.775	-999	39.606
1967	-0.238	0.287	-0.19	-0.061	-999	48.41	-999	42.786
1968	0.118	-0.204	0.209	0.049	-999	51.184	-999	54.524
1969	-0.652	-0.241	-0.546	-0.524	-999	42.646	-999	42.432
1970	-0.383	-1.644	-0.084	-0.994	-999	42.091	-999	36.29
1971	0.173	0.213	0.128	0.252	-999	55.126	-999	53.509
1972	-0.43	0.108	-0.273	-0.361	-999	50.802	-999	47.974
1973	0.53	-0.512	0.48	0.11	-999	57.834	-999	63.293
1974	0.727	1.1	0.466	0.912	-999	52.21	-999	60.882
1975	1.106	2.853	0.579	2.066	-999	71.675	-999	72.592
1976	-0.65	-0.141	-0.392	-0.673	-999	46.673	-999	44.431
1977	0.096	-0.845	0.069	-0.238	-999	54.895	-999	52.751
1978	-0.027	0.148	0.018	-0.023	-999	47.593	-999	56.796
1979	-0.035	-0.142	-0.119	-0.04	-999	49.731	-999	47.595
1980	-0.977	-1.197	-0.567	-1.138	-999	32.561	-999	32.888
1981	-1.497	-2.373	-0.906	-2.095	-999	31.942	-999	25.732
1982	-0.447	0.049	-0.283	-0.301	-999	46.935	-999	41.121
1983	-1.32	-2.896	-0.86	-1.989	-999	29.18	-999	27.745
1984	1.534	0.413	0.978	1.631	-999	60.213	-999	62.992
1985	0.131	1.343	0.177	0.268	-999	48.941	-999	50.171
1986	0.523	1.514	0.137	1.07	-999	51.099	-999	56.688
1987	-0.175	-0.297	-0.315	-0.185	-999	47.083	-999	42.983
1988	0.471	-0.156	0.526	0.26	-999	56.705	-999	62.1
1989	1.345	1.758	0.944	1.456	-999	69.78	-999	78.9
1990	-0.458	0.276	-0.453	-0.412	-999	36.636	-999	45.414
1991	0.087	-0.039	0.03	0.126	-999	55.968	-999	56.63
1992	-0.524	-1.048	-0.283	-0.818	-999	40.456	-999	41.031
1993	-0.204	-0.312	-0.054	-0.211	-999	48.685	-999	48.763

Spatial Data: Selection, Download, and GIS



Interface: Feedback



Summary of Monitors' Capabilities

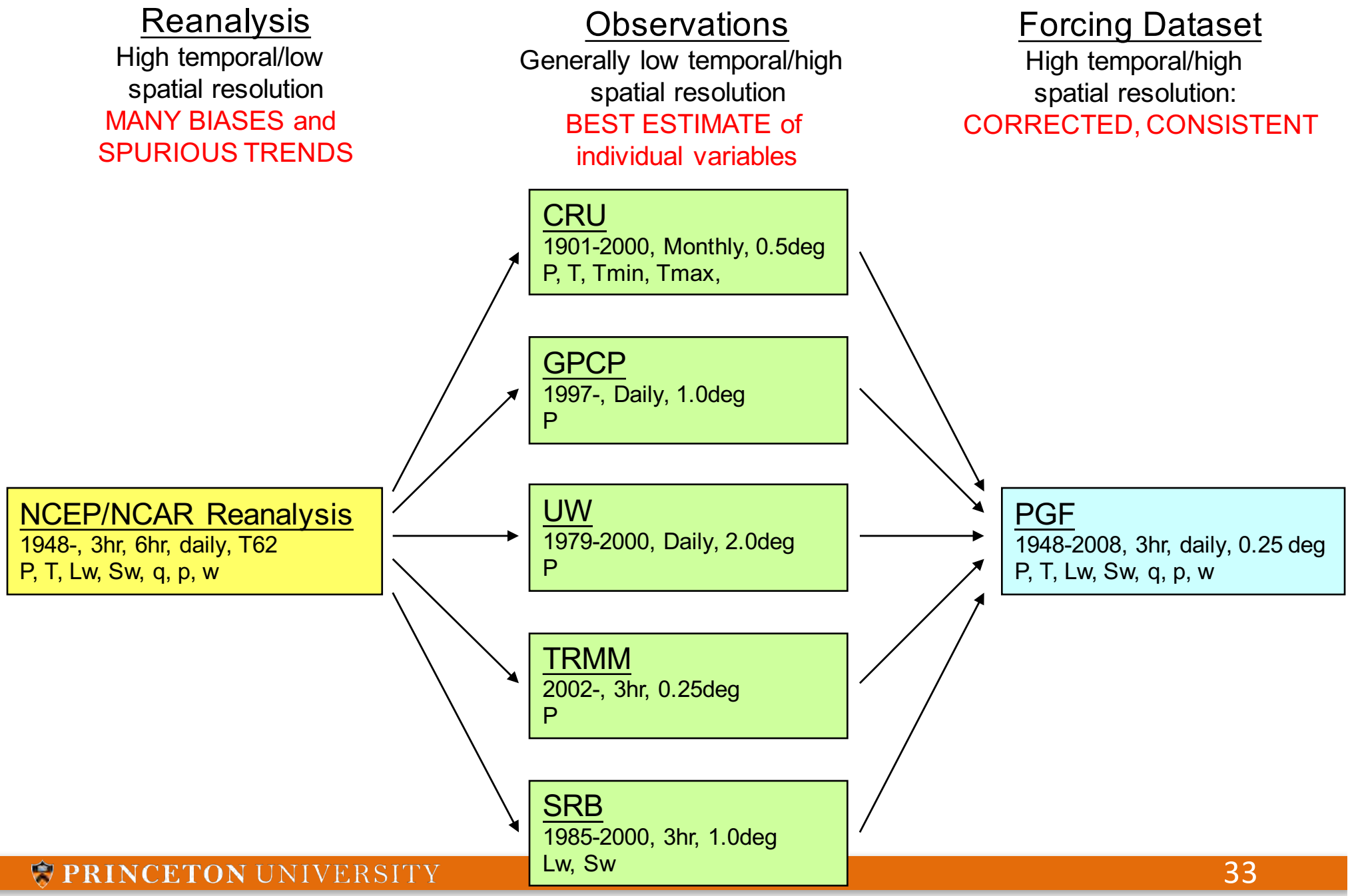
- Multiple Languages
- Short-Term Forecast (7 days)
- Seasonal Forecast (6 months)
- Standard Precipitation Index (SPI) and Drought Index
- Vegetation Monitoring (NDVI)
- Download point data
- Download spatial data
- Provide feedback

http://stream.princeton.edu

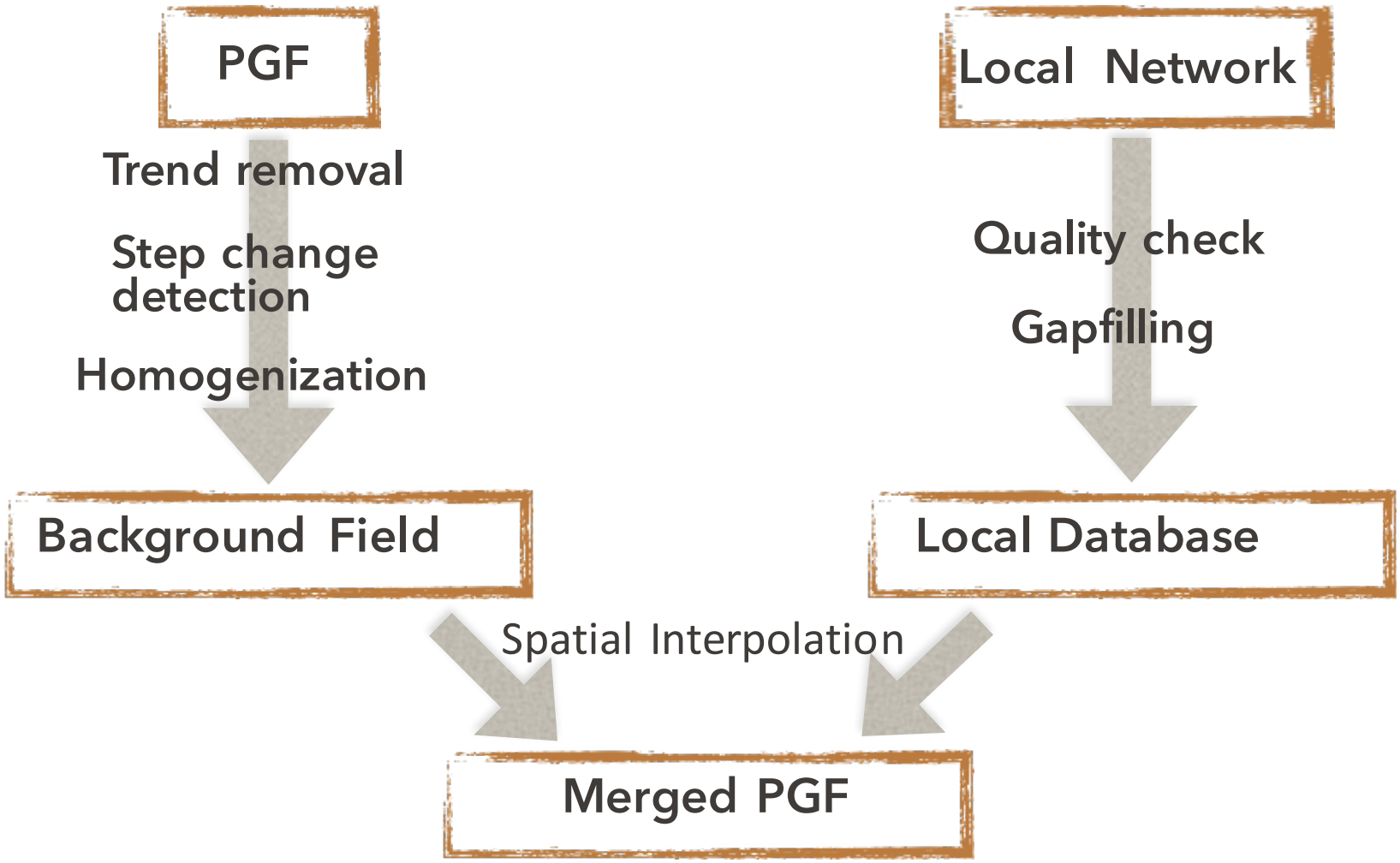
DATA SCIENCE AND HYDROLOGY BEHIND THE FLOOD AND DROUGHT MONITORS

Sources of precipitation data in the LACFDM
Validation of satellite precipitation
Merging *in-situ* and satellite data

Historical Meteorological Dataset

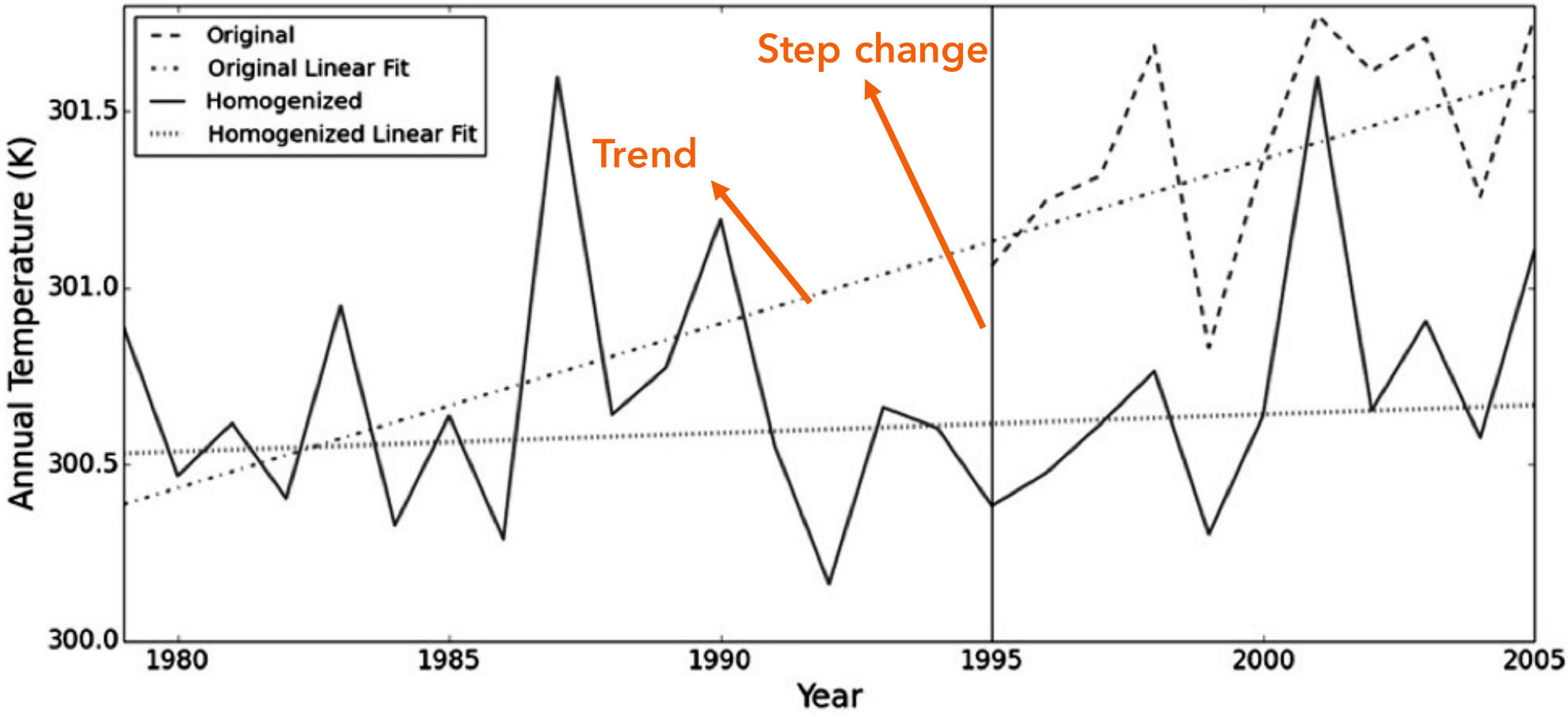


Sources of Meteorological Data



Detection and correction of temporal inhomogeneties

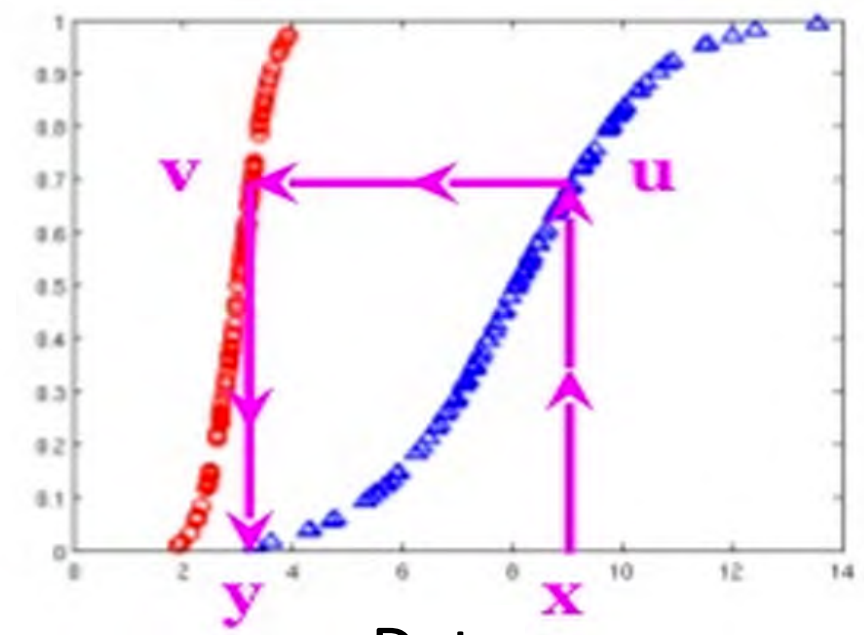
e.g. trends and step changes

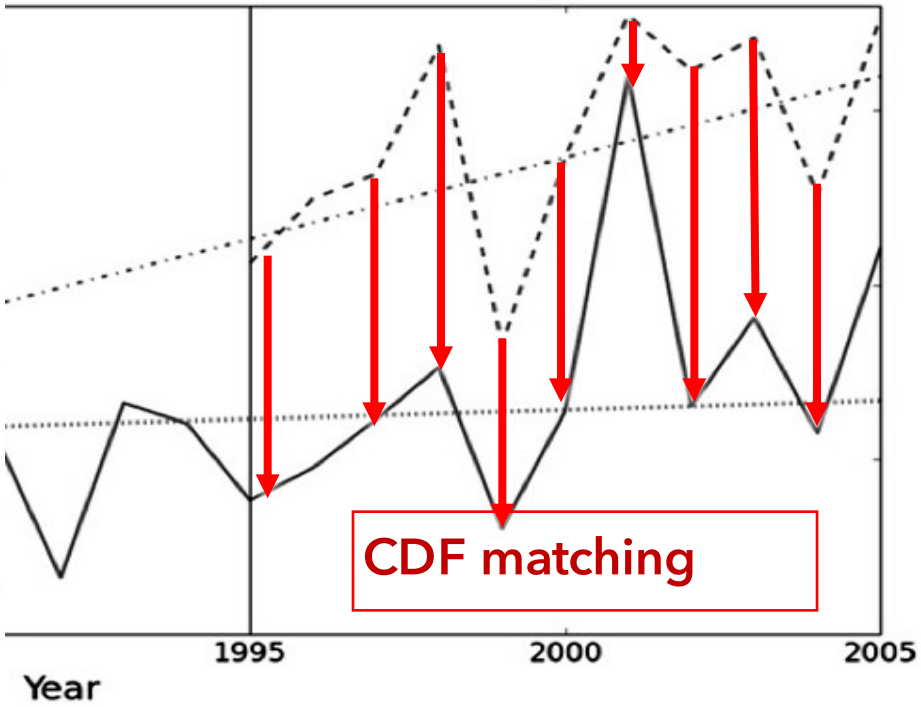


Detection and correction of temporal inhomogeneties

homogenization: cumulative distribution matching

CDF





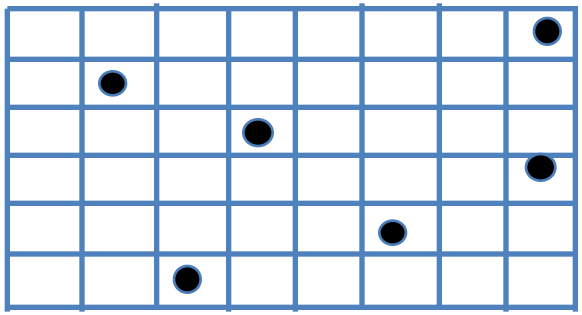
Methodology behind the statistical merging

X: 'correct' precipitation value; X_b: satellite background estimates;
X_a :the best estimate of the precipitation.

Satellite retrievals (pixel scales)
X_b + errors

In-situ gauge observations
$Y=H\,X$

Errors tend to be spatially correlated so that they have an exponential-type covariance structure: $C \sim e^{-\beta d}$, where d = distance between two points



Grid with locations of gauges (●)
H: a matrix of [0, 1] that maps where the gauges are located

Merge the estimate X_b with observations Y

Best statistical estimate will be X_a

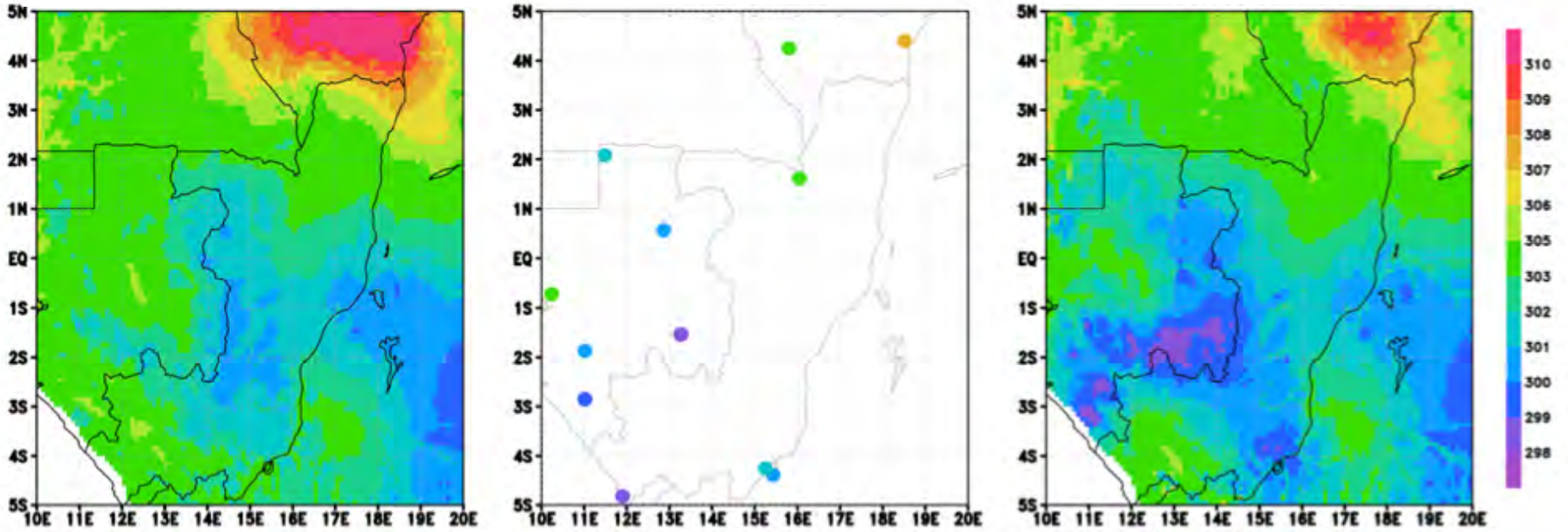
$$X_a = X_b + K\,(Y - H\,X_b)$$
$$\text{with the weights: } K = CH^T(HCH^T)^{-1}$$

Sub-Saharan Africa (Chaney et al., 2014)

- Merging station data:

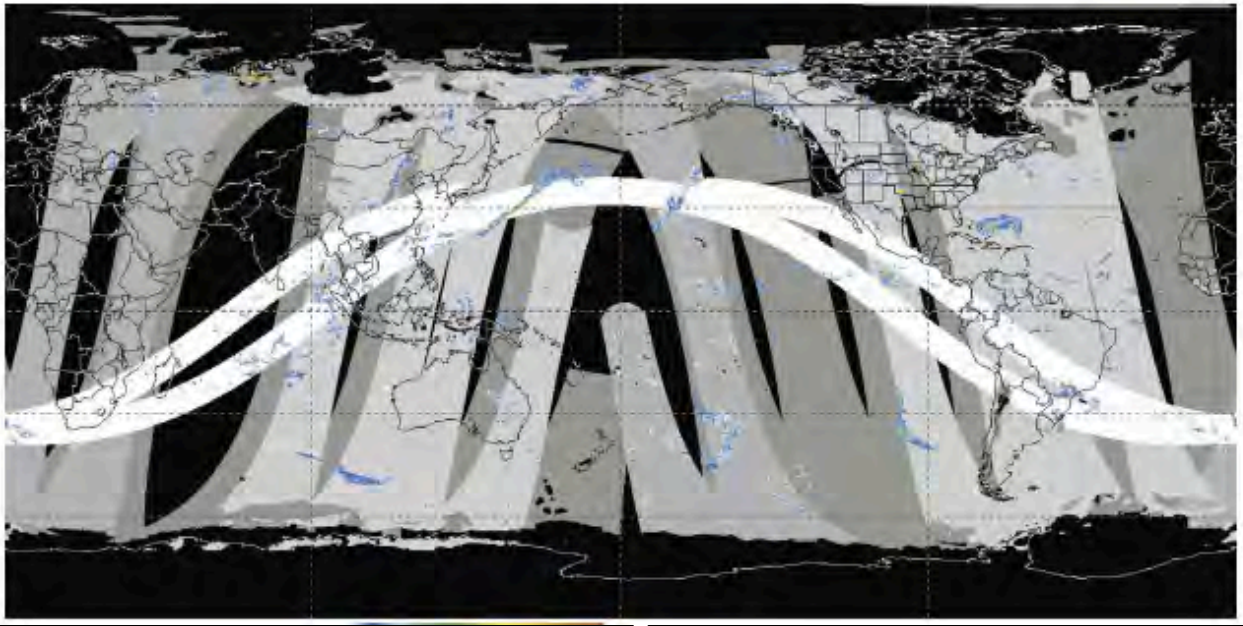
Daily maximum temperature correction in the Gabon region in Central Africa on Feb 01 2000

Background field **Observation** **Corrected field**



Realtime Satellite Precipitation - TMPA (Example)

TMPA – TRMM Multi-Satellite Precipitation Analysis



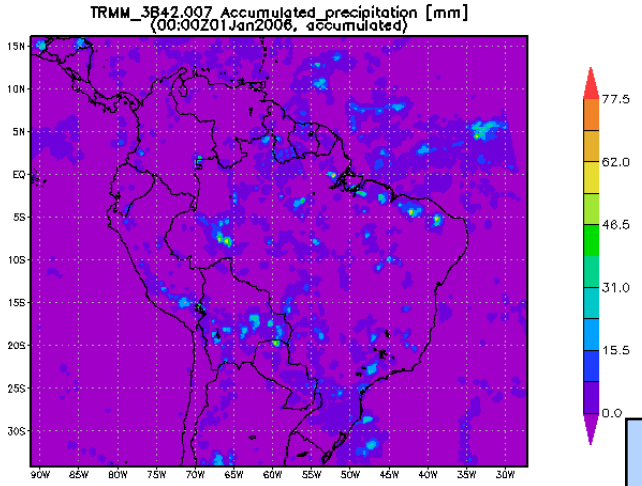
3-hour period centered at 0000 UTC 25 May 2004
- Different Sources:
  - TMI (white)
  - SSM/I (light gray)
  - AMSR-E (medium gray)
  - AMSU-B (dark grey)

A diverse, growing set of <u>input precipitation estimates</u> – various
- periods of record
- regions of coverage
- sensor-specific strengths and limitations

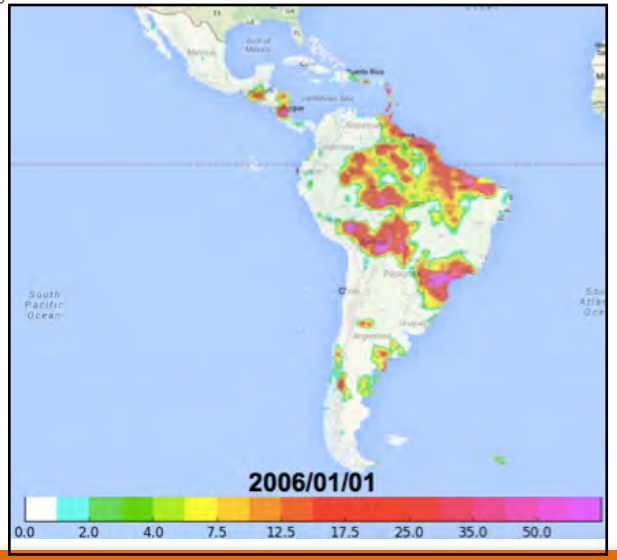
Real-Time Meteorological Data: Satellite Precipitation

Monitor uses TRMM 3B42v7 daily precipitation estimates, bias corrected against the historical climatology

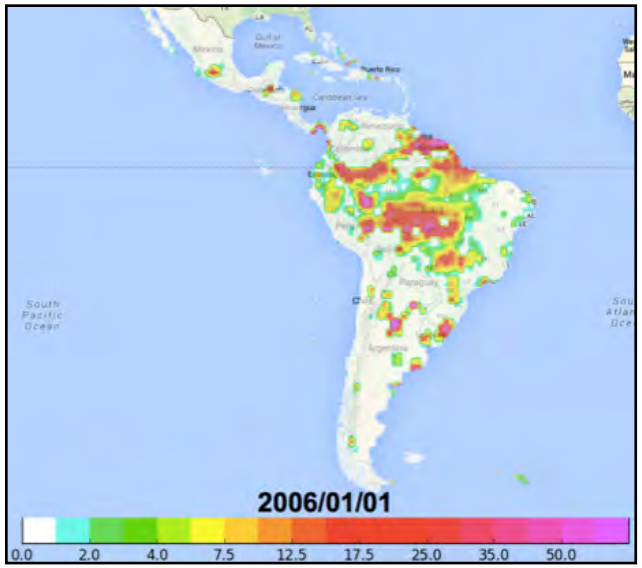
TRMM



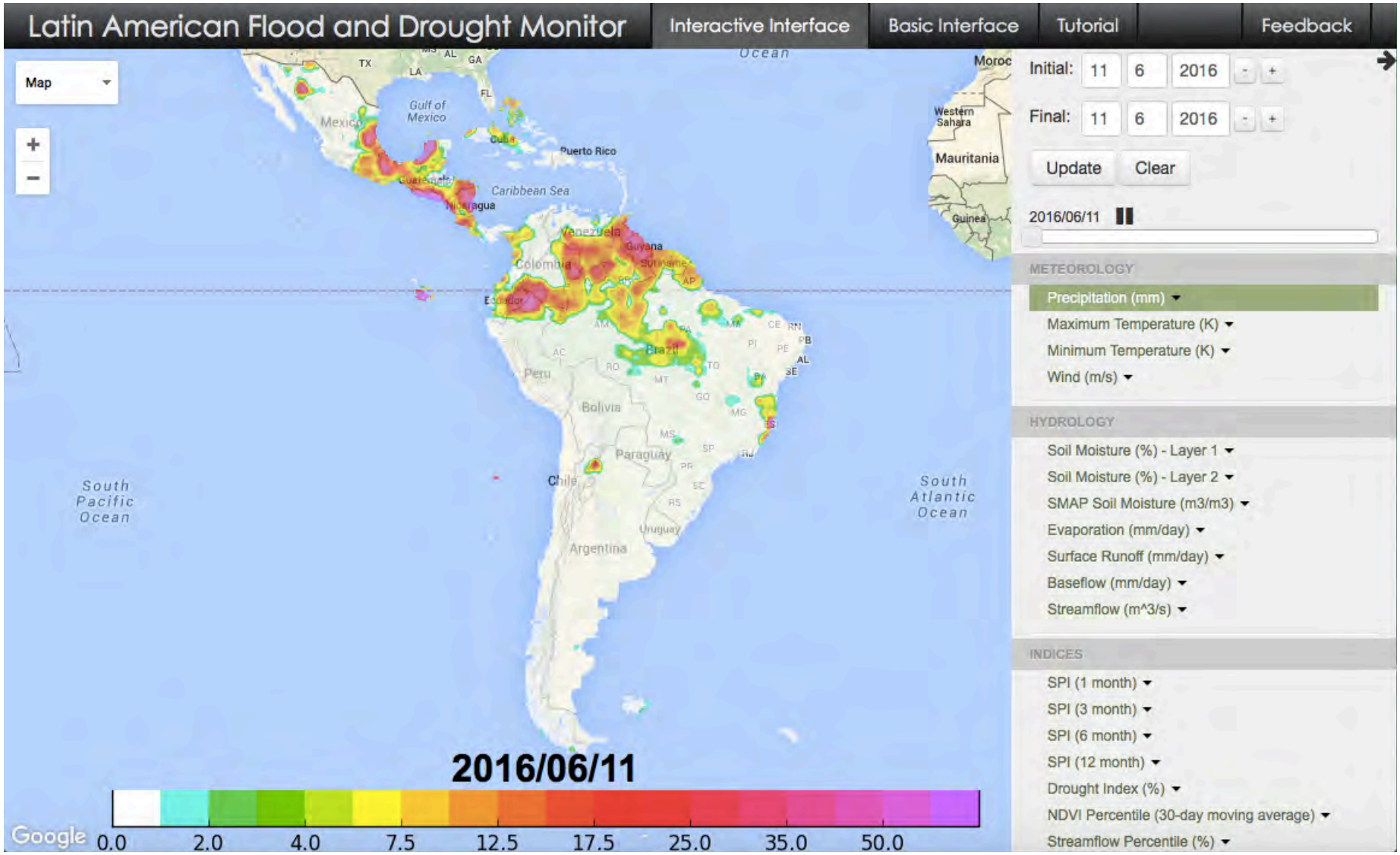
Bias Corrected



PGF

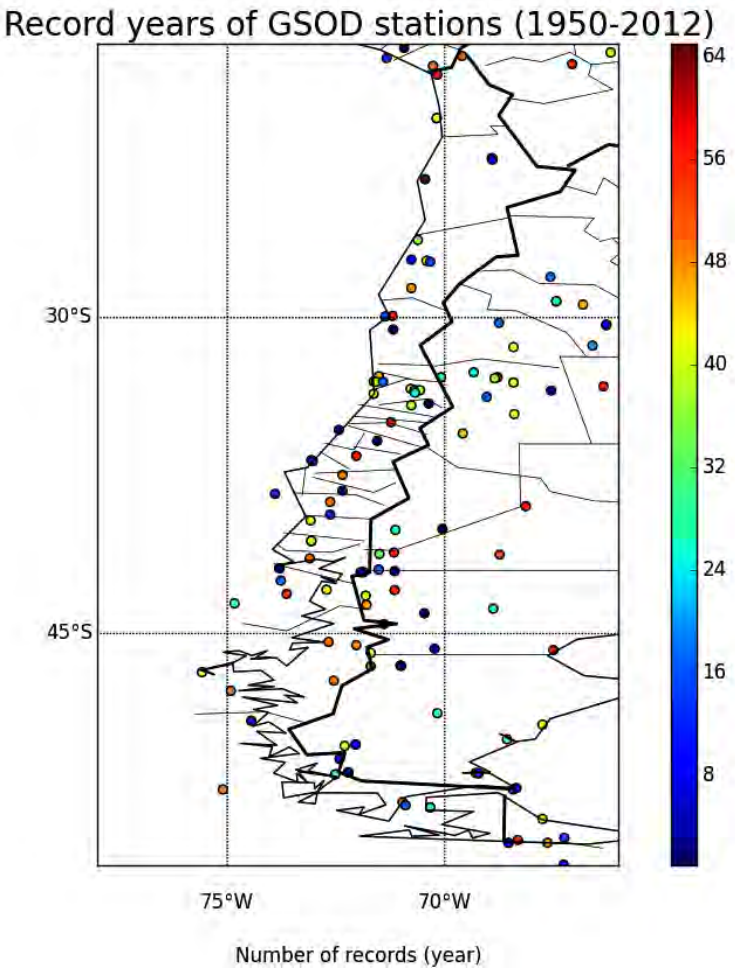


Bias corrected precipitation

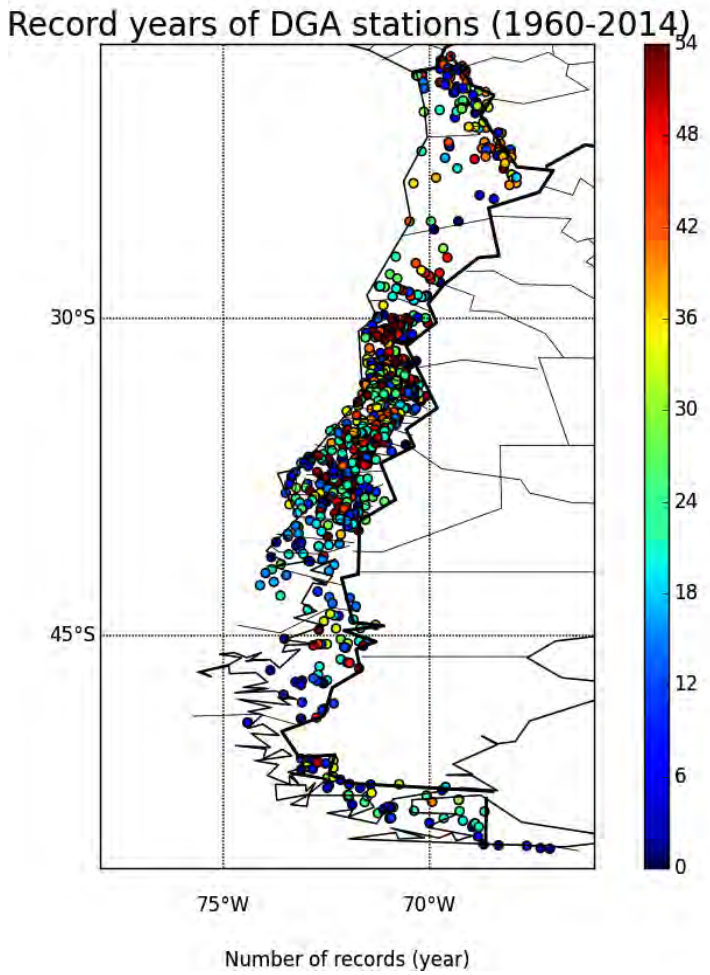


Create a merged station database:

GSOD and DGA (Chile)



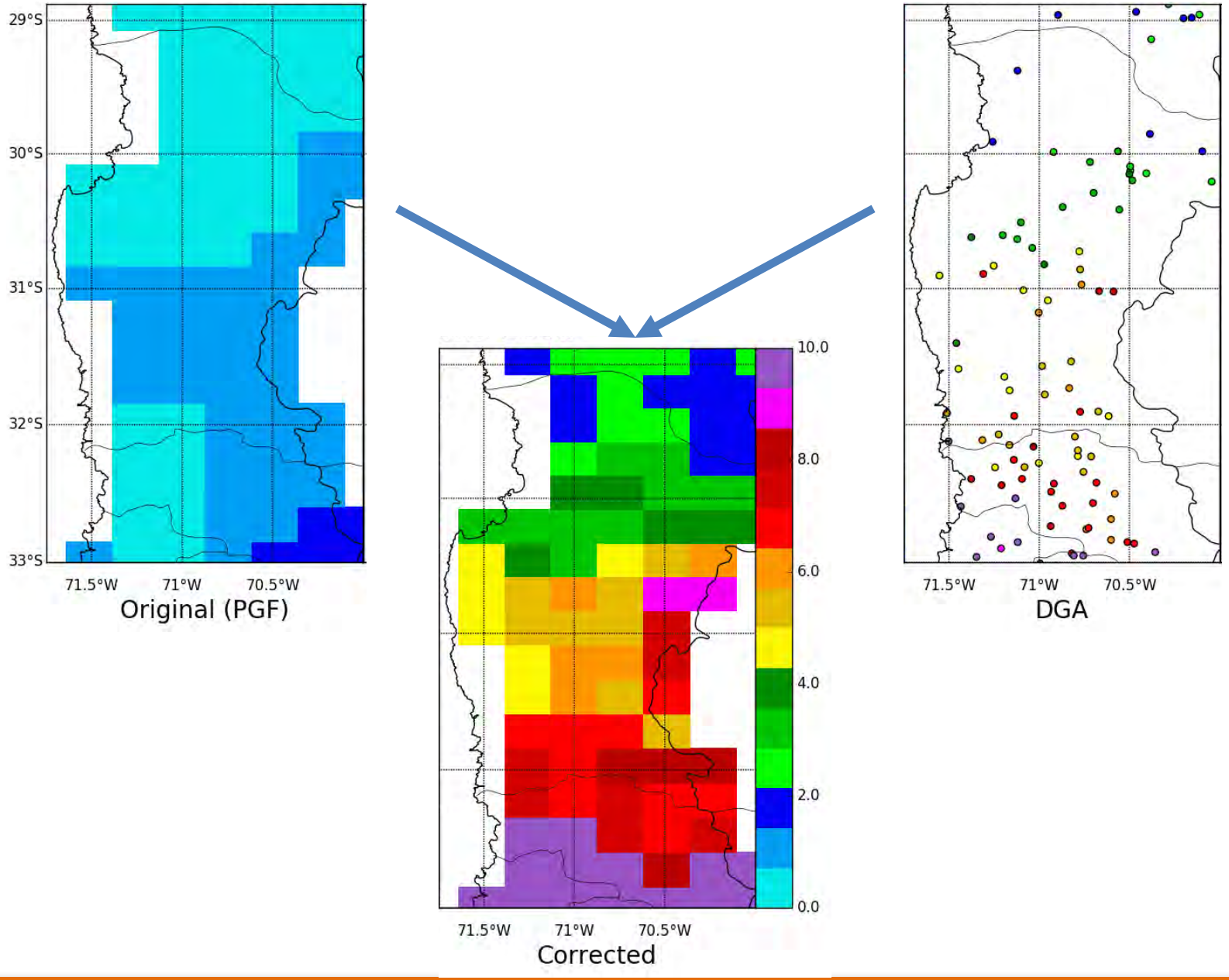
128 stations within the domain



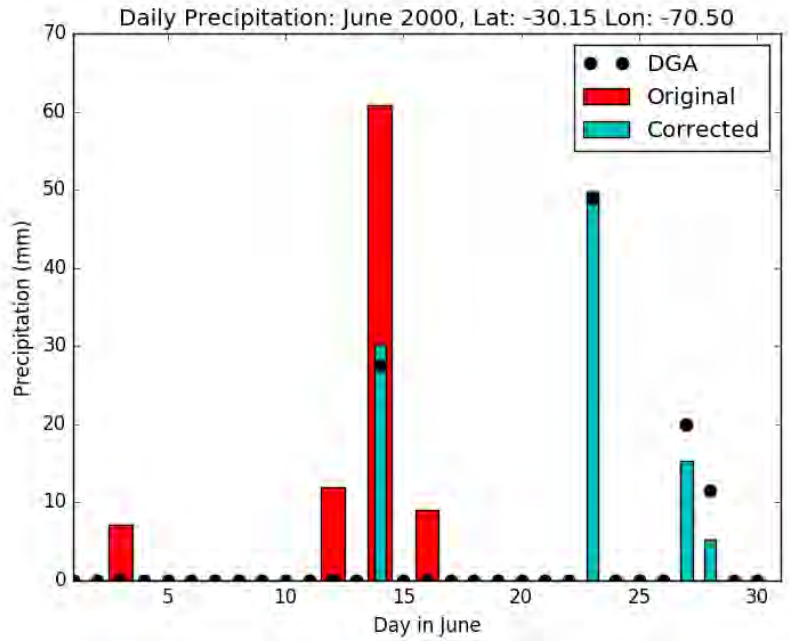
723 stations

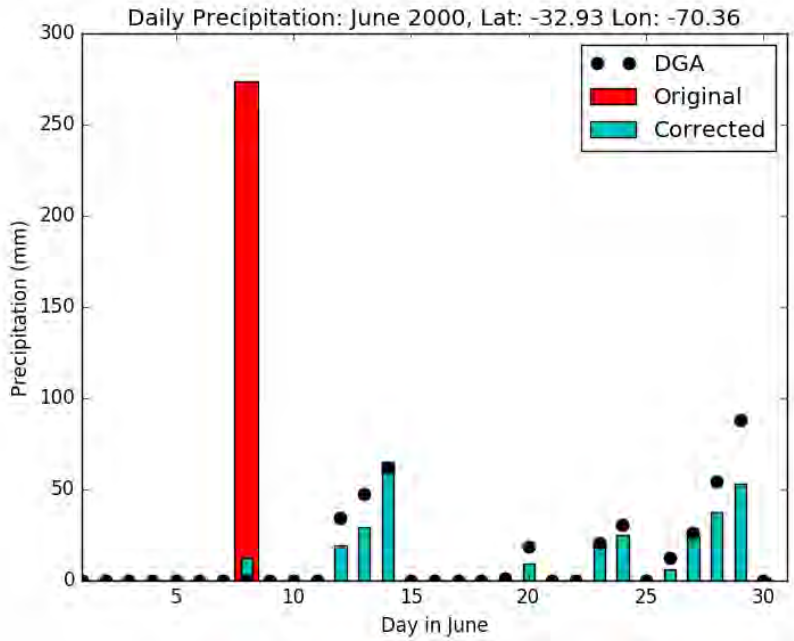
Merging Station Data:

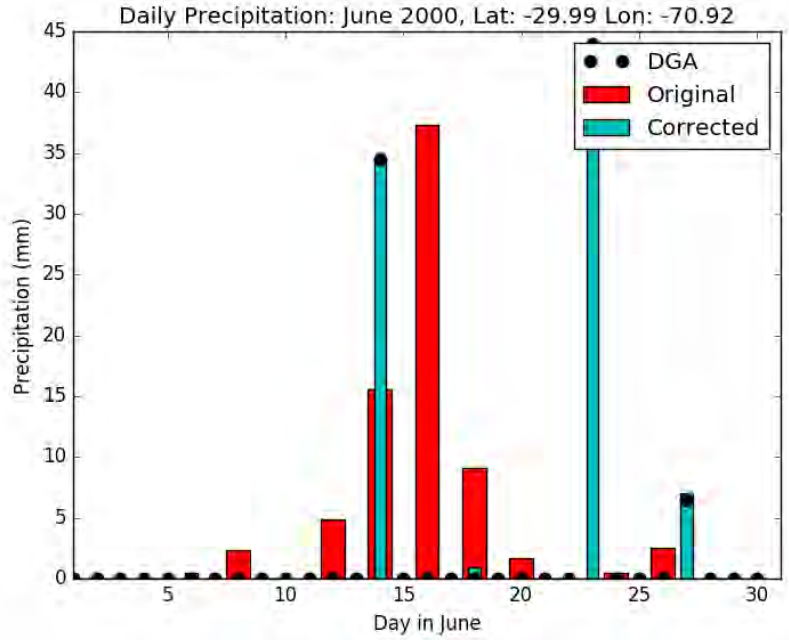
Daily precipitation in Central Chile on Jun 1 2000

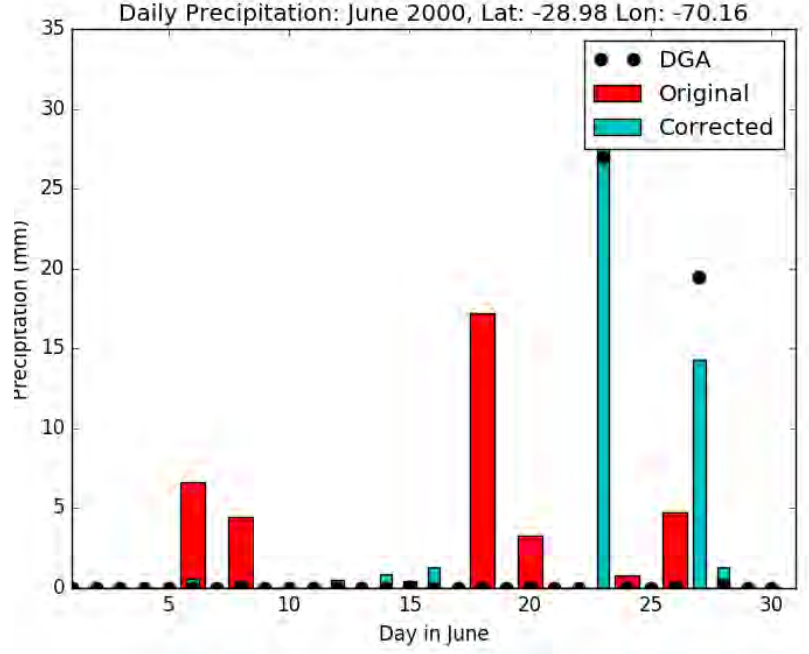


Merging Station Data: Timeseries









Validation and Merging Example

- Download Station Data from:

  http://www.cazalac.org/mwar_lac/index.php?id=129

- Use LAFDM to download data for one station

- Compare time series:
  - 2008 – PGF
  - 2009 – TMPA v7 3B42RT

- Consider the bias, number of rain days

- Download and compare other sites

- Example of merging all stations with gridded dataset

Thank you for your attention!
Questions or comments?