# Data Analytics for Climate Change Impacts on Contaminated sites



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#### **Climate Resilience**

Climate resilience is defined as the capacity of an individual site to perform according to its regulatory requirements while impacted by potential stresses imposed by climate variability, weather extremes, and related impacts projected by future climate scenarios.



### GAO Report, DOE CARP/VARP

#### May 2020

#### ENVIRONMENTAL LIABILITIES

DOE Needs to Better Plan for Post-Cleanup Challenges Facing Sites



Highlights of GAO-29-373, a report to the Committee on Armed Services, U.S. Senate

#### Why GAO Did This Study

After over 70 years of nuclear weapons production and energy research at hundreds of sites across the country DOE faces over \$500 billion in environmental liabilities associated with cleanup of hazardous contamination and long-term management of these sites. LM is responsible for the portion of these labilities associated with long-term management of sites after active cleanup has been completed. LM oversees 100 sites across the country Depending on the sites' clean-up standards and intended reuse, LM will likely be managing some sites for centuries.

#### What GAO Recommends

GAO is making three recommendations, including that DOE develop agreements and procedures for circumstances that require new cleanup work and that it develop plans to assess and to mitigate the effects of climate change on its sites. DOE agreed with all three recommendations. "The Secretary of Energy should direct the Director of LM to develop plans to assess the effect of climate change on LM's sites and to mitigate any significant impacts. These plans should incorporate principles from GAO's Disaster Resilience Framework, as appropriate."

#### 2021 Climate Adaptation and Resilience Plan



Report to the White House National Climate Task Force and Federal Chief Sustainability Officer August 2021

#### VULNERABILITY ASSESSMENT AND RESILIENCE PLANNING GUIDANCE

THIS GUIDANCE OUTURES & QUARTE CHARGE VIOLANDABLEY ADDRESS AND RESULTACE PLANNING INCLUSS TO HELP THE DEPARTMENT OF IDENTIFIA ADDRESS AND MANAGE CUARTE CHARGE RELATIO RESIS TO DEPARTMENT AL ADDRESS AND CHARGE STATUS DEPARTMENT OF ENERGY, SUSTAINABILITY PERFORMANCE DIVISION

## **Climate-resilience Python Package**

The goals are to:

- 1. Aid the long-term climate resilience and vulnerability assessment for soil and groundwater-contaminated sites.
- 2. Simplify the process of downloading, preprocessing, and visualizing spatial and temporal information regarding different sites across the US.
- Formal documentation supplements the package with an easy-to-use resource with sample scripts and notebooks to demonstrate its usage.
- It can easily be installed using `pip` python package manager.

PyPI: https://pypi.org/project/climate-resilience/

Documentation: <u>https://climate-resilience.readthedocs.io/en/latest/introduction.html</u> GitHub: <u>https://github.com/ALTEMIS-DOE/climate-resilience</u> The package used Google Earth Engine to download the CMIP5 climate model dataset.

Requires a download configuration where the following configuration variables can be specified to download subset of data:

- 1. Variables
- 2. Models
- 3. Scenarios
- 4. Date range



Google Earth Engine

## **Climate Projection Data in Resilience Assessment**

#### CMIP5 climate model dataset

- CMIP: Climate Model Inter-comparison Project model ensembles for supporting IPCC (Intergovernment Panel for Climate change) reports
- 50+ Global Climate Models simulation (1950-2100) from 10+ world-wide institutes are ensembled
- Four RCP (Representative Concentration Pathway) scenarios are analyzed for different warming conditions, including RCP2.6 (requires GHG emission start declining at 2020 and go to zero by 2100), RCP4.5, RCP6.0, and RCP8.5 (GHG continue to rise through the 21st century)

#### List of Climate Disturbance Factors:

- Precipitation (total/extreme precipitation)
- Temperature
- Drought and wildfire index
- Flooding
- Groundwater analysis



## **Climate Data Pipeline and Assessment Workflow**







## **Preprocess/Visualization**

- Computation of climate metrics, for example, the number of extreme precipitation days and extreme degree days.
- Integrate external datasets, such as the Standardized Precipitation Evapotranspiration Index (SPEI),
- Provide effective visualization and integrated insights for long-term drought analysis.
- Include the bias-correction pipeline to use meteorological measurements to improve climate projection. Map visualization noteboo





Box plot visualization notebook



Below is a screenshot of boxplot of annual precipitation in different regions of the United States.

### **Annual Average Temperature: All Sites**



Average over the past 56 years (1950-2006)







## **Annual Total Precipitation: All Sites**



#### Average over the past 56 years (1950-2006)



## **Extreme Precipitation**

- EPA definition: "Extreme precipitation events are defined as days with precipitation in the top 1% of all days having recordable precipitation."
- "Number of extreme precipitation days" is computed by counting precipitation greater than the threshold, set as 99th percentile of precipitation in the historical period.



## **Extreme Precipitation Days: All Sites**



### Annual Average SPEI: All Sites

Projected SPEI (2015-2100) based on historical climatological dataset (1981-2014)



#### Intensive Site Assessment: EM SRS

Datasets are publicly available at: <u>https://github.com/ALTEMIS-DOE/EM\_climate\_data</u>

	hist_mean	hist_std	rcp45	rcp85	shifting_rcp45	shifting_rcp85
Annual precipitation (mm/day)	3.24	0.14	3.52	3.58	Medium	High
Extreme precipitation day	2	0.74	2.48	3.17	Low	Medium
Annual avg Tmax (C)	24.79	0.31	26.63	27.5	High	High
Maximum Daily Precipitation (mm/day)	61.79	11.22	67.11	75.09	Low	Medium
Drought Index (SPEI)	-0.01	0.3	0.15	0.22	Negative	Negative
Wildfire (CFWI)	7.24		9.18	7.93	Low	Low

#### https://github.com/ALTEMIS-DOE/LM climate data



Since this is a tool to aid the research and analysis of site data for climate resilience strategies,

it is expected to grow as new useful concepts come into the picture.

In terms of functionalities, two main features are being developed:

- Bias Correction
- Probable Maximum Precipitation (PMP)

In terms of efficiency, the download pipeline can be optimized by resorting to alternate sources for data instead of Google Earth Engine.

This toolkit has been used for developing the **Climate Adaptation and Resilience Plan (CARP)** and the **Vulnerability Assessment and Resilience Planning guidance (VARP)** for the 118 DOE Office of Legacy Management and Environmental Management sites.

PyPI: <u>https://pypi.org/project/climate-resilience/</u> Documentation: <u>https://climate-resilience.readthedocs.io/en/latest/introduction.html</u> GitHub: <u>https://github.com/ALTEMIS-DOE/climate-resilience</u> Thank you!