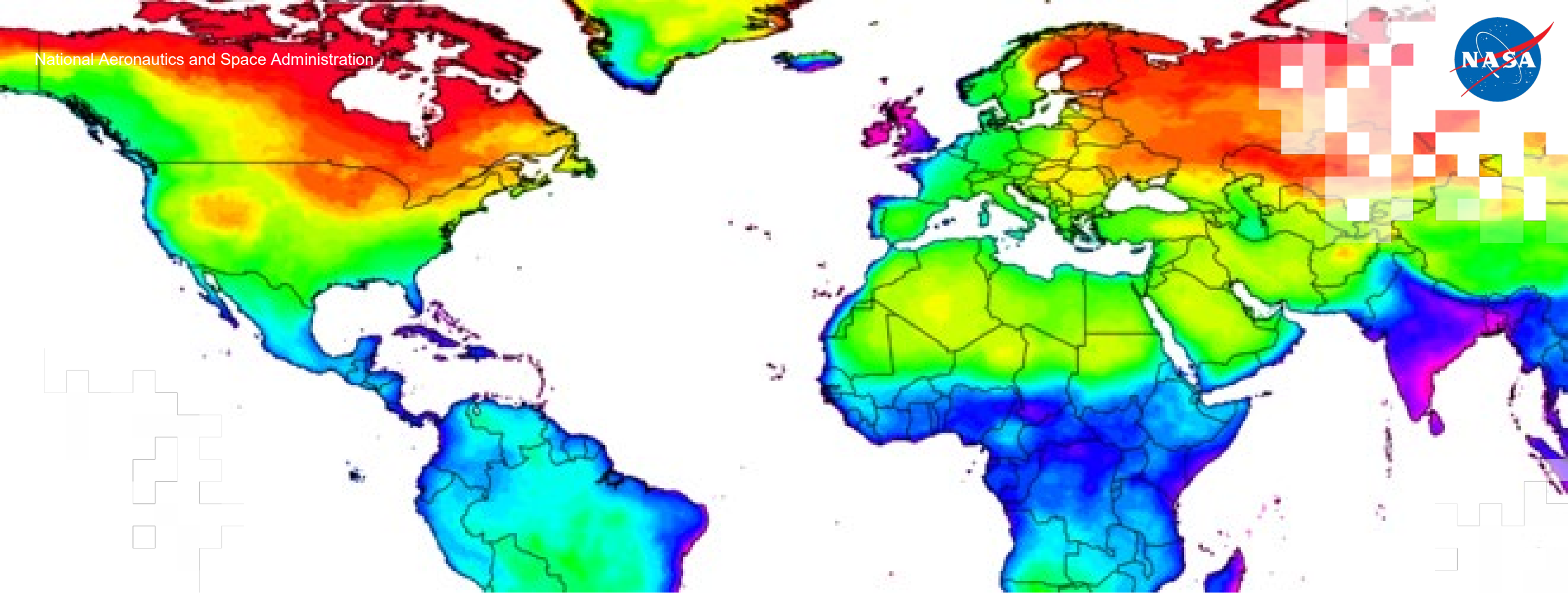


Assessing Extreme Weather Statistics using NASA Earth eXchange Global Daily Downscaled Projections Coupled Model Intercomparison Project Phase 6 (NEX-GDDP-CMIP6)

Part 2: Extreme Event Statistics during 21st Century using NEX-GDDP Data

Amita Mehta (612, GESTAR II), Hugo Kyo Lee (NASA JPL), Alexander Goodman (NASA JPL), Aashish Panta (University of Utah)

September 17, 2025

Part 1 Review: NEX-GDDP-CMIP6

- **NASA Earth eXchange (NEX)**
  - Collaborative supercomputing and data analytics platform to improve availability of Earth science data from NASA missions and models
- **Downscaling**
  - Process that transforms coarse-resolution climate model data into high-resolution—suitable for regional and local impact studies
  - Two types of downscaling: dynamical and statistical
- **NEX-GDDP-CMIP6**
  - Statistically downscaled output from 35 of CMIP6 models at daily global ¼-degree output
  - Four SSPs (2.5, 4.5, 7.0, 8.5) from 2015 to 2100
  - Created using two-step methodology: bias correction and spatial disaggregation

Part 1 Review: Data, Access, and GEE Demonstration

- **Nine Daily Downscaled Variables:**
  - Relative and specific humidities
  - Precipitation
  - Surface downwelling longwave and shortwave radiation
  - Near-surface wind speed
  - Minimum, maximum, and average temperatures
  - One file for each year (2015–2100) per variable
- **Where can GDDP be accessed?**
  - NASA Center for Climate Simulation
  - Amazon Web Services
  - Google Earth Engine (GEE)

- **GEE Analysis using JavaScript Codes:**
  - Annual mean and time series (2020–2100) surface air temperature and precipitation in Nebraska (USA)
  - Extreme cold and hot event frequencies
  - Extreme dry and wet event frequencies

Training Outline

Part 1

NEX-GDDP-CMIP6 Overview, Data Access and Application using Google Earth Engine

September 10, 2025

Part 2

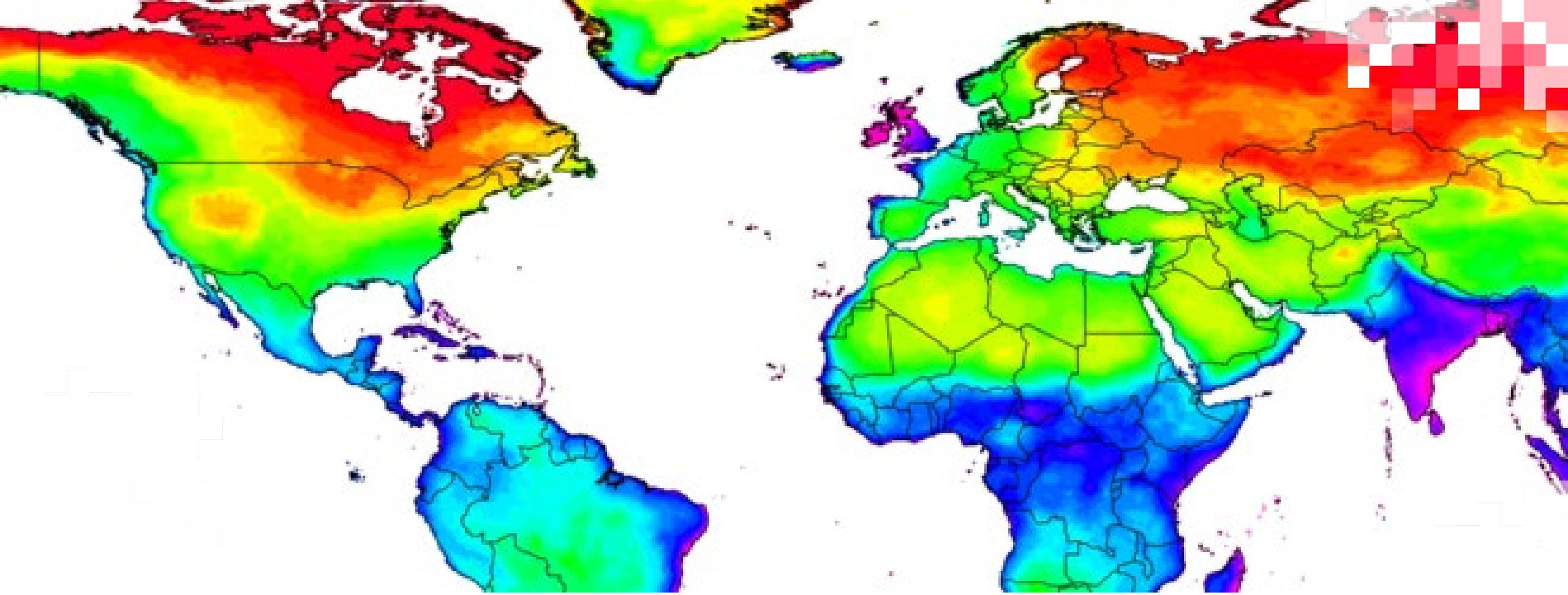
Extreme Event Statistics during 21st Century using NEX-GDDP Data

September 17, 2025

Homework

Opens September 17 – Due October 17 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.



Part 2: Extreme Event Statistics During the 21st Century using NEX-GDDP Data

Part 2 Objectives

By the end of Part 2, participants will be able to:

- Use given Python/Jupyter Notebook code for GDDP data access and spatial/temporal customization.
- Recognize how to calculate frequency and intensity of extreme hot/cold and dry/wet events for a region of interest using the Python/Jupyter Notebook code.
- Identify changes in the extreme event statistics over the 21st century for a region of interest.
- Visualize maps of key variables for a region of interest using NEX-GDDP Dashboard.

Part 2 Outline

Introduction: Computing Environment for Part 2

- **Topic:** Accessing and running analysis scripts using BinderHub.
- **Presenter:** Alex Goodman (JPL)

Data Access Option 1: Amazon Web Service (AWS)

- **Topic:** Finding and downloading NEX-GDDP-CMIP6 NetCDF files from AWS cloud storage to a local disk.
- **Presenter:** Hugo Kyo Lee (JPL)

Data Access Option 2: Streamlining Data Loading

- **Topic:** Introduction to the intake catalog for efficient handling of NEX-GDDP-CMIP6 data.
- **Presenter:** Aashish Panta (University of Utah)

Hands-on Lab: Calculating Climate Indices

- **Activity 1:** Run scripts to calculate ETCCDI* indices (e.g., TXx, TNn, PRCPTOT) from the downloaded data.
- **Activity 2:** Analyze and visualize the calculated indices for a specific region of interest.
- **Discussion:** Interpreting trends and patterns in the results.
- **Interactive dashboard:** Aashish Panta (University of Utah)

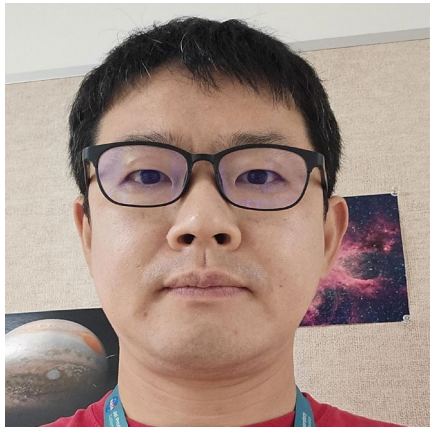
* Expert Team on Climate Change Detection and Indices

How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

Part 2 Trainers and Contributors

Hugo Kyo Lee
Data Scientist
NASA JPL



Alexander Goodman
Data Scientist
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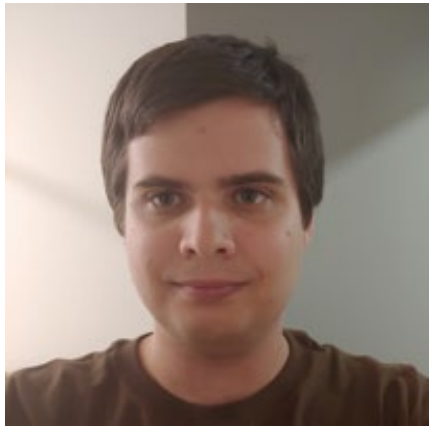
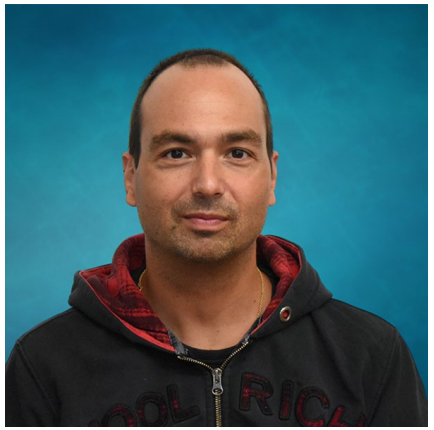


Aashish Panta
Graduate Student
University of Utah

Valerio Pasucci
Founding Director (CEDMAV)
University of Utah

Giorgio Scorzelli
Director, Software Development, University of Utah



CEDMAV: Center for Extreme Data Management Analysis and Visualization

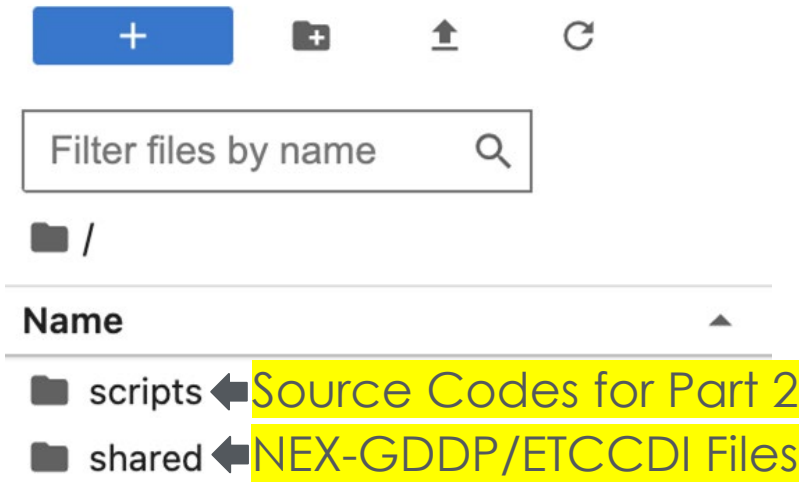
Computing Environment for Part 2

What is Binder Hub?

- A web service that turns a source code repository (such as GitHub) into a live, executable environment

Why are we using it?

- You can run in your web browser, avoiding complex local setup.
- **Consistency & Reproducibility:** Everyone has the exact same software and libraries.
  http://ocw-jpl.org/v2/gh/aashishpanta0/nasa-arset-training/HEAD
  (You can find the link in the Webex chat window.)



Data Access Option 1: Amazon Web Service (AWS)

- **NEX-GDDP-CMIP6 NetCDF files are stored in an AWS S3 bucket.**
- https://registry.opendata.aws/nex-gddp-cmip6/

Registry of Open Data on AWS aws

NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6)

air temperature | climate | climate model | climate projections | CMIP6 | cog | earth observation | environmental | global | model | NASA Center for Climate Simulation (NCCS) | near-surface relative humidity | near-surface specific humidity | netcdf | precipitation

Description

The NEX-GDDP-CMIP6 dataset is comprised of global downscaled climate scenarios derived from the General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 6 (CMIP6) and across two of the four "Tier 1" greenhouse gas emissions scenarios known as Shared Socioeconomic Pathways (SSPs). The CMIP6 GCM runs were developed in support of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6). This dataset includes downscaled projections from ScenarioMIP model runs for which daily scenarios were produced and distributed through the Earth System Grid Federation. The purpose of this dataset is to provide a set of global, high resolution, bias-corrected climate change projections that can be used to evaluate climate change impacts on processes that are sensitive to finer-scale climate gradients and the effects of local topography on climate conditions.

Update Frequency

No future updates planned.

Resources on AWS

Description
The NEX-GDDP-CMIP6 archive. Files are in NetCDF format with the CF-1.7 metadata conventions.

Resource type
S3 Bucket

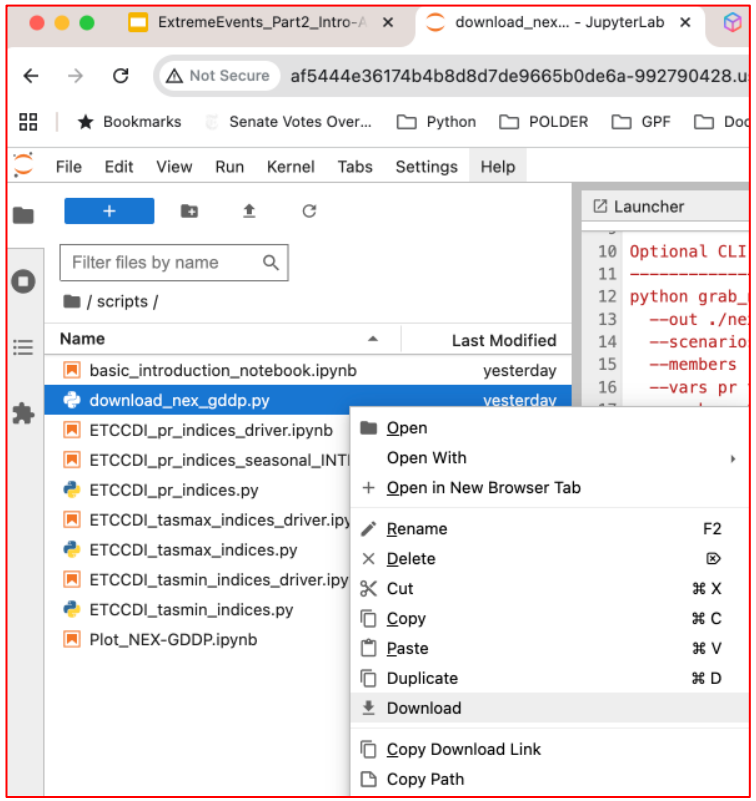
Amazon Resource Name (ARN)
`arn:aws:s3:::nex-gddp-cmip6`

AWS Region
`us-west-2`

AWS CLI Access (No AWS account required)
`aws s3 ls --no-sign-request s3://nex-gddp-cmip6/`

Explore
Browse Bucket

1. Go to scripts folder
2. Download: 'download_nex_gddp.py'



Data Access Option 2: Streaming NEX-GDDP

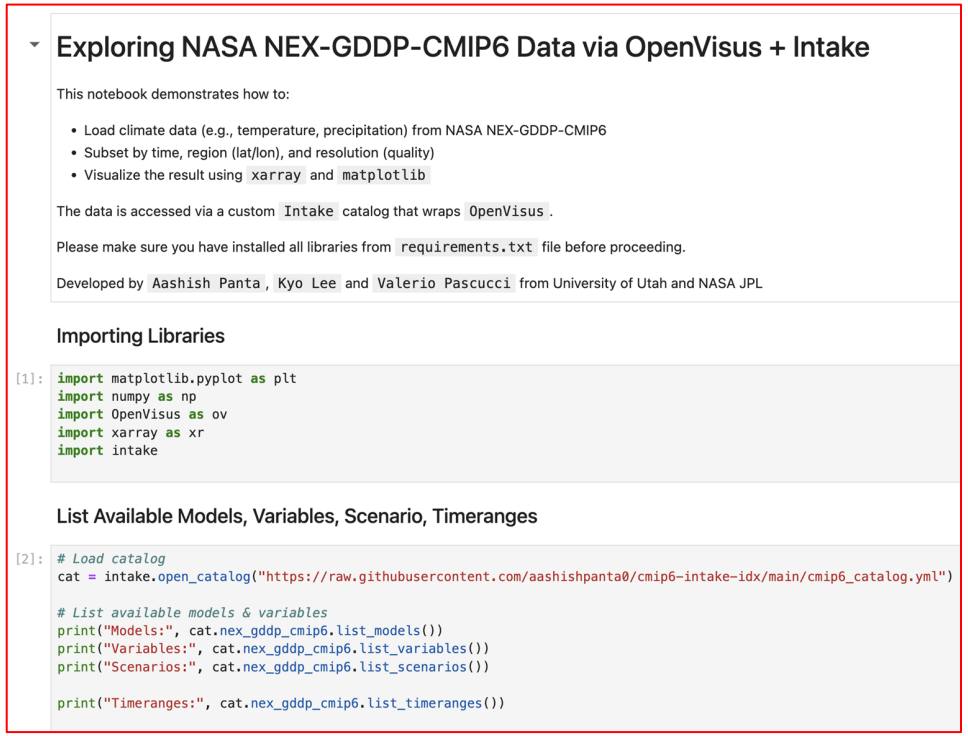
What is an Intake Catalog (cmip6_catalog.yml)?

- A metadata file that points to NEX-GDDP. It's like a library card catalog for the NEX-GDDP data.

Why are we using it?

- You can easily search and browse available data.
- Data is only loaded into memory without downloading.

1. Go to scripts folder
2. Click 'basic_introduction_notebook.ipynb'



Exploring NASA NEX-GDDP-CMIP6 Data via OpenVisus + Intake

This notebook demonstrates how to:

- Load climate data (e.g., temperature, precipitation) from NASA NEX-GDDP-CMIP6
- Subset by time, region (lat/lon), and resolution (quality)
- Visualize the result using `xarray` and `matplotlib`

The data is accessed via a custom `Intake` catalog that wraps `OpenVisus`.

Please make sure you have installed all libraries from `requirements.txt` file before proceeding.

Developed by `Aashish Panta`, `Kyo Lee` and `Valerio Pascucci` from University of Utah and NASA JPL

Importing Libraries

[1]:
```
import matplotlib.pyplot as plt
import numpy as np
import OpenVisus as ov
import xarray as xr
import intake
```

List Available Models, Variables, Scenario, Timeranges

[2]:
```
# Load catalog
cat = intake.open_catalog("https://raw.githubusercontent.com/aashishpanta0/cmip6-intake-idx/main/cmip6_catalog.yml")

# List available models & variables
print("Models:", cat.nex_gddp_cmip6.list_models())
print("Variables:", cat.nex_gddp_cmip6.list_variables())
print("Scenarios:", cat.nex_gddp_cmip6.list_scenarios())

print("Timeranges:", cat.nex_gddp_cmip6.list_timeranges())
```

The Expert Team on Climate Change Detection and Indices (ETCCDI)

https://etccdi.pacificclimate.org/list_27_indices.shtml

- A set of 27 internationally recognized indices for analyzing changes in climate extremes (e.g., frequency of hot days, heavy rainfall)
- Input Variables: Precipitation (pr), Daily Maximum Temperature (tasmax), Daily Minimum Temperature (tasmin)

- Scripts for our hands-on lab:
  - ETCCDI_pr_indices_driver.ipynb: The main notebook for loading GISS-E2-1-G precipitation data and running calculations of eight indices.
  - ETCCDI_pr_indices.py: A Python module containing the functions (subroutines) that compute ten indices.

1. Go to scripts folder
2. Click 'ETCCDI_pr_indices_driver.ipynb'

ETCCDI pr Indices Driver

Run cells **top-to-bottom**. Steps:

1. Parameters
2. Helpers
3. Locate & load data
4. Compute indices
5. Save to NetCDF

[ ]:

```
# === Step 1: Parameters ===
ROOT = "/home/jovyan/shared/NEX-GDDP-CMIP6/"
MODEL = "GISS-E2-1-G"
SCENARIO = "historical"   # "historical","ssp126","ssp245","ssp370","ssp585"
MEMBER = "r1i1p1f2"
START_YEAR = 1985
END_YEAR   = 2014
SEASON = "annual"         # "annual","MAM","JJA","SON","DJF"
OUTDIR = "./etccdi_out"
```

Analyze the Calculated Indices for a Specific Country of Interest

- A long-term mean (climatology) of ETCCDI indices
- Computes annual regional values (area-weighted mean) and plots a time series + histogram across years
- Fits a linear trend to the annual values and plots it, with slope and R^2

1. Go to scripts folder
2. Click 'ETCCDI_country_stats.ipynb'

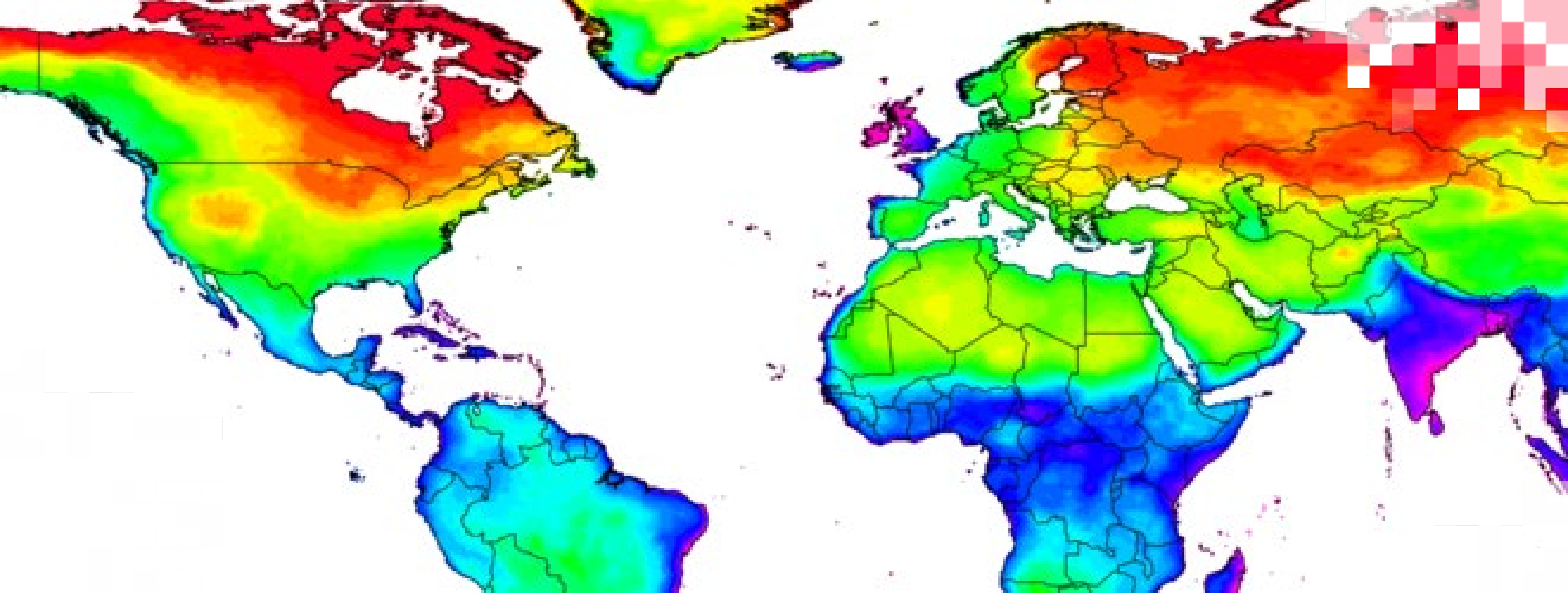
ETCCDI Multi-Year Mean + Time-Series Stats + Linear Trend

How to use: Edit only the **Parameters** cell below, then run all cells (Kernel → Restart & Run All). This notebook:

1. Loads an ETCCDI NetCDF
2. Computes the **multi-year mean** and plots a **map** + **spatial histogram** + **spatial stats**
3. Computes **annual regional values** (area-weighted mean) and plots a **time series** + **histogram across years**
4. Fits a **linear trend** to the annual values and plots it, with slope and R^2

[ ]:
```
# Step 1 — List available NetCDF files
import os, glob

# Directory containing your ETCCDI NetCDF outputs
DATA_DIR = "/home/jovyan/shared/NEX-GDDP-CMIP6/ETCCDI/"  # or user-calculated indices in ./etccdi_out/"

# Gather *.nc files
NC_FILES = sorted([os.path.basename(p) for p in glob.glob(os.path.join(DATA_DIR, "*.nc"))])

print(f"Found {len(NC_FILES)} .nc files in {DATA_DIR}")
for i, name in enumerate(NC_FILES, 1):
    print(f"{i:2d}. {name}")
```

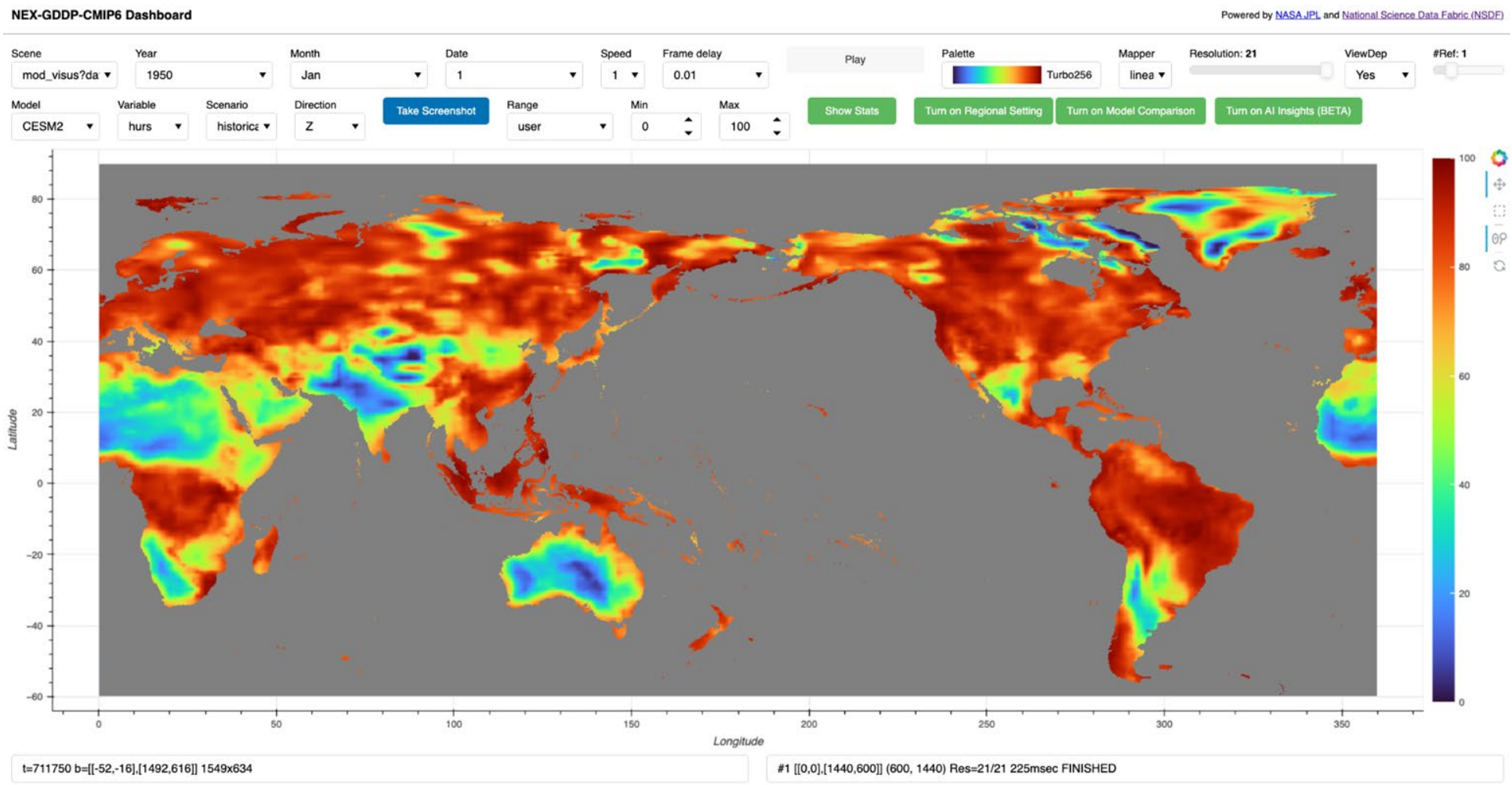
[ ]:
```
# Step 2 — Parameters (EDIT by uncommenting and setting values; no defaults)
#
# Required — pick one file from the list printed in Step 1:
FILE_NAME = "ETCCDI_pr_GISS-E2-1-G_historical_annual_1985-2014_Rx5day.nc"
#

FILE_PATH = DATA_DIR + FILE_NAME

REGION_METHOD = "country"           # or "bbox"
COUNTRY_NAME = "Thailand"
```

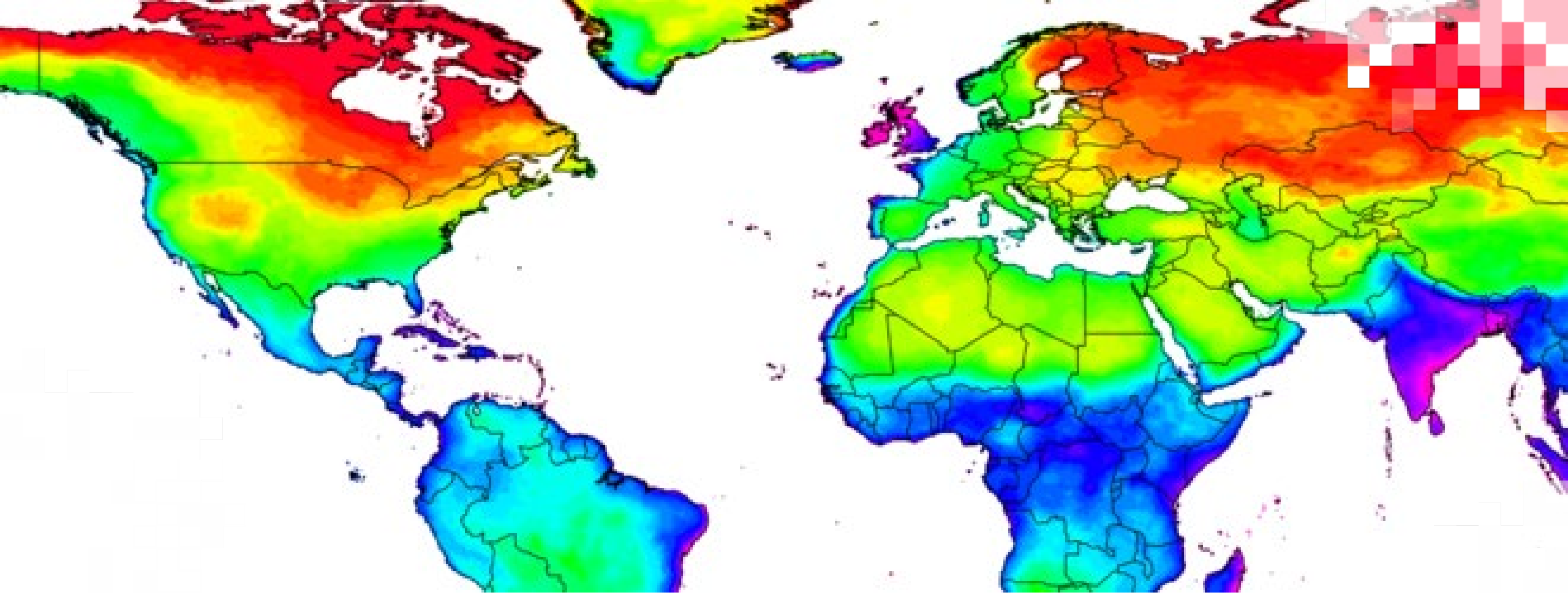


Demo: Interactive Dashboard

Interactive Dashboard for NEX-GDDP-CMIP6

Dashboard

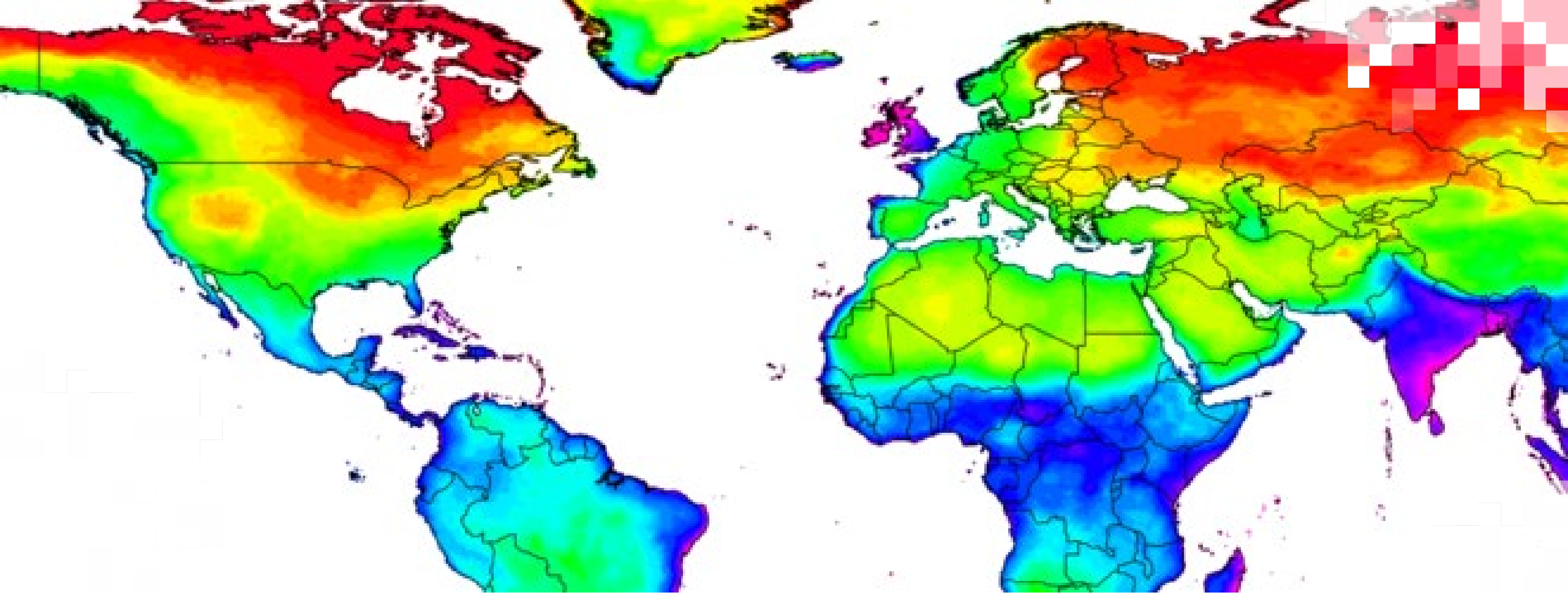




Part 2 Summary

Summary

- Provided a hands-on guide to analyzing extreme weather events using the NEX-GDDP-CMIP6 dataset
- **Computing Environment:** Used BinderHub to launch a pre-configured Python environment directly in your browser, ensuring a consistent and reproducible setup for all participants
- **Data Access:** Two methods for accessing data:
  - Downloading NetCDF files directly from Amazon Web Services (AWS)
  - Streaming data efficiently into memory using an Intake catalog, avoiding the need for local downloads
- **Hands-On Lab:** Jupyter Notebook to calculate several Expert Team on Climate Change Detection and Indices (ETCCDI). This involves analyzing variables like daily maximum/minimum temperature and precipitation to identify trends in climate extremes for a country or region of interest
- **Visualization:** Interactive NEX-GDDP-CMIP6 dashboard, a powerful tool for visualizing changes in key climate variables over the 21st century



Training Summary

NEX-GDDP Overview, Data Access, Analysis

- **Overview of GDDP**
  - Statistically downscaled output from 35 of CMIP6 models at daily global ¼-degree output
  - Four SSPs (2.5, 4.5, 7.0, 8.5) from 2015 to 2100
  - Created using two-step methodology: bias correction and spatial disaggregation
- **Where can GDDP be accessed?**
  - NASA Center for Climate Simulation
  - Amazon Web Services
  - Google Earth Engine (GEE)
- **Demonstrations and Exercises:**
  - Extreme hot and cold, wet and dry events between 2020 and 2100 using GEE
  - Calculation of ETCCDI indices (GitHub Repository)
  - Interactive GDDP Dashboard

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 17 September 2025
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 17 October 2025**

- **Certificate of Completion:**
  - Attend all live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Contact Information

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Thank You!