CLIMVIEWER: A SCALABLE, INTERACTIVE PLATFORM FOR CLIMATE & WEATHER DATA EXPLORATION

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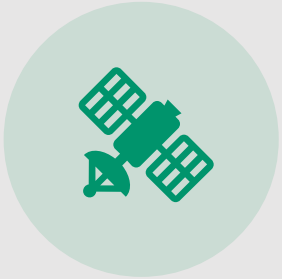
NATIONAL COMPUTATIONAL INFRASTRUCTURE (NCI)

eResearch Conference 2025

NCRIS National Research Infrastructure for Australia
An Australian Government Initiative

NCI AUSTRALIA

DATA COLLECTIONS @ NCI



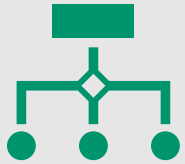
Australia's largest research data collection: climate, weather, Earth systems, environmental, satellite, geophysics, plus specialised domains (astronomy, genomics).

PBs of nationally and internationally significant datasets, co-located with HPC and analysis systems.

Prioritised with partners: ANU, Bureau of Meteorology, CSIRO, Geoscience Australia, ARC Centres of Excellence..

Data principles: FAIR, high-performance programmable access, open where possible, modern standards, transdisciplinary access.

EXISTING CLIMWX DATASET VISUALIZATION TOOLS



Local Applications

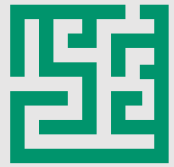
Ncview: Plot NetCDF files locally—basic and static

ECMWF Metview: Advanced desktop tool with scripting & interactive plots

Web Platforms

ec*Charts*: Interactive forecast visualization via dashboards

NOAA View: Predefined maps and interfaces with limited customization



Gaps

Local tools doesn't target at dataset; web tools limited in analytics/customizability

MOTIVATION & CHALLENGES

Growing high-res datasets

harder to explore & visualize

Existing tools

limited or inflexible

Need

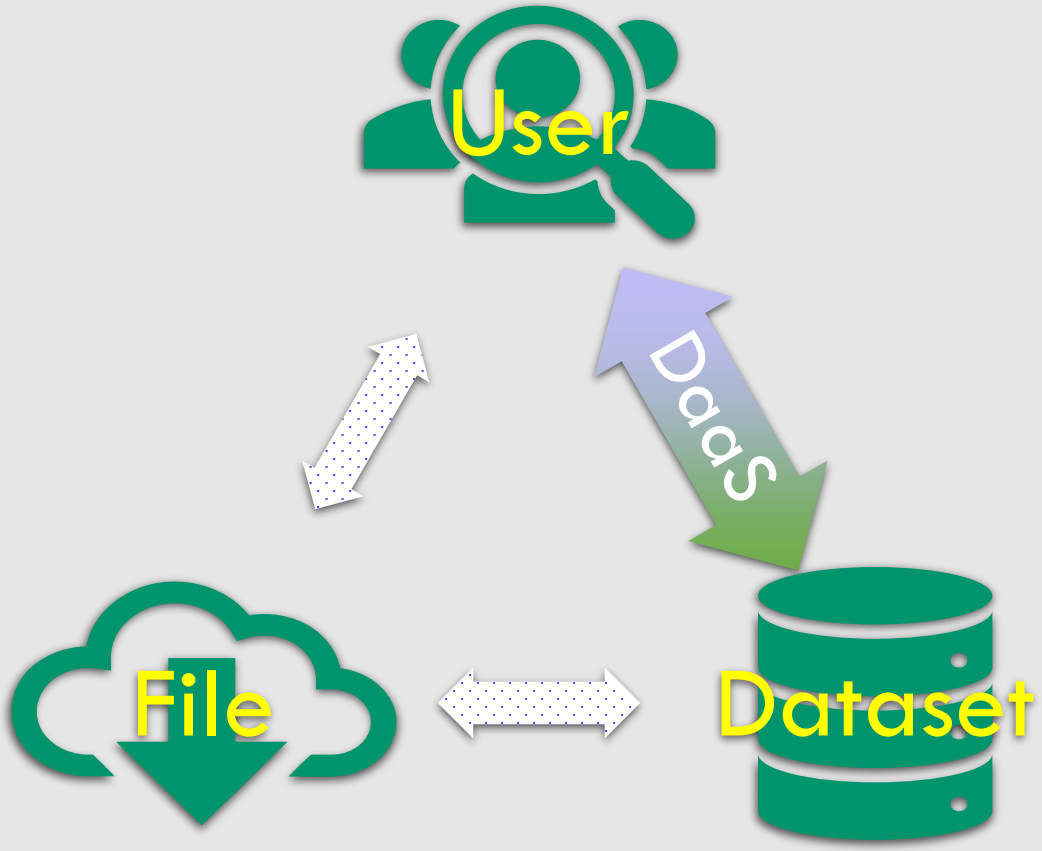
scalable, customizable, interactive viewer

Goal

visualize ClimWx dataset locally

DATASET AS A SERVICE

Dataset as a Service (DaaS) is a data delivery and management model where datasets are hosted, curated, and served on demand — usually through APIs, cloud platforms, or catalogs — so that users can easily discover, access, and use data without managing storage or infrastructure themselves.



NCI INTAKE DATA CATALOG

https://opus.nci.org.au/spaces/DAE/pages/275349609/Analysing+data+using+intake+indexes

Intake-esm is Python plugin to catalog Earth System Model datasets (CSV/JSON index), built on intake, pandas and Xarray

NCI uses these catalogs for climate/weather, geophysics satellite datasets

Provides fast metadata-based data discovery and dataset loading

INTAKE-ESM USAGE

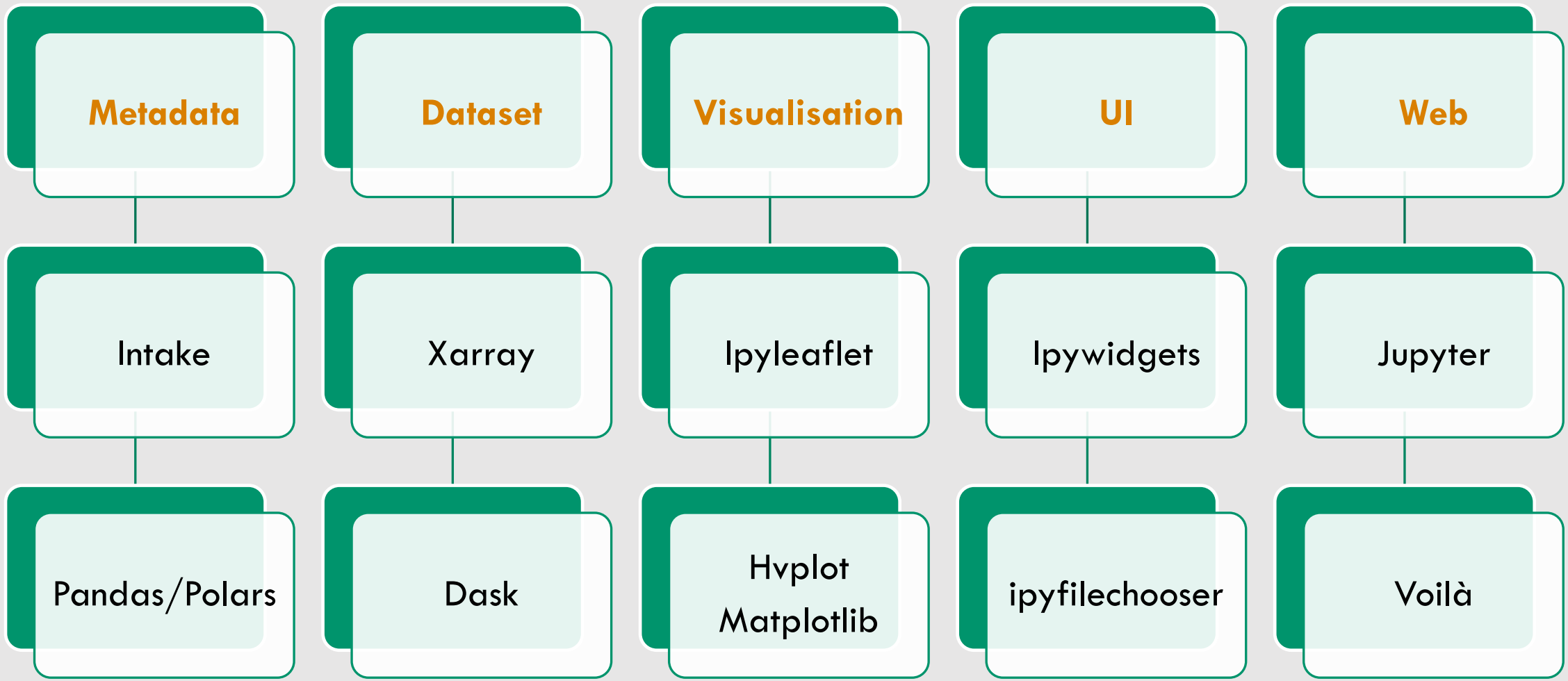
Without Intake Catalog	With Intake catalog

`base_dir = "/g/data/rr3/publications/CMIP5/output1/CSIRO-BOM/ACCESS1-3/historical/mon/atmos/Amon/r1i1p1/latest/tas"`
 	
`nc_files = sorted(glob.glob(os.path.join(base_dir, "*.nc")))`
 	
`ds = xr.open_mfdataset(nc_files, combine='by_coords')`
	`cat = intake.open_esm_datastore("cmip5_catalog.json")`
	
	`subset = cat.search(variable_id="tas", model="MPI-ESM-LR")`
	
	`ds = subset.to_dataset_dict()["CMIP5.MPI-ESM-LR.tas"]`

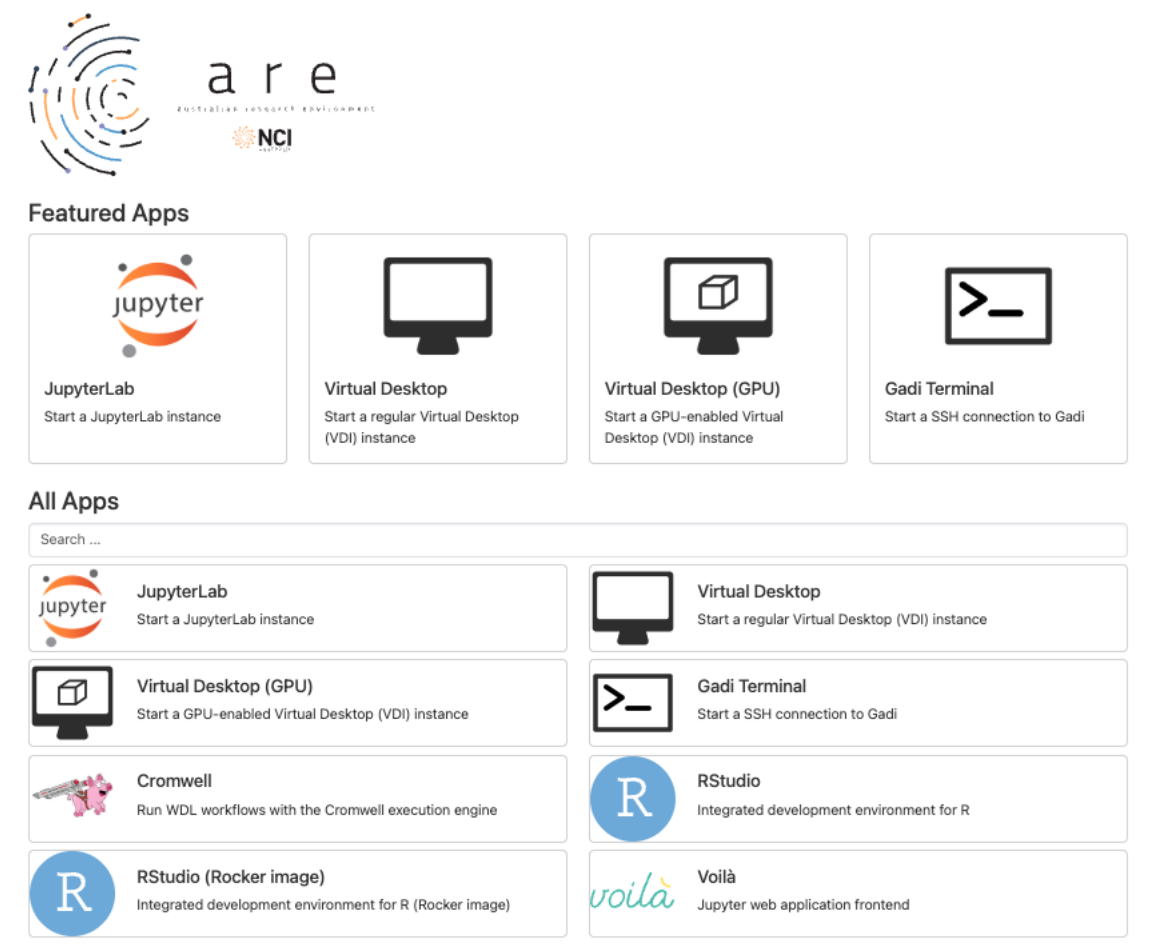
CLIMVIEWER FEATURES

- **Search and access** datasets using NCI (or user-generated) intake-ESM catalogs
- Support for **loading** NetCDF, Zarr, and related formats through Xarray
- **Animate** 2D,3D and 4D datasets along time or height sequential
- **Interactively zoom in&out for scope and details**
- Global and local **statistics for selected location** from map
- **Customized plot** such as color scheme, contours, labels etc.
- Dask-based **distributed processing** for performance and scalability
- Support massive **computing resources** across multiple cores or nodes

CLIMVIEWER ARCHITECTURE



NCI INTEGRATION VIA ARE

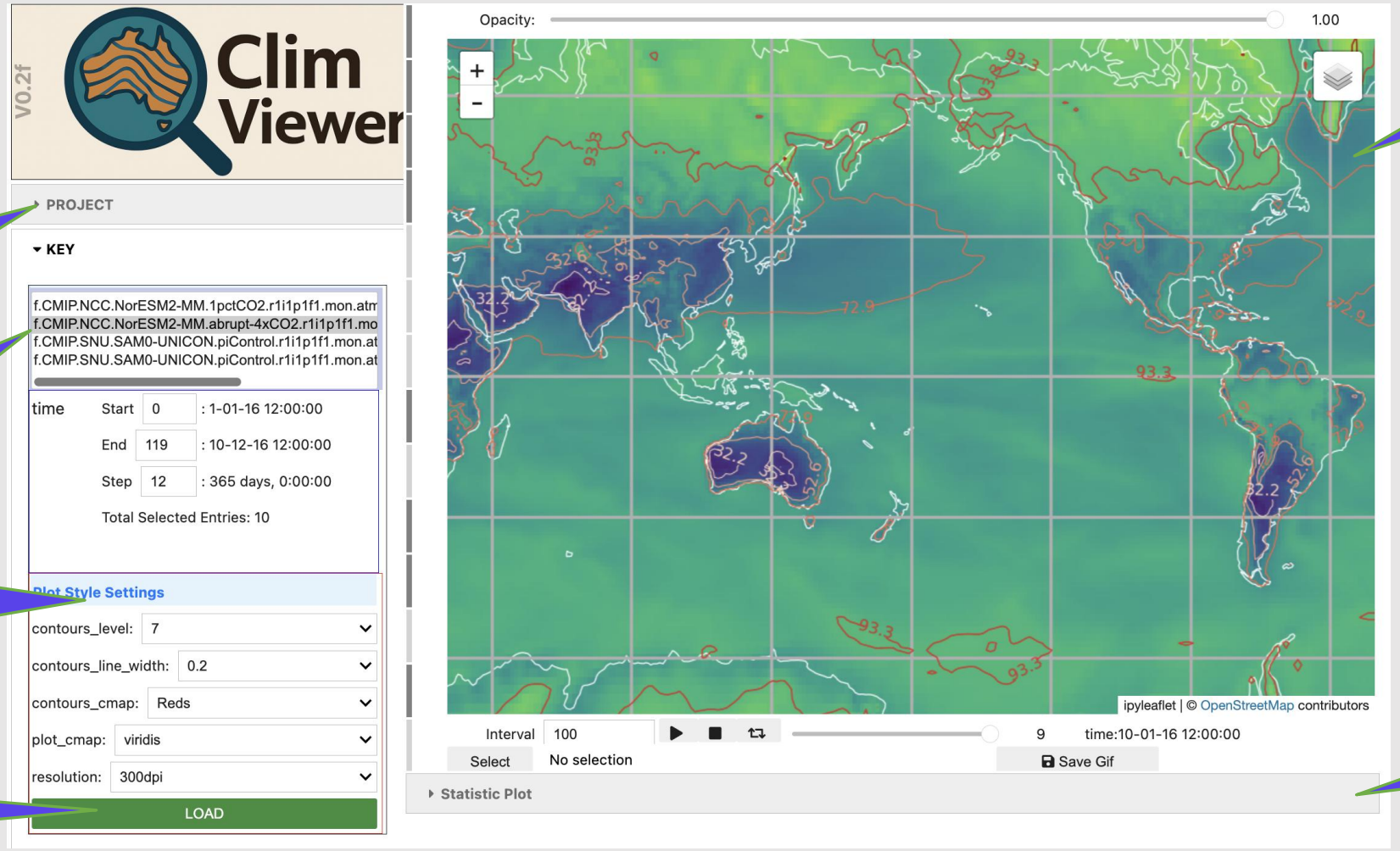


- Deployed and loaded via NCI ARE.
- Customized compute resources including single and multiple nodes
- Supports catalogs for multiple NCI local collections like CMIP5, CMIP6, ERA5, BARRA2, BARPA, CCAM, WeatherBench etc.
- Operating on web GUI interface via Voila

are.nci.org.au

https://opus.nci.org.au/spaces/DAE/pages/325387079/Voil%C3%A0+Apps+on+ARE

CLIMVIEWER INTERFACE



Step 1 Select data collection

Step 2 Select dataset

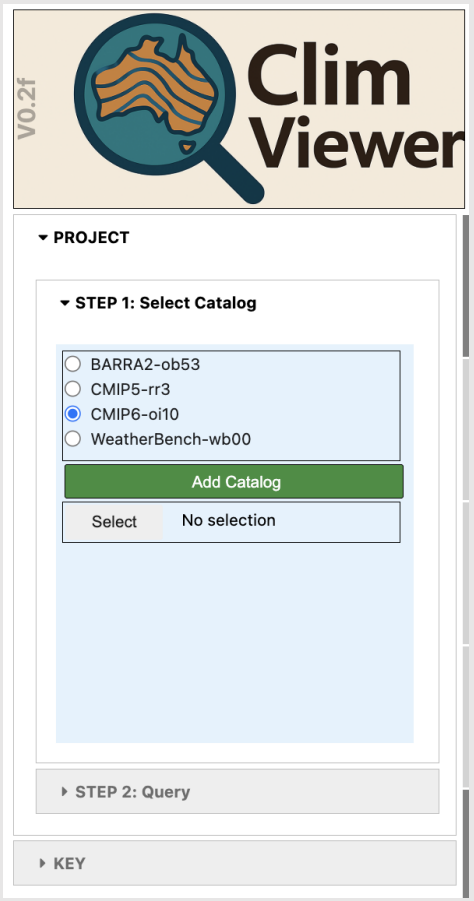
Step 3 Configure plots

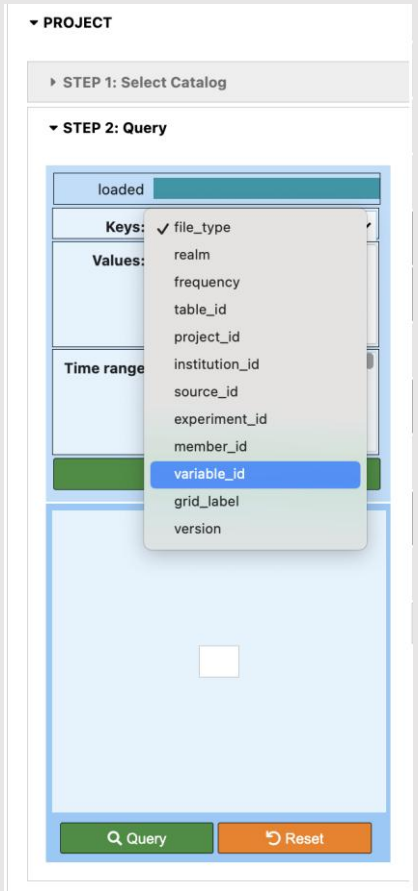
Step 4 Start

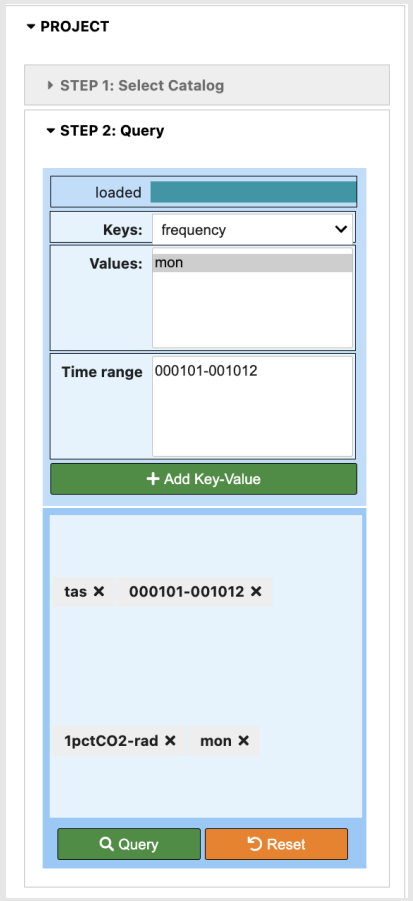
Step 5a Animate plots

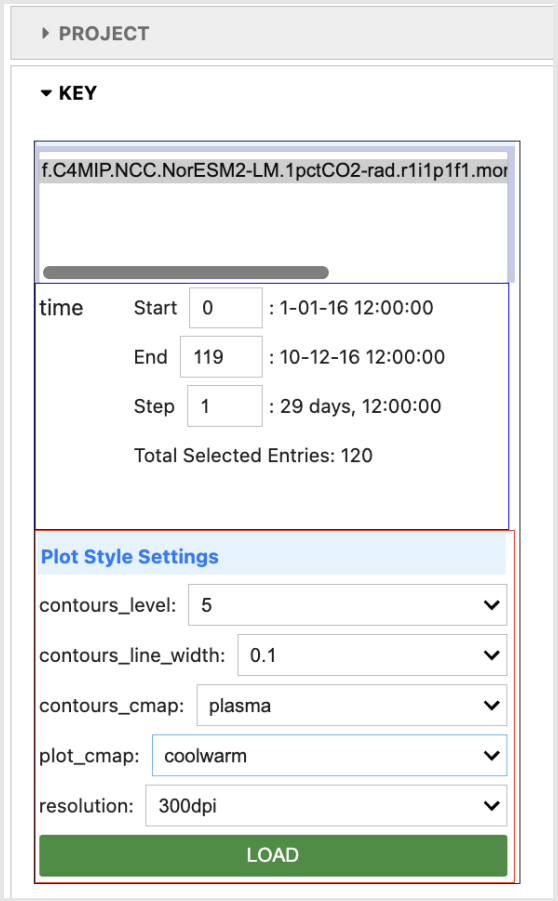
Step 5b Statistic analysis

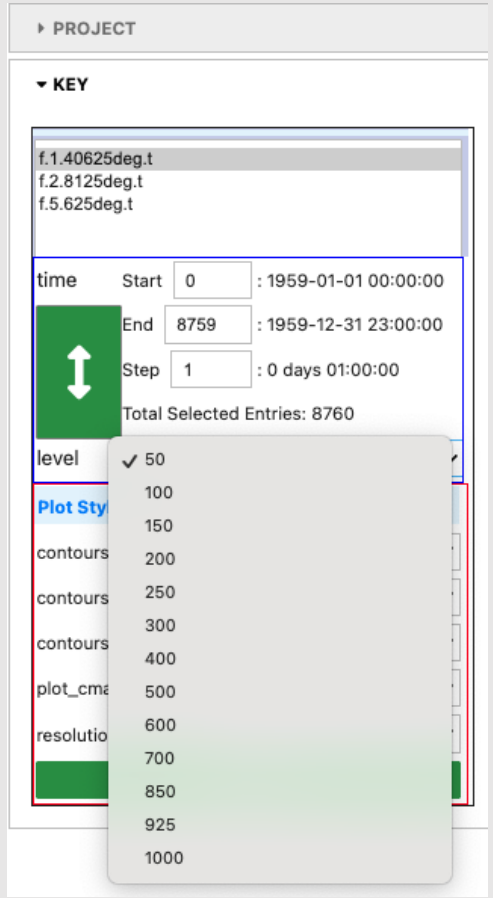
SEARCH METADATA AND LOADING DATASET





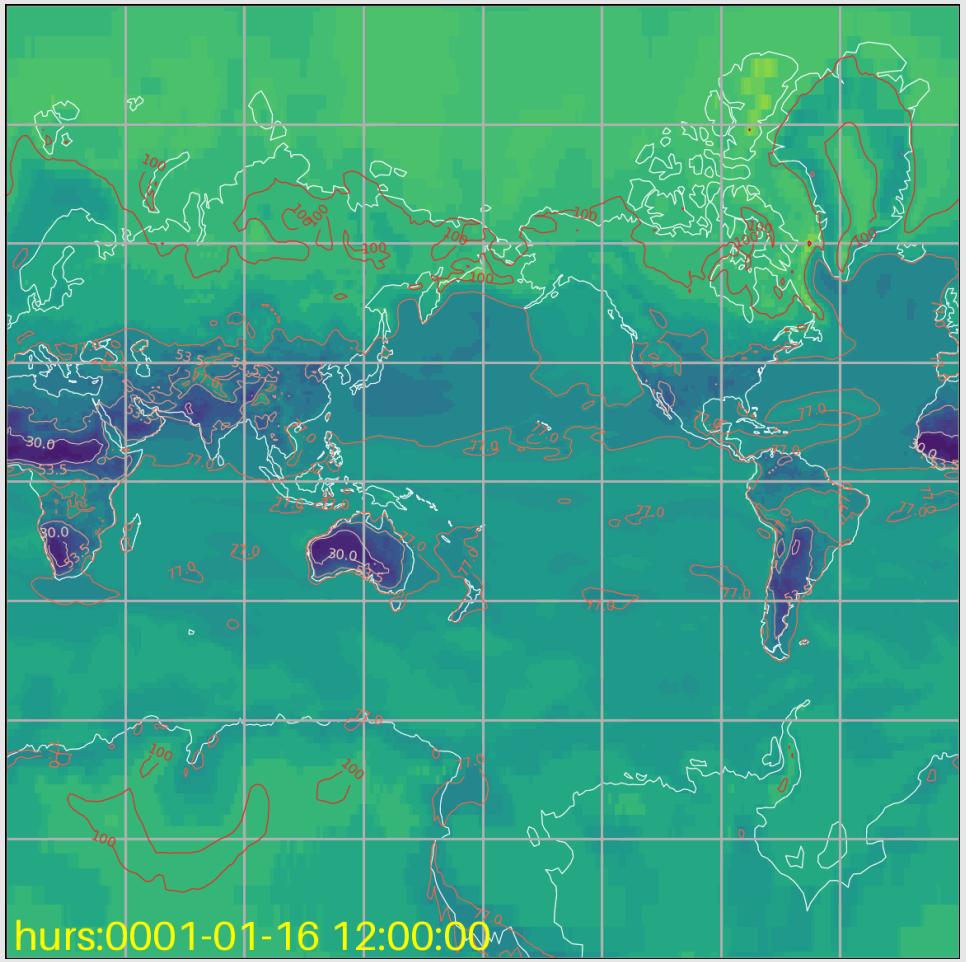




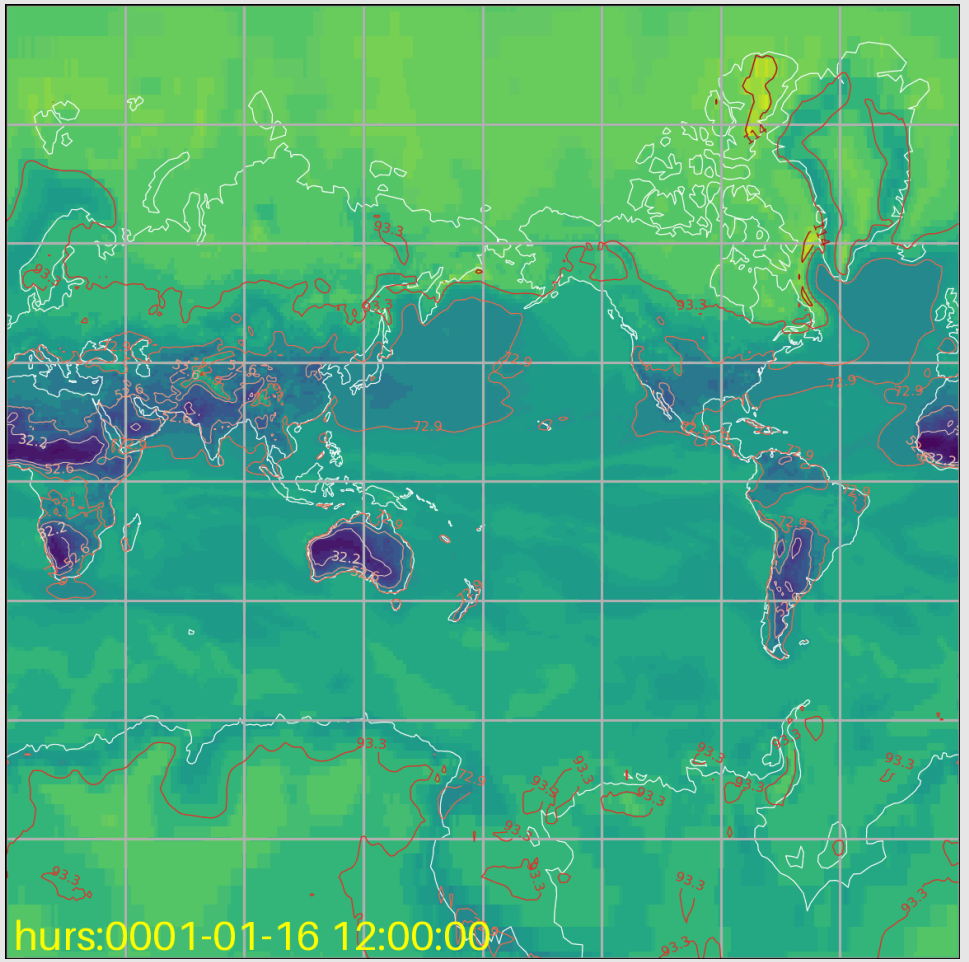


Select Data Collection => Search keys => Select series (3D) Select series (4D)

ANIMATE PLOTS



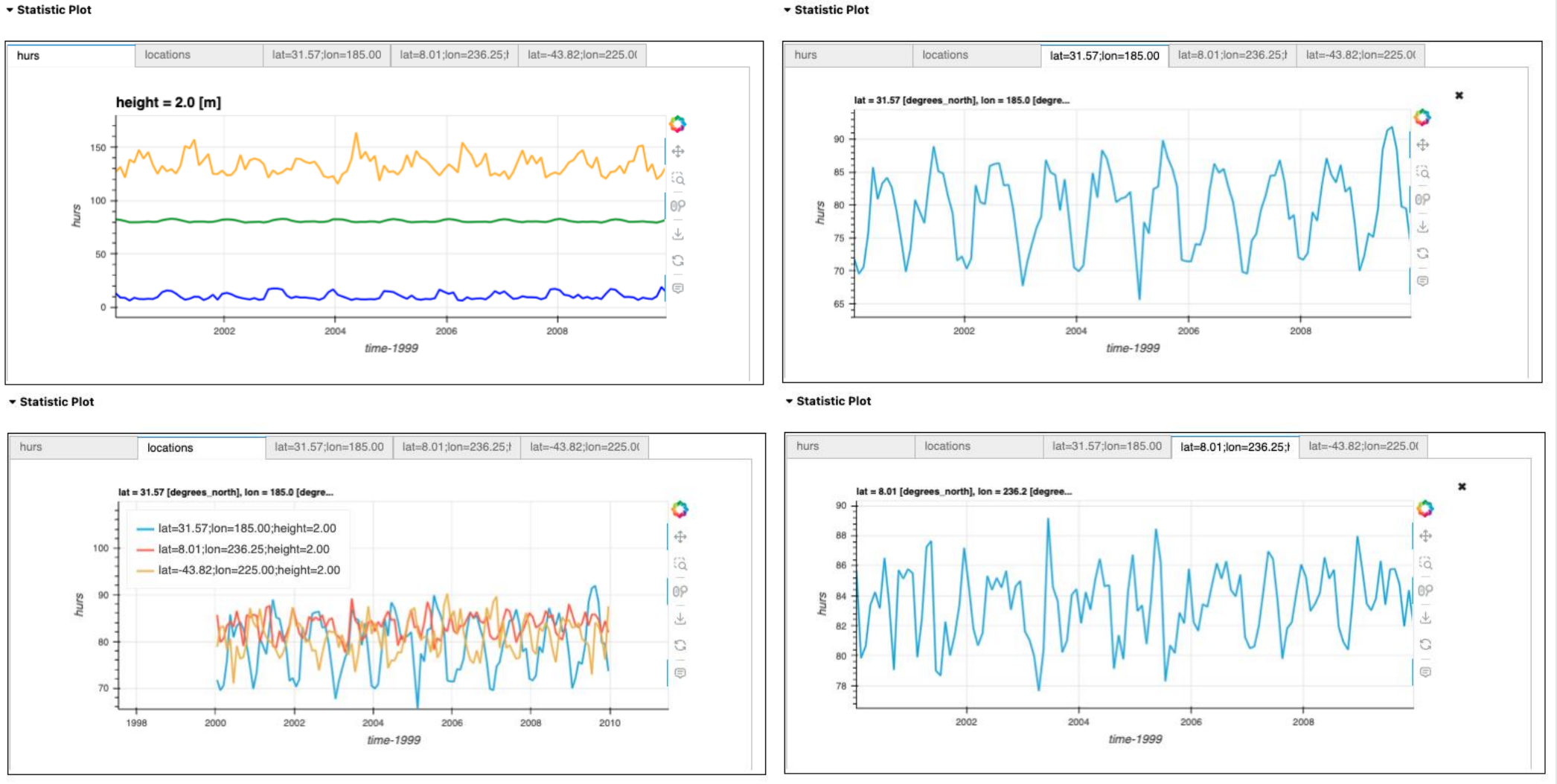
Sequential 12 months in 1year (nskip=0)



Fixed datetime in 10 years (nskip=12)

Relative Humidity at the Surface (in %)

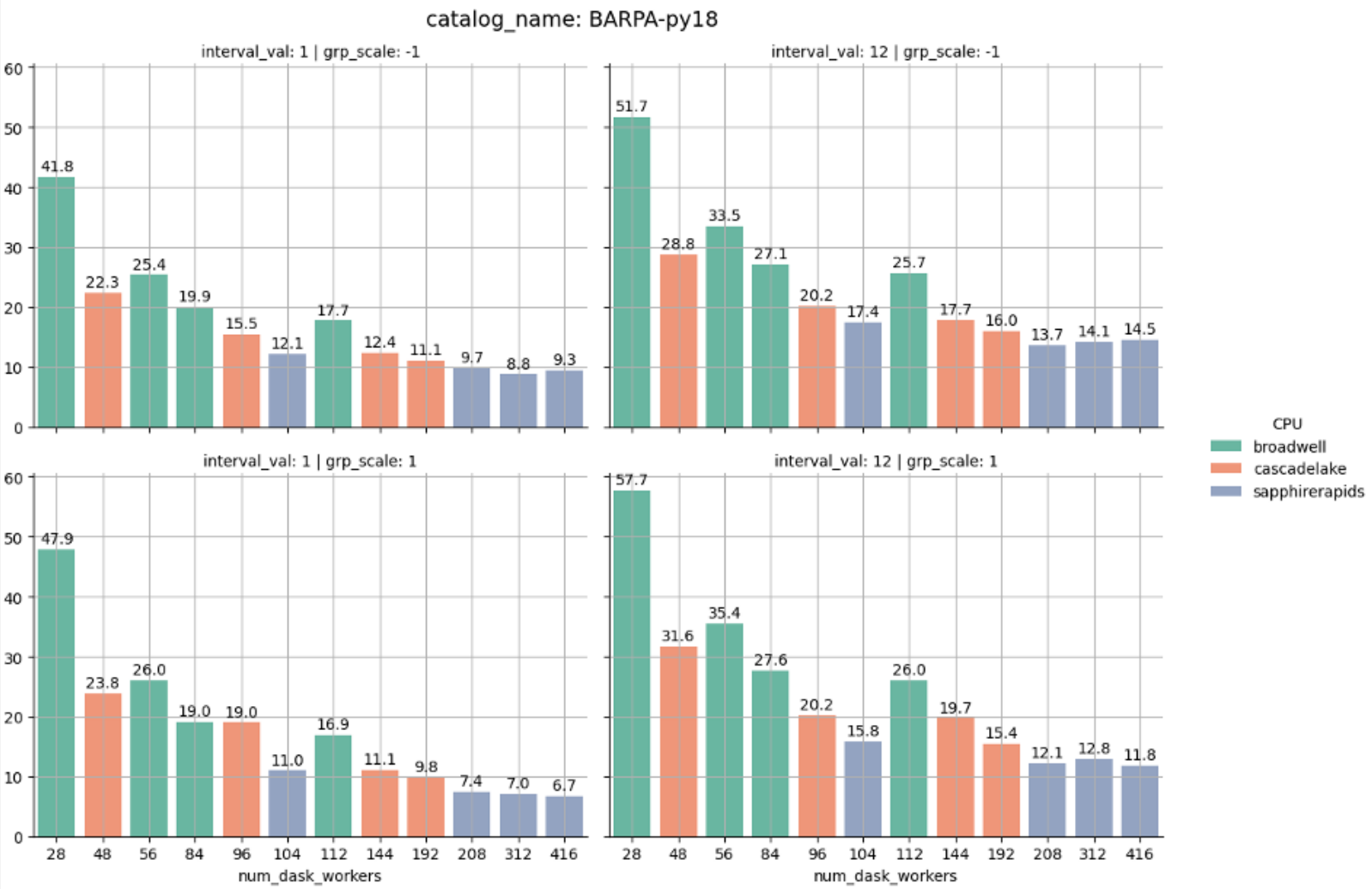
GLOBAL AND LOCALIZED STATISTICS



SCALABILITY & COMPUTE CONTROL

- Hotspots on statistics analysis and image rendering to overlays
- Access patterns may vary from sequential to non-contiguous slices
- Enhance scalability performance by tuning
  - Distributed computing platform covers multiple compute nodes and different CPU architectures
  - Load distribution over Dask cluster i.e. statically create 1 group per Dask worker or dynamically process 1 slice per Dask worker each time

SCALABILITY BENCHMARKING



CPU Architecture	CPU Model	CPU Freq(GHz)	Node Cores
Broadwell	E5-2690v4	2.6	2 x 14
CascadeLake	Platinum 8274	3.2	2 x 24
SapphireRapids	Platinum 8470Q	2.1	2 x 52

Total time slices= 1000

- **Scaling & Performance**
  - good scalability
  - Diminishing returns
- **Time Handling (interval_val)**
  - Sequential steps (interval_val=1) run faster.
  - Skipped slices (interval_val=12) add I/O & locality overheads.
- **CPU Architecture**
  - **Sapphire Rapids:** Best performance
  - **Cascade Lake:** Mid-tier
  - **Broadwell:** Slowest
- **Other Insights**
  - grp_scale: has minor impact compared to CPU & interval effects.
    - -1: Nchunk = number of slices
    - 1: Nchunk = number of cores
  - Hardware + workflow choices both are critical for efficiency.

SUMMARY & NEXT STEPS

- ClimViewer
  - fills the gap between local desktop tools and inflexible dashboards
  - offers powerful, interactive and scalable data visualization over large datasets
- Future work
  - Enhance search and custom analytics
  - Support additional formats or derived variables
  - Implement a wider range of data analysis workflow
  - Enable more scientific plot patterns

THANK YOU!