# FAIR Climate Services using the xarray ecosystem and OGC Standards

DAVID HUARD

Pangeo Showcase
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Consortium sur la climatologie régionale et l'adaptation aux changements climatiques

# Climate services translate historical observations and future projections into actionable information

# Canadian Climate Services Ecosystem

Environment and Climate Change Canada
Canada

CANADIAN CENTRE FOR CLIMATE SERVICES

PACIFIC CLIMATE IMPACTS CONSORTIUM

ClimateWest

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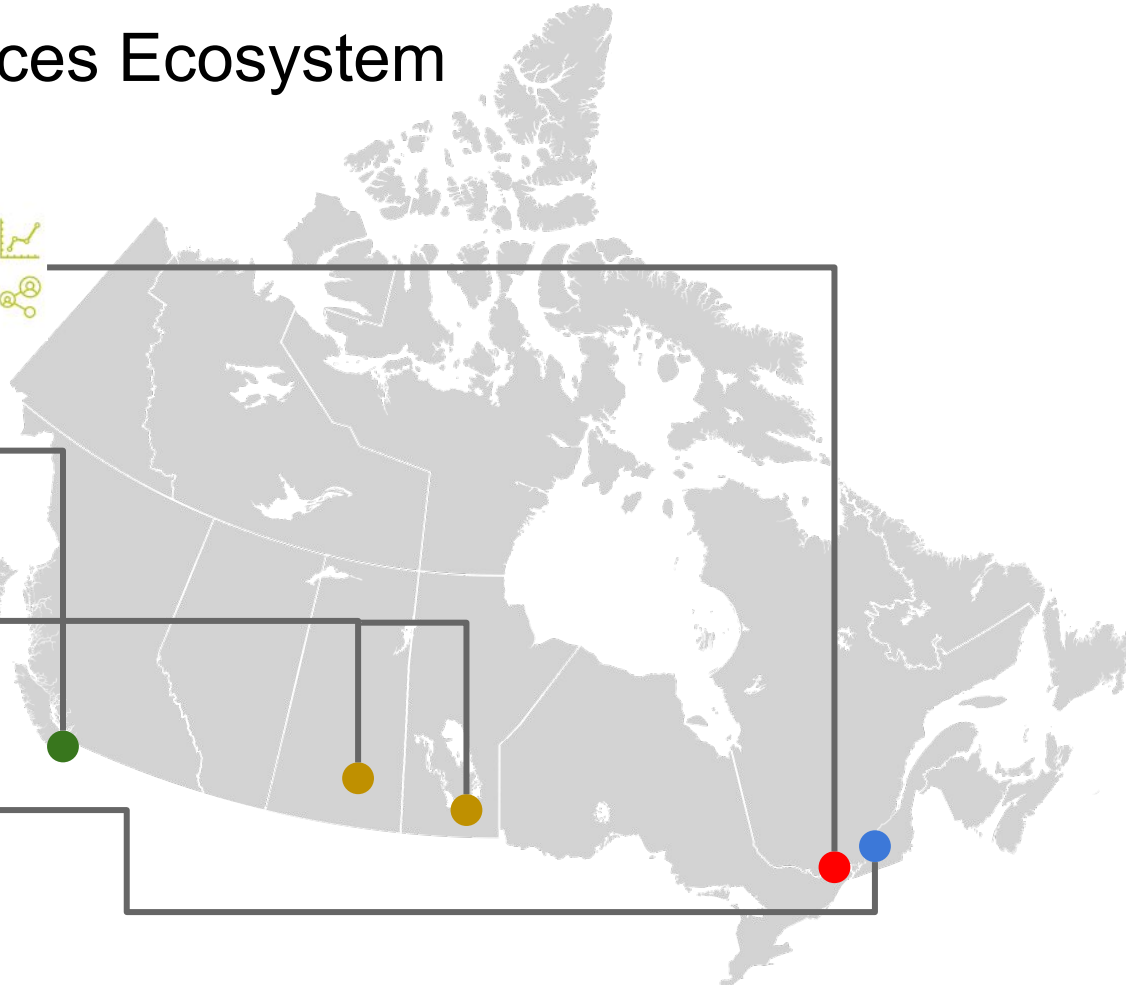
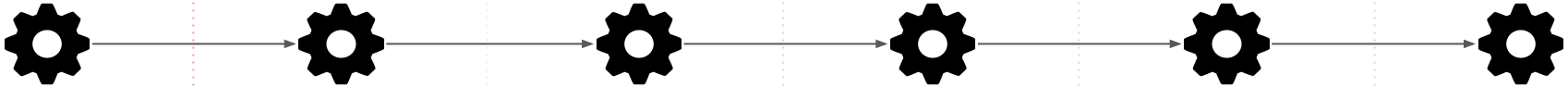


# Climate service providers are facing common challenges



**Data discovery and selection**

Finding appropriate historical observations and future climate projections

**Subsetting and regridding**

Spatial interpolation or averaging over area and periods of interest

**Statistical downscaling and bias adjustment**

Reducing model biases by comparing with observations over a common period

**Climate indicators**

Computing derived variables that can inform planning and risk analysis to support decision-making

**Ensemble statistics and robustness metrics**

Assessing uncertainties and level of confidence

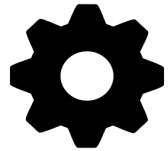
**Visualization**

Communicating results clearly and concisely

**FAIR Data**

**FAIR Services**

# What could FAIR mean for climate analytics ?



**F** Public catalogs of well-documented analytical processes

**A** Low bandwidth, CPU and storage requirements for end-users

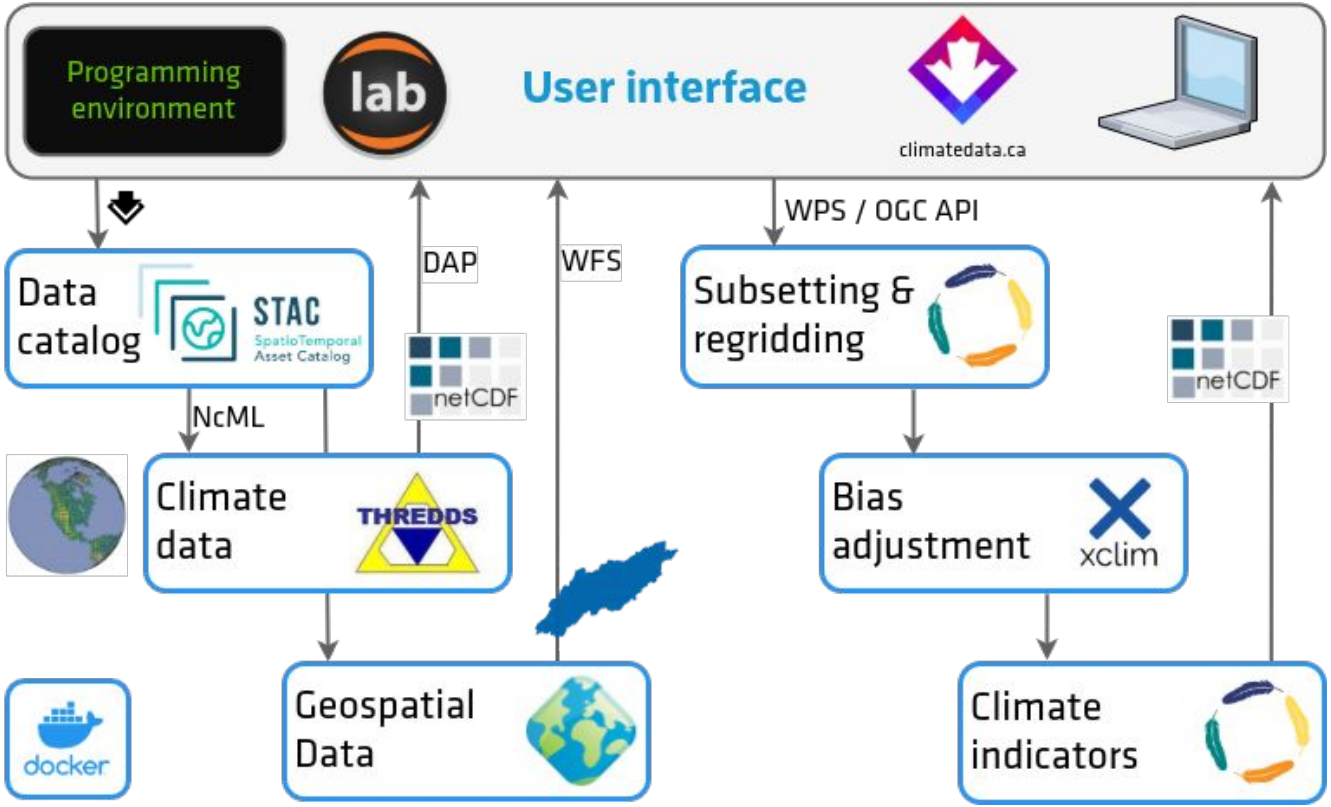
**I** Standards for data inputs, outputs and processing API

**R** Open-source software, rich metadata and provenance information

The climate science community is already well positioned:

- Common data format (netCDF) and metadata convention (CF)
- Federated data distribution architecture (Earth System Grid Federation)

# A standards-based climate service cyber-infrastructure

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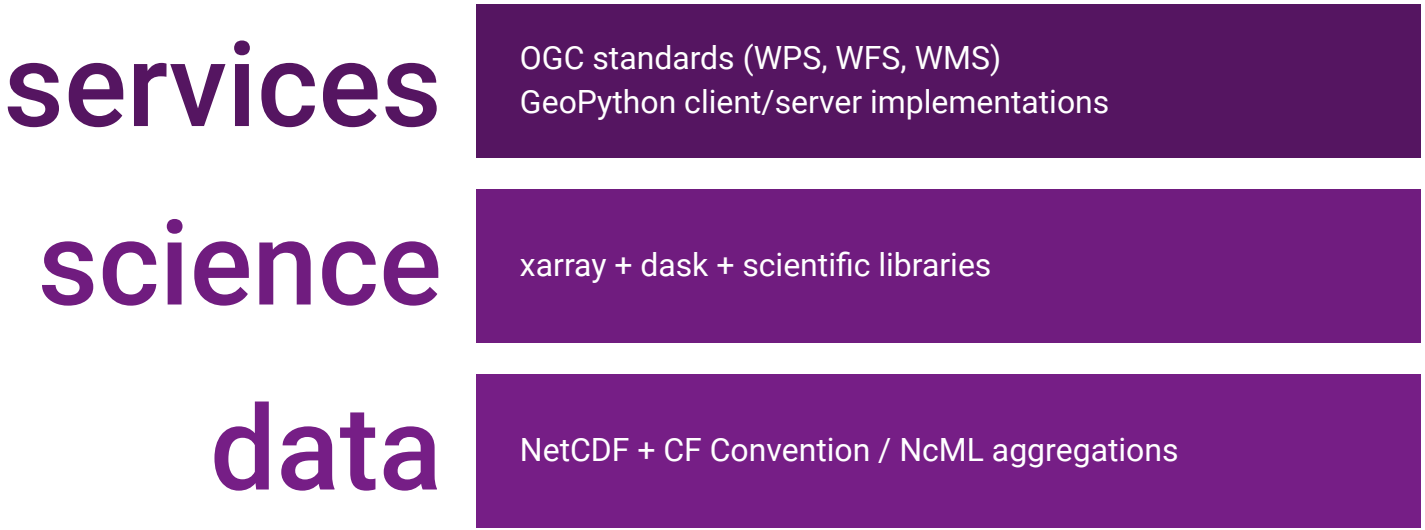
canarie

# We’re building the software stack in distinct “layers”



data

# NcML aggregations

NcML aggregates individual files into “views” accessible through DAP (THREDDS)

- Multiple variables and ensemble members

Can modify data and metadata without changing netCDF files.

- Fix publishing errors (metadata, dimension names, etc.)

Data as Code (kind of)

- NcML files (xml) are hosted on git and auto-deployed on THREDDS

Results in dramatically smaller catalogs (Intake for now)

# science

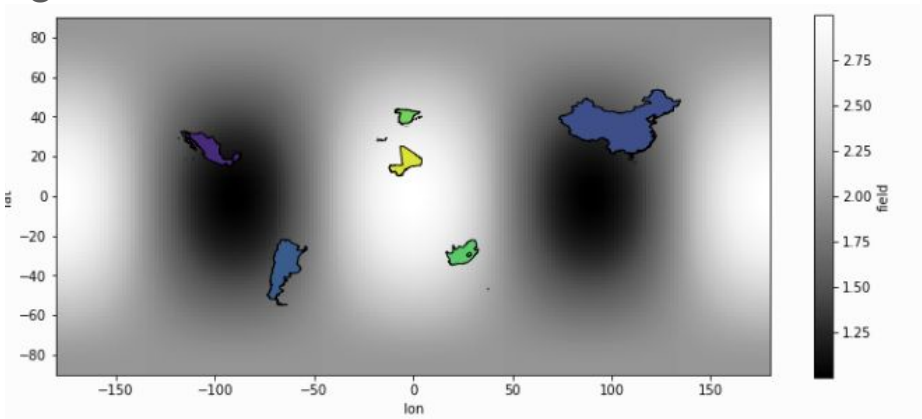
# Regridding on a sphere: xESMF

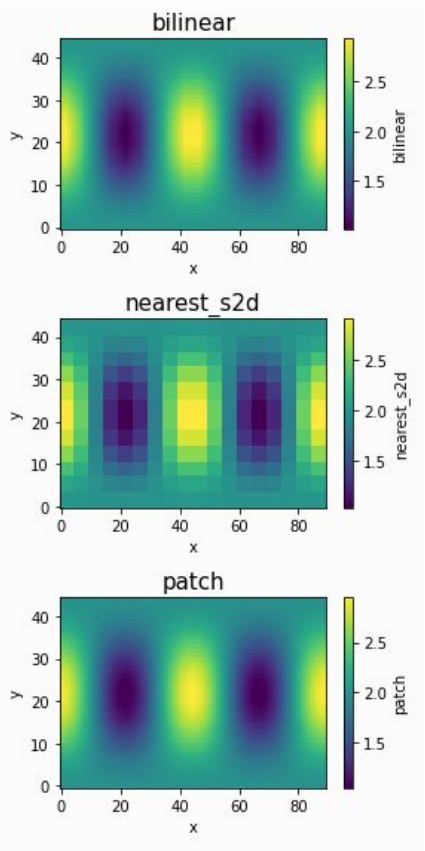
xarray wrapper around ESMFPy

Bilinear, Nearest Neighbour, Patch, Conservative

Masking support

New: Polygonal average




https://github.com/pangeo-data/xESMF

science

# Climate indices and stats: xclim

Over 50 climate indicators (fire weather index, cooling degree days, ...)

Bias-adjustment (empirical quantile mapping, quantile delta mapping, ...)

Frequency analysis

Ensemble analysis

Utilities to deal with model calendars, missing data criteria, units, output metadata, translation.


https://github.com/Ouranosinc/xclim

# services

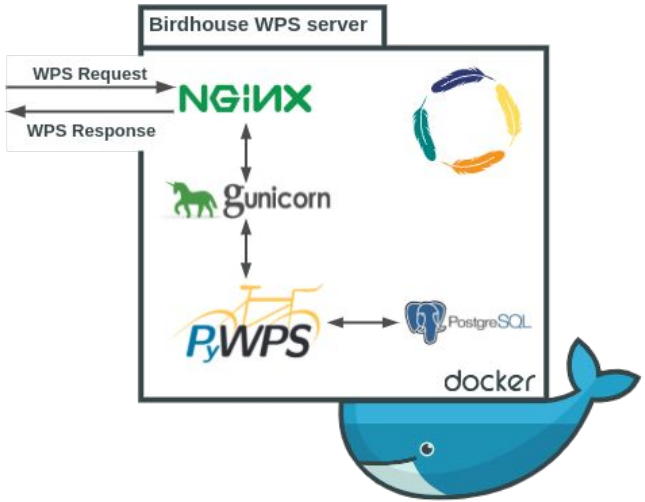
## Web services: birdhouse server

Expose climate services on the web using OGC standards

Client-server communication use the Web Processing Services (WPS) API

*PyWPS* wraps scientific applications into WPS processes

*Birdy* client provides native-like interface to services




https://github.com/bird-house

pangeo-showcase.ipynb

Code git Python 3

```
import xarray as xr
from birdy import WPSClient
```

```
# Establish connection to WPS server
wps = WPSClient('https://pavics.ouranos.ca/twitcher/ows/proxy/finch/wps')
wps
```

```
wps.average_polygon?
```

```
# CanESM5 orography on ESGF CMIP6
nc_url = "http://crd-esgf-drc.ec.gc.ca/thredds/dodsC/esgD_dataroot/AR6/CMIP6/ScenarioMIP/CCCma/CanESM5/ssp460/r1i1p1f1/fx/orog/gn/v20190429/orog_fx_CanESM5_ssp460_r1i1p1f1_gn.nc"
ds = xr.open_dataset(nc_url)
ds.orog.plot()
```

```
# Compute average over Colorado
resp = wps.average_polygon(nc_url, shape="./colorado.geojson")
```

```
resp.get()
```

```
av = resp.get(asobj=True).output
display(av)
print(av.orog.data)
```

```
```

www.ouranos.ca

**DAVID HUARD**
Recherche et soutien à l'innovation
huard.david@ouranos.ca

@ouranos_cc

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