

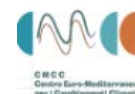
<http://climate4impact.eu/>

Bridging CMIP5 and CORDEX data infrastructure to impact users

How open source software and open standards for data access and exploration are successfully applied in the “Climate for impact” portal.

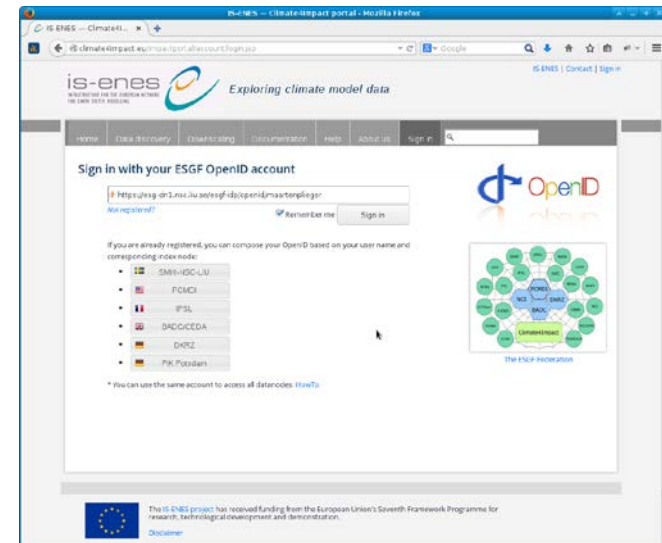
CERFACS, KNMI, University of Cantabria, SMHI, Wageningen University, CMCC, STFC, IPSL

Maarten Plieger, Wim Som de Cerff, Ernst de Vreede,
Christian Pagé, Natalia Tatarinova,
Antonio Cofiño, Manuel Vega Saldarriaga,
Ronald Hutjes, Fokke de Jong,
Lars Bärring, Elin Sjøkvist



<http://climate4impact.eu/>

- Platform for impact researchers to explore climate data and perform analysis
- Current phase:
 - Implementing real use cases from impact researchers
 - Bulk download, bulk processing, etc...
- Search ESGF infrastructure (CMIP5 / CORDEX)
- Visualize ESGF data - using ADAGUC Web Map Services
- Perform calculations / process data - PyWPS and ICCLIM
 - Climate indices calculation and data reduction
 - Personal store for processing outcomes
- Upload and store your own data
 - Visualize your own data online!
 - Process your own data online!



Intro

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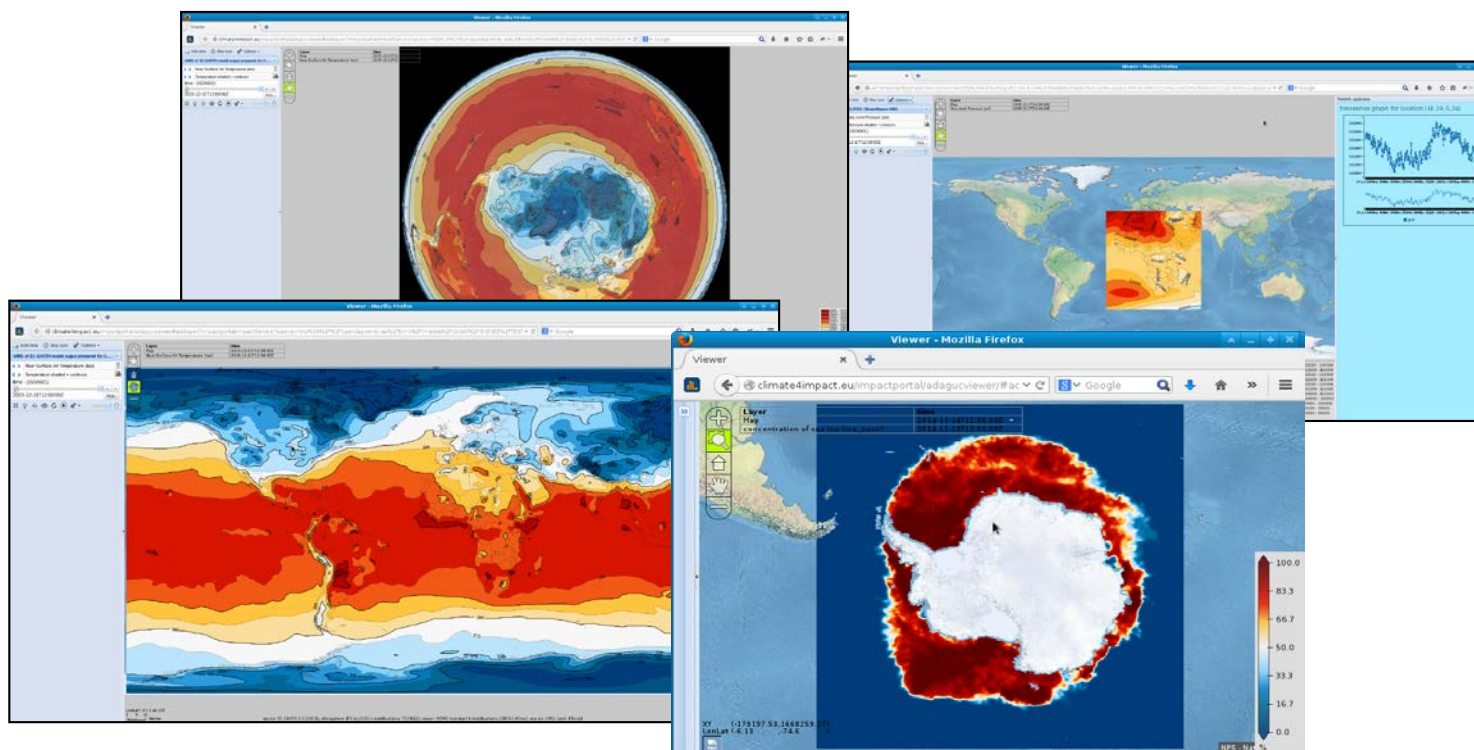
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Real use of open standards and open source software:

- Data access over OPeNDAP → THREDDS
- Online analysis using Web Processing Services → PyWPS and ICCLIM
- Online visualization using Web Map Services → ADAGUC WMS
- Single Sign On using OpenId, delegation using MyProxy X509



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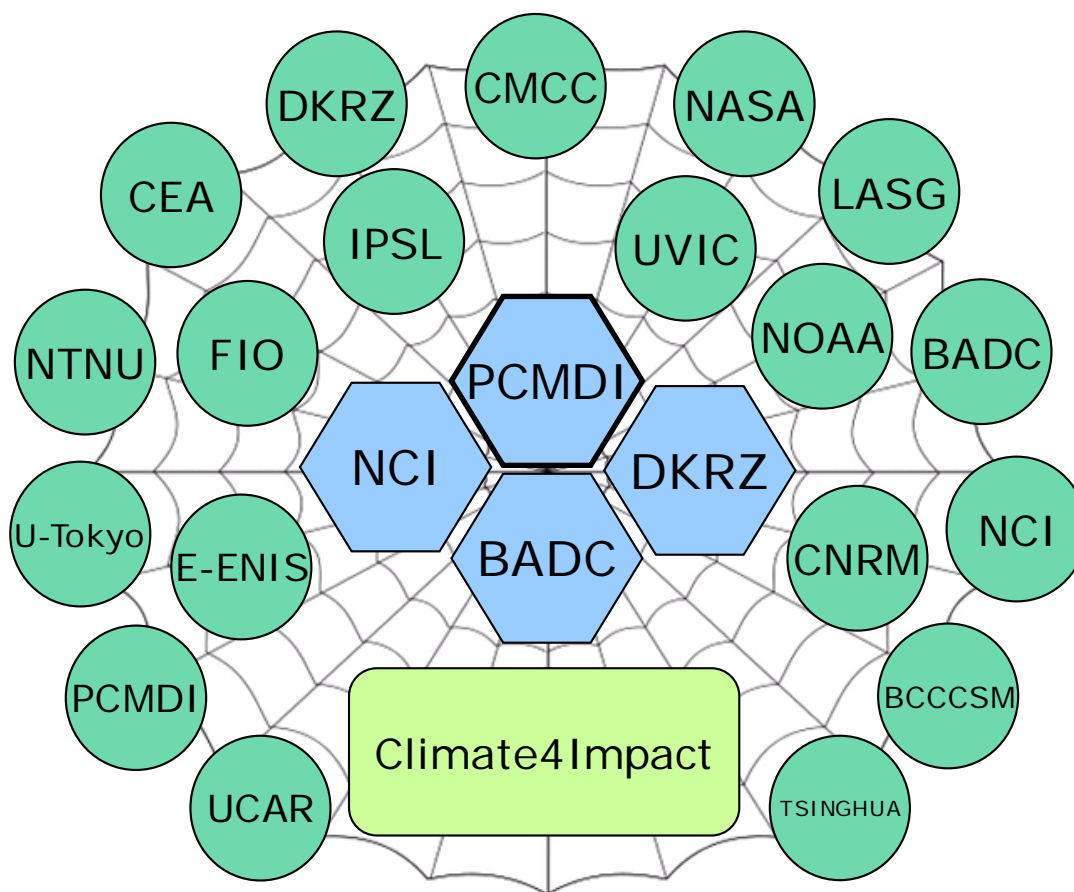
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Earth System Grid Federation



- Robust and distributed
- Index nodes (blue)
- Data nodes (green)
- Global Climate Model Data (CMIP5)
- Regional Climate Model Data (CORDEX)
- ~3 Petabyte of data
- **Search API offered**
- **OpenDAP data access offered**
- Climate4impact builds on and contributes to this global infrastructure

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The screenshot displays the Climate4Impact web application interface. At the top, there is a navigation bar with buttons for Intro, Data, Search, Visualize, Process, Download, and Conclusion. Below this is a browser window showing the URL climate4impact.eu/impactportal/data/basicsearch.jsp#project_CMIP5=1&variable_tasmin=1&time_frequency_day=1&experiment_rcp45=1. The main content area features the is-enes logo and the tagline "Exploring climate model data". A search bar is present in the top right corner. Below the search bar, there is a navigation menu with options: Home, Data discovery, Downscaling, Documentation, Help, About us, and Sign in. The search results are displayed in a table format, showing filters for Project (CMIP5, CORDEX), Variable (Temperature, Precipitation, Windspeed, etc.), Frequency (3 hourly, daily, monthly), Time frame, Experiment (Historical, RCP26, RCP45, RCP60, RCP85, Evaluation, 1pctCO2), Domain (Search domain (CORDEX)), and Models (Found 182 model(s)). The search results section shows "Found 106 datasets. (see esgf query)".

Search based on feedback from impact researchers → quick preset of common queries

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New faceted search

The screenshot displays the Climate4Impact web application in a Mozilla Firefox browser. The URL bar shows `localhost/impactportal/data/esgsearch.jsp`. The application header includes the 'is-enes' logo and the tagline 'Exploring climate model data'. A navigation menu at the top contains links for Home, Data discovery, Downscaling, Documentation, Help, About us, and Account. Below this, a secondary menu highlights 'Faceted Search' among other options like Search, Catalogs, and Map & Plot.

The main content area is titled 'Faceted search' and features a 'Filters' section with various filter categories and their counts: `cf_standard_name (16)`, `model (1)`, `data_node (1)`, `experiment_family (2)`, `product (1)`, `ensemble (10)`, `project (1)`, `institute (1)`, `time_frequency (1)`, `realm (1)`, `cmor_table (1)`, `experiment (1)`, `variable_long_name (19)`, and `variable (19)`. Below the filters, a 'Selected filters' section shows the active filters: `data_node : albedo2.dkrz.de`, `experiment : rcp45`, `project : CMIP5`, `time_frequency : day`, `variable : tas`, and `model : EC-EARTH`.

The results section, titled 'Datasets: Found 10, displaying 10 of 10 results.', lists the following dataset identifiers:

- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r7i1p1.v20130218`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r13i1p1.v20121115`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r14i1p1.v20121115`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r11i1p1.v20130314`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r1i1p1.v20121115`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r6i1p1.v20130315`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r12i1p1.v20120924`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r8i1p1.v20120609`
- `cmip5.output1.IJCHEC.EC-EARTH.rcp45.day.atmos.day.r2i1p1.v20120629`
- `cmip5.outout1.IJCHEC.EC-EARTH.rcp45.dav.atmos.dav.r9i1o1.v20120629`

Faceted search allows to drill down search results using available filters in the federation
Results from a search query are treated as a new dataset

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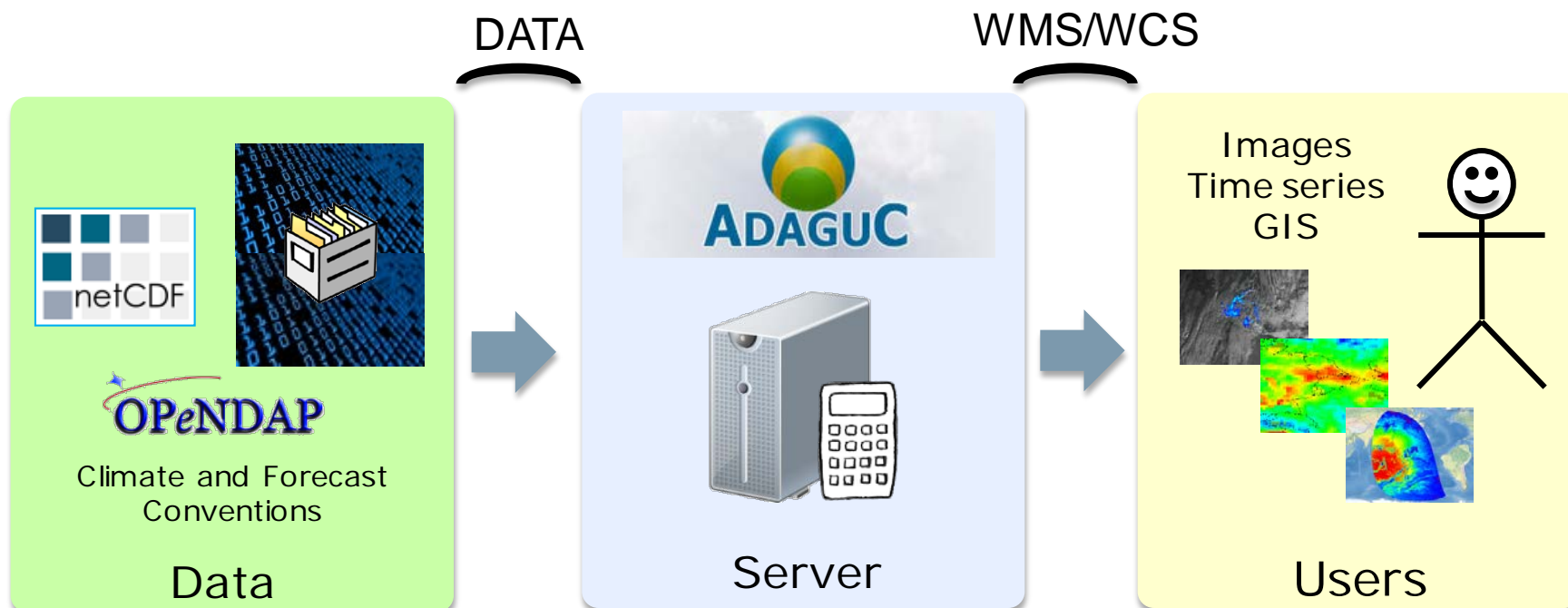
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ADAGUC Web Map and Web Coverage server



e.g.:

Geographical visualization framework using open standards and formats: <http://adaguc.knmi.nl/>

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Web Map Services based on OPeNDAP resources

Climate4impact.eu allows for creation of WMS visualizations on OPeNDAP endpoints:

Go to “Data discovery” →
“Explore your own catalogs
or files”

Metadata with variables to
be visualized is displayed

ADAGUC viewer displaying the WMS

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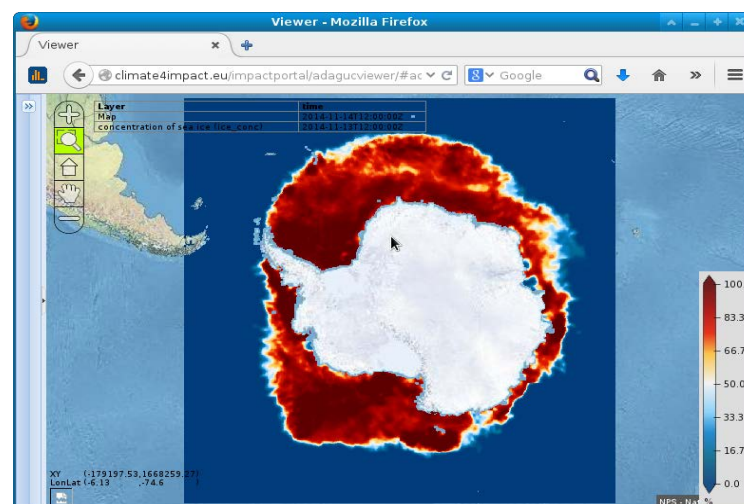
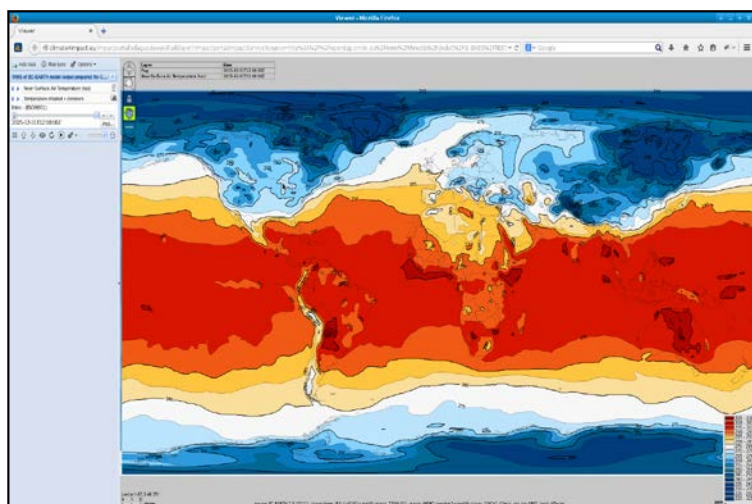
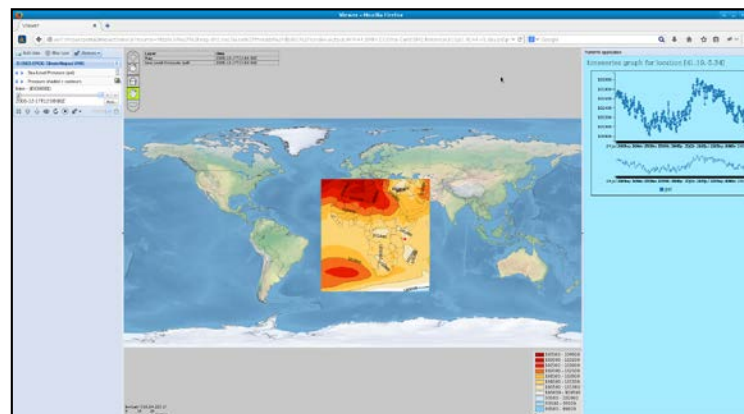
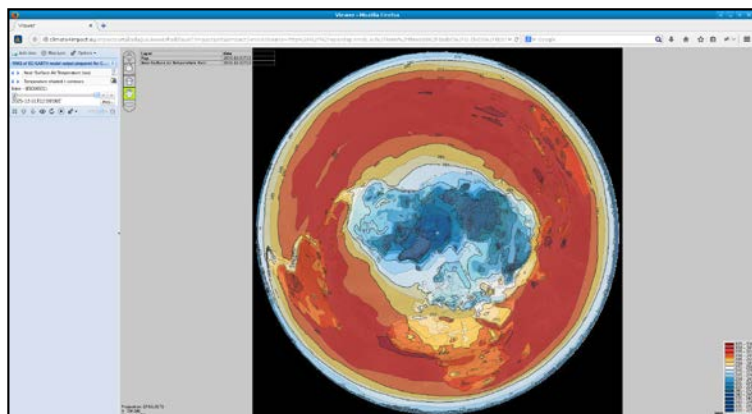
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Example: Many existing resources with OpenDAP enabled can already be visualized!



CMIP5 - global climate models

CORDEX - regional climate models

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Web Processing Service for climate indices calculations

- Uses PyWPS and ICCLIM
 - Climate indices calculation
 - Subsetting over a large time period
- User interface is build automatically based on DescribeProcess XML file.
- Interface supports:
 - Link to basket
 - Comboboxes / select from list
 - Strings/text elements
- IS-ENES2 is working on an indices wizard for user friendly indices calculation
- Climate indices calculations have added value!

The screenshot shows the 'IS-ENES — Climate4Impact portal' in a Mozilla Firefox browser. The page title is 'IS-ENES — Climate4Impact portal - Mozilla Firefox'. The URL bar shows 'climate4impact.eu/impactportal/account/wpsuseprocessor.jsp?processo...'. The page header includes the 'is-enes' logo and the tagline 'Exploring climate model data'. The navigation bar has links for Home, Data discovery, Downscaling, Documentation, Help, About us, and Account. The main content area is titled 'Use a processor' and contains a 'Processing details and options' section. This section includes fields for Title, Identifier, Abstract, and Location. The 'Options' section includes a 'Threshold' field (set to 25), a 'Maximum temperature variable' field (set to tsmax), a 'Slice mode (temporal grouping to apply for calculations)' field (set to year), an 'Input file(s)' field (with a message 'Please select a file from the basket'), and an 'Output file name' field (set to SU.nc). A 'Start processing' button is located at the bottom right of the 'Processing details and options' section.

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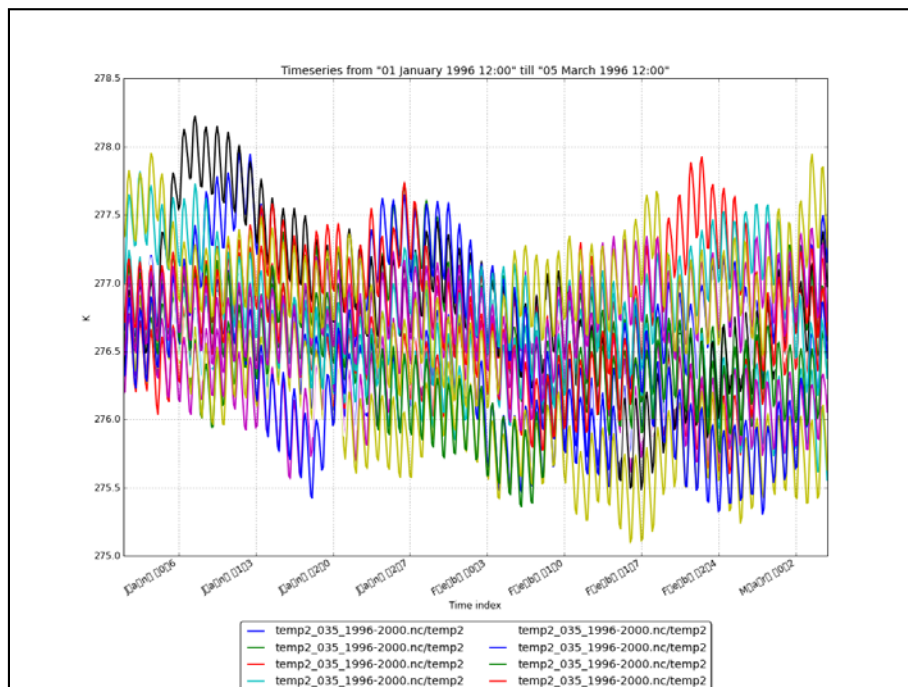
Visualize

Process

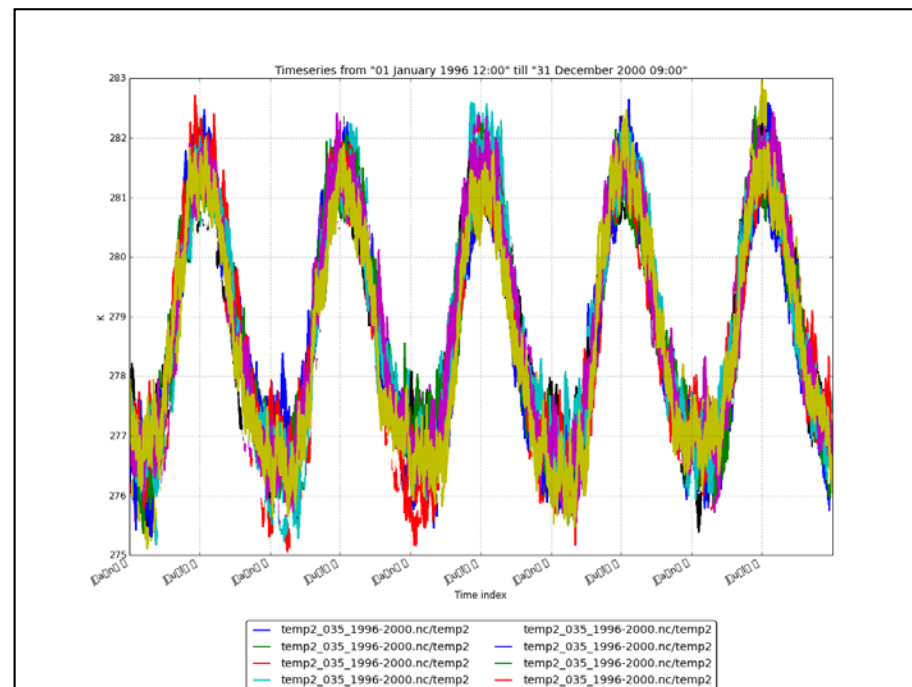
Download

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Multi member timeseries – created with WPS



3 months



5 years

Temperature for several ensembles from the ESSENCE dataset

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Web Processing Service

Job progress can be viewed from anywhere

enes
EUROPEAN NETWORK
FOR EARTH SYSTEM MODELLING

ENES Portal Interface for
the Climate Impact Communities

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[Data discovery](#)
[Map & Plot](#)
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🛒 (9)

[Account](#)
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[Jobs \(7\)](#)

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- By default the basket contains:
 - “Remote data” for links
 - “My data” for your own data
- Script based download allows to select and download multiple files
- Client certificate (x509) is embedded in download script
 - No need for MyProxy login
 - No need for firewall changes
- The basket allows for uploading your own files
 - Can be used in processing or visualization

The screenshot shows the 'Basket' section of the Climate4Impact web portal. The table lists files categorized under 'Remote data' and 'My data'. The 'Remote data' section includes several files with columns for File, DAP, HTTP, Filesize, and Date. The 'My data' section includes files like 'polar_stereo_m.nc' and 'tas_WAS-44_ECMWF-ERAINT_evaluation_r1i1p1_IITM-RegCM4-1_v411_mon_198901-199012.nc'.

File	DAP	HTTP	Filesize	Date
Remote data				
0.50 deg. regular grid			-	2015-01-22...
0.44 deg. rotated grid			-	2015-01-22...
tx_0.44deg_rot_v10.0.nc	true		691.9M	2015-01-22...
tn_0.44deg_rot_v10.0.nc	true		691.9M	2015-01-22...
tg_0.44deg_rot_v10.0.nc	true		691.9M	2015-01-22...
tasmax_day_IPSL-CM5A-LR_historical_r1i1p1_18500101-18991231.nc	true	true	673.2M	2015-03-19...
tasmax_day_IPSL-CM5A-LR_historical_r1i1p1_18500101-19491231.nc	true	true	1.346G	2015-03-19...
tasmax_day_IPSL-CM5A-LR_historical_r1i1p1_19000101-19491231.nc	true	true	673.2M	2015-03-19...
tasmax_day_IPSL-CM5A-LR_historical_r1i1p1_19500101-19991231.nc	true	true	673.2M	2015-03-19...
tasmax_day_IPSL-CM5A-LR_historical_r1i1p1_19500101-20051231.nc	true	true	754.0M	2015-03-19...
tasmax_AFR-44_CNRM-CERFACS-CNRM-CM5_rcp45_r1i1p1_CLMcom-CCLM4-8-17_v1_day_2096	true		-	2015-04-01...
My data				
polar_stereo_m.nc	true	true	906.824K	2015-01-23...
tas_WAS-44_ECMWF-ERAINT_evaluation_r1i1p1_IITM-RegCM4-1_v411_mon_198901-199012.nc	true	true	2.314M	2015-01-23...
tas_WAS-44_ECMWF-ERAINT_evaluation_r1i1p1_IITM-RegCM4-1_v411_day_19890101-19901231.nc	true	true	70.463M	2015-01-23...

Buttons at the bottom: View/Browse file, Download file, Script download, Upload file, Delete file(s), Reload basket.

Footer: You are logged in as <https://esg-dn1.msc.liu.se/esgf-idp/openid/maartenpijler>

Disclaimer: The IS-ENES project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration.

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Conclusion and next steps

- Climate4impact enables impact research
- Climate4impact is flexible due to applied technologies and standards
 - ADAGUC WMS can be used to visualize local and remote files
 - PyWPS with ICCLIM is suitable as generic processing framework for climate indices
 - OPeNDAP can be used to access small bits of large files over the internet quickly
- Climate4Impact enables easier use of ESGF services
 - Search many datasets from several projects
 - Data access and visualization via OPeNDAP
 - Security is offered in a more user friendly way
- Next steps:
 - Improve user interface → make more user friendly
 - Implement use cases from climate impact researchers
 - Finalize the connection to the University of Cantabria downscaling portal
 - Climate indices calculation wizard



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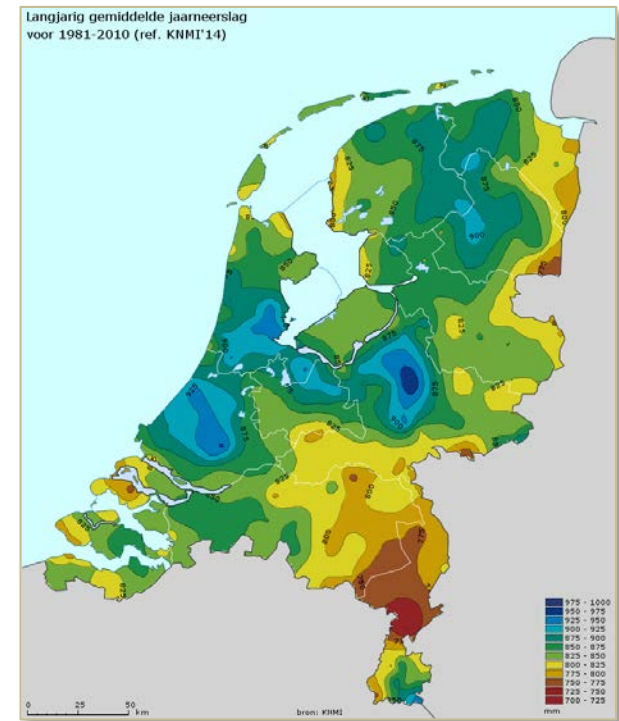
Process

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Conclusion

Web Map Service – for visualizations

- Generates visualizations of geospatial data in the form of 2D images, suitable for transfer over the internet (JPG/PNG/GIF)
- REST based:
 - Compose an URL with key value pairs, and you will get an image!
- Standard is developed and maintained by the Open Geospatial Consortium
- Generated images are geo-referenced
 - Images from several sources can be easily combined
- Images have dimensions
 - Time, elevation, member
- WMS services can be viewed in many web based clients
 - OpenLayers, Leaflet, GoogleMaps, ADAGUC viewer, ...



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OPeNDAP – for data access and subsetting



- OPeNDAP is the name of the organization and the name of the protocol
 - Open-source Project for a Network Data Access Protocol
- Data is stored at remote server
- Data model is similar to NetCDF's data model (with differences)
 - N-dimensional array container, with variables, dimensions and attributes
- Only requested pieces of data are sent
 - Accessing small pieces of large files on a remote server can still be quick
 - Data is requested based on sub-setting along dimensions
- OPeNDAP resources can be opened locally on your computer as if it were local files using the NetCDF library
 - Local files versus remote files is transparent
- The concept of a file is gone, an OPeNDAP endpoint can represent thousands of files aggregated along a dimension
 - E.g. Usually concatenate a large time series observation to one endpoint using the time dimension

OPeNDAP within ESGF is served using the THREDDS data server

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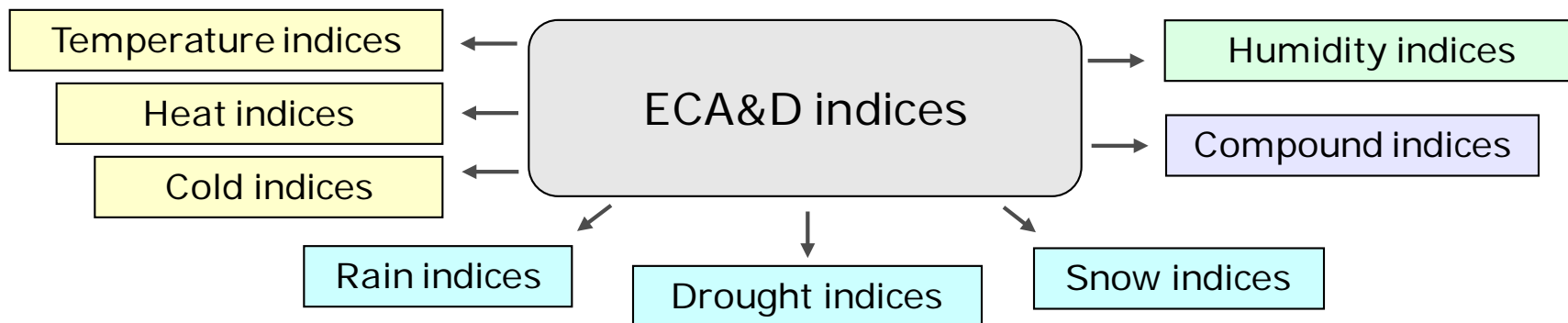
Visualize

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Indices calculation using ICCLIM – developed in IS-ENES



- Intra-period extreme temperature range [$^{\circ}$ C] - **ETR**
- Warm days (days with mean temperature > 90th percentile of daily mean temperature) - **TG90p**
- Summer days (days with max temperature > 25 $^{\circ}$ C) - **SU**

- Python code developed at CERFACS, started in September 2013
 - Generic and modular approach, can be reused in other environments
 - C functions called for optimization
- I/O interface is structured for optimal performance, with wrapper functions
- Some percentile-based indices (TG10p, TX10p, TN90p, etc): **OpenClimateGIS**

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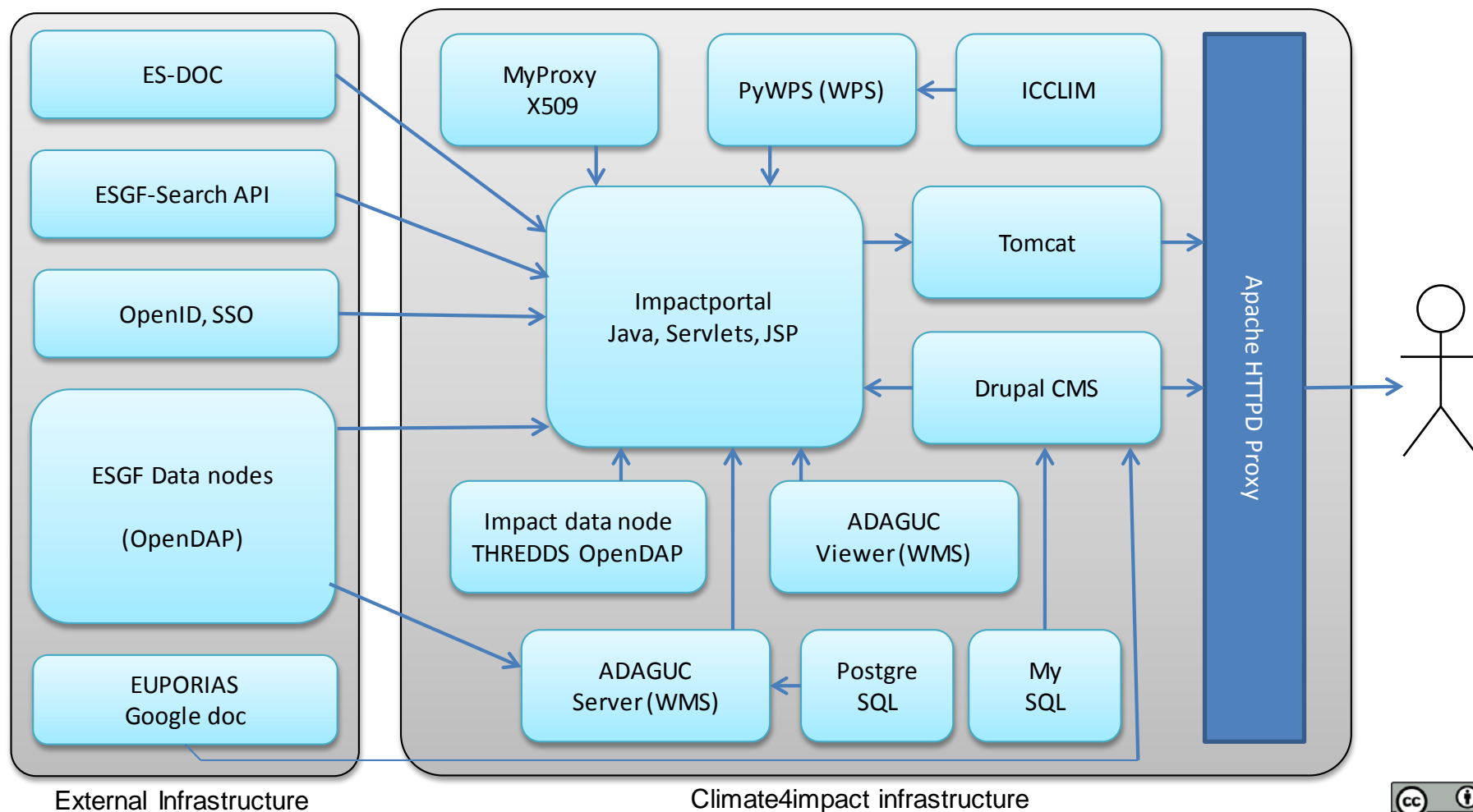
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How components fit together



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