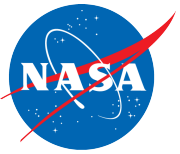


Climate Model Diagnostic Analyzer

Seungwon Lee, Lei Pan, Chengxing Zhai, Benyang Tang,
Jonathan Jiang, Terry Kubar, Juilin Li, Joao Teixeira,

Jet Propulsion Laboratory, Caltech

Jia Zhang, Wei Wang

Carnegie Mellon University

2015 IEEE International Conference on Big Data, Santa Clara, CA, Oct 29 – Nov 1, 2015

Background/Motivation

- Both NRC Decadal Survey and the latest IPCC Assessment Report stressed the need for the comprehensive and innovative evaluation of climate models with the synergistic use of global observations in order to maximize the investments made in Earth observational systems and also to capitalize on them for improving our weather and climate simulation and prediction capabilities.

- NASA has accumulated Earth observing satellite measurements, reanalysis datasets, and model-based datasets for over 40 years along with many analysis tools. The rapidly growing datasets and analytics tools challenge individual Earth scientists in organizing their work and concurrently challenge the whole community in sharing the datasets and tools and derived knowledge.

Objectives

- Develop a novel methodology to diagnose model biases in contemporary climate models, to identify the physical processes responsible for creating model biases, and to incorporate the understanding into new model presentation that reduce the model biases.

- Implement the methodology as a web-service based, cloud-enabled, provenance-supported climate-model evaluation system named Climate Model Diagnostic Analyzer (CMDA) for the Earth science modeling and model analysis community.

- Develop an online collaborative environment for CMDA, where Earth scientists can easily publish their climate data and analytics tools, share them within groups, and find those of others.

What is CMDA?

- Enables multi-aspect, physics-based climate data analyses.
- Facilitates comprehensive and synergistic use of observational data, reanalysis data, and model outputs.
- Is a web-service oriented system.
- Does not require local software/library installation.
- Provides all the input data needed for analysis.
- Runs on the Amazon cloud system.
- Collects provenance and supports provenance-based search and reanalysis.
- Recommends relevant datasets and analysis tools based on usage history analyses.
- Provides an environment to share datasets and analysis tools and results.

CMDA Data Sets

Model Outputs from CMIP5 project

- Experiments:
  - Historical, AMIPs, Forecast
- Models:
  - CCCMA/canesm2, GFDL/esm2g, GISS/e2-h, GISS/e2-r, NCAR/cam5, NCC/noresm, UKMO/hadgem2-es, CCCMA/canam4, CSIRO/mk3.6, GFDL/cm3, IPSL/cm5a-lr, MIROC/miroc5, UKMO/hadgem

To be Evaluated

References

Reanalysis Data from ECMWF and Merra

- Vertical Wind
- Relative Humidity

References

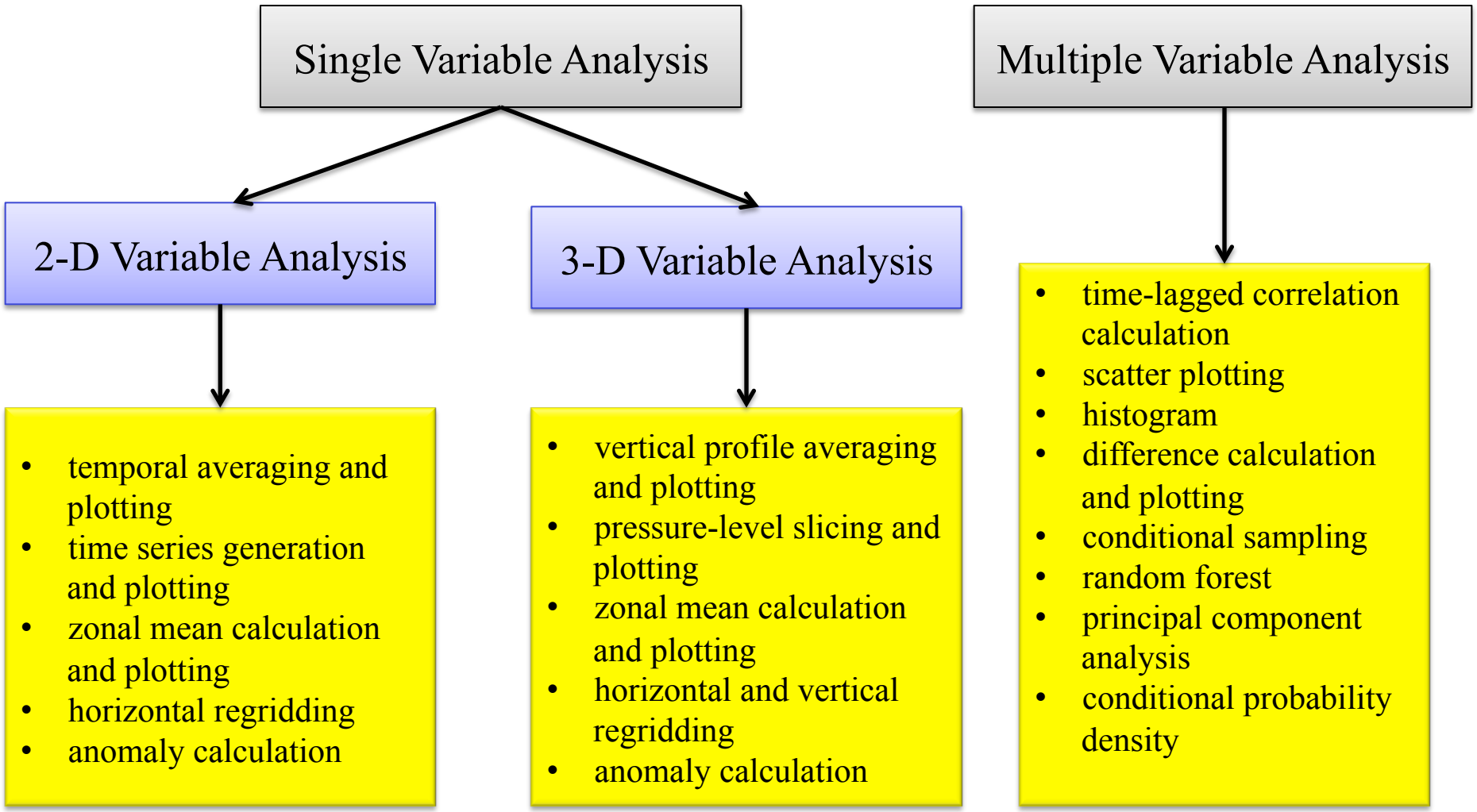
Observation Data from Obs4MIPs

- AMSR-E surface temperature
- AIRS and MLS air temperature & water vapor content
- MODIS total cloud fraction, leaf area index
- GPCP and TRMM precipitation
- AVISO sea surface height
- CERES radiation fluxes

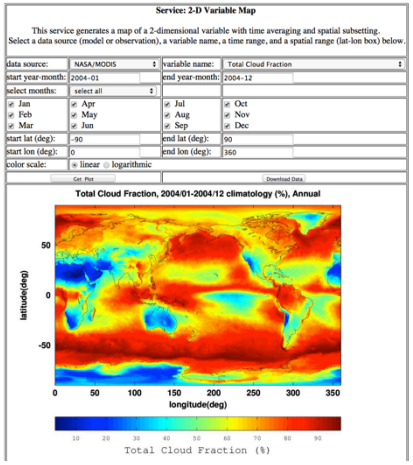
CMDA Data Sets

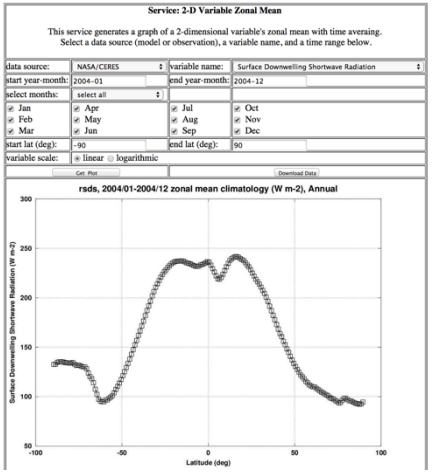
- Type: climate model outputs, observational datasets, and reanalysis datasets.
- Variable: cloud, precipitation, ocean, land, radiation, and atmosphere.
- Number: 336 datasets
- Volume: 450 GB
- 297 model datasets: CMIP5 model outputs for historical runs with six climate models and AMIP runs with six climate models
- 32 observational datasets: satellite data and ship-floats data
- 7 reanalysis datasets: ECMWF interim data

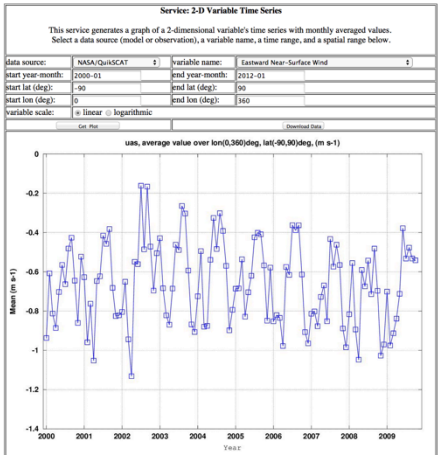
CMDA Analysis Tools

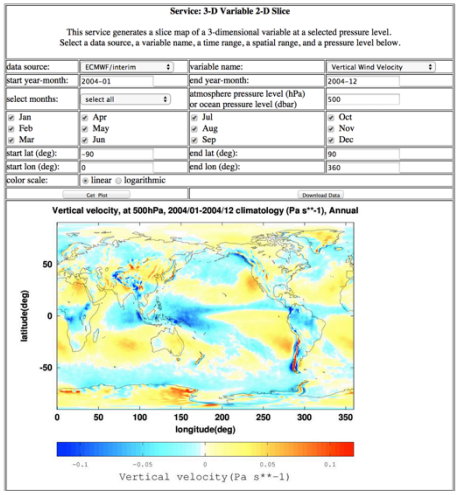


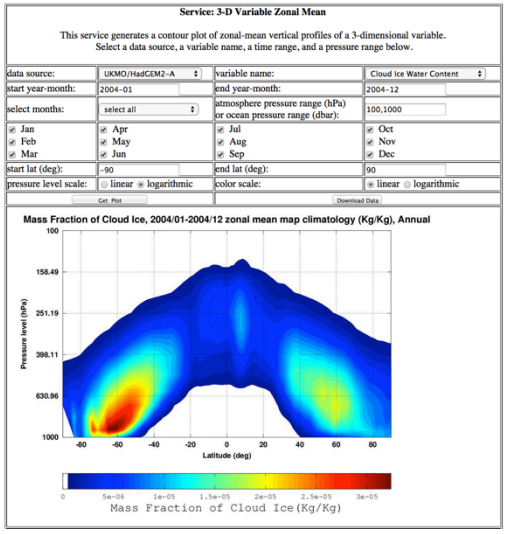
CMDA Analysis Tools

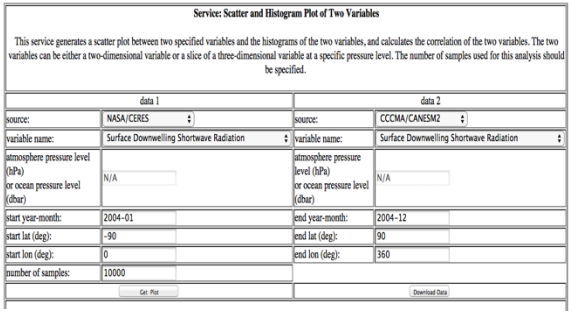


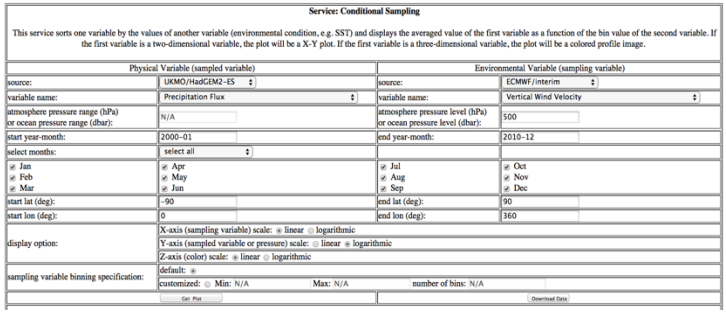


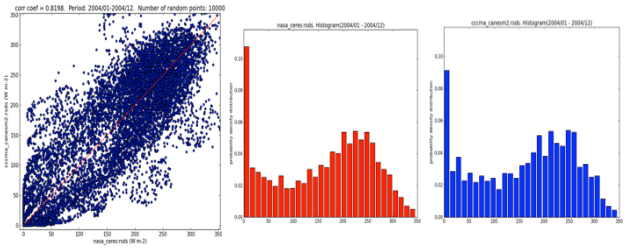


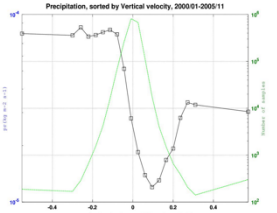


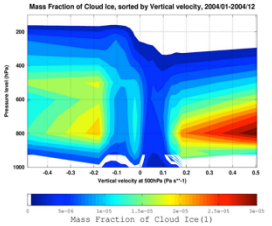












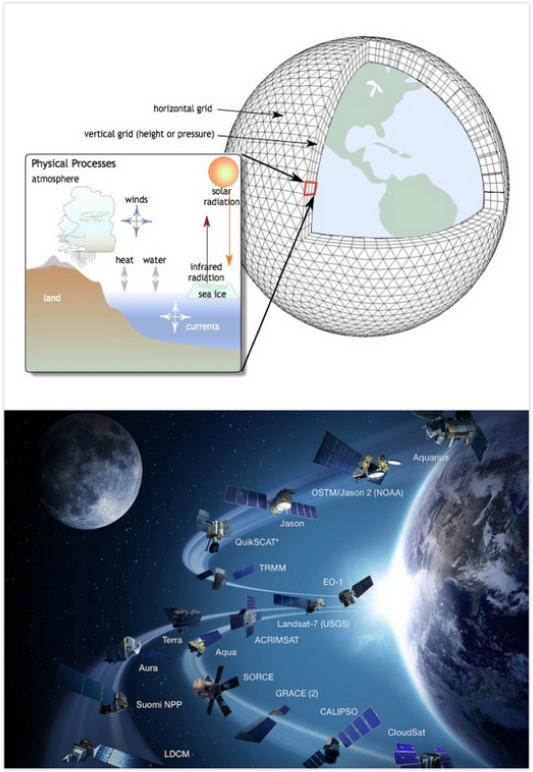
CMDA Collaborative Tools

- Building a provenance tracking system for CMDA.
- Building a provenance-driven recommendation engine for CMDA.
- Building data and analysis sharing capabilities for CMDA.
  - Service configuration/execution provenance
  - Data usage provenance
  - Service usage provenance
  - Provenance-based search
  - Data recommendation
  - Service recommendation
  - Bug report
  - Web service publication and interface design

CMDA Collaborative Tools

Jet Propulsion Laboratory
California Institute of Technology
Carnegie Mellon University

Web Service | Dataset | Analytics | Scientist | About | Log in



Climate Model Diagnostic Analyzer

A repository of web services for multi-aspect physics-based and phenomenon-oriented phenomenon-oriented climate model performance evaluation and diagnosis through the comprehensive and synergistic use of multiple observational data, reanalysis data, and model outputs.

This repository is specially customized to support the 2015 JPL Center for Climate Sciences Summer School. The theme of the summer school is **Using Satellite Observations to Advance Climate Models**. This repository provides datasets and analysis tools for the students to use for their group research projects.

2014 JPL Summer School

Using Satellite Observations to Advance Climate Models

Providing Diagnostic Analysis Tools for Climate Community

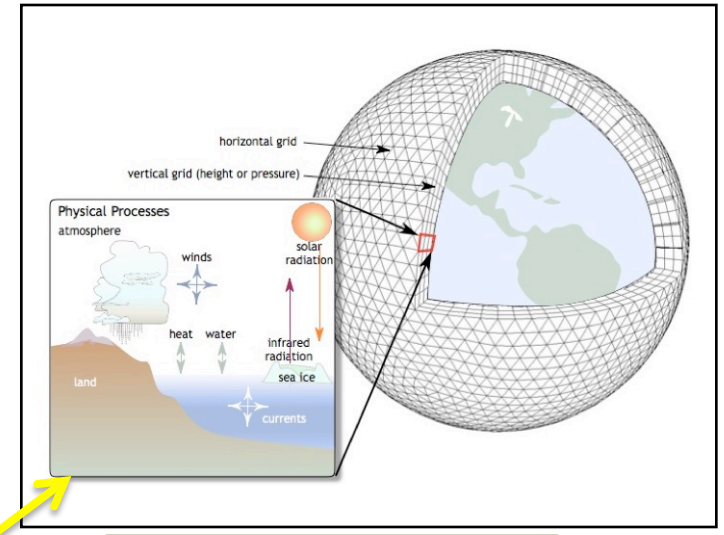
Climate Model Diagnostic Analyzer

Providing Climate Datasets for Climate Community

Supporting JPL Center for Climate Sciences Summer School Group Projects

2015 JPL Summer School

Using Satellite Observations to Advance Climate Models



Climate Model Diagnostic Analyzer

Providing Diagnostic Analysis Tools for Climate Community

Supporting JPL Center for Climate Sciences Summer School Group Projects

Providing Climate Datasets for Climate Community

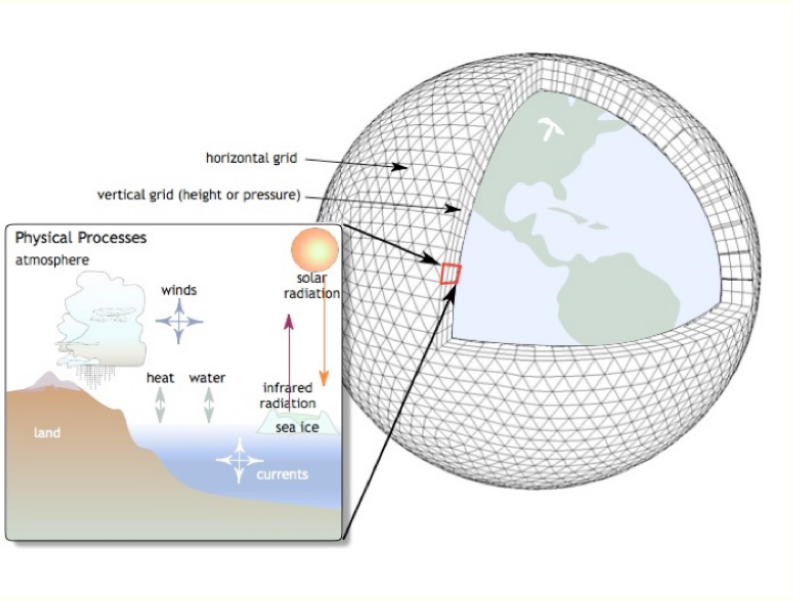
Summer School Activities

- Hands-on experience with climate science research
- Five group research topics have been designed.
- A student will be assigned to a virtual machine in the Amazon Cloud.
- The machine has all the datasets and analysis tools needed to do the group research projects.
- Only thing a student needs from his/her machine is a web browser with an internet connection.
- One-hour introduction session (tools, topics, group formation) was given on Tuesday.
- Two practice sessions were held on Tuesday and Thursday afternoons.
- Final presentation on Friday

Landing Page of CMDA

Climate Model Diagnostic Analyzer

2015 JPL Center for Climate Sciences Summer School: Using Satellite Observations to Advance Climate Models



1. Introduction

Climate Model Diagnostic Analyzer (CMDA) is a repository of web services for multi-aspect physics-based and phenomenon-oriented climate model performance evaluation and diagnosis through the comprehensive and synergistic use of multiple observational data, reanalysis data, and model outputs. This repository is specially customized to support the 2015 JPL Center for Climate Sciences Summer School. The theme of the summer school is Using Satellite Observations to Advance Climate Models. This repository provides datasets and analysis tools for the students to use for their group research projects.

2D Variable Map

Service: 2-D Variable Map

This service generates a map of a 2-dimensional variable with time averaging and spatial subsetting.
Select a data source (model or observation), a variable name, a time range, and a spatial range
(lat-lon box) below.

Variable

model: GFDL/ESM2G ;

variable: Precipitation Flux ;

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

start year-month: (earliest:1996-01)	2004-01	end year-month: (latest:2005-12)	2004-12
start lon (deg):	0	end lon (deg):	360
start lat (deg):	-90	end lat (deg):	90

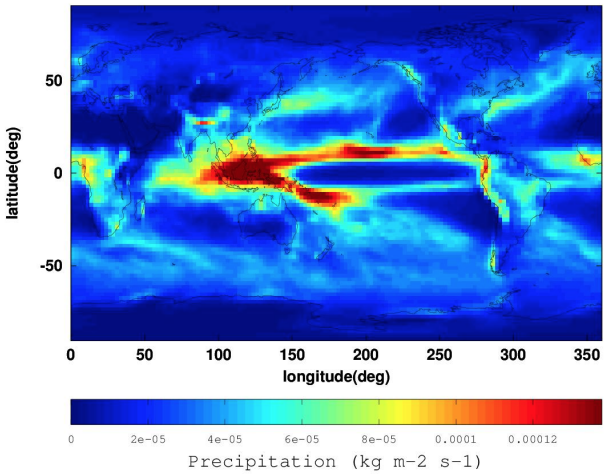
Display Options:

color scale: linear logarithmic

Execution purpose:

Get Plot Download Data

Precipitation, 2004/01-2004/12 climatology (kg m-2 s-1), Annual



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Single Variable Analysis

2D Variable Zonal Mean

Service: 2-D Variable Zonal Mean

This service generates a graph of a 2-dimensional variable's zonal mean with time averaing.
Select a data source (model or observation), a variable name, and a time range below.

Variable

model: GFDL/ESM2G ;

variable: Precipitation Flux ;

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

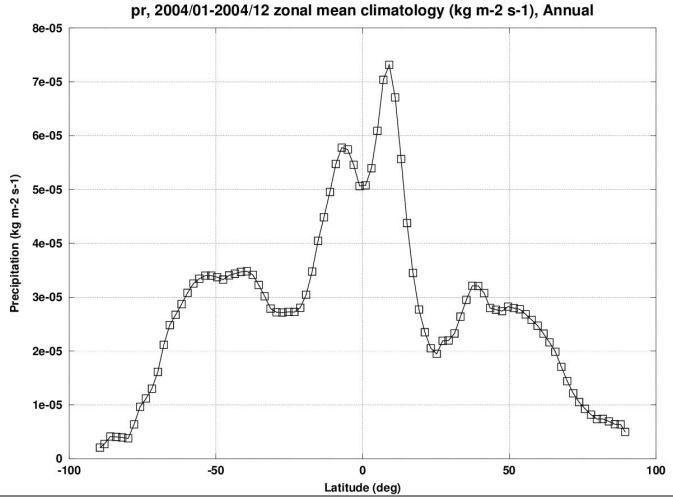
start year-month: (earliest:1996-01)	2004-01	end year-month: (latest:2005-12)	2004-12
start lon (deg):	0	end lon (deg):	360
start lat (deg):	-90	end lat (deg):	90

Display Options:

color scale: linear logarithmic

Execution purpose:

Get Plot | Download Data



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Single Variable Analysis

2D Variable Time Series

Service: 2-D Variable Time Series

This service generates a graph of a 2-dimensional variable's time series with monthly averaged values.
Select a data source (model or observation), a variable name, a time range, and a spatial range below.

Variable

model: GFDL/ESM2G ;
variable: Precipitation Flux ;

Data Subsetting

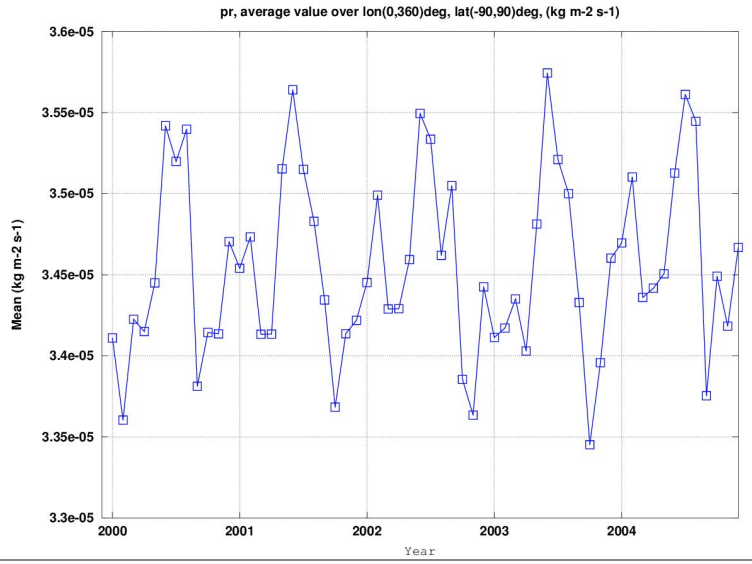
start year-month: (earliest:1996-01)	2000-01	end year-month: (latest:2005-12)	2004-12
start lon (deg):	0	end lon (deg):	360
start lat (deg):	-90	end lat (deg):	90

Display Options:

variable scale: linear logarithmic

Execution purpose:

Get Plot | Download Data



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Single Variable Analysis

3D Variable Slice Map

Service: 3-D Variable 2-D Slice

This service generates a slice map of a 3-dimensional variable at a selected pressure level.
Select a data source, a variable name, a time range, a spatial range, and a pressure level below.

Variable

model: GFDL/ESM2G ;
variable: Air Temperature ;
atmospheric pressure (hPa): 500

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

start year-month: (earliest:1991-01) 2003-01 — end year-month: (latest:2005-12) 2004-12
start lon (deg): 0 — end lon (deg): 360
start lat (deg): -90 — end lat (deg): 90

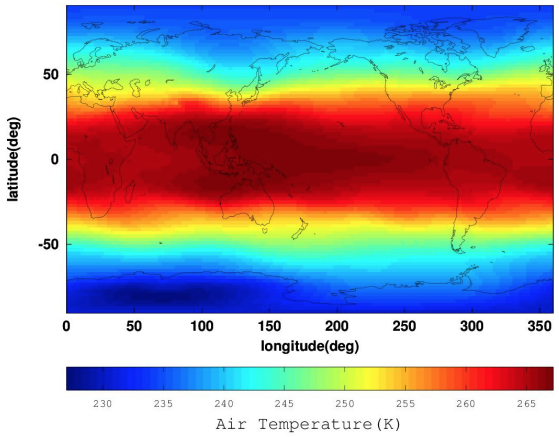
Display Options:

variable scale: linear logarithmic

Execution purpose:

Get Plot | Download Data

Air Temperature, at 500hPa, 2003/01-2004/12 climatology (K), Annual



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Single Variable Analysis

3D Variable Zonal Mean

Service: 3-D Variable Zonal Mean

This service generates a contour plot of zonal-mean vertical profiles of a 3-dimensional variable.
Select a data source, a variable name, a time range, and a pressure range below.

Variable

model: GFDL/ESM2G ;
variable: Air Temperature ;
atmospheric pressure range (hPa): 100,1000

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
start year-month: (earliest:1991-01) 2002-01 — end year-month: (latest:2005-12) 2004-12
start lat (deg): -90 — end lat (deg): 90

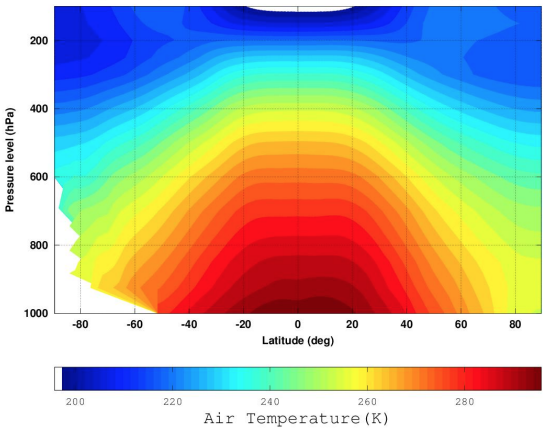
Display Options:

color scale: linear logarithmic
pressure level scale: linear logarithmic

Execution purpose:

Get Plot | Download Data

Air Temperature, 2002/01-2004/12 zonal mean map climatology (K), Annual



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Single Variable Analysis

3D Variable Vertical Profile

Service: 3-D Variable Average Vertical Profile

This service generates the average of a three-dimensional variable over a specified region and time and display the average as a function of pressure level as an X-Y plot.

Variable

model: GFDL/ESM2G ;

variable: Air Temperature ;

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

start year-month: (earliest:1991-01) 2004-01 — end year-month: (latest:2005-12) 2004-12

start lon (deg): 0 — end lon (deg): 360

start lat (deg): -20 — end lat (deg): 20

Display Options:

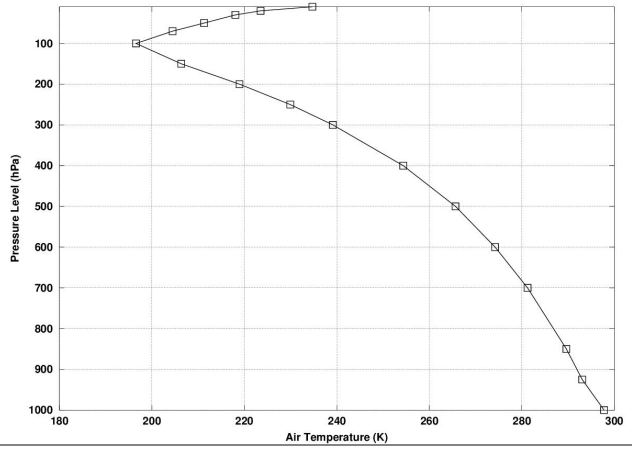
pressure level scale: linear logarithmic

variable scale: linear logarithmic

Execution purpose:

Get Plot | Download Data

ta, 2004/01-2004/12 vertical profile climatology (K), Annual



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Single Variable Analysis

Scatter/Histogram/Correlation

Service: Scatter and Histogram Plot of Two Variables

This service generates a scatter plot between two specified variables and the histograms of the two variables, and calculates the correlation of the two variables. The two variables can be either a two-dimensional variable or a slice of a three-dimensional variable at a specific pressure level. The number of samples used for this analysis should be specified.

Variable 1

model:	NASA/GPCP
variable:	Precipitation Flux
pressure:	N/A

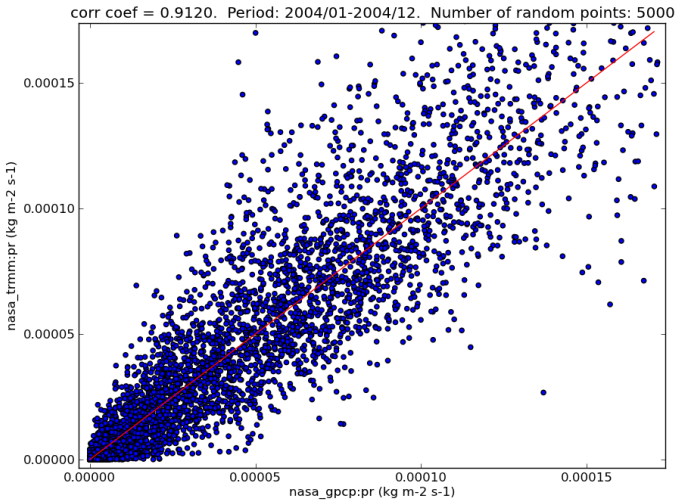
Variable 2

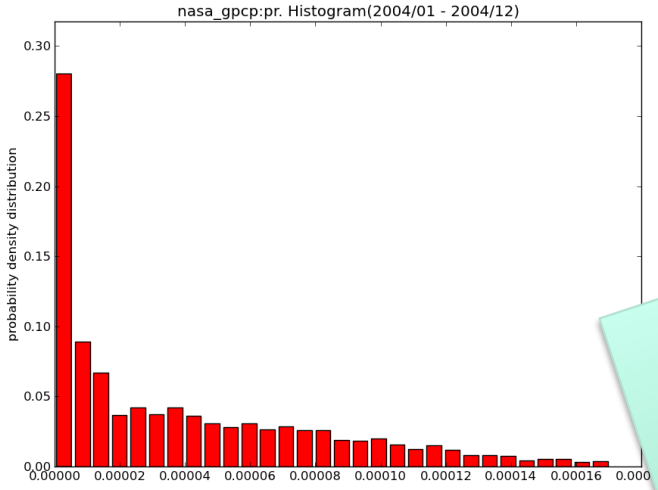
model:	NASA/TRMM
variable:	Precipitation Flux
pressure:	N/A

Data Subsetting

start year-month: (earliest:1998-01)	2004-01	end year-month: (latest:2011-06)	2004-12
start lon (deg):	0	end lon (deg):	360
start lat (deg):	-20	end lat (deg):	20
number of samples:	5000		
Execution purpose:			

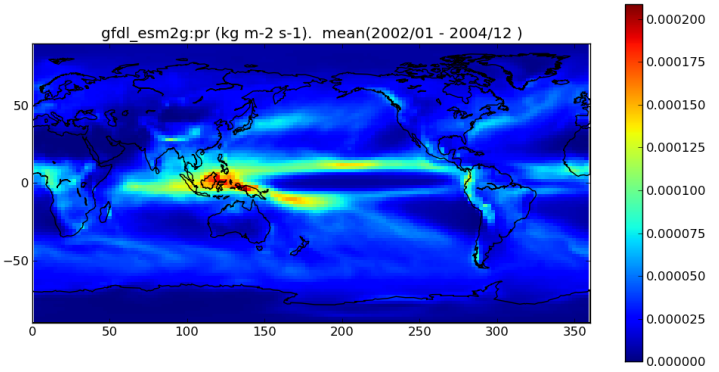
Get Plot Download Data

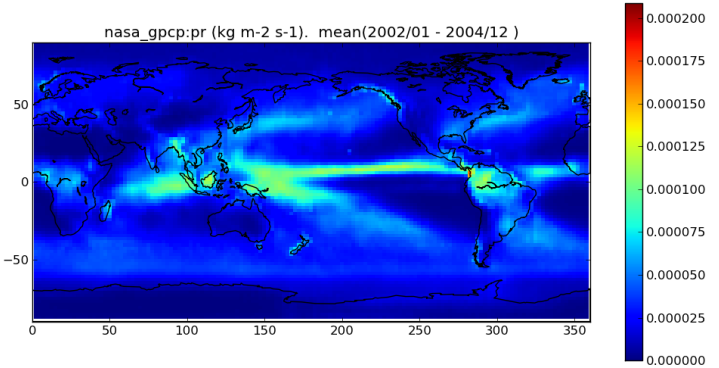


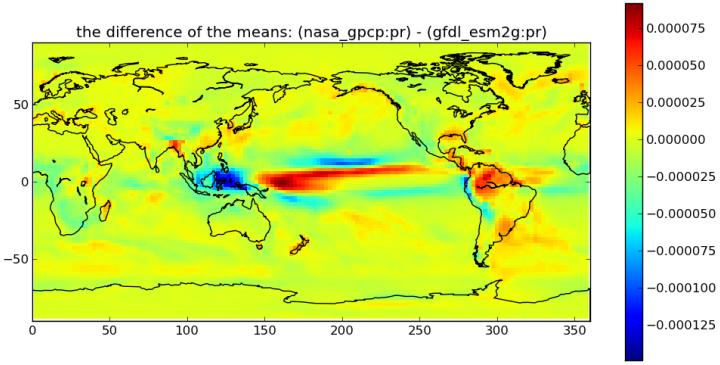


Multi Variable Analysis

Difference Plot







Multi Variable Analysis

Time Lagged Correlation

Service: Time-Lagged Correlation Map of Two Variables

This service generates a time-lagged correlation map between two specified variables.
The two variables can be either a two-dimensional variable or a slice of a three-dimensional variable at a specific pressure level.

Variable 1

source:	NASA/TRMM
variable name:	Precipitation Flux
pressure :	N/A

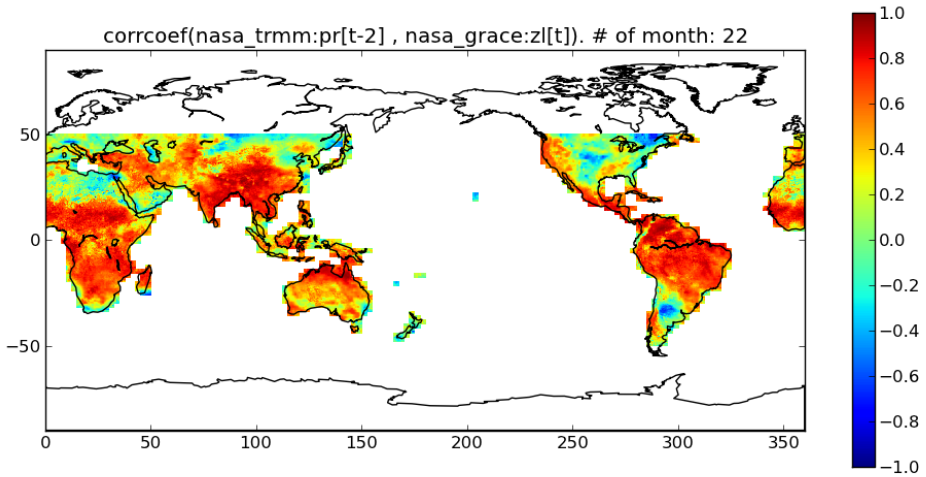
Variable 2

source:	NASA/GRACE
variable name:	Equivalent Water Height Over Land
pressure :	N/A

Data Subsetting

start year-month: (earliest:2003-02)	2004-01	end year-month: (latest:2011-12)	2005-12
start lon (deg):	0	end lon (deg):	360
start lat (deg):	-90	end lat (deg):	90
lag (month):	2		
Execution purpose:			

Get Plot Download Data



Multi Variable Analysis

Conditional Sampling 1

Service: Conditional Sampling with One Variable

This service sorts one variable by the values of another variable (environmental condition, e.g. SST) and displays the averaged value of the first variable as a function of the bin value of the second variable. If the first variable is a two-dimensional variable, the plot will be a X-Y plot. If the first variable is a three-dimensional variable, the plot will be a colored profile image.

Physical Variable (sampled variable)

source: GFDL/ESM2G
variable name: Cloud Ice Water Content
atmospheric pressure range (hPa): 200,900

Environmental Variable (sampling variable)

source: GFDL/ESM2G
variable name: Sea Surface Temperature
pressure : N/A
sampling variable binning specification: default: customized:
Min: N/A Max: N/A number of bins: N/A

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
start year-month: (earliest:1996-01) 2003-01 — end year-month: (latest:2005-12) 2004-12
start lon (deg): 0 — end lon (deg): 360
start lat (deg): -90 — end lat (deg): 90

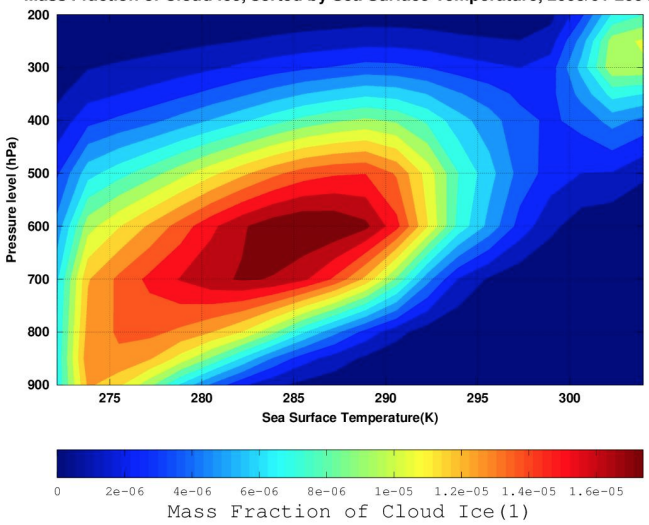
Display Options:

X-axis (sampling variable) scale: linear logarithmic
y-axis (sampling variable or pressure) scale: linear logarithmic
z-axis (color) scale: linear logarithmic

Execution purpose:

Get Plot Download Data

Mass Fraction of Cloud Ice, sorted by Sea Surface Temperature, 2003/01-2004/12



Multi Variable Analysis

Conditional Sampling 2

Service: Conditional Sampling with Two Variables

This service sorts one variable called sampled variable by the values of two variables called sampling variables and displays the averaged value of the sampled variable in color as a function of the bin value of the two sampling variables in X-Y axis. There are overlaid contours which show the number of samples in each of the two sampling variable bin.

Physical Variable (sampled variable)

source: GFDL/ESM2G
variable name: Total Cloud Fraction
pressure range: N/A

Environmental Variable 1 (sampling variable)

source: GFDL/ESM2G
variable name: Sea Surface Temperature
pressure : N/A
sampling variable binning specification: default: customized:
Min: N/A Max: N/A number of bins: N/A

Environmental Variable 2 (sampling variable)

source: GFDL/ESM2G
variable name: Vertical Wind Velocity
atmospheric pressure (hPa): 500
sampling variable binning specification: default: customized:
Min: N/A Max: N/A number of bins: N/A

Data Subsetting

select months: select all — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

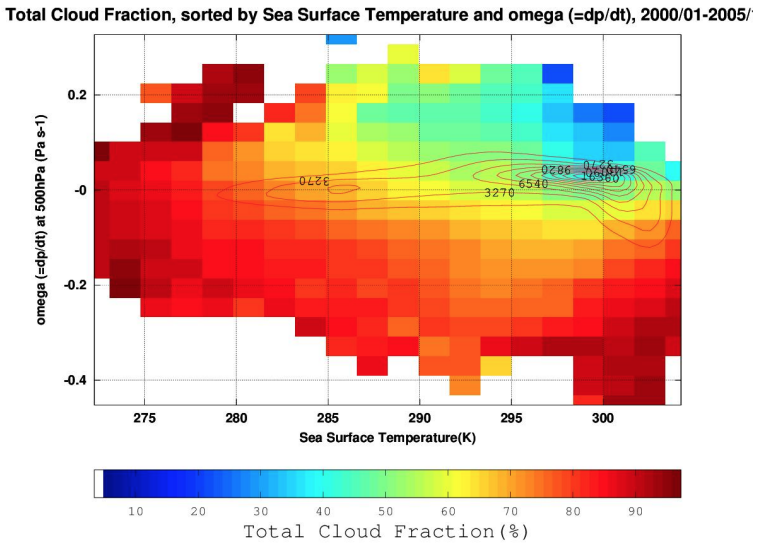
start year-month: (earliest:1996-01) 2000-01
end year-month: (latest:2005-12) 2005-12
start lon (deg): 0
end lon (deg): 360
start lat (deg): -50
end lat (deg): 50

Display Options:

X-axis (sampling variable) scale: linear logarithmic
y-axis (sampling variable or pressure) scale: linear logarithmic
z-axis (color) scale: linear logarithmic

Execution purpose:

Get Plot Download Data

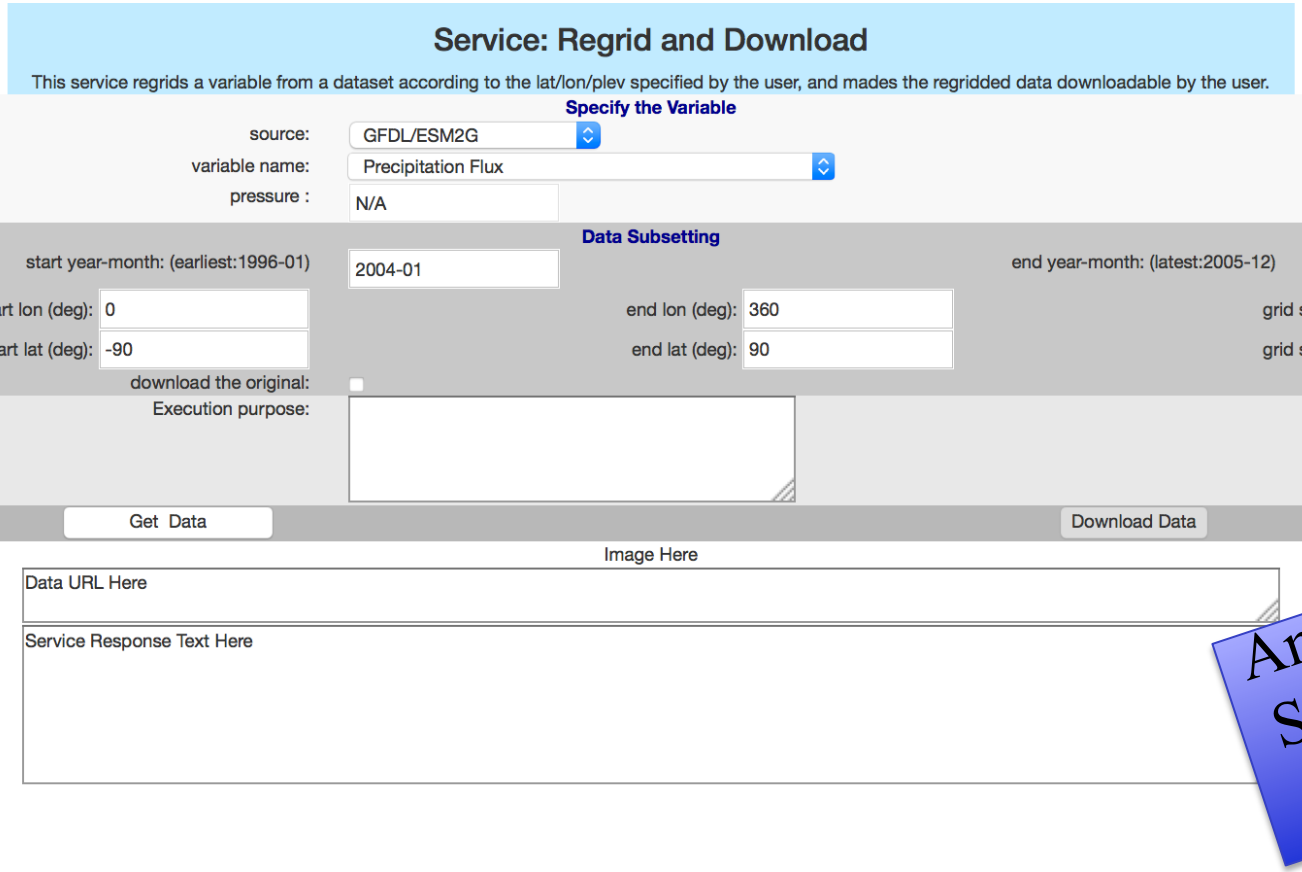


Multi Variable Analysis

Analysis Support Tools

- Regrid and Download Service
  - Regrid existing data in user-specified horizontal and vertical resolutions and download the new regridded dataset. Downloading the original dataset is an option to choose.
- Dataset Search Service
  - Find datasets available in the server with respect to data source (model center, observation instrument) and variable name (temperature, humidity, etc).

Regrid and Download



Analysis Support Service

Dataset Search

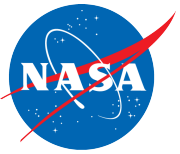
Select data to show in the table

Select Models or Instruments: 12 datasets

Select variables: all variables

Make Table

#	Agency	Model or Instrument	Variable shortname	Variable longname	Units	Grid dims	Start time	End time
1	NASA	GRACE	zl	Equivalent Water Height Over Land	cm	2	200302	201112
2	NASA	GRACE	zo	Equivalent Water Height Over Ocean	cm	2	200302	201112
3	NASA	MODIS	clt	Total Cloud Fraction	%	2	200003	201109
4	NASA	MODIS	lai	Leaf Area Index	1	2	200002	200912
5	NASA	AMSRE	tos	Sea Surface Temperature	K	2	200206	201012
6	NASA	TRMM	pr	Precipitation Flux	kg m-2 s-1	2	199801	201312
7	NASA	GPCP	pr	Precipitation Flux	kg m-2 s-1	2	197901	201106
8	NASA	QuikSCAT	uas	Eastward Near-Surface Wind	m s-1	2	199908	200910
9	NASA	QuikSCAT	vas	Northward Near-Surface Wind	m s-1	2	199908	200910
10	NASA	QuikSCAT	sfcWind	Near-Surface Wind Speed	m s-1	2	199908	200910
11	NASA	AVISO	zos	Sea Surface Height	m	2	199210	201012
12	NOAA	NODC	ohc700	Ocean Heat Content Anomaly within 700 m Depth	1e18 joules	2	195501	201212
13	NOAA	NODC	ohc2000	Ocean Heat Content Anomaly within 2000 m Depth	1e18 joules	2	200501	201212
14	NASA	CERES	rlds	Surface Downwelling Longwave Radiation	W m-2	2		201002
15	NASA	CERES	rsds	Surface Downwelling Shortwave Radiation	W m-2			201002
16	NASA	CERES	rlus	Surface Upwelling Longwave Radiation	W m-2			201002
17	NASA	CERES	rsus	Surface Upwelling Shortwave Radiation	W m-2			201002
18	NASA	CERES	rldscs	Surface Downwelling Clear-Sky Longwave Radiation	W m-2			201002



Group Research Topics

Topic #1

- **Topic**: The Global Warming *"Hiatus"*
- **Datasets**: ARGO ocean temperature, AMSRE sea surface temperature, ECMWF Reanalysis surface winds, TOA shortwave and longwave
- **Geographic foci**: mid latitudes (+-60-30), low latitudes (+-30-0)
- **Introduction**: Over the past 15 years the global-mean surface air temperature (GMSAT) has risen slower than predicted by many climate models. Described as a 'hiatus' in global warming, much effort has been spent to understand the failure to predict this apparent 'warming slowdown'. However, while GMSAT is an important variable for many obvious reasons, it is not a robust measure of global net heat flux convergence. Because the heat capacity of the atmosphere is quite small compared to the ocean, much of the year-to-year GMSAT temperature variability simply reflects ocean surface temperature variability. Thus, to answer whether warming has slowed during the 'hiatus' period requires quantifying changes in the energy storage in Earth's largest thermal reservoir: the ocean.
- **Questions:**
  1. Global warming is a consequence of an energy imbalance: more shortwave radiation absorbed at the top of the atmosphere (TOA) than re-emitted longwave and reflected shortwave. Calculate the global net radiative flux imbalance at the top of the atmosphere (TOA). How does this compare with published estimates? How has this number changed through time?
  2. If Earth's radiative flux imbalance was entirely absorbed in the troposphere (assume the lower 10 km of atmosphere), what would be the average annual change in tropospheric temperature? How does your predicted temperature change compare to the actual change through time?
  3. Repeat all parts of question (2) but instead consider that the entire radiative flux imbalance warms the upper 10 m, 100 m, 700 m, and 2000 m of the global ocean, respectively. Compare the predicted temperature changes against observations by using AMSRE SST data as a proxy for the upper 10 m ocean temperature, and ARGO data for the upper 100, 700 and 2000 m. How do the actual warming trends of each of these depth categories compare against predictions?
  4. Divide the ocean into 6 basins: Southern Ocean, N. Pacific, S. Pacific, Indian, N. Atlantic, and S. Atlantic. Which basins and which depth account for the greatest observed warming?
  5. Calculate the surface wind field anomaly over the hiatus period from the long-term mean. Are there any patterns or correlation the between surface wind field anomaly and your answer for (4)?
- Contact Scientist: Dr. Ian Fenty (Ian.Fenty@jpl.nasa.gov), Dr. Dimitris Menemenlis (Dimitris Menemenlis@jpl.nasa.gov)

Topic #2

- Topic: Observed Variability of Clouds and Precipitation
- Datasets: MODIS total cloud fraction, TRMM precipitation, AMSR-E sea surface temperature, CERES surface downwelling longwave and shortwave radiation
- Geographic foci: global, tropics (15S-15N), subtropics (15-30S/N), mid-latitude (30-50S/N) and selected regions (ITCZ, northeast Pacific and southeast Pacific)
- Questions:
  - What are the spatial distributions of clouds and precipitation? Are their distributions related to underlying sea surface temperature? (2-D maps; zonal-mean plots; scatter plots; conditional sampling plots)
  - What are the seasonal and interannual variations of clouds and precipitation over the regional above? Are there detectable trends in each region? Are these temporal evolutions correlated with underlying sea surface temperature changes?
  - What are the radiative effects of clouds? How are the cloud radiative effects varying with time?
  - What is the histogram of precipitation? Are there detectable changes of precipitation histogram over the past decade?
- Contact Scientist: Dr. Hui Su (Hui.Su@jpl.nasa.gov)

Topic #3

- Topic: Modelled Variability of Clouds and Precipitation
- Datasets: CMIP5 simulations of total cloud fraction, precipitation and surface radiative fluxes
- Geographic foci: global, tropics (15S-15N), subtropics (15-30S/N), mid-latitude (30-50S/N) and selected regions (ITCZ, northeast Pacific and southeast Pacific)
- Questions: How do climate models simulate the spatial and temporal variabilities of clouds and precipitation? Are model performances related to models' climate sensitivity?
- Approach: compare modeled and observed clouds and precipitation in 2-D maps, zonal-mean plots, time series, scatter plots, difference plots; conditional sampling plots; then group models by high-climate-sensitivity and low-climate sensitivity models
- Models' equilibrium climate sensitivity (K):
  - CCCMA/CANESM2: 3.69
  - GFDL/ESM2G: 2.39
  - GISS/E2H: 2.30
  - GISS/E2R: 2.11
  - NCAR/CAM5: 4.1
  - NCC/NORESM: 2.8
  - UKMO/Hadgem2-ES: 4.59
- Contact Scientist: Dr. Hui Su (Hui.Su@jpl.nasa.gov)

Topic #4

- Topic: Vegetation phenology and climatic controls
- Datasets: MODIS leaf area index, AIRS surface air temperature, TRMM precipitation, CERES surface downwelling shortwave radiation
- Geographic foci: northern latitude forests of North America, African sahel, Australia
- Questions:
  - How is the seasonal phenology of northern latitude forests influenced by near surface temperature and precipitation?
  - How are arid system vegetation dynamics influenced by temperature and precipitation?
  - Can radiation, temperature and precipitation forcing be used to determine the extent to which these systems are energy vs water limited?
  - What can these datasets say about inter-annual variability in phenology, and the climatic drivers of that variability?
- Contact Scientist: Dr. Darren Drewry (Darren.T.Drewry@jpl.nasa.gov), Dr. Konstantinos Andreadis (Konstantinos.M.Andreadis@jpl.nasa.gov)

Topic #5

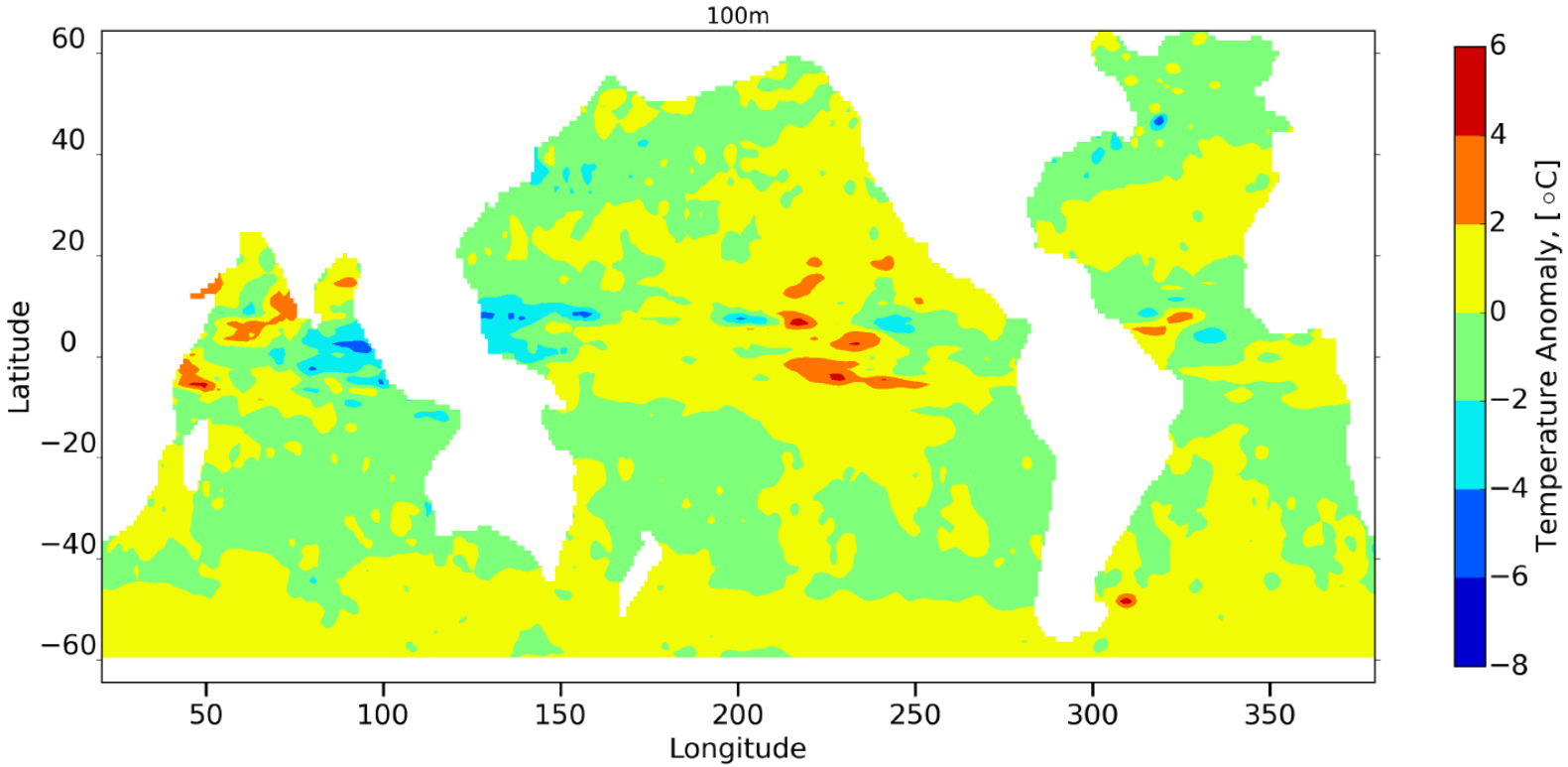
- Topic: Land water storage variability as a function of human and natural controls
- Datasets: GRACE moisture storage (equivalent water height over land), TRMM precipitation, CERES surface downwelling shortwave radiation
- Geographic foci: Northern India, southwest US
- Questions:
  - Is there an apparent seasonality in GRACE soil water storage in heavily managed (agricultural) regions?
  - How does that seasonality temporally align with seasonality in precipitation, relative to the agricultural seasons when soil water is used for irrigation?
  - From these datasets, what conclusions can we draw regarding the primary driver of soil water storage in this system? Can these datasets be used to identify energy and water-limited environments?
- Contact Scientist: Dr. Konstantinos Andreadis (Konstantinos.M.Andreadis@jpl.nasa.gov)

Students Presentation Highlights

Group 1

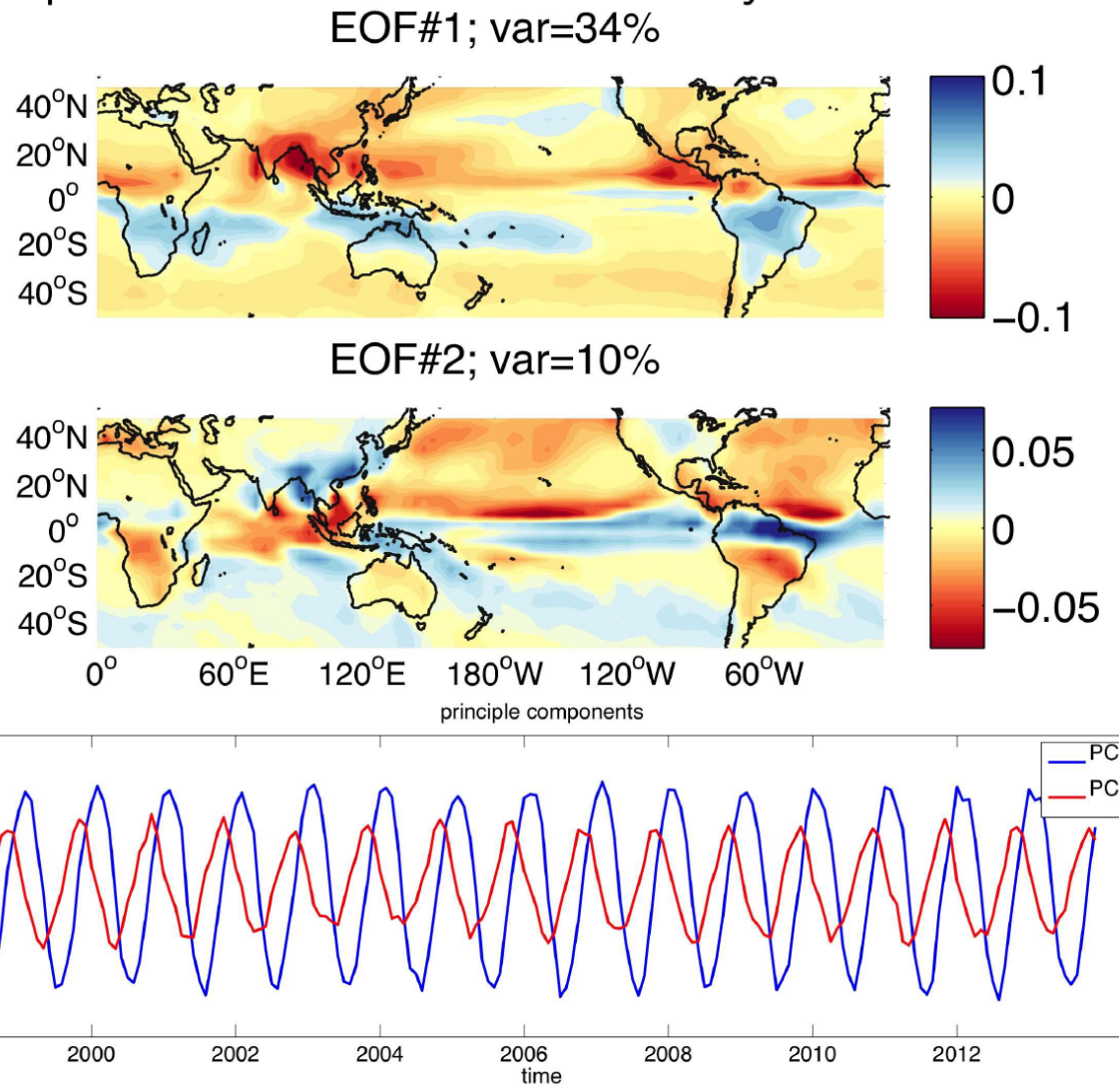
Temperature from Argo floats (2004-2012)

Global



Group 2

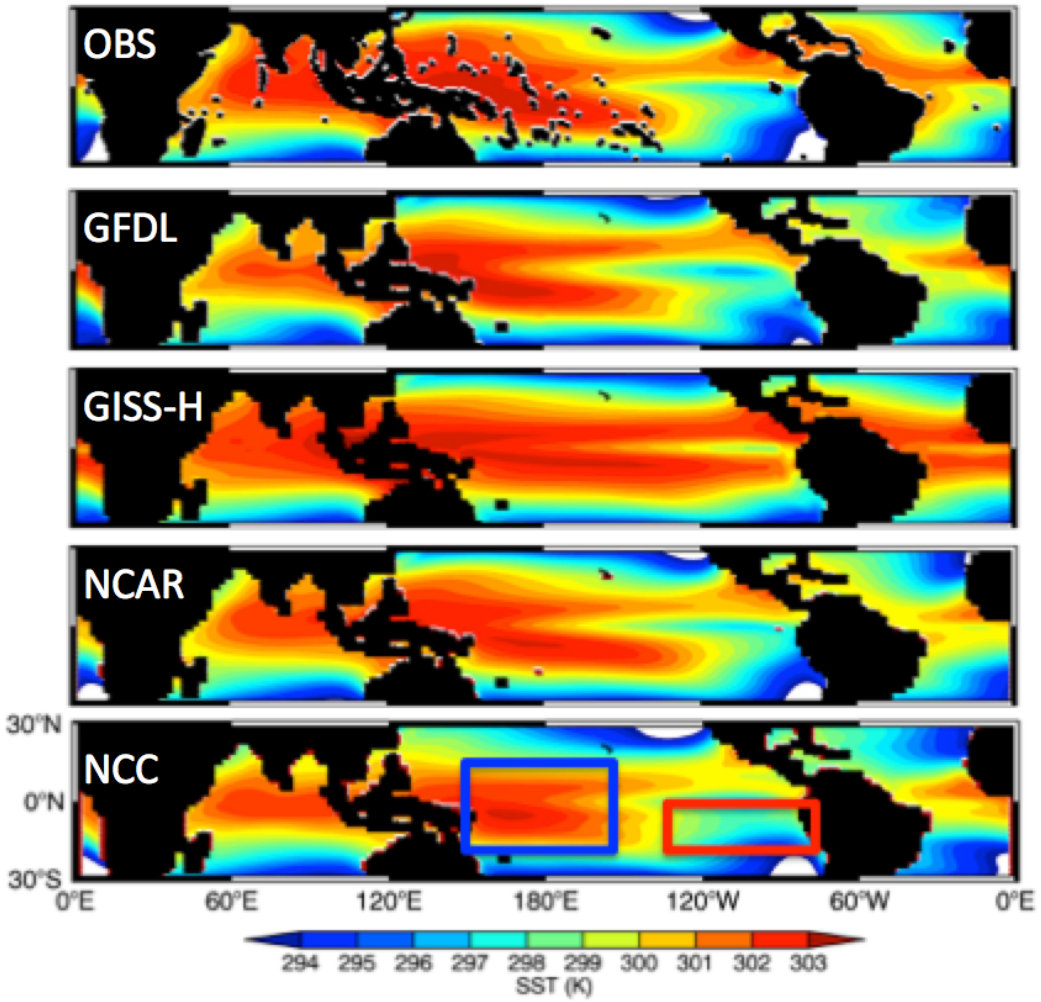
TRMM precipitation seasonal variability



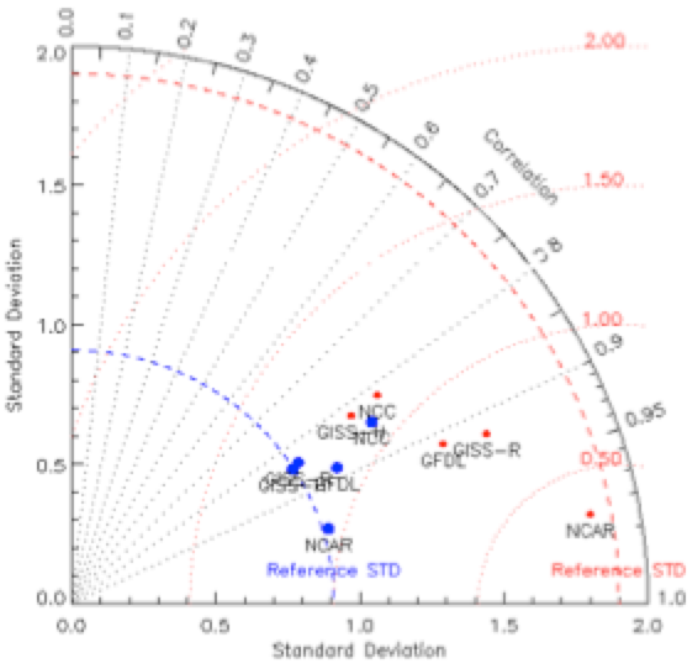
Group 3

Model Tropical SST Bias

Annual Average SST

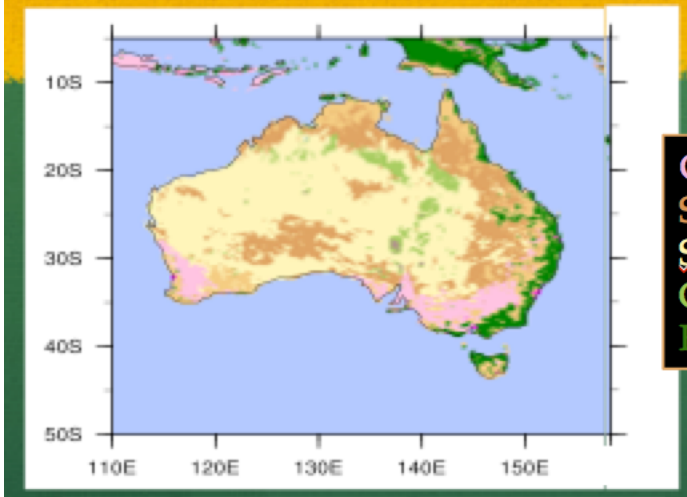


Annual Average SST

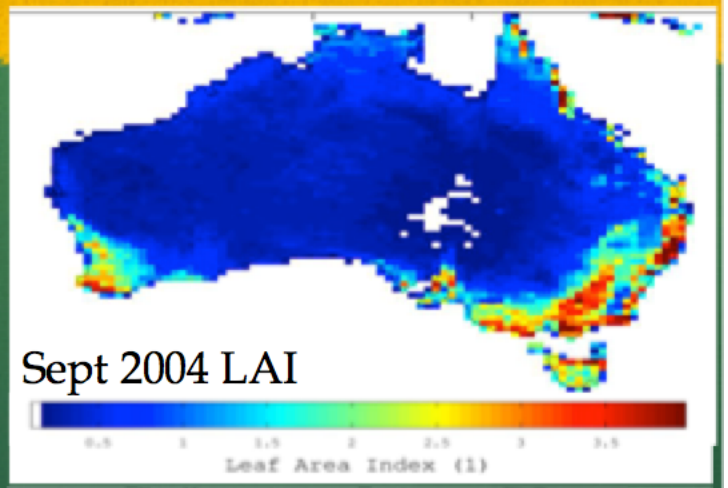


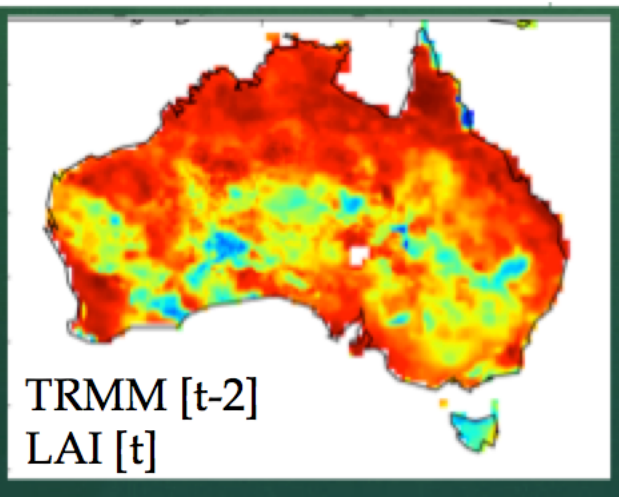
Group 4

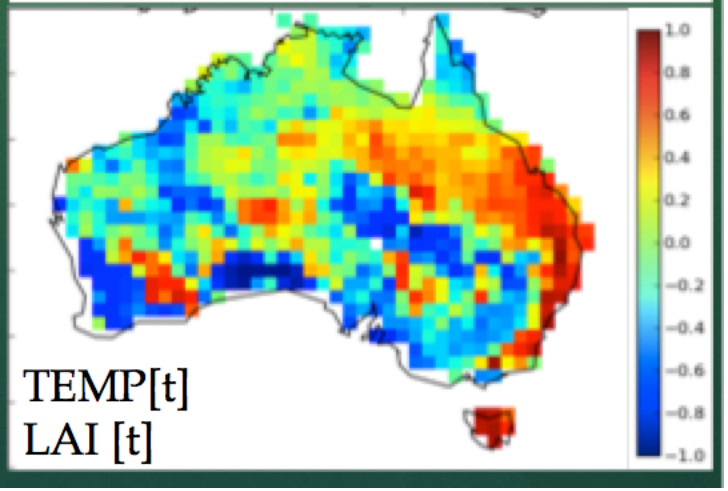
Australia



Cropland
Savanna
Shrubland
Grassland
Forest

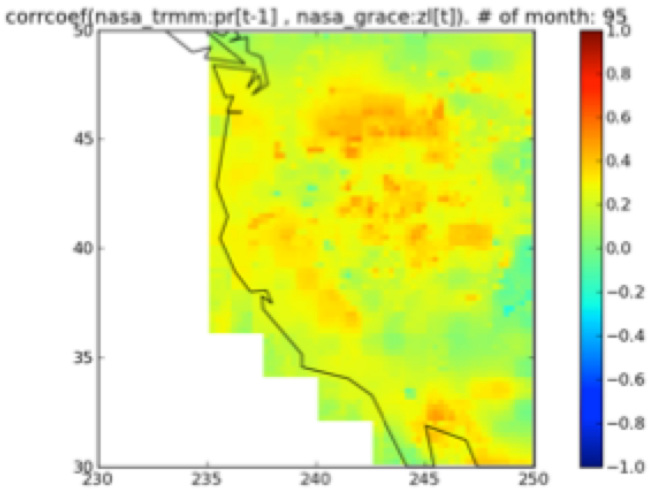




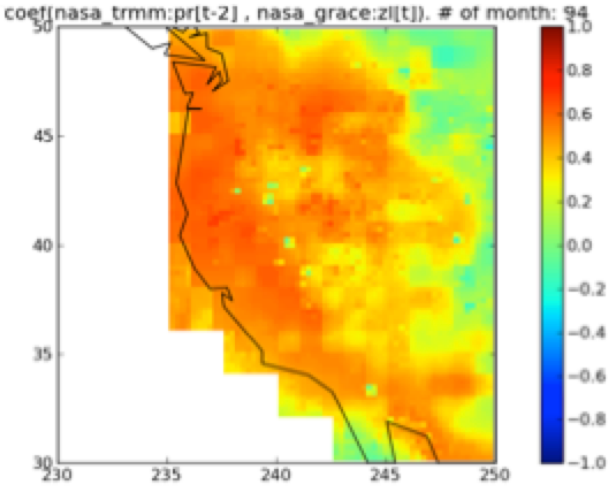


Group 5

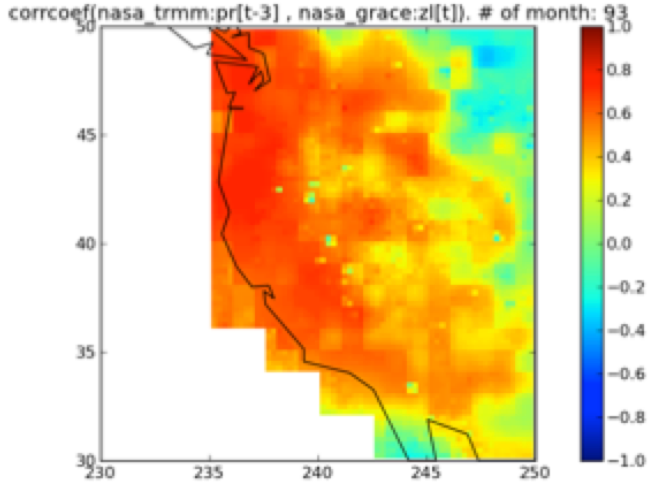
1-month Lag



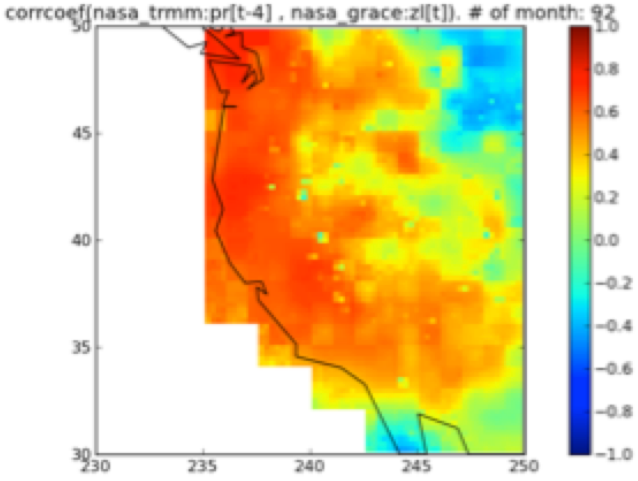
2-month Lag



3-month Lag



4-month Lag



Student Survey

- A Google Survey form was sent out after the summer school.
- 20 students responded to the survey.
- Survey results are analyzed. See next slides.

2015 JPL Summer School Group Project Survey

* Required

How was your overall experience of the summer school group research project? *

- Very satisfactory
- Somewhat satisfactory
- Somewhat unsatisfactory
- Very unsatisfactory

Were the research topics interesting and useful to you? *

- Strongly agree
- Somewhat agree
- Somewhat disagree
- Strongly disagree

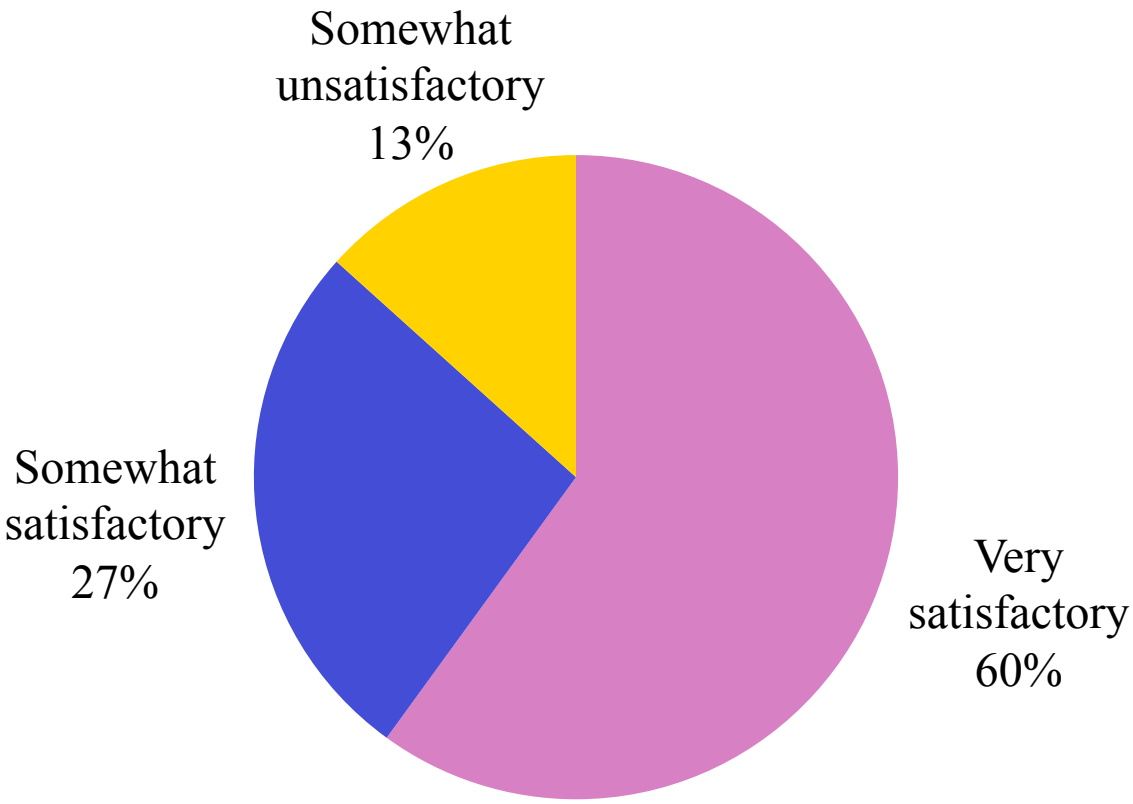
How was your overall experience with the climate data analysis tool? *

- Very satisfactory
- Somewhat satisfactory
- Somewhat unsatisfactory
- Very unsatisfactory

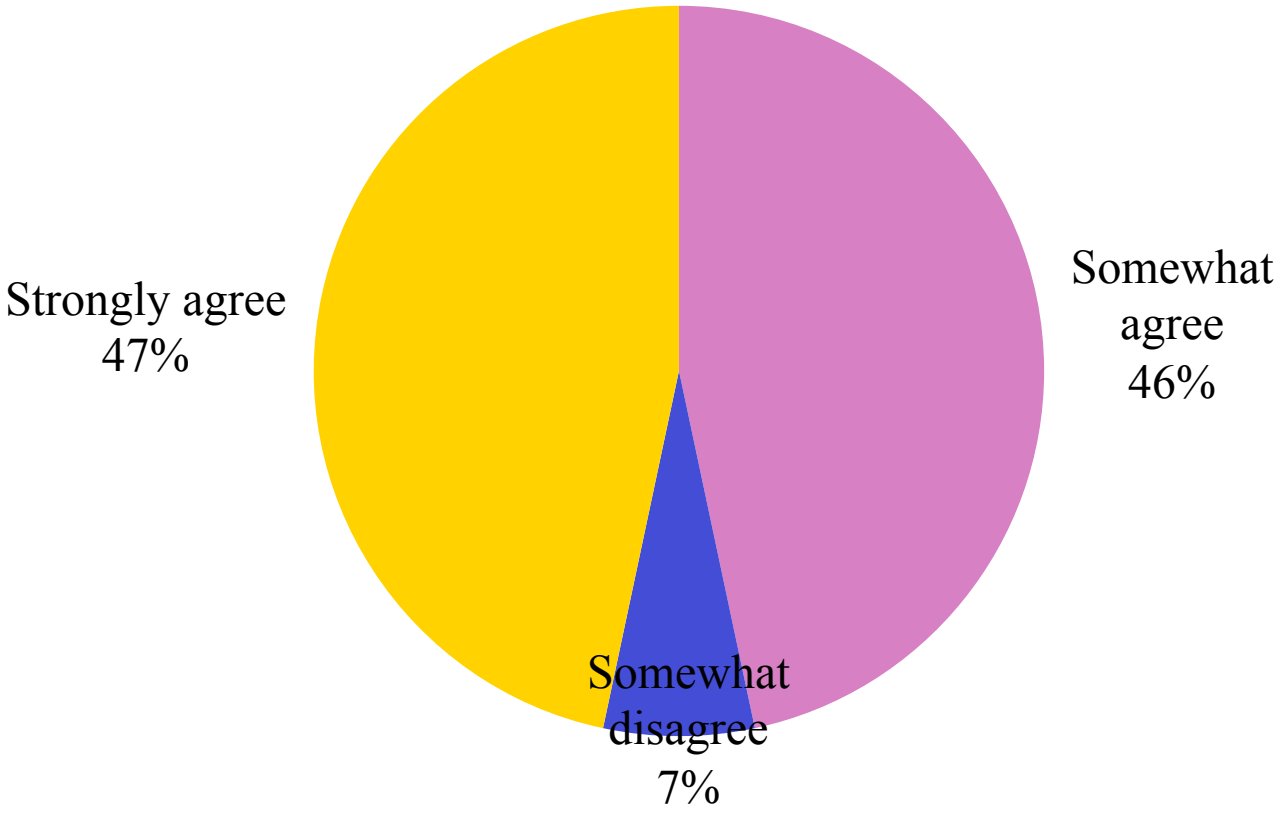
How easy was to use the climate data anlaysis tool? *

- Very easy
- Somewhat easy
- Somewhat difficult
- Very difficult

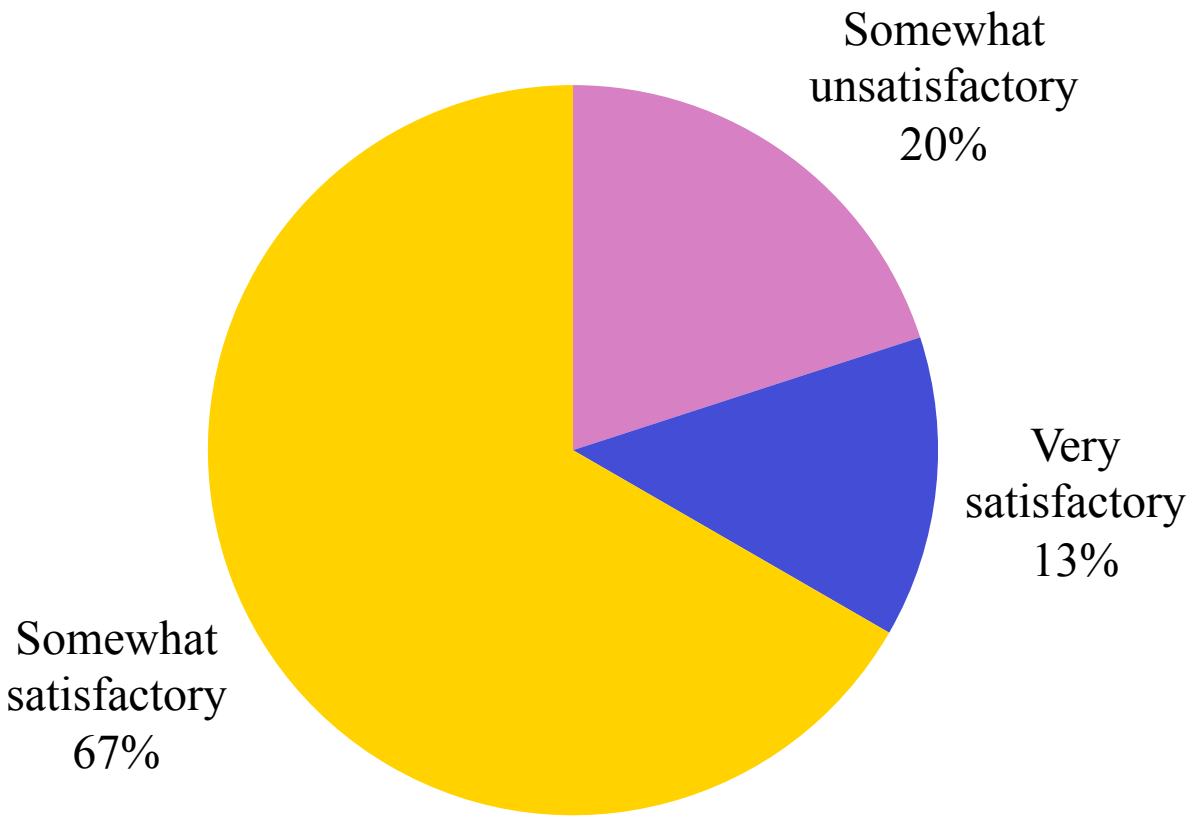
How was your overall experience of the summer school group research project?



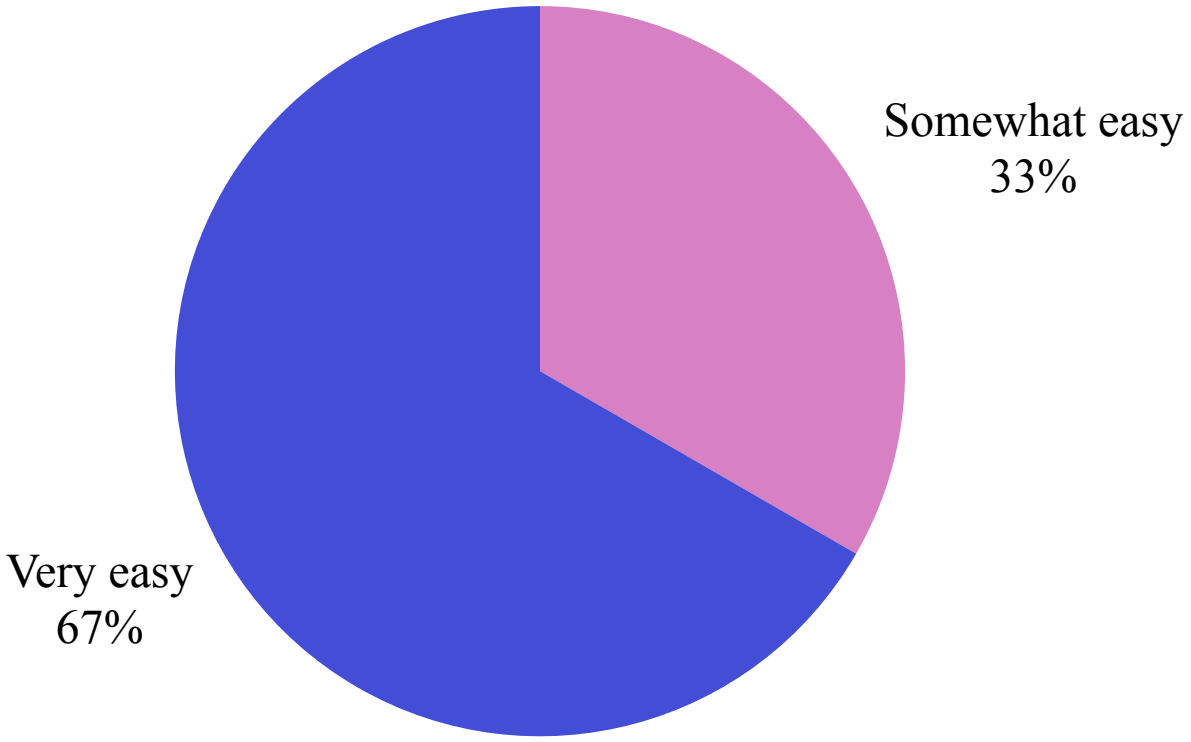
Were the research topics interesting and useful to you?



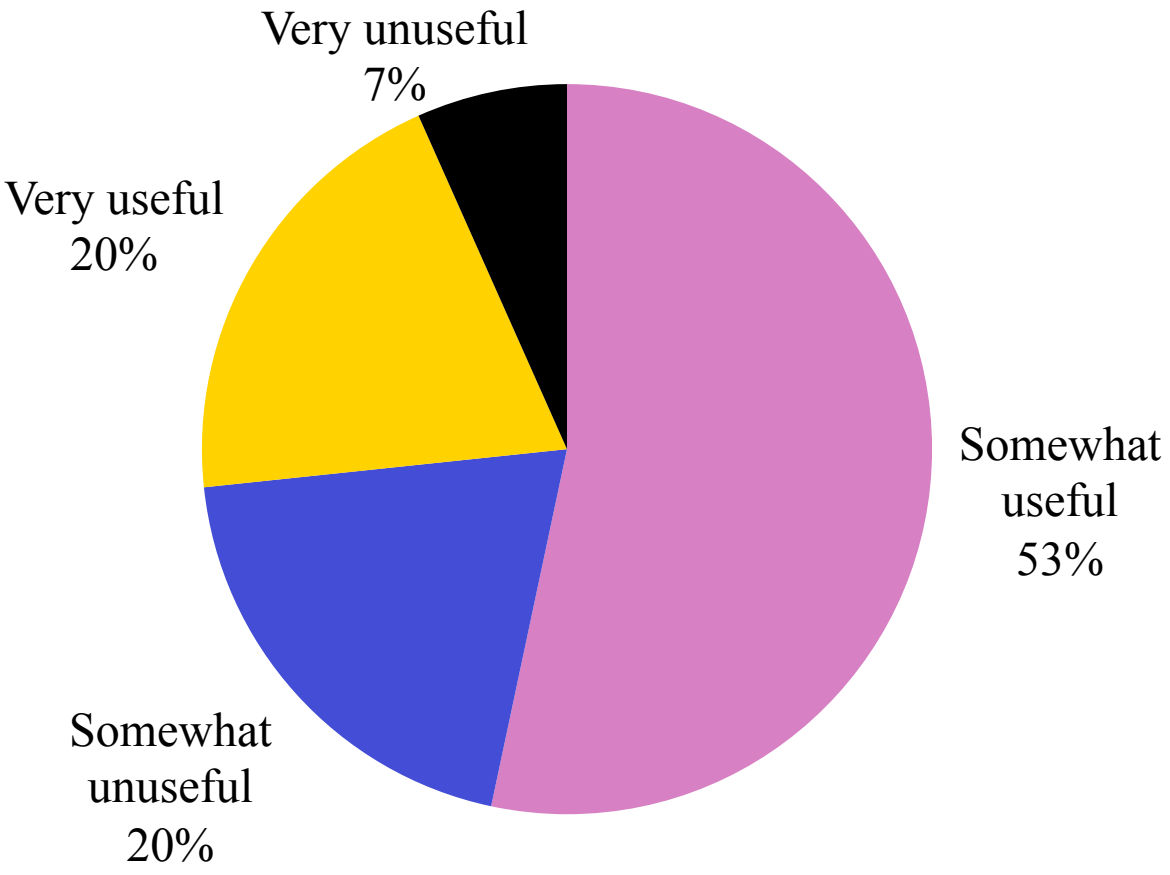
How was your overall experience with the climate data analysis tool?



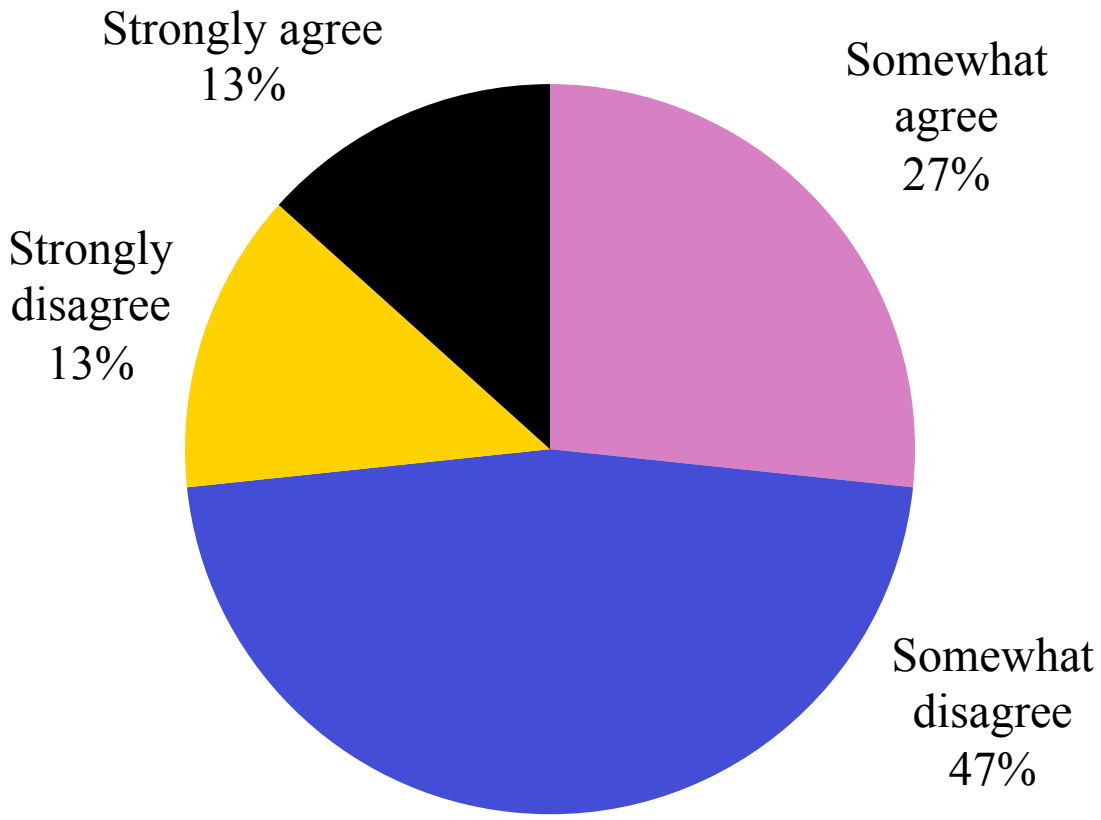
How easy was to use the climate data analysis tool?



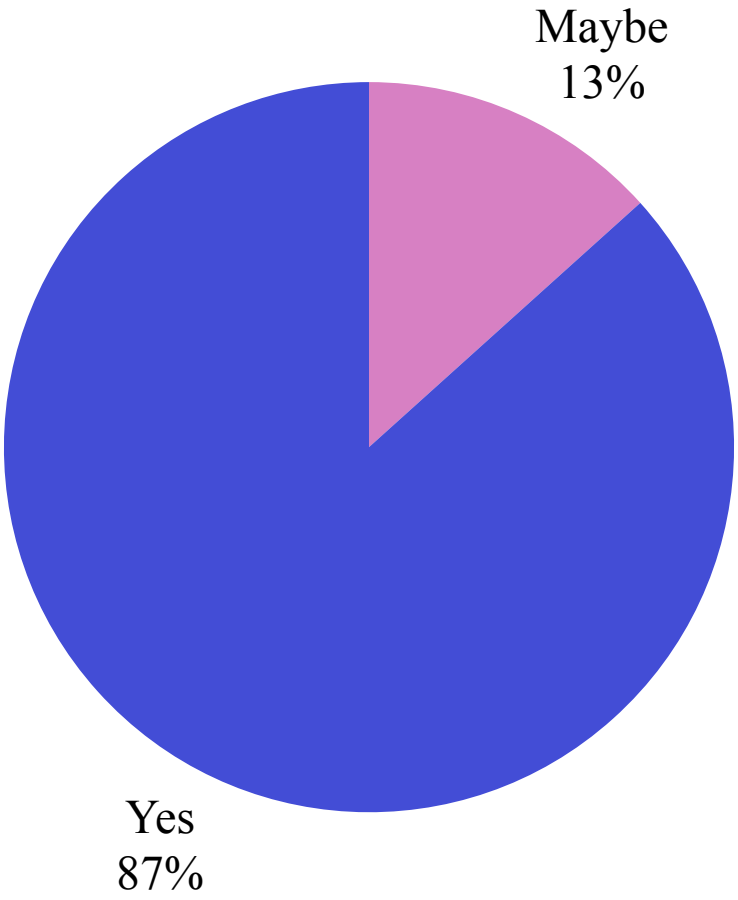
How useful were the analysis capabilities of the tool for your project?



Was the group project time sufficient?



Would you like to continue to use the climate data anlysis tool for your future research work?



Suggestions to analysis tools

- Control Color Bar
- Make subplots
- Average Specific Axis.
- Automatic update of the time range W.R.T the choice of dataset.
- Plot time series
- Compute area means

Suggestions to datasets

- Higher temporal resolution
- Longer time series for the CMIP dataset
- I would be interested in viewing data on aerosols such as aerosol optical thickness and the aerosol Angstrom exponent (which is available from MODIS).
- Have a small chart that shows what years overlap for different data sets. It is difficult to have a large dataset for satellite observations because many are only a few years long, but having an idea of which ones have an overlap of years would be helpful.

Comments on Experience

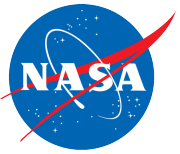
- I had a great experience in group research. But it would be better if we have more time to discuss, or perhaps organize the group research lunch or dinner to further our research after lectures. Also, at first place, tell everyone to contribute one simple idea to the group research, and then ask the group members to vote, then follow one topic line would be better.
- I think the groups could have been smaller, and more time to work on them
- It was an interesting experience. I think my group was too large to function well -- we were six people, and I think 3-4 would be optimal. I think we also had too many strong personalities... again, limiting the number of group members would help.
- It was much fun and very good for group building. I think two afternoons was a little bit short on the time, but one can never have too much time for research. Great overall experience--there were some issues with GRACE data, but the instructors always found a workaround, which is important in real-world research environment. I think Dr. K. had a work call that he rescheduled in order to come to be at our presentation--that was very kind of him. Of course, we all just showed up to his work call later.

Comments on Experience

- I feel it would have been nice to perhaps have one more day dedicated to the project. I feel like I was just starting to get some good ideas about how/what we could discuss. This might have been different if we had been able to play with the tool earlier.
- I had a good experience, especially because I found that I particularly enjoyed working with one other group member and we agreed to try to collaborate sometime down the road. I would have liked a few references or a short written introduction because I was relatively unfamiliar with the topic, and some background would have been helpful to me in formulating my investigation.
- I thought the group project portion of the summer school was great, but that it could have been extended a bit. Also, it would be nice to have a little more opportunity to include our own research interests into the project. More time and supervision would be helpful, but that might require a longer summer school. Overall, with the amount of time dedicated to the project, I thought that the learning experience was very good.
- I was expecting that the project would be towards my own research. I would have preferred that.

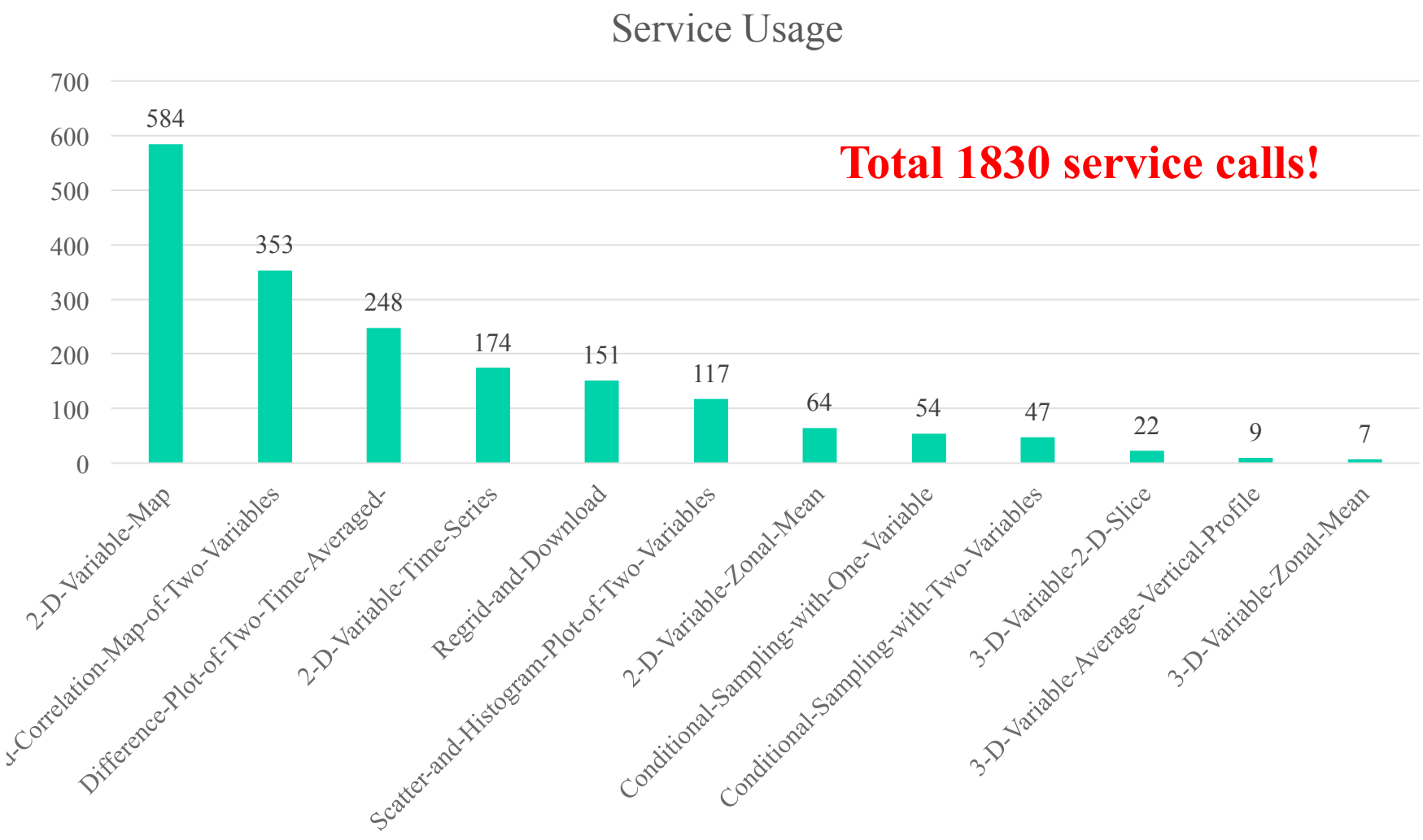
Comments on Experience

- It would be useful a guided project with steps, something like a tutorial, with some punctual goals, not very complicated but very well established in order to accomplish them.
- The topics were diverse, and gave the opportunity to explore climatological data. However, I felt like if my group had just one more day, we could have done a better job. I think perhaps narrowing each topic to a specific scientific question could have been more useful in producing better results in a short time.
- I think having 6 people in a group may be too large, simply because it was only a 10 minute presentation, but other than that it was a really neat tool to work with.
- It would be better if the 2 minutes presentation about what are the goal of the project be placed right after the discussion on Tuesday or Wednesday. In this case, people can get an idea about what other people want to do for the project. Also, other people can give some advices on Tuesday, which is early enough for helping students' project.
- It was a very nice experience, it might be nice to present the research project and the tool a bit earlier in the summer school.
- Thumbs up for the selection process, it was simple and straight forward. I really liked that an advisor recommendation letter was not required.

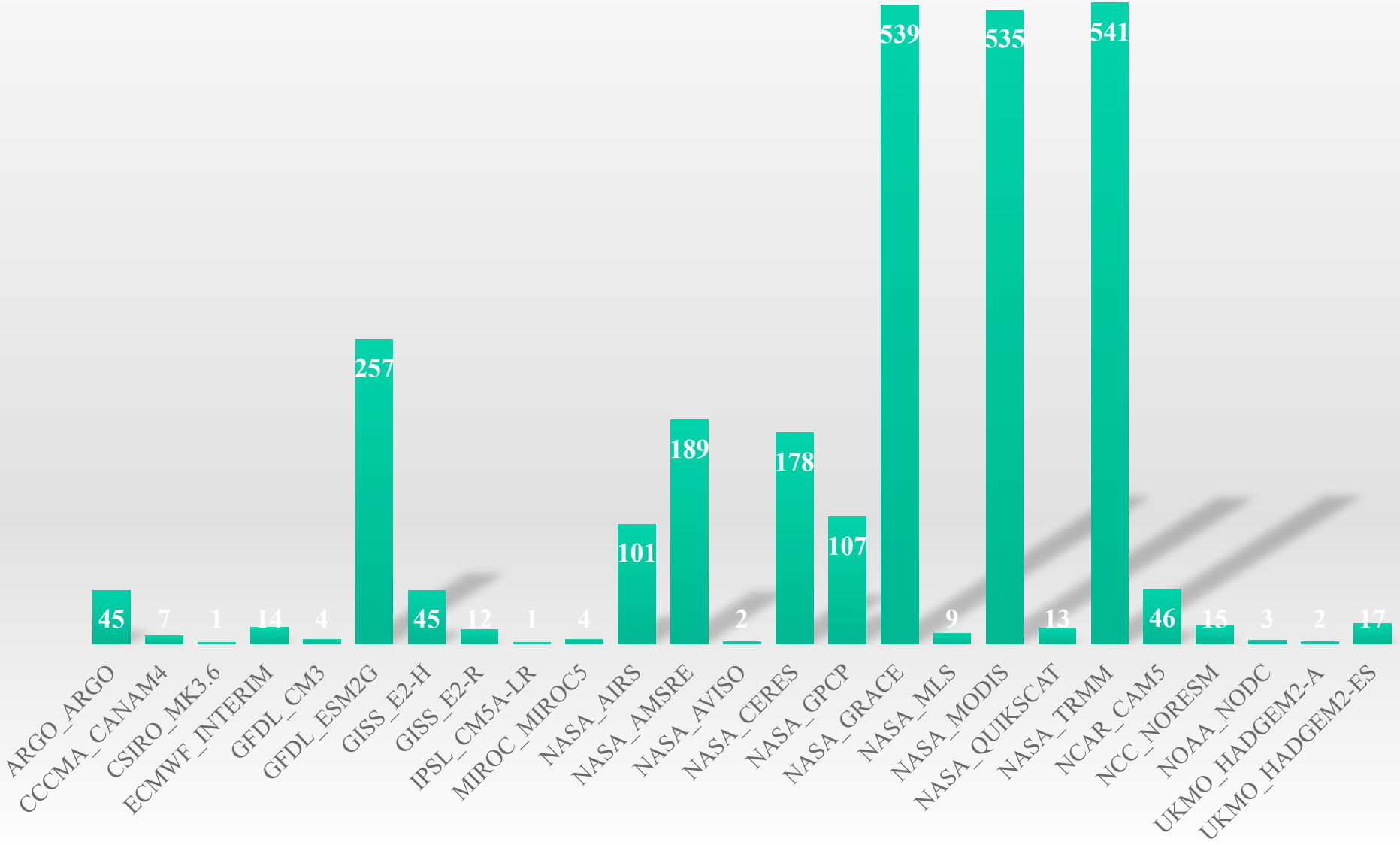


Summer School
Service Usage Statistics

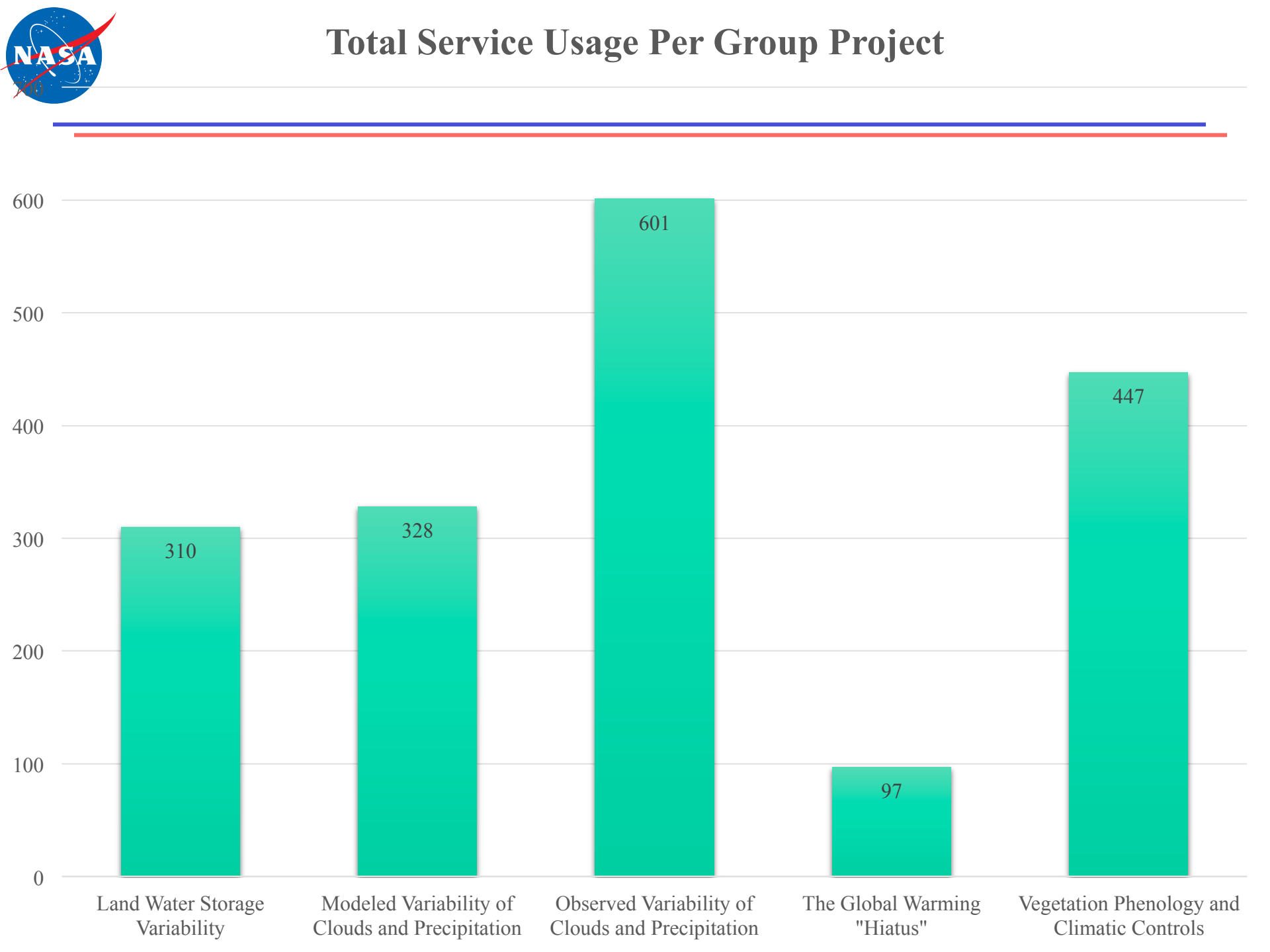
Overall Service Usage



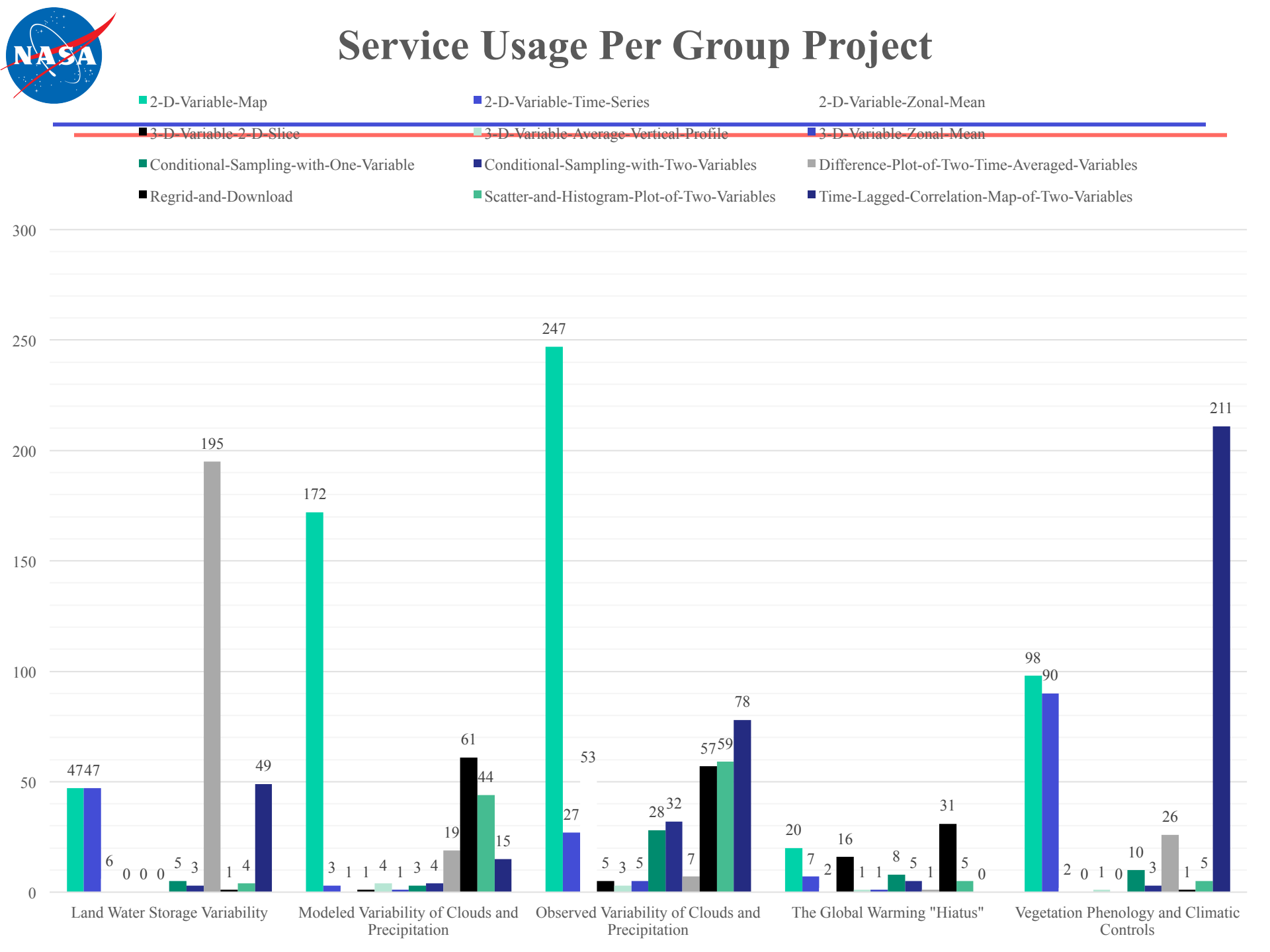
Overall Dataset Usage



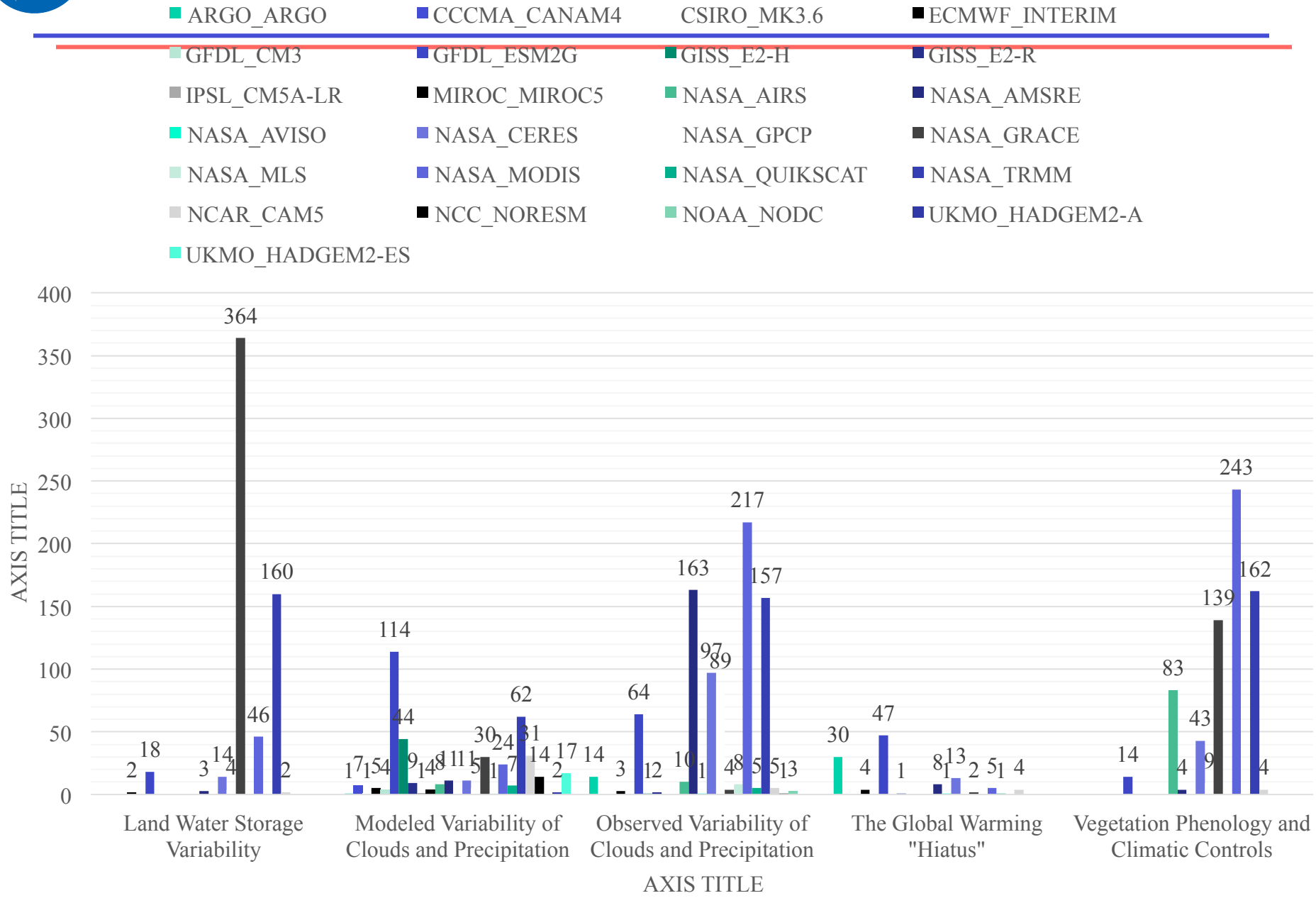
Total Service Usage Per Group Project



Service Usage Per Group Project



Data Usage per Group Project



CMDA Summary

- CMDA provides the climate modeling and model analysis community with climate datasets and diagnostic tools to evaluate climate models.
- CMDA helps the scientists identify the physical processes responsible for creating model biases.
- CMDA facilitates community-wide use and relatively effortless adoption of the novel diagnostic methodology through web-service and cloud technology.
- CMDA collects processing history and allow provenance-based search and recommendation.
- CMDA provides an online collaborative environment for scientists to share data and analysis tools and results with others.