

# Building Model Evaluation And Decision Support Capacity For CORDEX

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Cameron Goodale, Andrew Hart, Paul Zimdars, Dan Crichton*

# Agenda

- Motivation
- System Architecture
- Connections to CORDEX
- Where we are headed

# Motivation

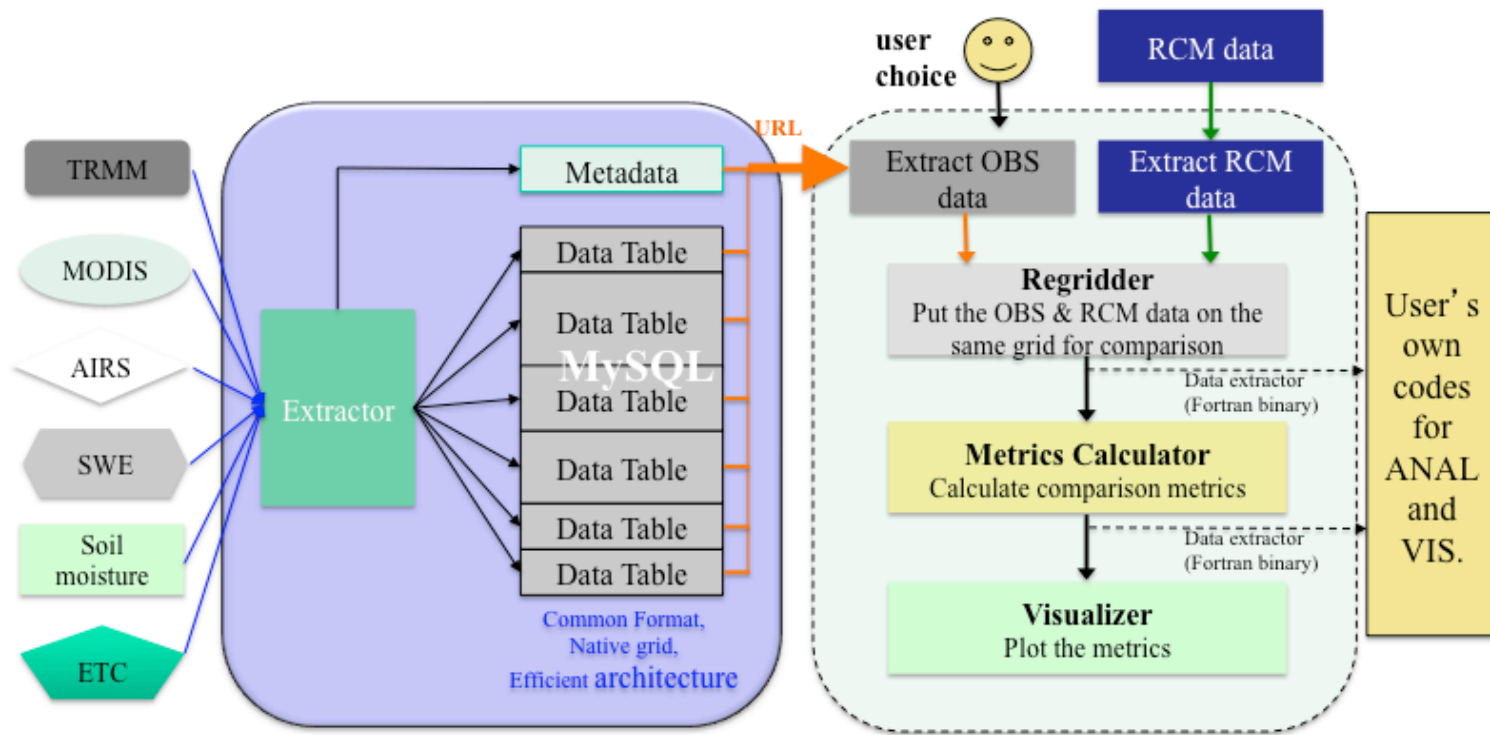
- Global Climate Models (GCMs) provide the only quantitative, physically-based means for predicting climate change.
- Regional climate models (RCMs) are key to downscaling global predictions for quantifying climate change impacts on scales relevant to decision-support and assessment activities.
- It is imperative that GCMs and RCMs are evaluated against observations so that model shortcomings can be improved and their strengths & weaknesses quantified.
- Systematic evaluations of GCMs have been undertaken for some time (e.g., AMIP, CMIP), this is not the case for RCMs.
- NASA can provide critical and unique observational resources and technological leadership to facilitate RCM evaluation and thus make key contributions to the climate assessment process.

# A New Regional Climate Model Evaluation Framework

- Goal
  - Make the evaluation process for regional climate models simpler and quicker things that used to take weeks should take days.
  - Allow researchers to spend more time analyzing results and less time coding and worrying about file formats, data transfers.
- Benefits
  - Improved understanding of model strengths/weaknesses allows model developers to improve the models
  - Improved understanding of uncertainties in predictions of specific variables over specific regions for end-users

# RCMES

## High-level Technical Architecture

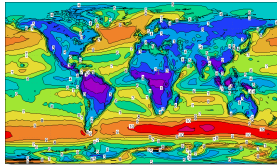
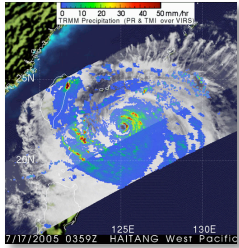


**Raw Data:**  
 Various  
 Formats,  
 Resolutions,  
 Coverage

**RCMED**  
 (Regional Climate Model Evaluation Database)  
 A large scalable database to store data in  
 a common format

**RCMET**  
 (Regional Climate Model Evaluation Toolkit)  
 A library of codes for extracting data  
 from RCMED and model and for  
 calculating evaluation metrics

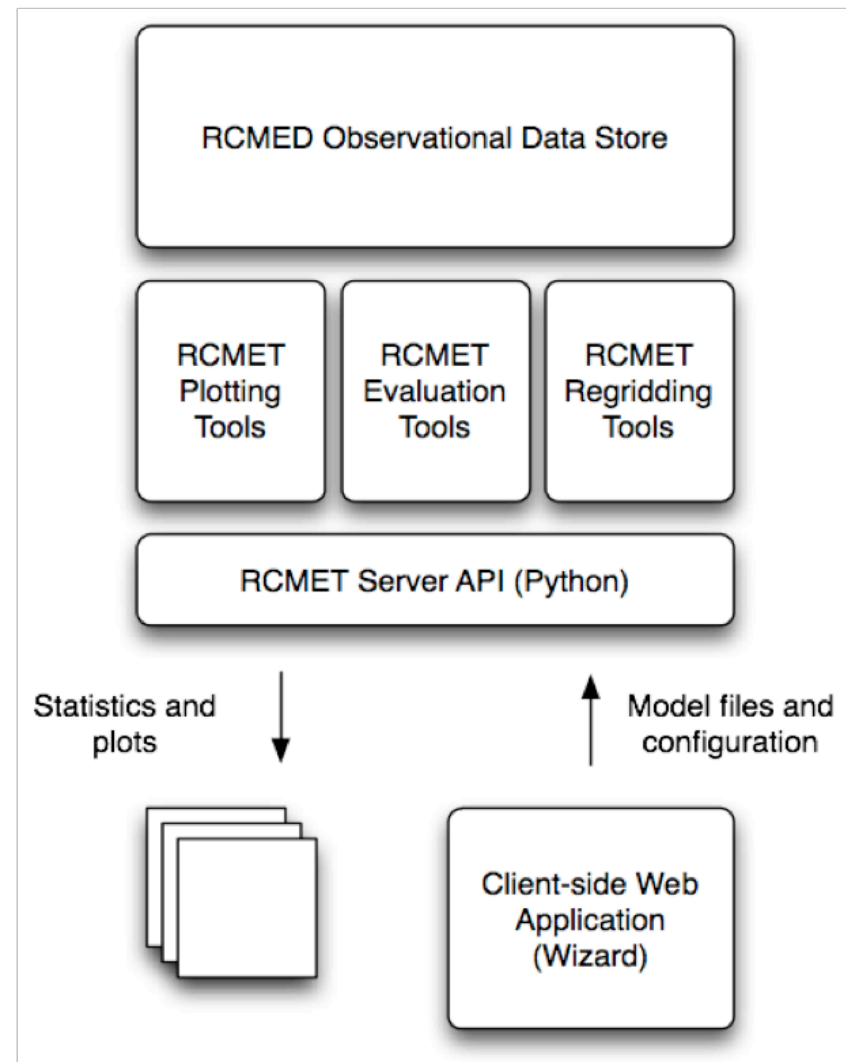
# Value Added



- RCMED Datasets (now or near-term):
  - MODIS (satellite cloud fraction): [daily 2000 – 2010]
  - TRMM (satellite precipitation): 3B42 [daily 1998– 2010]
  - AIRS (satellite surface + T & q profiles) [daily 2002 – 2010]
  - ERA-Interim (reanalysis): [daily 1989 – 2010]
  - NCEP Unified Rain Gauge (gridded precipitation): [daily 1948 – 2010]
  - CRU TS 3.0: precipitation, Tavg, Tmax, Tmin [monthly 1901 – 2006]
  - Snow Water Equivalent over Sierra Nevada Mts [monthly 2000-2010]
  - NASA MERRA Land Surface Assimilation [daily, 1979-2011]
  - .....CERES-radiation, CloudSat, MISR/MODIS-aerosol, etc
- RCMET Metrics:
  - Bias (e.g. seasonal means or variance)
  - RMS error (e.g. interannual variability)
  - Anomaly Correlation (spatial patterns of variability)
  - PDFs (likelihoods, extremes and their changes)
- Visualizations
  - Taylor Plots & Portrait Diagrams (overall model performance)
  - Statistical Tests
  - User-defined regions (e.g. water shed, desert, sea, political)

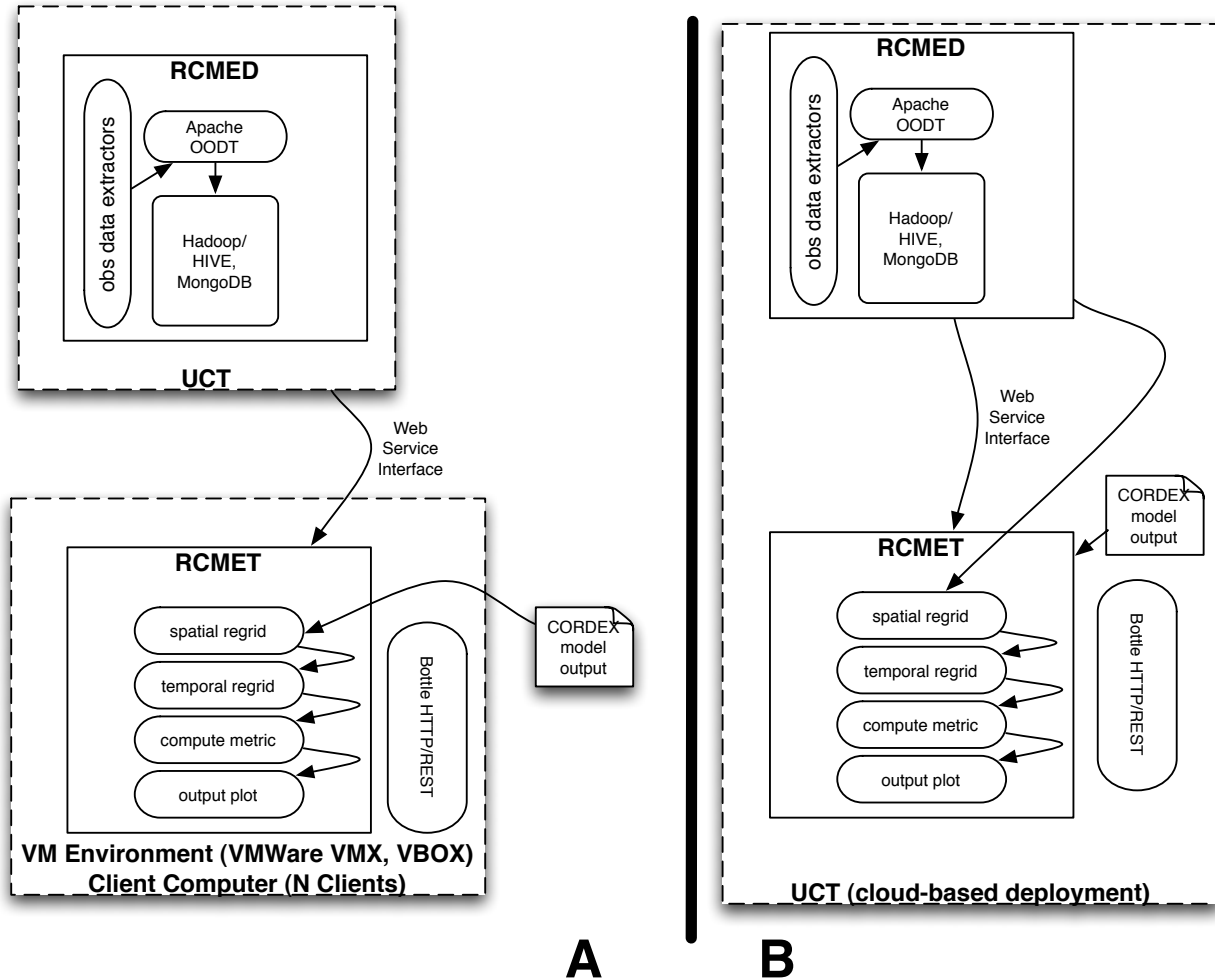
# RCMET Architecture

- Retrieve obs data from RCMED
- Regrid onto obs or model grid
- Monthly, annual, or seasonal temporal compositing
- Perform metric (bias, RMSE, etc.)
- Output plot using NCAR NCL
- Web UI, Command Line, Script Based



# Deployment Scenarios

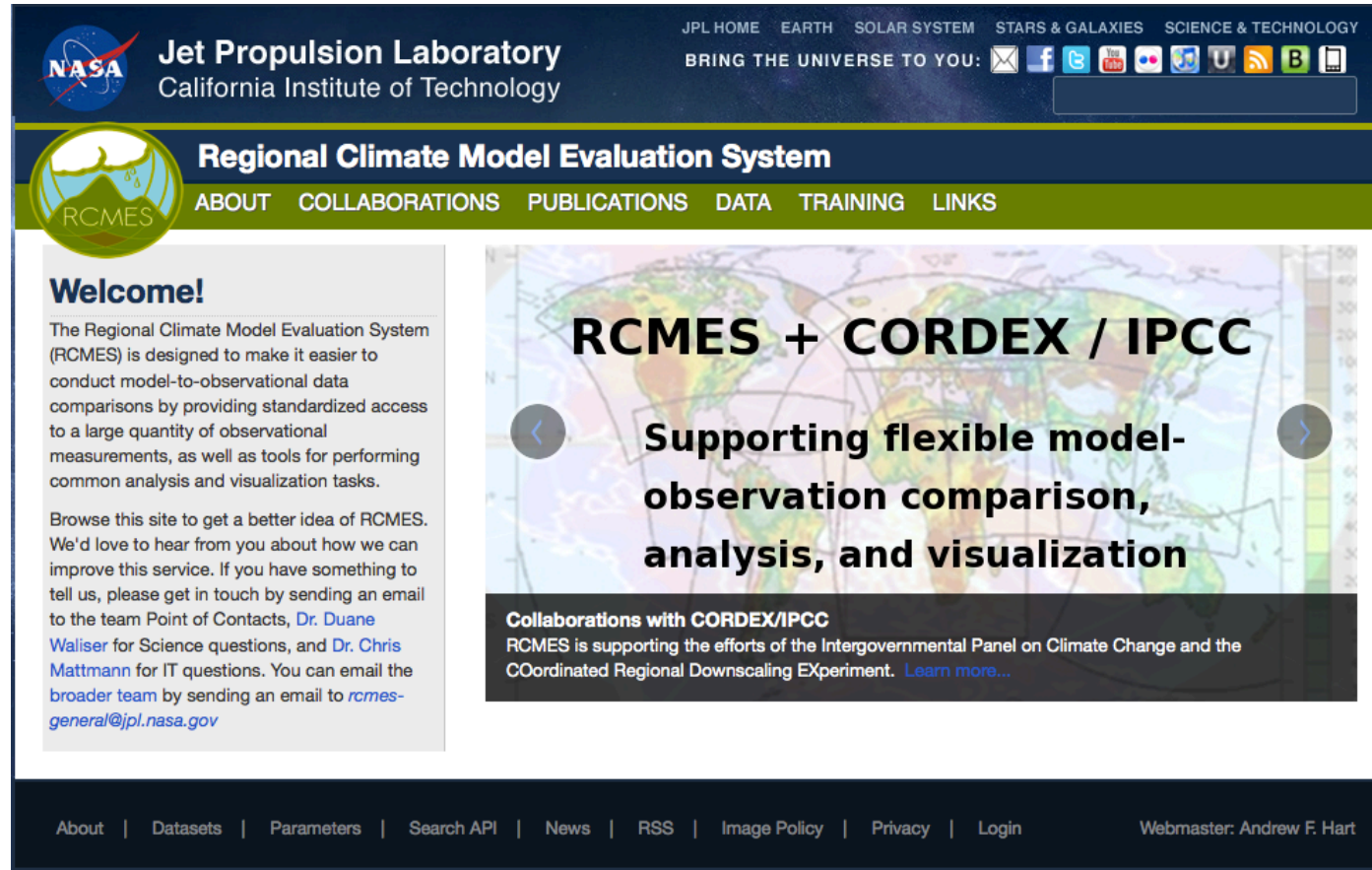
- Config A  
 Centralized  
 RCMED  
 VM-based  
 RCMET
- Config B  
 Centralized  
 RCMET  
 and  
 RCMED





# Our new website

- New Public Facing Web site
- Links to Publications, data available from RCMED
- Software/API Specifications
- Information about Collaborators

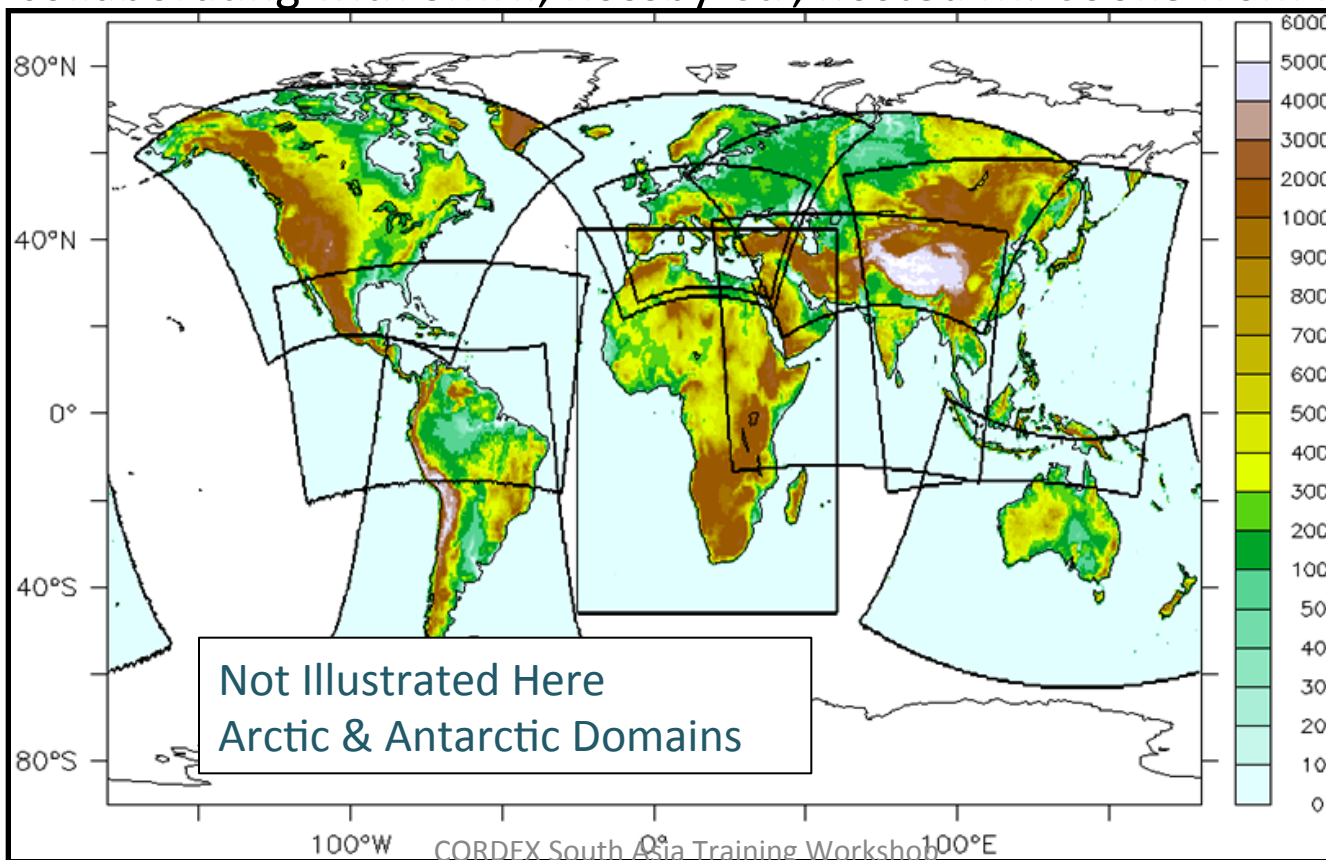


The screenshot shows the homepage of the Regional Climate Model Evaluation System (RCMES) website. At the top, there is a NASA logo and the text "Jet Propulsion Laboratory California Institute of Technology". Navigation links include "JPL HOME", "EARTH", "SOLAR SYSTEM", "STARS & GALAXIES", and "SCIENCE & TECHNOLOGY". A search bar is present with the text "BRING THE UNIVERSE TO YOU:". Below this is a green navigation bar with the RCMES logo and the title "Regional Climate Model Evaluation System". The main content area features a "Welcome!" section with a description of RCMES and contact information for Dr. Duane Waliser and Dr. Chris Mattmann. A large banner image shows a world map with the text "RCMES + CORDEX / IPCC Supporting flexible model-observation comparison, analysis, and visualization". At the bottom, there is a footer with links for "About", "Datasets", "Parameters", "Search API", "News", "RSS", "Image Policy", "Privacy", and "Login", along with the text "Webmaster: Andrew F. Hart".

<http://rcmes.jpl.nasa.gov/>

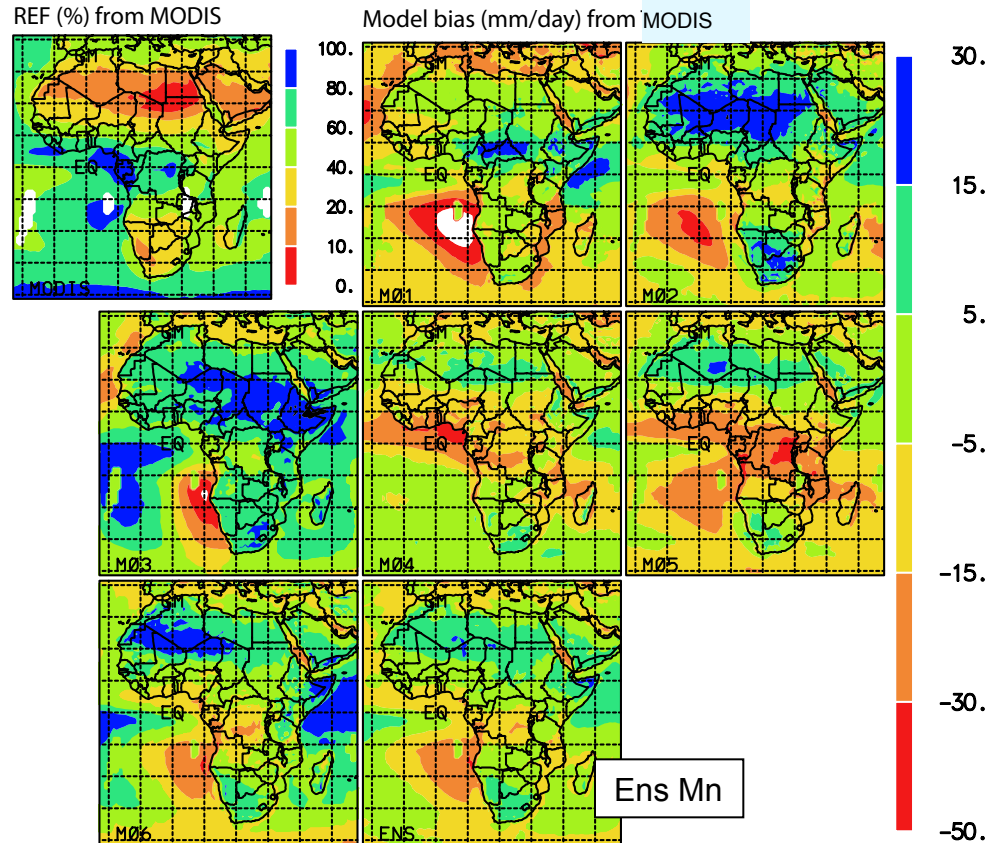
# Application to WCRP CORDEX

- **Africa** – collaboration & analysis ongoing (UCT, Rossby Ctr), funded by CDKN
- **N. America** –funded via NASA for U.S. NCA (NCAR, NARCCAP)
- **E. Asia** – exploring collaboration (KMA, APCC), participating in both workshops
- **S. Asia** – hosting Dr. Sanjay at JPL and participating/presenting in October mtg.
- **Arctic** – collaborating with SMHI, Rossby Ctr; hosted M. Cooke from Paul Kushner

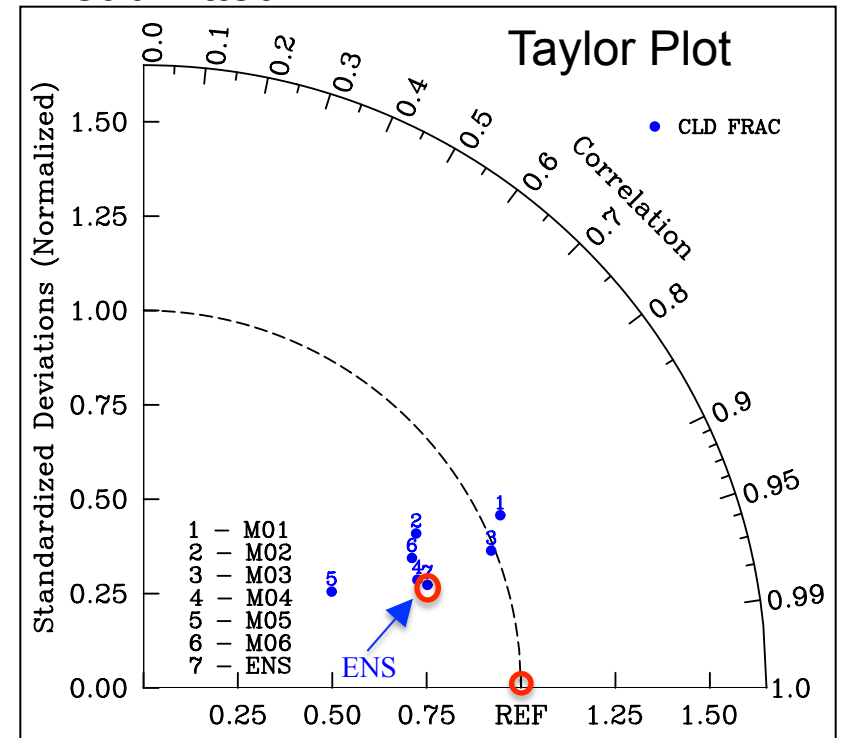


# Example application for CORDEX-Africa

## Annual Cloudiness Climatology Against MODIS; 2001-2008



Kim et al. 2012a; *Climate Dynamics*, submitted.

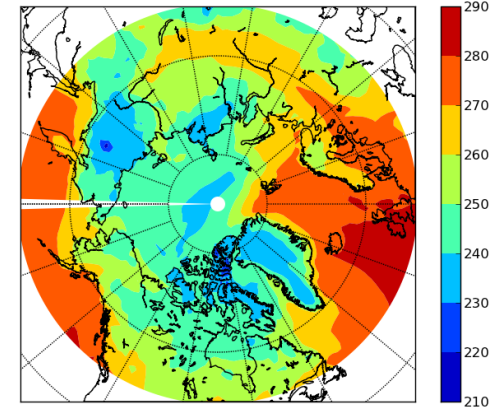


NOTE: The blank areas in the REF (MODIS) data are due to missing values.

# Demonstration: CORDEX Arctic

Worked with Melanie Cookie/Paul Kushner (U. Toronto), Cameron Goodale, (JPL)

## Compared Near-Surface Air Temperature with ERA 2 Metre Temp

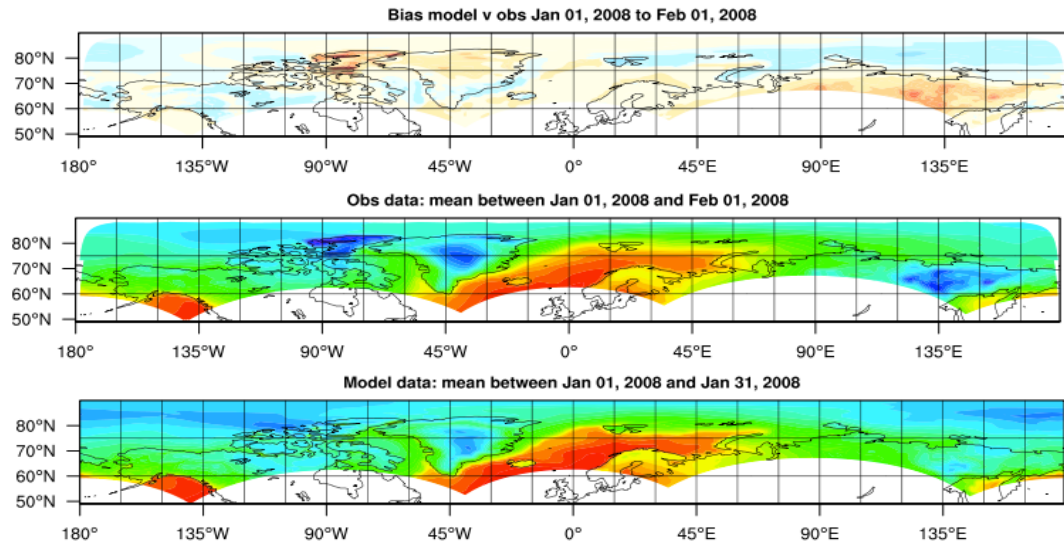


Selected time range:

2008/01/01 00:00

2008/02/01 00:00

- Use Model grid
- Calculate time mean for full period.
- Bias: mean bias across full time range

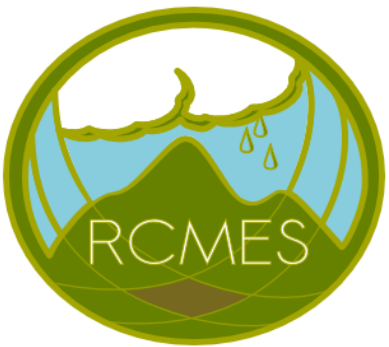
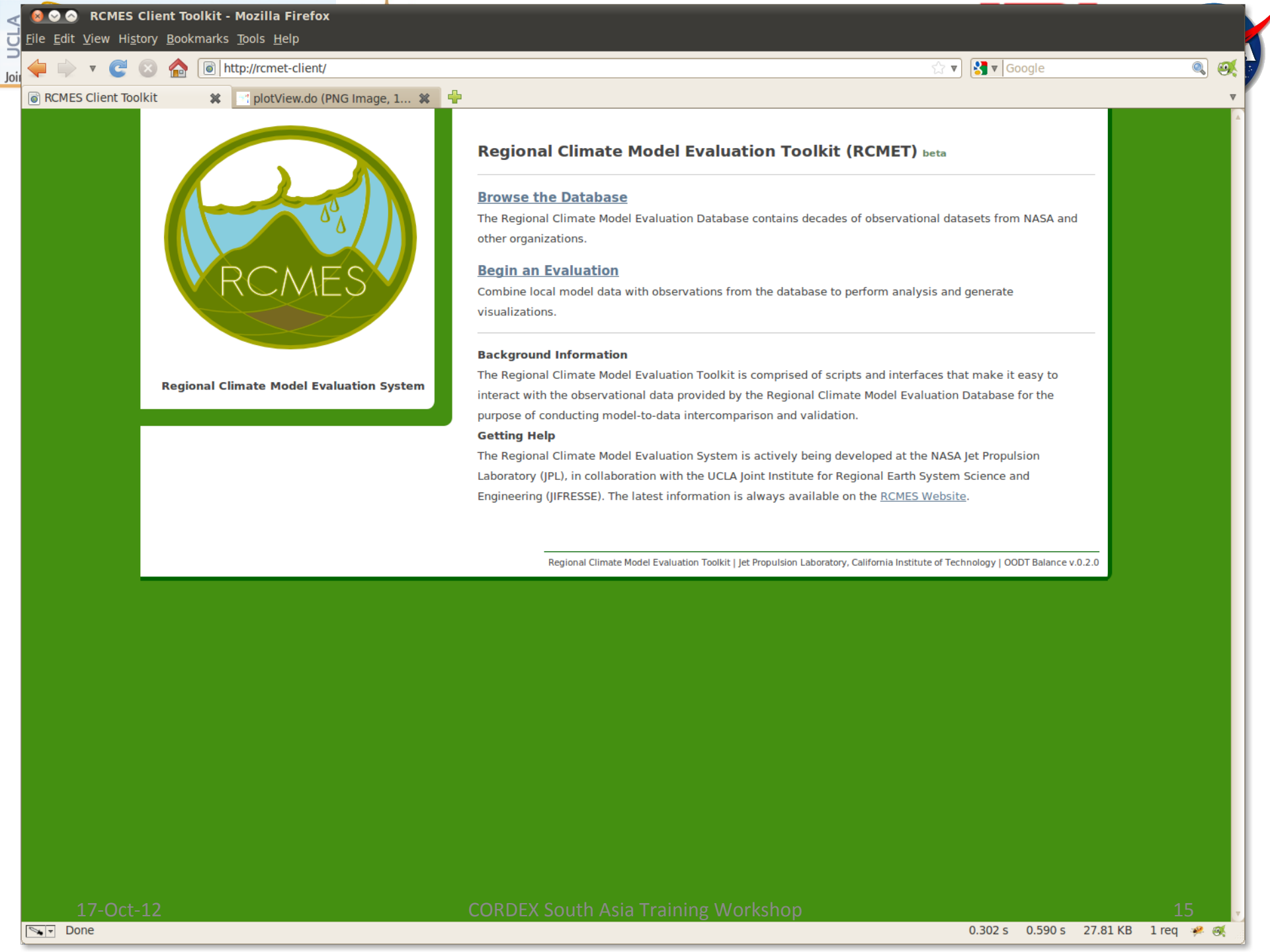


<ftp://ftp.cccma.ec.gc.ca/pub/yjiao/CanRCM4/>

# Where Are We Headed

- Improved Packaging
- ESG Support
- Simpler UI
- Open Source
- Modularization of API
- Management of Evaluation Runs
- Multi observation and model support
- GIS Support

- Walk through of the current system



**Regional Climate Model Evaluation System**

## Regional Climate Model Evaluation Toolkit (RCMET) beta

### [Browse the Database](#)

The Regional Climate Model Evaluation Database contains decades of observational datasets from NASA and other organizations.

### [Begin an Evaluation](#)

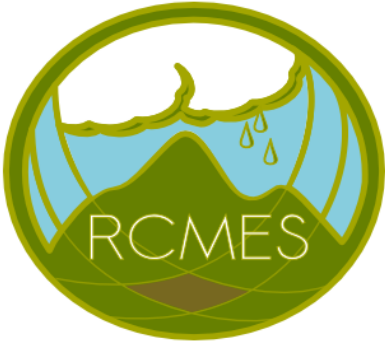
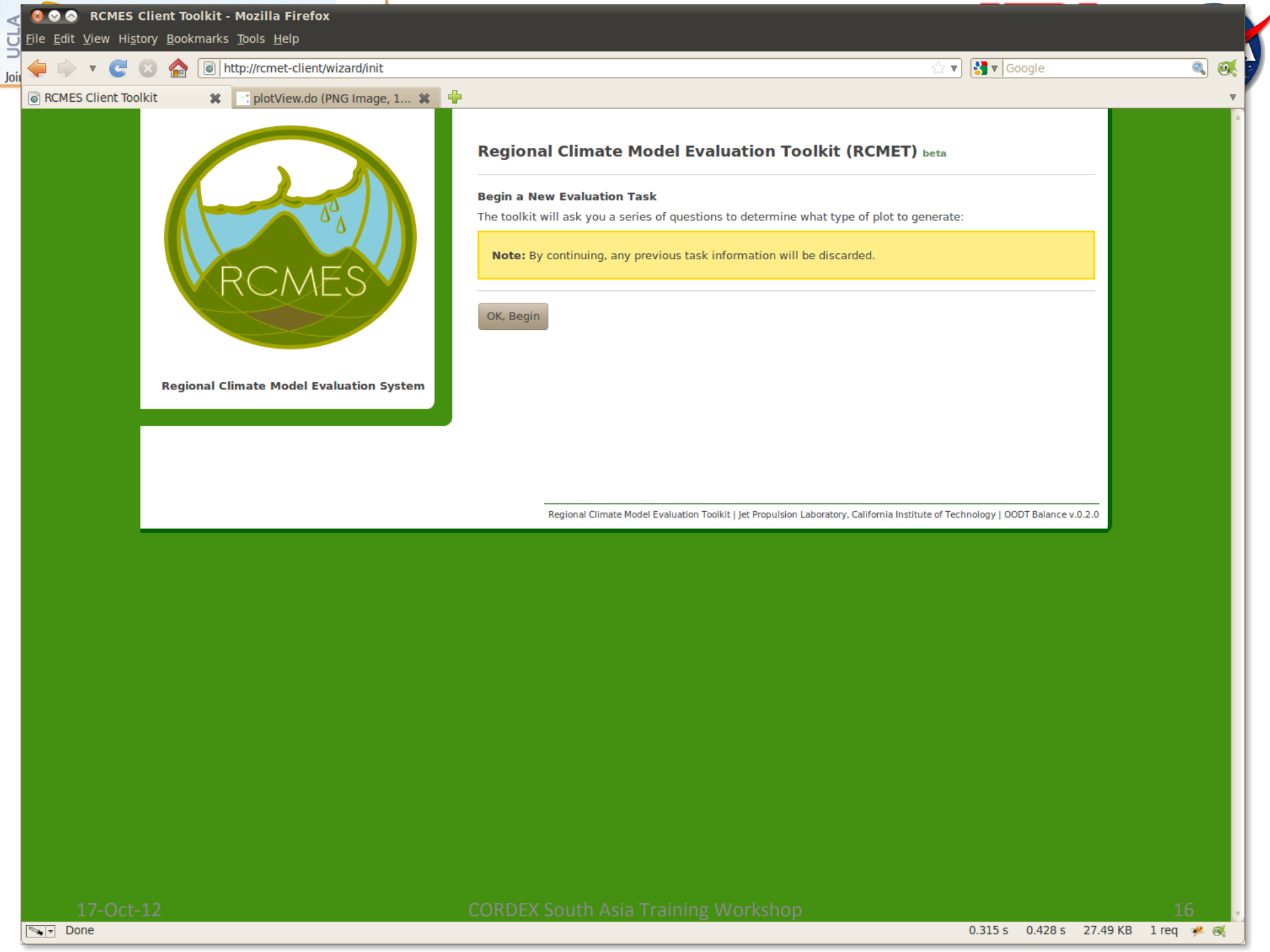
Combine local model data with observations from the database to perform analysis and generate visualizations.

### **Background Information**

The Regional Climate Model Evaluation Toolkit is comprised of scripts and interfaces that make it easy to interact with the observational data provided by the Regional Climate Model Evaluation Database for the purpose of conducting model-to-data intercomparison and validation.

### **Getting Help**

The Regional Climate Model Evaluation System is actively being developed at the NASA Jet Propulsion Laboratory (JPL), in collaboration with the UCLA Joint Institute for Regional Earth System Science and Engineering (JIFRESSE). The latest information is always available on the [RCMES Website](#).



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## Regional Climate Model Evaluation Toolkit (RCMET) beta

### Begin a New Evaluation Task

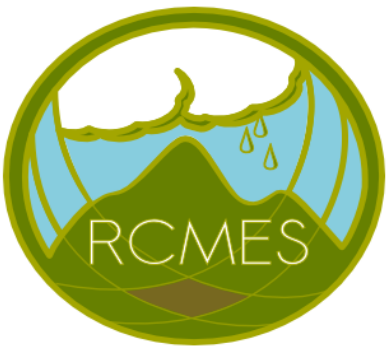
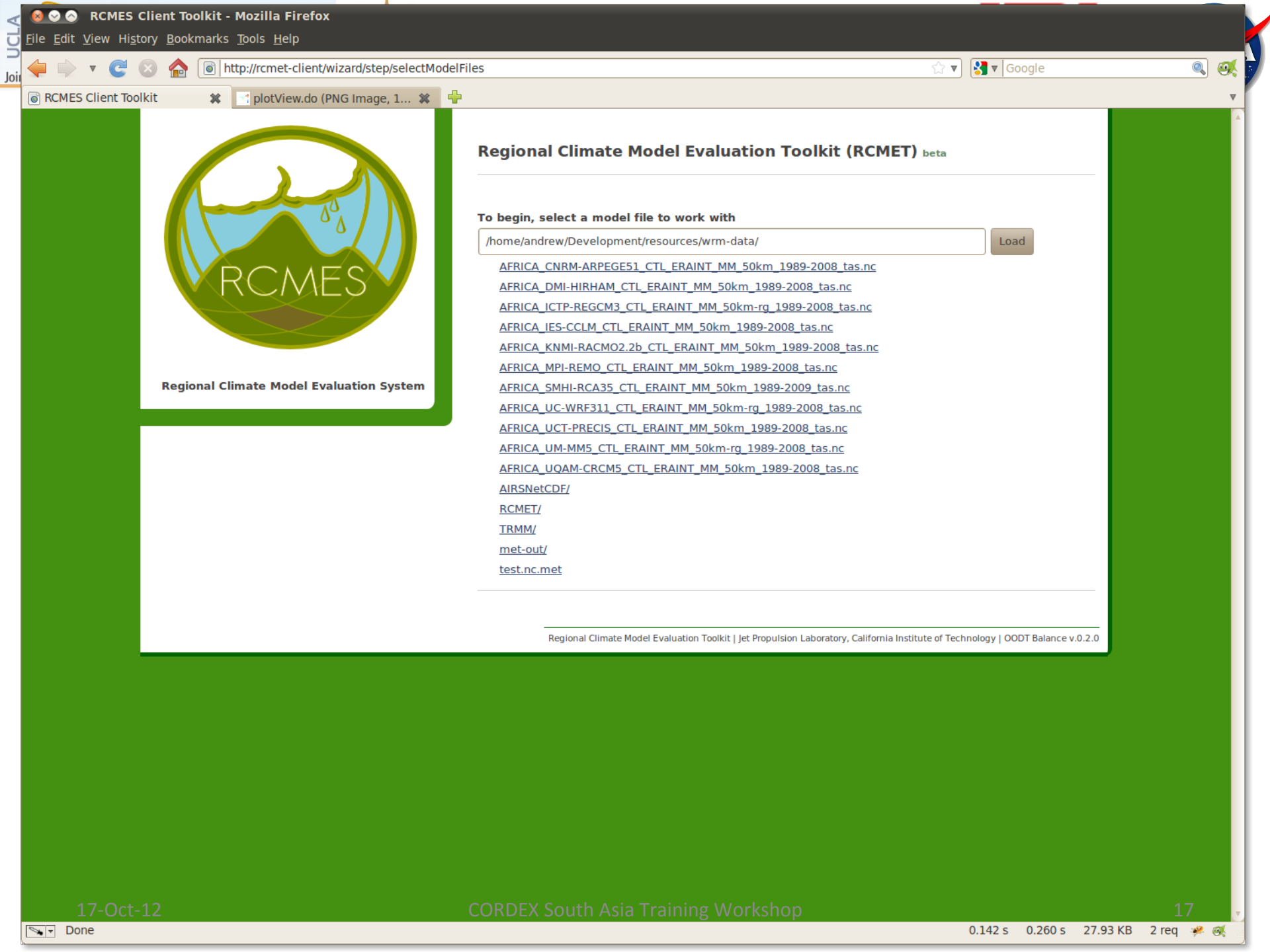
The toolkit will ask you a series of questions to determine what type of plot to generate:

**Note:** By continuing, any previous task information will be discarded.

OK, Begin

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Regional Climate Model Evaluation System

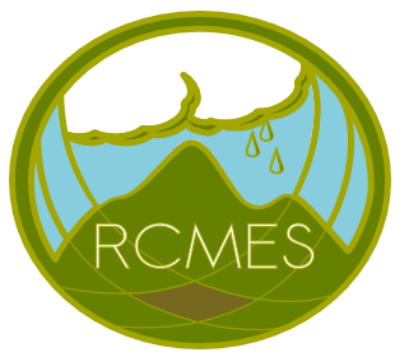
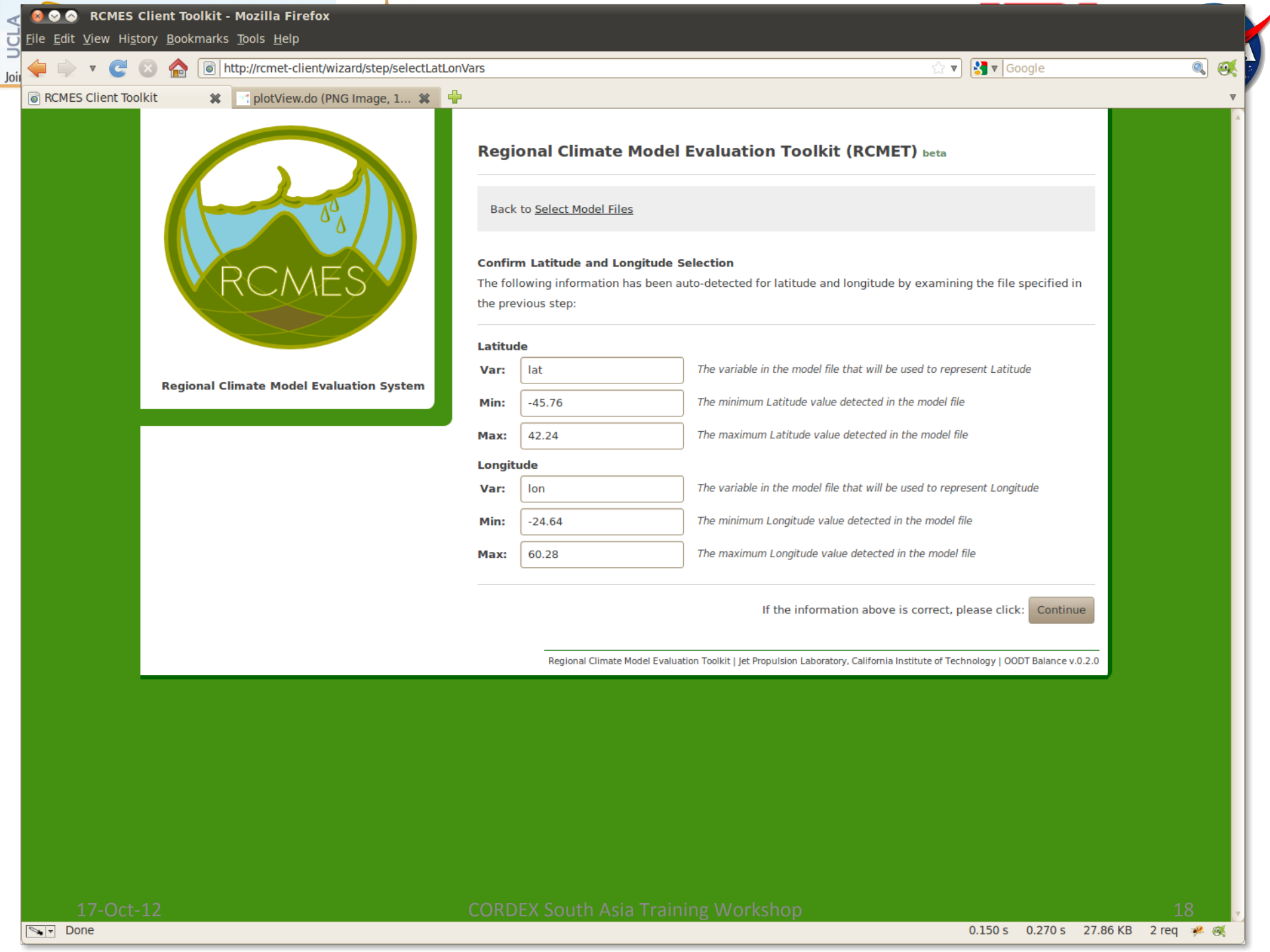
## Regional Climate Model Evaluation Toolkit (RCMET) beta

To begin, select a model file to work with

Load

- [AFRICA\\_CNRM-ARPEGE51\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_DMI-HIRHAM\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_ICTP-REGCM3\\_CTL ERAINT\\_MM\\_50km-rg\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_IES-CCLM\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_KNMI-RACMO2.2b\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_MPI-REMO\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_SMHI-RCA35\\_CTL ERAINT\\_MM\\_50km\\_1989-2009\\_tas.nc](#)
- [AFRICA\\_UC-WRF311\\_CTL ERAINT\\_MM\\_50km-rg\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_UCT-PRECIS\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_UM-MM5\\_CTL ERAINT\\_MM\\_50km-rg\\_1989-2008\\_tas.nc](#)
- [AFRICA\\_UOAM-CRCM5\\_CTL ERAINT\\_MM\\_50km\\_1989-2008\\_tas.nc](#)
- [AIRSNetCDF/](#)
- [RCMET/](#)
- [TRMM/](#)
- [met-out/](#)
- [test.nc.met](#)

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## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Model Files](#)

### Confirm Latitude and Longitude Selection

The following information has been auto-detected for latitude and longitude by examining the file specified in the previous step:

#### Latitude

**Var:**  *The variable in the model file that will be used to represent Latitude*

**Min:**  *The minimum Latitude value detected in the model file*

**Max:**  *The maximum Latitude value detected in the model file*

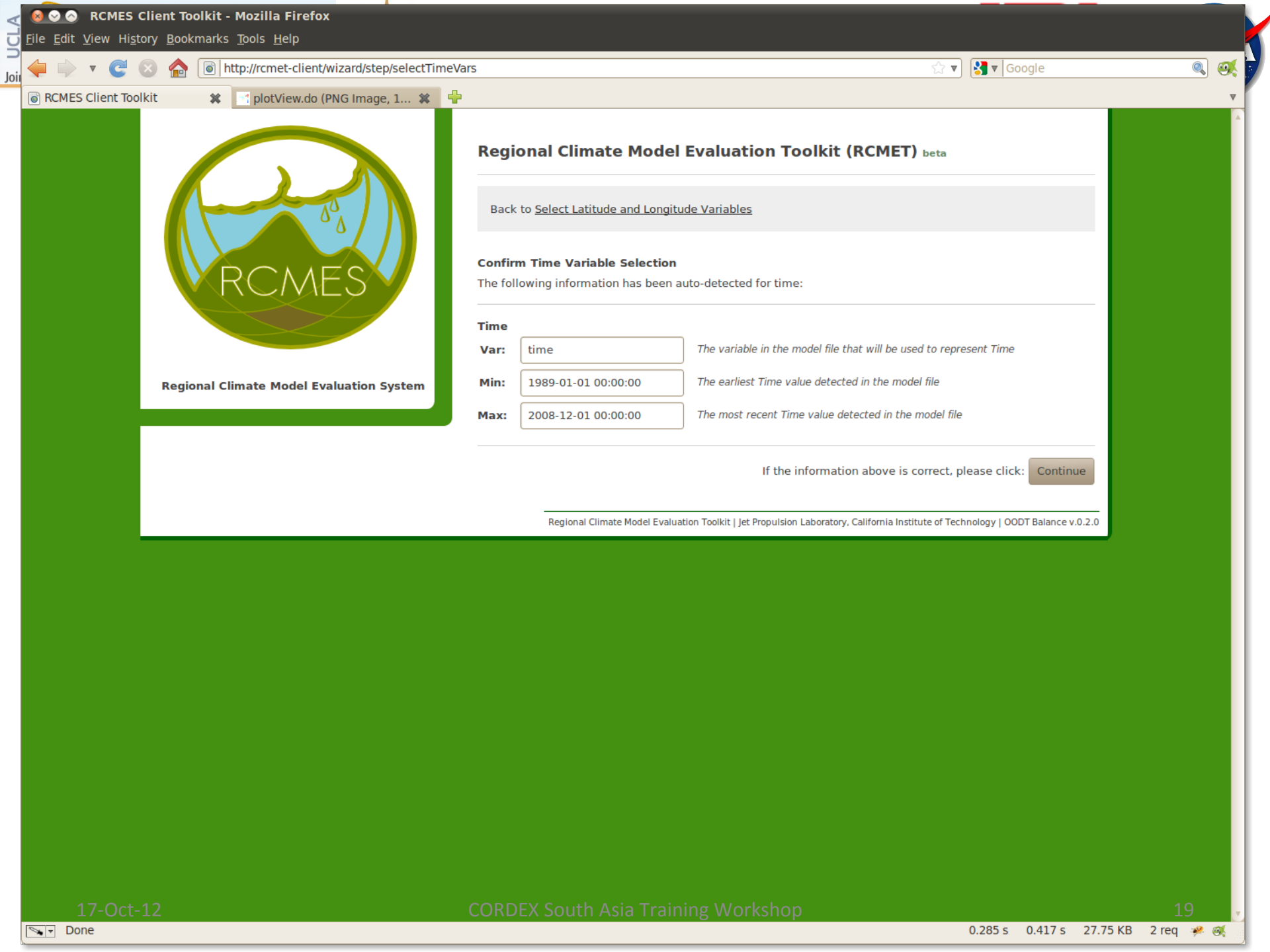
#### Longitude

**Var:**  *The variable in the model file that will be used to represent Longitude*

**Min:**  *The minimum Longitude value detected in the model file*

**Max:**  *The maximum Longitude value detected in the model file*

If the information above is correct, please click:



Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Latitude and Longitude Variables](#)

### Confirm Time Variable Selection

The following information has been auto-detected for time:

**Time**

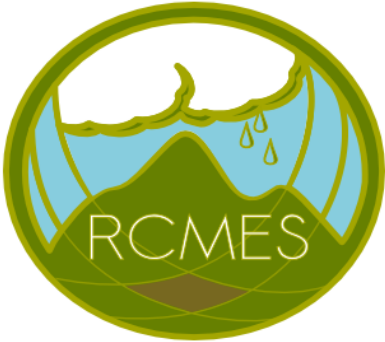
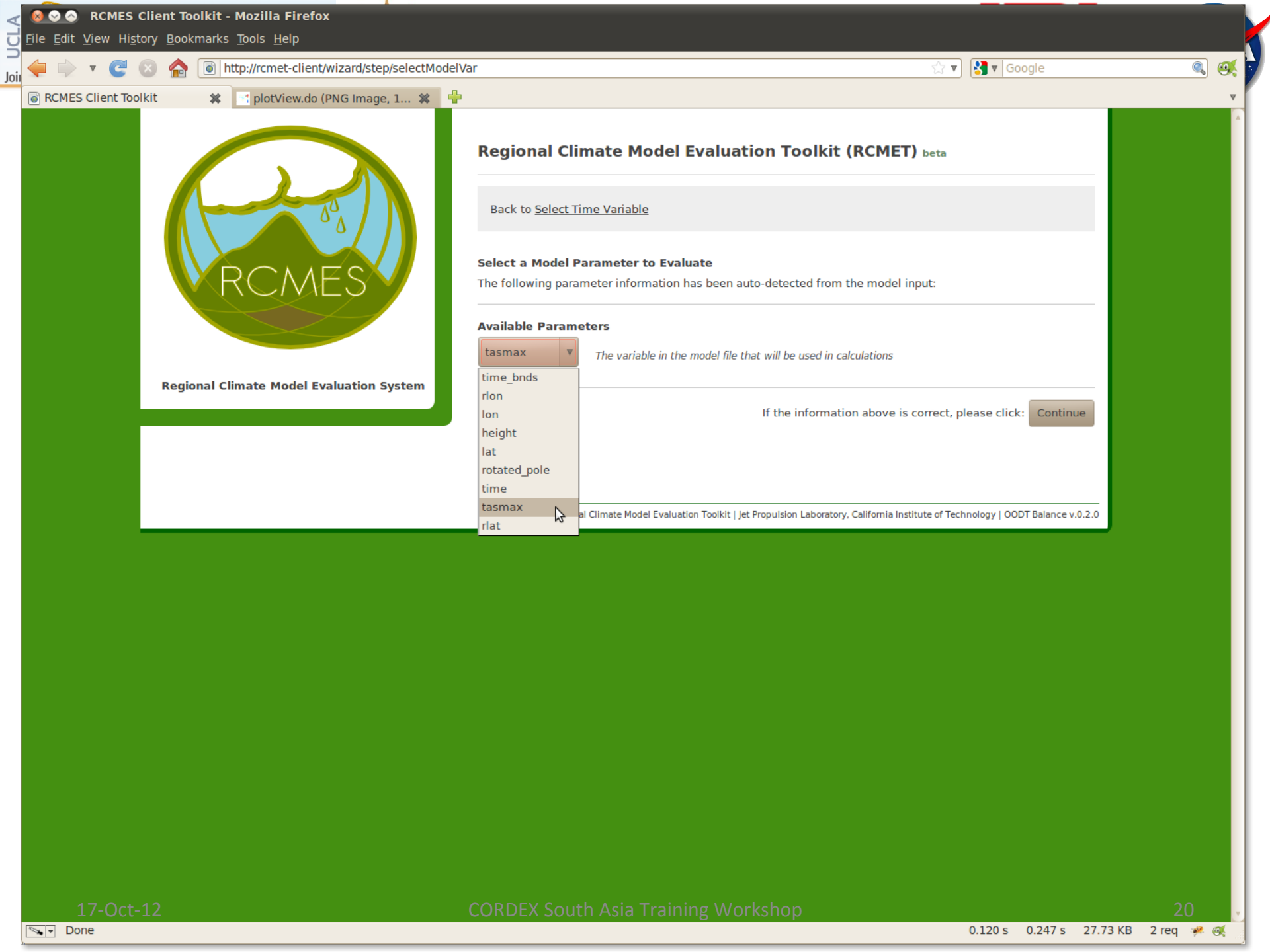
**Var:**  *The variable in the model file that will be used to represent Time*

**Min:**  *The earliest Time value detected in the model file*

**Max:**  *The most recent Time value detected in the model file*

If the information above is correct, please click:

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## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Time Variable](#)

### Select a Model Parameter to Evaluate

The following parameter information has been auto-detected from the model input:

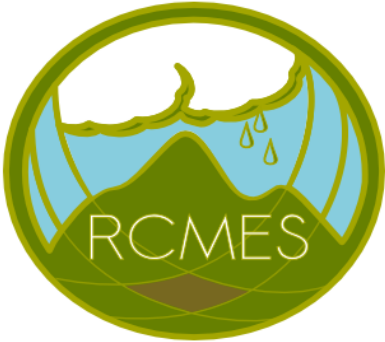
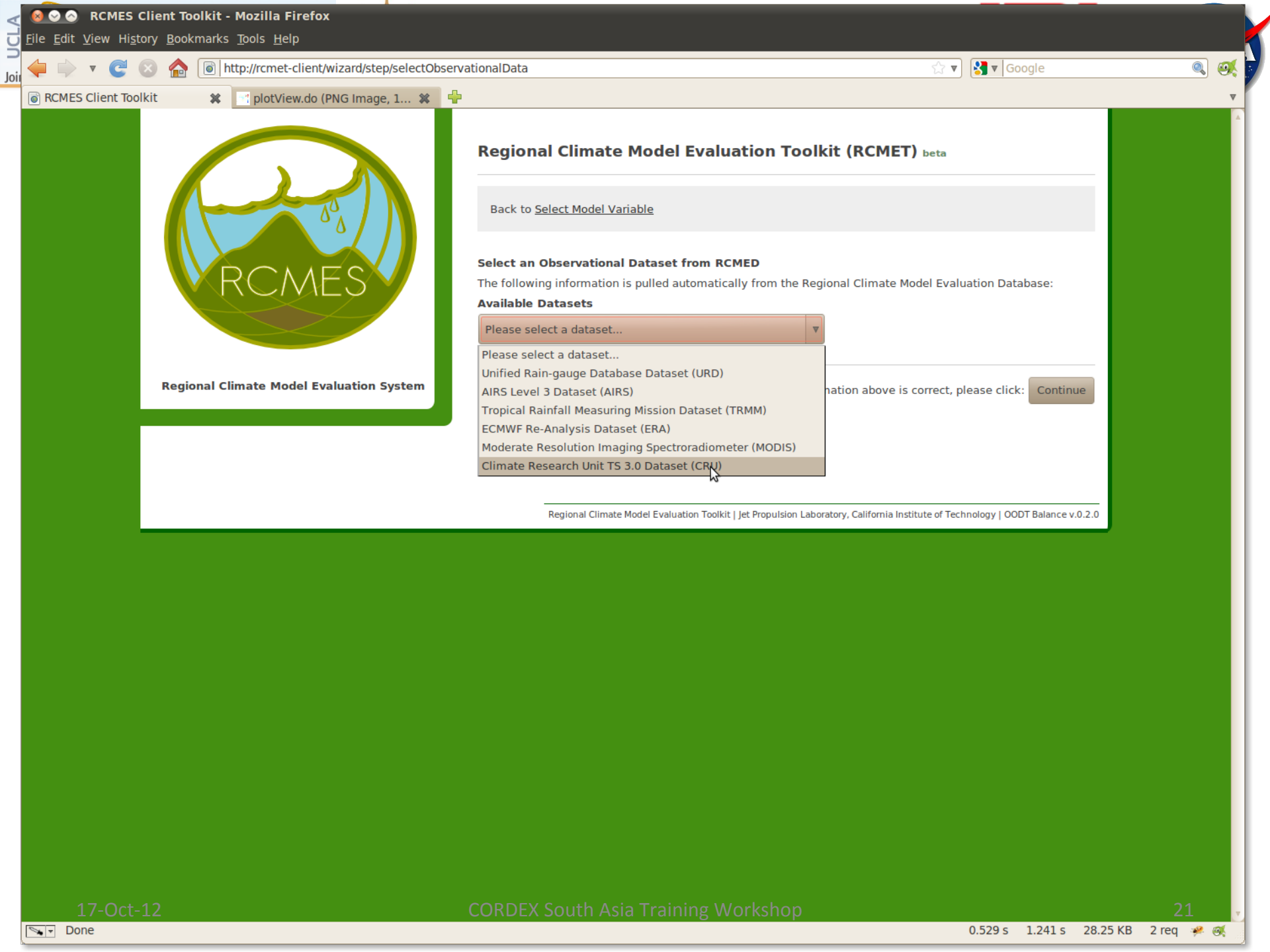
#### Available Parameters

- tasmax
- time\_bnds
- rlon
- lon
- height
- lat
- rotated\_pole
- time
- tasmax
- rlat

*The variable in the model file that will be used in calculations*

If the information above is correct, please click: [Continue](#)

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## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Model Variable](#)

### Select an Observational Dataset from RCME

The following information is pulled automatically from the Regional Climate Model Evaluation Database:

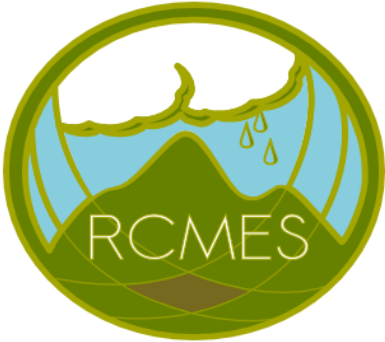
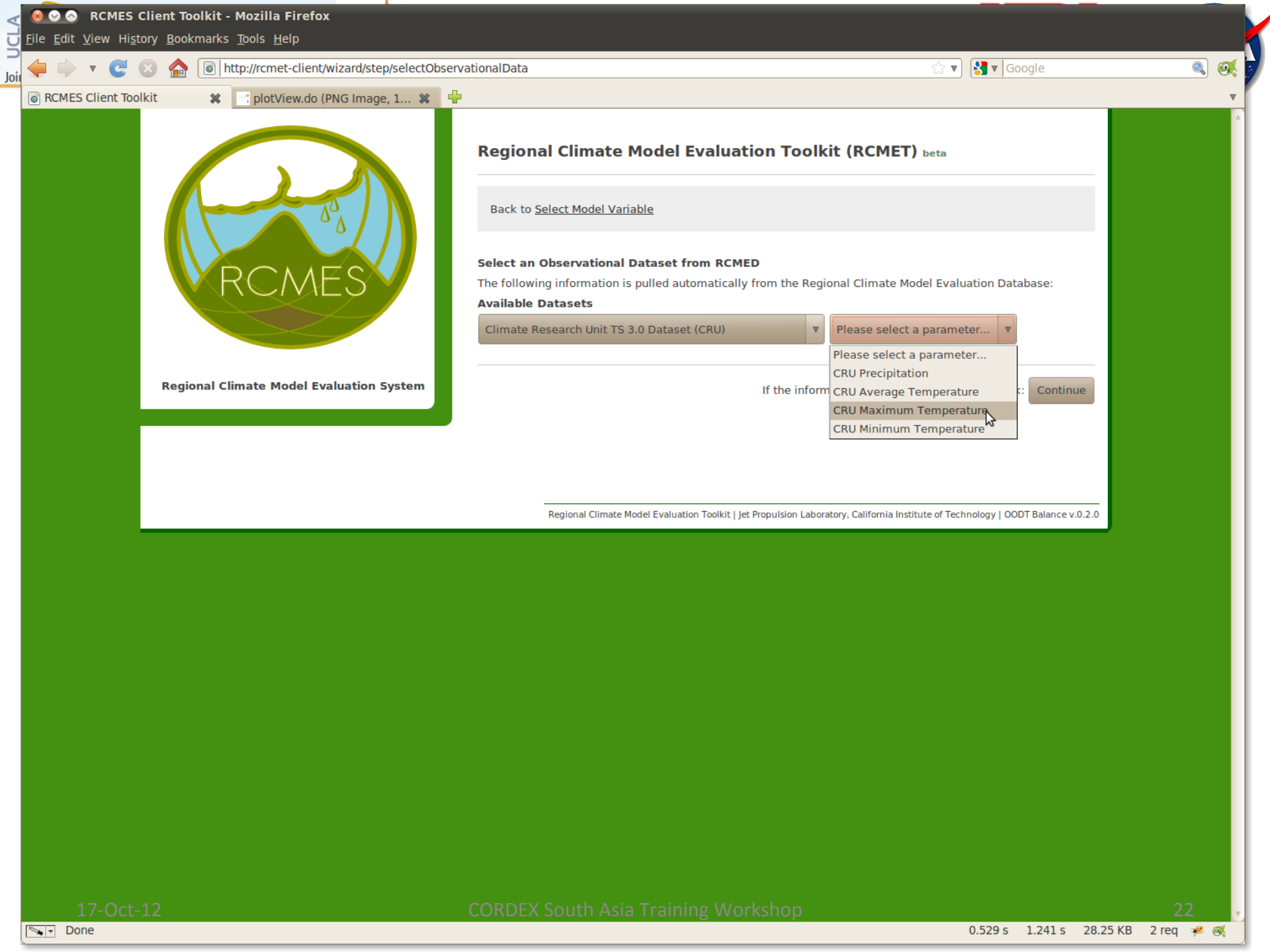
#### Available Datasets

Please select a dataset... ▼

- Please select a dataset...
- Unified Rain-gauge Database Dataset (URD)
- AIRS Level 3 Dataset (AIRS)
- Tropical Rainfall Measuring Mission Dataset (TRMM)
- ECMWF Re-Analysis Dataset (ERA)
- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Climate Research Unit TS 3.0 Dataset (CRU)

Information above is correct, please click:

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Model Variable](#)

### Select an Observational Dataset from RCME

The following information is pulled automatically from the Regional Climate Model Evaluation Database:

#### Available Datasets

Climate Research Unit TS 3.0 Dataset (CRU)

Please select a parameter...

Please select a parameter...

CRU Precipitation

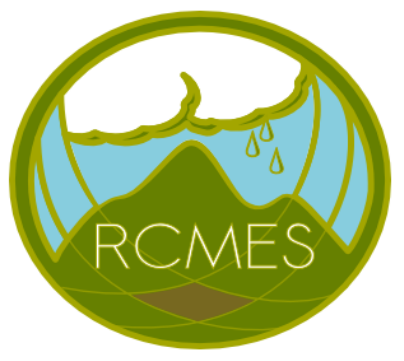
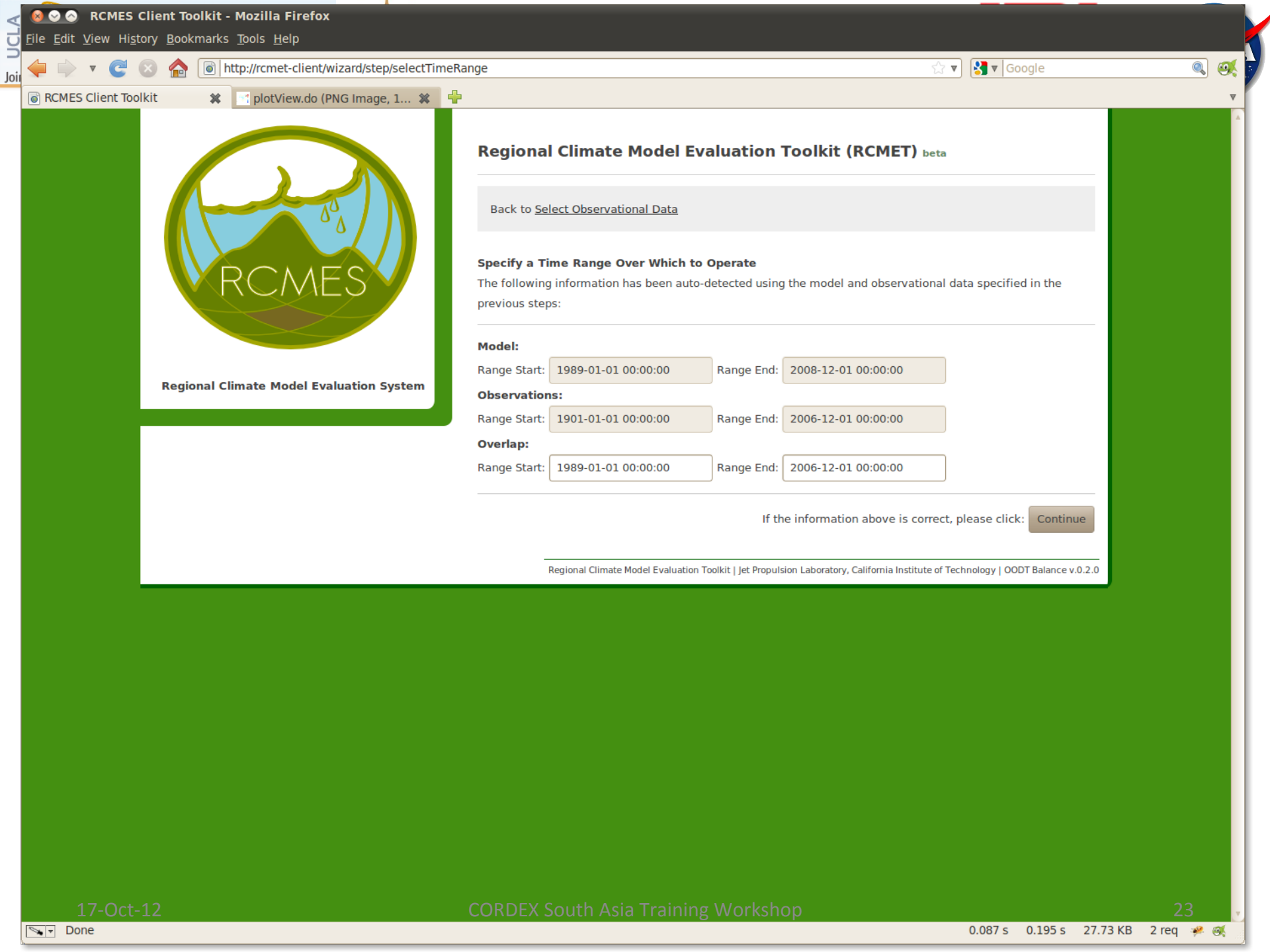
CRU Average Temperature

CRU Maximum Temperature

CRU Minimum Temperature

If the information is not available, you can select a parameter from the dropdown menu.

[Continue](#)



Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

[Back to Select Observational Data](#)

### Specify a Time Range Over Which to Operate

The following information has been auto-detected using the model and observational data specified in the previous steps:

**Model:**

Range Start:  Range End:

**Observations:**

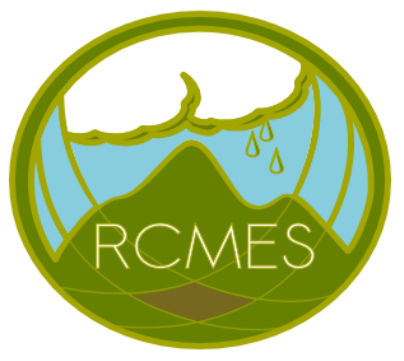
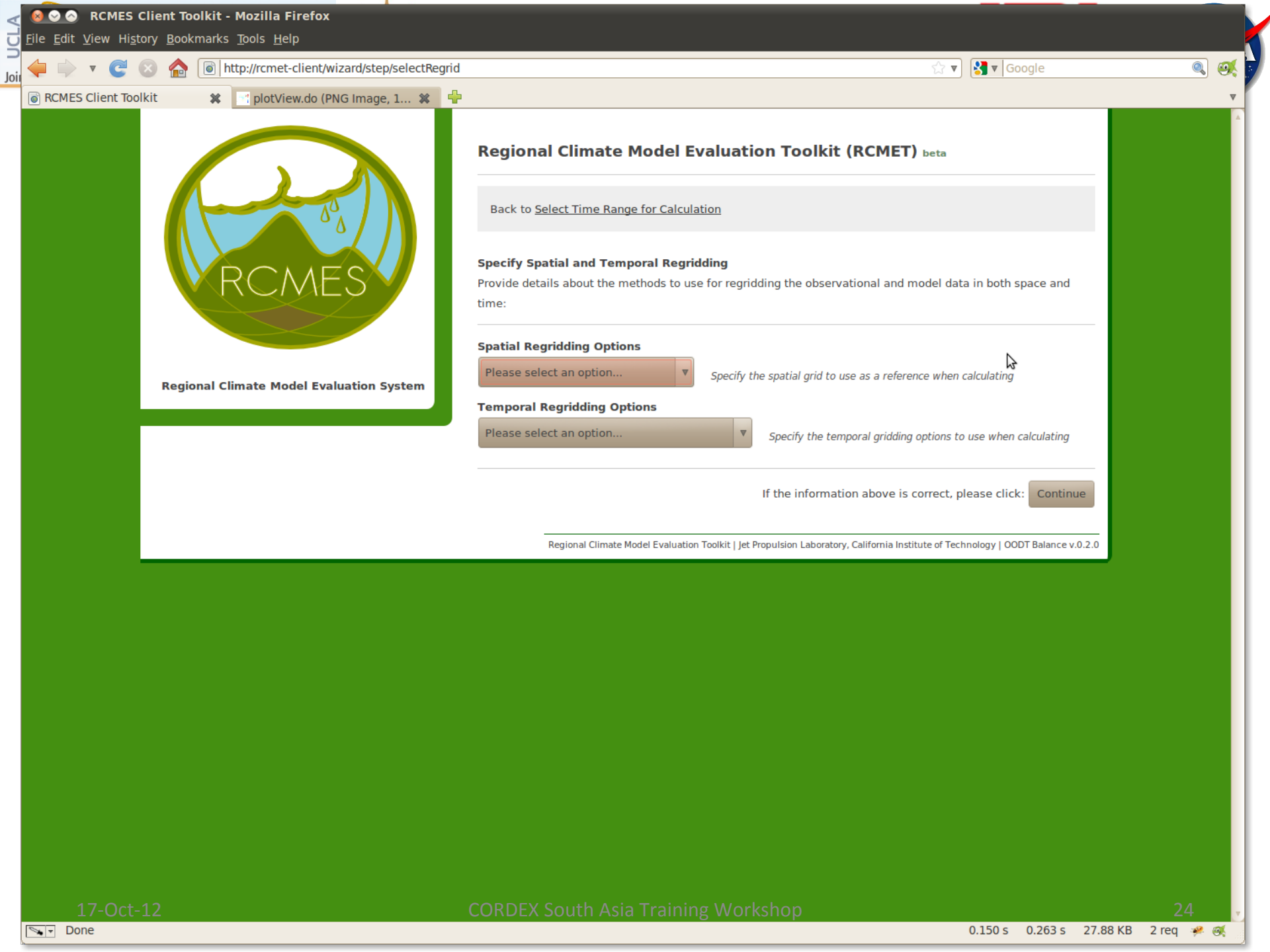
Range Start:  Range End:

**Overlap:**

Range Start:  Range End:

If the information above is correct, please click:

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

[Back to Select Time Range for Calculation](#)

### Specify Spatial and Temporal Regridding

Provide details about the methods to use for regridding the observational and model data in both space and time:

#### Spatial Regridding Options

Specify the spatial grid to use as a reference when calculating

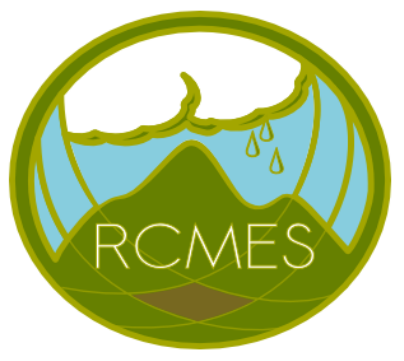
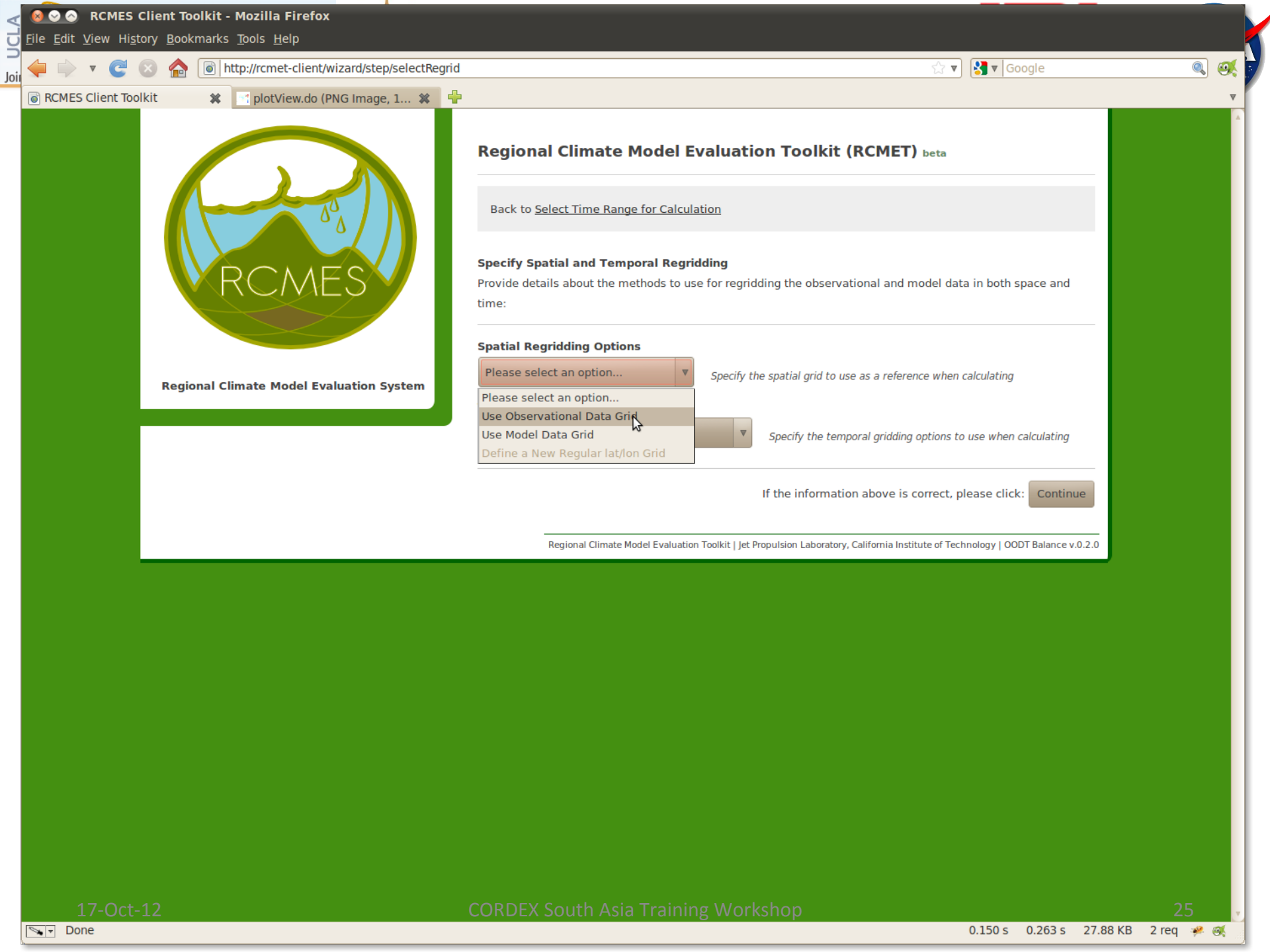
#### Temporal Regridding Options

Specify the temporal gridding options to use when calculating

If the information above is correct, please click:

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

[Back to Select Time Range for Calculation](#)

### Specify Spatial and Temporal Regridding

Provide details about the methods to use for regridding the observational and model data in both space and time:

#### Spatial Regridding Options

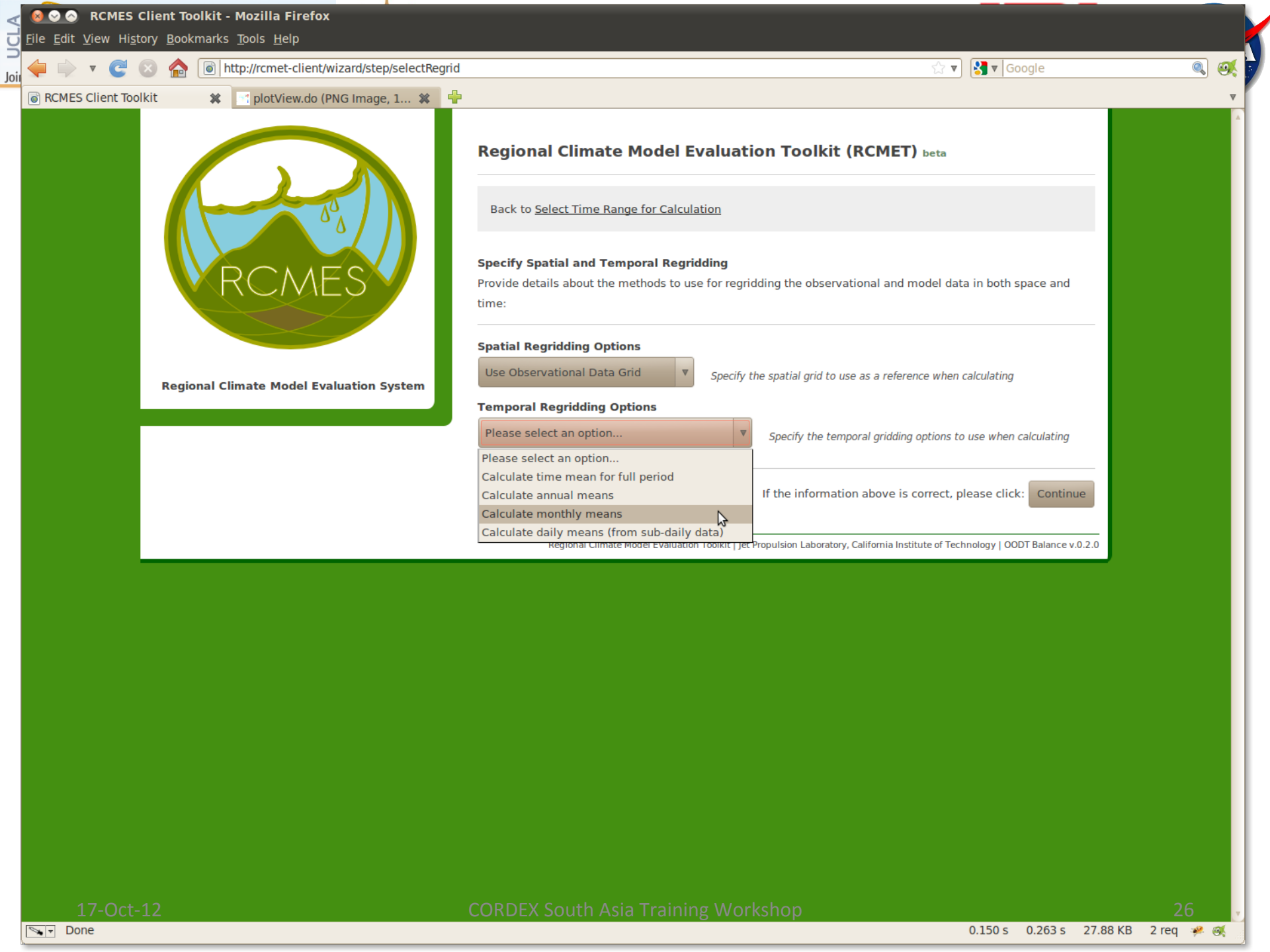
Please select an option...  
 Please select an option...  
 Use Observational Data Grid  
 Use Model Data Grid  
 Define a New Regular lat/lon Grid

*Specify the spatial grid to use as a reference when calculating*

*Specify the temporal gridding options to use when calculating*

If the information above is correct, please click:

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Time Range for Calculation](#)

### Specify Spatial and Temporal Regridding

Provide details about the methods to use for regriding the observational and model data in both space and time:

#### Spatial Regridding Options

Use Observational Data Grid

Specify the spatial grid to use as a reference when calculating

#### Temporal Regridding Options

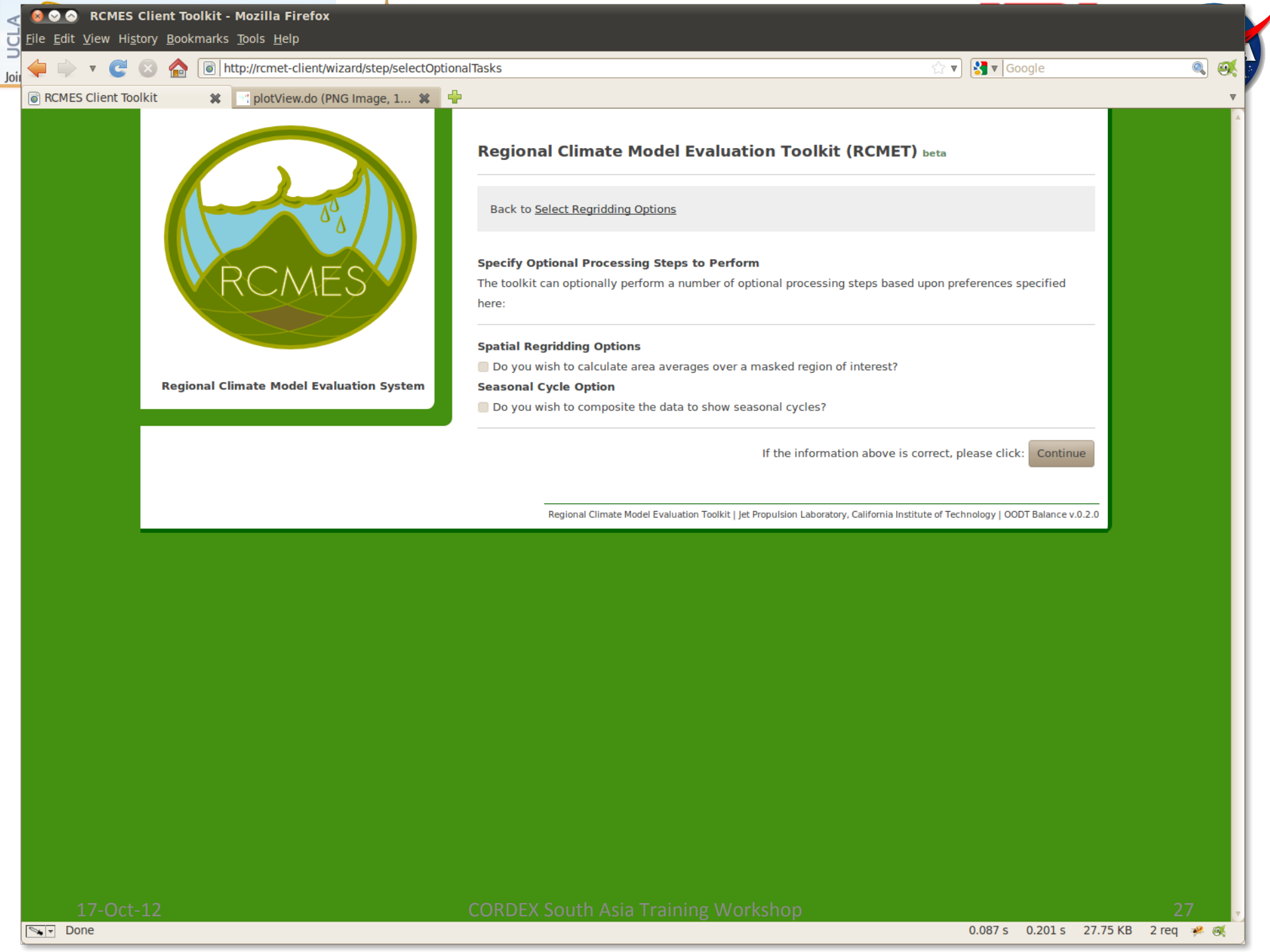
Please select an option...

Specify the temporal gridding options to use when calculating

- Please select an option...
- Calculate time mean for full period
- Calculate annual means
- Calculate monthly means
- Calculate daily means (from sub-daily data)

If the information above is correct, please click: [Continue](#)

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Regridding Options](#)

### Specify Optional Processing Steps to Perform

The toolkit can optionally perform a number of optional processing steps based upon preferences specified here:

#### Spatial Regridding Options

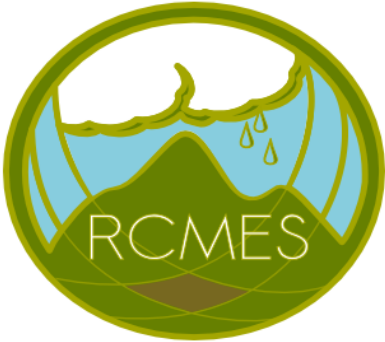
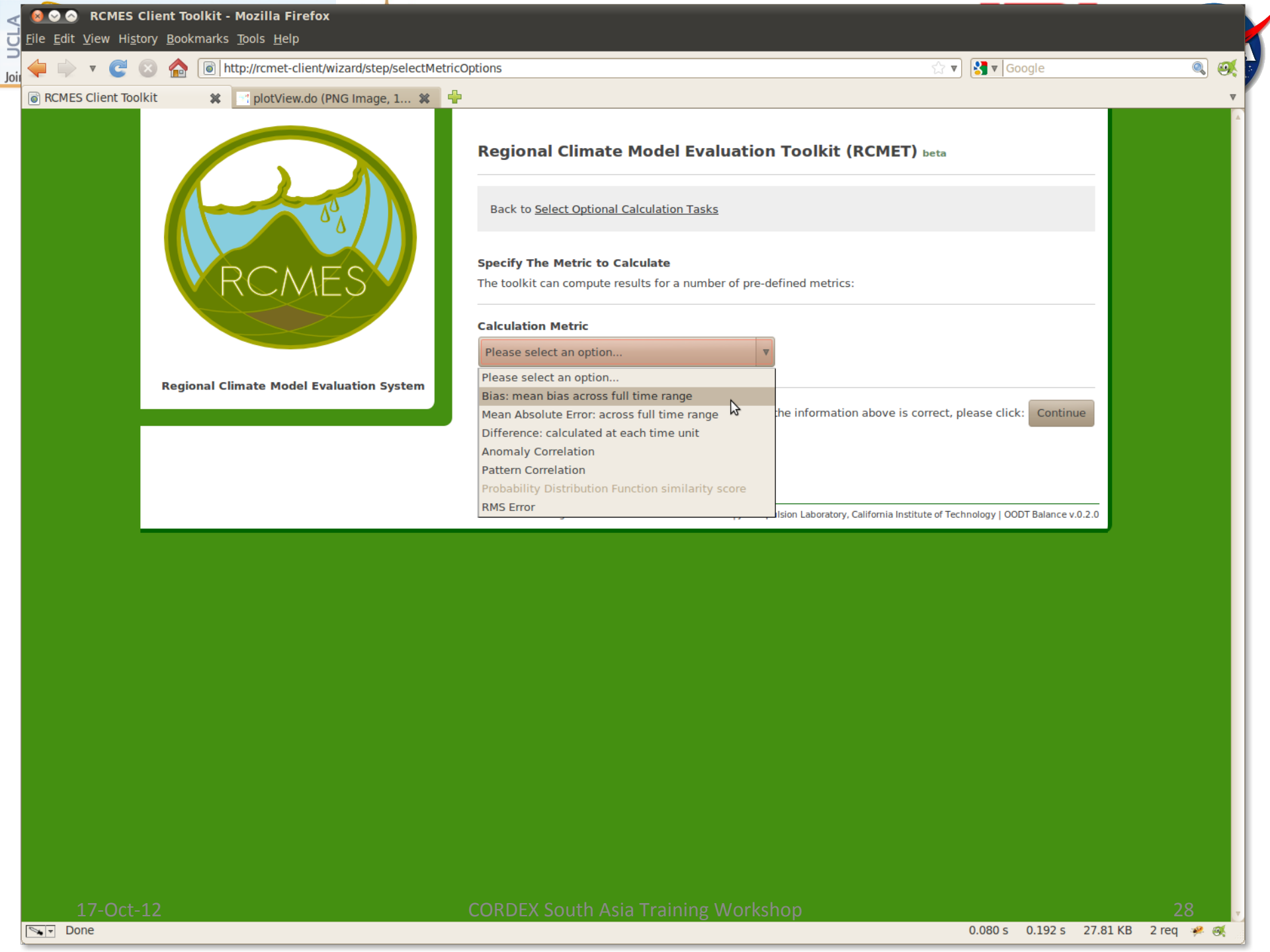
Do you wish to calculate area averages over a masked region of interest?

#### Seasonal Cycle Option

Do you wish to composite the data to show seasonal cycles?

If the information above is correct, please click:

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Optional Calculation Tasks](#)

### Specify The Metric to Calculate

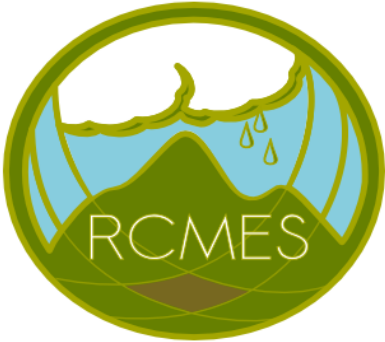
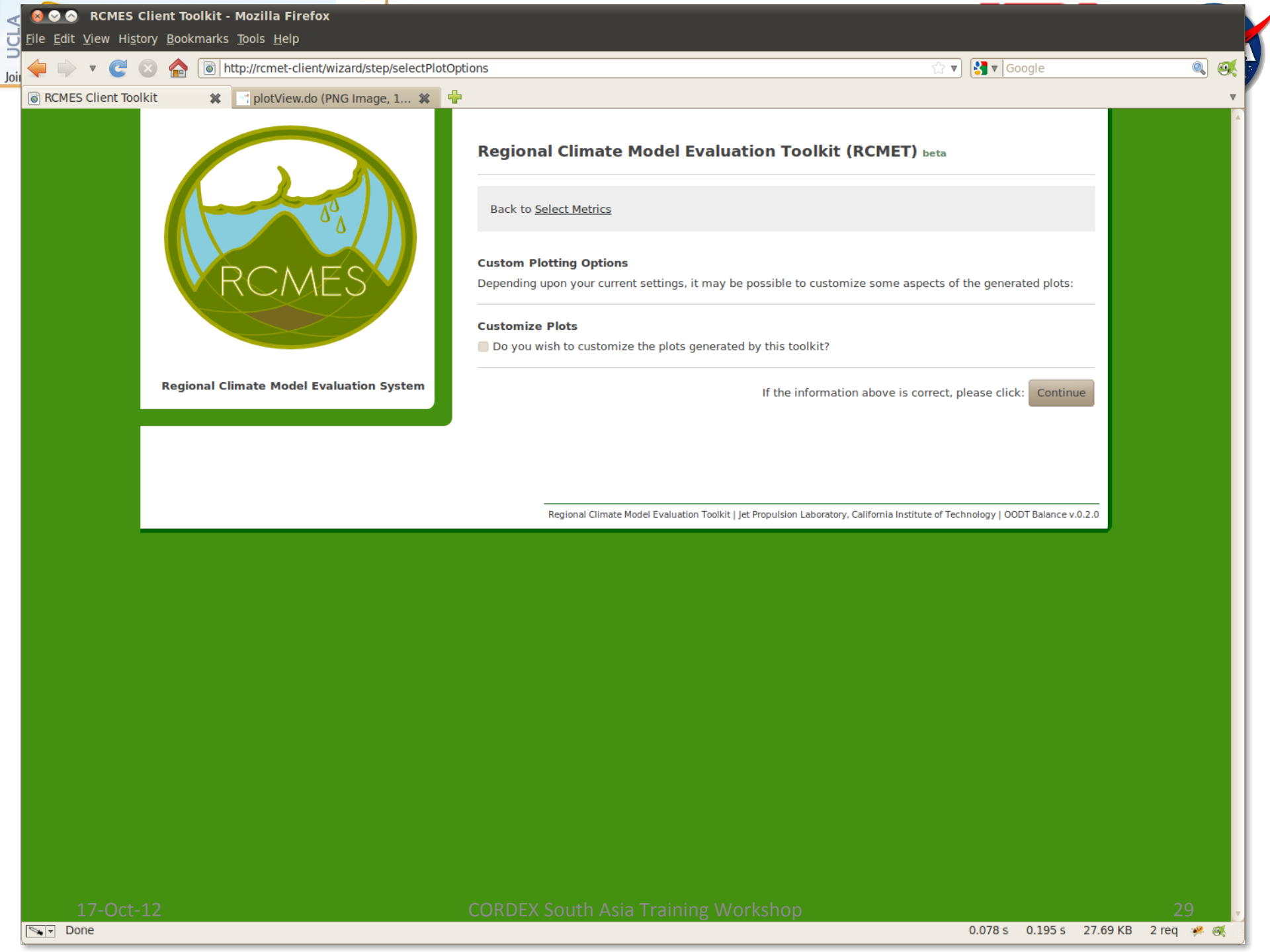
The toolkit can compute results for a number of pre-defined metrics:

#### Calculation Metric

- Please select an option...
- Please select an option...
- Bias: mean bias across full time range
- Mean Absolute Error: across full time range
- Difference: calculated at each time unit
- Anomaly Correlation
- Pattern Correlation
- Probability Distribution Function similarity score
- RMS Error

If the information above is correct, please click: [Continue](#)

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Regional Climate Model Evaluation System

## Regional Climate Model Evaluation Toolkit (RCMET) beta

Back to [Select Metrics](#)

### Custom Plotting Options

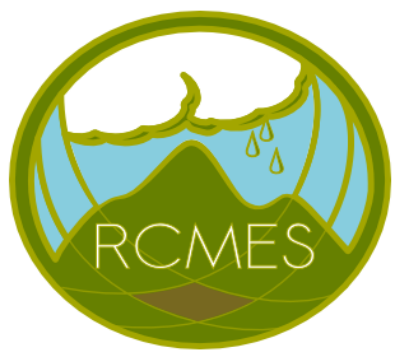
Depending upon your current settings, it may be possible to customize some aspects of the generated plots:

### Customize Plots

Do you wish to customize the plots generated by this toolkit?

If the information above is correct, please click: [Continue](#)

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Regional Climate Model Evaluation System

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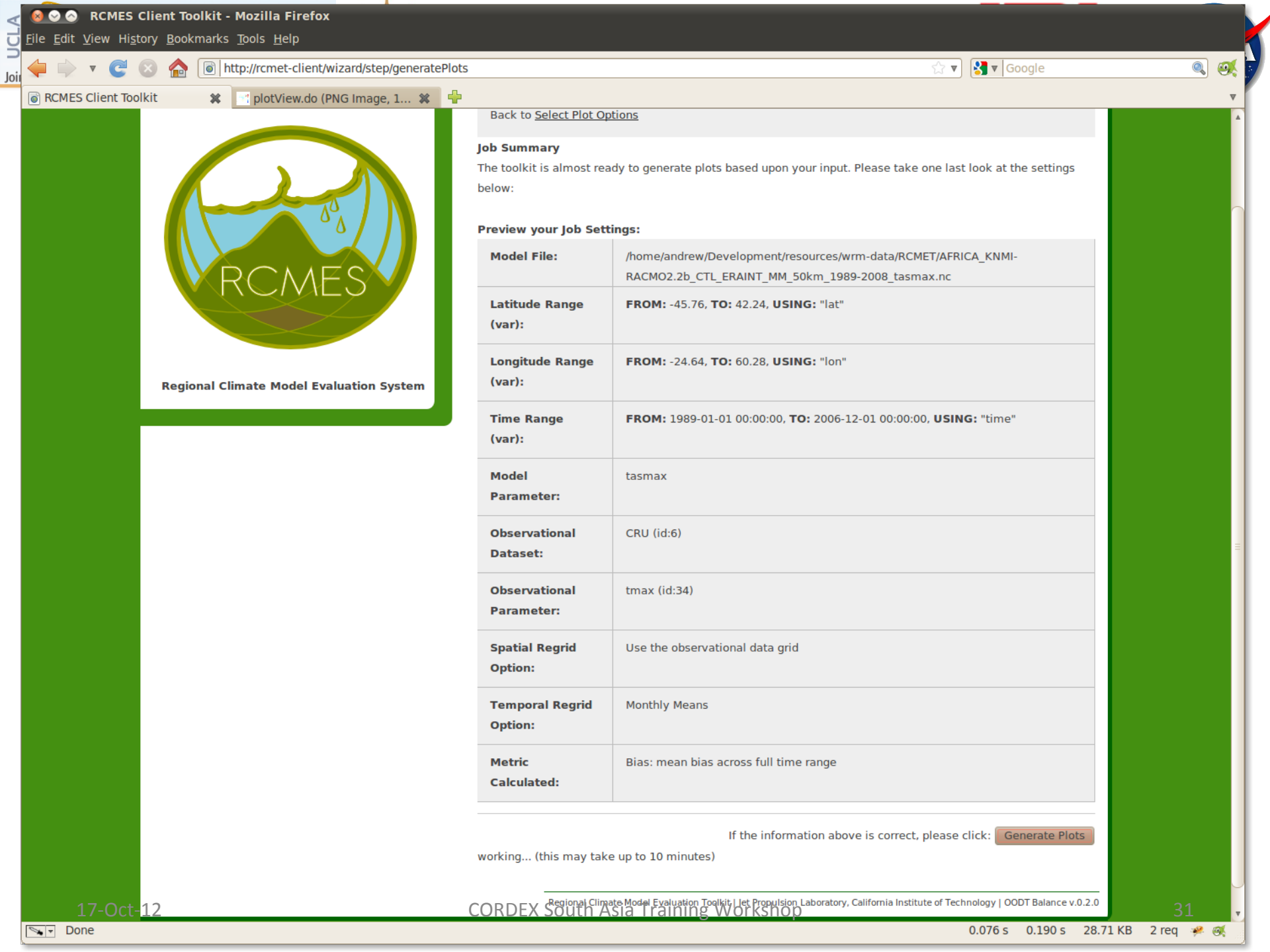
[Back to Select Plot Options](#)

### Job Summary

The toolkit is almost ready to generate plots based upon your input. Please take one last look at the settings below:

### Preview your Job Settings:

<b>Model File:</b>	/home/andrew/Development/resources/wrm-data/RCMET/AFRICA_KNMI-RACMO2.2b_CTL_ERAIN_TMM_50km_1989-2008_tasmax.nc
<b>Latitude Range (var):</b>	<b>FROM:</b> -45.76, <b>TO:</b> 42.24, <b>USING:</b> "lat"
<b>Longitude Range (var):</b>	<b>FROM:</b> -24.64, <b>TO:</b> 60.28, <b>USING:</b> "lon"
<b>Time Range (var):</b>	<b>FROM:</b> 1989-01-01 00:00:00, <b>TO:</b> 2006-12-01 00:00:00, <b>USING:</b> "time"
<b>Model Parameter:</b>	tasmax
<b>Observational Dataset:</b>	CRU (id:6)
<b>Observational Parameter:</b>	tmax (id:34)
<b>Spatial Regrid Option:</b>	Use the observational data grid
<b>Temporal Regrid Option:</b>	Monthly Means
<b>Metric Calculated:</b>	Bias: mean bias across full time range



Regional Climate Model Evaluation System

[Back to Select Plot Options](#)

### Job Summary

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<b>Spatial Regrid Option:</b>	Use the observational data grid
<b>Temporal Regrid Option:</b>	Monthly Means
<b>Metric Calculated:</b>	Bias: mean bias across full time range

If the information above is correct, please click: [Generate Plots](#)

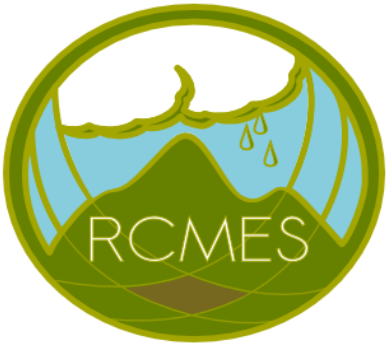
working... (this may take up to 10 minutes)

RCMES Client Toolkit - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://rcmet-client/wizard/step/generatePlots

RCMES Client Toolkit plotView.do (PNG Image, 1...)



**Regional Climate Model Evaluation System**

<b>Latitude Range (var):</b>	<b>FROM:</b> -45.76, <b>TO:</b> 42.24, <b>USING:</b> "lat"
<b>Longitude Range (var):</b>	<b>FROM:</b> -24.64, <b>TO:</b> 60.28, <b>USING:</b> "lon"
<b>Time Range (var):</b>	<b>FROM:</b> 1989-01-01 00:00:00, <b>TO:</b> 2006-12-01 00:00:00, <b>USING:</b> "time"
<b>Model Parameter:</b>	tasmax
<b>Observational Dataset:</b>	CRU (id:6)
<b>Observational Parameter:</b>	tmax (id:34)
<b>Spatial Regrid Option:</b>	Use the observational data grid
<b>Temporal Regrid Option:</b>	Monthly Means
<b>Metric Calculated:</b>	Bias: mean bias across full time range

If the information above is correct, please click:

**Plotted Results**

Your plotted files are ready. To view, click on a link below. Each link opens in a new window.

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[Model Data Plot](#)

[Observational Data Plot](#)

[Comparison Plot](#)

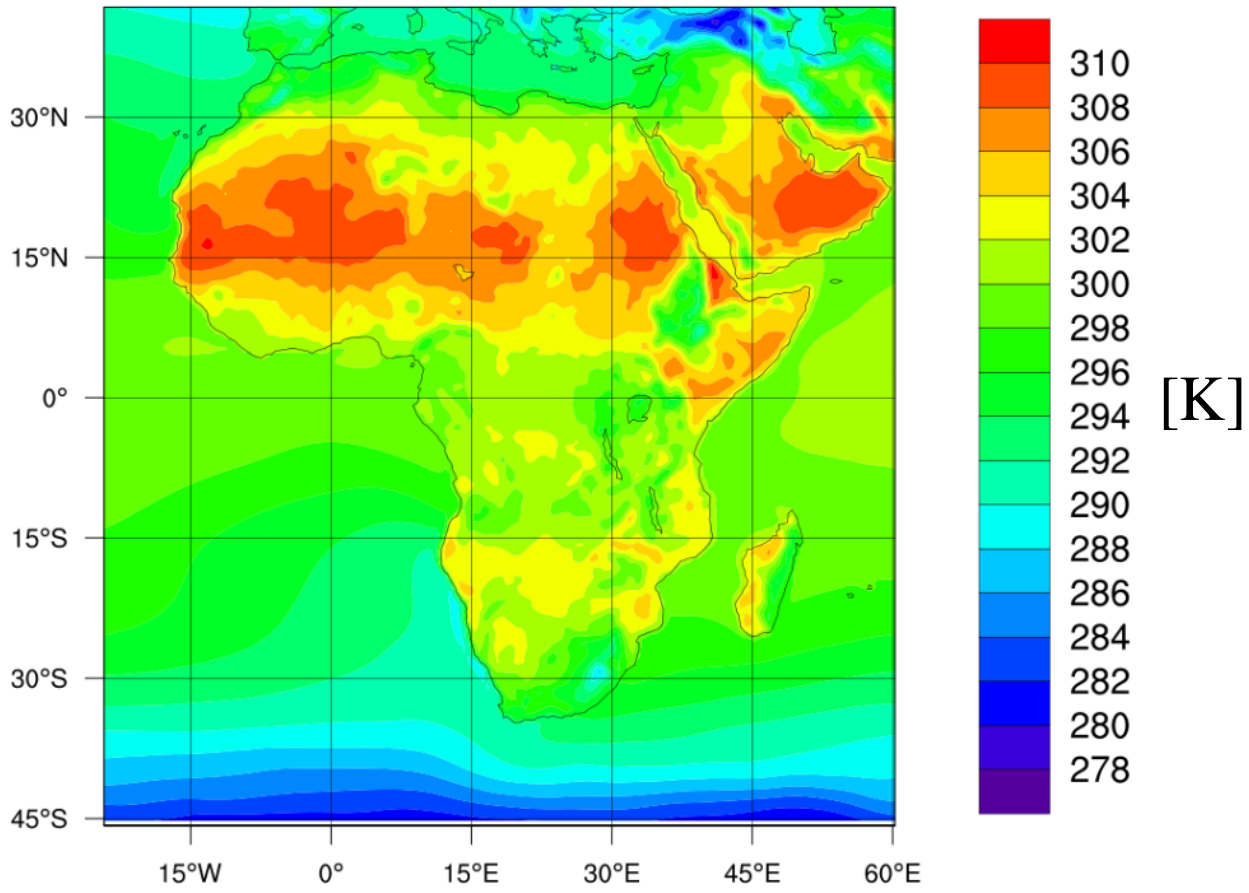
Regional Climate Model Evaluation Toolkit | Jet Propulsion Laboratory, California Institute of Technology | OODT Balance v.0.2.0

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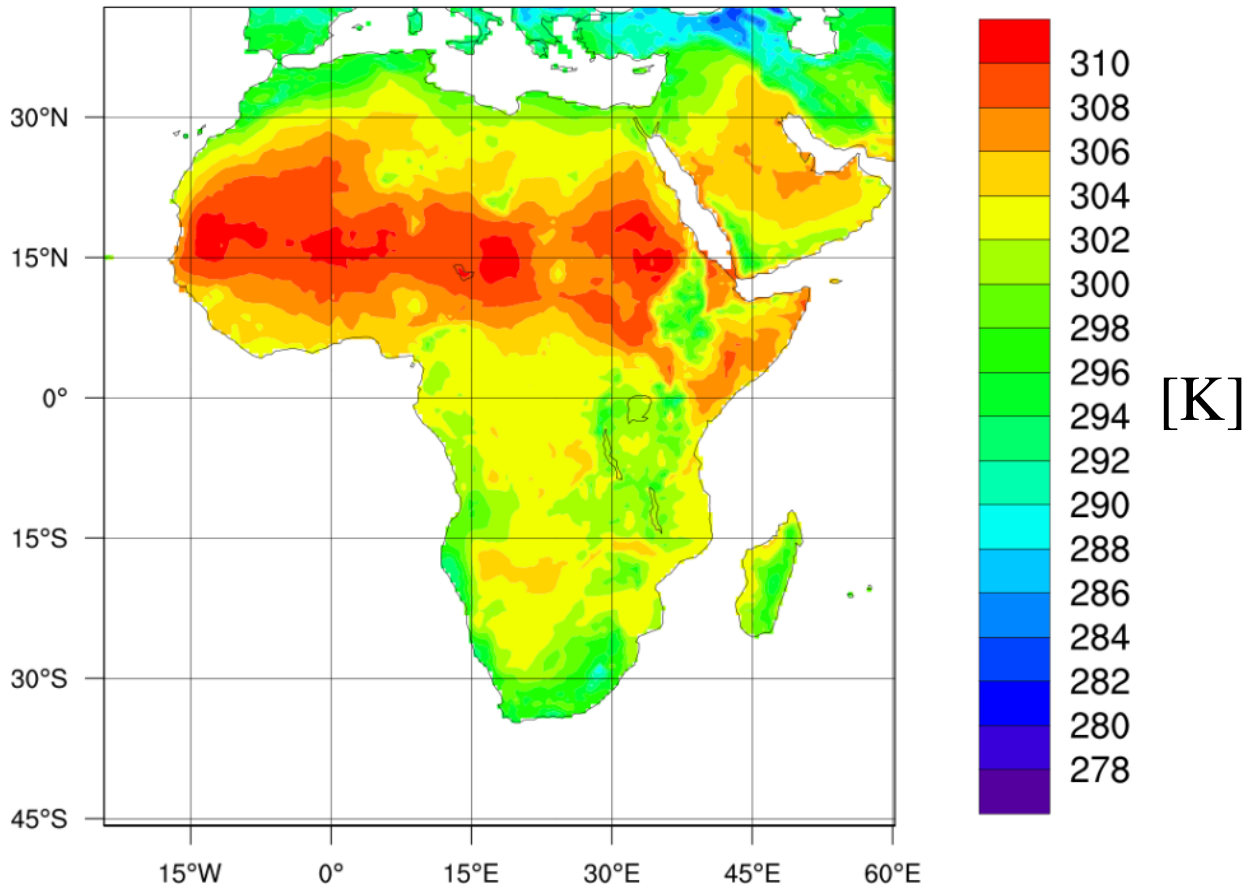
Done 0.076 s 0.190 s 28.71 KB 2 req



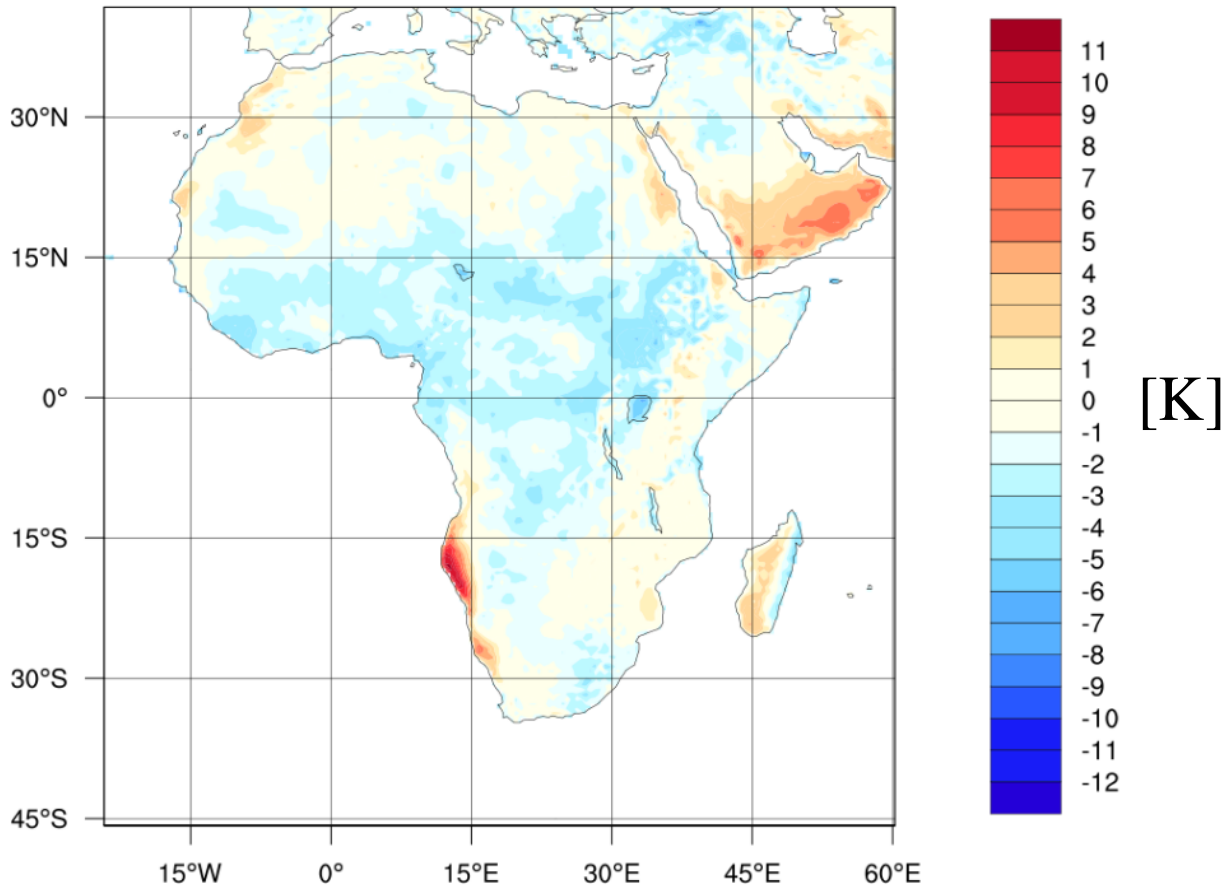
### Model data: mean between Jan 1989 and Dec 2006



### Obs data: mean between Jan 1989 and Dec 2006



### Bias model v obs Jan 1989 to Dec 2006



# Thank you!

## *Some recent CORDEX Arctic Analyses*

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