Earth System Models and Data Access, Analysis and Management

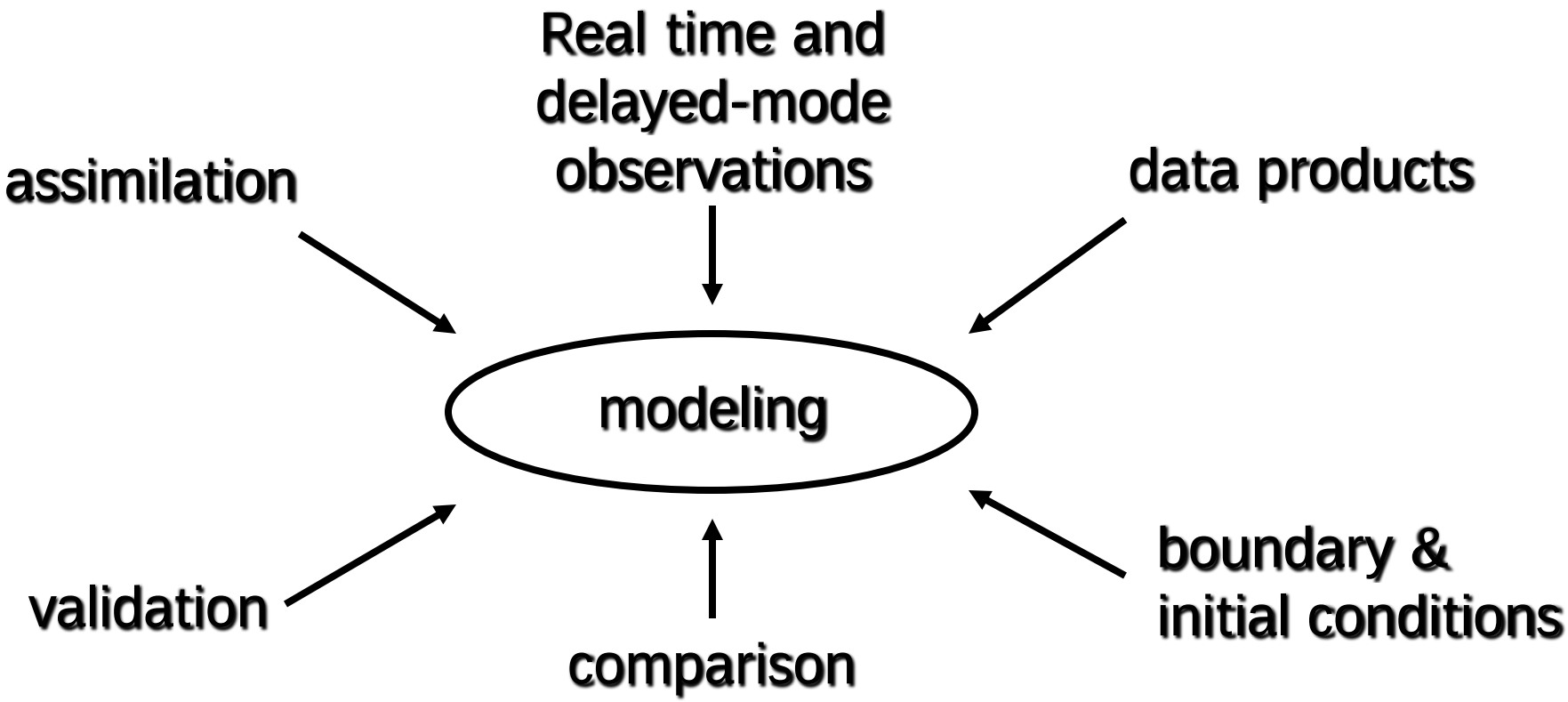
Ben Poulter

Challenges

Earth system science presents unique data challenges

- Where to find data?
- Data types and storage
- Reading data

Data and products need to be useable



Where to find data?

- Climate data
- Remote sensing data
- Model data

Some Climate Data Sources

Climate Projections

- IPCC Data Distribution Centre
  - http://ipcc-ddc.cru.uea.ac.uk/
- Program for Climate Model Diagnosis and Intercomparison
  - http://www-pcmdi.llnl.gov/

IPCC Data Distribution Center

- The IPCC Data Distribution Centre is probably the best site for public-access climate model data

- Observed climate data 1901-1990
  - Gridded to 0.5 x 0.5°
  - 10 and 30 year means

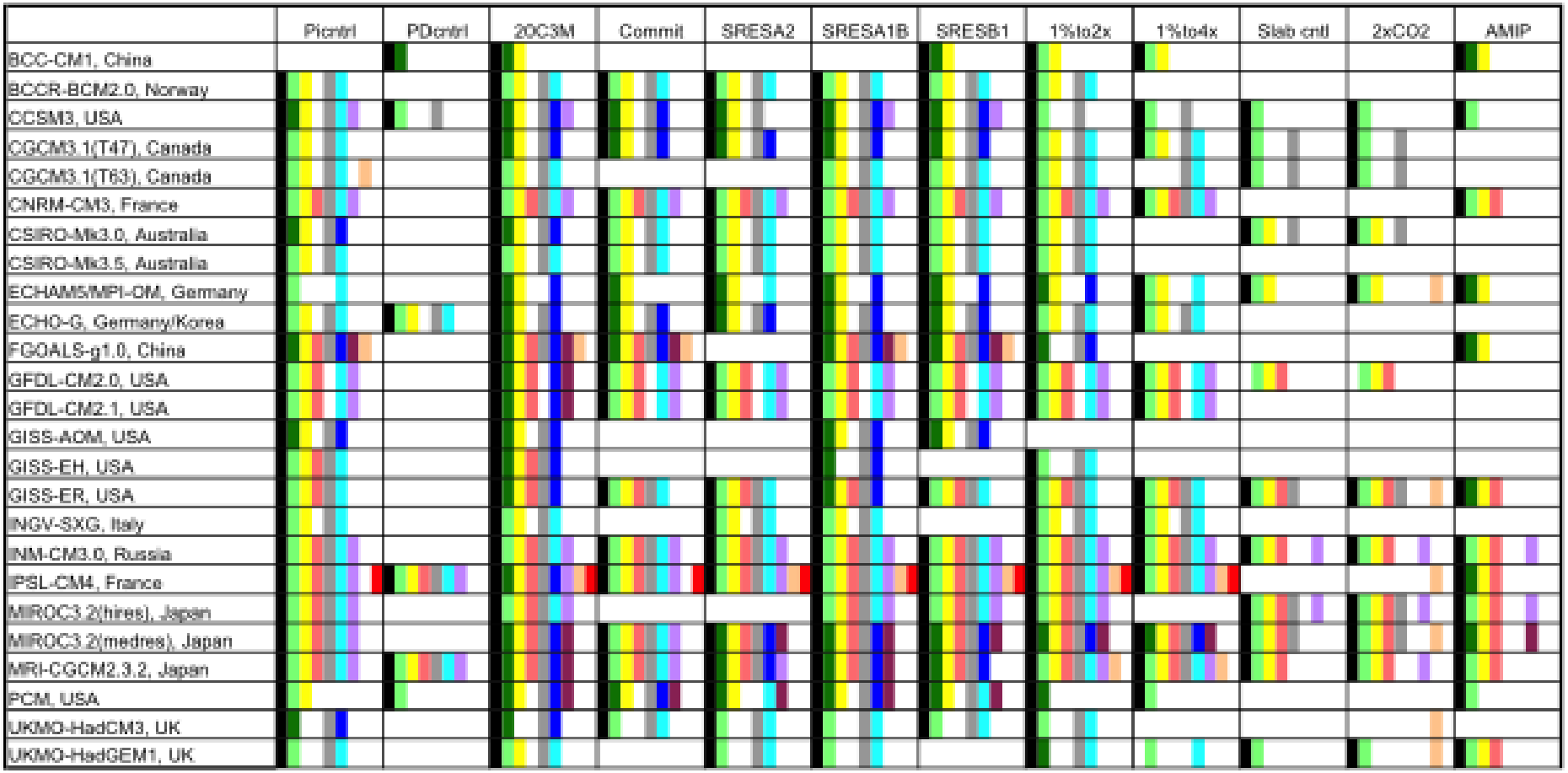
- http://ipcc-ddc.cru.uea.ac.uk/

IPCC Data Distribution Center

- GCM data from
  - CCC (Canada)
  - CSIRO (Australia)
  - ECHAM4 (Germany)
  - GFDL-R30 (U.S.)
  - HadCM3 (UK)
  - NIES (Japan)
  - ….
- Can obtain actual (not scaled) GCM output

shaded area indicates that at least some but not necessarily all fields are available for data type indicated

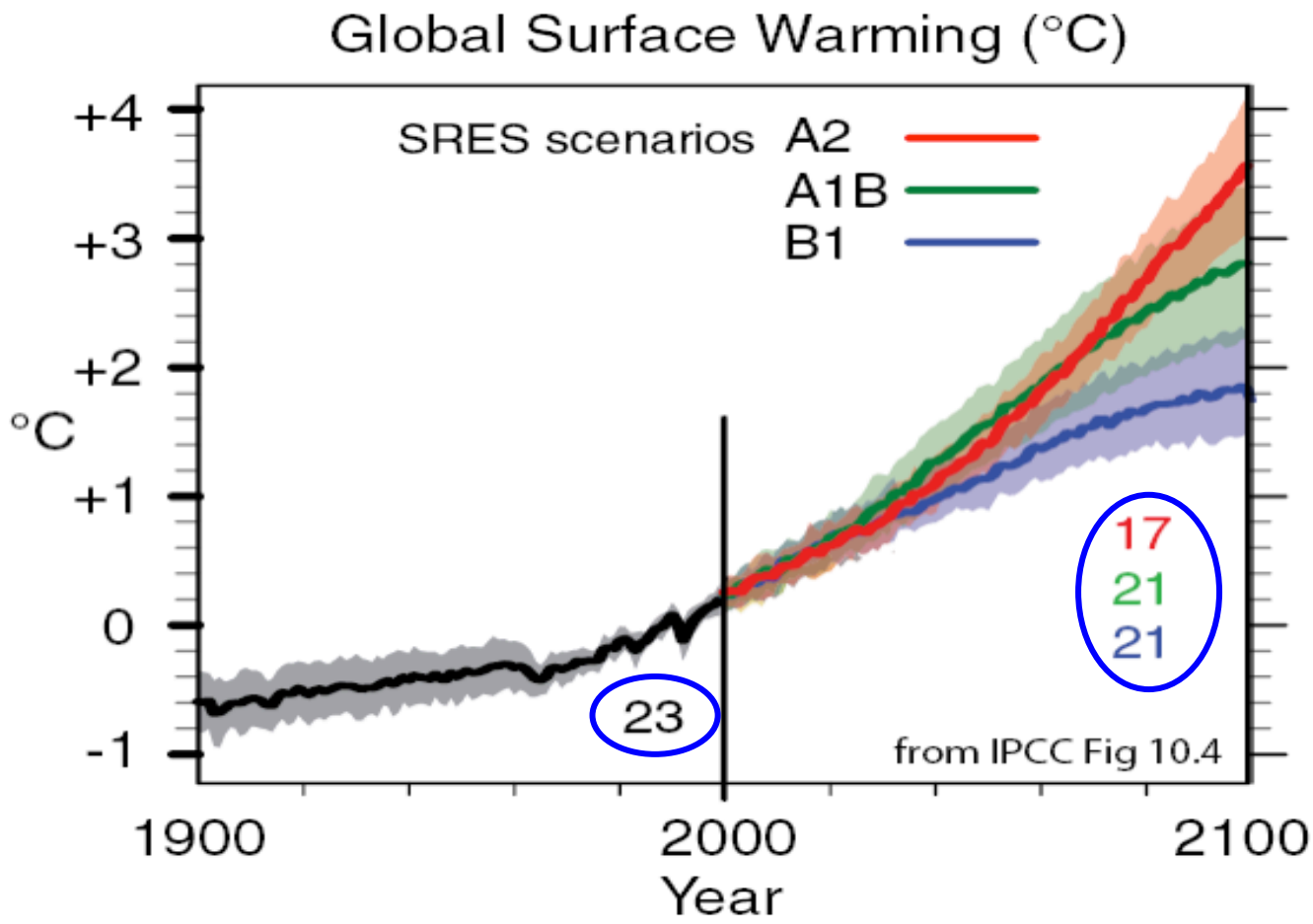
- time-independent land surface
- >1 1 monthly-mean atmosphere
- daily-mean atmosphere
- 3-hourly atmosphere
- time-independent ocean
- >1 1 monthly-mean ocean
- >1 1 Extreme Indices
- Forcing
- ISCCP Simulator



AR4 Data Magnitude

- The IPCC Fourth Assessment Report (IPCC AR4) required the largest collection of climate model data assembled and distributed to analysts to date, and was unprecedented in scale and scope:
  - ~500 TB (1012 bytes) of data generated
  - 35+ TB of data available for access
  - 80+ TB of data downloaded
  - 11 experiments, 23 models from 10 nations
  - 500+ registered users
  - More than 200 refereed papers

- CMIP5->AR5 promises to be even larger.


Global Surface Warming (°C)
SRES scenarios
A2
A1B
B1
+4
+3
+2
+1
0
-1
°C
23
17
21
21
from IPCC Fig 10.4
1900
2000
2100
Year

MODIS

NASA Earth Data | Data Discovery ▾ | Data Centers ▾ | Community ▾ | Science Disciplines ▾ | Search EOSDIS ▾

DAAC Home

ORNL DAAC Distributed Active Archive Center for Biogeochemical Dynamics

About Us | About Data | Get Data | Data Tools | Help

home sign-in

search for in Metadata go ?

MODIS Land Product Subsets

Overview

The goal of the MODIS Land Product Subsets project is to provide summaries of selected MODIS Land Products for the community to use for validation of models and remote-sensing products and to characterize field sites. Output files contain pixel values of MODIS land products in text format and in GeoTIFF format. In addition, data visualizations (time series plots and grids showing single composite periods) are available.

MODIS Land Product Subsets Resources

The following MODIS Land Product Subsets resources are maintained by the ORNL DAAC:

- MODIS Land Products Offered
- Background
- Citation Policy
- Methods and formats
- MODIS Sinusoidal Grid - Google Earth KMZ
- Classroom Exercises
- Learn More

Get MODIS Subsets (Collection 5)

Field Site and Flux tower
Obtain MODIS subsets for areas centered on more than 1,000 field sites and flux towers from around the world:

- Data for Selected Field Sites

Global Tool
Order MODIS subsets for any site, area (from 1 pixel up to 201 x 201 km) and time period globally:

- Create Subset

Web Service
Programmatically obtain MODIS subsets for any land location, time period and area (from 1 pixel up to 201 x 201 km) using a SOAP Web Service

- Web Service Info

Related MODIS Links

- MODIS Website
- Land Processes DAAC
- MODIS Land Validation Strategy

See comments about this web site.

OAK RIDGE

ORNL DAAC: Data Citation | Data Provider Information | Privacy Policy | NASA | EOSDIS Data Centers | Rate Us | Site Map

Contact Us
Email: USO@daac.ornl.gov

MODIS

Product	Acronym	Name	Frequency (Days)	Resolution (Meter)
MCD12Q1	LC	MODIS/Terra+Aqua Lan Cover (LC) Type Yearly L3 Global 500m SIN Grid	annual	500
MCD12Q2	LCD	MODIS/Terra+Aqua Land Cover Dynamics (LCD) Yearly L3 Global 500m SIN Grid	annual	500
MCD43A	MCD43A	MODIS/Terra+Aqua BRDF and Calculated Albedo (BRDF/MCD43A) 16-Day L3 Global 500m SIN Grid	16	500
MCD43A1	BRDF	MODIS/Terra+Aqua BRDF/Albedo (BRDF/MCD43A1) 16-Day L3 Global 500m SIN Grid	16	500
MCD43A2	BRDF/QA	MODIS/Terra+Aqua BRDF/Model Quality (BRDF/MCD43A2) 16-Day L3 Global 500m SIN Grid V005	16	500
MCD43A4	NBAR	MODIS/Terra+Aqua Nadir BRDF-Adjusted Reflectance (NBAR) 16-Day L3 Global 500m SIN Grid	16	500
MOD09A1	SREF	MODIS/Terra Surface Reflectance (SREF) 8-Day L3 Global 500m SIN Grid	8	500
MOD11A2	TEMP	MODIS/Terra Land Surface Temperature/Emissivity (LST) 8-Day L3 Global 1km SIN Grid	8	1000
MOD13Q1	NDVI/EVI	MODIS/Terra Vegetation Indices (NDVI/EVI) 16-Day L3 Global 250m SIN Grid [Collection 5]	16	250
MOD15A2	LAI/FPAR	Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation (FPAR) 8-Day Composite [Collection 5]	8	1000
MOD15A2GFS	LAI	Gap-Filled,Smoothed Leaf Area Index (LAI) 8-Day Composite [Collection 4]	8	1000
MOD16A2	ET	MODIS/Terra Evapotranspiration (ET) 8-Day L4 Global Collection 5	8	1000
MOD17A2	GPP	MODIS/Terra Gross Primary Production (GPP) 8-Day L4 Global	8	1000
MOD17A2_51	GPP	MODIS/Terra Gross Primary Production (GPP) 8-Day L4 Global Collection 5.1	8	1000
MOD17A3	NPP	MODIS/Terra Net Primary Production (NPP) Yearly L4 Global 1km SIN Grid	annual	1000
MYD09A1	SREF	MODIS/Aqua Surface Reflectance (SREF) 8-Day L3 Global 500m SIN Grid	8	500
MYD11A2	TEMP	MODIS/Aqua Land Surface Temperature/Emissivity (LST)8-Day L3 Global 1km SIN Grid	8	1000
MYD13Q1	NDVI/EVI	MODIS/Aqua Vegetation Indices (NDVI/EVI) 16-Day L3 Global 1km SIN Grid	16	250
MYD15A2	LAI/FPAR	MODIS/Aqua Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation (FPAR) 8 Day Composite	8	1000
MYD17A2	GPP	MODIS/Aqua Gross Primary Production (GPP) 8 Day L4 Global	8	1000
MYD17A3	NPP	MODIS/Aqua Net Primary Production (NPP) Yearly L4 Global 1km SIN Grid	8	1000

Transferring data from daac.ornl.gov...

MODIS

Image © 2006 TerraMetrics, NASA

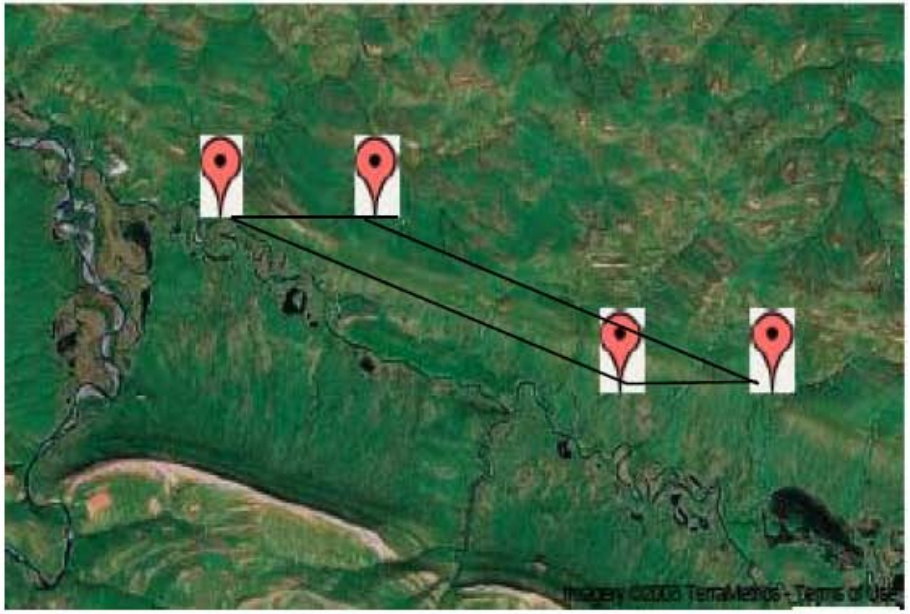


Image © 2006 TerraMetrics - Terms of Use

Comparison of AR4 and AR5

Number of fields per climate modeling system requested

	subdaily		daily		monthly		annual		**totals**	
	AR4	**AR5**	**AR4**	**AR5**	**AR4**	**AR5**	**AR4**	**AR5**	**AR4**	**AR5**
atmosphere	9	100	18	75	47	223	0	8	**74**	**406**
land surface	0	3	0	5	9	82	0	0	**9**	**90**
ocean	0	1	0	3	12	127	0	79	**12**	**210**
sea ice	0	0	0	4	4	40	0	0	**4**	**44**
totals	**9**	**104**	**18**	**87**	**72**	**472**	**0**	**87**	**99**	**750**

Taken from Gary Strand: The IPCC Process: Data Management and Lessons Learned

Earth System Grid

Earth System Grid

Home | Data | About ESG | Account | Login

Resource Metadata

BACK TO SEARCH

ESM2M Control-1990 dyn_veg warmbrdf Simulation
Full Name: Earth System Model Version 2 Modular Ocean Model 4 Dynamic Vegetation Warm Bidirectional Reflection Distribution Function
Description: Simulation to arrive at the initial conditions for CMIP5 Experiment 3.1

Properties | Components | Grids | Reference | Experiment

Basic | Technical | All

Project	CMIP5
Contact Name	John Dunne
Contact Email	john.dunne@noaa.gov
Principal Investigator	John Dunne
Physical Domain	Earth system
Discipline	Climate
Institution	Geophysical Fluid Dynamics Laboratory
Funding Source	NOAA
Simulation Start Date	1990-01-01T11:08:33
Simulation End Date	1990-12-31T11:07:54
Calendar	No leap
Simulation Status	Completed

Earth System Grid

ESM2M Control-1990 dyn_veg warmbrdf Simulation
Full Name: Earth System Model Version 2 Modular Ocean Model 4 Dynamic Vegetation Warm Bidirectional Reflection Distribution Function
Description: Simulation to arrive at the initial conditions for CMIP5 Experiment 3.1

Properties | **Components** | Grids | Reference | Experiment

- ESM2M Control-1990 dyn_veg warmbrdf Simulation
  - Physical Domain: Earth system
  - Version: quebec
  - AM2 Control-1990 dyn_veg warmbrdf Simulation
    - Physical Domain: Atmosphere
    - Version: quebec
    - AM2 FV Dynamical Core Control-1990 dyn_veg warmbrdf Simulation
      - Physical Domain: Atmosphere
      - Version: quebec
    - Atmospheric Chemistry Control-1990 dyn_veg warmbrdf Simulation
      - Physical Domain: Atmosphere
      - Version: quebec
  - LM2 Control-1990 dyn_veg warmbrdf Simulation
  - MOM4 Control-1990 dyn_veg warmbrdf Simulation
  - SIS Control-1990 dyn_veg warmbrdf Simulation
    - Physical Domain: Ice
    - Version: quebec
  - TOPAZ Control-1990 dyn_veg warmbrdf Simulation
    - Physical Domain: Ocean
    - Version: quebec

Earth System Grid

Resource Metadata

BACK TO SEARCH

ESM2M Control-1990 dyn_veg warmbrdf Simulation
Full Name: Earth System Model Version 2 Modular Ocean Model 4 Dynamic Vegetation Warm Bidirectional Reflection Distribution Function
Description: Simulation to arrive at the initial conditions for CMIP5 Experiment 3.1

Properties | Components | Grids | Reference | Experiment

Basic | Technical | All

Year Released	2009
Version	quebec
License	GPL
Previous Version	
Connection Type	tem
Parallelization Ty	
Coding Language	F90 C
Machine Name	High Performance Computing System (HPCF)
Operating System	Linux
Platform	SGI
Processor	Itanium
Compiler	Intel 9.1.051
Maximum Processors	5,000
Cores per Processor	4
Hardware Type	Beowulf
Interconnect Type	NUMAlink

Connection Type

The software package or mechanism used to transfer and transform data between model components.

GFDL model experiments - demonstration server - Netscape

File Edit View Go Communicator Help

Bookmarks Location: http://ferret.pmel.noaa.gov:8180/DecCen_devel/servlets/constrain?var=21 What's Related

GFDL model experiments - demonstration server

Search: Go

single data set | compare two

Datasets
Variables
Constraints
Output

Output Options
Previous Output

Define variable

About

LAS UI Version 6.2

Datasets > DecCen > GPS 01
Variable(s): **theta**

Select your desired view (geometry of output) and output (type of product).
Then set the 4-D region (lon-lat-depth-time) and any additional constraints.
Help

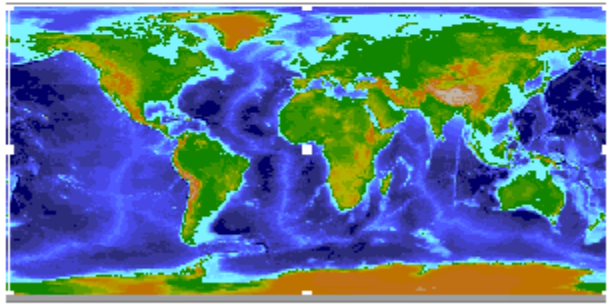
Select view: xy (lat/lon) slice

Select output: Shaded plot (GIF)

Select region: Full Region Go

Next >

Don't use map applet



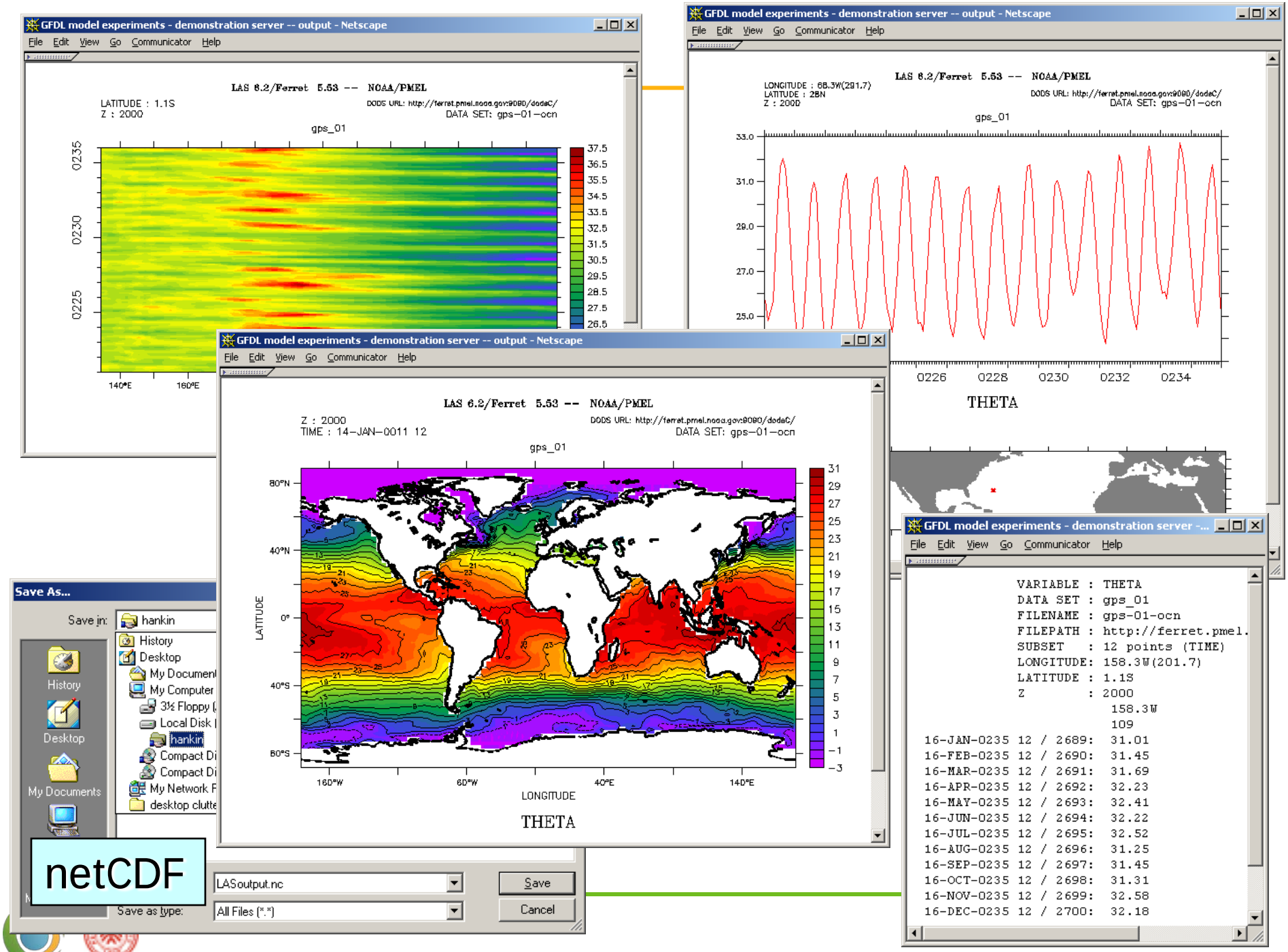
88.6289978
180.0 W 180.0 E
88.6289978

Zoom In Zoom Out

Select time: 14-Jan-0011 12:00:00 14-Jan-0011

Select depth: 2000 2000

Applet map running


GFDL model experiments - demonstration server -- output - Netscape
File Edit View Go Communicator Help
LAS 6.2/Ferret 5.53 -- NOAA/PMEL
LATITUDE : 1.1S
Z : 2000
DODS URL: http://ferret.pmel.noaa.gov:9090/dodsC/
DATA SET: gps-01-ocn
gps_01
0235
0230
0225
140°E
160°E
37.5
36.5
35.5
34.5
33.5
32.5
31.5
30.5
29.5
28.5
27.5
26.5
LONGITUDE : 68.3W(291.7)
LATITUDE : 28N
Z : 2000
33.0
31.0
29.0
27.0
25.0
0226
0228
0230
0232
0234
THETA
Z : 2000
TIME : 14-JAN-0011 12
80°N
40°N
0°
40°S
80°S
LATITUDE
160°W
60°W
40°E
140°E
LONGITUDE
31
29
27
25
23
21
19
17
15
13
11
9
7
5
3
1
-1
-3
Save As...
Save in:
hankin
History
Desktop
My Documents
My Computer
Local Disk
Compact Di
My Network F
desktop clutte
LASoutput.nc
Save as type:
All Files (*.*)
Save
Cancel
netCDF
VARIABLE : THETA
DATA SET : gps_01
FILENAME : gps-01-ocn
FILEPATH : http://ferret.pmel.
SUBSET : 12 points (TIME)
LONGITUDE: 158.3W(201.7)
LATITUDE : 1.1S
Z : 2000
158.3W
109
16-JAN-0235 12 / 2689: 31.01
16-FEB-0235 12 / 2690: 31.45
16-MAR-0235 12 / 2691: 31.69
16-APR-0235 12 / 2692: 32.23
16-MAY-0235 12 / 2693: 32.41
16-JUN-0235 12 / 2694: 32.22
16-JUL-0235 12 / 2695: 32.52
16-AUG-0235 12 / 2696: 31.25
16-SEP-0235 12 / 2697: 31.45
16-OCT-0235 12 / 2698: 31.31
16-NOV-0235 12 / 2699: 32.58
16-DEC-0235 12 / 2700: 32.18

Data types and storage

- netcdf

netCDF files

- **self describing**
  - (ideally) all info contained within file
  - no external information needed to determine file contents
- **portable** [machine independent]

- **software** [source Unidata]
  - designed for generality, not high performance
  - parallel reads are possible; no parallel writes [version 3.6]

- **variable model: simple array oriented**
  - (may) have descriptive info [meta data]
  - limited data structures
    - no ragged arrays; no record/nested structures
  - only one "unlimited" (record) dimension [version 3.6]

Examining a netCDF file

- ncdump file_name | less
  - dumps the entire contents of a file
- ncdump -h file_name | less
  - dumps the header info
  - NCL equivalent: **print** (f)
- ncdump -v U file_name | less
  - NCL equivalent: **print** (U)
- Note: ncdump is a Unidata utility
  - not a netCDF Operator (NCO)
  - not associated with NCL

- **ncview** to visualize file contents [COARDS]

- **ncl_filedump** file_name [more general]
  - netCDF, GRIB, HDF, HDF-EOS

Parts of netCDF file

ncdump -h 1999.nc

DIMENSIONS:

```
dimensions:
   lat = 64 ;
   lon = 128 ;
   time = 12 ;
```

FILE ATTRIBUTES:

```
global attributes:
   :title = “Temp: 1999" ;
   :source = “NCAR” ;
   :conventions = "None" ;
```

VARIABLES:
Names , Attributes, Coordinates

```
variables:
  float lat(lat) ;
    lat:long_name = "latitude" ;
    lat:units = "degrees_north" ;
  float lon(lon) ;
    lon:long_name = "longitude" ;
    lon:units = "degrees_east" ;
  int time(time) ;
    time:long_name = "time" ;
    time:units = "Month of Year" ;
  float T(time, lat, lon) ;
   T:long_name = “Temperature”;
   T:units = “C" ;
   T:missing_value = 1.e+20f ;
   T:_FillValue = 1.e+20f
```

exercise: ncdump –h UV300.nc | less

netCDF [NCL] Variable model

X

Scalar
or
Array

attributes

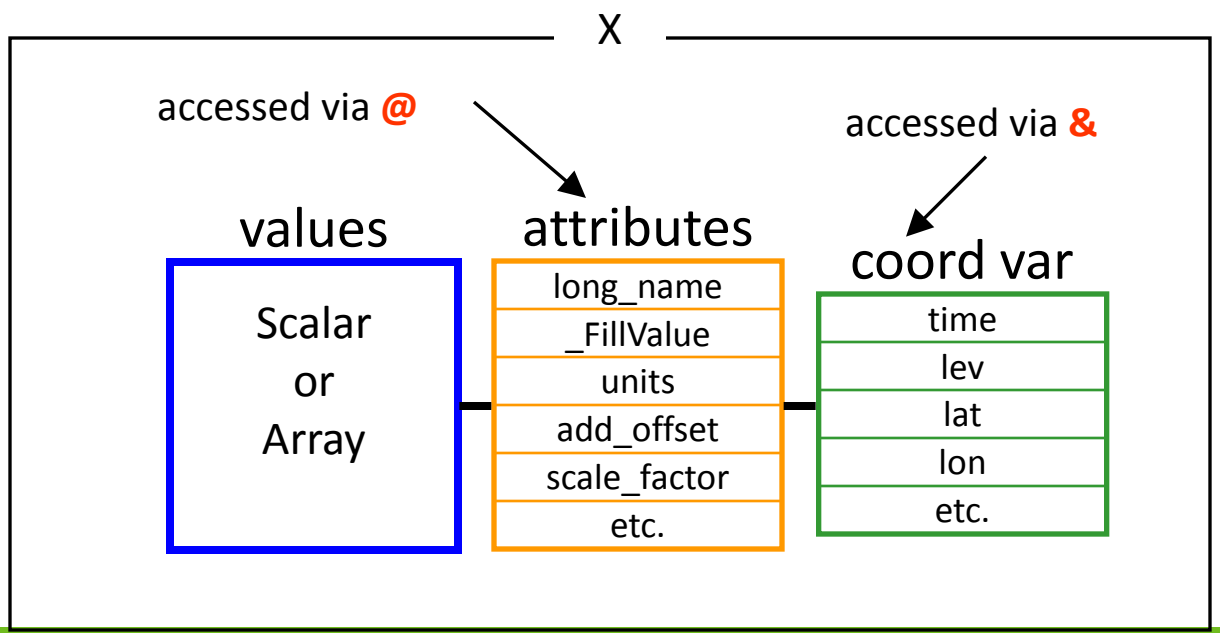
long_name
_FillValue
units
add_offset
scale_factor
etc.

coordinates

time
lev
lat
lon
etc.

```
f = addfile("foo.nc","r")    ;
grb/hdf
x = f->X
```

NCL reads the scalar/array, attributes, and coordinate variables as an object



netCDF Version 3.6

- current version 3.6 [released Feb 2005]
  - **L**arge **F**ile **S**upport [LFS] available
    - Files > 2GB, though any one variable can not > 2GB
    - All 64-bit architectures have LFS
    - Some 32-bit OS have LFS, **including linux**
    - Portability can be issue if others do not have LFS

netCDF Version 4.0 [Oct

- **netCDF API implemeneted on top of HDF5**
  - will write HDF5 but use netCDF API
- **many new capabilities**
  - backward compatible
  - compression
  - multiple unlimited dimensions
  - parallel IO
  - multi-dimensional coordinate variables [? V4.1]
  - hierarchial grouping of data
  - user data types

☺ NCL developers working with Unidata ☺

netCDF Info

- URLs
  - http://www.unidata.ucar.edu/software/netcdf
    - What's New
  - http://www.unidata.ucar.edu/software/netcdf/docs/**BestPractices**.html
    - Good info to know
  - http://www.unidata.ucar.edu/software/netcdf/**netcdf-4/**
    - Learn about netCDF-4

Detailed Look netCDF Variable (ncl)

```
ncl <return>                                  ; interactive mode
ncl 0 > f = addfile ("UV300.nc", "r")         ; open file
ncl 1 > u = f->U                              ; import STRUCTURE
ncl 2 > printVarSummary (u)                   ; overview of variable
```

```
Variable:  u
Type: float
Total Size:  65536 bytes
             16384 values
Number of Dimensions:  3
Dimensions and Sizes:   [time | 2] x  [lat | 64] x [lon | 128]
Coordinates:
             time:  [ 1 .. 7 ]
             lat:  [ -87.8638 ..  87.8638 ]
             lon: [ 0 .. 357.185]
Number of Attributes: 5
    _FillValue :        1e36
    units :             m/s
    long_name  :        Zonal Wind Component
    short_name :        U
    missing_value :     1e36
```

Classic netCDF Variable Model

NCL syntax/funcs

query

use

modify

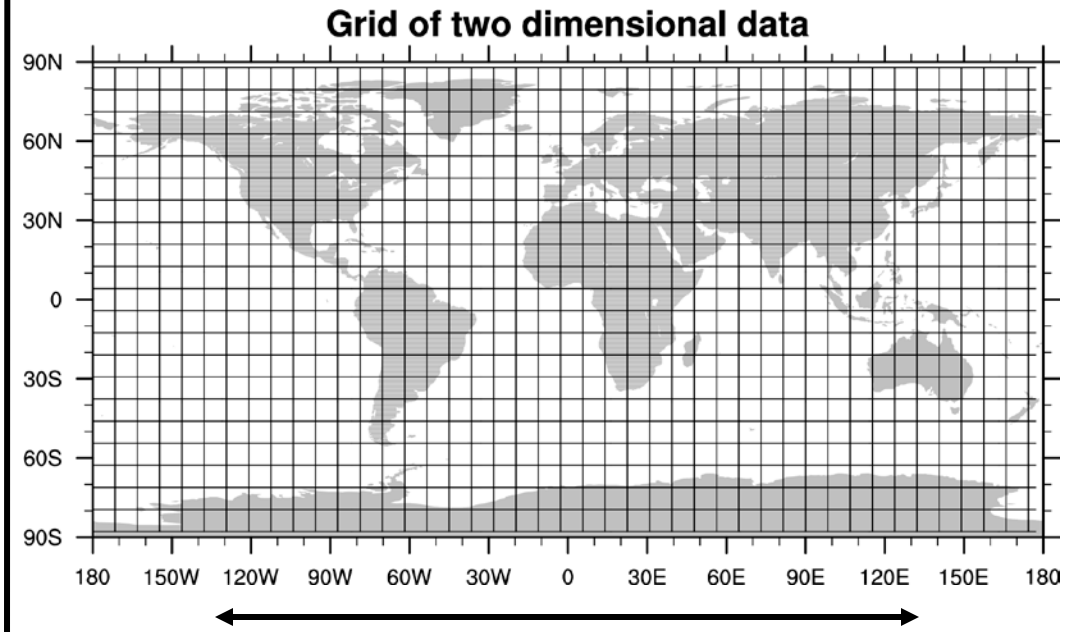
add

any aspect of data object

Picture: 2D netCDF Variable Model

coordinate variables

Latitude coordinate variable (1D, **&**)



Longitude coordinate variable (1D, **&**)

attributes **@**:

- long_name
- units

NCL is **NOT LIMITED** to netCDF conforming variables

- eg: 2D coordinate arrays (curvilinear coords)

UNLIMITED dimension

- **special dimension**
  - essentially a "record" dimension
  - time dimension is most frequently "unlimited"
  - used by the NCO to concatenate files
  - **no** special meaning to NCL
- **when creating output file in NCL (optional)**
  - **filedimdef** (outputfile, "time", -1, True)
- **example:** ncdump -h T2m_ud.nc

```
netcdf T2m_ud {
dimensions:
    time = UNLIMITED  ; // (204 currently)
    lat = 94 ;
    lon = 192 ;
    lev = 18}
```

Reading data

- Visualization
  - NCVIEW
  - FERRET
  - R
  - PANOPLY
  - …

Data visualization: Panoply

Sources

Create New Plot | Open Dataset | Remove | Remove All | Hide Info

Datasets | Catalogs | Bookmarks

Name	Long Name	Type
cruncep_tair_1901-2010_m...	cruncep_tair_1901-2010_monthly.nc	Local File
lat	latitude	—
lat_bnds	lat_bnds	—
lon	longitude	—
lon_bnds	lon_bnds	—
mask	mask	[lon][lat]
tair	Temperature	[lon][lat][time]
time	time	—
time_bnds	time_bnds	—

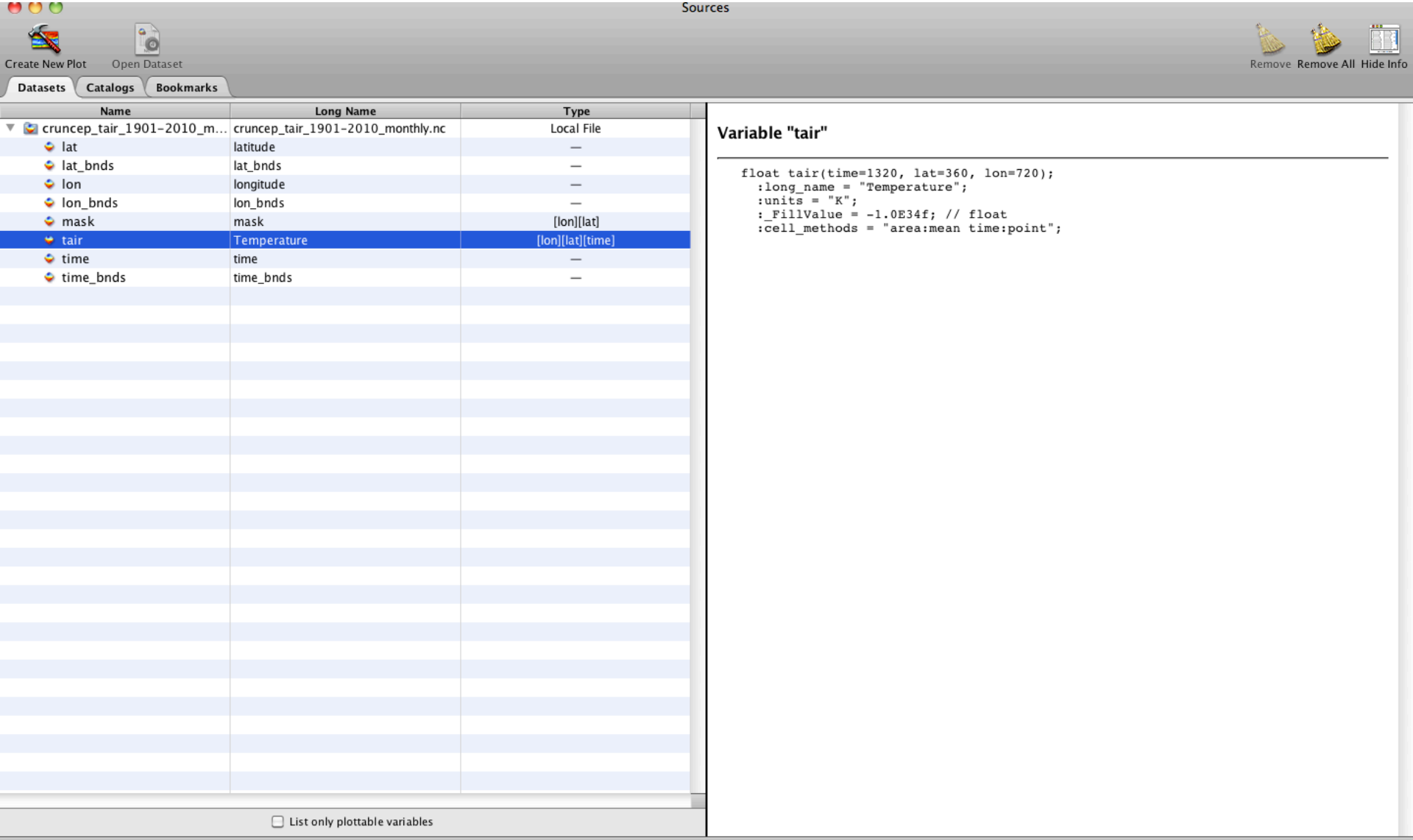
List only plottable variables

File "cruncep_tair_1901-2010_monthly.nc"

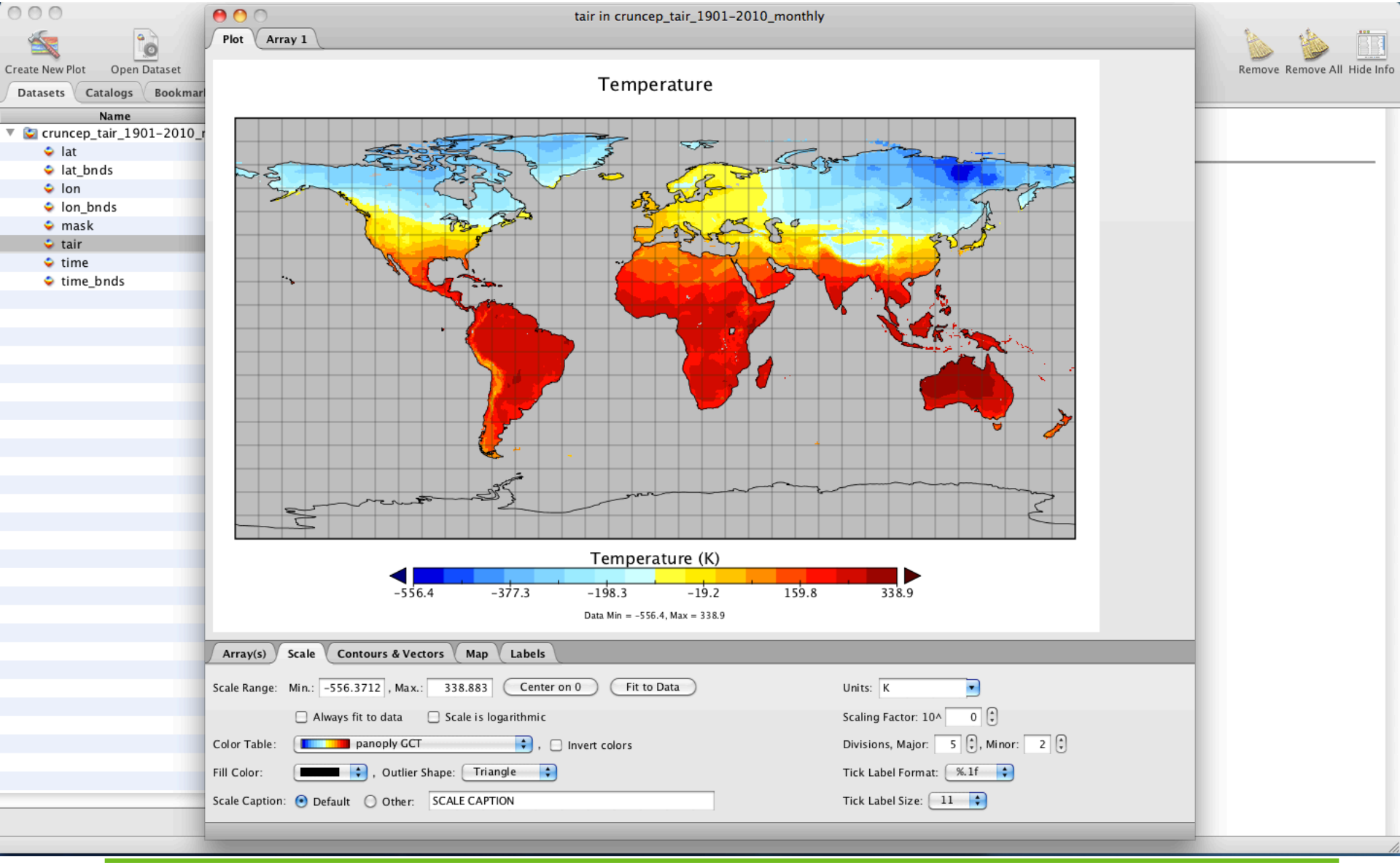
```
netcdf file:/Users/poulter/Desktop/cruncep_tair_1901-2010_monthly.nc {
 dimensions:
   lon = 720;
   nb2 = 2;
   lat = 360;
   time = UNLIMITED;   // (1320 currently)
 variables:
   double lon_bnds(lon=720, nb2=2);
   double lat_bnds(lat=360, nb2=2);
   double time_bnds(time=1320, nb2=2);
     :units = "days since 1700-01-01 00:00:00";
     :calendar = "proleptic_gregorian";
   float tair(time=1320, lat=360, lon=720);
     :long_name = "Temperature";
     :units = "K";
     :_FillValue = -1.0E34f; // float
     :cell_methods = "area:mean time:point";
   int mask(lat=360, lon=720);
   double lon(lon=720);
     :long_name = "longitude";
     :units = "degrees_east";
     :standard_name = "longitude";
     :axis = "X";
     :bounds = "lon_bnds";
     :_CoordinateAxisType = "Lon";
   double lat(lat=360);
     :long_name = "latitude";
     :units = "degrees_north";
     :standard_name = "latitude";
     :axis = "Y";
     :bounds = "lat_bnds";
     :_CoordinateAxisType = "Lat";
   double time(time=1320);
     :bounds = "time_bnds";
     :units = "days since 1700-01-01 00:00:00";
     :calendar = "proleptic_gregorian";
     :_CoordinateAxisType = "Time";

 :CDI = "Climate Data Interface version 1.5.0 (http://code.zmaw.de/projects/cdi)";
 :Conventions = "CF-1.4";
 :history = "Mon Nov 21 14:27:29 2011: cdo mergetime tmptair2.nc tmptair1.nc /home/orch
 :file_name = "out/cru9_tair_1901_2010_2D.nc";
 :model_name = "STOMATE-SECHIBA-LPJ";
 :CDO = "Climate Data Operators version 1.5.0 (http://code.zmaw.de/projects/cdo)";
}
```

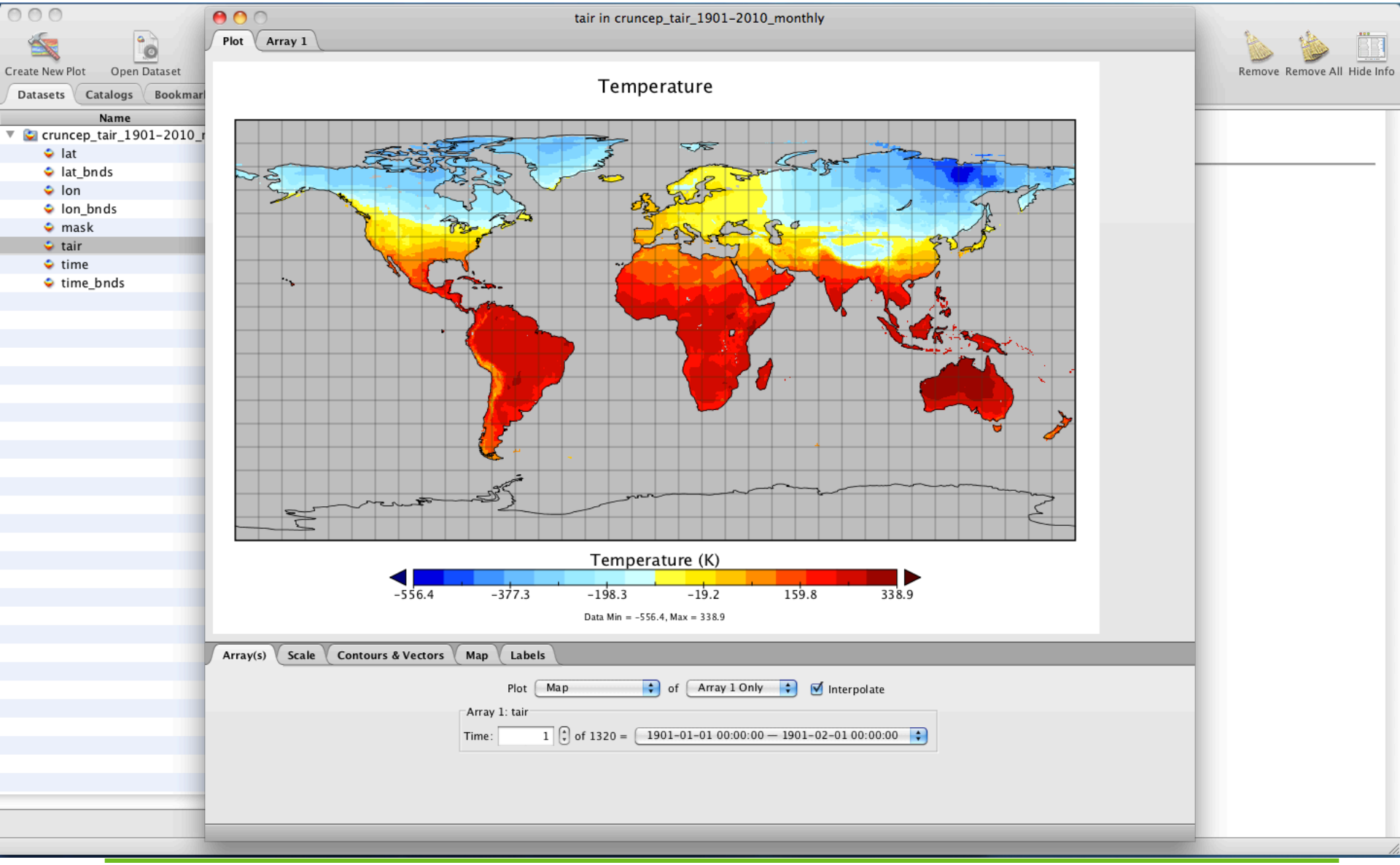
Data visualization: Panoply



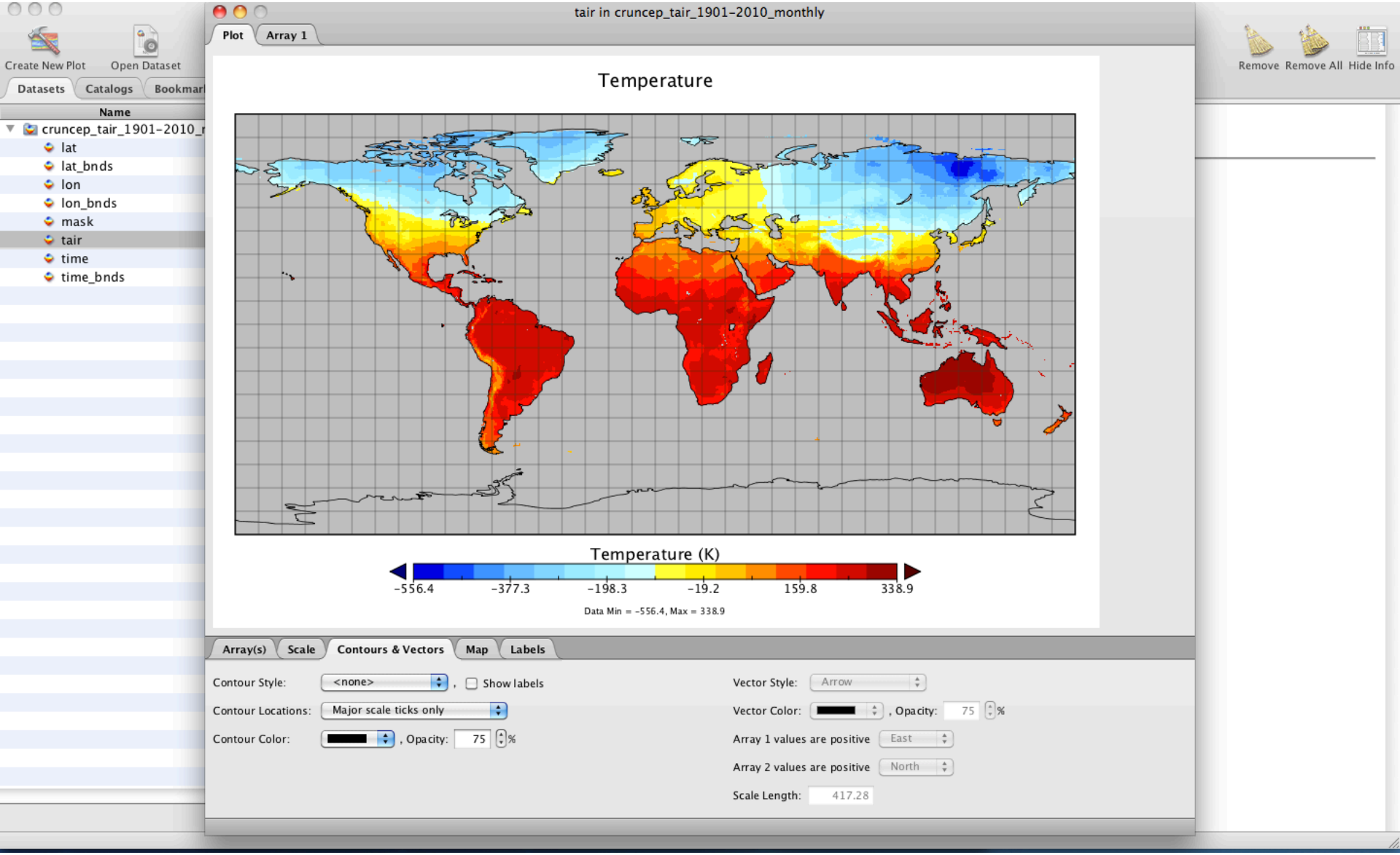
Data visualization: Panoply



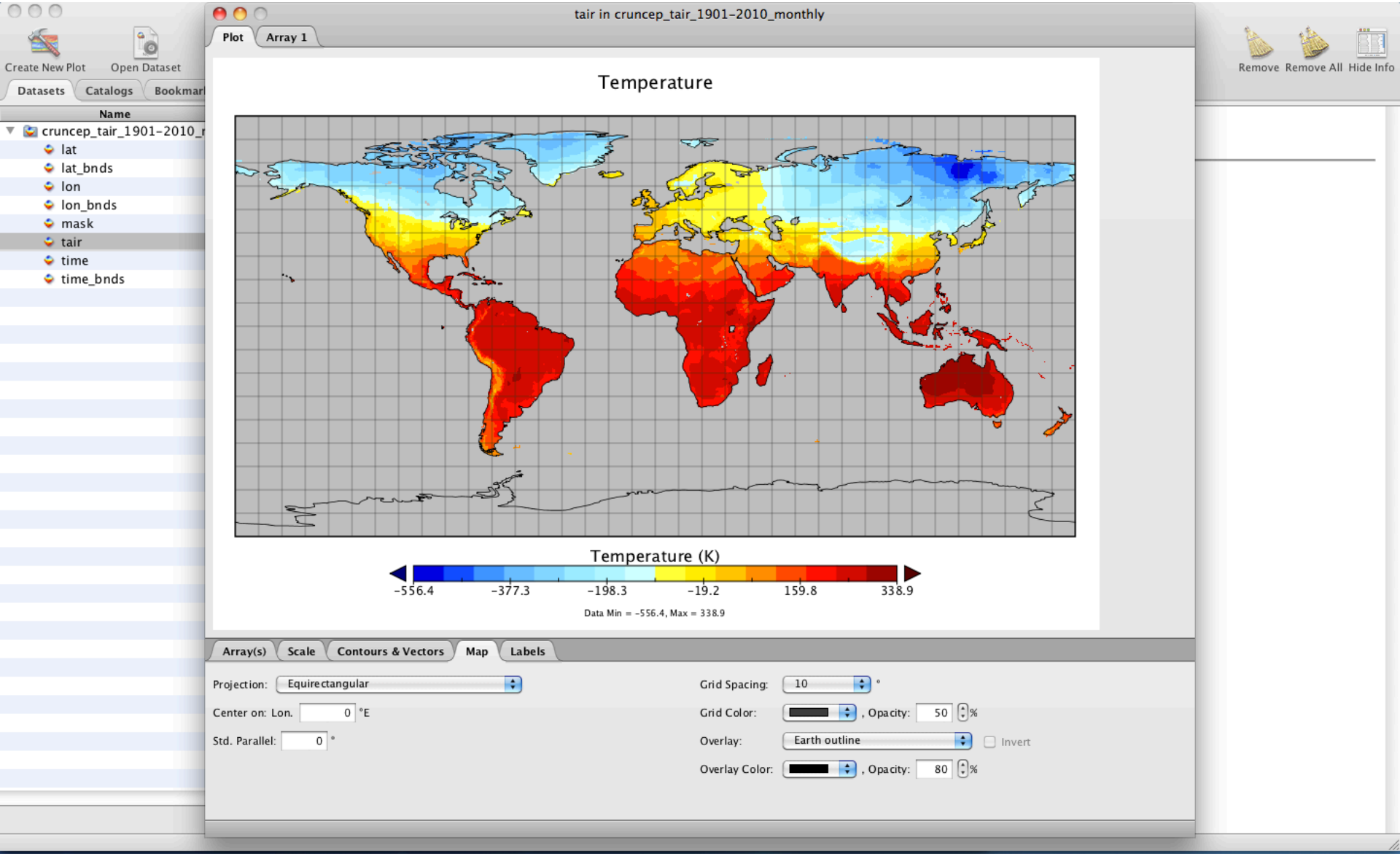
Data visualization: Panoply

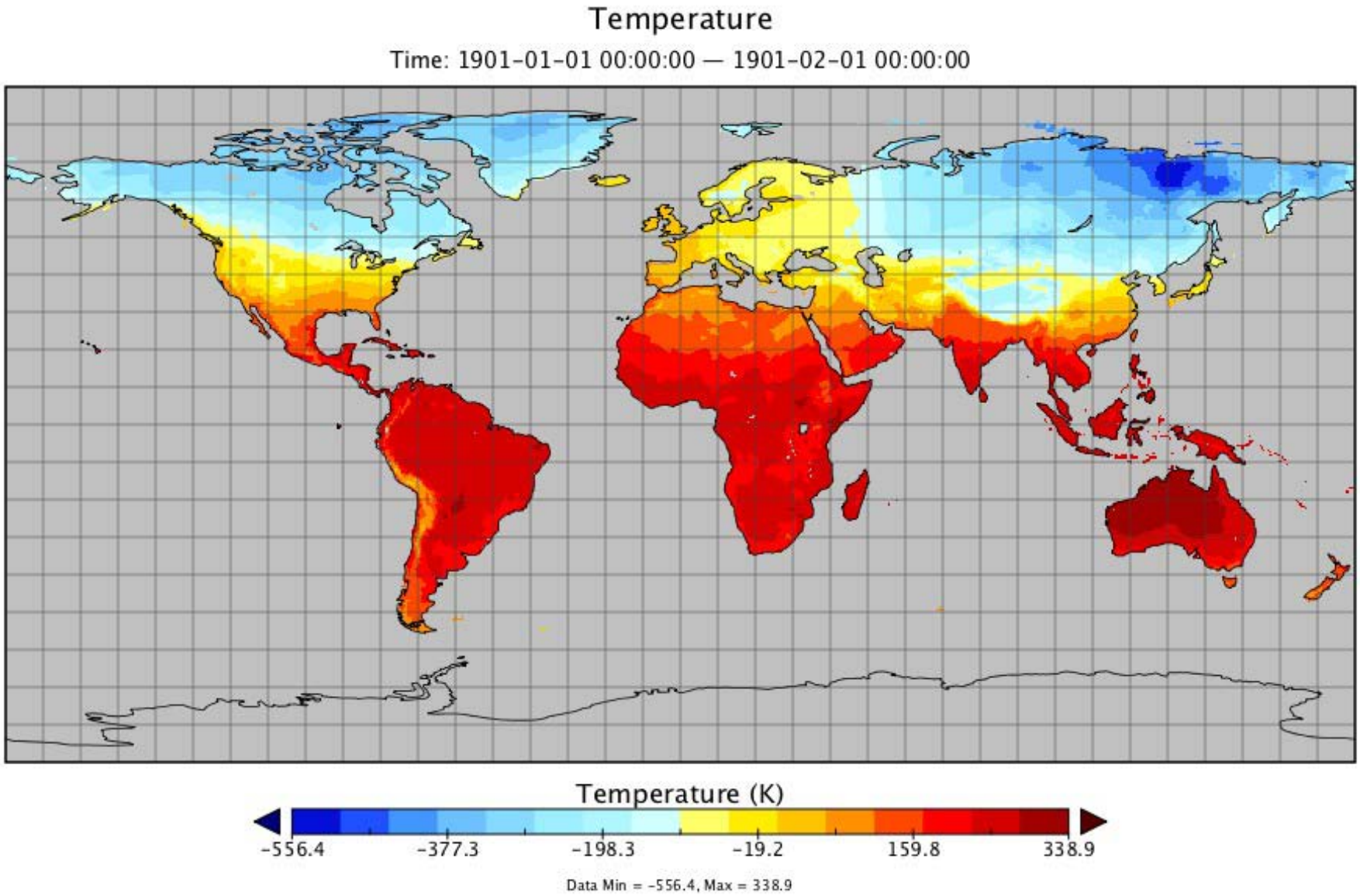


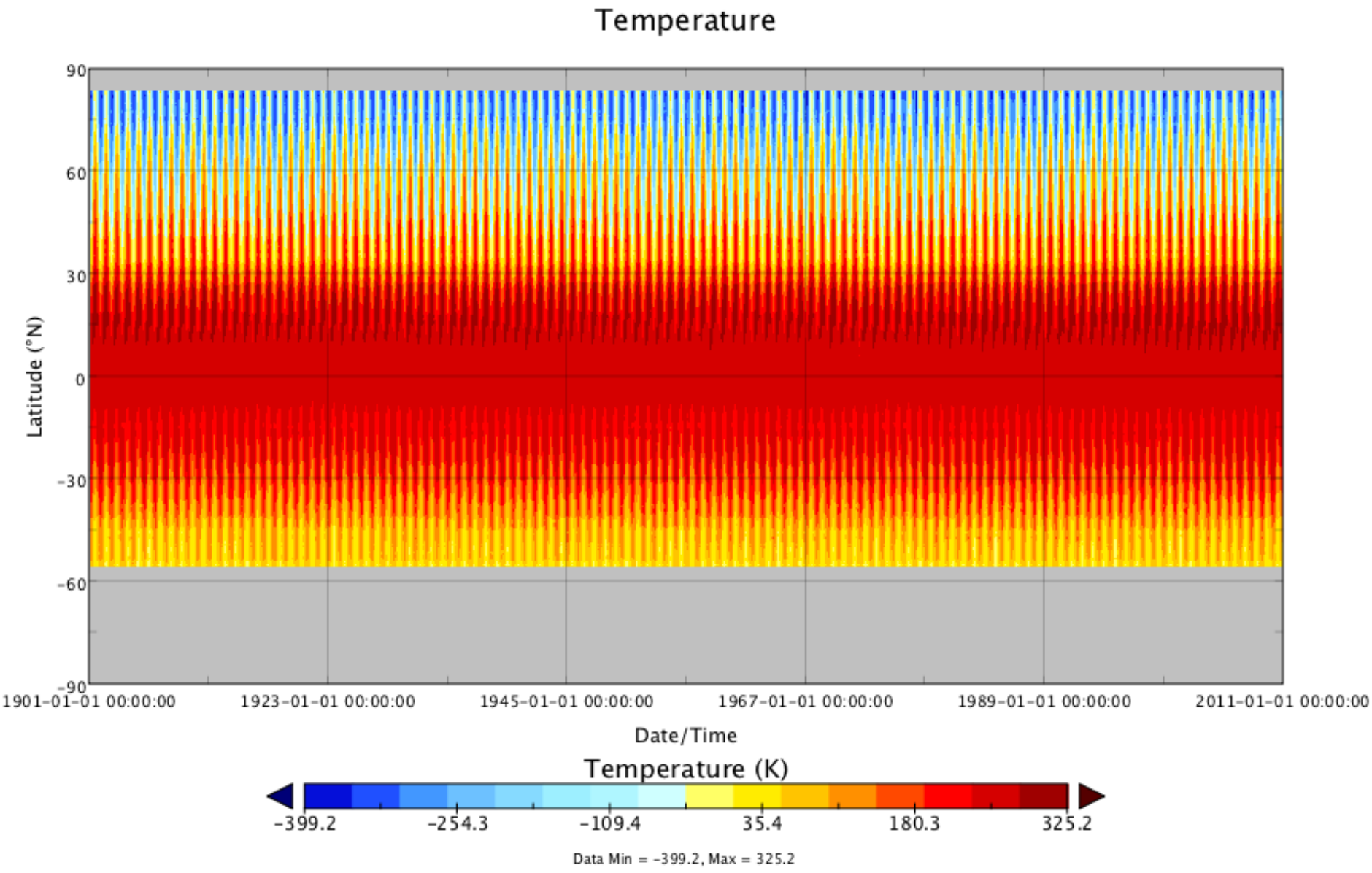
Data visualization: Panoply



Data visualization: Panoply




Temperature
Time: 1901-01-01 00:00:00 — 1901-02-01 00:00:00
Temperature (K)
-556.4
-377.3
-198.3
-19.2
159.8
338.9
Data Min = -556.4, Max = 338.9


Temperature
90
60
30
0
-30
-60
-90
Latitude (°N)
1901-01-01 00:00:00
1923-01-01 00:00:00
1945-01-01 00:00:00
1967-01-01 00:00:00
1989-01-01 00:00:00
2011-01-01 00:00:00
Date/Time
Temperature (K)
-399.2
-254.3
-109.4
35.4
180.3
325.2
Data Min = -399.2, Max = 325.2

Reading data

- Analysis
  - NCL
  - C, Fortran…
  - R
  - CDO

R: analysis

Advantages:
- Free
- Large user community
- Statistics
- Data processing
- Visualization

Data type:
- Ascii
- Binary
- Ncdf
- Shapefiles
- rasters

Library based:
- ncdf
- raster
- Maptools
- sp
- fields

R: analysis

```
#Libraries
library(ncdf)
library(sp)
library(maptools)

fdir.vpd <- "/Users/poulter/Desktop/"
fpath.sites <- "/Users/poulter/BenWork/Research/WUE/data/"

#Read sites
sites.df <- read.table(paste(fpath.sites, "isonet.metadata.txt", sep=""), header=T)
sites.shp <- SpatialPointsDataFrame(data.frame(x=sites.df$long, y=sites.df$lat), data.frame(z=1:nrow(sites.df)))

#Read VPD
vpd.file <- open.ncdf(paste(fdir.vpd, "vpd.nc", sep=""))
VPDlat <- get.var.ncdf(vpd.file, "lat")
VPDlon <- get.var.ncdf(vpd.file, "lon")

#Create VPD spdf
VPDlatmat <- matrix(VPDlat, length(VPDlon), length(VPDlat), byrow=T)
VPDlonmat <- matrix(VPDlon, length(VPDlon), length(VPDlat), byrow=F)
VPDdf <- data.frame(x=as.vector(VPDlonmat), y=as.vector(VPDlatmat), z=rep(1,length(as.vector(VPDlatmat))))
coordinates(VPDdf) <- ~x+y
gridded(VPDdf) <- TRUE

#Sample VPD
VPDsites <- overlay(VPDdf, sites.shp)

#Get site VPD
site.vpd <- matrix(0,12*110,nrow(sites.df))
for(m in 1:(12*110)){
        site.vpd[m,] <- get.var.ncdf(vpd.file, "vpd", start=c(1,1,m), count=c(-1,-1,1))[VPDsites]
}
```

R: animations

CDO

- Suite of Command Line Operators
- Files: netCDF/GRIB/SERVICE/EXTRA/IEG
- Stand alone operators; results can be piped
- Very efficient for specific tasks
- Available for various computer architectures:
  - Solaris, AIX, Linux, Mac

CDO

```
#!/bin/sh
#Jan 2011
#Calculate climate trends
#Run on obelix

#Directory
fIn=/home/orchidee03/bpoulter/MsTMIP/data/
fOut=/home/orchidee03/bpoulter/WUE/

#Variables
rain=$fdirIn'daily/cruncep_rain_1901-2010_monthly.nc’

##########################################
#Trend in precip
#Calculate RAIN trends
cdo splitseas $rain $fOut'rain_1901-2009_season_'

#Calculate seasonal and annual means
cdo yearsum $rain $fOut'rain_1901-2009_annual_sum.nc'
cdo yearsum $fOut'rain_1901-2009_season_JJA.nc' $fOut'rain_1901-2009_season_JJA_sum.nc'

#Calculate RAIN trends
cdo trend $fOut'rain_1901-2009_annual_sum.nc' $fOut'rain_1901-2009_annual_interc.nc' $fOut'rain_1901-2009_annual_slope.nc'
cdo trend $fOut'rain_1901-2009_season_JJA_sum.nc' $fOut'rain_1901-2009_season_JJA_interc.nc' $fOut'rain_1901-2009_season_JJA_
```

Interpolation

- Spatial [rectilinear, curvilinear,..]; Uses SCRIP
- Vertical: hybrid to pressure, pres-to-pres/height
- Temporal: months to days to hours

Questions