NARCCAP and NetCDF

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Outline

- NARCCAP overview
- Program goals
- How NARCCAP data is used
- How netCDF supports NARCCAP
  - Geo-oriented data model
  - Integrated metadata
  - Ecosystem of smart software

NARCCAP

North **A**merican **R**egional **C**limate **C**hange **A**ssessment **P**rogram

International collaboration producing high-resolution climate change simulation data for North America

http://www.narccap.ucar.edu/

NARCCAP Team

Linda Mearns,NCAR
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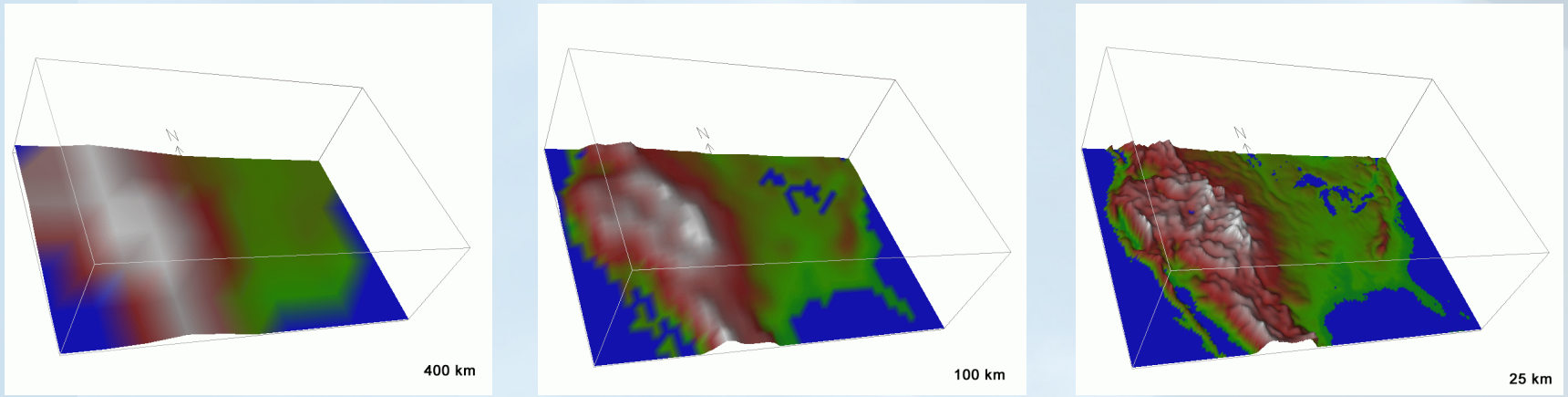
* Deceased June 2008

Regional Climate Problem



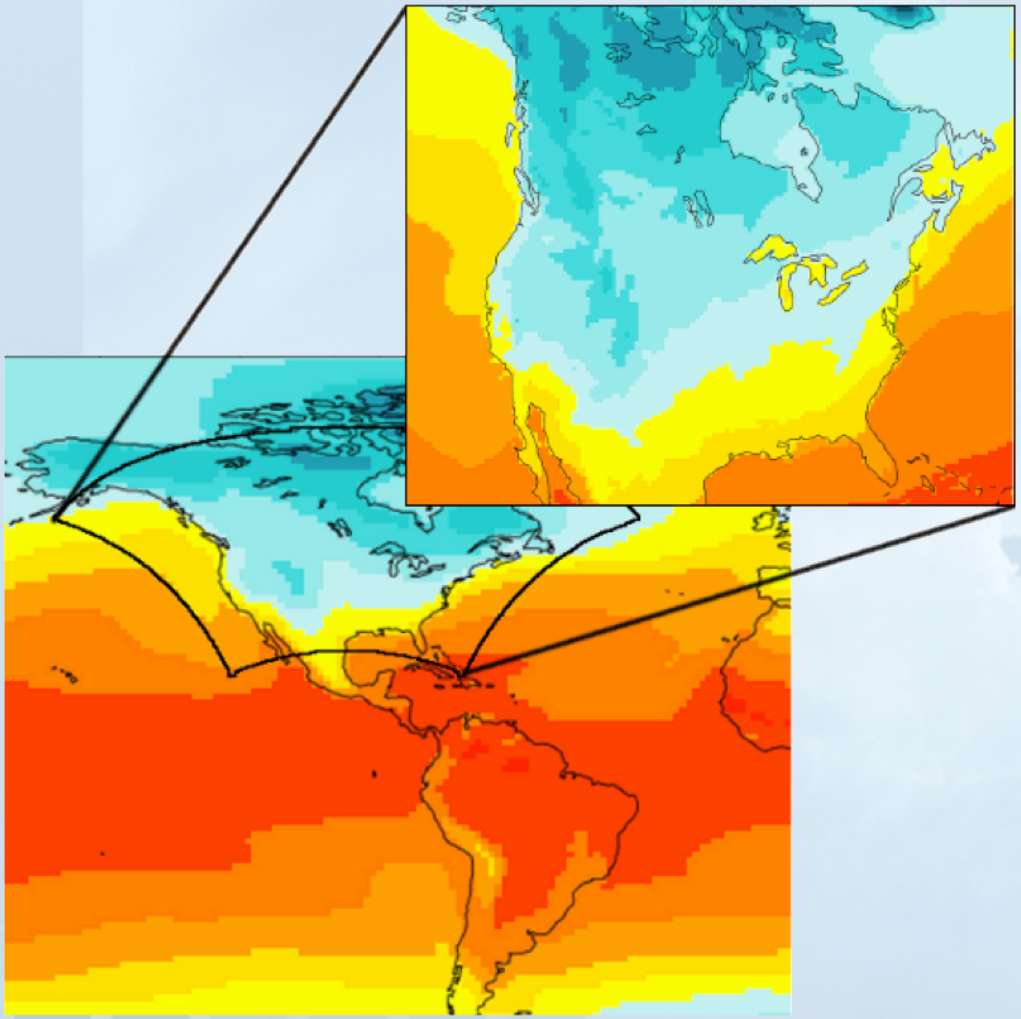
Regional modeling requires higher resolution

½ grid size → 8 × grid points

and 2 × timesteps

→ much greater computational requirements

Solution



Nest high-res regional models (RCMs) inside coarser global models (GCMs) over domain of interest

NARCCAP at a Glance

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- 6 RCMs…
- …nested in 4 GCMs…
  - 30 years current (1971-2000)
  - 30 years future (2041-2070)
- …and NCEP
  - 25 years historical (1980-2004)
- Plus 2 timeslice experiments

Experimental Design

		DRIVER				
		NCEP	CCSM	CGCM3	HadCM3	GFDL
MODEL	CRCM	X	X	X	—	—
	WRFG	X	X	X	—	—
	MM5I	X	X	—	X	—
	RCM3	X	—	X	—	X
	ECP2	X	—	—	X	X
	HRM3	X	—	—	X	X
	TMSL		X	—	—	X

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	MM5I	X	X	—	X	—
	RCM3	X	—	X	—	X
	ECP2	X	—	—	X	X
	HRM3	X	—	—	X	X
	TMSL		X	—	—	X

Phase I: NCEP

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- Drive RCMs with NCEP-2 Reanalysis
- Reanalysis: NWP with data assimilation
  - estimate of historic state of atmosphere
  - as close as we can come to “observations”
- 25 years: 1980-2004

Phase II: Downscaling GCMs

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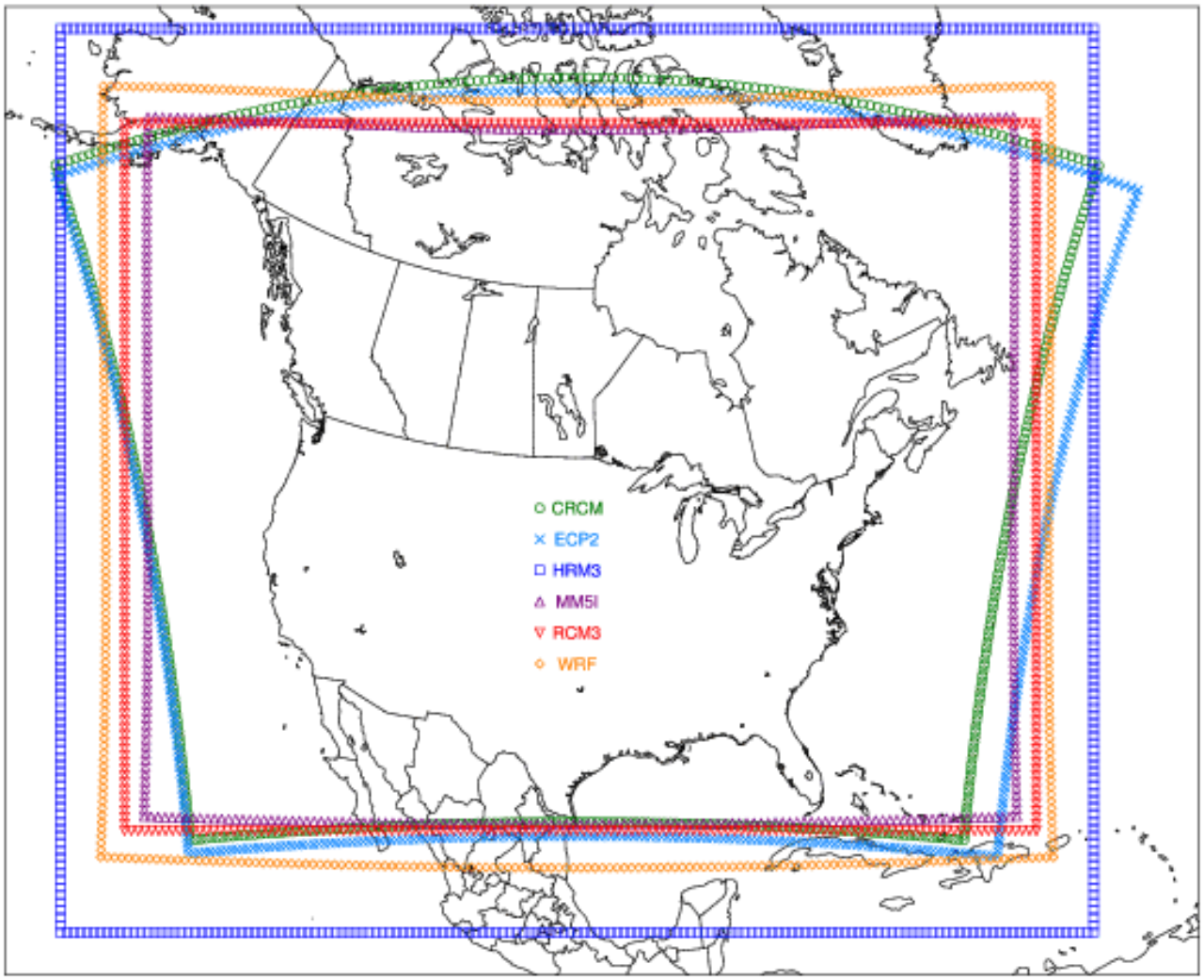
- 4 GCMs
  - CCSM
  - CGCM3
  - GFDL
  - HadCM3
- Two 30-year runs
  - current (1971-2000)
  - future (2041-2070)
- SRES A2 emissions scenario for future run

Timeslice Experiments

- Run GCM globally at ~50 km resolution but without the ocean model
- Historical run: Use observed SST
- Scenario run: Observed SST + delta based on corresponding coarse AOGCM
- 2 models: GFDL, CCSM (aka CAM3)
- Same time coverage as GCM-driven runs

NARCCAP RCM Domains



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Simulation Output

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- 40+ 2-D variables
- 7 3-D variables on 28 levels
- 3-hourly frequency
- Total data volume: ~40-60 TB
- CF-compliant netCDF
- Plus derived and summary variables, interpolations, etc.

Program Goals

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- Evaluate RCM/GCM performance and uncertainty (model analysis)
- Generate high-res climate change scenario data for impacts analysis
- Support further dynamical downscaling experiments

NARCCAP Users

- Data access is free (no-cost)
- Registration and statement of research required
- 600+ registered users

Model Analysis Users

- Comparisons
  - Between models
  - Between current and future
- Bias Evaluation, Process Analysis

"We will use NARCCAP precipitation and temperature data to check the outputs of different coupled combinations between global and regional models to try to answer the question: 'Among all combinations, which coupled models perform best throughout the southern U.S and northern Mexico?'"

Further Downscaling Users

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- Statistical
- Dynamical
- Uncertainty

  “NARCCAP output serves as boundary conditions with which to drive inner nests of the WRF model centered over southern Ontario. This allows climate simulations to be dynamically downscaled over the region of interest”

Mahoney, et al:

Dynamical downscaling of NARCCAP using WRF: High-resolution simulations of extreme precipitation events in three NARCCAP climate experiments

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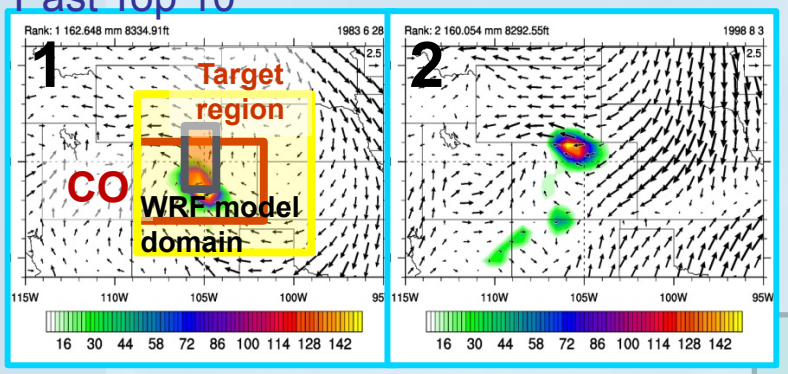
Past Top 10



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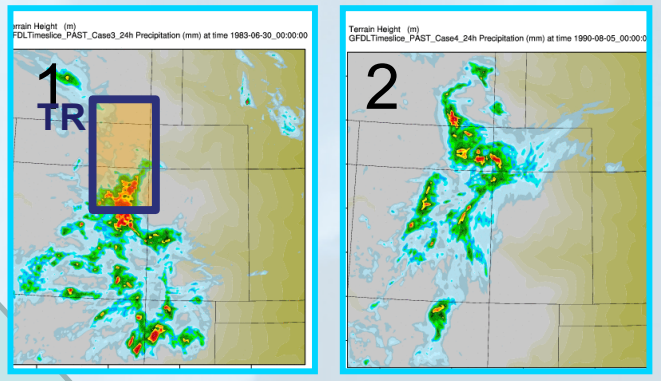

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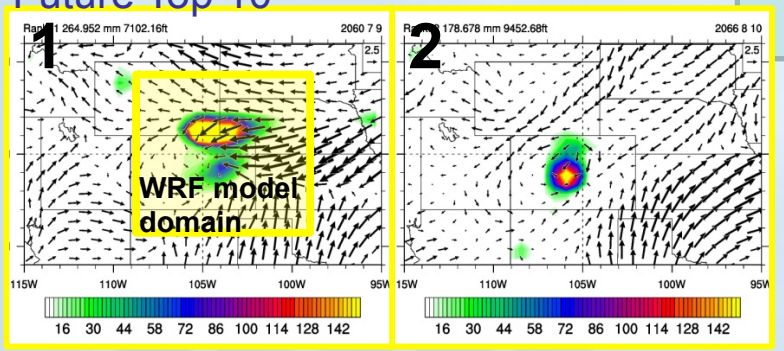
Future Top 10



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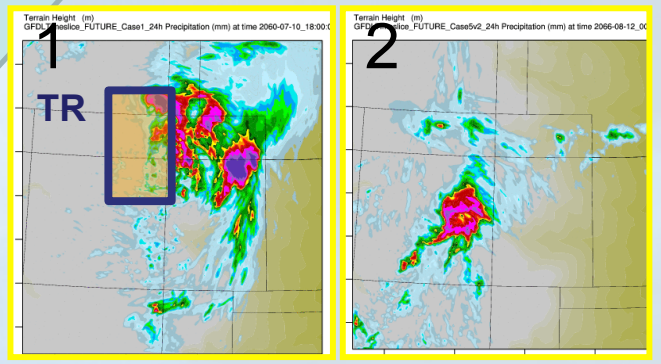

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Impacts Users

- Ecology, biology, adaptation, water management
- Plug into other models
- “Data from these climate change models or scenarios will be used as inputs to the SWAT model to forecast the impacts on water quantity and quality as well as crop and timber yields. We also will examine the likely changes in the ecosystem services based on forecasts of land use change in the region.”

Yongqiang Liu
Center for Forest Disturbance Science
USDA Forest Service, Athens, GA

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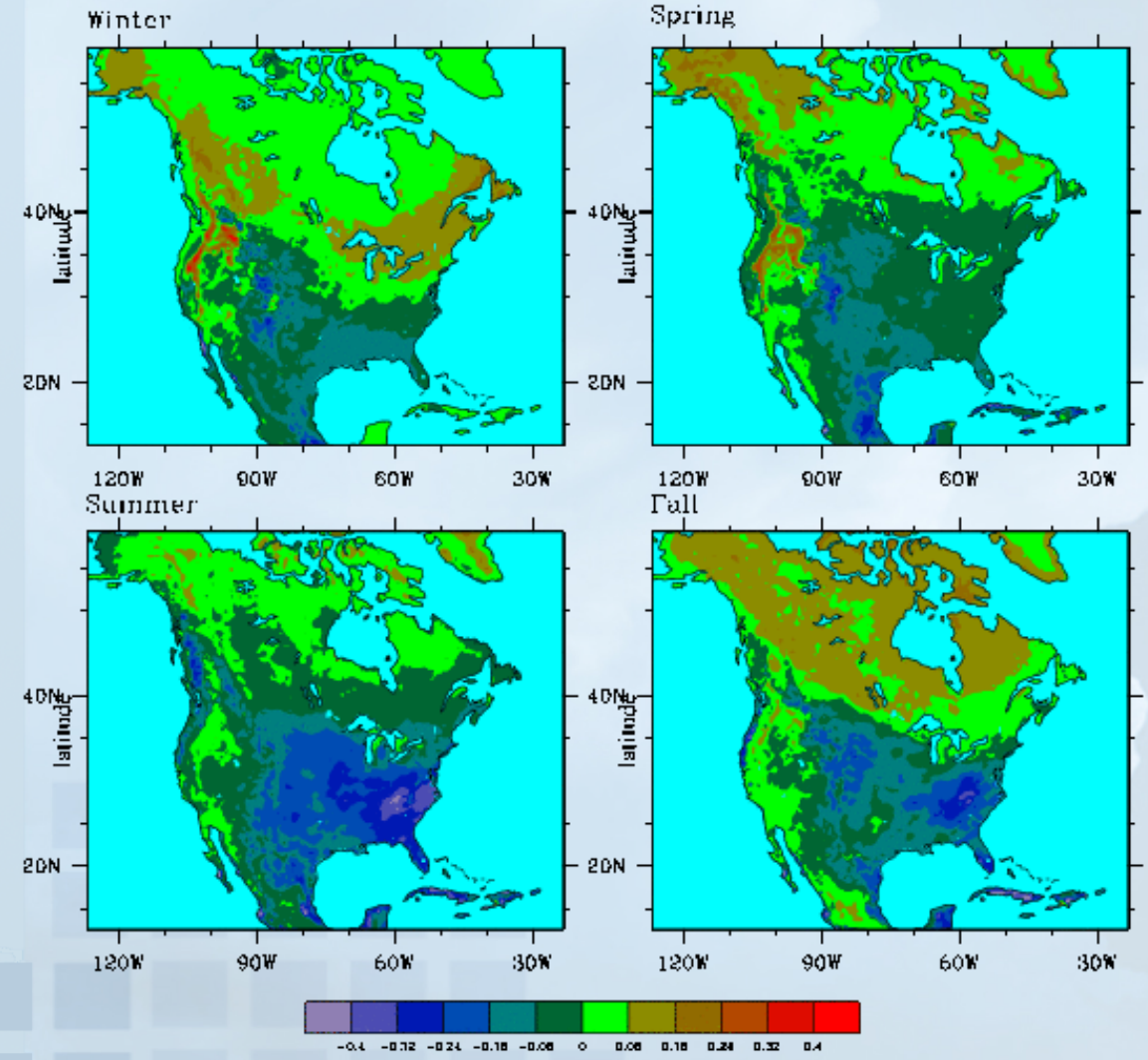

- Change in burning window for prescribed burning
- Available days for burns are reduced in most areas.
- Largest reduction in southeast by up to 30% during summer.
- Increase slightly in the west coast and inter-mountains.

What are the IMPACTS of Climate Change on Asphalt Concrete Pavements?

Jennifer Jacobs Ph.D., P.E. - University of New Hampshire

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Results:

Future Model versus Hindcast Model

Difference in Time to Distress (Future - Hindcast) in Months. Negative values indicate distress occurs earlier.

	Months to Failure	
	Secondary	Interstate
Berlin, NH		
CRCM+CGCM3	-24	-36
RCM3+CGCM3	-24	-26
RCM3+GFDL	-22	-36
Boston, MA		
CRCM+CGCM3	-58	-81
RCM3+CGCM3	-47	-62
RCM3+GFDL	-55	-59
Concord, NH		
CRCM+CGCM3	-33	-11
RCM3+CGCM3	-23	-2
RCM3+GFDL	-13	-21

The “Other” Category

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“I'm working on a regional downscaling effort at Oregon State University using RegCM3. I am having trouble formatting our NetCDF output to be CF-1.0 compliant so that it properly imports into ArcGIS. I would like access to the NARCCAP output so I can have a working datasets to compare to. I think we'd benefit by being able to compare our 50km North America runs to those on NARCCAP.”

Citation

- First NCAR dataset to receive a DOI
- Why one DOI?
- Challenge of finding NARCCAP papers – register, but once gotten can't track w/o citations.

NARCCAP & NetCDF

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- NARCCAP data is stored & distributed in CF-compliant netCDF format
- Archive based on PCMDI / IPCC AR4
  - Grouped by model, run, data structure, use
  - 5 years, 1 variable per file
- Quality-checked and corrected

CF Metadata Standard

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- Set of rules about data naming conventions and metadata contents
- Extensive and detailed
- Resolves many representation questions
- NARCCAP data follows v1.0

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How Does NARCCAP Benefit from Using NetCDF?

NetCDF makes it easier for users, especially non-climate scientists, to use the data. Less attention needed for handling the data means more available for thinking about what the data means.

GCM-Oriented Data Model

- Designed for climate model output
- Close match to native representation
- Data is located in time and space
- Common format for many models
- Standard: used by CMIP and other important archives

Integrated Metadata

- Self-describing
- Data can’t be separated from metadata
- Provenance-tracking via history attribute
- Support for discovery and automation
- Allows work at a higher level of abstraction
- Enables smart software

Smart Tool: ncview

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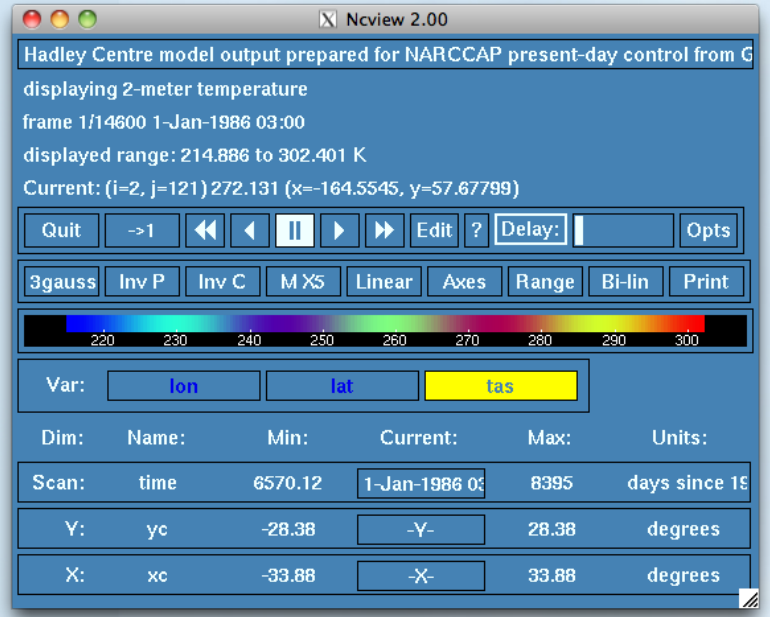

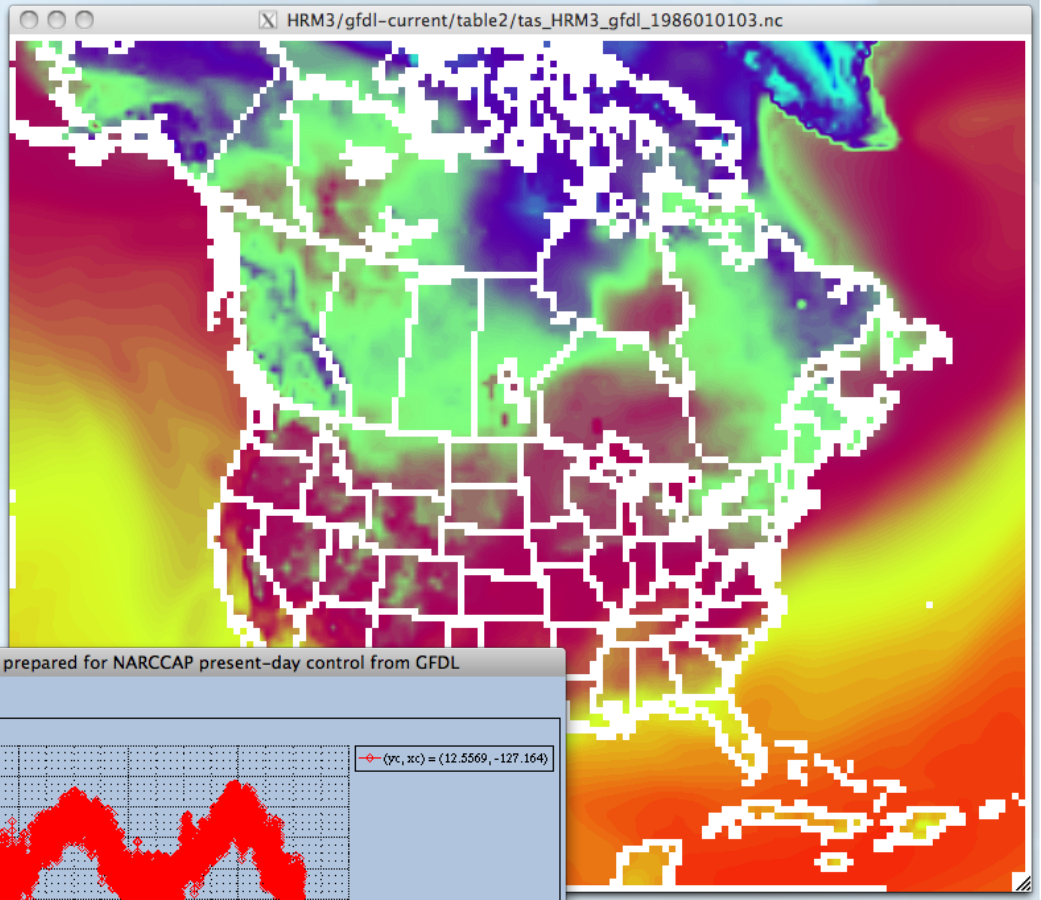

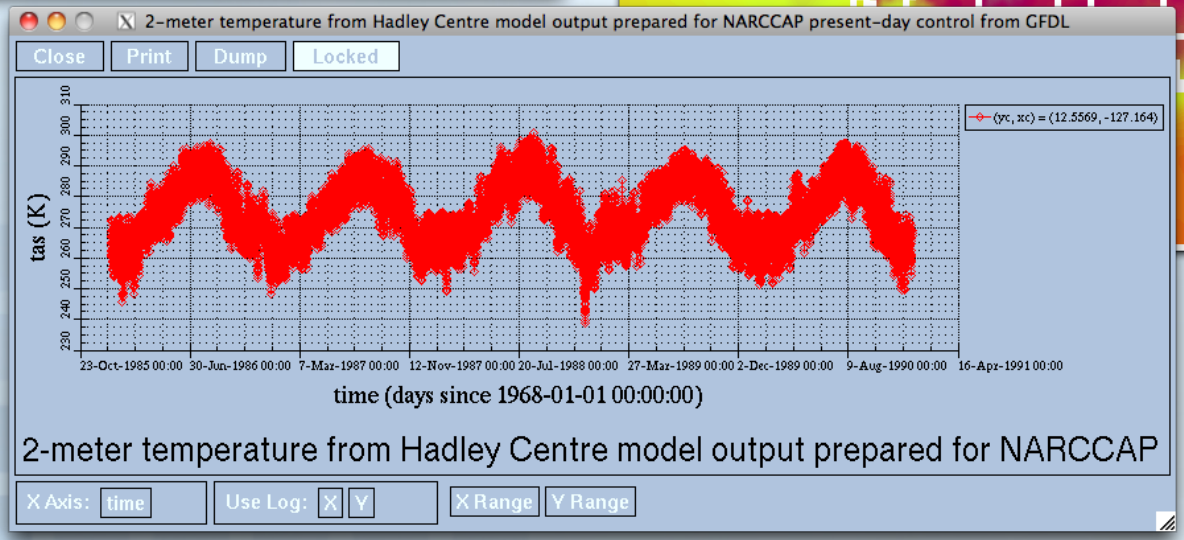

Smart Software Ecosystem

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Unidata's netcdf software page lists 100+ entries. Smart software examples:

- Basic data inspection: ncview
- Analysis/visualization language: NCL
- High-level climate analysis: cdo
- All-in one interaction environment: CDAT
- Publishing & distribution: ESG

GIS Interoperability

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- Impacts researchers use GIS heavily
- If netCDF file is CF-compliant, can import data directly into ArcMAP 9+ using the multi-dimension toolbox
- Caveats:
  - Stringent CF-adherence needed
  - Do data transformation outside Arc

databasin.org

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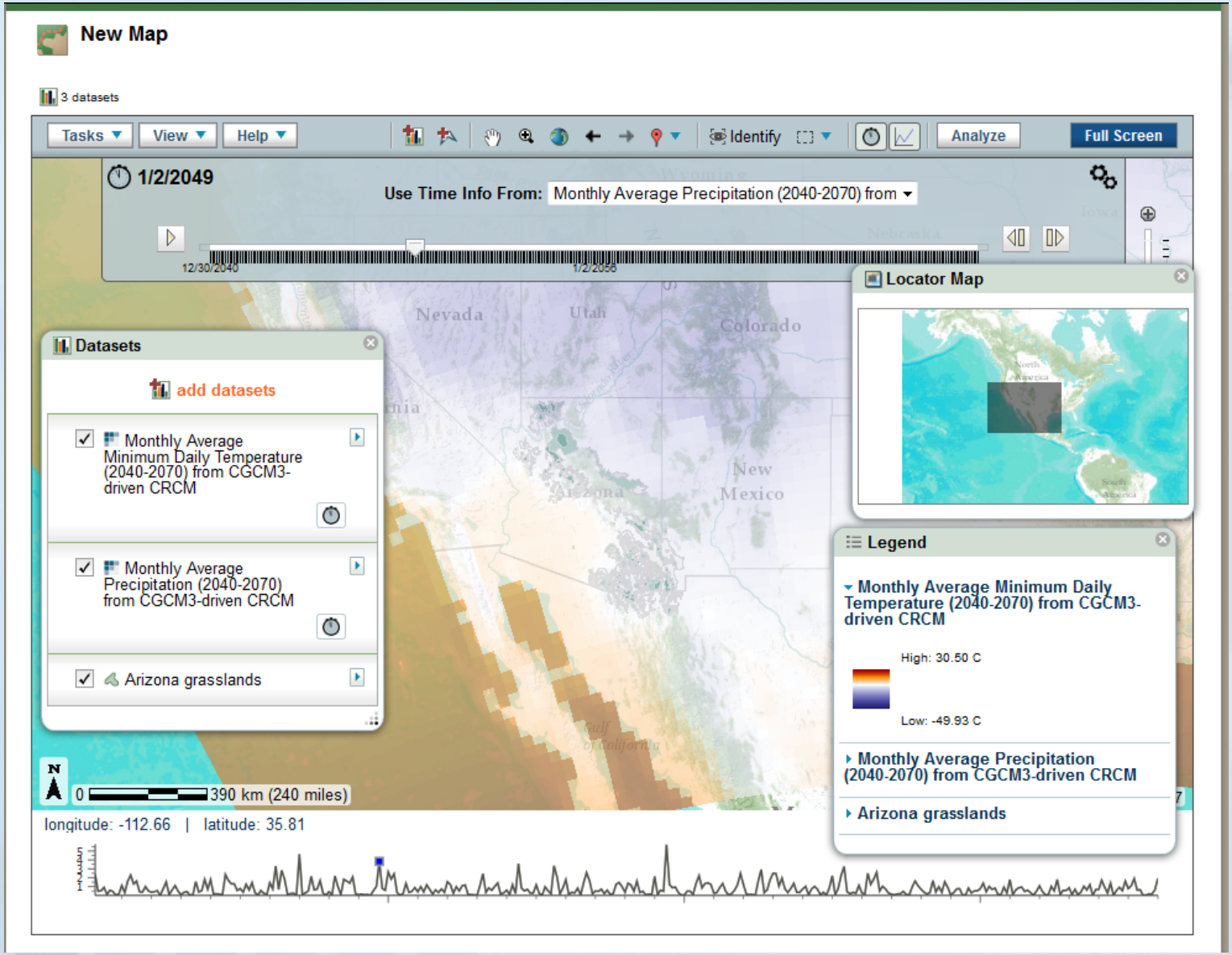

Conclusion

Using netCDF benefits NARCCAP

- Makes data more accessible
- Aligns archive with community standards
- Empowers users by allowing them to:
  - work at a higher level of abstraction
  - using more powerful tools
  - without worrying about details of file formatting and data representation

A (Possibly) Controversial Recommendation:

ASSUME LFS

(Large File Support)