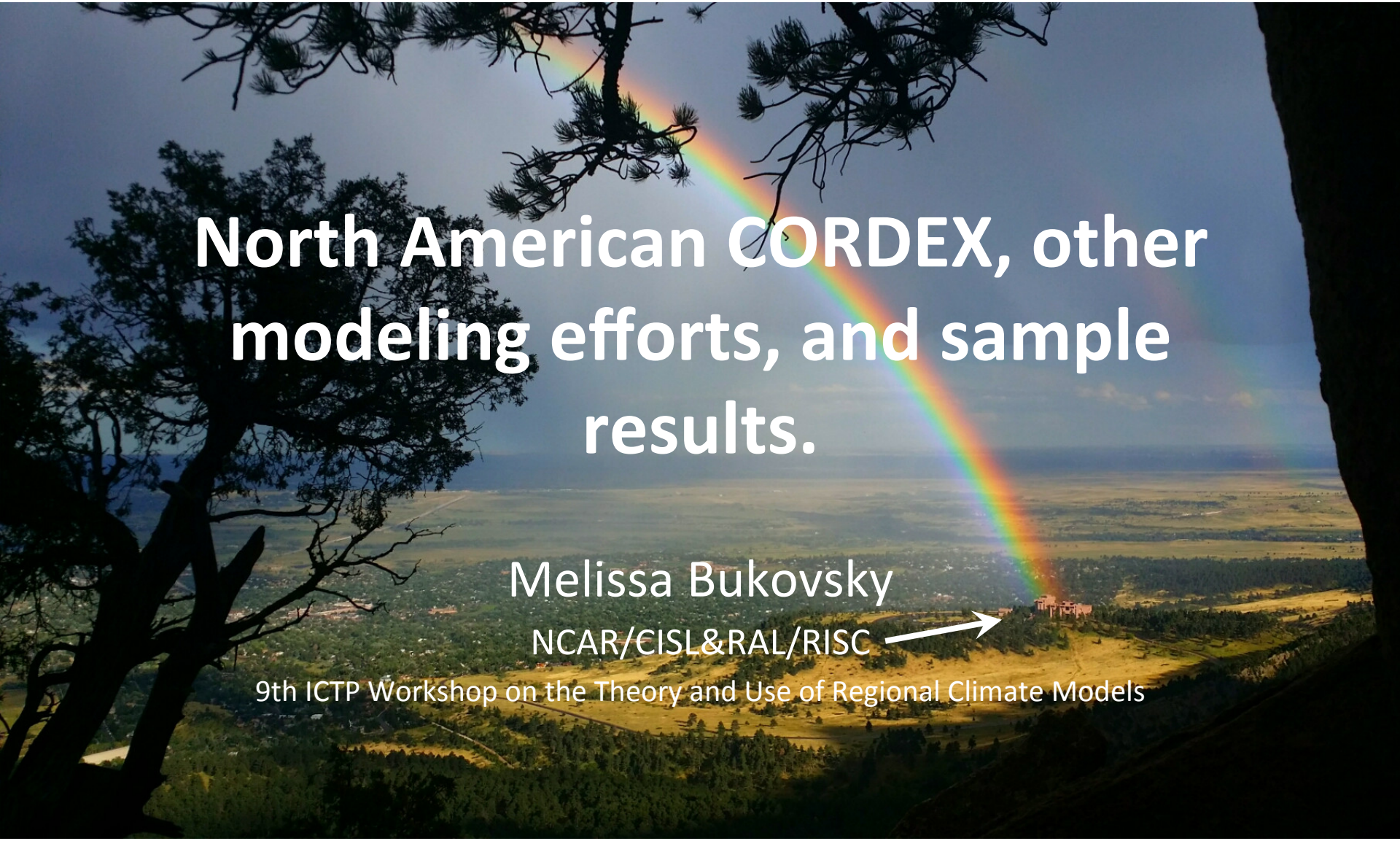


North American CORDEX, other modeling efforts, and sample results.

Melissa Bukovsky

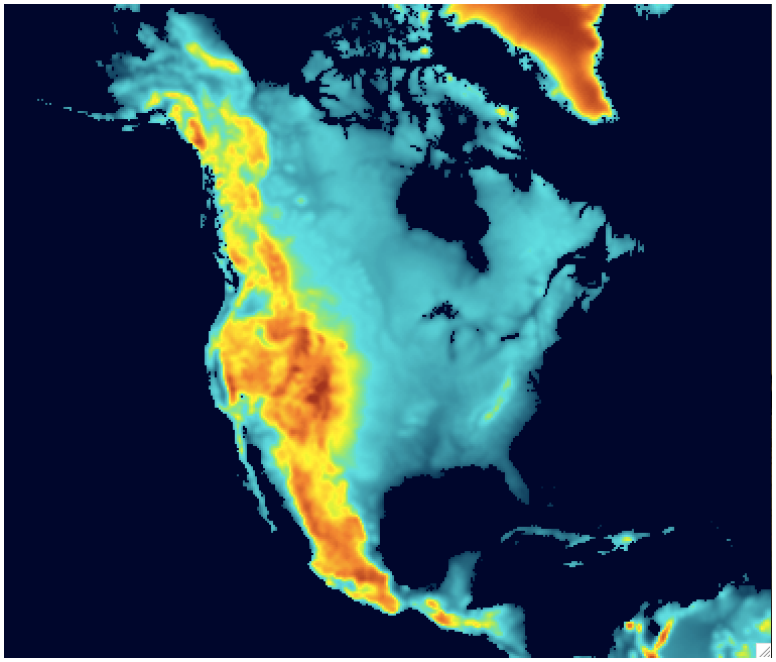
NCAR/CISL&RAL/RISC

9th ICTP Workshop on the Theory and Use of Regional Climate Models

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NA-CORDEX

- ERA-Interim Driven Simulations
  - 1990-2009 (or 1980 up to 2015)
  - 10 RCMs
- GCM-driven Simulations
  - 6 RCMs, 6 CMIP5 GCMs
  - 150 yr transient simulations.
    - 1950-2100
  - 25-km & 50-km resolution
  - RCP8.5 future scenario
    - Some also use RCP 4.5
    - One simulation uses RCP 2.6
  - Full range of climate sensitivity in CMIP5 sampled



WCRP CORDEX

NA-CORDEX.org

	GFDL-ESM2M (2.5)	MPI-ESM-LR (3.6)	HadGEM2-ES (4.6)	CanESM2 (3.7)	EC-EARTH (3.3)	MPI-ESM-MR (3.4)
RegCM4 (Iowa State & NCAR)	25km 50km	25km 50km	25km 50km			
WRF (U. of Arizona & NCAR)	25km 50km	25km 50km	25km 50km			
HIRHAM5 (DMI)					50km	
CanRCM4 (CCCma)				25km 50km		
CRCM5* (UQAM & OURANOS)	25km	25km 50km		50km 25km		50km 25km
RCA4 (SMHI)				50km	50km	

*With and without nudging depending on institute.

Orange = RCP 4.5 and RCP 8.5
Black = RCP 8.5 Only
Purple = RCP 2.6, RCP 4.5, and RCP 8.5

Home

WCRP CORDEX

NA-CORDEX

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HOME

The North American CORDEX Program

Regional climate change scenario data and guidance for North America, for use in impacts, decision-making, and climate science

The NA-CORDEX data archive contains output from regional climate models (RCMs) run over a domain cove
North America using boundary conditions from global climate model (GCM) simulations in the CMIP5 archiv
simulations run from 1950-2100 with a spatial resolution of 0.22°/25km or 0.44°/50km. Data is available for
relevant variables at daily and longer frequencies in CF-compliant netCDF format.

Download data from the NA-CORDEX search page on the NCAR Climate Data Gateway.

This data is freely available under the Terms of Use. When publishing research based on this data, be sure to
dataset citation like the following:

> Mearns, L.O., et al., 2017: *The NA-CORDEX dataset*, version 1.0. NCAR Climate Data Gateway, Boulder
> accessed [date], https://doi.org/10.5065/D6SJ1JCH

- See Data for a full description of the available data and detailed download instructions.
- See Simulations for information about the models and RCM/GCM combinations.
- See Guidance for information about how to properly make use of this data.
- See CORDEX for more information about the international program that NA-CORDEX is a component of.

Time aggregations

Spatial and temporal sub-setting

Interpolated

Bias corrected

When publishing research based on NA-CORDEX data, be sure to include a citation for the dataset itself. The following form follows AMS style and is consistent with the simpler versions of the ESIP recommendations:

> Mearns, L.O., et al., 2017: *The NA-CORDEX dataset*, version 1.0. NCAR Climate Data Gateway, Boulder CO, accessed [date], https://doi.org/10.5065/D6SJ1JCH

The full set of authors for the dataset, and their associated roles and affiliations, is as follows:

Editors		
Program Lead	Linda O. Mearns	NCAR
Data Manager	Seth McGinnis	NCAR
Compiler	Daniel Korytina	NCAR
Modelers		
CanRCM4	John Scinocca Slava Kharin Yanjun Jiao Minwei Qian Michael Lazare	CCCma
CRCM5-OURANOS	Sébastien Biner	Ouranos
CRCM5-UQAM	Katja Winger	UQAM
HIRHAM5	Ole Christensen	DMI
RCA4	Grigory Nikulin	SMHI
RegCM4	Raymond Arritt Daryl Herzmann	Iowa State University
	Melissa Bukovsky	NCAR
WRF	Melissa Bukovsky	NCAR
	Hsin-I Chang	University of Arizona
Major Contributors		
	Chris Castro	University of Arizona
	Anne Frigon	Ouranos
	William Gutowski	Iowa State University

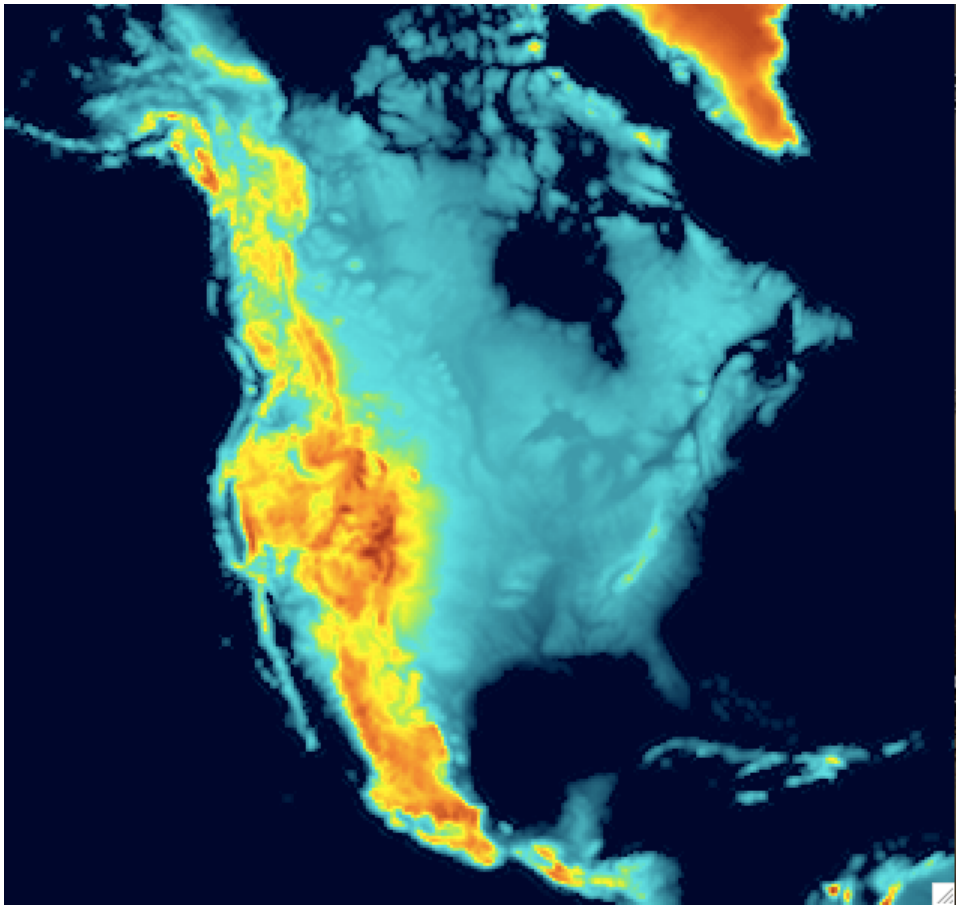
If a citation format requires a full list of authors in lieu of an *et al* listing, please use this ordering:

Mearns, Linda; McGinnis, Seth; Korytina, Daniel; Arritt, Raymond; Biner, Sebastien; Bukovsky, Melissa; Chang, Hsin-I; Christensen, Ole; Herzmann, Daryl; Jiao, Yanjun; Kharin, Slava; Lazare, Michael; Nikulin, Grigory; Qian, Minwei; Scinocca, John; Winger, Katja; Castro, Chris; Frigon, Anne; Gutowski, William

(Ordering: editors by seniority, then modelers alphabetical by last name, then contributors alphabetical by last name.)

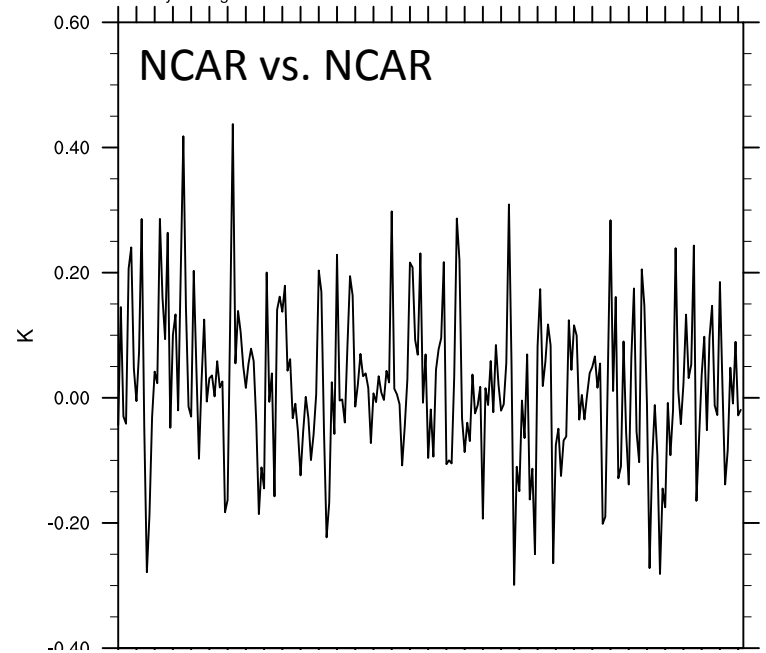
RegCM NA-CORDEX Configuration

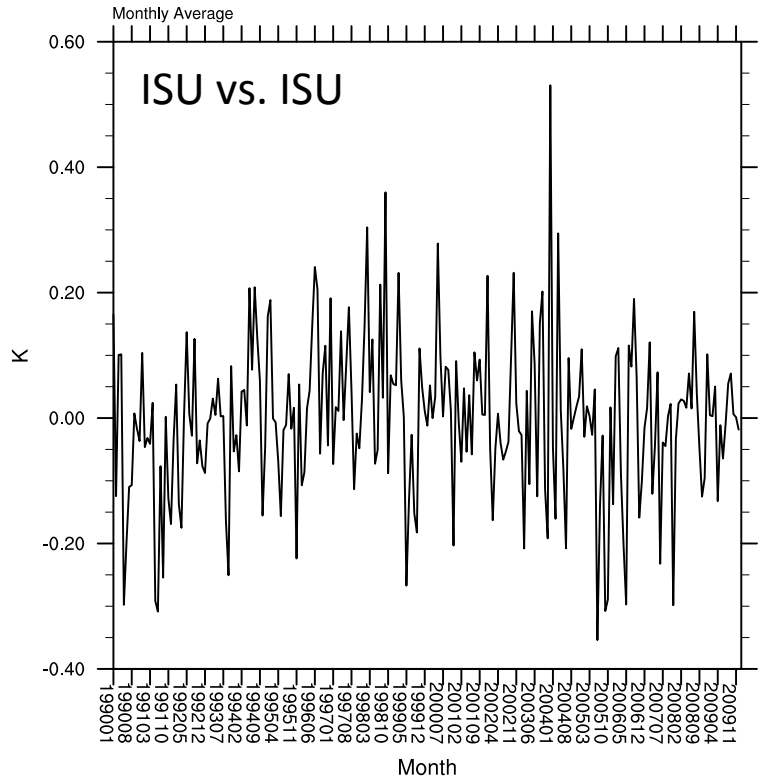
- RegCM4 rc13
  - Grell CPS w/ FC closure over land, Emanuel over ocean
  - SUBEX MPS
  - BATS
  - No sea ice
  - Lake model on
  - 164x192x18 (50km)
  - 328x384x18 (25km)

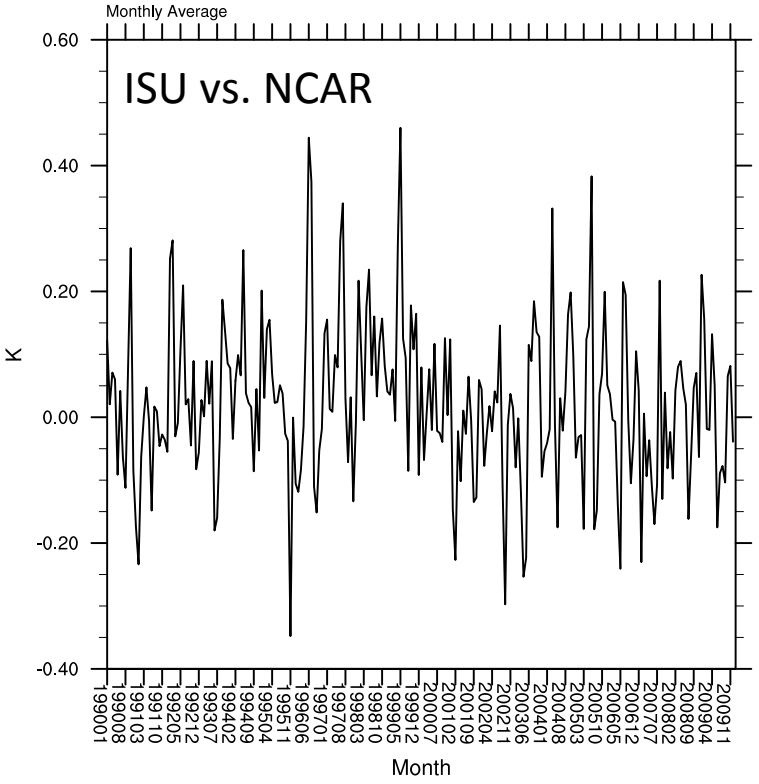


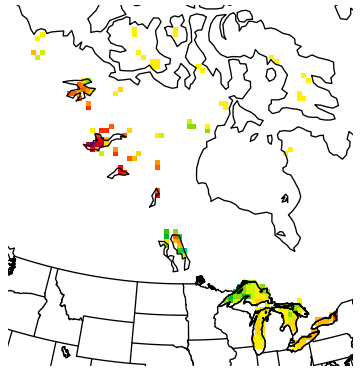
25km Terrain Height (m)

Machine Variability vs. Internal Variability









U.S. Department of Energy

FACETS

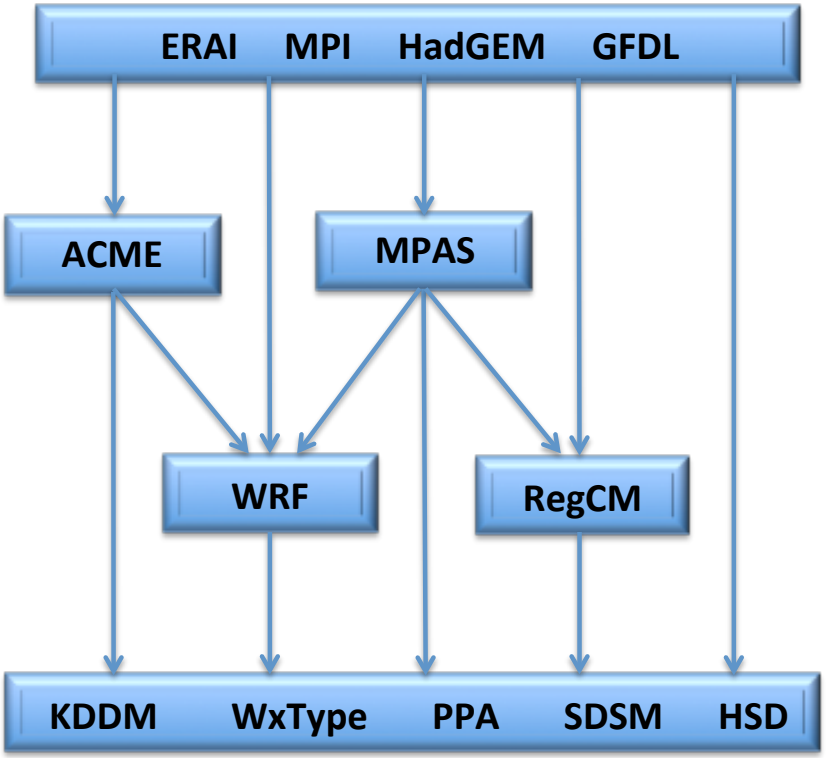
Framework for Assessing Climate's Energy-Water-Land Nexus using Targeted Simulations

Lead PI, W. Gutowski; NCAR co-PI, L. Mearns

- Team: Iowa State, NCAR, PNNL, Cornell, UCLA, Texas A&M

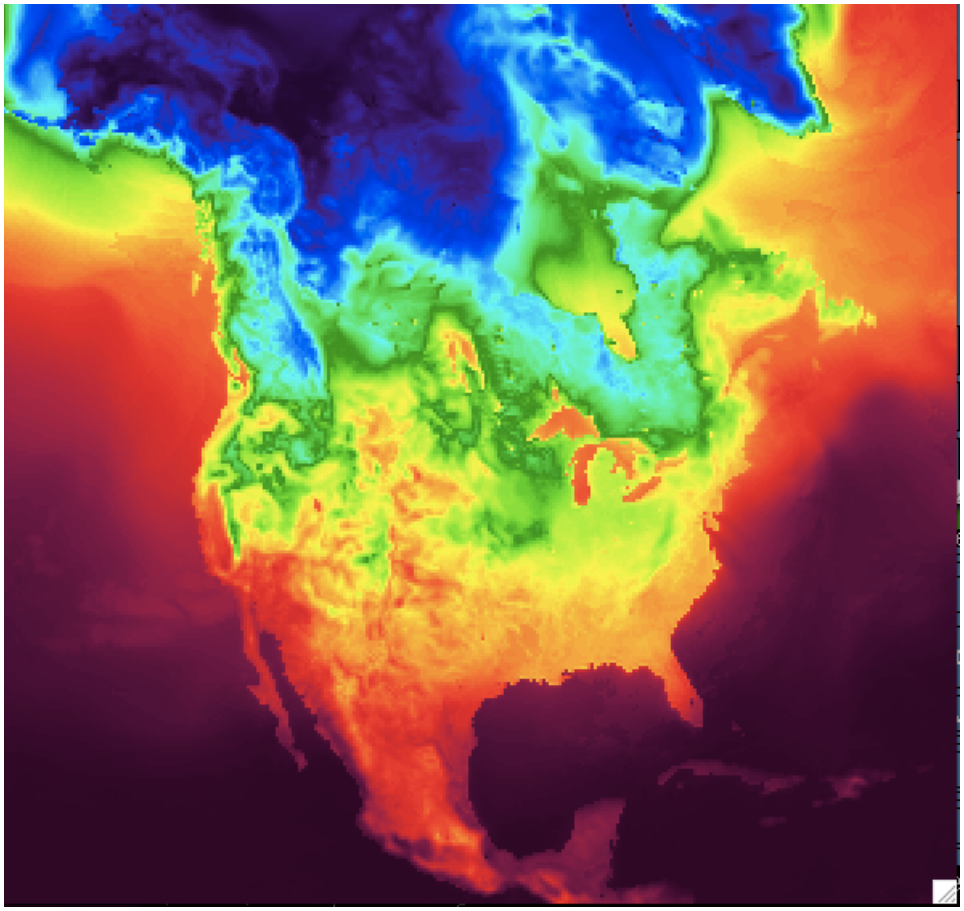
- Oversimplified project summary: Development of the everything-and-the-kitchen-sink approach to evaluating models across scales.
  - Develop and apply a model evaluation framework to understand and quantify climate model simulation skill using a range of analysis techniques.
- Diverse modeling approaches, using and building on the NA-CORDEX archive, including:
  - Variable resolution AGCMs
  - Regional climate models
  - Empirical and statistical downscaling
  - Hybrid statistical-dynamical downscaling

- 50km, 25km, 12km simulations
  - 25 year timeslices
  - 50km & 25km runs from NA-CORDEX for WRF and RegCM
  - New 25km and 50km simulations use CORDEX domain, 12km use smaller domain
  - RCP8.5, end-of-century
- Additional simulations with SSP3 and SSP5 land-use and land cover changes.
- Wind farm effects in additional 4km simulations.
- 4 different ESD methods, one hybrid method.



DOE-FACETS

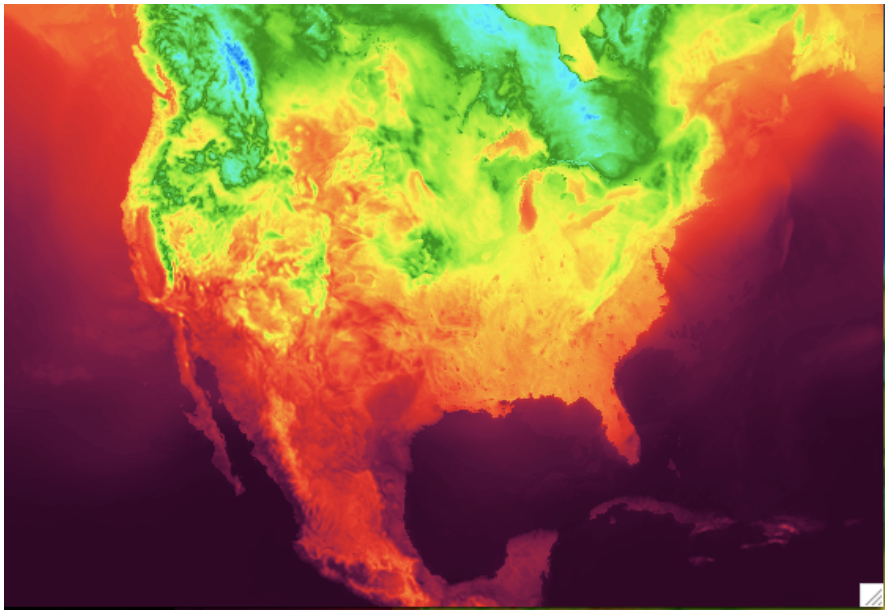
2m Temperature: 13UTC, 1 Jan 2000



⬅ 25km NA-CORDEX Domain

⬇

⬇ 12km FACETS Domain



Run Cost: Example 1

Based on completed simulations on NCAR's Yellowstone.

(not a direct comparison – too many differences between models)

RegCM4

- 151 years @ 25km
  - 323,000 core hours
  - 900 wall clock hours = 38 days
  - 41 TB
  - 328 x 384 x 18

WRF

- 151 years @ 25km
  - 720,000 core hours
  - 2160 wall clock hours = 90 days
  - 95 TB (more variables saved)
  - 318 x 302 x 28

Run Cost: Example 2

Based on completed simulations on NCAR's Cheyenne.

(not a direct comparison – too many differences between models)

WRF – North America

- 151 years @ 25km
  - 181,200 core hours
  - 1057 wall clock hours = 44 days
  - 432 procs
  - 64 TB (cut a lot of variables)
  - 318 x 302 x 28

WRF - FACETS

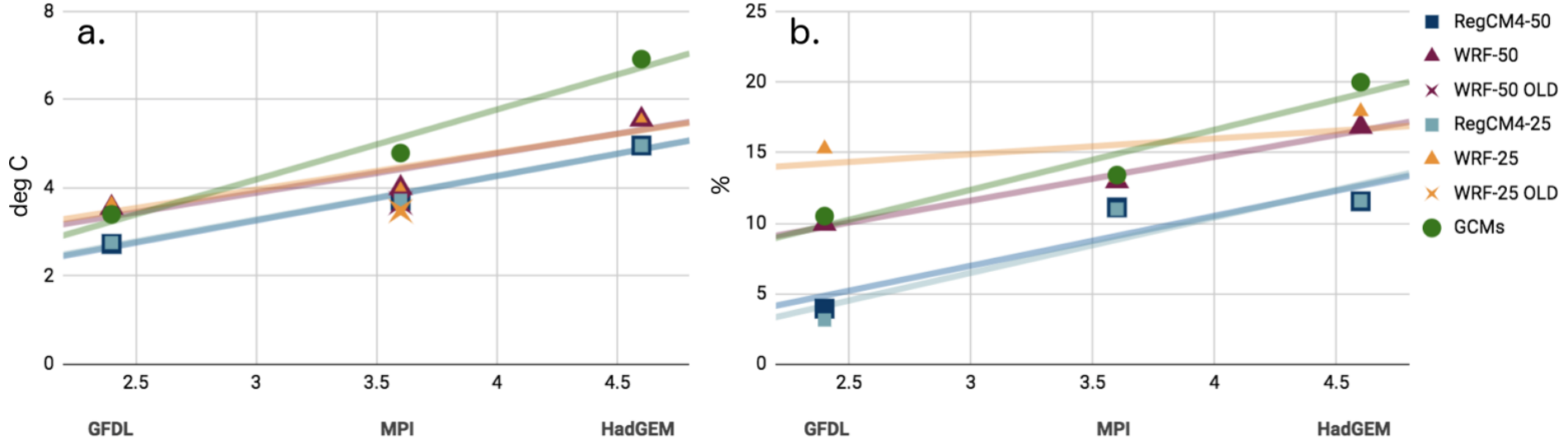
- 26 years @ 12km
  - 138,000 core hours
  - 884 wall clock hours = 37 days
  - 468 procs
  - 28 TB
  - 600 x 425 x 45

Based on analysis in review at Climatic Change

THE SENSITIVITY OF RCMS TO ECS

Climate Change vs. ECS

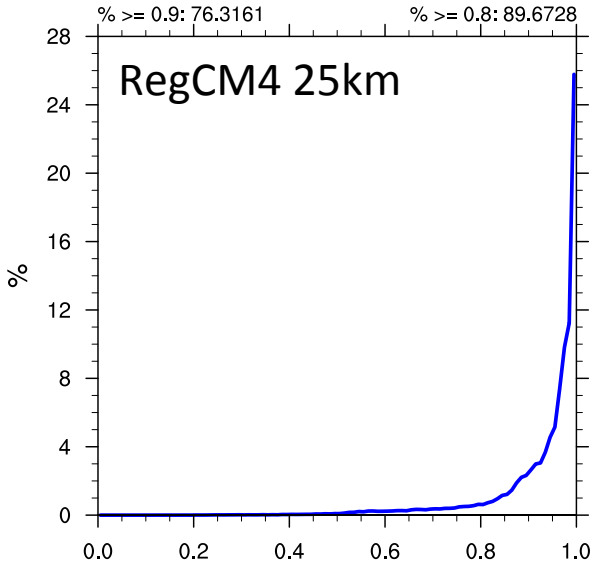
1951-2000 vs. 2050-2099
Domain-wide, Annual Mean
2m Temperature (left), Precipitation (right)

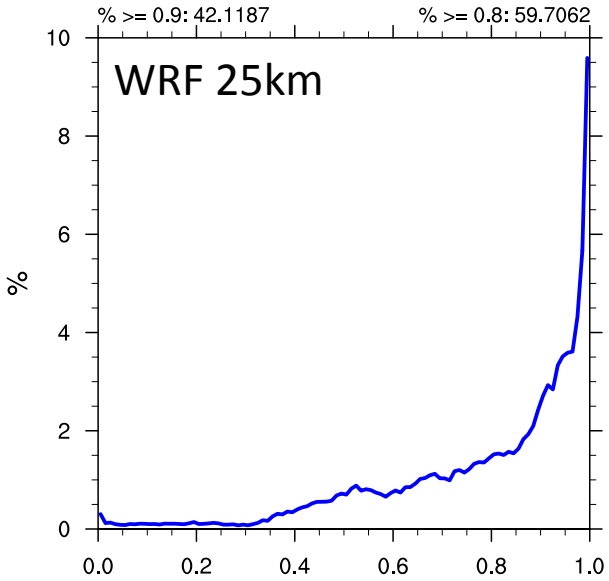


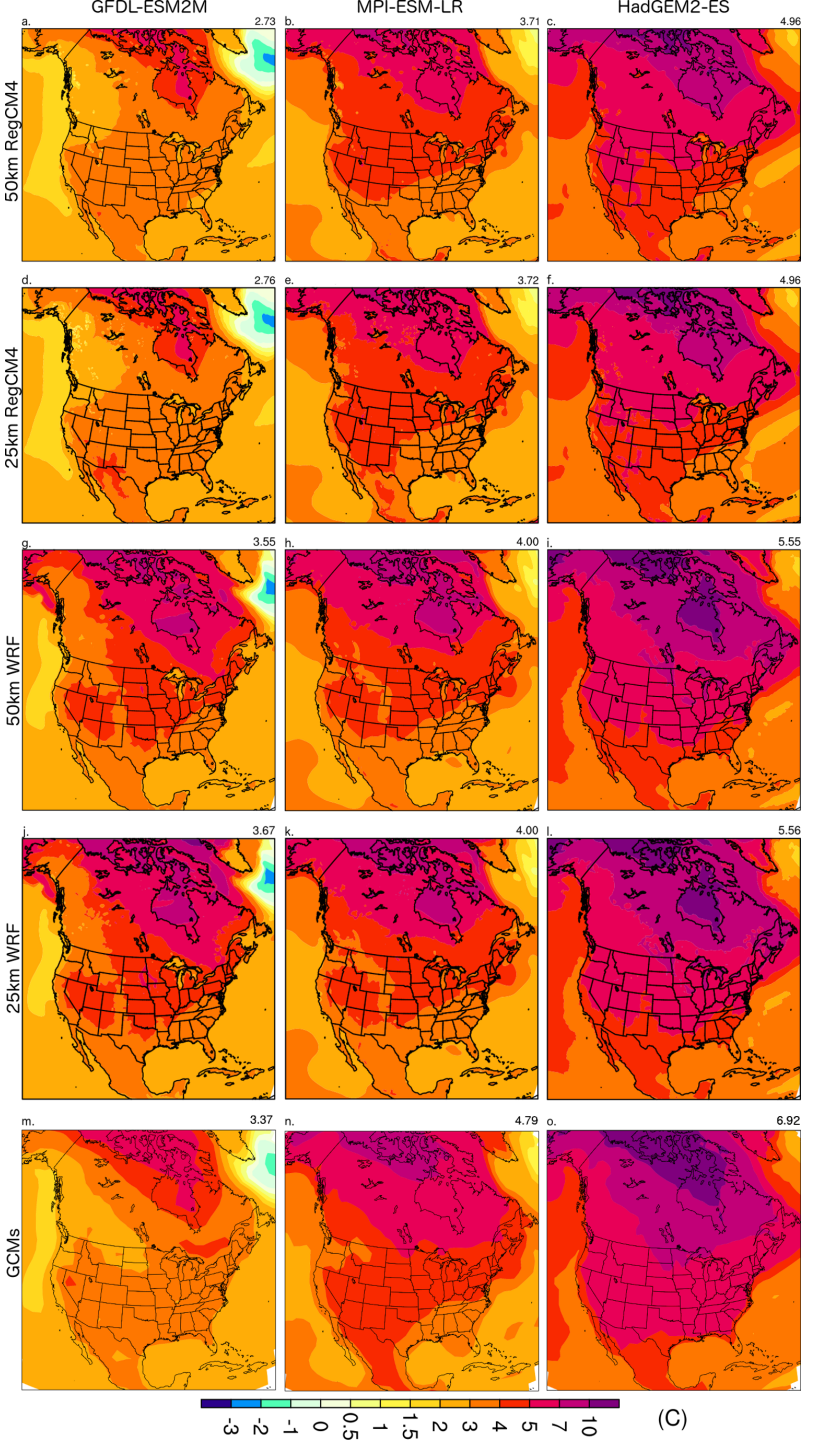
- Climate change does scale with ECS.
- RCMs have a distinct sensitivity/response too.
- Resolution does not change response.
- Holds for all seasons (Pr relationship weaker in summer)
- Increased sampling of change space possible by sampling different RCMs and GCMs
- Does effect other variables (not shown).

R^2	RegCM4 50km	RegCM4 25km	WRF 50km	WRF 25km	GCMs
Tas	0.99	0.98	0.88	0.84	0.97
Pr	0.83	0.84	0.98	0.27	0.93

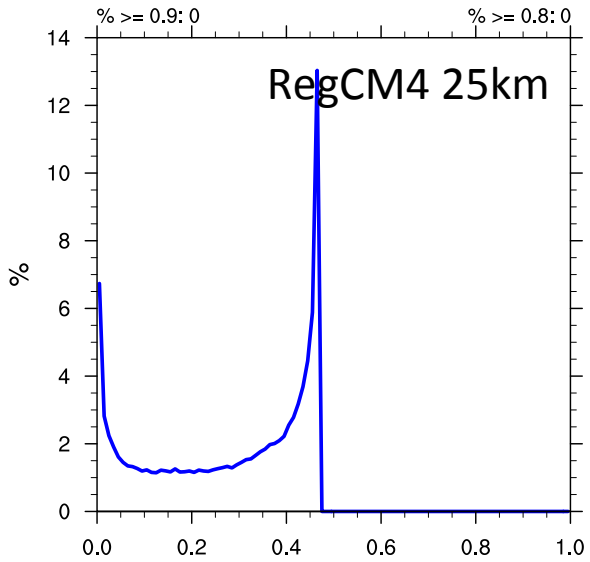
Relationship at Grid-Box Level

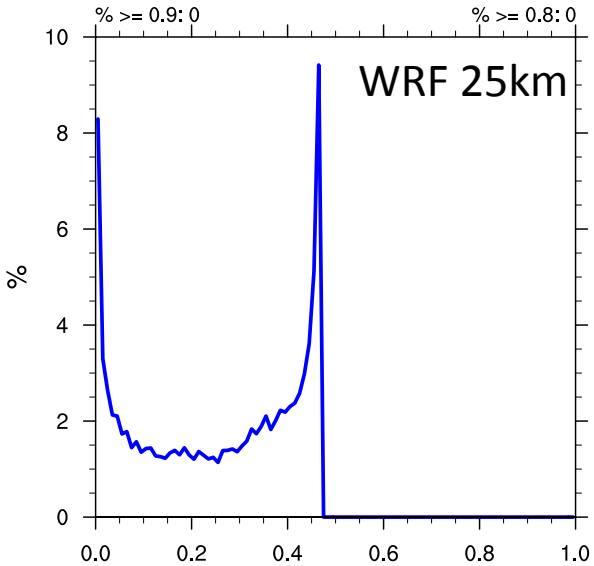


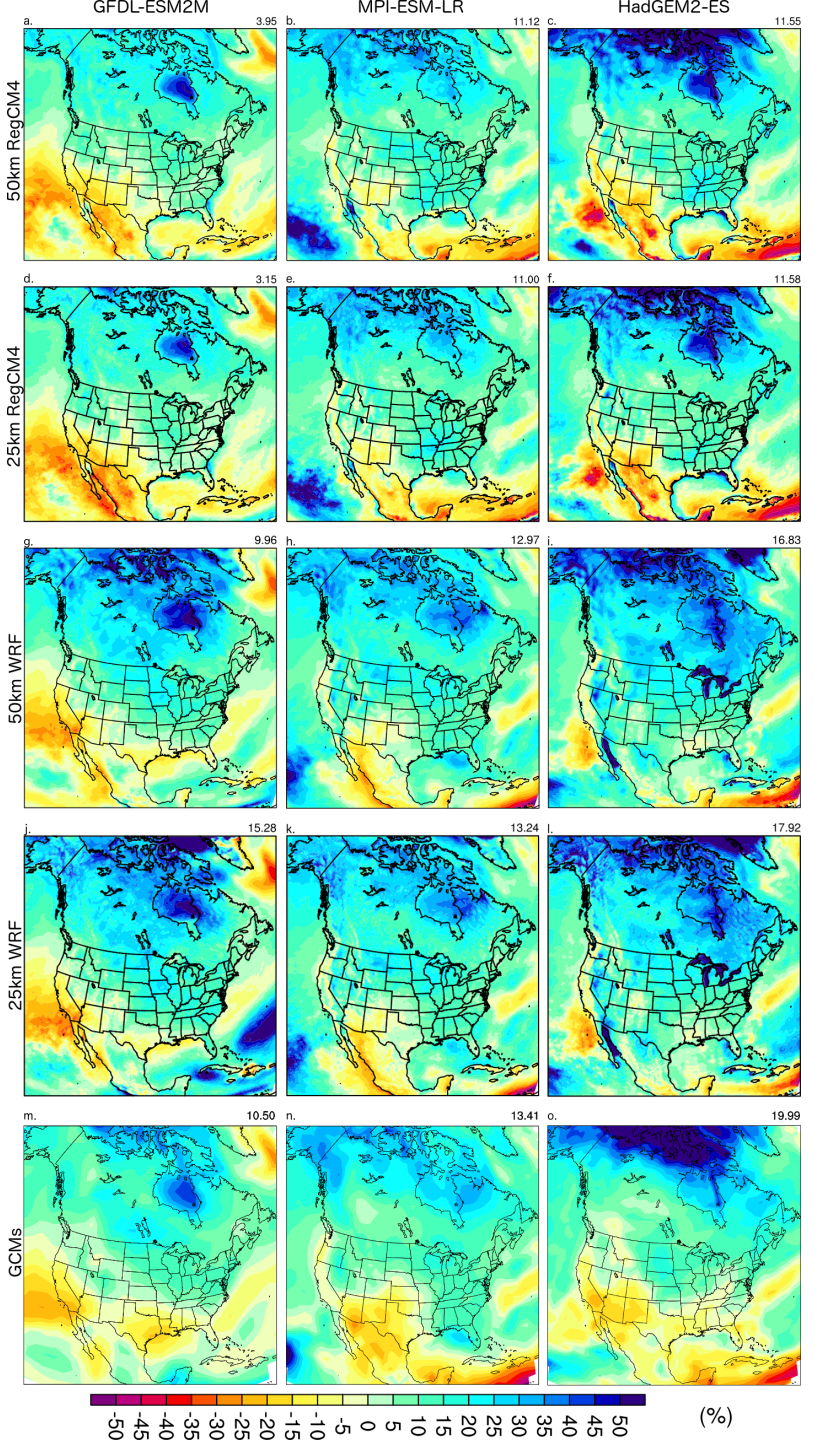




Relationship at Grid-Box Level

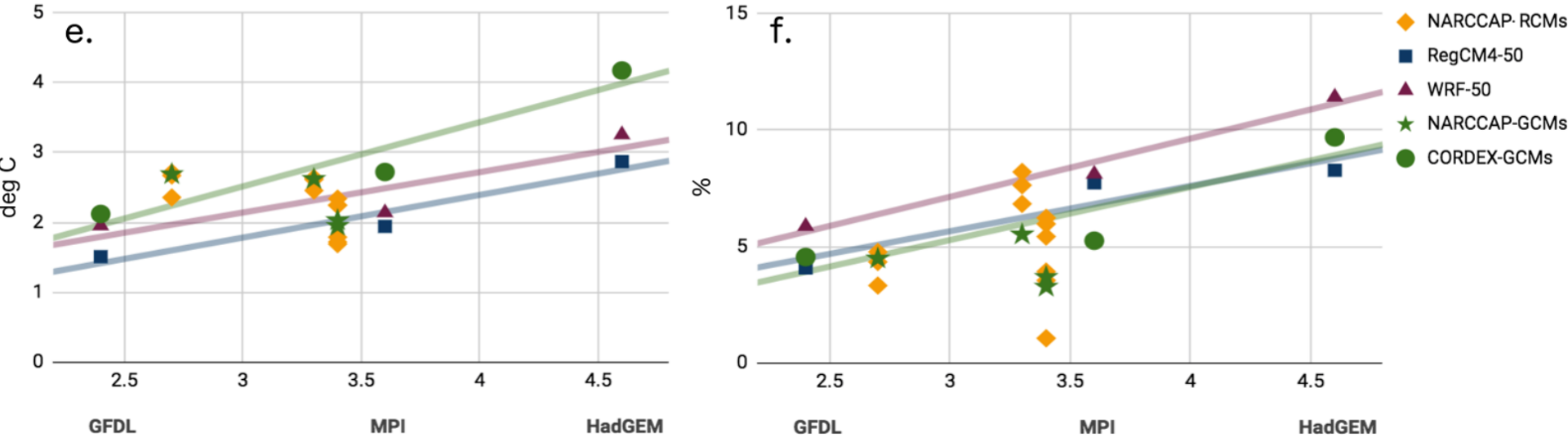






Climate Change vs. ECS

1970-1999 vs. 2041-2069
Domain-wide (NARCCAP common domain), Annual Mean
2m Temperature (left), Precipitation (right)



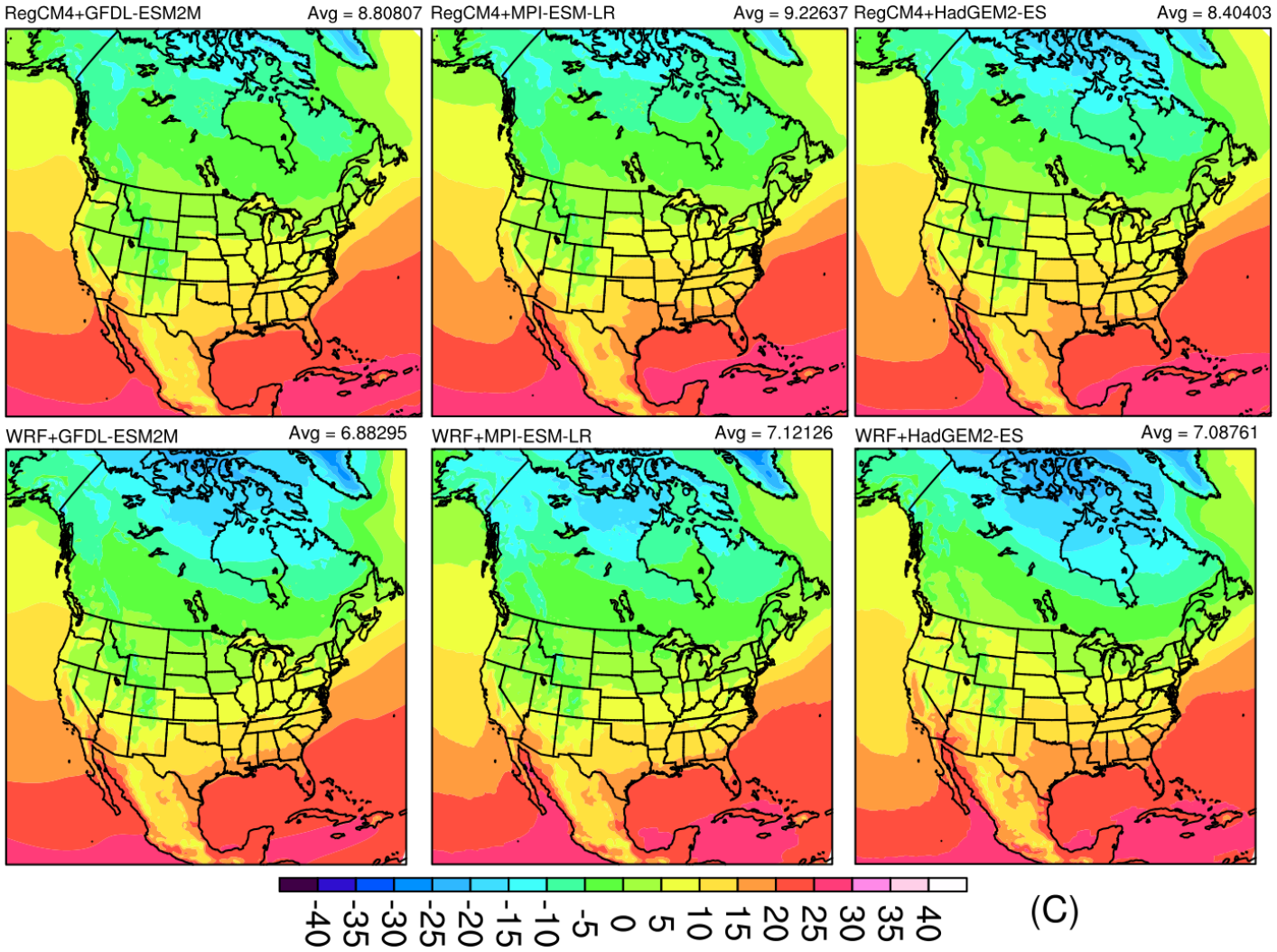
In comparison to NARCCAP:

- Using 6 RCMs produces less spread in temperature projections than a well-sampled ECS and 2 RCMs.
- NARCCAP projections cluster around their GCM projections for temperature.
- For precipitation, using 6 RCMs produced about the same spread (7%) as 2 RCMs with well-sampled ECS.
  - Would spread be further increased with more CORDEX RCMs?

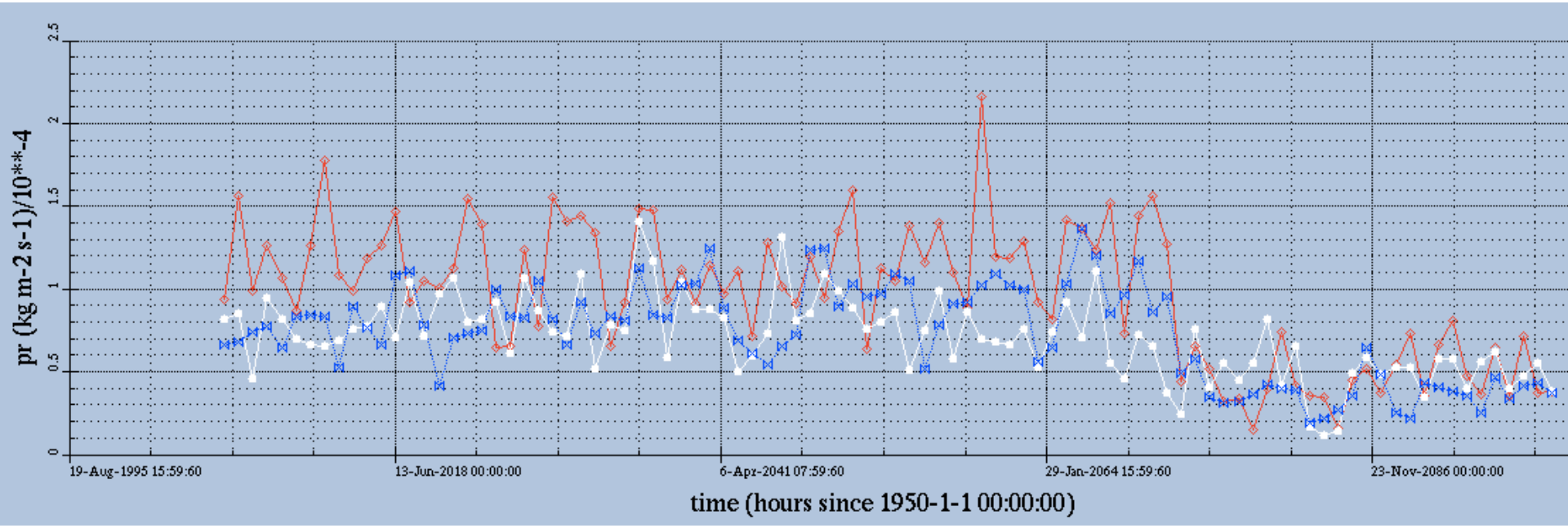
Don’t do this!

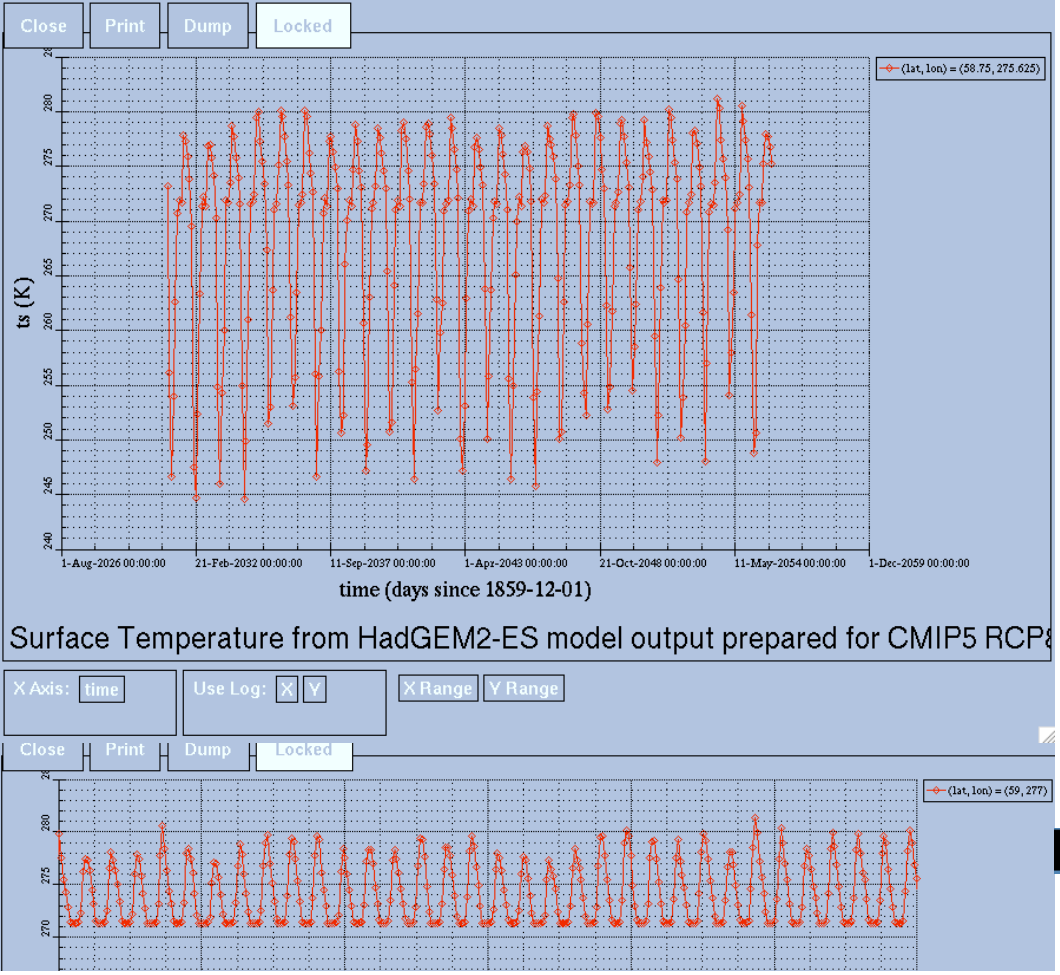
LESSONS?

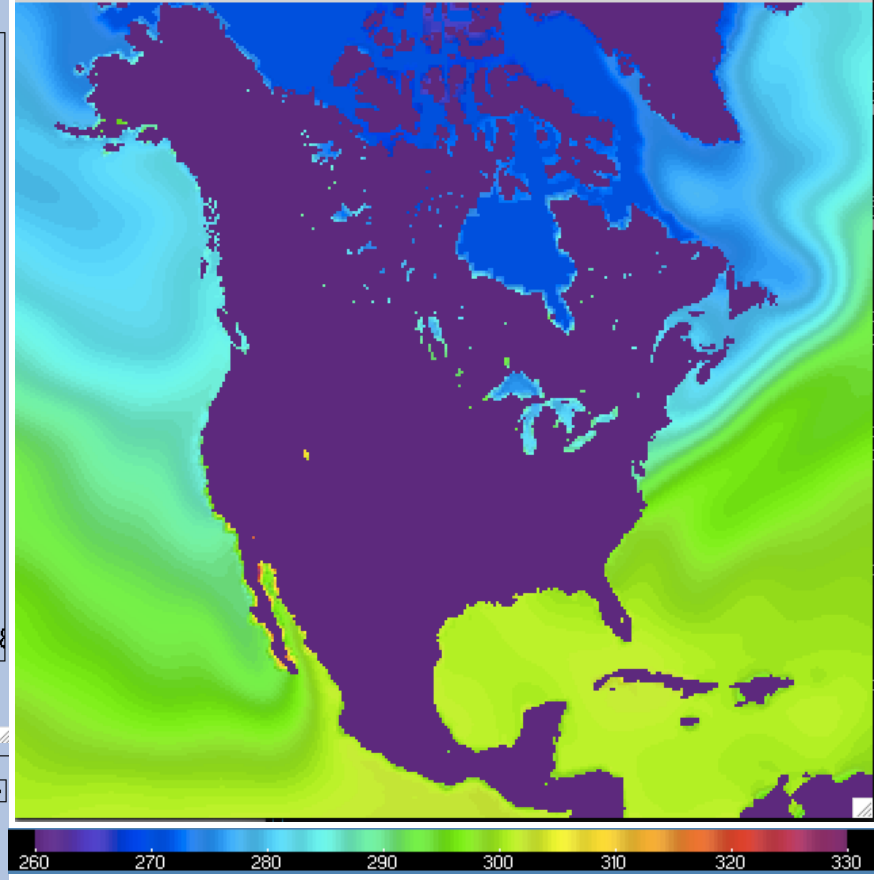
Don’t Forget to Turn On Sea-Ice in 1 Run



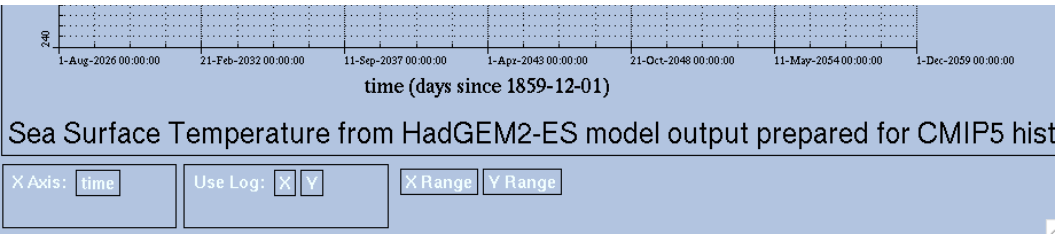
Don’t start using the wrong boundary conditions part of the way through a run.







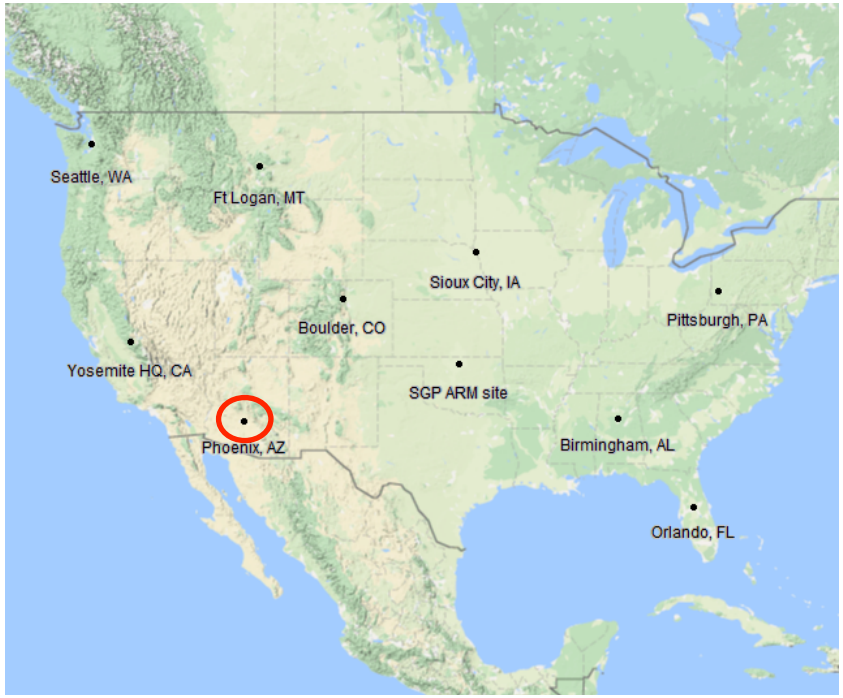
Don’t use “tos” instead of “ts” for SSTs if you might have sea ice form in your region and no sea ice in your simulation!



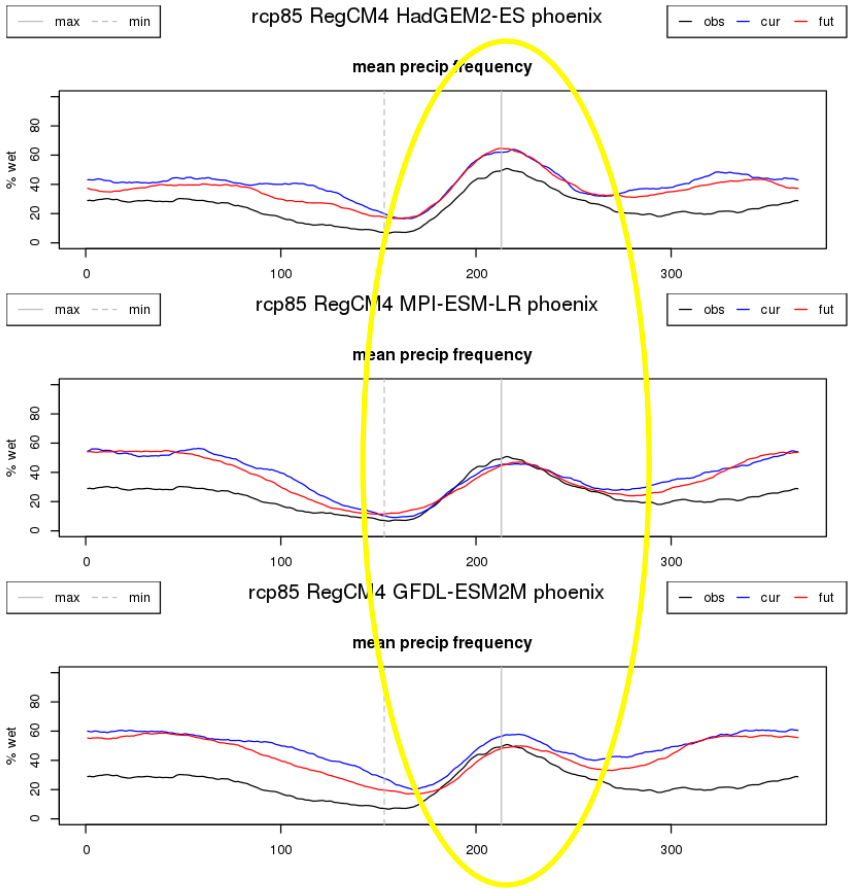
PERFORMANCE EXAMPLES

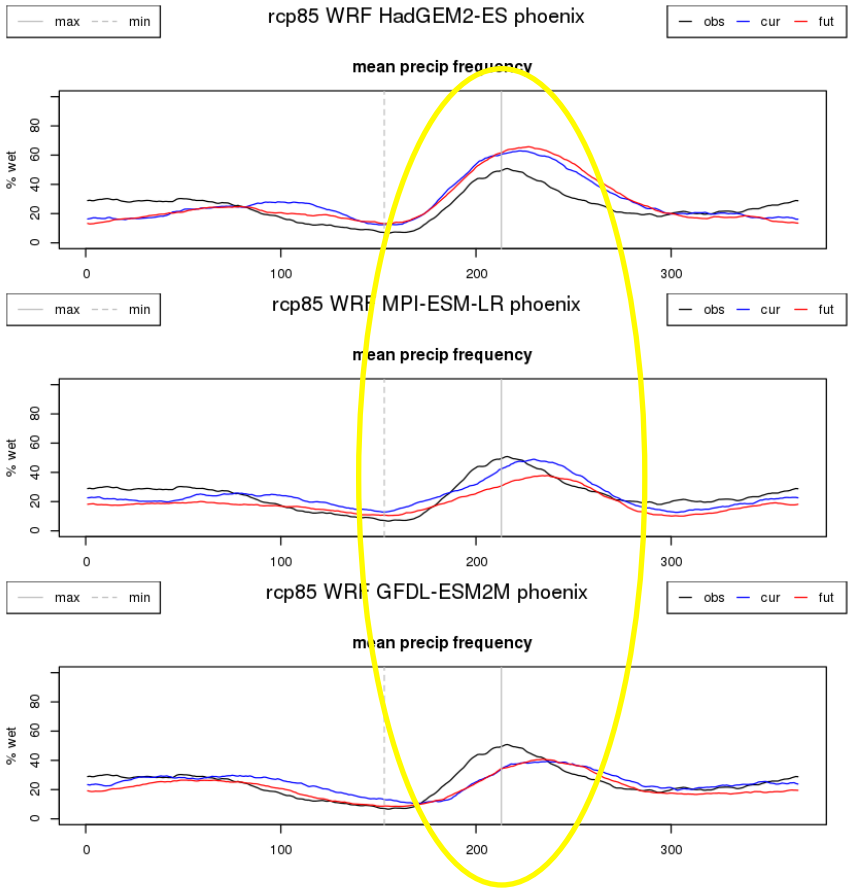
Phoenix, AZ

- North American monsoon is an important feature

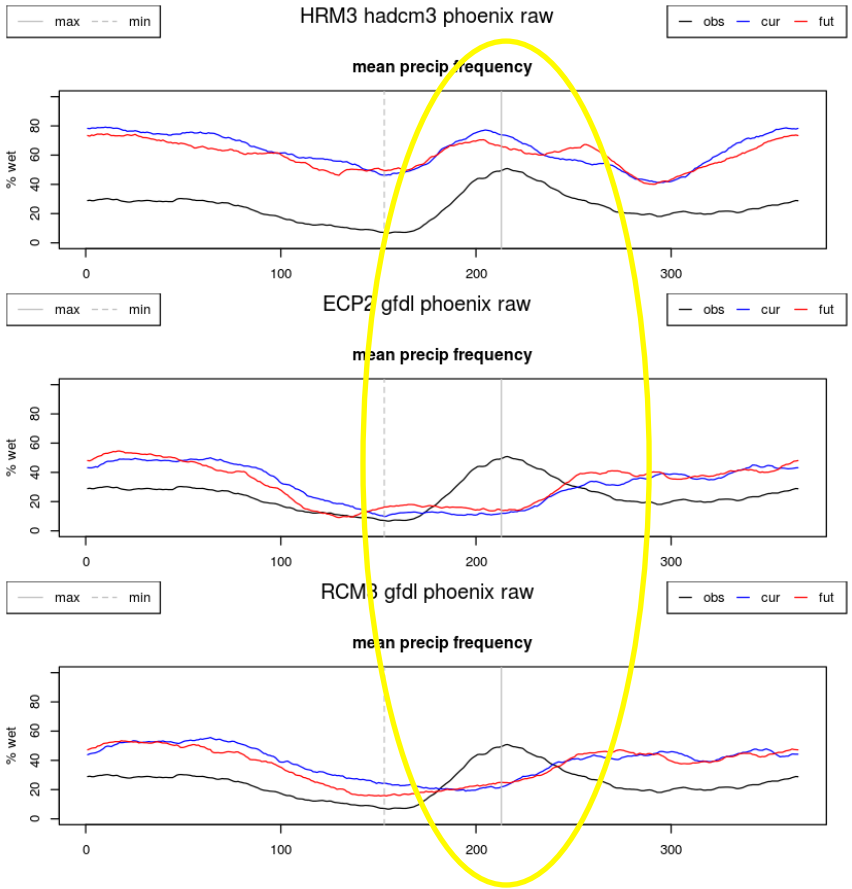


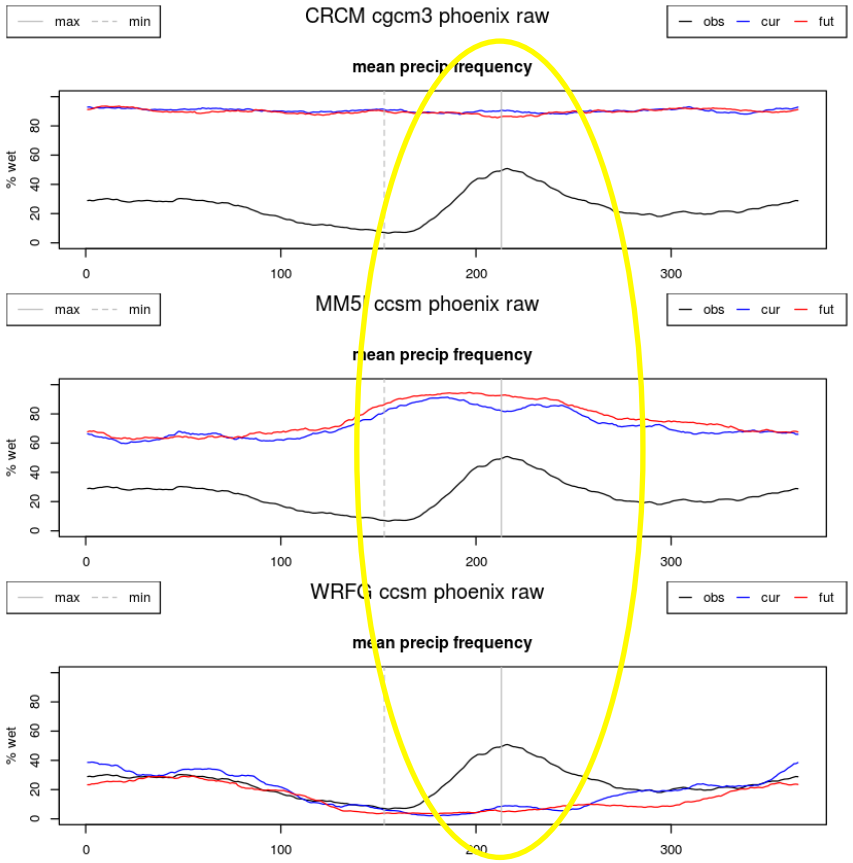
Phoenix: all models get the monsoon!



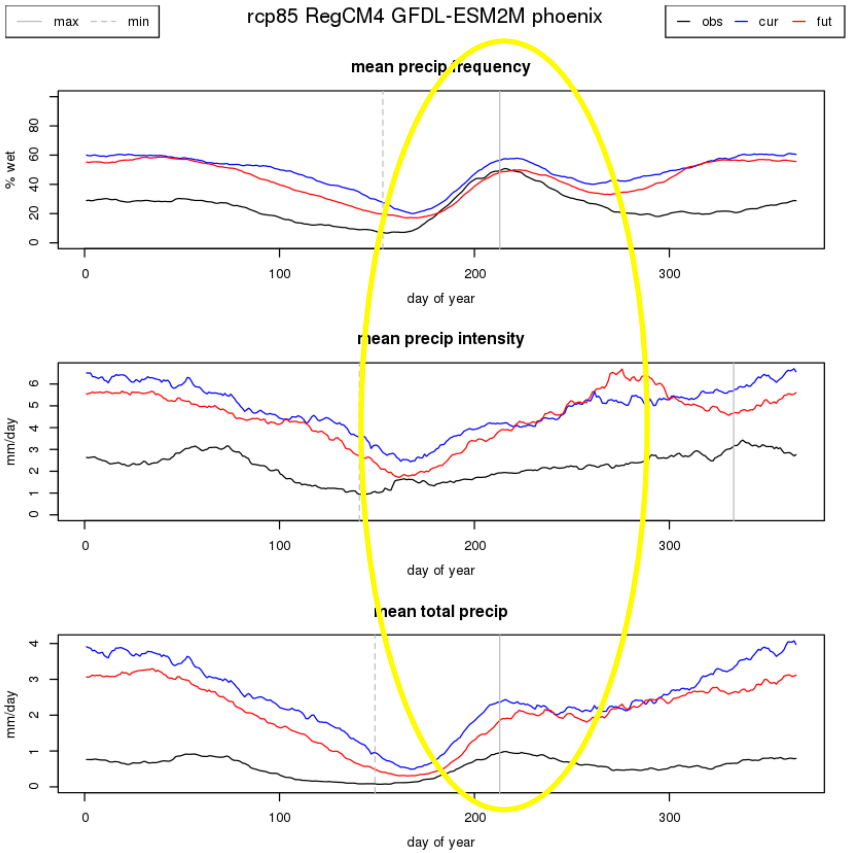


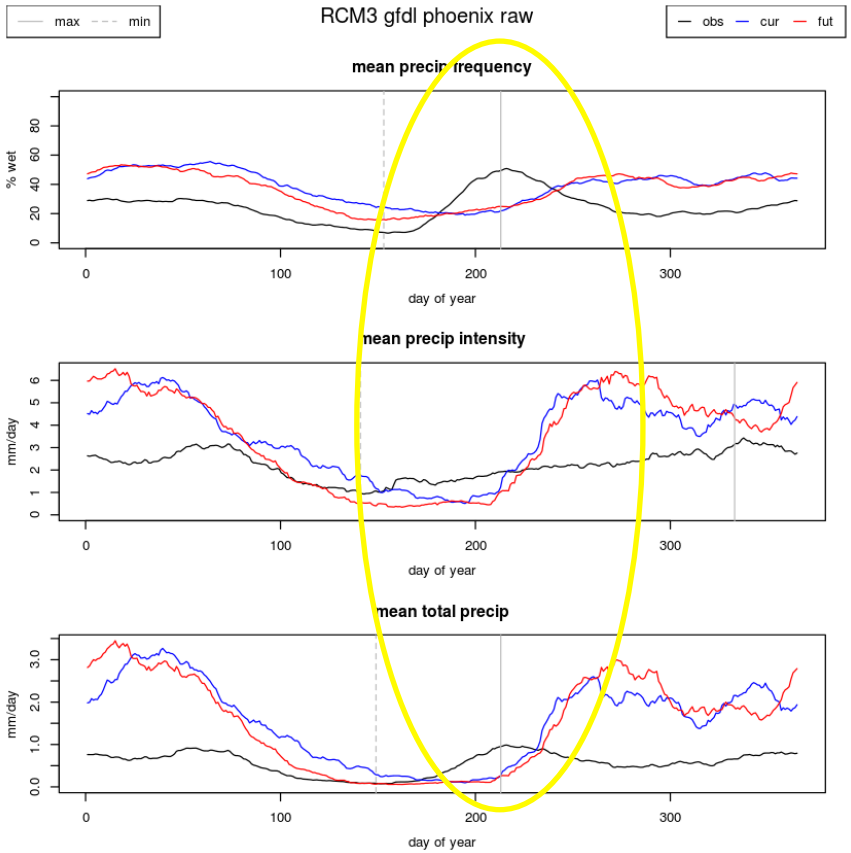
Phoenix: NARCCAP models did NOT get the monsoon





Phoenix: CORDEX vs NARCCAP ⇒ thermodynamic errors vs circulation errors

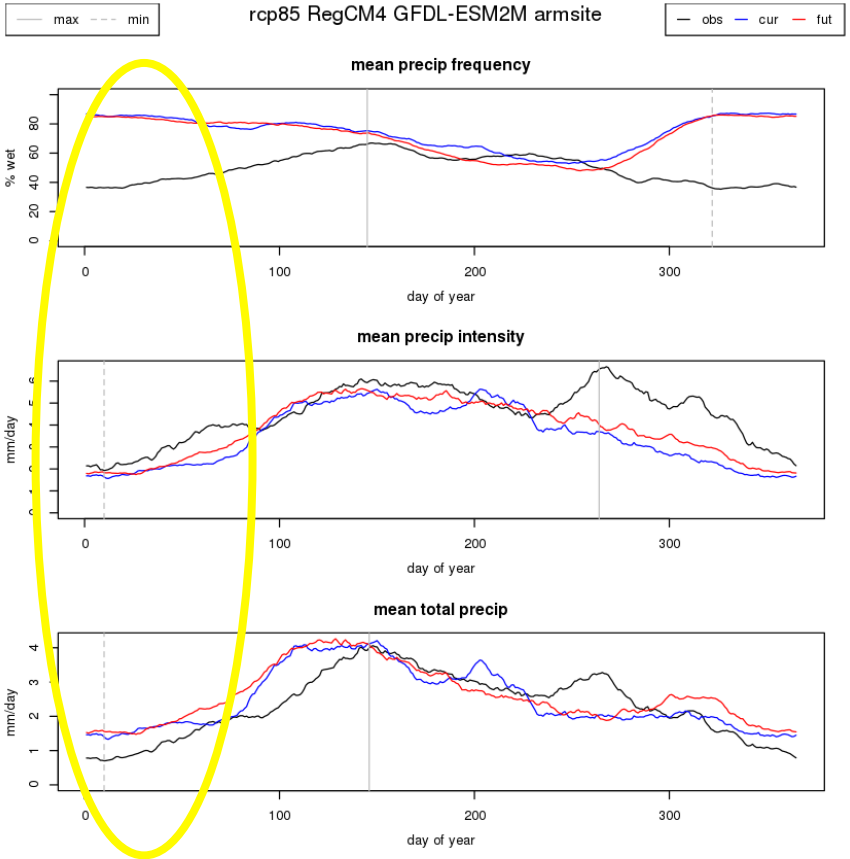


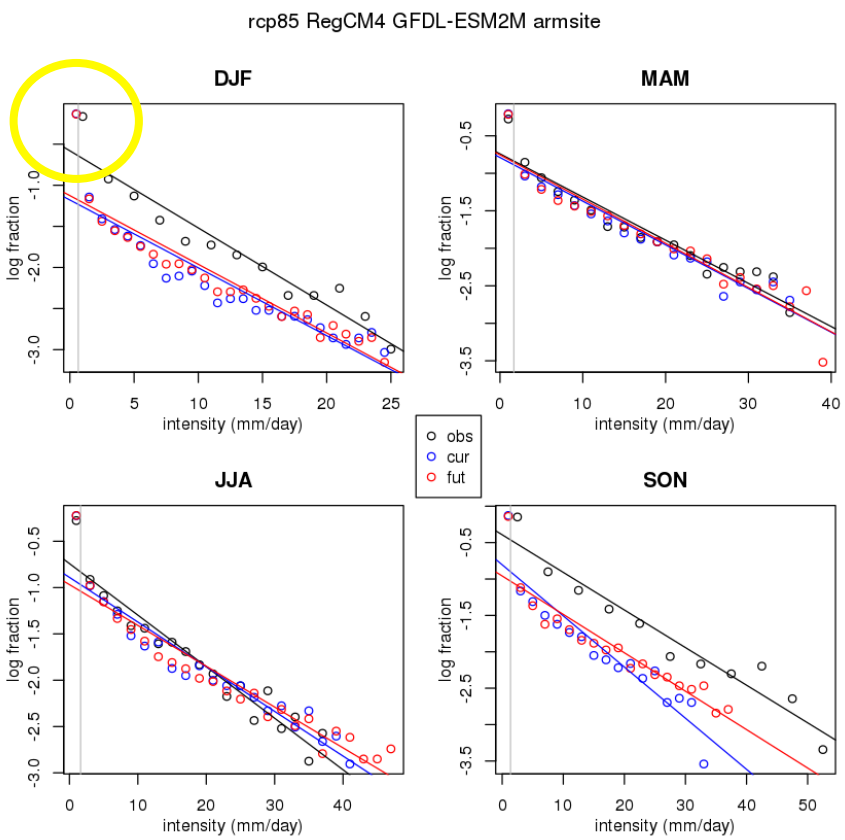


SGP ARM site, OK

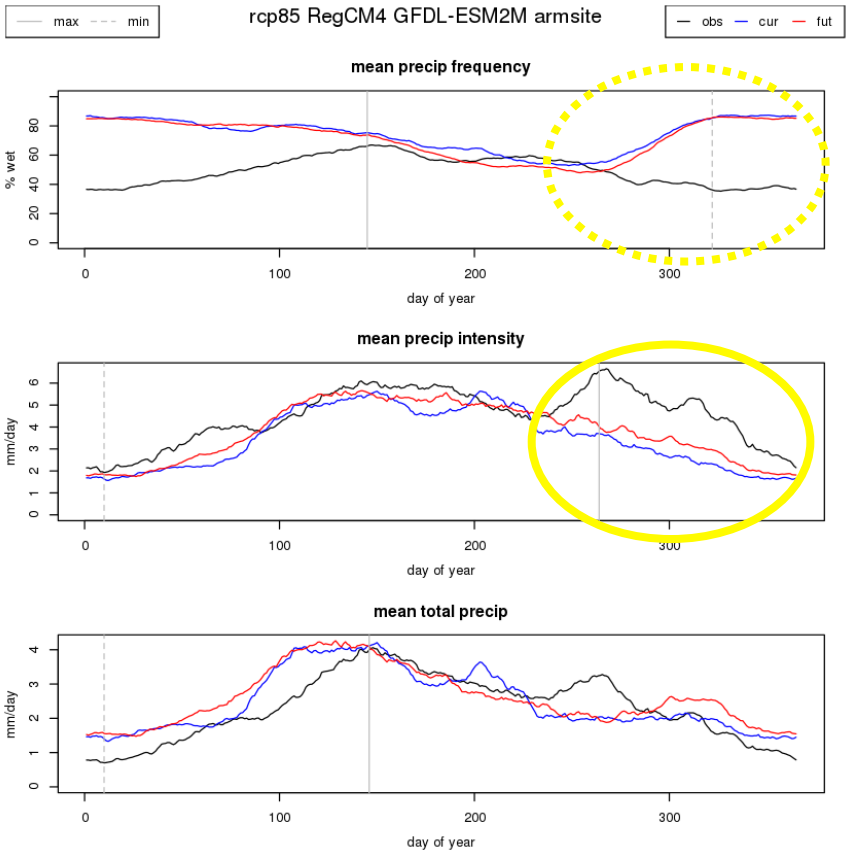
- DoE Climate Research Facility
- All 3 WRF simulations look reasonable
- Drizzle problems in RegCM4 simulations

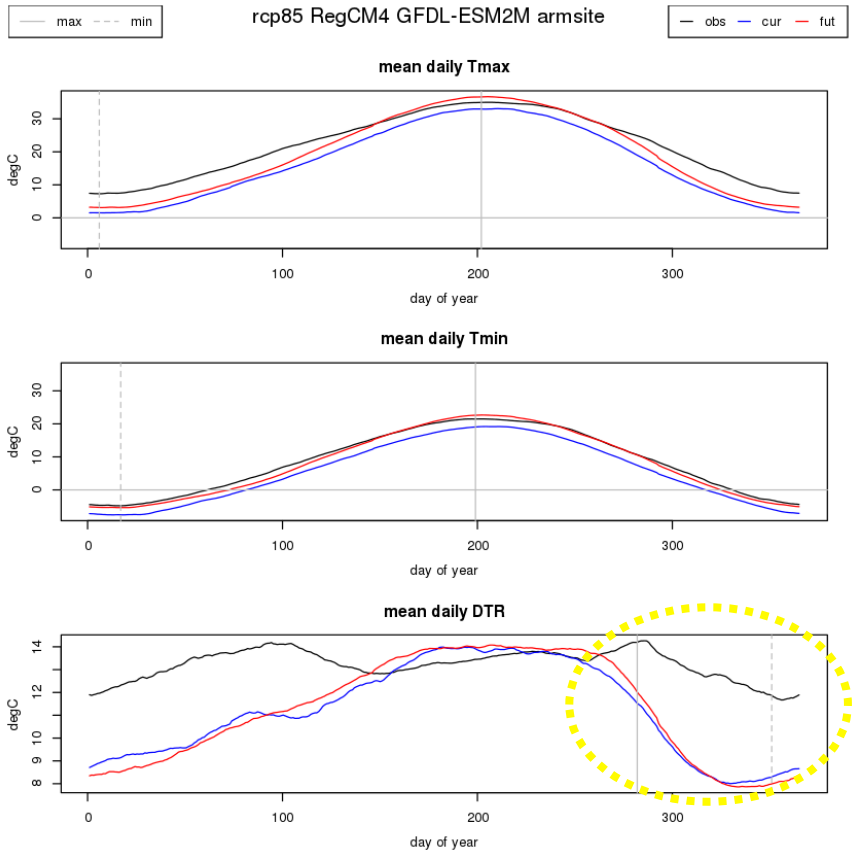
ARM site RegCM4 (1): Too much cold season drizzle ⇔ no ice microphysics in RCM?





ARM site RegCM4 (2): Missing cold-front convective lines ⇒ drizzle erodes instability?






Pine Pollen
NCAR
(last Thursday)
The End