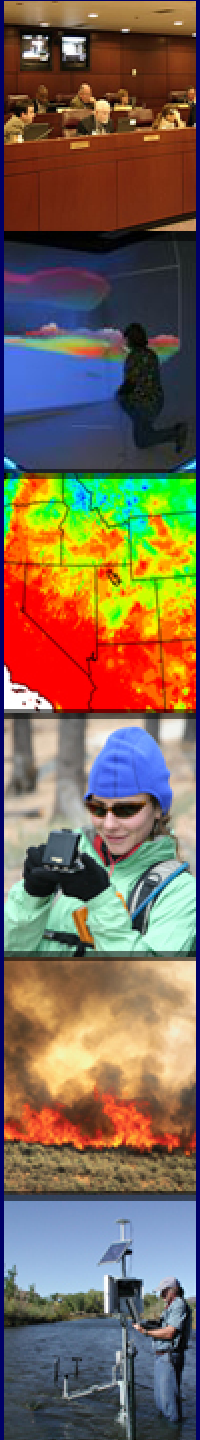


Nevada Infrastructure for Climate Change Science, Education, and Outreach

Climate Modeling Component

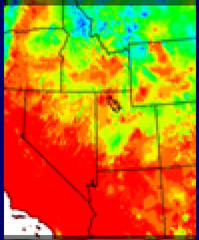
Regional Climate Modeling: Methodological issues and experimental designs

John Mejia, Darko Koracin, and collaborators.

Desert Research Institute, Reno, NV

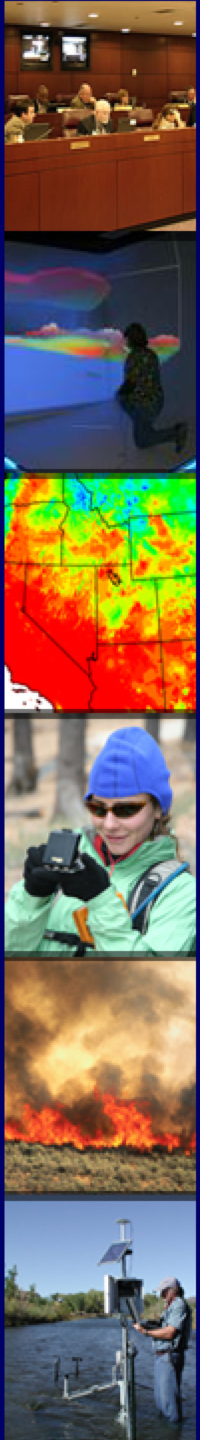
2 February 2010, Las Vegas, NV






Concept of Regional Climate Models (RCMs)

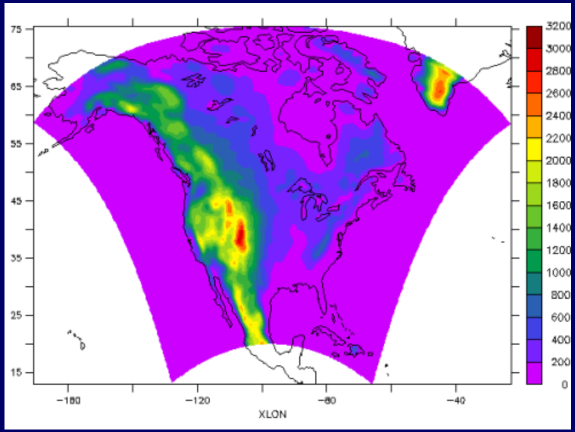
- Forcing data derived from Atmospheric – Ocean Global Climate Models (AO-GCM).
- Nested RCM technique or limited area models as a tool for dynamical downscaling.
- Similar to numerical weather forecasting but with long-term integrations (computer resources limitations) and some adaptation for consistency with the changing climate.



Regional Climate Modeling: Present and Future assessments

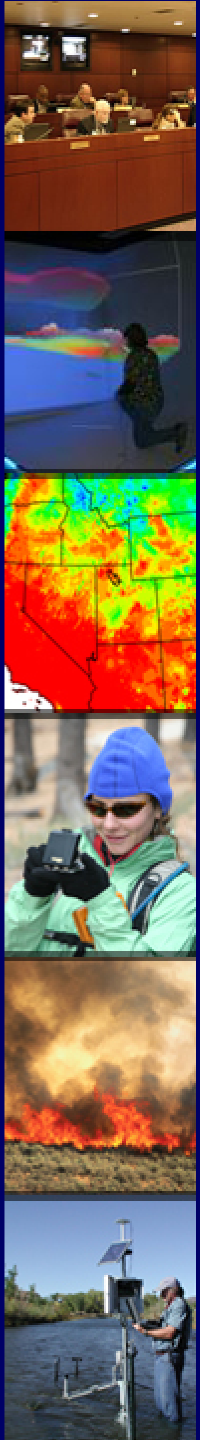
•**World Climate Research Programme (WCRP) /CORDEX :** Multiple agencies and models with fixed AOGCM forcing. Africa and other continental size regions; 50 km grid size.

•**North American Regional Climate Change Assessment Program (UCAR/NARCCAP) :** Multiple model and AOGCM forcing. Systematically investigating the uncertainties in future climate projections; 50 km grid size.



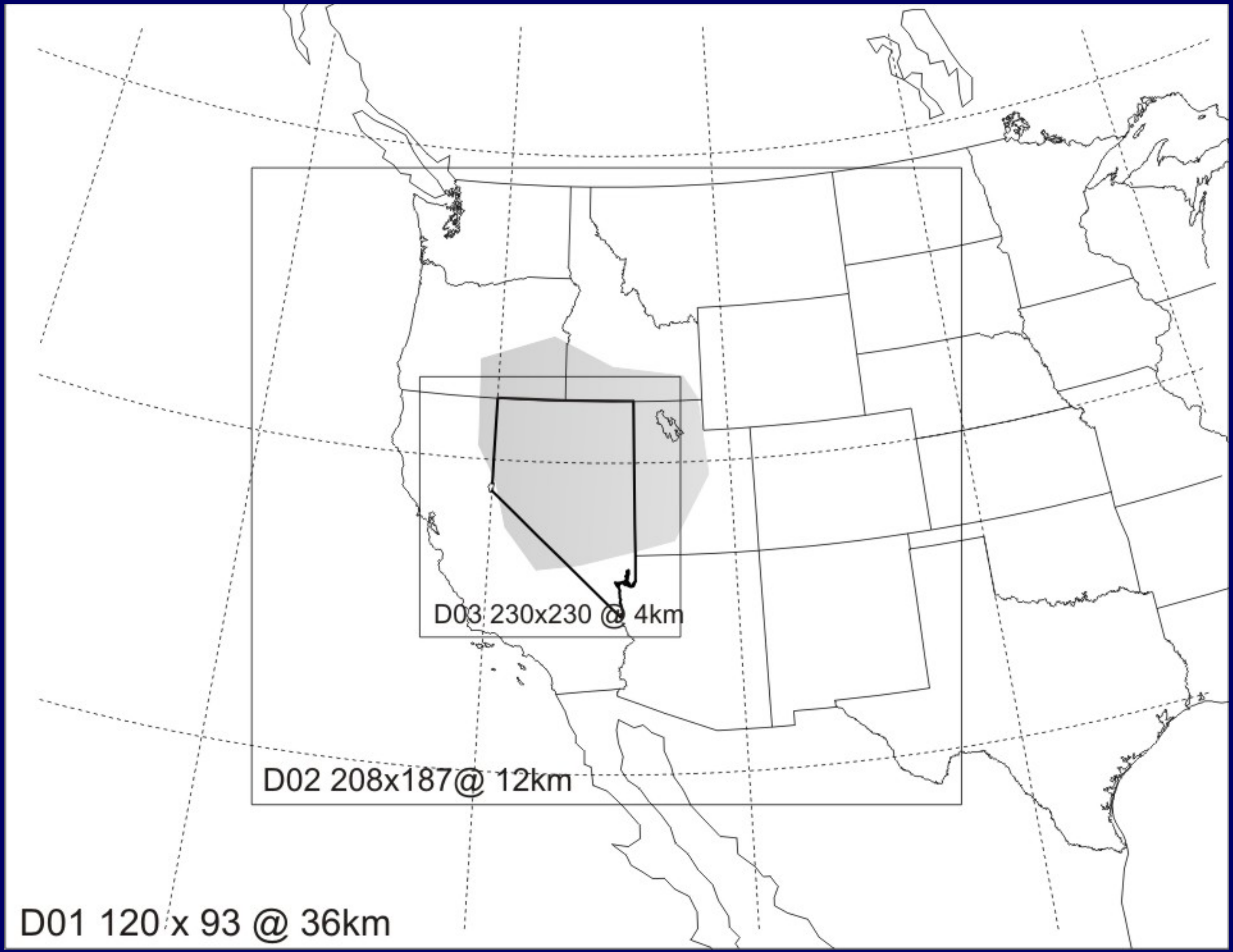
•**Illinois State Water Survey Climate extension of WRF** model. (Dr. Liang personal communication) Integrated Regional Earth System Modeling. Ensemble

…Just to mention a few …

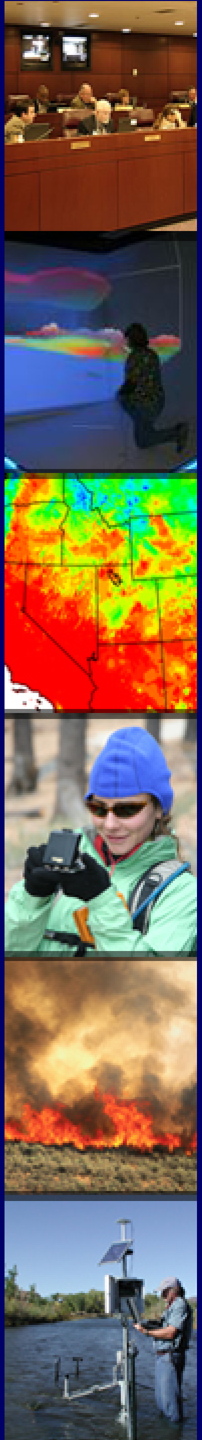


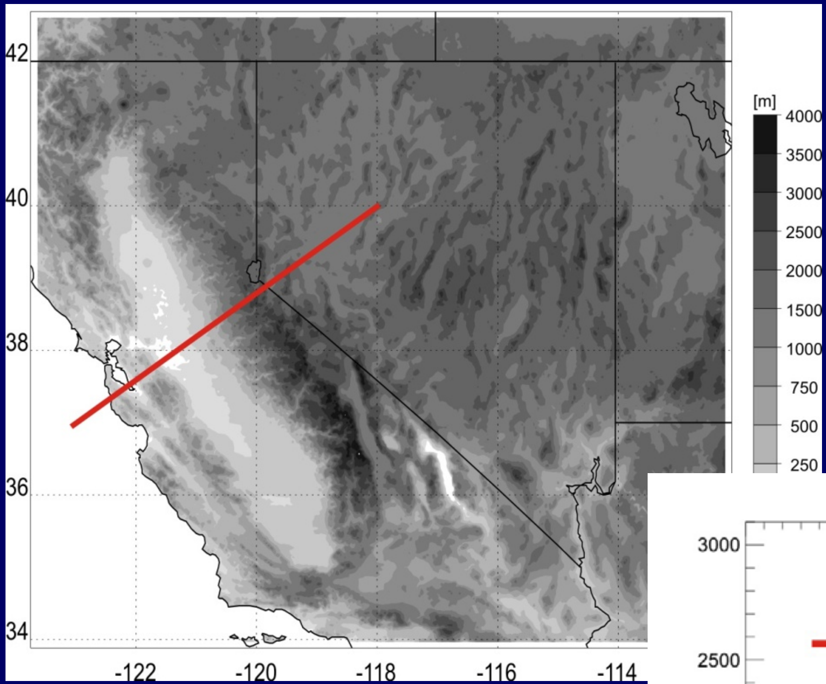
Objective

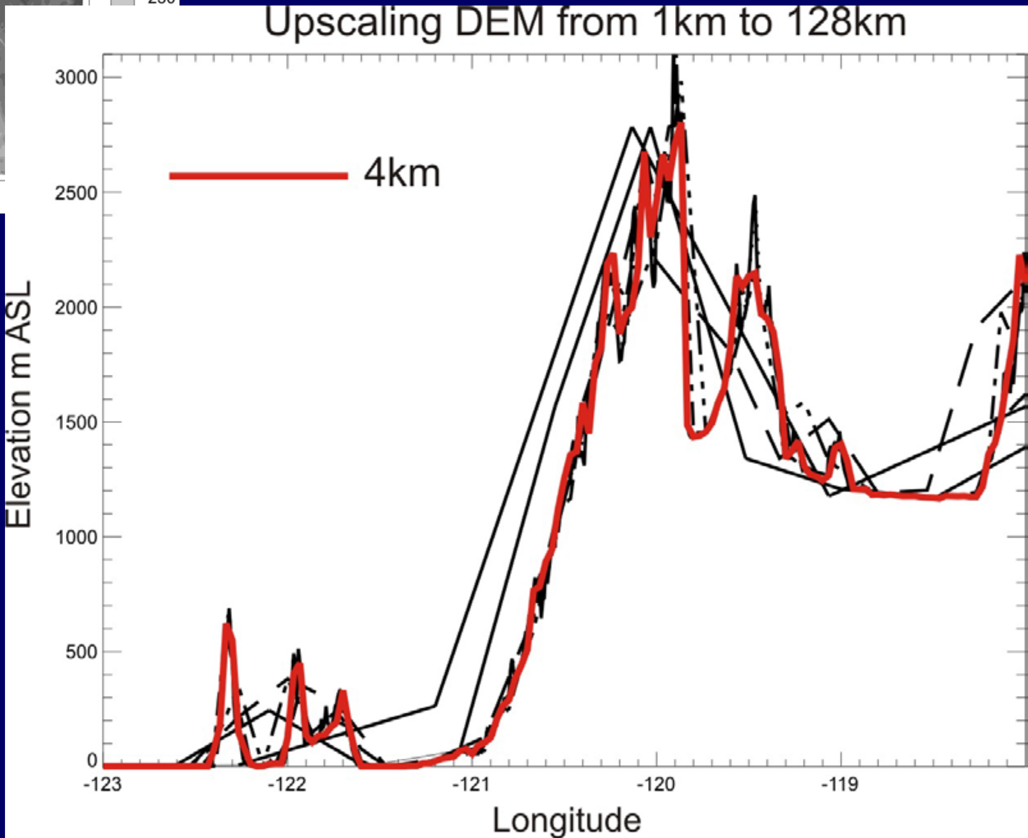
- This task aims to implement and develop transportable methodologies to improve the applicability of GCMs in climate impact, developing and using a state-of-the-art RCM based in WRF, and to provide these results to the research, education and decision making community.



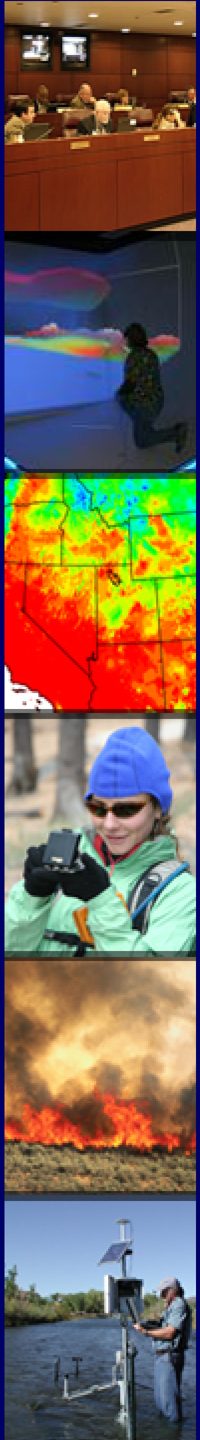
Surface boundary improvement





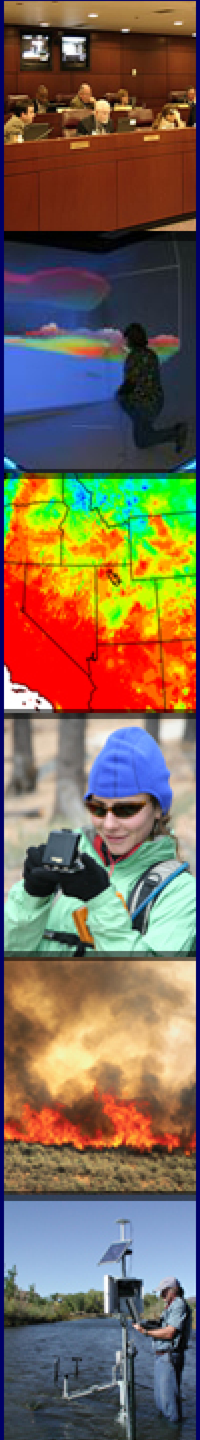


Our inner domain uses 4km resolution….
Is that enough?
Also….Vegetation type, Albedo, Soil type…



Dynamical downscaling: Regional climate modeling using Weather and Research Forecasting (WRF) model

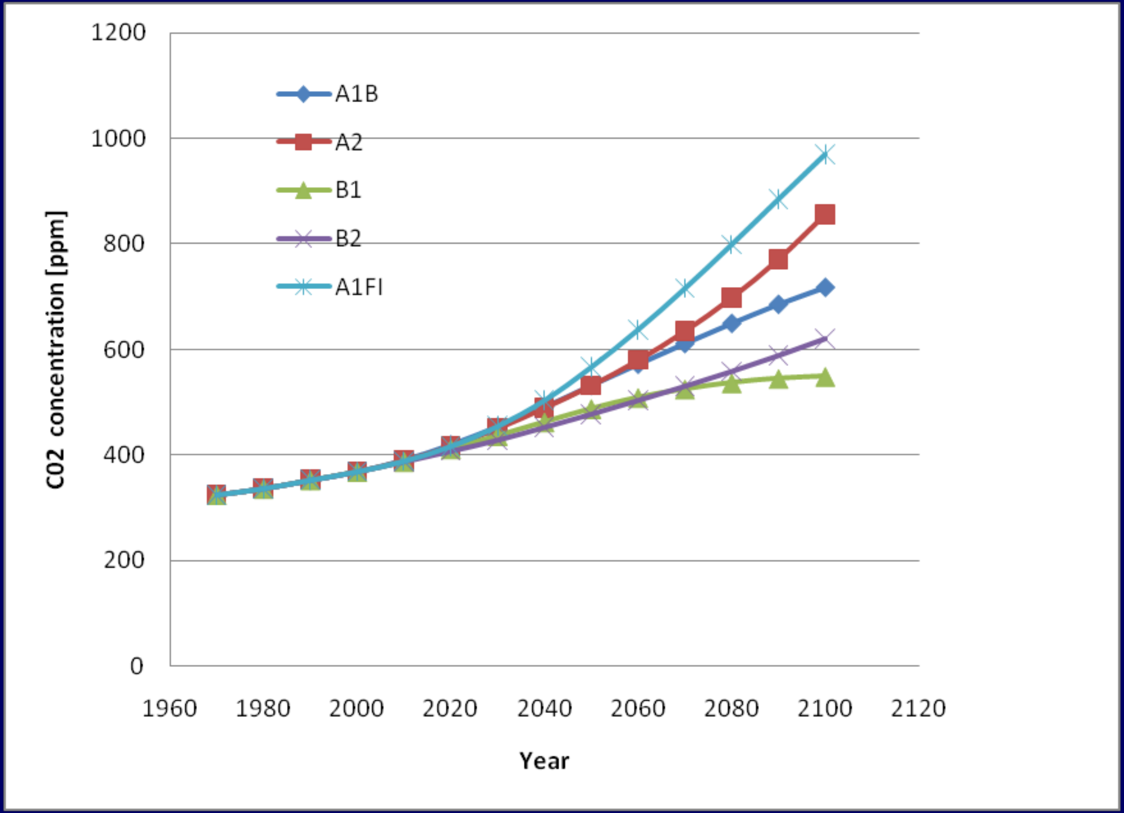
- Forcing data: Initial efforts using CCSM3 (soon V.4) and NCEP/NCAR global reanalysis products (NNRP).
- SST Updates.
- Integration mode: Spectral nudging (k=3) over D01 with relatively weak nudging factors. Only layers above the PBL are nudged.
- Convection: Kain-Fritsch for D01 and D02.
- Microphysics : single-moment 5-class.
- PBL: YSU
- LSM: a modified 4-layer NOAH-distributed (NCAR; Gochis and Chen 2009); water routing routine for surface and underground runoff.
- Radiation (SW and LW): RRTMG and CAM with GHG and aerosols updates.



Considered GHC and aerosol emission scenarios

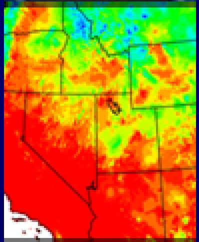
- Selected scenarios for our project:

  B1, A1B and A2 (‘low’, ‘medium’, and ‘high’ scenario, respectively).



CO2 emissions for different socio-economical and environmental scenarios (IPCC-2007 report: http://www.ipcc-data.org/)





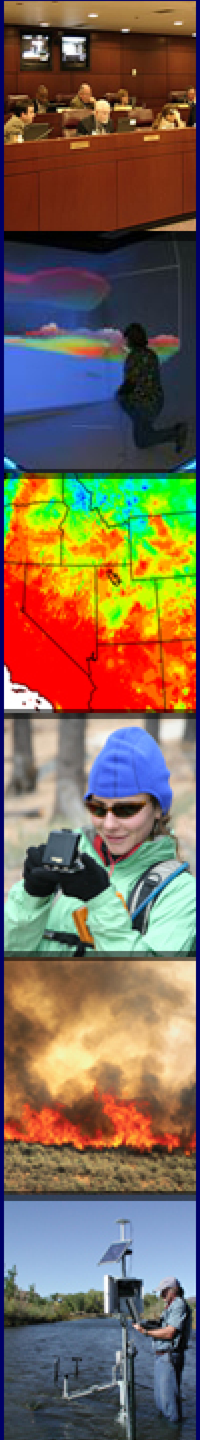

Dynamical downscaling: Regional climate modeling using Weather and Research Forecasting (WRF) model

- PLAN:

Scenario	1970s	1980s	1990s	2000s	2010s	2020s	2030s	2040s	2050s	2060s	2070s	2080s	2090s
NCEP	■	■	■	■									
CCSM-A1B	■	■	■	■	■			■	■			■	■
CCSM-A2				■	■			■	■			■	■
CCSM-B2				■	■			■	■			■	■

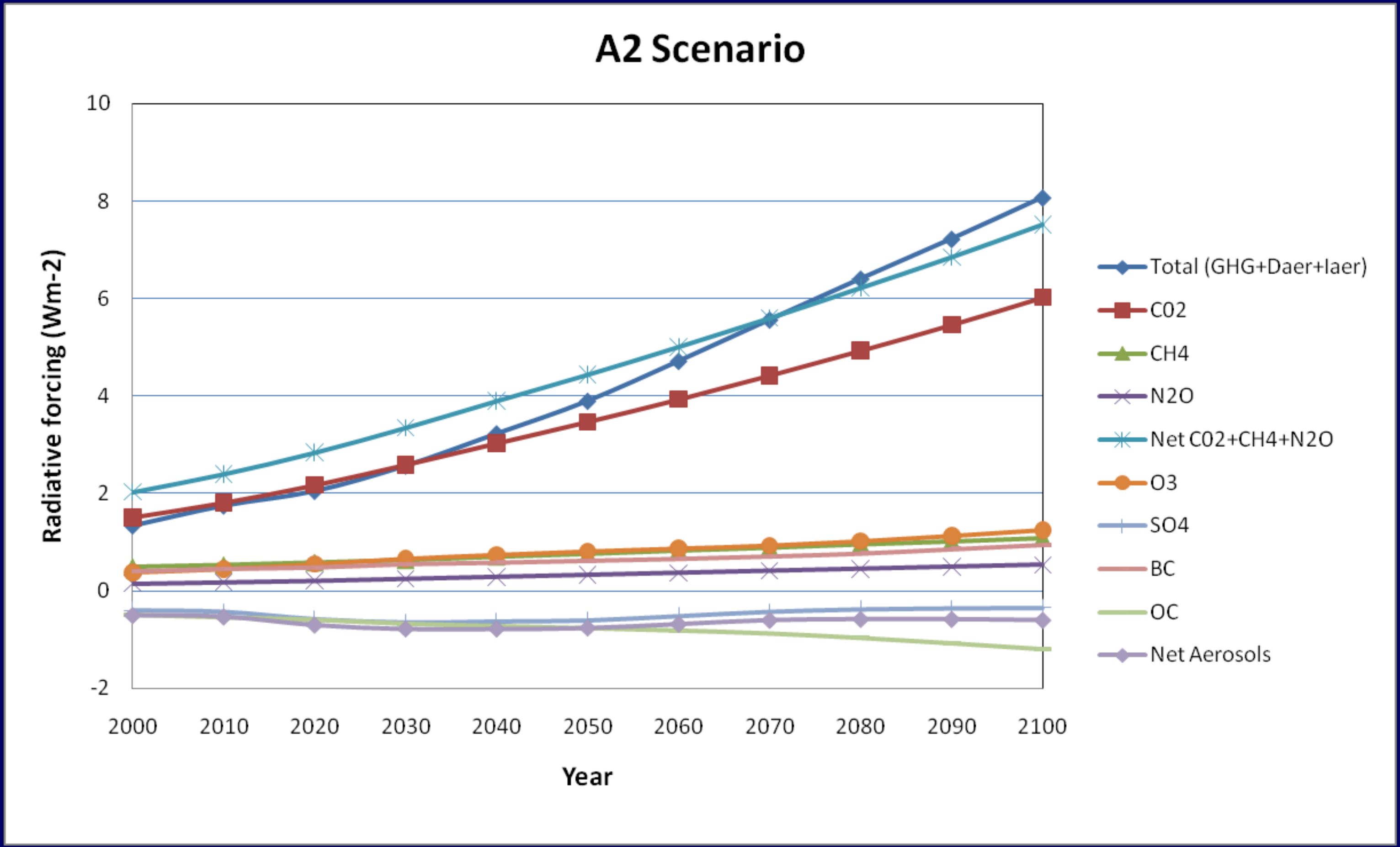
Schematic of the integration periods (shaded boxes) for different scenarios for the RCM downscaling approach. All simulations total 250 years.

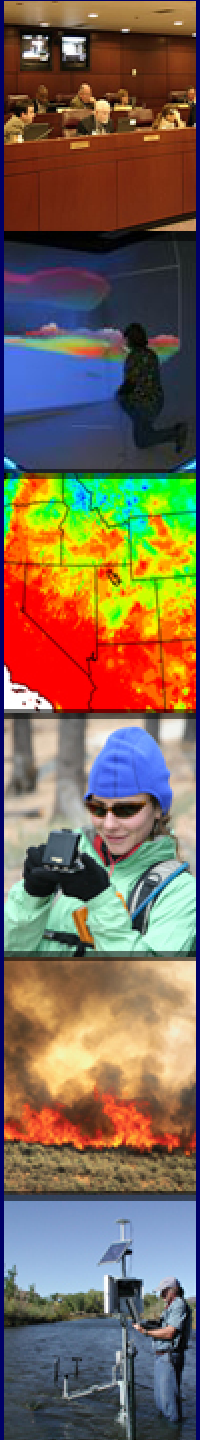
- Bulk of the computation would take about 6 months
- Hourly and 3 hourly RCM output data.
- Some data archiving issues: Available storage space 150T but need about 300TB.



Adaptation of WRF for long-term integration mode

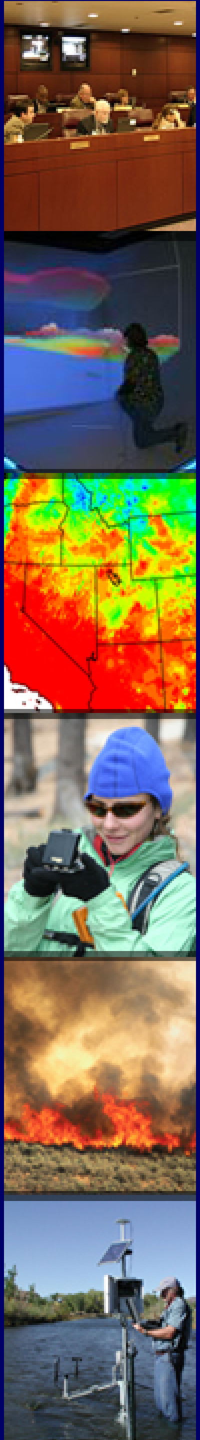
- e.g. Radiative forcings, emissivity, land use, vegetation type…





Cyberinfrastructure

- "GridLogin": 80 nodes (8 cores each = 640 cores); each node with 16GB and 146 Gb disk space. Infiniband connectivity . 150 TB storage capacity. (Physically at DRI)

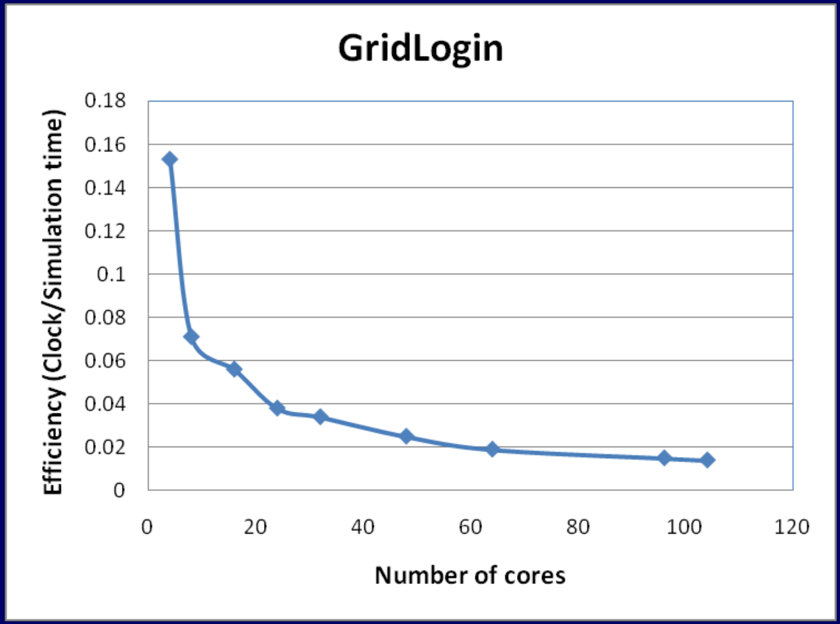


Cluster performance

- Computer system is operational, but the performance and stability is still not satisfactory.

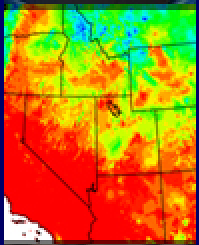
CORES	4	8	16	24	32	48	64	96	104
Clock time (hh:mm:ss)	4:36:11	2:07:32	1:41:06	1:09:13	1:01:12	00:45:05	00:34:08	00:27:19	00:25:50
Efficiency (Clock/Simulation time)	0.153	0.071	0.056	0.038	0.034	0.025	0.019	0.015	0.014

30-hour WRF clock time for different core numbers in GridLogin and its efficiency



30-hour WRF clock time for different core numbers in GridLogin and its efficiency.

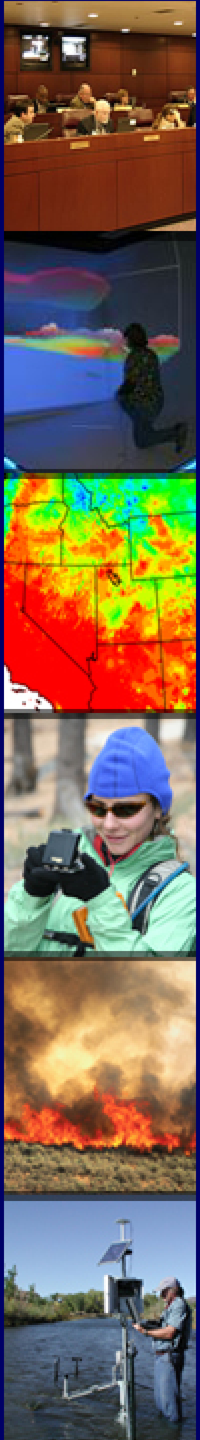




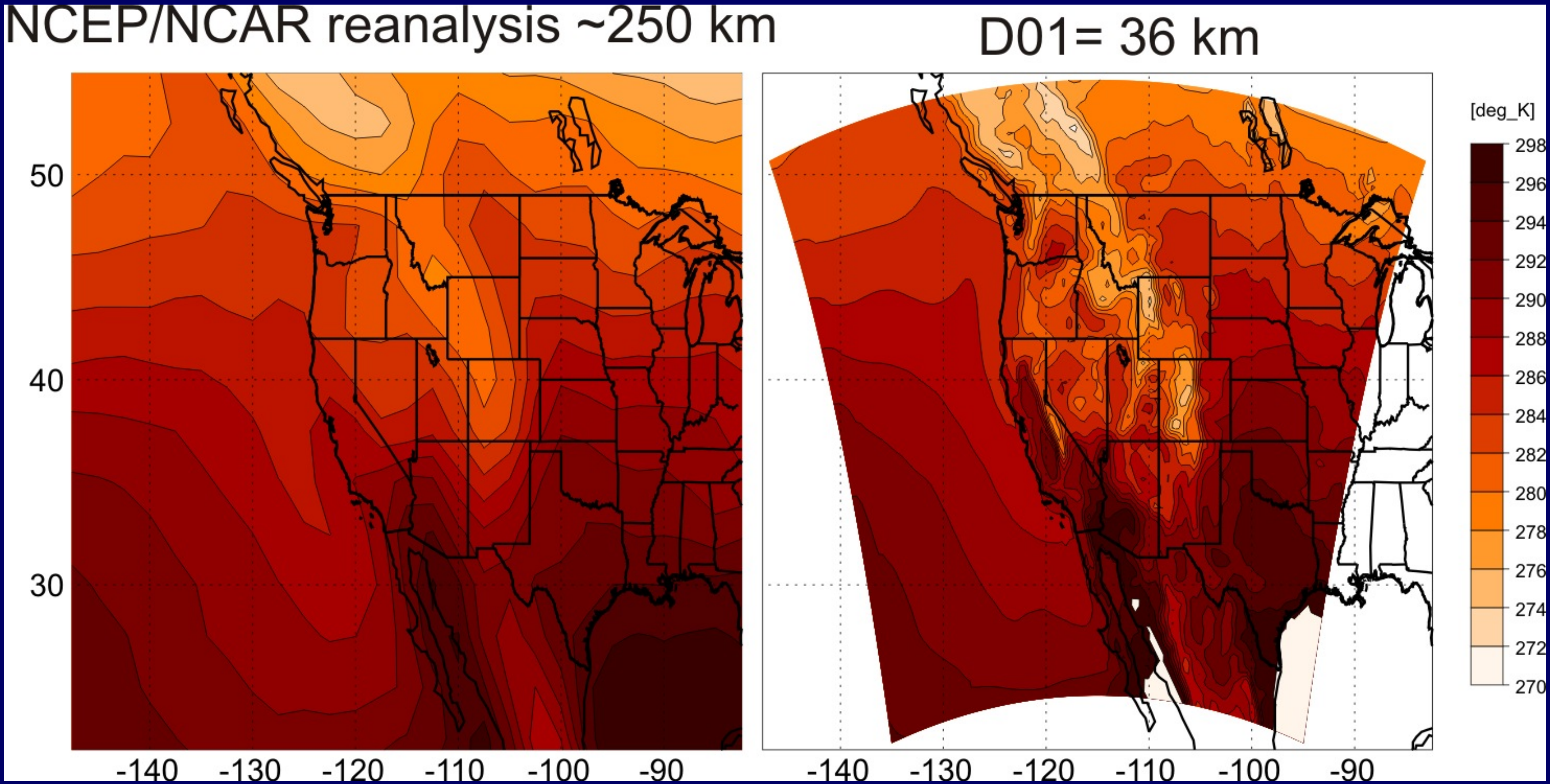

As we speak…

		Year 1				Year 2				Year 3				Year 4				Year 5			
NCEP/NCAR-WRF		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Years	Spinup May 1 to Aug 31																				
70-75	■	■	■	■																	
75-80	■	■	■																		
80-85	■	■	■																		
85-90	■	■	■																		
90-95	■	■																			
95-00	■	■																			
00-05	■	■																			
2005-2008	■																				
Total Processors	512																				
Estimated time	45 days																				

Fall-Winter ,
1970

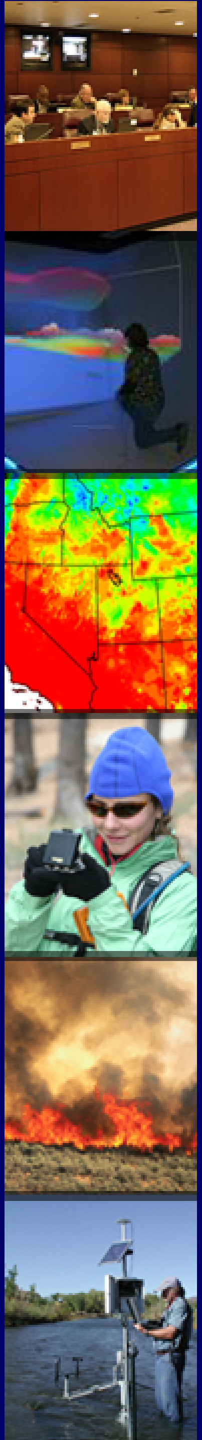


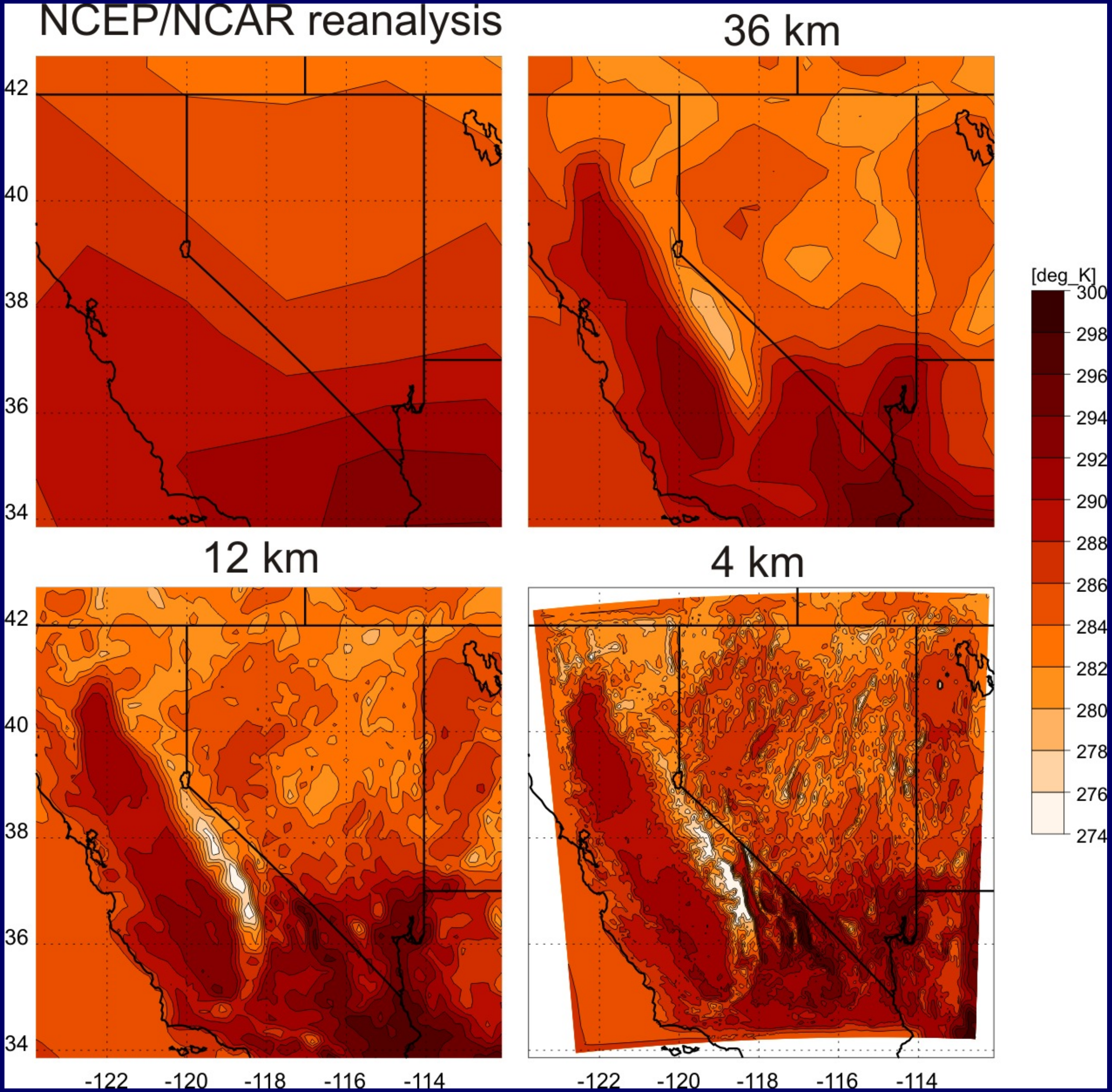
An example of Dynamical Downscaling: Mean Surface Temperatures



Fall-Winter , 1970

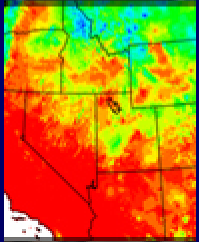
Downscaling Sfc Temperatures





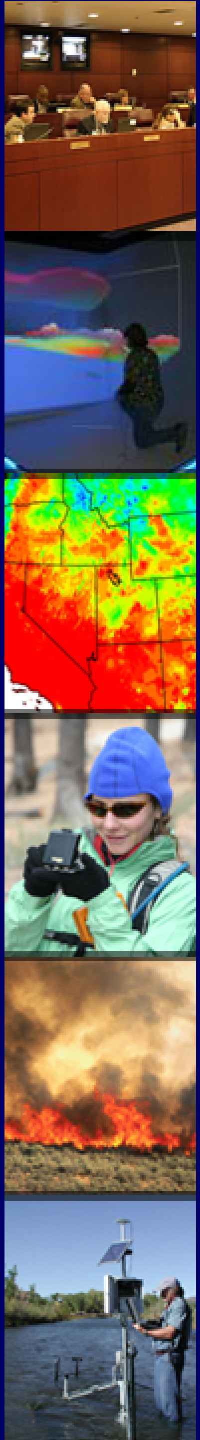
Fall-Winter , 1970



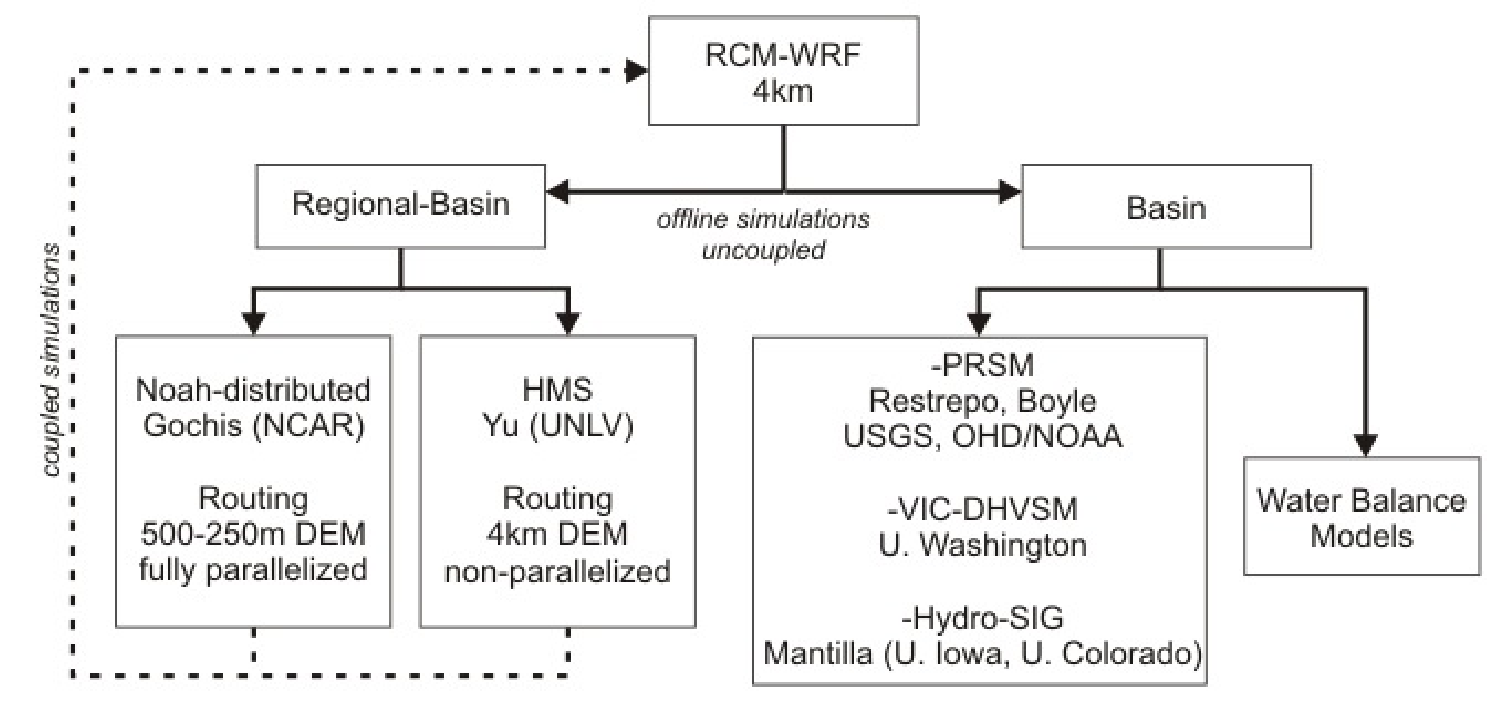



Linkages with Other Components

- Cyberinfrastructure
  - Link to data portal and processing software
- Landscape change (land-atmosphere interactions)
  - Paleoclimate modeling
  - Climate modeling
- Water Resources
  - Climate predictions of water resources, their variability, uncertainties, and socio-economic impacts
- Policy
  - Alternative Future scenarios (urbanization); socio-economic aspects of future water supply
- Education – Graduate students, post doctoral fellows



Linkages with Other Components: Hydrological applications

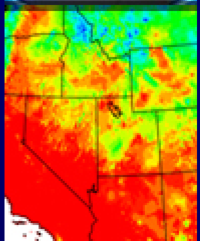
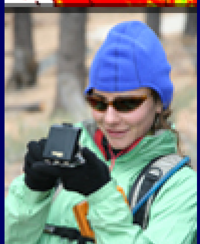


Links with different hydrological modeling teams.

Foster a more formal and dynamical collaboration between different hydrological groups and our Climate Modeling activities

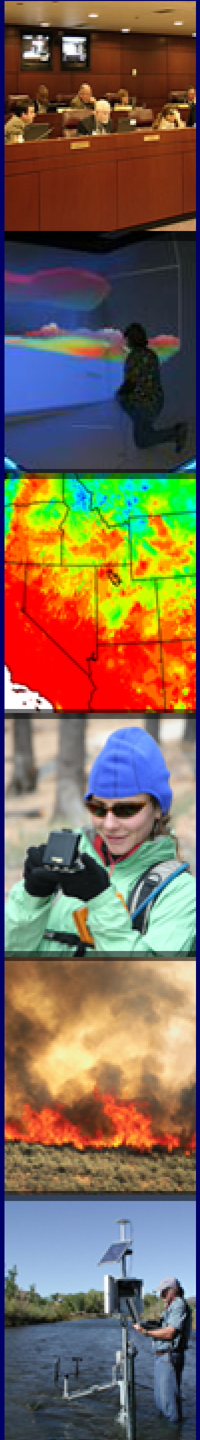
My personal focus: The land-atmosphere coupling –Hydroclimatology studies.



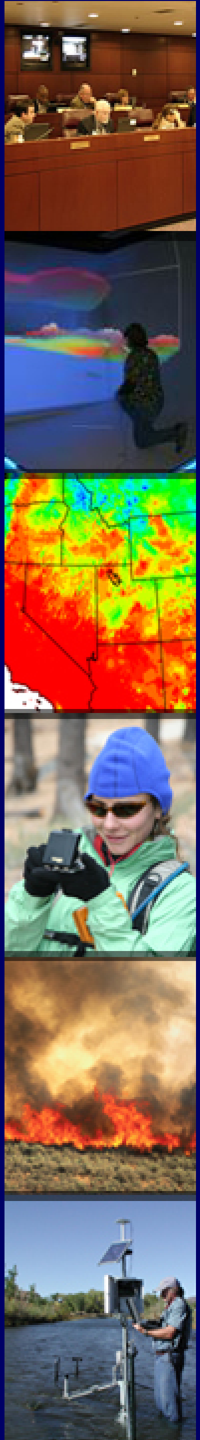
Output Variables

3D fields (3 hourly)	**3D fields (hourly)**
U: x-wind component	TSLB: Soil Temperature
V: y-wind component	SMOIS: Soil Moisture
W: z-wind component	SH2O: Soil Liquid Water
H: Geopotential Height	
T: Potential Temperature	
P: Pressure	
QVAPOR: Water Vapor Mixing Ratio	
QCLOUD: cloud water mixing ratio	
QRAIN: Rain Water Mixing Ratio	
QICE: Ice Mixing Ratio	
QSNOW: Snow Mixing Ratio	
2D fields (3 hourly)	**2D fields (hourly)**
Fraction of Frozen Precipitation	POTEVP: accumulated potential evaporation
SST: Sea Surface Temperature	SNOPCX: snow phase change heat flux
	SOILTB: bottom soil temperature
	Q2: QV at 2 M
	T2: TEMP at 2 M
	TH2: POT TEMP at 2 M
	PSFC: SFC PRESSURE
	U10: U at 10 M
	V10: V at 10 M
	SMSTAV: Moisture Availability
	SMSTOT: Total Soil Moisture
	SFROFF: Surface Runoff
	UDROFF: Underground Runoff
	SFCEVP: Surface Evaporation
	GRDFLX: Ground Heat Flux
	ACGRDFLX: Accumulated Ground Heat Flux
	ACSNOW: Accumulated Snow
	ACSNOM: Accumulated Melted Snow
	SNOW: Snow Water Equivalent
	SNOWH: Physical Snow Depth
	....



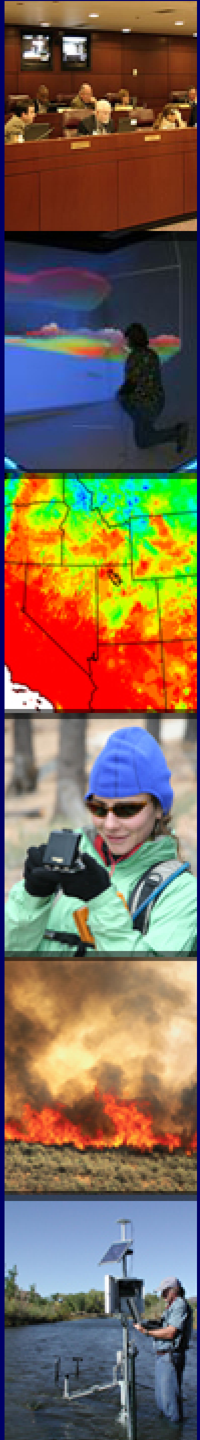
Output Variables

2D fields (hourly)
……..
RHOSN: Snow Density
CANWAT: Canopy Water
TSK: Surface Skin Temperature
RAINC: Accumulated Total Cumulus Precipitation
RAINNC: Accumulated Total Grid Scale Precipitation
SNOWNC: Accumulated Total Grid Scale Snow And Ice
GRAUPELNC: Accumulated Total Grid Scale Graupel
SWDOWN: Downward Short Wave Flux At Ground Surface
GLW: Downward Long Wave Flux At Ground Surface
ACSWUPT: Accumulated Upwelling Shortwave Flux At Top
ACSWUPTC: Accumulated Upwelling Clear Sky SW Flux At Top
ACSWDNT: Accumulated Downwelling Shortwave Flux At Top
ACSWDNTC: Accumulated Downwelling Clear Sky SW Flux At Top
ACSWUPB: Accumulated Upwelling Shortwave Flux At Bottom
ACSWUPBC: Accumulated Upwelling Clear Sky SW Flux At Bottom
ACSWDNB: Accumulated Downwelling Shortwave Flux At Bottom
CSWDNBC: Accumulated Downwelling Clear Sky SW Flux At Bottom
ACLWUPT: Accumulated Upwelling Longwave Flux At Top
ACLWUPTC: Accumulated Upwelling Clear Sky Longwave Flux At Top
ACLWDNT: Accumulated Downwelling Longwave Flux At Top
ACLWDNTC: Accumulated Downwelling Clear Sky Longwave Flux At Top
ACLWUPB: Accumulated Upwelling Longwave Flux At Bottom
ACLWUPBC: Accumulated Upwelling Clear Sky Longwave Flux At Bottom
ACLWDNB: Accumulated Downwelling Longwave Flux At Bottom
ACLWDNBC: Accumulated Downwelling Clear Sky Longwave Flux At Bottom
OLR: TOA Outgoing Long Wave
EMISS: Surface Emissivity
PBLH: PBL Height
HFX: Upward Heat Flux At The Surface
QFX: Upward Moisture Flux At The Surface
LH: Latent Heat Flux At The Surface
ACHFX: Accumulated Upward Heat Flux At The Surface
ACLHF: Accumulated Upward Latent Heat Flux At The Surface



Future steps

- Soon! ~ 2 months. Simulations from present climate (1970-2008).
- Statistical and dynamical downscaling applied to hydrological modeling (offline and couple modes)
- Analysis of Extreme weather events and statistics
- Ensemble approach to regional climate projections



Acknowledgements

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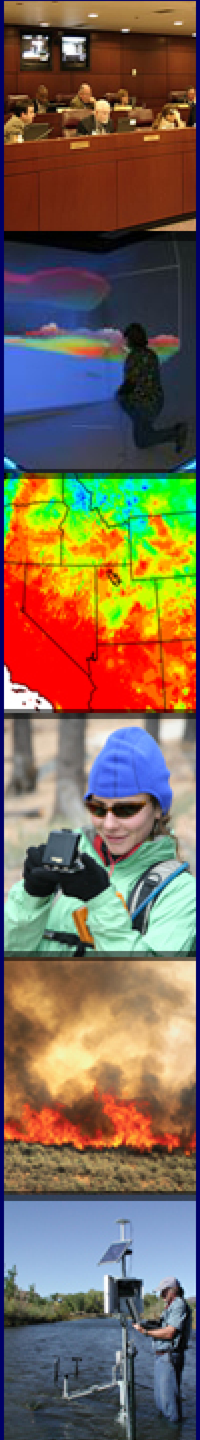

Contact us

John.mejia@dri.edu

Darko.Koracin@dri.edu