Multi-Model Ensembles for Seasonal and Interannual Prediction of Precipitation

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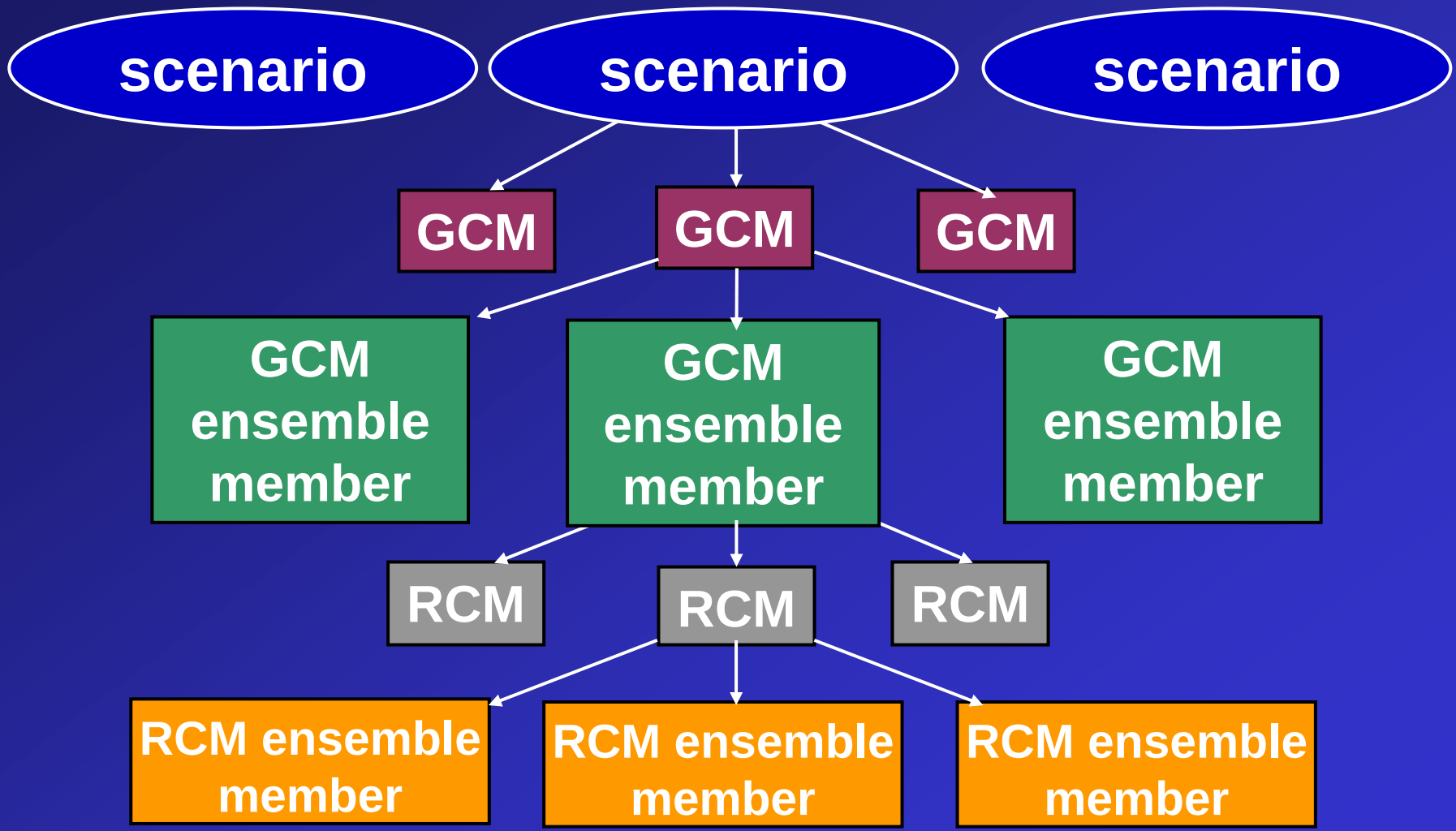
Context: Dynamical downscaling by nested limited-area models

- Use a high-resolution, limited-area model to obtain results on decision-relevant scales from a global model.
- Divergence of solutions is constrained by imposition of lateral boundary data.

Ensemble Forecasting Methods

- Same model, different initial conditions
  - also called “perfect model” approach
  - usually underdispersive
- Same initial conditions, different model
  - also called “perfect data” approach
- Combination
  - Neither the models nor the data are perfect!

Mother Of Ensembles
(aka Shukla Staircase, other names)



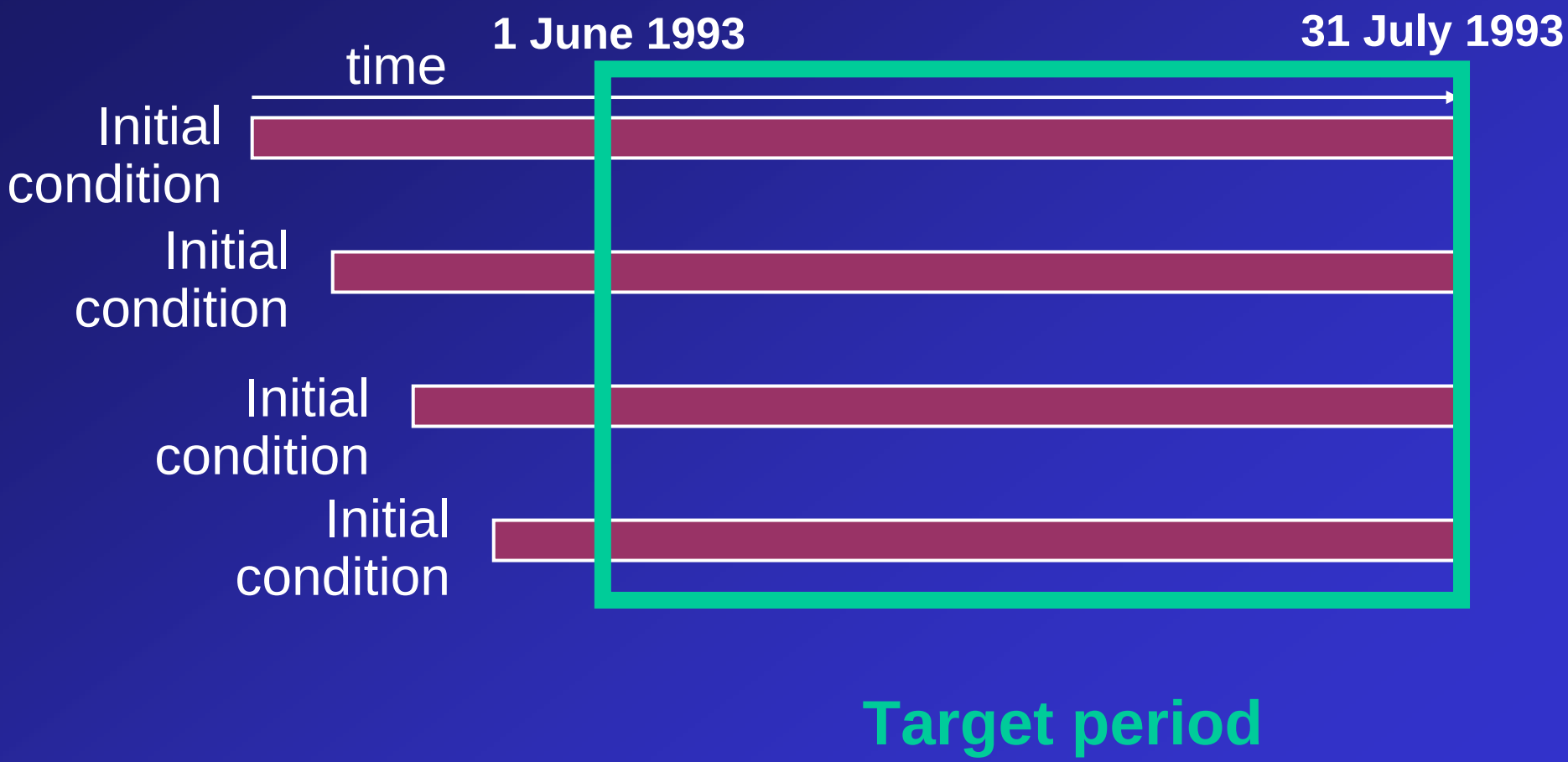
How much of this is necessary?

- What are the greatest sensitivities in nested global-regional climate models?
- How can we most efficiently employ our computer time and (most important) people?
- Results from ensemble studies using GCMs and short-range forecast models may not be applicable:
  - nested simulations are strongly constrained by lateral boundary conditions.

Approach

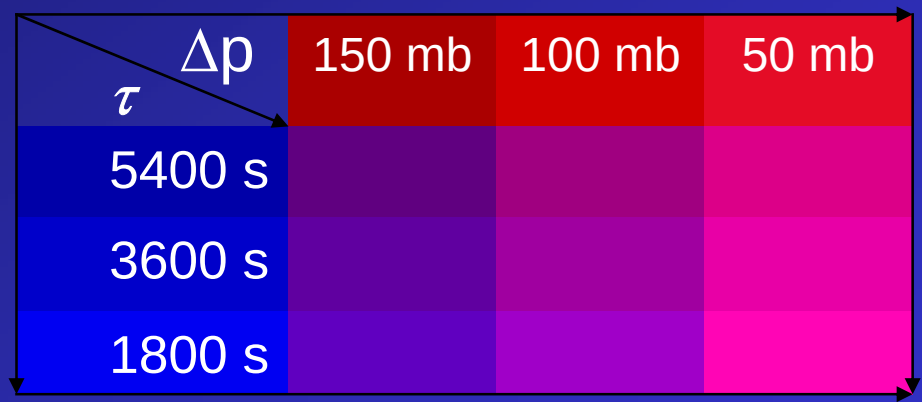
- Compare four different types of ensembles:
  - lagged average ensemble (sensitivity to initial conditions)
  - perturbed physics ensemble (sensitivity to closure parameters)
  - mixed physics ensemble (sensitivity to closure schemes or assumptions)
  - multi-model ensemble (inter-model variability)
- Test case: PIRCS 1B record regional flood over north-central U.S. (1 June - 31 July 1993)

Lagged-average ensemble

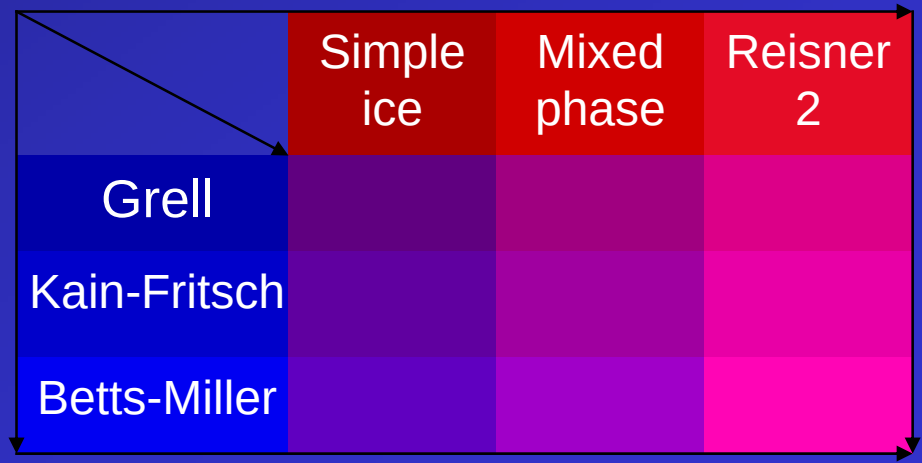


Physics ensembles

Perturbed physics ensemble: Vary two closure parameters in the deep convection scheme across plausible ranges



Mixed physics ensemble: Use different choices for parameterization of deep convection and parameterization of grid-scale microphysics

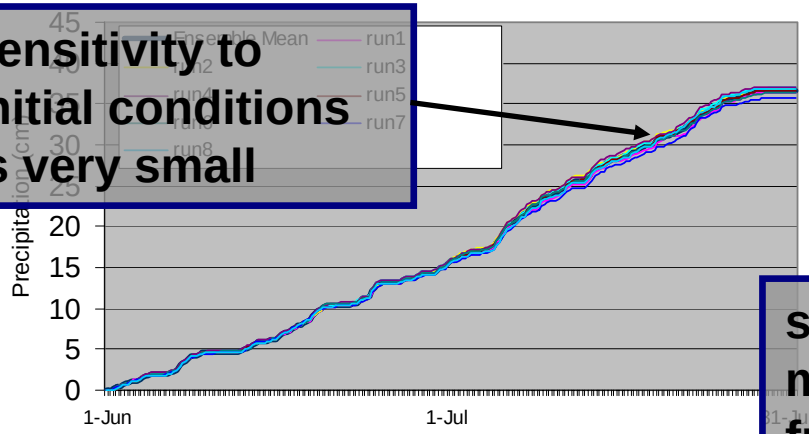


Multi-Model Ensemble

- PIRCS 1B model participants
- 12 regional climate models from collaborators in North America, Europe and Australia

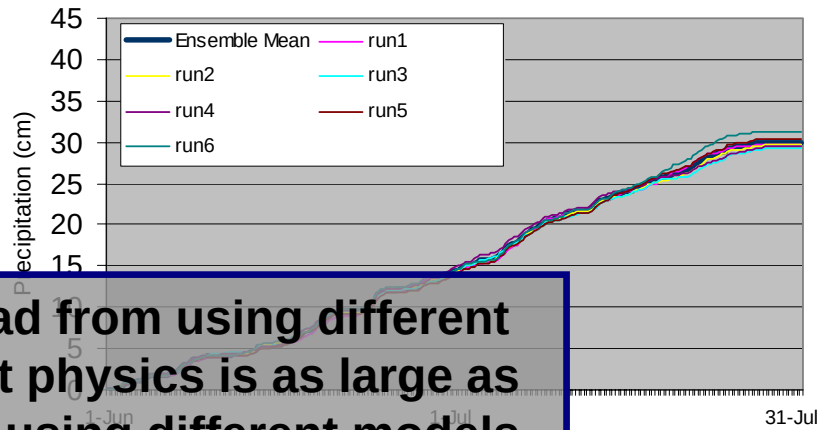
Area-averaged precipitation in the north-central U.S.

Lagged



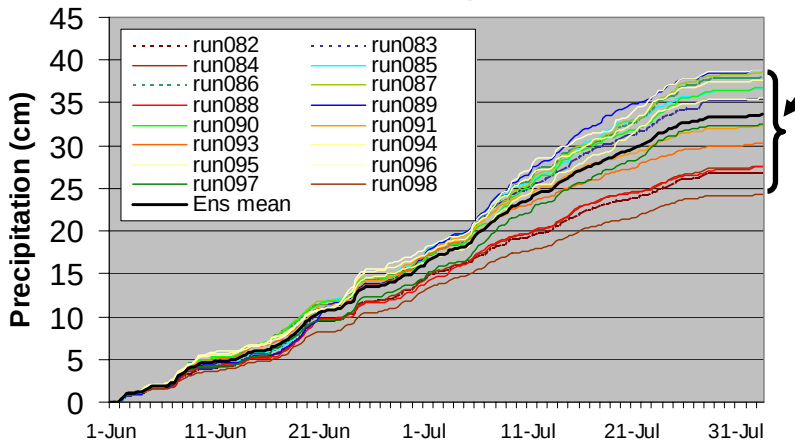
sensitivity to initial conditions is very small

Perturbed Physics

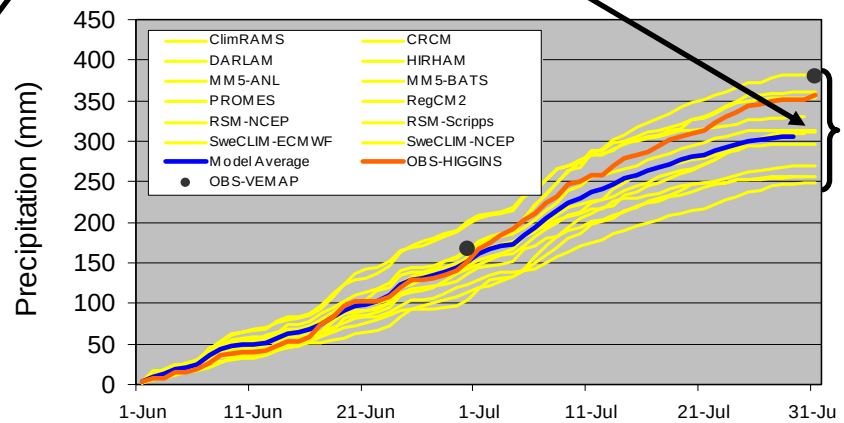


spread from using different moist physics is as large as from using different models

Mixed Physics

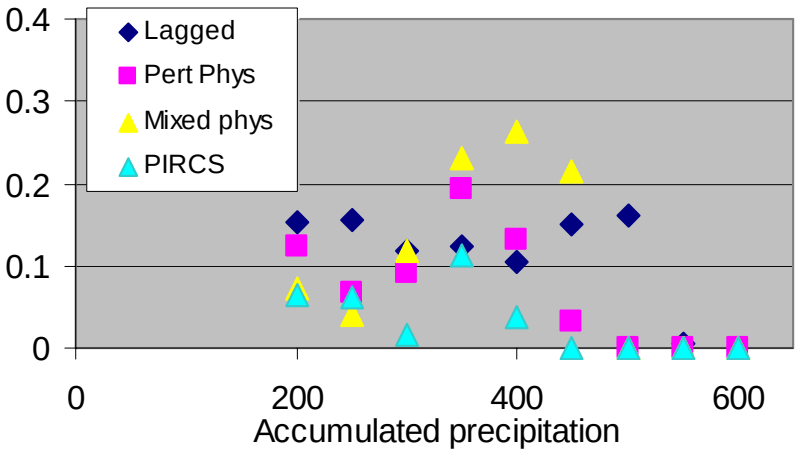


Multi-Model (PIRCS 1B)

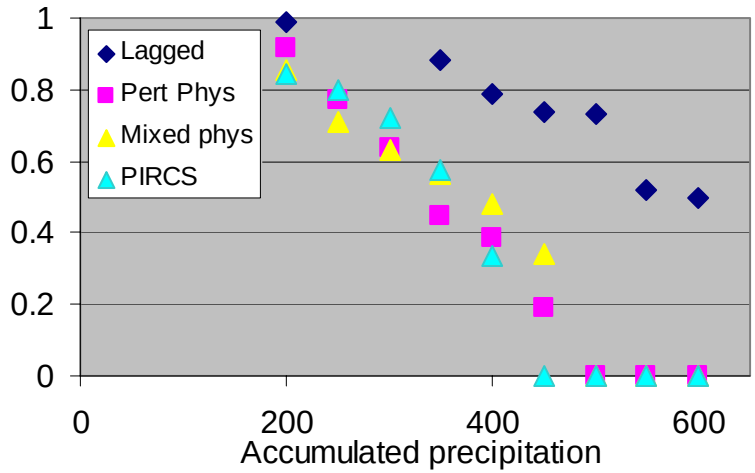


Verification results

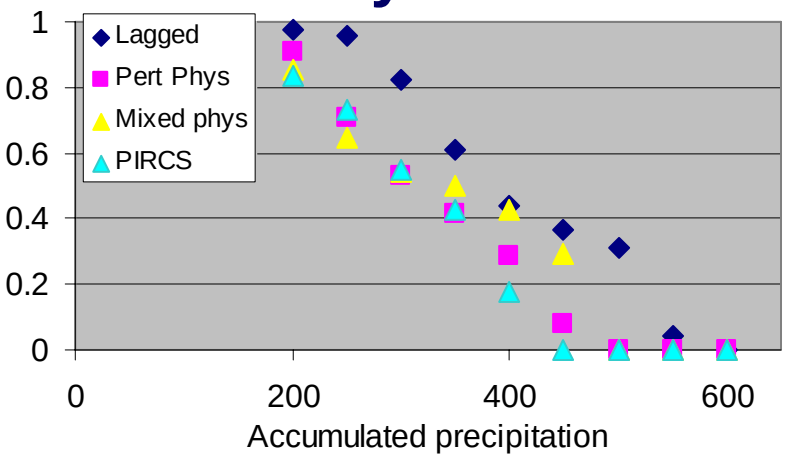
Equitable Threat Score



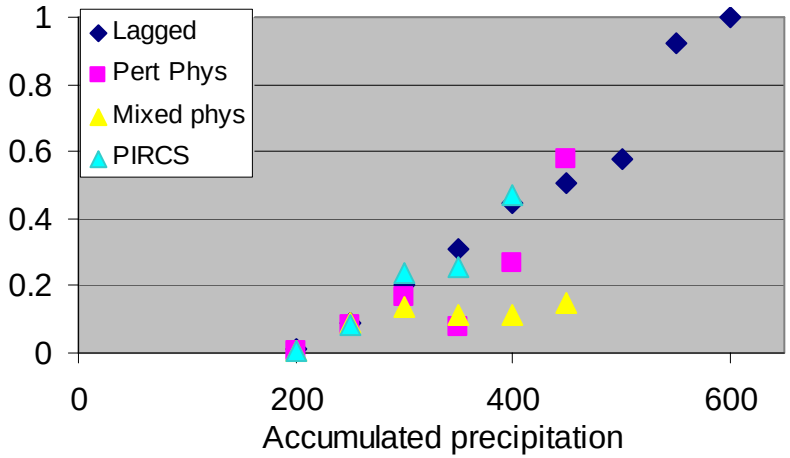
Bias



Probability of Detection



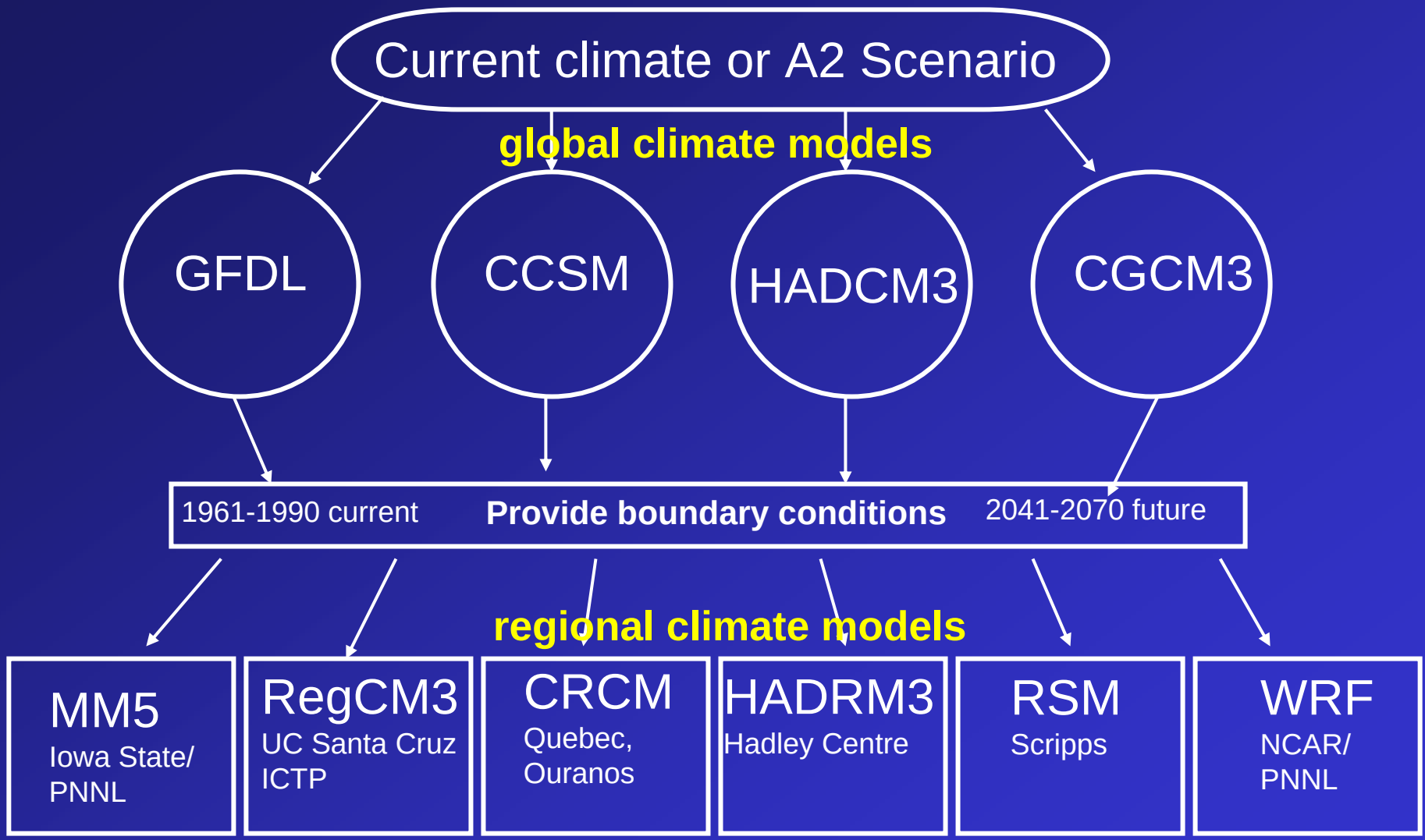
False Alarm Rate



Extension to multi-year and multi-GCM ensembles: NARCCAP

- NARCCAP = North America Regional Climate Change Assessment Program
- Goal is to explore multiple uncertainties: How does uncertainty propagate from global models through the regional models?
- Develop high-resolution realizations of regional climate scenarios for use in impacts models.
  - Output will be made widely available to the community for impacts studies and additional analysis projects.

NARCCAP PLAN



NARCCAP Plans

- Phase I: 1979-2004 driven by Reanalysis 2
  - establish uncertainty in RCMs
- Phase IIa: RCMs driven by AOGCM 20th century climate (nominally 1971-2000)
  - includes free-running ocean model (fully predictive)
  - combined GCM-RCM uncertainty
- Phase IIb: RCMs driven by AOGCM SRES A2 scenario 2041-2070

North America Regional Climate Change Assessment Program: Participants

- Christopher Anderson, Raymond Arritt, William Gutowski, Gene Takle, Iowa State University, USA
- Erasmo Buono, Richard Jones, Hadley Centre, UK
- Daniel Caya, OURANOS, Canada
- Phil Duffy, Lawrence Livermore National Laboratories, USA
- Filippo Giorgi, Jeremy Pal, Abdus Salam ICTP, Italy
- Isaac Held, Ron Stouffer, NOAA Geophysical Fluid Dynamics Laboratory, USA
- René Laprise, Univ. de Québec à Montréal, Canada
- Ruby Leung, Pacific Northwest National Laboratories, USA
- Linda O. Mearns, Doug Nychka, Phil Rasch, Tom Wigley, National Center for Atmospheric Research, USA
- Ana Nunes, John Roads, Scripps Institution of Oceanography, USA
- Steve Sain, Univ. of Colorado at Denver, USA
- Lisa Sloan, Mark Snyder, Univ. of California at Santa Cruz, USA

Summary

- Nested seasonal models show little sensitivity to initial conditions
- Use of different moist physics parameterizations produced about as much spread as use of completely different models:
  - possibly a simpler alternative to multi-model ensemble forecasts
- Proposal: The general approach and especially the “NARCCAP paradigm” would be useful to provide input for hydrologic models in HEPEX.

Without sufficient resolution, it just doesn't look right!