The Experimental Climate Prediction Center (ECPC)'s Regional Spectral Model

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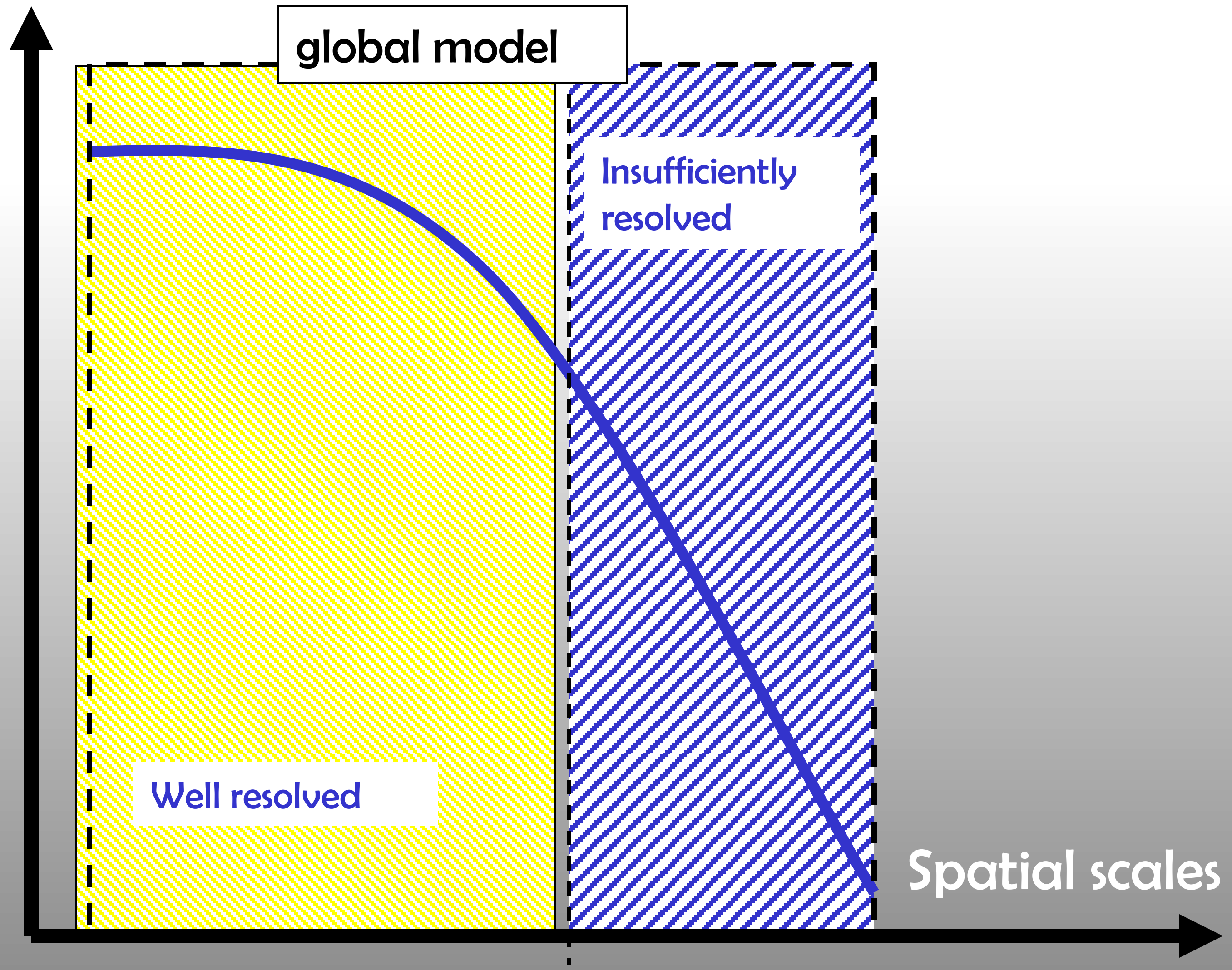
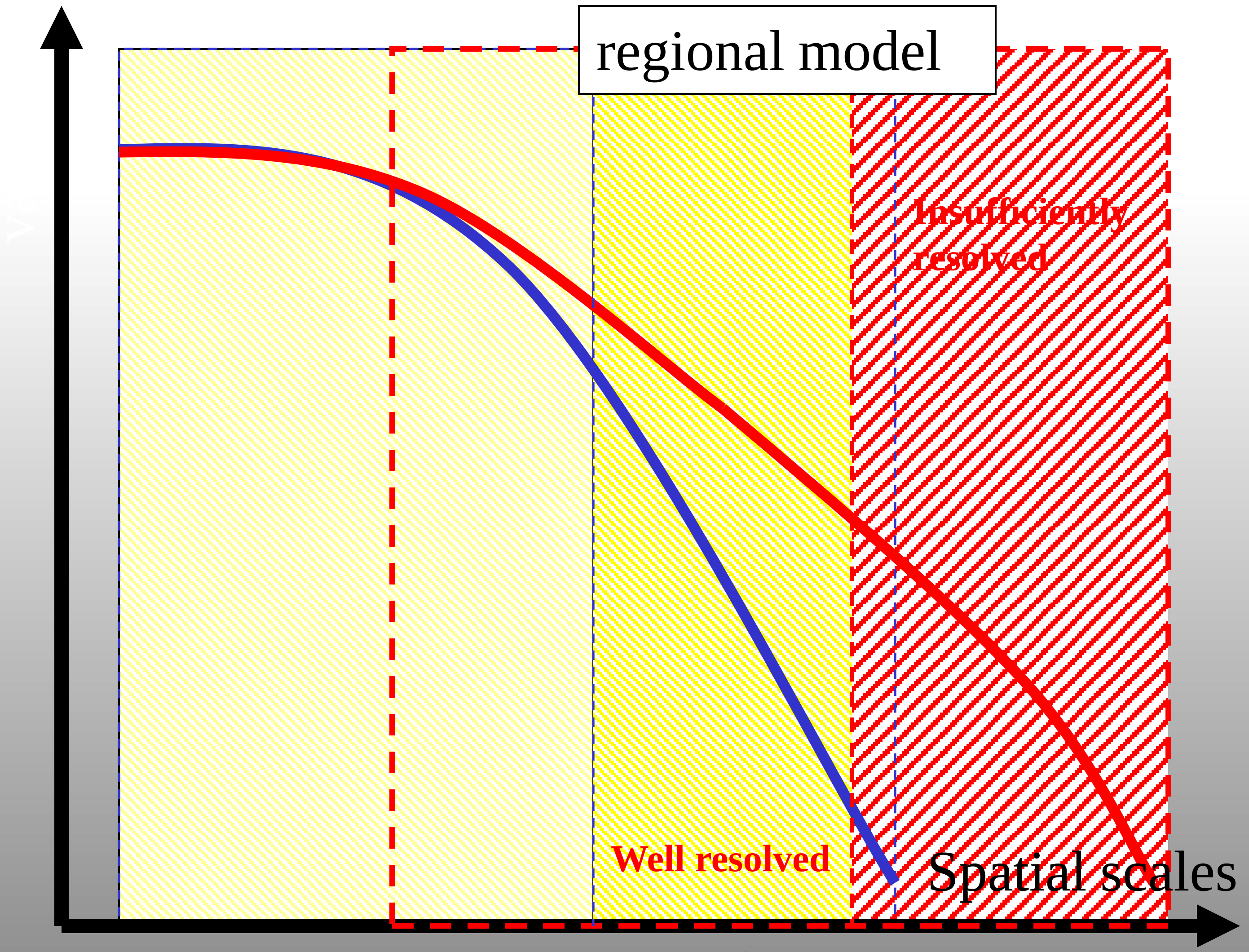
- Dynamical downscaling became more popular in the last decade due to the improvements in the nesting approaches used in regional models to downscale the global analyses.

- In contrast to the statistical downscaling, the regional downscaling through dynamically consistent numerical models can represent the evolution of non-linear systems from large-scale analyses.



Courtesy of Hans von Storch



Courtesy of Hans von Storch

Added value

- The ECPC-Regional Spectral Model (RSM) is a hydrostatic, primitive equation system, with “normalized pressure” or “sigma” as vertical coordinate.
- In the ECPC’s system, regional and global models share most of their codes.
- The new ECPC-RSM is coupled to an updated version of the 4-layer Noah Land-Surface Model (Noah LSM; Mitchell *et al*. 2004), and also includes the Scale-Selective Bias Correction (SSBC; Kanamaru and Kanamitsu 2007) that is similar to the spectral nudging technique described in von Storch *et al.* (2000).

One of the strategies used to improve high-resolution downscaled long-term simulations is the spectral nudging, which is an attempt to preserve the large-scale features from the global solution into the regional domain during long integrations.

Scale-Selective Bias Correction

(SSBC; Kanamaru and Kanamitsu 2007)

$$\frac{dP^{new}}{dt} = \frac{1}{1+\alpha}\frac{dP^{old}}{dt}$$

P: Perturbation

$P = F - F^{anl}$

$\alpha = 0.9$

- Tendency of perturbation (dP/dt) is damped for U and V.
- Area average is corrected for T and q.
- Surface pressure ($\ln p_s$) correction is also applied.

Advantages of Spectral Nudging: No dependency on domain size

Kanamaru and Kanamitsu, MWR 2007

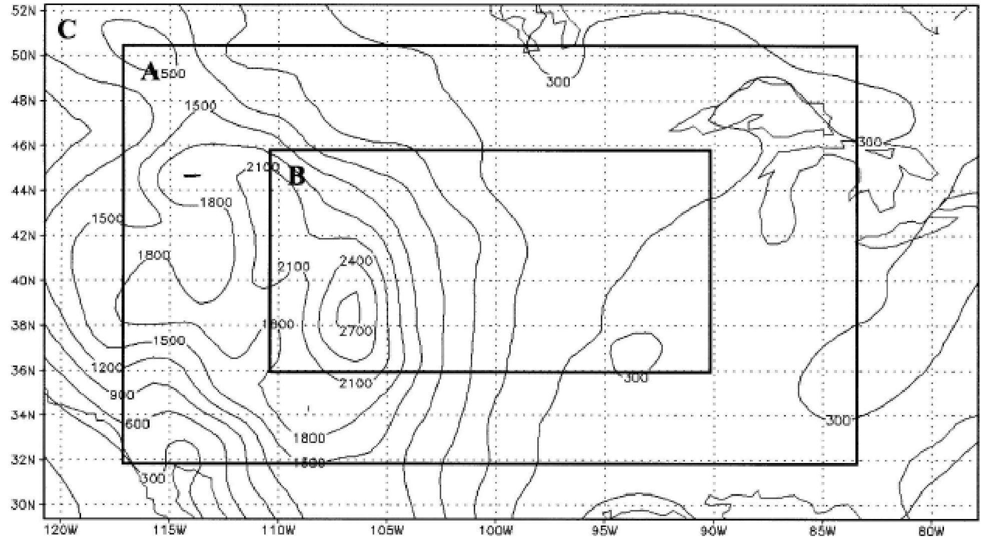


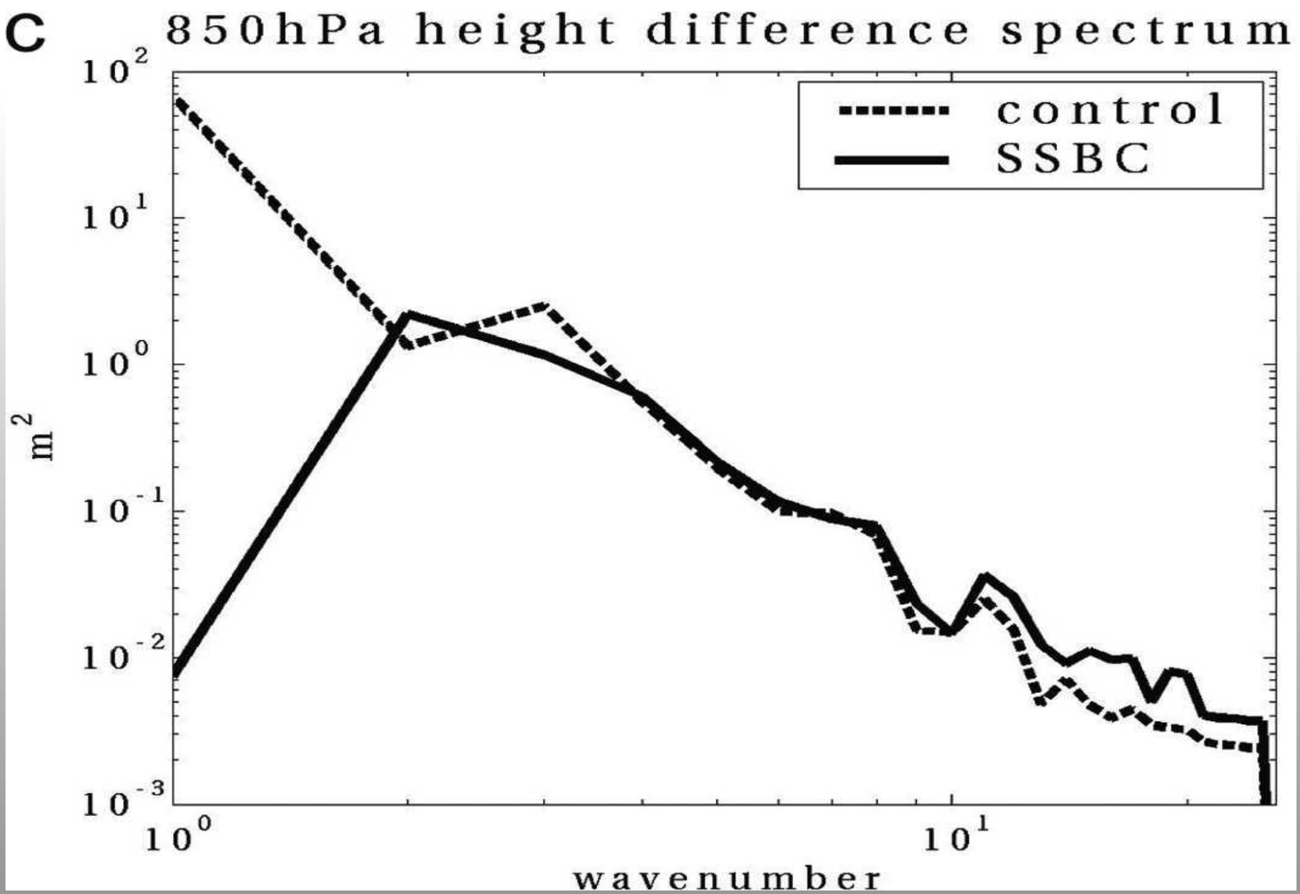
FIG. 3. Three domain sizes for the domain size sensitivity experiment (Fig. 4 and Table 2): (a) 48 × 35 grids, 2880 km × 2100 km; (b) 24 × 17 grids, 1440 km × 1020 km; and (c) 60 × 43 grids, 3600 km × 2580 km.

TABLE 2. RMSD of 500-hPa height (m) between the regional model and the reanalysis field in winter of 2000/01 calculated for the common area (domain B). The model was run for the different domain sizes shown in Fig. 3.

	A	B	C
Control	5.9	15.1	7.6
SSBC	2.9	2.4	2.5

LB Nudging → Control

Spectral Nudging → SSBC



SSBC: Kanamaru and Kanamitsu, MWR 2007

Physics I

Description of IR and solar radiation schemes: SW radiation scheme based on Chou (1992) includes the absorption and scattering due to ozone, water vapor, oxygen, carbon dioxide, clouds, and aerosols. LW radiation scheme from Chou and Suarez, 1994.

Principal references: Chou, M. D, 1992: A solar-radiation model for use in climate studies. *J. Atmos. Sci.*, 49, 762-772. Chou, M. D., and M. J. Suarez, 1994: An efficient thermal infrared radiation parameterization for use in general circulation models. Technical Report Series on Global Modeling and Data Assimilation/NASA Technical Memorandum 1994-104606, 3, 85 pp.

The cloud scheme is based on relative humidity threshold values (Slingo, 1987).
Principal reference: Slingo, J. M., 1987: The development and verification of a cloud prediction model for the ECMWF model. *Quart. J. Roy. Meteor. Soc.*,113, 899-927.

Physics II

Description of deep convection scheme: Simplified Arakawa-Schubert (SAS) formerly by Grell (1993), version from Pan and Wu (1995), adapted by Hong and Pan (1998).

Principal reference: Hong, S. –Y., and H. –L. Pan, 1998: Convective trigger function for a mass-flux cumulus parameterization scheme. *Mon. Wea. Rev.*, 126, 2599-2620.

Description of boundary layer scheme: Boundary layer diffusion scheme based on Troen and Mahrt (1986) nonlocal diffusion. The turbulent diffusivity coefficients are function of the boundary layer heights and scale parameters derived from similarity (Hong and Pan, 1996).

Principal reference: Hong, S. -Y., and H. -L. Pan, 1996: Nonlocal boundary layer vertical diffusion in a Medium-Range Forecast Model. Mon. Wea. Rev., 124, 2322-2339.

Physics III

Description of land surface scheme: Updated four-layer (0-10 cm, 10-40 cm, 40-100 cm, 100-200cm) soil model Noah (Mitchell *et al*., 2004).

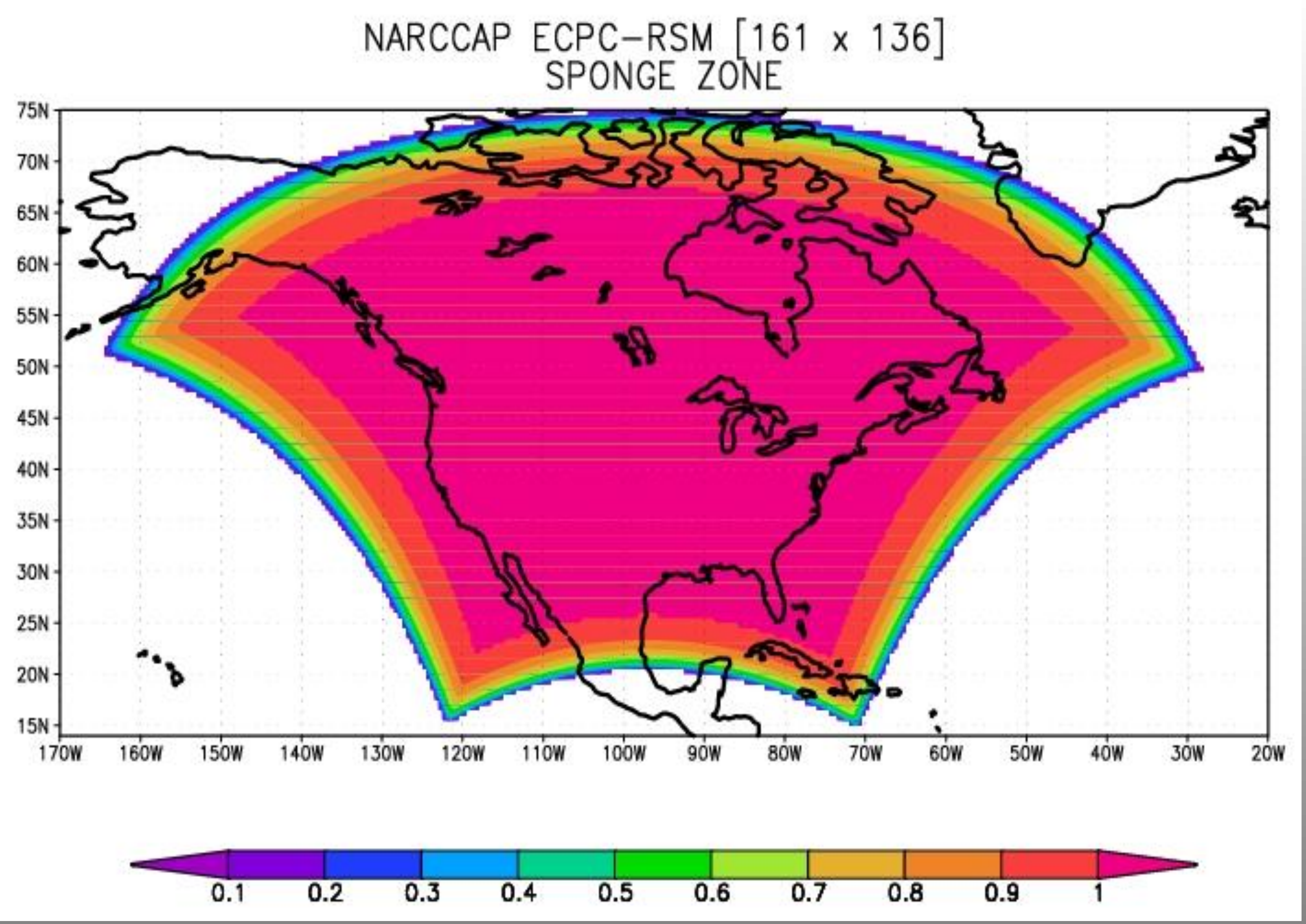
Principal reference: Mitchell, K. E., and Coauthors, 2004: The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system. *J. Geophys. Res.*, 109, D07S90, doi:10.1029/2003JD003823.

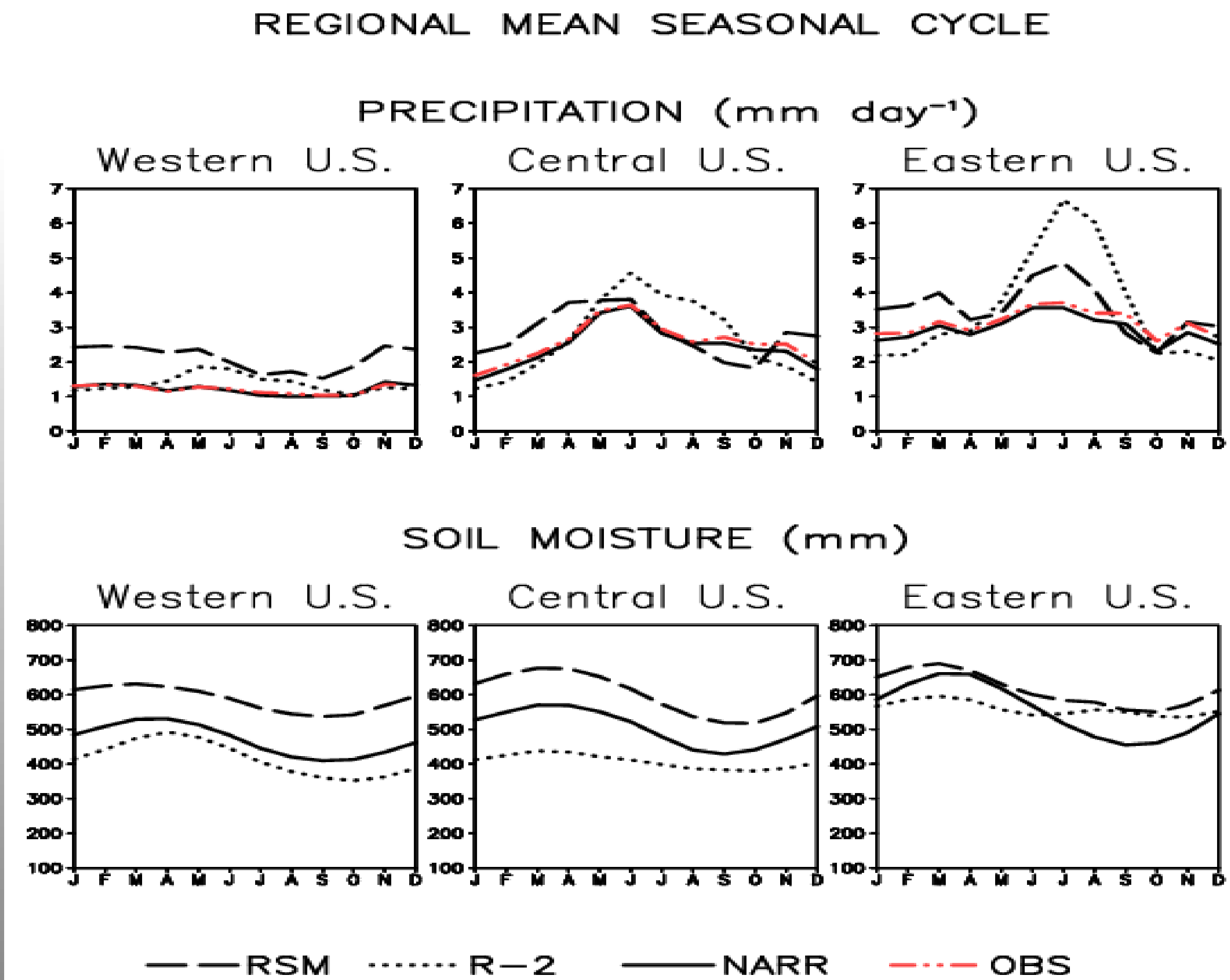
NARCCAP

ECPC-Regional Spectral Model: NARCCAP General Configuration

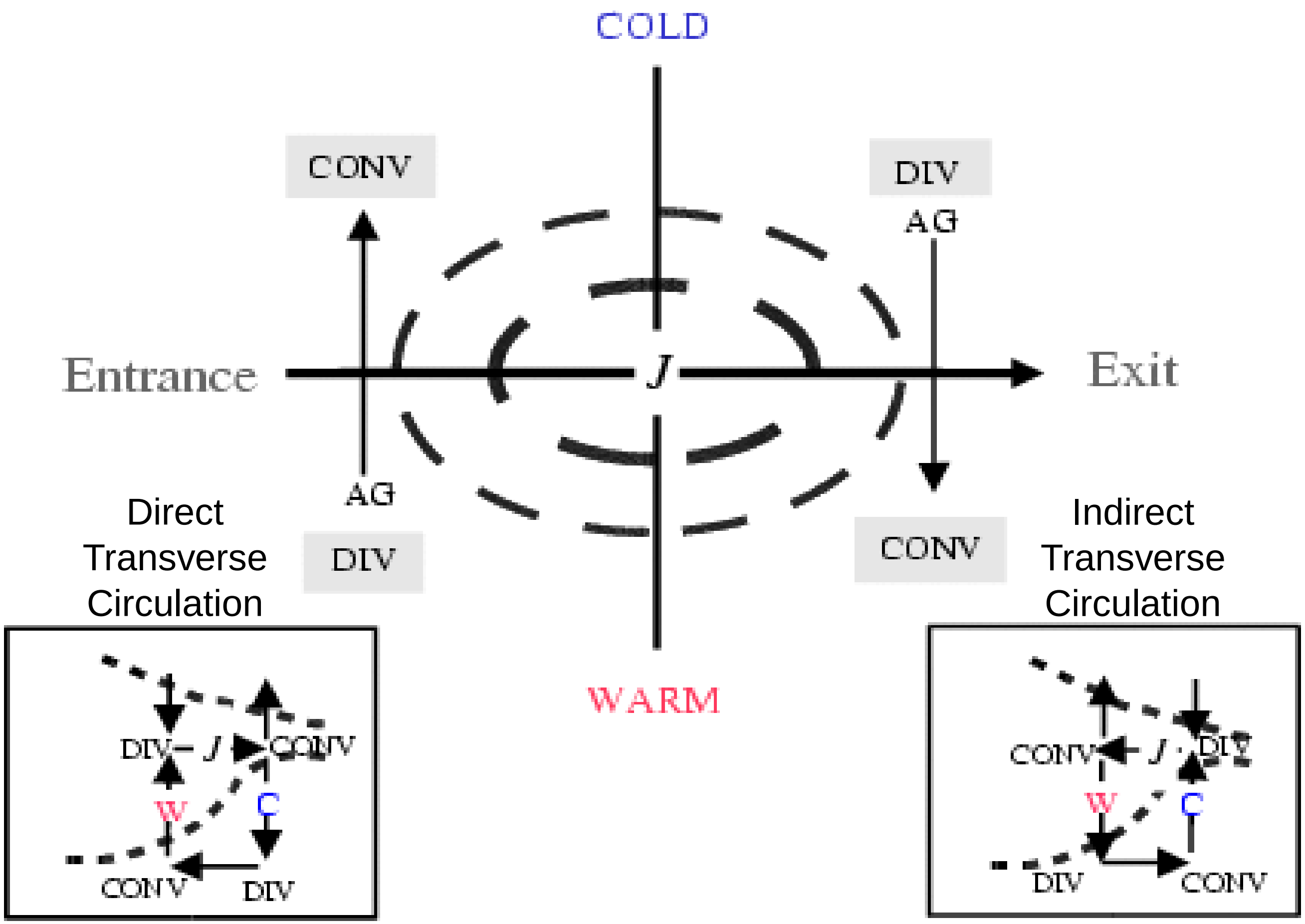
Hydrostatic, Primitive Equations (RSM; Juang *et al*. 1997)	50-km resolution, 28 vertical layers	Noah Land-Surface Model (Mitchell *et al.* 2004); 4-soil layers	Simplified Arakawa-Schubert cumulus convection scheme (SAS; Hong and Pan 1998)	Boundary Forcing: Scale-Selective Bias Correction(SSBC; Kanamaru and Kanamitsu 2007)

The 50-km/28-layer Model Domain



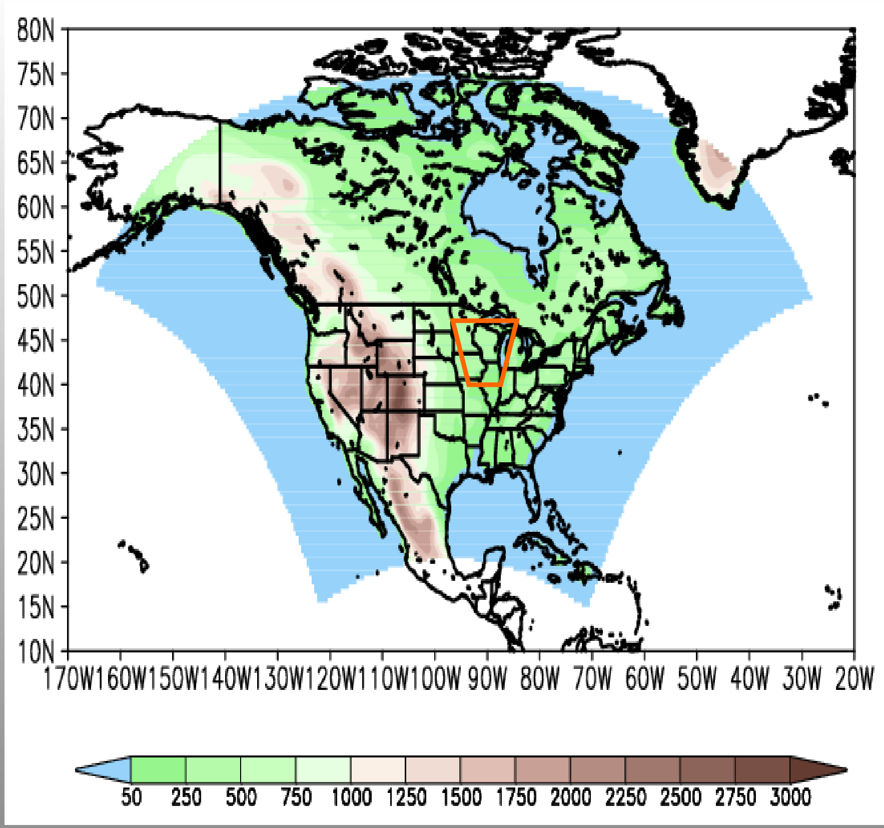

REGIONAL MEAN SEASONAL CYCLE
PRECIPITATION (mm day⁻¹)
Western U.S.
Central U.S.
Eastern U.S.
0
1
2
3
4
5
6
7
J F M A M J J A S O N D
SOIL MOISTURE (mm)
Western U.S.
Central U.S.
Eastern U.S.
100
200
300
400
500
600
700
800
J F M A M J J A S O N D
RSM
R-2
NARR
OBS

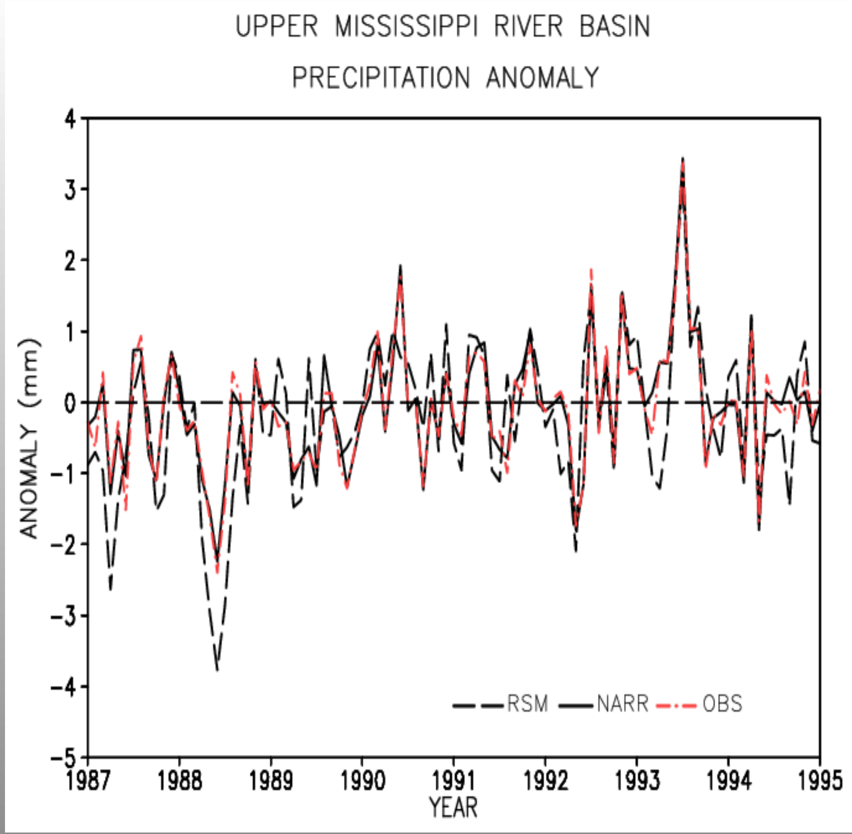
Jet Streak

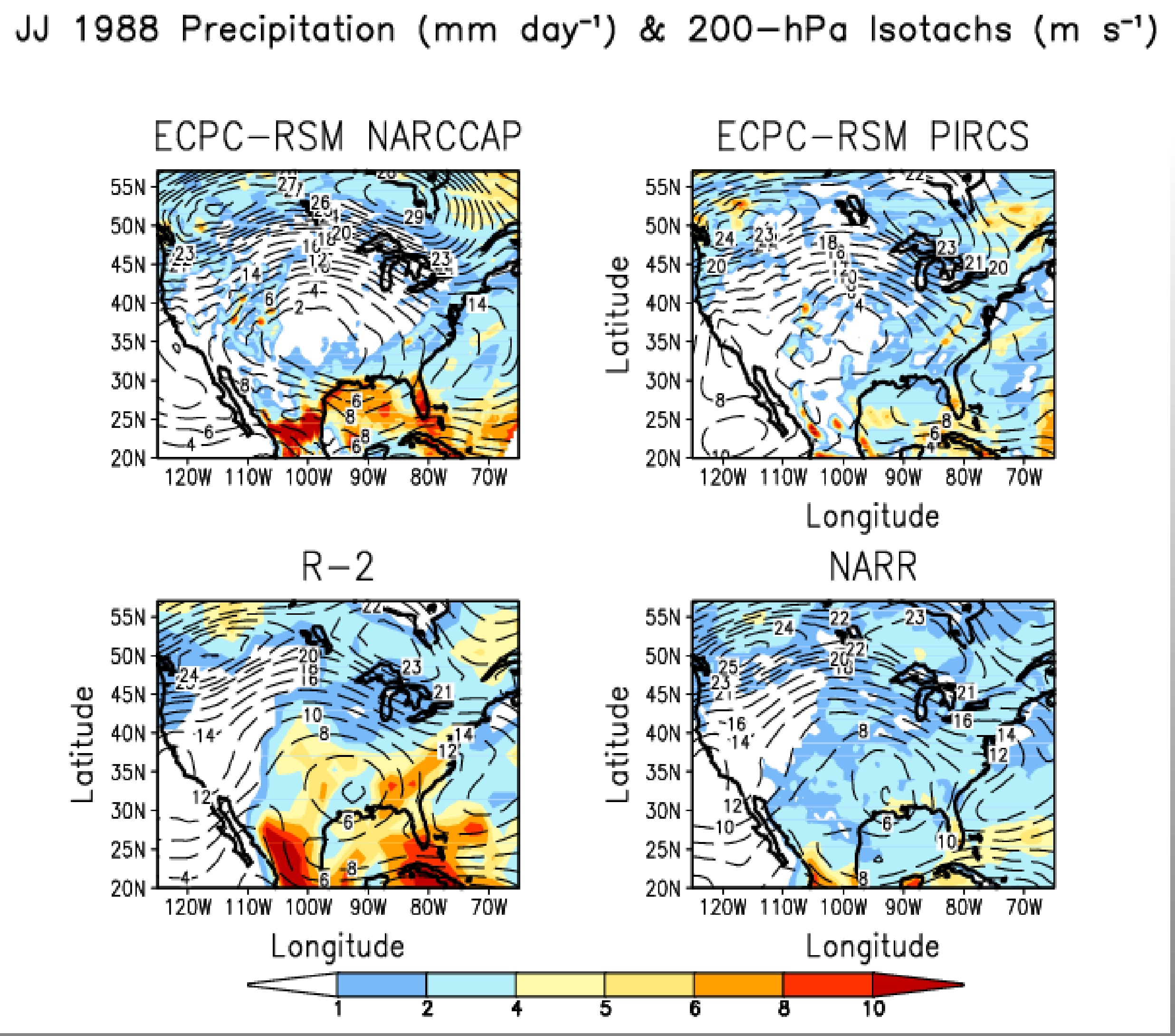


From Nunes and Roads JGR 2009

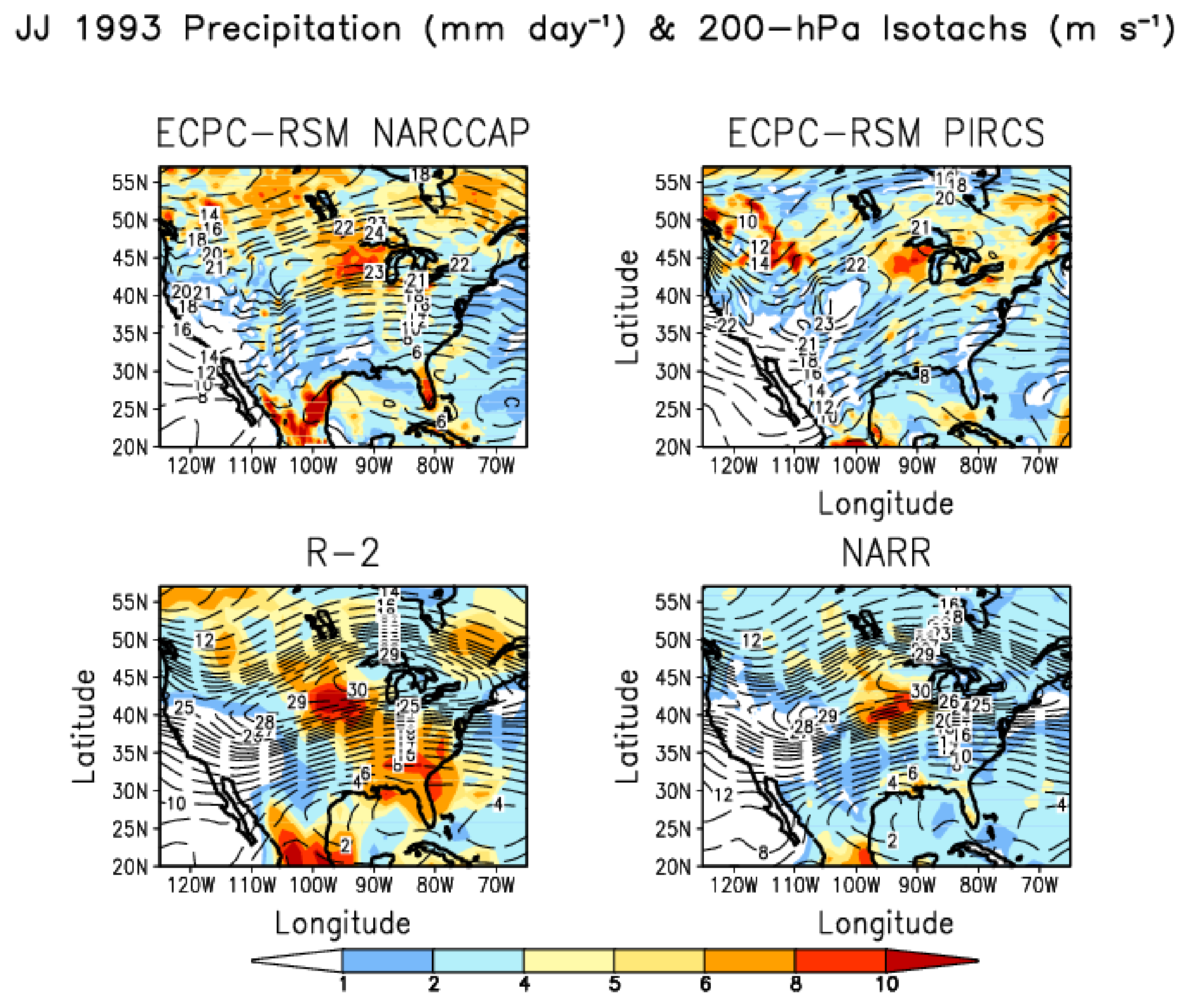
The 50-km/28-layer Model Domain





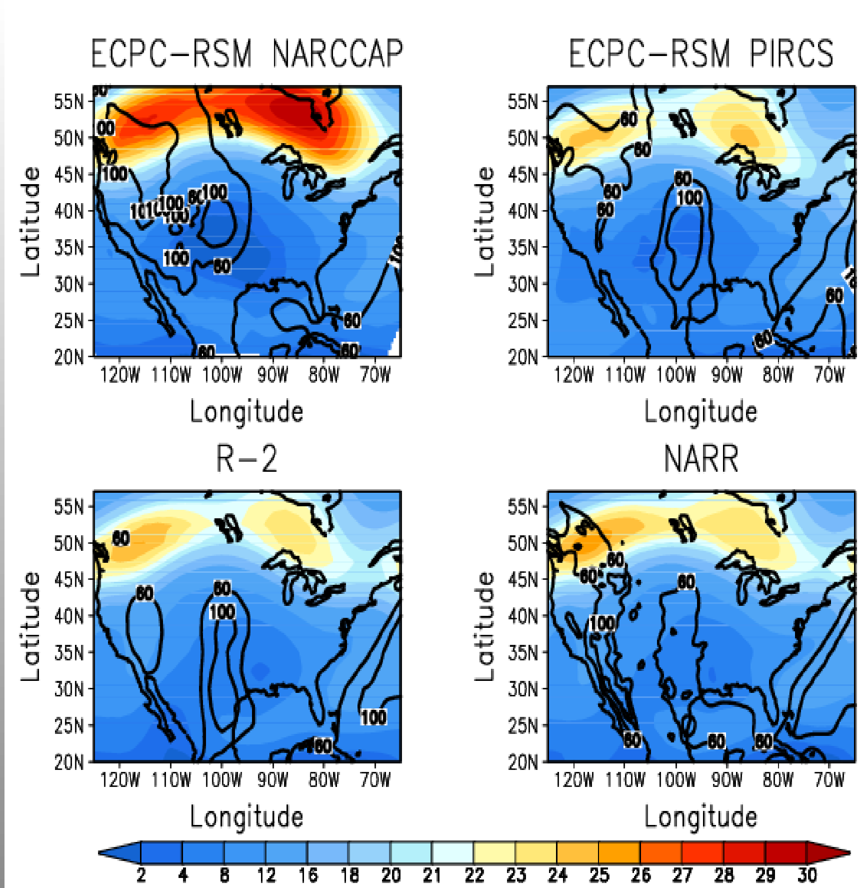


The NARCCAP ECPC-RSM shows more precipitation over the western and dryness over the central US in comparison to PIRCS, R-2 and NARR.

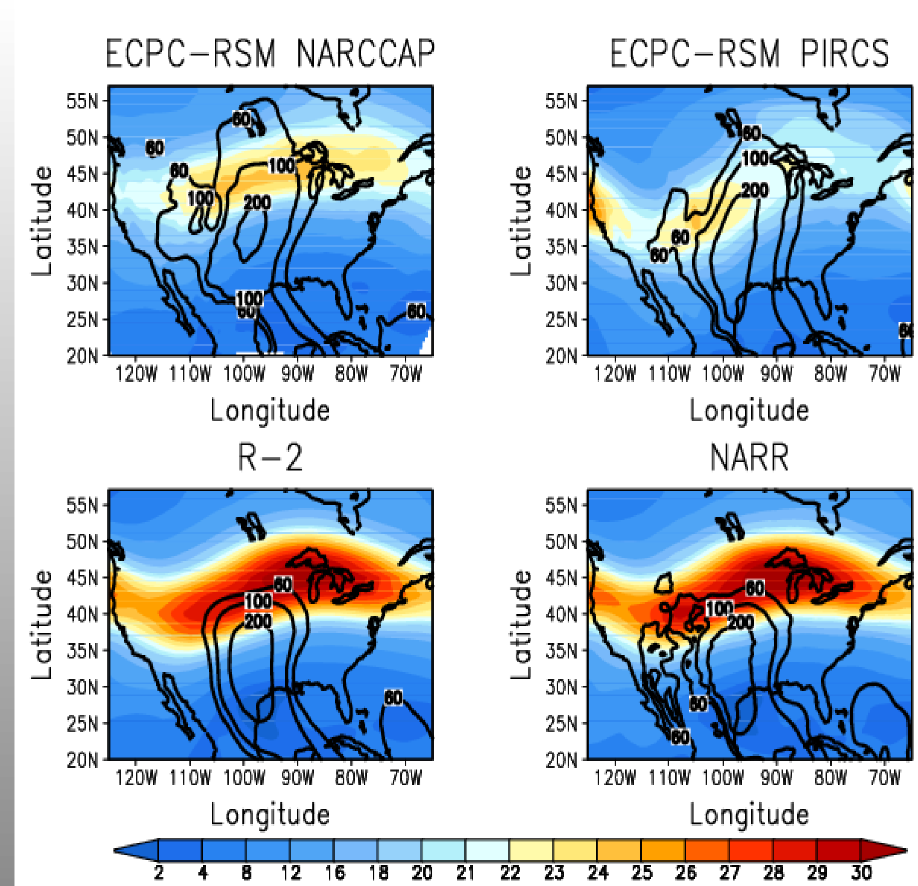


Both ECPC-RSMs show a weaker jet streak, with a precipitation core shifted northeast of the observed location pictured in NARR and R-2.

JJ 1988 200–hPa Wind (m s^{-1}) and QV (kg m^{-1} s^{-1})



JJ 1993 200–hPa Wind (m s^{-1}) and QV (kg m^{-1} s^{-1})

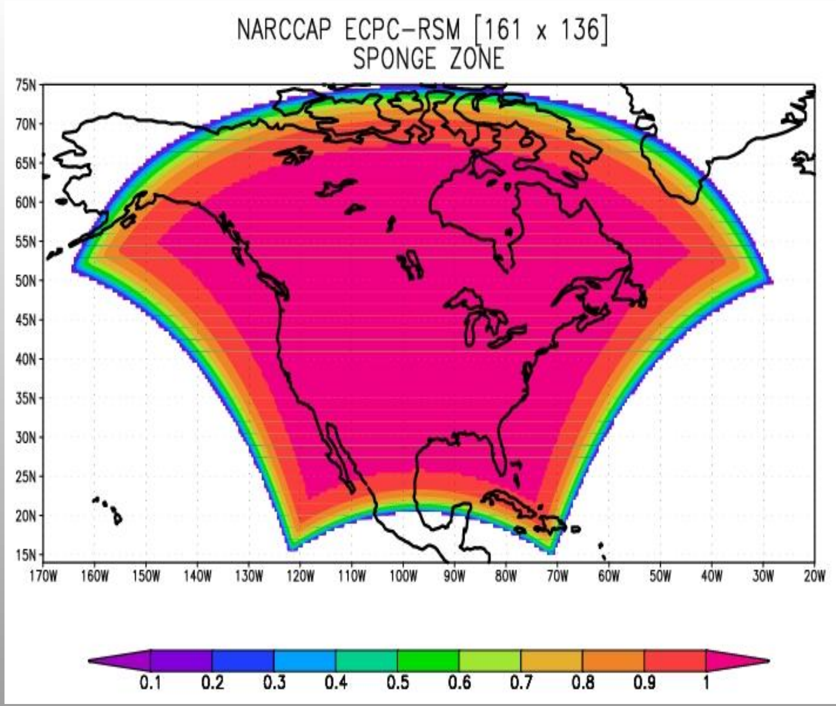


ECPC-RSM AOGCM Forced Runs

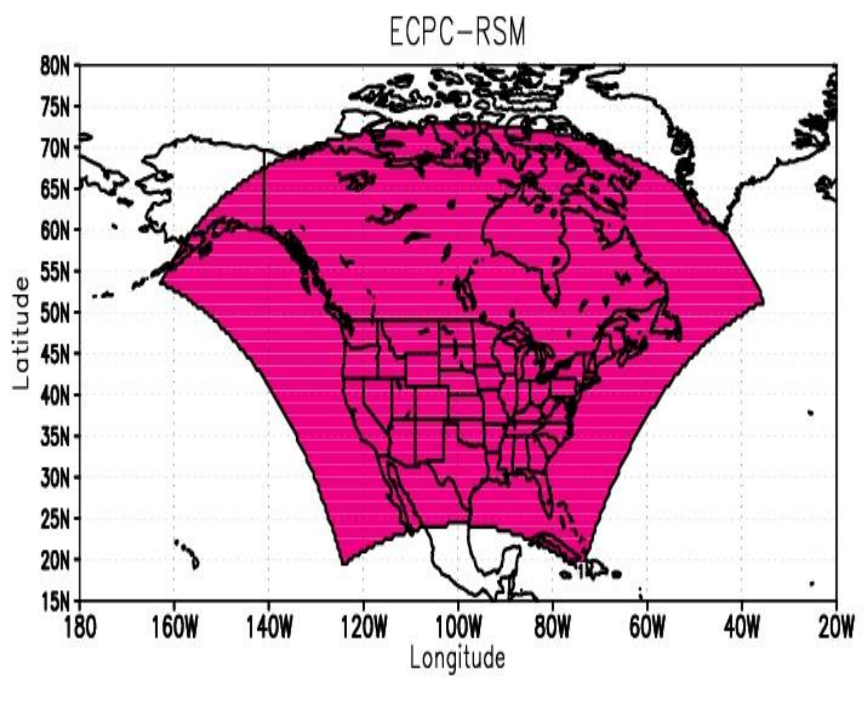
- Phase IIa: control [1968-2000] and future climate [2038-2070] runs

- ECPC-RSM will be using initial and boundary conditions from the GFDL CM2.1 and the HADCM3, over a new domain, for the regional climate simulation of the present or control climate and SRES A2 future climate projections.

Reanalysis Forcing



AOGCM Forcing



Acknowledgments

This research used NCEP/DOA AMIP-II reanalysis obtained from the NCEP (NOMADS2) data server, and the NCEP North American Regional Reanalysis (NARR) data from http://www.emc.ncep.noaa.gov/mmb/rreanl. The NOAA/Climate Prediction Center provided daily precipitation values.