High Resolution River Routing in the CCSM2 Climate System Model

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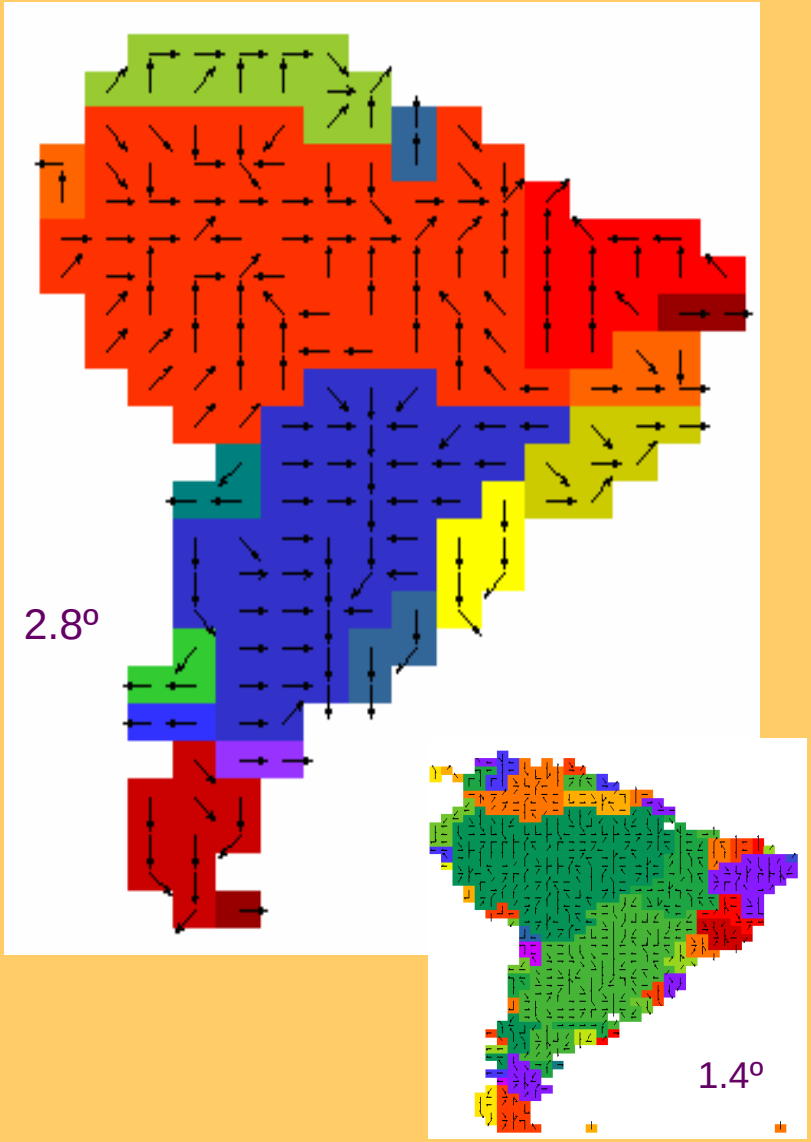
Abstract

The delivery of freshwater to the ocean from continental runoff is a critical factor in the global climate system. The current version of the NCAR climate model CCSM2 (Community Climate System Model, version 2) uses river routing at half degree resolution. While this is acceptable in the current model, high power computer architectures now available such as the IBM Power 4 and Cray X1 are allowing development of higher resolution climate component models and parameterizations. Subgrid orography parameterizations will allow for the production of more accurate runoff within a grid cell. Higher resolution routing is necessary to take advantage of this improvement. Other new parameterizations are adding chemical species to the terrestrial biosphere that will need to be transported via rivers to the oceans.

Cell to Cell Routing



Mass balance on a cell
(after Vorosmarty et al. 1989)

$$\frac{dS}{dt} = \sum F_{in} - F_{out} + R$$

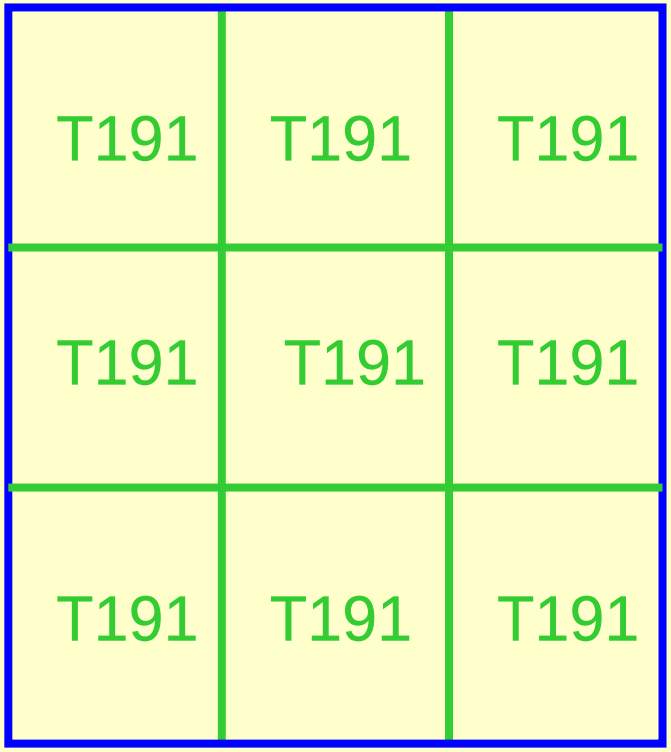
S = storage of river water within cell
F = flux of river water entering/leaving a cell

F = KS
K = v/d
v = flow velocity
d = distance between centers of cells in downstream direction
R = runoff generated within cell

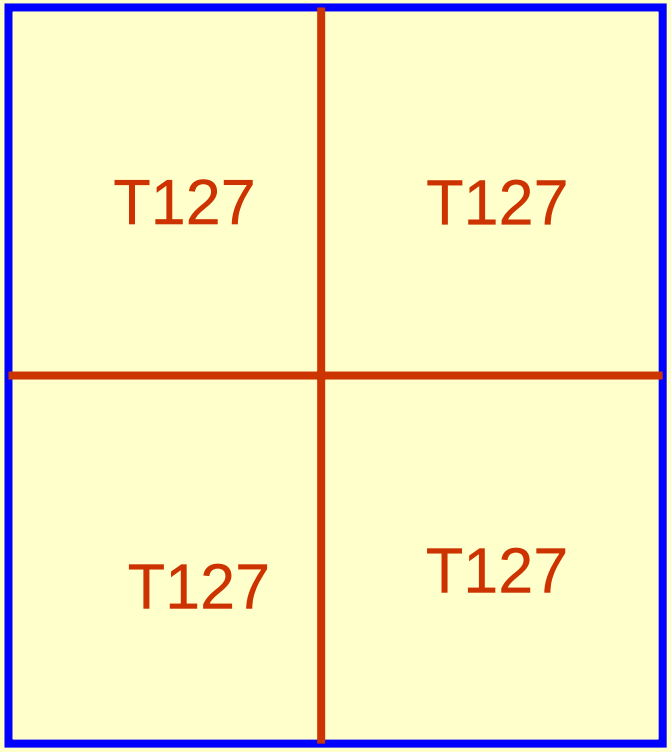
F_{out} routed according to flow direction map

Resolution Grids

T42

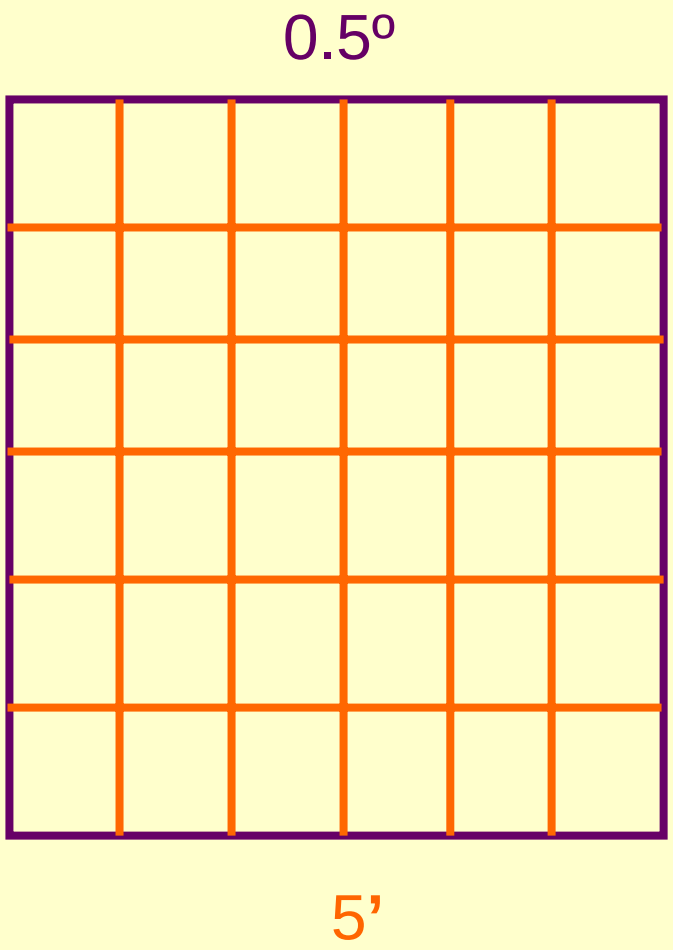


T191



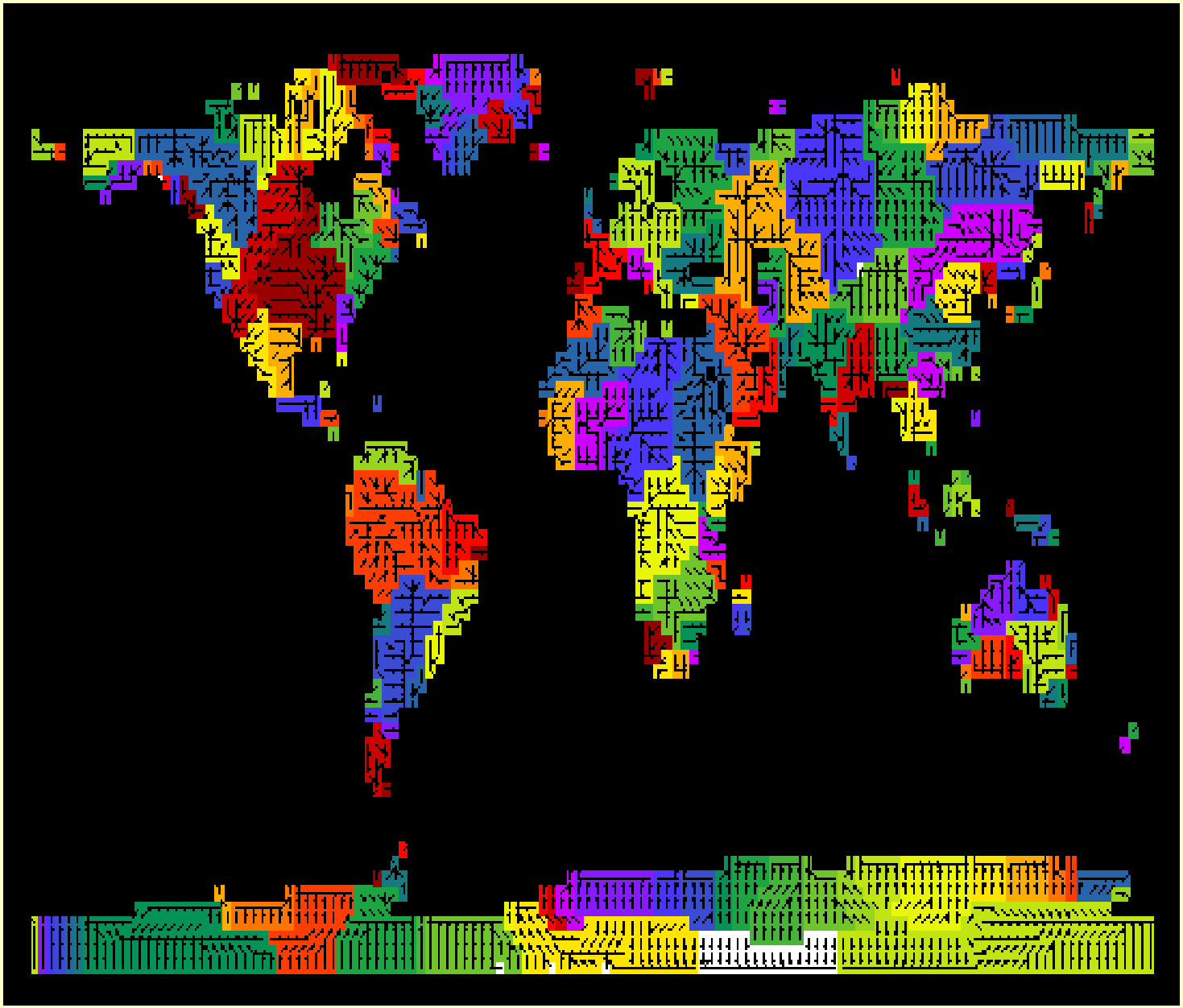
T127

Higher Resolution Grids

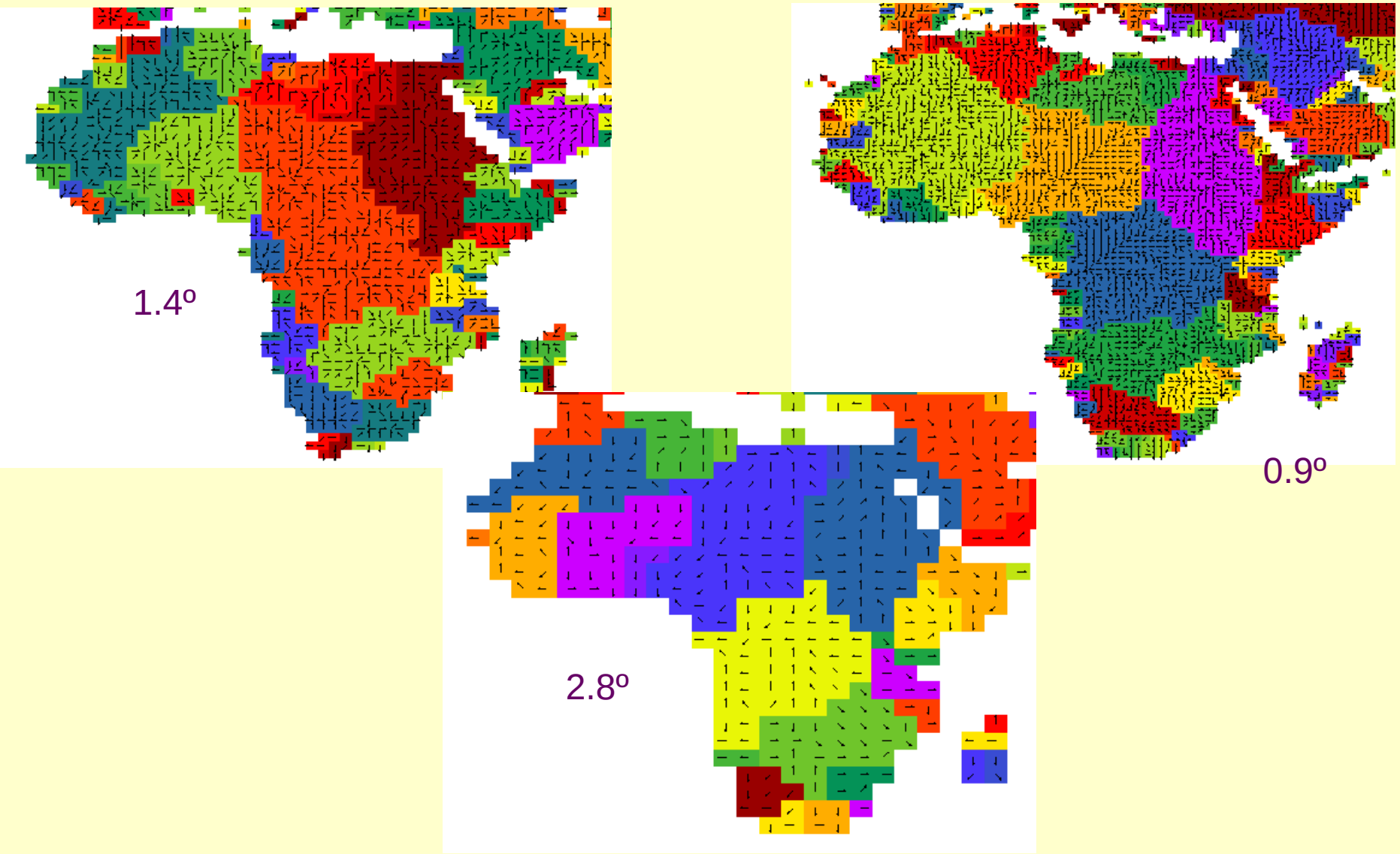


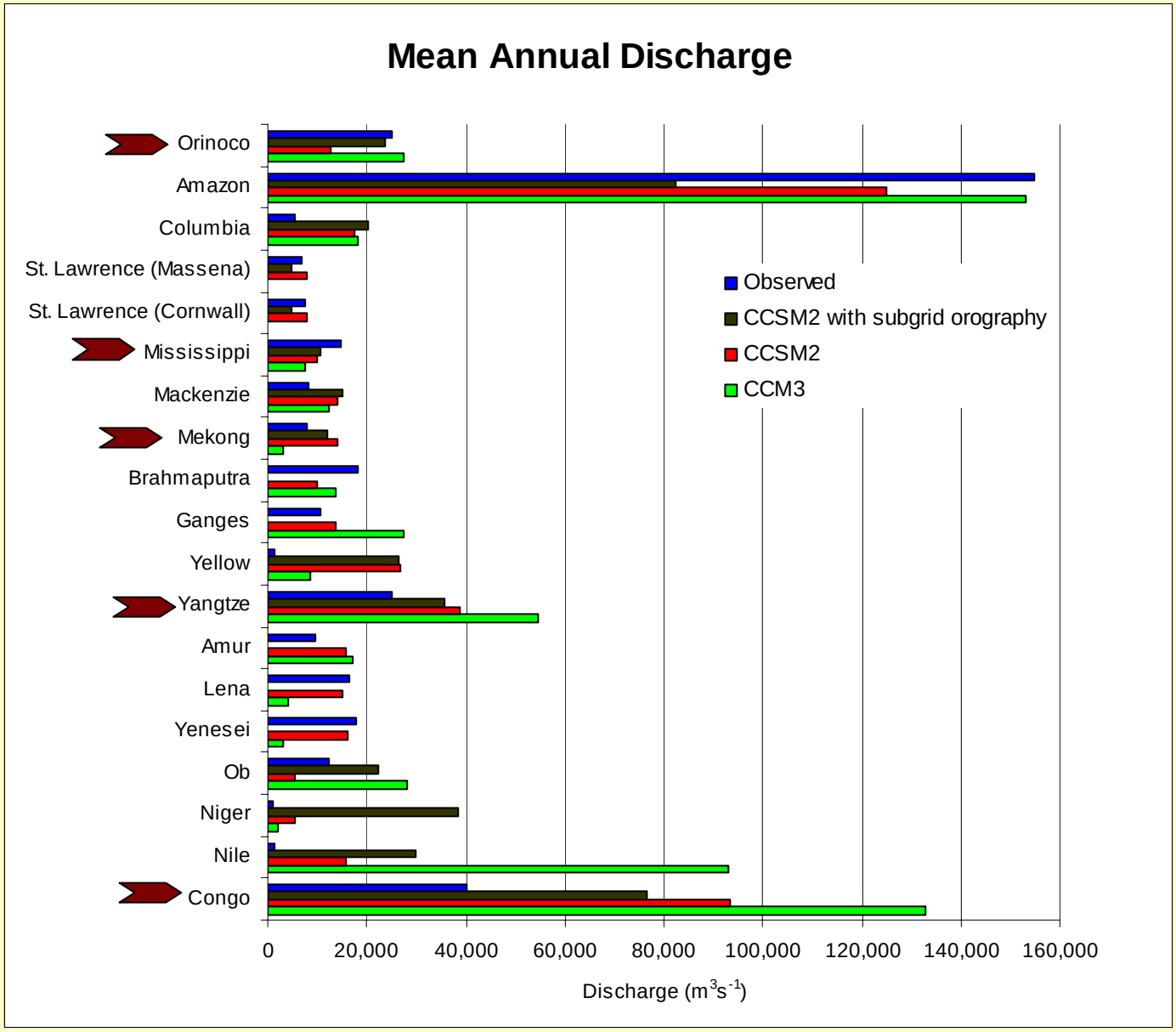
Resolution Dimensions

Resolution	Approximate Grid Cell Size	Grid Cell Dimensions
T42	3 °	128 x 64
T127	1.5 °	256 x 128
T191	1 °	384 x 192
Half degree	0.5 °	720 x 360
Five minute	5’	4320 x 2160



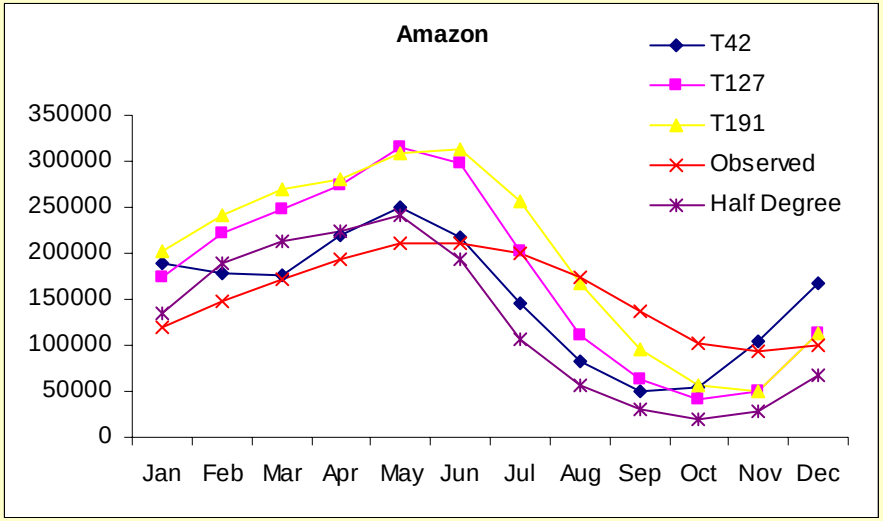
Africa River Basins

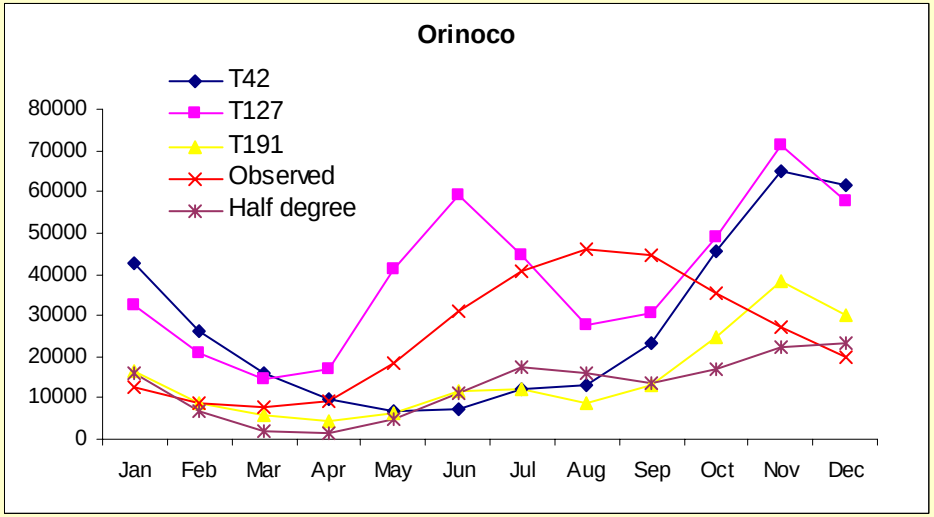


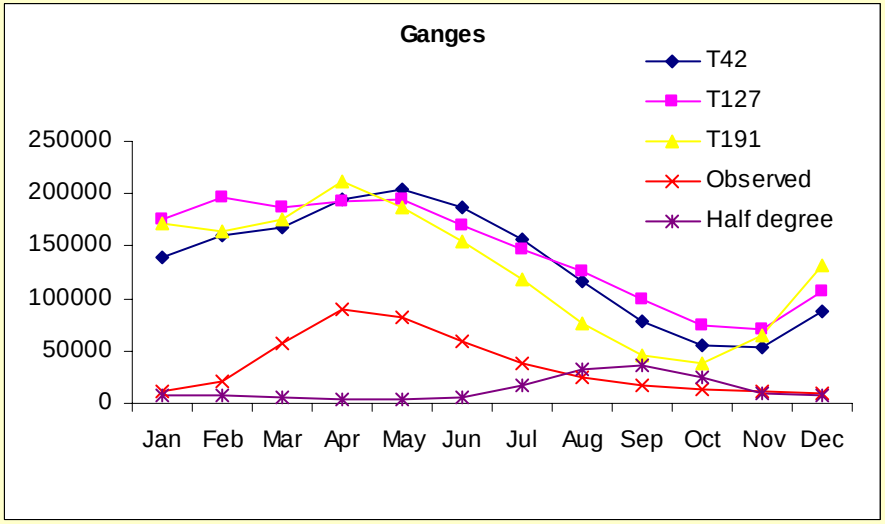


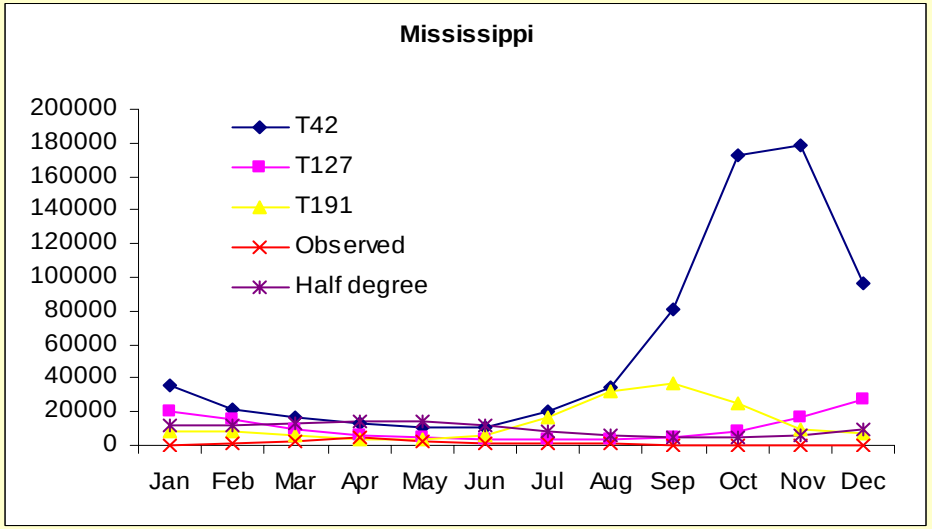
Arrows denote rivers that showed improved accuracy with subgrid orography.

Combined Resolution Effects



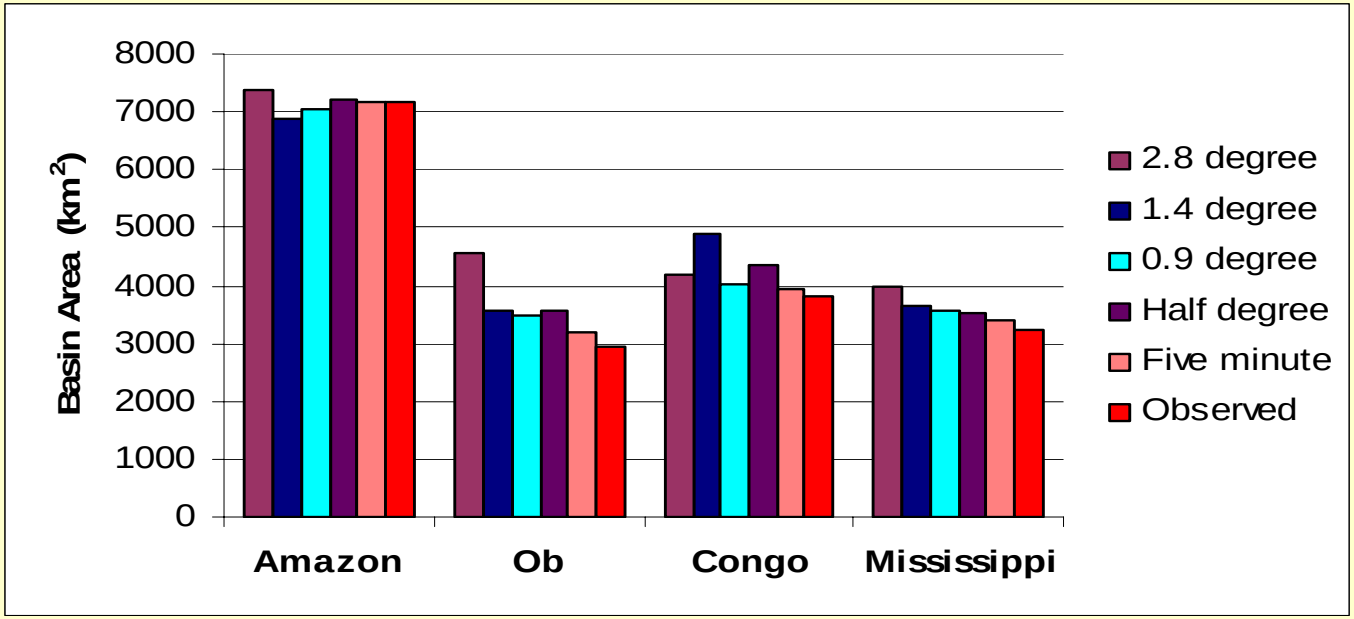






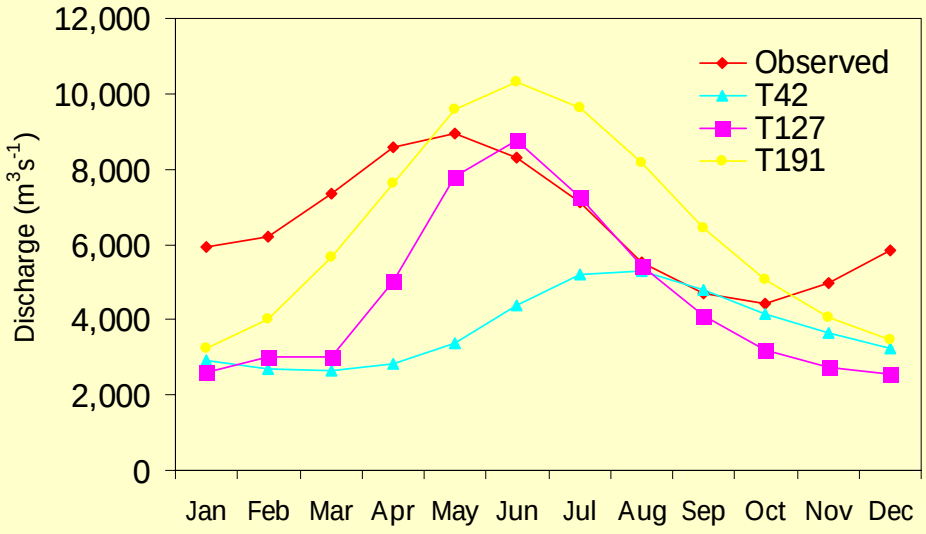
In these cases, both the underlying runoff and routing were done at different resolutions

Basin Areas at Higher Resolution

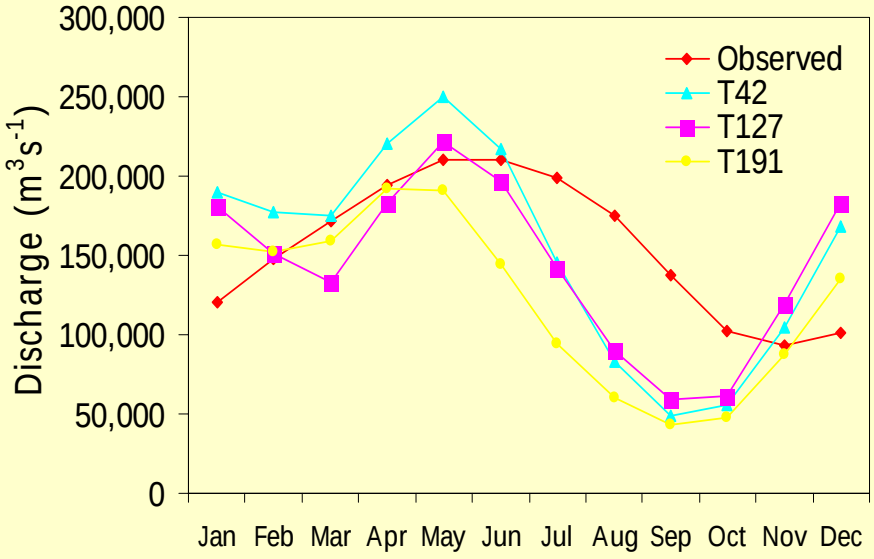


Routing Resolution Effects

Danube

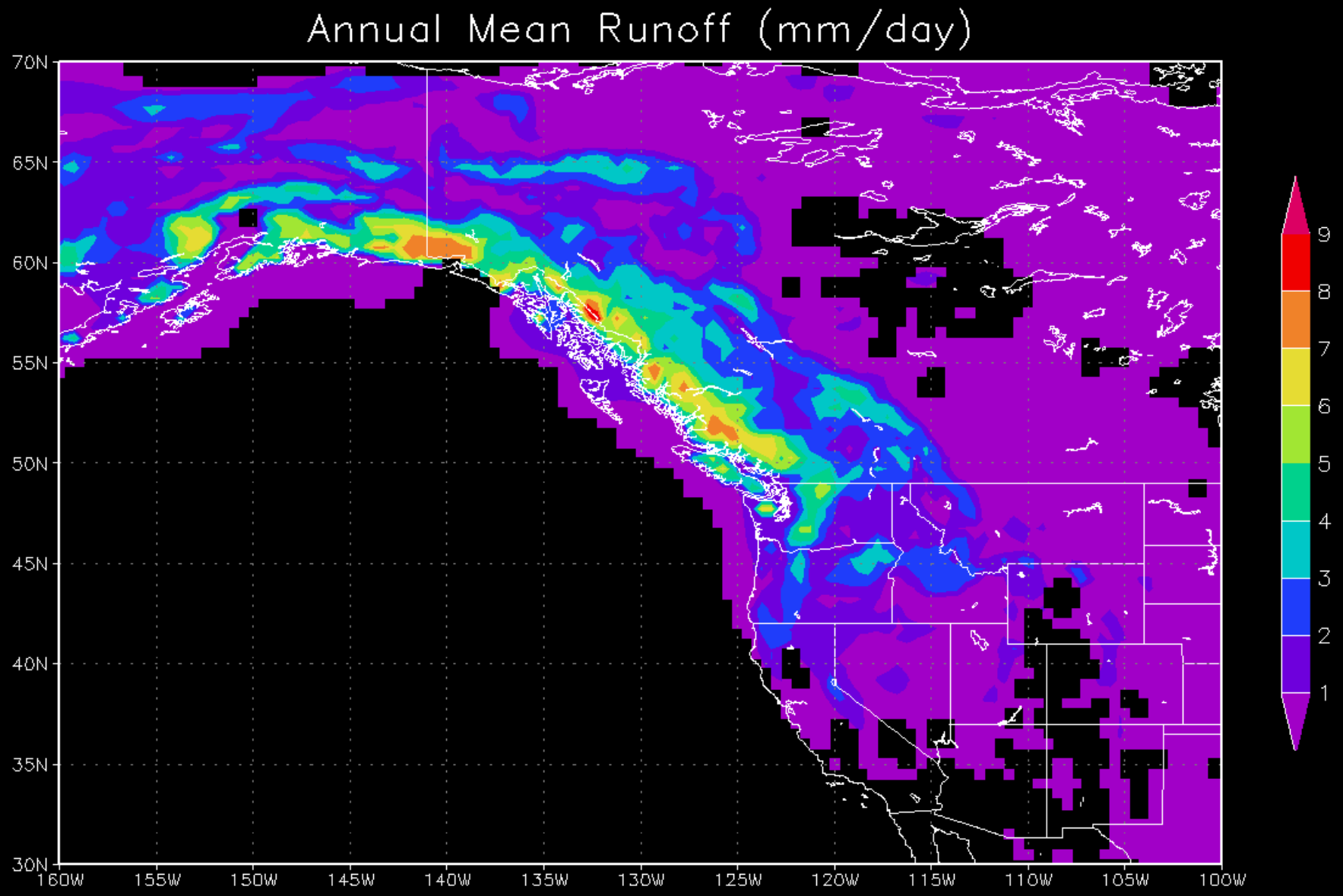


Amazon

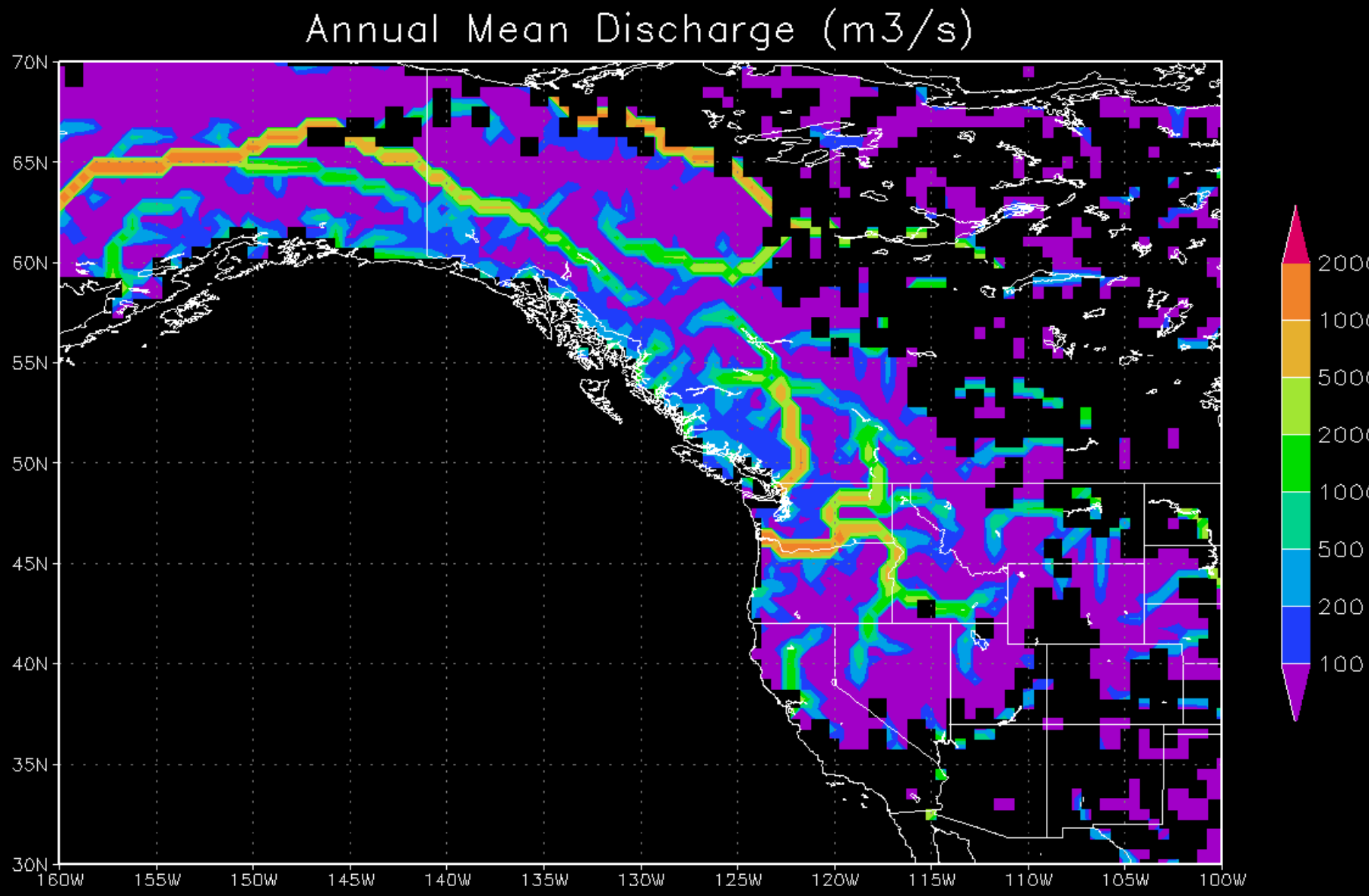


In these cases, only the routing was done at different resolutions. The underlying runoff data was the same.

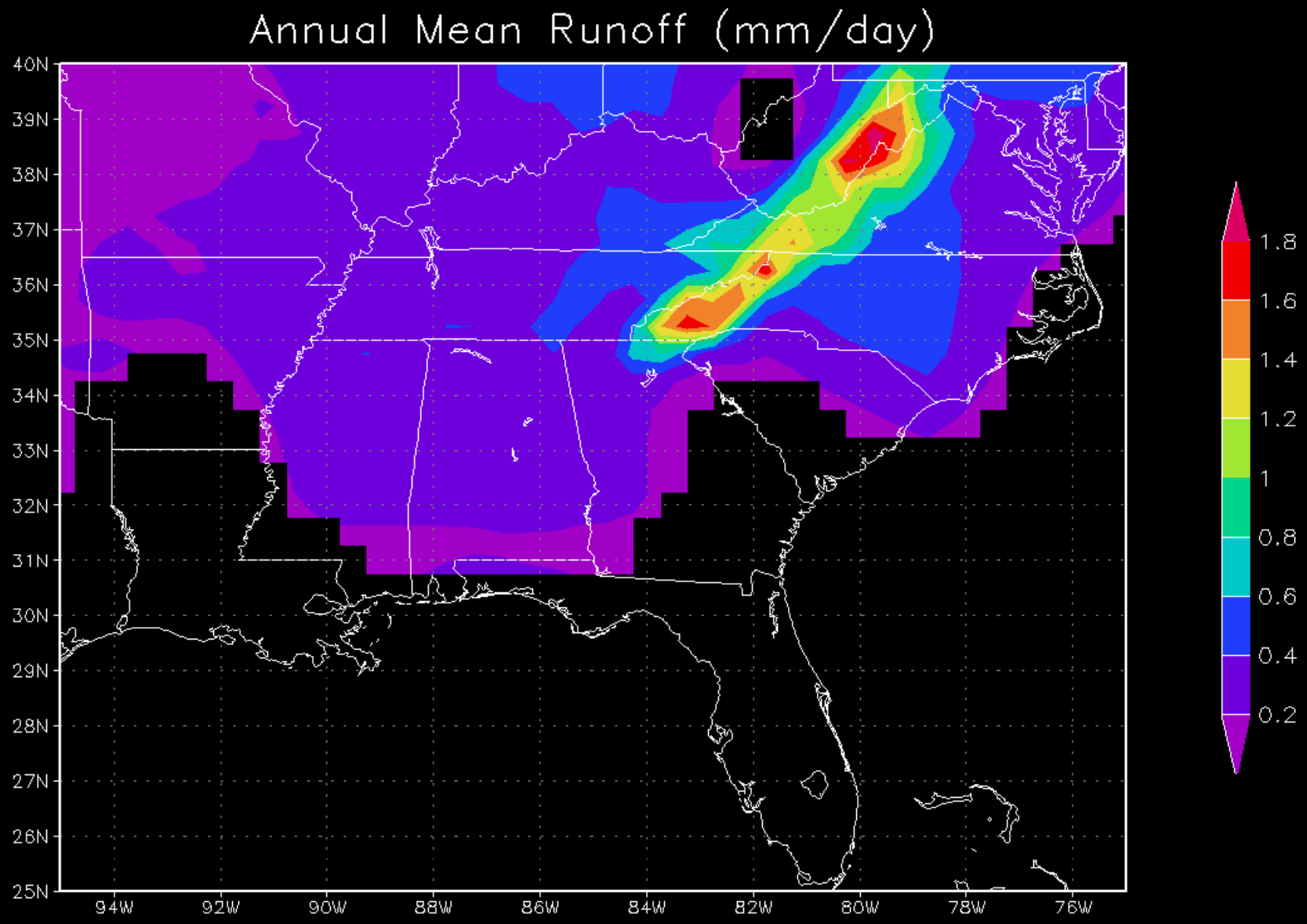
Northwest Runoff



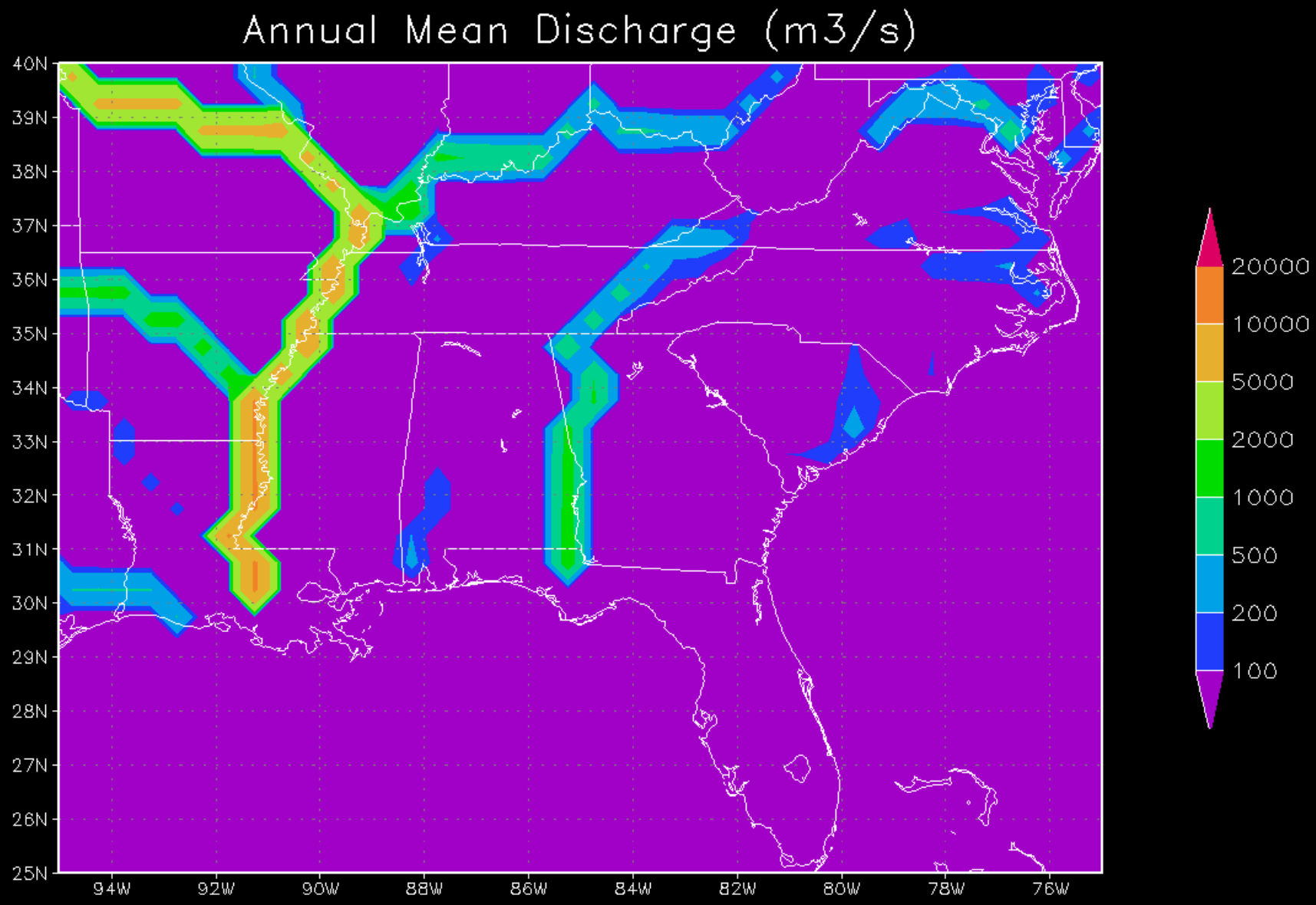
Northwest Discharge



Southeast Runoff



Southeast Discharge



Conclusions

- Accuracy of results improved with higher resolution river routing in some cases.
- Higher model resolution input data to routing scheme improved results further.
- River basin area tended to be closer to observed area with higher resolution routing grid.
- Subgrid orography demonstrated improved mean annual river discharge in a number of basins, including the Congo and Yangtze Rivers.

Acknowledgements

- DOE SciDAC
- DOE Laboratory Directed Research & Development
- ORNL CCS resources
- UT-ORNL Joint Institute for Computational Sciences
- This research was supported by Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the U.S. Department of Energy under contract DE-AC05-00OR22725.