Manifestations of Climate Change in Annual-Mean Runoff and Streamflow, with a Focus on the United States

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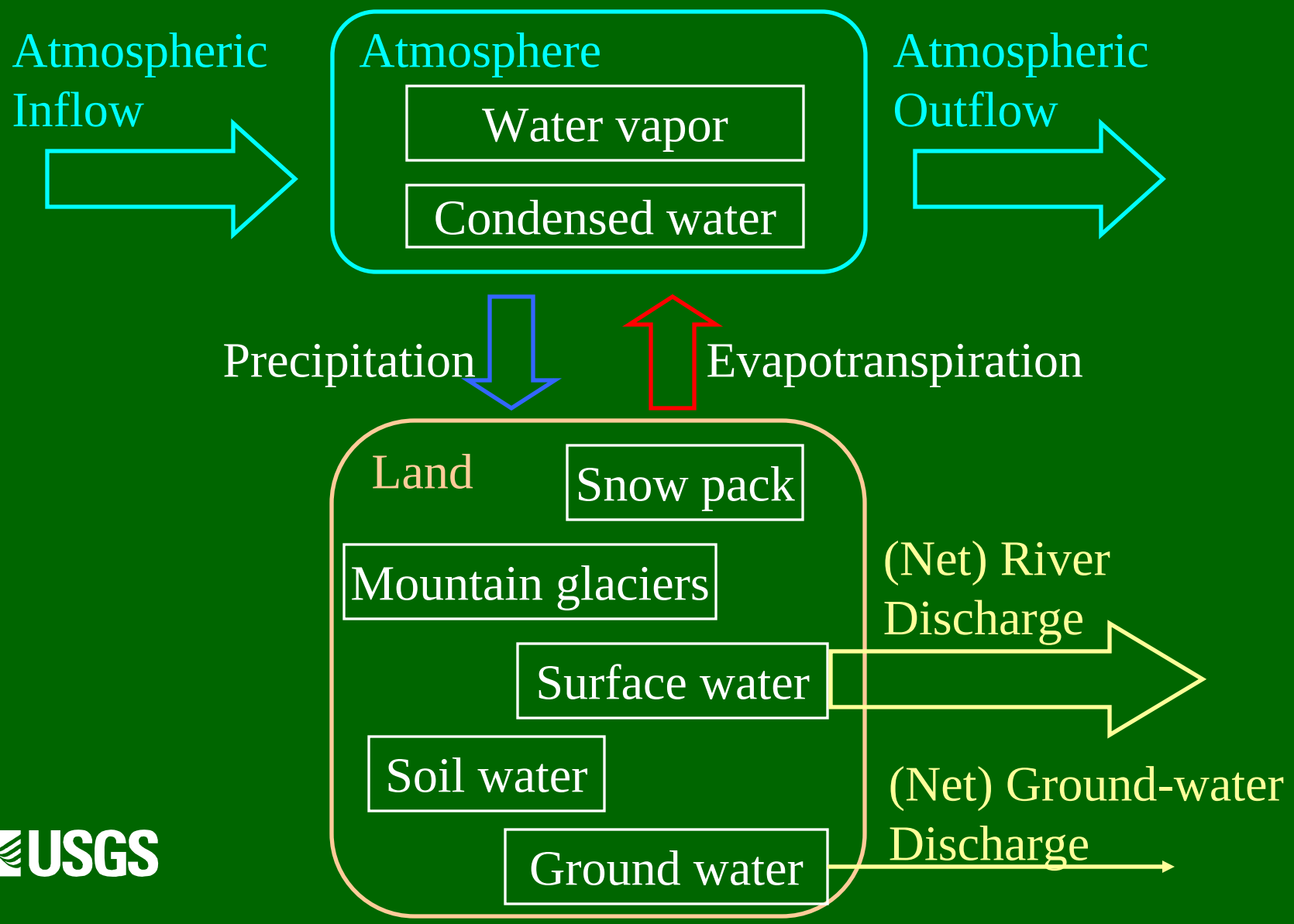
"Climate Change and Water Resources"
U.S. Army Corps of Engineers—U.S. Geological Survey
Joint Headquarters Meeting
Washington, DC
May 31, 2007

Atmosphere-Land Column Water Balance



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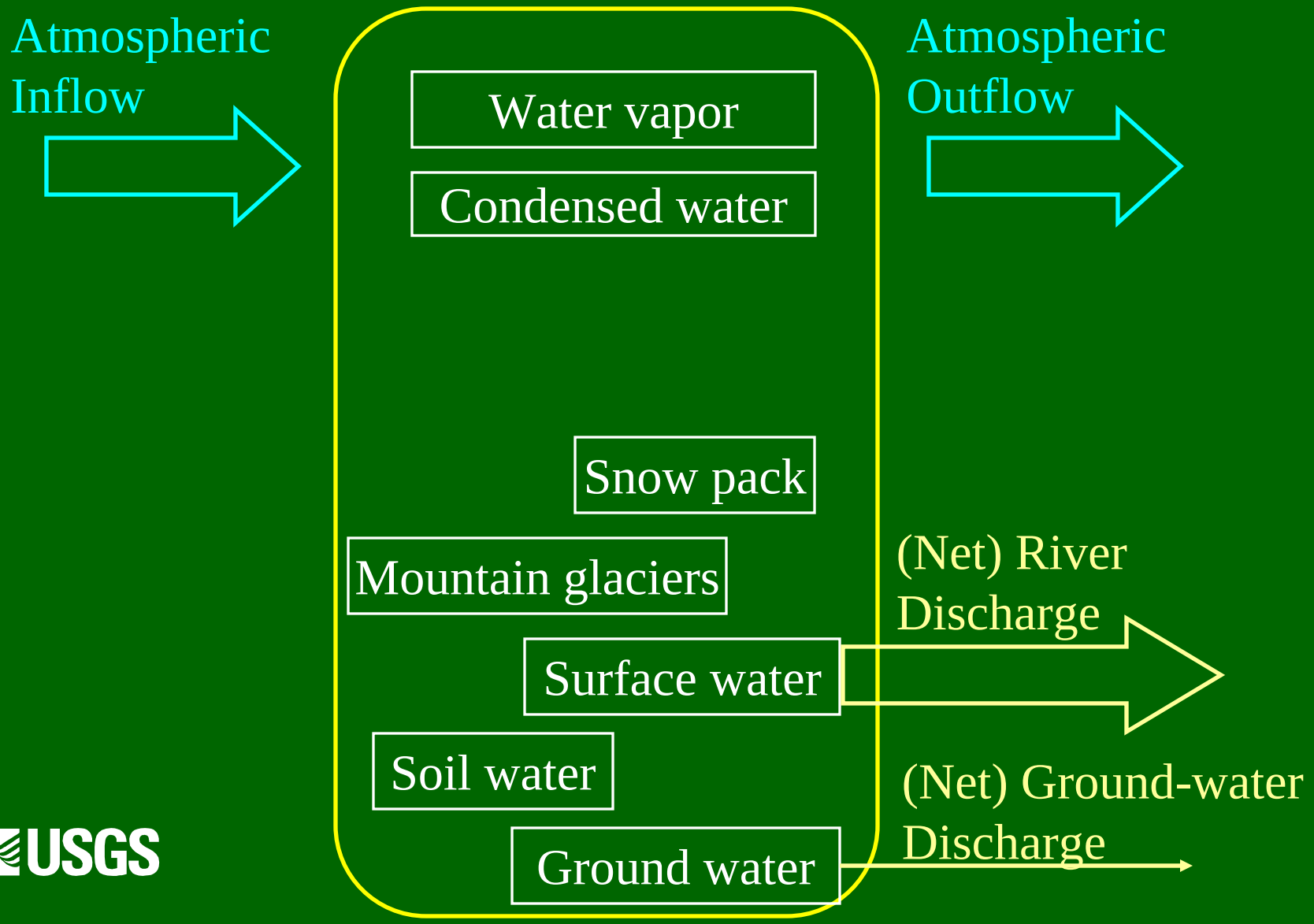
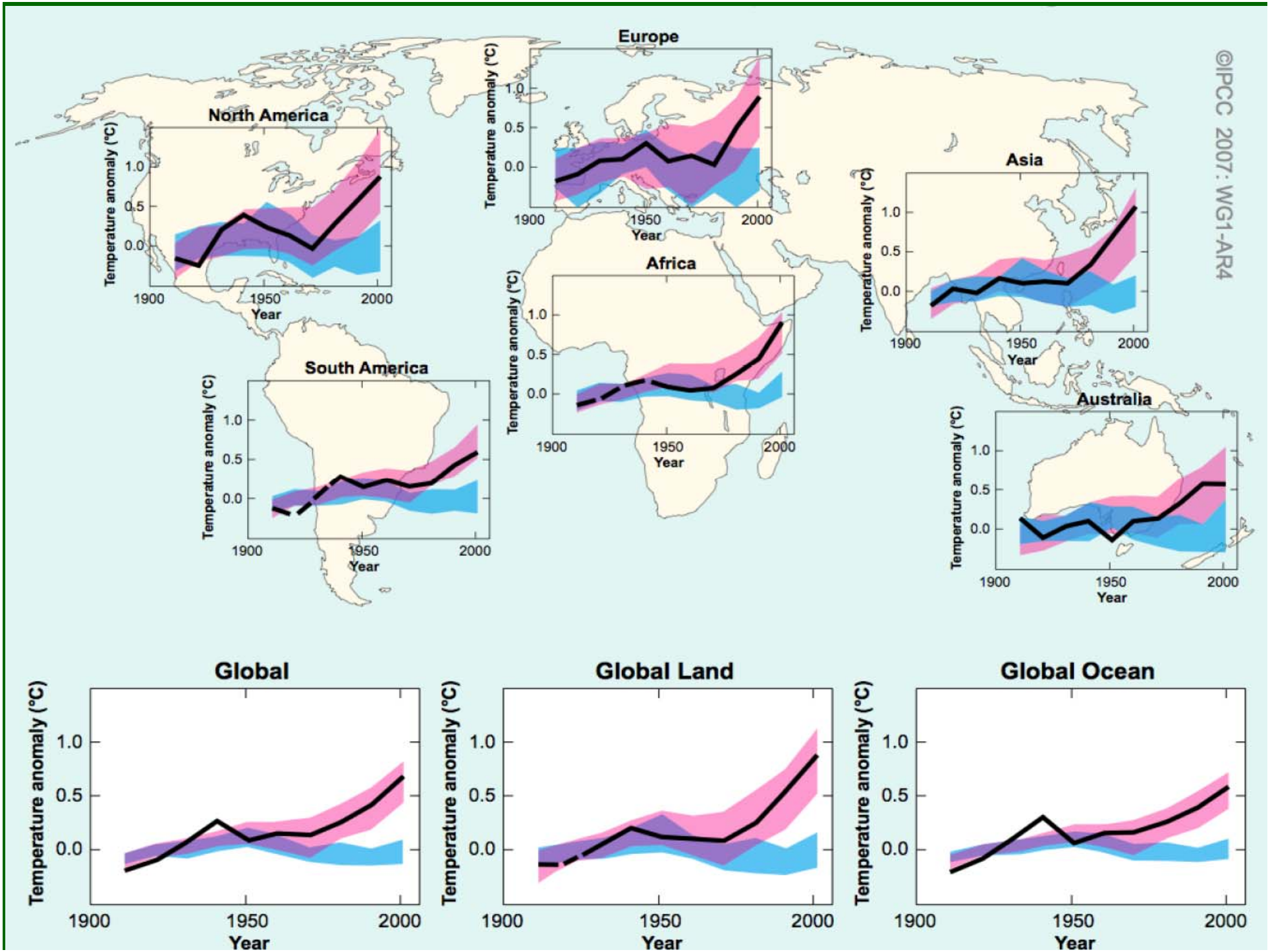
Atmosphere-Land Column Water Balance

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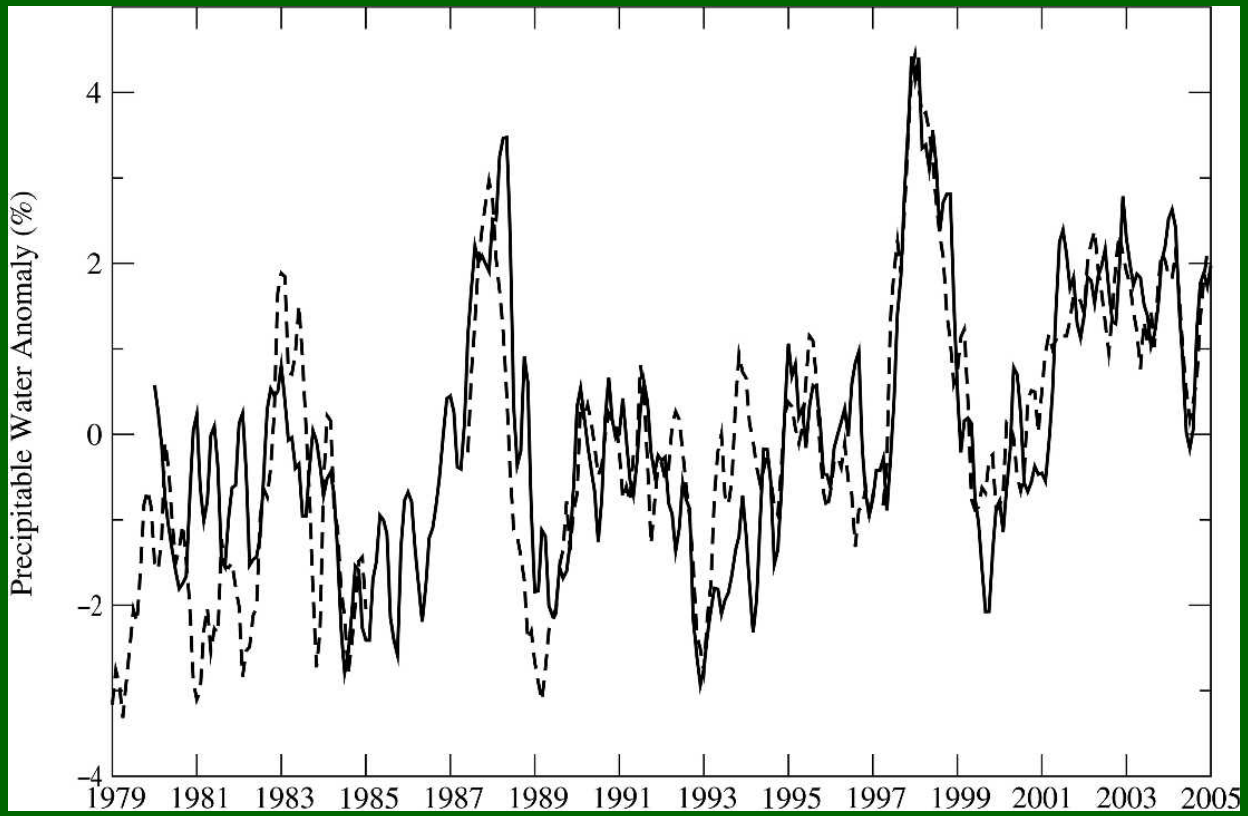
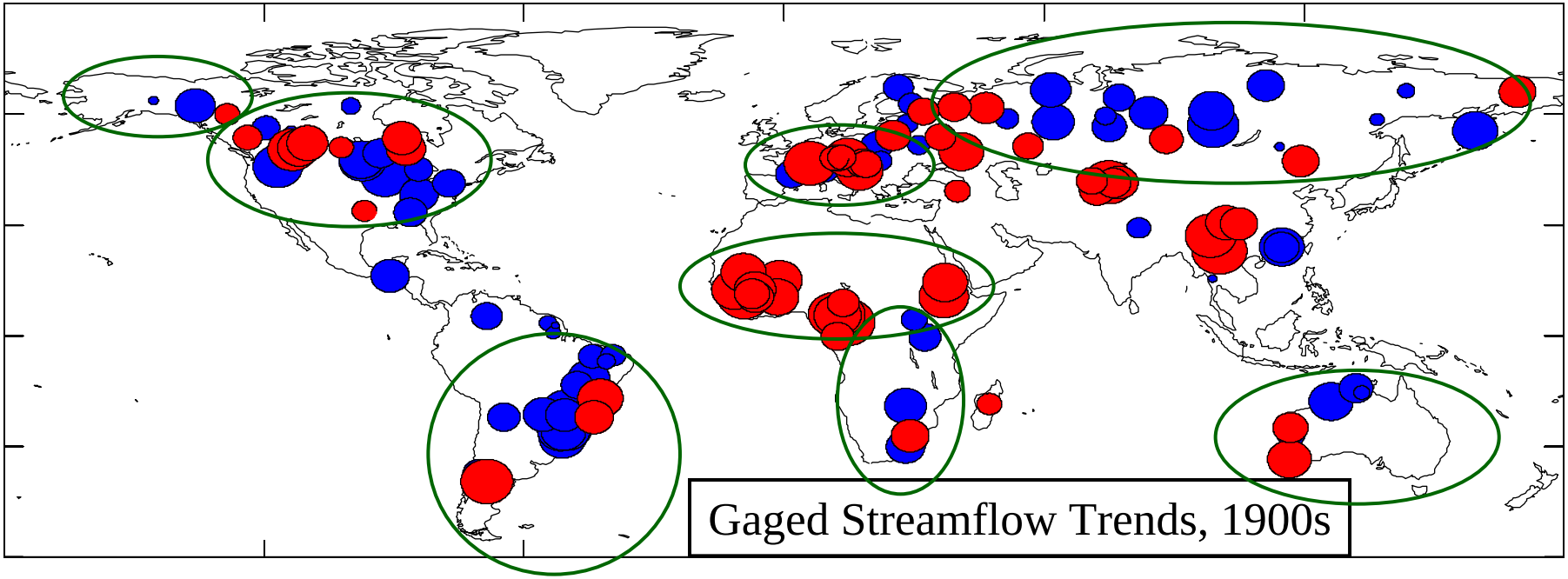
North America
Europe
Asia
Africa
South America
Australia
Global
Global Land
Global Ocean
Temperature anomaly (°C)
Year
1900
1950
2000
0.0
0.5
1.0

Robustness of Hydrospheric Response

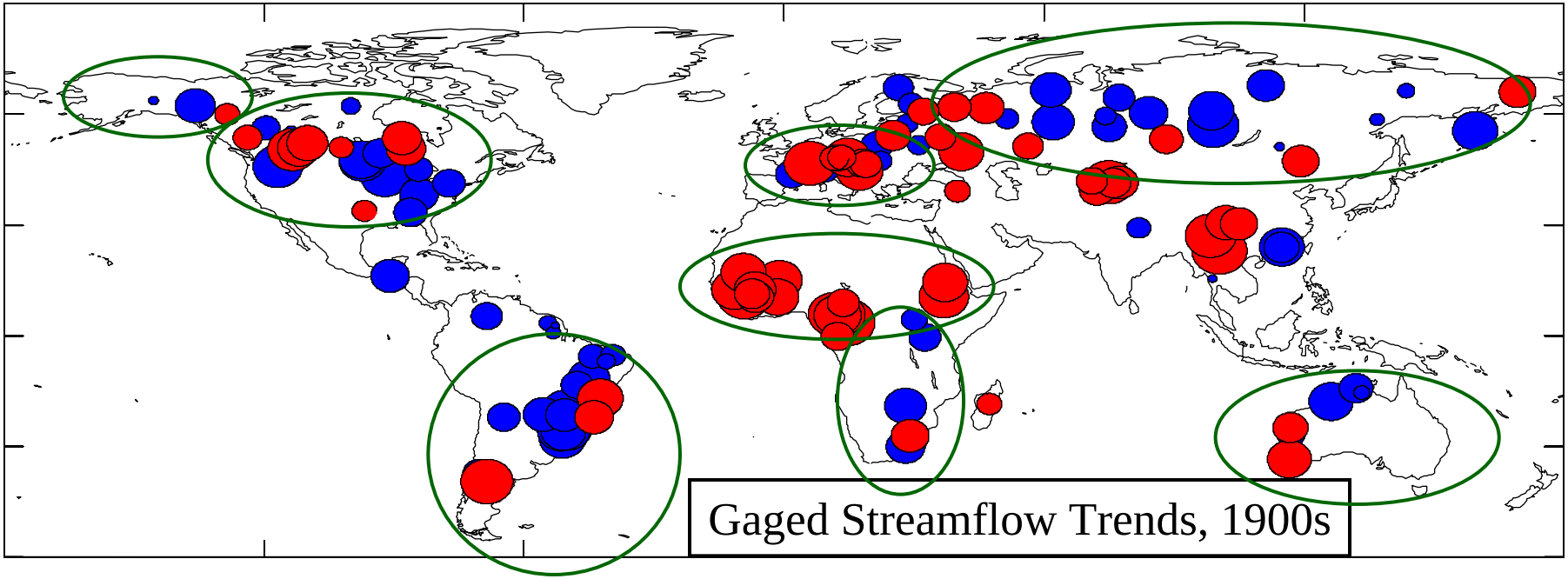


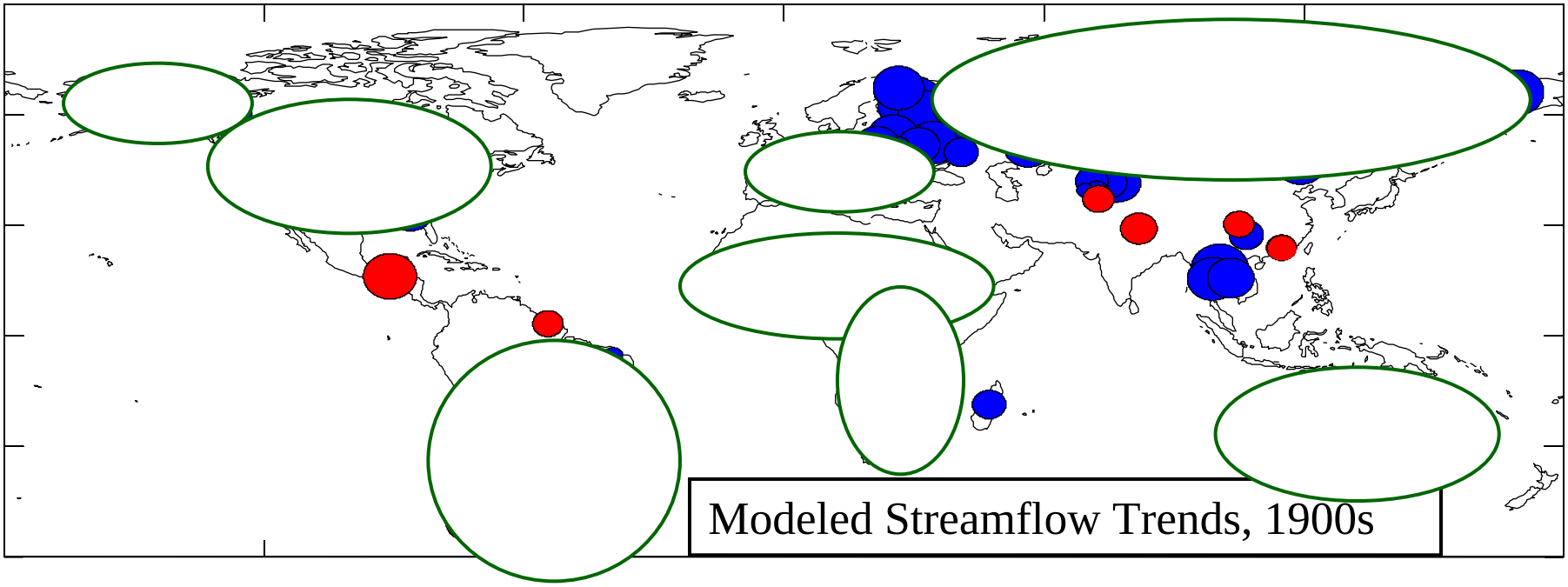
Atmospheric water content anomaly, 30S-30N over ocean; GFDL GCM; SMMR,SMM/I observations (Held and Soden, 2006)

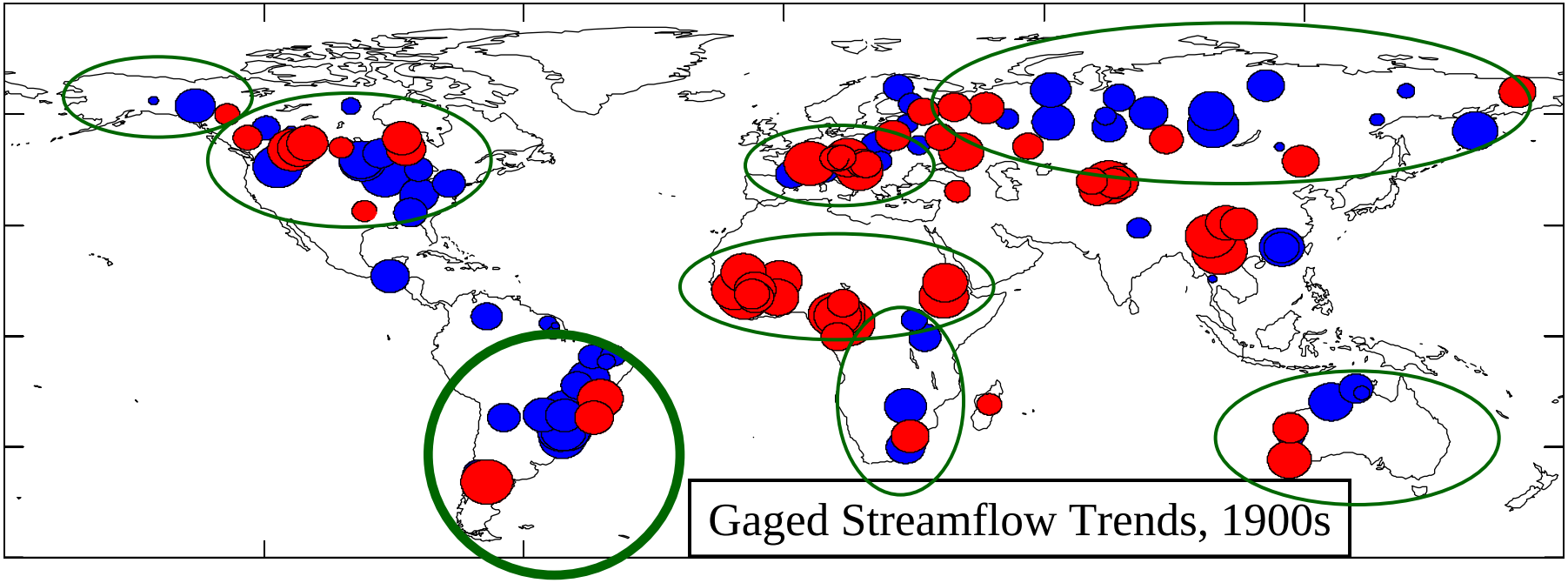


streamflow decreased

streamflow increased


Gaged Streamflow Trends, 1900s


Modeled Streamflow Trends, 1900s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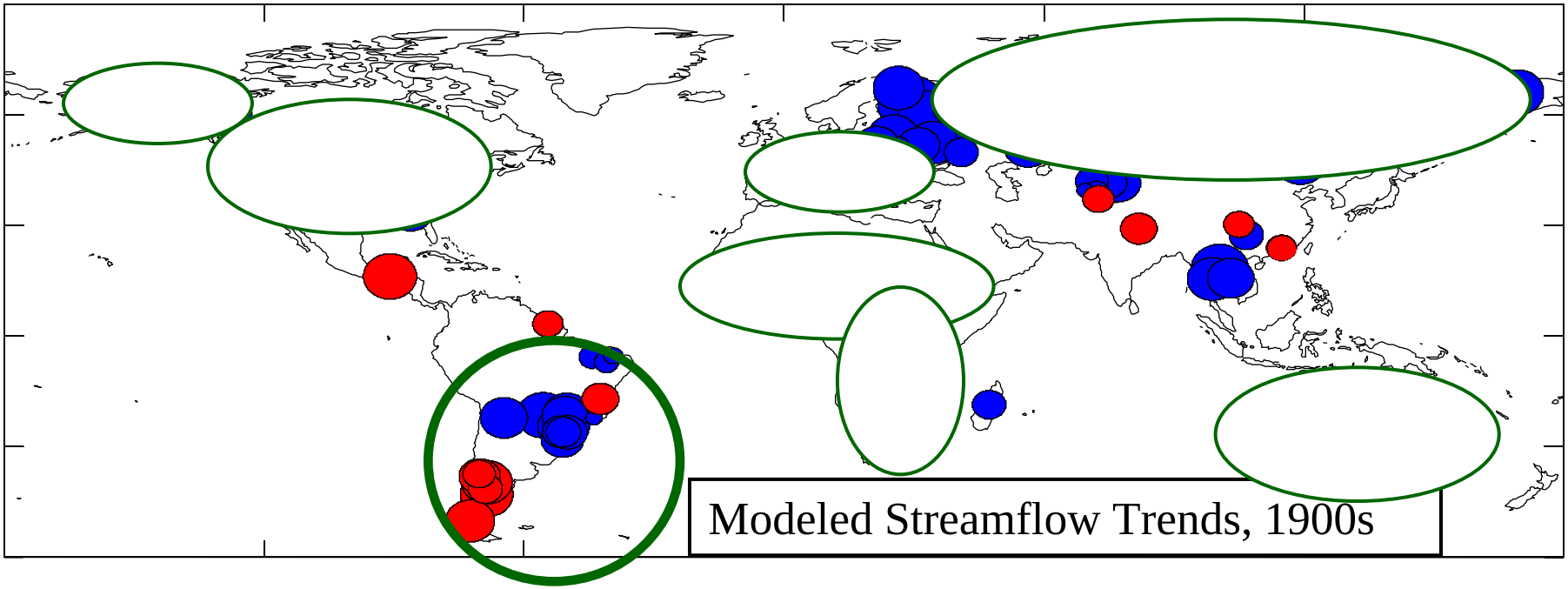
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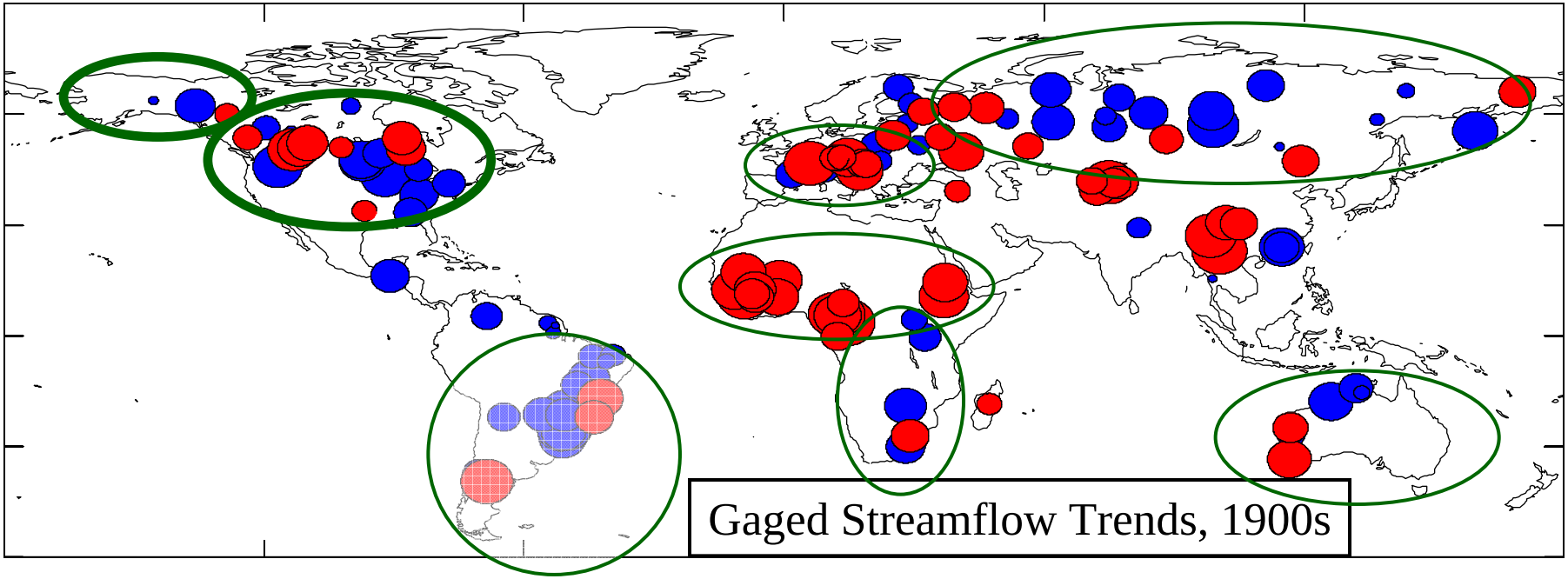
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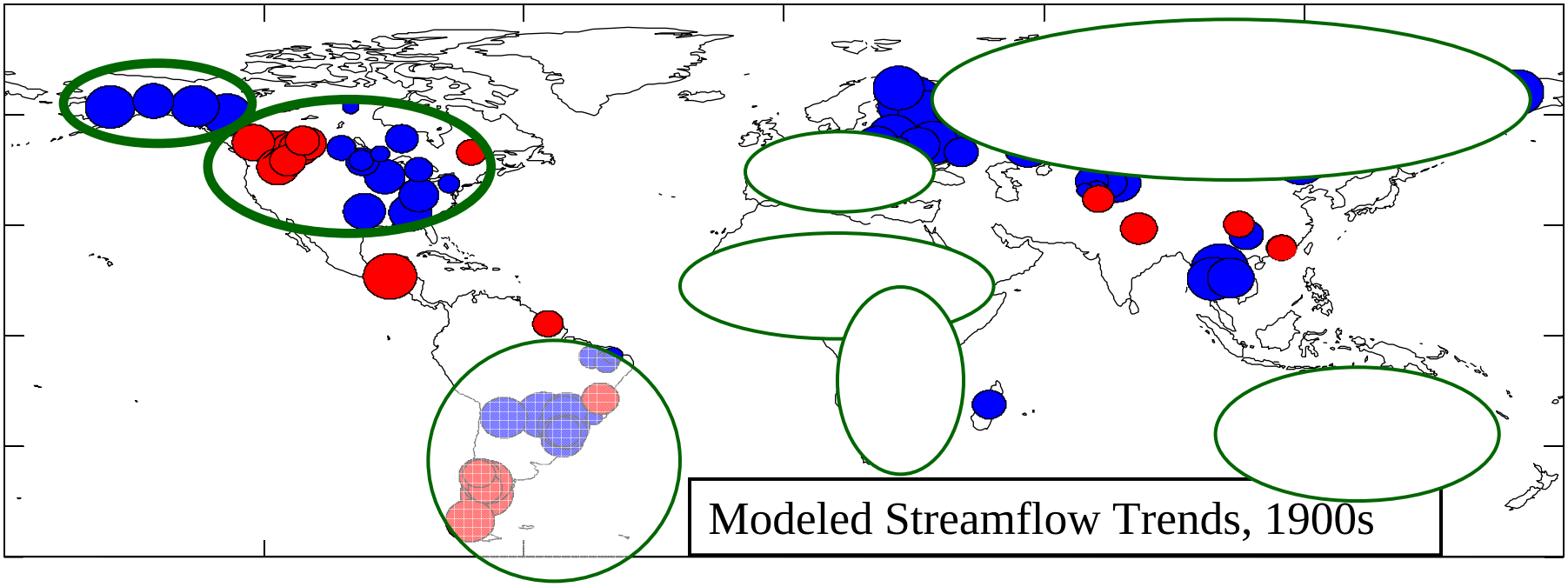
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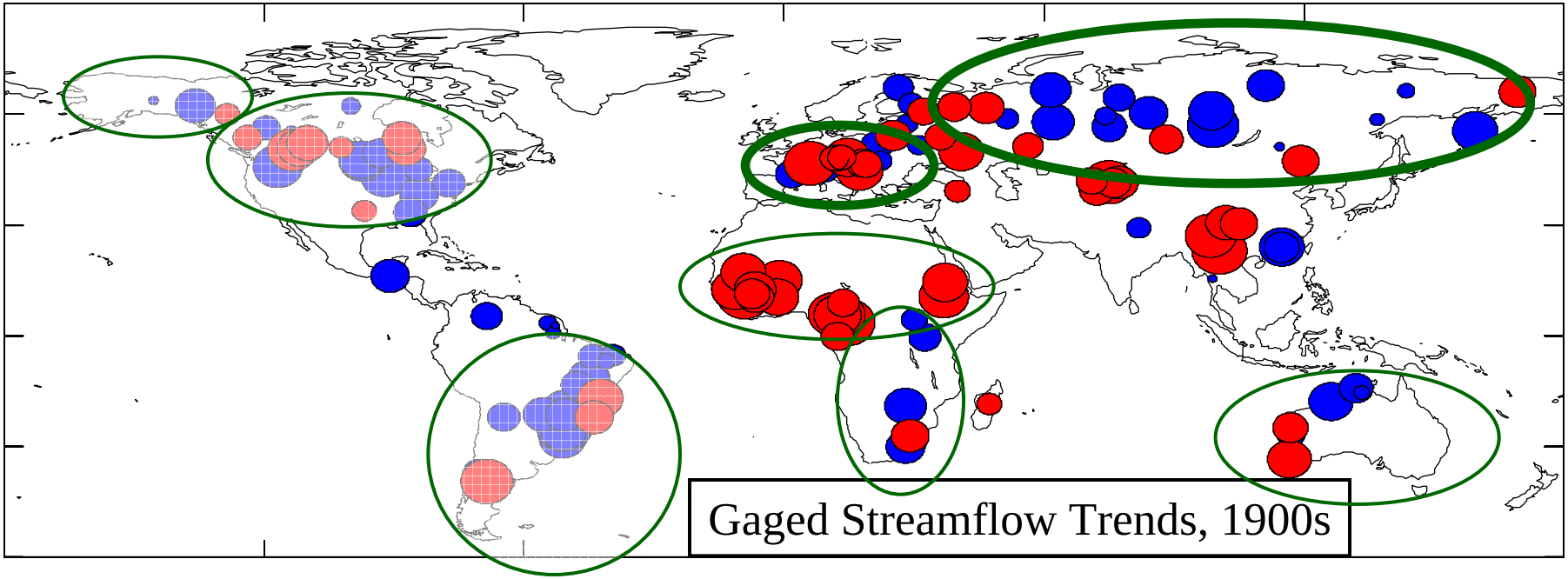
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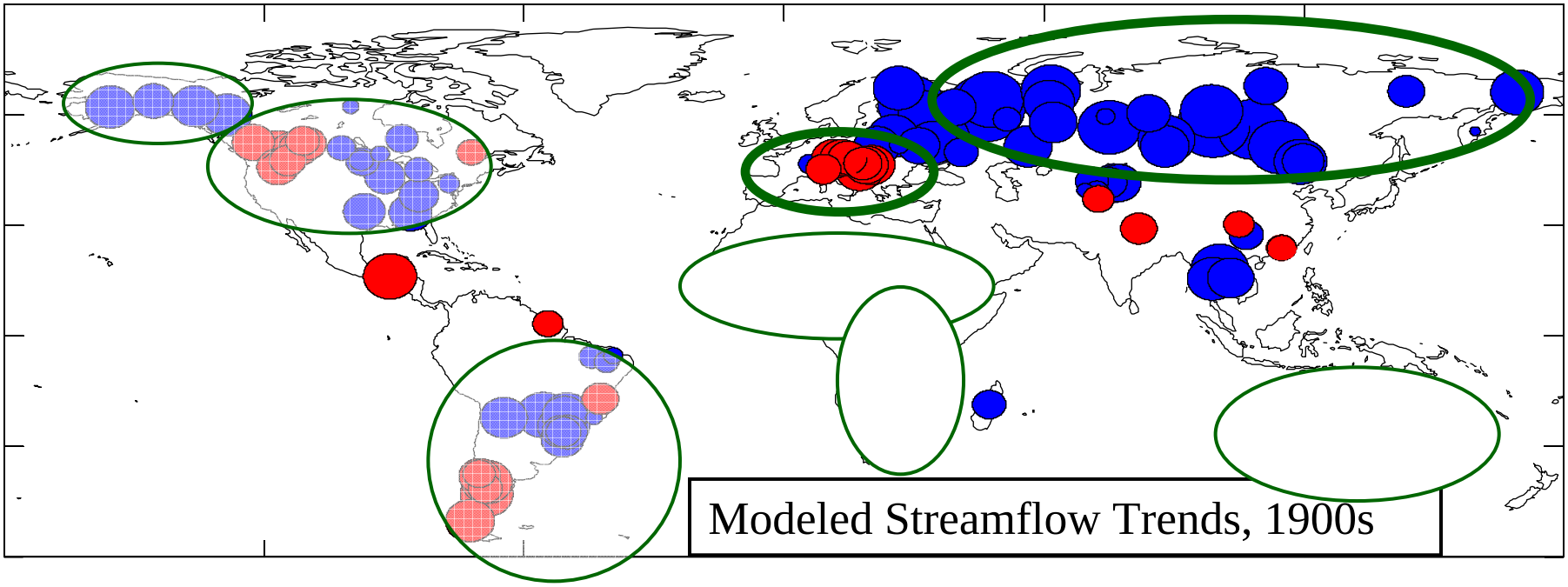
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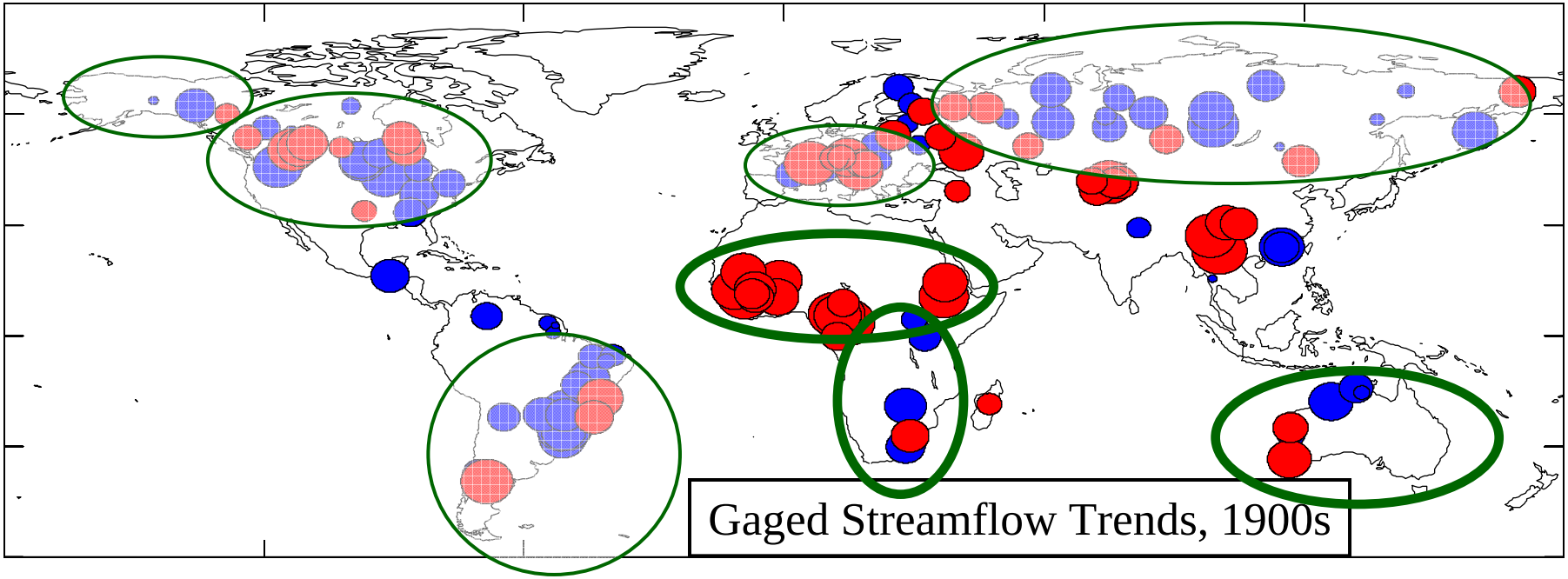
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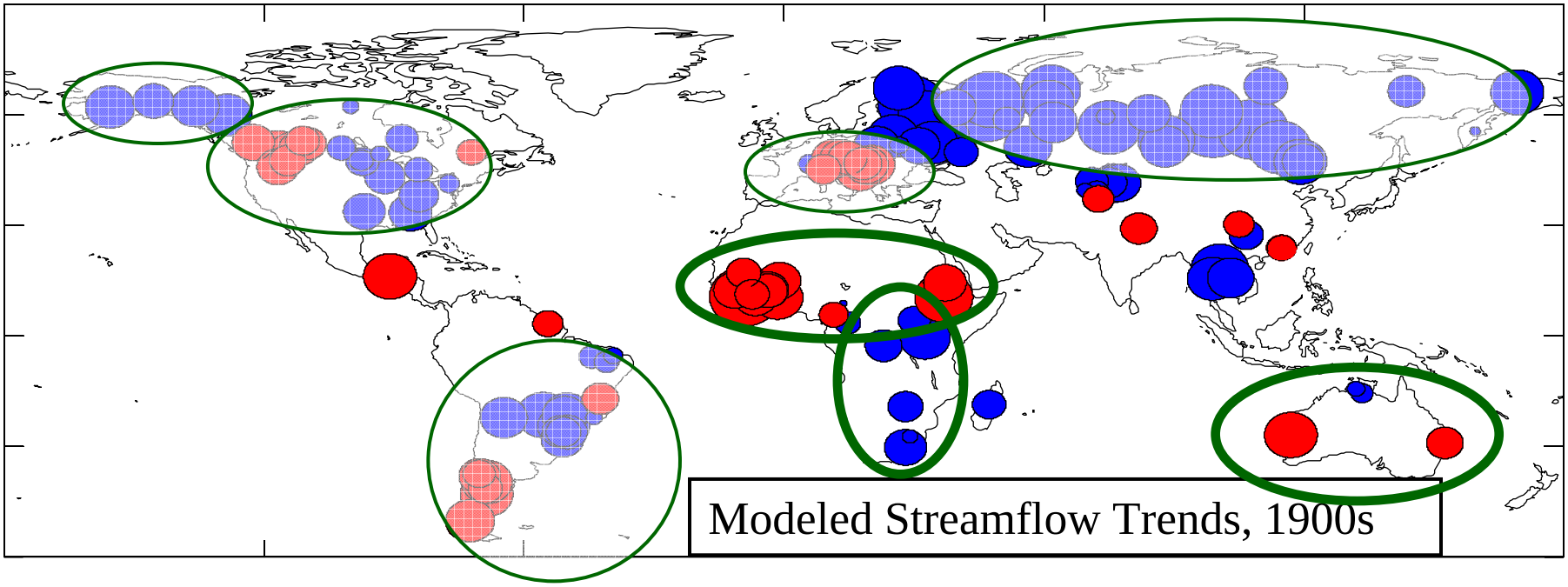
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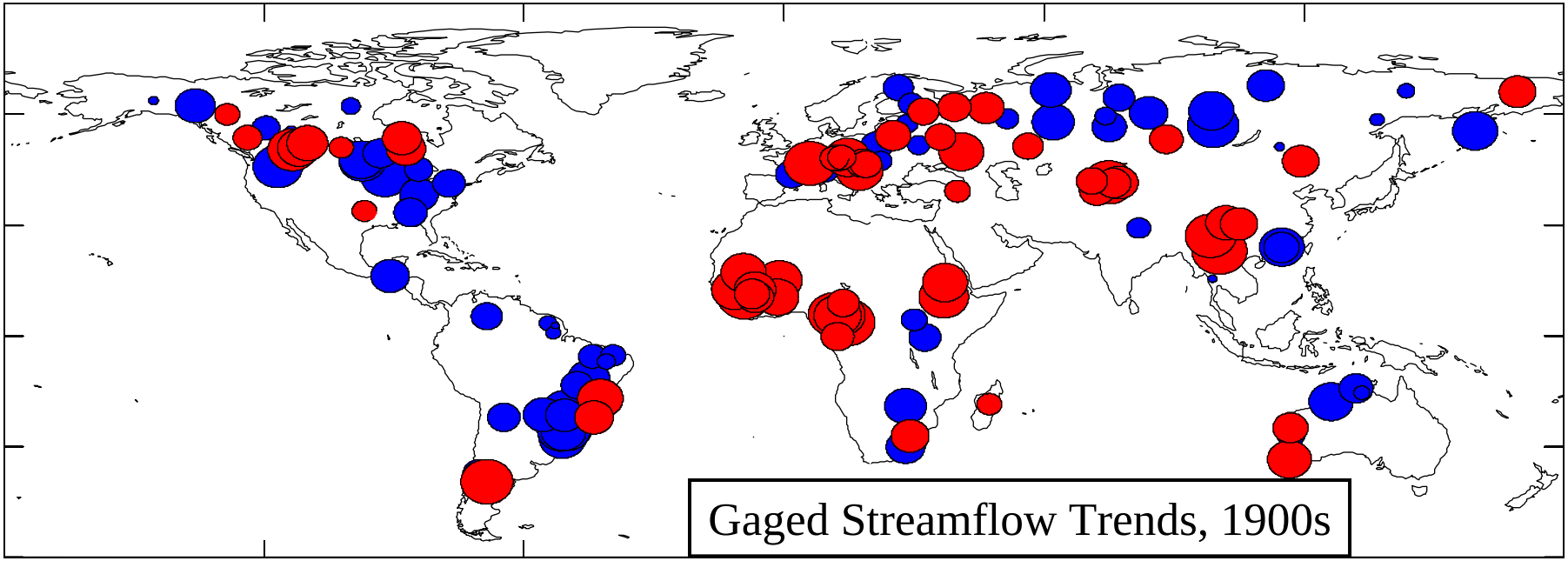
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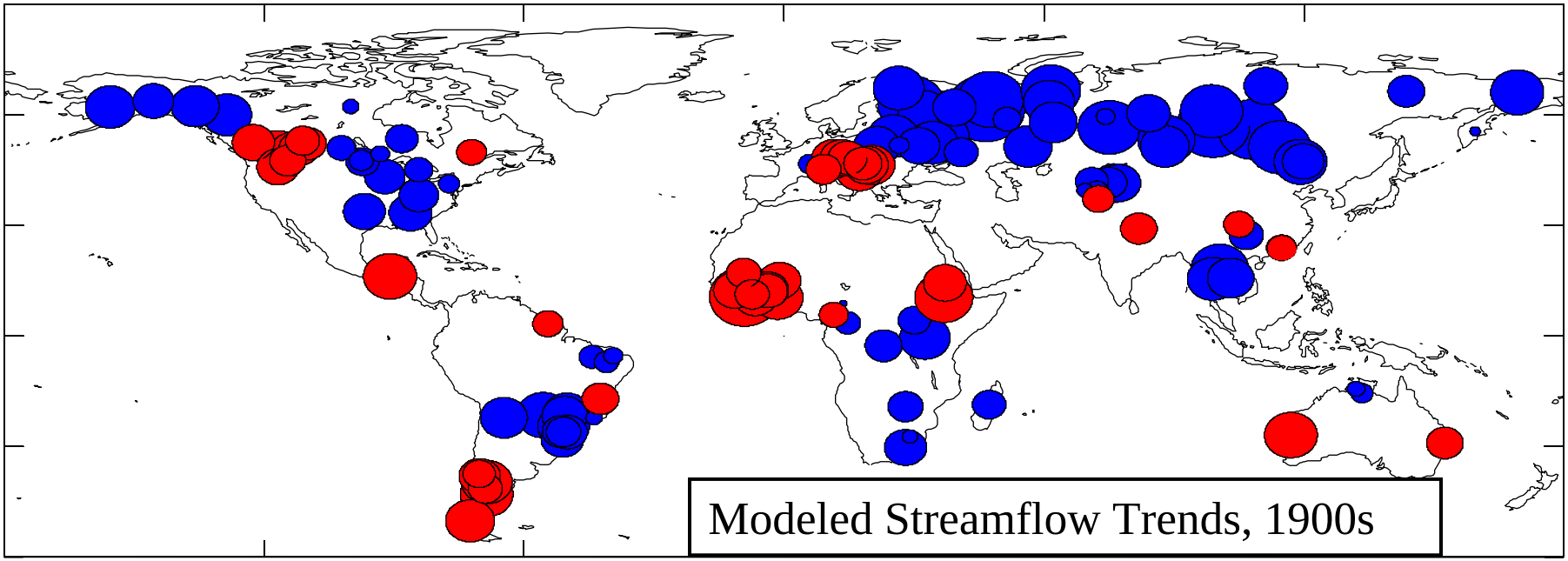
Modeled Streamflow Trends, 1900s

It now appears likely that a substantial part of global streamflow variability during the 20th century was not a random internal fluctuation of the climate system, but rather was caused by externally forced changes in climate.

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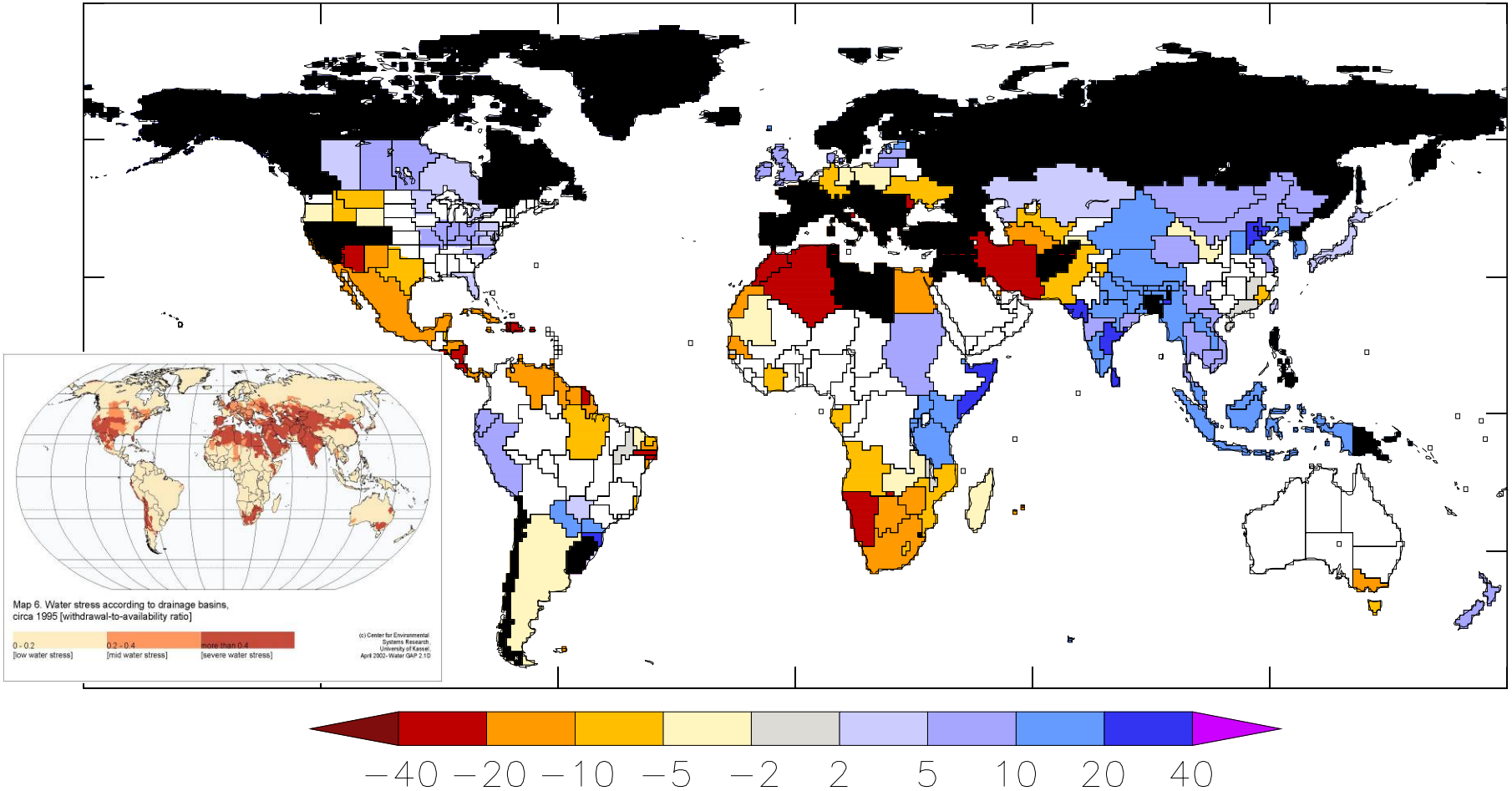
Model-Projected Changes in Annual Runoff, 2041-2060

Percentage change relative to 1900-1970 baseline. Any color indicates that >66% of models agree on sign of change; diagonal hatching indicates >90% agreement.



(After Milly, P.C.D., K.A. Dunne, A.V. Vecchia, Global pattern of trends in streamflow and water availability in a changing climate, *Nature*, **438**, 347-350, 2005.)

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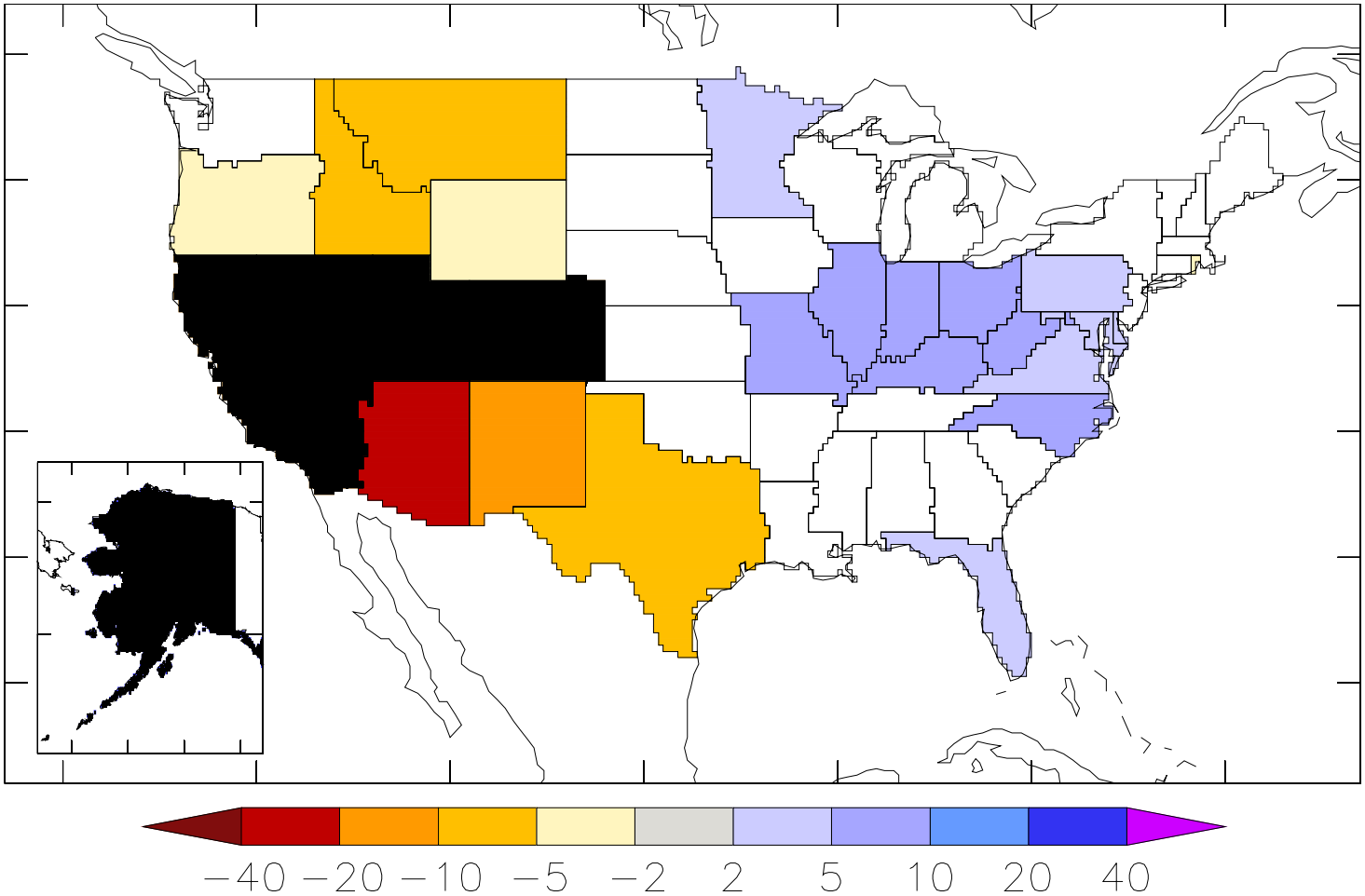

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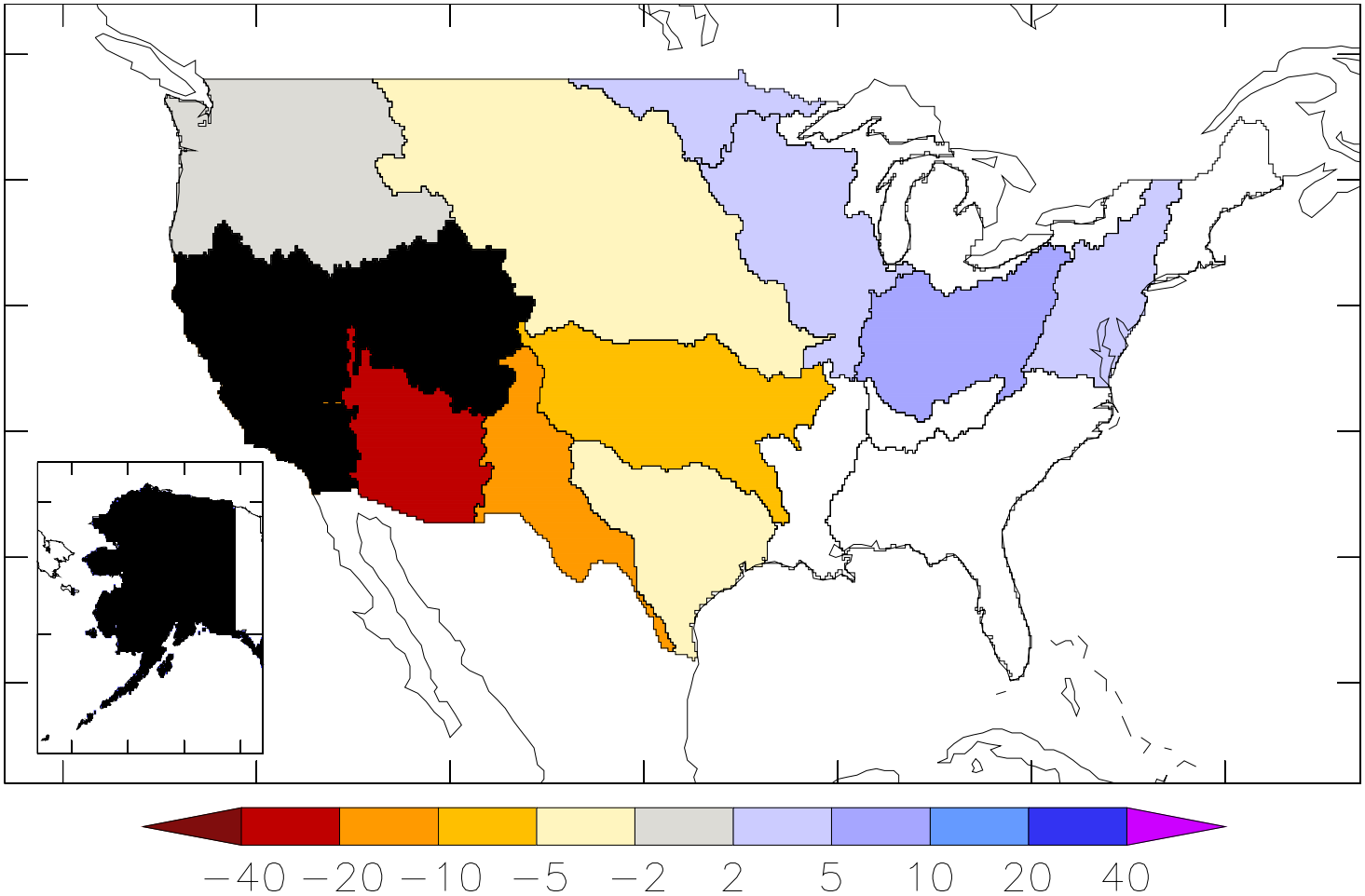

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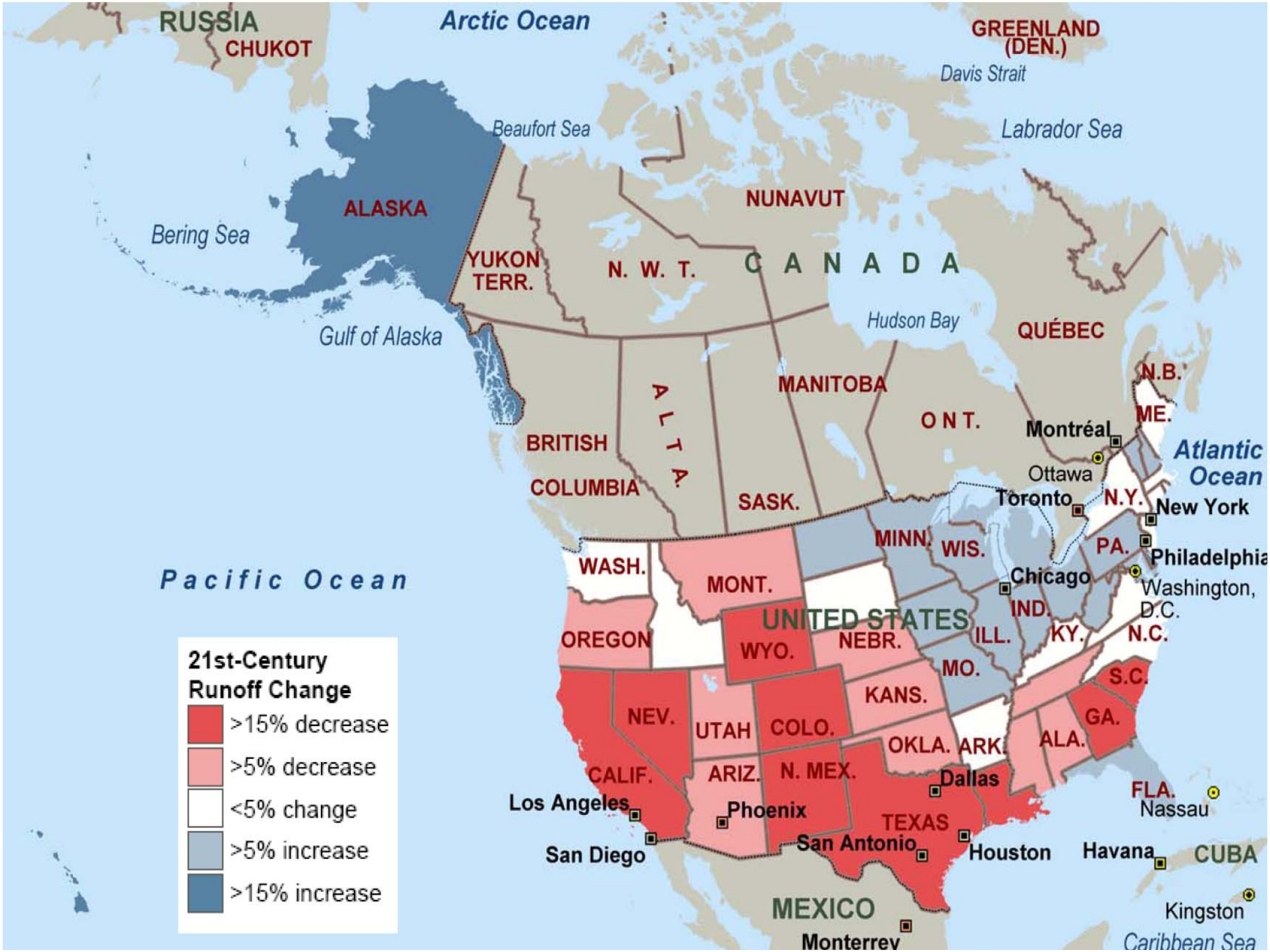
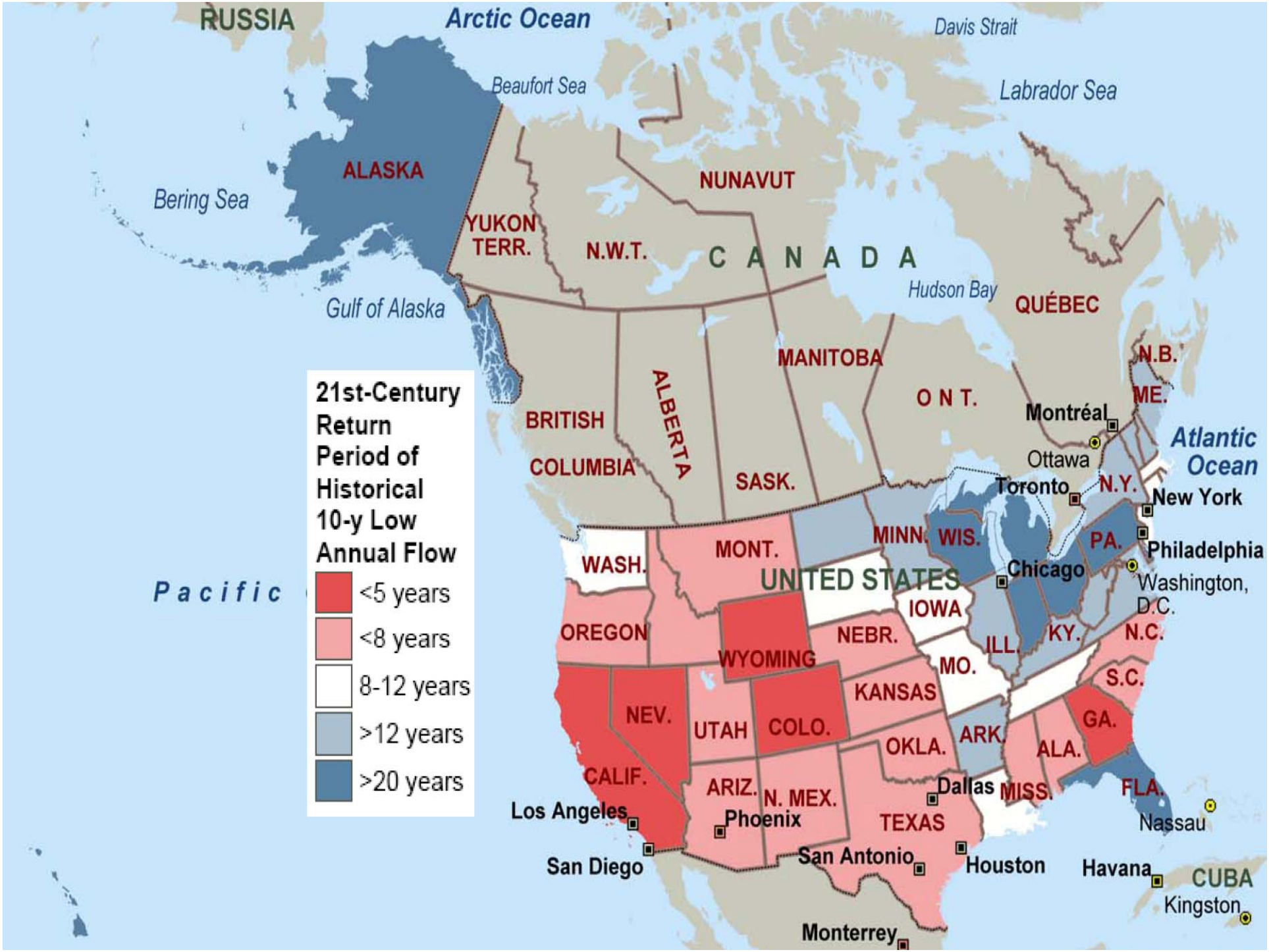

RUSSIA
CHUKOT
Arctic Ocean
GREENLAND (DEN.)
Davis Strait
Beaufort Sea
Labrador Sea
ALASKA
Bering Sea
NUNAVUT
YUKON TERR.
N. W. T.
CANADA
Hudson Bay
QUÉBEC
Gulf of Alaska
N.B.
MANITOBA
ALTA.
ONT.
ME.
Montréal
BRITISH COLUMBIA
Ottawa
Atlantic Ocean
Toronto
N.Y.
New York
SASK.
MINN.
WIS.
PA.
Philadelphia
WASH.
MONT.
Chicago
Washington, D.C.
Pacific Ocean
UNITED STATES
IND.
OREGON
WYO.
NEBR.
ILL.
KY.
N.C.
MO.
S.C.
KANS.
NEV.
UTAH
COLO.
GA.
OKLA.
ARK.
ALA.
CALIF.
ARIZ.
N. MEX.
Dallas
FLA.
Nassau
Los Angeles
Phoenix
TEXAS
San Antonio
San Diego
Houston
Havana
CUBA
MEXICO
Kingston
Monterrey
Caribbean Sea
21st-Century Runoff Change
>15% decrease
>5% decrease
<5% change
>5% increase
>15% increase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ALBERTA
O N T.
Montréal
BRITISH COLUMBIA
Ottawa
Atlantic Ocean
SASK.
Toronto
N.Y.
New York
21st-Century Return Period of Historical 10-y Low Annual Flow
<5 years
<8 years
8-12 years
>12 years
>20 years
MINN.
WIS.
PA.
Philadelphia
WASH.
MONT.
UNITED STATES
Chicago
Washington, D.C.
Pacific
IOWA
OREGON
NEBR.
ILL.
KY.
N.C.
WYOMING
MO.
S.C.
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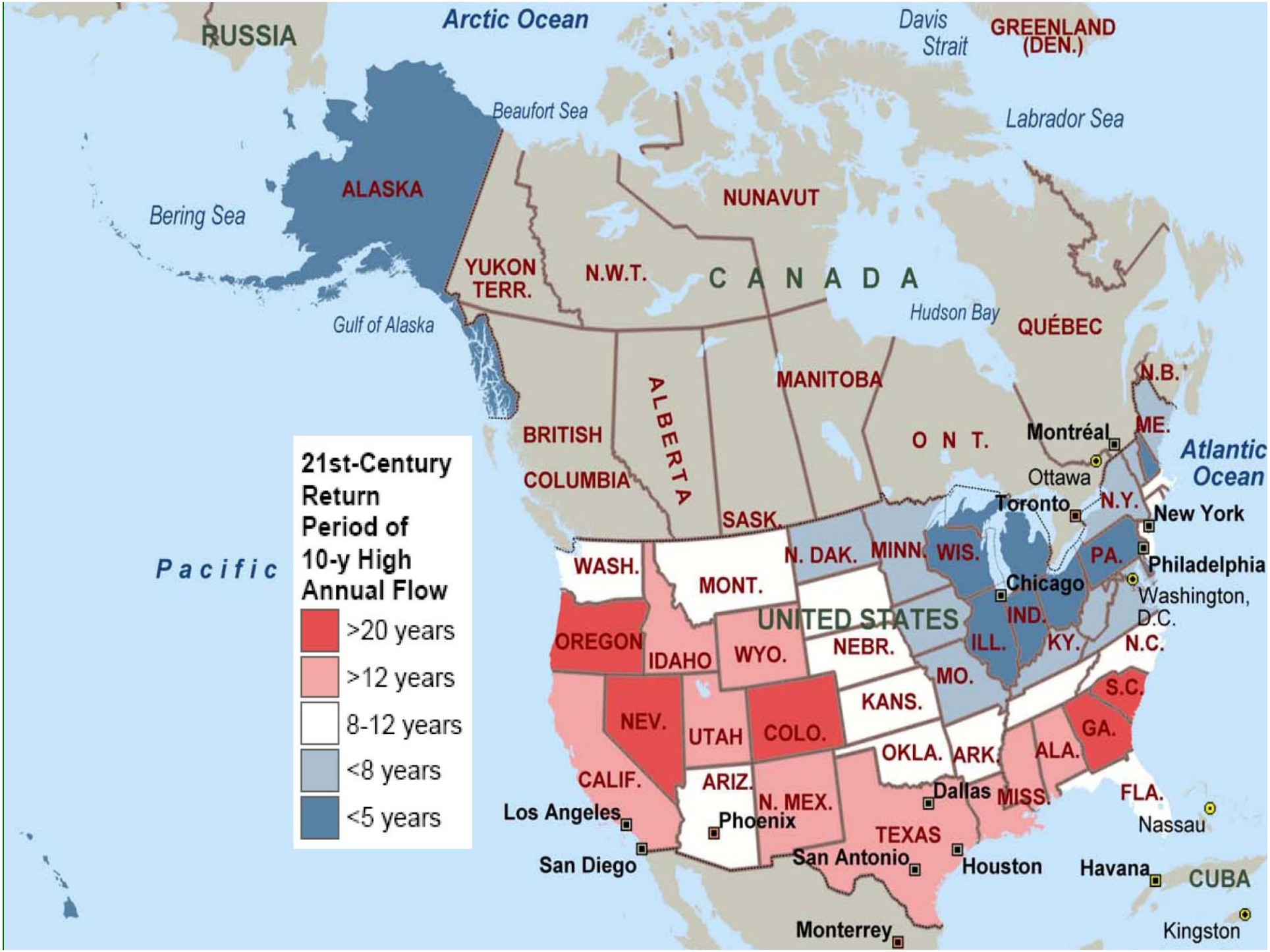
Havana
CUBA
Kingston
Monterrey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Pacific
WASH.
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MINN.
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Philadelphia
Chicago
Washington, D.C.
UNITED STATES
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OREGON
IDAHO
WYO.
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KANS.
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ARK.
ALA.
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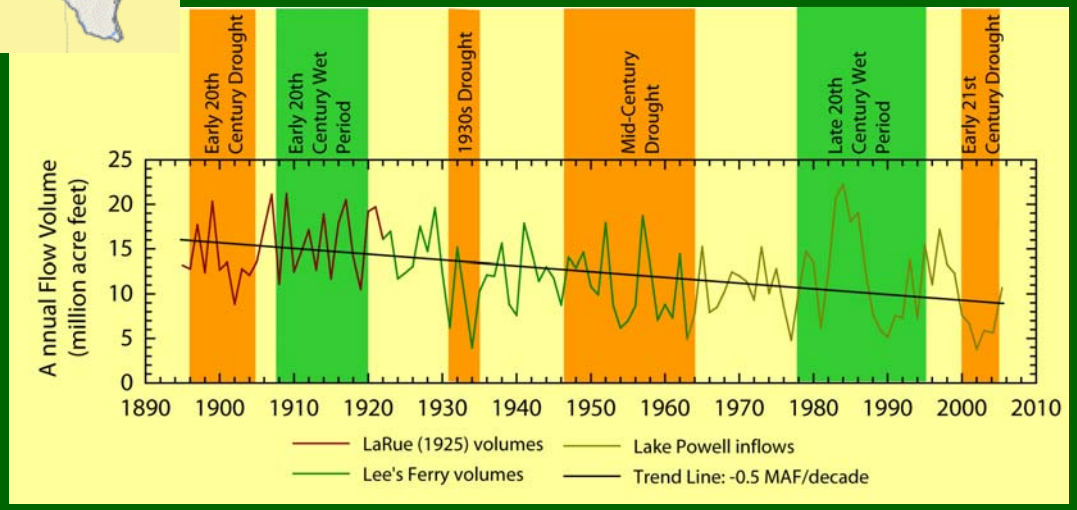
Los Angeles
Phoenix
TEXAS
Nassau
San Diego
San Antonio
Houston
Havana
CUBA
Monterrey
Kingston
21st-Century Return Period of 10-y High Annual Flow
>20 years
>12 years
8-12 years
<8 years
<5 years

Changes in Annual Runoff

Colorado River at Lee's Ferry

USGS Fact Sheet 2004-3062, Version 2, August 2004



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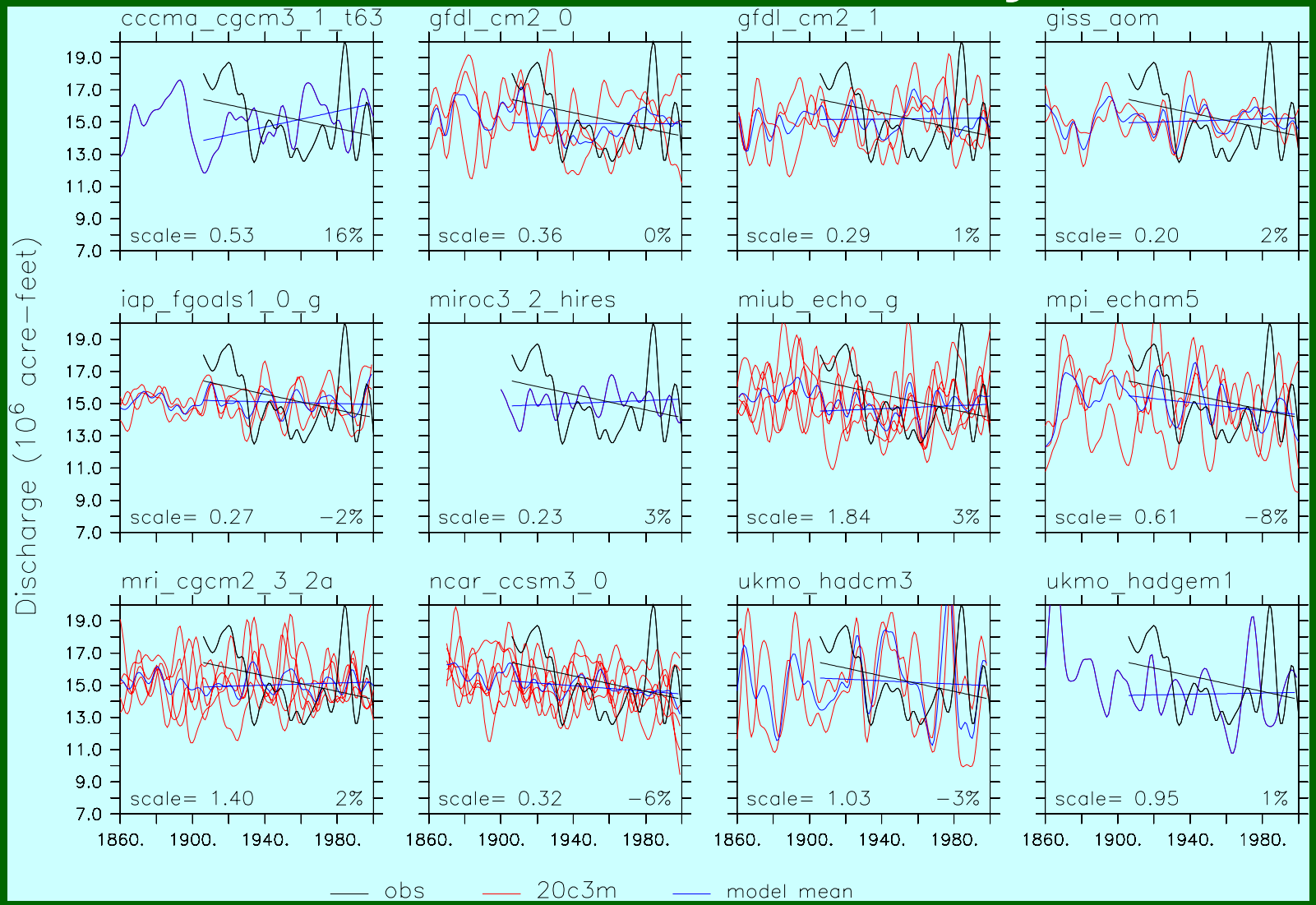
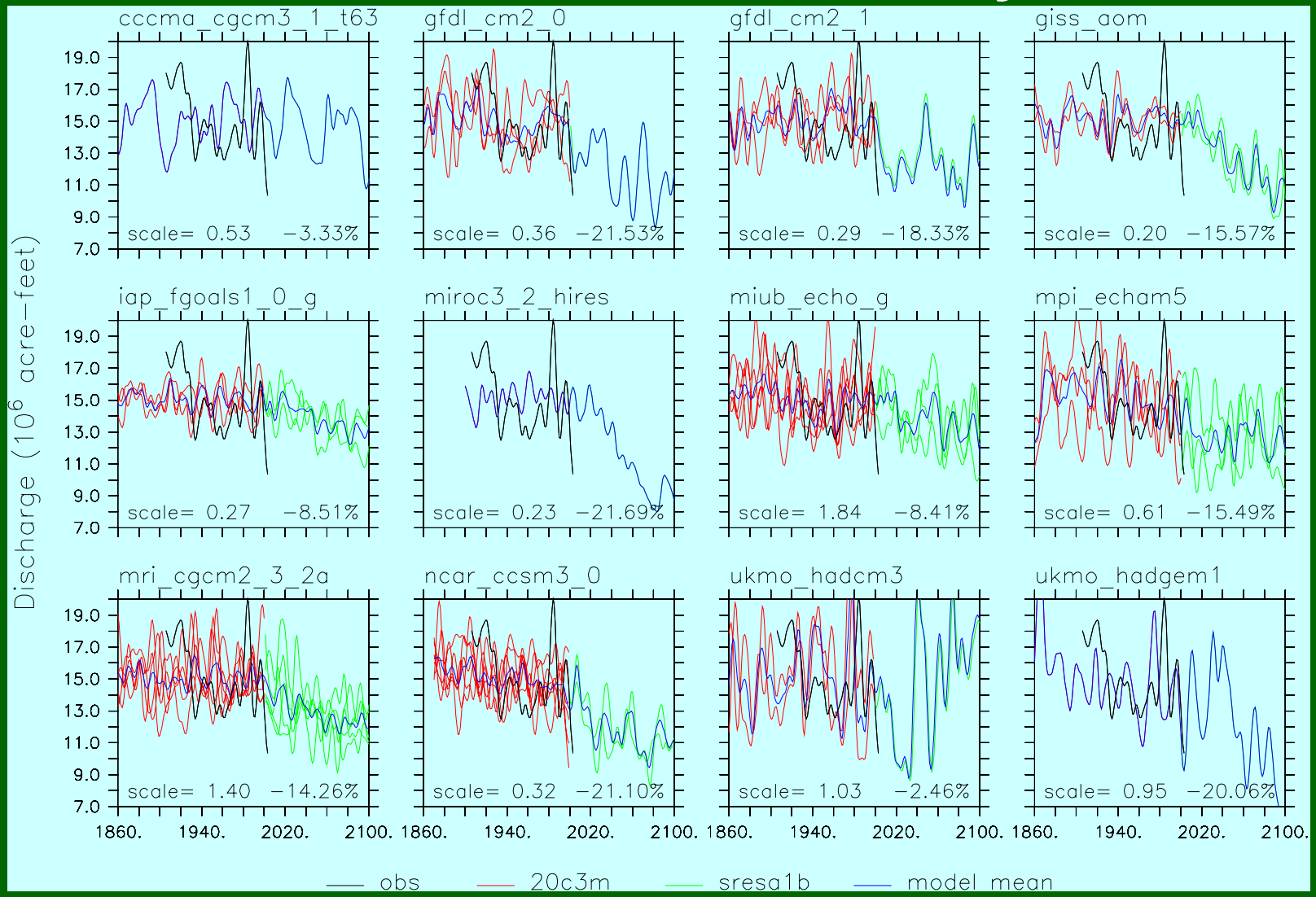
Colorado River at Lee's Ferry



Model results are scaled to match adjusted flow record from Webb et al. (2005), which has linear slope of –16%/century.

Colorado River at Lee's Ferry



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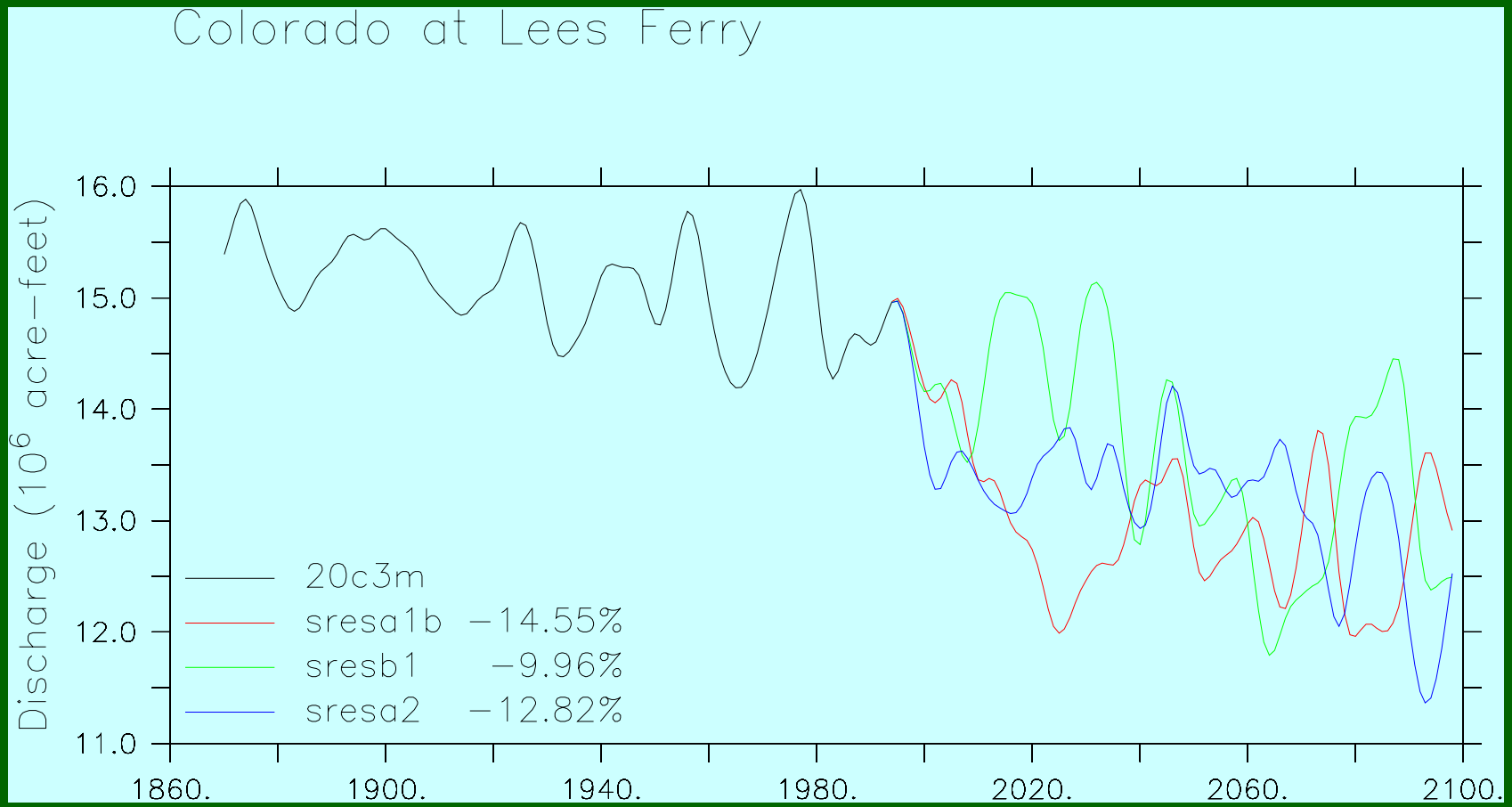

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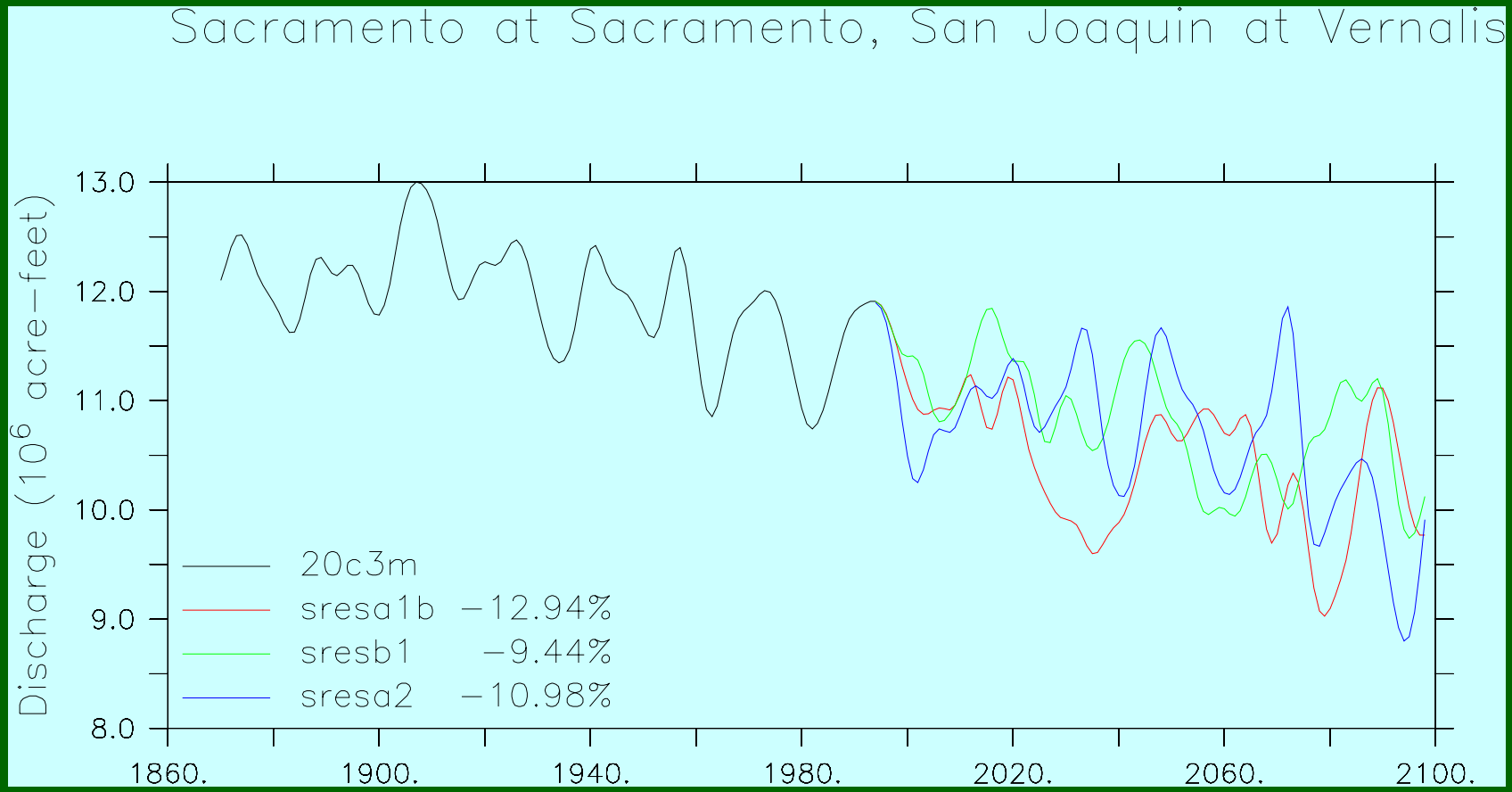
Combined SF Bay Inflows



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Concluding Comments

- Climate models have significant, though imperfect, skill in characterizing regional trends in mean annual streamflow.
- Climate models project substantial regional changes in mean annual streamflow for the 21st Century.

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