Solar Effect on North American Hydroclimatology Through Pacific Sea-Surface Temperatures and Atmospheric Vorticity

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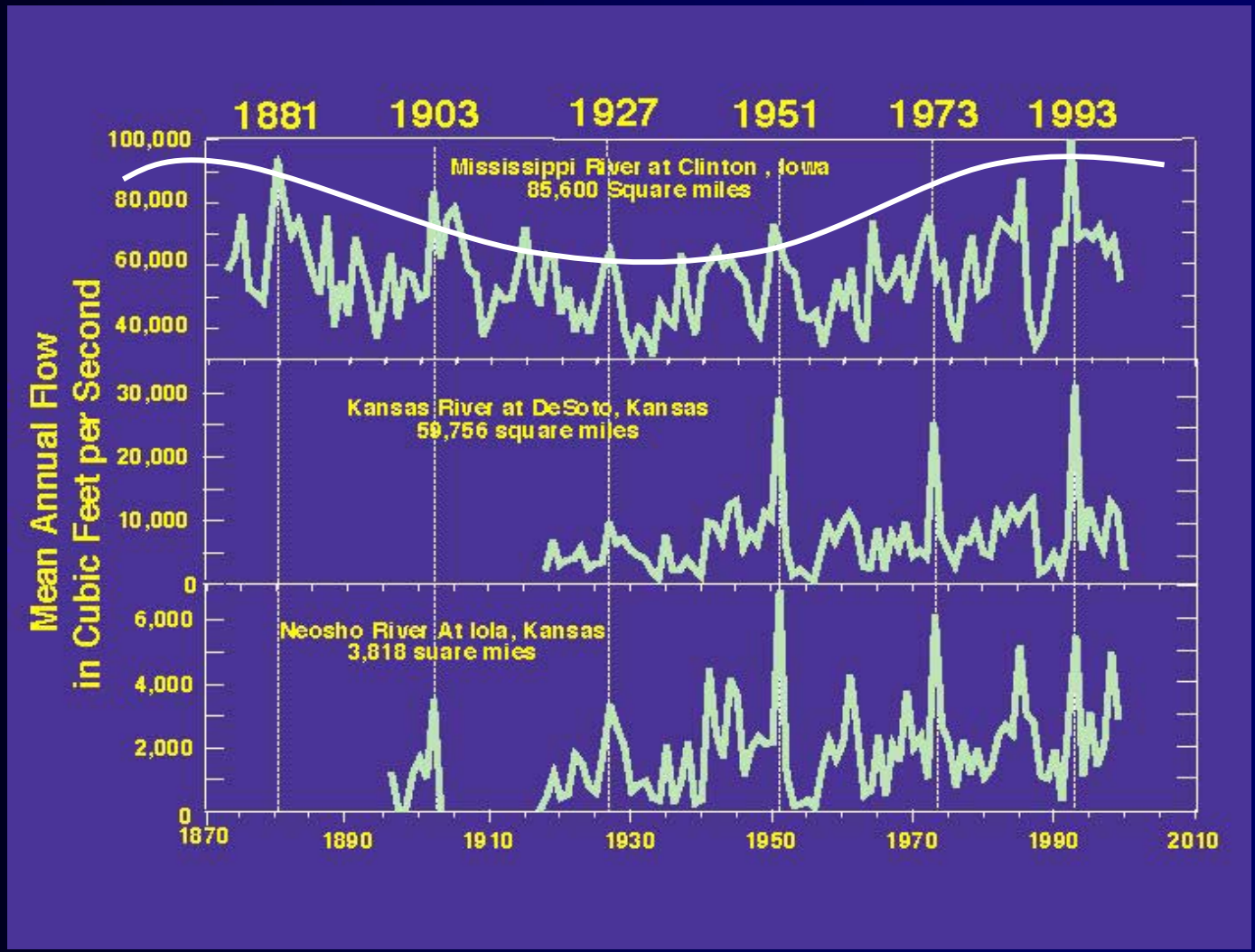
REOCCURING FLOODS-- Mississippi and Missouri Rivers, August 1993

Floods and droughts are cyclical
Streamflow is a good integrater of climate

USGS

In the Midwest, large floods occur on the average every 22 years, while smaller floods generally occur midway between.



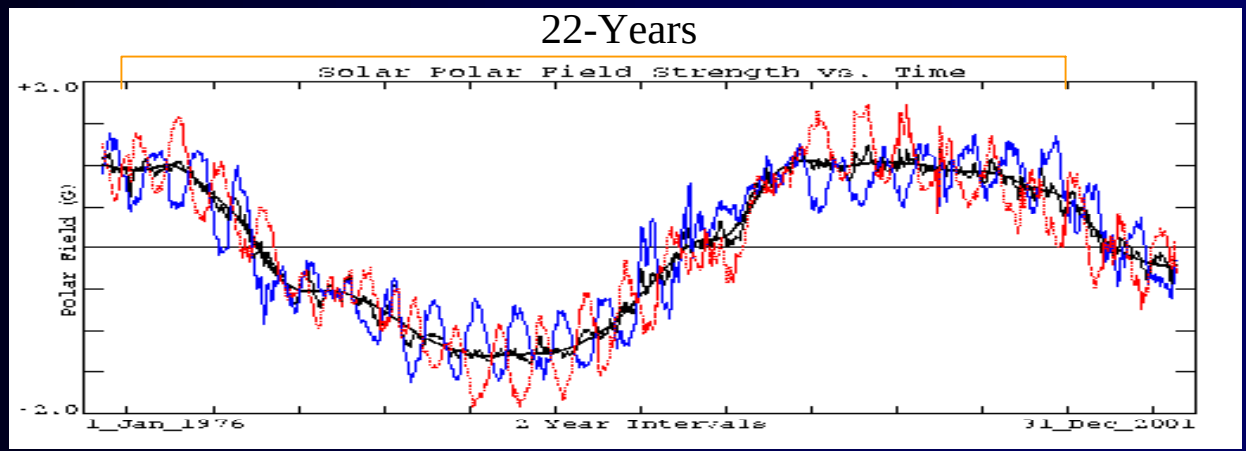
USGS

Sunspots-- 11 years

Irradiance-- 11 years

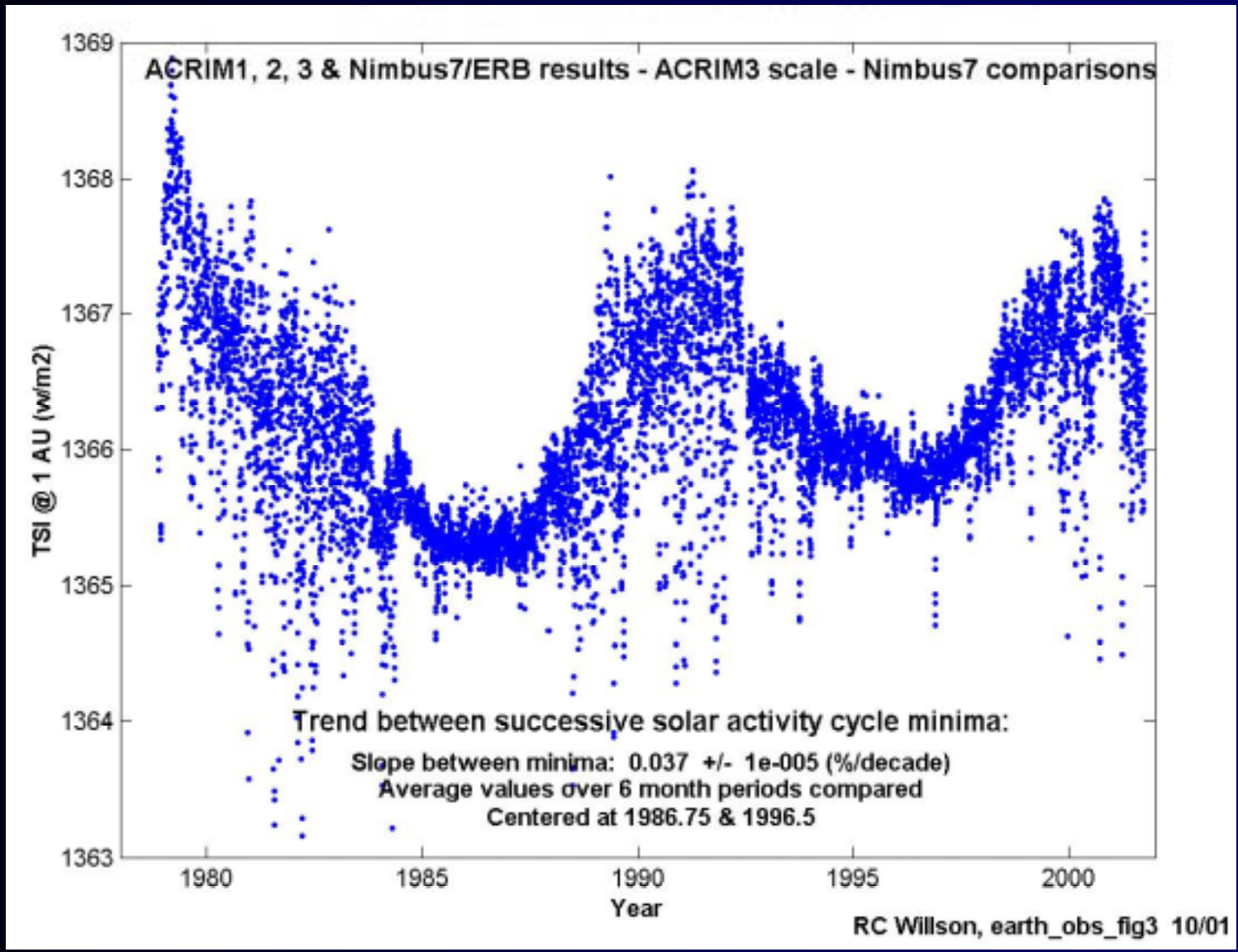
Gleisberg Cycle 80-100 years

Magnetic strength and polarity-- 22 years



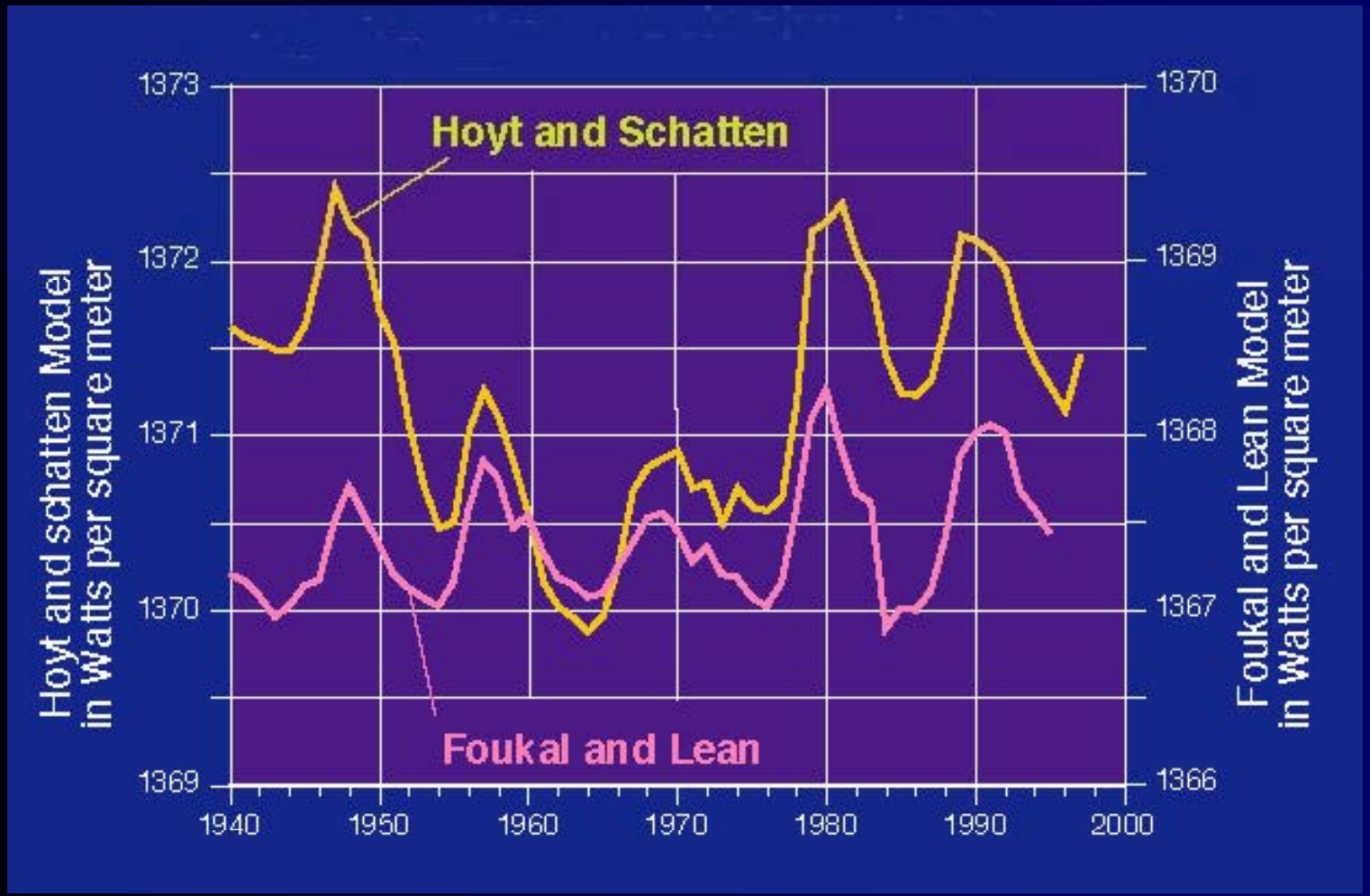
USGS

ACRIM Composite Total Solar Irradiance



USGS

Two Models for Solar Irradiance



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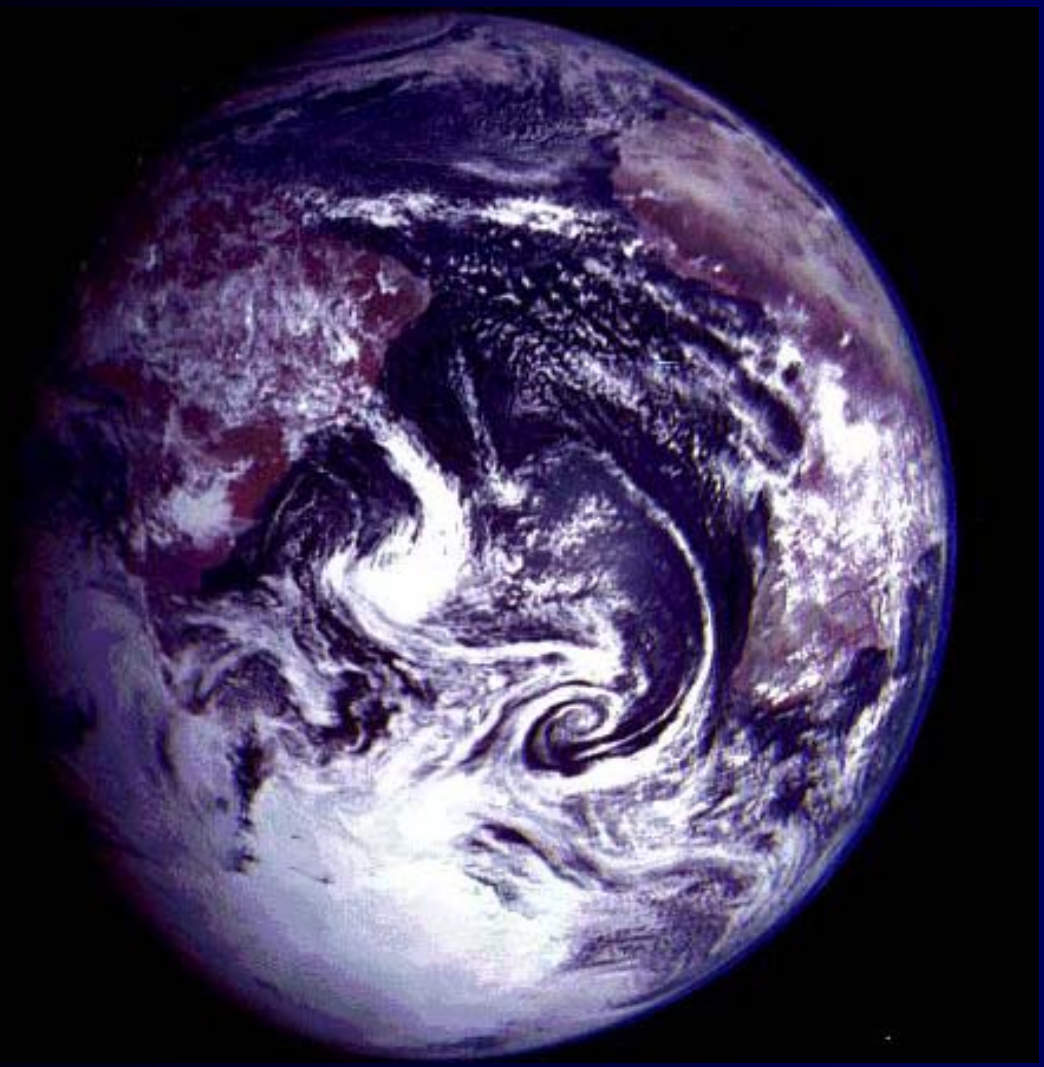
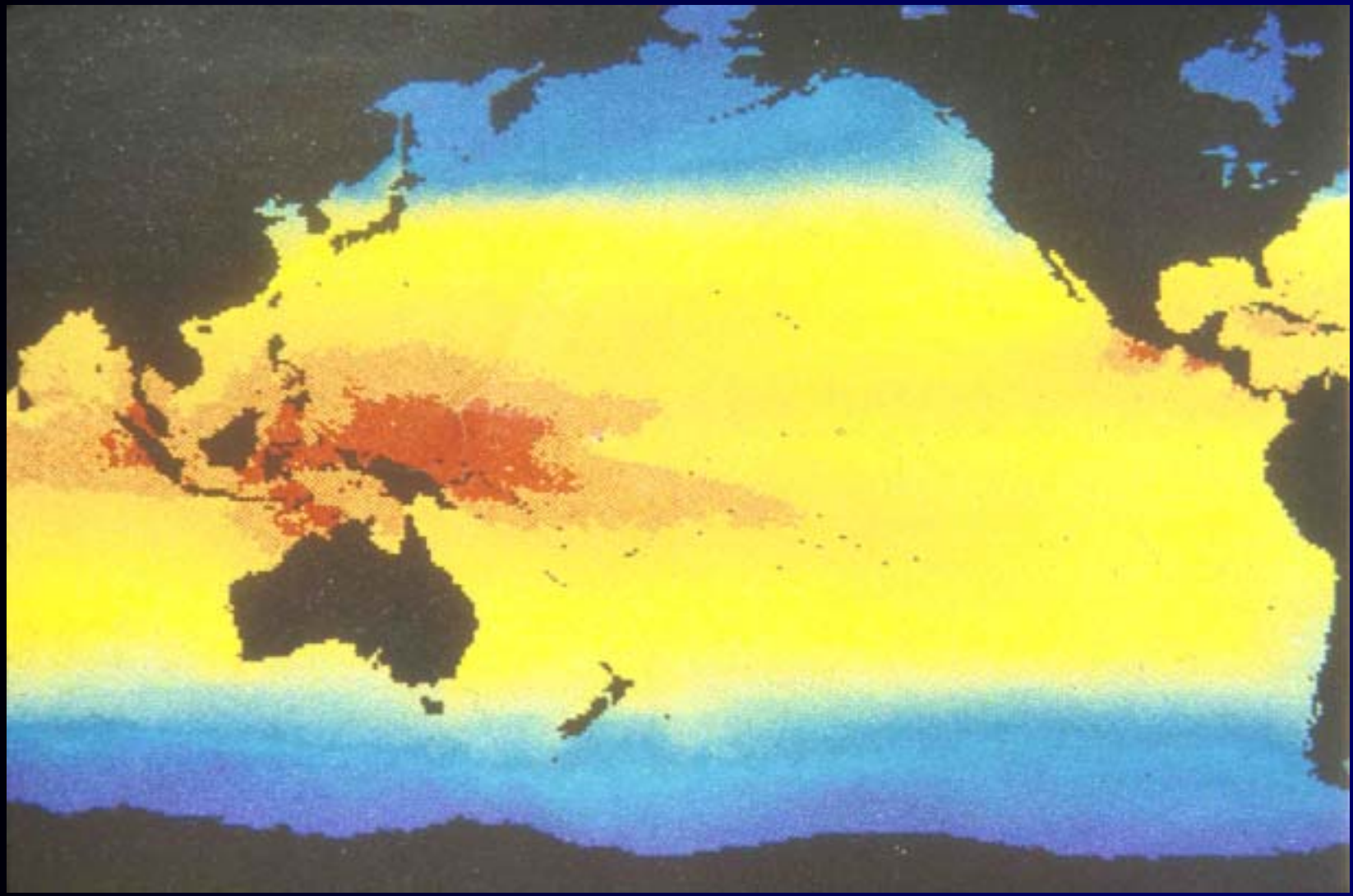


The most important factor in the global weather machine is the world's oceans.

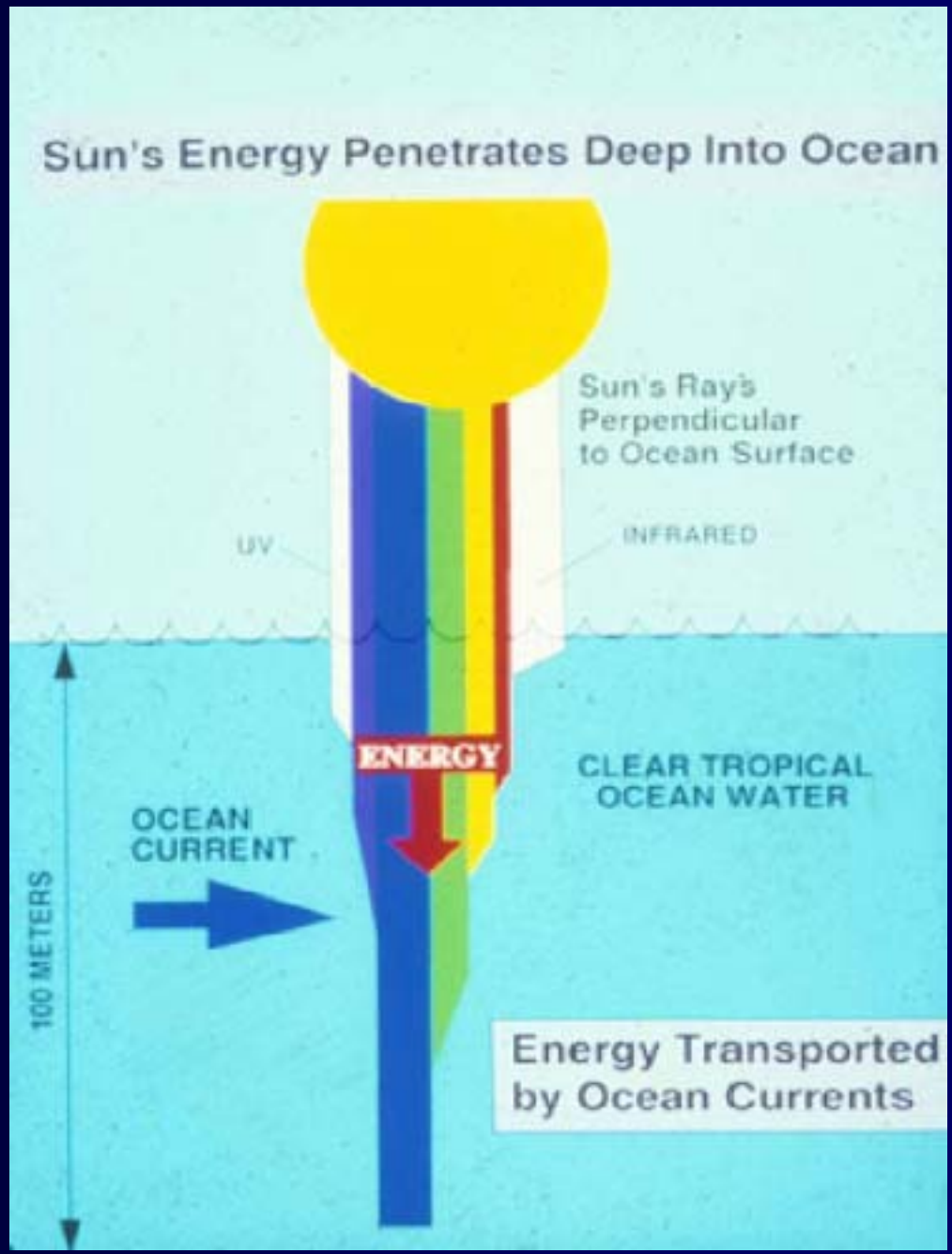
USGS

Pacific Warm Pool



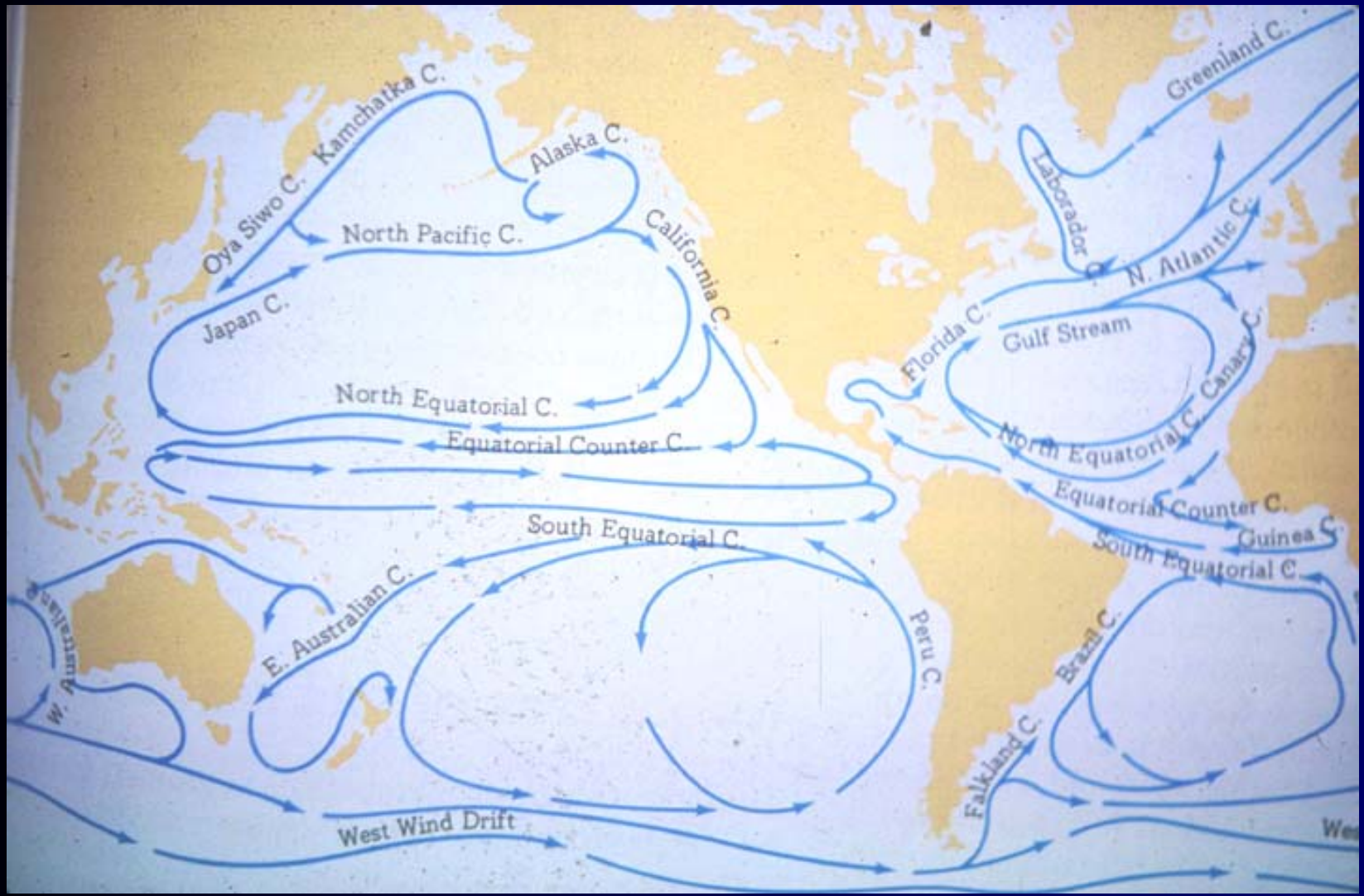
USGS

In clear tropical ocean water the Sun's energy can penetrate to a depth of nearly 100 meters

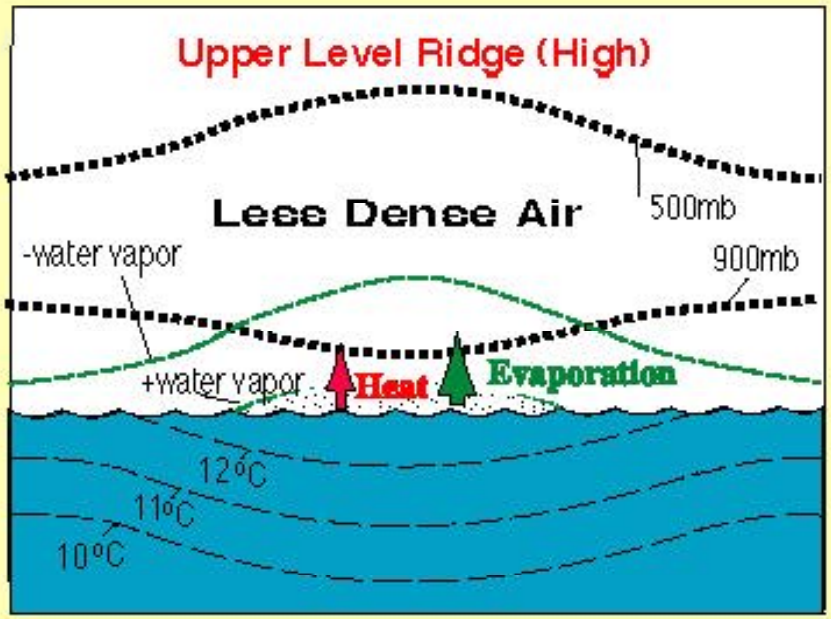


USGS

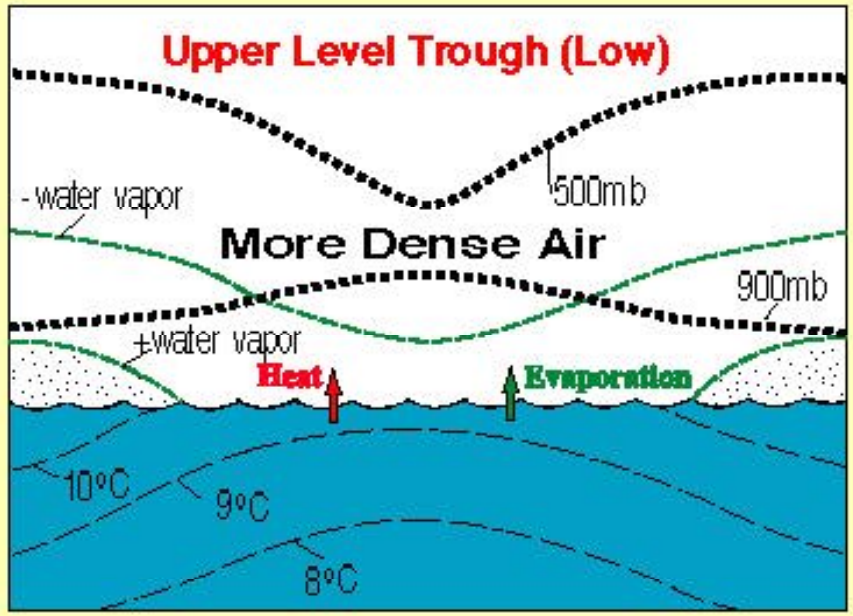
Major Ocean Currents



Effect of Sea Surface Temperatures on Upper Atmospheric Pressure Patterns



WARM OCEAN WATER
(WOW)



COOL OCEAN WATER
(COW)

Creates a Ridge above

Creates a Trough above

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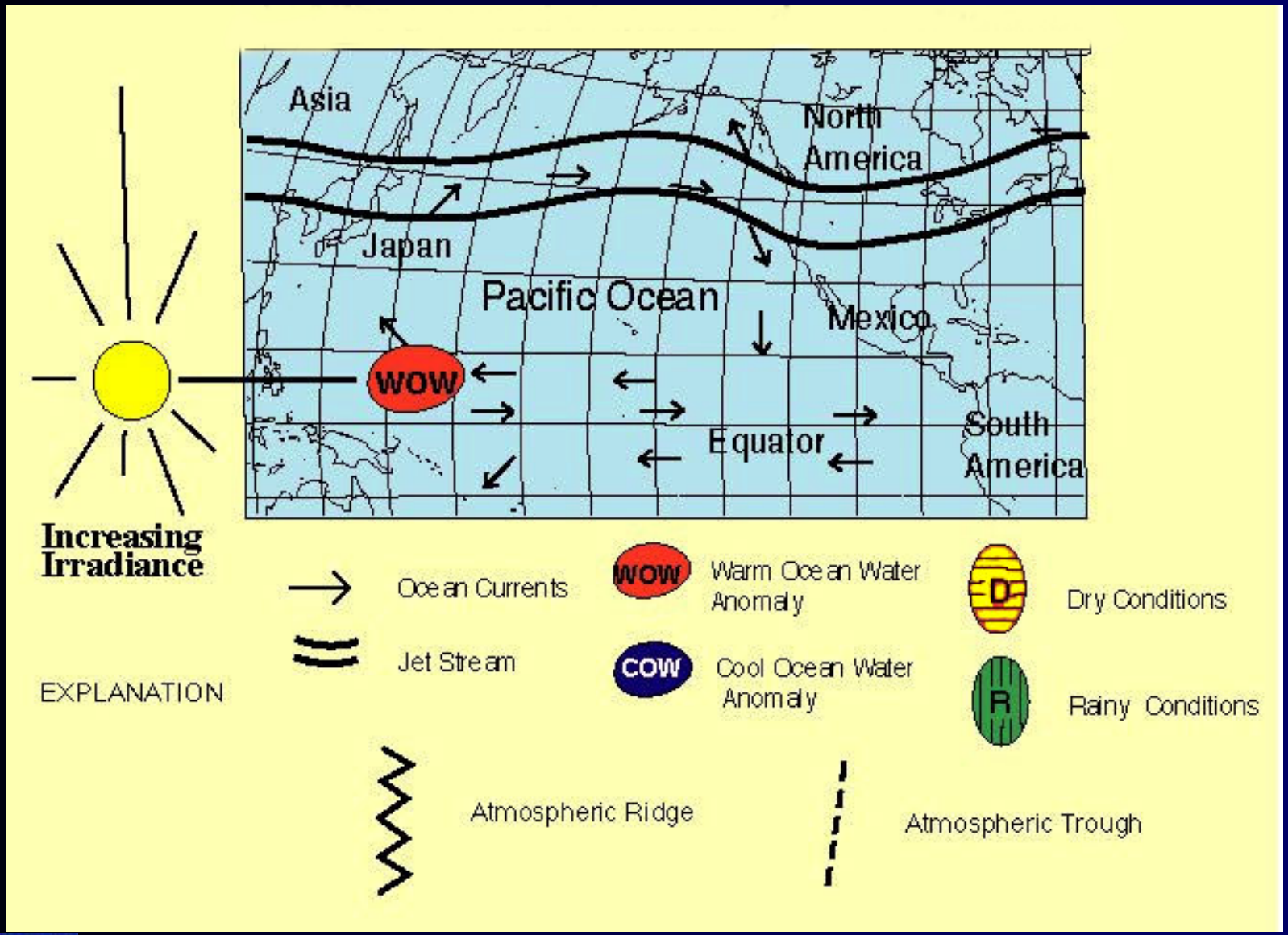
A. After a period of increased solar irradiance



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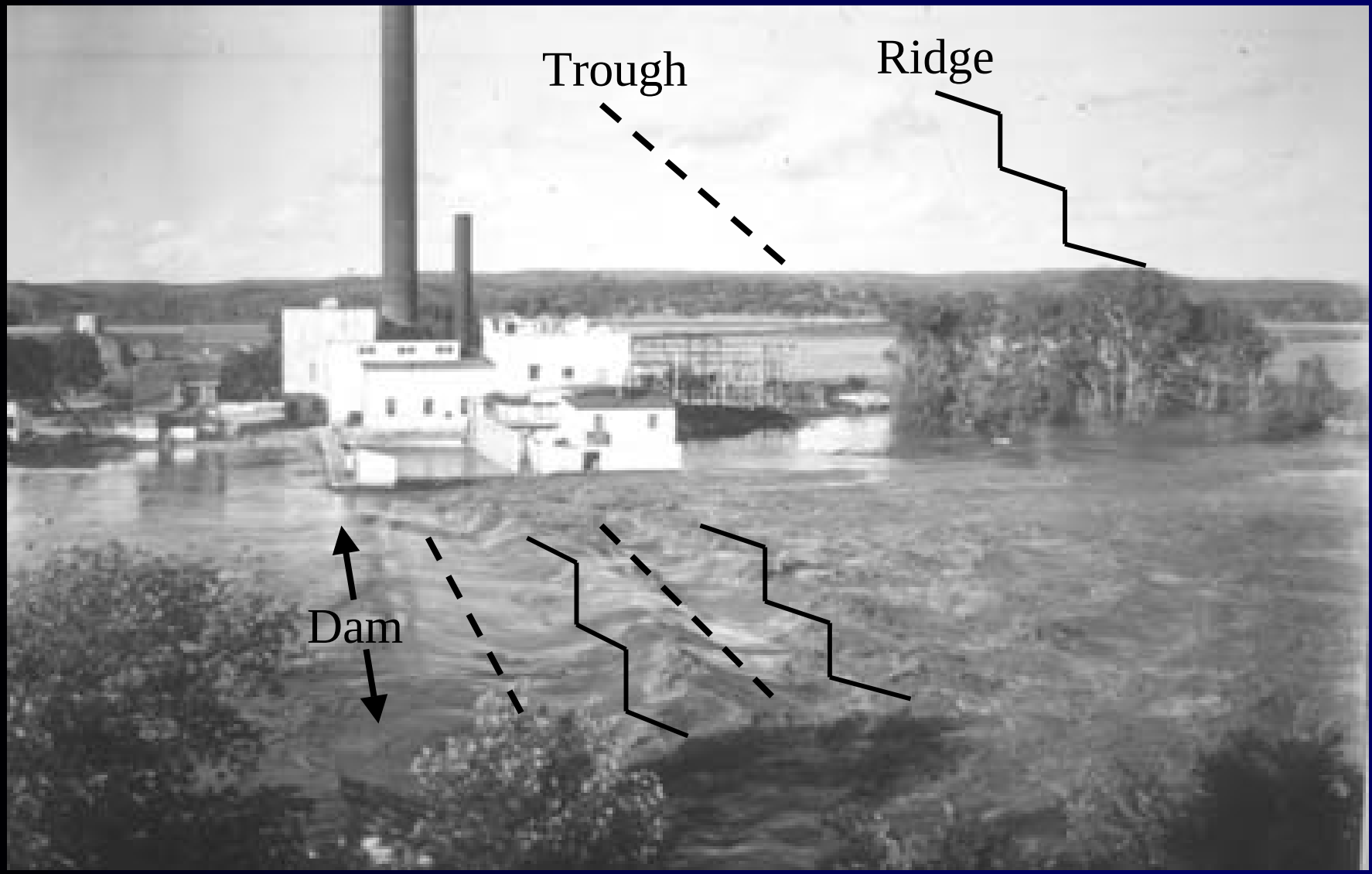
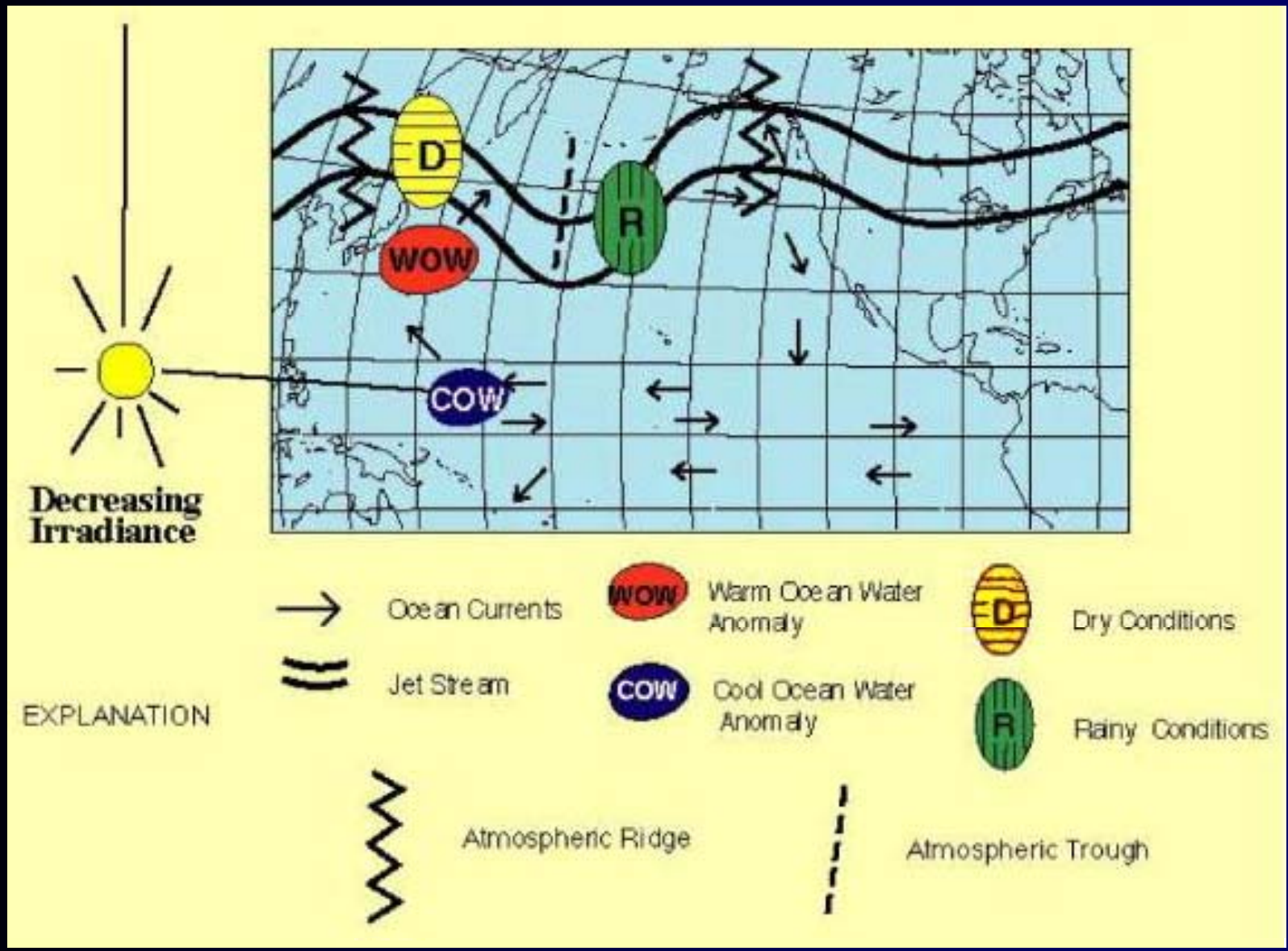


Waves in the jet stream behave like water flowing over an obstacle. Ridges and troughs are induced downstream.

USGS

B. 2 Years later (solar irradiance decreases)



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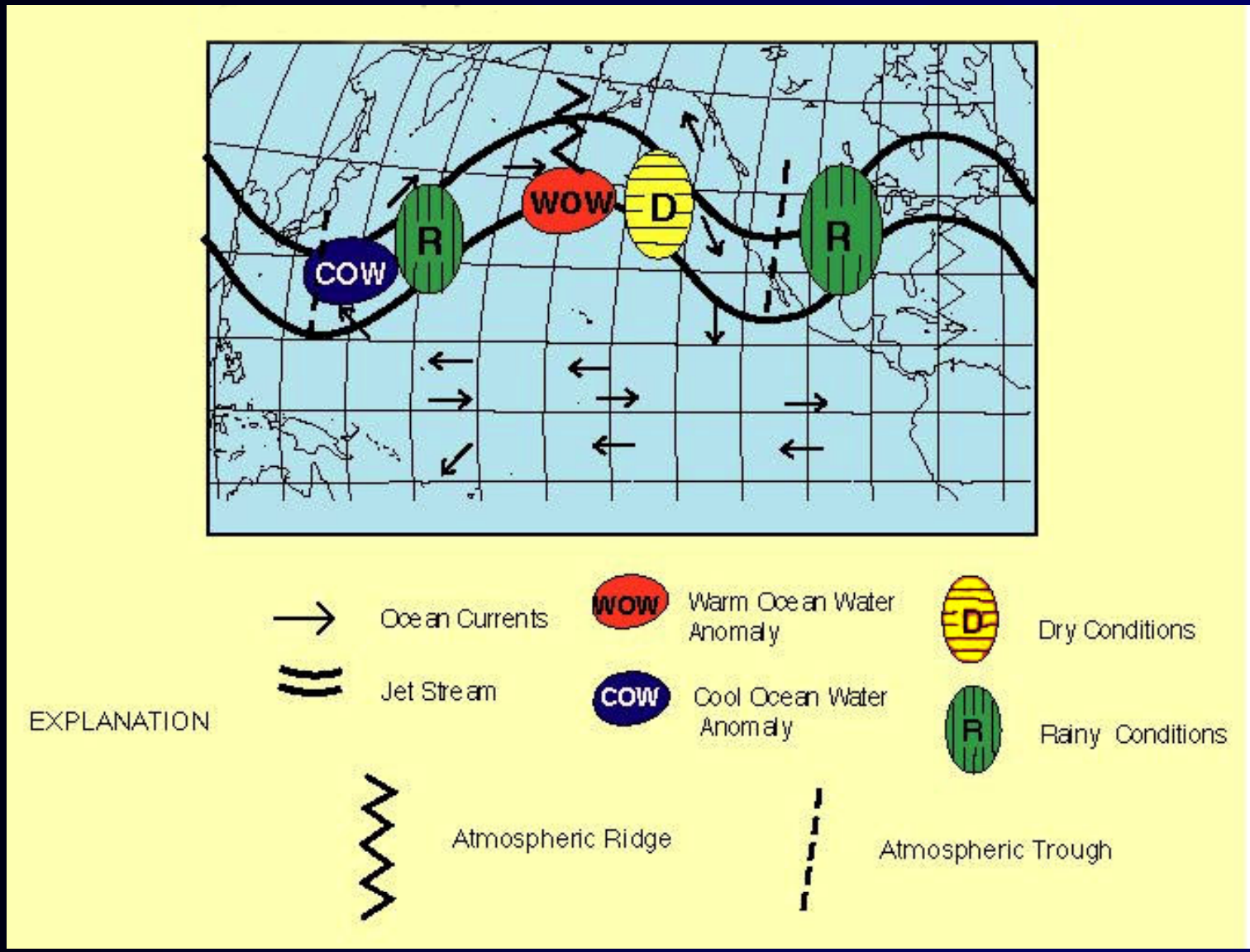
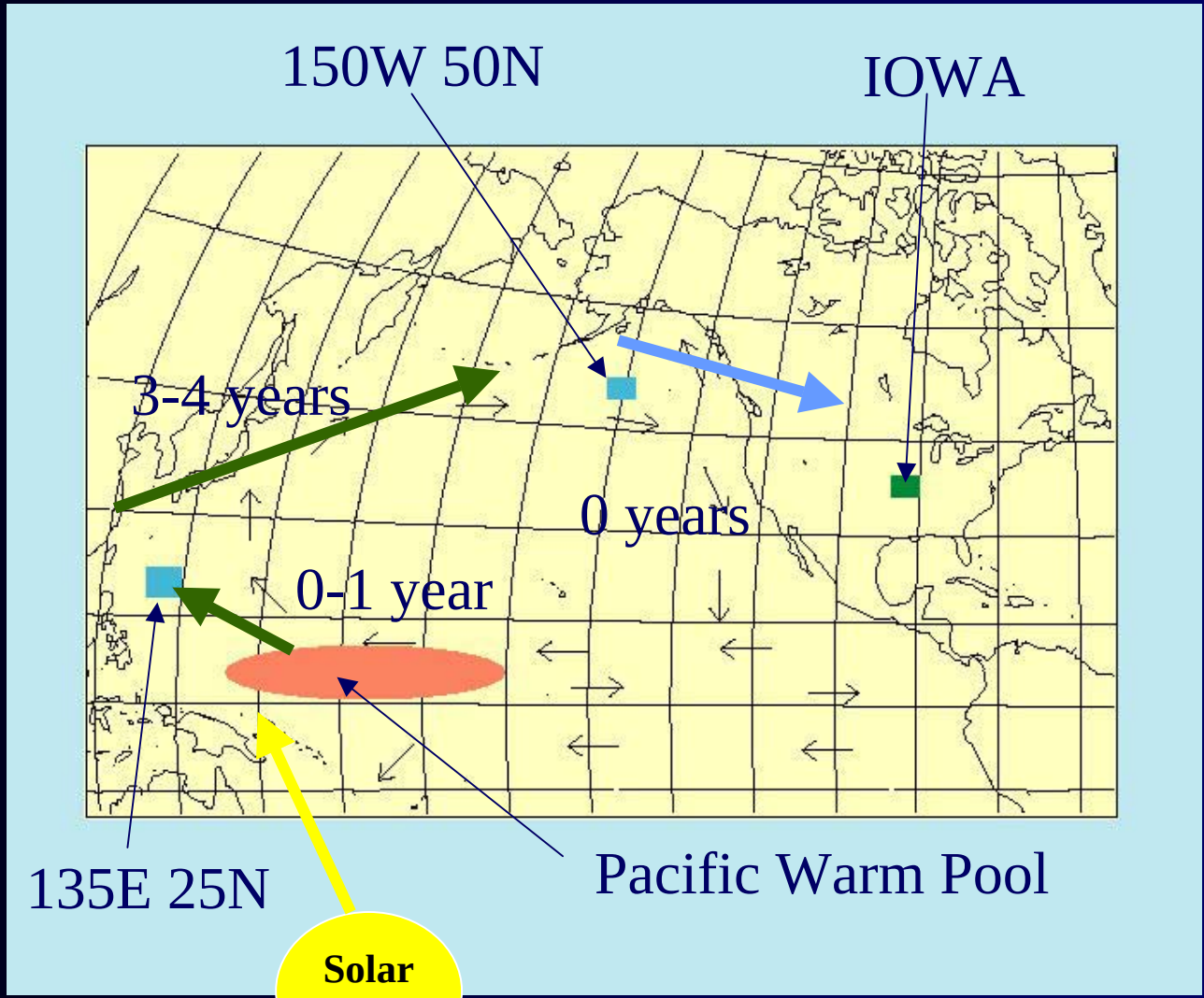
C. 5 Years later



Schematic of the physical processes of the solar connection with North American Hydrology



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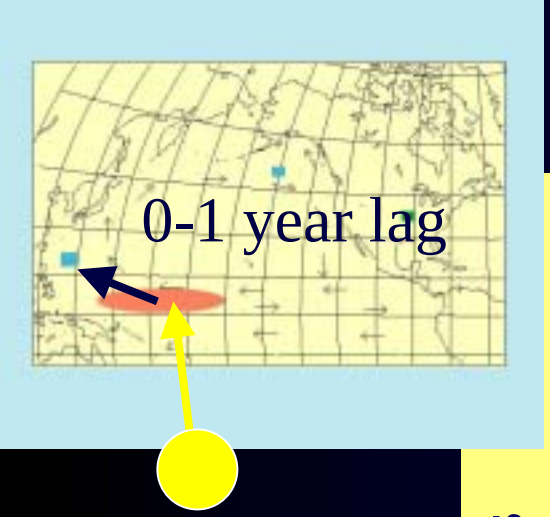
Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow



Sea Surface Temp
135E 25N

Solar Irradiance
lagged 0-1 year

Irradiance in Watts per square Meter

Sea Surface Temperature in Degrees Farenheit

1367
1366
1365
79
78
77
1950
1960
1970
1980
1990
2000

SST 130-140E 20-30N

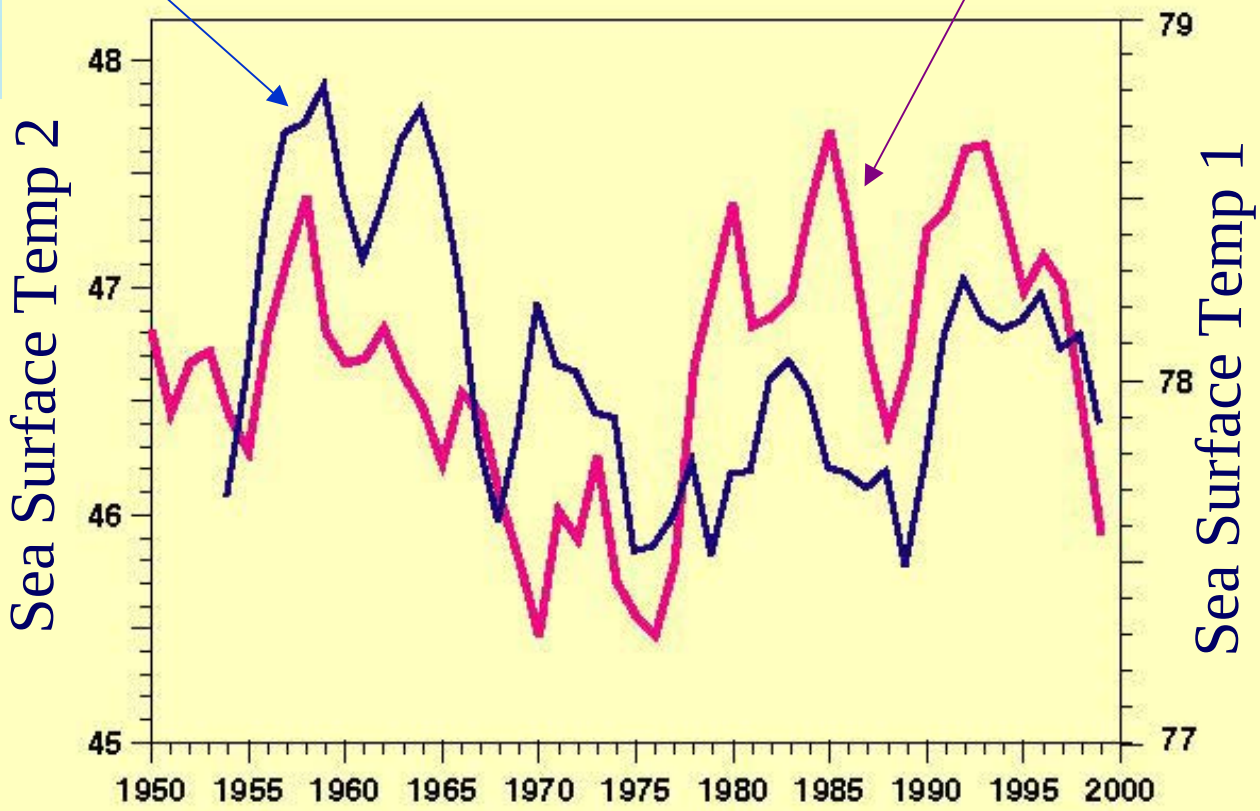
3-Year Moving Averages

USGS

Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow

Sea Surface Temp 2 at 135E 25N lagged 3-4 years

Sea Surface Temp 1 at 150W 50N



1970-1999 R= 0.49

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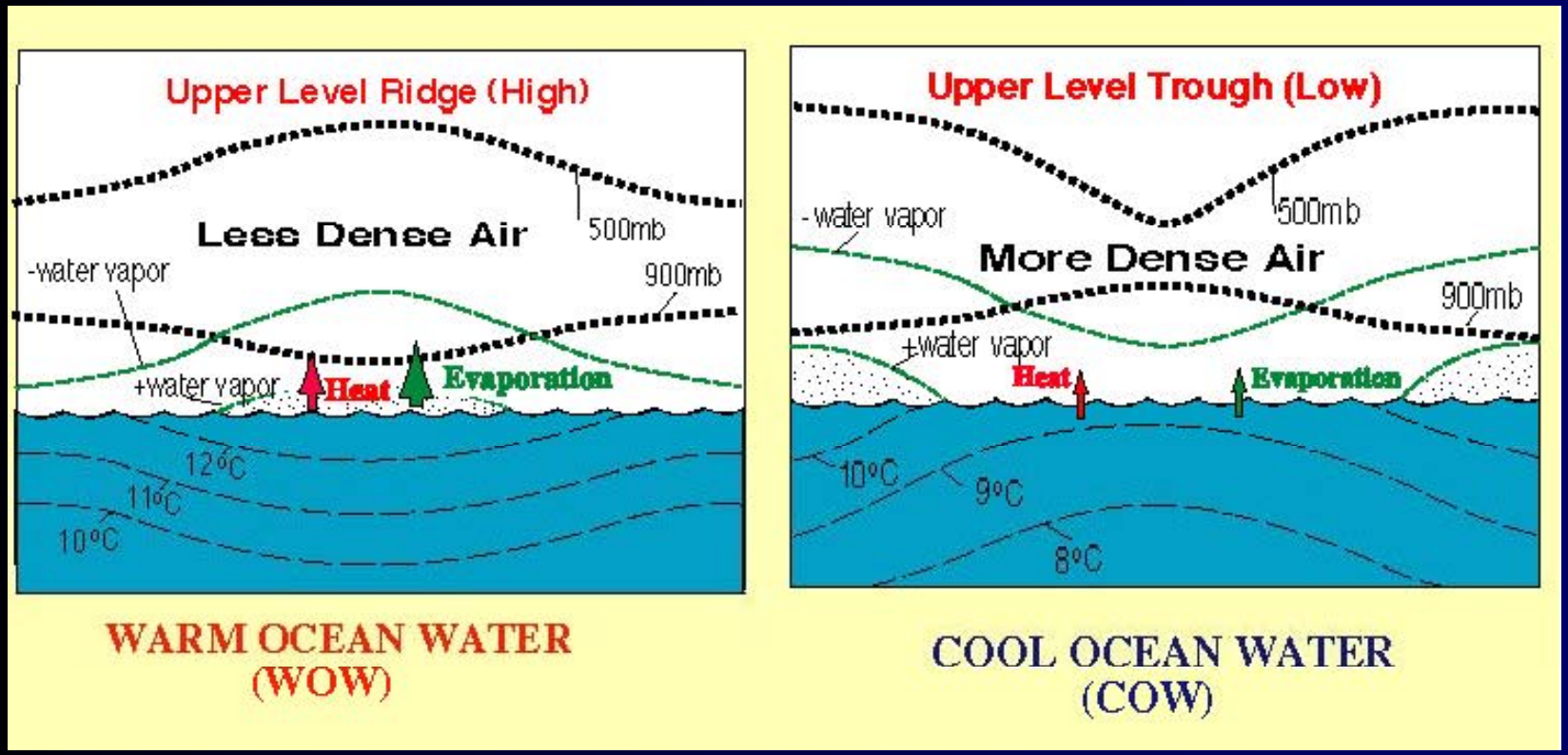
Effect of Sea Surface Temperatures on Upper Atmospheric Pressure Patterns



Creates a Ridge above

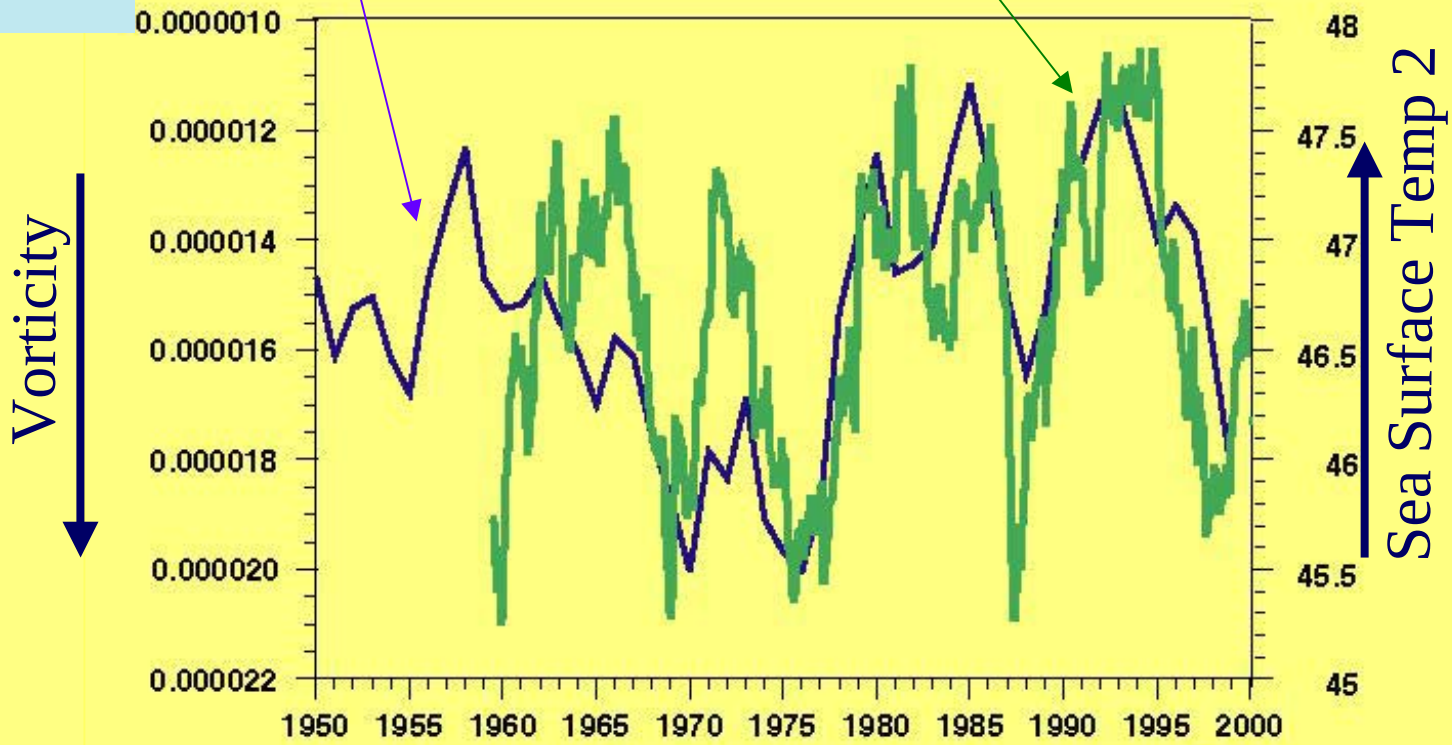
Creates a Trough above

USGS

Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow

Sea Surface Temp 2 at 150W 50N

Vorticity at Jet Stream Level 150W 50N



1970-1999 R= - 0.58

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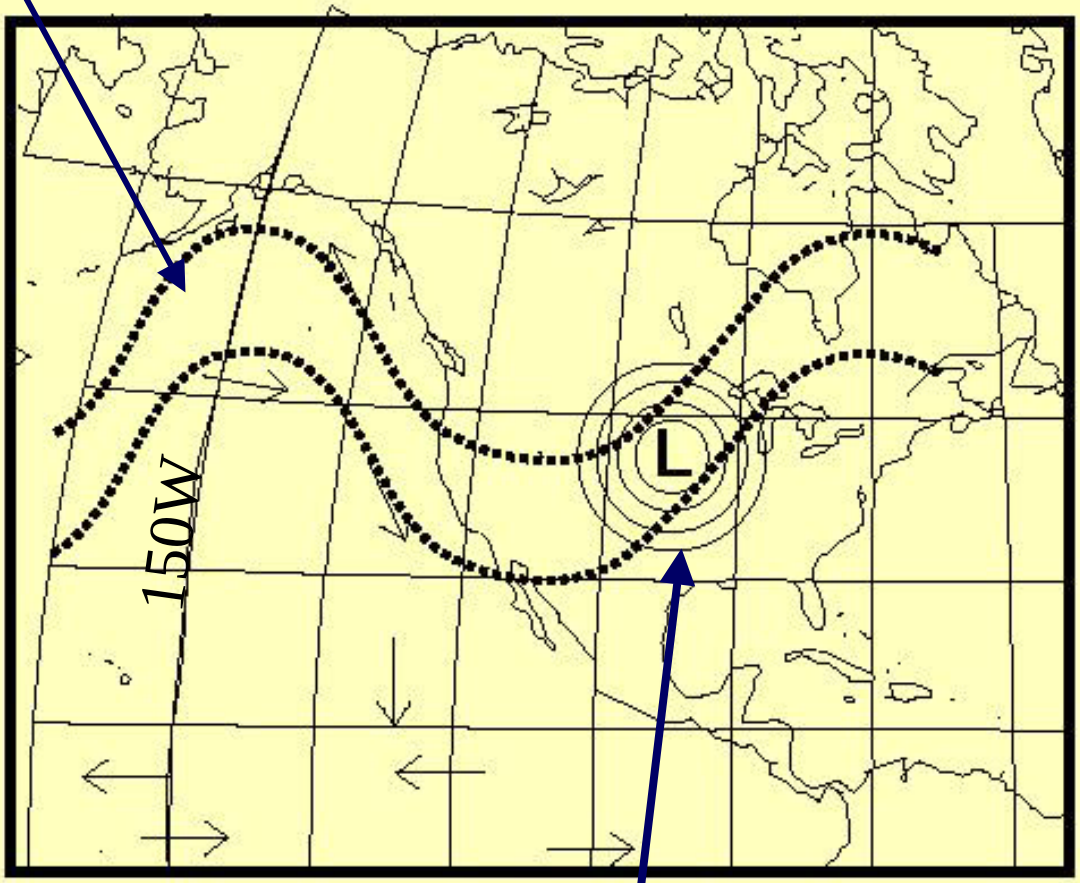
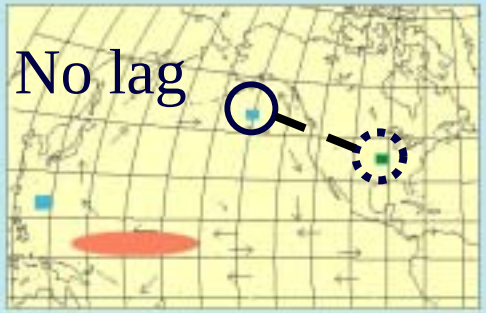
Jet Stream Level-- **Ridges - Low Vorticity**
Troughs- High Vorticity



Surface Layer-- **Low Pressure Centers- High Vorticity-- Stormy**
High Pressure Centers- Low Vorticity-- Fair

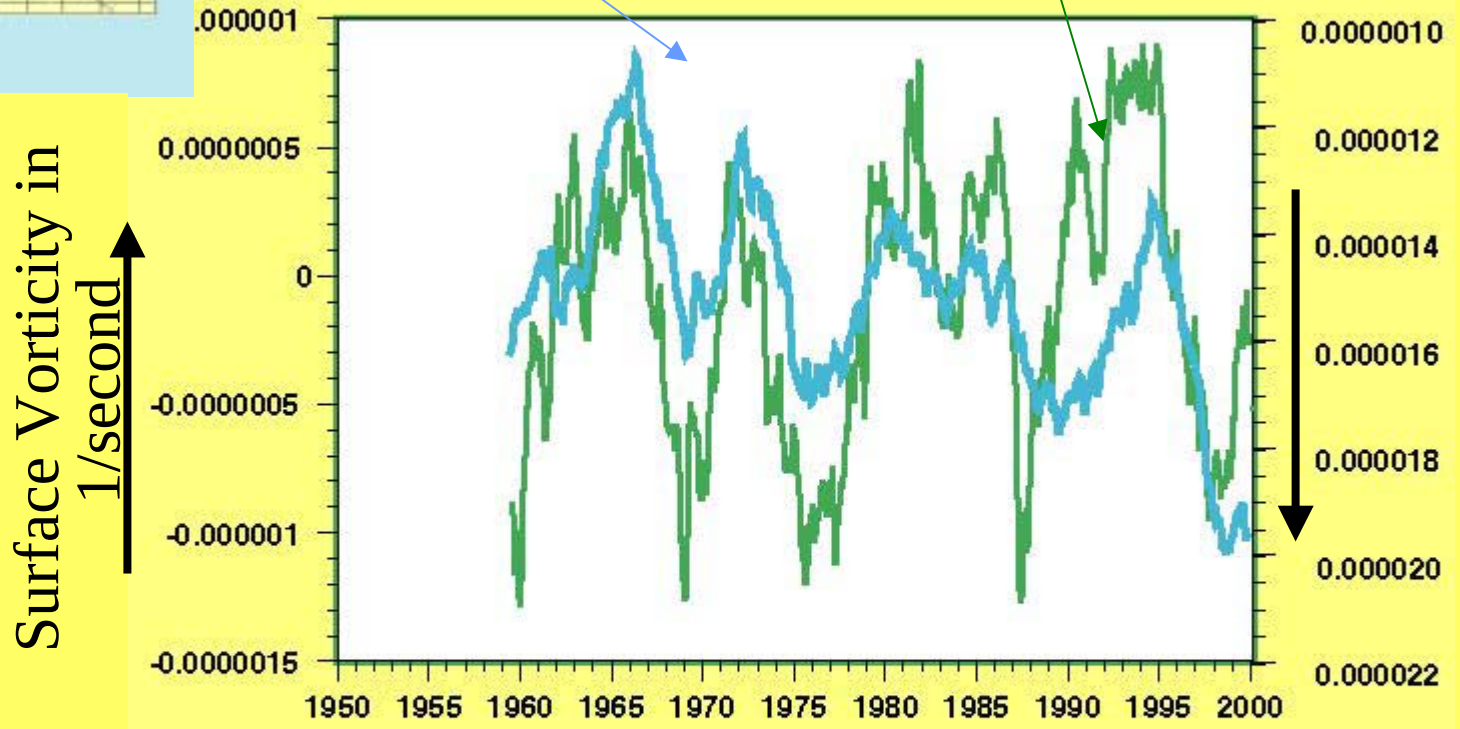
USGS

Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow



Surface Layer Vorticity Over Iowa

Jet Stream Level Vorticity at 150W 50N



Vorticity surface layer of 2 lines 40.95N 95.62 to 90W and 40.95 to 42.86N 91.88W 36 month moving average

R= - 0.45

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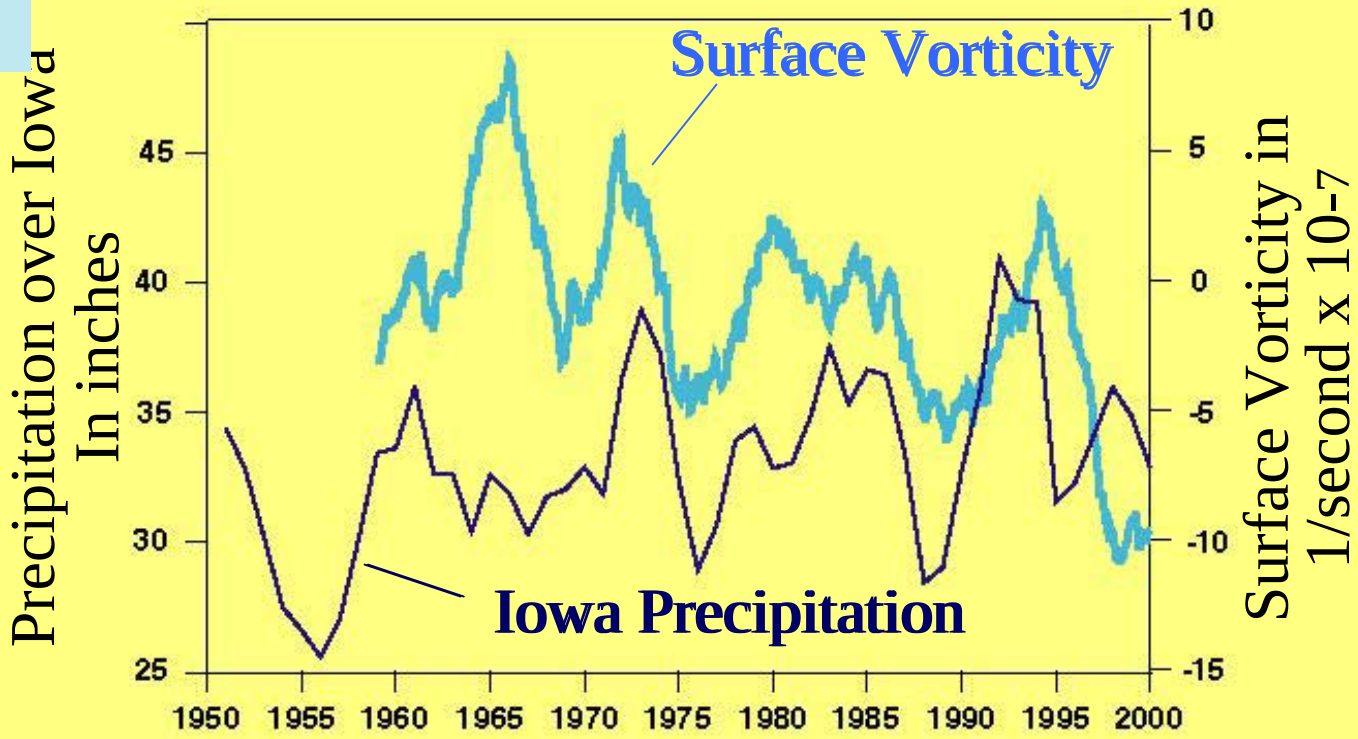
Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow



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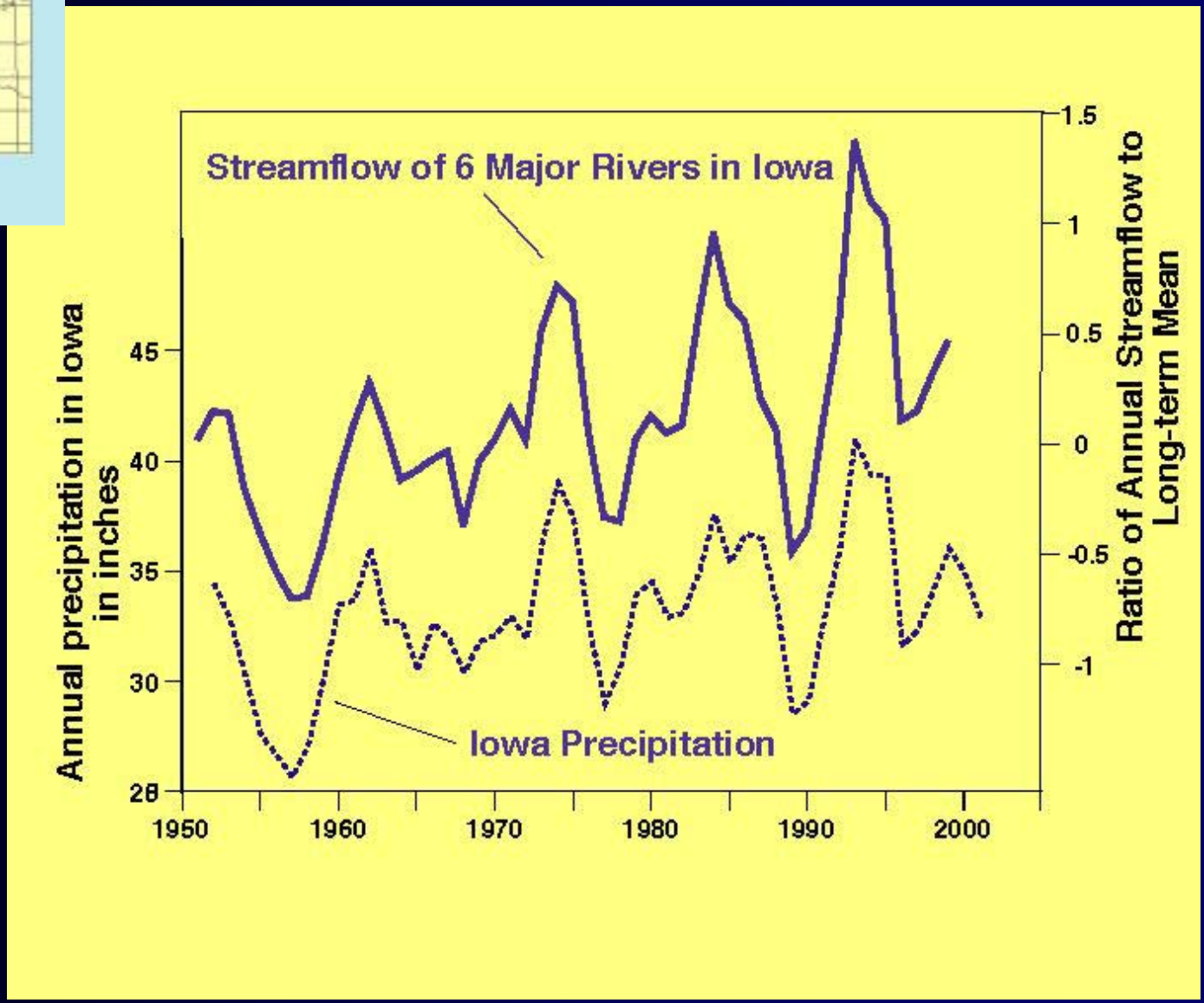

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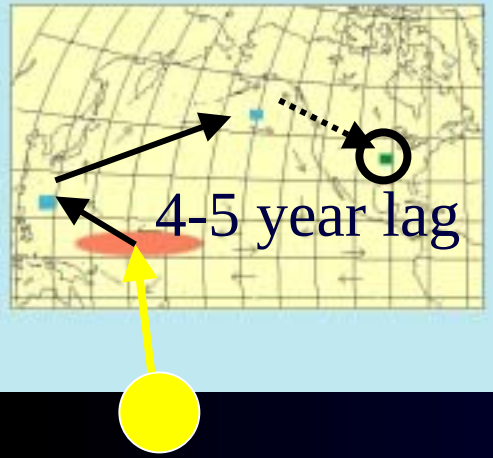
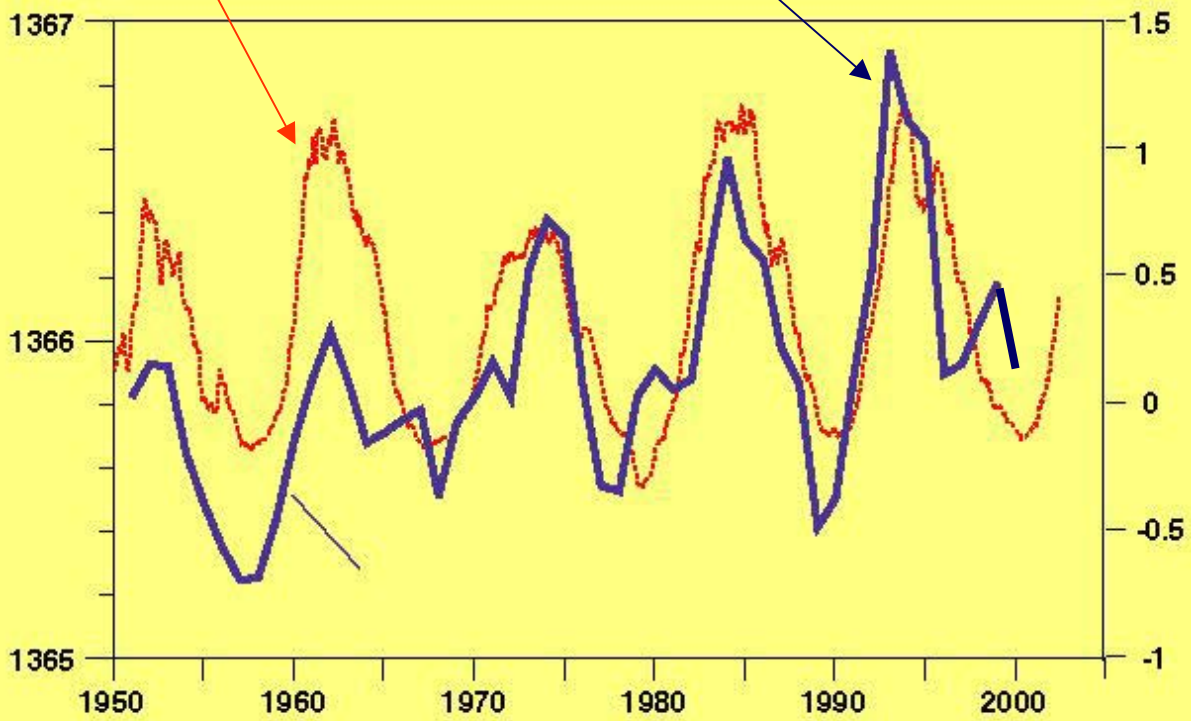


Evidence for the Link between Irradiance, SST, Vorticity, Precipitation, and Streamflow

Solar Irradiance Lagged 4-5 Years

Streamflow of 6 Major Rivers in Iowa



1970-1999 R=0.76

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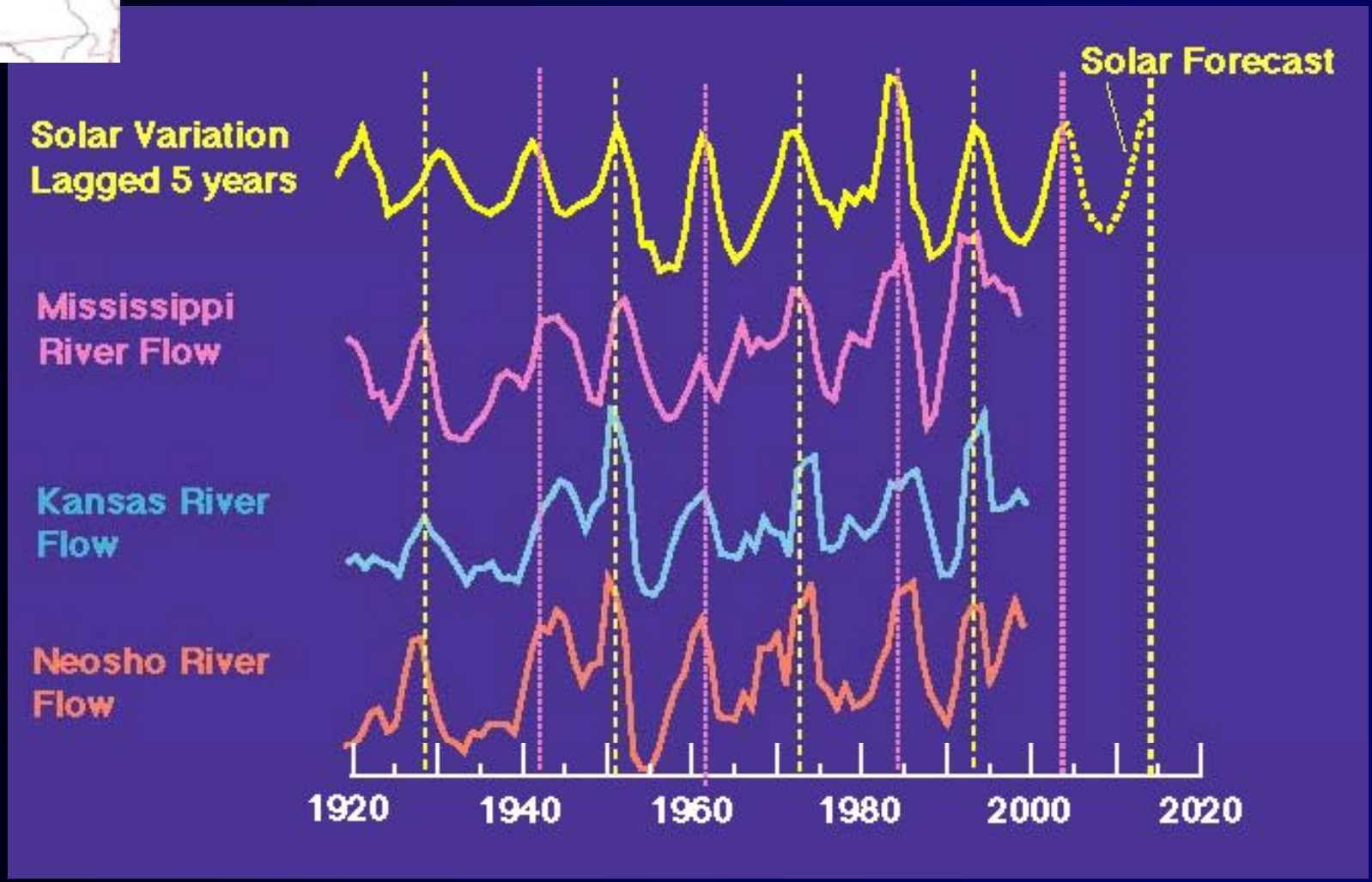
Streamflow Predictions from Solar Irradiance Variations



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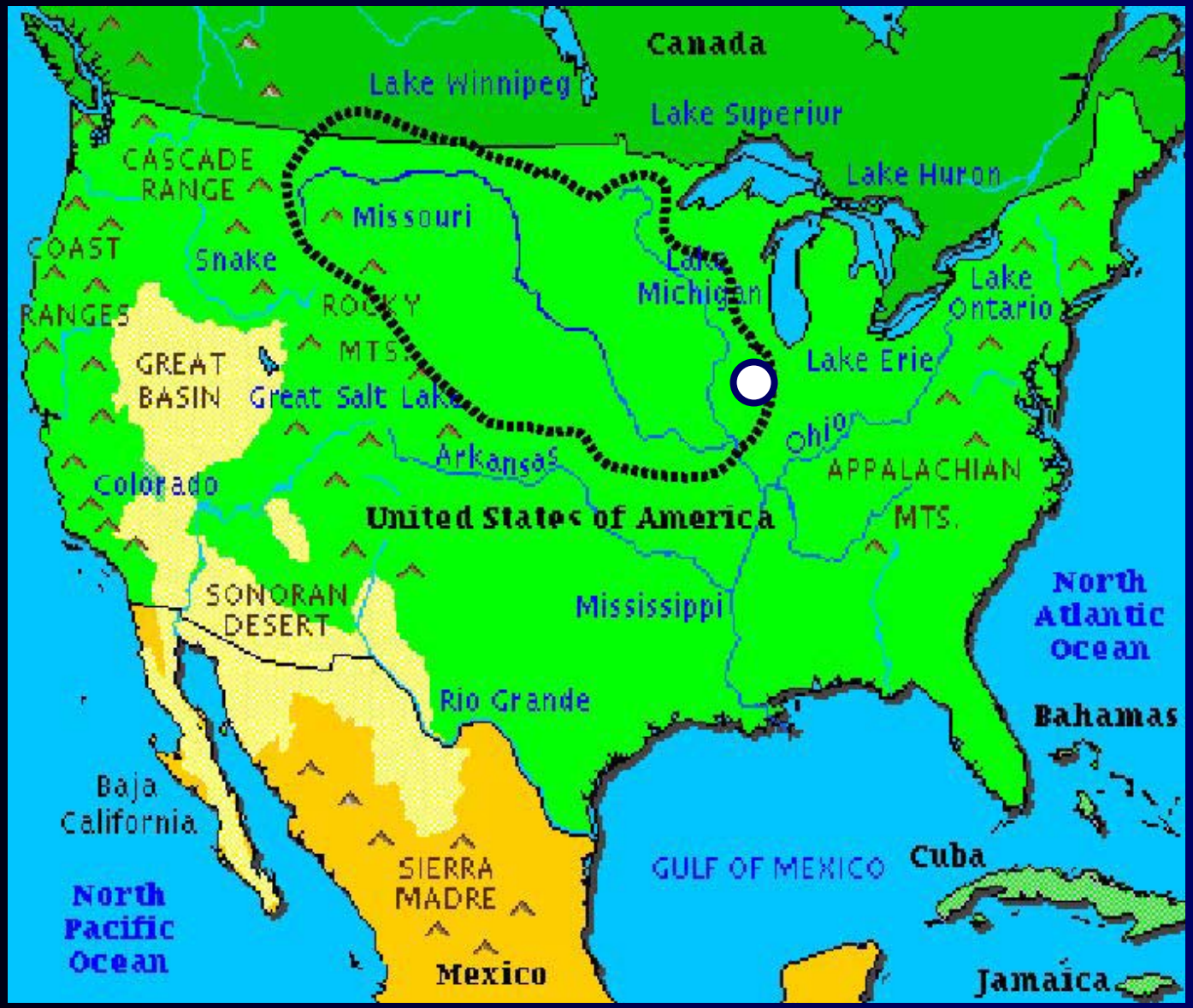
Mississippi River Basin at St. Louis, Missouri



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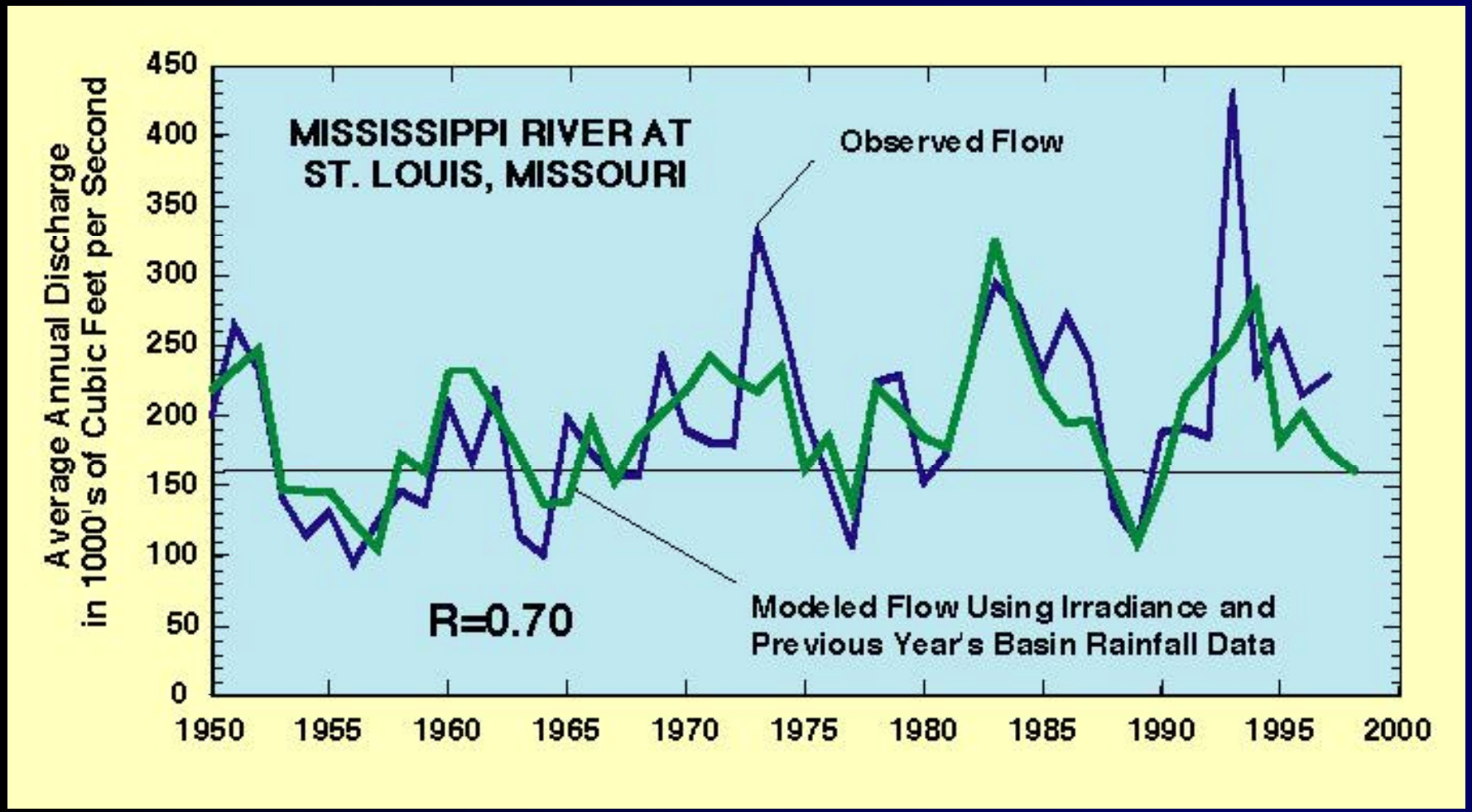
Model for Mean Annual Flow of Mississippi River at St. Louis, Missouri



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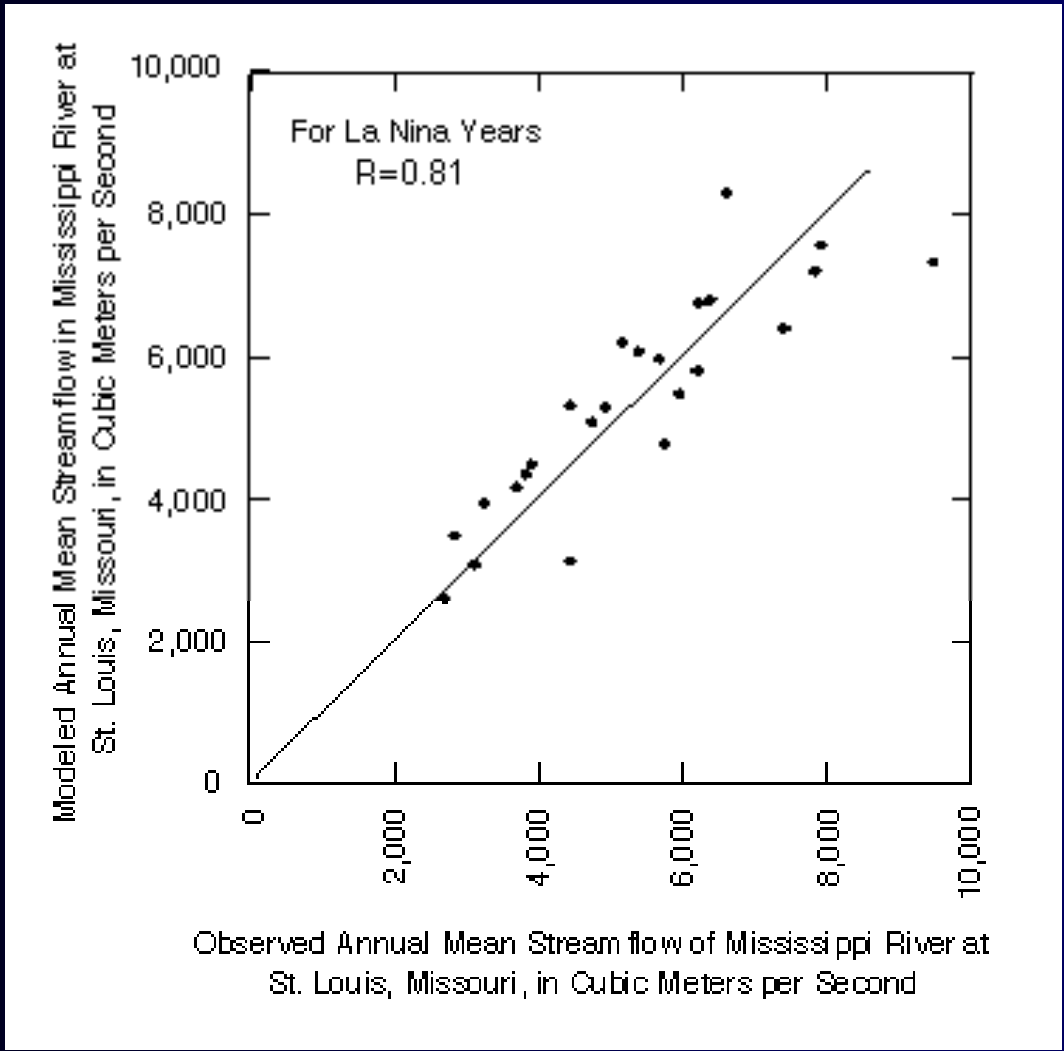
Relation between observed streamflow to the Mississippi River at St. Louis, Missouri, and streamflow generated from the multivariate model using La Nina years only, 1950-97.



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Great Lakes

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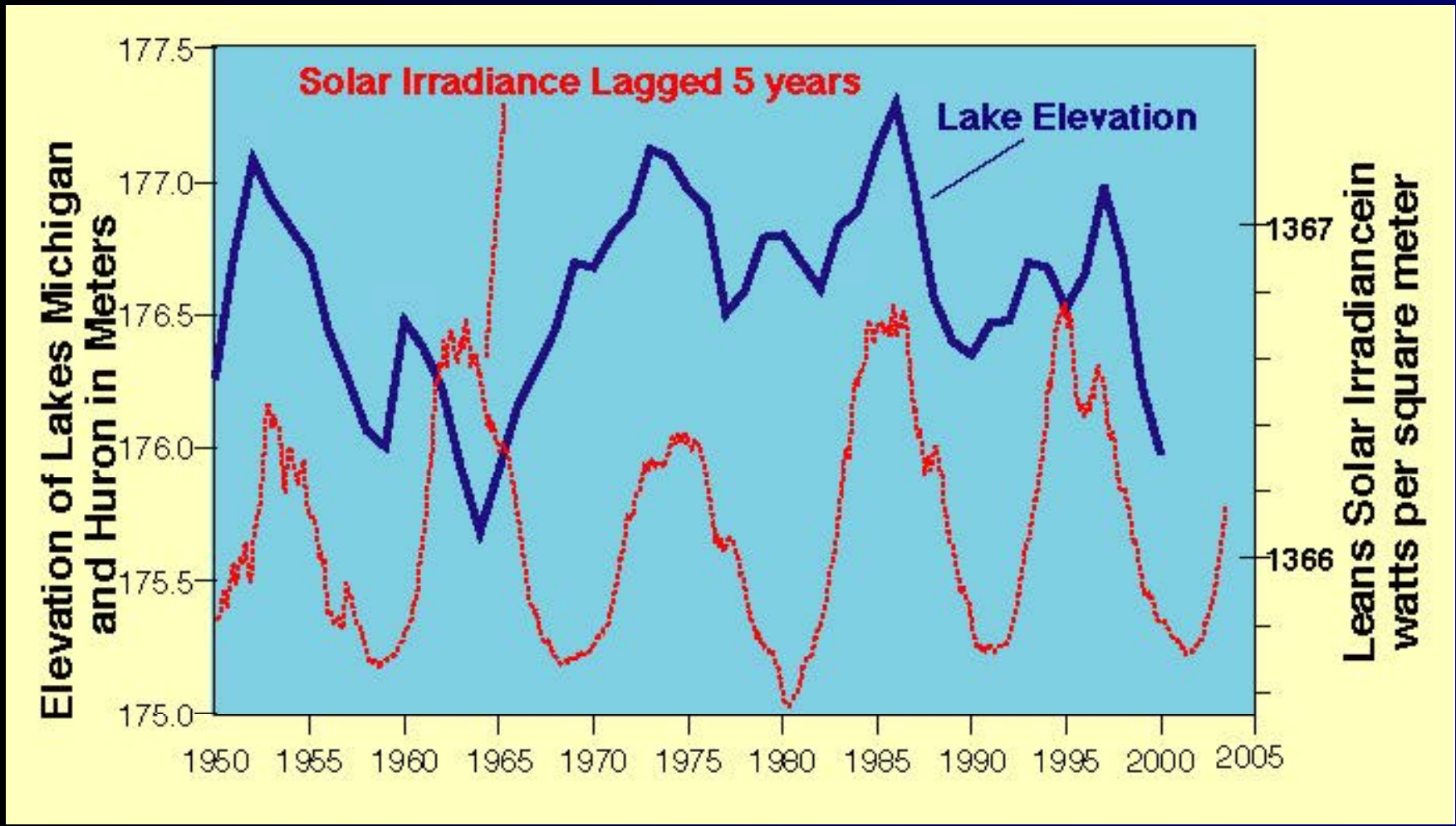
Solar irradiance and levels of Lake Michigan and Lake Huron



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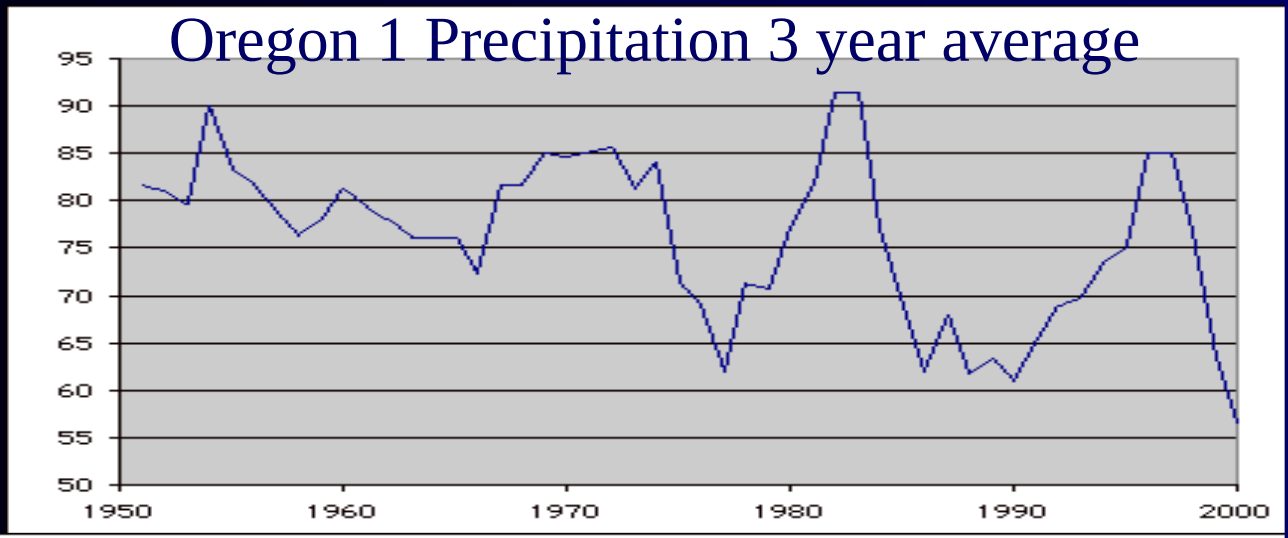
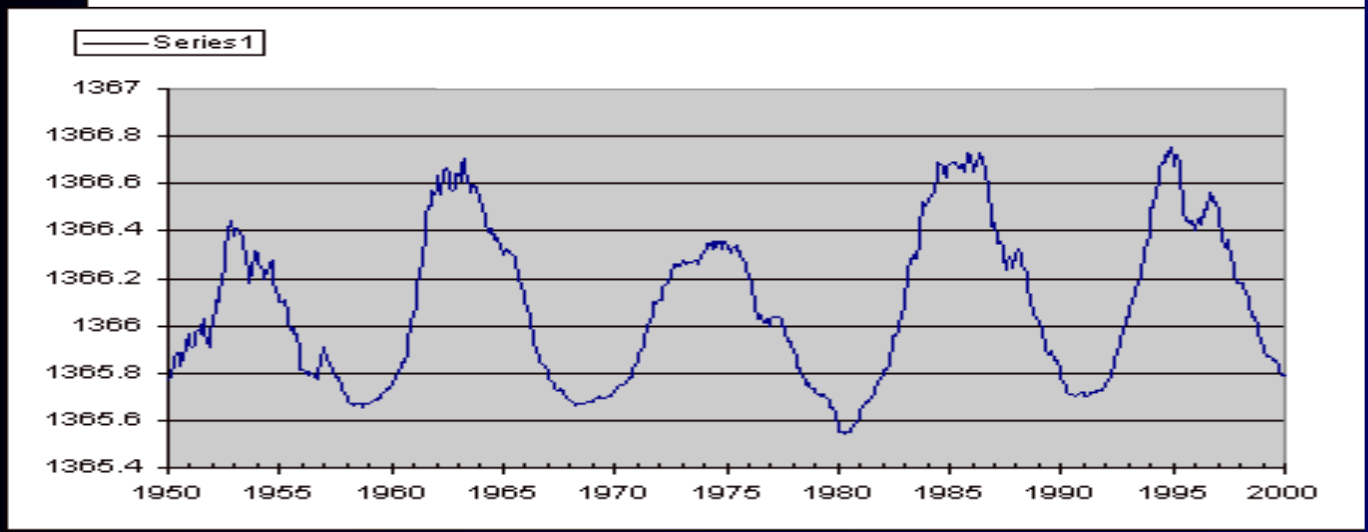
Solar Irradiance and Pacific Northwest Precipitation





Solar Irradiance Lagged 3-4 years

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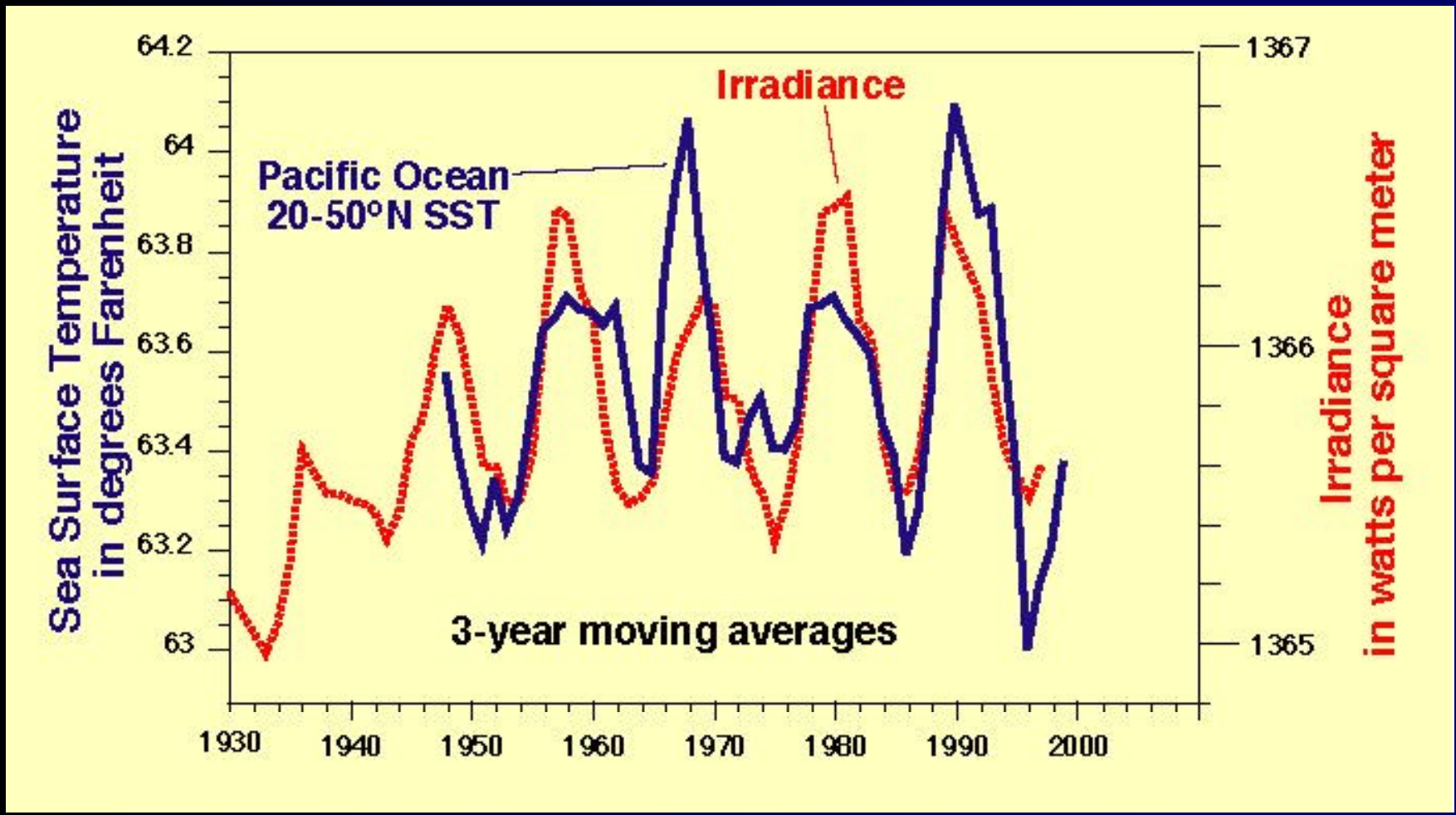
Average SST for Pacific Ocean 20-50N versus Irradiance



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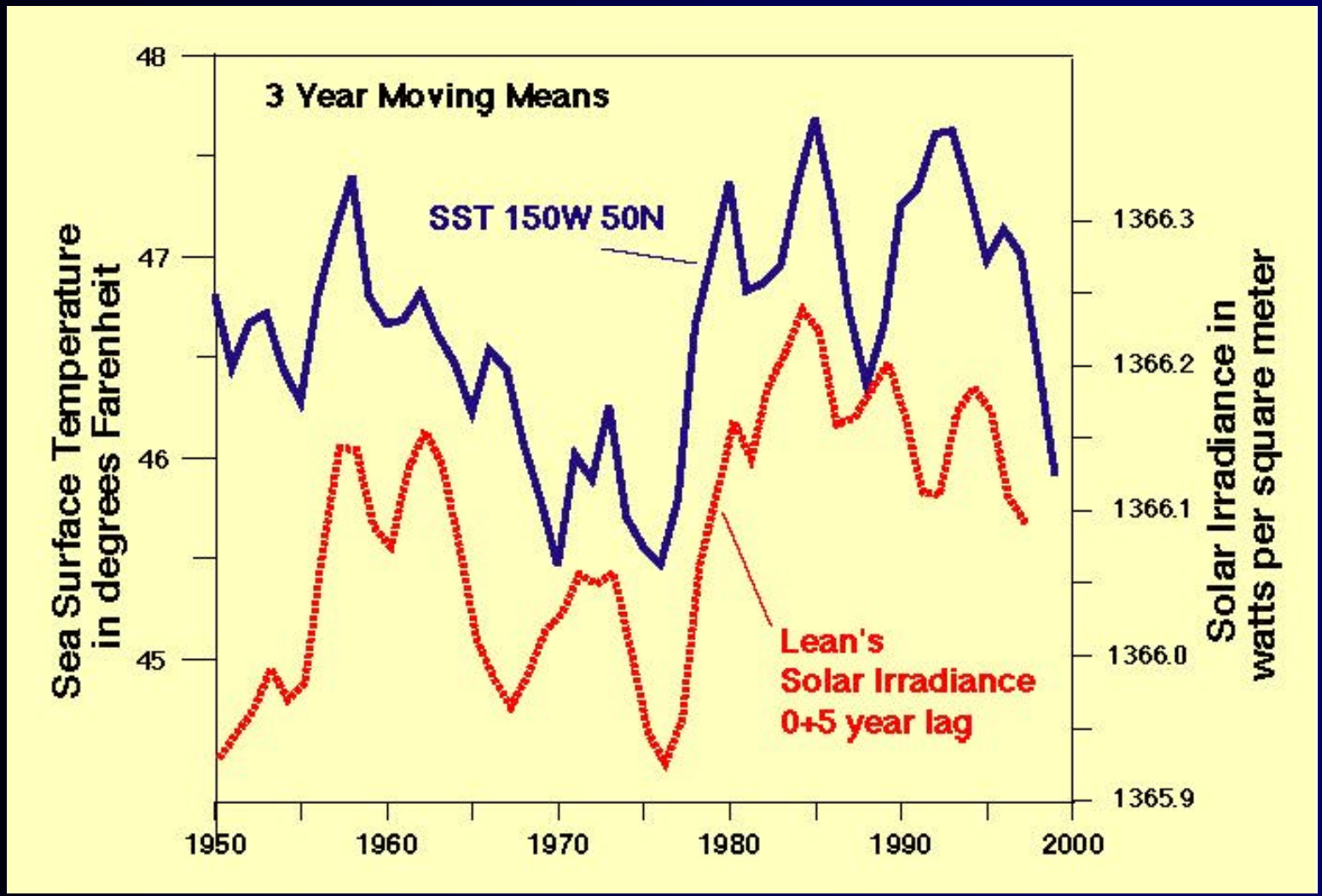
SST at 150W 50N and Solar Irradiance at Lags of 0 and 5 Years Averaged



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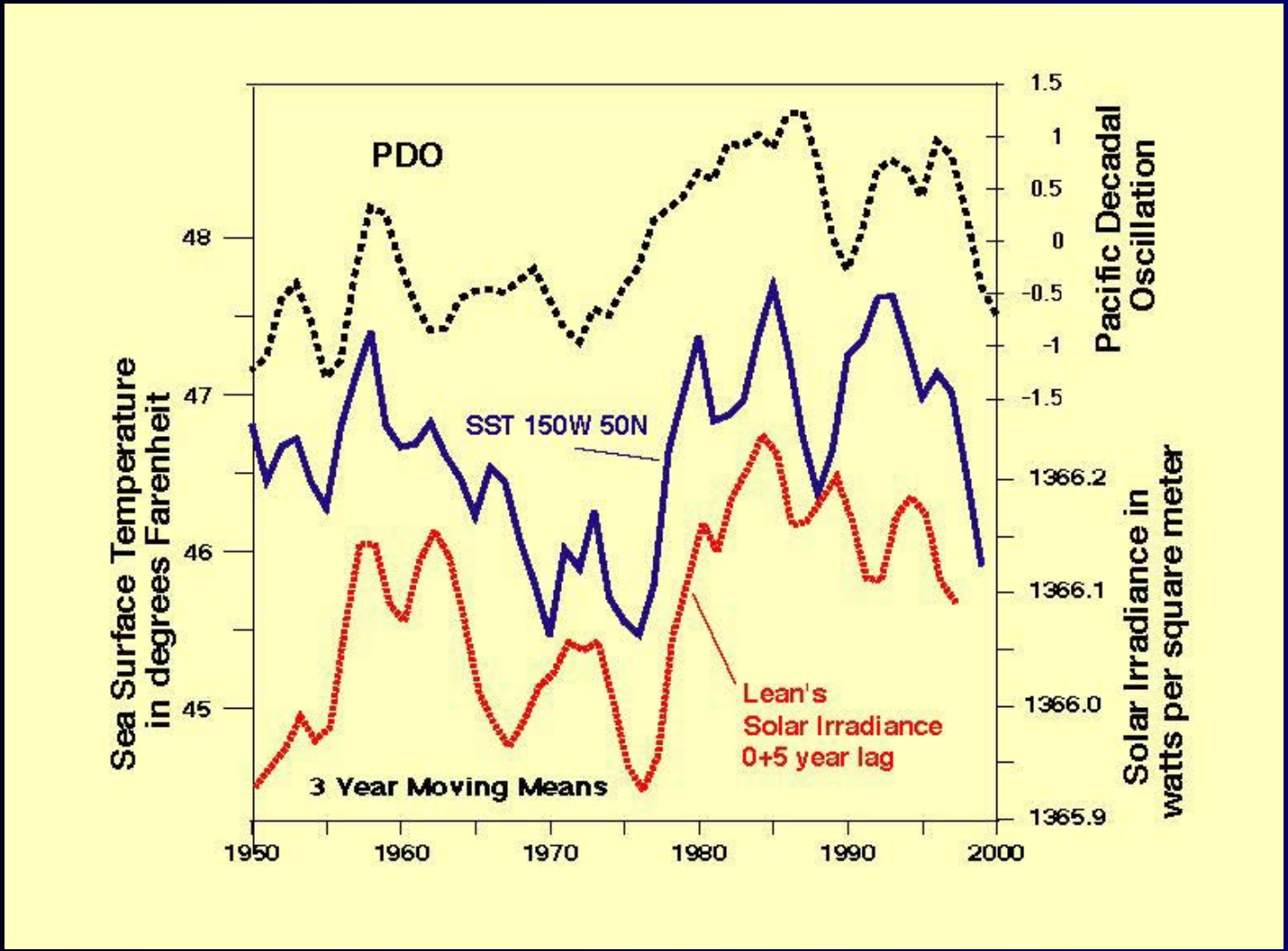
The Pacific Decadal Oscillation (PDO) can be compared with solar irradiance too



USGS

Conclusions

1. Variations in Solar Irradiance can and do effect regional hydrocliamtology on an annual and interannual time scale.

2. The mechanism for this process can be described physically. High North Pacific SST and High Surface vorticity over Iowa occur 4-5 years after High Irradiance

3. Models can be developed from the physical relationships that will enable forecasting of water resources

4. Additional research is needed to determine effect of El Nino/La Nina, Quasi-biennial Oscillation, Seasonality, and Regionality (sweetspots)

USGS

WEB SITE:

http://ks.water.usgs.gov/Kansas/climate/

USGS