Suggested Physics between Cosmic Ray Flux and Regional Hydroclimate

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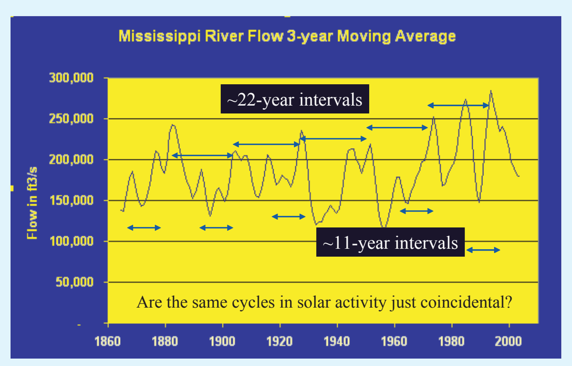
Abstract

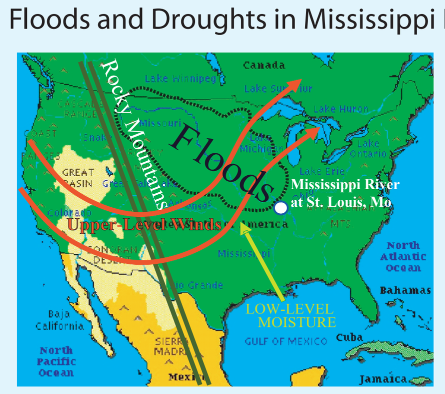
The effects of solar variability on regional hyroclimate were examined using a sequence of physical connections between total solar irradiance (TSI) modulated by galactic cosmic rays (GCRs), and ocean and atmospheric patterns that affect precipitation and streamflow. The solar energy reaching the Earth's surface and its oceans is thought to be controlled through an interaction between GCRs, which are known to ionize the atmosphere and increase cloud formation, and TSI. High (low) GCR flux may promote cloudiness (clear skies) and higher (lower) albedo at the same time that TSI is lowest (highest) in the solar cycle which in turn creates cooler (warmer) ocean temperature anomalies. These anomalies have been shown to affect atmospheric flow patterns and ultimately precipitation over the Midwestern United States. This investigation identified a relation among TSI and geomagnetic index aa (GI-AA), and streamflow in the Mississippi River Basin for the period 1878-2004. The GI-AA was used as a proxy for GCRs. There appears to be a solar "fingerprint" that can be seen in climatic time series in other regions of the world, with each series having a unique lag time between the solar signal and the hydroclimatic response. A progression of increasing lag times can be spatially linked to the ocean conveyor belt, which transports the solar signal over a time span of several decades. The lag times for any one region vary slightly and may be linked to the fluctuations in the velocity of the ocean conveyor belt. The lag time between the solar signal and streamflow in the Mississippi River at St. Louis, Missouri, is approximately 34 years. The current drought (1999-2006) in the Mississippi River Basin appears to be caused by a period of lower solar activity that occurred between 1963 and 1977.

Regional Climate

Mississippi Floods and Droughts Appear to be Cyclical



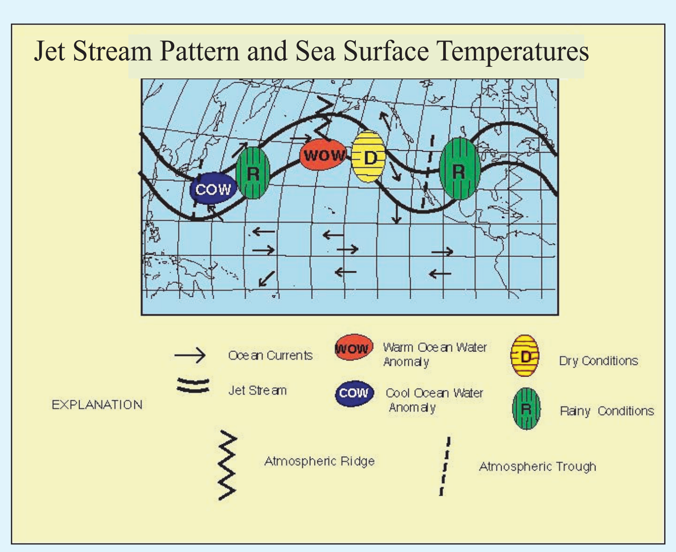
Floods and Droughts in Mississippi River Basin



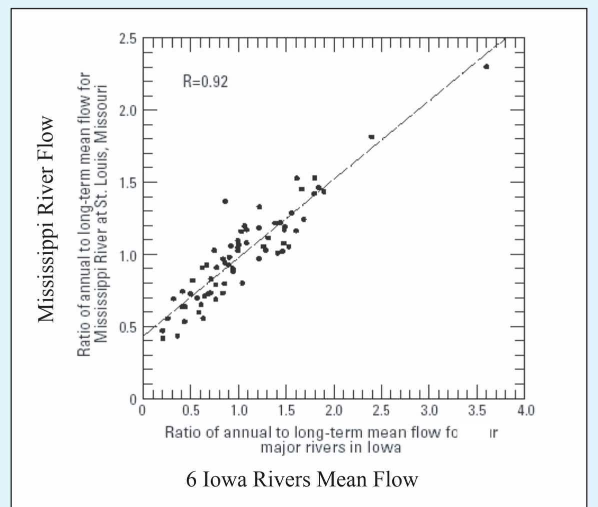
Floods-- A persistent trough at the upper levels over the Rocky Mountains pulls Gulf of Mexico moisture northward into the basin.

Drought-- Persistent Ridge at the upper levels over the Rocky Mountains prevents moisture from moving north from the Gulf of Mexico into the basin.

Jet Stream Pattern and Sea Surface Temperatures

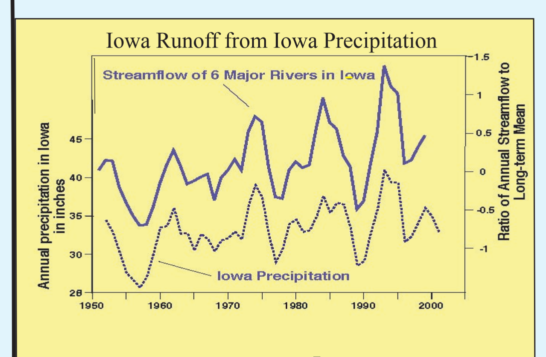


Physical Connection of Mississippi Floods/Droughts to Sea Surface Temperatures

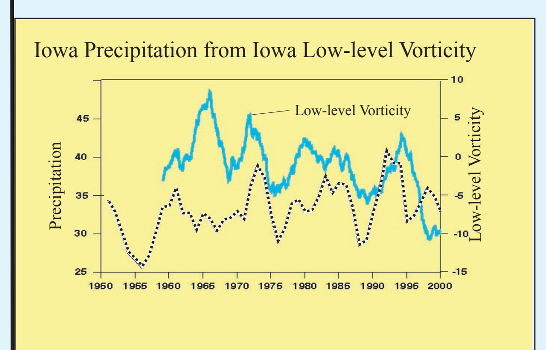


6 Iowa Rivers Mean Flow

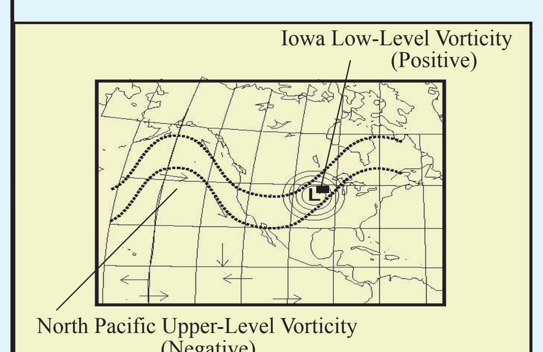
Iowa Runoff from Iowa Precipitation



Iowa Precipitation from Iowa Low-level Vorticity

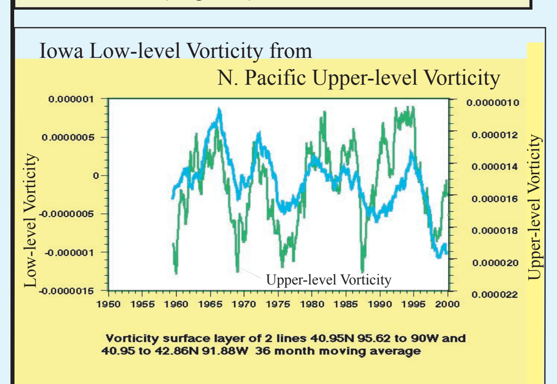


Iowa Low-Level Vorticity (Positive)

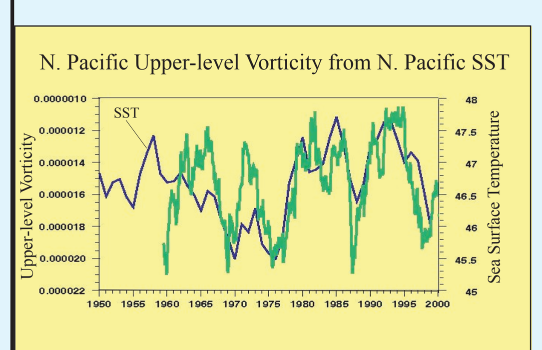


North Pacific Upper-Level Vorticity (Negative)

Iowa Low-level Vorticity from N. Pacific Upper-level Vorticity

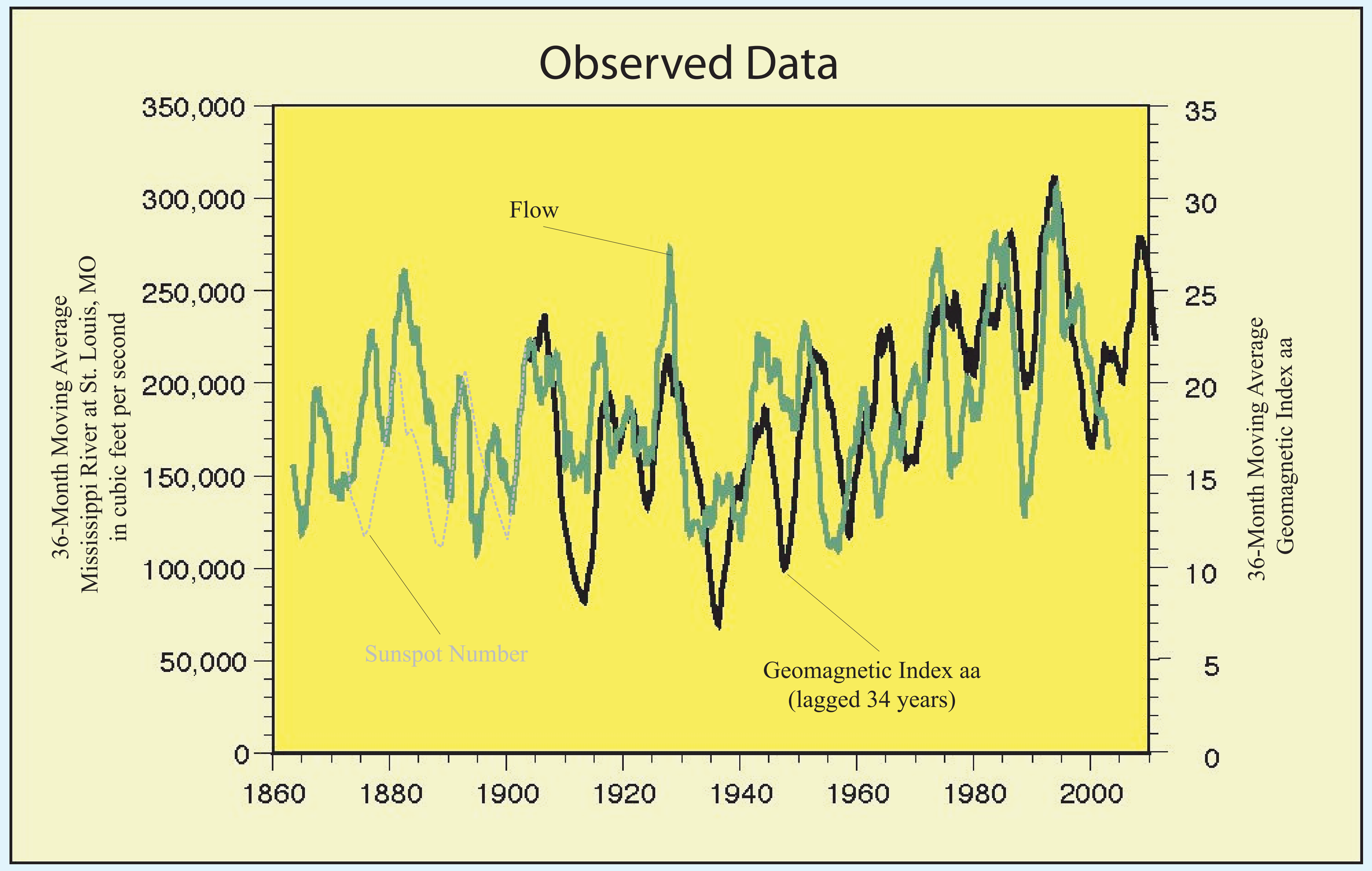


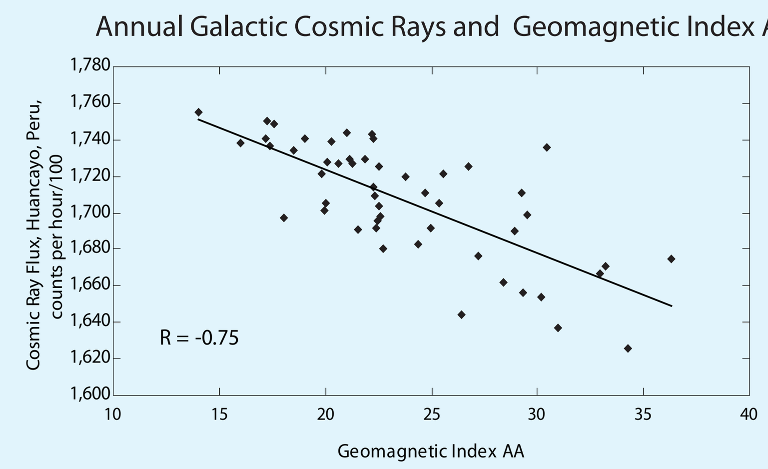
N. Pacific Upper-level Vorticity from N. Pacific SST



N. Pacific SST from Tropical Ocean Temperatures

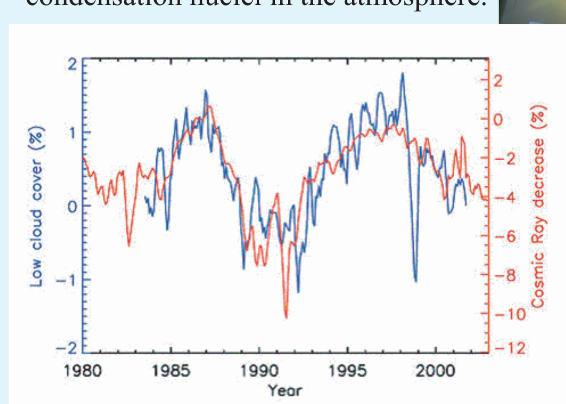
Galactic Cosmic Ray Connection between Geomagnetic Index AA and Mississippi River Flow





Galactic Cosmic Rays and Clouds

Henrik Svensmark– Danish Space Research Institute Experiments at CERN, in Switzerland, show cosmic ray flux can influence the number of condensation nuclei in the atmosphere.



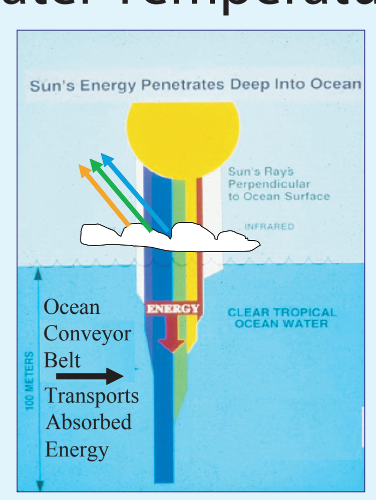
N. Marsh and H. Svensmark's low clouds and cosmic ray flux, updated by N.J. Shaviv (2005).

Solar Irradiance, Clouds, and Ocean Water Temperatures

Any variation in the total solar irradiance will affect the amount of energy absorbed by the ocean

Any increase in cloudiness could diminish solar energy input to the oceans by increasing albedo.

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

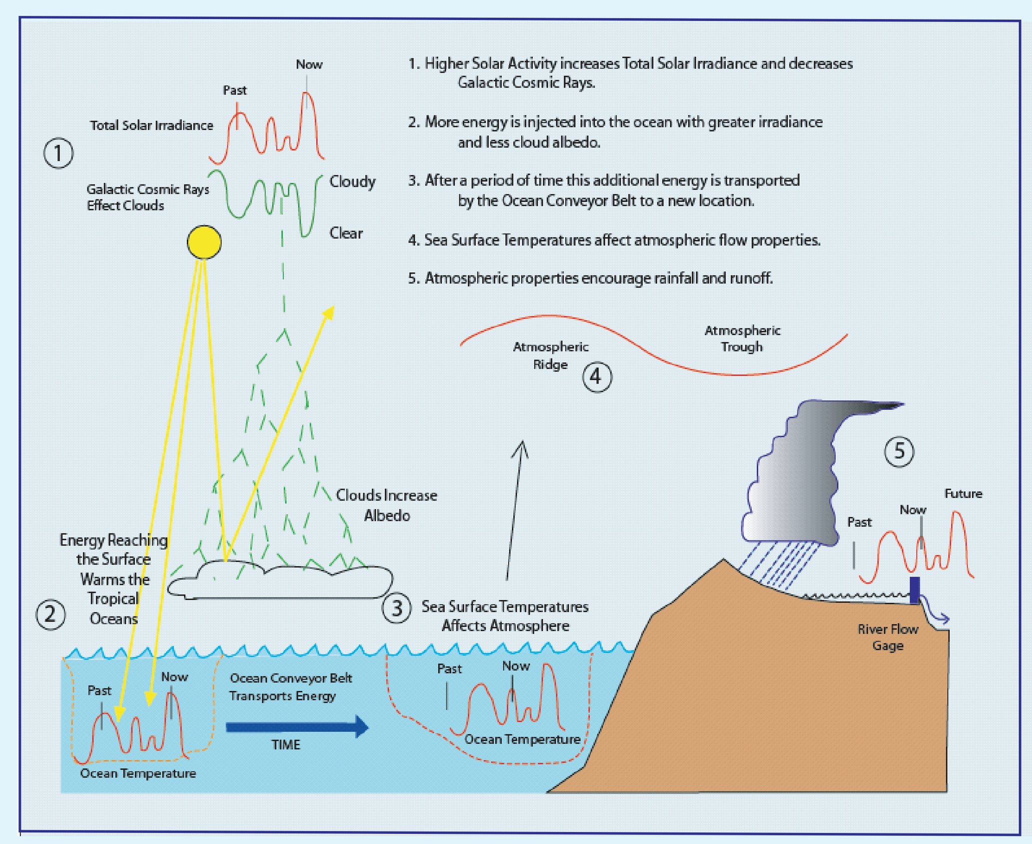


Proposed Mechanism

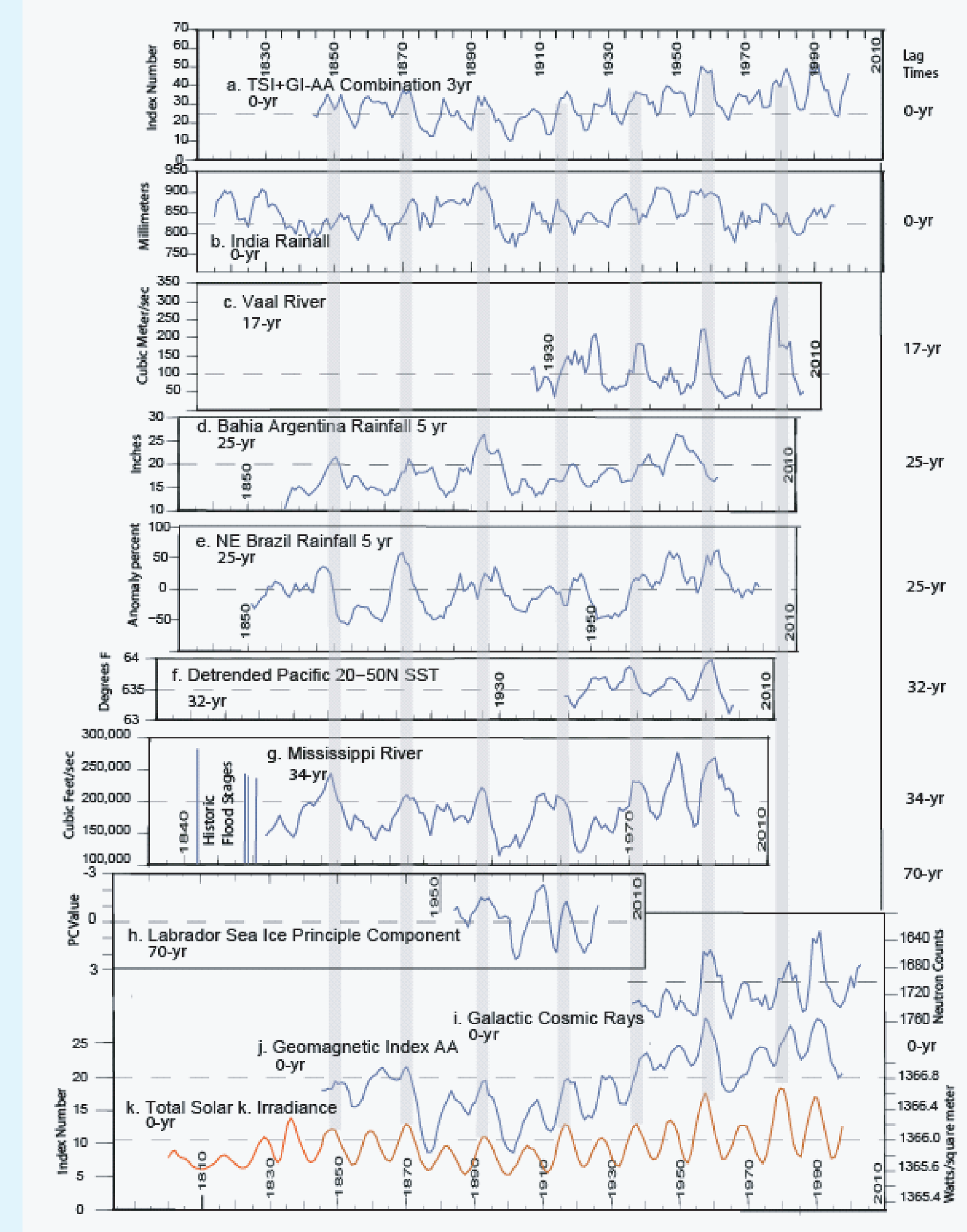
A. Through an interaction between total solar irradiance (TSI) and Galactic Cosmic Rays (GCRs), where high (low) GCR flux promotes cloudiness (clear skies) and higher (lower) albedo at the same time that TSI is lowest (highest) in the solar cycle. Therefore, less energy (more energy) would be absorbed at a sensitive location within the ocean. (Indonesian Flow Through Area)

B. Warm ocean water anomalies force atmospheric troughing (wetter conditions) downwind, while cooler anomalies force atmospheric ridging (dryer conditions) downwind.

C. The Ocean Conveyor Belt is an intricate part of the solar/climate connection. Temperature and salinity variations may modulate the relative velocity of the conveyor system with high (low) salinity and cold (warm) SSTs decreasing (increasing) the lag time between input and response.

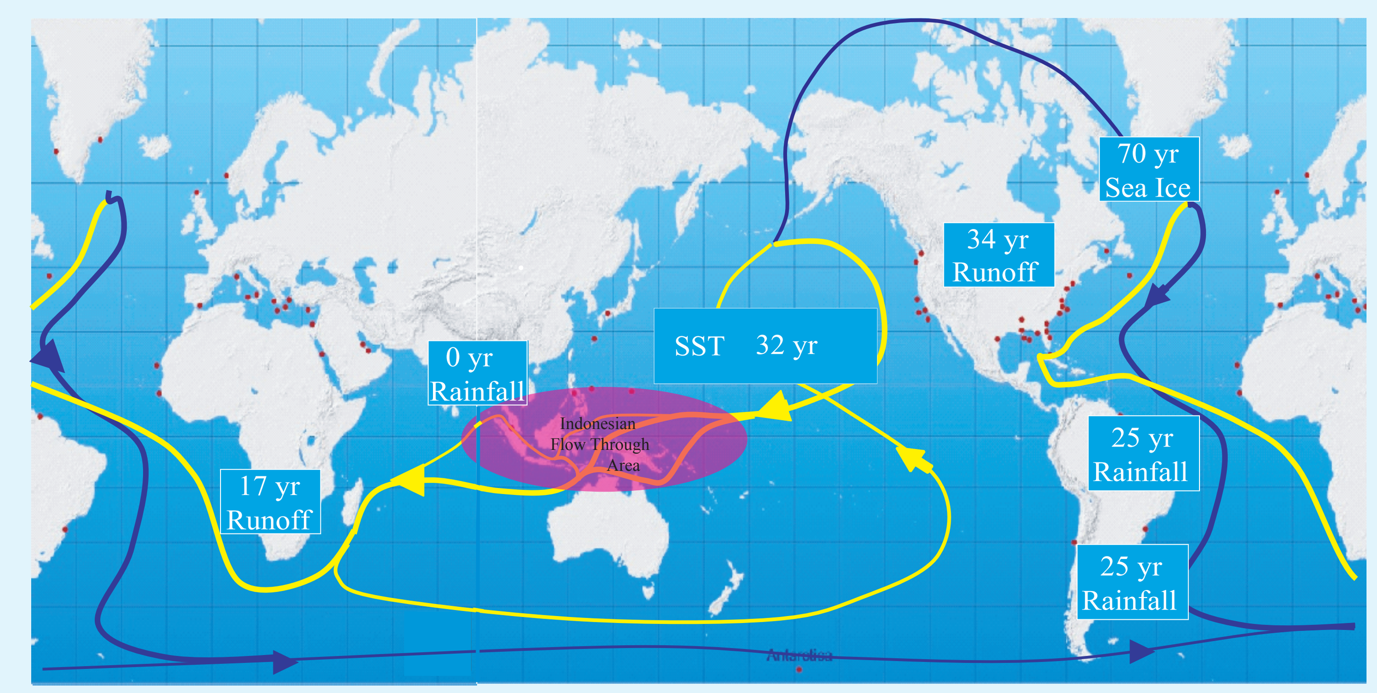


Worldwide Regional Climatic Time Series and Solar Activity



	Lag Time in Years
TSI-GeoMag Combo	0
India Monsoon Rainfall	0
Africa River Runoff	17
Argentina Rainfall	25
Brazil Rainfall	25
Pacific SST	32
Mississippi Runoff	34
Labrador Sea Ice	70
Cosmic Ray Flux	0
GeoMag Index AA	0
Total Solar Irradiance	0

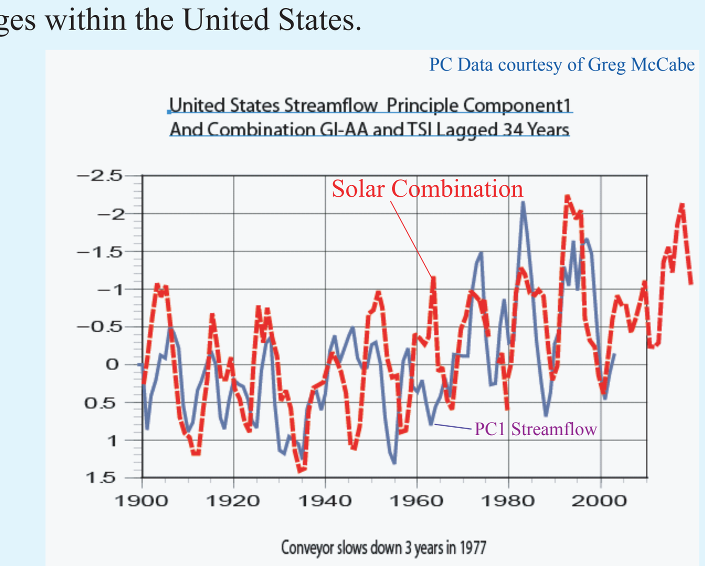
The Great Ocean Conveyor Belt and Lag Times



Past and Future Streamflow

Combination of Geomagnetic Index aa and Solar Irradiance, with 3-year slowingof the conveyor belt in 1977 compared with the 1st principal component of streamflow from all gages within the United States.

PC Data courtesy of Greg McCabe



References

Perry, C.A., 2006, Midwestern streamflow, precipitation, and atmospheric vorticity influenced by Pacific sea-surface temperatures and total solar-irradiance variations: International Journal of Climatology, v. 26, p. 207-218.

Perry, C.A., 2007, Evidence for a physical linkage between galactic cosmic rays and regional climate time series: Advances in Space Research, v. 40, p. 353-364.

Shaviv, Nir J., 2005. Cosmic rays and climate. PhysicaPlus, no. 5.