Using AVHRR satellite data to discern decadal trends in Wisconsin thunderstorms

Alex Harrington[1] and Andrew K. Heidinger[2]

1 Cooperative Institute for Meteorological Satellite Studies (CIMSS), 2 National Oceanic Atmospheric Administration (NOAA)/CIMSS

Research Overview: What is AVHRR?

*The five channel Advanced Very High Resolution Radiometer (AVHRR) has been recording data since 1981. Led by Dr. Andrew Heidinger (NOAA, at CIMSS), CIMSS currently is studying various ways to utilize AVHRR data for climate studies. Towards this goal, the Extended Clouds from AVHRR (CLAVR-x) processing system is used to generate pixel-level and gridded cloud, surface, and atmospheric properties (Heidinger, 2006). The gridded data, referred to as the Extended Pathfinder Atmospheres (PATMOS-x) dataset, is produced globally at a resolution of about 55 km and spans the 1982 – 2005 timeframe. Some of the PATMOS-x products include:

*Global Precipitation Indices (GPI): unitless value indicating the percent frequency of convective (thunderstorm) activity within the 55 km grid cell, where a given pixel within a grid cell is defined to be convectively active if the 11 micron brightness temperature (BT) is less than 235 K. Fig. 1 shows the average frequency of convection across the globe during July 1993.

*Fig. 2 delineates the daily mean surface skin temperatures across Wisconsin and vicinity during a severe weather episode over southern Wisconsin on 07 July, 1991.

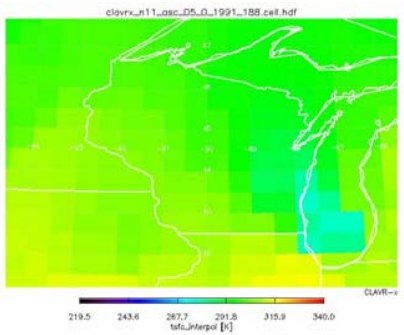

Figure 2. Replicated daily mean surface temperature [K] valid 07 July 1991

*Fig. 3 Depicts an AVHRR IR RGB enhanced image, valid 1933Z 07 June 1984. It shows convective activity across Iowa and Minnesota, several hours prior to the spin-up of an F-5 tornado that would devastate Barneveld, Wisconsin at 0550Z 08 June. Noteworthy is the presence of Raleigh-Benard convective rolls ahead of ensuing convection across Iowa and southern Wisconsin.

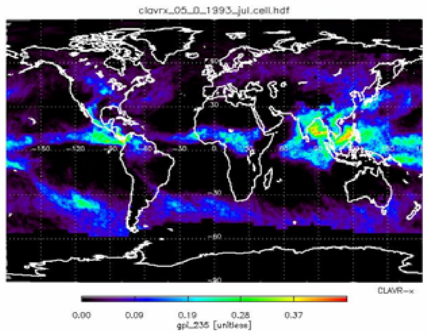

Figure 1. Monthly mean Global GPI [unitless] valid July 1993

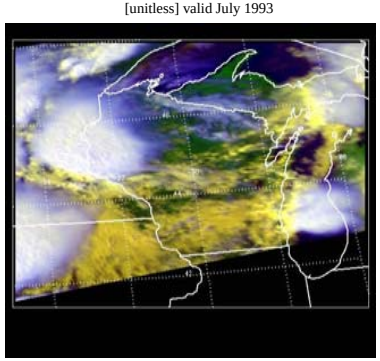

Figure 3. CLAVR-x IR Color-enhanced satellite image valid 1933Z 07 June 1984

Benefits from GOES-R and NPOESS:

*The 2012-2014 launching of GOES-R and NPOESS offers an additional three-to-seven channels at far greater temporal coverage in comparison to current AVHRR attributes. Furthermore, with finer temporal and spatial coverage, GOES-R/NPOESS may facilitate a better understanding of the near-instantaneous impacts precipitation has on the "greenness" of vegetation, and subsequent impacts on local environmental changes in moisture and heat fields. Thus, GOES-R/NPOESS will enable investigation of convective trends on a much finer scale.

Discerning thunderstorm trends in Wisconsin:

*Using 55-km PATMOS-x data derived from the Advanced Very High Resolution Radiometer (AVHRR), I am researching Wisconsin thunderstorm trends from 1982-2005. Wisconsin has been broken up into four quadrants: northwest, southwest, northeast, and southeast respectively.

*Fig. 4 shows a twenty-four year time series of mean July GPI values, (i.e., BT's less than 235K), over the southwestern Wisconsin domain. Qualitative observations argue a considerable decrease in July convective activity in comparison to the 1980-90s; and, as seen in Fig. 4, is validated, with GPI frequencies nearing the two-decadal mean. Daily and monthly trends of warm BT's, of approximately the surface temperature, are connected to clear, dry conditions, with little to no thunderstorm activity. Interestingly, thunderstorm extremities; including the absence of, during the 1988-89 drought, and the overwhelming presence of, during the 1993 Mississippi flood, have been documented.

*Fig. 5 shows that deep convection shows up well in the PATMOS-x retrieved cloud top temperature. Valid 07 July 1991, qualitative observations of severe thunderstorm occurrence over southern Wisconsin, correlate with daily mean cloud top temperature of approximately 215K.

*Recent efforts involve the comparison of land-surface composition and convective frequency.

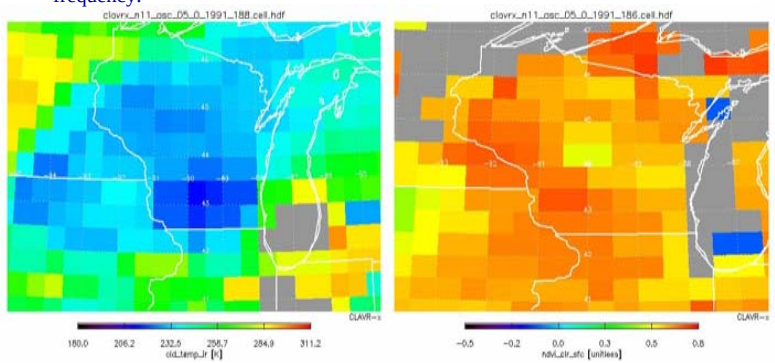

Figure 5. Daily mean CTT [K] valid 07 July 1991

Figure 6. Daily Mean NDVI [unitless] valid 05 July 1991

*Fig. 6 indicates the Normalized Difference Vegetation Index (NDVI) values over the state of Wisconsin two days prior to the 07 July 1991 severe weather episode. Noteworthy is NDVI values likely approaching 0.7-0.8 [unitless]; thus, corresponds to a "green-spike" from standard radiation calibrations (Petty, 2004). Consequently, moisture and heat fluxes are greatest where the largest density of green vegetation and subsequent evapotranspiration occurs. Coincidently, the zonal movement of the convective complex across southern Wisconsin on 07 July 1991 was perhaps enhanced by additional moisture and heat provided by extensive vegetation over the Mississippi and Wisconsin River Valleys.

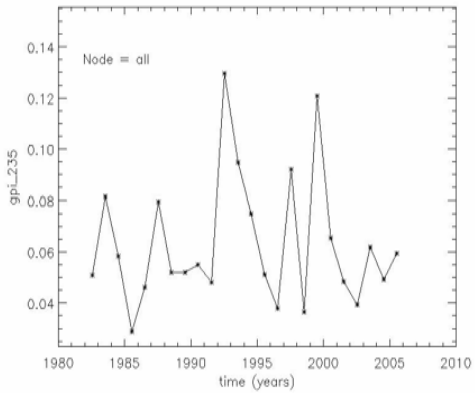

Figure 4. Twenty-four year time series of mean July GPI [unitless] over southwestern Wisconsin.

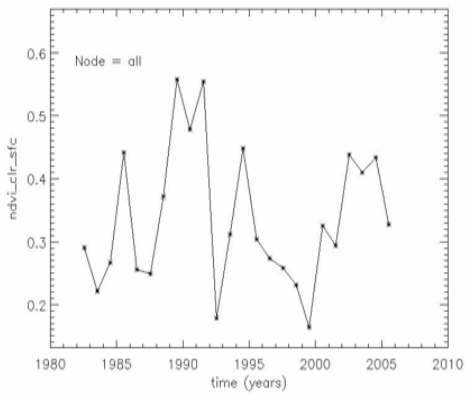

Figure 7. Twenty-four year time series of mean July NDVI [unitless] over southwestern Wisconsin.

Future aspects of research:

*Future work includes the integration of 1km and 4km pixel-level AVHRR data to help examine the impacts of land-surface properties on the convective trends in greater detail , including the "urban island heat effect." Figs. 4 and 7 show preliminary results of a twenty-four year times series comparison of PATMOS-x NDVI trends and convection (GPI) over southwestern Wisconsin. Concurrently, a decrease in overall NDVI correlates with a return to a two-decadal mean in convective activity. Future efforts will examine the intimate relationship between NDVI and convection. Perhaps this undertaking will show a weak correlation; thus, leading to the investigation of synoptic and mesoscale regimes for discernable causations of convective trends.

REFERENCES:

Heidinger, Andrew. "Clouds from AVHRR Extended (CLAVR-x) Research at CIMSS." 2006. 5 Aug. 2006. http://cimss.ssec.wisc.edu/clavr/.

National Oceanic Atmospheric Administration (NOAA). 10 Dec. 2003. 5 Aug. 2006. www.osdpd.noaa.gov.

Petty, Grant W. A First Course in Atmospheric Radiation. Sundog Publishing, 2004.