

Climate and Atlantic Hurricane Activity

Chunzai Wang (AOML/PHOD)

Sang-Ki Lee (UM/CIMAS)

David B. Enfield (AOML/PHOD)

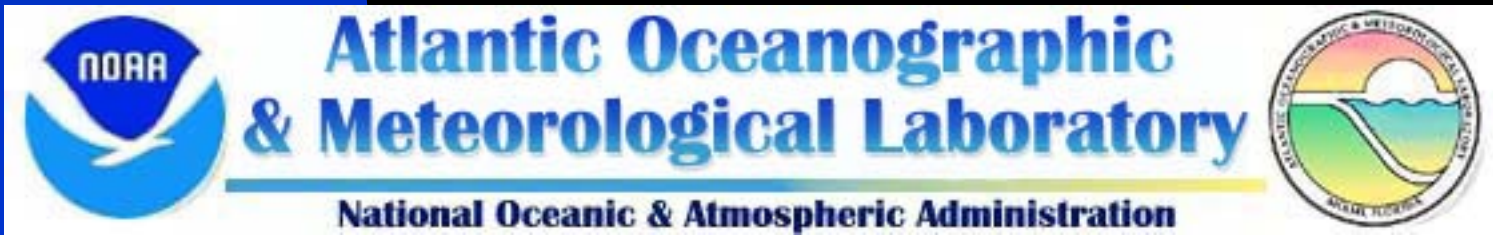
Jason P. Dunion (AOML/HRD)

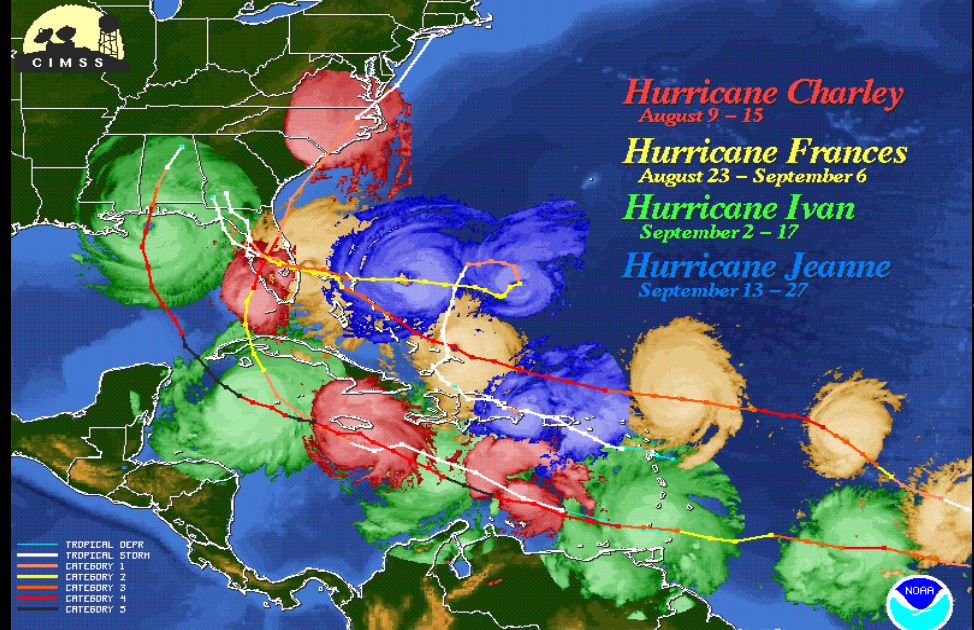
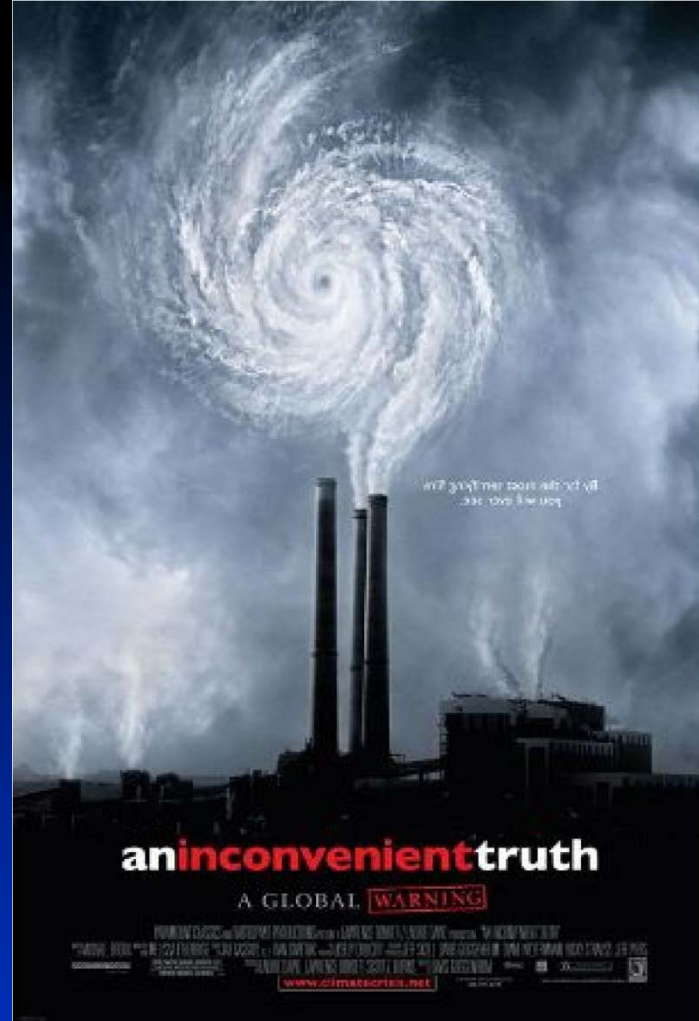
Stanley B. Goldenberg (AOML/HRD)

Chris Landsea (National Hurricane Center)

Outline

- Global warming and U.S. landfalling hurricanes.
- Atlantic warm pool (AWP) and Atlantic hurricane activity.
- Saharan air layer and Atlantic tropical cyclones (TCs).
- Summary and future work.



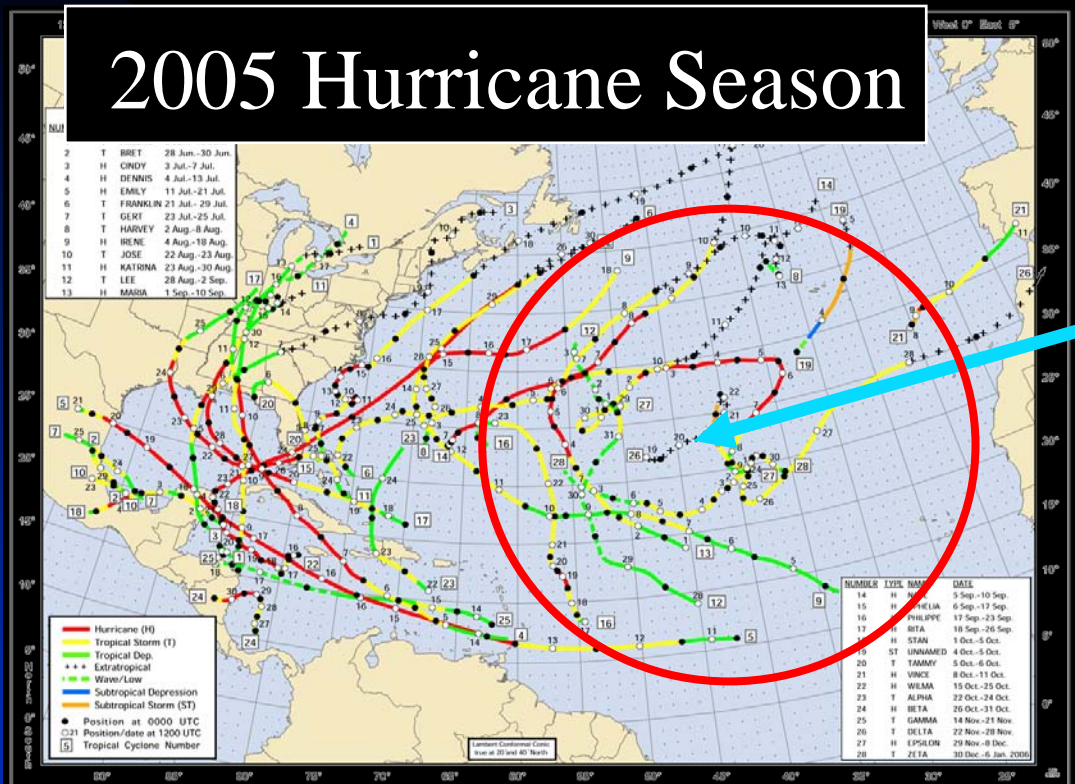


Because of “An Inconvenient Truth” and his efforts in climate change, Al Gore was awarded the 2007 Nobel Peace Prize.

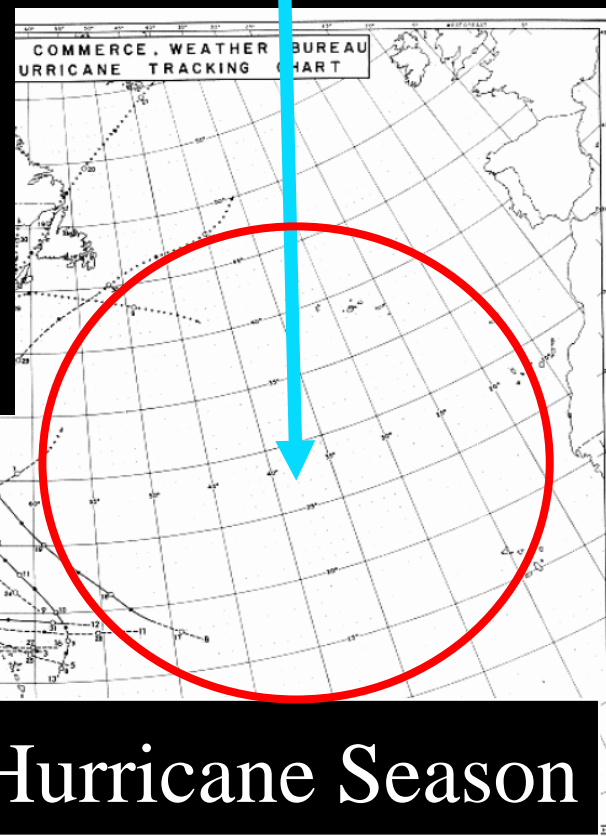
However, 2006 and 2007 are quiet years!

Hurricane data problem: Hurricanes were hardly detected over the open ocean before the era of satellite technology (around the mid-1960s) & aircraft reconnaissance (around the mid-1940s).

2005 Hurricane Season



Open Atlantic
Ocean Differences



1933 Hurricane Season

An AOML's paper "Global warming and United States landfalling hurricanes" was published on January 23, 2008 (Wang and Lee, *GRL*).

USA TODAY Home News Travel Money Sports Life Tech

Print edition News Inside News Cars

Today's Sections
01/23/2008

News Sports Money Life Previous editions:
Search Archives

Page 2A E-mail | Save | Print | RSS

Study: Climate change could cut hurricanes

By Seth Borenstein
The Associated Press

WASHINGTON ? Global warming could reduce how many hurricanes hit the USA, according to a new federal study that clashes with other research.



Good Morning America | World News |
ABC News Now | i-Caught

Fri Jan 25

Home | News Brief | World | US & International | Politics | Money |

Home > [Technology & Science](#)

Study: Warming May Cut US Hurricane Hits

New Federal Study Says Global Warming May Lessen U.S. Hurricane Strikes, but Not All Agree

TIME IN PARTNERSHIP WITH **CNN** SEARCH

HOME U.S. WORLD BLOGS BUSINESS & TECH **New! GLOBAL BUSINESS** HEALTH

MAGAZINE SPI

Study: Warming May Cut US Hurricane Hits

By AP/SETH BORENSTEIN Wednesday, Jan. 23, 2008



MiamiHerald.com

HURRICANES

Global warming might keep hurricanes away from U.S.

Check your assumptions at the door – it turns out that global warming may be inhibiting rather than enhancing hurricanes.

Posted on Wed, Jan. 23, 2008

[reprint](#) [AIM](#) [del.icio.us](#) [Digg](#)

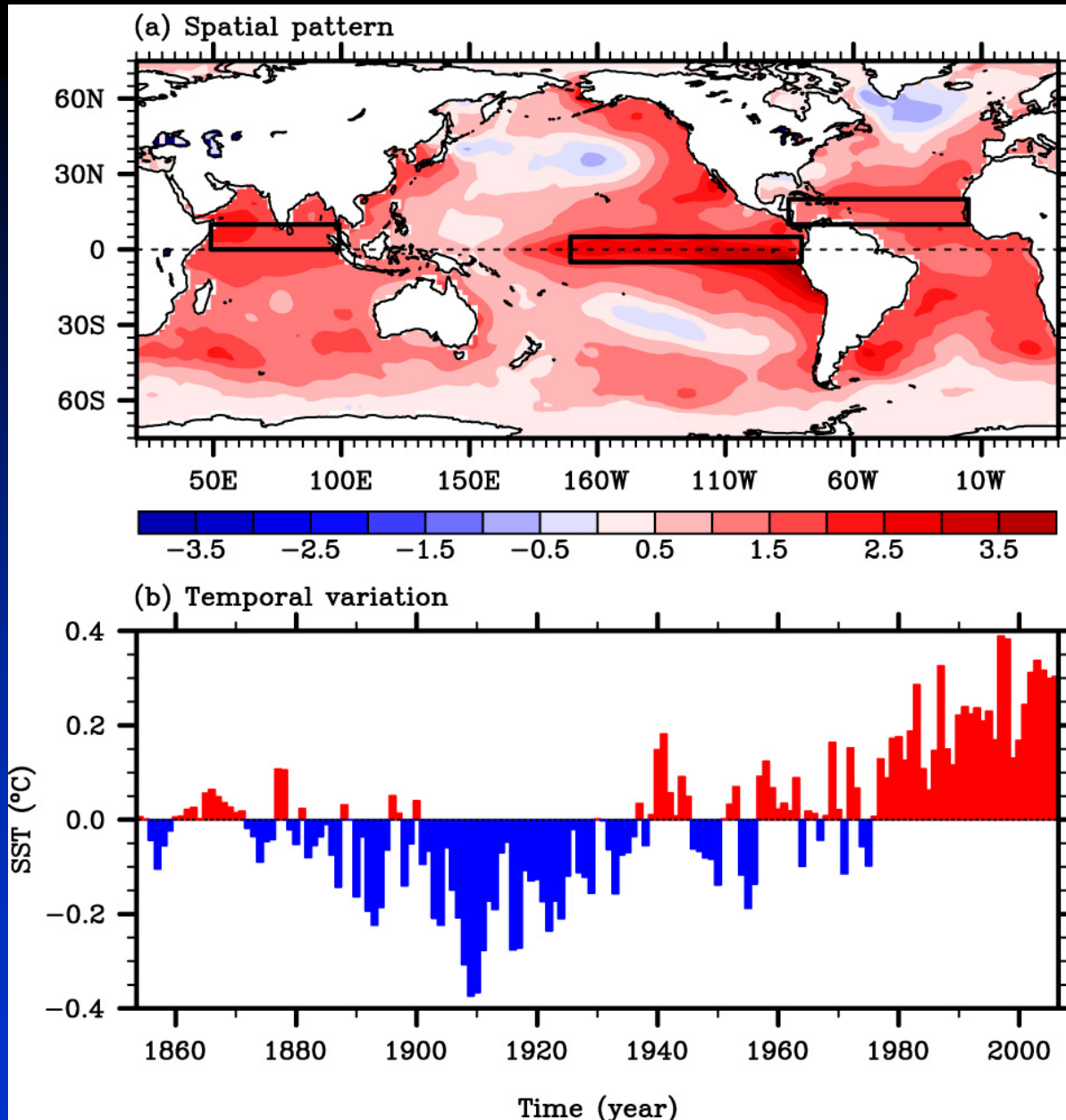
By MARTIN MERZER
mmerzer@MiamiHerald.com

Intensifying one of the hottest debates in science, a new report concludes that global warming actually is diminishing the number of hurricanes that strike Florida and the rest of the United States – and the phenomenon is likely to continue.

The paper was covered by more than 300 newspapers worldwide (plus many TV & radio shows).

NOAA Atlantic Oceanographic & Meteorological Laboratory

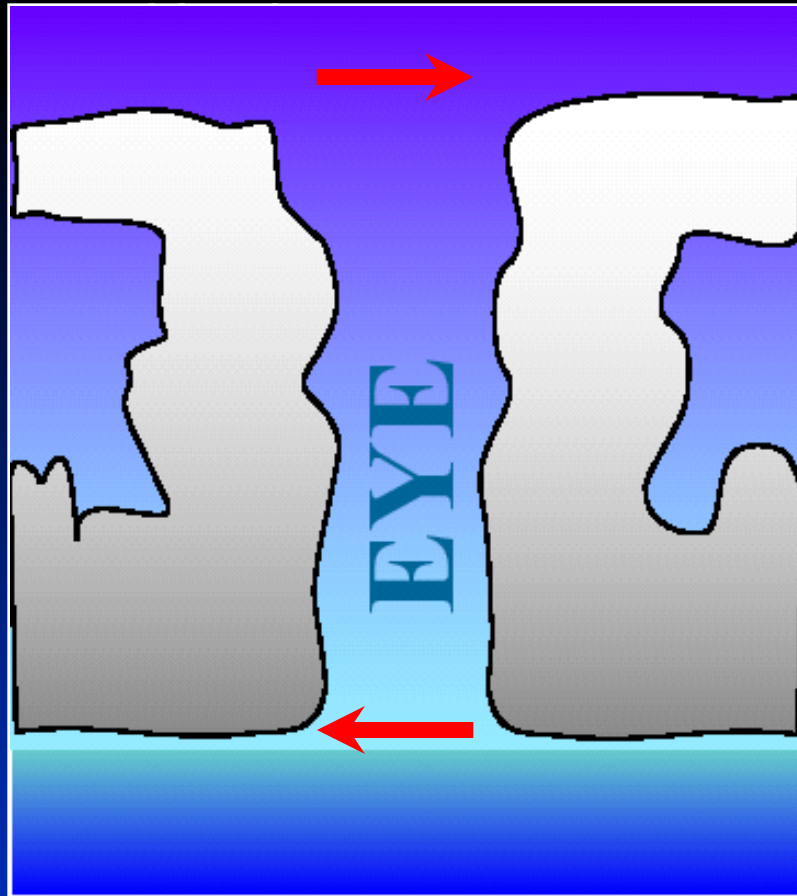
Warming Occurs Almost Everywhere over the Global Ocean



The first EOF mode from the ERSST data over the past 153 years (1854-2006).

Three tropical oceans compete with one another for affecting Atlantic hurricanes.

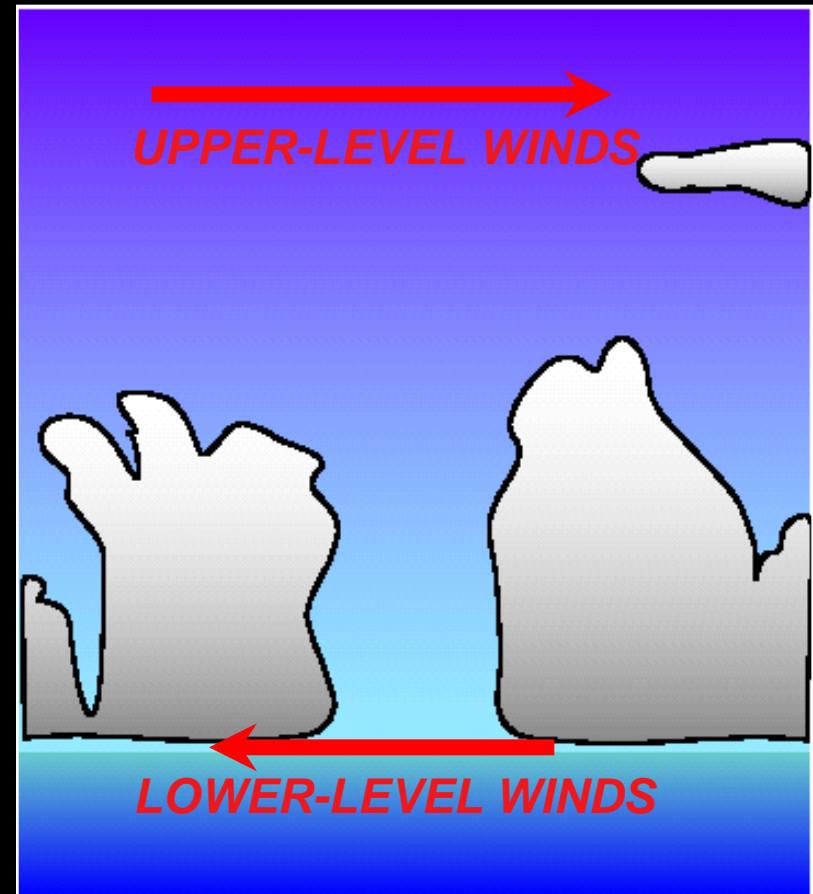
Effects of Vertical Wind Shear (VWS) on Atlantic



WEAK SHEAR => FAVORABLE



VWS either helps a vertically coherent storm vortex to develop or hinders it from doing so, depending on its magnitude.

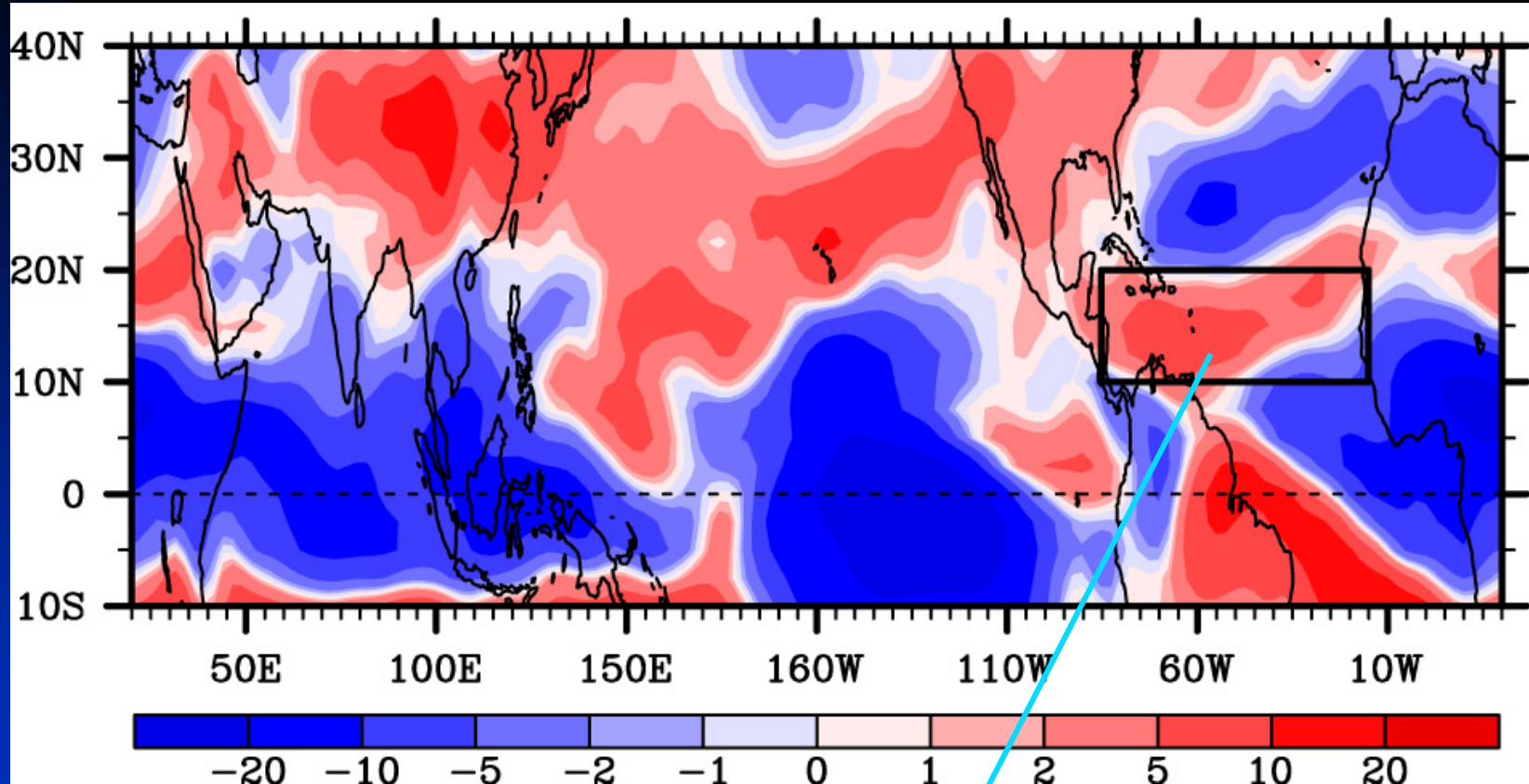


STRONG SHEAR => UNFAVORABLE



As the global ocean is warmed up, the vertical wind shear in the hurricane MDR is increased.

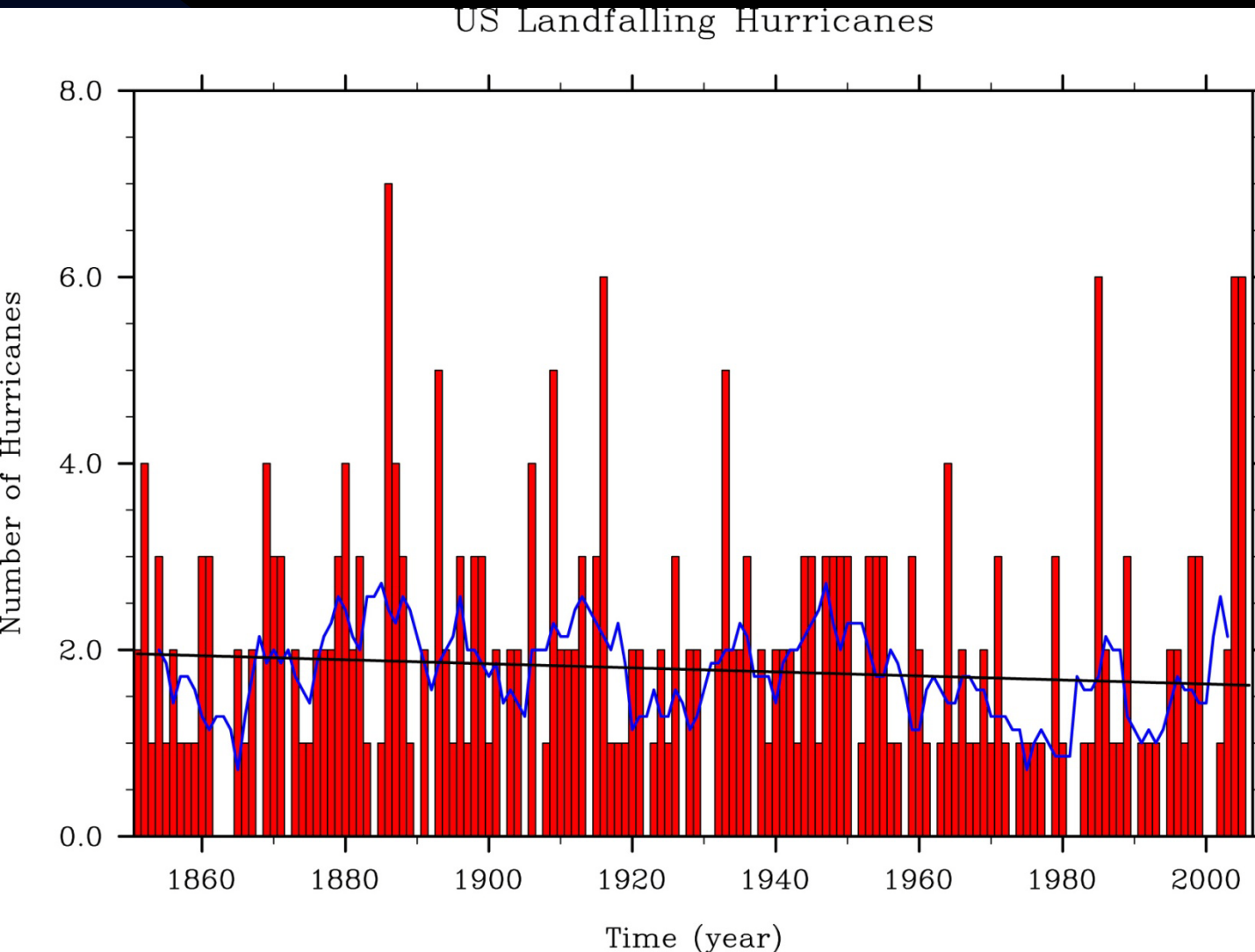
Regression of vertical wind shear (June-November) onto global warming index



Global warming of the sea surface is associated with a secular increase of tropospheric vertical wind shear in the hurricane main development region (MDR), unfavorable for Atlantic hurricanes.

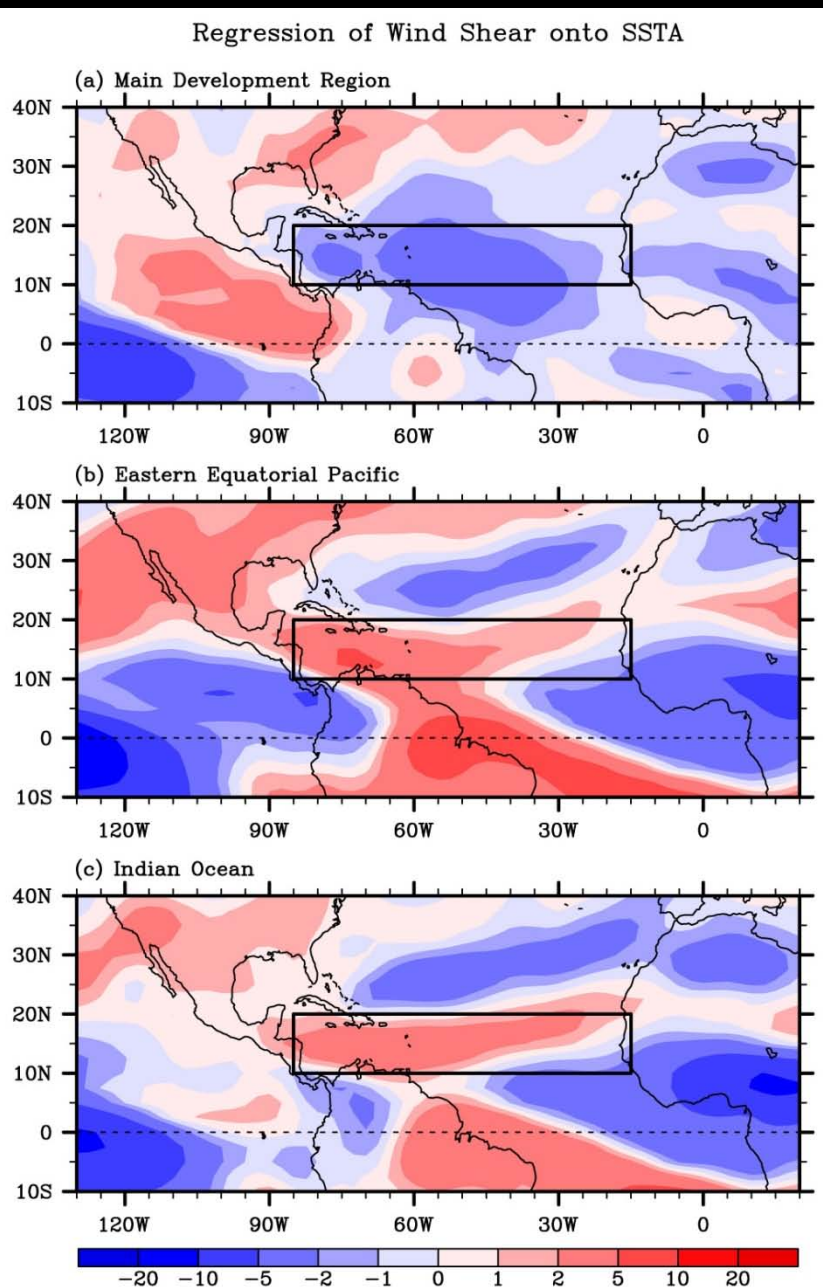
NOAA Atlantic Oceanographic & Meteorological Laboratory

Given hurricane data problem, the most reliable hurricane measurement over the long term is U.S. landfalling hurricanes.



- It shows a weak downward trend.
- However, trend is robust because it is independent of the beginning of linear fit as long as the fitted data cover at least a full cycle of AMO.
- It shows an upward trend from the 1970s because the period of 1970-2006 is from cool (1970-90) to warm (1995-2006) AMO phases.

Why does global warming produce an increase of wind shear in the MDR?



All oceans make contributions!

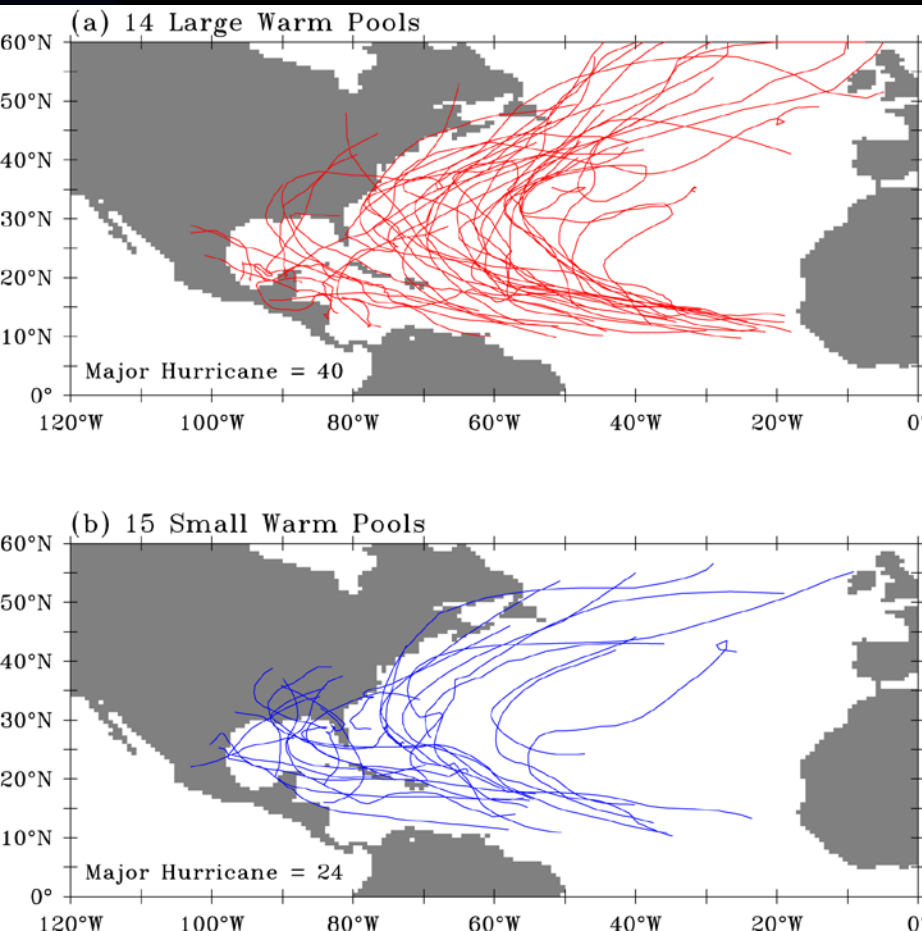
- Tropical oceans compete with one another.
- Warming in the main development region (MDR) reduces vertical wind shear in the MDR.
- Warmings in the Pacific and Indian Oceans enhance vertical wind shear in the MDR.

Whether future global warming increases vertical wind shear in the MDR for Atlantic hurricanes will depend on the relative role induced by secular warmings over the three tropical oceans.

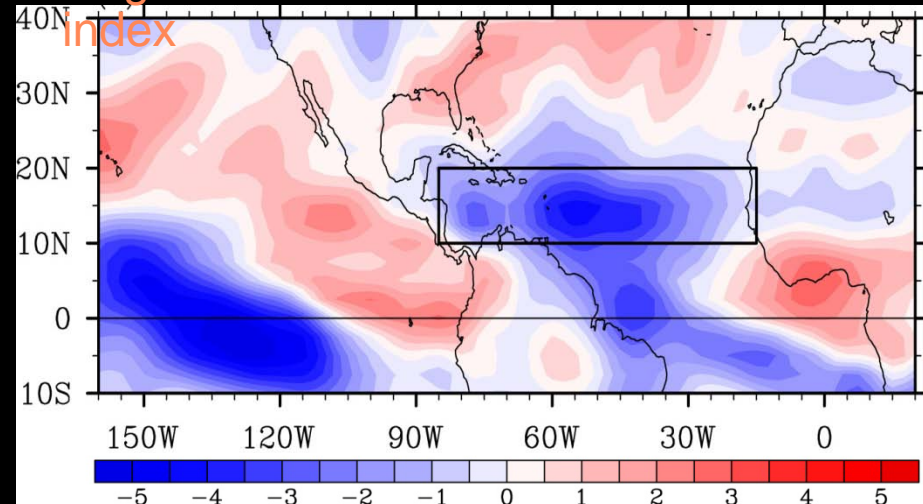
Atlantic Warm Pool (AWP) and Atlantic Hurricanes

Hurricane composites for large & small AWP

Why does the AWP affect hurricanes?



Regression of wind shear onto AWP



AWP acts as a link between AMO & TCs:

- About 80%, large (small) AWP occur during warm (cool) phases of AMO.
- Climate response to North Atlantic SST is primarily forced at low latitudes.
- AWP is the path of or a birthplace for TCs.

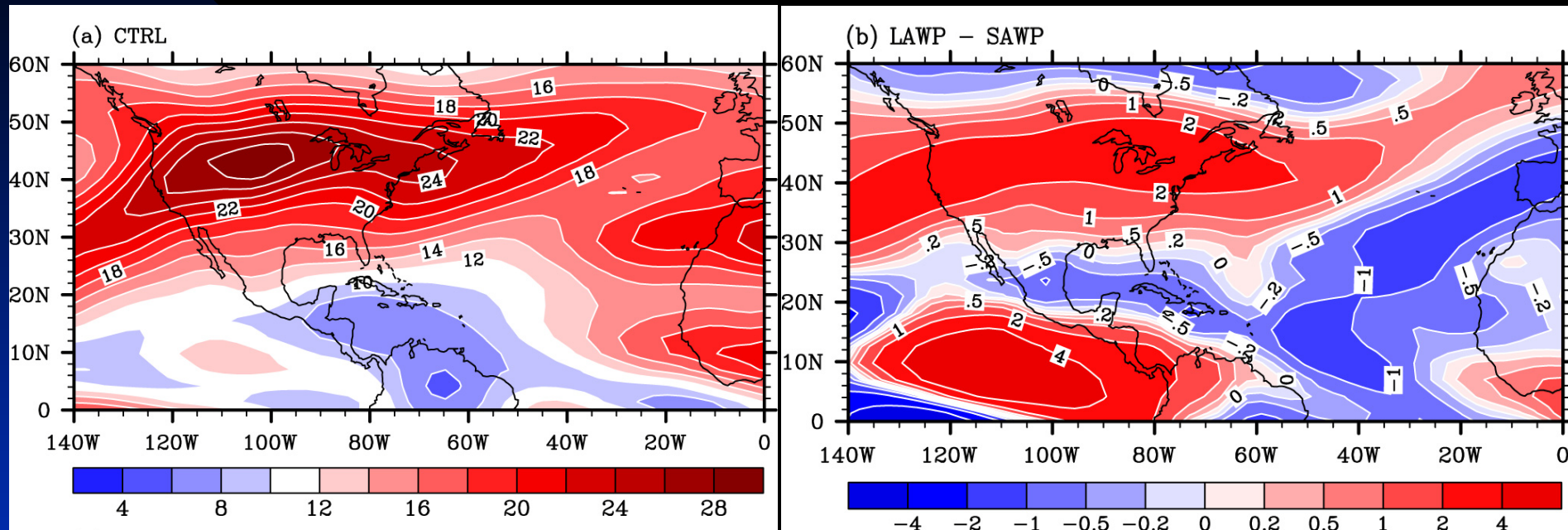
Large (small) AWP => Low (high) shear => More (less) hurricanes.

NCAR Community Atmospheric Model (Version 3.1; CAM3.1)

- A global spectral model (T42 with 26 vertical layers; equivalent to a $2.8^\circ \times 2.8^\circ$ horizontal resolution).
- SST from the Hadley Centre (UK) as the model-forcing.
- The control (CTRL) ensemble (with 18 members) run: Climatological SST is prescribed globally.
- The large AWP (LAWP) ensemble run: SST composite for large AWP is used in the AWP region.
- The small AWP (SAWP) ensemble run: SST composite for small AWP is used in the AWP region.
- The difference is taken between the LAWP and SAWP runs.

Impact of the AWP on Atlantic Hurricanes: via Wind Shear

Vertical Wind Shear (JJASON): $WS = \sqrt{(U_{200} - U_{850})^2 + (V_{200} - V_{850})^2}$

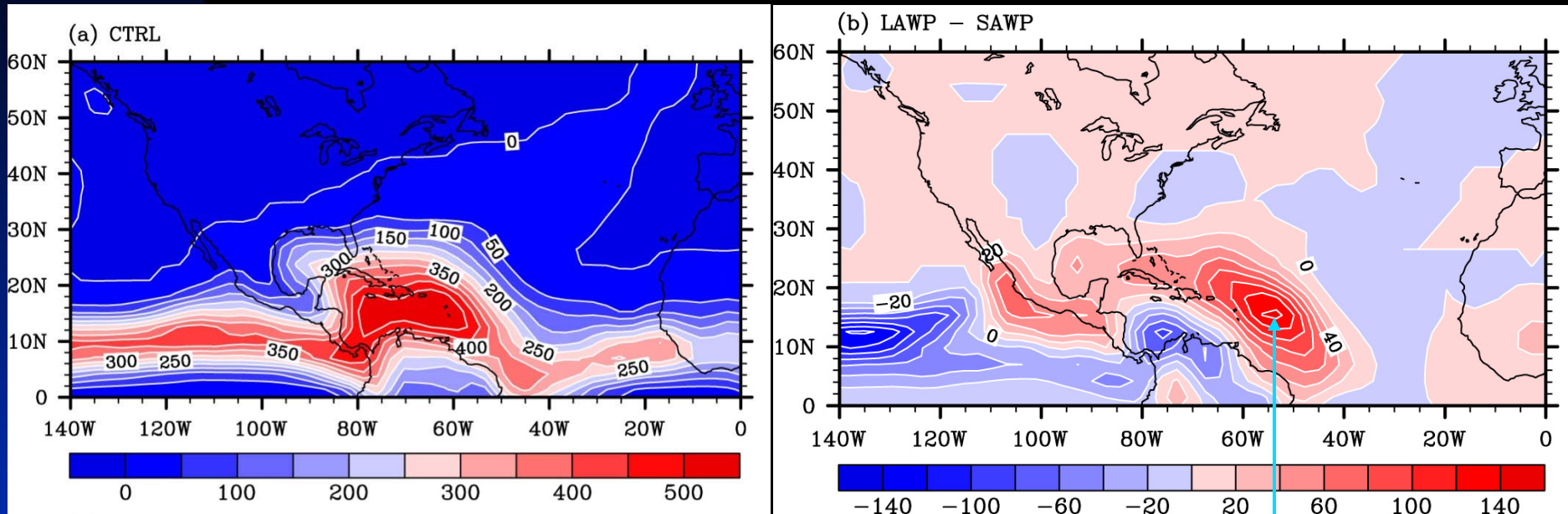


The AWP reduces lower tropospheric easterly flow and upper tropospheric westerly flow, resulting in a reduction of the vertical wind shear in the MDR that favors Atlantic hurricanes. This is because the atmospheric response to the AWP's heating is baroclinic (Gill 1980). See poster for the details.

Impact of the AWP on Atlantic Hurricanes: via Atmos. Instability

Convective Available Potential Energy (CAPE)

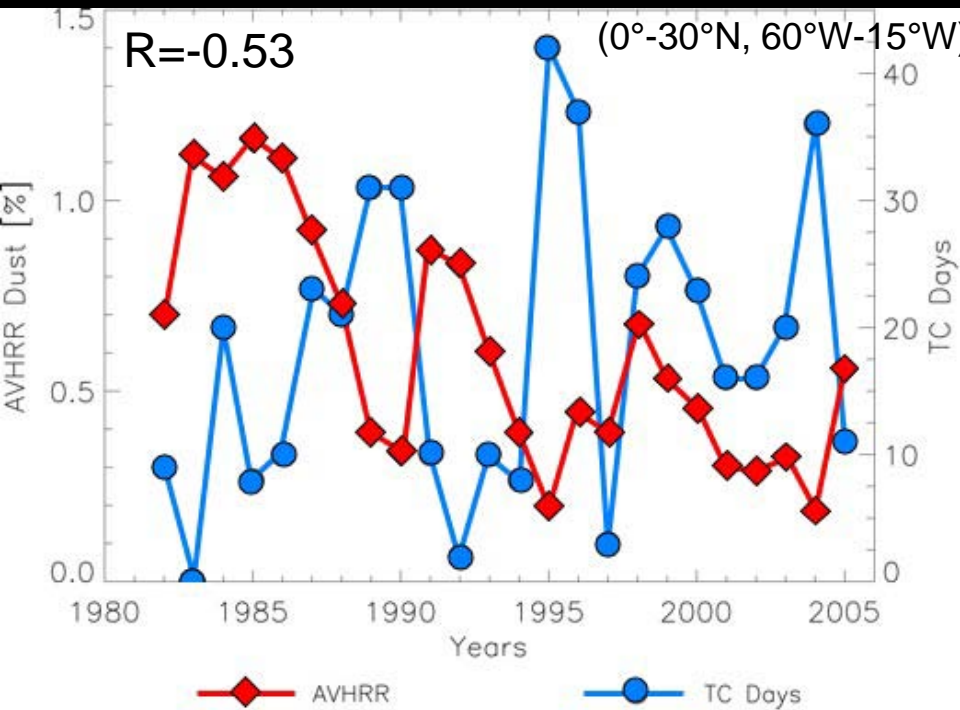
The higher the CAPE value, the more energy available to foster storm growth



The orientation lies along the track of historical hurricanes.

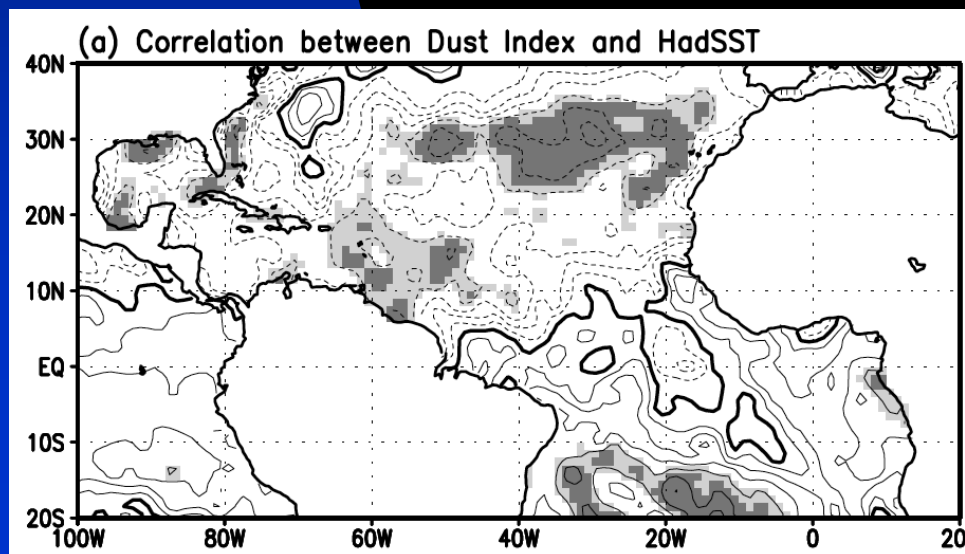
A large AWP tends to increase CAPE due to the increased near-surface air temperature and water vapor content, which provides the fuel for moist convection and thus increases Atlantic hurricane activity.

Saharan Air Layer (SAL) and Atlantic Tropical Cyclones (TCs)



Four mechanisms by which SAL can act to suppress TC intensity:

- Increase the static stability.
- Promote convectively driven downdraft around TCs.
- Correspond to easterly jet at 600-800 mb and thus increase the vertical wind shear.
- Cool SST in the tropical N. Atlantic.



Consistent with negative SST-dust correlation of Lau and Kim (2007, *GRL*).

Summary & Future Work

- Global warming is associated with a secular increase of vertical wind shear in the MDR which coincides with a downward trend in U.S. landfalling hurricanes.
- Whether future global warming increases Atlantic hurricane activity will depend on relative warming role of the three tropical oceans.
- The AWP acts as a link between the AMO and hurricanes/climate response.
- Large (small) AWP reduces (enhances) vertical wind shear in the MDR and increases (decreases) the moist static instability of the troposphere, both of which favor (disfavor) Atlantic TC activity.
- Saharan air layer can act to suppress TC intensity.
- AOML will continue to investigate the climate factors affecting hurricanes and will work to transition improvements into NOAA's hurricane outlook program.
- Long-term goal: Collaborate with other institutes (GFDL, NCEP, RSMAS, ...) to use dynamical models for hurricane season outlooks.