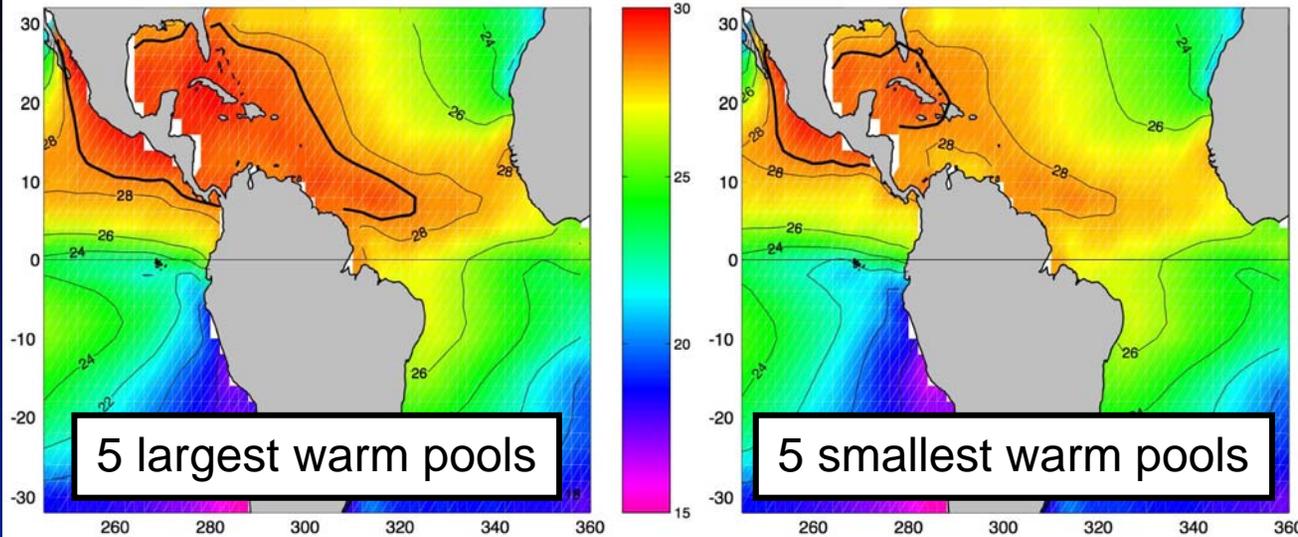


Large Scale Climate Dynamics

(Rainfall and Drought)



All tied together:

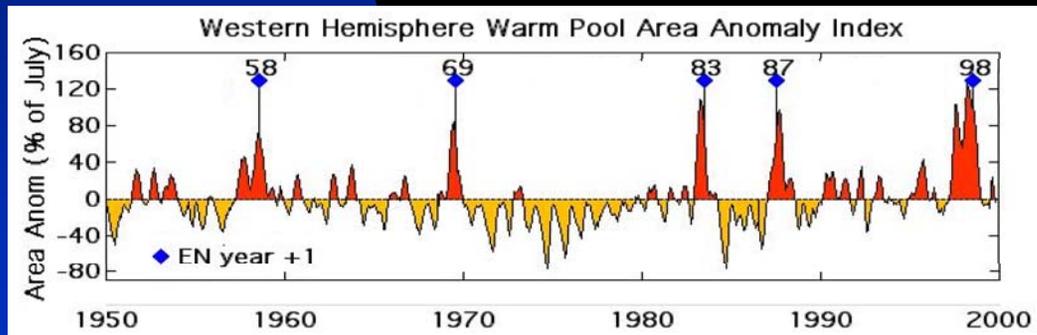
- Atlantic Warm Pool
- AMO
- Rainfall
- Hurricanes

Physical Oceanography

- David Enfield
- Chunzai Wang
- Sang-Ki Lee
- Ernesto Muñoz

Hurricane Research

- Jason Dunion
- Stan Goldenberg
- Chris Landsea
- Frank Marks



Supported by NOAA CPO/CPA, NWS

Atlantic Oceanographic & Meteorological Laboratory

National Oceanic & Atmospheric Administration

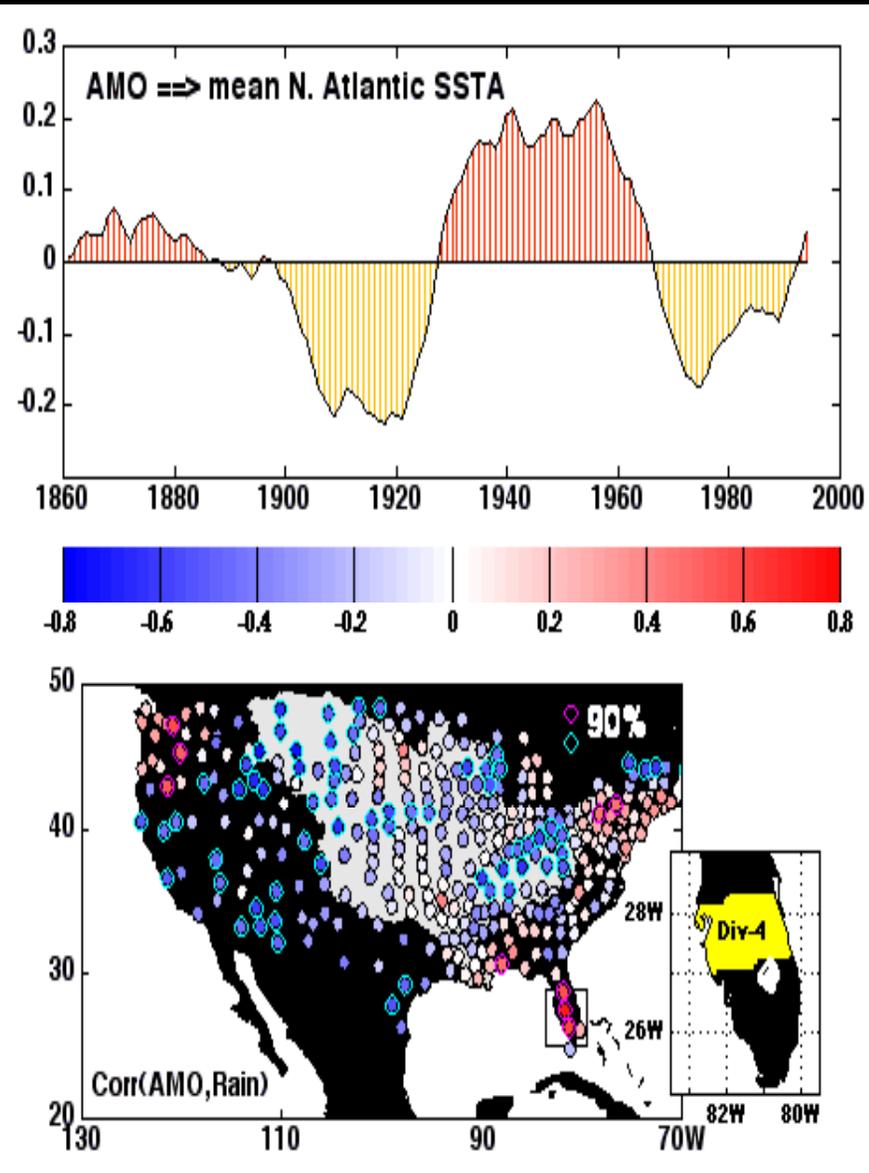
Rationale for Warm Pool Research

Why Study the Warm Pool?

- ◆ ENSO impacts climate mainly in winter; we need a value-added paradigm for summer climate prediction, especially for rainfall in the eastern US, and for Atlantic hurricanes
- ◆ The Indo-Pacific and Atlantic compete with each other and the atmosphere responds to inter-basin anomalies. We can no longer afford to make projections based only on the Pacific
- ◆ Warm pool size is an expression of SST anomalies, but weighted toward regions of maximum SST $> 28^{\circ}\text{C}$ where deep convective heating occurs -- also a good match for tropical cyclogenesis
- ◆ Applicability to summer precip and hurricanes aligns the WP research extremely well with NOAA goals & stakeholder needs

Correlation of AMO with U.S. divisional rainfall (1895-1999)

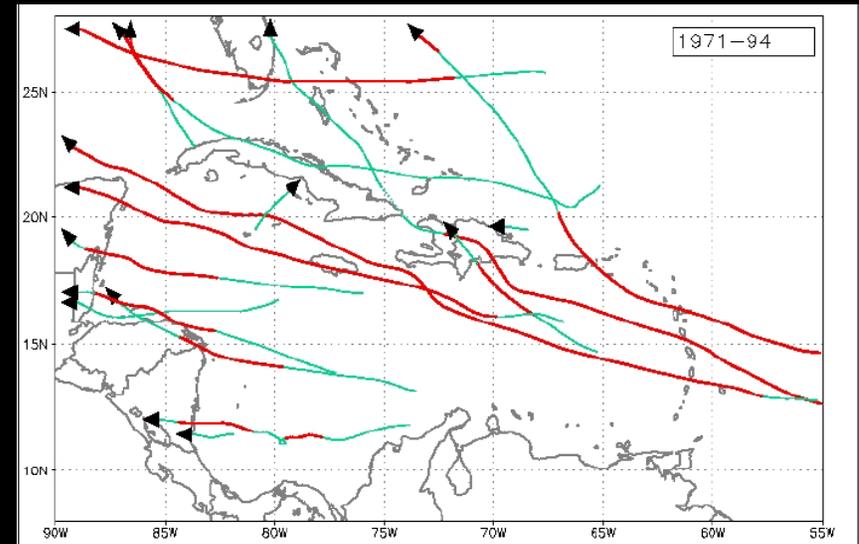
Enfield et al. (2001)



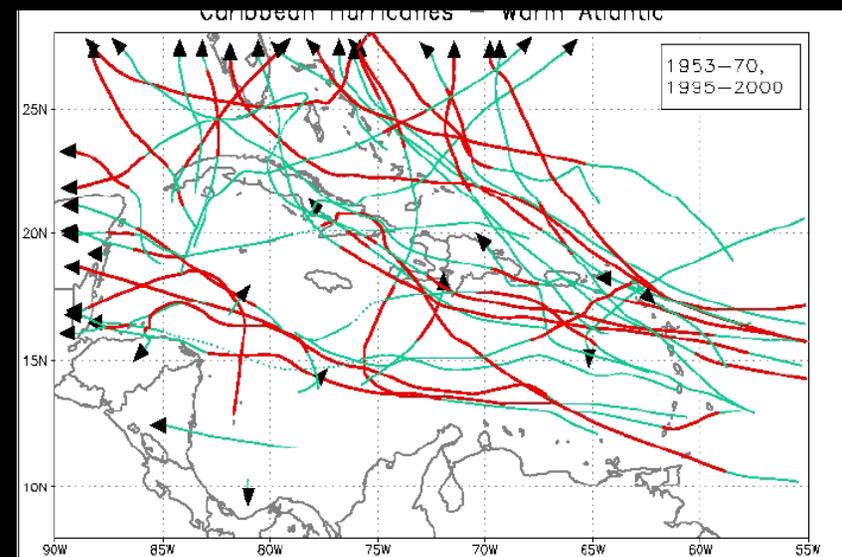
AMO vs. Hurricanes

Goldenberg et al. (Science, 2001)

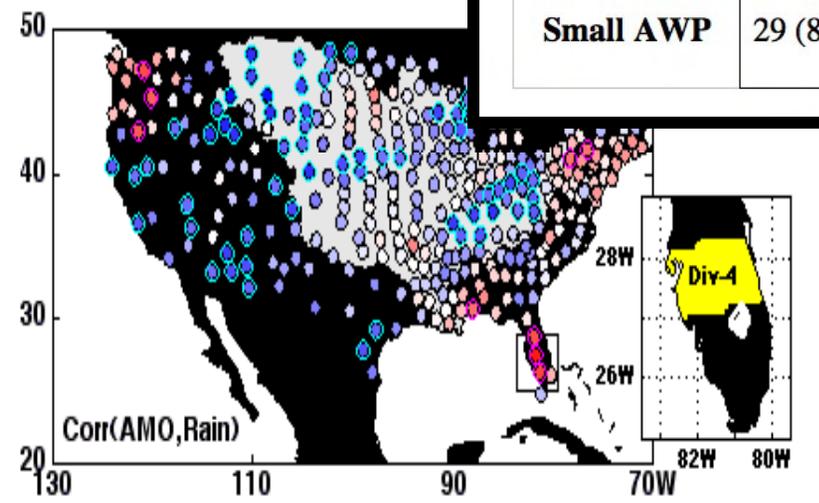
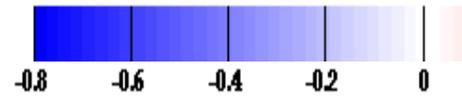
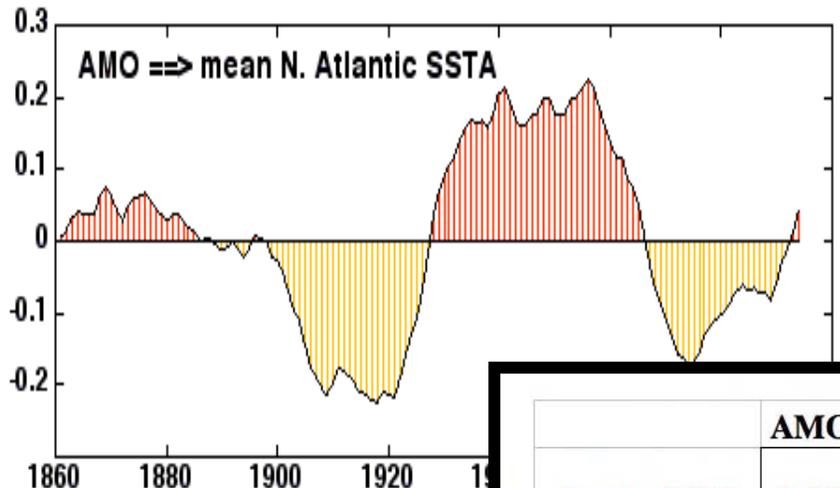
Cool Atlantic



Warm Atlantic



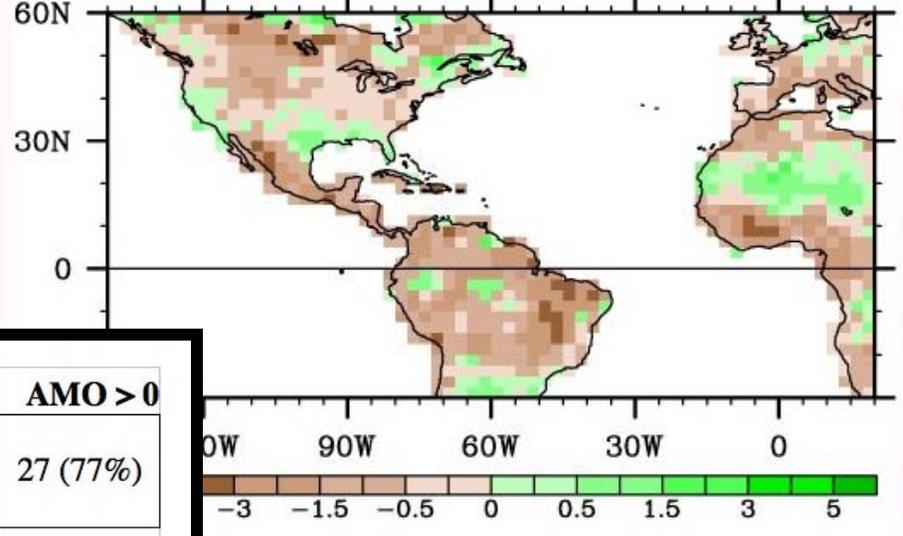
AMO & WP ==> similar impacts
 Rainfall regressions very similar



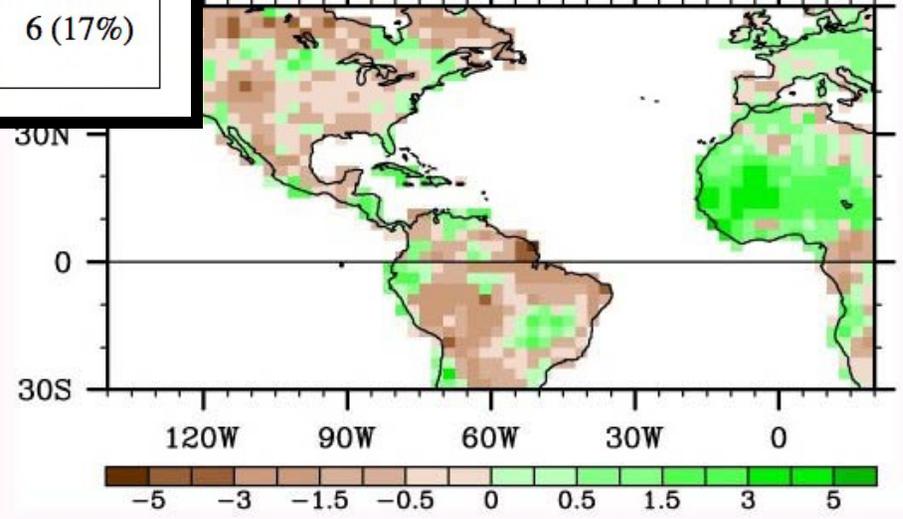
	AMO < 0	AMO > 0
Large AWP	8 (23%)	27 (77%)
Small AWP	29 (83%)	6 (17%)

Regression onto PDSI

(a) Atlantic Warm Pool (AWP)



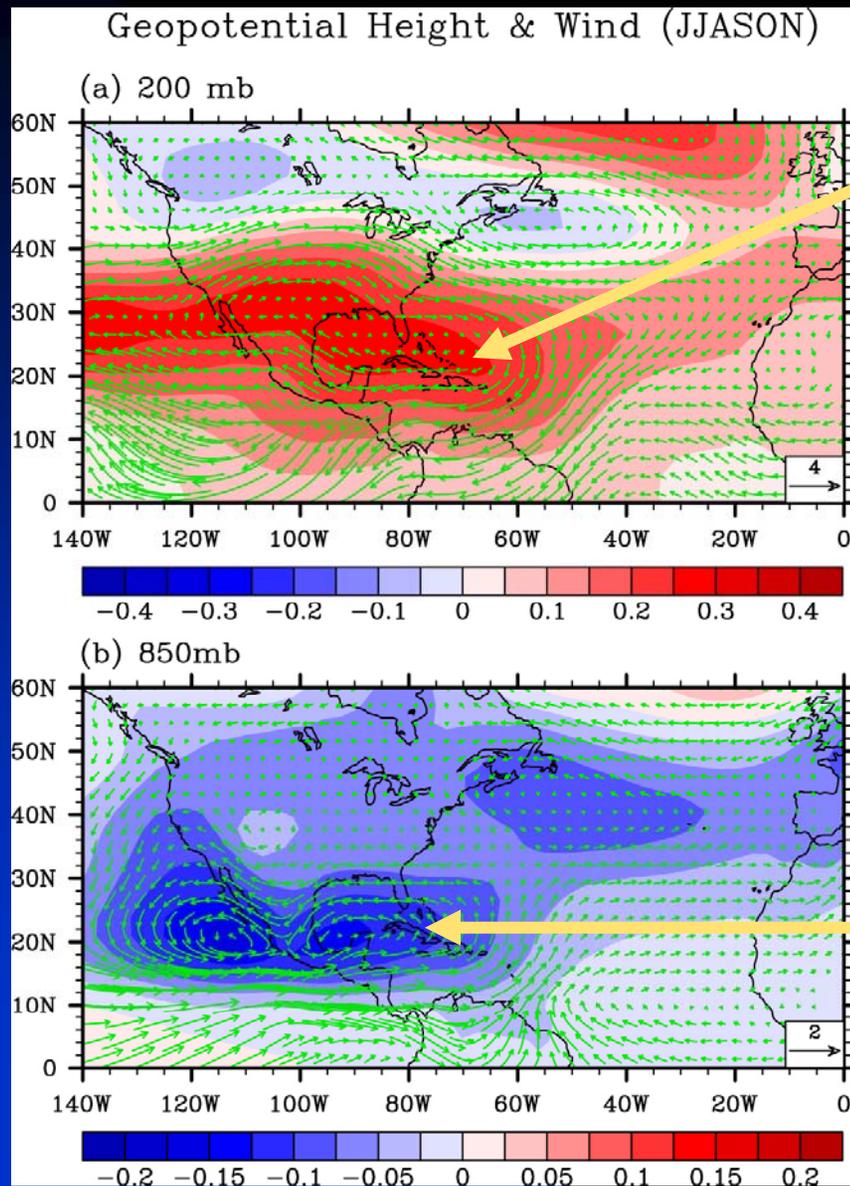
Atlantic Multidecadal Oscillation (AMO)



Gill atmosphere response to Warm Pool anomalies

Forced AGCM

Large minus Small AWP



200 mb anticyclone

This is the textbook
baroclinic response of a
“Gill atmosphere” to an
off-equatorial
heating anomaly

850 mb cyclone

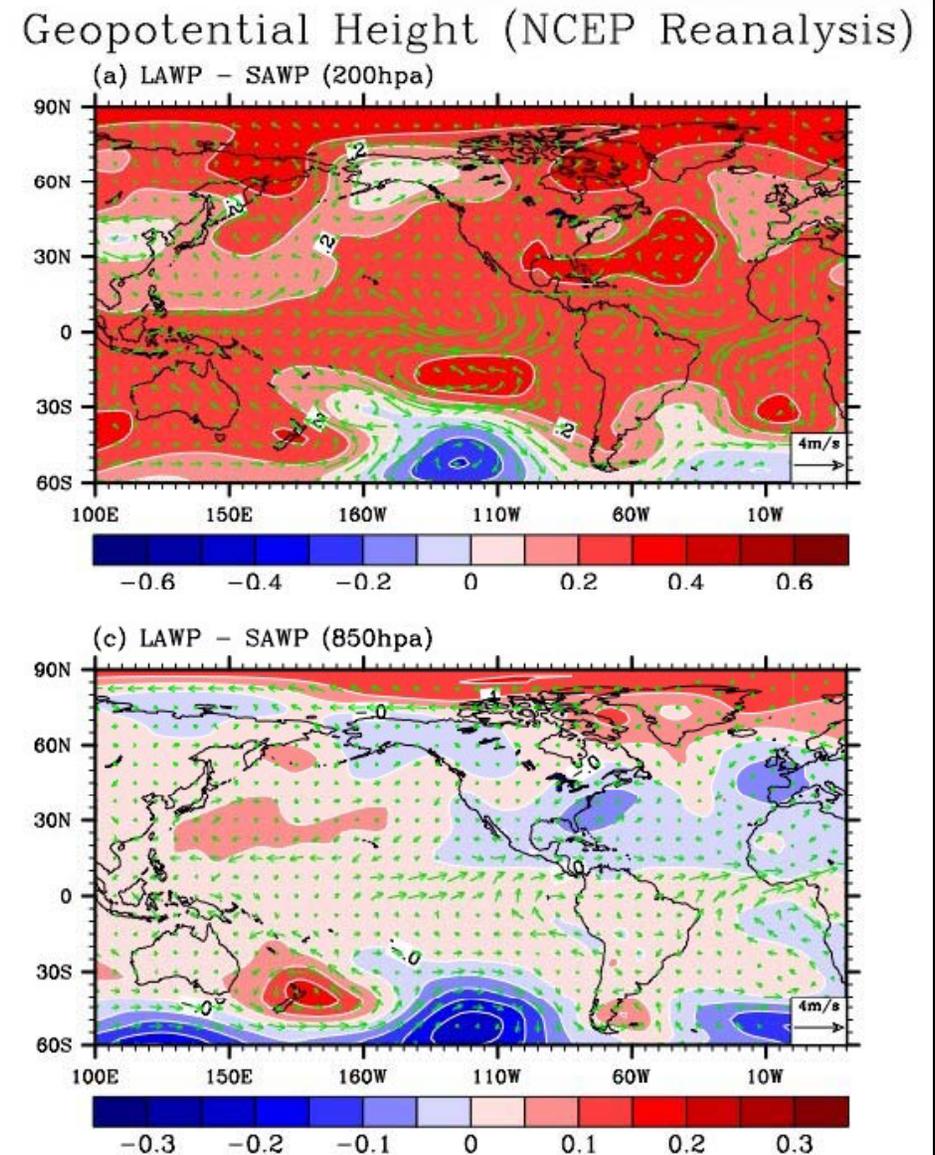
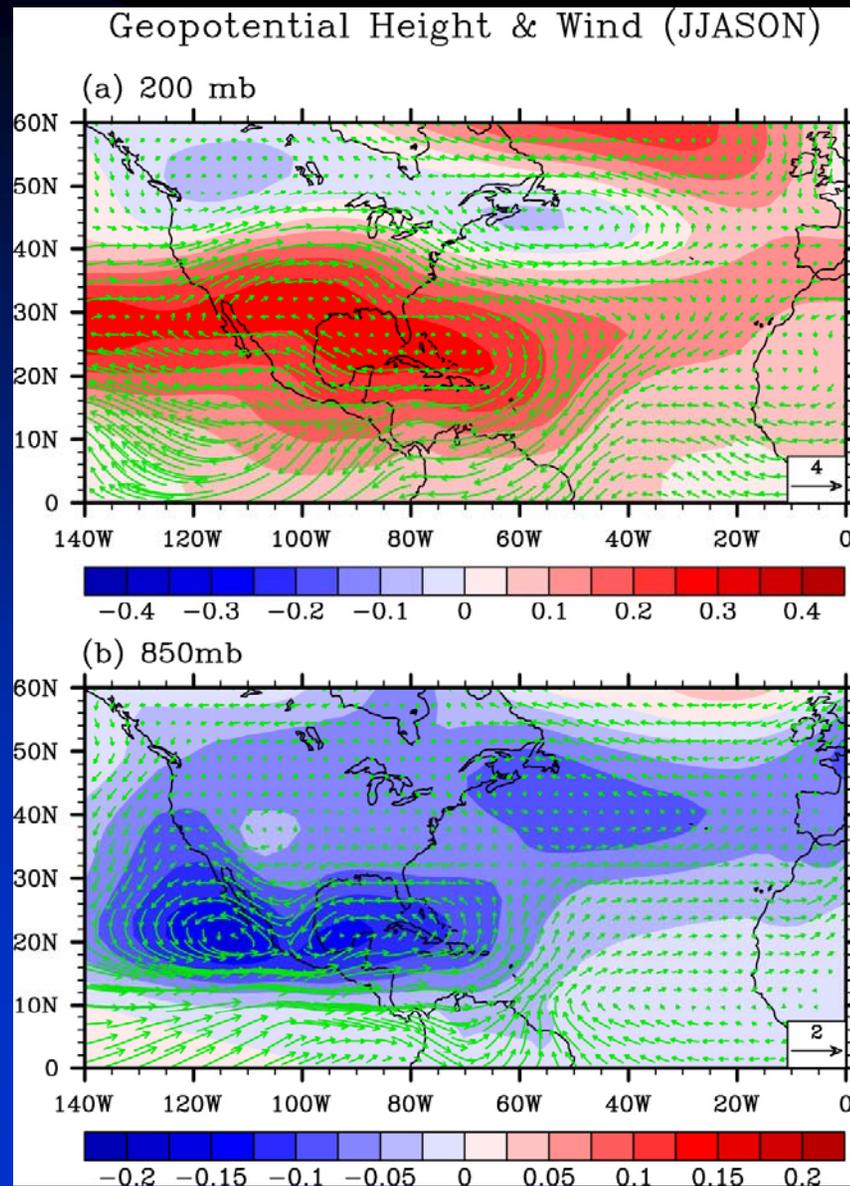
Gill atmosphere response to Warm Pool anomalies

Forced AGCM

Large minus Small AWP

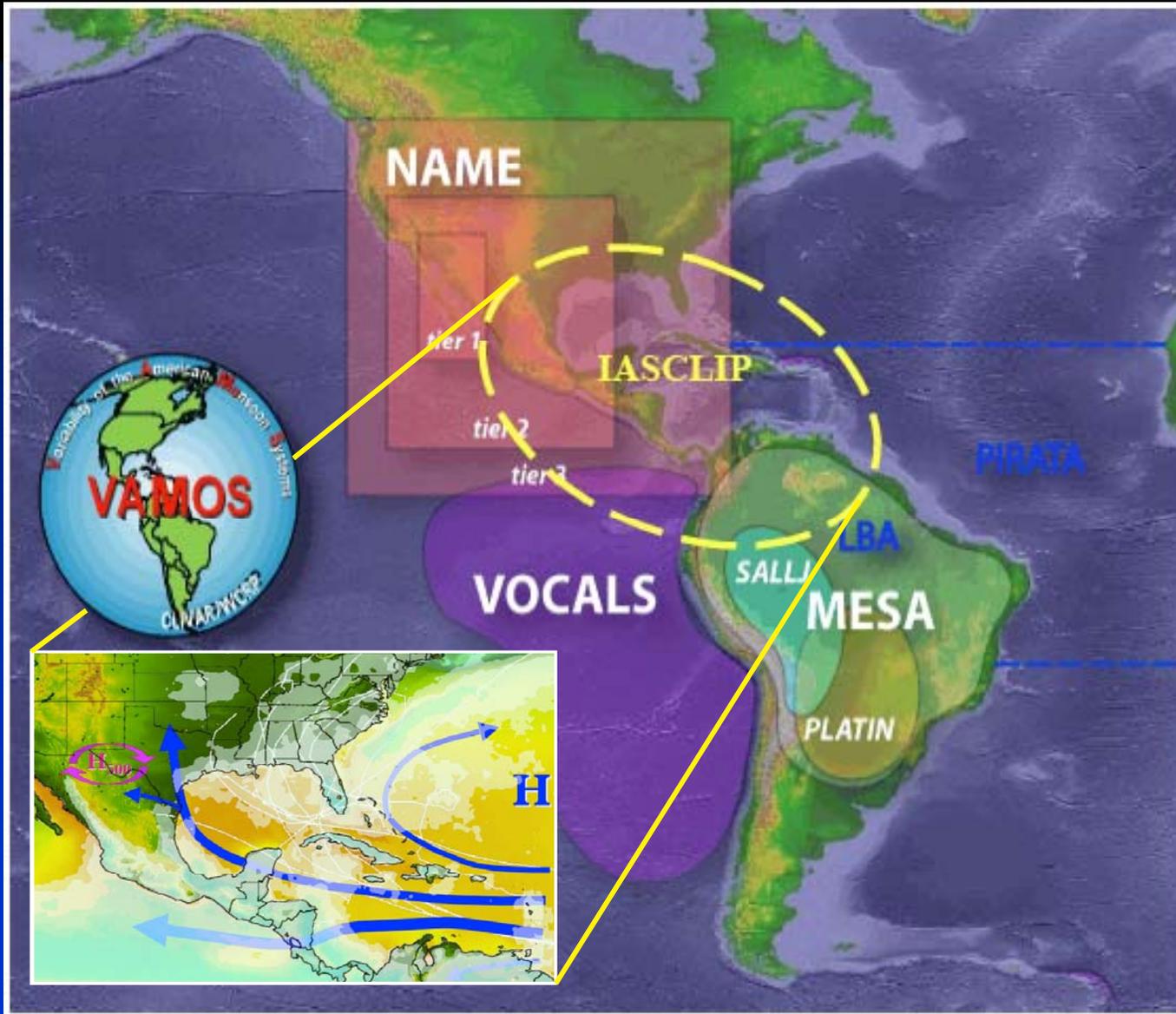
Obs (NCEP reanalysis)

Large minus Small AWP



IASCLIP = Intra Americas Study of Climate Processes

A CLIVAR-VAMOS Monsoons Program (FY09 - FY14)

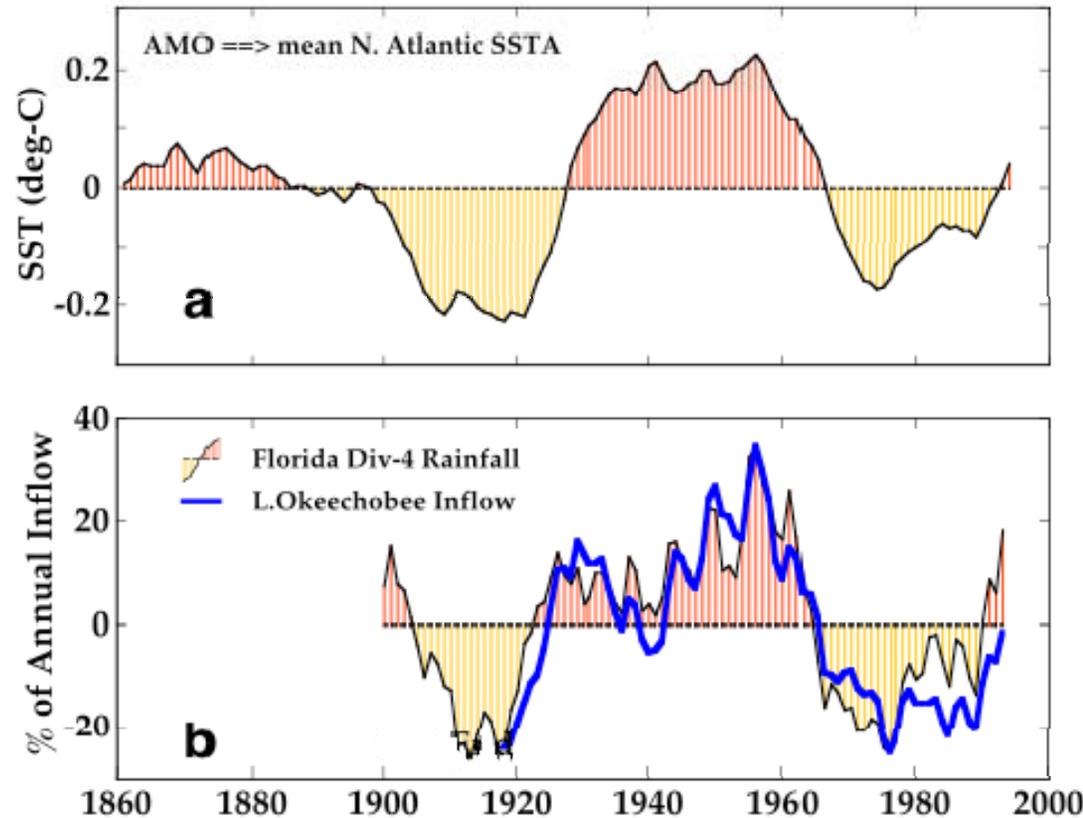
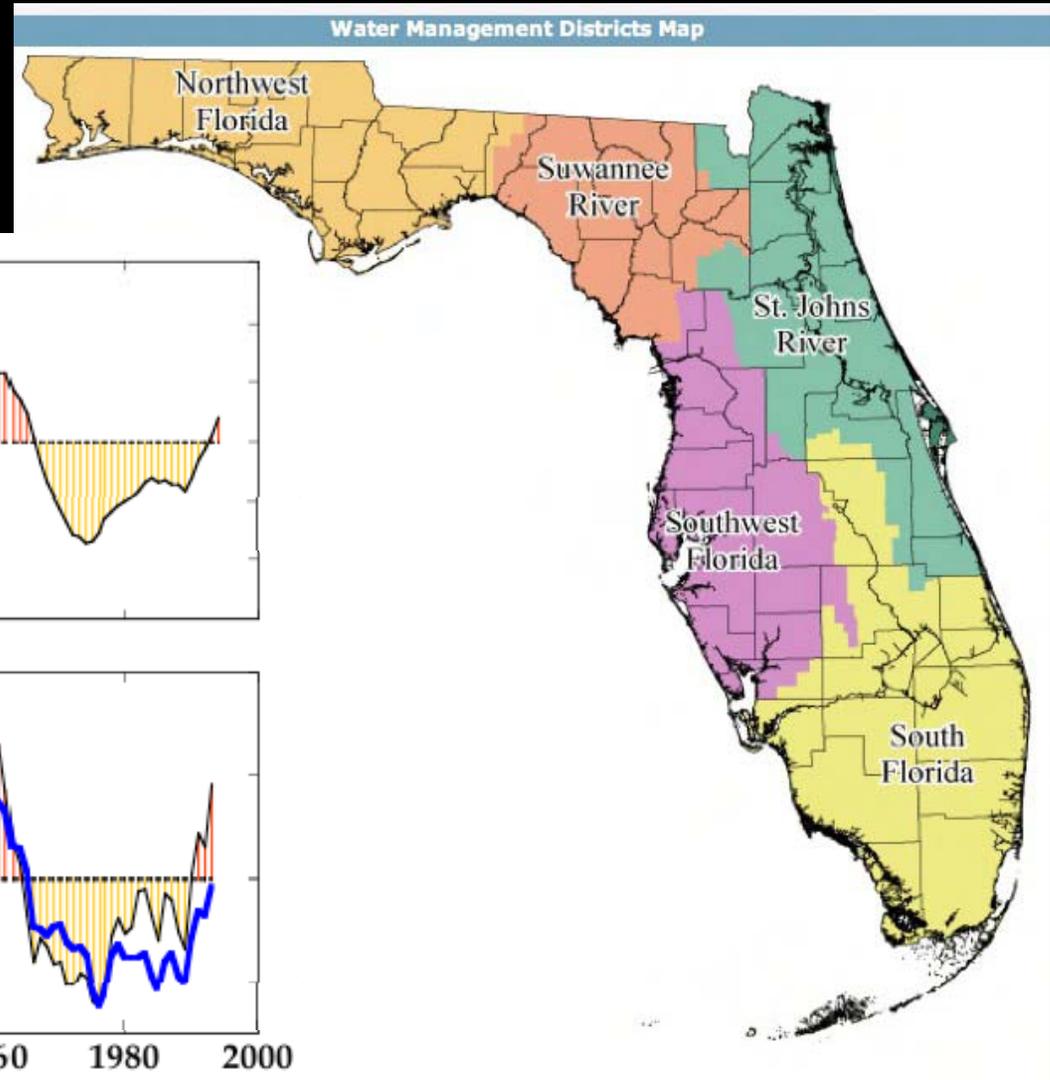


Florida Water Management Districts

AOML research is influencing water planning

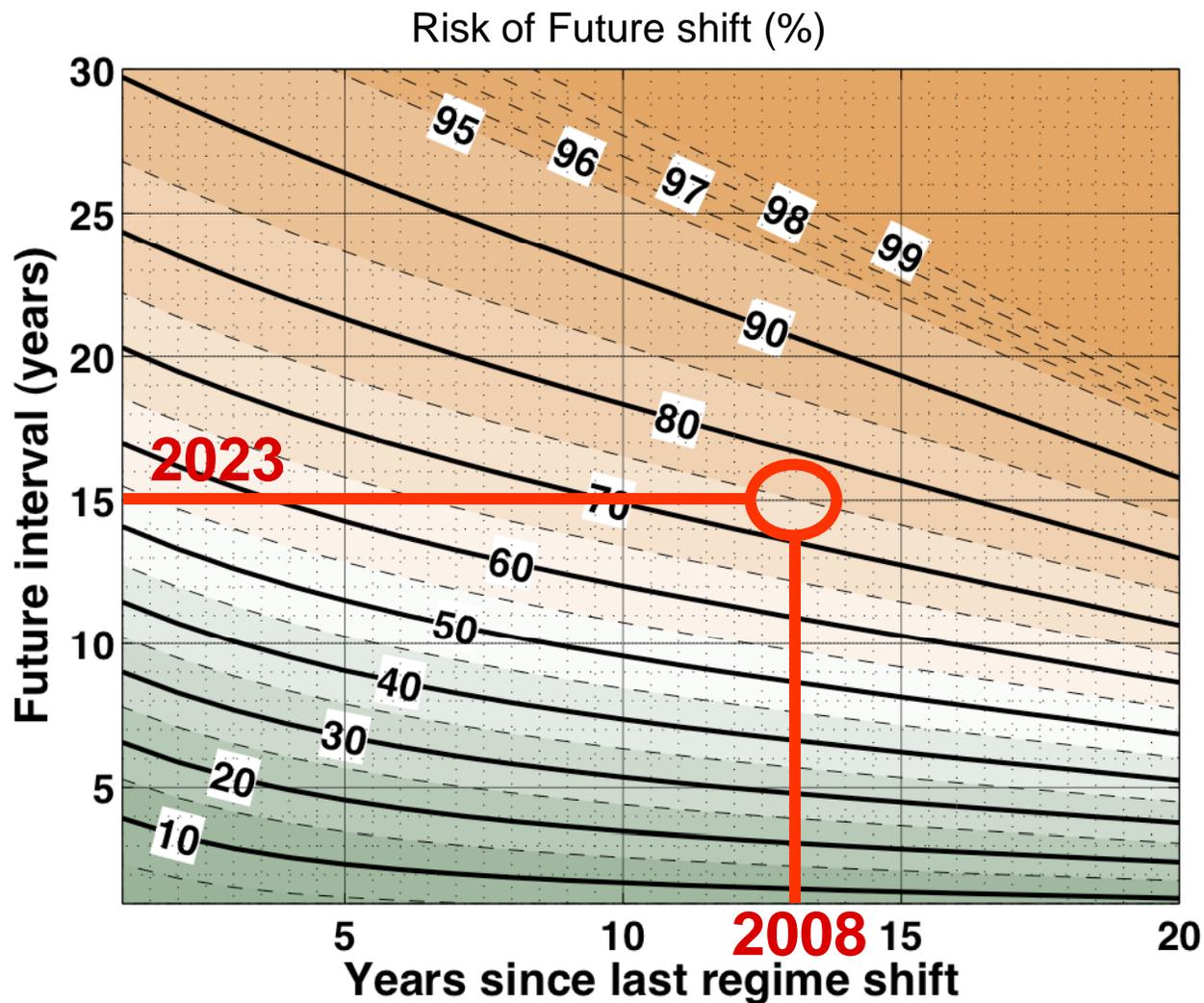
Statute-mandated 20-year water plans every 5 years

Lake Okeechobee inflow
vs. AMO



A decision support tool for long-term planning

Let t_1 = years since last shift; t_2 = years until the next shift
We now compute the conditional probability for t_2 given t_1



Climate Indices on WWW (ESRL)

CLIMATE INDICES PLOTTING PAGE	
<p>PNA WPI NAO EPO NAO (Jones) NP NOI PDO</p>	
<p>Atmosphere:</p> <p>QBO Global Angular Momentum SOI AAO AO MJO</p>	
<p>Precipitation:</p> <p>Indian Monsoon Sahel SW Monsoon ESPI Brazil</p>	
<p>ENSO:</p> <p>MEI Nino 1+2 Nino 3 Nino 3.4 Nino 4 BEST Tropical Pacific EOF</p>	
<p>SST:Pacific</p> <p>ONI Nino 1+2 Nino 3 Nino 3.4 Nino 4 TNI WHWP Pacific Warm Pool Tropical Pacific EOF</p>	
<p>SST:Atlantic</p> <p>TNA TSA Atlantic Tripole WHWP Atlantic Multi-decadal Oscillation Atlantic Meridional Mode North Tropical Atlantic Index (NTA) Caribbean Index (CAR)</p>	
<p>Other:</p> <p>Global Mean Lan/Ocean Temperature Solar Flux Trend Hurricane Activity</p>	

Climate Indices: Monthly Atmospheric and Ocean Time Series	
<p>Atlantic multidecadal Oscillation Long Version</p>	<p>AMO, smoothed</p> <p>Note: this index is newly computed from a new dataset. Please use it and note that it supersedes the old indices. The data is calculated from the Kalplan SST. See the AMO webpage for more details.</p> <p>Enfield, D.B., A. M. Mestas-Nunez and P.J. Trimble, 2001: The Atlantic multidecadal oscillation and it's relation to rainfall and river flows in the continental U.S.. Geophysic Research Letters, Vol. 28, 2077-2080.</p>
TNA	<p>Tropical Northern Atlantic Index* Anomaly of the average of the monthly SST from 5.5N to 23.5N and 15W to 57.5W. GISST and NOAA OI 1x1 datasets are used to cre index. Climatology is 1951-2000.</p> <p>Enfield, D.B., A.M. Mestas, D.A. Mayer, and L. Cid-Serrano, 1999: How ubiquitous is dipole relationship in tropical Atlantic sea surface temperatures? JGR-O, 104, 7841-7848. AOML and PSD</p>
WHWP	<p>Western Hemisphere warm pool* Monthly anomaly of the ocean surface area warm than 28.5°C in the Atlantic and eastern North Pacific. Climatology is 1951-2000.</p> <p>Wang, C., and D.B. Enfield, 2001: The tropical Western Hemisphere warm pool, Geophys. Res. Lett., 28, 1635-1638. AOML and PSD</p>
<p>Atlantic multidecadal Oscillation Long Version</p>	<p>AMO, unsmoothed</p> <p>Note: this index is newly computed from a new dataset. Please use it and note that it supersedes the old indices. The data is calculated from the Kalplan SST. See the AMO webpage for more details.</p> <p>Enfield, D.B., A. M. Mestas-Nunez and P.J. Trimble, 2001: The Atlantic multidecadal oscillation and it's relation to rainfall and river flows in the continental U.S.. Geophysic Research Letters, Vol. 28, 2077-2080.</p>

www.cdc.noaa.gov/ClimateIndices/List/

Summary and Future Vision

- ◆ With its focus on the AWP, AOML climate research is **unique**; it's relevant to society and it's well **aligned with NOAA's strategic goals**.
- ◆ Research methods are varied & robust, using both models and obs, it's **cross-disciplinary** with hurricane research, and **collaborative** with RSMAS.
- ◆ The AOML research is **helping to shape the research agenda** for the next decade ==> on track to achieve improved predictions for summer climate.
- ◆ We are **providing services** to users and we are **engaging with hydrologists** who influence public water policy.
- ◆ **Immediate future**: CLIVAR-VAMOS is expected to begin the IASCLIP program and NOAA CPO will issue AO's for IAS research in FY09; AOML will begin coupled model experiments and research on the interactions of global warming with natural variability.
- ◆ **By 2015**: Models should be improved and prediction methods will be transitioned to operations. This will follow the example set by the NAME program and predictions will be based on BOTH ocean basins.