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Stephen A. Smith

Occupation

1993-present
Executive Director, Southern Alliance for Clean Energy, Knoxville, Tennessee.

1992-1993
Oak Ridge Education Project (OREP), Knoxville, Tennessee, Staff. Addressing environmental and national policy issues surrounding the Oak Ridge Nuclear Reservation, Oak Ridge, Tennessee

Academic

1988-1992
University of Tennessee College of Veterinary Medicine, Knoxville, Tennessee. Doctor of Veterinary Medicine degree.

1983-1988
Kentucky Wesleyan College, Owensboro, Kentucky.
Bachelors of Science degree, Biology Major, Chemistry Minor.

Professional Experience

- Currently serve as Co-Chair United States Climate Action Network
- Currently serve on North Carolina Legislative Commission on Global Climate Change and the North Carolina Climate Action Planning Advisory Group
- Currently serve on TVA'S Green Power Marketing Team
- Currently serve on FPL's Green Power Marketing Advisory Group
- 2000-2005 served on Center for Resource Solutions (CRS) National Board for Green Power Accreditation
- 2000-2004 served two terms on TVA's Regional Resource Stewardship Council.
- 1997-1998 Served on the Tennessee Valley Electric System Advisory Committee for the Secretary of Energy.
- TVERC representative to the Tennessee Valley Authority's Energy Vision 2020 Integrated Resource Plan (IRP) Review Group, May 1994-June 1995
- Testified on the operations of the Tennessee Valley Authority, before U.S. House of Representatives, Committee on Public Works and Transportation, Subcommittee on Investigations and Oversight, March 9, 1994.
- Testified before the Georgia Public Service Commission on Georgia Power's Green Power Program
- Testified before the Florida Public Service Commission on Florida Power and Light's Green Power Program

STATE OF FLORIDA

OFFICE OF THE GOVERNOR
EXECUTIVE ORDER NUMBER 07-127

Establishing Immediate Actions to Reduce Greenhouse Gas Emissions within Florida

WHEREAS, with nearly 1,350 miles of coastline and a majority of citizens living near that coastline, Florida is more vulnerable to rising ocean levels and violent weather than any other state; and

WHEREAS, global climate change is one of the most important issues facing the State of Florida this century; and

WHEREAS, Florida is the second fastest growing state in the union with respect to the annual increase of new greenhouse gas emissions; and

WHEREAS, immediate actions are available and required to reduce emissions of greenhouse gases within Florida; and

WHEREAS, efforts are underway at the national level to begin addressing greenhouse gas emissions; and

WHEREAS, Florida has committed to becoming a leader in reducing emissions of greenhouse gases which are causing changing Earth's climate; and

WHEREAS, Florida, together with international leaders and experts, is hosting the Serve to Conserve Climate Change Summit on July 12 and 13, 2007 in Miami, Florida;

NOW, THEREFORE, I, CHARLIE CRIST, as Governor of Florida, in obedience to my solemn constitutional duty to take care that the laws be faithfully executed, and pursuant to the Constitution and laws of the State of Florida, do hereby promulgate the following Executive Order, to take immediate effect:

Section 1. I hereby establish greenhouse gas emission reduction targets for the State of Florida as follows: by 2017, reduce greenhouse gas emissions to 2000 levels; by 2025, reduce greenhouse gas emissions to 1990 levels; by 2050, reduce greenhouse gas emissions by 80% of 1990 levels.

Section 2. I hereby direct the following actions by members of my Administration in order to produce immediate reductions in greenhouse gas emissions within Florida;

1. The Secretary of Environmental Protection shall immediately develop rules as authorized under Chapter 403, Florida Statutes, to achieve the following:
    - Adoption of a maximum allowable emissions level of greenhouse gases for electric utilities in the State of Florida. The standard will

require at minimum, three reduction milestones as follows: by 2017, emissions not greater than Year 2000 utility sector emissions; by 2025, emissions not greater than Year 1990 utility sector emissions; by 2050, emissions not greater than 20% of Year 1990 utility sector emissions (i.e., 80% reduction of 1990 emissions by 2050);

- Adoption of the California motor vehicle emission standards in Title 13 of the California Code of Regulations, effective January 1, 2005, upon approval by the U.S. Environmental Protection Agency of the pending waiver, which includes emission standards for greenhouse gases, submitted by the California Air Resources Board; and
- Adoption of a statewide diesel engine idle reduction standard.

2. The Secretary of Community Affairs shall immediately:
   - Convene the Florida Building Commission for the purpose of revising the Florida Energy Code for Building Construction to increase the energy performance of new construction in Florida by at least 15% from the 2007 Energy Code. The Commission should consider incorporating standards for appliances and standard lighting in the Florida Energy Code. Target implementation date for the revised Florida Energy Code for Building Construction is January 1, 2009;
   - Initiate rulemaking of the Florida Energy Conservation Standards, Chapter 9B-44, Florida Administrative Code, with an objective to increase the efficiency of applicable consumer products authorized

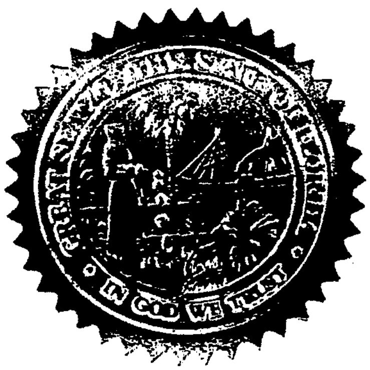
under s. 553.957, Florida Statutes, by 15% from current standards for implementation by July 1, 2009.

Section 3. I hereby request the Florida Public Service Commission to take the following actions for the electric utility sector in order to open the market to clean, renewable energy technologies, thus avoiding future greenhouse gas emissions:

- Not later than September 1, 2007, initiate rulemaking to require that utilities produce at least 20% of their electricity from renewable sources (Renewable Portfolio Standard) with a strong focus on solar and wind energy;
- Not later than September 1, 2007, initiate rulemaking to reduce the cost of connecting solar and other renewable energy technologies to Florida's power grid by adopting the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems as the uniform statewide interconnection standard for all utilities; and
- Not later than September 1, 2007, initiate rulemaking to authorize a uniform, statewide method to enable residential and commercial customers who generate electricity from on-site renewable technologies of up to 1 megawatt in capacity to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity (net metering).

Section 4. All state agencies departments under the direction of the Governor are hereby directed, and all other state agencies are hereby requested, to assist those carrying out the directions in this Executive Order.

IN TESTIMONY WHEREOF, I have hereunto set my hand and have caused the Great Seal of the State of Florida to be affixed at Tallahassee, The Capitol, this 13th day of July, 2007.



GOVERNOR

ATTEST:

SECRETARY OF STATE

Docket No. 07-0467-EI
Title: EO 07-128
Exhibit No. (SS-3
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STATE OF FLORIDA

OFFICE OF THE GOVERNOR
EXECUTIVE ORDER NUMBER 07-128

Establishing the Florida Governor's Action Team on Energy and Climate Change

WHEREAS, Florida has one of the nation's fastest growing populations with an average of 980 new residents arriving per day and approximately 84.6 million visitors per year; and

WHEREAS, as the fourth most populous state, Florida ranks third nationally in total energy consumption; and

WHEREAS, more than 70 percent of Florida's electricity is generated by fossil fuels which contribute to the state's carbon emissions; and

WHEREAS, Florida is encouraging alternative energy generation to promote energy diversity and reduce pollution; and

WHEREAS, with nearly 1,350 miles of coastline and a majority of citizens living near that coastline, Florida is more vulnerable to rising ocean levels and violent weather than any other state; and

WHEREAS, the potential impacts of climate change could significantly impact Florida's businesses, public infrastructure and disturb the way of life enjoyed by millions of Floridians; and

WHEREAS, global climate change is one of the most important issues facing Florida this century; and

WHEREAS, the actions Florida takes to reduce greenhouse gas emissions, in concert with actions taken elsewhere in the United States and the world, could significantly reduce the potential for adverse impacts in Florida; and

WHEREAS, Florida, together with international leaders and experts, is hosting the Serve to Conserve Climate Change Summit on July 12 and 13, 2007 in Miami, Florida;

NOW, THEREFORE, I, CHARLIE CRIST, as Governor of Florida, in obedience to my solemn constitutional duty to take care that the laws be faithfully executed, and pursuant to the Constitution and laws of the State of Florida, do hereby promulgate the following Executive Order, to take immediate effect:

Section 1. I hereby create the Florida Governor's Action Team on Energy and Climate Change to develop a comprehensive Energy and Climate Change Action Plan that will fully achieve or surpass Executive Order targets for statewide greenhouse gas reductions specified in Executive Order 07-127. Action Team members shall be gubernatorial appointees representing diverse expertise and stakeholder interests including, but not limited to, consumers, environment, business, industry, energy, state and local government, and academia. The Action Team shall hold its first meeting within 30 days of appointment.

Section 2. I hereby order the preparation of the Florida Energy and Climate Change Action Plan be guided by an evaluation of the possible consequences to Florida's environment, economy, and society from global climate change. The Florida Energy and Climate Change Action Plan shall include policy recommendations and necessary changes to existing law. The Florida Energy and Climate Change Action Plan shall be completed in two phases.

Phase I: By November 1, 2007, the Action Team shall issue recommendations including any necessary legislative initiatives to address the following:

1. Strategies and mechanisms for the consolidation and coordination of energy policy in Florida;
2. Additional greenhouse gas emission reduction strategies beyond those directed in Executive Order 07-127 , as well as an overall blueprint for development of actions;
3. Policies to enhance energy efficiency and conservation, including statewide targets;
4. Market-based regulatory mechanisms, such as cap and trade programs, for use in efficiently reducing greenhouse gas emissions;

5. Strategies to diversify Florida's electric generation fuels to reduce greenhouse gas emissions and protect Florida's consumers from fuel price volatility;
6. Policies for emission reporting and registry that measure and document emission reductions;
7. Strategies for reducing the greenhouse gas emissions from motor vehicles;
8. Strategies for increasing the amount of renewable transportation fuels and for reducing the carbon content of fuels, such as a low carbon fuel standard;
9. Policies to reduce greenhouse gas emissions from state and local governments not addressed in Executive Order 07-126;
10. Policies to reward early emission reductions in advance of statewide or national greenhouse gas regulatory programs; and
11. Other policies for efficiently reducing emissions in Florida in conjunction with, or independent of regional, national, or international agreements.

Phase II: By October 1, 2008, the Action Team shall issue recommendations including any necessary legislative initiatives to address the following:

1. Adaptation strategies to combat adverse impacts to society, public health, the economy, and natural communities in Florida;
2. Policies to reduce the increases in greenhouse gas emissions from new growth;
3. Carbon capture and storage technologies;

4. Land use and management policies that improve the long-term storage of carbon in Florida's biomass;
5. Strategic investments and public-private partnerships in Florida to spur economic development around climate-friendly industries and economic activity that reduces emissions in Florida; and
6. Strategies and mechanisms for the long-term coordination of Florida's public policy in the areas of economic development, university-based research and technology development, energy, environmental protection, natural resource management, growth management, transportation, and other areas as needed to assure a future of prosperity for Floridians in reducing greenhouse gas emissions.

Section 3. The Secretary of the Department of Environmental Protection shall direct the professional staffing and assistance required by the Action Team in completing the Florida Energy and Climate Action Plan. The Department of Environmental Protection, the Department of Community Affairs, and the Department of Transportation shall provide staff and consultants, as required by the Secretary of the Department of Environmental Protection. The Public Service Commission and the Fish and Wildlife Conservation Commission are requested to provide assistance as required by the Secretary of the Department of Environmental Protection.

Section 4. Action Team members shall not be compensated for their services or reimbursed for travel or per diem expenses. Public officers and employees shall be reimbursed by their respective agencies in accordance with chapter 112, Florida Statutes.

Section 5. Public access to records generated by the Action Team and any technical advisory committees deemed necessary in furtherance of this order shall be governed by the Public Records Laws of Chapter 119, Florida Statutes. All meetings of the Action Team shall be governed by the Open Meetings Laws of Chapter 286, Florida Statutes.

Section 6. The Department of Environmental Protection shall provide administrative support necessary to implement the provisions of this Executive Order. All state agencies under the direction of the Governor are hereby directed, and all other state agencies are hereby requested to assist those carrying out the directions in this Executive Order.

IN TESTIMONY WHEREOF, I have hereunto set my hand and have caused the Great Seal of the State of Florida to be affixed at Miami this 13th day of July, 2007.

GOVERNOR

ATTEST:

SECRETARY OF STATE

Specific Authority 455.271(6)(b) FS. Law Implemented 455.271(6)(b) FS. History–New ________.

DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION

Florida Real Estate Commission

RULE NO.:	RULE TITLE:
61J2-14.008	Definitions

PURPOSE AND EFFECT: To clarify the Division's lack of jurisdiction over escrow funds placed with a title company or attorney and to discuss the definition of "Deposit" within the same rule.

SUBJECT AREA TO BE ADDRESSED: Definition of "Deposit" and escrow funds held by a title company or attorney.

SPECIFIC AUTHORITY: 475.05, 475.25(1)(k) FS.

LAW IMPLEMENTED: 475.25(1)(k) FS.

A RULE DEVELOPMENT WORKSHOP WILL BE HELD AT THE DATE, TIME AND PLACE SHOWN BELOW:

DATE AND TIME: August 14, 2007, 8:30 a.m. or as soon thereafter as possible

PLACE: Division of Real Estate, Commission Meeting Room 901, North Tower, 400 West Robinson Street, Orlando, Florida 32801

THE PERSON TO BE CONTACTED REGADING THE PROPOSED RULE DEVELOPMENT FOR A COPY OF THE PRELIMINARY DRAFT, IF AVAILABLE IS: Lori Crawford, Deputy Clerk, Division of Real Estate, 400 West Robinson Street, Hurston Building, North Tower, Suite 801n, Orlando, Florida 32801

THE PRELIMINARY TEXT OF THE PROPOSED RULE DEVELOPMENT IS NOT AVAILABLE.

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Notices for the Department of Environmental Protection between December 28, 2001 and June 30, 2006, go to http://www.dep.state.fl.us/ under the link or button titled "Official Notices."

DEPARTMENT OF ENVIRONMENTAL PROTECTION

RULE NO.:	RULE TITLE:
62-285.300	Electric Utility Greenhouse Gas Reduction Program

PURPOSE AND EFFECT: The department is initiating rulemaking to cap greenhouse gas emissions from the electric utility sector such that by 2017, statewide utility sector emissions not exceed year 2000 levels; by 2025, emissions not exceed 1990 levels; and by 2050, emissions not exceed 20 percent of 1990 levels. The department proposes to create new rule Chapter 62-285, F.A.C., Greenhouse Gas Emissions Reduction, and develop new Rule 62-285.300, F.A.C., Electric Utility Greenhouse Gas Reduction Program, to accomplish this purpose. The effect of the rule would be to reduce greenhouse gas emissions from electric generating units. The department will not be offering any rule proposals at the August 22 workshop. The purpose of this first workshop is to provide an opportunity for interested persons to provide comments and recommendations to the department at the outset of the proposed rule development project. Written comments may be submitted to the contact person listed below.

SUBJECT AREA TO BE ADDRESSED: Pollution abatement from electric generating units.

SPECIFIC AUTHORITY: 403.061, 403.087 FS.

LAW IMPLEMENTED: 403.031, 403.061, 403.087 FS.

A RULE DEVELOPMENT WORKSHOP WILL BE HELD AT THE DATE, TIME AND PLACE SHOWN BELOW:

DATE AND TIME: August 22, 2007, 9:00 a.m.

PLACE: Department of Environmental Protection, Carr Building, Room 170, 3800 Commonwealth Blvd., Tallahassee, Florida

Pursuant to the provisions of the Americans with Disabilities Act, any person requiring special accommodations to participate in this workshop/meeting is asked to advise the agency at least 48 hours before the workshop/meeting by contacting: Ms. Lynn Scearce, (850)921-9551. If you are hearing or speech impaired, please contact the agency using the Florida Relay Service, (800)955-8771 (TDD) or (800)955-8770 (Voice).

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE DEVELOPMENT AND A COPY OF THE PRELIMINARY DRAFT, IF AVAILABLE, IS: Mr. Larry George at the Florida Department of Environmental Protection, Division of Air Resource Management, 2600 Blair Stone Road, MS 5500, Tallahassee, Florida 32399-2400, or larry.george@dep.state.fl.us, phone (850)921-9555

THE PRELIMINARY TEXT OF THE PROPOSED RULE DEVELOPMENT IS NOT AVAILABLE.

DEPARTMENT OF ENVIRONMENTAL PROTECTION

RULE NO.:	RULE TITLE:
62-285.400	Adoption of California Motor Vehicle Emissions Standards

PURPOSE AND EFFECT: The department is initiating rulemaking to adopt the California emissions standards for new motor vehicles pursuant to section 177 of the federal Clean Air Act. The department proposes to create new rule Chapter 62-285, F.A.C., Greenhouse Gas Emissions Reduction, and develop new rule Rule 62-285.400, F.A.C., Adoption of California Motor Vehicle Emissions Standards, to accomplish this purpose. The effect of the rule would be to require that new motor vehicles sold in the state meet the California emissions standards. The department will not be offering any rule proposals at the August 23 workshop. The purpose of this first workshop is to provide an opportunity for interested persons to provide comments and recommendations to the department at the outset of the proposed rule development project. Written

Docket No. 07-0467-EI
Title: DEP Workshop
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Electric Utility Greenhouse Gas Emissions Reduction

Initial Rule Development Workshop

August 22, 2007

Department of Environmental Protection
Division of Air Resource Management

Governor's Executive Order 07-127

"The Secretary of Environmental Protection shall immediately develop rules as authorized under Chapter 403, Florida Statutes, to achieve the following:

Adoption of a maximum allowable emissions level of greenhouse gases for electric utilities in the State of Florida. The standard will require at minimum three reduction milestones as follows: by 2017, emissions not greater than Year 2000 utility sector emissions; by 2025, emissions not greater than Year 1990 utility sector emissions; by 2050, emissions not greater than 20% of Year 1990 utility sector emissions (i.e., 80% reduction of 1990 emissions by 2050)"

Year 2000 & Year 1990 Utility Greenhouse Gas Emissions

First estimates:

- Year 2000: 135,080,858 tons CO_2
- Year 1990: 100,109,860 tons CO_2

Year 2000 value from eGrid (Emissions & Generation Resource Integrated Database) developed by EPA, Office of Atmospheric Programs, Climate Protection Partnerships Division. http://www.epa.gov/cleanenergy/egrid/index.htm

Year 1990 data estimated by applying ratio of 1990/2000 utility emissions from EPA State Inventory Tool to Year 2000 value.

Year 2004 Utility Greenhouse Gas Emissions

Coal	65,484,849 tons CO_2
Oil & petcoke	33,404,545 tons CO_2
Natural gas	44,846,881 tons CO_2
➢ Total fossil fuel	143,736,276 tons CO_2

All emissions data from eGrid. Does not include 1,265,244 tons CO_2 emissions from burning of non-biogenic solid waste such as plastics and tires in waste-to-energy facilities.

Fossil-fuel electricity generation accounts for about 45% of Florida's greenhouse gas emissions

Required Utility Greenhouse Gas Reductions from Year 2004 Levels

- By 2017 6%
- By 2025 30%
- By 2050 86%

- But, electric power usage in the state is growing…

Year 2004 Net Generation by Source

- Fossil-fuel generation
  - Coal 61,982,540 MWh
  - Oil & petcoke 37,232,873 MWh
  - Natural gas 76,624,773 MWh
  - Interchange power 18,649,000 MWh
  - Subtotal 194,489,186 MWh (83% of grand total)
- Other generation
  - Biomass 4,950,744 MWh
  - Nuclear 31,215,576 MWh
  - Hydroelectric 265,258 MWh
  - Other waste & phosphate* 2,862,650 MWh
- Grand Total **233,783,414 MWh**

Interchange data from Florida Reliability Coordinating Council; all other data from eGrid. eGrid assigns 70% of generation from solid waste to biomass; 30% to other waste (plastics, tires, etc.).
*Includes waste heat cogeneration in phosphate industry.

Projected Electricity Usage

Year 2016: 325,566,000 MWh

- Equates to 33% increase from actual 2006 net generation—same rate of increase as from 1996 to 2006

Year 2016 projection from "2007 Regional Load and Resource Plan" by Florida Reliability Coordinating Council, available on Public Service Commission website at: www.psc.state.fl.us/utilities/electricgas/10yearsiteplans.aspx.

No Year 2017, 2025 or 2050 projections available.

FLORIDA

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Year 2004 Average CO_2 Emission Rates for Florida Fossil-Fuel Units

Coal	2,113 lb/MWh
Oil & petcoke	1,794 lb/MWh
Natural gas	1,171 lb/MWh

- Weighted avg. 1,635 lb/MWh

CO_2 Emission Rates for Fossil-Fuel Generating Units Compared

- Year 2004 statewide average emission rate:
  1,635 lb/MWh

- Statewide average emission rate to meet 135 million ton cap with total generation of 325 million MWh, 83% of which supplied by fossil fuel (values selected for illustrative purposes; not a DEP-presumed scenario)
  1,000 lb/MWh

- Emission rates achievable by today's new units:
  - Natural gas combined cycle — 800 lb/MWh
  - Pulverized coal or IGCC (w/o carbon capture & storage) — 1,750 lb/MWh

Challenges in Meeting the Caps

- Slowing the state's growth in electricity usage
- Increasing generation from proven non-fossil sources
- Reducing statewide average fossil fuel emission rate
- Developing and deploying advanced technologies

FLORIDA

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Title: DEP Workshop
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Initial Rule Development Issues

- Definition of electric utility sector
- Nailing down Year 2000 and Year 1990 utility sector emission levels
- How to treat out-of-state interchange power
- Possible rule approaches

FLORIDA

Comments

- Mail to:
  Mr. Larry George, Program Administrator
  Division of Air Resource Management, MS-5500
  Department of Environmental Protection
  2600 Blair Stone Rd.
  Tallahassee, FL 32399-2400

  cc: Ms. Lynn Scearce, Rules Coordinator (same address)

- Or e-mail to: larry.george@dep.state.fl.us and lynn.scearce@dep.state.fl.us

- All comments are public records and will be posted on the department's website at www.dep.state.fl.us/air

- To receive updates on this rule development project by e-mail, provide name, affiliation, and e-mail address to Ms. Lynn Scearce at lynn.scearce@dep.state.fl.us

The map on the following page is from J.G.Titus and C.Richman, 2000, "Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations Along the U.S. Atlantic and Gulf Coasts." *Climate Research* (in press).

SUGGESTED CAVEATS

Research Papers: *"This map is based on modeled elevations, not actual surveys or the precise data necessary to estimate elevations at specific locations. The map is a fair graphical representation of the total amount of land below the 1.5- and 3.5-meter contours; but the elevations indicated at particular locations may be wrong. Those interested in the elevations of specific locations should consult a topographic map. Although the map illustrates elevations, it does not necessarily show the location of future shorelines. Coastal protection efforts may prevent some low-lying areas from being flooded as sea level rises; and shoreline erosion and the accretion of sediment may cause the actual shoreline to differ from what one would expect based solely on the inundation of low land. This map illustrates the land within 1.5 and 3.5 meters of the National Geodetic Vertical Datum of 1929, a benchmark that was roughly mean sea level in the year 1929 but approximately 20 cm* [or fill in local estimate] *below today's sea level."*

Publications for the General Public: If possible, the aforementioned caveat should be printed; but sometimes space constraints will make that impossible. We recommend that as much of the following be included as possible: *"Elevations based on computer models, not actual surveys. Coastal protection efforts may prevent some low-lying areas from being flooded as sea level rises. The 1.5-meter contour depicted is currently about 1.3-meters* [use local estimate if possible] *above mean sea level, and is typically 90 cm* [use local estimate if possible] *above mean high tide. Parts of the area depicted in red will be above mean sea level for at least 100 years and probably 200 years* [use local estimates if possible]. *The 3.5-meter contour illustrates the area that might be flooded over a period of several centuries."*

Newspapers and Magazines: The amount of space available for a caption is typically even less in a newspaper or wide-circulation magazine. We must simply recognize that those publications are unlikely to explain the difference between elevation and land lost due to sea level rise, let alone the potential errors. Fortunately, however, magazines and newspapers tend to publish such small maps that the scale will probably be an order of magnitude smaller than what we offer here, which substantially reduces the need for a caveat. The January 1, 2000 edition of *The New York Times* published a few of our maps after this article was accepted for publication. We found their caveat to be acceptable. With minor edits, that caveat read: "*Regions shown in black are some of the areas that could be flooded at high tide if global warming causes sea level to rise 2 feet in the next 100 years. The indicated areas account not only for the effects of global warming, but also for other effects such as tidal variations and land subsidence.*"

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Title: CO_2 Impacts
Exhibit No. (SS-6)
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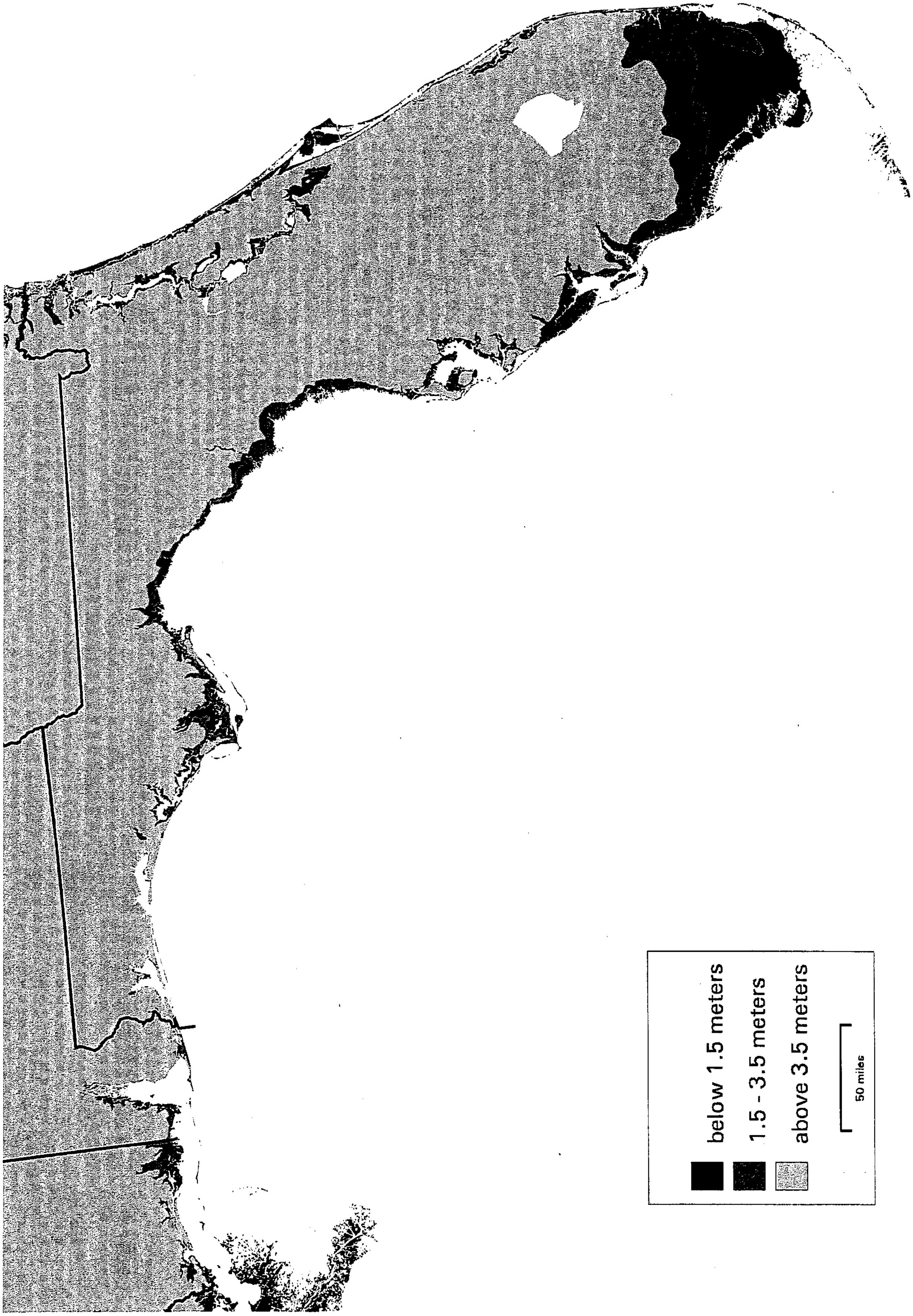

nature Vol 436|4 August 2005|doi:10.1038/nature03906

Docket No. 07-0467-EI
Title: CO2 Hurricane Study
Exhibit No. (SS-7)
Page 1 of 3

LETTERS

Increasing destructiveness of tropical cyclones over the past 30 years

Kerry Emanuel[1]

Theory[1] and modelling[2] predict that hurricane intensity should increase with increasing global mean temperatures, but work on the detection of trends in hurricane activity has focused mostly on their frequency[3,4] and shows no trend. Here I define an index of the potential destructiveness of hurricanes based on the total dissipation of power, integrated over the lifetime of the cyclone, and show that this index has increased markedly since the mid-1970s. This trend is due to both longer storm lifetimes and greater storm intensities. I find that the record of net hurricane power dissipation is highly correlated with tropical sea surface temperature, reflecting well-documented climate signals, including multidecadal oscillations in the North Atlantic and North Pacific, and global warming. My results suggest that future warming may lead to an upward trend in tropical cyclone destructive potential, and—taking into account an increasing coastal population—a substantial increase in hurricane-related losses in the twenty-first century.

Fluctuations in tropical cyclone activity are of obvious importance to society, especially as populations of afflicted areas increase[5]. Tropical cyclones account for a significant fraction of damage, injury and loss of life from natural hazards and are the costliest natural catastrophes in the US[6]. In addition, recent work suggests that global tropical cyclone activity may play an important role in driving the oceans' thermohaline circulation, which has an important influence on regional and global climate[7].

Studies of tropical cyclone variability in the North Atlantic reveal large interannual and interdecadal swings in storm frequency that have been linked to such regional climate phenomena as the El Niño/Southern Oscillation[8], the stratospheric quasi-biennial oscillation[9], and multi-decadal oscillations in the North Atlantic region[10]. Variability in other ocean basins is less well documented, perhaps because the historical record is less complete.

Concerns about the possible effects of global warming on tropical cyclone activity have motivated a number of theoretical, modelling and empirical studies. Basic theory[11] establishes a quantitative upper bound on hurricane intensity, as measured by maximum surface wind speed, and empirical studies show that when accumulated over large enough samples, the statistics of hurricane intensity are strongly controlled by this theoretical potential intensity[12]. Global climate models show a substantial increase in potential intensity with anthropogenic global warming, leading to the prediction that actual storm intensity should increase with time[1]. This prediction has been echoed in climate change assessments[13]. A recent comprehensive study using a detailed numerical hurricane model run using climate predictions from a variety of different global climate models[2] supports the theoretical predictions regarding changes in storm intensity. With the observed warming of the tropics of around 0.5 °C, however, the predicted changes are too small to have been observed, given limitations on tropical cyclone intensity estimation.

The issue of climatic control of tropical storm frequency is far more controversial, with little guidance from existing theory. Global climate model predictions of the influence of global warming on storm frequency are highly inconsistent, and there is no detectable trend in the global annual frequency of tropical cyclones in historical tropical cyclone data.

Although the frequency of tropical cyclones is an important scientific issue, it is not by itself an optimal measure of tropical cyclone threat. The actual monetary loss in windstorms rises roughly as the cube of the wind speed[14] as does the total power dissipation (PD; ref. 15), which, integrated over the surface area affected by a storm and over its lifetime is given by:

$$PD = 2\pi \int_0^{\tau} \int_0^{r_0} C_D \rho |\mathbf{V}|^3 r \, dr \, dt \qquad (1)$$

where C_D is the surface drag coefficient, ρ is the surface air density, $|\mathbf{V}|$ is the magnitude of the surface wind, and the integral is over radius to an outer storm limit given by r_0 and over τ, the lifetime of the storm. The quantity PD has the units of energy and reflects the total power dissipated by a storm over its life. Unfortunately, the area integral in equation (1) is difficult to evaluate using historical data sets, which seldom report storm dimensions. On the other hand, detailed studies show that radial profiles of wind speed are generally geometrically similar[16] whereas the peak wind speeds exhibit little if any correlation with measures of storm dimensions[17]. Thus variations in storm size would appear to introduce random errors in an evaluation of equation (1) that assumes fixed storm dimensions. In the integrand of equation (1), the surface air density varies over roughly 15%, while the drag coefficient is thought to increase over roughly a factor of two with wind speed, but levelling off at wind speeds in excess of about 30 m s^{-1} (ref. 18). As the integral in equation (1) will, in practice, be dominated by high wind speeds, we approximate the product $C_D \rho$ as a constant and define a simplified power dissipation index as:

$$PDI \equiv \int_0^{\tau} V_{max}^3 \, dt \qquad (2)$$

where V_{max} is the maximum sustained wind speed at the conventional measurement altitude of 10 m. Although not a perfect measure of net power dissipation, this index is a better indicator of tropical cyclone threat than storm frequency or intensity alone. Also, the total power dissipation is of direct interest from the point of view of tropical cyclone contributions to upper ocean mixing and the thermohaline circulation[7]. This index is similar to the 'accumulated cyclone energy' (ACE) index[19], defined as the sum of the squares of the maximum wind speed over the period containing hurricane-force winds.

The analysis technique, data sources, and corrections to the raw data are described in the Methods section and in Supplementary Methods. To emphasize long-term trends and interdecadal variability, the PDI is accumulated over an entire year and, individually, over

[1]Program in Atmospheres, Oceans, and Climate, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA.

each of several major cyclone-prone regions. To minimize the effect of interannual variability, we apply to the time series of annual PDI a 1-2-1 smoother defined by:

$$x_i^0 = 0.25(x_{i-1} + x_{i+1}) + 0.5x_i \qquad (3)$$

where x_i is the value of the variable in year i and x_i^0 is the smoothed value. This filter is generally applied twice in succession.

Figure 1 shows the PDI for the North Atlantic and the September mean tropical sea surface temperature (SST) averaged over one of the prime genesis regions in the North Atlantic[20]. There is an obvious strong relationship between the two time series ($r^2 = 0.65$), suggesting that tropical SST exerts a strong control on the power dissipation index. The Atlantic multi-decadal mode discussed in ref. 10 is evident in the SST series, as well as shorter period oscillations possibly related to the El Niño/Southern Oscillation and the North Atlantic Oscillation. But the large upswing in the last decade is unprecedented, and probably reflects the effect of global warming. We will return to this subject below.

Figure 2 shows the annually accumulated, smoothed PDI for the western North Pacific, together with July–November average smoothed SST in a primary genesis region for the North Pacific. As in the Atlantic, these are strongly correlated, with an r^2 of 0.63. Some of the interdecadal variability is associated with the El Niño/Southern Oscillation, as documented by Camargo and Sobel[19]. The SST time series shows that the upswing in SST since around 1975 is unusual by the standard of the past 70 yr.

There are reasons to believe that global tropical SST trends may have less effect on tropical cyclones than regional fluctuations, as tropical cyclone potential intensity is sensitive to the difference between SST and average tropospheric temperature. In an effort to quantify a global signal, annual average smoothed SST between 30°N and 30°S is compared to the sum of the North Atlantic and western North Pacific smoothed PDI values in Fig. 3. The two time series are correlated with an r^2 of 0.69. The upturn in tropical mean surface temperature since 1975 has been generally ascribed to global warming, suggesting that the upward trend in tropical cyclone PDI values is at least partially anthropogenic. It is interesting that this trend has involved more than a doubling of North Atlantic plus western North Pacific PDI over the past 30 yr.

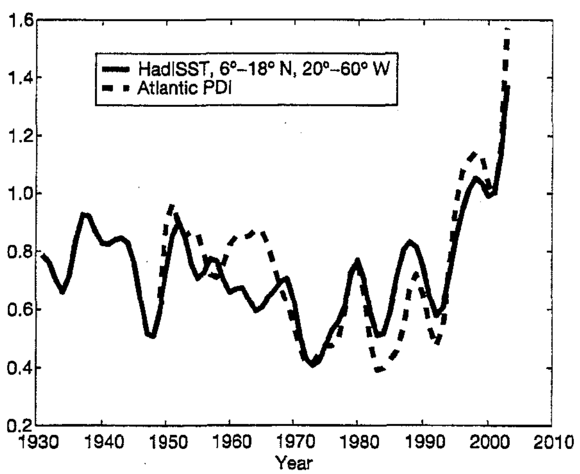

Figure 1 | A measure of the total power dissipated annually by tropical cyclones in the North Atlantic (the power dissipation index, PDI) compared to September sea surface temperature (SST). The PDI has been multiplied by 2.1×10^{-12} and the SST, obtained from the Hadley Centre Sea Ice and SST data set (HadISST)[22], is averaged over a box bounded in latitude by 6°N and 18°N, and in longitude by 20°W and 60°W. Both quantities have been smoothed twice using equation (3), and a constant offset has been added to the temperature data for ease of comparison. Note that total Atlantic hurricane power dissipation has more than doubled in the past 30 yr.

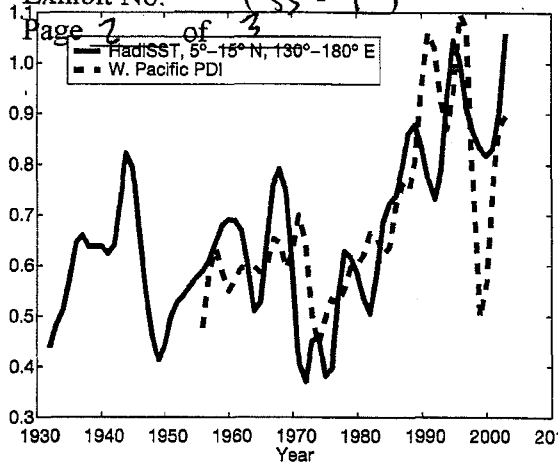

Figure 2 | Annually accumulated PDI for the western North Pacific, compared to July–November average SST. The PDI has been multiplied by a factor of 8.3×10^{-13} and the HadISST (with a constant offset) is averaged over a box bounded in latitude by 5°N and 15°N, and in longitude by 130°E and 180°E. Both quantities have been smoothed twice using equation (3). Power dissipation by western North Pacific tropical cyclones has increased by about 75% in the past 30 yr.

The large increase in power dissipation over the past 30 yr or so may be because storms have become more intense, on the average, and/or have survived at high intensity for longer periods of time. The accumulated annual duration of storms in the North Atlantic and western North Pacific has indeed increased by roughly 60% since 1949, though this may partially reflect changes in reporting practices, as discussed in Methods. The annual average storm peak wind speed summed over the North Atlantic and eastern and western North Pacific has also increased during this period, by about 50%. Thus both duration and peak intensity trends are contributing to the overall increase in net power dissipation. For fixed rates of intensification and dissipation, storms will take longer to reach greater peak winds, and also take longer to dissipate. Thus, not surprisingly, stronger storms last longer; times series of duration and peak intensity are correlated with an r^2 of 0.74.

In theory, the peak wind speed of tropical cyclones should increase

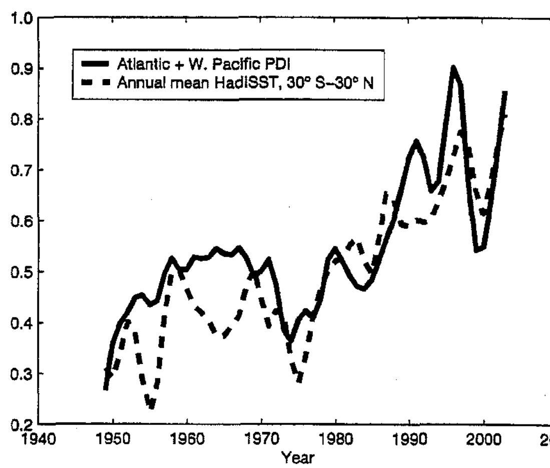

Figure 3 | Annually accumulated PDI for the western North Pacific and North Atlantic, compared to annually averaged SST. The PDI has been multiplied by a factor of 5.8×10^{-13} and the HadISST (with a constant offset) is averaged between 30°S and 30°N. Both quantities have been smoothed twice using equation (3). This combined PDI has nearly doubled over the past 30 yr.

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by about 5% for every 1 °C increase in tropical ocean temperature. Given that the observed increase has only been about 0.5 °C, these peak winds should have only increased by 2–3%, and the power dissipation therefore by 6–9%. When coupled with the expected increase in storm lifetime, one might expect a total increase of PDI of around 8–12%, far short of the observed change.

Tropical cyclones do not respond directly to SST, however, and the appropriate measure of their thermodynamic environment is the potential intensity, which depends not only on surface temperature but on the whole temperature profile of the troposphere. I used daily averaged re-analysis data and Hadley Centre SST to re-construct the potential maximum wind speed, and then averaged the result over each calendar year and over the same tropical areas used to calculate the average SST. In both the Atlantic and western North Pacific, the time series of potential intensity closely follows the SST, but increases by about 10% over the period of record, rather than the predicted 2–3%. Close examination of the re-analysis data shows that the observed atmospheric temperature does not keep pace with SST. This has the effect of increasing the potential intensity. Given the observed increase of about 10%, the expected increase of PDI is about 40%, taking into account the increased duration of events. This is still short of the observed increase.

The above discussion suggests that only part of the observed increase in tropical cyclone power dissipation is directly due to increased SSTs; the rest can only be explained by changes in other factors known to influence hurricane intensity, such as vertical wind shear. Analysis of the 250–850 hPa wind shear from reanalysis data, over the same portion of the North Atlantic used to construct Fig. 1, indeed shows a downward trend of 0.3 m s^{-1} per decade over the period 1949–2003, but most of this decrease occurred before 1970, and at any rate the decrease is too small to have had much effect. Tropical cyclone intensity also depends on the temperature distribution of the upper ocean, and there is some indication that sub-surface temperatures have also been increasing[21], thereby reducing the negative feedback from storm-induced mixing.

Whatever the cause, the near doubling of power dissipation over the period of record should be a matter of some concern, as it is a measure of the destructive potential of tropical cyclones. Moreover, if upper ocean mixing by tropical cyclones is an important contributor to the thermohaline circulation, as hypothesized by the author[7], then global warming should result in an increase in the circulation and therefore an increase in oceanic enthalpy transport from the tropics to higher latitudes.

METHODS

Positions and maximum sustained surface winds of tropical cyclones are reported every six hours as part of the 'best track' tropical data sets. (In the data sets used here, from the US Navy's Joint Typhoon Warning Center (JTWC) and the National Oceanographic and Atmospheric Administration's National Hurricane Center (NHC), 'maximum sustained wind' is defined as the one-minute average wind speed at an altitude of 10 m.) For the Atlantic, and eastern and central North Pacific, these data are available from the NHC, while for the western North Pacific, the northern Indian Ocean, and all of the Southern Hemisphere, data from JTWC were used.

Owing to changes in measuring and reporting practices since systematic observations of tropical cyclones began in the mid-1940s, there are systematic biases in reported tropical cyclone wind speeds that must be accounted for in analysing trends. The sources of these biases and corrections made to account for them are described in Supplementary Methods.

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Supplementary Information is linked to the online version of the paper at www.nature.com/nature.

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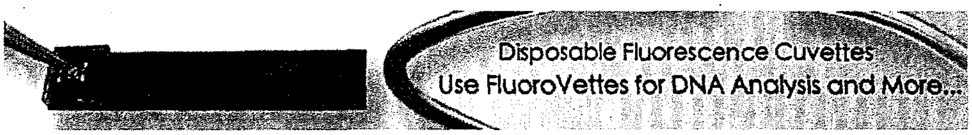

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REPORTS

Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment

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We examined the number of tropical cyclones and cyclone days as well as tropical cyclone intensity over the past 35 years, in an environment of increasing sea surface temperature. A large increase was seen in the number and proportion of hurricanes reaching categories 4 and 5. The largest increase occurred in the North Pacific, Indian, and Southwest Pacific Oceans, and the smallest percentage increase occurred in the North Atlantic Ocean. These increases have taken place while the number of cyclones and cyclone days has decreased in all basins except the North Atlantic during the past decade.

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During the hurricane season of 2004, there were 14 named storms in the North Atlantic, of which 9 achieved hurricane intensity. Four of these hurricanes struck the southeast United States in rapid succession, causing considerable damage and disruption. Analysis of hurricane characteristics in the North Atlantic (1, 2) has shown an increase in hurricane frequency and intensity since 1995. Recently, a causal relationship between increasing hurricane frequency and intensity and increasing sea surface temperature (SST) has been posited (3), assuming an acceleration of the hydrological cycle arising from the nonlinear relation between saturation vapor pressure and temperature (4). The issue of attribution of increased hurricane frequency to increasing SST has resulted in a vigorous debate in the press and in academic circles (5).

Numerous studies have addressed the issue of changes in the global frequency and intensity of hurricanes in the warming world. Our basic conceptual understanding of hurricanes suggests that there could be a relationship between hurricane activity and SST. It is well established that SST > 26°C is a requirement for tropical cyclone formation in the current climate (6, 7). There is also a hypothesized relationship between SST and the maximum potential hurricane intensity (8, 9). However, strong interannual variability in hurricane statistics (10-14) and the possible influence of interannual variability associated with El Niño and the North Atlantic Oscillation (11, 12) make it difficult to discern any trend relative to background SST increases with statistical veracity (8). Factors other than SST have been cited for their role in regulating hurricane characteristics, including vertical shear and mid-tropospheric moisture (15). Global modeling results for doubled CO_2 scenarios are contradictory (15-20), with simulations showing a lack of consistency in projecting an increase or decrease in the total number of hurricanes, although most simulations project an increase in hurricane intensity.

Tropical ocean SSTs increased by approximately 0.5°C between 1970 and 2004 (21). Figure 1 shows the SST trends for the tropical cyclone season in each ocean basin. If the Kendall trend analysis is used, trends in each of the ocean basins are significantly different from zero at the 95% confidence level or higher, except for the southwest Pacific Ocean. Here we examine the variations in hurricane characteristics for each ocean basin in the context of the basin SST variations. To this end, we conducted a comprehensive analysis of global tropical cyclone statistics for the satellite era (1970-2004). In each tropical ocean basin, we examined the numbers of tropical storms and hurricanes, the number of storm days, and the hurricane intensity distribution. The tropical cyclone data are derived from the best track archives of the Joint Typhoon Warning Center and of international warning centers, including special compilations and quality control (22).

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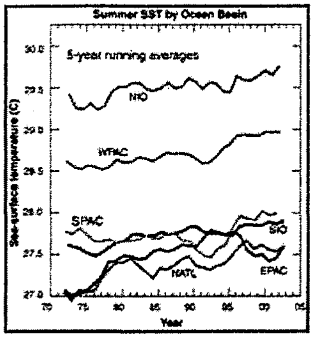

Fig. 1. Running 5-year mean of SST during the respective hurricane seasons for the principal ocean basins in which hurricanes occur: the North Atlantic Ocean (NATL: 90° to 20°E, 5° to 25°N, June–October), the Western Pacific Ocean (WPAC: 120° to 180°E, 5° to 20°N, May–December), the East Pacific Ocean (EPAC: 90° to 120°W, 5° to 20°N, June–October), the Southwest Pacific Ocean (SPAC: 155° to 180°E, 5° to 20°S, December–April), the North Indian Ocean (NIO: 55° to 90°E, 5° to 20°N, April–May and September–November), and the South Indian Ocean (SIO: 50° to 115°E, 5° to 20°S, November–April). [View Larger Version of this Image (28K GIF file)]

Tropical cyclonic systems attaining surface wind speeds between 18 and 33 m s^{-1} are referred to as tropical storms. Although storms of intensity >33 m s^{-1} have different regional names, we will refer to these storms as hurricanes for simplicity. Hurricanes in categories 1 to 5, according to the Saffir-Simpson scale (23), are defined as storms with wind speeds of 33 to 43 m s^{-1}, 43 to 50 m s^{-1}, 50 to 56 m s^{-1}, 56 to 67 m s^{-1}, and >67 m s^{-1}, respectively. We define the ocean basins that support tropical cyclone development as follows: North Atlantic (90° to 20°W, 5° to 25°N), western North Pacific (120° to 180°E, 5° to 20°N), eastern North Pacific (90° to 120°W, 5° to 20°N), South Indian (50° to 115°E, 5°–20°S), North Indian (55° to 90°E, 5°–20°N), and Southwest Pacific (155° to 180°E, 5° to 20°S). Within these basins, total tropical storm days are defined as the total number of days of systems that only reached tropical storm intensity. Total hurricane days refer to systems that attained hurricane status, including the period when a system was at tropical storm intensity. Total tropical cyclone number or days refers to the sum of the statistics for both tropical storms and hurricanes.

Figure 2 shows the time series for the global number of tropical cyclones and the number of cyclone days for the period 1970–2004, for hurricanes, tropical storms, and all cyclonic storms. None of these time series shows a trend that is statistically different from zero over the period (24). However, there is a substantial decadal-scale oscillation that is especially evident in the number of tropical cyclone days. For example, globally, the annual number of tropical cyclone days reached a peak of 870 days around 1995, decreasing by 25% to 600 days by 2003.

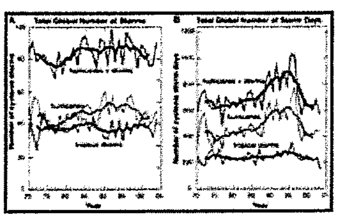

Fig. 2. Global time series for 1970–2004 of (**A**) number of storms and (**B**) number of storm days for tropical cyclones (hurricanes plus tropical storms; black curves), hurricanes (red curves), and tropical storms (blue curves). Contours indicate the year-by-year variability, and the bold curves show the 5-year running average. [View Larger Version of this Image (34K GIF file)]

Figure 3 shows that in each ocean basin time series, the annual frequency an\ d duration of hurricanes exhibit the same temporal characteristics as the global time series (Fig. 2), with overall trends for the 35-year period that are not statistically different from zero. The exception is the North Atlantic Ocean, which possesses an increasing trend in frequency and duration that is significant at the 99% confidence level. The observation that increases in North Atlantic hurricane characteristics have occurred simultaneously with a statistically significant positive trend in SST has led to the speculation that the changes in both fields are the result of global warming (3).

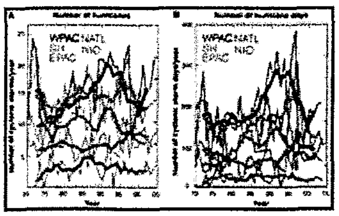

Fig. 3. Regional time series for 1970-2004 for the NATL, WPAC, EPAC, NIO, and Southern Hemisphere (SIO plus SPAC) for (A) total number of hurricanes and (B) total number of hurricane days. Thin lines indicate the year-by-year statistics. Heavy lines show the 5-year running averages. [View Larger Version of this Image (48K GIF file)]

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It is instructive to analyze the relationship between the covariability of SST and hurricane characteristics in two other ocean basins, specifically the eastern and western North Pacific. Decadal variability is particularly evident in the eastern Pacific, where a maximum in the number of storms and the number of storm days in the mid-1980s (19 storms and 150 storm days) has been followed by a general decrease up to the present (15 storms and 100 storm days). This decrease accompanied a rising SST until the 1990-1994 pentad, followed by an SST decrease until the present. In the western North Pacific, where SSTs have risen steadily through the observation period, the number of storms and the number of storm days reach maxima in the mid-1990s before decreasing dramatically over the subsequent 15 years. The greatest change occurs in the number of cyclone days, decreasing by 40% from 1995 to 2003.

In summary, careful analysis of global hurricane data shows that, against a background of increasing SST, no global trend has yet emerged in the number of tropical storms and hurricanes. Only one region, the North Atlantic, shows a statistically significant increase, which commenced in 1995. However, a simple attribution of the increase in numbers of storms to a warming SST environment is not supported, because of the lack of a comparable correlation in other ocean basins where SST is also increasing. The observation that increases in North Atlantic hurricane characteristics have occurred simultaneously with a statistically significant positive trend in SST has led to the speculation that the changes in both fields are the result of global warming (3).

Examination of hurricane intensity (Fig. 4) shows a substantial change in the intensity distribution of hurricanes globally. The number of category 1 hurricanes has remained approximately constant (Fig. 4A) but has decreased monotonically as a percentage of the total number of hurricanes throughout the 35-year period (Fig. 4B). The trend of the sum of hurricane categories 2 and 3 is small also both in number and percentage. In contrast, hurricanes in the strongest categories (4 + 5) have almost doubled in number (50 per pentad in the 1970s to near 90 per pentad during the past decade) and in proportion (from around 20% to around 35% during the same period). These changes occur in all of the ocean basins. A summary of the number and percent of storms by category is given in Table 1, binned for the years 1975-1989 and 1990-2004. This increase in category 4 and 5 hurricanes has not been accompanied by an increase in the actual intensity of the most intense hurricanes: The maximum intensity has remained remarkably static over the past 35 years (solid black curve, Fig. 4A).

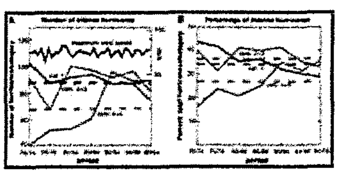

Fig. 4. Intensity of hurricanes according to the Saffir-Simpson scale (categories 1 to 5). (**A**) The total number of category 1 storms (blue curve), the sum of categories 2 and 3 (green), and the sum of categories 4 and 5 (red) in 5-year periods. The bold curve is the maximum hurricane wind speed observed globally (measured in meters per second). The horizontal dashed lines show the 1970-2004 average numbers in each category. (**B**) Same as (A), except for the percent of the total number of hurricanes in each category class. Dashed lines show average percentages in each category over the 1970-2004 period. [View Larger Version of this Image (23K GIF file)]

Table 1. Change in the number and percentage of hurricanes in categories 4 and 5 for the 15-year periods 1975-1989 and 1990-2004 for the different ocean basins.

	Period	
Basin	1975-1989	1990-2004

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	Number	Percentage	Number	Percentage
East Pacific Ocean	36	25	49	35
West Pacific Ocean	85	25	116	41
North Atlantic	16	20	25	25
Southwestern Pacific	10	12	22	28
North Indian	1	8	7	25
South Indian	23	18	50	34

Cyclone intensities around the world are estimated by pattern recognition of satellite features based on the Dvorak scheme (25). The exceptions are the North Atlantic, where there has been continuous aircraft reconnaissance; the eastern North Pacific, which has occasional aircraft reconnaissance; and the western North Pacific, which had aircraft reconnaissance up to the mid-1980s. There have been substantial changes in the manner in which the Dvorak technique has been applied (26). These changes may lead to a trend toward more intense cyclones, but in terms of central pressure (27) and not in terms of maximum winds that are used here. Furthermore, the consistent trends in the North Atlantic and eastern North Pacific, where the Dvorak scheme has been calibrated against aircraft penetrations, give credence to the trends noted here as being independent of the observational and analysis techniques used. In addition, in the Southern Hemisphere and the North Indian Ocean basins, where only satellite data have been used to determine intensity throughout the data period, the same trends are apparent as in the Northern Hemisphere regions.

We deliberately limited this study to the satellite era because of the known biases before this period (28), which means that a comprehensive analysis of longer-period oscillations and trends has not been attempted. There is evidence of a minimum of intense cyclones occurring in the 1970s (11), which could indicate that our observed trend toward more intense cyclones is a reflection of a long-period oscillation. However, the sustained increase over a period of 30 years in the proportion of category 4 and 5 hurricanes indicates that the related oscillation would have to be on a period substantially longer than that observed in previous studies.

We conclude that global data indicate a 30-year trend toward more frequent and intense hurricanes, corroborated by the results of the recent regional assessment (29). This trend is not inconsistent with recent climate model simulations that a doubling of CO_2 may increase the frequency of the most intense cyclones (18, 30), although attribution of the 30-year trends to global warming would require a longer global data record and, especially, a deeper understanding of the role of hurricanes in the general circulation of the atmosphere and ocean, even in the present climate state.

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BILLION DOLLAR CLIMATE AND WEATHER DISASTERS 1980-2005

NOAA's NATIONAL CLIMATIC DATA CE... ASHEVILLE, NORTH CAROLINA

NUMBER OF EVENTS
21 - 25
16 - 20
13 - 15
10 - 12
7 - 9
4 - 6
1 - 3

DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	NORMALIZED DAMAGES (Billions of Dollars)	PERCEN[T] DAMAG[ES]
Tropical Storms/Hurricanes	24	35.8%	308	55.4%
Non-Tropical Floods	12	17.9%	55	9.9%
Heatwaves/Droughts	11	16.4%	145	26.1%
Severe Weather	7	10.4%	13	2.4%
Fires	6	9.0%	13	2.4%
Freezes	2	3.0%	6	1.1%
Blizzards	2	3.0%	9	1.6%
Ice Storms	2	3.0%	5	~0.9%
Noreaster	1	1.5%	2	~0.2%
	67		556	

IMPORTANT NOTE: The national map by state relects a summation of each billion event for each state affected—ie, it does not mean that each state shown suffered at least $1 billion in losses for each event. For example, an event causing $1 billion in overall U.S. damages spread over 5 states, would cause well under $1 billion in damage in each affected state. However, larger multi-billion dollar events would sometimes cause over $1 billion in damages in one or more states.