Integrated analysis of atmospheric water cycle in intense marine storms

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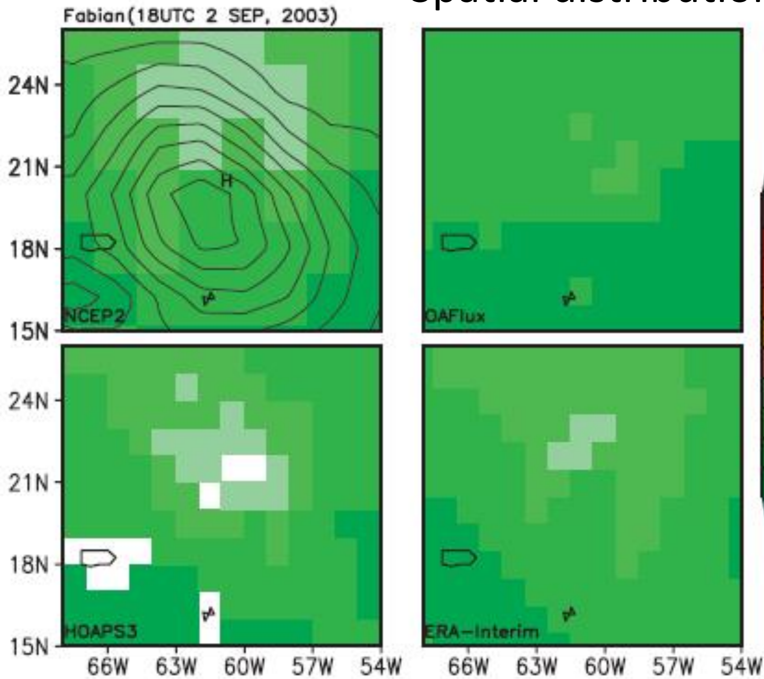
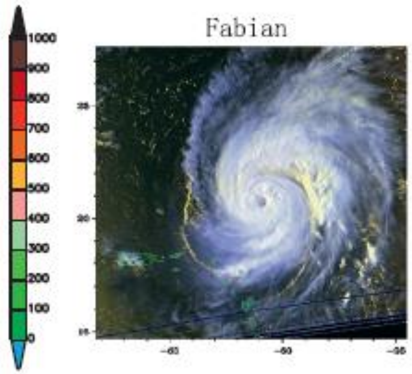
Objective: characterizing and understanding the coupled roles of surface latent heat fluxes, atmospheric latent heating, and precipitation in intense storms that are characterized by high surface wind speeds

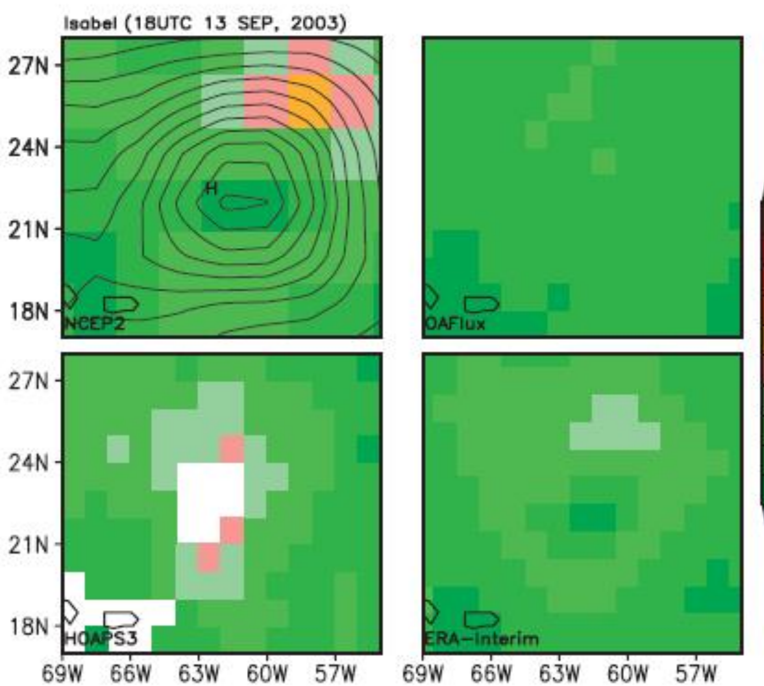
- Question 1: What is the role of the surface evaporative flux and atmospheric latent heating in the life cycle of the integrated kinetic energy, precipitation, and intensification of hurricanes?

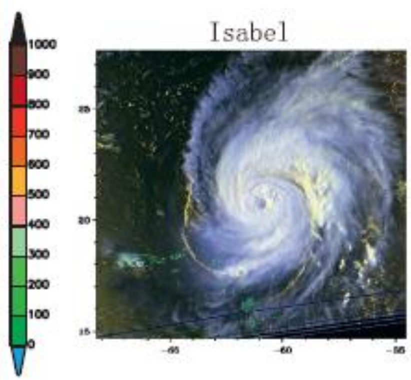
- Question 2: How does the hydrological cycle in the high latitudes of the Southern Ocean influence the interannual variability of Antarctic sea ice?

Spatial distribution of **LHF** (W m^{-2}) for Hurricane Fabian (18 UTC, 2 Sep 2003) and Hurricane Isabel (18 UTC, 13 Sep 2003)









We need a high-resolution satellite-derived ocean surface flux product that better represents hurricane-related air-sea fluxes and is useful for hurricane studies

XSeaFlux

STEP1: Recent new satellite-derived surface and near-surface parameters with improved retrieval methods as input meteorological state variables (SST, U, Qa)

Sea surface temperature

• Operational SST produced by NOAA (Reynolds et al. 2007). XSeaFlux includes a parameterization and additional satellite products to determine the diurnal cycle of SST (Clayson and Weitlich 2007).

Near surface wind

• NCDC blended ocean surface wind speed derived from multiple satellites (Zhang et al. 2006). Wind speed for multiple satellites is obtained from the Remote Sensing Systems for the uniformity of the retrieval algorithms.

Near surface air temperature and specific humidity

• Retrievals of Qa and Ta using SSM/I data. A first-guess SST and a neural network technique, in addition to improvements gained by properly accounting for the effects of high cloud liquid water contents (Roberts et al. 2010).

XSeaFlux

STEP2: Improved bulk flux model that includes careful consideration of the flux transfer at high winds

Impacts of Ocean Wave *Bourassa (2006)*

$$LHF = \rho_a L_v C_E U(Q_s - Q_a)$$

$$\downarrow$$

$$|U - 80\% U_{orb}|$$

$$\downarrow$$

$$U_{orb} = \pi H_s / T_p$$

H_s: significant wave height
T_p: dominant wave period

NOAA NCEP new generation wave model (WAVEWATCH III)

Impacts of Sea Spray *Andreas et al. (2007)*

$$LHF = LHF_i + LHF_s$$

$$\downarrow$$

$$LHF_s = \rho_s L_v \left\{ 1 - \left[\frac{r(\tau_{f,50})}{50\mu m} \right]^3 \right\} V_L(u_*)$$

$\tau_{f,50}$ the approximate residence time for droplets with an initial radius of $50\mu m$

$r(\tau_{f,50})$ the radius these droplets have when they fall back into the sea, and the reiterates the hypothesis that droplets lead the spray latent heat flux

$V_L(u_*) = 1.10 \times 10^{-7} u_*^{2.22}$ wind function

Humidity Exchange over the Sea (HEXOS) experiment and Fronts and Atlantic Storm-Tracks Experiment (FASTEX).

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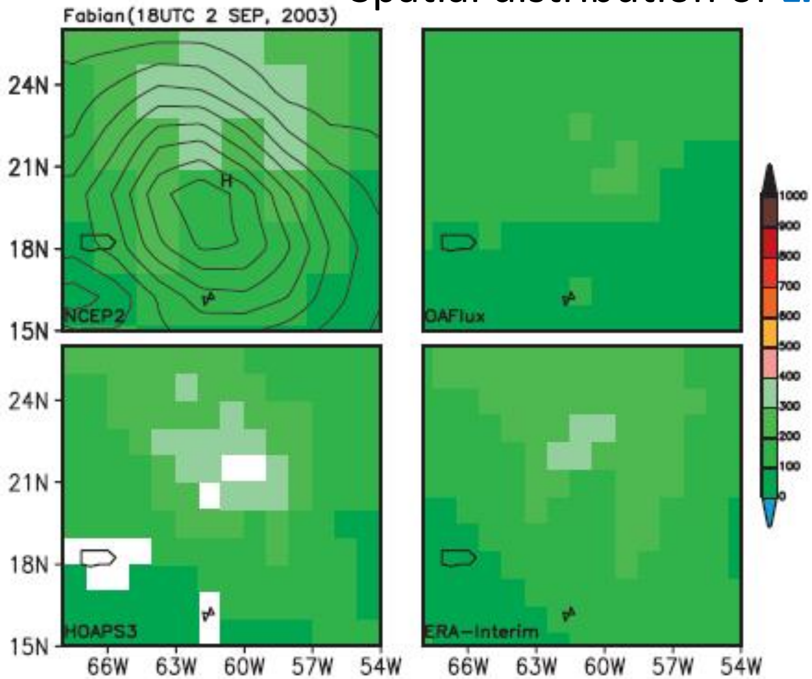
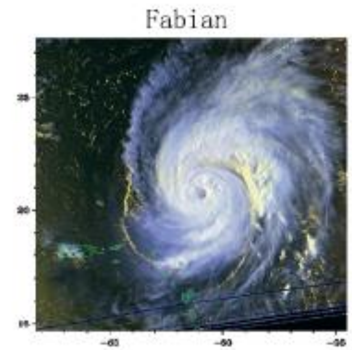
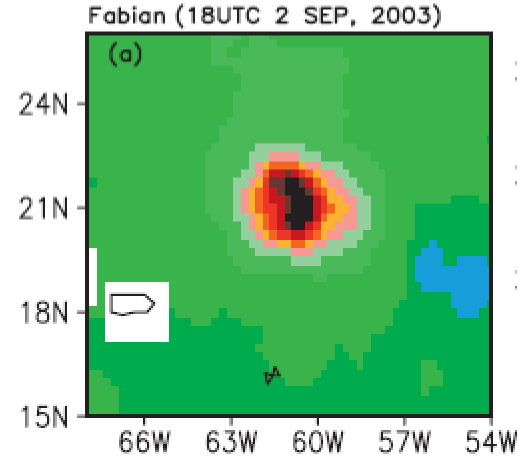
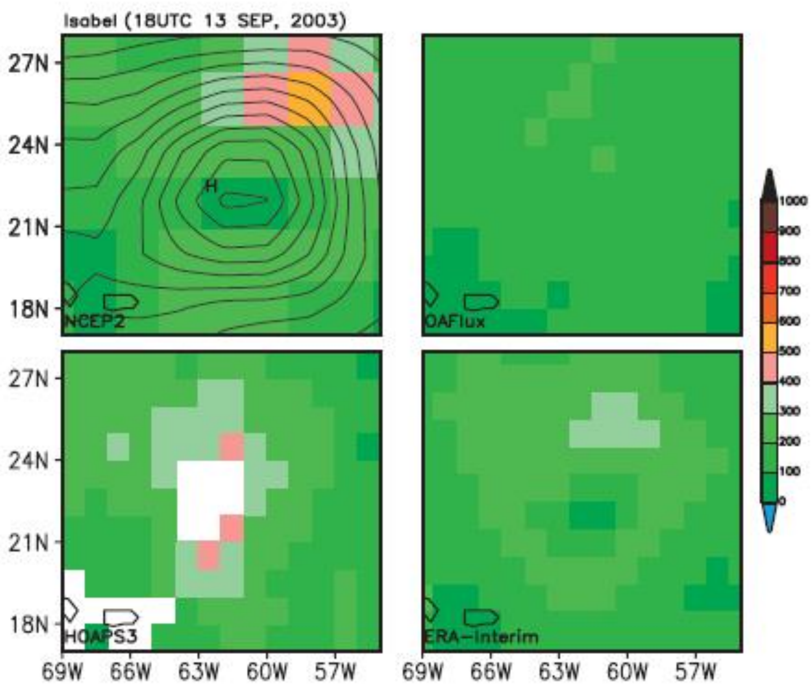
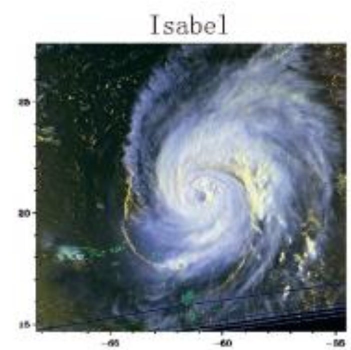
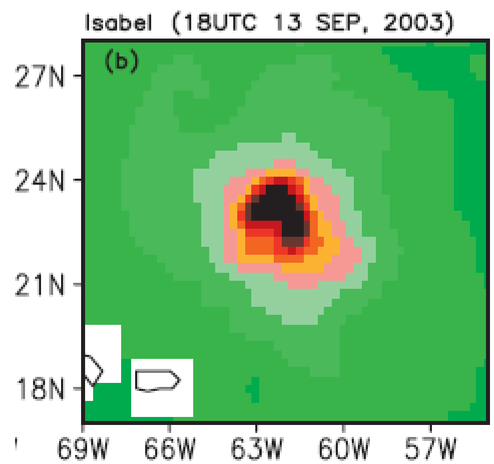




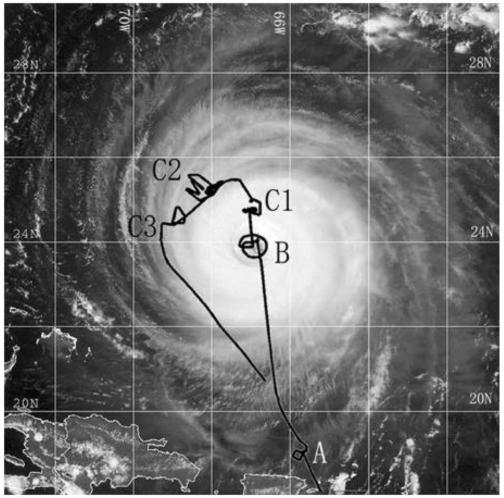








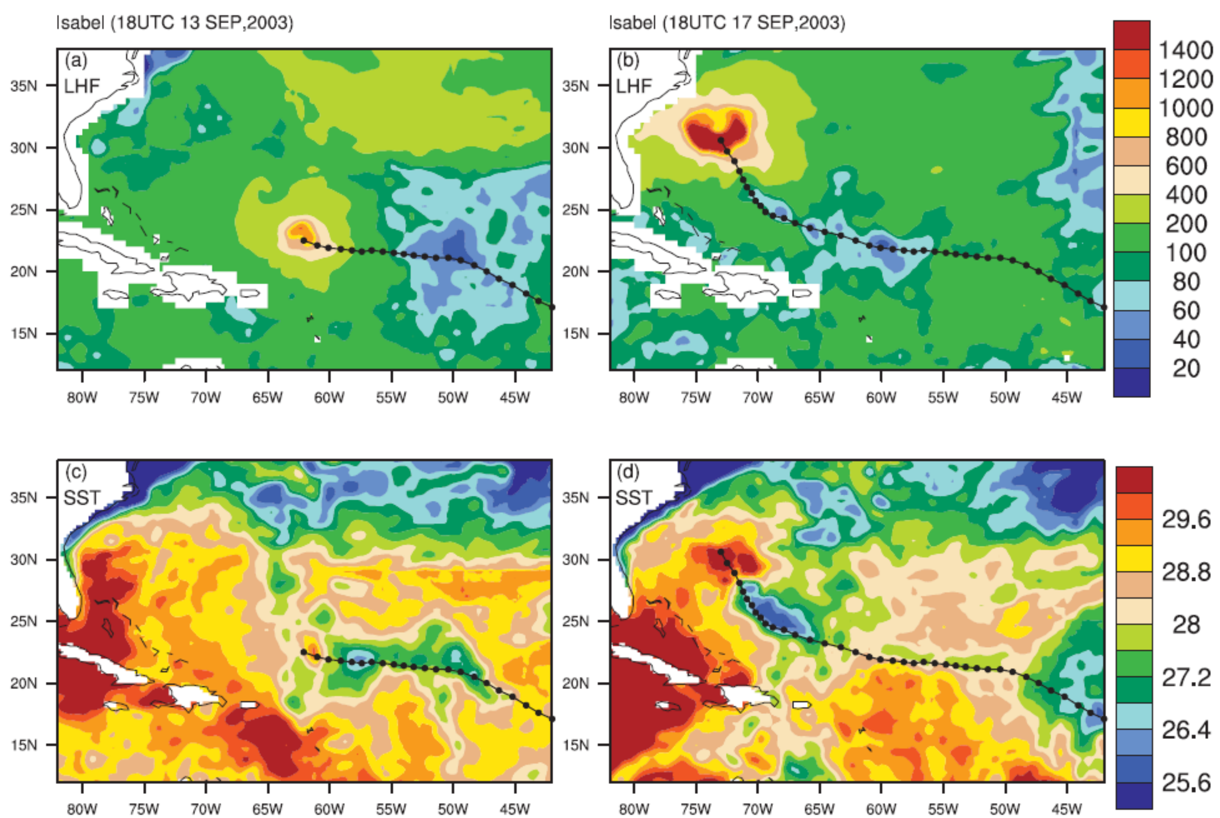
Coupled Boundary Layer Air-Sea Transfer (CBLAST) field experiment 2003



Comparison of LHF (NWP, satellite, and CBLAST)

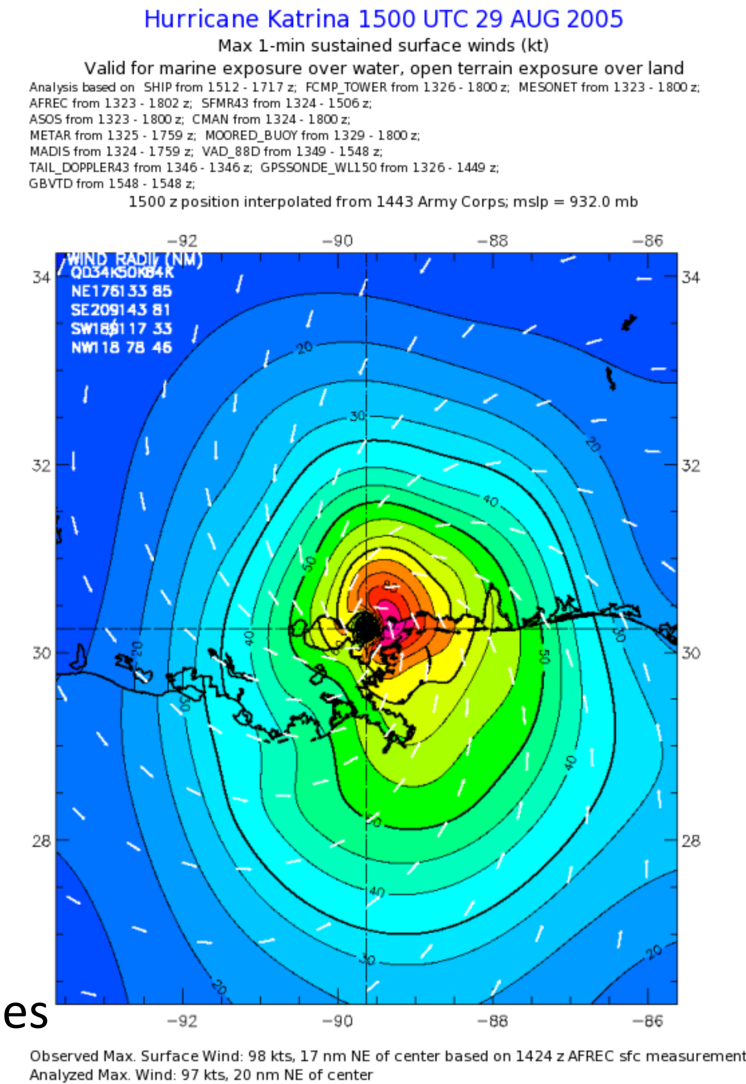
	NCEP2	OAFlux	HOAPS3	ERA-Interim	XSeaFlux
bias (W m^{-2})	-99.5	-150.0	-72.3	-123.2	26.9
correlation	0.51	0.46	0.48	0.58	0.91

Spatial distribution of LHF (W m^{-2}) and SST (°C) for Hurricane Isabel



We need a better ocean surface wind speed data set for hurricane studies (i.e., missing wind data)

Y



- X_1: A radial wind speed model *(Holland et al. 2010)* and extended best track data set

- X_2: NCDC blended ocean surface wind speed derived from multiple satellites *(Zhang et al. 2006)*

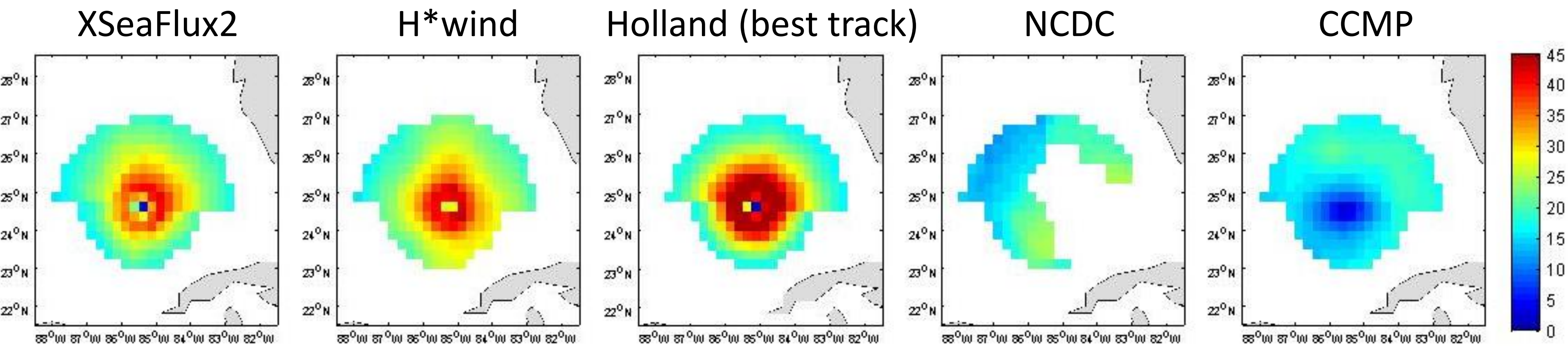
- X_3: CCMP ocean surface velocity derived from multiple satellites, in-situ data from ships and buoys, and ECMWF reanalysis/analysis *(Atlas et al. 2011)*

$$Y = a_1X_1 + a_2X_2 + a_3X_3$$

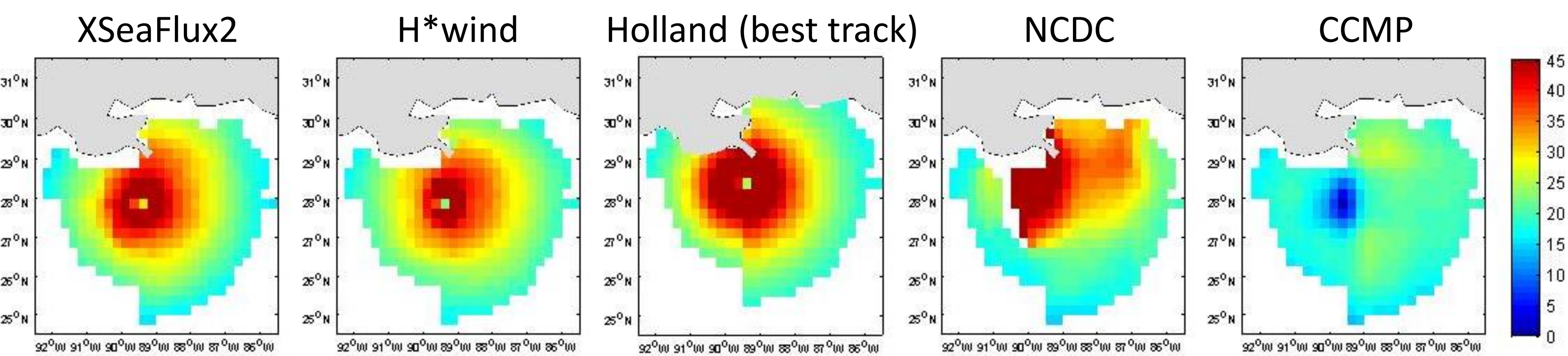
The model is trained for the period 1998-2008 of Y, and then used to reconstruct wind speed for hurricanes

Hurricane Katrina

August 27 (1930 UTC)



August 29 (0430 UTC)



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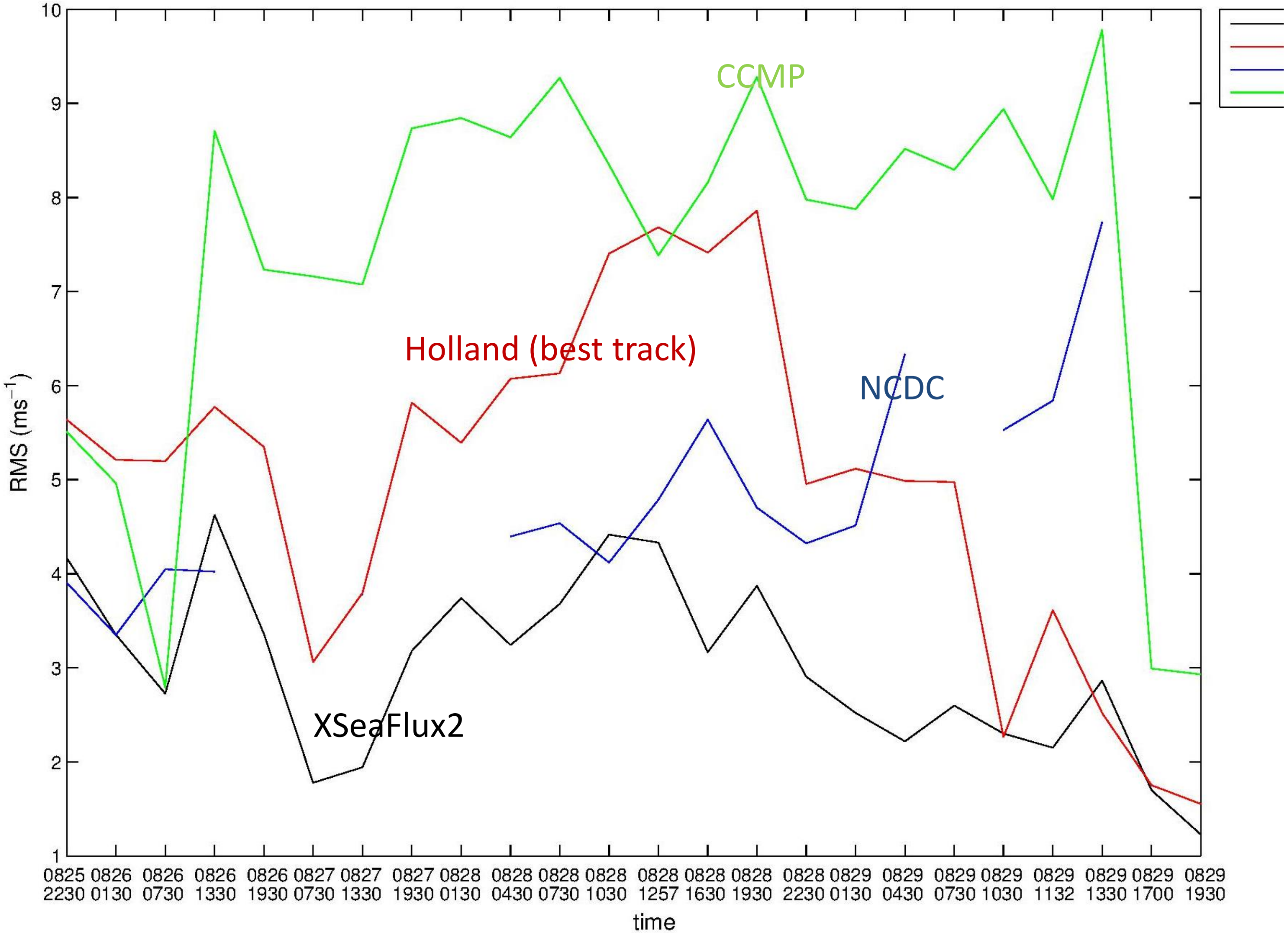

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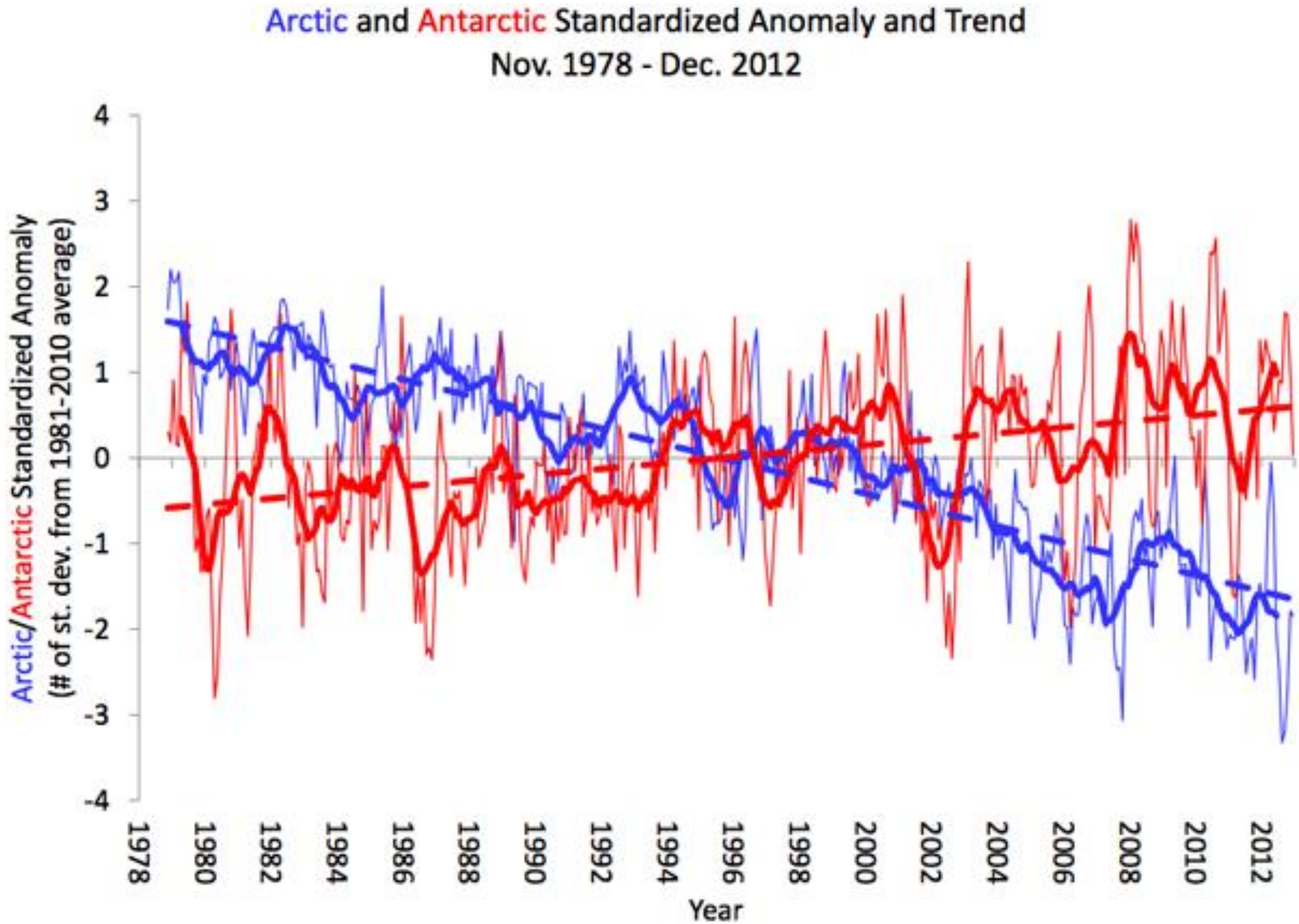


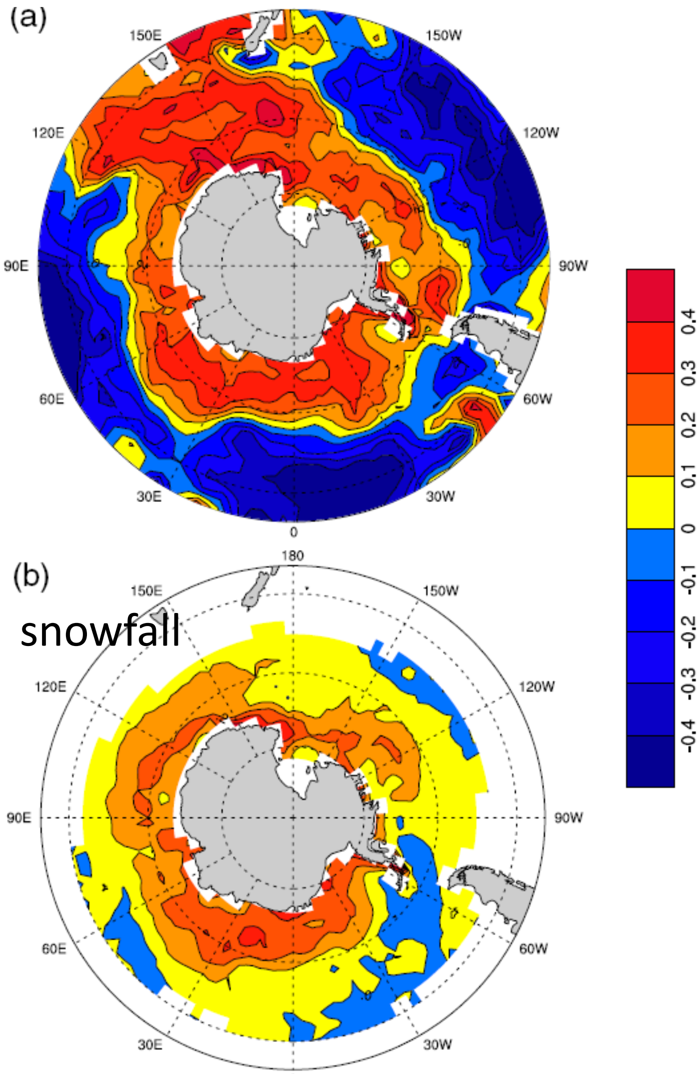
Arctic and Antarctic Standardized Anomaly and Trend
Nov. 1978 - Dec. 2012
Arctic/Antarctic Standardized Anomaly
(# of st. dev. from 1981-2010 average)
4
3
2
1
0
-1
-2
-3
-4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year

“Observation”
ECMWF reanalysis

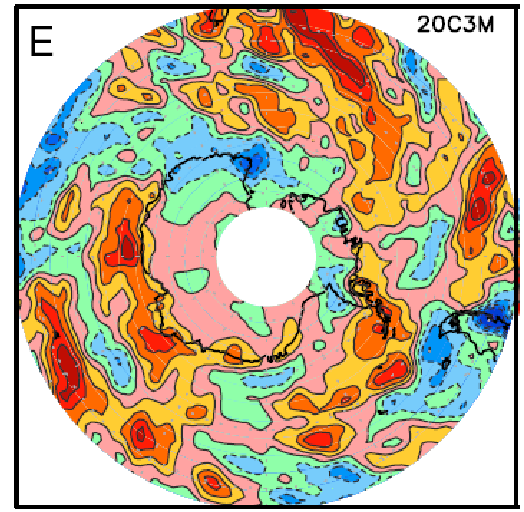
Model
NCAR CCSM3

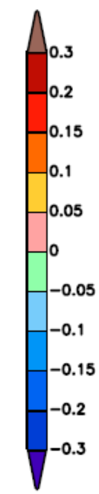
Difference between 1990s and 1950s

total precipitation
(liquid precipitation + snowfall)

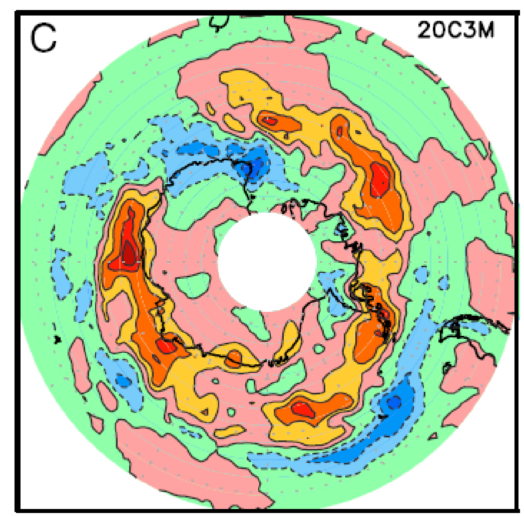


total precipitation





snowfall



Second half of the 20th century

As the Southern Ocean warmed, the hydrological cycle accelerated and there was more precipitation in the high-latitude of the Southern Ocean…

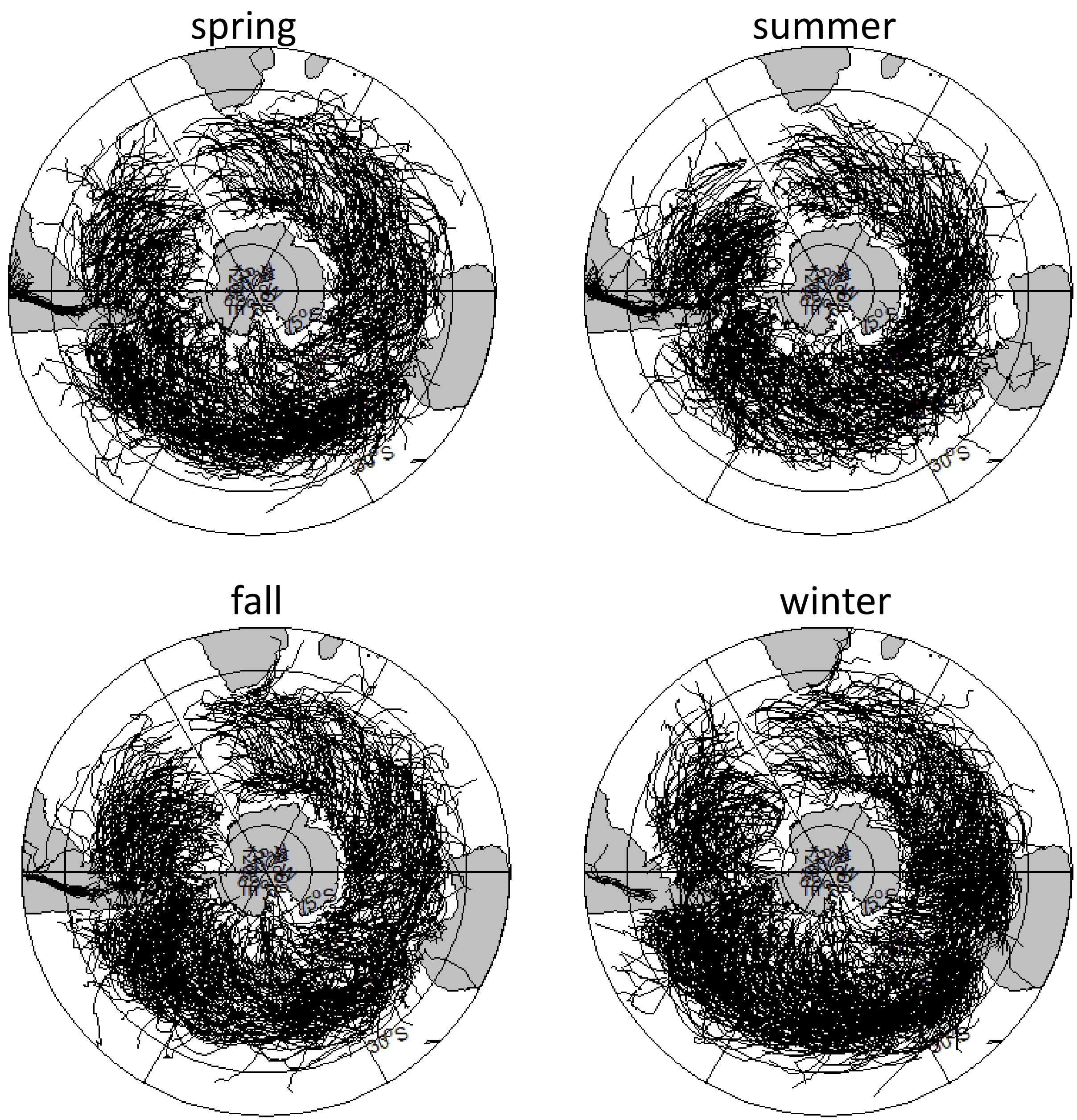
Increased precipitation stabilized upper ocean, and reduced upward ocean heat transport, decreasing the heat available from the ocean to melt the ice from below

Increased precipitation was mostly in the form of snow. This increased surface albedo, reducing absorbed solar radiation and encouraging ice growth

Increasing of Antarctic sea ice

Better understand the role of storms in contributing to the subseasonal variability of the identified processes, and the role of the hydrological cycle in contributing to the interannual variability of ocean surface buoyancy flux and Antarctic sea ice

Storm track (1979-2012)



Thanks for your attention!