卫星海洋环境动力学国家重点实验室
State Key Laboratory of Satellite Ocean Environment Dynamics (SOED)

A New Tropical Cyclone Genesis Index with Ocean Properties

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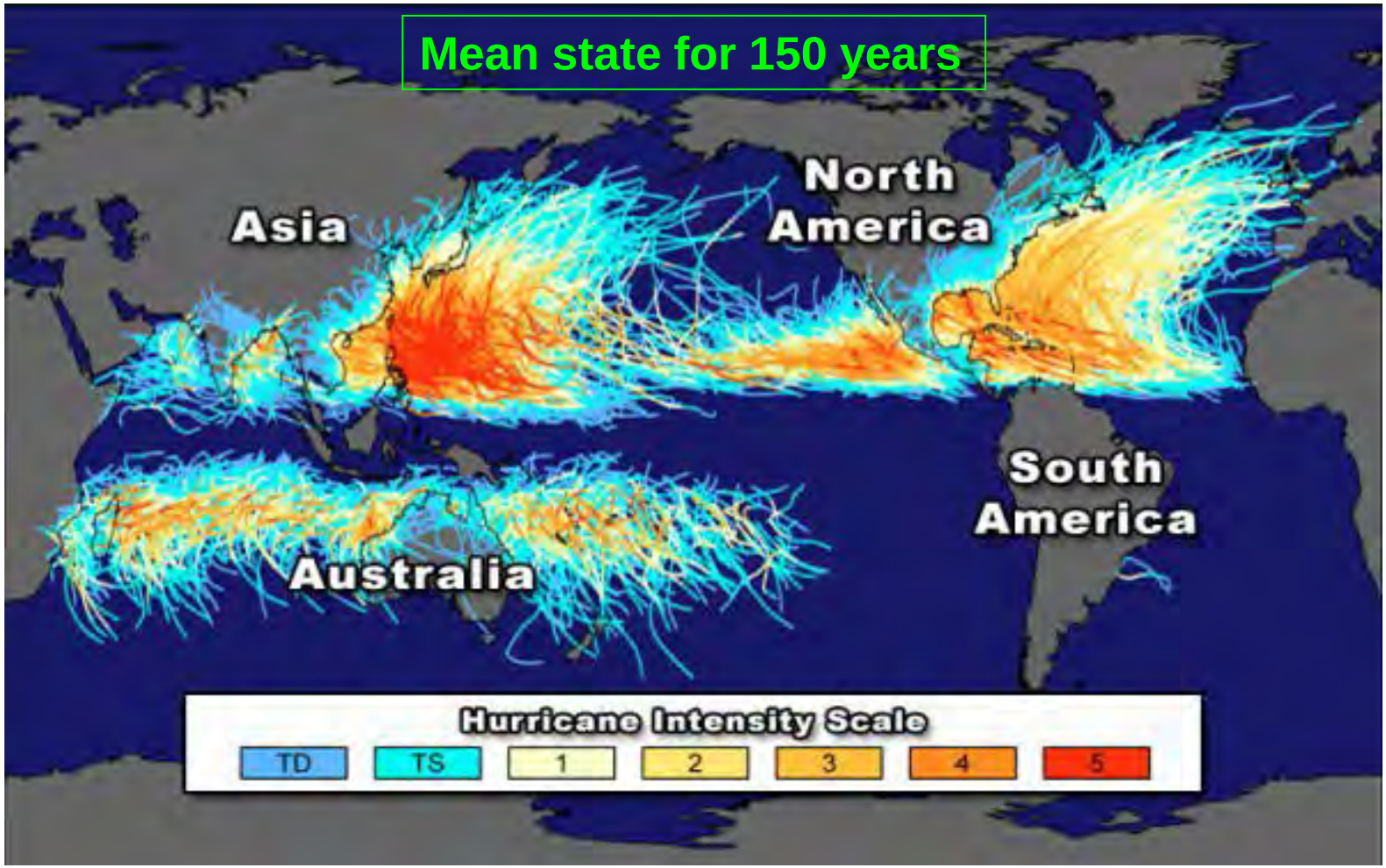
Outline

- Motivation
- Statistical Method and Procedure
- Calibration of the new GPI
- Conclusion and Discussion

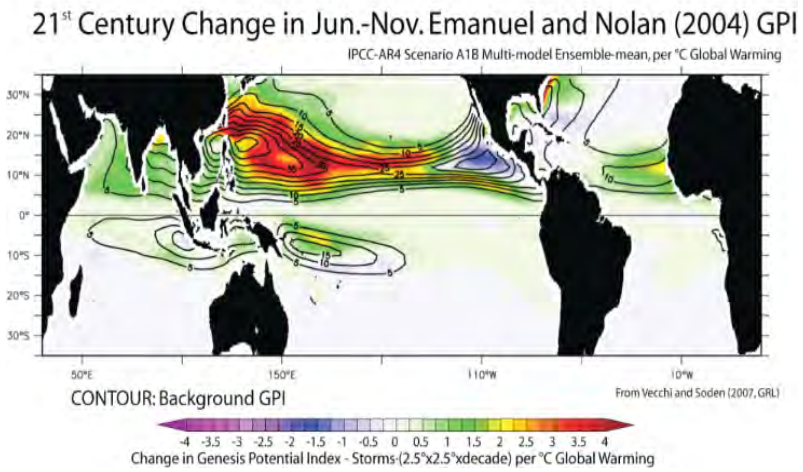
1. Motivation

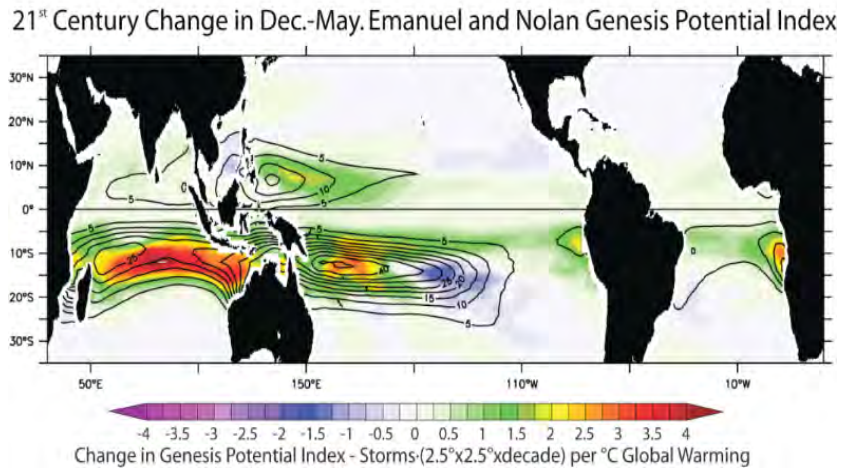
Statistics of typhoon have obvious scientific and social importance.

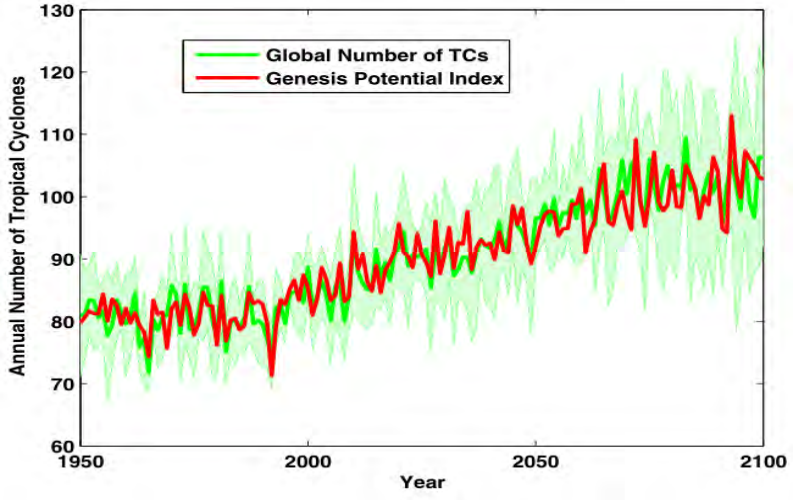


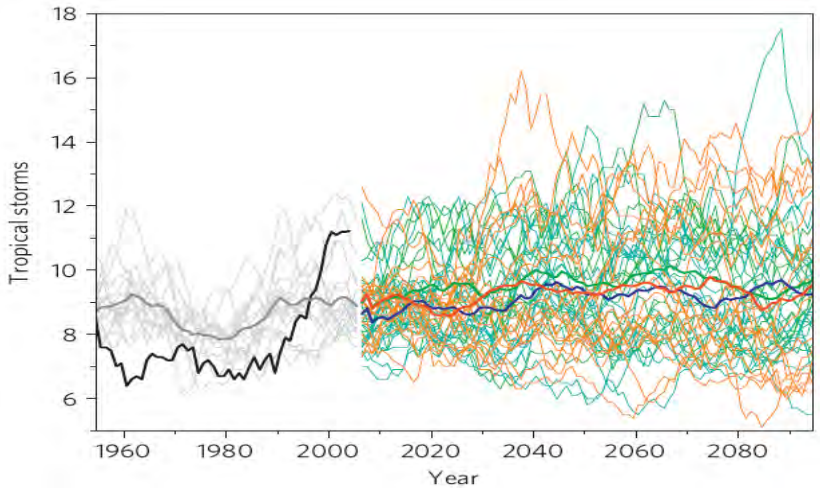
1. Motivation

Genesis Potential Index (GPI) is a useful tool









Emanuel, 2013

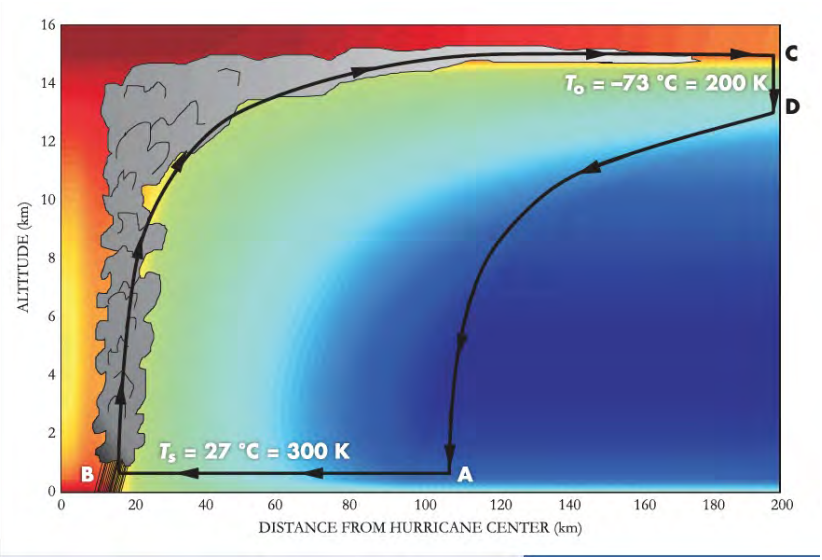
Villarini & Vecchi, 2012

1. Motivation: Existing GPIs

➢Gray (1979) $(Seasonal\ GP) \propto [(Vor)(Cariolis)(Vs)(SST)(moiststability)(H)]$

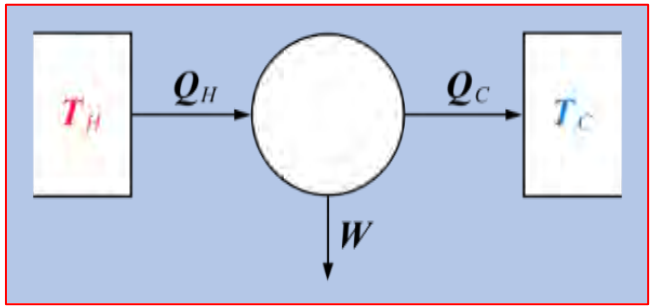
➢ Emanuel and Nolan (2004): GPI04

$$GPI = \left|10^5 \eta\right|^{3/2} \left(\frac{H}{50}\right)^3 \left(\frac{V_{pot}}{70}\right)^3 (1+0.1vshear)^{-2}$$



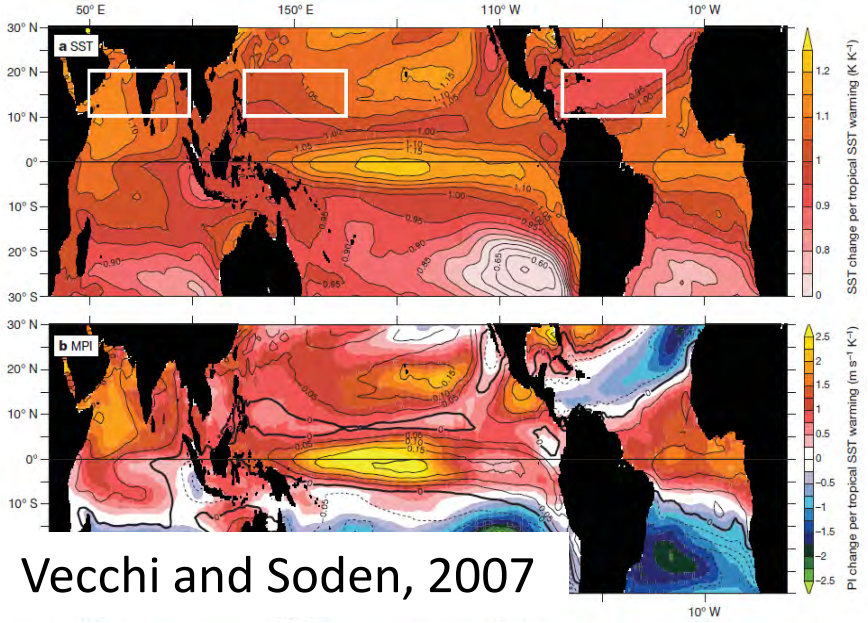
➢ Murakami and Wang (2010): GPI10

$$GPI = \left|10^5 \eta\right|^{3/2} \left(\frac{H}{50}\right)^3 \left(\frac{V_{pot}}{70}\right)^3 (1+0.1vshear)^{-2} \left(\frac{-\omega+0.1}{0.1}\right)$$



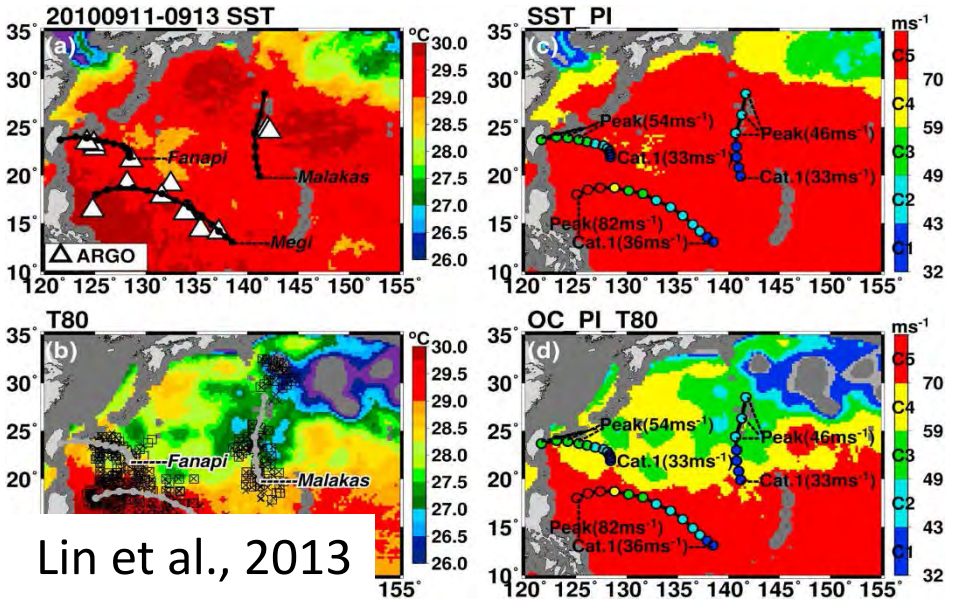
1. Motivation: Oceanic impacts on TC

The remote SST



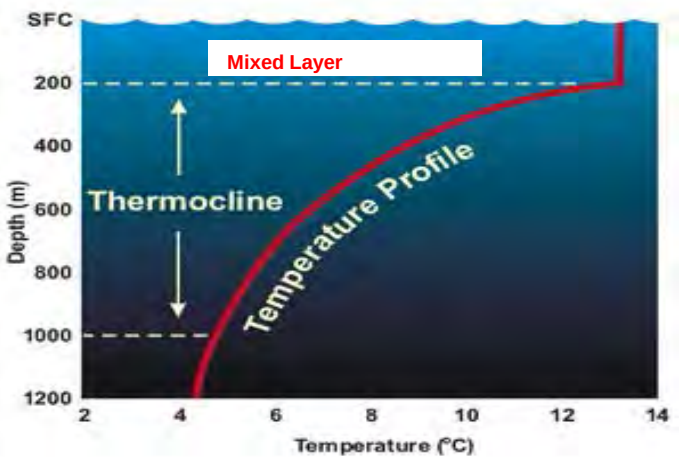
Vecchi and Soden, 2007

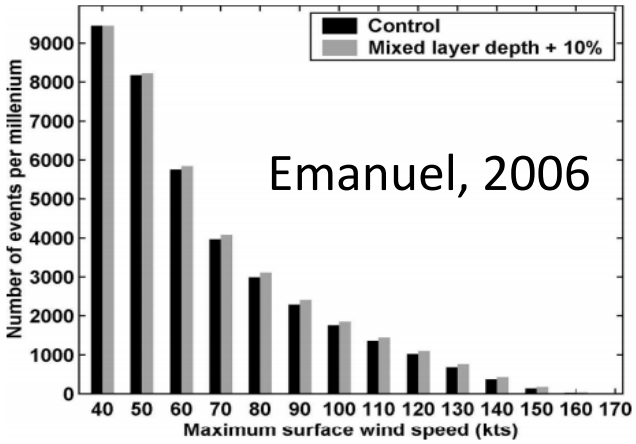
Upper mixed layer



Lin et al., 2013

Mixed layer depth

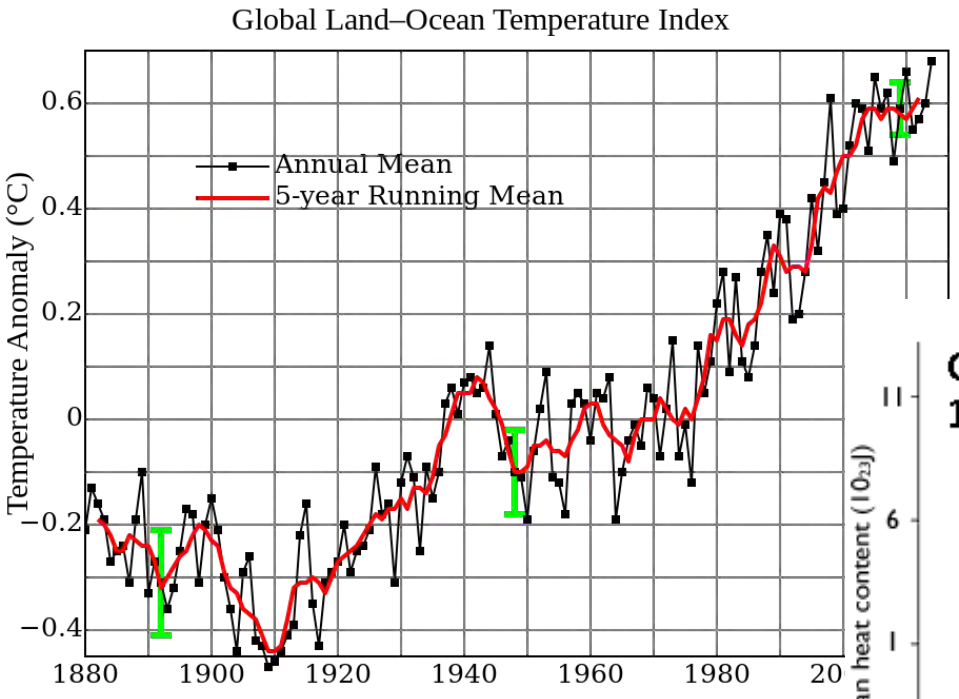


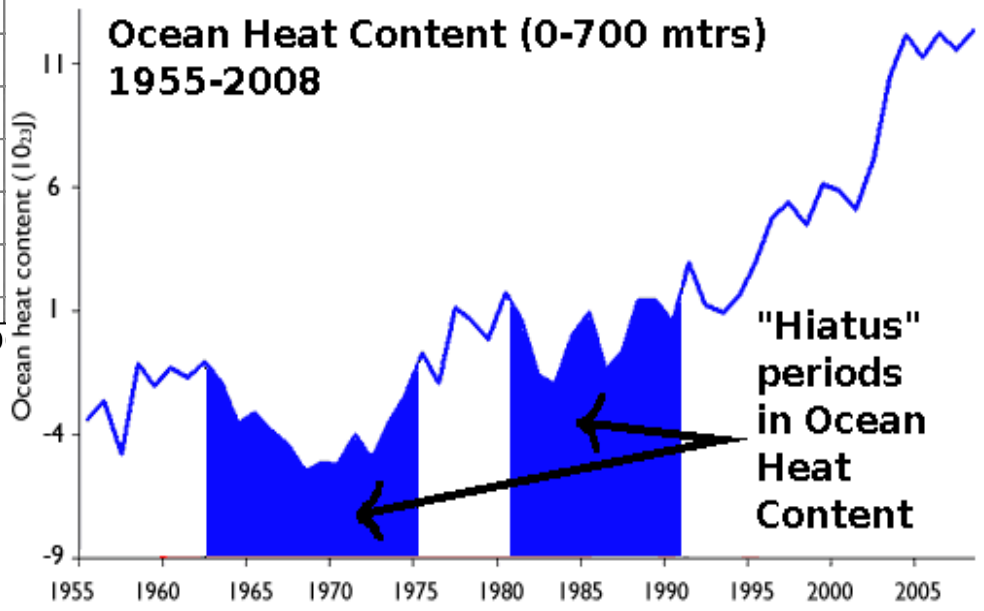


Emanuel, 2006

1. Motivation:

Oceanic response to the climate change: Hiatus





1. Motivation

- Goal:
  - A new Genesis Potential Index (GPI) of TC

- Two requirements:
  - Explicitly adopt necessary oceanic factors;
  - Have a better, or at least comparable, ability to represent the TC genesis over the western Pacific Ocean

2. Procedure

Selected candidate oceanic properties

(1) local SST

(2) relative SST

(3) heat flux(Q_{SH}, Q_{LH}, Q_{SW}, Q_{LW})

(4) mix layer depth (MLD)

(5) $\bar{T}_{mld}$

(6) $T_{surface} - T_{mld}$

(7) Q_{ohc}

→ **Mix layer**

(8) the thermocline depth

(9) lapse rate at the thermocline

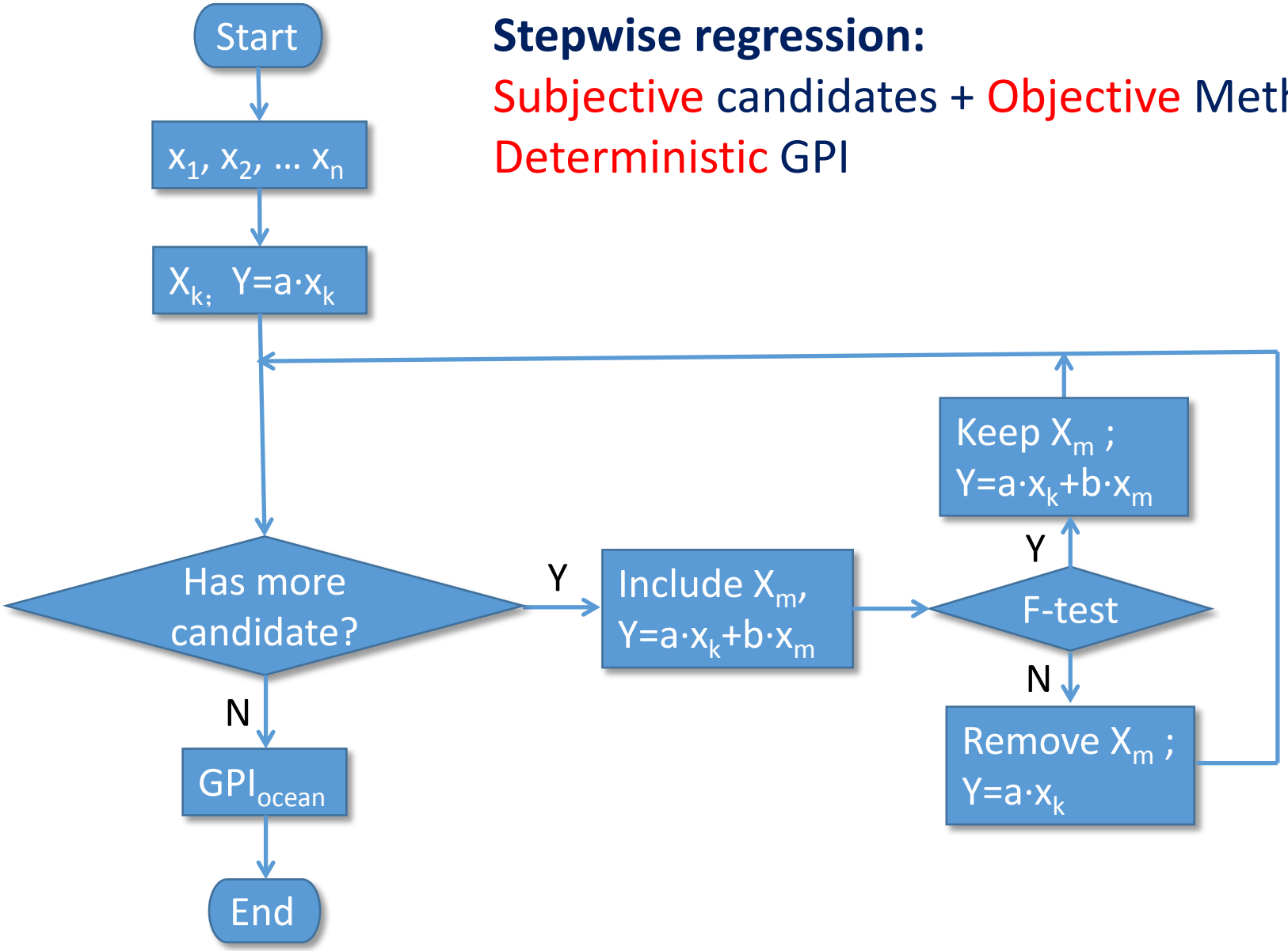
→ **Thermocline**

(10) $D_{20}; D_{26}; \bar{T}_{D_{20}}; \bar{T}_{D_{26}}$

2. Procedure

Stepwise regression:

Subjective candidates + Objective Method ≈ Deterministic GPI

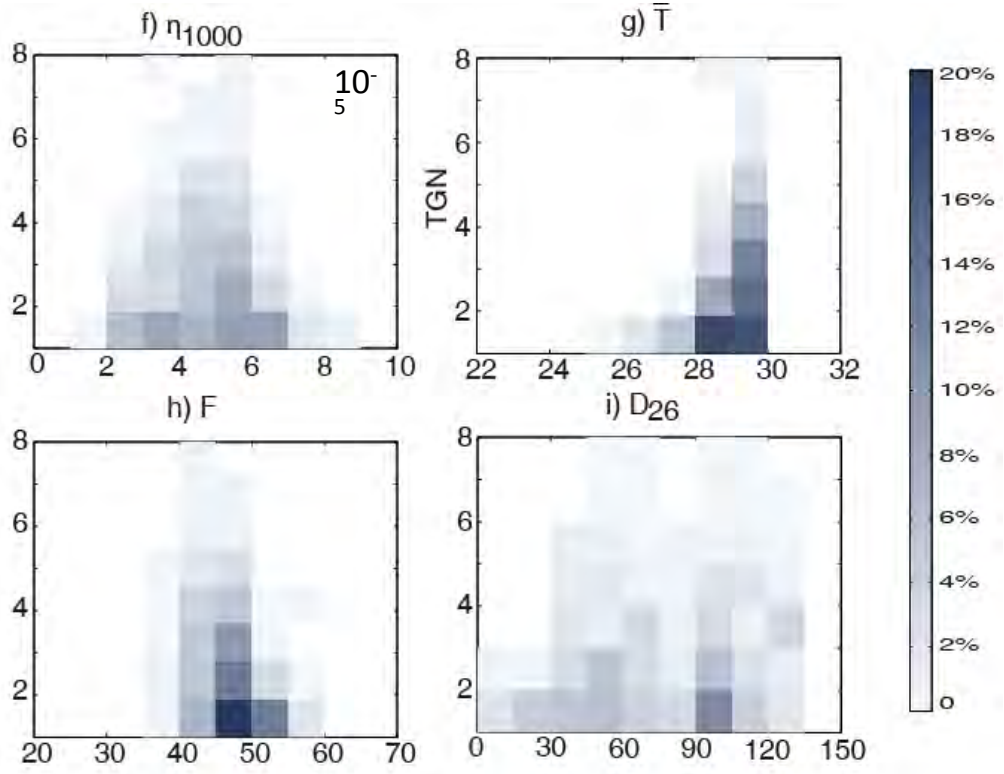


2. Procedure: Data

- Tropical cyclone
  - JTWC
- Atmosphere
  - NCEP-1: 2.5° × 2.5 °; monthly
  - ERA-40
- Ocean
  - Hadley EN4: 1° ×1° ; 42 layer; monthly;
  - Hadley SST: 1° ×1 ° ; monthly
- Flux
  - NCEP-1

2. Procedure: Format of each factor

$$GPI_{ocean} = p\left|10^5\eta_{1000}\right|^f \left(\frac{\overline{T}}{26}\right)^g \left(\frac{F}{45}\right)^h \left(\frac{D_{26}}{80}\right)^i$$



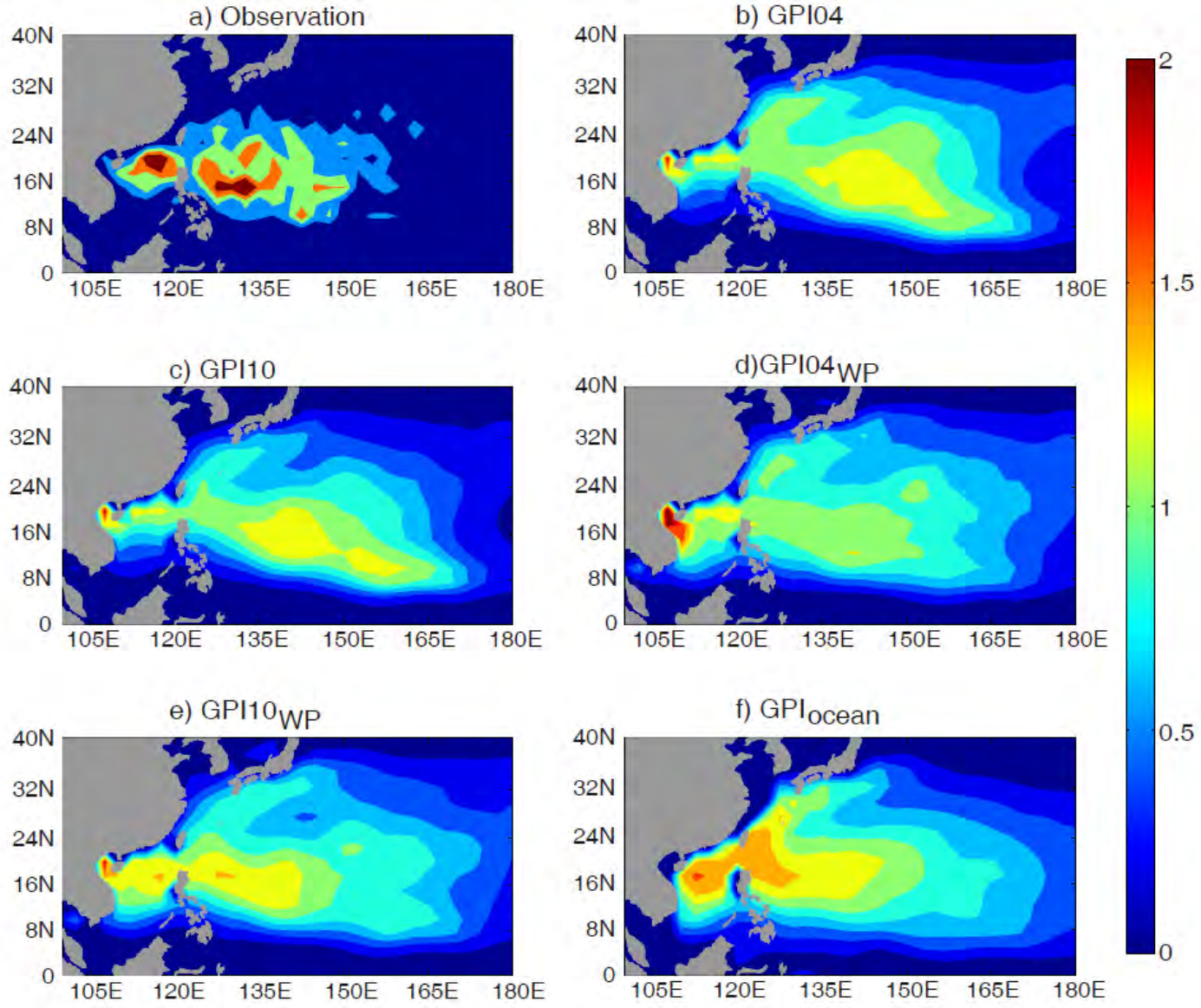
Coefficients	*f*	*g*	*h*	*i*
GPI_{ocean}	0.9	7.64	-2.73	0.25

3. Calibration: Spatial correlation

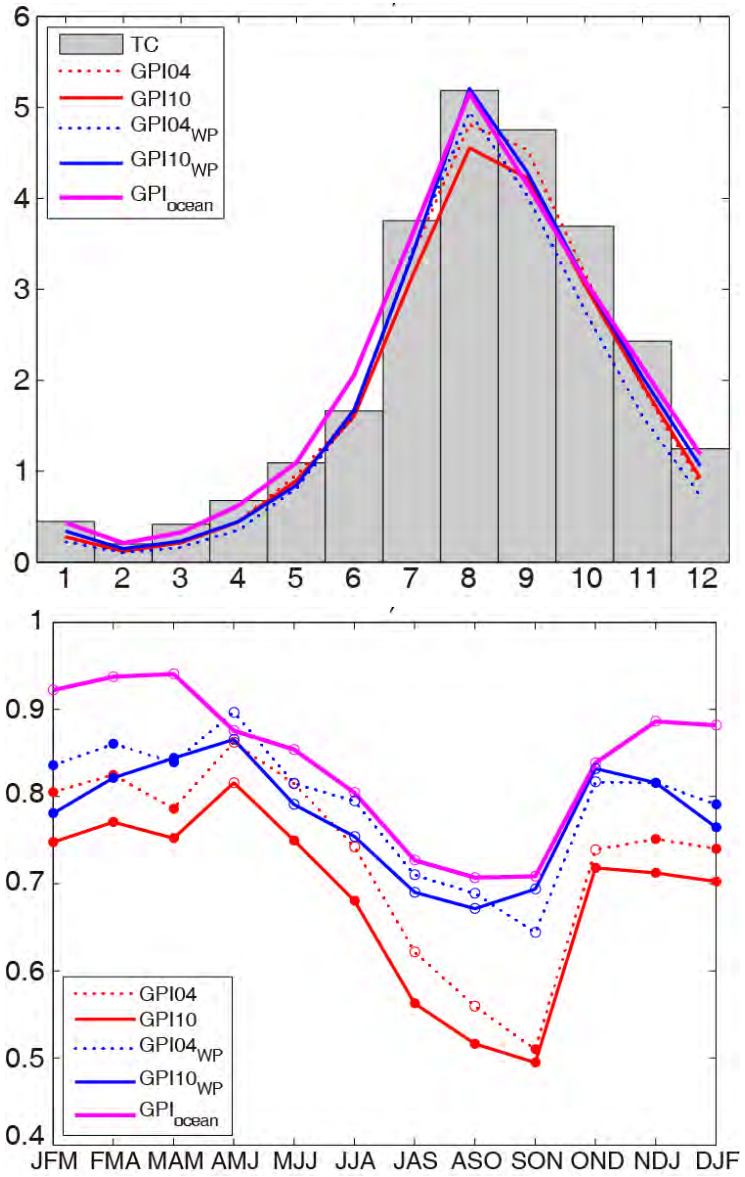
Significance test on the correlation: t-test and z-test

	GPI04 0.39	GPI10 0.45	$GPI04_{WP}$ 0.50	$GPI10_{WP}$ 0.53	GPI_{ocean} 0.54
GPI04 0.39	Nan	5.03/4.87	3.78/3.71	4.60/4.47	3.86/3.76
GPI10 0.45		Nan	2.03/2.02	3.48/3.43	2.59/2.55
$GPI04_{WP}$ 0.50			Nan	2.26/2.24	**1.49/1.48**
$GPI10_{WP}$ 0.53				Nan	**0.24/0.24**
GPI_{ocean} 0.54					Nan

3. Calibration: Spatial Distribution

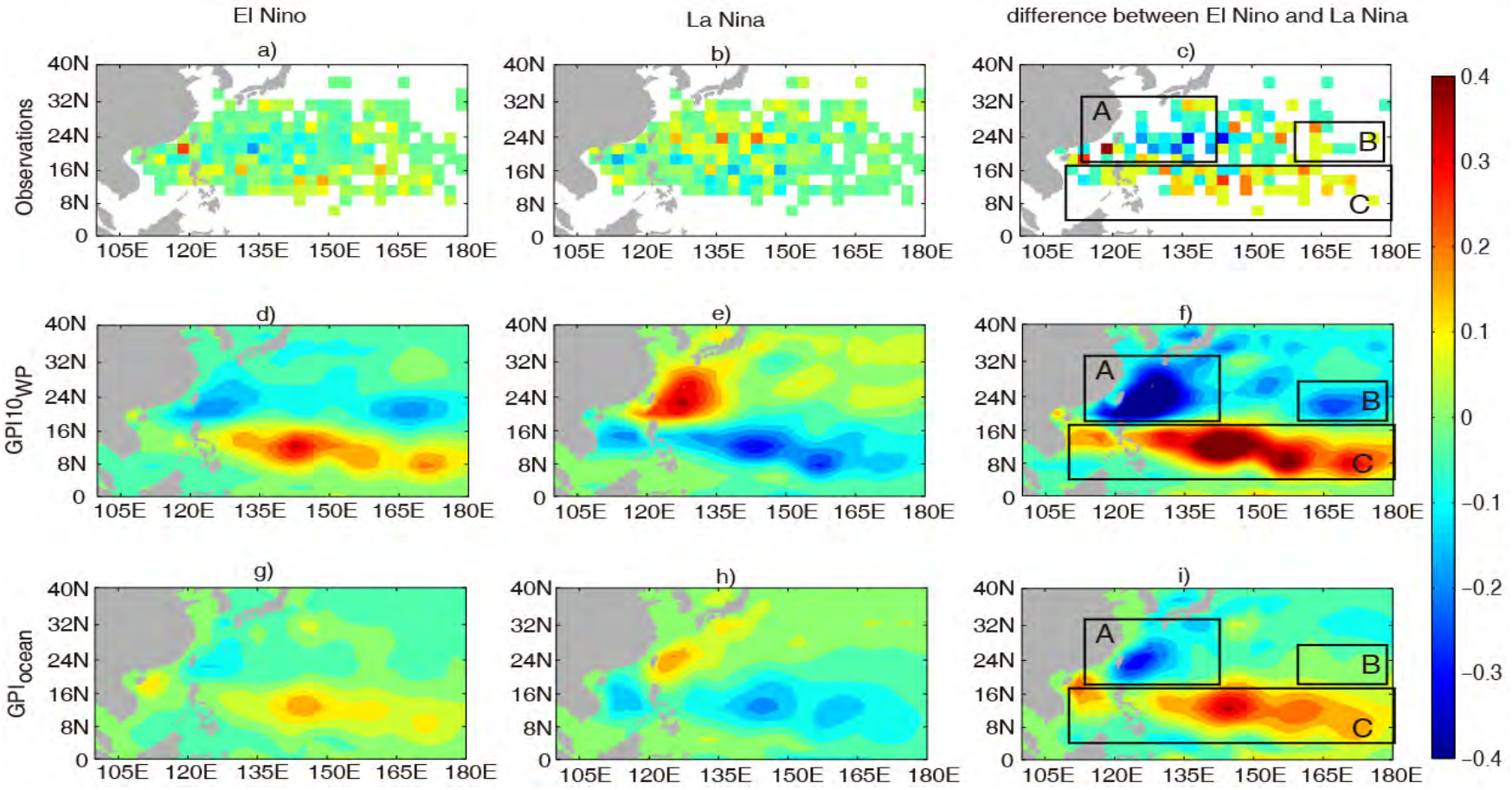


3. Calibration: Seasonal variation



3. Calibration: Interannual variation

El Niño Years				La Niña Years			
1951	1969	1987	2002	1950	1964	1975	1998
1957	1972	1991	2004	1954	1970	1978	1999
1963	1977	1994	2009	1955	1971	1985	2007
1965	1982	1997	2012	1956	1973	1988	2010

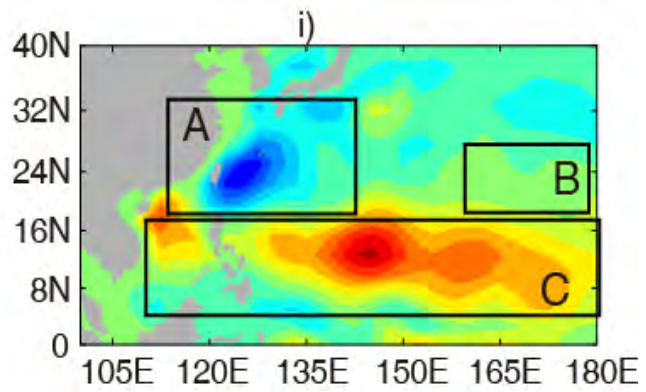


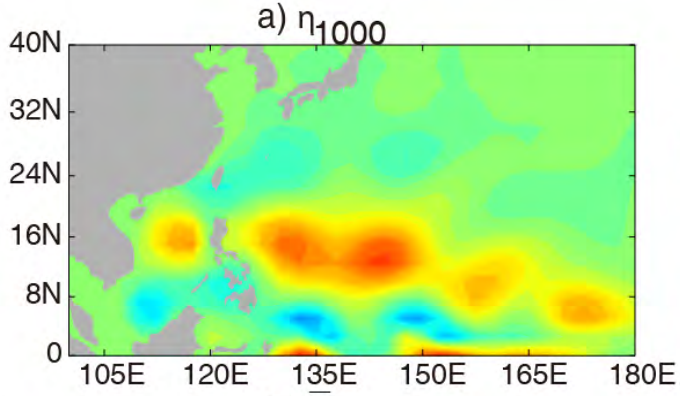
3. Calibration: Interannual variation

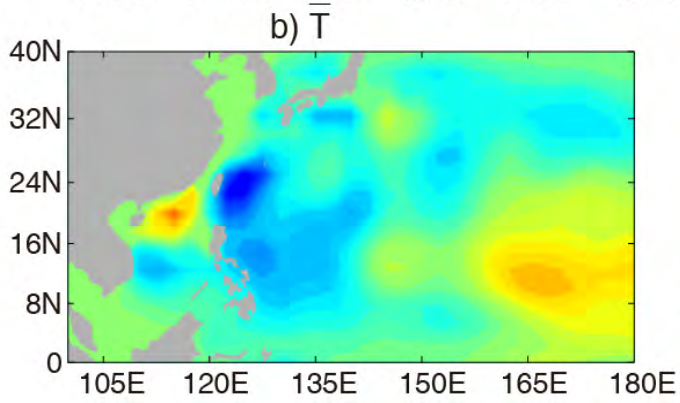
Individual perturbation on GPI_{ocean}:

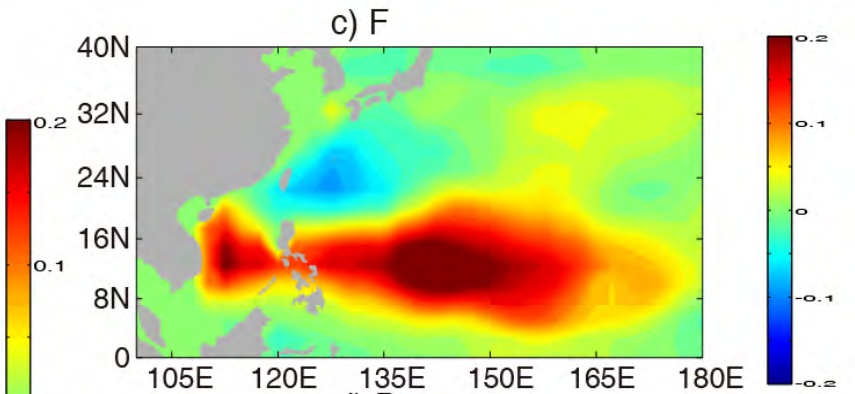
Only one factor takes the interannual values

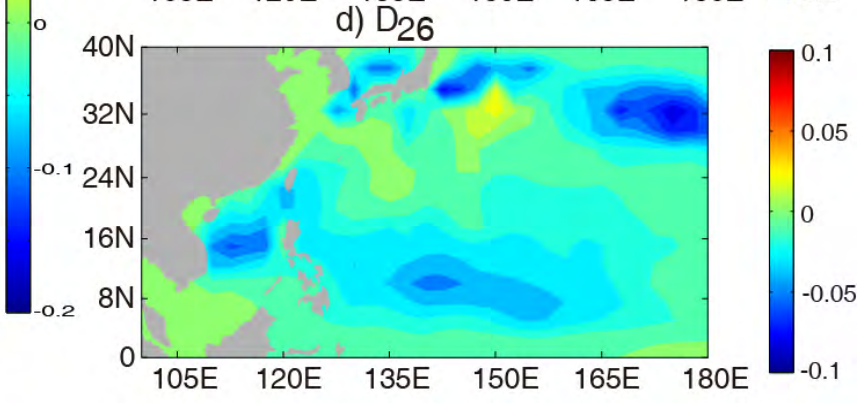
All other factors are fixed to the climatology











4. Conclusion and Discussion

- A new TC genesis index (GPI_{ocean}) is created by explicitly using oceanic parameters. However, necessary atmospheric parameters above the sea surface need to be included.

- GPI_{ocean} has a comparable effectiveness for representing TC genesis over the western Pacific as the best existing GPIs.

- GPI_{ocean} is an empirical tool that connects the statistics of TC genesis and the ocean subsurface processes.

4. Conclusion and Discussion

- Small-scale processes (such as the ocean waves, diapycnal mixing, and ocean spray) are not selected, since they are not common outputs of ocean models.

- When choosing the necessary atmospheric factors, we intend to select the ones at the sea surface.

- The research domain is limited to the western Pacific Ocean, which can make our result more reliable.

THANKS!