# Predictability of blocking and tropical cyclone activities?

# -- An assessment with a large ensemble simulation --

**Masahide Kimoto[1],
Joutaro Chiba[2],
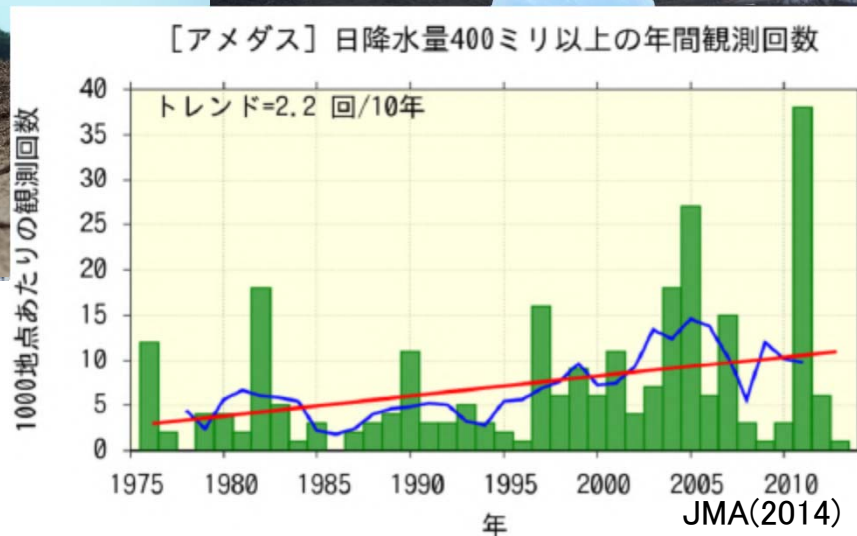and
Takuhiko Katayama[3]**

**1 Atmosphere and Ocean Research Institute, The University of Tokyo
2 Climate Prediction Division, Japan Meteorological Agency
3 The Tokio Marine Research Institute**

# Some of the changes in extreme weather and climate events observed since about 1950 have been linked to human influence
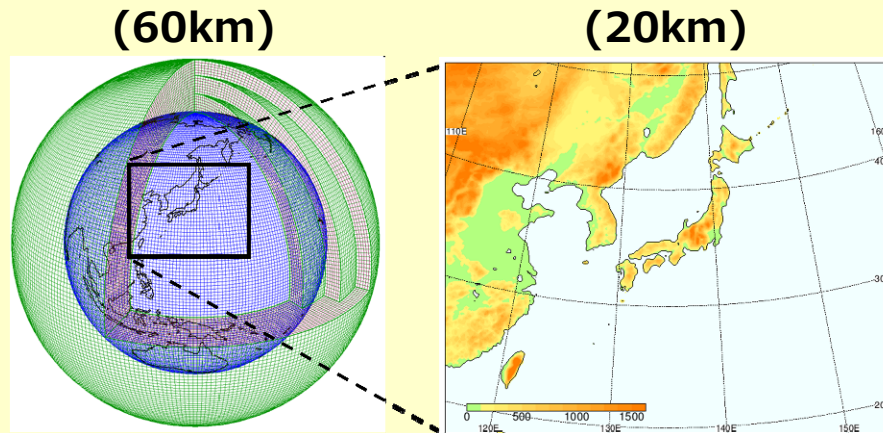
[アメダス] 日降水量400ミリ以上の年間観測回数

トレンド=2.2 回/10年

1000地点あたりの観測回数

40
35
30
25
20
15
10
5
0

1975　1980　1985　1990　1995　2000　2005　2010

年

JMA(2014)

AR5 WGI SPM

IPCC AR5 Synthesis Report

ipcc
ON climate change

WMO    UNEP

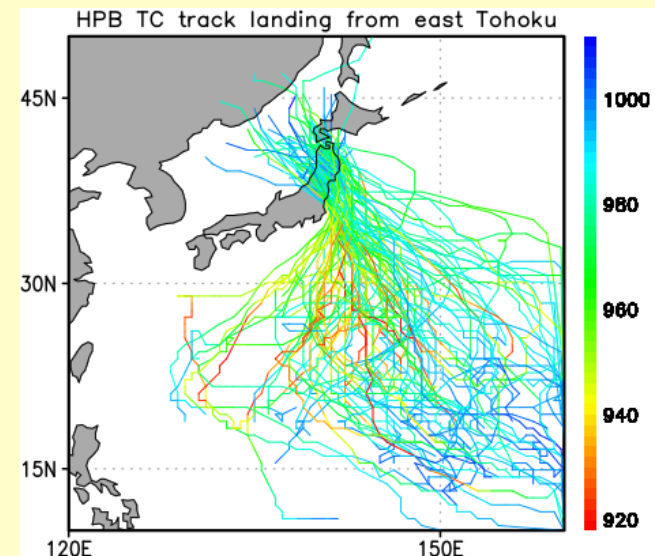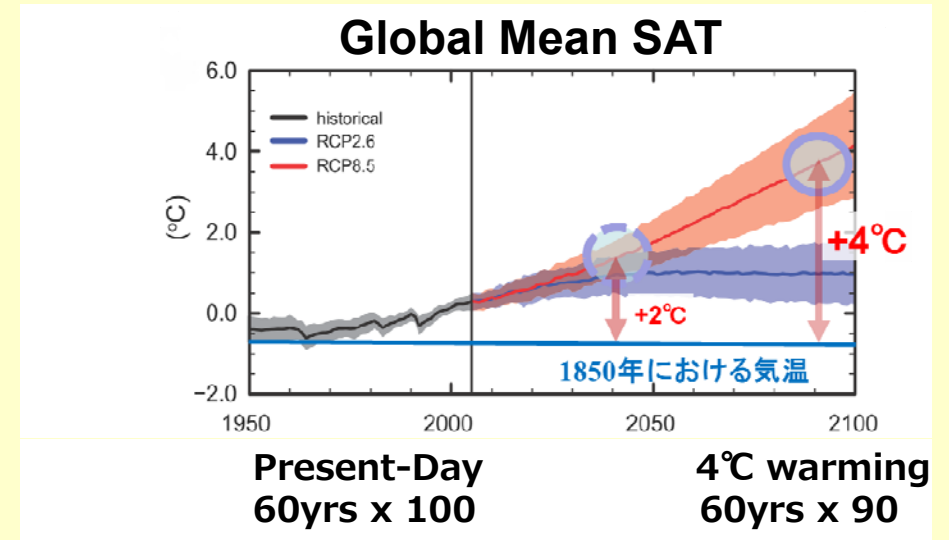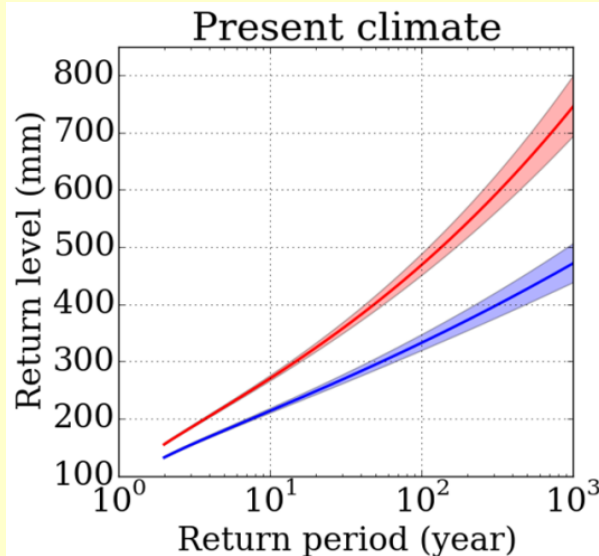# d4PDF  database for Policy Decision making for Future climate change

- **A common scenario for policy decision making in Japan**

- **Highly reliable information from a large ensemble of climate model simulation**

http://www.miroc-gcm.jp/~pub/d4PDF/   Mizuta et al. (2017; BAMS)

## High-res global and regional database

**(60km)**          **(20km)**

(画像:気象庁提供)

### Global Mean SAT



- historical
- RCP2.6
- RCP8.5

+4℃

+2℃

1850年における気温

**Present-Day 60yrs x 100**          **4℃ warming 60yrs x 90**

### Present climate



Return level (mm) vs Return period (year)

### HPB TC track landing from east Tohoku

# Data

## d4PDF (database for Policy Decision making for Future climate change) (Mizuta et al. 2017; BAMS)

Present-day experiment
- Boundary conditions: Observed SST and sea ice
- Period: 1951～(2010)

**A 100-member AMIP**

| AGCM | MRI-AGCM3.2（Mizuta et al. 2012） |
|---|---|
| Horizontal resolution | TL319 (～60 km） |
| Vertical | 64 levels（top at 0.01hPa） |

Observation

Atmosphere
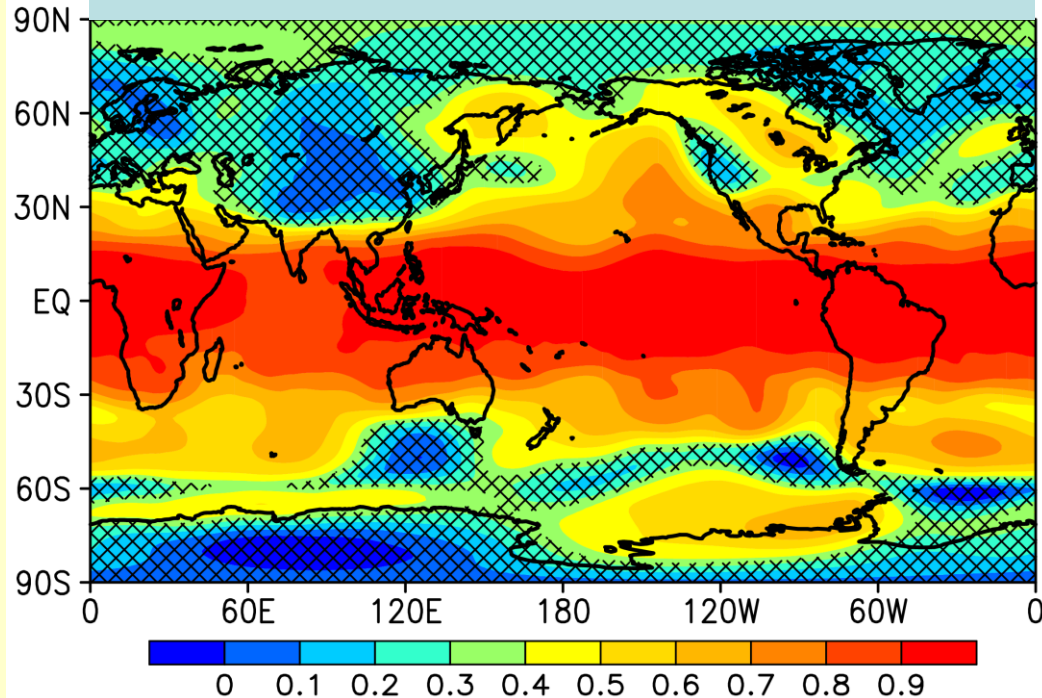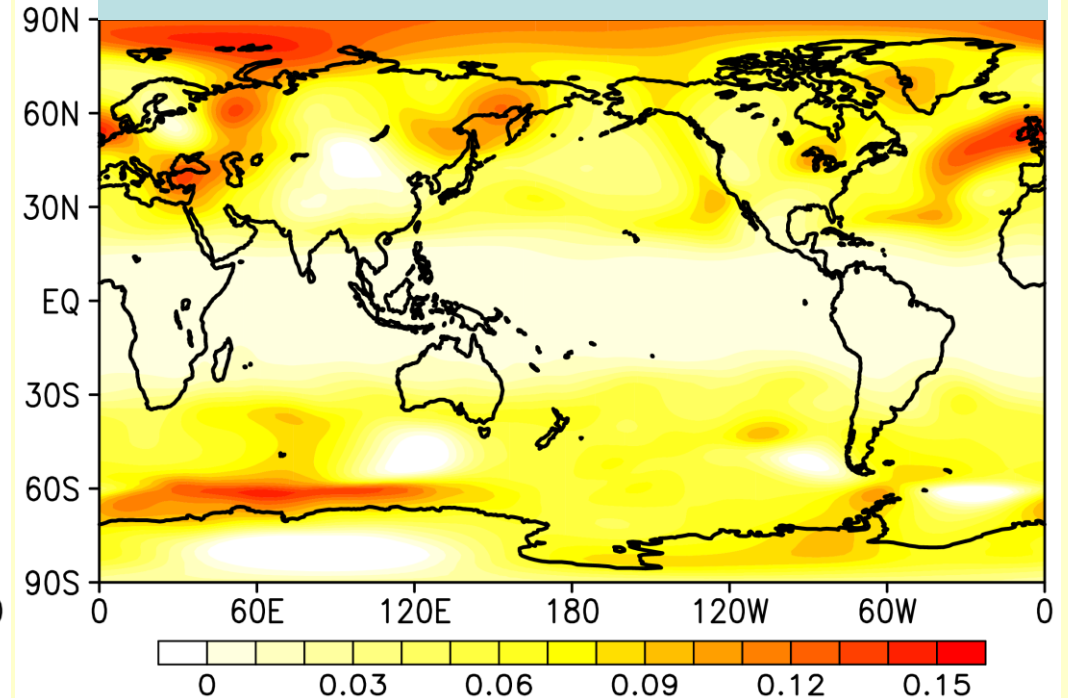- **JRA-55**：A 55-yr reanalysis by JMA (Kobayashi et al. 2015)

SST
- **COBE-SST2**（Hirahara et al. 2014）

# 1. Forced Predictability of Blocking?

# Correlation coefficient of DJF-mean Z500 anomalies between observation and model ensemble mean
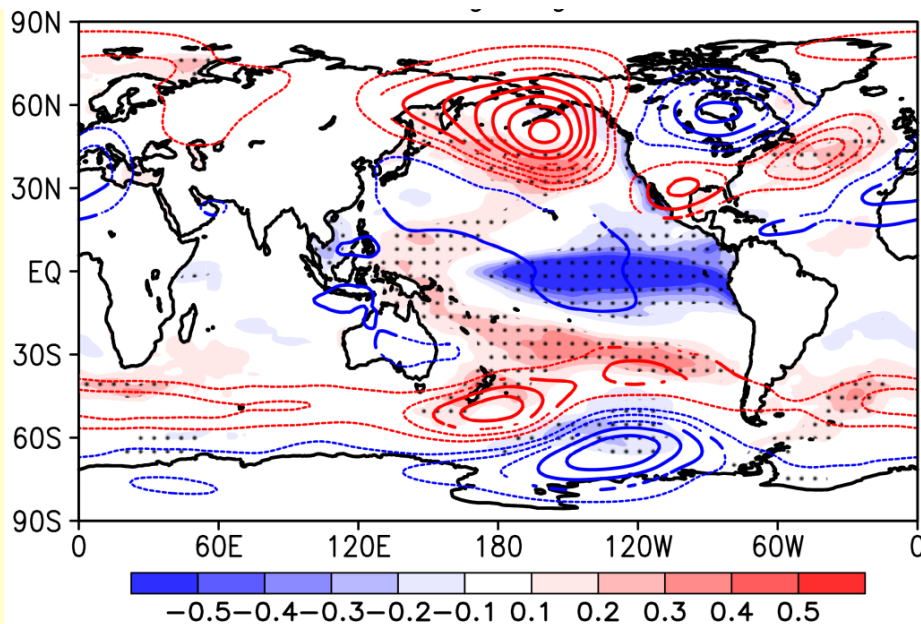
# Interannual variability over Kamchatka
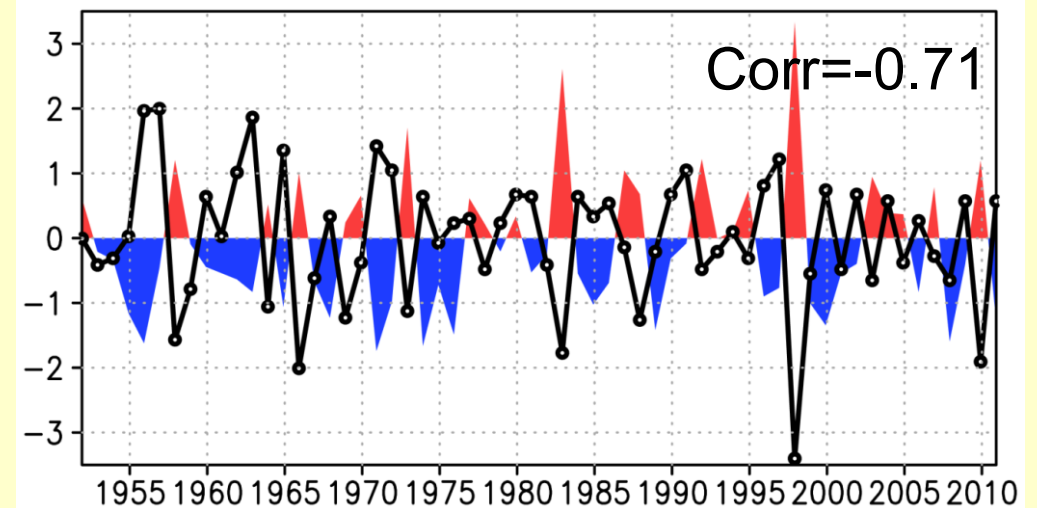
## Z500 averaged over Kamchatka (KAZ500)



Corr=0.59

Observation
Model ensemble mean
Model ensemble members
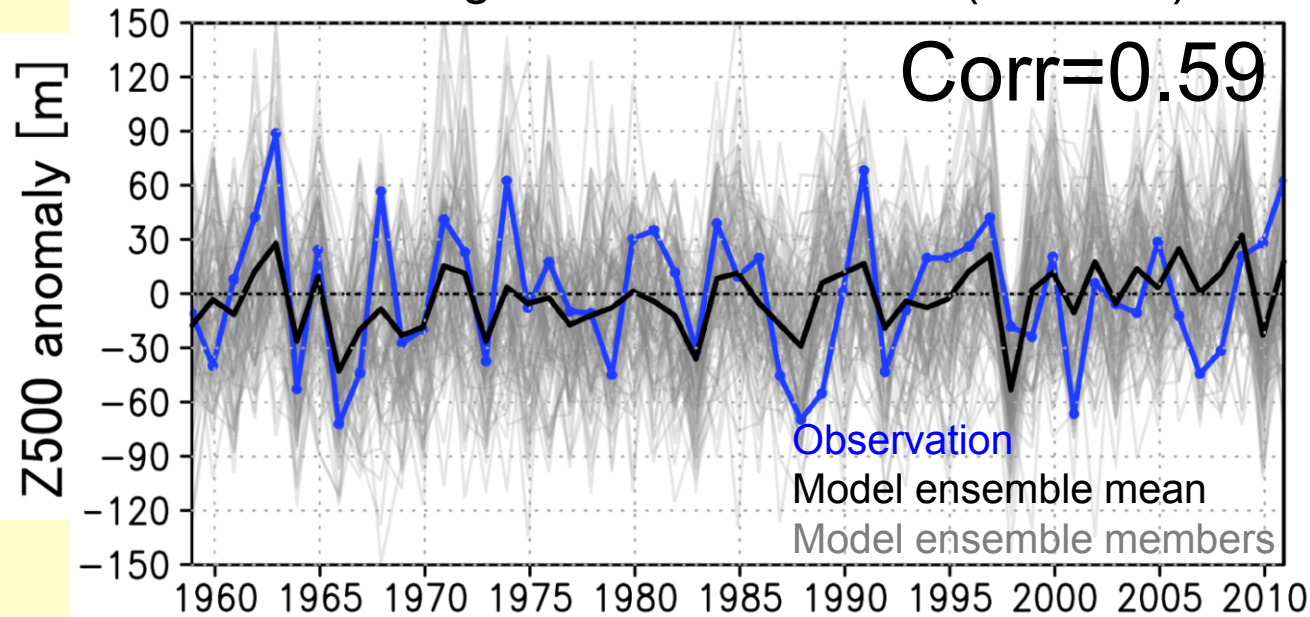


Corr. between Obs. & ensemble mean

Kamchatka ≡ (150E-170E, 55N-65N)
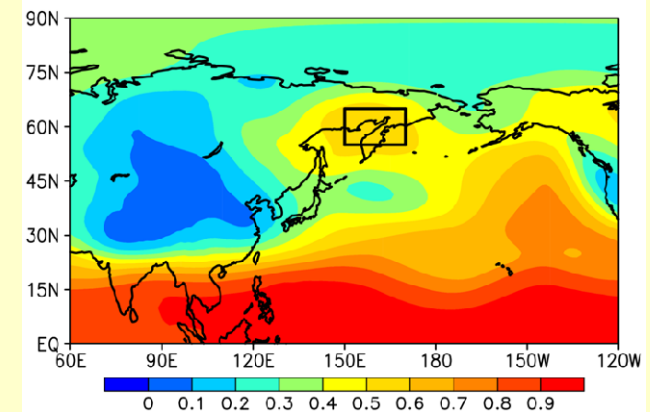
## SST & Z500 regressed against KAZ500



## NINO3 (color) vs. KAZ500



Corr=-0.71

# Extraction of positive anomaly events over KA

Events ≡ 5-day running mean ESZ500 > 1σ over 3 consecutive days

5-day running mean Z500 anomaly (1σ)



(150E-170E, 55N-65N)



➢ Composite of onsets
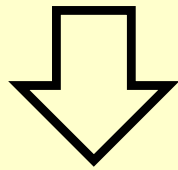
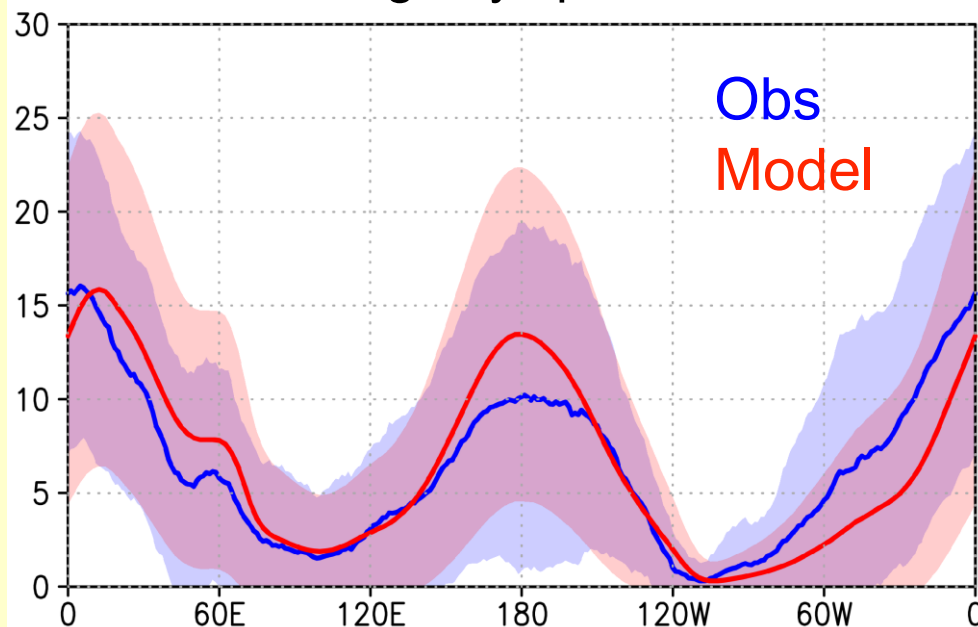| | Case # |
|---|---|
| Observation (1958-2010) | 98 |
| d4DF (1951-2010) | 11318 |
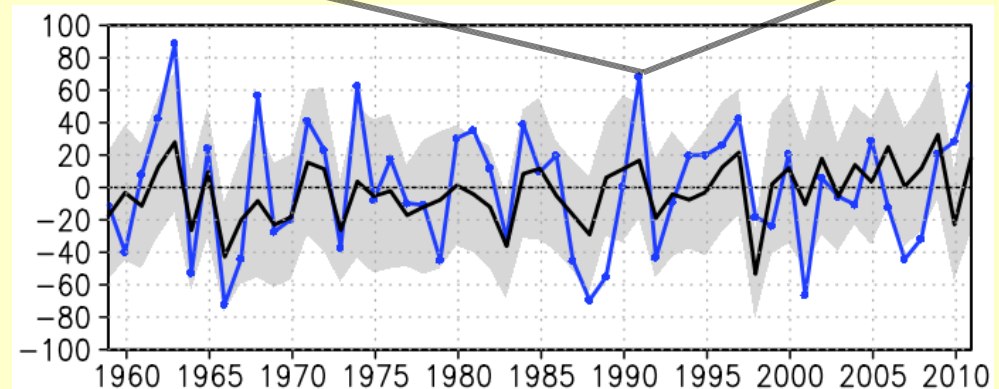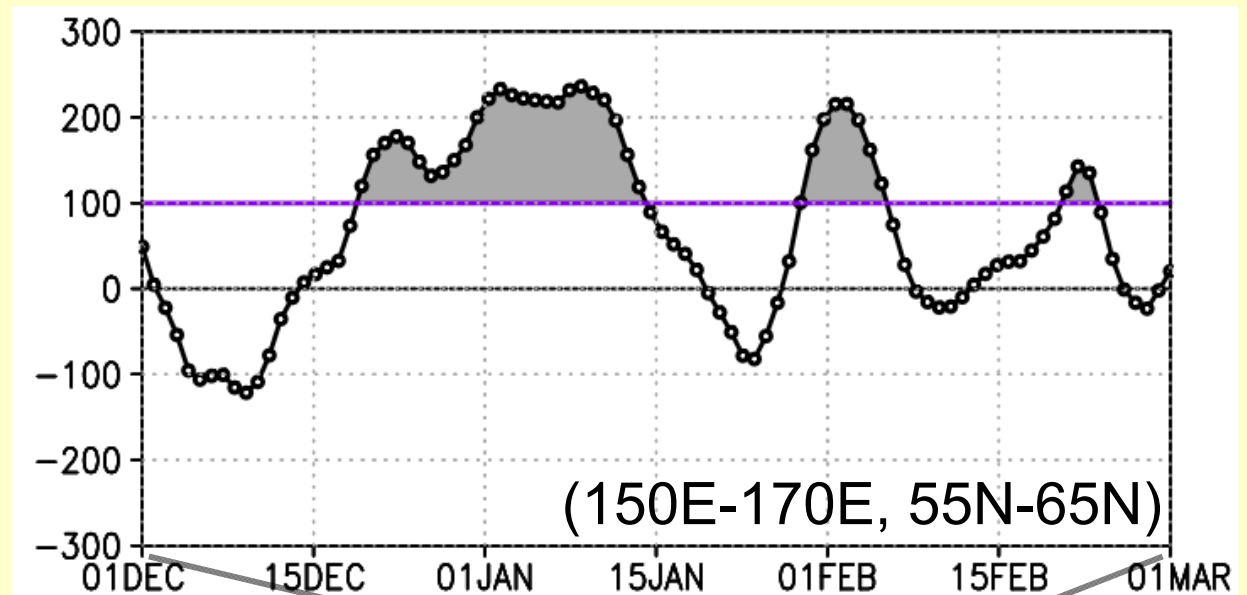
# Onset composites
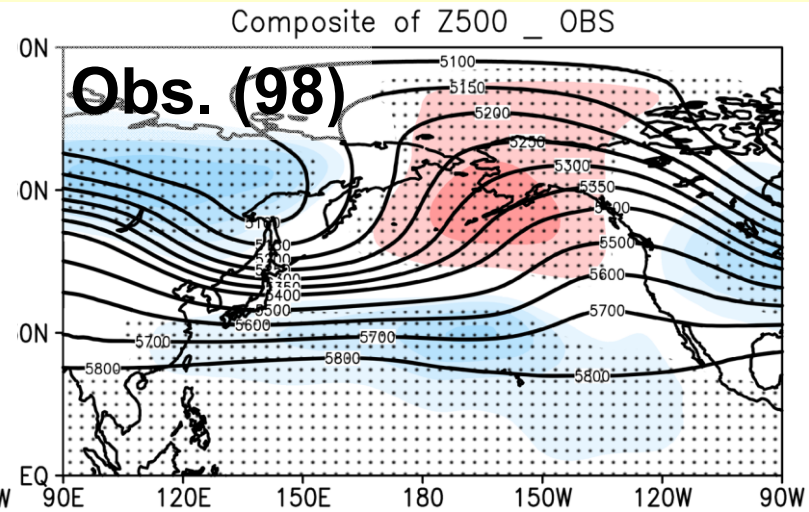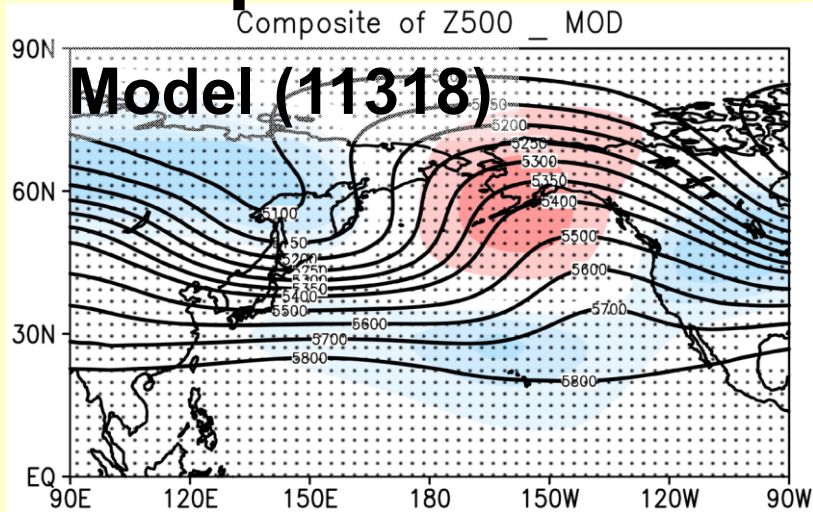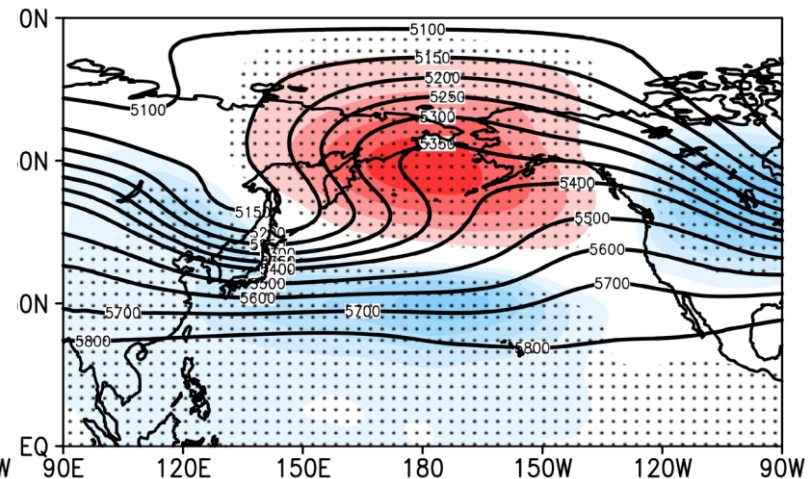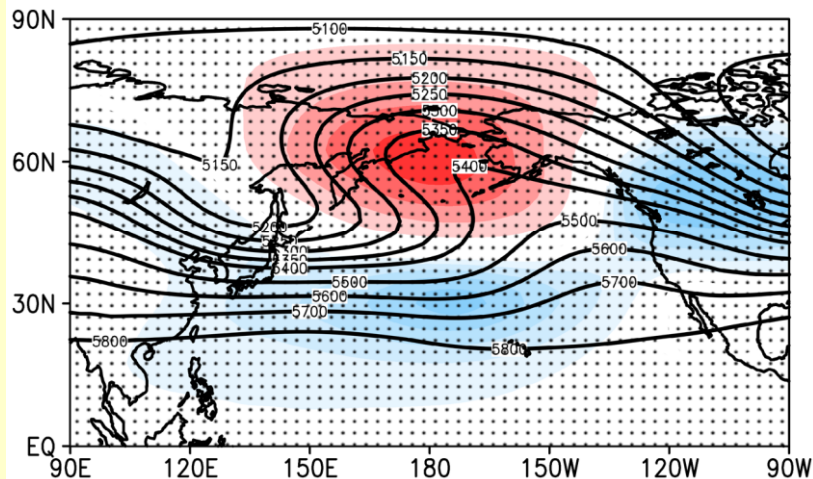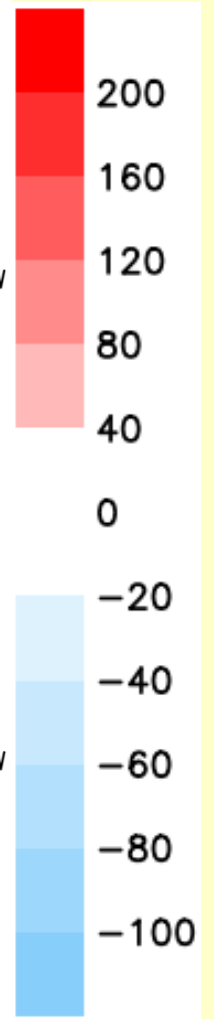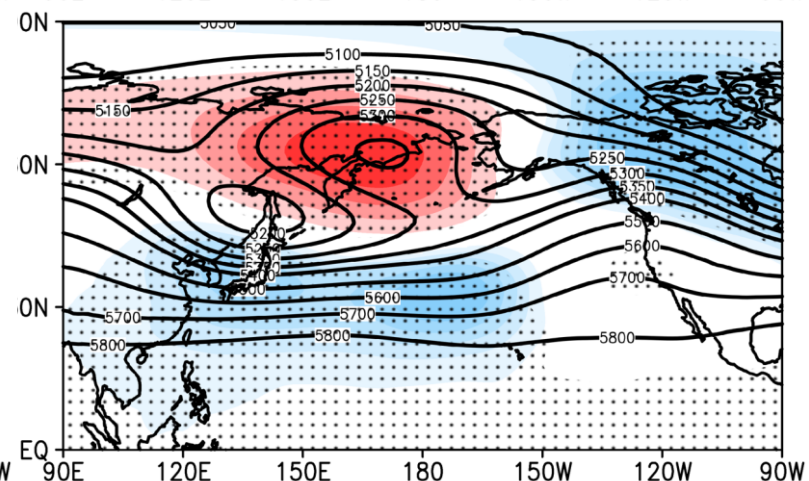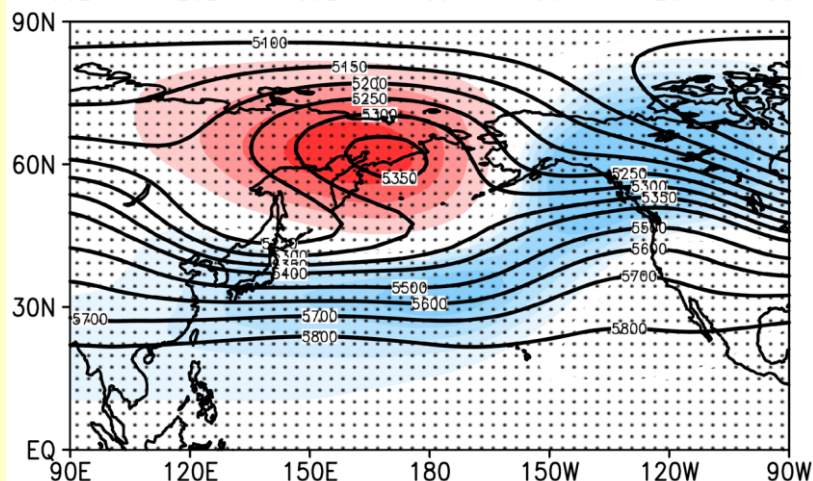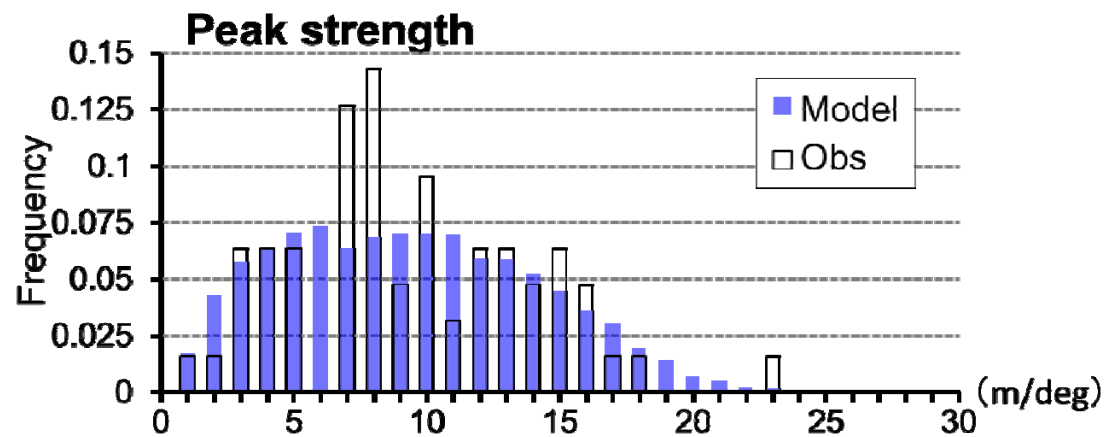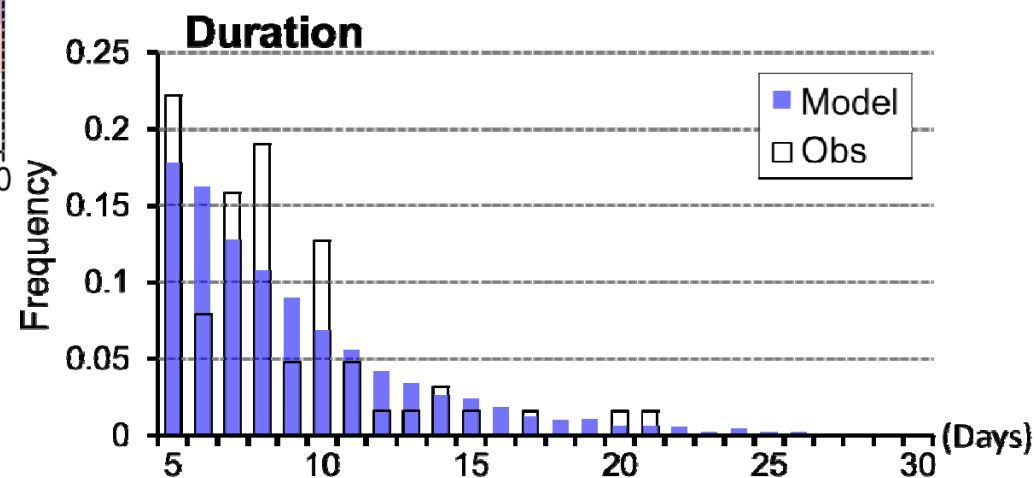
# Simulated blocking

Blocking days per winter



Obs
Model

Blocking Index by Tibaldi and Molteni (1990)

@Kamchatka

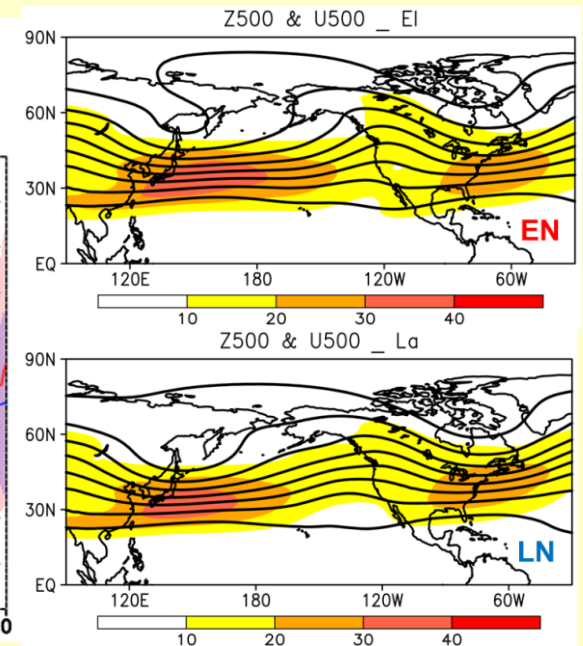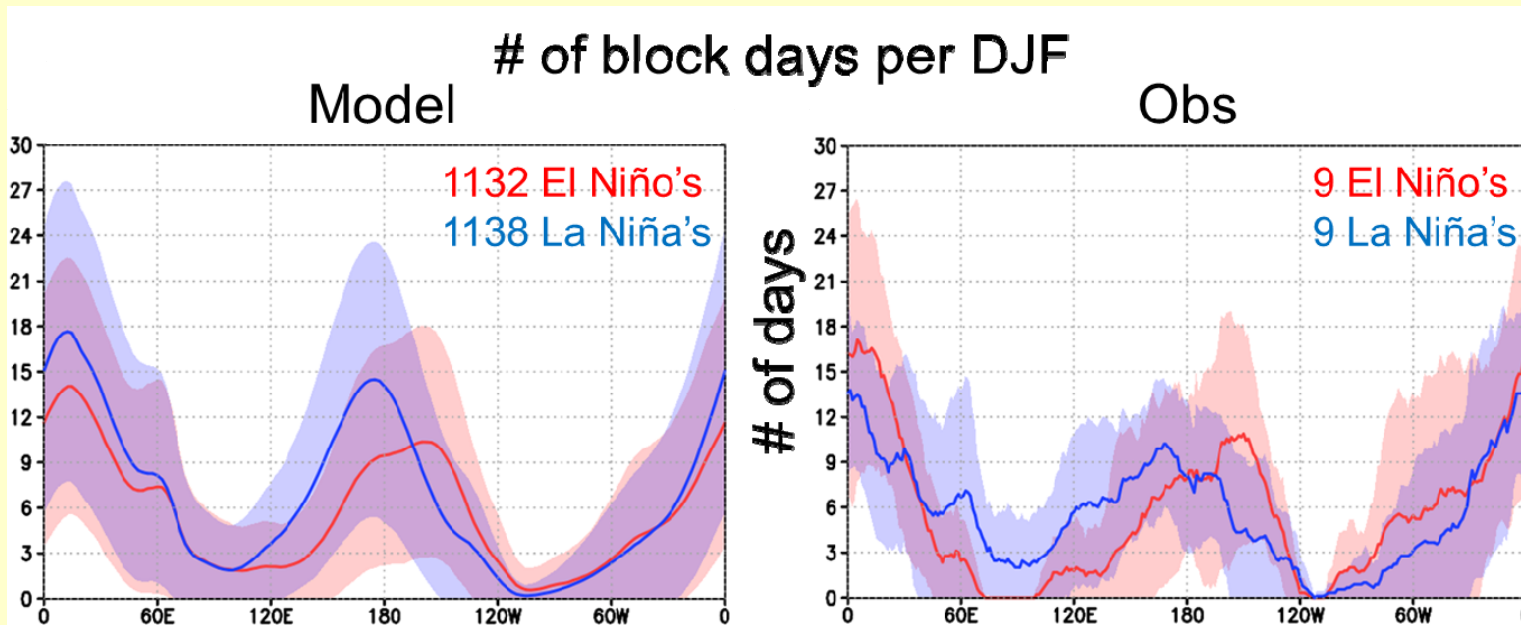| Kamchatka (150E-170E) | # of events | # of events per DJF |
|---|---|---|
| Obs | 63 | 1.2 |
| Model | 8571 | 1.4 |



Duration

Model
Obs

(Days)



Peak strength

Model
Obs

(m/deg)

# Forced interannual variability of blocking activity



Number of events vs. NINO3  Corr = -0.71
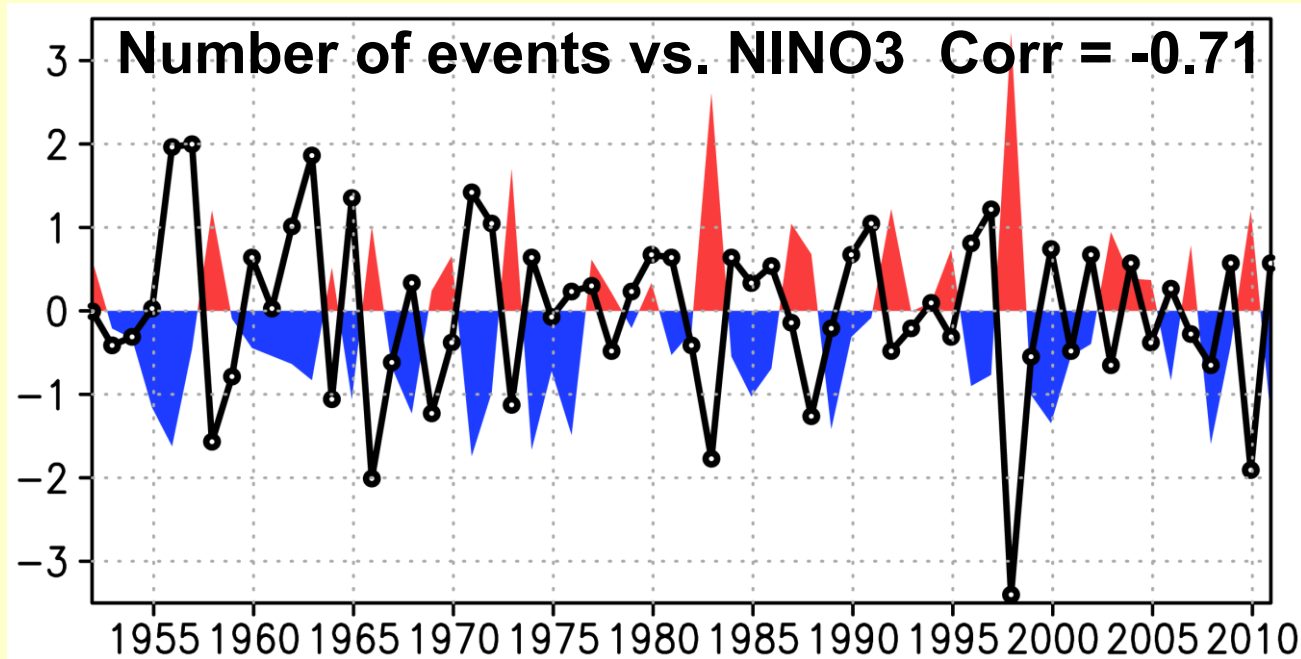
| Regression against NINO3 | |
|---|---|
| # of events | -0.2±0.03 /K |
| Persistence | -1.1±0.09 day/K |
| Strength | -1.1±0.11 m/deg·K |

# of block days per DJF

Model

1132 El Niño's
1138 La Niña's

Obs
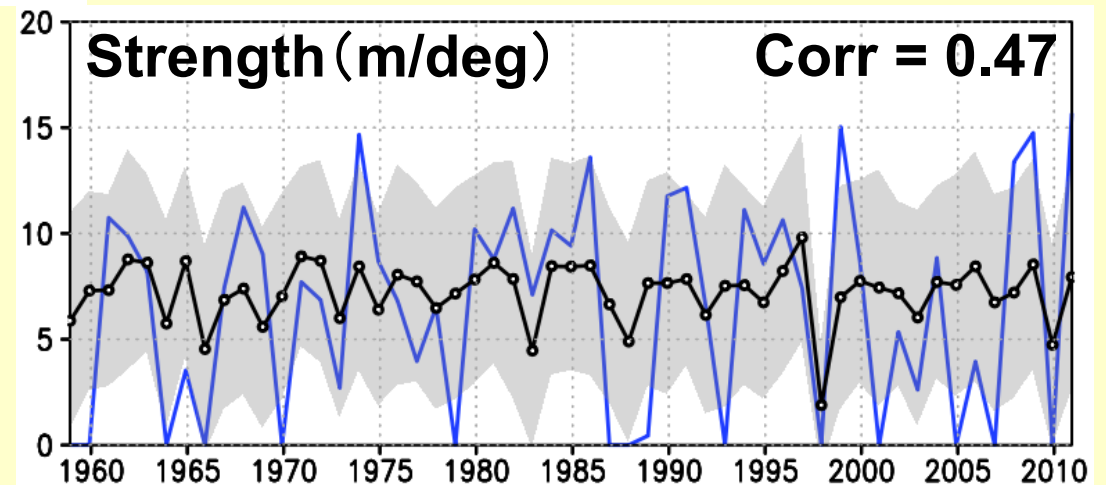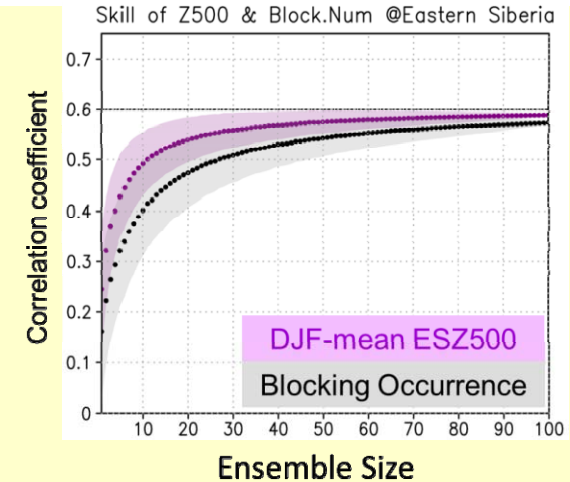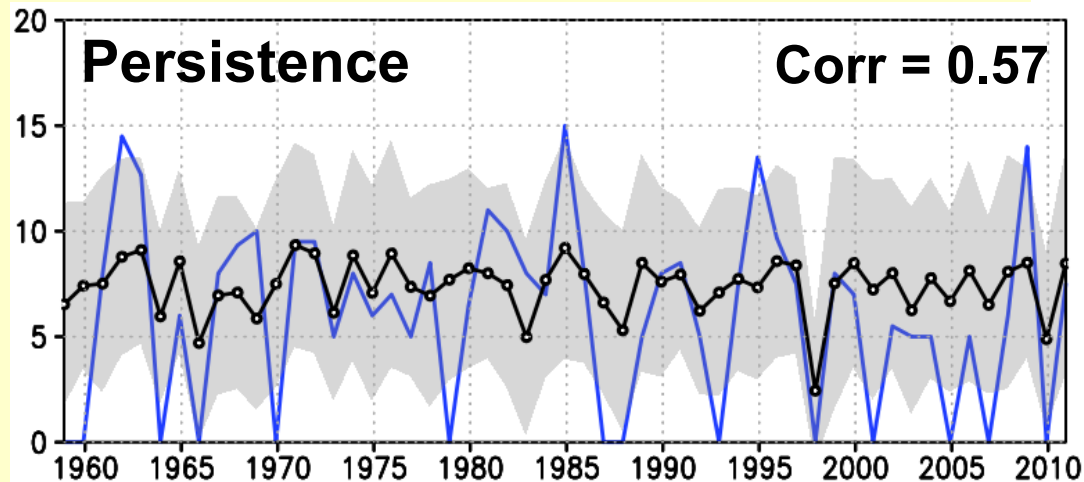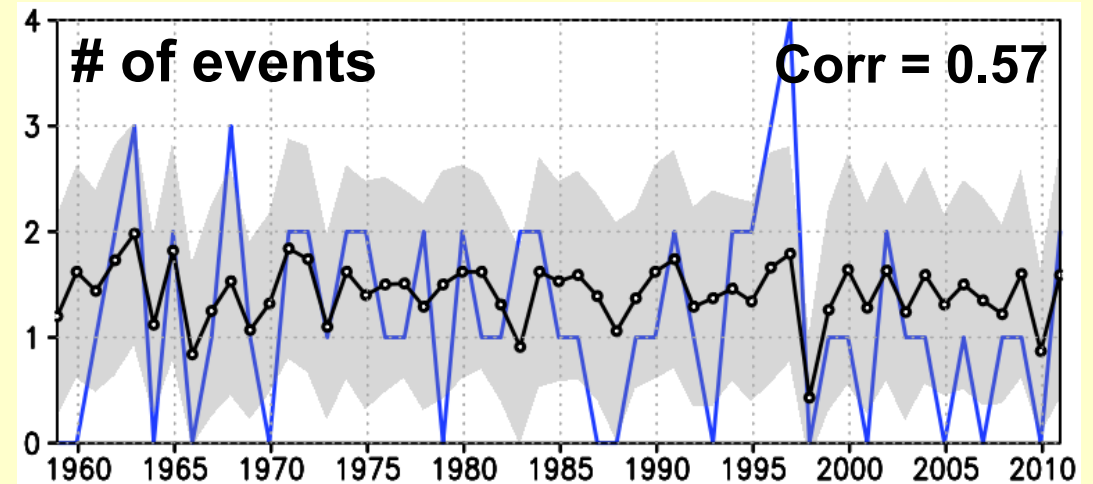
9 El Niño's
9 La Niña's

# of days

# Interannual variability of blocking activity: Comparison w/ Observation
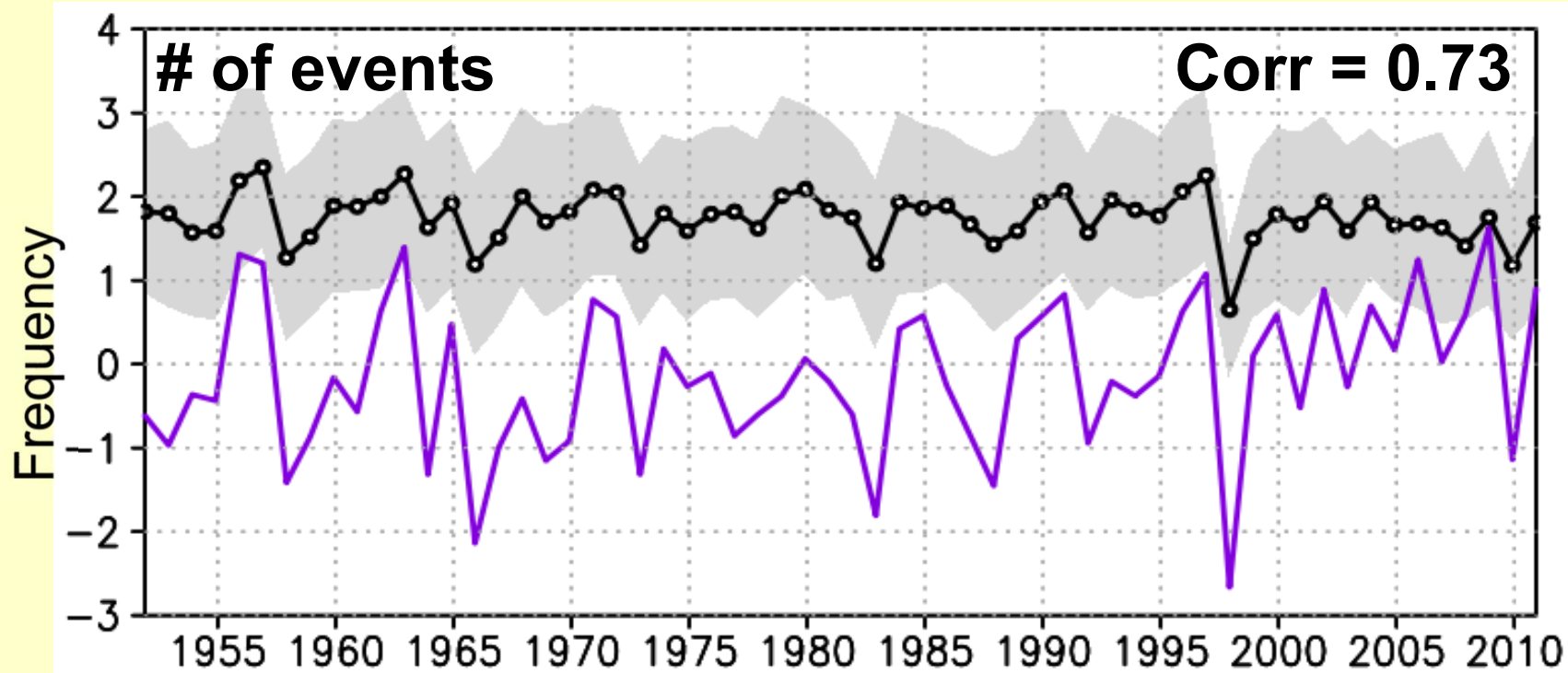
@Kamchatka
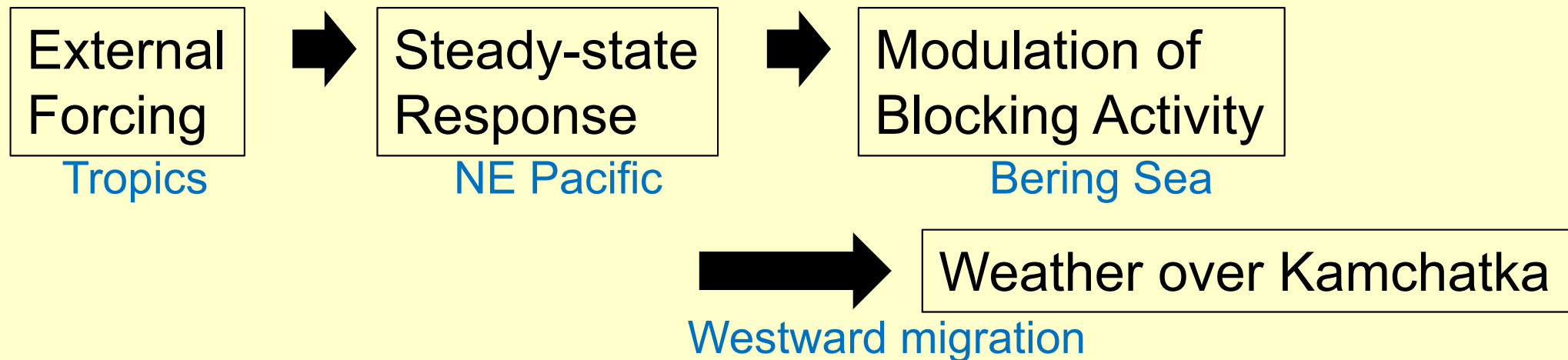Blue : Obs
Black: Model ensemble mean
Shades: 1σ spread

# Contribution of blockings over the Bering Sea



Black：# of block occurrence over the Bering Sea (/DJF, 100EM）
Shades: 1σ spread
Purple: DJF Z500 anomaly over Kamchatka (×1/20, 100EM）

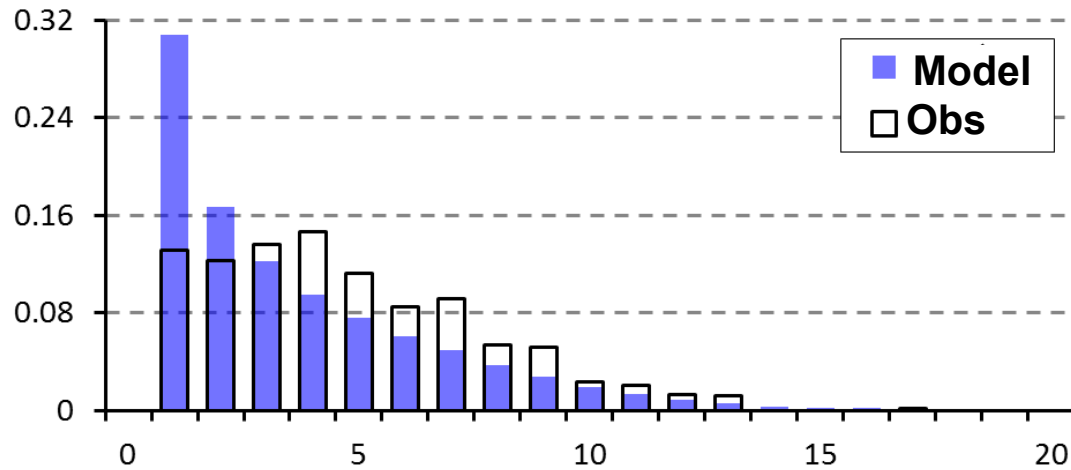| External Forcing | ➡ | Steady-state Response | ➡ | Modulation of Blocking Activity |
| --- | --- | --- | --- | --- |
| Tropics | | NE Pacific | | Bering Sea |

➡ Weather over Kamchatka

Westward migration

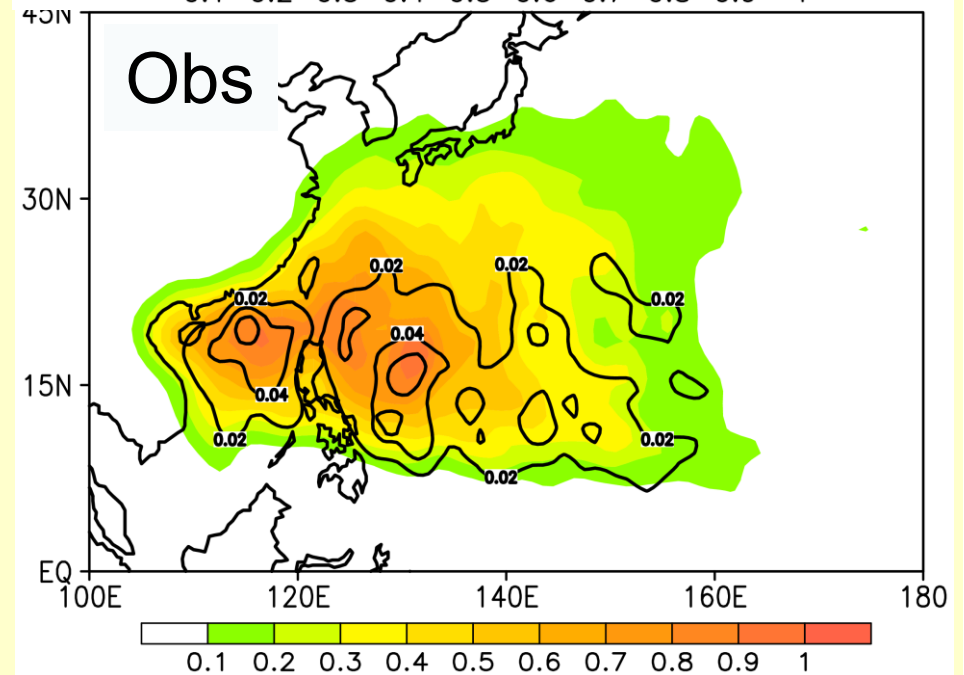# 2. Seasonal Predictability of TC activities?

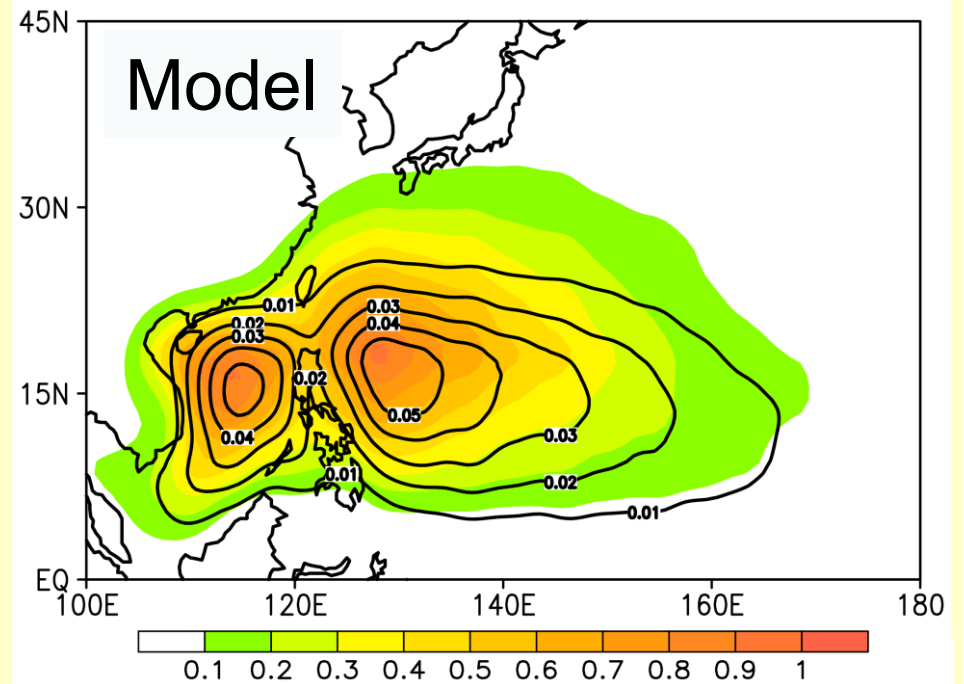# Validation of simulated TCs

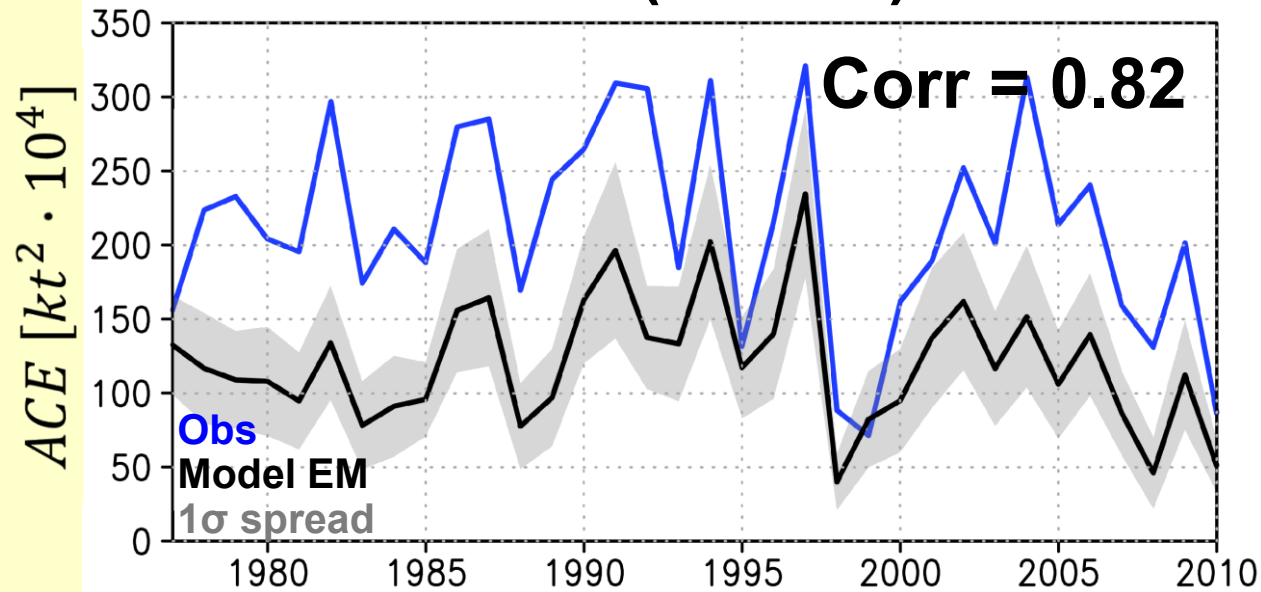PDFs of formation (contour) and track (shades)

## Duration (days)



## Max wind speed (m/s)



d4PDF TC track data provided by K. Yoshida



Model



Obs

# ACE (annual)

**Corr = 0.82**



Obs
Model EM
1σ spread
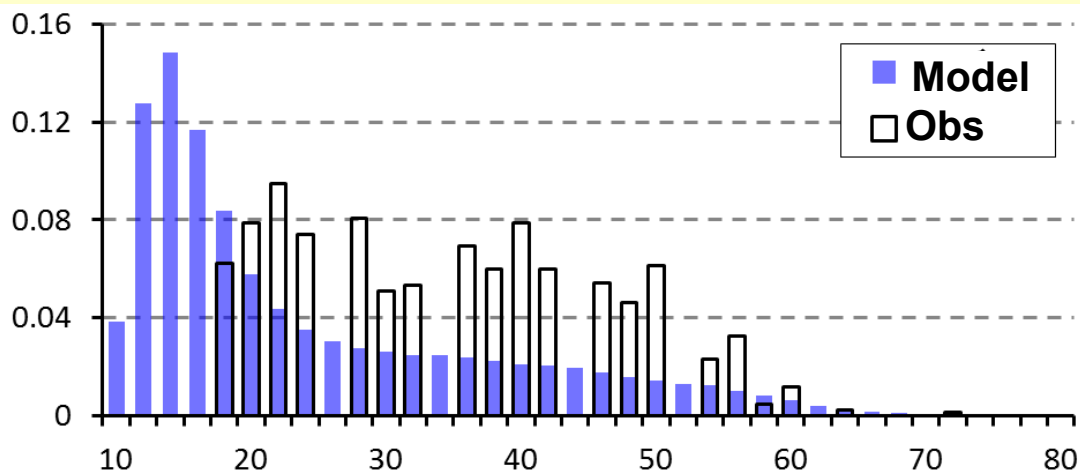
**ACE** (Accumulated Cyclone Energy)

$$ACE = 10^{-4} \sum (v_{max})^2 \; [kt^2]$$

$\propto$ (Number) $\times$ (Duration) $\times$ (Strength)

Domain: WNPAC(100E-180E,0-60N)

### ACE monthly climatology



Obs
Model
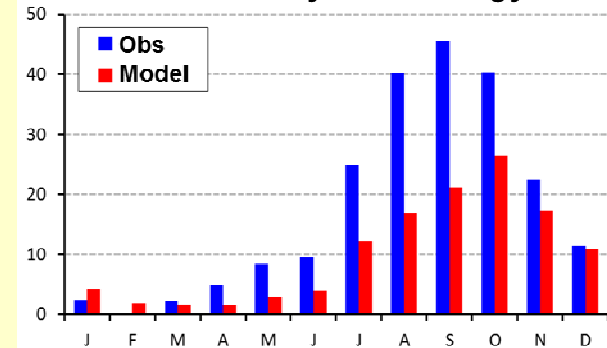
# Correlation Coefficients

| Model | ACE | NUM | DUR | MAX |
|-------|-----|-----|-----|-----|
| ACE | **0.82** | **0.67** | **0.88** | **0.69** |
| NUM | **0.92** | **0.58** | 0.38 | 0.10 |
| DUR | **0.95** | **0.86** | **0.76** | **0.79** |
| MAX | **0.86** | **0.71** | **0.86** | 0.47 |

Obs

# SST regressed against ACE
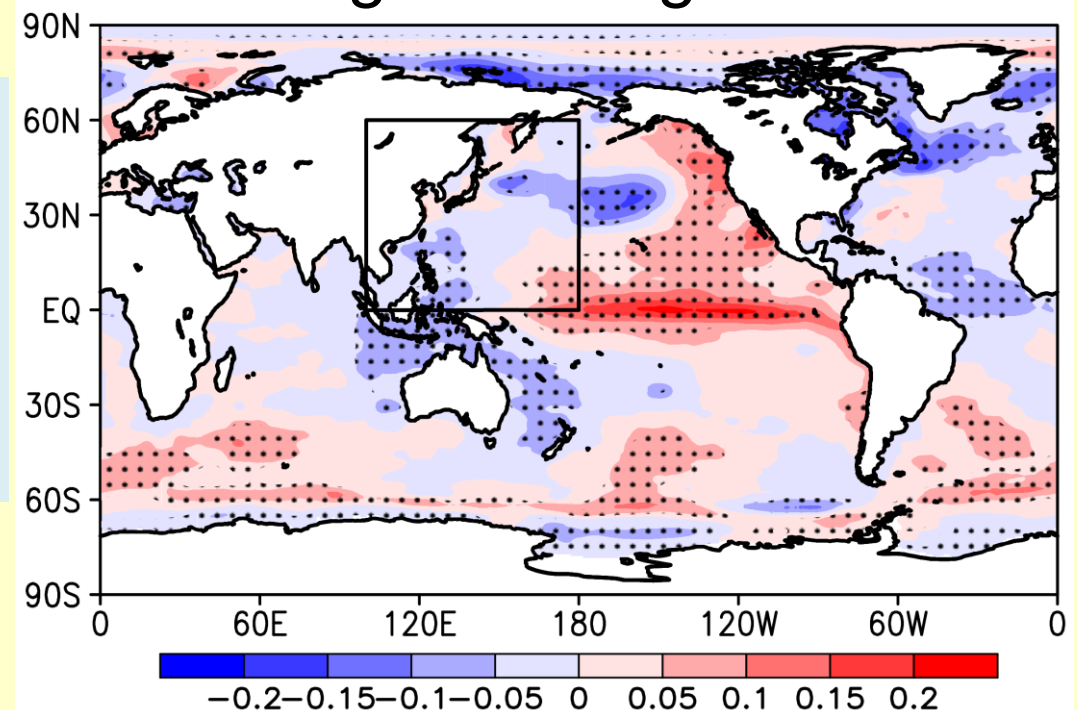
# Factors contributing to interannual variability of ACE


WIND850/OLR regressed against ACE (JJA)


WIND850/OLR against MWI


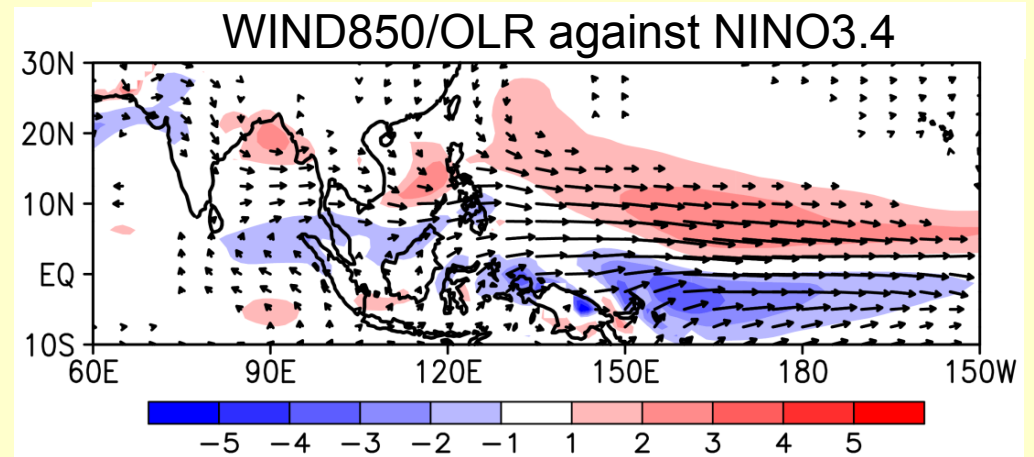WIND850/OLR against NINO3.4
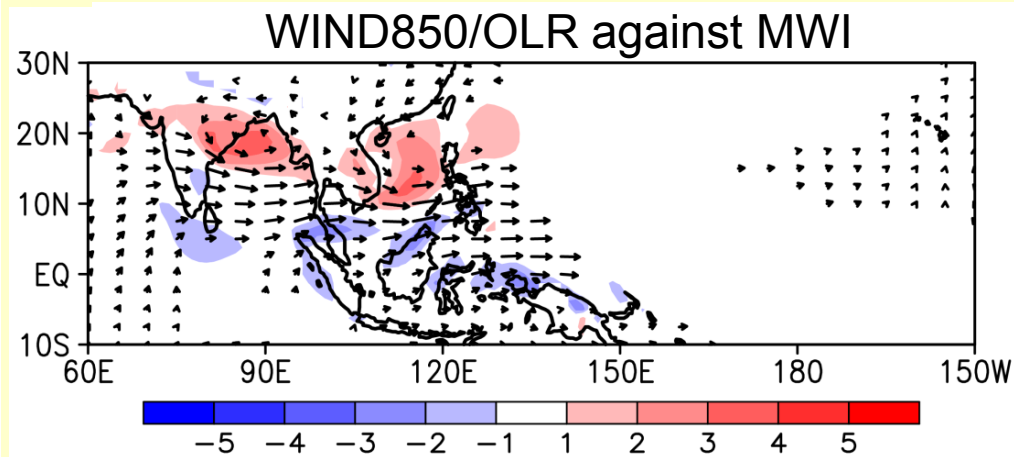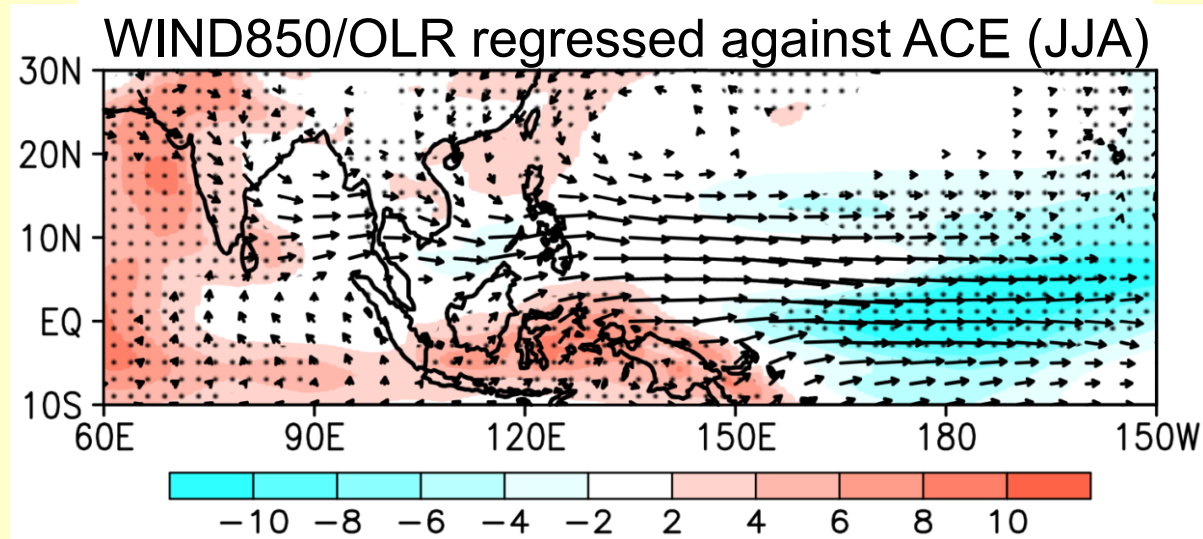
**Asian Monsoon**

Convergence/Shear line w/trades

↓ positive vorticity

Trigger of TC formation

（Sadler 1967）

**El Niño**

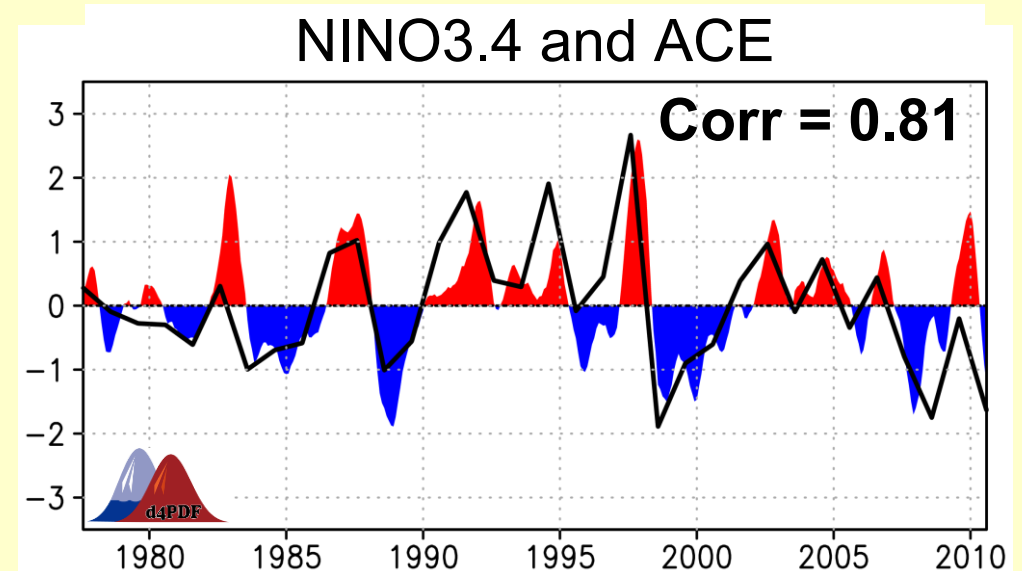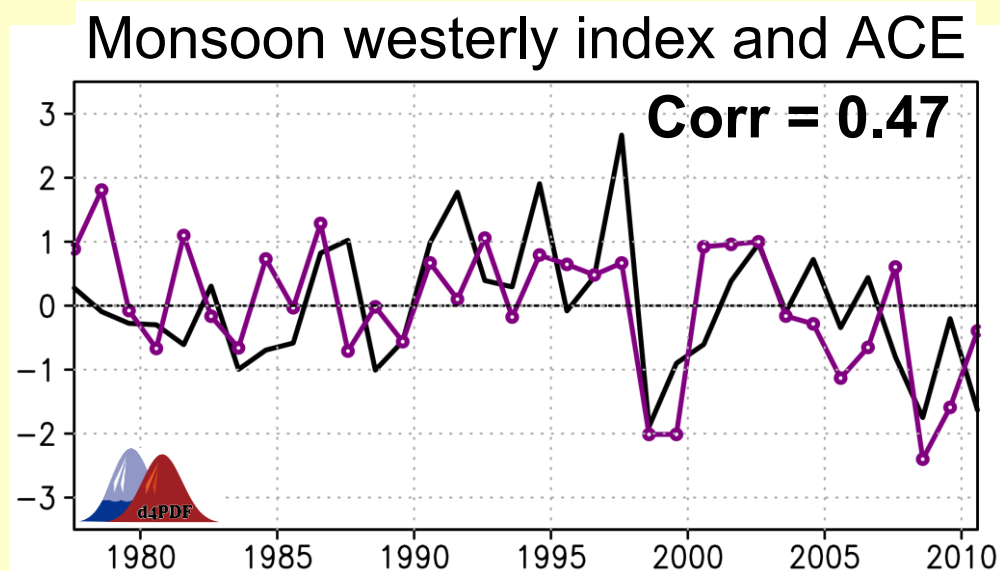Formation: increase in central PAC

↓ westward migration

Long duration over high SST

↓ energy input from ocean

More duration/stregth

（Camargo and Sobel 2005）

# ENSO/Monsoon contributions



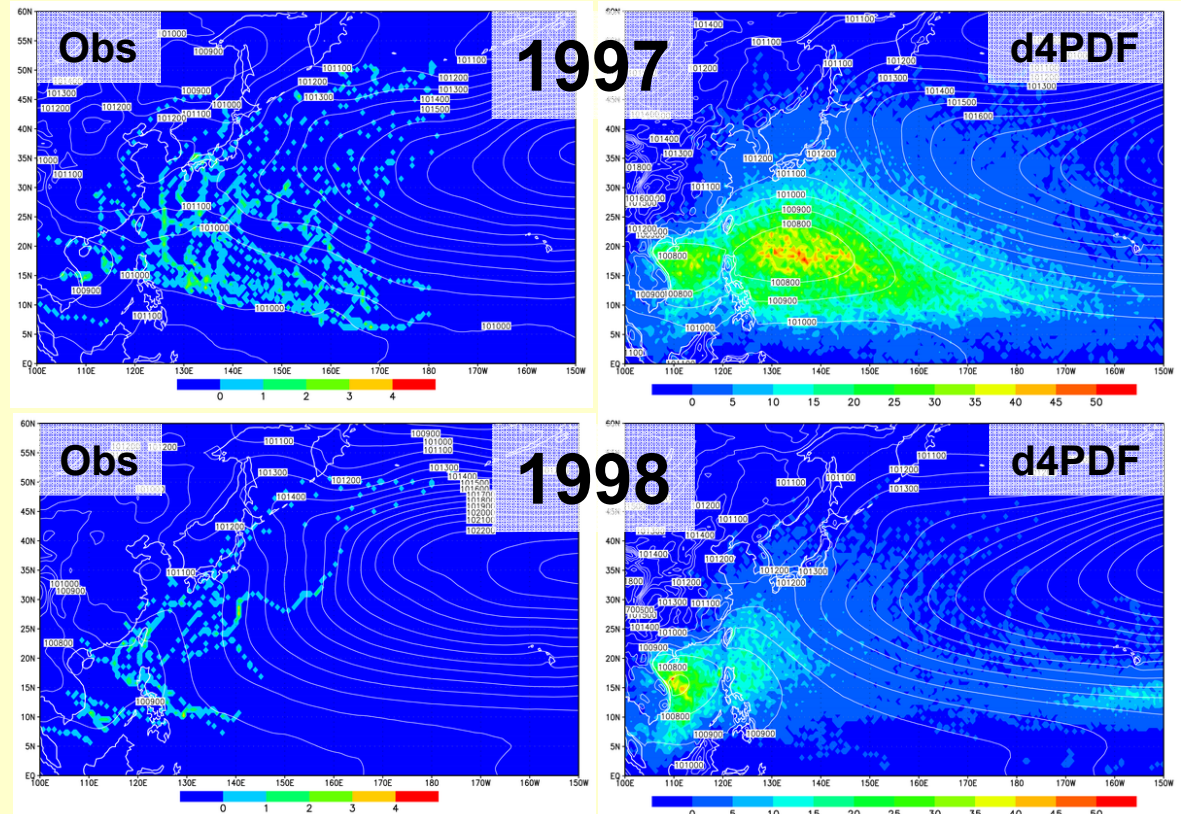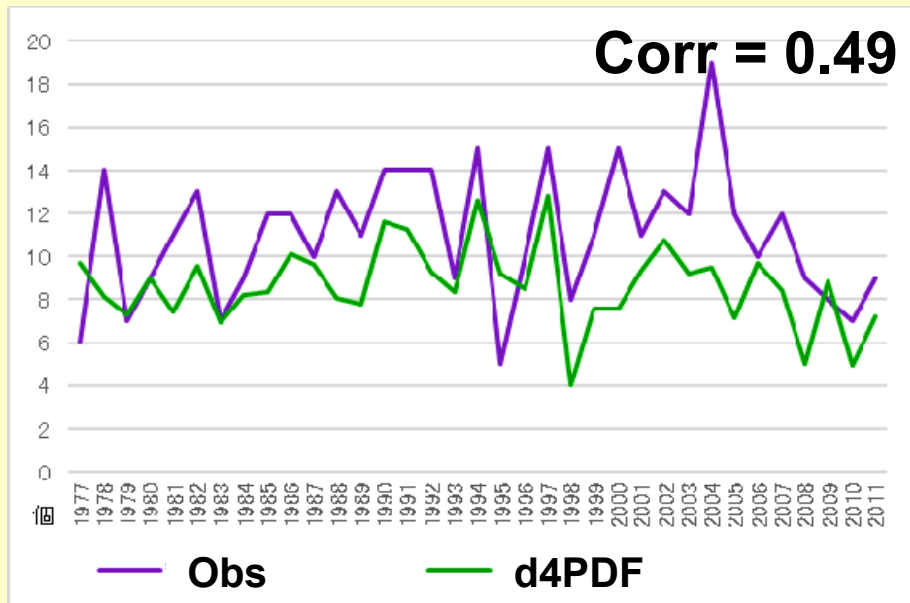Monsoon westerly index and ACE — Corr = 0.47

NINO3.4 and ACE — Corr = 0.81

## Multiple Regression

$$ACE = \alpha \times NINO3.4 + \beta \times Monsoon + \epsilon$$

| | Multiple Reg. | Fractional Contribution (%) | | |
| --- | --- | --- | --- | --- |
| | | NINO+MWI | NINO3.4 | Monsoon |
| Model | 0.90 | 0.79 | 0.59 | 0.15 |
| Obs | 0.76 | 0.56 | 0.51 | 0.05 |

# # of TCs approaching Japan*

* within 300km from JMA stations
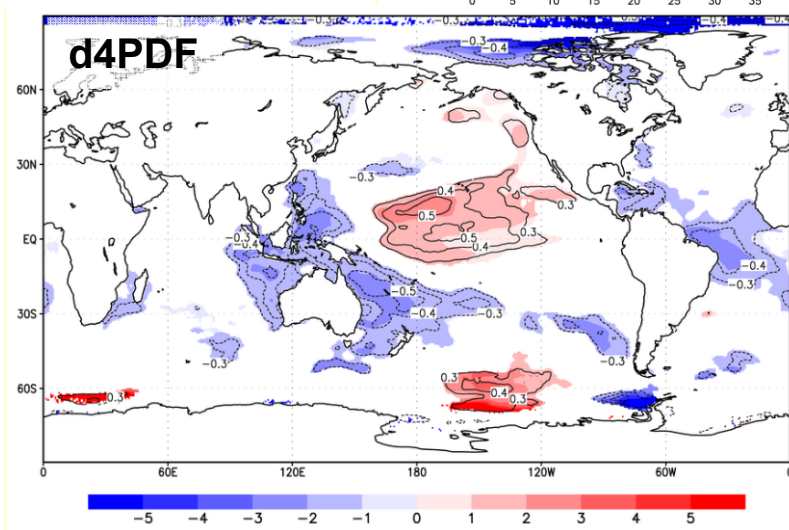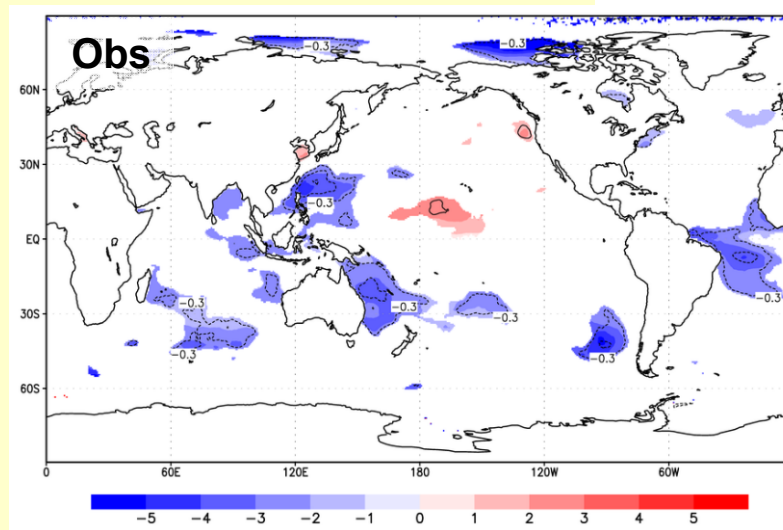
# Summary

- Large ensemble data set enables to explore forced modulation of subseasonal variability, such as blocking, tropical cyclones, and possibly other high-impact weather events.



**Large-scale circulation associated w/ > 100mm/day events in July**

d4PDF 20km rainfall X 60km fields

West Kyushu

East Kyushu

30yrs X 100 member

Z850(color), vertically integrated moisture flux (→)

Fig. courtesy of Y. Imada