Climate Mechanism for Stronger Typhoons in a Warmer World

Nam-Young Kang[1,2] and James Elsner[2]

[1] National Typhoon Center / KMA
[2] Geophysical Fluid Dynamics Institute / FSU

Relevant works to this topic

Publications

N.-Y. Kang and J. B. Elsner, An empirical framework for tropical cyclone climatology, Climate Dynamics, 39, 659-680 (2012).

N.-Y. Kang and J. B. Elsner, Consensus on climatic trends in western North Pacific tropical cyclones, Journal of Climate, 25, 7564-7573 (2012).

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Thank you

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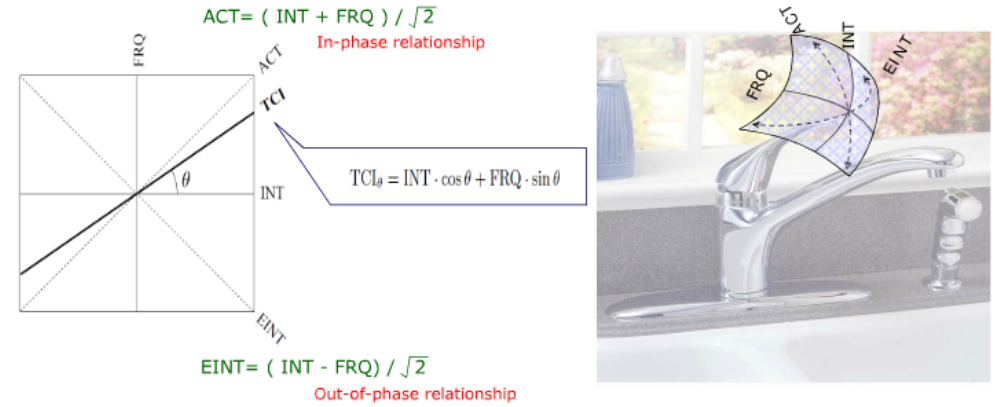
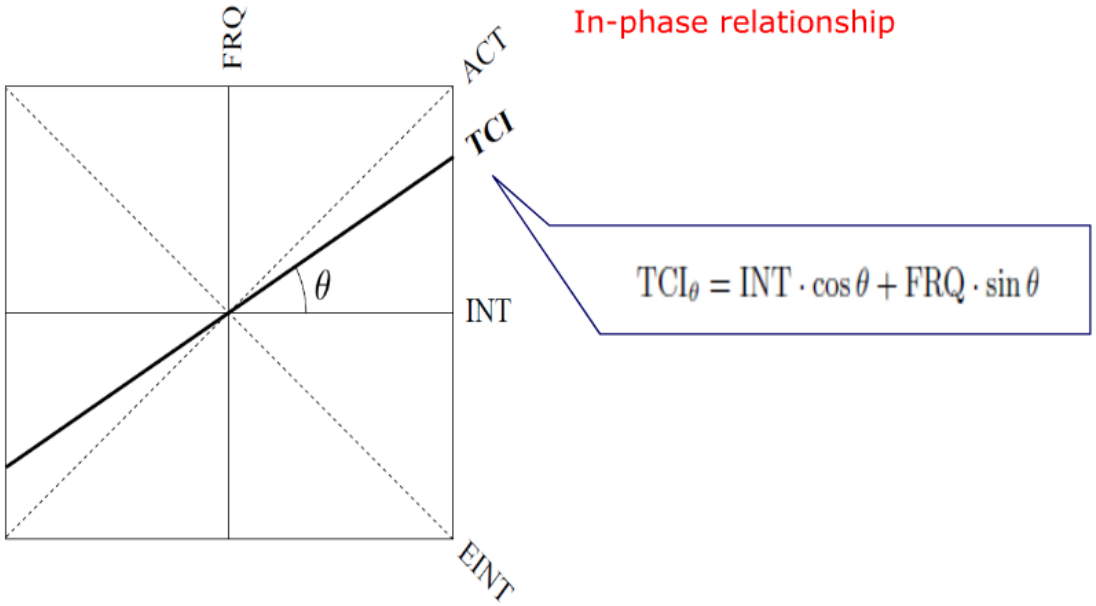
1. Analysis Framework



- TCI represents a weighted linear combination of INT and FRQ.
- ACT and EINT are the special cases when θ is +45° and -45°, respectively.

ACT= (INT + FRQ) / $\sqrt{2}$

In-phase relationship



EINT= (INT - FRQ) / $\sqrt{2}$

Out-of-phase relationship

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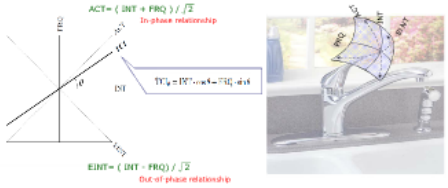

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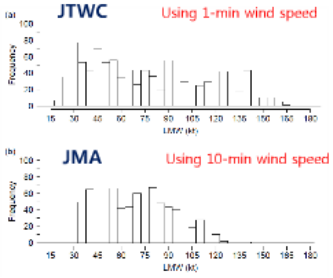
2. Reliable Data Period of Observational consensus

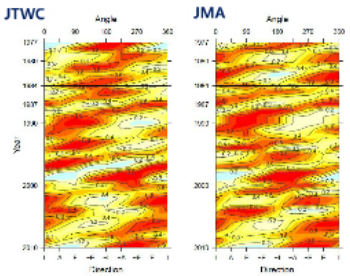
Histogram of lifetime-maximum wind (LMW)



Data : JTWC & JMA / 1977-2009 (34 years)

Ranked probabilities of TC climate indicators

0.55 quantile is used as threshold LMW level



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3. Global Warming Effect on Western North Pacific TCs

Correlation screen of El Niño and global ocean warmth with TC climate variabilities

Time series of global ocean warmth and EINT

Schematic diagram of trade-off between I and F

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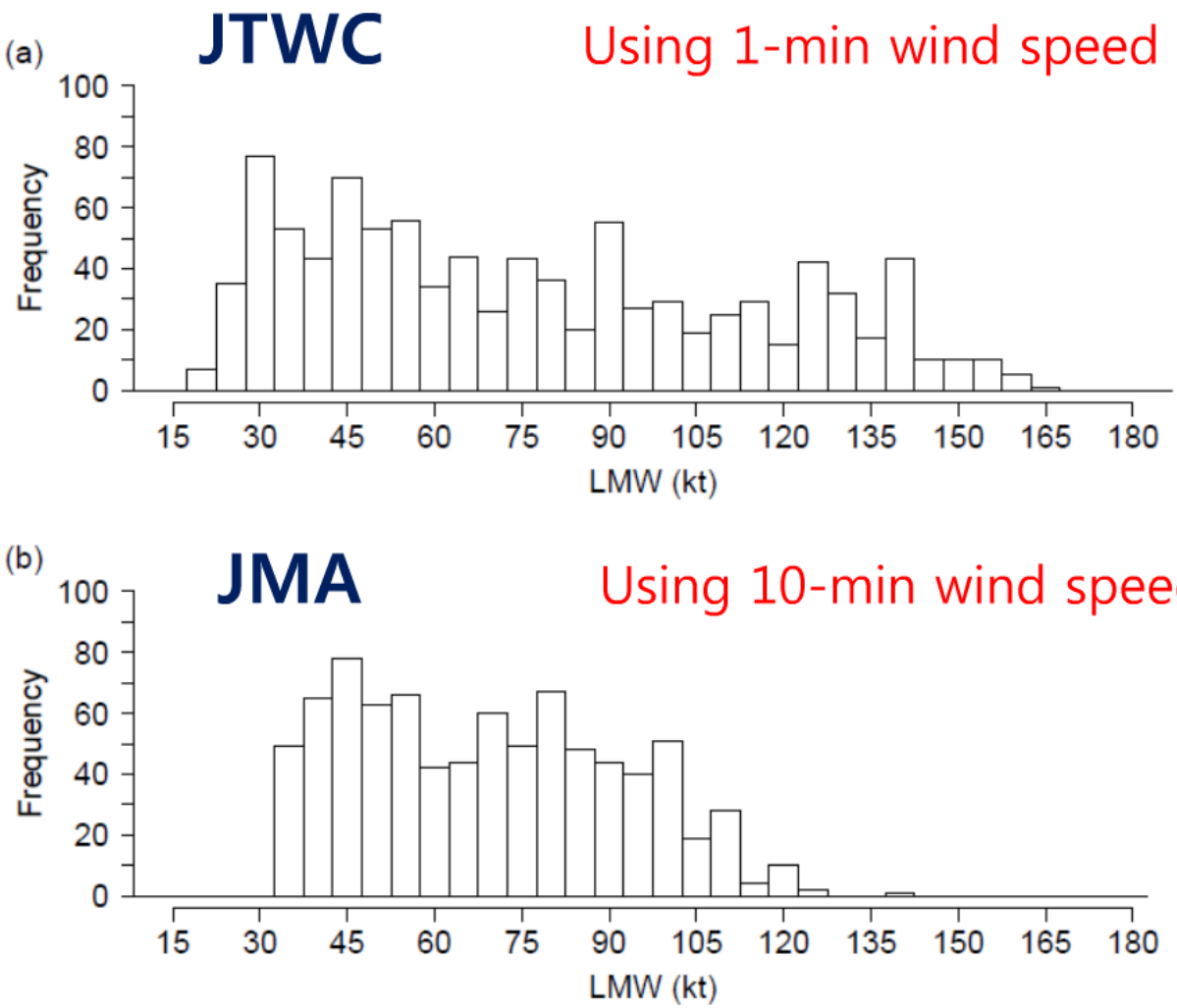

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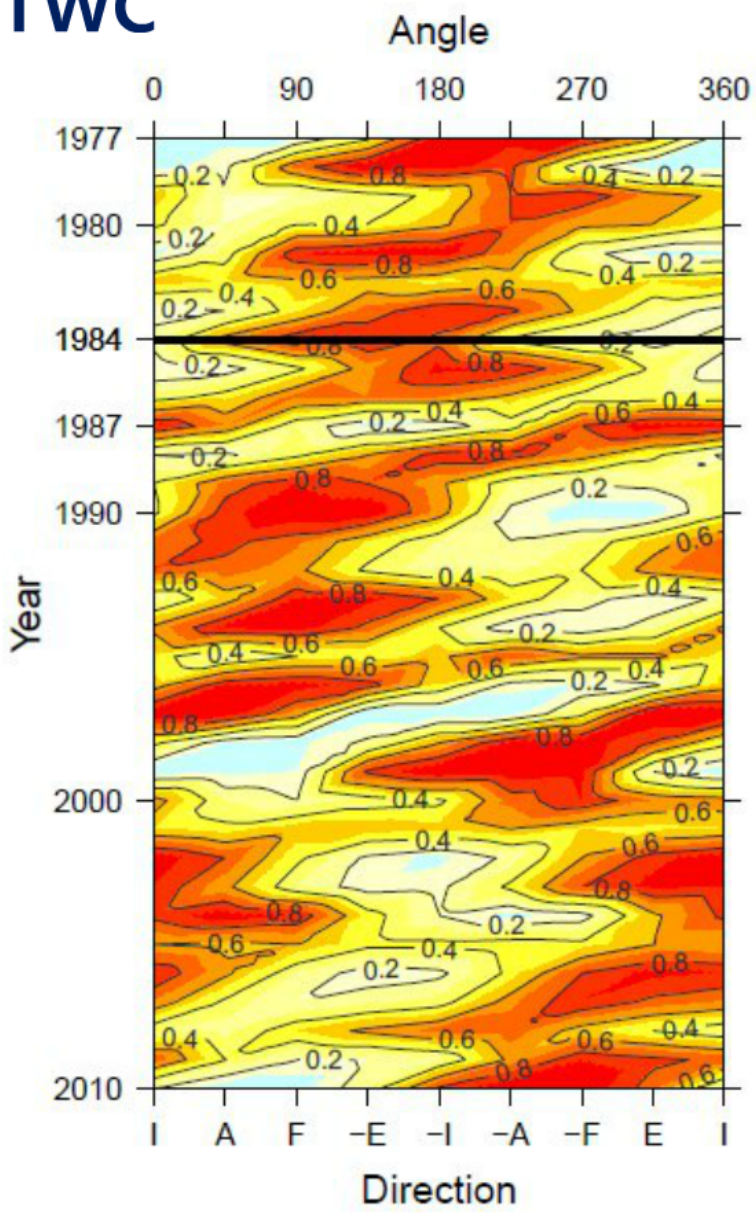
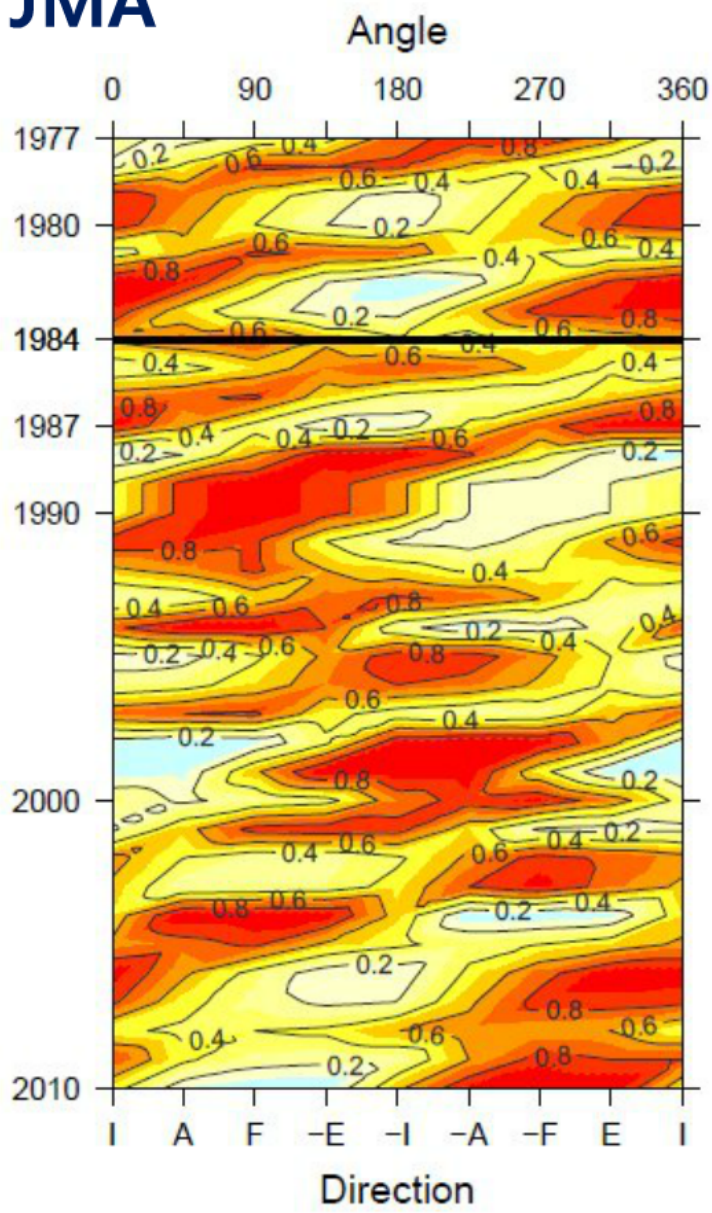
JTWC



JMA



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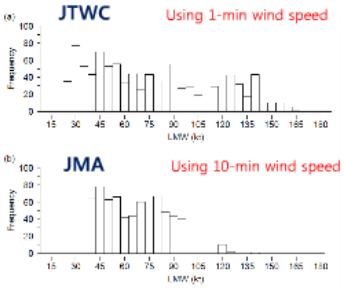

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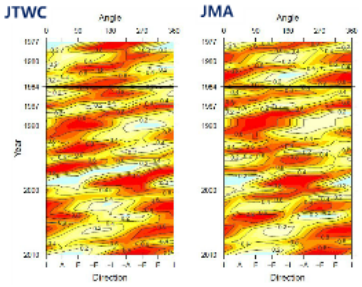

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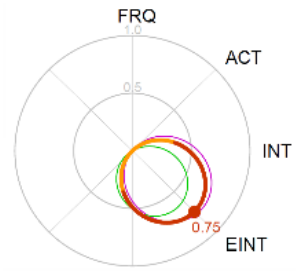
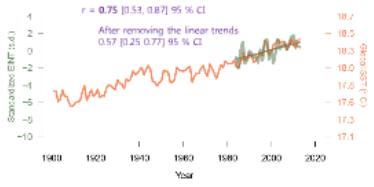


Data : JTWC / JJASON 1984-2013 (30 years)

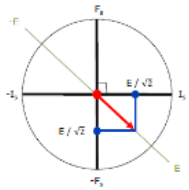
Time series of global ocean warmth and EINT



Data : NOAA ERSST V3b / JJASON 1901-2013 (113 years)
JTWC / JJASON 1984-2013 (30 years)

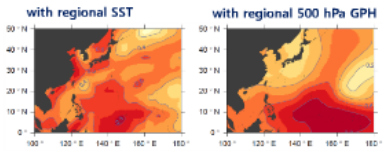
The results clarify that super typhoons are getting stronger at the expense of TC occurrence in our warming world.

Schematic diagram of trade-off between I and F

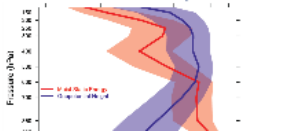


Reference σ : σ_I (standard deviation of I) and σ_F (standard deviation of F), simultaneously.
Trade-off rate : Trade-off rate is a fixed value which is determined by σ_I and σ_F.
For example, global trade-off rate is 0.21 ms^{-1} per TC.
As E increase, the trade-off amounts increase at this fixed rate.
Trade off amount : **[intensity]** $(E / \sqrt{2}) \times \sigma_I$ **[frequency]** $(E / \sqrt{2}) \times \sigma_F$

Correlation of global ocean warmth

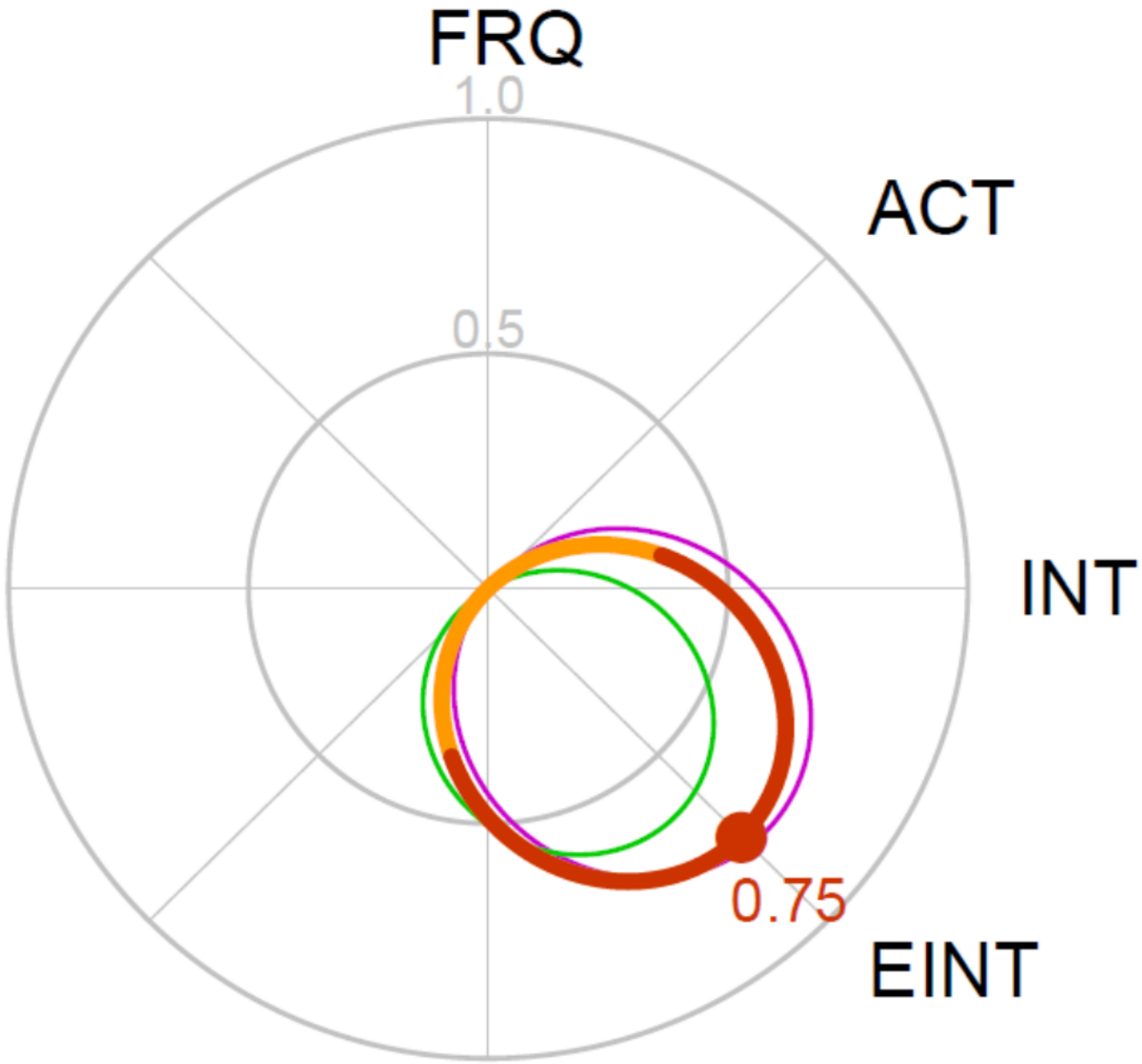


Correlation profile of global ocean warmth with MSE and GPH in the WNP tropics (0-30N, 100E-180)



Global warming and super typhoons

Correlation screen of El Niño and global ocean warmth with TC climate variabilities



Data : JTWC / JJASON 1984-2013 (30 years)

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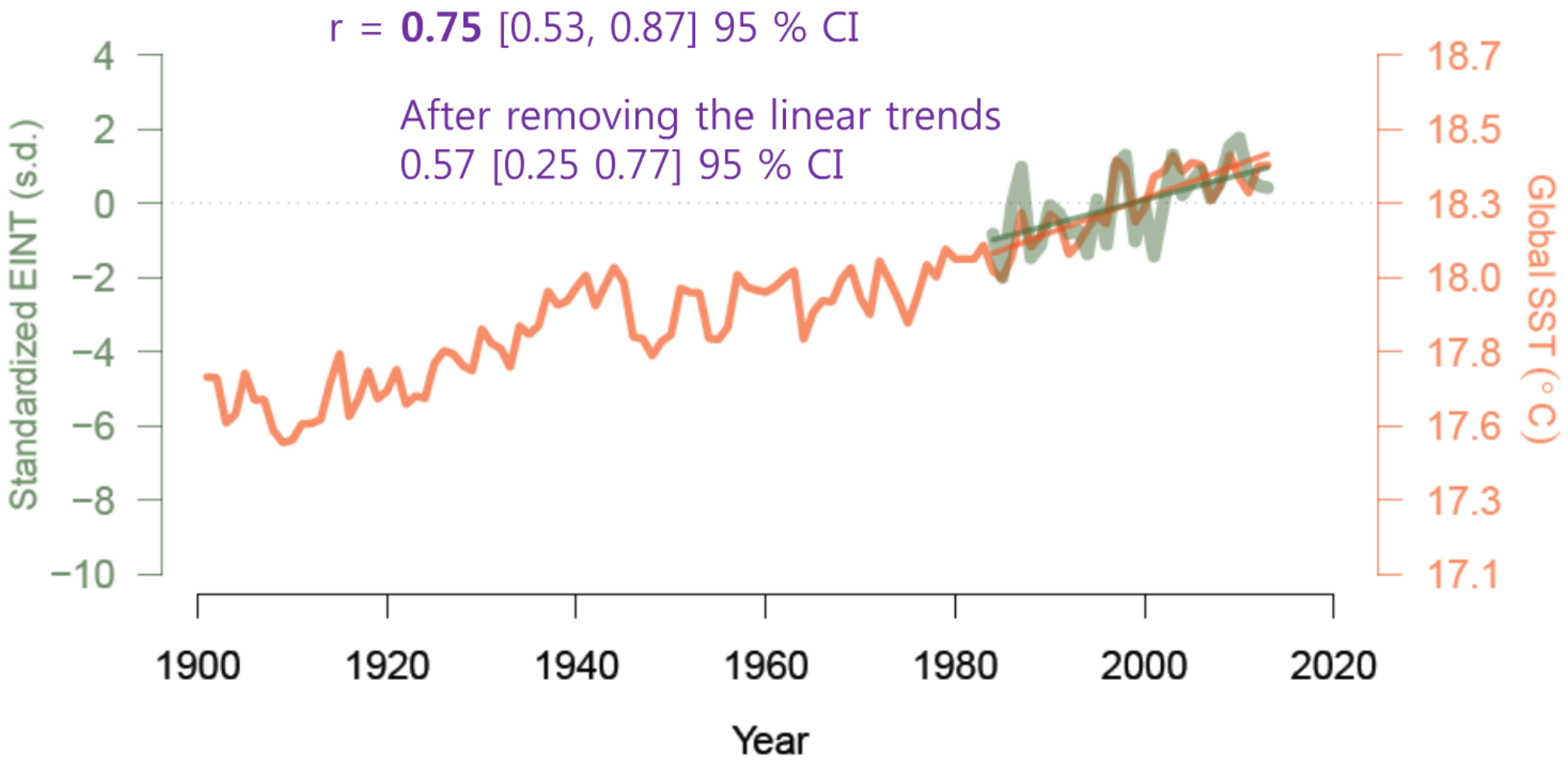

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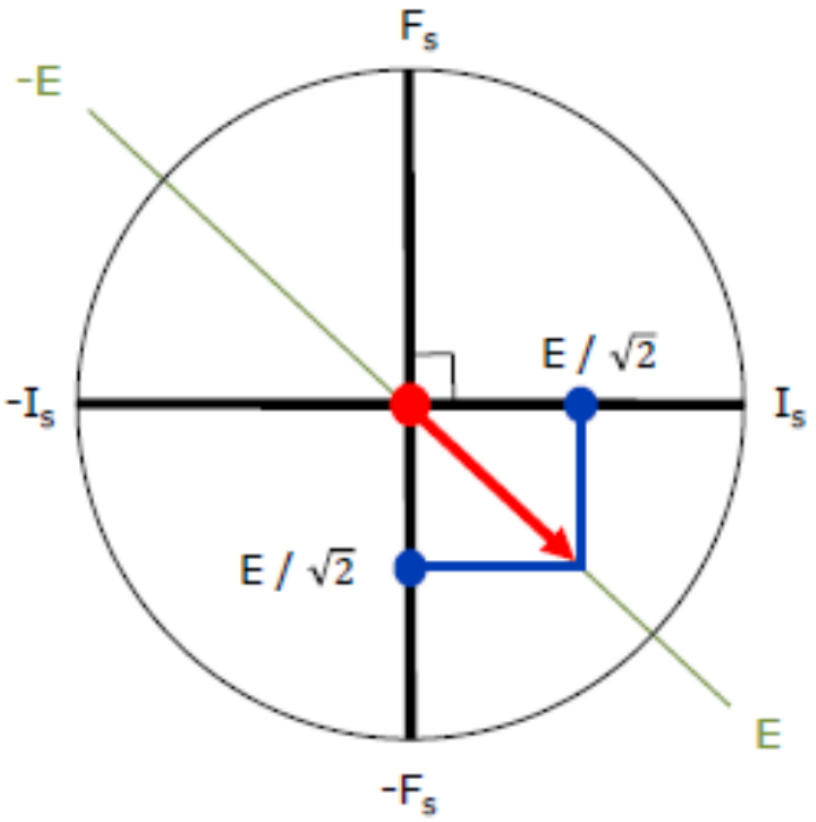

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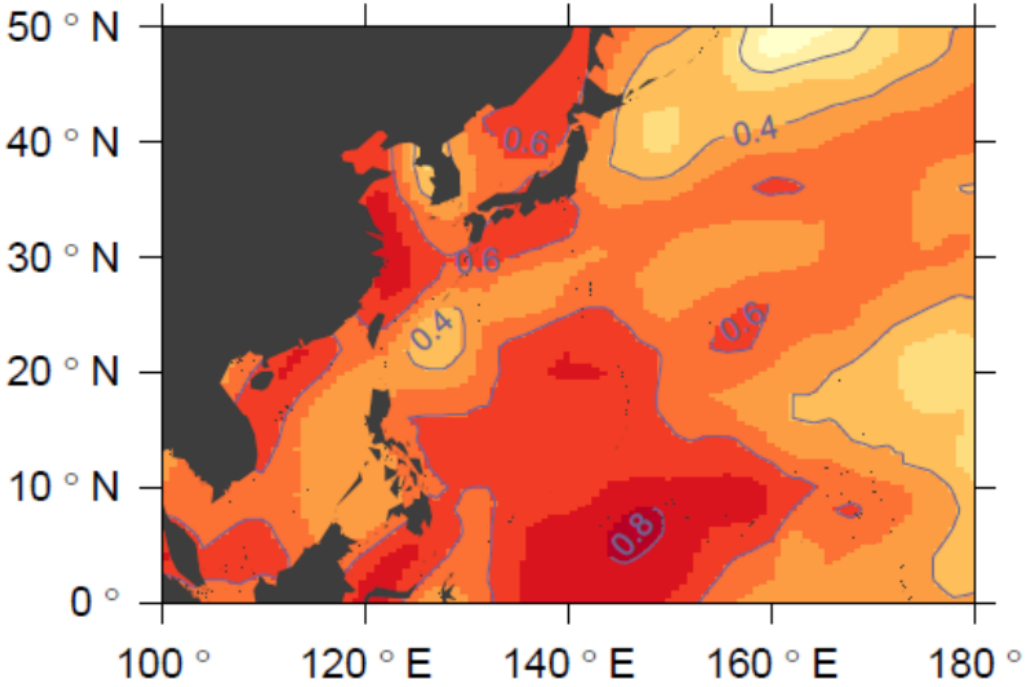
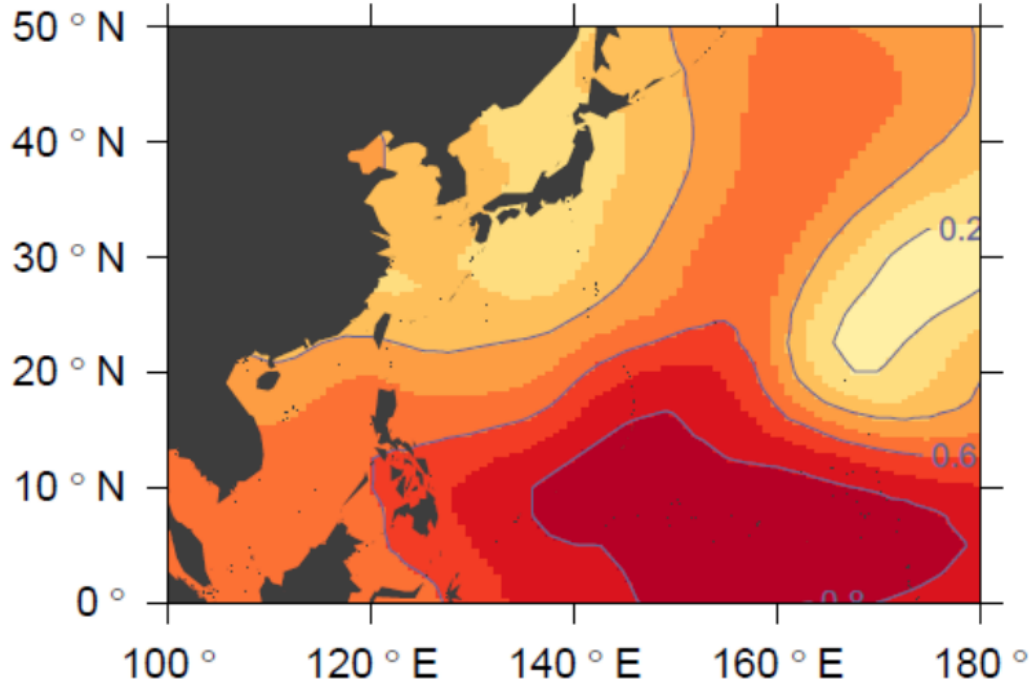
Correlation of global ocean warmth

with regional SST



with regional 500 hPa GPH



Partial correlation (El Nino influence removed)

Data : NCEP reanalysis / JJASON 1984-2013 (30 years)

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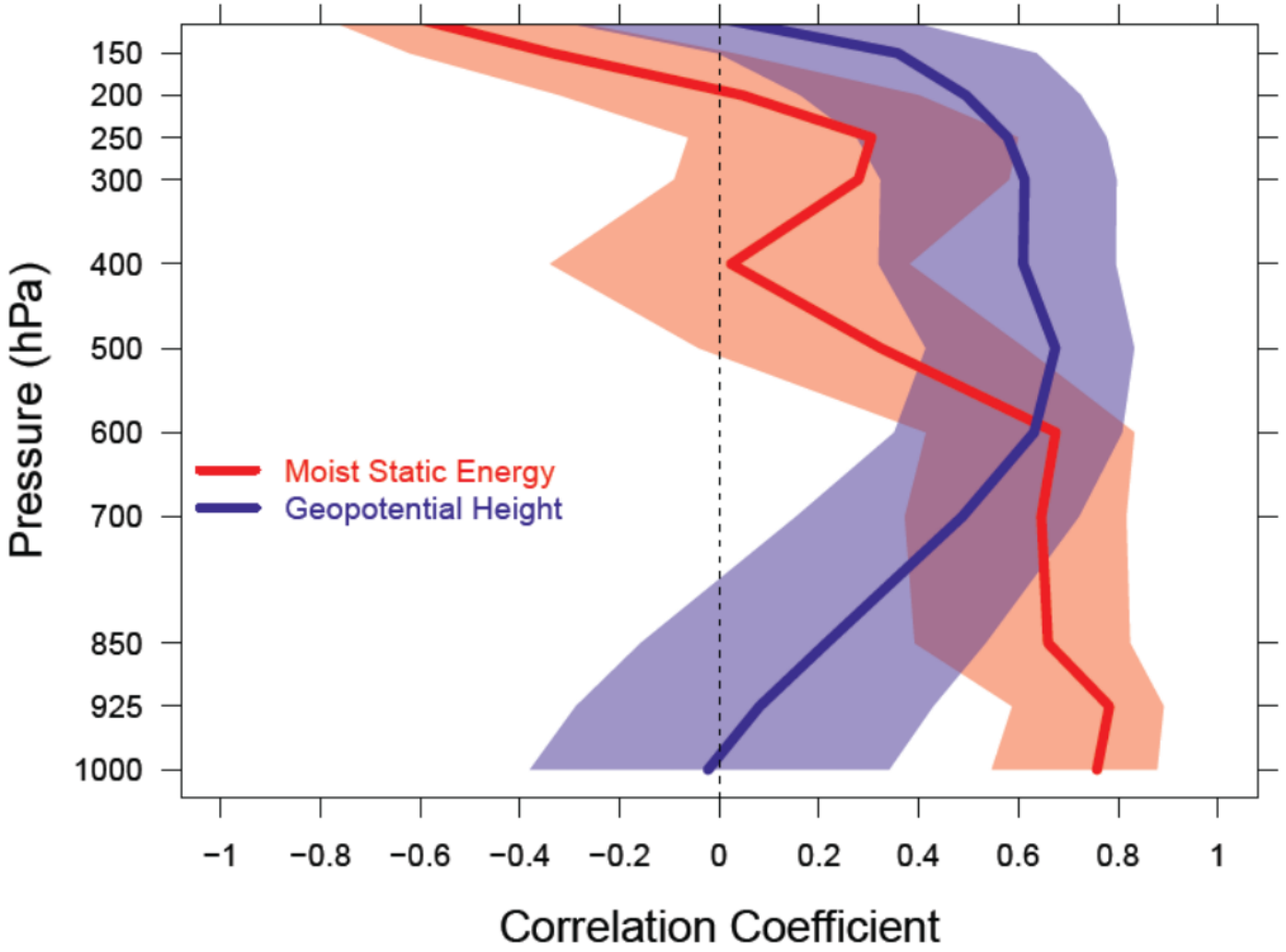


Partial correlation (El Nino influence removed)

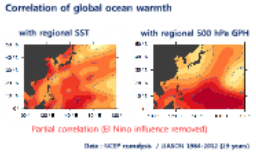
Data : NCEP reanalysis / JJASON 1984-2013 (30 years)

Global warming and super typhoons

+ GPH

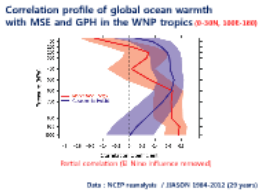
Stratification of Temperature anomaly over the region

Air temperature anomaly aloft increases following the moist adiabat



+ SST → + Moisture

Abundant moisture in the lower atmosphere

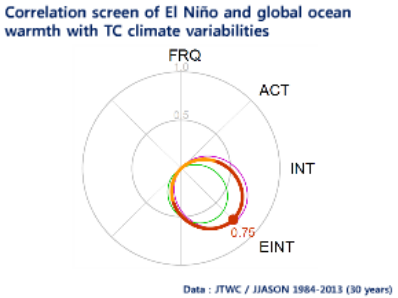


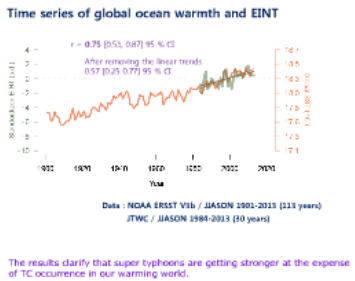
Moist static energy increases in the lower atmosphere

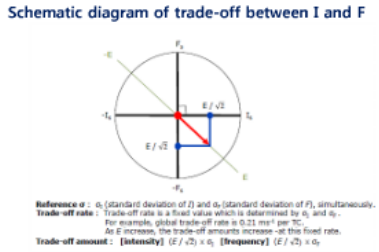
+ Convective instability

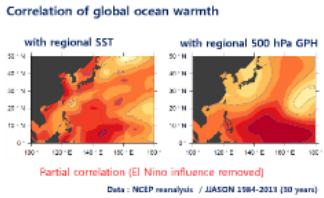
Less occurrences
but
extreme intensity

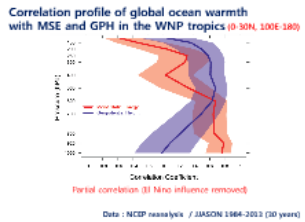

YouTube

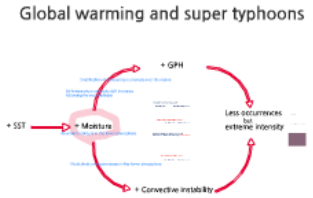




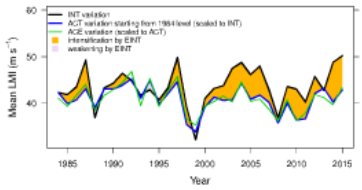


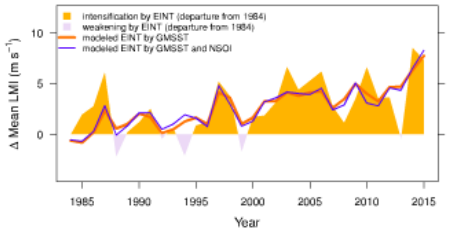




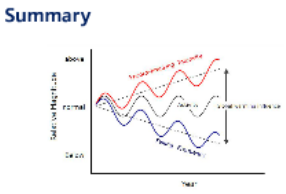


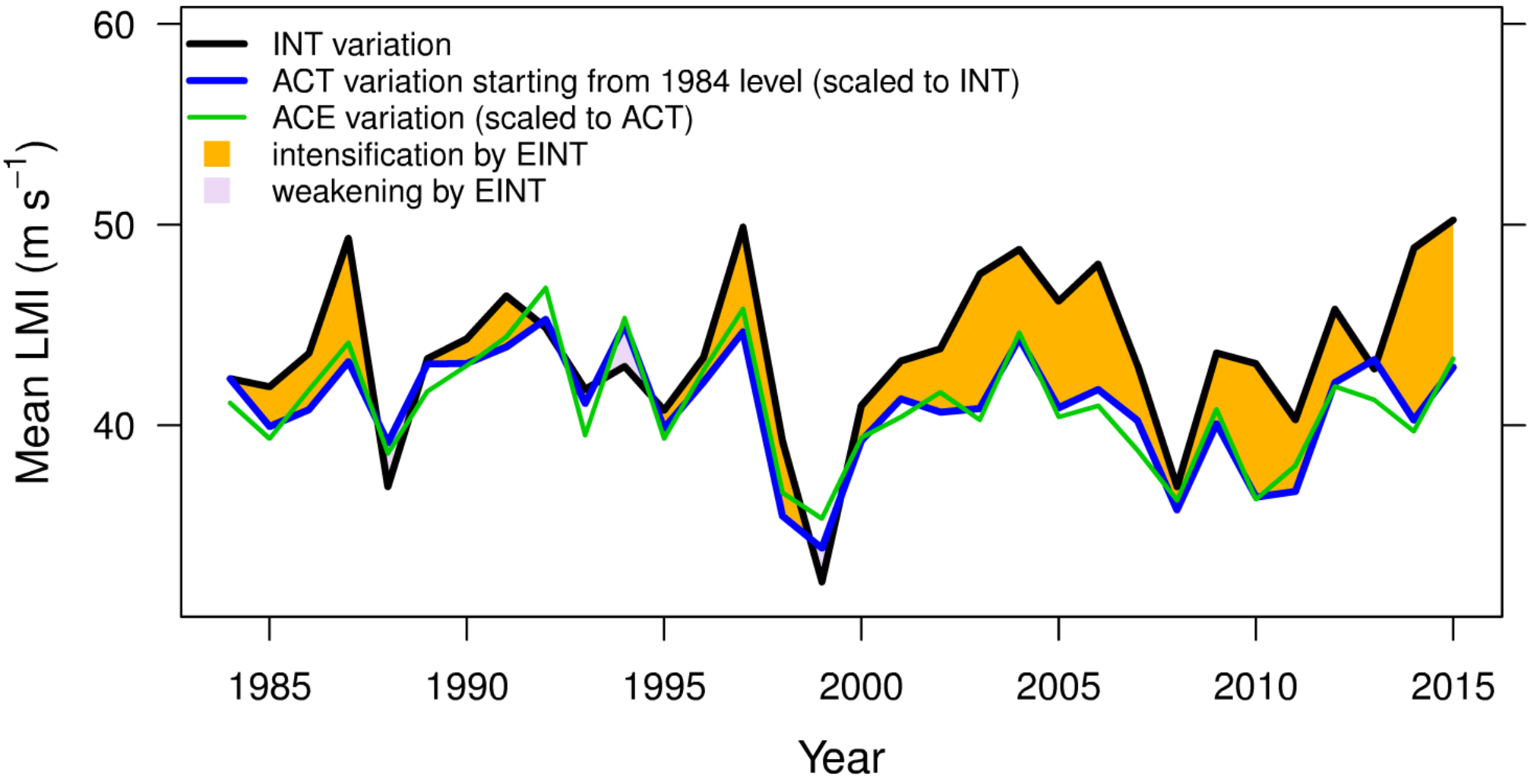
4. Global warming influence on 2015 WNP TC intensities

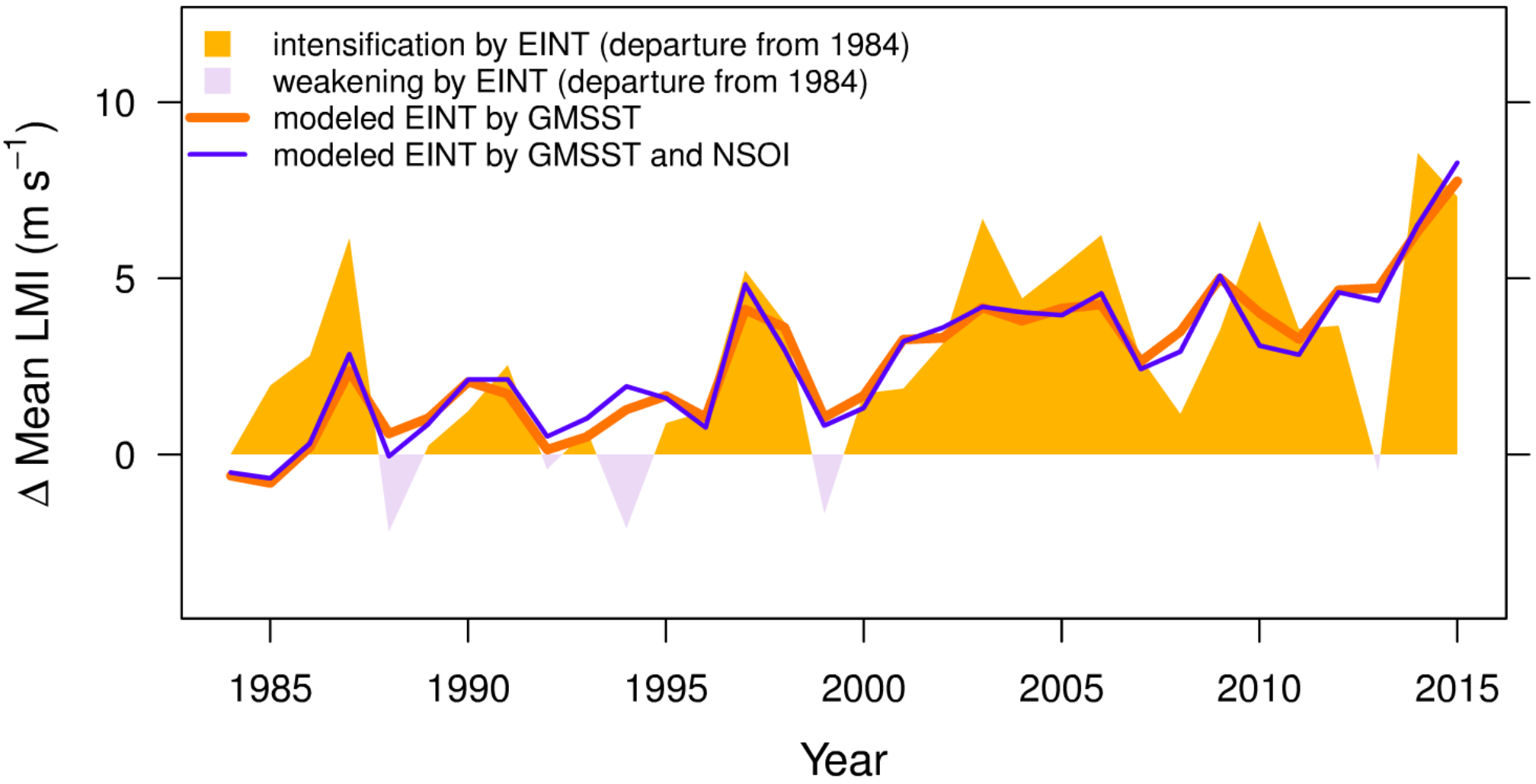




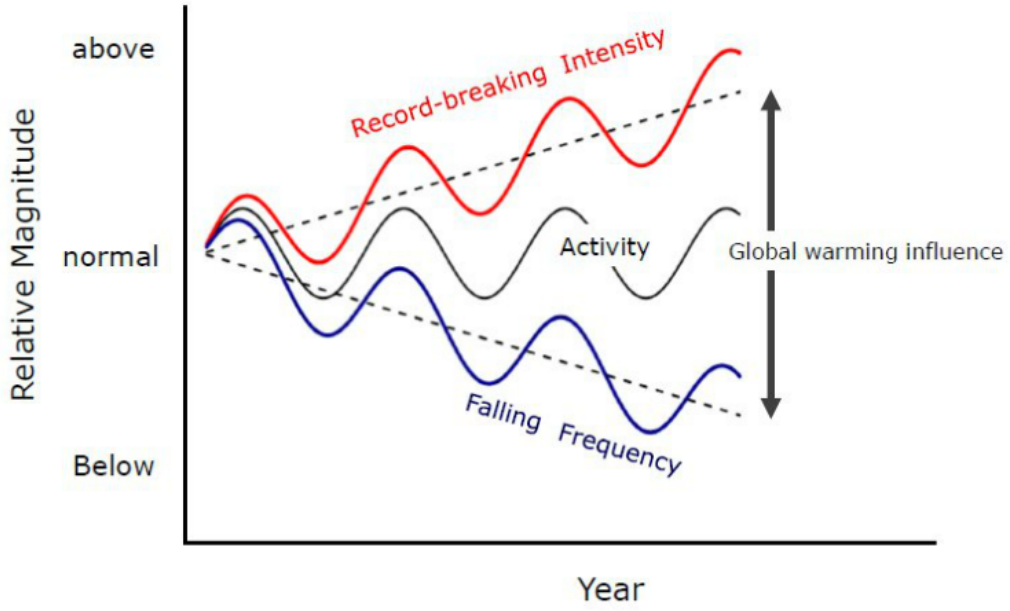
5. Summary




INT variation
ACT variation starting from 1984 level (scaled to INT)
ACE variation (scaled to ACT)
intensification by EINT
weakening by EINT
Mean LMI (m s^{-1})
60
50
40
1985
1990
1995
2000
2005
2010
2015
Year


intensification by EINT (departure from 1984)
weakening by EINT (departure from 1984)
modeled EINT by GMSST
modeled EINT by GMSST and NSOI
Δ Mean LMI (m s^{-1})
10
5
0
1985
1990
1995
2000
2005
2010
2015
Year

Summary



Intensity variation is the linear combination of activity and the efficiency of intensity, while frequency variation is that of activity and the negative effciency of intensity.

Global warmth does not affect TC activity but the efficiency of intensity, in the western North Pacific.

In a linear perspective, this climate structure brings about a record-breaking intensities and falling frequencies under global warming.

Thank you