Tropical Cyclone Genesis

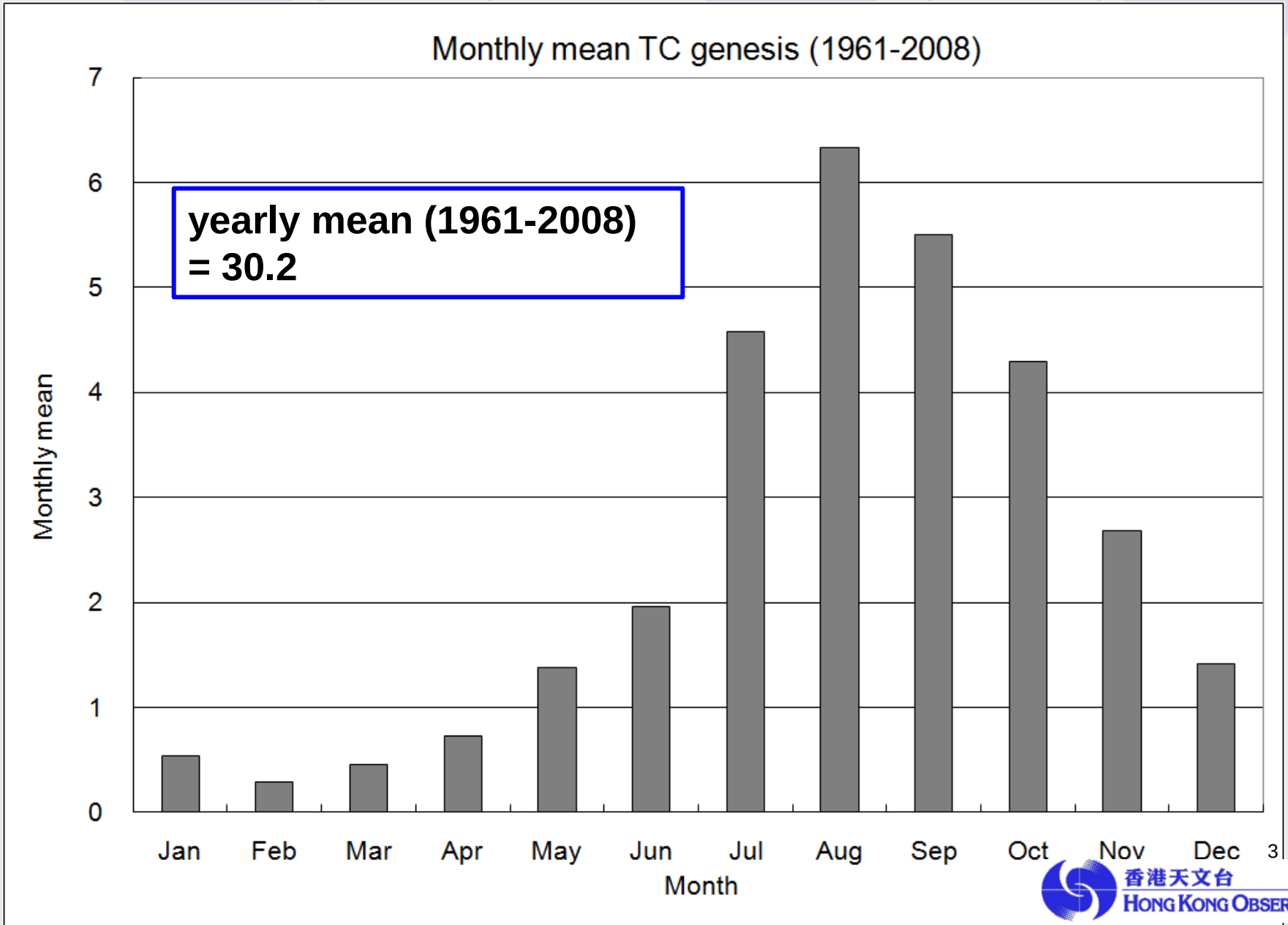
Lee Sai Ming
Hong Kong Observatory,
Hong Kong, China

Typhoon Committee Roving Seminar
30 Nov – 3 Dec 2010, Thailand

Contents

- Climatology of TC genesis over western North Pacific (0-45N 100E -180E)
  - based on HKO TC best track analysis
- ENSO's impact on TC genesis
  - based on HKO's definition of El Niño and La Niña
- Past trend
- Future projection

Monthly climatology of TC genesis over the western North Pacific



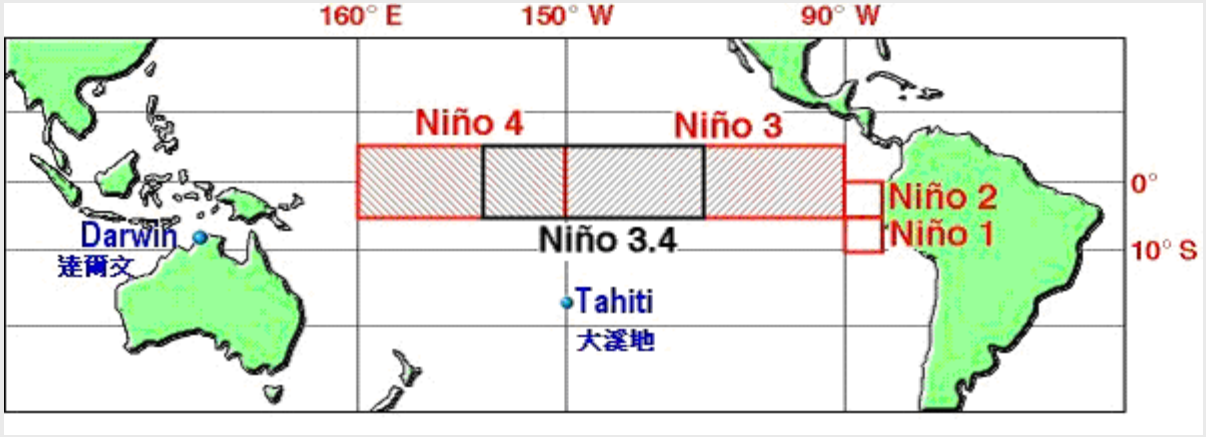
香港天文台
HONG KONG OBSERVATORY

Definition of El Niño and La Niña

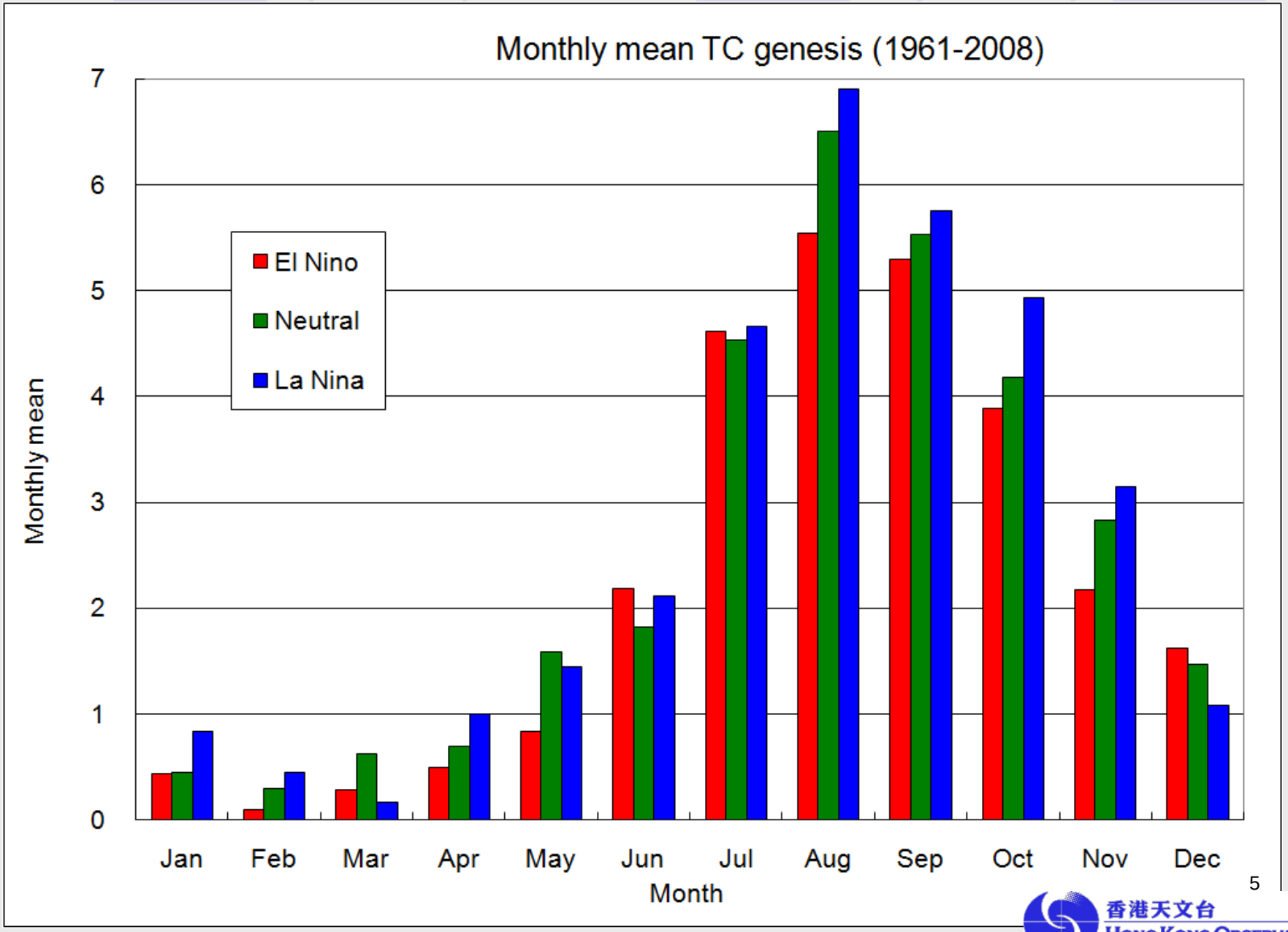
- Based on SST anomaly index of Niño 1-4 regions
- An El Niño (A La Niña) event is established when

  (i) the SST anomaly index maintains at +0.5°C or above (-0.5°C or below) for at least 5 to 6 months; or

  (ii) the SST anomaly index remains at +0.5°C or above (-0.5°C or below) for 5 consecutive months and the sum of anomaly reaches +4.0°C or above (-4.0°C or below)



Monthly climatology (3 ENSO situations)



ENSO's impact on TC genesis number

- Question: Are the differences significant?
- Compare against ENSO-neutral situation instead of a 30-year climatology
- Reason:
  1. The 30-year climatology is a composite of the 3 ENSO situations.
  2. The relative weights of contribution from the 3 ENSO situations vary with the 30-year time window
- True impact may be masked when compared to a 30-year climatology.

ENSO's impact on TC genesis number

- Monthly observations (e.g. June) of TC genesis under the 3 ENSO situations are considered independent because they are separated by at least a year
- TC genesis number is a whole number
- Cannot assume TC genesis number follows the normal distribution
- Cannot use the Student's t test if the distribution is not normal
- Use Wilcoxon-Mann-Whitney test
  - No distributional assumption required

Ref.: Wilks D. S. (2006): Statistical Methods in the Atmospheric Sciences
Conover, W. J. (1999): Practical Nonparametric Statistics.

ENSO's impact on TC genesis number

- Null hypothesis H_0:

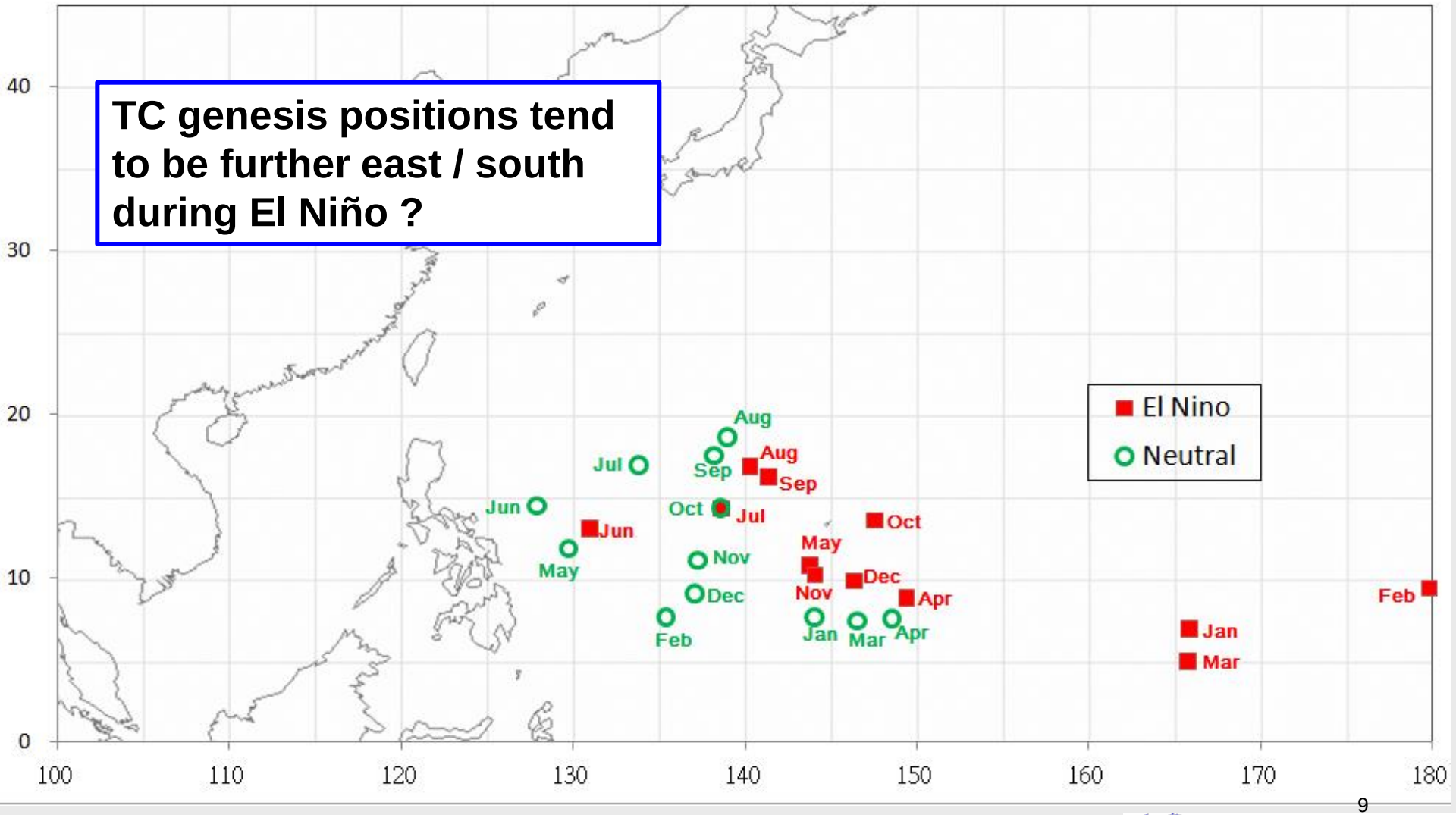
  The mean monthly number of TC genesis under the El Niño (La Niña) situation is the same as that under the ENSO-neutral situation

- Alternative hypothesis H_a:

  The mean monthly number of TC genesis under the El Niño (La Niña) situation is different from that under the ENSO-neutral situation

- No significant result can be obtained at the 5% significance level, i.e. we are not able to reject H_0

El Niño's impact on TC genesis position



香港天文台
HONG KONG OBSERVATORY

El Niño's impact on TC genesis position

Mean latitude

	Neutral	El Niño	Test result
Jan	7.7	6.9	Not sig.
Feb	7.7	9.4	Not sig.
Mar	7.4	5.0	Not sig.
Apr	7.6	8.8	Not sig.
May	11.8	10.8	Not sig.
Jun	14.4	13.0	Not sig.
Jul	16.9	14.3	Sig. at 5%
Aug	18.6	16.8	Sig. at 5%
Sep	17.5	16.2	Sig. at 5%
Oct	14.3	13.6	Not sig.
Nov	11.1	10.2	Not sig.
Dec	9.1	9.8	Not sig.

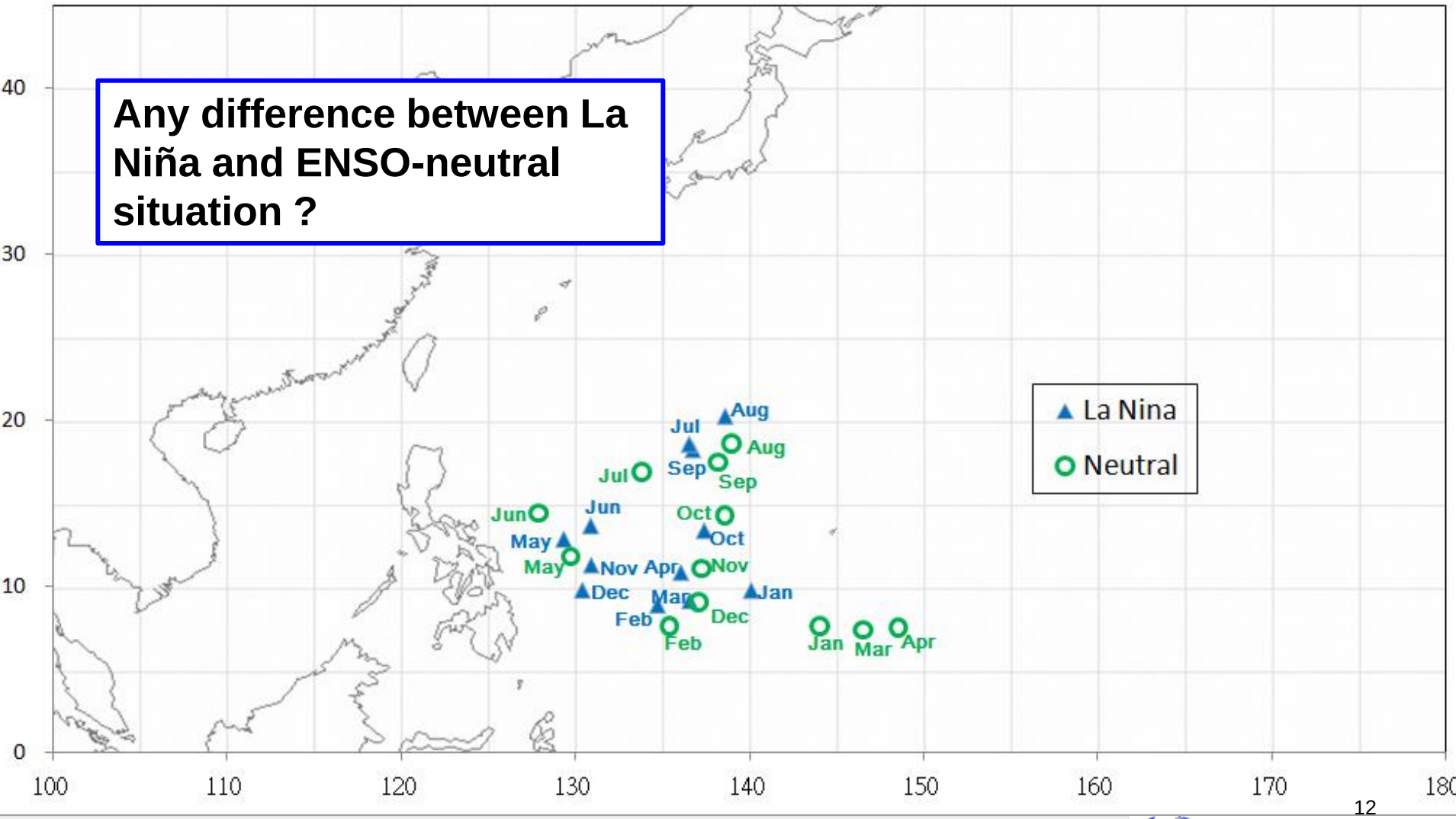
El Niño's impact on TC genesis position

Mean longitude

	Neutral	El Niño	Test result
Jan	144.0	165.9	Sig. at 5%
Feb	135.4	179.8	Not sig.
Mar	146.5	165.8	Sig. at 5%
Apr	148.5	149.4	Not sig.
May	129.7	143.8	Sig. at 5%
Jun	127.9	131.0	Not sig.
Jul	133.8	138.6	Not sig.
Aug	139.0	140.3	Not sig.
Sep	138.2	141.4	Not sig.
Oct	138.6	147.6	Sig. at 5%
Nov	137.3	144.1	Not sig.
Dec	137.1	146.3	Not sig.

Caution: data sample sizes are small (<=10 data points) for El Niño months of Jan to May

La Niña's impact on TC genesis position



香港天文台
HONG KONG OBSERVATORY

La Niña's impact on TC genesis position

Mean latitude

	Neutral	La Niña	Test result
Jan	7.7	9.8	Not sig.
Feb	7.7	8.9	Not sig.
Mar	7.4	9.2	Not sig.
Apr	7.6	10.8	Sig. at 5%
May	11.8	12.9	Not sig.
Jun	14.4	13.7	Not sig.
Jul	16.9	18.2	Not sig.
Aug	18.6	20.2	Sig. at 5%
Sep	17.5	18.6	Not sig.
Oct	14.3	13.4	Sig. at 5%
Nov	11.1	11.3	Not sig.
Dec	9.1	9.8	Not sig.

Caution: 11 data points for Apr during La Niña

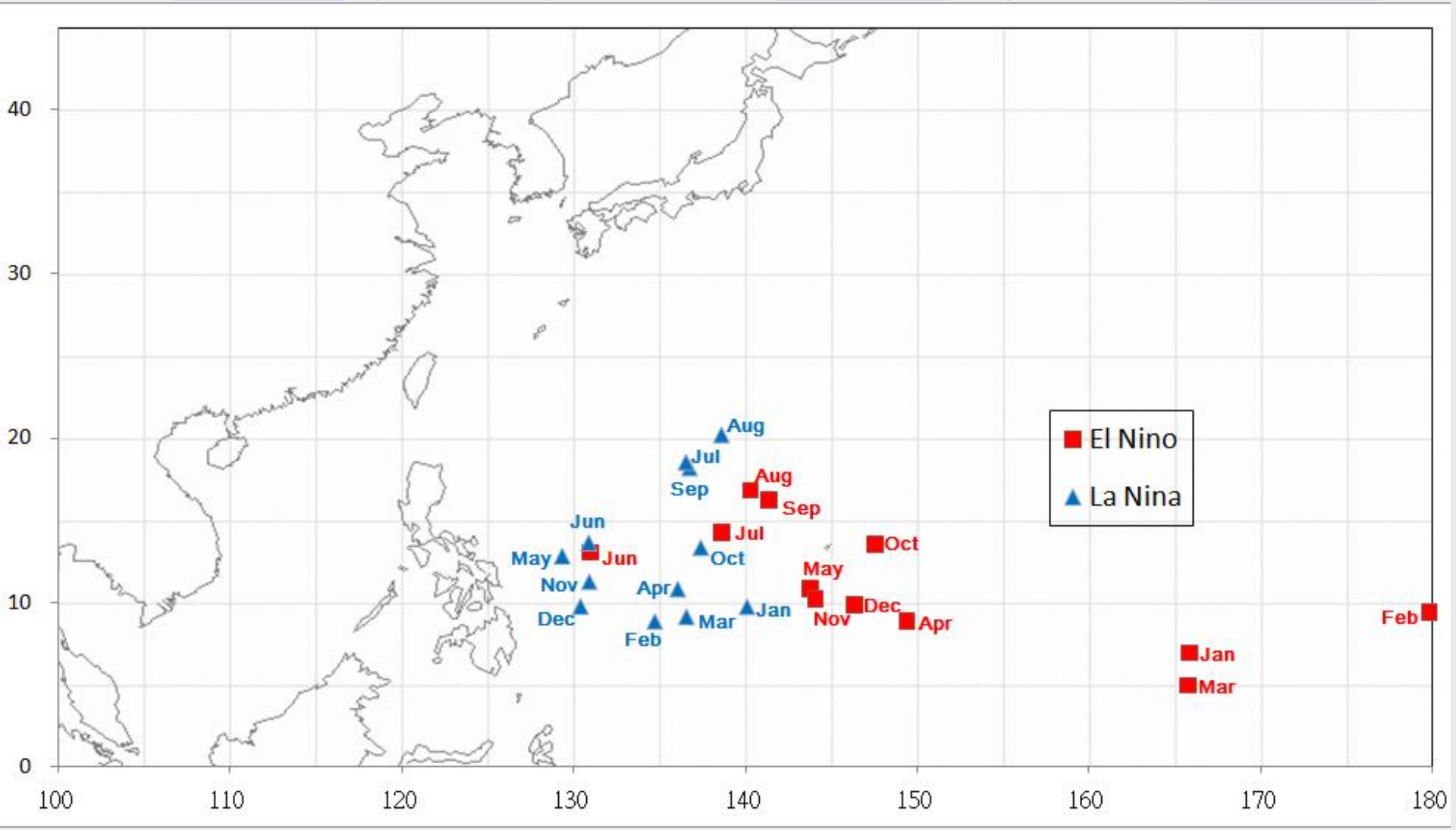
La Niña's impact on TC genesis position

Mean longitude

	Neutral	La Niña	Test result
Jan	144.0	140.1	Not sig.
Feb	135.4	134.7	Not sig.
Mar	146.5	136.6	Not sig.
Apr	148.5	136.0	Sig. at 5%
May	129.7	129.4	Not sig.
Jun	127.9	130.9	Not sig.
Jul	133.8	136.7	Not sig.
Aug	139.0	138.6	Not sig.
Sep	138.2	136.5	Not sig.
Oct	138.6	137.4	Not sig.
Nov	137.3	130.9	Not sig.
Dec	137.1	130.4	Not sig.

Caution: 11 data points for Apr during La Niña

Difference between El Niño and La Niña



Compare El Niño against La Niña

Mean latitude

	El Niño	La Niña	Test result
Jan	6.9	9.8	Not sig.
Feb	9.4	8.9	Not sig.
Mar	5.0	9.2	Not sig.
Apr	8.8	10.8	Not sig.
May	10.8	12.9	Not sig.
Jun	13.0	13.7	Not sig.
Jul	14.3	18.2	Sig. at 5%
Aug	16.8	20.2	Sig. at 5%
Sep	16.2	18.6	Sig. at 5%
Oct	13.6	13.4	Not sig.
Nov	10.2	11.3	Not sig.
Dec	9.8	9.8	Not sig.

Compare El Niño against La Niña

Mean longitude

	El Niño	La Niña	Test result
Jan	165.9	140.1	Sig. at 5%
Feb	179.8	134.7	Not sig.
Mar	165.8	136.6	Not sig.
Apr	149.4	136.0	Not sig.
May	143.8	129.4	Not sig.
Jun	131.0	130.9	Not sig.
Jul	138.6	136.7	Not sig.
Aug	140.3	138.6	Not sig.
Sep	141.4	136.5	Not sig.
Oct	147.6	137.4	Sig. at 5%
Nov	144.1	130.9	Sig. at 5%
Dec	146.3	130.4	Sig. at 5%

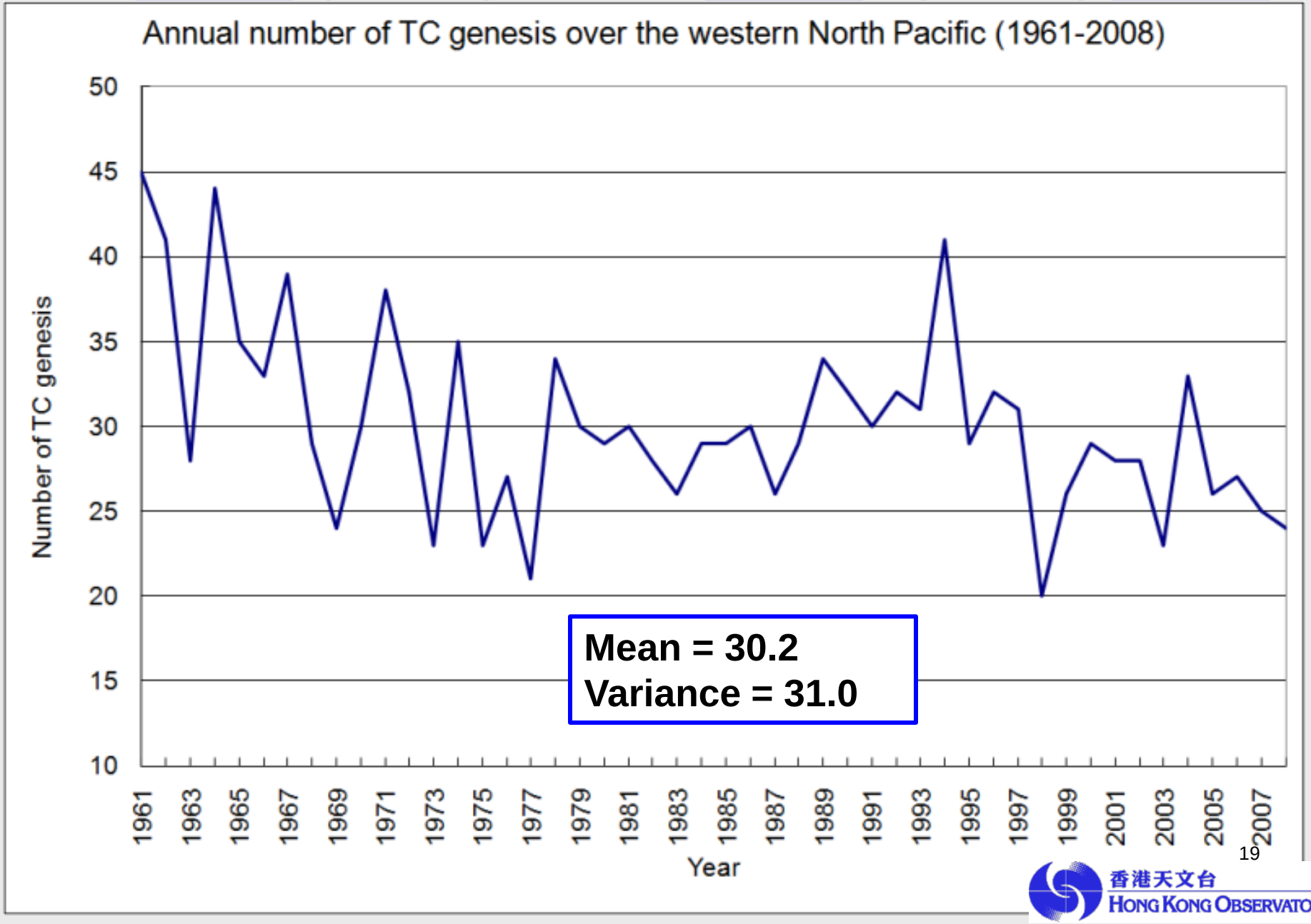
Caution: 14 data points for Dec during La Niña

Physical mechanism

- enhanced TC genesis in the SE quadrant: increase of the low-level shear vorticity generated by El Niño–induced equatorial westerlies
- suppressed TC generation over the NW quadrant: upper-level convergence induced by the deepening of the east Asian trough and strengthening of the WNP subtropical high, both resulted from El Niño forcing

  - How Strong ENSO Events Affect Tropical Storm Activity over the Western North Pacific, B. Wang and J. C. L. Chan, Journal of Climate

Past trend of TC genesis (1961-2008)



Past trend of TC genesis

- Assessment Report on Impacts of Climate Change on Tropical Cyclone Frequency and Intensity in the Typhoon Committee Region
  - Prepared by an expert team of Typhoon Committee

1. Significant interdecadal and interannual variation in the frequency of TC genesis over the western North Pacific in the last 50 years
2. Based on available publications, the expert team cannot conclude whether or not there is a long term trend in the TC frequency

Past trend of TC genesis

- Assessment Report on Impacts of Climate Change on Tropical Cyclone Frequency and Intensity in the Typhoon Committee Region

3. The expert team conducted an independent analysis using 5 best track datasets: JTWC, RSMC-Tokyo, CMA, HKO, International Best Track Archive for Climate Stewardship (IBTrACS)
4. Result: a decreasing trend or no trend in the annual number of TC formation (TS or above) in WNP

Future projection of TC genesis

- Assessment Report on Impacts of Climate Change on Tropical Cyclone Frequency and Intensity in the Typhoon Committee Region

1. The majority of the climate models projects a reduction in the number of TCs in the WNP in different greenhouse gas scenarios.
2. Uncertainties and limitations in climate modelling and downscaling technique may affect the reliability of the projections.

Past trend of TC genesis

- Tropical cyclones and climate change
  - authored by an expert team of WMO
  - published on Nature Geoscience

1. It remains uncertain whether past changes in tropical cyclone frequency exceed the variability expected through natural causes, after accounting for changes over time in observing capabilities.
2. Trend detection is complicated by the large fluctuations in the frequency and intensity of tropical cyclones and the limitations in the availability and quality of global historical record.

Future projection of TC genesis

- Tropical cyclones and climate change

1. It is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged owing to greenhouse warming.
2. Low confidence in projected changes in individual basins.

Impact of Global Warming on El Niño

- The impact of global warming on the tropical Pacifica Ocean and El Niño
  - Prepared on behalf of the Climate Variability and Predictability (CLIVAR) Pacific Panel
  - Published on Nature Geoscience

1. It is not yet possible to say whether ENSO activity will be enhanced or damped, or if the frequency of events will change.

Thank you