海水溫度氣候場對氣候系統模擬之影響

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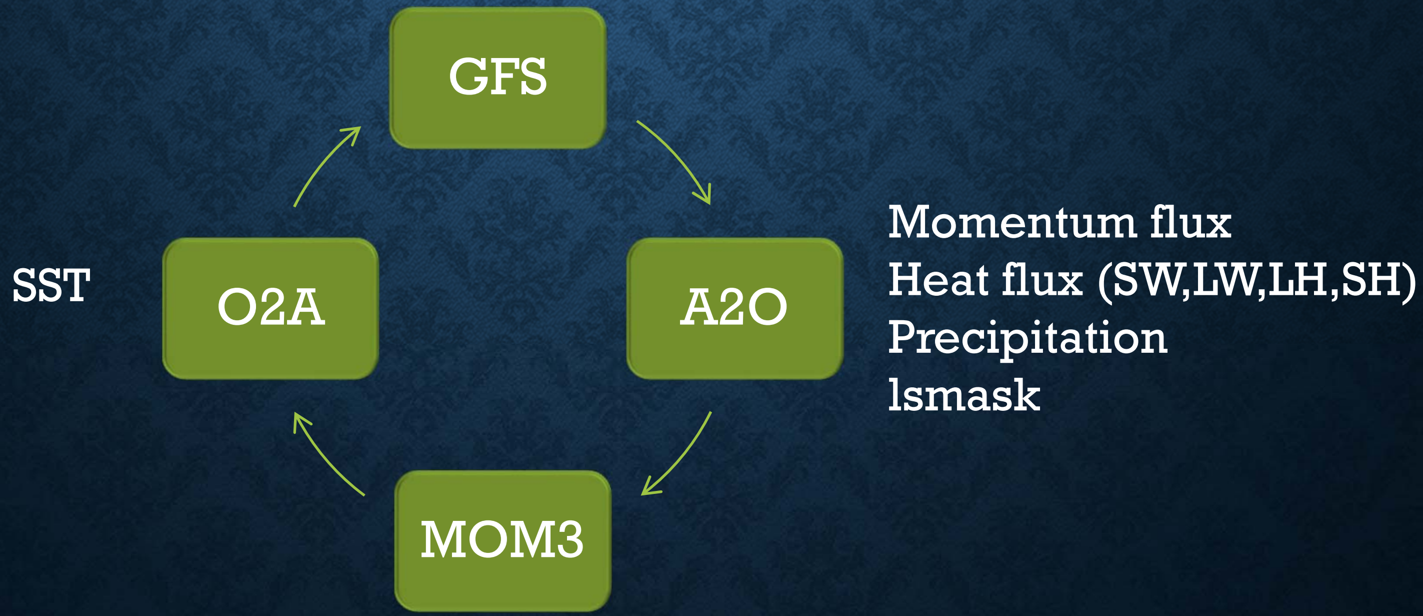
CWB CFS 1-TIER COUPLED MODEL (CWB/CFS1T1)

- 大氣模式：CWB GFS model

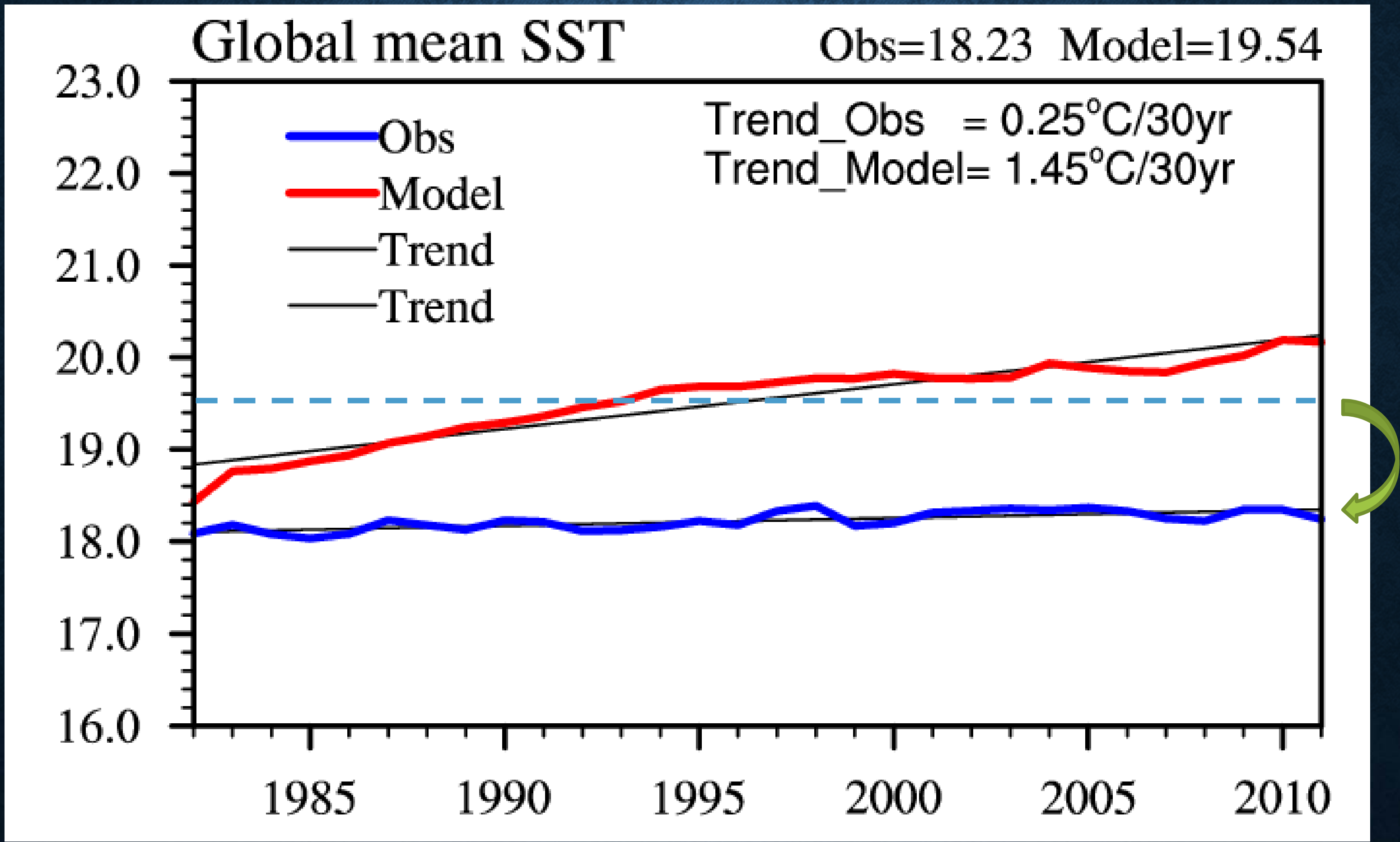
  (mks, T119L40, dt=600s, NSAS cumulus parameterization)

- 海洋模式：GFDL MOM3 model

  (cgs, domain:0-360, 74S-64N, 0-4428m, dt=3600s)



Motivation: Why should we consider the heat flux correction strategy?



Li and Hogan (1999): *A realistic simulation of both the seasonal cycle and the interannual variation may be achieved when a realistic annual-mean state is reproduced.*

$$\frac{\partial T_1}{\partial t} = -u_1 \frac{\partial T_1}{\partial x} - v_1 \frac{\partial T_1}{\partial y} - w_1 \frac{\partial T_1}{\partial z} + Q + A(i,j)$$

$$A(i,j) = -\alpha(T_1 - \bar{T}_{obs})$$

$$\alpha = 1/5 * 86400$$

version	Heat flux correction factors
Li and Hogan(1999)	SST, wind
CWB/CFS1T1	SST, momentum flux

New Heat Flux Correction Method:

Modify the annual mean of ocean temperature

$$\frac{\partial T_k}{\partial t} = -u_k \frac{\partial T_k}{\partial x} - v_k \frac{\partial T_k}{\partial y} - w_k \frac{\partial T_k}{\partial z} + Q + A(i,j,k)$$

$$A(i,j,k) = -\alpha(T_k - \bar{T}_k)$$

$$\alpha = 1/86400$$

其中k為垂直各層，T為海水溫度，$\bar{T}_k$ 為30年平均GODAS海水溫度之annual cycle， α 為damping factor。u、v、w分別為東西、南北和垂直方向海流；Q為熱力通量

step	processes		target
1	Coupled Model +ocean temperature correction term	30 year	Get annual mean ocean temperature correction by using damping factor 1/1day
2	Coupled model + ocean temperature annual mean correction term	30 year	

0-366m: w=1，459m : w=0.8，584m : w=0.6 ，747m : w=0.4，949m : w=0.2，Below: w=0

實驗版本	
Control	CWB/CFS1T1
Exp	CWB/CFS1T1 + heat flux correction
積分時間	30年 free run
診斷項目	climatology, ENSO, MJO

OBS：校驗所使用的觀測資料

變數		資料來源
SST	海面溫度	OISSTv2 data
Precip	降水	GPCP precipitation data
T2m	2米溫度	CFSR data
Wind	風場	CFSR data
OT	海水溫度	GODAS data

CLIMATOLOGY
(30 YEAR AVERAGED)

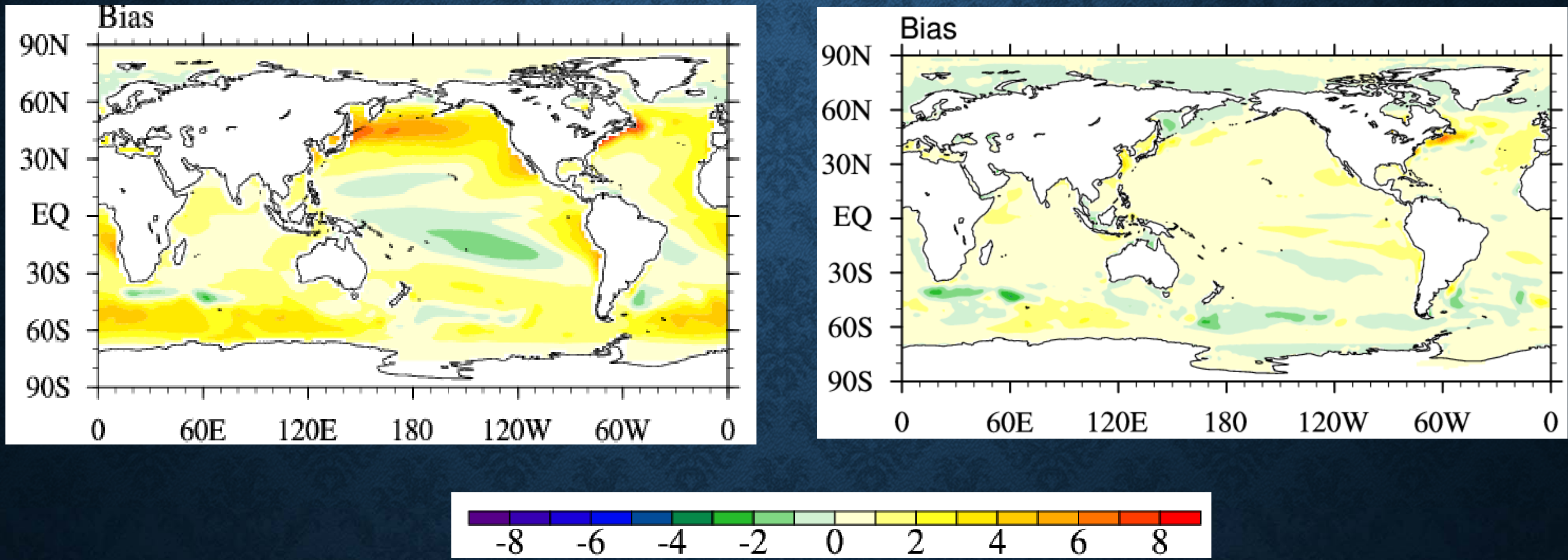
SST Bias

Control

Exp

NRMSE=0.32

NRMSE=0.12



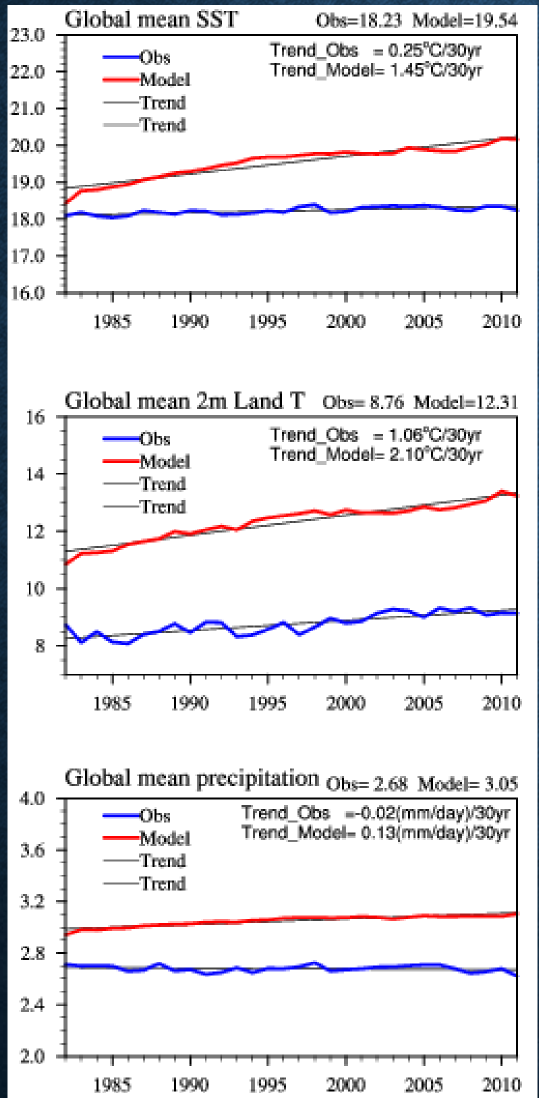
The Trend of Global Mean Variables

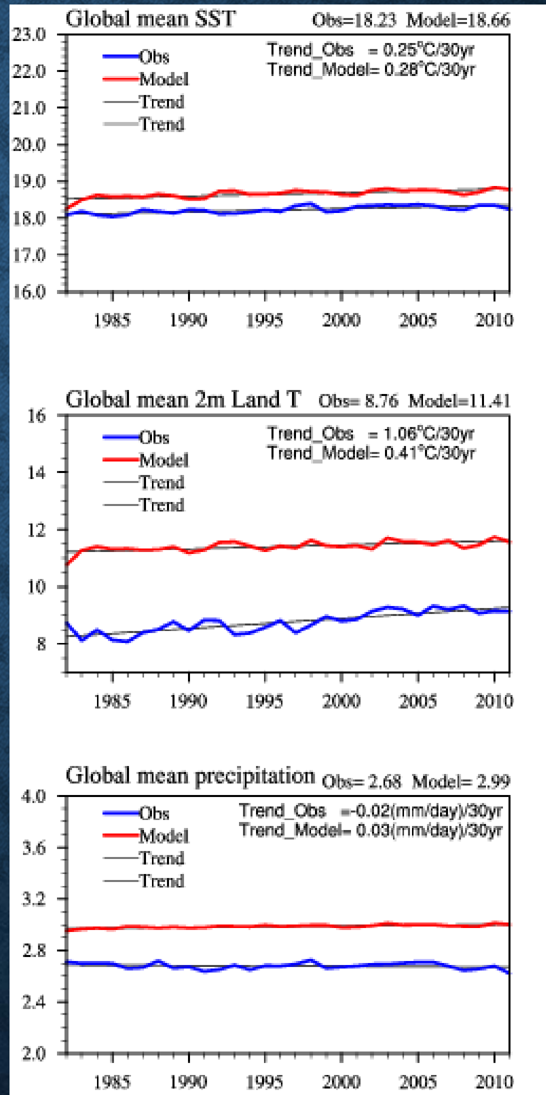
Control **Exp**

海面溫度

陸地2米溫度

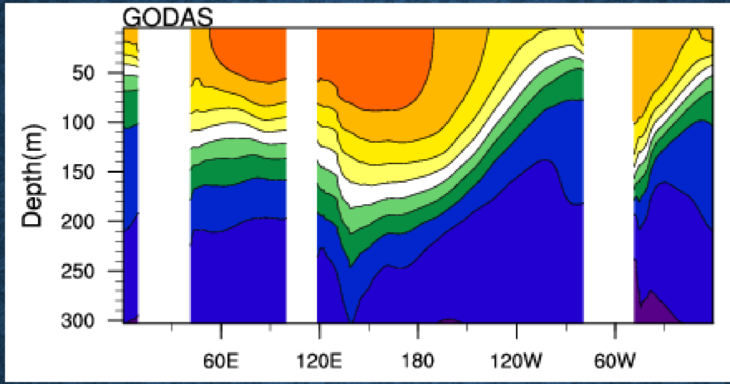
降水





Ocean Temperature averaged over (2S-2N)

OBS



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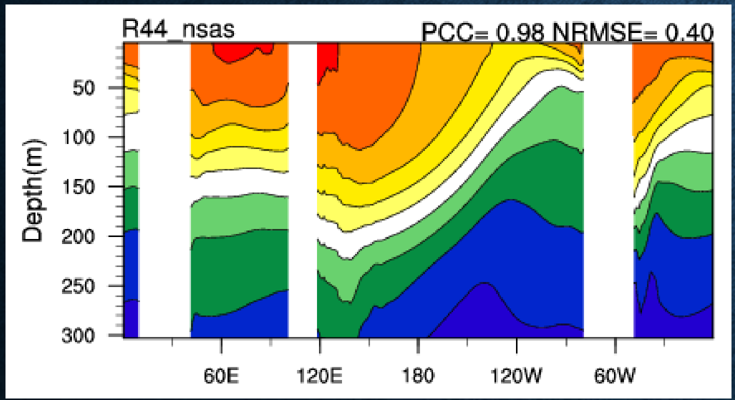

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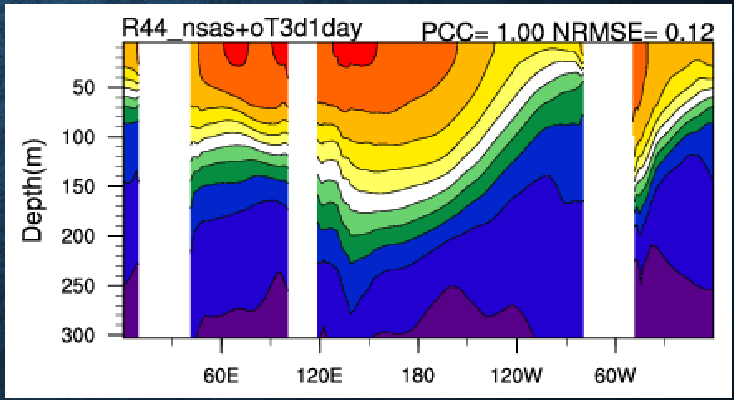
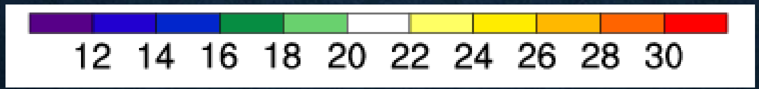


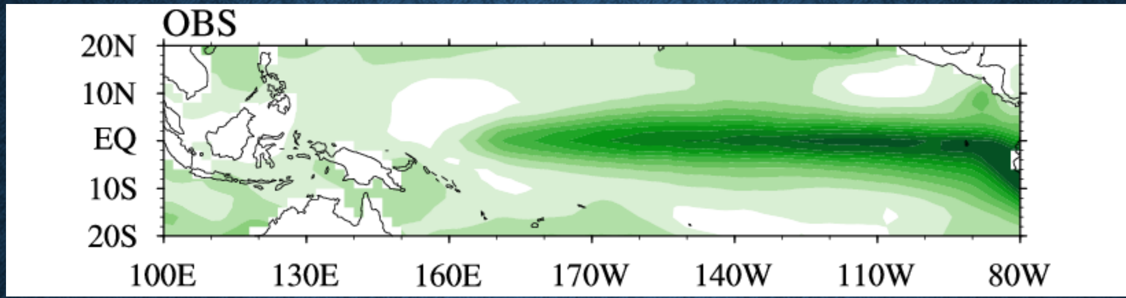


ENSO
(El Niño / Southern Oscillation)

聖嬰現象(ENSO)為赤道東太平洋大範圍的海溫變化，
透過大氣與海洋之交互作用影響全球氣候。

Standard Deviation of SST

OBS



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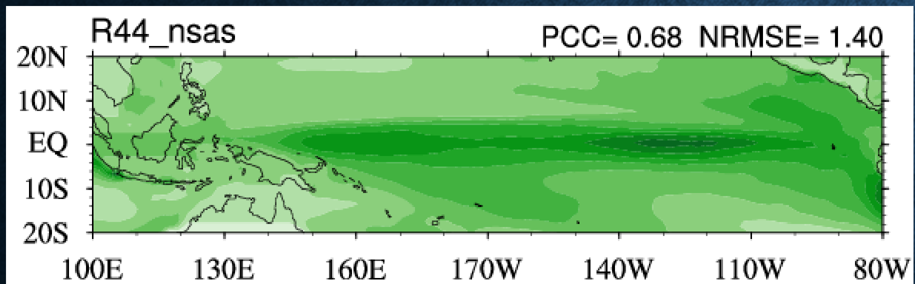

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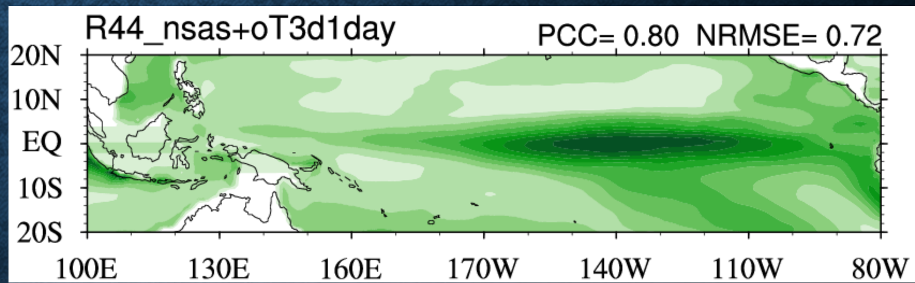
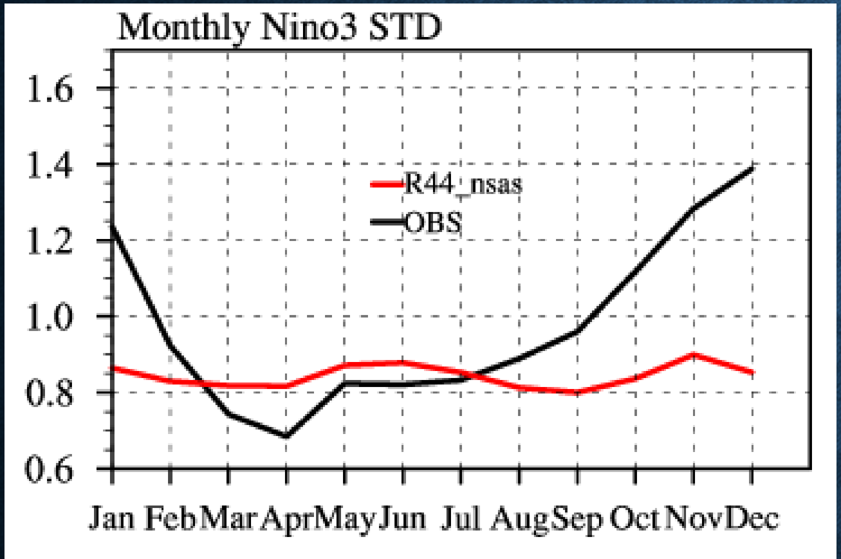


NINO3 Annual Cycle

Control



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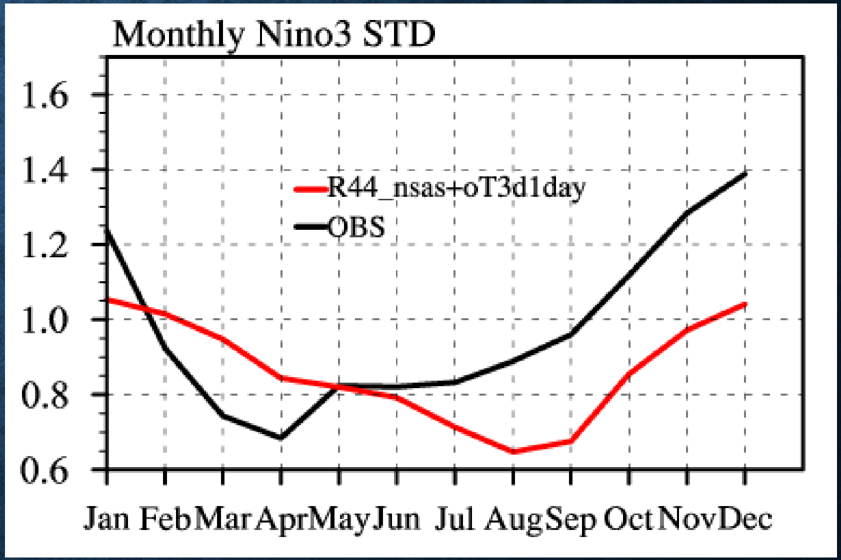
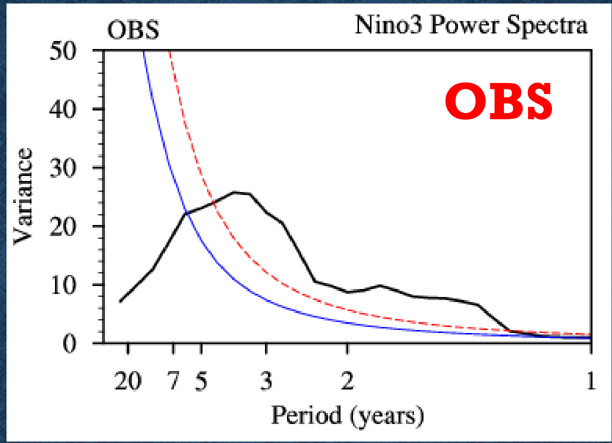
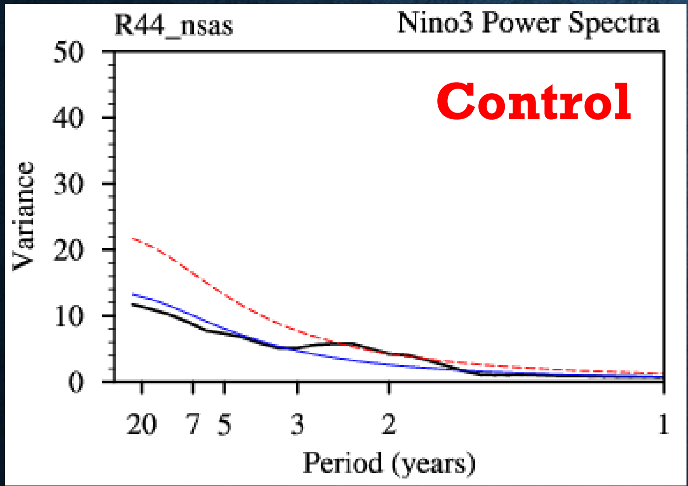
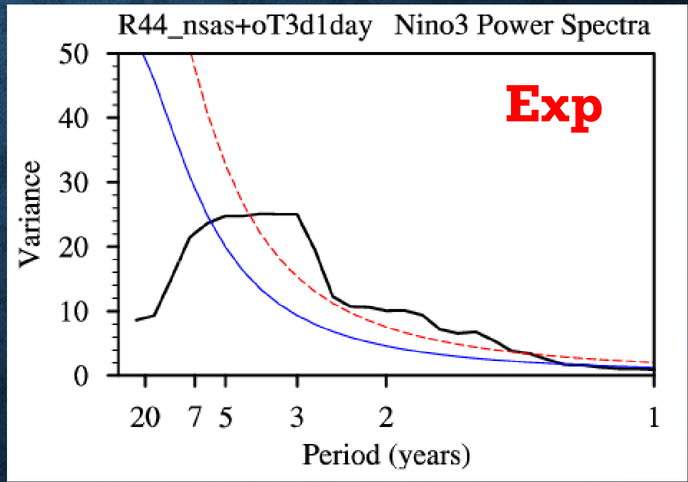


NINO3 Power Spectrum







AIR-SEA INTERACTION DIAGNOSTIC METHOD
CHEN ET AL.(2015)

- 利用海洋資料月平均場包括海溫、ocean currents、upwelling data計算thermodynamic equation每一項.

$$\frac{\partial T'}{\partial t} = -u'\frac{\partial \bar{T}}{\partial x} - \bar{u}\frac{\partial T'}{\partial x} - u'\frac{\partial T'}{\partial x} - w'\frac{\partial \bar{T}}{\partial z} - \bar{w}\frac{\partial T'}{\partial z} - w'\frac{\partial T'}{\partial z}$$

$$-v'\frac{\partial \bar{T}}{\partial x} - \bar{v}\frac{\partial T'}{\partial x} - v'\frac{\partial T'}{\partial x} + \frac{Q'}{\rho CpH} + R$$

- 計算11-1月海面溫度的平均值

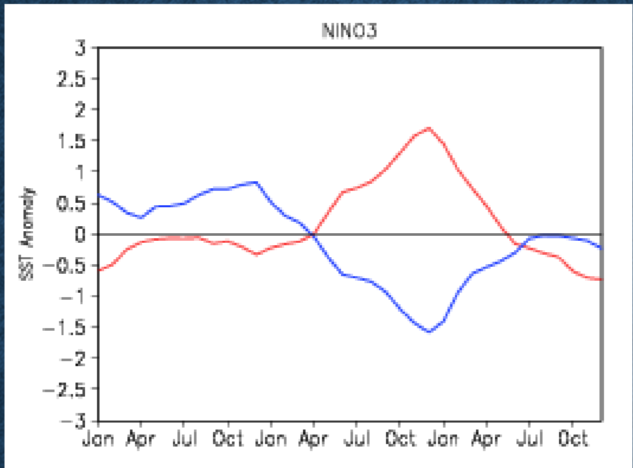
  SST ≥ 0.5 Std ⇨ El Nino Cases

  SST ≤ -0.5 std ⇨ La Nina Cases

- composite every each term for El Nino and La Nina cases

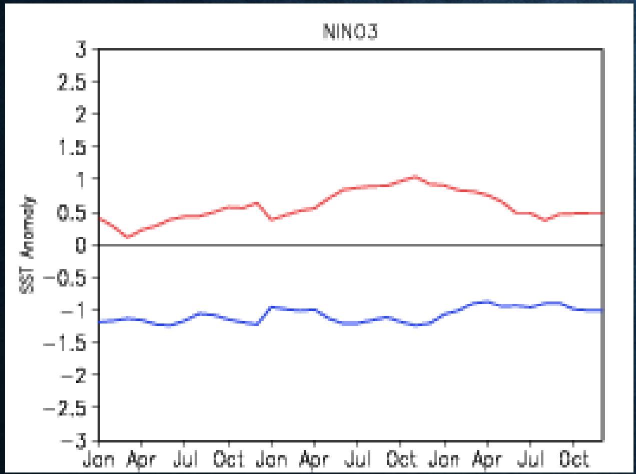
NINO3 SST Anomaly of Composite El Nino & La Nina cases

GODAS



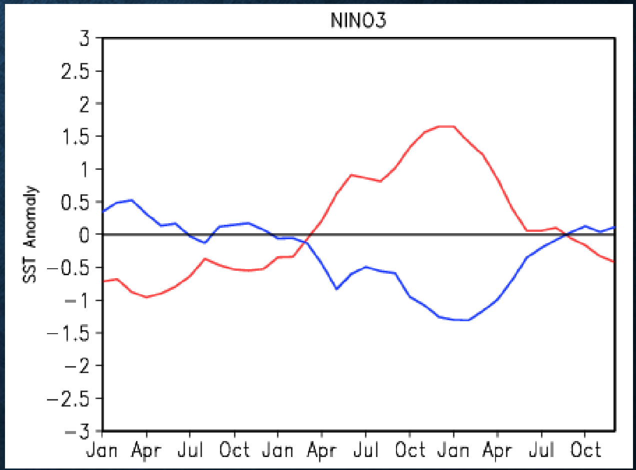
(year-1) (year0) (year+1)

Control



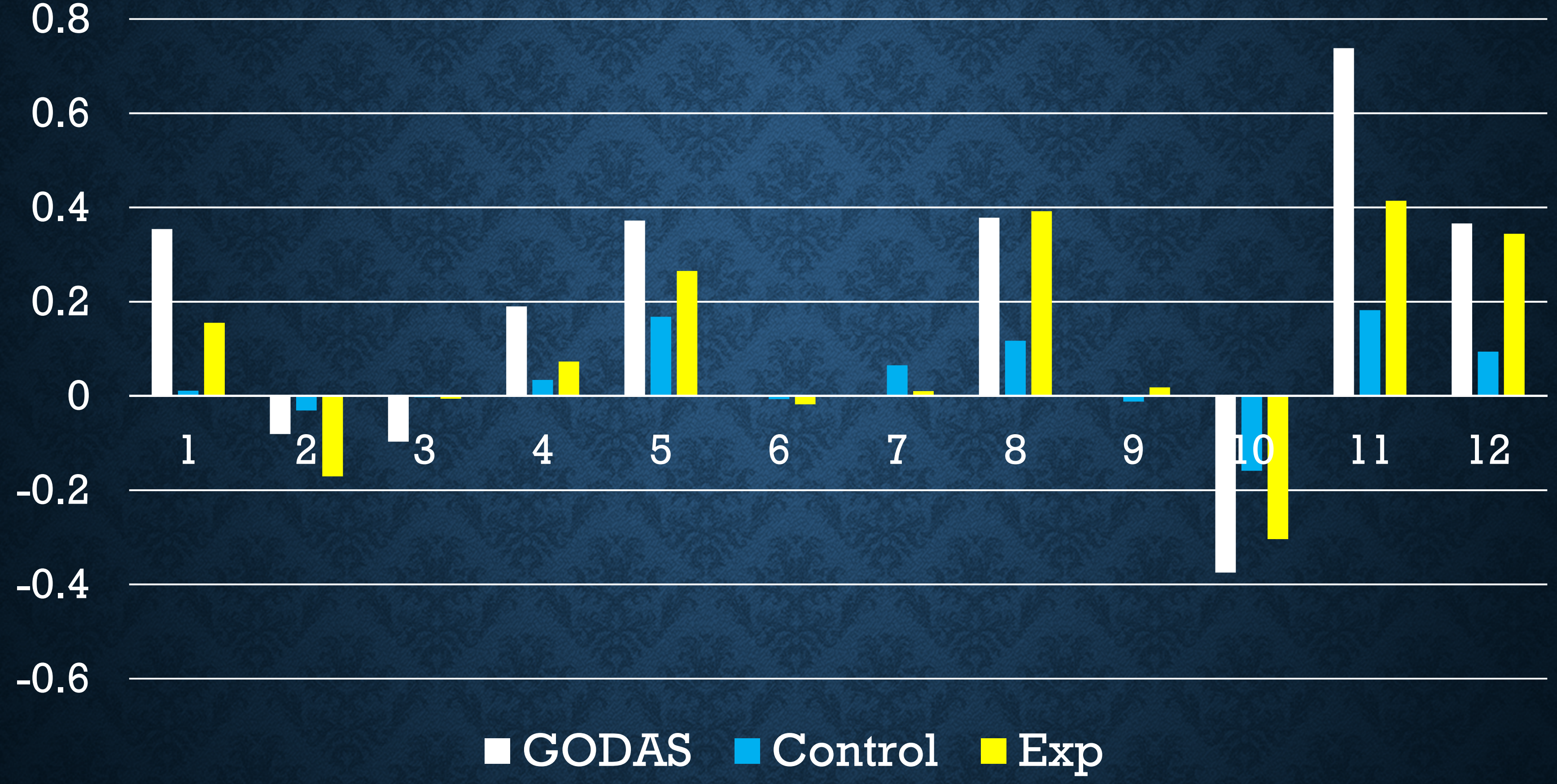
(year-1) (year0) (year+1)

Exp



(year-1) (year0) (year+1)

El Nino - La Nina



$$\underset{(12)}{\frac{\partial T'}{\partial t}} = \underset{(1)}{-u'\frac{\partial \bar{T}}{\partial x}} \underset{(2)}{- \bar{u}\frac{\partial T'}{\partial x}} \underset{(3)}{- u'\frac{\partial T'}{\partial x}} \underset{(4)}{- w'\frac{\partial \bar{T}}{\partial z}} \underset{(5)}{- \bar{w}\frac{\partial T'}{\partial z}} \underset{(6)}{- w'\frac{\partial T'}{\partial z}} \underset{(7)}{- v'\frac{\partial \bar{T}}{\partial y}} \underset{(8)}{- \bar{v}\frac{\partial T'}{\partial y}} \underset{(9)}{- v'\frac{\partial T'}{\partial y}} \underset{(10)}{+ \frac{Q'}{\rho C p H}} \underset{(11)}{+ R}$$

Mixed layer depth=50m

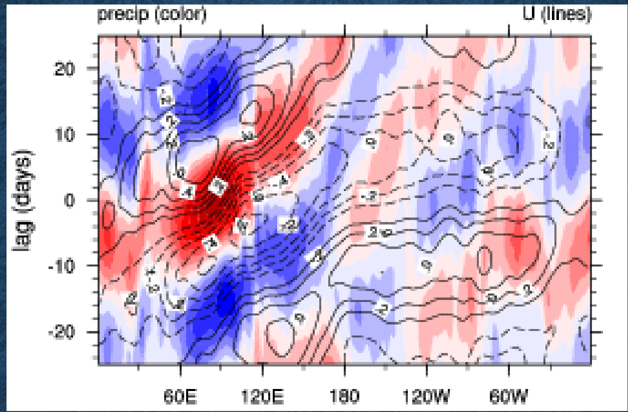
MJO
(MADDEN-JULIAN OSCILLATION)

季內震盪(Madden-Julian Oscillation，簡稱MJO)，主要是熱帶地區對流東傳，其週期約為30 至60 天(Madden and Julian,1972)，為影響亞洲與西北太平洋區sub-seasonal 的主要氣候系統。

LAG CORRELATION DIAGRAM FOR WINTER

將南北緯10 度
30 年冬季平均降水
與850 百帕緯向風場
經20-100天band pass
filter 與印度降水計
算其lag correlation

OBS



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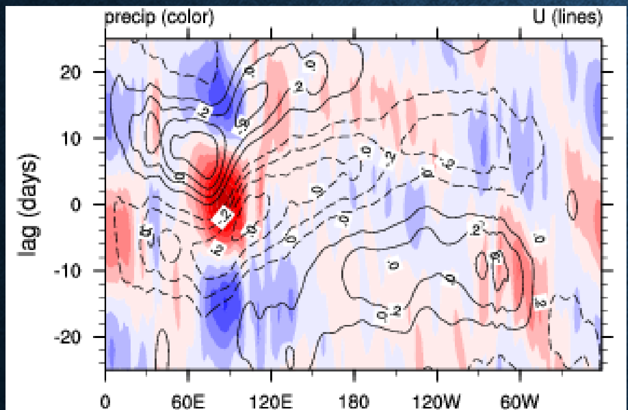

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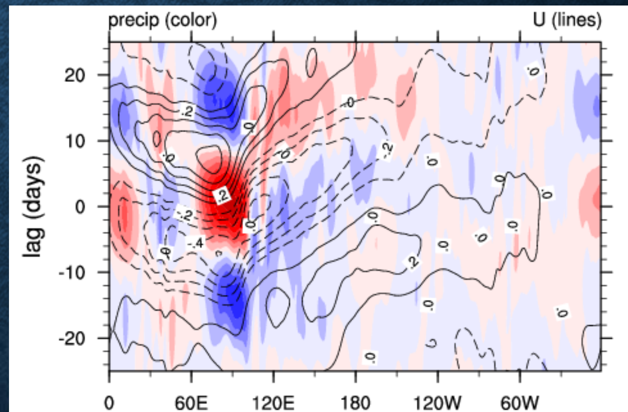
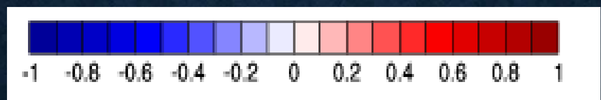
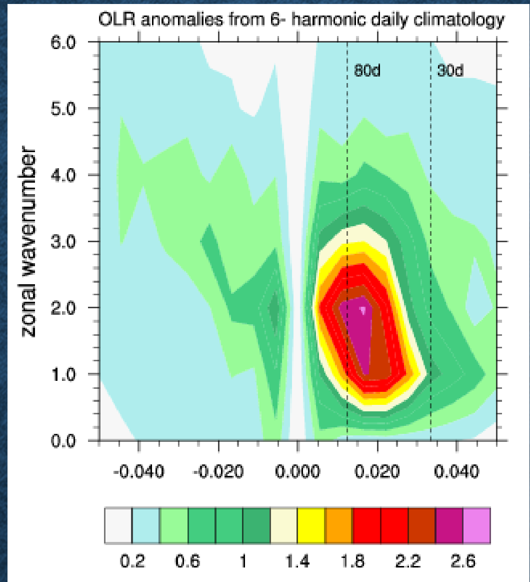




Wavenumber-Frequency Spectra for Winter

OBS



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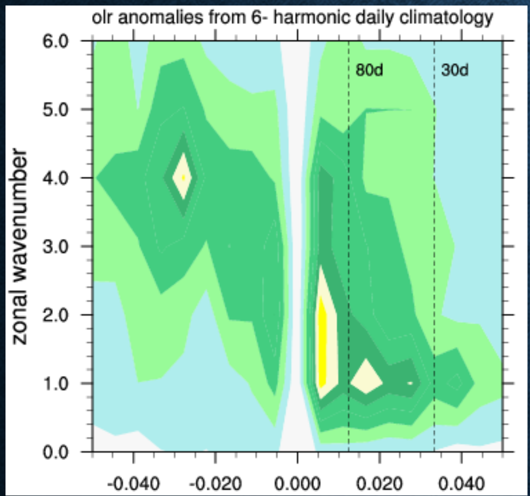

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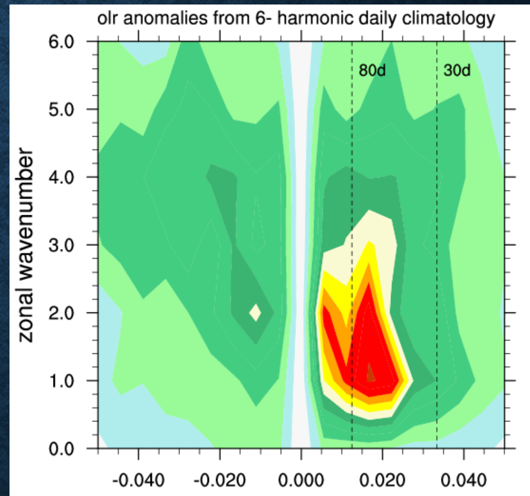

南北緯10 度平均之OLR日資料計算其時間空間之波譜圖
橫軸為頻率，縱軸為波數

結論

- 本研究使用一步法海氣耦合模式評估加入heat flux correction修正氣候偏差對模式模擬ENSO及MJO模擬之影響。
- 測試結果顯示海水溫度場加入heat flux correction修正氣候偏差後對ENSO與MJO之預報均有明顯改進。
- 結果顯示氣候值的修正對一步法海氣耦合模式之預報影響甚大，未來需要更積極改進。
- 此種Heat Flux Correction方法可改善模式預報，未來可考慮應用於下一代之氣候模式。