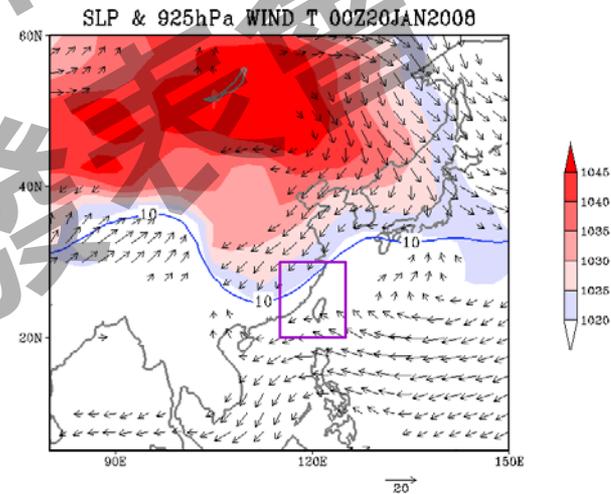


台灣冬季寒潮長期變遷： 過去及模式未來推估

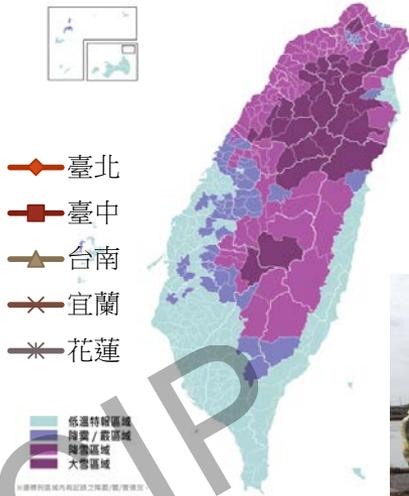
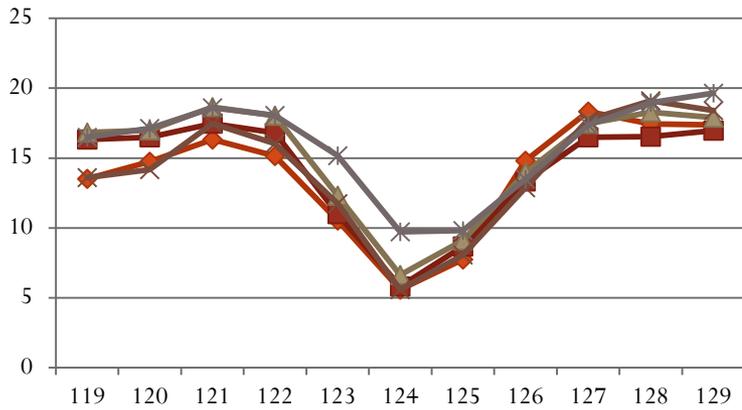
The variability of Cold Surge Frequency in Taiwan: Present and Future Projection



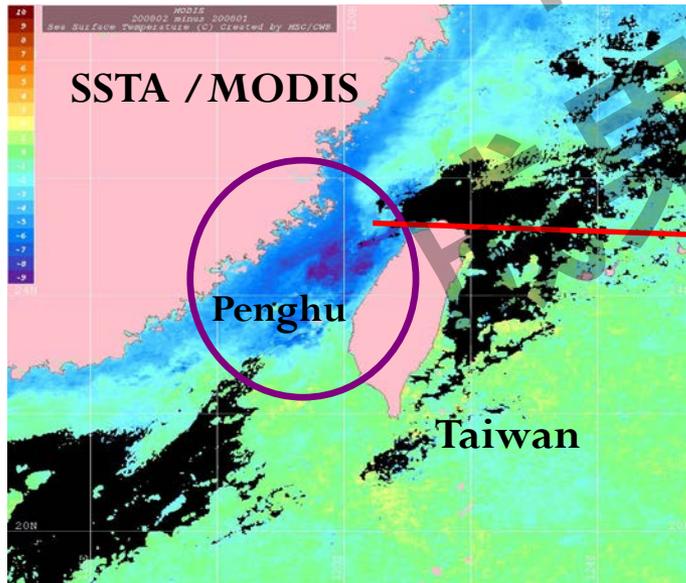
洪志誠，張智鈞
cchong@utapei.edu.tw



2016/1



2008/2



Over 150 tons fishery lost Almost 90% fish died in this extreme cold anomaly

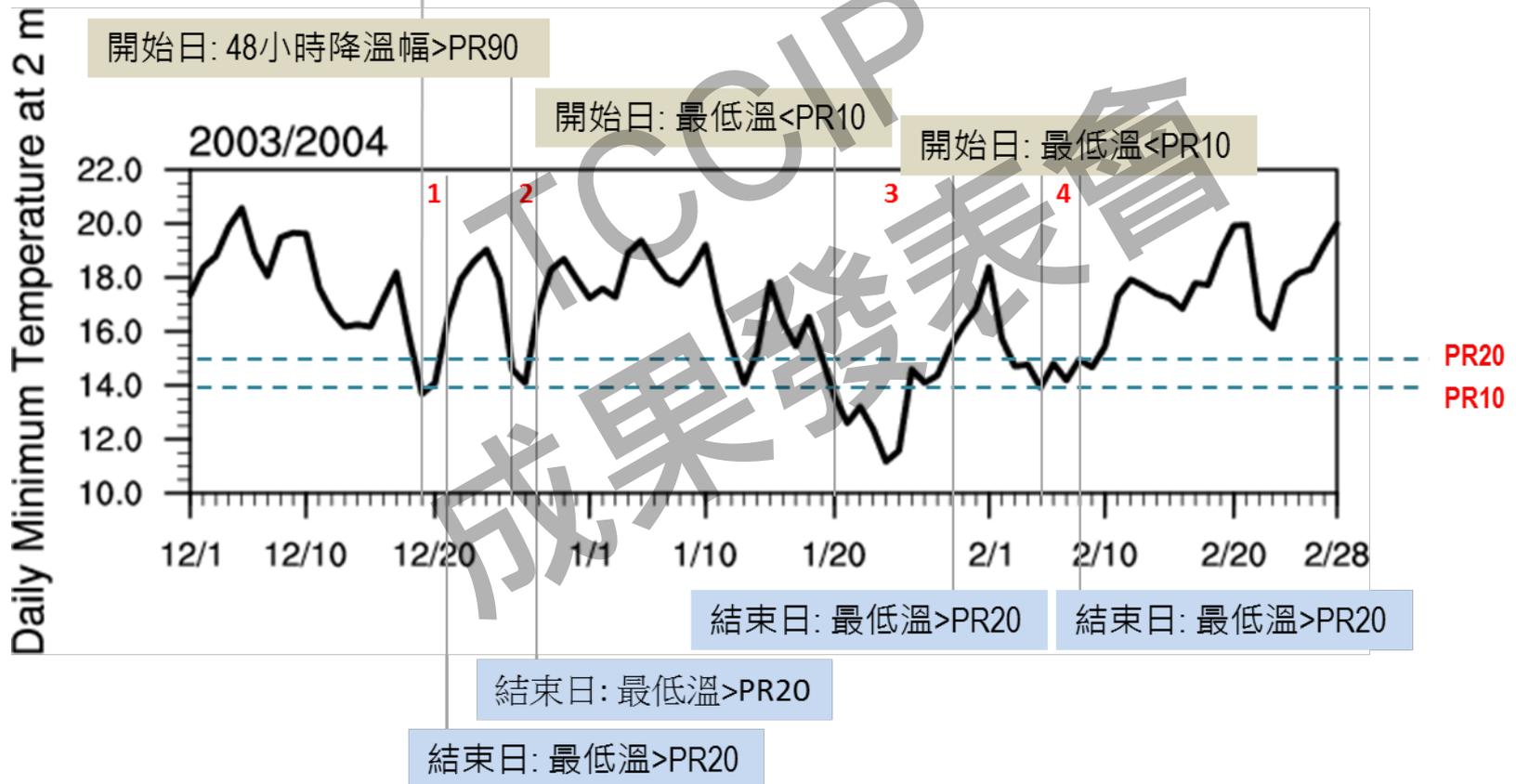
台灣寒潮定義

開始日: 日最低溫 < PR10 或 48小時降溫幅度 > PR90

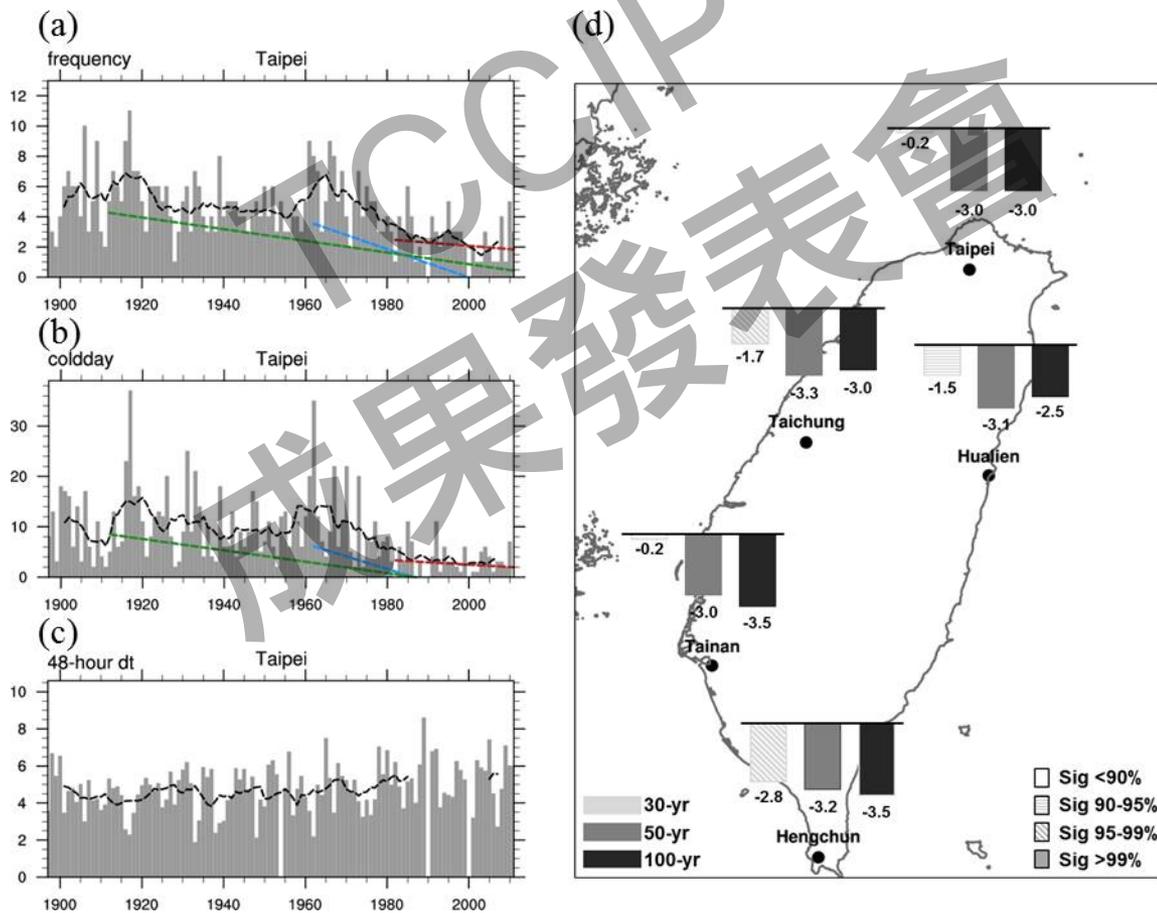
結束日: 日最低溫 > PR20 或 24小時升溫幅度 > PR90

(盧與李 · 2009)

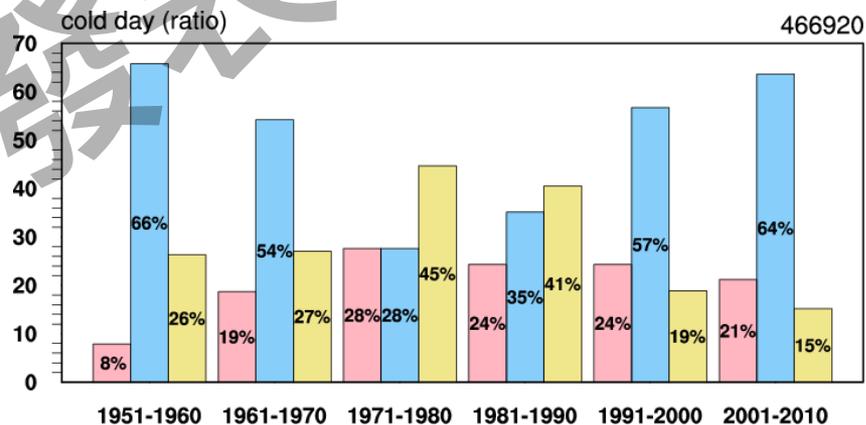
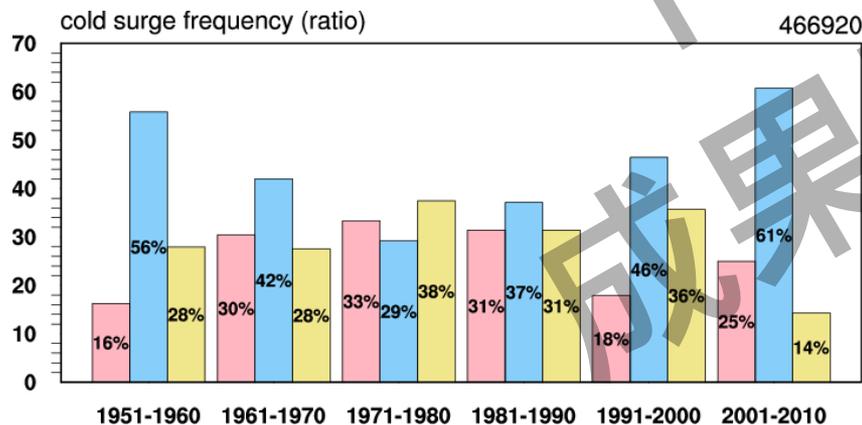
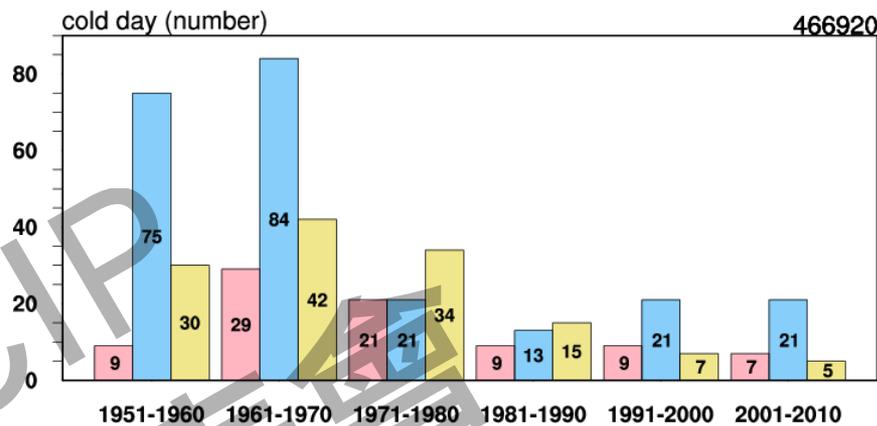
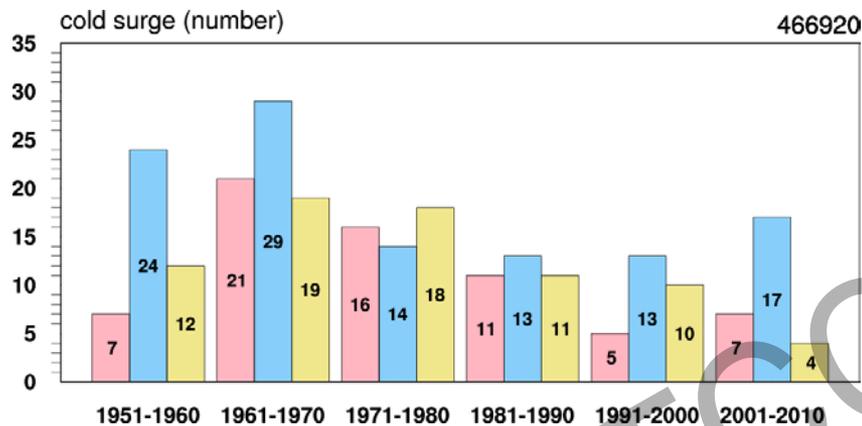
開始日: 48小時降溫幅 > PR90



站名	站號	最低溫PR10	最低溫PR20	24小時升溫 PR90	48小時降溫 PR90
淡水	466900	8.5	10.2	2.6	-4.4
台北	466920	9.7	11.2	2.4	-3.8
彭佳嶼	466950	9.9	11.3	2.6	-4.3
花蓮	466990	12.2	13.4	2	-3
宜蘭	467080	10.5	11.6	2.2	-3.6
台南	467410	10.3	11.8	2.4	-3.5
高雄	467440	12.5	13.9	2.2	-3.3
嘉義	467480	8.9	10.4	2.5	-3.6
台中	467490	8.9	10.6	2.5	-3.6
恆春	467590	15.5	16.6	2	-2.7
台東	467660	13.6	14.8	1.9	-3
阿里山	467530	-1.7	-0.2	2.8	-3.8
玉山	467550	-8.1	-6.6	2.5	-3.7

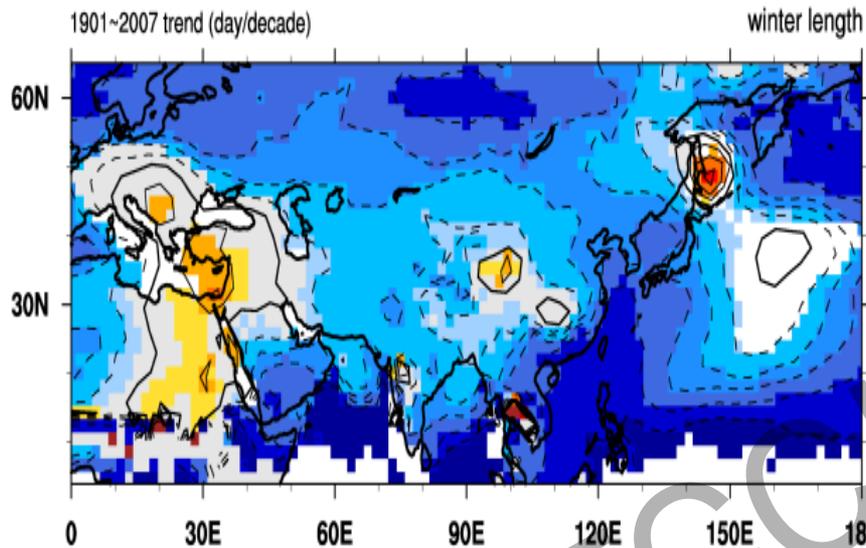


冬季寒潮各月份變化

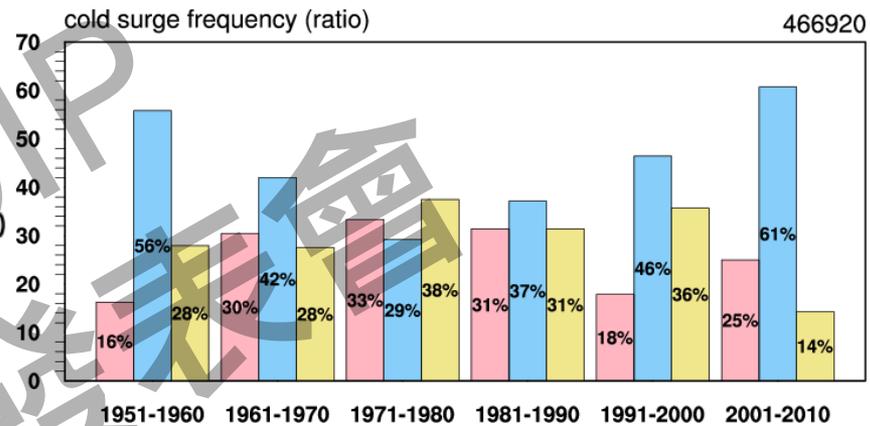
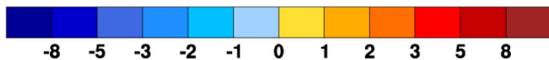
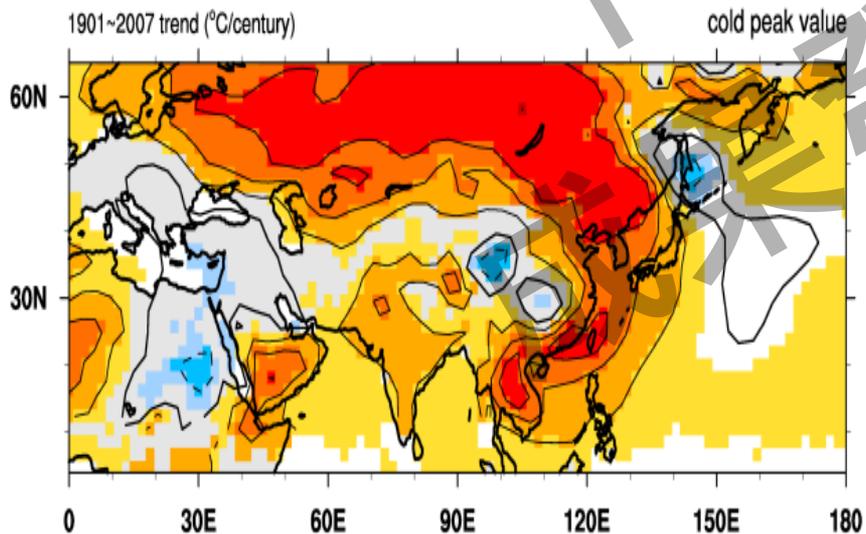


冬季各月份寒潮個案及低溫日均呈減少趨勢，但1月份寒潮發生頻率在近期有上升的趨勢

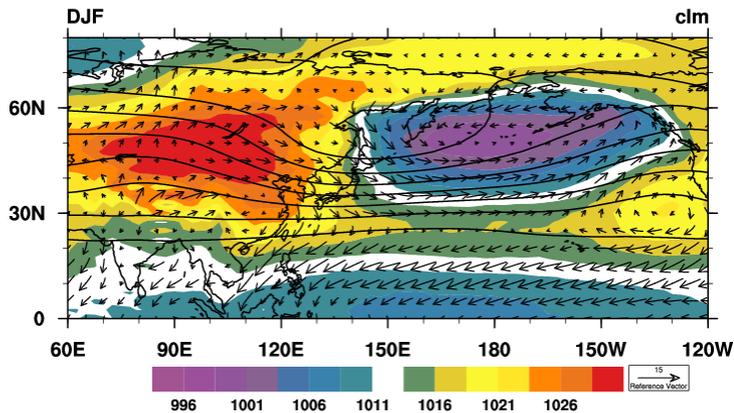
冬季長度變化趨勢



冬季峰值變化趨勢



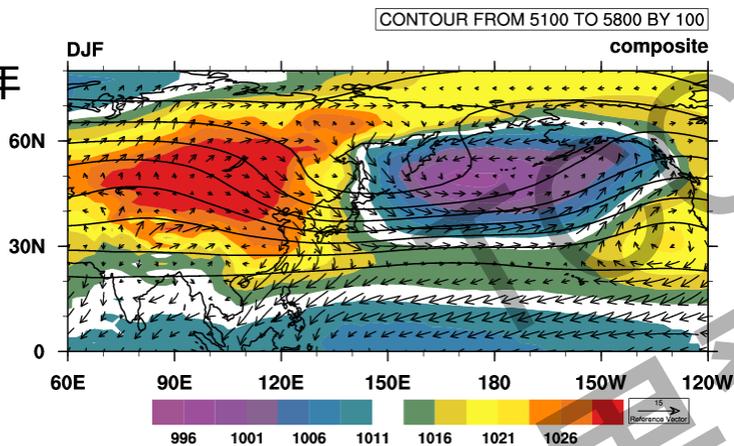
氣候平均



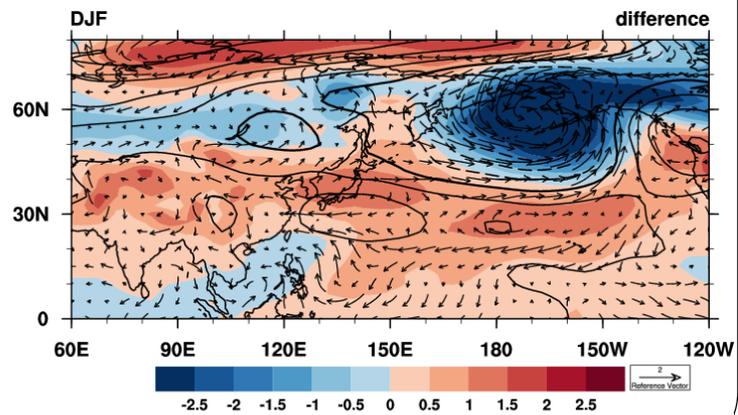
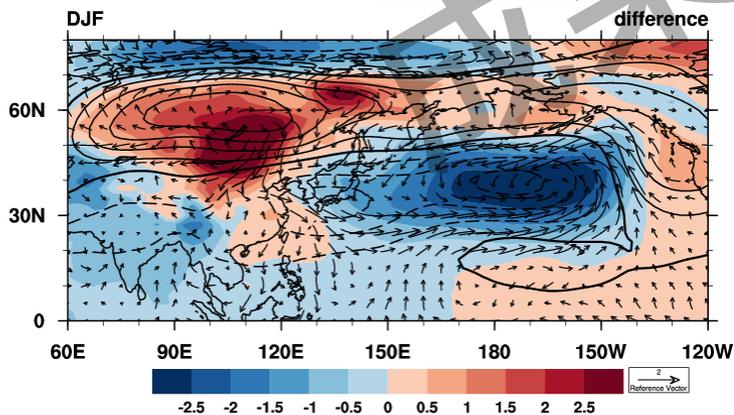
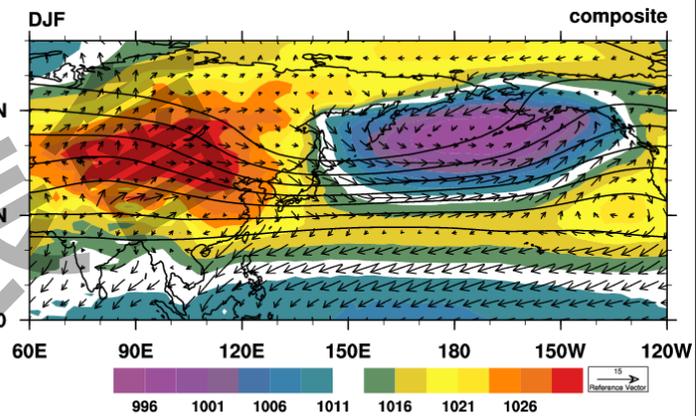
選取標準:

標準化後之每年寒潮發生總數大於(小於)1個標準差者為偏多(偏少)年

寒潮偏多年

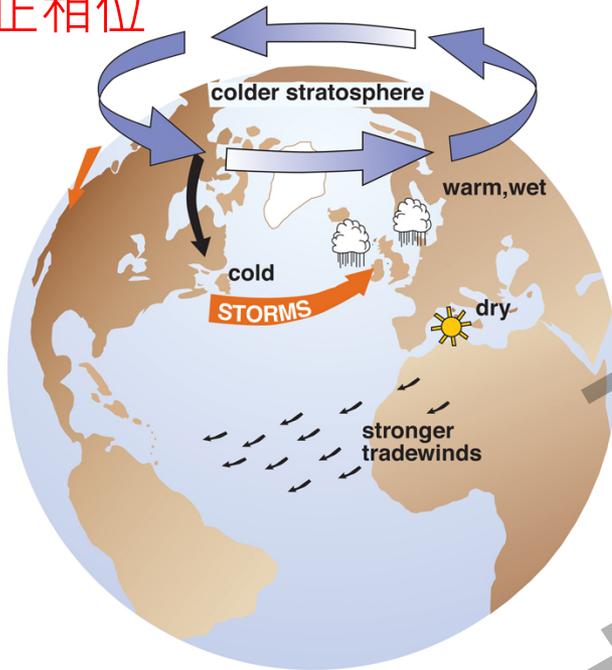


寒潮偏少年

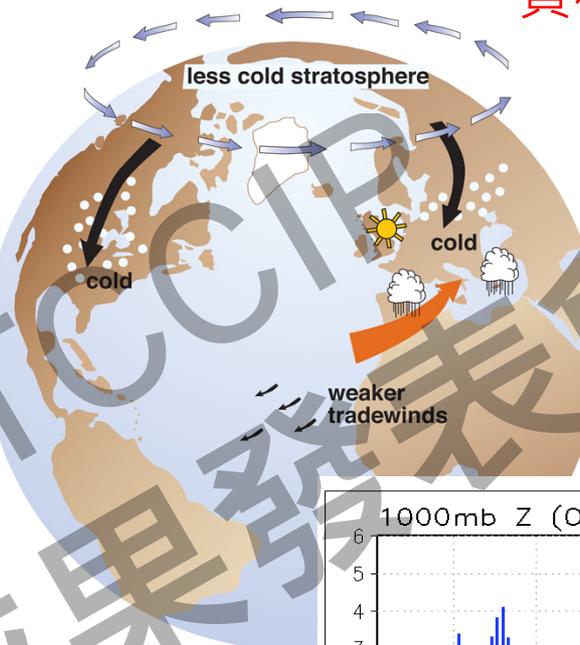


北極震盪惹的禍？

正相位

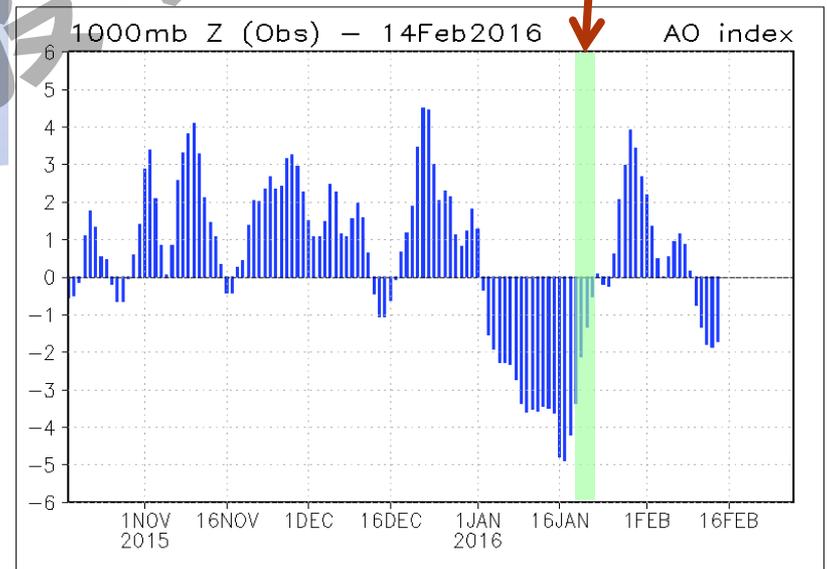


負相位

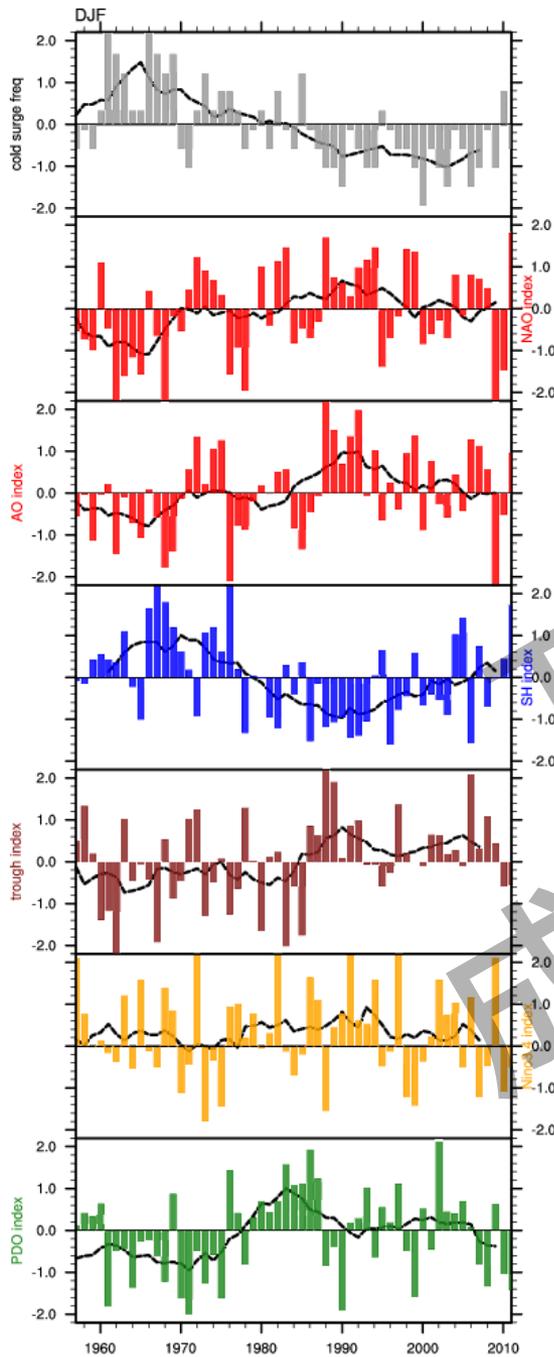


寒潮期間AO
負相位

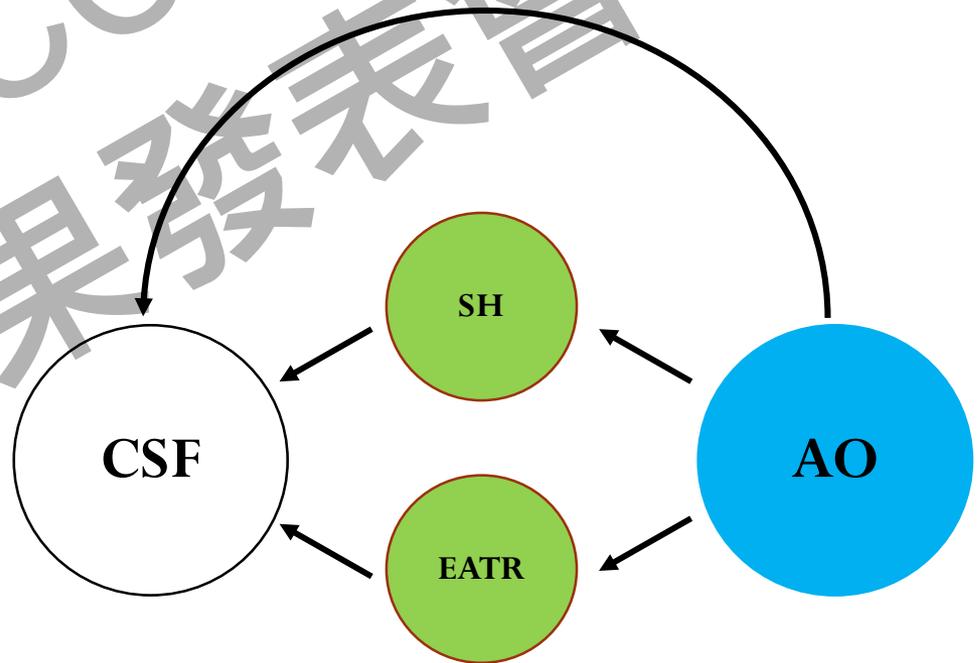
Credit: J. Wallace, University of Washington



寒潮與大尺度環境因子

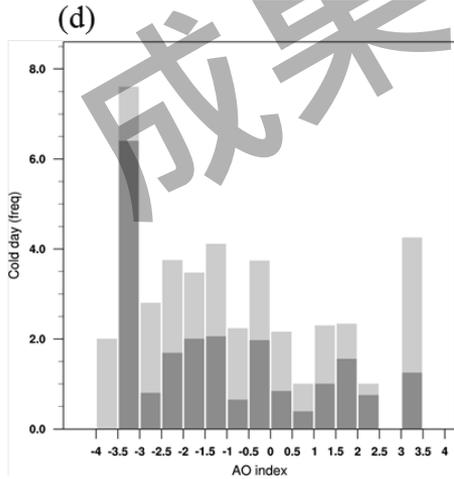
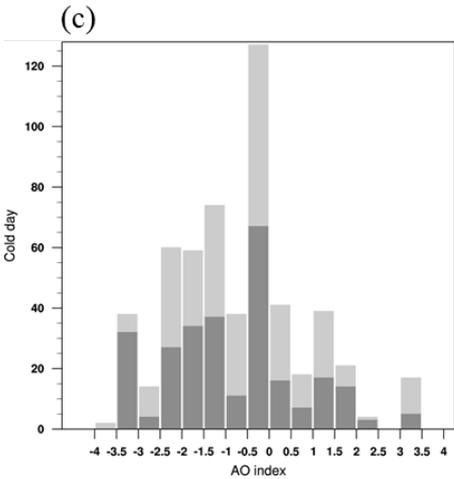
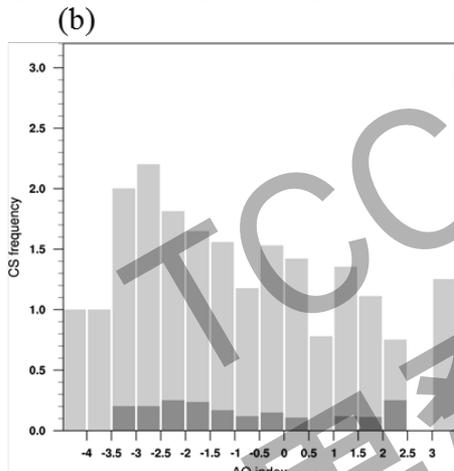
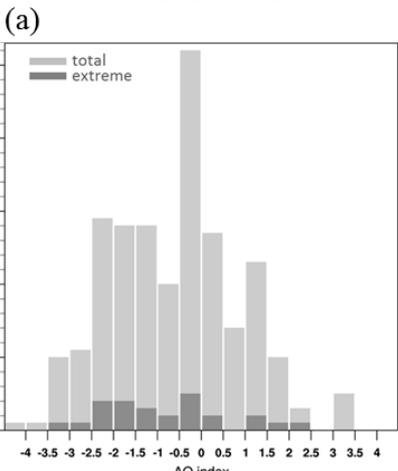
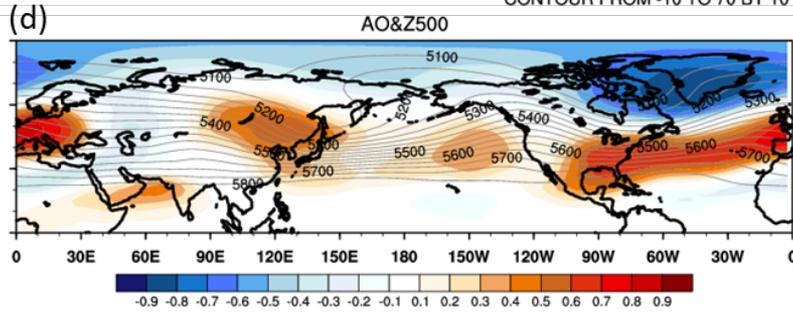
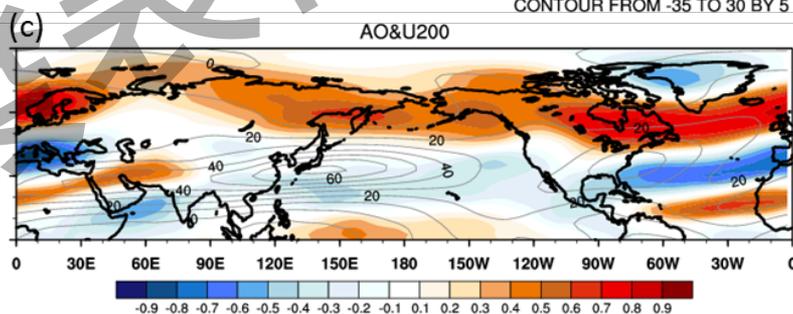
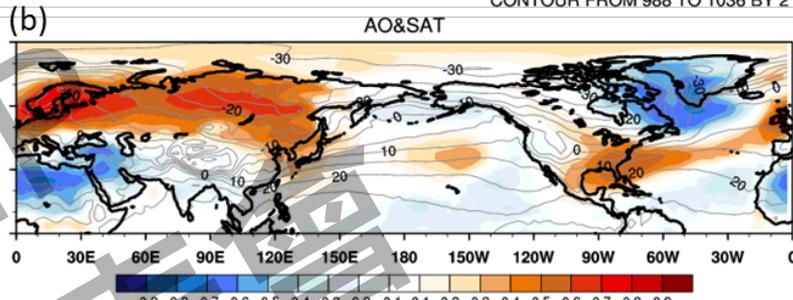
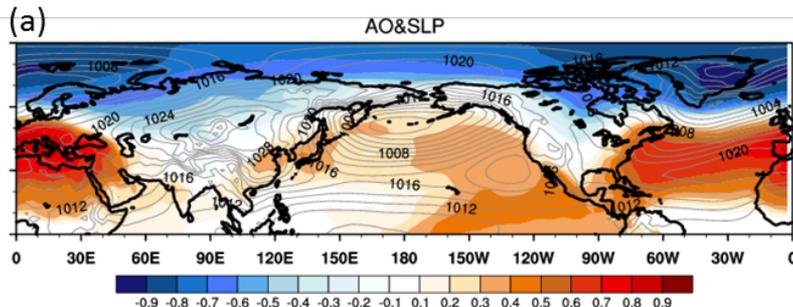
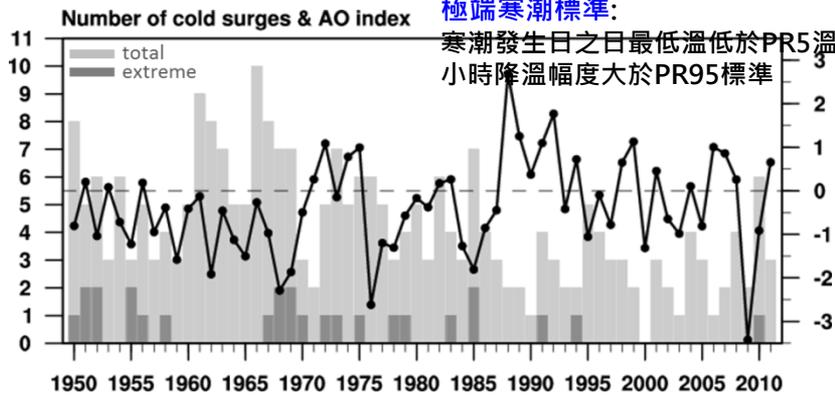


	CSF	SH	NAO	AO	PDO	EATR	Nino3.4
CSF	1	0.8(0.5)	-0.8(-0.2)	-0.8(-0.3)	-0.6(-0.1)	-0.9(-0.6)	-0.3(-0.1)
SH	0.8(0.5)	1	-0.7(-0.1)	-0.8(-0.3)	-0.8(-0.2)	-0.7(-0.5)	-0.7(-0.3)
NAO	-0.8(-0.2)	-0.7(-0.1)	1	0.9(0.8)	0.5(-0.1)	0.7(0.1)	0.2(-0.2)
AO	-0.8(-0.3)	-0.8(-0.3)	0.9(0.8)	1	0.3(-0.3)	0.8(0.4)	0.3(-0.2)
PDO	-0.6(-0.1)	-0.8(-0.2)	0.5(-0.1)	0.3(-0.3)	1	0.2(0)	0.5(0.5)
EATR	-0.9(-0.6)	-0.7(-0.5)	0.7(0.1)	0.8(0.4)	0.2(0)	1	0.3(0.3)
Nino3.4	-0.3(-0.1)	-0.7(-0.3)	0.2(-0.2)	0.3(-0.2)	0.5(0.5)	0.3(0.3)	1



極端寒潮標準:

寒潮發生日之日最低溫低於PR5溫度且48
小時降溫幅度大於PR95標準



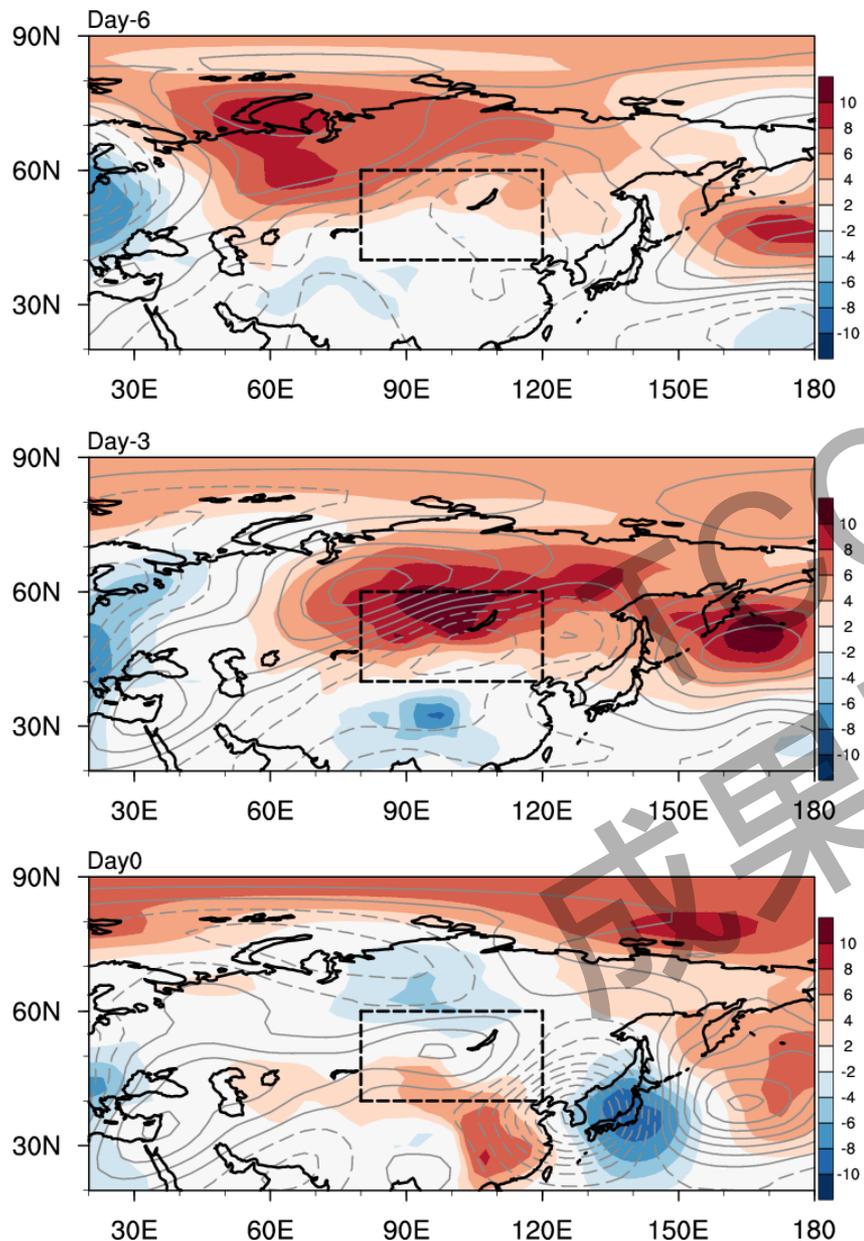
CONTOUR FROM 988 TO 1036 BY 2

CONTOUR FROM -35 TO 30 BY 5

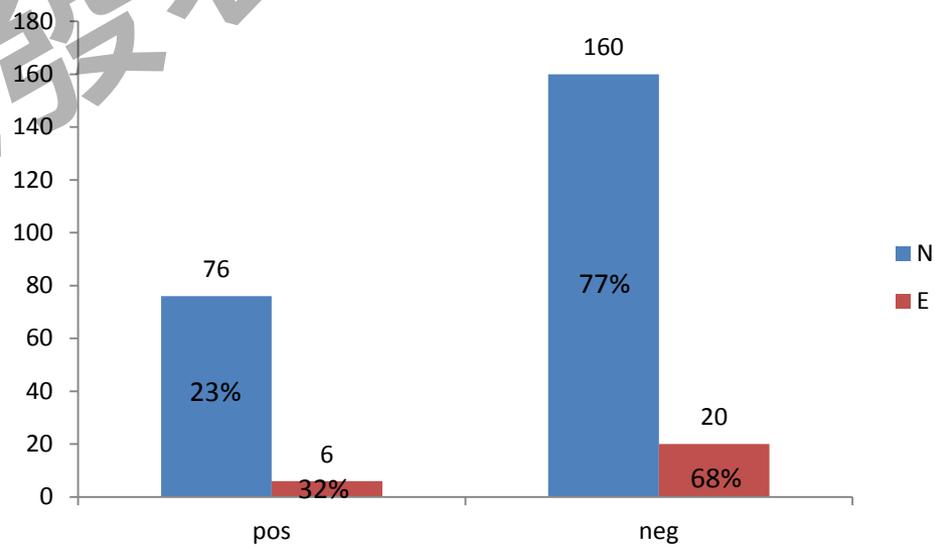
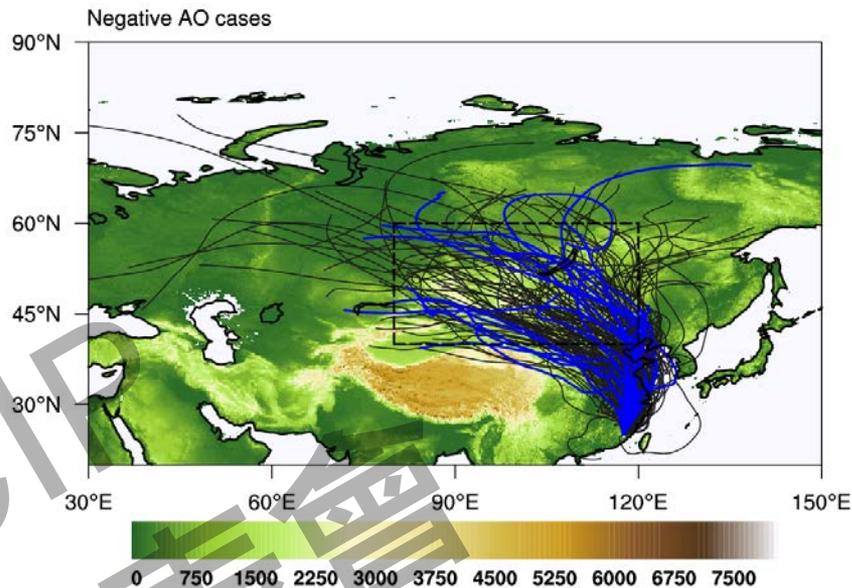
CONTOUR FROM -10 TO 70 BY 10

CONTOUR FROM 5100 TO 5800 BY 50

AO負相位極端寒潮個案合成



AO負相位寒潮軌跡



CMIP5模式選取

Number	Modeling Center (or Group)	Institute ID	Model name	Resolution
1	Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia	CSIRO-BOM	ACCESS1-0	145x192
2			ACCESS1-3	145x192
3	Beijing Climate Center, China Meteorological Administration	BCC	BCC-CSM1-1	64x128
4			BCC-CSM1-1m	160x320
5	Centro Euro-Mediterraneo per I Cambiamenti Climatici	CMCC	CMCC-CESM	48x96
6			CMCC-CM	240x480
7			CMCC-CMS	96x192
8	Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique	CNRM-CERFACS	CNRM-CM5	128x256
9	Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence	CSIRO-QCCCE	CSIRO-Mk3-6-0	96x192
10	NOAA Geophysical Fluid Dynamics Laboratory	NOAA GFDL	GFDL-CM3	90x144
11			GFDL-ESM2G	90x144
12			GFDL-ESM2M	90x144
13	Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	MOHC	HadGEM2-AO	145x192
14			HadGEM2-CC	145x192
15	Institute for Numerical Mathematics	INM	INM-CM4	120x180
16	Institut Pierre-Simon Laplace	IPSL	IPSL-CM5A-LR	96x96
17			IPSL-CM5A-MR	143x144
18	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC	MIROC5	64x128
19	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	MIROC	MIROC-ESM	64x128
20	Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)	MPI-M	MPI-ESM-LR	96x192
21			MPI-ESM-MR	96x192
22	Meteorological Research Institute	MRI	MRI-CGCM3	160x320

Model Performance index

$$e_{vm}^2 = \sum_n \left(w_n (\bar{s}_{vmn} - \bar{o}_{vn})^2 / \sigma_{vn}^2 \right), \quad (1)$$

$$I_{vm}^2 = e_{vm}^2 / \overline{e_{vm}^2}^{m=20C3M}, \quad (2)$$

$$I_m^2 = \overline{I_{vm}^2}^v. \quad (3)$$

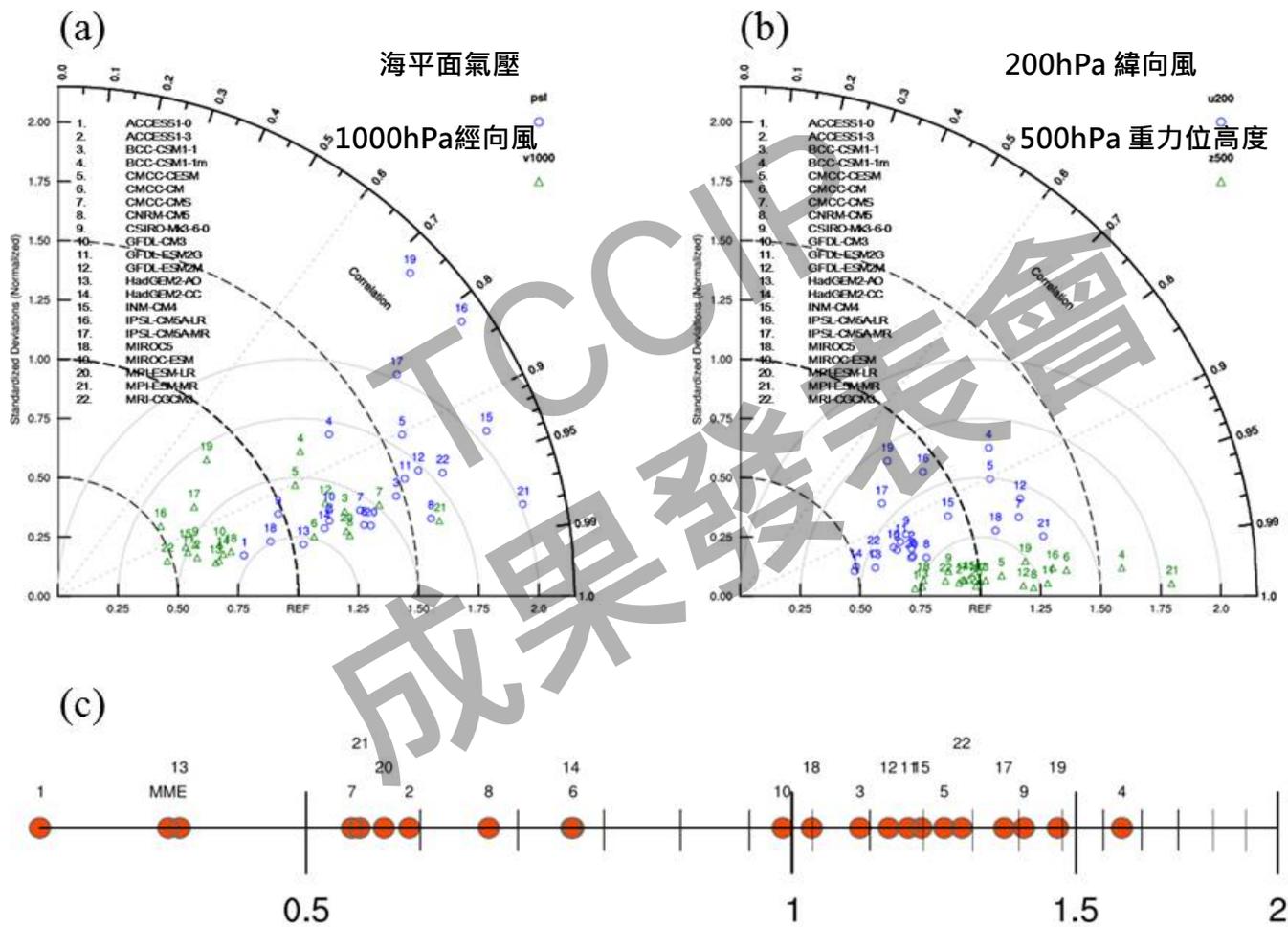
w_n = proper weights needed for area and mass averaging

\bar{s}_{vmn} = simulated climatology for climate variable (v), model (m), and grid point (n)

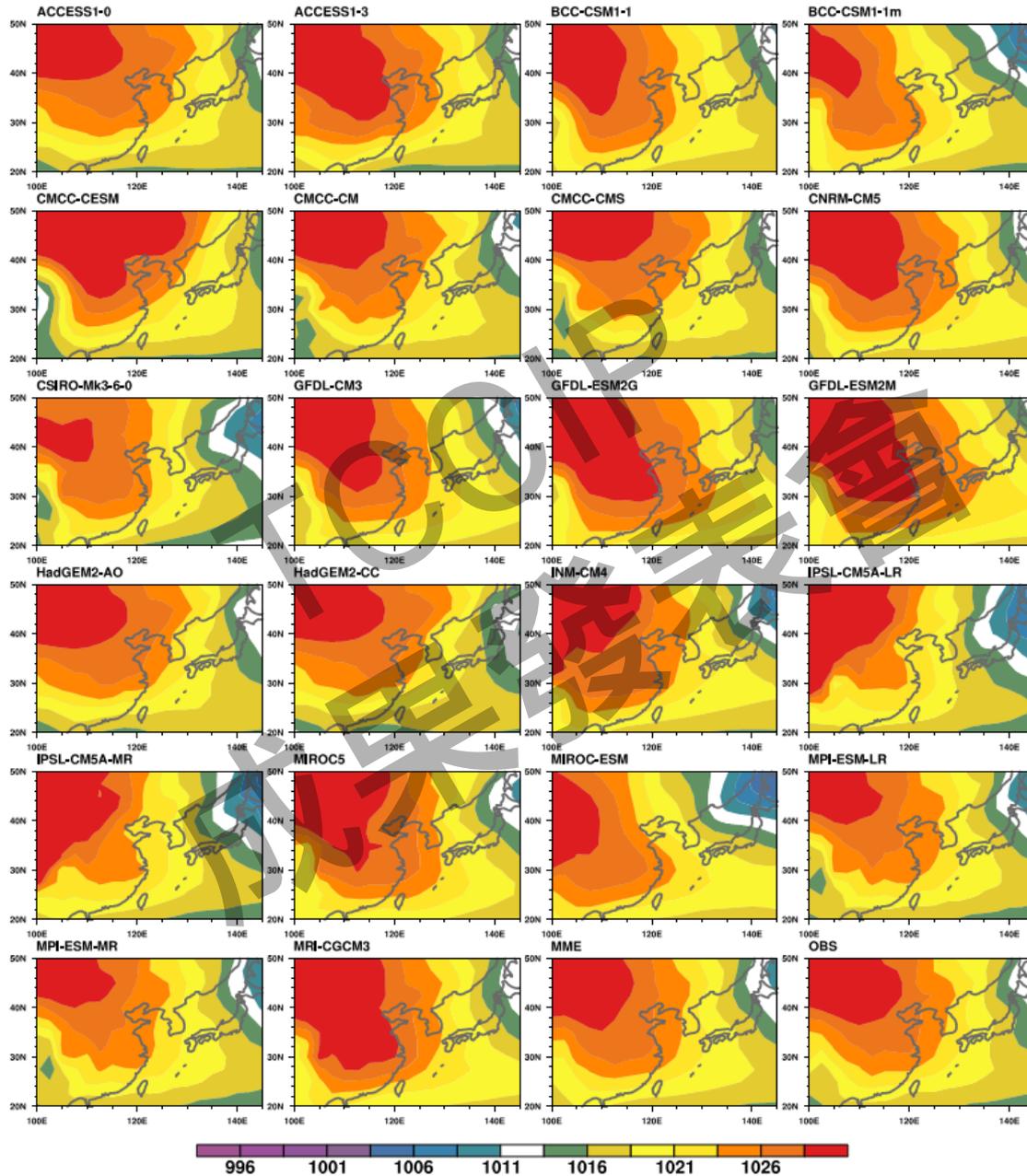
\bar{o}_{vn} = corresponding observed climatology

σ_{vm}^2 = interannual variance from the validating observations

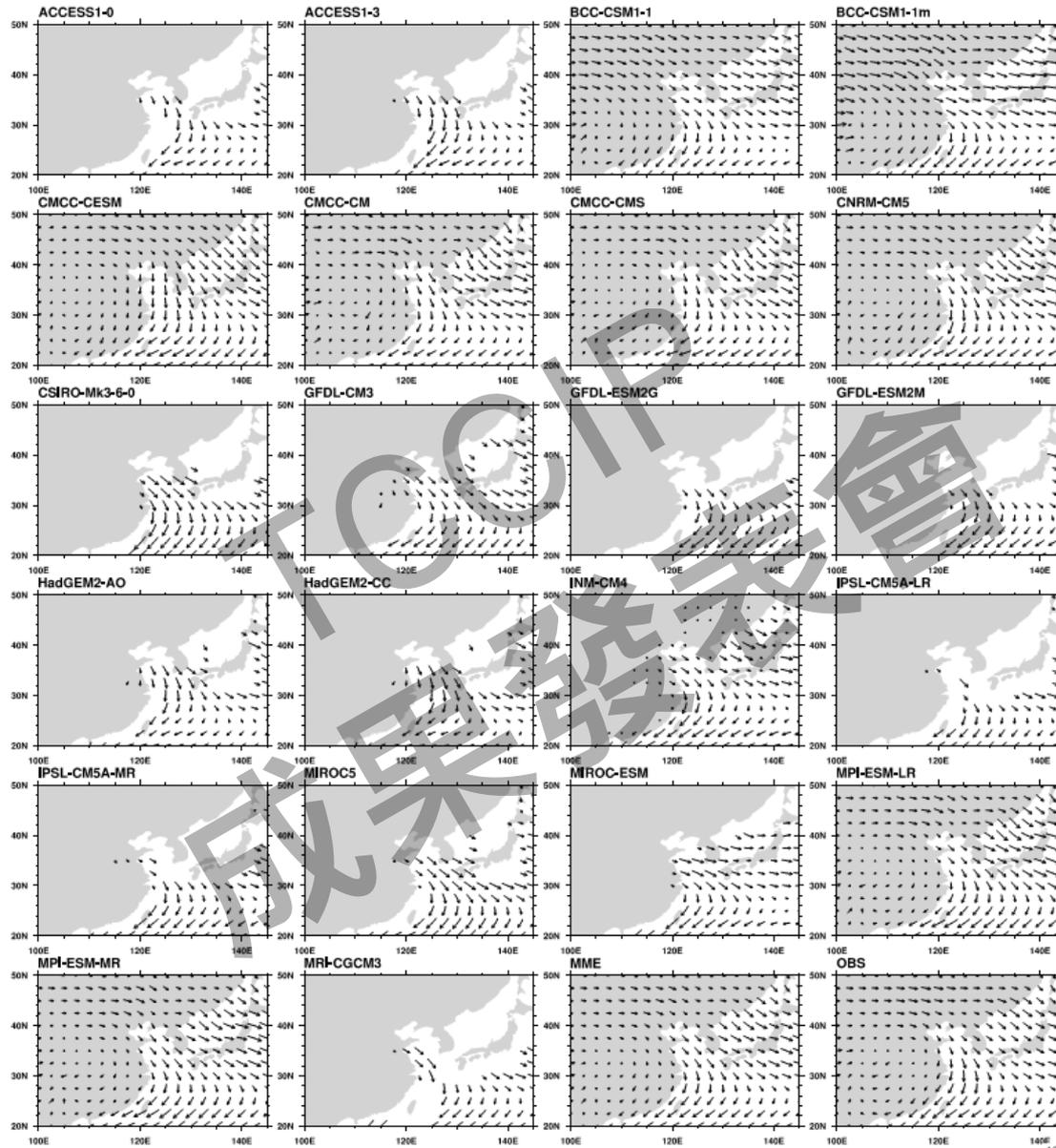
CMIP5模式冬季氣候平均場評估



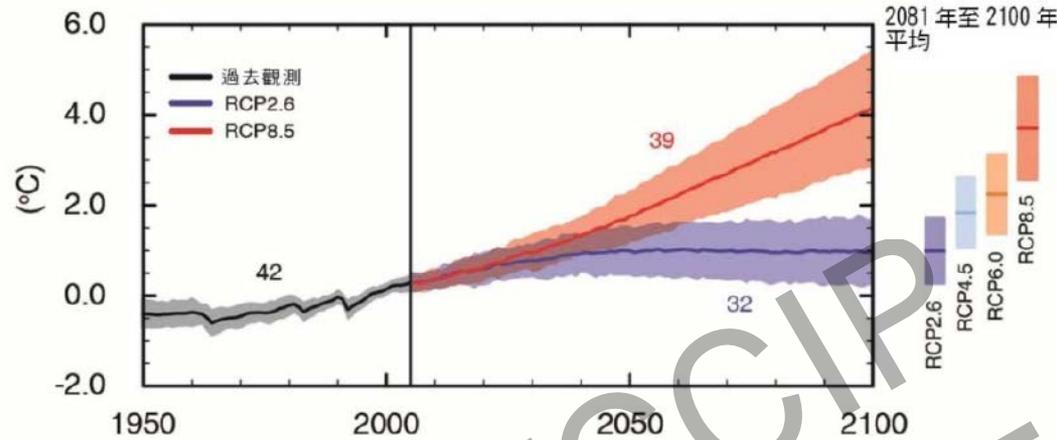
psl



1000hPa wind



(a) 全球地表與海表溫度的變化

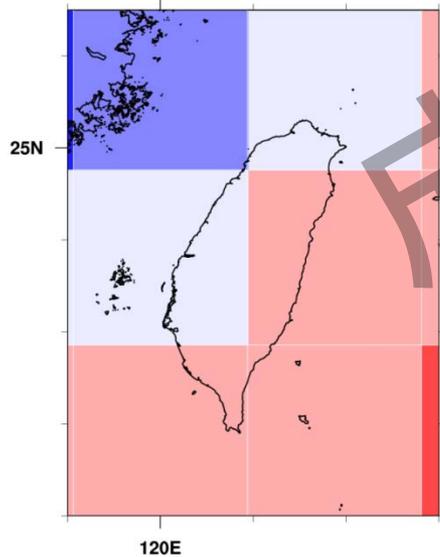


全球平均溫度 (2081-2100)

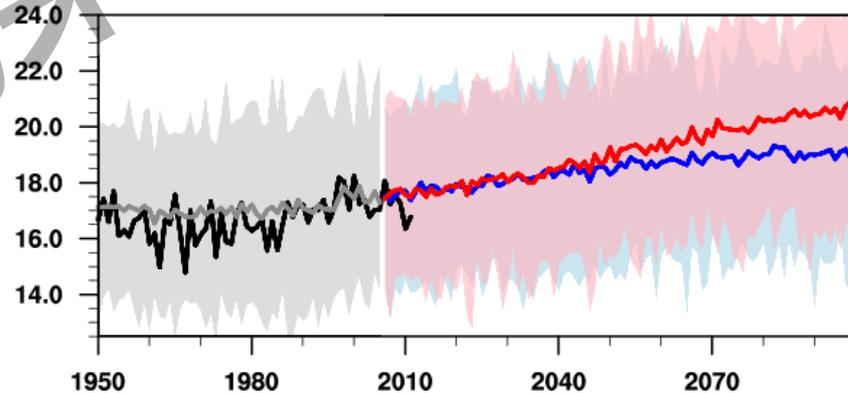
RCP4.5: +1.8°C

RCP8.5: +3.7°C

Daily Minimum Temperature at 2 m



obs
Historical
RCP4.5
RCP8.5



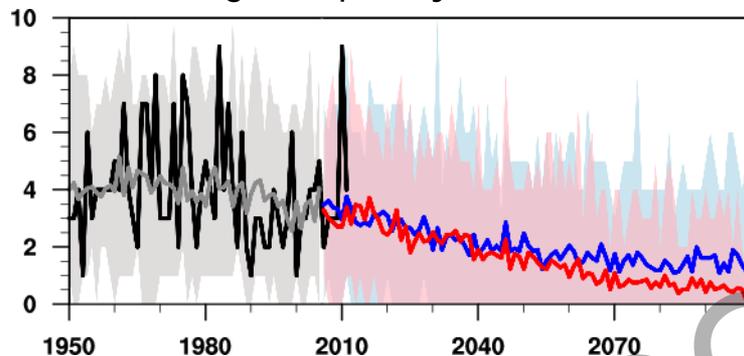
台灣冬季溫度 (2081-2100)

RCP4.5: +1.8°C

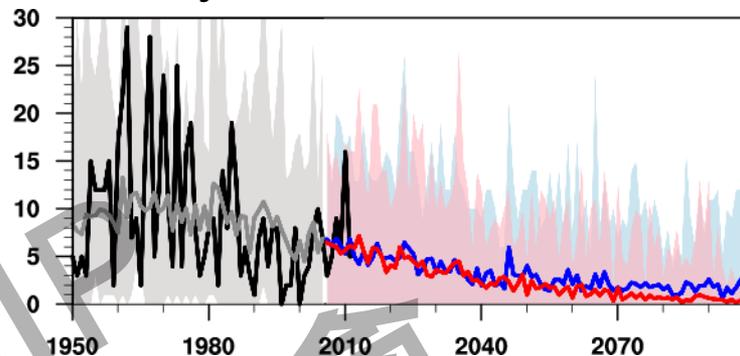
RCP8.5: +3.2°C

CMIP5 台灣寒潮未來推估

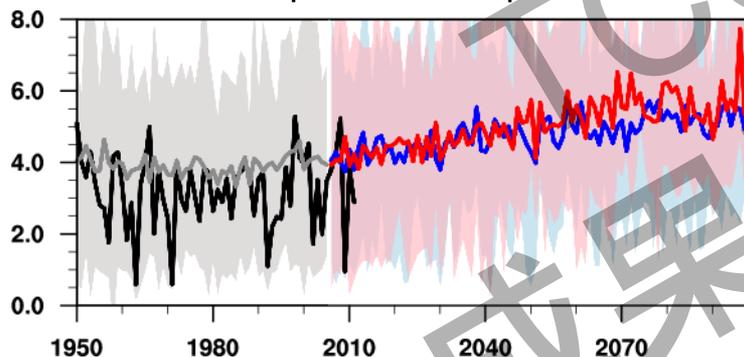
Cold surge frequency



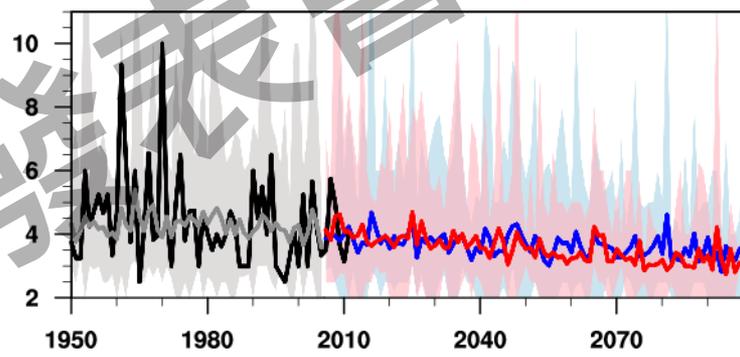
Cold day



48-hour temperature drop



duration



1979-2003(Historical)

2075-2099(RCP4.5)

2075-2099(RCP8.5)

寒潮頻率
低溫日
降溫幅度
持續時間

	D	J	F	DJF	D	J	F	DJF	D	J	F	DJF
CSF	0.7	1.7	1.3	3.7	0.3	0.7	0.4	1.4	0.1	0.3	0.2	0.6
CD	1	4.2	3.2	8.5	0.2	1	0.5	1.7	0.04	0.3	0.2	0.6
TD	4.7	3.8	3.6	3.9	5.7	5	4.8	4.9	5.7	5.5	5.4	5.5
DUR	3.9	4.7	4.1	4.3	3.2	3.6	3.4	3.5	2.7	3.2	2.9	3

寒潮發生次數 & AO相位 (CMIP5)

model	non-extreme		extreme	
	pos	neg	pos	neg
OBS	76	160	6	20
ACCESS1-0	99	96	15	11
ACCESS1-3	○ 82	97	19	10
BCC-CSM1-1	73	61	⊙ 2	5
BCC-CSM1-1m	73	57	4	3
CMCC-CESM	○ 80	92	⊙ 5	11
CMCC-CM	97	86	10	10
CMCC-CMS	105	88	○ 10	13
CNRM-CM5	88	86	⊙ 10	16
CSIRO-Mk3-6-0	93	81	○ 15	17
GFDL-CM3	89	76	○ 7	10
GFDL-ESM2G	99	93	○ 8	11
GFDL-ESM2M	94	91	○ 14	17
HadGEM2-AO	93	83	12	13
HadGEM2-CC	86	82	⊙ 10	15
INM-CM4	○ 98	99	16	13
IPSL-CM5A-LR	97	79	13	12
IPSL-CM5A-MR	○ 86	88	13	12
MIROC5	86	81	13	9
MIROC-ESM	92	87	17	14
MPI-ESM-LR	○ 84	92	⊙ 4	7
MPI-ESM-MR	99	85	13	5
MRI-CGCM3	108	72	12	7

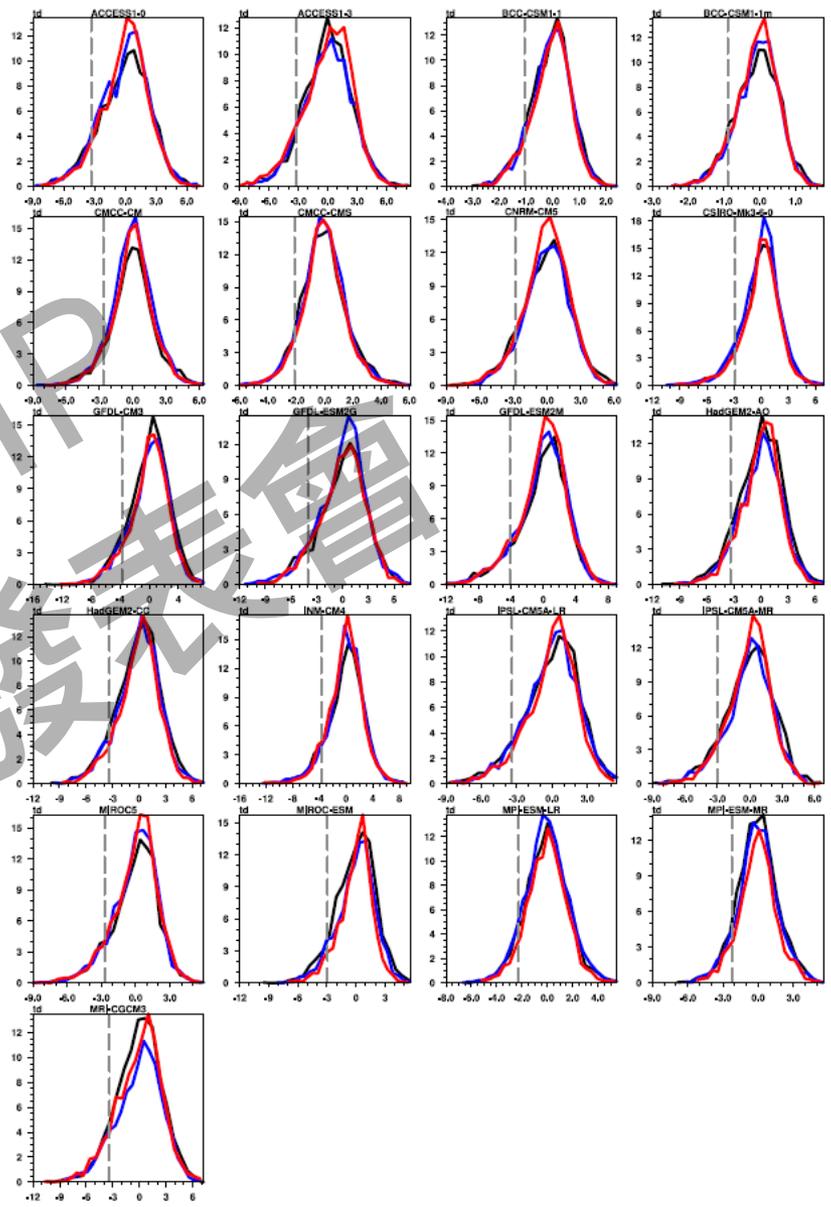
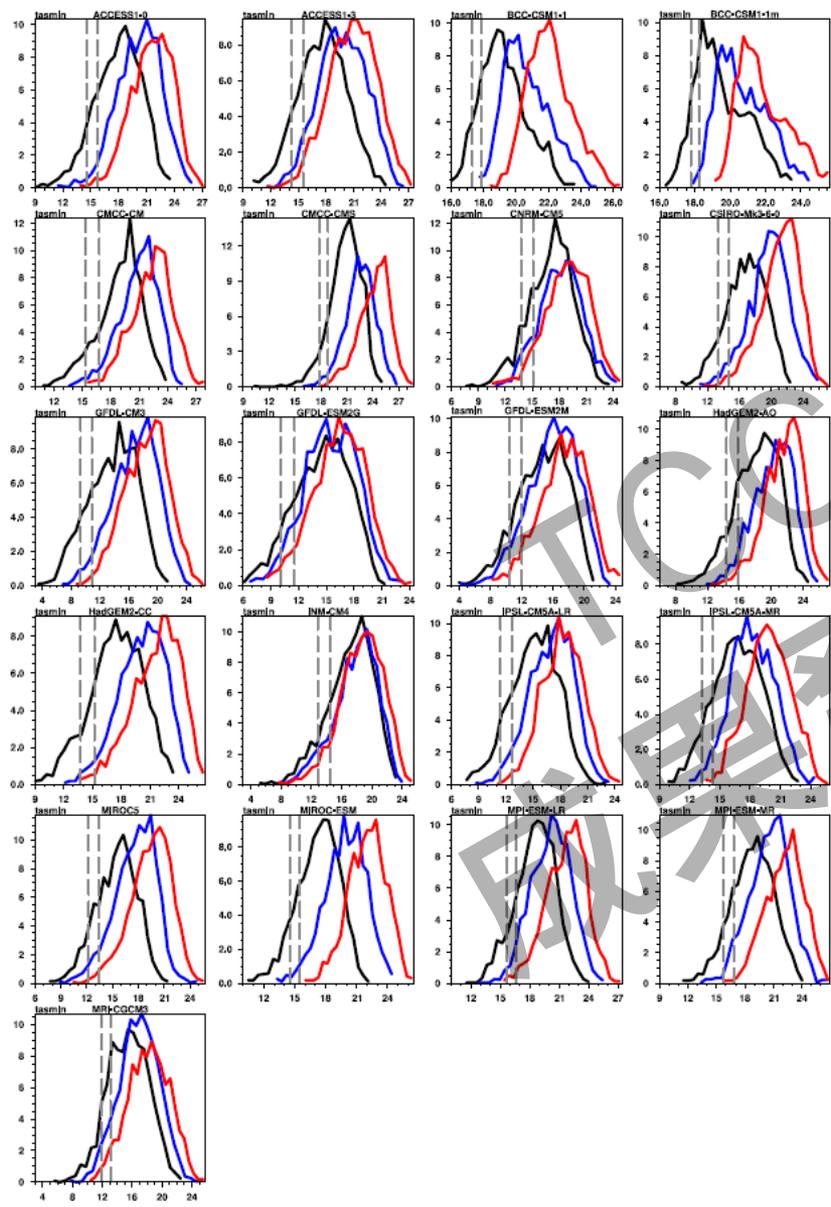
負相位-正相位總數

⊙ >60%

○ 50-60%

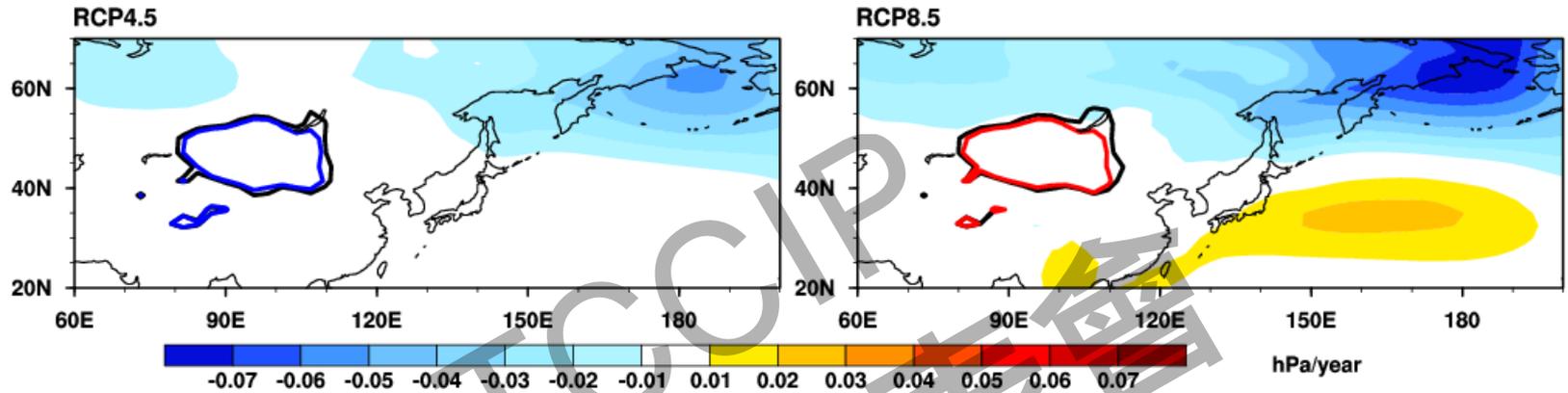
tmin

48hour t-drop

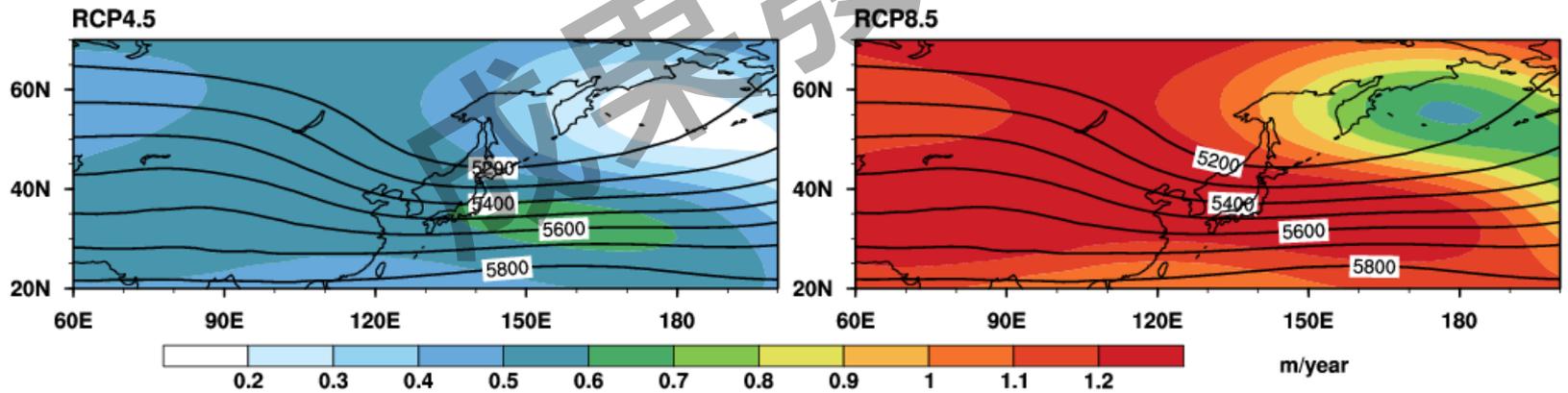


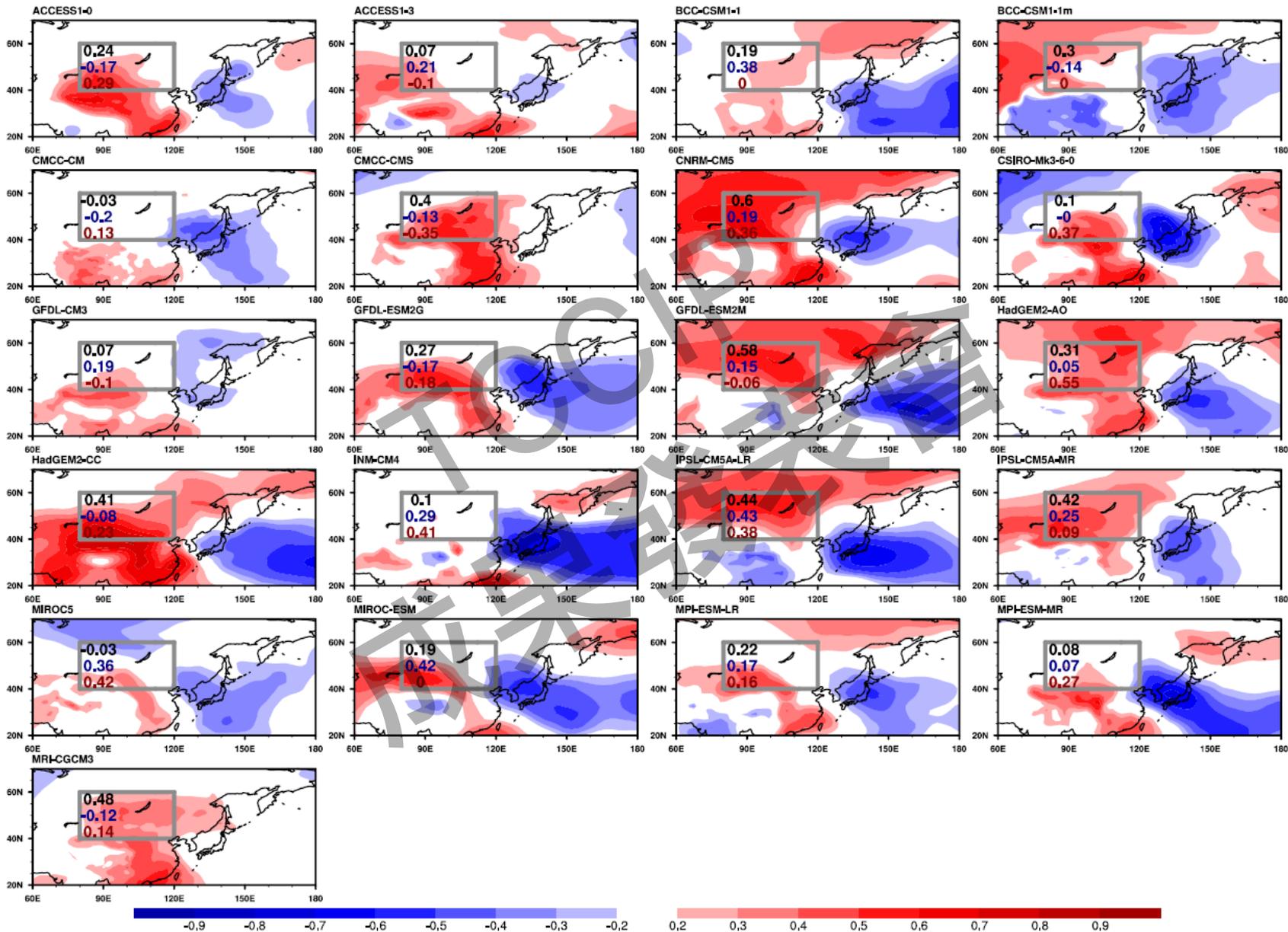
Linear trend of the period 2006-2099 DJF

SLP



Z500





結論

- ❖ 臺灣5個百年測站近30、50及100年的寒潮頻率長期線性趨勢顯示，近50年及近100年的寒潮頻率在5個測站都為明顯減少，減少的幅度平均可達3次以上，南部測站的減少幅度又較中部及北部大，近30年變化來看，臺中、花蓮及恆春站仍有明顯的減少趨勢，其中以恆春站減少2.8次最大，臺北及臺南站則無顯著的趨勢出現。
- ❖ CMIP5系集平均的溫度變化在RCP4.5情境下，臺灣地區至21世紀末時，日最低溫度約較現今氣候上升約 2°C ，RCP8.5反應更為嚴重的暖化程度，至21世紀末，平均溫度提高約 $3-4^{\circ}\text{C}$ 左右。
- ❖ RCP4.5、RCP8.5情境的未來推估結果皆顯示臺灣寒潮發生頻率與低溫日都呈現逐年減少的趨勢，根據暖化程度的不同，在RCP8.5情境下冬季寒潮的減少最為明顯且劇烈，21世紀末幾乎沒有寒潮事件的發生，寒潮頻率及低溫日由現今氣候下平均3.7次/年及8.5日/年減少至世紀末的0.6次/年及0.6日/年。
- ❖ CMIP5系集平均顯示西伯利亞高壓強度在21世紀末的強度及範圍相較於現今氣候態並無明顯改變，顯示寒潮發生頻率的減少主要是暖化所導致全球地面溫度上升造成。
- ❖ 以台北測站為代表統計台灣極端寒潮事件與AO之相關性，1950-2011年冬季共發生26次極端寒潮事件，其中20次發生在AO負相位，僅有6次發生在AO正相位。極端寒潮多發生於1985/86年以前，1985年後冬季僅發生3次。觀測分析中非極端寒潮也有傾向發生在AO負相位的結果，而CMIP5模式中此項特徵並不明顯。