




CMIP5模式對臺灣梅雨季 大尺度環流的模擬能力評量

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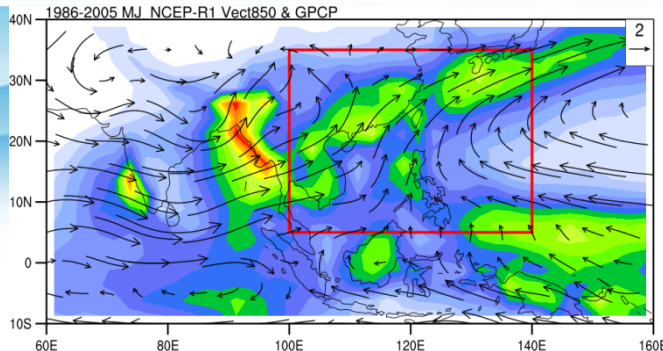
Objective

-  梅雨季劇烈降雨是台灣重要的災害性天氣現象，尤其近年來，都市快速發展，使得劇烈降水造成的災害有增加的趨勢。
-  利用數值模式研究氣候變遷是重要工具，近十餘年氣候數值模式的模擬技術進展快速，但關於降雨特性的模擬能力仍相當不足，對東亞雨量長期平均時空分布特性也還不能正確掌握。
-  本研究檢驗第五期耦合模式比對計畫(CMIP5)模式對於臺灣梅雨季東亞區域環流的模擬能力，挑選具適當模擬能力的模式，作為未來利用模式進行氣候變化趨勢推估時的參考依據。

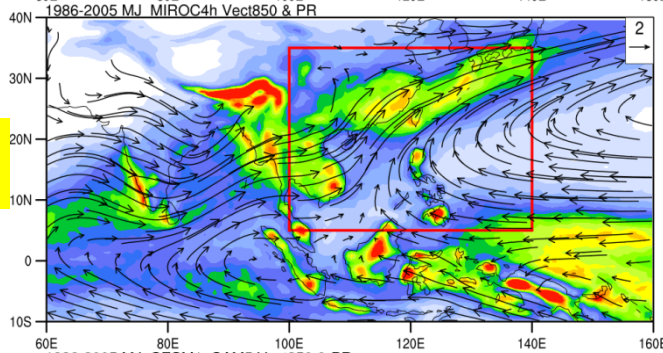
No	Model	Country	Institution
1	ACCESS1.0	Australia	Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM)
2	ACCESS1.3		
3	BCC-CSM1.1	China	Beijing Climate Center, China Meteorological Administration
4	BCC-CSM1.1m		
5	BNU-ESM		
6	CanCM4	Canada	Canadian Center for Climate Modelling and Analysis
7	CanESM2		
8	CCSM4	USA	US National Centre for Atmospheric Research
9	CESM1 (BGC)		National Science Foundation, Department of Energy, National Center for Atmospheric Research
10	CESM1 (CAM5)		
11	CESM1 (FASTCHEM)		
12	CESM1 (WACCM)		
13	CMCC-CESM	Italy	Centro Euro-Mediterraneo per I Cambiamenti Climatici
14	CMCC-CM		
15	CMCC-CMS		
16	CNRM-CM5	France	Centre National de Recherches Meteorologiques and Centre Europeen de Recherches et Formation Avancees en Calcul Scientifique
17	CNRM-CM5-2		
18	CSIRO-Mk3.6.0	Australia	Queensland Climate Change Centre of Excellence and Commonwealth Scientific and Industrial Research Organization
19	FGOALS-g2	China	LASG (Institute of Atmospheric Physics) - CESS (Tsinghua University)
20	FIO-ESM		The First Institute of Oceanography, State Oceanic Administration
21	GFDL-CM2.1	USA	NOAA Geophysical Fluid Dynamics Laboratory
22	GFDL-CM3		
23	GFDL-ESM2G		
24	GFDL-ESM2M		
25	GISS-E2-H	USA	NASA Goddard Institute for Space Studies
26	GISS-E2-H-CC		
27	GISS-E2-R		
28	GISS-E2-R-CC		
29	HadCM3	UK	Met Office Hadley Centre
30	HadGEM2-AO	Korea	National Institute of Meteorological Research/Korea Meteorological Administration
31	HadGEM2-CC	UK	Met Office Hadley Centre
32	HadGEM2-ES		
33	INM-CM4	Russia	Russian Institute for Numerical Mathematics
34	IPSL-CM5A-LR	France	Institute Pierre Simon Laplace
35	IPSL-CM5A-MR		
36	IPSL-CM5B-LR		
37	M IROC4h	Japan	University of Tokyo, National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
38	MIROC5		
39	MIROC-ESM		
40	MIROC-ESM-CHEM		
41	MPI-ESM-LR	Germany	Max Planck Institute for Meteorology
42	MPI-ESM-MR		
43	MPI-ESM-P		
44	MRI-CGCM3	Japan	Meteorological Research Institute
45	MRI-ESM1		
46	NorESM1-M	Norway	Norwegian Climate Centre
47	NorESM1-ME		

Obs.

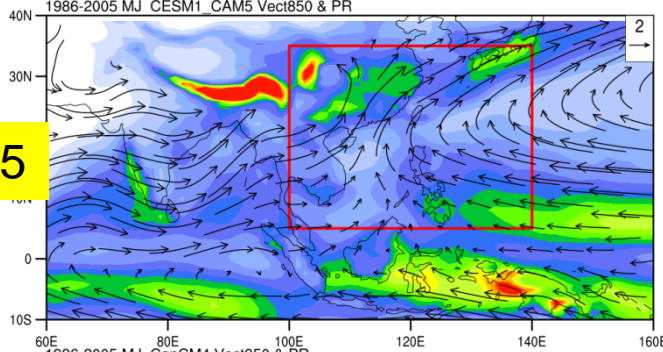
GPCP
NCEP-R1



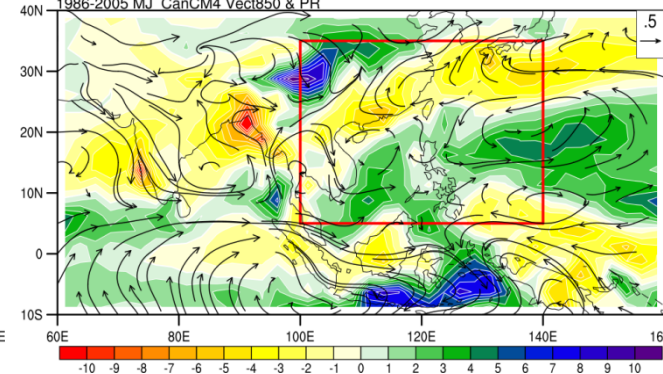
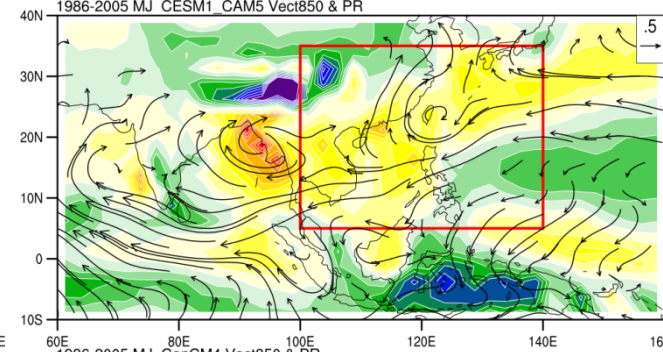
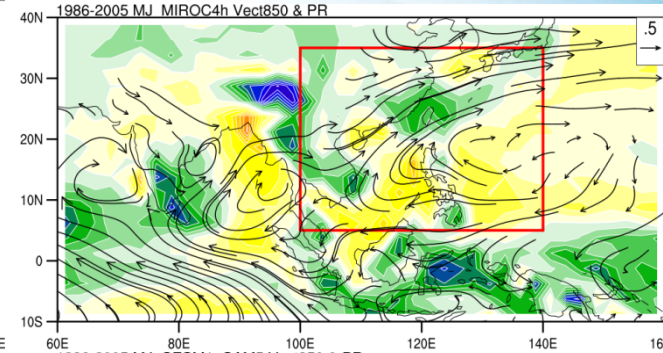
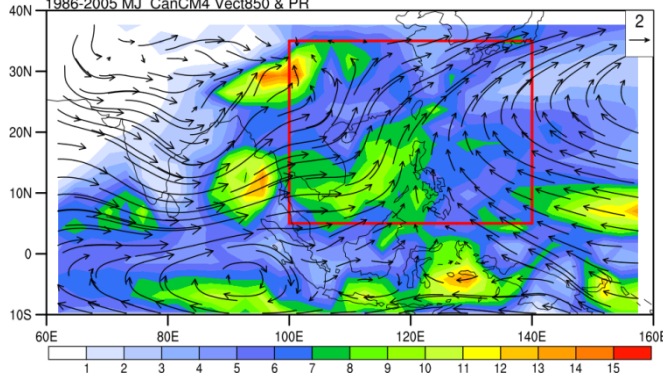
MIROC4h



CESM1-CAM5



CanCM4



PR=0.70
U850=0.88
V850=0.84

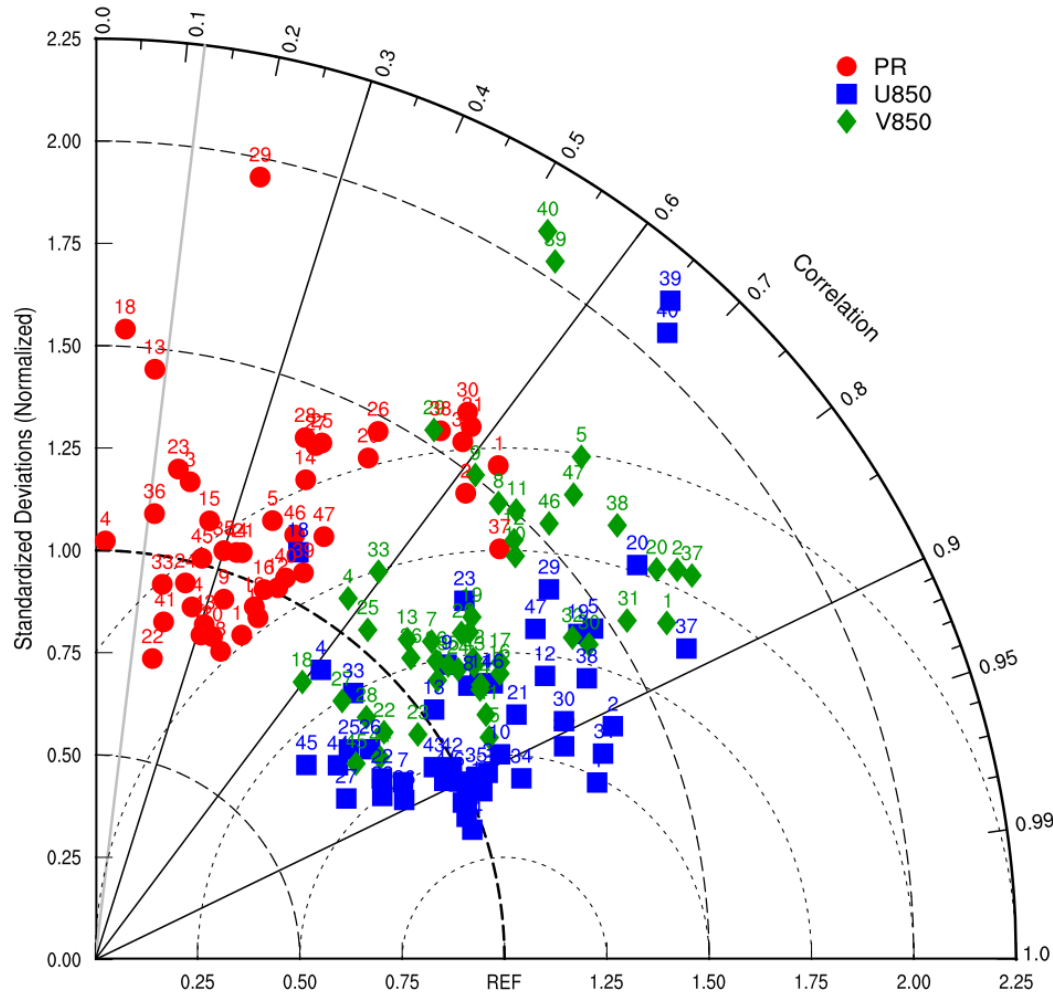
PR=0.34
U850=0.89
V850=0.72

PR=-0.18
U850=0.90
V850=0.75

模式挑選-梅雨季氣候特徵

- 台灣附近區域(100E-140E, 5N-35N)梅雨季雨量氣候值空間分佈特徵

1986-2005 MJ Taylor diagram (100E-140E, 5N-35N)

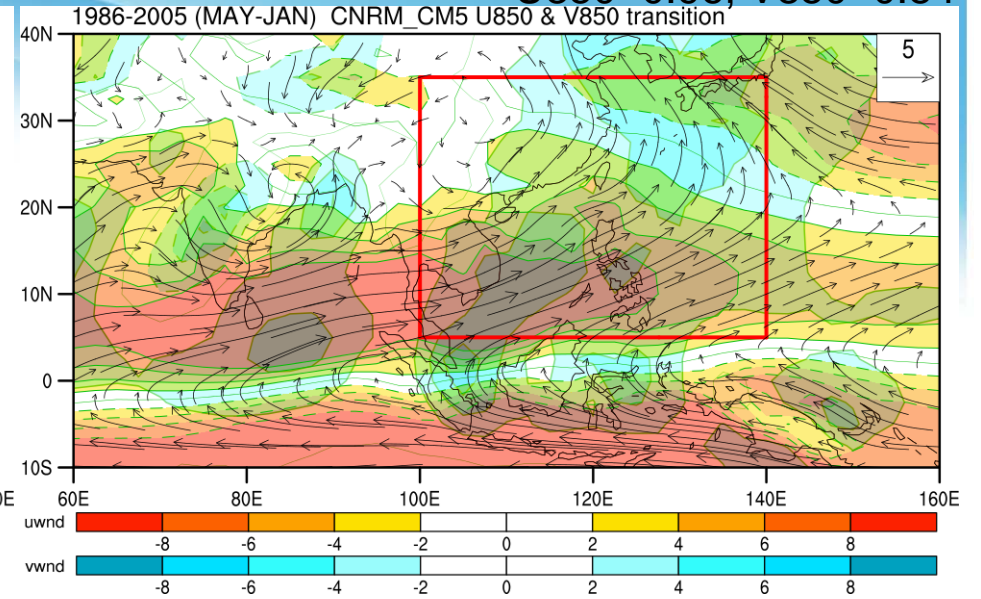
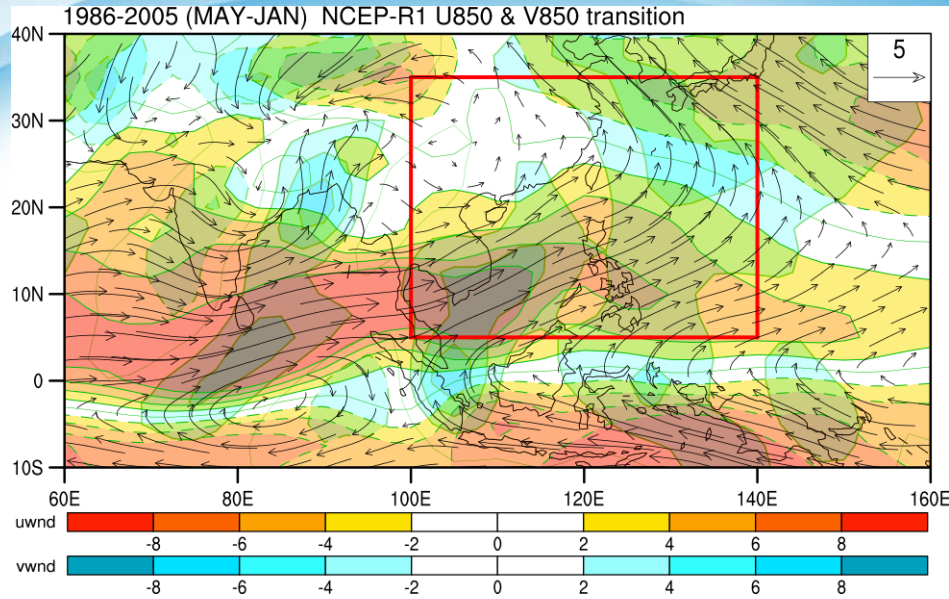


NO	Model	PR	U850	V850
1	ACCESS1.0	0.63	0.94	0.86
2	ACCESS1.3	0.62	0.91	0.83
3	BCC-CSM1.1	0.19	0.90	0.77
4	BCC-CSM1.1m	0.02	0.61	0.57
5	BNU-ESM	0.37	0.83	0.70
6	CanCM4	-0.18	0.90	0.75
7	CanESM2	-0.13	0.87	0.73
8	CCSM4	0.38	0.81	0.66
9	CESM1 (BGC)	0.34	0.77	0.62
10	CESM1 (CAM5)	0.34	0.89	0.72
11	CESM1 (FASTCHEM)	0.41	0.81	0.68
12	CESM1 (WACCM)	0.44	0.85	0.71
13	CMCC-CESM	0.10	0.80	0.70
14	CMCC-CM	0.40	0.95	0.82
15	CMCC-CMS	0.25	0.92	0.87
16	CNRM-CM5	0.42	0.93	0.82
17	CNRM-CM5-2	0.43	0.92	0.81
18	CSIRO-Mk3.6.0	0.05	0.45	0.60
19	FGOALS-g2	0.41	0.83	0.74
20	FIO-ESM	0.48	0.81	0.82
21	GFDL-CM2.1	0.34	0.86	0.75
22	GFDL-CM3	0.19	0.85	0.79
23	GFDL-ESM2G	0.17	0.72	0.82
24	GFDL-ESM2M	0.23	0.92	0.78
25	GISS-E2-H	0.40	0.77	0.64
26	GISS-E2-H-CC	0.47	0.79	0.72
27	GISS-E2-R	0.39	0.84	0.69
28	GISS-E2-R-CC	0.37	0.87	0.75
29	HadCM3	0.21	0.77	0.54
30	HadGEM2-AO	0.56	0.89	0.84
31	HadGEM2-CC	0.58	0.93	0.84
32	HadGEM2-ES	0.58	0.91	0.83
33	INM-CM4	0.18	0.70	0.59
34	IPSL-CM5A-LR	0.26	0.92	0.81
35	IPSL-CM5A-MR	0.30	0.90	0.77
36	IPSL-CM5B-LR	0.13	0.89	0.75
37	MIROC4h	0.70	0.88	0.84
38	MIROC5	0.55	0.87	0.77
39	MIROC-ESM	0.47	0.66	0.55
40	MIROC-ESM-CHEM	0.45	0.67	0.53
41	MPI-ESM-LR	0.20	0.89	0.85
42	MPI-ESM-MR	0.31	0.88	0.78
43	MPI-ESM-P	0.31	0.87	0.79
44	MRI-CGCM3	0.33	0.78	0.82
45	MRI-ESM1	0.26	0.74	0.80
46	NorESM1-M	0.43	0.82	0.72
47	NorESM1-ME	0.48	0.80	0.72

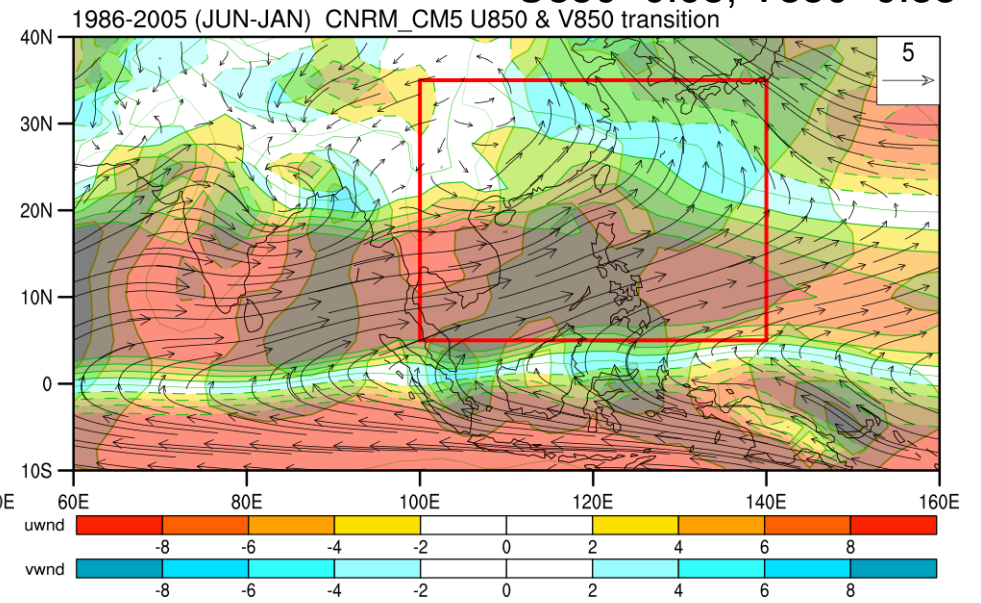
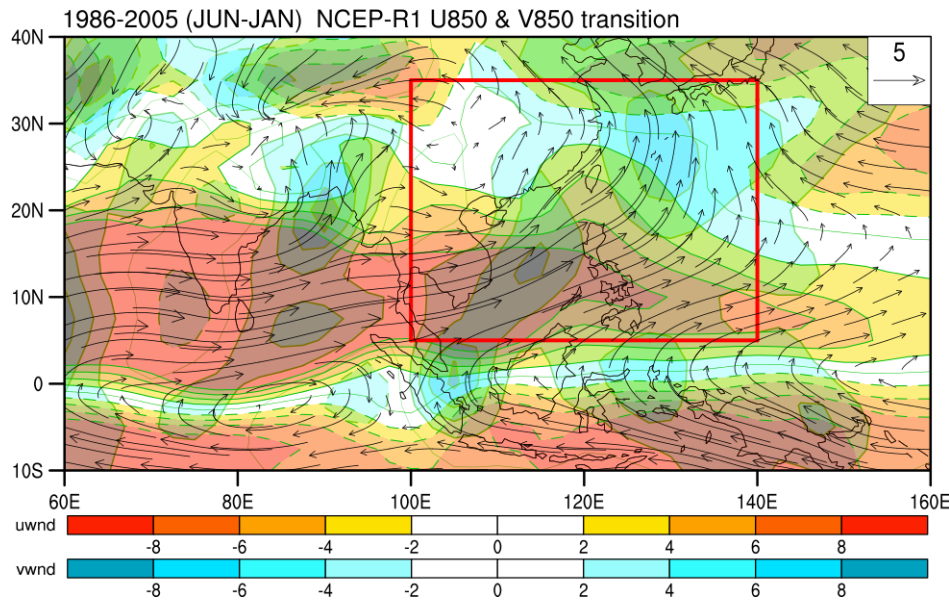
**Obs. GPCP
NCEP-R1**

CNRM-CM5

U850=0.96, V850=0.84



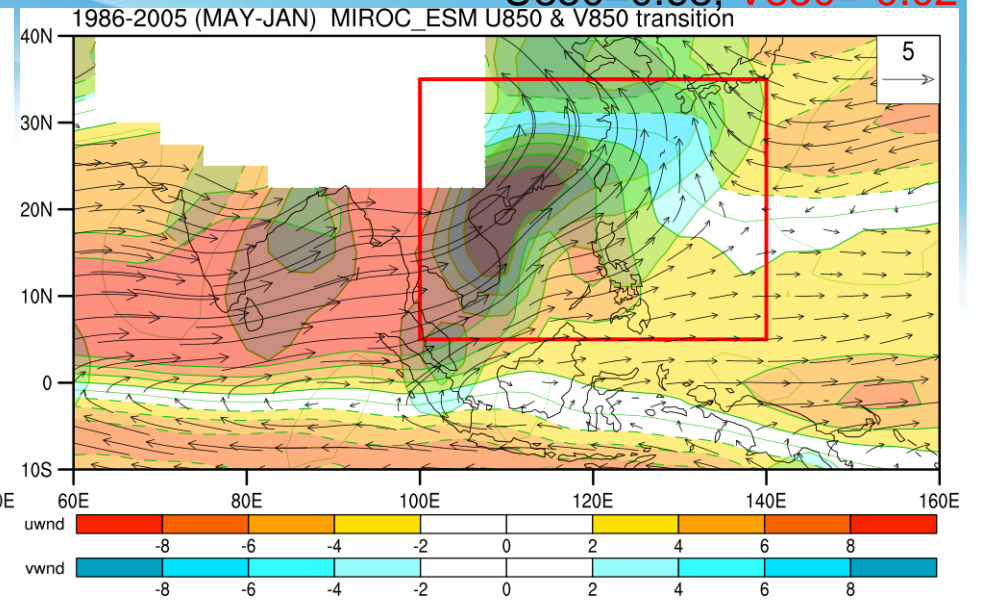
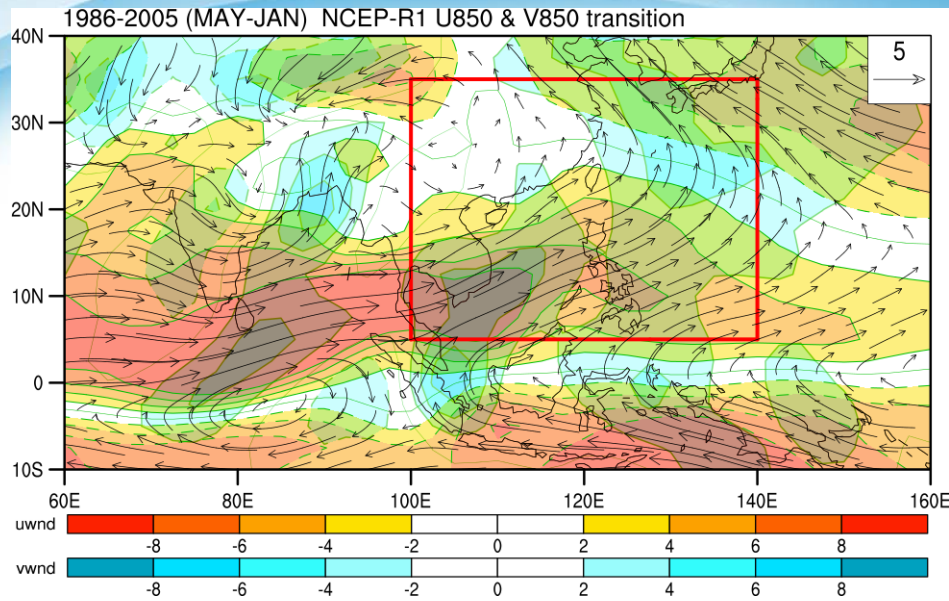
U850=0.95, V850=0.88



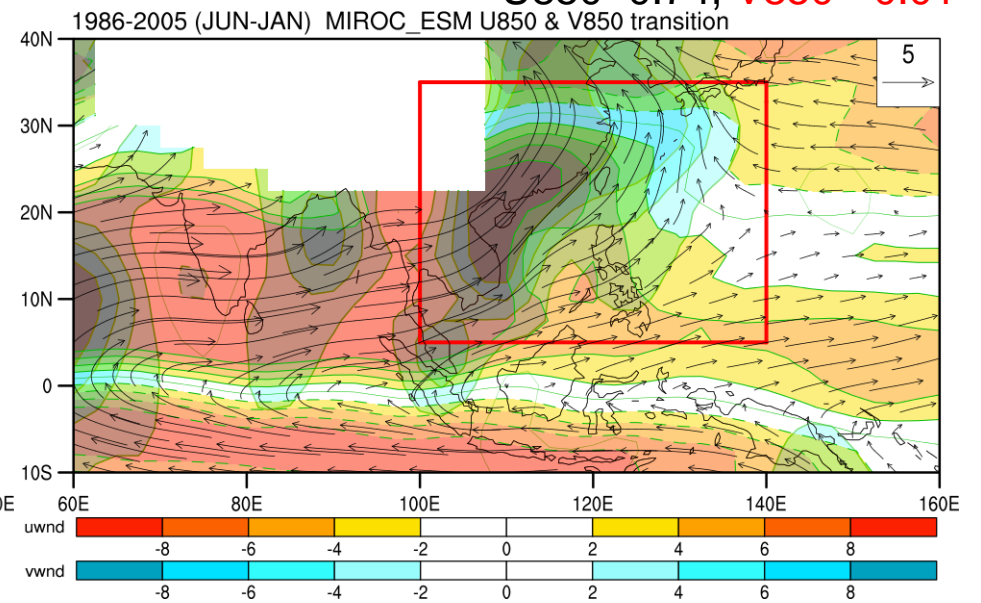
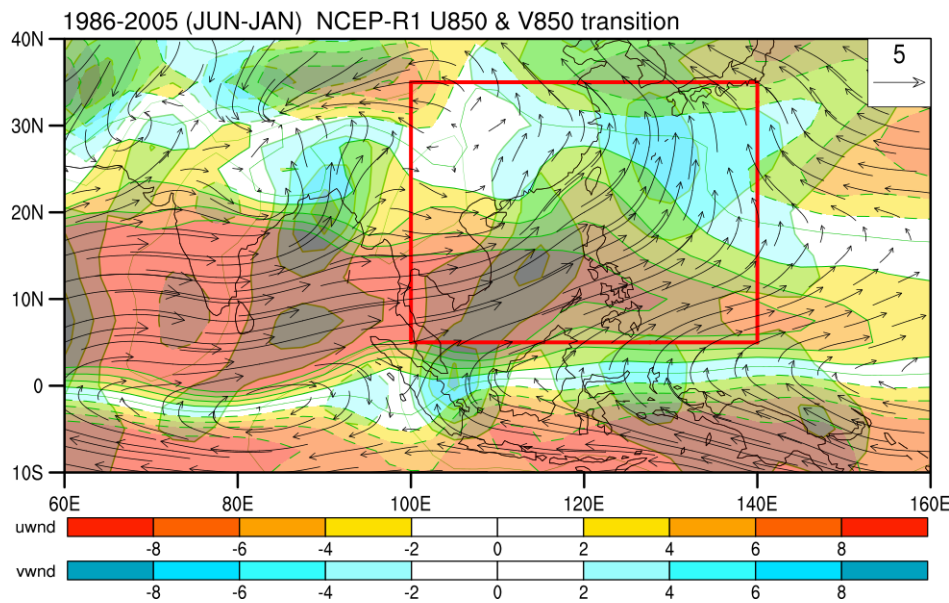
Obs.

MIROC-ESM

U850=0.68, V850=-0.02

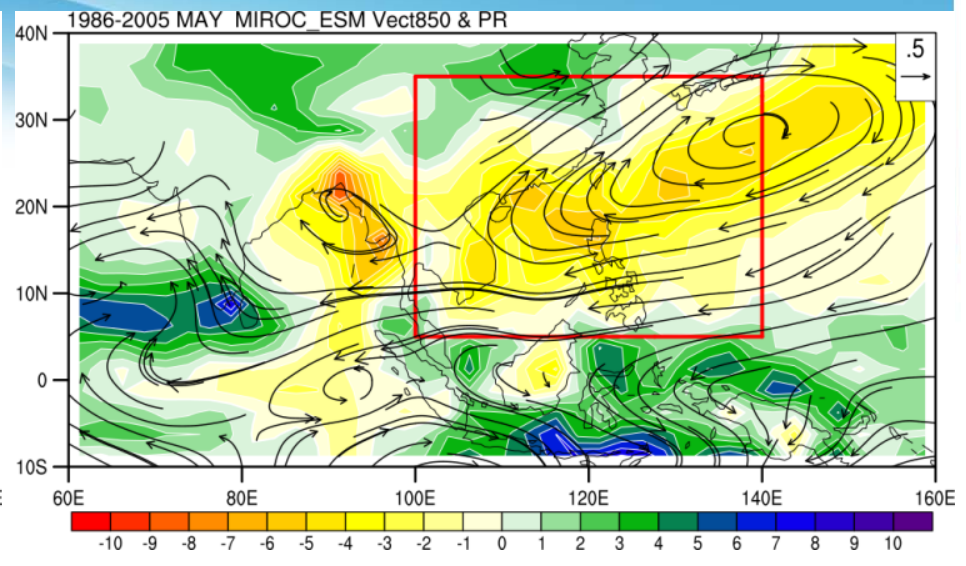
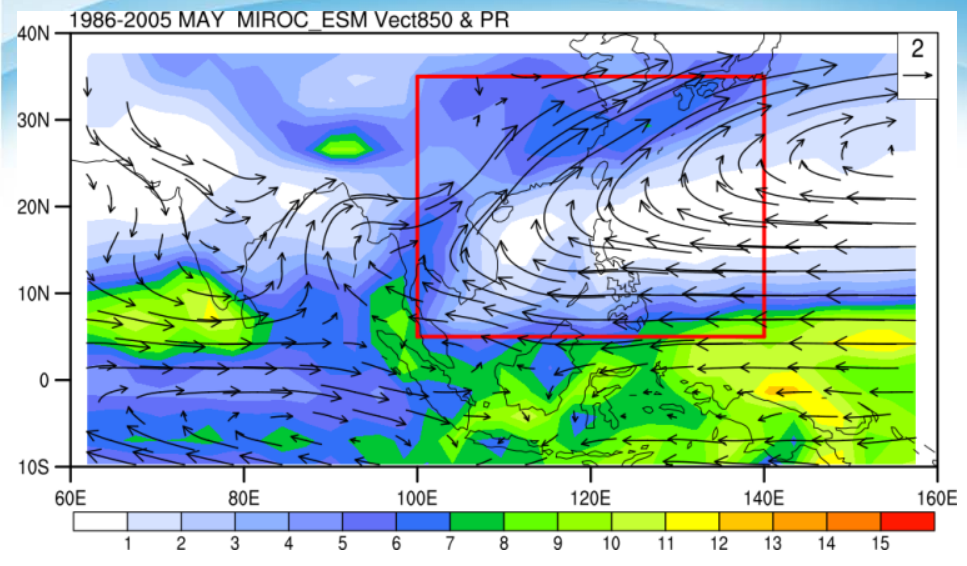


U850=0.74, V850=-0.01

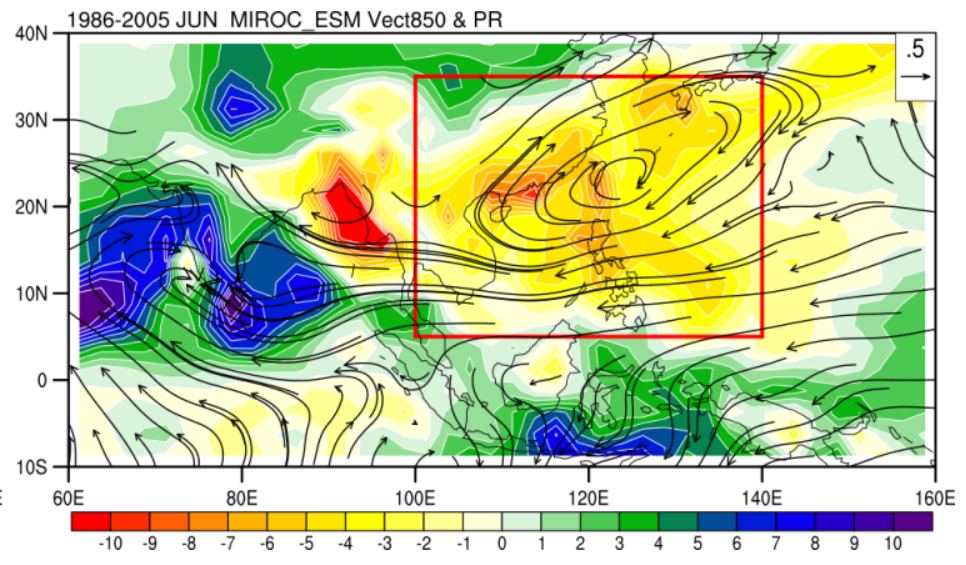
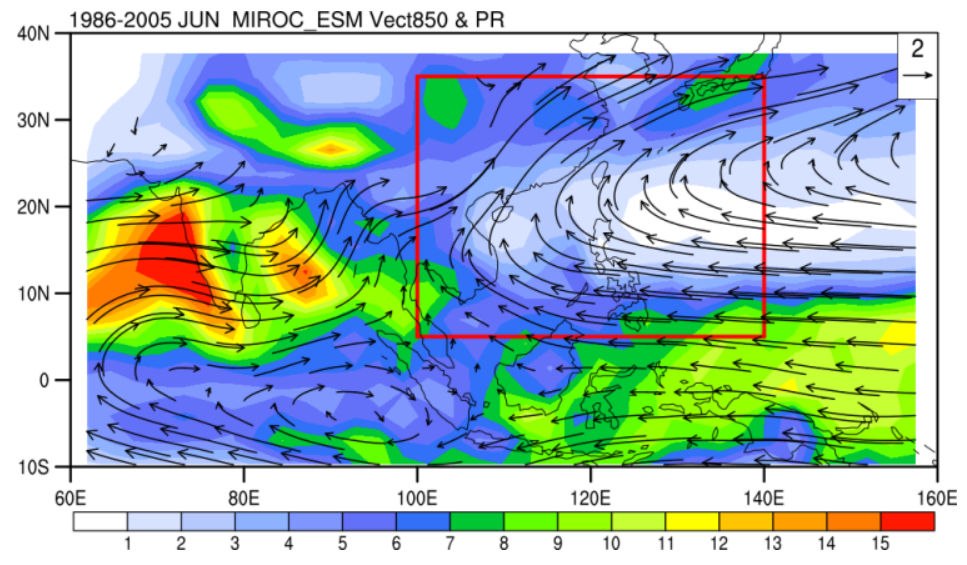


MIROC-ESM

PR=0.40, U850=0.76, V850=0.50



PR=0.47, U850=0.55, V850=0.50



模式挑選-梅雨季氣候特徵

- 台灣附近區域(100E-140E, 5N-35N)梅雨季雨量氣候值空間分佈特徵
- 台灣附近區域(100E-140E, 5N-35N)梅雨季850hPa風場季節變化空間特徵

NO	Model	U850		V850	
		MAY-JAN	JUN-JAN	MAY-JAN	JUN-JAN
1	ACCESS1.0	0.90	0.94	0.45	0.81
2	ACCESS1.3	0.88	0.93	0.28	0.71
3	BCC-CSM1.1	0.92	0.93	0.34	0.59
4	BCC-CSM1.1m	0.90	0.92	0.37	0.48
5	BNU-ESM	0.80	0.93	0.38	0.58
6	CanCM4	0.93	0.92	0.56	0.73
7	CanESM2	0.95	0.93	0.57	0.74
8	CCSM4	0.85	0.92	0.16	0.43
9	CESM1 (BGC)	0.85	0.92	0.11	0.32
10	CESM1 (CAM5)	0.86	0.88	0.45	0.58
11	CESM1 (FASTCHEM)	0.88	0.91	0.21	0.49
12	CESM1 (WACCM)	0.77	0.86	0.47	0.60
13	CMCC-CESM	0.88	0.91	0.78	0.73
14	CMCC-CM	0.95	0.95	0.76	0.62
15	CMCC-CMS	0.96	0.95	0.83	0.70
16	CNRM-CM5	0.96	0.95	0.84	0.88
17	CNRM-CM5-2	0.96	0.94	0.83	0.90
18	CSIRO-Mk3.6.0	0.96	0.95	0.50	0.68
19	FGOALS-g2	0.83	0.89	0.05	0.16
20	FIO-ESM	0.72	0.83	0.20	0.56
21	GFDL-CM2.1	0.92	0.96	0.51	0.76
22	GFDL-CM3	0.92	0.95	0.75	0.88
23	GFDL-ESM2G	0.94	0.96	0.55	0.82
24	GFDL-ESM2M	0.93	0.96	0.24	0.65
25	GISS-E2-H	0.83	0.89	0.18	0.39
26	GISS-E2-H-CC	0.82	0.86	0.30	0.48
27	GISS-E2-R	0.89	0.92	0.37	0.46
28	GISS-E2-R-CC	0.87	0.93	0.46	0.55
29	HadCM3	0.93	0.94	0.70	0.80
30	HadGEM2-AO	0.95	0.98	0.70	0.85
31	HadGEM2-CC	0.93	0.97	0.74	0.83
32	HadGEM2-ES	0.95	0.97	0.61	0.76
33	INM-CM4	0.89	0.90	0.35	0.55
34	IPSL-CM5A-LR	0.82	0.93	0.30	0.75
35	IPSL-CM5A-MR	0.85	0.94	0.40	0.72
36	IPSL-CM5B-LR	0.90	0.93	0.36	0.65
37	MIROC4h	0.79	0.81	0.55	0.71
38	MIROC5	0.82	0.81	0.71	0.85
39	MIROC-ESM	0.68	0.74	-0.02	-0.01
40	MIROC-ESM-CHEM	0.74	0.77	-0.03	-0.02
41	MPI-ESM-LR	0.93	0.92	0.80	0.85
42	MPI-ESM-MR	0.90	0.89	0.76	0.85
43	MPI-ESM-P	0.93	0.91	0.81	0.85
44	MRI-CGCM3	0.94	0.94	0.56	0.77
45	MRI-ESM1	0.94	0.93	0.56	0.69
46	NorESM1-M	0.86	0.94	0.34	0.62
47	NorESM1-ME	0.87	0.94	0.37	0.59

模式挑選

- 台灣附近區域梅雨季雨量氣候值空間分佈特徵
- 台灣附近區域梅雨季風場季節變化的空間特徵
- 台灣區域梅雨季佔全年總雨量的比例

CWB測站

平地 11.4%~34.3%

山地 12.4%~34.4%

外島 17.4%~33.1%

GPCP

台灣 (119E-123E, 21N-26N)

25.9 %

測站	站碼	%
Tanshui	46690	20.9
Keelung	46694	15.4
Taipei	46692	23.6
Hsinchu	46757	30.0
Wuqi	46777	32.8
Taichung	46749	34.3
Chiayi	46748	29.7
Tainan	46741	33.6
Kaohsiung	46744	33.4
Hengchun	46759	25.7
Yilan	46708	14.9
Suao	46706	11.4
Hualien	46699	18.9
Chenggong	46761	17.8
Taitung	46766	20.9
Dawu	46754	23.5
Anbu	46691	12.9
Zhuzihu	46693	12.4
Sun Moon Lake	46765	34.4
Alishan	46753	30.3
Yushan	46755	30.6
Pengjiayu	46695	21.0
Penghu	46735	28.7
Dongjidao	46730	33.1
Lanyu	46762	17.4

NO	Model	%
1	ACCESS1.0	25.0
2	ACCESS1.3	18.0
3	BCC-CSM1.1	21.0
4	BCC-CSM1.1m	18.2
5	BNU-ESM	21.7
6	CanCM4	27.2
7	CanESM2	26.9
8	CCSM4	16.4
9	CESM1 (BGC)	11.6
10	CESM1 (CAM5)	15.1
11	CESM1 (FASTCHEM)	16.2
12	CESM1 (WACCM)	17.4
13	CMCC-CESM	16.0
14	CMCC-CM	27.3
15	CMCC-CMS	23.1
16	CNRM-CM5	23.9
17	CNRM-CM5-2	26.0
18	CSIRO-Mk3.6.0	18.9
19	FGOALS-g2	16.4
20	FIO-ESM	28.5
21	GFDL-CM2.1	18.6
22	GFDL-CM3	20.2
23	GFDL-ESM2G	20.1
24	GFDL-ESM2M	19.0
25	GISS-E2-H	14.5
26	GISS-E2-H-CC	16.6
27	GISS-E2-R	19.1
28	GISS-E2-R-CC	18.3
29	HadCM3	22.6
30	HadGEM2-AO	31.1
31	HadGEM2-CC	27.5
32	HadGEM2-ES	23.1
33	INM-CM4	16.7
34	IPSL-CM5A-LR	22.6
35	IPSL-CM5A-MR	22.0
36	IPSL-CM5B-LR	20.1
37	MIROC4h	25.3
38	MIROC5	30.5
39	MIROC-ESM	13.9
40	MIROC-ESM-CHEM	15.1
41	MPI-ESM-LR	25.1
42	MPI-ESM-MR	23.3
43	MPI-ESM-P	26.6
44	MRI-CGCM3	21.9
45	MRI-ESM1	20.1
46	NorESM1-M	20.0
47	NorESM1-ME	18.8

NO	Model	PR
1	ACCESS1.0	0.63
2	ACCESS1.3	0.62
3	BCC-CSM1.1	0.19
4	BCC-CSM1.1m	0.02
5	BNU-ESM	0.37
6	CanCM4	-0.18
7	CanESM2	-0.13
8	CCSM4	0.38
9	CESM1 (BGC)	0.34
10	CESM1 (CAM5)	0.34
11	CESM1 (FASTCHEM)	0.41
12	CESM1 (WACCM)	0.44
13	CMCC-CESM	0.10
14	CMCC-CM	0.40
15	CMCC-CMS	0.25
16	CNRM-CM5	0.42
17	CNRM-CM5-2	0.43
18	CSIRO-Mk3.6.0	0.05
19	FGOALS-g2	0.41
20	FIO-ESM	0.48
21	GFDL-CM2.1	0.34
22	GFDL-CM3	0.19
23	GFDL-ESM2G	0.17
24	GFDL-ESM2M	0.23
25	GISS-E2-H	0.40
26	GISS-E2-H-CC	0.47
27	GISS-E2-R	0.39
28	GISS-E2-R-CC	0.37
29	HadCM3	0.21
30	HadGEM2-AO	0.56
31	HadGEM2-CC	0.58
32	HadGEM2-ES	0.58
33	INM-CM4	0.18
34	IPSL-CM5A-LR	0.26
35	IPSL-CM5A-MR	0.30
36	IPSL-CM5B-LR	0.13
37	MIROC4h	0.70
38	MIROC5	0.55
39	MIROC-ESM	0.47
40	MIROC-ESM-CHEM	0.45
41	MPI-ESM-LR	0.20
42	MPI-ESM-MR	0.31
43	MPI-ESM-P	0.31
44	MRI-CGCM3	0.33
45	MRI-ESM1	0.26
46	NorESM1-M	0.43
47	NorESM1-ME	0.48

模式挑選-梅雨季氣候特徵

- 台灣附近(100E-140E, 5N-35N)雨量氣候之模式與觀測之間的空間相關係數 (PCC >0.3)
- 台灣附近850hPa風場之模式與觀測之間的空間相關係數 (PCC >0.3)
- 台灣(119E-123E, 21N-26N)梅雨季佔全年雨量的比例 (>15%)

NO	Model	U850		V850	
		MAY-JAN	JUN-JAN	MAY-JAN	JUN-JAN
1	ACCESS1.0	0.90	0.94	0.45	0.81
2	ACCESS1.3	0.88	0.93	0.28	0.71
5	BNU-ESM	0.80	0.93	0.38	0.58
8	CCSM4	0.85	0.92	0.16	0.43
9	CESM1 (BGC)	0.85	0.92	0.11	0.32
10	CESM1 (CAM5)	0.86	0.88	0.45	0.58
11	CESM1 (FASTCHEM)	0.88	0.91	0.21	0.49
12	CESM1 (WACCM)	0.77	0.86	0.47	0.60
14	CMCC-CM	0.95	0.95	0.76	0.62
16	CNRM-CM5	0.96	0.95	0.84	0.88
17	CNRM-CM5-2	0.96	0.94	0.83	0.90
19	FGOALS-g2	0.83	0.89	0.05	0.16
20	FIO-ESM	0.72	0.83	0.20	0.56
21	GFDL-CM2.1	0.92	0.96	0.51	0.76
25	GISS-E2-H	0.83	0.89	0.18	0.39
26	GISS-E2-H-CC	0.82	0.86	0.30	0.48
27	GISS-E2-R	0.89	0.92	0.37	0.46
28	GISS-E2-R-CC	0.87	0.93	0.46	0.55
30	HadGEM2-AO	0.95	0.98	0.70	0.85
31	HadGEM2-CC	0.93	0.97	0.74	0.83
32	HadGEM2-ES	0.95	0.97	0.61	0.76
35	IPSL-CM5A-MR	0.85	0.94	0.40	0.72
37	MIROC4h	0.79	0.81	0.55	0.71
38	MIROC5	0.82	0.81	0.71	0.85
39	MIROC-ESM	0.68	0.74	-0.02	-0.01
40	MIROC-ESM-CHEM	0.74	0.77	-0.03	-0.02
42	MPI-ESM-MR	0.90	0.89	0.76	0.85
43	MPI-ESM-P	0.93	0.91	0.81	0.85
44	MRI-CGCM3	0.94	0.94	0.56	0.77
46	NorESM1-M	0.86	0.94	0.34	0.62
47	NorESM1-ME	0.87	0.94	0.37	0.59

NO	Model	%
1	ACCESS1.0	25.0
5	BNU-ESM	21.7
10	CESM1 (CAM5)	15.1
12	CESM1 (WACCM)	17.4
14	CMCC-CM	27.3
16	CNRM-CM5	23.9
17	CNRM-CM5-2	26.0
21	GFDL-CM2.1	18.6
26	GISS-E2-H-CC	16.6
27	GISS-E2-R	19.1
28	GISS-E2-R-CC	18.3
30	HadGEM2-AO	31.1
31	HadGEM2-CC	27.5
32	HadGEM2-ES	23.1
35	IPSL-CM5A-MR	22.0
37	MIROC4h	25.3
38	MIROC5	30.5
42	MPI-ESM-MR	23.3
43	MPI-ESM-P	26.6
44	MRI-CGCM3	21.9
46	NorESM1-M	20.0
47	NorESM1-ME	18.8

22個

具梅雨季模擬能力的模式

No.	Model Name	Country	Institution
1	ACCESS1.0	Australia	Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology (CSIRO)
2	BNU-ESM	China	Beijing Normal University (BNU)
3	CESM1 (CAM5)	USA	National Science Foundation, Department of Energy, National Center for Atmospheric Research (NCAR)
4	CESM1 (WACCM)		
5	CMCC-CM	Italy	Centro Euro-Mediterraneo per I Cambiamenti Climatici
6	CNRM-CM5	France	Centre National de Recherches Meteorologiques and Centre Europeen de Recherches et Formation Avancees en Calcul Scientifique
7	CNRM-CM5-2		
8	GFDL-CM2.1	USA	NOAA Geophysical Fluid Dynamics Laboratory (GFDL)
9	GISS-E2-H-CC	USA	NASA Goddard Institute for Space Studies (GISS)
10	GISS-E2-R		
11	GISS-E2-R-CC		
12	HadGEM2-AO	Korea	National Institute of Meteorological Research/Korea Meteorological Administration
13	HadGEM2-CC	UK	Met Office Hadley Centre
14	HadGEM2-ES		
15	IPSL-CM5A-MR	France	Institute Pierre Simon Laplace
16	MIROC4h	Japan	University of Tokyo, National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
17	MIROC5		
18	MPI-ESM-MR	Germany	Max Planck Institute for Meteorology
19	MPI-ESM-P		
20	MRI-CGCM3	Japan	Meteorological Research Institute
21	NorESM1-M	Norway	Norwegian Climate Centre
22	NorESM1-ME		

結 論

- 1) CMIP5模式對於東亞地區梅雨季風場都具有不錯的氣候模擬能力，但對於高壓脊的強度和位置的模擬差異甚大。對於梅雨鋒面的模擬能力有限，大都無法準確掌握梅雨季氣候平均的最大降水區域，降雨有明顯低估的情形存在。
- 2) 模式對於環流場的模擬能力都優於降雨，緯向風場的結果比經向風要好。
- 3) 模式對於梅雨季緯向風環流轉變的模擬優於經向風，模式較能掌握6月經向風場的環流轉變。MIROC-ESM和MIROC-ESM-CHEM無法掌握到梅雨季西太平洋地區經向風場的轉變特徵。
- 4) 依據梅雨季氣候特性選取22個CMIP5模式，作為未來進行氣候變遷推估的參考模式。