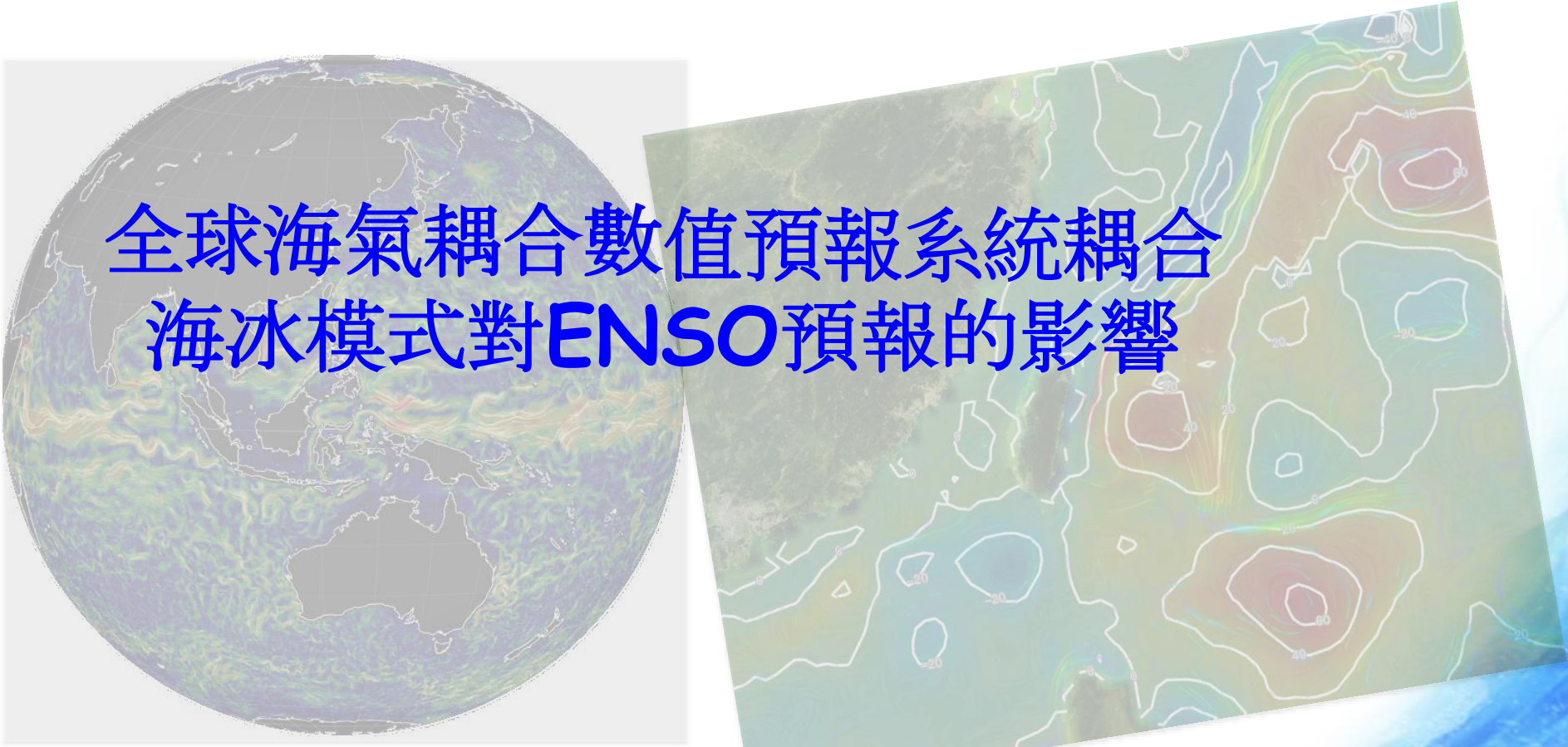




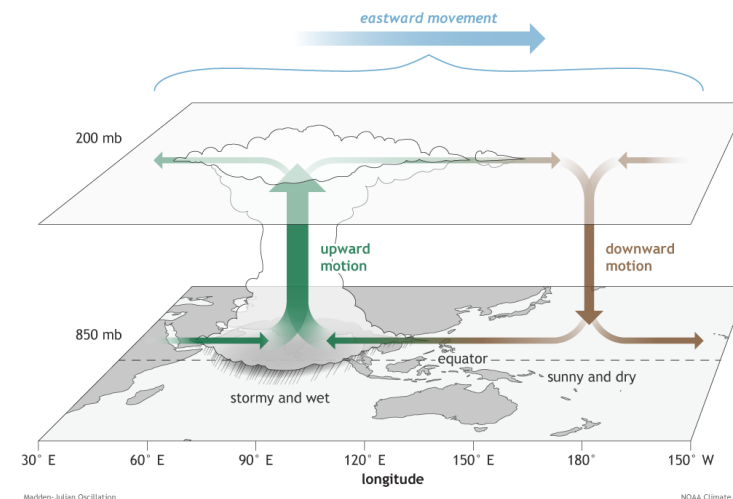
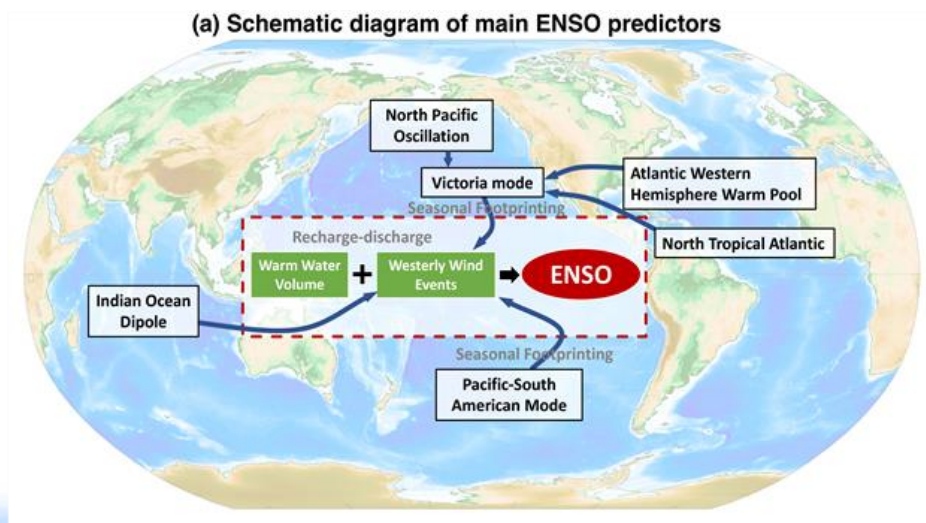
全球海氣耦合數值預報系統耦合 海冰模式對**ENSO**預報的影響

邵允銓¹、曾喜絃²、曾于恒^{1,2}、劉邦彥³

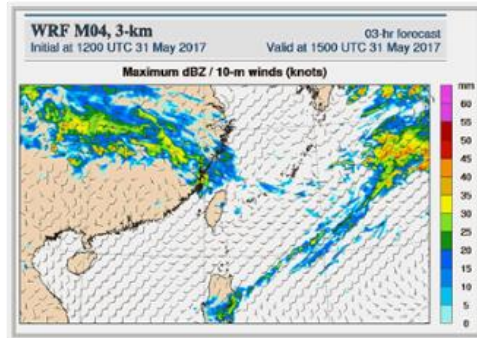
國立台灣大學海洋研究所
國立台灣大學海洋中心
中央氣象署科技發展組

Motivation

1. 季內至季節性(subseasonal to seasonal, S2S)預報的優劣，受到預報模式是否能正確反應海氣交互作用的影響很大，在ENSO預報中，更是要同時考慮海、氣、冰的交互作用。
2. 海氣交互作用包含了一連串在空間跟時間上跨尺度的動力過程，例如季內的MJO預報，跨季節性的ENSO預報。
3. 建立一套海氣冰交互作用的跨尺度耦合系統預報模式，提升氣象署季內至季節性預報產品的可預報度。

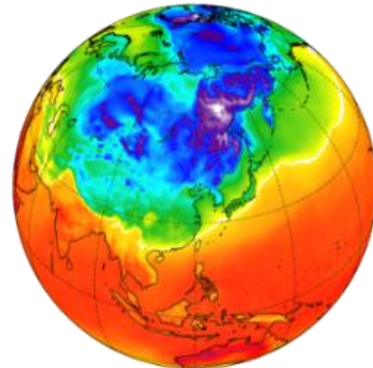


Modeling systems in CWA



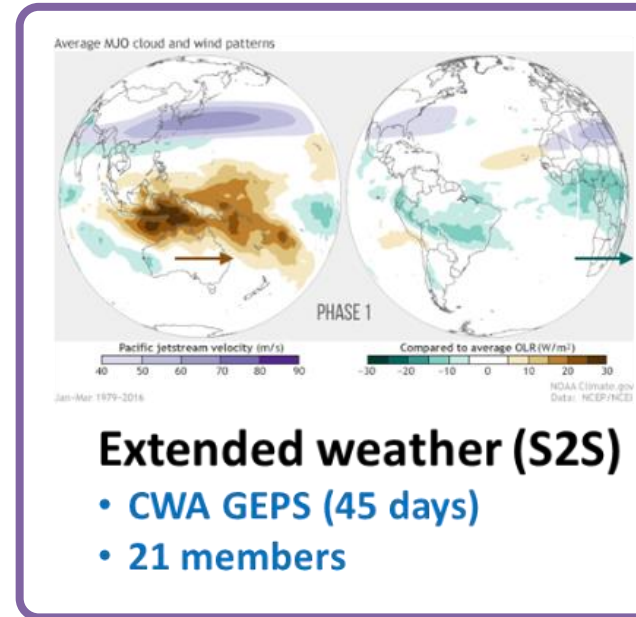
Regional weather

- CWA WRFD (5 days)
- CWA TWRF (5 days)
- CWA WEPS (5 days)
- CWA RWRF (13 hours)
- CWA CEPS (13 hours)



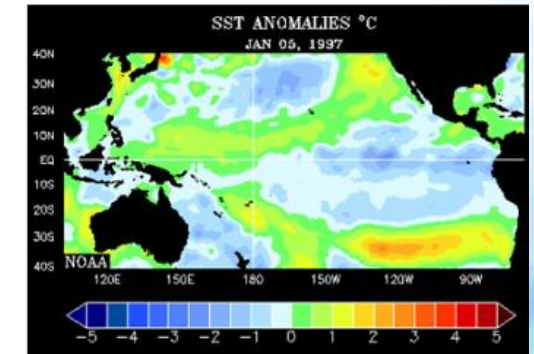
Global weather

- CWA TGFS (16 days)



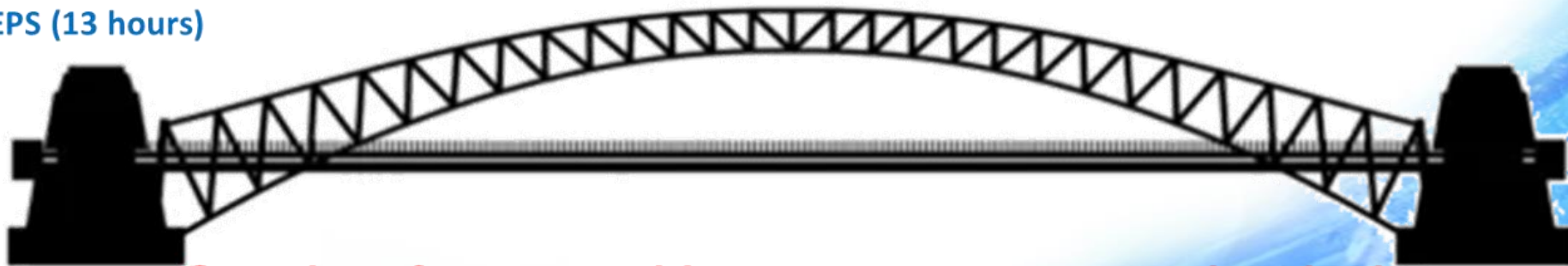
Extended weather (S2S)

- CWA GEPS (45 days)
- 21 members



Short-term climate

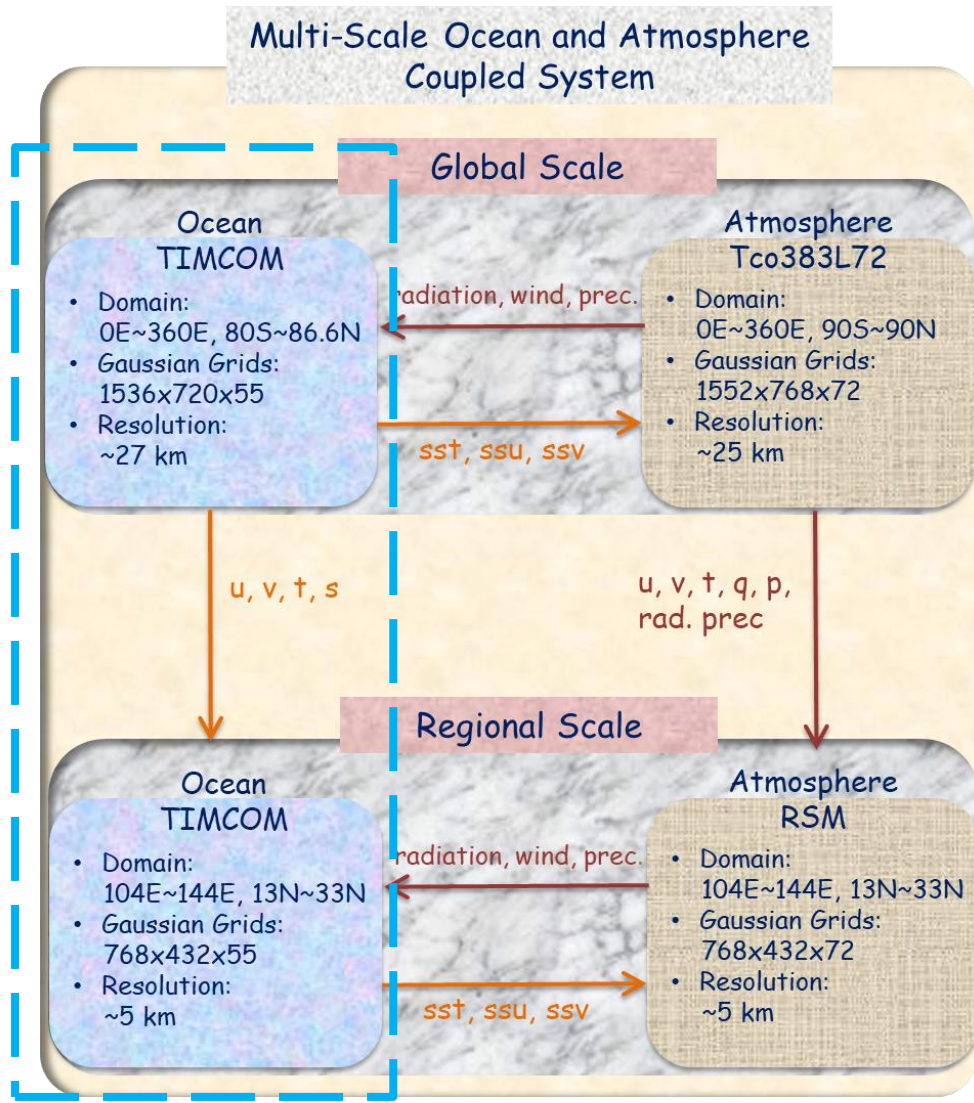
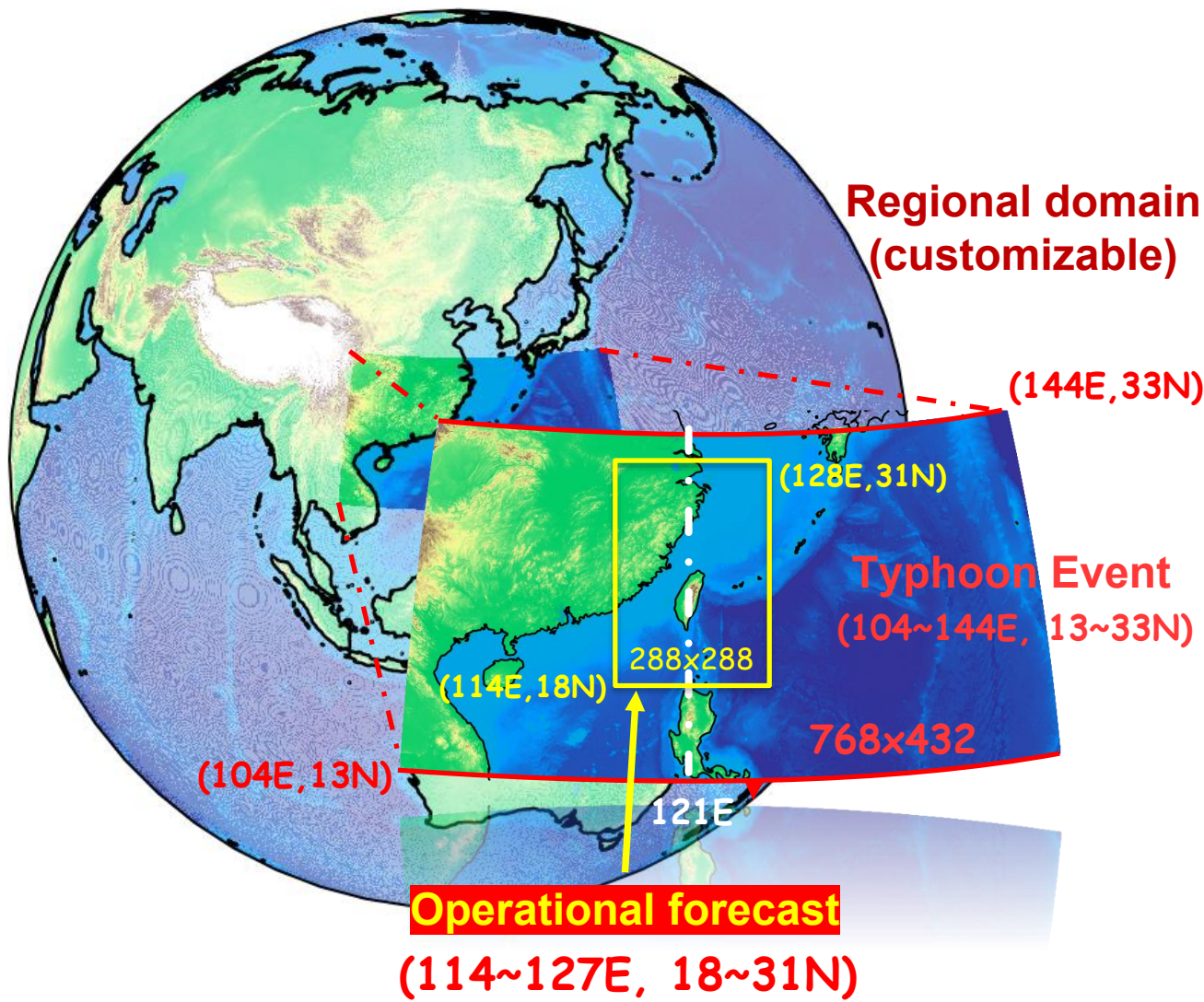
- CWACFS (8 months)
(Global + RSM)
- 30 members/month



Seamless forecast guidance ranges to seasonal outlook

Model Framework

Central Weather Administration Global Ensemble Prediction System version 3



Coupler instance

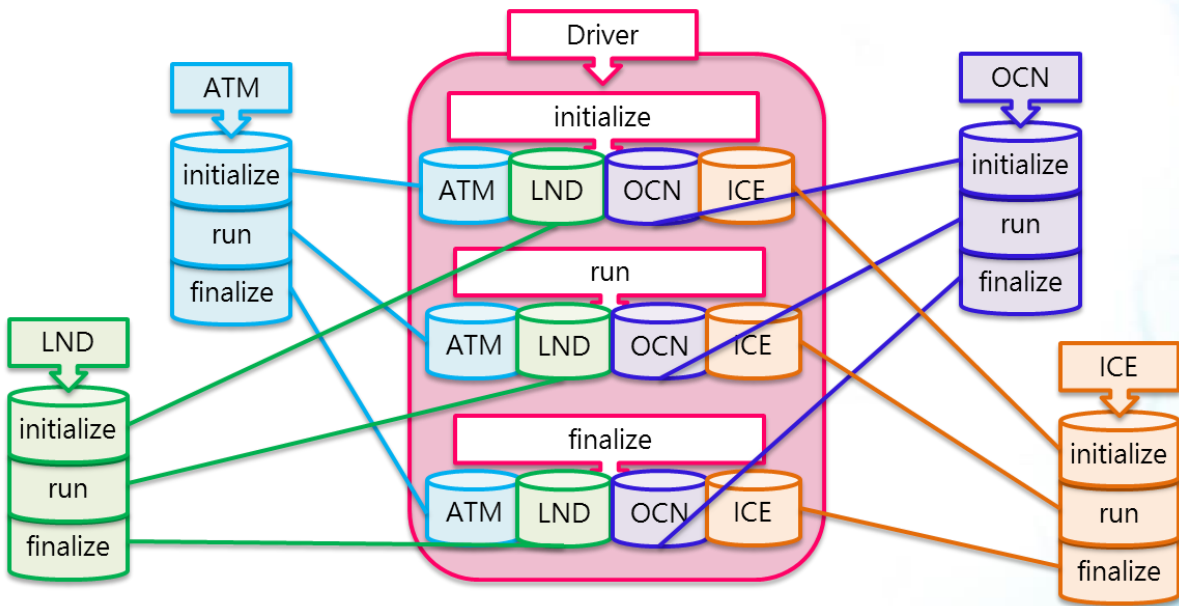
Decomposition and Reorganization

Advantage:

- 1. Flexible
- 2. Division

Disadvantage:

- 1. steep learning/developing curve



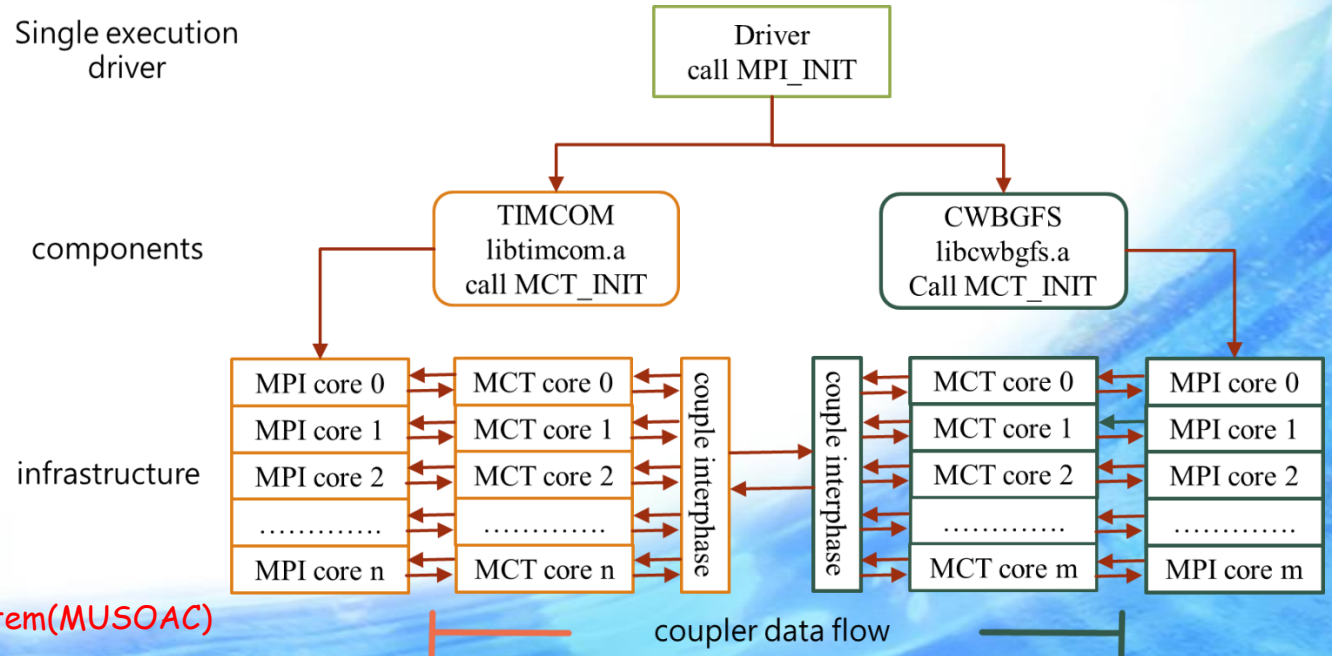
Collection and Connection

Advantage:

- 1. customization
- 2. Easy to use

Disadvantage:

- 1. Complicated if there are many components



CWA & NTU :
MULTi-Scale Ocean and Atmosphere Coupled modelling system(MUSOAC)

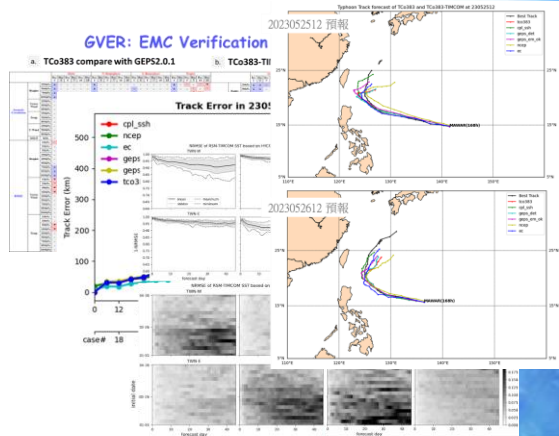
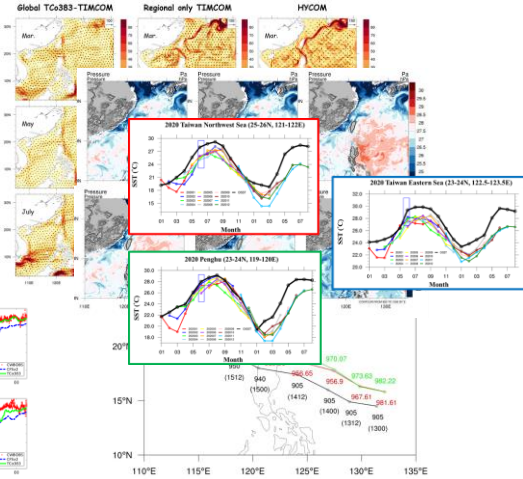
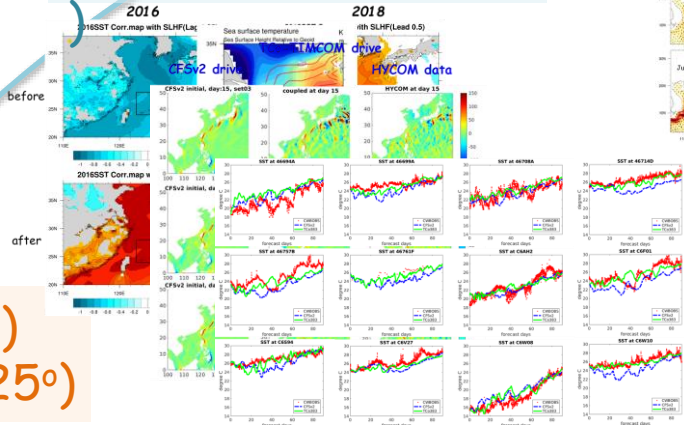
Evolution

Version & Resolution

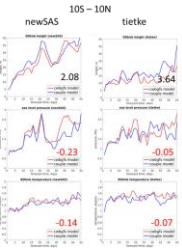
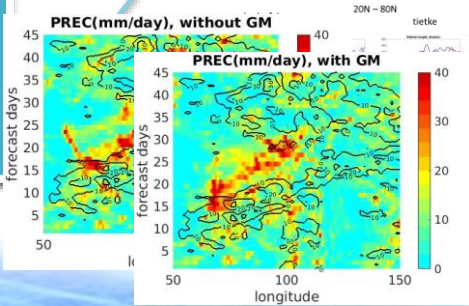
Tco383L72(0.235°)
TIMCOMv3.1(0.237°)
RSM(5km)
TIMCOMv3.1(5km)

Tco383L72(0.235°)
TIMCOMv2.1(0.237°)
RSM(8km)
TIMCOMv1.8(8km)

TL319L60(0.375°)
TIMCOMv1.9(0.375°)
TIMCOMv1.8(0.125°)



TL319L60(0.375°)
TIMCOMv1.9(1.125°)



Intraseasonal Oscillation- MJO

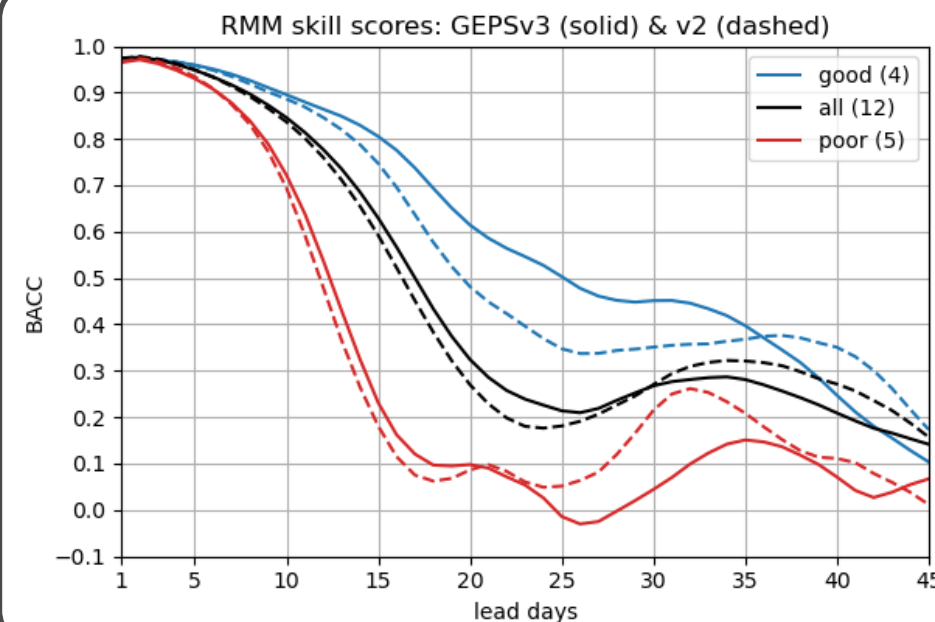
Skill Days (BACC>0.5)	ENSO	v3 (Coupled)	v2 (Uncoupled)	Improvement
2001/01/25	La Niña	20	17	+3
2005/01/05	El Niño	21	18	+3
2006/01/12	La Niña	33	16	+17
2008/01/29	La Niña	23	19	+4
2002/01/24	neutral	16	15	+1
2004/01/28	neutral	17	16	+1
2012/01/29	La Niña	16	14	+2
2003/01/30	El Niño	11	10	+1
2009/01/26	La Niña	13	11	+2
2016/01/14	El Niño	10	13	-3
2018/01/19	El Niño	12	12	0
2019/01/20	El Niño	12	9	+3
Average		17	14	+3

The hindcast of January of 2001-2020 are diagnosed.

case reference date:

intraseasonal convection @ Eq. EIO
20-80 day OLR over 10S-10N, 75-95E

- Oceanic coupling provides predictability source during week 3-5



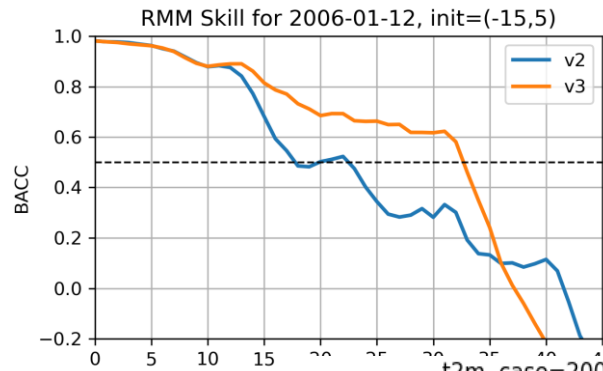
*score are calculated for I.C. = -15 to +5 relative to the ref. dates

2006 MJO Case (La Niña)

In week 3 to 5:

coupled (GEPSv3)

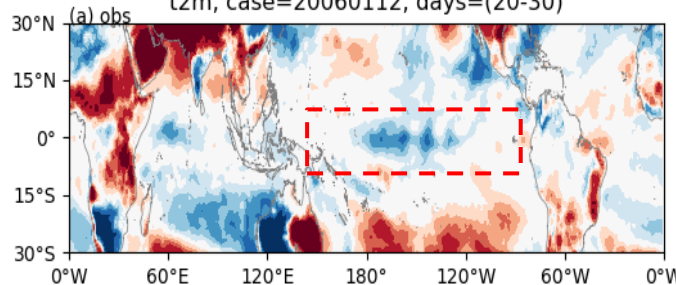
- better tropical SST representations
- more accurate ENSO teleconnections
- improved MJO predictions



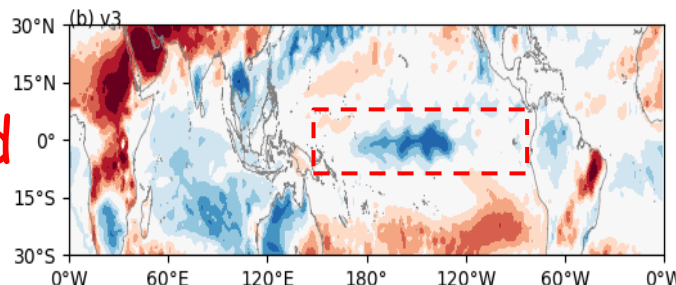
T2m

U200

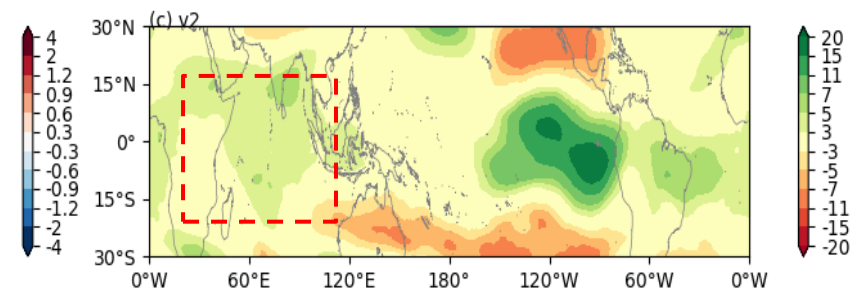
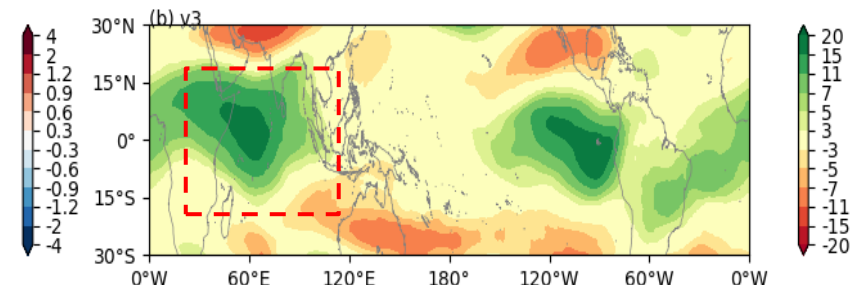
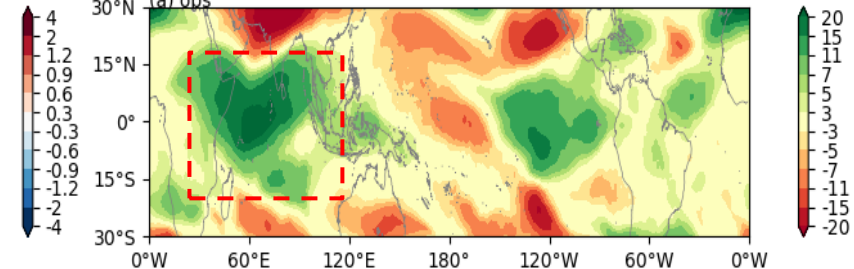
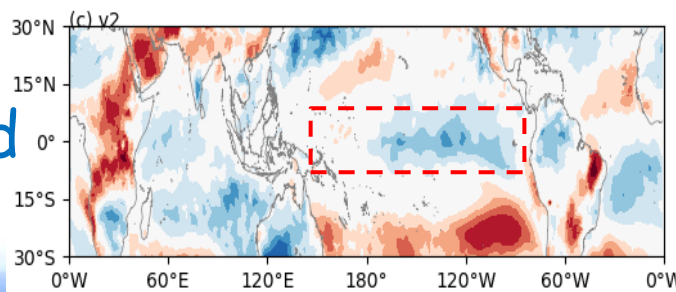
obs



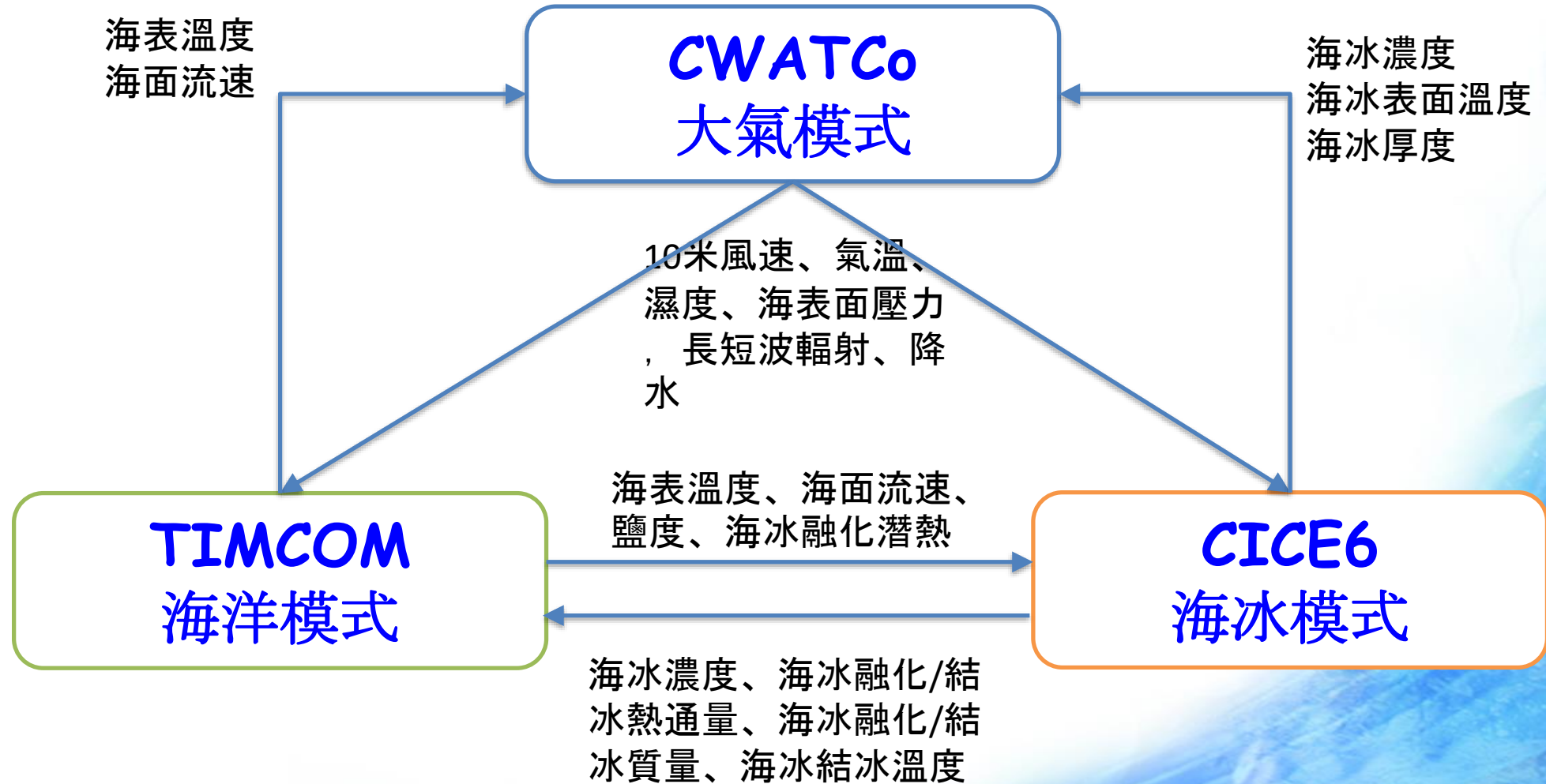
coupled



uncoupled



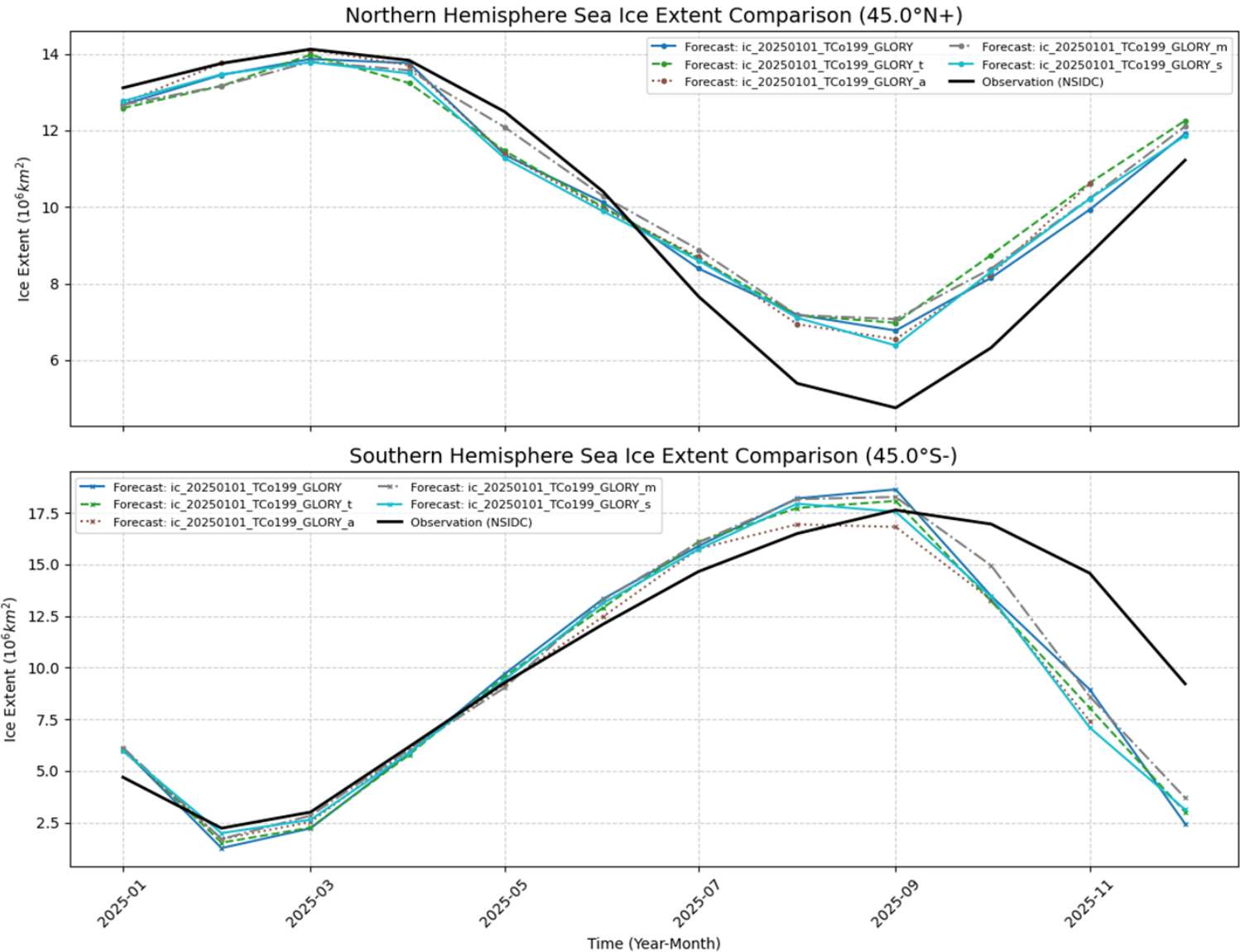
耦合海冰模式



耦合模式長期積分海冰模式參數調校

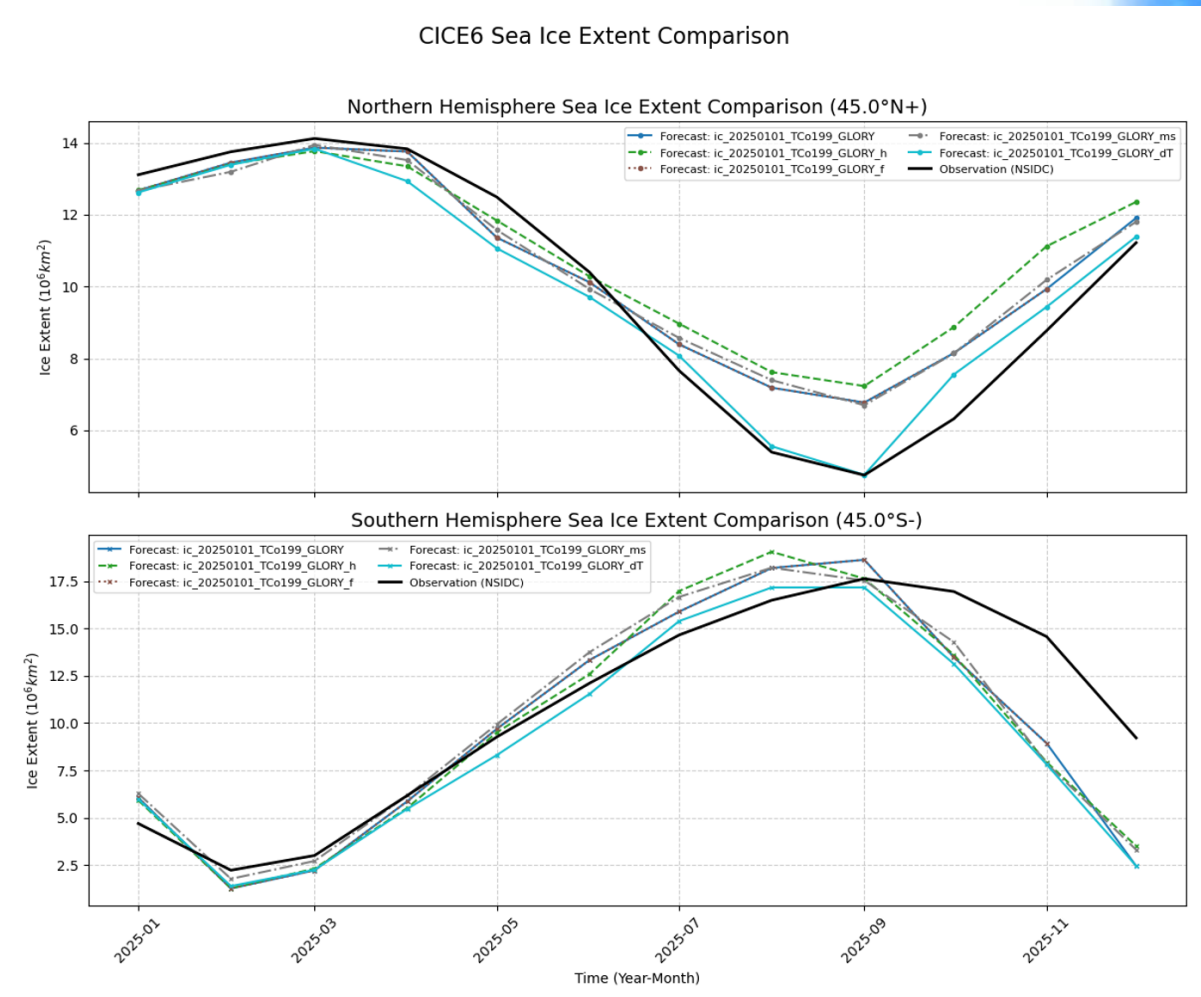
CICE6 Sea Ice Extent Comparison

實驗	目標問題	參數名
GLORY_t	開啟海底應力參數化，透過增加底層摩擦力修正淺海區（如北極架）的海冰漂移與堆積	seabed_stress
GLORY_a	調降雪面反照率，增加雪層對短波輻射的吸收，以緩解圖中 8-10 月北極冰區過大的問題。	R_snw_ndtd
GLORY_m	降低雪粒徑演化的溫度門檻，使冰面能更早從「冷雪」轉為「融雪」狀態，提早觸發反照率回饋。	dT_mlt
GLORY_s	直接調降裸冰 (Bare Ice) 的反射率。當夏季雪完全融化後，此參數將主導冰面的熱預算與消融效率。	R_ice



耦合模式長期積分海冰模式參數調校

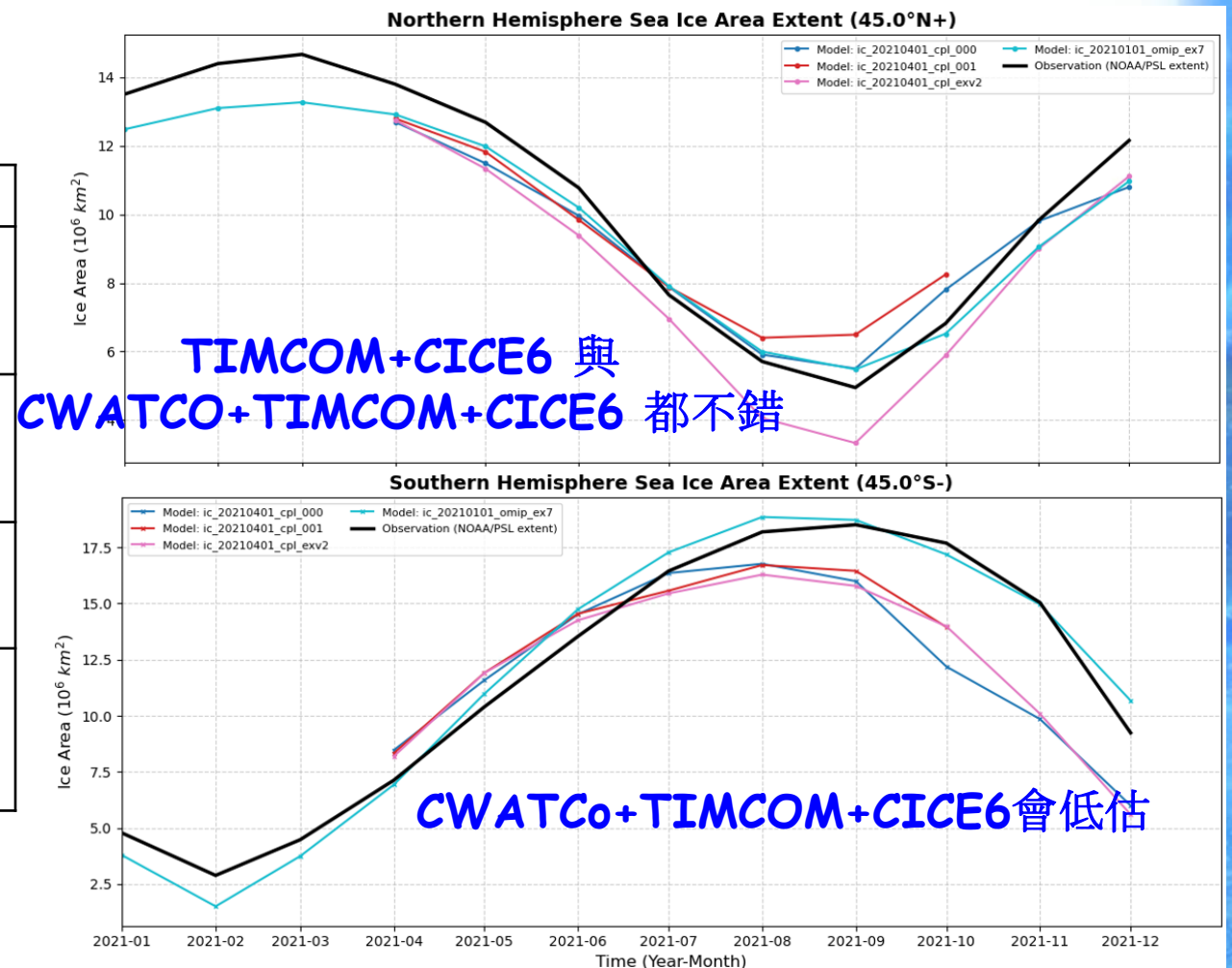
實驗	目標問題	參數名	調整值
GLORY_h	T2m 冷偏差。增加粗糙度會大幅提升顯熱通量 (Sensible Heat Flux)。既然氣溫太冷，增加「空氣與冰摩擦」產生的熱交換，強迫暖空氣把熱量交給冰面。	iceruf	0.0005 =>0.005
GLORY_f	SST 冷偏差。目前用 constant，熱傳導是固定的。改用 mushy 會讓冰底熱通量隨鹽水比例動態調整，增加海洋對冰底的融化貢獻。	fbot_xfer_type	constatn => mushy
GLORY_ms	結合m跟s並調整大一點。	dT_mlt R_ice	0.5 => 0.05 -0.1 => -1
GLORY_dt	大氣模式步長調小，以不影響積分時間為主。	dt	900 => 300



耦合模式長期積分海冰模式參數調校

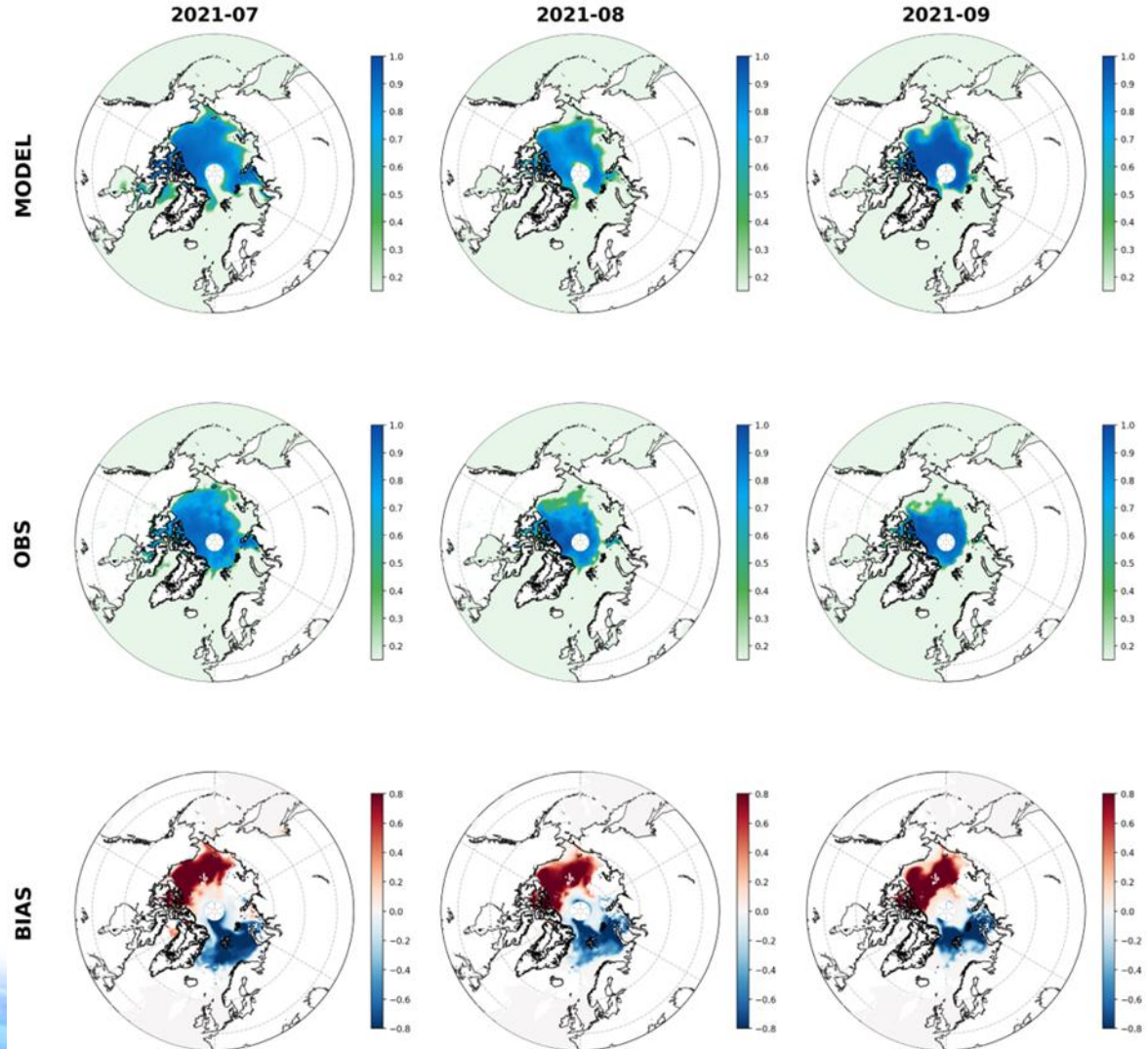
實驗	目標問題	參數名	調整值
CPL_000	將海冰表溫度更新到 TCo199, 使用海冰流速修正風應力	highfreq	True
CPL_001	將海冰表溫度更新到 TCo199, 不用海冰流速修正風應力	highfreq	False
CPL_exv2	沒有將海冰表面溫度更新到 TCo199	tice	更新至 sfc_sice.f90
OMIP_ex7	TIMCOM+CICE6		

大氣模式 dt = 300s

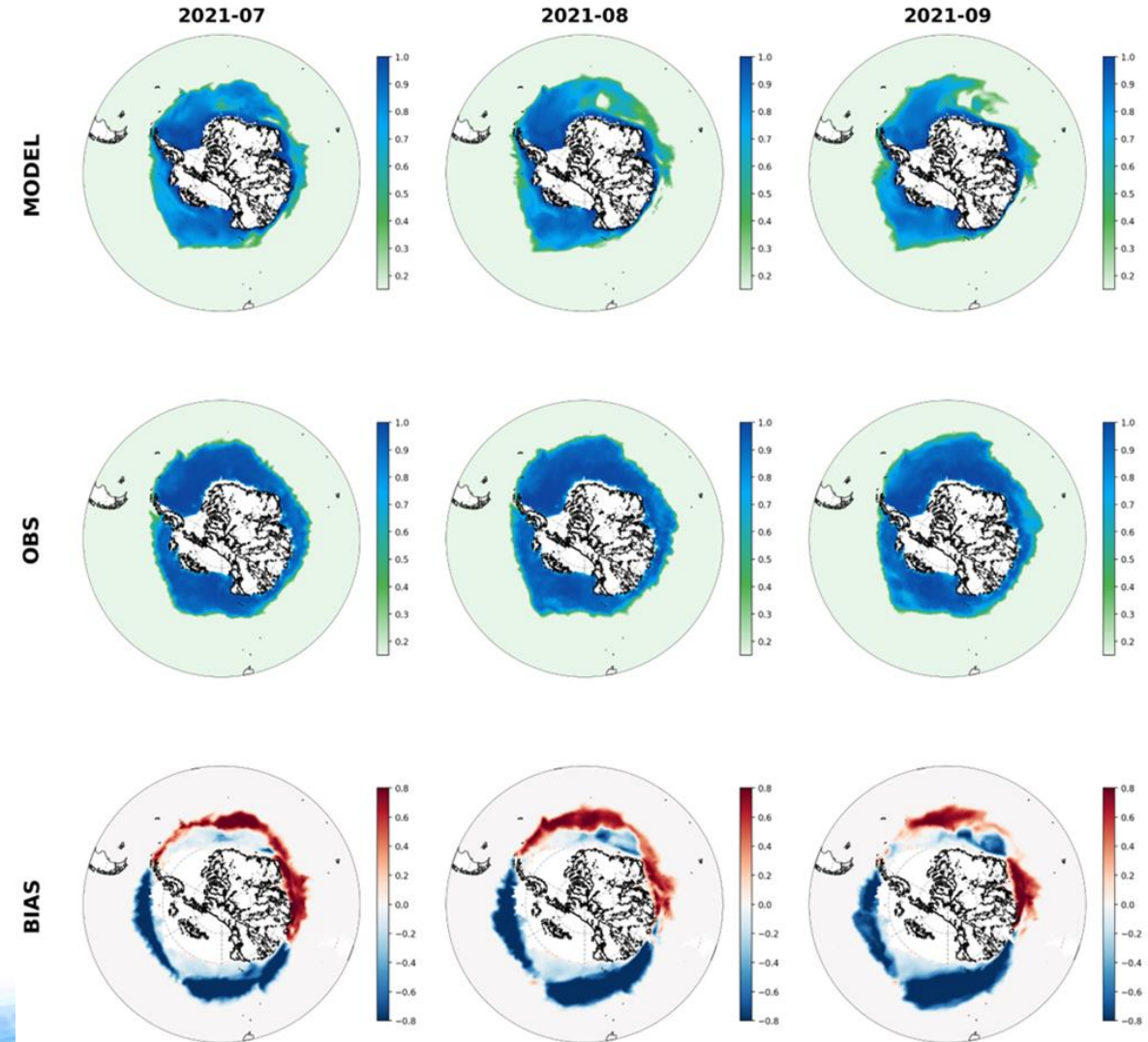


耦合模式長期積分海冰模式參數調校

NH Sea Ice Spatial Bias Analysis (Circle Map)
Comparison: Model vs Obs 2021



SH Sea Ice Spatial Bias Analysis (Circle Map)
Comparison: Model vs Obs 2021



2015年ENSO預報案例驗證

實驗設計

Exp-cplICE

TCo383 + TIMCOM + CICE6
IC of CICE6 is from HYCOM

Exp-control

TCo383 + TIMCOM
ICE data is from NSIDC

起報日期: 2015-01-01、01-08、01-15、01-22、01-29

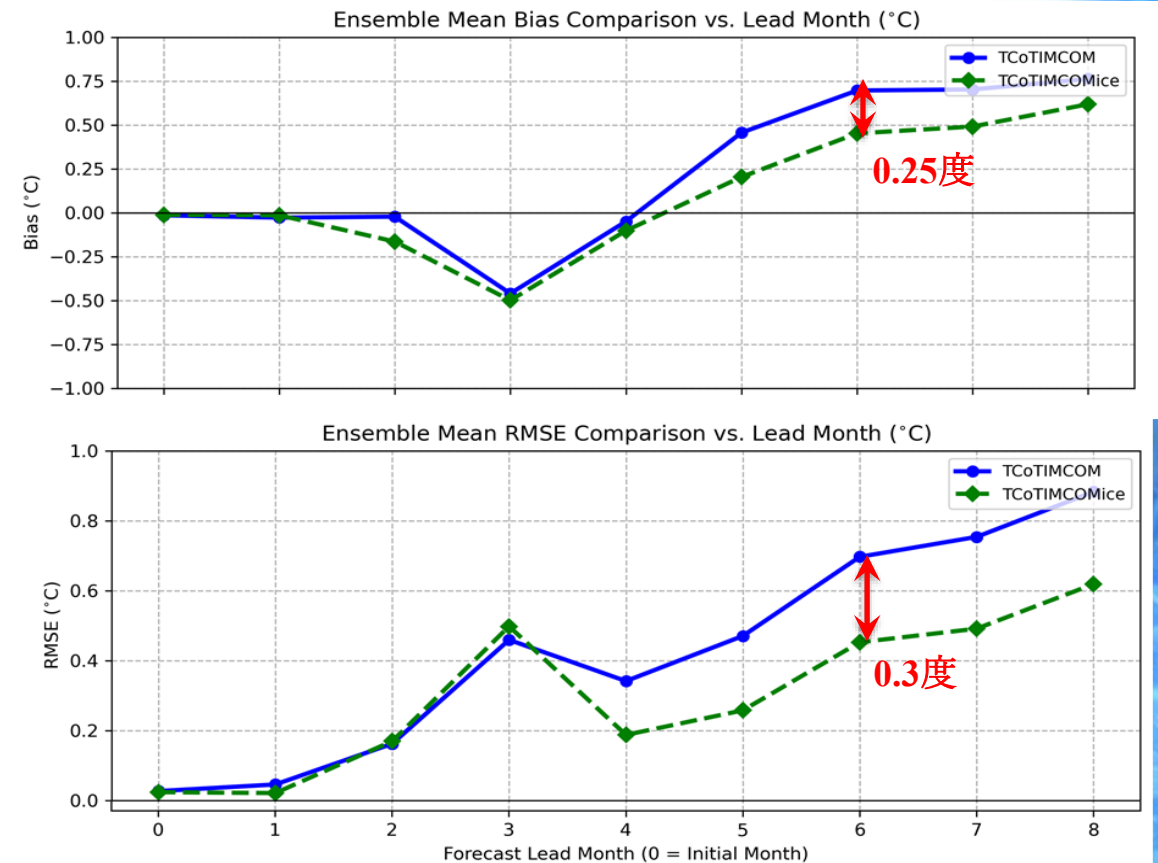
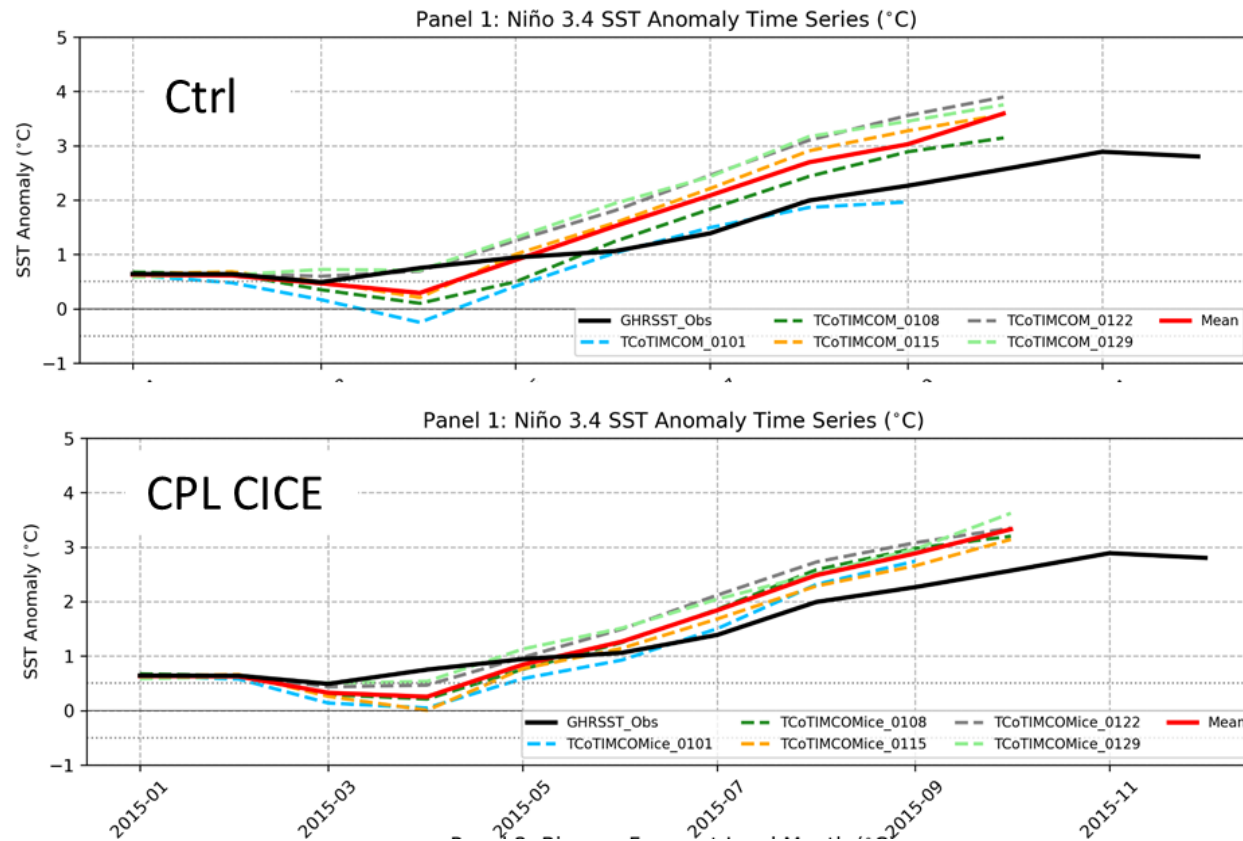
積分長度: 270天

耦合系統能量收支

海冰擴張面積

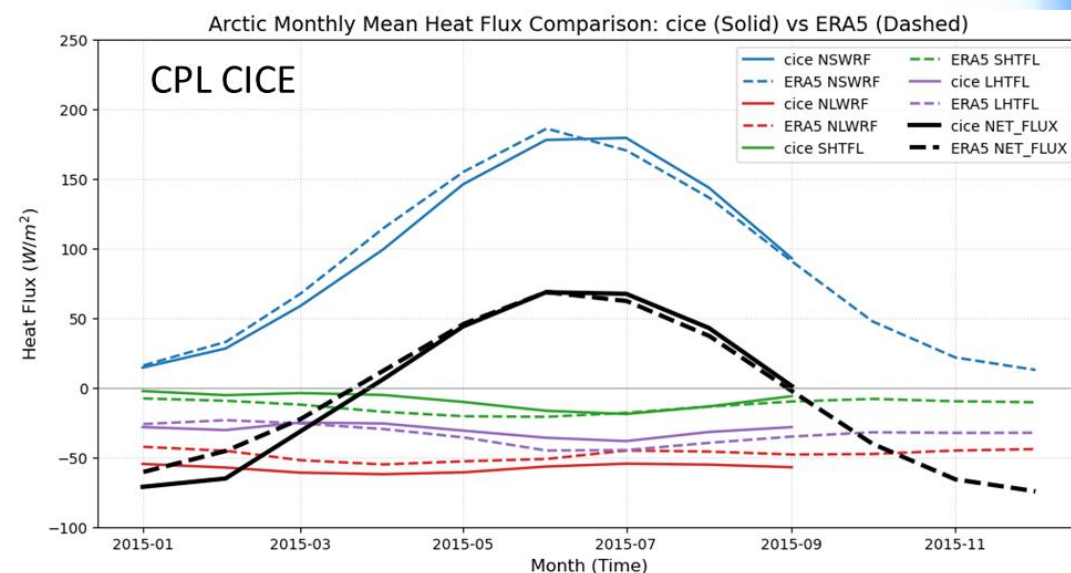
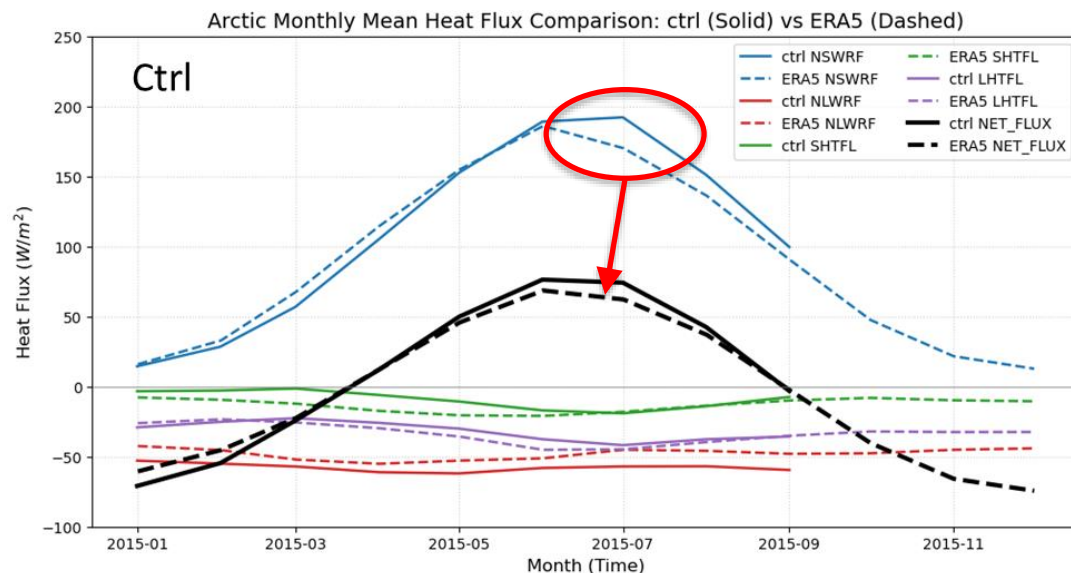
Niño3.4 海表面溫度距平

ENSO預報Niño3.4 海表面溫度距平



- **cplICE比ctrl 在Niño3.4 海表面溫度距平的長期預報可改善0.2-0.3度，有助於改善ENSO預報**

耦合系統能量收支



- 太陽短波輻射主導能量收支。
- **Ctrl**與**cplICE** 在冬季的總收支略低於**ERA5**資料，主要是模式淨長波輻射較低。
- **Ctrl**在夏季的總收支略高於**ERA5**資料，主要是模式淨短波輻射較高。
- **cplICE** 對總收支的長期積分表現比**Ctrl**好，推測可能是海冰延伸面積的季節變化改善了極區的反照率。

結論與後續工作

- 以 **JRA55-do** 大氣資料驅動 **TIMCOM-CICE6** 耦合模式，海冰延伸面積的季節性變化與再分析資料相近。
- 未將海冰表面溫度耦合至大氣模式時，會造成北半球夏季融冰過多。
- 作用於海冰網格上的風應力沒有對海流速作修正時，會導致北半球夏季融冰偏少。
- 耦合海冰模式有助於提升**ENSO**預報的準確度，主要在於整個耦合系統會有更好能量收支表現。
- **CWATCO-TIMCOM-CICE** 皆會產生南半球夏季融冰過快的問題，後續需要再進一步的測試找出原因。



Thanks for your attention