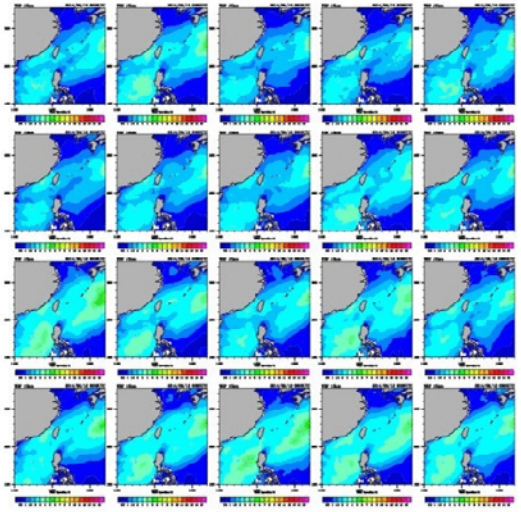
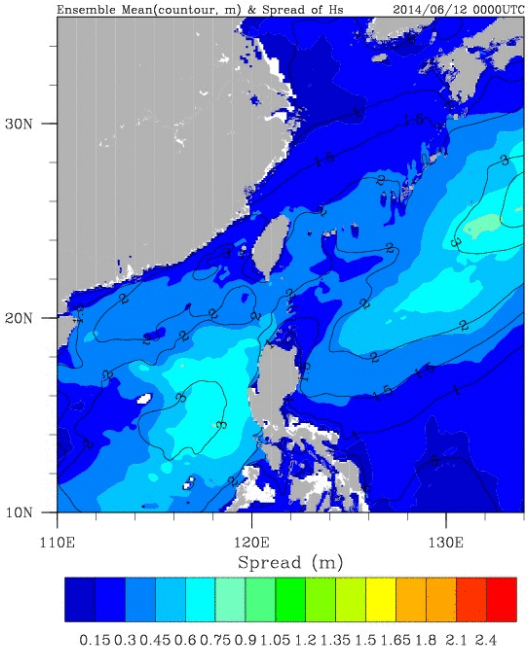
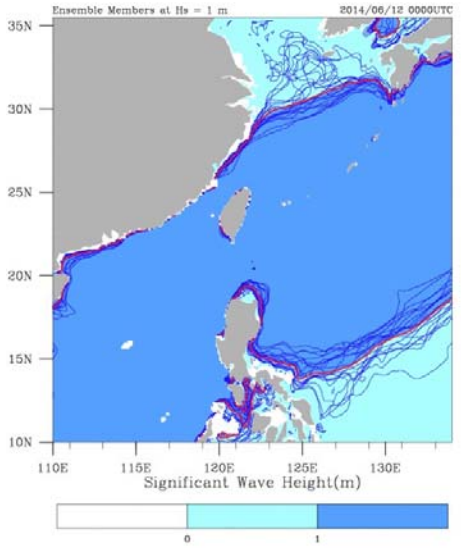
波浪系集預報系統之分析研究

張恆文[1] 顏厥正[1] 陳仁曾[2] 朱啟豪[2] 滕春慈[2]







工業技術研究院
Industrial Technology
Research Institute

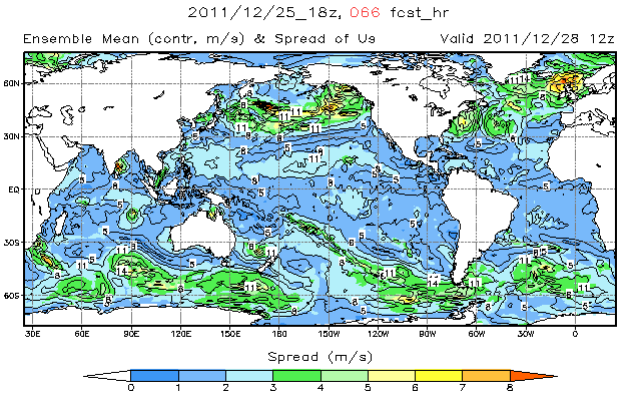
簡報大綱

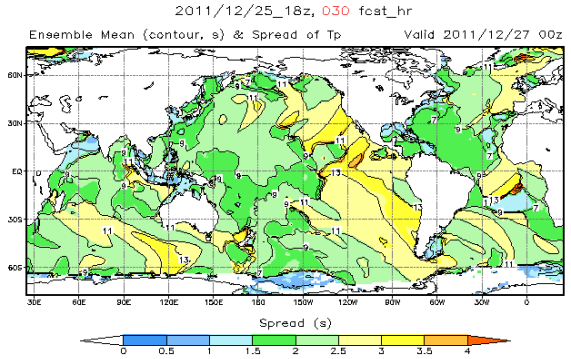
- 研究目標及相關研究
- 成員建置方法及分歧度分析
- 結論

目標：發展多重網格之系集預報，提供機率性預報指引，涵蓋模式預報的不確定性。發展系集預報系統，須提供有效且合理的系集預報成員，以產生足夠的預報系集分岐(SPRD)。

NOAA：The Global Ensemble Ocean Wave Forecast System (GEOWaFS)

- 20 (GEFS) 風場和1個作業化GFS 控制場 since 2006
- 0.1°x0.1°(全球), 240hrs, 4次/1天
- 風速, 示性波高, 主頻週期
- Ensemble mean, spread and probability
- 使用前一個run的6小時預報來當浪場的起始值





Chen(2006)&Cao(2007)

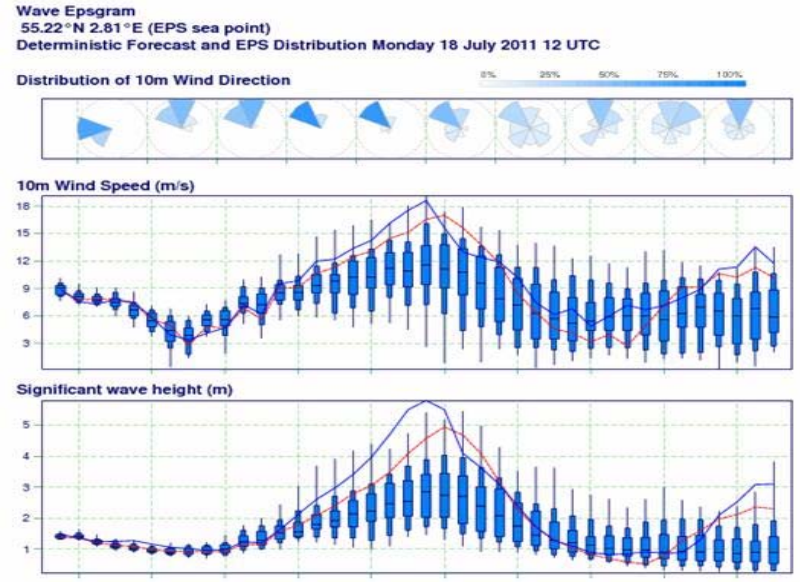
- 系集分岐隨時間增加
- 比確定性預報更符合實際且更合理，亦是較佳的預報及決策工具

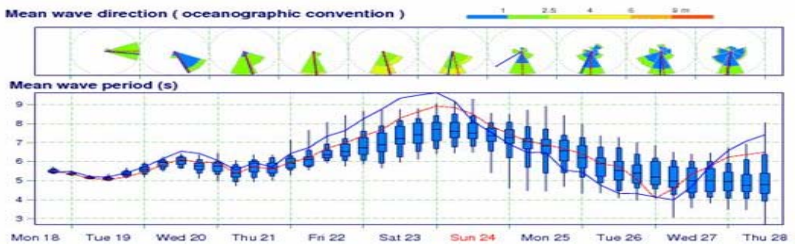
美國海軍FNMOC
2014加拿大20個

multicenter

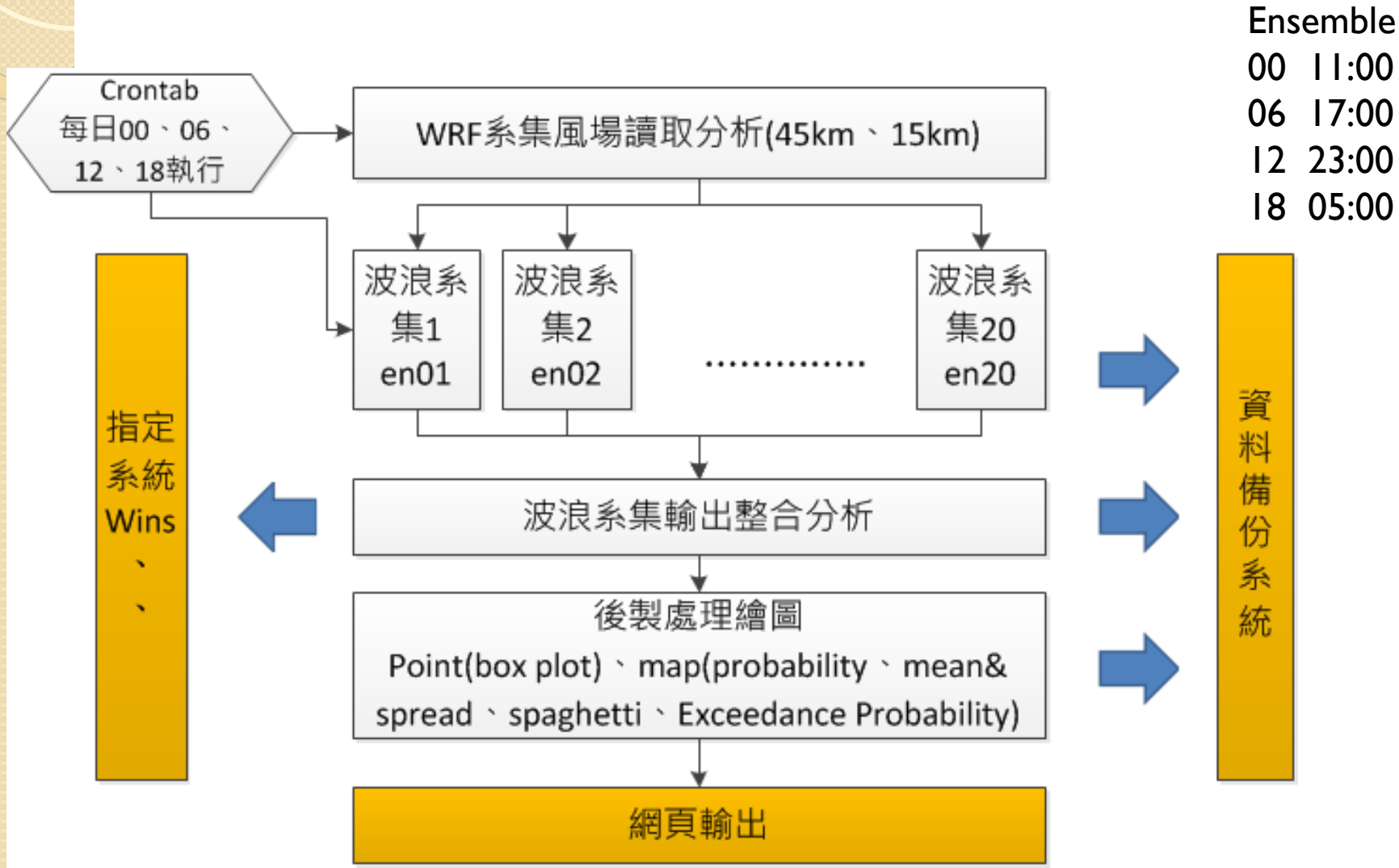
ECMWF： Wave Ensemble Prediction System meteogram (Wave EPSgram)

- 50組初始平均擾動生成風場和1個作業化波浪起始場 (WAM) 1998-2010
- 產生其他50個member(240hrs, 4次/1天)
- 10m風速、10m風向、示性波高、平均波向與週期等
- 盒鬚圖
- 0.5°x0.5°(全球)





CWB系集預報流程



Ensemble
00 11:00
06 17:00
12 23:00
18 05:00

系集波浪預報之成員建置方法及分歧度分析

應用統計指標來評估合適的系集成員，評估系集分歧度是否足夠，據以最大程度涵蓋可能的發生機率

- Talagrand Rank Histograms(TRH)
  針對已知的真值而言，可評估系集預報系統相對於該真值的離散程度，也能了解系集預報的偏差(Bias)情形。

- Spread(SPRD)、Root Mean Square Error(RMSE)
  系集預報和系集平均的差異。Rank Histogram 對於離散程度的評估較為定性判斷，因此透過ensemble spread可提供一個定量的數值協助判斷。

- member equal-likelihood(MEL)
  以真值和各成員預報值進行比較，若系集成員預報值和真值最接近，則此系集成員累加一次直到統計完所有時間和網格點資料。由於期望每個成員對於真值的預報命中率一致，因此圖形平坦時，為最佳的情形。

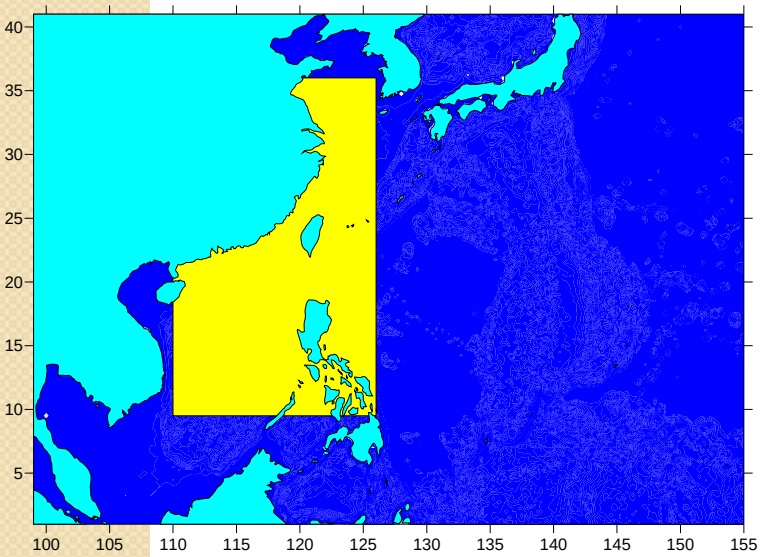
perfect : RMSE=SPRD

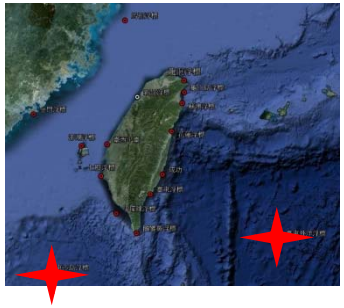
Spread too small：RMSE > SPRD

Spread too large：RMSE < SPRD

系集波浪預報之成員建置方法及分歧度分析

東北季風(2012/1~2)及颱風時期(2012/7~8)的系集預報風場進行計算分析





Buoy

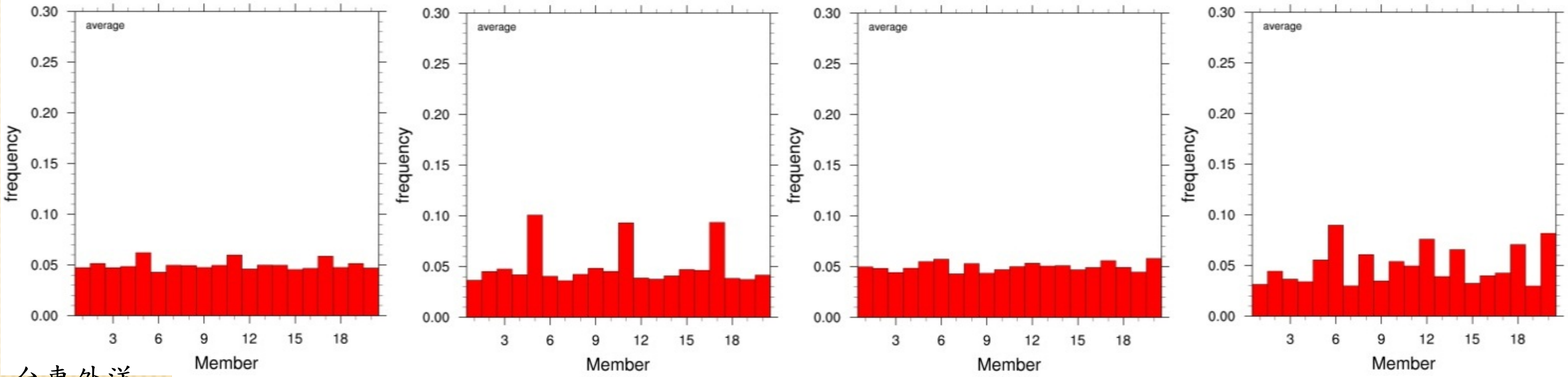
2次/1天
Tolman

2012	1214	天秤	TEMBIN	08/26～08/28	中度	特殊路徑	965.0	35.0	180	50	21
2012	1214	天秤	TEMBIN	08/21～08/25	中度	特殊路徑	945.0	45.0	180	50	33
2012	1213	啟德	KAI-TAK	08/14～08/15	輕度	--	995.0	20.0	150	--	10
2012	1211	海葵	HAIKUI	08/06～08/07	中度	--	960.0	35.0	180	50	11
2012	1209	蘇拉	SAOLA	07/30～08/03	中度	2	960.0	38.0	220	80	31

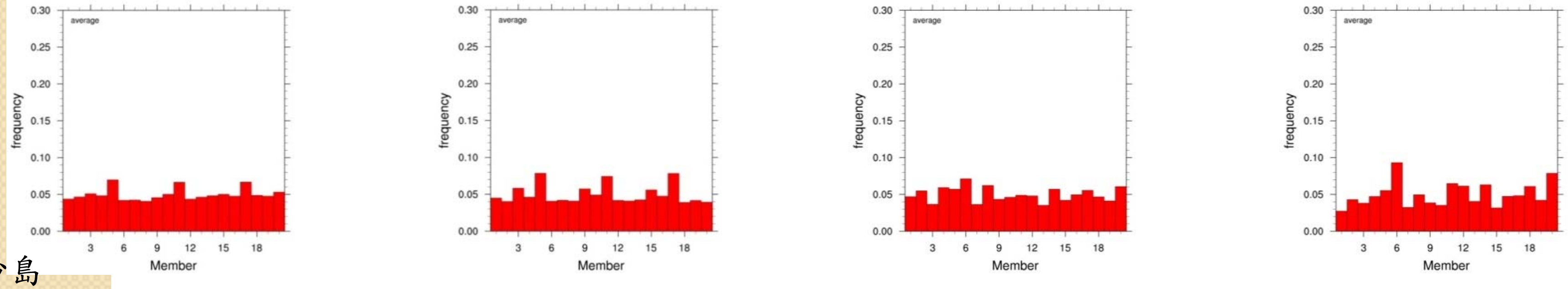
member equallikelihood
2012/1~2

2012/8

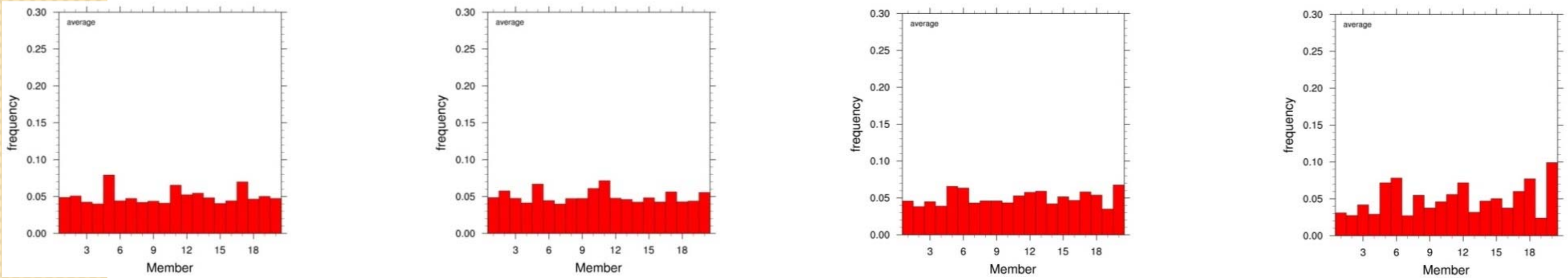
Wind wave Wind wave



台東外洋



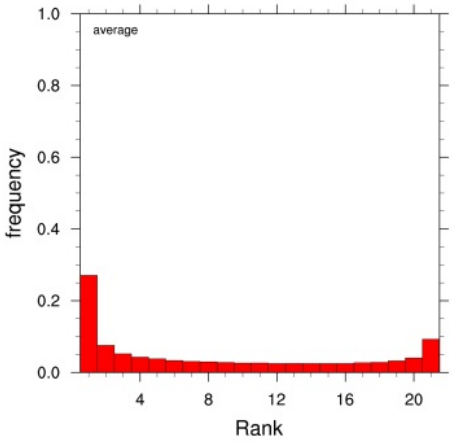
東沙島



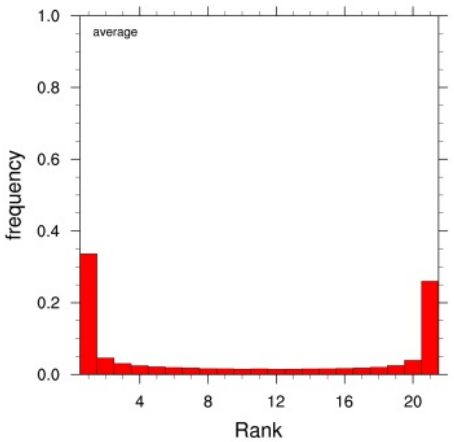
Talagrand Rank Histograms

2012/1~2

Wind



wave



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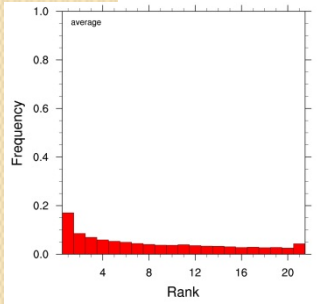

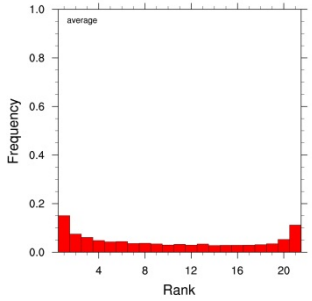

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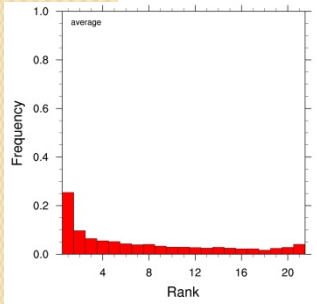
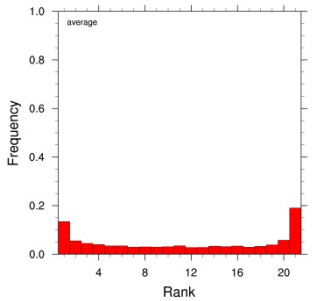
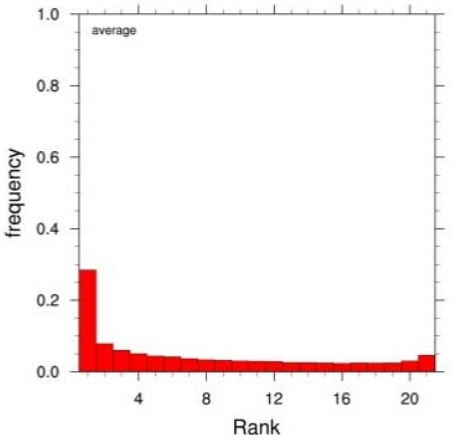


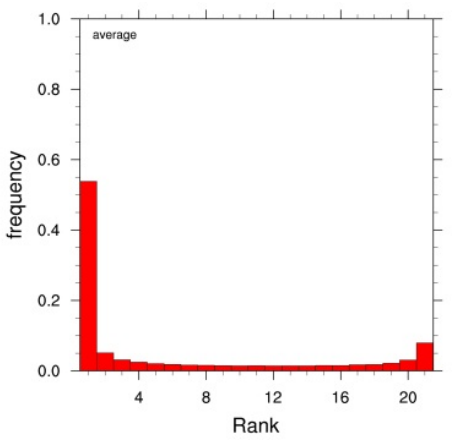


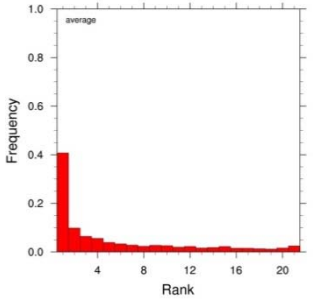
2012/8

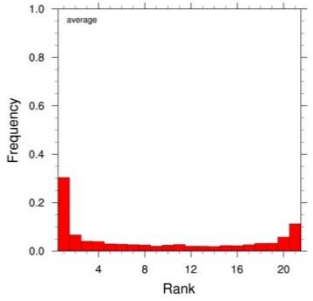
Wind

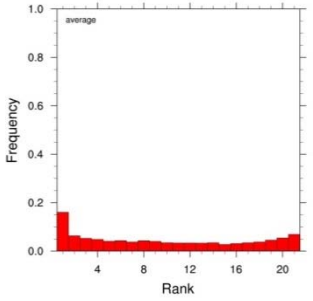


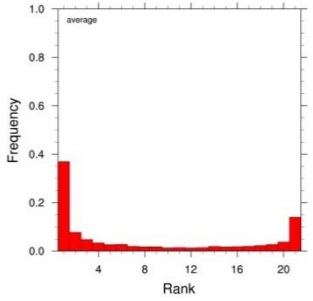
wave







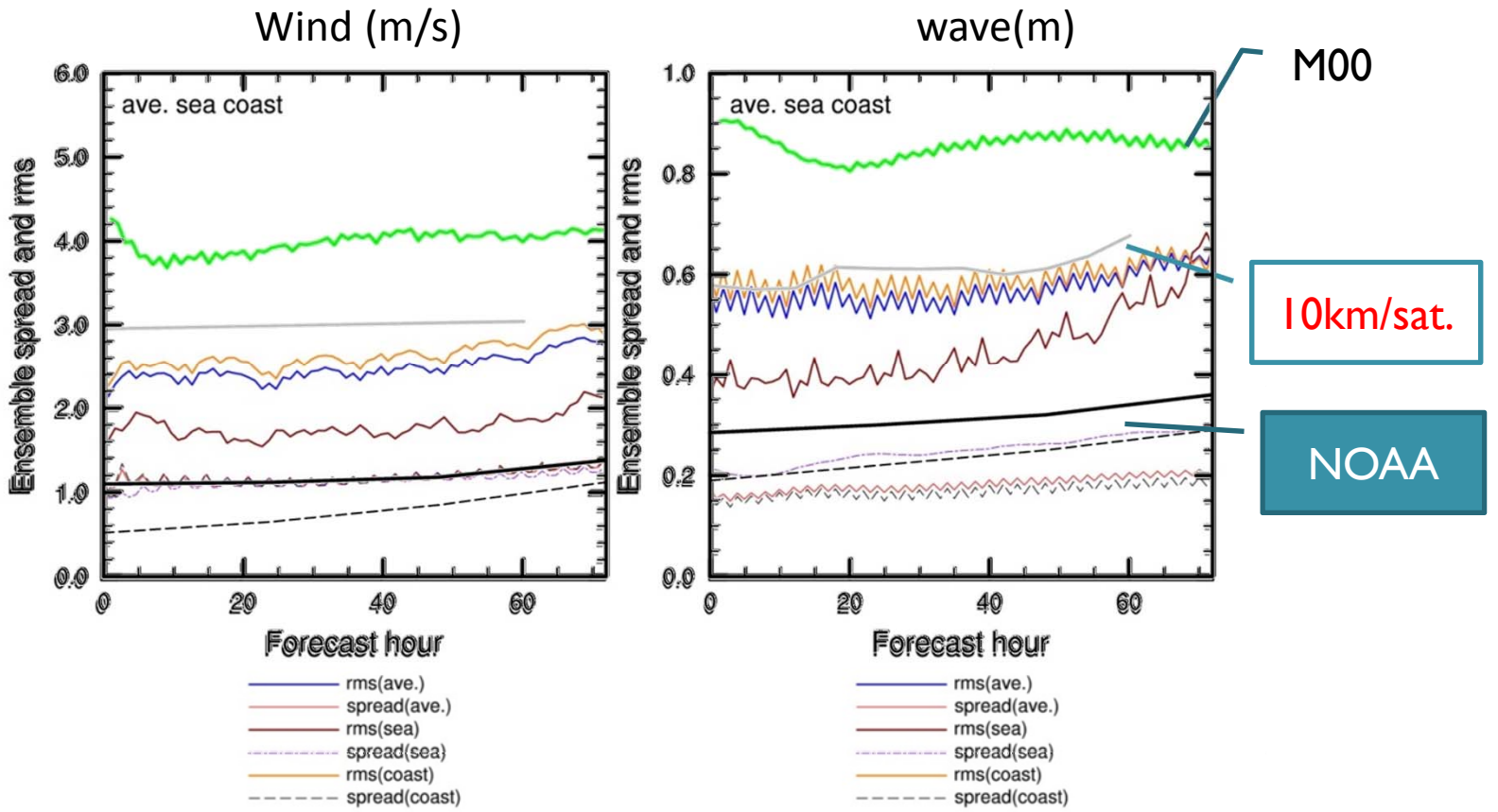




SPREAD

Root Mean Square Error

2012/1~2



Validation and Application of Jason-1 and Envisat Significant Wave Heights

Tom H. Durrant and Diana J. M. Greenslade
CAWCR/Bureau of Meteorology
Melbourne
Australia

AUSWAM

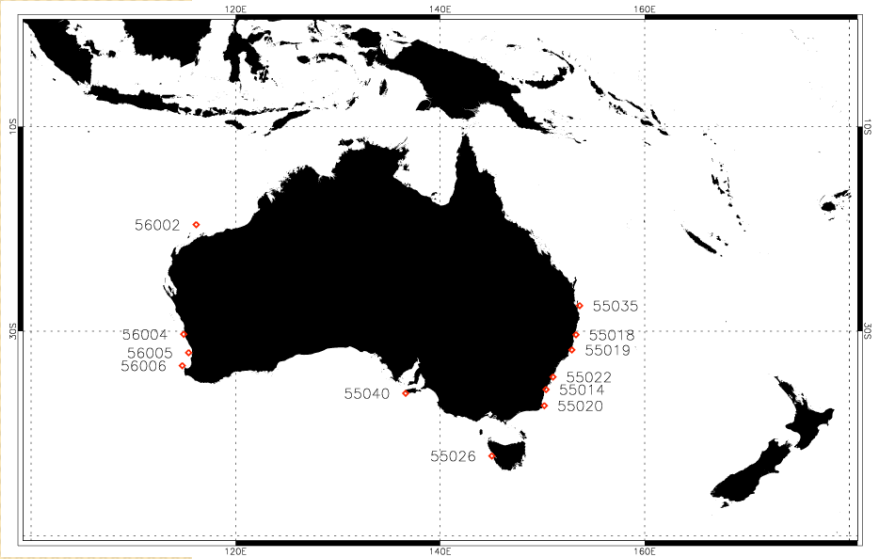


Figure 7 *Locations and names of the buoys used for verification of the model runs.*

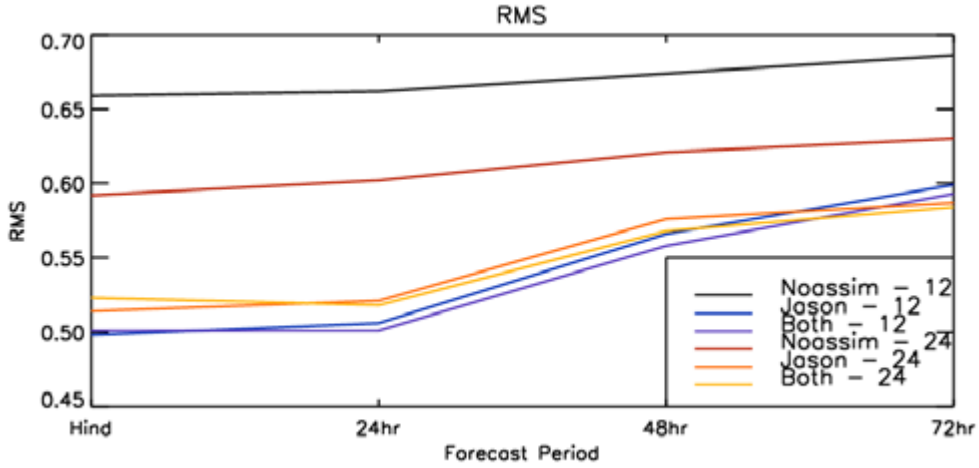


Figure 10 *Summary of verification statistics (Bias, Scatter Index and RMS difference) for all model runs compared to the buoys shown in Figure 7.*

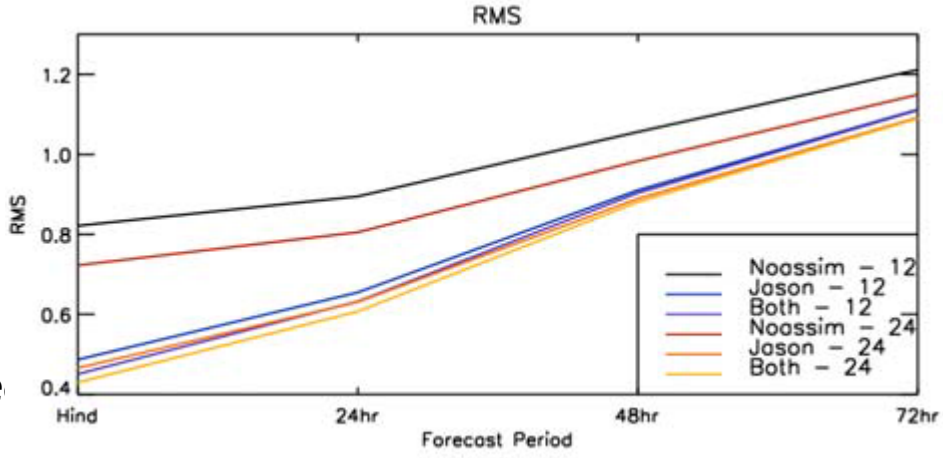
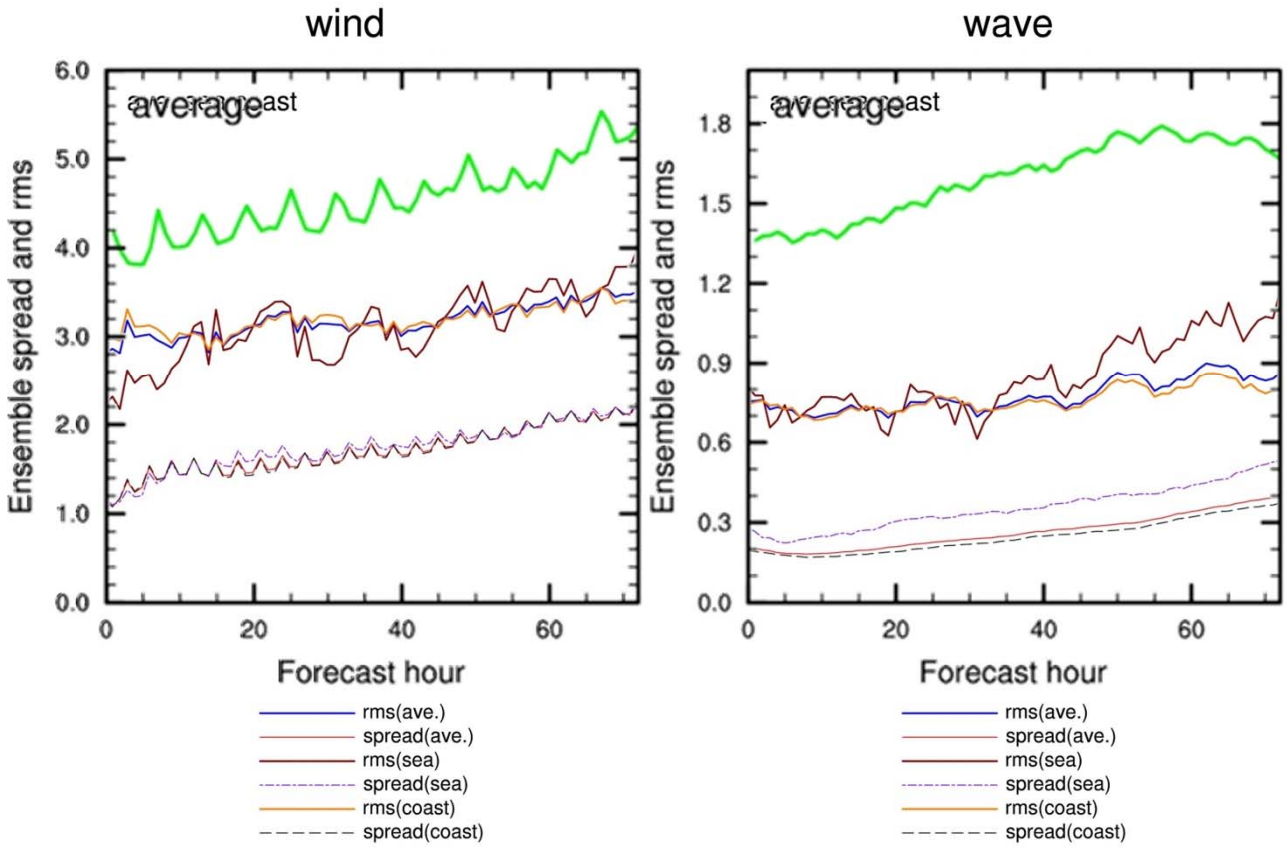


Figure 15 *Summary of verification statistics (Bias, Scatter Index and RMS difference) for all model runs compared to Jason-1 and Envisat satellite altimeter observations.*

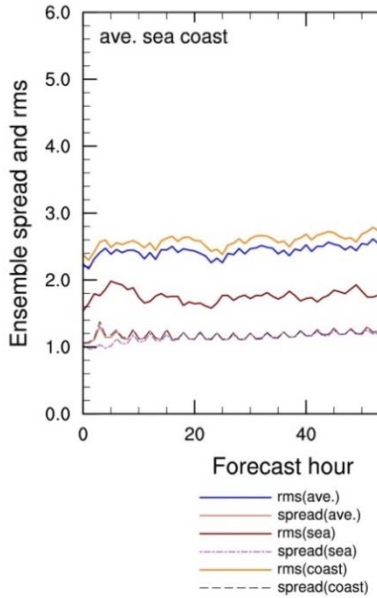
SPREAD

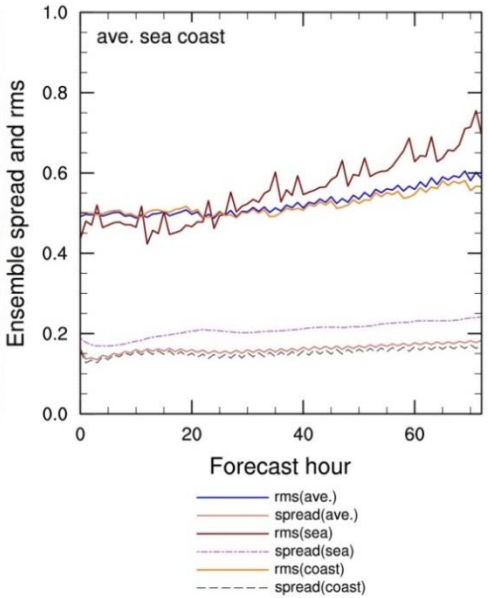
Root Mean Square Error

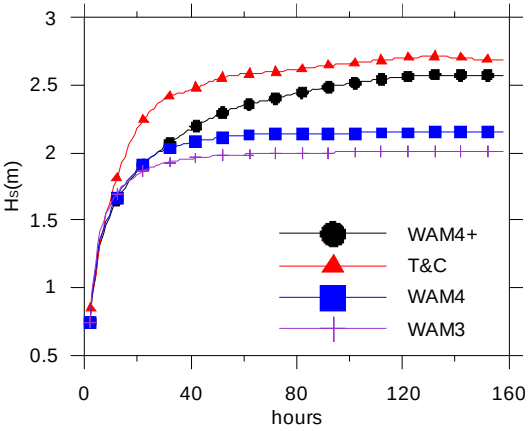
2012/8



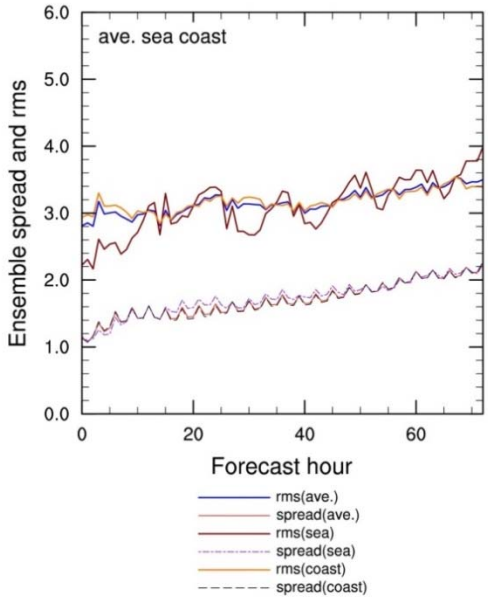
WAM4
2012/1~2

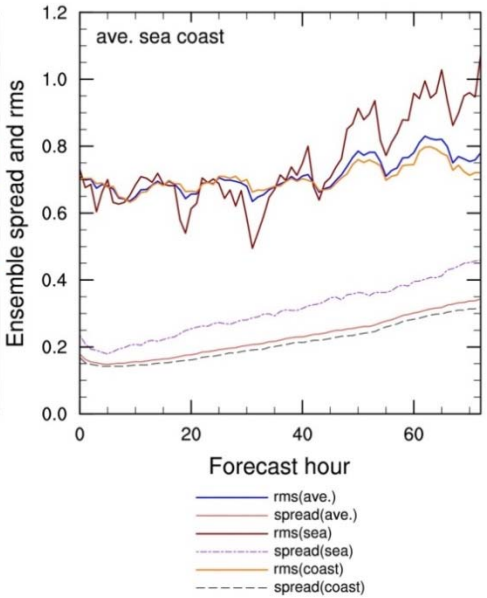




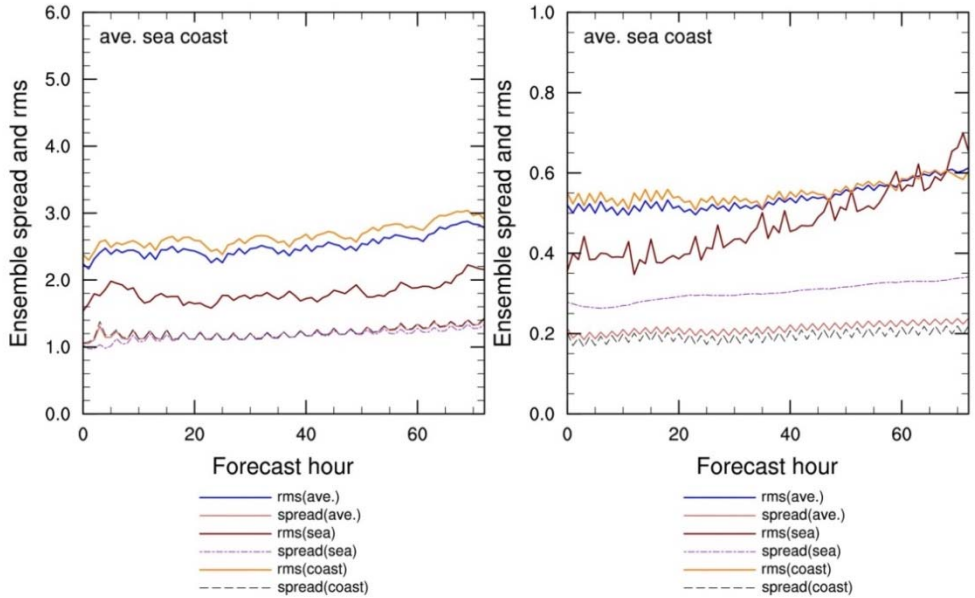


WAM4
2012/8





10T10W
2012/1~2



10T10W
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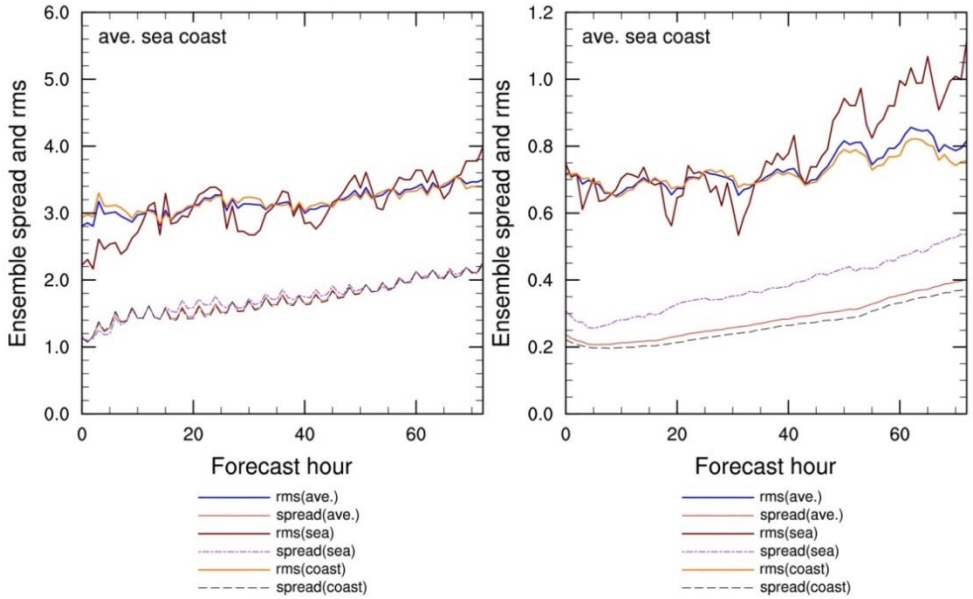
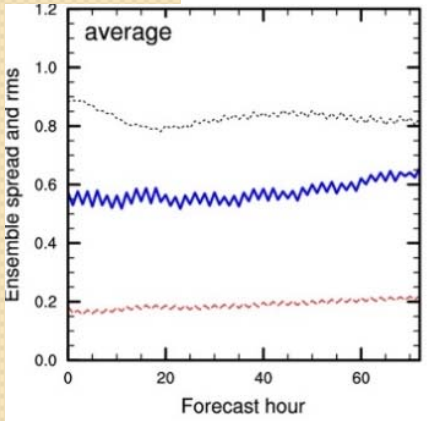


2012/1~2

Tolman



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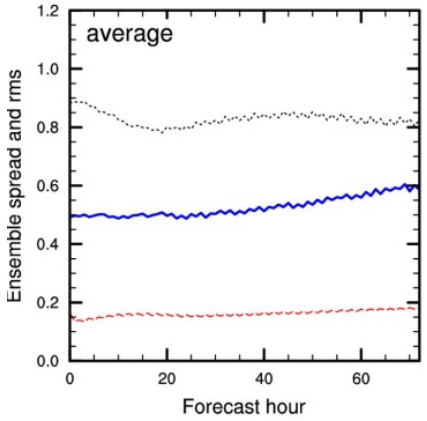

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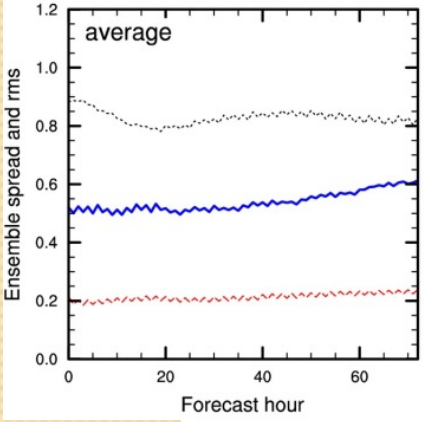
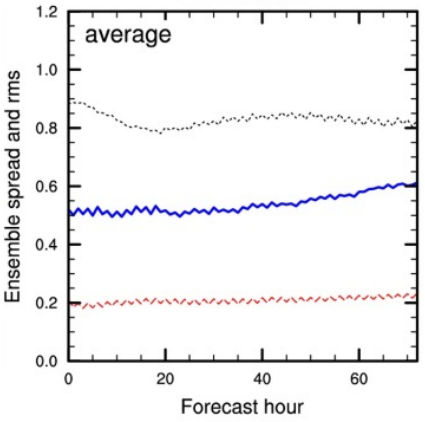
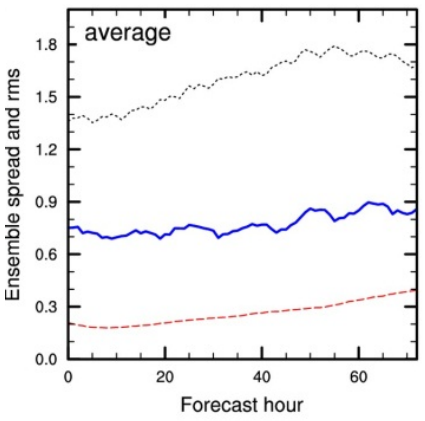


10W10T



2012/8

Tolman



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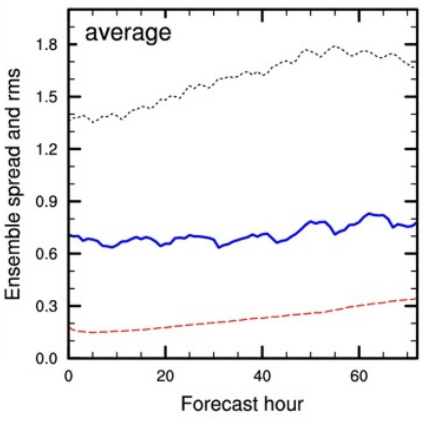

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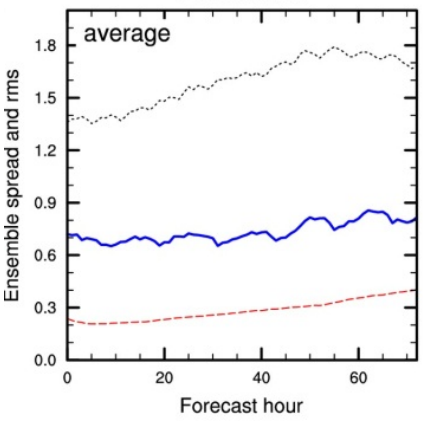

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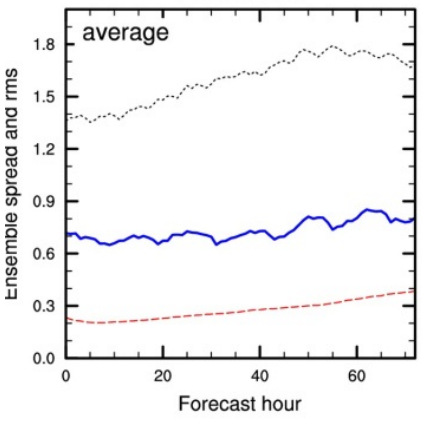
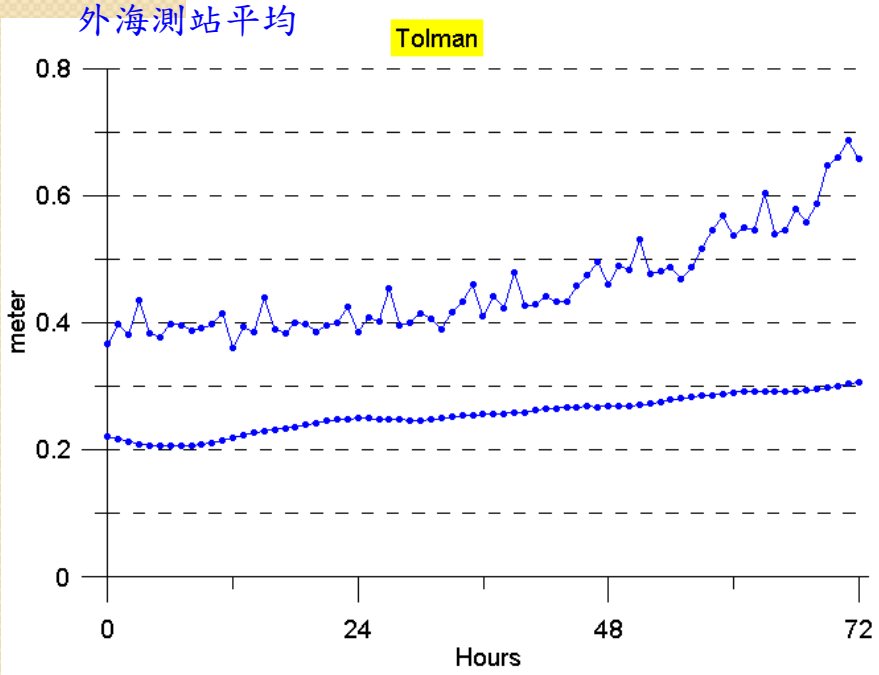
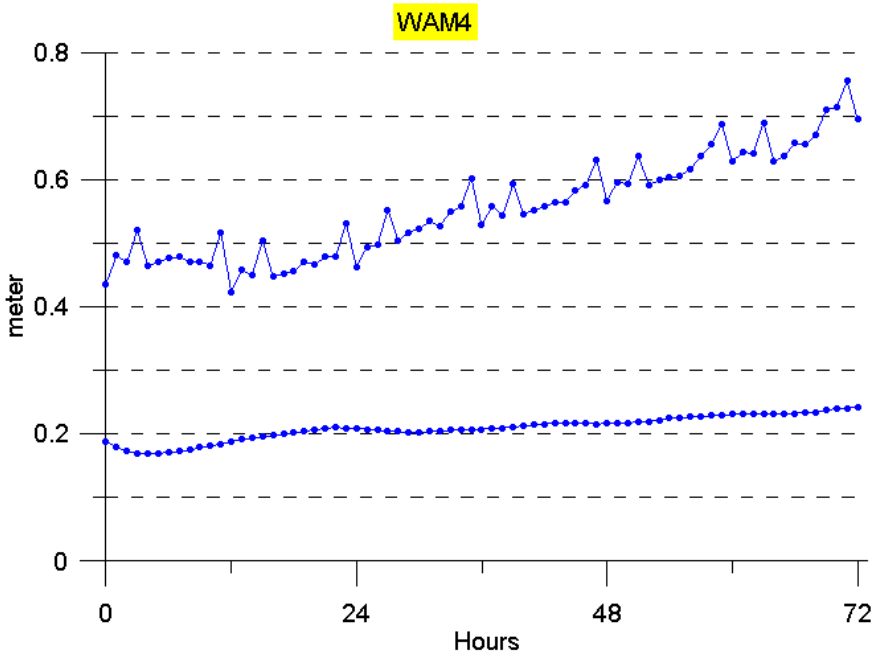
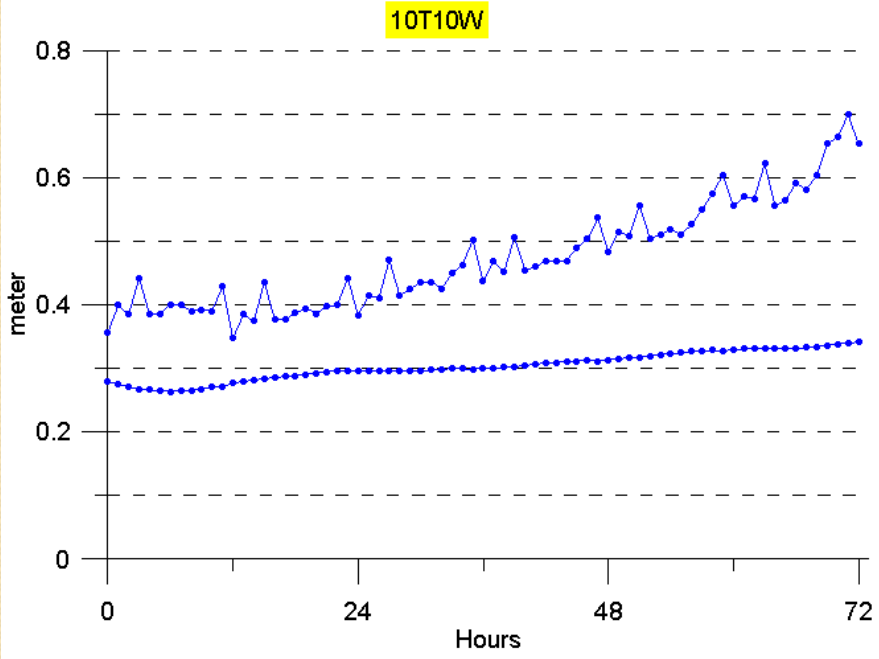
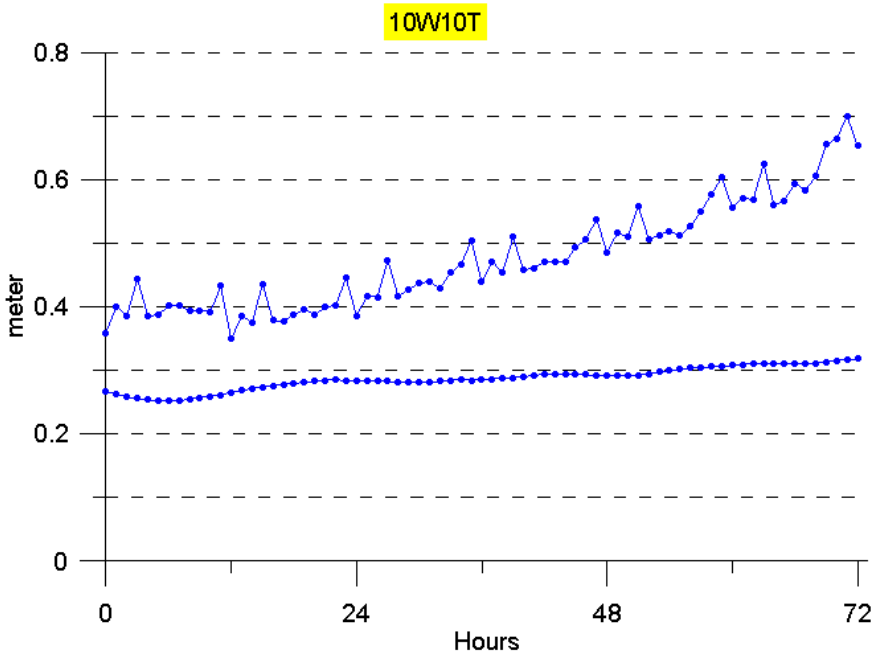


外海测站平均

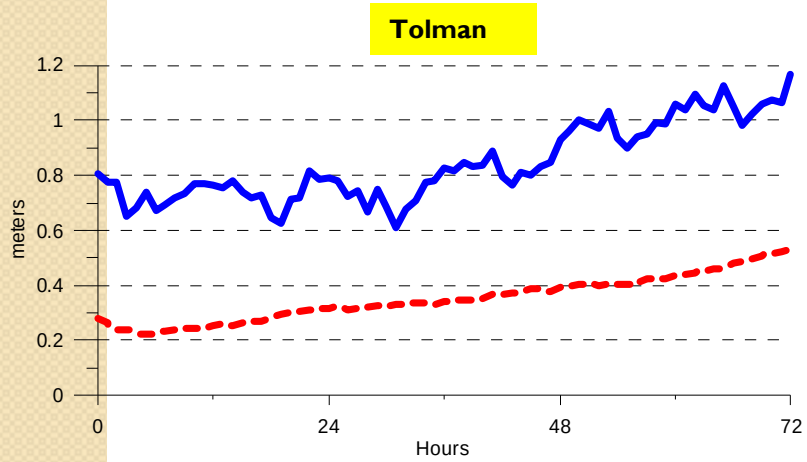

Tolman
0.8
0.6
0.4
0.2
0
meter
0
24
48
72
Hours

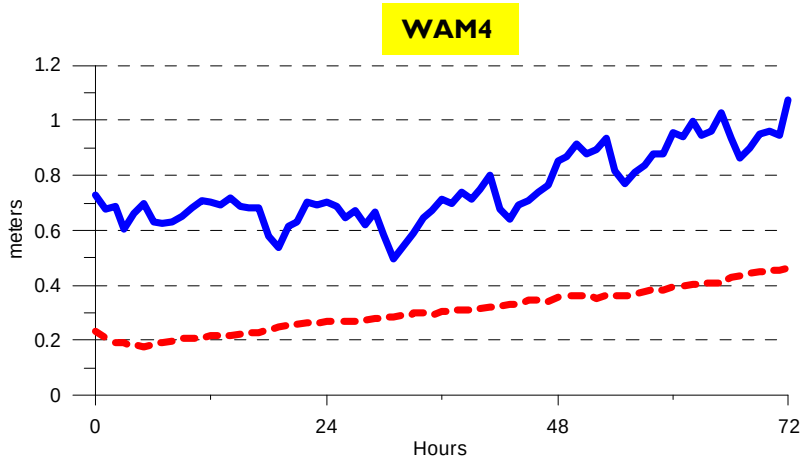

WAM4
0.8
0.6
0.4
0.2
0
meter
0
24
48
72
Hours

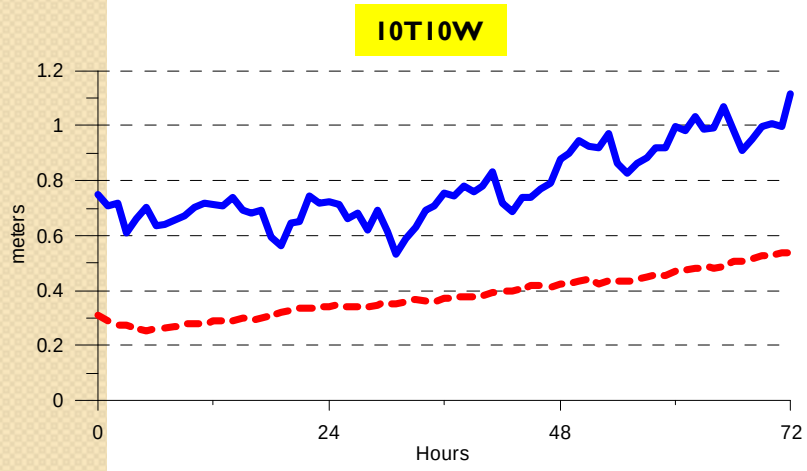

10T10W
0.8
0.6
0.4
0.2
0
meter
0
24
48
72
Hours

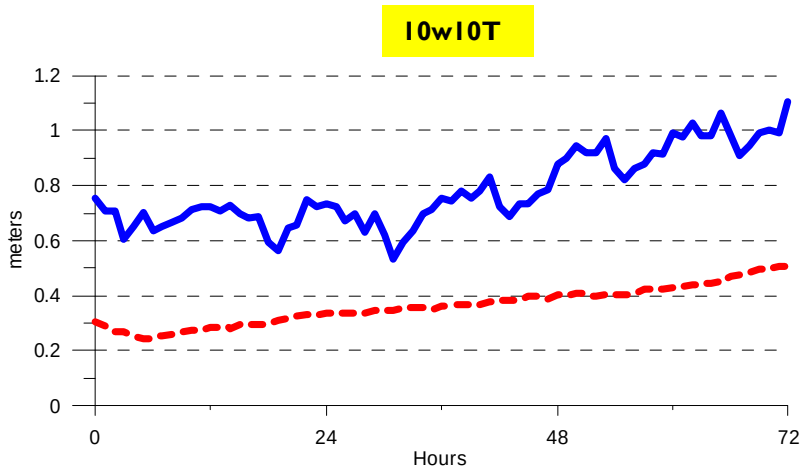

10W10T
0.8
0.6
0.4
0.2
0
meter
0
24
48
72
Hours

所有测站平均


Tolman
meters
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
Hours

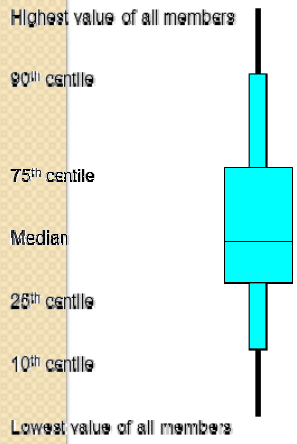

WAM4
meters
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
Hours


I0TI0W
meters
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
Hours


I0wI0T
meters
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
Hours

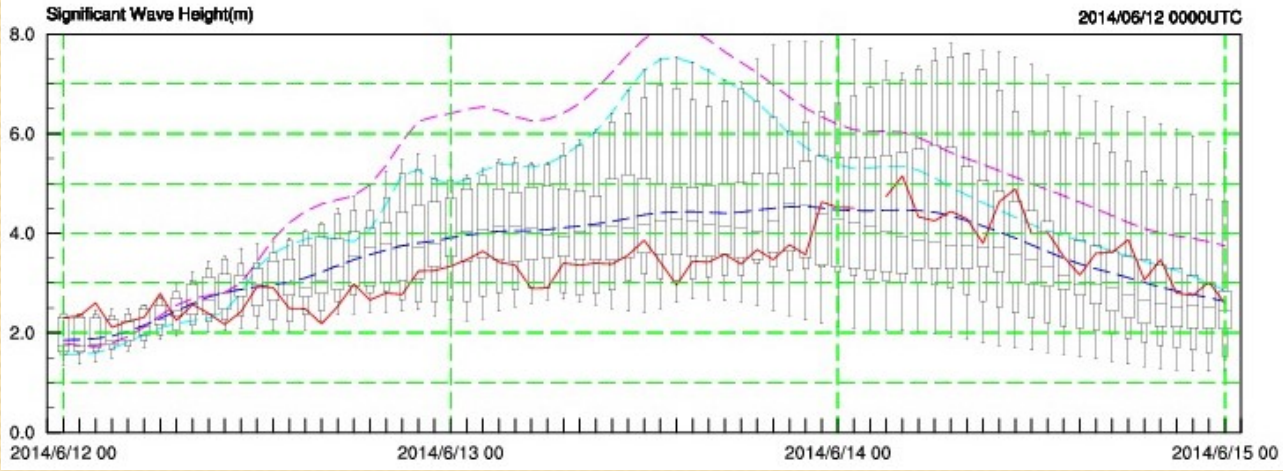
結論建議

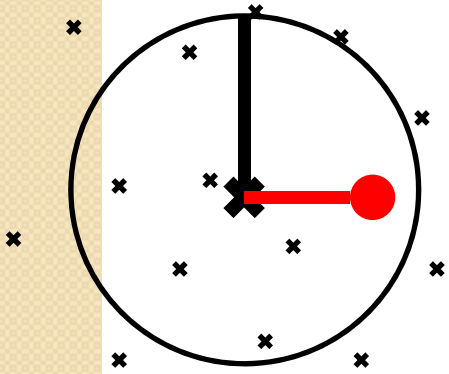
- 本研究以外洋二個測站為主要選取系集成員的依據，在風場不變的情形下，分別針對1~2月及8月颱風時期選取適當的風場輸入公式(Tolman及WAM4)進行調整，再利用系集成員各半的組合方式，保留各個風場輸入公式在不同風場狀況下的優點，同時提高SPRD，使得系集系統已較能掌握模式的不確定因素。而部分靠岸測站而言，是否因為模式解析度不夠或是地形的掌握較差導致結果較不理想，仍然需要進一步的研究。
- 系集預報的主要目的是期望預報的SPRD能包含模式的不確定性，故希望讓SPRD愈接近RMSE愈好，依據前面的分析結果顯示，需從二方面著手，拉近風場的SPRD及RMSE，此部分在氣象局的氣象系集團隊正朝向改變邊界層粗糙度的方向進行，將使得陸地的RMSE降低，會影響到近陸域的風場，至於海洋風場的部分則建議需進一步考慮波浪形成的粗糙度進行風波的藕合研究；在波浪方面，未來除了使用改善風場外，近岸模式的建置亦需同步改善，重新調整率定決定性波浪預報在近岸的使用，以降低RMSE。



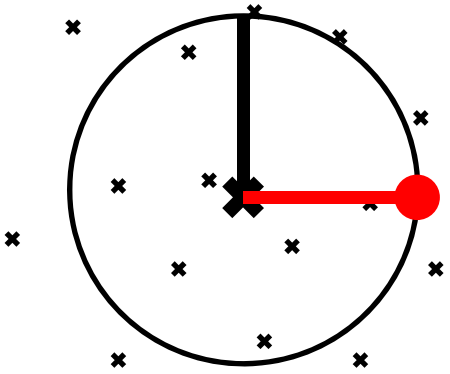
Thank you for your attention!

Industrial Technology Research Institute
Green Energy and Environment Research Laboratories

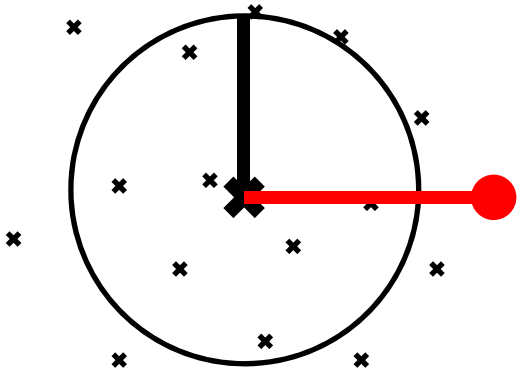




SPRD>RMSE



SPRD=RMSE



SPRD<RMSE

一個好的系集系統，通常當RMSE增加時，SPRD也隨之增加