

**Intercomparison of operational wave forecasting systems against buoys:
data from ECMWF, MetOffice, FNMOC, NCEP, MeteoFrance, DWD,
BoM, SHOM, JMA and KMA**
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0.1 Forewords

Outputs from different operational forecasting centres are compared to buoy and platform data as broadcasted to the meteorological community via the Global Telecommunication System (GTS). On a monthly basis, data are gathered informally from operational weather services with an interest in wave forecasting (Bidlot and Holt, 2006). The different data sets are subsequently merged and made available to all participating partners for further evaluation. In this document, examples, in graphical and tabular forms, are shown. These results have been processed at ECMWF and should serve as an example to the kind of information that could be obtained from such comparison. No statement of quality, nor reasons why the different systems are performing differently will be given.

0.2 Data

Before using observations for verification, care has to be taken to process the data to remove any erroneous observations and also in order to match the scale of both model and observations. This scale matching is achieved by averaging the hourly data in ± 2 hour time windows centered on the four major synoptic times corresponding to the normal model output times. The original quality control and averaging procedure was discussed in Bidlot *et al.* (2002). It was extended to include platform data as described in Sætra and Bidlot (2004). Note that in this paper we refer to these data as buoy data since most of them are from moored buoys, except if stated otherwise.

The intercomparison relies on the exchange of model output at buoy locations. An agreed upon list of locations is used where observations are known to be available. Because buoy networks are changing with time, as witnessed by a rapid increase in the number of buoys available via the GTS since the mid-nineties, updates to the list have been necessary. Not all participating centres have been able to update their list however. Other participants are only running limited area model(s) or do produce the parameter(s) that can be compared to the buoy data. Because of the limited number of buoys, a fair comparison between the different systems can only be achieved if the same number of buoys and the same number of buoy-model collocations are used.

In this document, data that are common to ECMWF, MetOffice, FNMOC, NCEP, MeteoFrance, DWD, BoM, SHOM, JMA and KMA are used. The other participants are left blank in the plots below.

References

- Bidlot J.-R., D. J. Holmes, P. A. Wittmann, R. Lalbeharry, H. S. Chen, 2002: Intercomparison of the performance of operational ocean wave forecasting systems with buoy data. *Wea. Forecasting*, **17**, 287-310.
- Bidlot J.-R. and M.W. Holt, 2006: Verification of operational global and regional wave forecasting systems against measurements from moored buoys. *JCOMM Technical Report*, **30**. WMO/TD-No. 1333.
- Sætra, Ø. and J.-R. Bidlot, 2004: On the potential benefit of using probabilistic forecast for waves and marine winds based on the ECMWF ensemble prediction system. *Wea. Forecasting*, **19**, 673-689.

0.3 Results

In the remaining pages, some of the results of the comparison with buoys are presented for all common buoys and for common buoys within a sub-area as displayed by the corresponding maps. Summary forecast scores are shown first, followed by density scatter diagrams with associated statistics for each subarea. Only common data to ECMWF, MetOffice, FNMOC, NCEP, MeteoFrance, DWD, BoM, SHOM, JMA and KMA are used.

0.3.1 Comparison for all buoys

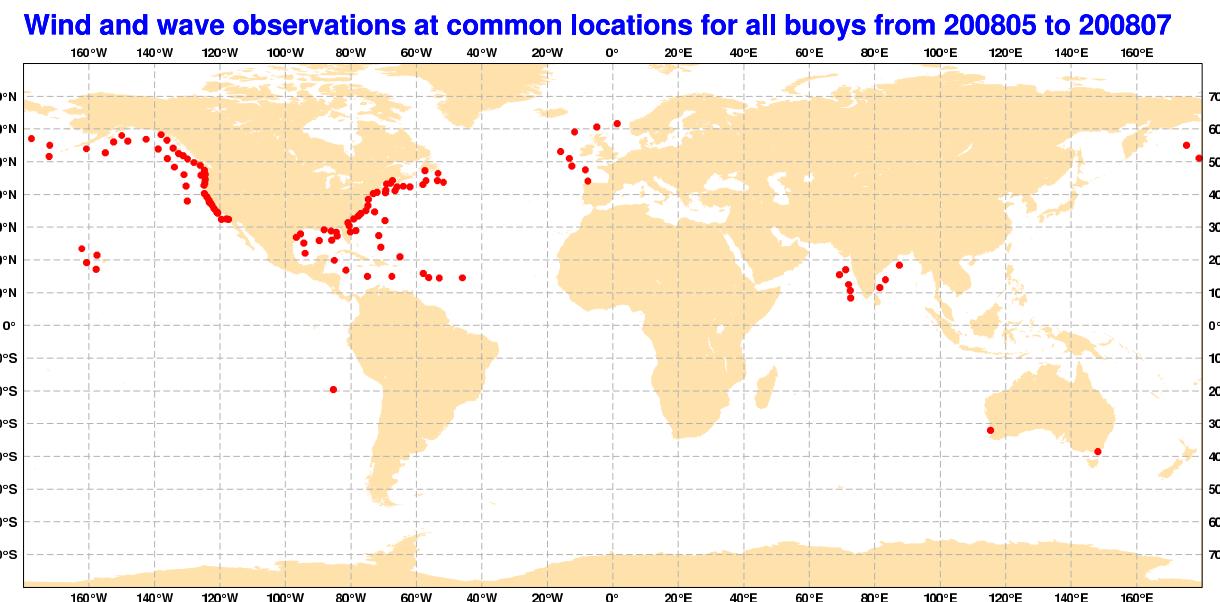


Figure 1: Buoy locations

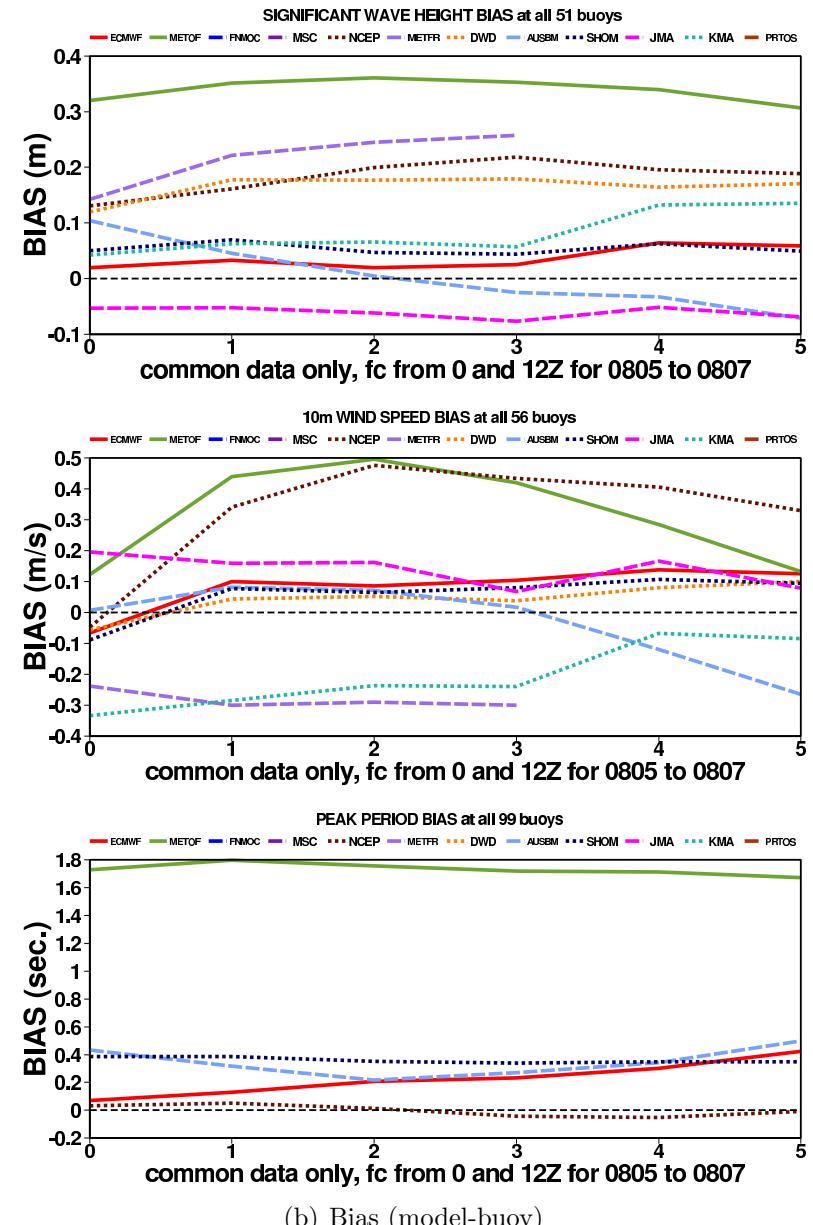
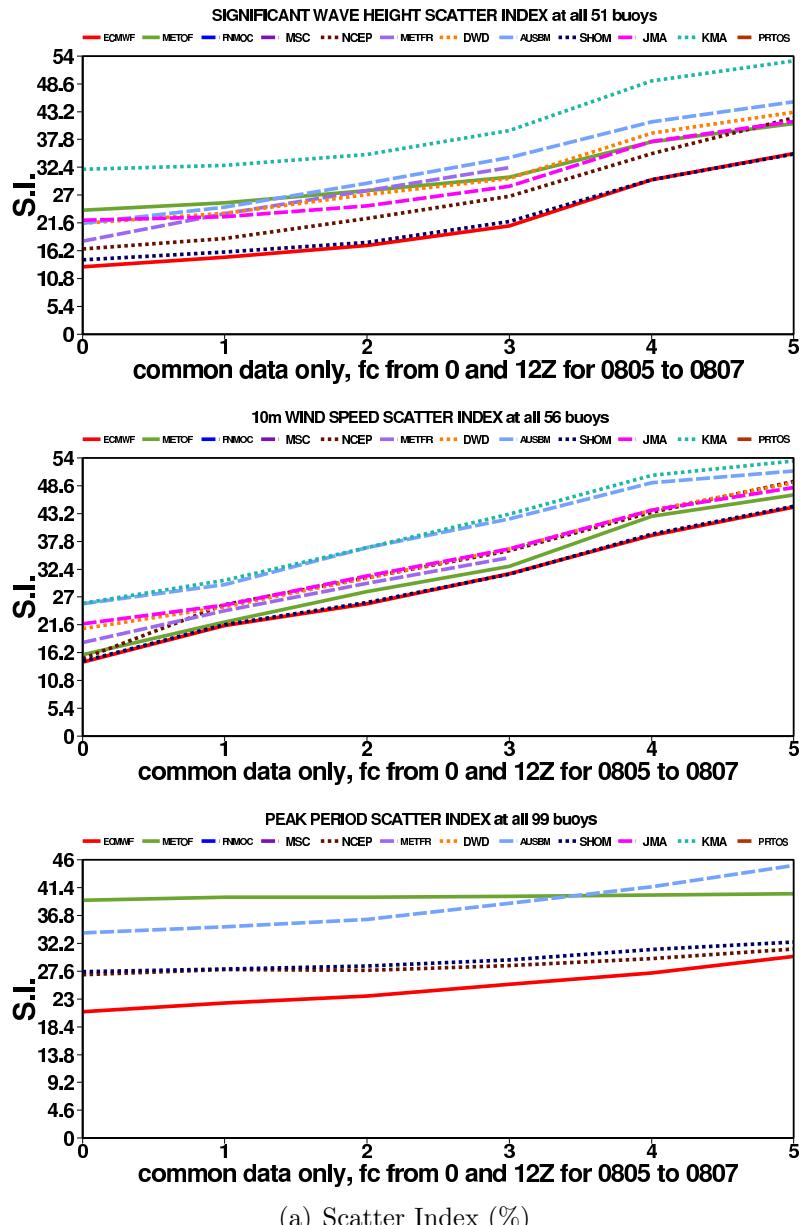
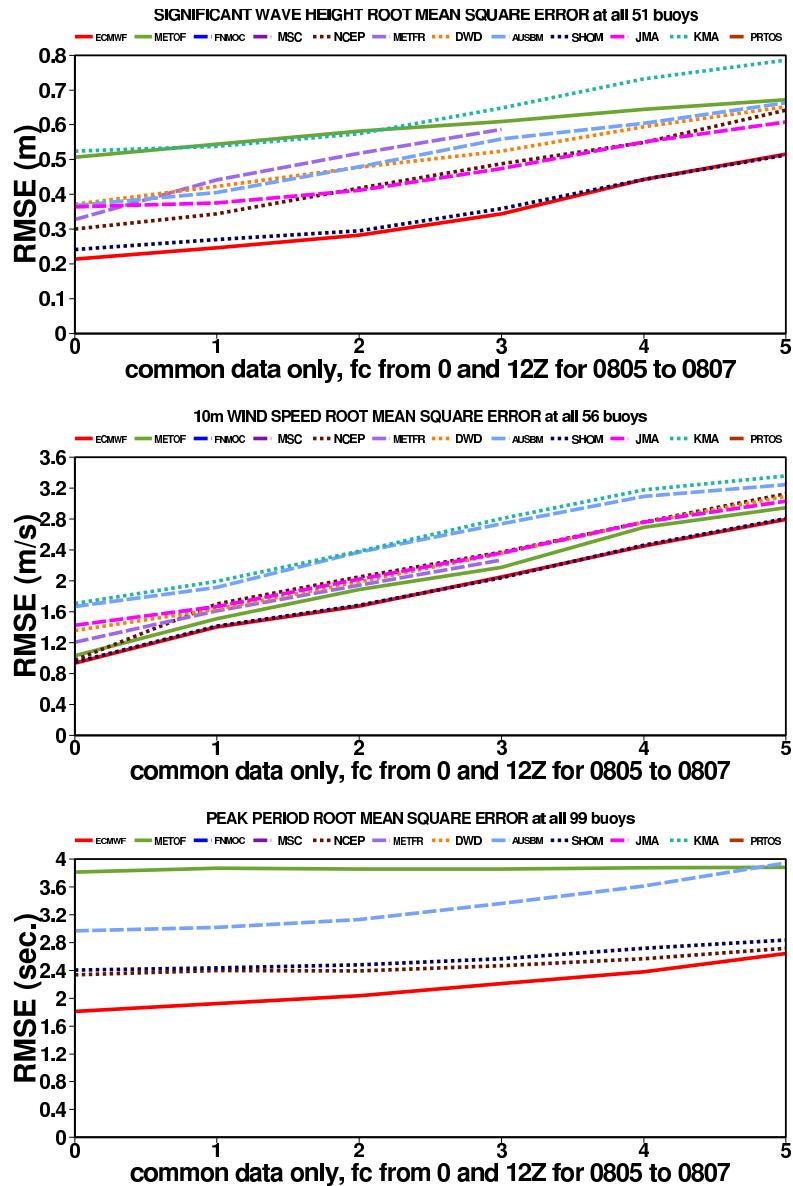
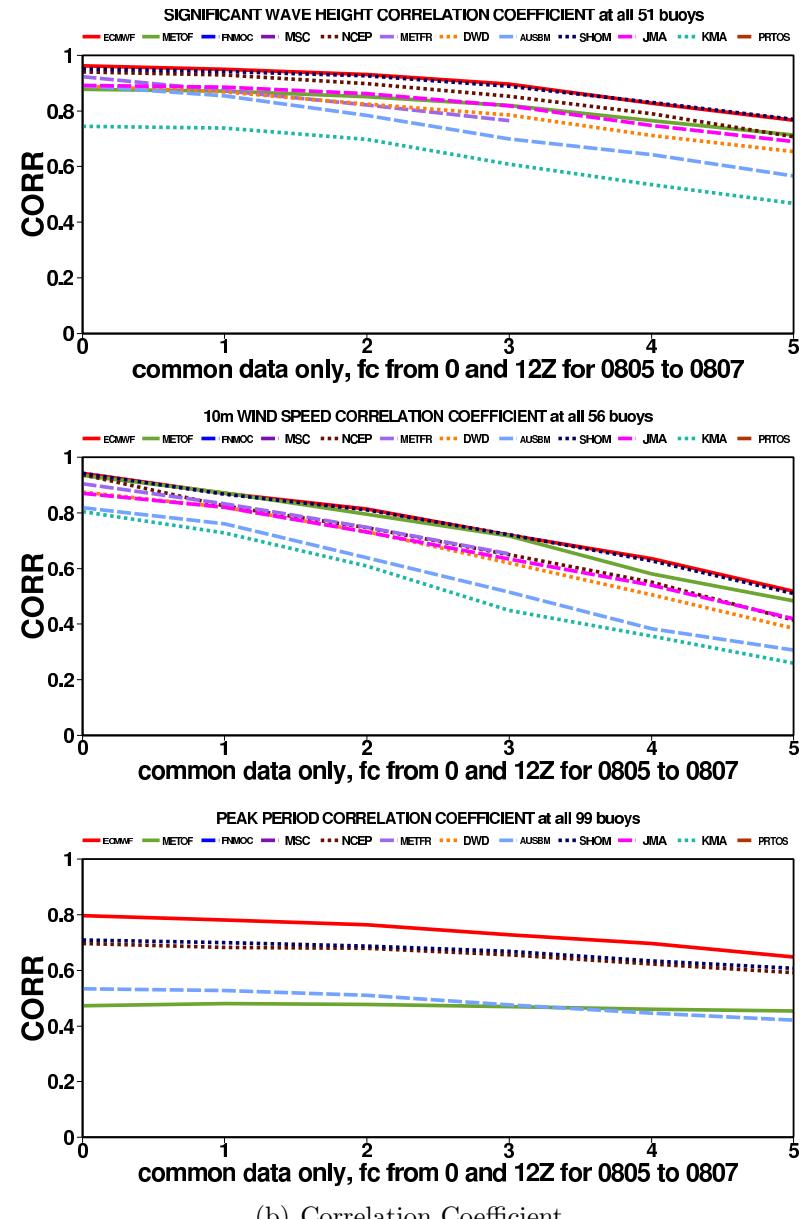


Figure 2: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common all buoys.



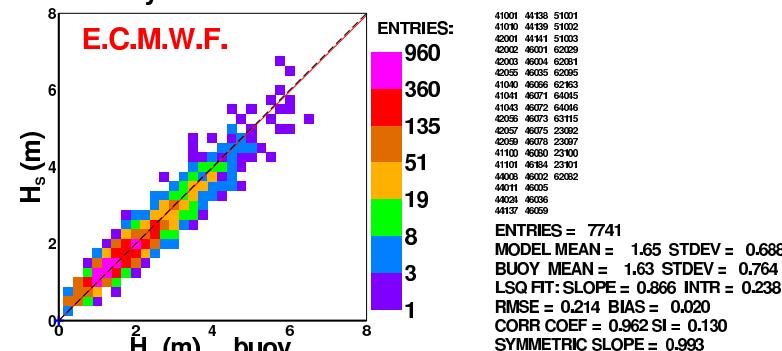
(a) R.M.S.E.



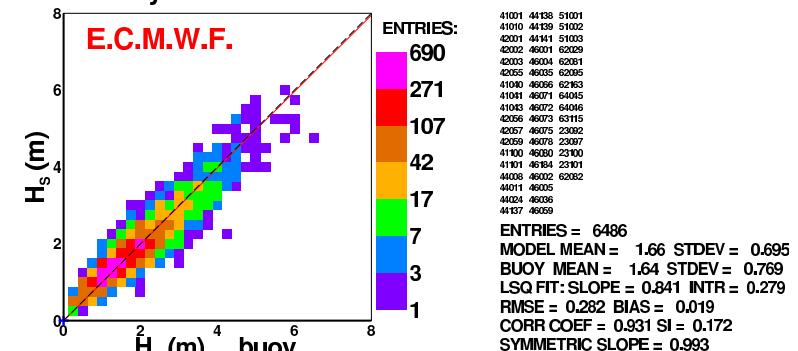
(b) Correlation Coefficient

Figure 3: Forecast root mean square error (RMSE) and linear correlation coefficient at common all buoys.

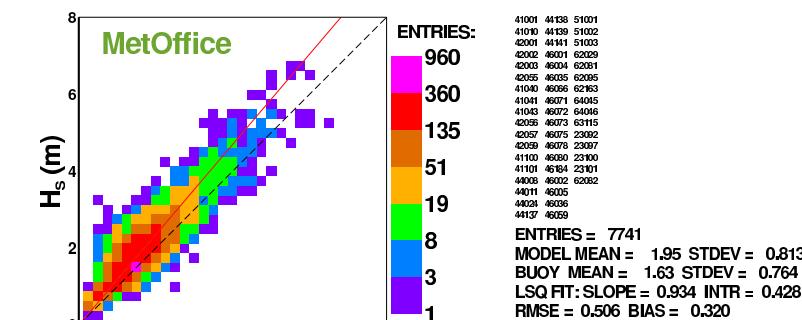
all buoys 0805 to 0807



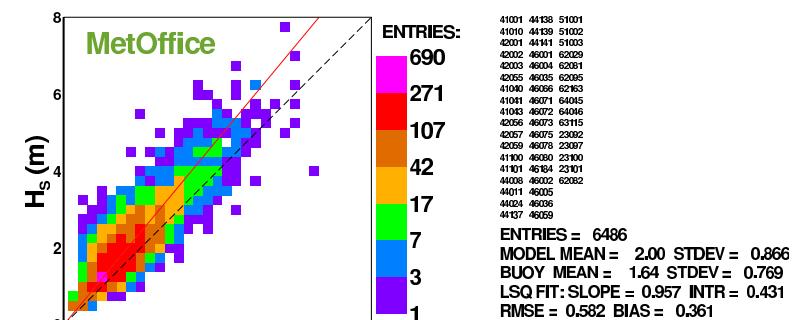
all buoys 0805 to 0807



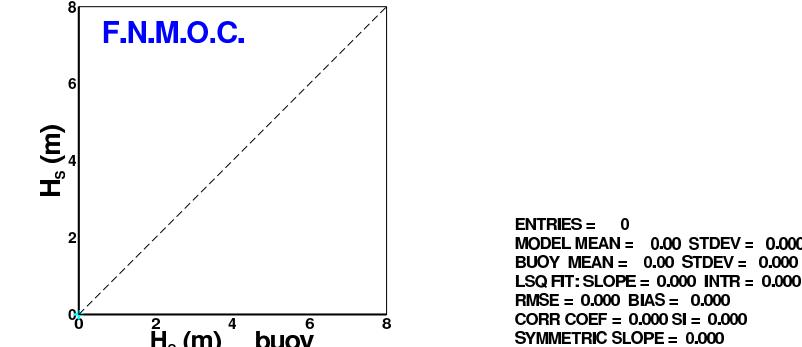
MetOffice



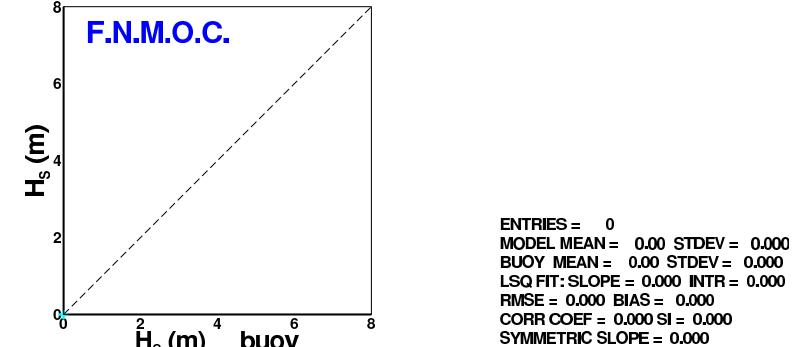
MetOffice



F.N.M.O.C.



F.N.M.O.C.

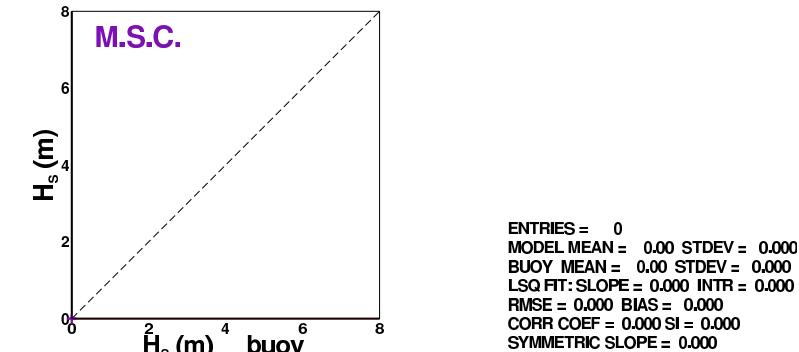


(a) t+0

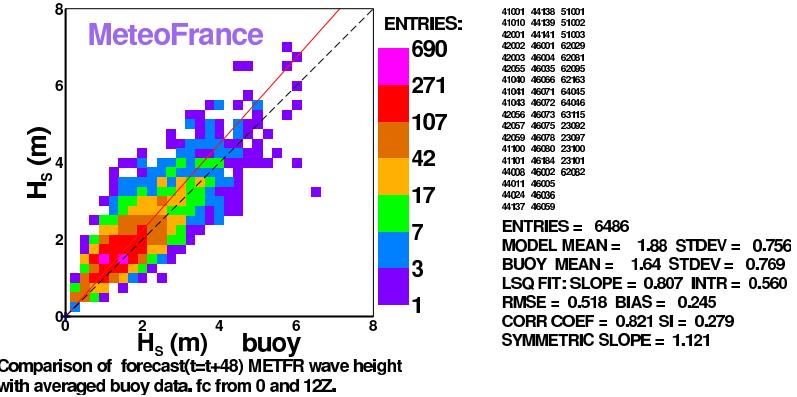
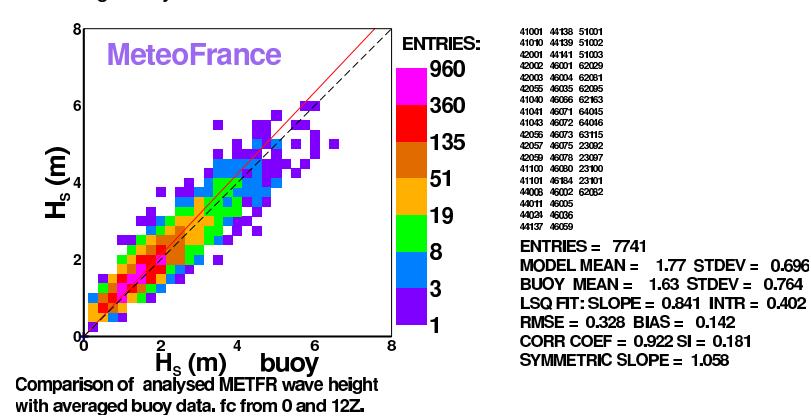
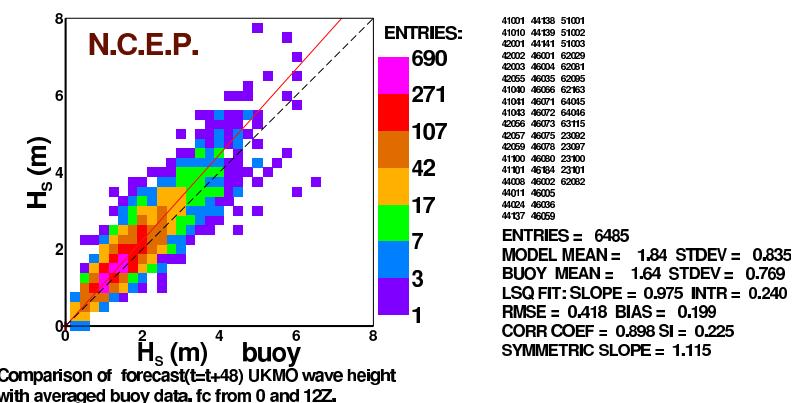
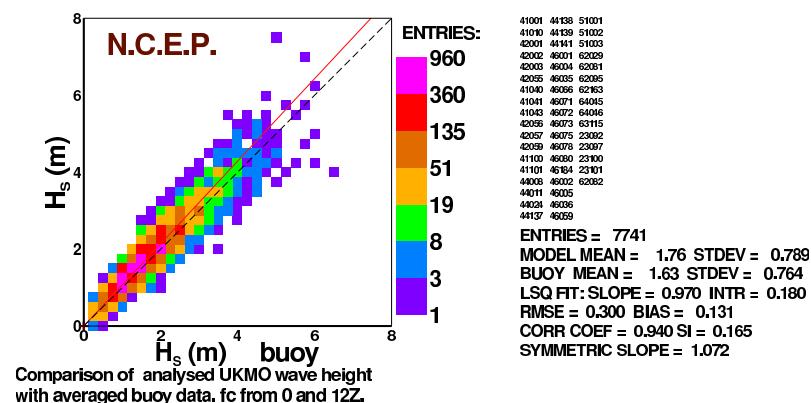
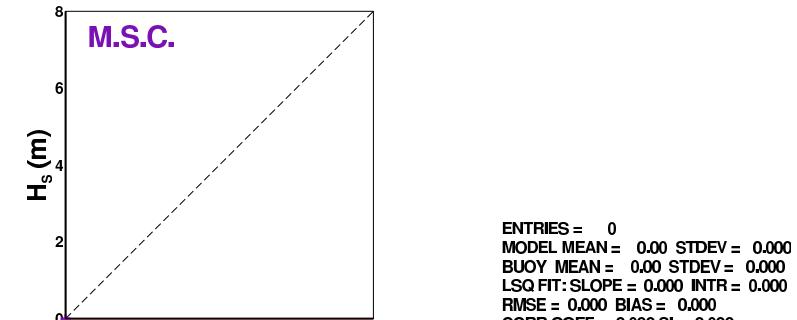
(b) t+48

Figure 4: Scatter diagrams for wave height at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



all buoys 0805 to 0807

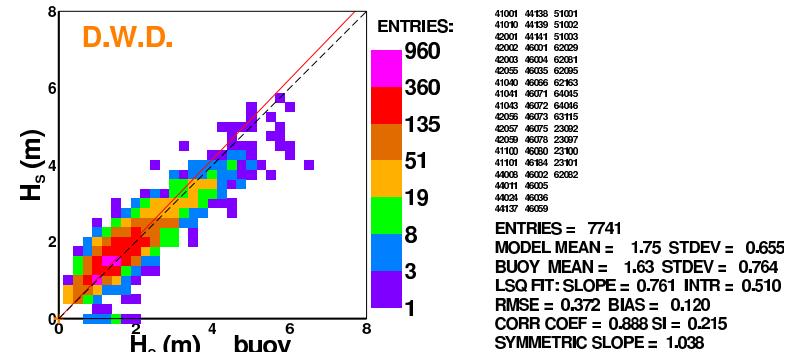


(a) $t=0$

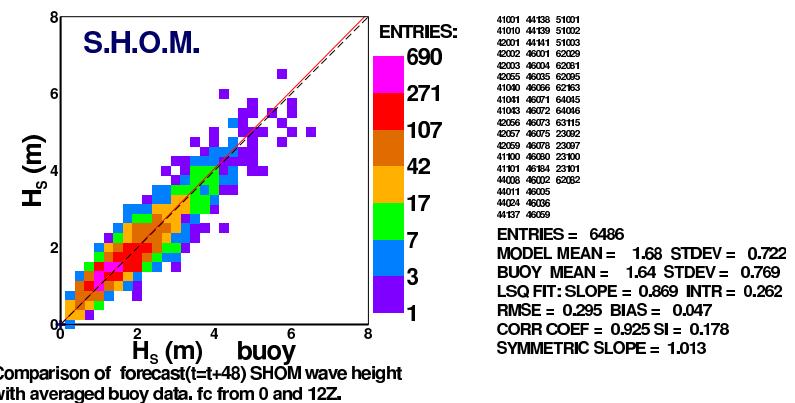
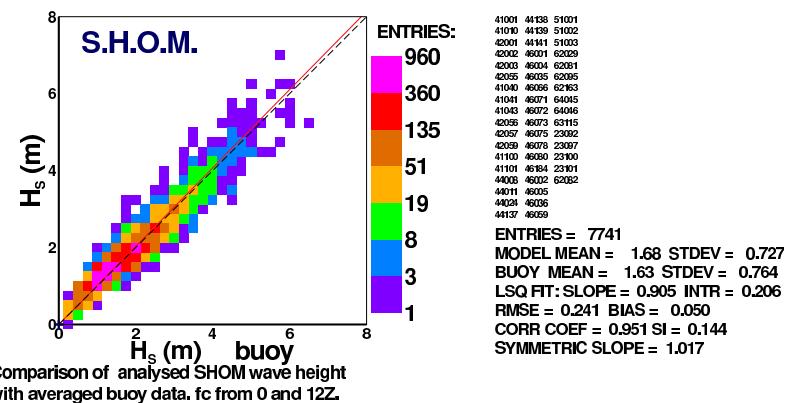
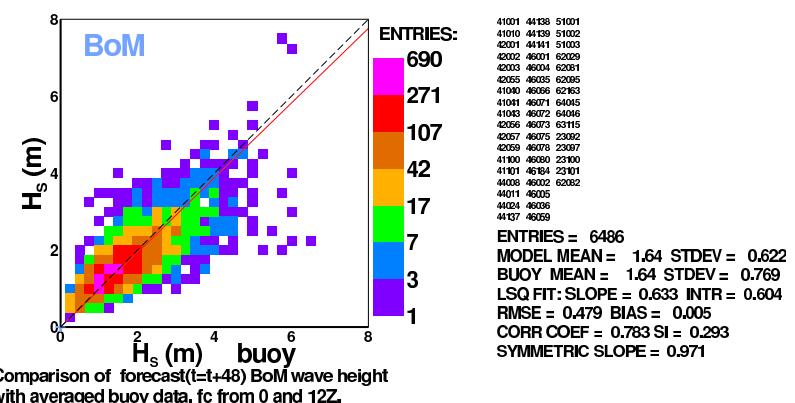
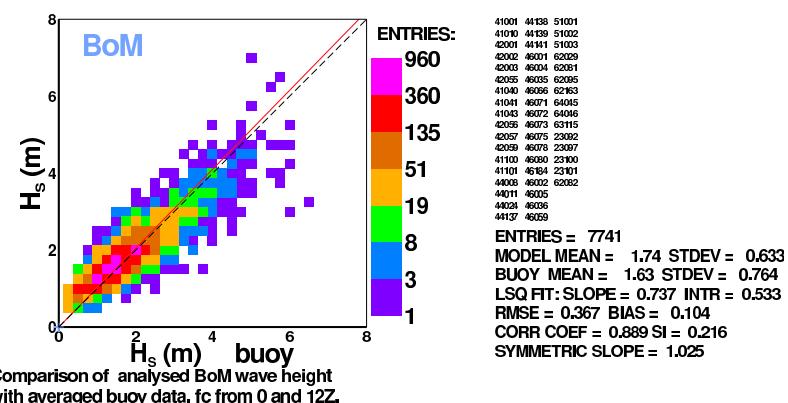
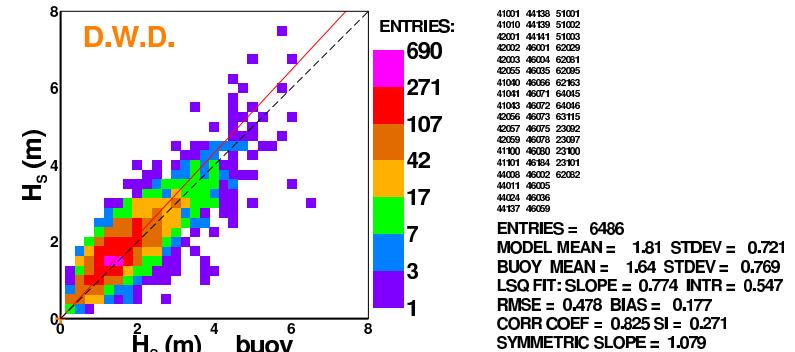
(b) $t=48$

Figure 5: Scatter diagrams for wave height at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



all buoys 0805 to 0807

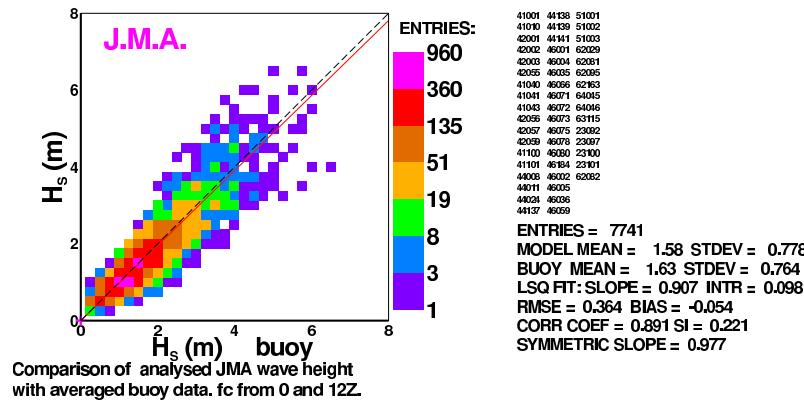


(a) $t+0$

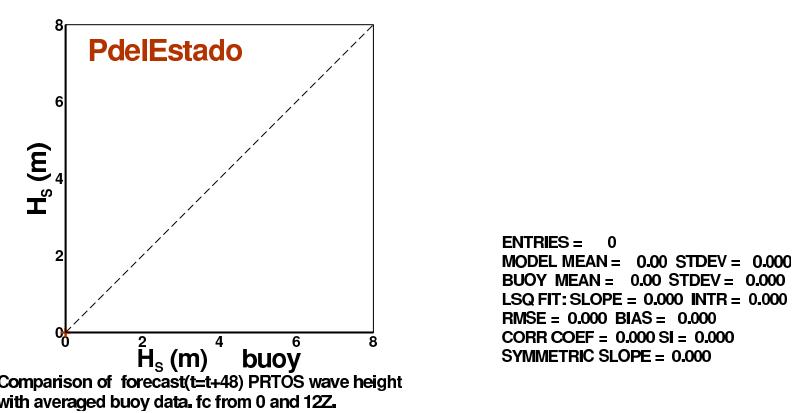
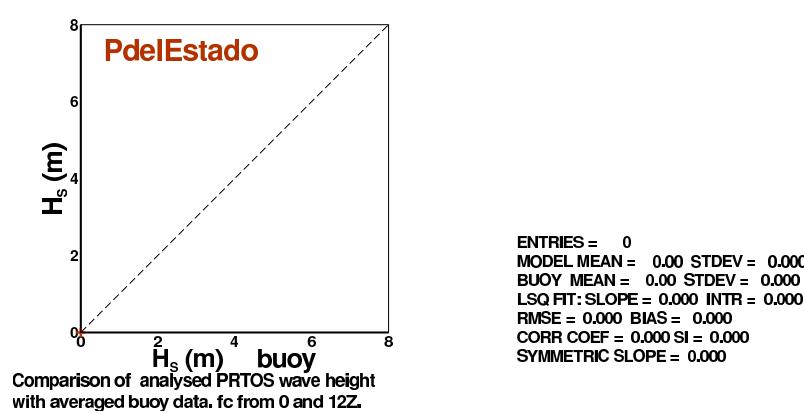
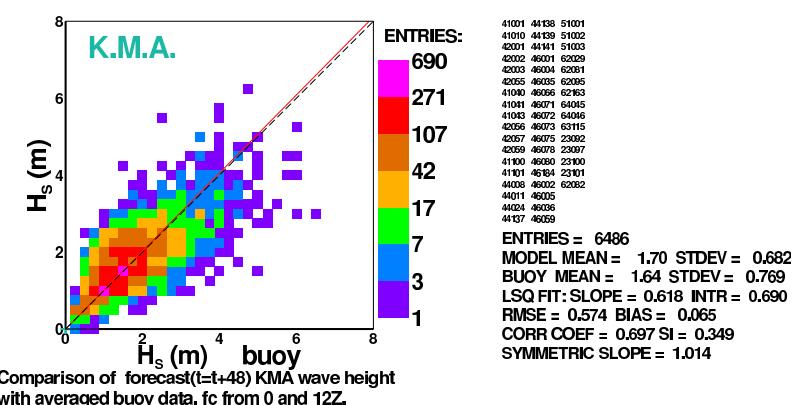
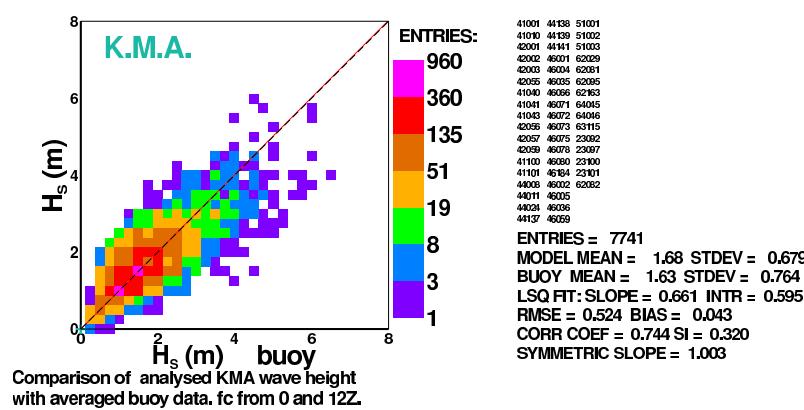
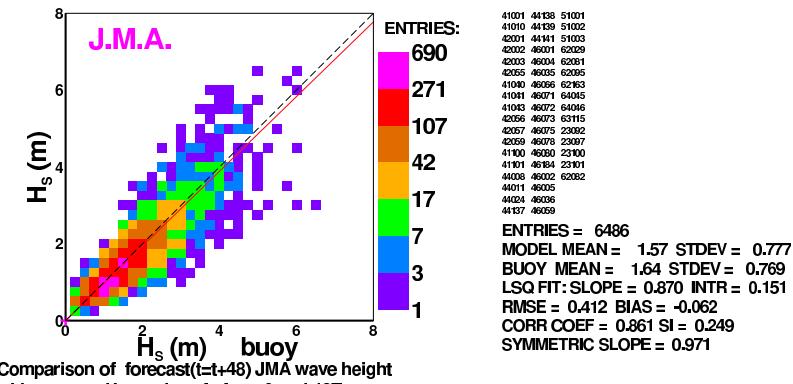
(b) $t+48$

Figure 6: Scatter diagrams for wave height at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



all buoys 0805 to 0807

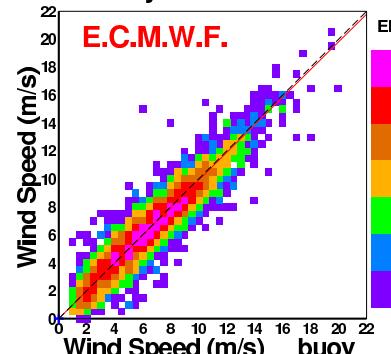


(a) $t=0$

(b) $t+48$

Figure 7: Scatter diagrams for wave height at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



41001 44138 46059 62082
41010 44139 51001
42001 44140 51002
42002 44141 51003
42003 44142 51004
42005 46001 62081
41040 46004 62085
41041 46033 62193
41043 46058 64045
42055 46071 64046
42057 46073 63115
42059 46073 23002
41100 46075 23007
41101 46093 23008
44008 46184 23101
44011 46052 23170
44024 46005 23172
44137 46036 23174

ENTRIES = 7412

MODEL MEAN = 6.43 STDEV = 2.749

BUOY MEAN = 6.49 STDEV = 2.768

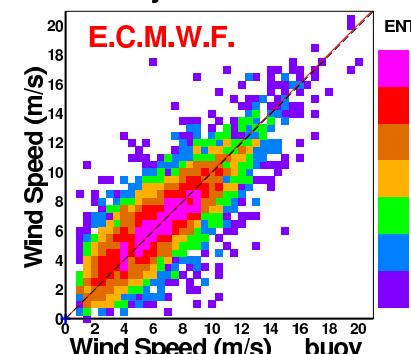
LSQ FIT: SLOPE = 0.936 INTR = 0.348

RMSE = 0.937 BIAS = -0.066

CORR COEF = 0.943 SI = 0.144

SYMMETRIC SLOPE = 0.990

all buoys 0805 to 0807



41001 44138 46059 62082
41010 44139 51001
42001 44140 51002
42002 44141 51003
42003 44142 51004
42005 46001 62081
41040 46004 62085
41041 46033 62193
41043 46058 64045
42055 46071 64046
42057 46073 63115
42059 46073 23002
41100 46075 23007
41101 46093 23008
44008 46184 23101
44011 46052 23170
44024 46005 23172
44137 46036 23174

ENTRIES = 6198

MODEL MEAN = 6.57 STDEV = 2.674

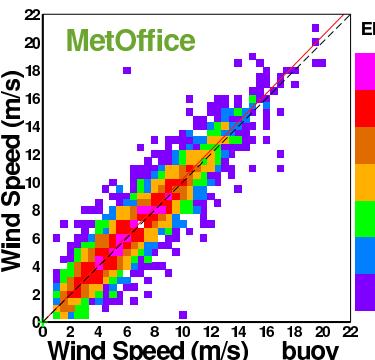
BUOY MEAN = 6.49 STDEV = 2.776

LSQ FIT: SLOPE = 0.783 INTR = 1.492

RMSE = 1.671 BIAS = 0.086

CORR COEF = 0.813 SI = 0.257

SYMMETRIC SLOPE = 1.006



41001 44138 46059 62082
41010 44139 51001
42001 44140 51002
42002 44141 51003
42003 44142 51004
42005 46001 62081
41040 46004 62085
41041 46033 62193
41043 46058 64045
42055 46071 64046
42057 46072 63115
42059 46073 23002
41100 46075 23007
41101 46093 23008
44008 46184 23101
44011 46052 23170
44024 46005 23172
44137 46036 23174

ENTRIES = 7412

MODEL MEAN = 6.62 STDEV = 2.873

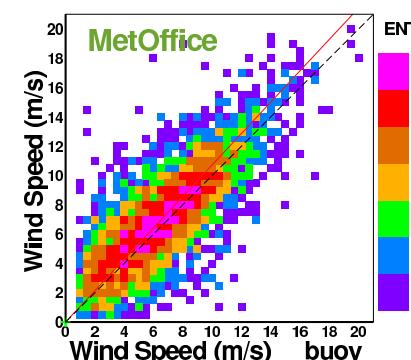
BUOY MEAN = 6.49 STDEV = 2.768

LSQ FIT: SLOPE = 0.970 INTR = 0.317

RMSE = 1.032 BIAS = 0.123

CORR COEF = 0.935 SI = 0.158

SYMMETRIC SLOPE = 1.022



41001 44138 46059 62082
41010 44139 51001
42001 44140 51002
42002 44141 51003
42003 44142 51004
42005 46001 62081
41040 46004 62085
41041 46033 62193
41043 46058 64045
42055 46071 64046
42057 46072 63115
42059 46073 23002
41100 46075 23007
41101 46093 23008
44008 46184 23101
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44024 46005 23172
44137 46036 23174

ENTRIES = 6198

MODEL MEAN = 6.98 STDEV = 2.896

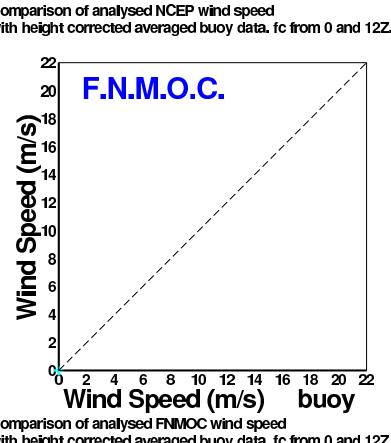
BUOY MEAN = 6.49 STDEV = 2.776

LSQ FIT: SLOPE = 0.829 INTR = 1.606

RMSE = 1.887 BIAS = 0.495

CORR COEF = 0.795 SI = 0.281

SYMMETRIC SLOPE = 1.071



ENTRIES = 0

MODEL MEAN = 0.00 STDEV = 0.000

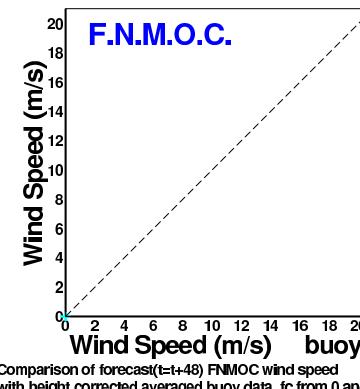
BUOY MEAN = 0.00 STDEV = 0.000

LSQ FIT: SLOPE = 0.000 INTR = 0.000

RMSE = 0.000 BIAS = 0.000

CORR COEF = 0.000 SI = 0.000

SYMMETRIC SLOPE = 0.000



ENTRIES = 0

MODEL MEAN = 0.00 STDEV = 0.000

BUOY MEAN = 0.00 STDEV = 0.000

LSQ FIT: SLOPE = 0.000 INTR = 0.000

RMSE = 0.000 BIAS = 0.000

CORR COEF = 0.000 SI = 0.000

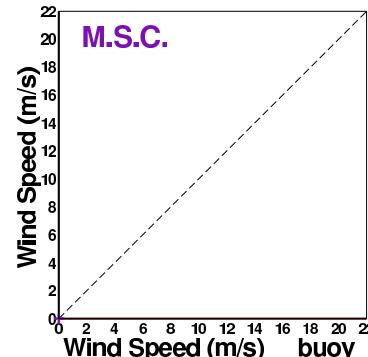
SYMMETRIC SLOPE = 0.000

(a) t+0

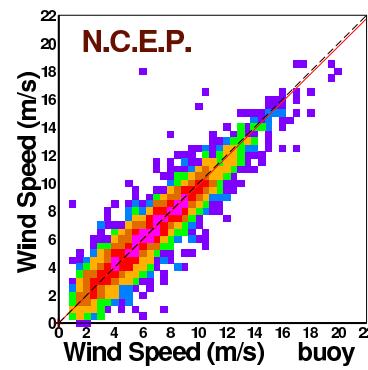
(b) t+48

Figure 8: Scatter diagrams for wind speed at step 0 and 48 for the displayed centres at all buoys.

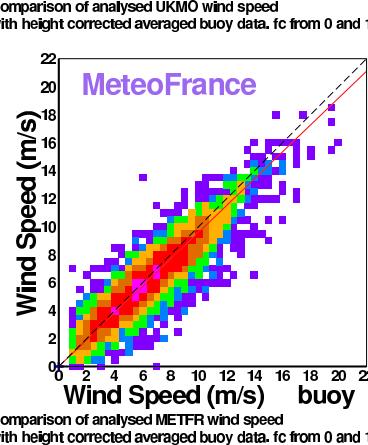
all buoys 0805 to 0807



ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



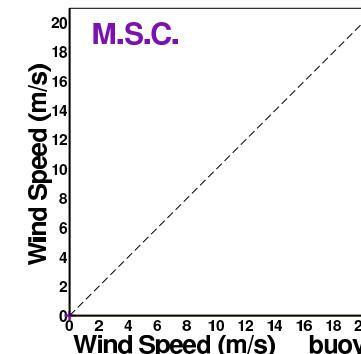
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42001 44139 51001
42001 44140 51002
42002 44141 51003
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42005 46001 62081
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42008 46003 62003
42009 46004 64045
42009 46071 64046
42057 46072 63115
42059 46073 23002
41100 46077 23007
41101 46080 23008
44003 46184 23101
44011 46002 23170
44024 46003 23172
44137 46036 23174
ENTRIES = 7412
MODEL MEAN = 6.44 STDEV = 2.699
BUOY MEAN = 6.49 STDEV = 2.768
LSQ FIT: SLOPE = 0.914 INTR = 0.513
RMSE = 0.975 BIAS = -0.048
CORR COEF = 0.937 SI = 0.150
SYMMETRIC SLOPE = 0.990



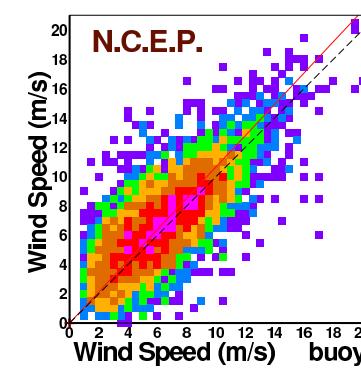
ENTRIES: 210
41001 41133 46059 62082
41019 44139 51001
42001 44140 51002
42002 44141 51003
42003 44150 62029
42004 46001 62085
42005 46002 62025
42006 46003 62003
42007 46004 64045
42009 46072 23002
41100 46075 23007
41101 46080 23008
44003 46184 23101
44011 46002 23170
44024 46003 23172
44137 46036 23174
ENTRIES = 7412
MODEL MEAN = 6.25 STDEV = 2.616
BUOY MEAN = 6.49 STDEV = 2.768
LSQ FIT: SLOPE = 0.855 INTR = 0.701
RMSE = 1.205 BIAS = -0.238
CORR COEF = 0.905 SI = 0.182
SYMMETRIC SLOPE = 0.961

(a) t+0

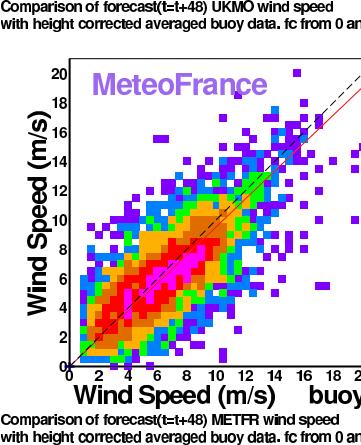
all buoys 0805 to 0807



ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



ENTRIES: 90
41001 44133 46059 62082
42001 44139 51001
42002 44141 51003
42003 44150 62029
42055 46001 62081
42056 46002 62005
41001 46003 62003
41003 46004 64045
42009 46071 64046
42057 46072 63115
41100 46073 23002
41101 46080 23008
44003 46184 23101
44011 46002 23170
44024 46003 23172
44137 46036 23174
ENTRIES = 6198
MODEL MEAN = 6.96 STDEV = 2.835
BUOY MEAN = 6.49 STDEV = 2.776
LSQ FIT: SLOPE = 0.763 INTR = 2.012
RMSE = 2.052 BIAS = 0.475
CORR COEF = 0.747 SI = 0.308
SYMMETRIC SLOPE = 1.065

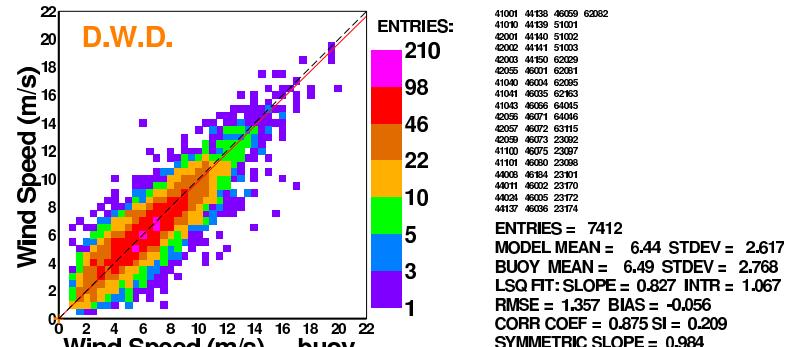


ENTRIES: 90
41001 44133 46059 62082
42001 44139 51001
42002 44141 51003
42003 44150 62029
42055 46001 62081
42056 46002 62005
41001 46003 62003
41003 46004 64045
42057 46071 64046
42059 46072 63115
42059 46073 23002
41100 46075 23007
41101 46080 23008
44003 46184 23101
44011 46002 23170
44024 46003 23172
44137 46036 23174
ENTRIES = 6198
MODEL MEAN = 6.20 STDEV = 2.627
BUOY MEAN = 6.49 STDEV = 2.776
LSQ FIT: SLOPE = 0.708 INTR = 1.605
RMSE = 1.944 BIAS = -0.289
CORR COEF = 0.748 SI = 0.296
SYMMETRIC SLOPE = 0.954

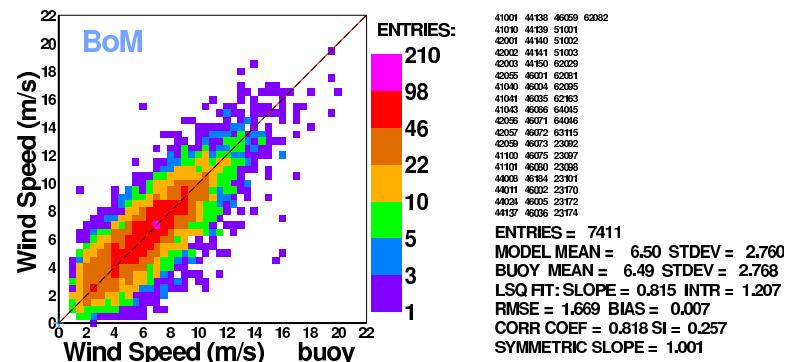
(b) t+48

Figure 9: Scatter diagrams for wind speed at step 0 and 48 for the displayed centres at all buoys.

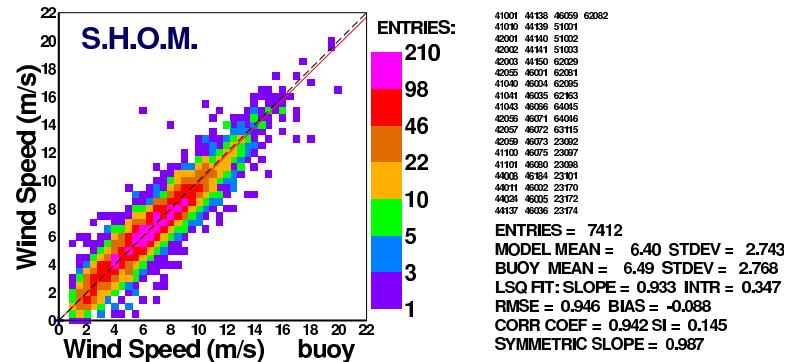
all buoys 0805 to 0807



Comparison of analysed DWD wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



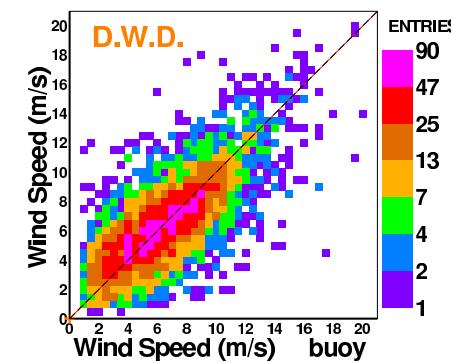
Comparison of analysed BoM wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



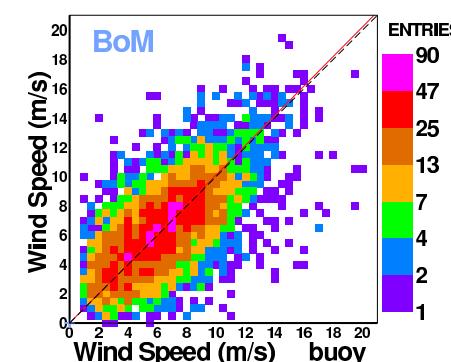
Comparison of analysed SHOM wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.

(a) t+0

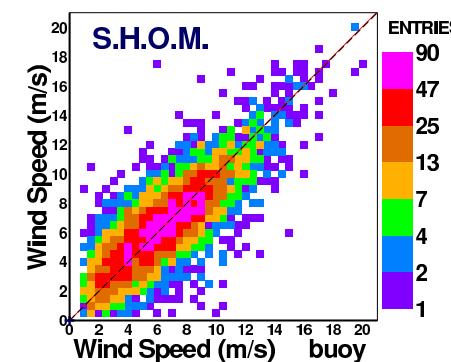
all buoys 0805 to 0807



Comparison of forecast(t=+48) DWD wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



Comparison of forecast(t=+48) BoM wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.

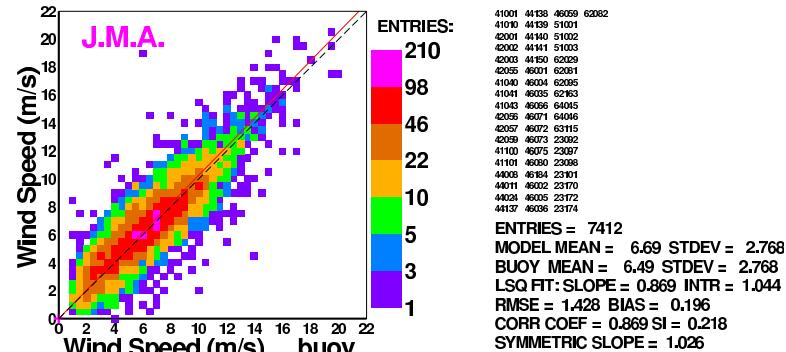


Comparison of forecast(t=+48) SHOM wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.

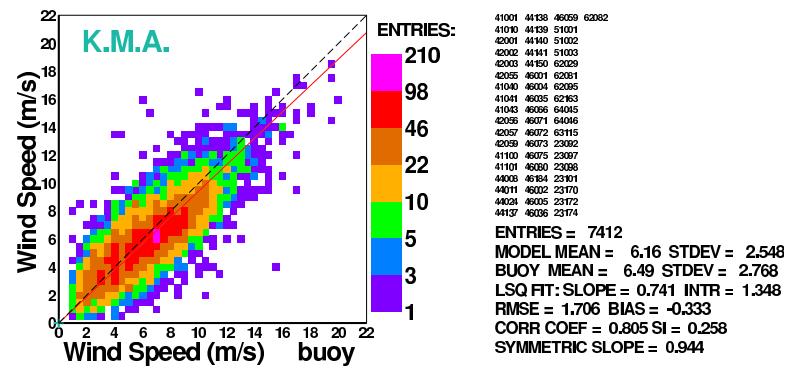
(b) t+48

Figure 10: Scatter diagrams for wind speed at step 0 and 48 for the displayed centres at all buoys.

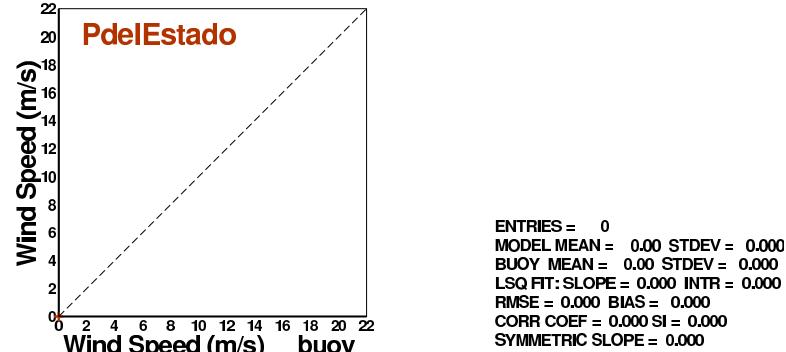
all buoys 0805 to 0807



Comparison of analysed JMA wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



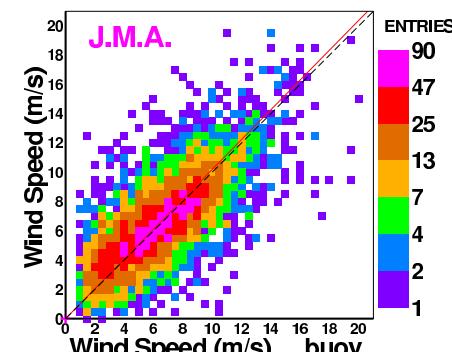
Comparison of analysed KMA wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



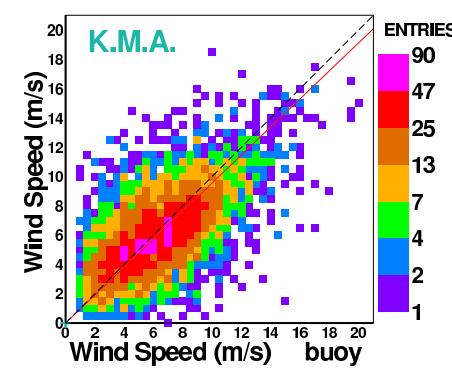
Comparison of analysed PRTOS wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.

(a) t+0

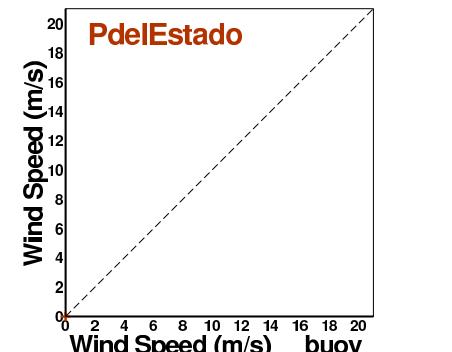
all buoys 0805 to 0807



Comparison of forecast(t-t+48) JMA wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.

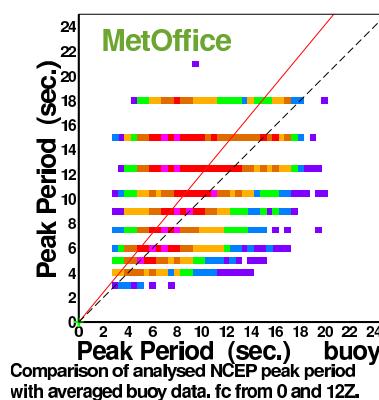
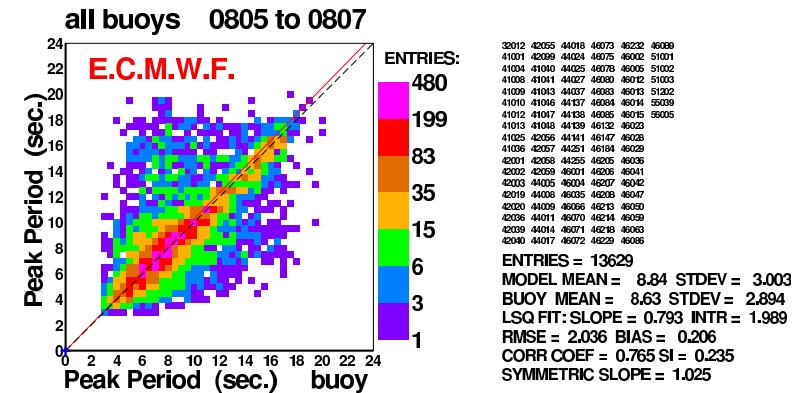
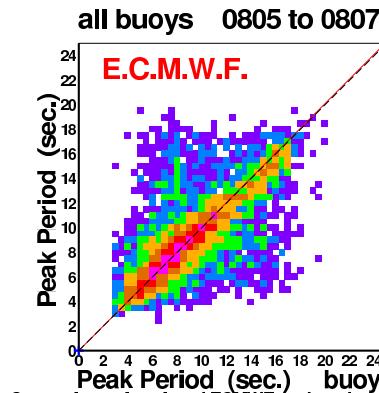


Comparison of forecast(t-t+48) KMA wind speed
with height corrected averaged buoy data. fc from 0 and 12Z.



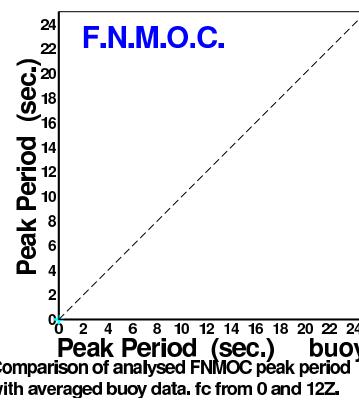
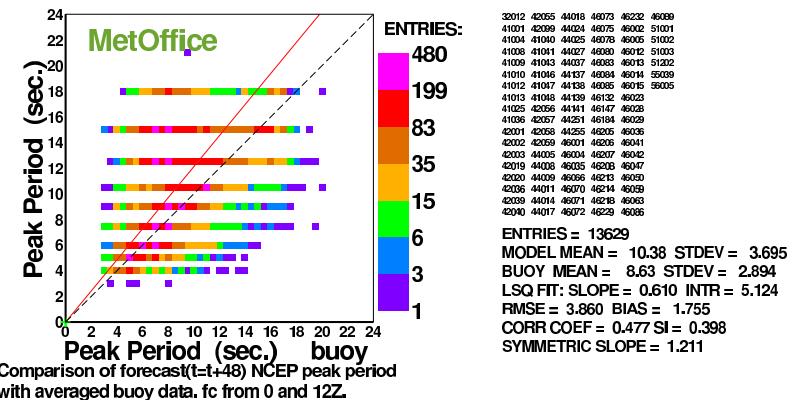
(b) t+48

Figure 11: Scatter diagrams for wind speed at step 0 and 48 for the displayed centres at all buoys.

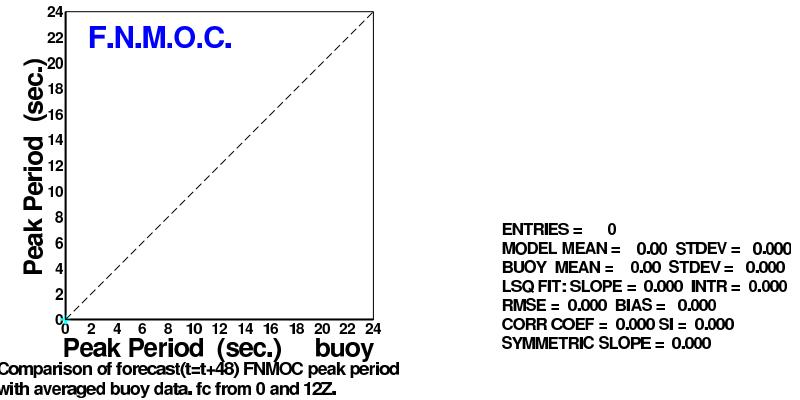


32012 42055 44018 46073 46232 46069
41001 42039 44024 46075 46002 51001
41004 41049 44025 46078 46005 51002
41008 41011 44027 46080 46012 51003
41009 41013 44027 46083 46013 51002
41010 41016 44037 46084 46014 55009
41012 41017 44038 46085 46015 55005
41013 41018 44139 46132 46023
41025 42056 44111 46147 46028
41035 42057 44251 46154 46029
42001 42058 44252 46155 46030
42002 42059 46001 46063 46031
42003 42060 46002 46064 46032
42005 44005 46004 46207 46042
42018 44039 46055 46208 46047
42023 44039 46070 46213 46059
42026 44039 46071 46218 46063
42033 44011 46070 46214 46059
42039 44014 46071 46218 46063
42040 44017 46072 46229 46066

ENTRIES = 16158
MODEL MEAN = 10.37 STDEV = 3.621
BUOY MEAN = 8.64 STDEV = 2.882
LSQ FIT: SLOPE = 0.595 INTR = 5.232
RMSE = 3.811 BIAS = 1.728
CORR COEF = 0.473 SI = 0.393
SYMMETRIC SLOPE = 1.206



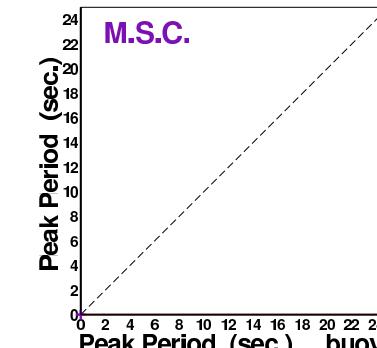
(a) t+0



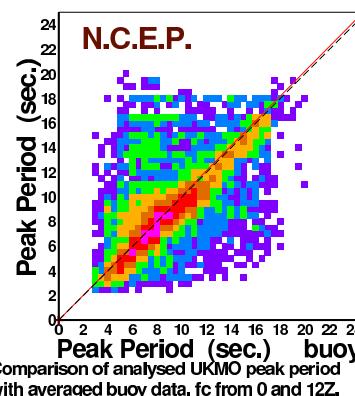
(b) t+48

Figure 12: Scatter diagrams for peak period at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



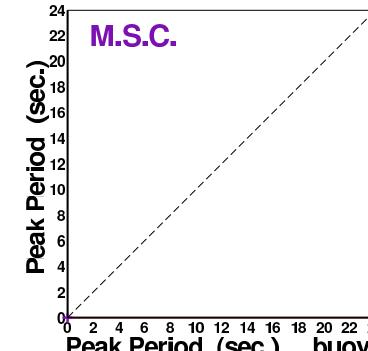
ENTRIES = 0
 MODEL MEAN = 0.00 STDEV = 0.000
 BUOY MEAN = 0.00 STDEV = 0.000
 LSQ FIT: SLOPE = 0.000 INTR = 0.000
 RMSE = 0.000 BIAS = 0.000
 CORR COEF = 0.000 SI = 0.000
 SYMMETRIC SLOPE = 0.000



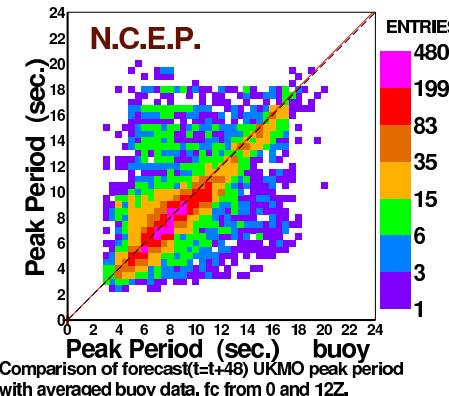
ENTRIES: 630
 251
 100
 40
 16
 7
 3
 1
 3012 4035 44018 46073 46232 46089
 41001 42099 44024 46075 46005 51001
 41004 41010 44025 46078 46005 51002
 41008 41011 44027 46080 46012 51003
 41009 41016 44027 46080 46013 51020
 41019 41016 44037 46084 46014 55039
 41020 41016 44038 46085 46015 55005
 41015 41016 44039 46102 46021 46005
 41025 42056 44111 46117 46023
 41035 42057 44251 46164 46029
 42001 42058 44255 46205 46036
 42002 42059 46001 46205 46041
 42003 42060 46002 46205 46042
 42008 44003 46205 46207 46047
 42020 44009 46056 46213 46059
 42005 44011 46070 46214 46059
 42038 44014 46071 46218 46063
 42040 44017 46072 46229 46065

ENTRIES = 16155
 MODEL MEAN = 8.68 STDEV = 3.085
 BUOY MEAN = 8.64 STDEV = 2.882
 LSQ FIT: SLOPE = 0.745 INTR = 2.238
 RMSE = 2.334 BIAS = 0.034
 CORR COEF = 0.696 SI = 0.270
 SYMMETRIC SLOPE = 1.011

all buoys 0805 to 0807

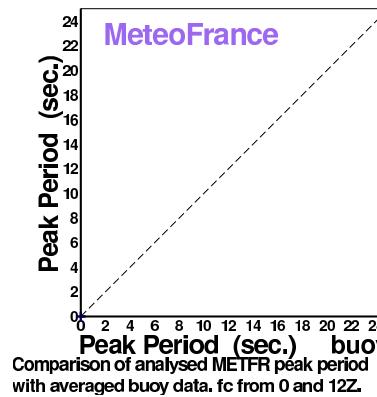


ENTRIES = 0
 MODEL MEAN = 0.00 STDEV = 0.000
 BUOY MEAN = 0.00 STDEV = 0.000
 LSQ FIT: SLOPE = 0.000 INTR = 0.000
 RMSE = 0.000 BIAS = 0.000
 CORR COEF = 0.000 SI = 0.000
 SYMMETRIC SLOPE = 0.000

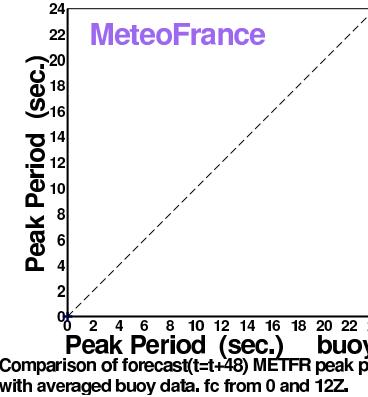


ENTRIES: 480
 199
 83
 35
 15
 6
 3
 1
 3012 40265 44016 46073 46232 46089
 41001 41009 44024 46075 46005 51001
 41004 41010 44025 46078 46005 51002
 41008 41011 44027 46080 46012 51003
 41009 41013 44037 46083 46013 51202
 41010 41016 44137 46084 46014 55039
 41011 41016 44138 46085 46015 55005
 41013 41016 44139 46132 46023
 41025 42056 44111 46117 46023
 41035 42057 44251 46164 46029
 42001 42058 44255 46205 46036
 42002 42059 46001 46205 46041
 42003 42060 46002 46205 46042
 42019 44008 46005 46205 46047
 42020 44009 46056 46213 46059
 42036 44011 46070 46214 46059
 42038 44014 46071 46218 46063
 42040 44017 46072 46229 46065

ENTRIES = 13628
 MODEL MEAN = 8.64 STDEV = 3.074
 BUOY MEAN = 8.63 STDEV = 2.894
 LSQ FIT: SLOPE = 0.722 INTR = 2.412
 RMSE = 2.394 BIAS = 0.014
 CORR COEF = 0.680 SI = 0.277
 SYMMETRIC SLOPE = 1.008



ENTRIES = 0
 MODEL MEAN = 0.00 STDEV = 0.000
 BUOY MEAN = 0.00 STDEV = 0.000
 LSQ FIT: SLOPE = 0.000 INTR = 0.000
 RMSE = 0.000 BIAS = 0.000
 CORR COEF = 0.000 SI = 0.000
 SYMMETRIC SLOPE = 0.000



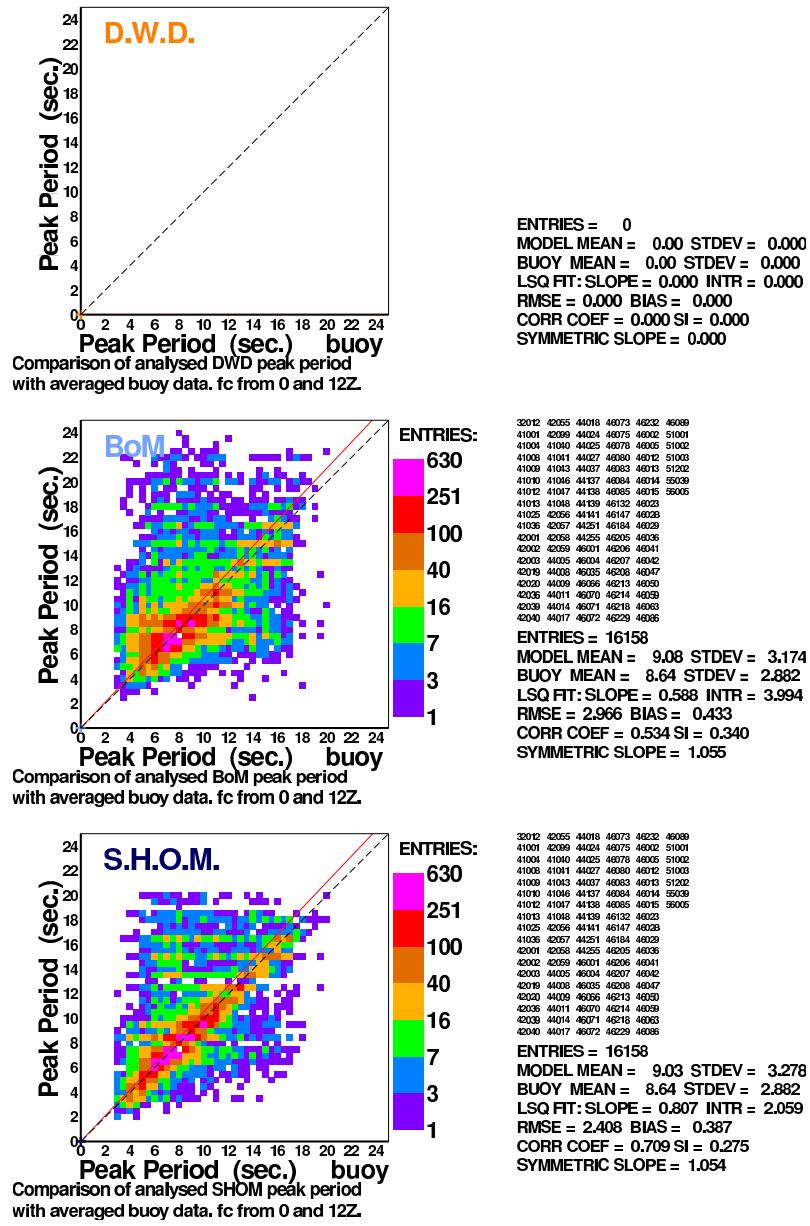
ENTRIES = 0
 MODEL MEAN = 0.00 STDEV = 0.000
 BUOY MEAN = 0.00 STDEV = 0.000
 LSQ FIT: SLOPE = 0.000 INTR = 0.000
 RMSE = 0.000 BIAS = 0.000
 CORR COEF = 0.000 SI = 0.000
 SYMMETRIC SLOPE = 0.000

(a) t+0

(b) t+48

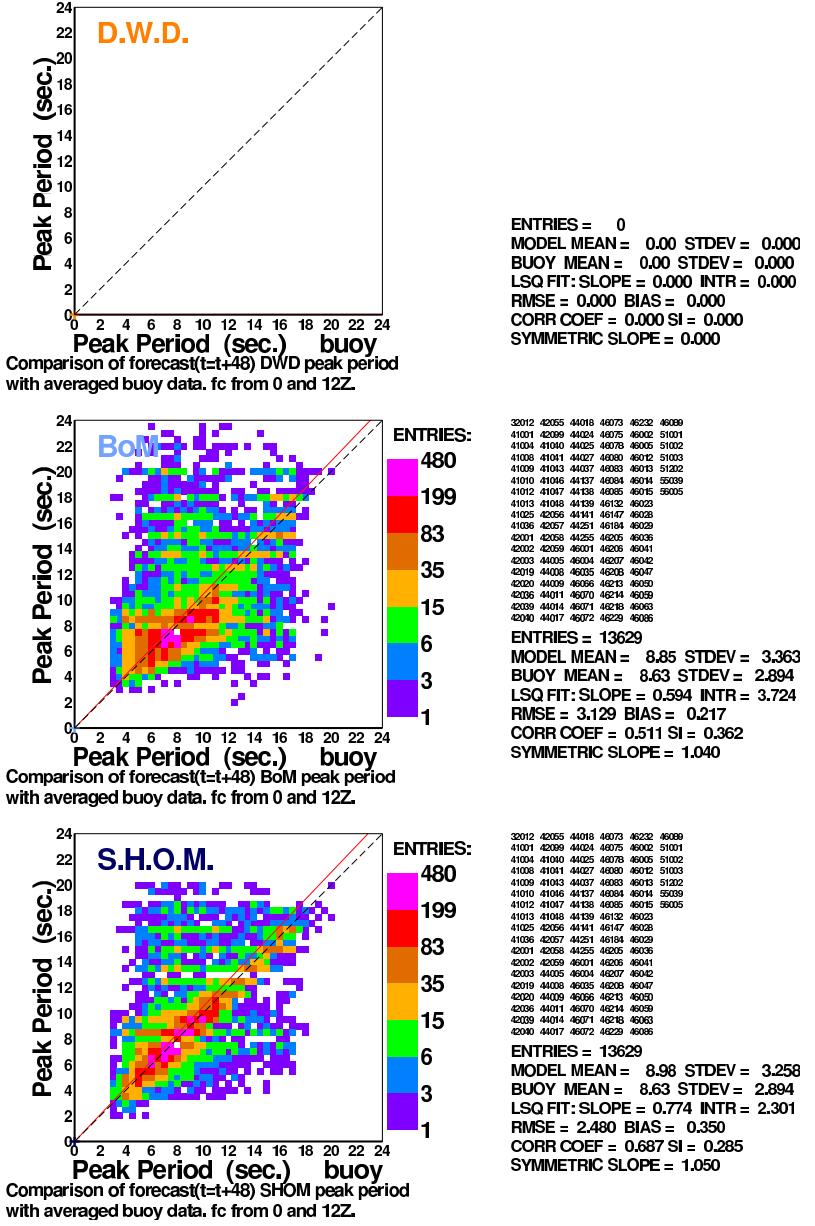
Figure 13: Scatter diagrams for peak period at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807



(a) t+0

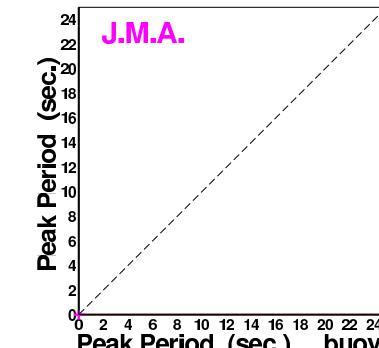
all buoys 0805 to 0807



(b) t+48

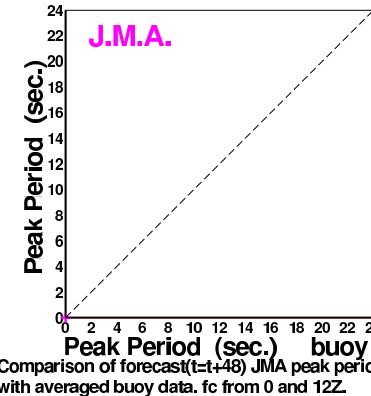
Figure 14: Scatter diagrams for peak period at step 0 and 48 for the displayed centres at all buoys.

all buoys 0805 to 0807

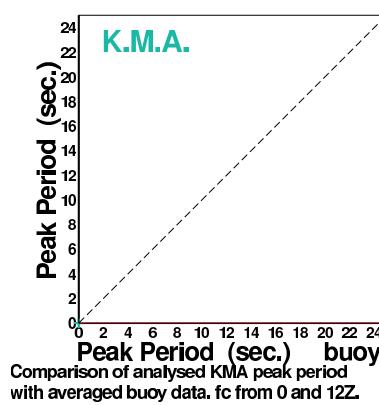


ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000

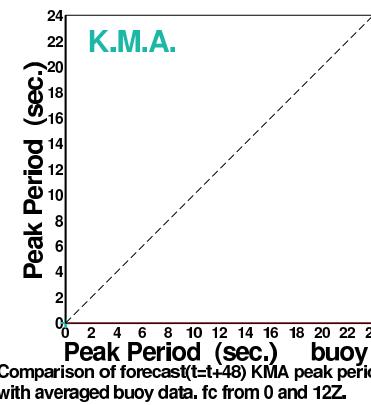
all buoys 0805 to 0807



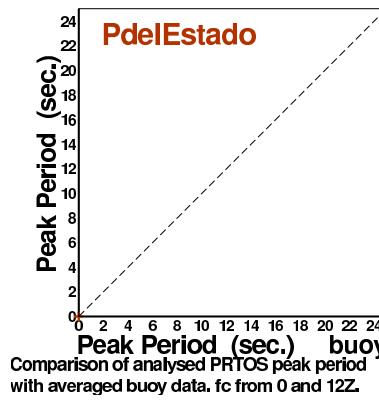
ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



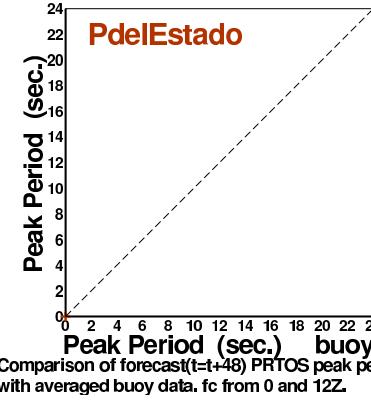
ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000



ENTRIES = 0
MODEL MEAN = 0.00 STDEV = 0.000
BUOY MEAN = 0.00 STDEV = 0.000
LSQ FIT: SLOPE = 0.000 INTR = 0.000
RMSE = 0.000 BIAS = 0.000
CORR COEF = 0.000 SI = 0.000
SYMMETRIC SLOPE = 0.000

(a) t+0

(b) t+48

Figure 15: Scatter diagrams for peak period at step 0 and 48 for the displayed centres at all buoys.

0.3.2 Comparison for Hawaiian buoys

Number of common observations for Hawaiian buoys (HW) from 200805 to 200807 (wind, Hs, Tp)

| | | | | | | | | | | | |
|----------|-------|-----|-----|-----|-------------------|----------|-------|-----|-----|-----|-----------------------------------|
| 1 | 51001 | 177 | 177 | 182 | Hawaii North West | 3 | 51003 | 176 | 176 | 182 | Hawaii West |
| 2 | 51002 | 176 | 176 | 181 | Hawaii South West | 4 | 51202 | 0 | 0 | 182 | Hawaii Mokapu Point (scripps 098) |

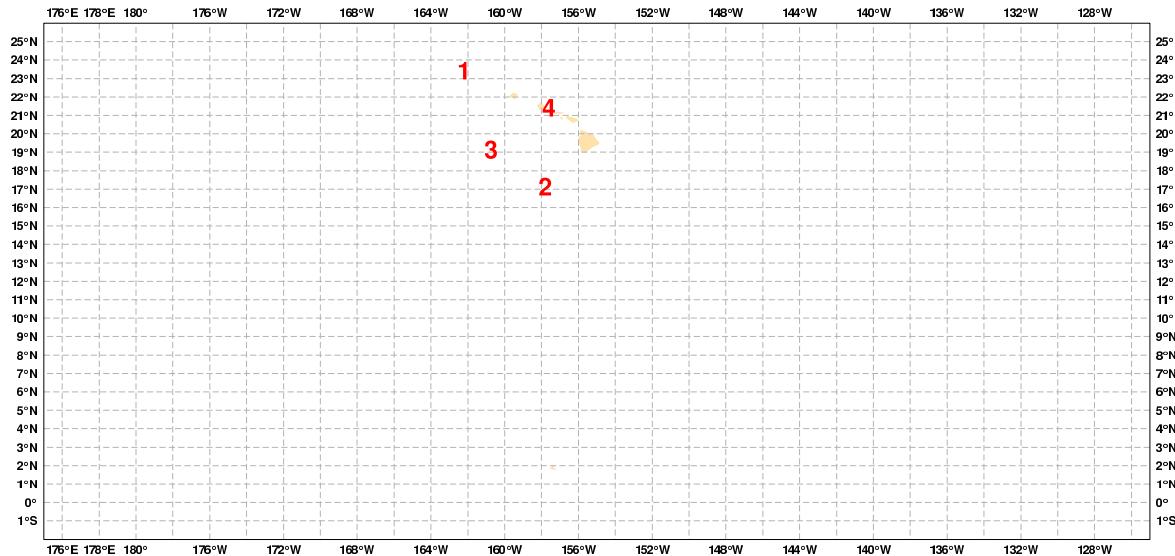


Figure 16: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

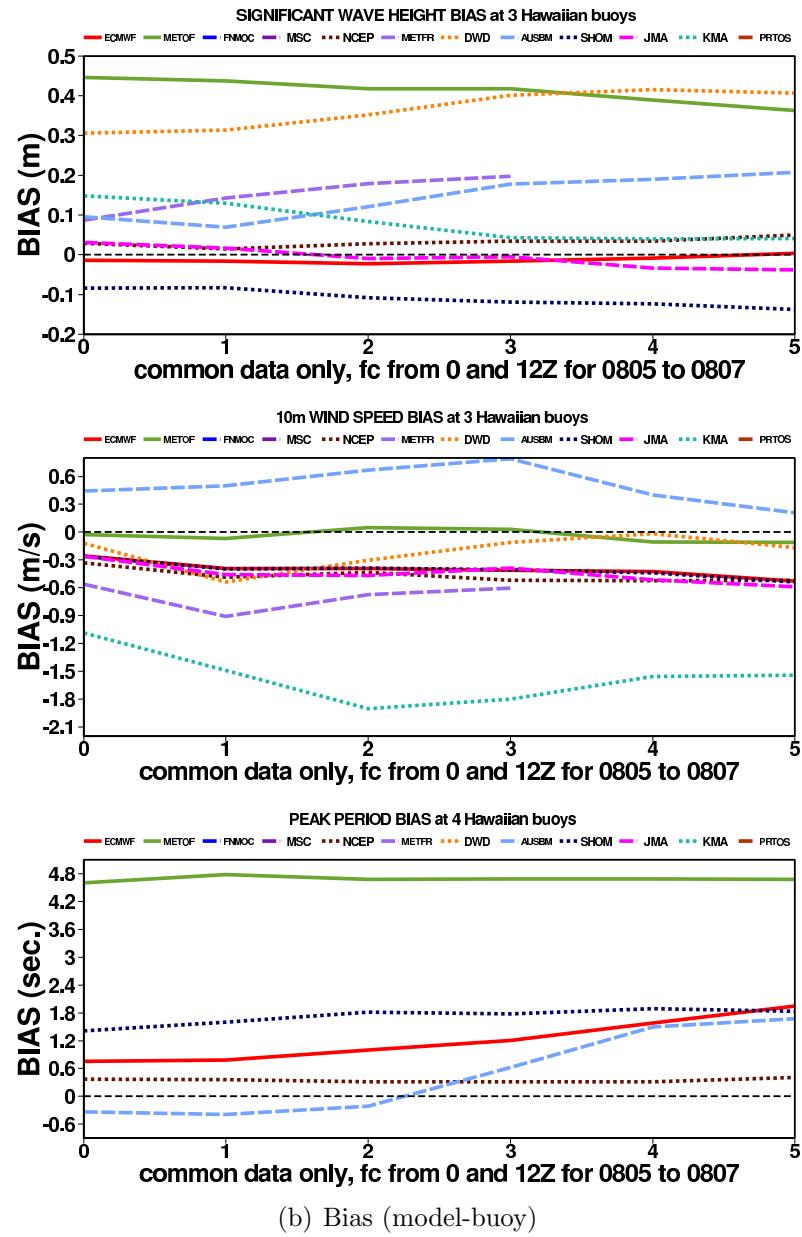
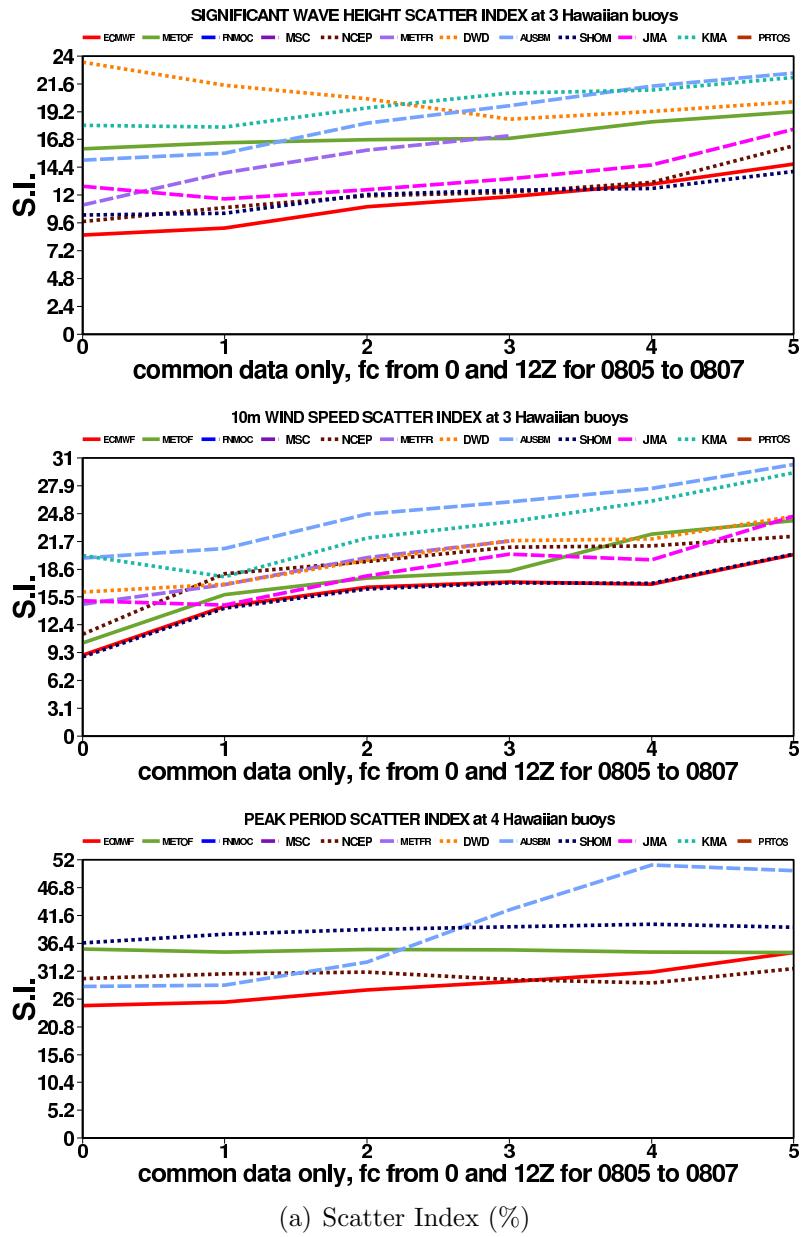
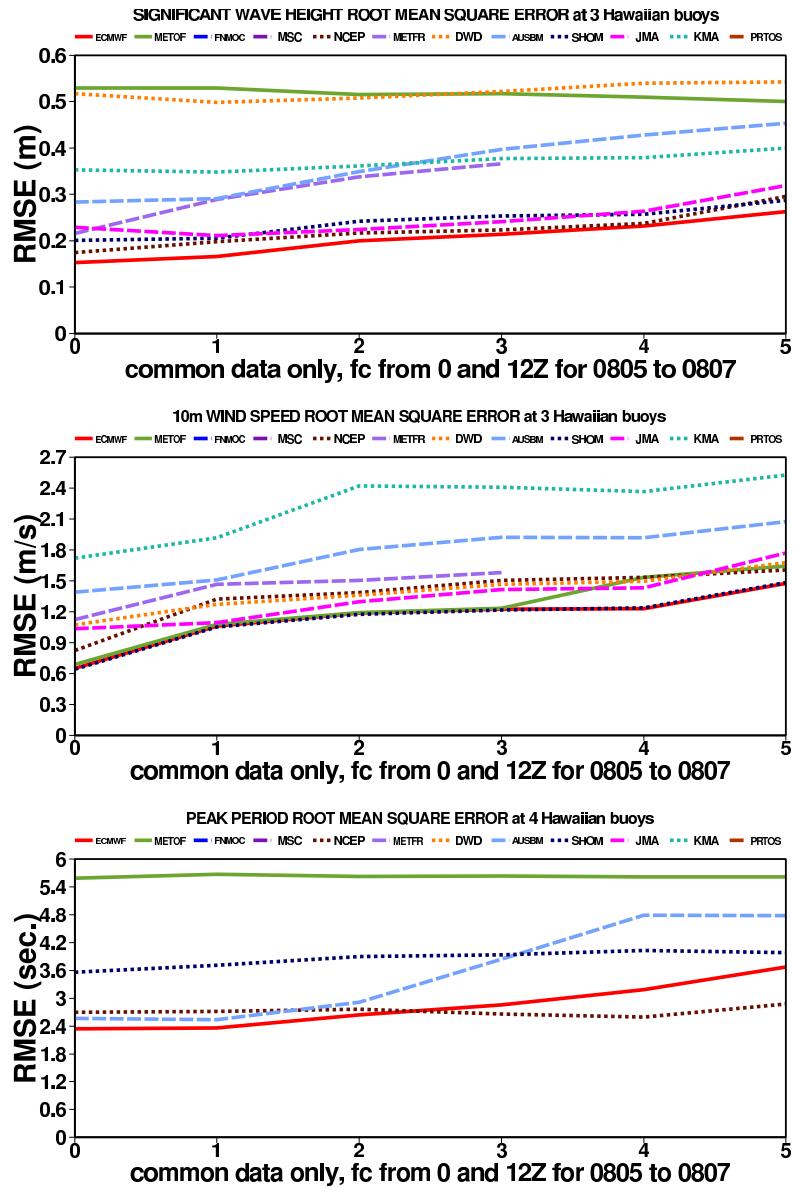
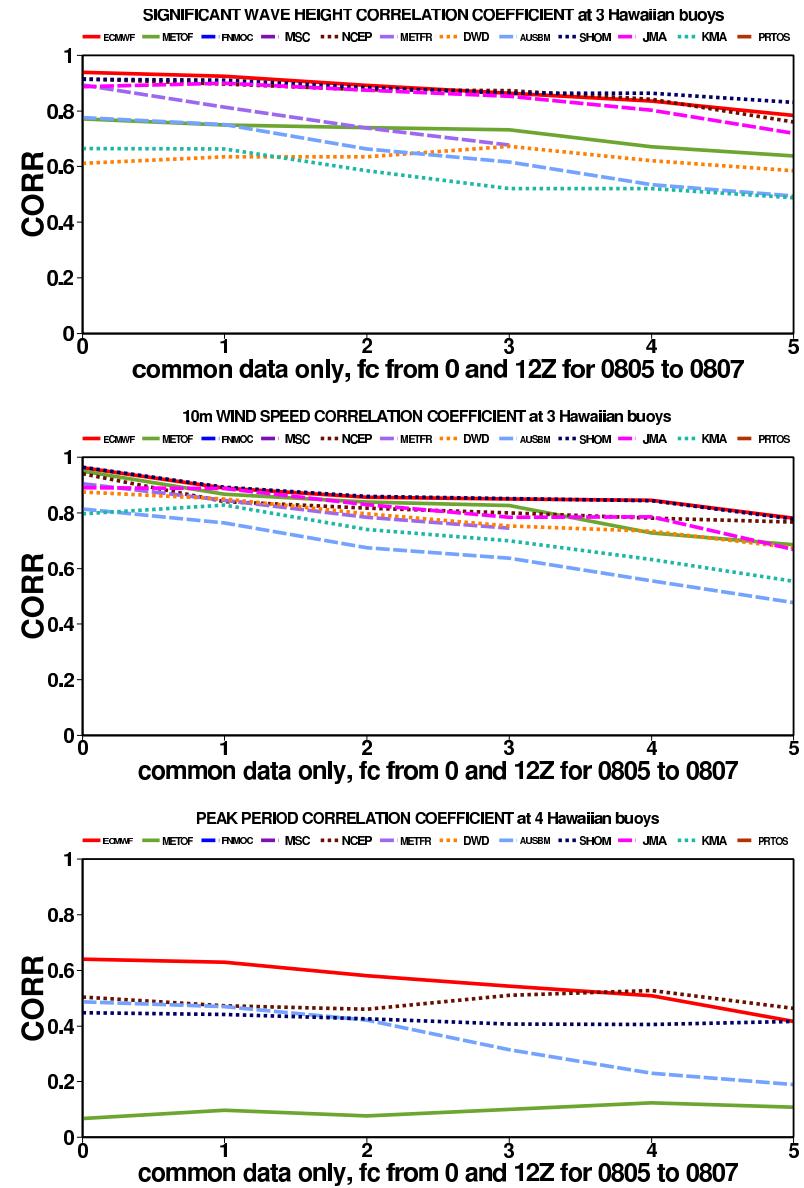


Figure 17: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common Hawaiian buoys.



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 18: Forecast root mean square error (RMSE) and linear correlation coefficient at common Hawaiian buoys.

0.3.3 Comparison for North Pacific buoys

Number of common observations for North Pacific buoys (NPC) from 200805 to 200807 (wind, Hs,Tp)

| | | | | | | | | | | | |
|-----------|-------|-----|-----|-----|----------------------------------|-----------|-------|-----|-----|-----|--------------------------------------|
| 1 | 46001 | 180 | 180 | 182 | Gulf of Alaska | 12 | 46083 | 0 | 0 | 182 | Gulf of Alaska, Fairweather Grounds |
| 2 | 46004 | 175 | 177 | 181 | Canada West Coast, Middle Nomad | 13 | 46084 | 0 | 0 | 180 | Gulf of Alaska, Cape Edgecumbe |
| 3 | 46035 | 180 | 179 | 181 | Bering Sea | 14 | 46085 | 0 | 0 | 179 | Central Gulf of Alaska |
| 4 | 46066 | 180 | 180 | 182 | Gulf of Alaska, S Aleutians | 15 | 46132 | 0 | 0 | 182 | Canada West Coast, South Brooks |
| 5 | 46070 | 0 | 0 | 177 | Southwest Bering Sea | 16 | 46147 | 0 | 0 | 171 | Canada West Coast, South Moresby |
| 6 | 46071 | 103 | 103 | 105 | North Pacific, Western Aleutians | 17 | 46184 | 177 | 177 | 180 | Canada West Coast, North Nomad |
| 7 | 46072 | 71 | 180 | 182 | North Pacific, Central Aleutians | 18 | 46205 | 0 | 0 | 179 | Canada West Coast, W. Dixon Entrance |
| 8 | 46073 | 180 | 178 | 180 | Southeast Bering Sea | 19 | 46206 | 0 | 0 | 95 | Canada West Coast, La Perouse Bank |
| 9 | 46075 | 2 | 178 | 180 | North Pacific, Shumagin Islands | 20 | 46207 | 0 | 0 | 182 | Canada West Coast, East Dellwood |
| 10 | 46078 | 0 | 180 | 182 | Gulf of Alaska, Albatross Banks | 21 | 46208 | 0 | 0 | 180 | Canada West Coast, West Moresby |
| 11 | 46080 | 7 | 7 | 7 | Gulf of Alaska, Kennedy Entrance | | | | | | |

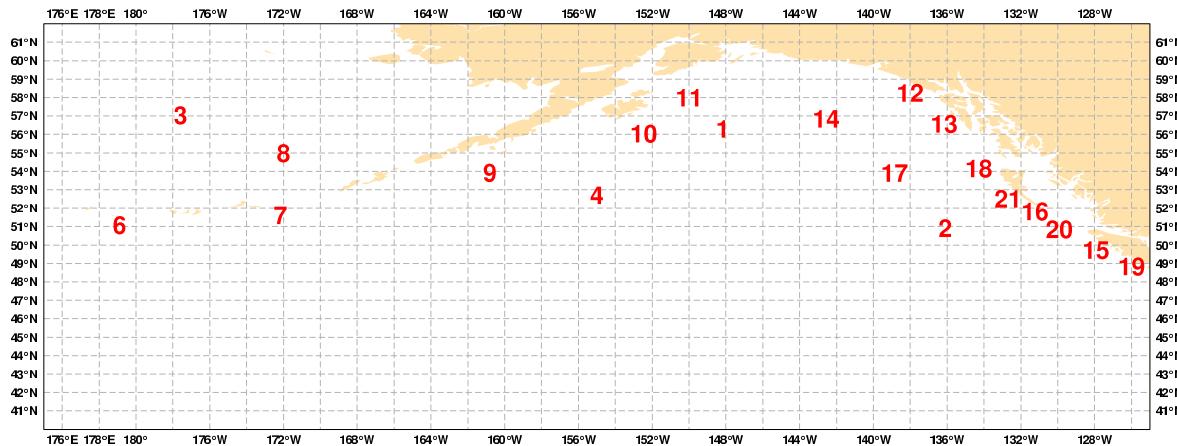
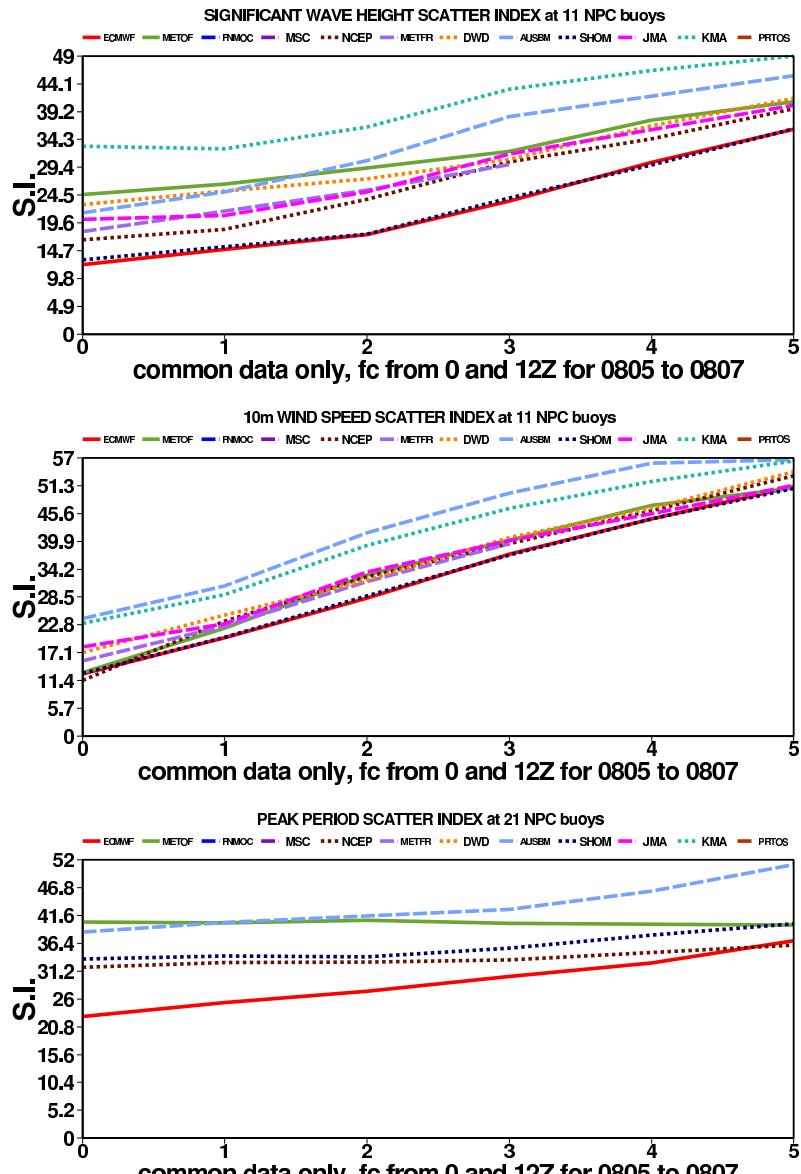
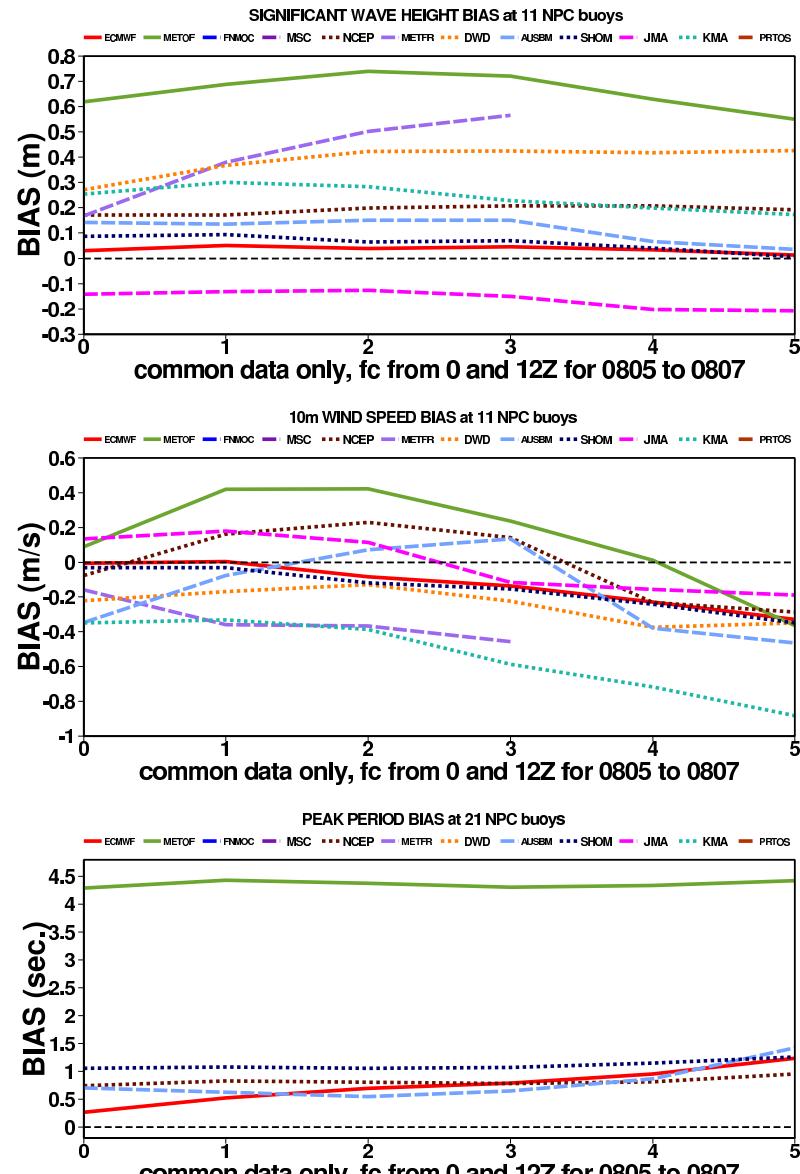


Figure 19: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

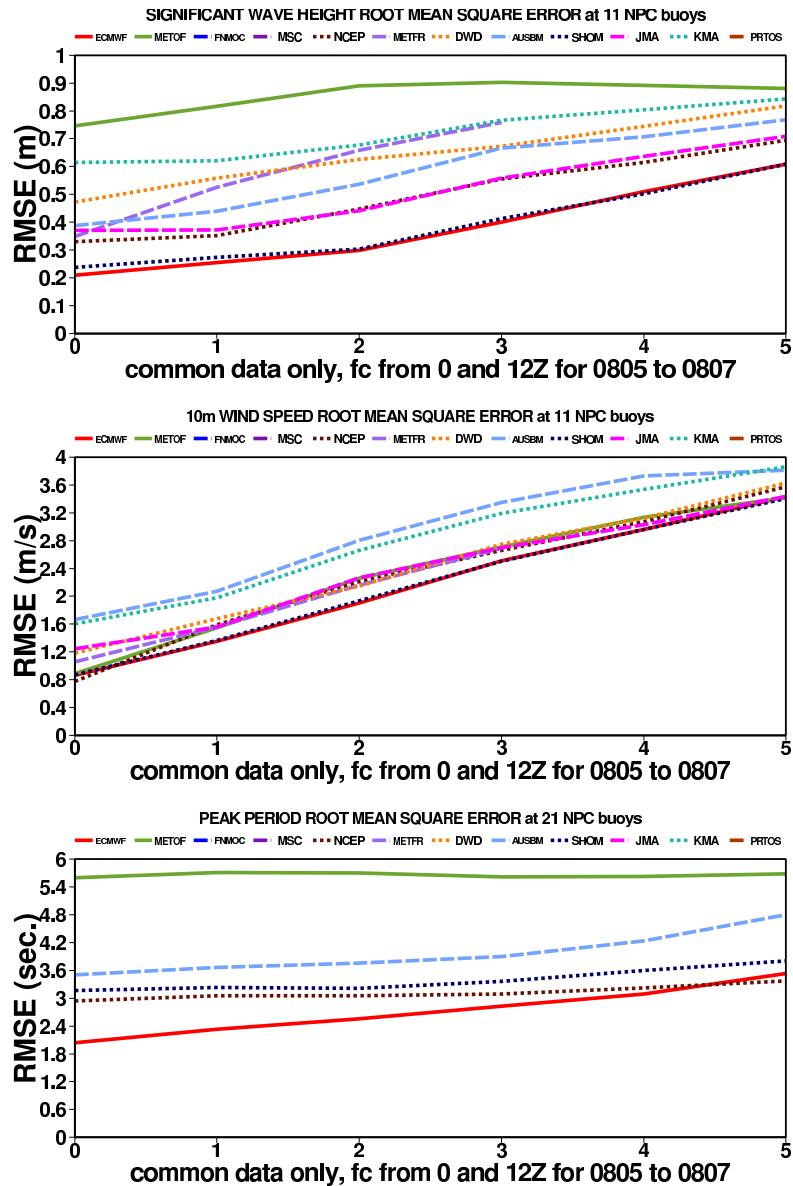


(a) Scatter Index (%)

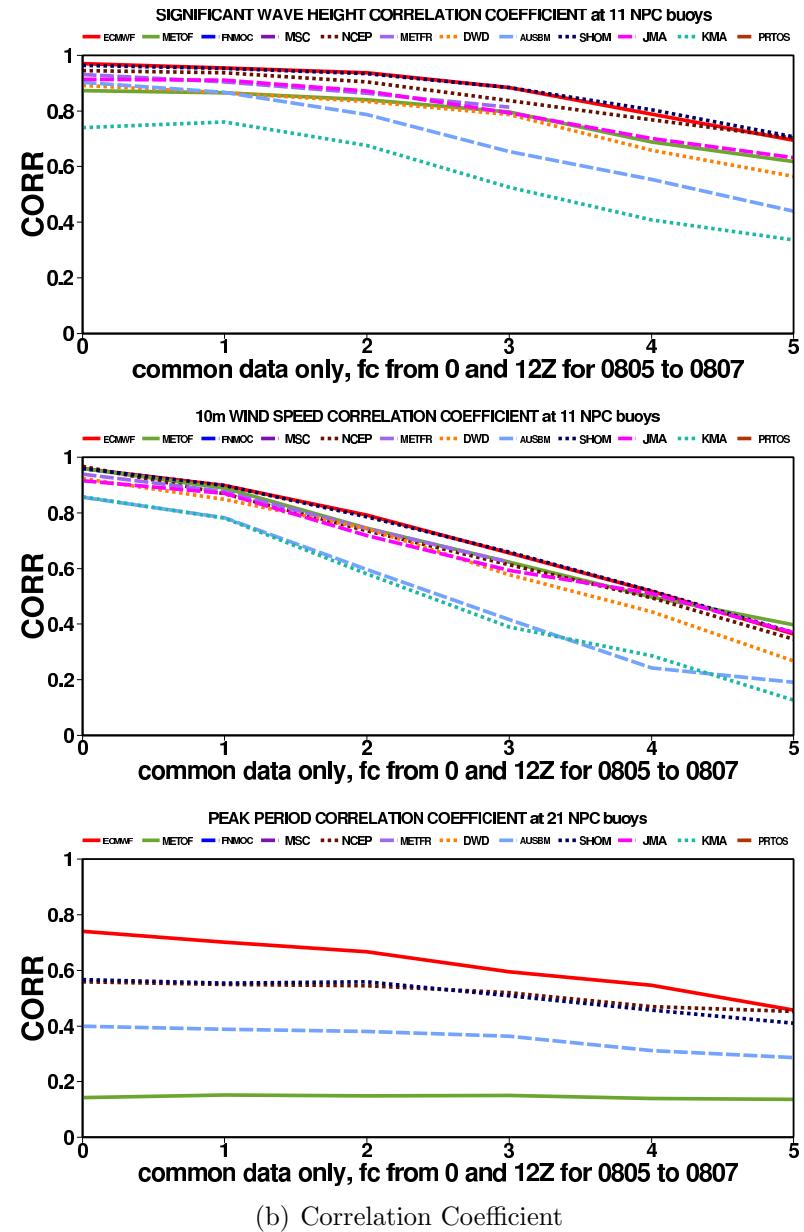


(b) Bias (model-buoy)

Figure 20: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common North Pacific buoys .



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 21: Forecast root mean square error (RMSE) and linear correlation coefficient at common North Pacific buoys .

0.3.4 Comparison for US West Coast buoys

Number of common observations for US West Coast buoys (USWC) from 200805 to 200807 (wind, Hs, Tp)

| | | | | | | | | | | | |
|-----------|-------|-----|-----|-----|-------------------------------------|-----------|-------|-----|-----|-----|--|
| 1 | 46002 | 134 | 135 | 135 | US West Coast, Oregon | 13 | 46047 | 0 | 0 | 182 | US South-West Coast, Tanner Banks |
| 2 | 46005 | 75 | 74 | 74 | US North-West Coast, W Astoria | 14 | 46050 | 0 | 0 | 182 | US West Coast, Yaquina Bay |
| 3 | 46012 | 0 | 0 | 182 | US South-West Coast, Half Moon Bay | 15 | 46059 | 176 | 176 | 182 | US West Coast, California |
| 4 | 46013 | 0 | 0 | 182 | US South-West Coast, Bodega | 16 | 46063 | 0 | 0 | 182 | US West Coast, Pt Conception |
| 5 | 46014 | 0 | 0 | 181 | US South-West Coast, Point Arena | 17 | 46086 | 0 | 0 | 41 | US South-West Coast, San Clemente Basin |
| 6 | 46015 | 0 | 0 | 175 | US West Coast, Port Orford | 18 | 46089 | 0 | 0 | 68 | US West Coast, Tillamook, OR |
| 7 | 46023 | 0 | 0 | 182 | US South-West Coast, Point Arguello | 19 | 46213 | 0 | 0 | 180 | US South-West Coast, Cape Mendocino (scripps 094) |
| 8 | 46028 | 0 | 0 | 181 | US South-West Coast, Cape St Martin | 20 | 46214 | 0 | 0 | 182 | US South-West Coast, Point Reyes (scripps 029) |
| 9 | 46029 | 0 | 0 | 182 | US West Coast, Columbia River Bar | 21 | 46218 | 0 | 0 | 182 | US South-West Coast, Harvest (scripps 071) |
| 10 | 46036 | 179 | 180 | 181 | Canada West Coast, South Nomad | 22 | 46229 | 0 | 0 | 182 | US West Coast, Coos Bay (scripps 126) |
| 11 | 46041 | 0 | 0 | 182 | US North-West Coast, Cape Elisabeth | 23 | 46232 | 0 | 0 | 181 | US South-West Coast, Coronado Islands MX (scripps 133) |
| 12 | 46042 | 0 | 0 | 158 | US South-West Coast, Monterey | | | | | | |

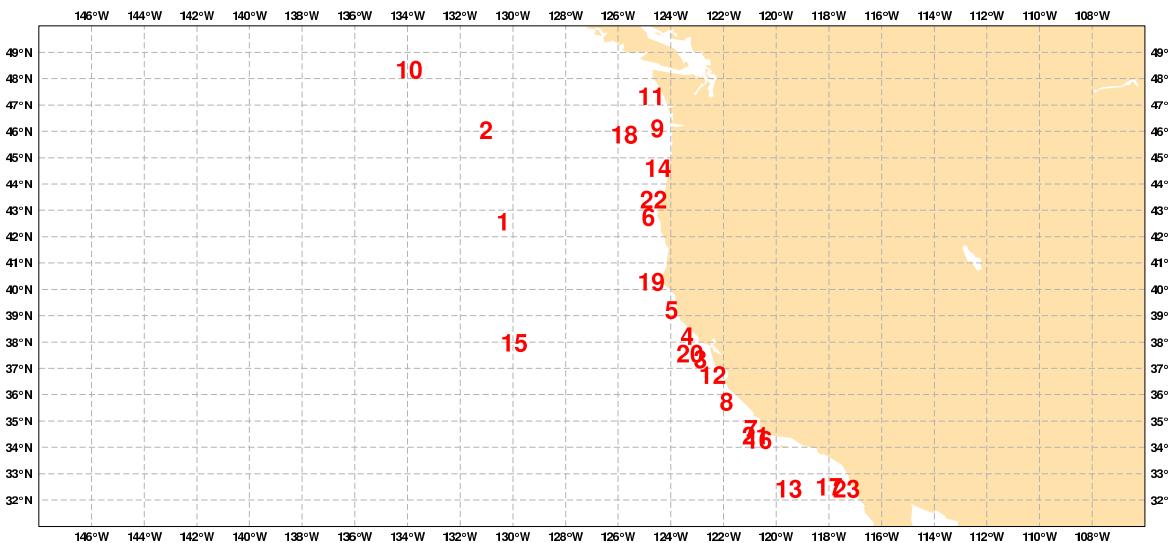


Figure 22: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

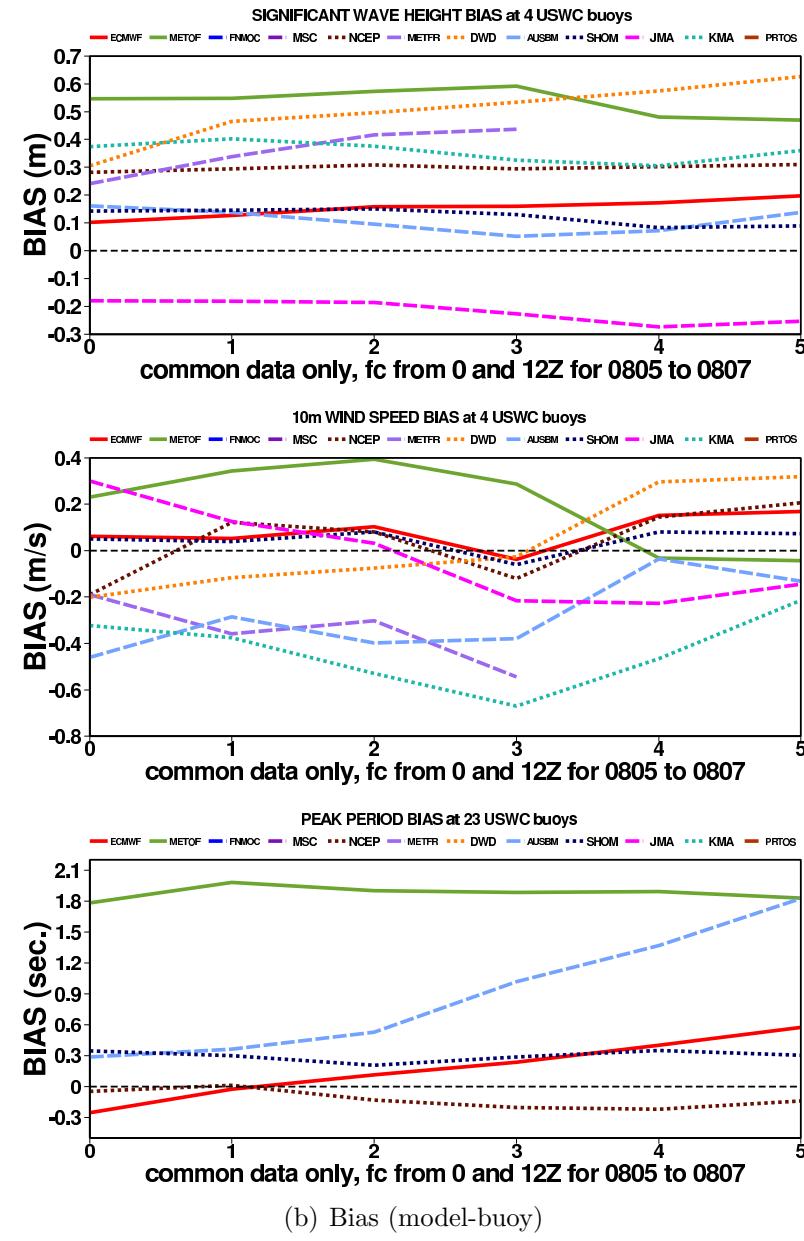
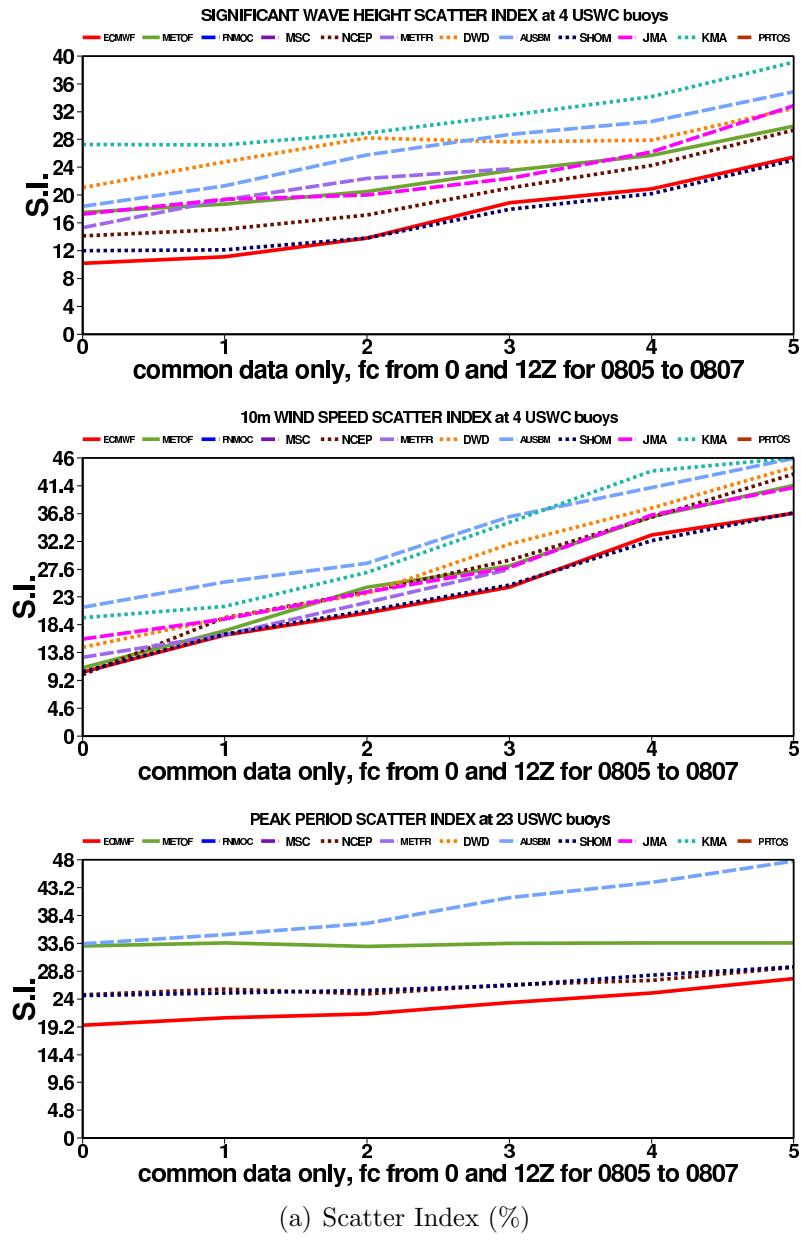
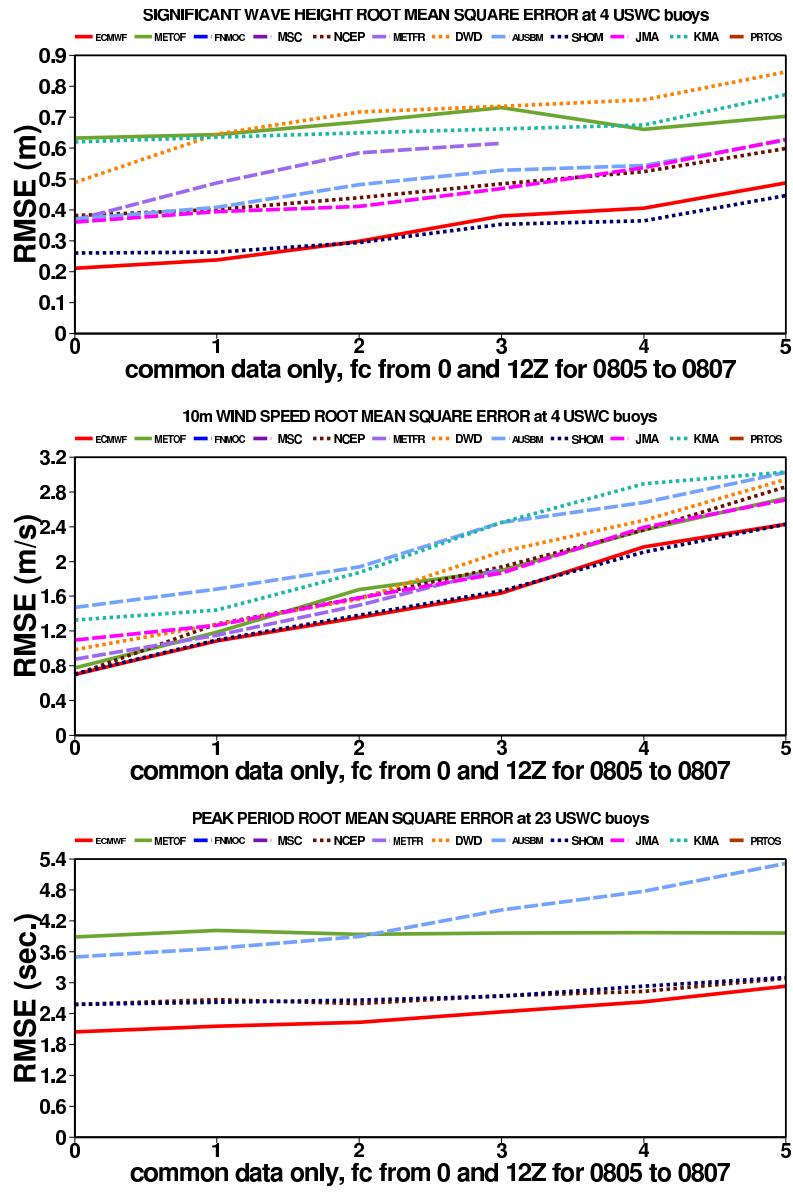
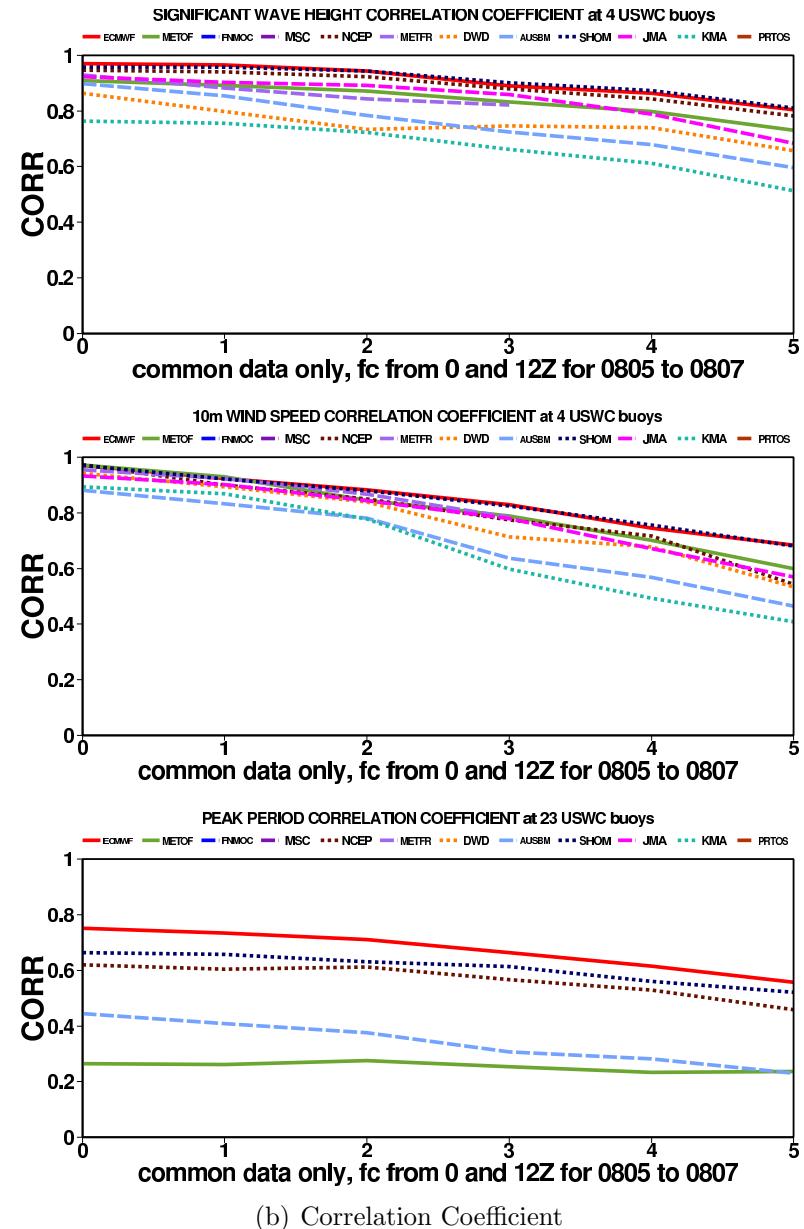


Figure 23: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common US West Coast buoys .



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 24: Forecast root mean square error (RMSE) and linear correlation coefficient at common US West Coast buoys .

0.3.5 Comparison for US East Coast buoys

Number of common observations for US East Coast buoys (USEC) from 200805 to 200807 (wind, Hs, Tp)

| | | | | | | | | | | | |
|-----------|-------|-----|-----|-----|--|-----------|-------|-----|-----|-----|--|
| 1 | 41001 | 71 | 71 | 75 | US East Coast, E Hatteras | 12 | 44006 | 168 | 180 | 182 | US North-East Coast, Nantucket |
| 2 | 41004 | 0 | 0 | 178 | US South-East Coast, Edisto | 13 | 44009 | 0 | 0 | 182 | US North-East Coast, Delaware bay |
| 3 | 41008 | 0 | 0 | 181 | US South-East Coast, Grays reef | 14 | 44011 | 177 | 178 | 181 | US North-East Coast, Georges Bank |
| 4 | 41009 | 0 | 0 | 148 | US East Florida , Cape Canaveral | 15 | 44014 | 0 | 0 | 120 | US East Coast, Virginia Beach |
| 5 | 41010 | 173 | 171 | 174 | US East Florida , Cape Canaveral East | 16 | 44017 | 0 | 0 | 181 | US North-East Coast, Momauk Point |
| 6 | 41012 | 0 | 0 | 125 | US East Florida , St Augustine | 17 | 44018 | 0 | 0 | 182 | US North-East Coast, SE Cape Cod |
| 7 | 41013 | 0 | 0 | 182 | US South-East Coast , Frying Pan Shoals | 18 | 44024 | 178 | 178 | 182 | US North East Coast, Northeast Channel |
| 8 | 41025 | 0 | 0 | 182 | US East Coast, Diamond Shoals (Red Buoy) | 19 | 44025 | 0 | 0 | 182 | US North East Coast, Long Island |
| 9 | 41036 | 0 | 0 | 182 | US East Coast, Onslow Bay offshore | 20 | 44027 | 0 | 0 | 177 | US North East Coast, Jonesport |
| 10 | 41048 | 0 | 0 | 178 | W Bermuda | 21 | 44037 | 0 | 0 | 181 | US North East Coast, Jordan Basin |
| 11 | 44005 | 0 | 0 | 16 | US North East Coast, Gulf of Maine | | | | | | |

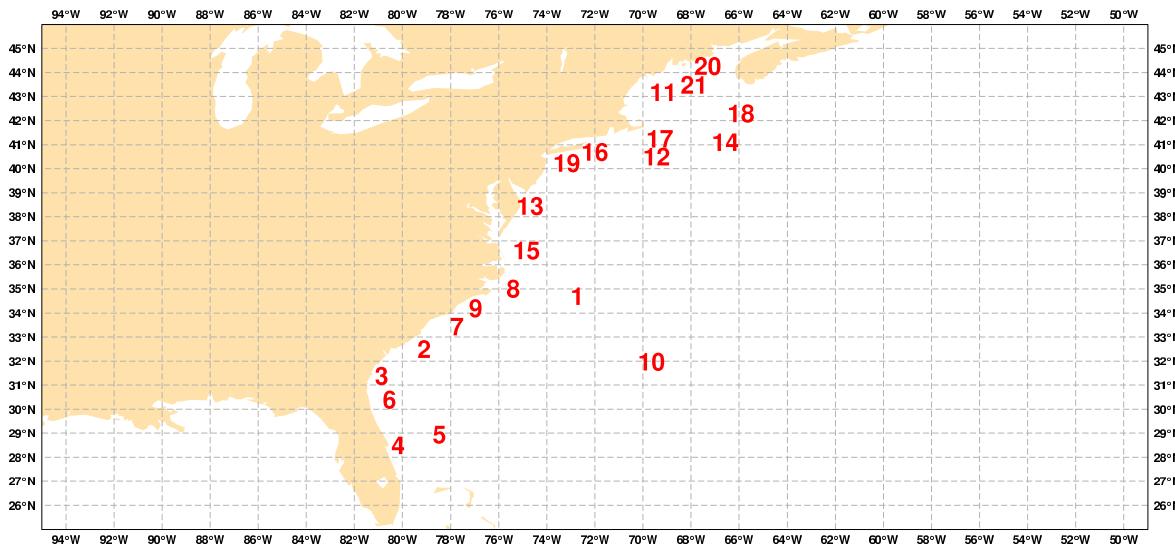
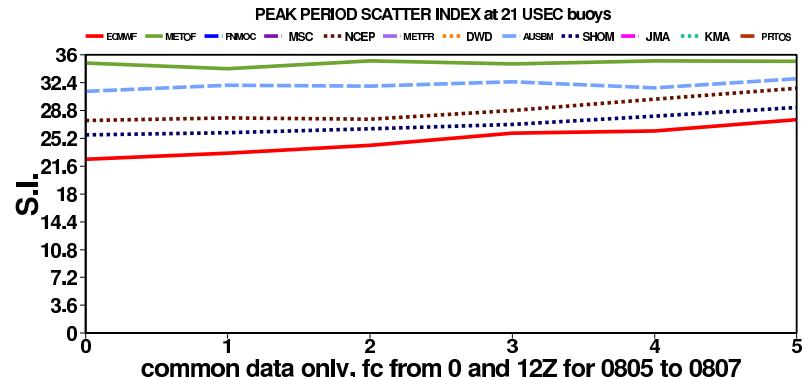
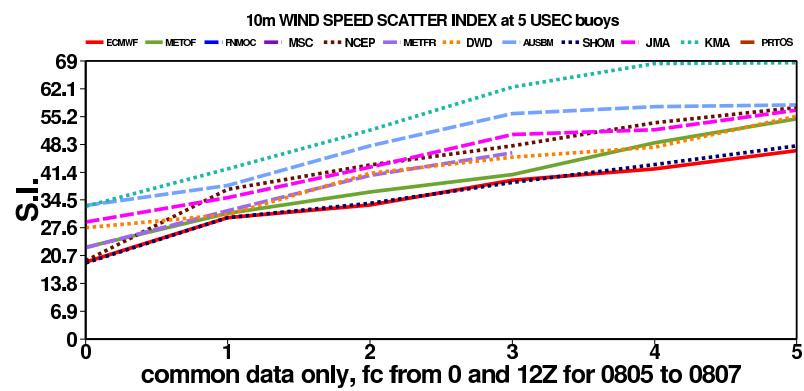
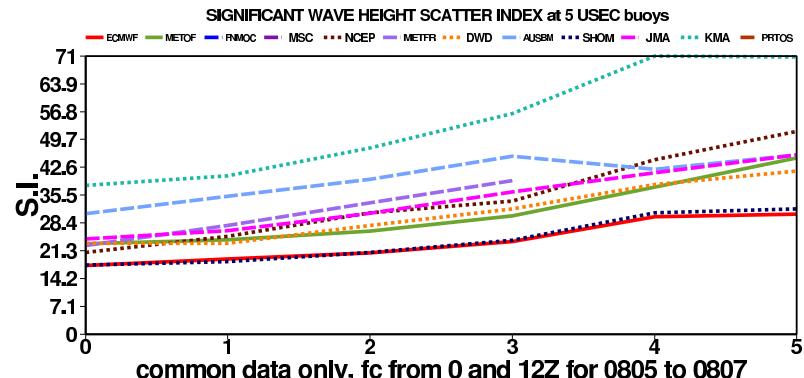
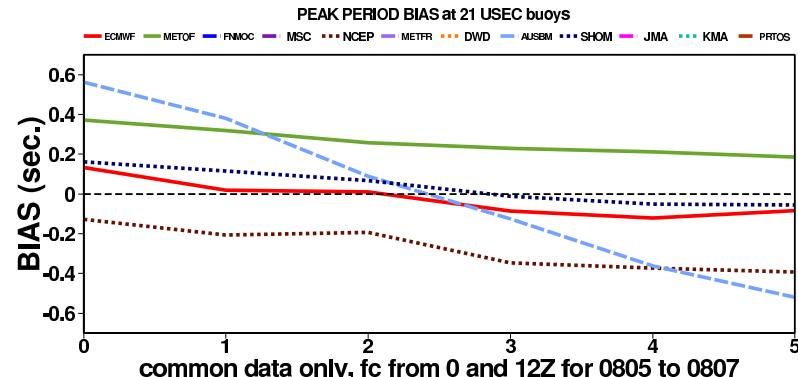
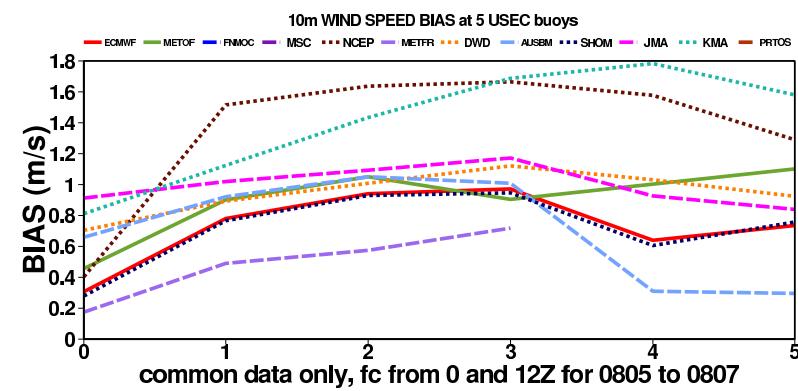
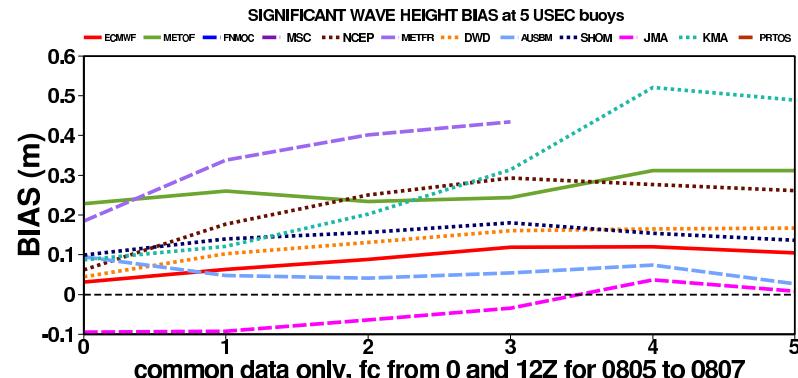


Figure 25: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

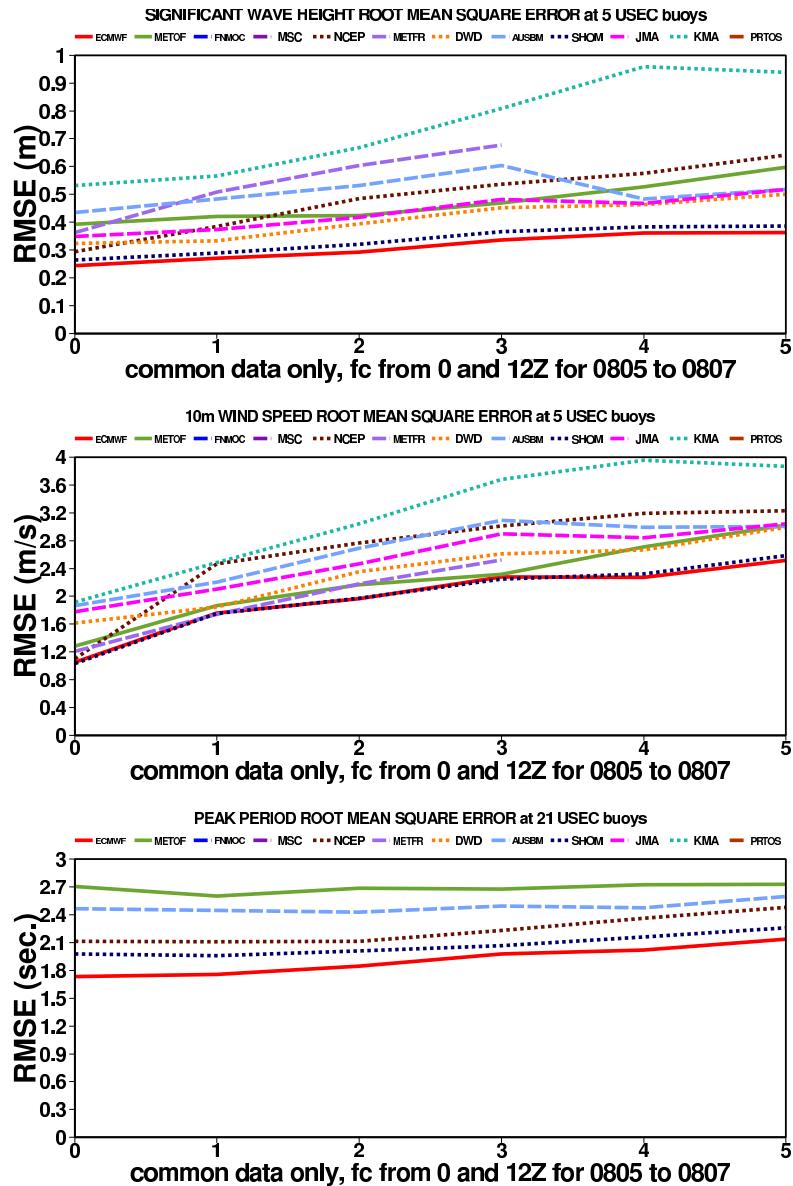


(a) Scatter Index (%)

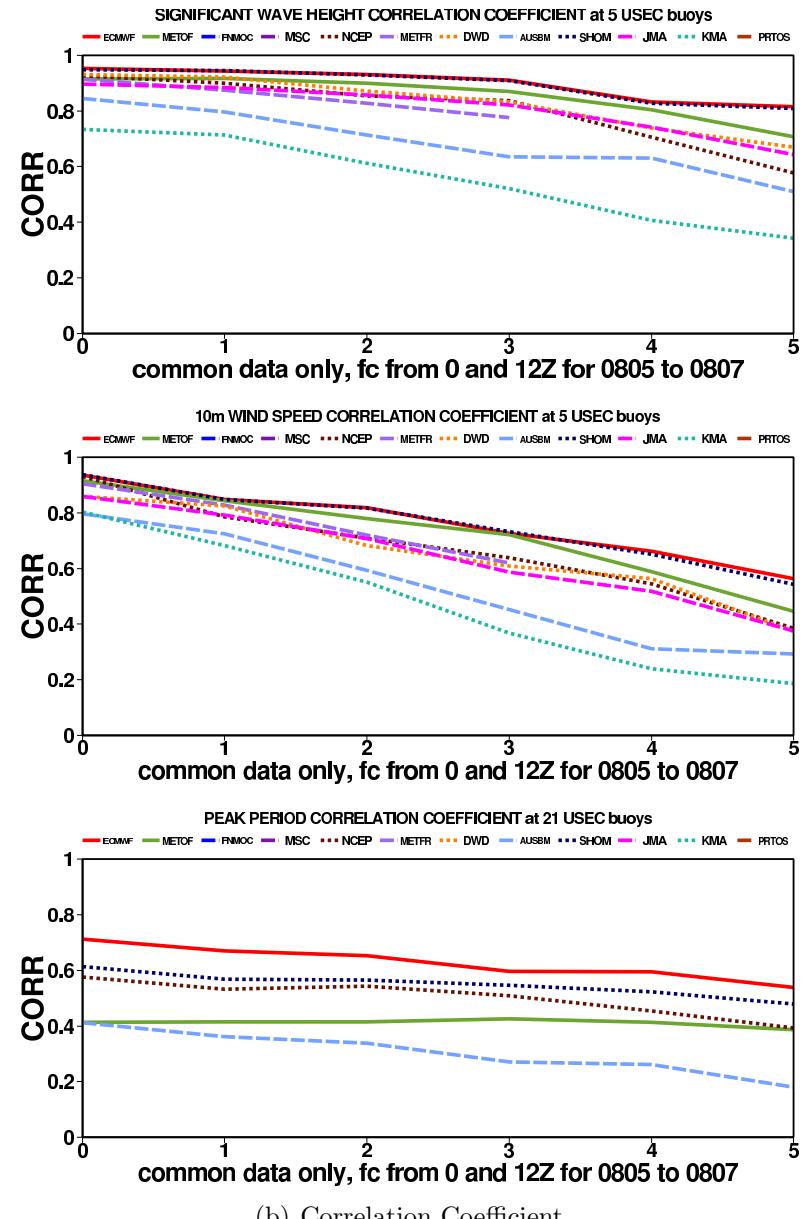


(b) Bias (model-buoy)

Figure 26: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common US East Coast buoys .



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 27: Forecast root mean square error (RMSE) and linear correlation coefficient at common US East Coast buoys .

0.3.6 Comparison for Gulf of Mexico buoys

Number of common observations for Gulf of Mexico buoys (GM) from 200805 to 200807 (wind, Hs, Tp)

| | | | | | | | | | | | |
|----------|-------|-----|-----|-----|-------------------------------|-----------|-------|-----|-----|-----|---|
| 1 | 42001 | 178 | 177 | 174 | Mid Gulf of Mexico | 6 | 42036 | 0 | 0 | 163 | Gulf of Mexico W Tampa |
| 2 | 42002 | 180 | 178 | 174 | Western Gulf of Mexico | 7 | 42039 | 0 | 0 | 173 | Gulf of Mexico Pensacola S |
| 3 | 42003 | 176 | 176 | 177 | East Gulf of Mexico | 8 | 42040 | 0 | 0 | 162 | Gulf of Mexico Mobile S |
| 4 | 42019 | 0 | 0 | 182 | Gulf of Mexico Lanelle | 9 | 42055 | 177 | 177 | 178 | Bay of Campeche |
| 5 | 42020 | 0 | 0 | 181 | Gulf of Mexico Corpus Christi | 10 | 42099 | 0 | 0 | 174 | Gulf Mexico, St Peterburg (scripps 144) |

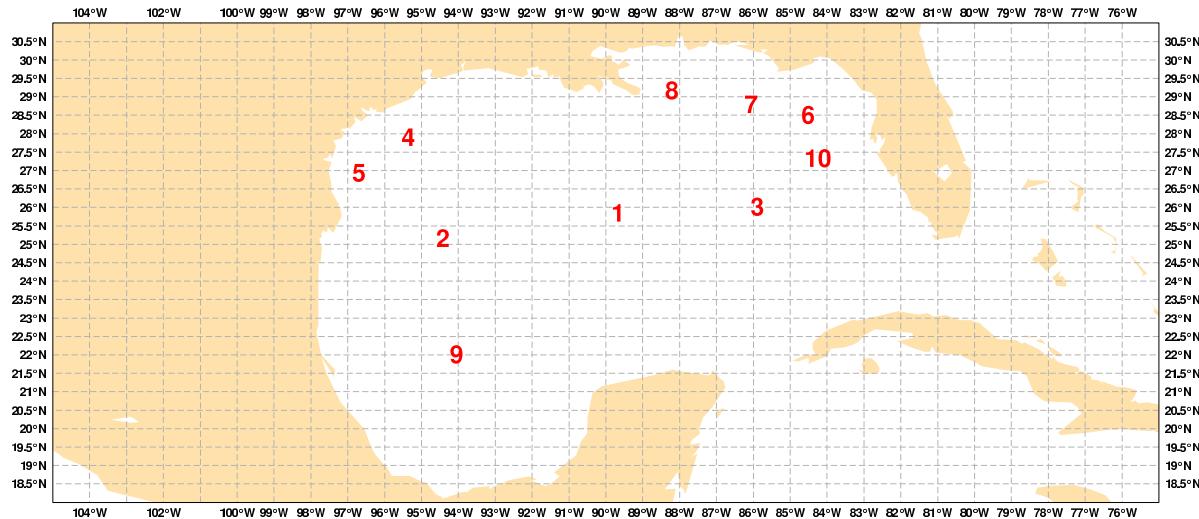


Figure 28: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

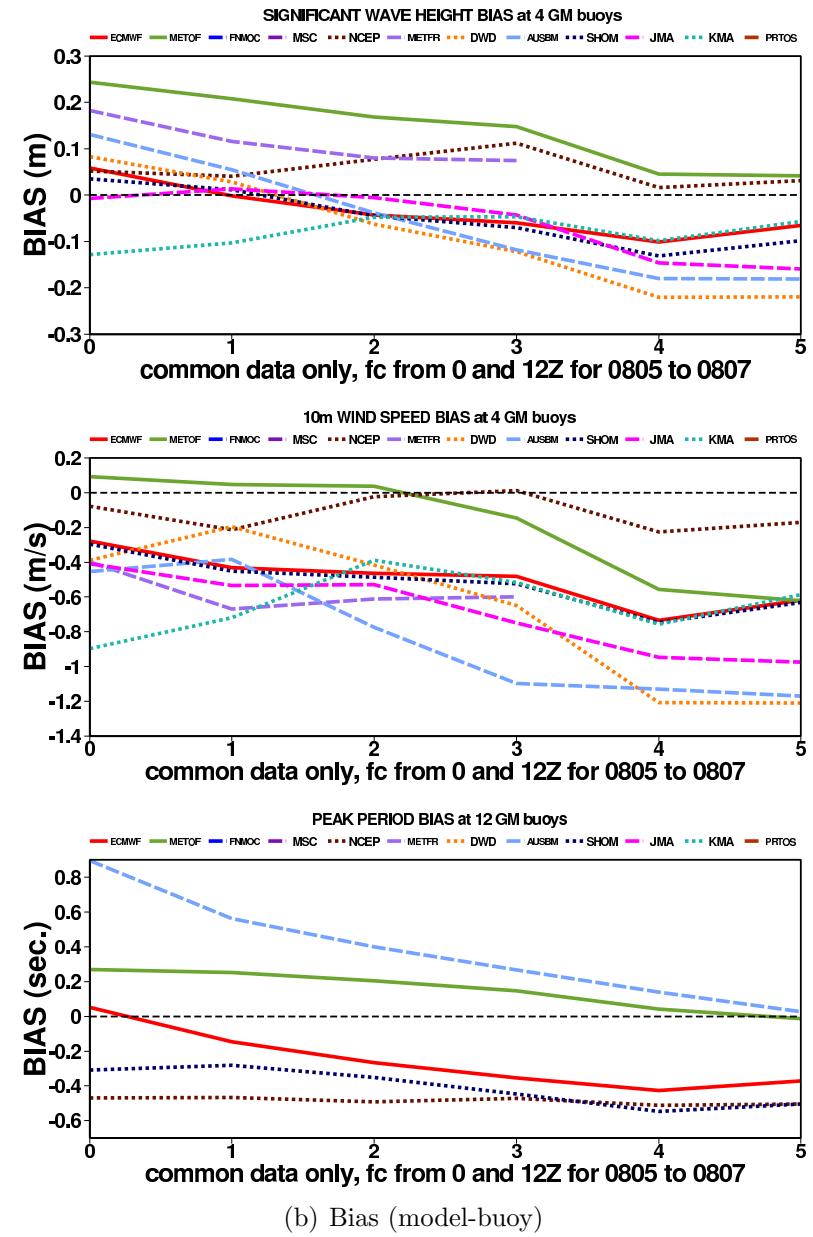
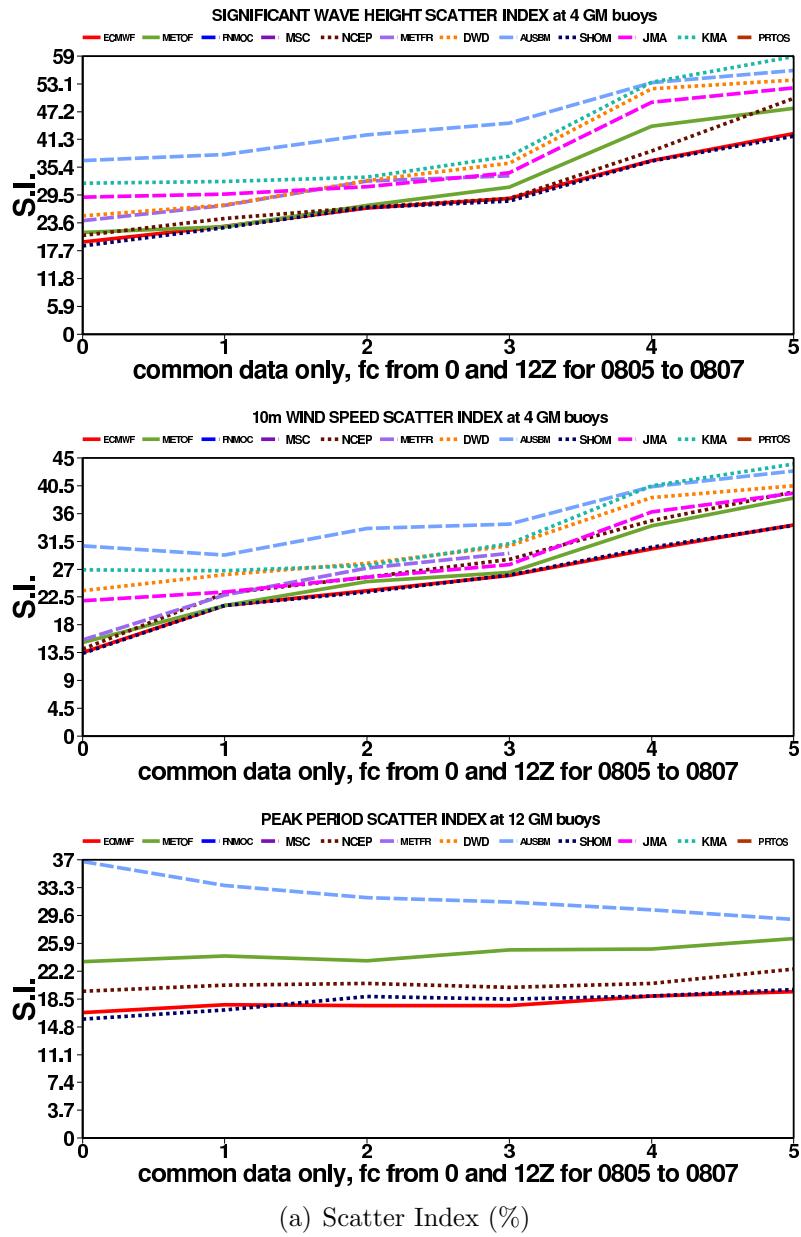


Figure 29: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common Gulf of Mexico buoys .

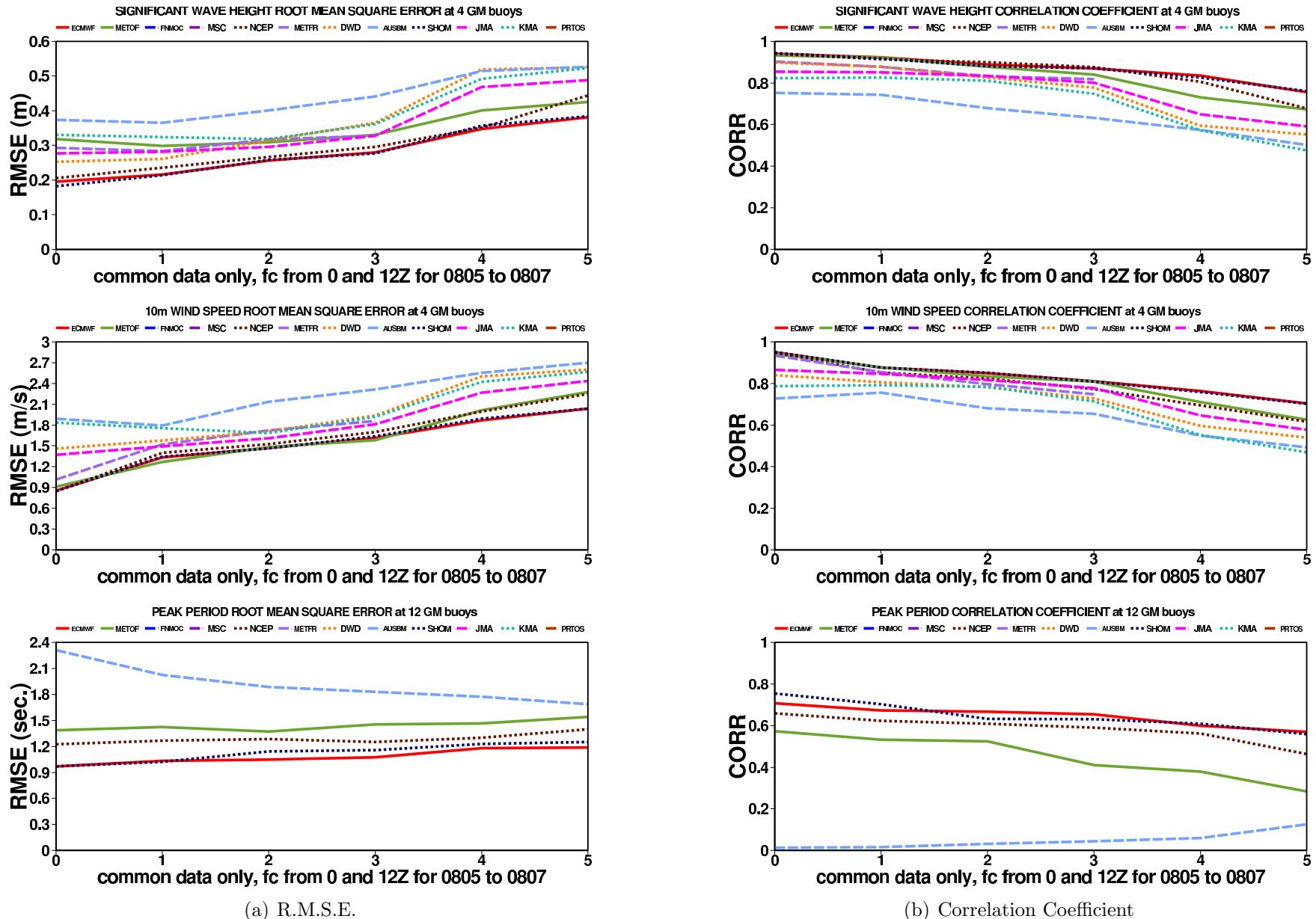


Figure 30: Forecast root mean square error (RMSE) and linear correlation coefficient at common Gulf of Mexico buoys .

0.3.7 Comparison for Canadian East Coast buoys

Number of common observations for Canadian East Coast buoys (CANEC) from 200805 to 200807 (wind, Hs,Tp)

| | | | | | | | | | | | |
|----------|-------|-----|-----|-----|--------------------------------|----------|-------|-----|-----|-----|------------------------------|
| 1 | 44137 | 162 | 178 | 180 | Nova Scotia, East Scotia slope | 5 | 44141 | 32 | 177 | 179 | Nova Scotia, Laurentian Fan |
| 2 | 44138 | 178 | 178 | 182 | Newfoundland, SW Grand Bank | 6 | 44150 | 180 | 0 | 0 | Nova Scotia, La Have Bank |
| 3 | 44139 | 179 | 179 | 181 | Newfoundland, Banquerau | 7 | 44251 | 0 | 0 | 127 | Newfoundland, Nickerson Bank |
| 4 | 44140 | 172 | 0 | 0 | Newfoundland, Tail Of The Bank | 8 | 44255 | 0 | 0 | 182 | Newfoundland, NE Bugeo Bank |

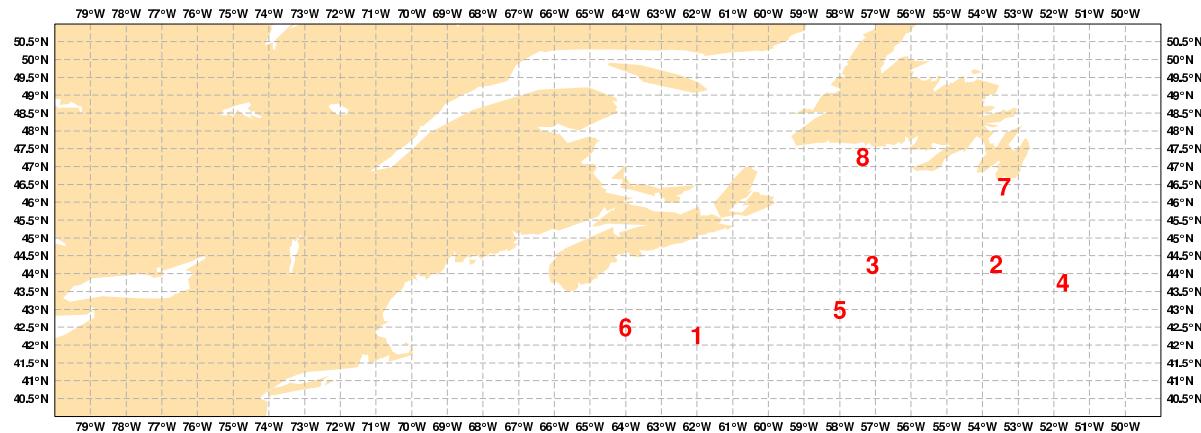


Figure 31: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

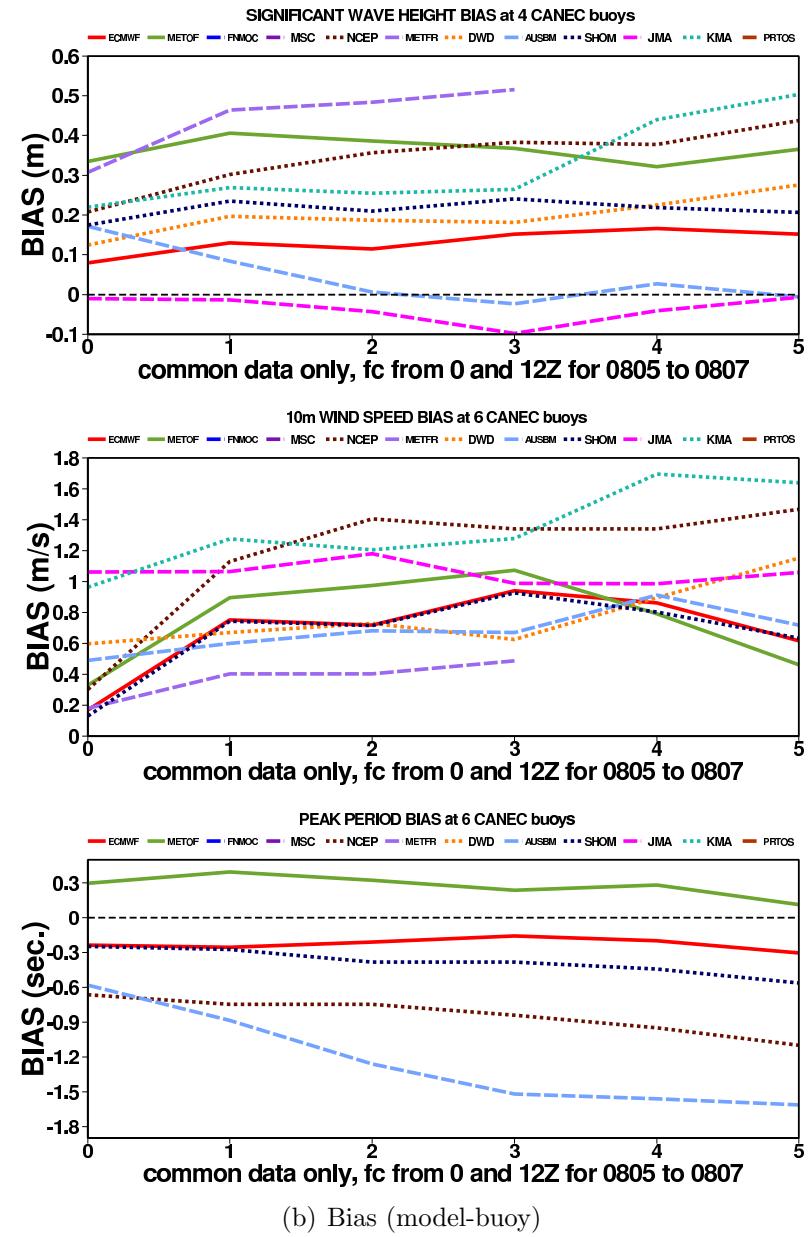
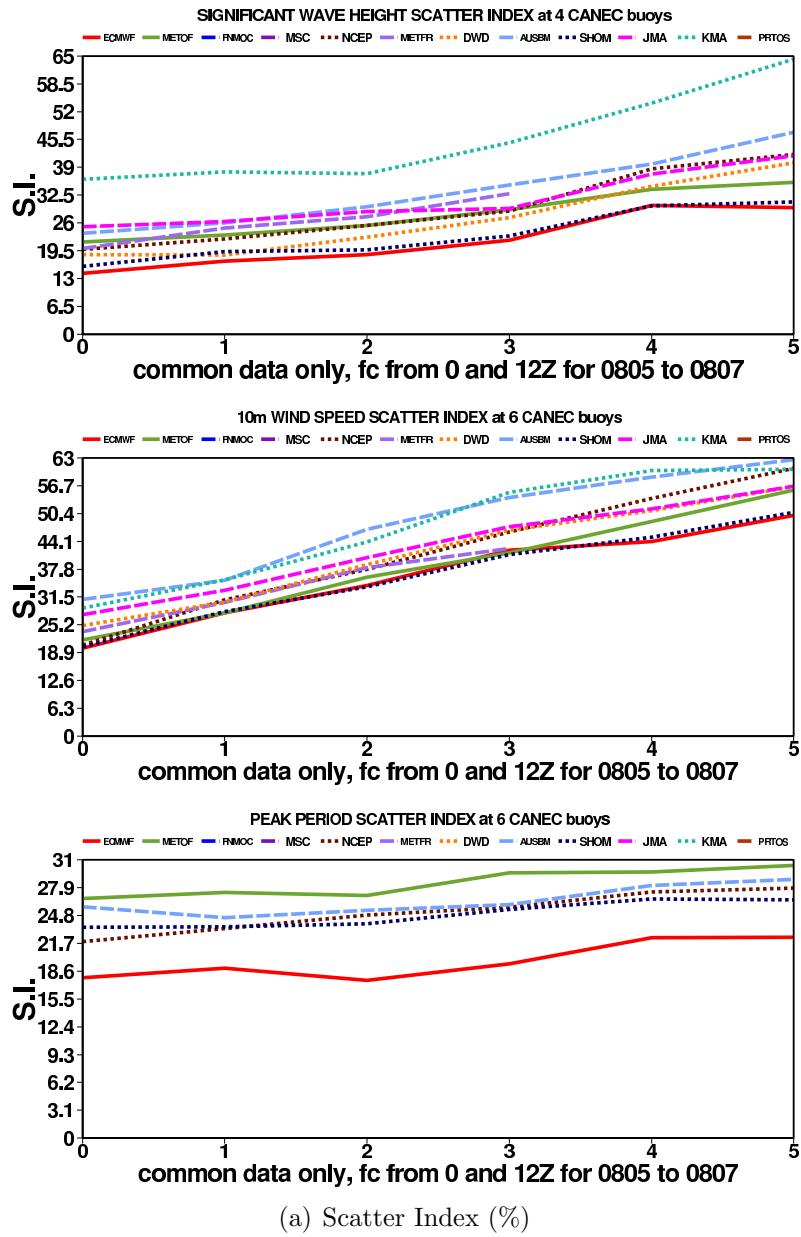
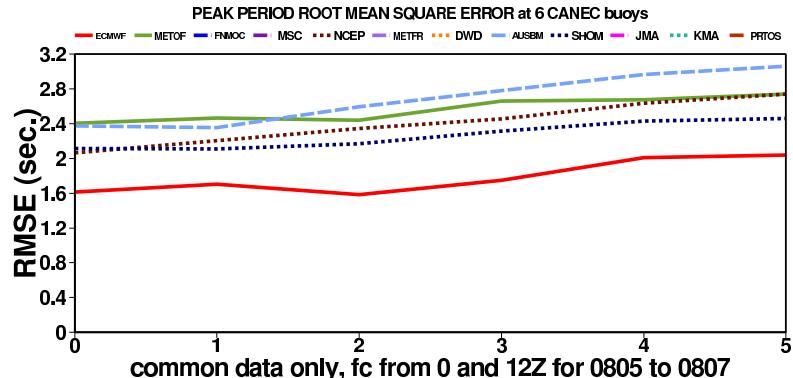
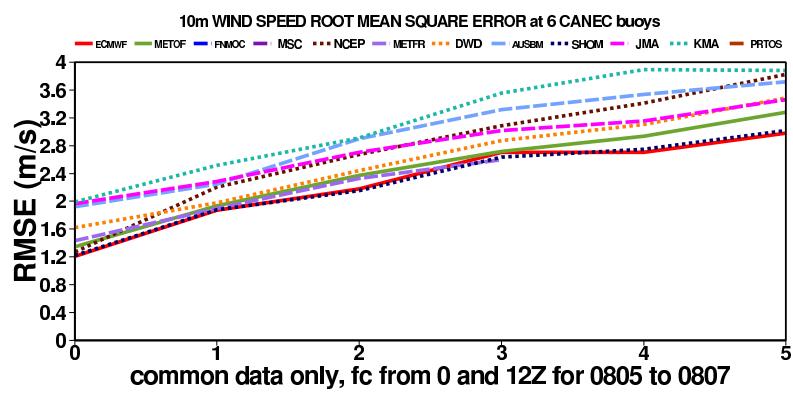
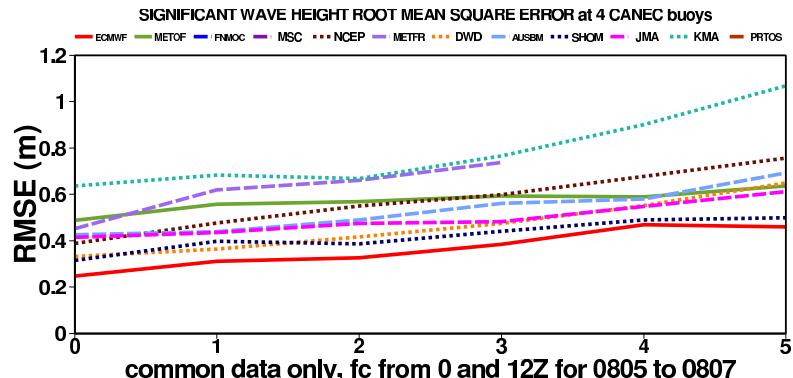
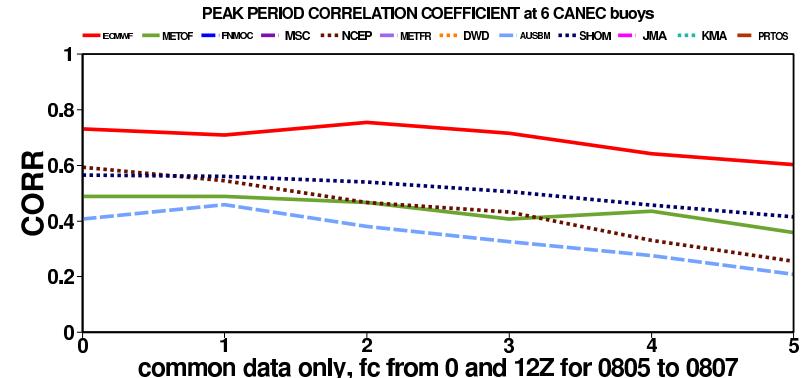
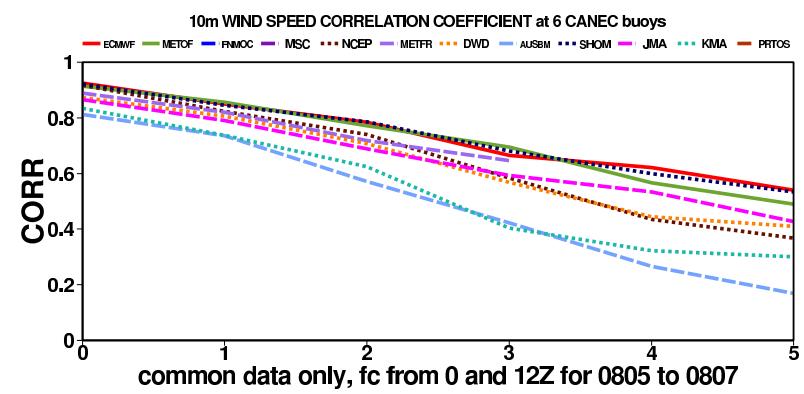
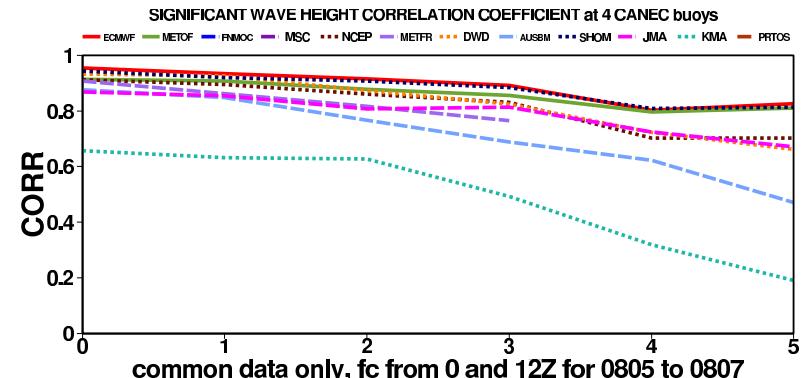


Figure 32: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common Canadian East Coast buoys .



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 33: Forecast root mean square error (RMSE) and linear correlation coefficient at common Canadian East Coast buoys .

0.3.8 Comparison for North East Atlantic buoys

Number of common observations for North East Atlantic buoys (NEATL) from 200805 to 200807 (wind, Hs,Tp)

| | | | | | | | | | | | |
|----------|-------|-----|-----|---|--------------------------------|----------|-------|-----|-----|---|--------------------------------------|
| 1 | 62029 | 115 | 177 | 0 | UK Celtic Sea shelf break (K1) | 5 | 62163 | 178 | 178 | 0 | UK Celtic Sea shelf break (Brittany) |
| 2 | 62081 | 180 | 180 | 0 | UK East Atlantic (K2) | 6 | 64045 | 21 | 175 | 0 | UK North-East Atlantic (K5) |
| 3 | 62082 | 92 | 92 | 0 | Estaca de Bares (Spain) | 7 | 64046 | 171 | 163 | 0 | UK North-East Atlantic (K7) |
| 4 | 62095 | 93 | 26 | 0 | West Ireland (M6), West Coast | | | | | | |

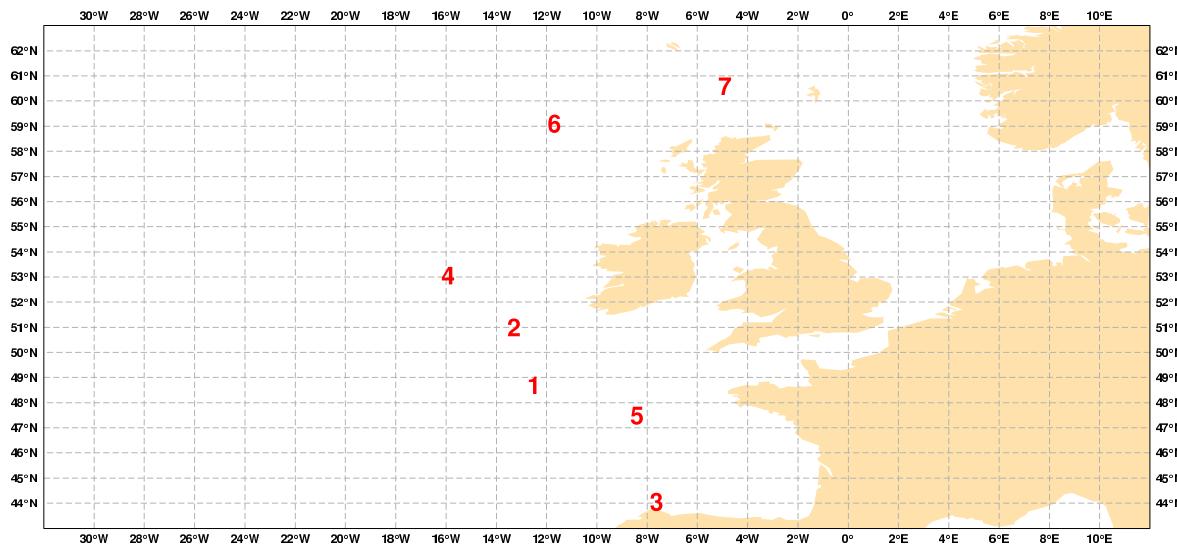


Figure 34: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

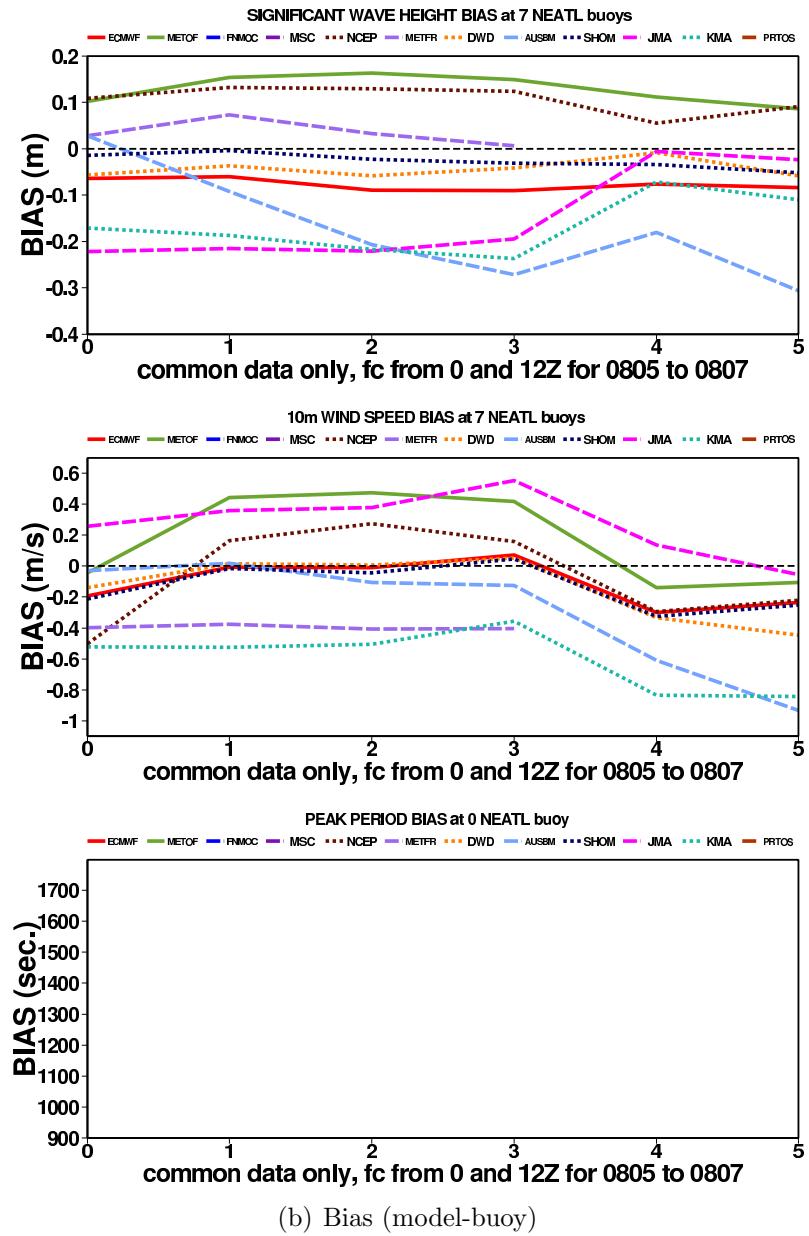
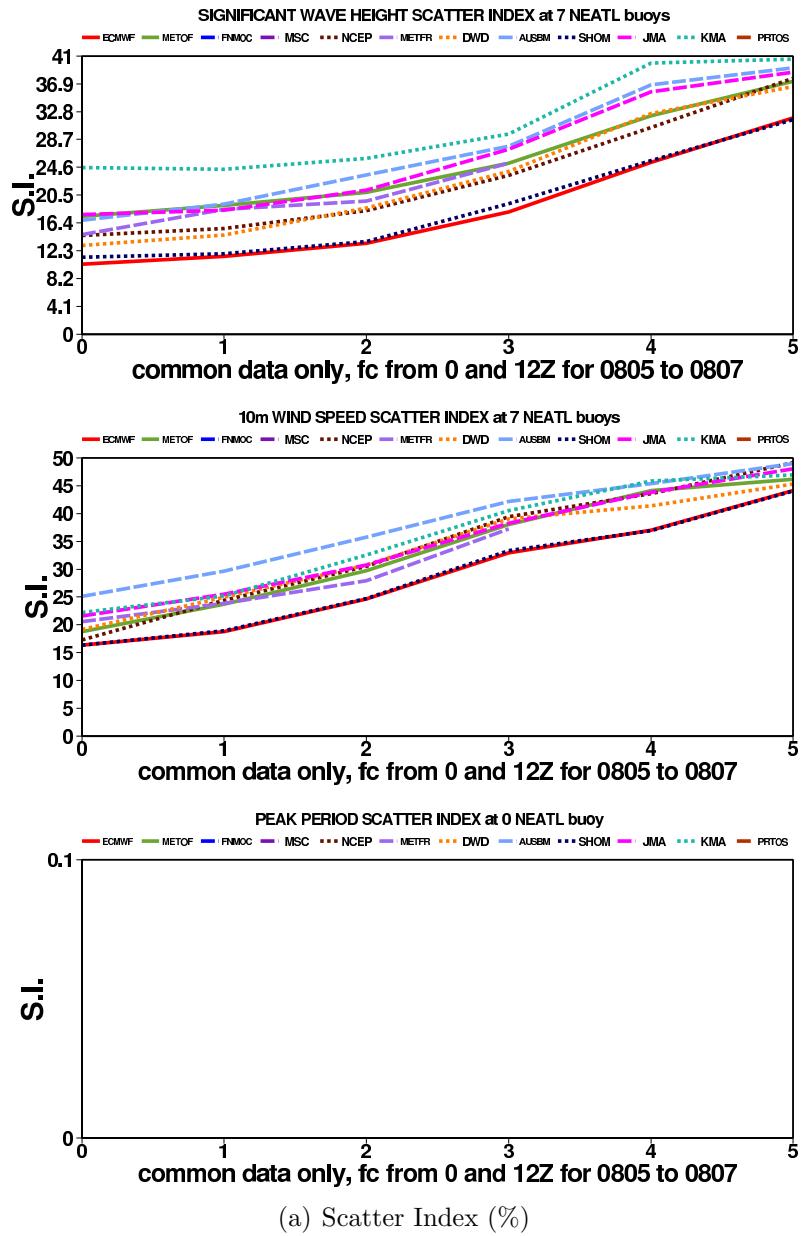
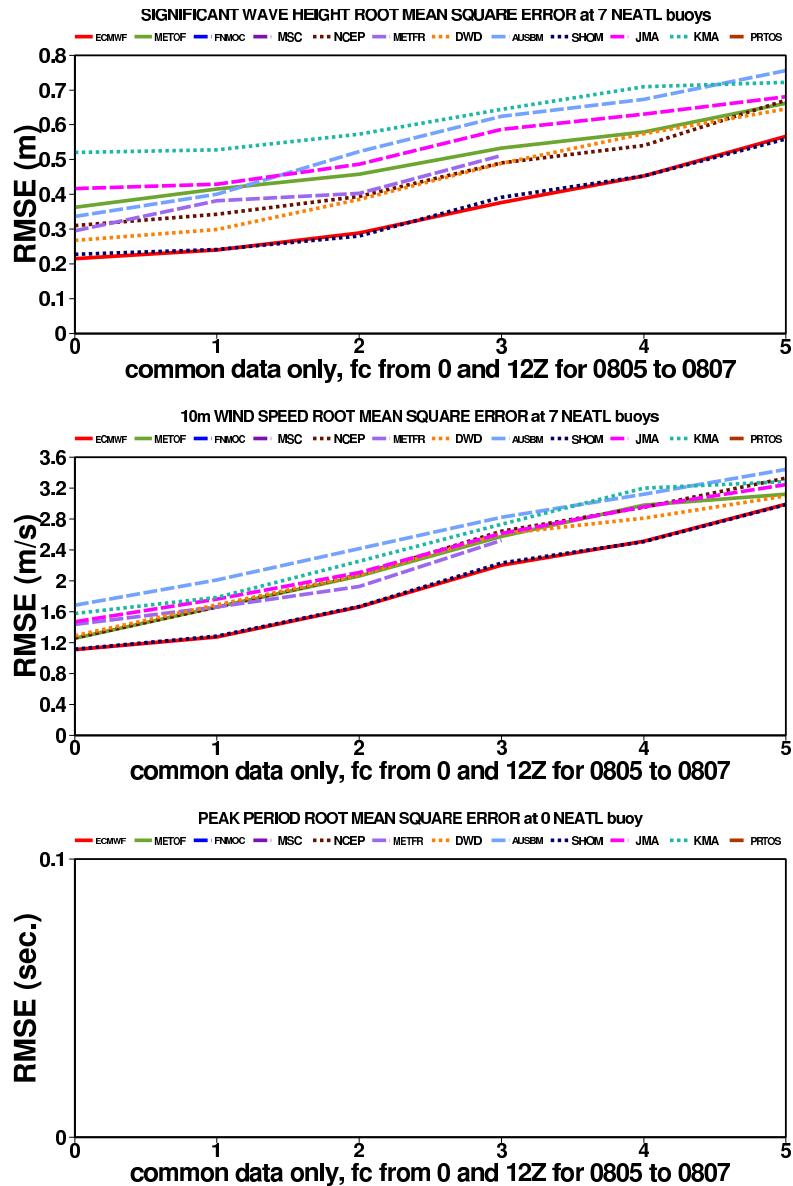
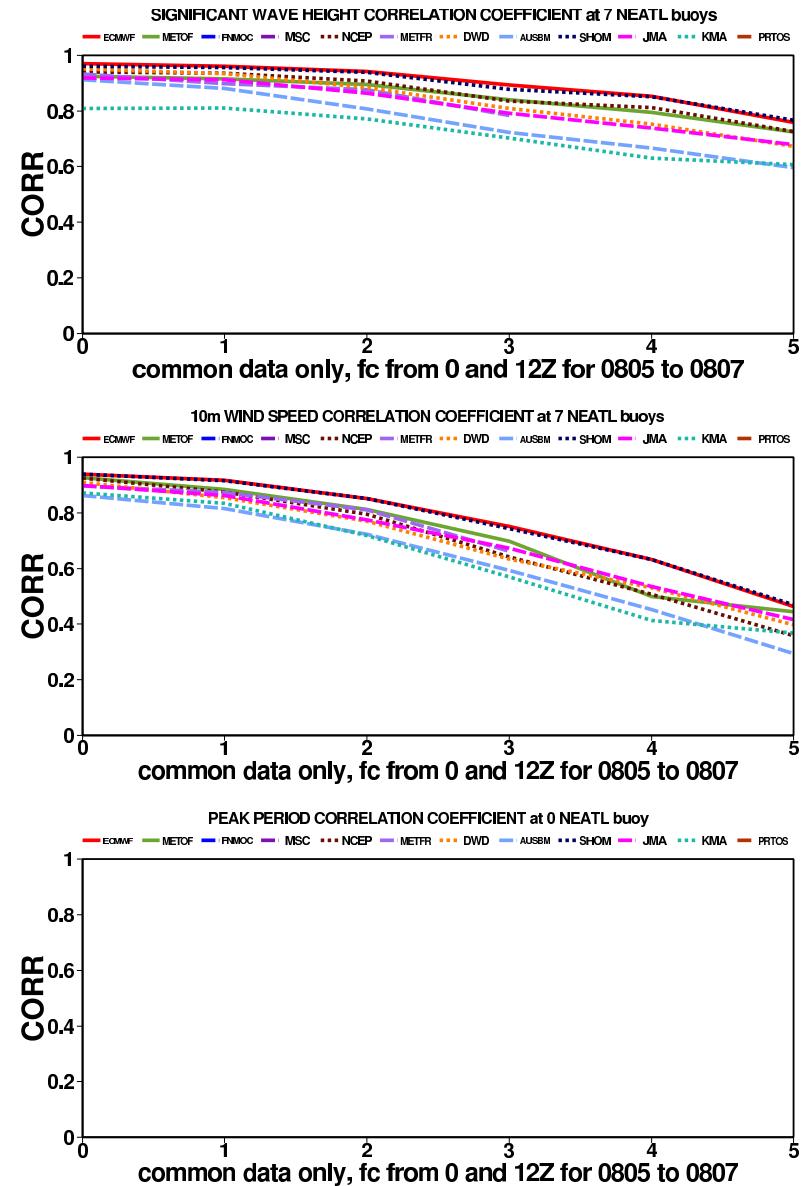


Figure 35: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common North East Atlantic buoys .



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 36: Forecast root mean square error (RMSE) and linear correlation coefficient at common North East Atlantic buoys .

0.3.9 Comparison for North Sea platforms

Number of common observations for North Sea (NSEA) from 200805 to 200807 (wind, Hs, Tp)

| | | | | | |
|---|-------|-----|-----|---|-------------------------------|
| 1 | 63115 | 171 | 173 | 0 | North Sea shelf break (?????) |
|---|-------|-----|-----|---|-------------------------------|

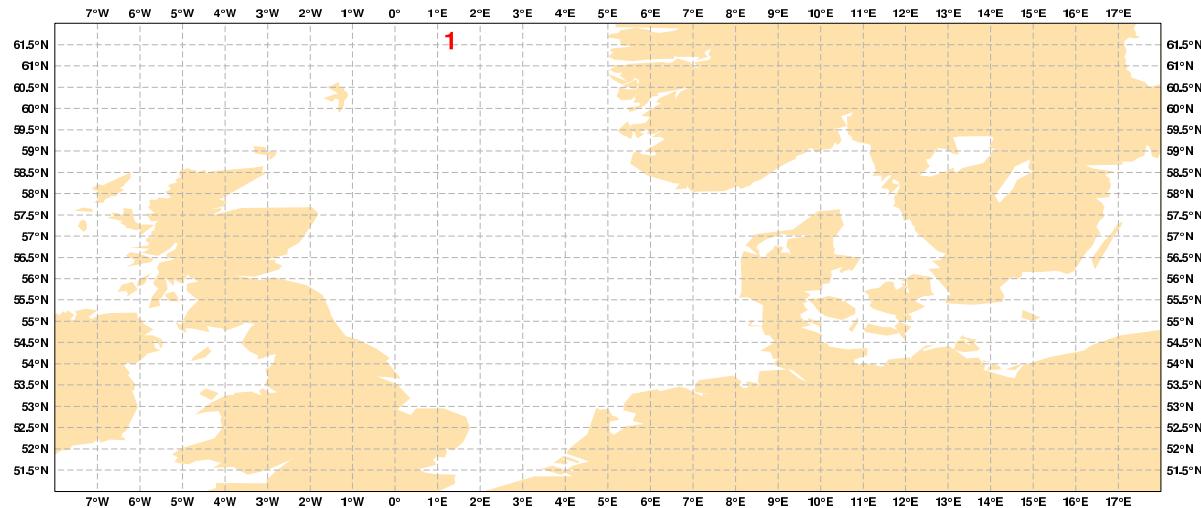
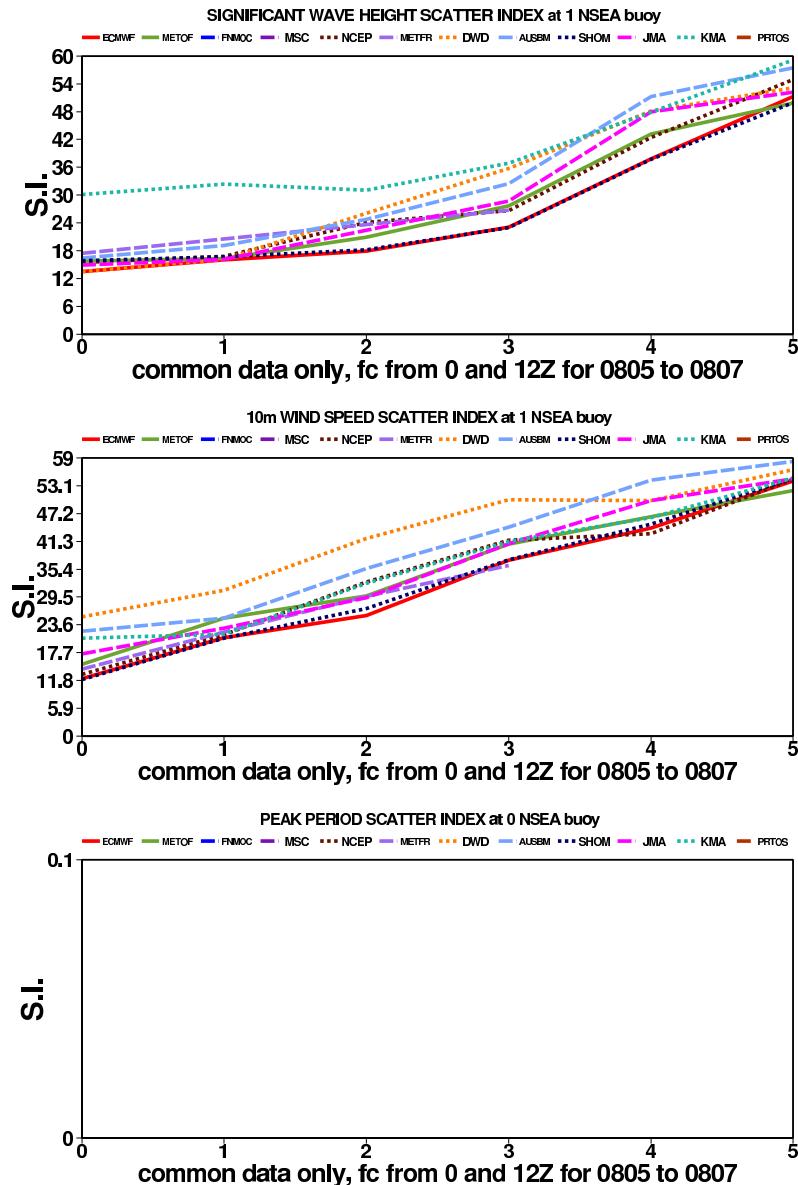
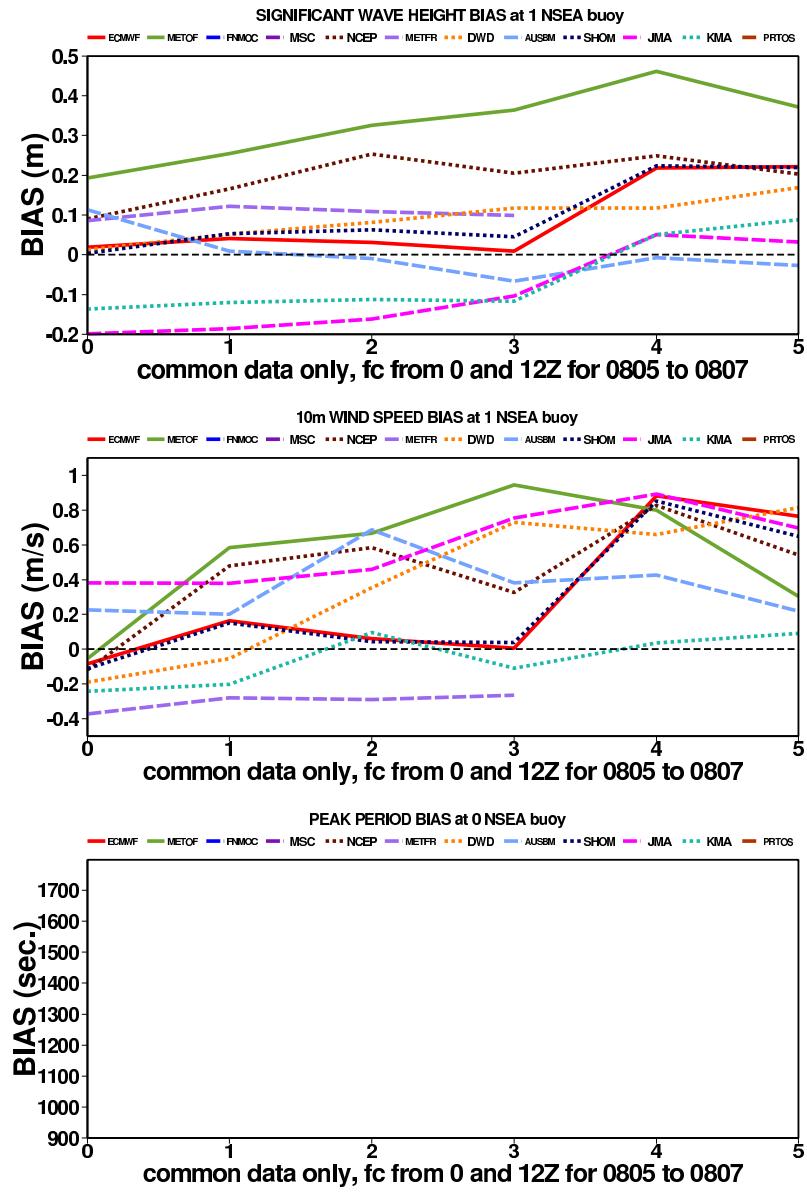


Figure 37: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

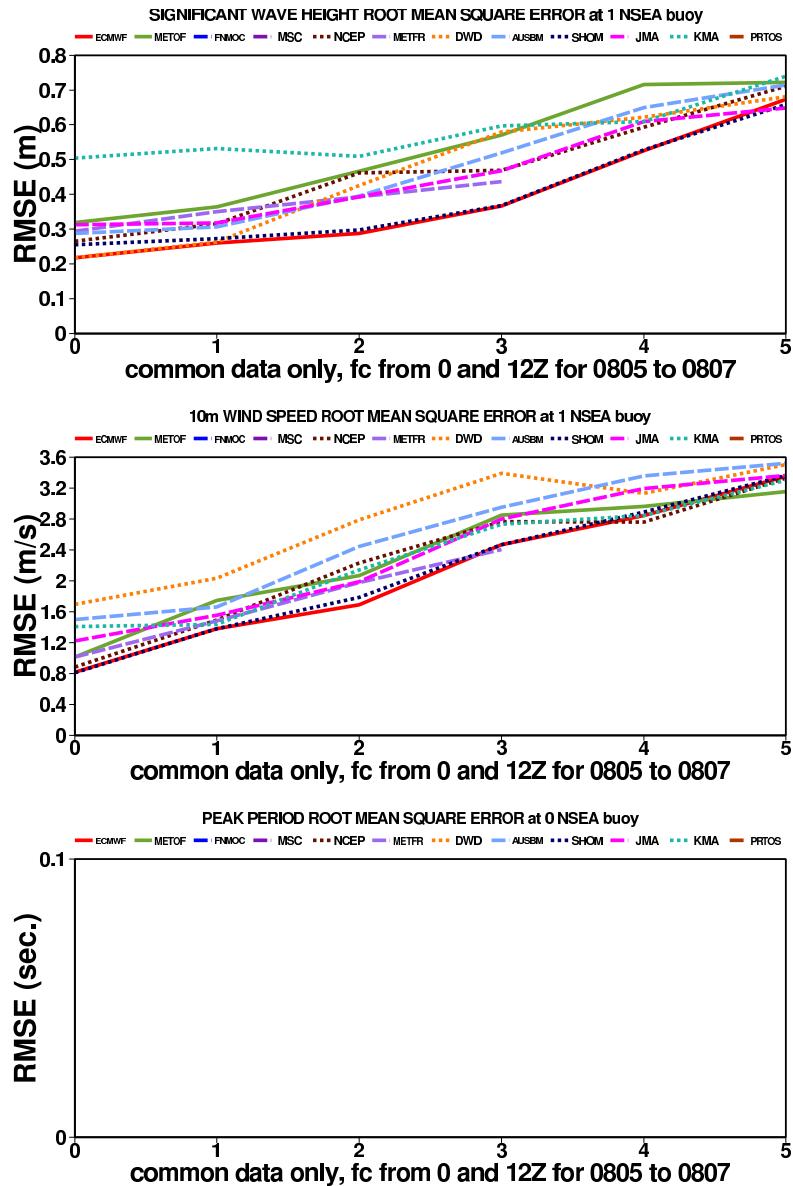


(a) Scatter Index (%)

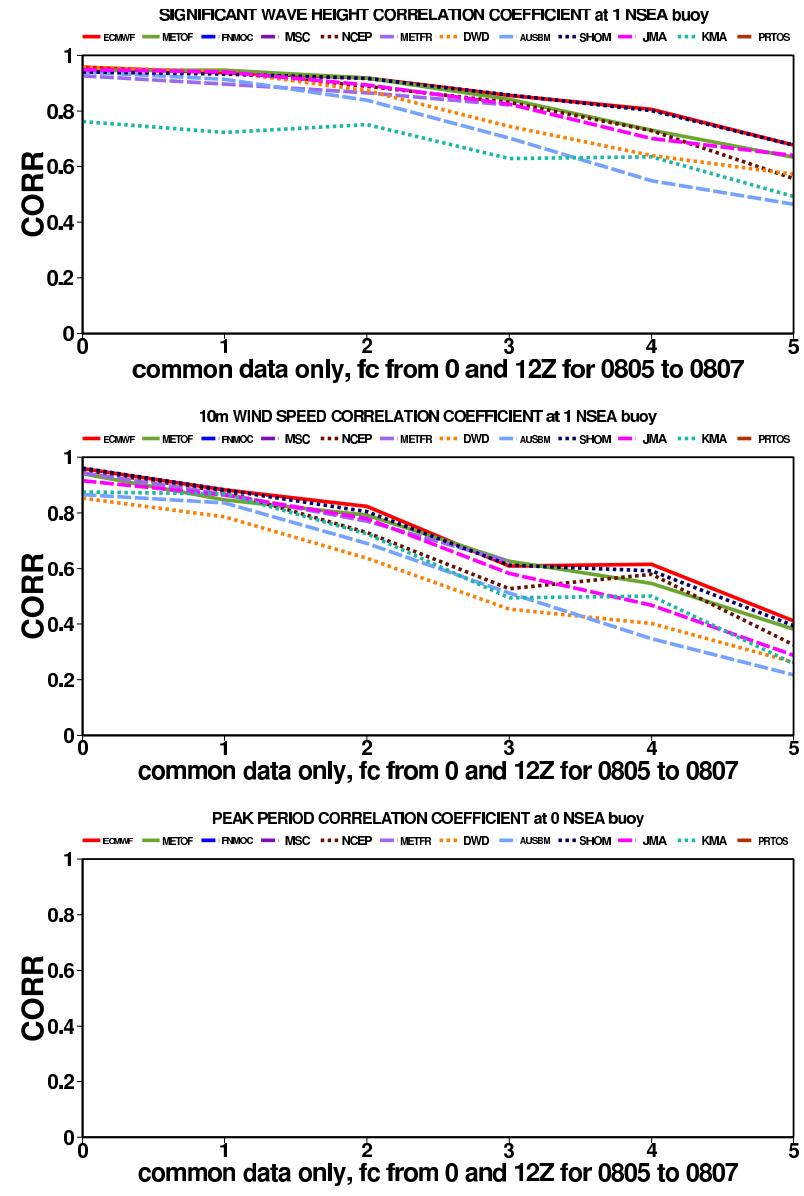


(b) Bias (model-buoy)

Figure 38: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common North Sea platforms.



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 39: Forecast root mean square error (RMSE) and linear correlation coefficient at common North Sea platforms.

0.3.10 Comparison for South African platform

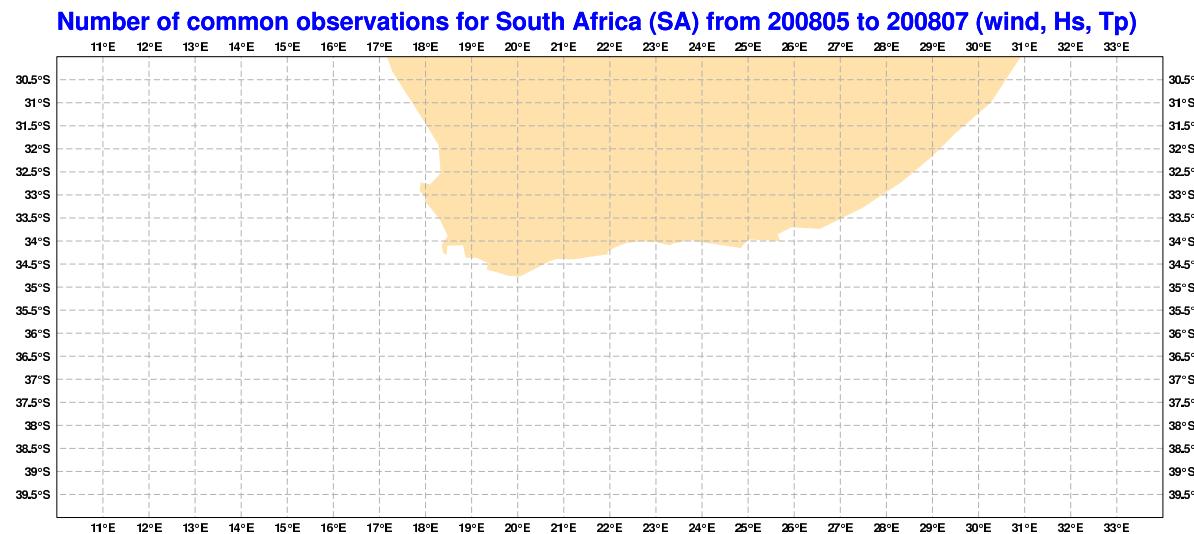


Figure 40: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

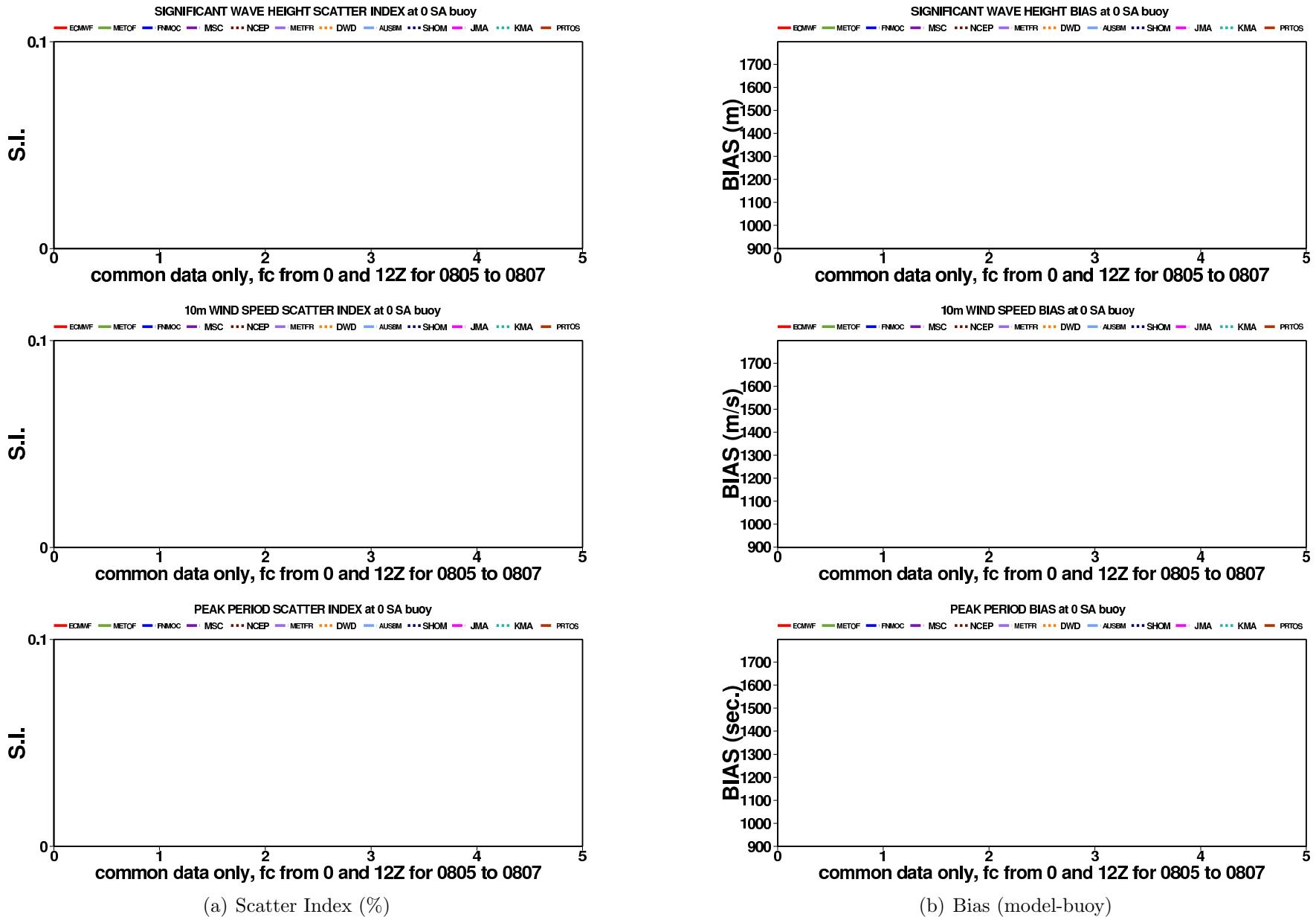


Figure 41: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common South African platform.

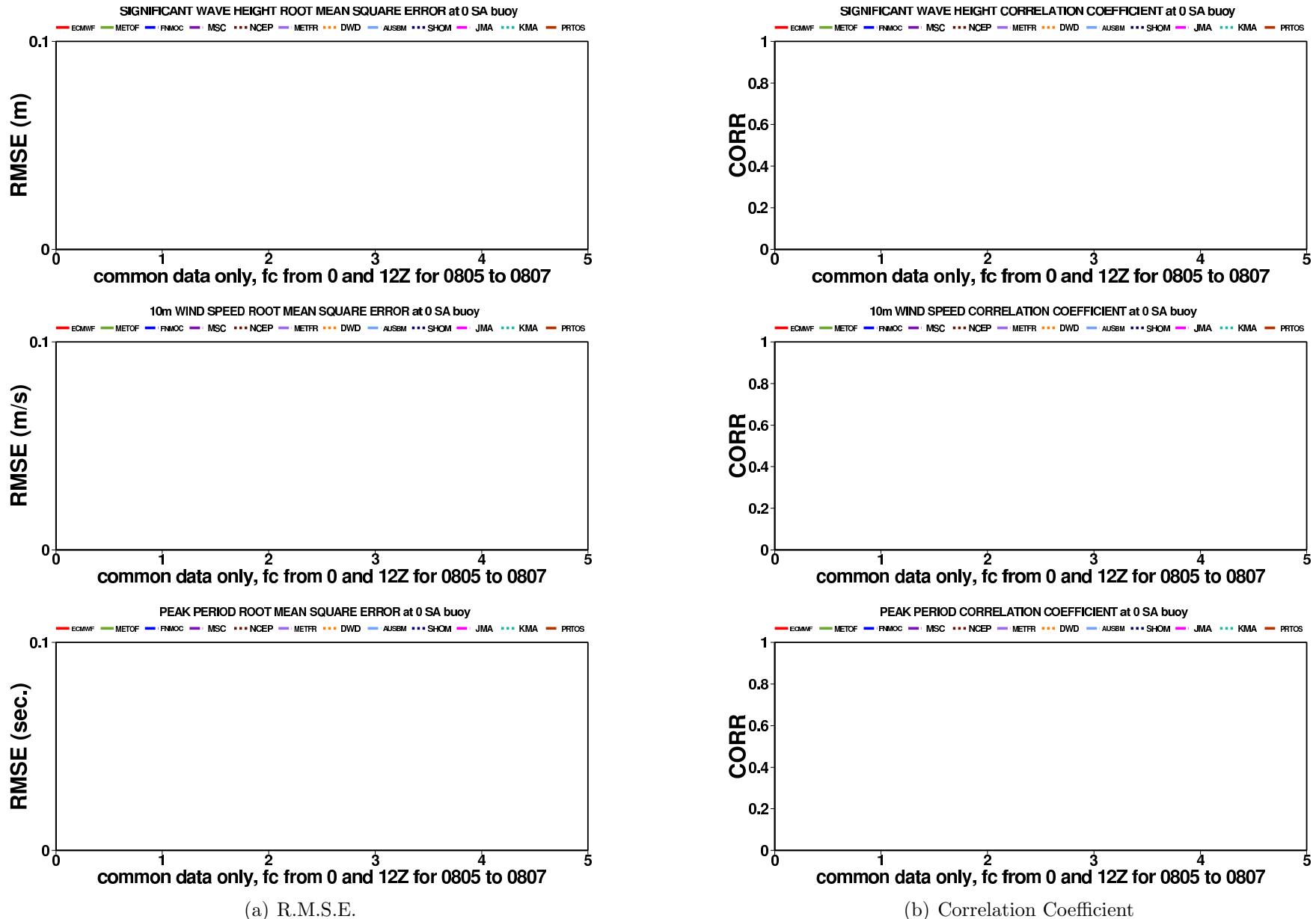


Figure 42: Forecast root mean square error (RMSE) and linear correlation coefficient at common South African platform.

0.3.11 Comparison for Indian buoys

Number of common observations for India (INDIA) from 200805 to 200807 (wind, Hs,Tp)

| | | | | | | | | | | | |
|----------|-------|----|----|---|---------------|----------|-------|----|----|---|---------------|
| 1 | 23092 | 94 | 72 | 0 | Arabian Sea | 5 | 23101 | 65 | 65 | 0 | Bay of Bengal |
| 2 | 23097 | 56 | 41 | 0 | Arabian Sea | 6 | 23170 | 24 | 0 | 0 | Arabian Sea |
| 3 | 23098 | 13 | 0 | 0 | Arabian Sea | 7 | 23172 | 52 | 0 | 0 | Arabian Sea |
| 4 | 23100 | 0 | 43 | 0 | Bay of Bengal | 8 | 23174 | 15 | 0 | 0 | Bay of Bengal |

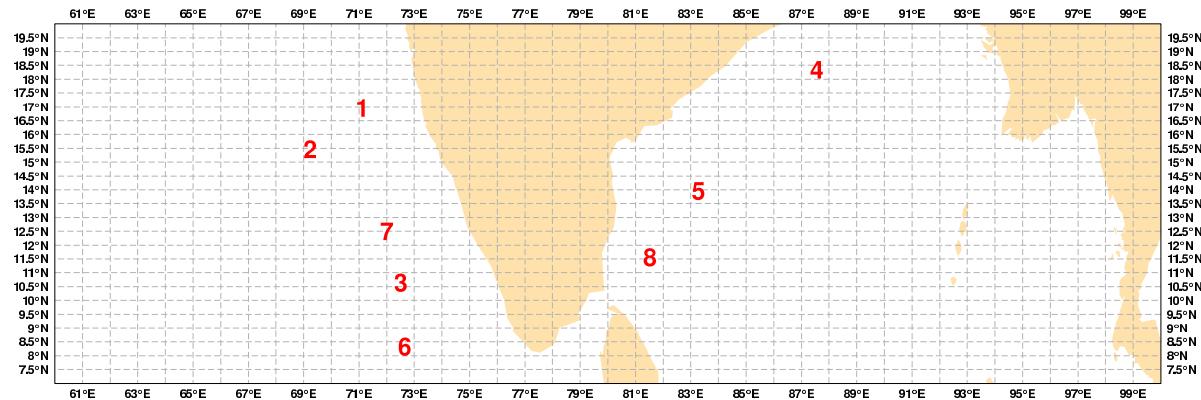


Figure 43: Buoy locations. The numbers in the table following each buoy identifier are the number of collocations between models and buoy wind speed, wave height and peak period.

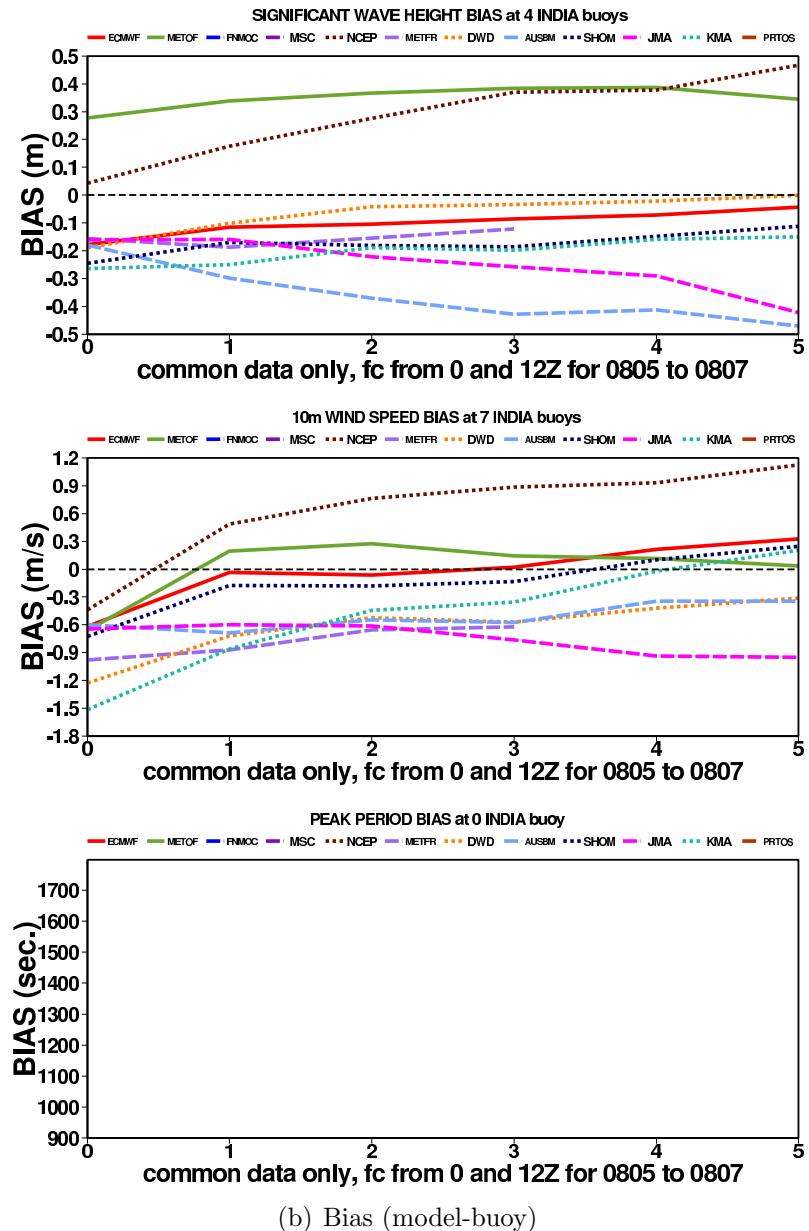
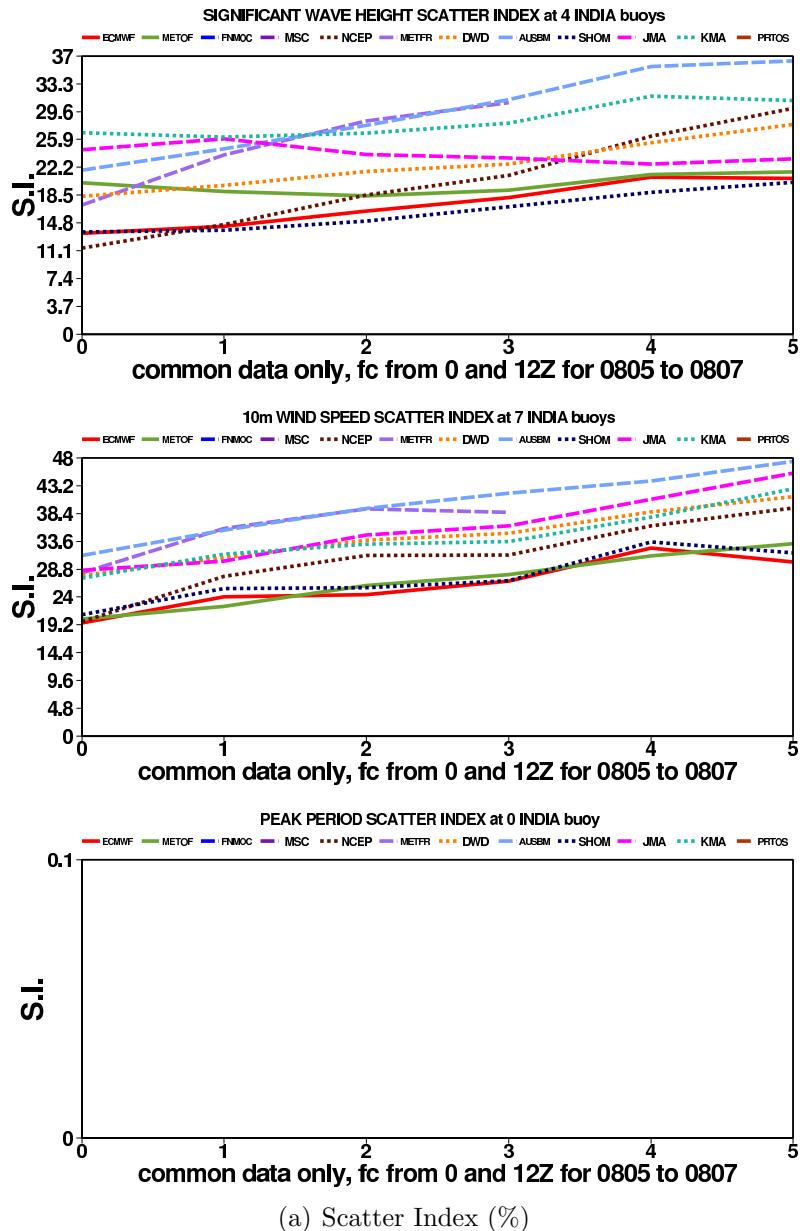
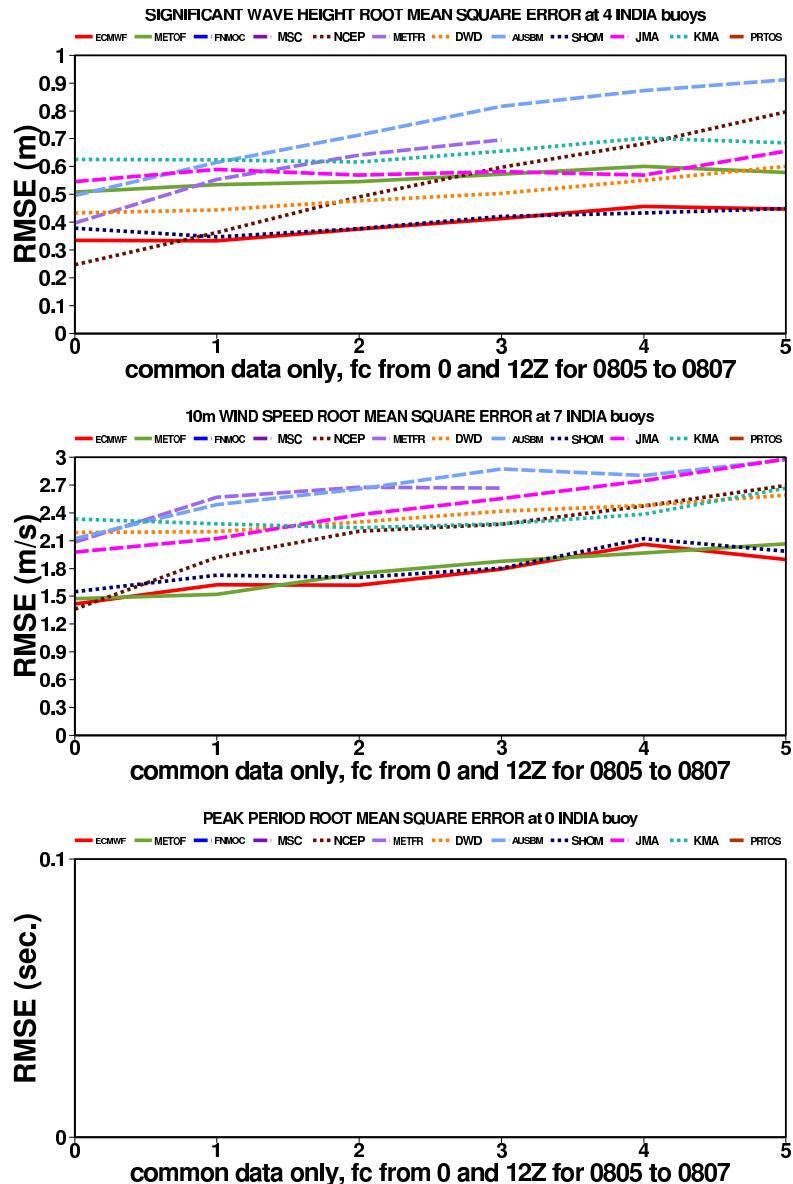
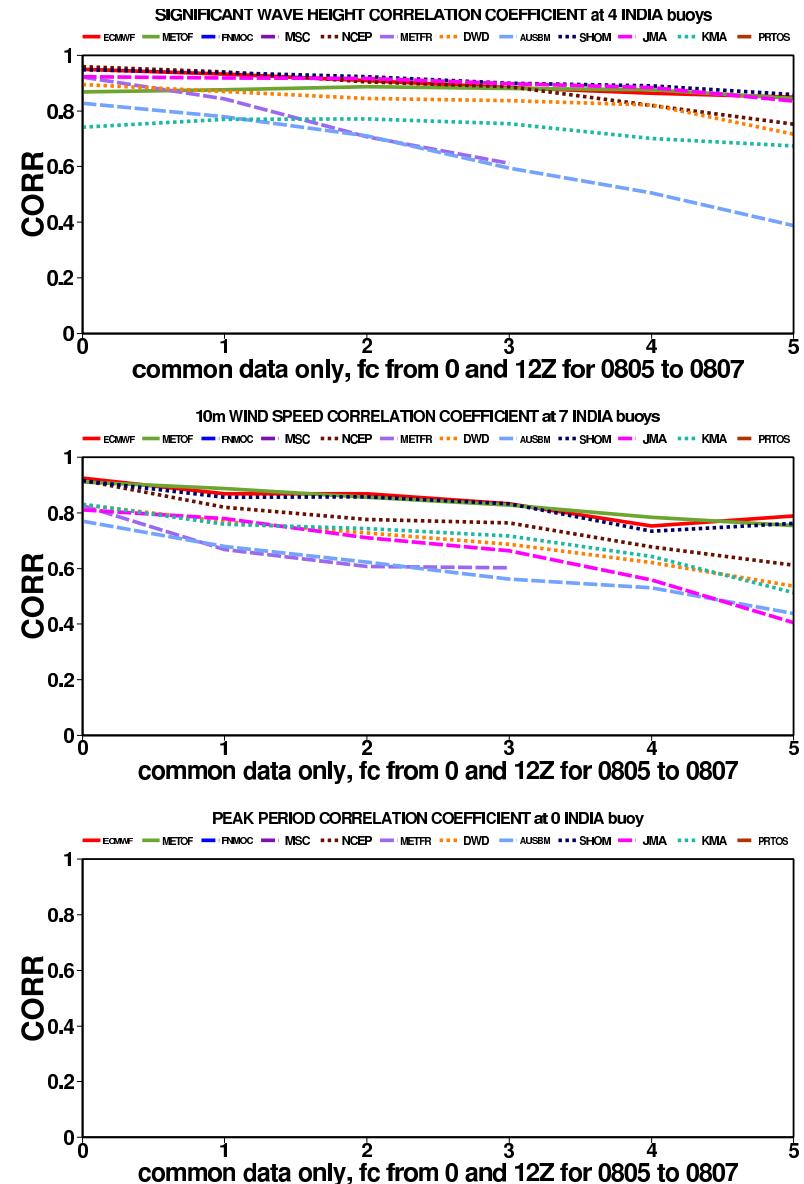


Figure 44: Forecast scatter index (standard deviation of the difference normalised by the mean of the observations) and bias (model-buoy) at common Indian buoys.



(a) R.M.S.E.



(b) Correlation Coefficient

Figure 45: Forecast root mean square error (RMSE) and linear correlation coefficient at common Indian buoys.