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The State of the Art and Science of Coastal Engineering

# New Wave Hindcast for the Río de la Plata Estuary

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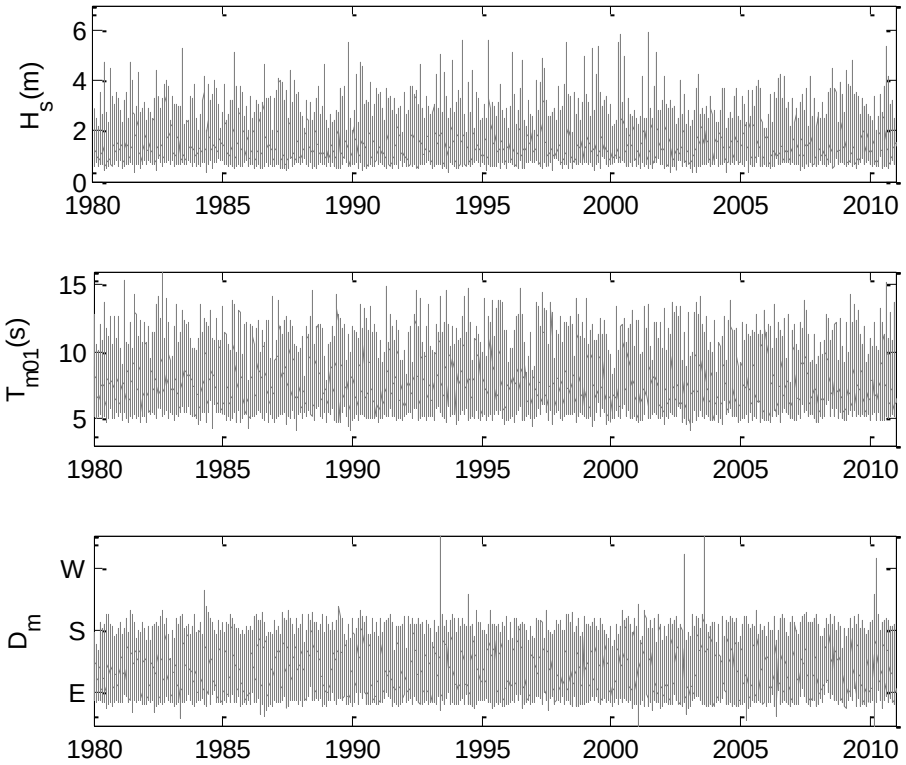
*Universidad de la República, Uruguay.*




# Content

- Introduction
- Peculiarities of the Río de la Plata
- Improvements of the new wave hindcast
- Input of water levels and currents
- Validation of CFSR Winds
- The wave model
- Results
- Conclusions and future work

Long-term and good quality wave data series are required for multiples activities.




Observations are commonly sparse and don't cover long periods.

So Wave Hindcast often is the best source for long-term wave data series.

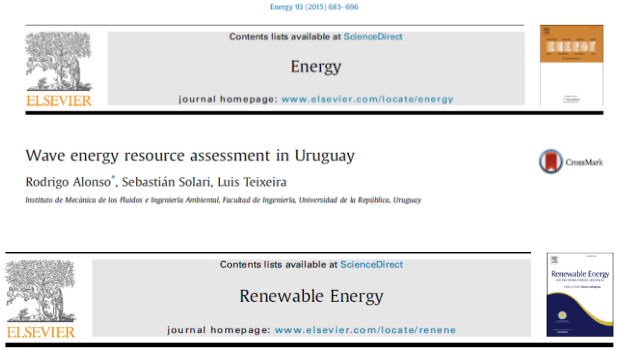
There are valious global wave hindcast where we can freely download wave data. e.g.: CAWCR Wave Hindcast iowaga ECMWF

But, in order to: Improve the resolution and take advantage of local data (bathymetry, bed composition, wave and wind observations, etc.)

A local hindcast is necessary.

The first wave hindcast for Uruguay was done in 2012.

In the context of a wave energy research project.



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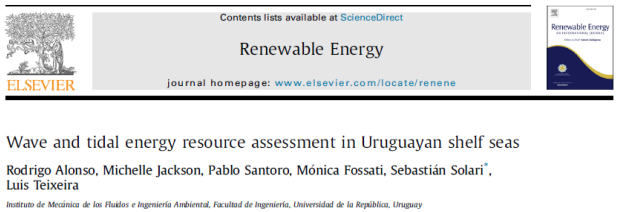

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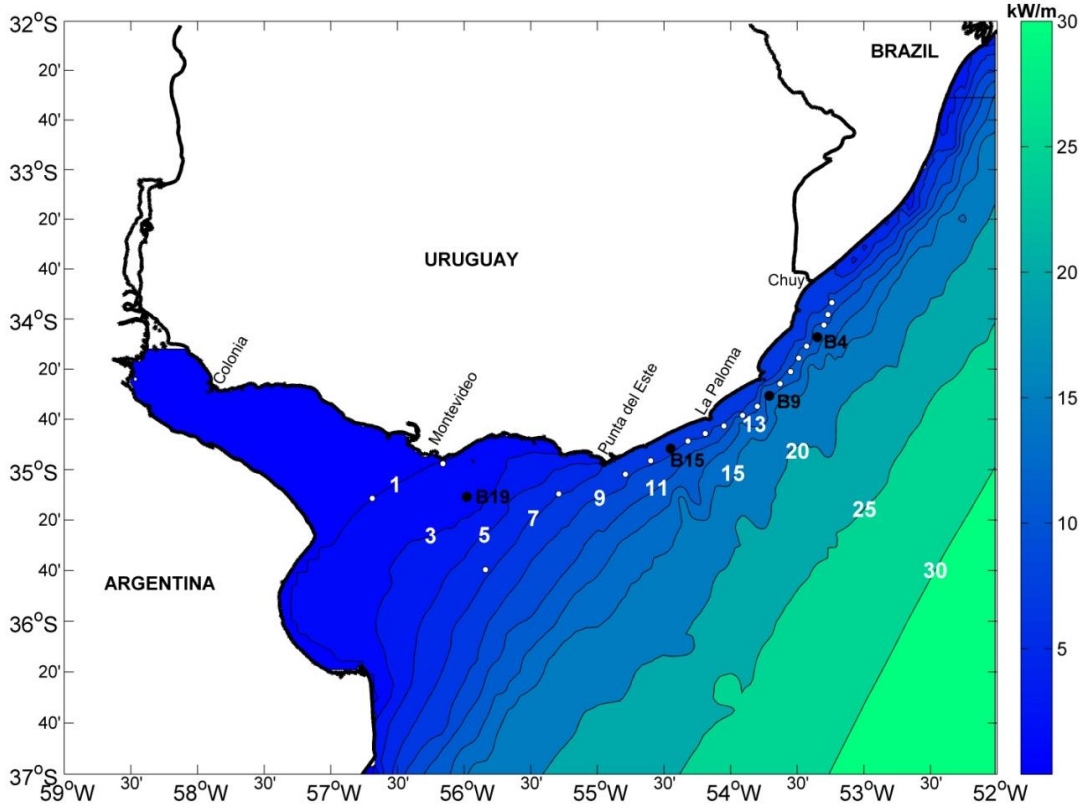


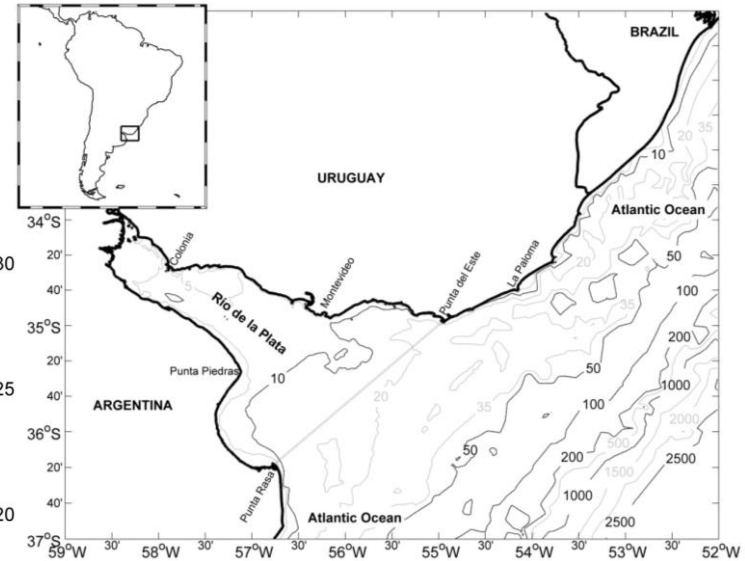


The focus was on the Atlantic, where wave power is higher.

The Río de la Plata was included, but with not enough attention.

| | *BIAS* | *RMSE* | *SI* |
|---|---|---|---|
| Atlantic region | 0.02 | 0.29 | 17.3 |
| *Outer RDP* | -0.05 | 0.28 | 27.8 |
| *Inner RDP* | -0.25 | 0.35 | 33.8 |

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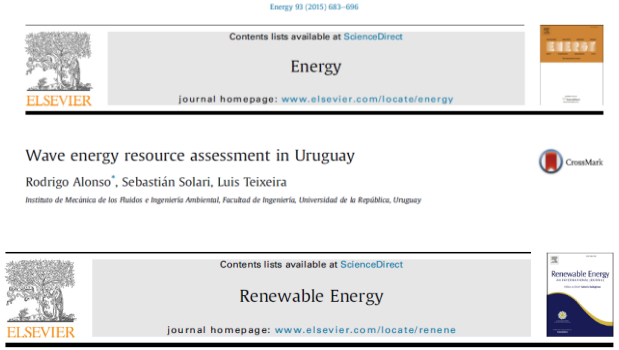

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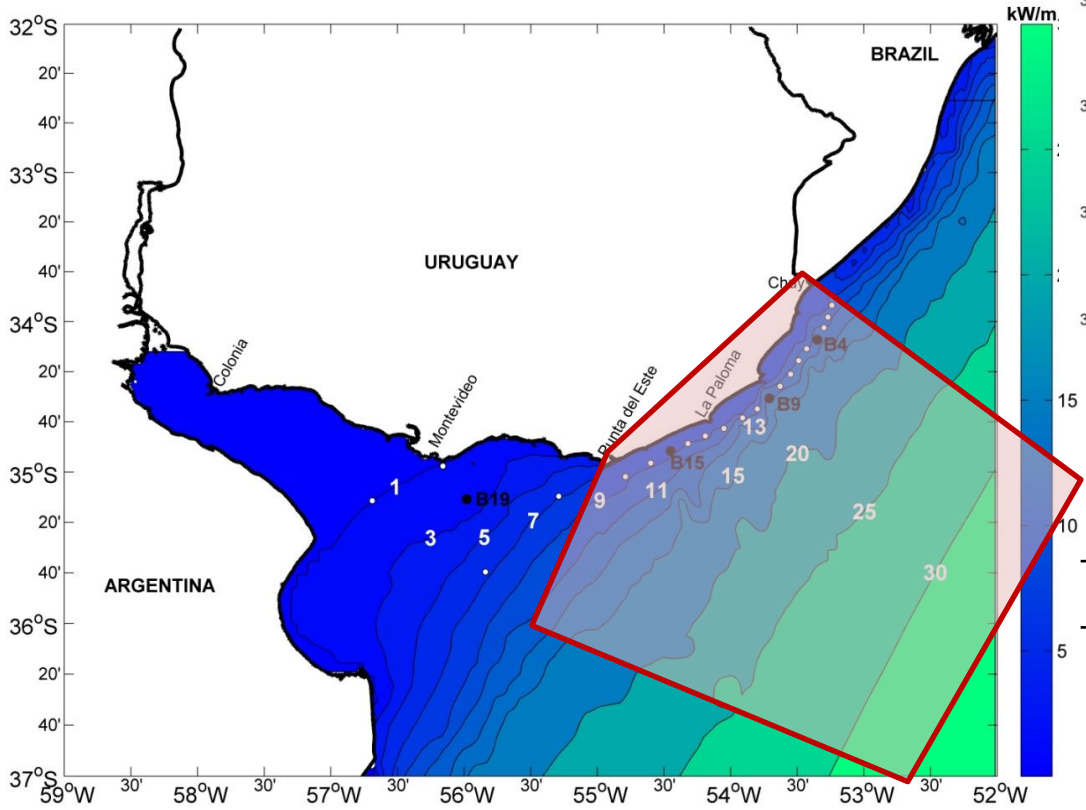


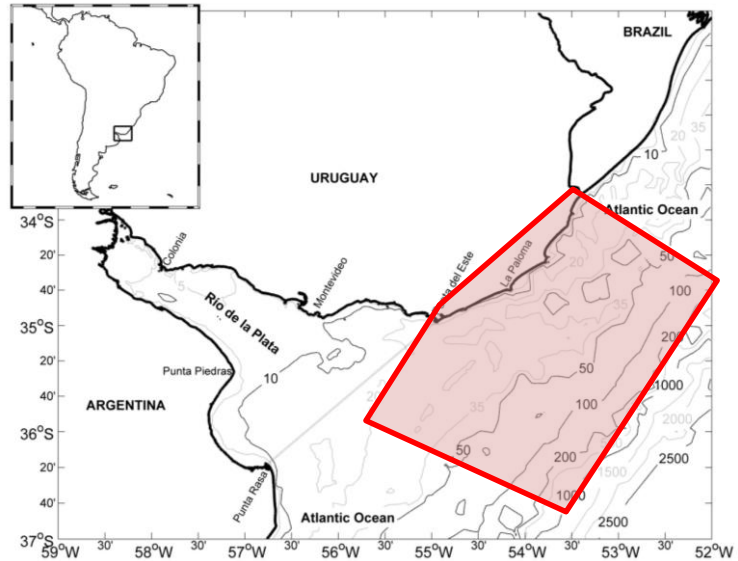


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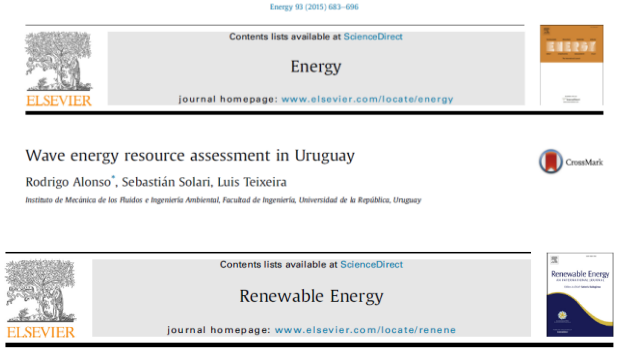

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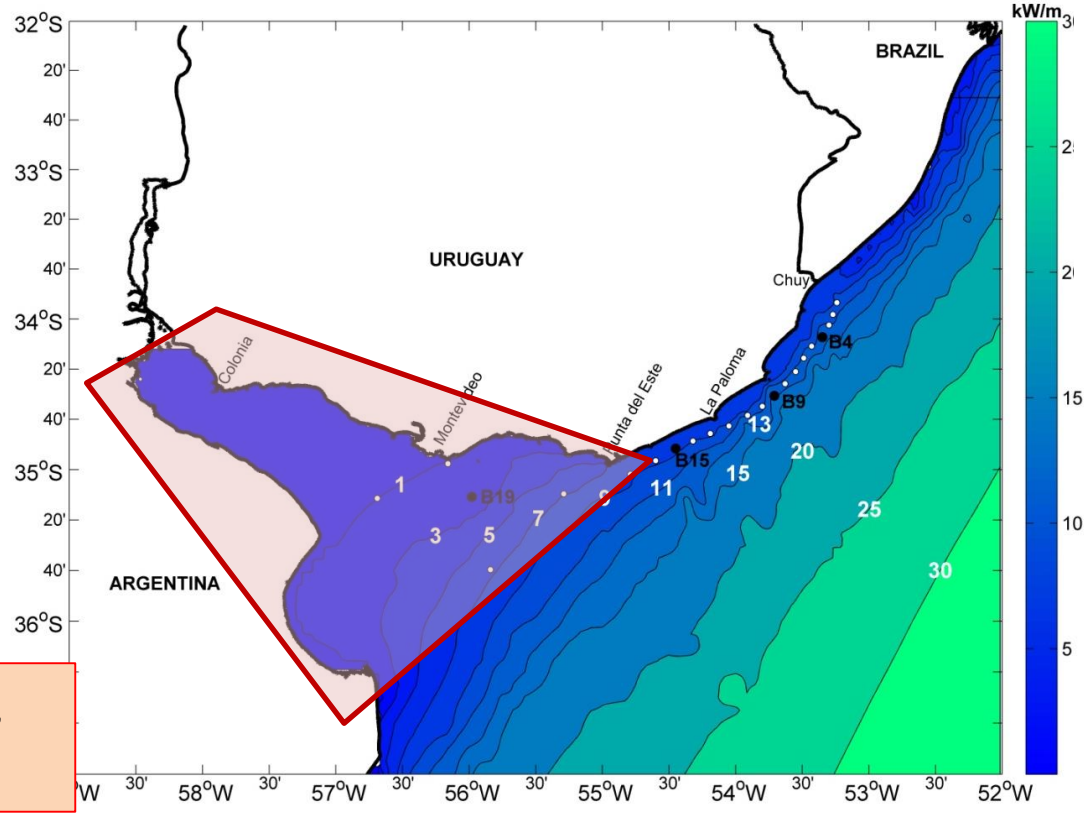


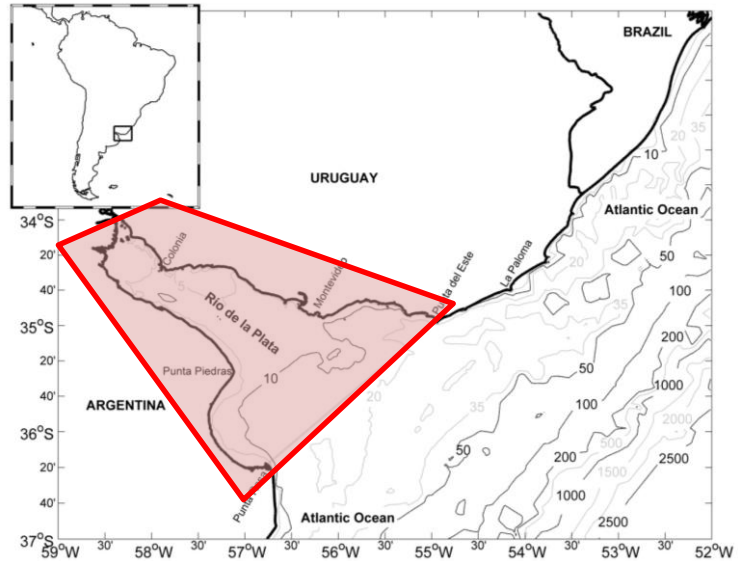


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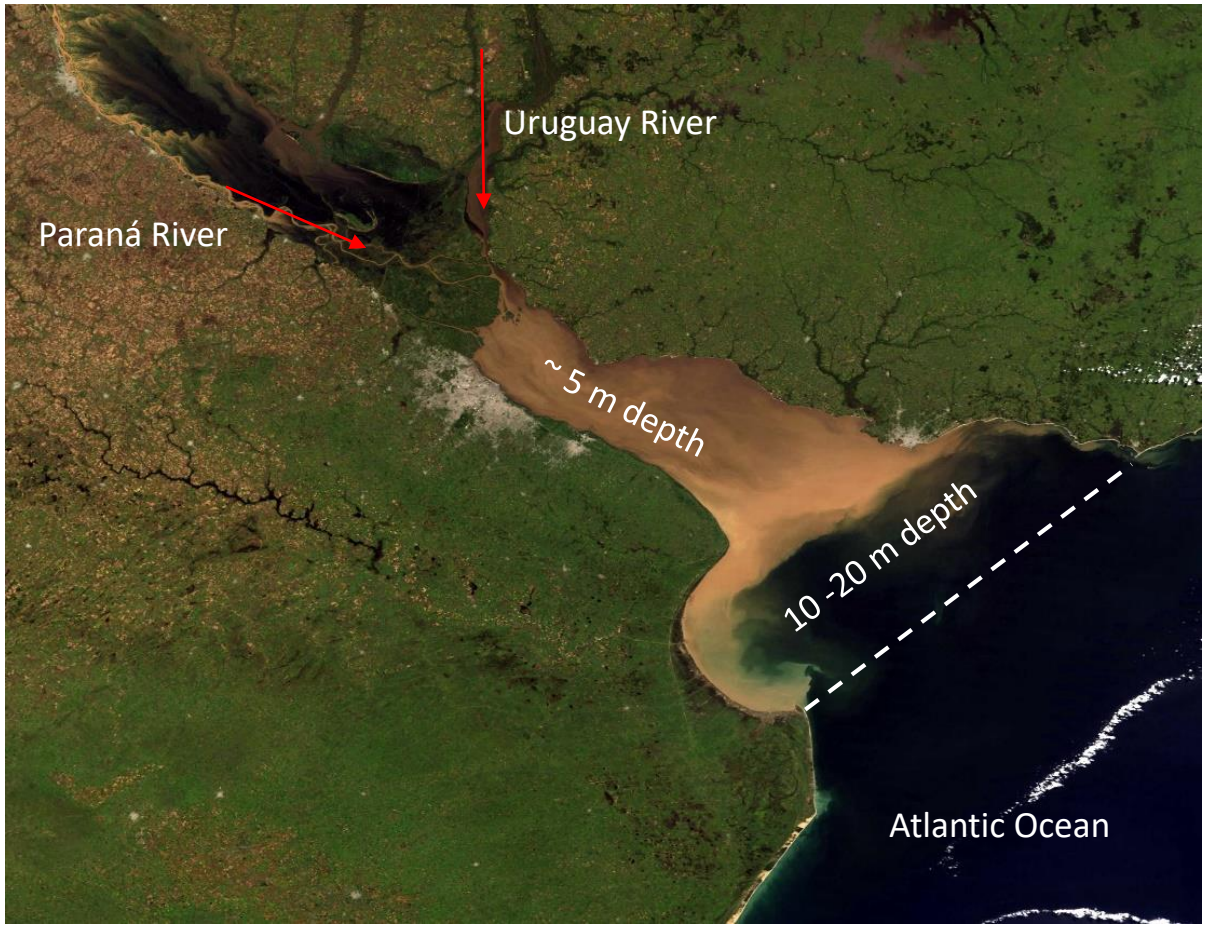
It is a large estuary formed by the confluence of Paraná and Uruguay rivers that discharge into the Atlantic Ocean. It is 290 km long and has a NW-SE orientation.




The outer zone is wide (O(200 km)), the depth varies between 10 and 20 m and the bottom is composed by sand,

The intermediate and inner zone is narrower (O(50 km)), shallower (O(5 m)) and the bottom is composed by fine sediment.

Scheme of the 1st hindcast

***Inputs:*** CFSR Winds 0.5°x 0.5° and 6 h

Bathimetry: GEBCO and nautical charts

Currents and water level variations: No

***Model:*** Wavewatch III v3.14, multi-grid mode (Global-Regional-Local), ST3 parametrization

***Outputs:*** Bulk wave paremeters (Hs, Tm, Tp, Dm, Dp,…) with 1'x 1' spatial resolution and 3 h time step.
Spectra series on 20 points.

GIS with all the nautical charts

~0.3°x 0.3° y 1 h

Yes, from TELEMAC 2D

***Inputs:*** CFSR Winds ~~0.5°x 0.5° and 6 h~~

Bathimetry: GEBCO and nautical charts

Currents and water level variations: ~~No~~

Global, South Atlantic, Regional, Local and Coast

ST4

v 5.16

***Model:*** Wavewatch III ~~v3.14~~, multi-grid mode ~~(Global-Regional-Local)~~, ~~ST3~~ parametrization

The Río de la Plata was taken into account for calibration

***Outputs:*** Bulk wave paremeters (Hs, Tm, Tp, Dm, Dp,…) with ~~1'x 1'~~ spatial resolution and

1 h ~~3 h~~ time step.

Spectra series on ~~20~~ points.

40 ''x 40 ''

Parameters of spectral partitions

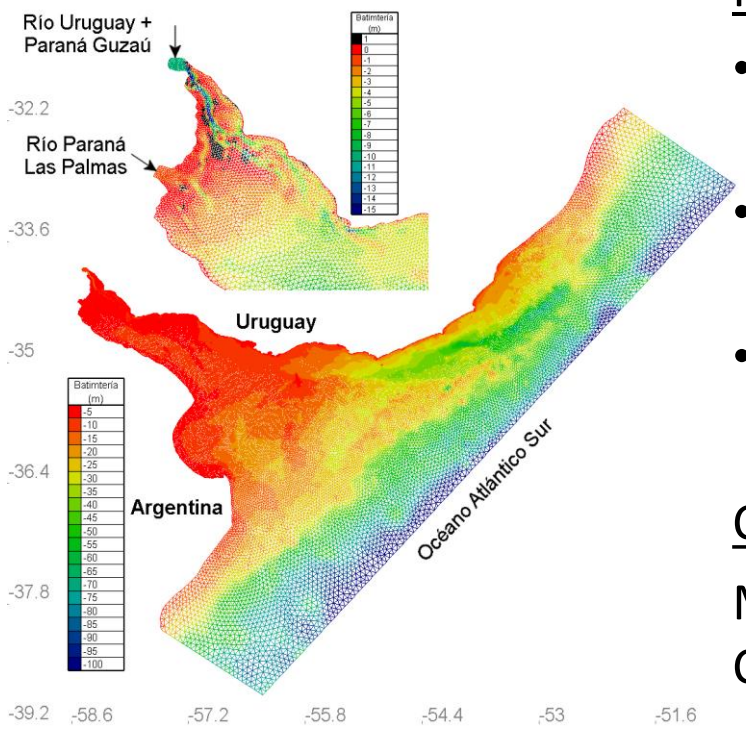
50 points

GIS with all the

- Incorporation of water levels and currents
- Winds with higher resolution
- Higher resolution of the wave model (spatial and spectra).
- New Parametrizations
- Calibration taken into account the Río de la Plata.
- More outputs with higher resolution.

50 points

TELEMAC 2D.
Non-structured grid ~1km resolution along the uruguayan coast

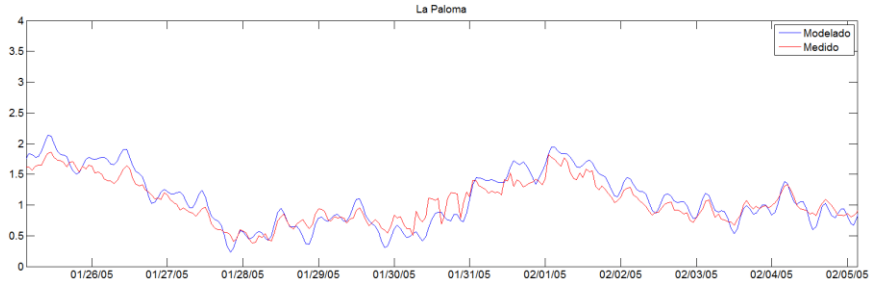


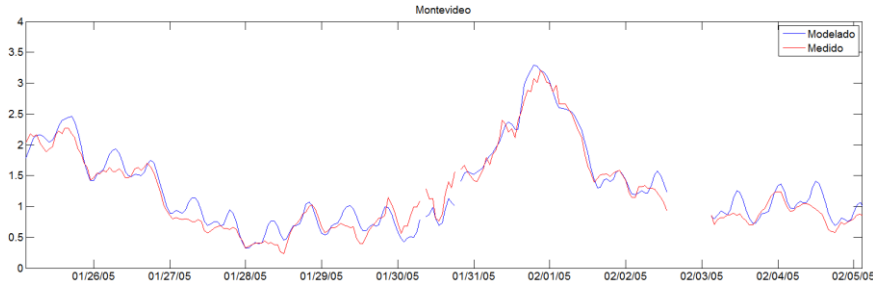

## Forcings:

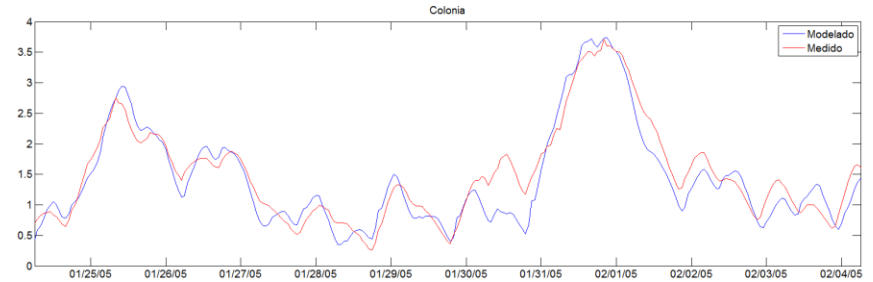
- Diary mean discharge of Uruguay and Paraná Rivers.
- Surface winds and pressure from CFSR
- Tides from AsTide

## Calibration

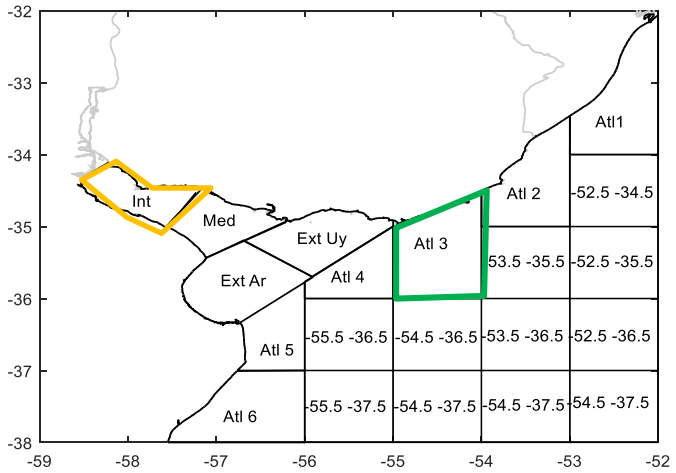
Manning (n) and Wind Drag ($C_D$).
Considering water level observations

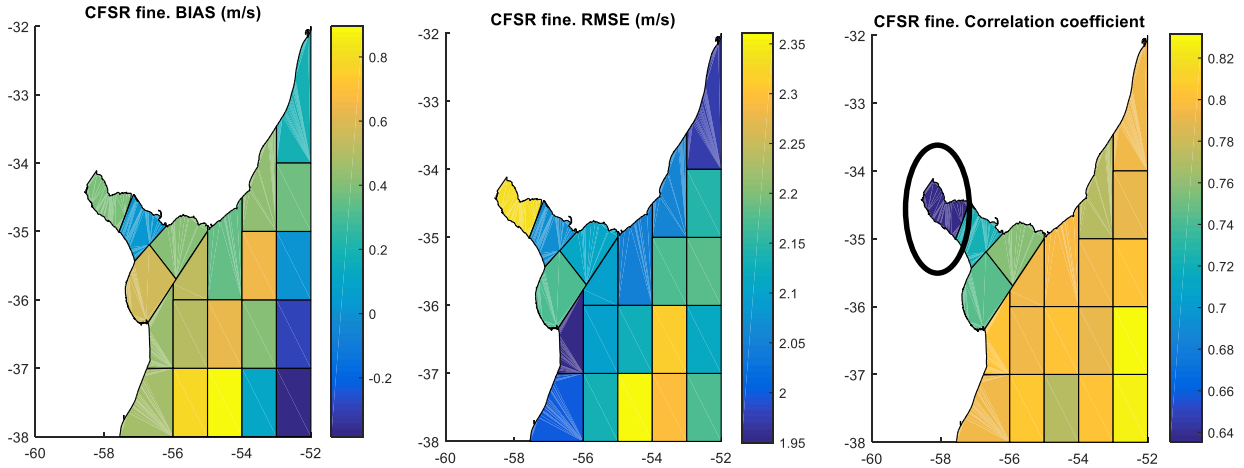


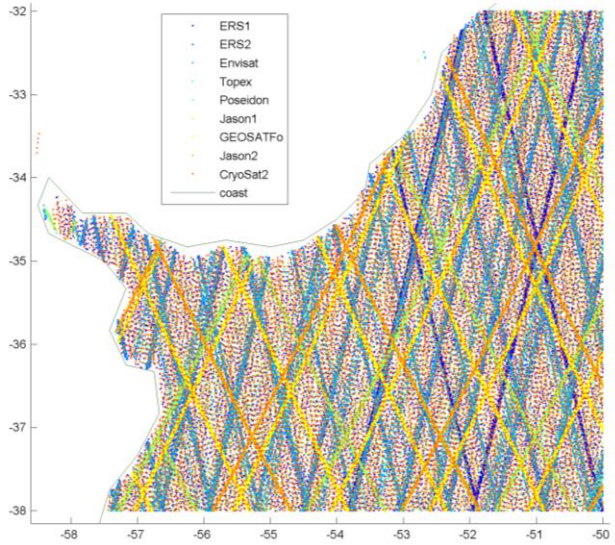



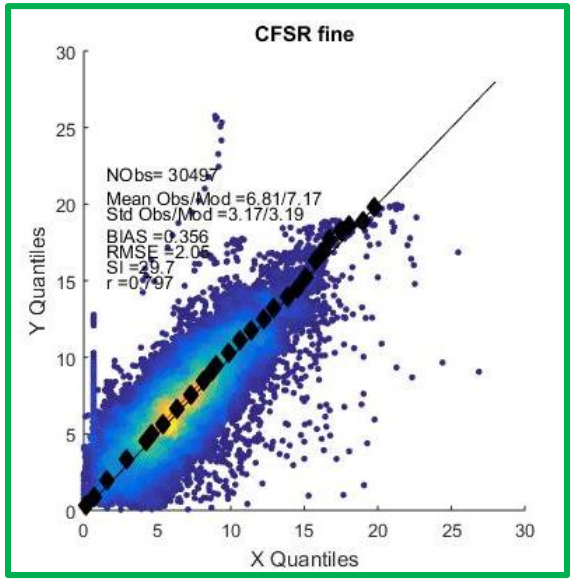



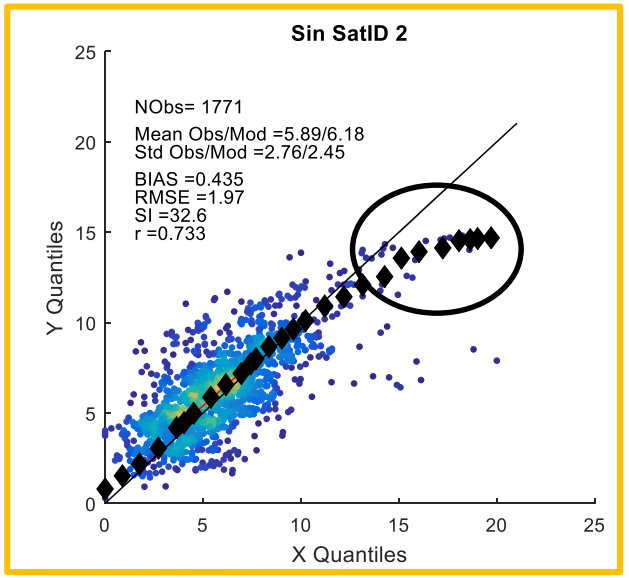

# Analysis for sub-regions considering altimetry data




Good general agreement

The worst performance is on the Inner RDP.

Differences on high cuantiles.

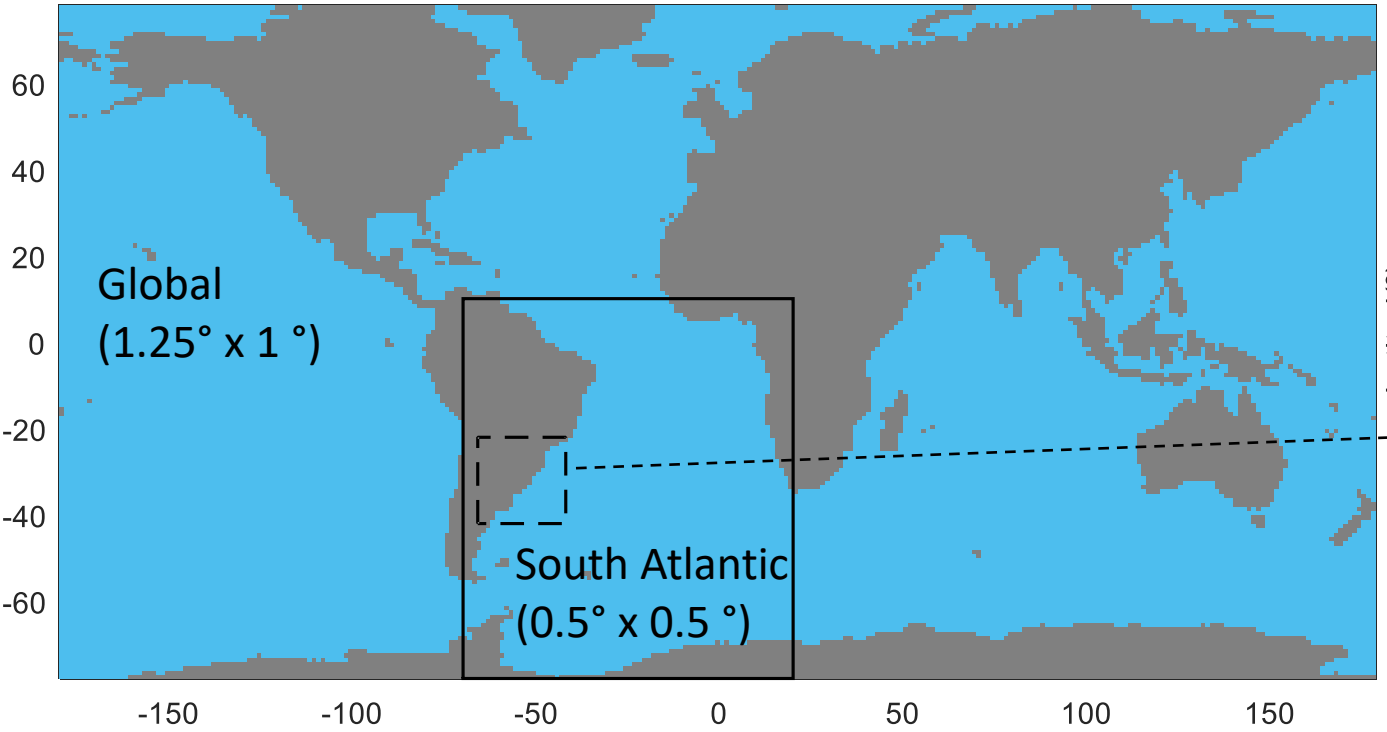
Caused by a few events.

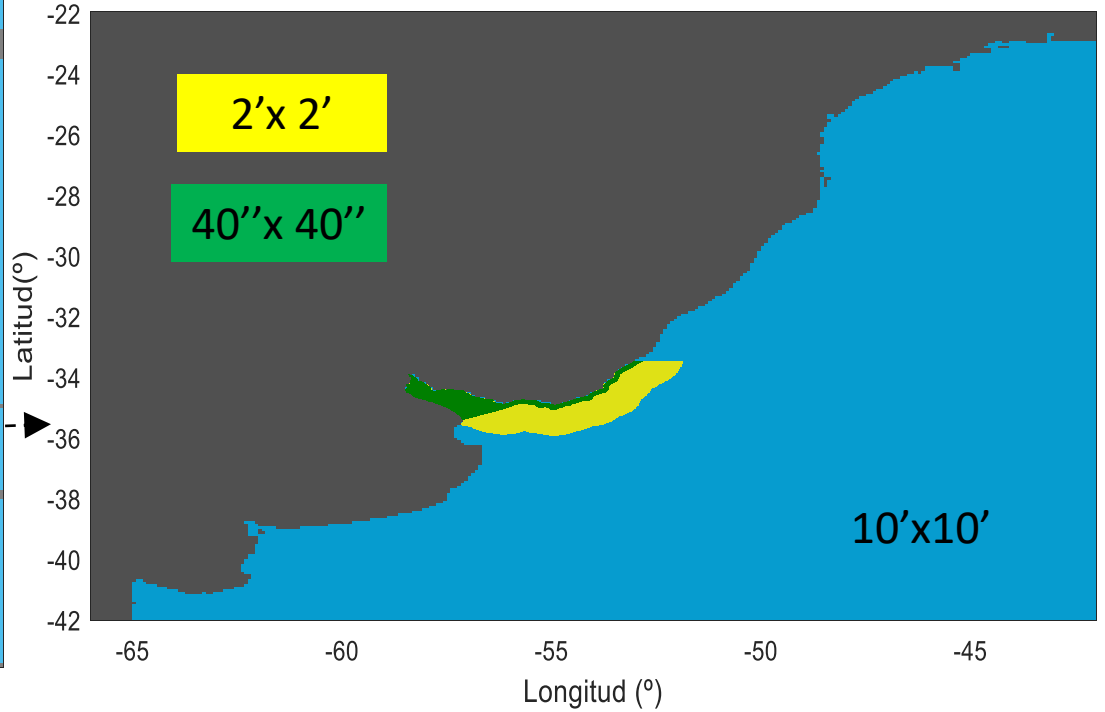
Not enough information to perform corrections.

## Configuration

WAVEWATCH III ® 5.16. Multi-grid mode.
Two-way nesting. 5 regular grids.

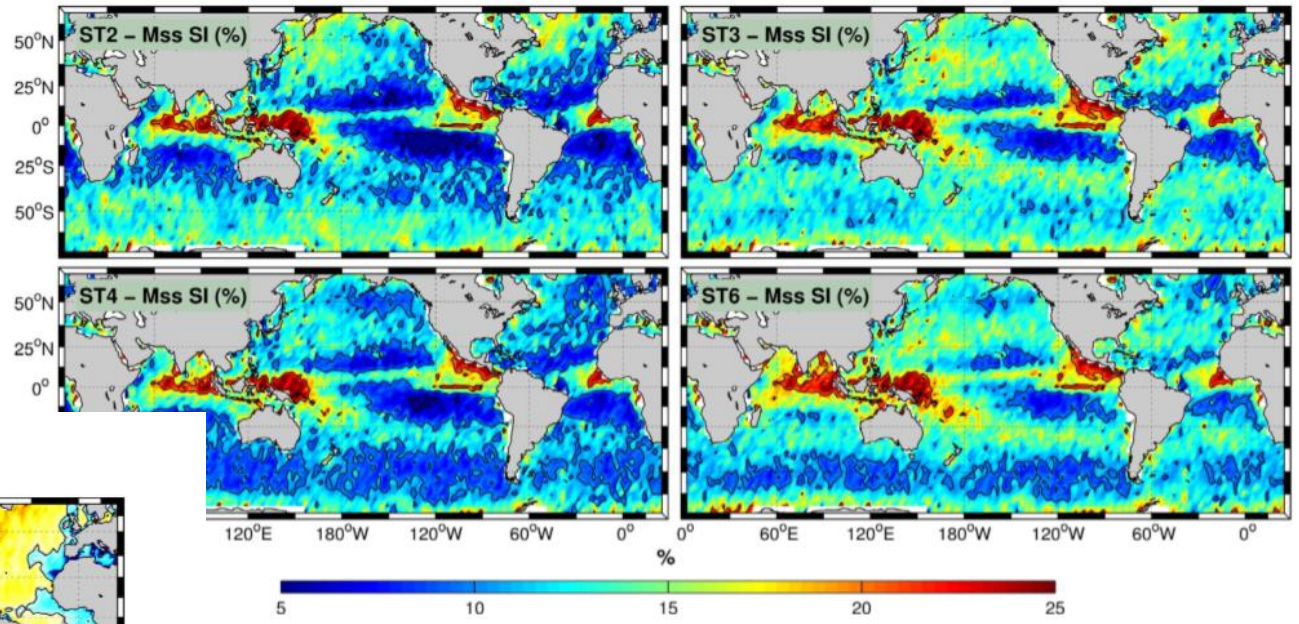
Forcings:
CFSR winds ~0.31° for all the grids.
TELEMAC wáter levels 2’ for high Rank grids (Green and yelllow)
TELEMAC currents 1’ for high Rank grids (Green and yelllow)




## Parametrization

Stopa et al. (2016). 1 year global hindcast for diferent parametrizations (ST2, ST3, **ST4** and ST5) contrasted with Hs altimeter data.




ter indices (in percentage) for ST2, ST ST3, ST4, and ST6 using co-located mean squared slopes from ENVISAT for 2011 gridded in 2° bins.



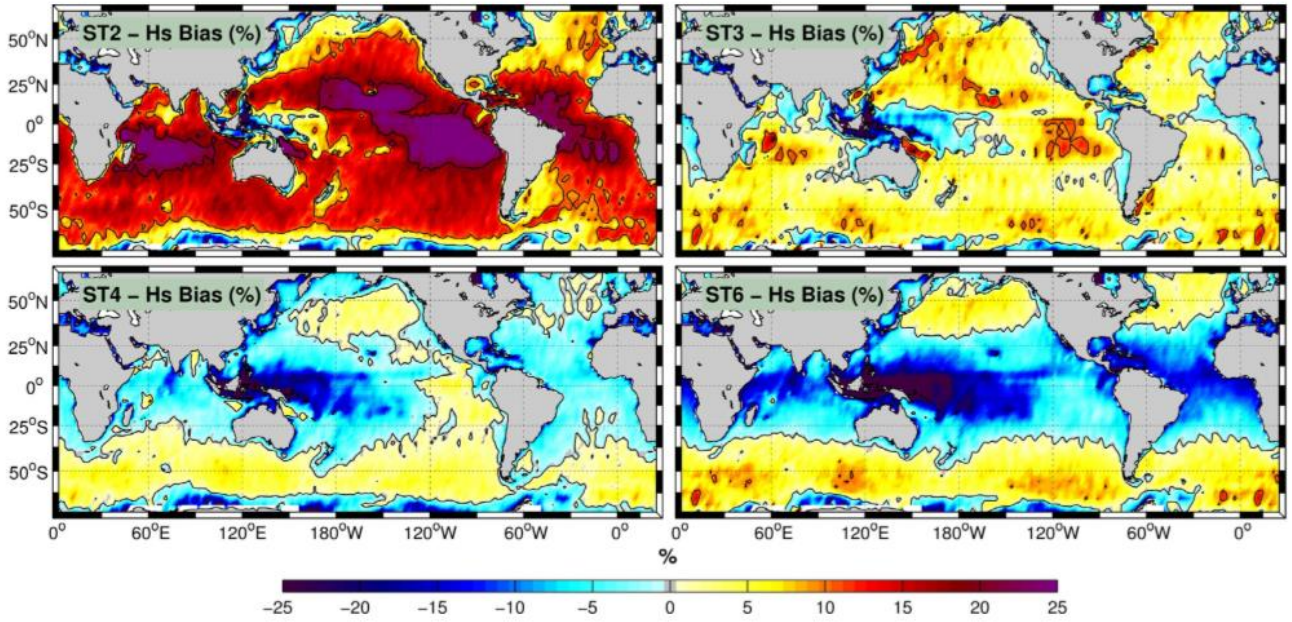
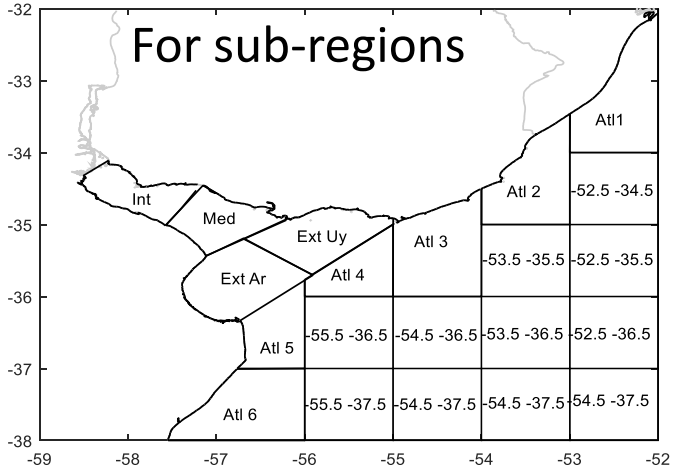


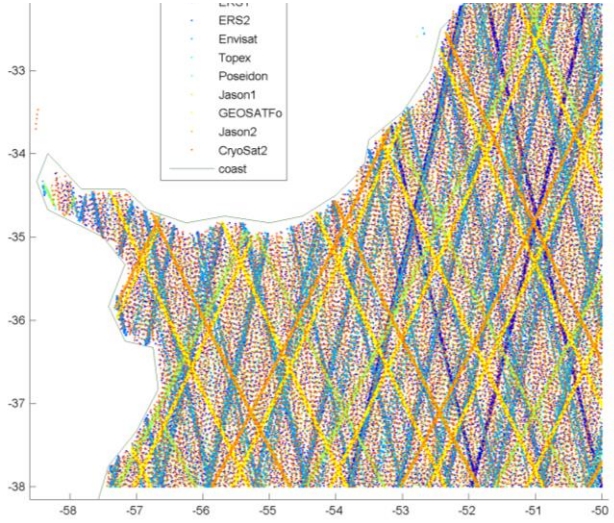

Fig. 3. Normalized wave height bias (in percentage) for ST2, ST3, ST4, and ST6 using co-located wave heights from ENVISAT for 2011 gridded in 2° bins.

**ST4** shows the best results for the western South Atlantic.

## Calibration




Altimetry data as reference




2002: More data than the average, and also more extreme data tan the average for all the sub-regions

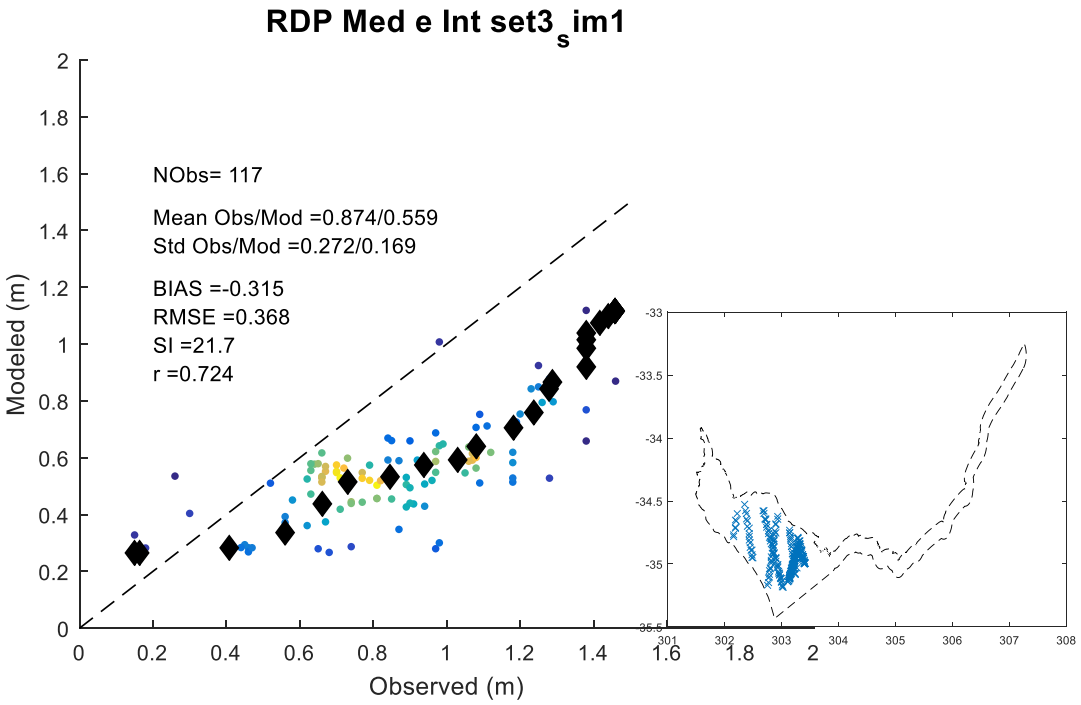
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Int2** | 0 | 52 | 102 | 91 | 187 | 156 | 64 | 84 | 99 | 108 | 11 | 121 | 210 | 108 | 155 | 102 | 121 | 109 | 203 | 29 | 55 | 201 | 41 | 109 |
| **Med2** | 0 | 241 | 570 | 598 | 728 | 734 | 625 | 617 | 610 | 686 | 73 | 1011 | 766 | 766 | 740 | 646 | 751 | 977 | 741 | 673 | 676 | 918 | 134 | 649 |
| **ExtU** | 0 | 257 | 561 | 461 | 783 | 736 | 581 | 587 | 542 | 662 | 78 | 1007 | 1234 | 715 | 1016 | 603 | 558 | 666 | 919 | 932 | 883 | 872 | 147 | 674 |
| **ExtA** | 0 | 378 | 640 | 605 | 932 | 914 | 689 | 720 | 691 | 896 | 101 | 1152 | 1057 | 967 | 971 | 831 | 839 | 961 | 742 | 671 | 737 | 1164 | 169 | 771 |
| **Atl1** | 88 | 1186 | 857 | 1547 | 1137 | 1024 | 814 | 752 | 821 | 871 | 98 | 1389 | 1405 | 1166 | 1196 | 1041 | 1091 | 1252 | 1058 | 978 | 897 | 1470 | 315 | 1015 |
| **Atl2** | 19 | 892 | 1460 | 1689 | 1672 | 1691 | 1440 | 1536 | 1470 | 1998 | 211 | 2925 | 2357 | 2202 | 2330 | 2069 | 1907 | 2437 | 1830 | 1826 | 1840 | 2272 | 286 | 1750 |
| **Atl3** | 0 | 474 | 1072 | 1092 | 1393 | 1234 | 1037 | 1139 | 1082 | 1335 | 148 | 2237 | 2114 | 1470 | 1921 | 1424 | 1270 | 1607 | 1575 | 1638 | 1699 | 1892 | 310 | 1326 |
| **Atl4** | 0 | 219 | 385 | 257 | 588 | 559 | 352 | 386 | 393 | 652 | 91 | 1110 | 1410 | 815 | 1249 | 753 | 623 | 540 | 784 | 826 | 896 | 720 | 113 | 633 |
| **Atl5** | 0 | 254 | 451 | 328 | 673 | 609 | 485 | 460 | 453 | 811 | 101 | 1368 | 1730 | 943 | 1535 | 861 | 733 | 645 | 1073 | 1108 | 1165 | 812 | 122 | 767 |
| **Atl6** | 0 | 303 | 457 | 370 | 836 | 719 | 471 | 491 | 498 | 855 | 101 | 1454 | 2394 | 928 | 1989 | 828 | 774 | 619 | 1704 | 1817 | 1835 | 1221 | 200 | 947 |
| **rec1** | 0 | 666 | 1659 | 1495 | 1998 | 1914 | 1621 | 1677 | 1672 | 2168 | 244 | 3228 | 2507 | 2338 | 2354 | 2172 | 1968 | 2465 | 1732 | 1682 | 1628 | 2182 | 288 | 1820 |
| **rec2** | 0 | 329 | 757 | 700 | 1051 | 926 | 745 | 781 | 762 | 950 | 110 | 1525 | 1731 | 1046 | 1500 | 968 | 849 | 1004 | 1168 | 1218 | 1332 | 1424 | 232 | 961 |
| **rec3** | 34 | 825 | 576 | 959 | 912 | 809 | 587 | 569 | 593 | 826 | 96 | 1521 | 2142 | 928 | 1725 | 856 | 751 | 703 | 1378 | 1383 | 1467 | 1149 | 219 | 951 |
| **rec4** | 37 | 959 | 1705 | 1961 | 2049 | 1926 | 1798 | 1807 | 1752 | 2289 | 248 | 3506 | 2557 | 2362 | 2519 | 2272 | 2153 | 2609 | 1898 | 1809 | 1843 | 2389 | 315 | 1956 |
| **rec5** | 0 | 513 | 1347 | 1367 | 1548 | 1542 | 1309 | 1379 | 1372 | 1454 | 156 | 2225 | 1722 | 1523 | 1602 | 1418 | 1466 | 1939 | 1449 | 1445 | 1452 | 2028 | 288 | 1389 |
| **rec6** | 0 | 535 | 1086 | 830 | 1498 | 1312 | 1032 | 1134 | 1087 | 1569 | 182 | 2406 | 2627 | 1729 | 2326 | 1638 | 1388 | 1603 | 1633 | 1645 | 1665 | 1608 | 264 | 1410 |
| **rec7** | 36 | 763 | 558 | 1054 | 876 | 709 | 596 | 578 | 598 | 973 | 121 | 1780 | 2098 | 1165 | 1828 | 1077 | 906 | 859 | 1285 | 1344 | 1563 | 1292 | 204 | 1016 |
| **rec8** | 67 | 1083 | 1420 | 1902 | 1724 | 1663 | 1477 | 1491 | 1472 | 1574 | 159 | 2394 | 1760 | 1549 | 1596 | 1491 | 1543 | 1989 | 1519 | 1486 | 1533 | 2068 | 313 | 1509 |
| **rec9** | 27 | 952 | 1324 | 1479 | 1676 | 1577 | 1342 | 1377 | 1379 | 1610 | 175 | 2436 | 2118 | 1673 | 1869 | 1576 | 1519 | 1839 | 1542 | 1486 | 1382 | 1840 | 278 | 1481 |
| **re10** | 76 | 921 | 456 | 1097 | 750 | 669 | 491 | 460 | 498 | 994 | 117 | 1639 | 2187 | 1093 | 1895 | 1032 | 863 | 693 | 1188 | 1361 | 1367 | 1077 | 205 | 965 |
| **re11** | 81 | 1127 | 483 | 1372 | 762 | 670 | 513 | 474 | 514 | 752 | 88 | 1429 | 2350 | 817 | 1850 | 731 | 671 | 569 | 1578 | 1750 | 1911 | 1163 | 228 | 986 |
| Total | 465 | 12929 | 17926 | 21254 | 23773 | 22093 | 18069 | 18499 | 18358 | 24033 | 2718 | 37863 | 38476 | 26303 | 34166 | 24389 | 22744 | 26085 | 26999 | 27107 | 27826 | 29762 | 4671 | |

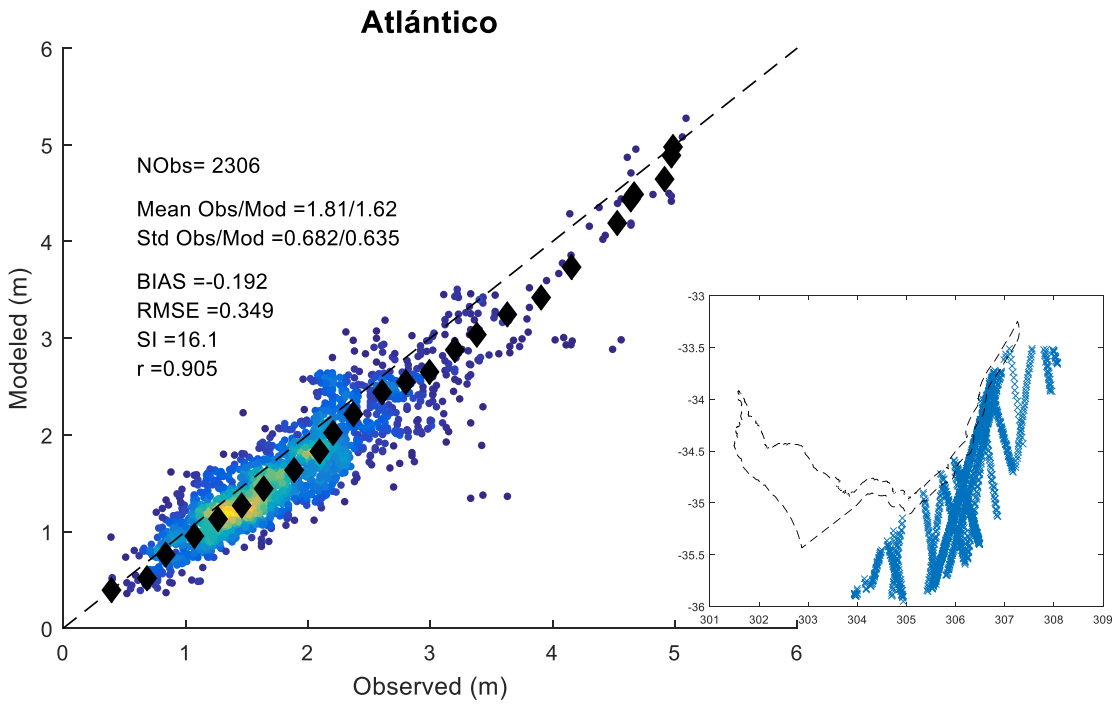
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Int2** | 0 | 3 | 14 | 17 | 9 | 29 | 27 | 11 | 19 | 12 | 1 | 11 | 9 | 4 | 5 | 4 | 14 | 5 | 12 | 3 | 8 | 10 | 3 | 11 |
| **Med2** | 0 | 16 | 81 | 49 | 50 | 37 | 36 | 94 | 48 | 77 | 11 | 85 | 75 | 61 | 121 | 43 | 73 | 118 | 74 | 76 | 61 | 56 | 12 | 63 |
| **ExtU** | 0 | 30 | 49 | 32 | 116 | 54 | 28 | 46 | 35 | 31 | 4 | 111 | 135 | 109 | 96 | 51 | 52 | 42 | 131 | 161 | 98 | 93 | 5 | 67 |
| **ExtA** | 0 | 17 | 105 | 61 | 81 | 86 | 50 | 82 | 74 | 102 | 12 | 73 | 75 | 103 | 109 | 53 | 61 | 124 | 97 | 73 | 86 | 96 | 14 | 76 |
| **Atl1** | 2 | 107 | 51 | 114 | 117 | 55 | 51 | 86 | 103 | 73 | 16 | 307 | 93 | 173 | 66 | 88 | 101 | 126 | 90 | 95 | 91 | 94 | 59 | 100 |
| **Atl2** | 0 | 77 | 154 | 166 | 182 | 154 | 145 | 117 | 106 | 283 | 23 | 271 | 268 | 201 | 159 | 132 | 184 | 294 | 170 | 159 | 284 | 218 | 24 | 173 |
| **Atl3** | 0 | 13 | 139 | 88 | 159 | 91 | 99 | 117 | 104 | 141 | 15 | 208 | 250 | 170 | 153 | 118 | 109 | 124 | 122 | 160 | 286 | 187 | 15 | 131 |
| **Atl4** | 0 | 44 | 81 | 19 | 115 | 57 | 34 | 29 | 48 | 64 | 7 | 108 | 120 | 89 | 75 | 84 | 47 | 30 | 79 | 97 | 89 | 51 | 4 | 63 |
| **Atl5** | 0 | 45 | 57 | 18 | 137 | 89 | 26 | 38 | 60 | 60 | 1 | 111 | 75 | 122 | 181 | 59 | 53 | 61 | 144 | 129 | 103 | 84 | 0 | 77 |
| **Atl6** | 0 | 26 | 46 | 14 | 130 | 80 | 54 | 40 | 55 | 78 | 7 | 106 | 243 | 117 | 147 | 80 | 42 | 55 | 113 | 346 | 149 | 148 | 0 | 93 |
| **rec1** | 0 | 43 | 239 | 143 | 261 | 124 | 108 | 189 | 133 | 222 | 27 | 222 | 371 | 310 | 217 | 250 | 183 | 228 | 102 | 129 | 224 | 177 | 20 | 181 |
| **rec2** | 0 | 43 | 107 | 81 | 196 | 72 | 82 | 81 | 44 | 67 | 11 | 105 | 196 | 168 | 135 | 84 | 95 | 83 | 71 | 98 | 115 | 134 | 32 | 96 |
| **rec3** | 0 | 59 | 59 | 103 | 137 | 41 | 56 | 26 | 83 | 66 | 7 | 144 | 264 | 131 | 238 | 84 | 75 | 71 | 127 | 112 | 116 | 76 | 42 | 95 |
| **rec4** | 0 | 78 | 173 | 185 | 265 | 168 | 200 | 157 | 170 | 242 | 29 | 353 | 258 | 221 | 278 | 183 | 161 | 259 | 210 | 168 | 166 | 269 | 34 | 195 |
| **rec5** | 0 | 53 | 233 | 144 | 192 | 107 | 130 | 119 | 121 | 116 | 15 | 142 | 236 | 223 | 142 | 132 | 112 | 205 | 111 | 102 | 181 | 216 | 7 | 138 |
| **rec6** | 0 | 34 | 132 | 76 | 233 | 108 | 109 | 119 | 98 | 176 | 18 | 193 | 278 | 173 | 152 | 198 | 151 | 81 | 106 | 125 | 288 | 160 | 53 | 140 |
| **rec7** | 0 | 62 | 49 | 110 | 100 | 29 | 41 | 48 | 53 | 89 | 11 | 202 | 209 | 217 | 238 | 96 | 66 | 101 | 123 | 110 | 121 | 132 | 24 | 101 |
| **rec8** | 0 | 91 | 147 | 208 | 213 | 138 | 126 | 104 | 144 | 181 | 19 | 253 | 147 | 148 | 145 | 134 | 173 | 181 | 154 | 113 | 151 | 218 | 35 | 148 |
| **rec9** | 0 | 116 | 121 | 178 | 151 | 122 | 121 | 130 | 102 | 193 | 17 | 256 | 229 | 225 | 157 | 103 | 159 | 173 | 150 | 157 | 152 | 171 | 34 | 147 |
| **re10** | 0 | 102 | 58 | 113 | 109 | 51 | 39 | 19 | 71 | 84 | 16 | 230 | 169 | 134 | 208 | 43 | 86 | 105 | 101 | 119 | 84 | 82 | 34 | 96 |
| **re11** | 0 | 120 | 63 | 133 | 108 | 42 | 38 | 15 | 79 | 38 | 11 | 240 | 231 | 135 | 189 | 60 | 79 | 76 | 127 | 131 | 135 | 84 | 31 | 98 |
| Total | 2 | 1179 | 2158 | 2052 | 3061 | 1734 | 1600 | 1667 | 1750 | 2395 | 296 | 3731 | 3931 | 3234 | 3211 | 2079 | 2076 | 2542 | 2414 | 2663 | 2988 | 2756 | 482 | |




## Calibration

Results with default parameters (4 month simulation)



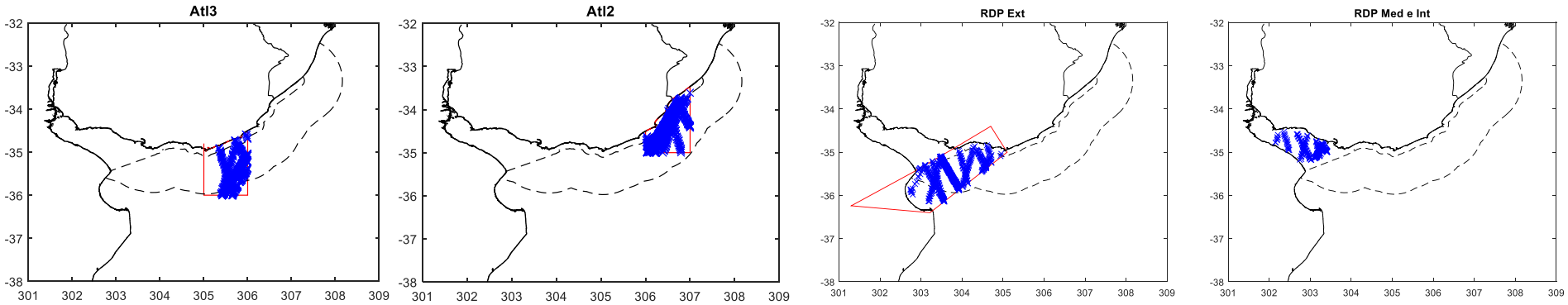

**BETAMAX** from ST4 wind input parametrization and **GAMMA** from JONSWAP bottom friction parametrization were chosen to tune.

## Calibration

No bottom friction →

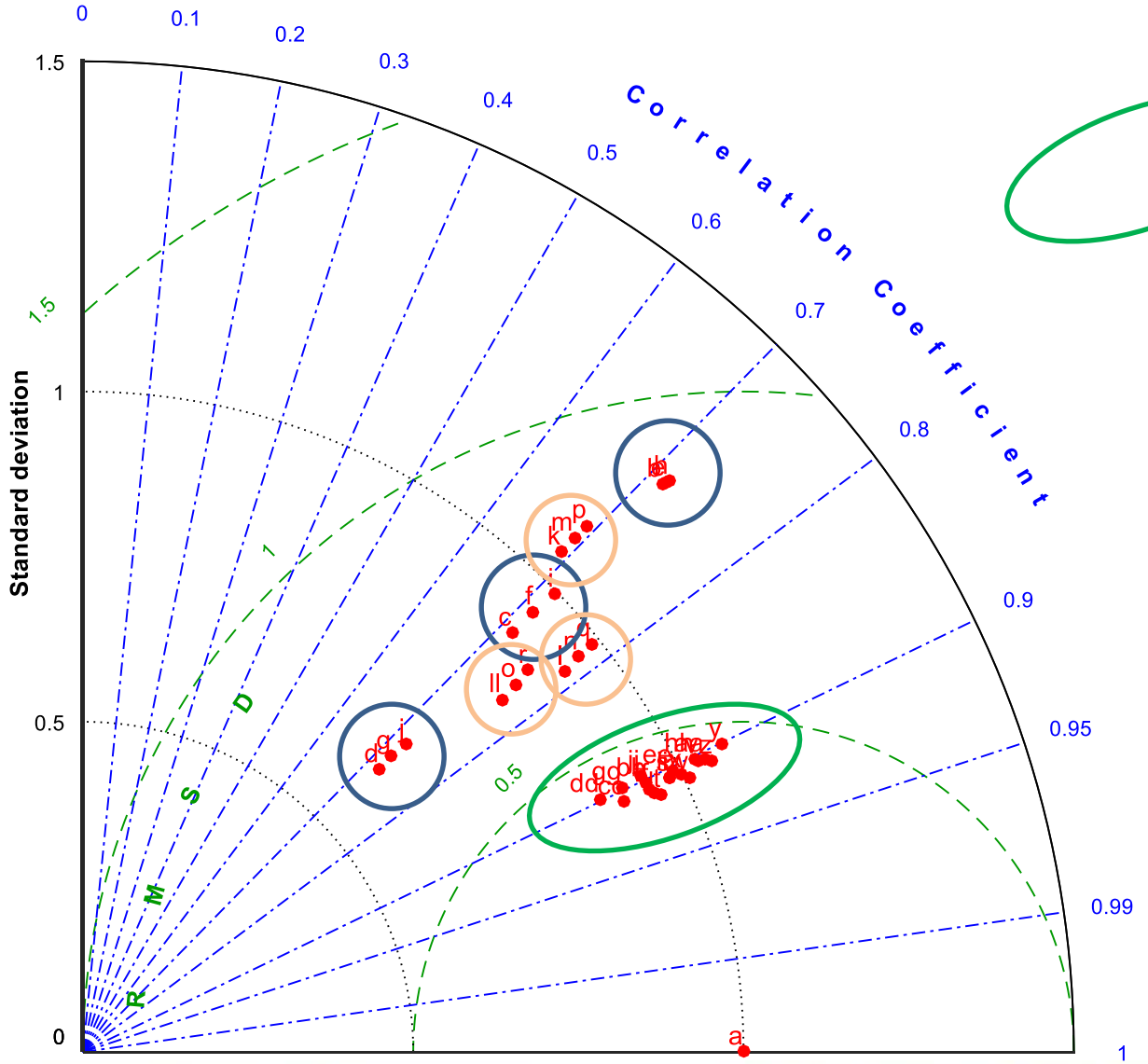
| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | **SIM11** | **SIM12** | **SIM13** |
| GAMMA=-0.03 | **SIM21** | **SIM22** | **SIM23** |
| GAMMA=-0.067 | **SIM31** | **SIM32** | **SIM33** |

[GAMMA]=$m^2s^{-3}$ Default




**Atl3** **Atl2** **RDP Ext** **RDP Med e Int**

## Calibration

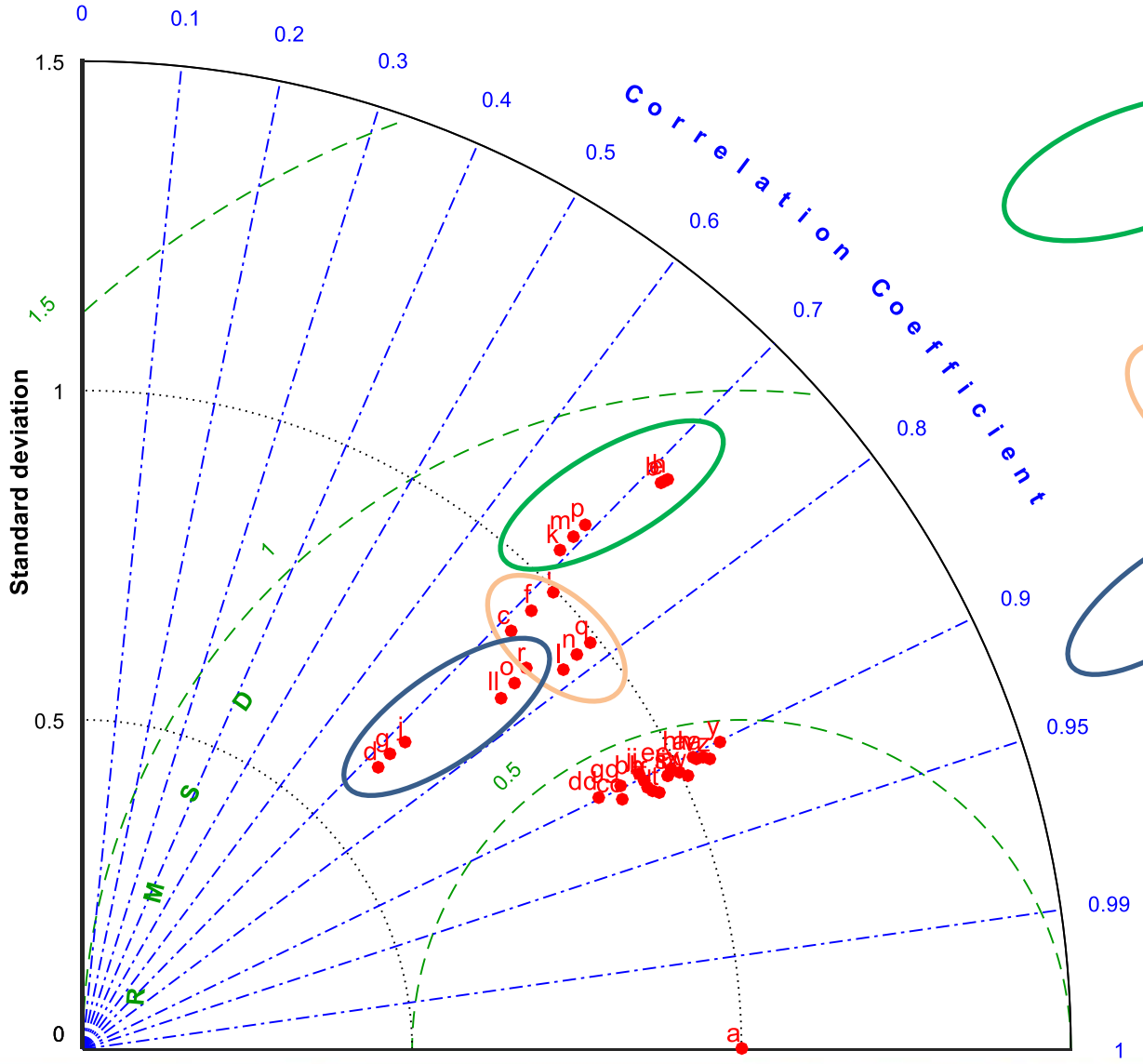



Atlantic coast (Atl3 and Atl 2)

Outer Río de la Plata (RDP Ext)

Middle Río de la Plata (RDP Med)

## Calibration




GAMMA = 0 (No bottom friction)

GAMMA = -0.03 $m^2s^{-3}$

GAMMA = -0.067 $m^2s^{-3}$ (Default)

## Calibration

BIAS (m)

**RDP Med e Int**

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 0.4 | 0.43 | 0.45 |
| GAMMA=-0.03 | -0.19 | -0.16 | -0.14 |
| GAMMA=-0.067 | -0.32 | -0.29 | -0.27 |

**RDP Ext**

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 0.12 | 0.15 | 0.17 |
| GAMMA=-0.03 | -0.17 | -0.14 | -0.12 |
| GAMMA=-0.067 | -0.30 | -0.27 | -0.25 |

**Atl3**

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 0.02 | 0.06 | 0.10 |
| GAMMA=-0.03 | -0.07 | -0.02 | 0.01 |
| GAMMA=-0.067 | -0.15 | -0.11 | -0.07 |

**Atl2**

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | -0.01 | 0.02 | 0.06 |
| GAMMA=-0.03 | -0.1 | -0.11 | -0.08 |
| GAMMA=-0.067 | -0.26 | -0.23 | -0.20 |

## Calibration

SI

### RDP Med e Int

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 27 | 27 | 27.1 |
| GAMMA=-0.03 | 22.5 | 22.9 | 23.3 |
| GAMMA=-0.067 | 21.7 | 21.6 | 21.5 |

### RDP Ext

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 39.6 | 40.3 | 40.9 |
| GAMMA=-0.03 | 31.3 | 31.9 | 32 |
| GAMMA=-0.067 | 31.8 | 32.2 | 32.6 |

### Atl3

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 15.8 | 16.5 | 17.2 |
| GAMMA=-0.03 | 15.1 | 15.7 | 16.4 |
| GAMMA=-0.067 | 15.3 | 15.9 | 16.5 |

### Atl2

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | 15.7 | 16 | 16.3 |
| GAMMA=-0.03 | 15.2 | 15.3 | 15.6 |
| GAMMA=-0.067 | 16 | 16 | 16.2 |

## Calibration

BIAS

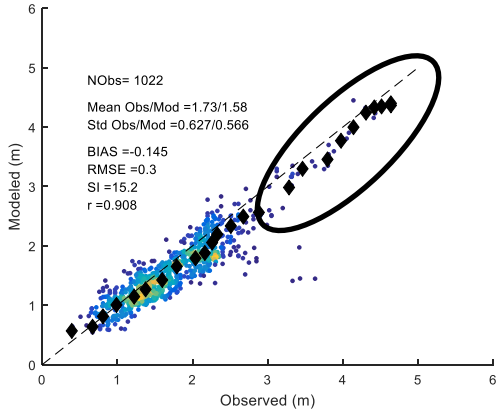
| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | + | + | + |
| GAMMA=-0.03 | - | - | - |
| GAMMA=-0.067 | - | - | - |

← Zero Bias, GAMMA between 0 and -0.03 $m^2s^{-3}$

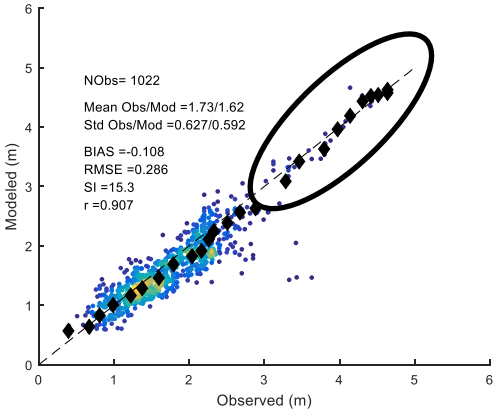
SI →

| | BETAMAX=1.43 | BETAMAX=1.55 | BETAMAX=1.66 |
|---|---|---|---|
| GAMMA=0 | | | |
| GAMMA=-0.03 | Minimun | | |
| GAMMA=-0.067 | | | |

BETAMAX =1.43

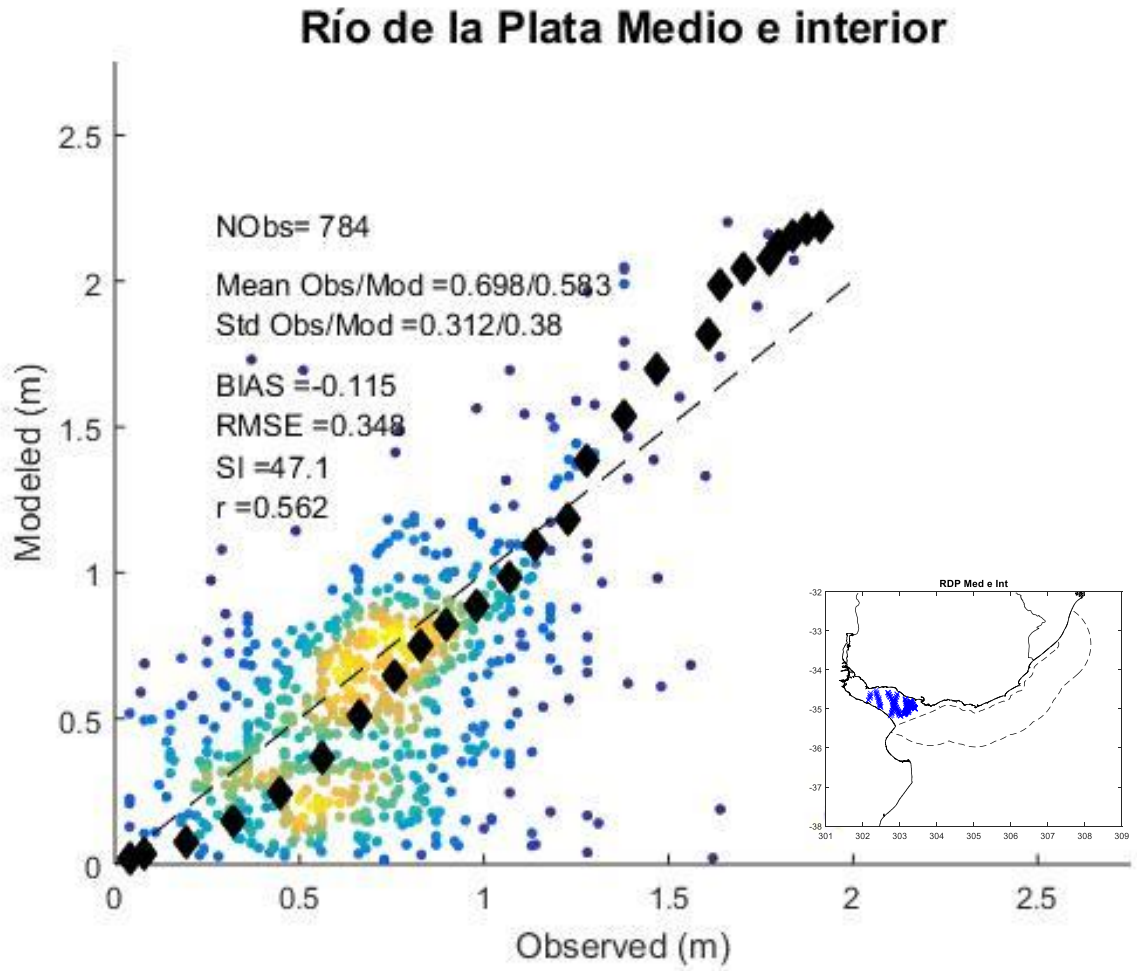



BETAMAX =1.55

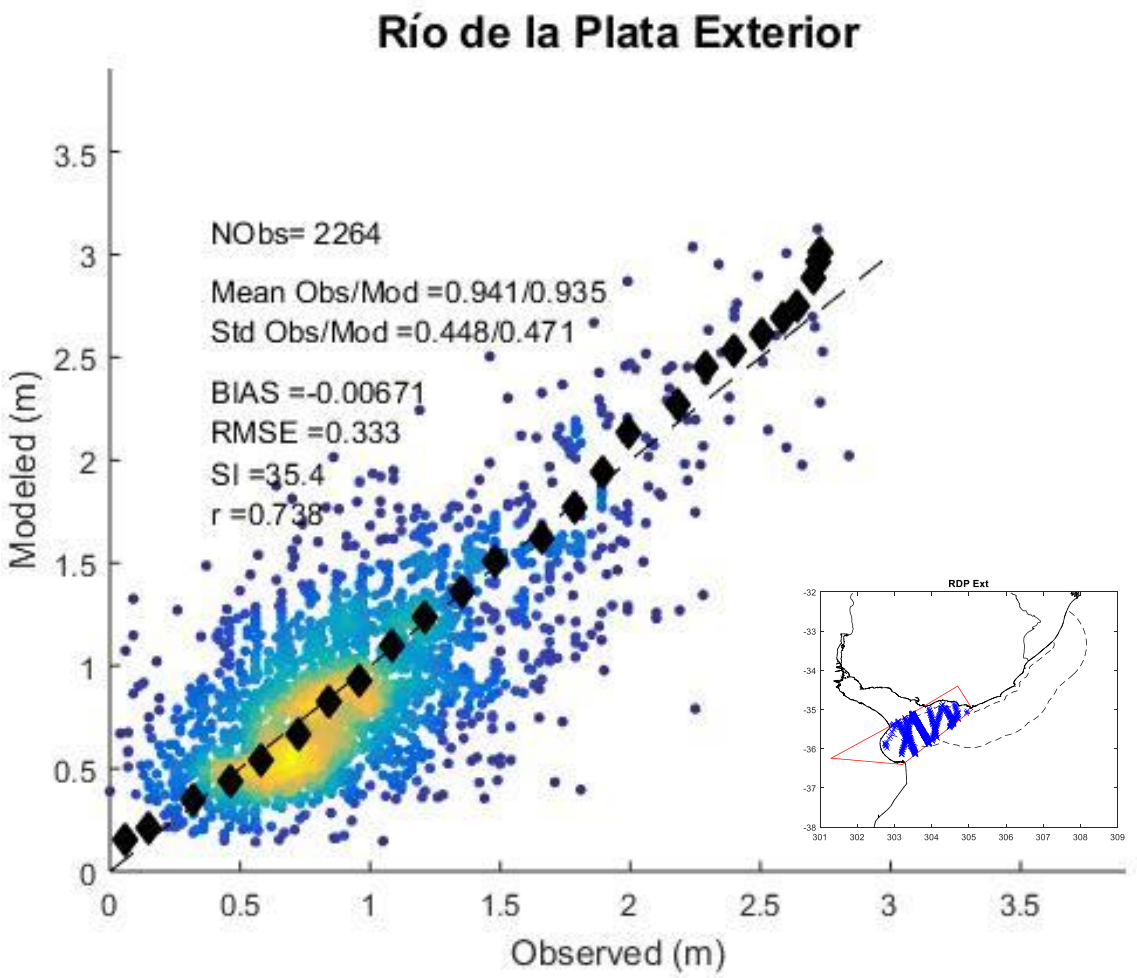



We set **BETAMAX = 1.55**, and continue tunning GAMMA. Obtaining the better results for **GAMMA=-0.012 $m^2s^{-3}$**

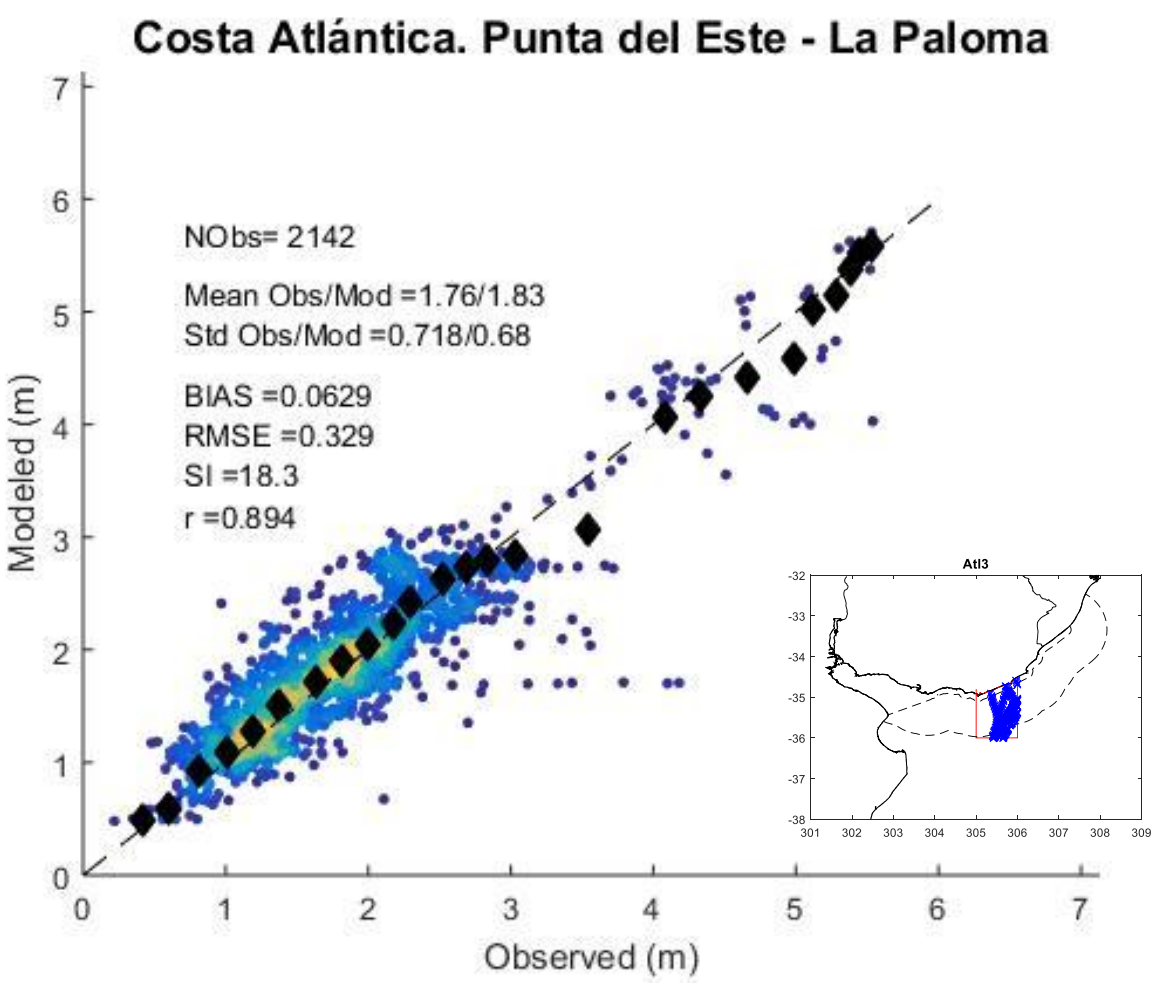
## RDP Med e Int



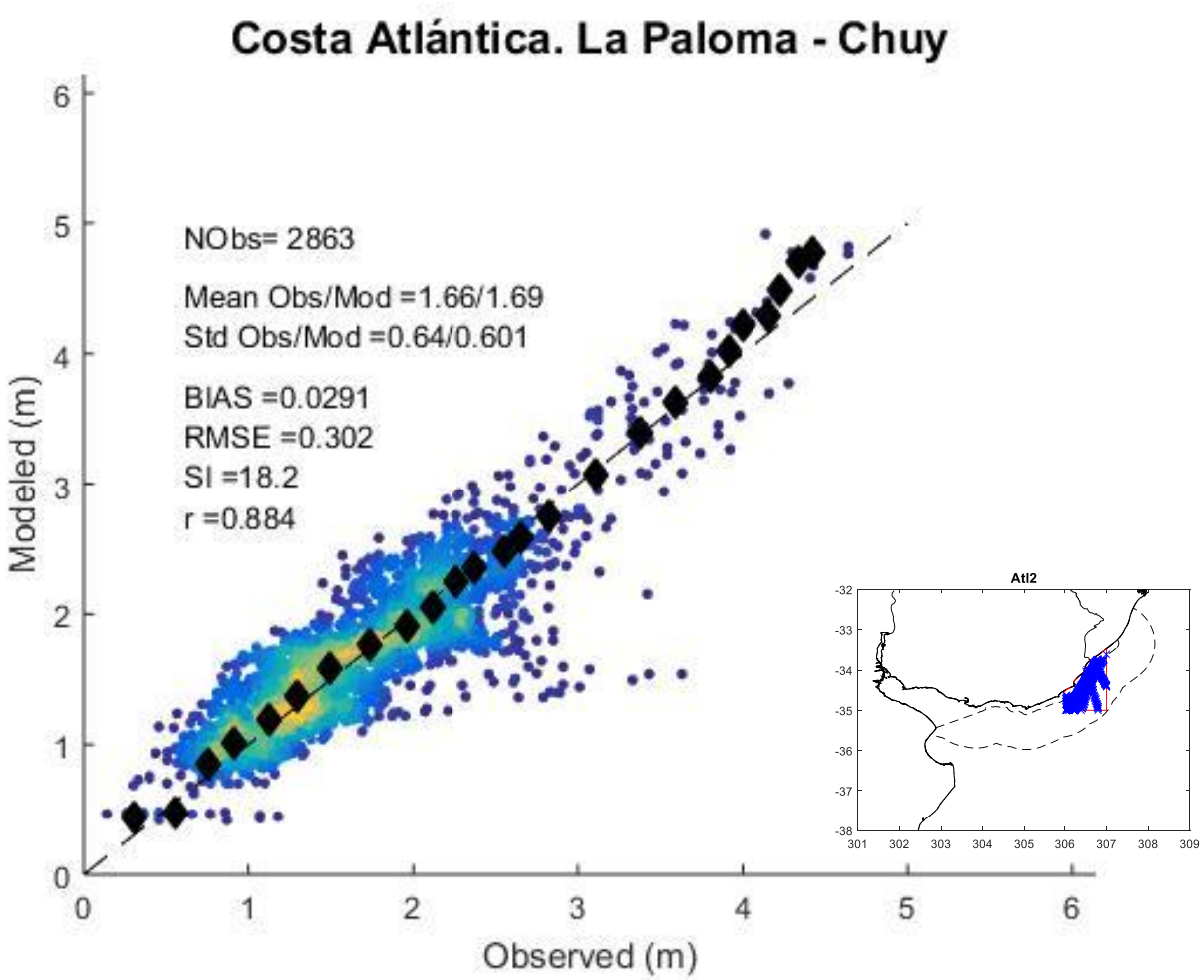

## RDP Ext



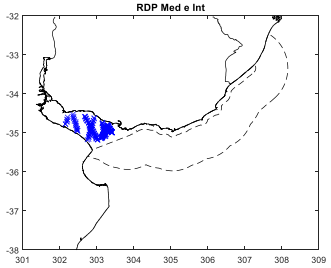

## Atl3


Costa Atlántica. Punta del Este - La Paloma
NObs= 2142
Mean Obs/Mod =1.76/1.83
Std Obs/Mod =0.718/0.68
BIAS =0.0629
RMSE =0.329
SI =18.3
r =0.894
Modeled (m)
Observed (m)
Atl3

## Atl2

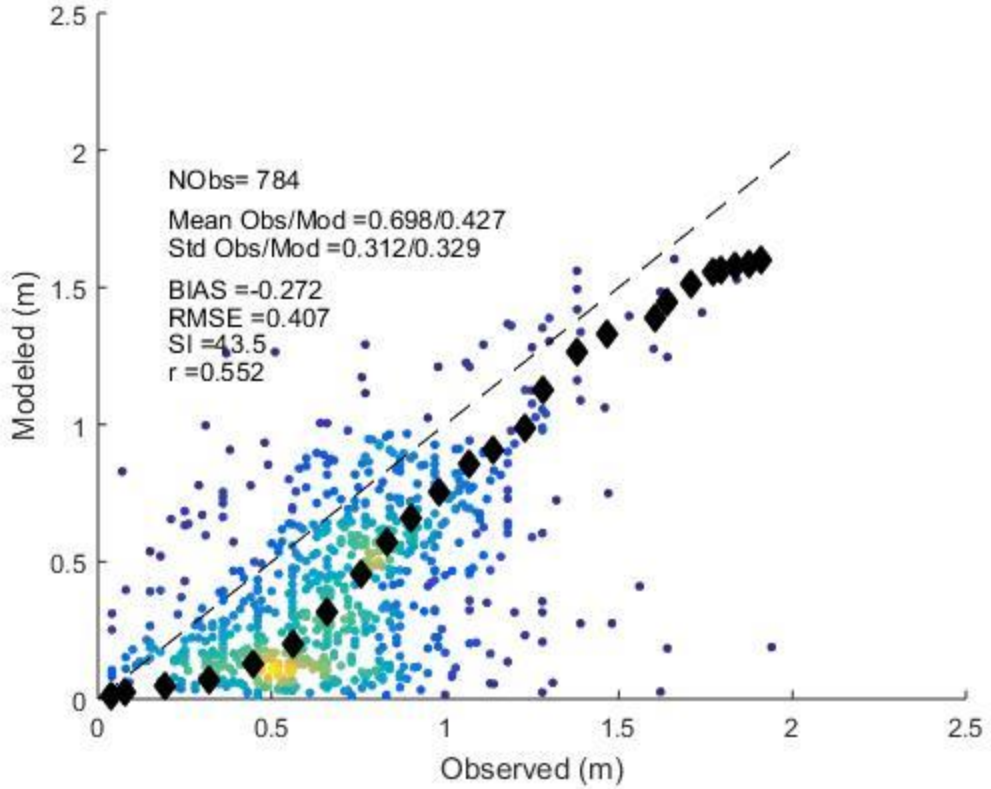

Costa Atlántica. La Paloma - Chuy
NObs= 2863
Mean Obs/Mod =1.66/1.69
Std Obs/Mod =0.64/0.601
BIAS =0.0291
RMSE =0.302
SI =18.2
r =0.884
Modeled (m)
Observed (m)
Atl2


ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018

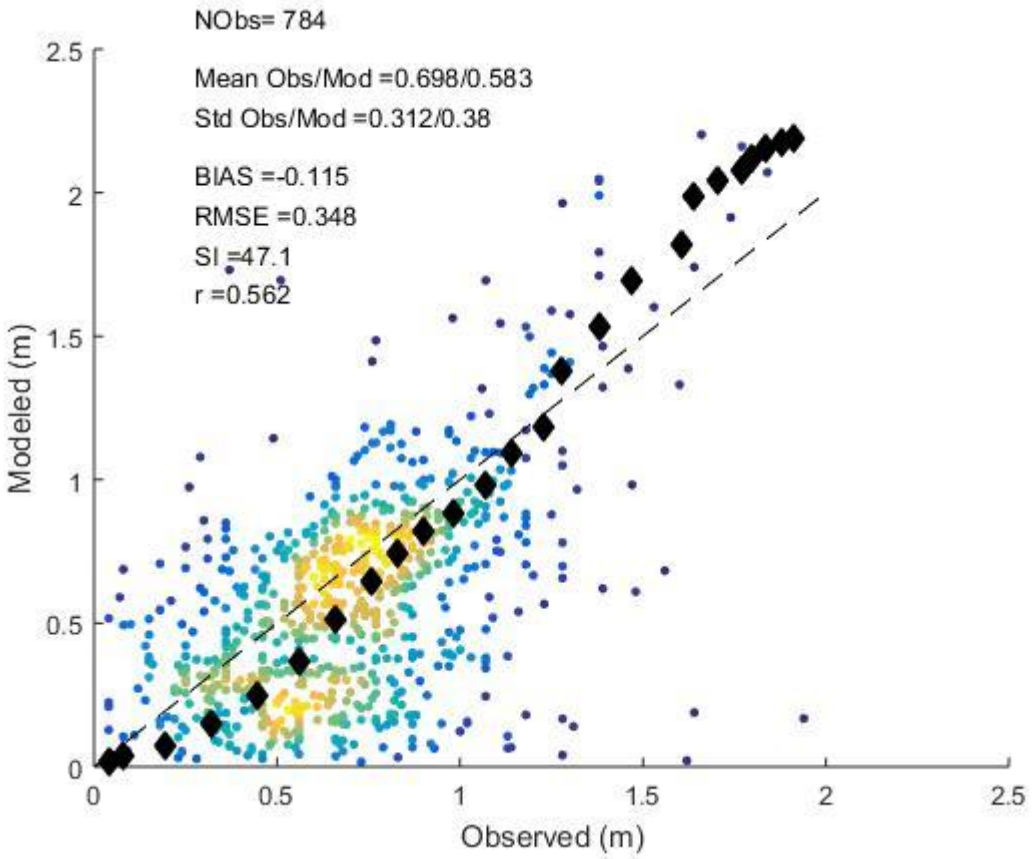



# Middle RDP

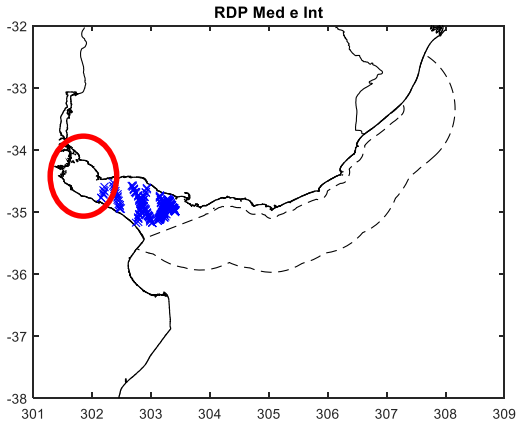
## 1st Hindcast

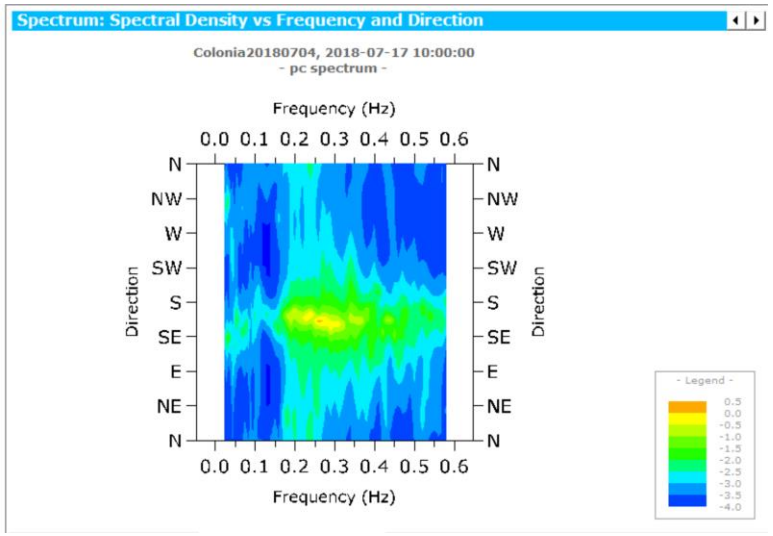



## The New




- A new wave hindcast for Uruguay was recently developed.
- It has a better performance than the previous one, particularly for the Río de la Plata.
- Results show the key role of bottom friction. So, parametrizations newer than JONSWAP must be tested, and more research is needed.
- A big portion of the errors that still persist are inherited from the wind fields. So improving them must be included on future works.
- In-situ measures are necessary to have better reference data than the provided by altimetry.

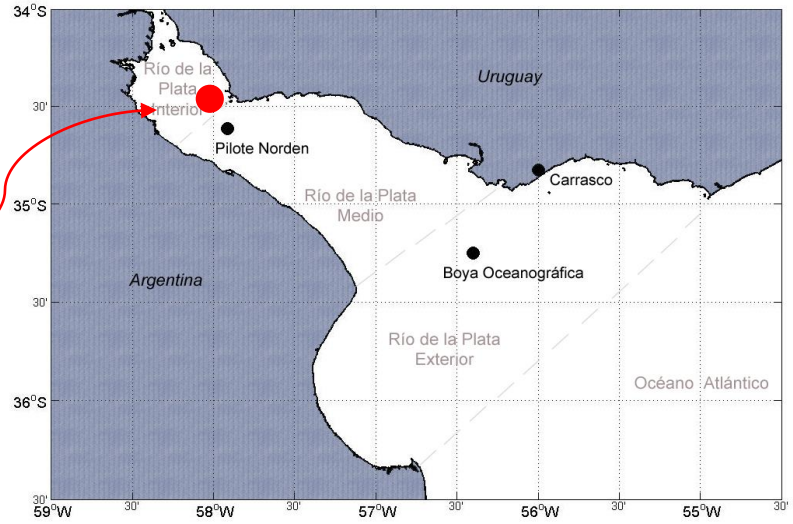




No altimetry data for the Inner RDP.

We recently deployed a GPS buoy Datawell (DWG-4)







# Thanks for your attention!

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