Wave climate from spectra and its impact on Longshore Sediment Transport

Rodrigo Alonso and Sebastián Solari

Instituto de Mecánica de los Fluidos e Ingeniería Ambiental.

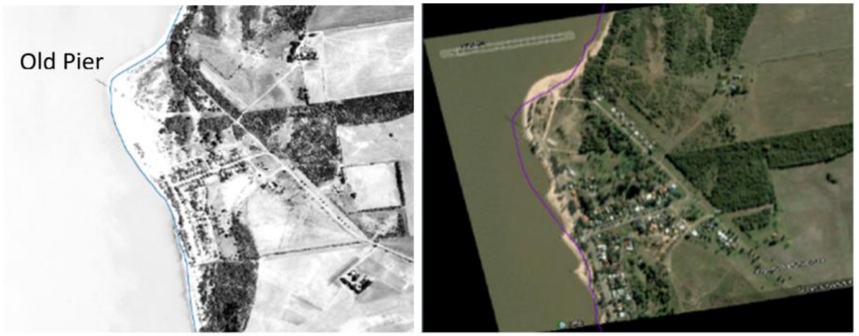
Facultad de Ingeniería.

Universidad de la República, Uruguay.

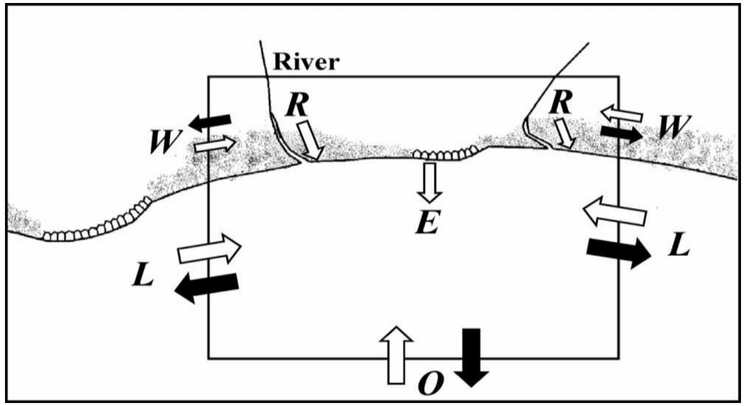
MOTIVATION

Longshore Sediment Transport (LST) is strong involved in most of shoreline changes at medium-term (i.e from month to decades).

Alonso et al. (2015)



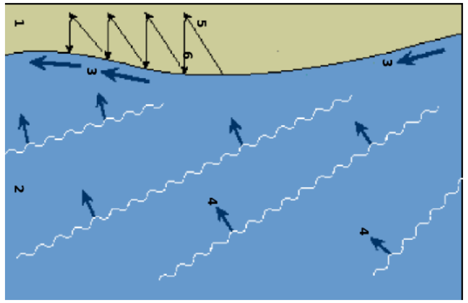
Alonso et al. (2018)



$$\frac{\partial V}{\partial t} = R + E + W_{in} + L_{in} + O_{in} - (W_{out} + L_{out} + O_{out}) \quad (1)$$

Usually the highest term on Coastal Sediment Budgets

LST is governed by wave climate.



Apply state of the art approaches of wave climatology to enhance LST assesment

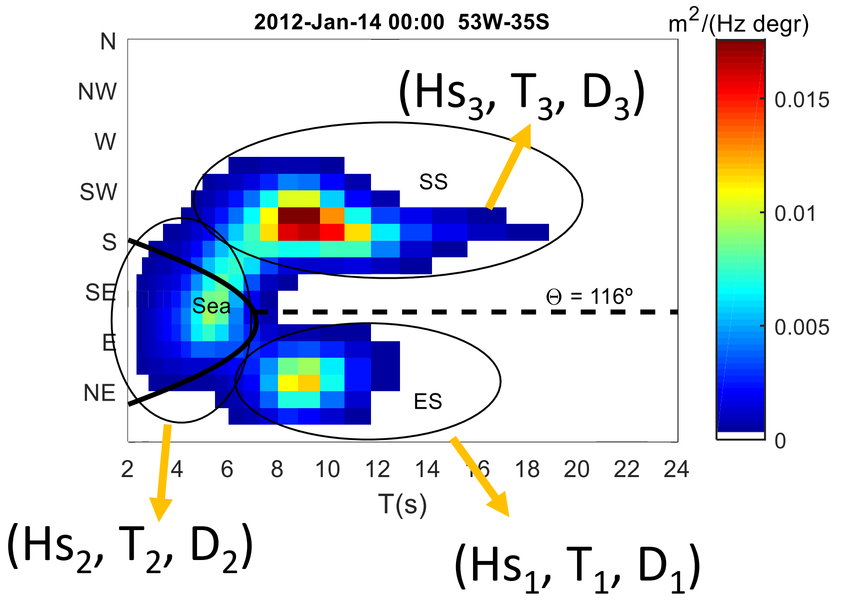
Approches of wave climatology used:

Long-term wave systems. Portilla et al. (2015)

Maximum correlation with wind velocity projection on the azimuth. Jiang & Mu (2018).

Approches of wave climatology used:

Long-term wave systems. Portilla et al. (2015)



S_1

S_T

S_{T+1}

S_{TN}

TN is the number of spectra

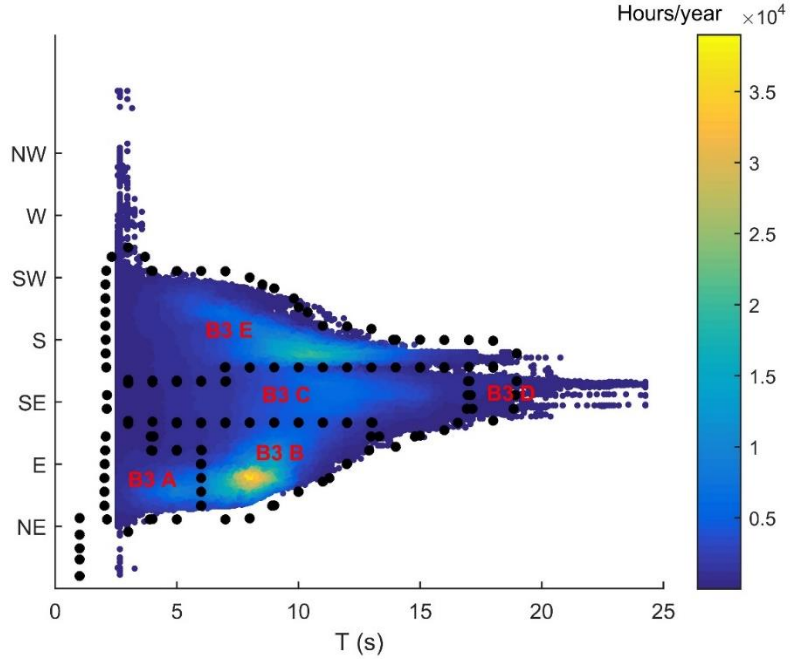
$Hs_{T,1}$; $T_{T,1}$; $D_{T,1}$

$Hs_{T,2}$; $T_{T,2}$; $D_{T,2}$

Hs_{T,J_T}; T_{T,J_T}; D_{T,J_T}

J_T is the number of partitions of the spectrum at instant T

Bivariate distribution of $T_{i,j}$ $D_{i,j}$



$$LST_{system} = f(H_{system}, T_{system}, D_{system})$$

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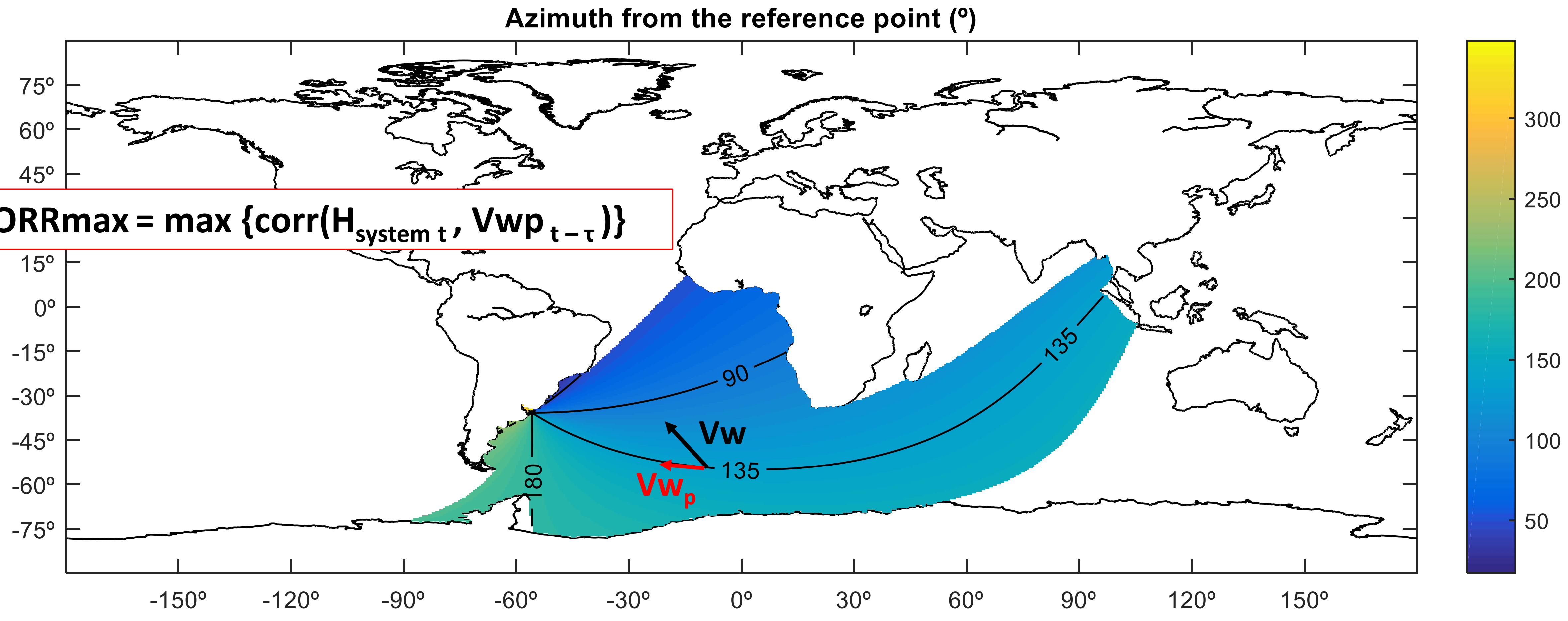
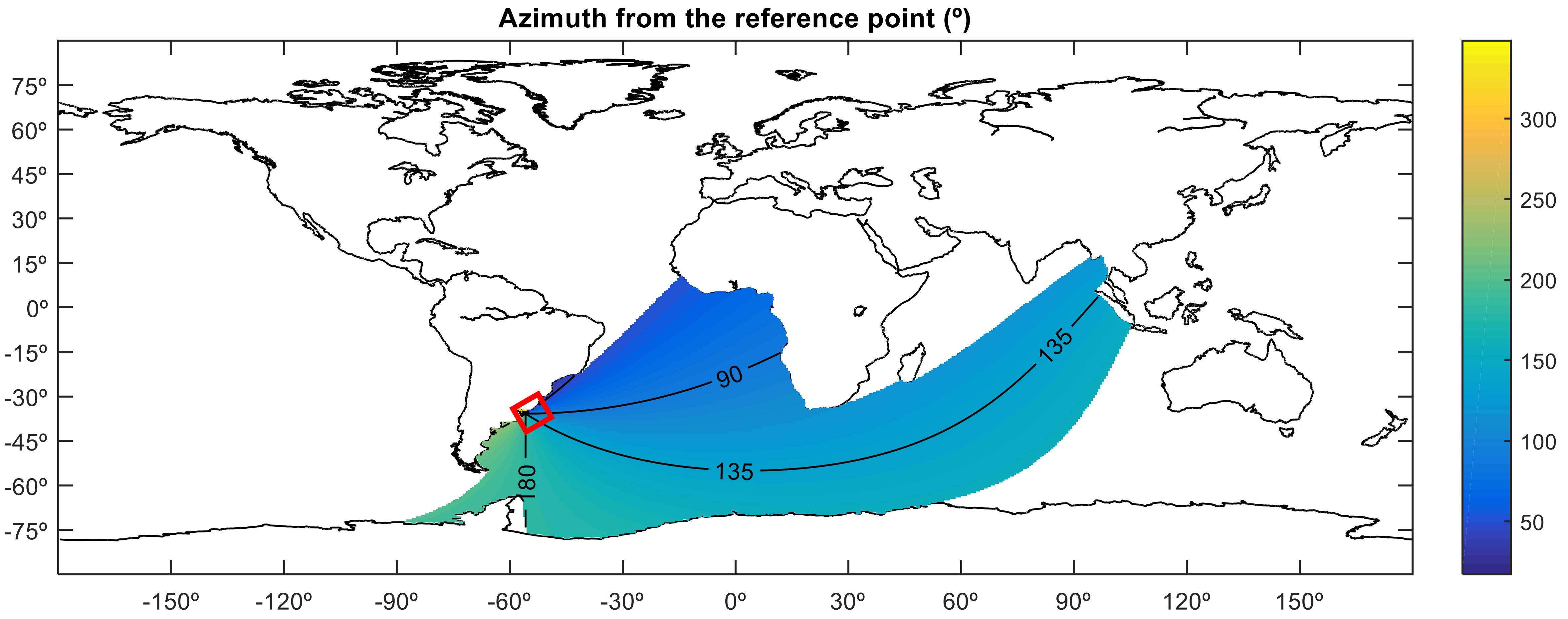
Approches of wave climatology used:

Maximum correlation with wind velocity projected in the azimuth. Jiang & Mu 201.

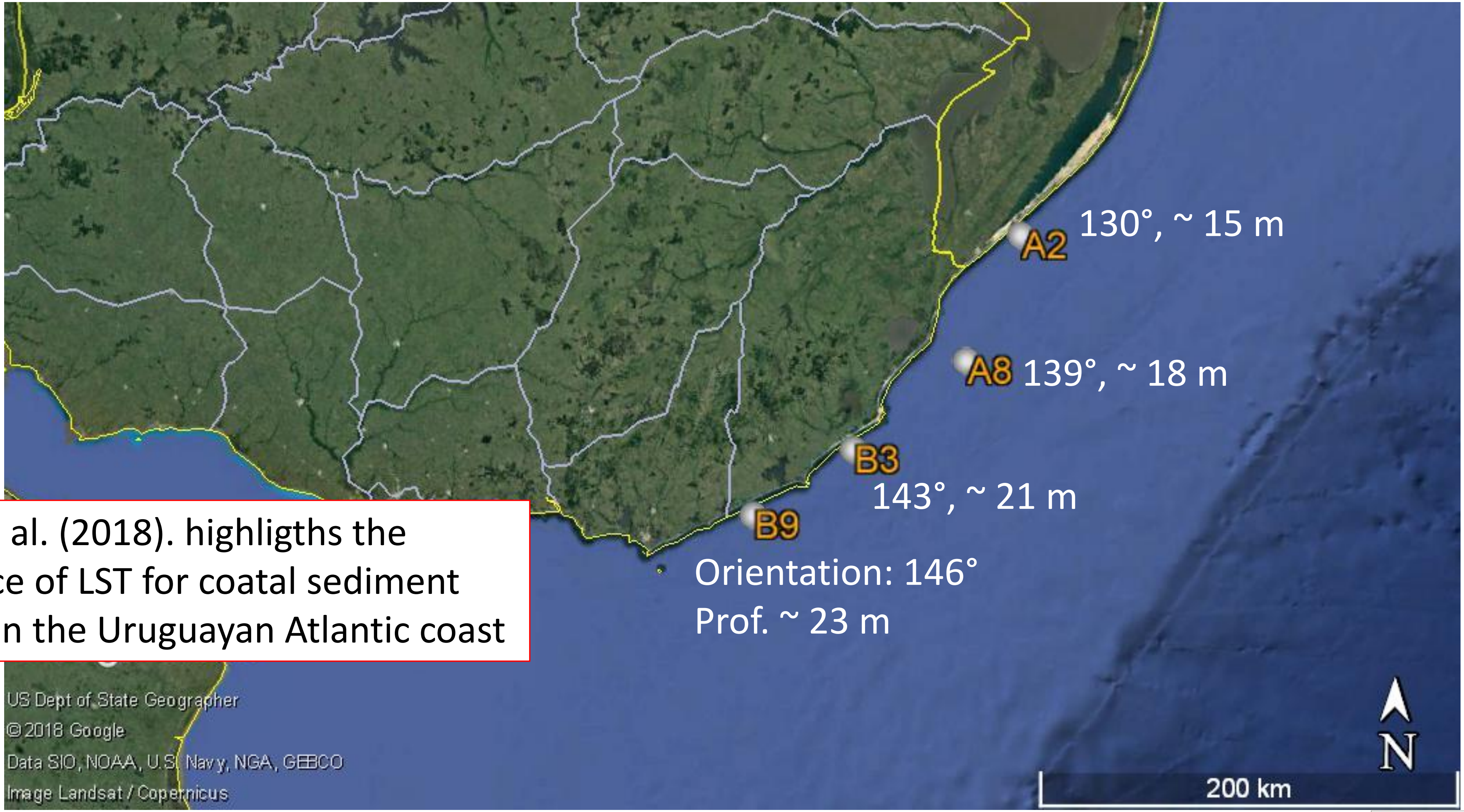


$$\textbf{CORRmax} = \max\{\mathrm{corr}(H_{system\ t}, Vwp_{t-\tau})\}$$

Case study:


Azimuth from the reference point (º)
75º
60º
45º
30º
15º
0º
-15º
-30º
-45º
-60º
-75º
-150º
-120º
-90º
-60º
-30º
0º
30º
60º
90º
120º
150º
90
135
135
180
300
250
200
150
100
50

Case study:



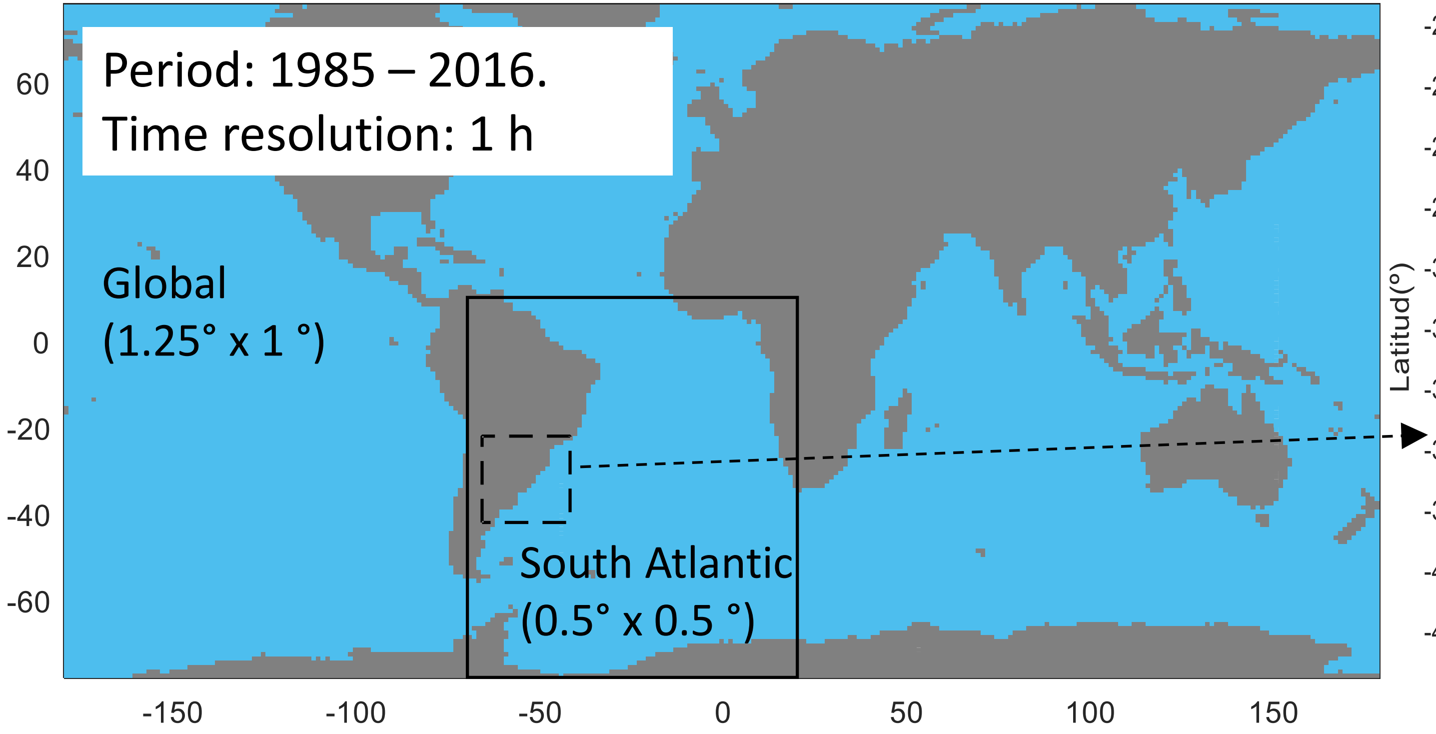
Solari et al. (2018). highligths the relevance of LST for coatal sediment Budget in the Uruguayan Atlantic coast

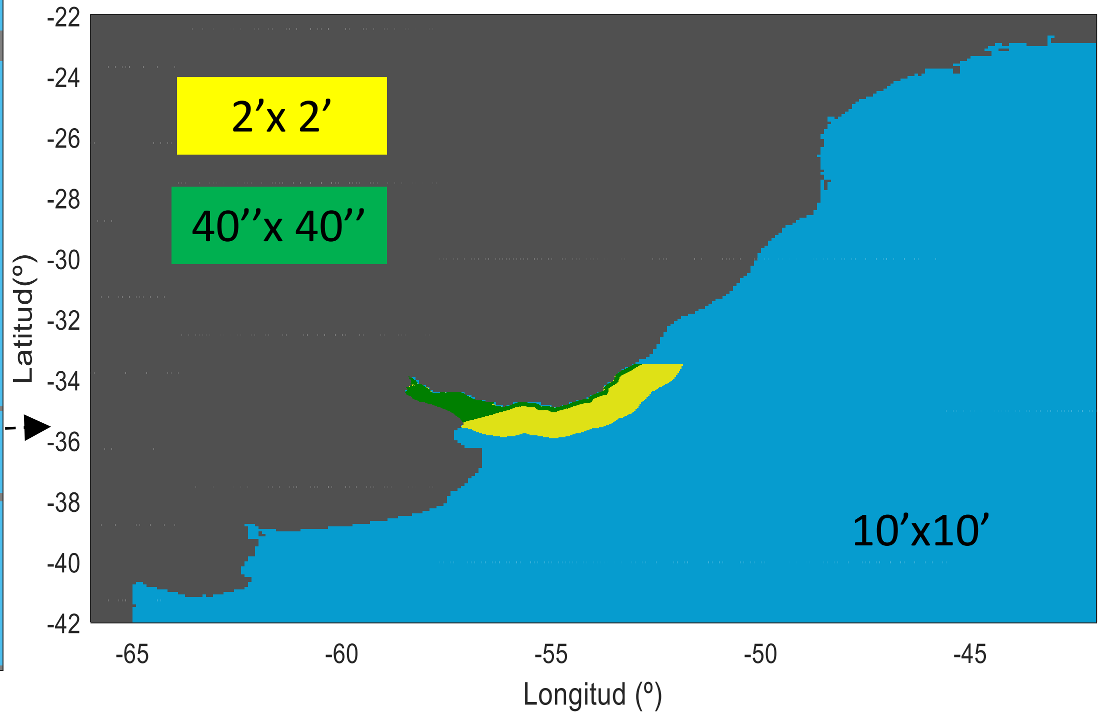
Database: Uruguayan wave hindcast. Alonso & Solari xxxx (under revision)

Model:
WAVEWATCH III ® 5.16. Multi-grid mode.
Two-way nesting. 5 regular grids.
Sin+Sds --> ST4

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

Period: 1985 – 2016.
Time resolution: 1 h





Methodology:

1) Wave spectral partition.
   Watersheed algorithm (Meyer (1994), available in Matlab), filtering systems with Hs < 0.25 m.

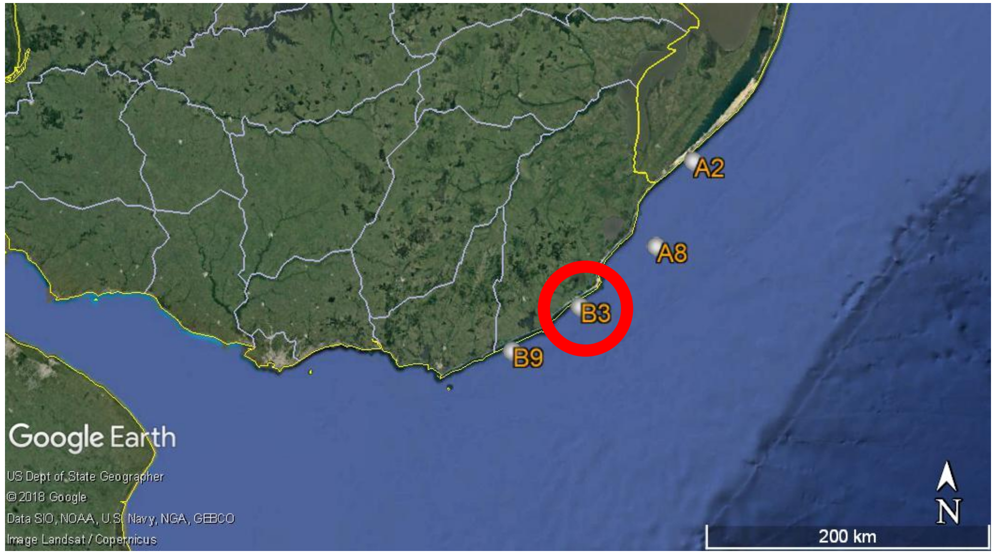
2) Long-term wave systems identification.
   Partition of the bivariate distribution of (T,D), filtering systems with frecuency of occurrence < 50 h / year.

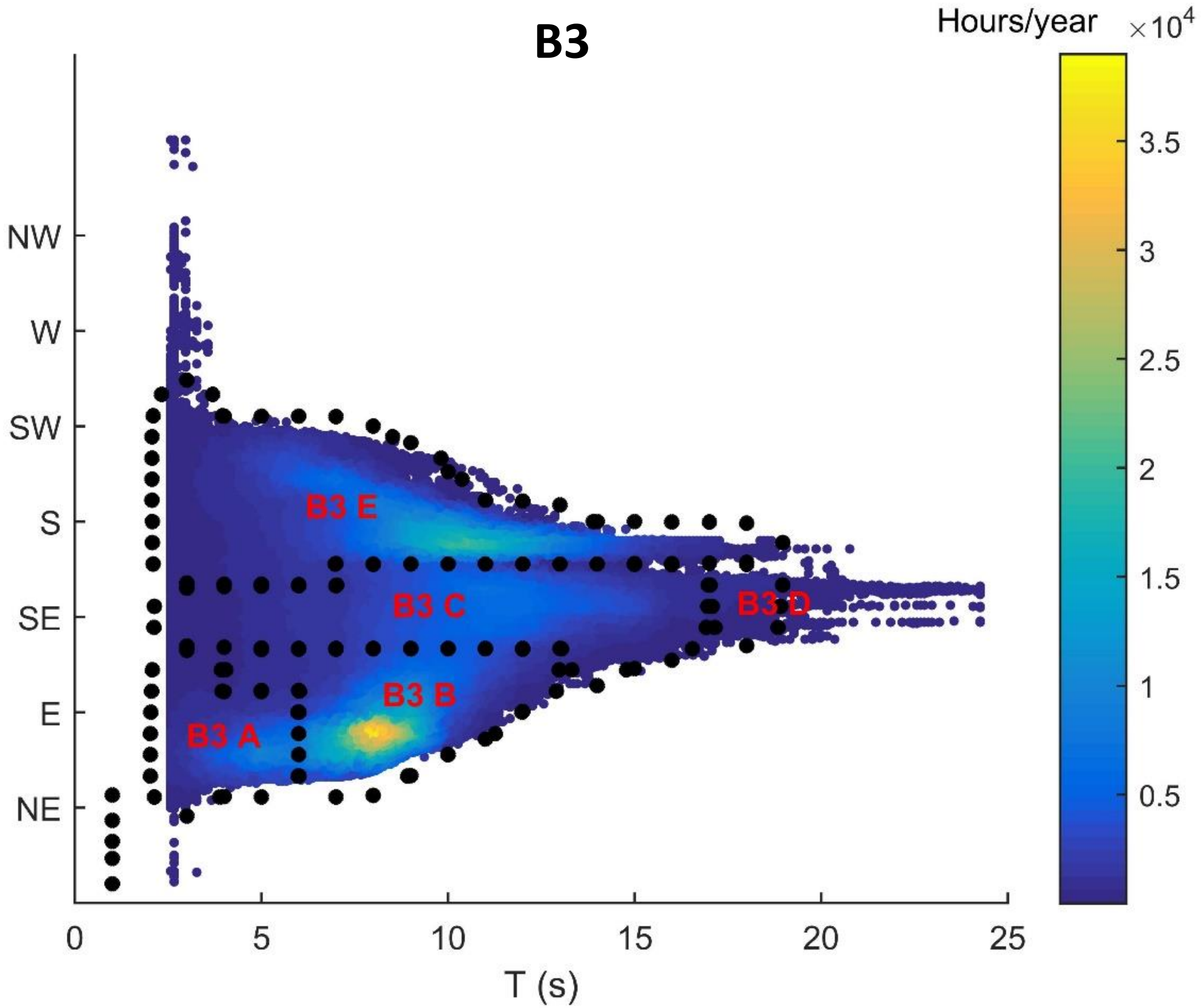
3) LST_{system} and LST estimations and identification of the most relevant.
   CERC formula improved by Mil-homens et al. (2013)

4) Exploration of the Long-term wave systems most relevant for LST.
   Region of origin, Sea fraction, Statistics of (H,T, D)

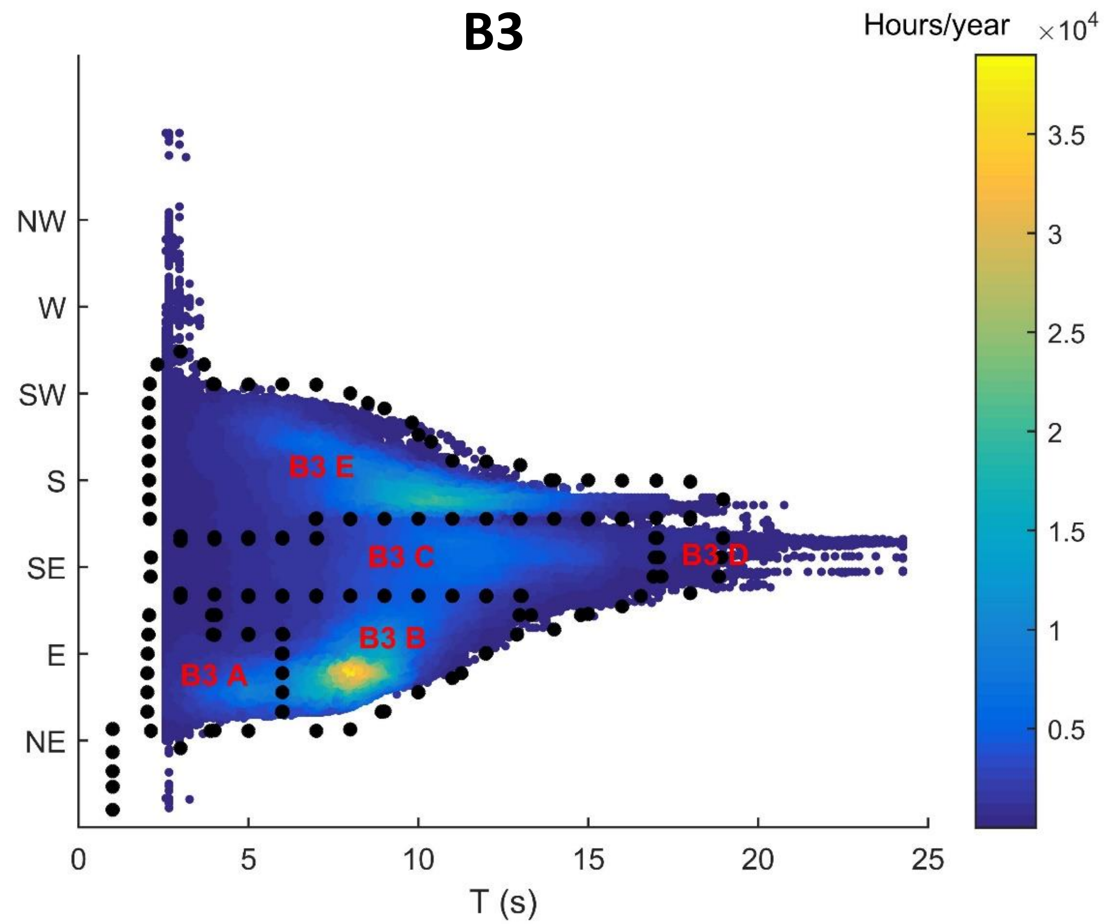
5) Analysis of the variability of LST_{system}
   Annual cycle, inter-anual variations and correlation with climate indexes.

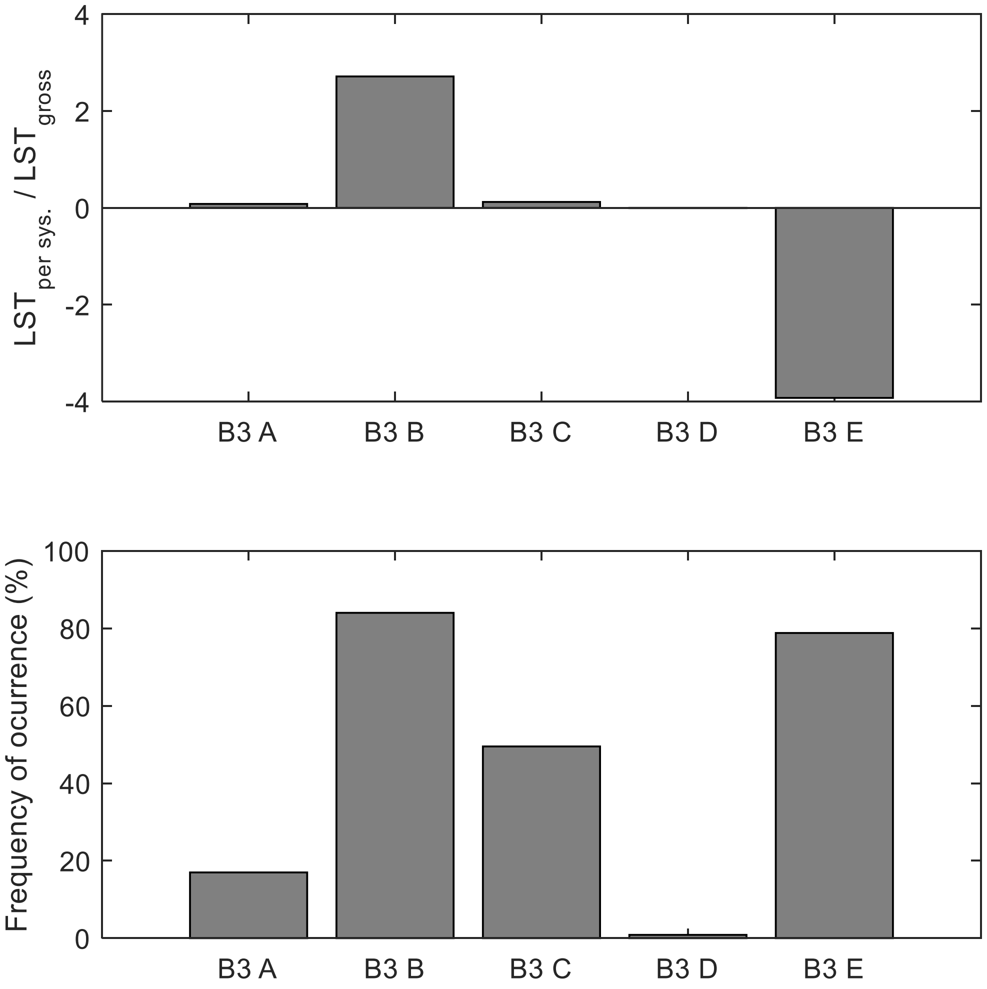
Results:


A2
A8
B3
B9
Google Earth
US Dept of State Geographer
© 2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
N
200 km

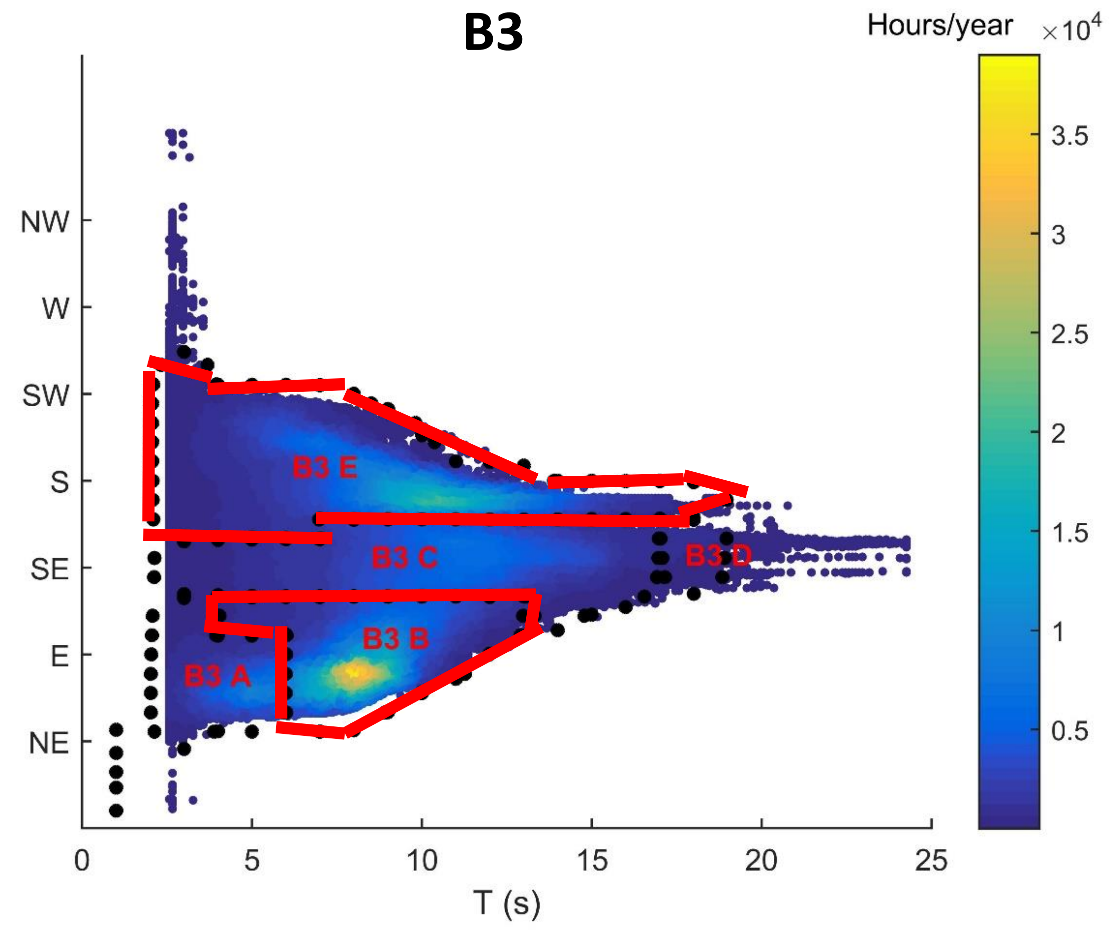

B3
Hours/year
$\times 10^4$
NW
W
SW
S
SE
E
NE
B3 A
B3 B
B3 C
B3 D
B3 E
0
5
10
15
20
25
T (s)
3.5
3
2.5
2
1.5
1
0.5

Results:

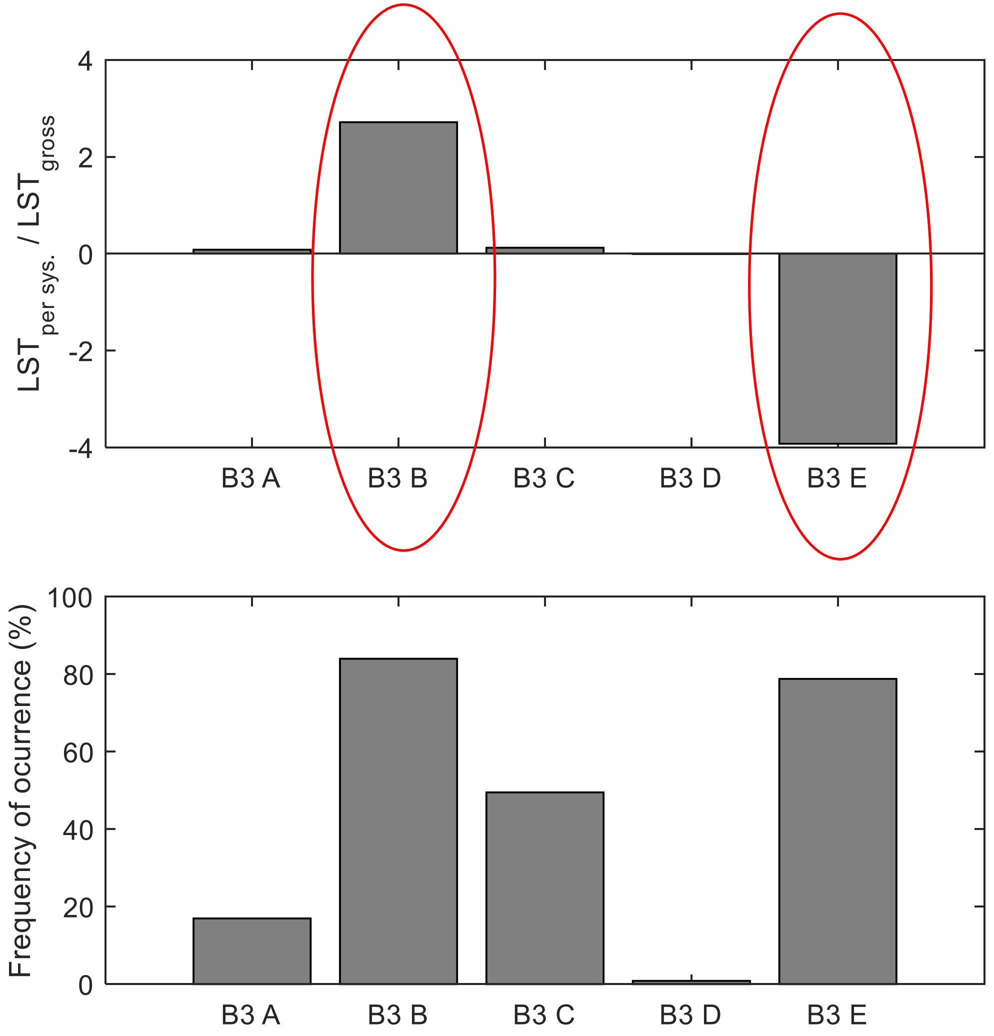

B3
Hours/year
×10^4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
B3 E
B3 C
B3 D
B3 B
B3 A
0
5
10
15
20
25
T (s)


LST per sys. / LST gross
4
2
0
-2
-4
B3 A
B3 B
B3 C
B3 D
B3 E
Frequency of ocurrence (%)
100
80
60
40
20
0
B3 A
B3 B
B3 C
B3 D
B3 E

Results:

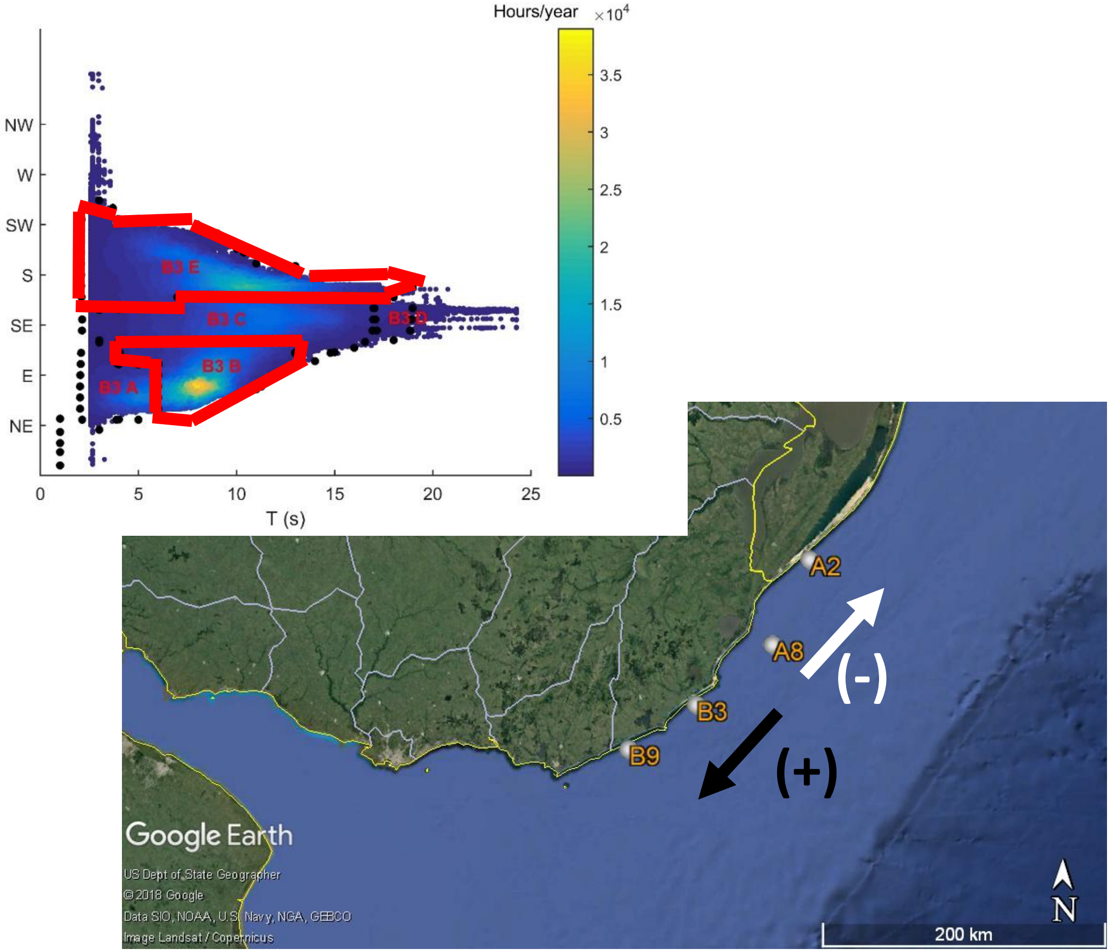


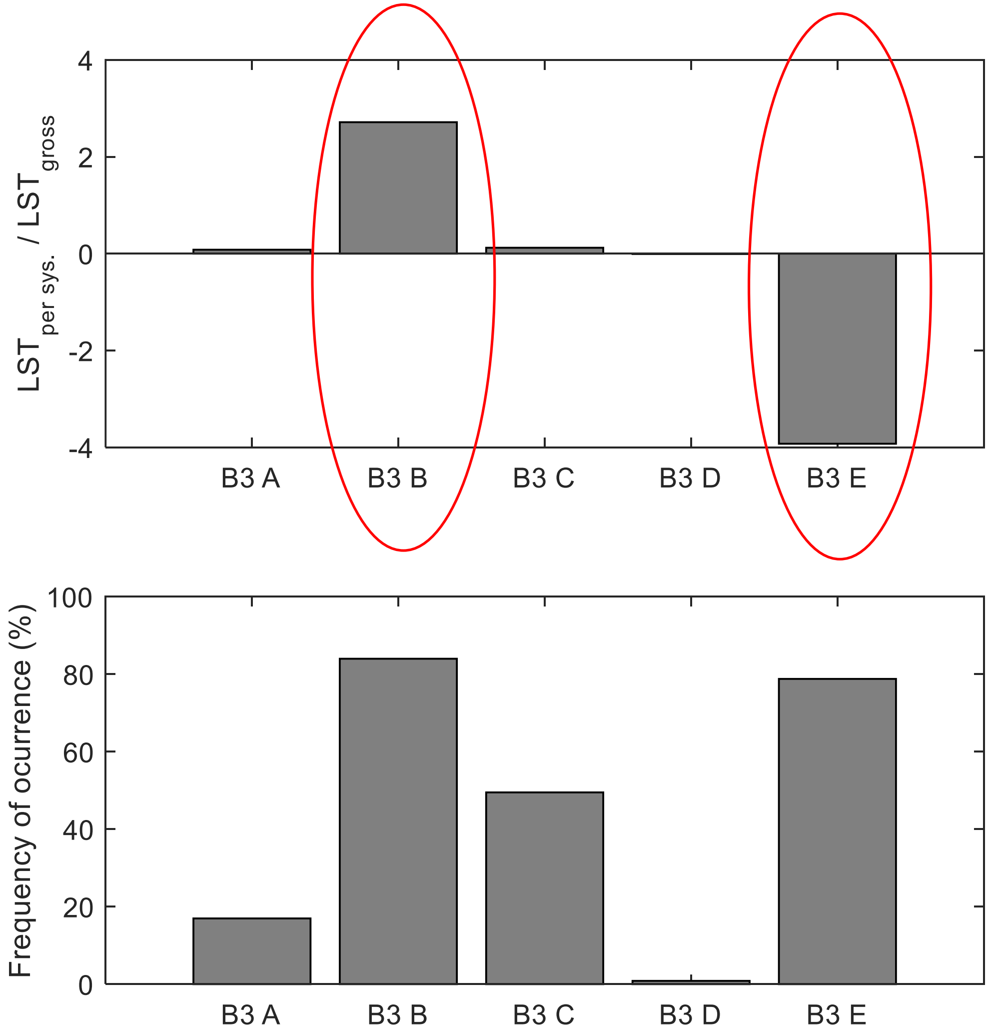
B3
Hours/year
×10^4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
B3 E
B3 C
B3 D
B3 B
B3 A
0
5
10
15
20
25
T (s)



LST per sys. / LST gross
4
2
0
-2
-4
B3 A
B3 B
B3 C
B3 D
B3 E
Frequency of ocurrence (%)
100
80
60
40
20
0
B3 A
B3 B
B3 C
B3 D
B3 E

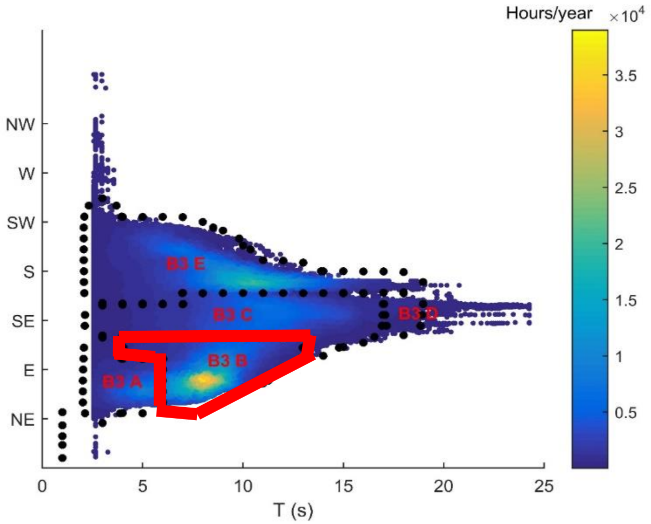
Results:

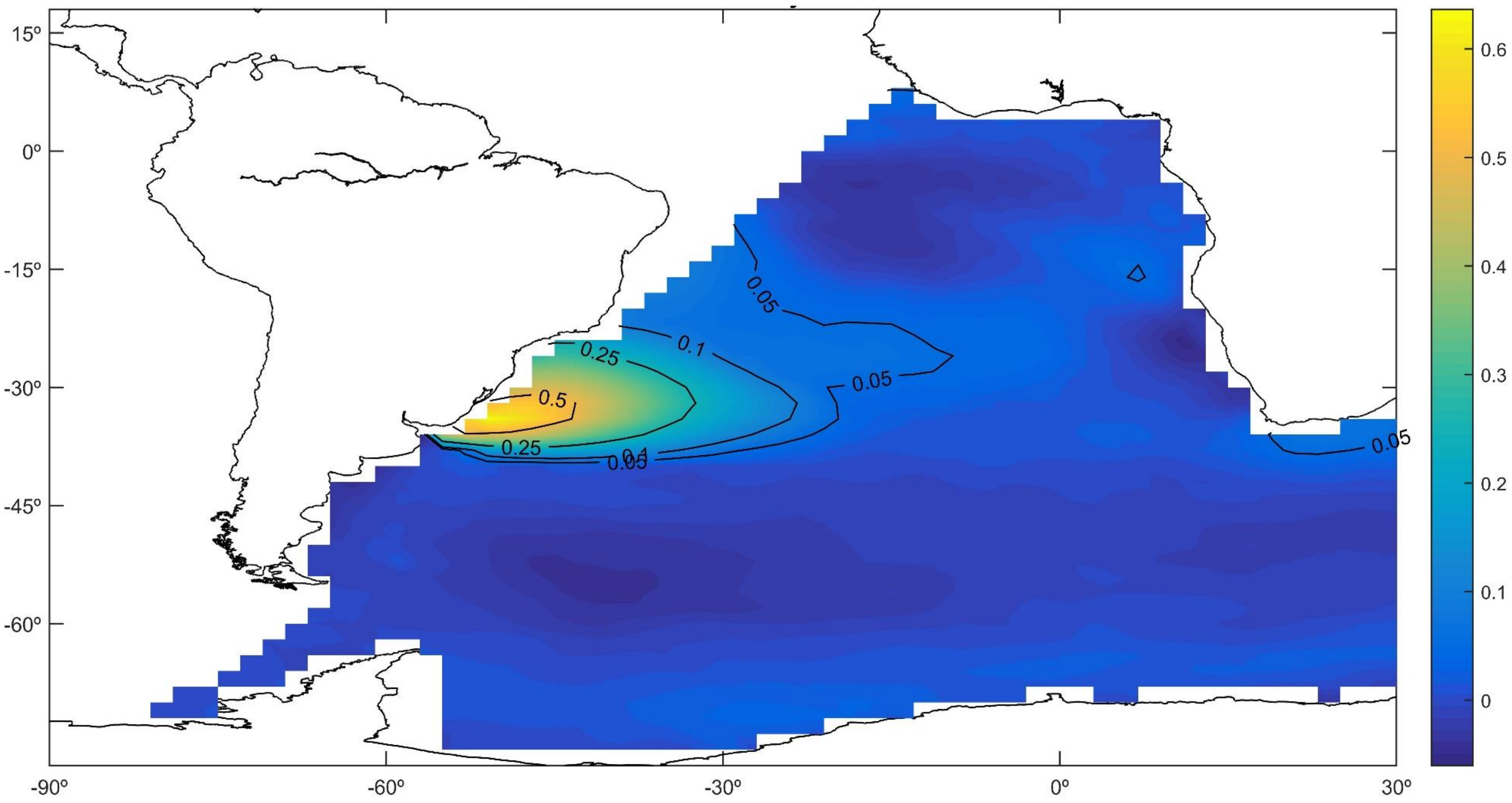

Hours/year
×10^4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
B3 E
B3 C
B3 D
B3 B
B3 A
0
5
10
15
20
25
T (s)
A2
A8
B3
B9
(-)
(+)
Google Earth
US Dept of State Geographer
© 2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
N
200 km


$LST_{per\ sys.} / LST_{gross}$
4
2
0
-2
-4
B3 A
B3 B
B3 C
B3 D
B3 E
Frequency of ocurrence (%)
100
80
60
40
20
0
B3 A
B3 B
B3 C
B3 D
B3 E

Results:

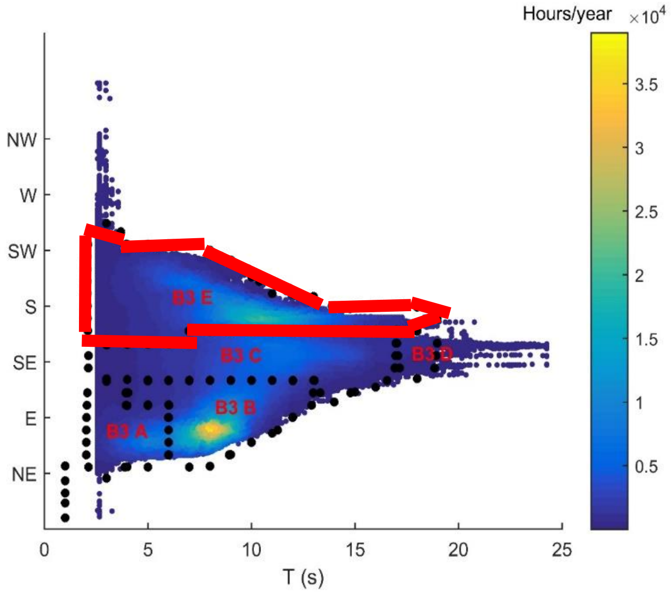
Easterly long-term wave system ($\mathbf{E_{WS}}$)

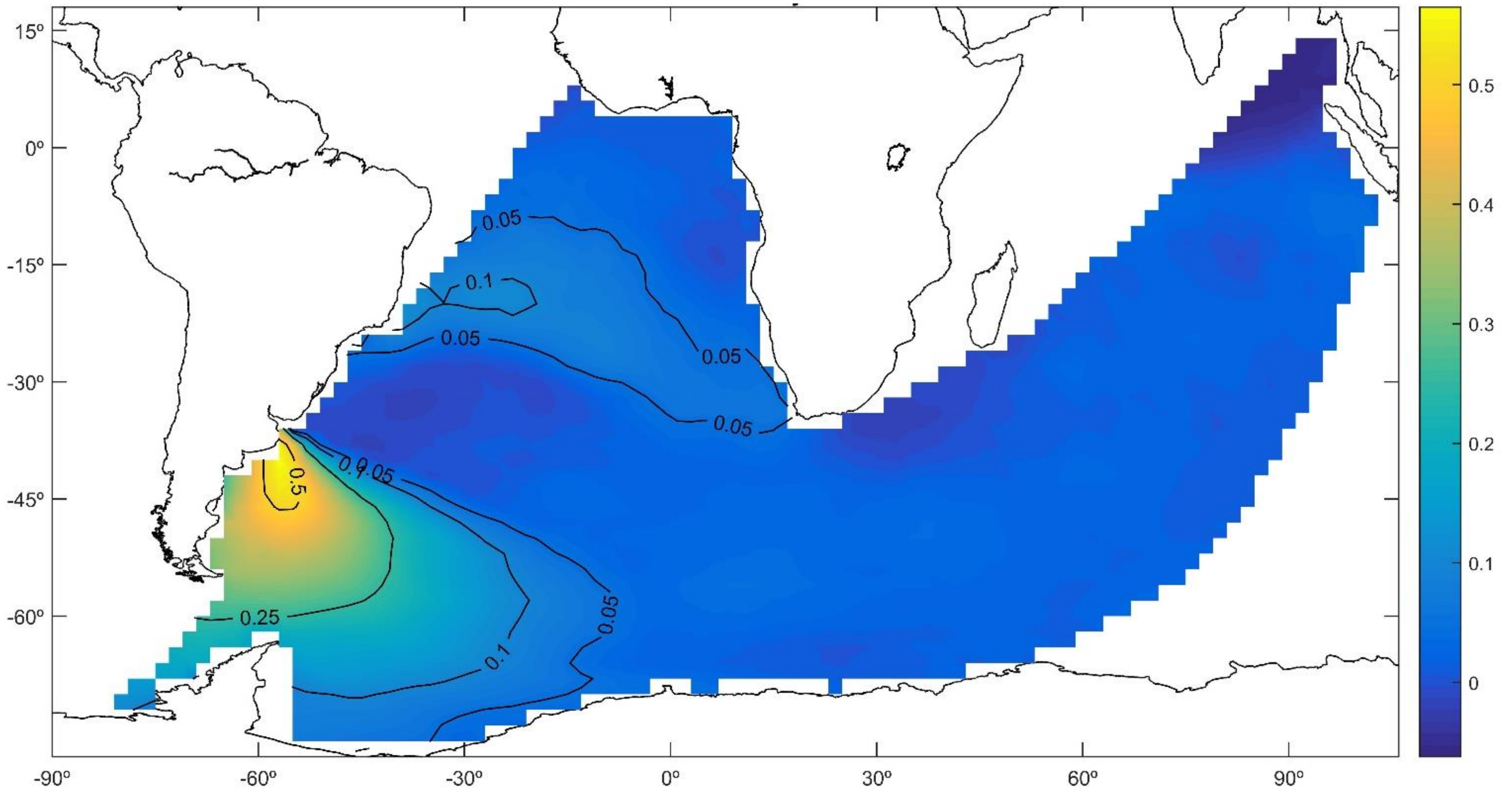




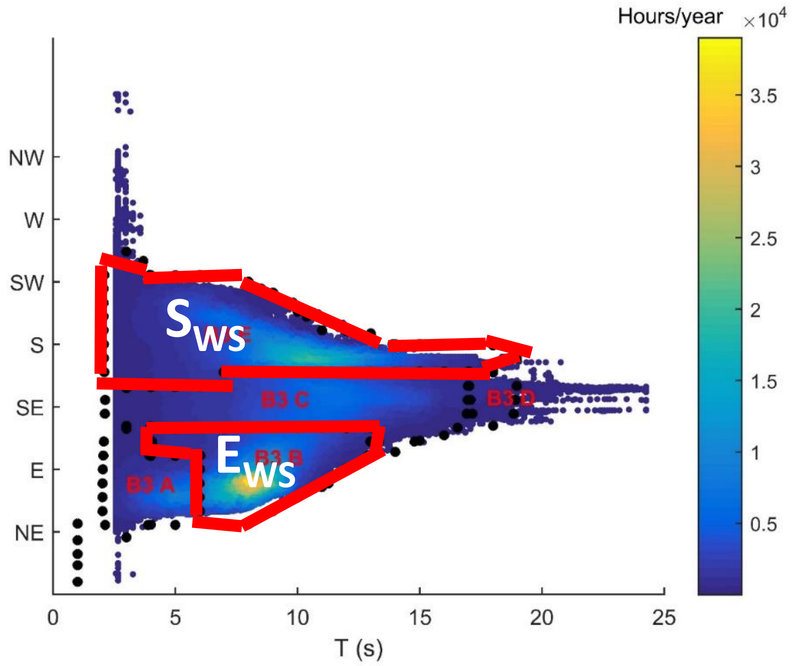
Results:

Southerly long-term wave system (S_{WS})





Results:



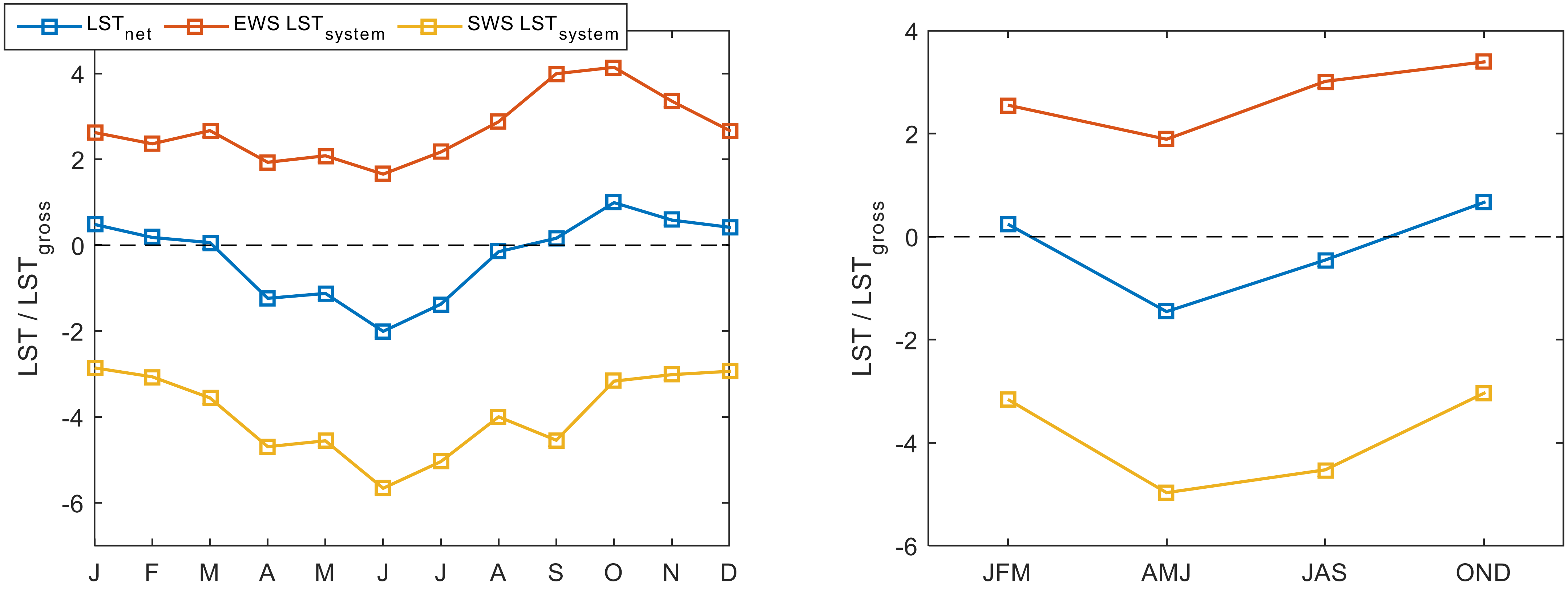
Hanson & Phillips (2001)

	Hours / year	Hmean (m)	Hstd (m)	Hmax (m)	Sea (%)
E_{ws}	6634.8	0.88	0.55	6.14	16.1 %
S_{ws}	6730.7	0.97	0.69	6.6	18.7%

	Tmean (S)	T range (S)	Dmean(°)	D range (°)
E_{ws}	8.3	[4 – 12]	88	[60 120]
S_{ws}	9.2	[3 – 19]	178	[150 240]

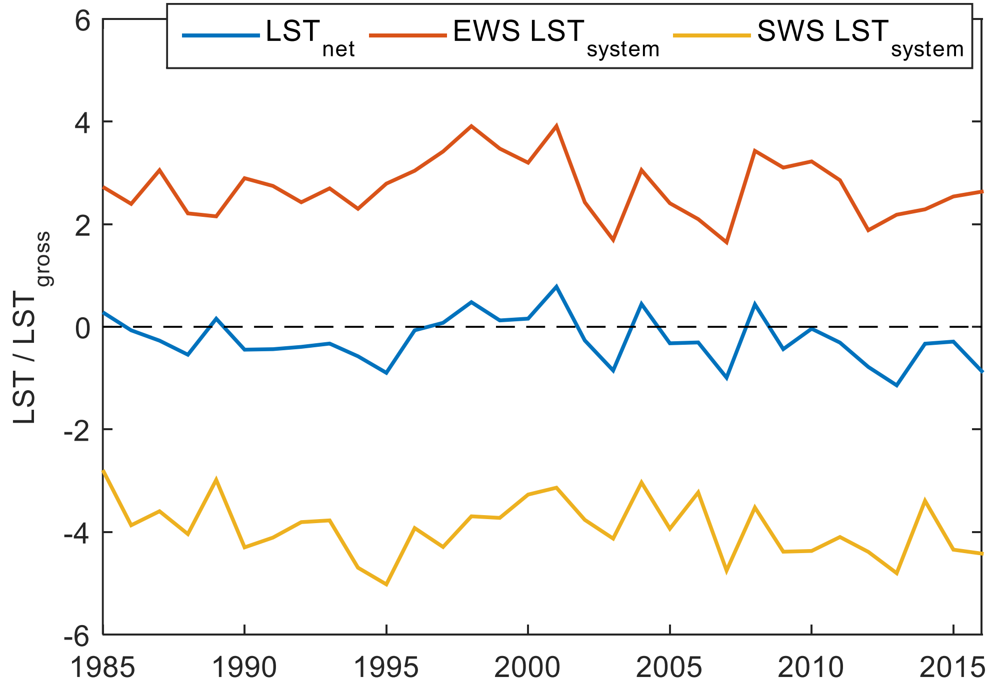
Results:

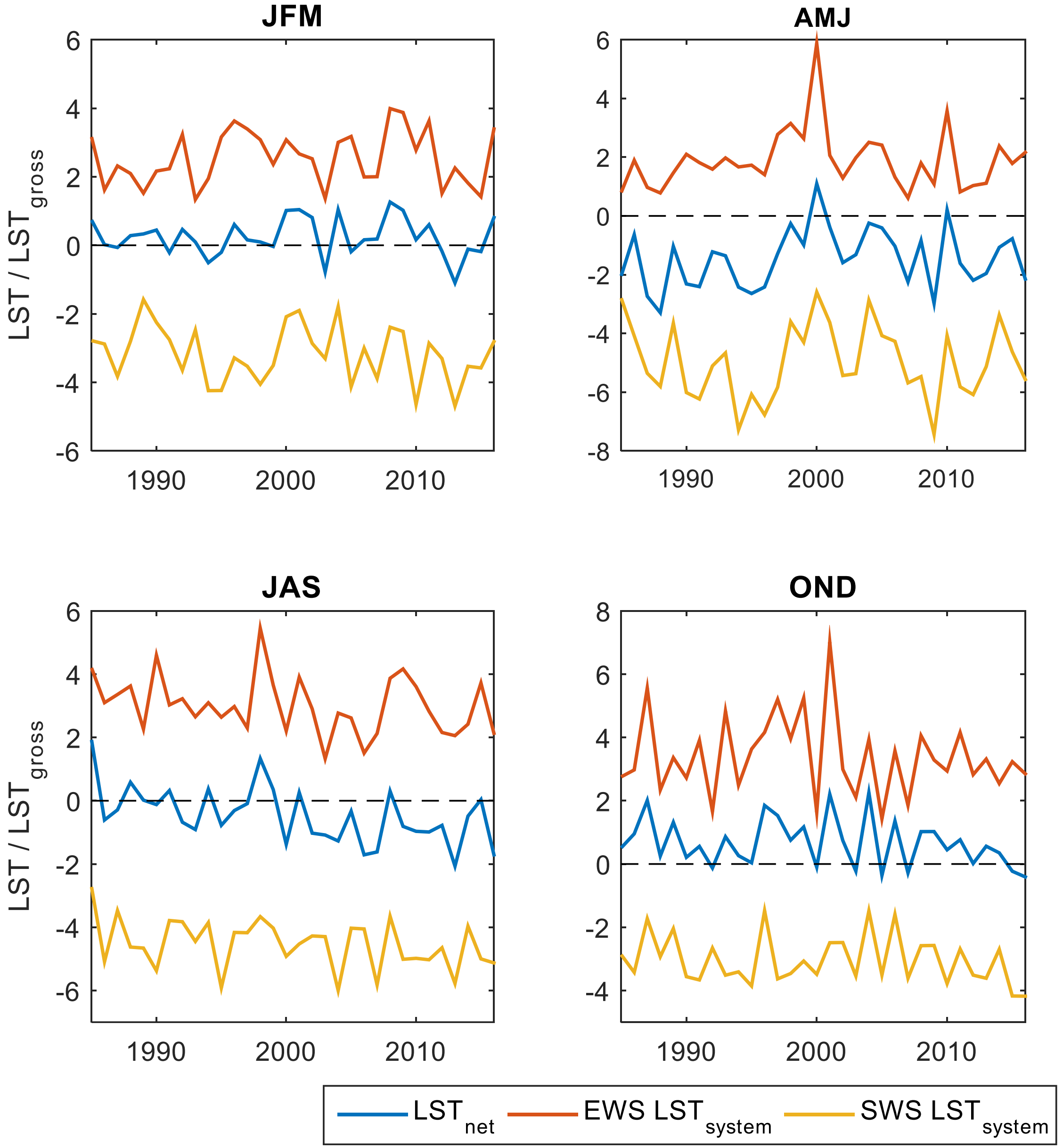
Annual cycle



Results:

Inter-annual variability





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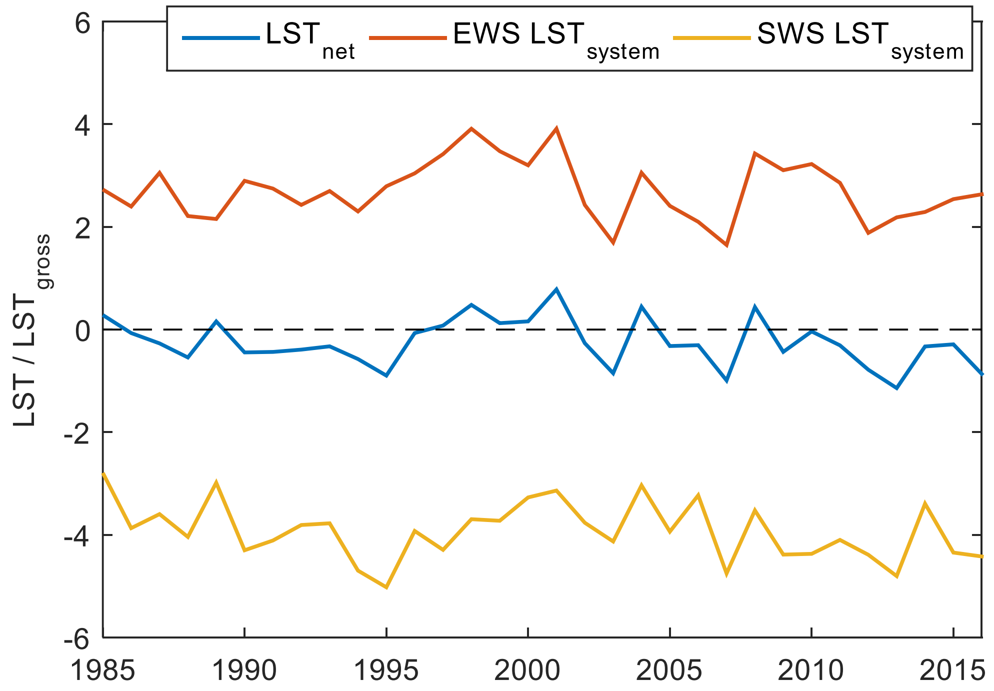
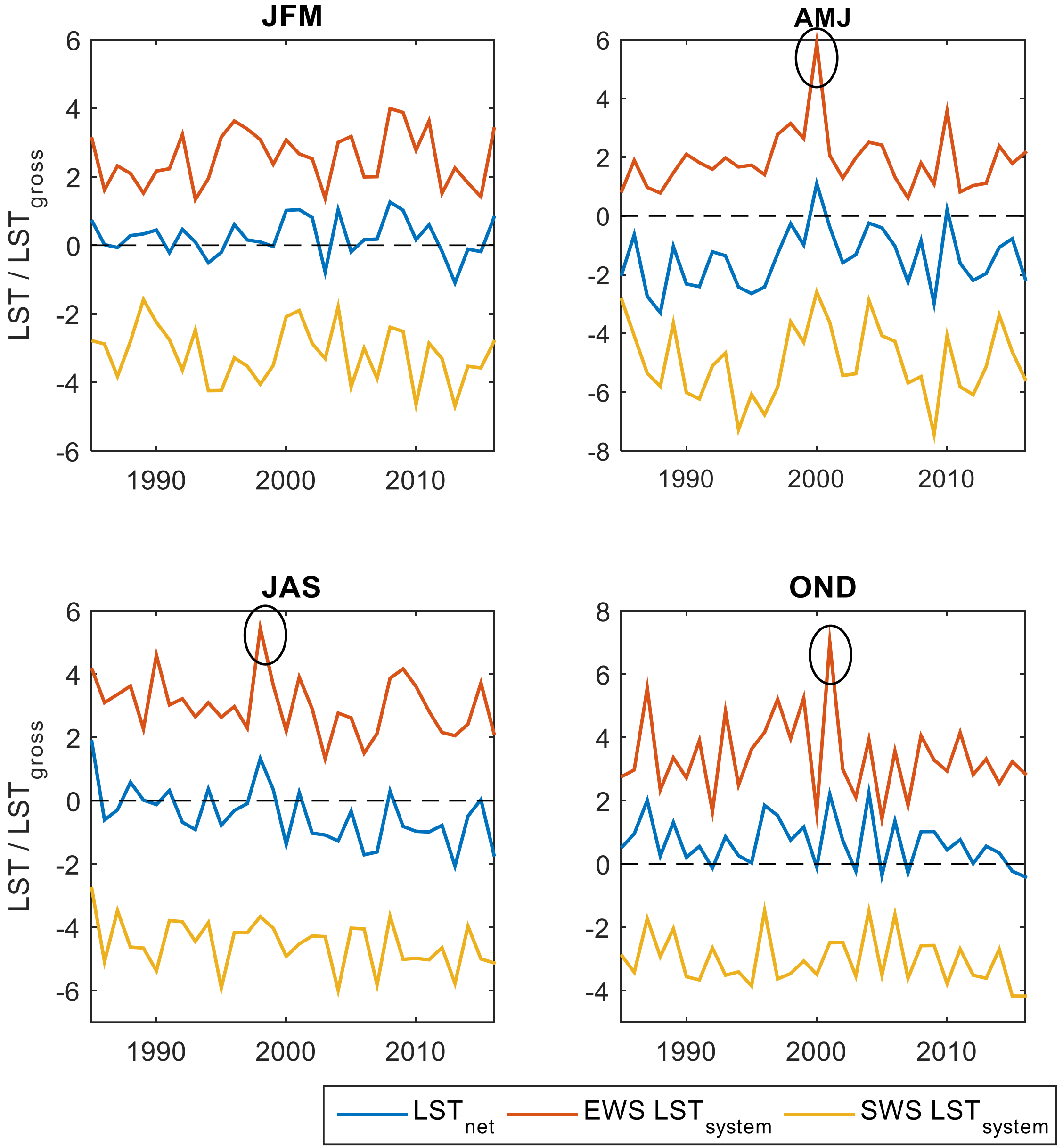
Results:

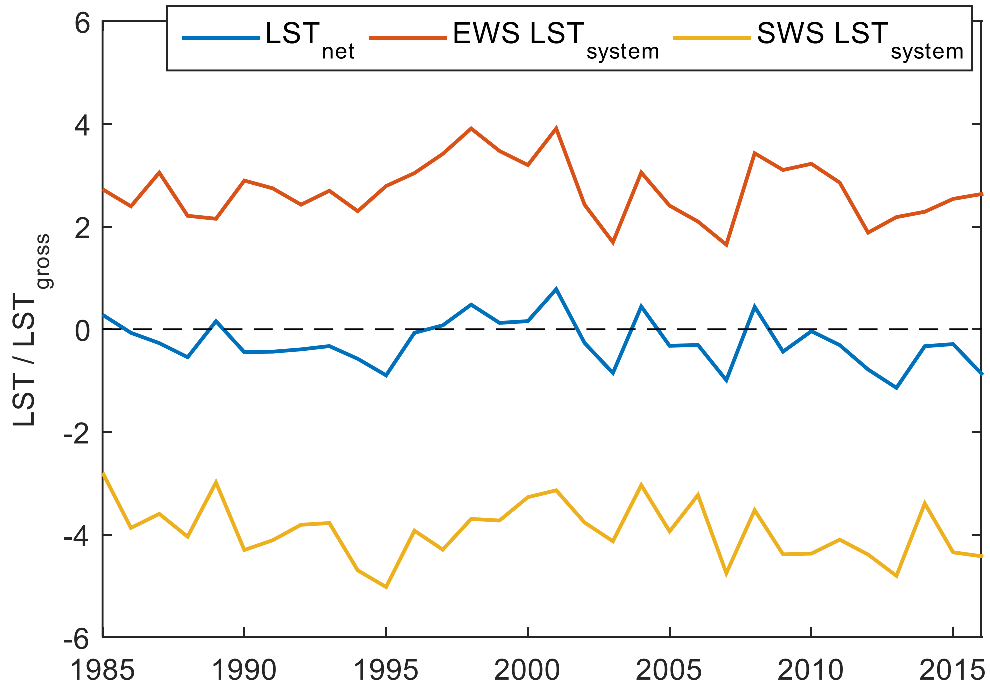
Inter-annual variability

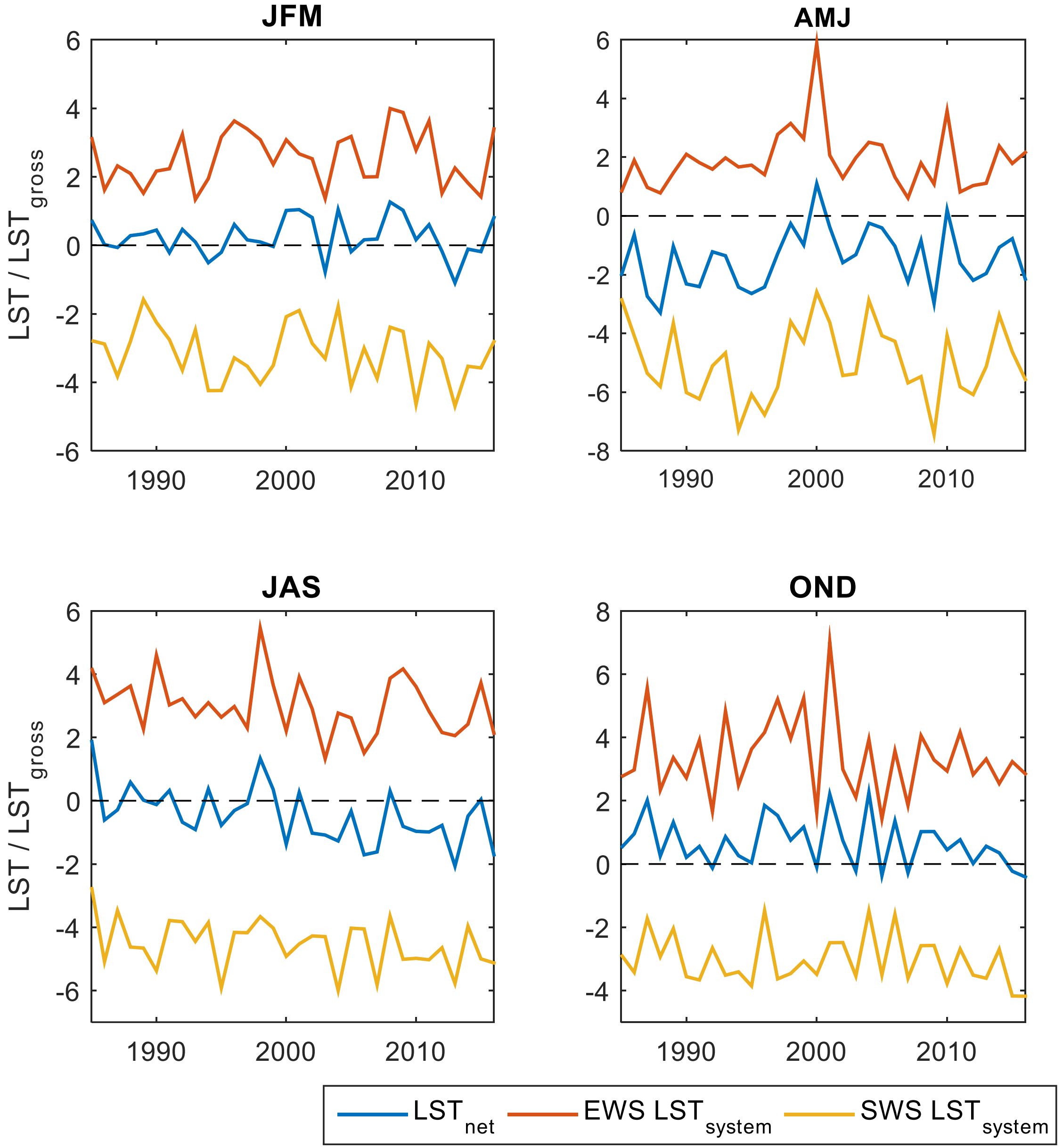




Results:

Inter-annual variability





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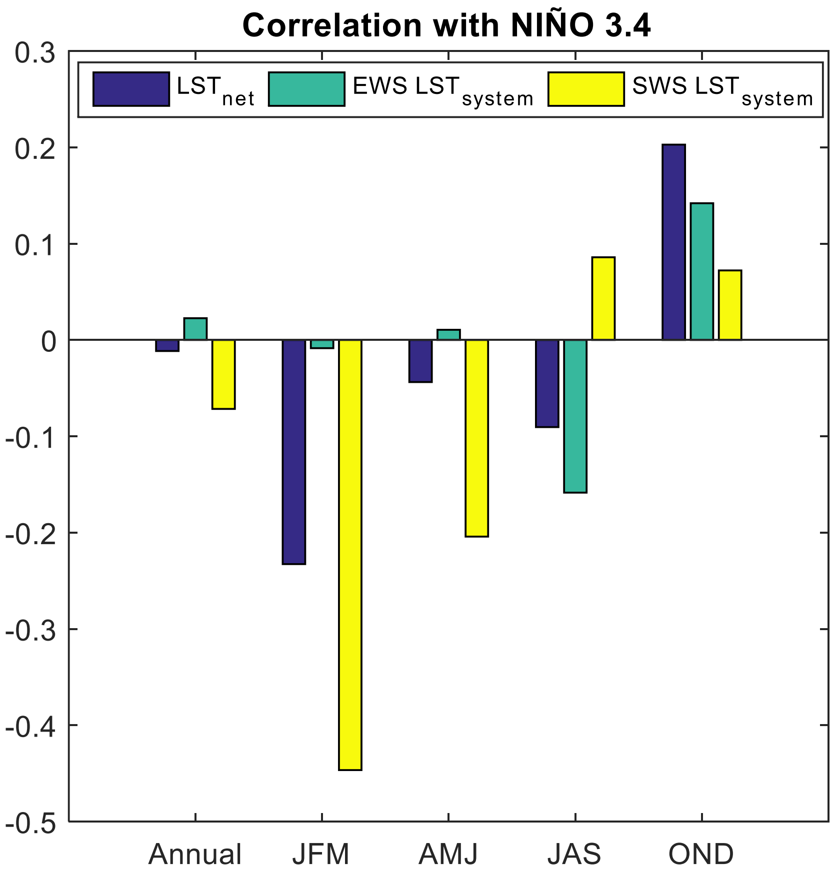
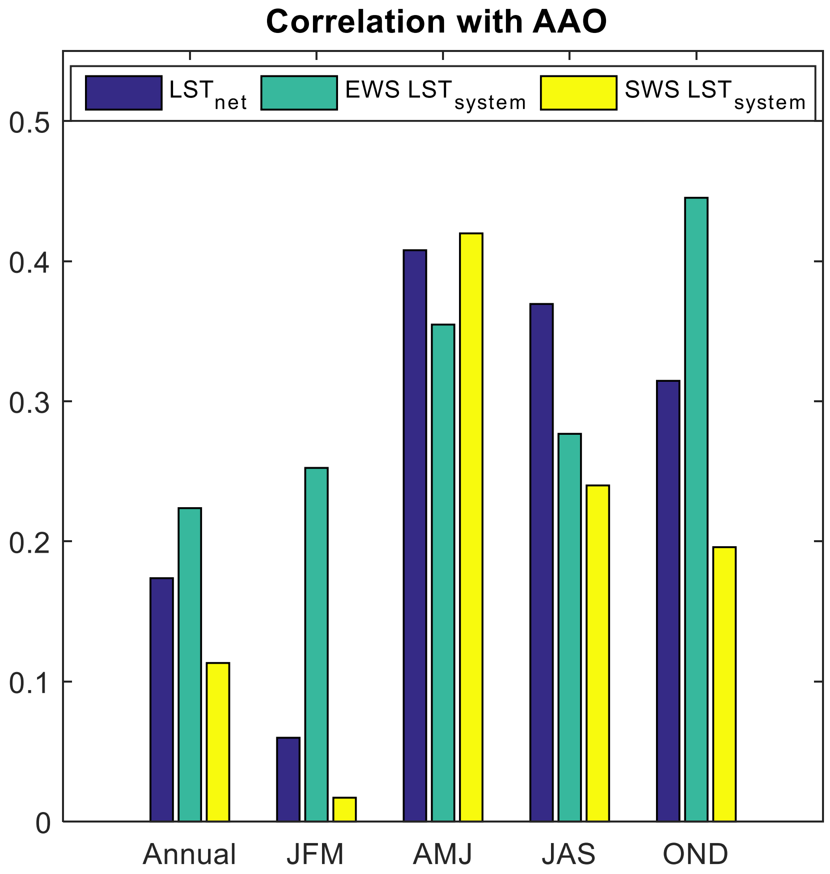
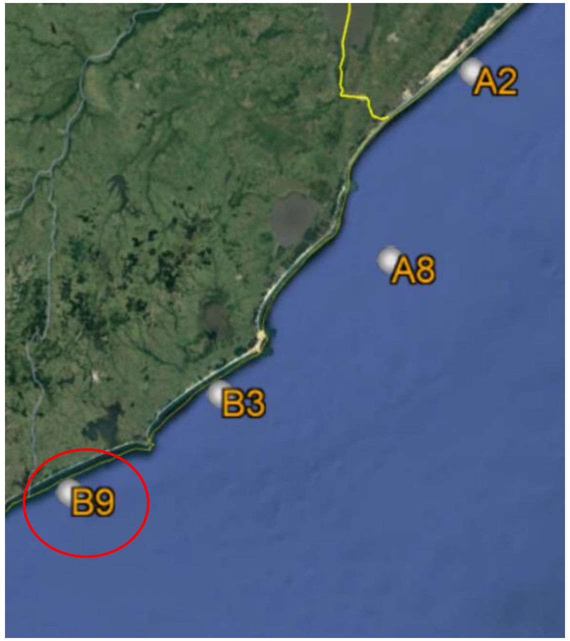
Results:

Correlation with climate indexes

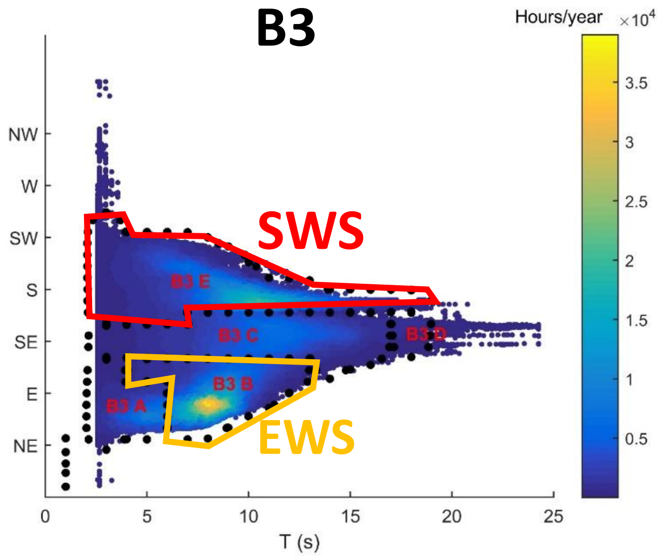




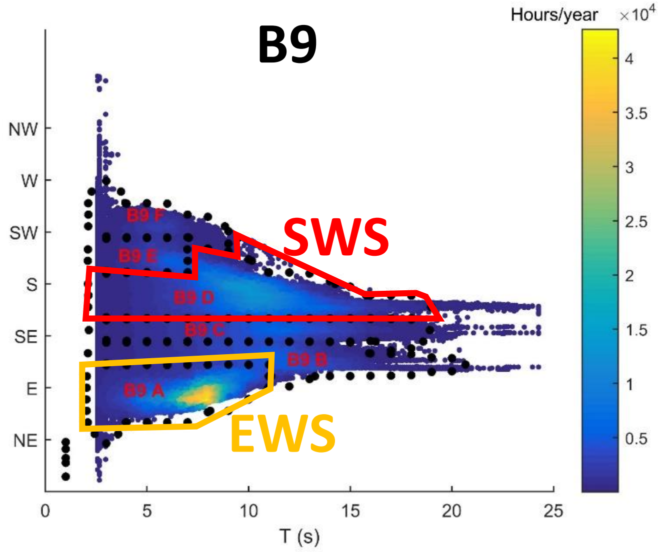
Results:



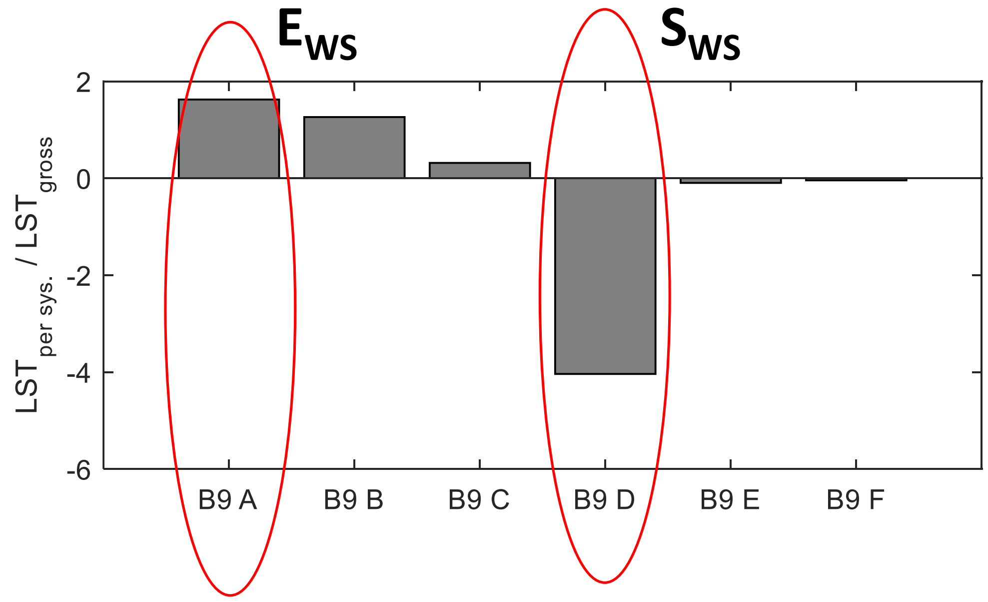
A2
A8
B3
B9



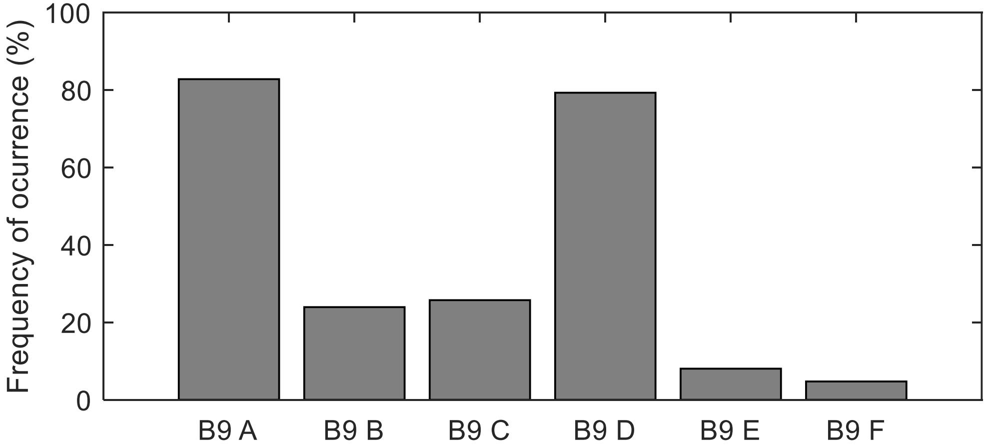
B3
Hours/year
×10^4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
SWS
EWS
0
5
10
15
20
25
T (s)



B9
Hours/year
×10^4
4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
SWS
EWS
0
5
10
15
20
25
T (s)

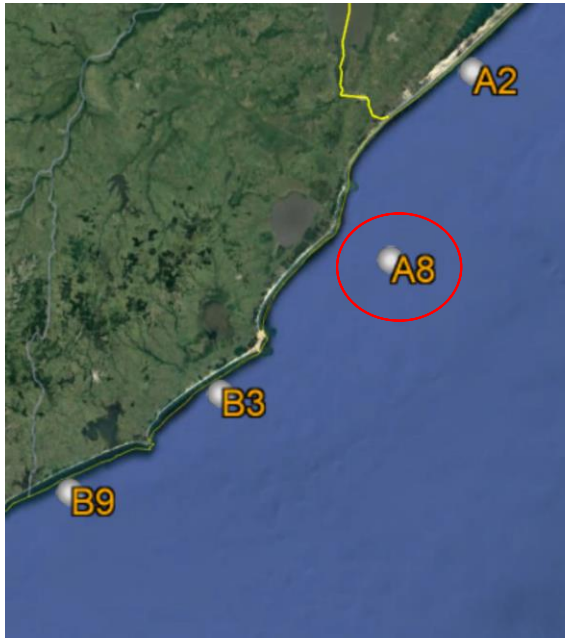


E_{WS}
S_{WS}
$LST_{per\ sys.} / LST_{gross}$
2
0
-2
-4
-6
B9 A
B9 B
B9 C
B9 D
B9 E
B9 F

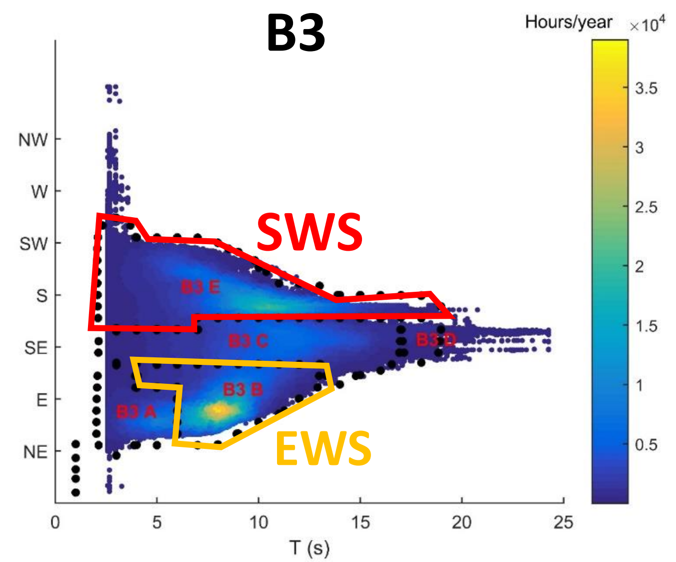


Frequency of ocurrence (%)
100
80
60
40
20
0
B9 A
B9 B
B9 C
B9 D
B9 E
B9 F

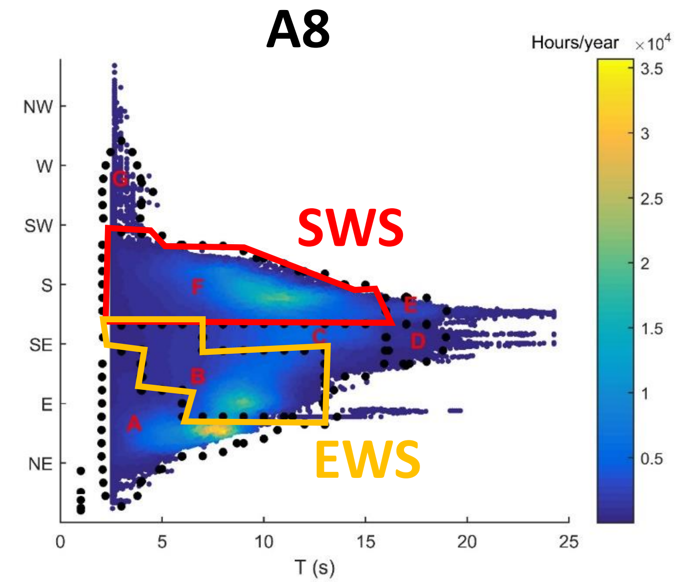
Results:



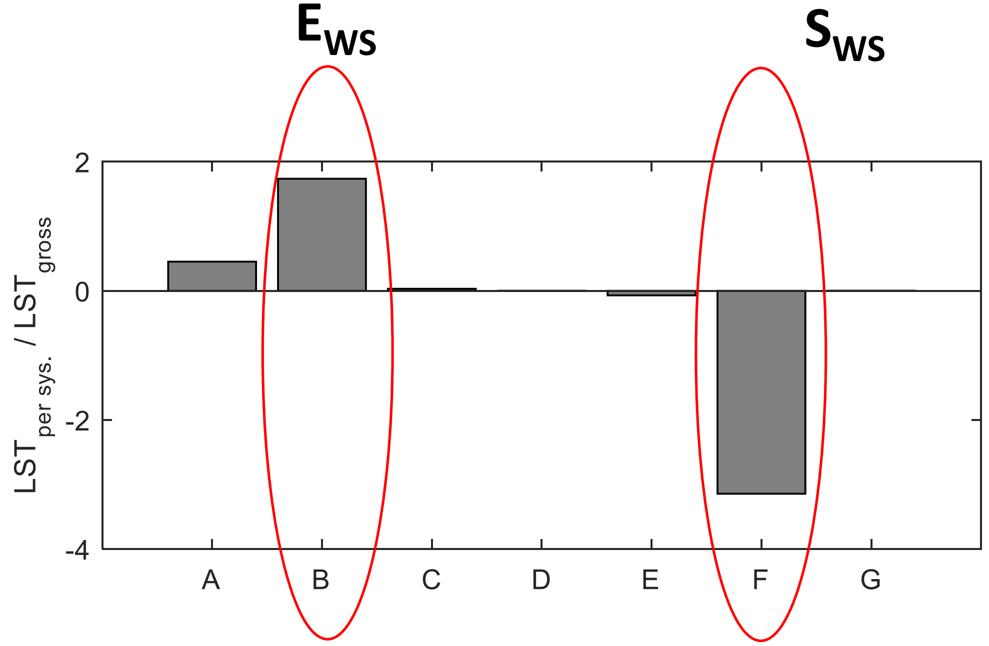
A2
A8
B3
B9



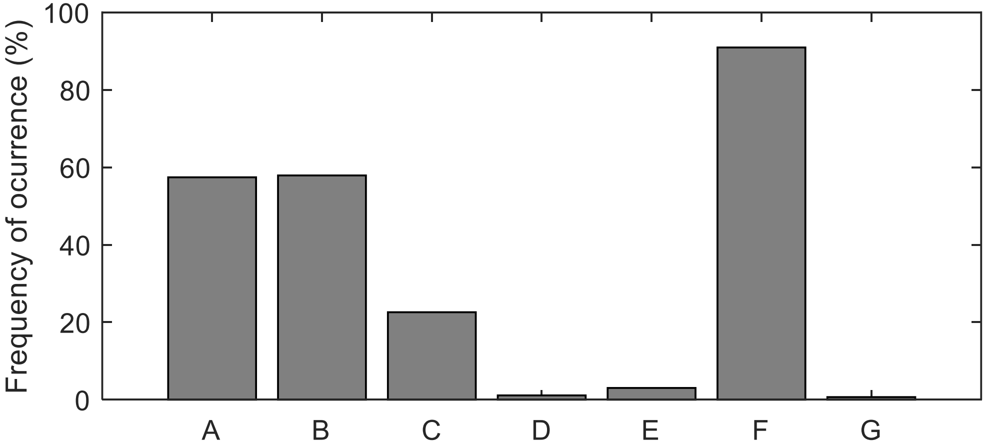
B3
Hours/year
×10^4
SWS
EWS
NW
W
SW
S
SE
E
NE
T (s)



A8
Hours/year
×10^4
SWS
EWS
NW
W
SW
S
SE
E
NE
T (s)

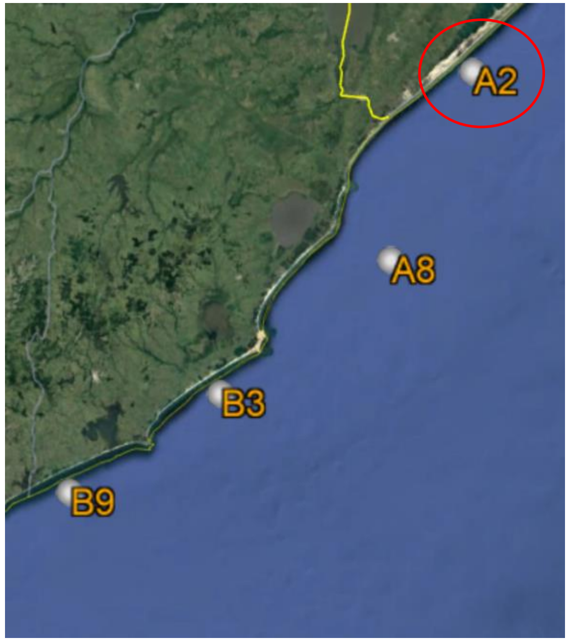


E_{WS}
S_{WS}
$LST_{per\ sys.} / LST_{gross}$
A
B
C
D
E
F
G

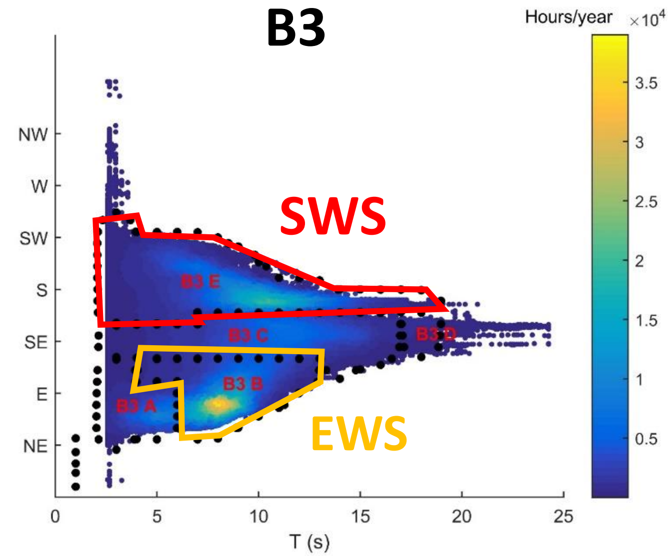


Frequency of ocurrence (%)
A
B
C
D
E
F
G

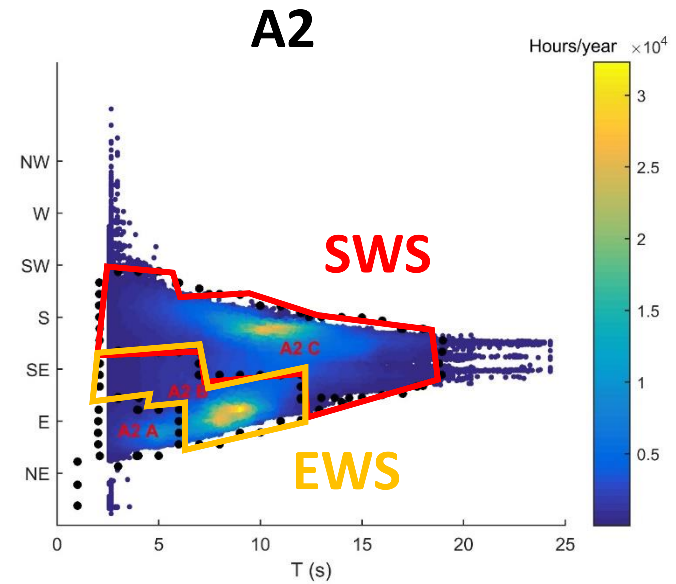
Results:



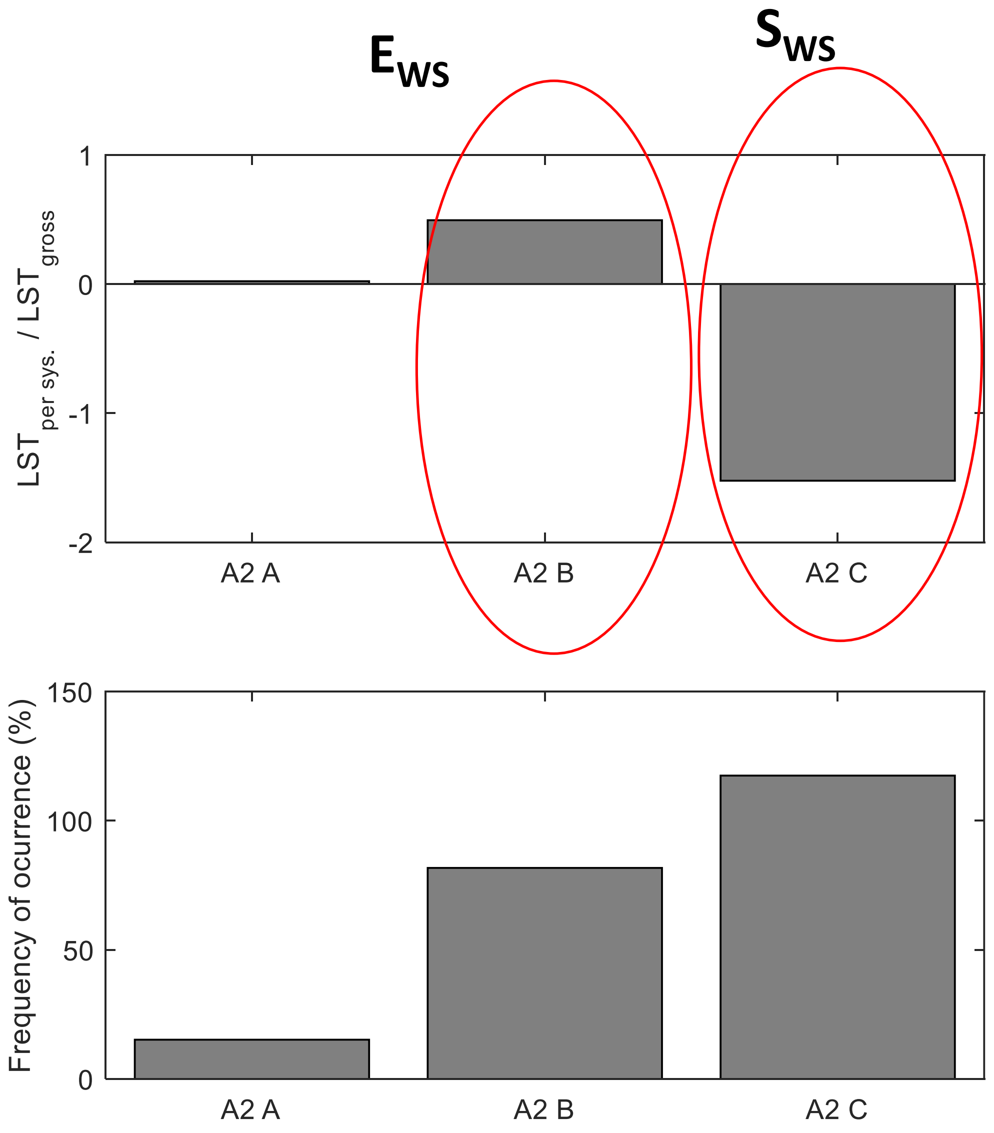
A2
A8
B3
B9



B3
Hours/year ×10^4
3.5
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
0
5
10
15
20
25
T (s)
SWS
EWS
B3 E
B3 C
B3 D
B3 B
B3 A



A2
Hours/year ×10^4
3
2.5
2
1.5
1
0.5
NW
W
SW
S
SE
E
NE
0
5
10
15
20
25
T (s)
SWS
EWS
A2 C
A2 B
A2 A



E_WS
S_WS
1
0
-1
-2
LST_per sys. / LST_gross
A2 A
A2 B
A2 C
150
100
50
0
Frequency of ocurrence (%)
A2 A
A2 B
A2 C

Conclusions:

- The two wave systems with highest capacity to transport sediment along the Uruguayan Atlantic coast were identified and characterized.

  EWS and SWS. They transport sediment in opposite directions.

- The Maximum correlation with wind projection on the azimuth allows to identify the generation zones of these systems.

  Future met-ocean work will focus there in order to impove data for coastal morphodynamics studies in the Uruguayan Atlantic coast.

- The LST_{system} approach shows to be able to provide a good insigth into LST dynamics.

  Annual cycle of the EWS and SWS are out of phase, acentuating the amplitude of the anual cycle of LST_{net}.

  Larger peaks on seasonal LST_{net} are associated with ESW.

  Negative (transport to the northeast) trends on seasonal transport are observed on JAS and OND associated with both systems.

  Significant correlation with climate indexes are obtained comparing seasonal transport and $LST_{system.}$ (LST_{ESE} with Niño 3.4 and LST_{SSE} with AAO).

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Thanks for your attention !

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