

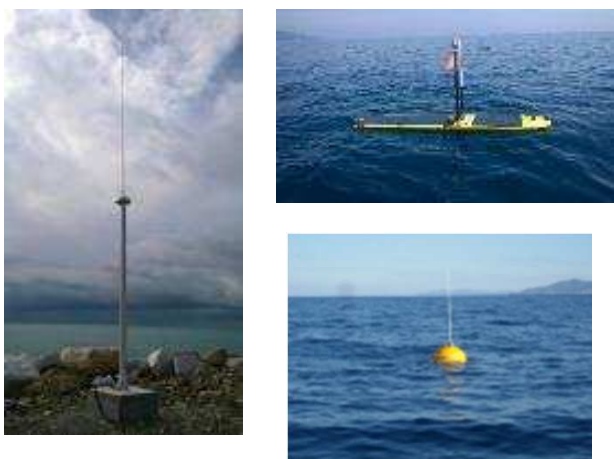
Gestione del rischio e adattamento al cambiamento climatico: strumenti per un territorio resiliente

*Genova, Mercoledì 6 Marzo
presso Galata - Museo del Mare*

Mareggiate intense e cambiamenti climatici, quali rischi a lungo termine?

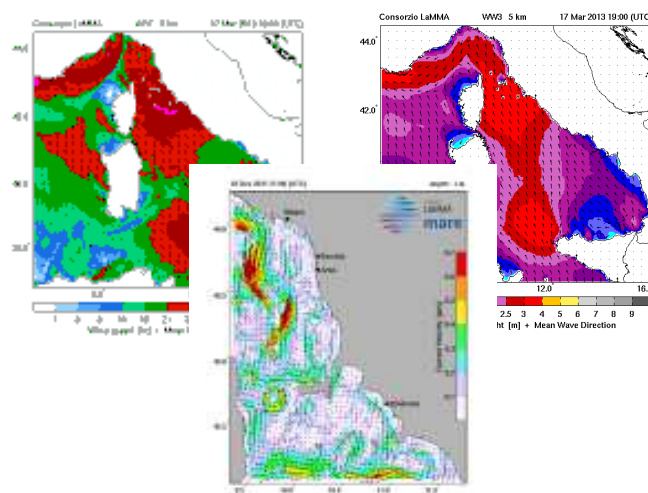
Brandini C., Perna M., Vannucchi V., Messeri G., Iannucilli M., Taddei S., Bendoni M., Vitale G., Cipriani L.

Osservazioni



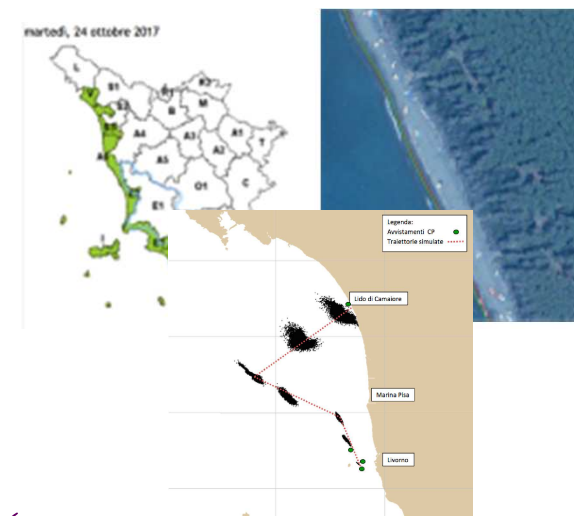
- ✓ Rete istituzionale dati in-situ (boe) → RT;
- ✓ Integrazione con altre osservazioni → ARPAT
- ✓ Rete di monitoraggio ad alta tecnologia: radar HF
- ✓ Veicolo autonomo di superficie (Wave Glider)
- ✓ Monitoraggio satellitare (stato del mare)
- ✓ Identificazione linea di riva

Modelli



- ✓ Un insieme di modelli: meteorologici, di moto ondoso e di circolazione
- ✓ Girano come downstream services di servizi a scala europea (ECMWF, CMEMS)
- ✓ Multiscala
- ✓ Ricerca & sviluppo: calibrazione, validazione and assimilazione;
- ✓ Spazializzazione (regionalizzazione dei dati)

Servizi



- ✓ H24 Servizio meteorologico ed oceanografico operativo
- ✓ Protezione civile
- ✓ Monitoraggio della linea di riva e delle onde a scala costiera
- ✓ Previsione sulla qualità delle acque di balneazione
- ✓ Supporto alla guardia costiera (SAR, tracking di inquinanti, balene, ecc.)
- ✓ Servizi on demand
- ✓ Weather routing
- ✓ Attività sui porti

La mareggiata di fine Ottobre 2018, effetti sulla costa toscana

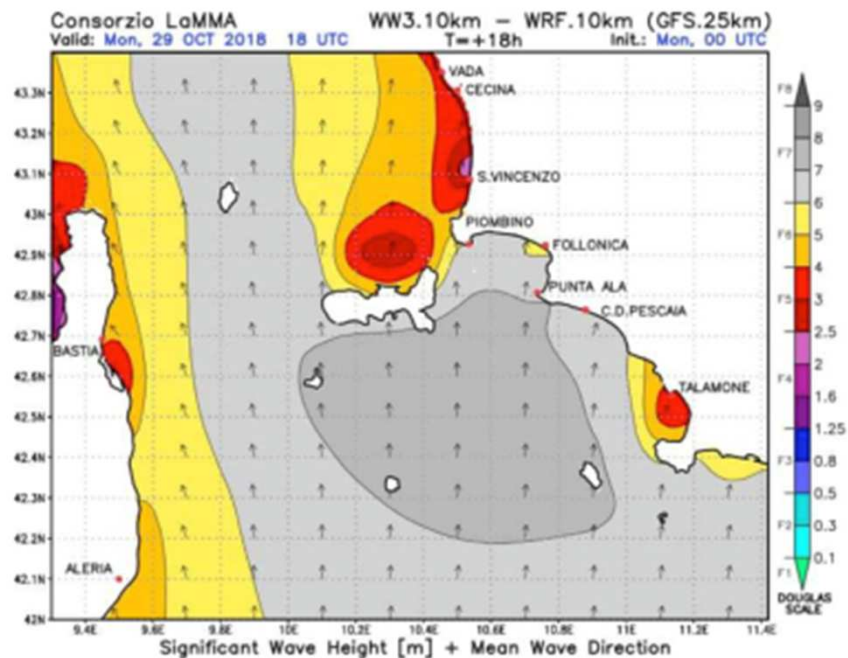


Figura 4 - Particolare dell'altezza d'onda significativa prevista dal modello d'onda WW3 del Lamma per la Toscana meridionale e l'Isola d'Elba

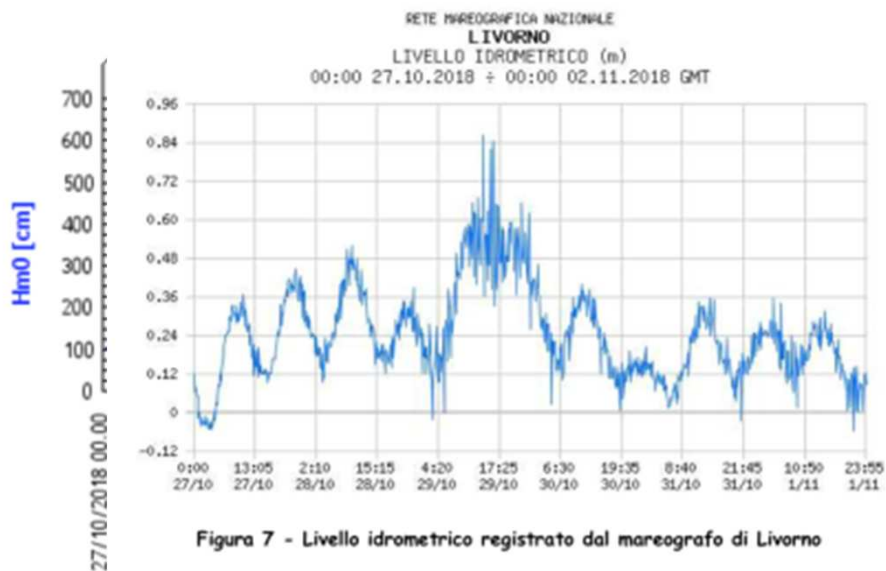


Figura 7 - Livello idrometrico registrato dal mareografo di Livorno

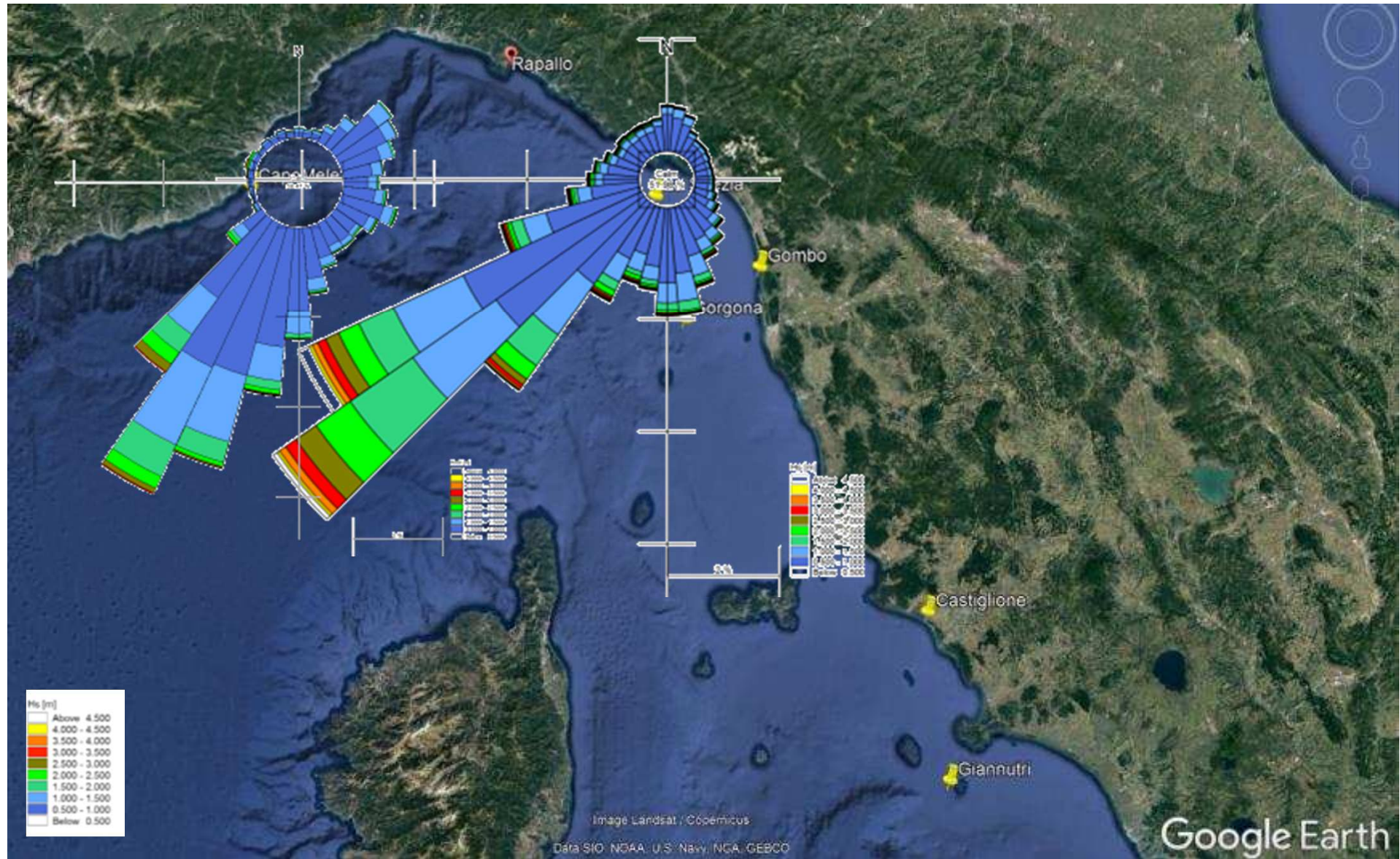


Mareggiate intense con evidenze di

LA SPEZIA						
Data	Durata [h]	CARATTERISTICHE AL PICCO				
		ORA	Hs	Tp	Dirp	
06/11/2000	08/11/2000	33	06/11/2000 14:00:00	5.77	-	191.13
03/02/2003	04/02/2003	30	04/02/2003 01:00:00	5.9	10	229.22
04/10/2003	06/10/2003	54	05/10/2003 06:00:00	6.5	10.5	210
21/12/2003	22/12/2003	27	21/12/2003 21:30:00	4.47	10.53	151.43
23/02/2004	24/02/2004	30	23/02/2004 13:30:00	6	10.5	262.1

GORGONA							CAPO MELE										
Data	D [h]	CARATTERISTICHE AL PICCO					Data	D [h]	CARATTERISTICHE AL PICCO								
		ORA	Hs	Tp	Tm	Dirp			ORA	Hs	Tp	Tm	Dirp				
20/11/2008	22/11/2008	41	22/11/2008 02:08	4.86	-	9.06	234.8										
29/11/2008	02/12/2008	35	01/12/2008 07:37	5.11	-	7.44	232										
24/12/2009	26/12/2009	29	25/12/2009 19:00	4.67	-	7.26	248.9										
01/01/2010	03/01/2010	39	02/01/2010 15:29	5.5	-	8.35	234.8										
15/12/2011	17/12/2011	67	17/12/2011 05:55	7.08	11.1	9.29	236										
05/01/2012	06/01/2012	35	05/01/2012 20:53	4.58	10	7.66	240										
27/10/2012	29/10/2012	58	28/10/2012 09:16	6.5	11.1	8.65	239	27/10/2012	28/10/2012	23	28/10/2012 03:00:00	4.26	9.57	7.81	216.56		
04/12/2012	05/12/2012	39	04/12/2012 16:43	5.12	10	7.93	243.3										
25/12/2013	26/12/2013							25/12/2013	26/12/2013	44	25/12/2013 23:30:00	5.35	9.38	8.01	187.03		
04/11/2014	05/11/2014							04/11/2014	05/11/2014	33	05/11/2014 00:00:00	4.73	10.06	8.2	165.94		
29/01/2015	31/01/2015	57	30/01/2015 03:00	5.2	9.07	7.2	255.9										
11/01/2016	14/01/2016	82	12/01/2016 01:00	6.61	9.97	8.44	246.1										
10/12/2017	16/12/2017	148	11/12/2017 23:00	4.58	10.57	7.48	237.7	10/12/2017	12/12/2017	44	11/12/2017 20:30:00	4.73	9.86	7.52	191.25		
08/12/2017	09/12/2017	42	08/12/2017 22:00	5.18	10.57	7.95	239.1				11/12/2017 21:30:00	4.73	10.55	7.52	192.66		
											11/12/2017 20:30:00	4.73	9.86	7.52	191.25		
10/12/2017	16/12/2017	148	11/12/2017 23:00	4.58	10.57	7.48	237.7	10/12/2017	12/12/2017	44	11/12/2017 21:30:00	4.73	10.55	7.52	192.66		
											13/12/2017 15/12/2017	40	14/12/2017 21:00:00	3.98	9.18	7.03	216.56
											16/01/2018 21:00:00	4.1	9.18	8.11	210.94		
16/01/2018	21/01/2018	134	17/01/2018 03:00	7.08	10.57	9.07	244.7	16/01/2018	17/01/2018	31	17/01/2018 05:00:00	4.1	9.47	7.62	215.16		
											17/01/2018 05:30:00	4.1	9.67	7.52	217.97		
29/10/2018	30/10/2018	33	30/10/2018 04:00	5.27	11.72	8.75	244.7	29/10/2018	30/10/2018	33	29/10/2018 23:00:00	6.41	9.57	8.5	271.41		





Due eventi, tra i tanti degli ultimi venti anni : la distruttiva mareggiata di fine Ottobre 2018



RAPALLO, Ottobre 2018



Fonte:
<http://www.genovatoday.it/video/rapallo-mareggiata-drone.html>

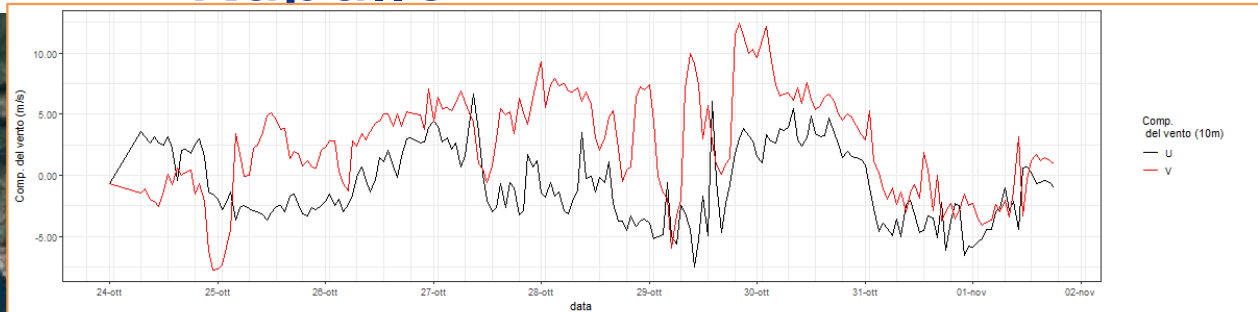
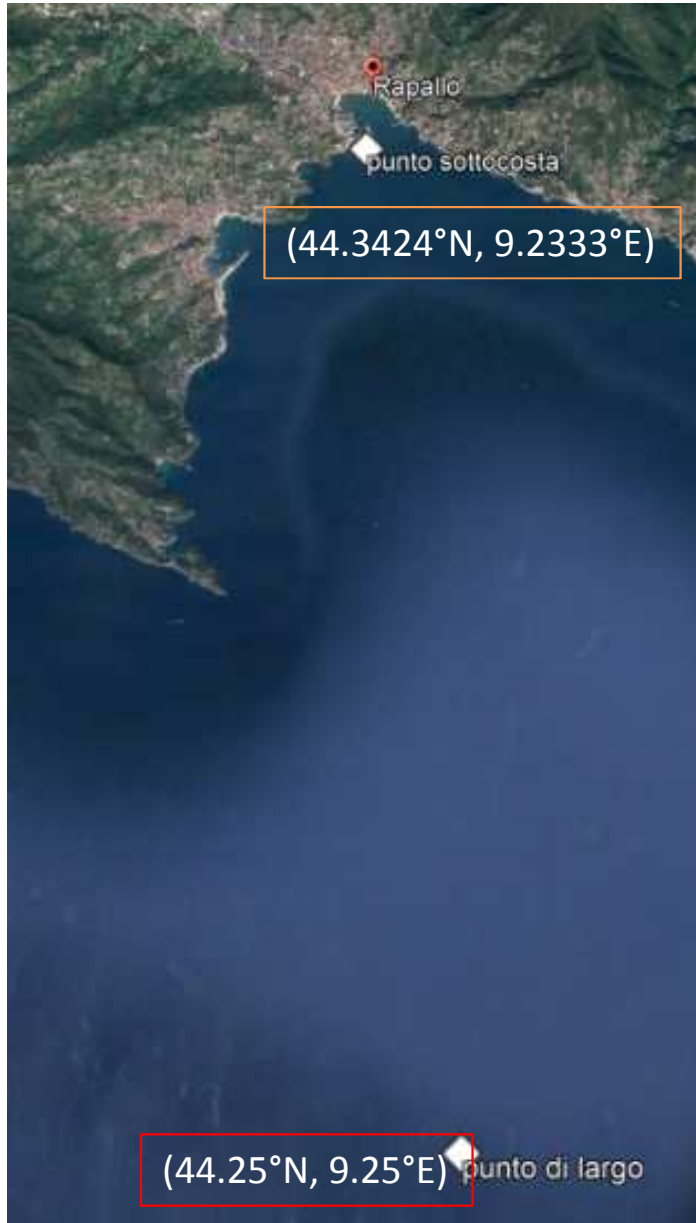
... e un evento anch'esso molto distruttivo, di diciotto anni prima...

RAPALLO, Novembre 2000

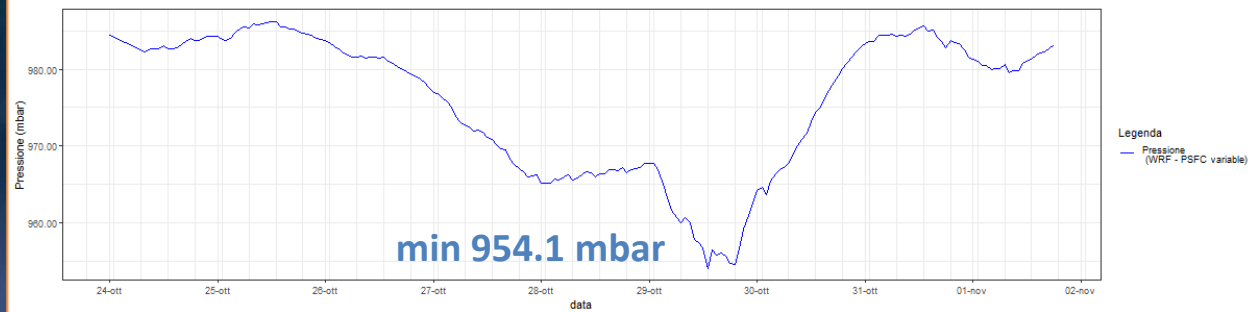


Fonte:
<http://www.youtube.com>

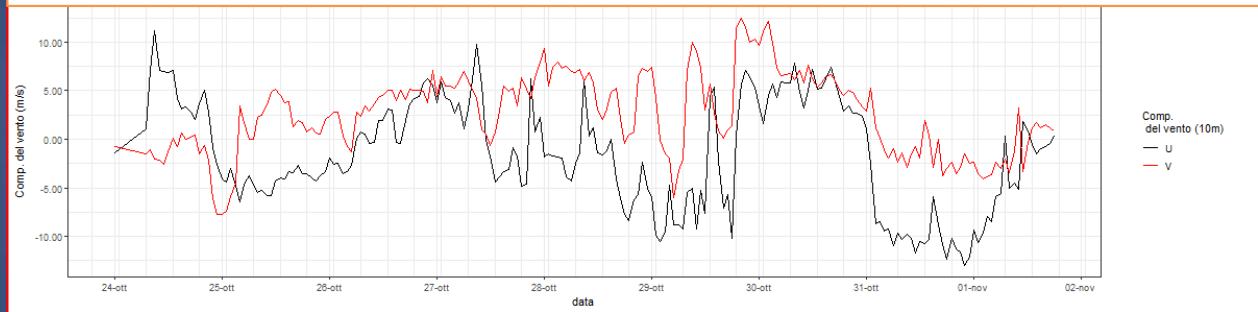
Ricostruzione dell'evento 2018 e impatto sul porto di Rapallo



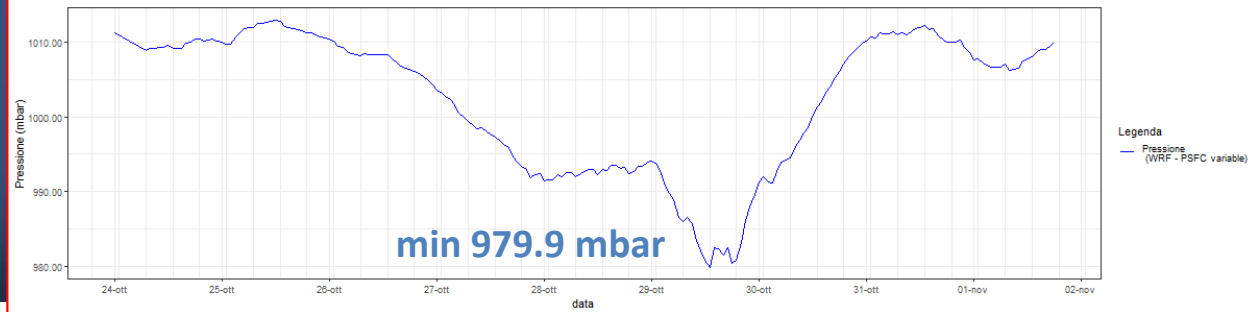
VENTO



PRESSIONE

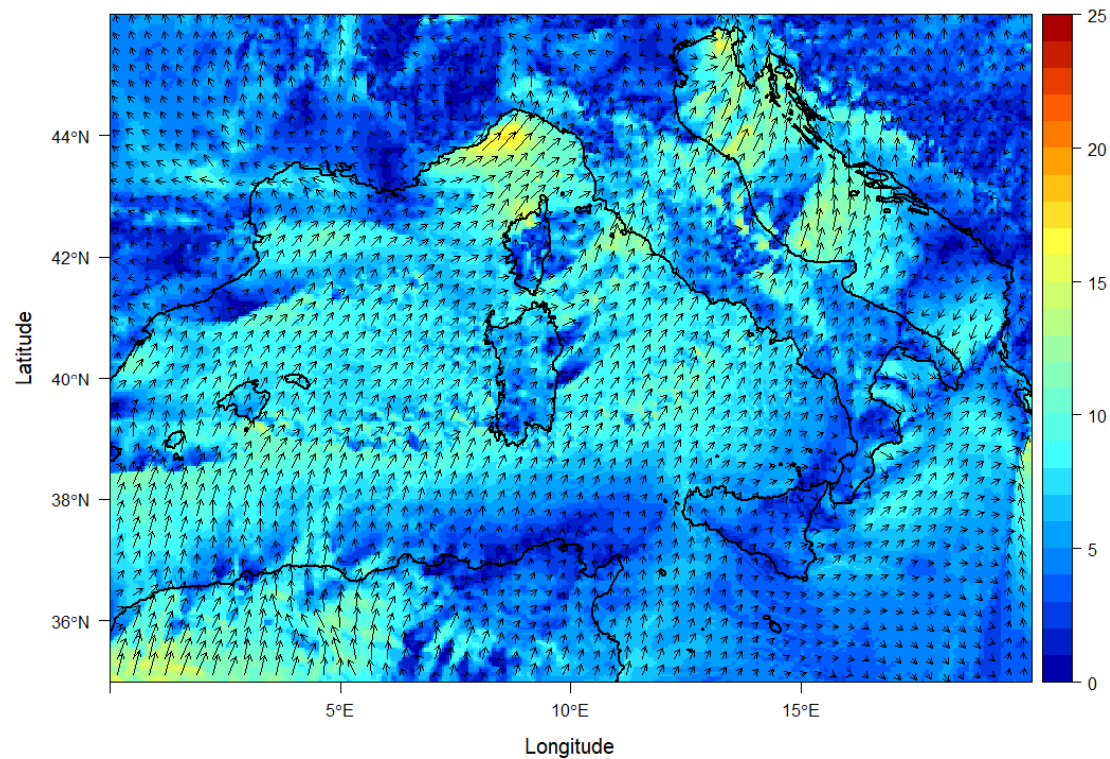


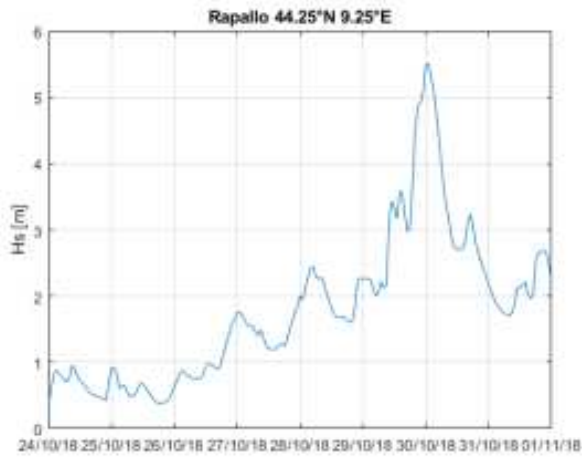
VENTO



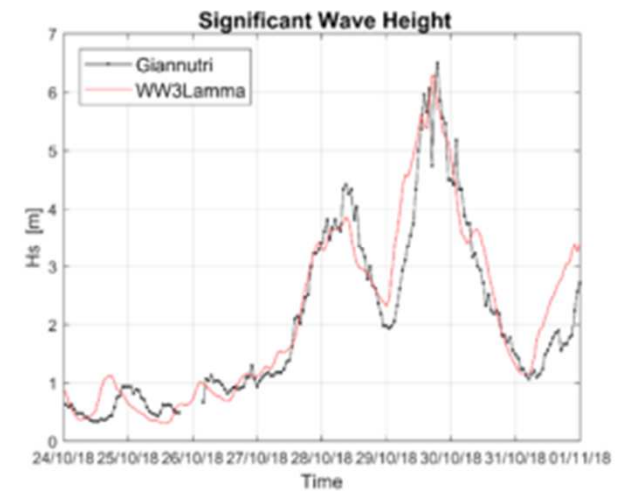
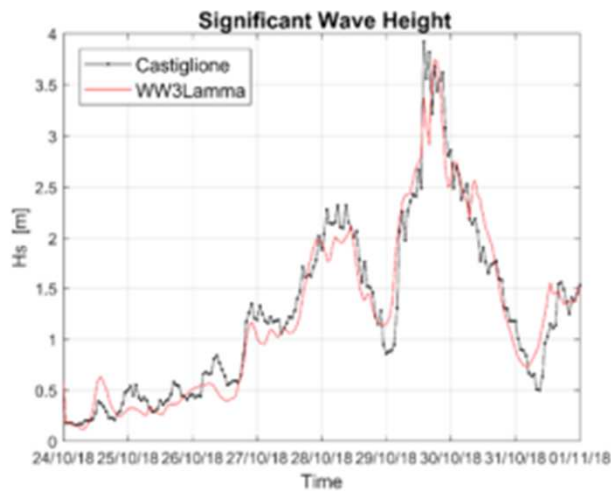
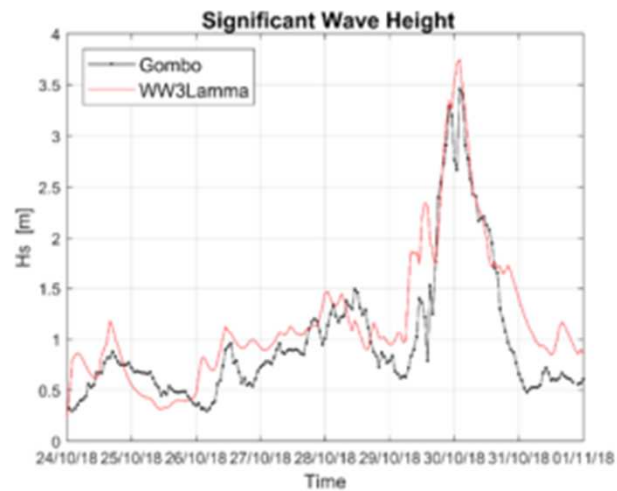
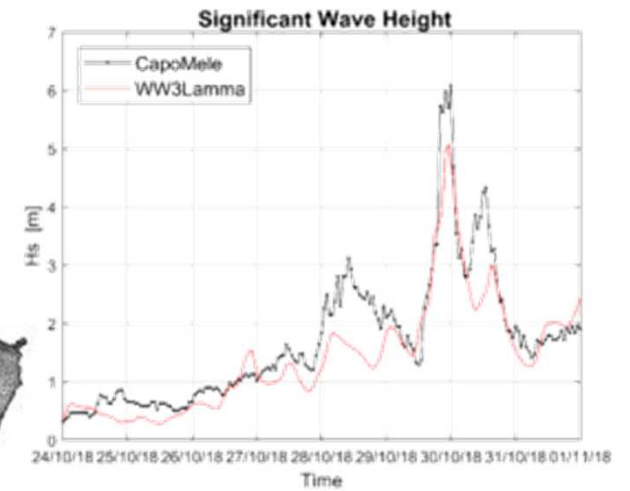
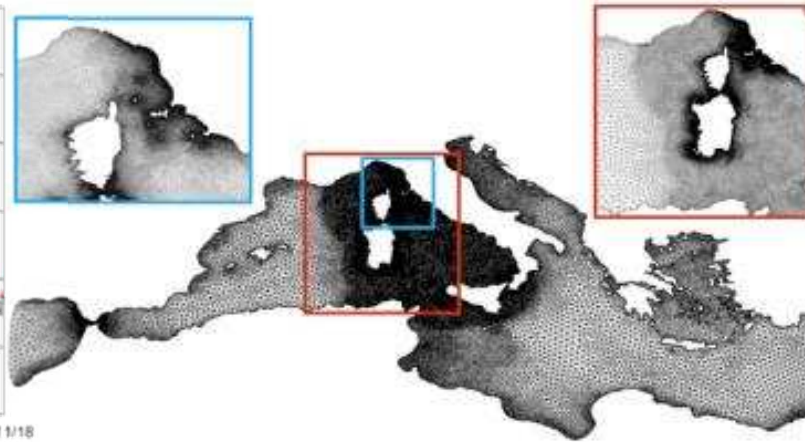
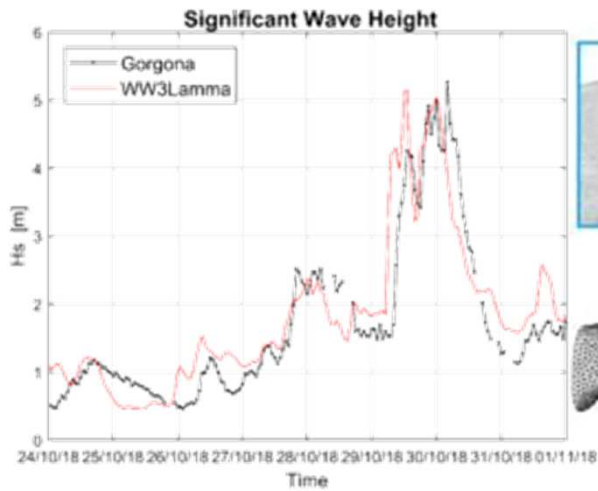
PRESSIONE

Evento del 28-30 Ottobre 2018 evoluzione



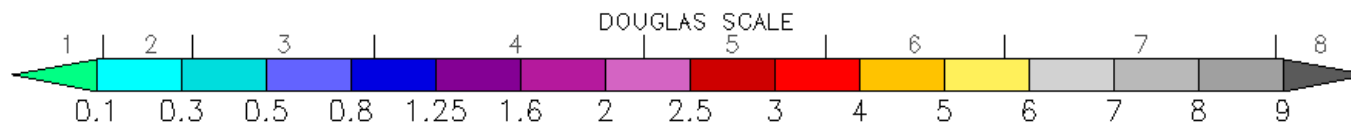
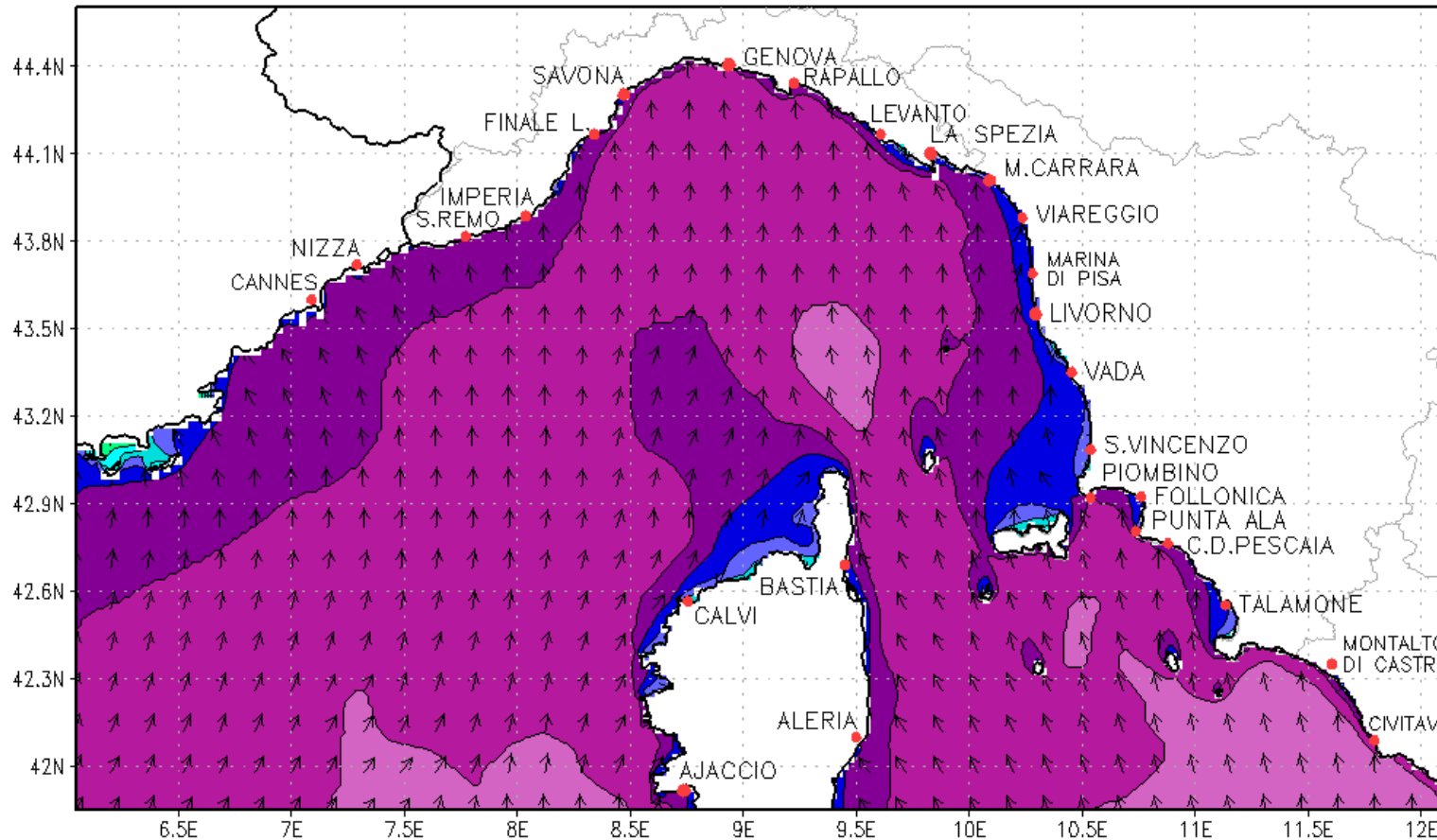


Modello di ricostruzione (hindcast) delle mareggiate: uso di modelli a maglia non strutturata



La previsione della mareggiata: le fasi iniziali, Sud e Scirocco

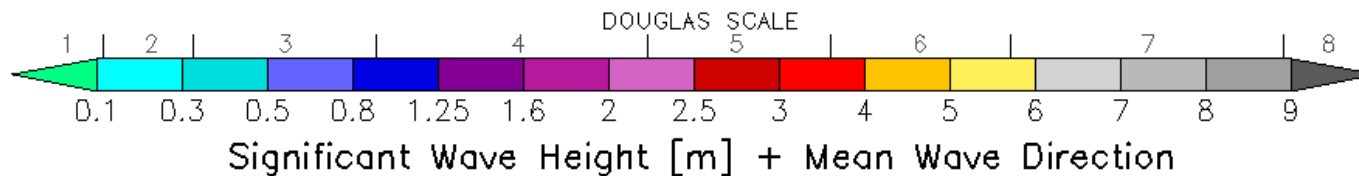
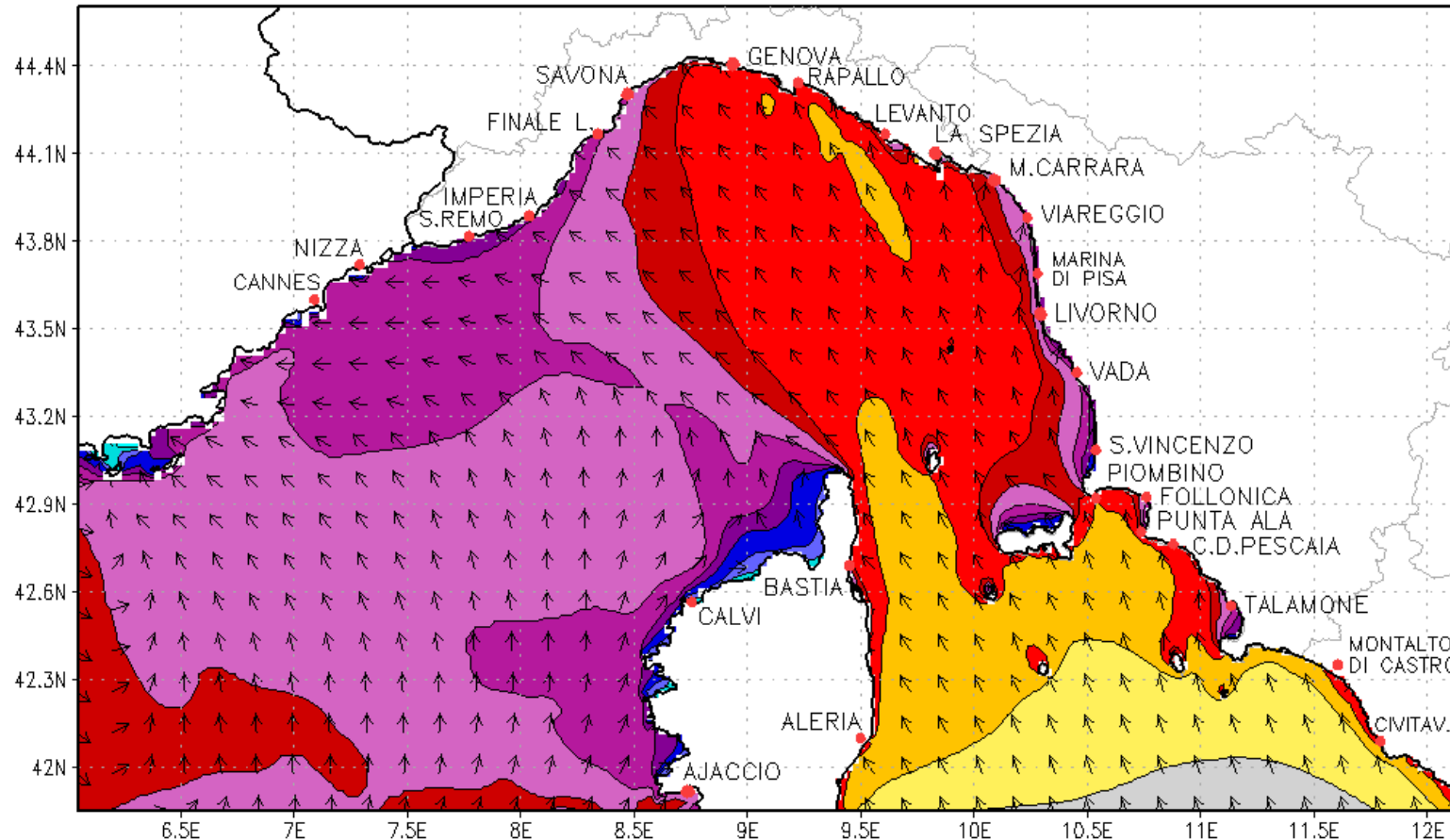
Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: Mon, 29 OCT 2018 00 UTC Valid: Mon, 29 OCT 2018 00 UTC
T=+0h



Significant Wave Height [m] + Mean Wave Direction

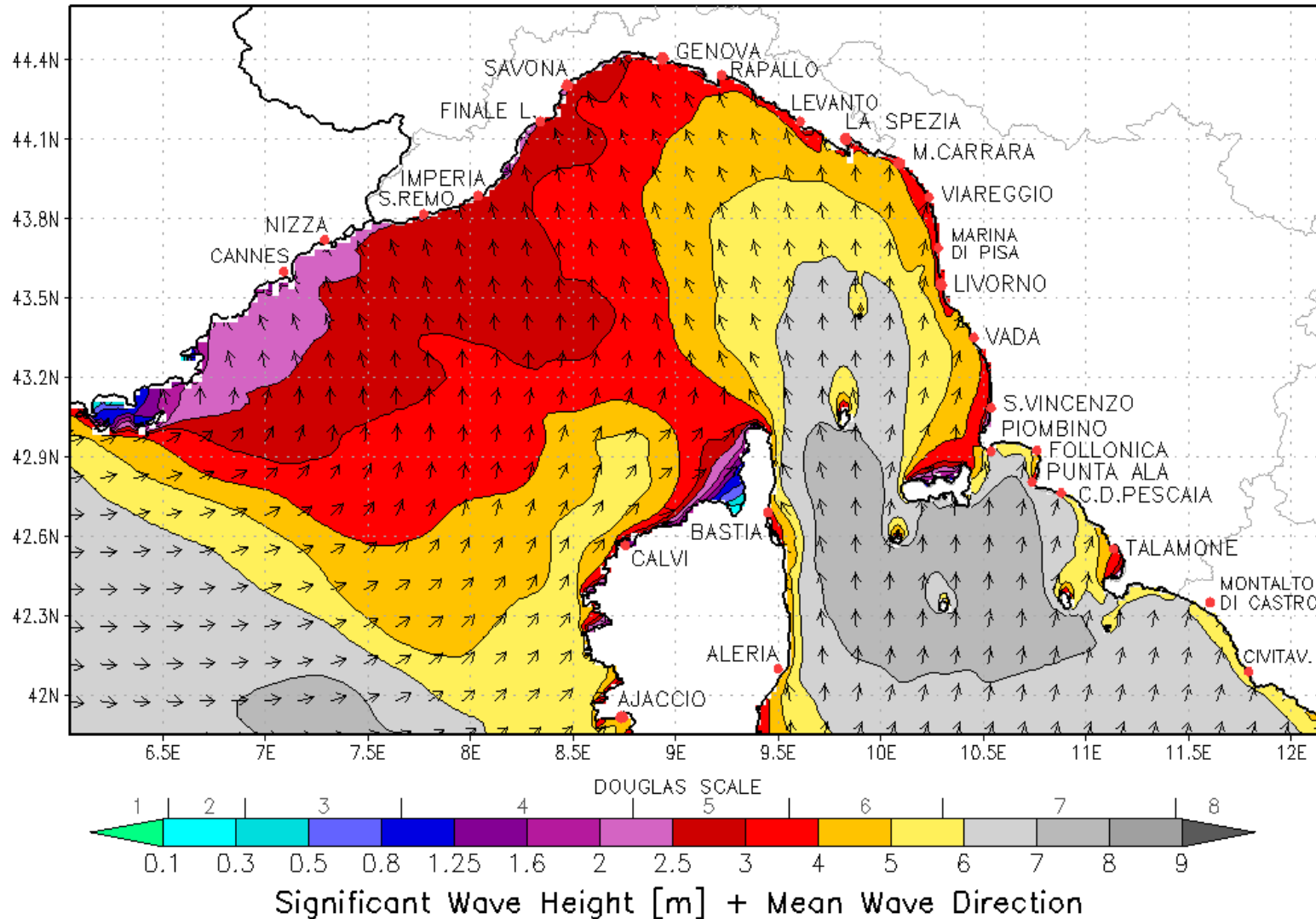
La previsione della mareggiata: Sud e Scirocco, il passaggio del minimo barico

Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: **Mon, 29 OCT 2018 12 UTC** Valid: **Mon, 29 OCT 2018 12 UTC** T=+0h



Il passaggio del minimo barico, inizia a montare il libeccio

Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: **Mon, 29 OCT 2018 12 UTC** Valid: **Mon, 29 OCT 2018 18 UTC** T=+6h



Il libeccio e il mare incrociato

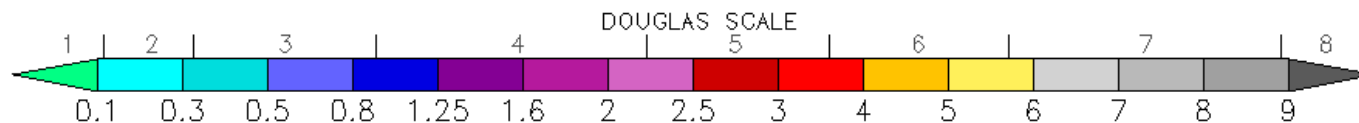
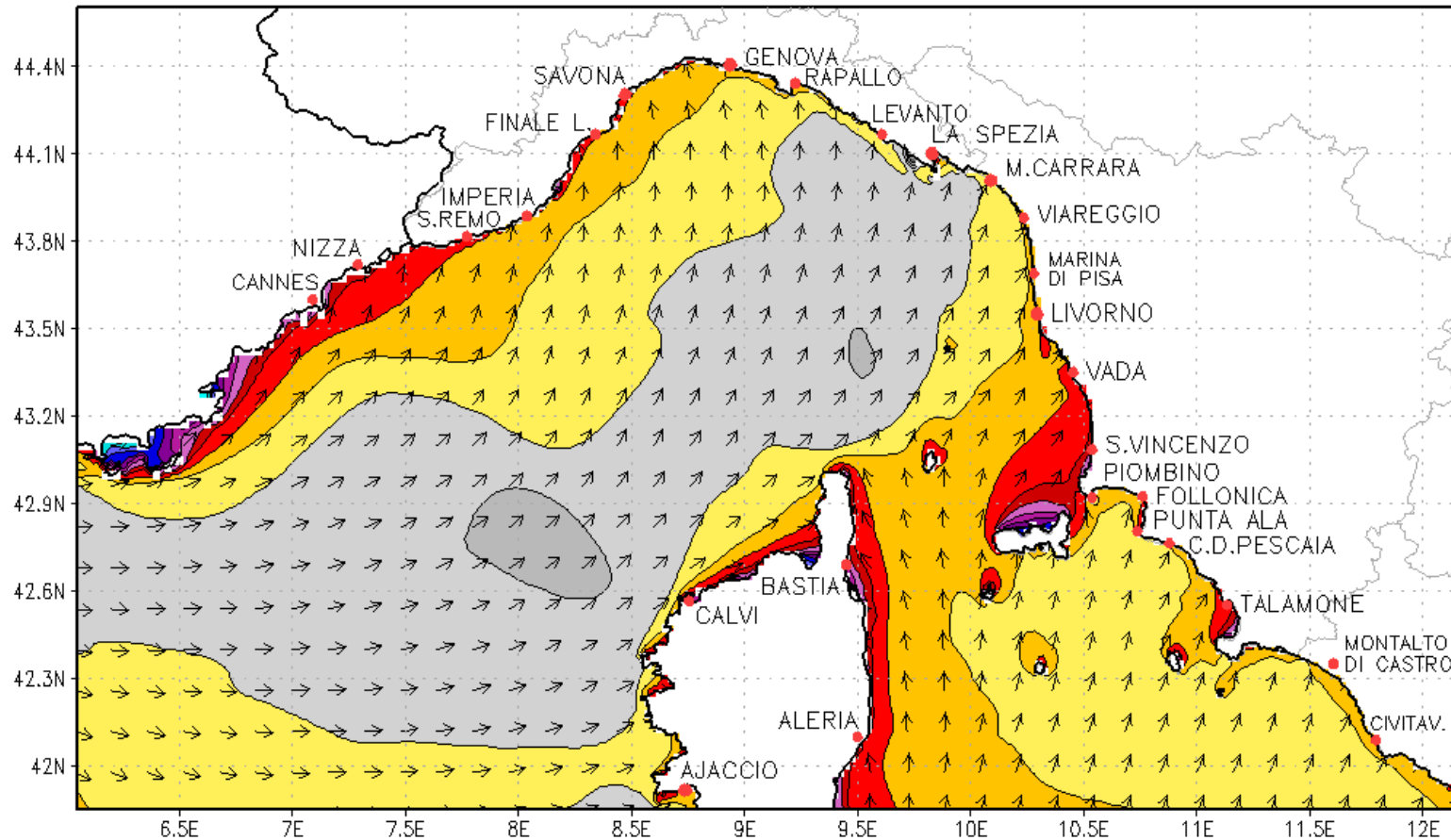
Consorzio LaMMA

WW3 3km – WRF ECMWF 3km

Init.: Mon, 29 OCT 2018 12 UTC

Valid: Mon, 29 OCT 2018 21 UTC

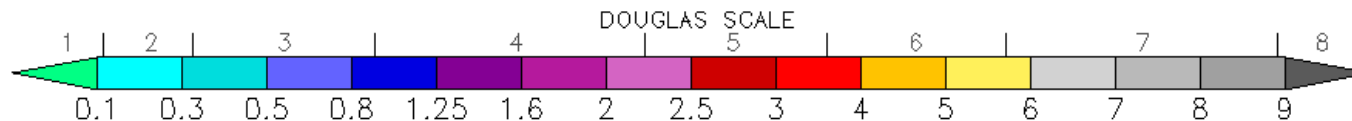
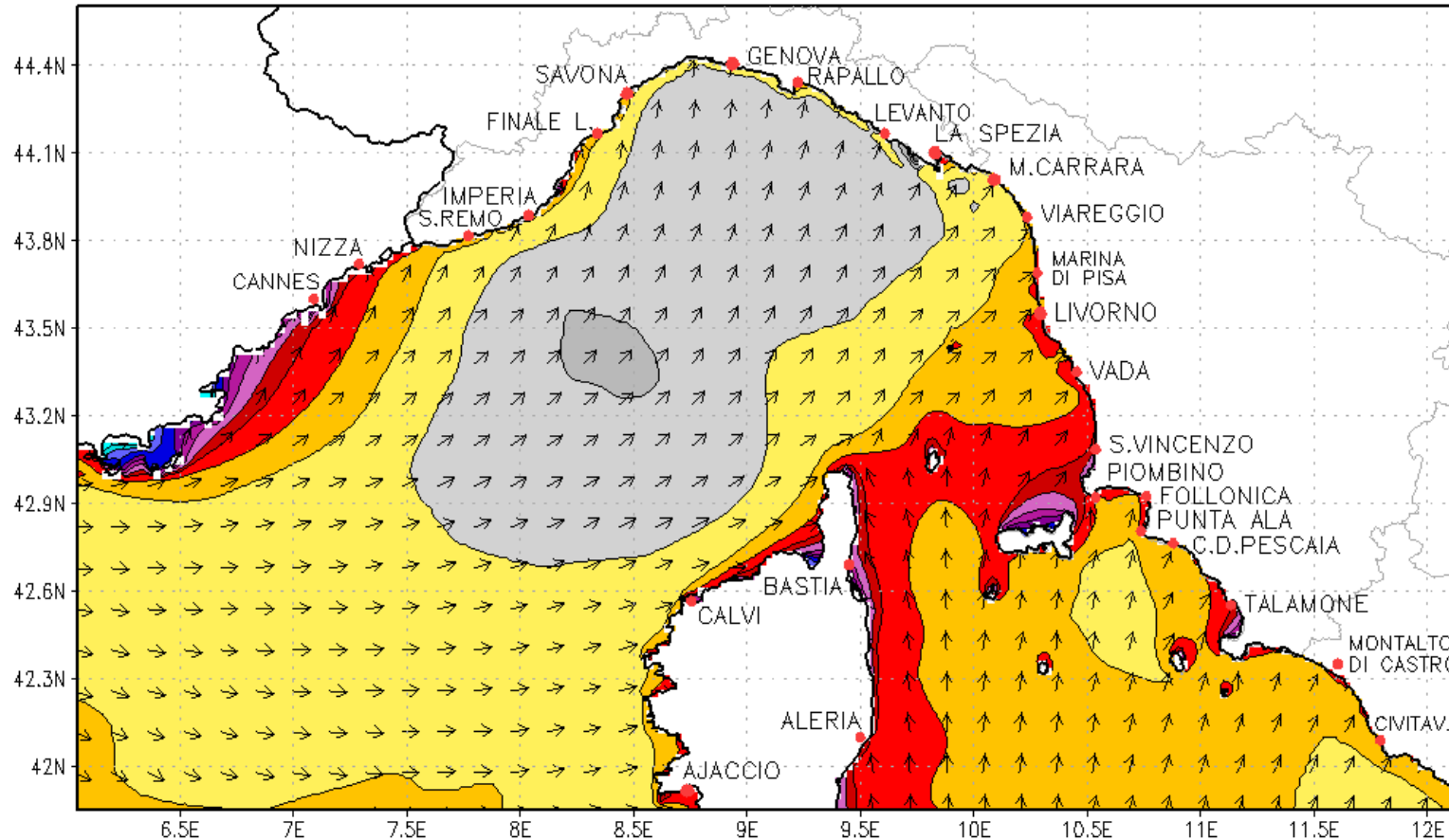
T=+9h



Significant Wave Height [m] + Mean Wave Direction

La previsione della mareggiata: il picco

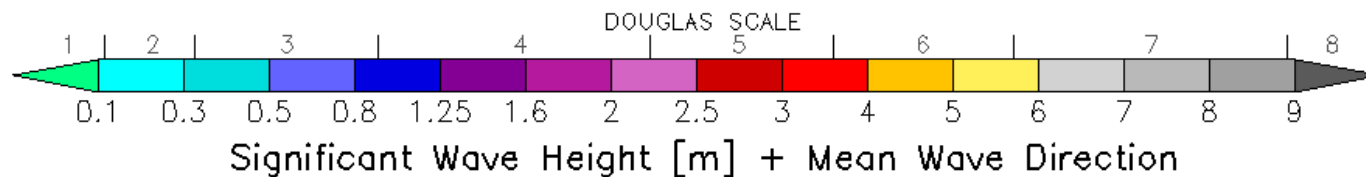
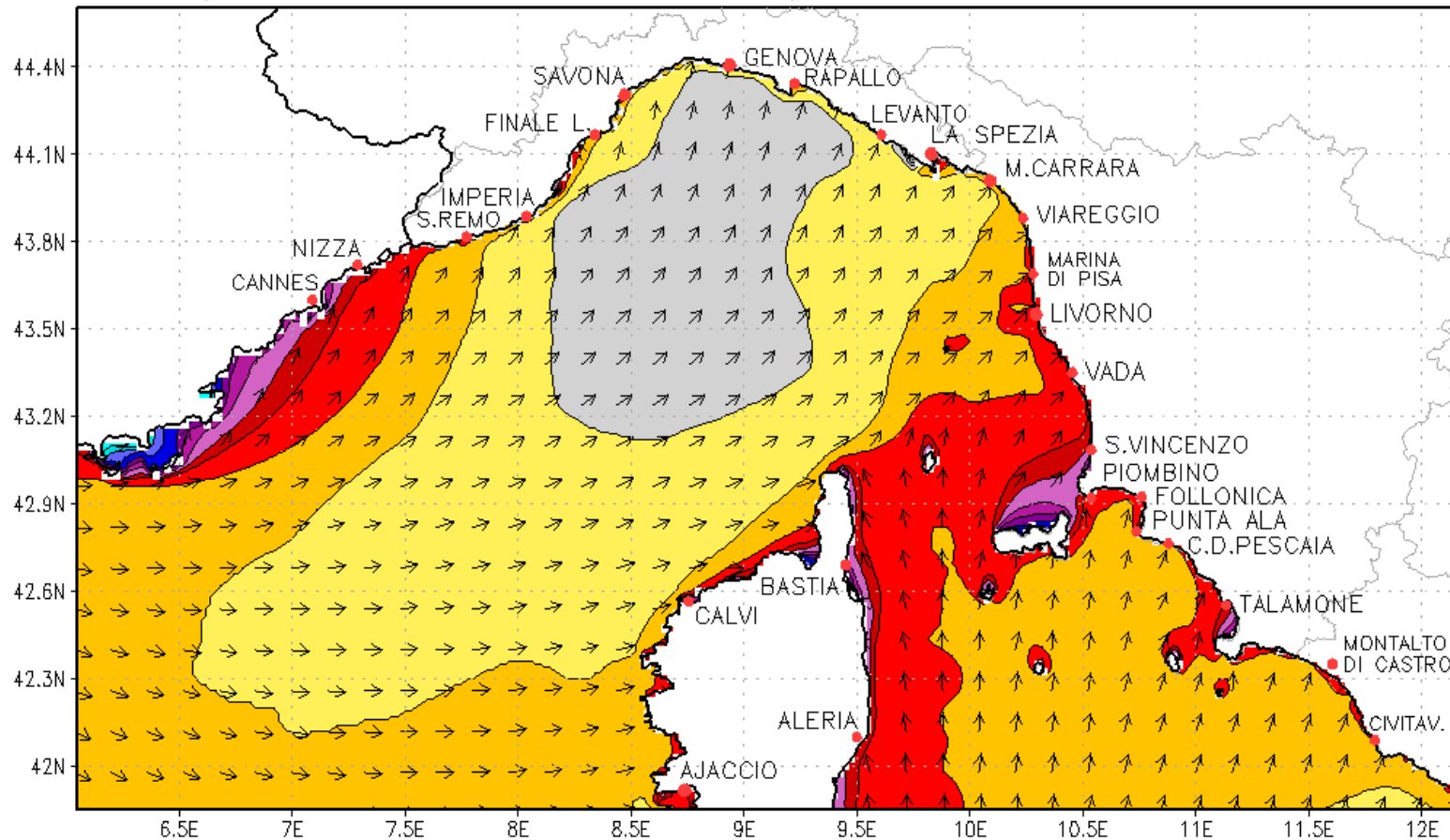
Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: Mon, 29 OCT 2018 12 UTC Valid: Mon, 29 OCT 2018 23 UTC T=+11h



Significant Wave Height [m] + Mean Wave Direction

La previsione della mareggiata

Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: Tue, 30 OCT 2018 00 UTC Valid: Tue, 30 OCT 2018 00 UTC
T=+0h



La coda della mareggiata

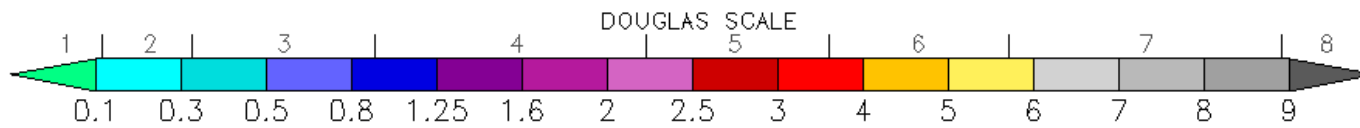
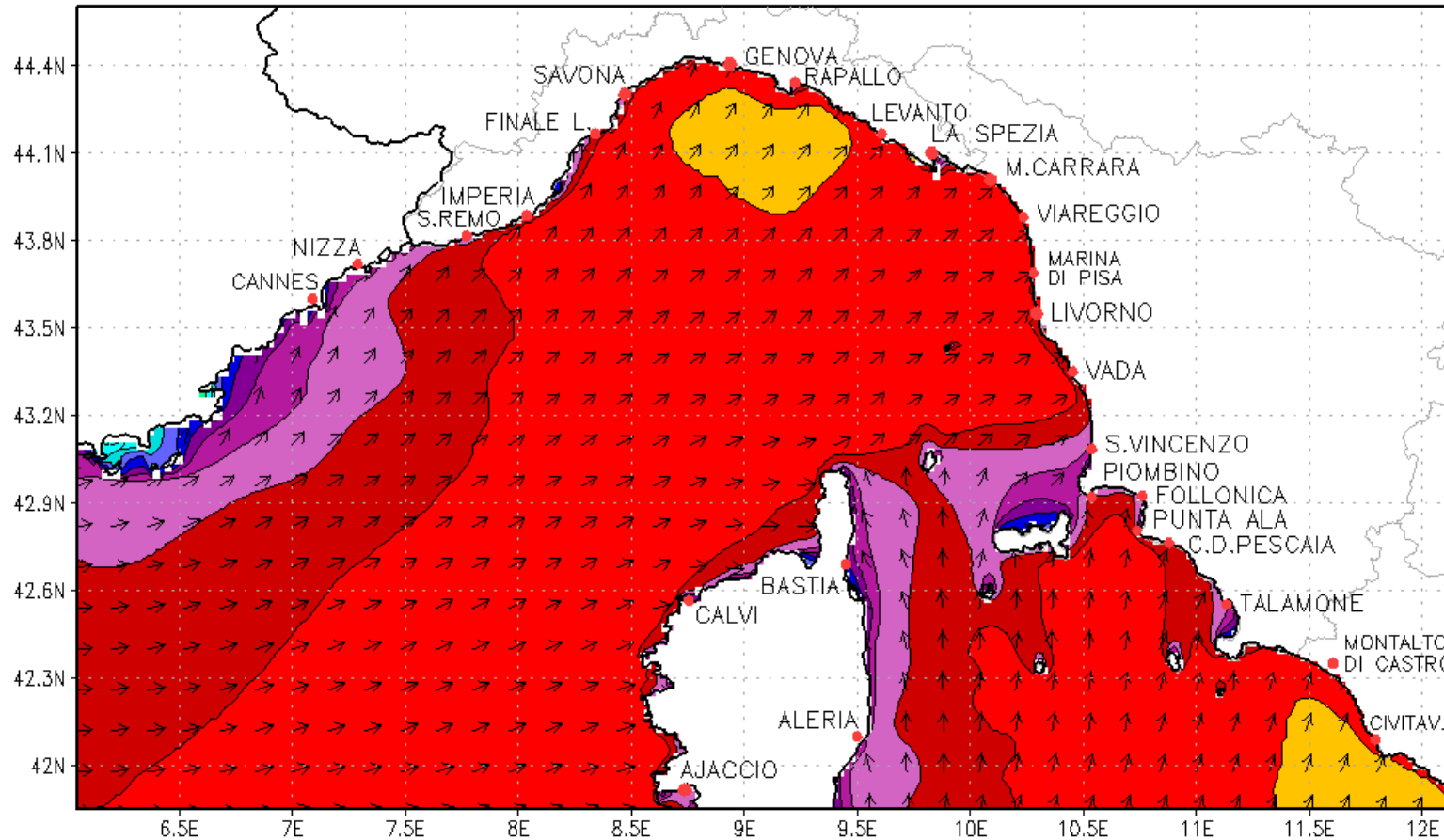
Consorzio LaMMA

WW3 3km – WRF ECMWF 3km

Init.: Tue, 30 OCT 2018 00 UTC

Valid: Tue, 30 OCT 2018 06 UTC

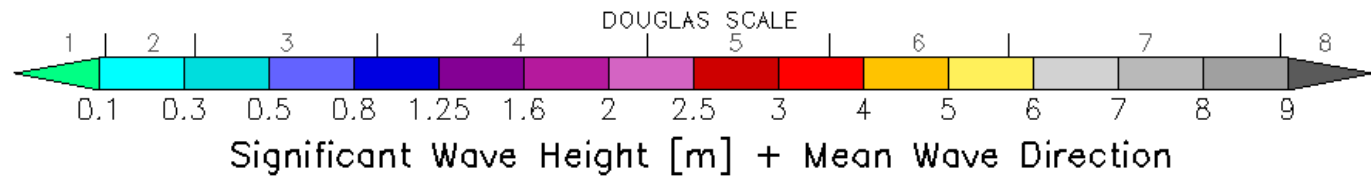
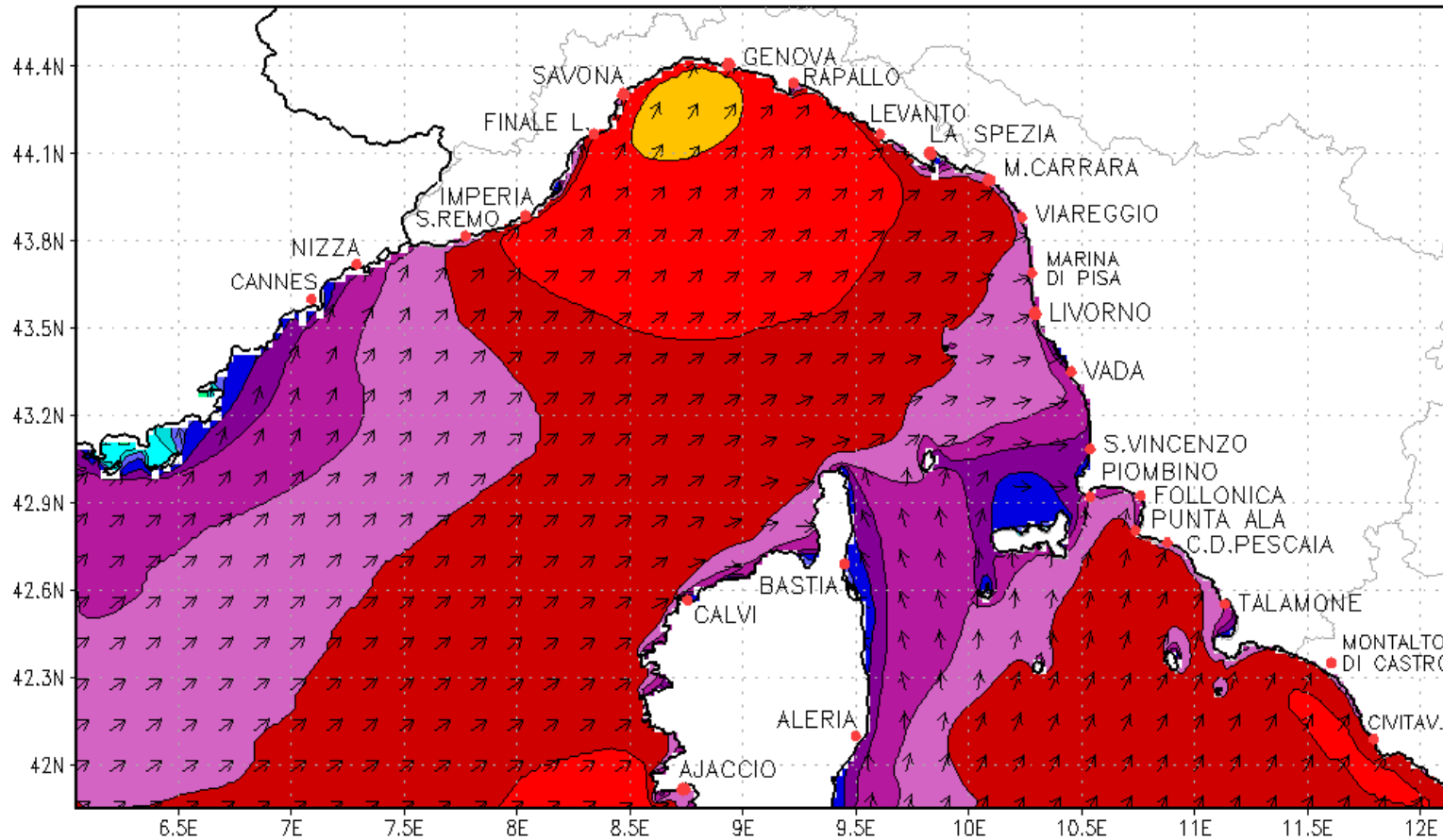
T=+6h



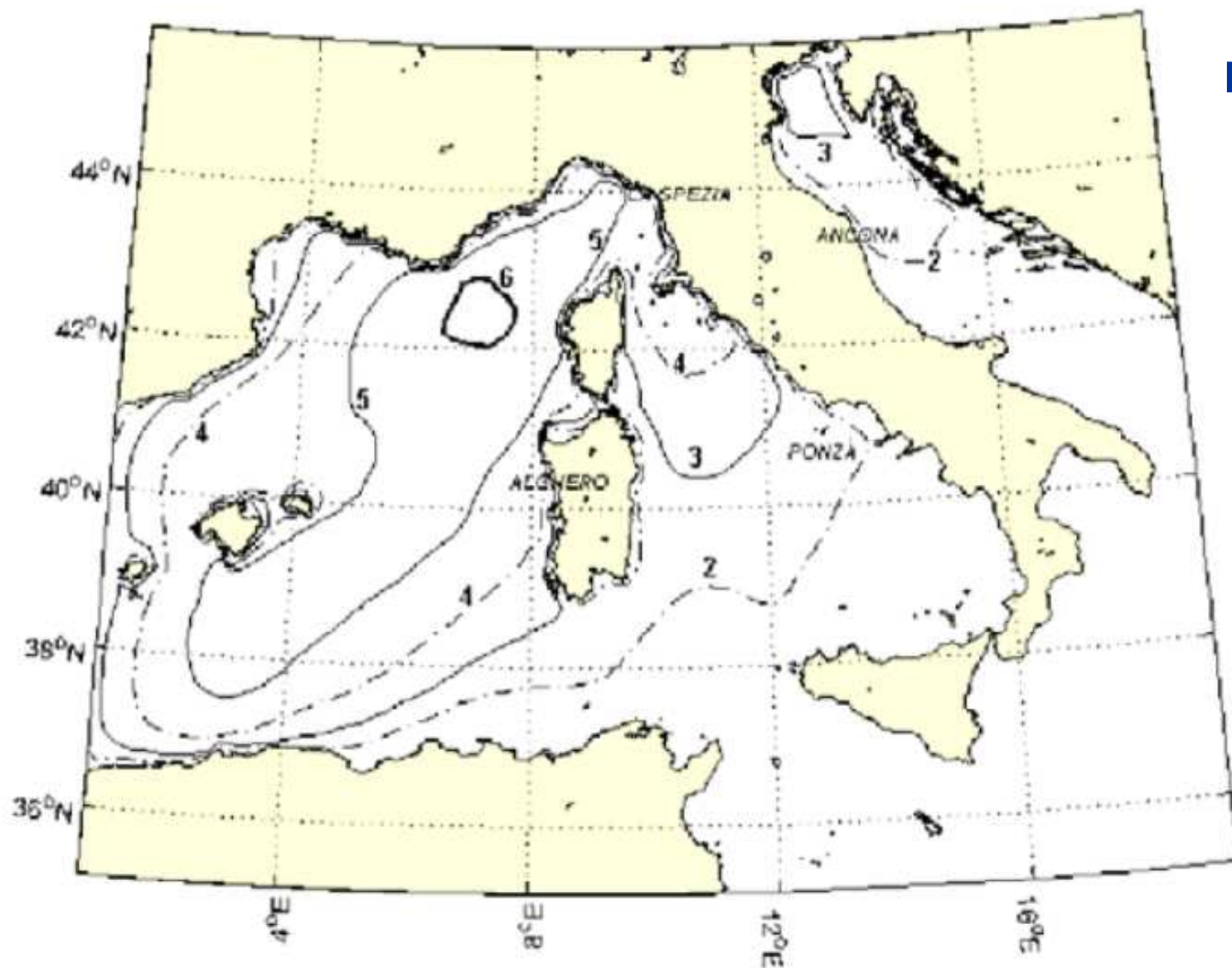
Significant Wave Height [m] + Mean Wave Direction

La coda della mareggiata

Consorzio LaMMA WW3 3km – WRF ECMWF 3km
 Init.: Tue, 30 OCT 2018 12 UTC Valid: Tue, 30 OCT 2018 12 UTC
T=+0h

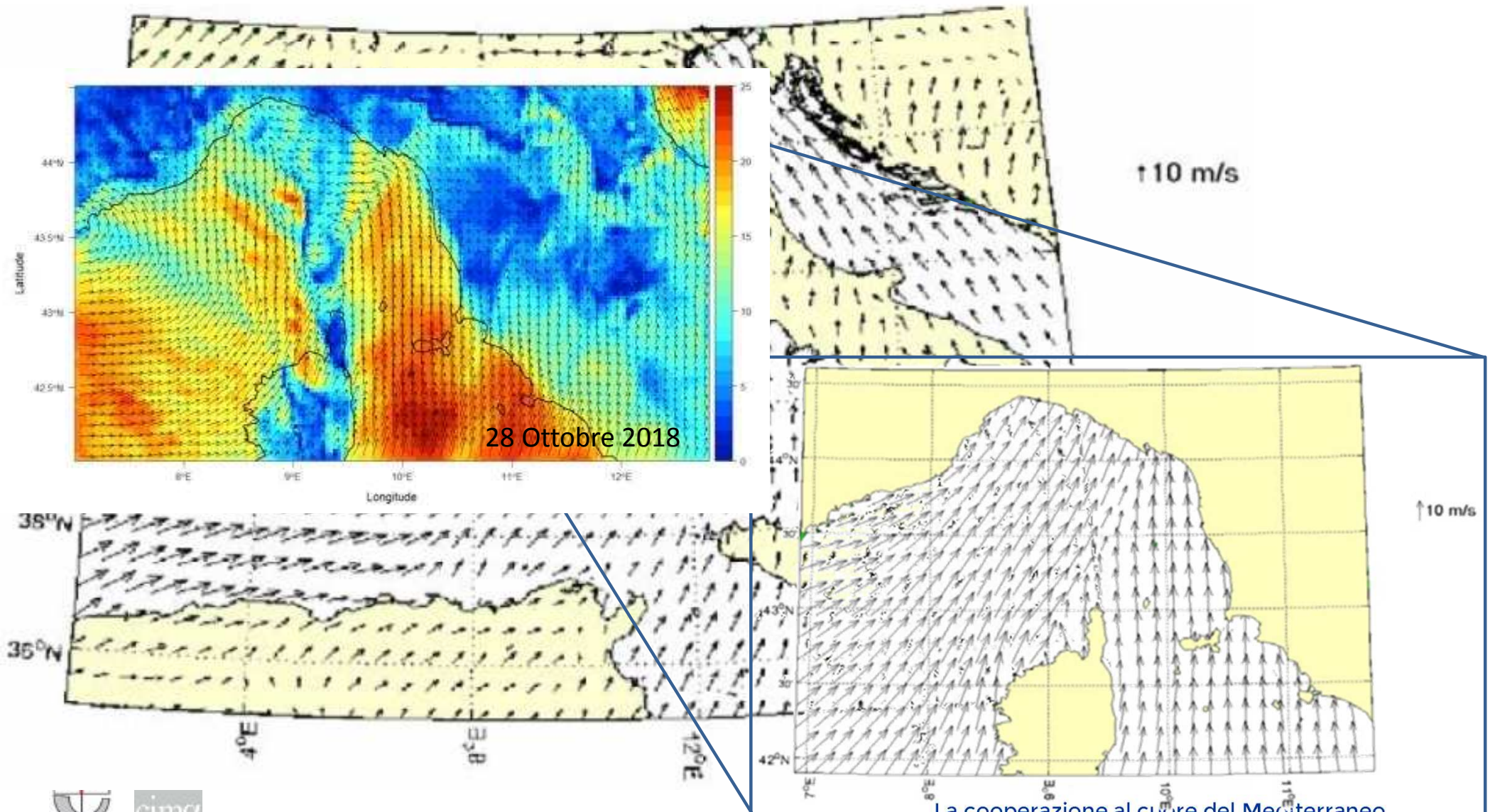


Il 6-8 Novembre 2000 successe un evento simile?



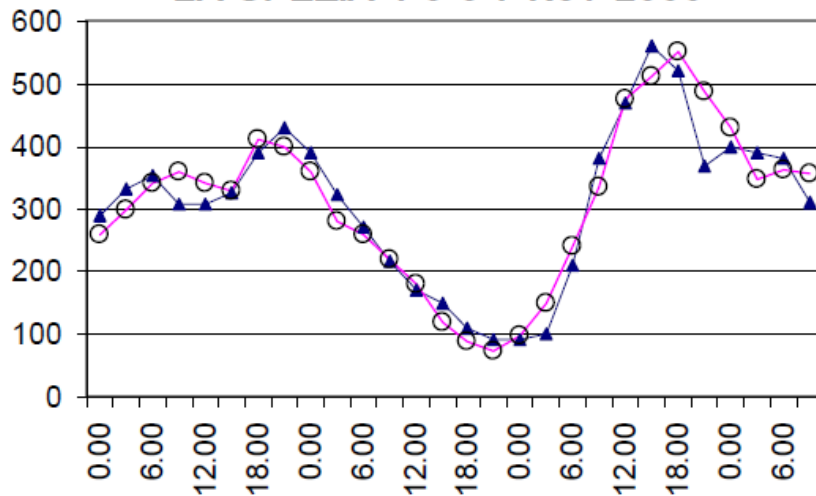
Da Brandini et al. 2002

Il 6-8 Novembre 2000 successe un evento simile?

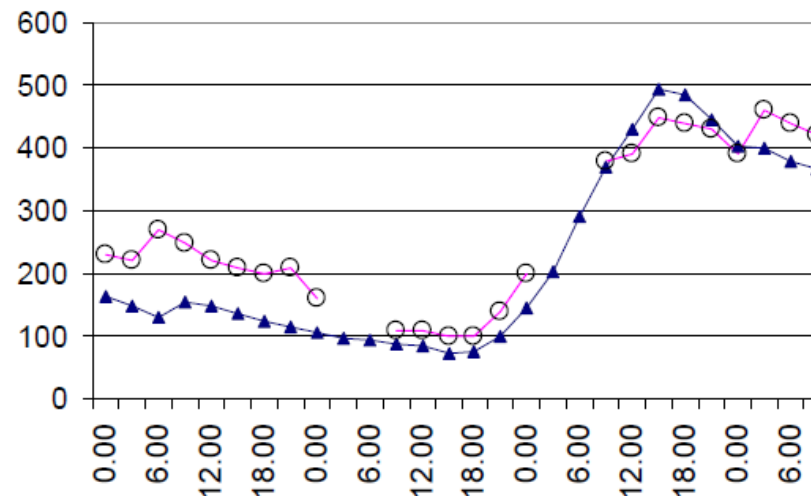


6-8 Novembre 2000, confronto con i dati della RON

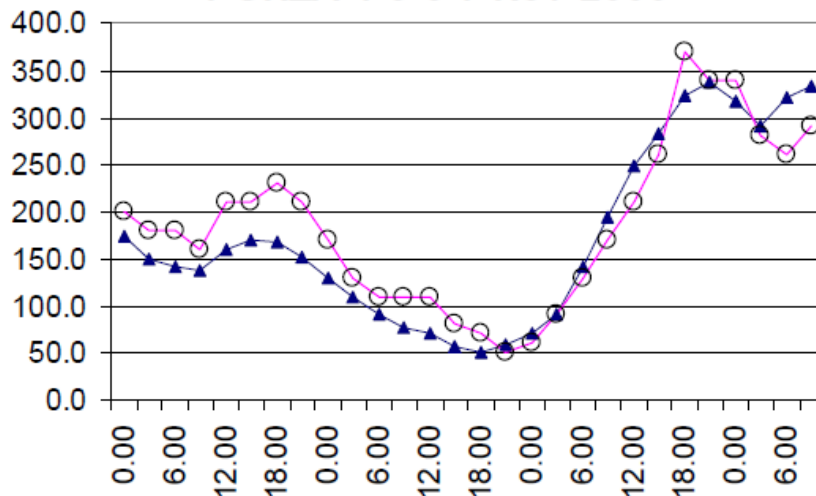
LA SPEZIA 4-5-6-7 Nov 2000



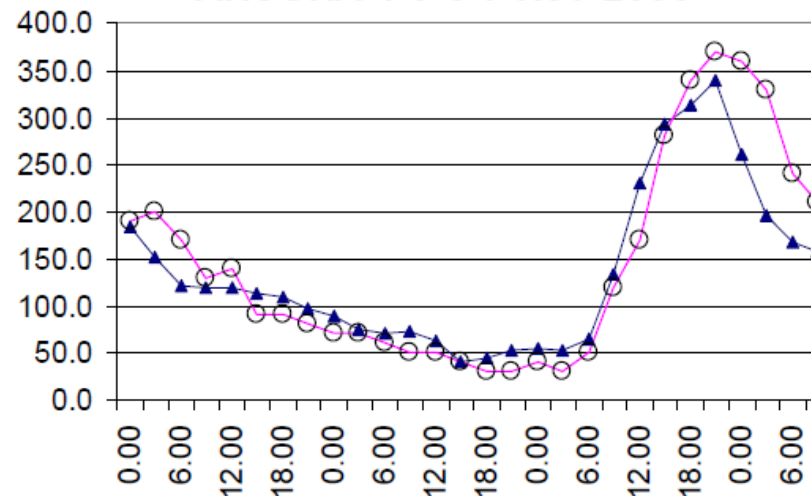
ALGHERO 4-5-6-7 Nov 2000



PONZA 4-5-6-7 Nov 2000



ANCONA 4-5-6-7 Nov 2000



Mareggiate intense e tipi di circolazione atmosferica: una prospettiva climatologica

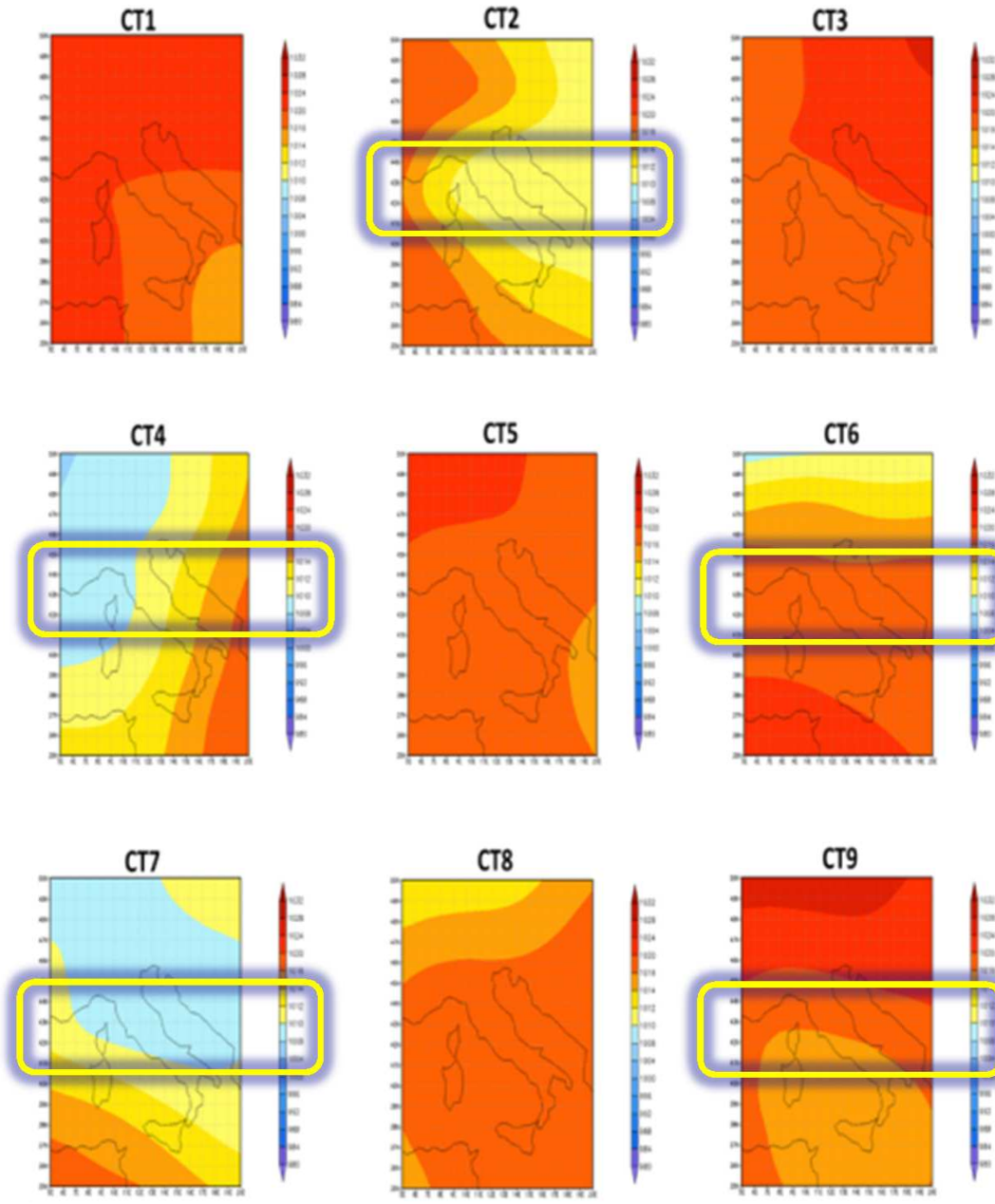
Mareggiate intense: la previsione del danno richiede un'attenta valutazione dell'impatto delle onde sulla costa (necessità di integrare modelli a diverse scale o di costruire indici di rischio affidabili). Ma è fattibile in tempo reale?

Circolazione generale: ci sono delle caratteristiche ricorrenti nella circolazione che caratterizzano le mareggiate intense?

Cambiamento climatico: ci sono evidenze riguardanti l'evoluzione di queste caratteristiche della circolazione che è necessario tener in considerazione per "prevedere" il rischio o "aggiornare" i criteri di progettazione da adottare per le opere di difesa costiera?

Weather Circulation Types centroids (PCT09 – MSLP)

Analisi dei tipi di circolazione



1. High pressure over central-northern Italy, low over Ionian Sea; easterly winds prevailing.
2. High pressure North of Alps, low over central Italy moving southward. Northerly wind over Northern Italy, cyclonic wind circulation over central-southern part of the country.
3. High pressure conditions over central-southern Europe
4. Atlantic trough associated with deep low pressure over gulf of Lion/Ligurian Sea. High pressure blocking over Balkans. Warm and moist southerly flow over central-northern Italy with very unsettled weather conditions.
5. High pressure over Central and Western Europe, low between Ionian Sea and Greece. Easterly winds prevailing.
6. High pressure over northern Africa and zonal flow over central Europe with steep pressure gradient. Westerly winds prevailing over central-northern Italy.
7. High pressure over Western Europe, north Atlantic flow associated with several low systems moving southeastward (unsettled conditions over most of Italy).

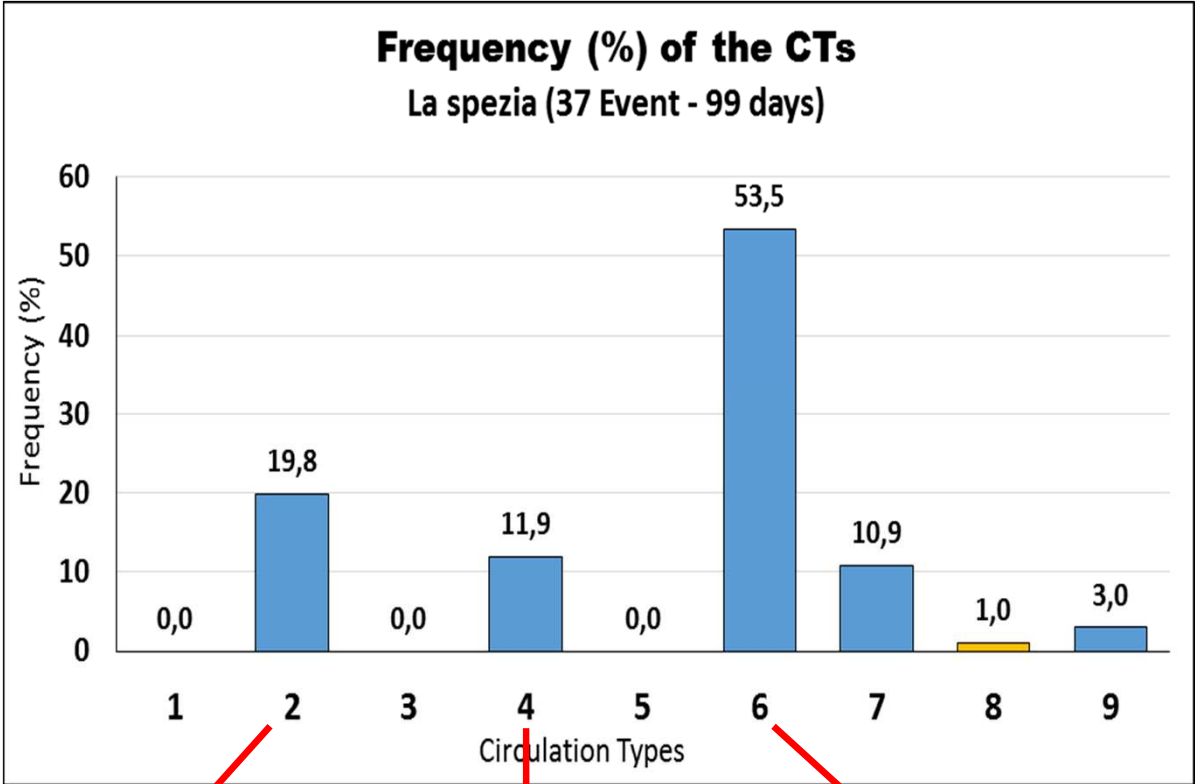
Mareggiate intense e tipi di circolazione



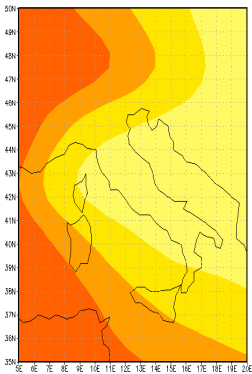
Alcune mareggiate intense e i tipi di circolazione (CTs) associati (PTC9)

Misure da boa	Data	CTs
La Spezia	25-27/12/1999	6
La Spezia	6-8/11/2000	4/6
Gorgona	30-31/3/2010	4/6
Gorgona	3-8/12/2011	6
Gorgona (*)	28-30/10/2018	4

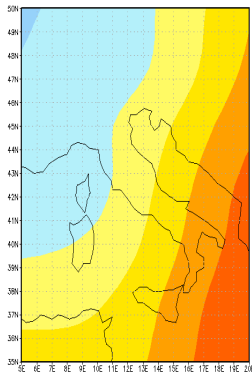
La spezia			
Frequency (%) of the CTs			
(37 Event - 99 days)			
TYPES CYCLONIC		TYPES ANTICYCLONIC	
CTs	%	CTs	%
2	19,8	1	0,0
4	11,9	3	0,0
6	53,5	5	0,0
7	10,9	8	1,0
9	3,0		
Tot	99,0	Tot.	1,0



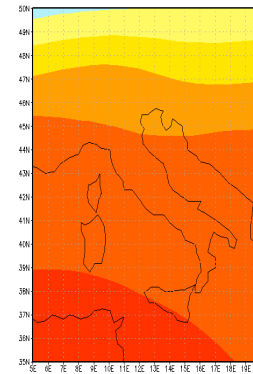
CT2



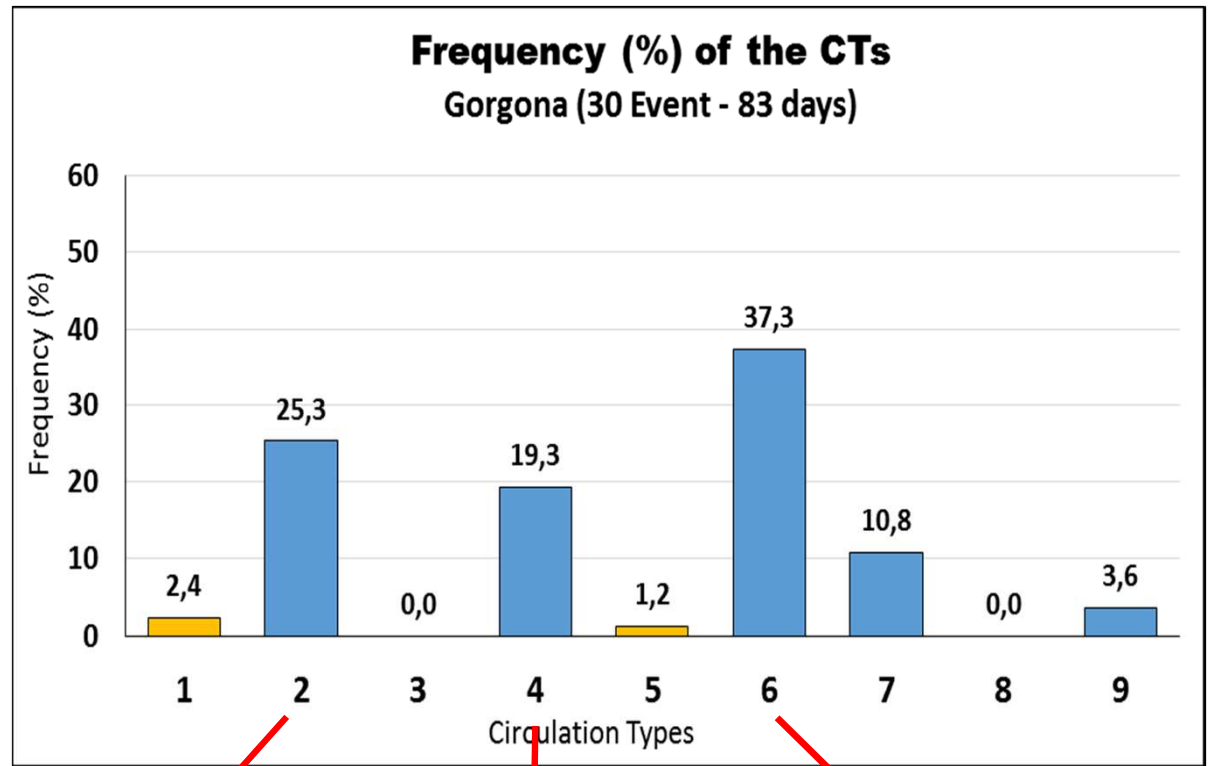
CT4



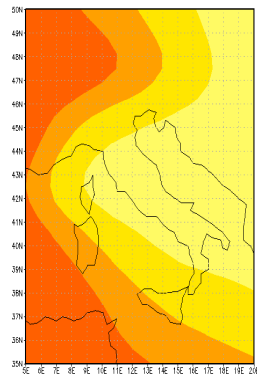
CT6



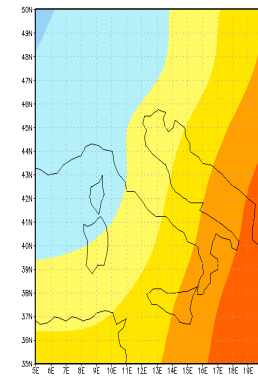
Gorgona			
Frequency (%) of the CTs			
(30 Event - 83 days)			
TYPES CYCLONIC		TYPES ANTICYCLONIC	
CTs	%	CTs	%
2	25,3	1	2,4
4	19,3	3	0,0
6	37,3	5	1,2
7	10,8	8	0,0
9	3,6		
Tot	96,4	Tot.	3,6



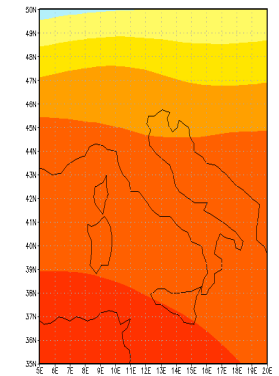
CT2



CT4

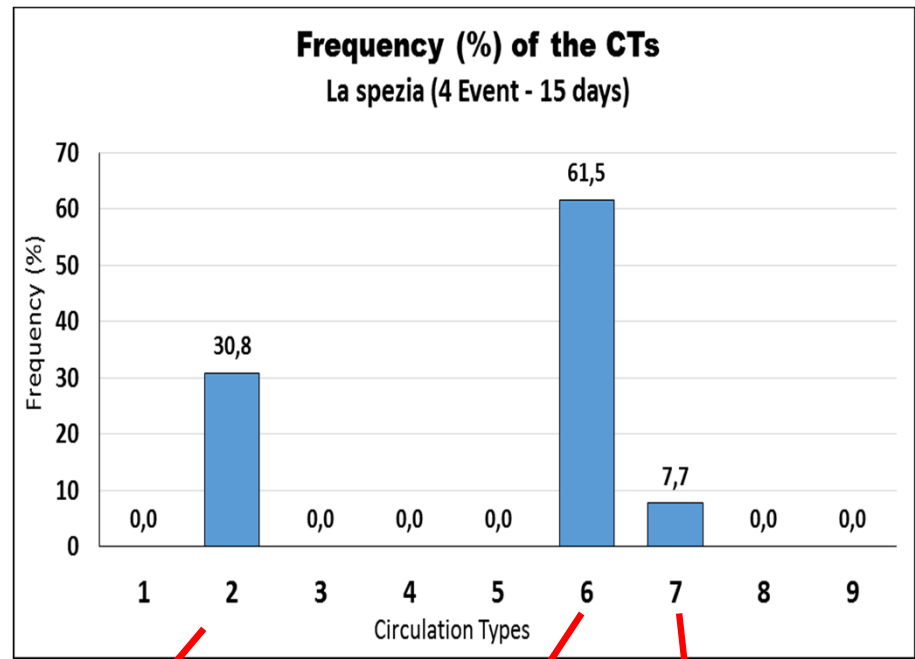


CT6

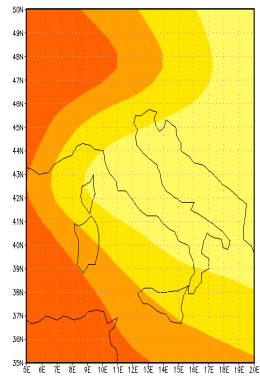


La Spezia Heavy sea storms (Hs>90° percentil) and daily CTs (PCT9)		
	DATA	CTs
Event 1 La Spezia	26/02/1990	6
	27/02/1990	6
	28/02/1990	6
	01/03/1990	2
	02/03/1990	2
Event 2 La Spezia	25/12/1999	6
	26/12/1999	6
	27/12/1999	6
Event 3 Gorgona	04/10/2003	6
	05/10/2003	2
	06/10/2003	6
Event 4 Gorgona	23/02/2004	7
	24/02/2004	2

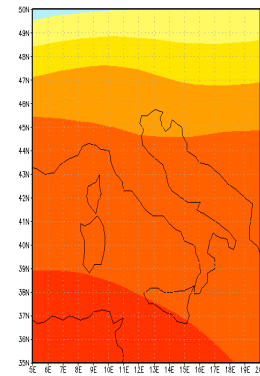
La spezia Frequency (%) of the CTs (4 Event - 15 days)			
TYPES CYCLONIC		TYPES ANTICYCLONIC	
CTs	%	CTs	%
2	30,8	1	0,0
4	0,0	3	0,0
6	61,5	5	0,0
7	7,7	8	0,0
9	0,0		
Tot	100,0	Tot.	0,0



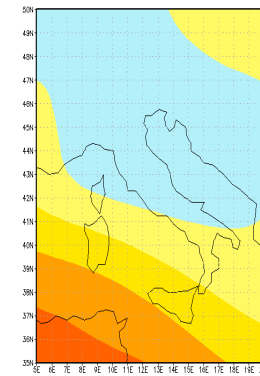
CT2



CT6

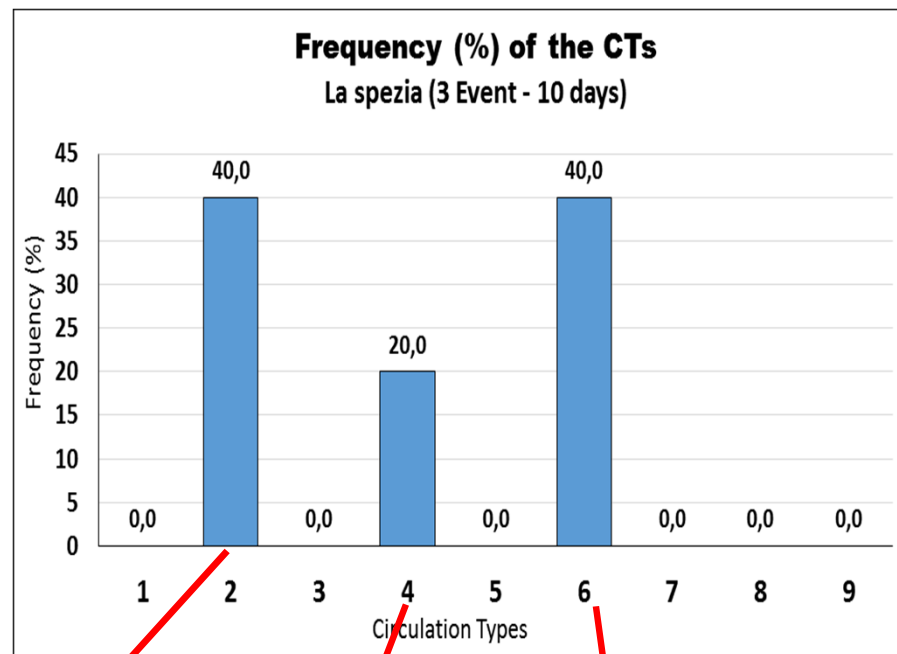


CT7

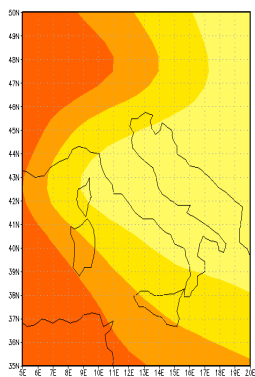


Gorgona		
Heavy sea storms (Hs>90° percentil) and daily CTs (PCT9)		
	DATA	CTs
Event 1 La Spezia	15/12/2011	6
	16/12/2011	6
	17/12/2011	2
Event 2 La Spezia	27/10/2012	4
	28/10/2012	2
	29/10/2012	2
Event 3 Gorgona	11/01/2016	6
	12/01/2016	6
	13/01/2016	2
	14/01/2016	4

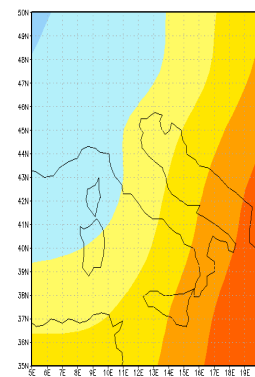
Gorgona			
Frequency (%) of the CTs			
(3 Event - 10 days)			
TYPES CYCLONC		TYPES ANTICYCLONIC	
CTs	%	CTs	%
2	40,0	1	0,0
4	20,0	3	0,0
6	40,0	5	0,0
7	0,0	8	0,0
9	0,0		
Tot	100,0	Tot.	0,0



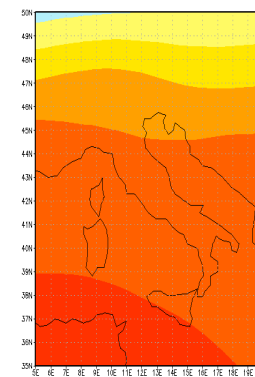
CT2



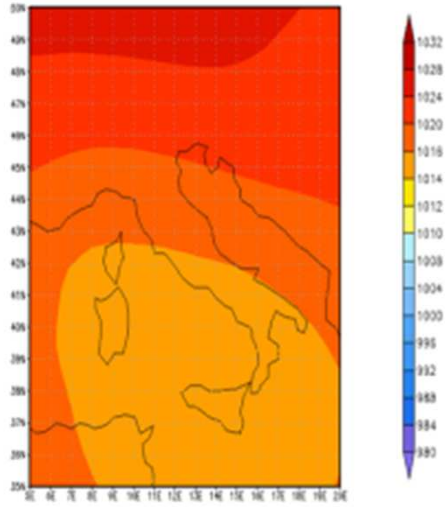
CT4



CT6



Trend of the Circulation Types (PCT9 - Vallorani et al.)



R	SPRING			SUMMER			AUTUMN			YEAR		
	Z (M-K)	Trend (Q*N)	Significance	Z (M-K)	Trend (Q*N)	Significance	Z (M-K)	Trend (Q*N)	Significance	Z (M-K)	Trend (Q*N)	Significance
1	0,31	0,25		4,61	6,44	*	0,13	0,27		2,30	4,91	*
2	-0,90	-0,43		5,30	6,95	*	2,59	2,23	*	5,59	11,13	*
3	-5,22	-4,21	*	-2,88	-3,40	*	-1,98	-1,55	*	-5,09	-15,55	*
4	3,62	2,66	*	3,44	1,84	*	0,21	0,027		3,21	6,19	*
5	-3,06	-1,18	*	-2,57	-1,91	*	-6,47	-10,21	*	-5,37	-4,48	*
6	-3,75	-3,15	*	-0,23	-0,14		1,09	0,55		-1,88	-2,92	
7	0,31	0,15		3,46	2,35	*	0,84	0,64		5,32	4,38	*
8	-0,78	-0,25		-0,92	-0,41		-1,09	-0,86		-1,98	-2,18	*
9	4,49	3,28	*	2,38	2,09	*	2,74	2,21	*	5,55	7,89	*

4		Cyclonic circulation with intense flow from S-SO and high pressure blocking over Balkans
5		High pressure over Central and Western Europe, low between Ionian Sea and Greece. Easterly winds prevailing
6		High pressure over northern Africa and zonal flow over central Europe with steep pressure gradient.
7		High pressure over Western Europe, north Atlantic flow associated with several low systems moving southeastward
8		High pressure over central-eastern Mediterranean Sea, low in the western part and North of Alps.
9		High pressure over central Europe and Northern Italy, low over central-southern part of the country ("cut-off").

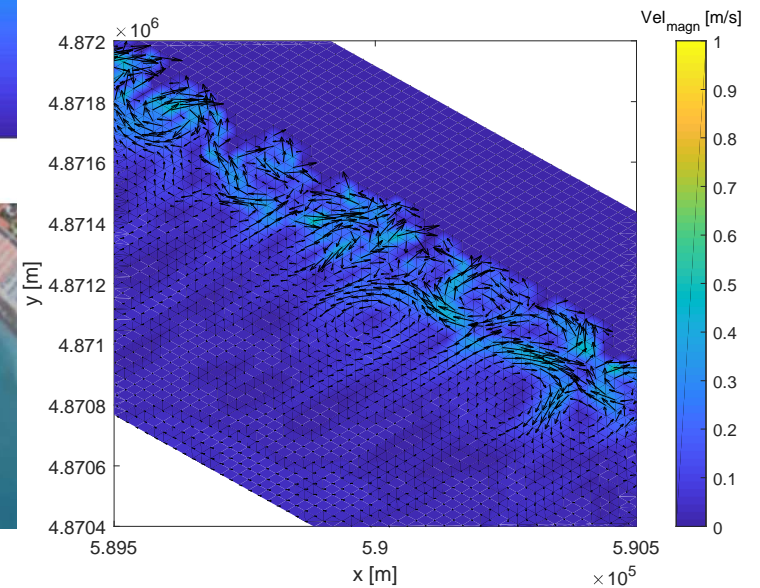
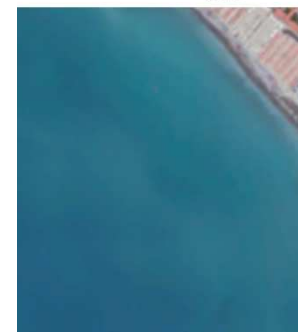
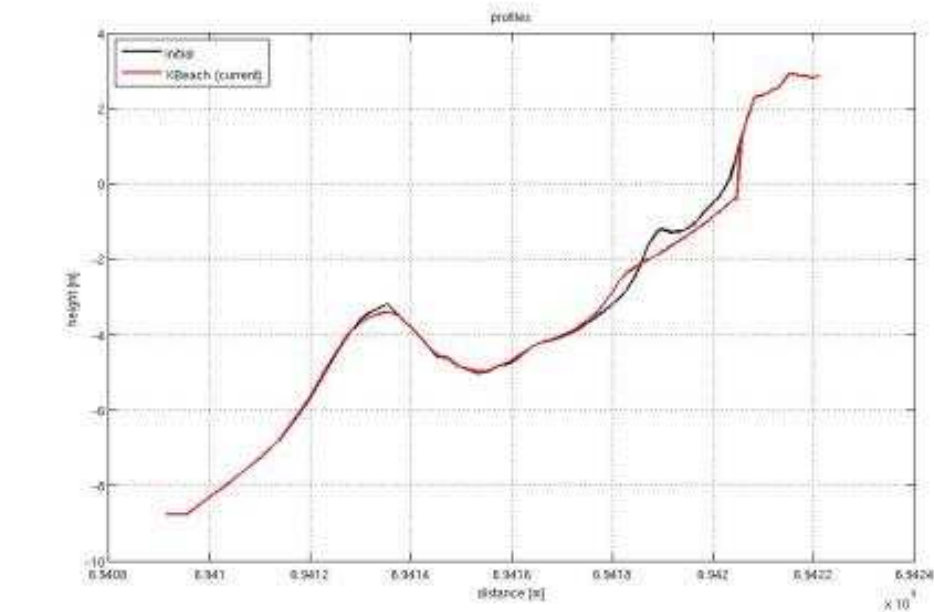
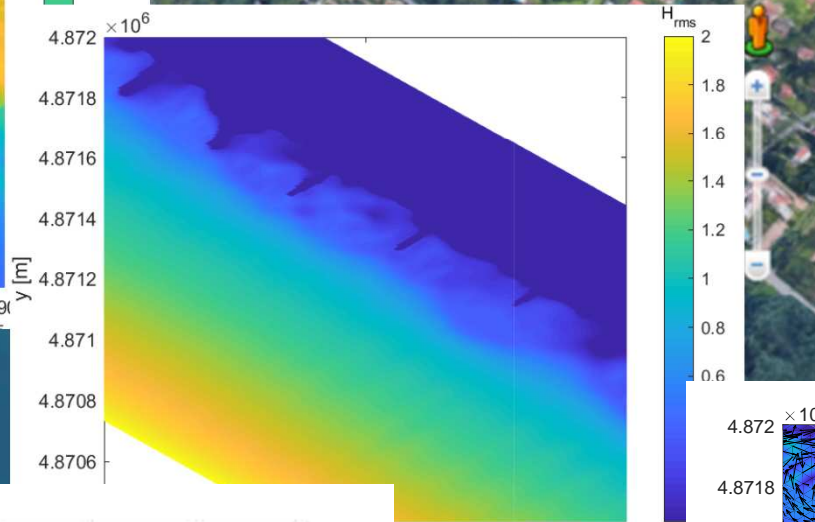
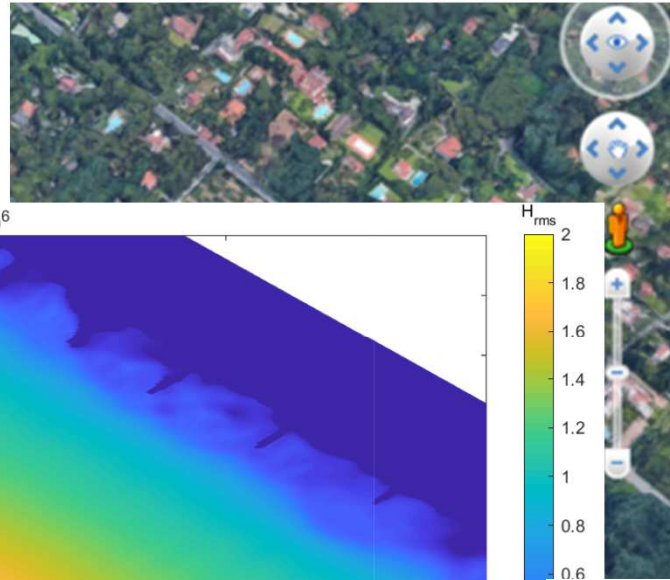
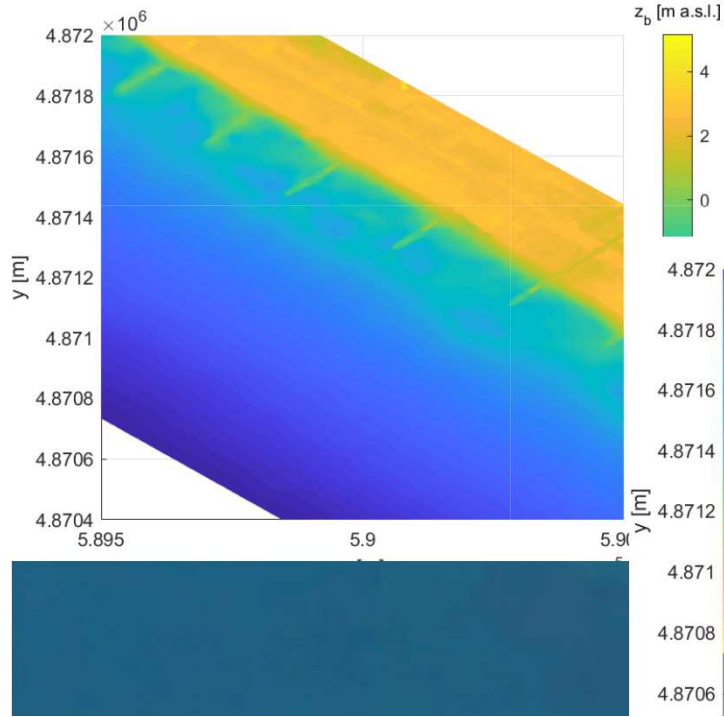
Le attività del progetto MAREGOT per la gestione del rischio costiero a breve e a lungo termine

Si possono identificare due attività di previsione e gestione del rischio costiero in relazione alle scale spaziali alle scale temporali di interesse:

rischio a breve termine - identificazione previsione e gestione del rischio legato all'impatto delle mareggiate sulla costa → lo strumento tecnico di riferimento è rappresentato dai modelli di previsione meteo marina eventualmente accoppiati con modelli di impatto delle onde sulla costa.

rischio a lungo termine - fa riferimento ai processi di erosione costiera di lungo periodo che possono portare alla perdita di ambienti naturali o costruiti.
→ anche in questo caso occorre fare riferimento agli scenari legati alla ricostruzione del clima a lungo termine del vento e delle onde, ed è pertanto necessario non limitarsi alla conoscenza di quanto avvenuto nel corso degli ultimi decenni, ma anche tenere conto degli scenari di cambiamento globale.

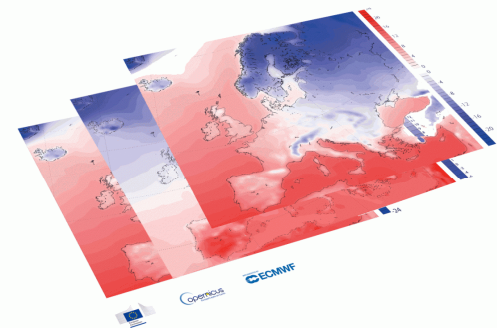
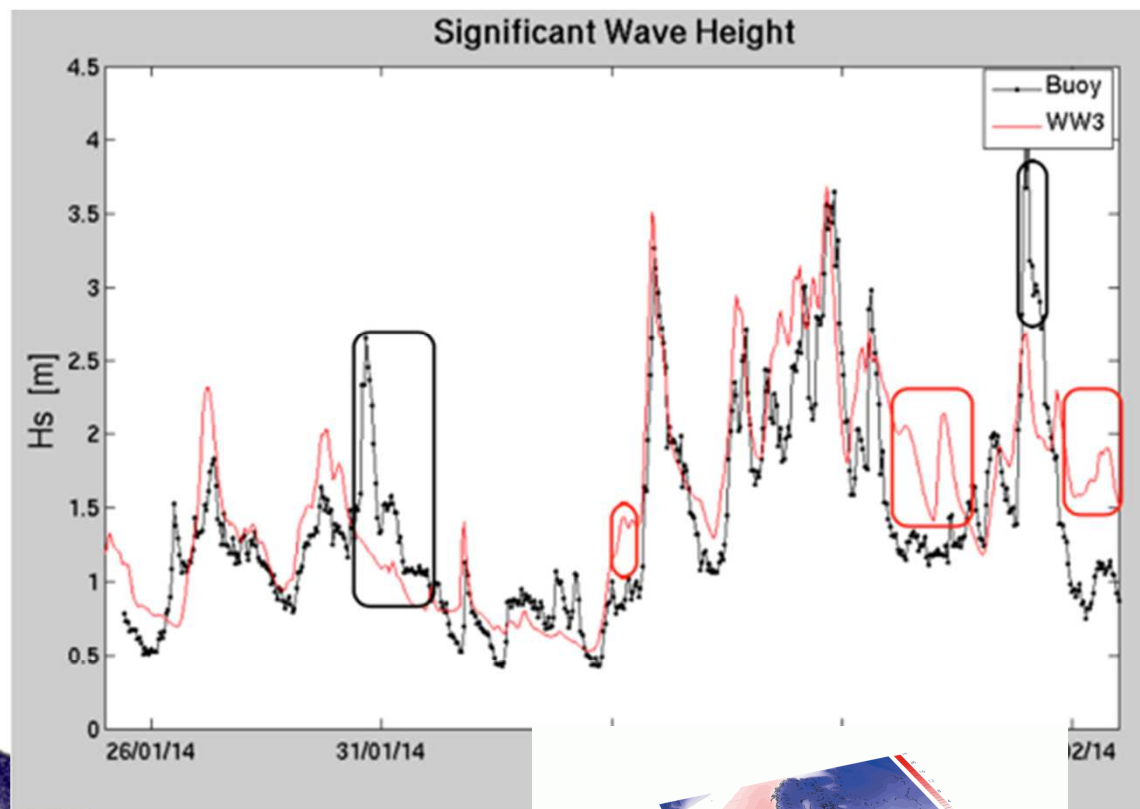
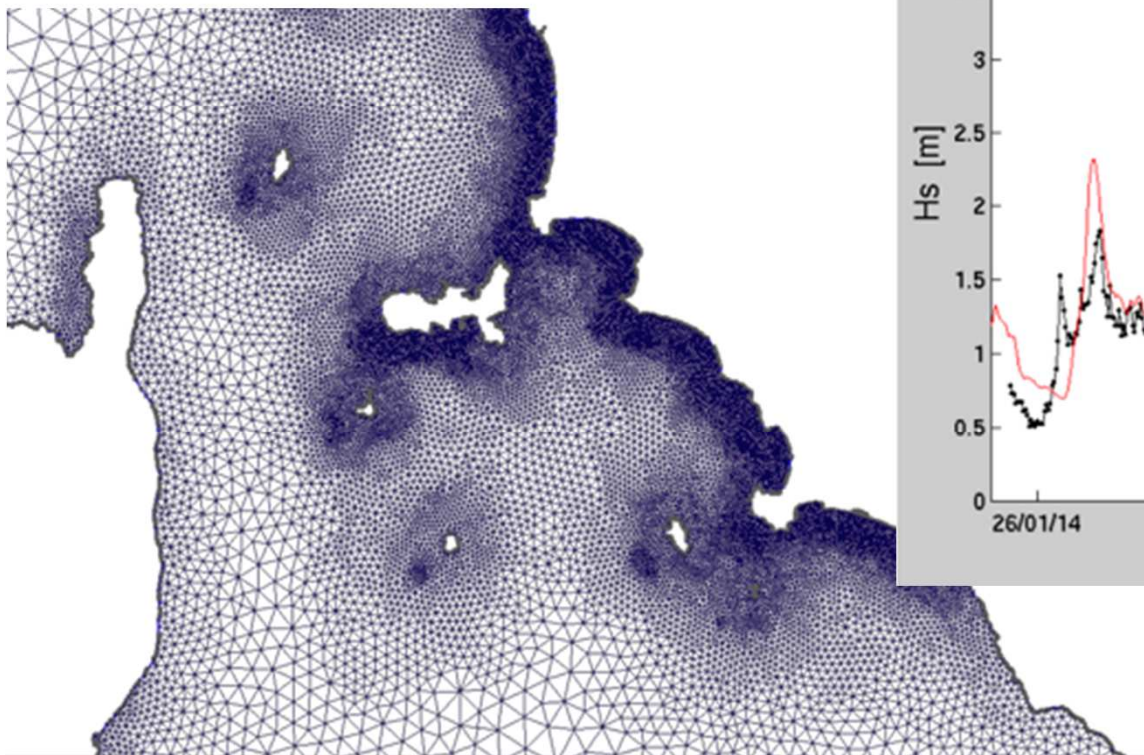
Applicazione di modelli di valutazione dell'impatto delle onde sulla costa (XBeach) come base per la costruzione di scenari di rischio a breve termine



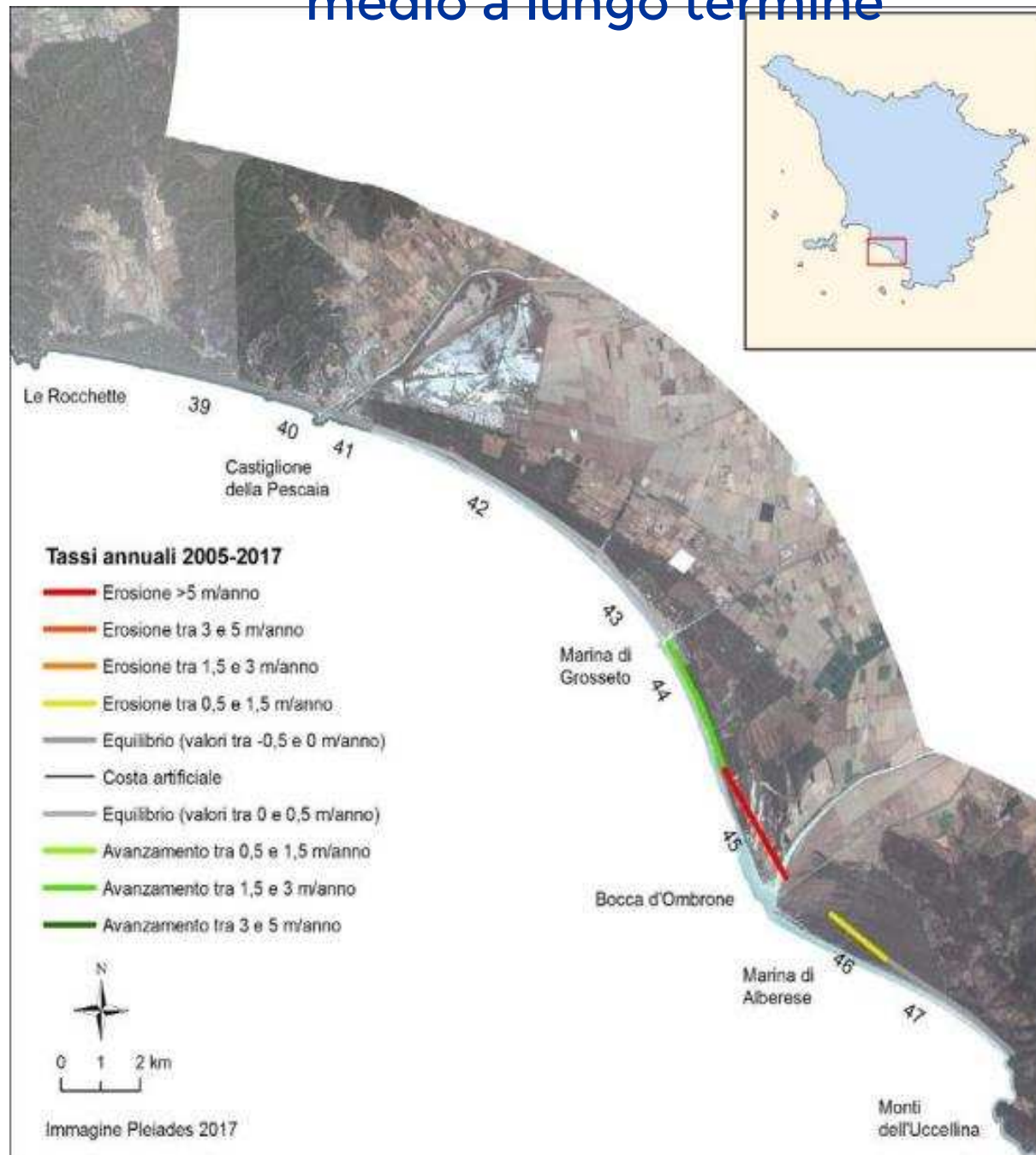


Migliorare i modelli meteomarini per:

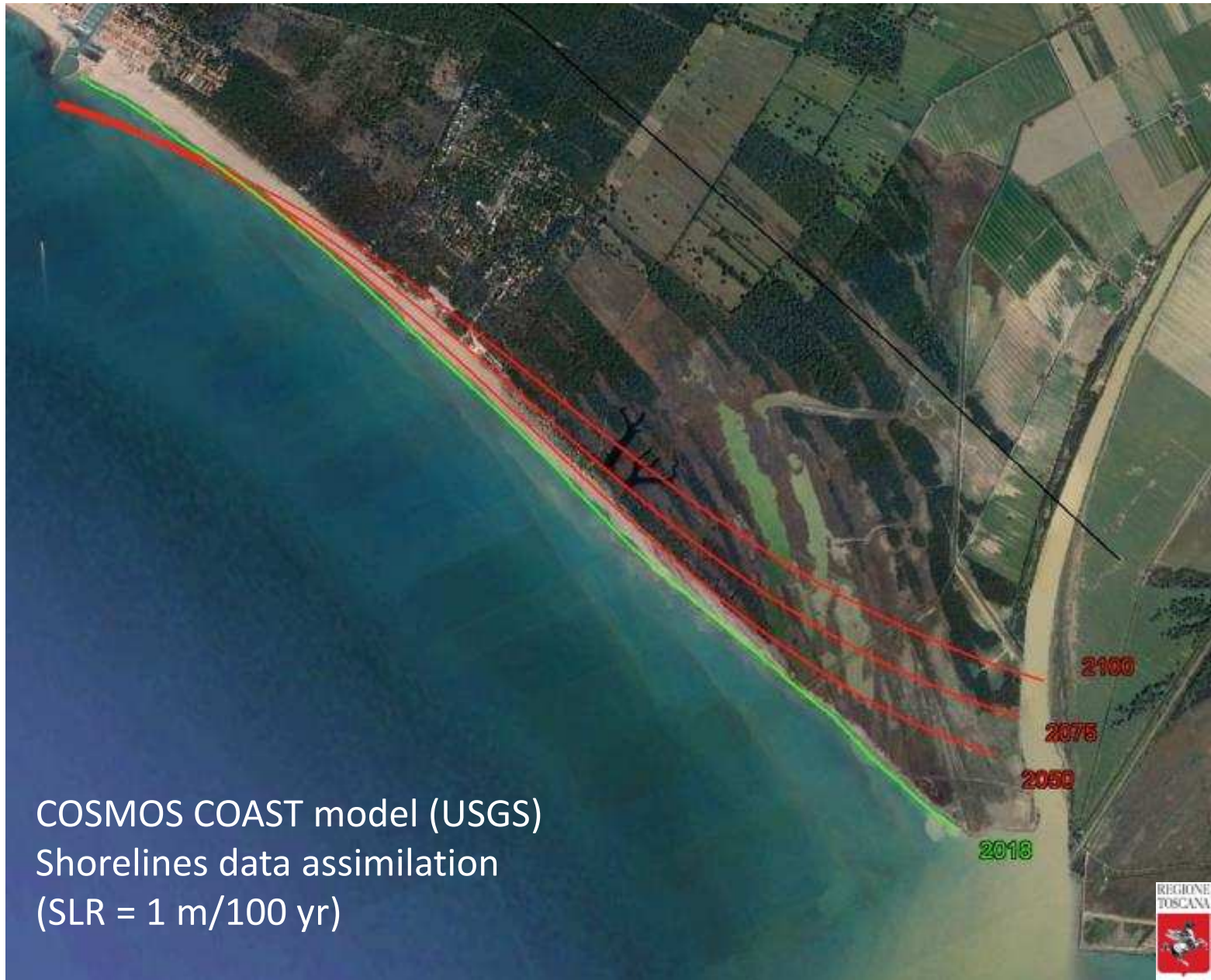
- Ridurre l'incertezza previsionale
- Ricostruire il passato (capire la storia dell'evoluzione costiera relativa agli ultimi decenni, e prevedere cosa succederà in futuro)



Il monitoraggio satellitare del linea di riva: uno strumento operativo per evidenziare i trend da medio a lungo termine



Esempio di applicazione di un modello morfologico a lungo termine per l'area della foce dell'Ombrone



COSMOS COAST model (USGS)
Shorelines data assimilation
(SLR = 1 m/100 yr)



Gestione del rischio e adattamento al cambiamento climatico: strumenti per un territorio resiliente

*Genova, Mercoledì 6 Marzo
presso Galata - Museo del Mare*

GRAZIE PER L'ATTENZIONE