



Model-based Marine Services: Ocean Waves and Coastal Hazards

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Introduction

- NMHSs' general guidance to marine prediction
- Wave mean parameters: definitions

Graphical products:
coastal hazards

Dangerous seas:
forecasting storms, waves
and currents

Ensemble prediction
products

Summary

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NMHSs' general guidance to marine prediction

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- **NMHSs' general guidance to marine prediction**

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Summary

Basic *source of information* to forecast products aimed at **safety at sea, aid to navigation, coastal hazards early warning**

Ocean wave prediction models: usually global, general purposes with/without local coastal components

Wave mean parameters: significant wave height, peak period and direction

Wind sea and swell(s) mean parameters: (relative) significant height, peak period and mean direction

other specific parameters, such as: wave setup, run-up, . . .

Storm surge prediction models: essentially coastal (local / regional)

storm surge level: water level forced by weather phenomena

total water level: usually at fixed points only (surge + astronomical tide)

currents: usually depth-averaged or surface current (if 3-D model)



Wave mean parameters: definitions

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Ocean waves superimpose with different amplitude, period and direction → **Wave field**

“Measures” of the wave field:

- **Significant wave height $H_s \sim H_{1/3}$** (mean height of the highest third). Is close to the visual estimation.
- **Mean period, mean direction:** mean is weighted on the energy
- **Peak period:** period that concentrates the highest energy in the wave field
- **Peak direction:** mean direction of waves with the peak period. Usually close to the direction of the maximum.



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Graphical products: coastal hazards

- Abnormal swells hit West coast of America
- “Day 1” storm develops SE of New Zealand

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Abnormal swells hit West coast of America

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Miércoles 06 de mayo de 2015 | 14:30

Por qué se están formando olas gigantes desde EE.UU. hasta Chile

Toda la costa del Océano Pacífico del continente americano está recibiendo olas gigantescas los últimos días que alcanzan los 10 metros de altura y ya causaron cinco muertos



Al menos cinco personas murieron desde el sábado en Chile, Panamá y México, a causa de las olas. Foto: Archivo / BBC

Desde California, en Estados Unidos, hasta Chile, toda la costa del Océano Pacífico del continente americano está recibiendo olas gigantescas desde este fin de semana y aún este martes.

En Coyuca, México, las olas alcanzaron un récord de 10 metros de altura, según las autoridades de protección civil. Al menos cinco personas murieron desde el sábado en Chile, Panamá y México, a causa de las olas. Y la alerta continúa en varios países.



“Day 1” storm develops SE of New Zealand

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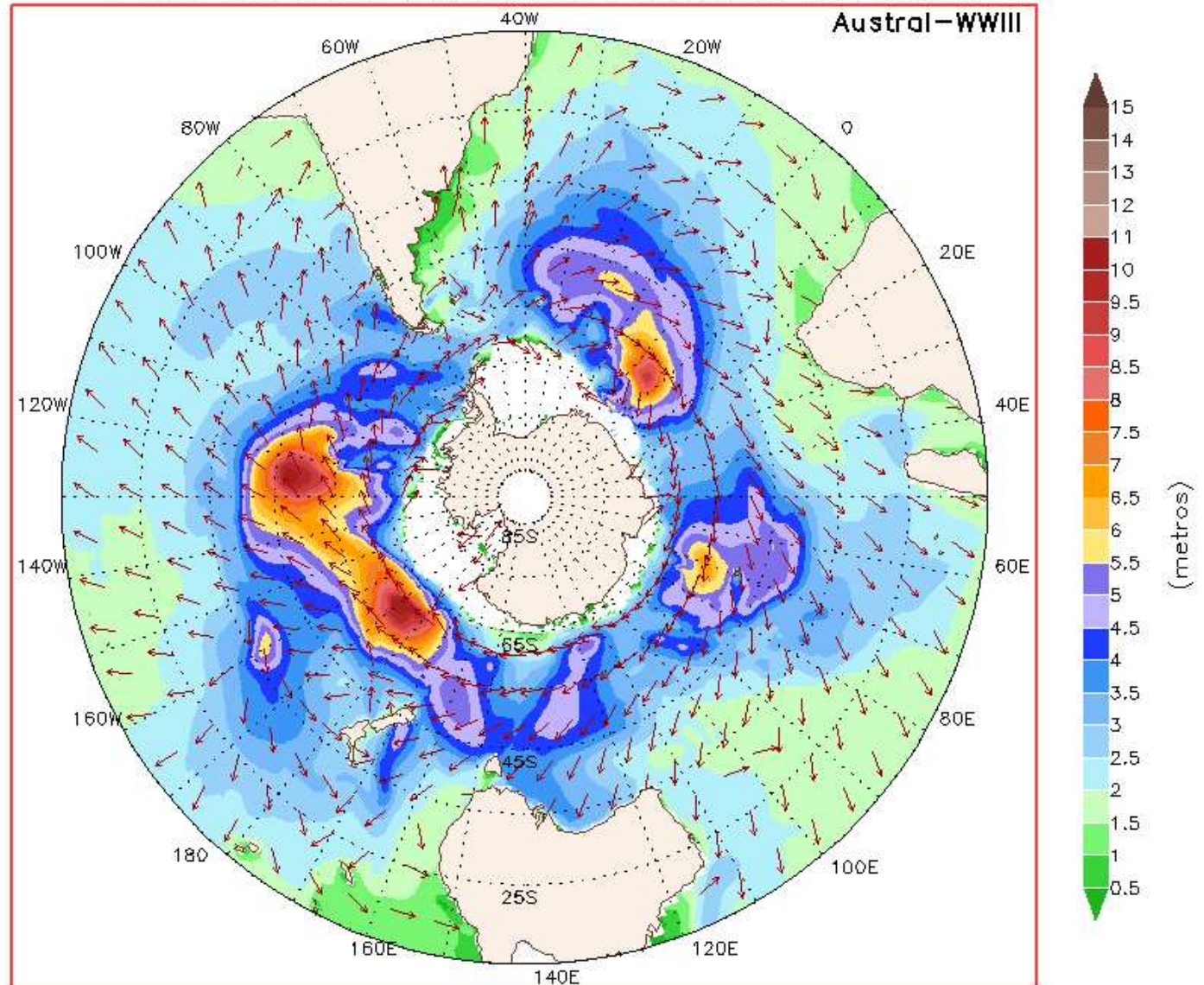
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ALTURA DE LA OLA SIGNIFICATIVA Y DIRECCION DEL MAXIMO



Basado en: 26-04-2015 00z

25-04-2015 20z



“Day 1” incipient swells from the storms

Introduction

Graphical products:
coastal hazards

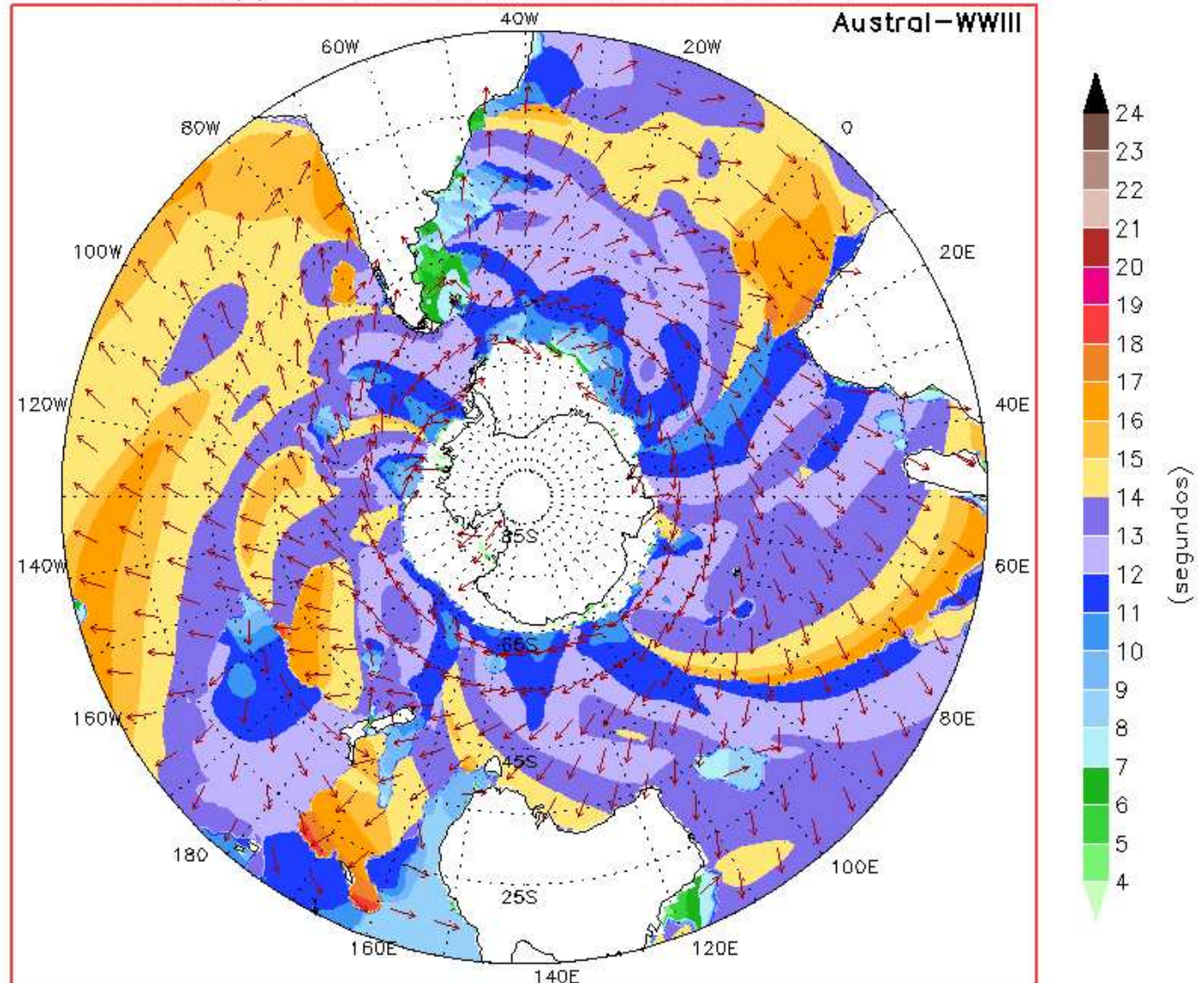
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PERIODO(s) Y DIRECCION DOMINANTE DE LAS OLAS



Basado en: 26-04-2015 00z

25-04-2015 20z



“Day 2” maximum development of the rear system

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Graphical products:
coastal hazards

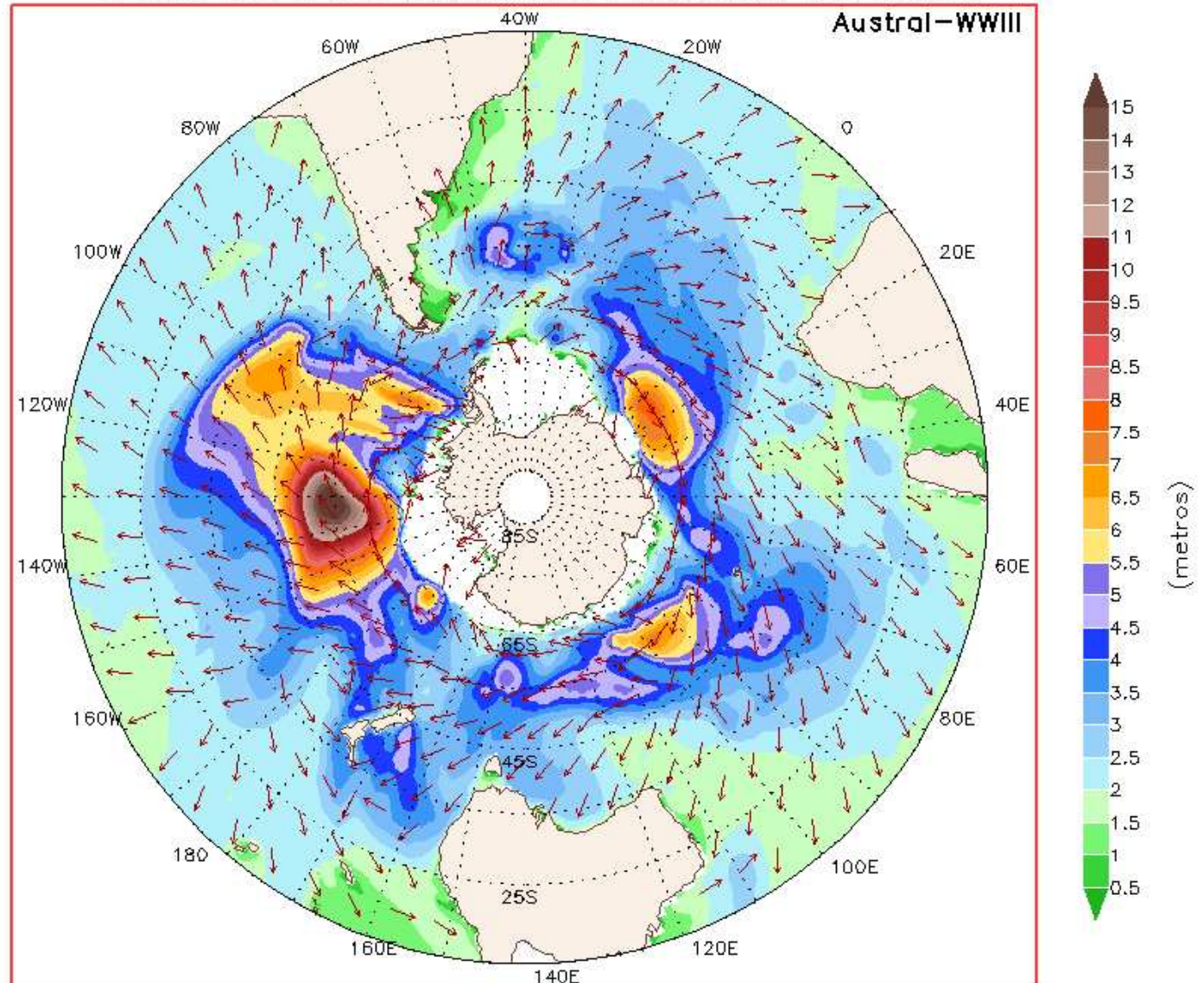
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ALTURA DE LA OLA SIGNIFICATIVA Y DIRECCION DEL MAXIMO



Basado en: 27-04-2015 06z

27-04-2015 06z



“Day 2” two distinct swell trains well identified

Introduction

Graphical products:
coastal hazards

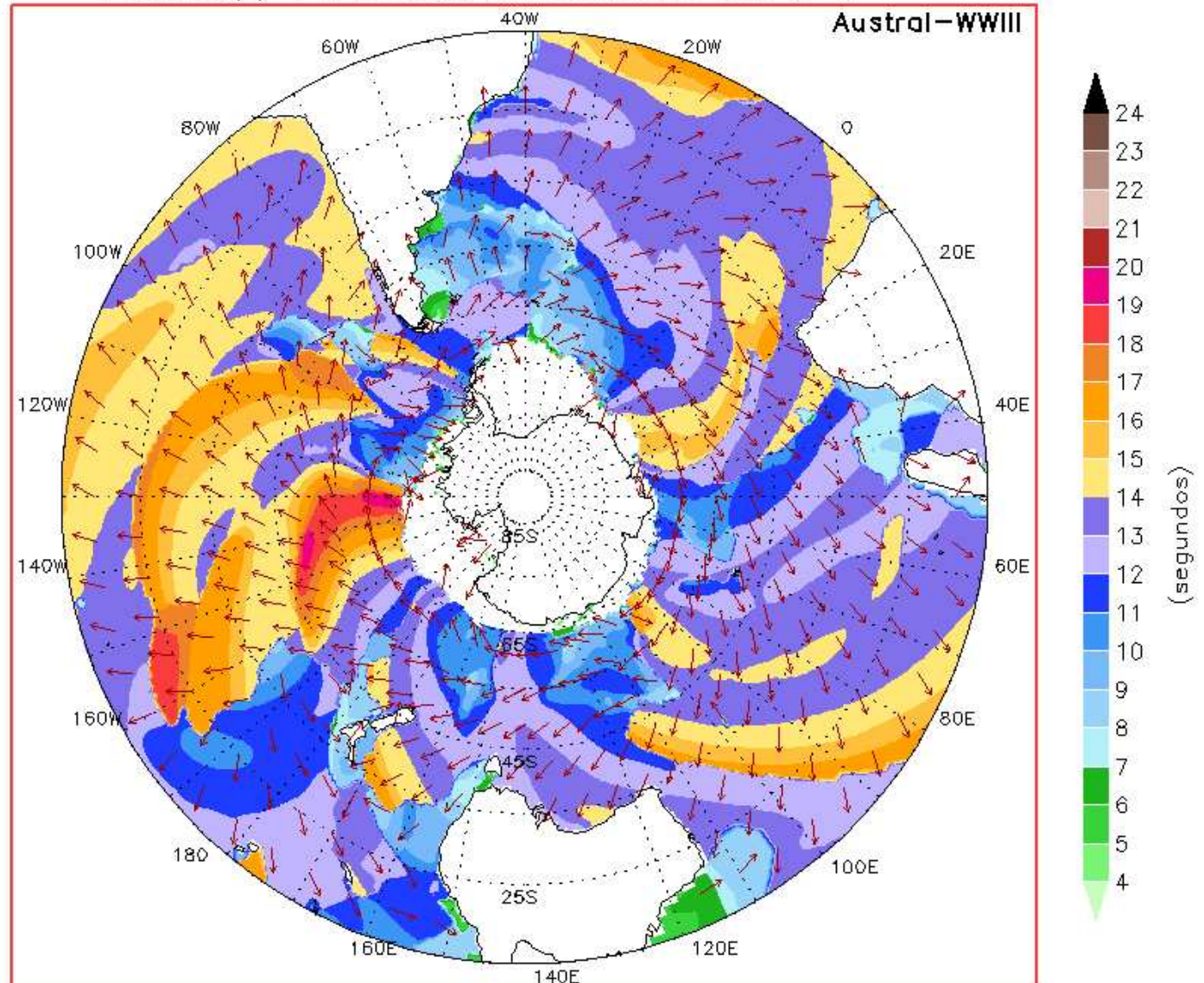
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Basado en: 27-04-2015 06z

27-04-2015 06z



“Day 3” Forerunner swell distinguished

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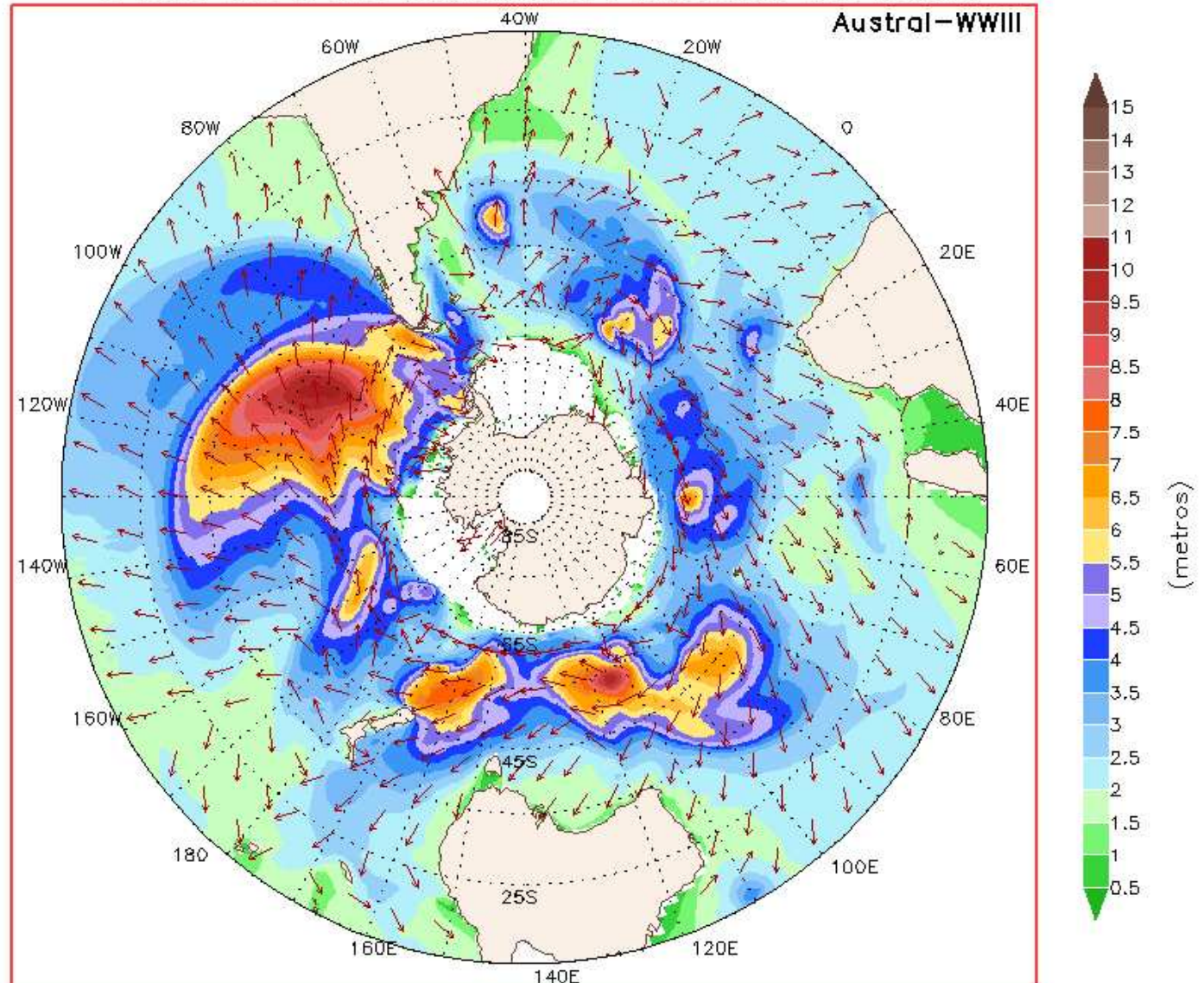
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ALTURA DE LA OLA SIGNIFICATIVA Y DIRECCION DEL MAXIMO



Basado en: 29-04-2015 00z

28-04-2015 21z



“Day 3” unusually long northward swell behind the storm

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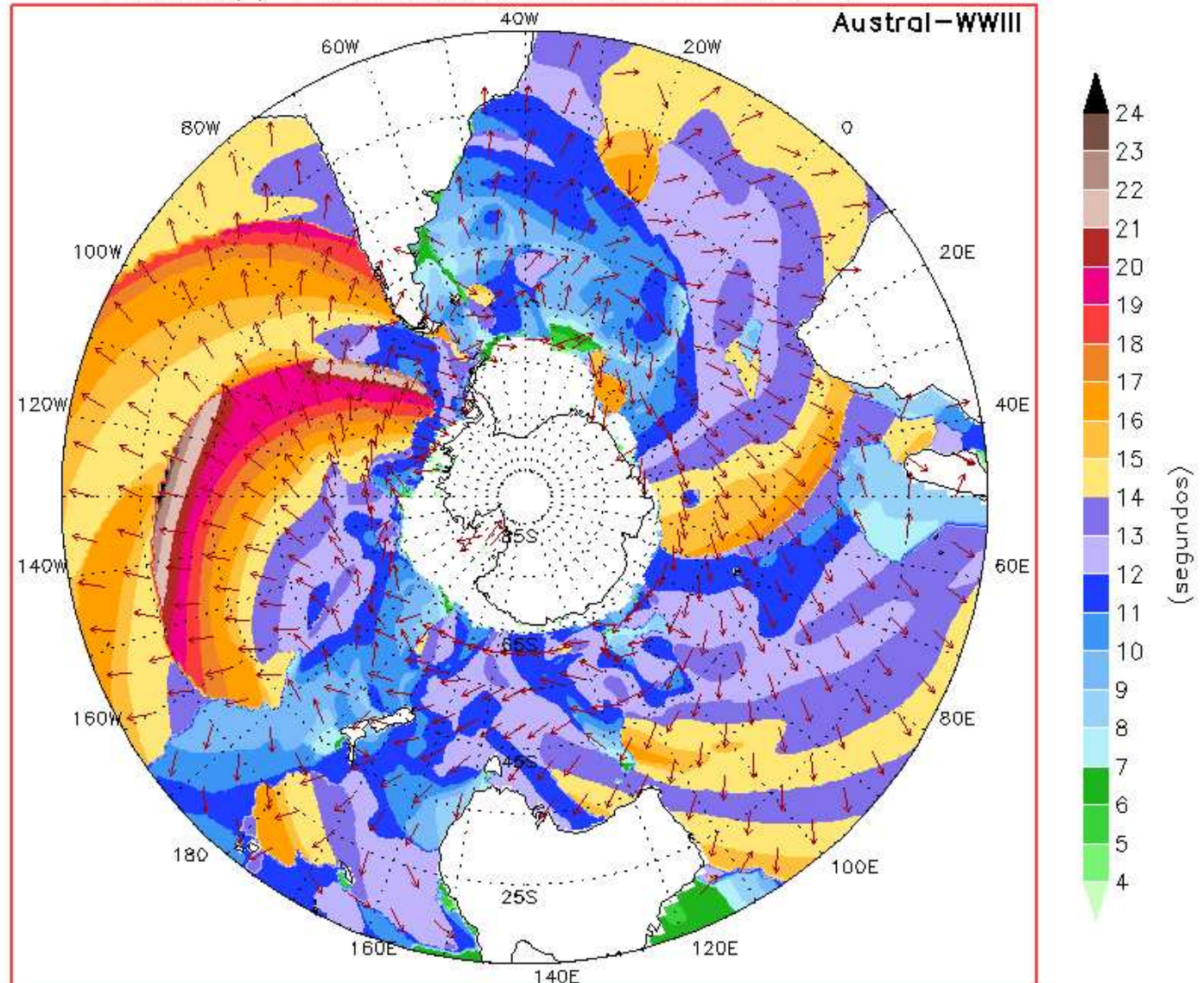
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Basado en: 29-04-2015 00z

28-04-2015 21z



“Day 4” both swells hit the coast

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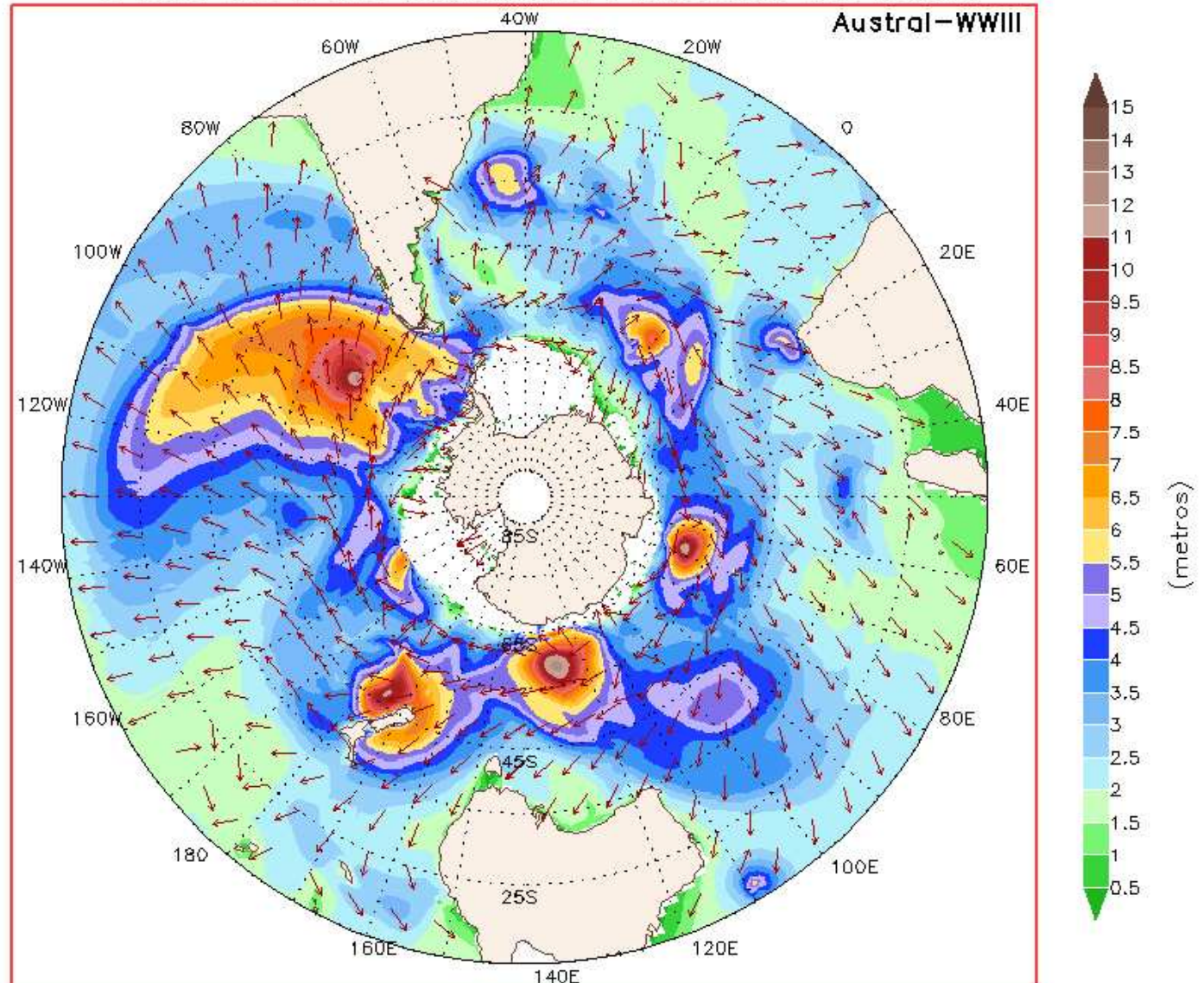
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Basado en: 29-04-2015 18z

29-04-2015 16z



“Day 4” wide development of the rear swell

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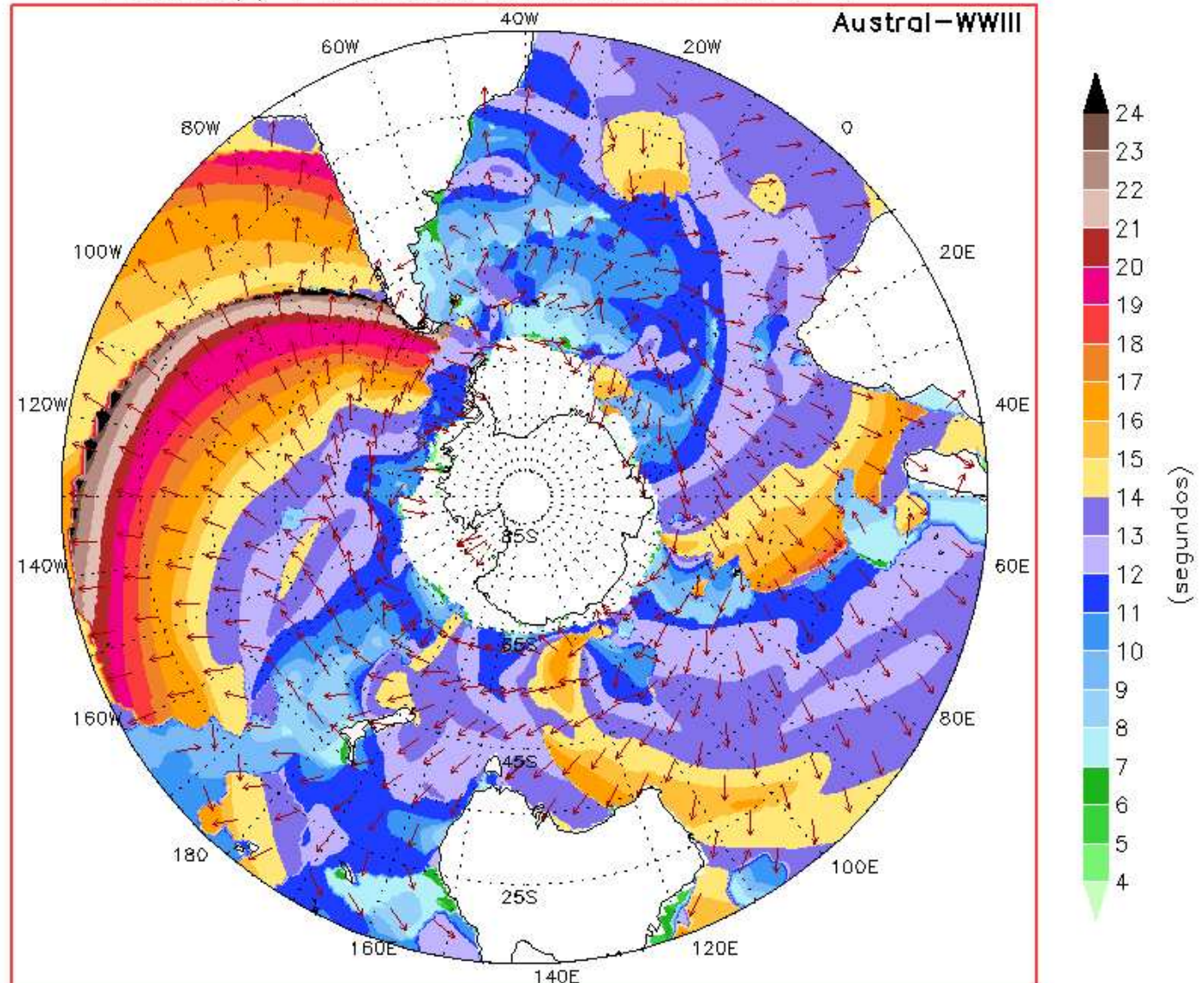
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Basado en: 29-04-2015 18z

29-04-2015 16z



“Day 6” highest waves (not the longest) still to come

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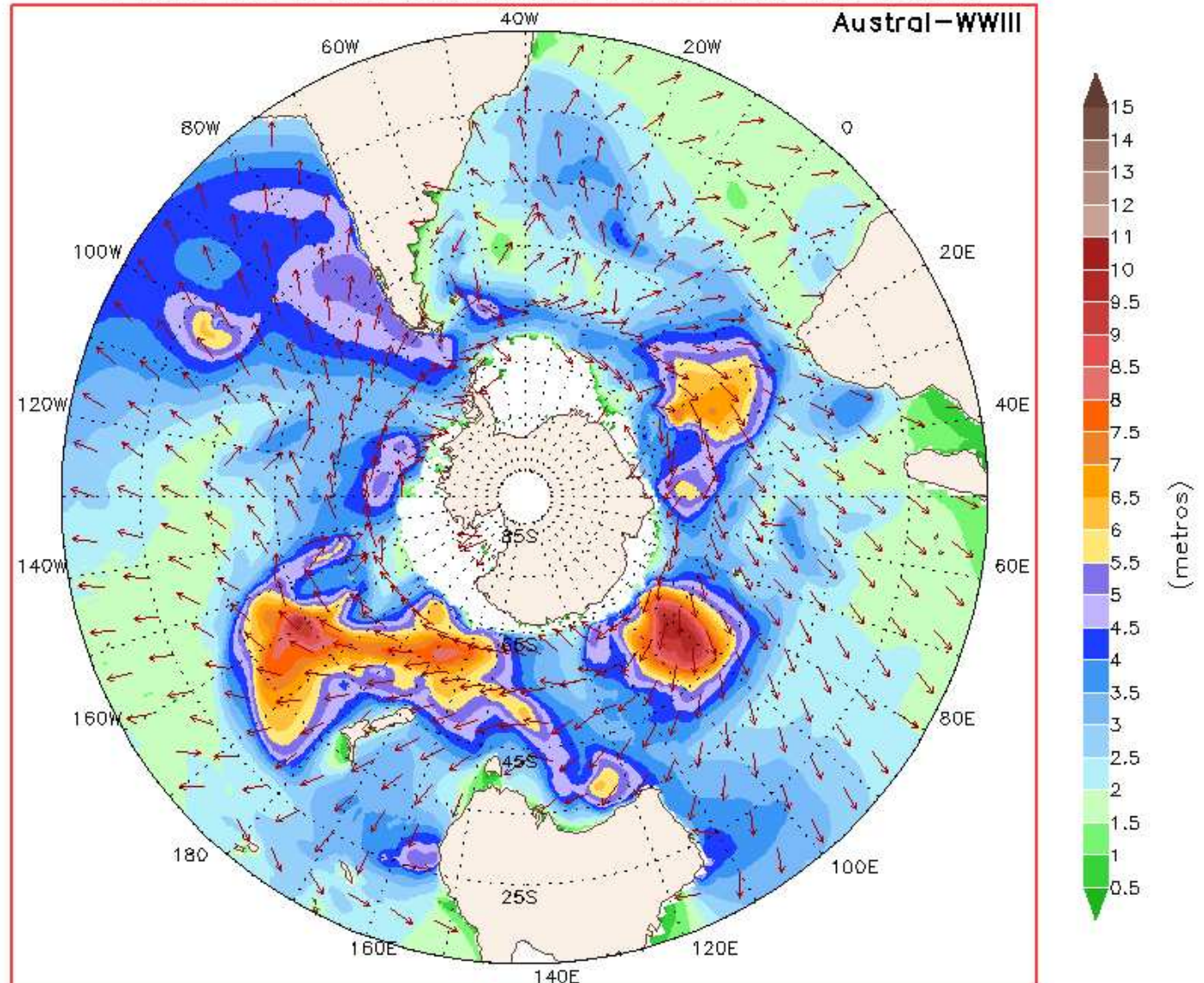
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ALTURA DE LA OLA SIGNIFICATIVA Y DIRECCION DEL MAXIMO



Basado en: 01-05-2015 12z

01-05-2015 09z



“Day 6” and the end of the event

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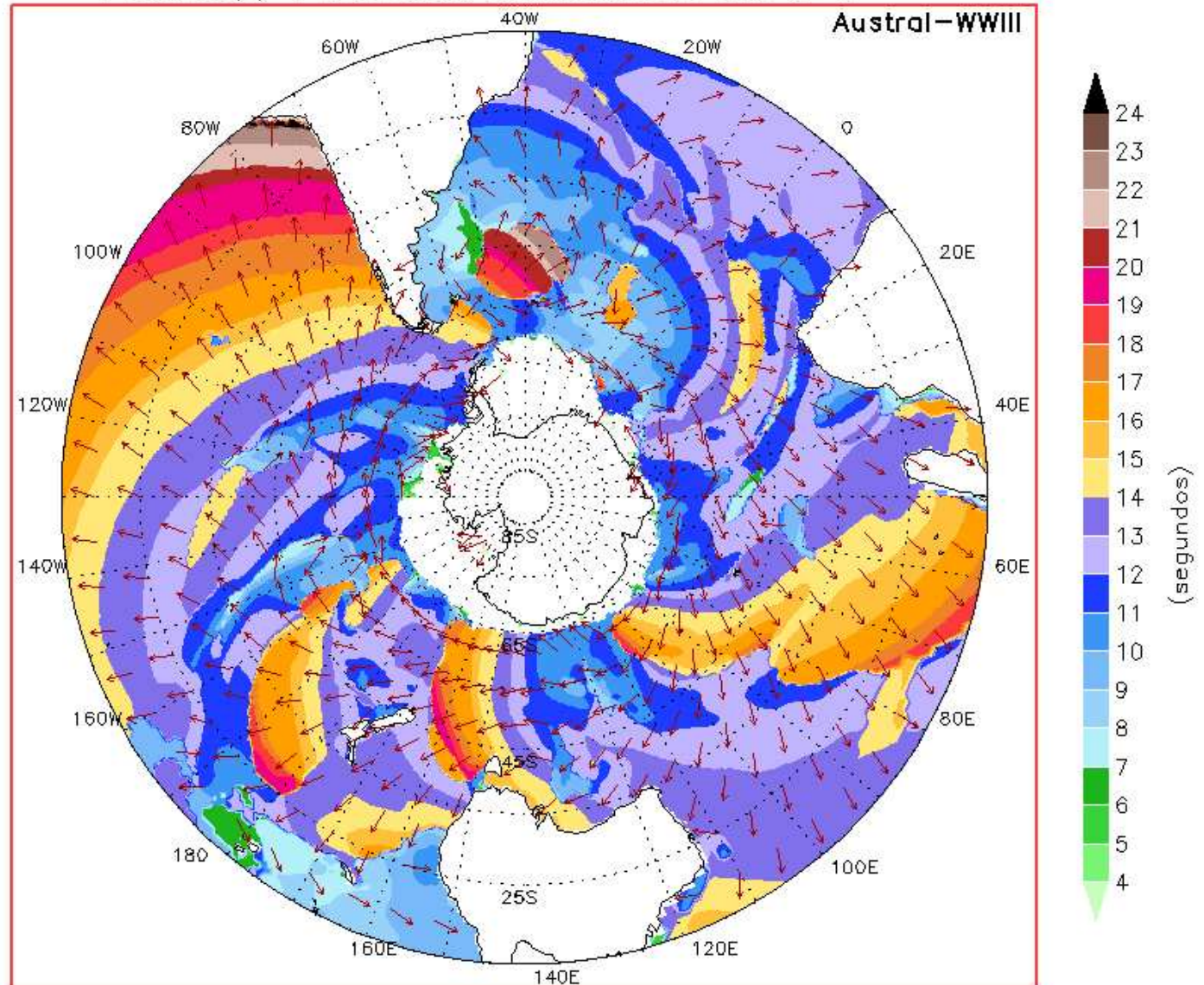
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- Storm surge:
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- Bahia Blanca: surge
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Dangerous seas: forecasting storms, waves and currents



Meaning of SWH: individual waves in the wave field

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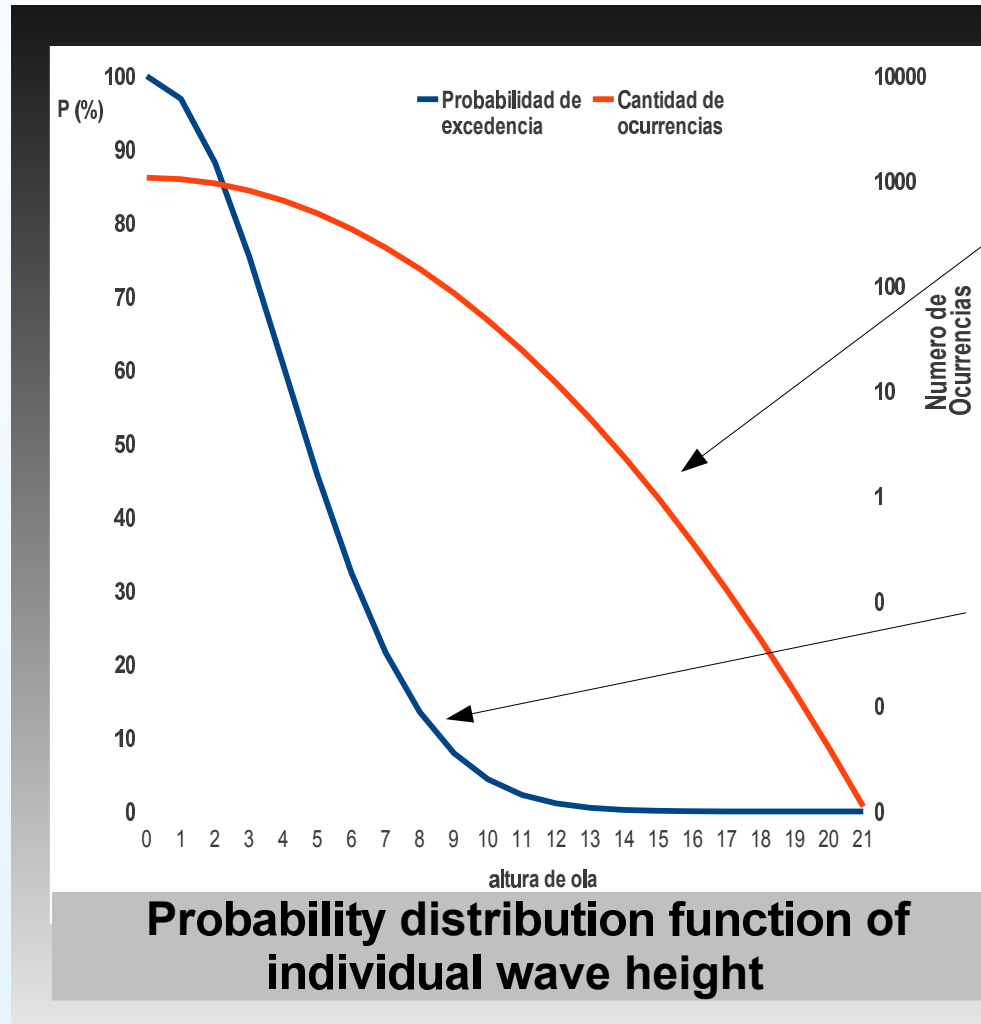
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This example corresponds to a wave field with $H_s = 8$ m.

- Roughly, if the mean period is 10 s for 3 hours, an individual 15 m wave is likely to happen. It is usually assumed that **$H_{max} \sim 2H_s$** in a wave field
- Ideally, about 13% of the **waves override the significant wave height**
- Extraordinary or freak waves **are not** included in this distribution



Text products: wave bulletins at fixed points

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Surfman, PMO-5

Combined seas, wave trains: similar to the live experience at sea

AltT : Total significant wave height.

n : Number of fields with $H_s > 0.05$ in 2-D spectrum.

x : Number of fields with $H_s > 0.15$ not in table.

Alt : Significant wave height of separate wave field.

Per : Peak period of separate wave field.

dir : Mean direction of separate wave field.

: Wave generation due to local wind probable.

Día & Hora Z	AltT (m)	n	x	Alt (m)	Per (s)	Dir (g)	Alt (m)	Per (s)	Dir (g)	Alt (m)	Per (s)	Dir (g)	Alt (m)	Per (s)	Dir (g)	Alt (m)	Per (s)	Dir (g)		
17 1	2.3	5		1.7	7.3	82	1.1	9.9	23	0.9	12.4	2	0.8	5.8	179					
17 2	2.3	5		1.6	7.4	80	1.0	10.0	27	1.0	12.2	3	0.7	5.8	179					
17 3	2.2	5		1.6	7.4	78	1.0	9.9	26	0.9	12.0	3	0.7	5.8	180					
17 4	2.1	4		1.5	7.4	76	1.3	10.3	15				0.7	5.9	182					
17 5	2.1	4		1.4	7.3	79	1.4	10.1	22				0.7	6.2	183					
17 6	2.1	5		1.2	7.2	86	1.2	9.2	32	0.8	11.1	3	0.7	6.3	185					
17 7	2.1	6		1.1	7.2	86	1.2	9.1	31	0.8	11.0	3	0.8	6.3	185	0.7	11.5	31		
17 8	2.1	5		1.1	7.1	86				0.8	10.8	4	0.7	6.3	185	1.5	11.3	32		
17 9	2.2	6		1.0	7.0	85				0.8	10.6	4	0.7	6.3	183	1.6	11.1	32		
17 10	2.2	7		0.9	7.0	85				0.8	10.4	4	0.7	6.3	184	1.7	10.9	33		
17 11	2.2	7		0.9	6.9	85	0.3	19.9	11	0.7	10.2	4	0.7	6.4	185	1.8	10.6	34		
17 12	2.3	6		0.9	6.4	84	0.6	18.6	15	0.6	10.2	4	0.6	6.5	187	1.9	10.3	34		
17 13	2.5	5		0.7	6.3	91	1.0	18.0	16				0.6	6.6	188	2.1	10.2	34		
17 14	2.7	6		0.5	6.4	86	1.4	17.3	15	*	1.3	5.5	51	0.5	6.7	190	1.7	10.1	34	
17 15	2.9	5					1.8	16.6	15	*	1.5	6.2	54	0.5	6.8	191	1.6	10.0	36	
17 16	3.1	5					2.1	15.9	15	*	1.6	6.2	56	0.4	6.7	191	1.6	9.8	37	
17 17	3.5	5					2.5	15.2	16	*	1.8	6.2	57	0.4	6.6	190	*	1.7	9.6	40
17 18	4.0	5					2.9	14.9	18				0.3	6.5	191	*	2.7	9.1	52	



Graphical products: the challenge of combined seas

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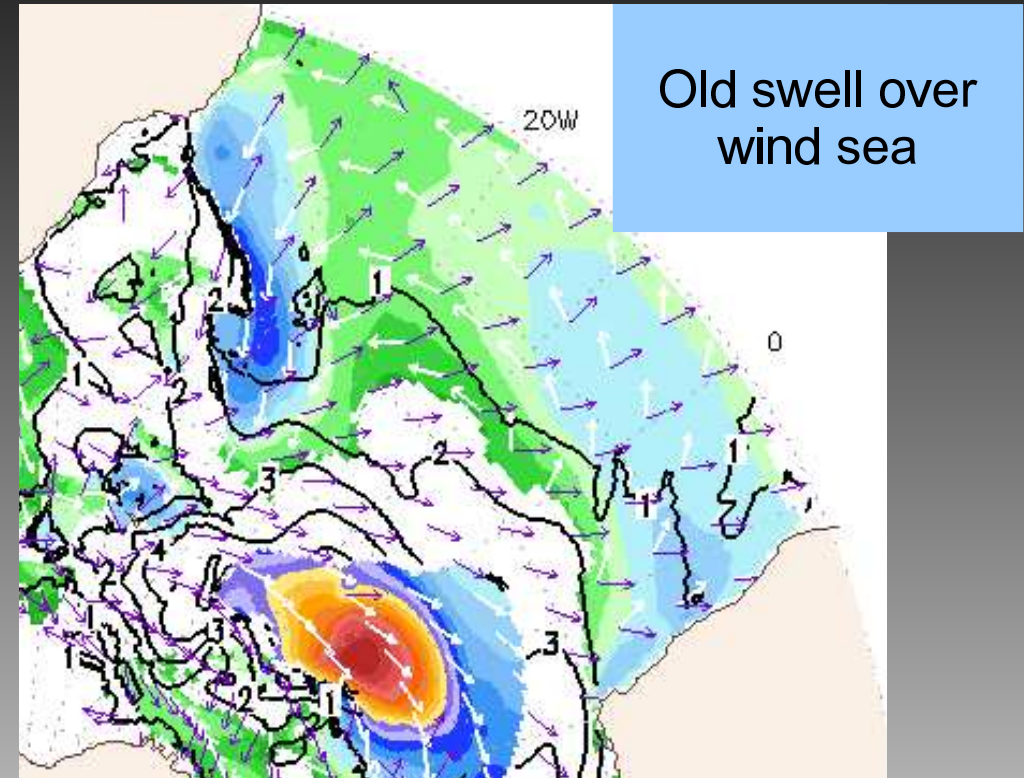
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Swell leaving its
generation area

Swell opposing to
wind sea

“Pure” wind sea



Mean wave height and direction
 Wind sea: shaded colors and white arrows
 Primary swell: black contours and purple arrows



16 June: storm developed high waves

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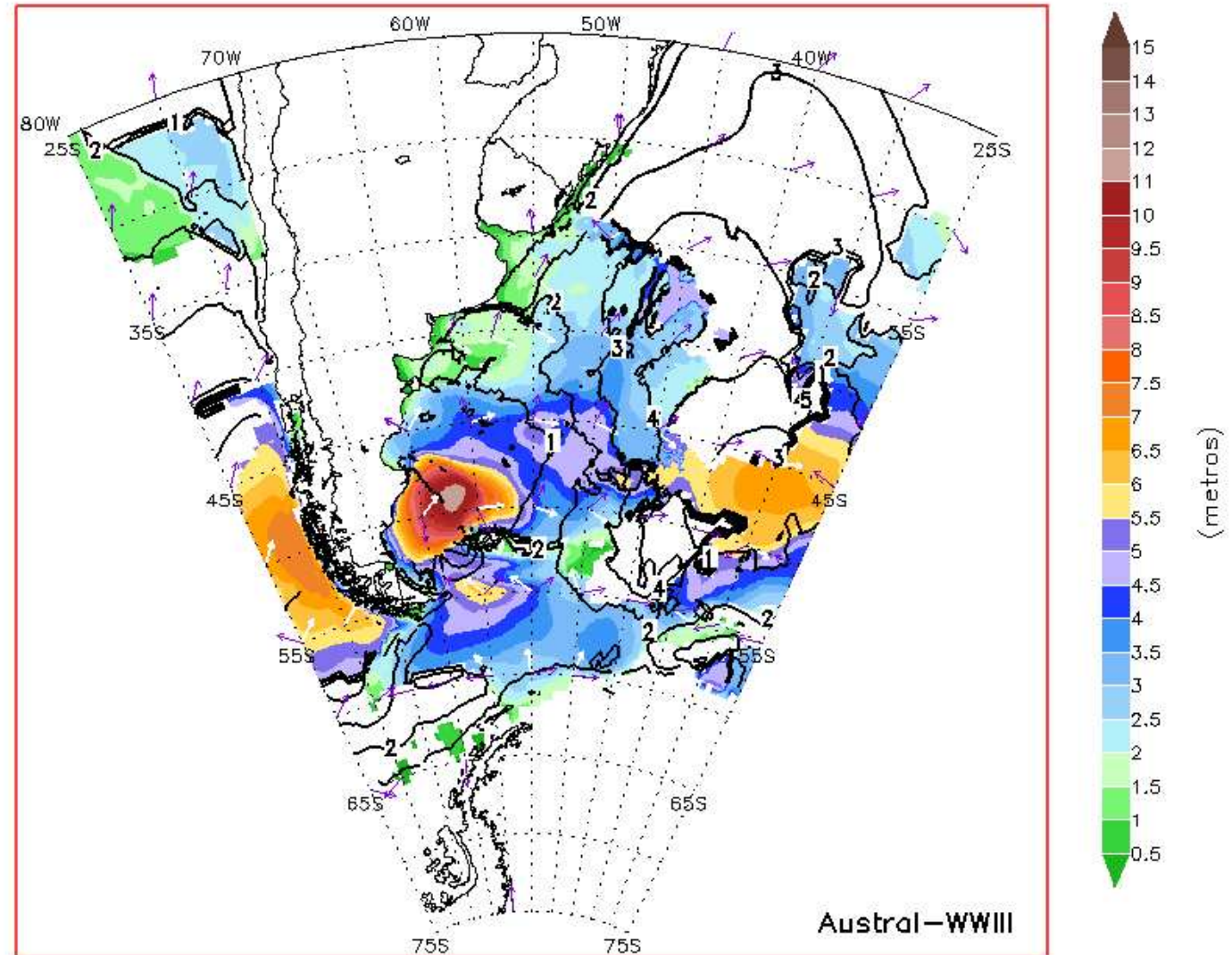
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ALTURA Y DIRECCION MEDIA DE OLAS
mar de viento: sombreado en colores y flechas blancas
principal mar de fondo: isoclinas negras y flechas purpura



Basado en: 16-06-2015 18z

16-06-2015 16z



17 June: cross seas south of the storm

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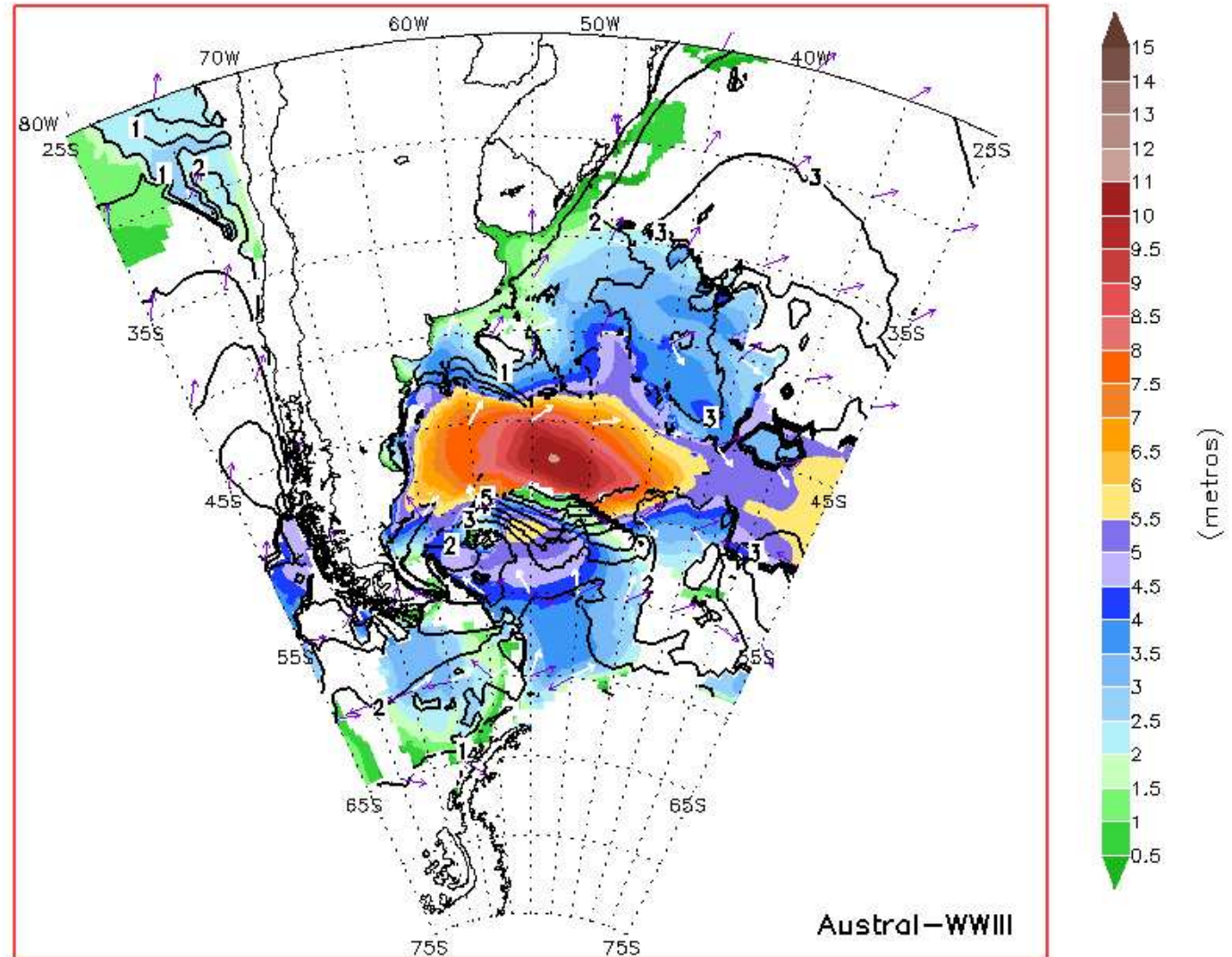
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Basado en: 17-06-2015 06z

17-06-2015 05z



17 June: cross seas south of the storm

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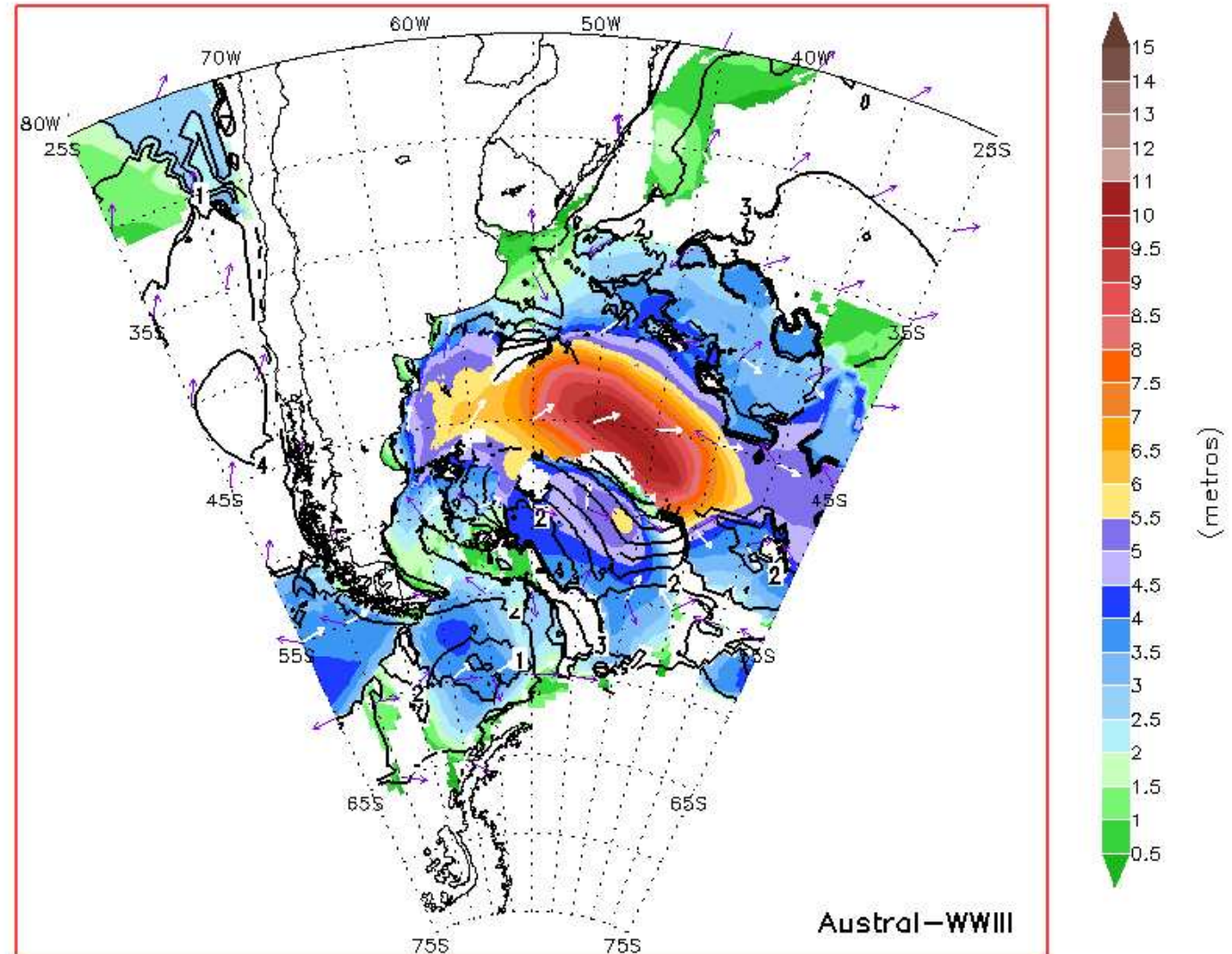
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Storm surge: elevations above normal due to storm

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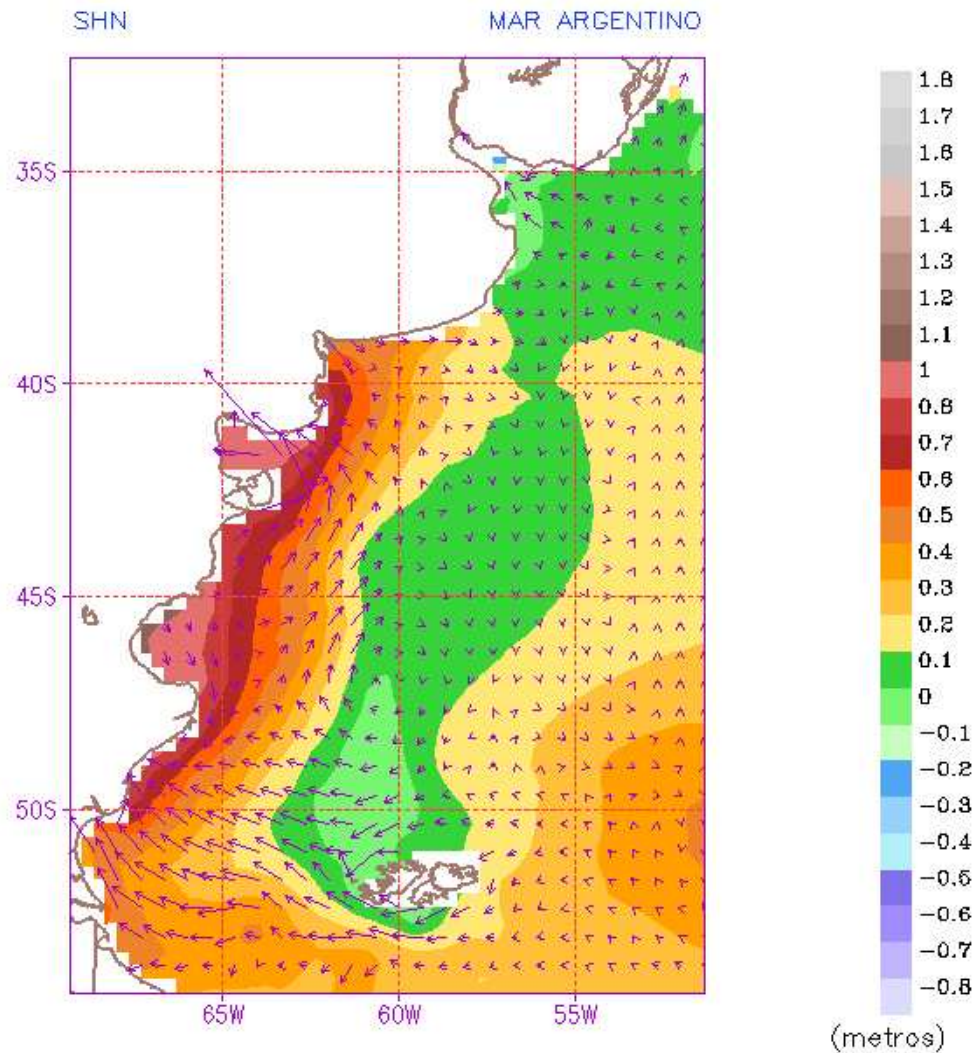
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MODIFICACION AL NIVEL DEL AGUA POR EFECTO METEOROLOGICO



2015/06/17/00z



Storm surge along-shelf currents

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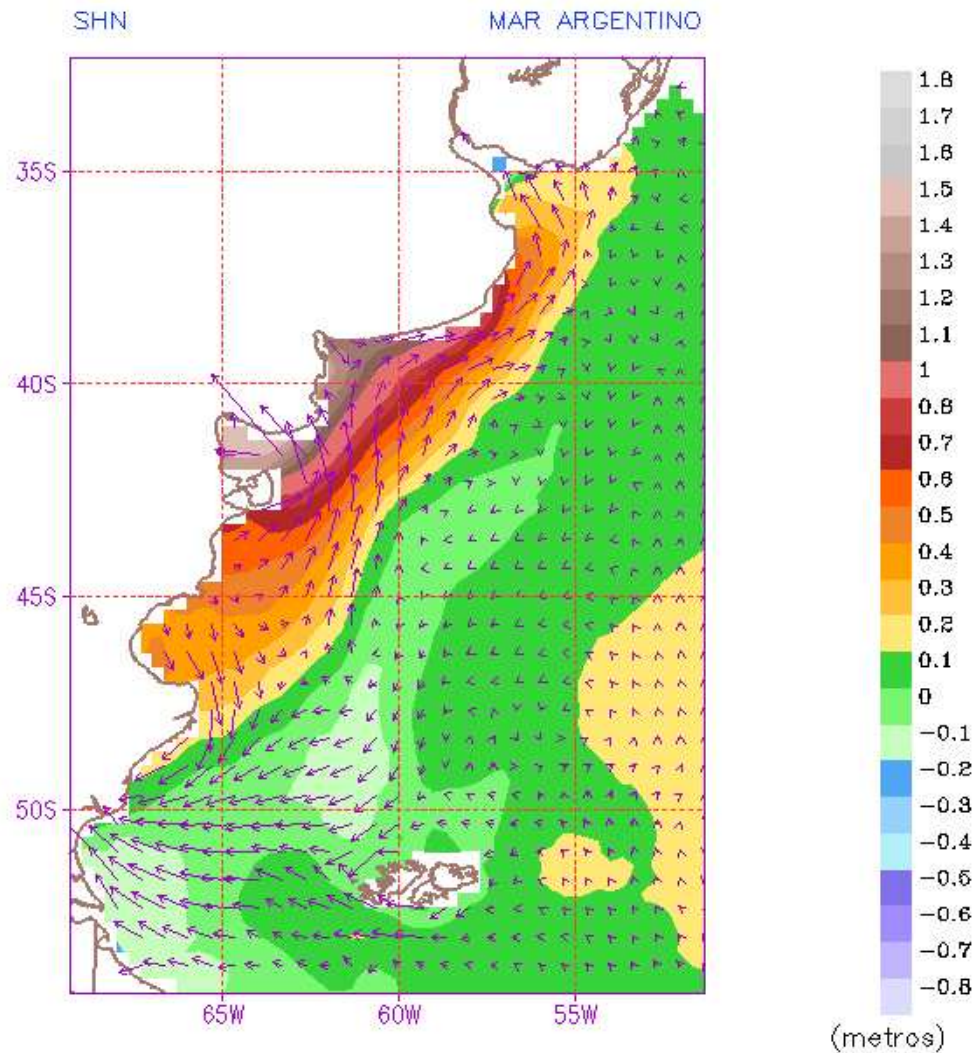
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2015/06/17/12z



Bahia Blanca: surge entering at low tide

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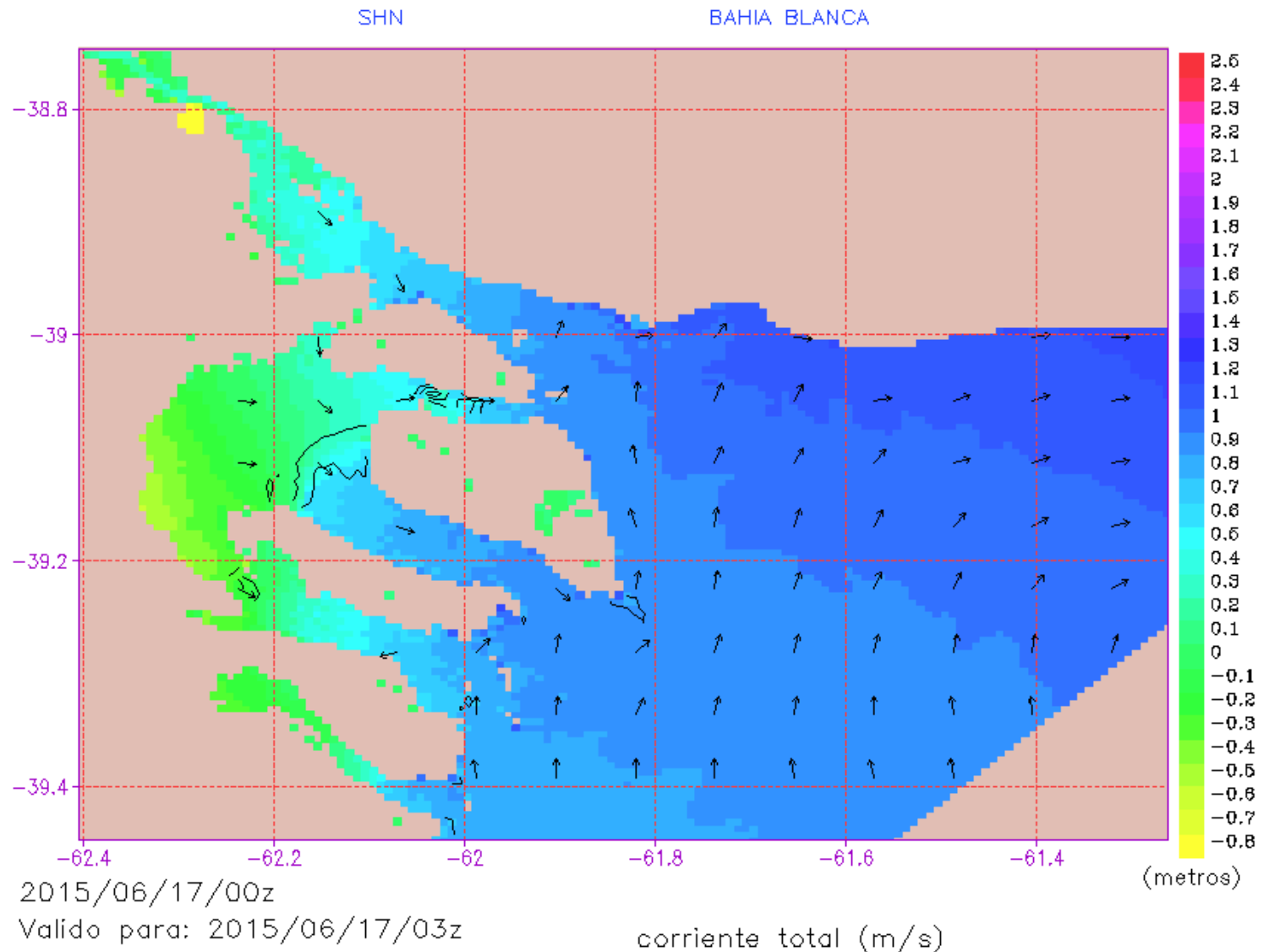
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Flood tide with abnormal water levels

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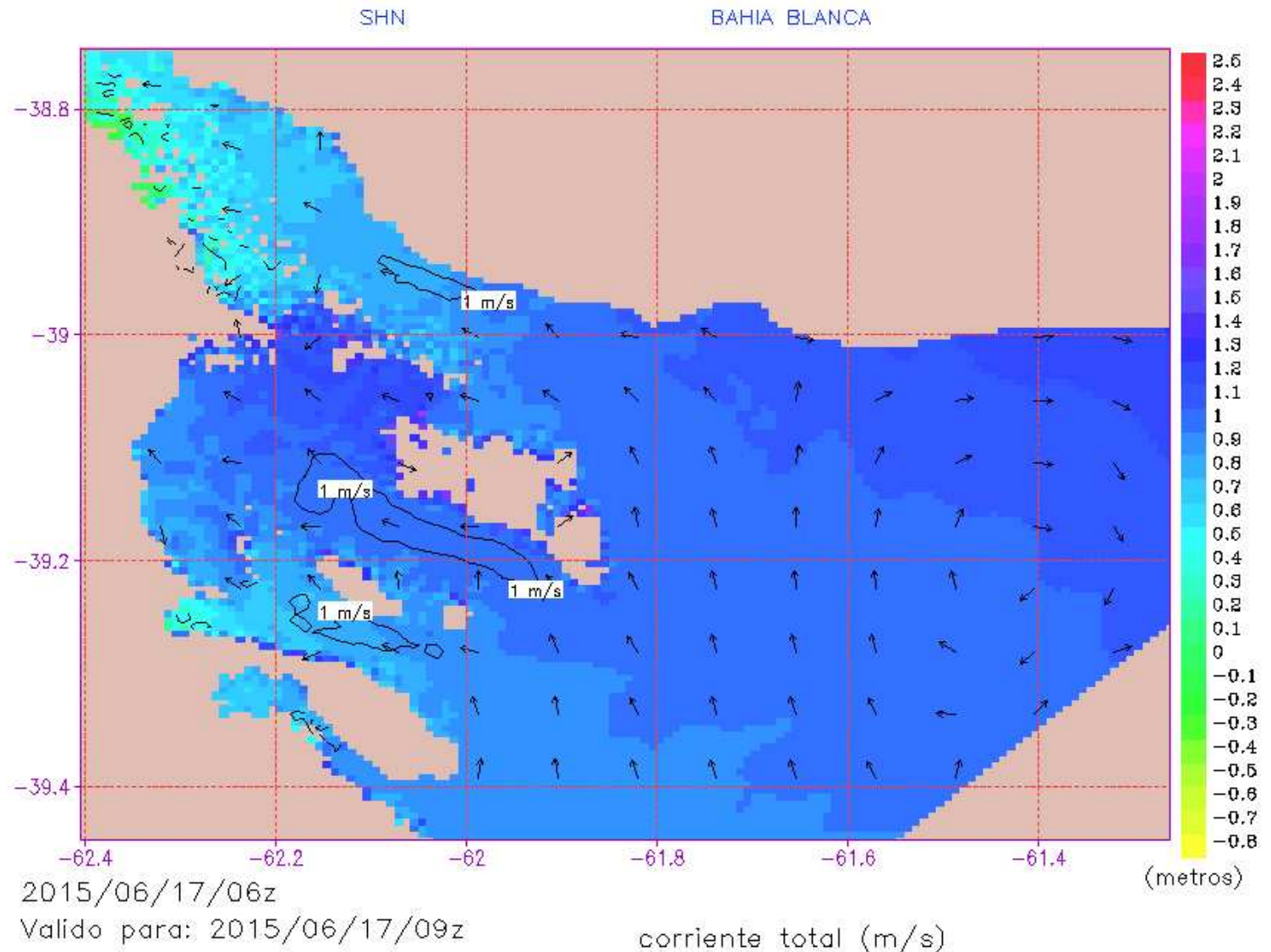
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Strong drain currents along the channel

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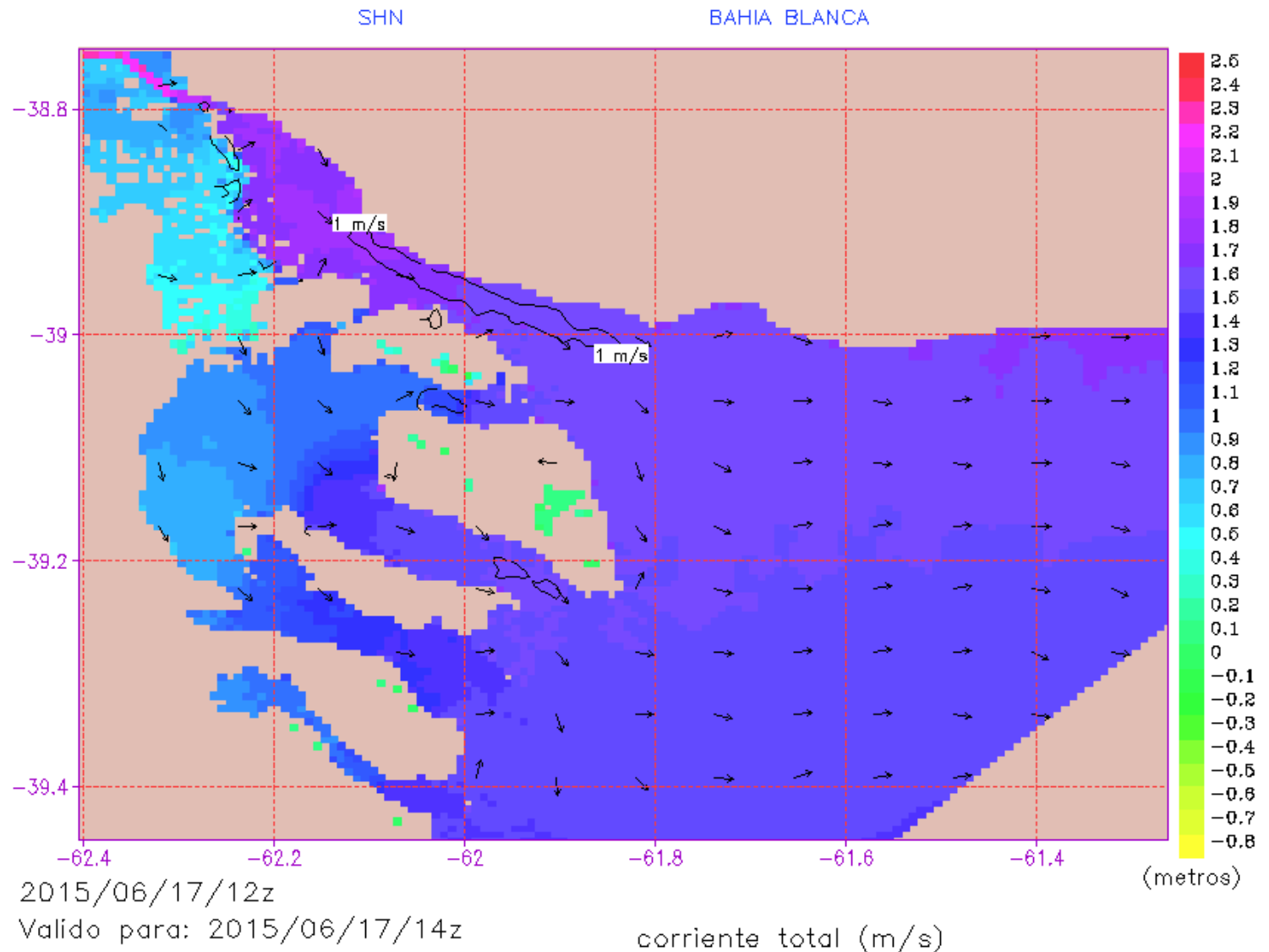
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The storm surge propagates into Rio de la Plata

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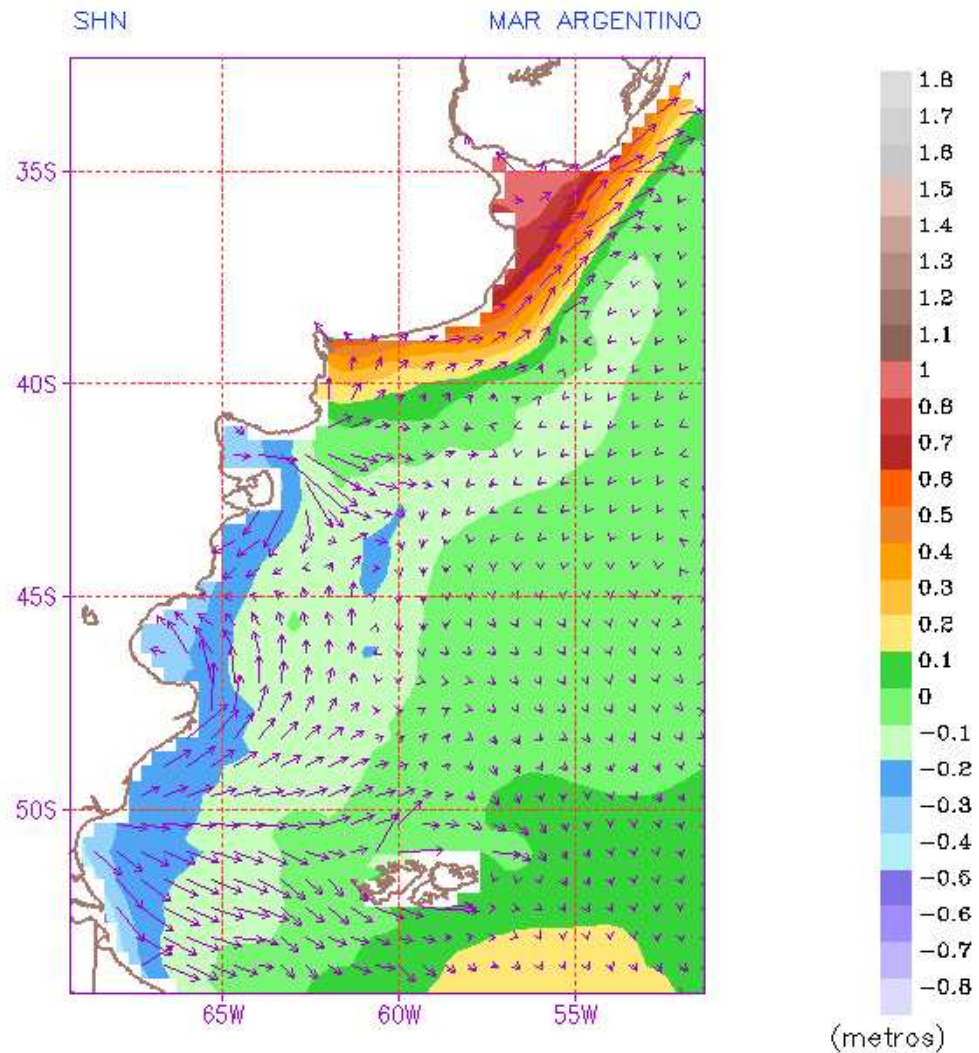
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2015/06/18/06z



Validation at Buenos Aires port with forecast range

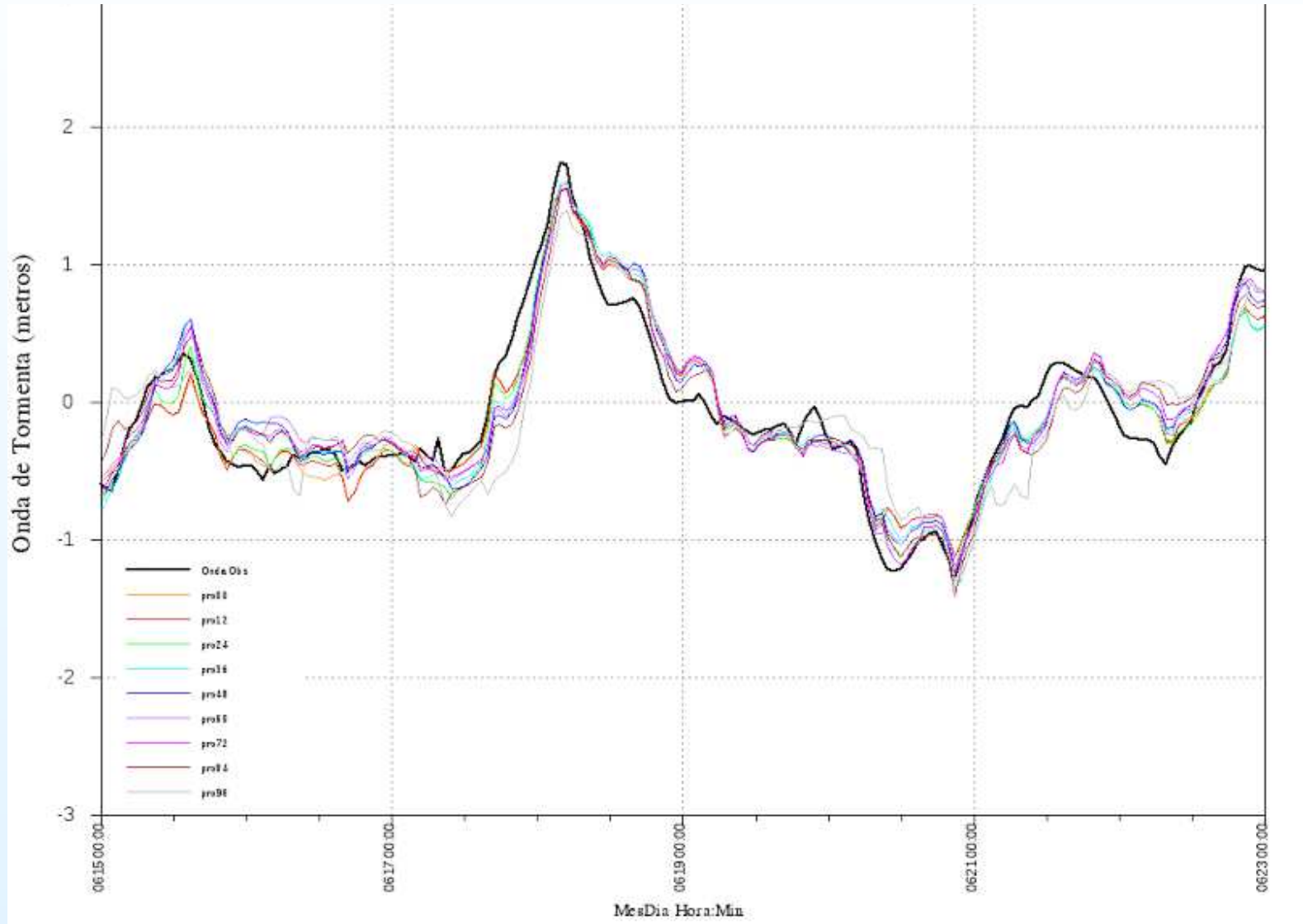
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- Meaning of SWH:
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Mean Sea Level Pressure 16 June 2015 12Z (from NCEP)

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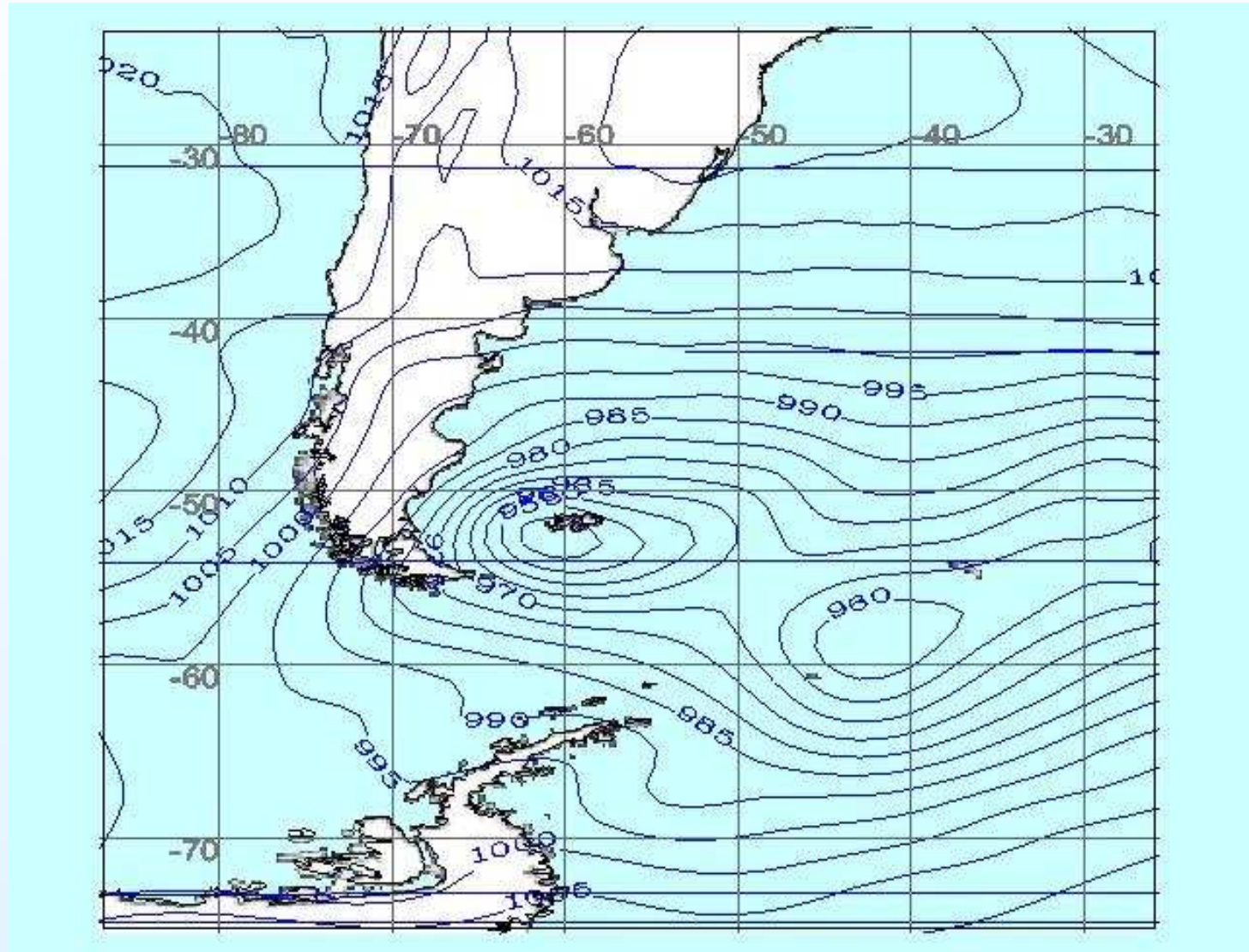
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Deterministic

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MSLP “spaghetti” diagram: 960 hpa (51 members from ECMWF)

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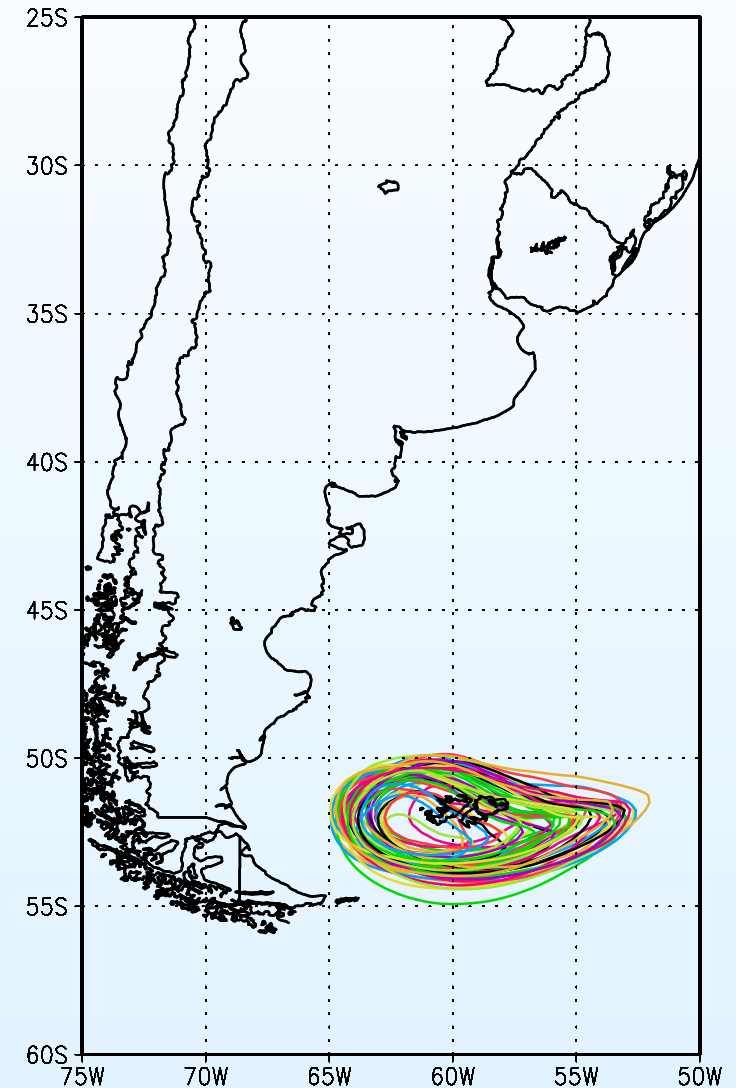
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Uncertainty in the forecast





MSLP ensemble mean and spread (from ECMWF)

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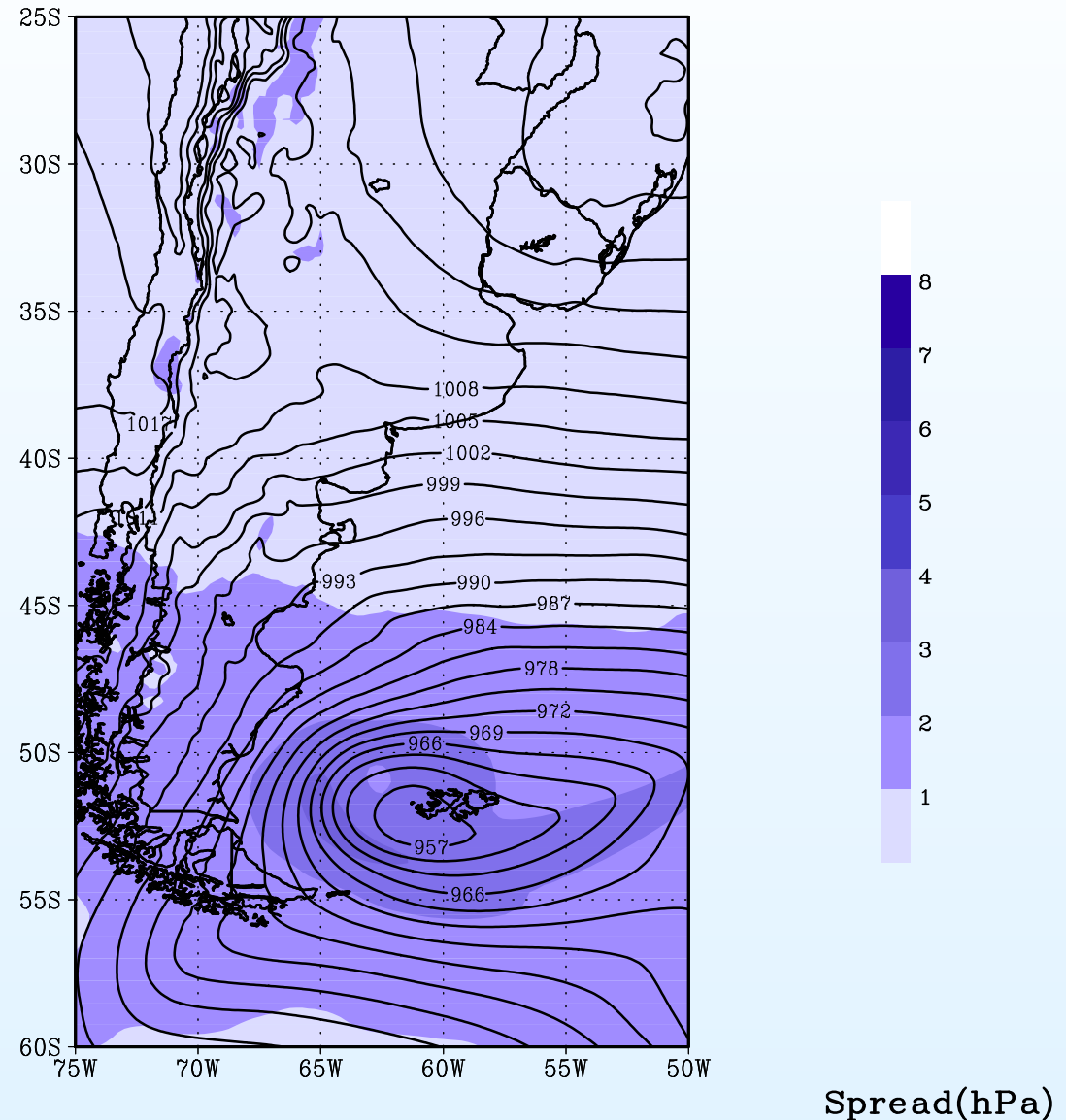
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Wind uncertainty (from ECMWF ensemble forecast)

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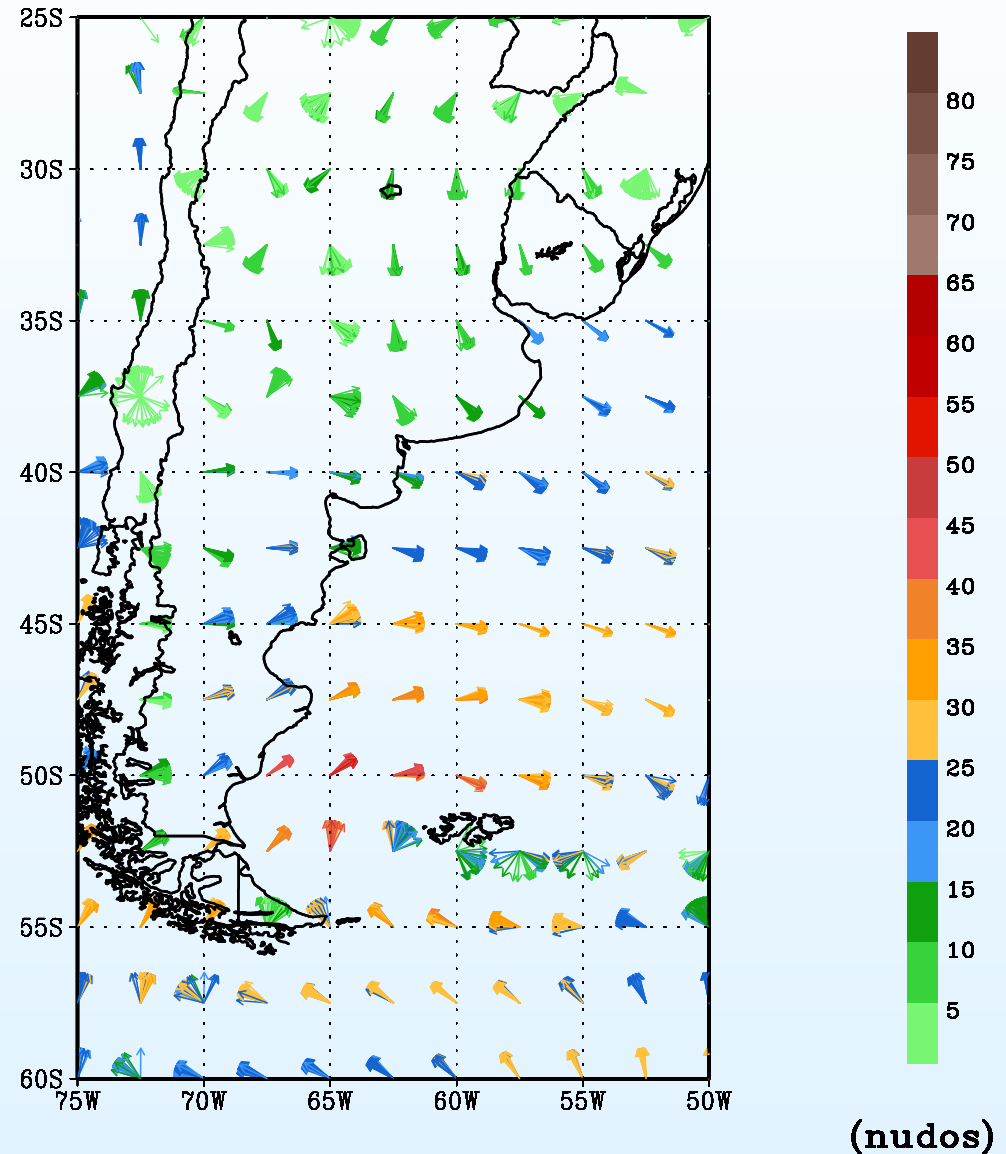
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SWH= 5 m and 10 m “spaghetti” (3 hs later, from NCEP)

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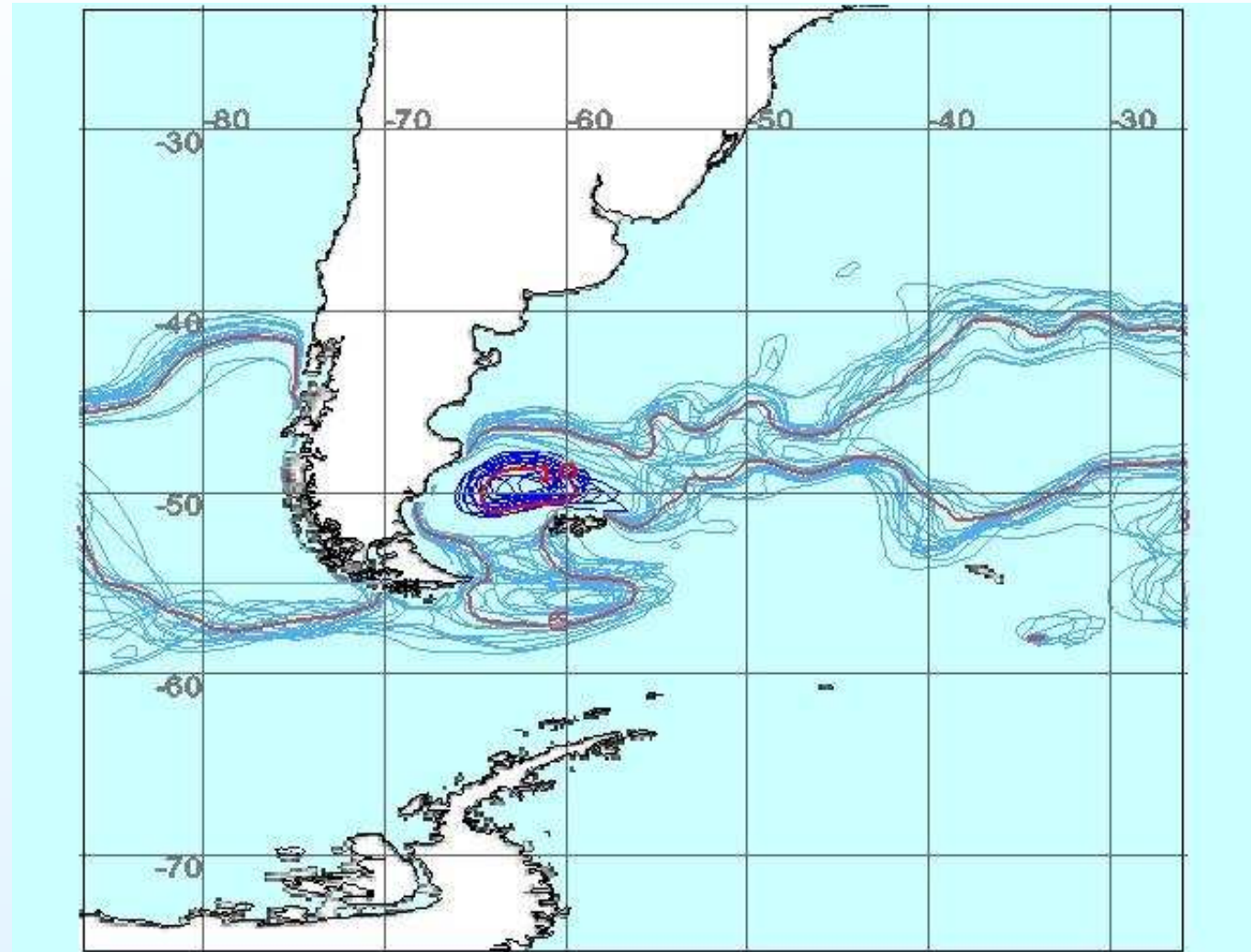
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Significant_height_of_combined_wind_waves_and_swell_surface - 2015-06-16 15:00:00Z



Probability of SWH >9 m (from NCEP, 50% in contours) Deterministic SWH forecast (from SHN-SMN, colors) 18Z

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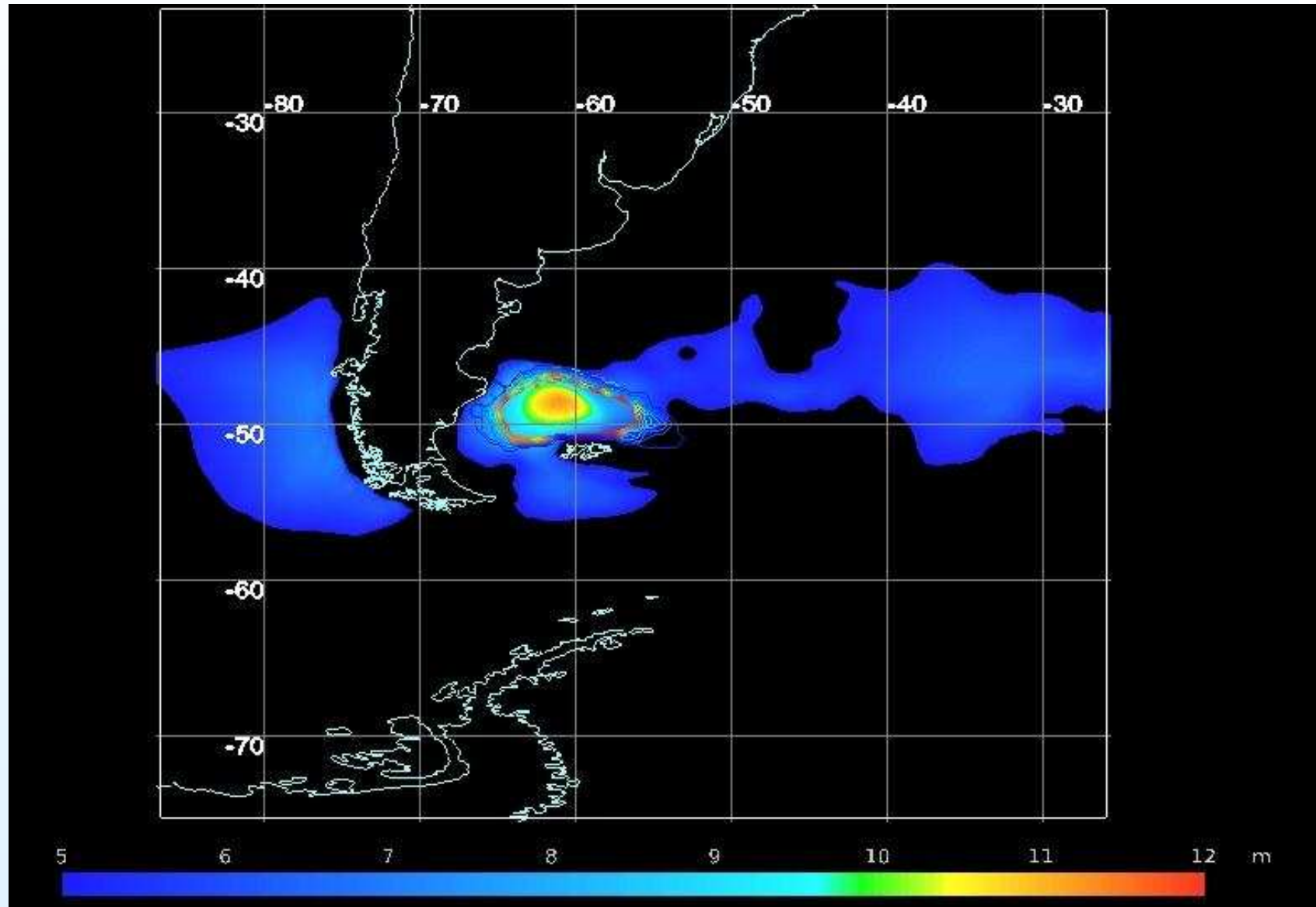
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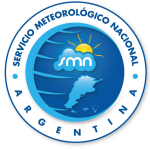
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Marine guidance products

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ECMWF

<http://www.ecmwf.int/en/forecasts/datasets/wmo-catalogue>

NCEP

<http://polar.ncep.noaa.gov>

SMN-SHN

<http://www.smn.gov.ar/?mod=archolas&id=16>

http://www.smn.gov.ar/pronos/ondatormenta_plataformario.php?id=1

Forecast quality

<http://www.ecmwf.int/en/forecasts/charts/medium/comparison-other-operational-centres>

http://www.jcomm.info/index.php?option=com_content&view=article&id=131&Itemid=37



Thanks

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§ Muchas Gracias §