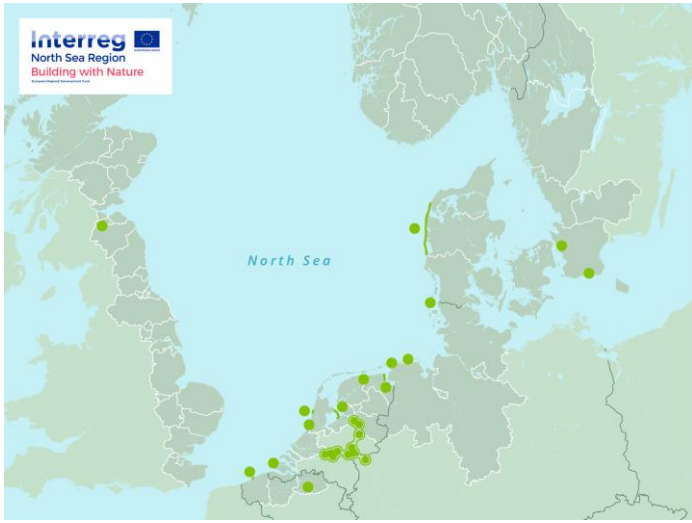
Assessment of the design and behaviour of nourishments in the North Sea Region: Towards A NSR Guideline for Nourishments

Coastal Dynamics Conference 2017, Helsingør - Denmark

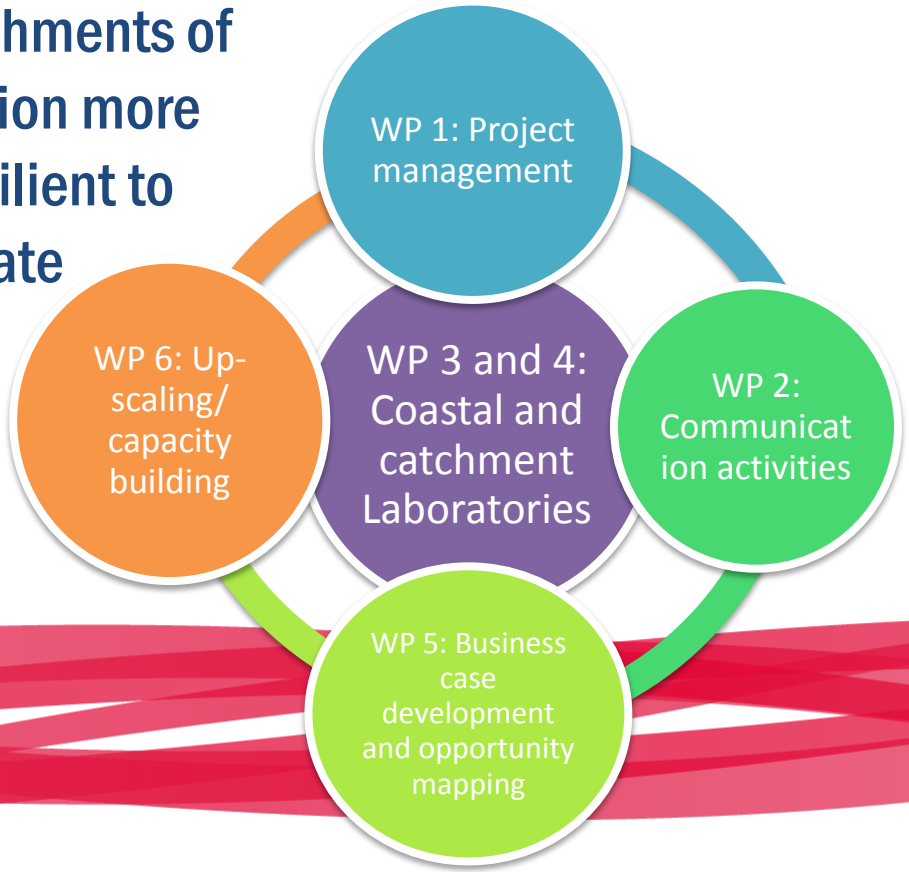
Rinse Wilmink - Rijkswaterstaat - The Netherlands
Quirijn Lodder – Rijkswaterstaat – The Netherlands
Per Sørensen – Danish Coastal Authority - Denmark

Interreg
North Sea Region
Building with Nature
European Regional Development Fund



EU Interreg Building with Nature

Aim: To make coasts, estuaries and catchments of the North Sea Region more adaptable and resilient to the effects of climate change.



Interreg
North Sea Region
Building with Nature
European Regional Development Fund

Partners in Interreg NSR Building with Nature

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Ministry of Environment and Food of Denmark
Coastal Authority

AGENTSCHAP MARITIEME DIENSTVERLENING en KUST
Vlaanderen is maritiem

Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz
NLWKN

Länsstyrelsen Skåne

VLAAMSE MILIEUMAATSCHAPPIJ

UNESCO-IHE
Institute for Water Education

LKN.SH
Agency for Coastal Defence, National Park and Marine Conservation Schleswig-Holstein

TWEED FORUM

SEPA
Scottish Environment Protection Agency

Common Wadden Sea Secretariat

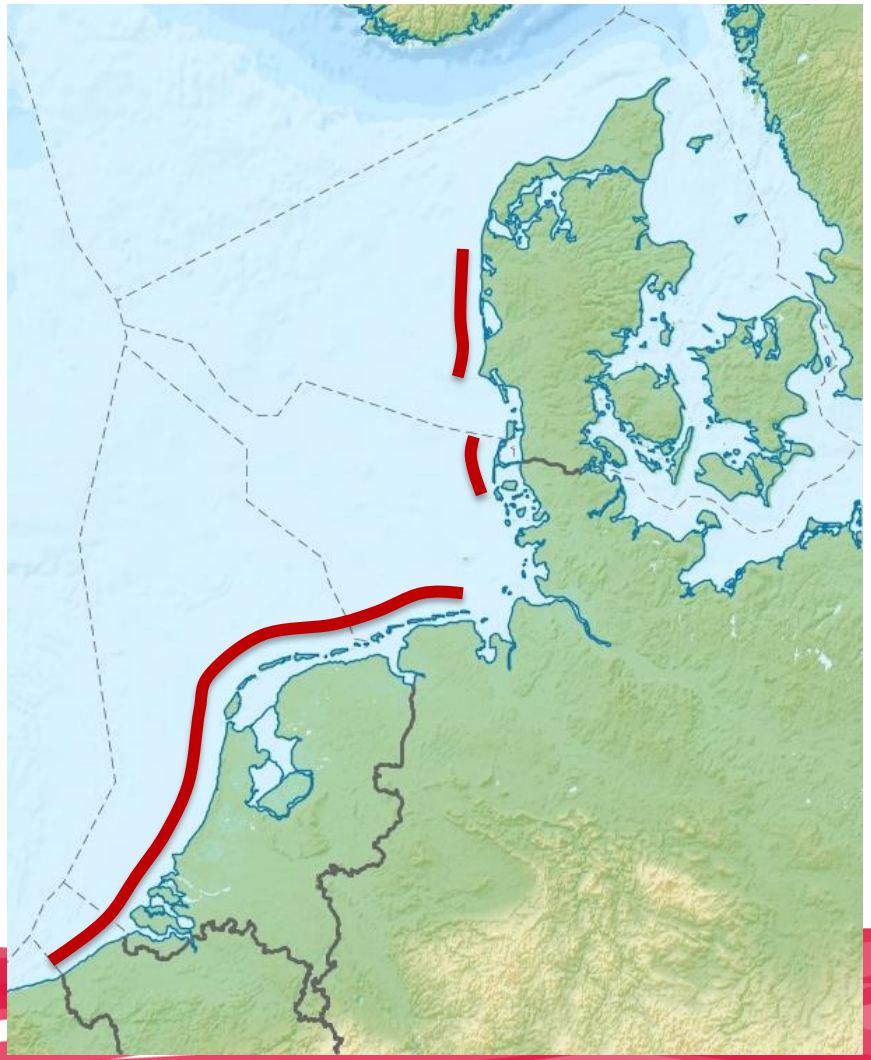
EcoShape
building with nature

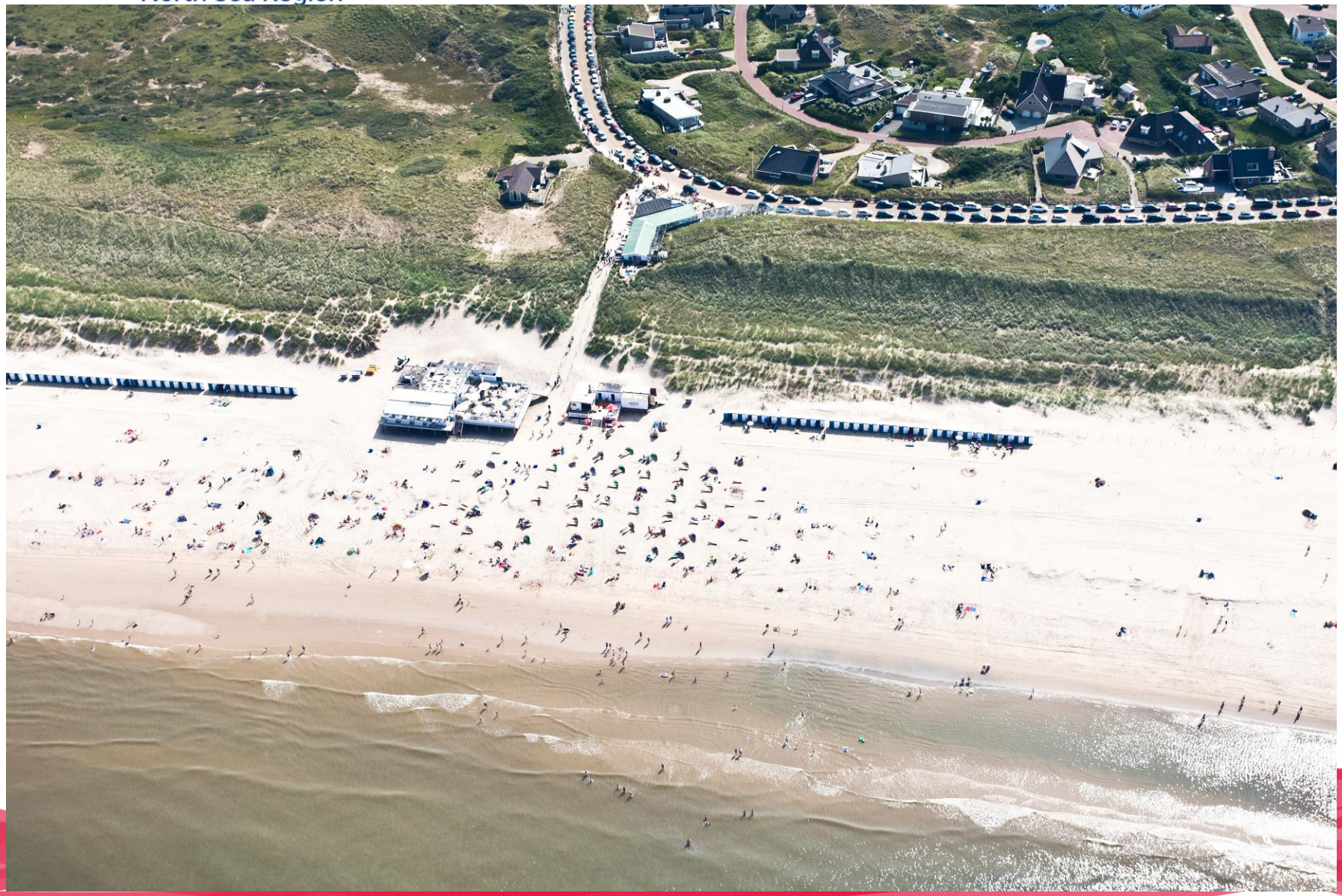
NVE

Waterschap Noorderzijlvest

The Scottish Government
Riaghaltas na h-Alba

Interreg
North Sea Region
Building with Nature
European Regional Development Fund





Coastal Work Package - Resilient coastal laboratories

By using:

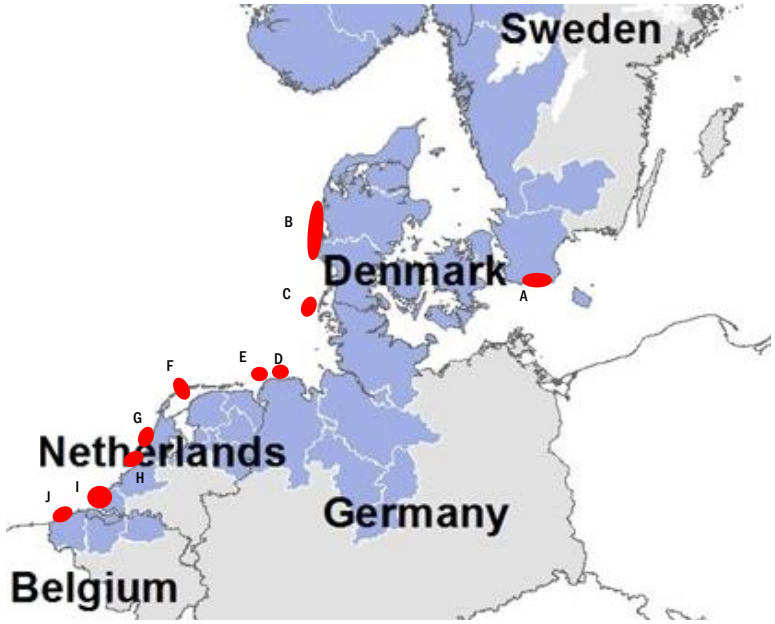
+ Using an existing evidence base
+ Share knowledge and coastal data
+ A shared assessment methodology

We assess:

+ the effectiveness of nourishments given local conditions

To come up with:

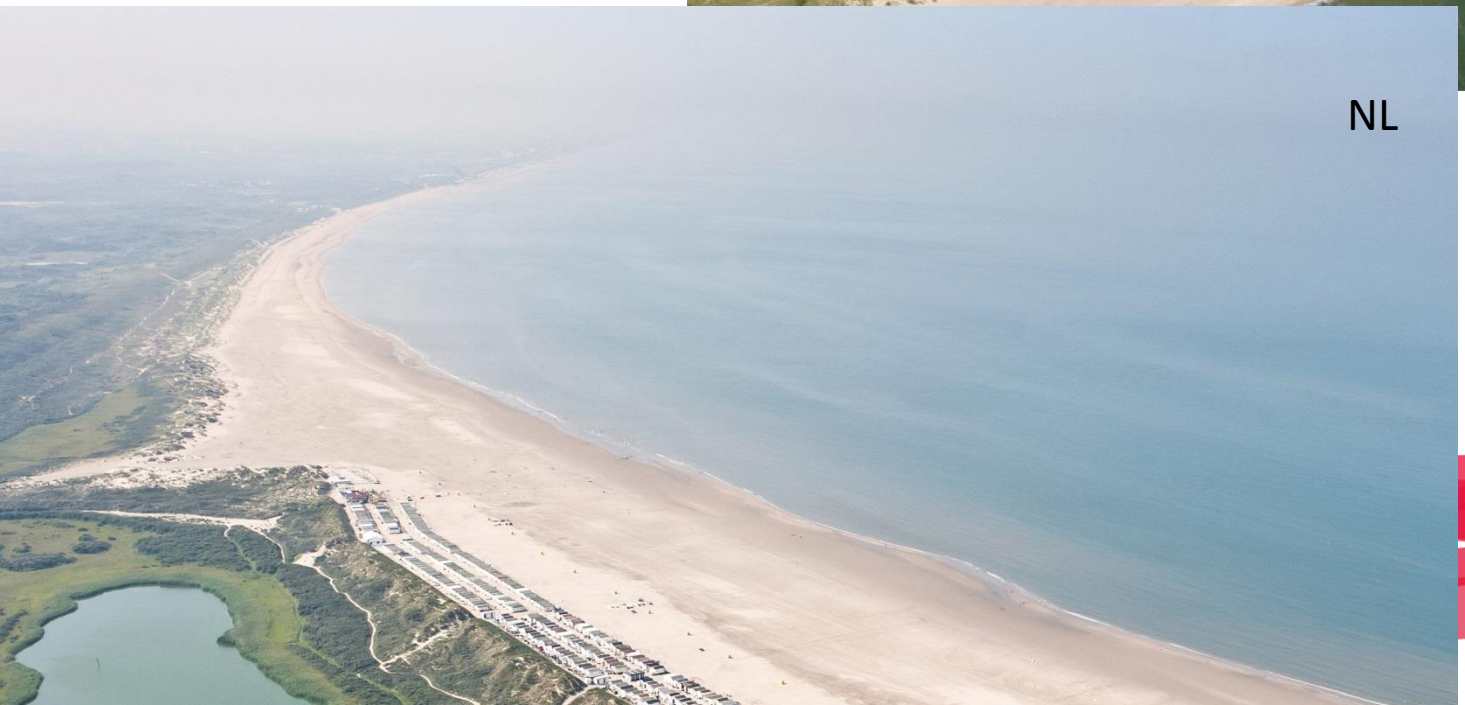
+ An NSR Guideline for nourishments



Coastal Laboratories. A: Ystad (Sweden), B: Danish West coast (Denmark), C: Sylt (State of Schleswig Holstein, Germany), D: Langeoog (State of Lower Saxony, Germany), E: Norderney (State of Lower Saxony, Germany), F: Ameland Inlet (The Netherlands), G: Bergen-Egmond (The Netherlands), H: Zandvoort (The Netherlands), I: Domburg (The Netherlands), J: Oostende-Mariakerke (Flanders, Belgium)

Interreg
North Sea Region
Building with Nature
European Regional Development Fund

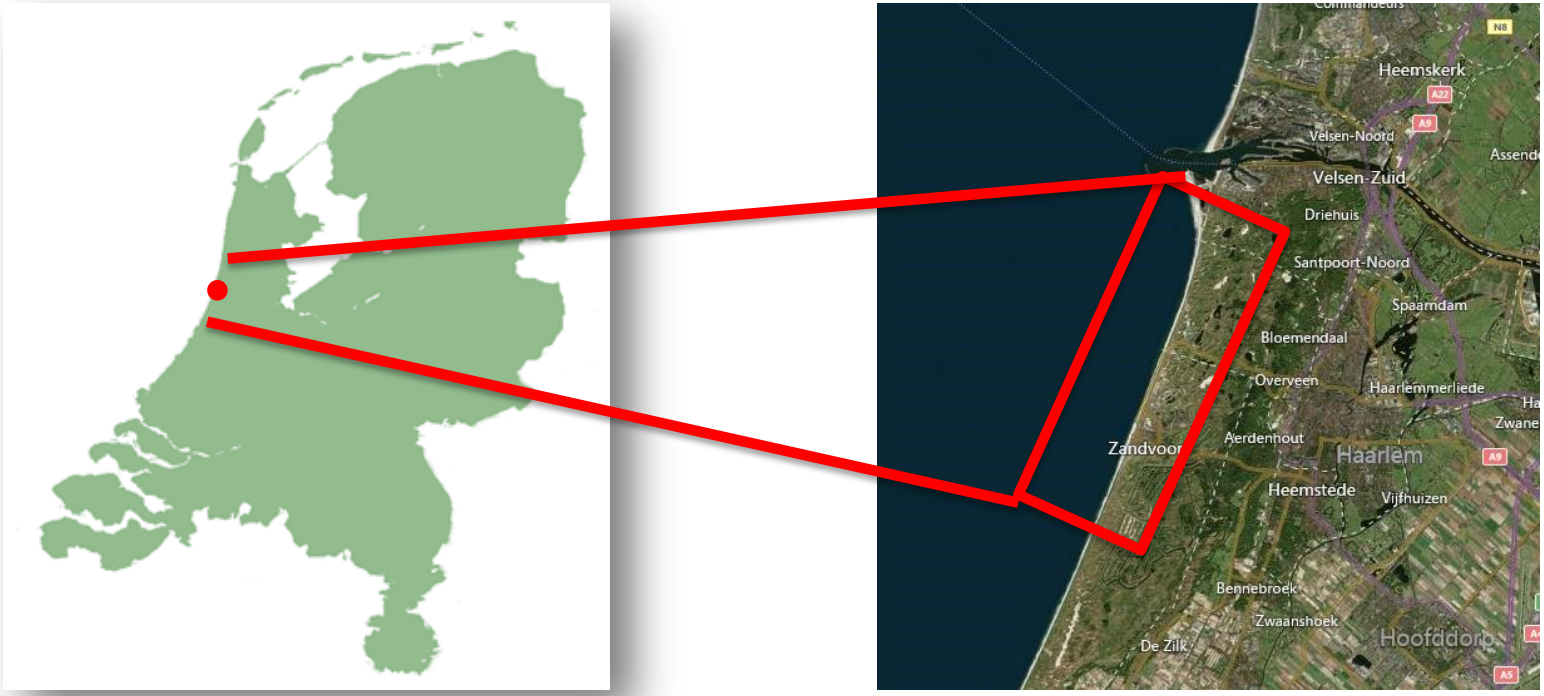
Belgium to Skagen (DK): Primarily sandy coastline.

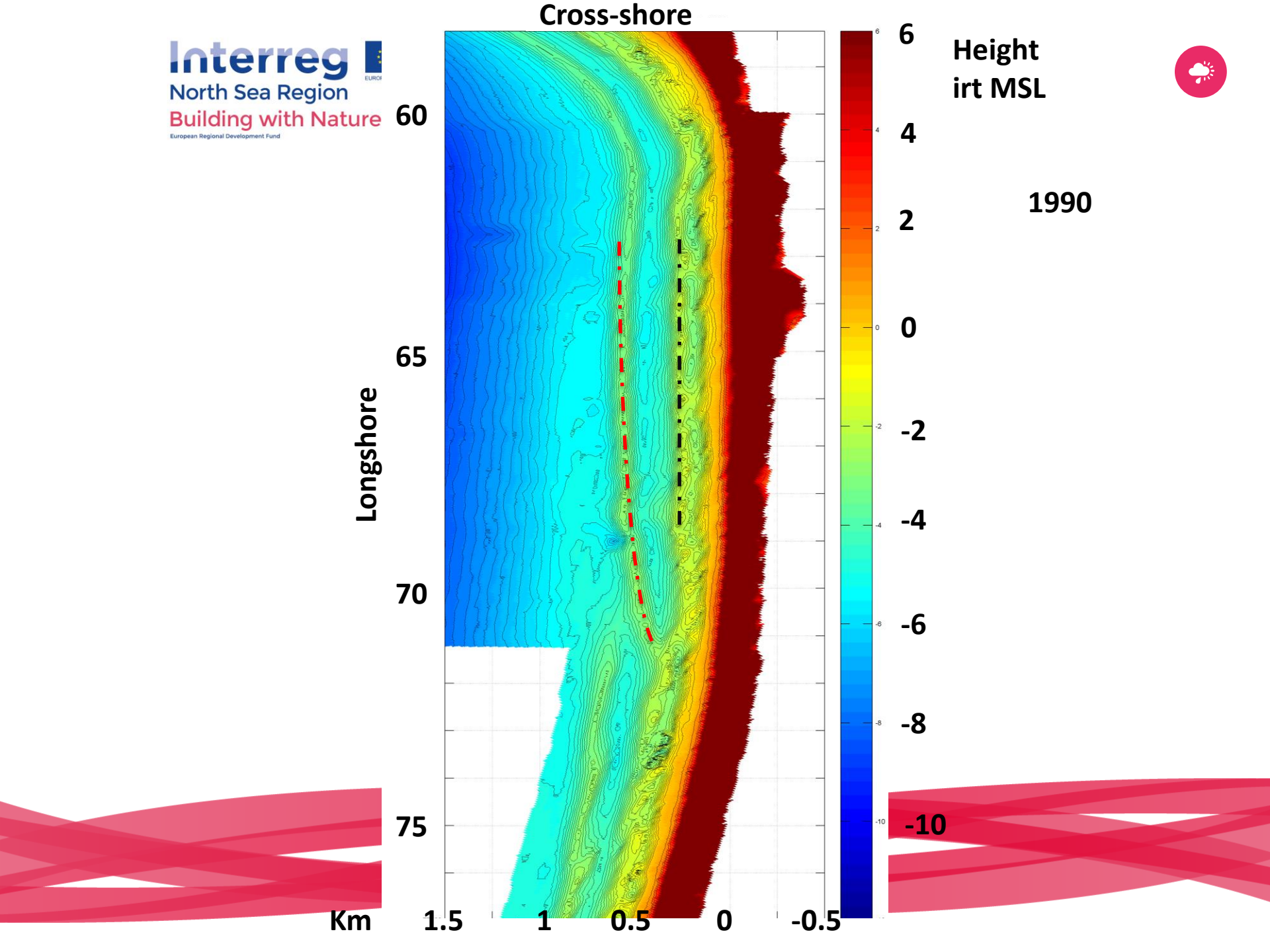


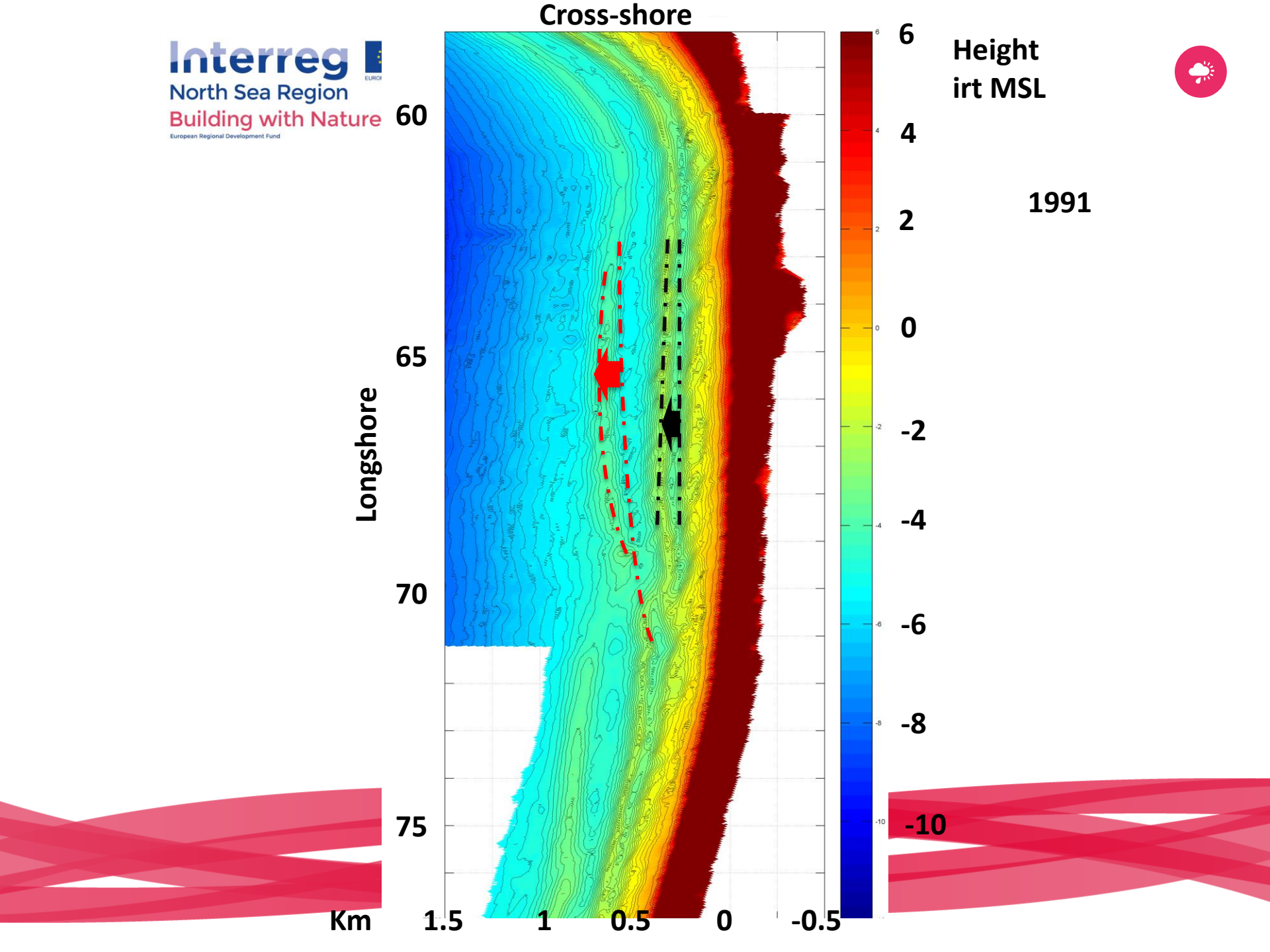
Examples of morphological development of (shoreface) nourishments in the North Sea region

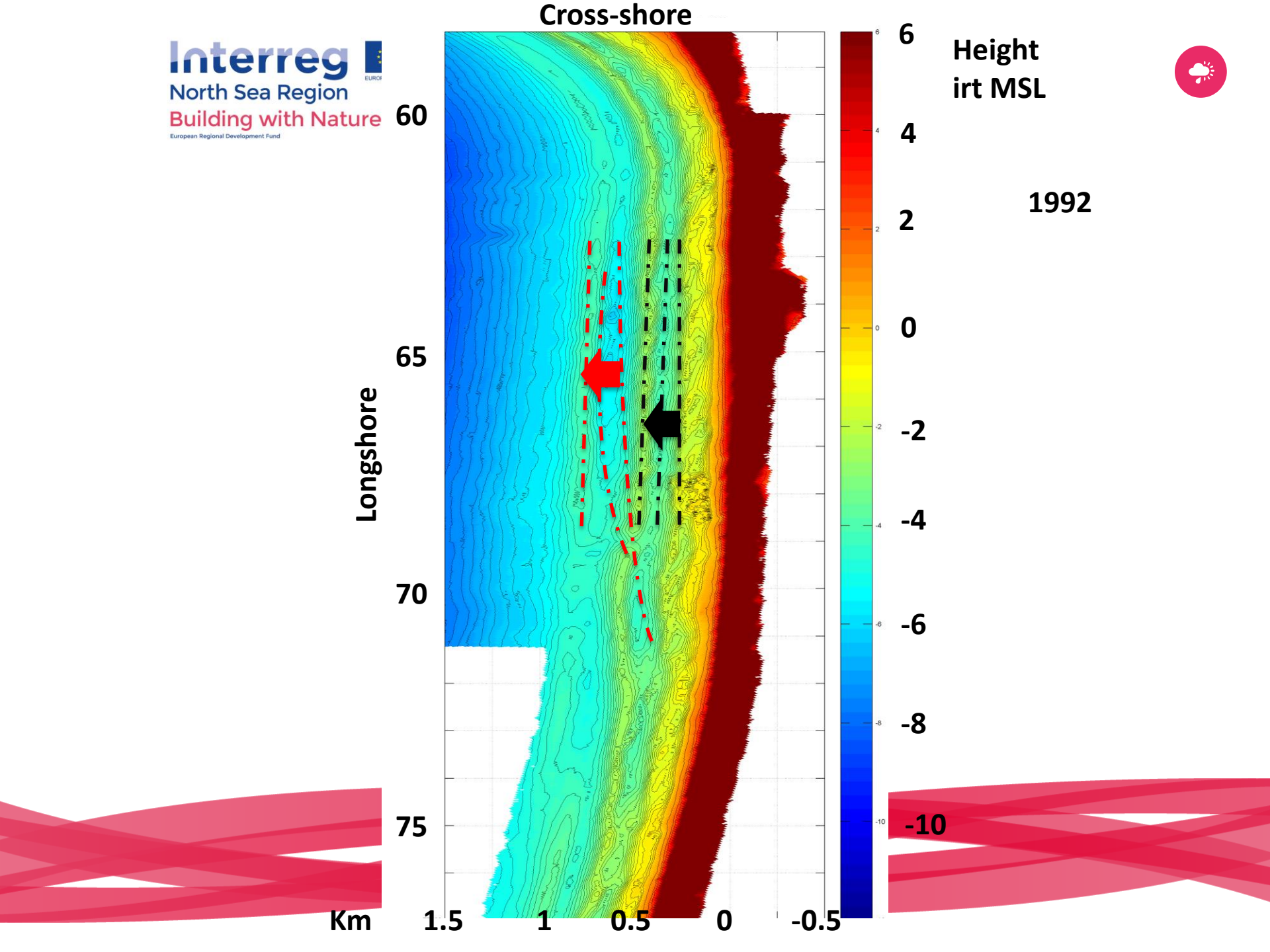
+ Netherlands
+ Denmark
+ (Germany)

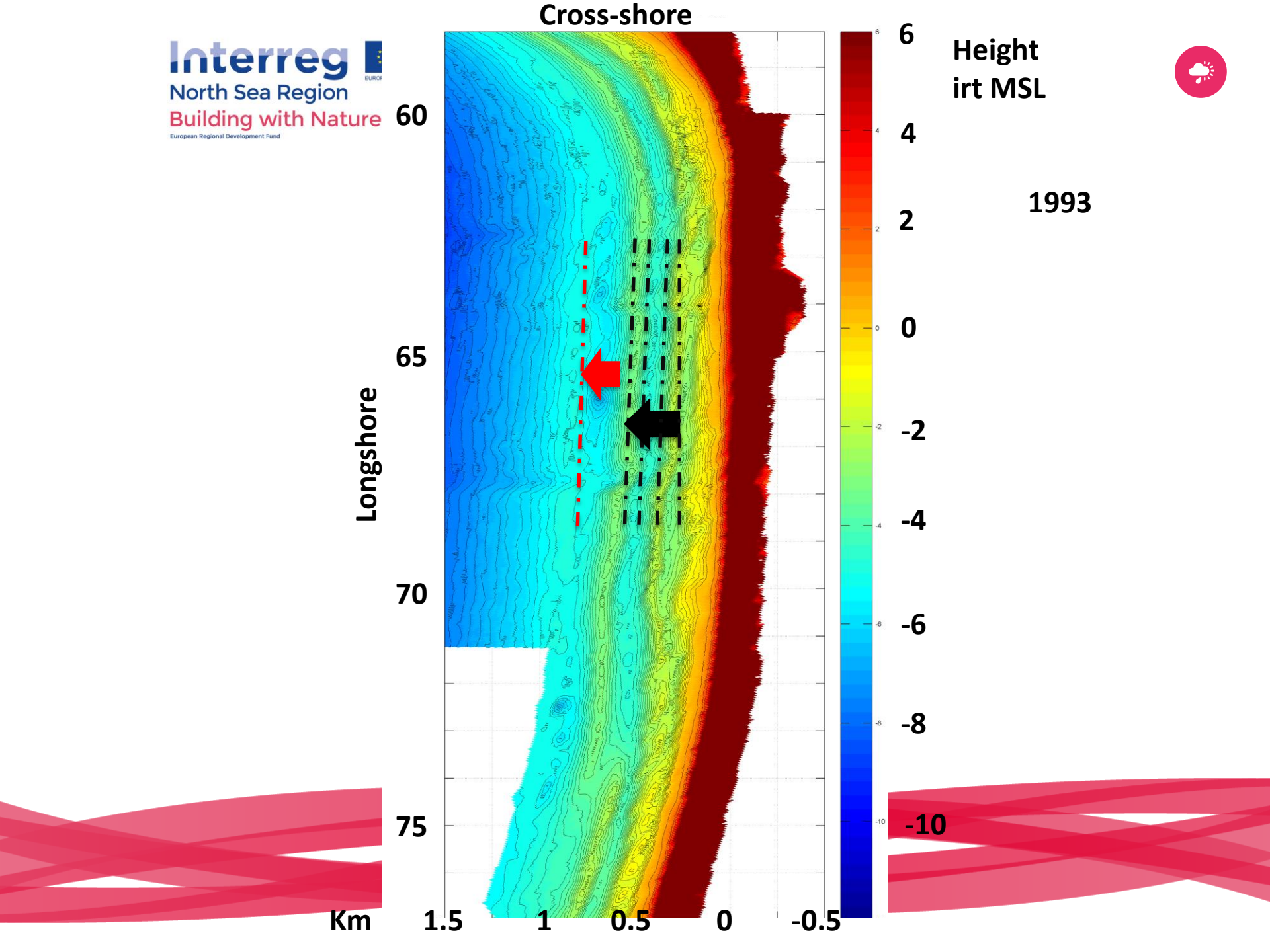
Morphological behaviour, Zandvoort NL

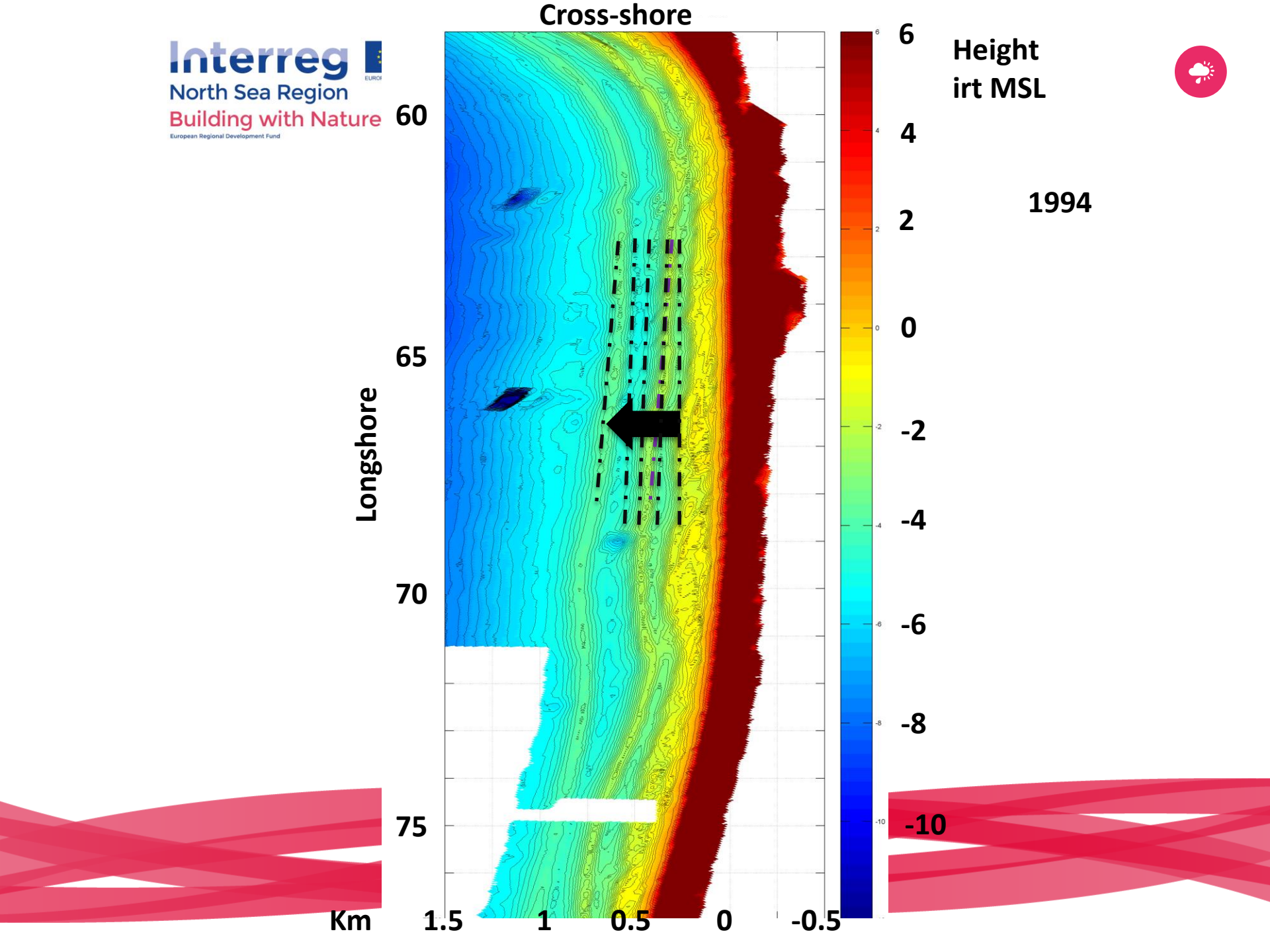


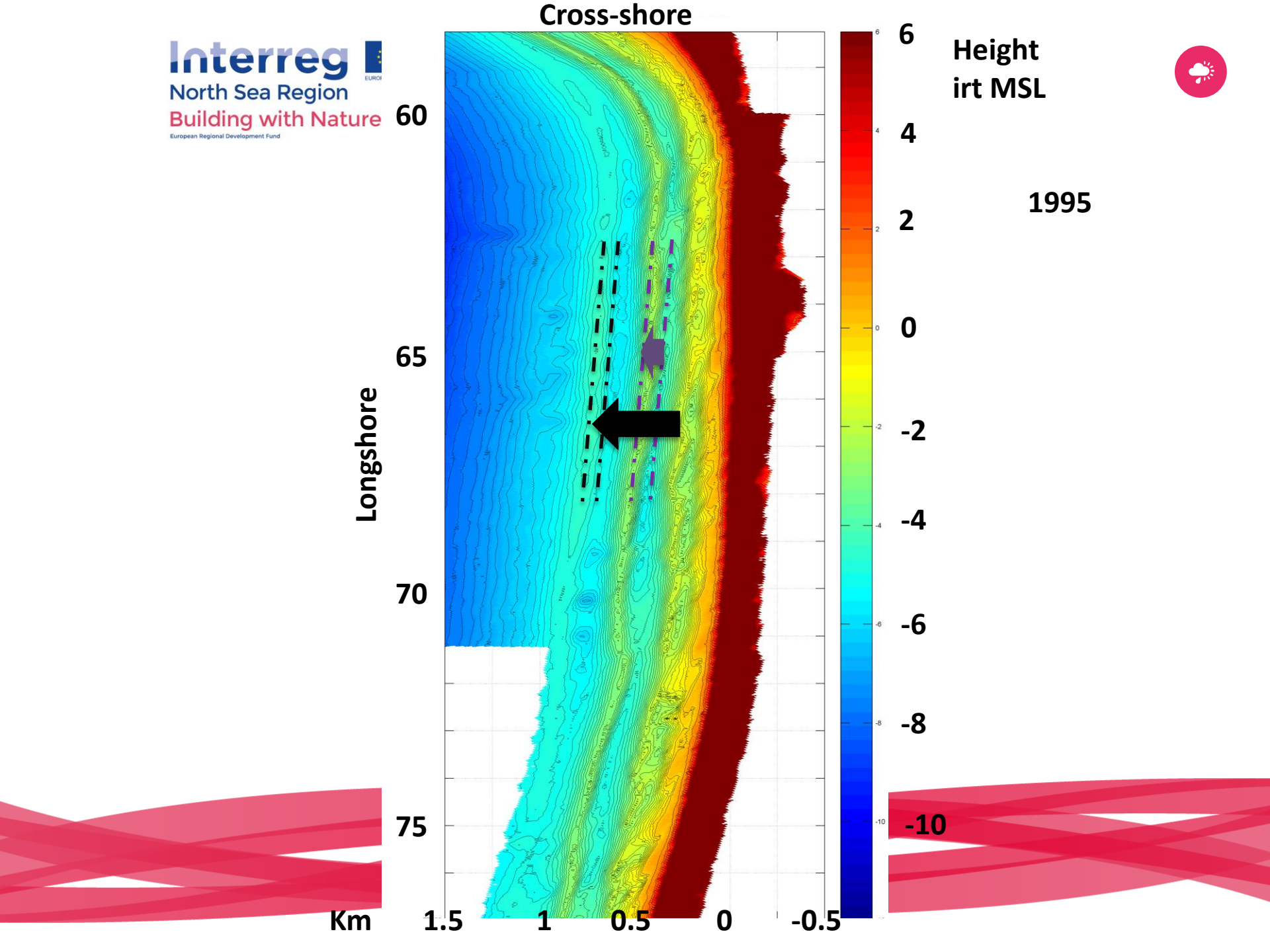

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1990

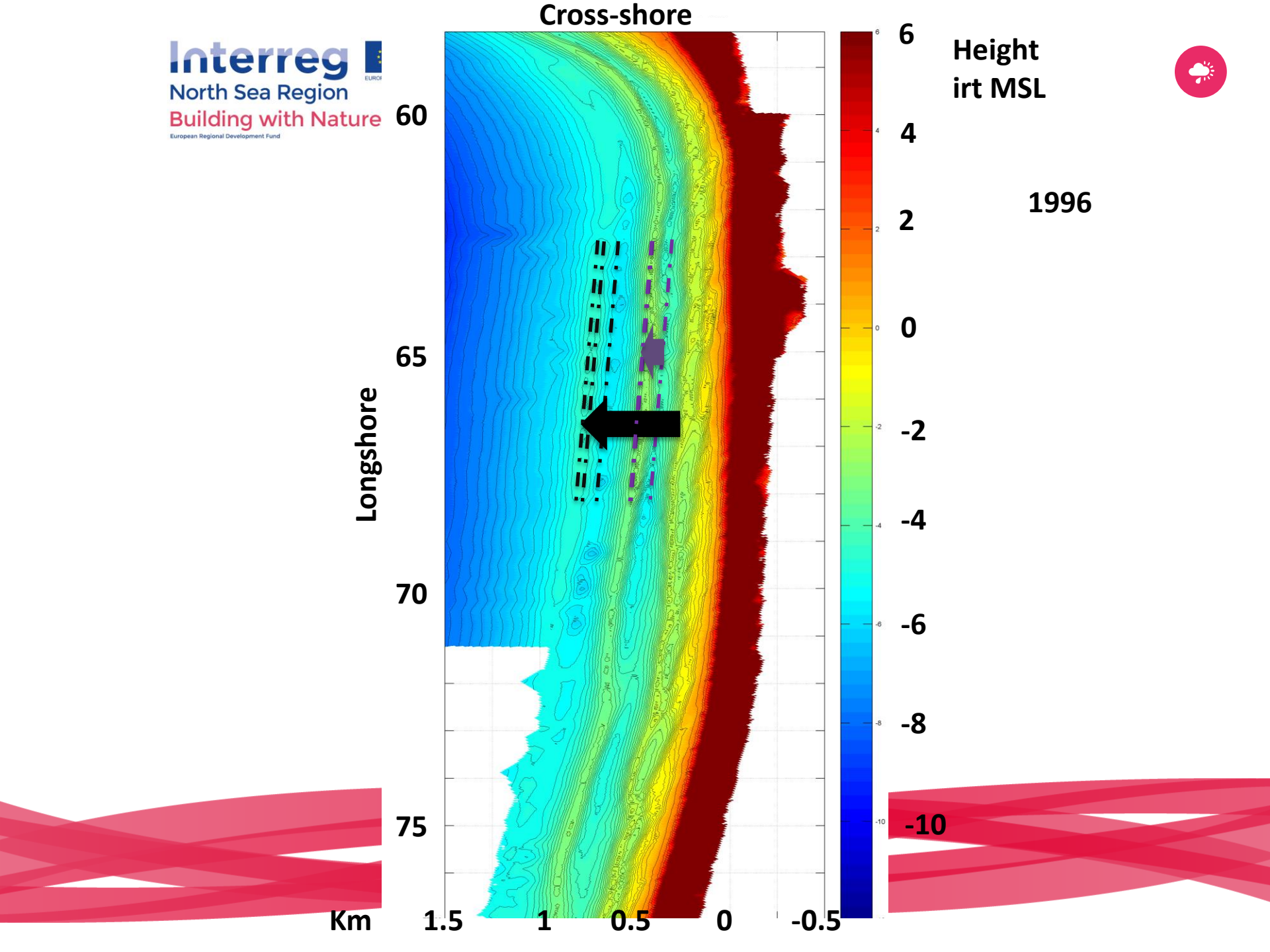

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1991

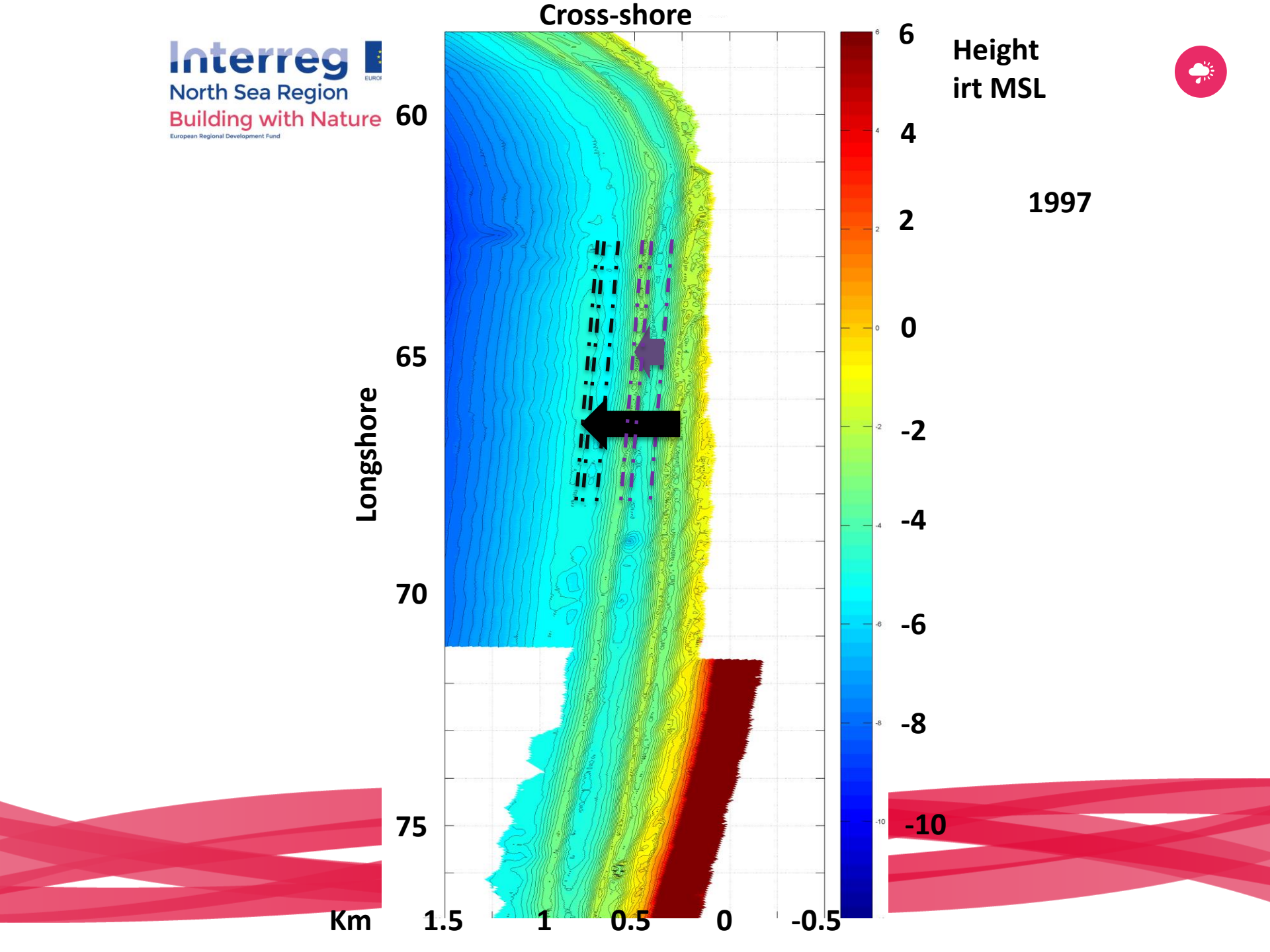

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1992

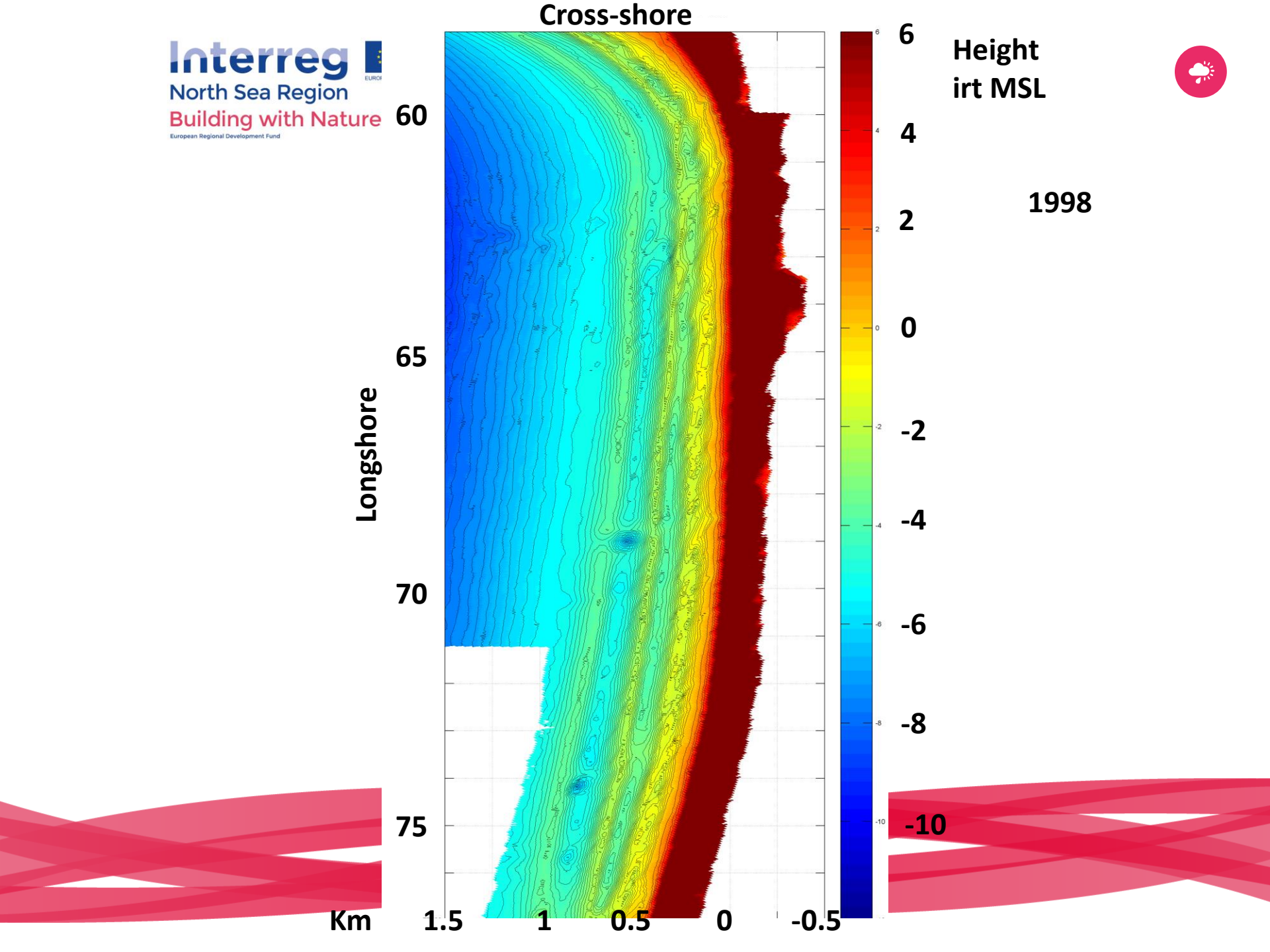

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1993

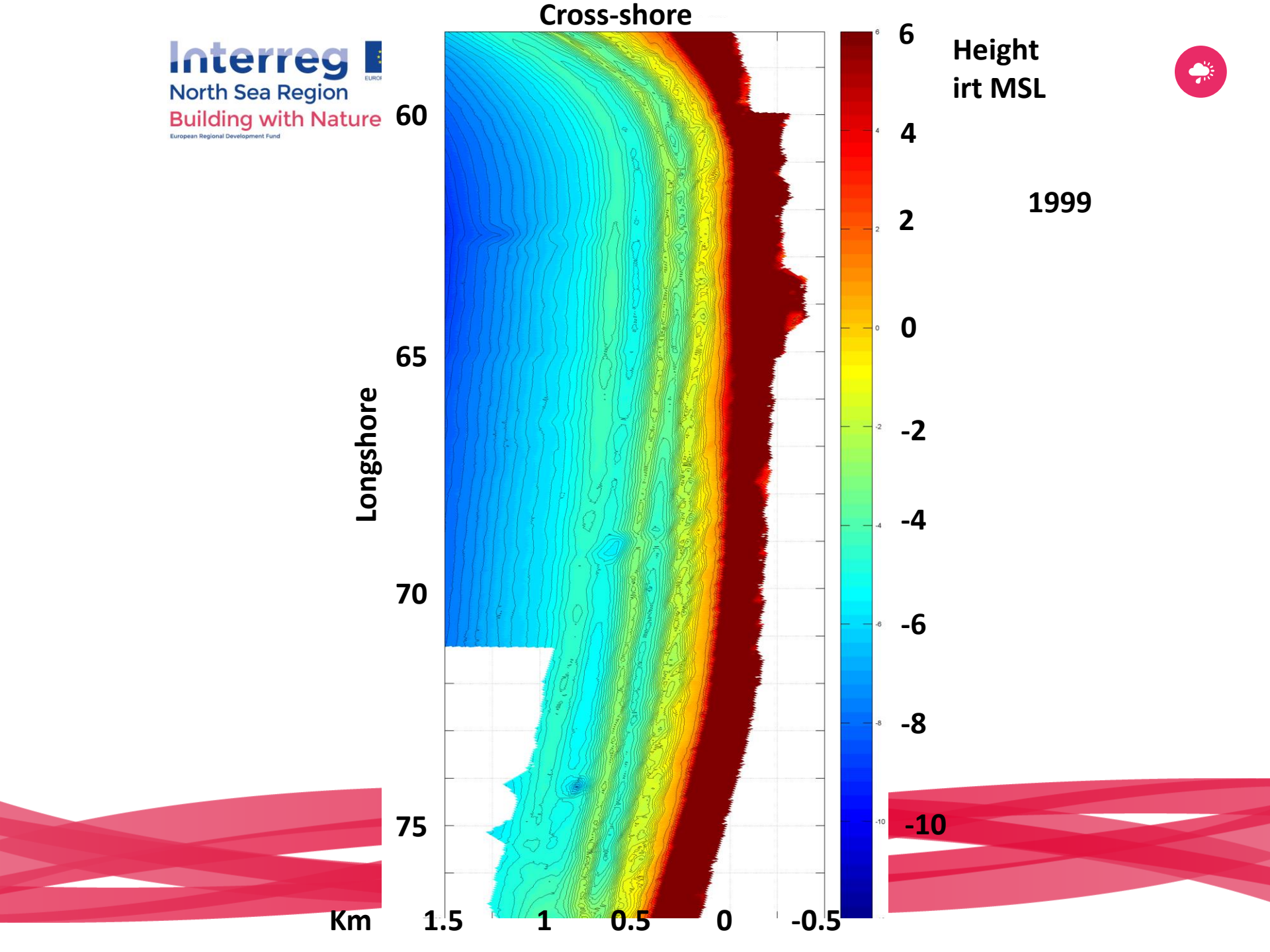

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1994

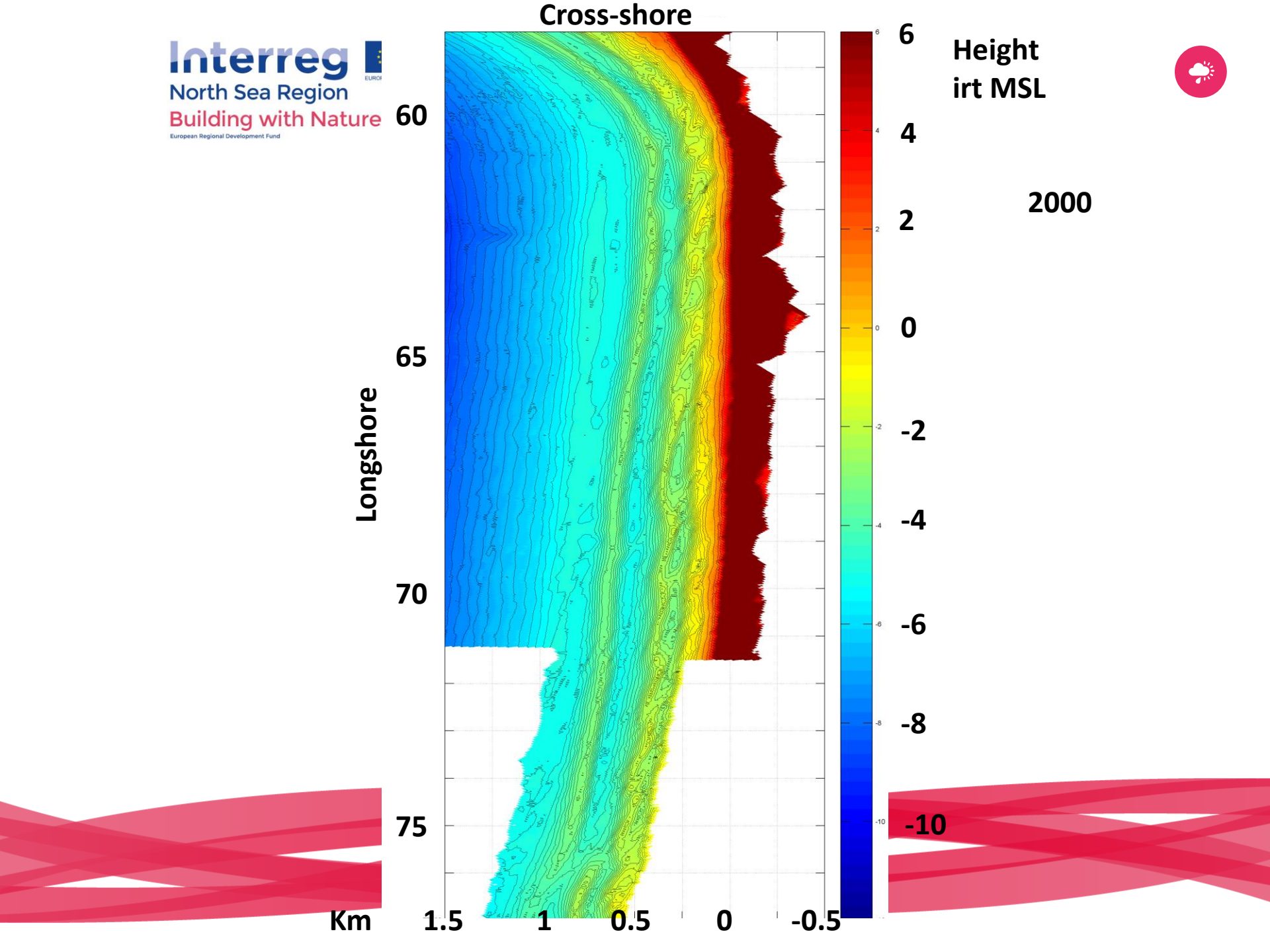

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1995

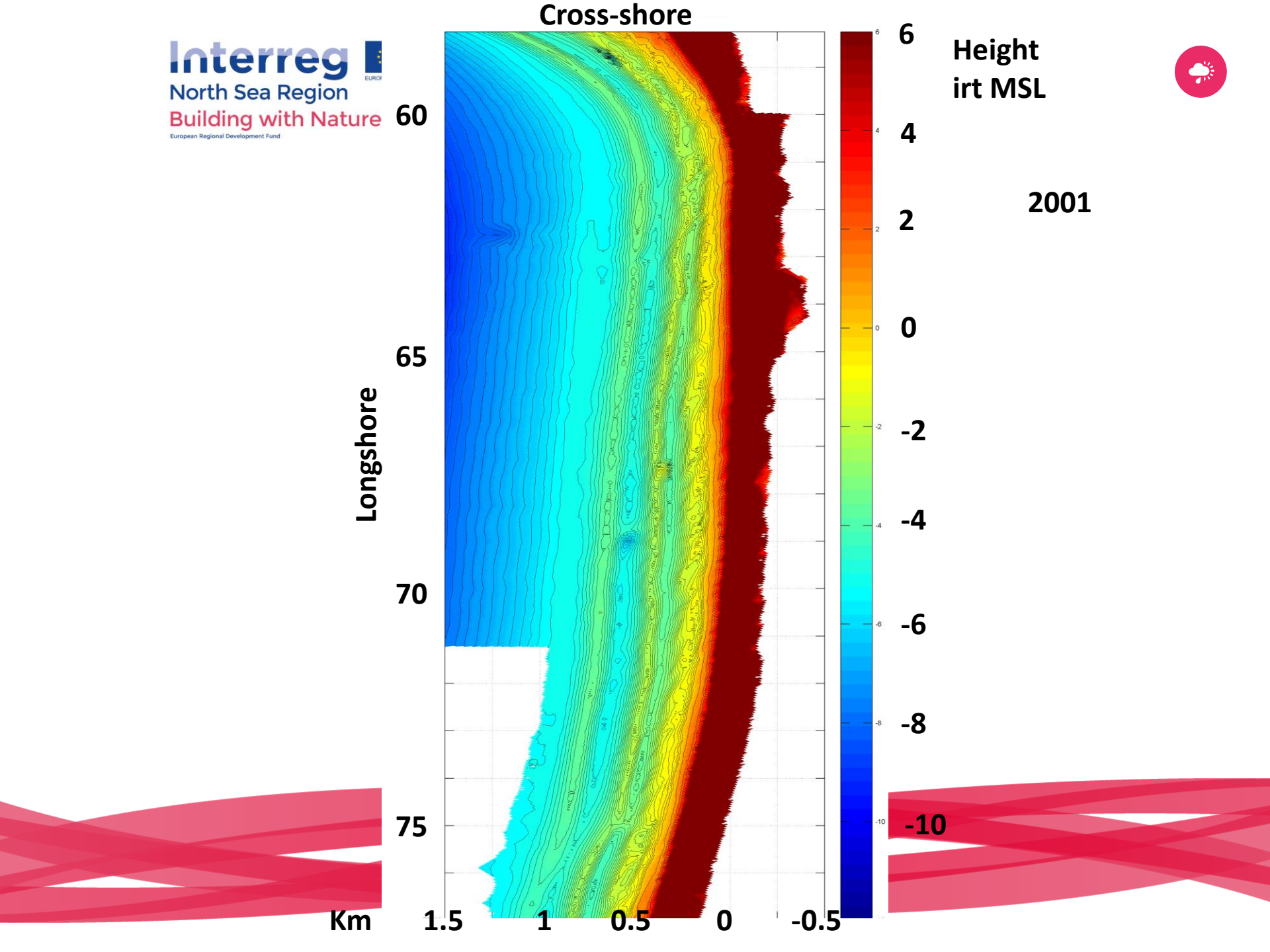

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1996

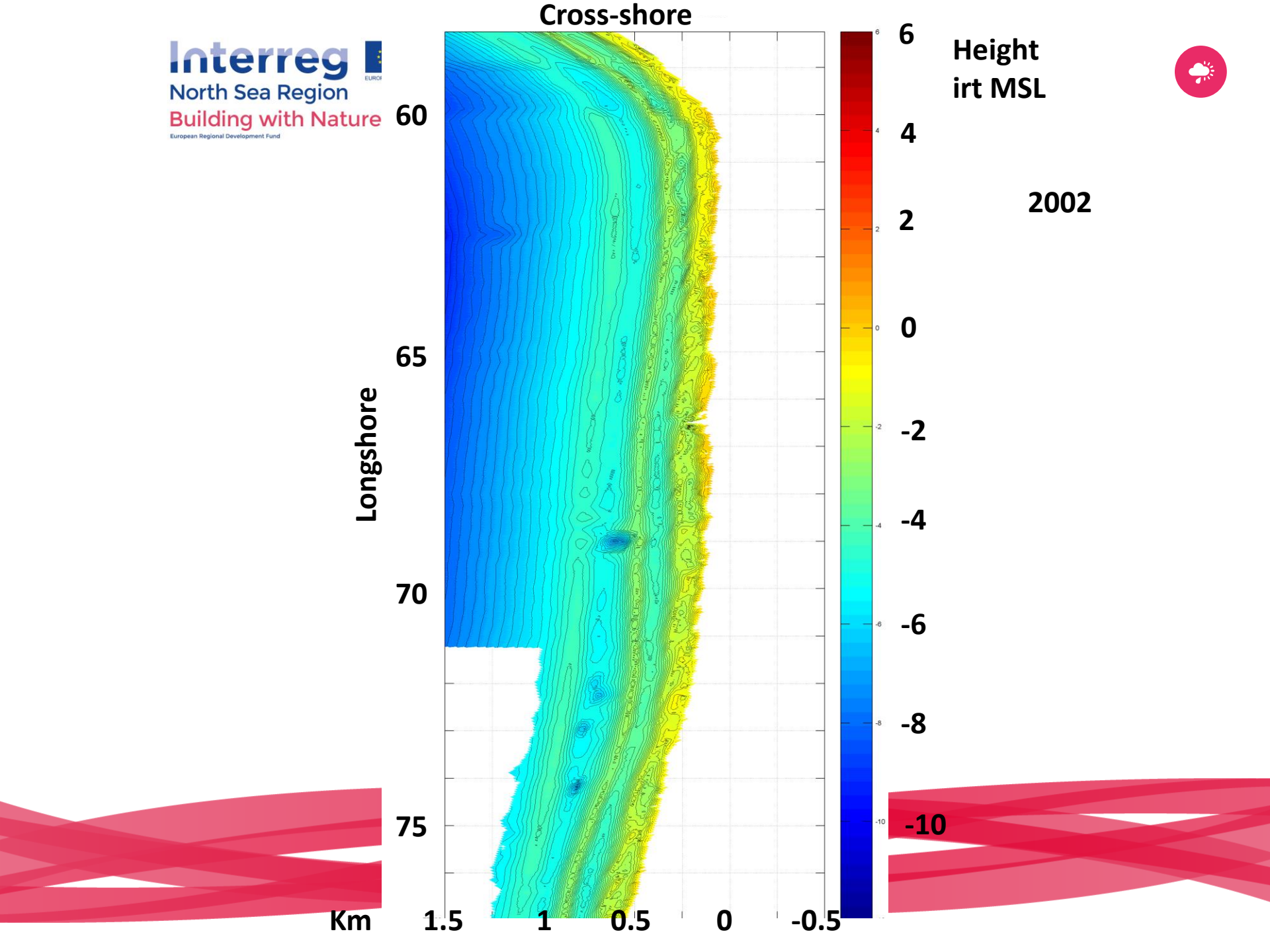

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1997

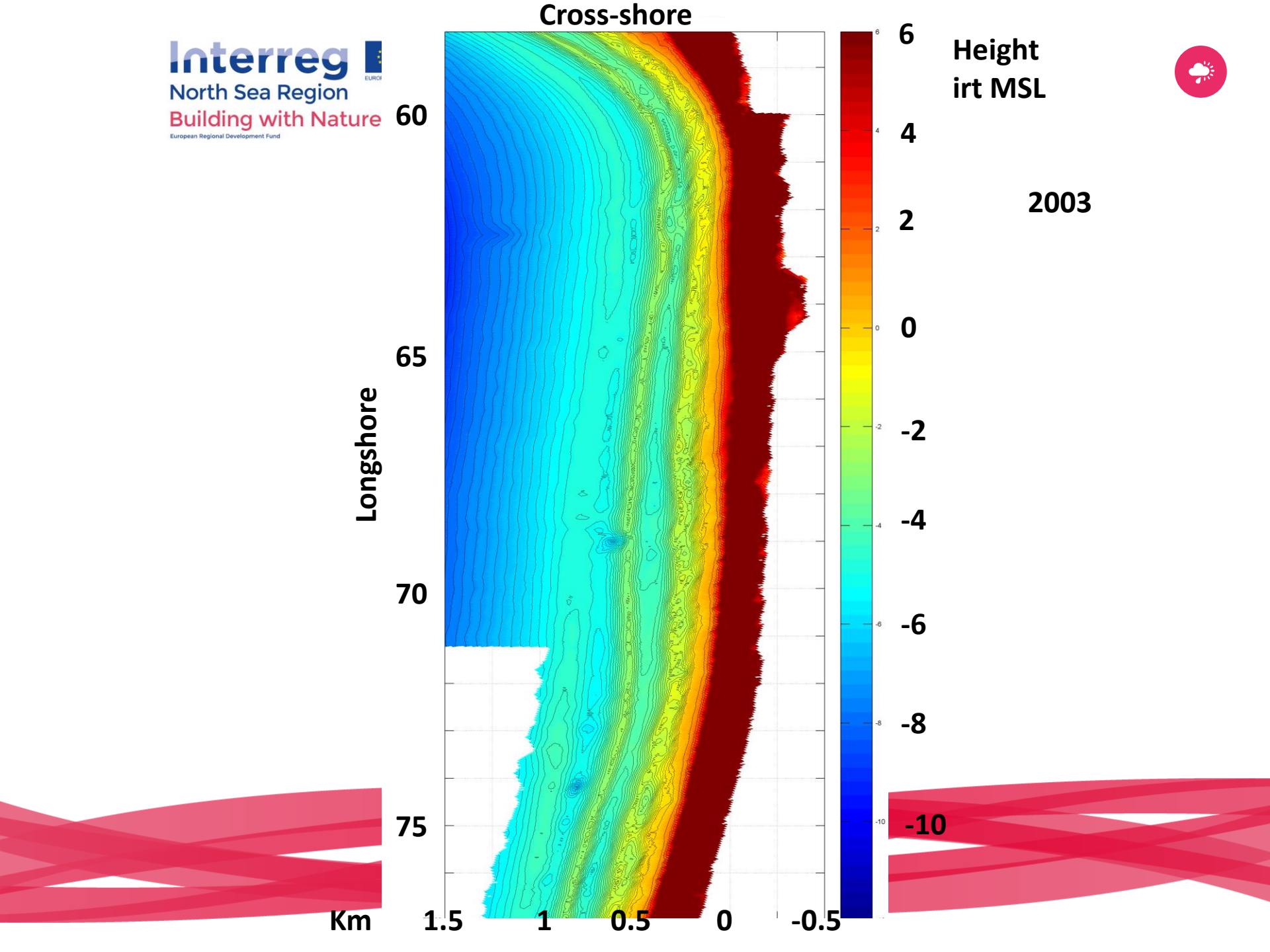

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1998

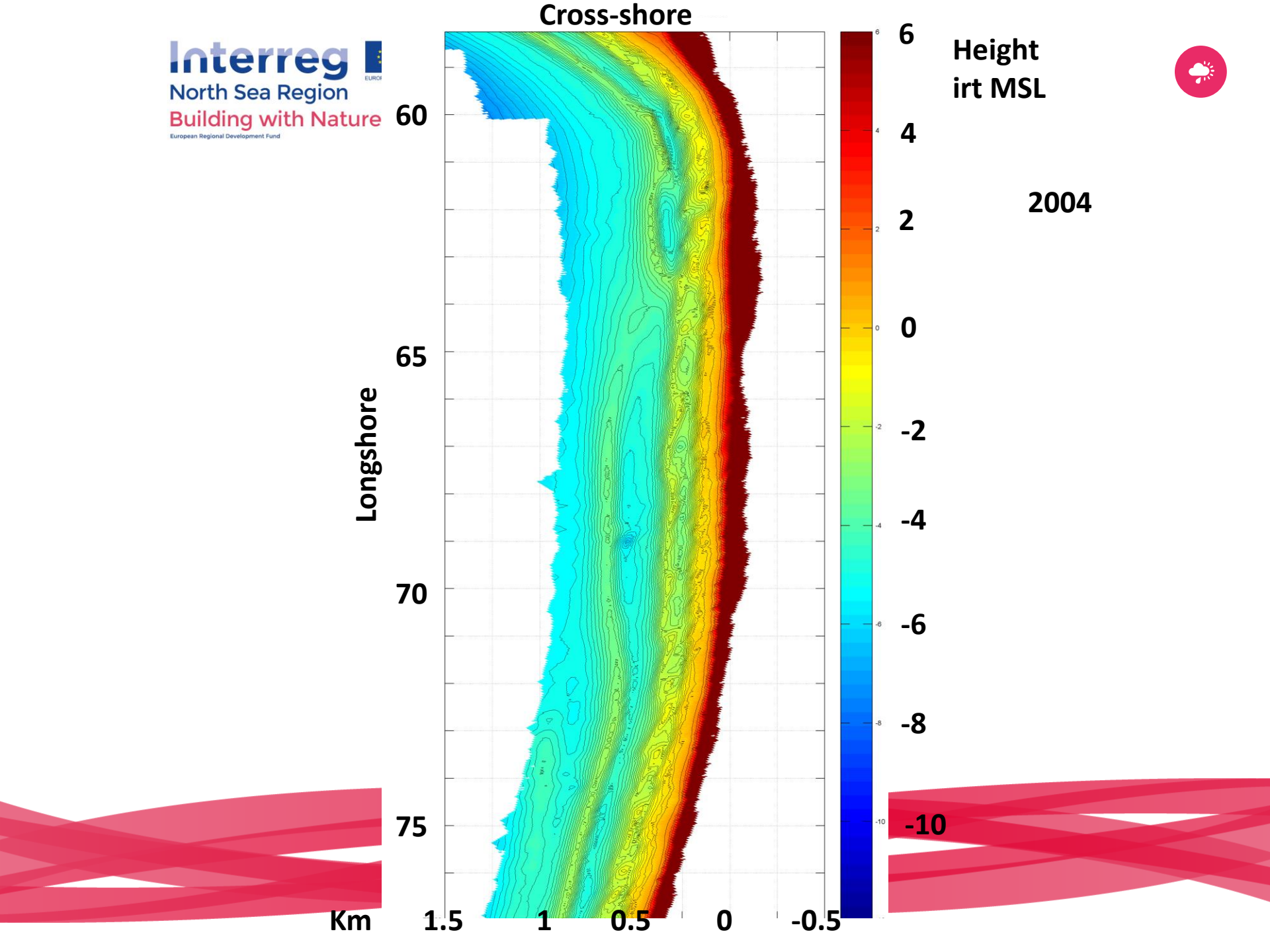

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
1999

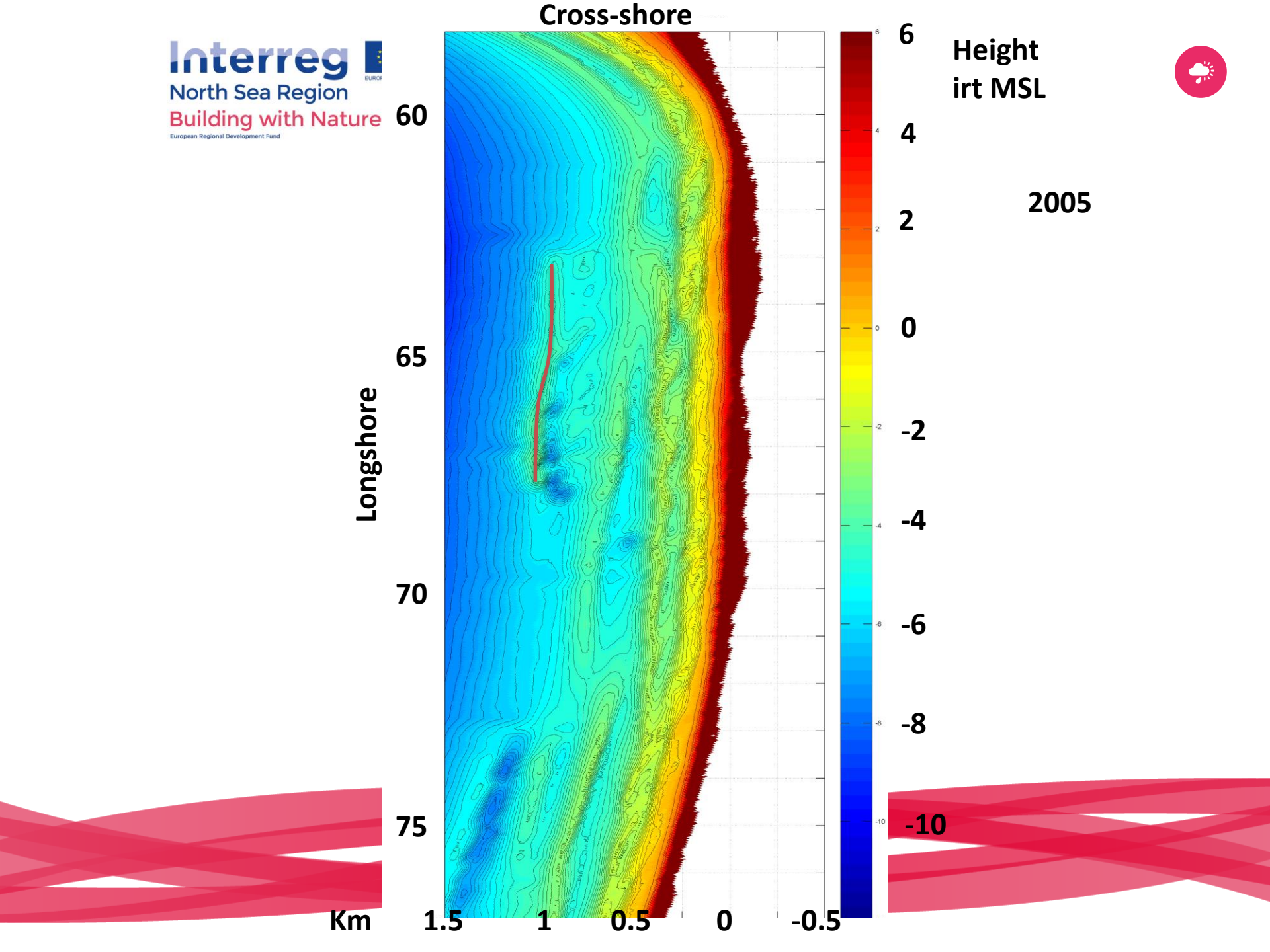

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2000

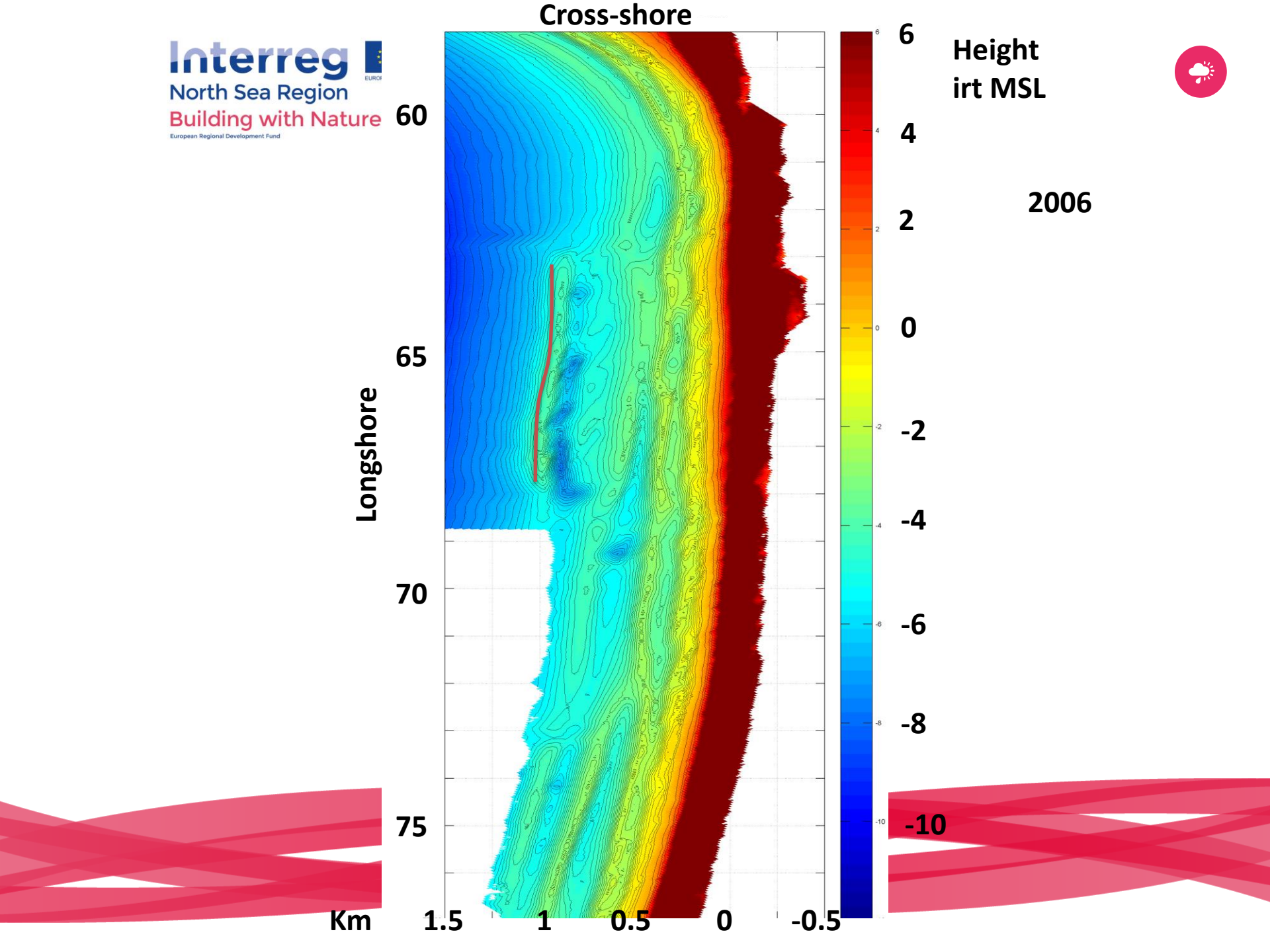

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2001

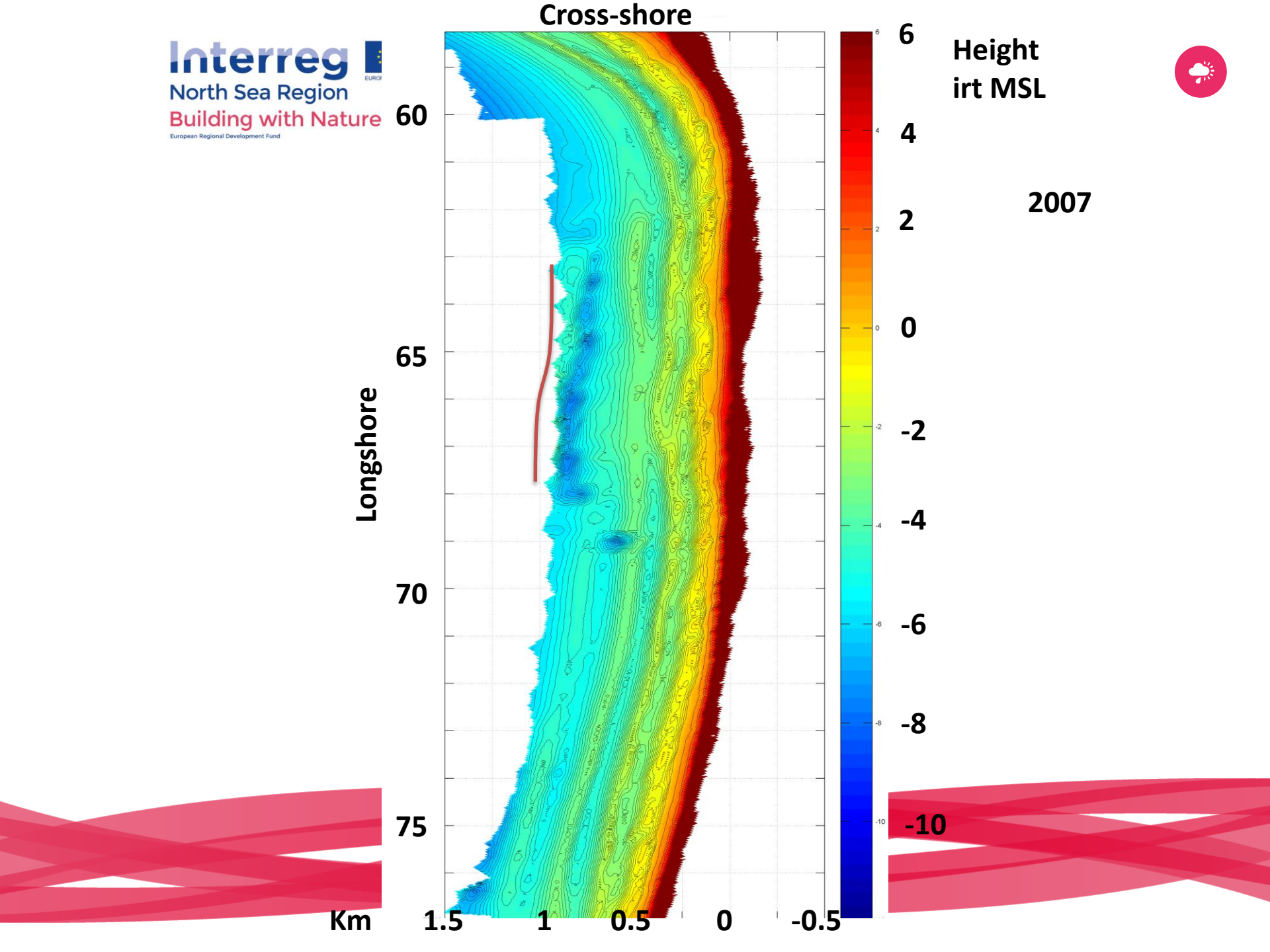

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2002

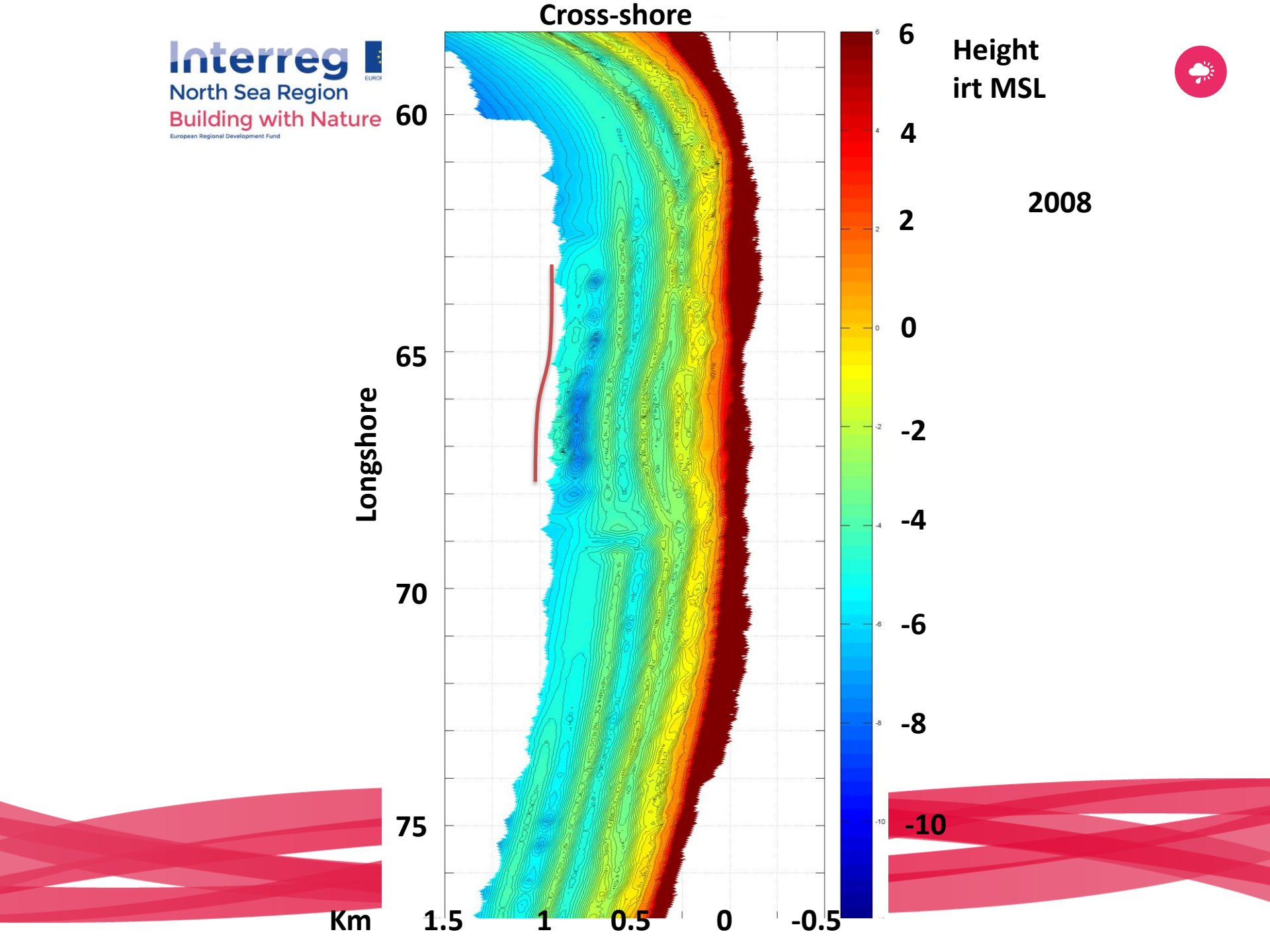

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2003

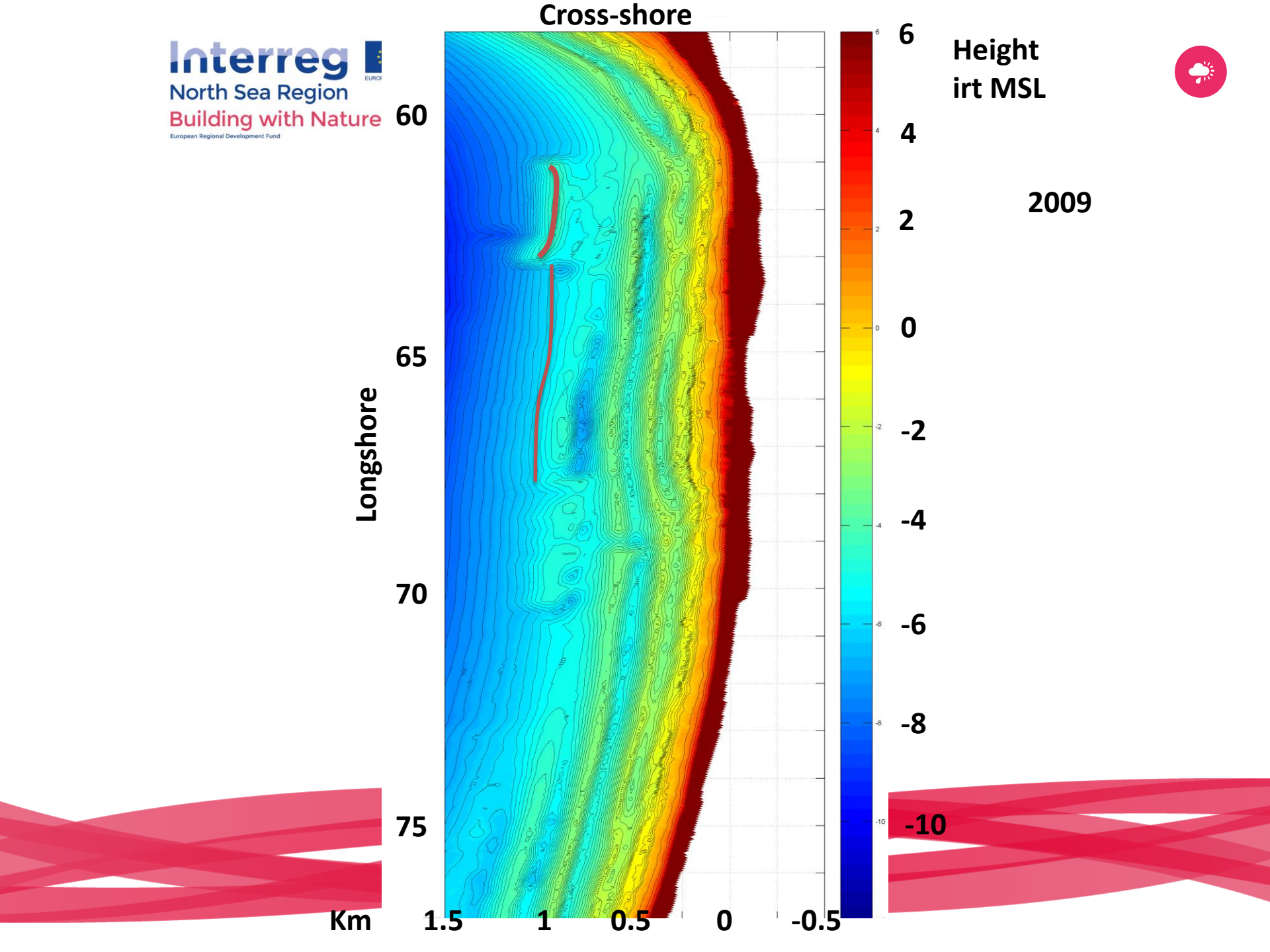

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2004

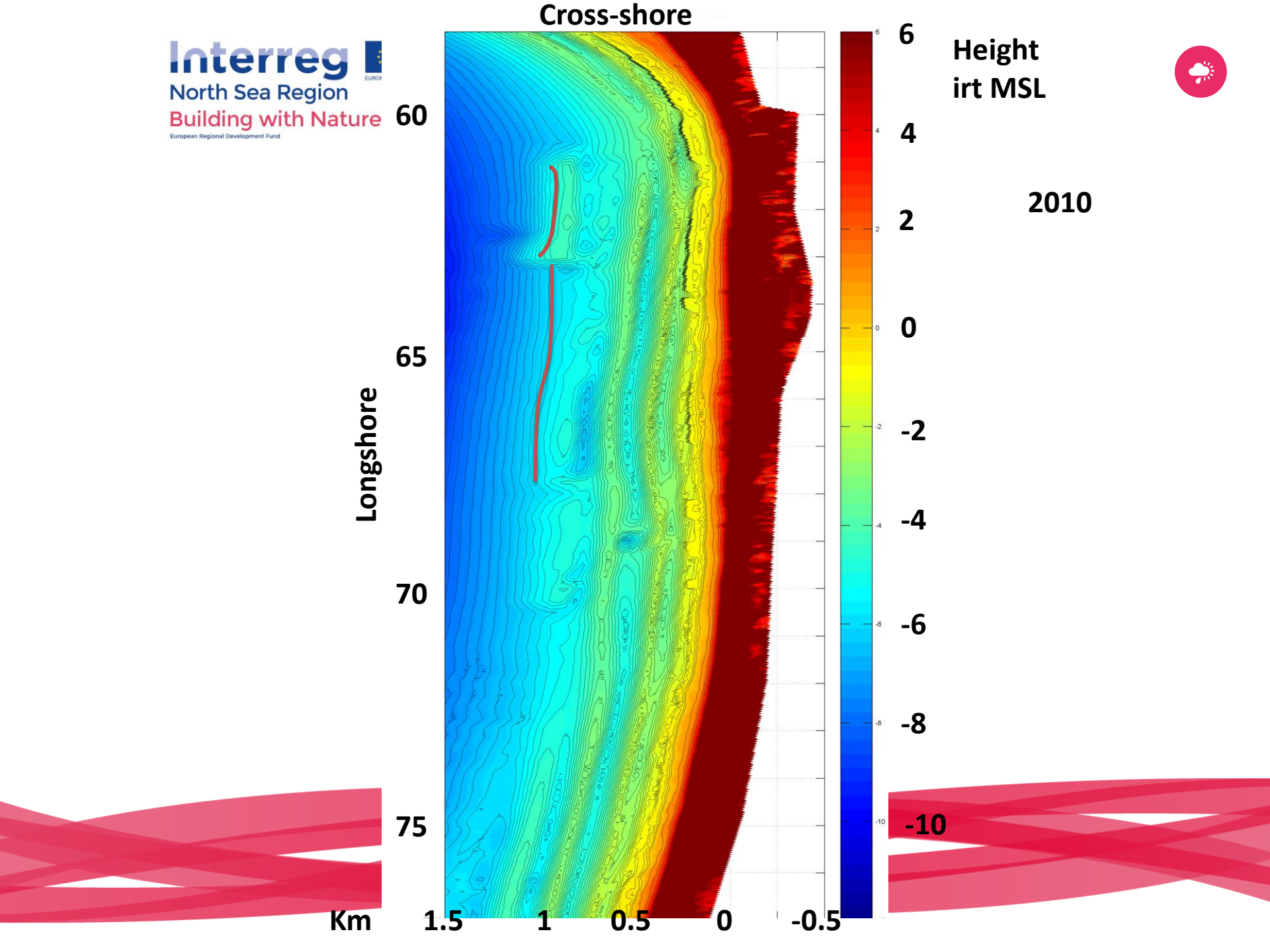

Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2005

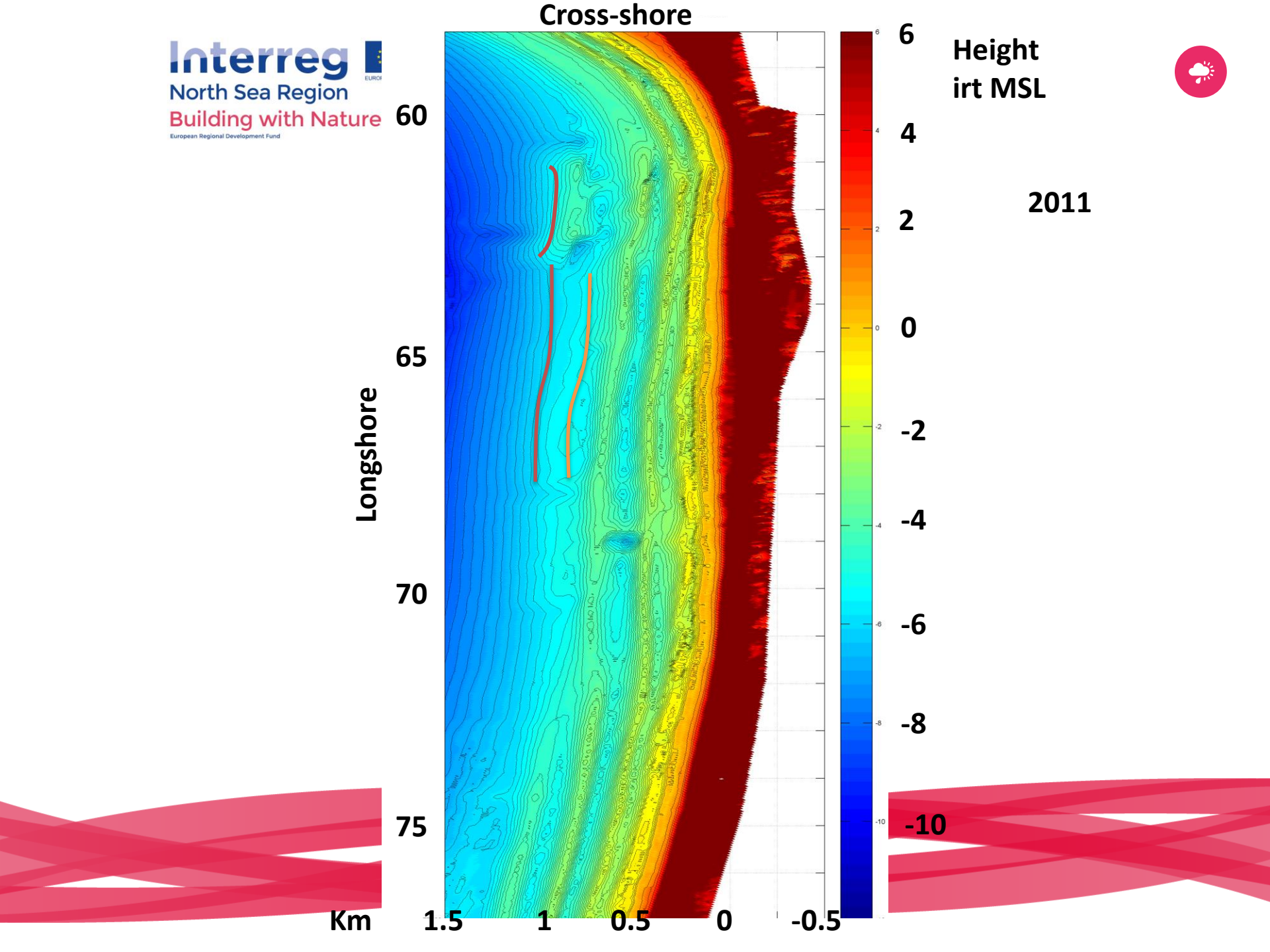

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2006

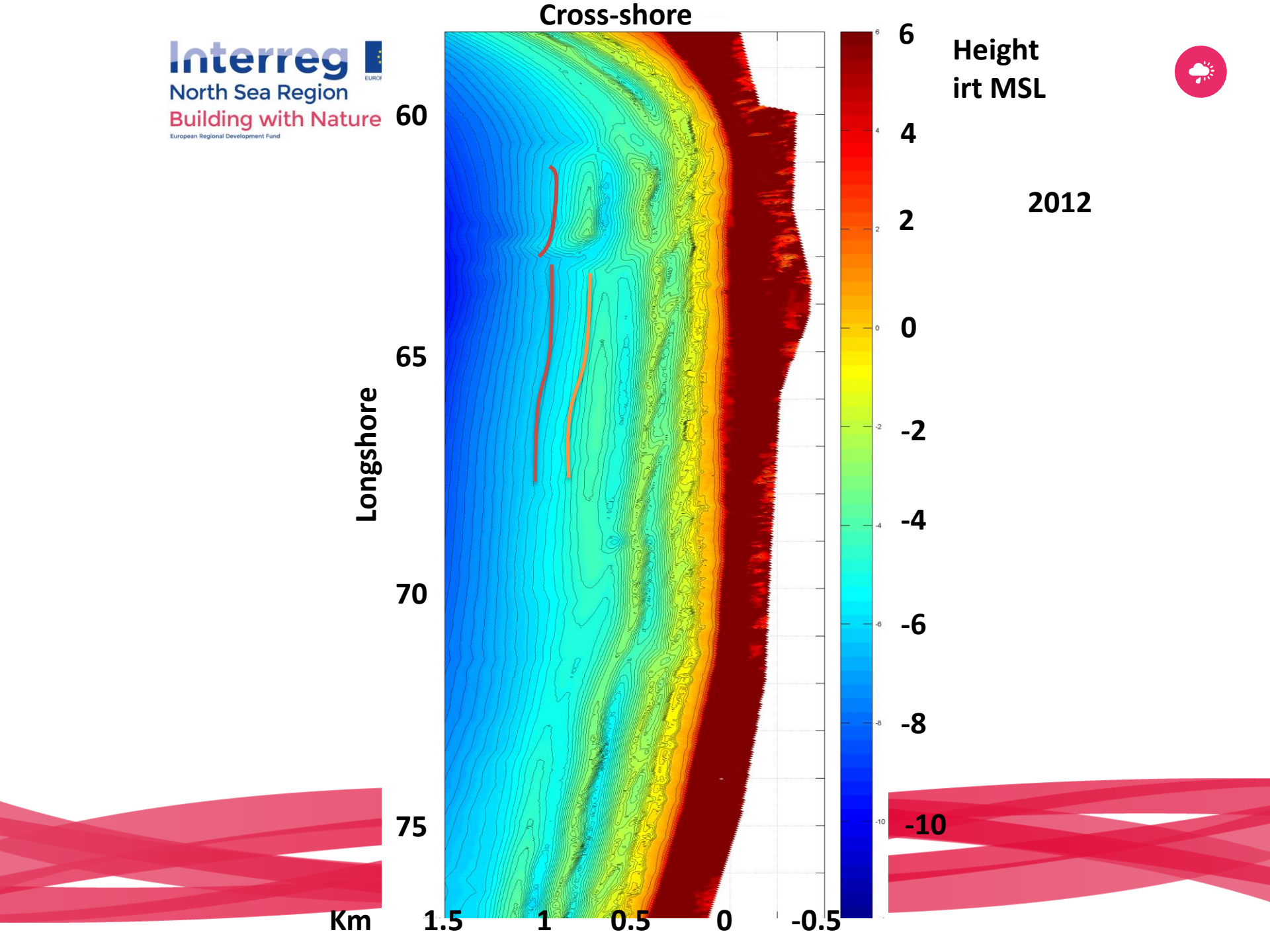

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2007

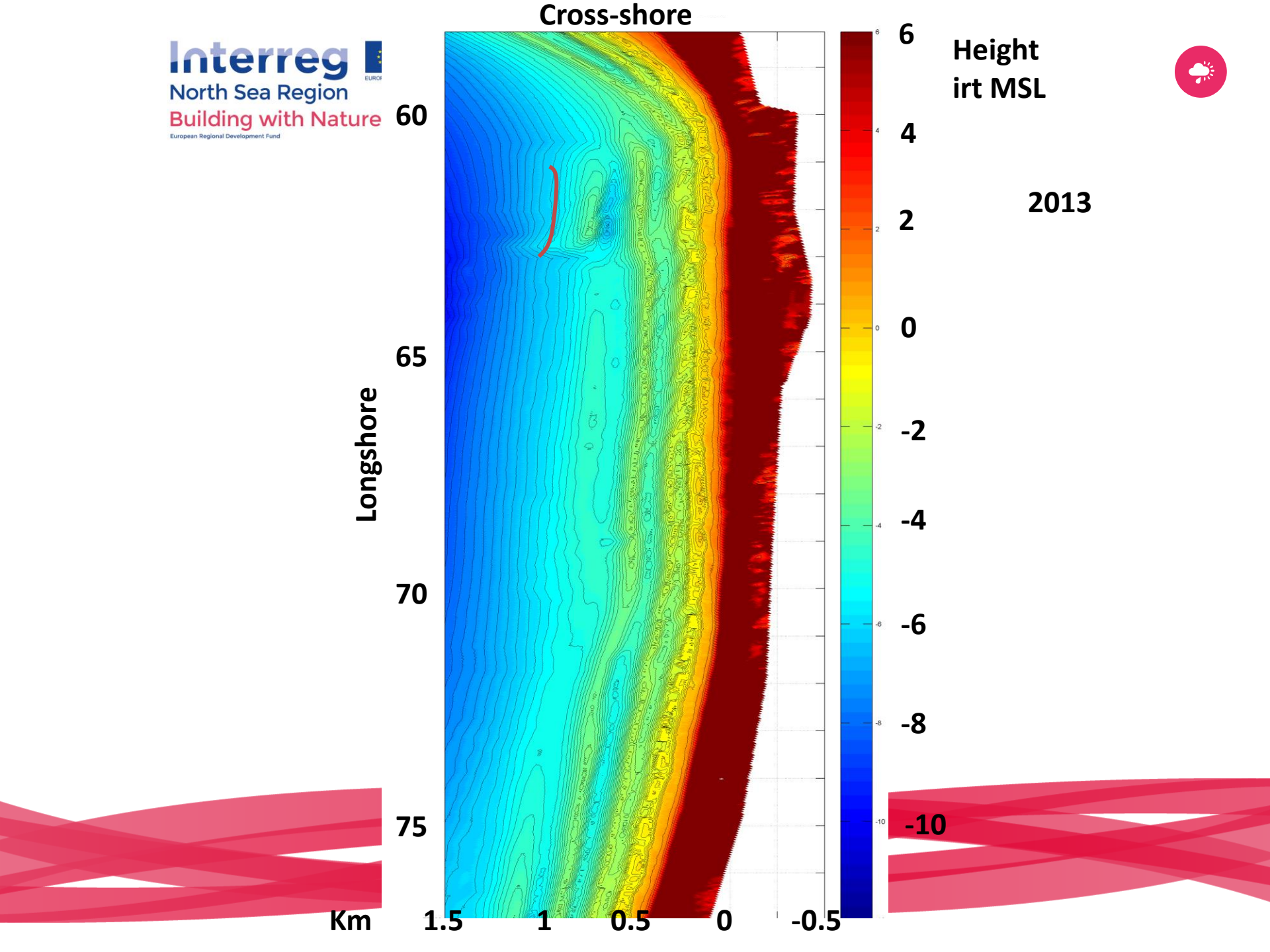

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2008

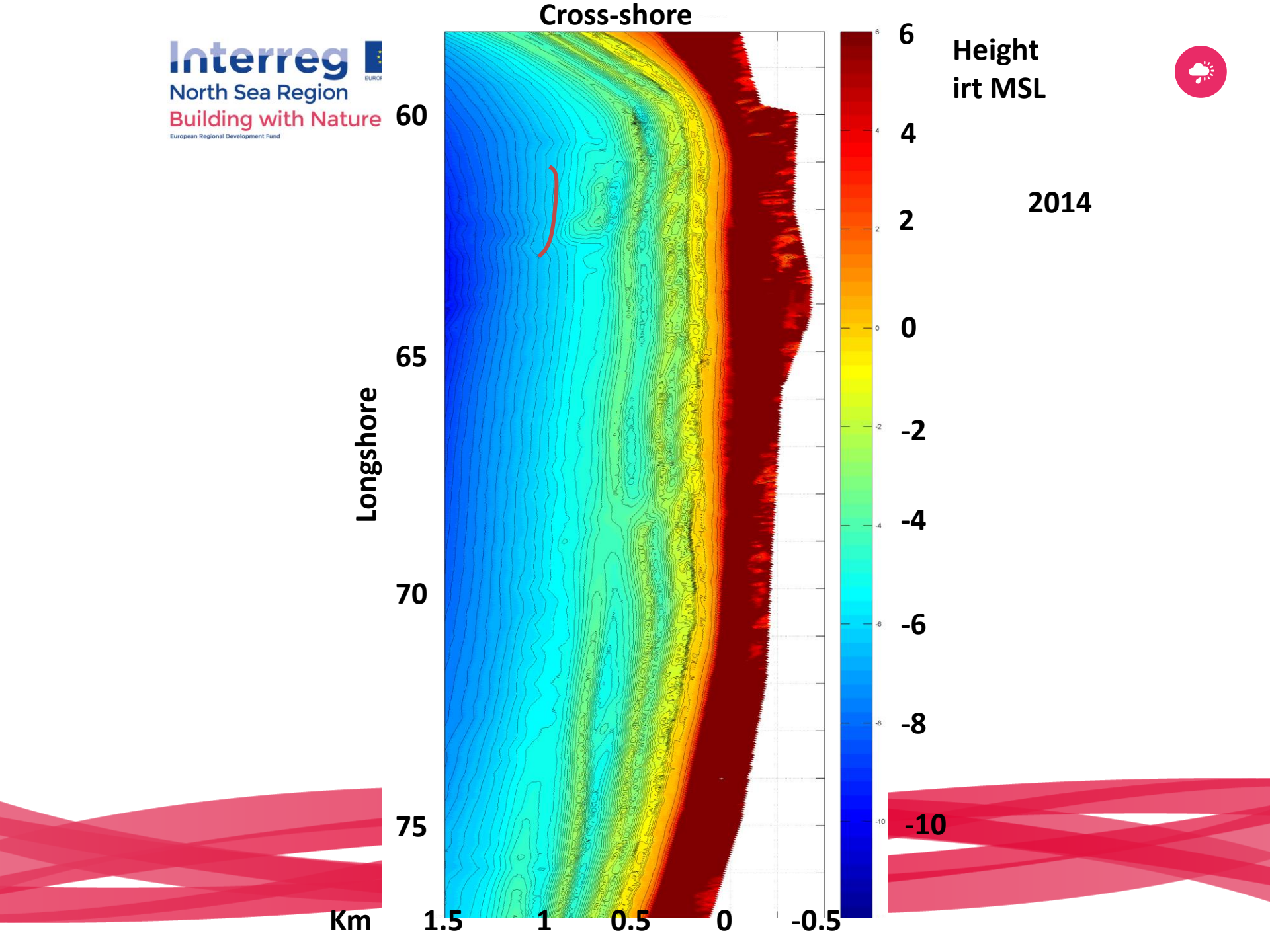

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2009

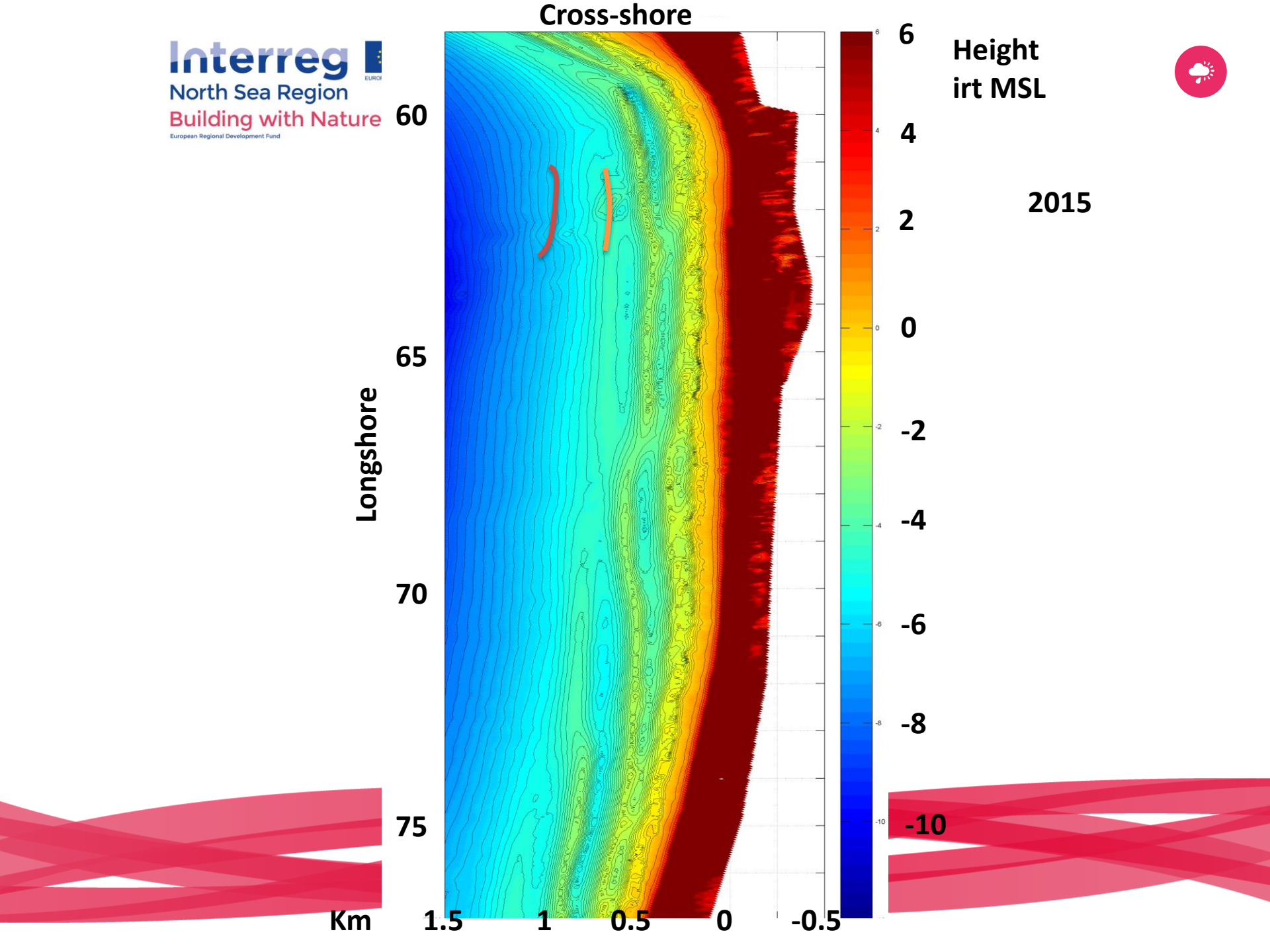

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2010

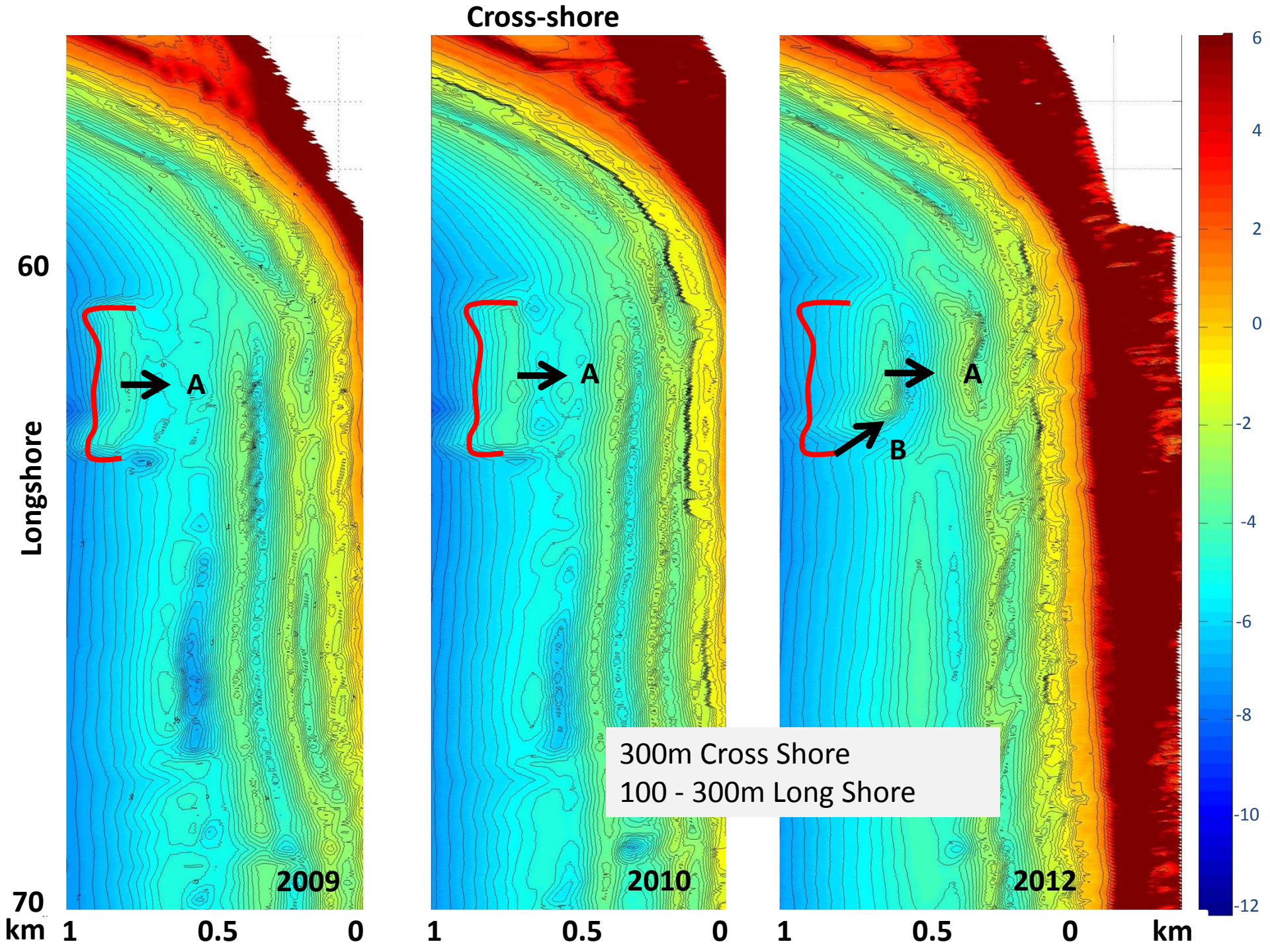

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2011

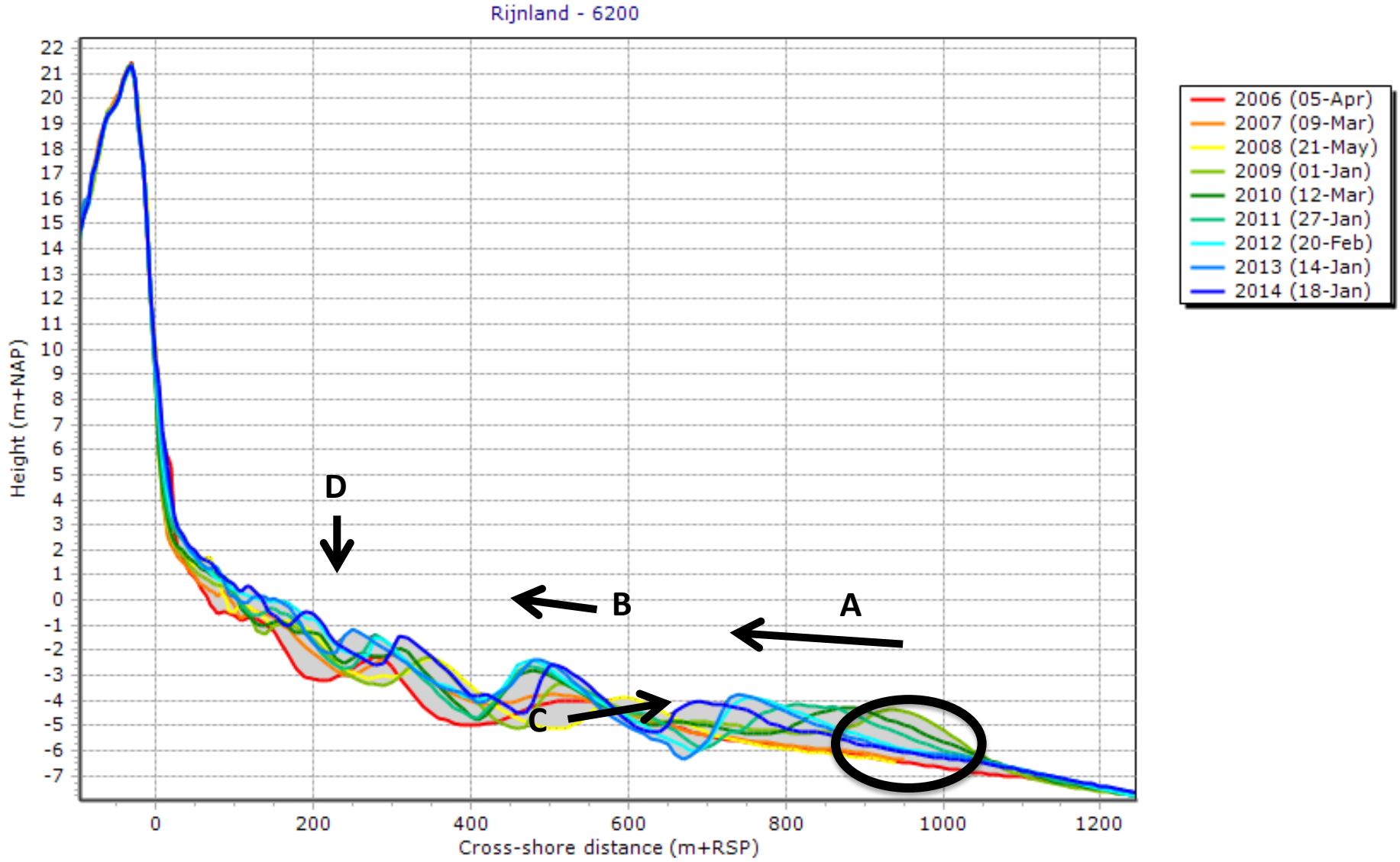

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2012

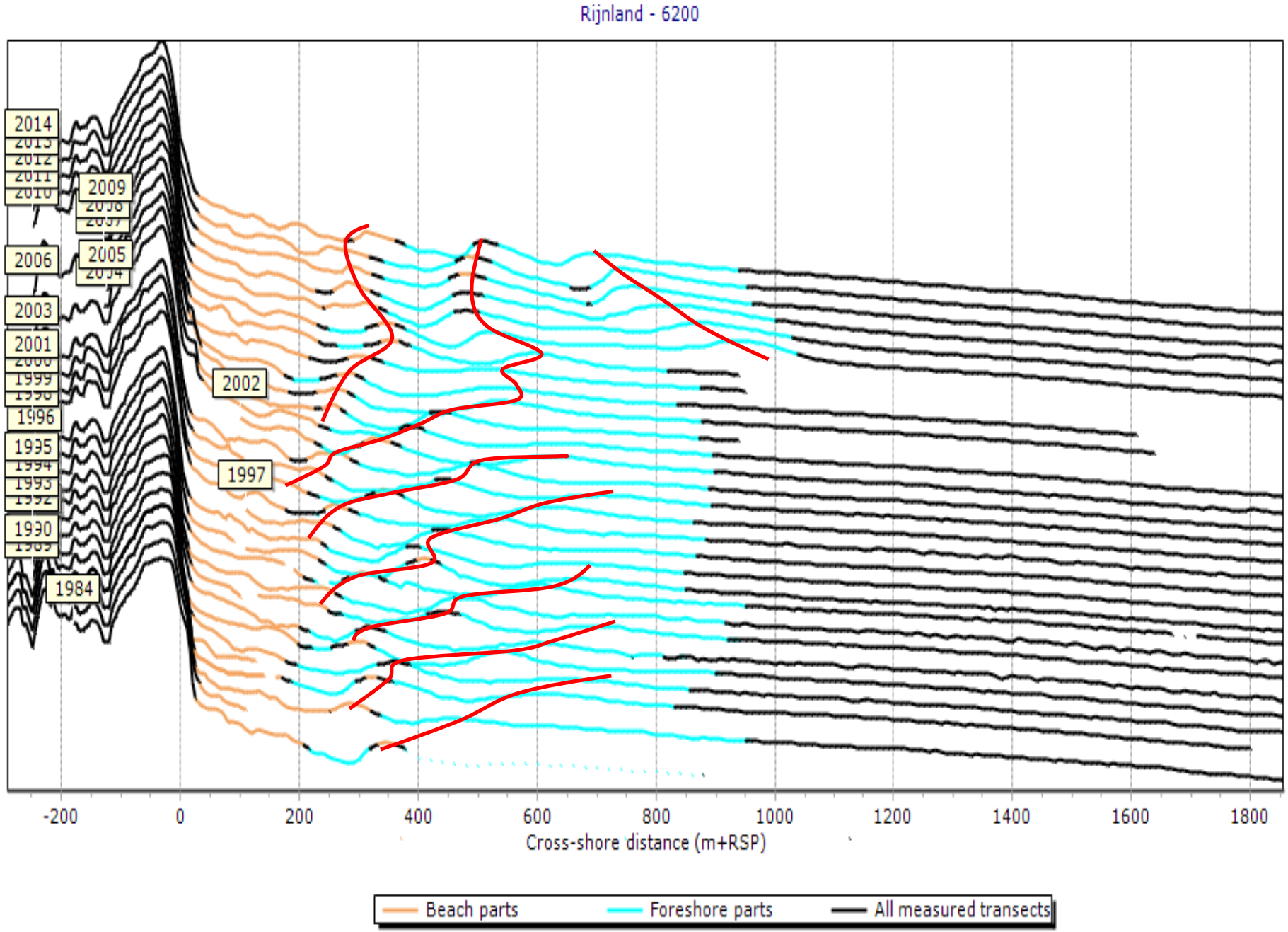

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
Height
irt MSL
6
4
2
0
-2
-4
-6
-8
-10
2013


Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
Height
irt MSL
6
4
2
0
-2
-4
-6
-8
-10
2014

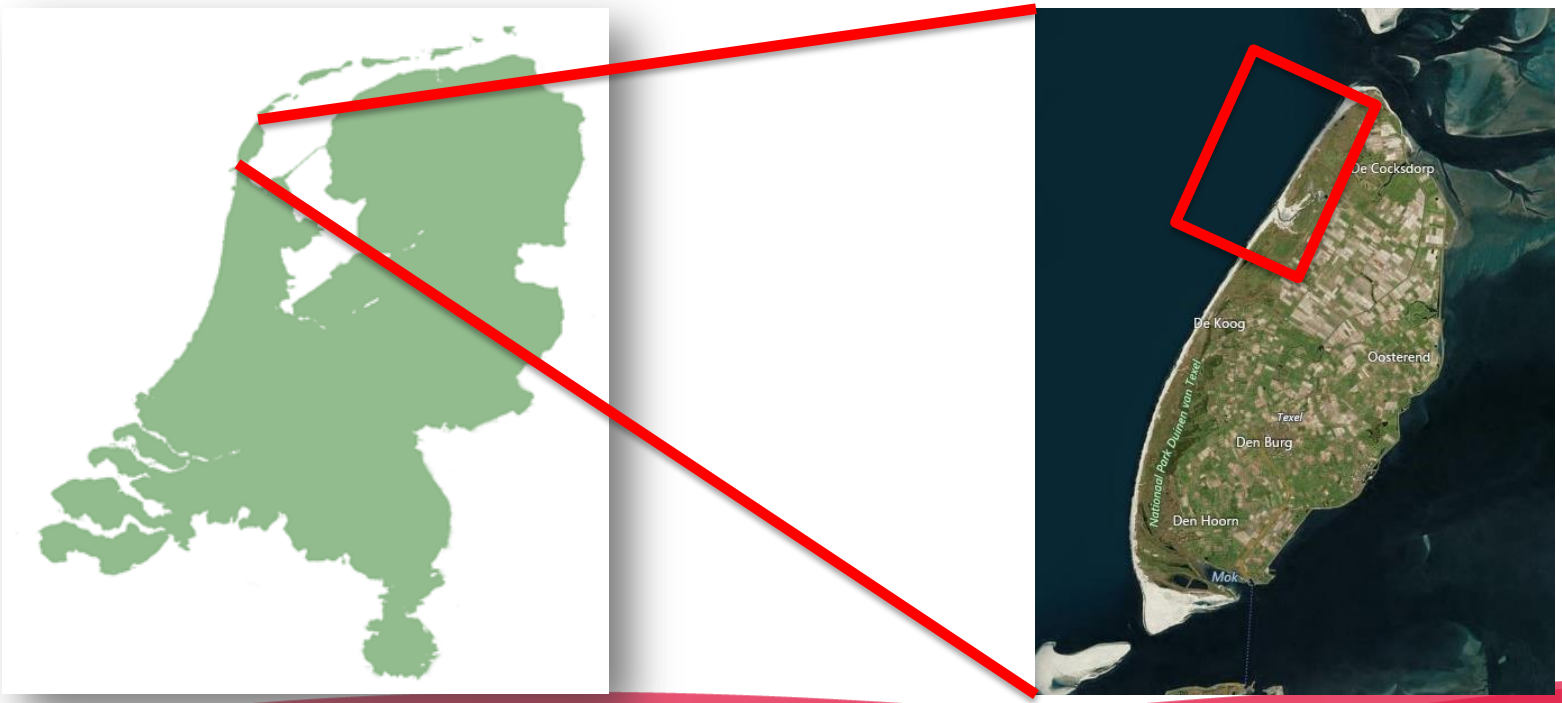

Interreg
North Sea Region
Building with Nature
European Regional Development Fund
Cross-shore
Longshore
60
65
70
75
Km
1.5
1
0.5
0
-0.5
6
4
2
0
-2
-4
-6
-8
-10
Height
irt MSL
2015


Cross-shore
60
Longshore
70
km
1
0.5
0
A
2009
2010
B
2012
300m Cross Shore
100 - 300m Long Shore
6
4
2
0
-2
-4
-6
-8
-10
-12

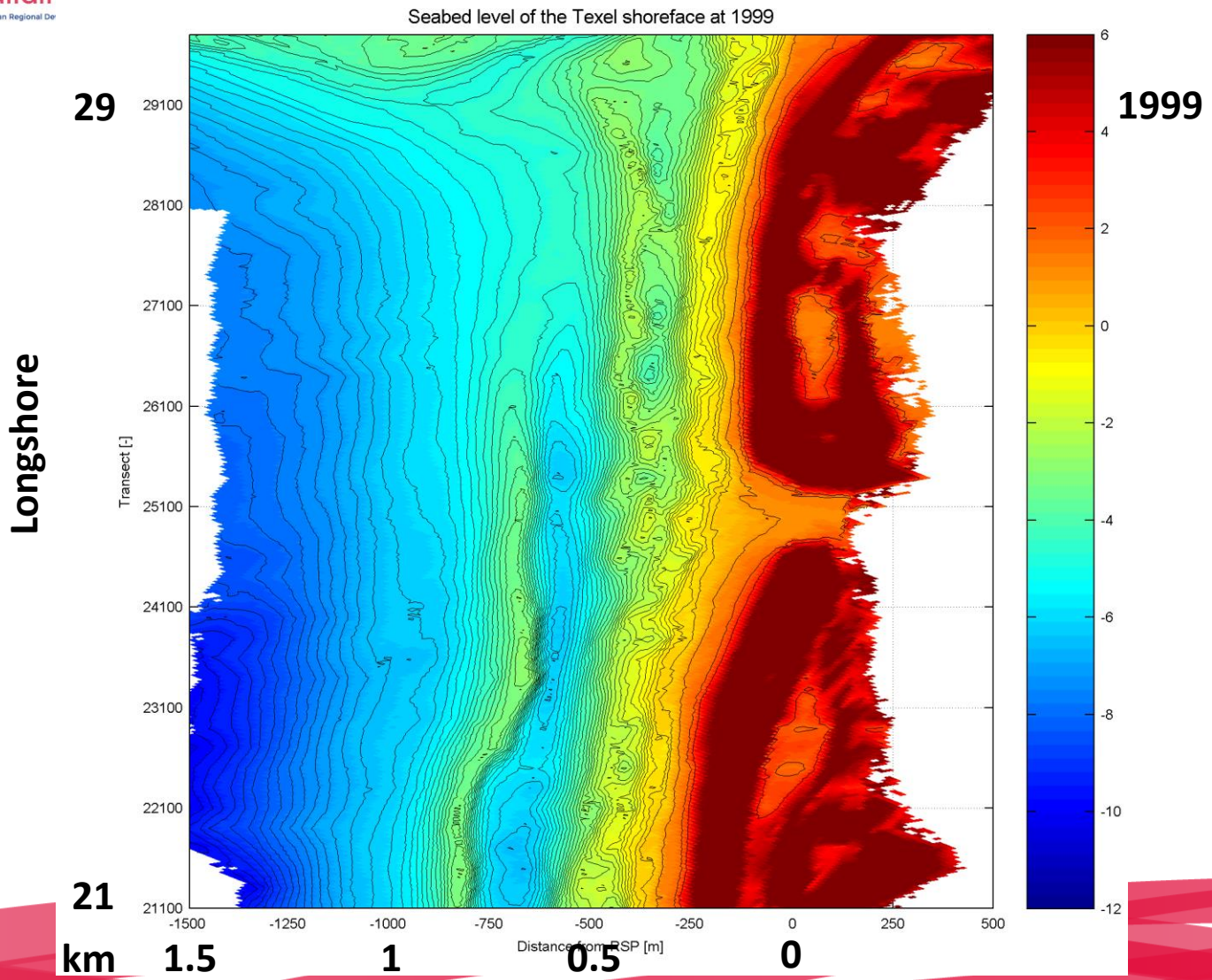

Rijnland - 6200
Height (m+NAP)
Cross-shore distance (m+RSP)
2006 (05-Apr)
2007 (09-Mar)
2008 (21-May)
2009 (01-Jan)
2010 (12-Mar)
2011 (27-Jan)
2012 (20-Feb)
2013 (14-Jan)
2014 (18-Jan)
A
B
C
D


Rijnland - 6200
2014
2009
2006
2005
2003
2001
2002
1997
1996
1995
1990
1984
-200
0
200
400
600
800
1000
1200
1400
1600
1800
Cross-shore distance (m+RSP)
Beach parts
Foreshore parts
All measured transects

Morphological behaviour, Eierland Texel, Netherlands

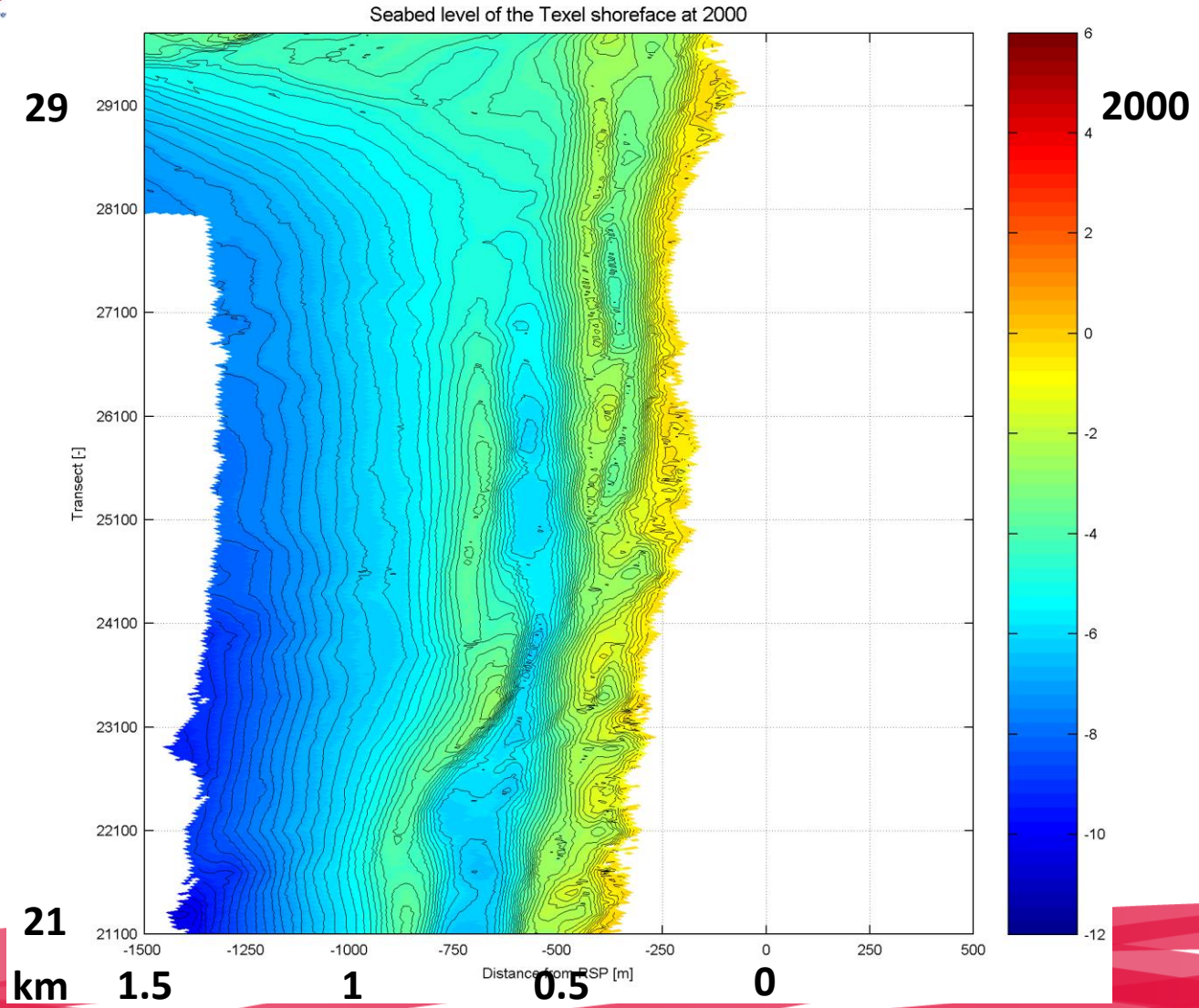


Cross-shore


Seabed level of the Texel shoreface at 1999
29
Longshore
21
1999
km
1.5
1
0.5
0
Transect [-]
Distance from RSP [m]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
6
4
2
0
-2
-4
-6
-8
-10
-12

Interreg North Sea Region Buildir

Cross-shore



29

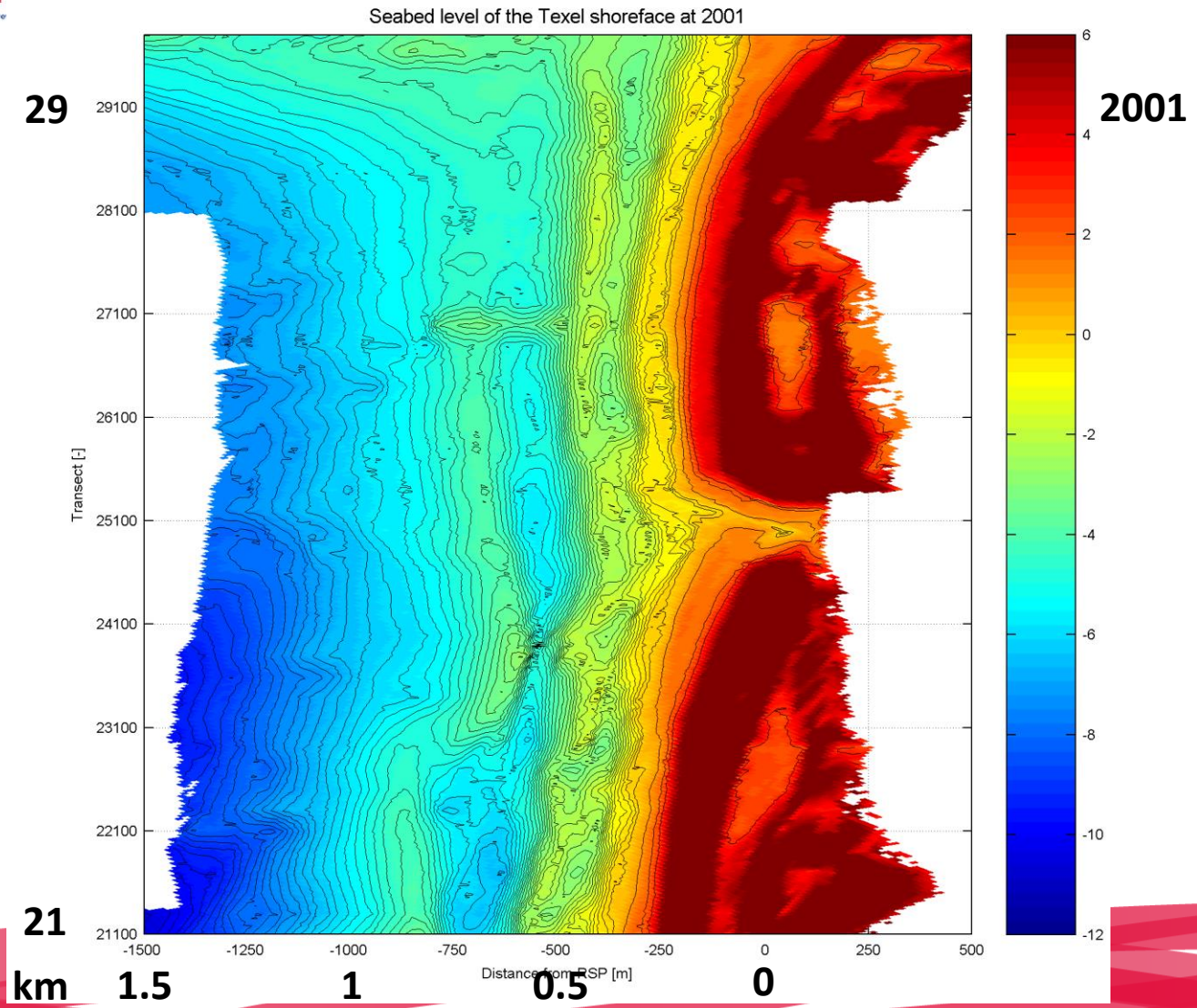
21

Longshore

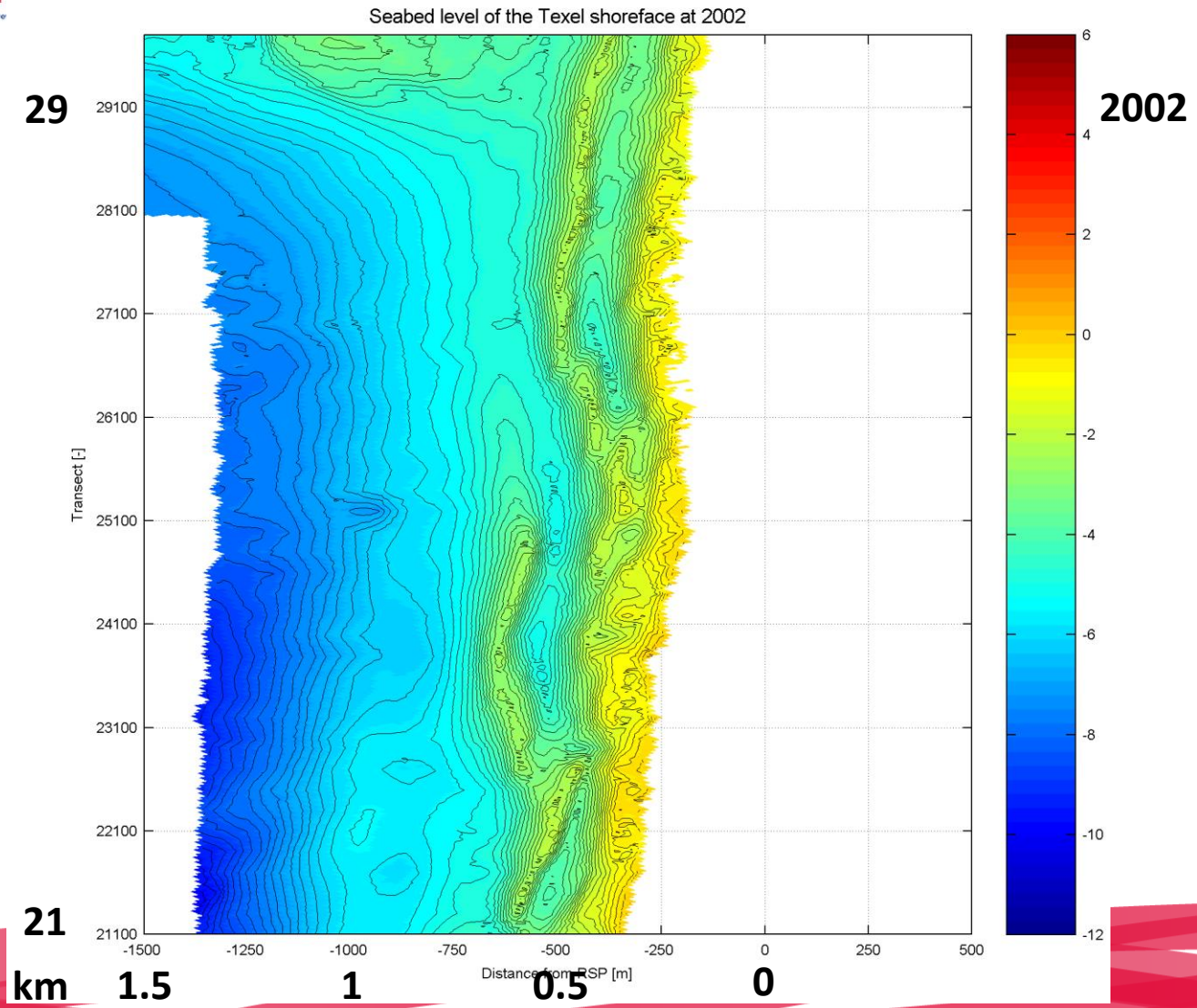
2000

km 1.5 1 0.5 0

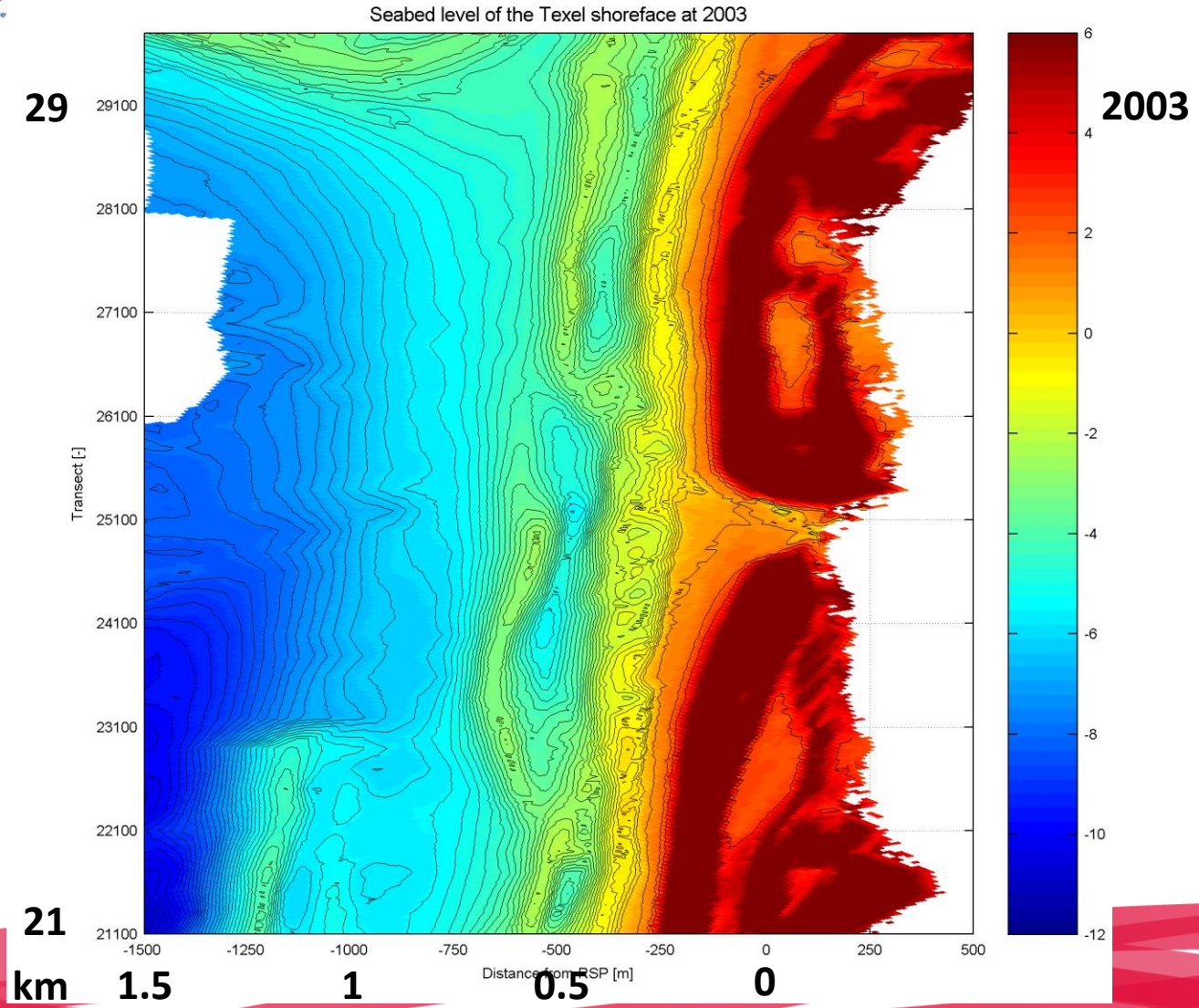
Cross-shore


Seabed level of the Texel shoreface at 2001
29
2001
Longshore
21
km
1.5
1
0.5
0
Transect [-]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
Distance from RSP [m]
6
4
2
0
-2
-4
-6
-8
-10
-12

Cross-shore

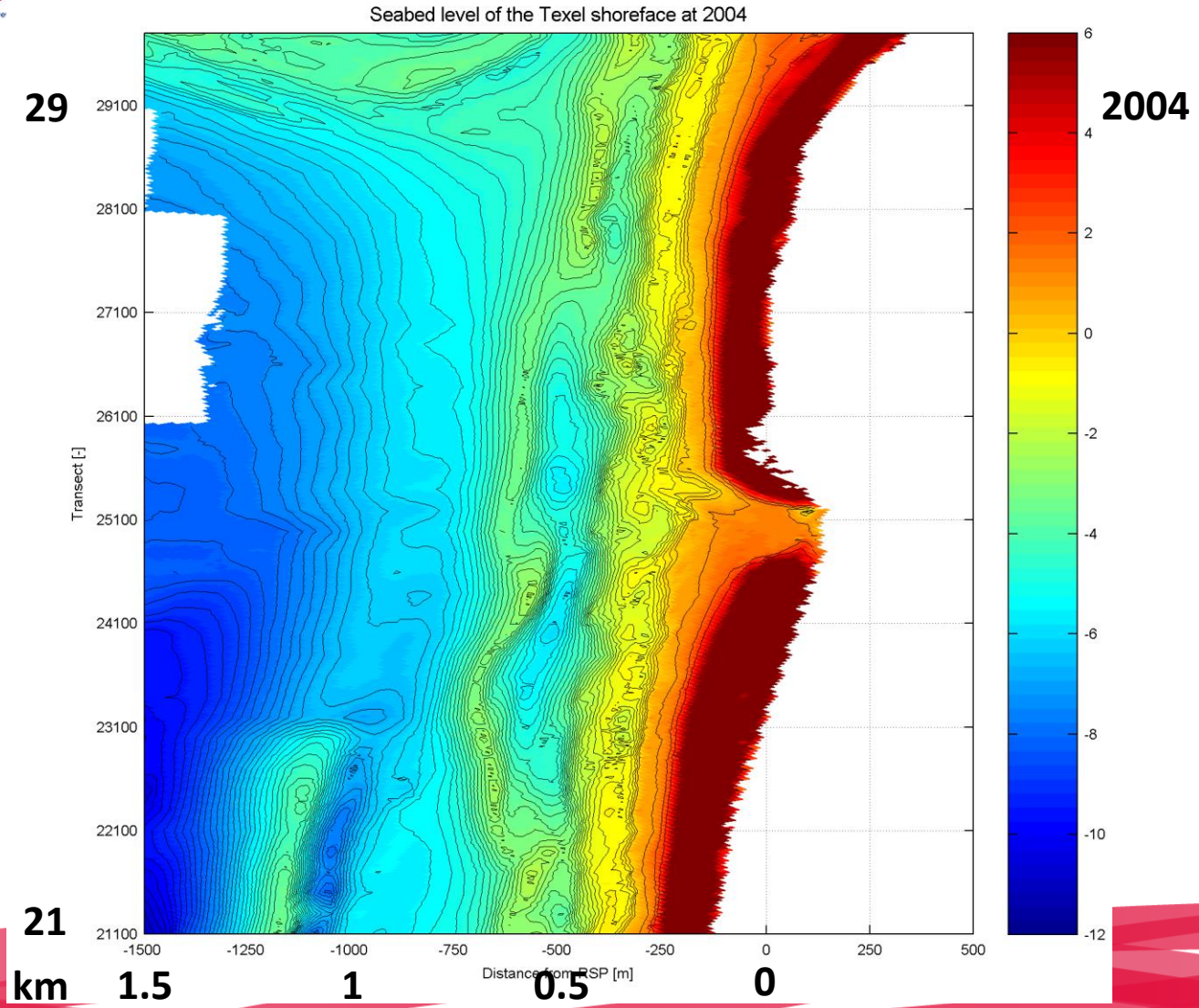

Seabed level of the Texel shoreface at 2002
29
Longshore
21
km
1.5
1
0.5
0
2002
Transect [-]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
Distance from RSP [m]
6
4
2
0
-2
-4
-6
-8
-10
-12

Cross-shore


Seabed level of the Texel shoreface at 2003
29
2003
Longshore
21
km
1.5
1
0.5
0
Transect [-]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
Distance from RSP [m]
6
4
2
0
-2
-4
-6
-8
-10
-12

Interreg North Sea Region Buildir

Cross-shore



29

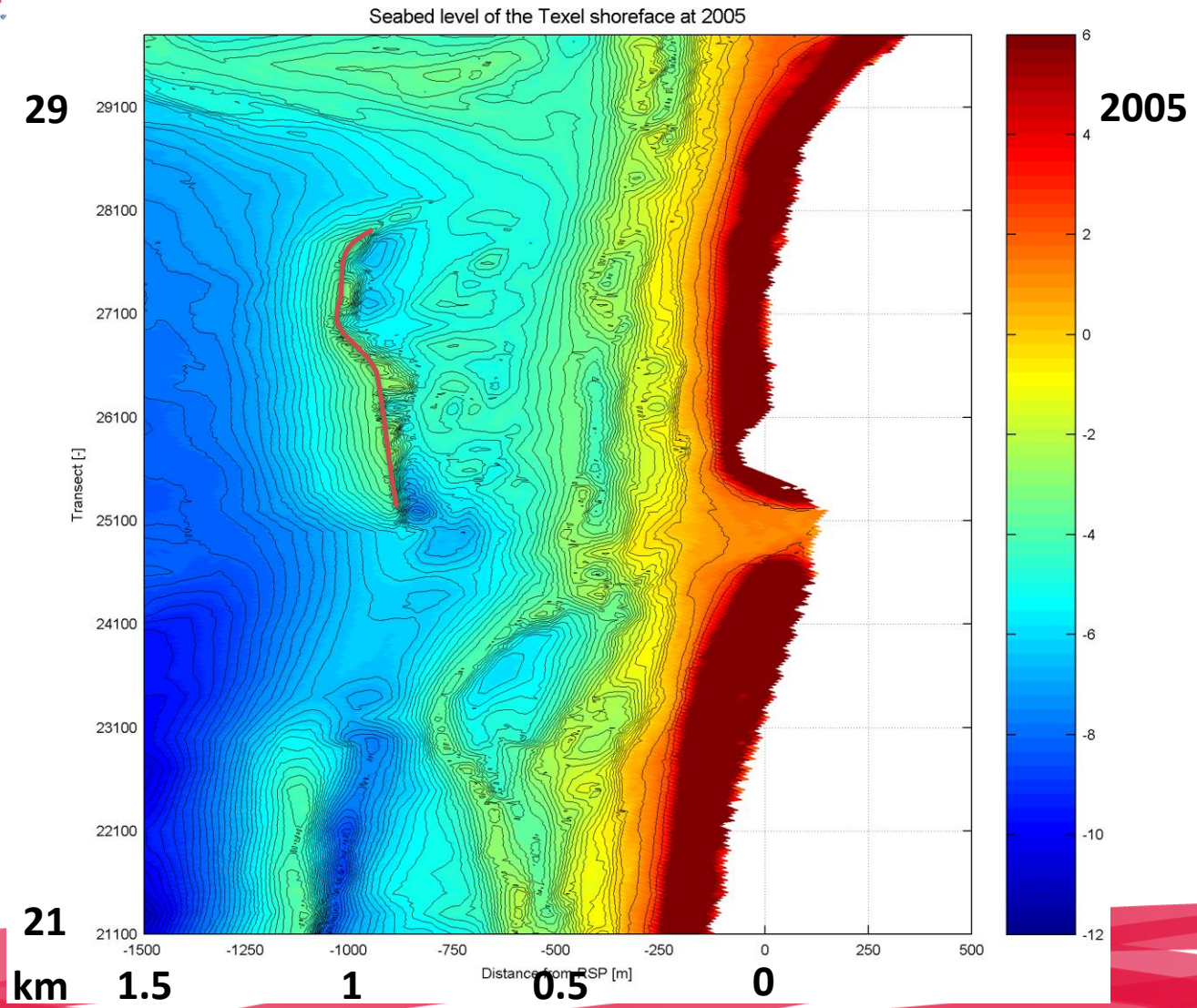
21

Longshore

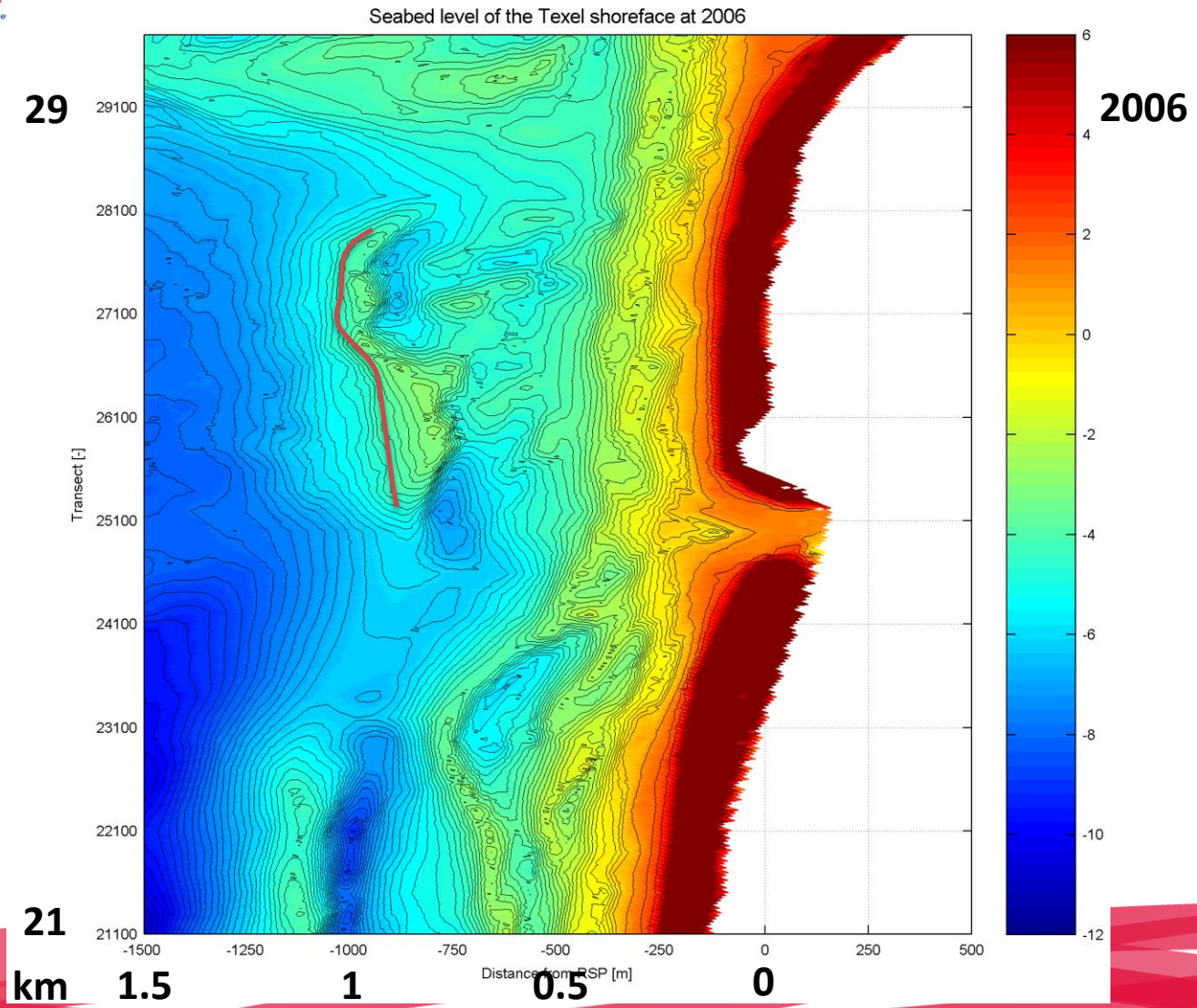
2004

km 1.5 1 0.5 0

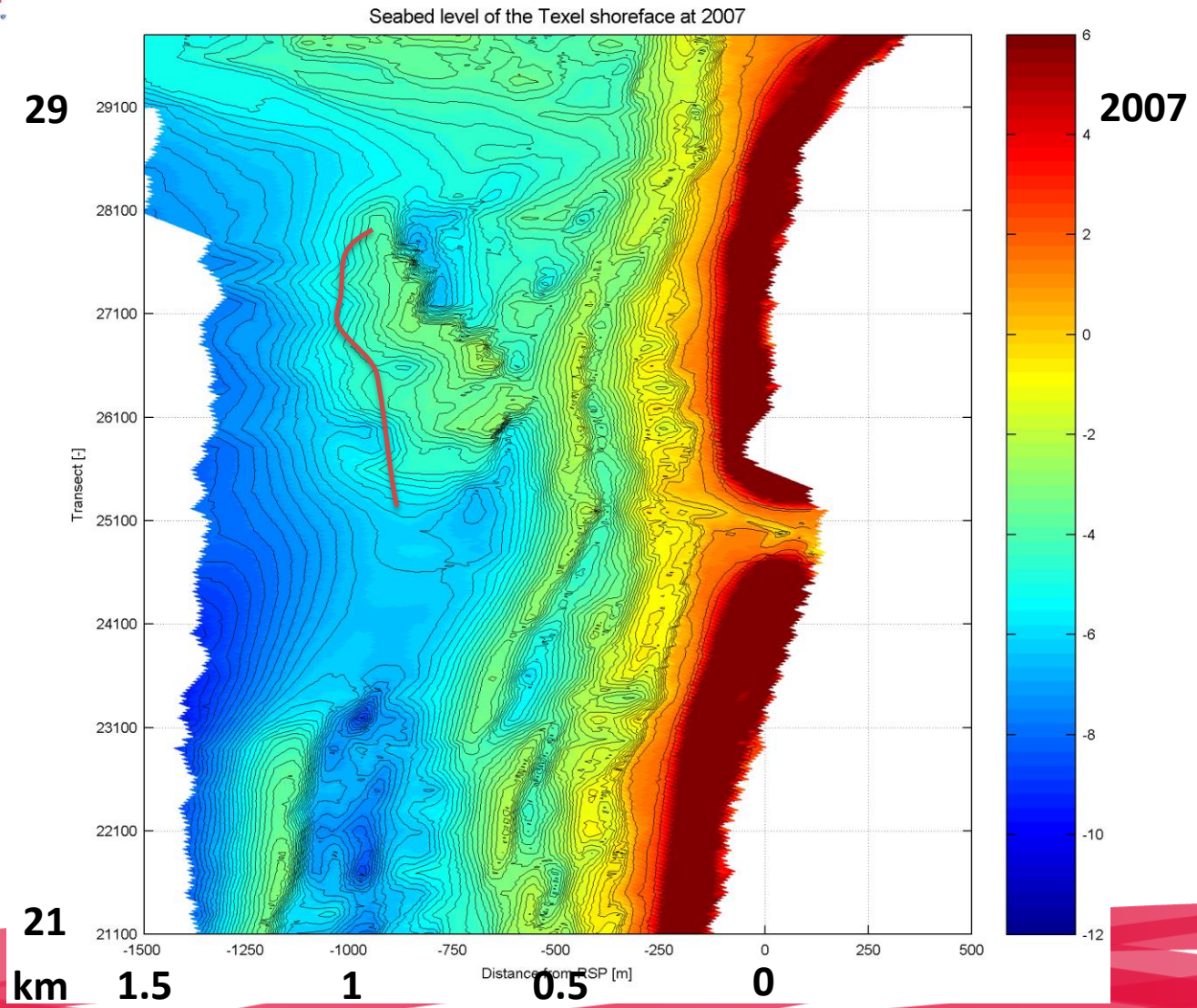
Cross-shore


Seabed level of the Texel shoreface at 2005
29
2005
Longshore
21
km
1.5
1
0.5
0
Transect [-]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
Distance from RSP [m]
6
4
2
0
-2
-4
-6
-8
-10
-12

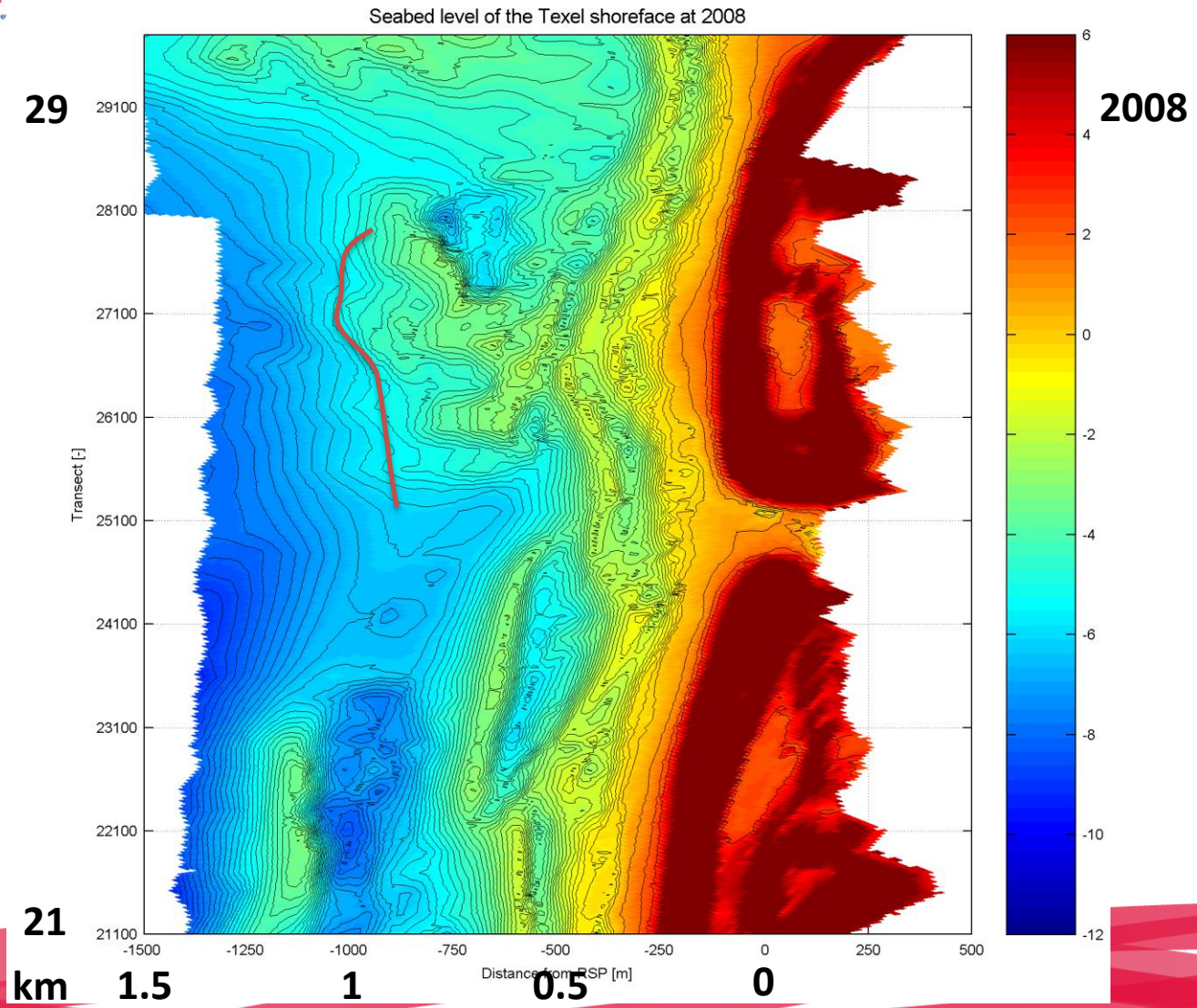
Cross-shore


Seabed level of the Texel shoreface at 2006
29
2006
Longshore
Transect [-]
29100
28100
27100
26100
25100
24100
23100
22100
21100
21
-1500
-1250
-1000
-750
-500
-250
0
250
500
Distance from RSP [m]
6
4
2
0
-2
-4
-6
-8
-10
-12
km
1.5
1
0.5
0

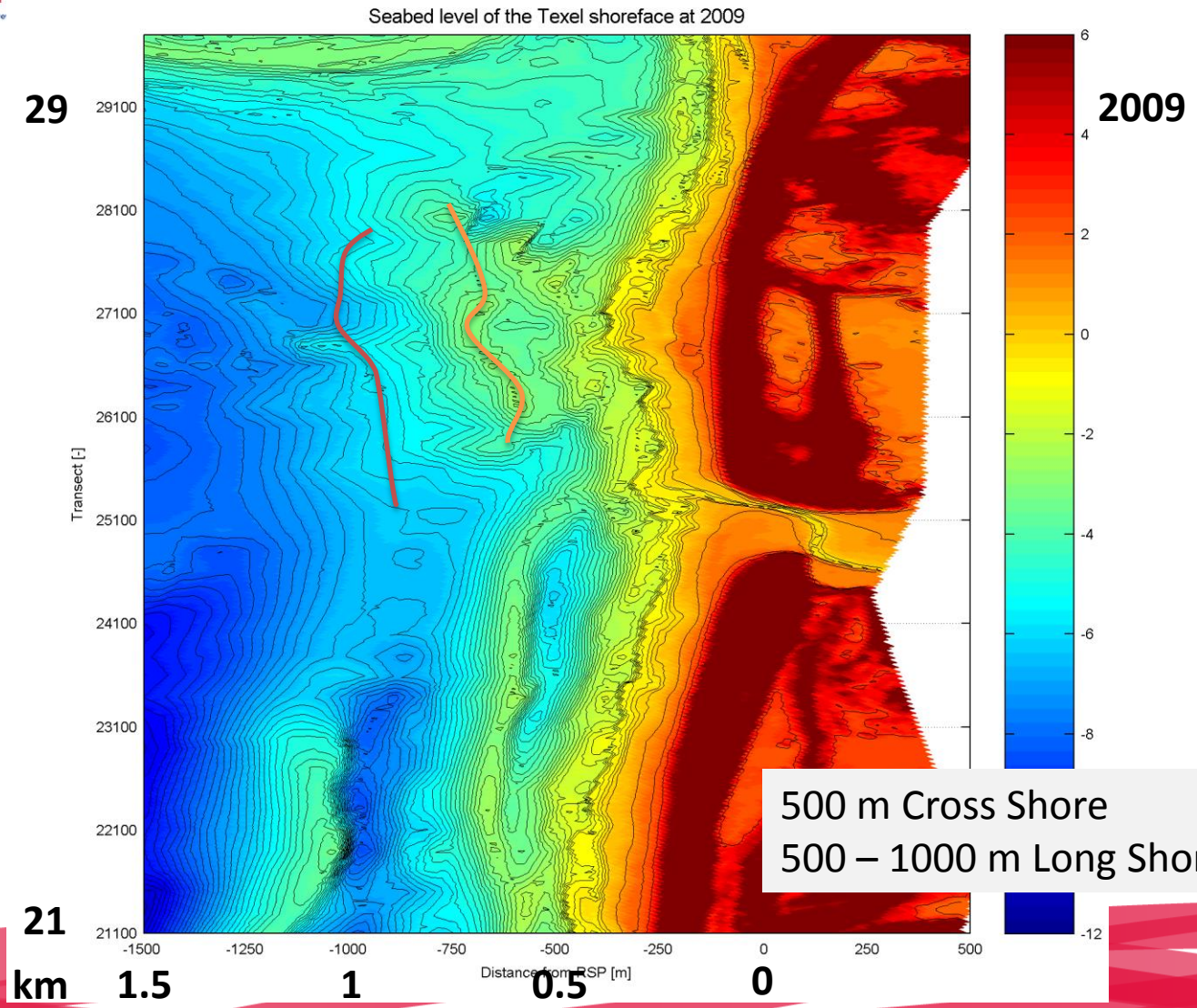
Cross-shore


Seabed level of the Texel shoreface at 2007
29
2007
Longshore
21
km
1.5
1
0.5
0
Transect [-]
Distance from RSP [m]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
6
4
2
0
-2
-4
-6
-8
-10
-12

Cross-shore

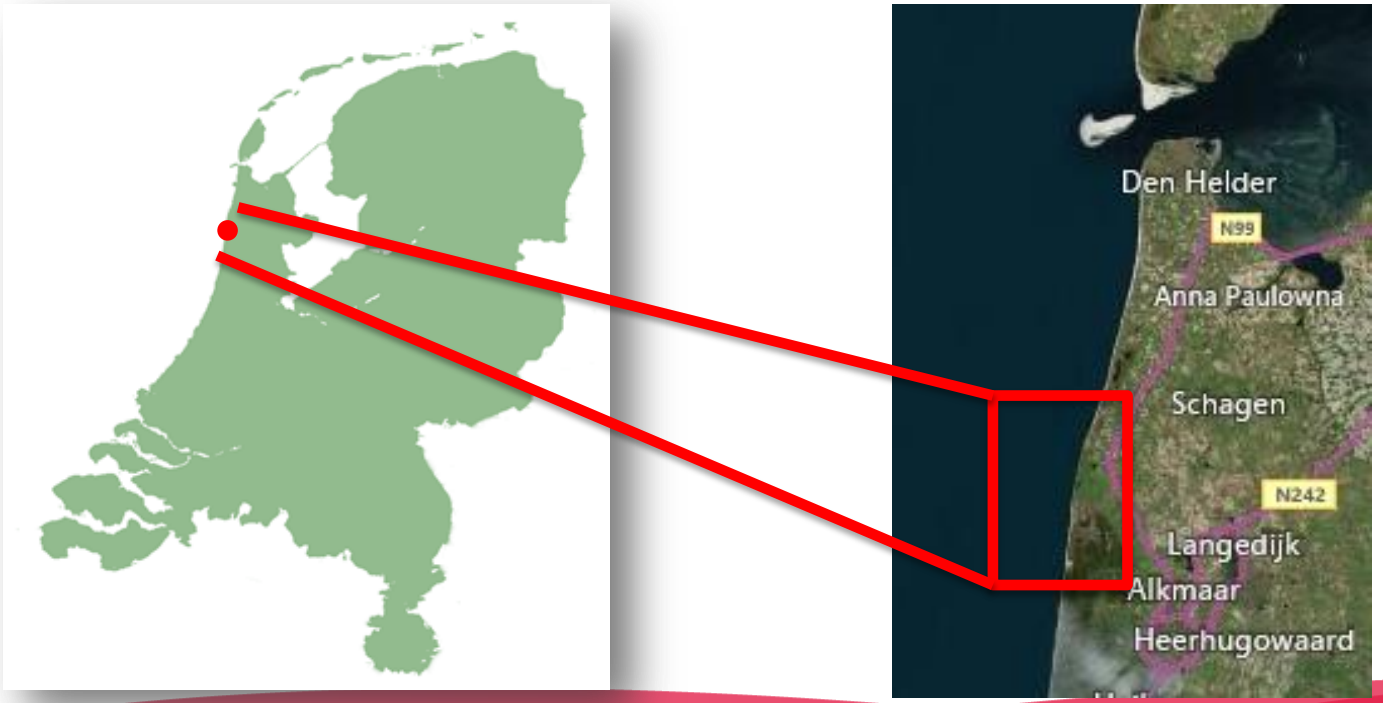

Seabed level of the Texel shoreface at 2008
29
2008
Longshore
21
km
1.5
1
0.5
0
Transect [-]
Distance from RSP [m]
29100
28100
27100
26100
25100
24100
23100
22100
21100
-1500
-1250
-1000
-750
-500
-250
0
250
500
6
4
2
0
-2
-4
-6
-8
-10
-12

Cross-shore

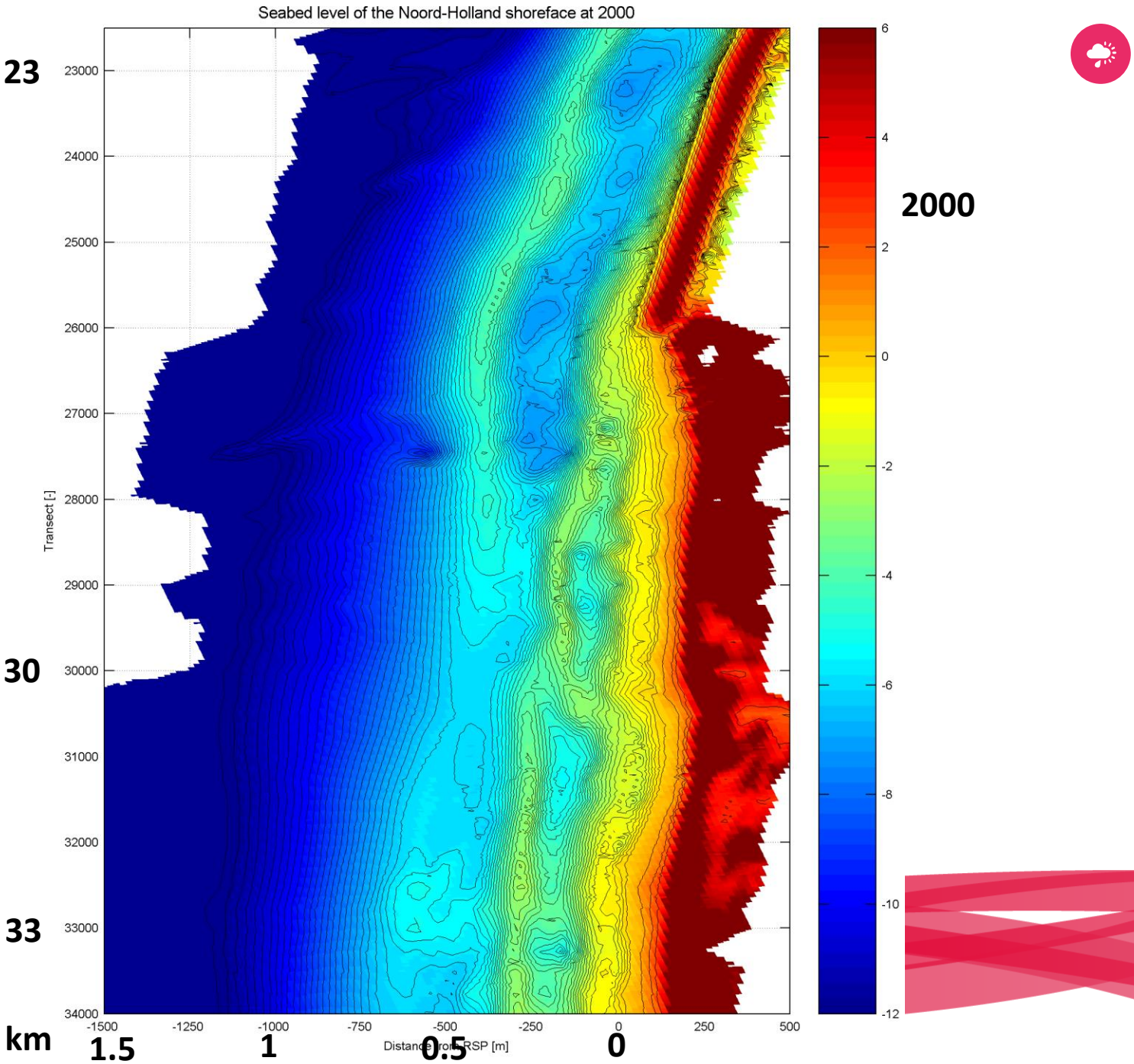


500 m Cross Shore
500 – 1000 m Long Shore

Morphological behaviour, Camperduin, Netherlands



Cross-shore



Longshore

23

30

33

km

1.5

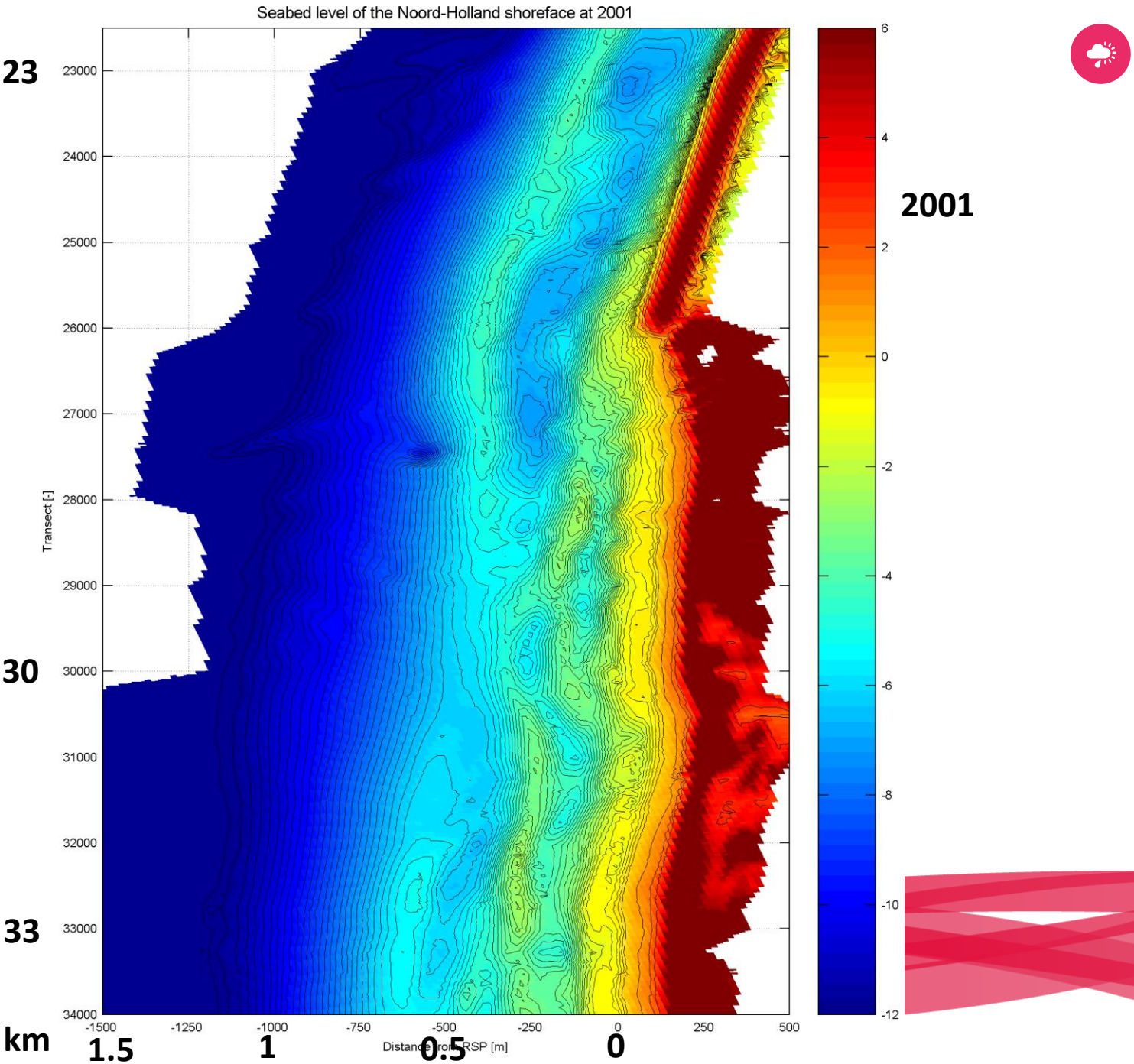
1

0.5

0

2000

Cross-shore



Longshore

23

30

33

km

1.5

1

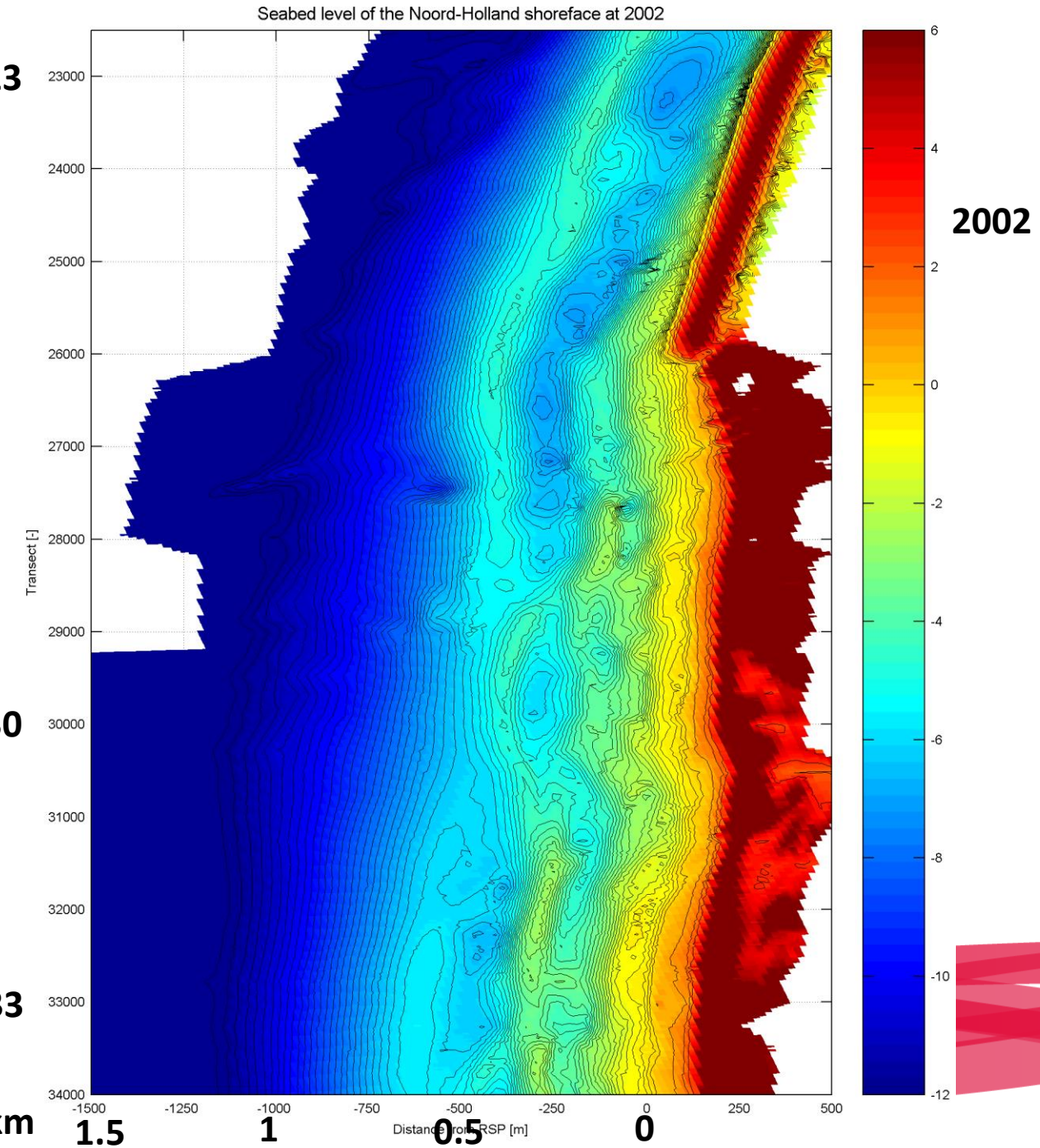
0.5

0

2001

Inte
North S
Buildin
European Regional Deve

Cross-shore



2002

Longshore

23

30

33

km

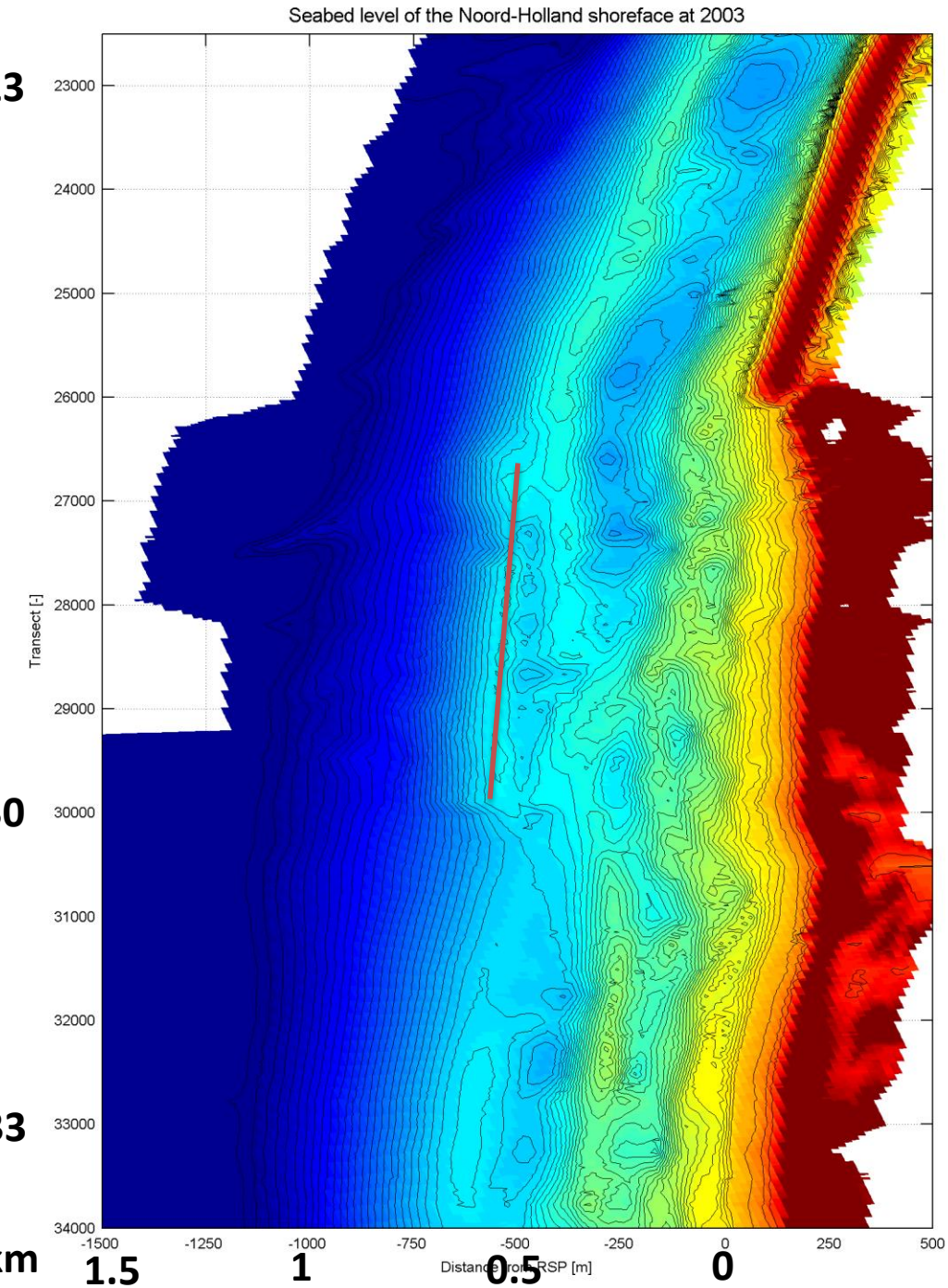
1.5

1

0.5

0

Cross-shore



2003

Longshore

23

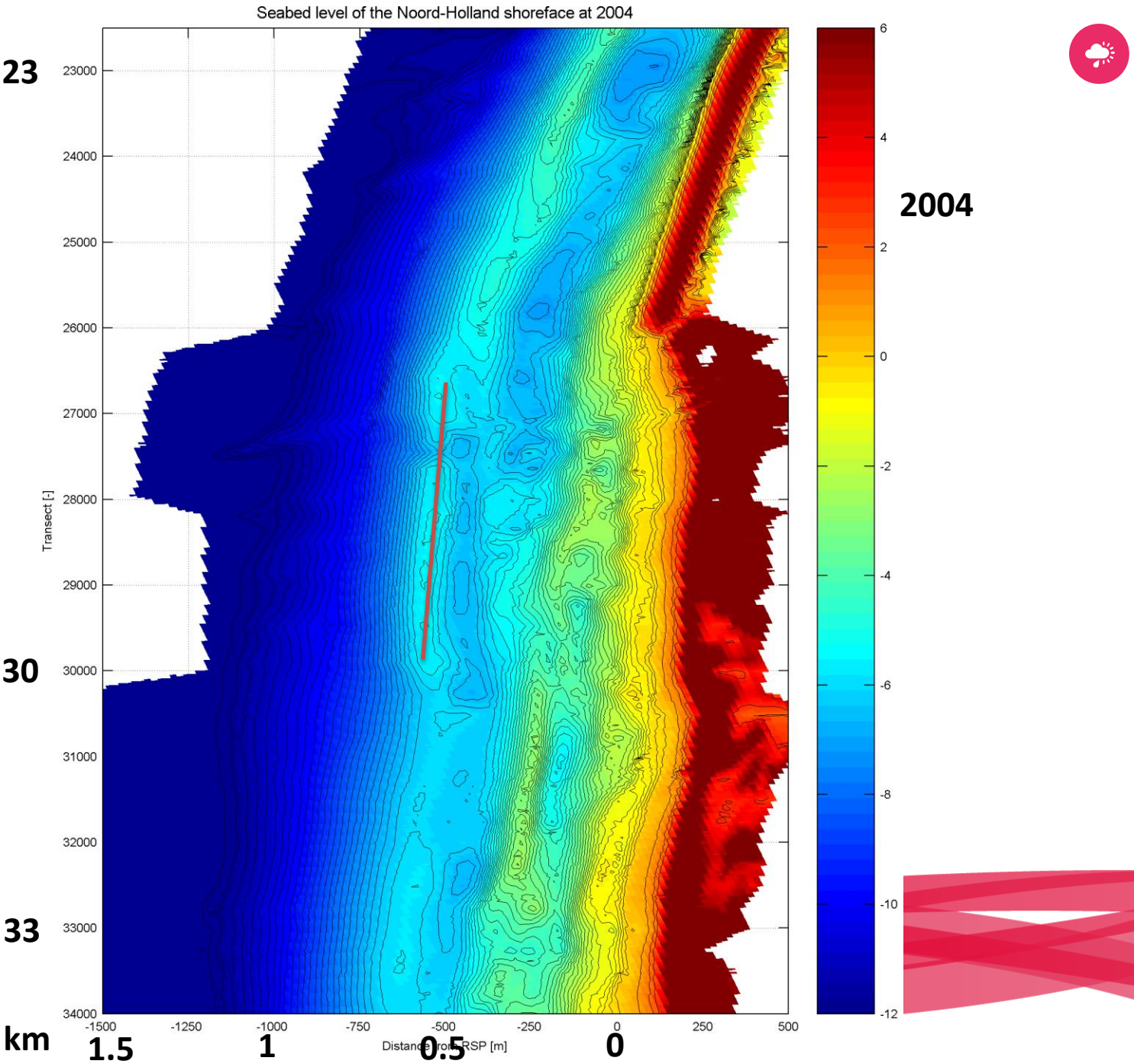
30

33

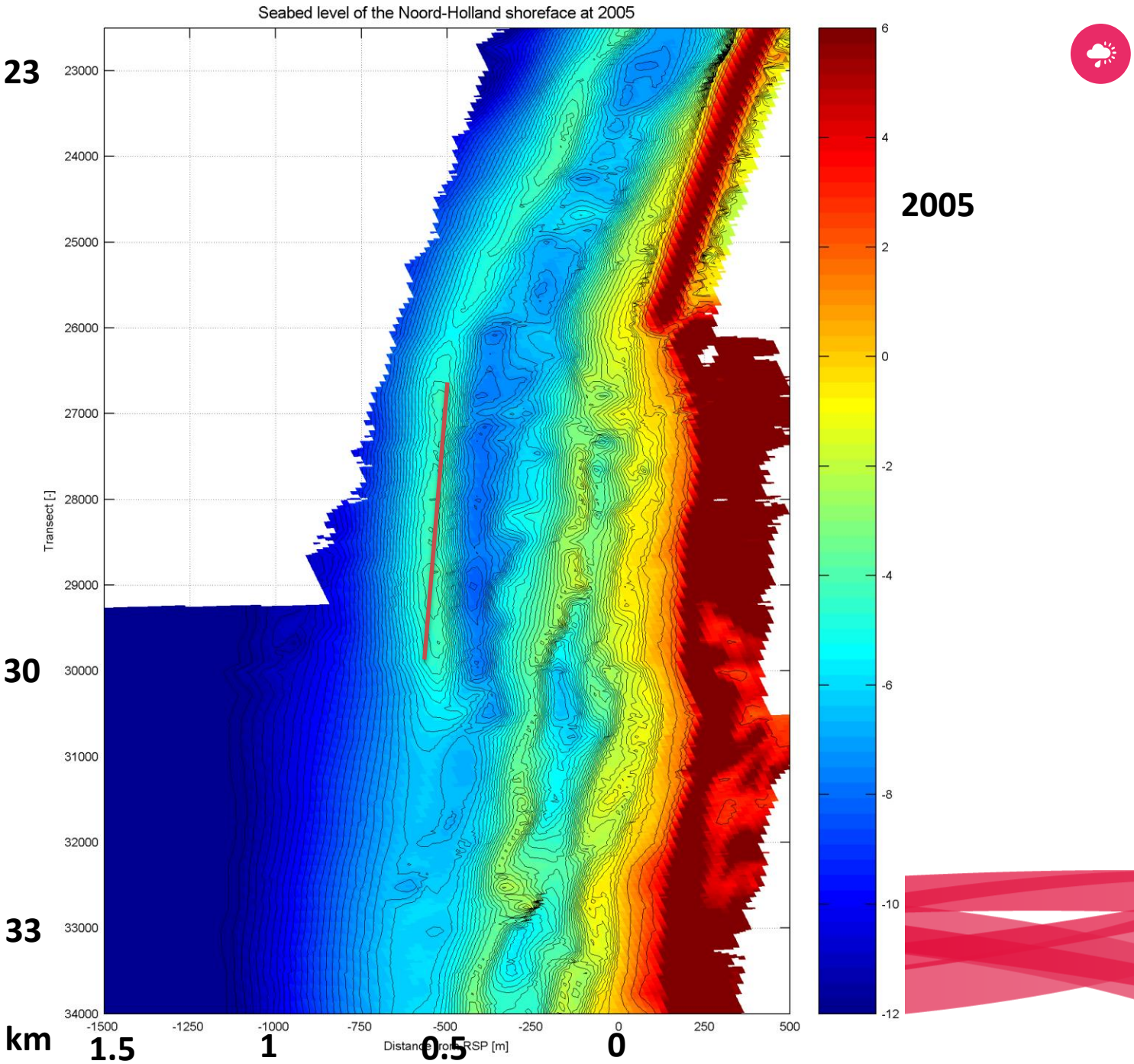
km

1.5 1 0.5 0

Cross-shore

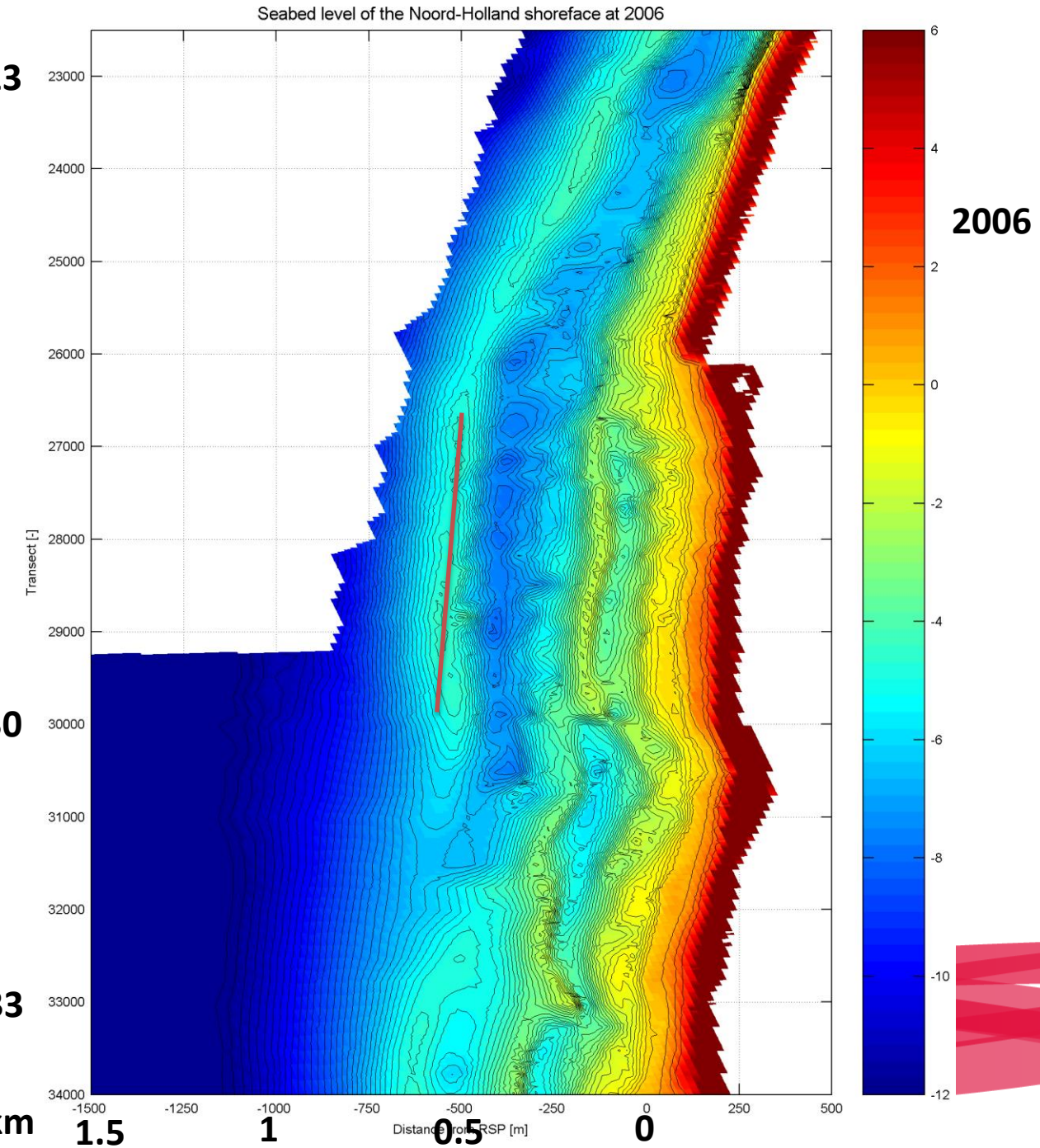

Seabed level of the Noord-Holland shoreface at 2004
Transect [-]
Distance from RSP [m]
2004
Longshore
23
30
33
km
1.5
1
0.5
0

Cross-shore


Seabed level of the Noord-Holland shoreface at 2005
Transect [-]
Distance from RSP [m]
2005
Longshore
23
30
33
km
1.5
1
0.5
0

Inte
North S
Buildin
European Regional Deve

Cross-shore



2006

Longshore

23

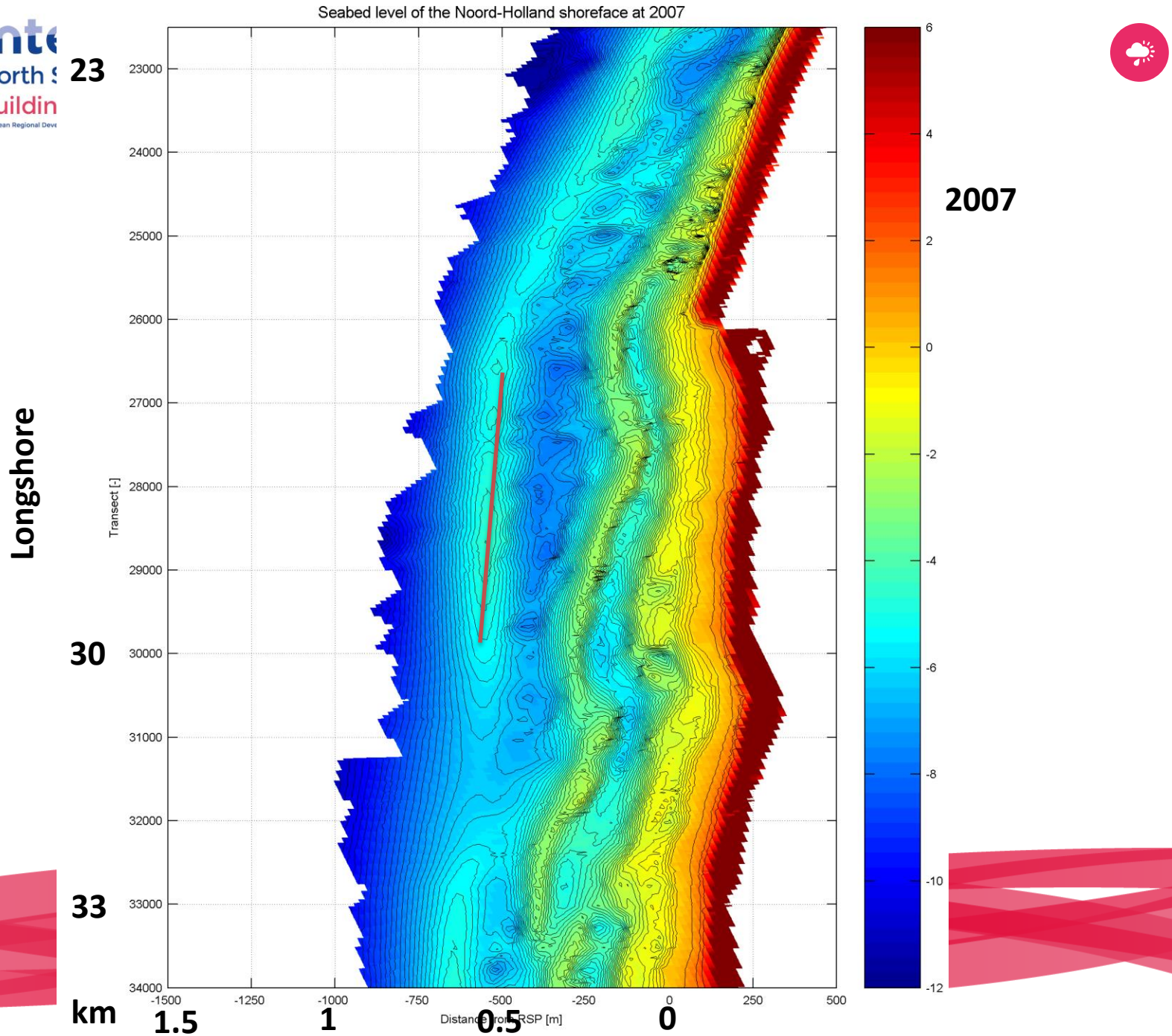
30

33

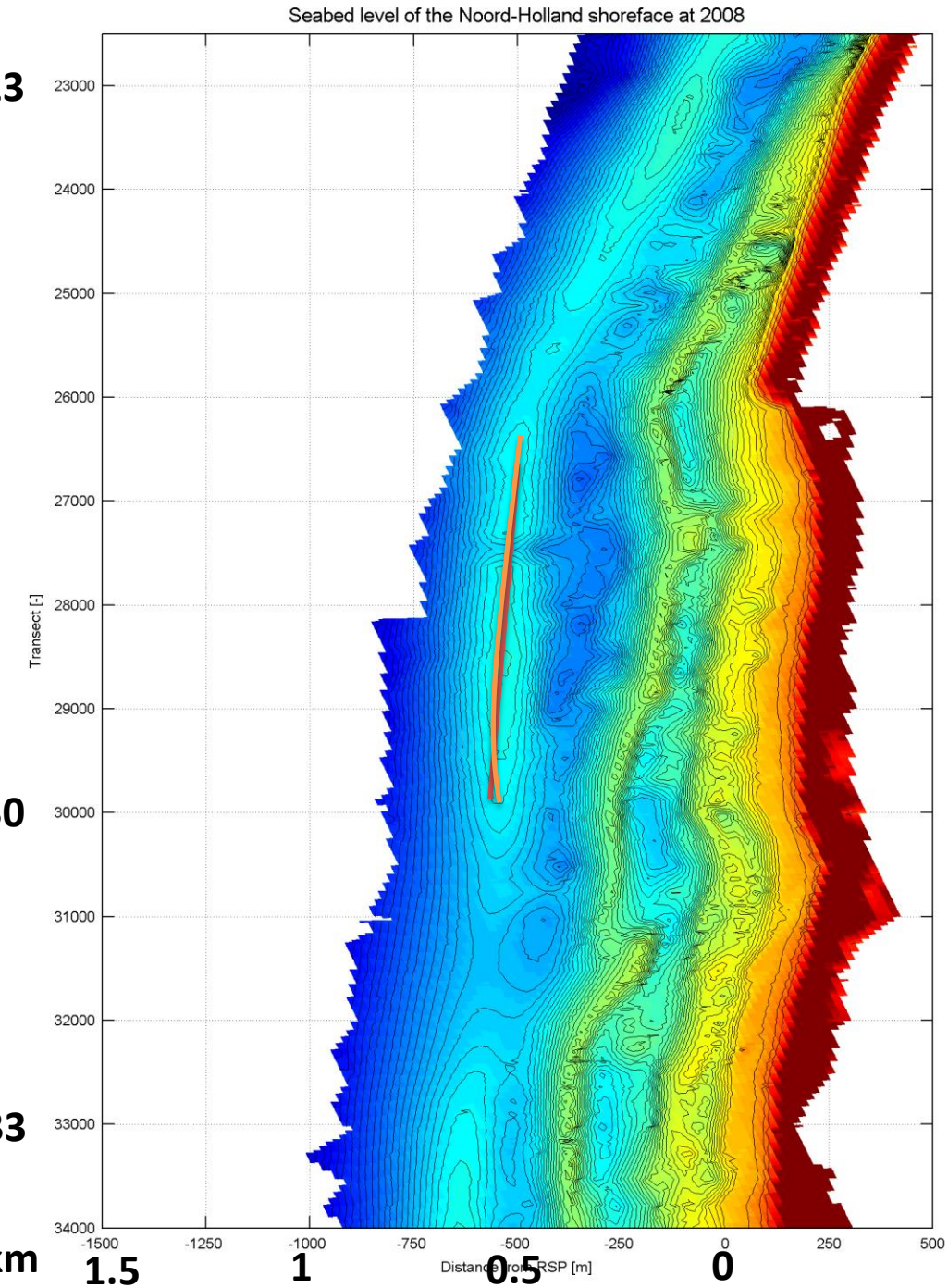
km

1.5 1 0.5 0

Cross-shore


Seabed level of the Noord-Holland shoreface at 2007
Transect [-]
Distance from RSP [m]
2007
Longshore
23
30
33
km
1.5
1
0.5
0

Cross-shore



2008

Longshore

23

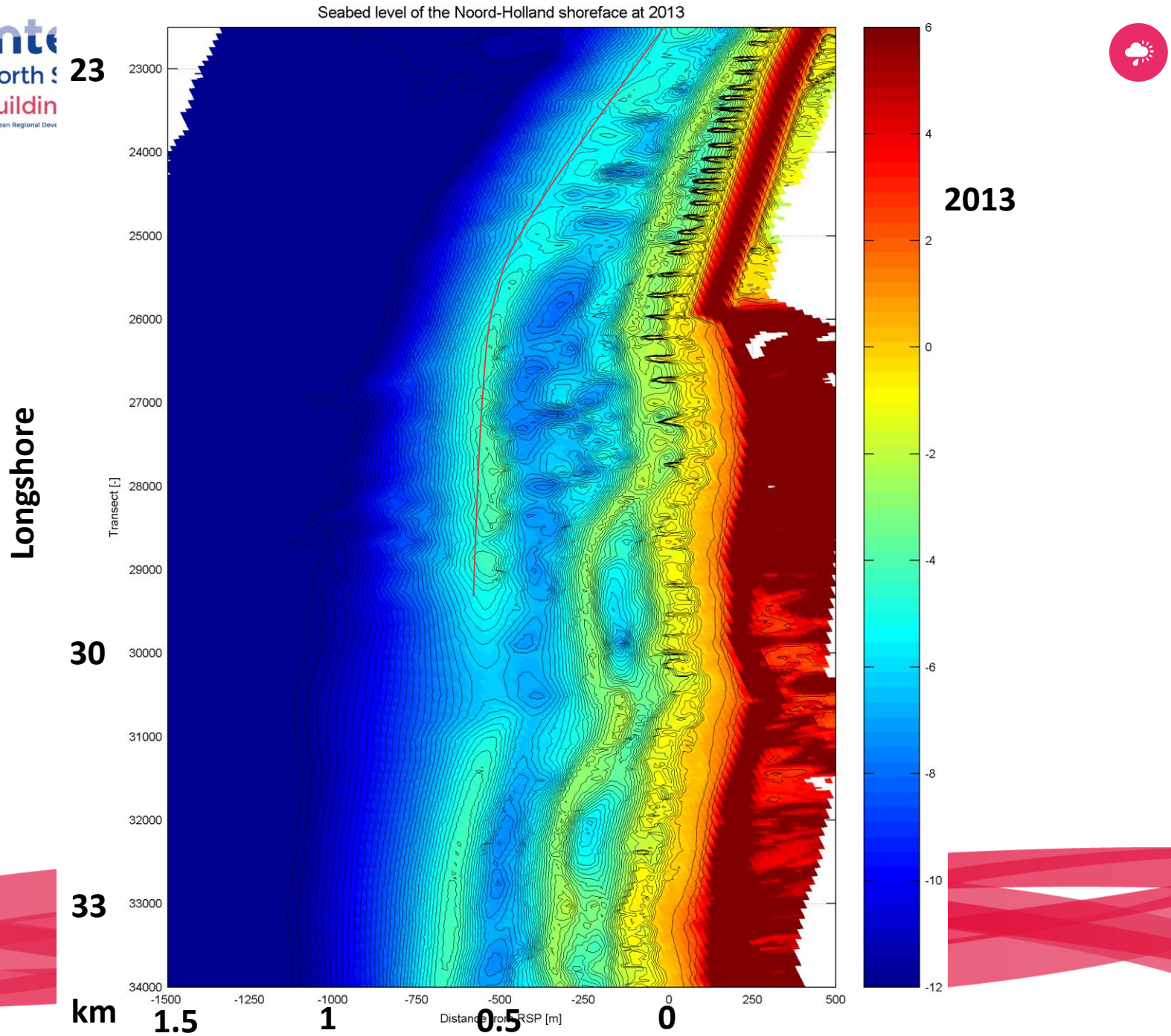
30

33

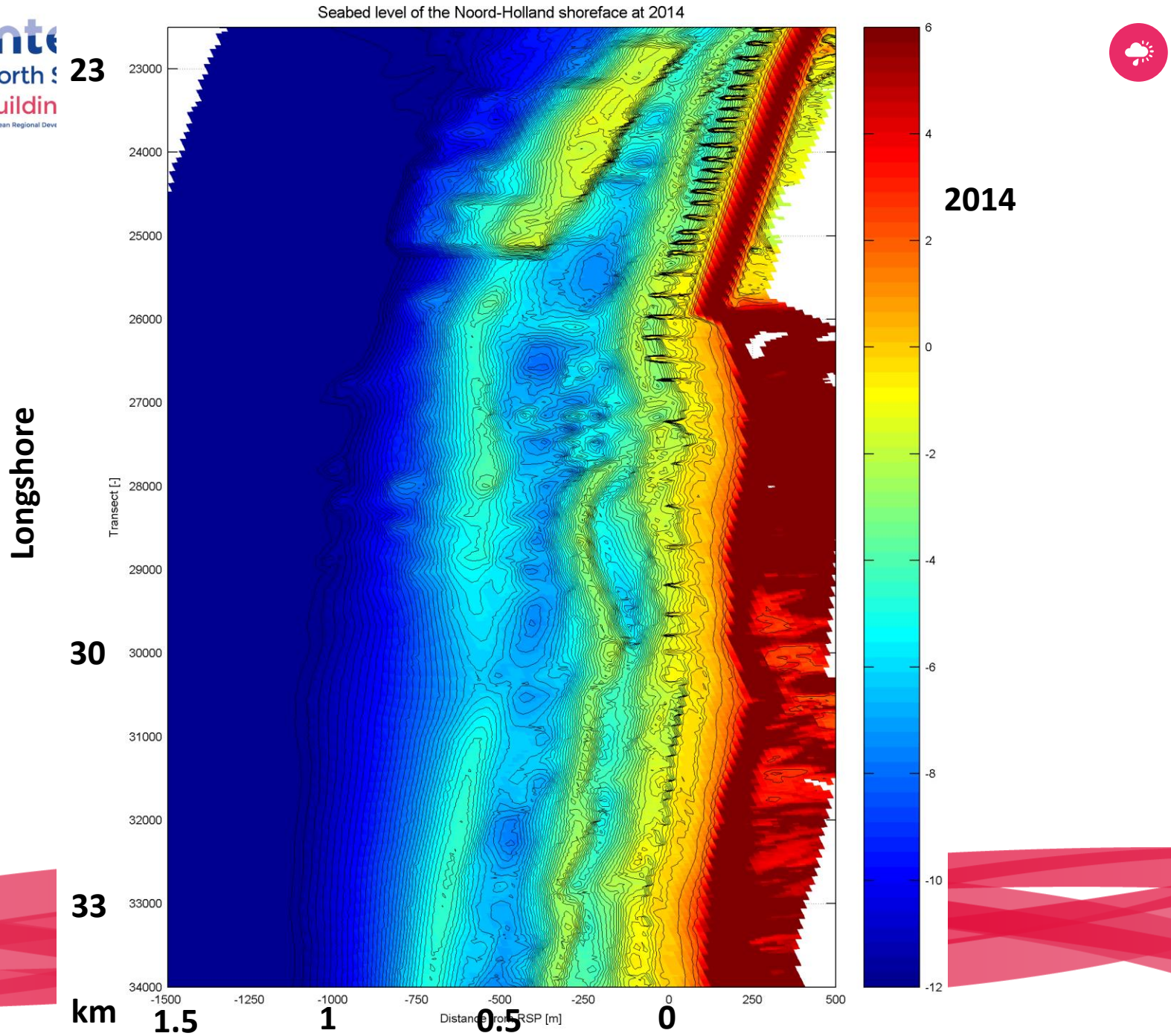
km

1.5 1 0.5 0

Cross-shore


Seabed level of the Noord-Holland shoreface at 2013
Transect [-]
Distance from RSP [m]
2013
Longshore
23
30
33
km
1.5
1
0.5
0

Cross-shore



Longshore

23

30

33

km

1.5

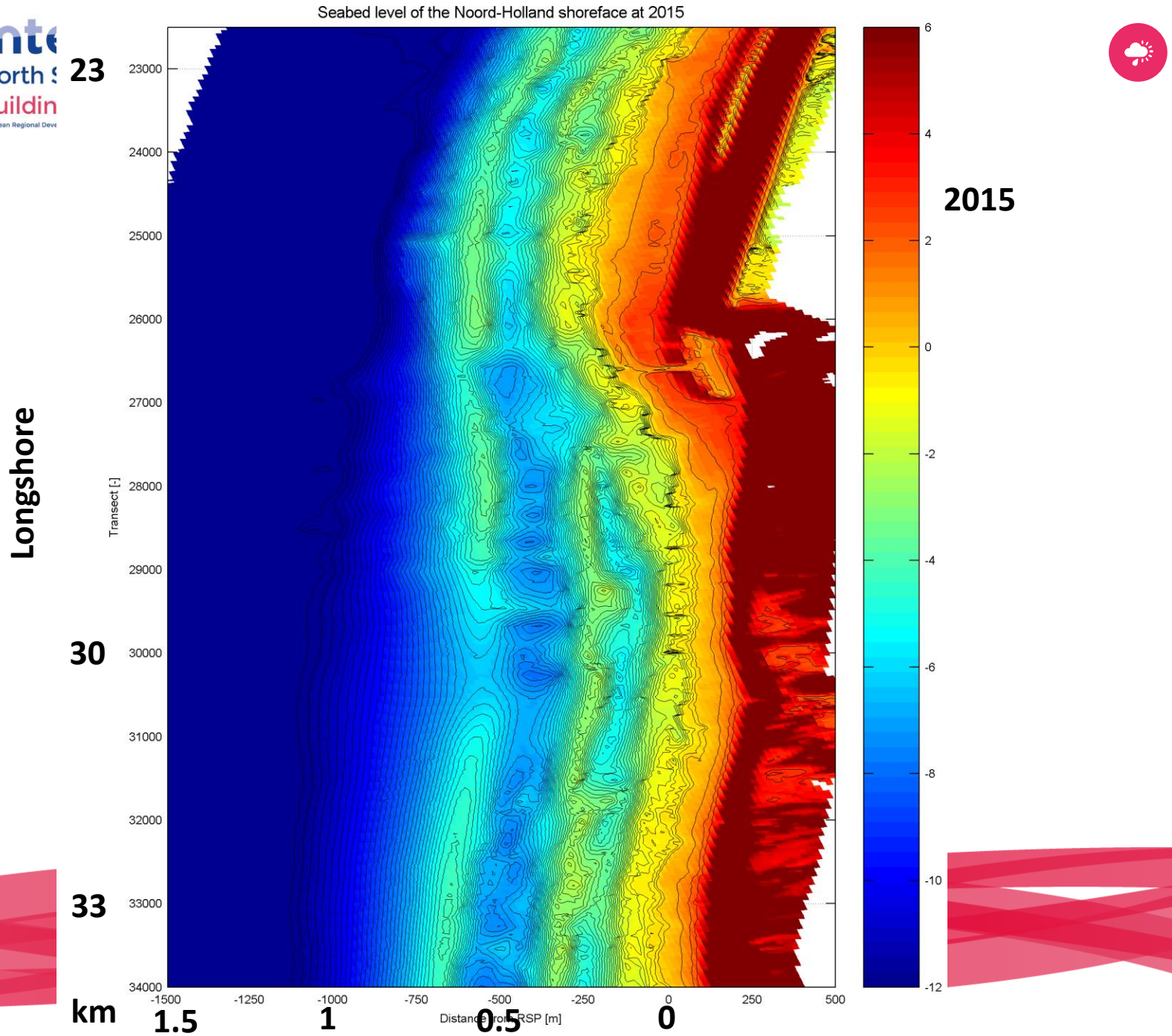
1

0.5

0

2014

Cross-shore



Longshore

23

30

33

km

1.5

1

0.5

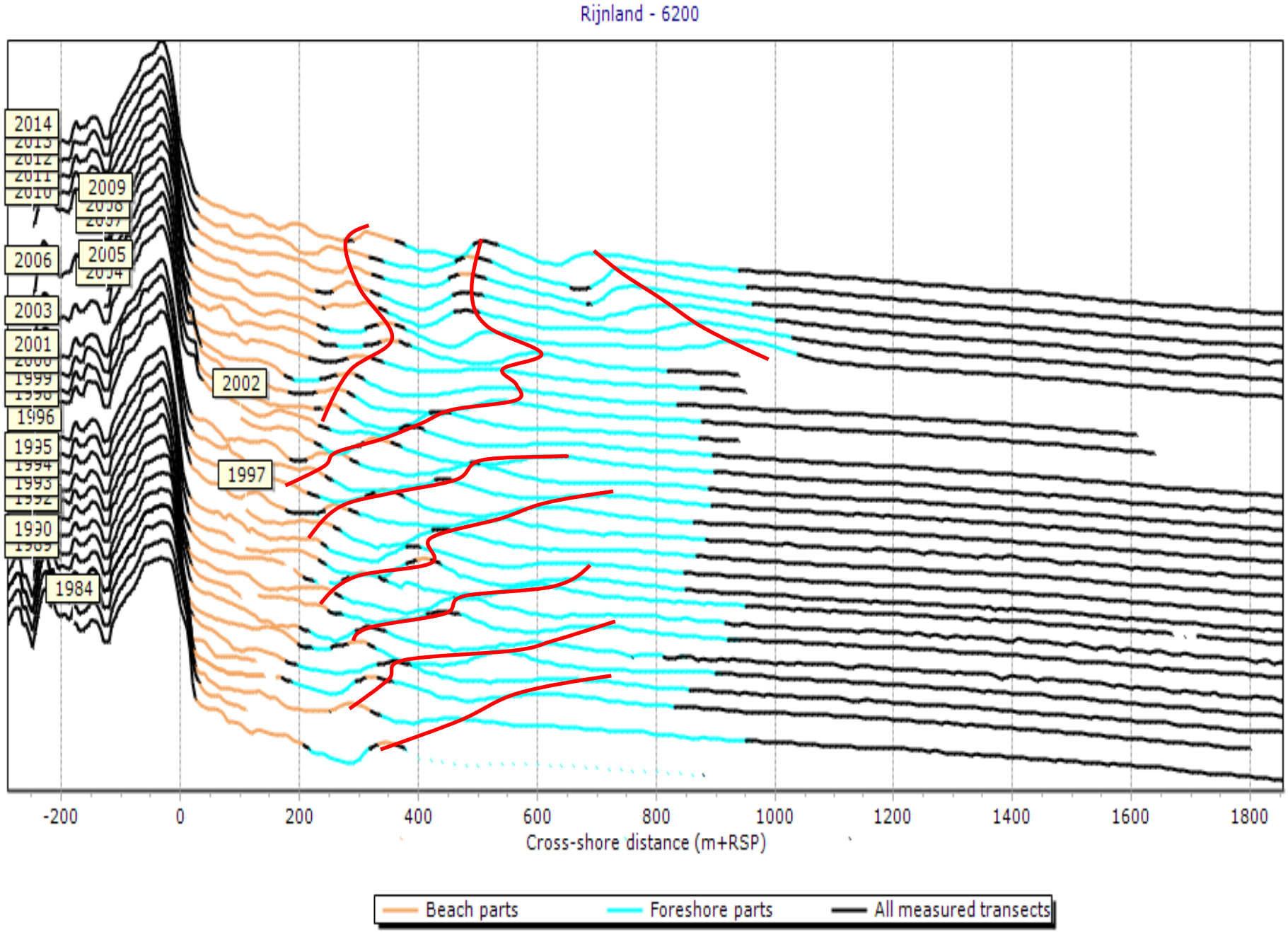
0

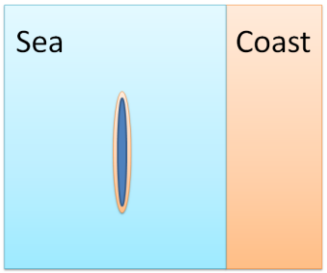
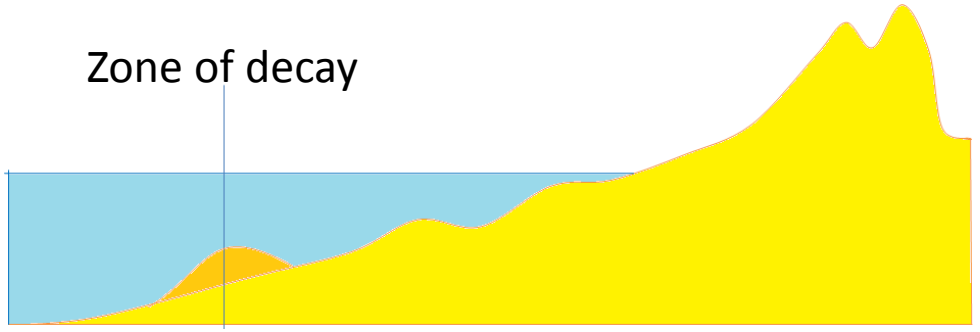
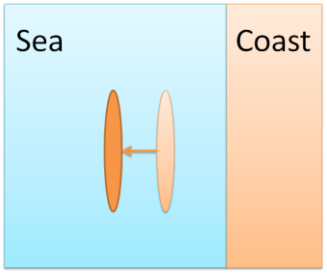
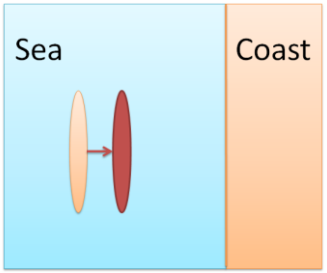
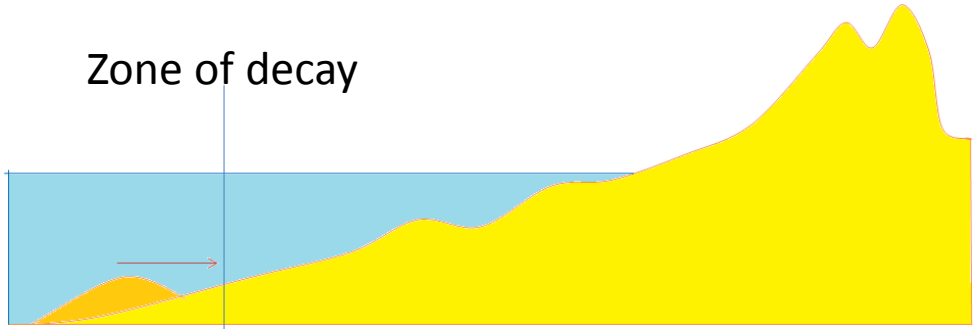
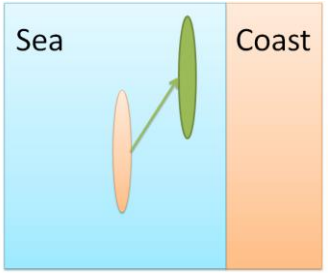
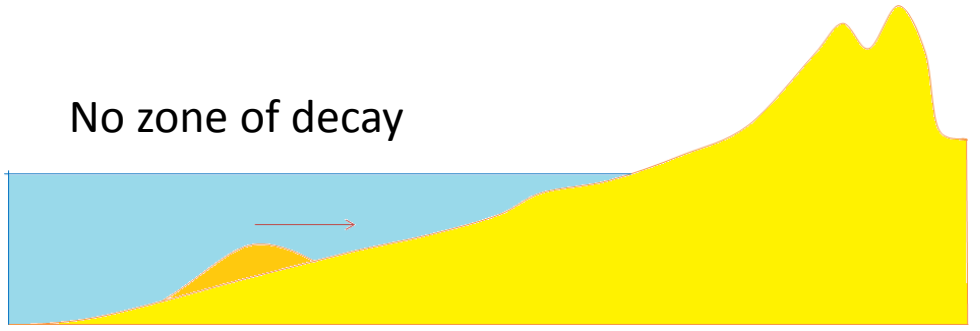
2015

Interreg
North Sea Region
Building with Nature
European Regional Development Fund

+ Blue circles, primarily Cross-Shore migration

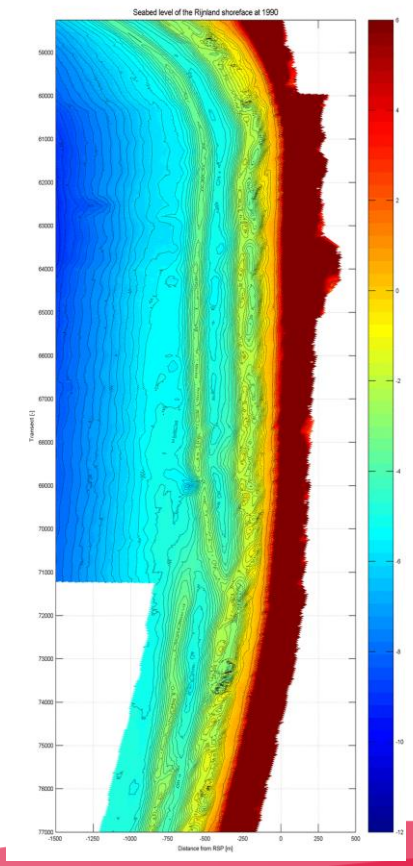
+ Green circles, primarily Cross- and Long Shore migration


Rijnland - 6200
2014
2009
2006
2005
2003
2001
2002
1997
1996
1995
1990
1984
-200
0
200
400
600
800
1000
1200
1400
1600
1800
Cross-shore distance (m+RSP)
Beach parts
Foreshore parts
All measured transects

Original cross-shore bar behaviour		
		
		
Original alongshore or no bar behaviour		

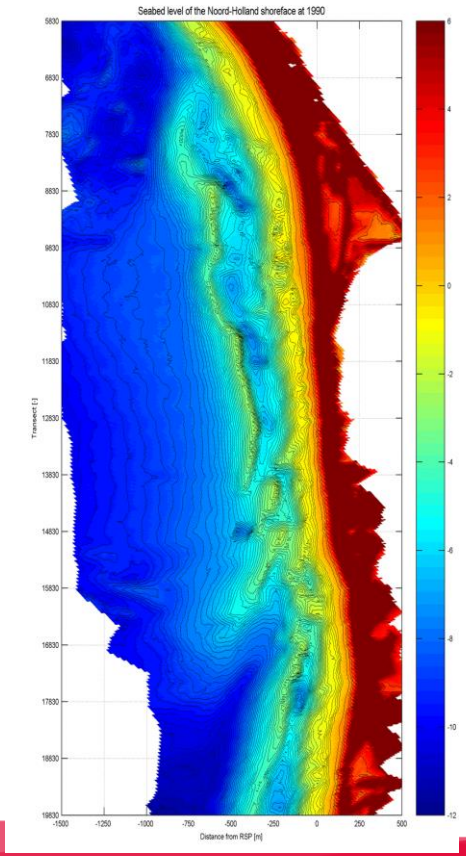
Bar behaviour

Cross-shore



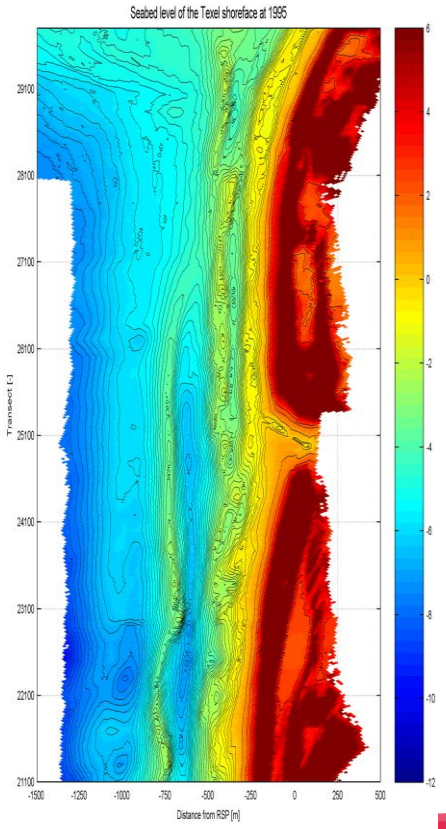
Zandvoort

Alongshore



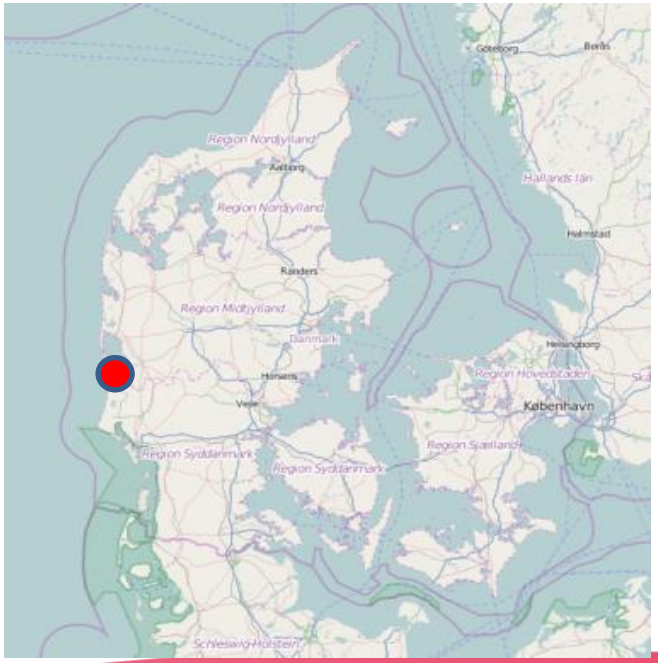
Callantsoog

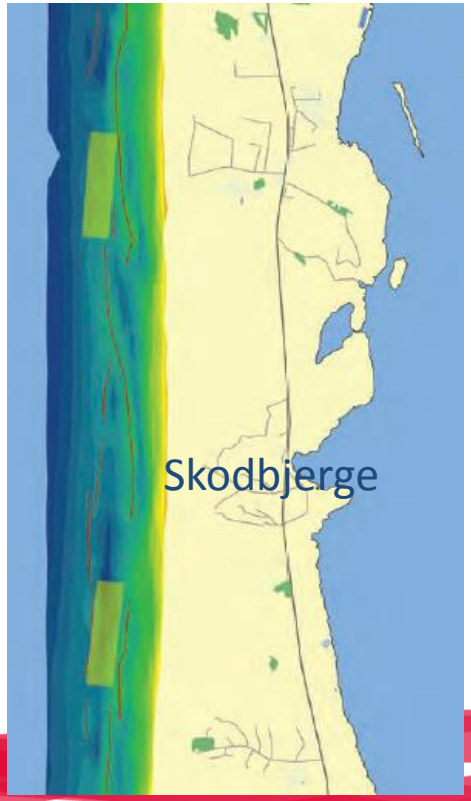
No bar migration

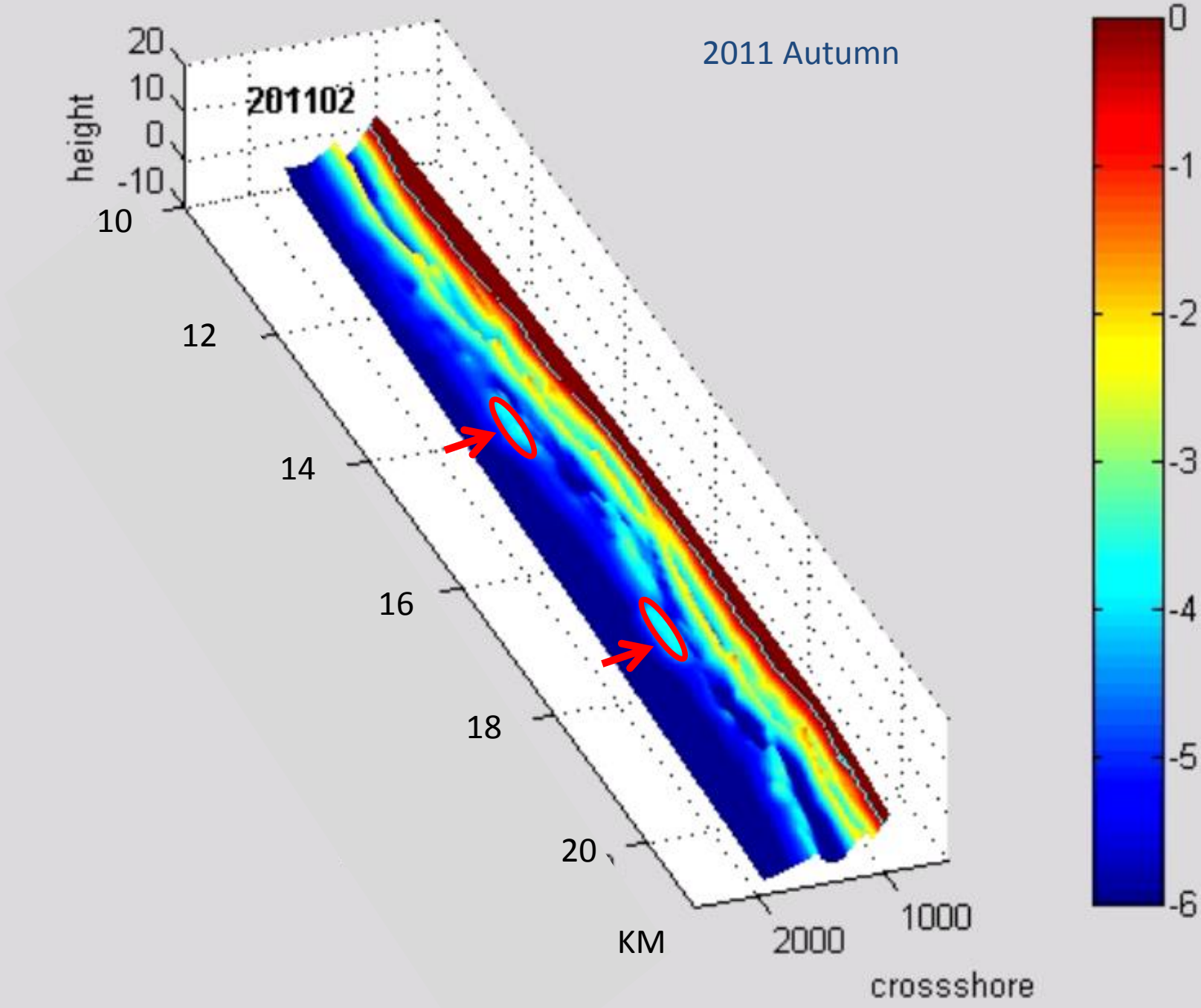


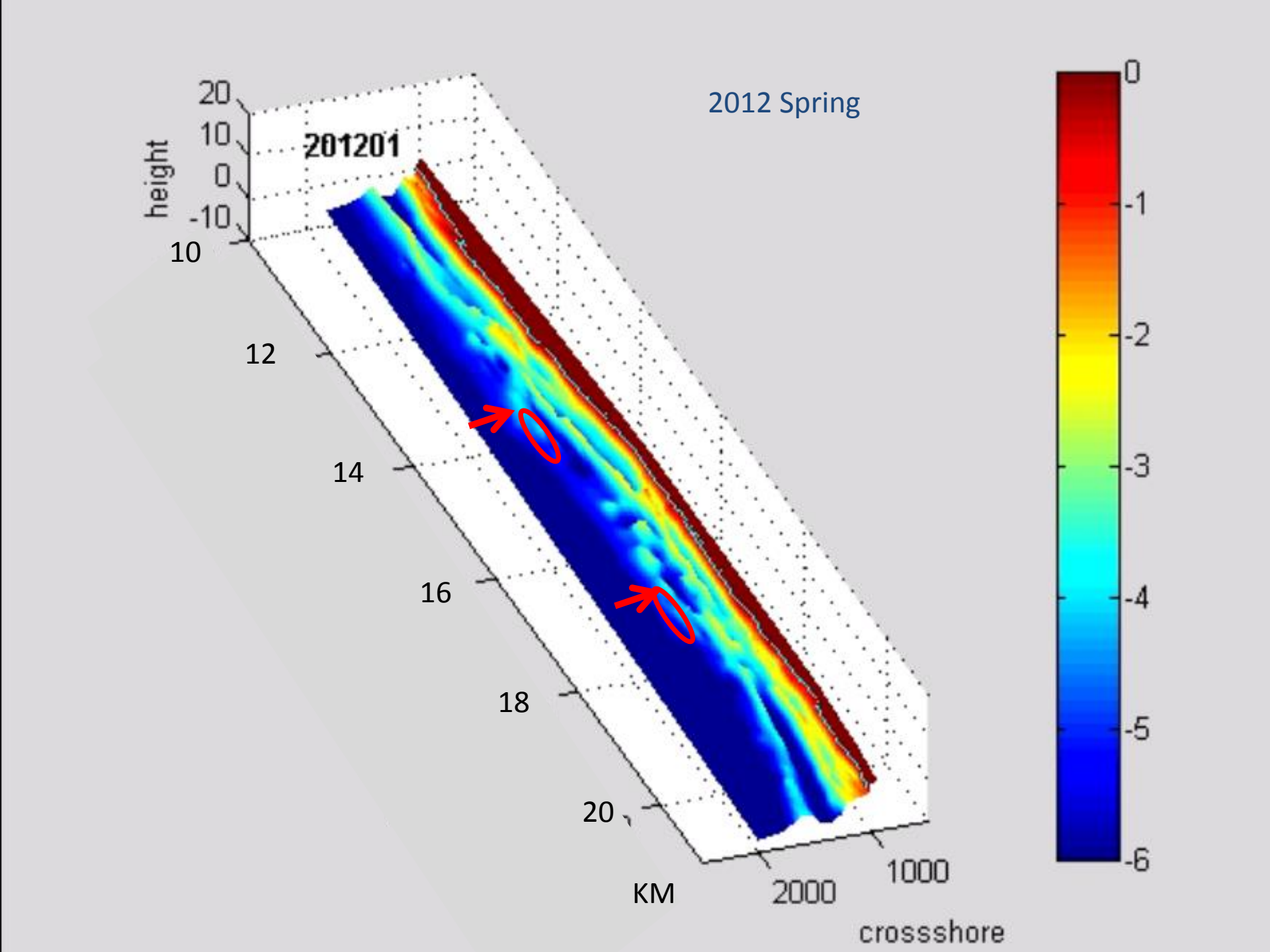
Noord-Texel

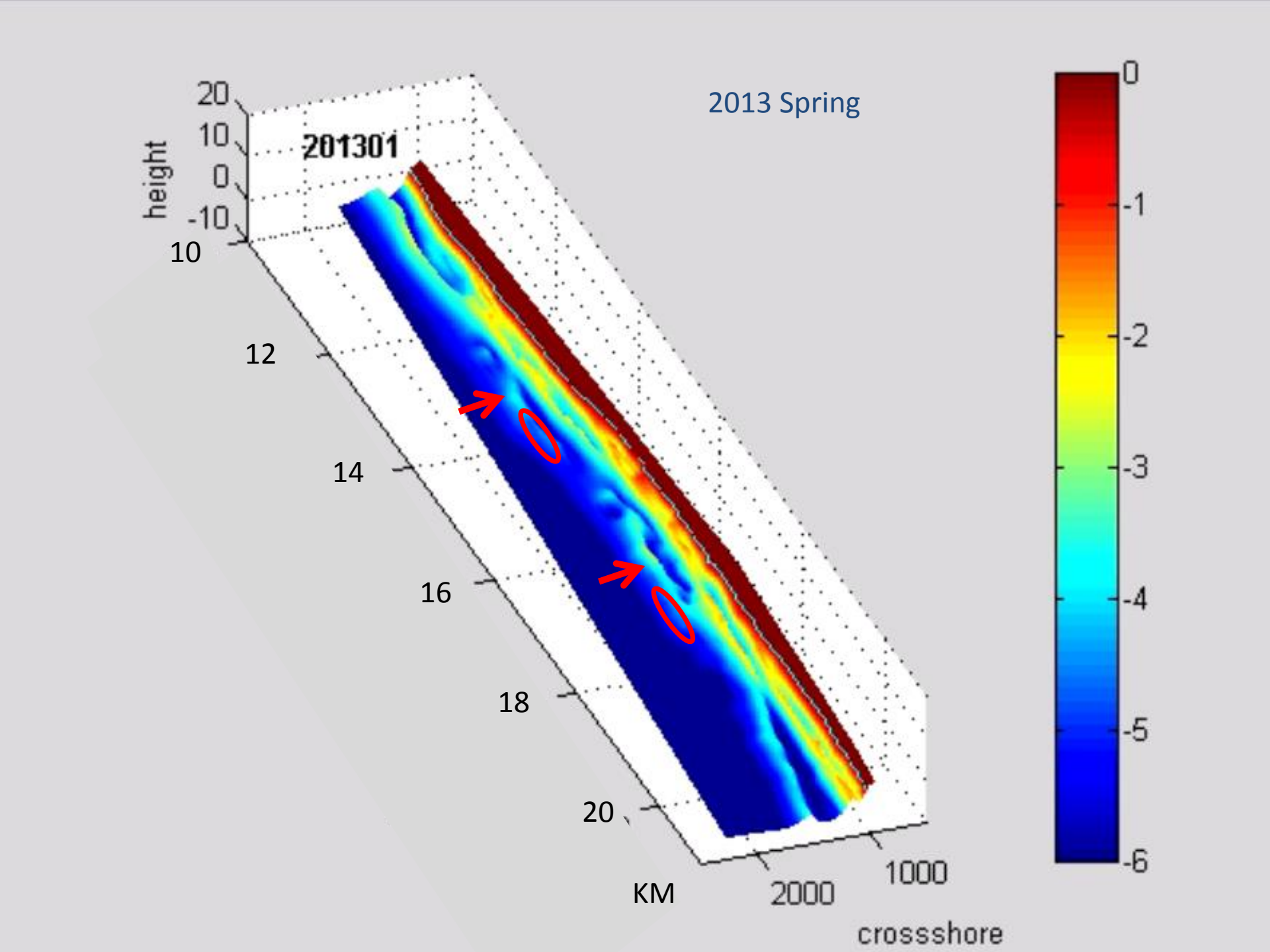
Morphological behaviour, Skodbjerge Denmark

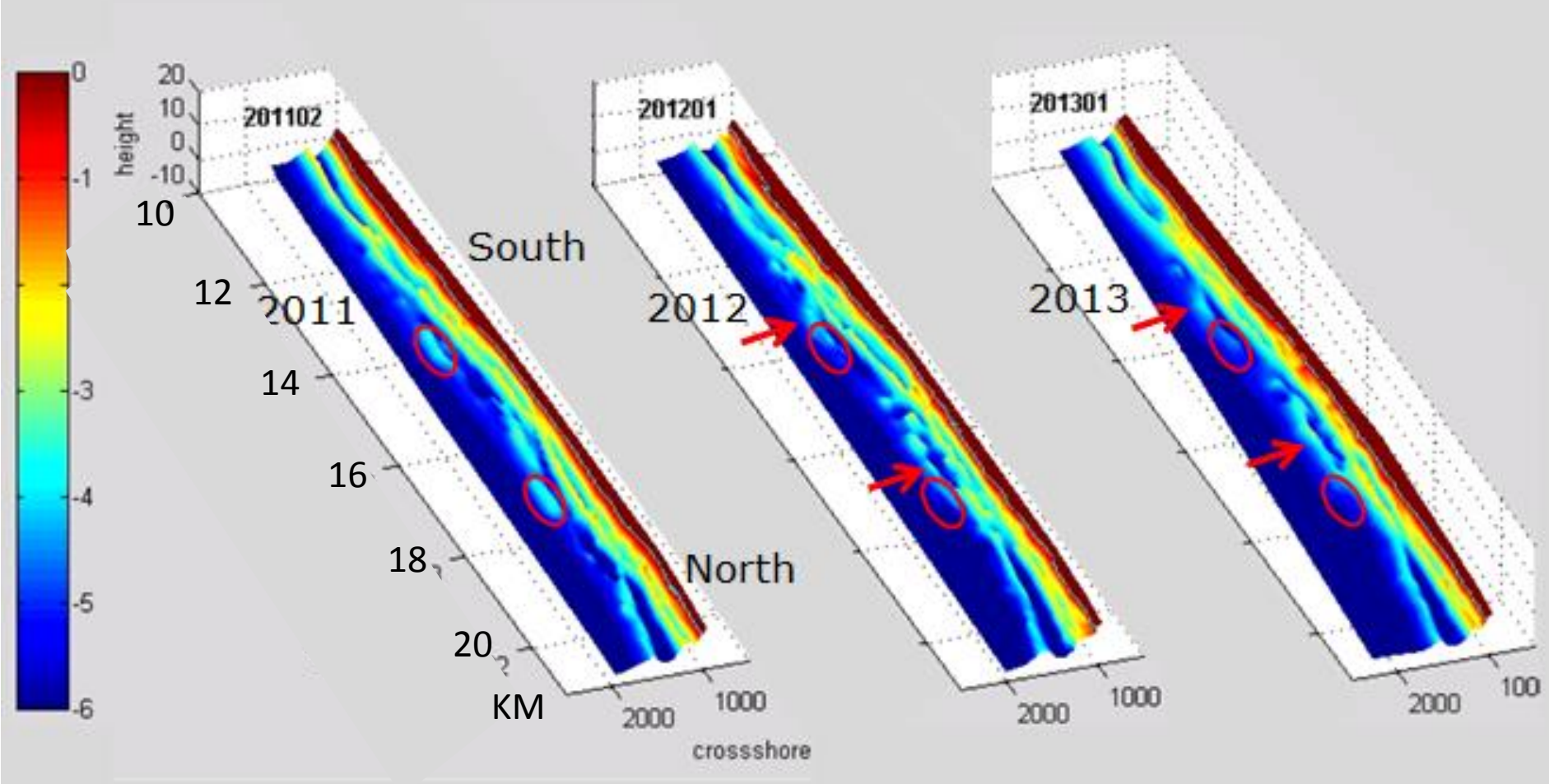





2011 Autumn
201102
height
20
10
0
-10
10
12
14
16
18
20
KM
2000
1000
crossshore
0
-1
-2
-3
-4
-5
-6


2012 Spring
201201
height
20
10
0
-10
10
12
14
16
18
20
KM
2000
1000
crossshore
0
-1
-2
-3
-4
-5
-6


2013 Spring
201301
height
20
10
0
-10
10
12
14
16
18
20
KM
2000
1000
crossshore
0
-1
-2
-3
-4
-5
-6



~ 50m Cross-shore
~ 750 Longshore

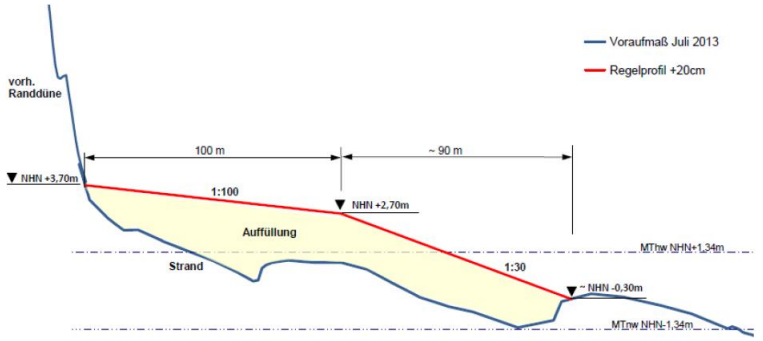
Conclusion

+ Seemingly different morphological behaviour of nourishments
+ But is there an overall system?

Probably due to:

+ Local Coastal Dynamics (forcing, coastal state, geology etc.)
+ Design of Nourishments

Interreg
North Sea Region
Building with Nature
European Regional Development Fund



General Nourishment Designs NSR

	Nourishment location w.r.t. erosion spot	Beach nourishment	Shoreface nourishment	Total volume (Mm^3)
1. DCA (Denmark, central North Sea coast)	Erosion hotspot	± 150-200 m3/m + 4m MSL Natural slope	seaward offshore bar volume of breaker bar	Erosion Trend * Lifespan
2. LKN.SH (Germany)	Erosion hotspot or damage driven	150 m3/m Natural slope: 1/10 ± 1 - 1,5 Mm3 - 400 mu	seaward offshore bar 300-400 M3/m	Erosion Trend * Lifespan. Max around 150 m3/m
3. NLWKN (Germany)	Erosion hotspot & Dune safety	± 300-400 m3/m + 3.7m MSL berm slope 1/100, beach slope 1/30	None	Reference height and slope 0,4-0,6 Mm3
4. RWS (Netherlands)	Erosion hotspot	150-250 m3/m + 3-3.5m MSL slope 1/20 - 1/30, 200-250 mu	-5m MSL seaward offshore bar volume of breaker bar	Erosion Trend * Lifespan. Max around 300 m3/m
3. MDK (Belgium)	Erosion hotspot	+ 4,67m MSL (storm level) With berm on seawall Slope: 1/25 till 1/35	Only 1 Connecting to the beach	Erosion Trend * Lifespan
3. LST (Sweden)	Erosion hotspot	-	Not yet done	Erosion Trend * Lifespan

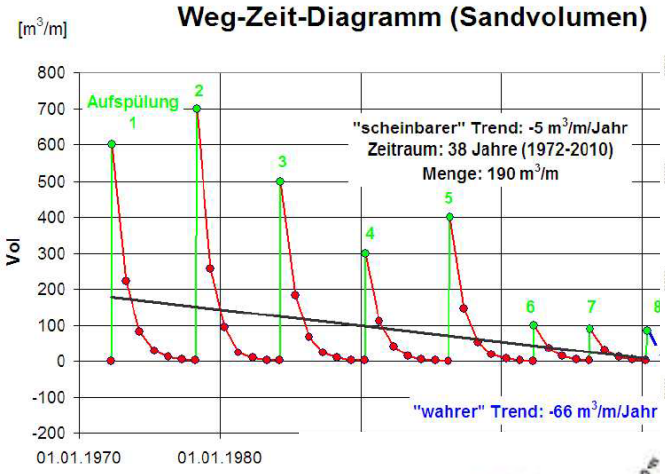
Interreg
North Sea Region
Building with Nature
European Regional Development Fund

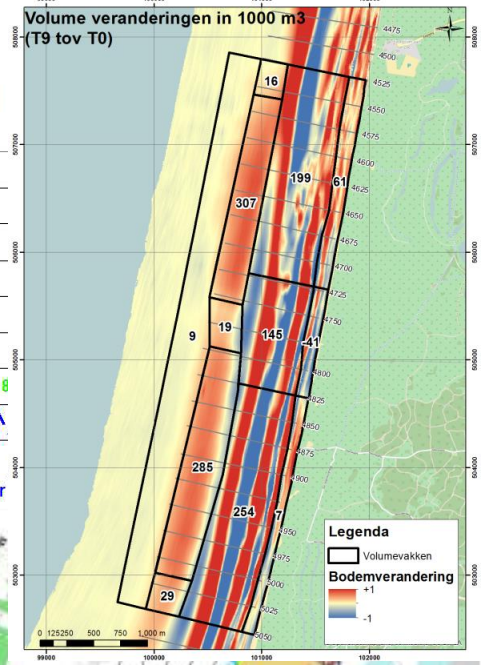
Co-analysis

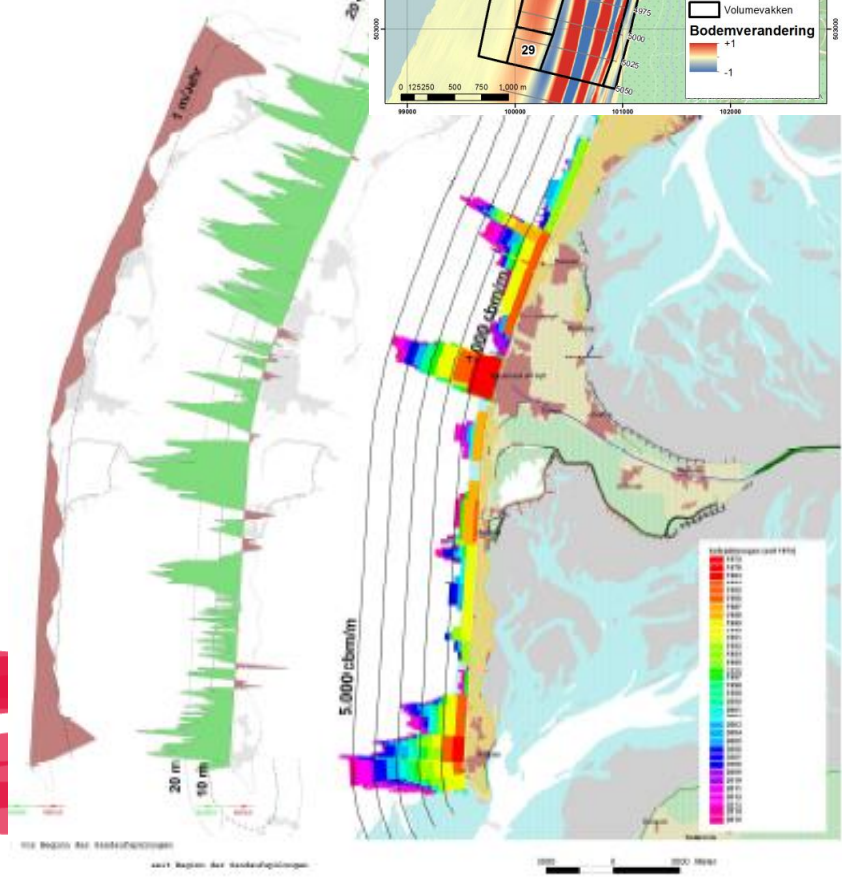
Try to quantify and understand the observed behavioural differences

+ Volume developments
+ LWM, HWM, Dunefoot
+ Bar dynamics

Using the same tools for the whole region



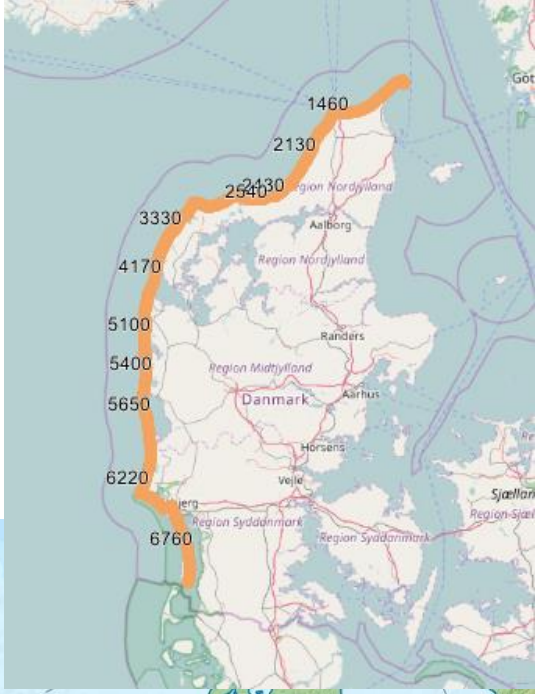


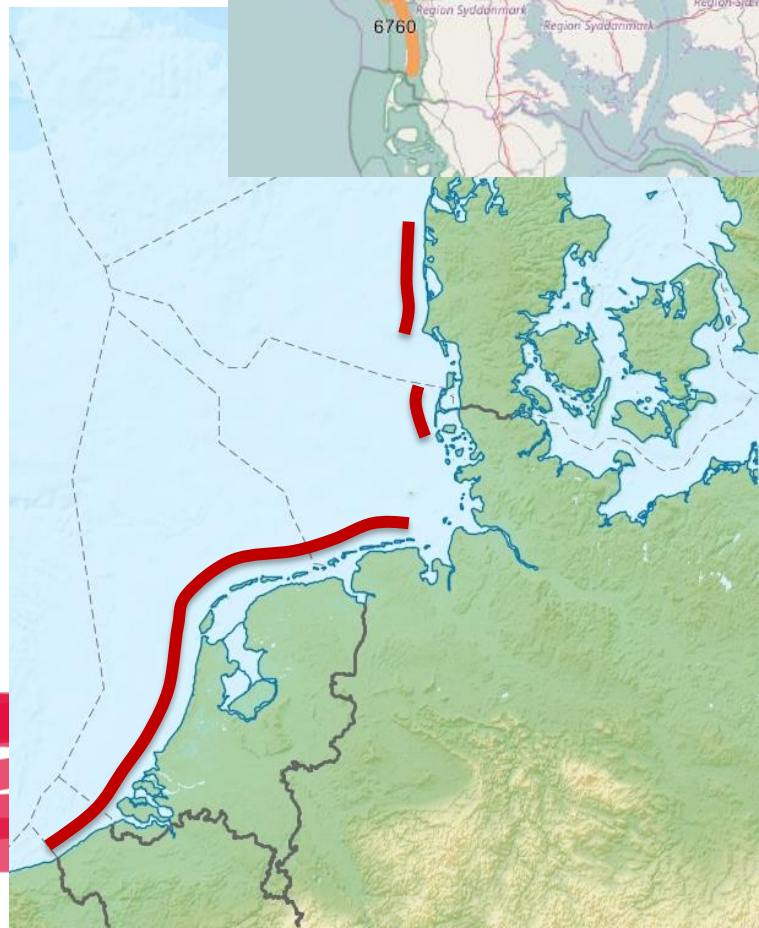


Interreg
North Sea Region
Building with Nature
European Regional Development Fund

Results up to now

+ Overview of current Nourishment Practice in North Sea Region
+ Data overview of available Bathymetrical, Hydrological and Meteo Data
+ Conceptual model for Dutch Shoreface nourishments
+ MorphAn coastal transects database BE-Skagen





Outlook

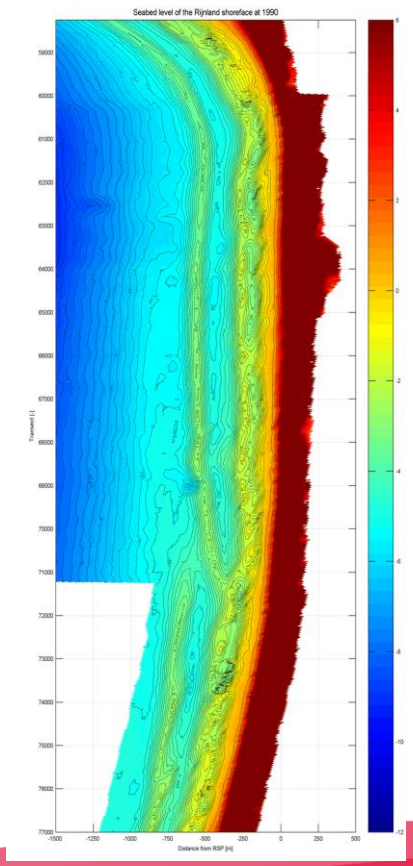
Work Package 3 Brief Gantt chart			Year	2016	2017	2018	2019	2020
Product	**Task**	**Description**	**Beneficiary**					
P1	**T1**	Work plan WP 3	All		**Mar**			
P2		Comparison current practice and coastal characteristics	All		**Mar**			
P3		Factsheet data	All		**Mar**			
P4	**T6**	Shared methodology co-analyses	All		**Dec**			
P5		**National Analyses**						
	T2	Dutch North Sea coast nourishments	RWS			**Dec**		
	T3	Danish North Sea coast	DCA			**Dec**		
	T4	East Frisian Island	NLWKN			**Dec**[1]		**Apr**[2]
	T5	Sylt shoreface nourishment	LKN.SH			**Dec**		
	T7	Swedish coastal retreat prevention (Grannian)	LS			**Dec**		
		Oostende - Mariakerke pilot project updates	MDK			**Dec**		
P6	**T6**	**Co-analysis of national analyses**	**All**				**Jul**	
P8	**T10**	Evidence base and guidance	All IHE CWSS				**Dec**	
		Finalization and preparation final event						**Jun**

Thank you for your attention

Rinse.Wilmink@rws.nl
Quirijn.Lodder@rws.nl
PSO@kyst.dk

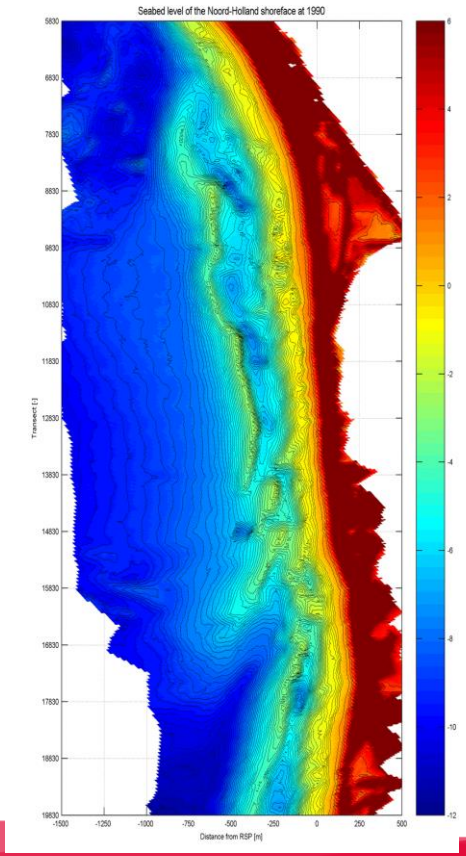
Bar behaviour

Cross-shore



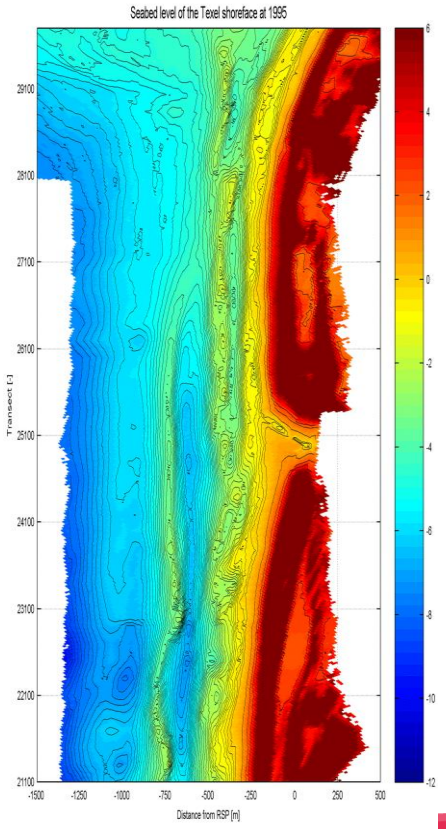
Zandvoort

Alongshore



Callantsoog

No bar migration

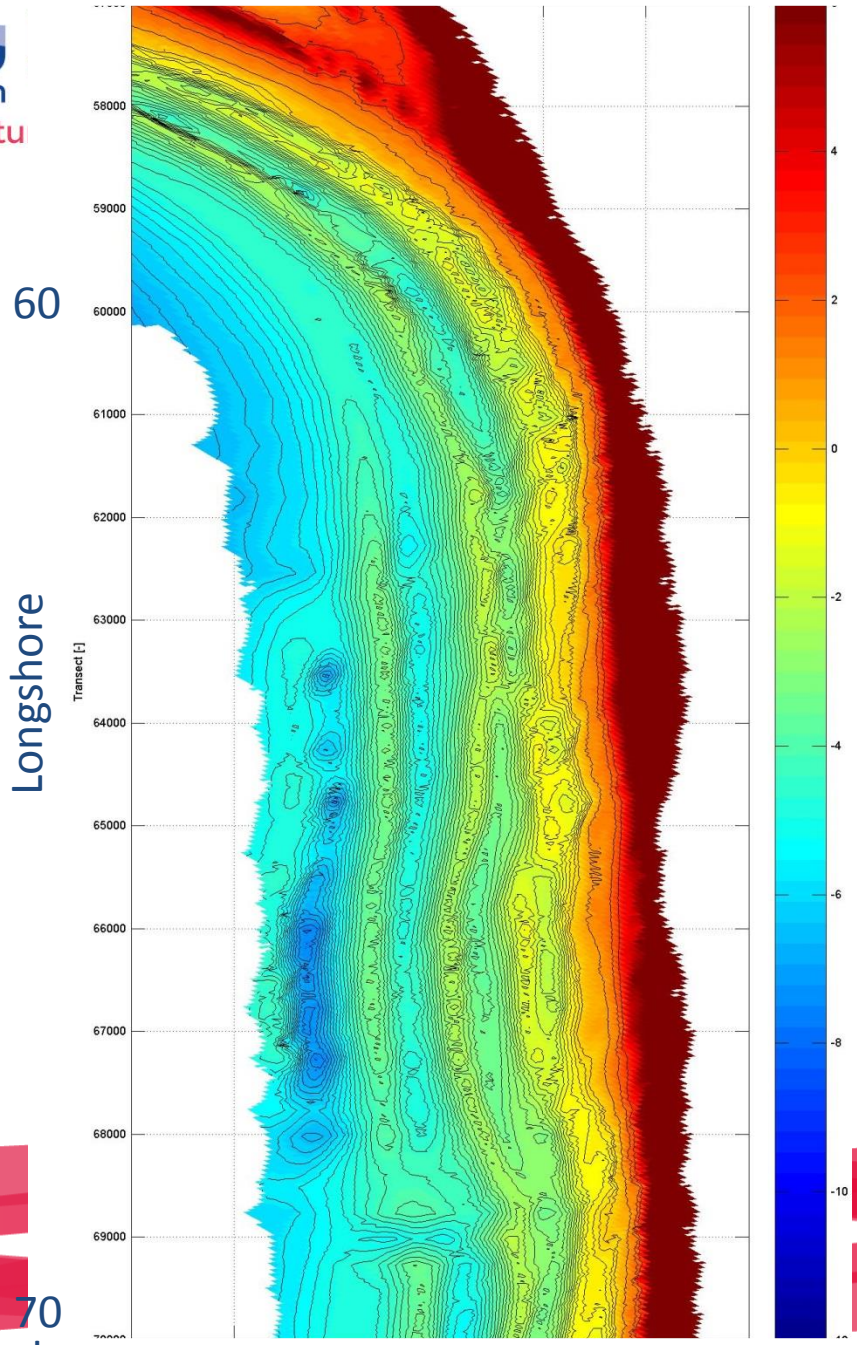


Noord-Texel

Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

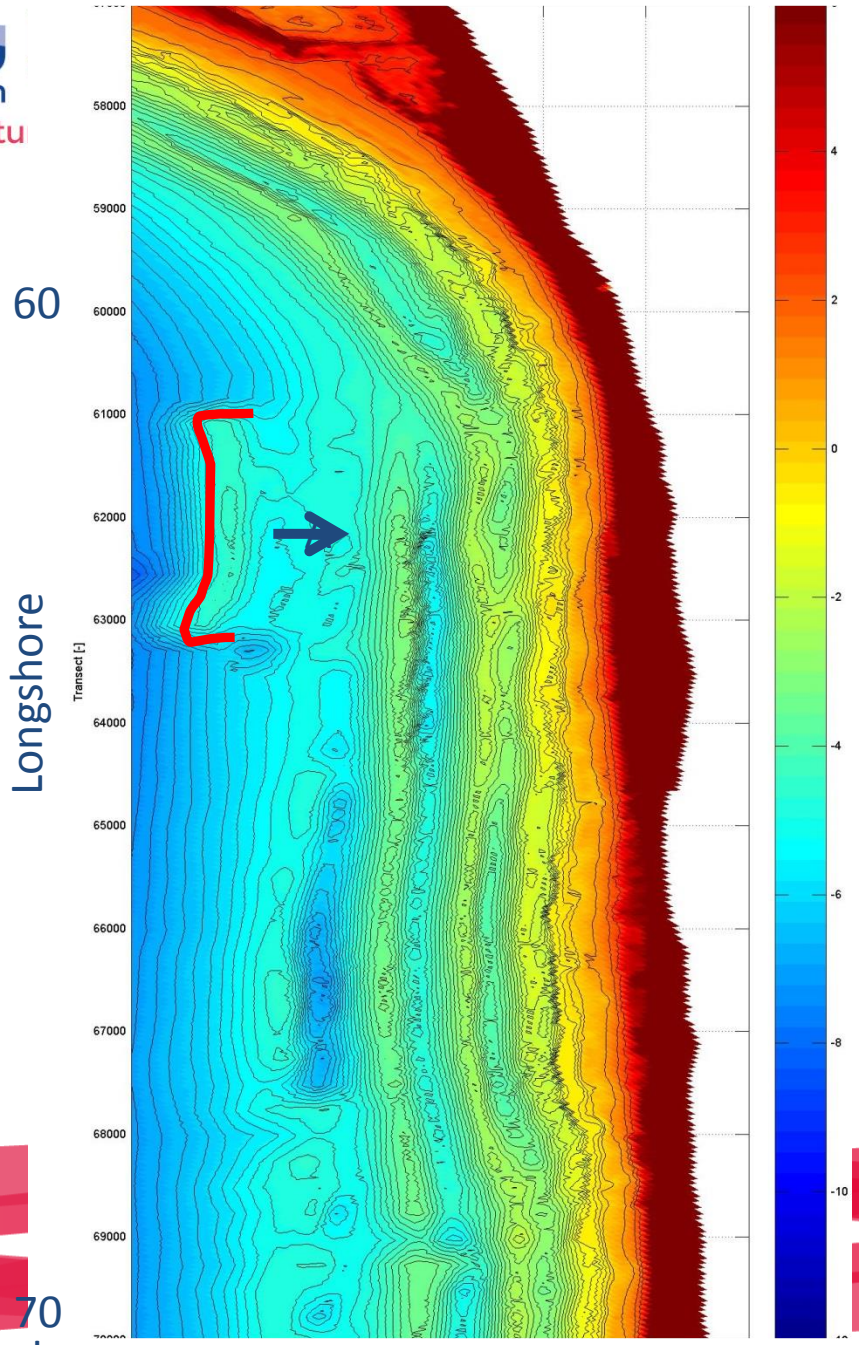
2008



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

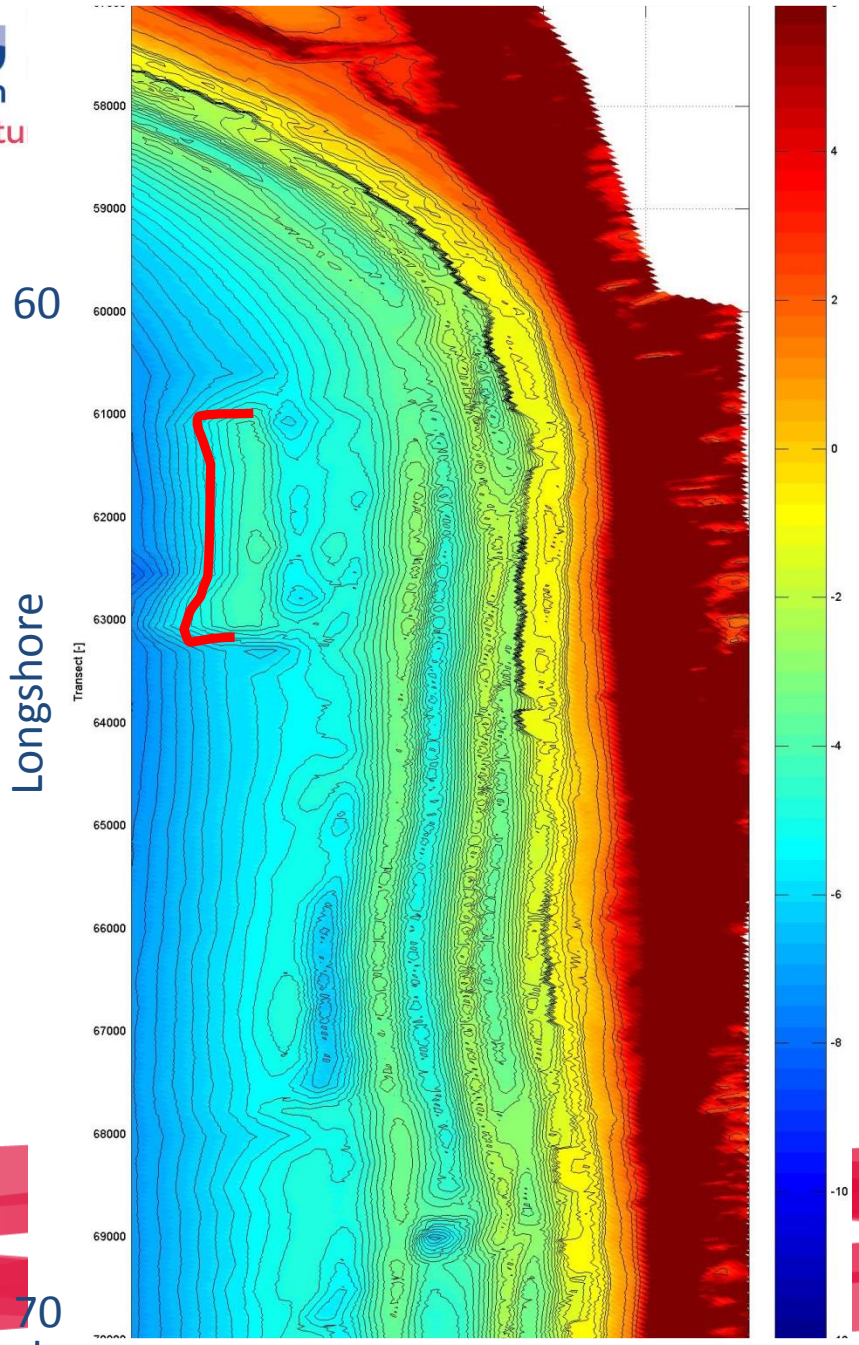
2009



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

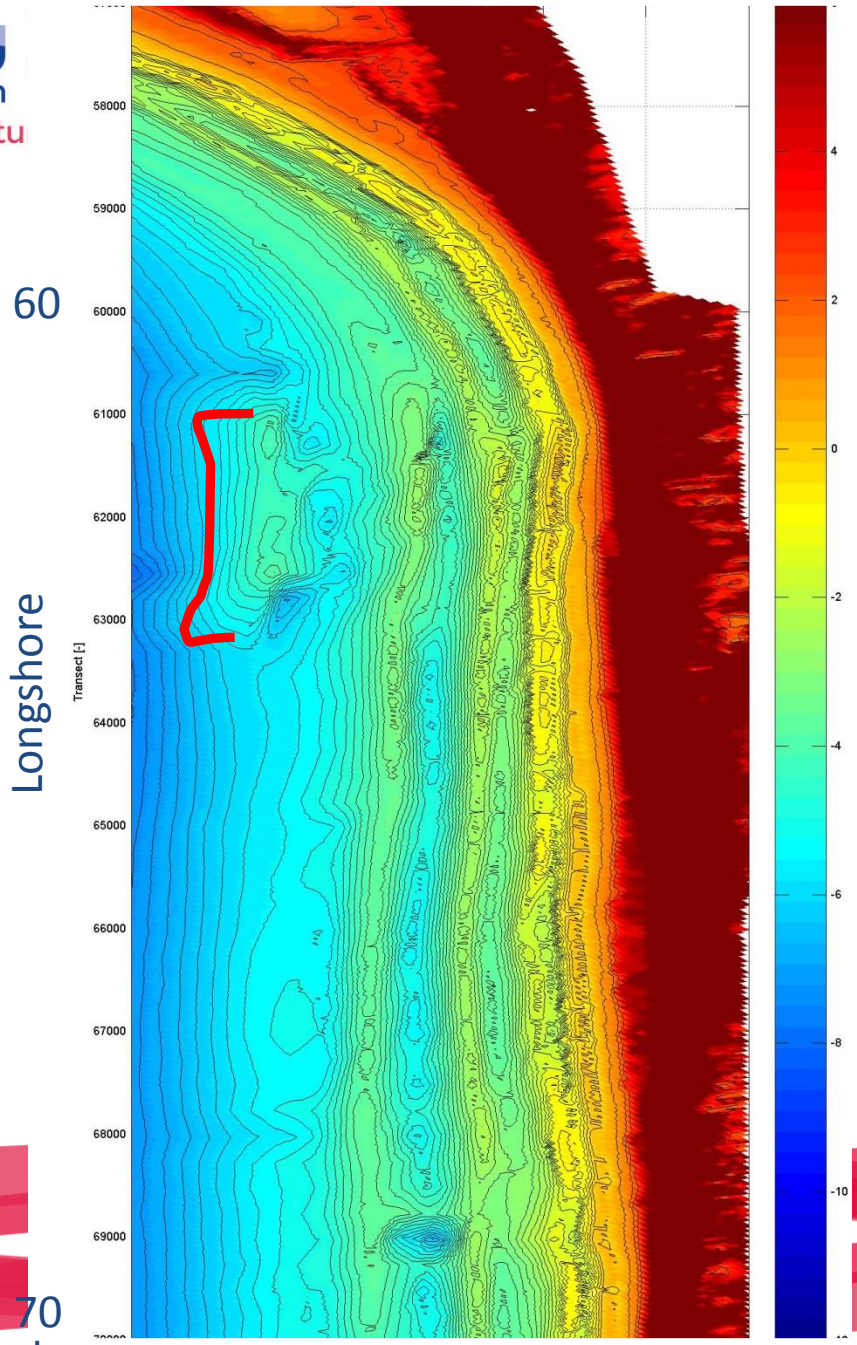
2010



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

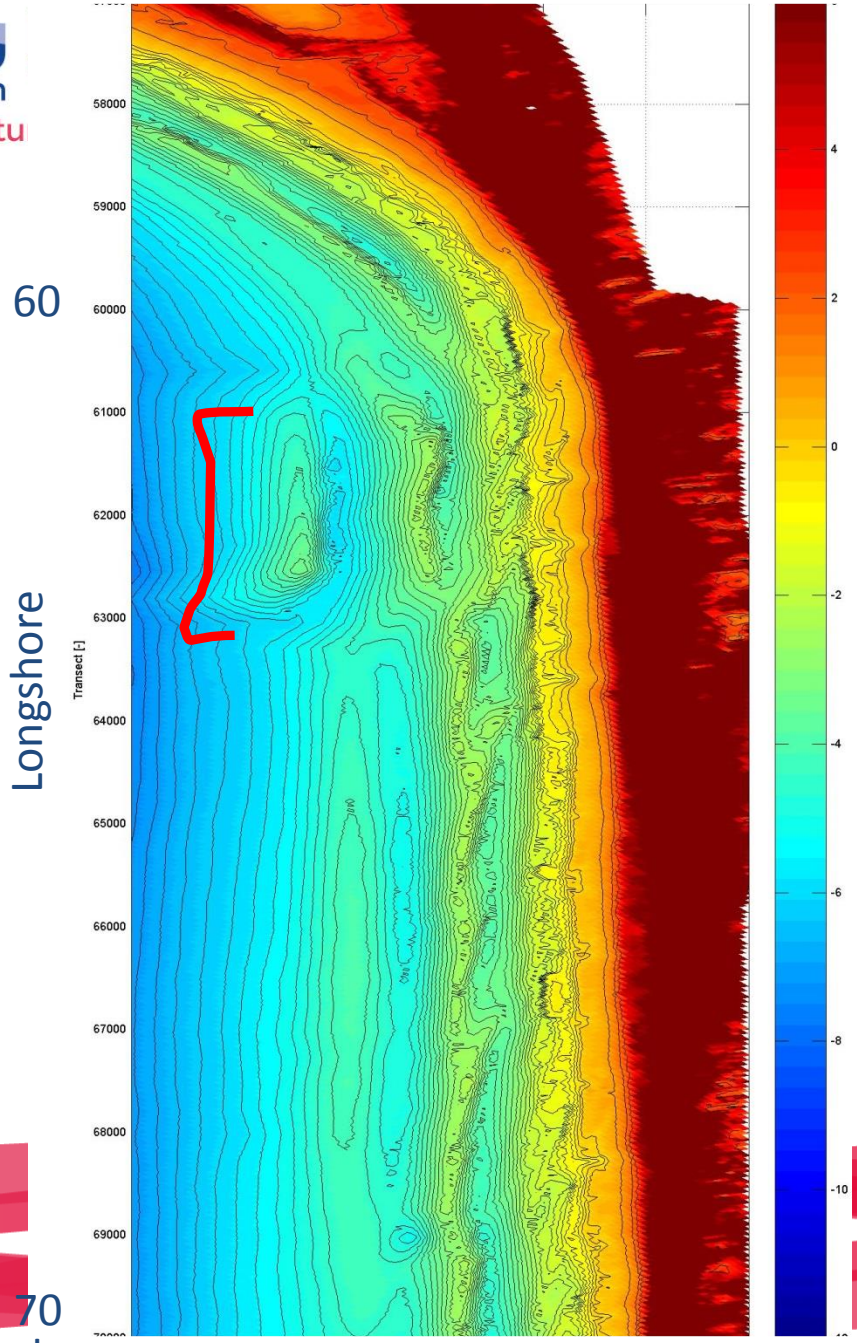
2011



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

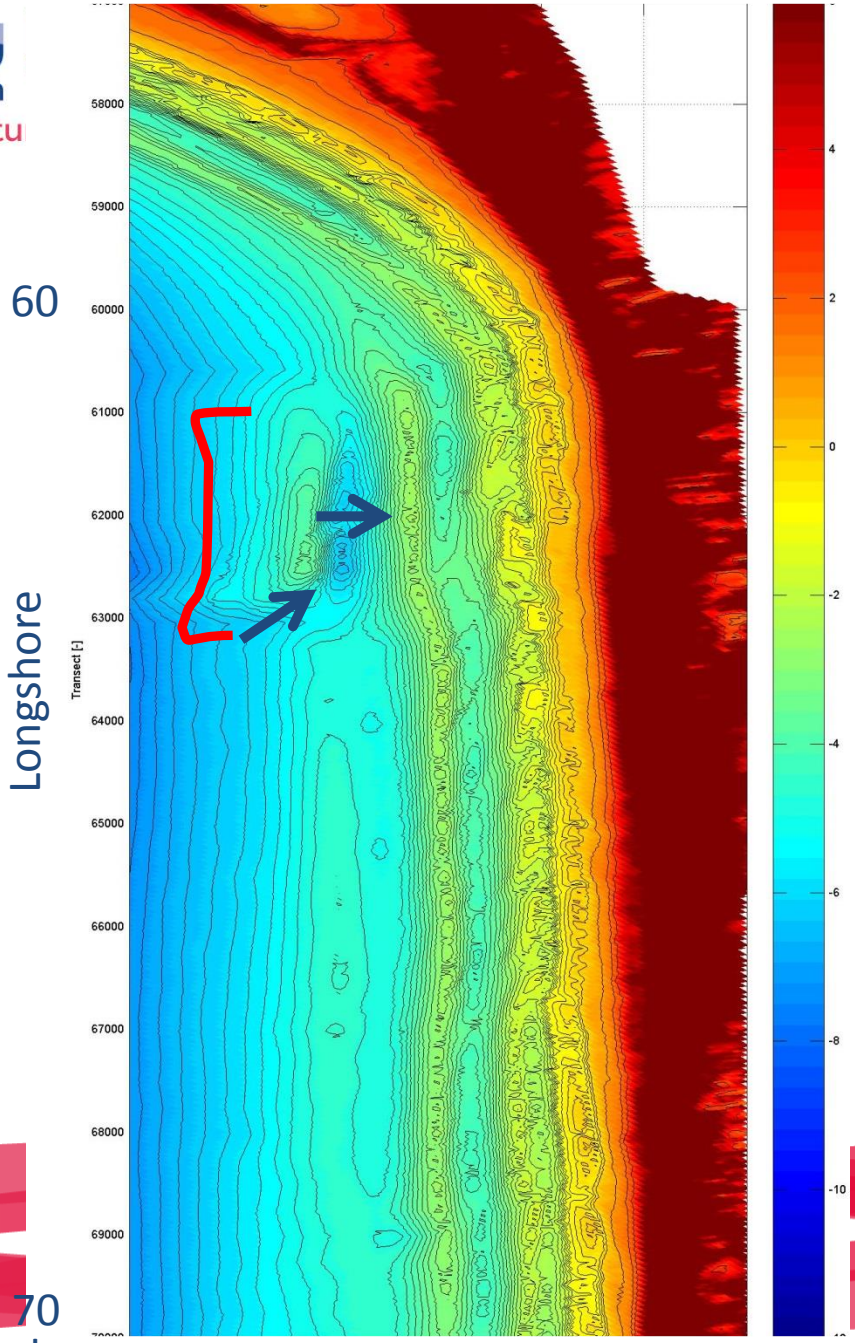
2012



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

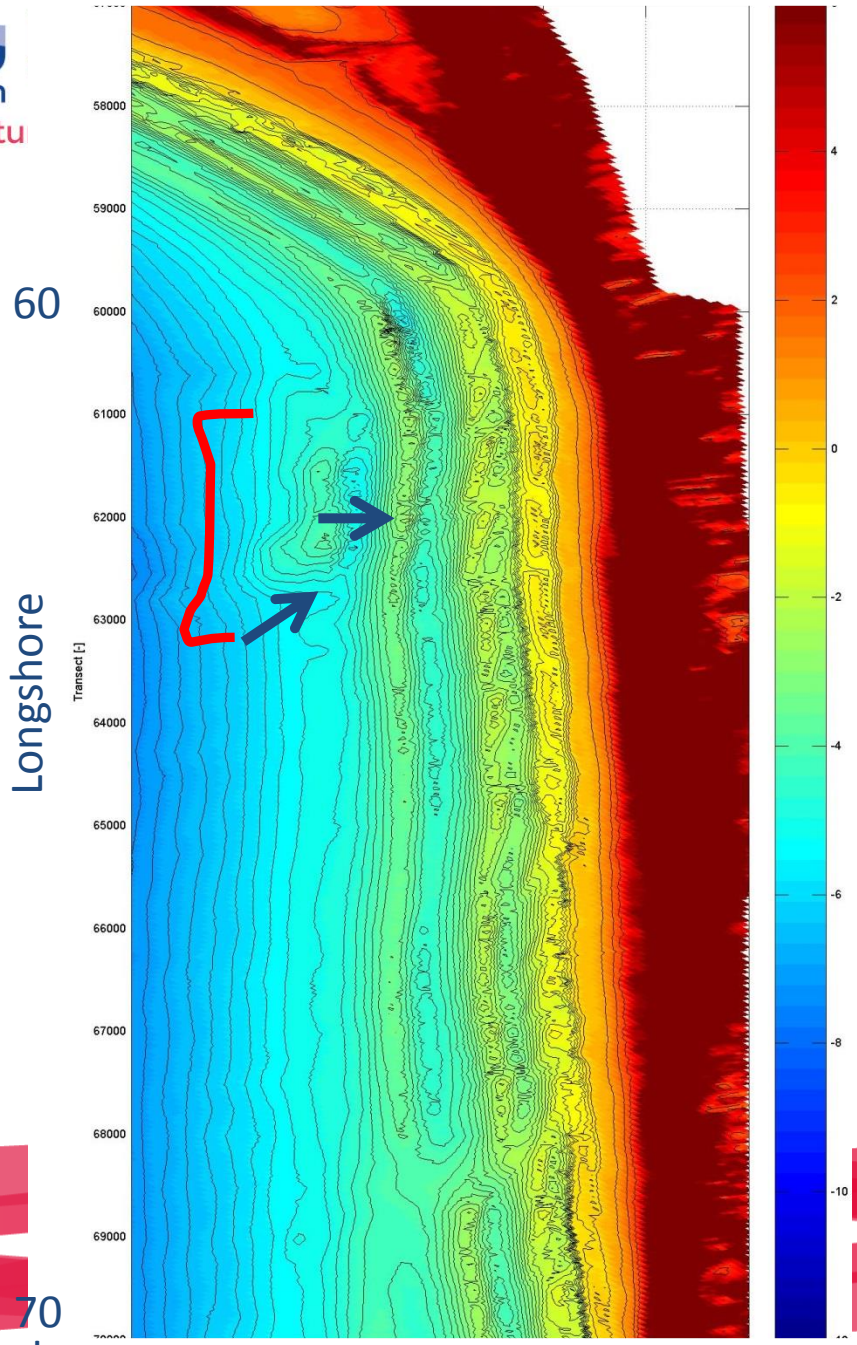
2013



Interreg
North Sea Region
Building with Natu
European Regional Development Fund

NL
Zandvoort

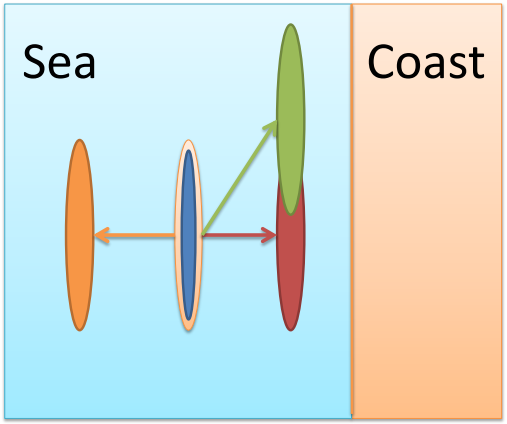
2014

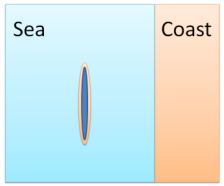
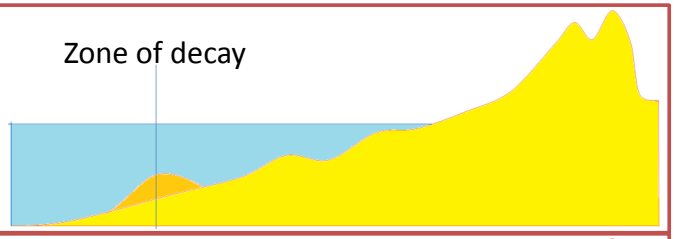
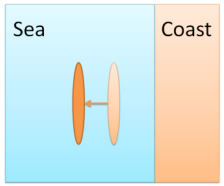
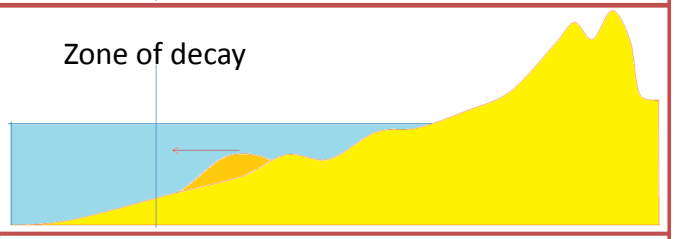
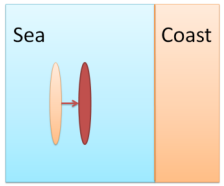
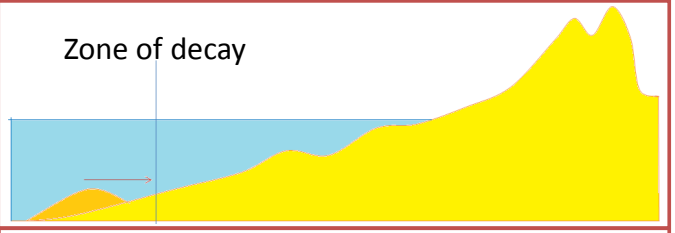
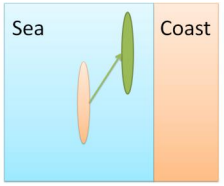
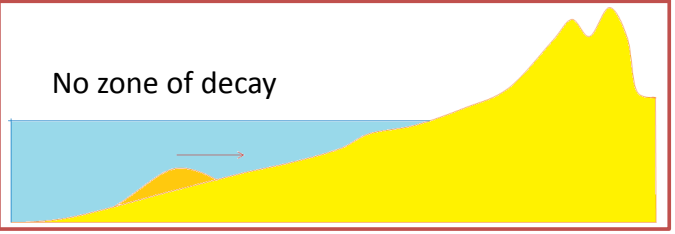


Interreg
North Sea Region
Building with Nature
European Regional Development Fund

+ Blue circles, primarily Cross-Shore migration

+ Green circles, primarily Cross and Long Shore migration

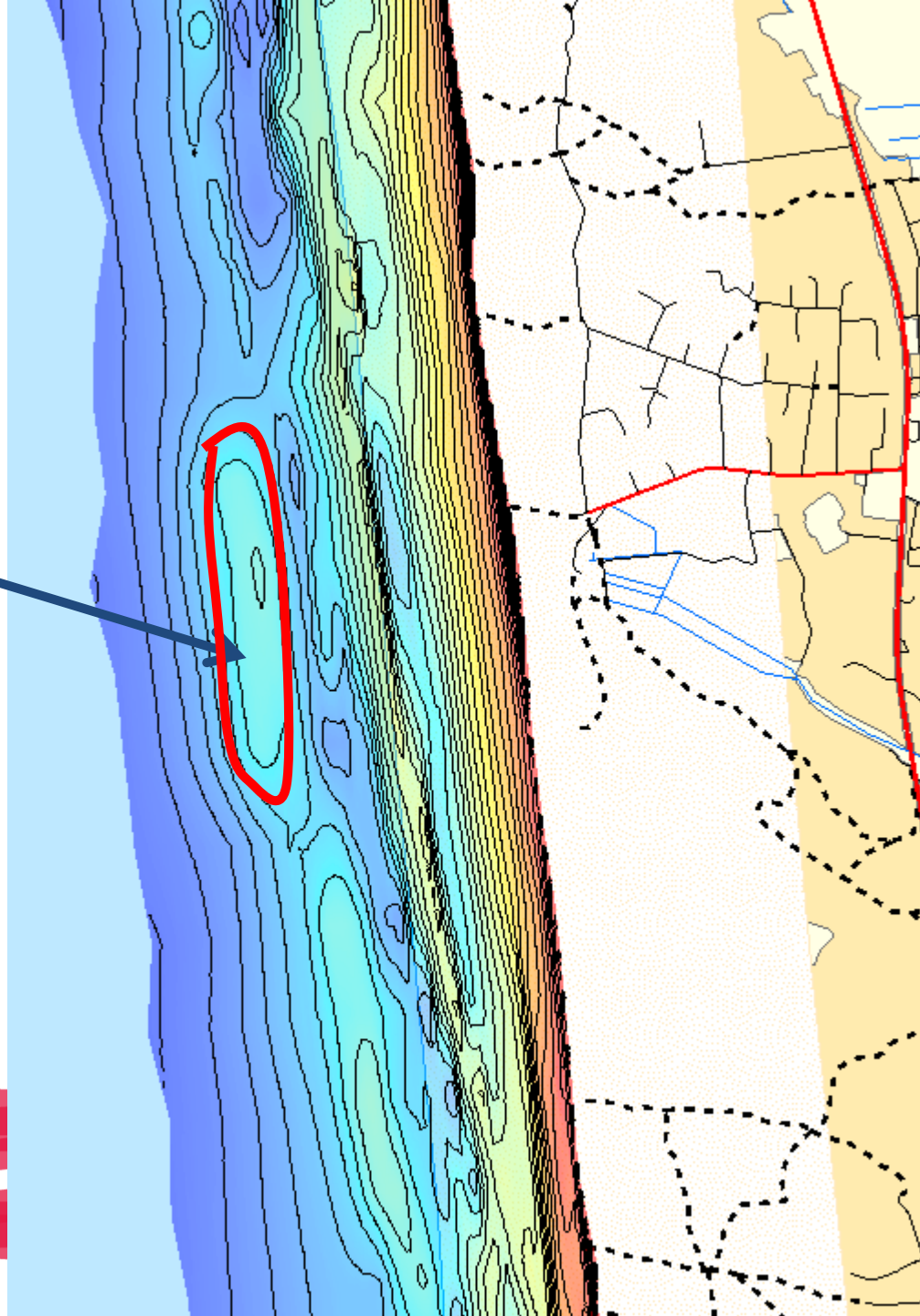


Original cross-shore bar behaviour		
		
		
Original alongshore or no bar behaviour		

Project partner	Flood risk reduction goal	Policy goals (criteria)	Compensate erosion goal	NBS/BwN in policy	Nourishment type (Beach / shoreface)
1. DCA (Denmark, central North Sea coast)	Yes	$P(f):\frac{1}{100}$, exceptional $P(f):\frac{1}{1000}$ (Hold the line)	Yes*	Yes	Both
2. LKN.SH (Germany)	Yes	(Hold the line)	Partly	Yes	Both
3. NLWKN (Germany)	Yes	Protect other functions (Hold the line and dune safety)	No	Yes	Beach
4. RWS (Netherlands)	Yes	1) $P(f):\frac{1}{300}$ $up\ to$ $P(f):\frac{1}{100.000}$ 2) Protect coastal functions (Hold the line)	Yes	Yes	Both
3. MDK (Belgium)	Yes	1) $P(f):\frac{1}{1000}$ 2) No fatal casualties allowed (Hold the line)	No	Yes	Beach and experimental shoreface
3. LST (Sweden)	No	Shoreline protection (Building prohibited within range coastal zone)	No*	No	Beach and experimental shoreface

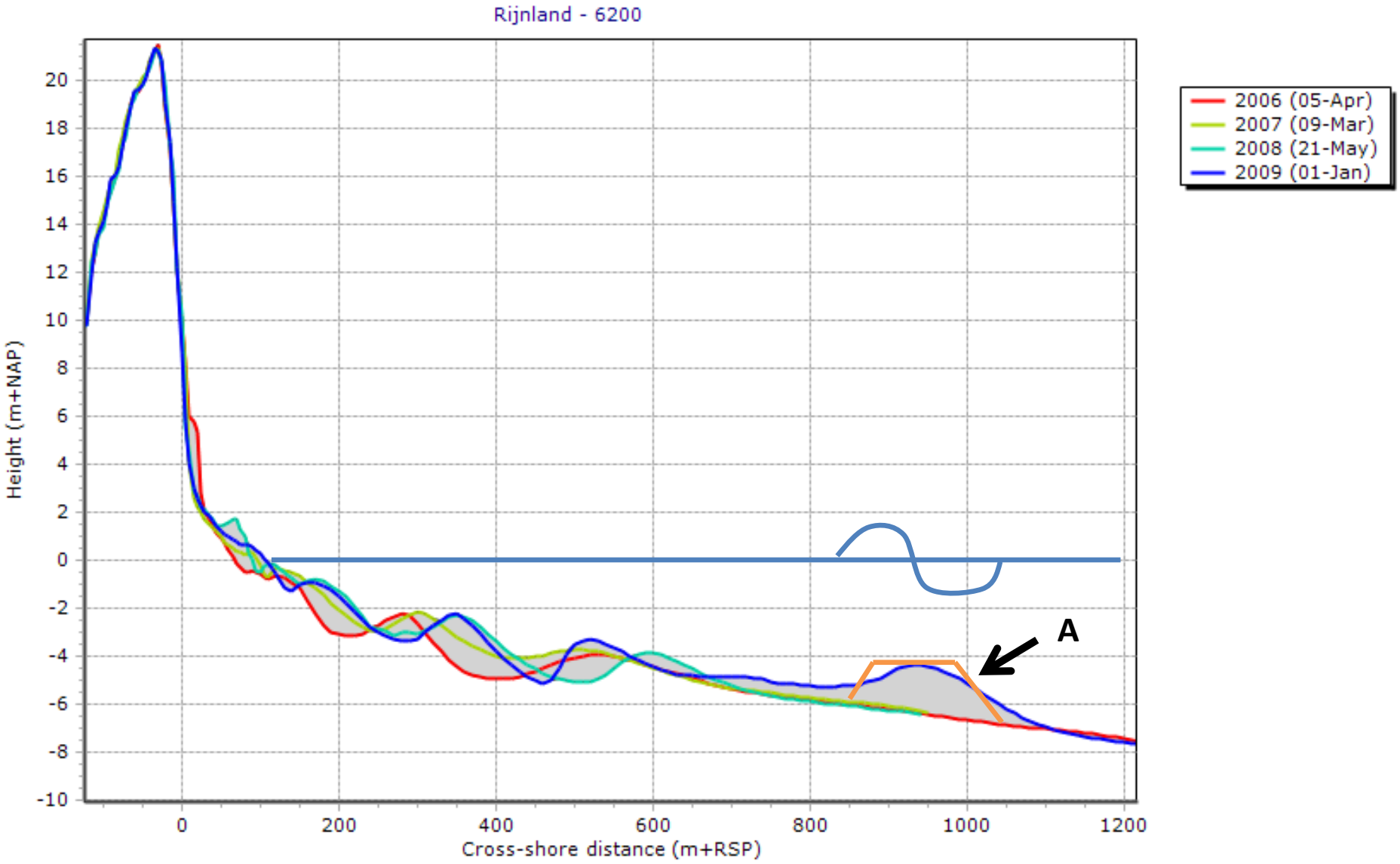
DK

Shoreface nourishment



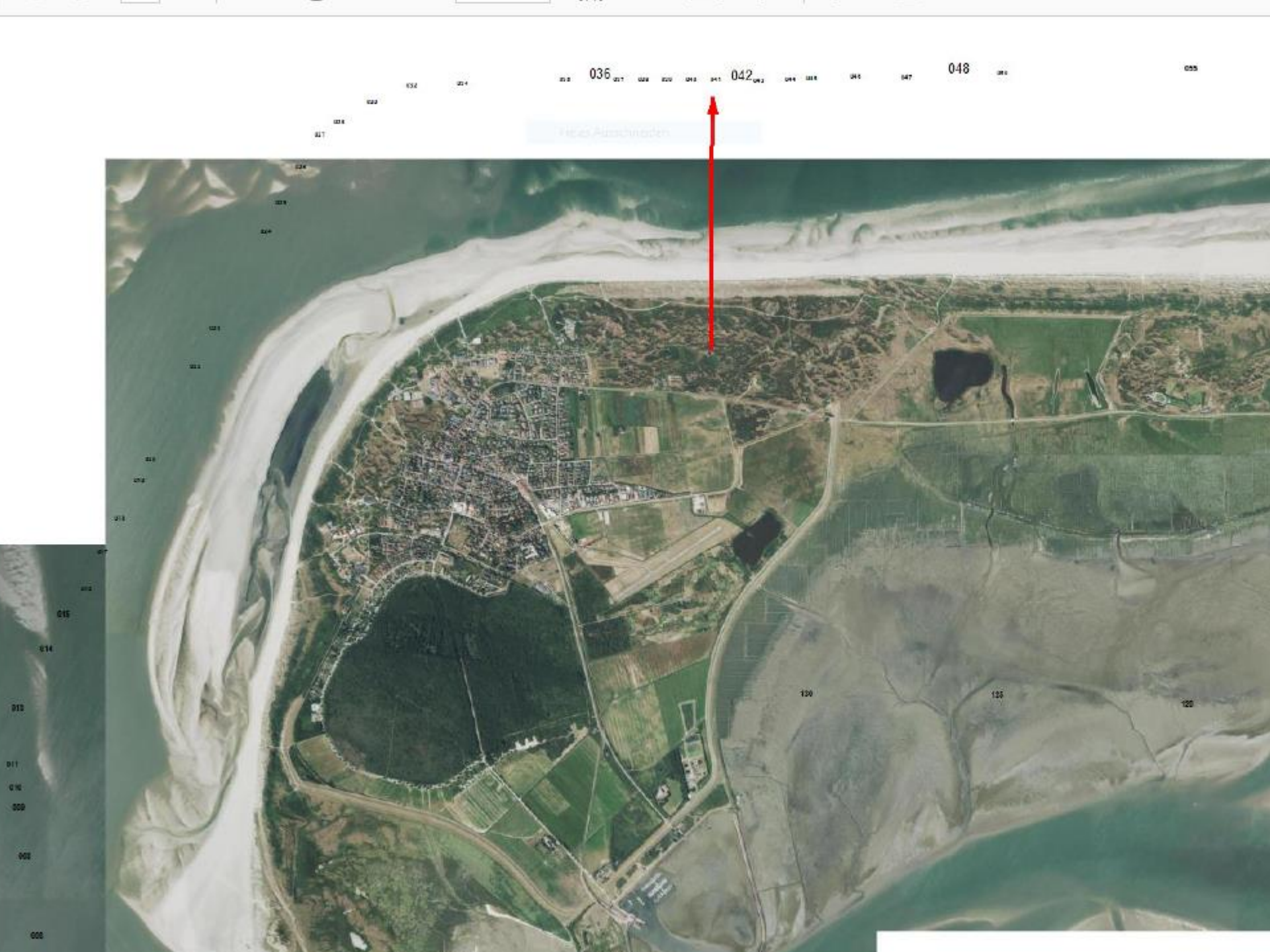
Interreg
North Sea Region
Building with Nature
European Regional Development Fund

NL

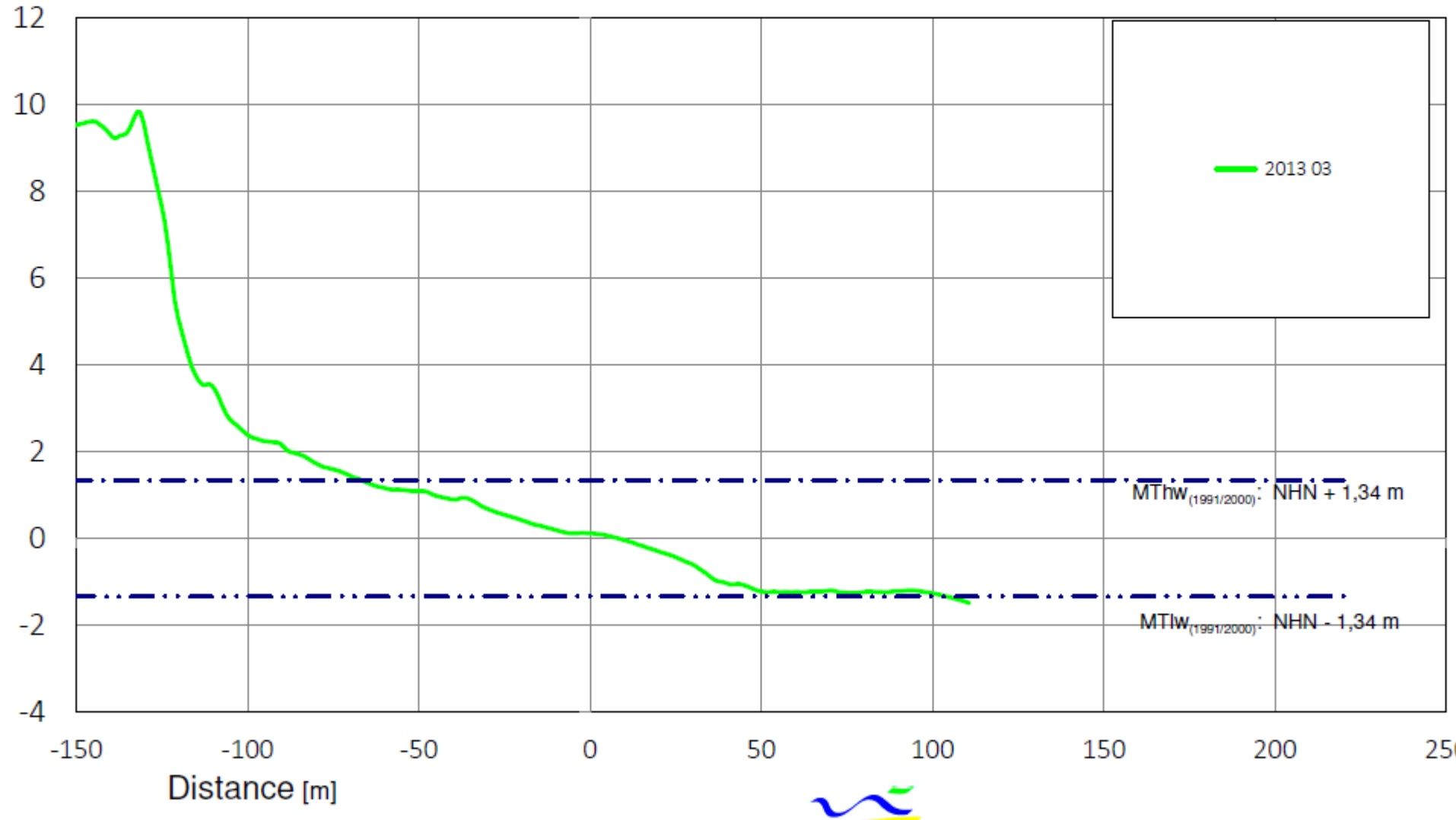


Design Parameters

Country	Location	Year	Position (km-km)	Volume (Mm^3)	Volume per m (m^3/m)	D50 Nourished (µm)	Placement depth (m i.r.t. MSL)
NL	Zandvoort 1	2004	62.75 - 67.75	2.2	440	250 – 300	-4
NL	Bloemendaal	2008	61 – 63	1.0	500	250 – 300	-5
NL	Zandvoort 2	2008	67.75 - 70.25	0.5	200	250 – 300	-5
DK	Sdr. Holmsland Tange	2010	11.6 - 21.0	7.7	57	300 – 400	-5
Dk	Skodbjerge North	2011	17.2 - 18.0	0.3	400	300 – 400	-5
DK	Skodbjerge South	2011	13.8 - 14.6	0.3	400	300 - 400	-5

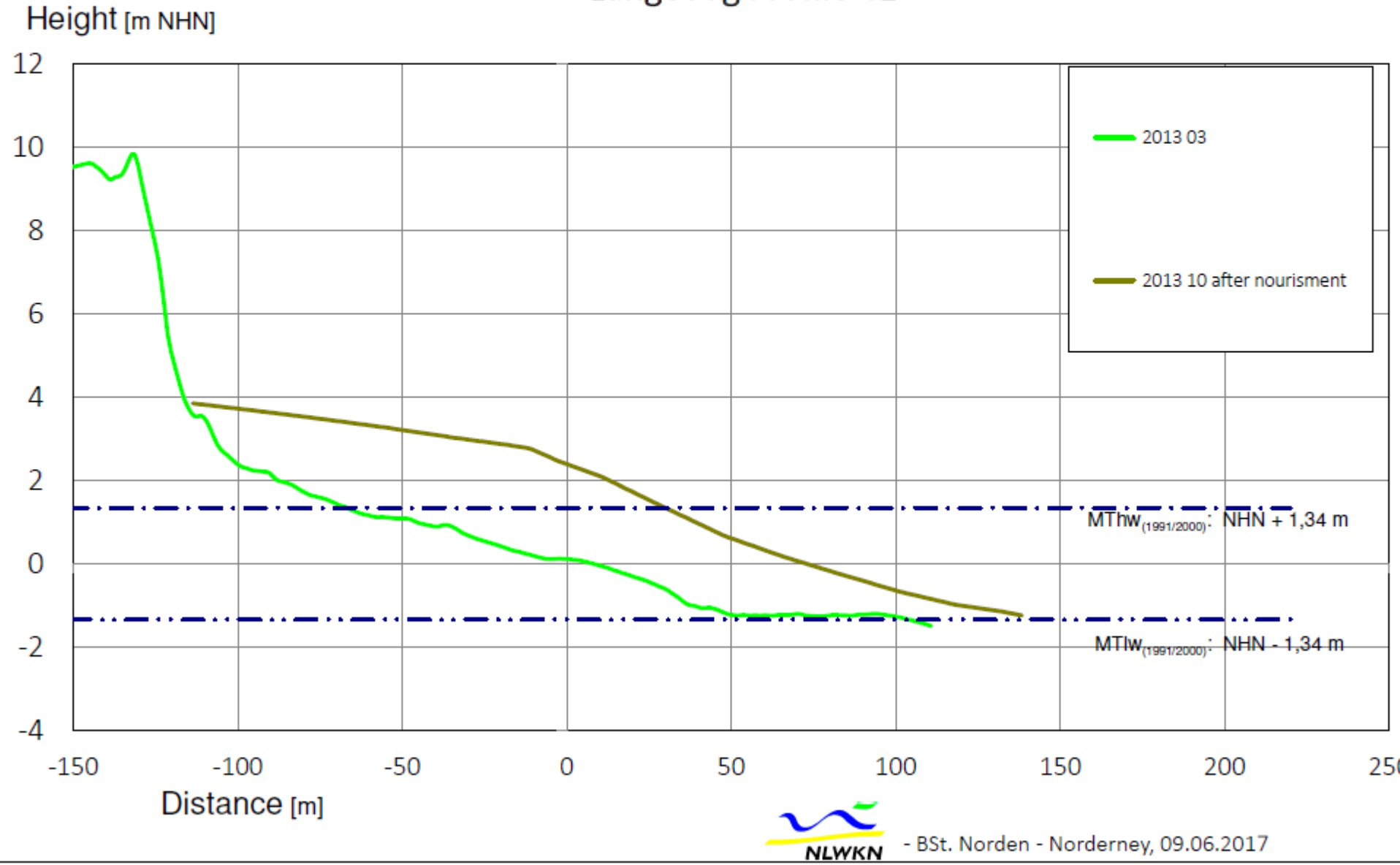

036
042
048

Langeoog Profile 41



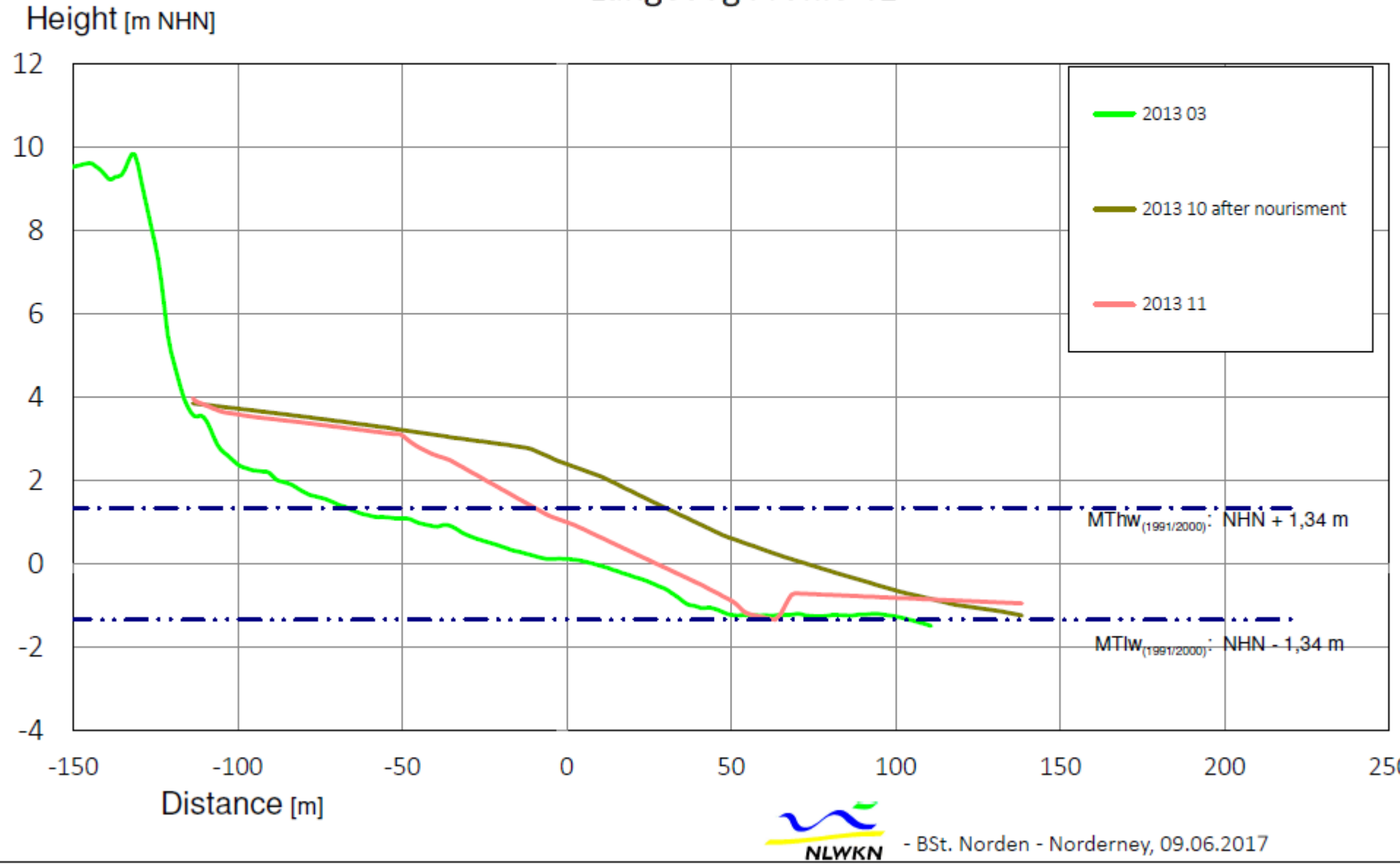
NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



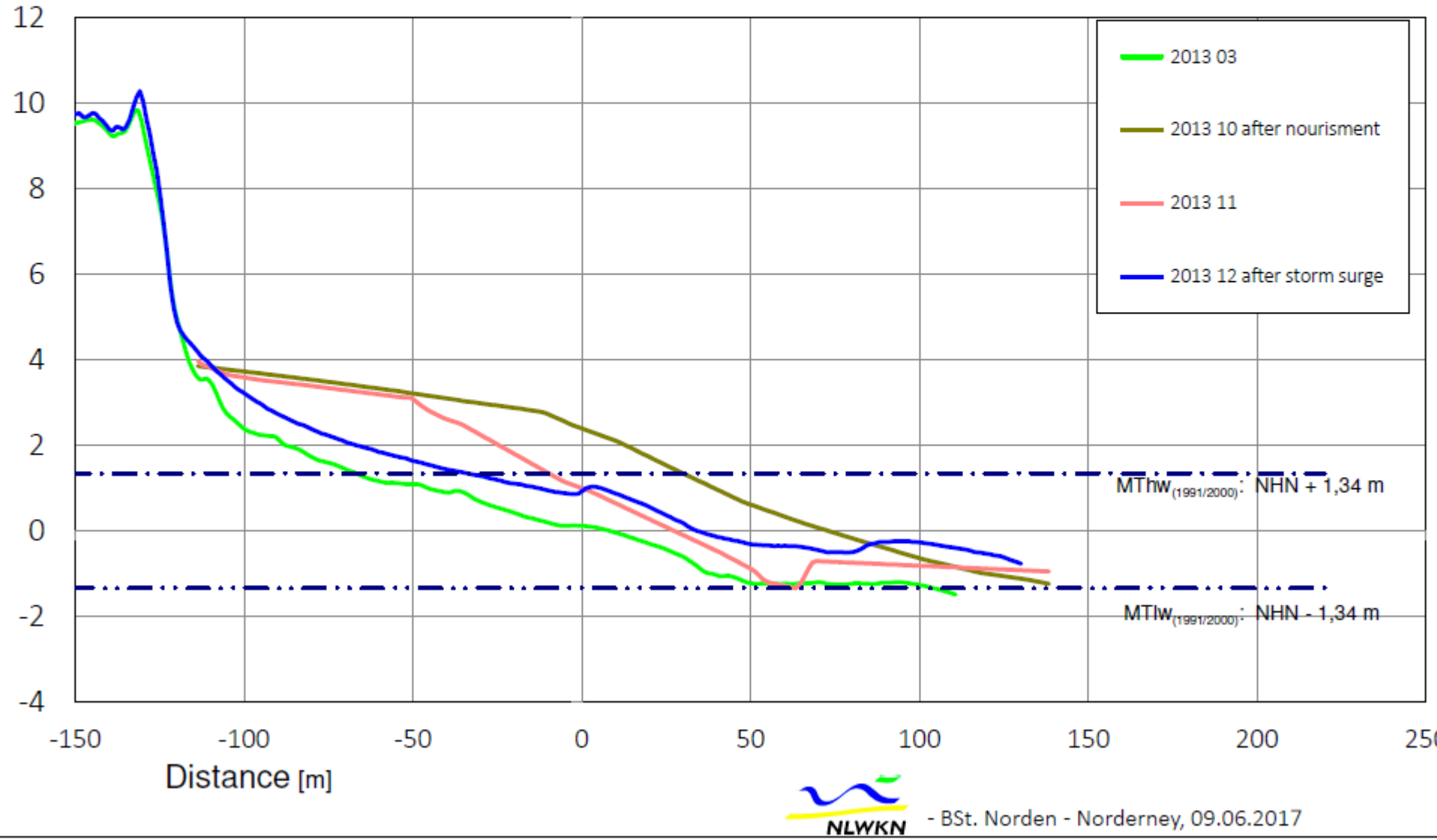
NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



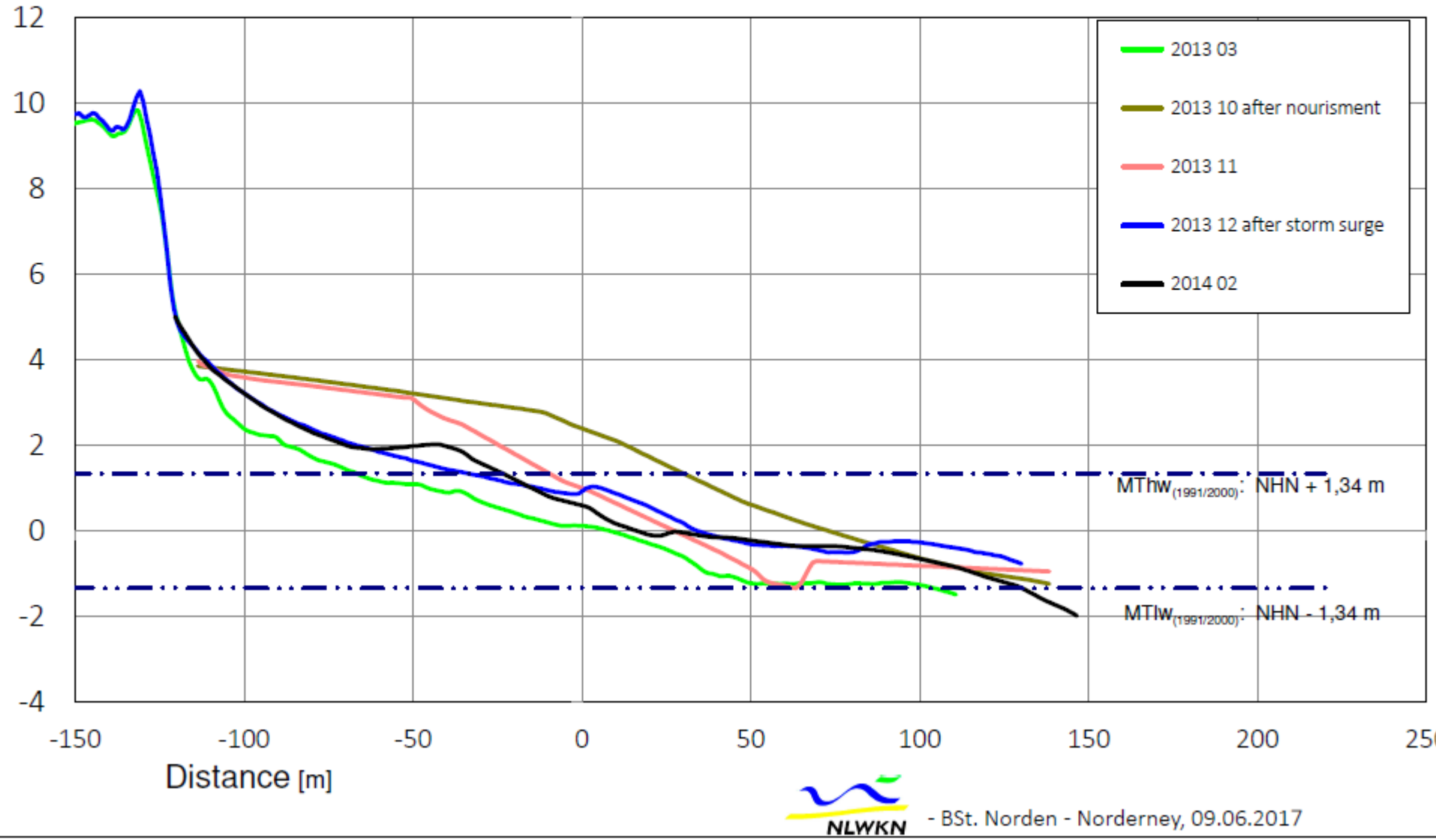
NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



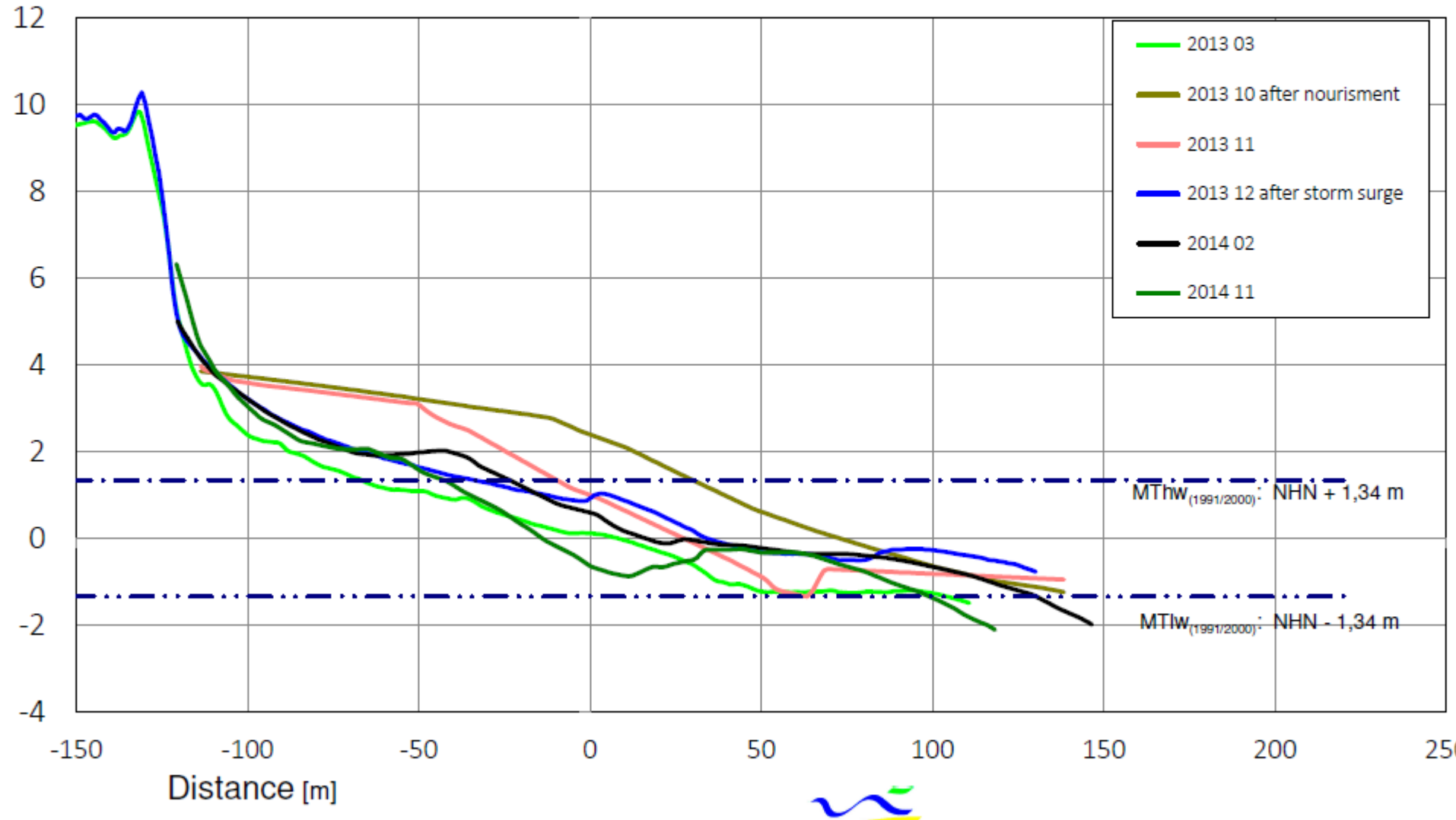
NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



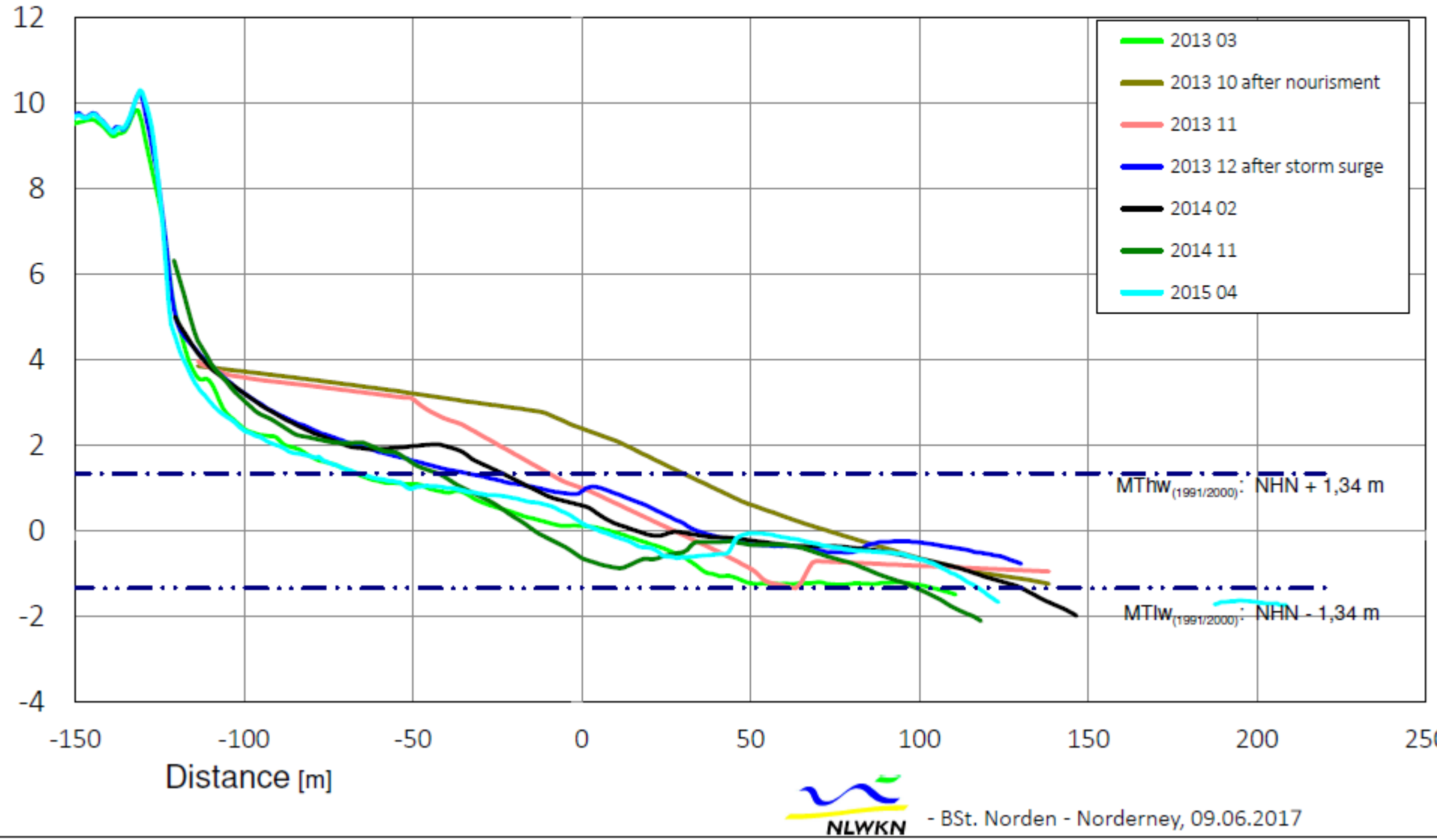
NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



NLWKN - BSt. Norden - Norderney, 09.06.2017

Langeoog Profile 41



NLWKN - BSt. Norden - Norderney, 09.06.2017

Interreg
North Sea Region
Building with Nature
European Regional Development Fund