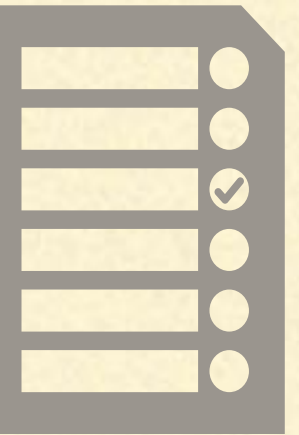


LONG-TERM EVOLUTION OF THE NORTHERN FRANCE COASTAL ZONE AND INFLUENCE ON HYDRODYNAMIC

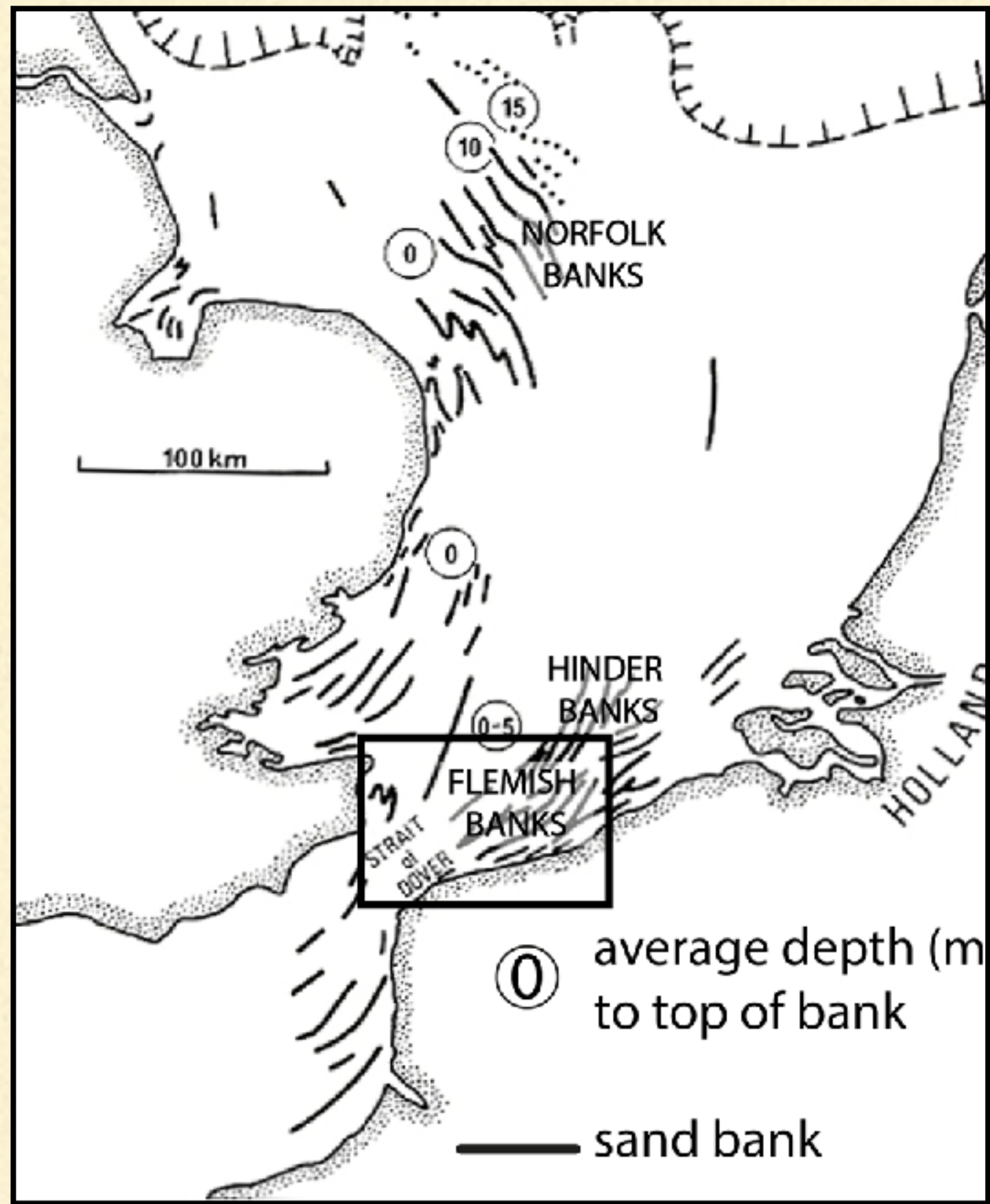
LATAPY Alexa (ULCO),
HEQUETTE Arnaud (ULCO),
NICOLLE Amandine (ENSTA Bretagne),
POUVREAU Nicolas (Shom),
WEBER Nicolas (Shom),
ROBIN—CHANTELOUP Jean-Baptiste (Univ. la Rochelle)



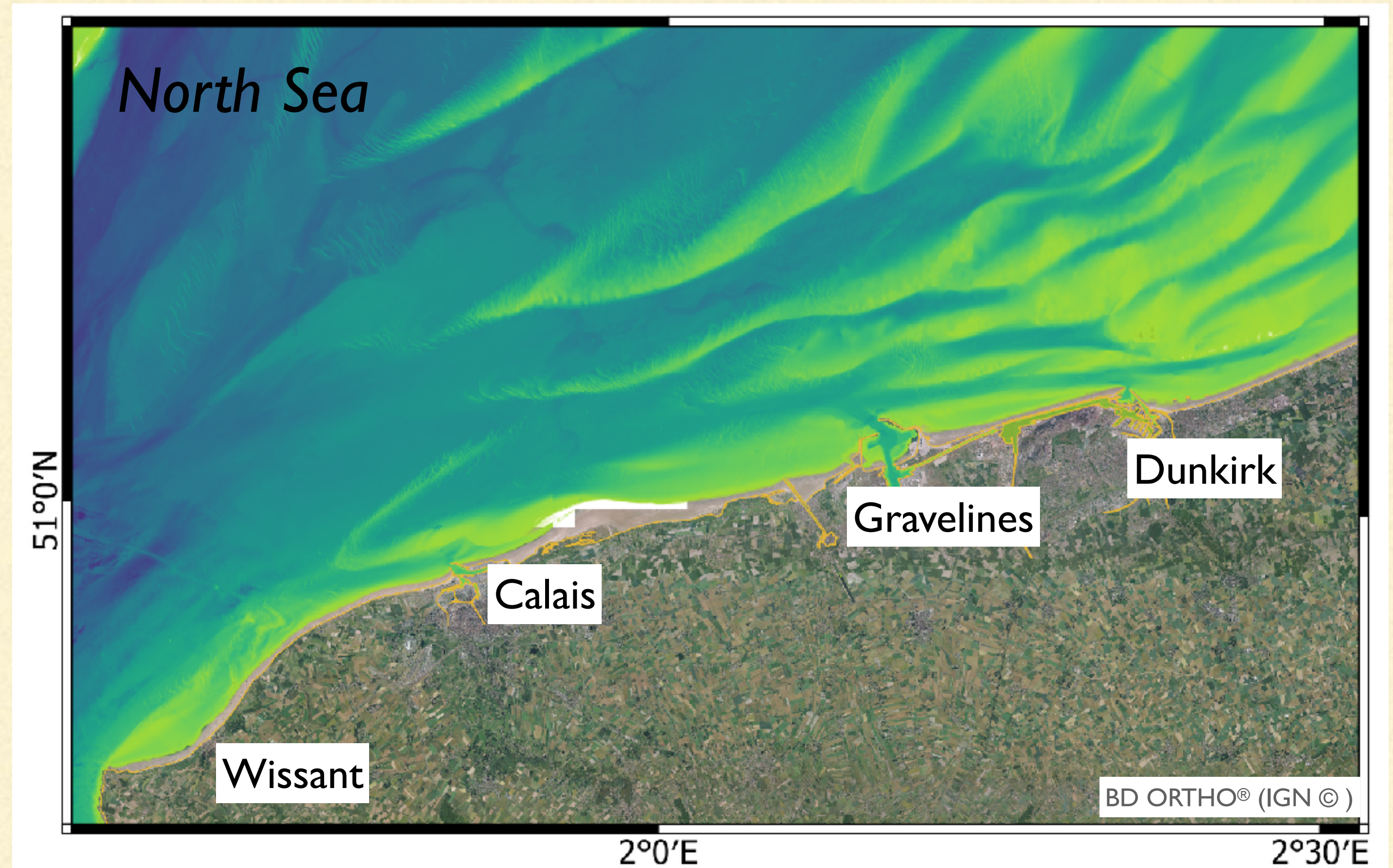
INTRODUCTION



- Seabed morphology $\Leftrightarrow$ hydrodynamic & sediment transport
(MacDonald & O'Connor, 1996 ; Thomas et al., 2011)



from Kenyon et al. (2009)



DEM HOMONIM (Shom, 2015) - diffusion.shom.fr

PROBLEMATIC

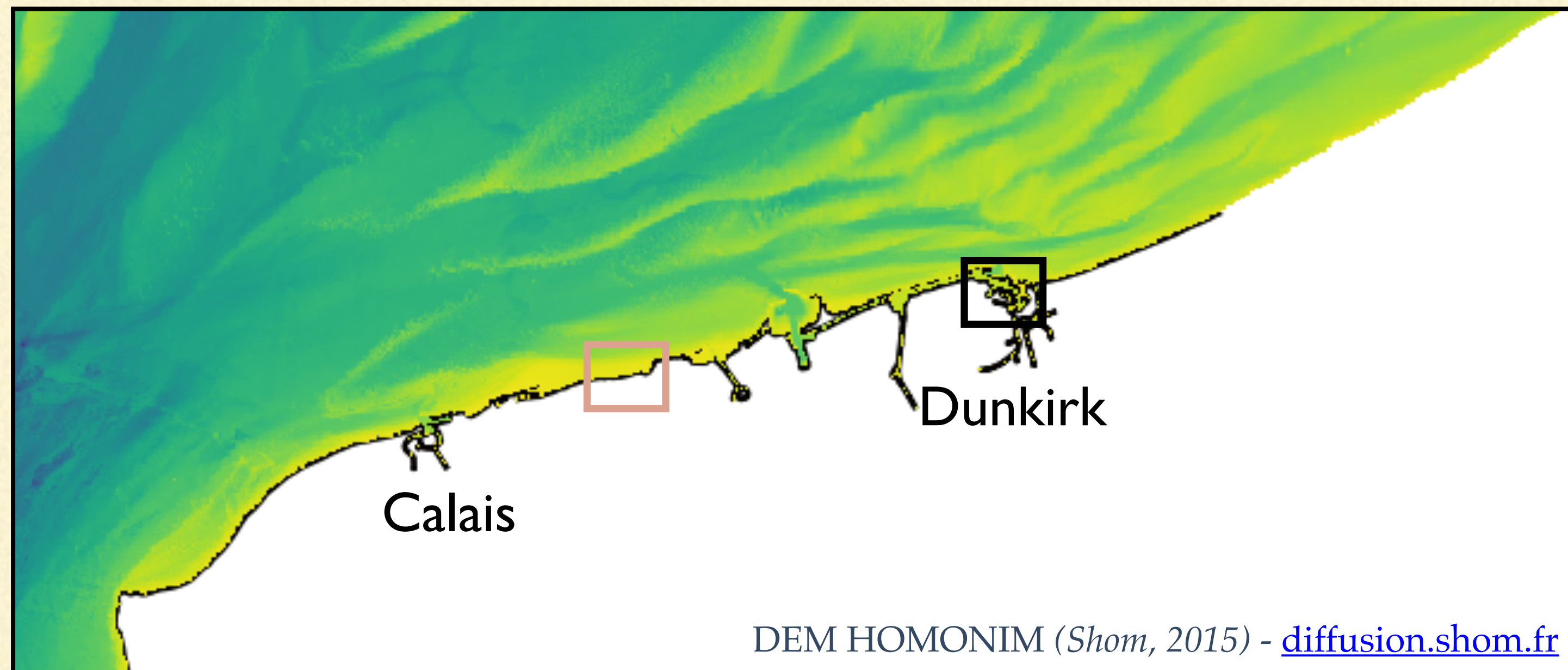
- How the seabed changed in almost two centuries along the Northern France coast ?
- What are the influence of coastal and morphological changes on hydrodynamic circulation ?

REGIONAL SETTING



MORPHOLOGICAL CHARACTERISTICS

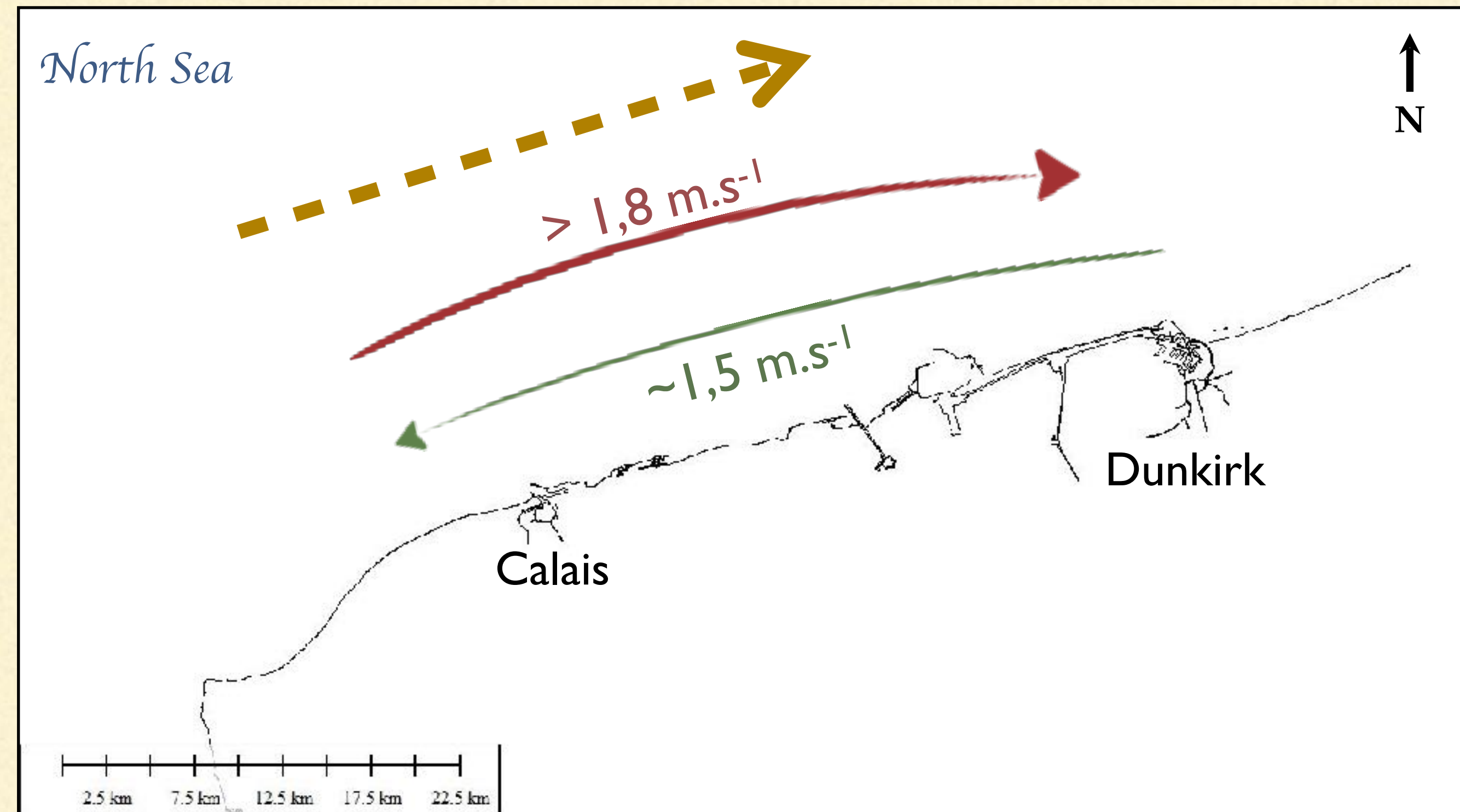
- Sandy beaches (wide, gently sloping)
- Anthropogenic impact : extension of the Dunkirk and Calais harbors
- Flemish sand banks (10-30 km long & 1-3 km wide)



www.megaconstrucciones.net

HYDRODYNAMIC

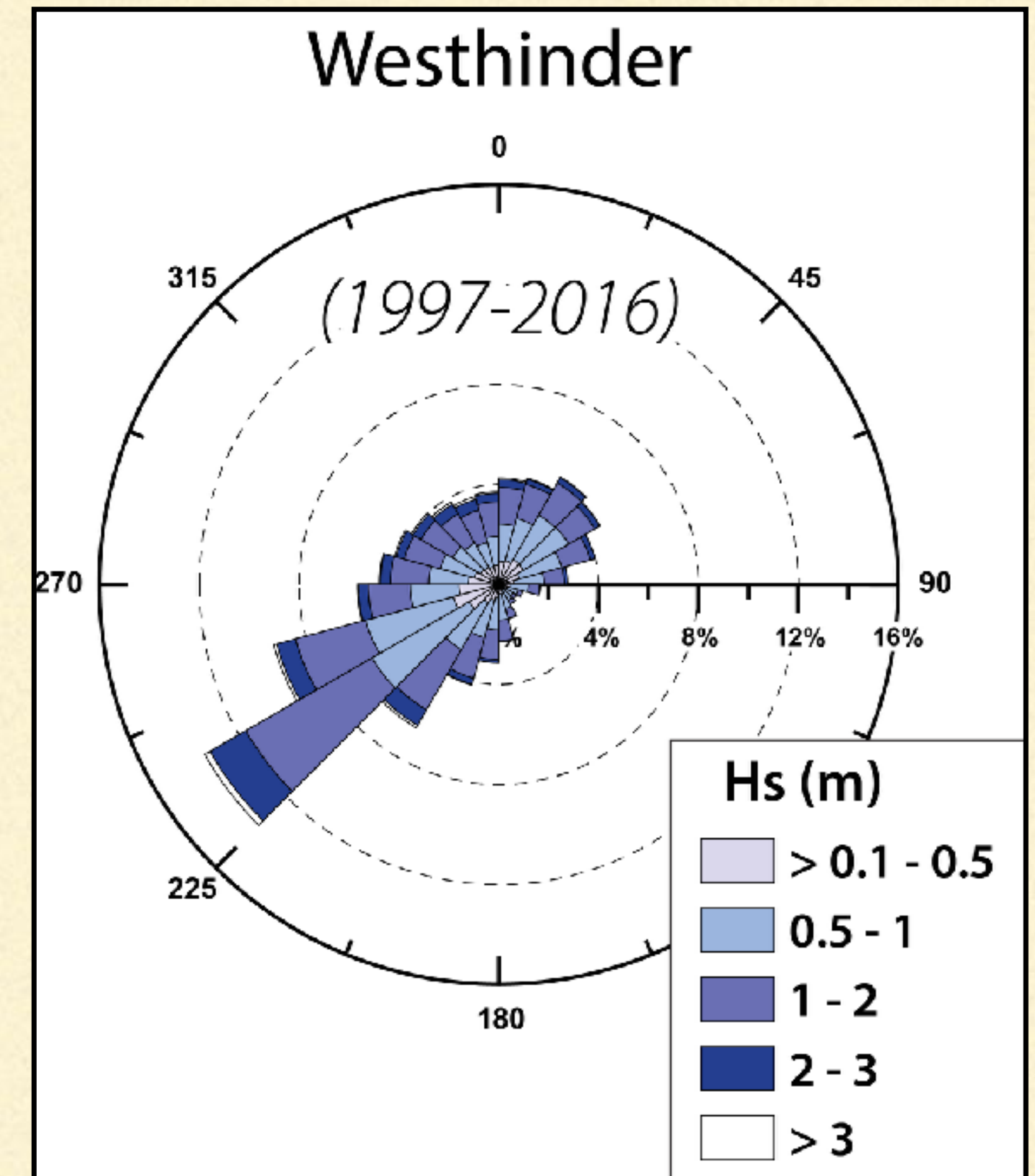
- Tide regime : semi-diurnal & macrotidal
- Strong tidal currents (**flood** > **ebb**) (Shom, 2014) → flood-dominated asymmetry (Héquette et al., 2008) → **net regional sediment transport** to the ENE



HYDRODYNAMIC

- Modal wave height : 0.6 m
- Period : 4-8 s
- Significant shoaling + energy dissipation over sand banks

Wave rose at the Westhinder buoy (1997-2016) (*Spodar et al., 2018*)

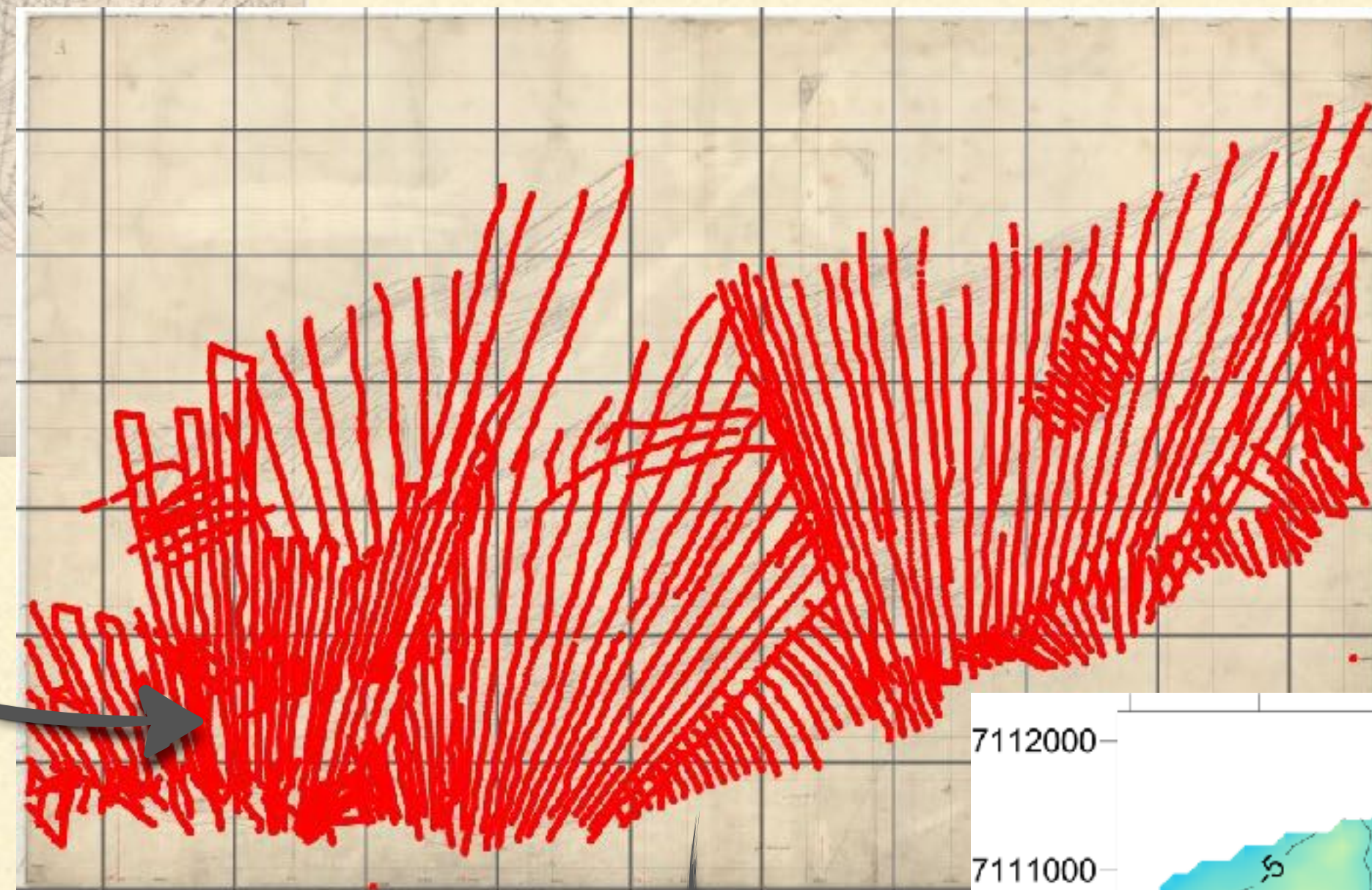


METHODOLOGY

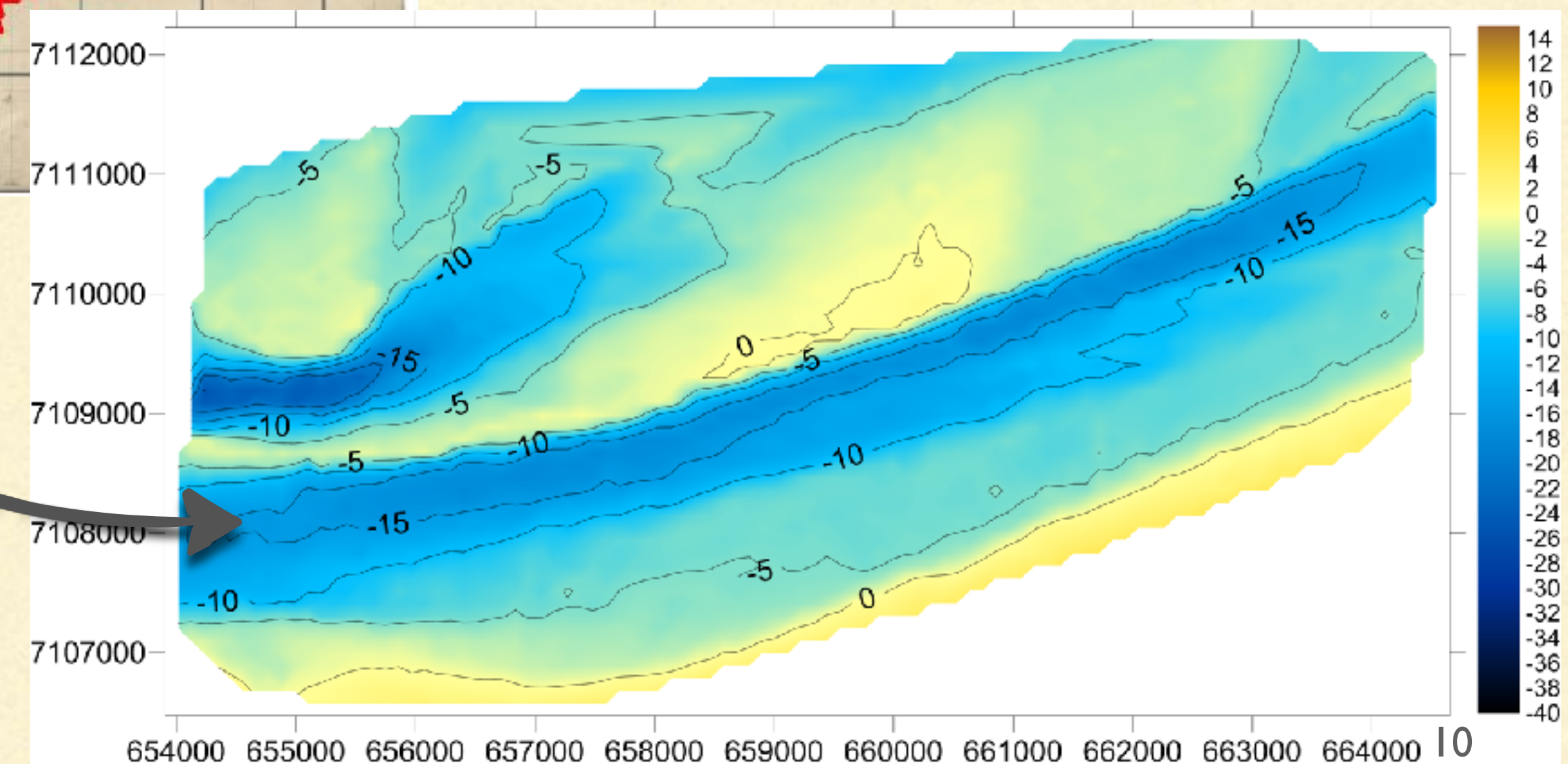


DIGITALIZATION OF OLD BATHYMETRIC CHARTS

ScanBathy
(GEBCO, 2016) :
Depth soundings
digitalization



- Export
- Conversion in present day geodesic system
- Positionning control
- DEMs



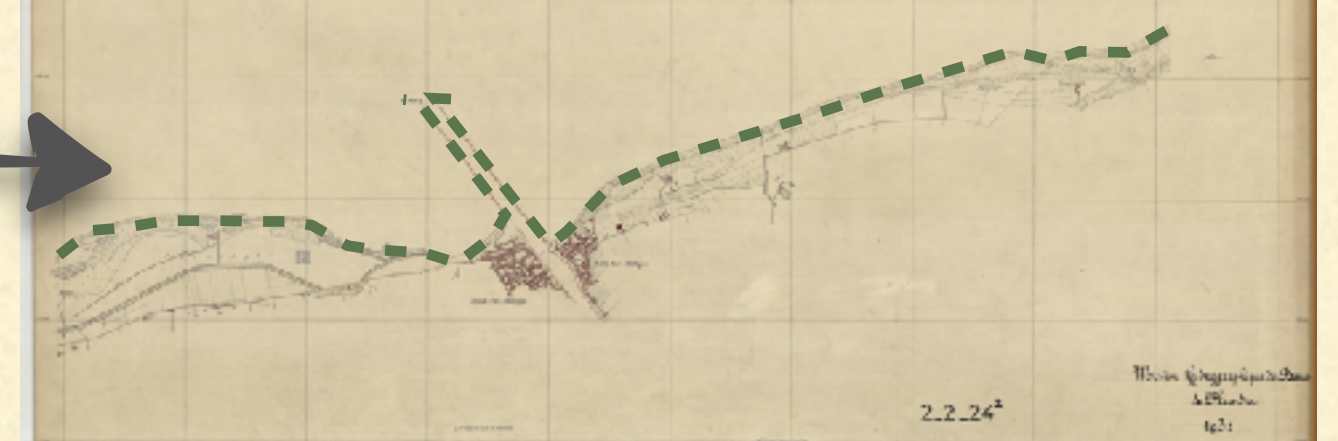
YEAR	SURVEY AREA
1836	Calais
1861	Dunkirk - Gravelines - Calais
1879	Dunkirk - Gravelines - Calais - Wissant
1894	Dunkirk
1910-1911	Dunkirk - Gravelines - Calais - Wissant
1929	Calais
1930-1932	Dunkirk - Gravelines - Calais
1962	Dunkirk
1974-1976	Gravelines - Calais - Wissant
1983	Calais
1994	Calais
2000	Dunkirk
2006	Dunkirk
2009	Calais

YEAR	SURVEY AREA
1836	Calais
1861	Dunkirk - Gravelines - Calais
1879	Dunkirk - Gravelines - Calais - Wissant
1894	Dunkirk
1910-1911	Dunkirk - Gravelines - Calais - Wissant
1921	Calais
1930-1931	Gravelines - Calais
1962	Dunkirk
1974-1976	Gravelines - Calais - Wissant
1983	Calais
1994	Calais
2000	Dunkirk
2006	Dunkirk
2009	Calais

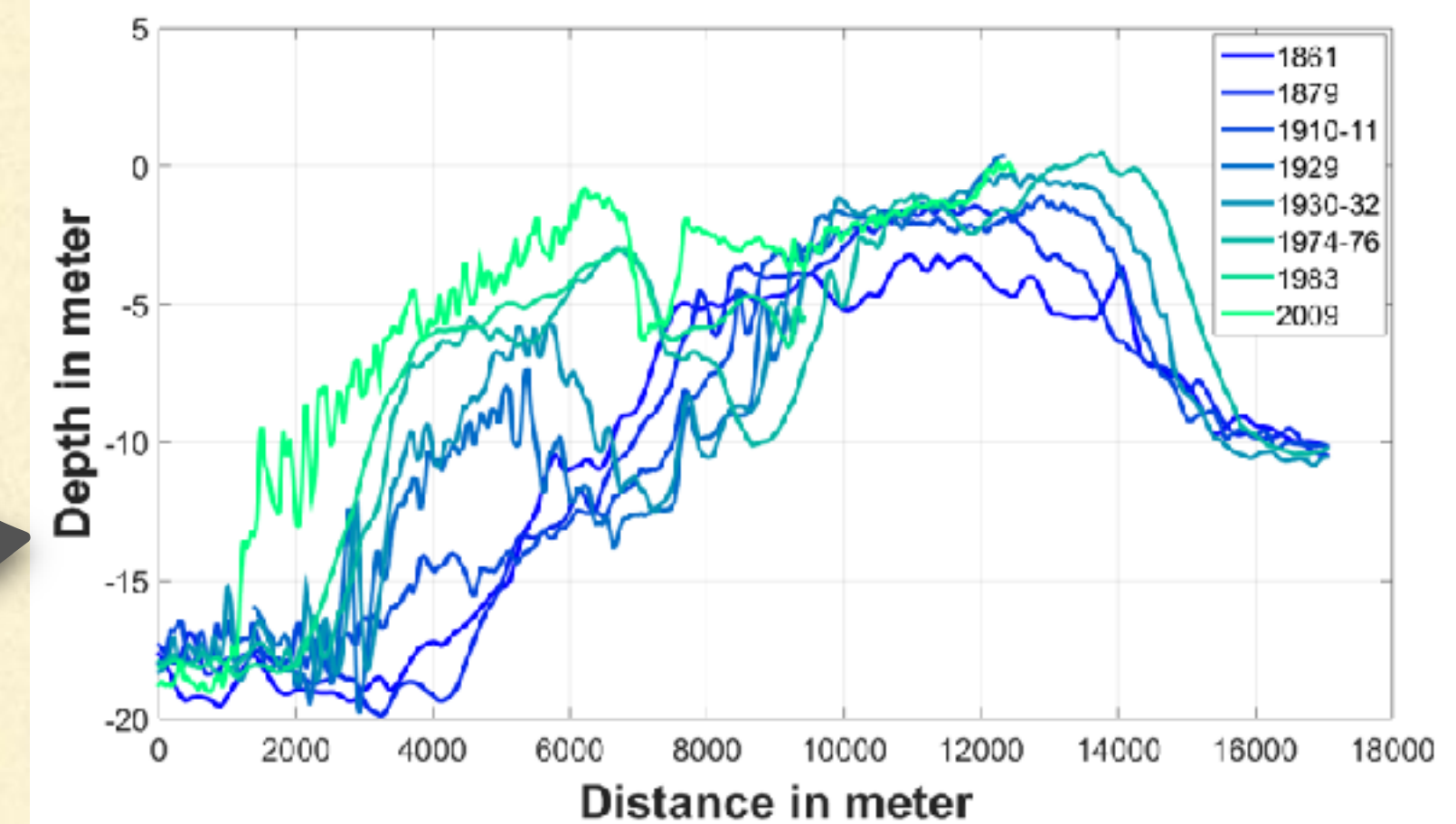
~350 000 soundings

QUANTIFICATION OF BATHYMETRIC CHANGES

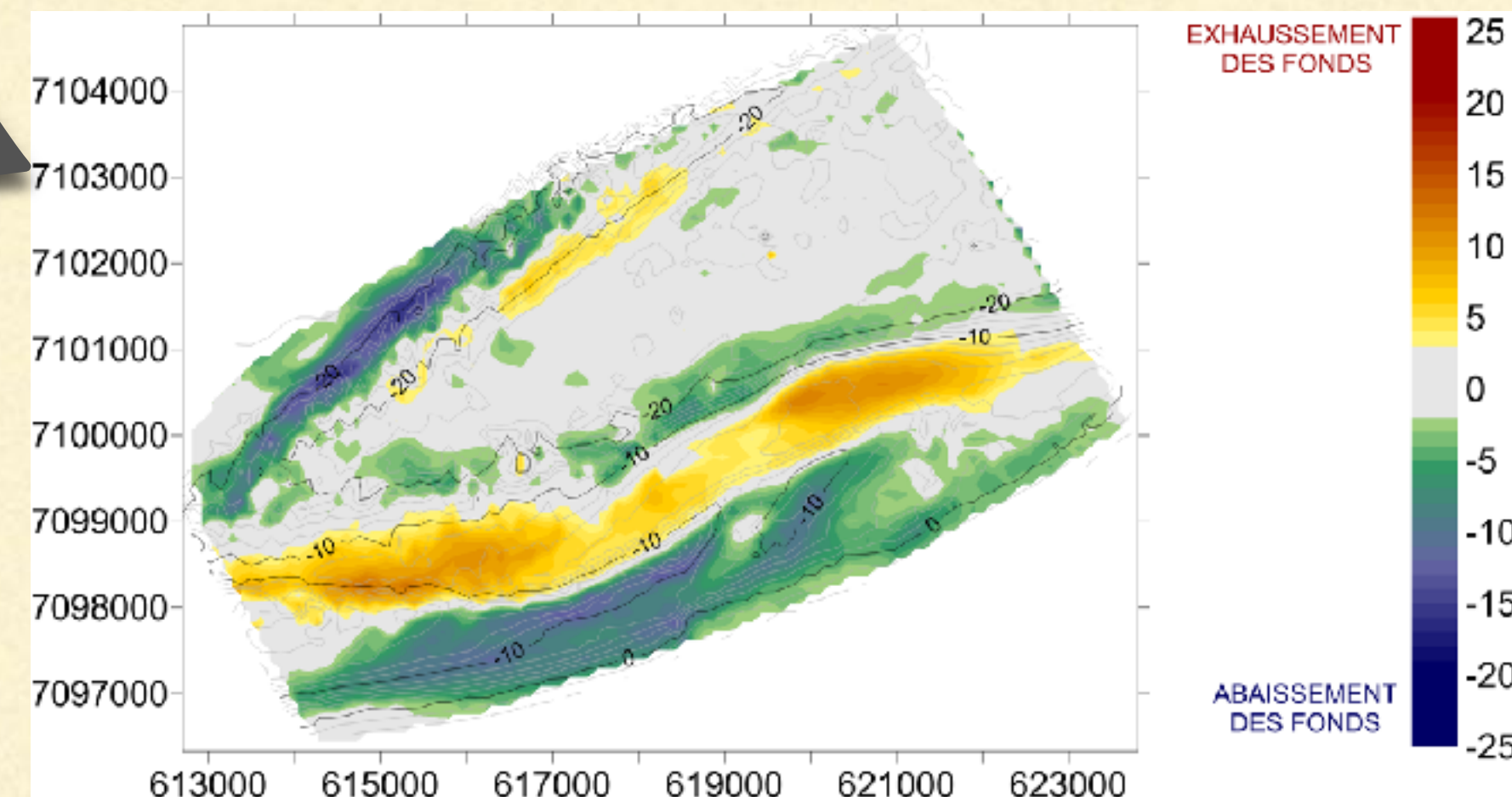
Shoreline digitalization



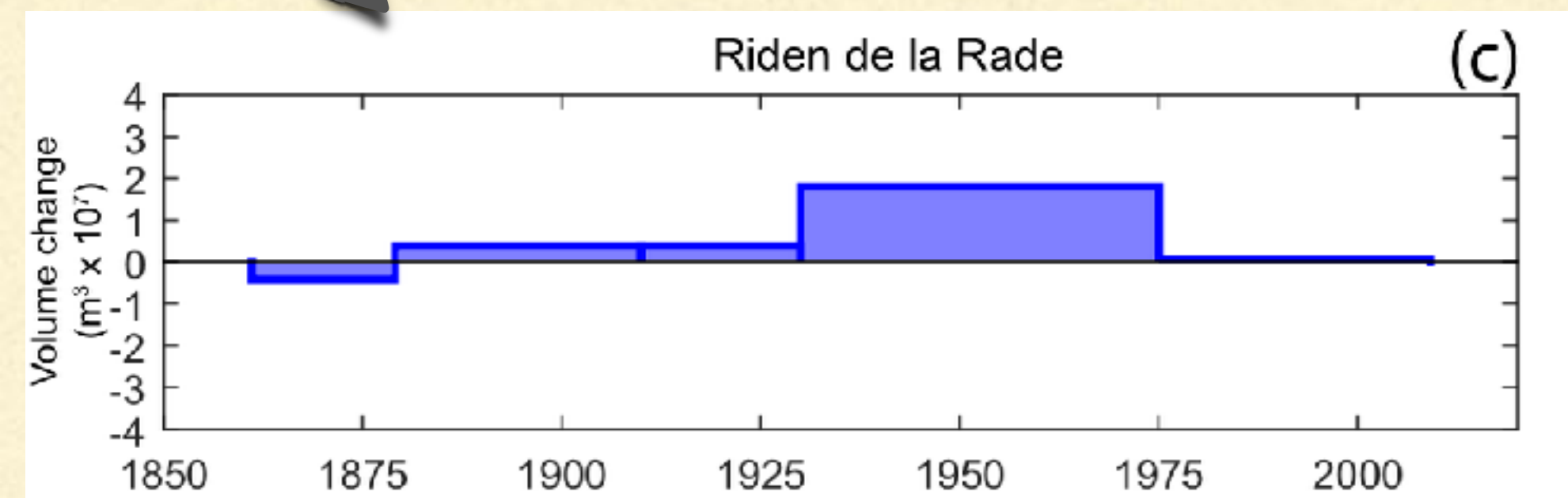
Cross-shore and long-shore transects



Bathymetric difference map



Volume changes computation



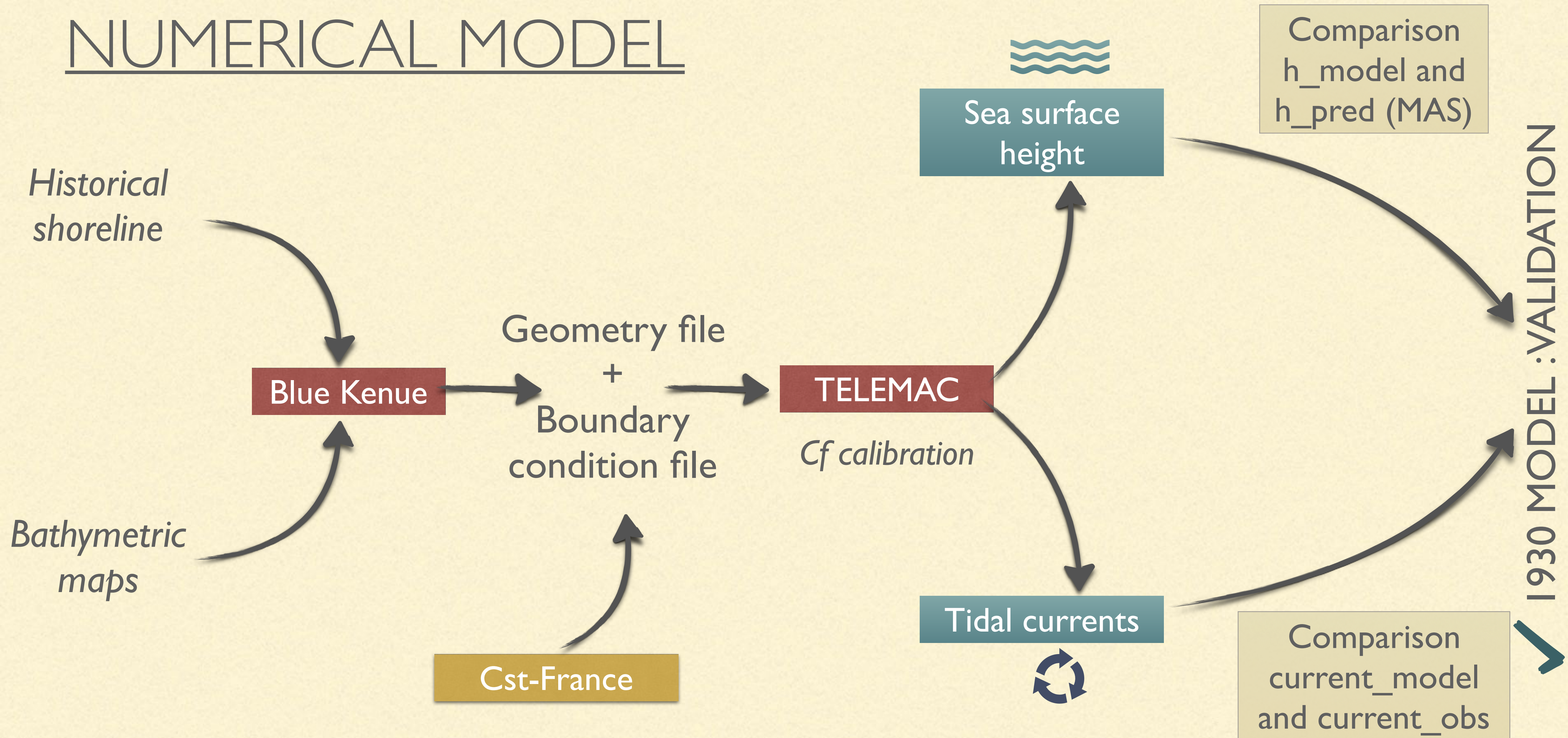
NUMERICAL MODEL

open TELEMAC-MASCARET
The mathematically superior suite of solvers

- TELEMAC 3D : finite element model simulate tidal propagation for different bathymetric settings
- Three-dimensional equations : transport-diffusion equation + Navier-Stokes equations + hydrostatic pressure hypothesis

YEAR	SURVEY AREA
1836	Calais
1861	Dunkirk - Gravelines - Calais
1879	Dunkirk - Gravelines - Calais - Wissant
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NUMERICAL MODEL

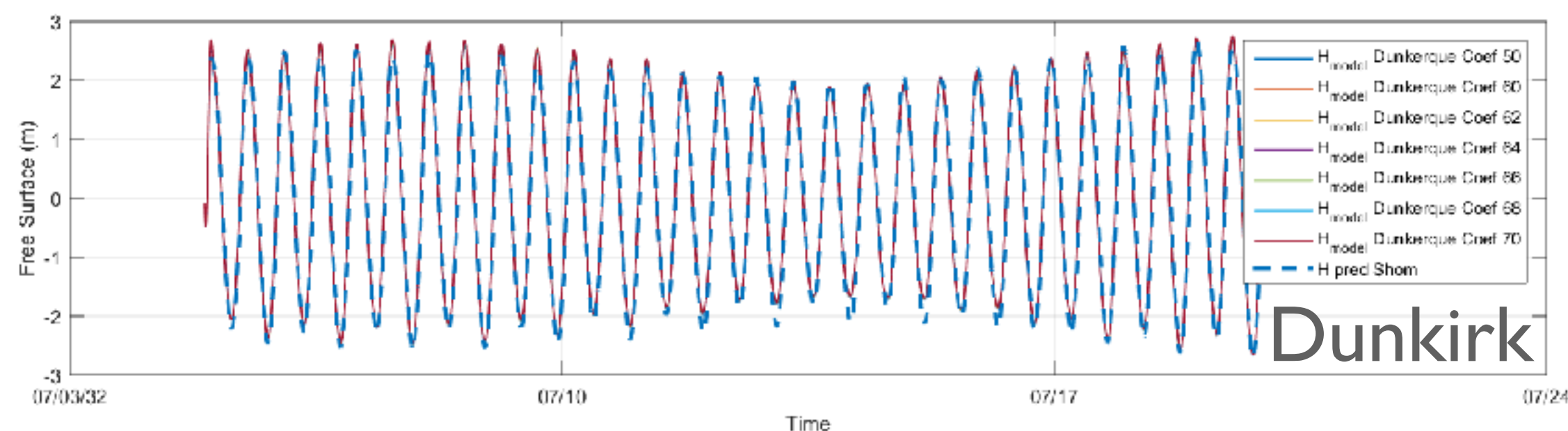
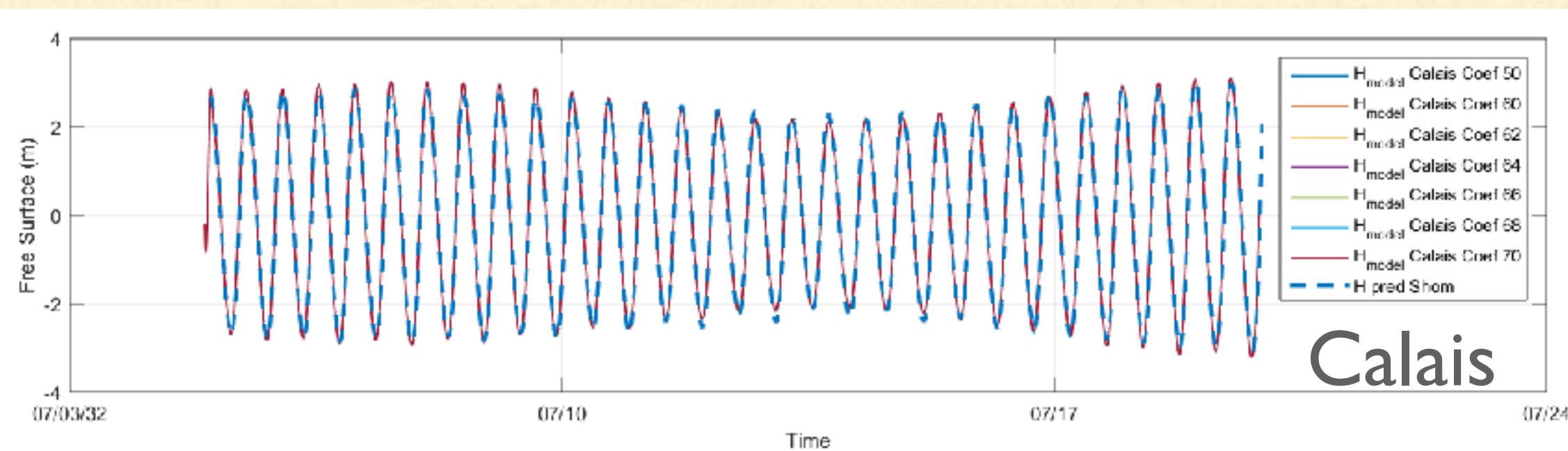


VALIDATION - FRICTION COEFF : 64

■ Sea surface height :

Mean range difference < 5.5 cm (< 2%)

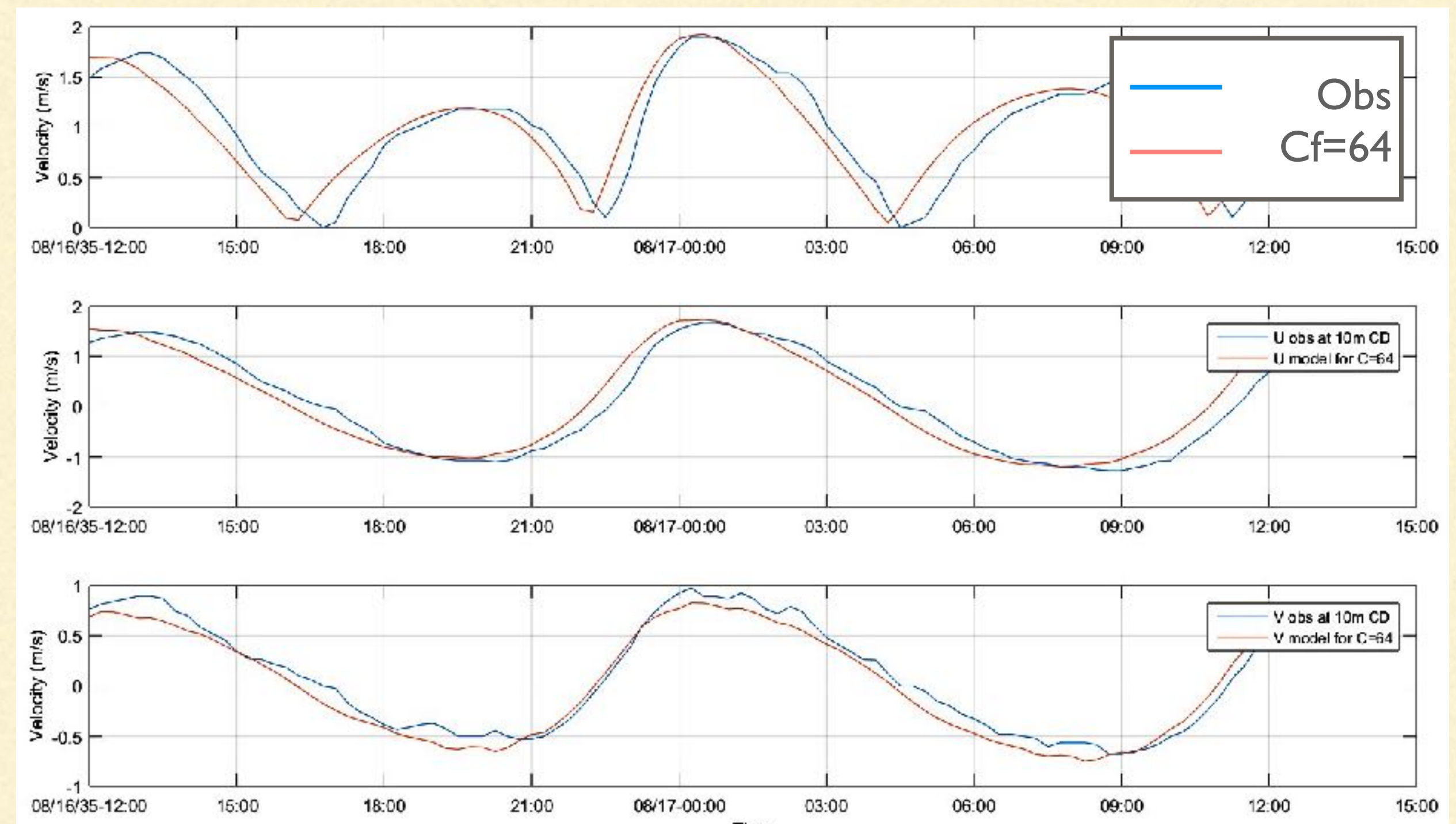
Phase shift HT & LT < 2min



■ Tidal currents :

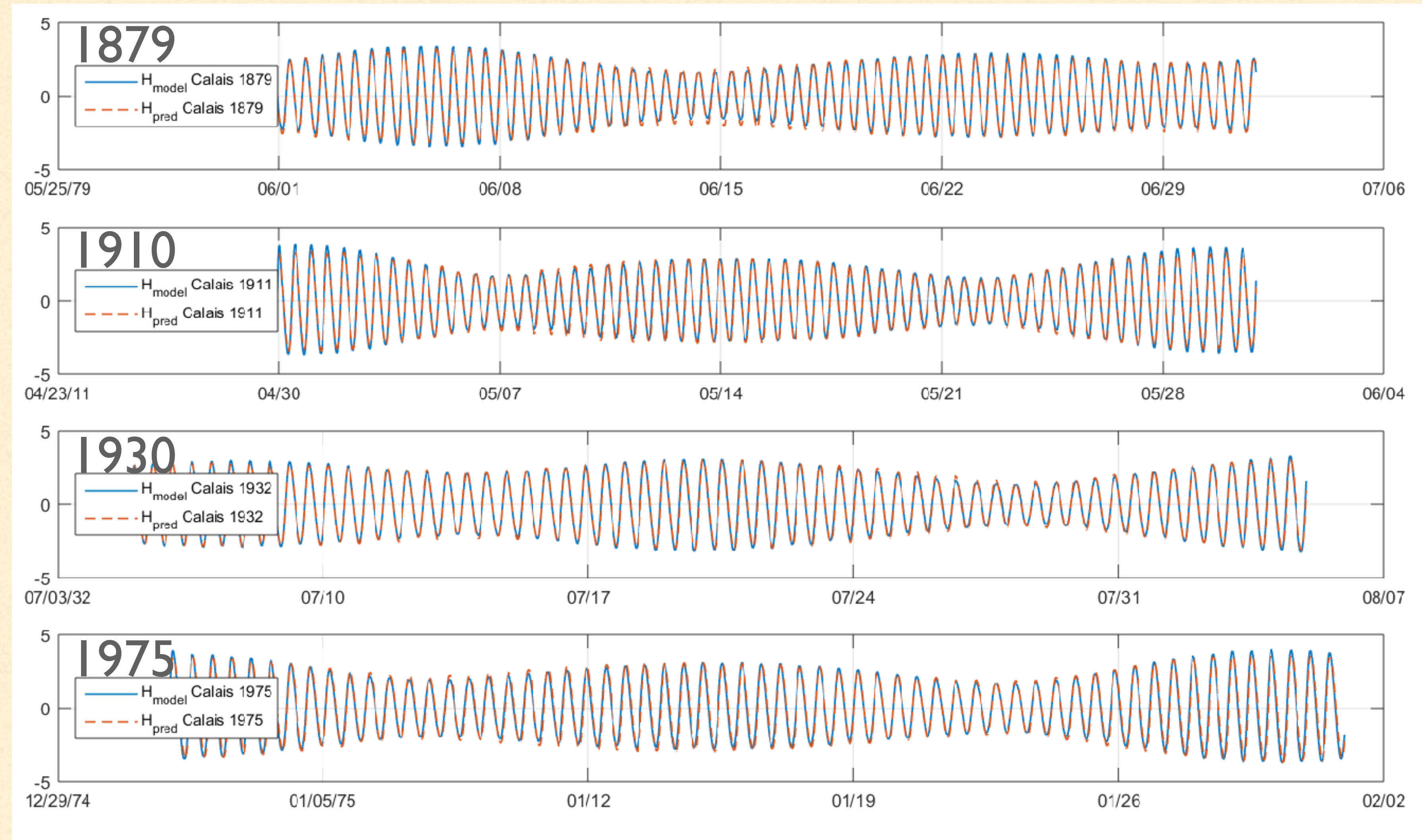
Mean velocity difference : < 3 cm.s⁻¹ (< 1%)

Phase shift Flood & Ebb < 25 min



VERIFICATION

- Mean range difference < 10 cm
- Phase shift < 05 min (except Low-Tide of 1975 model ~12 min)

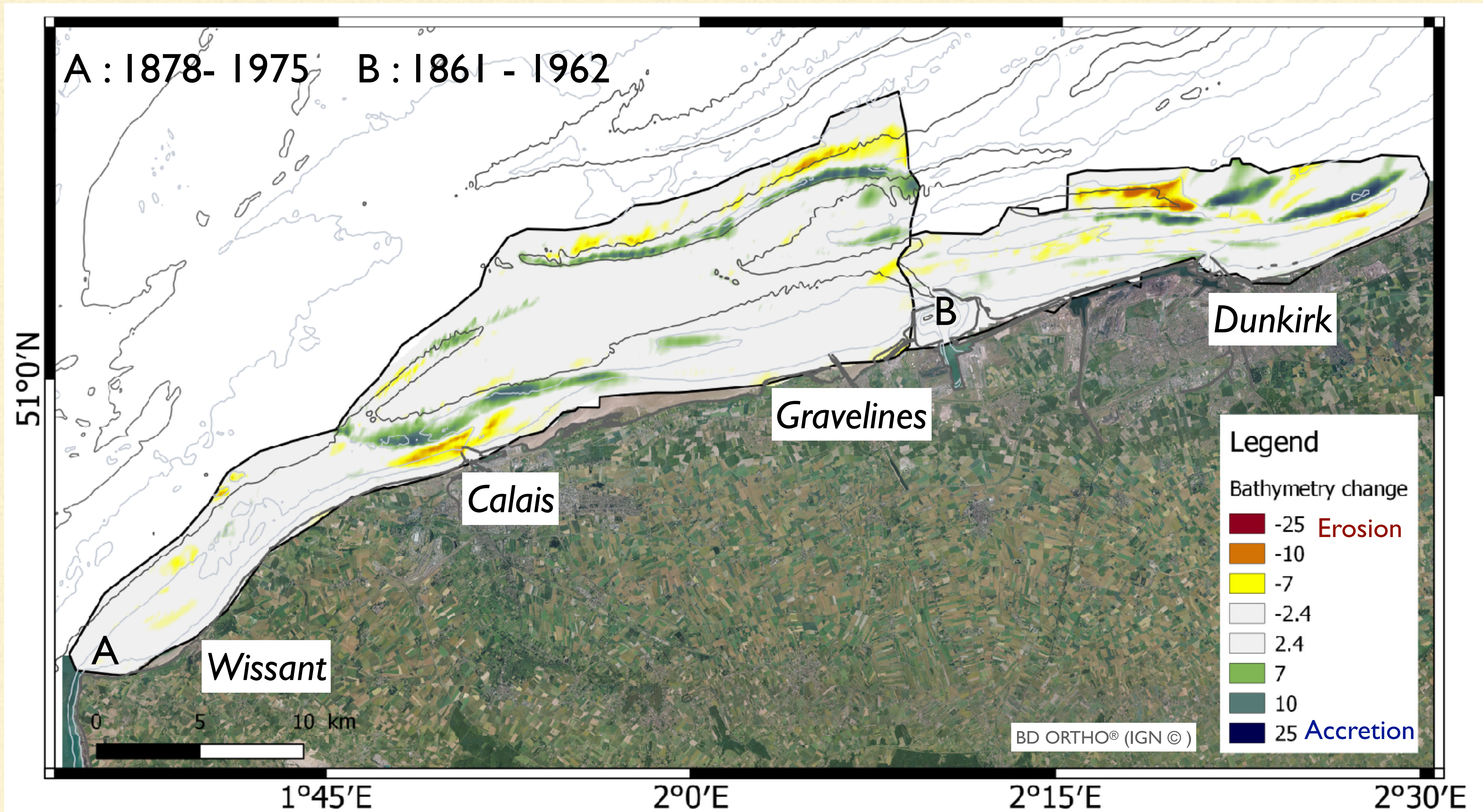


RESULTS

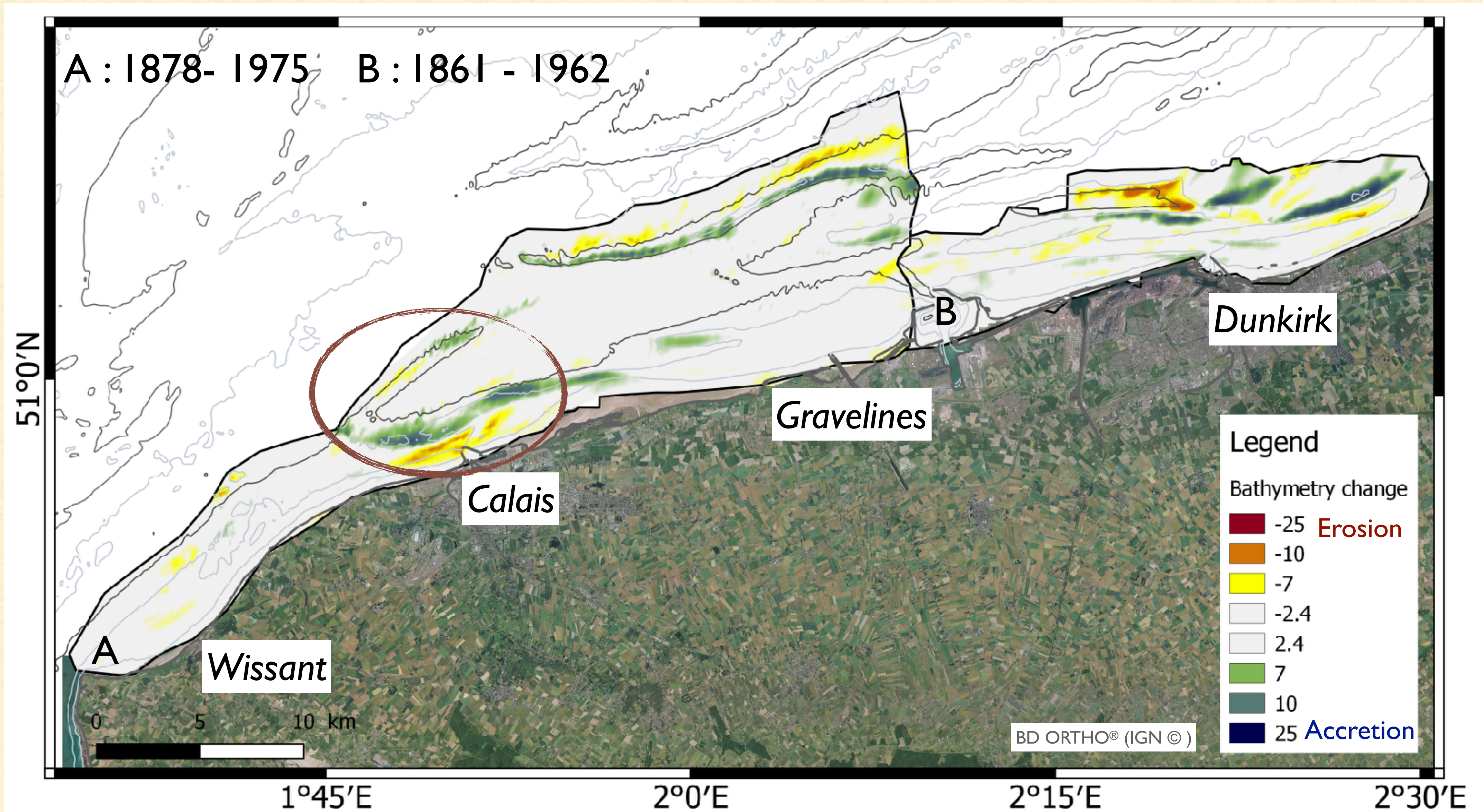
Bathymetry changes



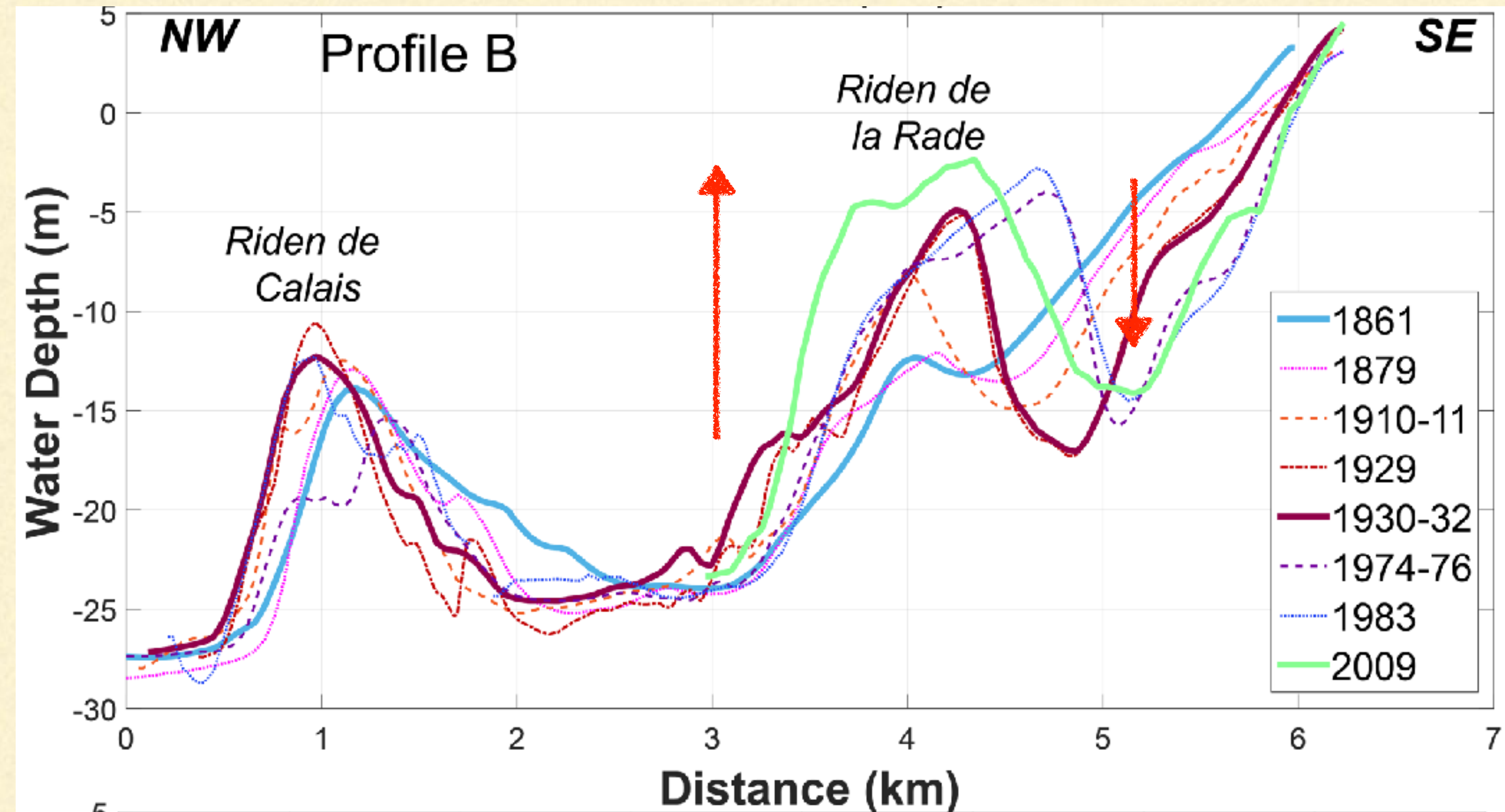
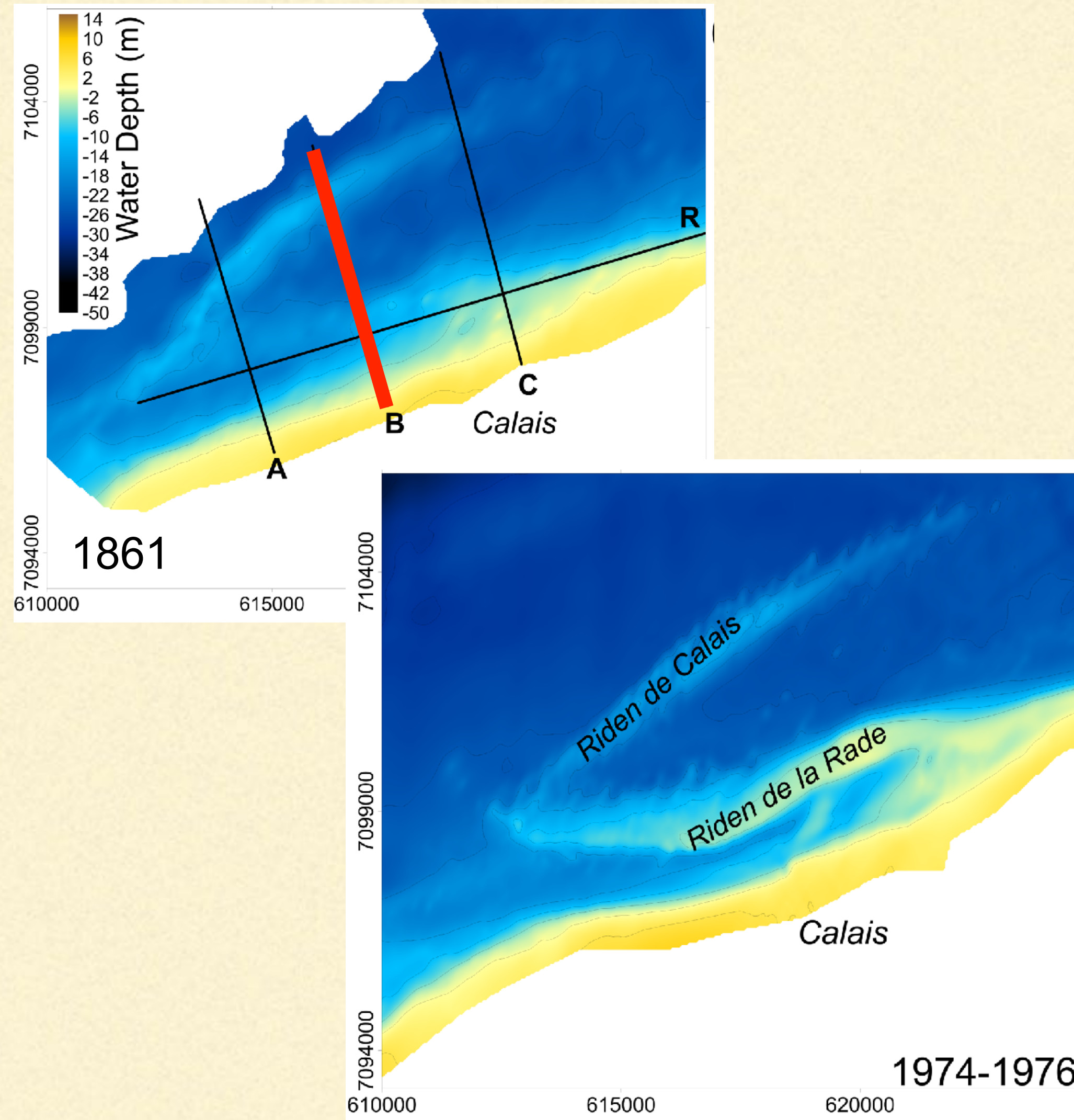
REGIONAL EVOLUTION



REGIONAL EVOLUTION

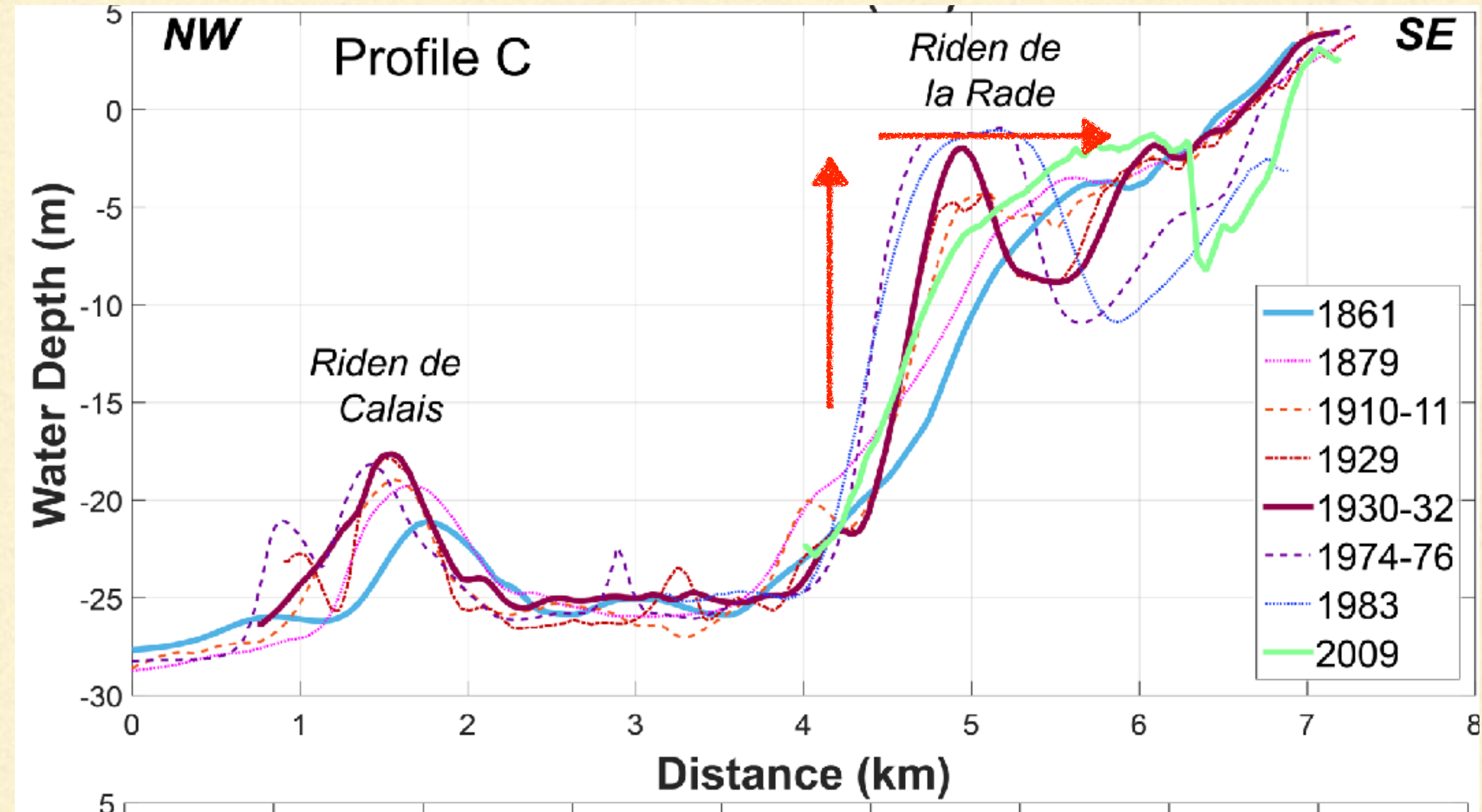
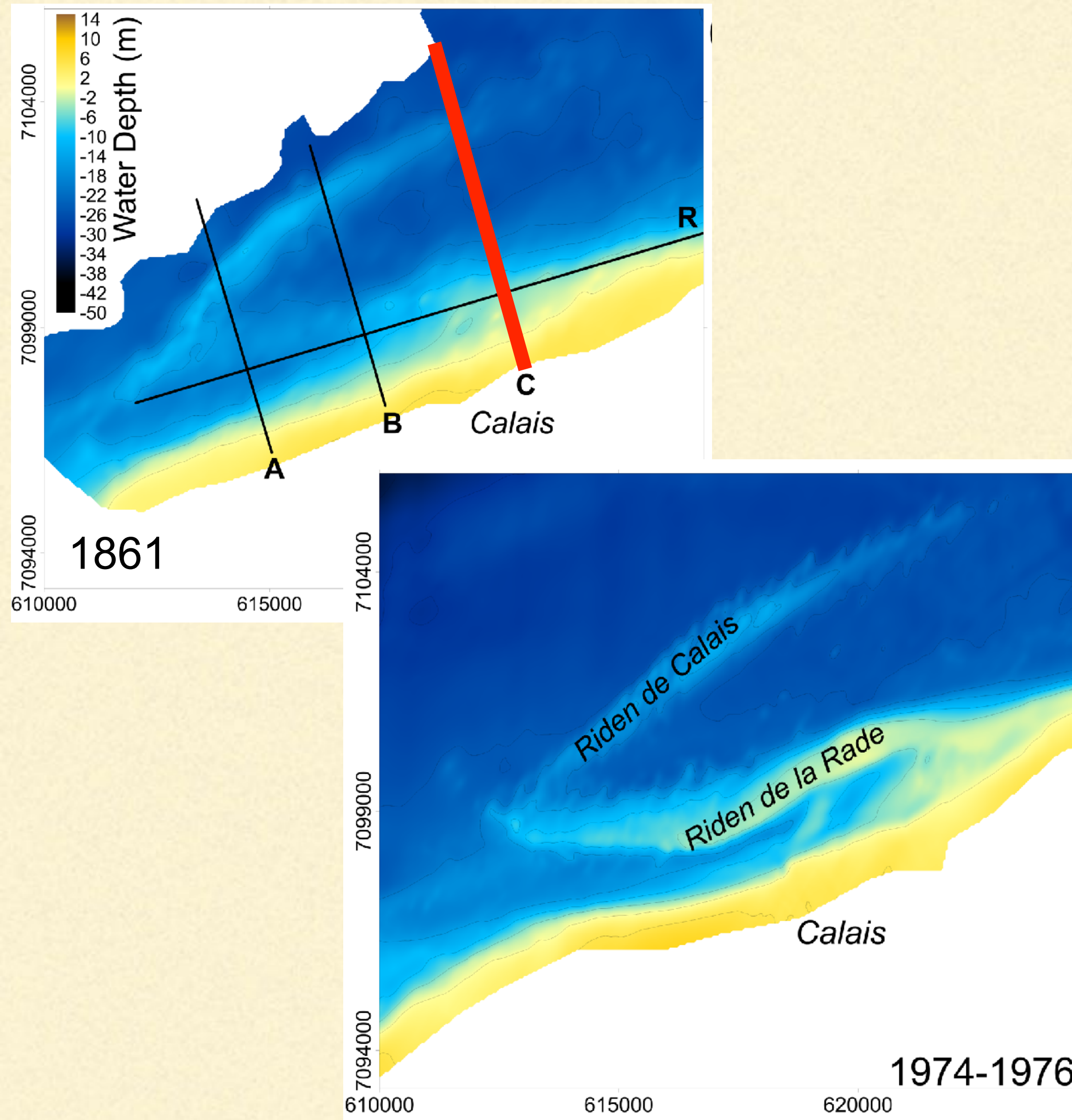


ZOOM : CALAIS NEARSHORE



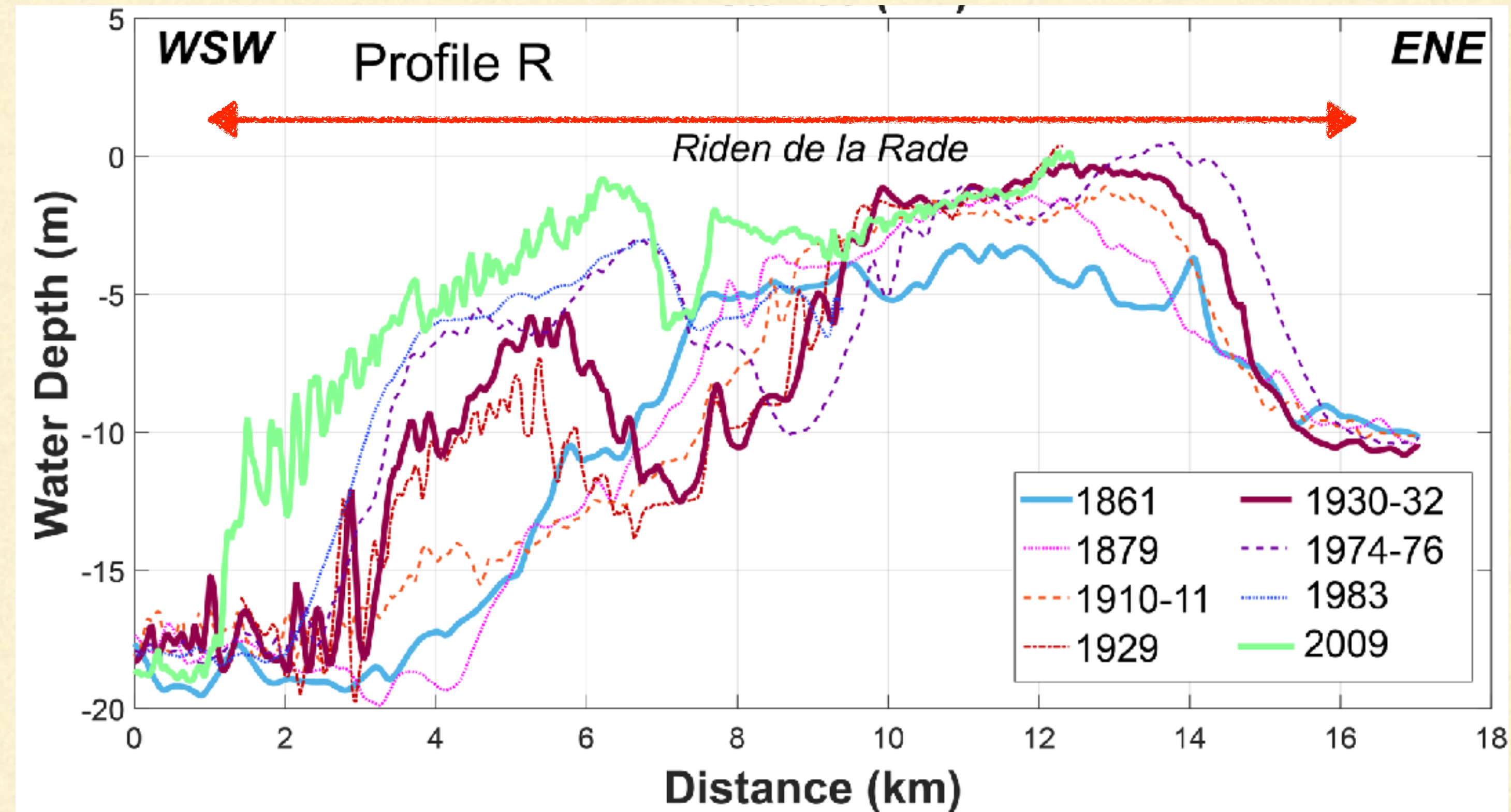
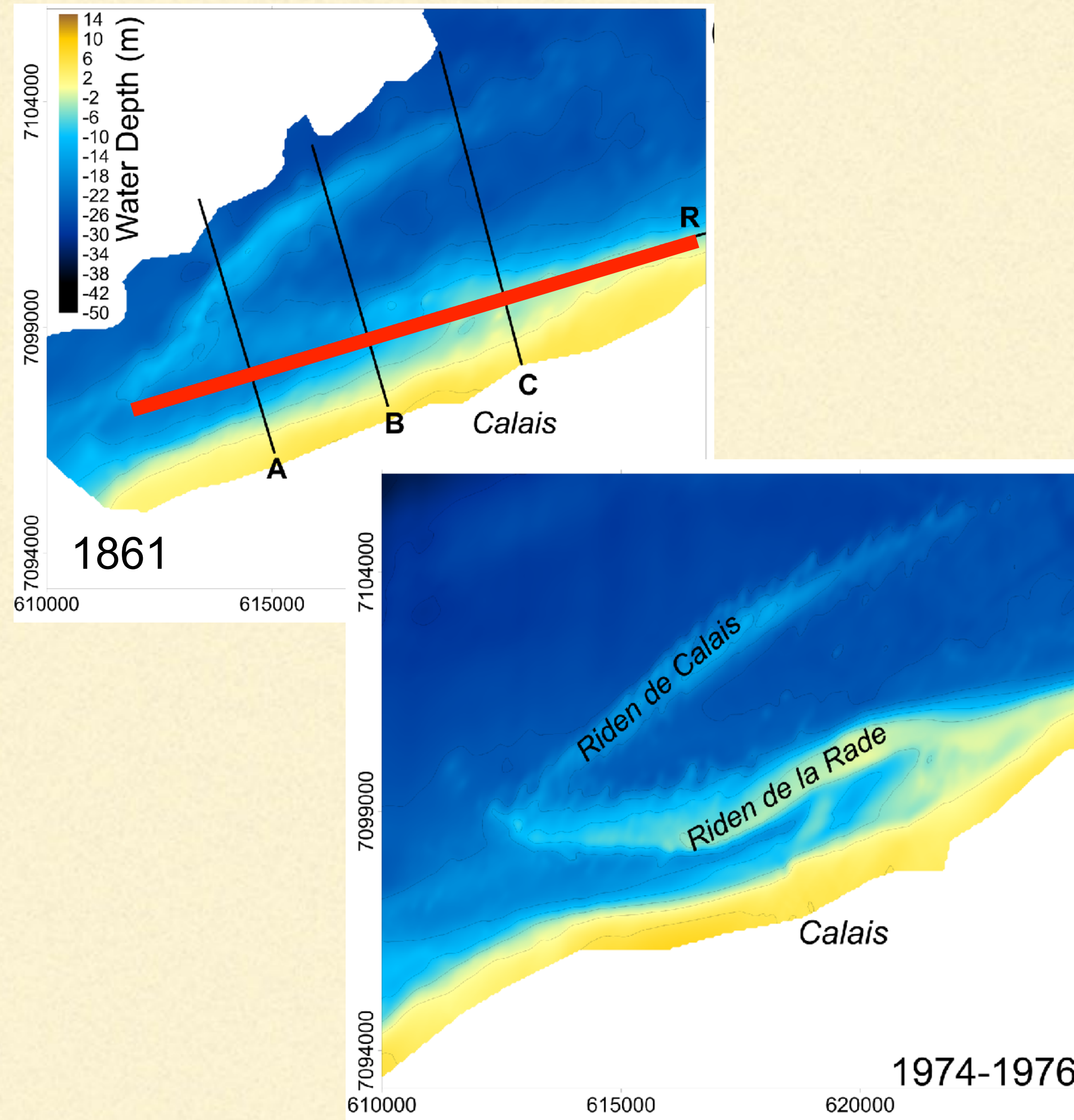
(Latapy et al., 2019)

ZOOM : CALAIS NEARSHORE



(Latapy et al., 2019)

ZOOM : CALAIS NEARSHORE



(Latapy et al., 2019)

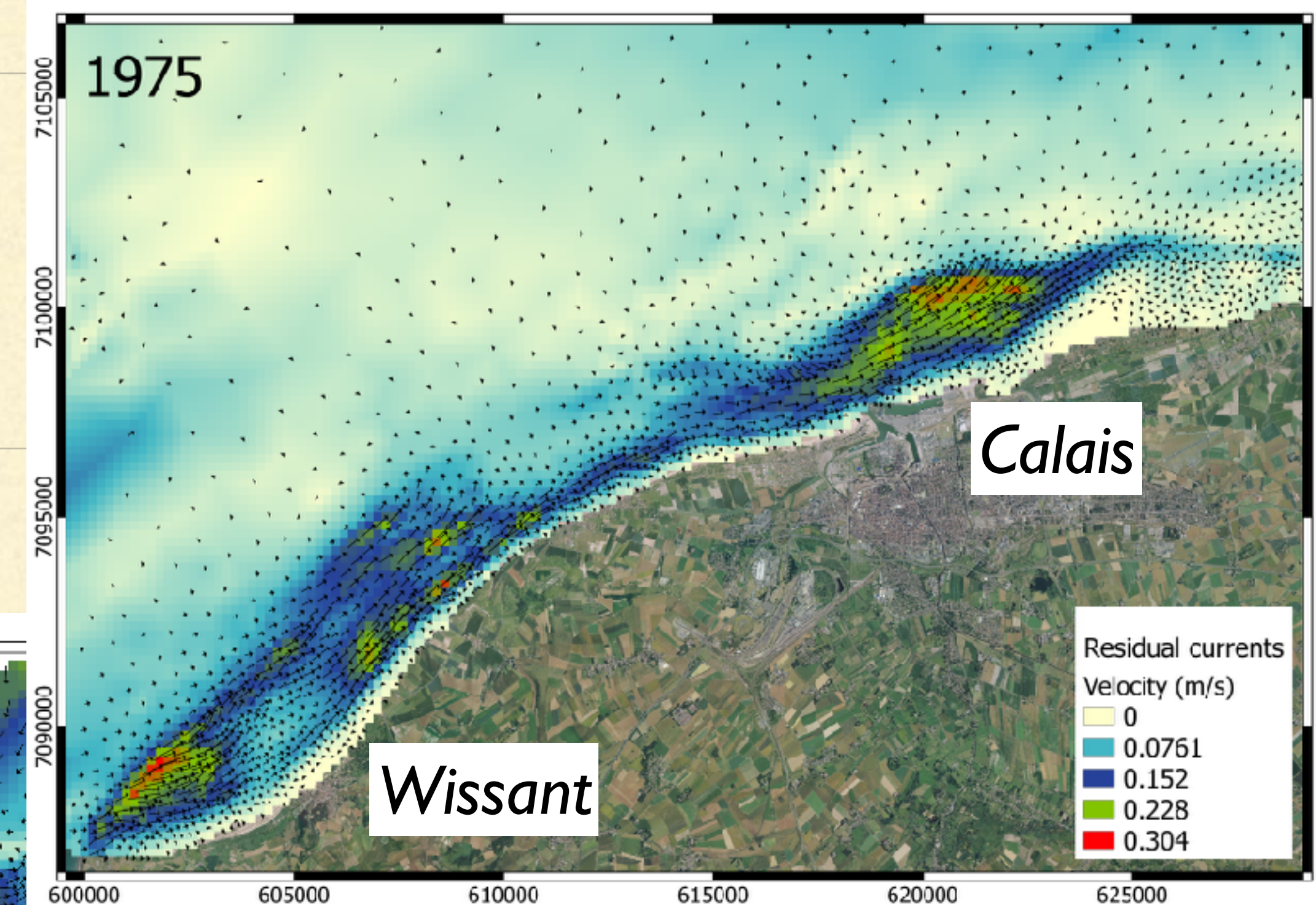
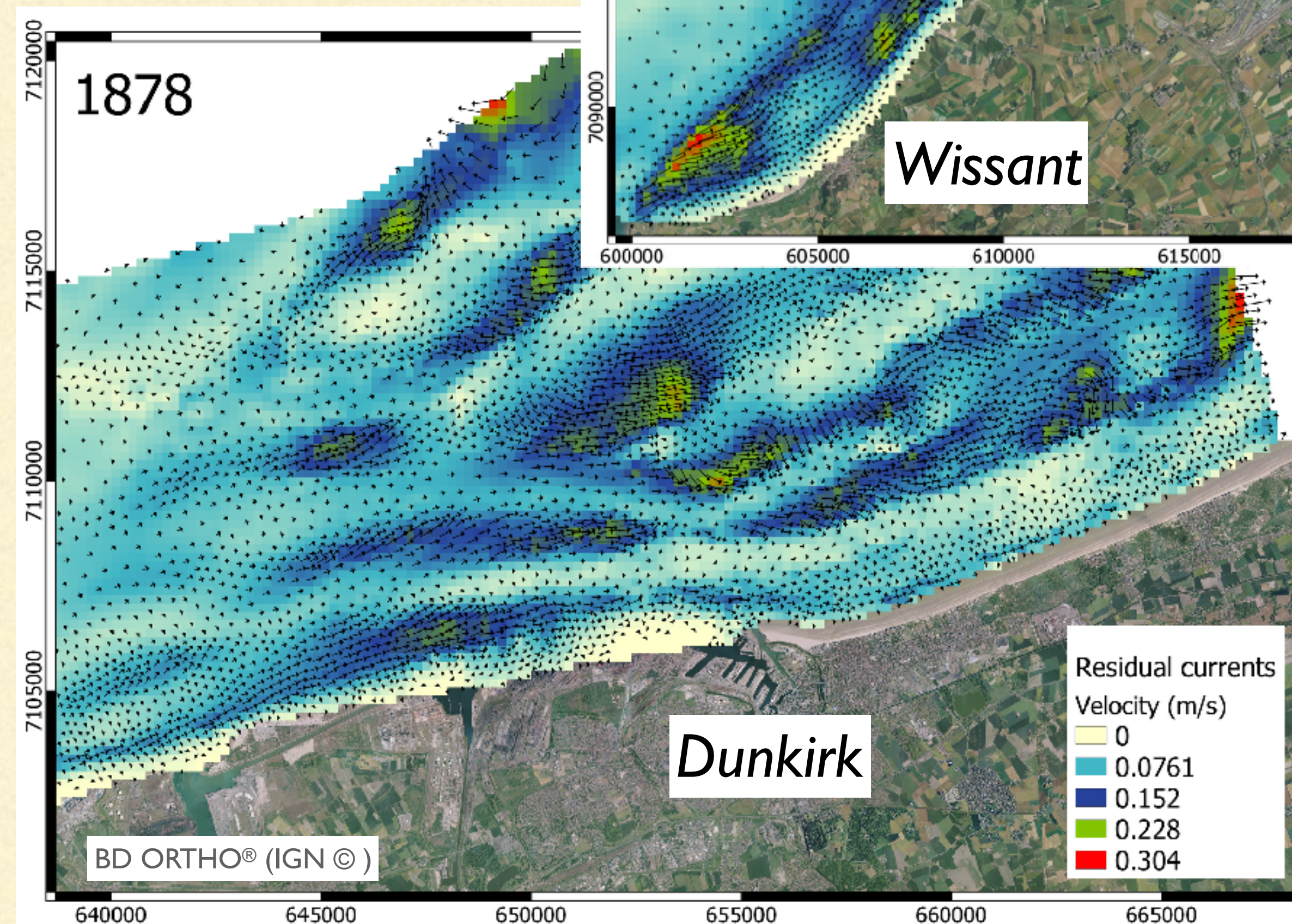
RESULTS

Hydrodynamic circulation

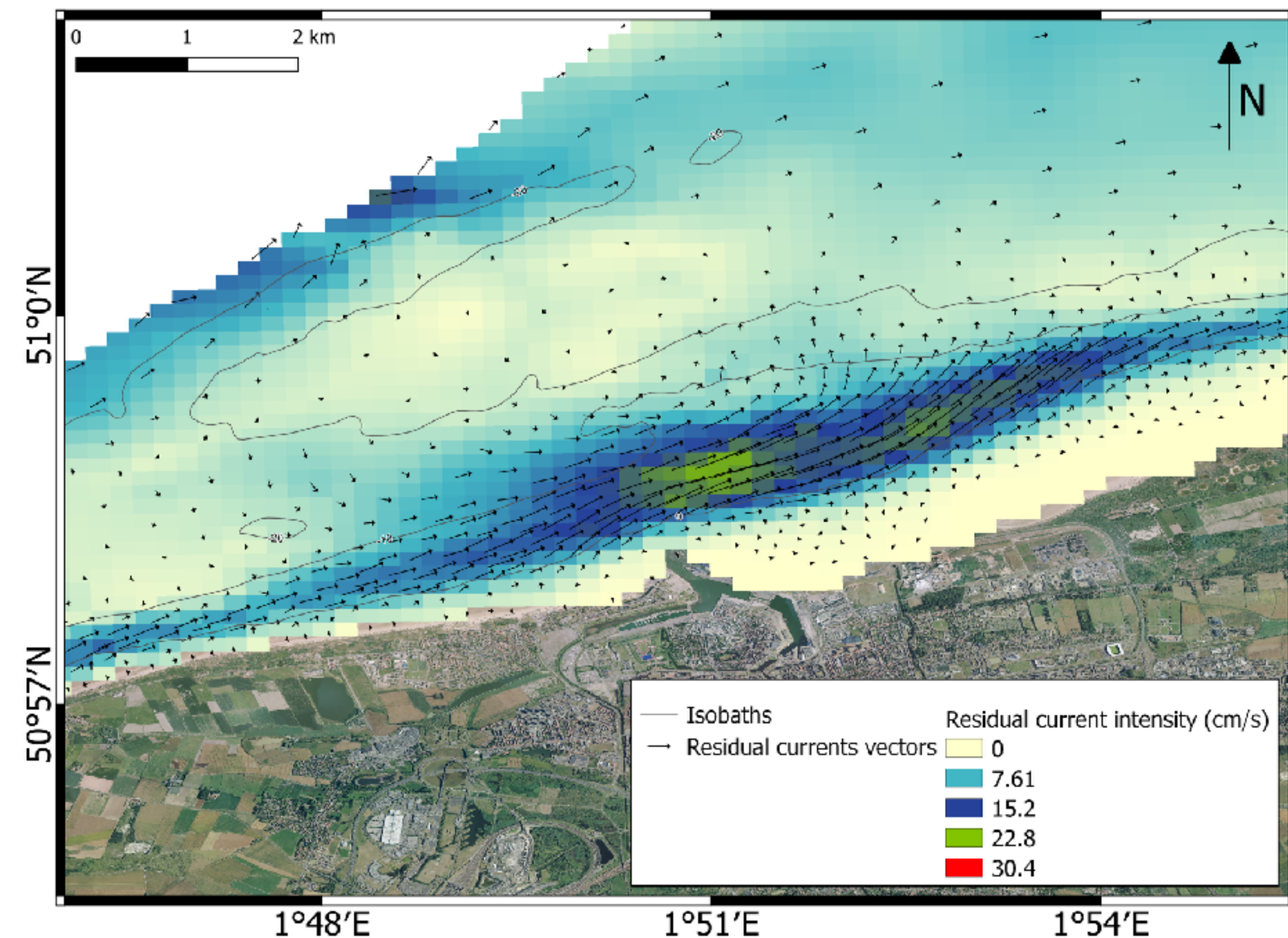
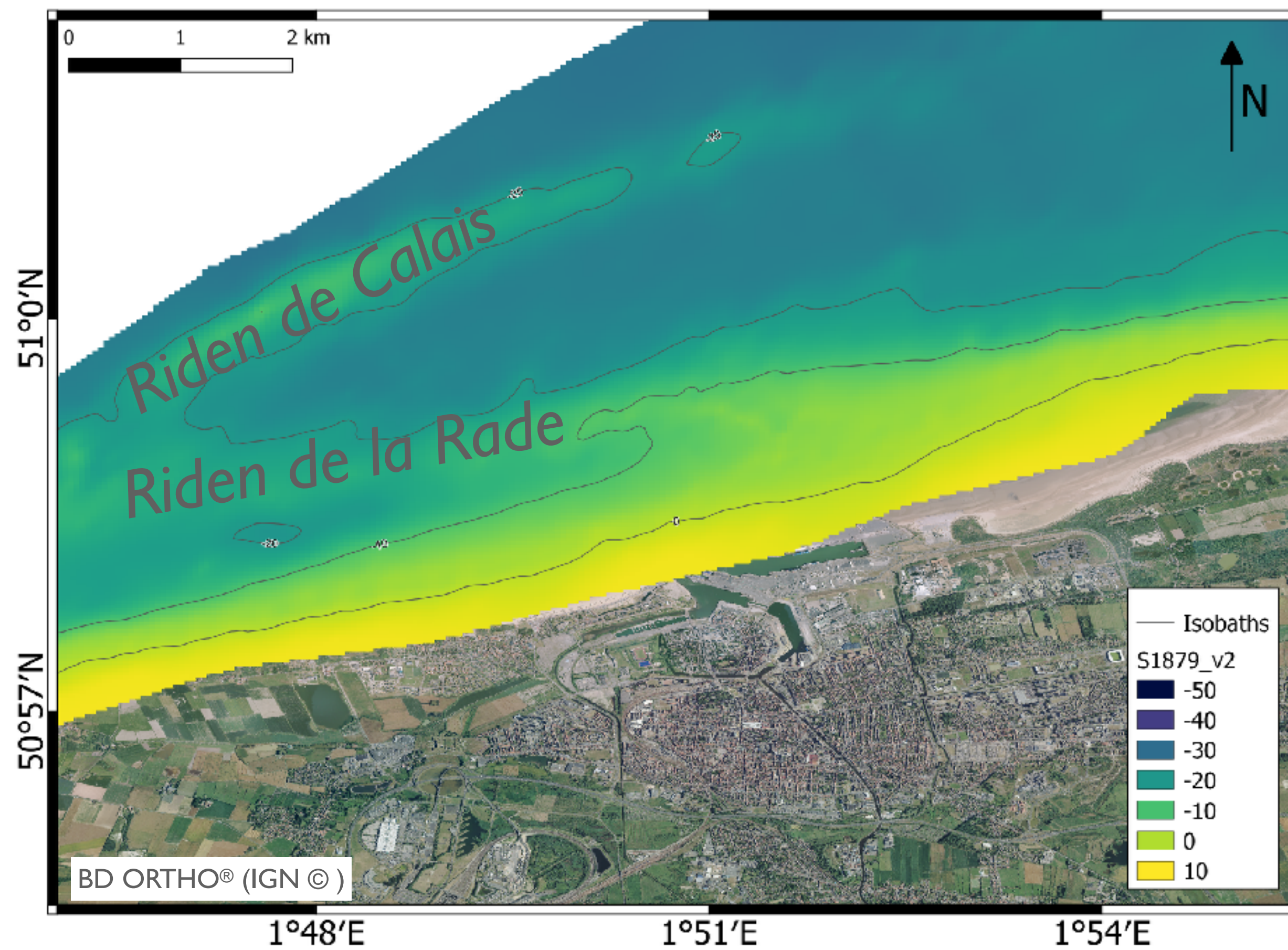


TIDAL SIMULATION

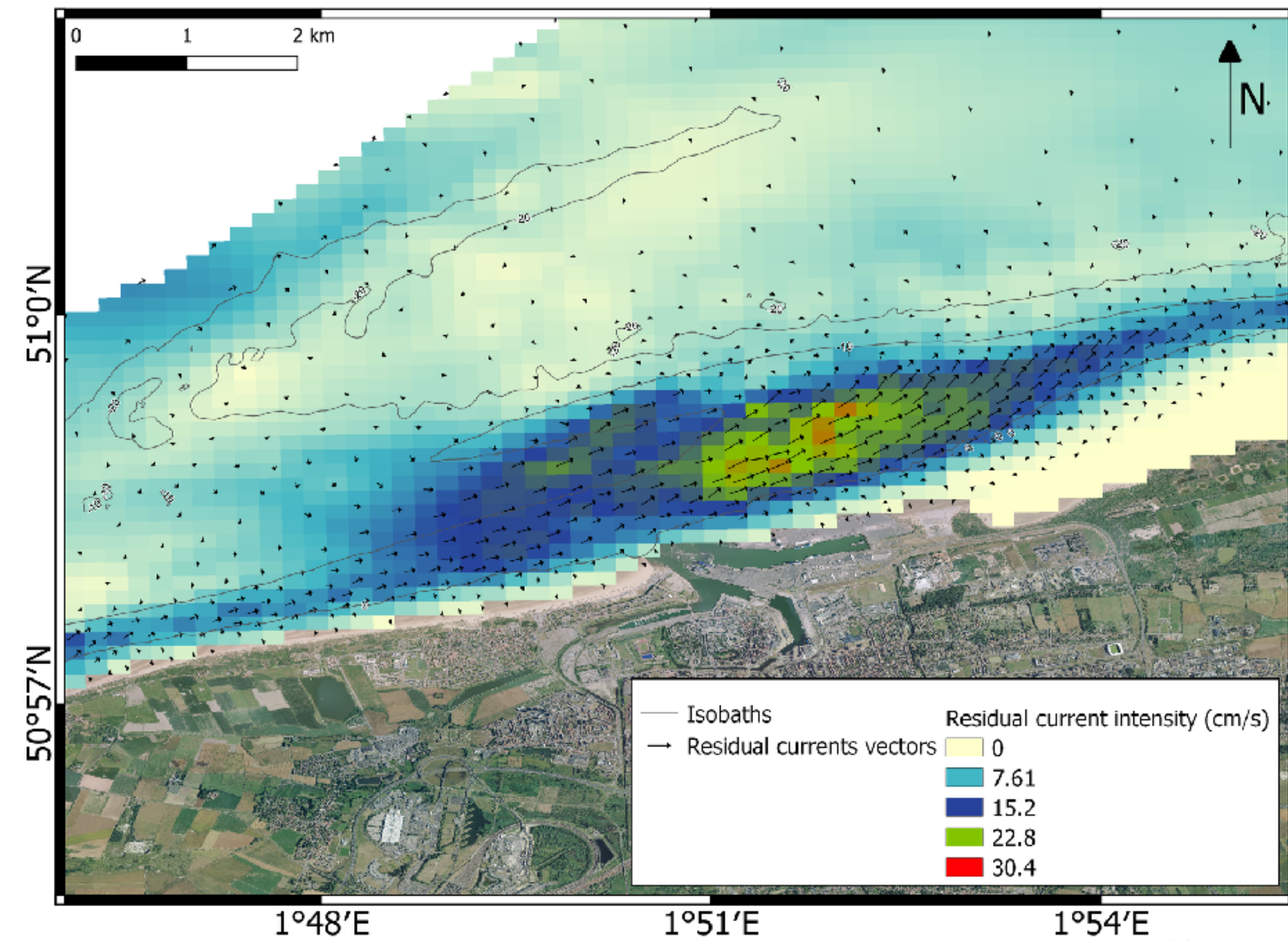
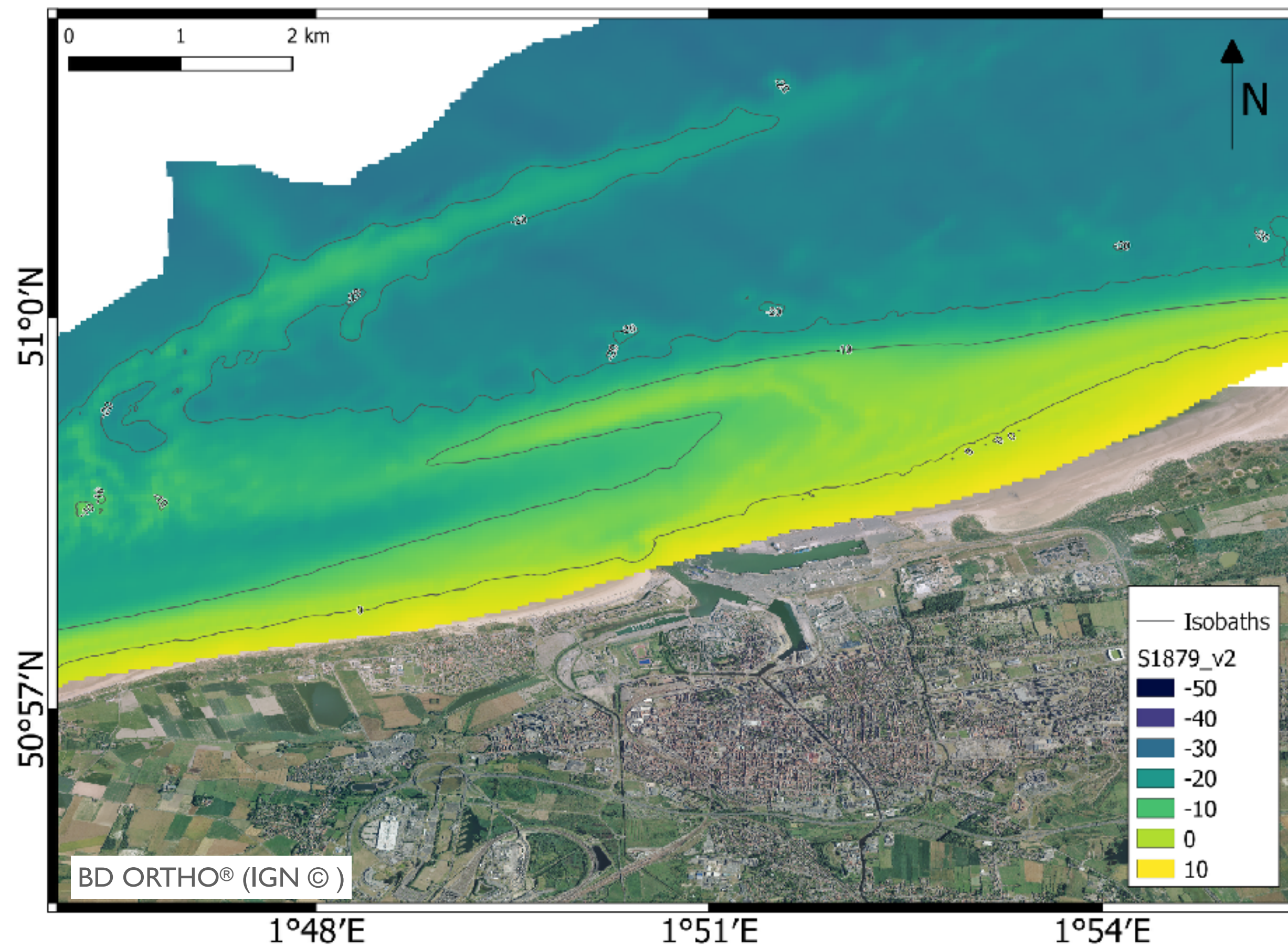
- 01/03/2015 → 15/04/2015 (equinox tides)
- Residuals currents computation



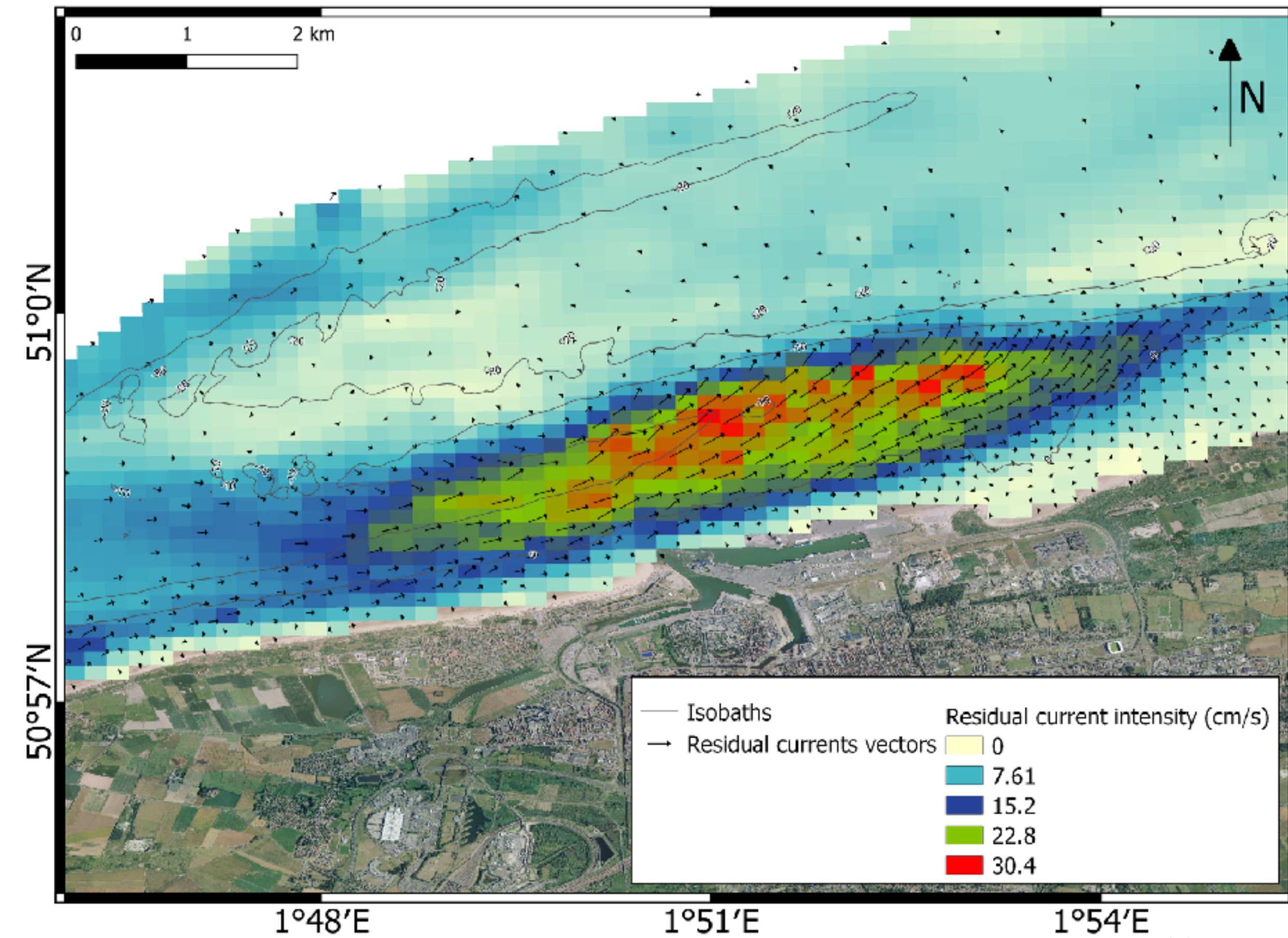
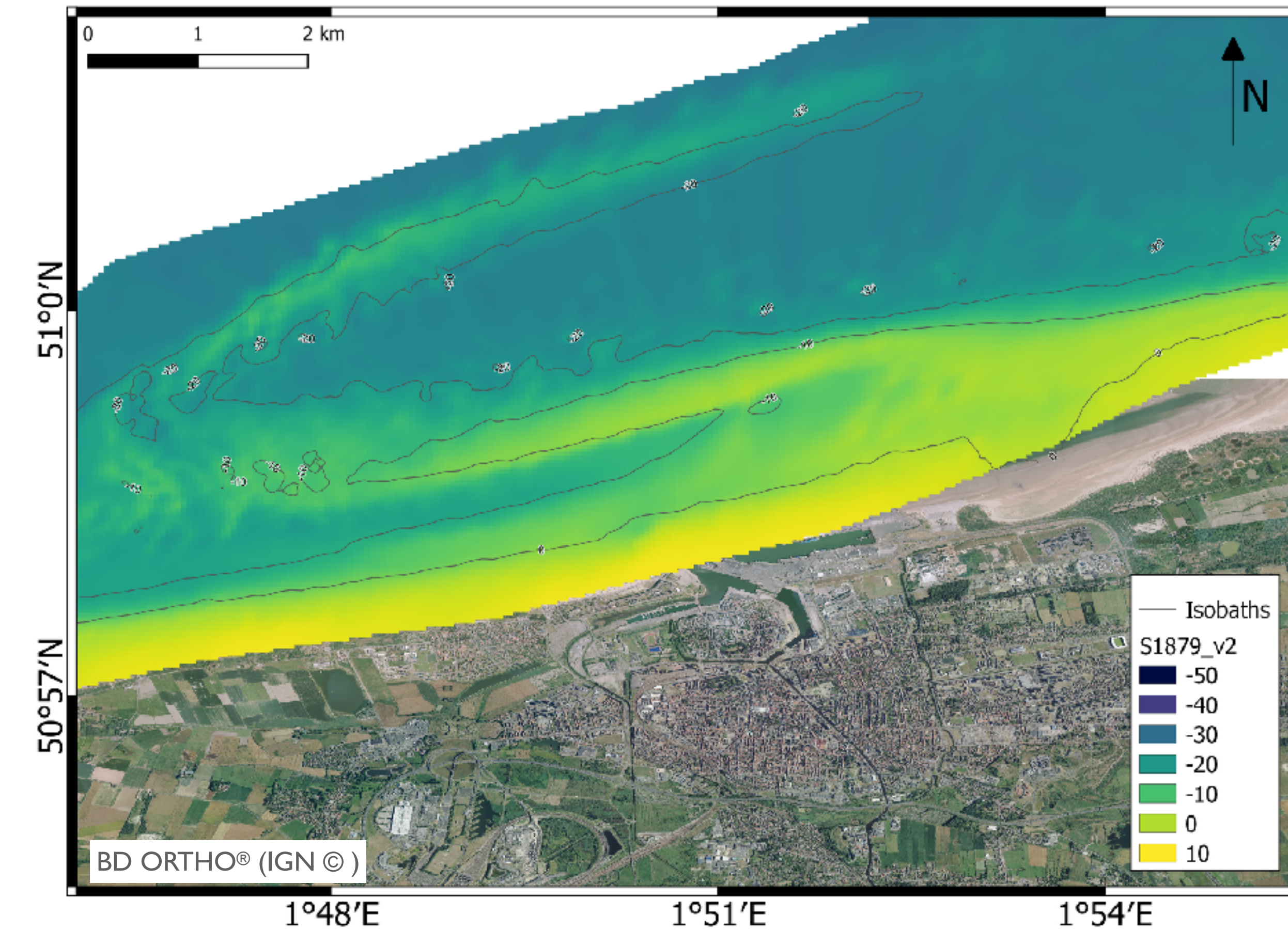
CALAIS - 1878



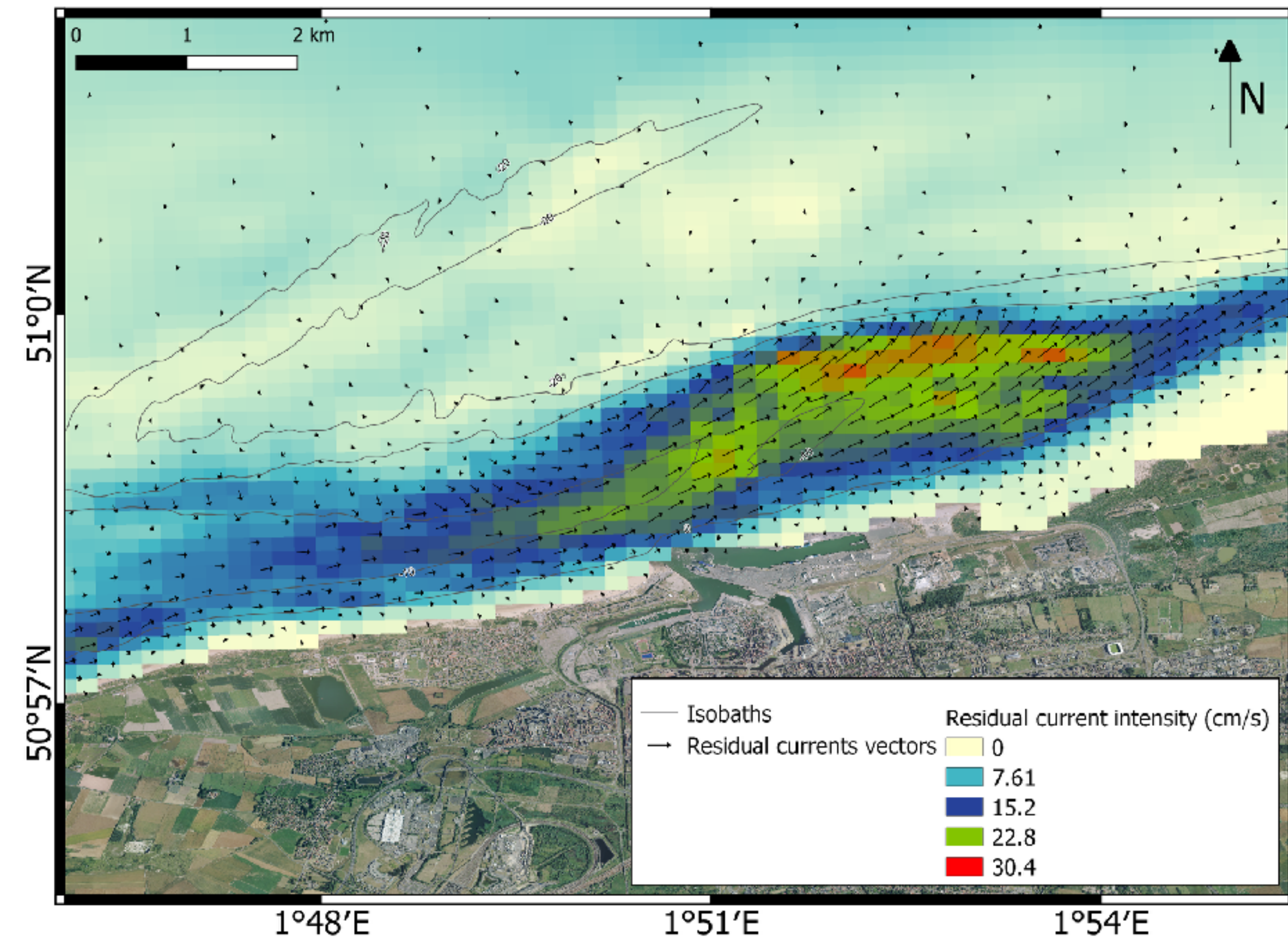
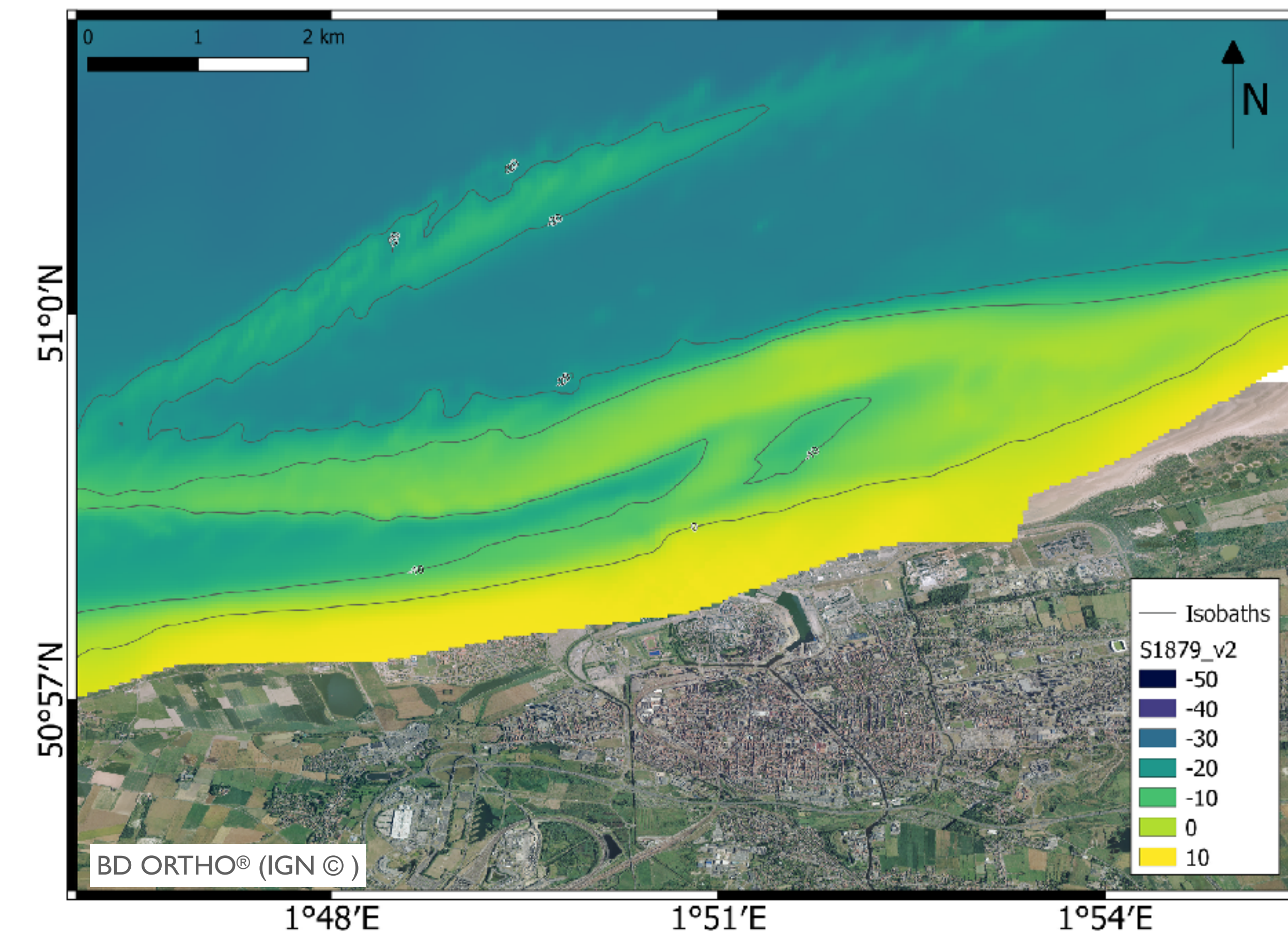
CALAIS - 1910



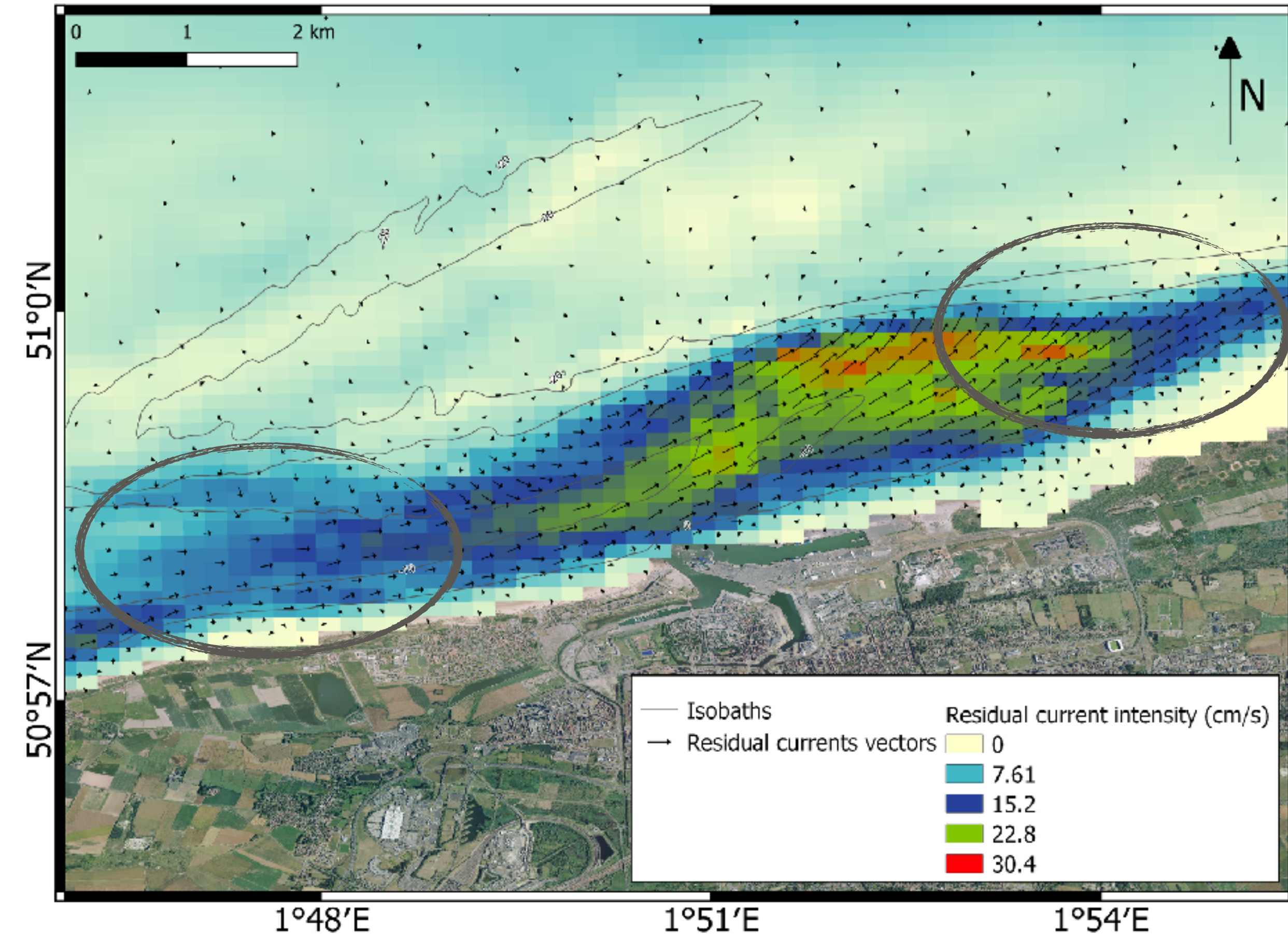
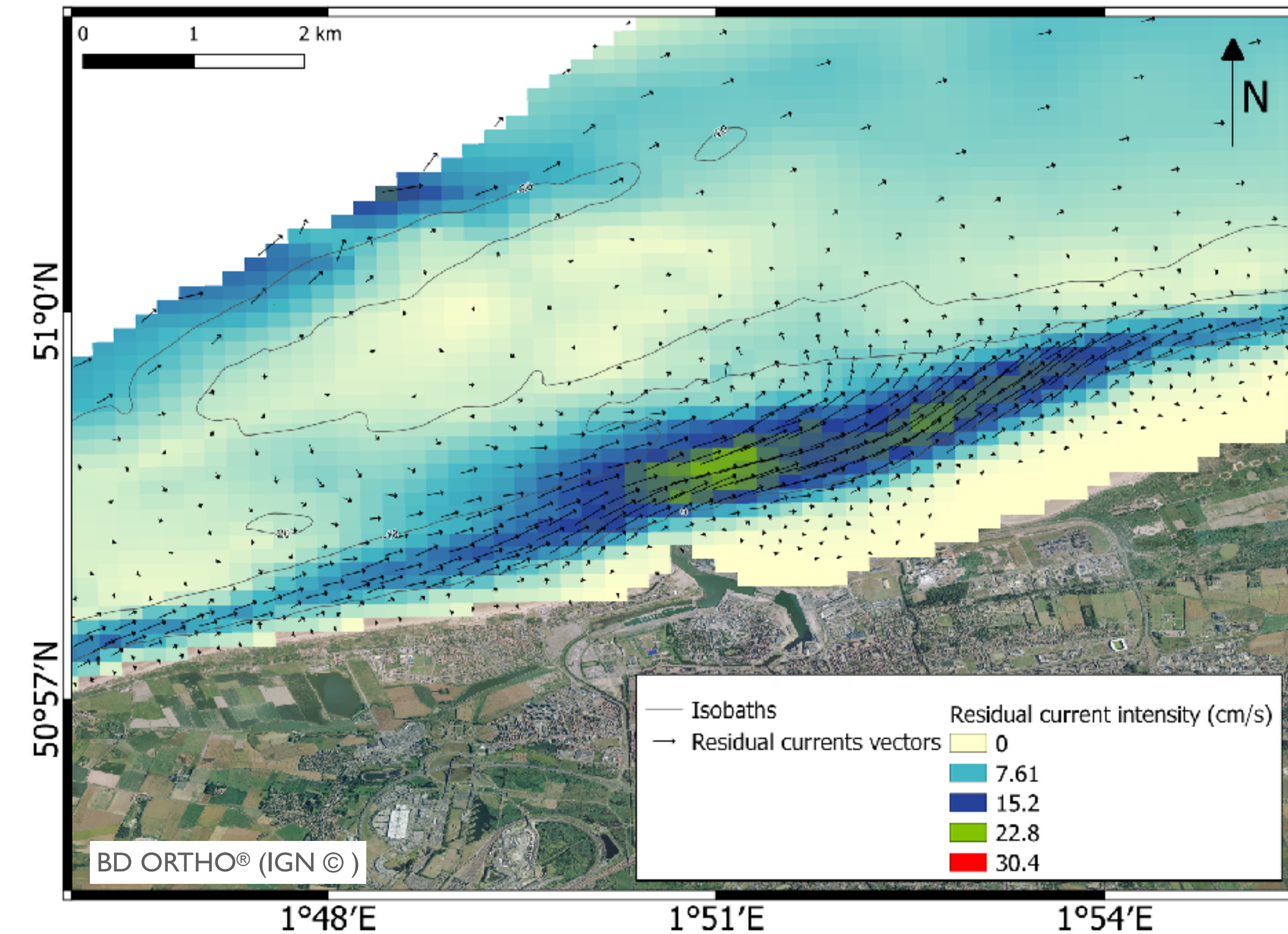
CALAIS - 1930



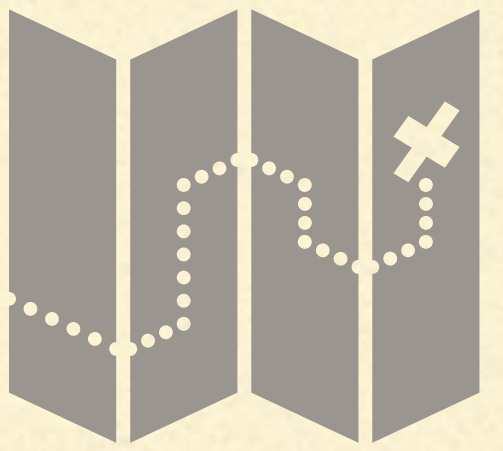
CALAIS - 1975



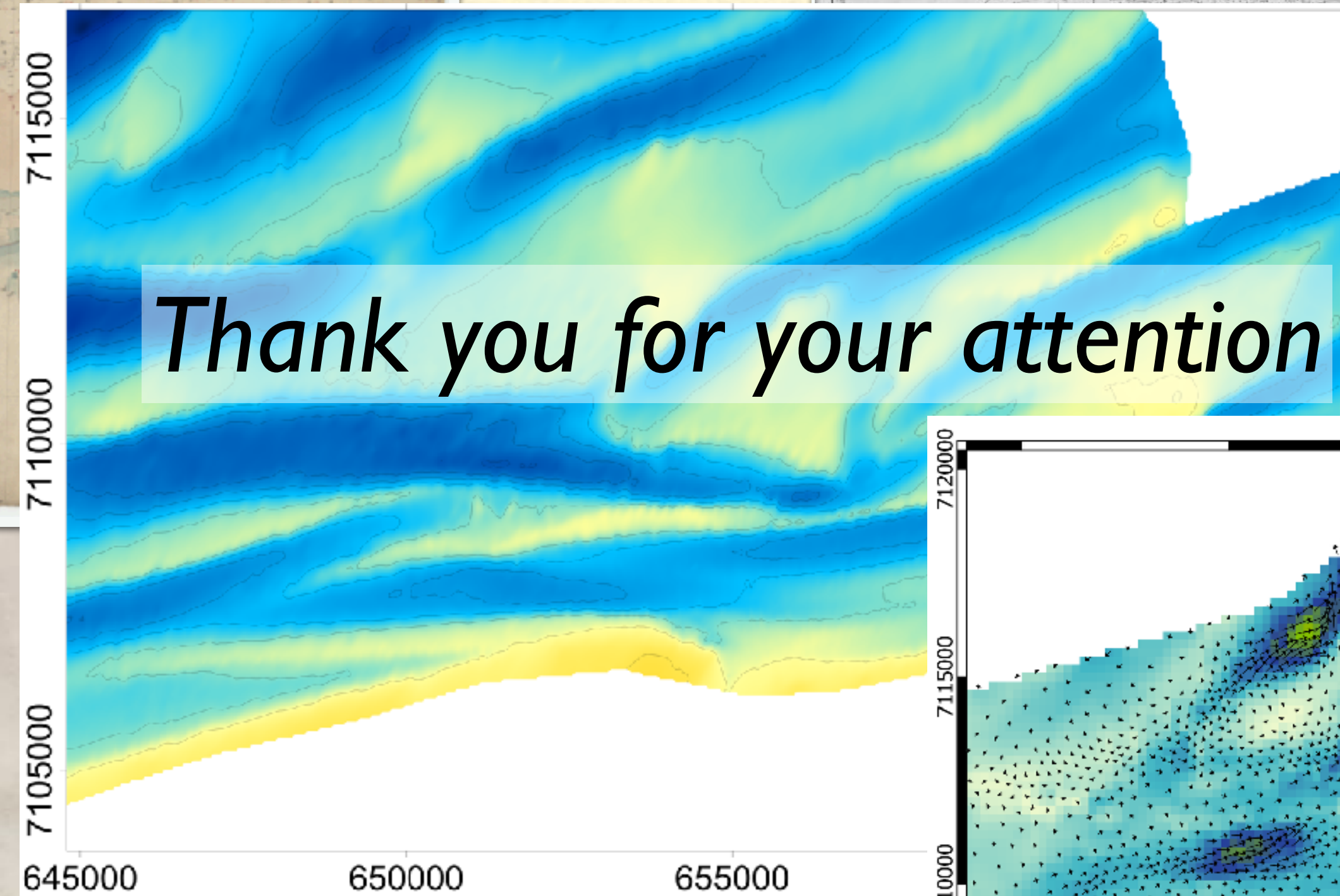
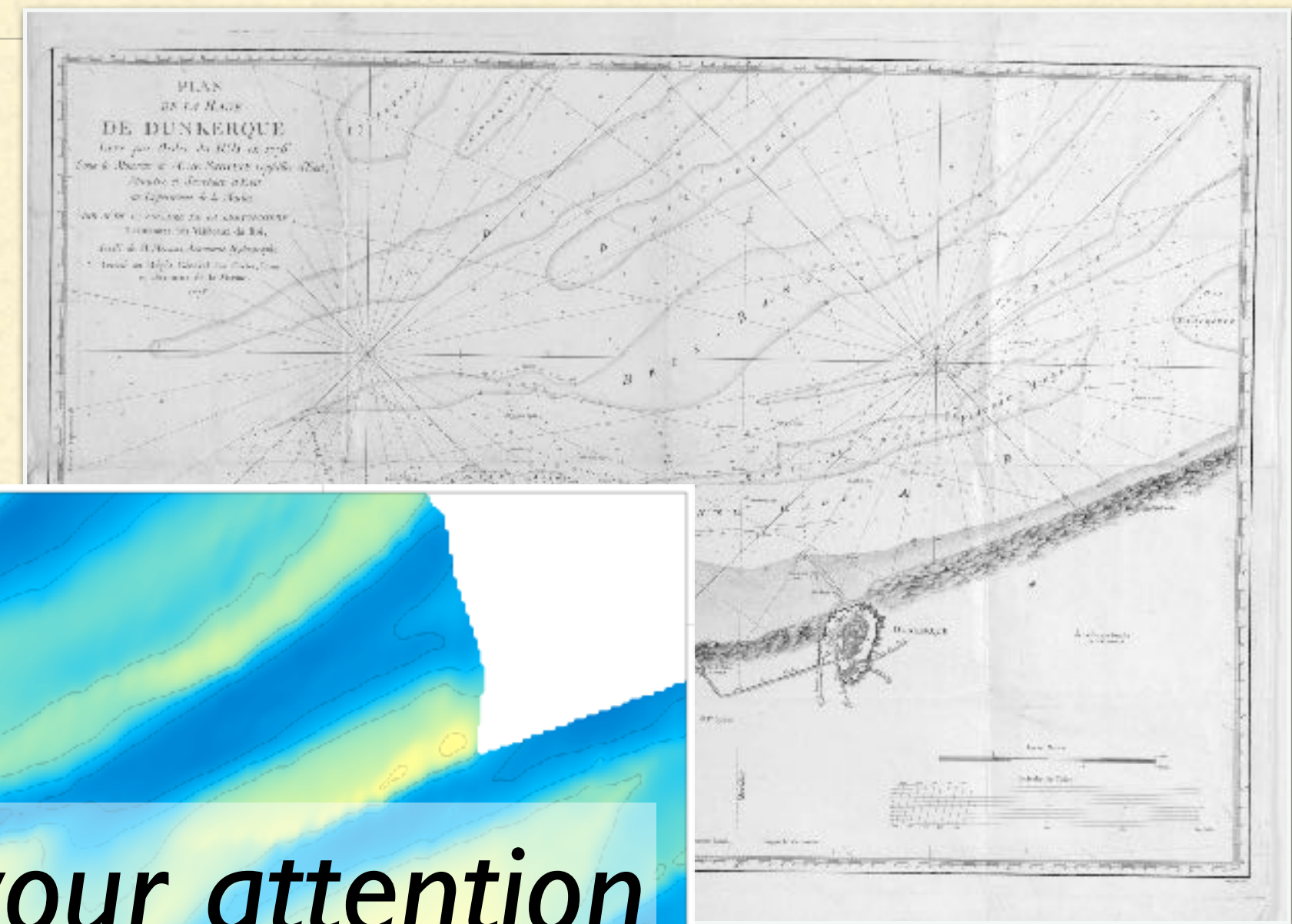
CALAIS - 1878 - 1975



CONCLUSION



-
- Significant morphological changes in the Northern France coastal zone
 - * Calais nearshore
 - * Wissant bay
 - * Dunkirk nearshore
 - Overall onshore migration of sand banks → storm-waves
Along-shore movements : elongation + migration toward the ENE → tidal currents
 - Tidal simulation : tidal residual currents changed over a century
 - Wave model with TOMAWAC (+ coupling) : in progress...



Thank you for your attention

