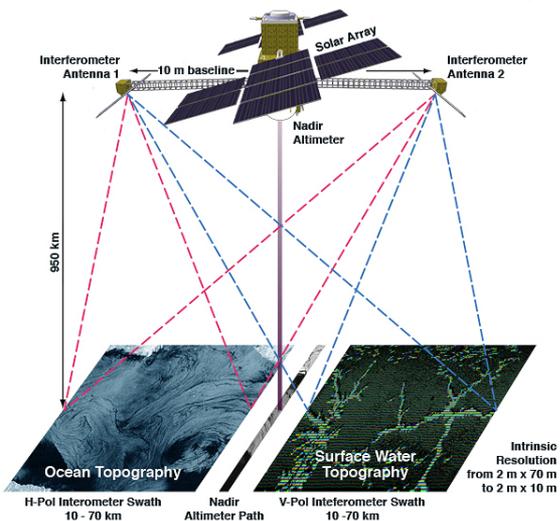


# Overview of the 4 SWOT projects Coastal and Estuarine Processes

B. Laignel, M. Simard, P. Demey, Han G.  
N. Ayoub, F. Lyard



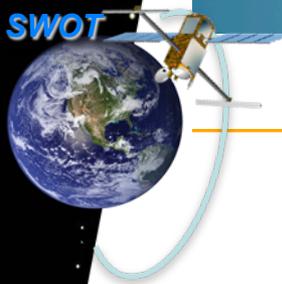


# Coastal zones (including estuaries & deltas) : Definition

The coastal zones & river mouths = environments with geomorphological, sedimentary, hydrodynamic & biological contexts very diverse & complex estuaries, deltas, bays, shelves, rocky coasts with cliffs, beaches with sand (with dunes or not), gravel, pebbles or mud..., & the wetlands (mangroves, coastal marshes, swamps...)



- = Among the most productive ecosystems on the planet, regulate water flow & mass (i.e., nutrient, carbon, salt), filter pollutants & contaminants & are highly efficient carbon sinks
- = Among the most affected by human impact (High urbanization & strong harbour, industrial & tourism activities)
- = Among the most affected by climate change (sea level rise, storm surges & river floods)



## Complex hydrodynamics

**Coastal & estuary zones (location at the land-sea interface)**

→ large variations of water level,

**in connection with hydro-meteo-marine phenomena:**

offshore currents, wind-driven shelf circulation & waves, tides, storm surges, sea level rise (climate change) & inputs from streamflow & groundwater



**Combined effects of these complex phenomena on the spatial and temporal variation of water levels : not well known & difficult to model**

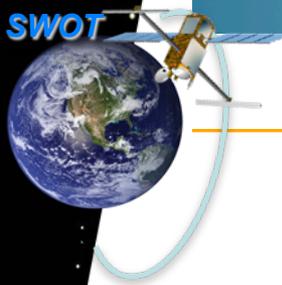
because of :

- sparse in situ observations of water levels
- tide gauges are located in sheltered areas (such as harbours)
- the effects of the phenomena and their interactions are different according to the morphology, sedimentary and climate contexts
- the scale of the physical processes can be small & difficult to observe by altimeters



**SWOT (SAR-interferometric altimeter): higher spatial resolution & excellent global coverage → fundamental data to:**

- map the spatial variability of water surface elevations under different hydrodynamic condition & and at different scales (local, regional and global)
- validate & calibrate our models (SWOT data assimilation in models)
- improve our knowledge of the complexity of the physical processes & their interactions in the coastal & estuarine systems



## Previous studies on the SWOT use in the coastal & estuarine environments

SWOT ability to reproduce the hydrodynamics in the coastal zones was studied mainly in macrotidal context

### Now:

Important to work in other environments with different tidal contexts in various climatic, morphological & sedimentological contexts representative of the earth → global & regional rules about:

- the SWOT ability to reproduce the spatial & temporal variability of the hydrodynamics in each of the major coastal environments (macro, meso & microtidal, & estuary, delta, shoreline with beaches or cliffs, shelf)
- the physical processes (wave, tide, storm surge, river flood...) in the continuum of the different environments
  - River-estuary-mouth-shelf continuum
  - Shoreline-neashore-shelf continuum
  - Wetland-estuary channels continuum
  - Wetland-shoreline continuum...



## 4 Projects : Phase 2016-2019

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### 1 project: continental shelf & the meso-scale

#### - Han project:

Research and Development of SWOT Measurements in the Canadian Oceans  
(Fisheries and Oceans Canada, Univ. Toronto & Univ. Waterloo)

### 1 project: estuary-mouth-shelf-continental slope-deep ocean continuum

#### - Ayoub and De Mey project (COCTO):

Coastal Ocean Continuum in surface Topography Observations  
LEGOS-IRD Toulouse, IFREMER-LOPS Brest, IRD Hanoi, LA

### 2 projects: coastline, estuary & coastal wetlands

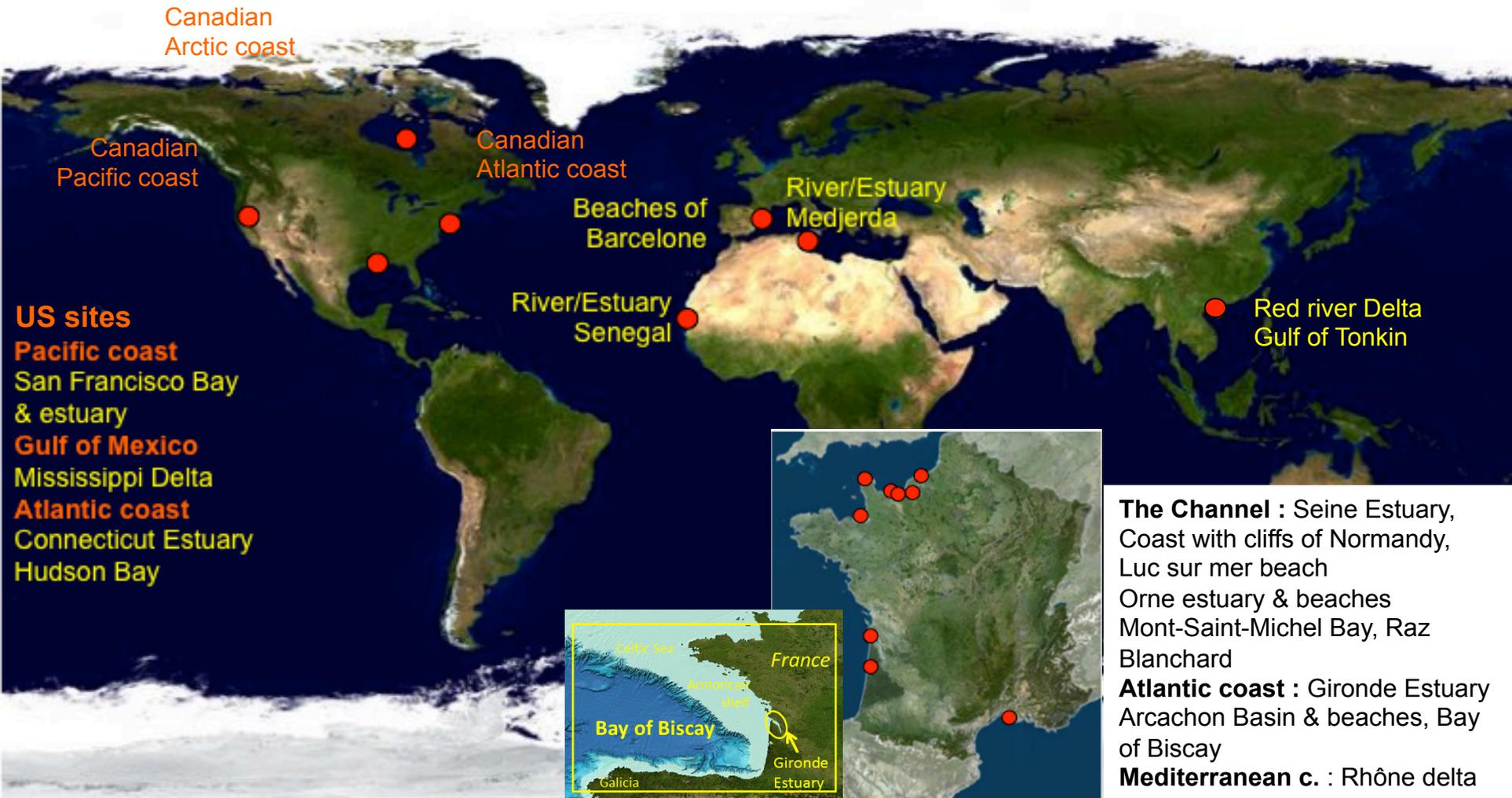
#### - Simard project:

Understanding SWOT measurements in Coastal Wetlands  
JPL Pasadena, M2C Rouen

#### - Laignel project:

Characterisation, modeling and SWOT potentiality to measure hydro-meteo-marine phenomena in the coastal (shoreline and neashore) and estuarine systems  
(18 teams (12 French, 2 European, 2 North american, 2 African): M2C & IDEES Rouen, LETG Caen, LDO Brest, EPOC Bordeaux, LEGOS-GET-CERFACS Toulouse, SERTIT Strasbourg, MINES ParisTech, LNHE, I-SEA Bordeaux, JPL Pasadena, Bedford Intitute, Univ. Berlin, Univ. Cantabria, INRGREF Tunis, Univ. Thies)

# Study sites/Study areas



## 21 study sites/study areas

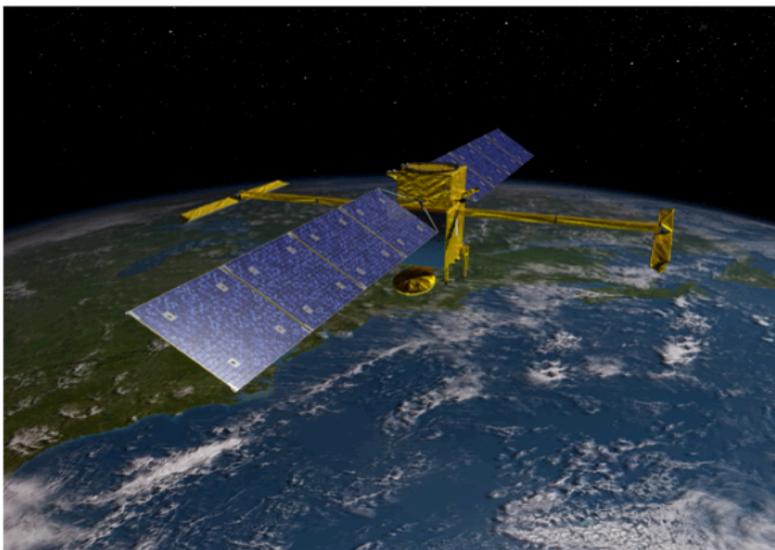
Selected in different tide contexts (macro, meso & microtidal), diverse morphologies (estuary, delta, bay, coast with sandy beaches or cliffs, shelf), different climates (temperate, mediterranean, tropical, arctic...), number of passages of SWOT from 1 to 6

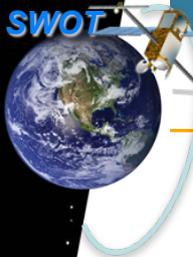


## Han project: Objectives

To improve knowledge of coastal & submesoscale processes & explore utility of SWOT in these coastal processes

- 1) Improve coastal tide models for more accurate tide correction in the Canadian coastal ocean (with assimilation of SWOT data)
- 2) Understand wave-current interactions in the Gulf Stream front zone
- 3) Diagnose the SWOT signature of interactions between geostrophic flows





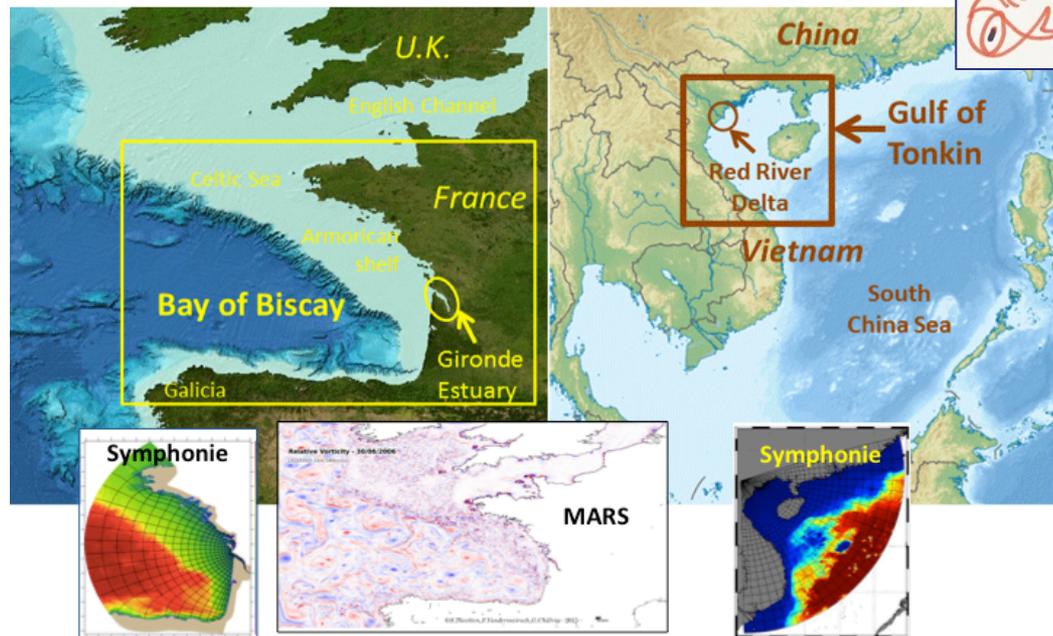
# Youb & De Mey project (COCTO): Objectives

To better understand the dynamics & the exchange in the estuary-mouth-shelf-continental slope-deep ocean continuum

- 1) Better understand the dynamics at the small scale (1-10 km) on the shelf & the continental slope & the impact of the dynamics on the shelf-ocean exchanges
- 2) Identify on the SSH signature the processes responsible of this small scale dynamics
- 3) Characterize the potential input of the SWOT observations in the modeling by assimilation & to compare this input with the in-situ & other satellite data

5 topics :

- Lower estuary dynamics
- Estuary to shelf transition zone
- Small-scale processes on the shelf
- Shelf break processes
- Multiscale estimation approaches





# Simard project: Objectives

- To assess the capabilities & limitations of SWOT to measure water level in tide-impacted wetlands located in estuaries & along coastlines (Mississippi delta)
- To define the SWOT science products specific to coastal wetlands

Above Ground Biomass for Tidal Marshes of Louisiana Using UAVSAR data



- 1) Assess the accuracy of SWOT's water level measurement in coastal wetland environments
- 2) Assess the ability of SWOT measurements to capture rapidly changing hydrology & phenology conditions in coastal wetlands
- 3) Define SWOT's science products in coastal wetlands (fresh & salt marshes & mangroves)

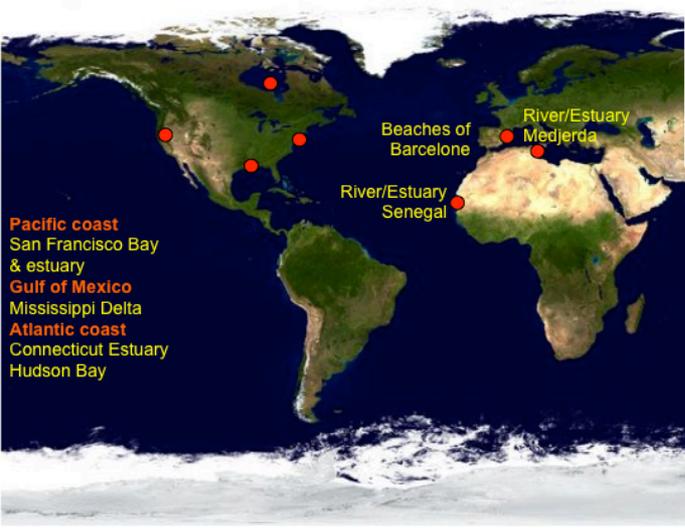




# Laignel project: Objectives

To better understand the interactions of the hydro-meteo-marine phenomena on the hydrodynamics in the estuary & coastal systems (coastline)  
SWOT ability to reproduce this hydrodynamics & these phenomena

- 1) Define the issues & applications of SWOT in these environments
- 2) Characterize the interactions of the hydro-meteo-marine phenomena on the temporal variability of the hydrodynamics & SWOT ability to reproduce the temporal variability of the water level
- 3) Model the spatial variability of the hydrodynamics & these phenomena & SWOT ability to reproduce the spatial variability in different hydrodynamics contexts & conditions by using the HR & ocean simulator
- 4) Compare the SWOT performance & potentiality with the other satellites
- 5) Calibrate & validate SWOT from Airborne campaigns (AirSWOT & LIDAR)



**The Channel** : Seine Estuary, Coast with cliffs of Normandy, Luc sur mer beach  
Orne estuary & beaches  
Mont-Saint-Michel Bay, Raz Blanchard  
**Atlantic coast** : Gironde Estuary  
Arcachon Basin & beaches  
**Méditerranée** : Rhône delta



# Methods

## Numerical modeling

T-UGOm, Symphonie, MARS3D (Ayoub)  
FVCOM, ROMS, SWAN (Han)  
T-UGOm, DELFT-3D, TELEMAC (Laignel)  
DELFT-3D (Simard)

## SWOT simulator

Ocean simulator (Ayoub, Han, Laignel)  
HR Simulator (Laignel, Simard)

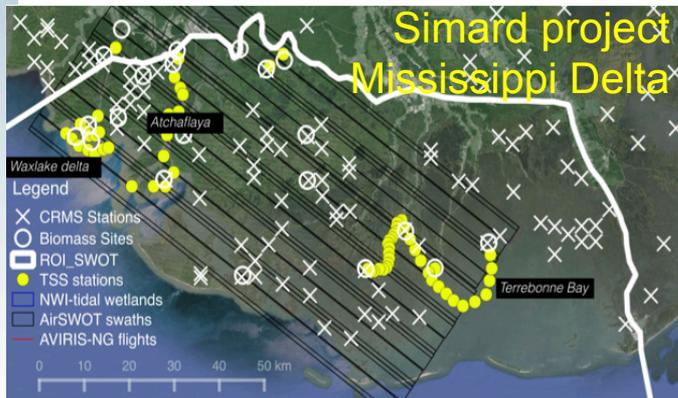
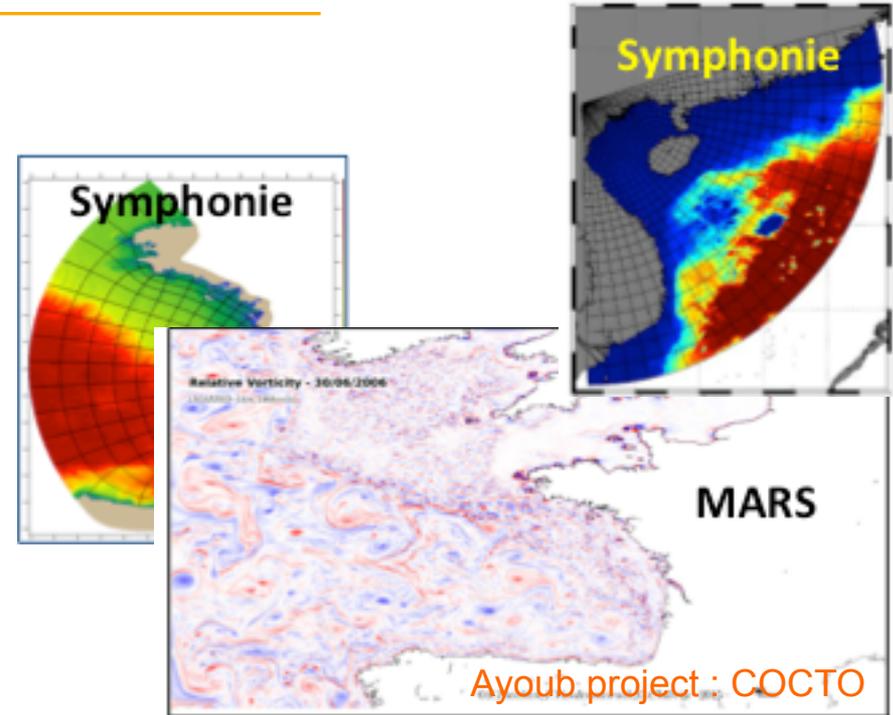
## SWOT Data Assimilation (Ayoub, Han)

Data Assimilation from Kalman filter

## Datasets

to calibrate & validate the models

to define the SWOT ability to reproduce the spatio-temporal hydrodynamics



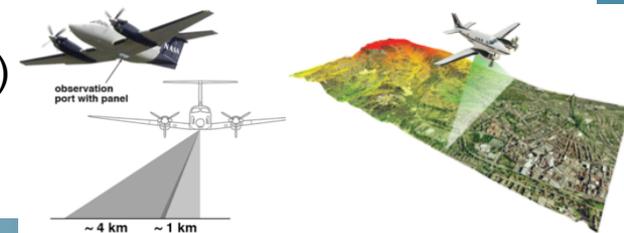
## In-situ time series from tide gauges

## Spaceborne data

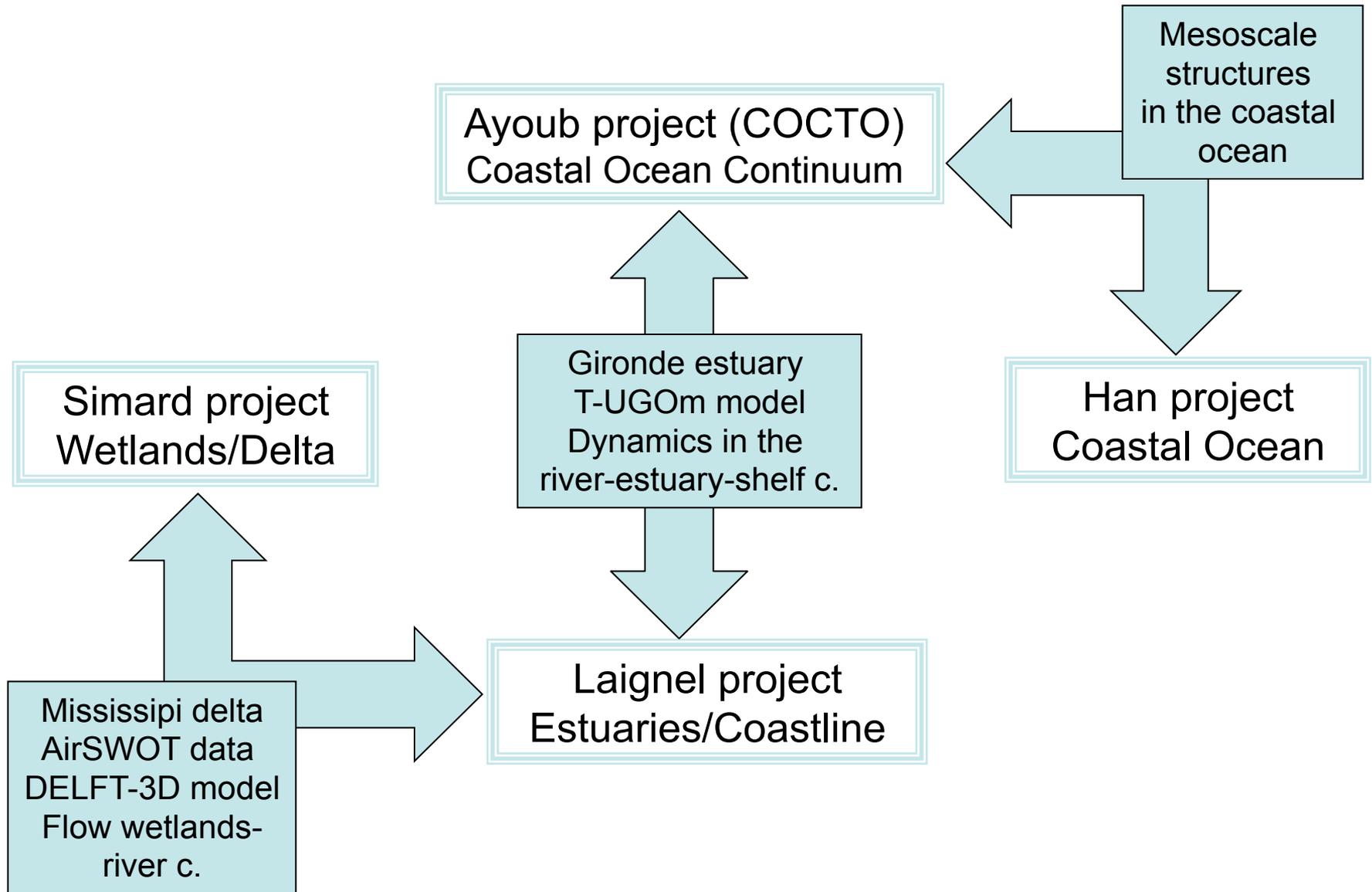
Landsat 8, Sentinel 1, 2, 3A & 3B,  
RadarSat-2, Cryosat-2, Jason-CS, TerraSAR-X...

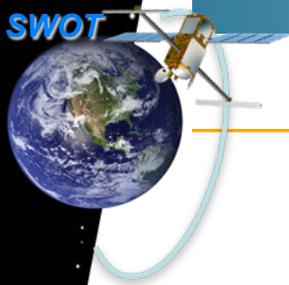
## Airborne campaigns data

UAVSAR, AVIRIS-NG (Simard)  
AirSWOT (Simard & Laignel)  
LIDAR (Laignel)

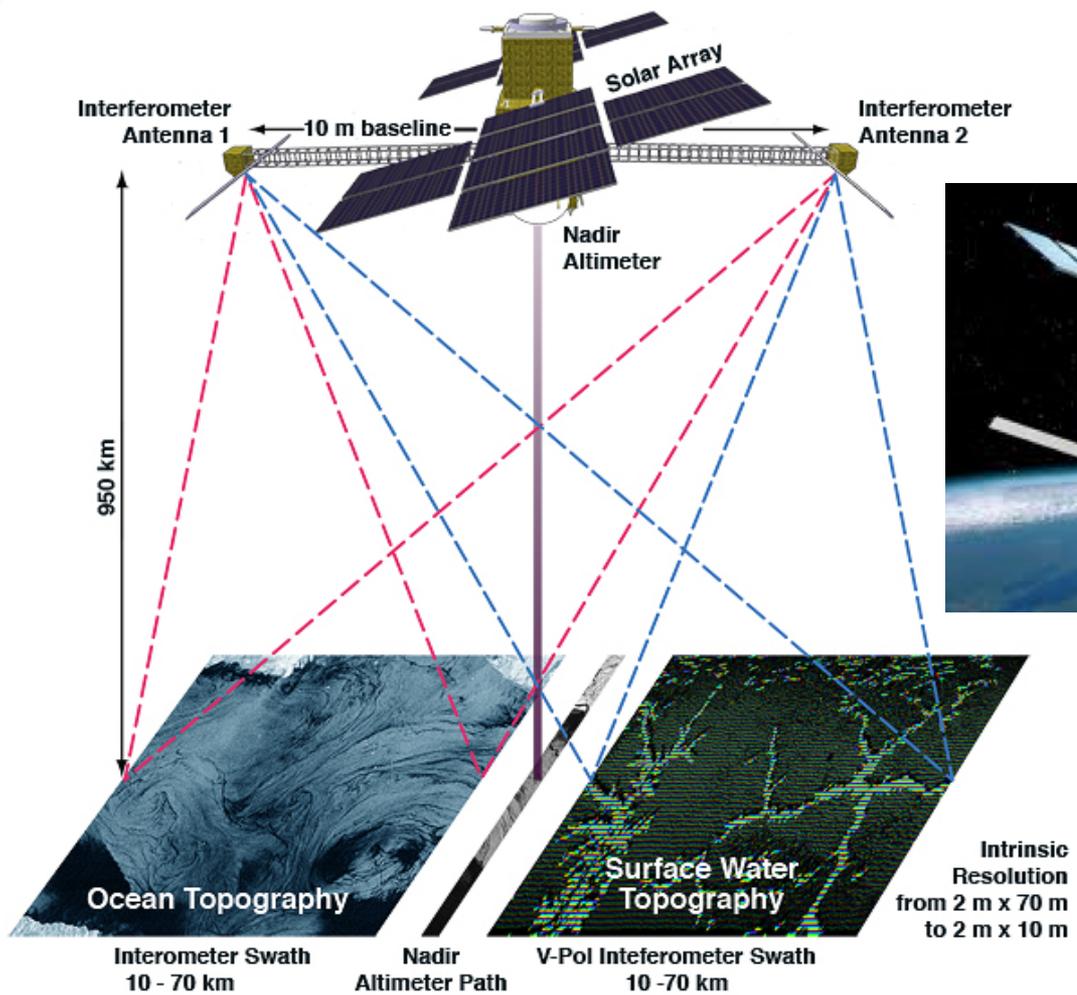


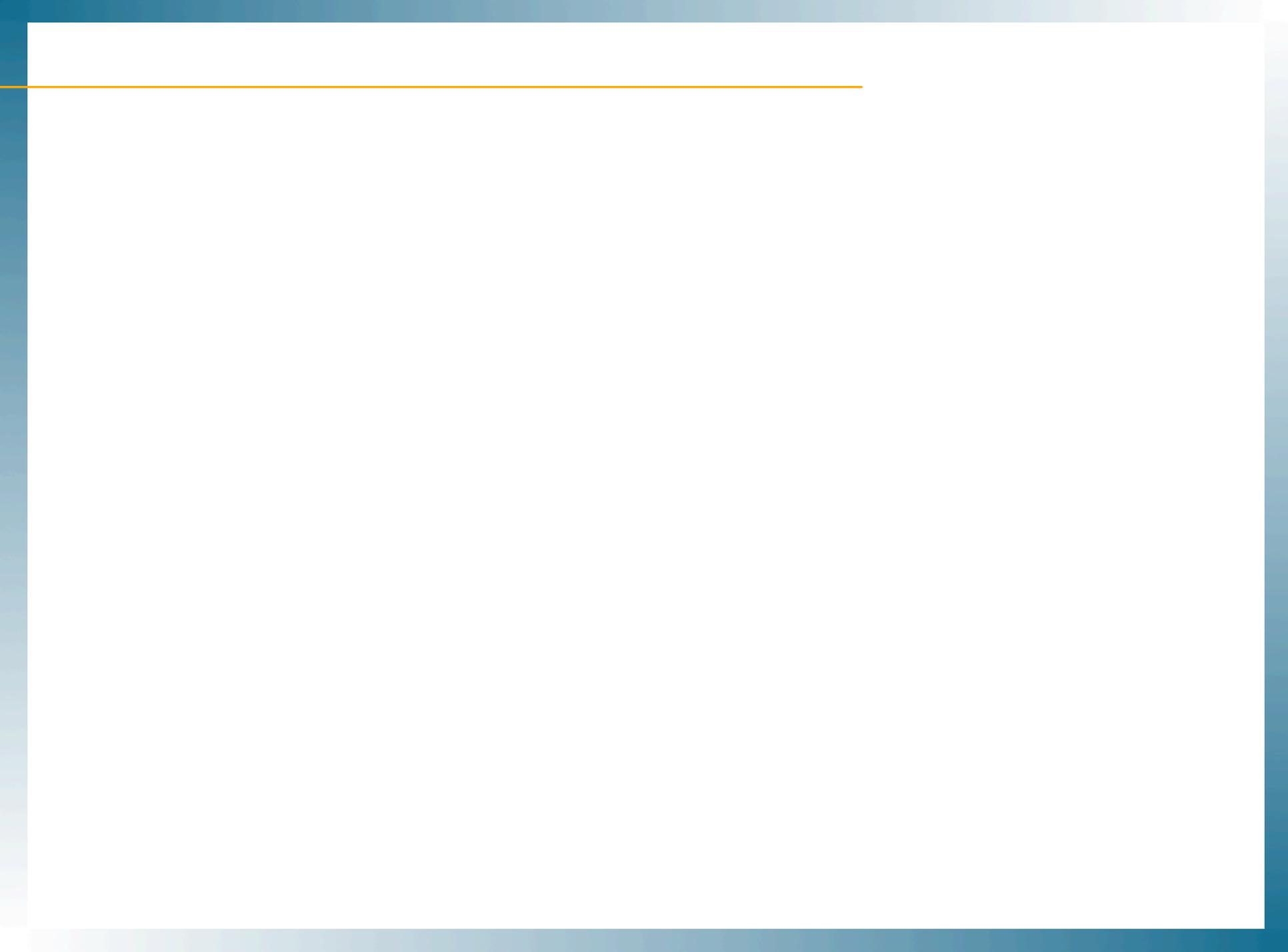
## Links between the projects



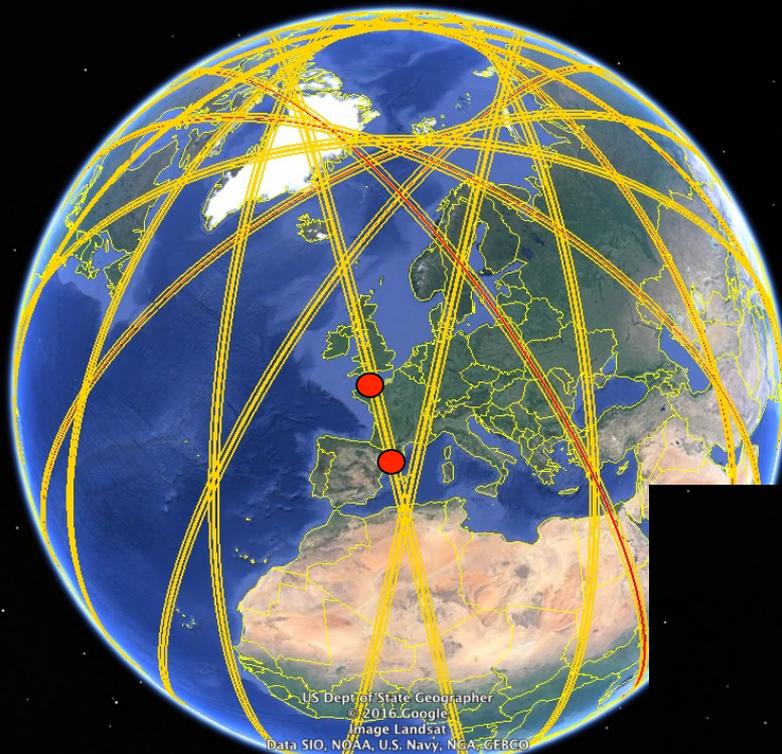


# Thanks





# Estuary and shoreline Sites - 1 day repeat (initial Cal/Val)



Date des images satellite : 14/12/2015 48°52'22.43"N



Cotentin Coast (SE Channel coast)  
Beaches of Barcelona

Connecticut Estuary  
Bay of Hudson



Date des images satellite : 14/12/2015 34°26'52.20"N 76°27'45.29"W altitude 11001.96 km