

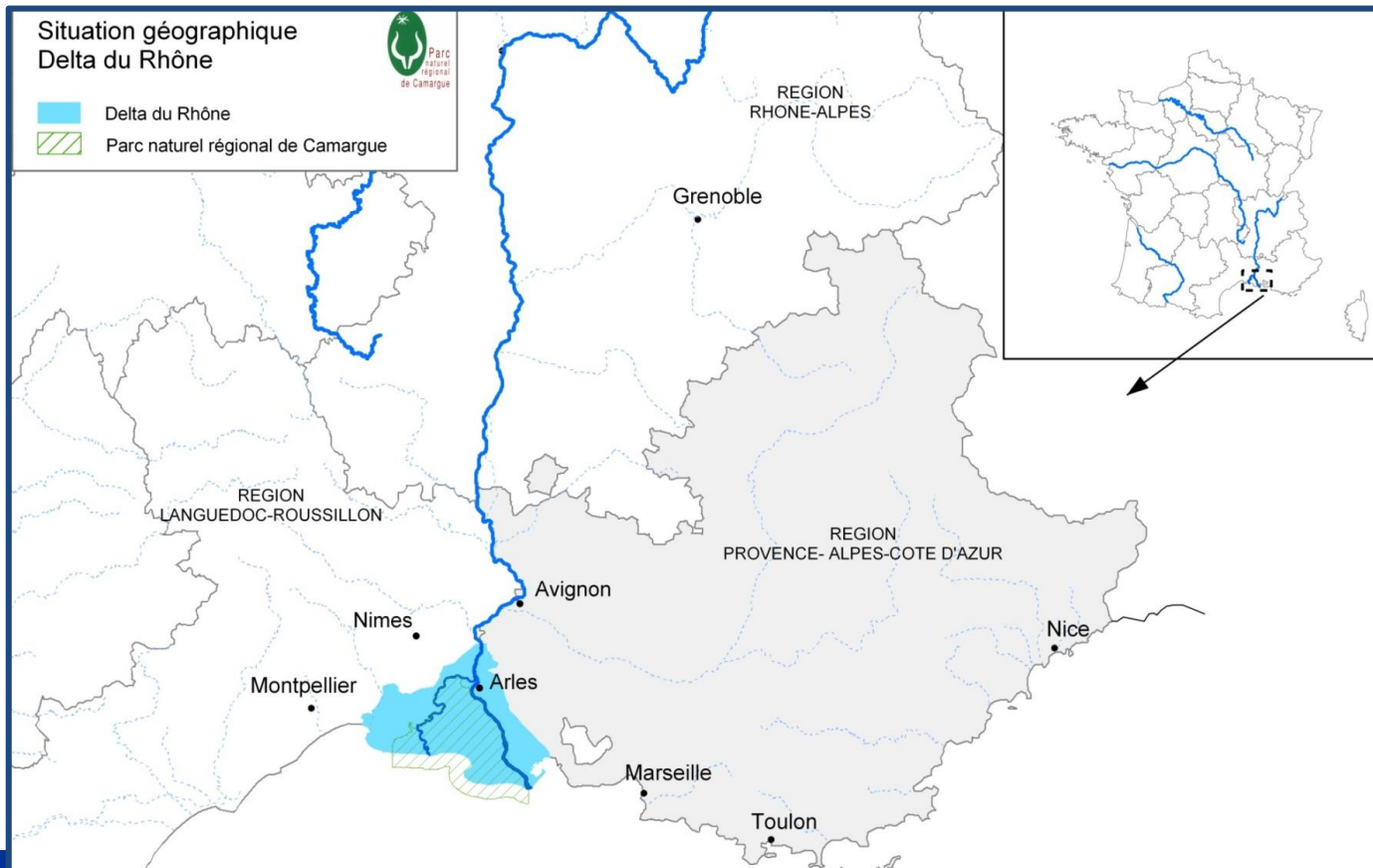
## Evolution of wetland functions and services in the Camargue and beyond

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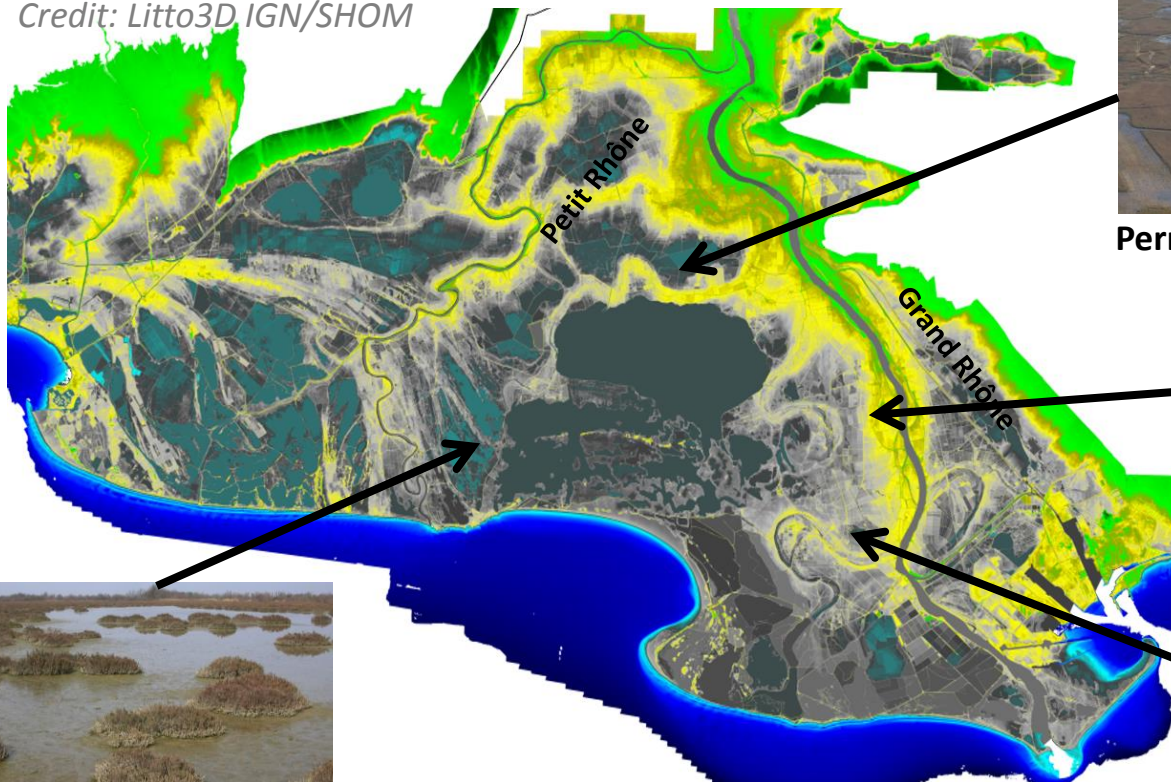
**Camargue = Rhône delta in southern France**  
**PA = MAB Unesco Reserve (193 000 ha)**

*Credit: PNRC*



**A delta with various natural & human-made wetland ecosystems having different seasonal water requirements and salt tolerance**

*Credit: Litto3D IGN/SHOM*



**Permanently flooded hunting marshes**



**Ricefields irrigated in April-August**



**Halophilous scrubs flooded with rainfall**



**Temporary & brackish marsh**

*Photo credits: Tour du Valat*



This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

*Ecopotential General Assembly & Meeting, Matalascañas, Spain 18-22 June 2018*

**Aim** : to make the best use of remote-sensing & modelling tools to document the evolution in the state of wetlands and the services they can/*will* deliver within a context of global changes, integrating feedback processes occurring at local scale and *future climate projections*



Photo credits: Tour du Valat, Olivier Pineau, Marc Thibault, Emilien Duborper, Philippe Sabine, Jean-Yves Mondou-Monval



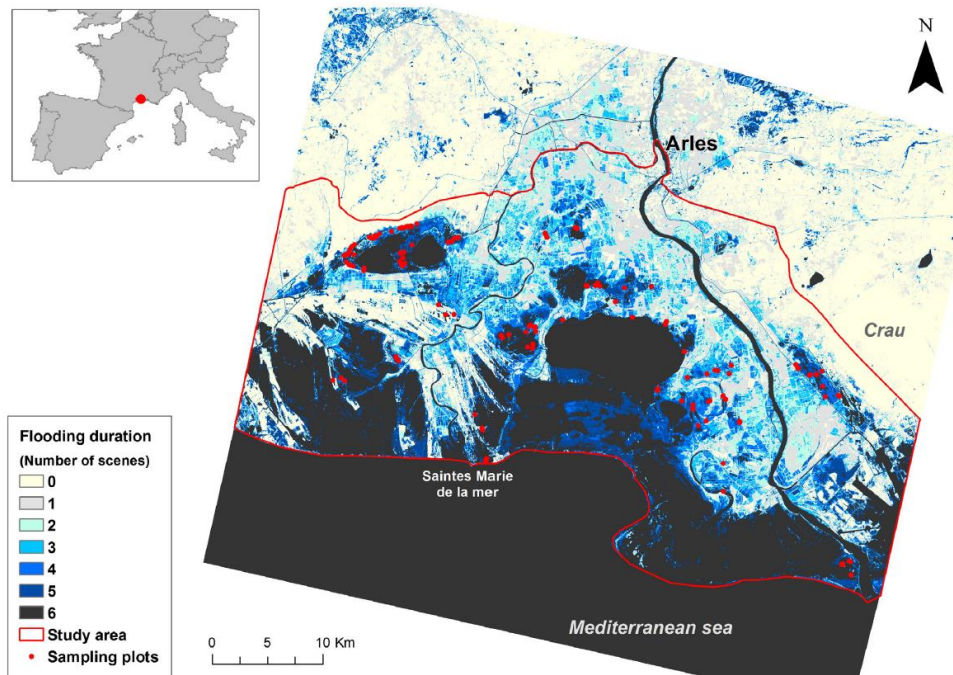
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**Monthly maps of water presence:** to document gain/loss in Mediterranean biodiversity, habitat shift, evolution in management practices...

**Challenge :**

**to detect water below  
emergent vegetation cover**



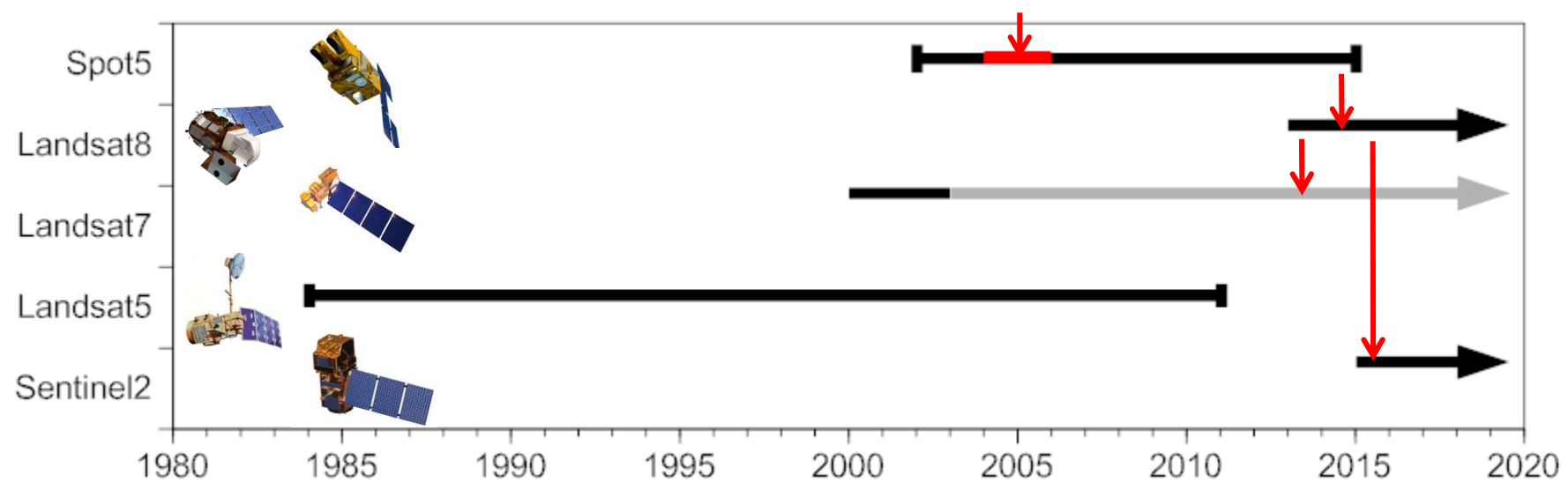
*Remote Sensing of Environment (2013) 138:165-171*



# Towards the monitoring of water in wetlands, including under vegetation, over a 40-yr period



Water presence formula (RSE, 2013)



- From the original SPOT5 formula developed in 2004-2006, 4 inundation maps were created in 2015. 850 randomly selected points per date were used as input data for corresponding date on Landsat8 scene in addition to 814 field plots to create a new formula with Landsat8
- From the new Landsat8 formula, 5 inundation maps were create in 2016. 850 randomly selected points per date were used as input data for corresponding date on Sentinel2 scene in addition of 908 new 2016-2017 field plots data to create a new formula for future follow-up
- From the new Landsat8 formula, 6 inundation maps were created in 2014. 850 randomly selected points per date were used as input data for corresponding date on Landsat7 to create a new formula with Landsat7 and Landsat5 for retrospective analysis.



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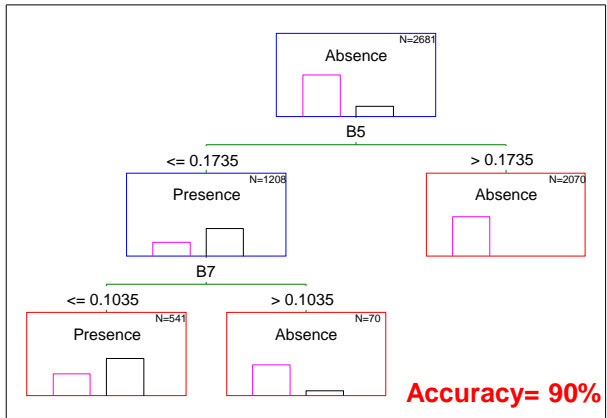
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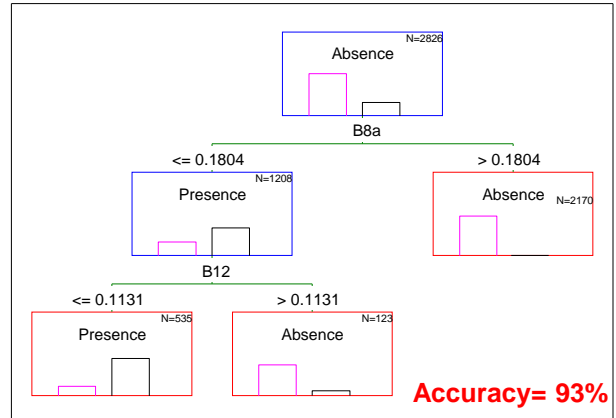
# Towards the monitoring of water in wetlands, including under vegetation, over a 40-yr period



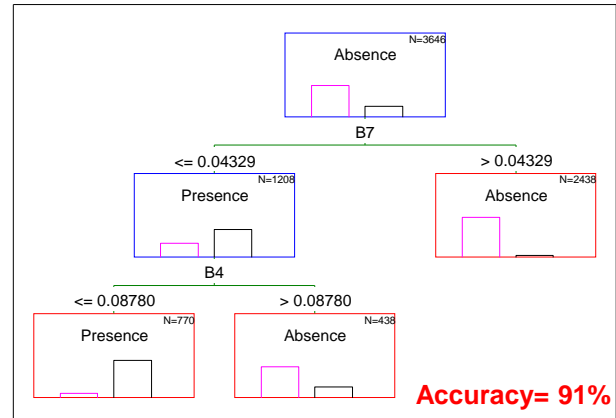
### Spot5 => Landsat8



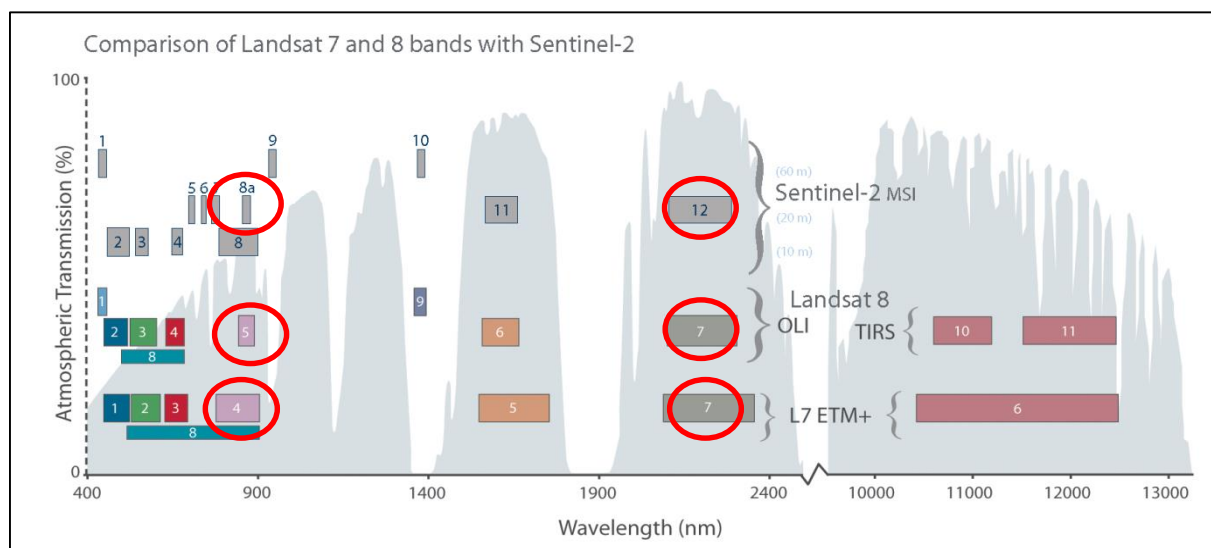
### Landsat8 => Sentinel2



### Landsat8 => Landsat5 & 7

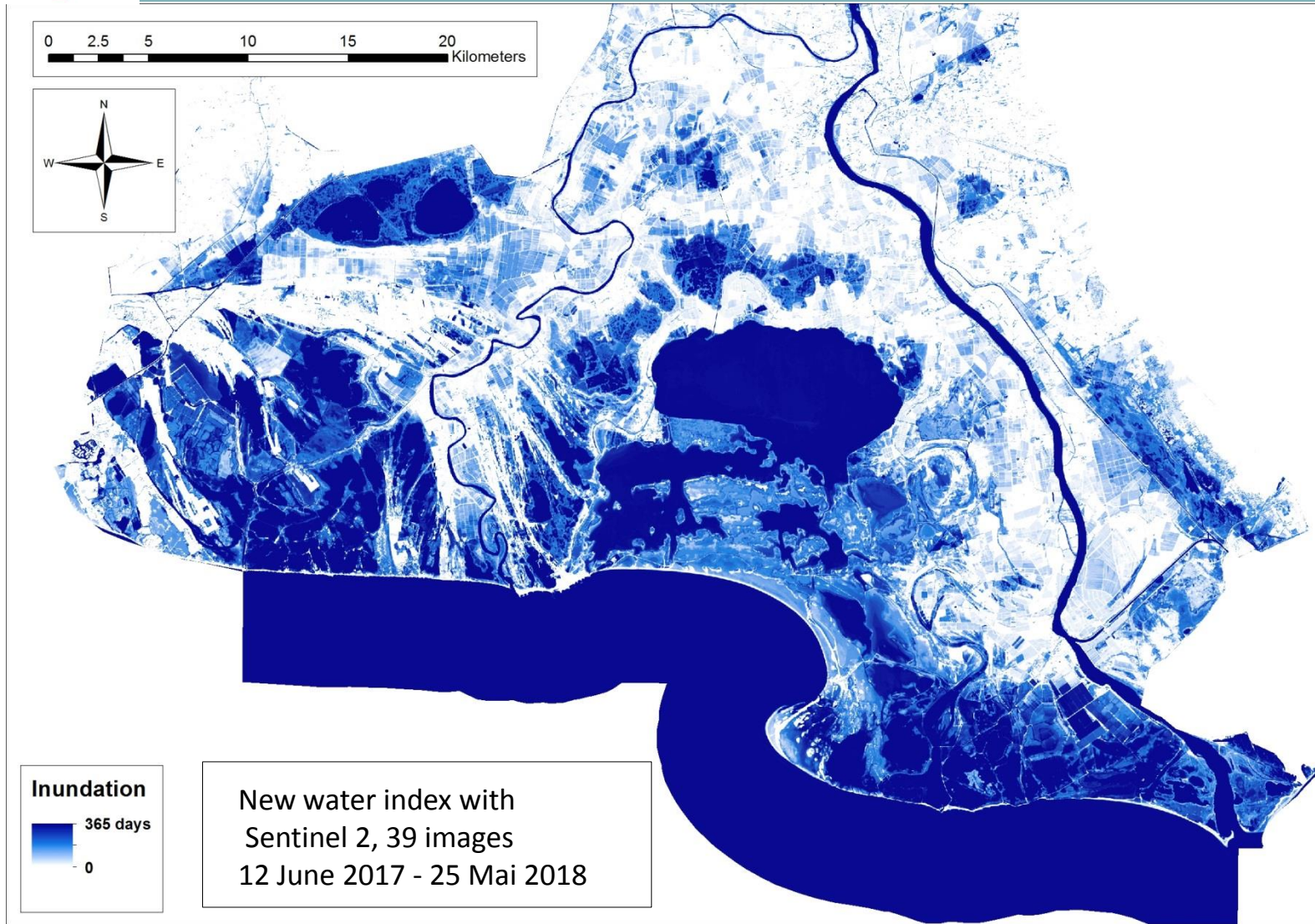


### Bands used for each new formula



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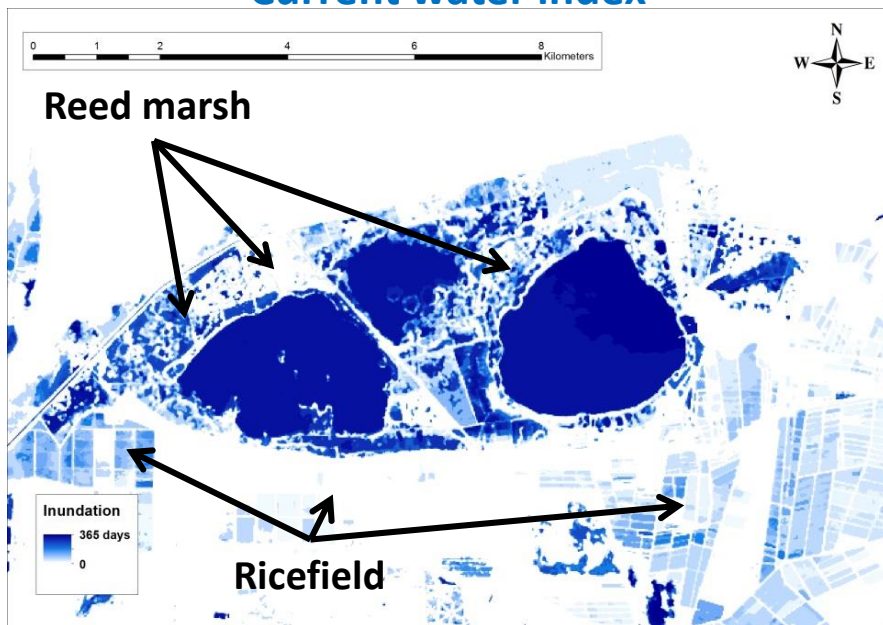
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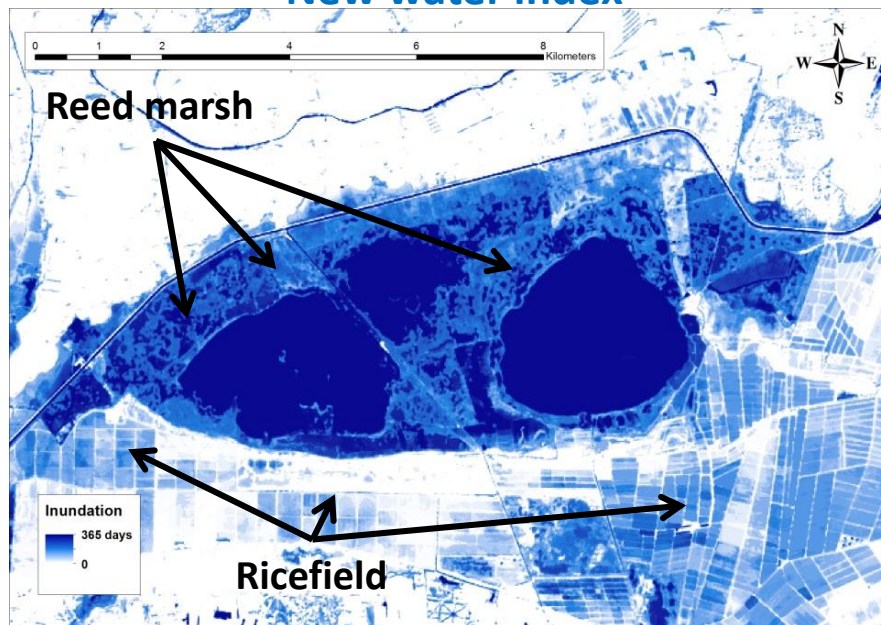


## The new water index detects water under reed and rice cover

### Current water index



### New water index



Annual spatial assessment of crops cultivated (based on their phenology & radiometric response) is requested by Camargue manager:

- (1) to improve collective management of agricultural land;
- (2) to qualify pesticide/fertiliser inputs;
- (3) to estimate water allocation to croplands vs wetlands;
- (4) to improve governance of agro-environmental schemes & CAP



Photo credits: Tour du Valat

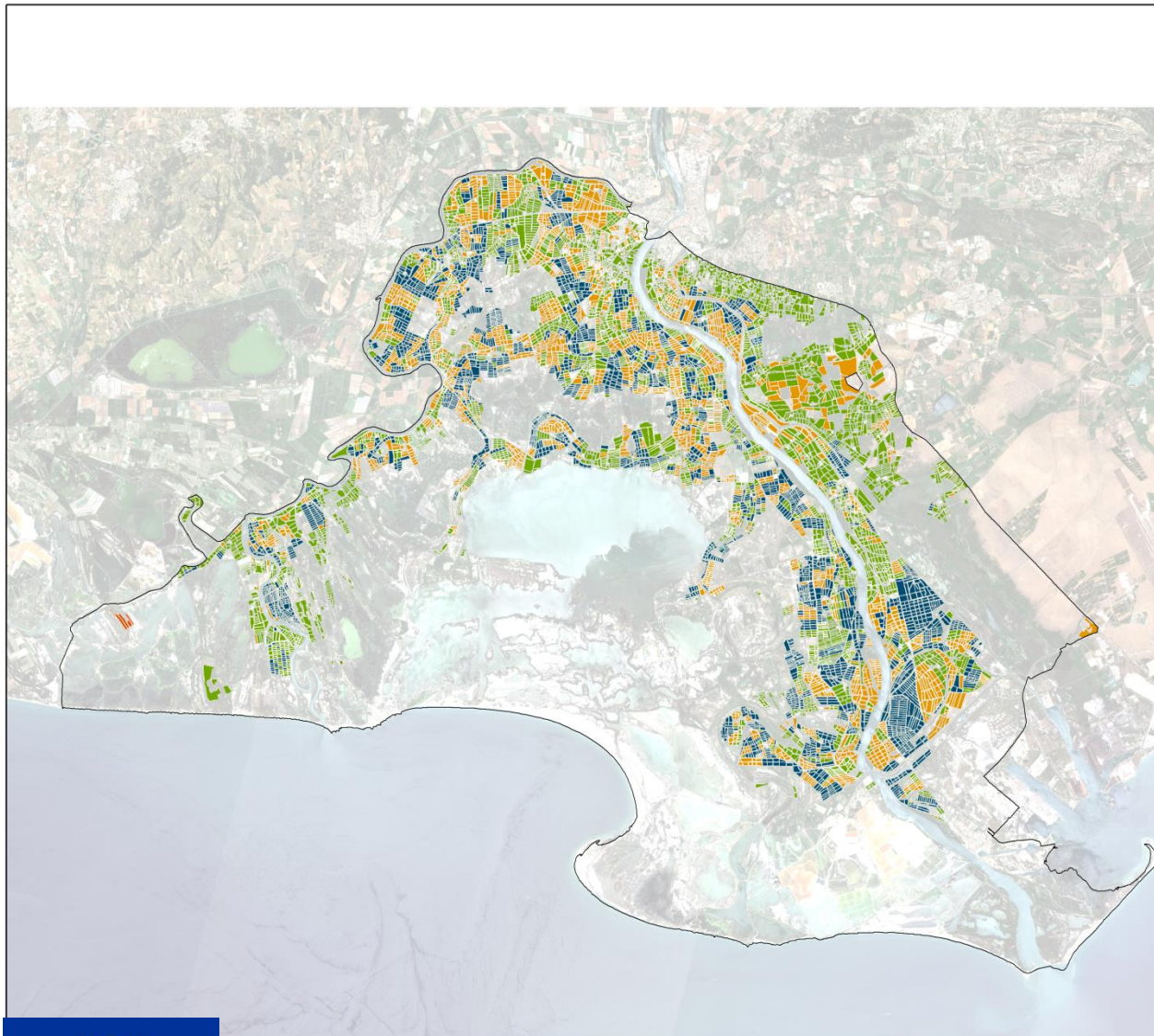


Photo credits: Marc Thibault



Photo credits: Tour du Valat





**Objective:** This stage of the project used Sentinel 1 and Sentinel 2 imagery to map the agricultural landscape in the Camarque, aiming to distinguish between wheat, rice, and other crop types.

**Legend**

Bouches du Rhone  
Area of Interest

**Classification results**

- Rice
- Wheat
- Other crop
- NA

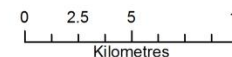
**Background: RGB Sentinel 2 imagery (27/06/2018)**

**Methodology:** The classification used a random forest algorithm, with field data and zonal statistics from satellite imagery as inputs. Field data (2018) contained records of 676 fields, of which 33% grew rice, 25% wheat, and 41% other crops (a combination of 11 different crop classes). Satellite imagery used consisted of 131 layers, 107 Sentinel 1 layers for which band ratio was calculated, and 24 Sentinel 2 layers at 10m and 20m each, with NDVI and GDVI derived where appropriate.

50% of records for each class were held back for validation.

**Results (see also validation map):** The estimate of error rate of the random forest model is 3.25%. The class error for "Other crops" is 0.0 for "Rice" 0.06, and for "Wheat" 0.05, with the most confusion occurring between "Wheat" and "Other crops".

Cartography by Environment Systems Ltd, July 2018, Version 001.  
Prepared by Elsa-Kristin Naumann  
Checked and approved by Dr. Jamie Williams, CSci



**Mapping of reed harvested areas:** to document the maintenance of this traditional use and its potential impacts on reed birds (currently done through airplane surveys)



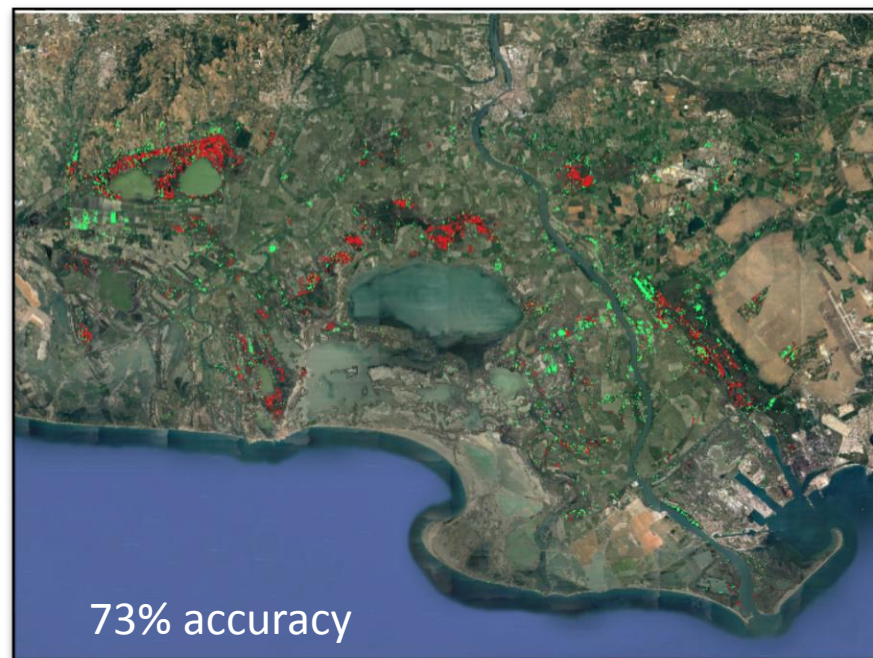
*Photo credits: Brigitte Poulin*

- **Input data:** randomly generated data (n=2994) from 3 years of aerial surveys
- **Satellites:** Sentinel1 (radar) & Sentinel2 (optic)
- **Diachronic approach:** one scene after the growth period of reed (September) and one scene after cutting but before the next growth season (March)
- **Data mining :** use of all bands & 22 radiometric indices (ie: NDVI) and their temporal differences
- **Statistical approach:** Classification tree with and without boosting algorithm on 2 or 3 reed classes (cut, uncut and one-year after cut)
- **Could spatio-temporal variations in NDVI be useful to identify harvested areas?**

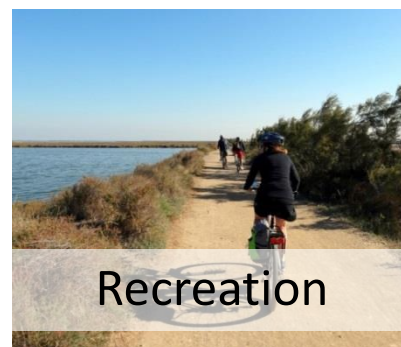
Harvested reedbed (red) with aerial survey



Harvested reed (red) with Sentinel data



The mediterranean basin is a hotspot of climate changes, putting at risk the biodiversity and the various services provided by wetlands ...



**Will semi-permanent marsh with emergent vegetation resist to climate change?**

*Photo credits: Tour du Valat*

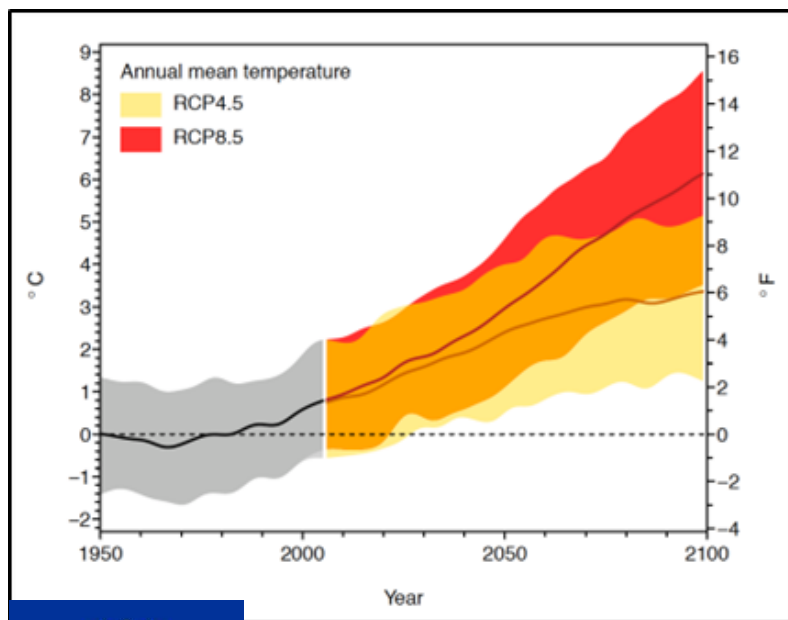
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**Aim: to predict the vulnerability of semi-permanent Mediterranean wetlands to climate change based on projections for 2050 & 2100 with RCP4.5 & RCP8.5 scenarios using <http://www.Mar-O-Sel.net>**

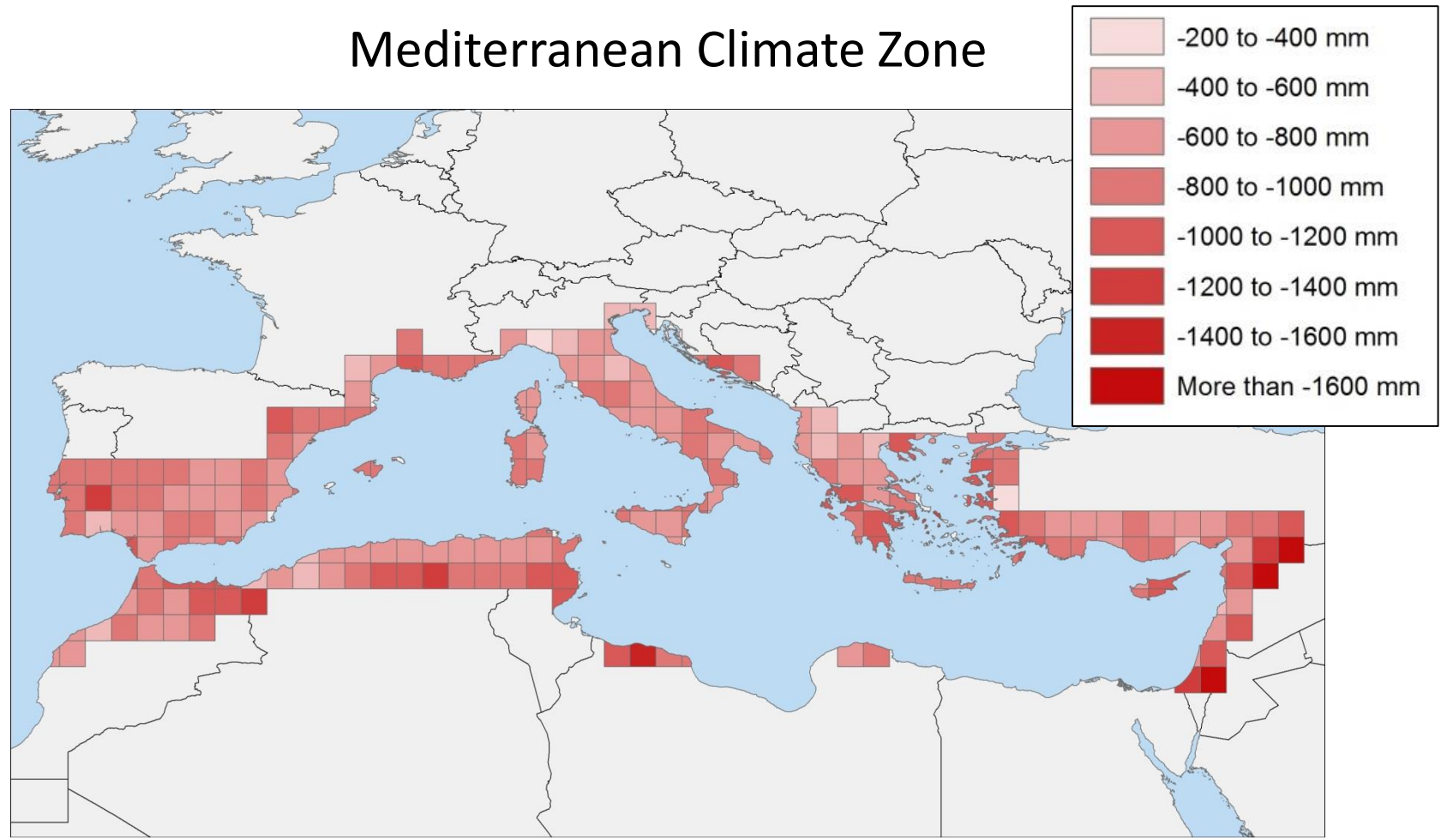
Future climate projections integrated to Mar-O-Sel software to run simulations on wetland hydrology throughout the Mediterranean area




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## Mediterranean Climate Zone



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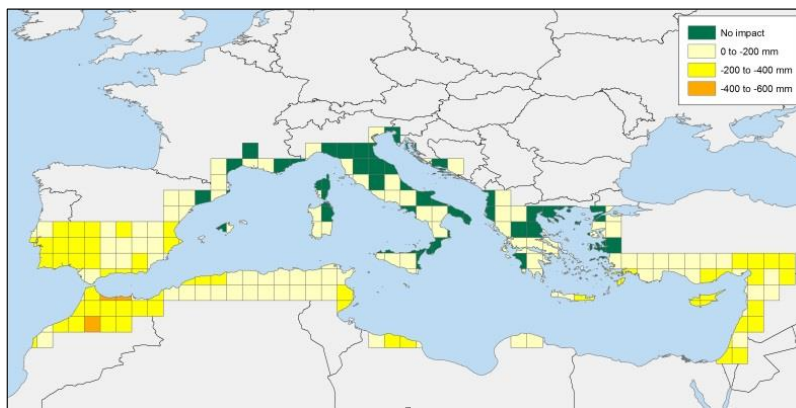
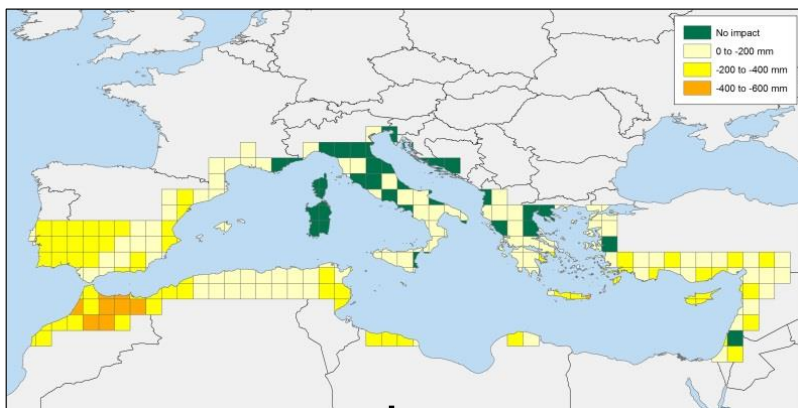
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Stabilization - RCP 4.5

2050

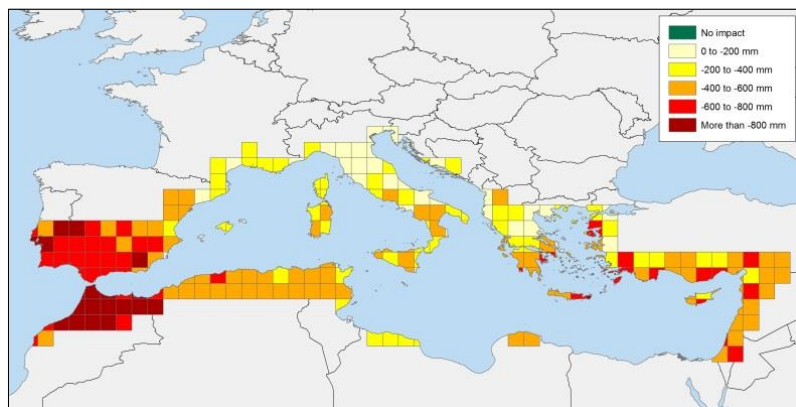
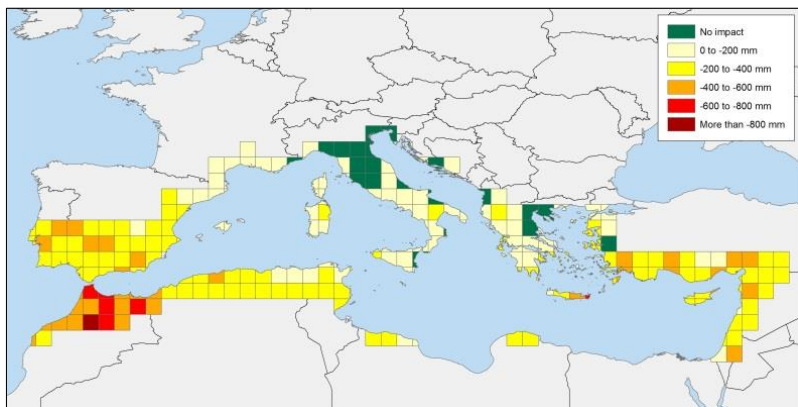
Current emission trend - RCP 8.5



- No change
- 200 mm
- 400 mm
- 600 mm
- 800 mm
- >-800 mm



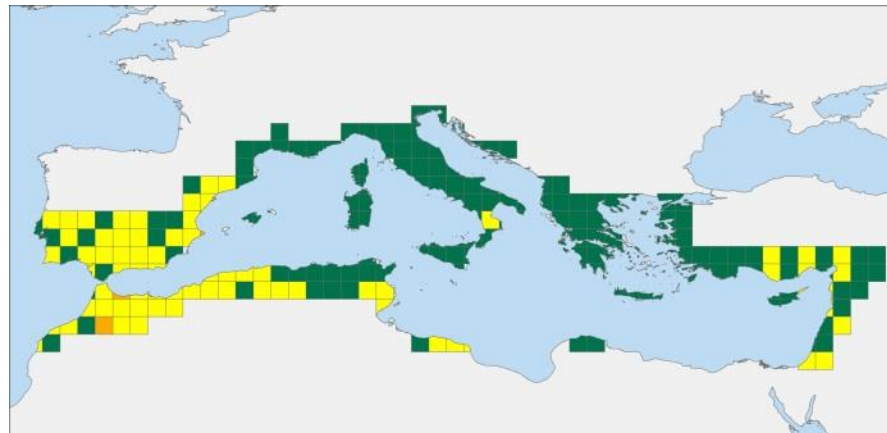
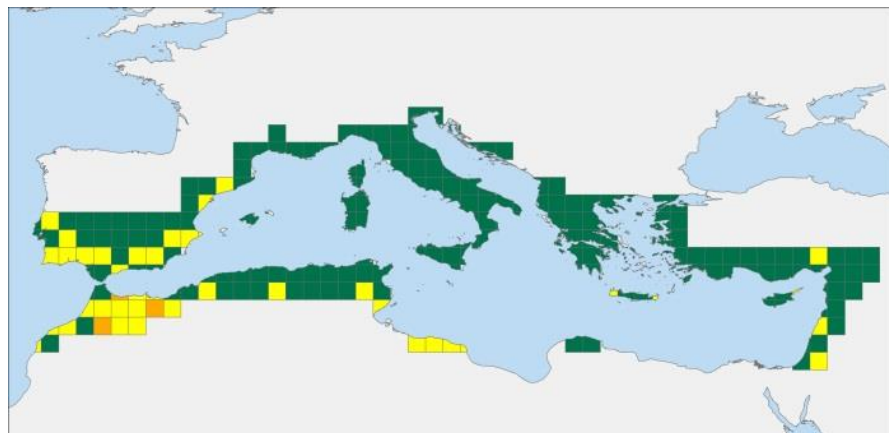
2100



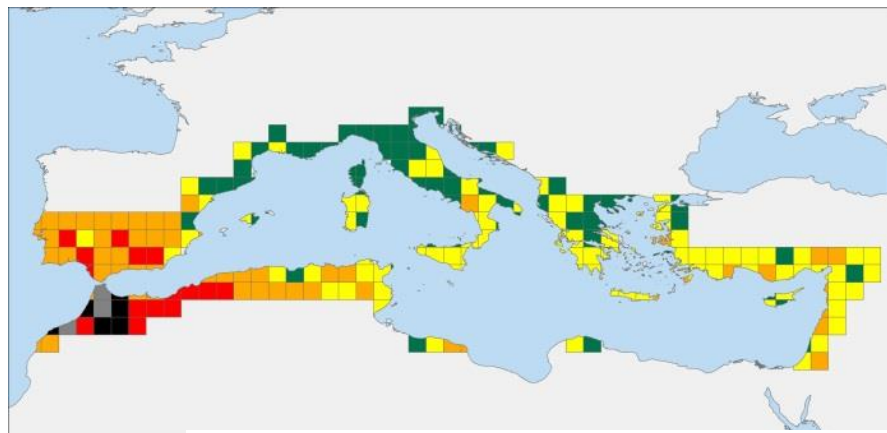
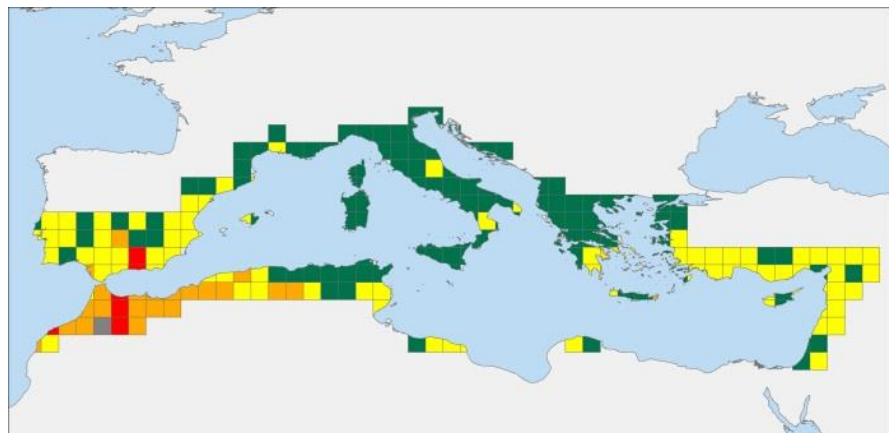
Stabilization - RCP 4.5

2050

Current trend - RCP 8.5



2100



State of emergent marsh:



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## Amount of water needed to preserve functions and values of seasonally-flooded wetlands

State of emergent marsh	Corresponding water loss (m <sup>3</sup> /ha/yr)
Slightly degraded	1055
Highly degraded	1722
Shift to open marsh	2263
Shift to temporary ponds	2857
Shift to drylands	3537

Thank you for your attention!



*Photo credits: Michel Gauthier-Clerc*



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