imaGeau
instrumentation du sous-sol

43rd IAH CONGRESS
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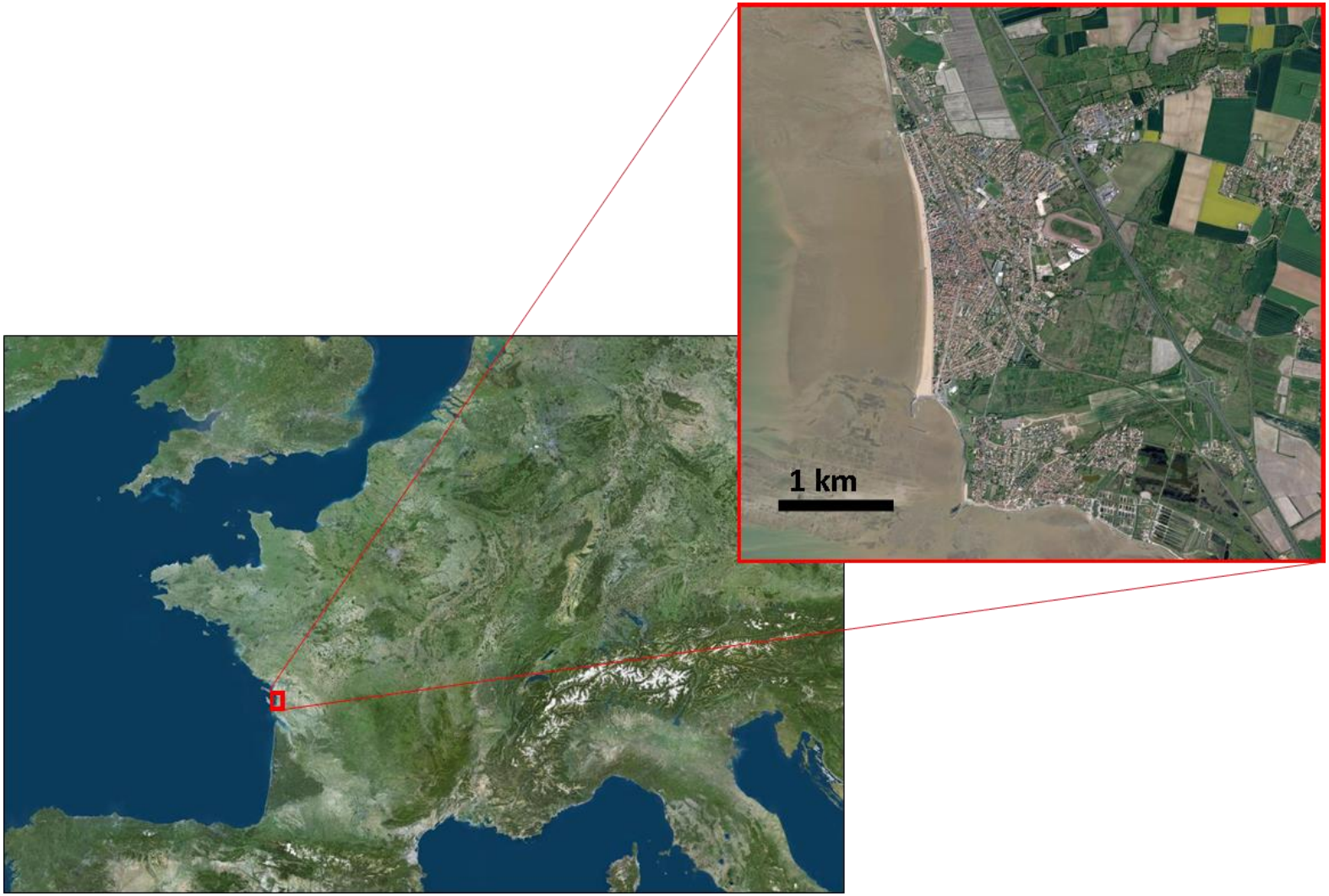
le Corum , Montpellier, France

Improved groundwater management in Chatelaillon coastal aquifer using in-situ geophysical monitoring

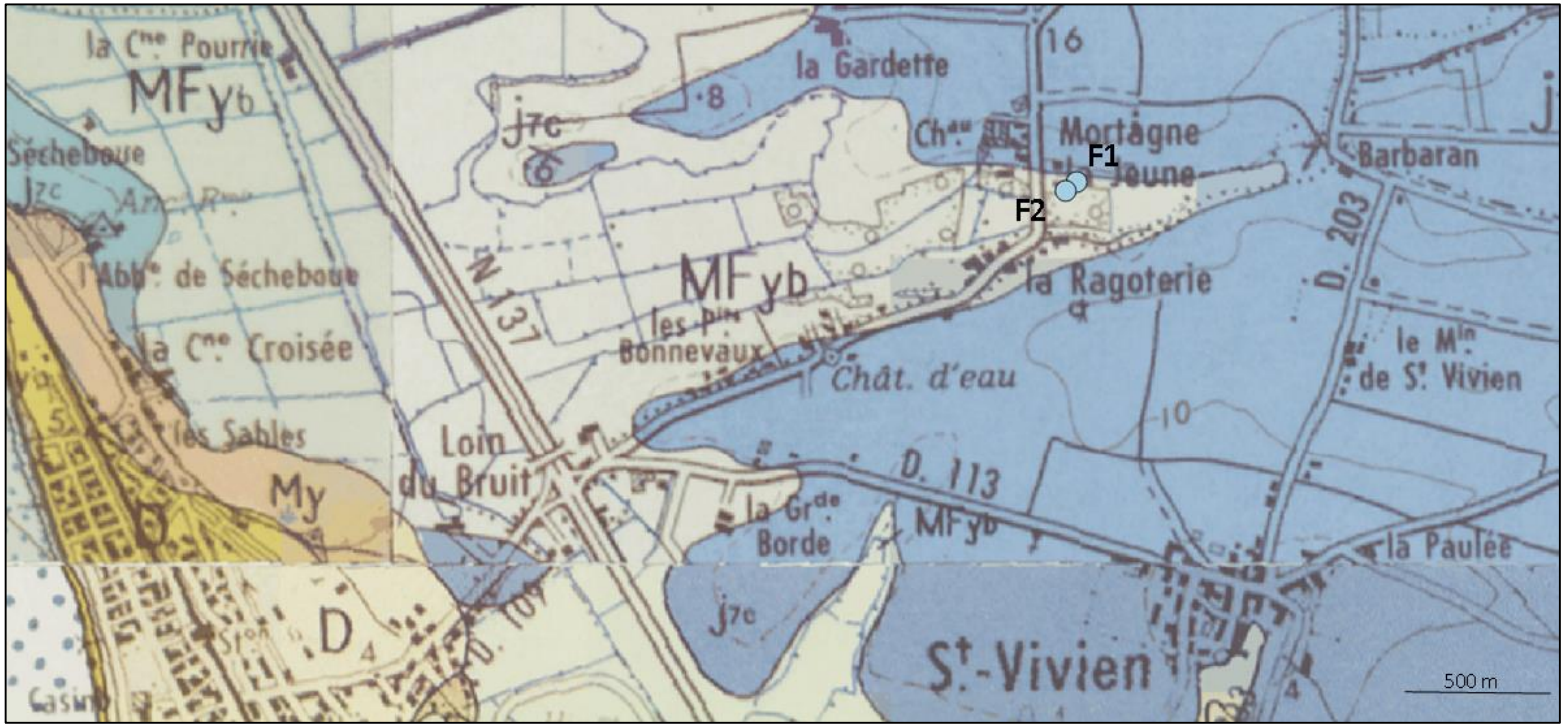
saur

Châtelaillon Plage

Water supply in Chatelaillon coastal aquifer



Water supply in Chatelaillon coastal aquifer

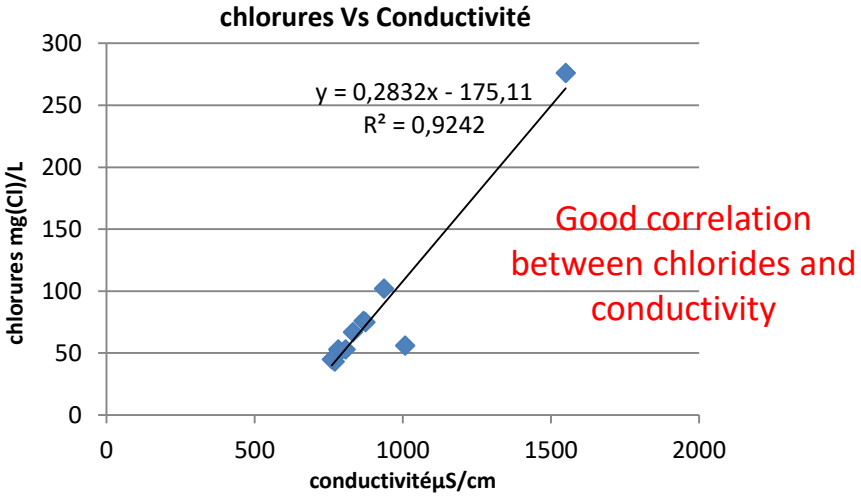


- Two wells F1 & F2 (20 m depth) are used to supply Chatelaillon touristic seaside resort in fresh water
- **Coastal limestone aquifer** composed by fissured limestone intercalated with blue marly sediments
- High touristic demand during summer season = groundwater extraction are multiplied by 2,5
- **Unconfined aquifer with high transmissivity,** subject to surface pollution (nitrates) and **saltwater intrusion** (pumping wells installed at 3 km from coastline)

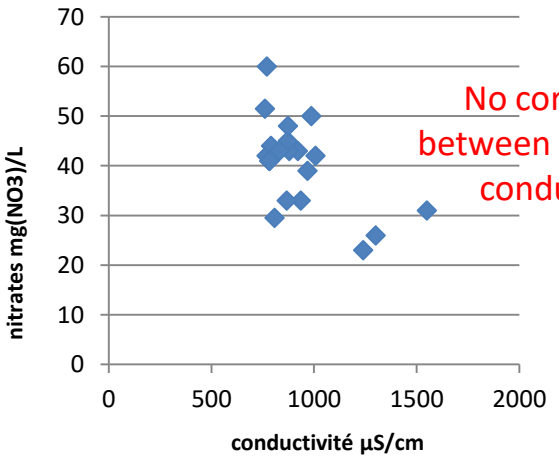
Water quality – extracted from ADES (French groundwater quality database) From 1996 to 2015 in F1 – F2 pumping wells

Paramètre	Nb Mesures	Minimum	Maximum	Moyenne
Chlorures (1337)	10	43.0 mg(Cl)/L	109.0 mg(Cl)/L	55.5 mg(Cl)/L
Conductivité à 25°C (1303)	20	757.0 µS/cm	1300.0 µS/cm	869.05 µS/cm
Nitrates (1340)	19	26.0 mg(NO3)/L	67.5 mg(NO3)/L	48.421 mg(NO3)/L

- High water conductivity (more than 1000 µS/cm) are often recorded
- High nitrates concentrations also recorded

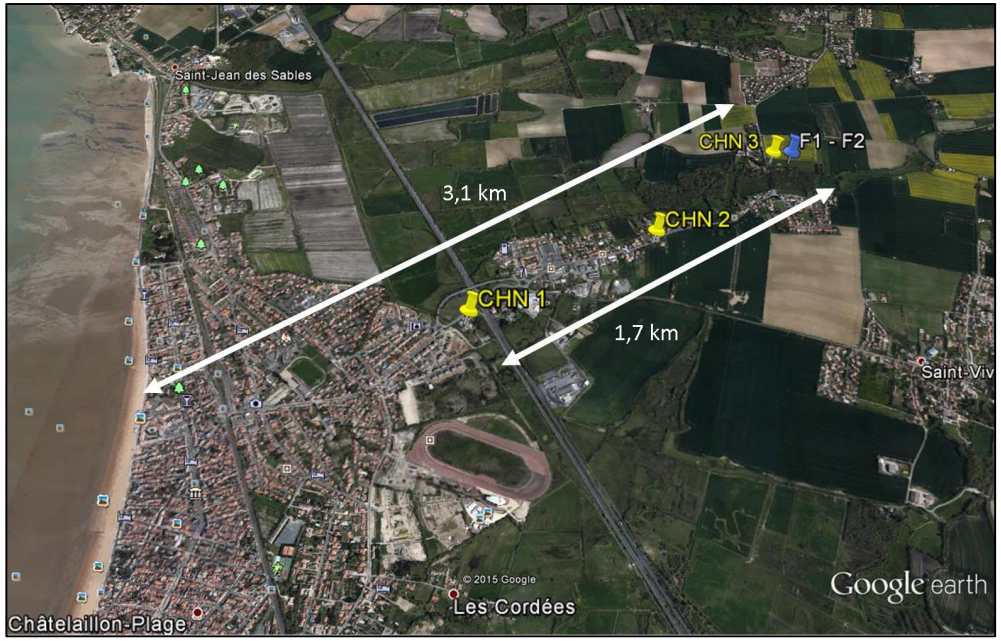


Good correlation between chlorides and conductivity



No correlation between nitrate and conductivity

Installation of a saltwater intrusion monitoring network

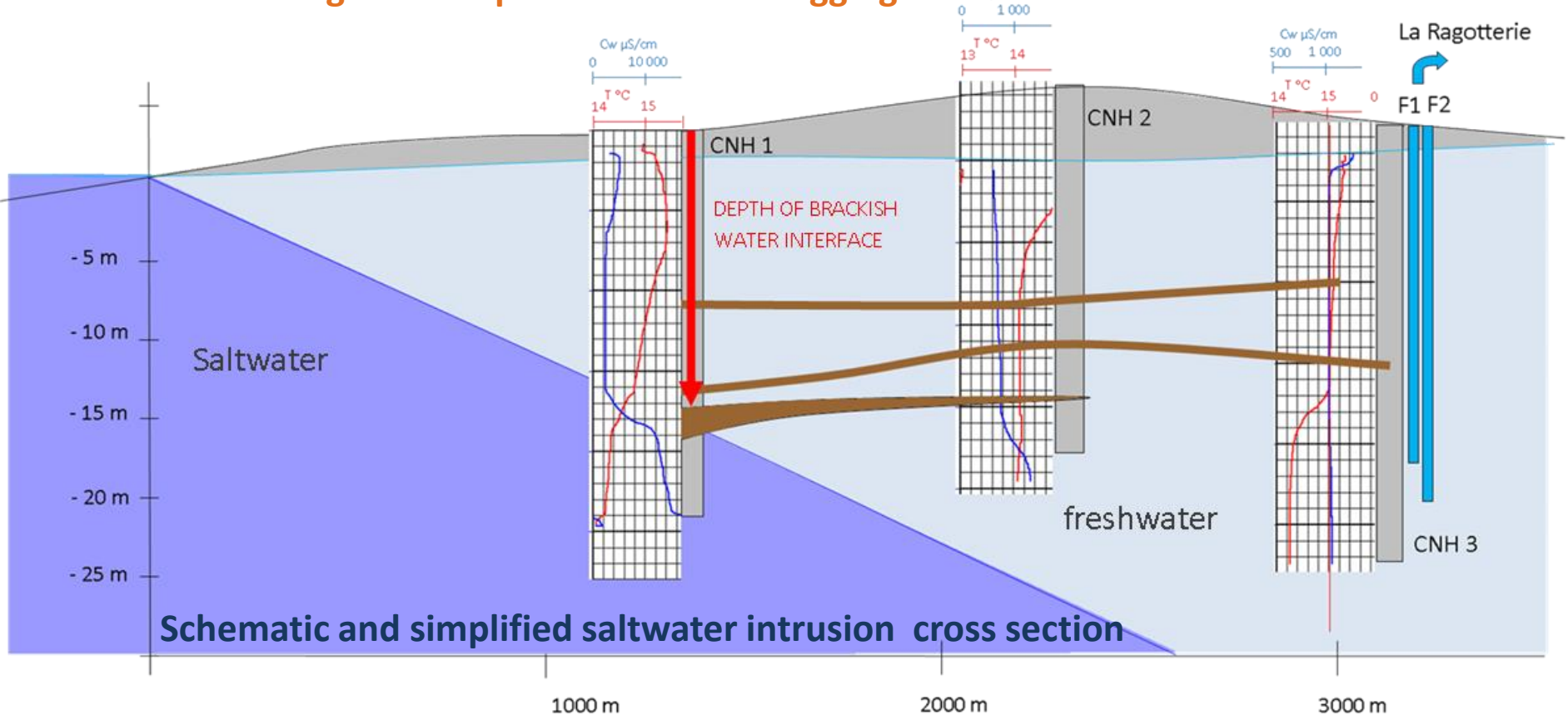


- **Installation of 3 downhole geophysical observatories in three piezometers (CHN1 – CHN2 and CHN3)**
- **Installation of a water conductivity probe on extracted groundwater in F1 and F2 production wells**
- **Objectives : to understand saltwater intrusion dynamics using high frequency acquisitions**

➡ 1) daily to hourly EC profiles with 70 cm electrode spacing are recorded in an automatic and remote controlled mode

➡ 2) analyse saltwater intrusion dynamics against groundwater extractions

Baseline : drilling of three piezometers and logging realisation



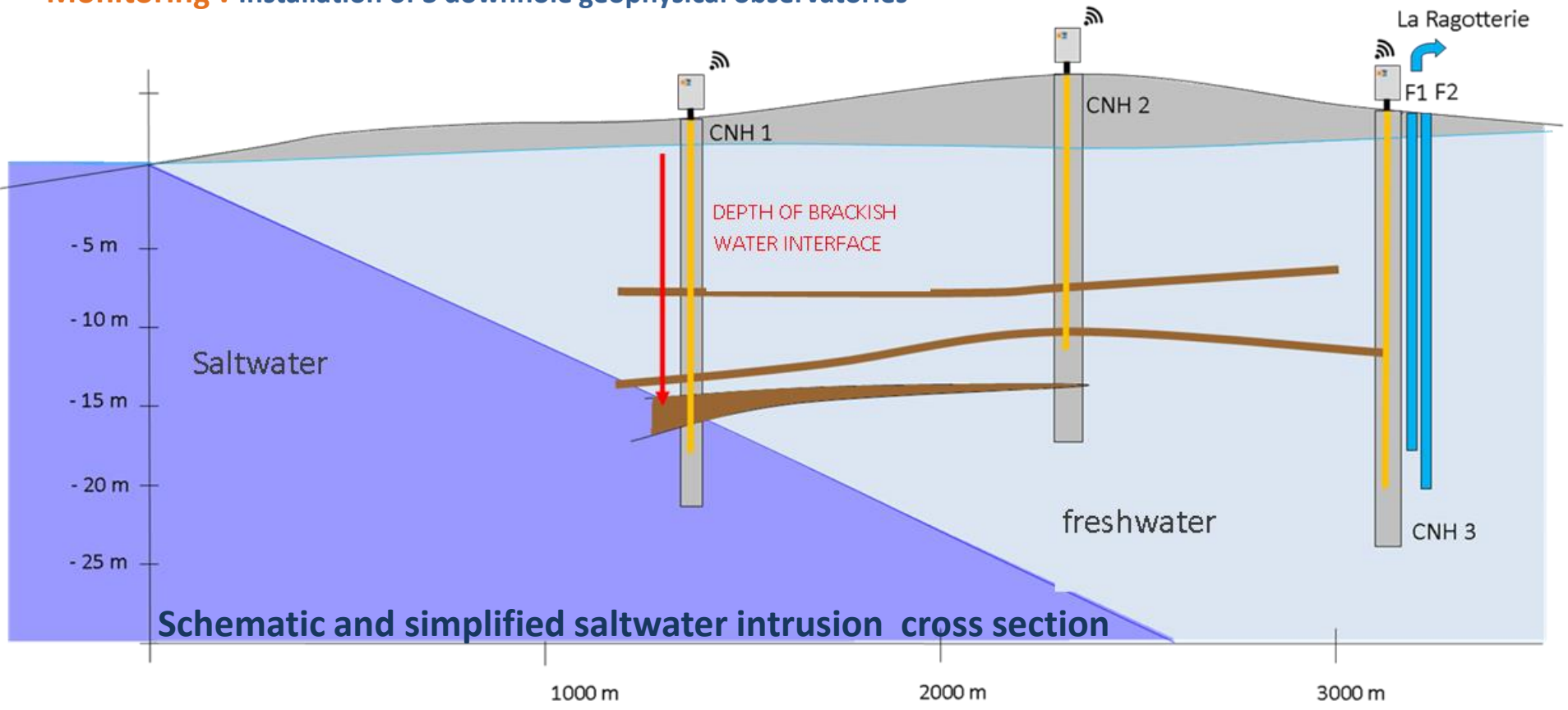
Schematic and simplified saltwater intrusion cross section

- Saltwater interface is reached at 14 meters depth in CHN1
- The two other piezometers are located in freshwater

- Freshwater is characterized by relatively high groundwater conductivities, close to 1000 µS/cm

Saltwater intrusion monitoring

Monitoring : Installation of 3 downhole geophysical observatories



Schematic and simplified saltwater intrusion cross section

- **Daily record of saltwater interface position in CHN1**
- **Daily EC profiles with 70 cm electrode spacing are recorded in an automatic and remote controlled mode**
- **Water level, groundwater extraction volume, and water conductivity are also recorded in pumping wells**

SMD : Measurement principle

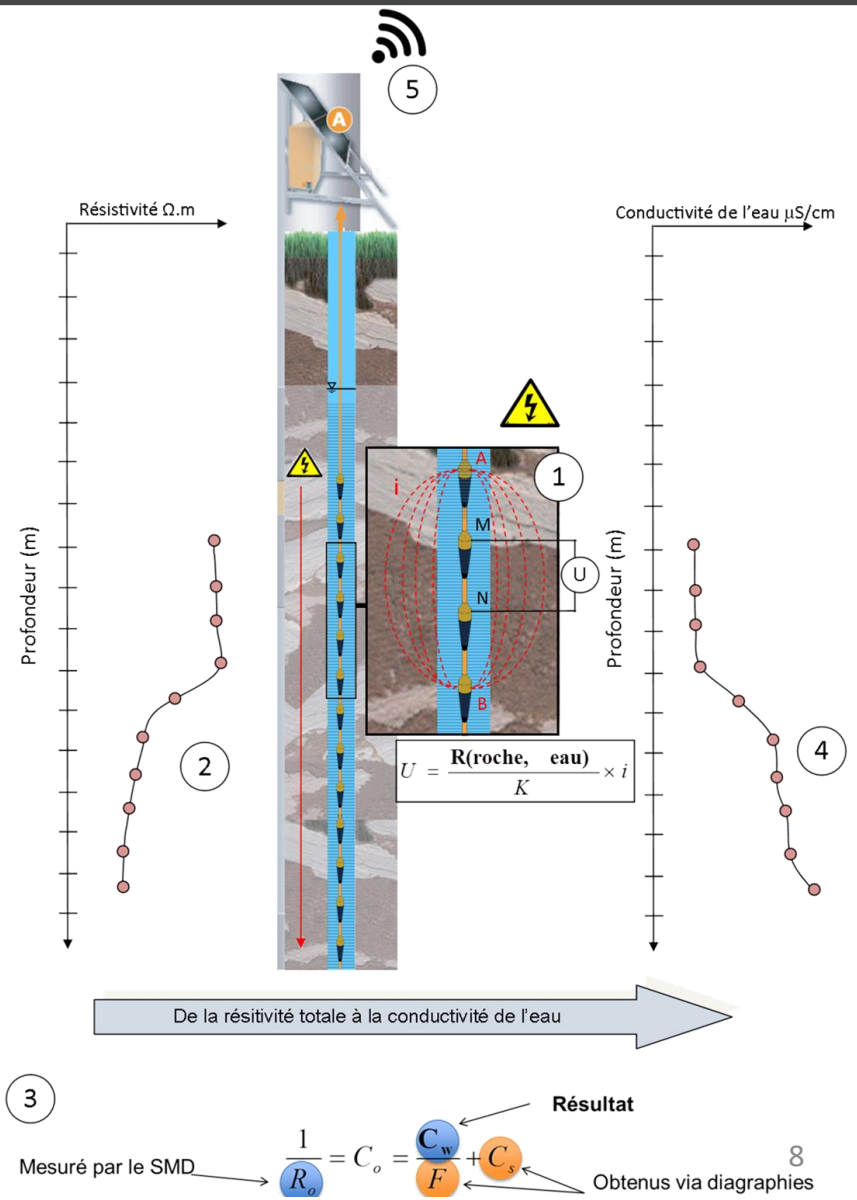
1 – The surface data acquisition box (A) injects a known current (i) between two electrodes (A and B) and measures the induced potential difference between two other electrodes (M and N)

2 – This process is repeated from the top of the electrodes cable to its bottom allowing the measurement of bulk resistivity profiles

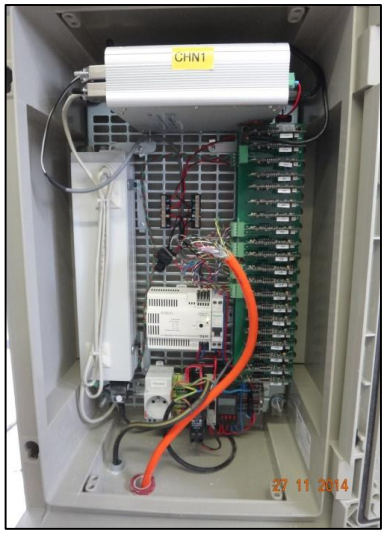
3 – According to Waxman-Smits equation (Figure 1, (3)), bulk resistivity is converted in to EC_{w20}

4 – **Normalized EC_{w20} profiles** are obtained

5 – Data remote transmission



Installation

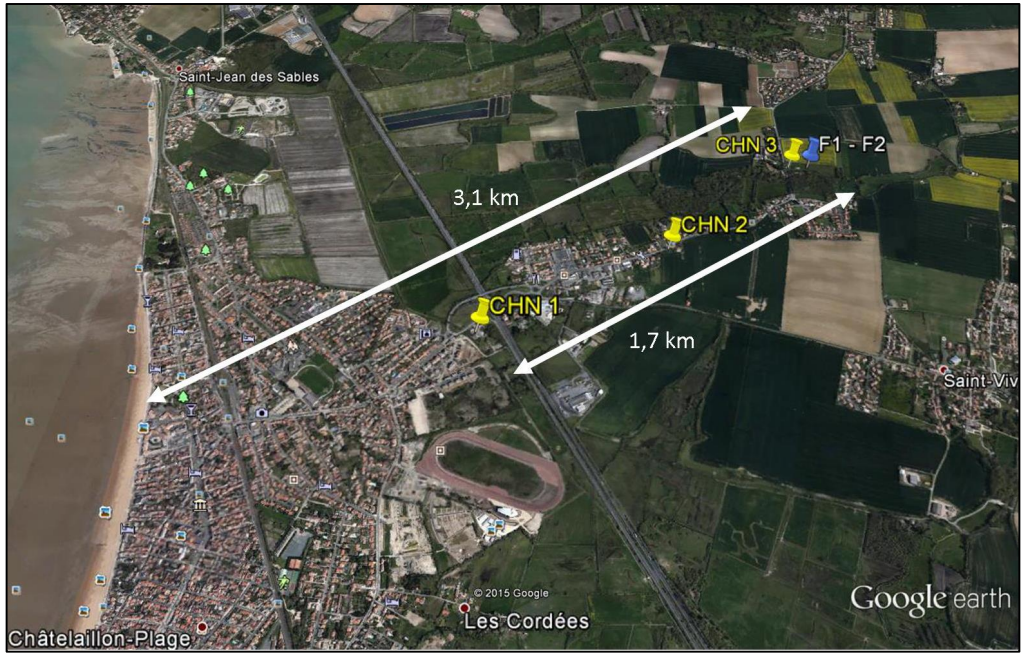


Inside the acquisition box

Chatelaillon SMD

Electrode

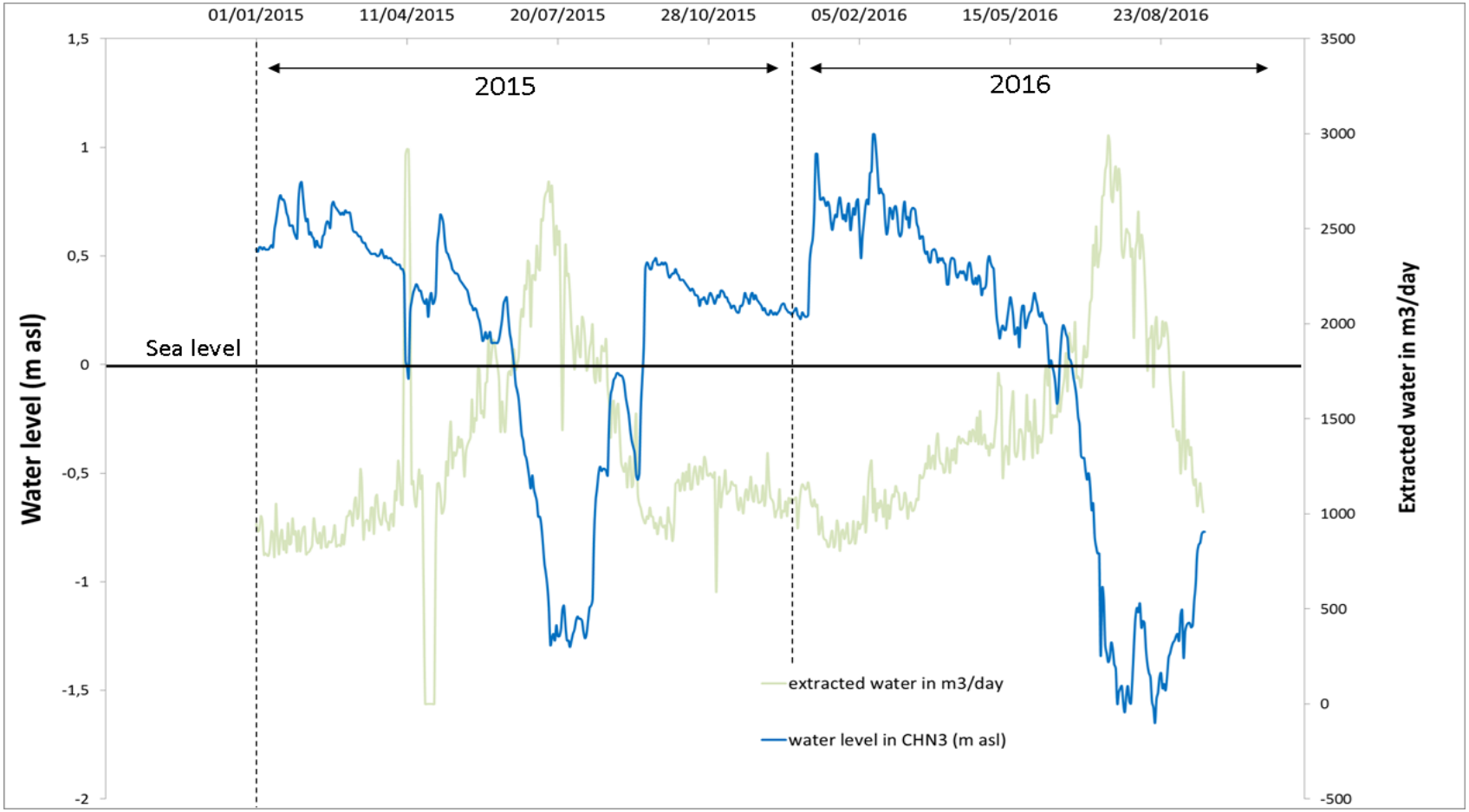
Electrode string installed into the piezometre



Saltwater intrusion monitoring

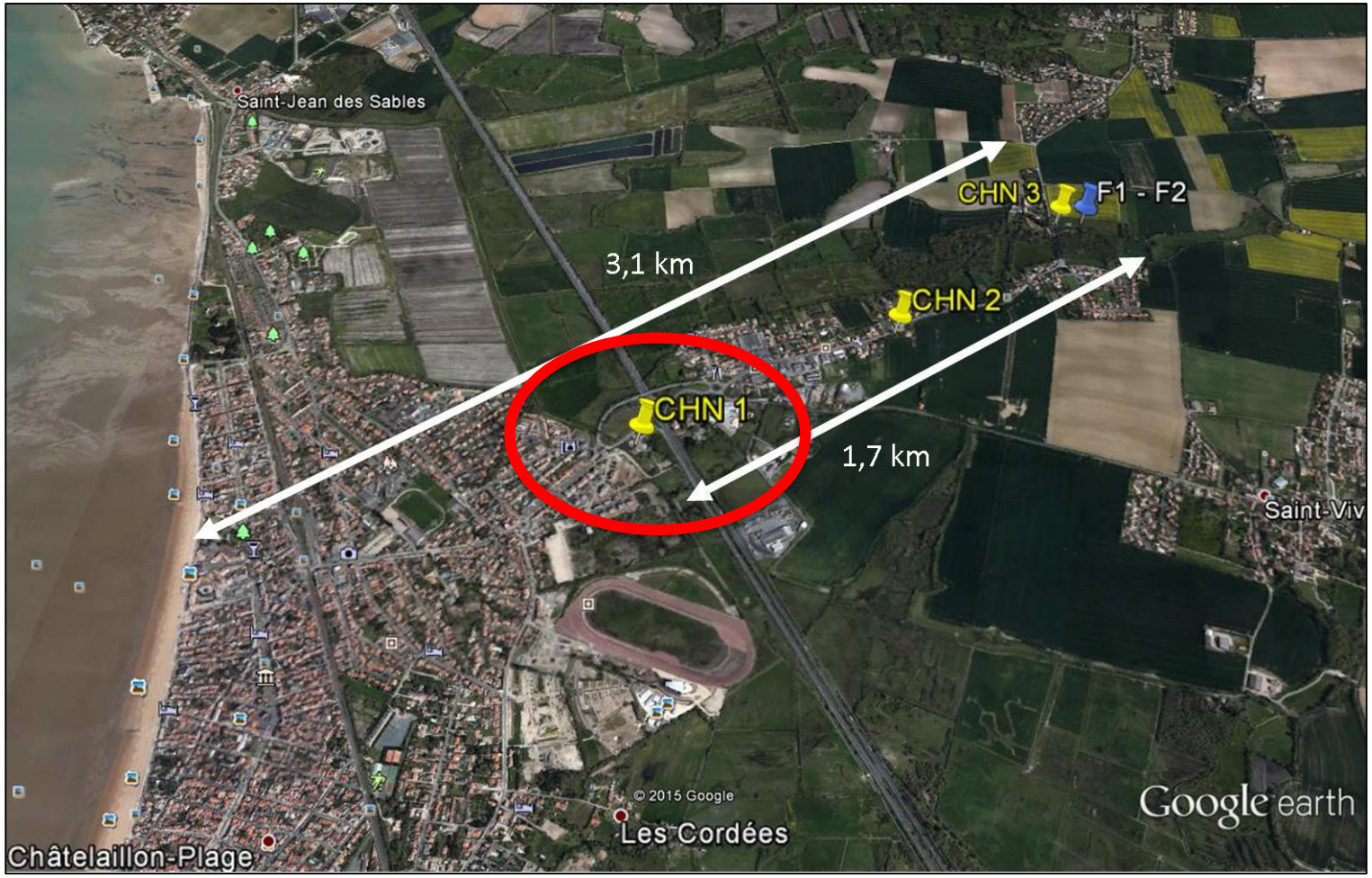
Results in 2015-2016

Water level evolution & extracted groundwater volume during 2015 and 2016



- In summer, water level drawdown is more than 1 meter below sea level

Depth of saltwater intrusion evolution at CHN1 geophysical observatory



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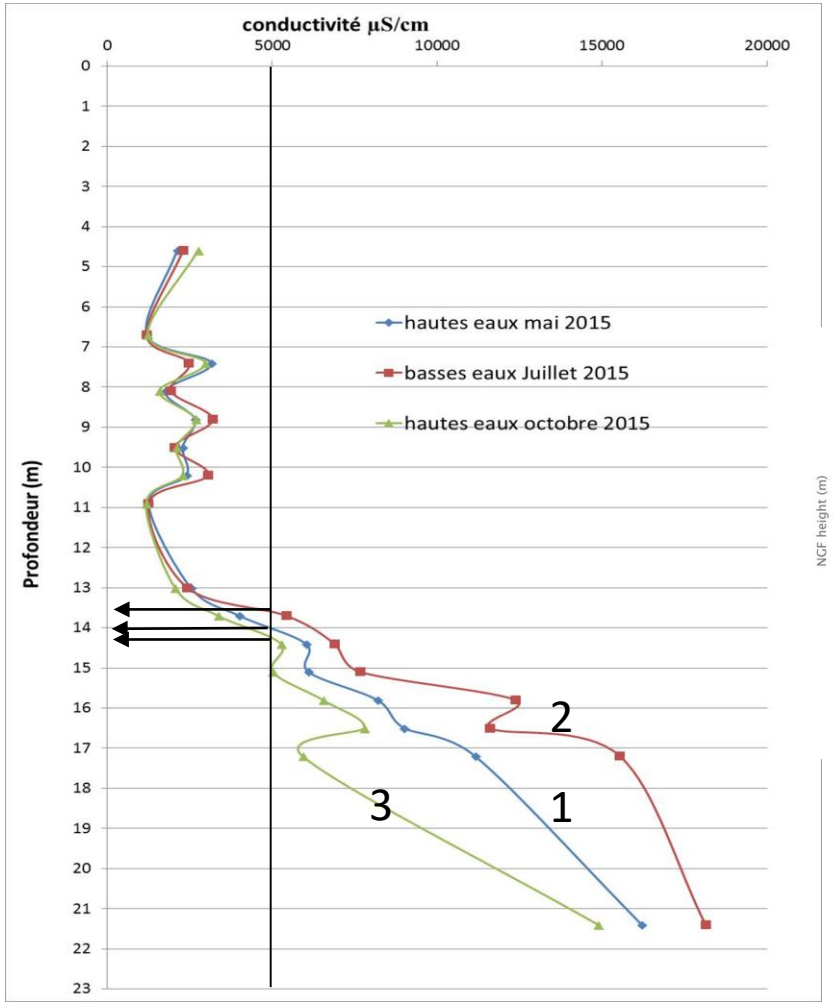
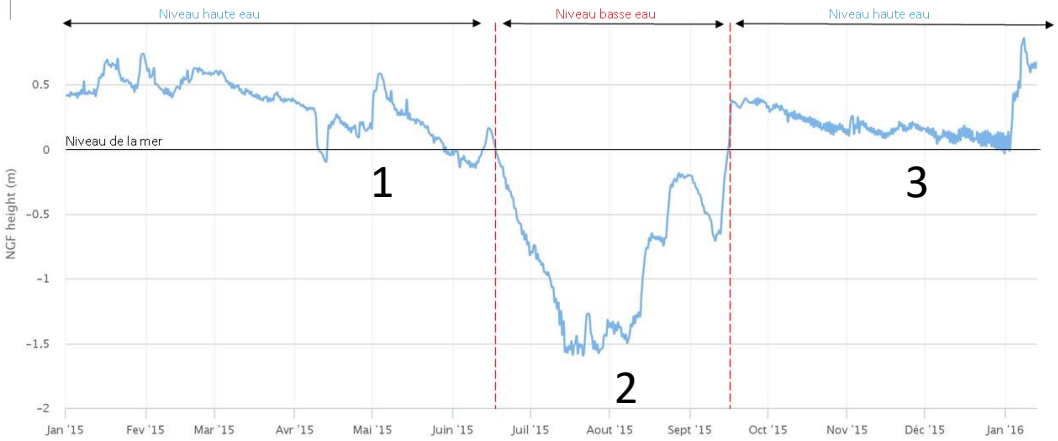
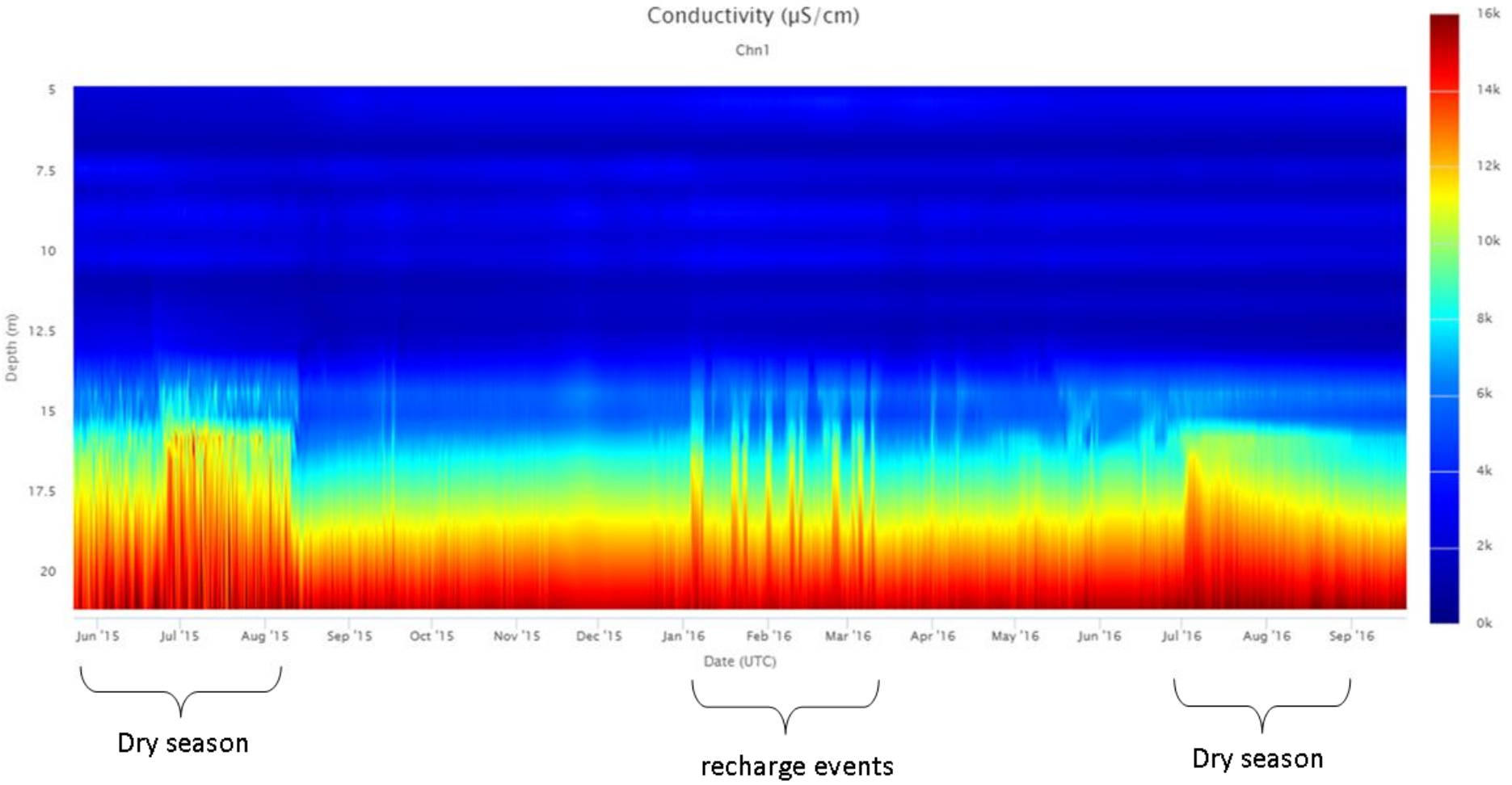


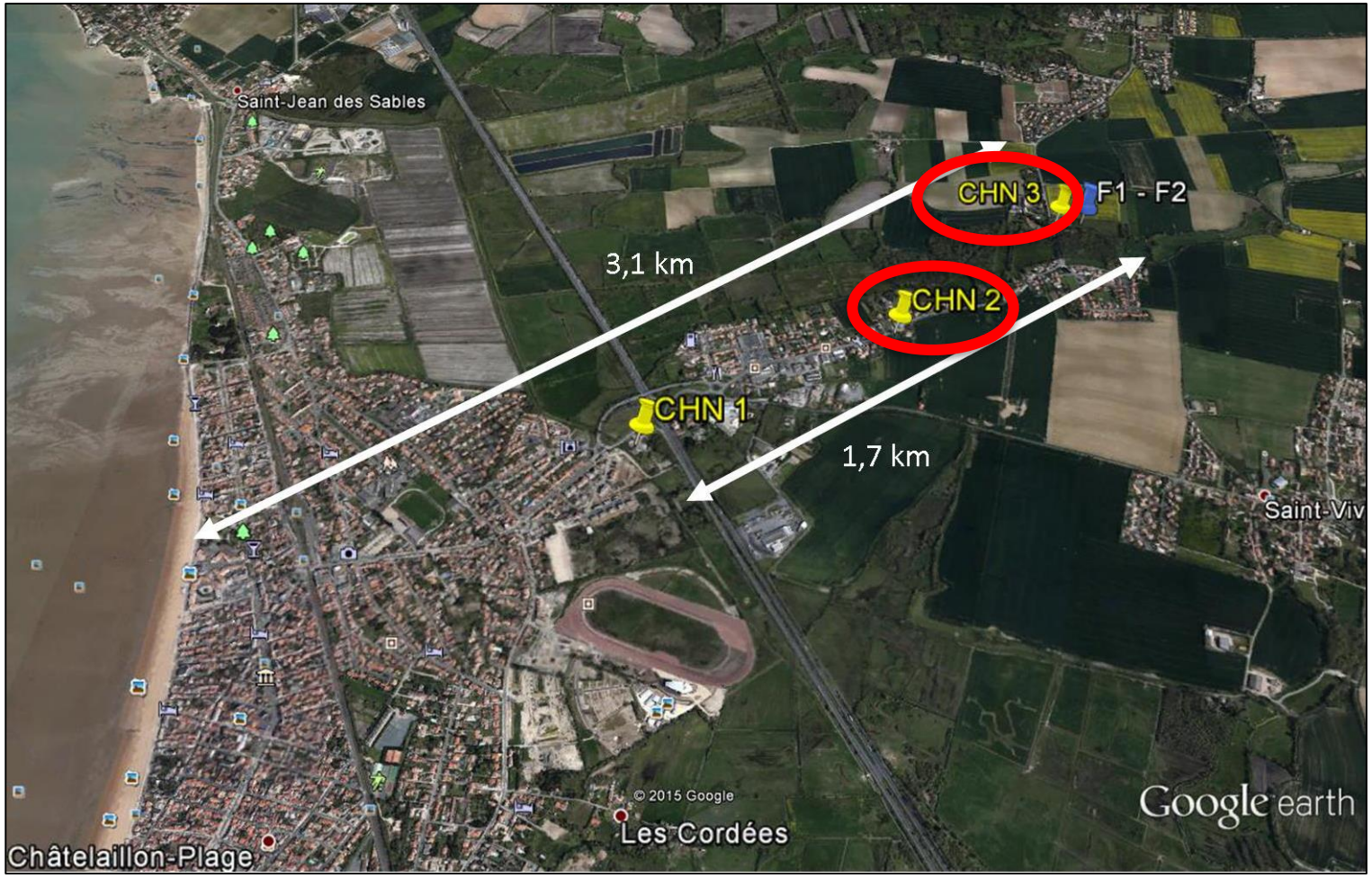
- **5000 µS/cm has been chosen as the top of brackish water interface (top of mixing zone)**
- **between recharge season and dry season, the top of saltwater intrusion (5000 µS/cm) moves from -14 to -13 m depth**



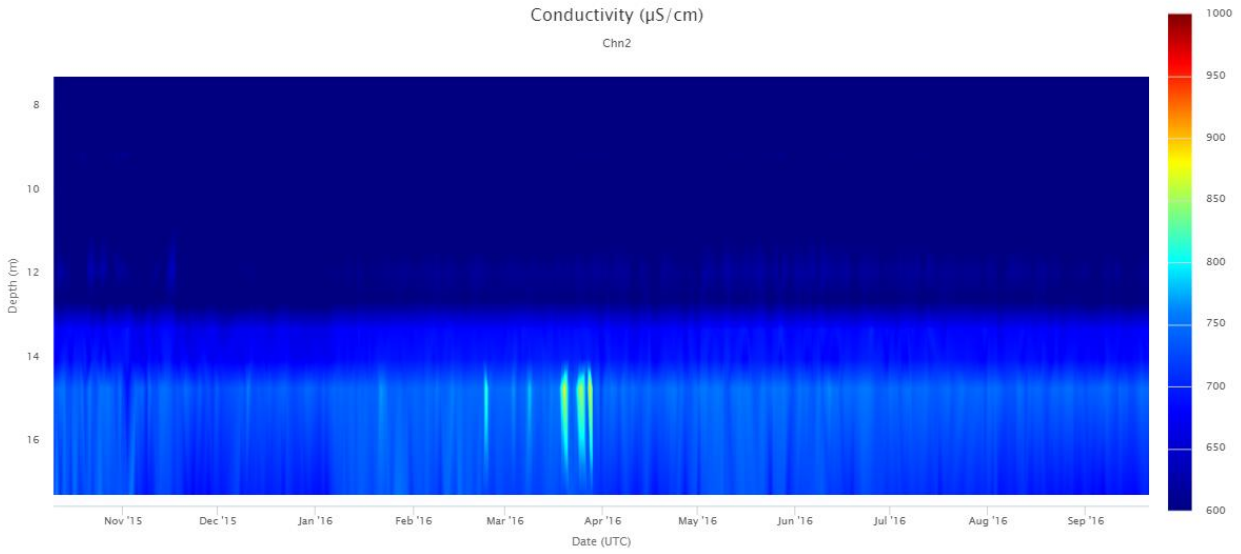
Water conductivity evolution at CHN1 geophysical observatory – daily acquisition

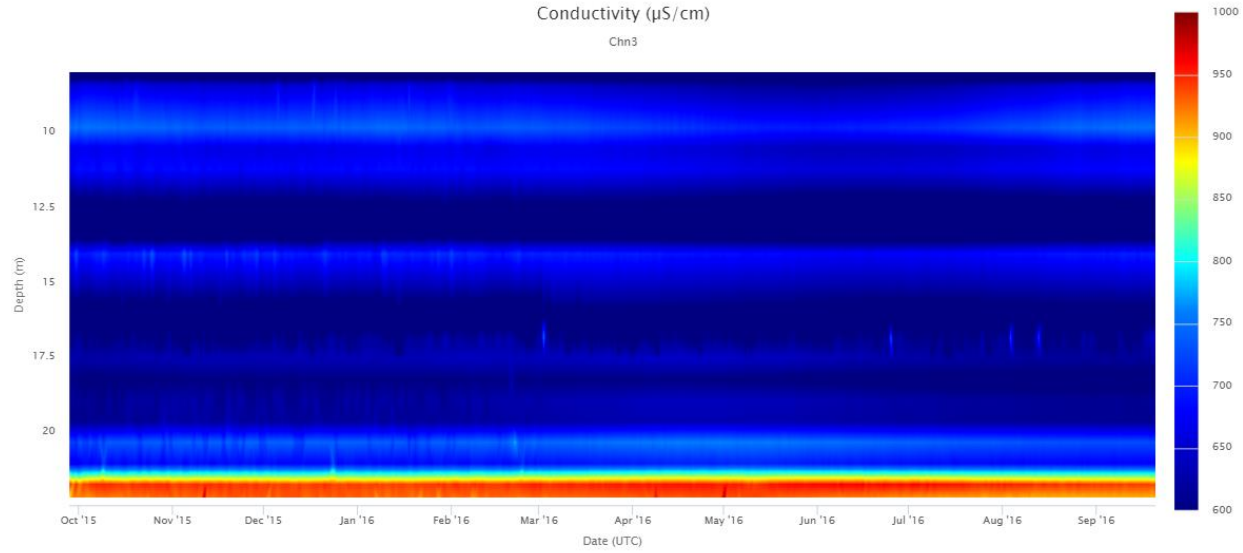


Water conductivity evolution at CHN2 and CHN 3 geophysical observatories



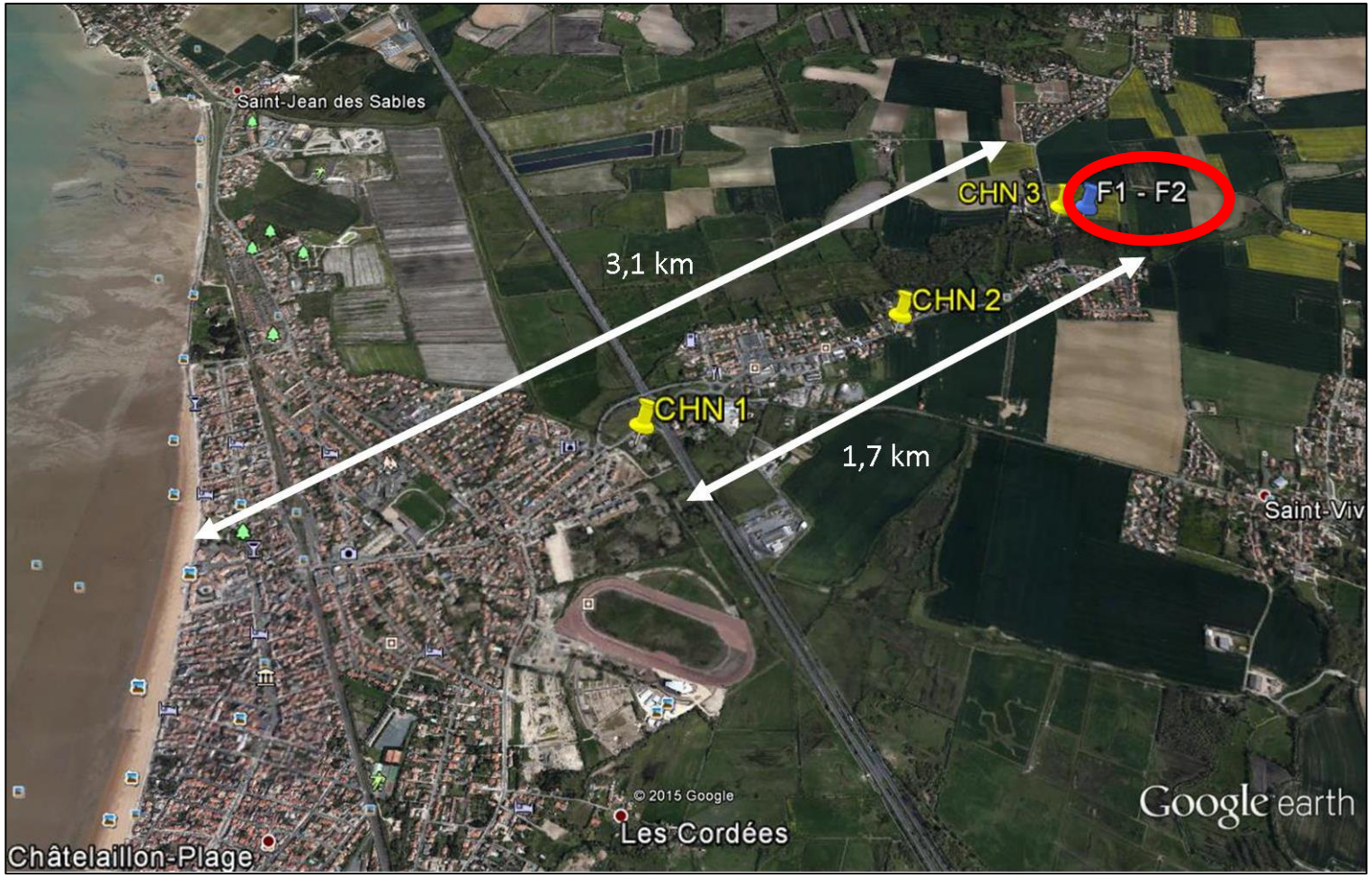
Saltwater intrusion monitoring



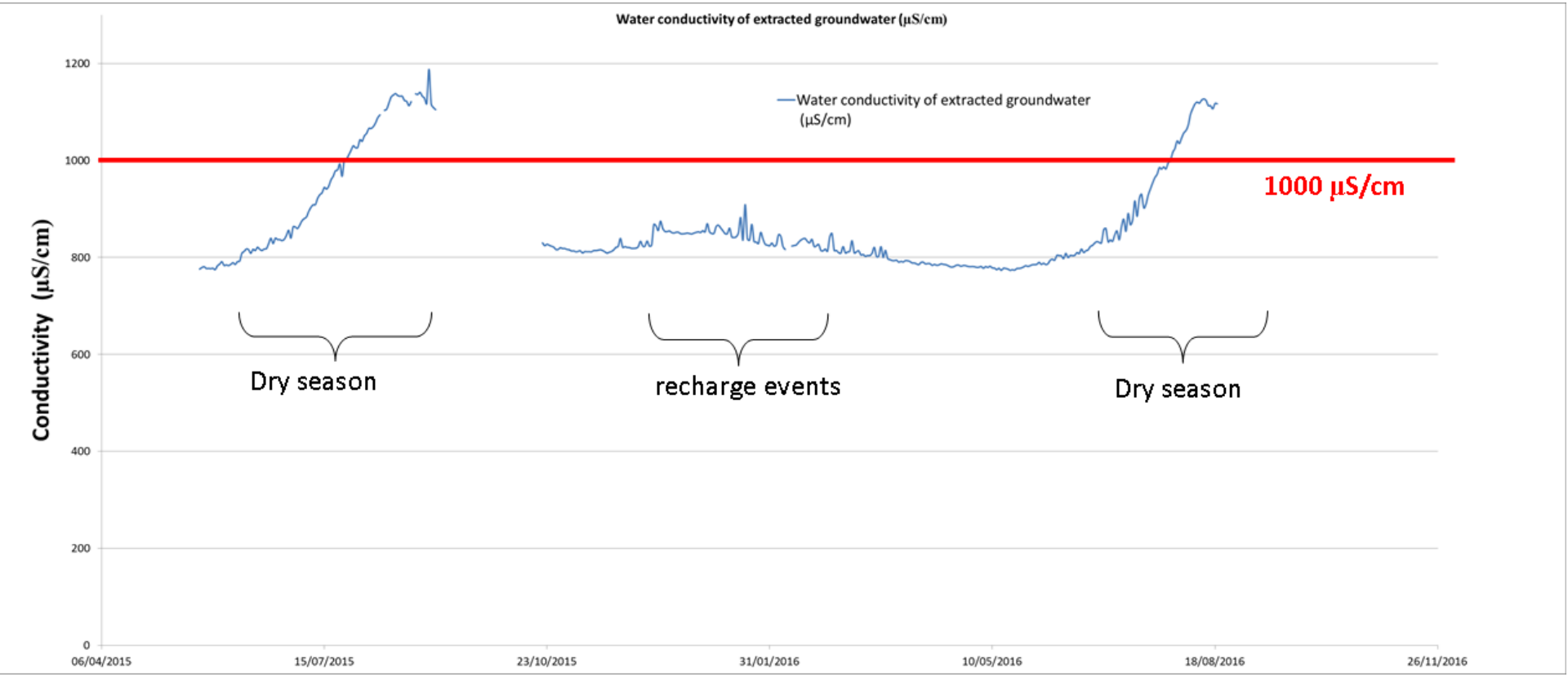


- **Above the saltwater intrusion, into the freshwater part of the aquifer very stable conductivities are measured**
- **Globally, less than 50 µS/cm evolution**
- **No significant water conductivity increase during dry season in the freshwater zone**
- **Some ponctual water conductivity increase during rain events**
- **1000 µS/cm values measured at the bottom of the aquifer 50 m from pumping wells**

Water conductivity evolution measured on extracted groundwater

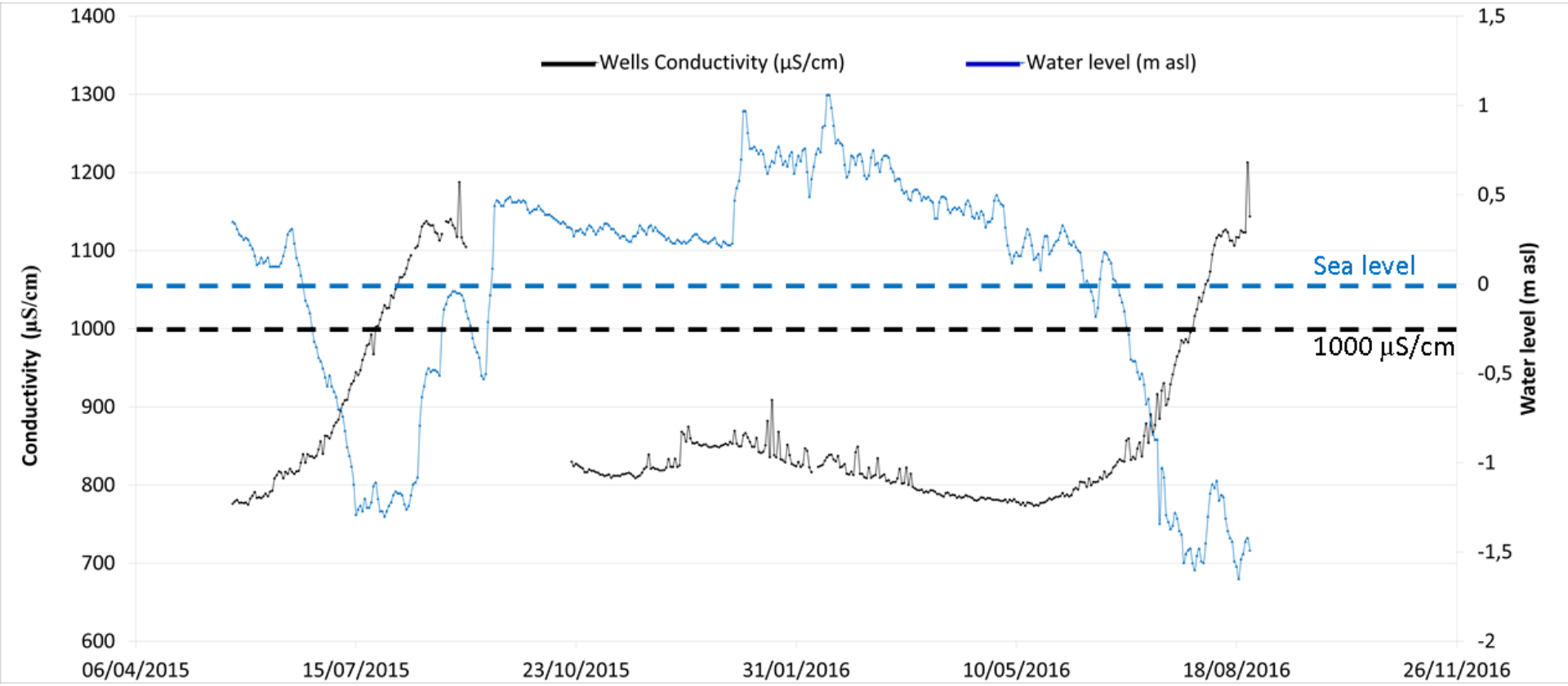


Water conductivity evolution measured on extracted groundwater



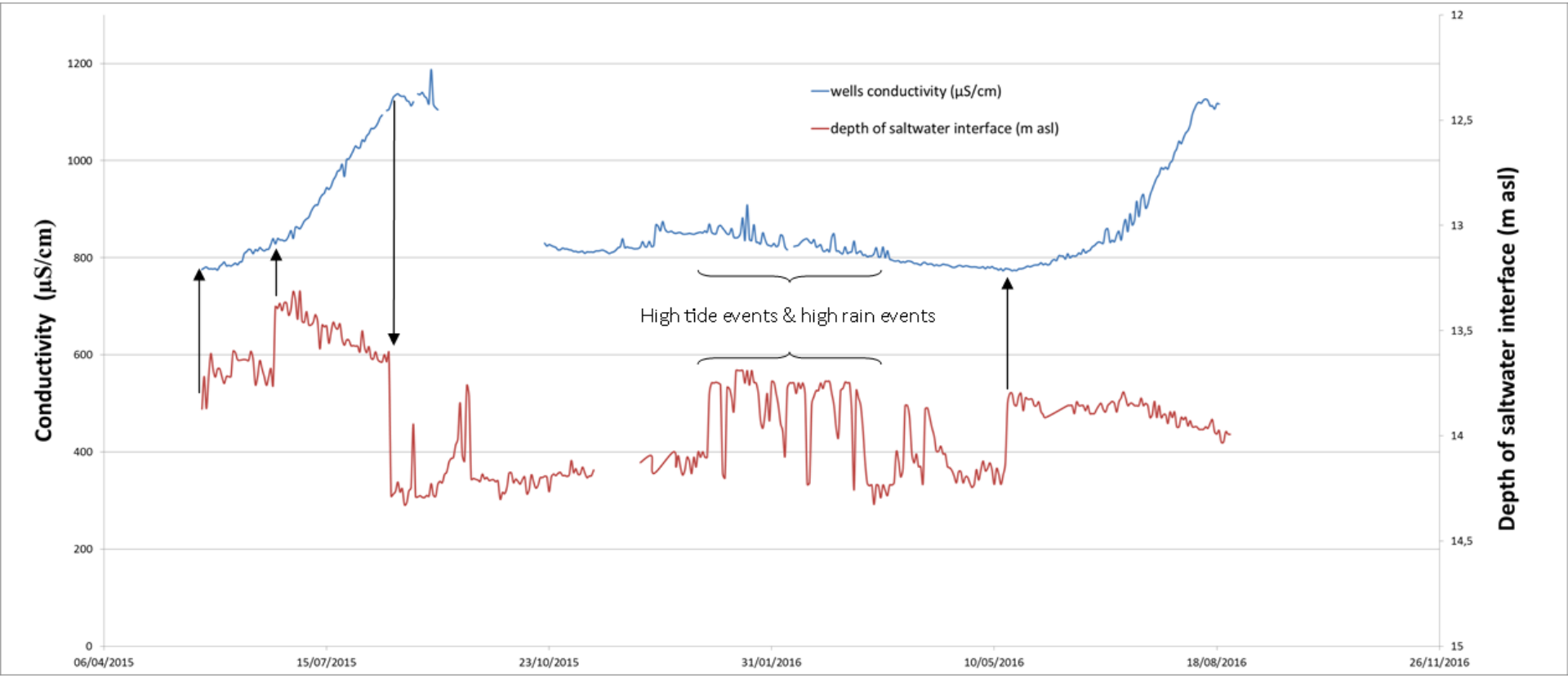
1000 µS/cm limit is exceeded during dry season (august)

Saltwater intrusion monitoring



- **Constant augmentation of water conductivity measured at the pumping well outlet as long as the water level goes bellow sea level**
- **Stabilized water conductivity at the pumping well around 800 µS/cm during recharge season with little variation caused by rain events**

Saltwater intrusion monitoring



- **Constant augmentation of water conductivity measured at the pumping well outlet as long as the top of brackish interface (measured in CHN 1 geophysical observatories) is above 14 m depth**
- **Stabilized water conductivity at the pumping well around 800 µS/cm during recharge season with little variation caused by rain events - top of brackish interface is above 14 m**

Conclusions

- A local "upconing" below the pumping wells causes water conductivity increase at the end of the dry season
- This upconing is local as it is not measured 50 m away from pumping wells

At the pumping wells outlet, an exceedance of 1000 µS/cm limit is observed as long as :

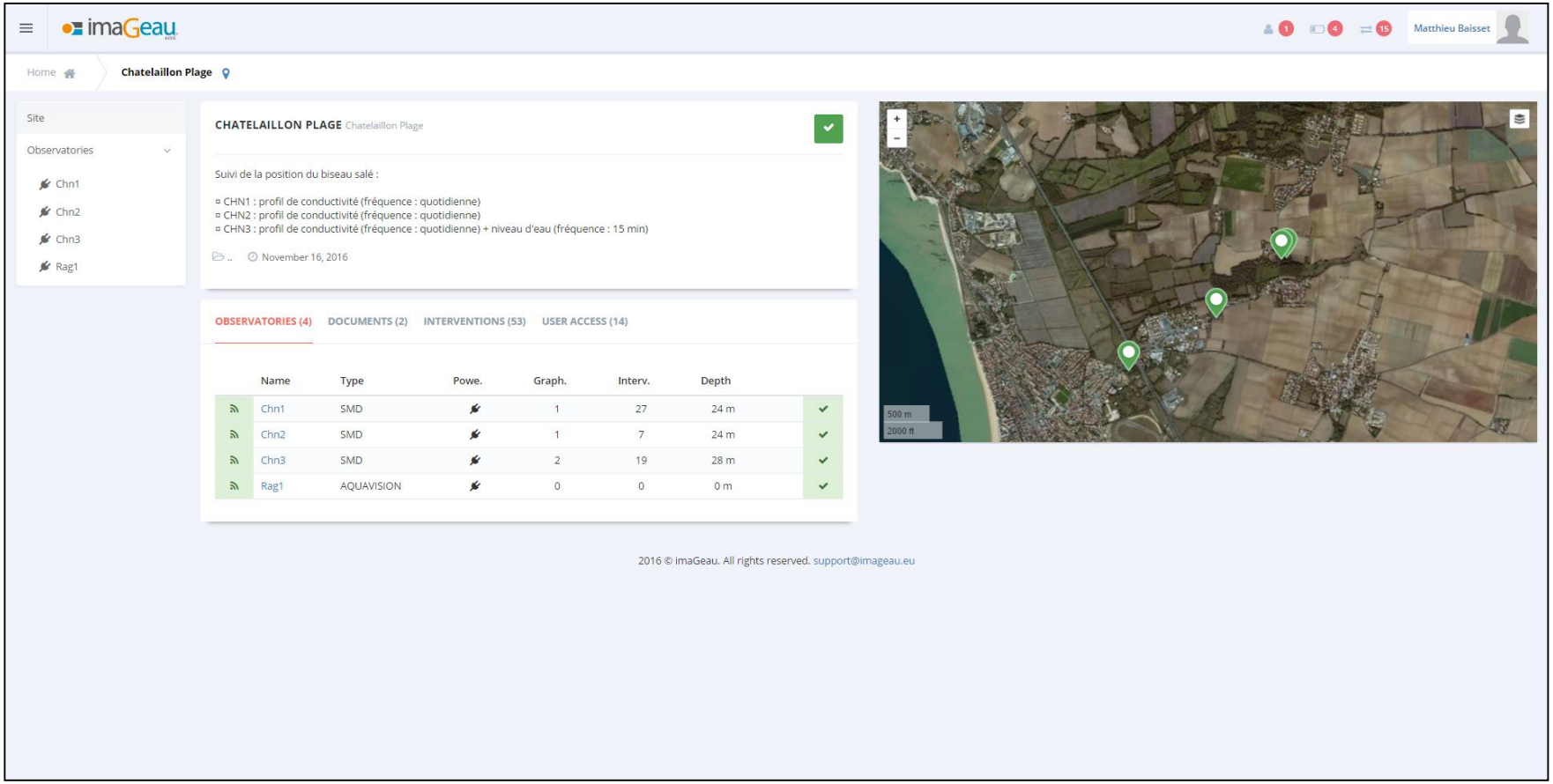
- The water level is below sea level

&

- The top of brackish interface (measured in CHN 1 geophysical observatories) is above 14 m depth

→ All this data is stored and automatically send to a Web Interface used by water operator (SAUR) to adapt its way of pumping

WEB INTERFACE



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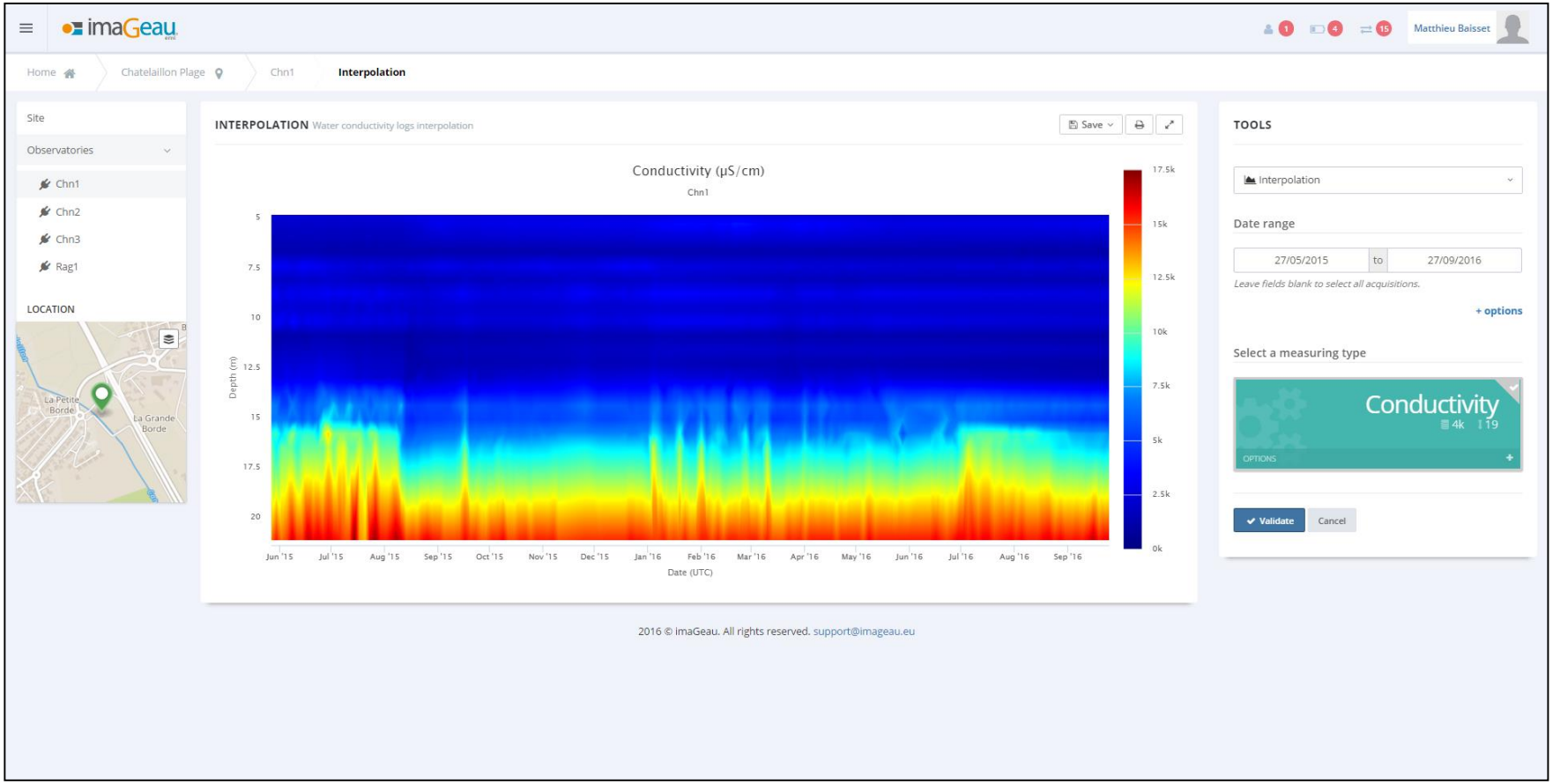
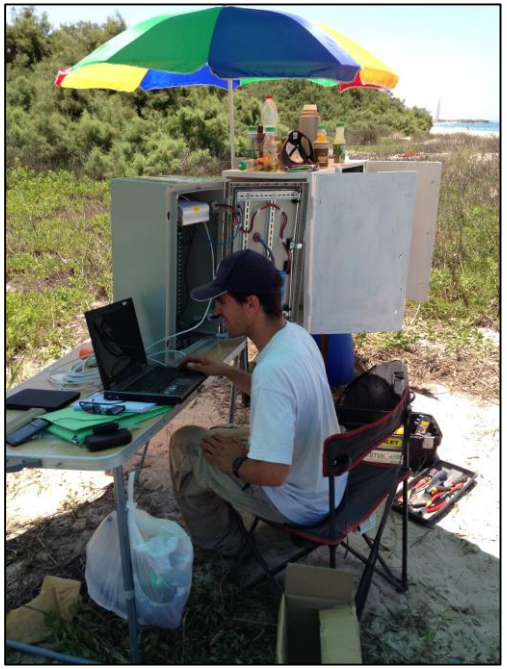


Alerts are automatically sent to help water operator in groundwater management



Thank you for your attention