MITIGATION STRATEGIES TO REDUCE SALTWATER INTRUSION IN COASTAL AQUIFERS: THE TESTING SITE OF CA' PASQUA, ITALY

EGU General Assembly 2020

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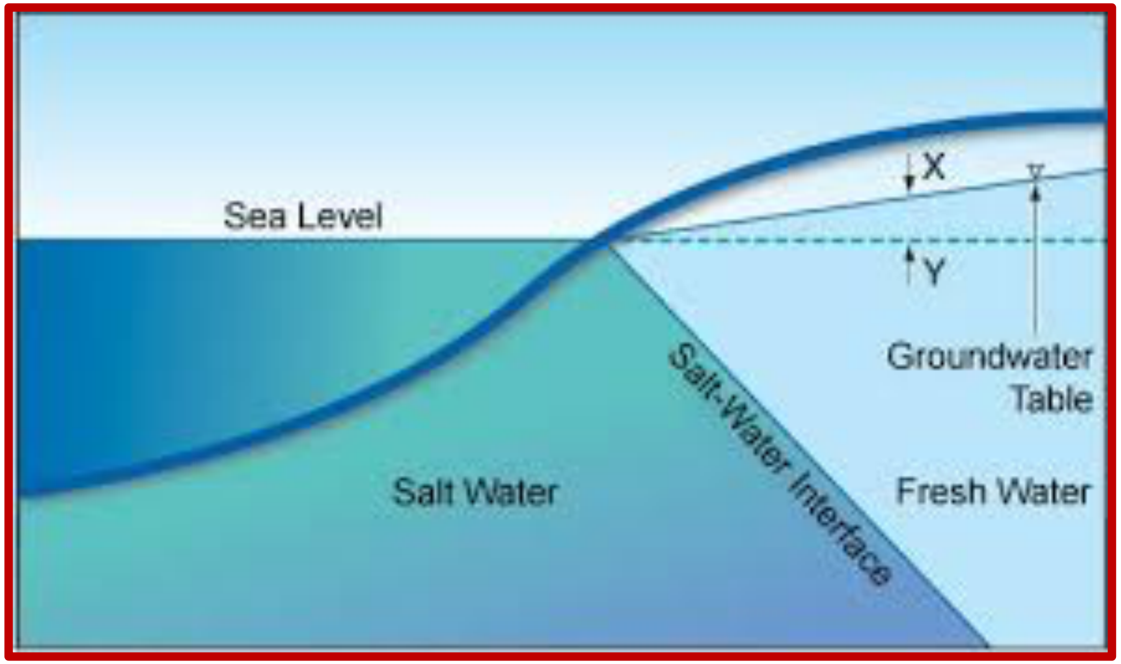
EUROPEAN UNION

with the contribution of the Italian partners: CNR,
Regione Veneto and Consorzio di Bonifica Adige Euganeo

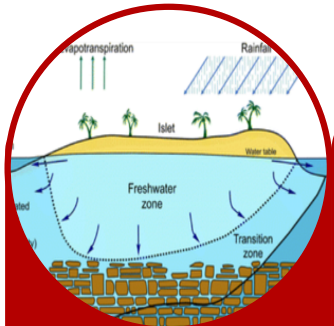
(Valentina Bassan, Nicola Dal Ferro, Cristina Da Lio, Giuseppe Gasparetto, Giulia Iacomello, Francesco Morari, Pietro Teatini, Luigi Tosi, Ester Zancanaro, ...)

SEAWATER INTRUSION

- movement of saline water into freshwater aquifers
- formation of the “salt wedge”



- Consequences



Deterioration of freshwater quality

Soil desertification

Damage to the harvest

- Goal

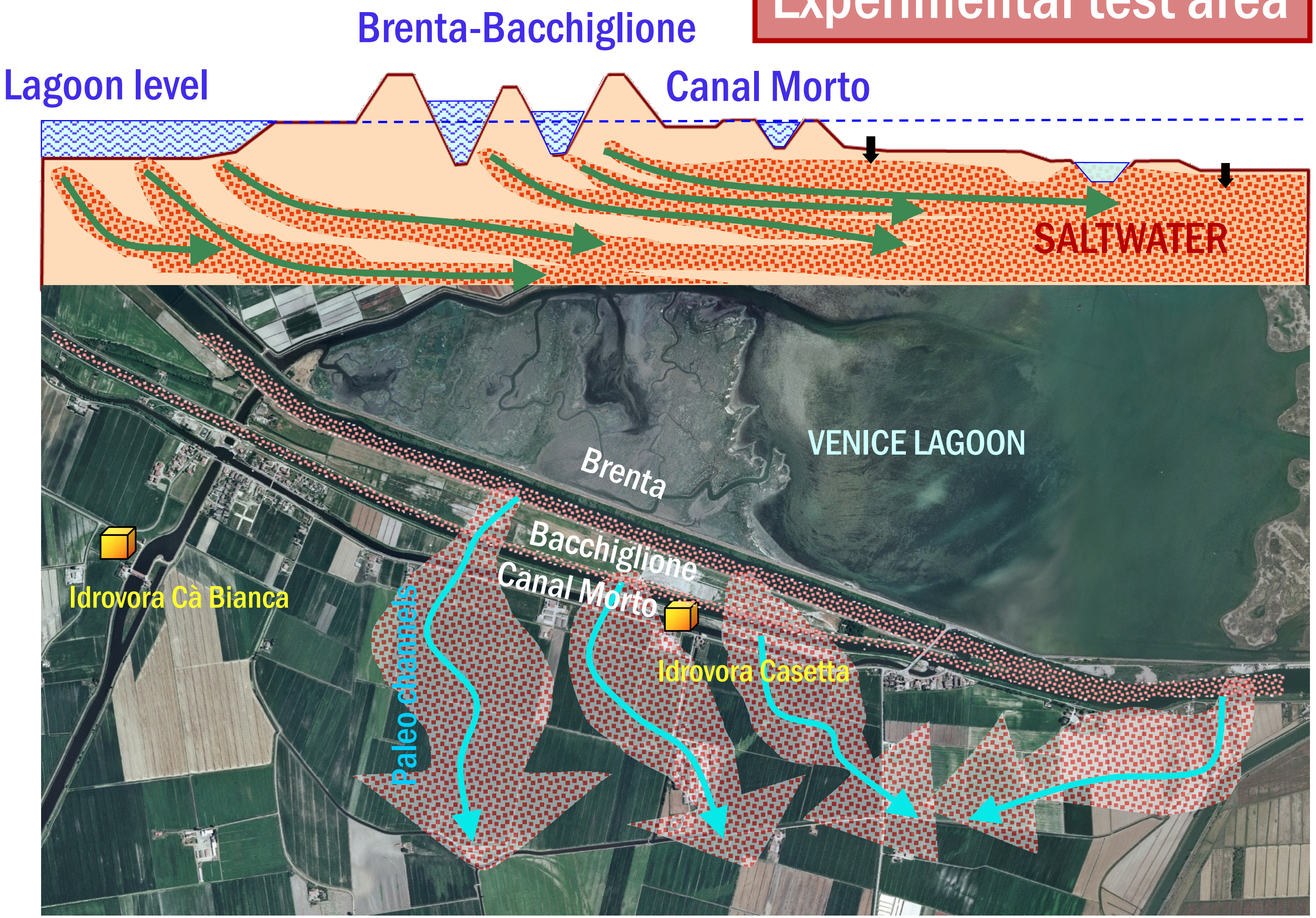
Complex multi-disciplinary analysis of the effects of saltwater intrusion in a pilot case study to suggest potential countermeasures

CASE STUDY

- Saltwater intrudes inland for 20 km from the coastline;
- Depth of fresh-saltwater interface varies from 2 to 30 meters below the ground surface;

CASE STUDY

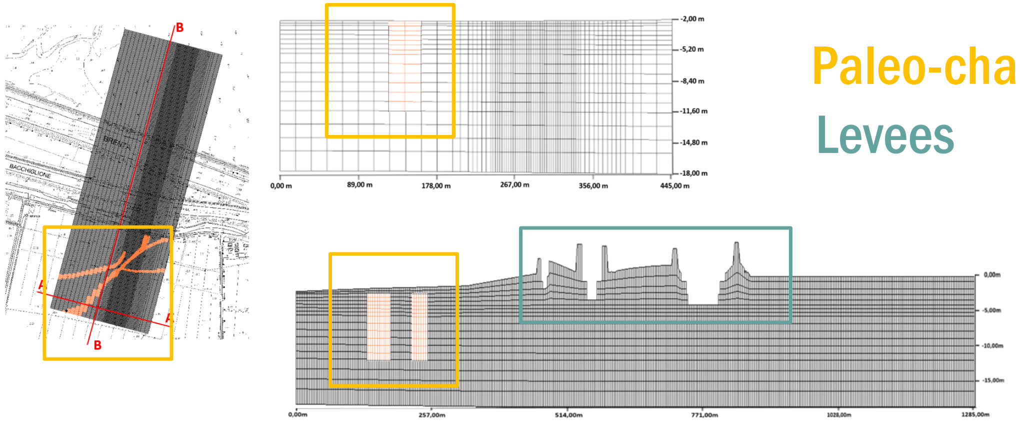
Experimental test area



MODEL DEVELOPMENT

GMS software: integration of SEAWAT with MT3DMS and MODFLOW for Variable Density Fluids

- Geometry and numerical domain



Paleo-channels

Levees

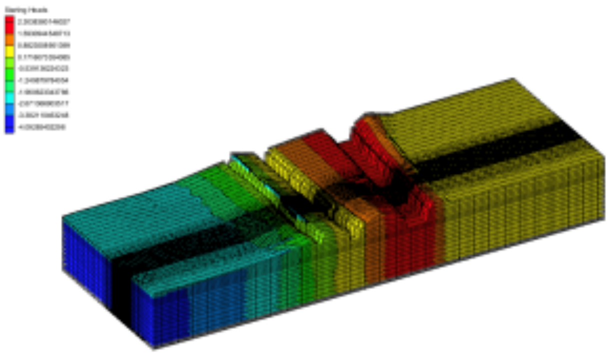
- Time resolution

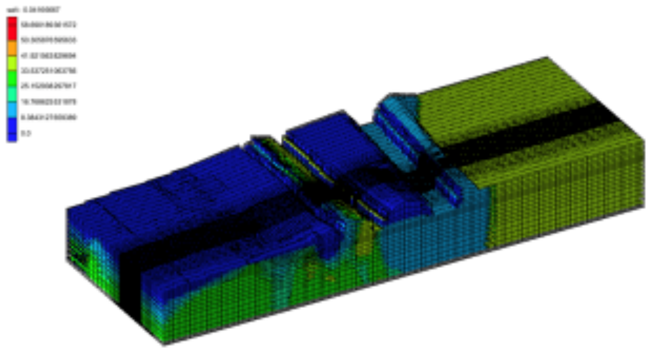
Warm –up simulations from 2012 to 2016

from 2016 to 2018 analysis of potential countermeasures such as drains and cut-off walls

- Initial conditions

Flow and salt concentration





MODEL DEVELOPMENT

- Boundary conditions: Flow conditions overview

RECH: Recharge Neumann Boudary Conditions [top layer]

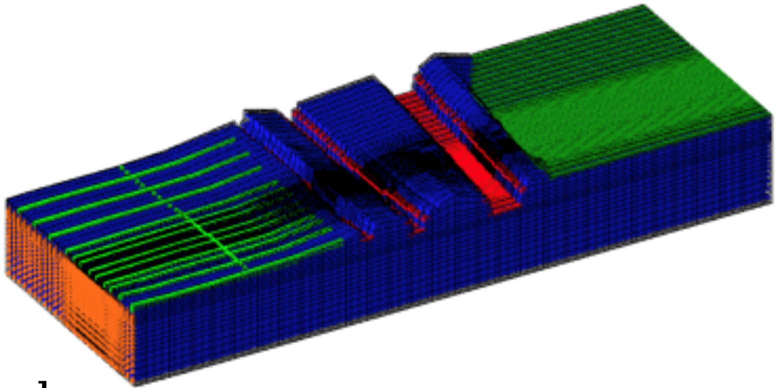
DRN: Time variant Drain Cauchy conditions

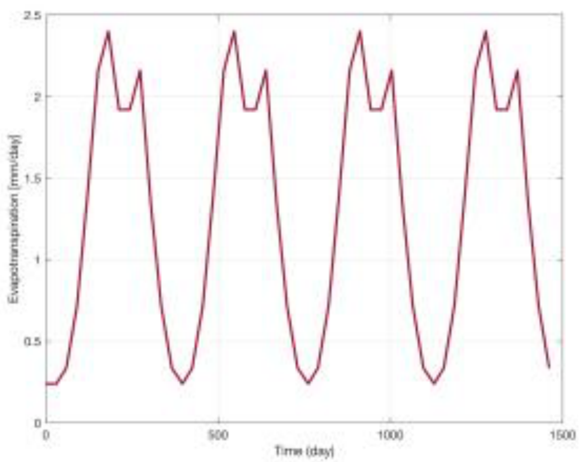
GHB: General-Head Cauchy Boundary Conditions

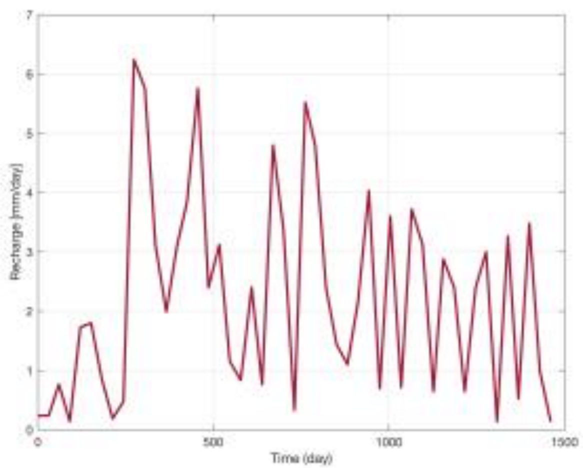
CHD: Time variant or Constant Head Dirichlet conditions

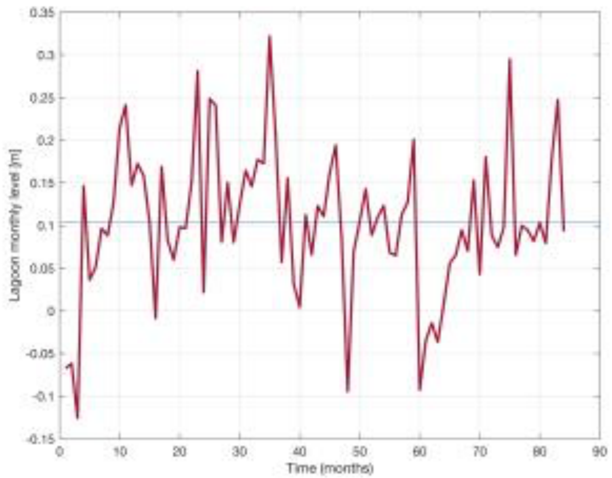
RIV: Time variant River Cauchy conditions

EVTR: Evapotranspiration Cauchy Boudary Conditions [top layer]









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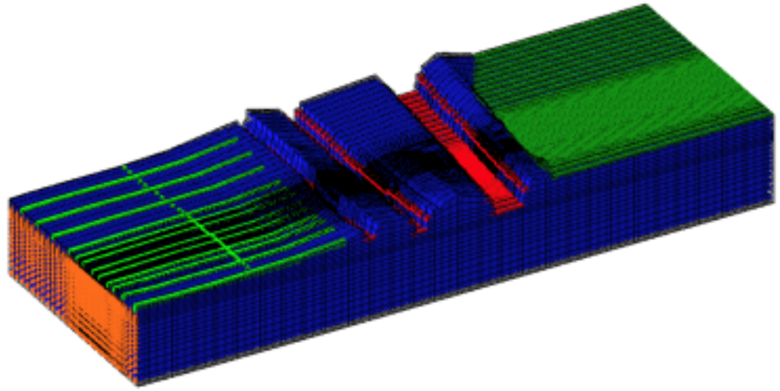
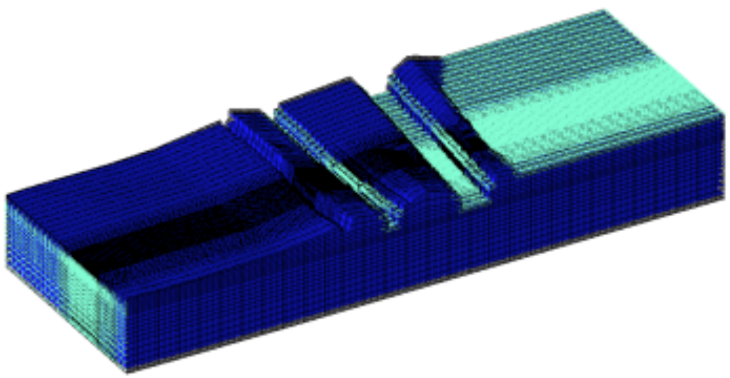


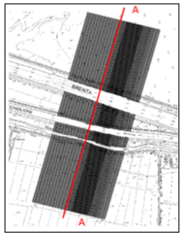
- Boundary conditions: Salt concentration conditions overview



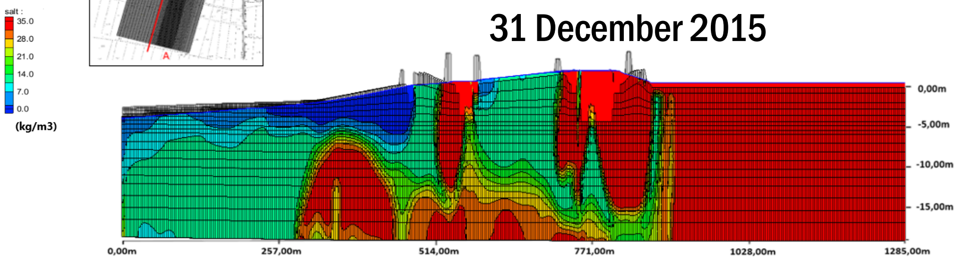
CONCENTRATION: Constant or time-variant salt concentration conditions; note that only freshwater flows in the Canal Morto

RESULTS

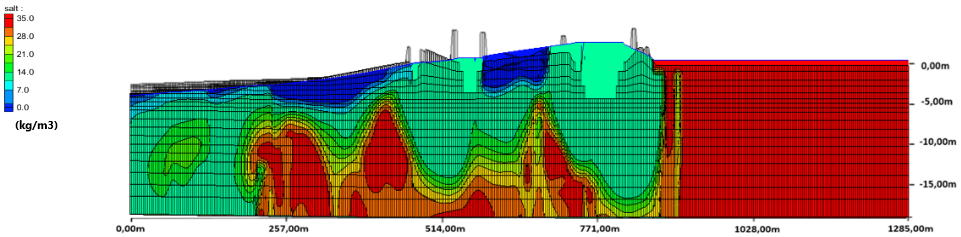
Salt intrusion time evolution



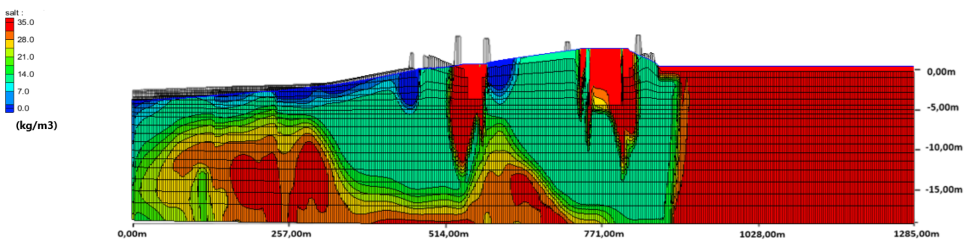
31 December 2015



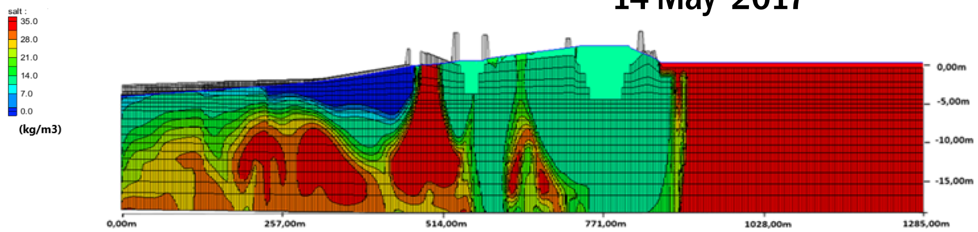
31 March 2016



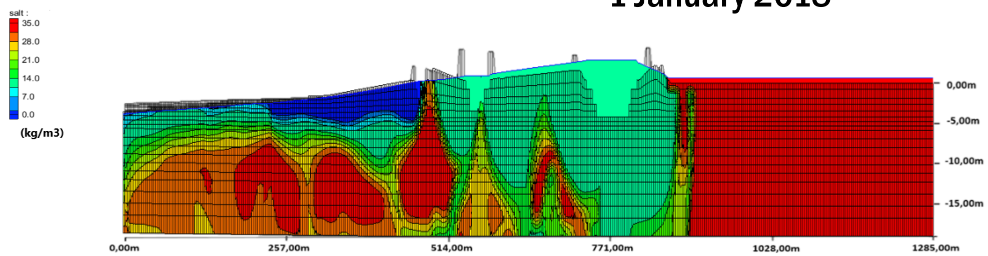
18 July 2016



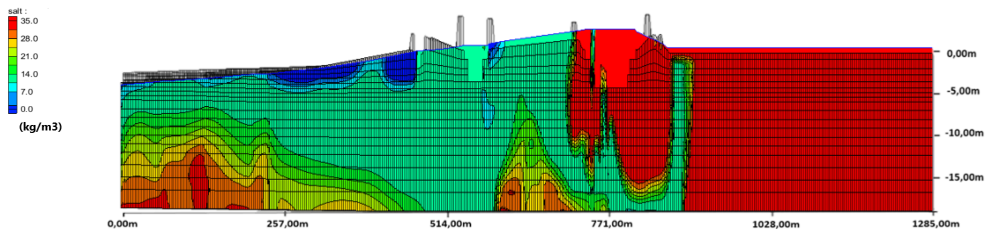
14 May 2017



1 January 2018



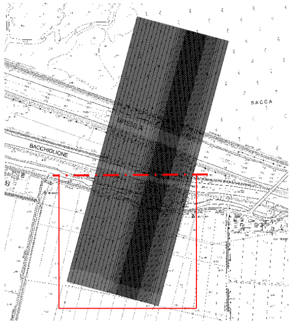
31 December 2018

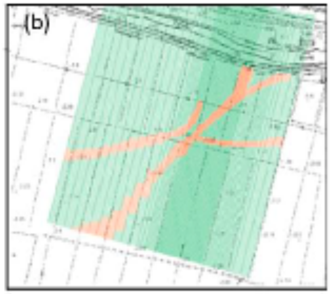


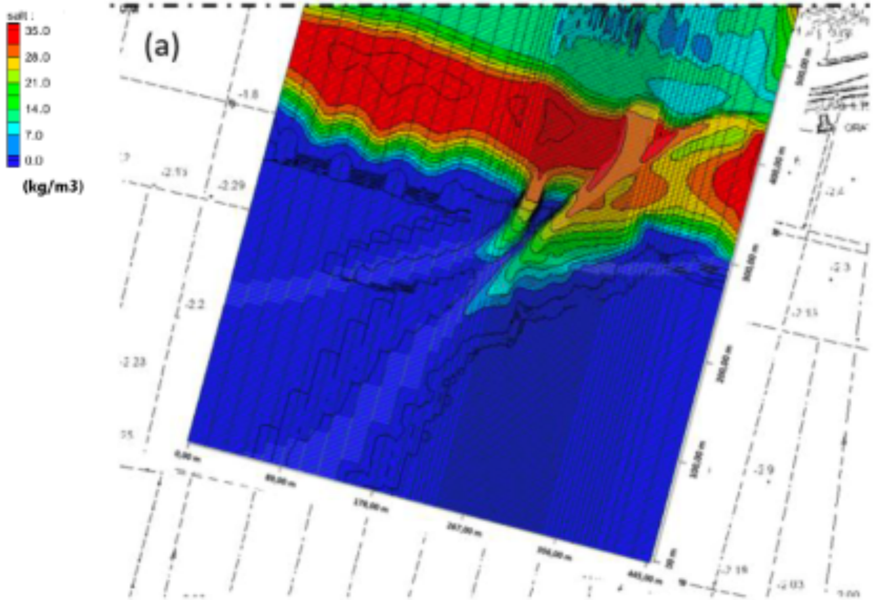
RESULTS

- Paleochannels

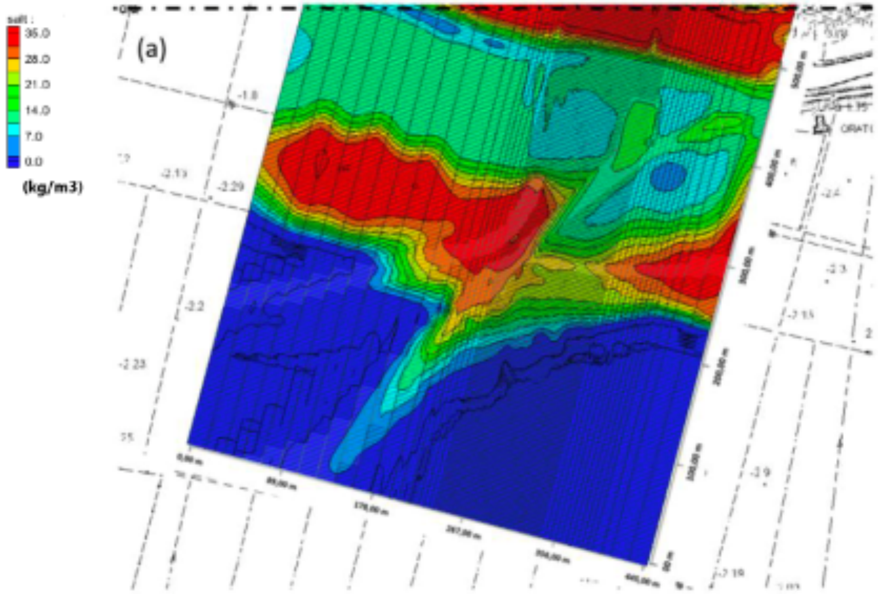
- Preferential pathways for the saline intrusion propagation due to higher conductivity;
- This effect is reproduced in the numerical simulations;
- The electrical resistivity tomography and lithological data confirm this behaviour;







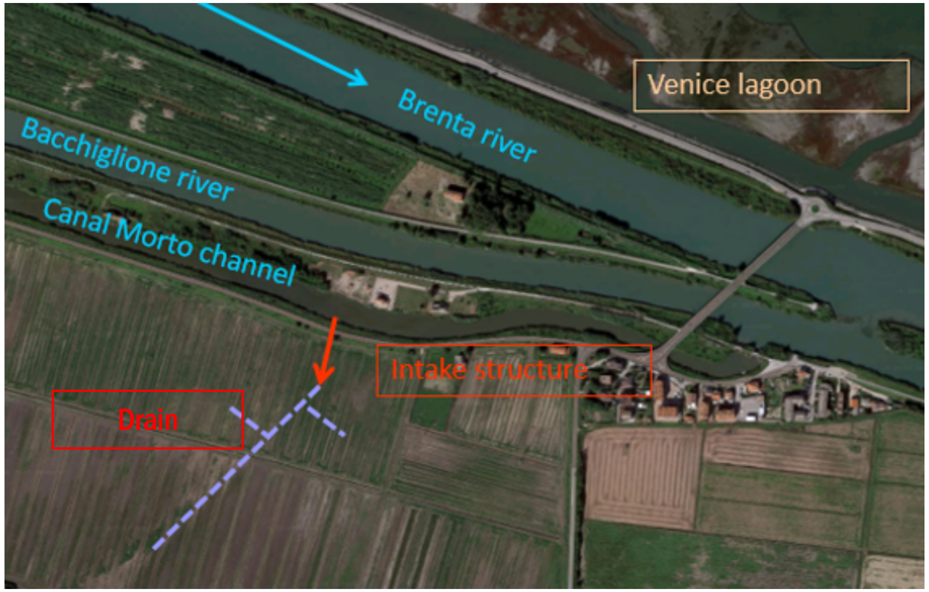
July 2012, 11 m depth

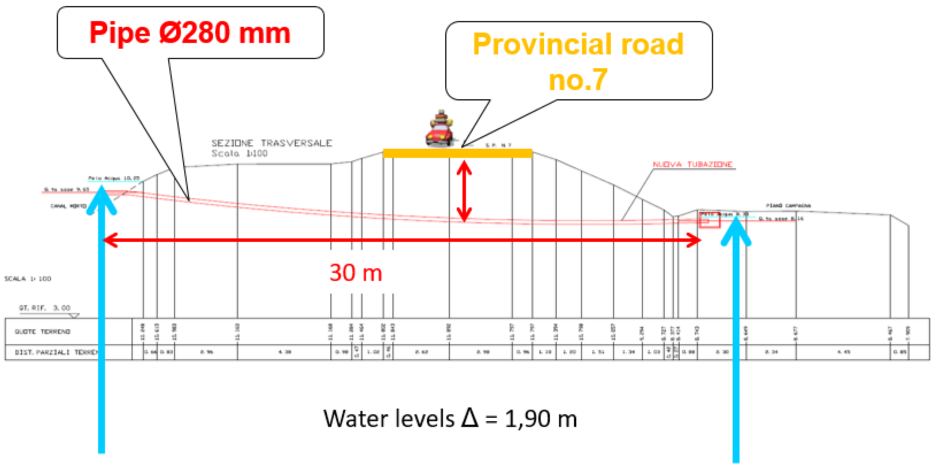


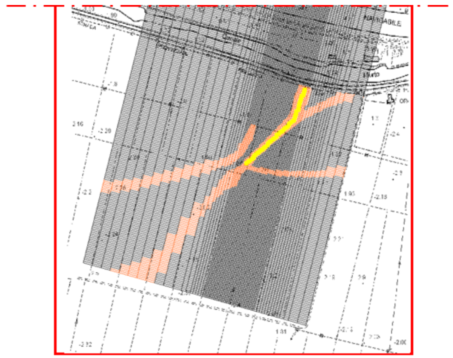
September 2012, 11 m depth

RESULTS

Drain countermeasure: location





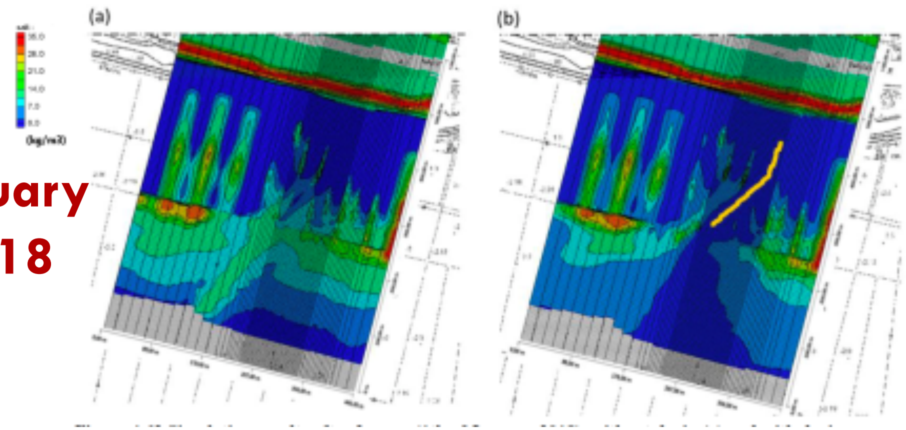


- The function of the drain is to carry part of the freshwater from the Morto channel to the agricultural field, displacing salt in the most superficial layers.
- The drain is implemented through the WELL package boundary condition in the software.

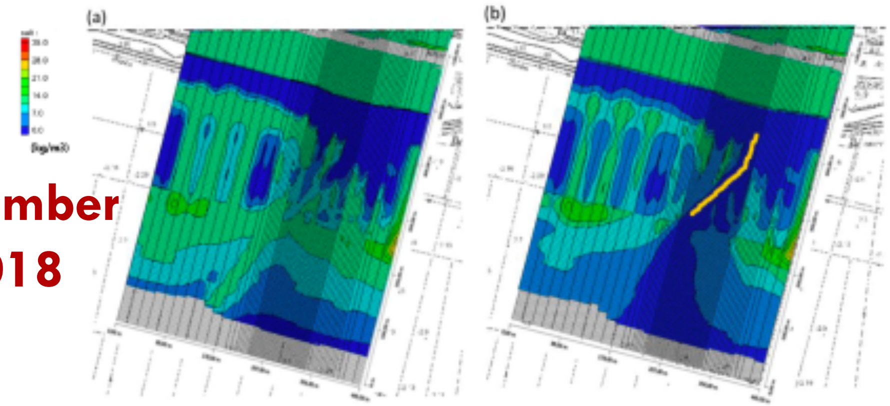
RESULTS

Drain countermeasure: simulations

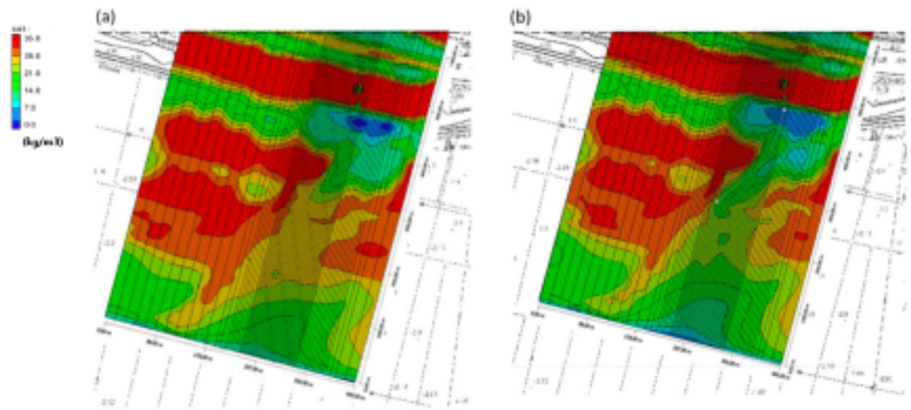
January 2018

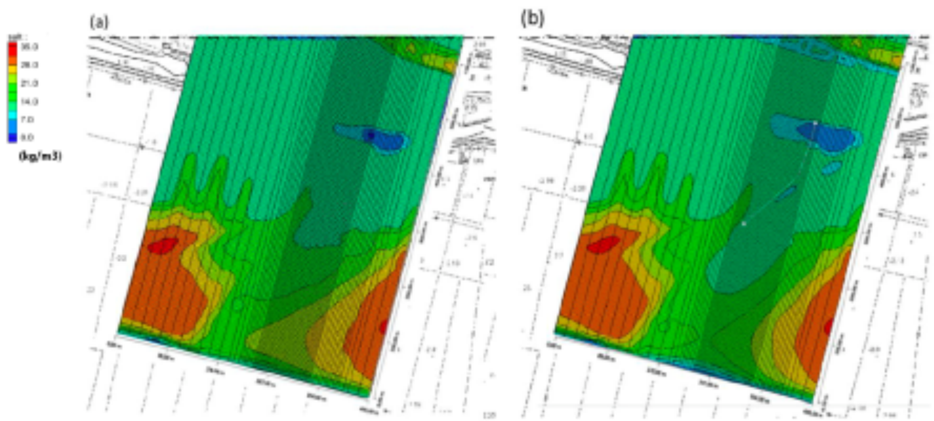


December 2018



Without drain (a) and with drain (b);
2 m depth





Without drain (a) and with drain (b);
7.5 m depth

CONCLUSION

- Simulations highlight a high vulnerability level of the area to the saline intrusion phenomenon, due to hydrological and geomorphological features.
- Seasonal variations of the boundary and initial conditions, seepage fluxes from the rivers and the presence of paleochannels highly influence the salt intrusion effects and the simulations results.
- Sensitivity analysis over the most influencing conditions is crucial to quantify the associated uncertainties and obtain reliable scenarios of the phenomenon to properly design countermeasures to preserve the agriculture productivity.
- The application of a drain could be an efficient countermeasures against the phenomenon but more investigations - geotechnical and hydraulic - are needed to define the best cost-benefit countermeasure design.

FURTHER DEVELOPMENTS

- Further in-situ and laboratory geophysical and hydraulic investigations needed;
- Application of seasonal lagoon levels and effect of the tide;
- Application of a cut-off wall;
- Potential climate change effect;
- Saturated and unsaturated conditions;

ACKNOWLEDGMENTS

We would like to thank **Ilaria Cunico** for her essential contribution to the project.