Combined use of physically based models and geostatistics to understand microbial contamination in the Thau Lagoon

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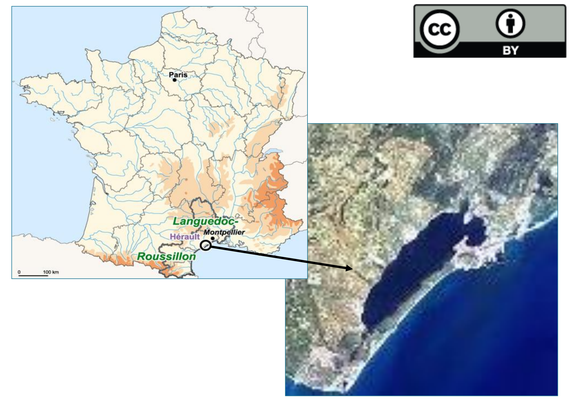


Introduction

The yearly shellfish harvest in the Thau lagoon (75 km^2) is producing about 13000 tons of oysters and 4000 tons of mussels, representing 10% of the French shellfish production.

The microbiological shellfish quality is directly related to the lagoon water quality which is depending on the watershed inputs. By dry weather or after rainfall events, the Thau lagoon shells are regularly impacted by microbial pollutions of faecal origin exceeding health standard, resulting in the closure of the shellfish harvest.

To improve the water quality, and in the face of increasing population pressure around the lagoon, the OMEGA Thau project (Environmental Management Tool and Alert Management) was initiated in 2006.

Material and Methods

Data. Acquisition during four rainfall events between September 2007 and February 2009:

- Punctual sampling of water quality and hydrological parameters (salinity, turbidity, temperature),
- Dynamic sampling procedure with a towed multi parameters measurement device: Easyfish.

Model. Hydrodynamical model **MARS-3D** (Lazure & Dumas, 2007; Fiandrino et al., 2009) coupled with models of Escherichia coli mortality in seawater.

Model calibration / validation

Observed and simulated salinity levels in seawater were compared spatially / temporally in order to choose the optimal parameters for the hydrodynamical model.

Dealing with parameters that are spatially and temporally structured (not random), the comparison is based on a geostatistical approach (Flipo et al., 2005) which accounts for:

- data uncertainty and spatial variability, captured by variogram analysis,
- the difference between measured (dynamic punctual sampling) vs. simulated (100m x 100m) support.

Methodology:

- Preliminary salinity data quality control and removal of erroneous data.
- Simulated outputs are extracted for time/depth/cells that are consistent with the Easyfish sensor route.
- Average salinity values and related uncertainties are estimated using block kriging.
- Simulated / measured values are compared for different simulation input parameters at cells for which the measured salinity can be interpolated with reasonable confidence (low kriging variance, limited depth/time variations).

References

Fiandrino A. et al., 2009. A hydrodynamic model for Mediterranean lagoons (MARS-3D): calibration and estimation of water residence time in the Thau lagoon (France). Poster 7.15 – European Conference on Coastal Lagoon Research –14th – 18th December 2009 Montpellier, France.

Flipo N., N. Jeannée, M. Poulin, S. Even, E. Ledoux, 2005. Assessment of nitrate pollution in the Grand Morin aquifers (France): combined use of geostatistics and physically-based modeling. In *Environmental Pollution*, 146 (2007) 241-256.

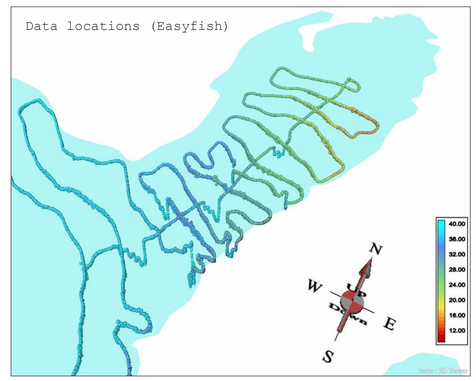
Lazure P., F. Dumas, 2007. An external-internal mode coupling for a 3D hydrodynamical model for applications at regional scale (MARS). In *Advances in Water Resources* 31 :233-250.

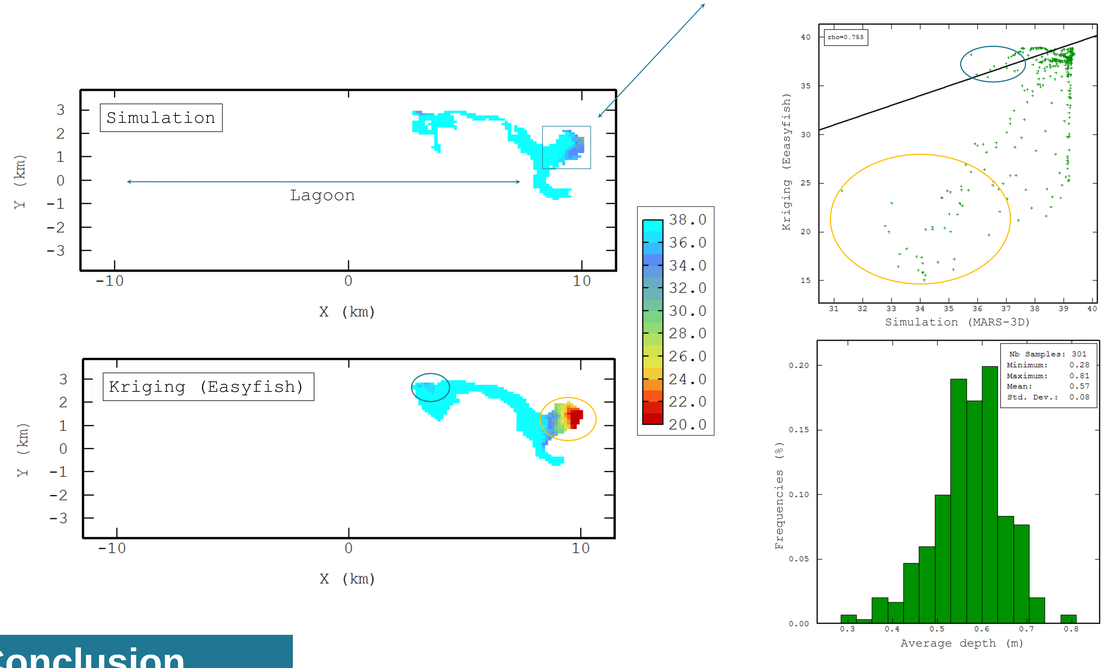
Results

Comparison is based on both visual inspection and numerical results about statistical errors between simulated / measured values (bias, R^2, MSE).

Examples below correspond to several days of the November 2008 event. 7 combinations of MARS parameters are compared and ranked according to their statistical scores.

Criterion	Simu 1	Simu 2	Simu 3	Simu 4	Simu 5	Simu 6	Simu 7	Average
Bias	5.46	5.34	5.20	4.84	4.41	5.13	4.75	5.02
Bias rank	7	6	5	**3**	**1**	4	**2**	
R²	0.42	0.39	0.45	0.55	0.60	0.47	0.54	0.49
R² rank	6	7	5	**2**	**1**	4	**3**	
MSE	8.10	8.01	7.84	7.46	7.03	7.71	7.32	7.64
MSE rank	7	6	5	**3**	**1**	4	**2**	





Conclusion

Accounting for the spatial / temporal measurement support is recommended before any comparison between simulations and observations. Geostatistics provides relevant methods for that purpose: exploratory data analysis, variogram analysis, block kriging, uncertainty estimation.

Once validated, the models became part of the environmental management tool developed to guide local authorities to achieve optimal water quality consistent with European standards for shellfish harvesting areas.