Modeling of the Galileo signals near a sea surface.

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I. Introduction

The Galileo system is obviously seen as a huge opportunity for the air traffic management since it is built to deliver guaranteed signals at sub-meter accuracies. In the same way, the Galileo system has to play a big role in the maritime transport. The accuracy and the reliability of the positioning based on Galileo can be of a great importance for shipping containers management or navigation in port areas, for maritime safety (avoiding shipwreck system), for search and rescue (specially in bad weather conditions),... Nevertheless, these opportunities of development for the Galileo positioning system in maritime domains are only available if the performances of the Galileo system are proved to be valid in any maritime environment. As a matter of facts, due the multiple electromagnetic reflection from the sea surface, the GNSS signal received above the sea surface could be significantly perturbed by the electromagnetic contributions from the sea, see figures 1 and 2. And so the maritime environment could seriously impact the performances of the Galileo system.

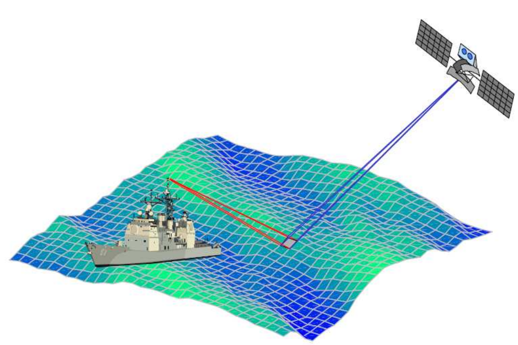


Fig. 1. Influence of the GNSS signal from the sea surface upon sea transport.

To quantify the potential loss of accuracy and possible deterioration of the Galileo signal, a fine electromagnetic model of a GNSS receiver near the sea surface must be developed.

II. State of art

For several years, the influence of the ocean surface upon the GNSS signals (mainly GPS signals) has been profusely studied by various scientific teams in the world [1], [2], [3], [4]. In few words, these scientific publications highlight the fact that the GNSS signal scattered from the sea (considered as a random rough surface) is greatly influenced by the state of the sea and the wind direction, see figure 3. This is the reason why the possibility to use a GNSS receiver as a remote sensing device for ocean monitoring is often investigated.

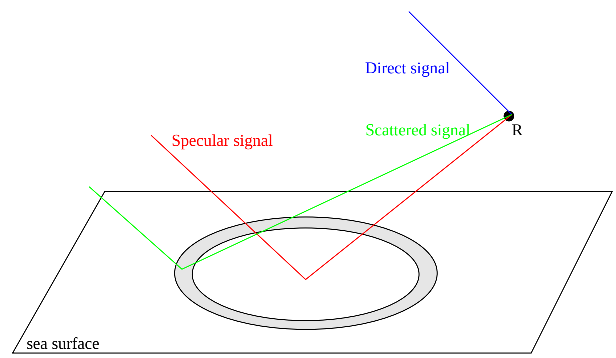


Fig. 2. Different delay associated to each contribution from the sea surface.

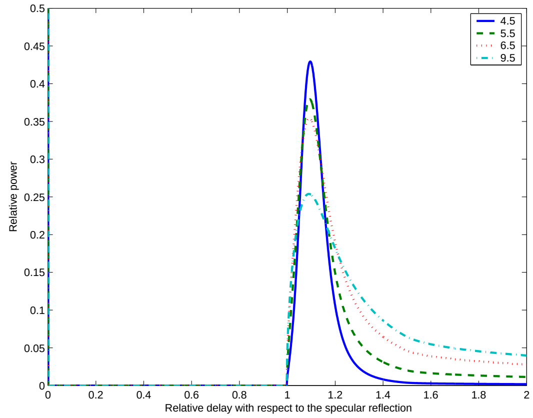
However, the most part of the scientific literature concerning the GNSS signals in maritime environments is dedicated to airborne or satellite GNSS receiver systems, and the observers are hardly ever supposed to be in the vicinity of the ocean surface. In the case of a faraway observer, the electromagnetic interactions with the ocean surface can be modeled using standard asymptotic approaches (Kirchhoff approximation for instance), for which the ocean is then only described by stationary statistical properties (slope probability density function,...).

Anyway, in the case of the sea transport or any other maritime activity, the GNSS receiver is supposed to be near or very near above the sea surface, and the electromagnetic model of the interaction with the sea surface remains an open problem.

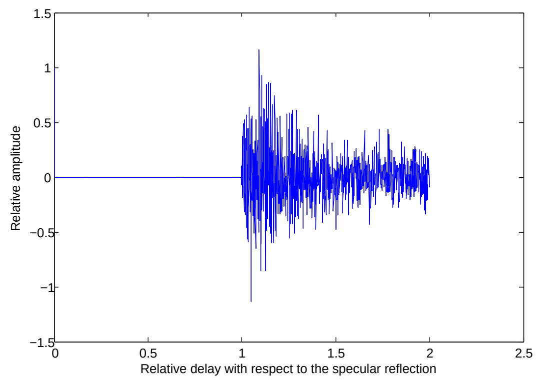
III. Current research

Very recently, we develop a reliable algorithm to estimate the signal scattered (in bistatic configurations) by a deterministic sea surface generated from a realistic sea spectrum (see figure 4) [5].

Using this approach, we can simulate the GNSS signals where the observer is a few dozen meters above the ocean surface. With these assumptions, the roughness of the ocean surface cannot be reduced to a simple statistical model and



(a) Power density (incoherent summation) with different Beaufort wind scale coefficients: 4.5, 5.5, 6.5 and 9.5.



(b) Amplitude distribution (summation of elementary contribution with random phase)

Fig. 3. Numerical simulation of the GPS signal (impulse response) received above sea surface at 5km height.

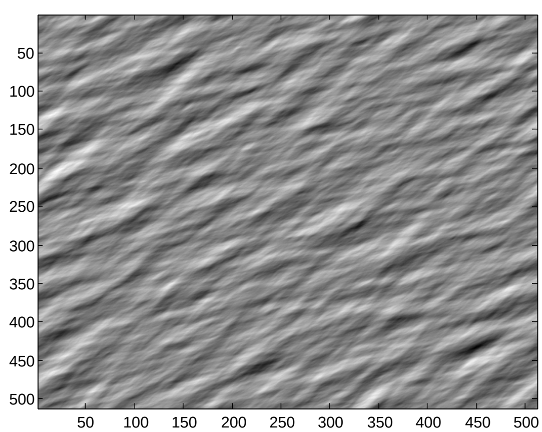


Fig. 4. Deterministic sea surface obtained by a numerical simulation based on the Elfouhaily sea spectrum.

the actual movement of the sea must be taken into account, see figures 5 and 6.

Our numerical results point out the influence of the sea movement upon the scattered GNSS signals quite near above the surface. And, our algorithm could be of a great interest to evaluate the reliability of GALILEO receiver systems in a maritime environment with various sea states and wind conditions.

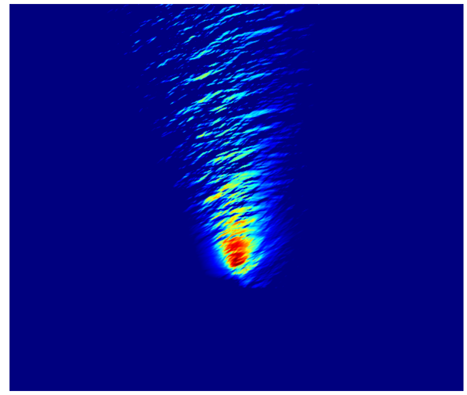


Fig. 5. Scattering of a GPS signal by the deterministic sea surface at 10 m height.

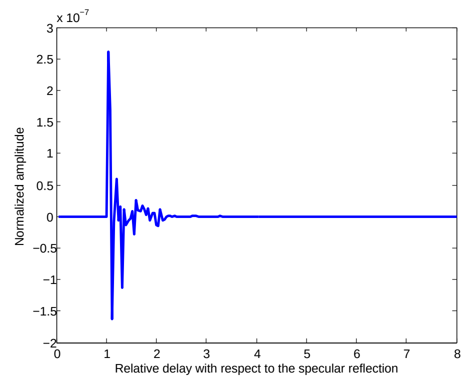


Fig. 6. Simulation of a GPS signal received at 10 m above the deterministic sea surface.

IV. Conclusion

Modeling and simulating GNSS signal for sea transport and maritime environment remains a challenging issue for our research laboratory and we are still developing the electromagnetic models dedicated to the interaction of the GNSS signal with the maritime environment: very near observer, coastal or shore environments,...

It worths to be mentioned that our laboratory is an active member of the "GALILEOCEAN" project. This project, recognized by the "Pôle de compétitivité mer Bretagne", is dedicated to the evaluation of the future European positioning system (GALILEO) in maritime environment.

References

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