Invitation à la soutenance publique de thèse de
David VINCENT

Pour l'obtention du grade de Docteur en sciences de l'ingénieur et technologie

« Titanic results: a numerical study of motion in the liquid bodies of a Saturnian icy moon »

qui se déroulera
le lundi 18 mai 2020 à 16h15
Par visioconférence
1348 Louvain-la-Neuve

Jury members:
Prof. Eric Deleersnijder (UCLouvain), supervisor
Prof. Véronique Dehant (UCLouvain), supervisor
Prof. Sandra Soares-Frazao (UCLouvain), chairperson
Prof. Vincent Legat (UCLouvain), secretary
Dr. Özgür Karatekin (Observatoire Royal de Belgique)
Dr. Gabriel Tobie (Univ. de Nantes, France)

Titan, Saturn’s largest moon, is a unique object in the Solar system since it has a substantial atmosphere, a surface with a complex interplay of geological processes and an outer ice shell overlying a subsurface ocean. The climate on this icy satellite boasts a multi-phase hydrological cycle where methane plays a role similar to that of water on Earth. Surface lakes and seas filled with liquid methane and ethane are found in the polar regions. The subsurface ocean, on the other hand, is filled with liquid water. It is responsible for the large surface deformation observed.

The first objective of this thesis is to adapt an Earth-based geophysical and environmental model, SLIM (www.climate.be/slim), to Titan’s specific conditions in order to study the tidal motion in the surface lakes and seas. The modified model is applied to the largest lake in the southern hemisphere, Ontario Lacus, and the two largest seas, Kraken and Ligeia Maria, which are located in the northern hemisphere. The predicted surface elevation and velocity fields are part of the data necessary to develop an exploration mission focusing on the surface lakes and seas of Titan. The natural modes of Ontario Lacus are also numerically studied. While resonantly forced modes could generate significant liquid motion, the natural periods are much shorter than the period of the astronomical forcings. Therefore, only atmospheric forcings could resonantly force the natural modes. Strong wind conditions corresponding to a stormy event are required to generate a surface elevation resulting in significant shoreline variations.

Then, the model is used to study the tides of Titan’s global subsurface ocean. To this end, the shallow water equations and the 3D hydrostatic equations under the Boussinesq approximation are modified in order to take into account the ice shell lying at the top of the ocean and the method is adapted to solve the equations on a sphere. The effects of the shell are represented by doubling the friction coefficient and adding a surface pressure term. The shell decreases the ocean surface elevation and slows down the flow without modifying significantly the global patterns of these fields. The magnitude of the diminutions depends on the mechanical behaviour of the ice shell. Surface and bottom heat fluxes play a significant role in the liquid motion of the ocean. The interactions between the tidal motion and the thermally driven flow are studied by means of the 3D version of SLIM. The surface heat flux significantly impacts the velocity field, both in terms of magnitude and orientation while the influence on the ocean’s surface elevation is almost negligible. These results could be useful for astrobiologists paying attention to the ocean habitability and to validate hypotheses about the internal structure.