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# Cooling patterns in rotating thin spherical shells – application to Titan's subsurface ocean

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Many water rich planetary bodies in the outer solar system are considered to be "ocean worlds" in the sense that these bodies likely harbor global layers of liquid water beneath their surface ice shells [1]. The existence of buried oceans in several moons of Jupiter and Saturn have been revealed by various geophysical techniques performed by the Galileo and Cassini-Huygens missions. In the particular case of Titan, the presence of an internal ocean was confirmed by three independent observations: electric signals measured by the Huygens probe during its descent through Titan's atmosphere [2], obliquity three times larger than expected [3] and gravitationnal tides [4, 5]. Moreover, the inversion of long-wavelength topography and gravity data collected by Cassini revealed the existence of significant ice shell variations indicating large heat flux variations coming from the ocean, with maximal values at the poles [6].

In the present study, we use rotating convection simulations in a thin spherical shell to study fluid dynamics in subsurface oceans of icy moons, with a particular focus on Titan. We find two types of persistent results, characterized by larger outer boundary heat flux either at polar regions or at the equatorial region. Simulations corresponding to larger Rossby numbers result in polar cooling with moderate lateral heterogeneity in heat flux, whereas lower Rossby numbers give equatorial cooling with more pronounced heat flux heterogeneity. The polar cooling scenario is in agreement with inferences for the heat flux at the top of Titan's ocean, which may provide a dynamical constraint for the vigor of convection in this layer. Our results may help unraveling the internal dynamics and the interactions among the different layers within the hydrosphere of Titan. Possible implications for the deep interiors of other icy moons are envisaged.

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## References

[1] Nimmo, F., Pappalardo, R., 2016. Ocean worlds in the outer solar system. J. Geophys. Res. 121(8), 1378–1399.

[2] Béghin, C., Randriamboarison, O., Hamelin, M., Karkoschka, E., Sotin, C., Whitten, R. C., Berthelier, J.-J., Grard, R., Simoes, F., 2012. Analytic theory of Titan's Schumann resonance: Constraints on ionospheric conductivity and buried water ocean. Icarus 218(2), 1028–1042.

[3] Baland, R.-M., Tobie, G., Lefèvre, A., Van Hoolst, T., 2014. Titan's internal structure inferred from its gravity field, shape, and rotation state. Icarus 237, 29–41.

[4] Iess, L., Jacobson, R., Ducci, M., Stevenson, D., Lunine, J. I., Armstrong, J. W., Asmar, S., Racioppa, P., Rappaport, N. J., Tortora, P., 2012. The tides of Titan. Science 337, 457–459.

[5] Mitri, G., Meriggiola, R., Hayes, A., Lefèvre, A., Tobie, G., Genova, A., Lunine, J. I., Zebker, H., 2014. Shape, topography, gravity anomalies and tidal deformation of Titan. Icarus 236, 169–177.

[6] Kvorka, J.,Čadek, O., Tobie, G., Choblet, G., 2018.Does Titan's long-wavelength topography contain information about subsurface ocean dynamics? Icarus 310, 149–164.