EPILOGUE
Dynamics on other planets …

Scale separation and boundary condition

In this course, most of the work is based on idealized theories that we tried to apply to real-world situations, in the Earth's Atmosphere and Ocean.

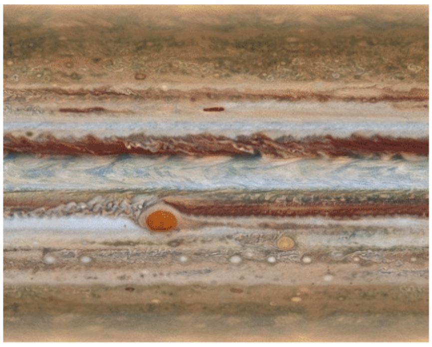
But, our atmosphere or ocean do not always comply with the theoretical framework because they are actually more complicated!

For instance, in the ocean, there are complicated coastlines, which are a bit annoying because they prevent the flow from going all around the world. These coastlines make the theory much more difficult to apply to the real world. And often, we put a rigid lid on the ocean as well, but in reality, there is none.

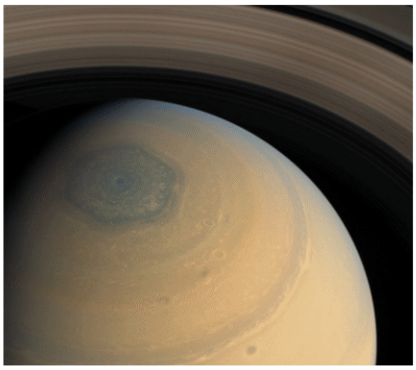
Scale separation is a big problem in the Atmosphere. In the Ocean, it is fairly easy because turbulence is very small-scale compared to the general circulation. The ocean Rossby radius is just a few hundred kilometers or less. But in the atmosphere, the Rossby radius is of the order of a thousand kilometers, which is pretty much the same scale as the low-frequency variability. The scale separation is really on the limit of being applicable. The atmosphere also has a boundary condition where you have mountains so that makes things more complicated.

To Jupiter and beyond

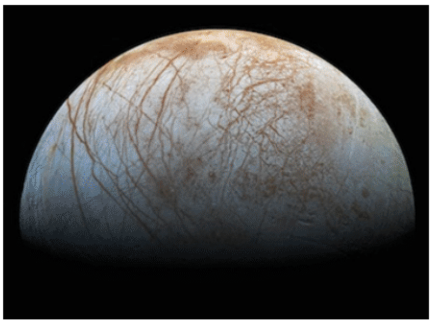
All these complications get in the way of trying to apply our beautiful theories. One way to cope with this is to leave the Earth and apply these theories to planets in which there appear to be fewer complications.



On the left is a picture of a planet where there is a beautiful scale separation and the fluid can go all the way around unimpeded. We observe zonal jets along with some small-scale eddies interacting with the large-scale flow. We even observe a beautiful example of a long-lived phenomenon that seems to be fueled upstream by a train of eddies, allowing it to maintain itself against dissipation. Of course, this planet is **Jupiter**.



On the right is **Saturn** with its banded cloud structures. It even has a marvelous perfect hexagon shape on its North Pole. This can be reproduced in theory and in experiments. With a laboratory tank, one can generate perfect symmetric patterns of various wavenumbers depending on the chosen parameters (rotation rate, temperature gradients, etc.)



On the left, it is one of the moons of Jupiter, called **Europa**. The whole moon is an ocean covered by a thick layer of ice - a rigid lid! So here, we have an ocean that goes all the way around the world and it has more water than we have here on Earth!

Well, it's easy to give a lecture course where you grab pictures from NASA and say how cool fluid dynamics is. But you can appreciate this directly from your own garden or even your balcony. Below is a final picture of Jupiter, taken by Nick Hall through a 20cm Newtonian reflector. You can marvel at the cloud bands and the zonal jets, along with the four moons all in a row.