Kelvin-Helmholtz waves in the Romanche-Fracture zone

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Background

- Kelvin-Helmholtz waves arise when there is a velocity shear in a fluid. This shear causes the faster-moving fluid to slide over the slower-moving fluid, leading to the development of characteristic rolling wave-like patterns. As an example, in the atmosphere, when the upper layer of air is moving at a higher speed than the lower-level air, it scoops the top of an existing cloud layer into wave-like shapes.

Figure 1: Kelvin-Helmholtz waves in the atmosphere. Credits: BBC

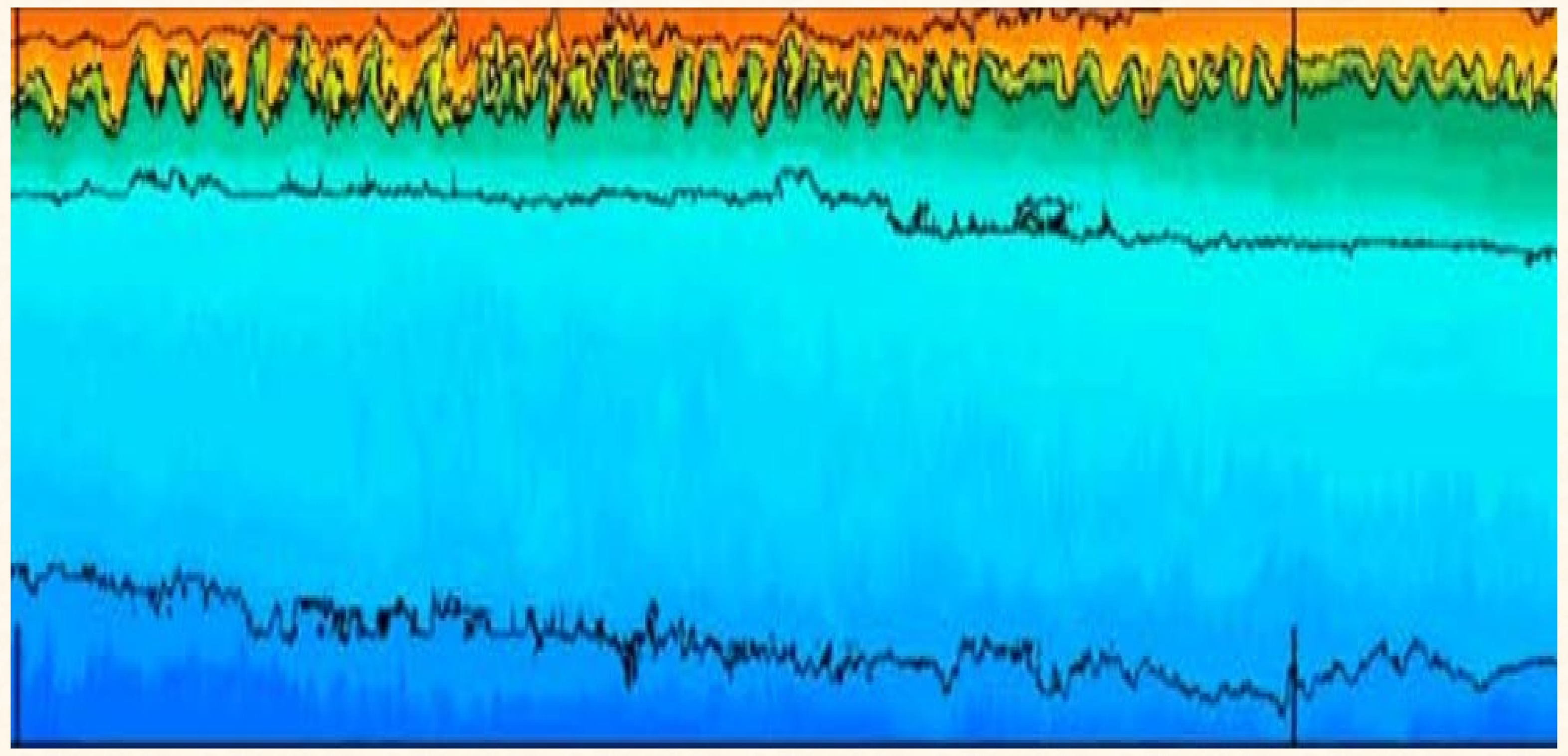

Figure 2: Kelvin-Helmholtz billow trains in the Romanche-Fracture zone [1]

- The presence of Kelvin-Helmholtz billows was found in the Romanche-Fracture zone in the Atlantic Ocean at a depth of approximately 4500m [1].

- As of now, little is known as to the underlying mechanism causing the formation of these Kelvin-Helmholtz billows. However, in the atmosphere, we know that the topography of mountains can result into the formation of mountain lee waves which in turn may lead to the formation of Kelvin-Helmholtz waves [2]. Our hypothesis is that a similar mechanism is at work here.

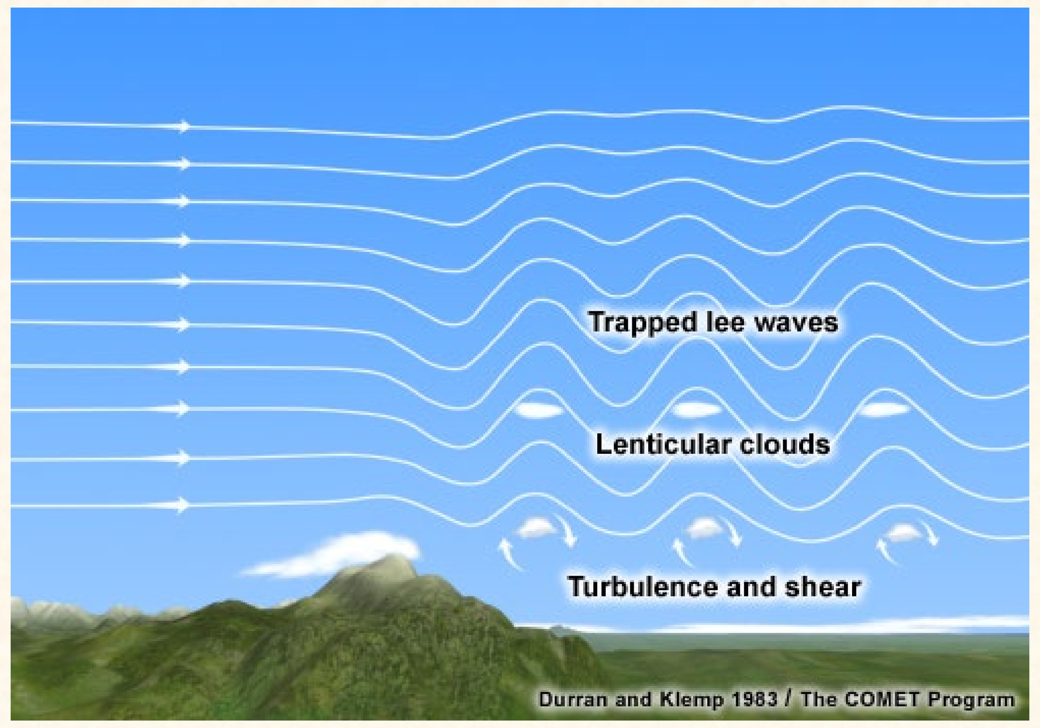

Figure 3: Mountain Lee waves and their associated turbulence. These may lead to the formation of Kelvin-Helmholtz waves. Credits: The COMET program

- Understanding the mechanism behind the formation of these Kevin-Helmholtz billow trains would lead to a better grasp of narrow circuits in global ocean water mass transport models. [1]

Method

- To test our hypothesis, we carry out a series of numerical simulations using Nek5000, a spectral element computational fluid dynamics software.

- Successfully reproducing these Kelvin-Helmholtz billow trains using our theory would confirm our hypothesis.

Results and Next Steps

- Successfully simulated lee waves using Nek5000.

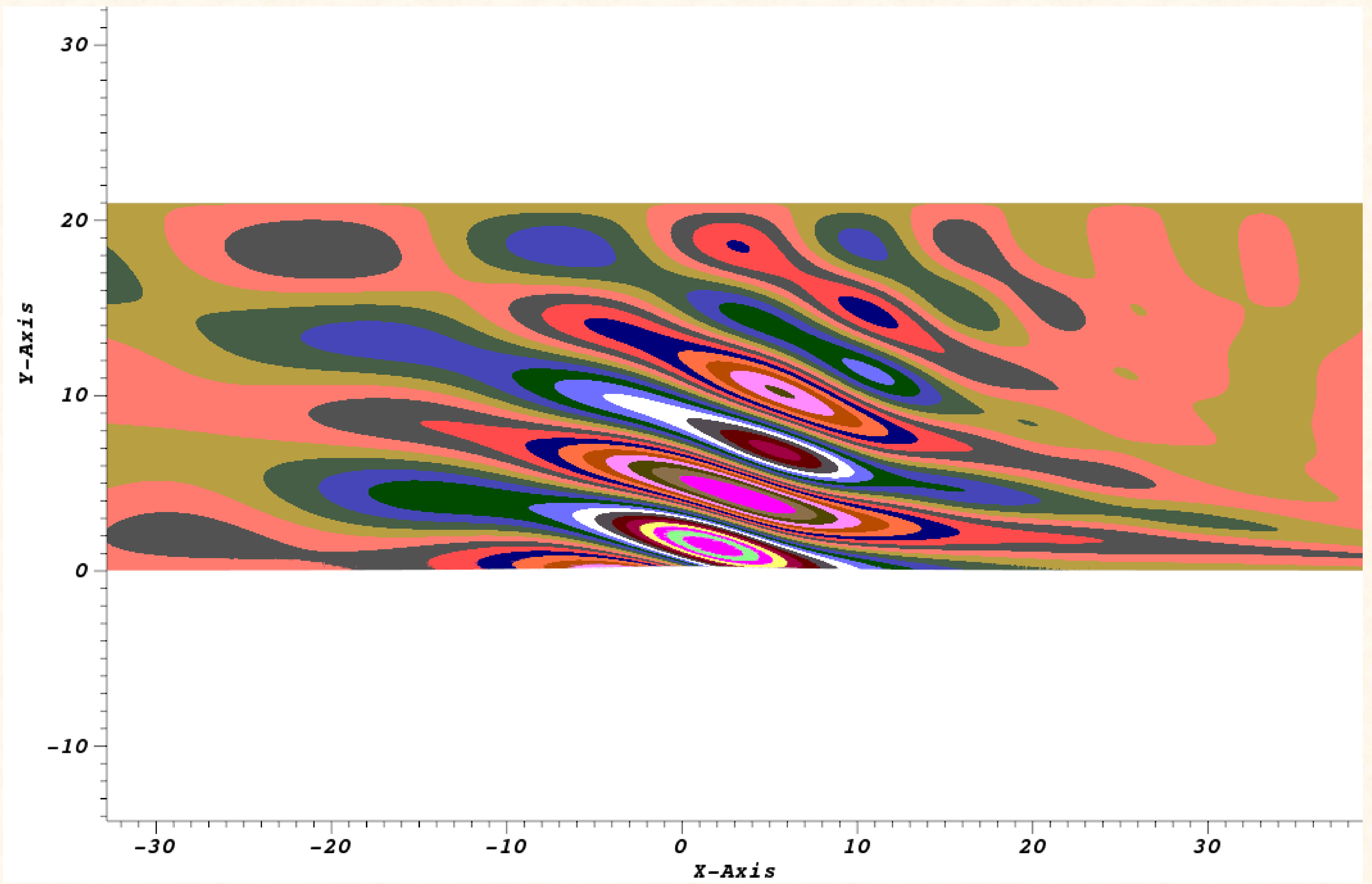

Figure 4: Numerical simulation of the vertical velocity field for a lee wave

- The next step is to improve the code to simulate fluid conditions in the Romanche-Fracture zone and observe whether we obtain Kelvin-Helmholtz billow trains.

References:

[1] Hans van Haren, H., L. Gostiaux, E. Morozov, and R. Tarakanov (2014), Extremely long Kelvin-Helmholtz billow trains in the Romanche Fracture Zone, Geophys. Res. Lett., 41, 8445–8451, doi:10.1002/ 2014GL062421.

[2] W.R. Peltier, J.F. Scinocca (1990) The Origin of Severe Downslope Windstorm Pulsations, Journal of Atmospheric Sciences, 47, 2853-2870, DOI :10.1175/1520-0469(1990)047<2853:TOOSDW>2.0.CO;2