Tabletop El Niño

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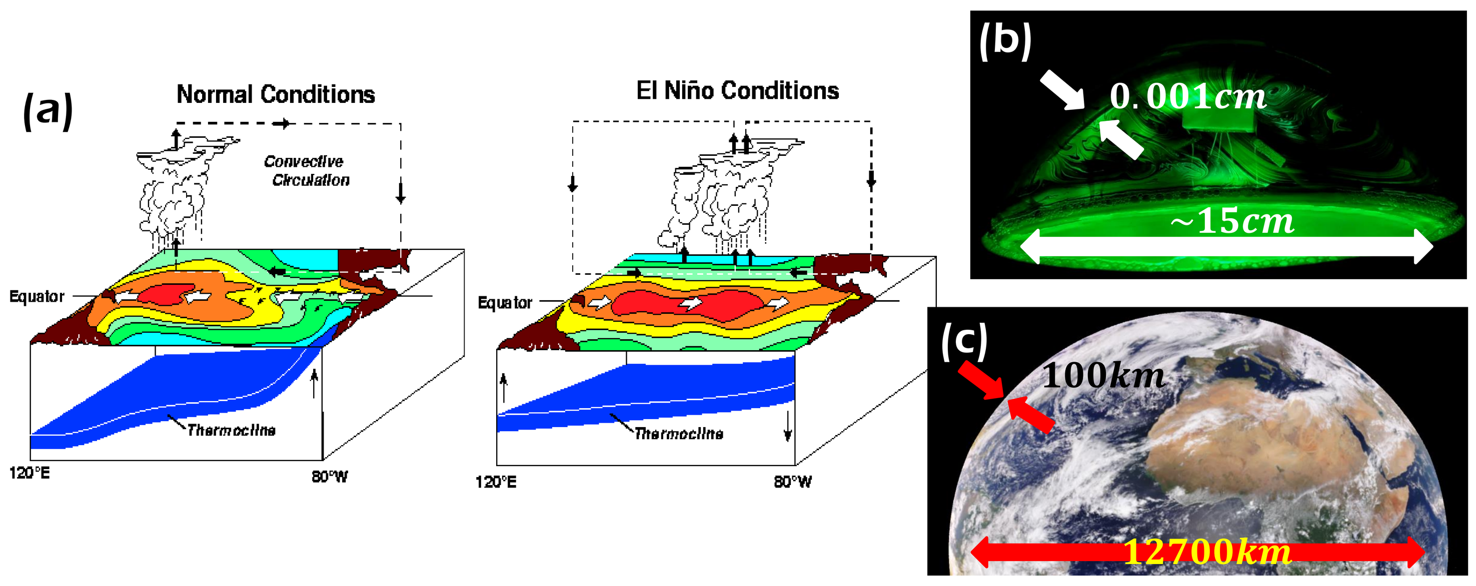
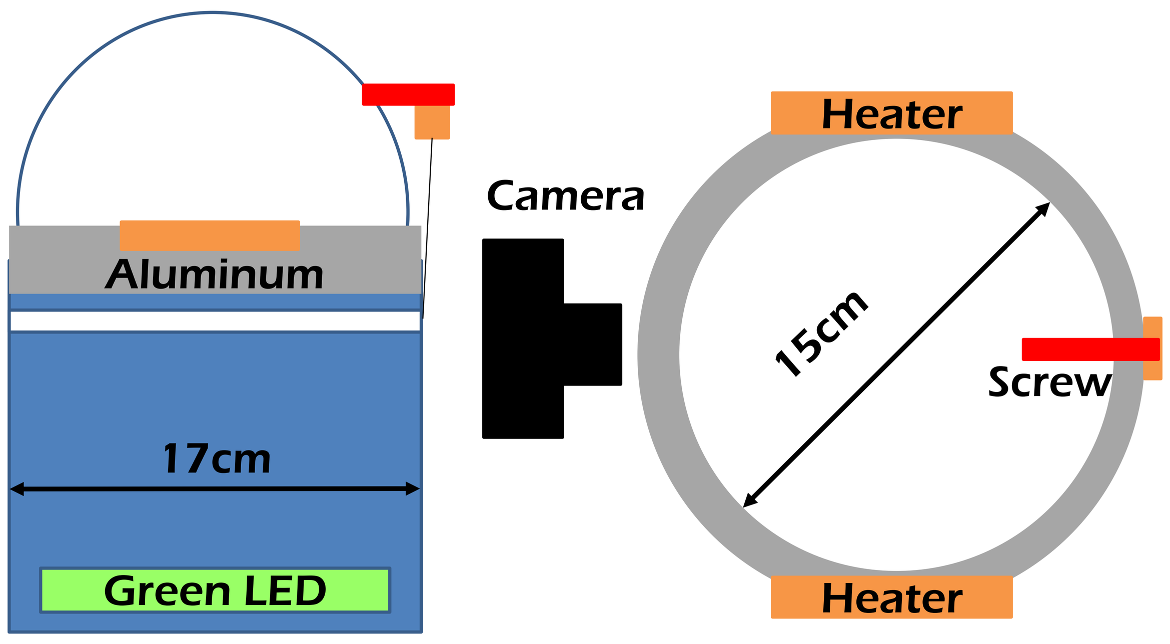
Motivation

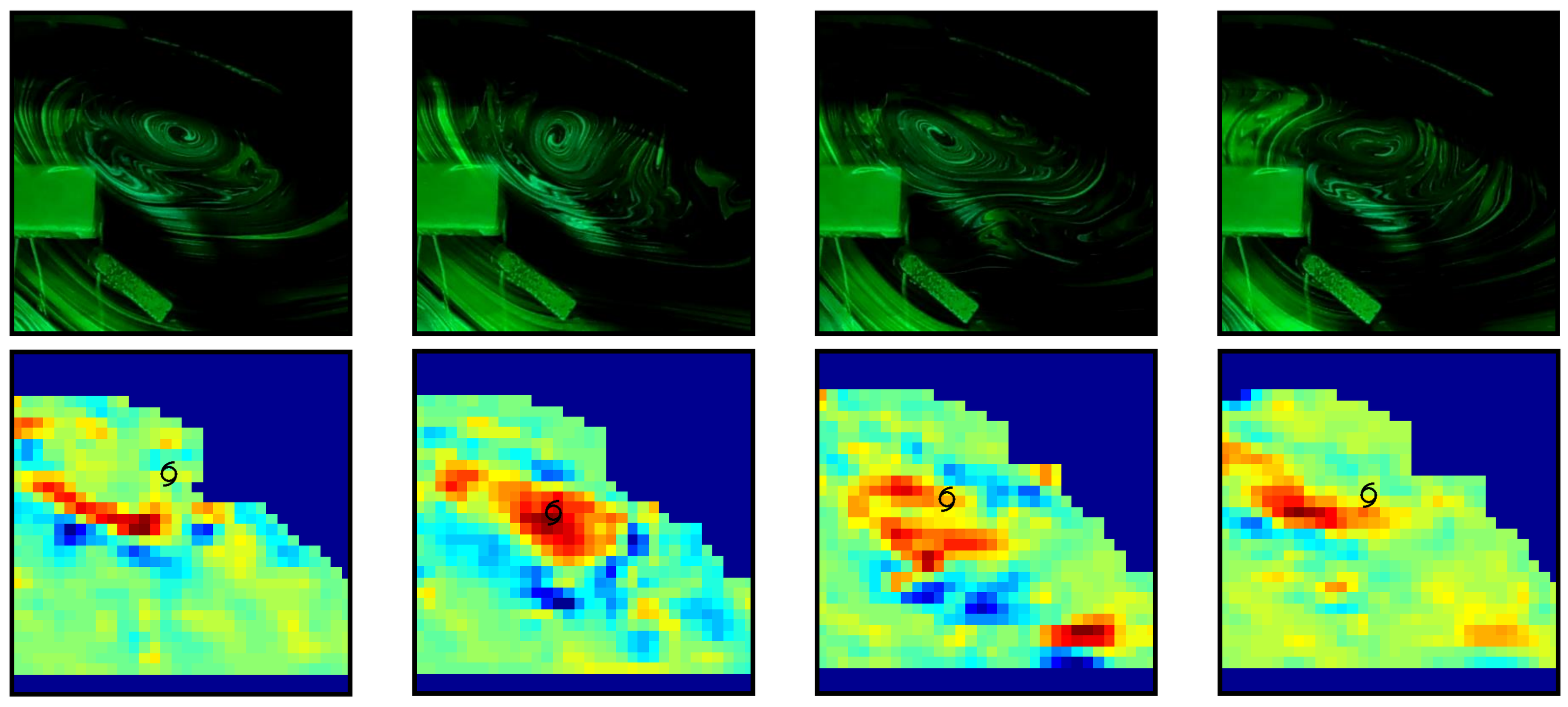
El Niño(a) has caused many disasters in South America, but it is difficult to use the numerical simulation to predict or simulate it. We want to build a structure and try to show the phenomenon in the laboratory. Because of the similar scale(b)(c), we can use the bubble to simulate the Earth. We heat the side to symbolize the intensity of El Niño, and adjust the temperature to find the influence on the field.



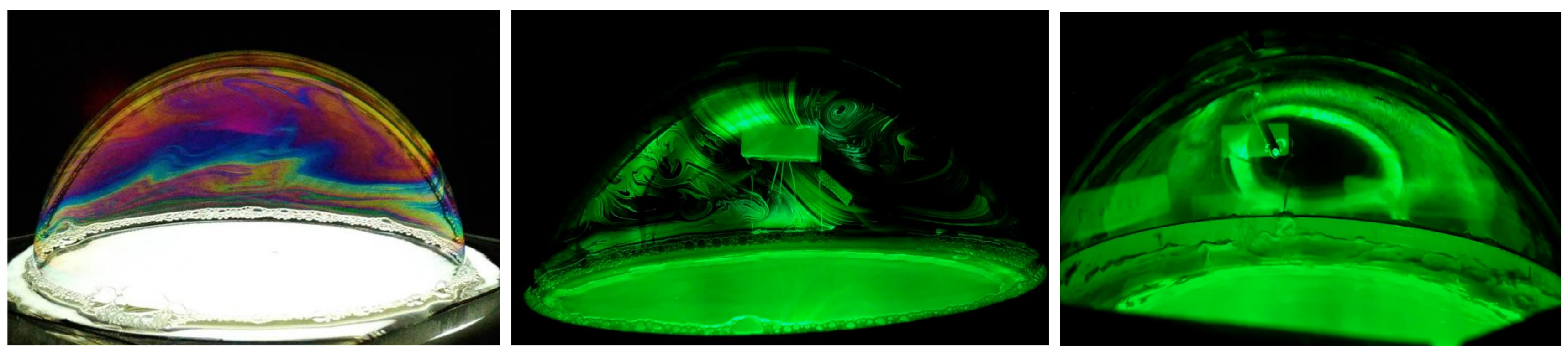
Set-up of experiment



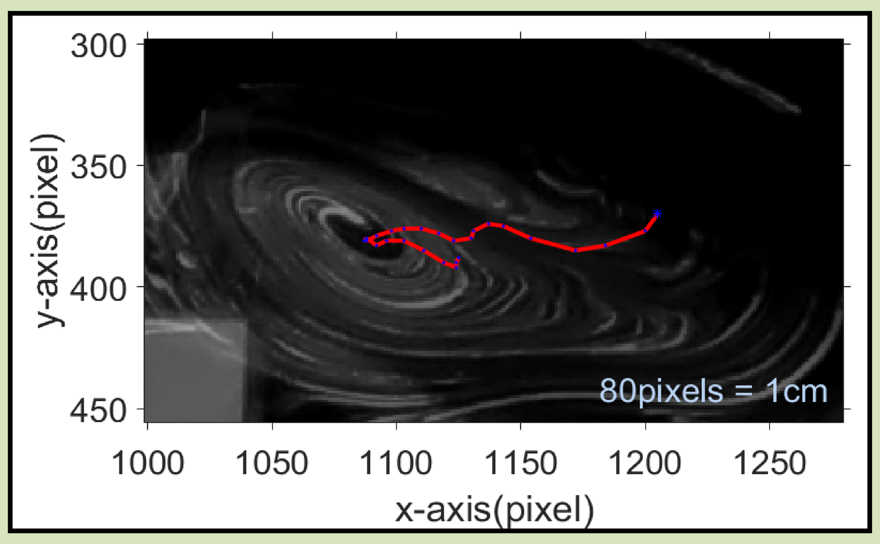
Temperature Control (Temperature error: ±1°C) → Take videos. → PIV (PIVlab) → Analyze (MATLAB)



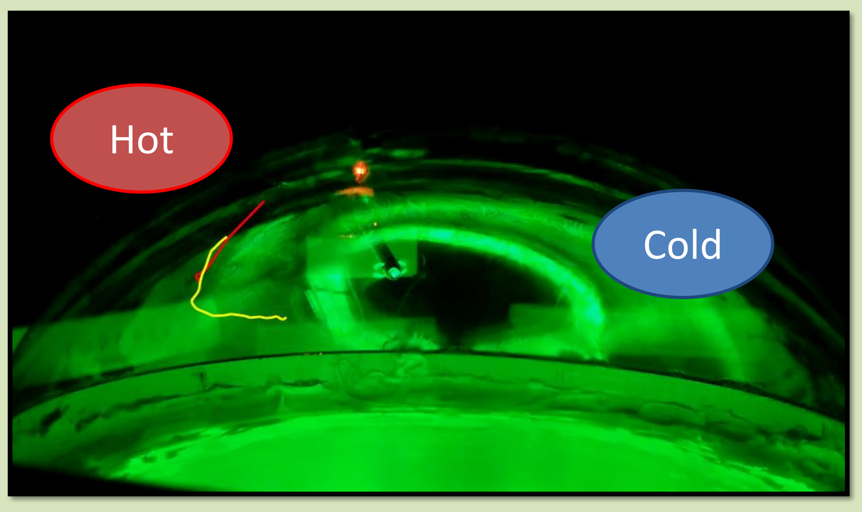
- The bubble water is made up of honey, glycerin, and soap water.
- We use the green LED to light the bubble because it is easier to be analyzed by PIV.
- We use the Arduino to control the temperature.



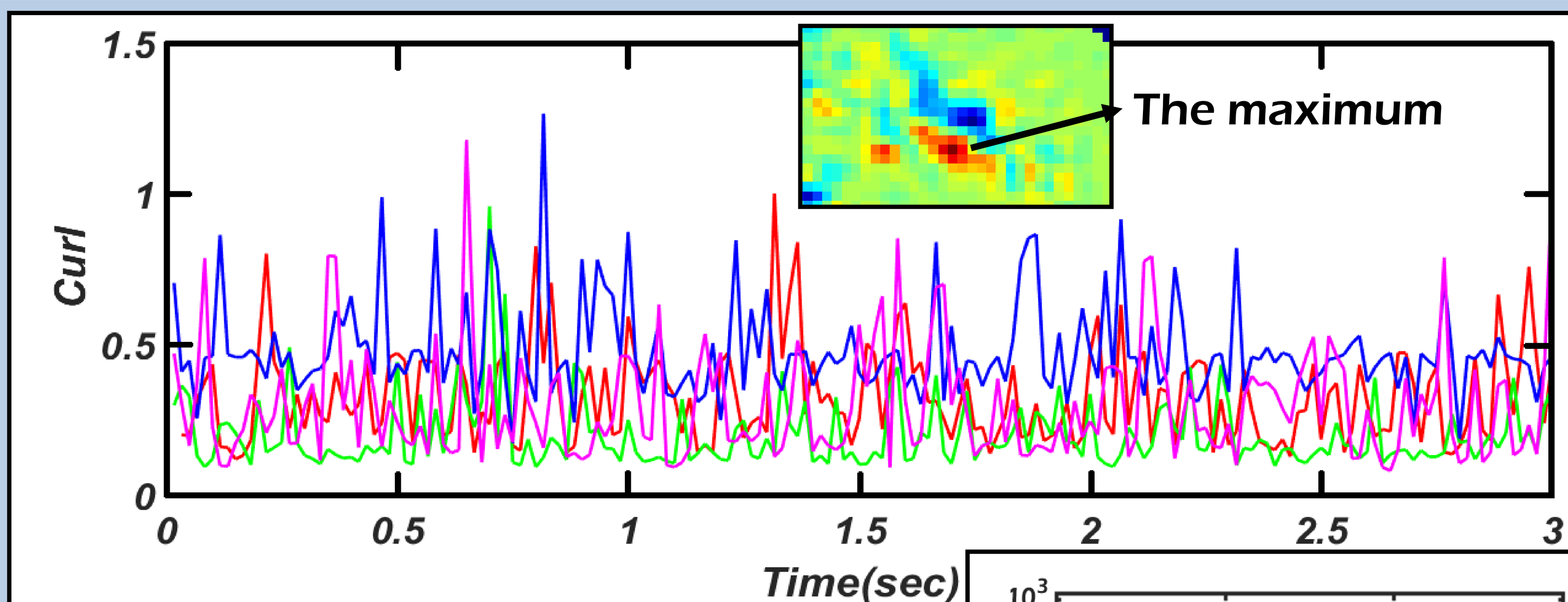
Result

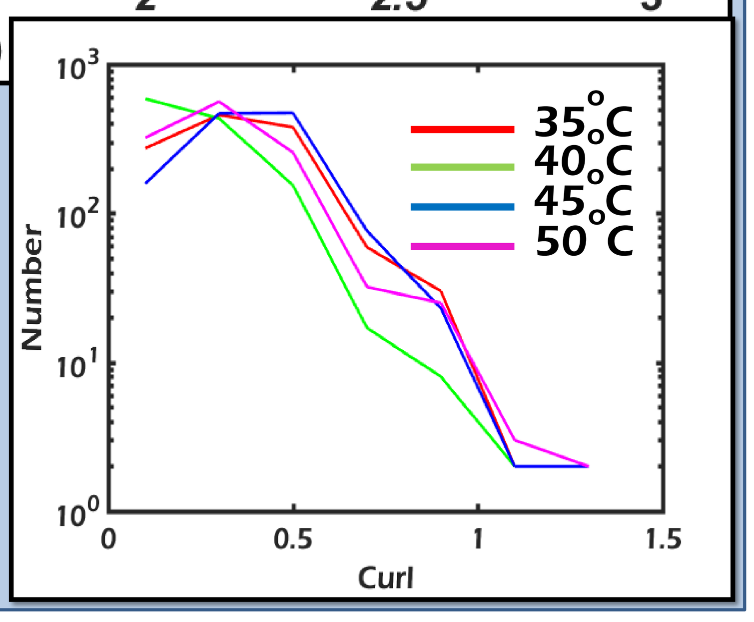


- If the vertical convection is weak, the vortex is stable and only moving on the horizontal direction.

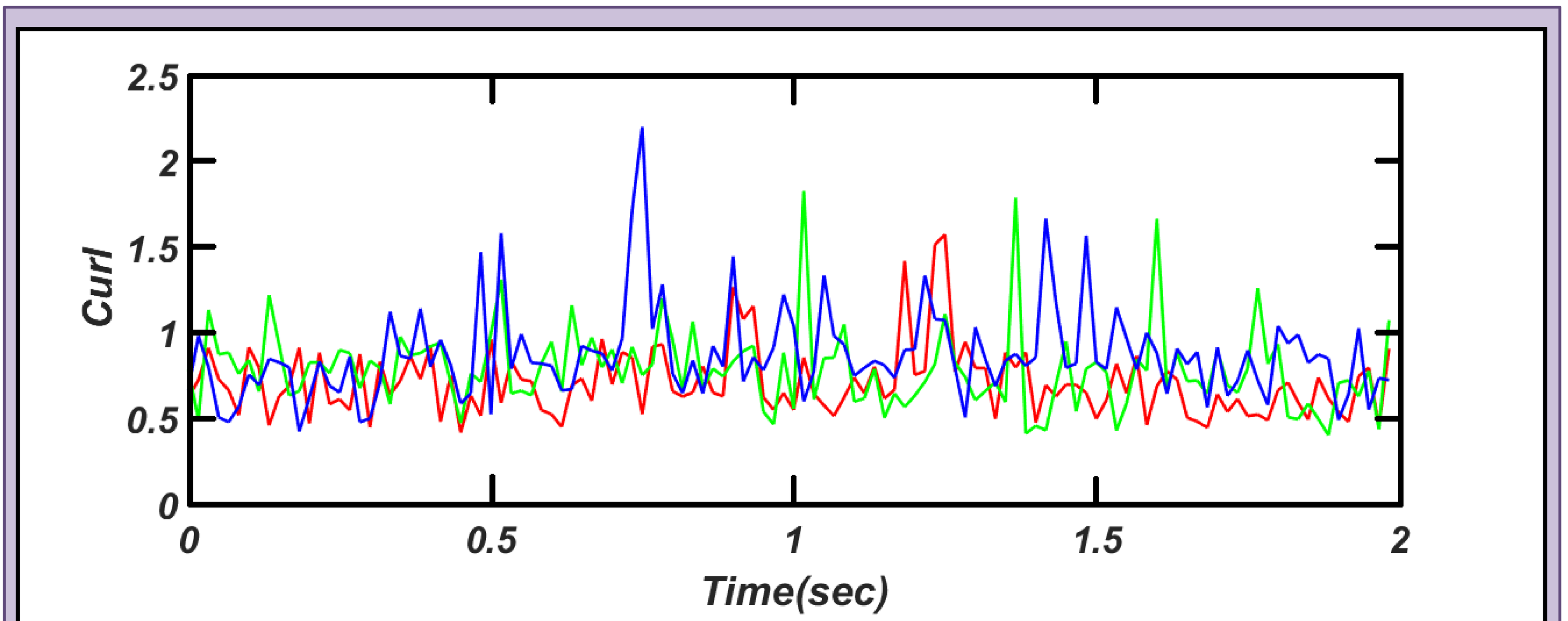


- The probability of vortices appear on the heating side is higher than other area.

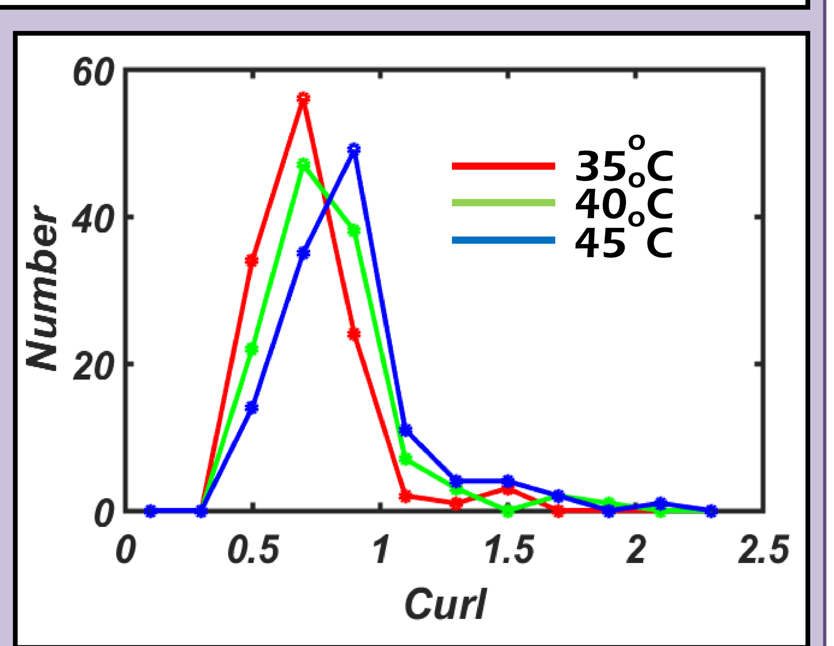




- Without heating on the bottom.
- The temperature of the side has less influence on the intensity of vortex.
- The number decades exponentially with the curl increasing.



- Fix the bottom at 55±1°C.
- Large curl means the vortex rotates at higher speed. In meteorology, it means the cyclone is more intensive.
- Higher temperature on the side, the vortex is more intensive. It means **the intensity of the cyclone is positive correlation with the intensity of El Niño.**



- The distribution has right shift with temperature increasing.
- The curl has a minimum. It means that these cyclones have certain intensity when El Niño happens.

- The temperature of the side becomes a main factor to influence the intensity of the vortex.
- When we heat on the bottom, we find the life of cyclone is shorter than without heating.

	Without heating on the bottom		Heating on the bottom	
	Standard deviation	Average	Standard deviation	Average
35°C	0.1568	0.3102	0.1586	0.6034
40°C	0.1318	0.2169	0.2329	0.6901
45°C	0.1563	0.4610	0.2797	0.7774
50°C	0.1515	0.2821	--	--

Conclusion

1. The vortices usually appear at the heating side. It means that **the cyclones usually appear at the east Pacific Ocean and seldom appear at west when El Niño happens.**
2. When the temperature is higher, the thermal convection becomes stronger. It means that **the intensity of the cyclones becomes stronger when El Niño happens**, and they will cause disasters.
3. The relation between the time which the cyclone keeps its intensity and the curl is an exponential function.

Reference

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2. T. H. Solomon, Eric R. Weeks, and Harry L. Swinney. *Phys. Rev. Lett. 71, 3975 (1993)*
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4. https://www.pmel.noaa.gov/elnino/what-is-el-nino