Chilling Out with Marine Cloud Brightening
- Artificial Cloud Creation to Cool the Planet -

Context

The average global temperature is expected to rise by at least 0.5C by 2040 and 1.8C by 2100. This is largely due to increased carbon emissions trapping heat in the Earth's atmosphere. This will lead to a variety of negative consequences for planet earth …

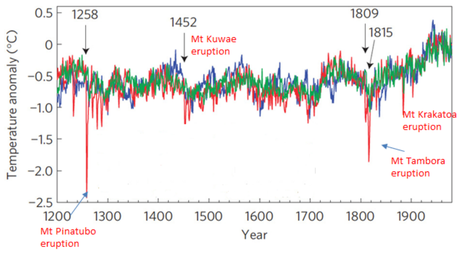
- **severe weather events**
- **rising sea levels**
- **desertification**
- **economic disruption**
- **health risks for humans**
- **animal / plant extinctions**

So, what can scientists or governments do about this ….

Decrease Carbon Emissions	Carbon Capture	Lessen the Heat that Reaches Us
1) Pursue Alternative Energy (Solar) 2) Make Cleaner Cars	1) Plant Trees 2) "Scrub" the Carbon out the Atmosphere	1) Mirrors in space 2) Make the Earth's surface reflective 3) Make the clouds reflective
It's too late for this. ✗	Takes too long Requires lots of energy ✗	Could work if it were cheap enough ✓

Inspiration

Seeing how volcanic eruptions and the artificial clouds that they created caused temporary **GLOBAL COOLING**, gave me hope and made me want to do this project.



* Chart which I annotated was originally published in a paper (Underestimation of volcanic cooling in tree-ring- based reconstructions of hemispheric temperatures) by Michael Mann. Jose Fuentes and Scott Rutherford from 2012

Problem & Hypothesis

Problem: Which type of (safe) artificially created cloud, with varying droplet size and salinity, will reflect the most heat in a controlled chamber?

Hypothesis: If 9 types of clouds are created with all of the combinations of droplet size (3, 7 and 10 uM) and salinity (0%, 3.5%, and 15%), then the clouds with a 3 uM droplet size and 15% salination will reflect the most heat.

Independent Variables: Size of the water droplets (in uM), Salinity of the water (% salt dissolved in water)

Dependent Variable: temperature at the bottom of the chamber (in degrees C)

Control Variables: Placement of piezo atomizer, Number of seconds atomizer was on to create clouds, Temperature of the room, Wattage of bulb in heat lamp, Number of seconds heat lamp was on

Procedures

PHASE 1 – Pre-Experiment Work
Step 1 – Build a Cloud Chamber
Step 2 – Prepare the 3 Water Samples

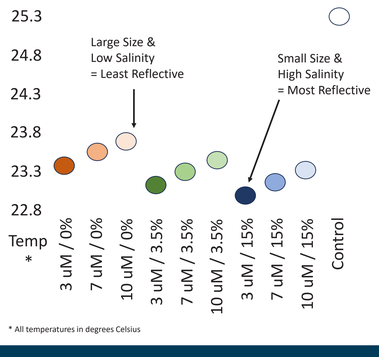
PHASE 2 – The Control
Step 3 – Turn on the Heat Lamp and Wait 30 Seconds
Step 4 – Measure the Temperature at the Bottom of the Chamber

PHASE 3 – The Experiment
Run the experiment 45 times (9 variations of droplet size and salinity that each get tested 5 times)

Step 5 – Create an Artificial Cloud
Step 6 – Turn on the Heat Lamp and Wait 30 Seconds
Step 7 – Measure the Temperature at the Bottom of the Chamber
Step 8 – Let the Chamber Cool to Room (~2 minutes) and Repeat 44 other times

Results

	Salinity	0%	3.50%	15%
Droplet Size				
	Trial *			
3 uM	1	23.27	23.14	22.98
	2	23.36	23.11	23.01
	3	23.34	23.09	22.92
	4	23.41	23.01	22.96
	5	23.48	23.19	22.99
7 uM	1	23.46	23.21	23.13
	2	23.44	23.24	23.18
	3	23.56	23.19	23.09
	4	23.61	23.27	23.12
	5	23.52	23.31	23.15
10 uM	1	23.61	23.38	23.27
	2	23.64	23.35	23.28
	3	23.71	23.31	23.19
	4	23.69	23.37	23.22
	5	23.66	23.42	23.18
Control				
Trial *	1	2	3	4	5
	25.23	25.25	25.29	25.18	25.2



* All temperatures in degrees Celsius

* This photograph and all of the other charts and illustrations were made by Johan Coisman.

Regression Analysis

R Squared	0.603345
Observations	50

	df	*F-Value*
Total	49	2.1E-05

	Coefficients	*P-value*
Intercept	24.10355	6.9E-66
Size of Droplet (uM)	0.063646	0.00469
Salinity (% salt)	-0.043239	0.00052

Conclusions

OBSERVATIONAL – "THE WHAT"

- Clouds made with the smallest water droplets and those with the highest salinity are better at reflecting heat

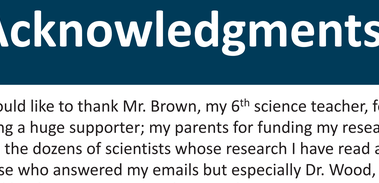
DERIVED – "THE HOW"

- I designed a good experiment. My R squared value of 0.6 shows that 60% of the variation in the dependent variables was explained by the independent variables.
- The results of my experiment and my independent variable coefficients were statistically significant at more than a 99% level of confidence because my F-value and P-values were less than 0.01

RESEARCHED – "THE WHY"

- Small droplets are likely more reflective because smaller water particles are more spherical and more reflective.
- Increasing the salinity likely makes water droplets more reflective because the salt crystals act like little mirrors

REFLECTION, INTERNAL REFLECTION and REFRACTION



Continued Research

1) Add temperature (ice crystals) as another independent variable

- Research suggests that this can make water droplets even more reflective

2) Study the synergy between droplet size and salinity and potentially temperature and other variables

- Use the statistical method of interaction terms

3) Build a device that can create massive artificial clouds

Acknowledgments

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