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Warming "In the Pipeline"

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Get a Boat, Pumpkin!

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Climate Science Study Group

Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius (°C)** → 2 degree Fahrenheit (°F)

ppm = parts per million CO_2 = Carbon Dioxide

1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes

1 trillion tonnes (1Tt) = 1000 gigatons

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This Study has a simple message: Global Warming doesn't stop when we cut emissions to ZERO.

Assume the Earth has a constant heating driver (i.e., heating is not decreasing or increasing, but it is definitely there):

- **This scenario means we have stopped emitting additional Greenhouse Gasses, so that heating does not increase further (which it is now doing as we keep adding GHGs to the amount already in the atmosphere). This means we go to ZERO Emissions. This is the stated goal of the "Net Zero by 2050" initiatives.**
- **Not adding GHGs does NOT rid the atmosphere of the GHGs which are already up there.**
- **Therefore, even if we eliminate EMISSIONS, there will still be an imbalance of ENERGY IN > ENERGY OUT.**
- **This imbalance will continue until the Earth heats up to where it can get rid of enough heat that ENERGY IN = ENERGY OUT. Remember: hotter things give off more heat than cooler things can.** [Refer to CSSG-2.21 on Clouds, where we considered a hot stovetop burner giving off more heat than a cooler burner.]
- Once we get to NET ZERO, we will be at what we will call the "COOL STOVE EQUILIBRIUM" in my stovetop demo discussed below. Because heating will continue, based on the GHGs already in the atmosphere, we will move to a hotter planet (with higher sea levels) until we are hot enough to get rid of the heat coming in. This is the "WARM SIMMER EQUILIBRIUM" of the Demonstration.
- The demo below uses a constant heating driver: the burner set on "simmer".
- COOL STOVE EQUILIBRIUM → constant heating driver → WARM SIMMER EQUILIBRIUM.

This is *Warming "In the Pipeline".*

The "Constant Heat" Stovetop Demonstration designed to mimic

Ocean Warming

and

Ice Cap Melting resulting in Sea Level Rise

Things to Note from our visible light photos:

- Floating ice in the forms of ice cubes
- Grounded ice in the form of a large block reaching significantly above the surface
- The black tape at the back of the kettle set to indicate "sea level" at start of heating
- The heating set to a high "Simmer"
- The watch to record time elapsed.

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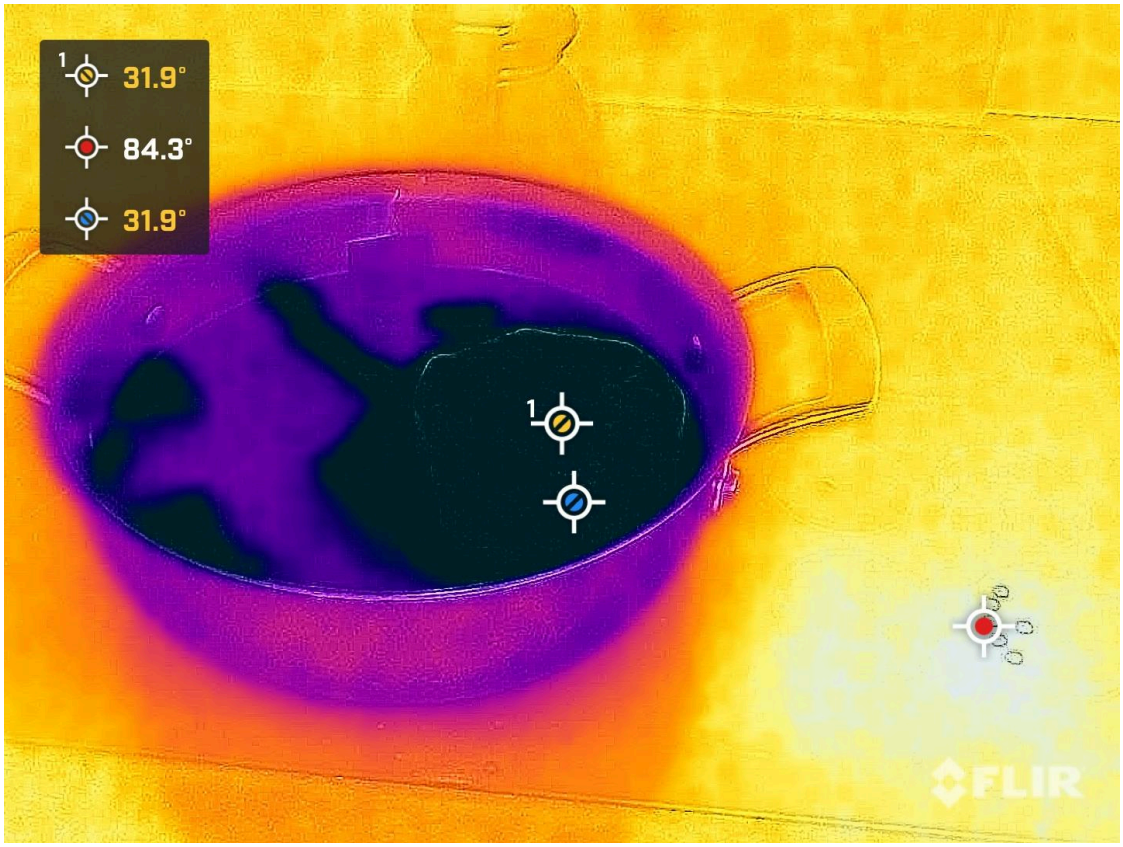

Things to Note from our infrared (IR) light photos:

- The temperature at the **center of the photo** is captured by the first (yellow) dot. The water has food coloring in it so the IR camera doesn't look through the water to the kettle surface.
- The temperature at the **warmest point** in the photo is shown by the second (red) dot. Because the burner is directly below the kettle, it is not detected. In most cases, the IR sensor notices the slight warmth at the control panel at the right.
- The **coolest temperature** in the scene is recorded by the third (blue) dot. Until all ice has actually been melted, this dot rests on ice.

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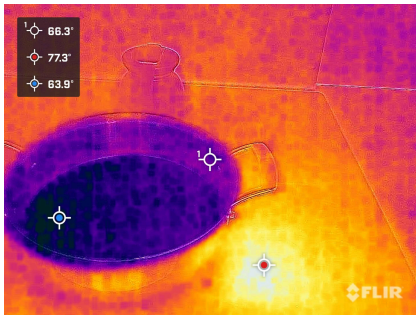
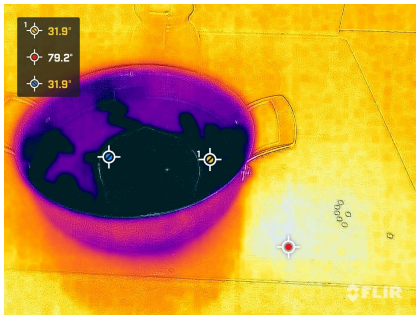
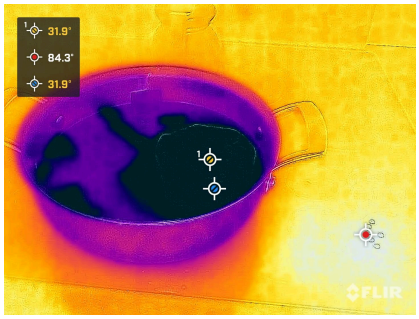
1. **This is the starting "COOL STOVE" EQUILIBRIUM.** At this point, ice is added, cooling the "Sea". Some ice will be floating; a large solid chunk will be heavy enough to be grounded.		
2. **Heat is now turned on** (see pattern in control panel in IR photo - the visible light photo was taken just before I turned the heat on, so it doesn't show the pattern). **The floating ice, having more surface area, should melt first, so little "Sea Level" rise should occur for awhile.**		
3. **The "Sea" is starting to attack the grounded ice, so "Sea Level" will start to rise.**		

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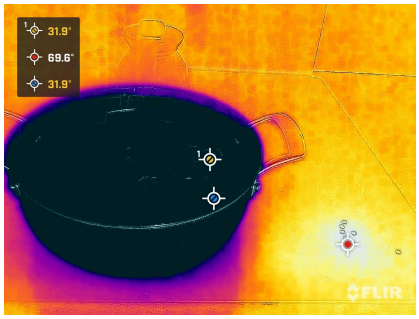
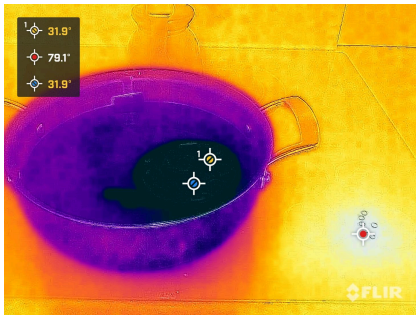
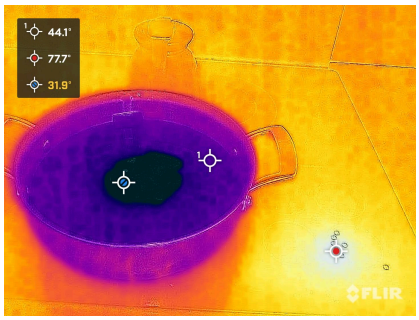
4. **Grounded ice continues to melt, so "Sea Level" continues to rise.**		
5. All grounding of ice has been lost. So now "Sea Level" will not change any more.		
6. Water has warmed a bit because the ice is localized and its melting doesn't cool all of the surface evenly.		

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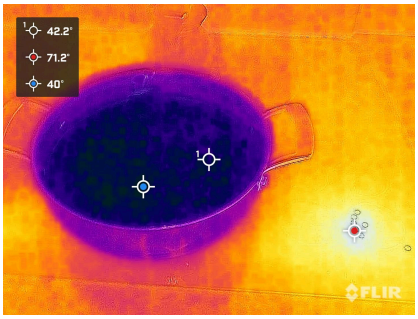
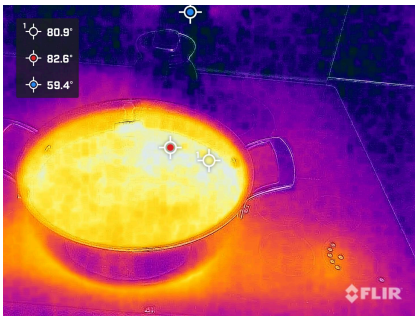
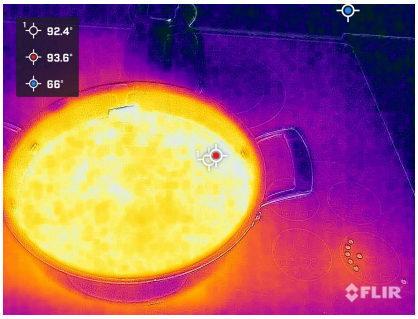
7 All the ice is now melted. So the water will now start to warm up.		
8 Steady Warming Continues. Notice the water in the kettle is now hot enough to register as the 'hot spot". **It's glowing more!**		
9. T=120 Minutes and beyond: A new "Warm Simmer" Equilibrium		

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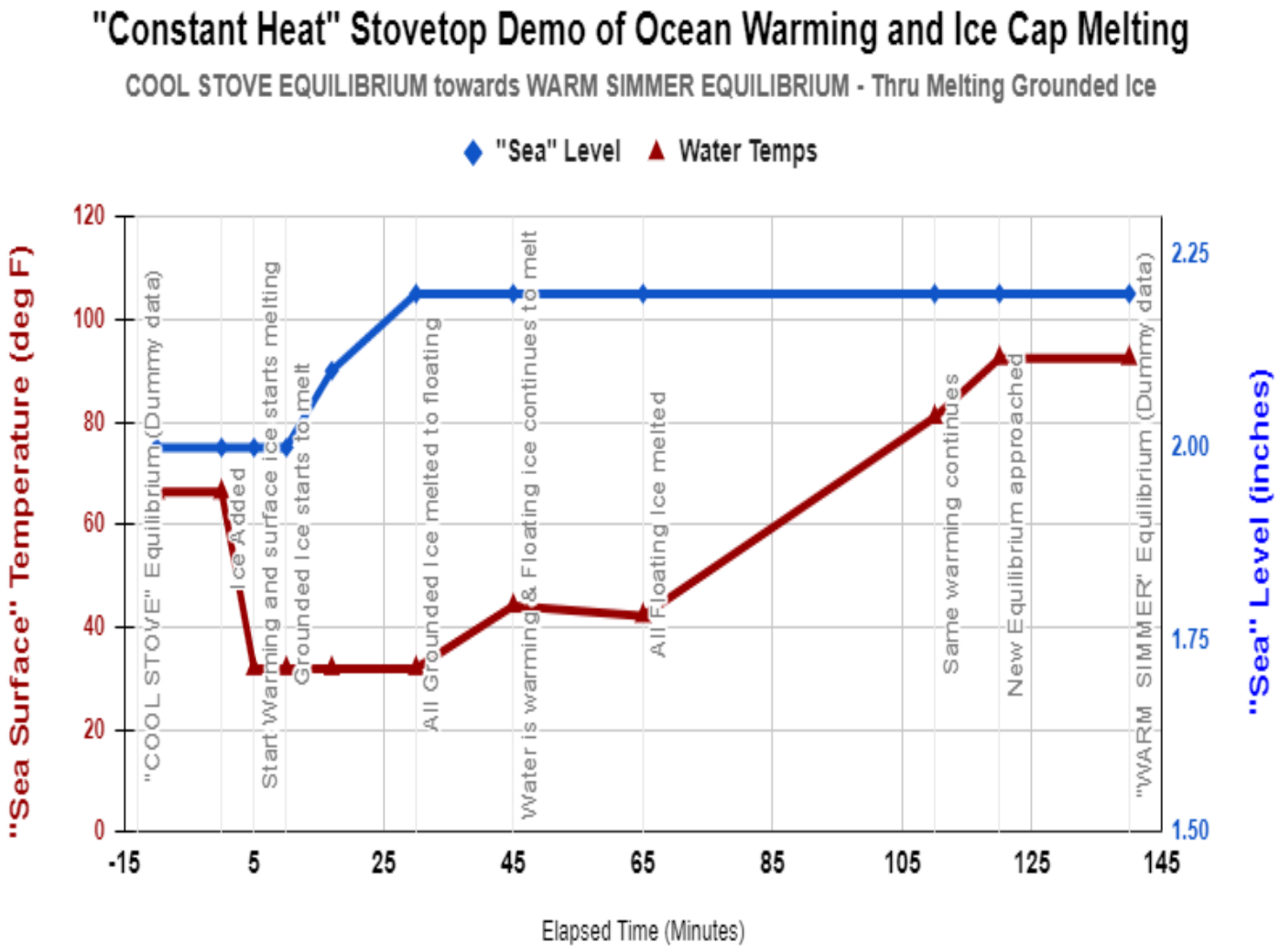
All this will be easier to understand by looking at the graph of the data (unfortunately, the software didn't allow me to make the notes more clear, but here's what I could get):



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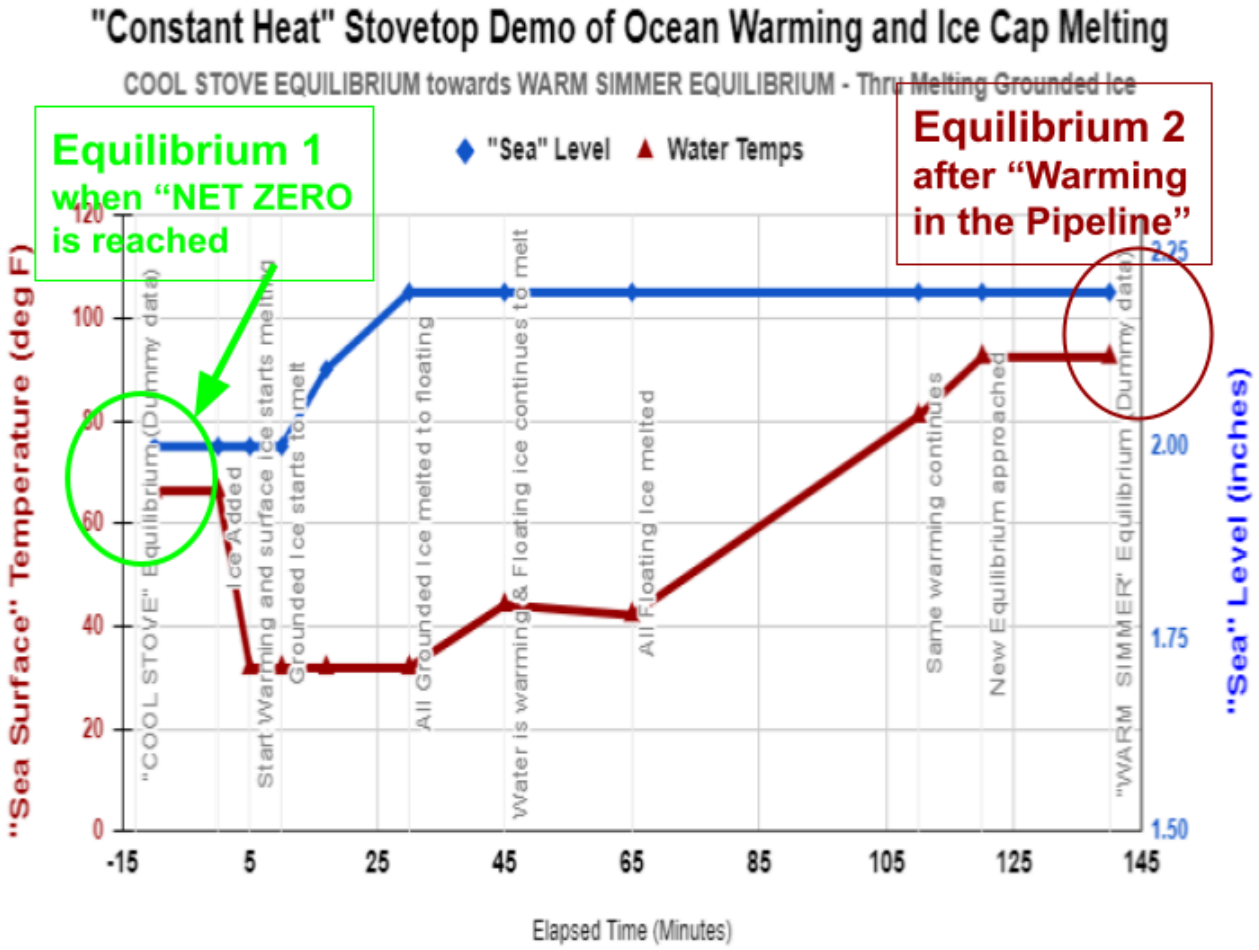
Some PUNCHLINES to notice:

- The whole setup mimics the period ***after*** we stop GHG emissions. There will still be steady heating, based on the GHGs already up there. For a long while: **ENERGY IN > ENERGY OUT**
- Warming and Sea Level rise will ***continue until*** the global temperature is high enough that the Earth can get rid of more energy so that **ENERGY IN = ENERGY OUT**
- The warming will take some time. Notice that, in this setup, water temperatures even went down near the melting ice. We see similar cooling near Greenland today, because of melting ice.
- Sea level will only rise from melting of Grounded Ice (like the glaciers, and the Greenland and Antarctica Ice Sheets). NOTE: Here's we're ignoring Sea Level Rise from expansion from warming.



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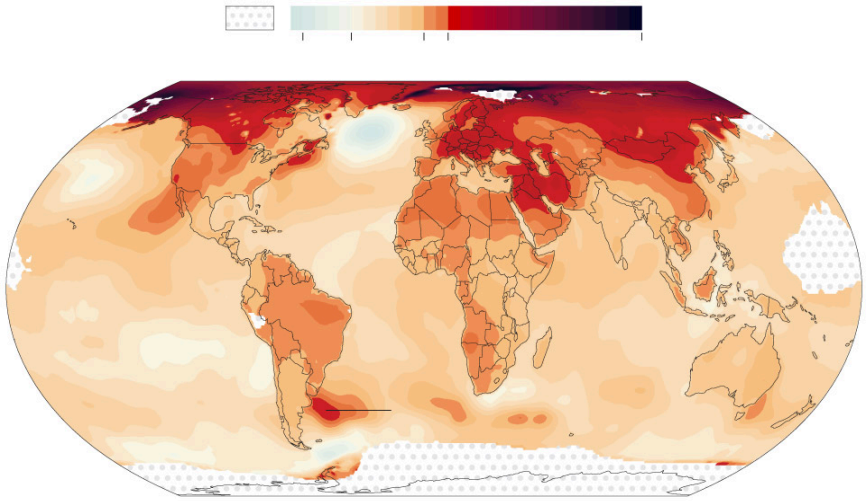
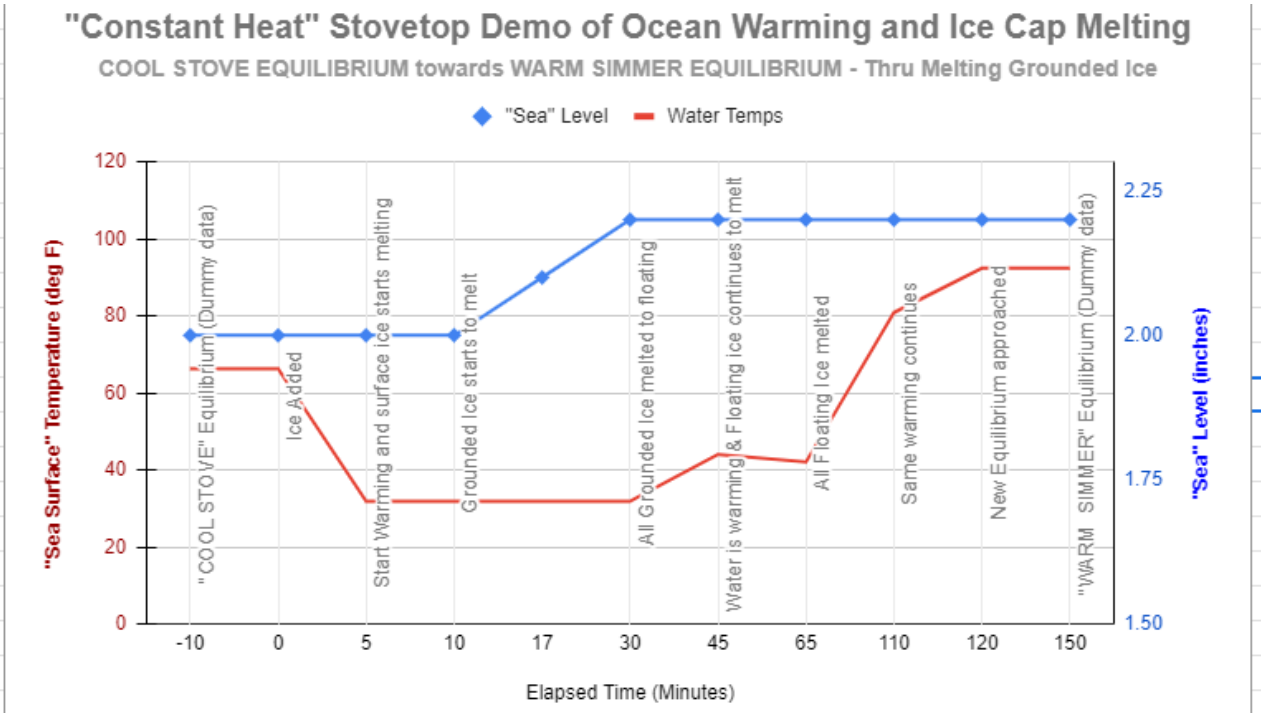
Here's the cooling spot near Greenland. It's actually colder there than before the warming shown, because of the melting ice in the area:



The chart below is included because it is formatted slightly differently, making it a little easier to read the notes.



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