The Effect of Global Warming on Pack Ice

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Executive Summary

The purpose of our program is to create a working model of the arctic that models pack ice. This pack ice is modeled using a number of variables, these variable are things such as: the specific heat of ice, the specific heat of water and the specific heat of transition from water to ice or ice to water. Each of these heats are measured in calories, a calorie being the amount of heat needed to raise one cubic centimeter one degree Celsius. There are many other variables that contribute to the computation of the probability of ice melting into water and water freezing into ice.

Our program answers the question of “What will happen to the arctic in the future?” Using our model, we are able to calculate what will likely become the outcome of the arctic at the current rate of climate change. Our model uses data previously gathered in the field to create an accurate model of ice.

Using our model, we intend to show what will happen in the future due to global climate change, this change greatly contributes to the melting and freezing of ice in the arctic regions. The polar regions greatly affect the global climate, and in return, greatly affect it. This relationship between the arctic pack ice and the global climate is what we are modeling. We are focusing specifically on the arctic regions because they hold the greatest potential for the change in the climate.

Project Description

Problem Statement

The melting of global ice is of great concern to many people because the increasing level of CO_2 is causing an increase in average global temperature of the atmosphere and the oceans. This drastic global temperature change could affect thousands of species by altering the environment. The melting of the arctic ice is directly affected by the amount of CO_2 in the atmosphere that is trapping more incoming infrared radiation. This additional CO_2 is due in large part to human activities such as burning fossil fuels.

The ice is very sensitive to changes in global climate. The heat from the sun melts the ice, decreasing the albedo and increasing the amount of heat absorbed by the ice, this continues in a cyclical pattern. The melting ice also cools down the oceanic “conveyer belt” that carries heated water from the equator to the poles to be cooled down, much like a gigantic refrigerator, the ice that is melted then cools down this conveyer belt, slowing down the whole process. The equator then gets warmer and the sea ice melts even more because the albedo is reduced by the melting. The sea ice can wither be an obstacle or a catalyst for global climate change. As the earth heats up, people want to know what is in their future in the way of global change.

Method

Netlogo was an obvious choice or this project since it's not only very easy to use, but also works great with the cellular automata model. The cellular automata model essentially allows very realistic ice melting and freezing patterns to be modeled based on the ice pack's location relative to its neighbors, and NetLogo's patches allow this to work perfectly. When too few ice patches are surrounding an ice patch, the ice patch is programmed to melt, whereas if enough ice patches are adjacent to the patch then the patch will remain frozen. Although this is the only variable currently affecting the ice patches, sunlight, albedo, and even enthalpy variables will likely be added later. There are simply too many variables to be analyzed in the arctic sea ice to complete in a matter of months, and it would likely take years to successfully find and program all of them.

It is important to note that patches on the diagonals count as half of the value as the vertical and horizontal patches. Since each horizontal and vertical patch count as one and each diagonal patch counts as one-half. Therefore, maximum value for any patch to have at once is six. In addition, the program also computes values for the melt and the freeze probability of the ice. The values determine the probability of either event occurring, thus making the ice freeze or thaw at a faster rate.

The advantages of modeling ice packs instead of going out and watching them are huge. What would take hundreds, thousands, or even hundreds of thousands of years can be modeled in as little as a few seconds using Netlogo. The advantages are especially powerful when the cost of getting a team of researchers to the arctic is considered; thousands of dollars could be saved by simply going to a computer screen instead of an expensive helicopter. Not to say that field research is obsolete, after all the entirety of the information used to create the model is gathered from scientists in the midst of the arctic. Then, if additional information contradicts the information in the program, the program can be easily updated to provide the most accurate results possible. A proper balance of field research and model research can save an organization millions in the long run, and possibly even uncover the fate of the planet if the ice caps melt completely.

Assumptions

We assume that the albedo of ice is one, this gives an easy way to measure numbers without going too far into decimal places to get the exact number. We also assume that the albedo of sea water is zero, this also makes for easier calculations.

We assume that the specific heat of water is one and that the specific heat of ice is one-half. Both of these numbers allow for easy calculation and are the caloric values for each, respectively. These numbers would mean exactly nothing without the specific heat of the phase change, which is eighty calories. At this point, the ice will turn into water after receiving eighty calories of heat and water will turn into ice after losing eighty calories of heat.

Given the allotted amount of time, we assume that the ice is only affected by the heat of the surrounding patches and the atmosphere outside of the viewable world. Each patch on the very edge of the world can take in heat from the invisible "patches" that surround them. Then, due to the Law of Thermodynamics, that heat is then passed evenly throughout the medium until it reaches the boundary line of two or more media. The heat can then be passed as a caloric value across the boundary into the other medium until it has either gained enough heat or lost enough heat to change phase.

Results

The program models the relationship between the ice and set variables taking the place of temperature, and does so quite accurately. Although the program does its job very well, it still has a higher melt probability than freeze probability due to the fact it takes the melt probability into account first in its calculations causing the program to melt the ice faster than freezing it.

Eventually, the program will model the temperature in relationship to the ice instead of ice in relationship to preset variables. The program will also use the relation between seasonal change and its effect on temperature in The Arctic.

Conclusions

We chose to make the world a box, not a torus. This is to prevent the opposite edges of the world from interacting with the other parts, and to be able to include seasonal changes in the model. The seasonal changes will vary the temperature of the edge of the world, thus changing the model through heat dissipation.

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Appendix A: NetLogo Code

```
breed [suns sun]

patches-own [
  frozen?
  frozen-neighbors
  specific-heat
  temp ; degrees above/below 0C
]


globals [
  specific-heat-ice
  specific-heat-water
  specific-heat-transition

]

to setup
  ca
  ask patches [
    ifelse ((distance patch 0 0) < 20) [
      freeze
      set temp random-float -10
    ]
    [
      melt
      set temp random-float 10
    ]
  ]
  set specific-heat-transition 80
  set specific-heat-ice 0.5
  set specific-heat-water 1
  ; sunsetup
end


to sunsetup
  create-suns 3 [
    setxy 40 35
    set shape "sun"
    set size 4
  ]
```

```
end

to go
  ask patches [
    set frozen-neighbors (count neighbors4 with [frozen?]
      + 0.5 * count neighbors with [(not member? self ([neighbors4] of myself)) and frozen?])
  ]
  computeProbabilities
  computeHeat
  tick
end


to melt
  set frozen? false
  set pcolor cyan
end

to freeze
  set frozen? true
  set pcolor white
end

to computeHeat
  ask patches with [frozen? = true] [ set specific-heat [ 2.108 ] ]
  ask patches with [frozen? = false] [ set specific-heat [ 4.186 ] ]
end

to computeProbabilities
  ask patches [
    ifelse ( frozen? ) [
      let melt-probability 1
      if ( frozen-neighbors > 0 ) [
        set melt-probability ((6 - frozen-neighbors) / 6)
      ]
      if (random-float 1 < melt-probability) [
        melt
      ]
    ]
    [
      let freeze-probability 1
      if ( frozen-neighbors < 6 ) [
        set freeze-probability (frozen-neighbors / 6)
      ]
      if (random-float 1 < freeze-probability) [
        freeze
```

```
      ]
    ]
  ]
end
```

Appendix B: Works Cited

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