10.03.12 Snow, the Earth System, and Climate Change

In previous weeks, the class focused on the history and policy of climate change. In a change of pace, we turned to the science behind the issue during the week of October 3. After a brief discussion of recent media coverage of the upcoming US general elections, Professor Tedesco introduced this week's guest speaker.

Dr. Allan Frei, Professor and Chairperson of Hunter College's Department of Geography, gave his presentation on Snow, the Earth System, and Climate Change. He began by explaining that most of the climate change discussions he had heard emphasized the Earth's atmosphere, rather than the land or water surface. He saw the need for a synopsis of climate change from the perspective of the Earth's surface.

Why the emphasis on snow? He explained that with the possible exception of vegetation, snow is the only major contributor to the Earth's climate system that varies sharply on seasonal time scales. In the winter, snow covers a portion of the high latitudes, which raises the Earth's albedo significantly. As spring melts the snow, the globe's albedo drops. This dynamic drastically changes the energy balance for the surface/atmosphere system.

Dr. Frei offered a graph showing changes in global average temperature, carbon dioxide concentrations and snow cover over the past 200 years. The chart showed clear trends in temperature and carbon dioxide concentrations (increasing steadily), but showed a step change in snow cover occurring around 1975 to 1980. Otherwise, snow cover remained more or less steady year to year for the study period.

He then gave a simplified overview of the soil physical system, with and without snow. Snowpack changes energy and mass balances, causes biological impacts and also spikes surface runoff during spring melting.

Tri asked how wind-blown snow is measured. Dr. Frei did not know, and remarked that scientists had yet to find a way to measure blowing snow effectively. Professor Tedesco mentioned that the measurement of wind-blown snow was a prominent topic at a symposium he, Tri and others had recently attended.

Dr. Frei described one cause of severe flooding: a warm spring rain on an existing snowpack. As the suddenly warm air melts the snow, surface runoff spikes upward, causing increased probability of flooding. When this condition is accompanied by rain, the snow is melted even faster, and rivers have an even greater likelihood of overflowing their banks.

In terms of climate change, Dr. Frei explained that increased surface water runoff (which is mostly freshwater) into the oceans influences the local salinity of the seawater. Given enough extra freshwater at one of three critical ocean locations, it is possible that the salinity would be impacted enough to interrupt the global thermohaline circulation system that moves ocean water between the deep ocean and the surface. Recent studies suggest that while the Earth is close to this potentially drastic climate

impact, even the largest estimates for warming and snow/ice melt will still not be quite enough to cause a failure of the thermohaline circulation system.

Dr. Frei explained the insulating properties of snowpack. The snow provides a barrier between the underlying soil and the atmosphere. As the air cools in the depths of winter, the snow keeps the soil at comparatively warm temperatures. Because of this, the elimination of snow caused by a warming climate may make the soils colder in the winter (having a negative impact on vegetation as roots freeze), since the insulating effects of the snow were greater than the increase in atmospheric temperatures that caused the snow's disappearance. In southeastern Alaska, yellow cedar was found to be in decline in the same areas that showed a marked decrease in snow cover, possibly due to this unintuitive effect.

Tri asked if snowpack removal and soil temperature changes could impact groundwater flow, independent of impacts to groundwater flow from changes in precipitation that might also be caused by climate change. Dr. Frei did not know, and suggested it as a topic for dissertation. There were no volunteers from the non-PhD students yet.

Dr. Frei then moved on to permafrost and changing land conditions in the Arctic. Permafrost contains organic material that could release carbon dioxide and/or methane gas upon melting. On the other hand, once the permafrost thaws, boreal forests could expand to fill the newly-opened ecological niche. Increased forest cover would serve as a carbon dioxide sink to partially (or wholly) mitigate the new source of greenhouse gas emissions. However (back on the first hand), a forested plain has a much lower albedo than a snowy tundra, and the decreased albedo is likely to be a stronger positive climate forcing than the increased uptake of carbon dioxide that the trees would provide.

In terms of surface air, Dr. Frei explained that snow keeps the surface air cooler than usual, due to increased albedo and the insulating effects of the snow separating the warmer soil from the cooler air. Dr. Frei noted that some scientists propose using the amount of snowfall in eastern Siberia (Russia), in conjunction with the state of the North Atlantic Oscillation, to predict some details of global weather systems months in advance.

Sam asked if the researchers could possibly sell these forecasts to private companies – for instance to those companies with an interest in preparing for the exact severity of an upcoming winter. Professor Tedesco explained that the results of a project with public funding cannot be sold, but the results could be used as a resource (by anyone, including the producer) to make predictions that could then be sold.

Dr. Frei described how the advent of satellite technology caused a decrease in direct surface observations around the globe. In the early years of the space age, scientists would hand-draw maps of the extent of snow cover by reviewing photographs from satellites.

At the close of his presentation, Dr. Frei opened the floor to general comments and questions.

Tri asked why Siberia was particularly important for global weather. After some deliberation, Professor Tedesco, Dr. Frei and Gerry seemed to combine forces to answer that the huge size of Siberia, the fact that it experiences the largest temperature swings of any place on Earth, and its distance from

temperature-stabilizing oceans causes Siberia to have a larger impact on weather system formation and global weather.

Kamila asked what the percentage of carbon dioxide versus methane storage was contained within the world's permafrost. Dr. Frei responded that the carbon is stored as complex organic molecules, and that the particular form of its release into the atmosphere depends on the details of the local conditions experienced by the permafrost during thawing (aerobic/anaerobic, moisture content, etc.).

Annesia asked where permafrost is located geographically, for instance, in inland or coastal areas. Professor Frei said that maps showing distribution of the permafrost layers were available online. Tri said that maps showing methane clathrates were also available.

Gerry asked how snow cover would be impacted given the prediction that climate change would cause fewer but more intense storms. Dr. Frei answered that scientists had not yet addressed the issue satisfactorily.

After a brief discussion about the presentation from the previous class, Professor Tedesco began a review of proposed final projects.

Christine proposed to embark on a review of the literature regarding feedback mechanisms and non-linear climate change, focusing on the sources of uncertainty in the burgeoning field. Dan remarked that ice sheet model outputs show a non-linear response (in terms of total ice sheet mass) versus carbon dioxide levels, indicating the potential to merge the two projects in search of thresholds in carbon dioxide concentrations that would spark non-linear climate changes. Professor Tedesco pointed out that one proposal has a geologic time scale, while the other is on the order of centuries. He wondered if the differing time scales could be reconciled. For Christine's project specifically, Professor Tedesco asked her to consider how uncertainties in climate response are presented to the public.

Gerry proposed studying the danger of communicating climate change to the public through a discussion on weather. Natural variability in weather is very large, and it is easy to confuse the message by referring to "hot summers" or "warm winters." Professor Tedesco said that people were not interested in a big Greenland melting year; they instead wanted to know short-term impacts closer to home. He asked Gerry how one should communicate the importance of Greenland's ice sheet to the general public. Gerry said that discussing climate in terms of weather may be an effective strategy, but could also be dangerous down the line. Professor Tedesco agreed, saying that a critic could dismiss such a position as being based on only two papers. Gerry responded that you run the risk of being accused of having a position that, as Bob said several lectures ago, "Everything is climate change." Gerry asked for a social scientist's help with the project. Sam made some tentative noises about volunteering to help separate out the "dangerous" issues, also tying into Gerry's project some of the implications of the media storm that surrounded Dick Muller when he shifted his stance on climate change.

Tri, after being rudely interrupted several times, proposed studying what motivates people to ask the particular climate change questions that they ask. Professor Tedesco approved the project.

Professor Tedesco mentioned an article about the “Anthropocene” in a recent copy of Global Change Journal. Lonnie volunteered to scan the articles for class analysis.

Kamila proposed studying the frequency of tropical storms in NYC in the past 30 years, and how climate change may change the frequency and magnitude thereof. Professor Tedesco asked if a large enough body of literature on that specific topic was available. He liked the idea, but wished Kamila could narrow the question and possibly link with someone else’s work. Kamila said she may team up with Gerry and Sam, to general approval from the class and Professor Tedesco.

Annesia proposed studying macroalgae’s contributions to the atmospheric carbon budget. Professor Tedesco asked if this was a popular topic, and what percentage of the total carbon budget may be contributed by macroalgae. Annesia said the answer was not yet known, but that coastal and oceanic algae in temperate zones were well-studied, yielding abundant literature. Professor Tedesco generally liked the idea. Sam mentioned he had just read about algae causing problems in the reflecting pools in the Washington, D.C., public spaces. Tri pointed out a related oyster culturing project before more rudeness was directed her way.

Alejandro proposed studying air pollution, specifically using a spectrometer to measure greenhouse gases in the atmosphere as they are extracted by proposed technologies.

Eric (I) described – at great length – a modified version of his final project proposal on the energy balance on a local scale. I would like to memorialize that Professor Tedesco thought it was a brilliant idea and agreed whole-heartedly to the proposal, offering a small grant to support the research, which I graciously turned down to avoid the appearance of impropriety. In truth, Professor Tedesco indicated the project may be acceptable given some additional modifications.

Rehnuma explained that as a master’s student, she had no research project to tie her proposal to. She suggested studying aragonite and calcite in the Hudson estuary, and accompanying distortions to cell walls in certain organisms. Professor Tedesco generally liked the idea, but asked how Rehnuma could convince a hot dog seller of the importance of her work. Rehnuma explained that the Hudson is contaminated, mollusks eat, their shells become distorted, and scientists use x-ray diffraction technology to look for the effects. Professor Tedesco promised to work with Rehnuma to find a climate change angle for the project.

Lonnie, also a master’s student, will continue to work with Professor Tedesco to finalize his project.

Professor Tedesco closed class by announcing that he was resigning as DEO to accept a temporary NSF position starting February 1. He will stay at CUNY, though he will spend 3 days per week in DC as a project manager.