

DR. MACDONALD: THANK YOU, RICK.

12 I'M GOING TO START OFF THIS PANEL ON  
13 ASSESSING IMPACTS AND URGENCY WITH A BRIEF DISCUSSION  
14 OF THE IDEA OF PROBABILITY IN GEOPHYSICAL PREDICTION.  
15 GEOPHYSICAL PREDICTIONS AND THE USERS OF GEOPHYSICAL  
16 PREDICTIONS HAVE ALWAYS HAD THIS KIND OF DIFFICULTY  
17 THAT I HAD WHEN I WAS A YOUNG WEATHER FORECASTER AT  
18 GRAND FORKS AIR FORCE BASE. THE PILOTS WOULD COME IN  
19 AND WOULD WANT TO KNOW, "I JUST WANT TO KNOW IF IT'S  
20 GOING TO BE SNOWING HEAVILY TONIGHT SO I CAN GET  
21 BACK."

22 I'D SAY, "WELL, WE'RE NOT REALLY SURE.  
23 THERE'S A 20-PERCENT CHANCE," AND THOSE KINDS OF  
24 THINGS. AND THAT GOES ON. IN FACT, GRAND FORKS  
25 ITSELF IS ONE OF THE MOST FAMOUS EXAMPLES OF THE

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1 DIFFERENCE BETWEEN THOSE WHO PROVIDE GEOPHYSICAL  
2 FORECAST AND THOSE WHO USE IT, AND THAT WAS IN THE  
3 1997 FLOOD THAT DEVASTATED GRAND FORKS. THE NATIONAL  
4 WEATHER SERVICE TWO MONTHS BEFORE THE FLOOD PUT OUT A  
5 FORECAST OF A 49-FOOT FLOOD CREST. AND THEY WERE  
6 PRETTY PROUD OF THEMSELVES BECAUSE IT WAS TWO MONTHS  
7 BEFORE IT HAPPENED, AND IT WAS TWO FEET ABOVE THE  
8 RECORD FLOOD EVER. SO THAT SOUNDS LIKE A GOOD  
9 FORECAST. AND THE CITY FATHERS AND MOTHERS OF GRAND  
10 FORKS DECIDED TO PUT THE LEVY 1 FOOT ABOVE THAT. SO  
11 THEY BUILT THEIR LEVIES WITH SANDBAGS AT 50 FEET WHEN  
12 THE FORECAST WAS 49. THE FLOOD CAME IN AT 54 FEET,  
13 WHICH WAS A PROBLEM FOR GRAND FORKS; AND THE MAYOR  
14 SAID AFTERWARDS HE FELT LIKE HE HAD BEEN TOTALLY  
15 MISLED; THAT IT WAS FORECAST TO BE 49 FEET. WHY  
16 WASN'T IT 49 FEET?

17 SO I WANT TO LOOK AT THE PROBABILITY  
18 ASPECTS OF OUR CLIMATE PREDICTIONS, AND I'M GOING TO  
19 TALK ABOUT THE POSSIBILITY OF LARGE TEMPERATURE  
20 INCREASES WITH A CO2 DOUBLING. SO A LOT OF PEOPLE  
21 HEAR WHEN THEY READ THE POPULAR PRESS THAT WE'RE  
22 GOING TO GET 3-DEGREE RISE WITH A DOUBLING OF CO2, AND  
23 THAT DOESN'T SOUND THAT BAD, ACTUALLY.

24 HOWEVER, WHAT WE HAVE BEEN LEARNING IN  
25 RECENT YEARS ARE TWO THINGS: ONE OF THEM IS REALLY

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1 PRETTY EASY TO UNDERSTAND QUALITATIVELY; AND THAT IS  
2 THAT JUST LIKE THE GRAND FORKS FLOOD, THE ACTUAL  
3 TEMPERATURE RISES AND OTHER GEOPHYSICAL PARTS OF A  
4 100-YEAR OR A DOUBLING OF CARBON DIOXIDE ARE PRETTY  
5 TOUGH. SO HERE IS SOME EXAMPLES OF MODELS, AND DOWN  
6 HERE IS WHAT IS CALLED THE EQUILIBRIUM CLIMATE  
7 SENSITIVITY, WHICH IS THE AMOUNT OF TEMPERATURE RISE  
8 THAT YOU WOULD GET OUT OF A DOUBLING OF CARBON  
9 DIOXIDE. AND WHAT YOU SEE ARE THESE PEAKS DOWN HERE  
10 AT ABOUT 2 OR 3 DEGREES CENTIGRADE, AND A BIG LONG  
11 TAIL OUT HERE. SO THIS ISN'T A BELL CURVE; THIS IS  
12 SOMETHING THAT EVIDENTLY HAS THE POSSIBILITY OF A  
13 MUCH LARGER TEMPERATURE RISE.

14 AND I WANT TO SAY THAT I'M TRYING TO TIME  
15 THE REALLY IMPORTANT PARTS OF THIS TALK WITH THE

16 THUNDER, SO I'M REALLY WORKING ON THAT HERE. IT IS A  
17 TOUGH FORECAST PROBLEM, BELIEVE ME.

18 (LAUGHTER)

19 SO THESE ARE MODELS WHERE YOU PUT IN  
20 DIFFERENT PARAMETERIZATIONS FOR WHAT ARE CALLED THE  
21 FEEDBACKS. SO THOSE ARE THINGS LIKE ICE/ALBEDO  
22 FEEDBACK AND HOW MUCH CARBON IS GOING TO COME OUT AND  
23 HOW STRONG THE WATER VAPOR EFFECT AND THOSE THINGS  
24 ARE. I'M GOING TO COME BACK TO THAT. BUT YOU DO  
25 HAVE THIS KIND OF UNSETTLING THING. AND RECENTLY

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1 THERE WAS A PAPER IN SCIENCE THAT TALKED ABOUT THIS.  
2 THE TITLE OF THE PAPER IS "WHY IS CLIMATE SENSITIVITY  
3 SO UNPREDICTABLE." AND THEY TOOK A LOOK AT THIS  
4 ISSUE; AND ESSENTIALLY, I WANT TO JUST DISTILL IT BY  
5 SAYING THAT THEIR ARGUMENT IS THAT WE REALLY PROBABLY  
6 CAN MODEL OUR ERRORS IN CLIMATE FEEDBACKS, LIKE WATER  
7 VAPOR FEEDBACK OR ICE/ALBEDO, AS A BELL CURVE, BUT  
8 WHEN YOU TRANSLATE THAT INTO CLIMATE SENSITIVITY, IT  
9 BASICALLY RESULTS IN THIS LARGE TAIL, AND THEY SHOWED  
10 A BUNCH OF EXAMPLES. AND IN THIS PARTICULAR ARTICLE,  
11 THEY MADE THE ARGUMENT THAT THESE FEEDBACKS ARE  
12 PROBABLY TOO DIFFICULT TO QUANTIFY MUCH BETTER THAN  
13 WE HAVE. THAT'S JUST PURELY A VERY INSENSITIVE  
14 CLIMATE.

15 NOW, WHAT I WANT TO DO HERE NOW IS LOOK AT  
16 THE POSSIBILITY OF TEMPERATURES HIGHER THAN A CERTAIN  
17 AMOUNT, AND I'M GOING TO SHOW YOU A SLIDE, WHICH IS  
18 AN ADAPTATION OF THEIR FIGURE 2(C) FROM THE RECENT  
19 ARTICLE IN SCIENCE BY ROE AND BAKER. SO WHAT WE HAVE  
20 HERE IS THE CUMULATIVE PROBABILITY, AND ON THIS GRAPH  
21 I DID A COUPLE OF THINGS TO MAKE THIS A LITTLE MORE  
22 DIRECTLY UNDERSTANDABLE, WHAT IT REALLY SAYS.  
23 FIRST OF ALL, I CONVERTED IT TO OVER CONTINENTS. IN  
24 THE FOURTH ASSESSMENT MODELS, WHAT WE SAW WAS THAT  
25 YOU GET ABOUT A 50 PERCENT HIGHER TEMPERATURE

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1 INCREASE OVER CONTINENTS THAN YOU DO OVER OCEANS. SO  
2 I DID THAT; AND ALSO JUST FOR AMERICAN AUDIENCES, I  
3 CONVERTED IT TO FAHRENHEIT. SO WE'RE LOOKING AT HERE  
4 THE TEMPERATURE RISE FOR A DOUBLING OF CO<sub>2</sub>, AND THIS  
5 IS THE EQUILIBRIUM, SO IT ISN'T REACHED RIGHT AWAY,  
6 OVER CONTINENTS. AND WHAT YOU SEE HERE IS IF WE  
7 THINK OF A 3-DEGREE-CENTIGRADE RISE AND IF YOU ADD  
8 THE OVER-CONTINENTS-ADDITIVE PART, 3 DEGREES IS  
9 6 DEGREES FAHRENHEIT, AND THEN OVER CONTINENTS IS  
10 ANOTHER 50 PERCENT. THAT IS 9 DEGREES FAHRENHEIT.  
11 SURE ENOUGH, ON THE GRAPH, WHEN YOU LOOK AT IT AT  
12 50-PERCENT PROBABILITY, YOU SEE THAT IT IS 9 PERCENT.  
13 BUT HERE IS THIS TERRIBLE TAIL.

14 SO WHEN I USED TO TALK TO THE PILOTS, I  
15 REMEMBER ONE PILOT CAME IN, HE SAYS, "CAN YOU  
16 GUARANTEE I CAN GET HOME FOR OUR ANNIVERSARY?"

17 I SAID, "YOU CAN GET HOME, EXCEPT THERE'S A  
18 20-PERCENT CHANCE IT WILL BE BELOW MINIMUMS."

19 HE SAID, "WHAT DOES THAT MEAN?"

20 I SAID, "THAT'S LIKE RUSSIAN ROULETTE."

21 (LAUGHTER)  
22 SO HERE IS THE RUSSIAN ROULETTE  
23 POSSIBILITY; THAT IS, FOR 16 AND 2/3 PERCENT, FOR A  
24 DOUBLING OF CARBON DIOXIDE, IF THE FEEDBACKS ARE KIND  
25 OF FEEDING ON EACH OTHER AND THEY'RE LINEARLY

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1 ADDITIVE AS ASSUMED IN THE ARTICLE, THAT WOULD BE A  
2 25-DEGREE-FAHRENHEIT RISE OVER THE CONTINENTS.  
3 SO AT SOME POINT, AT SOME POINT, WE GET AWAY FROM  
4 DISCUSSIONS OF ADAPTATION AND TO A VERY LARGE ISSUE  
5 OF THE SUPPORTABILITY OF OUR GLOBAL AGRICULTURE FOR  
6 THE 9 BILLION PEOPLE THAT WE EXPECT TO HAVE.  
7 25 DEGREES OVER THE CONTINENTS IS CERTAINLY A PRETTY  
8 SCARY VALUE IF IT'S A VERY SENSITIVE CLIMATE, WHICH  
9 IS POSSIBLE.

10 I THINK THE LESSON OUT OF THAT IS THAT WE  
11 NEED TO REDUCE THAT UNCERTAINTY IN FEEDBACK, AND I  
12 THINK THAT IT IS REALLY CRUCIAL THAT WE DO THAT,  
13 BECAUSE WE NEED TO KNOW FOR OUR POLICY, YOU KNOW,  
14 WHAT THOSE POSSIBILITIES ARE.

15 AND HERE IS CLIMATE FEEDBACKS: ICE/ALBEDO,  
16 WATER VAPOR, CARBON RELEASE FROM HIGH LATITUDES IN  
17 THE ARCTIC, CLOUDS, AEROSOLS. ALL OF THESE ARE  
18 FEEDBACKS. AND JUST AS AN EXAMPLE, WE SAW THE  
19 EVIDENCE IN THE ARCTIC THIS YEAR WHERE IN 2007 WE  
20 LOST SOMETHING LIKE 20 PERCENT MORE ICE IN THE SUMMER  
21 MELT SEASON THAN WE HAD EVER SEEN BEFORE; AND JUST  
22 TAKING ONE OF THE CLIMATE MODELS AND LOOKING AT THE  
23 ENSEMBLE OF MODELS AND THEN COMPARING WHAT HAPPENED  
24 IN 2007 VERSUS WHAT THE ENSEMBLE SAID, IT SAYS THAT  
25 WE PROBABLY DIDN'T HAVE OUR FEEDBACKS RIGHT. AND

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1 THAT'S NOT REALLY SURPRISING. IN MY OPINION, TO SOME  
2 EXTENT, WE REALLY ONLY HAVE ONE REALLY GOOD  
3 MEASUREMENT ON THE ARCTIC ICE ITSELF OF THE ENERGY  
4 BALANCE. THAT WAS THE SHEBA EXPERIMENT IN 1988,  
5 WHERE WE WENT OUT ON THE ICE AND REALLY FIGURED OUT  
6 THE ENERGY BALANCE.

7 SO THIS THING THAT THEY POINTED OUT IN THE  
8 ROE AND BAKER PAPER, WHICH IS WE HAVE TO HAVE THE  
9 FEEDBACKS RIGHT, THEY INTERACT WITH EACH OTHER, AND  
10 THE CLIMATE HAS A REALLY DANGEROUS POSSIBILITY, I  
11 THINK YOU CAN SEE THAT DANGEROUS POSSIBILITY RIGHT  
12 HERE IN THE DATA.

13 SIMILARLY, THERE IS A LOT OF CARBON AT HIGH  
14 LATITUDES. THERE'S AN ARTICLE ALSO IN SCIENCE THAT  
15 THERE'S SOMETHING LIKE 500 GIGATONS OF CARBON IN THIS  
16 STUFF CALLED YEDOMA, WHICH IS IN SIBERIA; AND THAT  
17 THERE IS SOME QUESTION ABOUT HOW MUCH OF THAT MIGHT  
18 COME OUT AS WE WARM SIGNIFICANTLY HIGH LATITUDES. SO  
19 THOSE FEEDBACKS ARE CERTAINLY SOMETHING TO WORRY  
20 ABOUT.

21 I THINK WHAT I'D SAY IS THAT GIVEN THE  
22 STAKES, A VERY INTENSE PROGRAM TO LOOK AT THESE  
23 FEEDBACKS IS A CRUCIAL THING TO DO.

24 AND I WANT TO SAY THAT I AM REALLY  
25 PRIVILEGED TO BE DIRECTOR OF EARTH SYSTEM RESEARCH

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1 LAB. WE HAVE, IN ADDITION TO THE CARBON OBSERVING  
2 PROGRAM, PHYSICAL SCIENCES, CHEMICAL SCIENCES, AND A  
3 GLOBAL SYSTEMS GROUP; AND IT'S A GROUP OF SCIENTISTS  
4 AND SUPPORT PEOPLE, OVER 600 PEOPLE LOCATED IN  
5 BOULDER THAT I THINK CAN CONTRIBUTE A LOT TO THIS.

6 SO, WITH THAT, I WOULD LIKE TO NOW  
7 INTRODUCE DR. RICHARD SOMERVILLE.