MS. HIGGASON: MY NAME IS KELLEY HIGGASON.
I'M WITH GULF OF THE FARALLONES NATIONAL MARINE SANCTUARY.
MY QUESTION IS FOR TED. HAVE YOU DONE ANY WORK LOOKING AT THE METHANE CLATHRATE RESERVES LOCATED IN PERMAFROST AND THE POSSIBLE DISASSOCIATION OF THOSE WITH INCREASED TEMPERATURES, AS WELL?
DR. SCHUUR: I, MYSELF, HAVE NOT WORKED ON METHANE CLATHRATE. THEY ARE BOTH BENEATH PERMAFROST AND IN THE SUBSEA ENVIRONMENT. THERE'S BEEN A LOT OF DISCUSSION OF WHETHER IN THE PAST THAT THOSE COULD BE RESPONSIBLE FOR CHANGES IN ATMOSPHERIC METHANE. AND I THINK SOMEONE SHOWED A PICTURE OF A RECENT SCIENCE PAPER THAT SHOWED THAT BIG CHANGES IN THE METHANE, THE ATMOSPHERIC METHANE IN THE PAST COULD HAVE BEEN A RESULT FROM SORT OF TERRESTRIAL METHANE RATHER THAN SOMETHING LIKE CLATHRATE CHANGES.
DR. SOLOMON: THANKS VERY MUCH FOR SOME REALLY EXCELLENT TALKS. I THOUGHT THEY WERE NICELY BALANCED. THE CROP TALK TALKED A LOT ABOUT THE
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DIFFICULTY OF CHARACTERIZING BENEFITS VERSUS THE IMPACTS. THE PERMAFROST TALK ALSO TOUCHED ON THIS ISSUE OF BALANCE.
BUT I DO HAVE A QUESTION FOR THE PERMAFROST TALK, AND THEN I HAVE A BROADER QUESTION FOR ALL OF YOU.
THE ISSUE WITH PERMAFROST AND THE RELEASE OF CO2 METHANE IS REALLY KEY, BUT THE PROBLEM IS WHEN YOU ACTUALLY LOOK AT THE EVIDENCE, AT THE OBSERVATIONAL EVIDENCE, AND YOU LOOK AT THINGS LIKE COULD IT BE 15 PERCENT OF FOSSIL FUEL, YOU KNOW, THAT WOULD BE HUGE, THAT WOULD BE HUGE. AND I THINK IT REQUIRES US TO GO BACK AND SAY: DO WE SEE EVIDENCE FOR THIS BEING TRUE? DO WE SEE OBSERVATIONS THAT CAN HELP US TO SUPPORT SUCH A CASE?
THE ARCTIC RIGHT NOW IS VERY WARM. IT'S WARMING AT TWICE THE RATE OF THE REST OF THE WORLD. DO WE SEE EVIDENCE OF RELEASE? DO WE SEE METHANE GOING UP? I DON'T THINK WE DO. AND THAT, YOU KNOW, THAT WORRIES ME. WHEN WE GO BACK TO THE EEMIAN, 125,000 YEARS AGO, IT IS WELL-ESTABLISHED THE ARCTIC WAS THREE TO FIVE DEGREES WARMER THAN IT IS TODAY FOR A LONG PERIOD, FOR THOUSANDS OF YEARS. DO WE SEE HIGH CO2 IN THE EEMIAN? WE MIGHT SEE IT GOING UP A LITTLE BIT. IT MAYBE WASN'T 270. IT WAS MORE LIKE
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PERHAPS AS HIGH AT 300 PARTS PER MILLION OF CO2. BUT IT WASN'T 390. IT WASN'T ANYTHING LIKE THE VALUES THAT WE SEE TODAY. WE DON'T SEE EVIDENCE FOR ENHANCED METHANE IN THE EEMIAN. NOW, I REALIZE IT HAS GOT A SHORT LIFETIME AND WE HAVE ISSUES OF ICE COOLERS IN TERMS OF THEIR RESOLUTION.
BUT I'M VERY CONCERNED THAT WHEN WE TALK ABOUT THIS KIND OF THING WE ACTUALLY CAREFULLY DISCUSS WHAT THE EVIDENCE REALLY IS OBSERVATIONALLY FOR A NET SOURCE OF METHANE AND CO2. SO THAT'S A

DIFFICULT QUESTION. IT'S A SPECIFIC QUESTION TO THE PERMAFROST TALK, AND I WOULD REALLY APPRECIATE YOUR RESPONSE ON THAT.

I THINK, MORE BROADLY, WHEN WE LOOK AT THE IMPACTS, SOMETHING THAT, I THINK, CHRIS TOUCHED ON -- AND I WOULD JUST LIKE TO SEE IF WE CAN GO BACK TO THIS -- WHEN WE'RE ASKED THE QUESTION OF WHAT KIND OF IMPACTS ARE WE SEEING TODAY THAT ARE THE MOST ROBUST, THAT TELL US THE MOST CLEARLY THAT WE HAVE A PROBLEM, THAT THERE ARE DAMAGES THAT DEMAND OUR ATTENTION, THERE'S A FEW THAT I THOUGHT YOU GUYS WOULD MENTION THAT I DIDN'T HEAR. ONE OF THEM, FOR EXAMPLE, MIGHT BE FIRES. I GUESS I WOULD LIKE TO ASK YOU TO GIVE US A LITTLE MORE GUIDANCE ON THAT SORT OF ISSUE. WHERE ARE THE UNAMBIGUOUS STRONG IMPACTS, IS A QUESTION FOR

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ALL OF YOU; AND FOR THE PERMAFROST TALK, CAN WE HAVE AT LEAST A LITTLE BIT OF DISCUSSION OF OBSERVATIONAL EVIDENCE FOR OR AGAINST WHAT YOU'RE DEALING WITH.

THANKS.

DR. SCHUUR: YES, I THINK THAT'S A GOOD QUESTION, AND PROBABLY THE POINT TO REITERATE IS THAT MOST OF THIS THOUSAND GIGATONS THAT I'M TALKING ABOUT IS CURRENTLY FROZEN AND NOT DECOMPOSED. SO THAT'S PROBABLY ONE OF THE KEY THINGS TO EMPHASIZE. AND I GUESS IN TERMS OF THE PAST, I THINK YOU CAN GO BACK TO THE LAST GLACIAL MAXIMUM TRANSITION, AND THERE IS THIS RECENT PAPER SHOWING THAT AT LEAST FOR METHANE, THIS LARGE CHANGE IN METHANE IN THE ATMOSPHERE THAT IS COINCIDING WITH THIS FLARE-UP OF THERMOKARST LAKES.

DR. SOLOMON: HOW LARGE? GLOBAL AVERAGE METHANE CONTRIBUTION, HOW LARGE?

DR. SCHUUR: I DO NOT KNOW THE ANSWER TO THAT QUESTION, BUT AT LEAST -- AT LEAST CONTRIBUTING IT MUCH -- SORRY -- AT LEAST AS MUCH AS OR MORE THAN THE SORT OF EXPANSION OF THE SIBERIAN PEAT LANDS, WHICH IS ALSO THOUGHT TO HAVE CONTRIBUTED METHANE AT THAT TIME. BUT I THINK WHAT IS AN IMPORTANT THING TO RECOGNIZE, WHICH YOU PROBABLY DO, IS SIMILAR CHANGES IN OCEAN CIRCULATION AND VENTING OF OCEAN CO2 OFTEN

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MASKS THE TERRESTRIALS. I THINK THE BIGGER SIGNAL THERE IS ON THE METHANE COMING FROM THESE THERMOKARST LAKES, BUT I DON'T THINK IT HAS BEEN CALCULATED, KNOWING METHANE EMISSIONS, HOW MUCH CO2 CAME OFF AT THAT TIME. BUT I THINK THAT IS PROBABLY A GOOD WAY TO THINK ABOUT THAT PERMAFROST CARBON POOL. IT IS CERTAINLY NOT ALL GOING INTO THE ATMOSPHERE AT ANY TIME SCALE, BUT SOME FRACTION OF IT MAY OR MAY NOT.

DR. FIELD: I MIGHT START OFF THE DISCUSSION OF, YOU KNOW, HAVE WE LOOKED THIS MORNING AT THE FULL RANGE OF TERRESTRIAL IMPACTS, AND I THINK THE ANSWER CLEARLY IS NOT. THIS WAS A SELECTION OF A FEW KEY IMPACTS WHERE THERE'S BEEN IMPORTANT NEW RESEARCH, AND IT WASN'T NECESSARILY INTENDED TO PROVIDE AN OVERVIEW OF THE IMPACTS WHERE WE HAVE SEEN

THE MOST CONSEQUENCES IN THE NEAR TERM OR NECESSARILY EVEN WHERE WE WILL SEE THE MOST CONSEQUENCES IN COMING DECADES.

I PRESENTED A SLIDE THAT HAD A LIST OF EIGHT IMPACT AREAS THAT REPRESENT FUTURE RISKS FOR NORTH AMERICA, BUT I THINK THAT WHEN YOU REALLY ASK WHAT ARE THE MOST IMPORTANT ONES, YOU HAVE TO ASK WHAT COMMUNITY YOU'RE TALKING ABOUT BEING IMPACTED. IF THE ISSUE IS NATURAL ECOSYSTEMS, THEN LOST BIODIVERSITY BECOMES VERY IMPORTANT. IF THE AREA OF

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CONCERN IS PEOPLE IN DEVELOPING COUNTRIES WHO LIVE NEAR THE COAST, THE COMBINATION OF SEA LEVEL RISE AND INCREASING FREQUENCY OF THE MOST SEVERE CATEGORIES OF HURRICANES. IF YOU'RE TALKING ABOUT FARMERS IN CALIFORNIA, IT IS VERY LIKELY TO BE THE INCREASED COMPETITION OVER WATER RESOURCES THAT ARE ALREADY OVER-ALLOCATED.

AND THEN I WILL ALSO REPEAT A POINT THAT I MADE EARLIER THAT I THINK WE'RE AT THE RELATIVELY EARLY DAYS OF THINKING ABOUT THE WAYS THAT THESE IMPACTS INTERACT NOT ONLY WITH EACH OTHER BUT WITH OTHER THINGS THAT ARE HAPPENING IN THE BROADER SOCIETY, SO THAT IF YOU TALK ABOUT, FOR EXAMPLE, COASTAL IMPACTS, IT'S NOT ONLY THE FACT THAT THE SEA LEVEL IS HIGHER AND NOT ONLY THE FACT THAT THAT IS INTERACTING WITH THE LIKELIHOOD OF INCREASED FREQUENCY IN THE MOST SEVERE CATEGORIES OF HURRICANES, BUT THERE IS A TREMENDOUS INCREASE IN NORTH AMERICA, FOR EXAMPLE, IN THE VALUE OF THE INFRASTRUCTURE THAT IS BUILT ON THE COAST. THERE IS AN INCREDIBLE INCREASE IN THE EXTENT TO WHICH ECOSYSTEMS ARE SQUEEZED BETWEEN DEVELOPMENT NEAR THE COAST AND WHAT IS CURRENTLY OCEAN. AND THESE IMPACTS, I WOULD SAY, THESE INTERACTING IMPACTS WE'RE AT THE VERY EARLY STAGES OF UNDERSTANDING; AND IF

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THERE IS ONE AREA IN THE WHOLE IMPACT DOMAIN THAT CONCERNS ME, IT IS THAT WE DON'T HAVE A HANDLE ON THE WAY THESE INTERACTIONS PLAY OUT.

DR. WEISS: FOR THE BENEFIT OF THE REPORTER, THAT WAS SUSAN SOLOMON ASKING THE QUESTION, IF YOU DIDN'T KNOW.

AND I WOULD LIKE TO POINT OUT THAT SHE RAISES A VERY GOOD POINT ABOUT HOW TO DEAL WITH THESE HIGH-RISK ISSUES; AND THAT AS FAR AS I KNOW, THE OBSERVATIONS OF METHANE OR METHANE ISOTOPIC COMPOSITION IN THE ATMOSPHERE DURING THE PERIOD THAT CHRIS WAS PRESENTING, THE MOST RECENT PERIOD, HAVE NOT SHOWN PREDOMINANT OR MAYBE EVEN DETECTABLE EFFECT OF THIS PROCESS, BUT THAT DOESN'T MEAN THAT IT ISN'T GOING TO HAPPEN.

NEXT QUESTION.

DR. KUTSCHER: CHUCK KUTSCHER, NATIONAL RENEWABLE ENERGY LABORATORY.

TED, YOU MENTIONED GREENING OF THE ARCTIC AS A POTENTIAL NEGATIVE FEEDBACK MECHANISM, AND I'M

WONDERING WHAT WOULD BE THE ALBEDO EFFECT ASSOCIATED WITH THAT.

DR. SCHUUR: THE ALBEDO EFFECT ASSOCIATED WITH GREENING, ACTUALLY THAT IS A GOOD THING TO TALK ABOUT BECAUSE WHEN I WAS TALKING I WAS THINKING

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STRICTLY ABOUT CARBON FEEDBACKS; AND OF COURSE, THERE'S ALBEDO FEEDBACKS, AS WELL.

WITH TUNDRA BECOMING MORE SHRUBBY, THIS HAS CONTRIBUTED TO LOCAL WARMING BECAUSE THE ALBEDO IS -- I THINK THERE'S MORE ENERGY ABSORBED BY SHRUBS THAN BY TUNDRA. SO THAT'S AN IMPORTANT OBSERVATION. THERE HAS BEEN A SEPARATE OBSERVATION THAT HAS TO DO WITH FIRES IN BOREAL FORESTS, WHEN YOU CONVERT THESE EVERGREEN FORESTS INTO DECIDUOUS FORESTS THAT LOSE THEIR LEAVES IN THE WINTERTIME, THE NET EFFECT OF AT LEAST SOME FIRES, EVEN THOUGH YOU PUT EMISSIONS INTO THE ATMOSPHERE, ARE OFFSET BY THE COOLING FROM ALBEDO. SO YOU KIND OF HAVE ALBEDO EFFECTS GOING ONE WAY WITH FIRES AND THE OTHER WAY WITH MORE SHRUBS. I THINK, IN GENERAL, IF YOU TURN THE TUNDRA INTO A BOREAL FOREST, YOU'RE ALSO GOING TO DECREASE THE ALBEDO AND INCREASE THE ENERGY THERE.

SO, I THINK, IF YOU THINK ABOUT ALL THE NET POSSIBILITIES OF ALBEDO, AT LEAST THE ONLY THING THAT SEEMS TO HELP US OUT, THIS COOLING FROM FIRES, THE BEST THAT ALBEDO SEEMS TO DO IS KIND OF OFFSET THE CARBON THAT GOT EMITTED BY THE FIRE. SOMETIMES, DEPENDING ON HOW MUCH CARBON IS EMITTED, YOU MIGHT GO INTO AN ACTIVE REAL COOLING IF YOU CONVERTED A LOT OF THE EVERGREEN FORESTS INTO DECIDUOUS FORESTS. I

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THINK, OVERALL, IT IS A MIXED EFFECT BECAUSE YOU HAVE POSITIVE AND NEGATIVE ALBEDO EFFECTS.

DR. WEISS: I WOULD LIKE TO TAKE ONE MORE SHORT QUESTION, AND THEN WE'LL GO TO THE POSTERS.

DR. FRIEDMANN: YEAH, MY QUESTION IS SHORT.

JULIO FRIEDMANN, FROM LAWRENCE LIVERMORE NATIONAL LABORATORY.

IT IS ACTUALLY FOR THE NON-TED PART OF THE PANEL, WHICH IS, PAUL PRESENTED SOME IMPACTS THAT WERE ON THE LEVEL OF SOCIAL ENVIRONMENTAL JUSTICE ISSUES. DAVID, I WAS HOPING YOU WERE GOING TO SHOW THE SLIDE THAT SHOWED CHANGES IN CALIFORNIA CROPS AND HOW THOSE WERE IMPACTED UNDER VARIOUS SCENARIOS.

THE QUESTION I'M ASKING IS: HOW CLOSE ARE WE TO DISPERTIZING IMPACTS AT A MUCH HIGHER LEVEL, SAY THE LEVEL OF A CONGRESSIONAL DISTRICT; AND IF WE ARE QUITE A LONG WAYS FROM THAT WHAT, WHAT IS THE PIECE THAT WE NEED TO FIX TO GET CLOSER TO THAT?

DR. LOBELL: SURE, I CAN SPEAK TO THAT.

WITH AGRICULTURE, WE HAVE STARTED TO GET NARROWER IN SPATIAL SCOPE AND ALSO IN TEMPORAL SCALES, LIKE I SHOWED 2030, WE'RE STARTING TO THINK MORE IN THE SHORT TERM.

THE LIMITING FACTOR IN A LOT OF THINGS WHEN YOU GET TO THOSE SCALES IS THE RAINFALL PROJECTIONS

ARE JUST SO UNCERTAIN FROM GCM'S AND EVEN REGIONAL CLIMATE MODELS. IN A LOT OF CASES, THAT'S REAL LIMITING. IN CALIFORNIA, THE WORK, YOU WERE NICE ENOUGH TO MENTION, WE HAVE FOUND RAINFALL DOESN'T MATTER SO MUCH BECAUSE ALL THE CROPS ARE IRRIGATED. AND SO WE CAN ACTUALLY MAKE SOME FAIRLY CONFIDENT PROJECTIONS BECAUSE TEMPERATURE IS FAIRLY WELL-KNOWN. BUT FOR MOST OF THE REGIONS RAINFALL IS IMPORTANT. NOW, THE SCALE I SHOWED, THE MAP OF THE WORLD, WE PICKED A LARGE ENOUGH SCALE, I THINK, WHERE THE RAINFALL UNCERTAINTIES ARE STILL THERE, BUT THEY'RE STARTING TO GET SWAMPED BY THE TEMPERATURE PROJECTIONS. SO THAT SEEMS TO BE THE SCALE NOW WHERE WE CAN REALLY SAY SOMETHING CONFIDENT, SORT OF A SUBCONTINENTAL SCALE. WHETHER WE CAN GET TO THE MUNICIPALITY LEVEL ANYTIME SOON WILL DEPEND ON PROGRESS, I THINK, IN CLIMATE MODELING AND, ALSO, IN CROP MODELING. BECAUSE ONE OF THE REAL CHALLENGES WE HAD IN CALIFORNIA WAS JUST A LACK OF KNOWLEDGE OF HOW CROPS RESPOND TO CLIMATE. IT SEEMS LIKE A SIMPLE THING TO UNDERSTAND. IT SEEMS LIKE CO2 RESPONSES SHOULD BE SIMPLE, BUT THERE IS A LOT OF GAPS IN OUR UNDERSTANDING OF HOW CROPS BEHAVE BEYOND A FEW MAJOR ONES.