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Activities and Findings

Project Activities and Findings:

During the 5 years of NSF grant ATM 95-22681 (Research on Greenhouse-Gas-Induced Climate Change, $1,605,000, 9/15/1995 to 8/31/2000) we have performed work which we shall describe below under three topics: (1) Development and Application of Atmosphere, Ocean, Photochemical-Transport, and Coupled Models; (2) Analysis Methods and Estimation; and (3) Climate-Change Scenarios, Impacts and Policy.

1. Development and Application of Atmosphere, Ocean, Photochemical-Transport, and Coupled Models

We have developed and applied the UIUC: (1) 2-layer and 7-layer tropospheric general circulation models (GC models or GCMs), (2) low (4? by 5?) and high resolution (1.3? by 1.3?) 11-layer troposphere/lower-stratosphere GCM, (3) 24-layer stratosphere/troposphere radiative-convective models, (4) 24-layer stratosphere/troposphere GCM, (5) 24-layer atmospheric chemistry transport model, (6) coupled 24-layer stratosphere/troposphere GC/photochemistry model, (7) 26-layer stratosphere/troposphere GCM, (8) 36-layer mesosphere/stratosphere/troposphere GCM, (9) 18-layer ocean GCM, (10) coupled 11-layer stratosphere/lower-stratosphere/18-layer ocean GCM, and (11) coupled 24-layer atmosphere-chemistry/ocean GCM. Several of these model developments and applications are described below.

1.1. 2-Layer and 7-Layer Troposphere General Circulation Model

We used our 2-layer tropospheric GC/mixed-layer-ocean/sea-ice model coupled to an ice-sheet/asthenosphere model to simulate the onset of the last glacial period 115,000 years ago and found that glacial onset required the reduction in the concentrations of CO2 and CH4 in addition to the Milankovitch radiative forcing (Schlesinger and Verbitsky 1996). In a non-GCM study, we have analyzed the paleotemperature-reconstruction support for the paleo-analog hypothesis and found it to be deficient (Kheshgi et al. 1997). We used our 7-layer tropospheric GCM to simulate the climate from 1979-1988 for the first program of the Atmospheric Model Intercomparison Project (AMIP, Phillips 1994).

1.2. 11-Layer Troposphere/Lower-Stratosphere General Circulation Model

This TLS-GCM was developed from our 7-layer troposphere GCM (Oh 1989) to determine the dependence on convection parameterization of the tropical intraseasonal oscillation (TIO). It was found that the simulated TIO is highly dependent on the relative humidity criterion for convection to occur, RHc. As RHc increases, the TIO in the simulations becomes stronger for all three convection parameterizations examined, namely, convective-adjustment, Kuo and Arakawa-Schubert convection parameterizations. This dependence of the amplitude of the simulated oscillation on RHc appears to explain the differences in the TIO among previous simulations by different GCMs (Wang 1996; Wang and Schlesinger 1995; Wang and Schlesinger 1999).

To enable construction of geographical scenarios of greenhouse-gas and anthropogenic-sulfate-aerosol induced climate changes for the Impact Analysis Study Group of the Stanford Energy Modeling Forum 14 û Integrated Assessment of Climate Change, Working Group II of the Intergovernmental Panel on Climate Change (IPCC), and others, we have performed several simulations of equilibrium climate with the 4? latitude by 5? longitude version of our TLS-GCM coupled to our mixed-layer-ocean/sea-ice (TLS/MLO) model. We have performed simulations with the TLS/MLO model for the present climate (control), the equilibrium climate resulting from doubling the CO2 amount (2xCO2), and the equilibrium climates induced by the anthropogenic emission of SO2 gas which is converted in the atmosphere into sulfate (SO4) aerosol. For the latter we have performed 9 simulations: a 1xSO4 simulation for the present-day atmospheric burden of SO4, a 10xSO4 simulation in which the global sulfate burden was decupled, and 7 simulations for regional 10xSO4 burdens û one each for Europe, North Africa, Siberia, Asia, North America and the Southern Hemisphere û and the seventh for all regions other than Europe. We have also performed a joint 2xCO2+5xSO4 simulation, as well as simulations for the solar constant increased by 2%, a perpetual Pinatubo-like volcano stratospheric sulfate aerosol, and a future tropospheric ozone increase calculated by our 24-layer atmospheric chemistry-transport model (ACTM, Section 1.4; (Rozanov et al. 1999c). Daily and monthly data for a large number of climatic quantities from these simulations are available at ftp://crgd.atmos.uiuc.edu/pub/emf.

The geographical patterns of climate change for arbitrary scenarios of future GHG concentrations and SO2 emissions can be constructed by multiplying the geographical patterns of equilibrium climate changes simulated by the TLS/MLO model, individually for increased CO2 and SO4 and normalized by their respective changes in annual global-mean surface-air temperature, by the change in this quantity simulated by a simple climate/ocean model (e.g. Schlesinger et al. 1997b; Schlesinger and Jiang 1991; Schlesinger et al. 1992), individually for the scenario of increased CO2 and SO4. This method is illustrated in Schlesinger et al. (1997a) where we applied it for two scenarios that stabilize the CO2 concentration at 550 ppmv, the IPCC Working Group I stabilization scenario which does not consider economics, and the stabilization scenario of Wigley et al. (1996) which does consider economics in an implicit manner. The method and our results have also been used to construct scenarios of SO4-induced climate change for use by IPCC Working Group II in their calculation of the impacts of climate change for the IPCC Third Assessment Report (Carter et al. 2000). We have also used the results from our simulations to calculate the geographical patterns of temperature change for the new IPCC emissions scenarios of SRES, the Special Report on Emissions Scenarios (Schlesinger et al. 2000). We have extended three of the above simulations û control, 2xCO2 and 10xSO4 û using the high-resolution, 1.33? latitude by 1.33? longitude version of our TLS/MLO model.

1.3. 24-Layer Stratosphere/Troposphere GCM (ST-GCM)

We have developed the UIUC 24-layer ST-GCM (Yang et al. 2000). This model is an extension of our TLS-GCM to include stratospheric processes above 50 hPa. The ST-GCM has 24 layers extending from the earth's surface to 1 hPa. The ST-GCM includes all of the dynamical and most of the physical features of the TLS-GCM. New solar and longwave radiation parameterizations were developed for the ST-GCM based on (Chou and Suarez 1999; Chou and Suarez 1994). The direct and indirect radiative forcing of sulfate aerosol are included and the treatment of cloud-radiation interaction has been updated. Because the drag effect of unresolved gravity waves is crucial for determining the wind and temperature profiles, the ST-GCM includes the Palmer et al. (Palmer et al. 1986) parameterization of orographically excited gravity-wave drag. The ST-GCM has been validated by comparing its simulated present-day climate with observations (Yang et al. 2000). The ST-GCM has been used to: (1) reconstruct the radiative forcing of historical volcanic eruptions (Andronova et al. 1999); (2) simulate the atmospheric climate from 1979 through 1995 for the AMIP-II project, the wind and temperature fields from which are used in our ACTM simulations described below; (3) simulate the distributions of source gases and ozone in the stratosphere coupled with our chemical-transport model (Rozanov et al. 1999c); and (4) study the climatic impact of the Mount Pinatubo volcanic eruption (Yang 1999).

1.4. 24-Layer Atmospheric Chemistry Transport Model

We have developed our 24-layer Atmospheric Chemistry Transport model (ACTM) to: (1) study the influence of anthropogenic chemical emissions on the composition of the atmosphere, holding climate unchanged; and (2) couple with our 24-layer ST-GCM. The ACTM consists of: (1) a hybrid advective transport routine (Zubov et al. 1999; Zubov et al. 1996a; Zubov et al. 1996b), that includes the Prather scheme for the vertical transport and a semi-Lagrangian scheme for the horizontal transport; (2) a photochemical routine in which the concentrations of 43 chemical species (O3, O(1D), O(3P), N, NO, NO2, NO3, N2O5, HNO3, HNO4, PAN, N2O, H, OH, HO2, H2O2, H2O, H2, Cl, ClO, HCl, HOCl, ClNO3, Cl2, Cl2O2, CF2Cl2, CFCl3, Br, BrO, BrNO3, HOBr, HBr, BrCl, CBrF3, CO, CH2, CH3, CH3O2, CH3OOH, CH3O, CH2O, CHO, CH3C(O)O2) are determined by 199 gas-phase and 8 heterogeneous reactions (Rozanov et al. 1999c); and (3) prescribed temperature, tropospheric humidity and circulation fields, including the mass fluxes for the convective motions, either from observations or simulated by a GCM. A detailed description of the ACTM and validation of its simulated ozone and long-lived species against satellite data have been presented by Rozanov et al. (1999a; 1999c) and Zubov et al. (1999). The ACTM has also been evaluated within the framework of the NASA-guided Models and Measurements II intercomparison project (Rozanov et al. 1999b). The ACTM has been used to determine: (1) the influence of aircraft emissions on the geographical distributions of ozone, NOx and HNO3 in the upper troposphere, (2) the influence of the long-range transport of ozone precursor gases from anthropogenic activity on tropospheric ozone production, and (3) the trends of ozone and other species during 1993-present using the United Kingdom Meteorological Office Assimilated winds and the observed changes of source gases (Egorova et al. 2001).

1.5. Coupled 24-Layer Stratosphere/Troposphere GC/Photochemistry Model

We have coupled our 24-layer ST-GCM with our 24-layer ACTM to form an ST-GCM with interactive photochemistry, our ST-GC/PC model. This model has been used to simulate the change in climate and atmospheric composition resulting from: (1) the 1991 Pinatubo volcanic eruption (Rozanov et al. 2001a), and (2) the difference in solar spectral irradiance between solar maximum and solar minimum (Rozanov et al. 2001b). The ST-GC/PC model coupled to our mixed-layer-ocean/sea-ice model is being used to simulate and understand the present climate and composition and the equilibrium change therein due to: (1) a doubling of the CO2 concentration, (2) the radiative forcing during the Last Glacial Maximum . (3) a doubling of the methane concentration and (4) anthropogenic changes in the emissions of ozone precursors The ST-GC/PC model coupled to our oceanic GCM is being used to simulate and understand the climatic effects of changes in solar spectral irradiance from 1871 to the present.

1.6. 18-Layer Ocean GCM

Our oceanic GCM calculates the oceanic velocity, temperature and salinity, and the thickness of sea ice. The original 6-layer version of our oceanic GCM with 4? latitude by 5? longitude resolution was developed, documented and validated by Han (1984a; 1984b). This OGCM was coupled to the Oregon State University two-layer atmospheric GCM and was used to perform the first coupled model simulation having both global geography and the annual cycle (Gates et al. 1985; Han et al. 1985). This coupled model was also used to simulate the early climate changes resulting from a doubling of the CO2 concentration (Schlesinger et al. 1985) and the penetrations into the ocean of CFC-11, CFC-12, tritium and a CO2-induced heating treated as a passive tracer (Jiang 1991). We have increased the number of vertical layers in the OGCM to 18, replaced the constant vertical viscosity and diffusivity with Richardson-number-dependent values (Pacanowski and Philander 1981), and coupled the OGCM to our atmospheric GCMs. The resulting coupled models are flux corrected.

1.7. Coupled 11-Layer Troposphere/Lower-Stratosphere/18-Layer Ocean GCM

We have coupled our 11-layer TLS GCM with our 18-layer ocean GCM. We are using this coupled model to simulate, without interactive photochemistry, the climate changes resulting from the changes in solar spectral irradiance from 1871 to the present.

1.8. Coupled 24-Layer Troposphere/Stratosphere/18-Layer Ocean GCM

We have coupled our 24-layer ST-GCM with our 18-layer ocean GCM and used it to simulate the changes in climate due to the eruption of the Pinatubo volcano (Yang 1999; Yang and Schlesinger 2000). We have also coupled our 24-layer ST-GC/PC model with our 18-layer ocean GCM. We will use this coupled model to simulate, with interactive photochemistry, the climate changes resulting from the changes in solar spectral irradiance from 1871 to the present.

1.9. Model Intercomparison Activities

During the grant we have participated in the model intercomparison activities of: (1) the Atmospheric Model Intercomparison Project (AMIP) parts I (Phillips 1994) and II (Gleckler 1999), (2) the Feedback ANalyses in GCMs and In Observations (FANGIO) program (Cess et al. 1996; Cess et al. 1997), (3) the Paleoclimate Model Intercomparison Project (PMIP Joussaume and Taylor 1995; Joussaume et al. 1999), (4) the NASA-sponsored Models and Measurements II program (Rozanov et al. 1999b), (5) the Intercomparison of Models Representing Direct Shortwave Radiative Forcing By Sulfate Aerosols (Boucher et al. 1998), (6) the Intercomparison of GCMs' Radiation Codes within the

framework of GRIPS, (7) part III of the Intercomparison of Radiation Codes used in Climate Models (ICRCCM-3) program (Barker et al. 2001; Partain et al. 1998), and (8) the Threshold Sea Surface Temperature for Convection project (Randall et al. 2001). We have also performed simulations in support of the Stanford Energy Modeling Forum 14 û Integrated Assessment of Climate Change and the IPCC Third Assessment Report (Section 1.2).

2. Analysis Methods and Estimation

2.1. Cause and Effect Analysis

In our antecedent 5-year NSF Grant (ATM-9001310) we developed the Cause-and-Effect Analysis (CEA) technique to determine the sensitivity and stability of geophysical models (Andronova and Karol 1993; Andronova et al. 1993; Andronova and Schlesinger 1991; Andronova and Schlesinger 1992). Under the present grant we further developed the CEA technique to determine the feedbacks of geophysical models (Andronova and Schlesinger 1996).

2.2. 65-70-Year Oscillation

In 1994 we analyzed the instrumental near-surface temperature record in conjunction with our simple climate/ocean model (Section 1.2) and discovered a 65-70-year oscillation in the global-mean temperature that was not global in extent, but rather located over the North Atlantic Ocean and adjacent coastal margins (Schlesinger and Ramankutty 1994a; Schlesinger and Ramankutty 1994b). In 1995 we showed that this oscillation was not the result of climatic (red) noise (Schlesinger and Ramankutty 1995).

2.3. Estimation of Climate Sensitivity and Sulfate Radiative Forcing

We have used our simple climate/ocean model (Section 1.2), calibrated to reproduce the annual cycle of surface-air temperature, together with the instrumental hemispheric near-surface temperature record from 1856 to 1997, to obtain maximum-likelihood estimates of the climate sensitivity, *T2x, and anthropogenic sulfate radiative forcing in reference year 1990, *FSO4(1990), for different radiative-forcing models (RFMs) (Andronova and Schlesinger 2000). We find that *T2x is quite sensitive to RFM while *FSO4(1990) is not. For radiative forcing by greenhouse gases (GHGs) and anthropogenic sulfate aerosols, *T2x = 5?C, which exceeds the maximum of the range given by the IPCC, 1.5?C-4.5?C (Kattenberg et al. 1996). When solar radiative forcing is included, *T2x is reduced by about 50%, to 2.7?C for the solar-radiative-forcing model constructed by Lean and colleagues (Fr÷hlich and Lean 1998; Lean et al. 1995) and to 2.4?C for the model constructed by Hoyt and Schatten (1993), that is, to near the IPCC 'best-estimate' value of 2.5?C. Clearly it is important in terms of climate impacts and policy to determine whether or not the sun's irradiance has varied during the past two centuries, which we are in the process of doing.

We have also determined probability distributions for *T2x and *FSO4(1990) for 16 RFMs (Andronova and Schlesinger 2001). This was done by performing the estimation for each of 5000 surrogate climate records for each RFM, each surrogate comprised of the temperature signal due to the RFM for its maximum-likelihood *T2x and *FSO4(1990), and a bootstrap sample of the difference between the observed and maximum-likelihood-simulated temperatures. The probability distributions are skewed toward the larger values of *T2x and *FSO4(1990). It was found that there is a 54% likelihood that *T2x lies outside the range given by IPCC (Houghton et al. 2001), 1.5?C * *T2x * 4.5?C.

3. Climate-Change Scenarios, Impacts and Policy

3.1. Climate Change Scenarios

As described in Section 1.2, we have constructed geographical scenarios of climate change for the four non-intervention marker emissions scenarios of SRES, the Special Report on Emissions Scenarios (Schlesinger et al. 2000). We have also used our simple climate/ocean model (Section 1.2) to calculate the changes in global-mean near-surface temperature and sea level for the Post-SRES emission scenarios that stabilize the CO2 concentration at one or more levels corresponding to each SRES marker scenario (Schlesinger and Malyshev 2001).

3.2. Analysis of Climate-Change Impacts

We have collaborated with Robert Mendelsohn of Yale University to develop climate-response functions (CRFs) for sensitive market sectors in the United States economy using two empirical methods. The Experimental approach constructs a process-based impact model from the results of controlled experiments. The Cross-sectional approach estimates CRFs directly from empirical evidence in the field. Both methods indicate that agriculture, forestry, and energy have a hill-shaped relationship to temperature. Precipitation, sea level rise, and carbon dioxide are also important (Mendelsohn and Schlesinger 1999). We have applied both CRF models to climate changes in 2100 using the geographical distributions of temperature and precipitation changes obtained as described in Section 1.2 from the 2xCO2 simulation with our 11-layer TLS-GC/mixed-layer-ocean model and our simple climate/ocean model. It is found that tropical countries are damaged by the climate changes while temperate countries are benefitted (Mendelsohn et al. 1998; Mendelsohn et al. 2000a). This impact analysis was extended to the results

of 13 other GCMs. The finding that there are climatic-change 'winners' and 'losers' is robust across all the GCMs (Mendelsohn et al. 2000b). Recently we have investigated the impacts of the SRES non-intervention emission scenarios using the geographical distributions of climate changes we calculated as described in Sections 1.2 and 3.1. For *T2x = 2.5?C and a CO2 concentration in 2100 of 612 ppmv, the Cross-sectional impact model predicts small global benefits across all 14 climate models, whereas the Experimental impact model predicts a range from small benefits to small damages (Mendelsohn et al. 2001).

We have collaborated with Larry Williams of the Electric Power Research Institute to develop and distribute a CD-based COuntry Specific Model for Intertemporal Climate (COSMIC) to calculate country-specific changes in the annual cycle of temperature and precipitation for each of 158 countries for each of 14 GCM simulations, this in response to a request for such a model from a Kenyan participant at the IPCC Asia-Pacific Workshop on Integrated Assessment Models, 10-12 March 1997 (Schlesinger and Williams 1997). As of 9 July 2001, CD copies of COSMIC have been distributed to 119 requestors from 43 countries (Albania, Australia, Belgium, Brazil, Bulgaria, Cameroon, Canada, China, Costa Rica, Djibouti, Egypt, Ethiopia, Finland, Germany, Greece, Hungary, India, Indonesia, Japan, Kiribati, Korea, Mauritius, Mexico, Mozambique, Netherlands, Norway, Philippines, Poland, Romania, Russia, Senegal, Slovenia, South Africa, Sri Lanka, Sudan, Swaziland, Sweden, Thailand, Tunisia, United Kingdom, United States, Vietnam, Zimbabwe). Larry Williams is presently completing Version II of COSMIC. This version combines the original COSMIC code with the Global Impacts Model (GIM Mendelsohn and Schlesinger 1999) to calculate the country-specific market impacts for 177 countries for each of 5 sectors (agriculture, forestry, energy, coastal resources, and water resources) for each of the 14 GCM simulations. Version II will be available not only on CD, but also on the web at the Consortium for International Earth Science Information Network (CIESIN) website for instantaneous online access and use by anyone in the world with an internet connection.

3.3. Analysis of Climate-Change-Abatement Policy

We have collaborated with Robert Lempert of Rand to analyze climate-change abatement policies. Most quantitative studies of climate-change policy attempt to predict the greenhouse-gas reduction plan that will have the optimum balance of long-term costs and benefits. We have found that the large uncertainties associated with the climate-change problem can make the policy prescriptions of this traditional approach unreliable. In our studies we constructed a large uncertainty space that includes the possibility of large and/or abrupt climate changes and/or technology breakthroughs that radically reduce projected abatement costs. We used computational experiments on a linked system of climate and economic models to compare the performance of a simple adaptive strategy û one that can make midcourse corrections based on observations of the climate and economic systems û and two commonly advocated æbest-estimateÆ policies based on different expectations about the long-term consequences of climate change. We found that the æDo-a-LittleÆ and æEmissions-StabilizationÆ best-estimate policies perform well i the respective regions of the uncertainty space where their estimates are valid, but can fail severely in those regions where their estimates are wrong. In contrast, the adaptive strategy can make midcourse corrections and avoid significant errors. While its success is no surprise, the adaptive-strategy approach provides an analytic framework to examine important policy and research issues that will likely arise as society adapts to climate change, and which cannot be easily addressed in studies using best-estimate approaches (Lempert et al. 1996).

An adaptive policy, however, unlike a prescriptive policy, can be fooled by climate variability into taking enhanced action when it should not or non-enhanced action when it should. We have examined this issue and found that: (i) adaptive strategies remain preferable to static, best-estimate policies even with very large levels of climate variability; (ii) the most robust strategies are innovation sensitive, that is, adjust future emissions-reduction rates on the basis of small changes in observed abatement costs but only for large changes in observed damages; and (iii) information about the size of the variability is about a third to an eighth as valuable as information determining the value of the key parameters that represent the long-term, future climate-change state-of-the-world (Lempert et al. 2000). We have vetted these issues in Op-Ed articles (Lempert and Schlesinger 1995; Lempert and Schlesinger 1997), an editorial essay (Lempert and Schlesinger 2000), and in a forthcoming book (Lempert and Schlesinger 2001).

We have collaborated with Gary Yohe of Wesleyan University to investigate the expected economic cost of protecting or abandoning coastal property in the United States in the face of rising sea level (Yohe and Schlesinger 1998).

We have collaborated with Marty Hoffert of New York University on the energy implications of future stabilization of atmospheric CO2 content (Hoffert et al. 1998). We found that CO2 stabilization with continued economic growth will require innovative, cost-effective and carbon-emission-free technologies that can provide additional tens of terrawatts of primary power in the coming decades, and certainly by mid-century, even with sustained improvement in the economic productivity of primary energy. As the target decreases in the 750 to 350 ppmv range, implementing atmospheric CO2 stabilization will become even more challenging because of the increasing demand for carbon-free power. The magnitude of the implied infrastructure transition suggests the need for massive investments in innovative energy research.

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Zubov, V. A., E. V. Rozanov, M. E. Schlesinger and N. G. Andronova, 1996b: Hybrid advection scheme for 3-dimensional atmospheric models: Testing and application for a study of NOx transport. , First General Assembly of the WCRP Project 'Stratospheric Processes and Their Role in Climate', Melbourne, Australia, pp. 421-424.

Project Training and Development:

Research Training:

Under NSF grant ATM 95-22681: (1) Wanqiu Wang obtained his Ph.D. in Atmospheric Sciences in 1996, (2) Fanglin Yang obtained his Ph.D. in Atmospheric Sciences in 2000; and (3) Jianjun Yin is working on his Ph.D. degree in Atmospheric Sciences.

Outreach Activities:

Presentations Given
Andronova, Natalia
1995
Seminar at University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences, 'The Role of Wetlands in Climate Change.' 4 October 1995.
1996
Invited lecturer at the International School of Physics 'Enrico Fermi', Varenna, Italy, 25 June-5 July. Presented lectures titled 'Has sun changed the climate?'
Invited lecturer in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 25 July-1 August. Presented lecture titled 'A role of wetlands in climate change.'
Invited lecturer on 'The role of wetlands in climate change' at the Aspen Institute on Global Change Meeting, Aspen, CO, 31 July-8 August.
1998
Presentation given at Environmental Horizons Conference: 'Selected Current Research and Development of the Climate Research Group,' Urbana, IL, April 21.
Invited lecturer in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 3-14 August. Presented lecture titled 'A role of wetlands in climate change.'
Attended the Joint International Symposium on Global Atmospheric Chemistry, Seattle, 21-25 August 1998. Presented a poster on the 'Influence of aircraft emissions on distribution of upper tropospheric ozone and NOx.'
Attended the AGU meeting, San Francisco, 6-12 December 1998. Presented the lecture 'The 3-D study of the influence of long-range transport on ozone and ozone-precursor gases over North-Atlantic Region.' (N. G. Andronova, E. V. Rozanov, V. A. Zubov, and M. E. Schlesinger).
1999
UIUC Department of Atmospheric Sciences seminar, 'Radiative Forcing by Volcanic Aerosols from 1850 through 1994,' 27 January 1999.
Invited participant with poster presentation: 'Modeling the Influence of Long-Range Gas Transport on Ozone and Ozone-Precursor Gases Over the North-Atlantic Region,' IGAC, 12-17 September, (N. G. Andronova, E. V. Rozanov, V. A. Zubov, and M. E. Schlesinger).
Presentation given at Environmental Horizons Conference: 'Modelling the Influence of the Anthropogenic Emissions of NOx And CO Over the U.S. on the Distribution of Tropospheric Ozone Over the World,' Urbana, IL, April 21.
2000
UIUC Atmospheric Sciences Department seminar, 'Objective Estimation of the Probability Density Function for Climate Sensitivity,' 6 December 2000.
Presentation of 'Representation of the chemical and climate interactions in the North Atlantic and Arctic Oscillations,' Chapman Conference, AGU, 28 November-1 December 2000m Orense, Galicia, Spain, (Natalia Andronova, Michael Schlesinger, Eugene Rozanov).
Study of a relationship between interannual climate variability and interannual variability of ozone in the stratosphere and troposphere Proceedings of the SPARC General Assembly 2000 (N. Andronova, M. Schlesinger, E. Rozanov and T. Egorova). Available at: http://www.aero.jussieu.fr/~sparc/SPARC2000_new/PosterSess2/SessionP2_5/andronova/SPARC_EOF_Ozone.htm
Presentation given at Environmental Horizons Conference: 'Statistical Estimation of Climate Sensitivity and Anthropogenic Sulfate Forcing,' Urbana, IL, April 19.
Invited lecturer at Presentation given at the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO,: 'Statistical Estimation of Climate Sensitivity and Anthropogenic Sulfate Forcing,' July

Rozanov, Eugene
1996
International Colloquium ' Impact of Aircraft emissions upon the Atmosphere', Paris, France, 15-18 Oct. 1996. Presented two posters: Hybrid Advection Scheme for 3-Dimensional Atmospheric Models: Testing and Application for a Study of NOx Transport (Zubov, V. A., E. V. Rozanov, M. E. Schlesinger, N. G. Andronova:) and Model evaluation of subsonic aircraft effect on the gas distribution and radiative forcing (Rozanov, E. V., T. A. Egorova, V. A. Zubov and Y. E. Ozolin).
1997
Presentation of 'Simulations of trace gas distributions with 3-D atmospheric chemical transport model: model description and validation against UARS-CLAES and TOMS data.' MOPITT workshop, Toronto, Canada, 4 October 1997 (Rozanov E. V., V. A. Zubov, M. E. Schlesinger, N. G. Andronova).
1998
EGS XXIII General Assembly, Nice, France, 20-24 April, 1998. Made the following presentations:
1. Three - Dimensional Simulations of Ozone in the Stratosphere and Comparison with UARS Data (poster);
2. Simulation of the annual cycle of total ozone over Northern high-latitudes and comparison with TOMS data. (oral);
3. Simulation of trace-gas distributions with UIUC 3-D atmospheric chemical transport model and comparison of source gas distribution with observations (oral);
4. The influence of aircraft emissions on the geographical distributions of ozone and reservoir species in the upper troposphere and stratosphere (poster).
AAEP conference, Virginia Beach, 28 April - 1 May 1998. Made the presentation: The influence of aircraft emissions on the geographical distributions of ozone and reservoir species in the upper troposphere and stratosphere (poster).
1999
GRIPS {General circulation model to Reality Intercomparison project for SPARC} workshop, Reading, UK, 22-26 March, 1999. Made the presentations:
1. Description and performance of the UIUC 24-layer stratosphere/troposphere general circulation model (poster);
2. Use of the Methane Distribution Simulated by an ACTM for Evaluation of a GCM's Performance in the Middle Atmosphere (poster).
Environmental Horizon Conference, UIUC, Urbana, USA, April, 1999. Made the presentation: Use of the Methane Distribution Simulated by an ACTM for Evaluation of a GCM's Performance in the Middle Atmosphere (poster).
2000
Attended GRIPS (General circulation model to Reality Intercomparison Project for SPARC) workshop, Toronto, Canada, 13-16 March, 2000. Presented lecture: The UIUC 3-D Stratosphere-Troposphere General Circulation Model with Interactive Ozone Photochemistry: Some results of the Control Run.
Attended SPARC General Assembly 2000, Mar Del Plata, Argentina - November 6-10, 2000. Presented 4 posters:
(1) Study of the effects of the Pinatubo volcanic eruption using the UIUC stratosphere/troposphere GCM with interactive photochemistry. Proceedings of the SPARC General Assembly 2000 (E. Rozanov, M. Schlesinger, F. Yang, S. Malyshev, N. Andronova, V. Zubov, and T. Egorova). Available at:
http://www.aero.jussieu.fr/~sparc/SPARC2000_new/PosterSess3/Session3_3/Rozanov/P_3_3_13/Pinatubo.html#Anchor-Study-49575
(2) Sensitivity of the UIUC stratosphere/troposphere GCM with interactive photochemistry to the observed increase of solar UV radiation. Proceedings of the SPARC General Assembly 2000 (Rozanov, E., M. E. Schlesinger, F. Yang, S. Malyshev, N. Andronova, V. Zubov, and T. Egorova). Available at:
http://www.aero.jussieu.fr/~sparc/SPARC2000_new/PosterSess3/Session3_3/Rozanov/P_3_3_12/SOLAR_UIFolder/SOLAR.html#Anchor-Sensitiv
(3) Simulation of the effects of the Montreal Protocol using the UIUC stratosphere/troposphere ACTM driven by the UKMO-assimilated winds. Proceedings of the SPARC General Assembly 2000 (T. A. Egorova, E. V. Rozanov, M. E. Schlesinger, S. L. Malyshev, N.G. Andronova, V. A. Zubov and I. L. Karol. Available at:
http://www.aero.jussieu.fr/~sparc/SPARC2000_new/PosterSess3/Session3_4/Egorova/egorova.html#Anchor-Simulation-11481; and
(4) Study of the relationship between interannual climate variability and the interannual variability of ozone and methane. Proceedings of the SPARC General Assembly 2000 (N. Andronova, M. Schlesinger, E. Rozanov and T. Egorova). Available at:
http://www.aero.jussieu.fr/~sparc/SPARC2000_new/PosterSess2/SessionP2_5/andronova/SPARC_EOF_Ozone.htm

Schlesinger, Michael
1995
Invited lecture, 'Uncertainties in Climate Modeling,' Stanford Energy Modeling Forum (EMF)û14 on Integrated Assessment of Global Climate Change, Study Group on Decisions Under Uncertainty, Palo Alto, CA, 19-20 January.
Lecture on 'To Abate or Not To Abate û That is the Greenhouse Question,' University of New Orleans, 9 February.
Lecture on 'What Caused the Last Ice Age?,' Tulane University, New Orleans, 10 February.
Invited lecture, 'To Abate or Not To Abate? û That Is the Greenhouse Question,' Sherwood Fusion Theory Conference, Incline Village, Nevada, 3 April.
Invited lecture, 'In Search of the 'Holy Grail' of Climate Change û The Elusive Climate Sensitivity, _T2x,' Stanford Energy Modeling Forum

(EMF)û14 on Integrated Assessment of Global Climate Change, Study Group on Decisions Under Uncertainty, Palo Alto, CA, 24-26 May.
Invited lecture, 'Has the Sun Changed Climate?,' IUGG XXI General Assembly, Boulder, CO, 2-14 July.
Invited participant in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 16-23 August.
UIUC Department of Atmospheric Sciences Seminar, 'Has the Sun Changed Climate?,' 30 August 1995.
Invited participant in the PMIP (Paleoclimate Model Intercomparison Project) Workshop, Collonges-la-Rouge, France, 1-6 October.
Invited participant in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Washington, DC, 29 November.
Invited participant in the World Bank/Federation of American Scientists Climate Change Colloquium Hearings, Warrenton, VA, 9-10 December.
1996
ACACIA Sulfate Aerosol Research Project Planning Meeting, NCAR, Boulder, CO, 27-28 February 1996. Presented invited lecture, 'The Dependence of Climate Sensitivity on Sulfate Aerosol Forcing.'
International Workshop on Climate Change: Integrating Science, Economics, and Policy, IIASA, Laxenburg, Austria, 19-20 March. Presented invited lecture, The Standard Error of Observationally Based Estimates of Climate Sensitivity.
EMF 14 Working Group Meeting on Integrated Assessment of Global Climate Change, IIASA, Laxenburg, Austria, 21-22 March. Presented invited lecture, 'Development of the Geographical Climate Scenarios for the Impact Analyses of Energy Modeling Forum 14 û Integrated Assessment of Climate Change.'
Invited lecturer at the International School of Physics 'Enrico Fermi', Varenna, Italy, 25 June - 5 July. Presented lectures titled 'Modelling and Simulation of Climate and Climate Change.'
Invited lectures on 'Empirical Estimation of Climate Sensitivity and Anthropogenic Sulfate Forcing' and 'When We DonÆt Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change' at the Aspen Global Change Institute Meeting, Aspen, CO, 31 July-8 August.
UIUC Department of Atmospheric Sciences seminar, 'When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change, 11 September 1996.
1997
Presented Keynote Address, When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change, 1997 Society for Computer Simulation Western MultiConference, 12-15 January, Phoenix, Arizona.
Invited participant in the Workshop on Climate Change: Thresholds and Response Functions, Potsdam Institute for Climate Impact Research (PIK), 23-24 January. Presented lecture titled When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change.
Invited participant in the IPCC Asia-Pacific Workshop on Integrated Assessment Models, 10-12 March 1997, United Nations University, Tokyo. Presented lecture titled Country-Specific Market Impacts of Climate Change.
Invited participant in the Tokyo Modeling Forum, 13-14 March 1997, United Nations University, Tokyo. Presented lecture titled Development of Geographical Climate Scenarios for the Impact Analyses of Energy Modeling Forum 14.
Presented invited lecture, When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change, at the Center for Integrated Study of the Human Dimensions of Global Change, Department of Engineering and Public Policy, Carnegie Mellon University, 24 March.
Presented invited lecture, When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change, at the Symposium on Global Climate Change: Uncertainties and Research Needs at the Annual Meeting of the American Chemical Society, San Francisco, 13 April.
Presented invited lecture, Transient climate models: A hybrid strategy at the Forest Service-NCAR Workshop, 3-4 June 1997, NCAR.
Presented invited lectures, Development of Geographical Climate Scenarios for the Impact Analyses of Energy Modeling Forum 14 and Empirical Estimation of Climate Sensitivity and Anthropogenic Sulfate Forcing, International Energy Workshop and the Energy Modeling Forum, 23-25 June 1997, International Institute for Applied Systems Analysis, Laxenburg, Austria.
Presented invited lecture, Empirical Estimation of Climate Sensitivity and Anthropogenic Sulfate Forcing, at the Second Meeting of The Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh, Pennsylvania, 29 Juneû2 July.
Presented invited lecture, Geographical Scenarios of Greenhouse-Gas and Anthropogenic-Sulfate-Aerosol Induced Climate Changes, at the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 4-15 August.
1998
Presented invited lecture, COSMIC: Country-Specific Model for Intertemporal Climate, Executive Board of ACACIA (A Consortium for Application of Climate Impact Assessments), 16 January, Phoenix, Arizona.
Presented invited lecture, Modeling and Analysis of Global Biosphere-Atmosphere Interactions, at the Third Meeting of The Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh, Pennsylvania, 18-20 May.
Presented invited lecture, Geographical Scenarios of Greenhouse-Gas and Anthropogenic-Sulfate-Aerosol Induced Climate Change, at the Conference 'Do We Understand Global Climate Change?', Norwegian Academy of Technological Sciences, Oslo, Norway, 11-12 June.
Presented invited lectures, Geographical Scenarios of Greenhouse-Gas and Anthropogenic-Sulfate-Aerosol Induced Climate Change and COSMIC: Country-Specific Model for Intertemporal Climate at the Community Meeting on Integrated Assessment, 9-10 July, Washington,

D.C.
Presented invited lecture on 'The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information' at the Aspen Global Change Institute Meeting on Innovative Energy Systems & CO2 Stabilization, Aspen, CO, 14-24 July.
Presented invited lecture, Geographical Distribution of Temperature Change for the New IPCC Scenarios: A First Look, at the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 3-11 August.
Presented invited lecture, Geographical distributions of temperature change for the new IPCC Scenarios: A First Look, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, 8 September.
Presented invited lecture, Geographical scenarios of greenhouse-gas and anthropogenic-sulfate-aerosol induced climate changes, Workshop on Climate Impact Response Functions, Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany, 2 September
Presented invited lecture, The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information, at the Rijksinstituut Voor Volkgezondheid En Milieu (RIVM), Bilthoven, Netherlands, 9 September.
Presented invited lecture, The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information, at Koninklijk Nederlands Meteorologisch Instituut (KNMI), de Bilt, Netherlands, 9 September.
Presented invited lecture, First-Look Estimates of Time-Dependent Geographical Scenarios of Temperature Change for the New IPCC SO2 Emission Scenarios, IPCC Working Group III Special Report on Emissions Scenarios Lead Authors Meeting, Beijing, China, 7-9 October.
Presented invited lecture, First-Look Estimates of Time-Dependent Geographical Scenarios of Temperature Change for the New IPCC SO2 Emission Scenarios, Peking University, Beijing, China, 5 October.
Presented invited lecture, The Dependence on Convection Parameterization of the Tropical Intraseasonal Oscillation Simulated by the UIUC 11-Layer Atmospheric GCM, GCSS-WGNE Workshop on Cloud Processes and Cloud Feedbacks in Large-Scale Models, European Centre for Medium Range Weather Forecasts, Shinfield Park, UK, 9-13 November 1998.
Presented invited lectures on 'The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information' and 'First-Look Estimates of Time-Dependent Geographical Scenarios of Temperature Change for the New IPCC SO2 Emission Scenarios' at the Center for International Climate and Environmental Research û Oslo (CICERO), Oslo, Norway, 16 November 1998.
1999
UIUC Department of Atmospheric Sciences seminar, 'Geographical Scenarios of Greenhouse Gas and Anthropogenic-Sulfate-Aerosol Induced Climate Changes,' 20 January 1999.
Invited participant at the Arctic Climate Change Workshop, Fairbanks, 13-15 May. Presented lecture on Anthropogenically Induced Climate Change in the Arctic.
Presented invited lecture on 'Geographical Distributions of Temperature Change for the SRES Scenarios of Greenhouse Gas and Sulfur Dioxide Emissions' at the June session of the United Nations Framework Convention on Climate Change, Bonn, Germany, 4 June.
Presented invited lecture on 'Climate Sensitivity, Sulfate Aerosol Induced Regional Temperature Changes, Climate Impacts and Adaptive Decision Strategies' and was a member of the 3-member panel at the Forum on The State of Climate Science Since IPCC 1995, Resources for the Future, Washington, DC, 7 June.
Invited participant in the Stanford Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 26 July û 3 August. Presented lecture 'The market impacts of the SRES non-intervention scenarios of greenhouse gas and sulfur dioxide emissions.'
Presented lectures on 'Geographical distributions of temperature change for the SRES scenarios of greenhouse gas and sulfur dioxide emissions' and 'The Impacts of Climate Variability on Near-Term Policy ' at the Aspen Global Change Institute Meeting on Ecological and Agricultural Consequences of Climatic Extremes and Variability, Aspen, CO, 13-22 August.
Invited participant in the United States - Canada Symposium on North American Climate Change and Weather Extremes, Atlanta, GA, 6-8 October. Presented lecture 'Understanding Extreme Weather in the Context of Climate Change.'
Invited participant in the Annapolis Center Workshop on Climate Change, Annapolis, MD, 4-5 November. Presented lecture 'A Method to Evaluate and Compare the Performance of General Circulation Models.'
Invited speaker at the AES Corporation Environmental and Social Responsibility Conference, Rio de Janeiro, Brazil, 8 November. Presented lecture 'Climate Science, Projections of Climate Changes and Their Impacts, and Robust Adaptive Decision Strategies.'
2000
UIUC Atmospheric Sciences Department seminar, 'Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information,' 26 January 2000.
Invited participant in the Third Lead Authors Meeting of IPCC Working Group III On Mitigation, Eisenach, Germany, 7-11 February. Presented lecture 'Climate Changes for the Post-SRES Scenarios.'
Invited participant in the NASA Workshop on Solar Influences on Climate, Tucson, AR, 6-8 March. Presented lecture 'Climate Modeling and the Use of Climate Models to Study the Influence of the Sun on Climate.'
Invited participant in the Contextual Determinants of Malaria Workshop, Lausanne, Switzerland, 15-18 May. Presented lecture 'Economical Construction of Geographical Scenarios of Climate Change.'
Invited lecture 'Anthropogenically Induced Climate Change' at the Program in Arms Control, Disarmament and International Security, University of Illinois at Urbana-Champaign, 20 September.
Invited participant in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 24 July -

4 August. Presented lecture 'Some Thoughts On Climate Extremes.'

Wanqiu Wang
1995
UIUC Department of Atmospheric Sciences Seminar, 'Simulation of Tropical Intraseasonal Oscillations by the UIUC GCM, ' 19 April 1995.

Yang, Fanglin
1998
UIUC Atmospheric Sciences Department seminar, 'Direct Radiative Forcing of Anthropogenic Sulfate Aerosol and Its Climatic Impact,' 28 January 1998.
Attended the Second International Conference û Atmospheric and Environmental Science at the Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), 24û28 August 1998, Beijing, China. Presented a talk on the Direct Radiative Forcing of Anthropogenic Sulfate Aerosol and Its Climatic Impact.
Invited Speech at IAP/CAS: On the Development and Application of UIUC 24-Layer Stratosphere/Troposphere and 36-Layer Mesosphere/Stratosphere/Troposphere General Circulation Models.
1999
UIUC Department of Atmospheric Sciences seminar, 'Radiative Forcing and Climatic Impact of the Mount Pinatubo Volcanic Eruption,' 1 September 1999.

Meetings Directed
Schlesinger, Michael
1996
Co-convened, with Judit Pap, the special session of the AGU 1996 Fall meeting, Has the Sun Changed Climate?, 26-27 December 1996.
1999
Co-convened, with Allen Solomon the Aspen Global Change Institute Meeting on Ecological and Agricultural Consequences of Climatic Extremes and Variability, Aspen, CO, 13-22 August.

Meetings Attended

Andronova, Natalia
1995
Invited participant in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 16-23 August.
1996
EMF 14 Working Group Meeting on Integrated Assessment of Global Climate Change, IIASA, Laxenburg, Austria, 21-22 March.
Invited participant in the IPCC Workshop on Regional Climate Change Projections for Impact Assessment, London, 24-26 September.
Invited participant at the International Workshop on Climate Change: Integrating Science, Economics, and Policy, IIASA, Laxenburg, Austria, 19-20 March. Co-author of the invited lecture, The Standard Error of Observationally Based Estimates of Climate Sensitivity.
Invited lecturer at the International School of Physics 'Enrico Fermi', Varenna, Italy, 25 June-5 July
Invited lecturer in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 25 July-1 August
1997
Invited participant in the Tokyo Modeling Forum, 13-14 March 1997, United Nations University, Tokyo. Presented lecture titled 'Development of Geographical Climate Scenarios for the Impact Analyses of Energy Modeling Forum 14.'
1998
Invited lecturer in the Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 3-14 August.
Attended the Joint International Symposium on Global Atmospheric Chemistry, Seattle, 21-25 August.
Attended the AGU meeting, San Francisco, 6-12 December.
2000
Representation of the chemical and climate interactions in the North Atlantic and Arctic Oscillations, Chapman Conference, AGU, Spain,

Thomas Reichler
1997
77th Annual Meeting of the American Meteorological Society, Long Beach, California, 2-7 February 1997.

Schlesinger, Michael

1995
Documenting and Detecting Long-Term Climate Change: Monitoring Requirements for GCOS, Asheville, North Carolina, 9-11 January. Presented invited lecture, 'Has the Sun Changed Climate?'
Organizing Committee Meeting for Workshops on Representing Climate Impacts in Integrated Assessment Models, Department of Agriculture, Washington, D.C., 1 March.
Meeting of National Technical Advisory Committee of the National Institute for Global Environmental Change, University of California, Davis, 4-5 April.
First International AMIP Scientific Conference, Monterey, California, 15-19 May.
Workshop on Regional Assessment of Climate Change Impacts in the Southeast: Integrated Assessment Options and Research Needs, Holiday Inn, World's Fair, in Knoxville, Tennessee, 17-20 July 1995.
1996
IPCC meeting on IPCC Workplan for 1996. Washington, D.C., 22 April.
Invited participant in the National Academy of Sciences Climate Research Committee Meeting, Washington, D.C., 10-12 June.
Invited participant in the Stanford Energy Modeling Forum Workshop on Climate Change Impacts and Integrated Assessment, Snowmass, CO, 25 July-1 August.
Invited participant in the IPCC Workshop on Regional Climate Change Projections for Impact Assessment, London, 24-26 September.
Participant in the SPARC (Stratospheric Processes and Their Role in Climate) 1st General Assembly, Melbourne, Australia, 2-6 December 1996. Presented poster on 'Hybrid Scheme for 3-Dimensional Transport of Chemical Species'.
1997
Paleoclimate Model Intercomparison Project (PMIP) Workshop, Danville, CA, 4-7 November.
1998
Sixth JapanûU.S. Workshop on Global Change, 24-26 February, East-West Center, Honolulu, Hawaii.
Participant in the Aspen Global Change Institute Meeting on Climate Extremes: Changes, Impacts, and Projections, Aspen, CO, 7-14 August.
GCSS-WGNE Workshop on Cloud Processes and Cloud Feedbacks in Large-Scale Models, 9-13 November 1998, held at the European Centre for Medium range Weather Forecasting, Shinfield Park, Reading, UK. Presented lecture, 'The Dependence on Convection Parameterization of the Tropical Intraseasonal Oscillation Simulated by the UIUC 11-Layer Atmospheric GCM.
Invited participant at the IPCC Third Assessment Report (TAR) meeting, Paris, 20 November û 1 December 1998.
1999
Invited participant at the International Workshop on Next Generation Climate Models for Advanced High Performance Computing Facilities, Honolulu, 1-3 March 1999.
1999 GRIPS (GCM-Reality Intercomparison Project) workshop, 22-25 March, University of Reading, UK. Presented talk on The Use of the Methane Distribution Simulated by an ACTM to Evaluate the Middle Atmosphere Performance of GCMs.
IPCC Working Group III Emissions Scenarios Special Report Lead Authors Meeting, 23-25 March, in London.
Workshop on Global Climate Science, 'Research Pathways for the Next Decade', A Discussion, National Environmental Policy Institute, 31 March, Georgetown University Conference Center, Washington, D. C. Presented invited talk on Reducing the Uncertainty in the Estimated Value of Climate Sensitivity.
Invited participant at the Fourth Meeting of The Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh, Pennsylvania, 23-25 May.
IPCC Expert Meeting on Mitigation and Stabilisation Scenarios for IPCCÆs Third Assessment Report, Copenhagen, 2-4 June.
Participant in the 1999 Open Meeting of the Human dimensions of Global Environmental Change Research Community, Shonan Village, Japan, 24-26 June 1999. Presented lecture titled 'The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information.'
Invited participant in the Special Report on Emissions Scenarios Lead Authors Meeting, International Institute for Applied Systems Analysis, Laxenburg, Austria, 27-30 June 1999.
IMAGE-2 Advisory Board Meeting, 15-17 November, Bilthoven, Netherlands.
Invited participant in the Thermohaline Circulation Workshop, Boulder, CO, 1-3 December.
2000
Invited participant at the Fifth Meeting of The Center for Integrated Study of the Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh, Pennsylvania, 19-21 July.

Verbitsky, Mikhail
1995
WAIS (West Antarctic Ice Sheet project) workshop, 5-6 September, Arlington, VA.
EISMINT (European Ice Sheet Modeling Initiative) workshop on ice sheet - lithosphere interaction, 18 - 20 May, Fort William, Scotland.
EISMINT (European Ice Sheet Modeling Initiative) International Symposium on Ice Sheet Modelling, 18-22 September, Chamonix Mont Blanc.
PMIP (Paleoclimate Models Intercomparison) workshop, 1-6 October, Collonges-la-Rouge.

1996
EISMINT (European Ice Sheet Modeling Initiative) planning workshop, 29 - 30 March, Brussels.

Yang, Fanglin
1995
IUGG XXI General Assembly, Boulder, Colorado, July 2-14, 1995.
1996
FANGIO Workshop, State University of New York at Stony Brook, Stony Brook, NY, 12-13 November, 1996.
1999
Frontiers in the Science of Climate Modeling, A Symposium in Honor of Professor Robert D. Cess, UCSD, La Jolla, October 19-21, 1999.

Journal Publications

Andronova, N. G. and M. E. Schlesinger, "Causes of Global Temperature Changes During the 19th and 20th Centuries", Geophys. Res. Lett., p. 2137, vol. 27, (2000). Published

Andronova, N., and M. E. Schlesinger, "Objective Estimation of the Probability Distribution for Climate Sensitivity", J. Geophys. Res., p. , vol. , (2001). Accepted

Andronova, N. G., E. V. Rozanov, F. Yang, M. E. Schlesinger and G. L. Stenchikov, "Radiative Forcing by Volcanic Aerosols from 1850 through 1994", J. Geophys. Res., p. 16,807, vol. 104, (1999). Published

Egorova, T. A., E. V. Rozanov and I. L. Karol, "The influence of ozone depletion in the lower stratosphere on the radiation balance of the troposphere", Izv. RAN Physics of Atmosphere and Ocean, p. 41, vol. 25, (1997). Published

Egorova T., V. Zubov, S. Yagovkina, and E. Rozanov, "Simulation of the atmospheric ozone distributions with the 2D model and validation against UARS and TOMS data", Physics and Chemistry of the Earth, p. 465, vol. 24, (1999). Published

Egorova T., V. Zubov, S. Yagovkina, and E. Rozanov, "Lightning production of NOx and atmospheric ozone", Physics and Chemistry of the Earth, p. 473, vol. 24, (1999). Published

Egorova T., E. Rozanov, V. Zubov, and S. Yagovkina, "The influence of global lightning source of NOx on atmospheric ozone and odd nitrogen", Izvestiya of Russian Academy of Sciences, Physics of Atmosphere and Ocean, p. 809, vol. 36, (2000). Published

Egorova, T. A., E.V. Rozanov, M. E. Schlesinger, N. G. Andronova, S. L. Malyshev, I.L. Karol, V. A. Zubov, "Assessment of the Effect of the Montreal Protocol on Atmospheric Ozone", Geophys. Res. Lett., p. 2389, vol. 28, (2001). Published

Hoffert, M. I., K. Caldeira, A. K. Jain, E. F. Haites, L. D. D. Harvey, S. D. Potter, M. E. Schlesinger, S. H. Schneider, R. G. Watts, T. M. L. Wigley and D. J. Wuebbles, "Energy Implications of future stabilization of atmospheric CO2 content", Nature, p. 881, vol. 395, (1998). Published

Jagovkina S. V., Karol I. L., Zubov V. A., Lagun V. E., Reshetnikov A. I., and Rozanov E. V., "Reconstruction of the methane fluxes from the west Siberia gas fields by the 3D regional chemical transport model", Atmospheric Environment, p. 5319, vol. 34, (2000). Published

Karol, I. L., Y. E. Ozolin and E. V. Rozanov, "Box and Gaussian plume models of the exhaust composition evolution of the subsonic transport aircraft in and out of the flight corridor", Ann. Geophys., p. 88, vol. 15, (1997). Published

Karol I. L., V. A. Zubov, E. V. Rozanov, C. Br³hl, and A. Zieger, "Model reconstruction of seasonal and latitudinal changes of transport, trace gases and temperature in the stratosphere during Pre-industrial and Last Glacial eras", Proceedings of Russian Academy of Sciences, Geophysics, p. 99, vol. 357, (1997). Published

Karol, I. L., Ozolin, Y. E., Kiselev, A. A., and Rozanov, E. V., "Plume Transformation Index (PTI) of the Subsonic Aircraft Exhausts and their Dependence on the External Conditions", Geophys. Res. Lett., p. 373, vol. 27, (2000). Published

Kheshgi, H. S., M. E. Schlesinger and A. G. Lapenis, "Comparison of Paleotemperature Reconstructions as Evidence for the Paleo-Analog Hypothesis", Climatic Change, p. 123, vol. 45, (1997). Published

Kukla, G., J. Gavin, M. Schlesinger and T. Karl, "Comparison of observed seasonal temperature maxima, minima, and diurnal range in North America with simulations from three global climate models", Atmos. Res., p. 267, vol. 37, (1995). Published

Lempert, R. J. and M. E. Schlesinger, "Robust Strategies for Abating Climate Change", Climatic Change, p. 387, vol. 45, (2000). Published

Lempert, R. J., M. E. Schlesinger, S. C. Bankes, "When We DonÆt Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change", Climatic Change, p. 235, vol. 33, (1996). Published

Lempert, R. J., M. E. Schlesinger, S. C. Bankes and N. G. Andronova, "The impacts of climate variability on near-term policy choices and the value of information", Climatic Change, p. 129, vol. 45, (2000). Published

Mendelsohn, R., and M. E. Schlesinger, "Climate-Response Functions", Ambio, p. 362, vol. 28, (1999). Published

Mendelsohn, R., W. Morrison, M. E. Schlesinger and N. G. Andronova, "Country-specific market impacts of climate change", Climatic Change, p. 553, vol. 45, (2000). Published

Mendelsohn, R., M. E. Schlesinger and L. Williams, "Comparing Impacts Across Climate Models", Integrated Assessment, p. 37, vol. 1, (2000). Published

Mendelsohn, R., M. Schlesinger and L. Williams, "The Climate Impacts of Sulfate Aerosols", Integrated Assessment, p. , vol. , (2001). Accepted

Ozhigina, N. A., E. V. Rozanov and I. L. Karol, "Function of Stratospheric aerosol in transformation of ultraviolet radiation flow at low sun", Izv. RAN Physics of Atmosphere and Ocean, p. 456, vol. 32, (1996). Published

Rozanov E. V., T. A. Egorova, and A. P. Nagurny, "Investigation of the effect of aerosol particles on characteristics of surface inversion layers in the Arctic", Russian Meteorology and Hydrology, p. 16, vol. , (1998). Published

Rozanov, E., V. Zubov, M. Schlesinger, F. Yang, and N. Andronova, "Three-Dimensional Simulations of Ozone in the Stratosphere and Comparison with UARS Data", Physics and Chemistry of the Earth, p. 459, vol. 24, (1999). Published

Rozanov, E., V. Zubov, M. Schlesinger, F. Yang and N. Andronova, "The UIUC 3-D Stratospheric Chemical Transport Model: Description and Evaluation of the Simulated Source Gases and Ozone", J. Geophys. Res., p. 11,755, vol. 104, (1999). Published

Rozanov, E., M. E. Schlesinger, V. A. Zubov, "The UIUC 3-D Stratosphere-Troposphere General Circulation Model with Interactive Ozone Photochemistry: Results of a 15-year Control Run", J. Geophys. Res., p. , vol. , (2001). Accepted

Yohe, G. W., and M. E. Schlesinger, "Sea Level Change: The Expected Economic Cost of Protection or Abandonment in the United States", Climatic Change, p. 447, vol. 38, (1998). Published

Zubov, V. A., E. V. Rozanov and M. E. Schlesinger, "Hybrid Scheme for 3 Dimensional Advective Transport", Mon. Wea. Rev., p. 1335, vol. 127, (1999). Published

Books or Other One-time Publications

Andronova, N. G. and M. E. Schlesinger, "Cause-and-Effect Analysis of feedbacks in a numerical model", (1996). Book, Published
Editor(s): H. Le Treut
Collection: Climate Sensitivity to Radiative Perturbations: Physical Mechanisms and Validation, NATO ASI Series I, 'Global Environmental Change', vol. 34
Bibliography: Springer-Verlag, Heidelberg

Andronova, N. G., "Biography of M. I. Byduko", (2001). Book, Accepted
Collection: Encyclopedia of Global Environmental Change, volume 1
Bibliography: John Wiley & Sons Ltd.

Egorova, T. A., E. V. Rozanov, M. E. Schlesinger, V. A. Zubov, S. L. Malyshev, F. Yang, N. G. Andronova, "Global distribution of Ozone and NOx simulated by UIUC ACTM using circulation from the UKMO assimilation dataset", (2000). Book, Published
Bibliography: WMO/TD No.987, February, 2000, pp. 6.3-6.4

Karol, I. L., E. V. Rozanov and V. A. Zubov, "Model reconstruction of zonally averaged seasonal stratospheric composition during the pre industrial and last glacial periods, in Atmospheric Ozone", (1997). Book, Published
Editor(s): R. D. Bojkov, and G. Visconti
Collection: Proceedings of XVIII Quadrennial ozone symposium
Bibliography: Parco Scientifico e Tecnologico d'Abruzzo, Italy,

Lempert, R. J., M. E. Schlesinger, S. C. Bankes and N. G. Andronova, "The Impacts of Climate Variability on Near-Term Policy Choices and the Value of Information", (2000). Book, Published
Editor(s): S. M. Kane and G. W. Yohe
Collection: Societal Adaptation to Climate Variability and Change
Bibliography: Kluwer, Dordrecht, 129-161

Lempert, R. J., M. E. Schlesinger, "Adaptive Decision Strategies", (2001). Book, Accepted
Editor(s): R. G. Watts
Collection: Innovative Energy Strategies for CO2 Stabilization
Bibliography: Cambridge University Press

Mendelsohn, R., W. Morrison, M. E. Schlesinger, N. G. Andronova, "Country-Specific Market Impacts of Climate Change", (1997). Book, Published
Collection: Proceedings of the IPCC Asia-Pacific Workshop on Integrated Assessment Models {IAMs}, 10-12 March 1997
Bibliography: United Nations University, Tokyo, 333-341

Nagurny, A. P., G. V. Alekseev and E. V. Rozanov, "Temperature inversions in Arctic atmosphere", (1996). Book, Published
Collection: Proceedings of the ACSYS conference on the dynamics of the Arctic Climate System
Bibliography: WCRP-94, WMO/TD No. 760, pp. 209-215

Ramaroson R., I. Karol, N. Ozhigina, Y. Ozolin, E. Rozanov, E. Stankova and M. Zatevakhin, "Numerical modeling of the chemical, dynamical and radiative effects on the evolution of atmospheric species in the cloud environment", (1997). Book, Published
Editor(s): Preprints of Third Conference on Atmospheric Chemistry, Long-Beach, California, 2-7 February 1997
Bibliography: Long-Beach, California, 2-7 February 1997, pp. 101-102

Randall, D. A., M. E. Schlesinger, V. Galin, V. Meleshko, J.-J. Morcrette, R. Wetherald, "Cloud Feedbacks", (2001). Book, Accepted
Editor(s): J. T. Kiehl and V. Ramanathan
Collection: Frontiers in the Science of Climate Modeling
Bibliography: Cambridge University Press

Rozanov, E. V., T. A. Egorova, V. A. Zubov and Y. E. Ozolin, "Model evaluation of subsonic aircraft effect on the gas distribution and radiative forcing", (1996). Book, Published
Collection: Proceedings of International Colloquium 'Impact of Aircraft emissions upon the Atmosphere', Paris, France, 15-18 Oct. 1996
Bibliography: Paris, France, 15-18 Oct. 1996, vol. II, pp. 641-646.

Rozanov E. V., T. A. Egorova, V. A. Zubov, Y. E. Ozolin and S. Jagovkina, "The Model Evaluation of Subsonic Aircraft Effect on Ozone and Radiative Forcing", (1997). Book, Published
Editor(s): A. Staniforth
Collection: Research Activities in Atmospheric and Ocean Modelling
Bibliography: Rep. 25, Jan. 1997, WMO/TD - No. 792, pp. 7.58-7.59

Rozanov, E. V., M. E. Schlesinger, F. Yang and N. Andronova, "UIUC-3D Model", (1999). Book, Published
Editor(s): Park, J. H., M. K. W. Ko, C. H. Jackman, R. A. Plumb, J. A. Kaye, K. H. Sage
Collection: Models and Measurements II, NASA/TM-1999-209554
Bibliography: NASA, Hampton, Virginia, 102-106

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Contributions

Contributions within Discipline:

We have and are conducting a program of research on the science, impacts and policy of human-induced climate change. Some of the highlights of this research are described below.

o We discovered a 65-70 year oscillation in the observed surface temperatures for the North Atlantic Ocean and its bordering continental regions (Schlesinger and Ramankutty 1994a; Schlesinger and Ramankutty 1994b), and we showed that this oscillation was not the result of climatic (red) noise (Schlesinger and Ramankutty 1995). Although this oscillation is not global, it is present in the observed record of global-mean surface air temperature. This oscillation is predominantly responsible for the observed increase in global-mean temperature from 1904 to 1944 and the subsequent decrease from 1944 to 1976 (Andronova and Schlesinger 2000). Our finding was reported in Discover magazine as one of 'The Top 75 Science Stories' of 1994.

o We have published in Geophysical Research Letters the paper 'Causes of Global Temperature Changes During the 19th and 20th Centuries' (Andronova and Schlesinger 2000), in which we stated:

'According to our results, the anthropogenic effect, while present during the entire 20th century, has steadily increased in size such that it presently is the dominant external forcing of the climate system. Nonetheless, the residual factor is at work within the climate system. What is the residual factor responsible for the observed 1904-1944 warming and subsequent 1944-1976 cooling? A possible explanation for this was given by (Schlesinger and Ramankutty 1994b) as being the result of a temperature oscillation over the North Atlantic Ocean and its adjacent land areas with a period of 65-70 years. Another possible explanation is a missing climate forcing (Hansen et al. 1997). Accordingly, it is prudent not to expect continued year-after-year warming in the near future and, in so doing, diminish concern about global warming should global cooling instead manifest itself again.'

Results from this paper were mentioned in the 14 July 2000 New York Times article by Andrew Revkin, 'Study Faults Humans for Large Share of Global Warming.' This research was also described in an Associated Press story and in several newspapers.

o We have forthcoming in the Journal of Geophysical Research the paper 'Objective Estimation of the Probability Density Function for Climate Sensitivity' (Andronova and Schlesinger 2001), wherein we stated:

'The size and impacts of anthropogenically induced climate change (AICC) strongly depend on the climate sensitivity, . If is less than the lower bound given by the Intergovernmental Panel on Climate Change (IPCC), 1.5?C, then AICC may not be a serious problem for humanity. If is greater than the upper bound given by the IPCC, 4.5?C, then AICC may be one of the most severe problems of the 21st century. Here we use a simple climate/ocean model, the observed near-surface temperature record and a bootstrap technique to objectively estimate the probability density function (pdf) for . We find that as a result of natural variability and uncertainty in the climatic radiative forcing, the 90% confidence

interval for _ is 1.0?C to 9.3?C. Consequently, there is a 54% likelihood that lies outside the IPCC range.'

o We have constructed and further developed the following suite of climate and chemistry models: (1) 2-layer and 7-layer tropospheric general circulation models (GC models or GCMs); (2) 11-layer troposphere/lower-stratosphere GCM (Wang and Schlesinger 1999); (3) 24-layer stratosphere/troposphere radiative-convective model; (4) 24-layer stratosphere/troposphere GCM (Yang et al. 2000); (5) 24-layer atmospheric chemistry transport model, wherein the concentrations of 43 chemical species are determined by 199 gas-phase and 8 heterogeneous reactions (Rozanov et al. 1999b); (6) coupled 24-layer stratosphere/troposphere GC/photochemistry model, with the same chemical species and reactions (Rozanov et al. 2001b); (7) 26-layer stratosphere/troposphere GCM; (8) 36-layer mesosphere/stratosphere/troposphere GCM; (9) 18-layer ocean GCM; (10) coupled 11-layer stratosphere/lower-stratosphere/18-layer ocean GCM; and (11) coupled 24-layer atmosphere-chemistry/ocean GCM.

o We used our 2-layer tropospheric GC/mixed-layer-ocean/sea-ice model coupled to an ice-sheet/asthenosphere model to simulate the onset of the last glacial period 115,000 years ago and found that glacial onset required the reduction in the concentrations of CO2 and CH4 in addition to the Milankovitch radiative forcing (Schlesinger and Verbitsky 1996).

o We used our 7-layer tropospheric GCM to simulate the climate from 1979-1988 for the first program of the Atmospheric Model Intercomparison Project (AMIP, Phillips 1994).

o We used our 11-layer tropospheric/lower-stratospheric GCM to determine the dependence on convection parameterization of the tropical intraseasonal oscillation (TIO). It was found that the simulated TIO is highly dependent on the relative humidity criterion for convection to occur, RHc. As RHc increases, the TIO in the simulations becomes stronger for all three convection parameterizations examined, namely, convective-adjustment, Kuo, and Arakawa-Schubert convection parameterizations. This dependence of the amplitude of the simulated oscillation on RHc appears to explain the differences in the TIO among previous simulations by different GCMs (Wang 1996; Wang and Schlesinger 1995; Wang and Schlesinger 1999).

o To enable construction of geographical scenarios of greenhouse-gas and anthropogenic-sulfate-aerosol induced climate changes for the Impact Analysis Study Group of the Stanford Energy Modeling Forum 14 û Integrated Assessment of Climate Change, Working Group II of the IPCC, and others, we have performed several simulations of equilibrium climate with the 4? latitude by 5? longitude version of our 11-layer tropospheric/lower-stratospheric GCM coupled to our mixed-layer-ocean/sea-ice model. We have performed simulations with this model for the present climate (control), the equilibrium climate resulting from doubling the CO2 amount (2xCO2), and the equilibrium climates induced by the anthropogenic emission of SO2 gas which is converted in the atmosphere into sulfate (SO4) aerosol. For the latter we have performed 9 simulations: a 1xSO4 simulation for the present-day atmospheric burden of SO4, a 10xSO4 simulation in which the global sulfate burden was decupled, and 7 simulations for regional 10xSO4 burdens û one each for Europe, North Africa, Siberia, Asia, North America and the Southern Hemisphere û and the seventh for all regions other than Europe. We have also performed a joint 2xCO2+5xSO4 simulation, as well as simulations for the solar constant increased by 2%, a perpetual Pinatubo-like volcano stratospheric sulfate aerosol, and a future tropospheric ozone increase calculated by our 24-layer atmospheric chemistry-transport model (Rozanov et al. 1999b). Daily and monthly data for a large number of climatic quantities from these simulations are available at ftp://crgd.atmos.uiuc.edu/pub/emf.

o We have calculated the change in global-mean temperature and sea level for the four marker scenarios developed by the IPCC Special Report on Emissions Scenarios (SRES) and for Post-SRES emissions scenarios that stabilize the CO2 concentration at several different levels, and we have calculated the corresponding geographical distributions of temperature change for 2100. We have published this research in Technological Forecasting and Social Change, 'Geographical Distributions of Temperature Change for Scenarios of Greenhouse Gas and Sulfur Dioxide Emissions' (Schlesinger et al. 2000), and in Integrated Assessment, 'Changes in Near-Surface Temperature and Sea Level for the Post-SRES CO2-Stabilization Scenarios' (Schlesinger and Malyshev 2001).

The geographical scenarios of the SO2-induced climate changes that we have constructed have been used by the IPCC in their analysis of the impacts of climate change (Carter et al. 2000). We have also provided to RIVM û the Bureau for Environmental and Nature Assessments National Institute of Public Health and the Environment located in de Bilt, Netherlands û our geographical distributions of greenhouse-gas (CO2) and sulfate aerosol (SO2) induced climate changes for use in their IMAGE integrated-assessment model.
o Our 24-layer tropospheric/stratospheric GCM has been used to: (1) reconstruct the radiative forcing of historical volcanic eruptions (Andronova et al. 1999); (2) simulate the atmospheric climate from 1979 through 1995 for the AMIP-II project, the wind and temperature fields from which are used in our Atmospheric Chemistry-Transport Model (ACTM) simulations; (3) simulate the distributions of source gases and ozone in the stratosphere coupled with our chemical-transport model (Rozanov et al. 1999b); and (4) study the climatic impact of the Mount Pinatubo volcanic eruption (Yang 1999).

o We have used our 24-layer atmospheric chemistry transport model to determine the effect of the Montreal Protocol on atmospheric ozone. In our paper 'Assessment of the Effect of the Montreal Protocol on Atmospheric Ozone,' published in Geophysical Research Letters the paper

(Egorova et al. 2001), we stated:

'Here we present the first 3D-model assessment of the effect of the MPA (Montreal Protocol and its Amendments) on atmospheric ozone, which has been performed with the University of Illinois at Urbana-Champaign (UIUC) Atmospheric Chemical Transport Model (ACTM). We find that the MPA has saved up to 2% of the present-day total ozone in the Northern Hemisphere and up to 5% in the Southern Hemisphere. Our calculations also show that CFCs do not play the major role in the observed recent total ozone variations.'

o We have used our coupled 24-layer stratosphere/troposphere GC/photochemistry model to study the effects on the stratosphere and troposphere of the June 1991 eruption of the Pinatubo volcano (Rozanov et al. 2001a) and, separately, the observed variation in solar ultraviolet radiation from solar minimum to solar maximum.

o We are presently using our coupled 11-Layer Troposphere/Lower-Stratosphere/18-Layer Ocean GCM to simulate the geographical distribution of climate change resulting from a shutdown of the ocean thermohaline circulation, which may occur in the future as a result of global warming. We are also using this model to simulate the geographical distribution of climate change from 1871 to the present, both with and without conjectured variations in the solar irradiance. By comparing these simulations with the corresponding observed geographical distributions of temperature, we seek to determine whether the sun has influenced climate. We do this because our research has shown that if the sun has influenced climate, the climate sensitivity is reduced by about 50% from its value if the sun has not influenced climate (Andronova and Schlesinger 2000; Andronova and Schlesinger 2001). Thus it is of major importance for the development of climate-change policy to determine whether the sun actually has influenced climate.

o We have participated in eight model intercomparison activities: (1) the Atmospheric Model Intercomparison Project (AMIP) parts I (Phillips 1994) and II (Gleckler 1999), (2) the Feedback ANalyses in GCMs and In Observations (FANGIO) program (Cess et al. 1996; Cess et al. 1997), (3) the Paleoclimate Model Intercomparison Project (PMIP Joussaume and Taylor 1995; Joussaume et al. 1999), (4) the NASA-sponsored Models and Measurements II program (Rozanov et al. 1999a), (5) the Intercomparison of Models Representing Direct Shortwave Radiative Forcing By Sulfate Aerosols (Boucher et al. 1998), (6) the Intercomparison of GCMs' Radiation Codes within the framework of GRIPS, (7) part III of the Intercomparison of Radiation Codes used in Climate Models (ICRCCM-3) program (Barker et al. 2001; Partain et al. 1998), and (8) the Threshold Sea Surface Temperature for Convection project (Randall et al. 2001).

o In our antecedent 5-year NSF Grant (ATM-9001310) we developed the Cause-and-Effect Analysis (CEA) technique to determine the sensitivity and stability of geophysical models (Andronova and Karol 1993; Andronova et al. 1993; Andronova and Schlesinger 1991; Andronova and Schlesinger 1992). Under the present grant we further developed the CEA technique to determine the feedbacks of geophysical models (Andronova and Schlesinger 1996).

o We have collaborated with Robert Lempert (Rand) on developing Robust Adaptive Strategies for Abating Climate Change (Lempert and Schlesinger 1995; Lempert and Schlesinger 1997; Lempert and Schlesinger 2000; Lempert and Schlesinger 2001a; Lempert and Schlesinger 2001b; Lempert et al. 1996; Lempert et al. 2000).

o We have collaborated with Robert Mendelsohn (School of Forestry and Environmental Studies, Yale University) on developing and applying climate-response functions which we have used to estimate the impacts of climate change on 5 market sectors û agriculture, forestry, coastal resource, energy, water (Mendelsohn et al. 1998; Mendelsohn et al. 2000a; Mendelsohn et al. 2001; Mendelsohn and Schlesinger 1999; Mendelsohn et al. 2000b).

o We have collaborated with Larry Williams (Electric Power Research Institute) to develop and distribute a CD-based COuntry Specific Model for Intertemporal Climate (COSMIC) to calculate country-specific changes in the annual cycle of temperature and precipitation for each of 158 countries for each of 14 GCM simulations, this in response to a request for such a model from a Kenyan participant at the IPCC Asia-Pacific Workshop on Integrated Assessment Models, 10-12 March 1997 (Schlesinger and Williams 1997). As of 9 July 2001, CD copies of COSMIC have been distributed to 119 requestors from 43 countries (Albania, Australia, Belgium, Brazil, Bulgaria, Cameroon, Canada, China, Costa Rica, Djibouti, Egypt, Ethiopia, Finland, Germany, Greece, Hungary, India, Indonesia, Japan, Kiribati, Korea, Mauritius, Mexico, Mozambique, Netherlands, Norway, Philippines, Poland, Romania, Russia, Senegal, Slovenia, South Africa, Sri Lanka, Sudan, Swaziland, Sweden, Thailand, Tunisia, United Kingdom, United States, Vietnam, Zimbabwe).

o We have collaborated with Gary Yohe (Wesleyan University) to investigate the expected economic cost of protecting or abandoning coastal property in the United States in the face of rising sea level (Yohe and Schlesinger 1998).

o We have collaborated with Marty Hoffert (New York University) on the energy implications of future stabilization of atmospheric CO2 content (Hoffert et al. 1998). We found that CO2 stabilization with continued economic growth will require innovative, cost-effective and carbon-emission-free technologies that can provide additional tens of terrawatts of primary power in the coming decades, and certainly by

mid-century, even with sustained improvement in the economic productivity of primary energy.

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Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Science and Technology Infrastructure:

Contributions: Beyond Science or Engineering:

Categories for which nothing is reported:

Organizational Partners
Activities and Findings: Any Project Training and Development
Contributions: To Any Other Disciplines
Contributions: To Any Contributions to Human Resource Development
Contributions: To Any Science or Technology Infrastructure
Contributions: Beyond Science or Engineering