

ATTACHMENT 1

GLOBAL CLIMATE CHANGE SCIENCE -- OVERVIEW OF RECENT DEVELOPMENTS

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**EEL ENVIRONMENT & ENERGY COMMITTEE
MONTEREY, CALIFORNIA**

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INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- O PERCEIVED TO PRODUCE THE STATE-OF-THE-ART ASSESSMENTS
- O FIRST ASSESSMENT REPORT IN 1990
- O THREE WORKING GROUPS:
 - WG I -- SCIENCE
 - WG II -- IMPACTS, ADAPTATION AND MITIGATION OPTIONS
 - WG III -- SOCIO-ECONOMICS
- O DECEMBER 1995 -- SECOND ASSESSMENT REPORT APPROVED

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IPCC SECOND ASSESSMENT REPORT

- O 50 CHAPTERS (1900+ PAGES) WRITTEN AND REVIEWED BY 2000 EXPERTS**
- O SUMMARY FOR POLICYMAKERS (SPM) -- WRITTEN BY MIX OF SCIENTISTS AND POLICYMAKERS, REVISED/APPROVED BY GOVERNMENTS**
- O SYNTHESIS REPORT**
 - WRITTEN BY 25 MOSTLY POLICYMAKERS, REVISED/APPROVED BY GOVERNMENTS**
 - DRAWS TOGETHER SPM RESULTS PLUS ADDRESSES ARTICLE 2 OF THE FCCC, WHICH CALLS FOR:**

"STABILIZATION OF GREENHOUSE GAS CONCENTRATIONS IN THE ATMOSPHERE AT A LEVEL THAT WOULD PREVENT DANGEROUS ANTHROPOGENIC INTERFERENCE WITH THE CLIMATE SYSTEM"

SCIENCE -- BASICS

- O GREENHOUSE EFFECT IS NATURAL AND BENEFICIAL
- O REAL CONCERN IS MAN-INDUCED ENHANCED GREENHOUSE EFFECT
- O GHG EMISSIONS AND CONCENTRATIONS ON THE RISE
- O GLOBAL MEAN TEMPERATURE UP 0.3-0.6 DEGREES C OVER PAST CENTURY, BUT WITHIN BOUNDS OF NATURAL CLIMATIC VARIABILITY
- O GLOBAL MEAN TEMPERATURE INCREASE 1.5-4.5 DEGREES C WITH 2XCO₂
- O AEROSOLS, EL NINO AND VOLCANIC ERUPTIONS IMPORTANT
- O MODELS TO PREDICT FUTURE QUITE LIMITED -- HOW MUCH, WHERE AND WHEN KNOWN WITH LITTLE CONFIDENCE
- O NO CONFIDENCE PREDICTING REGIONAL CLIMATE CHANGE
- O IMPACT STUDIES SCATTERED AND HIGHLY UNCERTAIN

IPCC SECOND ASSESSMENT REPORT -- KEY NEW FINDINGS/PREDICTIONS

- O TEMPERATURE AND SEA LEVEL RISE PREDICTIONS ADJUSTED DOWNWARD**
- O MAN'S INFLUENCE ON GLOBAL CLIMATE "DISCERNIBLE"**
- O IMPACTS -- THREATENING PREDICTIONS, ESPECIALLY REGARDING HUMAN HEALTH**
- O NO PROOF OF WIDESPREAD INCREASINGLY VARIABLE CLIMATE, BUT SOME PLAUSIBLE THEORIES OF GREATER EXTREMES IN FUTURE**

TEMPERATURE AND SEA LEVEL

OBSERVED DURING LAST 100 YEARS

- O TEMPERATURE -- 0.3-0.6 DEGREES C INCREASE (GLOBAL MEAN)**

- O SEA LEVEL -- 10-25 CM RISE, WITH "MUCH OF THE RISE MAY BE RELATED TO THE INCREASE IN GLOBAL MEAN TEMPERATURE"**

TEMPERATURE AND SEA LEVEL

PREDICTED CHANGE BY 2100 (FROM 1990)

O TEMPERATURE

- 1.0-3.5 DEGREES C INCREASE (GLOBAL MEAN)
- BEST ESTIMATE OF 2.0 DEGREES C INCREASE IS 33% LOWER THAN IN 1990 IPCC REPORT
- IN ALL CASES, THE AVERAGE RATE OF WARMING WOULD PROBABLY BE GREATER THAN ANY SEEN IN PAST 10,000 YEARS

O SEA LEVEL

- 15-95 CM (AT TIME OF CO₂ DOUBLING/ CONTINUED INCREASE AFTERWARDS)
- BEST GUESS OF 50 CM IS 25% LOWER THAN IN 1990 IPCC REPORT

MAJOR UNCERTAINTIES WITH IPCC PREDICTIONS OF THE FUTURE

- O ESTIMATION OF FUTURE EMISSIONS -- REQUIRES KNOWLEDGE OF ECONOMICS, POPULATION, TECHNOLOGIES, AS WELL AS THE UPTAKE BY LAND PLANTS AND OCEANS OF CO₂**
- O REPRESENTATION OF CLIMATE PROCESSES IN MODELS, ESPECIALLY FEEDBACKS**
- O UNDERSTANDING OF NATURAL VARIABILITY**

ANTHROPOGENIC INFLUENCE ?

IPCC SYNTHESIS REPORT:

- O 0.3-0.6 DEGREES C GLOBAL INCREASE IS "A CHANGE UNLIKELY TO BE ENTIRELY NATURAL IN ORIGIN"**
- O "THE BALANCE OF EVIDENCE... SUGGESTS A DISCERNABLE HUMAN INFLUENCE ON GLOBAL CLIMATE. THERE ARE UNCERTAINTIES IN KEY FACTORS, INCLUDING THE MAGNITUDE AND PATTERNS OF LONG-TERM NATURAL VARIABILITY."**
- O U.S. -- NOAA RESEARCH FINDS THE CHANCE OF CHANGES SINCE 1976 BEING PURELY NATURAL IS 1-20%**

ANTHROPOGENIC INFLUENCE ?

IPCC WG I -- CHAPTER 8:

- O "LARGE UNCERTAINTIES STILL APPLY TO CURRENT ESTIMATES OF THE MAGNITUDE AND PATTERNS OF NATURAL CLIMATE VARIABILITY, PARTICULARLY ON THE DECADAL-TO CENTURY-TIME SCALES THAT ARE CRUCIAL TO THE DETECTION PROBLEM"**
- O "WHEN WILL AN ANTHROPOGENIC EFFECT ON CLIMATE BE IDENTIFIED?"**
 - WE DO NOT KNOW**
 - FEW IF ANY WOULD BE WILLING TO ARGUE THAT UNAMBIGUOUS ATTRIBUTION OF THIS CHANGE TO ANTHROPOGENIC EFFECTS HAS ALREADY OCCURRED, OR IS LIKELY TO HAPPEN IN THE NEXT SEVERAL YEARS"**

OTHER POINTS

- O A SMALL CHANGE THAT IS ALMOST MEANINGLESS IN THE REAL WORLD CAN BE STATISTICALLY SIGNIFICANT**
- O MANY WILL CLAIM THIS "DETECTION OF A DISCERNIBLE INFLUENCE" AS A WATERSHED EVENT AND USE THIS AS REASON TO ARGUE FOR A PROTOCOL BEFORE THE AGBM**

PREDICTED ENVIRONMENTAL IMPACTS -- GENERAL

- O MIX OF ADVERSE IMPACTS, SOME POTENTIALLY IRREVERSIBLE, AND SOME BENEFICIAL IMPACTS**
- O COMPOSITION AND GEOGRAPHIC DISTRIBUTIONS OF MANY ECOSYSTEMS WILL SHIFT**
- O CLIMATE CHANGE IS AN ADDITIONAL STRESS ON TOP OF POLLUTION, INCREASED RESOURCE DEMANDS AND NONSUSTAINABLE MANAGEMENT PRACTICES**

ENVIRONMENTAL IMPACTS -- GENERAL UNCERTAINTIES

- O QUANTITATIVE PREDICTIONS OF IMPACTS FOR ANY PARTICULAR SYSTEM AT ANY PARTICULAR LOCATION ARE DIFFICULT BECAUSE:**
 - REGIONAL-SCALE CLIMATE CHANGE PREDICTIONS ARE UNCERTAIN**
 - UNDERSTANDING OF MANY CRITICAL PROCESSES IS LIMITED**
 - SYSTEMS ARE SUBJECT TO MULTIPLE CLIMATIC AND NON-CLIMATIC STRESSES**
 - FEW STUDIES HAVE CONSIDERED DYNAMIC RESPONSES**

- O UNAMBIGUOUS DETECTION OF CLIMATE-INDUCED CHANGES IN MOST ECOLOGICAL AND SOCIAL SYSTEMS WILL PROVE EXTREMELY DIFFICULT IN THE COMING DECADES**

PREDICTED ENVIRONMENTAL IMPACTS -- **FORESTS AND AGRICULTURE**

FORESTS

- O WARMING OF 1-3.5 DEGREE C OVER 100 YEARS WOULD BE EQUIVALENT TO A POLEWARD SHIFT OF PRESENT ISOTHERMS BY APPROXIMATELY 150-550 KM (TREE MIGRATION RATES 4-200 KM PER CENTURY)**
- O NEW ASSEMBLAGES OF SPECIES AND NEW ECOSYSTEMS MAY BE ESTABLISHED**
- O 1/7 TO 1/3 OF EXISTING FORESTED AREA WILL UNDERGO MAJOR CHANGES IN BROAD VEGETATION TYPES**
- O FOREST DIEBACK COULD LEAD TO LARGE C RELEASE**

AGRICULTURE

- O IMPACTS VARY CONSIDERABLY ACROSS REGIONS**
- O GLOBAL AGRICULTURAL PRODUCTIVITY COULD BE MAINTAINED RELATIVE TO CURRENT LEVELS UNDER 2XCO₂**

PREDICTED ENVIRONMENTAL IMPACTS - COASTAL SYSTEMS

- O RISE IN SEA LEVEL OR CHANGES IN STORMS/STORM SURGES COULD RESULT IN:**
 - EROSION OF SHORES**
 - INCREASED SALINITY OF ESTUARIES AND FRESHWATER AQUIFERS**
 - INCREASED COASTAL FLOODING**
 - ECOLOGICAL IMPACTS**
- O 50 CM SEA LEVEL RISE WOULD INCREASE FROM 46 TO 92 MILLION THE NUMBER OF PEOPLE PER YEAR AT RISK OF FLOODING DUE TO STORM SURGES**
- O ESTIMATED LAND LOSSES AS HIGH AS 80%**

PREDICTED ENVIRONMENTAL IMPACTS - HYDROLOGICAL SYSTEMS

- O MORE SEVERE FLOODS AND DROUGHTS IN SOME PLACES AND LESS SEVERE IN OTHERS**
- O CHANGES IN RUNOFF, QUANTITY AND QUALITY OF WATER SUPPLIES.**

PREDICTED ENVIRONMENTAL IMPACTS - HEALTH

- O MOSTLY ADVERSE IMPACTS, WITH SIGNIFICANT LOSS OF LIFE DUE TO:**
 - HEAT WAVES**
 - VECTOR-BORNE INFECTIOUS DISEASE SUCH AS MALARIA, DENGUE, YELLOW FEVER**
 - RESPIRATORY AND ALLERGIC DISORDERS**
 - DECLINE IN NUTRITIONAL STATUS**
 - LIMITATIONS ON FRESHWATER SUPPLIES**
- O 3-5 DEGREE C LEAD TO 10% INCREASE MALARIA (50-80 MILLION NEW CASES)**
- O QUANTIFYING THE POTENTIAL IMPACTS IS DIFFICULT DUE TO VARYING CIRCUMSTANCES SUCH AS NUTRITION, WEALTH, ACCESS TO QUALITY HEALTH SERVICES**

IMPACTS - WELFARE

O IMPACTS EXPECTED FOR:

- ENERGY
- INDUSTRY
- TOURISM
- TRANSPORTATION INFRASTRUCTURE
- HUMAN SETTLEMENTS
- INSURANCE
- CULTURAL SYSTEMS AND VALUES

O AMONG SECTORS AND ACTIVITIES STATED TO BE MOST SENSITIVE ARE:

- ENERGY DEMAND
- PRODUCTION OF RENEWABLE ENERGY SUCH AS HYDROELECTRICITY AND BIOMASS

VULNERABILITY

- O SOME COMMUNITIES MORE VULNERABLE BECAUSE OF INCREASING POPULATION DENSITY IN SENSITIVE AREAS**
- O DEVELOPING COUNTRIES, WHERE ECONOMIC AND INSTITUTIONAL CIRCUMSTANCES ARE LESS FAVORABLE, TYPICALLY MORE VULNERABLE**
- O QUANTITY AND QUALITY OF WATER SUPPLIES IS ALREADY A SERIOUS PROBLEM IN MANY REGIONS**
- O MANY OF THE WORLD'S POOREST PEOPLE POTENTIALLY MOST AT RISK OF WORSENING AGRICULTURAL SITUATIONS**
- O FRAGMENTED LANDSCAPES CAN INCREASE THE VULNERABILITY OF LIGHTLY-MANAGED AND UNMANAGED ECOSYSTEMS**
- O ADAPTATION OPTIONS FOR MANAGED SYSTEMS AVAILABLE BUT LESS SO FOR MANY REGIONS DUE TO HIGH COST OR LIMITED ACCESS TO TECHNOLOGIES AND INFORMATION**

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CLIMATE EXTREMES -- RECORD TEMPERATURES IN THE 1990'S

- O BRITISH -- GLOBAL MEAN TEMPERATURE IN 1995 HIGHEST SINCE RECORDS KEPT IN 1856**
- O NASA -- 1995 TIED WITH 1990 AS HOTTEST YEAR SINCE 1866**
- O BRITISH -- 1991-1995 WARMEST 5-YEAR PERIOD, EVEN WITH MT PINATUBO'S COOLING INFLUENCE FROM 1991-94**
- O SATELLITES -- 1995 AVERAGE COMPARED TO 1982-1991 -- MEASURE ENTIRE LOWER ATMOSPHERE, WHEREAS BRITISH AND NASA RESULTS ARE FOR SURFACE ONLY**

CLIMATE EXTREMES -- MORE FREQUENT/VIGOROUS STORMS NOW?

- O THE INSURANCE INDUSTRY IS CURRENTLY UNDER STRESS FROM A SERIES OF BILLION DOLLAR STORMS SINCE 1987**
- O THE IPCC IS CAUTIOUS:**
 - "SOME IN THE INSURANCE INDUSTRY PERCEIVE A CURRENT TREND TOWARD INCREASED FREQUENCY AND SEVERITY OF EXTREME CLIMATIC EVENTS. EXAMINATION OF THE METEOROLOGICAL DATA FAILS TO SUPPORT THIS PERCEPTION IN THE CONTEXT OF A LONG-TERM CHANGE, ALTHOUGH A SHIFT WITHIN THE LIMITS OF NATURAL VARIABILITY MAY HAVE OCCURRED."**
 - HIGHER LOSSES STRONGLY REFLECT INCREASES IN INFRASTRUCTURE AND ECONOMIC WORTH IN VULNERABLE AREAS**
 - ON REGIONAL SCALES THERE IS CLEAR EVIDENCE OF CHANGES IN SOME EXTREMES AND CLIMATE VARIABILITY INDICATORS. SOME CHANGES HAVE BEEN TOWARD GREATER VARIABILITY, SOME HAVE BEEN TOWARD LOWER VARIABILITY**
 - TO-DATE IT HAS NOT BEEN POSSIBLE TO FIRMLY ESTABLISH A CLEAR CONNECTION BETWEEN THESE REGIONAL CHANGES AND HUMAN ACTIVITIES**

CLIMATE EXTREMES -- MORE FREQUENT/VIGOROUS STORMS NOW?

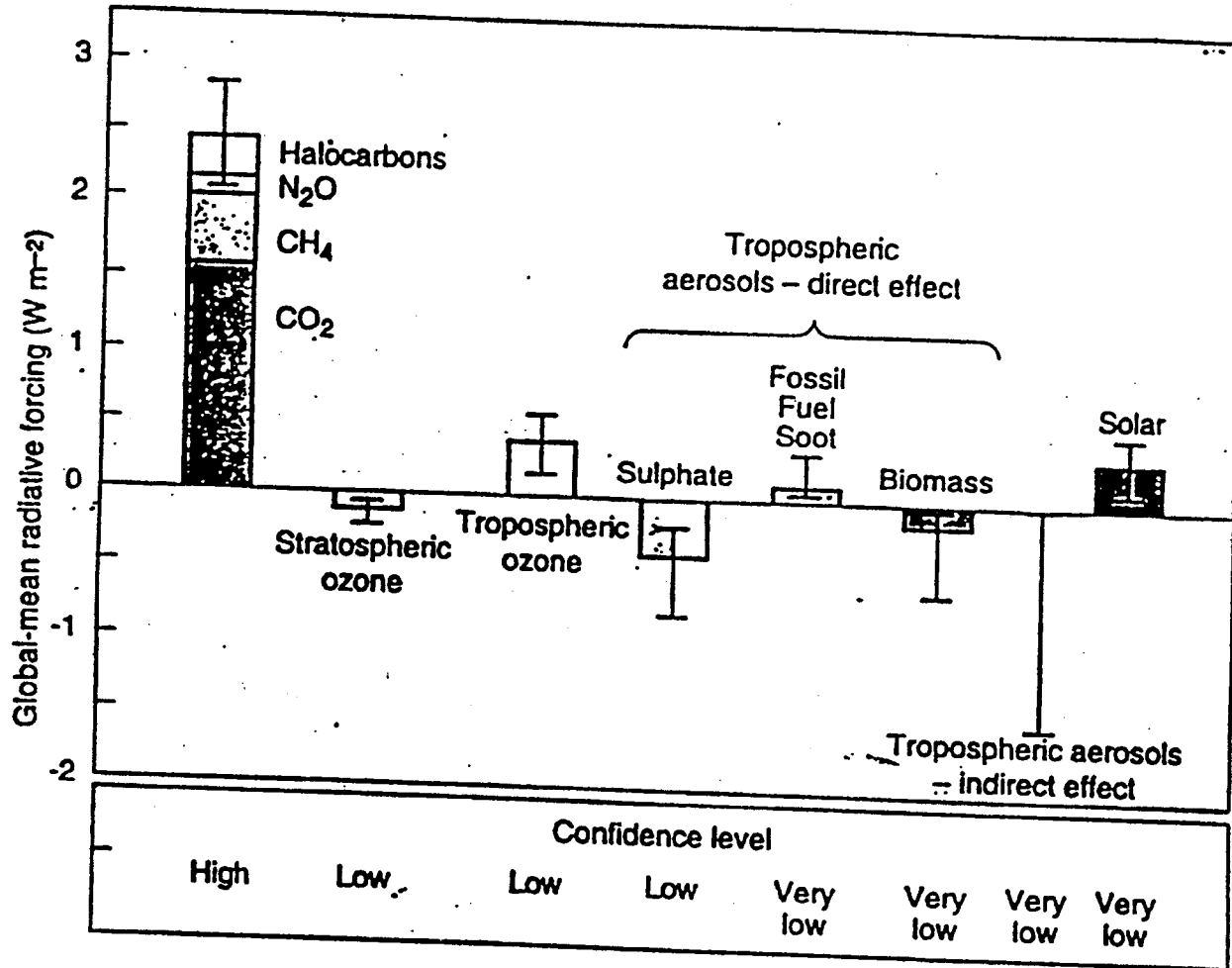
O REGARDING THE *FUTURE*:

- **PROSPECTS FOR MORE SEVERE FLOODS AND DROUGHTS IN SOME PLACES AND LESS SEVERE IN OTHERS**
- **THE RELIABILITY OF REGIONAL-SCALE PREDICTION IS LOW AND THE DEGREE TO WHICH CLIMATE VARIABILITY MAY CHANGE IS UNCERTAIN**

OTHER SIGNIFICANT FINDINGS

- O SULFATE AEROSOLS FROM SO₂ EMISSIONS DUE TO MAN AND VOLCANOS WORK COUNTER TO GHG
- O TROPOSPHERIC OZONE IS IMPORTANT GREENHOUSE GAS BUT NO_x CONTRIBUTION TO IT UNCERTAIN/VARIABLE SO NO_x GWP REMAINS UNDEFINED
- O SOME LONG-LIVED GHG -- HFC'S AND SF₆ -- CONTRIBUTE LITTLE TO RADIATIVE FORCING NOW BUT PROJECTED GROWTH COULD LEAD TO SEVERAL PERCENT TO RADIATIVE FORCING
- O GROWTH IN CONCENTRATION OF CFC'S SLOWED TO ABOUT ZERO

Global-mean radiative forcing 1850 — 1990



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OTHER WORKING GROUP I ISSUES -- STABILIZATION ANALYSES

- O IF CO₂ MAINTAINED AT 1994 LEVELS, REACH ABOUT 500 PPM BY 2100 (VERSUS 280 PPM IN 1750 AND 360 PPM NOW)**
- O TO STABILIZE AT 450 PPM, NEED TO DROP TO 1990 LEVELS IN 40 YEARS AND SUBSTANTIALLY LOWER AFTER THAT**
- O IPCC NOTES THAT THE INTEGRAL OF EMISSIONS IS KEY - THE EVENTUAL CONCENTRATION IS GOVERNED MORE BY THE ACCUMULATED CO₂ THAN BY THE WAY THOSE EMISSIONS CHANGE OVER THE PERIOD**

STABILIZATION ANALYSES

TOM WIGLEY (NCAR), RICH RICHELIS (EPRI) AND JAE EDMONDS (BATTELLE) ARTICLE IN NATURE ENTITLED "ECONOMIC AND ENVIRONMENTAL CHOICES IN THE STABILIZATION OF ATMOSPHERIC CO₂ CONCENTRATIONS"

- O MANY DIFFERENT PATHWAYS FOR REDUCING EMISSIONS**
- O IF ALLOWED TO EMIT "X" TONS, BEST ECONOMICALLY TO EMIT AT A HIGHER LEVEL EARLIER FOR SEVERAL REASONS, INCLUDING:**
 - STOCK FOR ENERGY PRODUCTION AND USE IS TYPICALLY LONG-LIVED AND MAKING UNANTICIPATED CHANGES IS VERY COSTLY**
 - IMPROVEMENTS IN THE EFFICIENCY OF ENERGY SUPPLY, TRANSFORMATION AND END-USE WILL RESULT IN LESS COSTLY REDUCTIONS**
- O NOT "DO NOTHING" OR "WAIT AND SEE" -- REQUIRES SUBSTANTIAL RD&D**
- O MINOR ENVIRONMENTAL IMPACT -- 0.2 DEGREE C GLOBAL MEAN TEMPERATURE INCREASE AND 4 CM SEA LEVEL RISE**
- O DOE/EPRI WORK INDICATES UP TO 80% COST REDUCTION BY THE COMBINATION OF ALLOWING EMISSION REDUCTIONS ON A PACE WITH NORMAL INVESTMENTS TO REPLACE INFRASTRUCTURE AND EQUIPMENT, PLUS JOINT IMPLEMENTATION**

OTHER WORKING GROUP II ISSUES

- O MITIGATION OPTIONS
- O ADAPTATION OPTIONS

WORKING GROUP III REPORT

- O EQUITY AND DISCOUNTING**
- O COST-BENEFIT ANALYSIS**
- O SOCIAL COSTS OF CLIMATE CHANGE**
- O ASSESSMENT OF RESPONSE OPTIONS**
- O COSTS OF MITIGATING GREENHOUSE GASES**
- O INTEGRATED ASSESSMENT**

HOW TO OBTAIN THE IPCC REPORTS

- O TARGET PUBLICATION DATE -- LATE MAY 1996
- O COST -- ABOUT \$90 IF PURCHASE 3 VOLUMES IN PAPERBACK BY MARCH 31, 1996