

CLIMATE CHANGE AND VARIABILITY: ROLE OF WMO



Dr Rupa Kumar Kolli

Chief, World Climate Applications & CLIPS Div.

World Climate Programme Department

World Meteorological Organization

Geneva, Switzerland

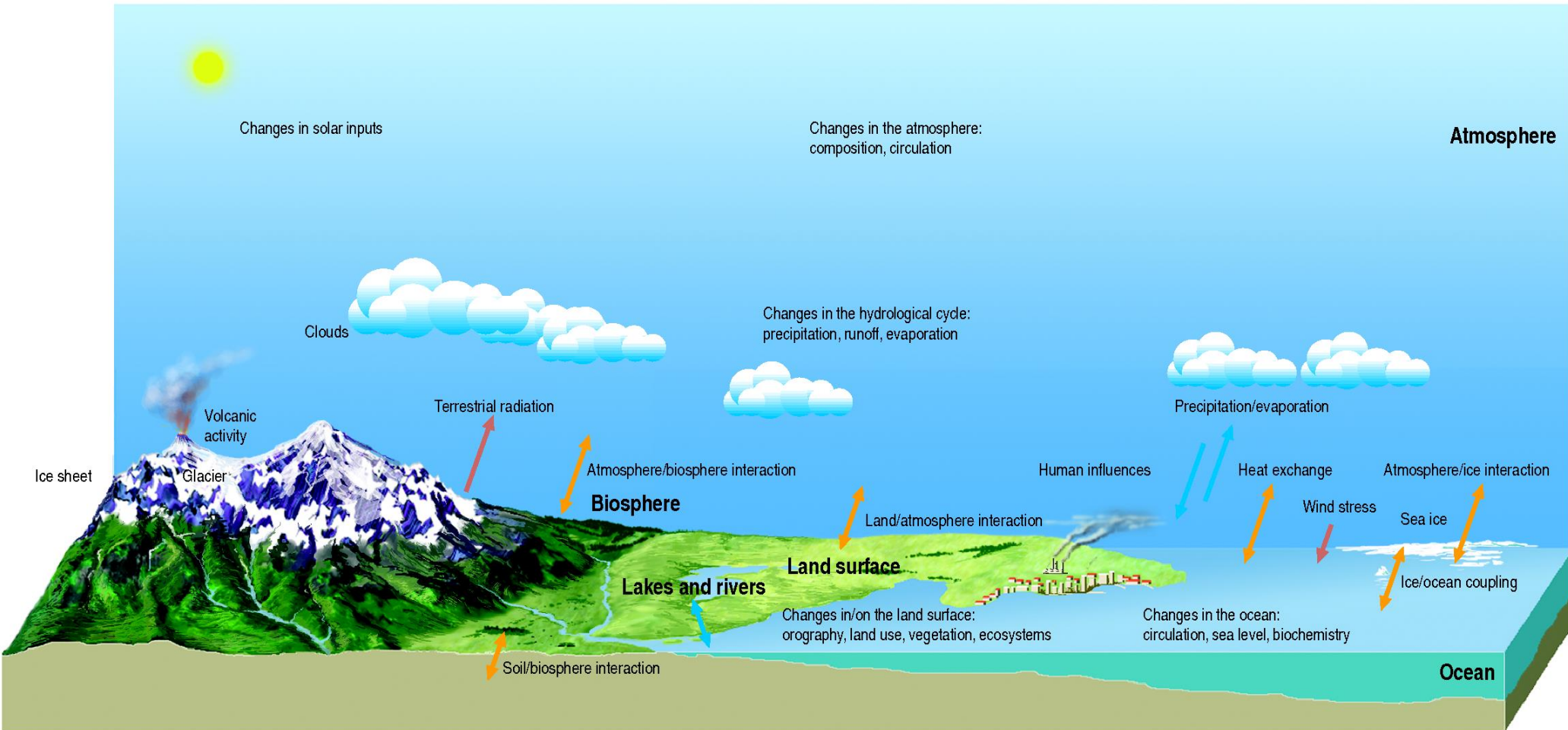
Outline

- Weather and Climate
- Climate Variability and “Change”
- Climate Change Framework
- WMO’s Role in Climate Issues
- WMO Programmes on Climate
- Latest IPCC Climate Change Assessment
- Concluding Remarks

Weather vs. Climate

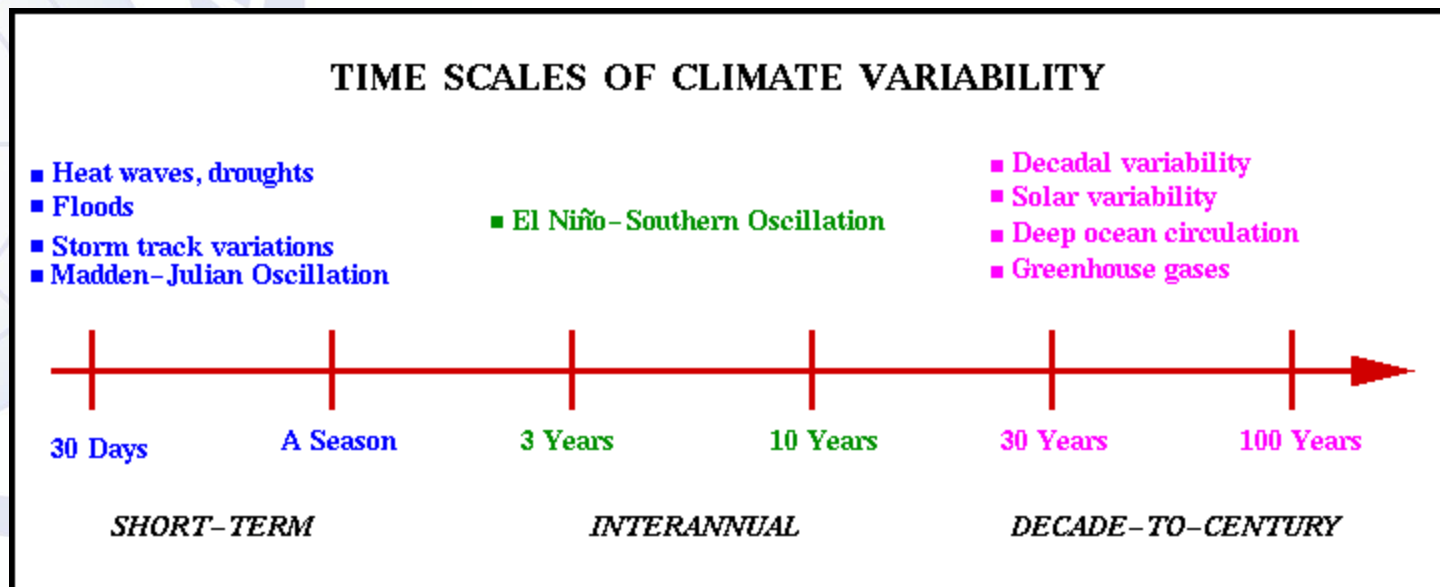
- “Weather” is a snapshot of the state of atmosphere over a relatively short period of time (usually less than a week)
- “Climate” represents an average or collective state of the weather patterns over a long period of time
- Climate = Time average of weather + climate extremes
- Climate is what you expect, weather is what you get

The Climate System



Climate is NOT constant

- Changes in Climate occur on all time and space scales characteristic of the Earth System

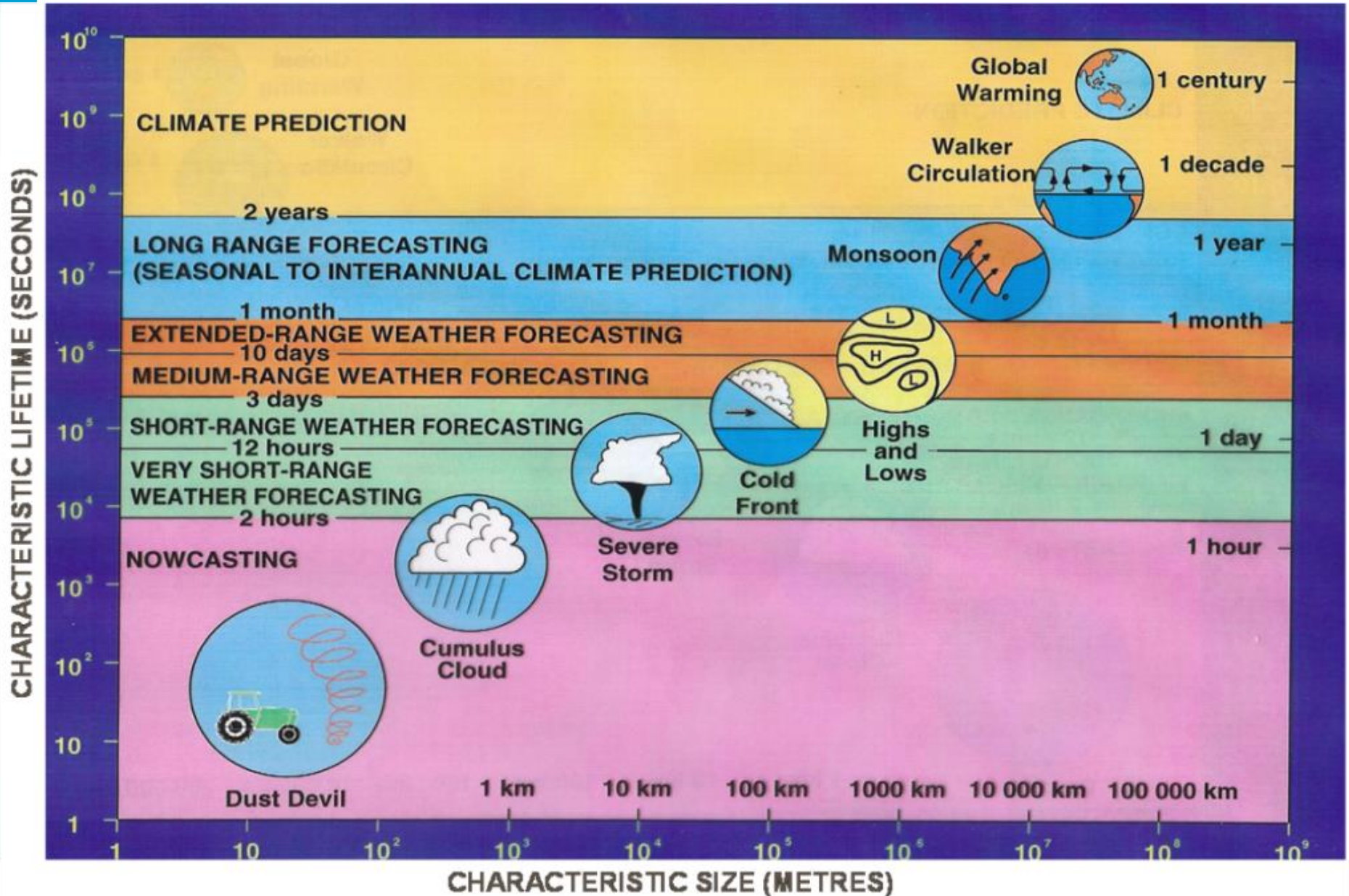


Climate Variability and Change

- Seasonal to interannual fluctuations are considered to be “climate variability”.
 - Anomalies can be expected to recur at intervals less than a decade and the long-term mean state essentially remains the same.
- Decadal and longer time scale changes are considered to be part of what is widely known as “climate change”.
 - Climatic characteristics tend to gradually move towards a substantially different mean state.

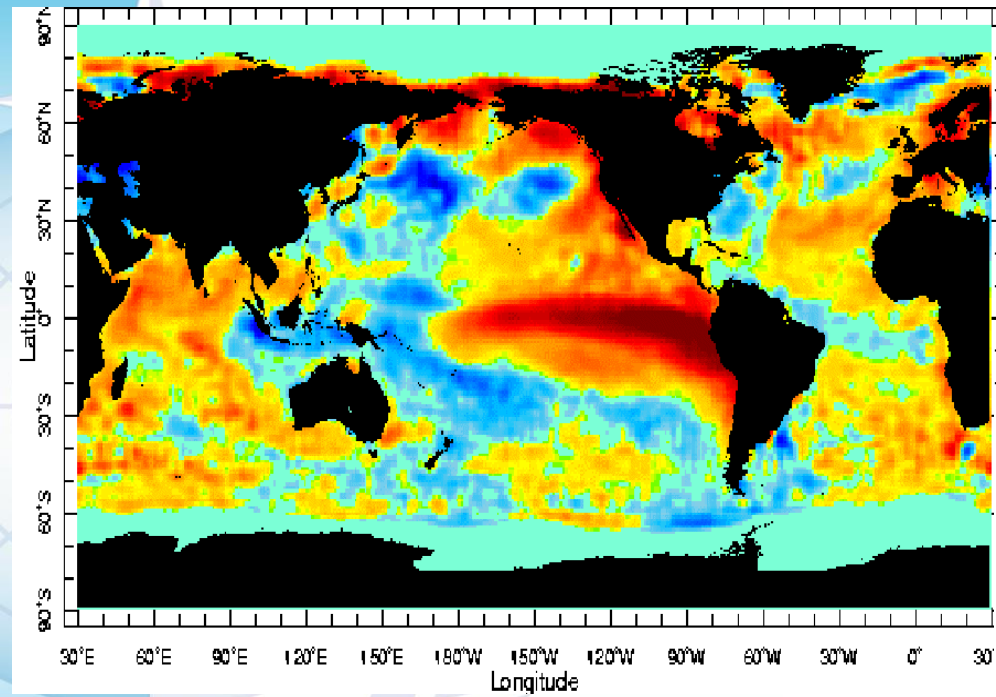


TIME AND SPACE SCALES OF CLIMATE PHENOMENA

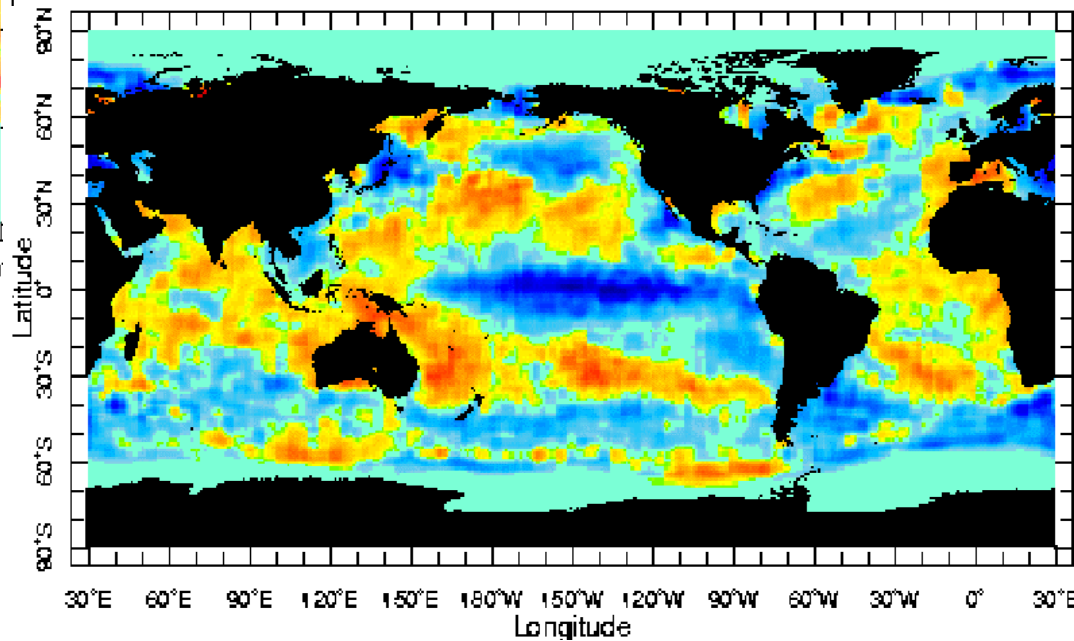


El Niño and La Niña

El Niño (1997)

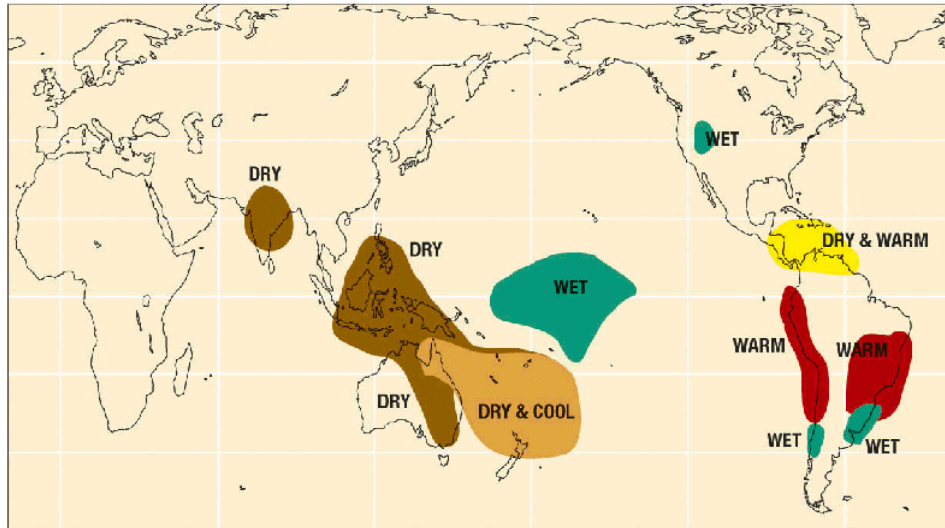


La Niña (1988)

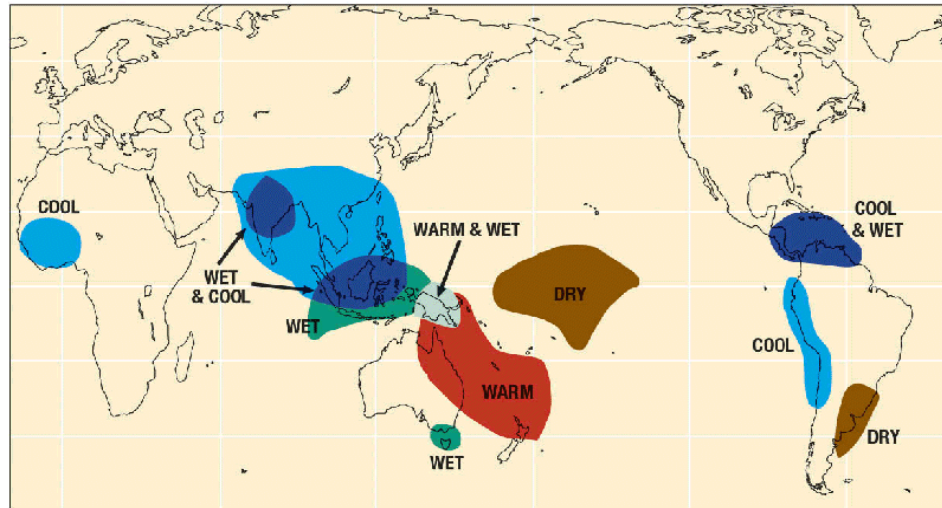


El Niño and La Niña Impacts

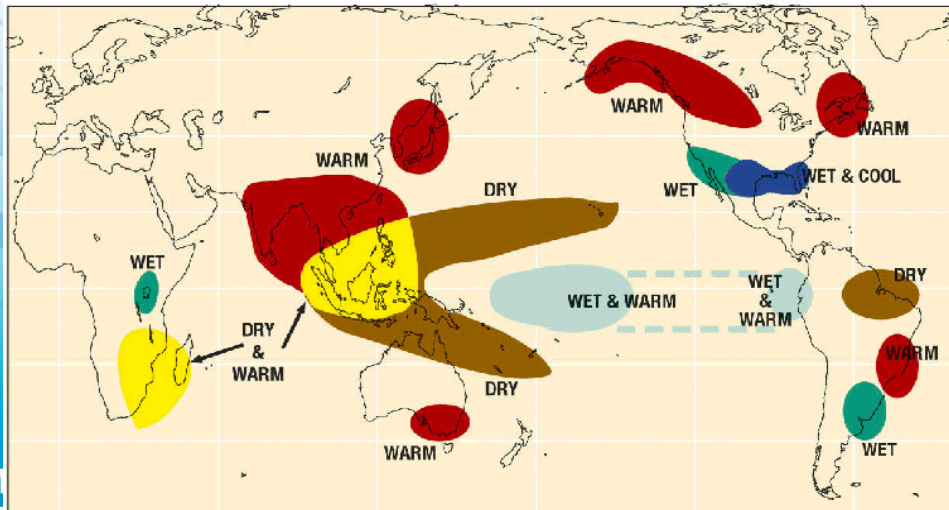
Warm episode relationships June–August



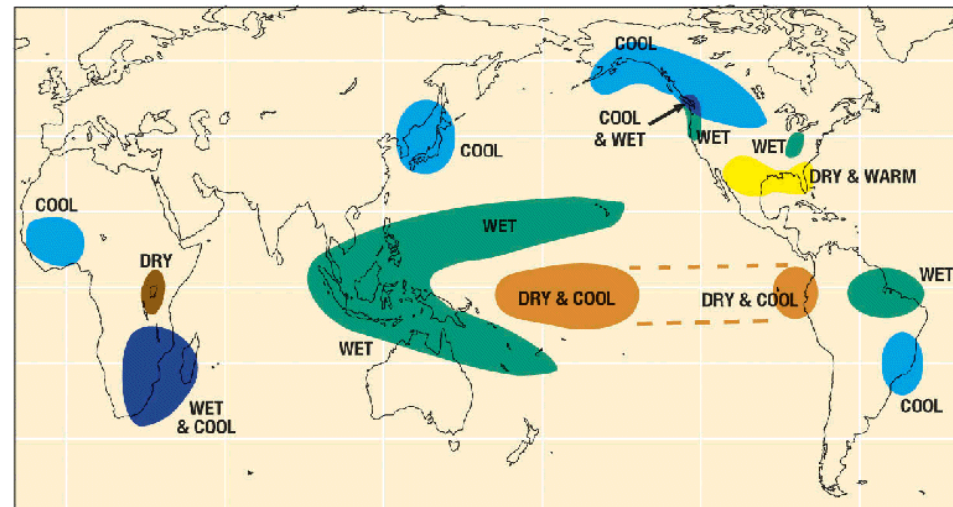
Cold episode relationships June–August



Warm episode relationships December–February



Cold episode relationships December–February



WMO El Niño and La Niña Update

- The WMO El Niño/La Niña Update is a global consensus statement.
- NMHSs provide information on expected impacts after considering other factors that influence regional climate.
- The latest WMO El Niño/La Niña Update (March 2007) confirms that the El Niño event of the latter half of 2006 has ended.
- A transition to La Niña has recently become a substantial possibility.

Climate Change

- Climate change refers to the variation in the Earth's global climate or in regional climates over time.
- It describes changes in the **variability** or **average** state of the atmosphere over time scales ranging from decades to millions of years.
- These changes can be caused by processes **internal** to the Earth, **external** forces or, more recently, **human** activities.

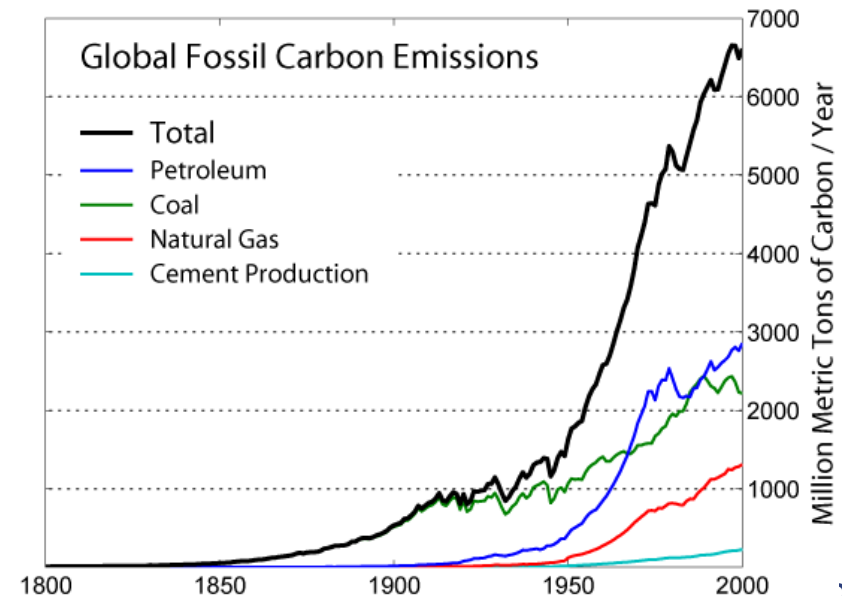
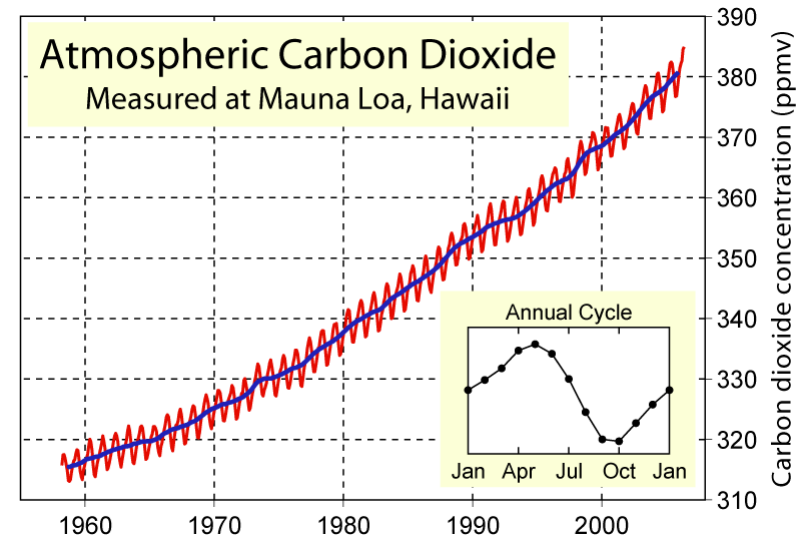
Natural and Human-induced Changes

■ Natural changes and variability: causal mechanisms

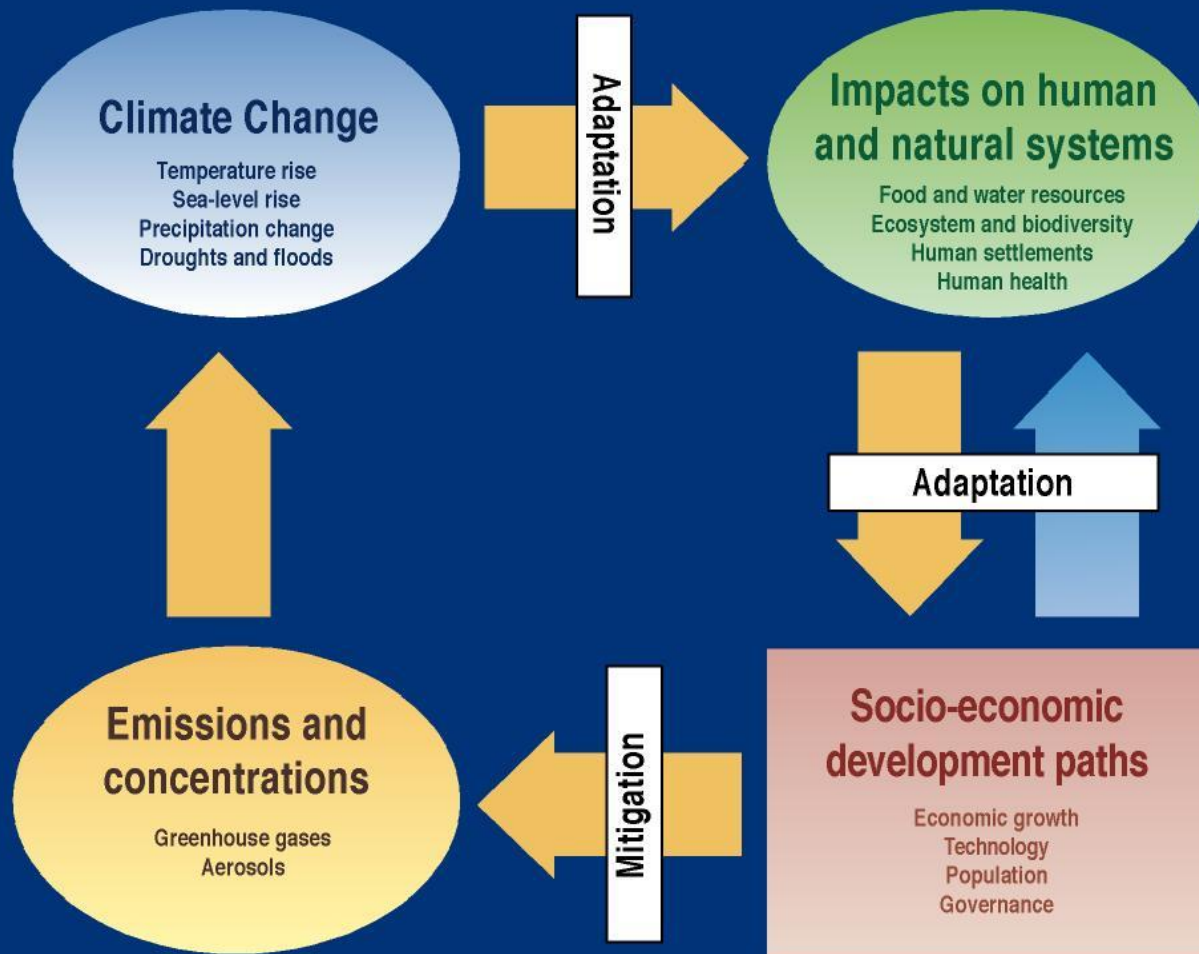
- Orbital variations
- Solar cycles
- Volcanoes
- Oceanic circulation

■ Anthropogenic forcings on climate

- Greenhouse effect
- Land-use land cover changes
- Sulphate aerosols
- Stratospheric ozone depletion/CFCs



Climate Change - an integrated framework



SYR FIGURE 1-1

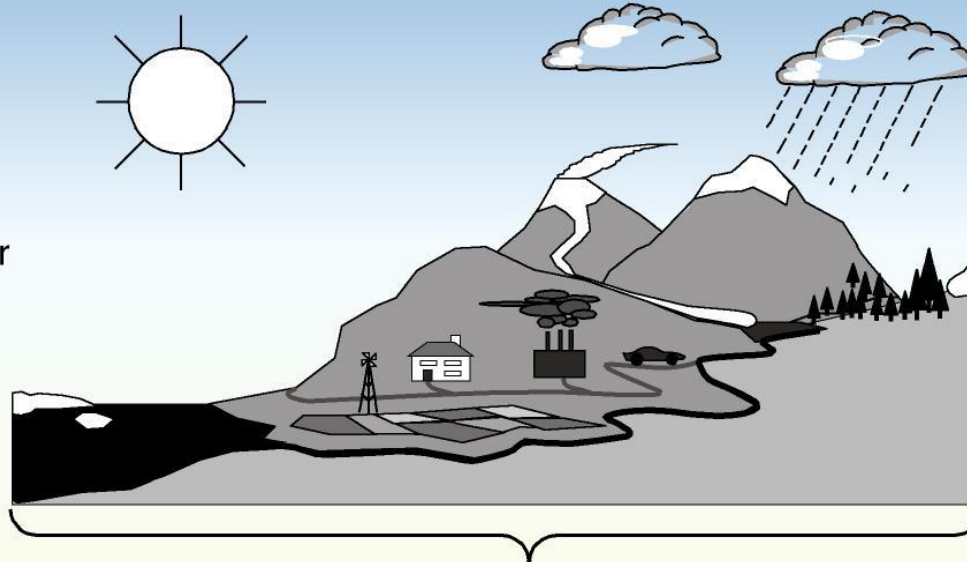
Key questions about the climate system and its relation to human kind

What changes have occurred?

Observations:

- temperatures
- precipitation
- snow / ice cover
- sea level
- circulation
- extremes

How well are the past and present climates understood?

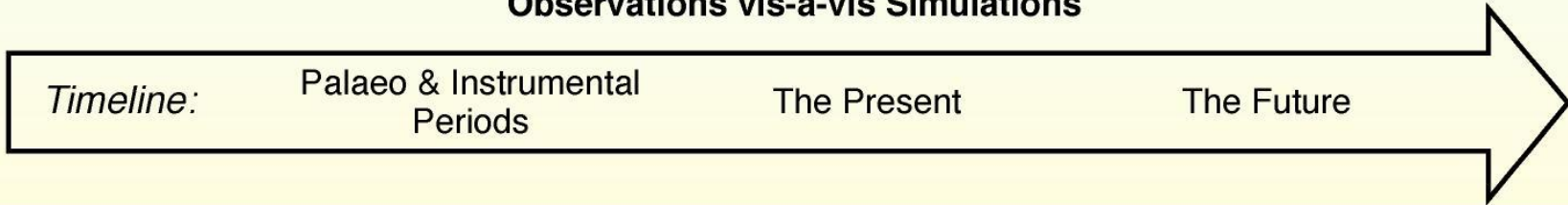


What changes could lie ahead?

Simulations:

- natural variation
- forcing agents
- global climate
- regional climate
- high impact events
- stabilisation

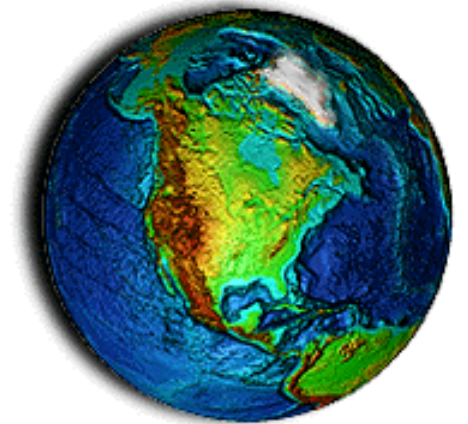
Observations vis-à-vis Simulations



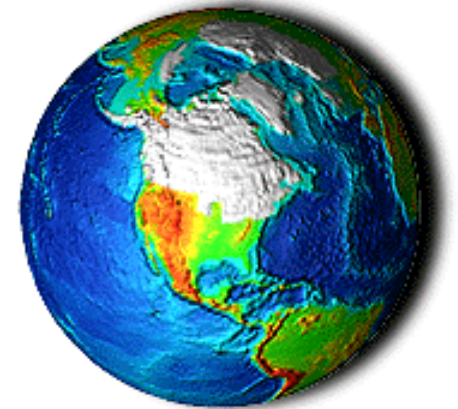
WG1 - TS FIGURE 1

Past Climates

- Instrumental records are available only for the past couple of centuries.
- To understand climate variability over longer time, we depend on proxy indicators.
- Tree rings, ice cores, lake sediments, corals, marine sediments, etc. are some of the proxy sources available in nature.
- Climate reconstructions from such indicators have provided important clues about the nature and characteristics of climate variability and change.



ICE SHEETS TODAY,
ARE SMALLER AND WERE
NOT IN EXISTENCE IN SOME
WARMER PERIODS, I.E.,
120-90 MILLION YEARS AGO.



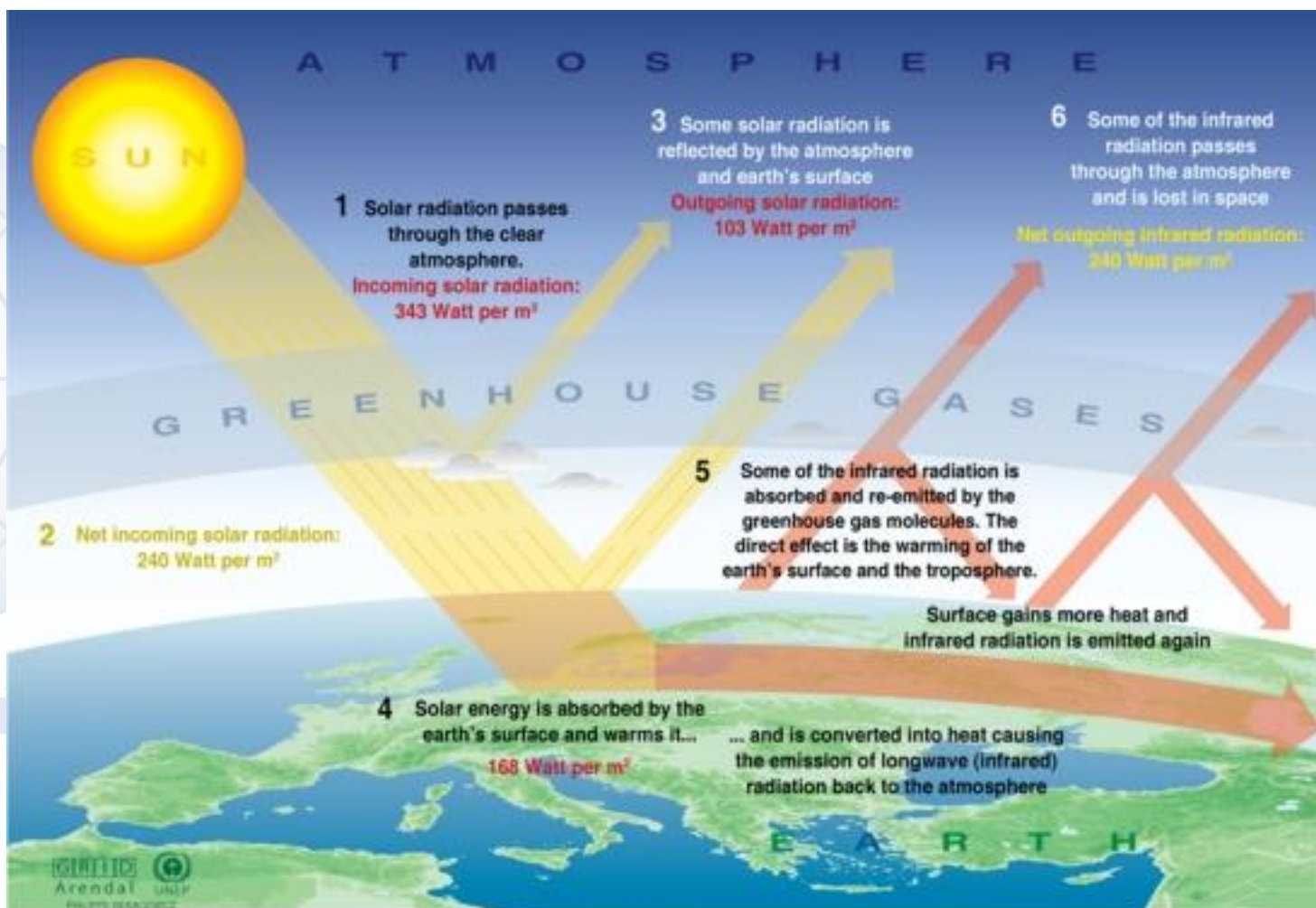
ICE SHEETS THROUGHOUT
THE N. HEMISPHERE
INDICATE COLD CONDITIONS
SOME 21,000 YEARS AGO.

Palaeoclimatic Sources



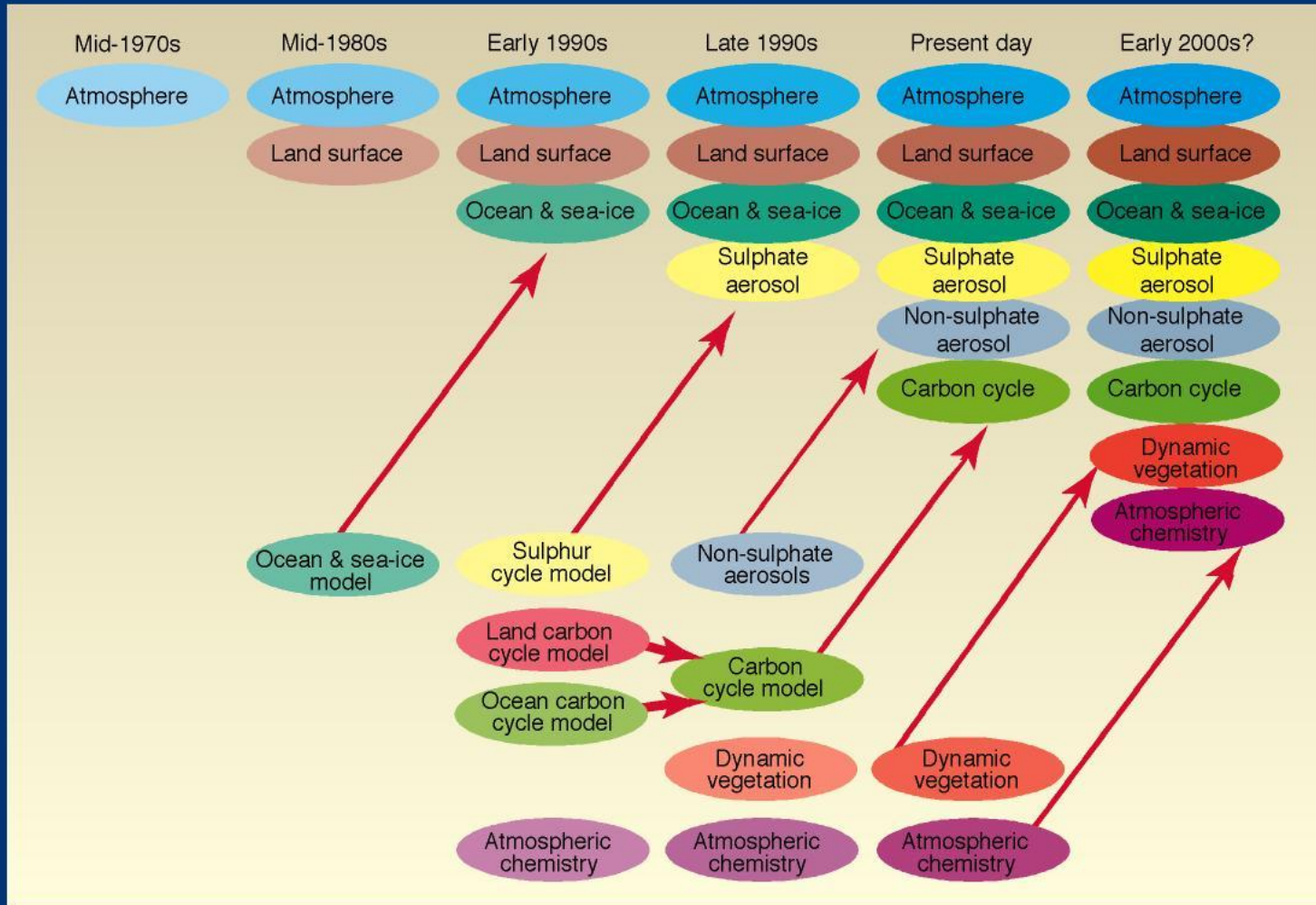
Source: NOAA

The Greenhouse Effect



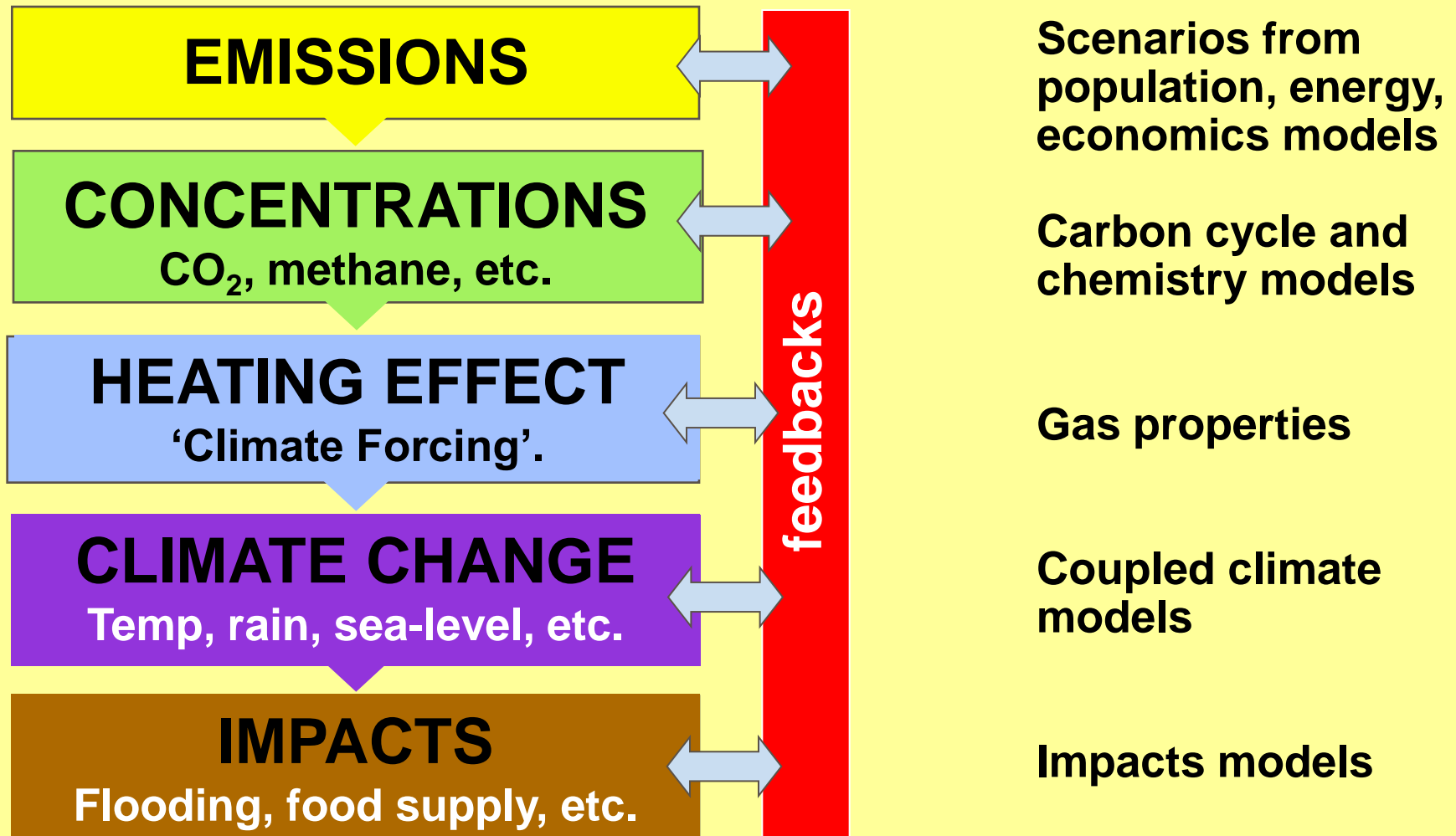
Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

The development of climate models, past, present and future



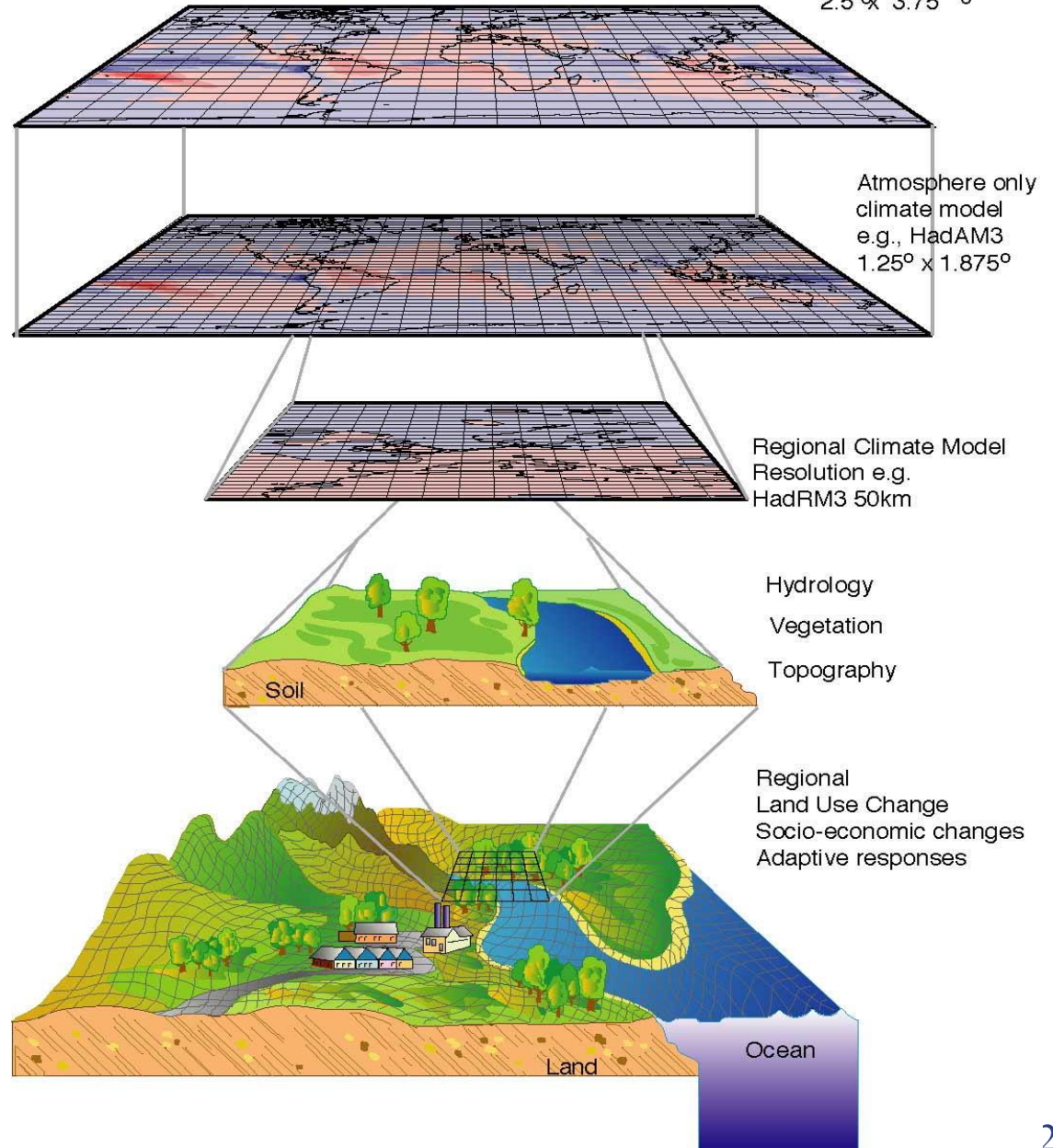
WG1 - TS BOX 3
FIGURE 1

Predicting climate change

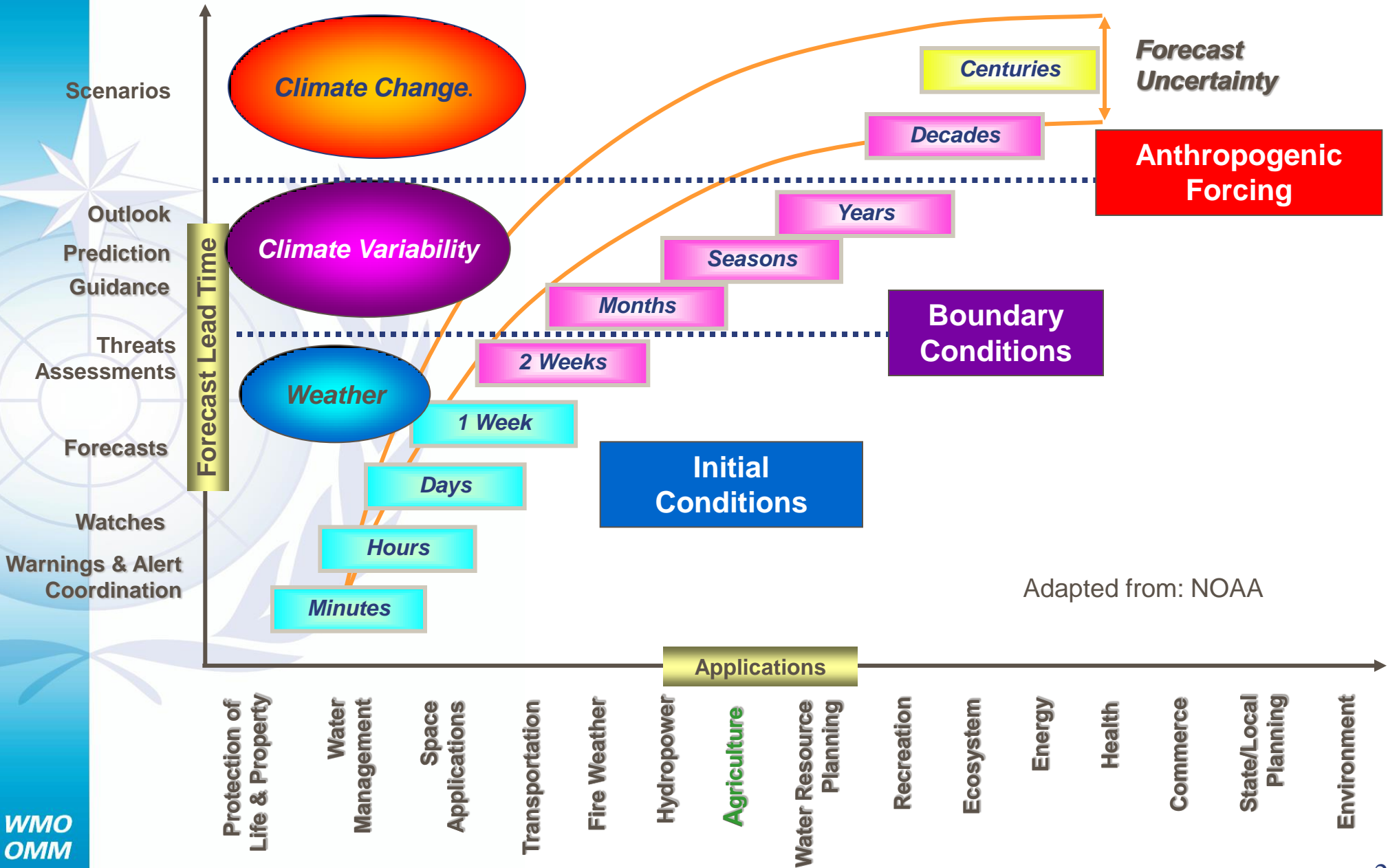


Global Projections to Regional Adaptive Responses: Modelling Path

Global Coupled Climate Model Resolution
e.g. HadCM3
2.5° x 3.75°



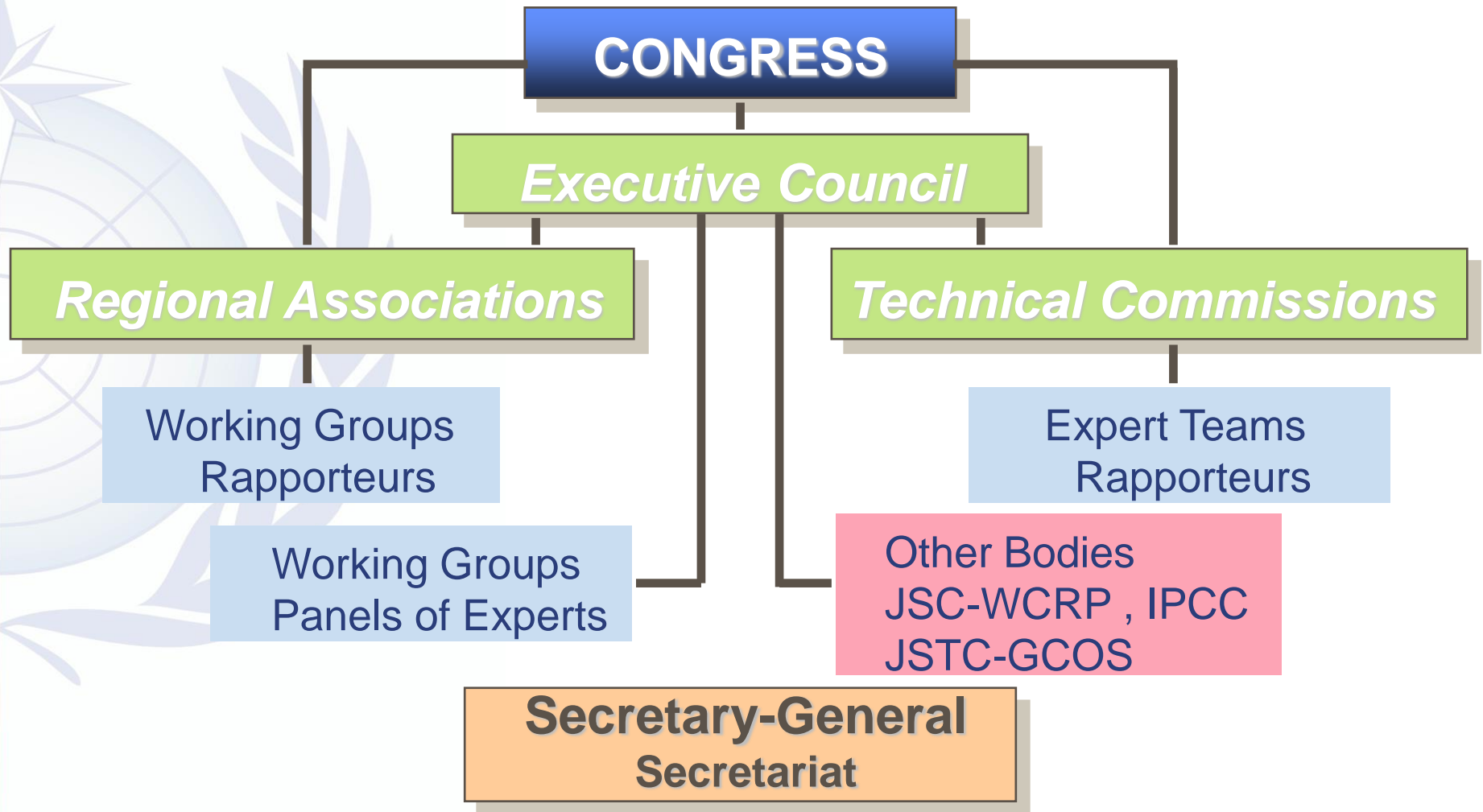
A Seamless Climate Prediction Framework



World Meteorological Organization

- Established in 1950 as a Specialized Agency of the United Nations.
- 187 Member states and territories.
- It is the UN System's Authoritative Voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.

WMO Structure



WMO Regions

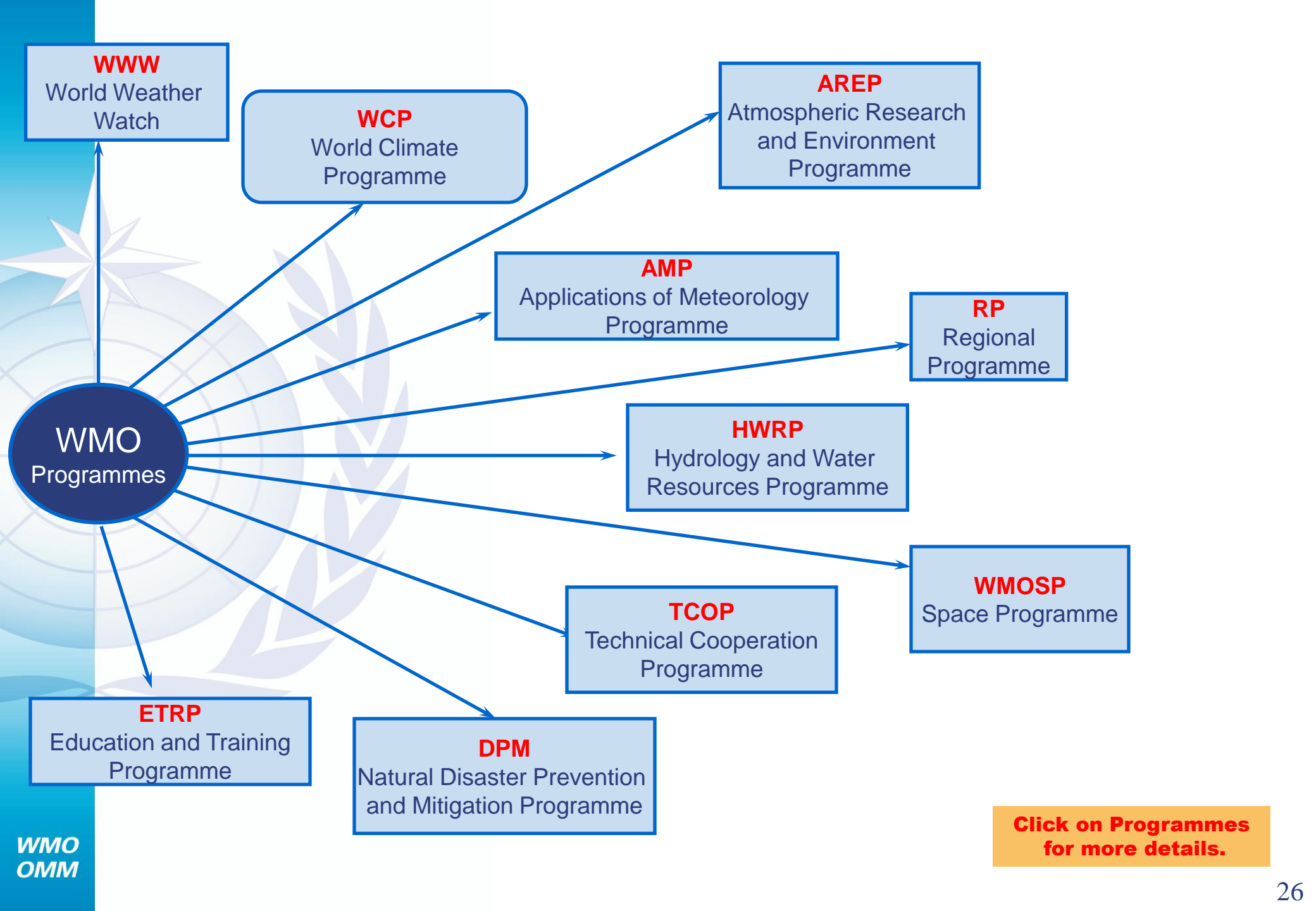


EC WG on Antarctic Meteorology



WMO's Climate-Related Activities

- Observations, data management and data exchange
- Research and predictions
- Climate products and services (for sector-specific applications)
- Capacity building, education and training
- Climate coordination
- WMO Commission for Climatology (Established in 1929)



WWW
World Weather
Watch

WCP
World Climate
Programme

AREP
Atmospheric Research
and Environment
Programme

AMP
Applications of Meteorology
Programme

RP
Regional
Programme

HWRP
Hydrology and Water
Resources Programme

WMOSP
Space Programme

TCOP
Technical Cooperation
Programme

ETRP
Education and Training
Programme

DPM
Natural Disaster Prevention
and Mitigation Programme

**Click on Programmes
for more details.**

WMO's historical role in Climate Change...

- **1976:** First authoritative statement on the accumulation of carbon dioxide in the atmosphere and the potential climate impacts.
- **1979:** First World Climate Conference.
 - Establishment of World Climate Programme (WCP).
- **1988:** Establishment of the Intergovernmental Panel on Climate Change (IPCC).
- **1990:** Second World Climate Conference (SWCC) which called for the establishment of a climate convention.
 - Establishment of the Global Climate Observing System (GCOS).
- **1992:** the Rio de Janeiro “Earth Summit”; the United Nations Framework Convention on Climate Change (UNFCCC) was signed by 154 states.

Global Climate Change Initiatives gain momentum

- **1994:** the UNFCCC entered into force.
- **1995:** the Conference of the Parties (CoP) became the Convention's ultimate authority/governing body; annual CoP sessions begin.
- **1995:** IPCC Second Assessment.
- **1997:** Kyoto Protocol
- **2001:** IPCC Third Assessment
- **2005:** Kyoto Protocol comes into force
- **2006:** Nairobi Programme of Work: Role of WMO/NMHSs
- **2007:** IPCC Fourth Assessment
- **200?:** World Climate Conference Three ...

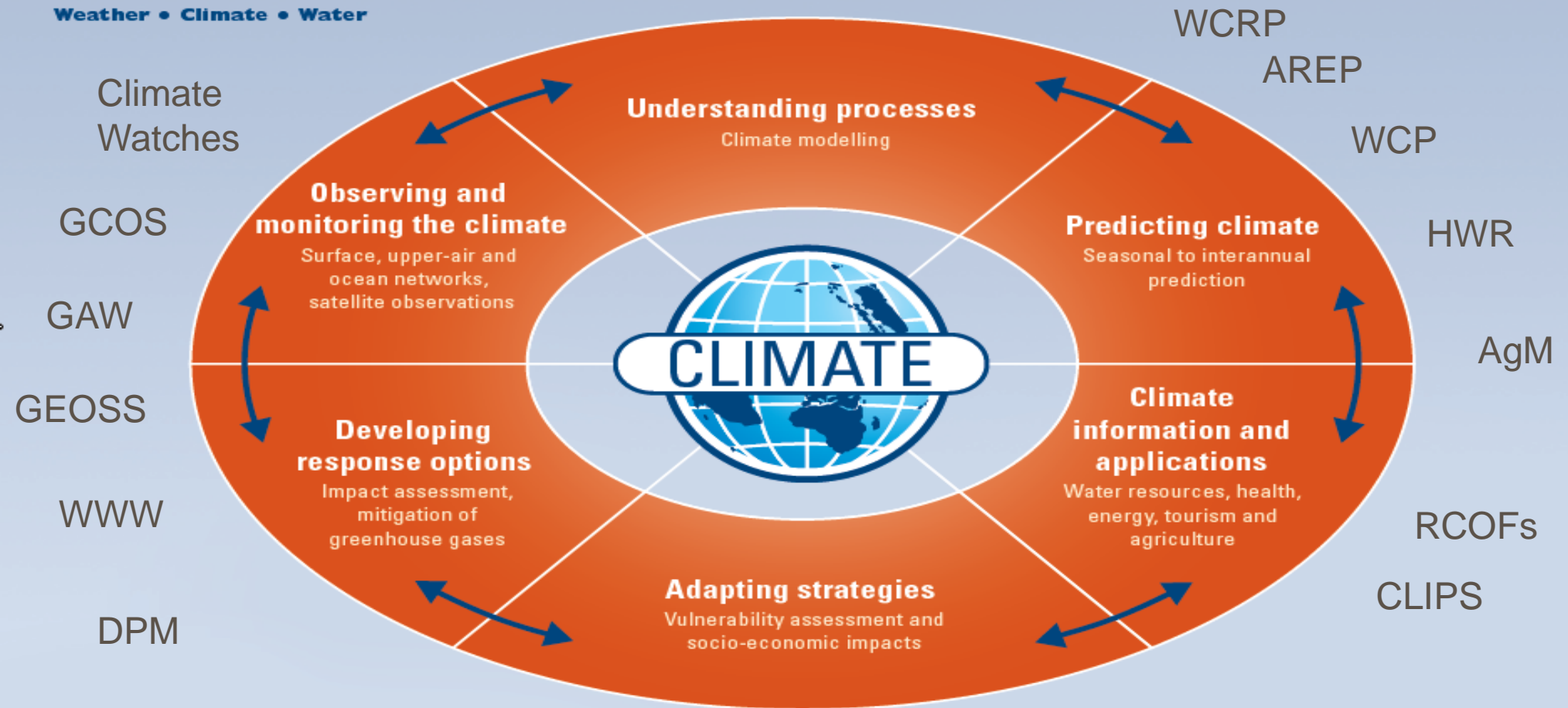


**World
Meteorological
Organization**

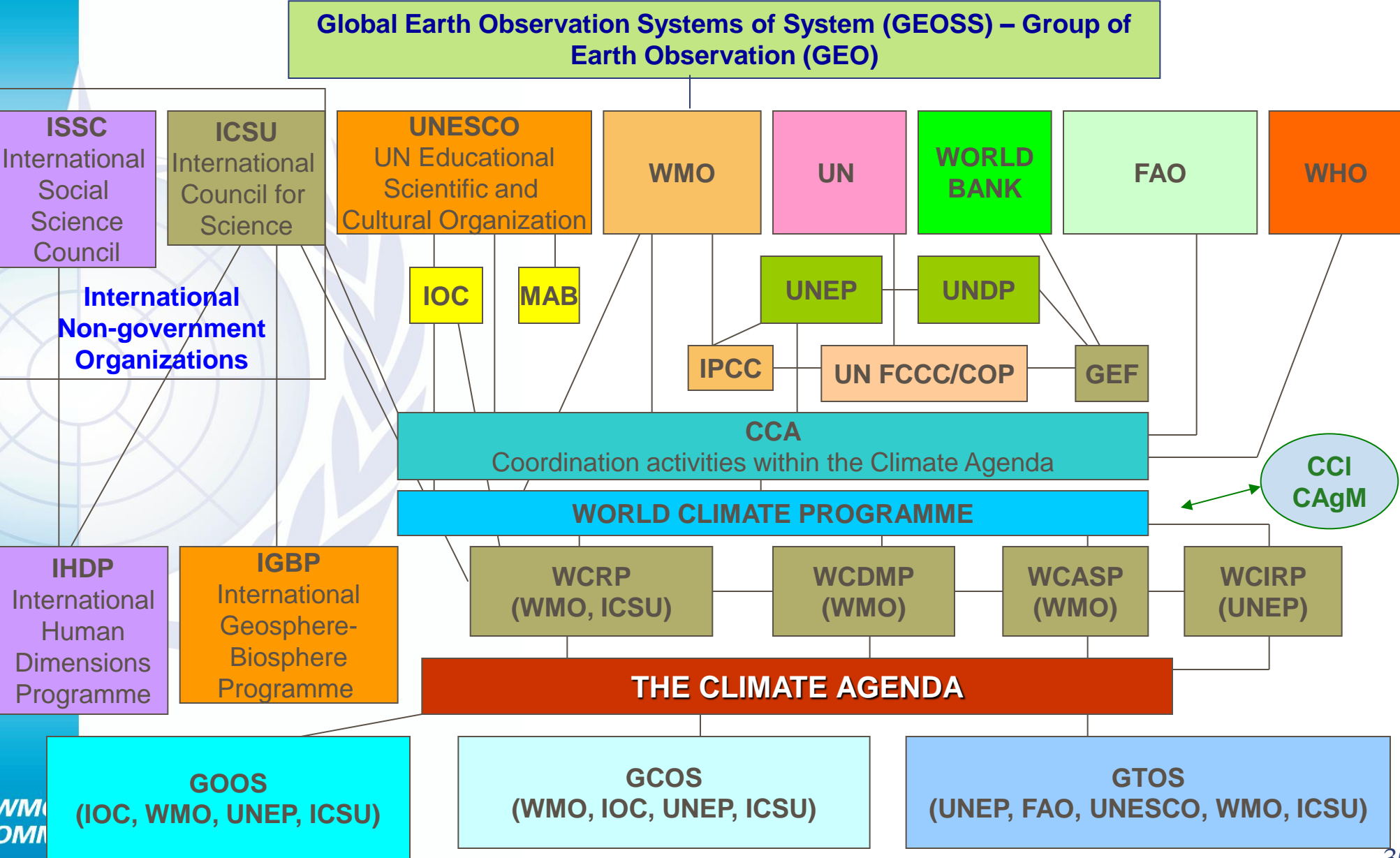
Climate in the 21st Century

**Integrated framework of WMO's climate activities – a response
to address Millennium Development Goals**

Weather • Climate • Water



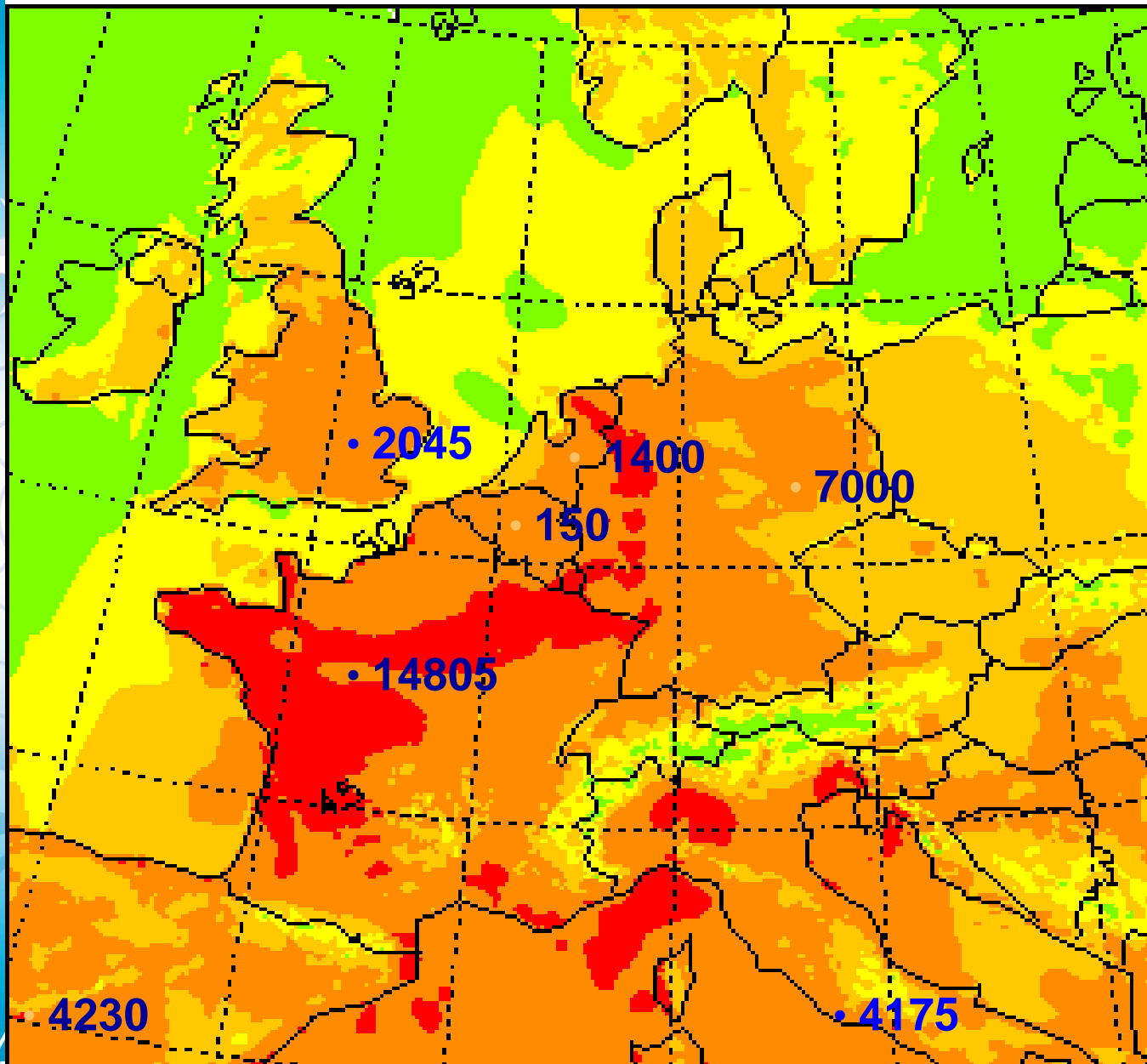
International Climate Activities



Emerging Opportunities: Towards Improved Societal Response and Sustainable Development

- Relevant climate information is expected to enhance policy and decision-making
 - Climate data
 - Climate analysis and monitoring capabilities
 - Specialized climate forecast products – Must become user centric
 - Climate risk modelling tools – Critical for decision making
- There is significant diversity in supply and demand of climate information at national level
 - Needs, requirements and capabilities of providers
 - Needs and requirements of the users related to policy and decision-making

Heat related extra deaths in Europe, August 2003



heat load

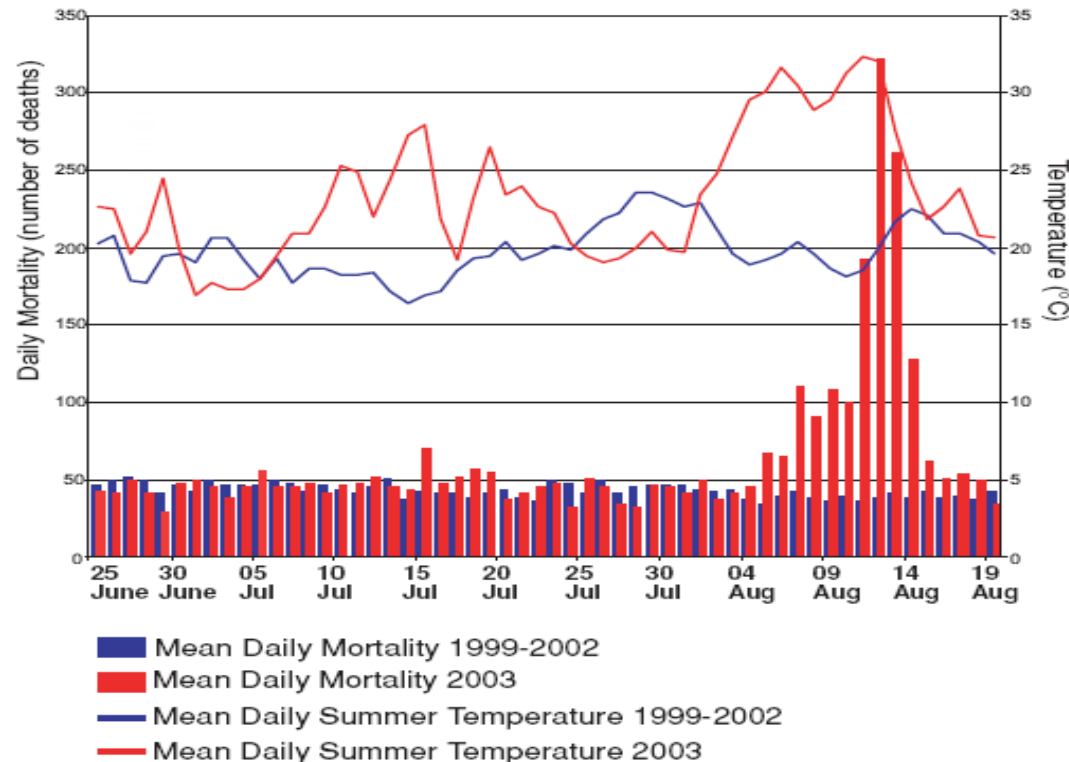


cold stress

PT map underlay
UTC13:00
Aug 9 2003

Impacts of extreme weather events are expected to increase

Example:
Deaths in
Paris in
2003 heat
wave



Heat-Health Warning Systems



Goals:

- Reduce mortality and morbidity associated with life-threatening heatwaves
- Strengthen WMO/NMHS partnerships with health and social services (global, regional, national) for effective service delivery – Met forecasts alone are insufficient
- Develop Guidance on and tools for:
 - early warning and detection of health effects of heatwaves;
 - national/local preparedness planning for extreme heat events;
 - public/media outreach;
 - interventions to save lives.

Climate Information and Prediction Services (CLIPS)

- The term “climate services” refers to the delivery of climate information and predictions from the scientific sources to end-users
- A service is a service only when it is used; our goal is to make people use climate services in real-world context
- Climate information is just one of the elements in the decision making matrix
- Databases of information gathered over many years; National Meteorological and Hydrological Services have great potential to exploit these resources to provide “effective” climate services.

WMO proactively pursues climate applications

- Espoo Conference (**Living with Climate Variability and Change**: July, 2006) highlights the role of users and decision makers in climate services.
- Madrid Conference (**Socio-economic Benefits of Meteorological Services**: March, 2007) highlights the quantification of socio-economic benefits of meteorological services.
- ‘**World Climate Conference Three**’ under active pre-planning discussions.
- Based on a formal statement issued for the first time at the UNFCCC COP-12 in 2006, the role of WMO and NMHSs has been officially recognized in the “**Nairobi Programme of Work on Impacts, Vulnerability and Adaptation to Climate Change**”.

IPCC Assessments of Climate Change

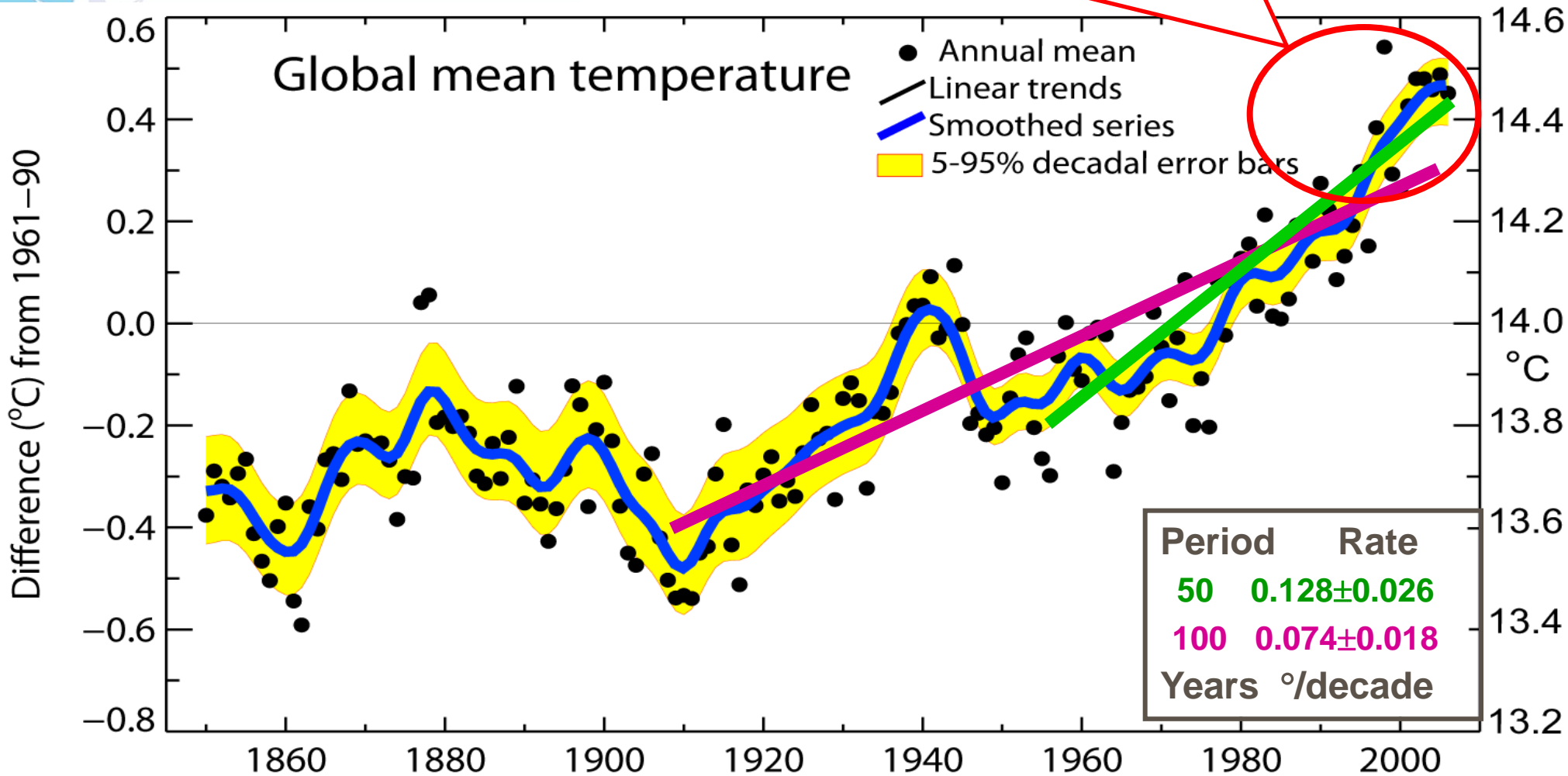
- 3 Working Groups
 - WG1: Scientific Basis
 - WG2: Impacts, Adaptation and Vulnerability
 - WG3: Mitigation
- Hundreds of scientists spread across the world participate.
- Analyses of a large number of new models and new scenarios.
- Policy-relevant but not policy-prescriptive assessment.
- Systematic peer review and Governmental review.
- Fourth Assessment Report in the process of being released; Summary for Policy Makers for WG1 and WG2 already released.

Direct Observations of Recent Climate Change (IPCC AR4)

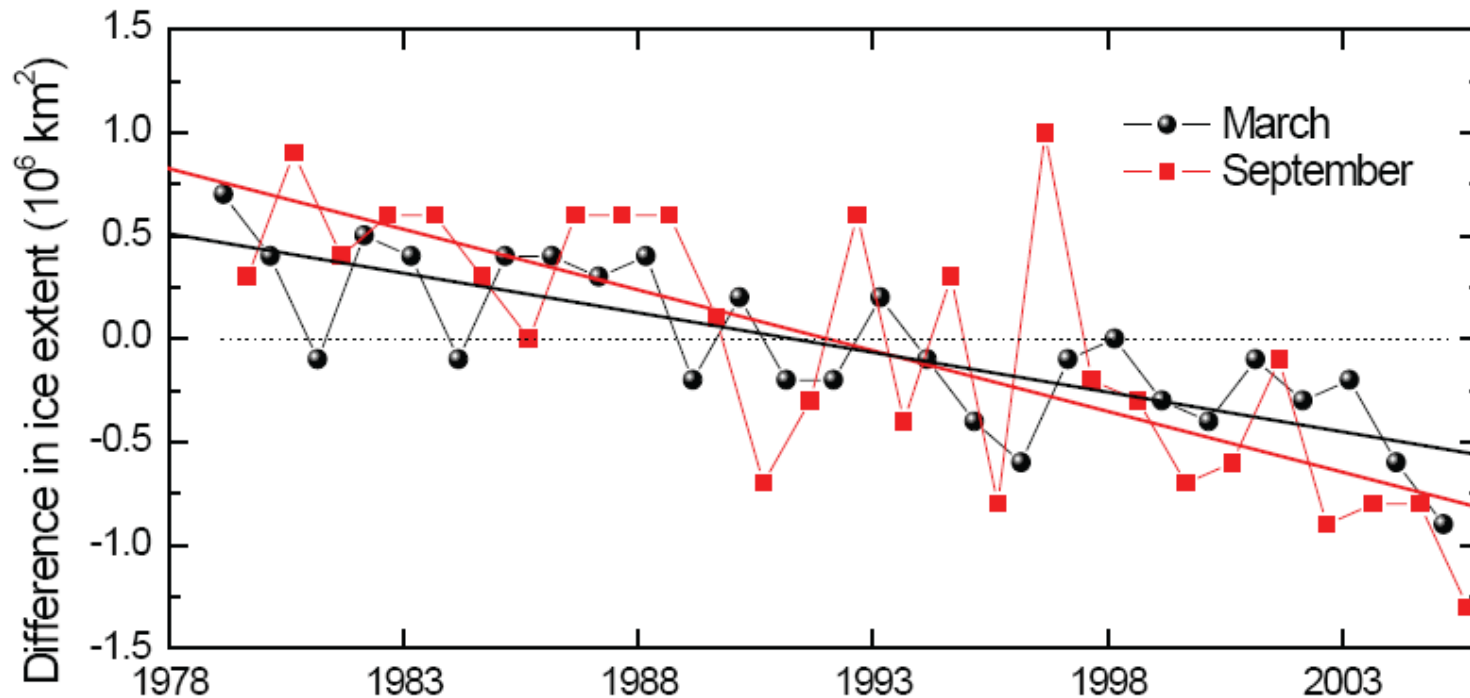
- Global average air temperature warming trend has accelerated (see, for example, the 100-year linear trends):
 - 1906-2005 : 0.74°C
 - 1901-2006 : 0.60°C
- Average ocean temperature increased to depths of at least 3000 m – ocean has absorbed 80% of heat added (sea water expansion and sea-level rise)

Global mean temperature

Warmest 12 years:
 1998, 2005, 2003, 2002, 2004, 2006,
 2001, 1997, 1995, 1999, 1990, 2000

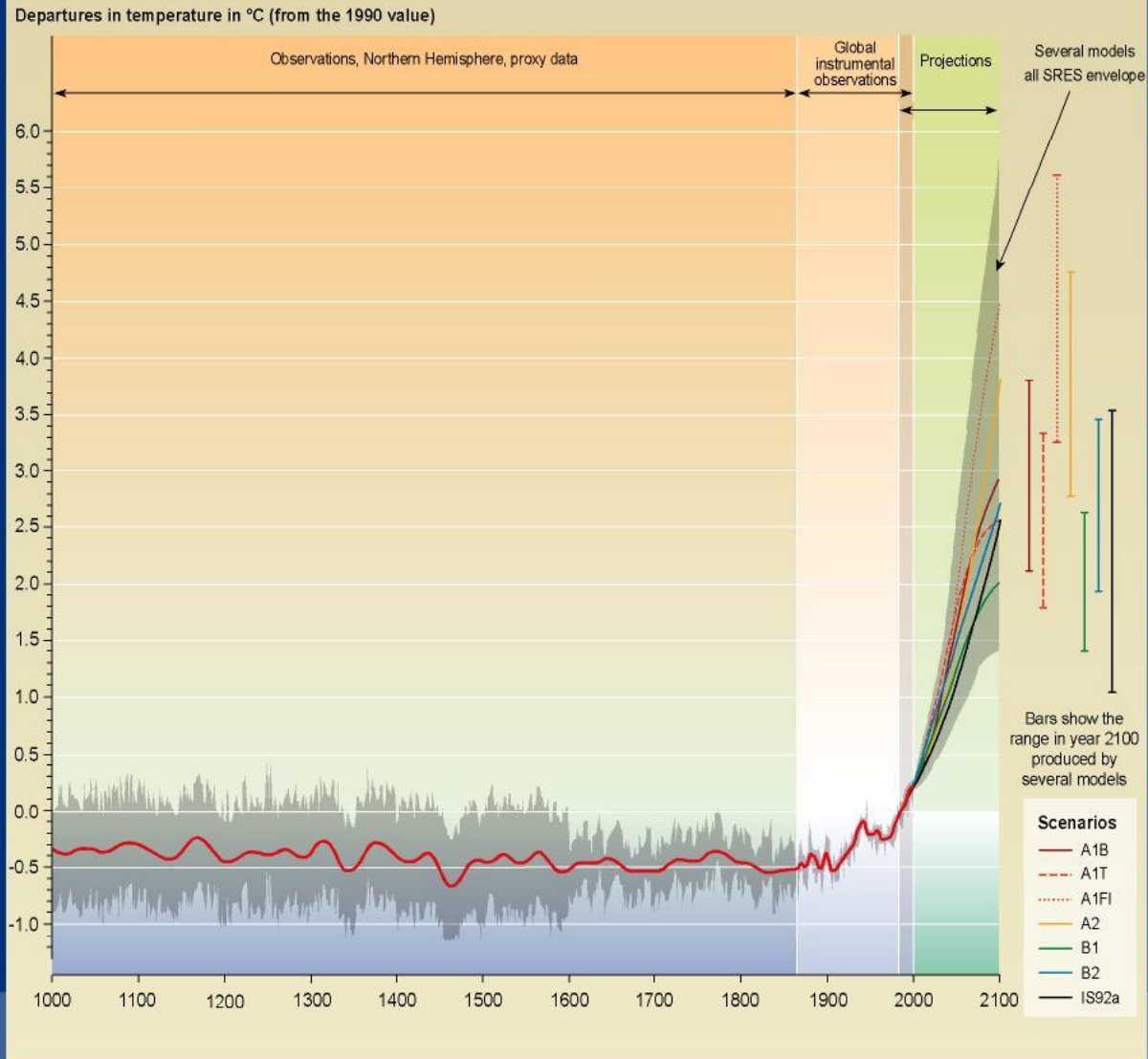


Decline in Arctic ice extent



Difference in ice extent in March (maximum) and September (minimum) from the mean values for 1979–2005. **The rates of decrease in March and September were 2% per decade and 7% per decade**, respectively. Recent data from March 2006 are also shown and represent a new record minimum for the period of observation.

Variations of the Earth's surface temperature: year 1000 to year 2100



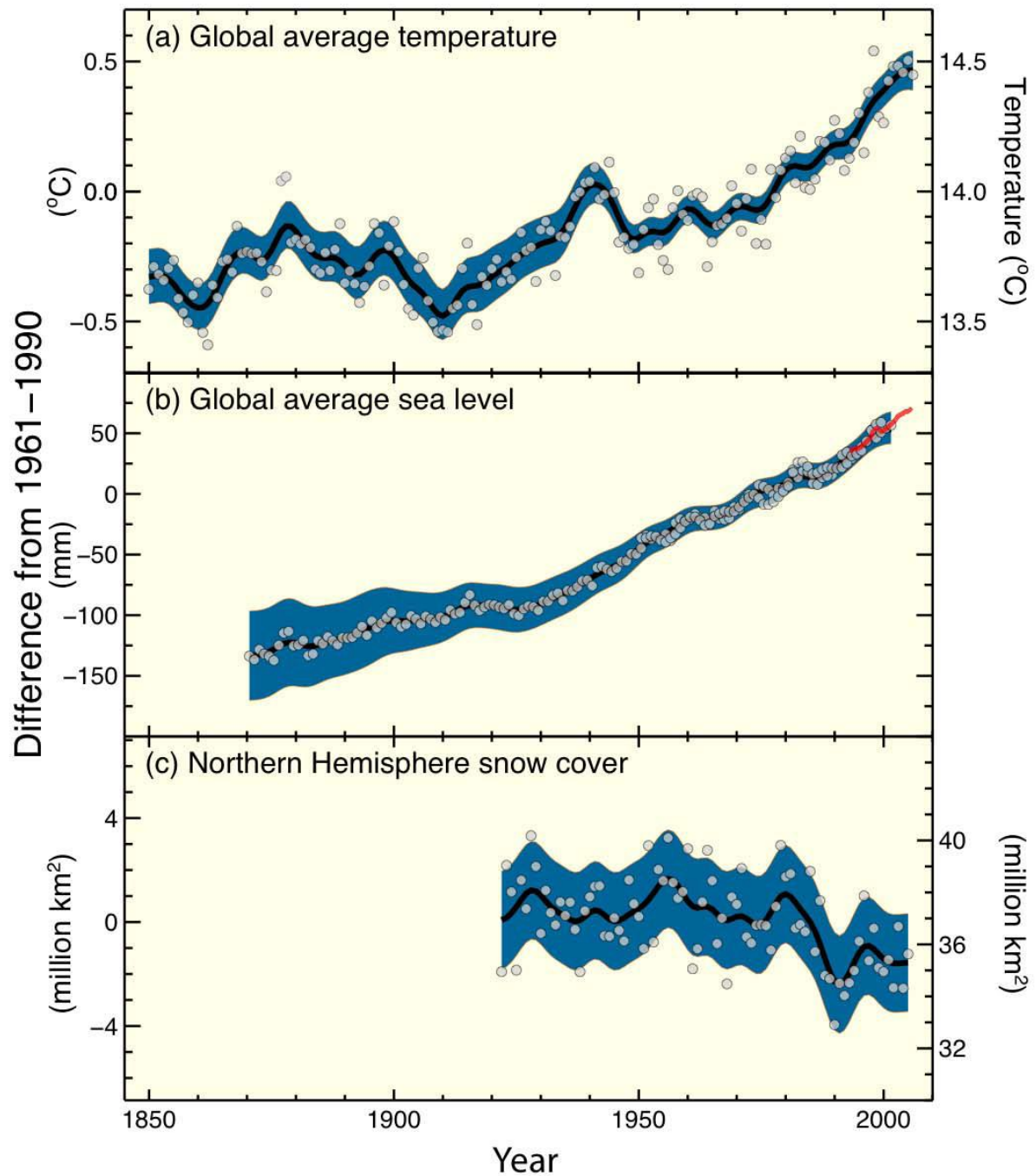
SYR - FIGURE 9-1b



IPCC Fourth Assessment Report (AR4)

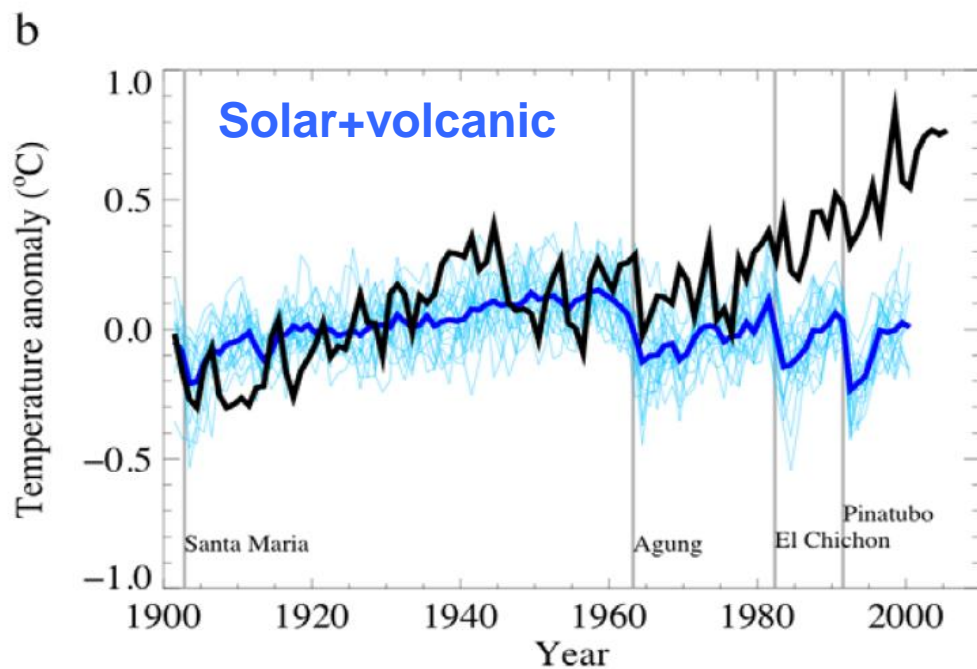
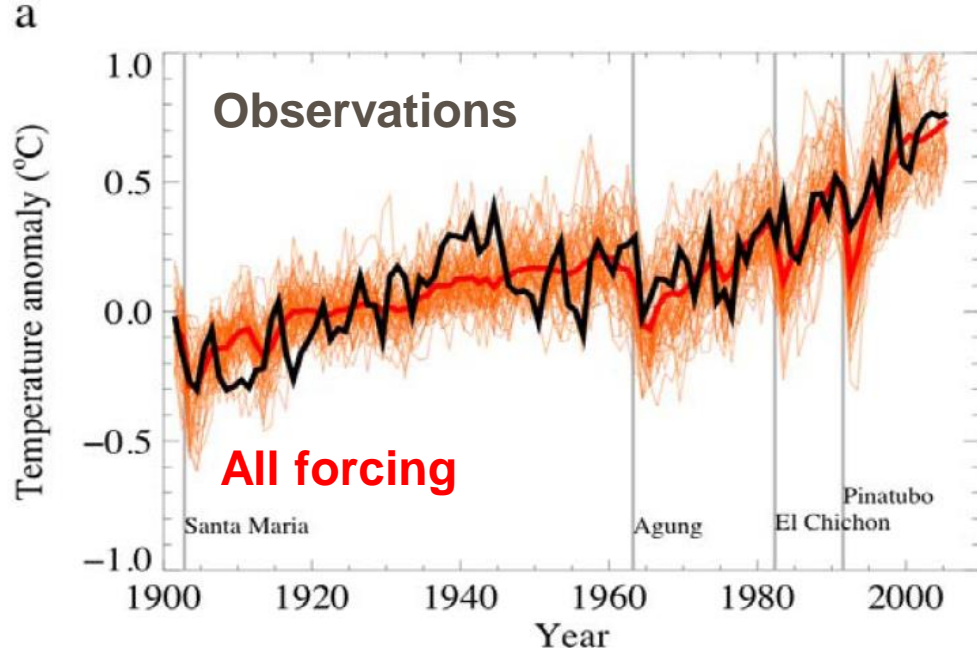
- Report of Working Group 1 (Physical Science Basis) released in February 2007.
- Warming of the climate system is unequivocal.
- Widespread melting of snow and ice, and rising global average sea level.
- For the next two decades a warming of about 0.2°C per decade is projected.
- Continued greenhouse gas emissions would cause further warming and induce many changes in the climate system during the 21st century.

Observed Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover (IPCC WG1 AR4)

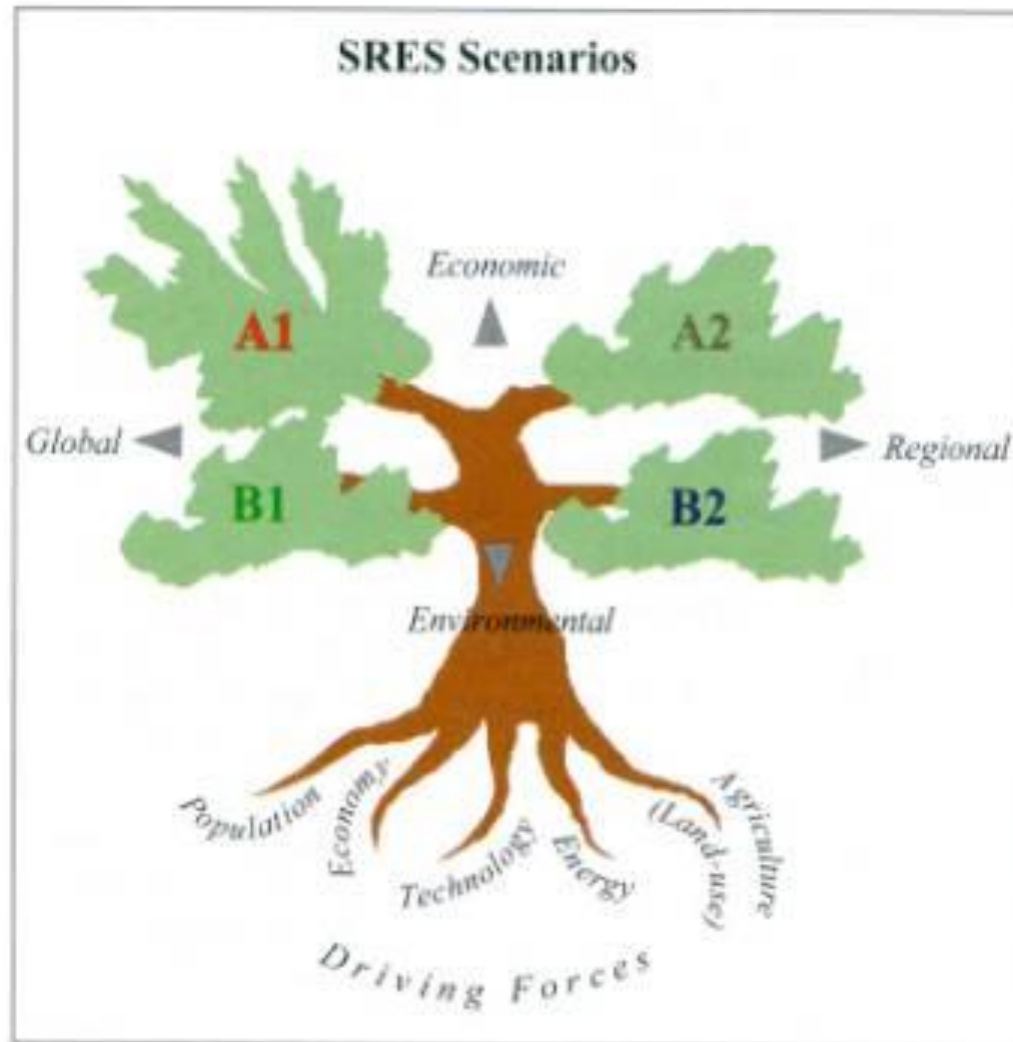


Attribution

- Observed changes are
 - ☑ consistent with expected responses to natural+human forcings
 - ☒ inconsistent with alternative explanations (e.g., natural only)



Emmission Scenarios

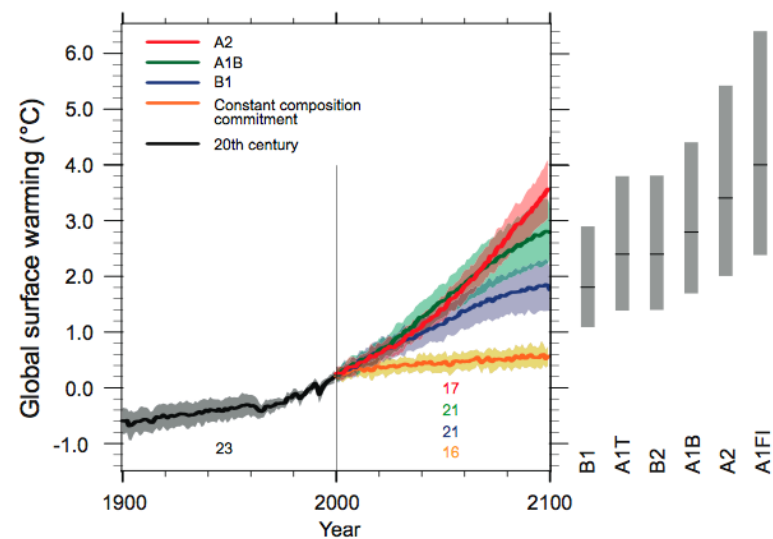


Projections of Future Changes in Climate

- Continued greenhouse gas emissions at or above current rates would
 - cause further warming
 - induce many changes in the global climate system during the 21st century
- Such changes would *very likely be* larger than those observed during the 20th century.

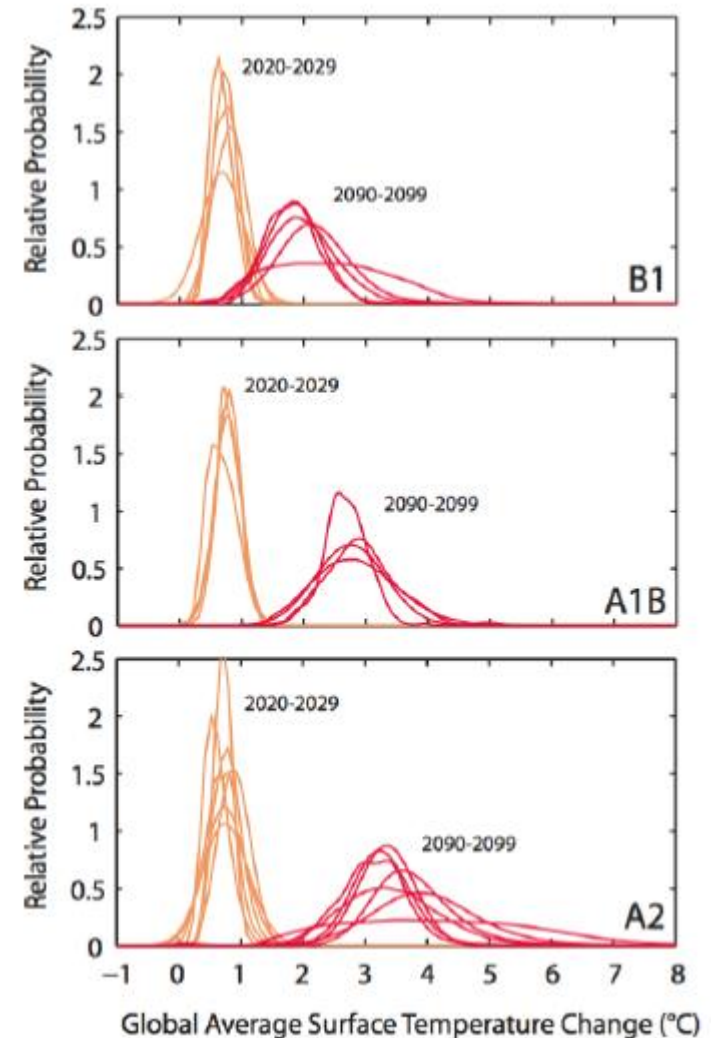
Projections of Future Changes in Climate

- Best estimate for low emission scenario (B1) is 1.8°C (likely range is 1.1°C to 2.9°C), and for high emission scenario (A1FI) is 4.0°C (likely range is 2.4°C to 6.4°C).
- Broadly consistent with span quoted for SRES in TAR, but not directly comparable



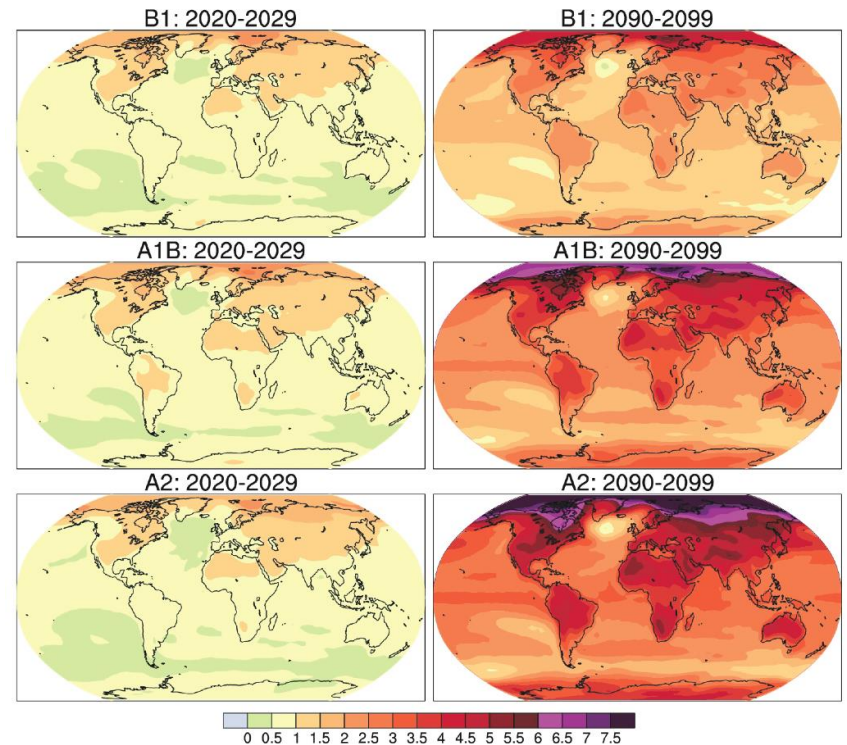
Projections of Future Changes in Climate

- Near term projections insensitive to choice of scenario
- Longer term projections depend on scenario and climate model sensitivities



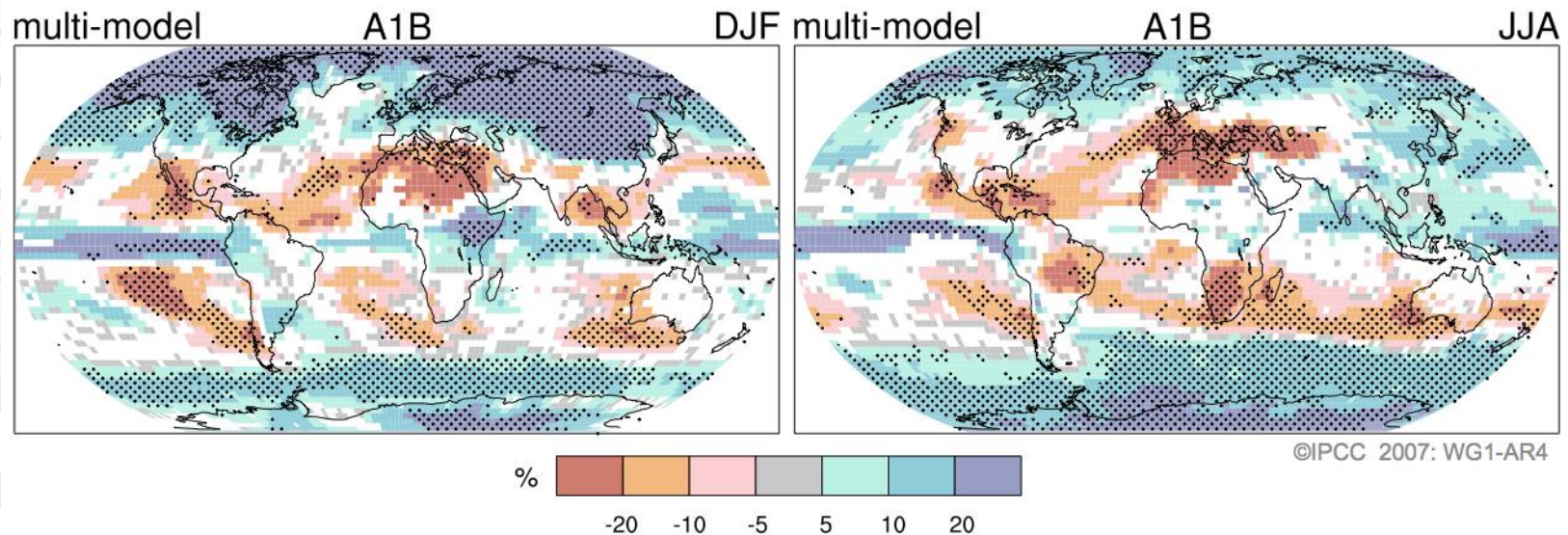
Projections of Future Changes in Climate

- Projected warming in 21st century expected to be
 - greatest over land and at most high northern latitudes; and
 - least over the Southern Ocean and parts of the North Atlantic Ocean



Projections of Future Changes in Climate

Projected Patterns of Precipitation Changes



- Precipitation increases very likely in high latitudes
- Decreases likely in most subtropical land regions

Climate Change Impacts

- Climate change, particularly the increasing surface temperature, is already affecting both natural and human-managed systems.
- All major socio-economic sectors will be affected, with a wide range of regional impacts:
 - Water
 - Ecosystems
 - Food
 - Coastal systems and low-lying areas
 - Industry, settlement and society
 - Health

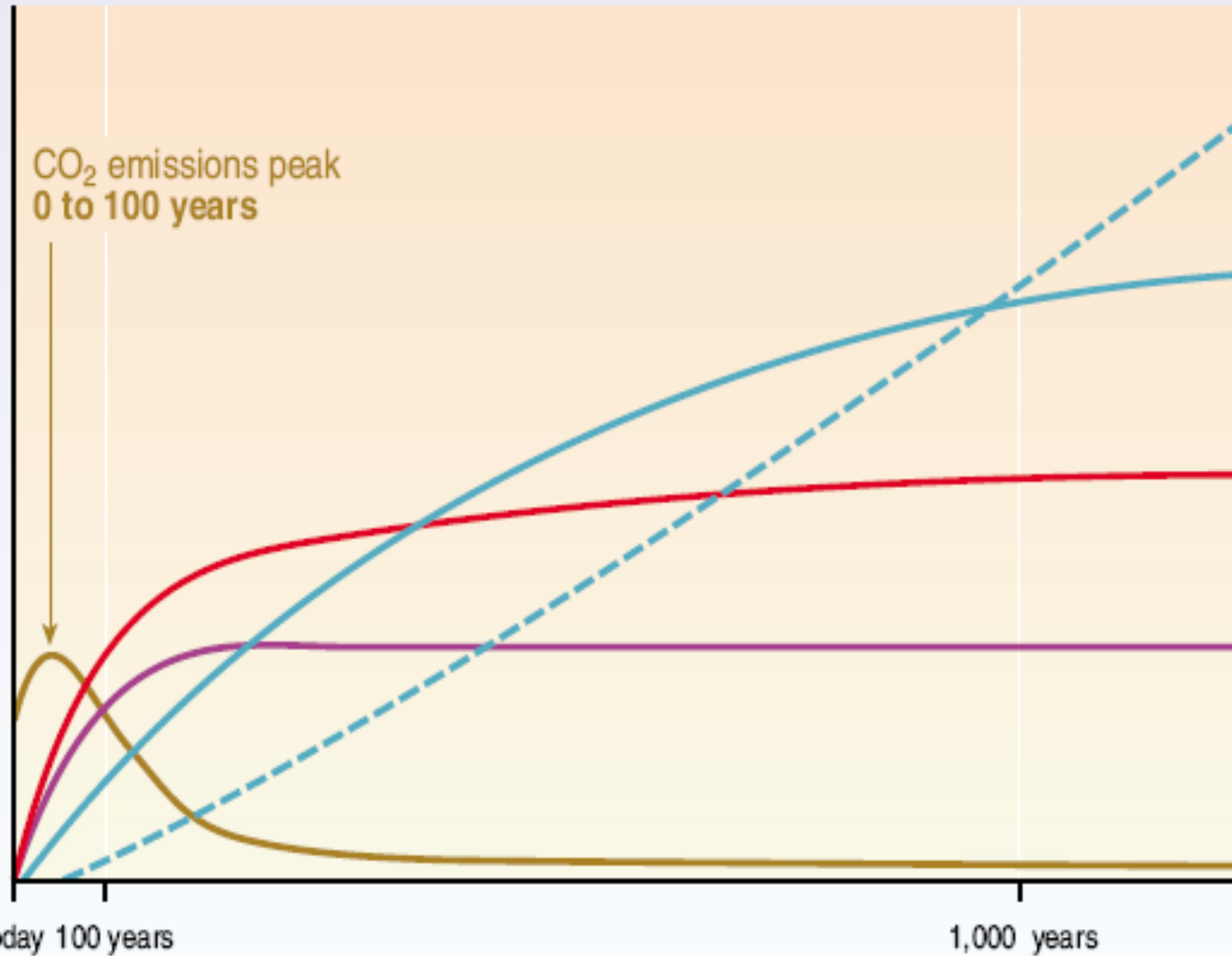
Mitigation

- Montreal Protocol (1987)
- UN Earth Summit, Rio (1992) → UNFCCC
- Kyoto Protocol (1997)
- Post-Kyoto?
- Aspects:
 - once in the atmosphere, gases mix quickly and spread widely;
 - most have long lifetimes;
 - ‘committed’ climate change

Mitigation : An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases. Mitigation can reduce, delay or avoid impacts.

CO₂ concentration, temperature, and sea level continue to rise long after emissions are reduced

Magnitude of response



Time taken to reach equilibrium

Sea-level rise due to ice melting:
several millennia

Sea-level rise due to thermal expansion:
centuries to millennia

Temperature stabilization:
a few centuries

CO₂ stabilization:
100 to 300 years

CO₂ emissions

Adaptation

- Some adaptation is occurring now, but it faces barriers, limits and costs
- Vulnerability can be exacerbated by other stresses (e.g. poverty, food insecurity, conflict, disease)
- Vulnerability depends not only on climate change but also on development paths; sustainable development can reduce vulnerability

Adaptation : Adjustment in natural or human systems to a new or changing environment.

Adaptation to climate change : Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.



Concluding Remarks

- We are already witnessing the warming of the climate system, termed “unequivocal” by global scientific consensus.
- This is unprecedented in at least the last 1300 years.
- Most of this warming has been convincingly attributed to human influence.
- Future projections of warming and other regional-scale climate patterns are gaining confidence.
- Climate change has significant and varied impacts on both natural and human-managed systems.
- Climate information needs to be integrated into decision making at all levels for sustainable development.



Thank You

World Weather Watch (WWW)

- Worldwide integrated system for generation, collection, processing and exchange of observations, analyses, forecasts, etc.
- Measures for standards, procedures and technology.
- Basic infrastructure for data and services.
- GOS, GTS, GDPFS, etc.
- THORPEX



World Climate Programme (WCP)

- Climate Data and Monitoring
- Climate Applications
- Climate Prediction
- Climate Services
- Climate Coordination
- Climate Research



Atmospheric Research and Environment Programme (AREP)

- Global Atmosphere Watch
- Forecasting high-impact weather
- Support to ozone and other environment-oriented conventions
- World Weather Research
- Physics and Chemistry of Clouds
- Weather modification research



Applications of Meteorology Programme (AMP)

- Public Weather Services
- Agricultural Meteorology
- Aeronautical Meteorology
- Marine Meteorology and Oceanography



Hydrology and Water Resources Programme (HWRP)

- Basic systems in hydrology
- Forecasting and applications in hydrology
- Sustainable development of water resources
- Capacity building
- Water-related issues



Education and Training Programme (ETRP)

- Human resources development
- Training activities
- Education and training fellowships
- Support to training events in other WMO programmes



Technical Cooperation Programme (TCOP)

- International cooperation and capacity building
- WMO Voluntary Cooperation Programme
- Regular budget cooperation activities
- Programme for the Least Developed Countries



Regional Programme (RP)

- Promote cooperation at regional/subregional levels
- Six Regions
 - I. Africa
 - II. Asia
 - III. South America
 - IV. North America, Central America and the Caribbean
 - V. Southwest Pacific
 - VI. Europe
- Institutional support
- Regional activities



WMO Space Programme (WMOSP)

- Space-based components of GOS
- Promotion of wider awareness and utilization of space-based data and products
- Involvement of space agencies
- Assimilation
- Education and training
- Research to operational systems
- Observing system integration



Natural Disaster Prevention and Mitigation Programme (DPM)

- Response to disaster reduction needs
- Contribution of NMHSs to national disaster preparedness programmes
- Participation in ISDR and other global fora dealing with disaster reduction
- Coordination with other WMO programmes on disaster related matters

