INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
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Notes to Lead Authors for the IPCC WG1 Fourth Assessment Report

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Introduction

The following comments on the WG1-AR4 chapter outline have been prepared by the WG1 co-chairs and reviewed by the WG1 Bureau for the benefit of Lead Authors. They summarize several inputs to the lead authors' deliberations: key issues raised by Governments at the 21st Session of the IPCC, in November 2003, suggestions by experts at two AR4 scoping meetings held during 2003, as well as input from the WG1 Bureau. The IPCC Panel has agreed that authors should have flexibility in dealing with detailed matters of content, while maintaining consistency with the subjects of the approved outline.

Part 1. Suggestions from IPCC WG1-IX and IPCC-XXI

1. Historical Overview of Climate Change Science

Suggestions by Governments

Introduce the IPCC definition of term “climate change” early on.

Describe the concept of the climate system, and changes over different time scales including paleoclimate in this chapter

Indicate what uncertainty issues are to be covered in this chapter, versus discussions that may be more detailed in each of the later chapters

2. Changes in Atmospheric Constituents and in Radiative Forcing

Suggestions by Governments

Include aerosol processes directly affecting clouds; indicate what cloud information is here and why, and what is in later chapters

It would be helpful to include definition of radiative forcing versus feedbacks e.g., for clouds

Indicate what time scale is considered as industrial era for the forcing definition, and indicate what groupings may be used among forcing agents

Include changes in short lived gases (ozone and aerosol precursors).

Users could benefit from consideration of frequently asked questions, e.g., solar forcing on Milankovitch versus industrial time scales

Boundary issues/ points of clarification

Aerosol and cloud issues also involve chapters 3, 7, and 8.

Chemistry – climate feedbacks involving gases are in chapter 7.

Comparisons between observed changes in constituents and estimated emissions would be covered here.

3. Observations: Surface and Atmospheric Climate Change

Suggestions by Governments

Include changes in cloud cover.

Include extreme events and monsoons. Consider possible transient changes in extremes as well as trends.

Include range of climatic variables, depending on data availability and literature (temperature, precipitation, pressure, humidity, radiation budget, extreme events, etc).

Consider storm surges and tropical storms.

Introduce the major components of the atmosphere including the boundary layer; would be helpful to note where boundary layer will be treated.

Consider consistency in regional coverage between chapters 3 and 11.

Consider broad range of extreme event types such as tropical storms, recurrence of droughts, etc.; consider range of regional aspects in extremes as well as means.

Consider information on lakes (including tropical lakes) and runoff

Consider data quality, spatial gaps, research needs, uncertainties.

Consider alternative less technical wording to ‘extra-tropical’

Boundary issues/ points of clarification

Variations in atmospheric composition are not dealt with in chapter 3 – they are in chapter 2 from an observational perspective and chapter 7 from a feedback process perspective.

Temperature and precipitation will be emphasized in the Technical Summary.

Interactions with WG2 needed on variables and descriptors of climate change (e.g., lakes and runoff; coastal zone issues, etc.), as in TAR.

Storm surges should be treated consistently across chapters 3, 5, and 11.

4. Observations: Changes in Snow, Ice and Frozen Ground

Suggestions by Governments

Include snow and ice in temperate regions and tropics.
Consider consistency across observations.

Boundary issues/ points of clarification

Implications of snow/ ice cover for albedo are to be considered in chapter 4, but albedo is covered more generally for global radiative forcing in chapter 2.
Coordination needed with WG2 on cryosphere variables and how they are handled, as in TAR.
The term "frozen ground" includes and is broader than "permafrost".

5. Observations: Oceanic Climate Change and Sea Level

Suggestions by Governments

Consider changes in ocean mixed layer depth and other water body structural changes.
Include changes in ocean carbon.
Include an overview of all budgetary components of sea level change.
Include the southern oceans, straits and marginal seas.
Consider consistency across observations.

Boundary issues/ points of clarification

Interactions with WG2 needed on variables and descriptors of climate change (e.g., lakes and runoff; coastal zone issues, etc.), as in TAR. Consider storm surges consistently across chapters 3, 5, and 11.
Changes in ocean carbon and carbon uptake are included in chapter 5 as a biological aspect of ocean physical processes and their implications for the carbon cycle budget are carried to chapter 7.
Changes in terrestrial water storage and other terms needed for sea level changes are to be covered within chapter 5.

6. Paleoclimate

Suggestions by Governments

Include issues with the representativeness and interpretation of proxy data in the discussion of uncertainties.
Where possible, link paleoclimatic information on climate variability (ENSO etc) back to chapter 3.
Consider extreme events where possible.
Consider consistency across observations.

Boundary issues/ points of clarification

Attribution of industrial-era climate change is the topic of chapter 9 but some aspects (e.g. Milankovitch cycle) are appropriate for chapter 6.
The appendix is intended to cover general issues in the use of paleoclimatic data, methods and statistical techniques.

7. Couplings Between Changes in the Climate System and Biogeochemistry

Suggestions by Governments

Consider a regional emphasis in coverage of air quality.

Boundary issues/ points of clarification

There are links to chapter 6 on feedbacks (e.g. greenhouse gas and temperature changes on paleoclimate timescales), but chapter 7 will have a process focus and emphasis on recent change.

Consider acidification of the ocean; could be covered in chapter 5 from an observational perspective or considered in chapter 7 from a process and feedback perspective.

Consider overlaps between aerosol/cloud issues in chapter 7 and chapter 3.

Aerosols are considered here for their effects beyond radiative forcing.

Air quality section is intended to consider aerosols as well as trace gases.

8. Climate Models and their Evaluation

Suggestions by Governments

Include discussion of component sub-models of the fully coupled AOGCMs.

Consider range of information beyond mean climate parameters.

Identify clearly models that are considered in chapter 8 and used in chapters 9 and 10.

Include extreme events.

Consider observational constraints on model evaluation.

Consider probabilistic use of climate models

Boundary issues/ points of clarification

Map comparison of models to observations back to observational chapters on atmosphere, ice, ocean where information is available.

Model evaluation will draw heavily on comparisons with observations but also what can be learned from model intercomparisons.

9. Understanding and Attributing Climate Change

Suggestions by Governments

Explain use of the term “prediction” rather than “projection” in the specific (i.e. diagnostic modeling) context of this chapter; treat consistently with IPCC definition and glossary, as in TAR.

Boundary issues/ points of clarification

Be clear about data coverage in space and time (e.g., pre-1900 in instrumental record)

10. Global Climate Projections

Suggestions by Governments

Include simulation of ice and snow changes.

Note cases where models have been compared with paleoclimatic data.

Include a focus on shorter term projections (< 50 y) and longer term projections (>100 years), depending on available literature.

Include projections of changes in extremes.

Include projections of sea level.

Use emission scenarios that have been previously assessed (in SRES or WGIII).

Boundary issues/ points of clarification

AOGCM runs beyond 2100 represent “physics tests”; assessment of socioeconomic scenarios and their uncertainties is outside the purview of WG1.

Models used in chapter 10 will include those with a range of feedback processes (e.g. cloud, ice and snow, carbon cycle, chemistry, as available in published literature).

11. Regional Climate Projections

Suggestions by Governments

Include coverage of extremes in subsections for the regions being considered, noting that some extremes are region specific.

Consider definition of sub-regions, relate to physical climate factors (such as the Mediterranean, etc.) instead of continental boundaries.

Include a careful assessment of uncertainties.

Boundary issues/ points of clarification

This chapter has multiple links to WG2 and sits tructure and region definitions should facilitate effective transfer of information.

Within each continent, regions may be treated differently, there should be a focus on aspects of regional climate change that can be understood in terms of climate processes.

Methodology for extremes would be covered under evaluation of regionalization methods.

Scales and subregions to be covered will depend on availability of data and literature.

Will clarify difference between emission scenarios and climate scenarios.

Summary of primary linking issues between chapters of the WG1 AR4 identified in IPCC WG1-IX session.

	Chapter										
Issue	1	2	3	4	5	6	7	8	9	10	11
Clouds		Aerosol radiative forcing related to clouds	Changes in cloud cover, thickness, etc.				Aerosol effects on circulation, hydrologic cycle		Modelled feedbacks and changes in clouds		
Storm surges			Surface observations		Coastal information						Storm surge modelling
Greenhouse gases		Observed changes				Paleoclimatic behavior of, and ice core data on	Chemistry – climate interactions beyond RF				
Extreme events			Observations			Paleoclimatic evidence for		Simulation of		Global projections	Regional projections
Regional change			Observed changes								Modelled and diagnosed changes
Carbon dioxide		Observed trends and radiative forcing			Ocean carbon processes and use as tracer	Paleoclimate behavior of, and ice core data on	Carbon cycle	Coupled carbon /climate models		Coupled carbon /climate projections	

Part 2. Notes from Expert Discussions at Marrakech and Potsdam Scoping Meetings, and WG1 Bureau Guidance

The input below is a summary of discussions by experts at the two scoping meetings along with suggestions from the WG1 Bureau. It includes both technical issues and some general matters, and has been compiled by the WG1 Technical Support Unit. It should be emphasized that these should be treated only as suggestions, noting the importance of the Lead Authors' expert judgement as well as the ultimate availability of published data and scientific literature during the assessment process.

1. Historical Overview of Climate Change Science

1.1 Introduction

(Describe scope, purpose of chapter, i.e., to provide a broad overview; highlight major advances rather than individual research programs, avoiding overlap with the TS of this report; discussion of history (including IPCC history); possible "box-type" timeline for illustration; provide a general "roadmap" to this report, discuss the new division of chapters compared to TAR).

1.2 Progress in Observations

(Consider insights gained from a variety of approaches including e.g., longer data record lengths, new data records such as permafrost and satellite sea level information, digitization of records thought to be lost or non-existent, new techniques for analysis of paleoclimatic data, better analysis of existing records such as reanalysis, etc.).

1.3 Progress in Understanding of Radiative Forcing, Processes, and Coupling

(Consider progress in understanding of e.g., the coupled Earth system, modes of variability, the mix of forcing types such as aerosols and tropospheric ozone, better laboratory measurements relating to spectroscopy and lifetimes, better understanding of some physical processes such as ice cloud physics, better understanding of key role of cloud/climate feedbacks and mechanisms, carbon cycle/climate coupling, etc.).

1.4 Progress in Climate Modelling

(Assess progress from deeper model hierarchy from SCM to EMIC TO AOGCM, development of new regional methods/models, increased number and diversity of models worldwide, changes re. flux adjustment, higher resolution).

1.5 Advances in Understanding Uncertainties

(Describe broad advances such as development of better statistical approaches, use of ensembles, new methods for uncertainty analysis in detection/attribution, etc.).

Appendix: Glossary of terms

2. Changes in Atmospheric Constituents and in Radiative Forcing

2.1 Introduction

2.2 Definition and Utility of Radiative Forcing

(Surface vs TOA and tropopause forcing to be covered in this chapter; tropics vs. high-latitude, upper and lower troposphere, etc.; assess applicability of forcing–response relationship for various forcing agents).

2.3 Recent Changes in Greenhouse Gases

(Update global records, discuss new information on observed trends in greenhouse gases and precursors, lifetimes, comparison to emissions estimates/source information; provide radiative forcing estimates for CO_2, methane, N_2O, CO, HCFs, PFCs, and other well-mixed greenhouse gases, tropospheric and stratospheric ozone, water vapor from anthropogenic sources, stratospheric water vapor).

2.4 Aerosols – Direct and Indirect Radiative Forcing

(Sources, sinks, microphysics, composition, trends; aerosol observations and related process studies (including in-situ and remote sensing); modelling of aerosol distributions and processes; estimation of aerosol RF from observations;include direct, semi-direct, and indirect radiative forcing estimates; consider absorbing and non-absorbing aerosols as well as mixed aerosol types and information on aerosol precursors).

2.5 Radiative Forcing due to Land Use Changes

(Surface albedo effects; consider information such as satellite measurements; land use and deforestation estimates).

2.6 Contrails and Aircraft-Induced Cirrus

(Consider new findings, incl. impact on DTR, satellite retrieval).

2.7 Variability in Solar and Volcanic Radiative Forcing

(Update on irradiance observations including possible trend in solar minimum; review solar reconstruction approaches and estimates; assess possible solar/climate linkages via e.g., stratosphere and cloud/cosmic ray and other; update on volcanic forcing and evaluation of total of solar plus volcanic forcing for comparison to anthropogenic terms).

2.8 Synthesis of Radiative Forcing Factors

(Update/simplification of RF chart; update of related uncertainties).

2.9 GWPs and Other Metrics for Comparing Different Emissions

(Progress on the GWP concept, consider new published metrics, consider approaches for very short-lived species including aerosols).

Appendix: Techniques, Error Estimation, and Measurement Systems

3. Observations: Surface and Atmospheric Climate Change

3.1 Introduction

(Describe organization of chapter: consider interdecadal variability and trends in the large scale atmospheric system, then describe observed regional changes, their seasonality, and their links to interdecadal variability; present variables in terms of variability and pdfs).

3.2 Changes in Surface Climate

(Temperature (including SST), pressure, humidity, and precipitation, urban heat island effects. Also evaluate availability of information on other variables including e.g., wind, waves, soil moisture, and include where possible).

3.3 Changes in the Free Atmosphere

(Temperature; humidity & cloud; e.g., consider MSU, ISCCP, radio-sonde).

3.4 Changes in Atmospheric Circulation

(Means and variances; introduce idea of EOFs and modes as lead-in to next section).

3.5 Patterns of Variability

(ENSO, NAO, PDO, AAO, etc.; note need for care in definitions, interactions between modes; changes and teleconnections; seasonality of changes; consider winds, wind stress, interactions with air/sea fluxes).

3.6 Changes in the Tropics and Sub-Tropics

(Include both "up and down" for monsoons, viz. India, SE Asia, Australia, West Africa, S & N America + arid regions (Middle East etc). Note some extra-tropical regions are monsoonal; evaluate trends related to ITCZ, consider as available other features of tropical climate).

3.7 Extra-Tropical Changes

(Consider e.g., storm tracks, "blocking", extra-tropical monsoons, other changes outside the tropics).

3.8 Changes in Extreme Events

(Assess available data on the range of extremes: cyclones, hurricanes, storms, heat waves, cold snaps, extreme precipitation, floods, droughts, etc.;also carefully consider what may be said regarding any particular climate events, such as recent floods in Europe)

3.9 Synthesis: Consistency Across Observations

(Draw together a consistent physically-based interpretation of the observations insofar as possible. Consider linkages between different regions (such as monsoon and extra-tropics, surface and mid-troposphere, etc.) and between patterns of variability (e.g., ENSO, PDO, NAO), and trends therein. Identify gaps, key advances since the TAR, key remaining uncertainties.)

Appendix: Techniques, Error Estimation, and Measurement Systems

4. Observations: Changes in Snow, Ice and Frozen Ground

4.1 Introduction

(Scope of chapter; brief summary of role of snow, ice and frozen ground in the climate system, e.g. highlight key processes, interactions, feedbacks).

4.2 Changes in Snow Cover and Albedo

(Observations of snow pack extent and thickness changes (liquid water equivalent); links to temperature, circulation, and precipitation changes; connections to albedo, vegetation; possible coupling to climate (e.g., monsoon/Himalaya); mountain snow pack changes; snow chemistry as it relates to climate change).

4.3 Sea Ice Extent and Thickness Changes

(Concentration, extent, motion; thickness (consider e.g., ICESat, 2003 Jan., CryoSat, 2004); export, surface fresh water flux (net freezing rate), seasonal and long-term changes in sea-ice and its coupling to climate; role of sea ice changes in gas exchange between ocean and atmosphere).

4.4 Changes in Glaciers and Small Ice Caps

(Consider information on glacier lengths (from last 250 years for many glaciers, World Glacier Monitoring); mass balance (available for some glaciers, e.g., Red Book); evaluate contribution to sea-level rise).

4.5 Changes and Stability of Ice Shelves

(Iceberg calving; observations of massive disintegration of shelves (like Larsen ice shelf; assessment of stability of others such as Ross); contribution to sea level rise).

4.6 Changes and Stability of Ice Sheets

(Mass balance (contributions to sea level rise, surface fresh water flux); Ice streams (export to ice shelves); Greenland (e.g., PARCA); Antarctica (e.g., EPICA, EISMINT, ITASE…);discuss new evidence on potential of ice sheet change from ice stream and other studies).

4.7 Changes in Frozen Ground

(Seasonally frozen ground, both polar and mountain; permafrost; observations regarding links to biogeochemistry i.e., exchange of gases such as methane, CO_2; seasonal and long-term changes in permafrost and their coupling to climate).

Appendix: Techniques, Error Estimation, and Measurement Systems

5. Observations: Oceanic Climate Change and Sea Level

5.1 Introduction

(Describe organization of chapter and links to other chapters; focus on ocean observations that relate specifically to climate change, not the broad role of the ocean in the climate system generally).

5.2 Changes in Ocean Salinity, Temperature, Heat Uptake, and Heat Content

(Reference back to chapter 3 re. SST; assess mixed layer temperature gradient; salinity changes, deeper ocean changes;; assess links to changes in climate such as monsoon, ENSO;, atmospheric hydrology, other atmosphere / ocean decadal/interdecadal observations; evaluate available data basin by basin, differences between regions; data on radiation / seawater evaporation / clouds / fluxes; relationship between sea level and upper ocean heat content; implications for global energy flow).

5.3 Biogeochemical Tracers

(Assess observations of biogeochemistry and ocean tracers, including eg., nutrients, CFCs, carbon; implications for time scales/processes of transport from tracer studies - heat penetration, composition change as an indicator of circulation change ;consider data on sea-air gas fluxes).

5.4 Changes in Ocean Circulation and Water Mass Formation

(Thermohaline circulation – link to cryosphere and paleo chapters – ice/snow/precip /runoff & effects on THC - evaluate observational evidence for changes; location of key currents and ocean fronts, gyres; latitudinal heat fluxes -- how well they are known and any evidence for changes; patterns of ocean variability; air-sea fluxes, including climate change in the surface water mass transformation rates and changes in the oceanic heat transport and fresh-water transports.)

5.5 Sea Level: Global and Regional Changes

(Assess global and regional sea level changes and their links to climate system: role of ocean mass-changes, thermal expansion, local oceanic processes, land ice, sea ice, geologic processes, etc. Summarize from TAR, note strong links to cryosphere chapter; include roles of other processes (e.g., aquifers, other terrestrial storage); assess regional and local variations in sea level rise; draw on new ocean heat content/uptake data as appropriate; consider storm surge, wave, tidal effects, tropical cyclone, coastal flooding (rivers + sea level), regional variability; consider interdecadal variability,; rates of sea-level rise; evaluate observed trends in sea-level in the 20th Century and explanations).

Appendix: Techniques Error Estimation, and Measurement Systems

(Include discussion of uncertainty, sensitivity of sea-level observations;amount of available subsurface data).

6. Paleoclimate

6.1 Introduction

(Describe organization and purpose of chapter).

6.2 Proxy Methods and their Uncertainty

(Generic concern: 'how to use paleo data critically'; consider types of, and uncertainty in, range of proxy records including temporal (dating), climate variable, spatial; consider annual vs non-annual, calibration issues).

6.3 Inferred Past Climate System Change

- *Intro: relevant earth climate history*
- *Include climate forcing, sea level, and biogeochemistry*
- *Consider organization of section: by climate focus or by temporal period? authors to choose*
- *Option 1: By climate focus*
  - *variables: temp, precip, modes, extremes, etc., each by time period*
  - *modes, physical features: ENSO, PDV, AO, NAO, monsoons, etc., each by time period*
  - *time period considered: e.g., last 100 my?,or begin with last 1 my, last 10 ky, to last 2000 yrs*
- *Option 2: By temporal period; variables/modes as above*
- *Common attributes independent of option*
  - *Global and regional foci where information is available*
  - *Paleo insights to forcing and responses*

6.4 Abrupt Climate Change

(Cold-climate abrupt change (build on strength of TAR); warm climate abrupt change (include new studies since TAR); consider climate thresholds, can any be identified? assess what can be said about whether probability of encountering one depends on magnitude. or rate of change, or both? consider special issue of ice sheets - Greenland as well as WAIS).

6.5 Paleo-Environmental Model Evaluation and Sensitivity

(Consider use of paleo modelling to provide insights regarding climate change simulation typically with lower resolution but millenial integrations; Global models - transient and equilibrium runs; regional models;strengths/weaknesses of paleo model evaluation ; what do paleo models do well, and not so well? Last 1000 years now done with full resolution AOGCMs drawing on paleo approaches; note need for interaction with chapters 8 and 9).

6.6 Synthesis: Insights Into Climate System Behavior

(Consider extent to which we understand what happened in the past and implications for present e.g., does paleo data/modelling/abrupt event record provide insight re. ice sheet stability? Summarize implications for climate sensitivity from paleoclimate models and observational studies; discuss observations/modelling of rates/magnitudes of recent/future change vs. the past – is current/recent magnitude or rate of change unprecedented? On what time scales?).

Appendix: Guide to the Use of Paleoclimatic Information

7. Couplings Between Changes in the Climate System and Biogeochemistry

7.1 Introduction to Biogeochemical Cycles

(Discuss purpose, evolution from TAR to consider coupled system with biogeochemistry, affected by human activities; adds to understanding by replacing parameterized features previously linked to observations (e.g. of CO_2 *concentrations) to become fully predictive as the climate system changes; prompted by increasing numerical capacity, complexity of models, and evolution of understanding; emphasis on chains of events;include brief tutorial on biogeochemical cycles).*

7.2 The Carbon Cycle and the Climate System

(Assess range of carbon cycle processes, controls, budgets, sources, sinks; evaluate progress in simulating/understanding inter-annual variability; consider effect of carbon coupling on future climate (e.g., potential for large carbon source if changes in ENSO or drought occur, etc.; evaluation of respiration in altered climates); include possible connections of carbon to nitrogen cycle (fertilization, N2O emissions); inversion analysis and implications for source/sink distributions; include ocean source/sinks,; assess results of C4MIP model intercomparisons;consider implications for scenarios and for stabilization).

7.3 Global Atmospheric Chemistry and Climate Change

(Discuss processes, controls, budgets, sources, sinks of each key trace gas; feedbacks with climate change; projections for each of CH_4 *and* N_2O*;* O_3*, and Sulfur. Consider possible coupling of stratospheric ozone changes to surface climate (bring forward relevant information from Special Report ozone/climate); assess lifetime changes due to chemical/dynamical feedbacks (eg.,* CH_4*); role of nitrogen and sulfur cycles, etc.; implications for scenarios and stabilization for* CH_4*,* N_2O*, and other gases; implications for scenarios for trop and strat ozone futures).*

7.4 Air Quality and Climate Change

(Trends in air quality and their influence on radiative forcing (e.g., from tropospheric ozone and aerosol increases), links of climate to sources, budgets; controls over sources and sinks, e.g., possible climate effects on isoprene emissions from vegetation; role of long-range transport; role of megacities; effects of climate change on chemical processing (e.g., changes in water vapor, temperature, and OH); direct and indirect feedbacks of air quality to climate; emissions of SO_2 *and relation to air-quality regulations).*

7.5 Aerosols and Climate Change

(Assess climate linkages for aerosols on larger scales; hydrologic cycle feedbacks; special issues relating to absorbing aerosols, i.e., soot; effects on surface energy budget; possible links of aerosols/diffuse flux to carbon cycle; range of aerosol/climate/chemistry interactions including influences on circulation patterns; regional-scale analyses of coupled aerosol/chemistry/climate simulations; effects of climate change on natural aerosol and aerosol precursor emissions).

7.6 The Changing Land Surface and Climate

(Assessment of process understanding of the role of human land use in climate change using increasingly sophisticated land models; evaluation of coupling of land-surface hydrology (not water cycle) to the climate system and its relevance; links to vegetation dynamics; evaluation of role of disturbances such as major fires).

7.7 Synthesis: Interactions among Cycles and Processes

(Implications of past changes for attribution and projections of future in a rapidly-evolving and fully coupled system; likely evolution of carbon, nitrogen, aerosols, chemistry, and land surface/hydrology in the 21st century; potential for 'surprises').

8. Climate Models and their Evaluation

8.1 Advances in Modelling

(Describe advances in modelling since the TAR: e.g., atmosphere and land surface description/parameterizations; dynamical core; river routing; hydrology; ocean mixing schemes, water mass formation; new parameterizations for sea ice, land ice, and snow cover; higher resolution, moist physics and radiative transfer descriptions; coupling, flux adjustment, numerical issues; consider advances in understanding model uncertainty)**.**

8.2 Evaluation of Contemporary Climate As Simulated by Coupled Global Models

Focus on base-state of 20th century climate

Partial list of variables for authors to consider, depending on available information (suggestion is map to observational chapters insofar as practical):

- *Atmosphere*
  - *Surface air temperature distribution (diurnal and annual cycle)*
  - *Temperature profile and latitudinal structure*
  - *Precipitation*
  - *Sea level pressure*
  - *3-D structure of the atmosphere (temperature, moisture, circulation)*
  - *Cloud cover (horizontal and vertical distribution)*
  - *Storm Tracks*
  - *ITCZ*
  - *Monsoon*
- *Ice*
  - *Snow cover*
  - *Sea ice*
  - *Ice sheets*
  - *Frozen ground*
- *Ocean*
  - *SST, SSS*
  - *3-D structure of T, S*
  - *Circulation*
  - *Water mass distribution*
  - *Location of deep water formation*
  - *Energy and moisture exchanges*
  - *Meridional heat transport*
  - *Exchange fluxes*
- *Radiative Fluxes*
  - *SW, LW, surface, TOA*

8.3 Evaluation of Large-Scale Climate Variability as Simulated by Coupled Global Models

(Modes – ENSO, PNA, NAO/AO, AAO, PDO, QBO, etc; Interactions between modes (e.g., interdecadal modulation of ENSO); Teleconnected processes –e.g., Atmospheric Bridge, Ocean subduction processes (midlats – tropics); this section will draw on WCRP MIPS and other global and regional model intercomparisons).

8.4 Evaluation of the Key Relevant Processes as Simulated by Coupled Global Models

(Process-oriented discussion of model simulation of fluxes, , clouds and water vapor feedbacks, heat and water transport, etc.).

8.5 Model Simulations of Extremes

(Consider full range of types of extreme events where information is available, assess how well models can simulate them, e.g.,temperature, precipitation, tropical storms, extra-tropical storms, wave height, droughts, flooding, etc.; assess where possible links to dynamical processes and modes - e.g., links to ENSO or NAO).

8. Climate Models and their Evaluation (continued)

8.6 Climate Sensitivity

(Concepts - equilibrium vs. transient climate sensitivity; dependence on basic state; range of sensitivity in models; relating sensitivity to feedback processes; range of transient sensitivity for next few decades based on current models and under idealized 1% forcing at e.g., years 35, 70 (CMIP2), and relationships to steady state; observational constraints on the range; probabilistic analysis of uncertainty range)

8.7 Evaluation of Model Simulations of Thresholds and Abrupt Events

(Concepts and uncertainties, predictability issues, THC collapse, WAIS and Greenland ice sheet meltdown, water hosing experiments; other low probability/high impact events; volcanoes).

8.8 Representing the Global System with Simpler Models

(Discuss formulation of simple climate models, EMICs; describe linkages to specific GCMs, range of GCMs; limitations, implementation, and uses).

9. Understanding and Attributing Climate Change

9.1 Introduction

(Describe organization and scope of chapter, include global and regional forcing–response assessment, perturbed climate during the instrumental era, with consideration where appropriate of earlier periods, with links to chapter 6).

9.2 Radiative Forcing and Climate Response

(Draw from chapters 2 and 8, literature, 20C3M; CMIP; include AOGCM and EMICs;assess responses to natural and anthropogenic forcing, consider spatial variability in forcing and possible regional responses or lack thereof)

9.3 Seasonal to Interannual Predictions of Climate Change and their Reliability

(Assessment of skill in forecasting ENSO and other climate changes in prediction mode; consider implications of such studies for evaluation of internal variability and forced responses across time scales - seasonal, inter-annual, decadal? longer? scope of this discussion will likely depend upon literature yet-to-be-published and requires careful examination).

9.4 Understanding Pre-Industrial Climate Change

(Draw on Chapters 2-8 and additional literature – global, and regional as appropriate. last 1000 (perhaps 2000?) years; needs coordination with Ch. 6)

- *Qualitative description (means, variability – include modes and extremes)*
- *Quantitative assessment*
  - *role of natural external forcing*
  - *inferred climate sensitivity, etc.*
- *Uncertainty*

9.5 Understanding Climate Change During the Instrumental Era

- *(Draw on Chapters 3-5, 7,8; 20C3M, detection literature).*
  - *global, and regional, as available from literature*
  - *new information from analyses of variables such as tropopause height, sea level pressure, precipitation, ocean heat content, etc.*
- *Qualitative description (means, variability, modes, and extremes, high-impact events)*
- *Quantitative assessment*
  - *detection/attribution*
  - *role of external forcing*
- *Information regarding climate sensitivity*
- *Relationship between sensitivity and predictability*
- *Uncertainty*

Appendix: Methods Used to Assess Predictability

Appendix: Methods Used to Detect Externally Forced Signals (Detection/Attribution)

Appendix: Methods Used to Assess Uncertainty

10. Global Climate Projections

10.1 Introduction

(Scope of chapter; note key role of climate sensitivity; describe model runs assessed, emphasis on two timescales: next few decades and next few centuries).

10.2 Projected Radiative Forcing

(Radiative forcings for range of scenarios considered).

10.3 Timescales of Response

(Ocean heat uptake; concept of "commitment to future climate change" as in TAR and its causes/connections: atmosphere, ocean, ice/snow, sea level; hemispheric contrast; uncertainties and virtual certainties – identify what is dependent on physics, inertia, and time scales, and what is less certain - e.g., feedbacks).

10.4 Climate Change to 2100 and Beyond

- *Projected Changes (Mean; PDF where possible; Moments)*
- *Discuss types of models, range of processes (e.g., coupled sulfur cycles, land models, etc.)*
- *Consider range of variables, depending on available literature:*
  - *SAT, Precipitation, Evaporation, DTR*
  - *Ocean temperature, circulation*
  - *Ice cover, ice thickness*
  - *Circulation patterns, regime shifts*
  - *Modes of variability and teleconnection patterns (ENSO, NAO, AAO,…)*
  - *Extremes (Temperature, Rain (drought/floods), Indices)*
  - *Abrupt changes*
  - *Climate classifications*
    - *Arctic, Tropics (monsoon, arid), mid-latitudes*
  - *Ice sheets/glaciers*
  - *Carbon cycle / Vegetation - projections of concentrations and feedbacks (link to chapter 2 and 7; include C4MIP information)*
  - *Atmospheric chemistry/climate where available - projections of concentrations and coupling (link to chapter 2 and 7)*

10.5 Sea Level Projections

(Review of processes affecting future as opposed to presently observed sea level rise (coordinated with chapter 4 and 5); methods of sea level projections and uncertainties associated with them; discussion of time scales for responses of ocean and atmosphere to forcing and stabilization scenarios; global and regional projections to and beyond 2100; long term stability of the Greenland and Antarctic ice sheets and their potential to affect sea level).

10.6 Scenarios and Simple Models

(Idealized runs (systematic comparison); simplified model projections and their limitations; SRES, stabilization experiments as available from assessed studies).

10.7 Uncertainties in Global Model Projections

(Ensembles, physics/parameterizations, predictability; quantification of uncertainties (link to Chapters 8 & 9); Linkage to chapters on climate models and D&A/processes and regional; consistency of physical arguments; link to chapter 7 for discussion of process-level understanding of human interactions not fully captured in all current AOGCMs such as aerosol–hydrologic cycle coupling, carbon cycle and chemistry, etc.).

11. Regional Climate Projections

11.1 Introduction

11.2 Evaluation of Regionalization Methods

(Highlight advances since TAR; techniques fine-tuned, breadth of application increased; time slice GCMs, RCMs, variable resolution/ nested grid approaches, empirical downscaling)

- *Method concepts, assumptions, caveats, key issues (e.g.,stationarity).*
- *Method evaluation: performance, skill, uncertainty; include updated discussion of differences among AOGCMs in each region as in TAR*
- *Inter-comparison of methodological strengths and weaknesses*

11.3 Alternative Simple Methods

(Perturbation techniques, pattern scaling, projections of historical trends)

11.4 Projections of Regional Climate Changes

(Introduction: each region addresses issues and projections as tailored products for a number of regions derived from published studies with AOGCMs, time slice GCMs, RCMs, and empirical downscaling.)

Optimize consistency of regions and variables with WG2

- *Foci to consider(where information exists):*
  - *Alternative seasons of relevance (in addition to DJF etc.)*
  - *Seasonal cycles*
  - *"Extremes" of relevance (eg: tropical storms, drought / flood, storm surges, heat waves, frost, extreme seasons, etc)*
  - *Mountain hydrology*
  - *Changes in circulation / regime (storm tracks, monsoon, NAO,ENSO, etc)*
  - *Variability (daily, intra-seasonal, inter-annual, decadal)*
  - *Regional effects of local forcings (aerosols, land surface change, etc; coordinate with chapters 9, 10, and 7 regarding teleconnections and responses to local forcing)*
  - *Available probabilistic projections based on ensembles*
  - *Evaluation of uncertainties relevant to the region*
  - *Regional consequences of abrupt climate changes/thermohaline circulation change if possible?*
  - *Discussion of regional sea level change?*
  - *Available hydrological cycle components (e.g., snow, soil moisture, runoff(?), potential evaporation, etc)*

Evaluate regions (major divisions same as approved WG2 set, see below) as well as appropriate sub-regions, based on physical climate, as in TAR. Suggestions for subregions here follow TAR and scoping meeting discussions:

- *Australia and New Zealand*
- *Asia*
  - *Southeast Asia + maritime continent*
  - *East Asia*
  - *India / South Asia*
  - *Middle East and Central Asia*
  - *North Asia*
- *Africa*
  - *Sub-Saharan and Southern Africa*
  - *North Africa (links to Mediterranean, Europe)*
- *Europe*
- *Latin America*
  - *South America*
  - *Central America and the Caribbean*

- *North America*
- *Polar Regions*
    - *Arctic*
    - *Antarctic*

11.5 Small Islands

(Synthesize small island results from continental regions in 11.4; include regional ocean circulation information where available, etc.)

11.6 Uncertainties in Regional Projections

(Evaluation of RCMs and other regionalization techniques.)