

USGS/CCSP SAP 3.4 “Abrupt Climate Change” Workshop I

March 26-28, 2007

Hyatt Regency Reston
Lake Thoreau Room
1800 Presidents Street
Reston, VA 20190

Objectives of the Meeting:

- Produce an outline of topics for consideration in the synthesis and assessment product.
- Establish writing assignments and tasks.

Monday March 26, 2007

Participation list:

Committee Members

- Peter Clark, Oregon State University
- Ed Cook, Columbia University
- Tom Delworth, NOAA
- Carrie Morrill, NOAA
- Dan Muhs, USGS
- Konrad Steffen, CIRES
- Andrew Weaver, University of Victoria, Canada

Administrative Committee

- Jack McGeehin, USGS, Designated Federal Officer (DFO)
- Dave Anderson, NOAA
- Dave Verardo, NSF
- John Barron, USGS

Speakers

- Mark Myers, Director, USGS
- Peter Schultz, CCSP
- Joan Fitzpatrick, USGS
- Robert Thomas, NASA
- Shawn Marshall, University of Calgary, Canada
- Bill Johns, University of Miami
- David Lawrence, National Center for Atmospheric Research
- Ron Stouffer, NOAA

Public

- Karen Wood, USGS

- Tom Armstrong, USGS
- Howie Spero, NSF
- Bruce Molnia, USGS
- Milan Pavich, USGS
- Anjuli Bamzai, DEO
- Kathryn Hayo, USGS
- Jill Dyszynski, USGS
- Michael Kerrigan, Kerrigan and Associates
- Peter Folger, CRS

Facilitation Team

- Tricia Gibbons, Facilitator, LEAD Alliance
- Kathleen Cleary, LEAD Alliance Recorder
- Carrie Miller, USGS

11:00 AM to 12:00 PM: Opening of Workshop

Jack McGeehin, Designated Federal Officer (DFO) of the SAP 3.4 Committee on Abrupt Climate Change officially called the meeting to order. Roll was taken by having each of the Committee members stand and introduce themselves. Two committee members were not in attendance: Richard Seager and Robert Webb. Richard Seager participated by submitting comments by email. These comments were read to the committee at various times during the workshop and the issues raised were addressed as necessary. Jack McGeehin announced that Peter Clark and Andrew Weaver will be the coordinating lead authors for SAP 3.4.

There were no formal public comments given during the public comment period, nor were there any submitted in writing. The public was invited to participate through the Q&A period and panel discussions that ensued in each subsequent session of the workshop.

Mark Myers, director of the U.S. Geological Survey, provided the opening remarks for the workshop. Director Meyer's expressed his vision of the USGS as a science organization and not a political department. USGS is unbiased in its approach, striving to accurately represent the state of the science. Abrupt climate change a very important issue – critical for society. Director Myers has seen the results of climate change in Alaska firsthand. He suggested that the impacts are very compelling, and that we need to get this information out to the public. Director Myers noted that he is looking forward to seeing the results of this study, both for its furthering our understanding of the science and as a mechanism to direct future research.

Peter Schultz, Acting Director of the Climate Change Science Program (CCSP) Office, spoke next concerning the background of the CCSP, its strategic plan, the synthesis and assessment (SAP) program, and interagency research activities and priorities. Peter introduced the CCSP Priority on Abrupt Climate Change that includes an integrated Earth system analysis capability that will serve as a primary means for detection and

monitoring of rapid changes in the Earth system; an improved decadal forecasting capability; a vigorous paleoclimate research program; and an accelerated effort to determine implications for society and ecosystems of abrupt change.

1:15 PM to 1:30 PM: Afternoon announcements/discussion

Discussion of overlap between SAPs. Potential for overlap most evident with SAP 1.2 on 3 of our 4 issues: MOC, methane, and ice sheets/glaciers. Joan Fitzpatrick is introduced to the committee as the DFO of SAP 1.2. Joan to be available for discussion throughout the workshop. Agreement among committee members that some overlap is good. Redundancy will help to solidify message with the public and policymakers. Excessive overlap can be avoided with careful planning. Engagement of lead authors of SAP 1.2 with lead authors of SAP 3.4 is important, earlier rather than later in the outlining and research process.

Discussion of Richard Seager's email comment arguing for the inclusion of climate extremes in this report: "In this I include hurricane intensity and trajectories but also the shift everywhere of more precip into high precip events. Hurricanes need no further explanation but changes in precip intensity are important to, for example, the naturally-filtered NYC water supply system because of the increased surface run off. Also include here heat waves - currently a major killer."

The committee felt that this topic was being addressed in SAP 3.3: Weather and Climate Extremes in a Changing Climate.

1:30 PM to 3:25 PM: Rapid Changes in Ice Sheet Mass Balance

This session followed closely the schedule posted in the workshop [agenda](#). [Synopses of the individual talks](#) can be found here.

- **Konrad Steffen**, Cooperative Institute for Research in Environmental Sciences, Boulder, Colorado, USA: "Cryospheric Contributions to Sea-Level Rise and Variability"
- **Robert Thomas**, NASA Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia, USA: "Ice-sheet contributions to sea-level change"
- **Shawn Marshall**, Department of Geography, University of Calgary, Calgary, Canada: "Sea level rise past, present, and future: the perspective from ice sheet models"

3:45 PM to 5:15 PM: Panel Discussion

Many definitions of "abrupt climate change." The Committee took a few minutes to discuss the definition of abrupt climate change that it will use for this report. The NRC Report "Abrupt Climate Change" used a definition that is a combination of technical and social terms. New definition should follow a common theme, include a timeframe and be

understandable by the general public. Dave Verardo cautioned the committee to think carefully about rates in a new definition of abrupt climate change. Andrew Weaver and Tom Delworth agreed to wordsmith a definition that will be presented later in the workshop.

Bob Thomas questioned why the committee is not considering sea ice in this section.

Andrew Weaver asked if the committee could consider sea ice in the MOC section.

Shawn Marshall agreed about the importance of considering sea ice as part of the climate system.

Koni Steffen suggested that sea-level rise is the biggest impact associated with the cryosphere. Sea ice is an important feedback mechanism, though. If the committee is going to consider sea ice it will need additional people. Or it would need a separate subcommittee to address the topic. Also, the committee should distinguish between abrupt warming and abrupt cooling.

Bob Thomas brought up the importance of ice shelves and their influence on glaciers. Also, he noted that ocean influence on ice sheets is important, because of the basal lubrication of glaciers.

Howie Spero: based on presentations, do we need to discuss uncertainty in the rate? IPCC has talked about a continuum of rates, can we be more specific?

Peter Clark stated that sea level rise estimates are key if current rates of melting continue.

The issue was raised about dealing with impacts and quantifying uncertainties, not only for the ice sheet section, but all sections of the report. The committee felt that it could and should identify impacts to society. Less certain was how to treat these impacts in the SAP, since the committee may not have the expertise to adequately treat these topics. At a minimum, it was agreed, the committee would identify important impacts and discuss them to the best of its ability. On the issue of quantifying uncertainty (e.g. a IPCC-like scale of uncertainty), the committee was uneasy with this approach, but put off a decision until later in the workshop.

Shawn Marshall pointed out that the committee had the opportunity here to provide a careful discussion of what's missing in the ice sheet models. He also suggested that the committee include an observational section in the report that addresses what is necessary to continue monitoring glaciers.

Dan Muhs asked if we should consider East and West Antarctica separately. Koni Steffen suggested that that would not be necessary as the processes are the same in both places.

Bruce Molnia stated that he wants to dispel the myth that temperate glaciers will disappear in one hundred years. Many of these are at high elevation.

Peter Folger said that with respect to this section of the report, sea level is what counts; it's what people care most about.

Anjuli Bamzai cautioned that you can add on new questions to this study, but if you drop a question, the reviewers may say that you have not addressed questions stated in the prospectus.

The committee debated a new title for this section. It was generally agreed that "Rapid Changes in Ice Sheet Mass Balance" was not a useful title. Does not include glaciers. New working title: "Rapid Changes in Glaciers and Ice Sheets and Impacts on Sea Level."

Discussion shifted to framework of SAP document. Held up SAP 1.1 (the only SAP completed and published at the time of this workshop) as an example. Each chapter in SAP 1.1 starts with "key findings," "recommendations," and an introduction. These sections are written in plain English, easily understandable by the general public. After that, the body of the chapter varied from one to the next. The committee agreed to follow this approach for SAP 3.4. The body of each chapter will be drafted based on the outline put forth by the subcommittee responsible for that section. The chapter subcommittees will use side bars whenever necessary to handle specific topics that warrant extra attention, issues of overlap with other SAPs, case studies, etc.

Jack McGeehin established the "Rapid Changes in Glacier and Ice Sheets and Impacts on Sea Level" subcommittee.

Konrad Steffen was nominated by Peter Clark to be the Chapter lead author for this section without objection by any committee members. Dan Muhs seconded. Konrad Steffen accepted the role.

Jack McGeehin discussed the role of contributing authors. Subcommittees are free to work together independent of the full FACA committee as long as they report back to the full FACA committee their findings. Contributing authors can be added by the subcommittees as necessary. However, the names of new contributing authors should be made available to the two coordinating lead authors (Peter Clark and Andrew Weaver) and the DFO (Jack McGeehin) before they are approached by the subcommittee.

Tuesday, March 27, 2007

Participation list:

Committee Members

- Peter Clark, Oregon State University
- Ed Cook, Columbia University

- Tom Delworth, NOAA
- Carrie Morrill, NOAA
- Dan Muhs, USGS
- Konrad Steffen, CIRES
- Andrew Weaver, University of Victoria, Canada

Agency Organizing Committee

- Jack McGeehin, USGS, Designated Federal Officer (DFO)
- Dave Anderson, NOAA
- John Barron, USGS
- Dave Verardo, NSF

Invited Speakers

- David Archer, University of Chicago
- Ed Brook, Oregon State University
- David Lawrence, National Center for Atmospheric Research
- Jean Lynch-Stieglitz, Georgia Institute of Technology
- Bill Johns, University of Miami
- Ron Stouffer, NOAA
- Shawn Marshall, University of Calgary, Canada
- Bob Thomas, NASA
- Pat Bartlein, University of Oregon
- Joan Fitzpatrick, USGS

Public

- Anjuli Bamzal, DOE
- Rick Rosen, NOAA
- Jim Todd, NOAA
- Howie Spero, NSF
- Milan Pavich, USGS
- Bruce Molnia, USGS
- Kathryn Hayo, USGS
- Jill Dysznski, USGS
- Michael Kerrigan, Kerrigan & Associates, Inc.
- Jane Leggett, CRS
- Amy Wagoner, NOAA
- Cheryl Fossani, NSF
- Johnny Casana, NSF

Facilitation Team

- Tricia Gibbons, LEAD Alliance
- Kathleen Cleary, LEAD Alliance
- Carrie Miller, USGS

8:00 AM to 8:15 AM: Morning announcements/discussion

Proposed definition for abrupt climate change presented by Tom Delworth: A large scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems.

This statement was generally agreed upon by the committee.

8:15 AM to 10:10 AM: Rapid Release of Methane from Hydrates

This session followed closely the schedule posted in the workshop [agenda](#). [Synopses of the individual talks](#) can be found here.

- **David Archer**, Department of Geophysical Sciences, University of Chicago, Chicago, Illinois, USA: “Methane hydrates and global warming: a risk analysis”
- **Ed Brook**, Department of Geosciences, Oregon State University, Corvallis, Oregon, USA: "The ice core record of abrupt changes in atmospheric methane"
- **David Lawrence**, National Center for Atmospheric Research, Boulder, Colorado, USA: “Vulnerability of Permafrost and Peatland Carbon Pools to High-latitude Warming: Amplifying Feedbacks to Climate Change?”

10:30 AM to 12:00 PM: Panel Discussion

Jack McGeehin gave a brief history of how this topic (methane) came about in prospectus. There is enough in the public interest to discuss, even if there is little evidence for an abrupt change. Committee can still provide useful recommendations. At this time, there is no one on the committee on this topic.

Issue is of importance to population centers in permafrost regions because of the potential impact to infrastructure.

Dave Anderson suggested that we need to better define the scope of this section.

Andrew Weaver said that the initial focus was hydrates but it has expanded. It leads into the discussion of other changes that are more likely or faster.

Dan Muhs asked if there is any speculation on hydrates from past events?

Peter Clark said that many people feel very strongly about the PETM.

Konrad Steffen asked about permafrost on the continental shelf.

Dave Lawrence responded that most people are talking about hydrates on the shelf, not permafrost.

Tricia Gibbons asked as a member of the general public, why should I care?

Dave Lawrence said that she should care because methane is a powerful greenhouse gas.

Ed Brook added that there is a very large reservoir of methane.

The committee felt that some of the questions in the prospectus are too broad (Question #2: What is the impact on the climate system of the release of varying quantities of methane over varying intervals of time?) or difficult to answer based on our current understanding of the science (Question 4: How much methane is likely to be released by thawing of the topmost layer (3m) of permafrost? Is thawing at great depths likely to occur?)

The committee felt that a new title is needed for this section. Current title too narrow. New working title: "Abrupt Changes in Atmospheric Methane."

The committee returned to the issue of dealing with uncertainty in this SAP. Ron Stouffer pointed out that SAP 3.3 is using a modified IPCC scale. Uses slightly different terms. Ed Cook and Dan Muhs suggested that the committee keep IPCC terminology but lose the percentage scale. Peter Clark wants to keep IPCC scale with uncertainty scale unchanged. Tom Delworth agrees that it should be kept unchanged to avoid confusion. Committee agrees that use of an uncertainty scale needs to be applied consistently between subcommittees. Final committee decision: use the IPCC likelihood scale with numbers.

Michael Kerrigan suggested that the report include a reader-friendly explanation of the scientific methodology and terminology either as an appendix or forward.

Jack McGeehin reiterated the importance of writing in layman terms. This is primarily a document for policymakers.

Jane Leggett requested a statement in the report of how federal funding has factored into abrupt climate change research and how funding should be focused in the future.

Key methane findings:

- No certain evidence in geologic past for catastrophic release of methane hydrates that caused an abrupt climate change
- Certain amount of permafrost could degrade (some has degraded); uncertainty as to its impact; however, we are seeing a slower gradual change.
- Huge potential for climate despite low probability.

Dan Muhs asked the panel if they agreed that a key finding could be that there is no certain evidence in the geological past for a catastrophic release of methane?

Jack McGeehin asked how about a similar statement from the modeling perspective.

Dave Lawrence said you might be able to make a definitive statement that a certain amount of permafrost will melt.

Dan Muhs said enough evidence exists to say, permafrost has already degraded.

Dave Lawrence responded that these are mostly isolated measurements. I feel that our work is in the early stages... would have to be toned down.

Dave Anderson said that this would be a chronic, ongoing thing.

Andrew Weaver pointed out that this would be an important thing to say, that this is not an abrupt runaway effect, but a slow gradual amplification.

Dave Lawrence said this is supported by the geologic record (not a runaway, an amplifier).

Dan Muhs said that there is plenty of evidence for the last interglacial for arctic having changed more.

Ed Brook said that he could not say for sure whether methane was higher- another brief interval of high methane could have been missed. Bounds can be placed.

Dave Anderson pointed out that along with the low probability statement should be the observation that the potential impact is very large.

Andrew Weaver said that the IPCC coverage was inadequate on methane. Only a paragraph.

Question about time frame of study. The committee felt that it could look 100 years or so out, further if necessary.

Anjuli Bamzai reiterated the importance of answering all the questions in the prospectus as presented. Committee should not change them. Also, she noted that there is a CCSP fact sheet on methane. Committee should check and see if it is still valid.

John Barron commented: Will David Lawrence's discussion of landscape change, abrupt change in sea ice, vegetation, other land surface characteristics be considered in the report?

Dave Lawrence said these should be mentioned in a chapter on methane. But not sea ice.

Koni Steffen said sea ice will get considered within the ice sheet chapter as a feedback.

Peter Clark and Andrew Weaver agreed that sea ice needs to be treated, possibly in more than one section of the report.

Jack McGeehin established the Abrupt Changes in Atmospheric Methane subcommittee. No lead author at this time. Ed Brook is being considered as a full committee member. He indicated that he would accept the position if offered and would serve as the chapter lead. David Archer and David Lawrence will also serve as contributing authors. Ed Brook will lead the break out group and present the draft outline to the committee on Wednesday.

1:15 PM to 1:30 PM: Afternoon announcements/discussion

Joan Fitzpatrick gave a short overview of SAP 1.2 prospectus (Arctic paleoclimate) in order to address issues of overlap. Subcommittees advised to stay in touch with both DFOs concerning how to address overlap. If necessary, DFOs will put committee members from one SAP directly in touch with committee members from the other SAP to work on integration of the two topics.

1:30 PM to 3:25 PM: Meridional Overturning Circulation Change and Influence on Climate

This session followed closely the schedule posted in the workshop [agenda](#). [Synopsis of the individual talks](#) can be found here.

- **Jean Lynch-Stieglitz**, Georgia Institute of Technology, Atlanta, Georgia, USA: “Atlantic MOC: Evidence for past variability and relationship to abrupt climate change during the last 80,000 years”
- **Bill Johns**, Division of Meteorology and Physical Oceanography, University of Miami, Miami, Florida, USA: “The Atlantic MOC: Modern observations, variability and detection of change.”
- **Ron Stouffer**, Climate Dynamics and Prediction Group, Geophysical Fluid Dynamics Laboratory, NOAA, Princeton, New Jersey, USA: “Modeling Abrupt Climate Change”

3:45 PM to 5:15 PM: Panel discussion

Addressed Richard Seager’s email comment: “Controls on the MOC: Coupled GCMs weaken the MOC in the 21st C because of surface warming and freshening - via increased poleward water vapour transport - of the subpolar seas, something all models get. However when I look at work by people like Gordon, Gnanadesikan, Toggweiler .. I see explanations for the MOC revolving around salt transport from the IO to the AO in Agulhas eddies and in terms of winds over the Southern Ocean. I find these explanations convincing but the way they control the MOC is indirect and it could be that models

handle them differently and all we are seeing in the models is the impact of the one control - the atmospheric hydrological cycle - that the models all agree on. Reality could be more complex leaving the possibility that the N Atlantic MOC could strengthen – just as some claim (e.g. Lund et al. and sometimes Keigwin) that it weakened in a colder climate (the Little Ice Age).”

Ron Stouffer suggested that we not commingle the transient and equilibrium response – they are different. For example, all models show a weakening in future decades, a transient response. But in the 2 times CO2 equilibrium runs, the MOC is not weak.

Bill Johns said Richard makes comments about processes and time scales. The slow upward diffusion varies on millennial scales. Other processes, like winds, are faster.

Tom Delworth asked if there studies that suggest whether the winds play a role in transient change in the MOC? He thinks we should consider Richard’s comments in this study.

Ron Stouffer: What’s in the IPCC is an excellent starting place. His advice is to start there. Impact on North America not addressed, but should be.

Andrew Weaver pointed out that Bill John’s RAPID talk was not available for IPCC. All new material for this study. Also, the paleo was separated out in IPCC. New angle might be to incorporate paleo into this section.

Bill Johns questioned how to address abruptness in the MOC section. Impacts (e.g. storms) possible due to changes in MOC.

Tom Delworth: An excellent point. Need to look at abrupt impacts from gradual MOC change.

Jean Lynch-Stieglitz thought much of the work Ron Stouffer and Bill Johns showed qualify as abrupt.

Tom Delworth said that one of our recommendations will be the need to resolve the correlation between the MOC and hurricane frequency.

Ed Cook pointed out that the AMO has come up a fair bit. Could it be connected with the MOC?

Tom Delworth: the hypothesis is that the AMO is linked to change in the MOC.

Ed Cook: the AMO has a strong influence on drought over North America.

Bill Johns: What we can say now is that many models have an AMO mode linked to the MOC. The mechanism is not that well understood.

Konrad Steffen asked if the disintegration of the Antarctic ice sheets would have an affect on the MOC.

Ron Stouffer. Unlikely. You have to get the melt water up to the North Atlantic.

Addressed Richard Seager's email comment: "The prospectus assigns the climate impact of the MOC heat transport to just Europe. This is wrong and leaves unchallenged the wrong - but common - belief that the MOC heat transport causes the difference in winter climate across the N Atlantic. Actually it warms both sides of the Atlantic by the same amount - a few deg C. The RAPID web site says the MOC heat transport explains the difference in climate between the west coast of Europe and the west coast of the Americas. While this is also not clear (see our 2002 QJRMS paper) it raises the spectre of a MOC collapse during the climates of Bristol and Cardiff into that of Vancouver."

Bill Johns notes that there is a review by the Potsdam group that is harsh on this idea.

Ron Stouffer said it's not just the MOC that makes Canada different from Europe. It's winds and winter climate, a combination of things going on.

Bill Johns said that the first part of Richard's comment is valid, and the second part is not.

Dan Muhs said that he gets the idea that we are debunking the myth that there will be abrupt change.

Tom Delworth agreed, but stated that the debunking is on our current generation of models. How good are they?

Jean Lynch-Stieglitz stated that none of the models simulate D O events. It's hard to assess what future changes will be based on the paleo record. The paleo record suggests abrupt changes have happened, but if they happen again, they will look very different.

Rick Rosen suggested that this chapter has the biggest 'so what' factor. Need to address what are the regional and global impacts. Why we care about the MOC. Address the difference between ocean and atmosphere heat transport. With methane the impact is clear. With the MOC, the impact is not so clear. Paleo may have something to tell us.

Jack McGeehin established a subcommittee for MOC section of report. Tom Delworth volunteered to be the chapter lead author. No objection from committee. Other members of this subcommittee: Andrew Weaver, Jean Lynch-Stieglitz, Bill Johns, Richard Seager (should he want to; subcommittee will invite him), Carrie Morrill and Peter Clark.

Discussion on draft version control:

- Chapter Leads responsible for managing and coordinating
- CLA integrates - Best Practice
- Maintain homogeneous styles, formatting, writing

- Consider having non-scientific readers...communication specialist, jargon filter, etc. Focus on summary and higher-level stuff, acronyms.

Anjuli Bamzai on managing drafts of the report. For SAP 3.1 the lead authors have set up a wiki web site, it helps to have a common web site.

Wednesday, March 28, 2007

Participation list:

Committee Members

- Peter Clark, Oregon State University
- Ed Cook, Columbia University
- Tom Delworth, NOAA
- Carrie Morrill, NOAA
- Dan Muhs, USGS
- Konrad Steffen, CIRES
- Andrew Weaver, University of Victoria, Canada

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- Bill Johns, University of Miami
- Shawn Marshall, University of Calgary, Canada
- Bob Thomas, NASA
- Pat Bartlein, University of Oregon

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- Mark Michelini, Versar
- Peter Folger, CRS
- Kathryn Hayo, USGS
- Jill Dysznski, USGS

Facilitation Team

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- Kathleen Cleary, LEAD Alliance
- Carrie Miller, USGS

8:00 AM to 8:15 AM: Morning announcements/discussion

Re-visited the definition of abrupt climate change. All committee members agreed to accept the definition stated below.

“A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human or natural systems.”

8:15 AM to 10:10 AM: Rapid Changes to the Hydrologic Cycle

This session followed closely the schedule posted in the workshop [agenda](#). [Synopses of the individual talks](#) can be found here.

- **Ed Cook**, Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA: "Large-Scale Hydroclimatic Variability And Change Over North America For The Past 1000 Years"
- **Richard Seager**, Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA: “Near term rapid climate change: The case of imminent drying of southwestern North America” (Talk given by Ed Cook)
- **Pat Bartlein**, Department of Geography, University of Oregon, Eugene, Oregon, USA: "Abrupt hydrological response to gradual forcing during the Holocene: the role of land-surface feedback in amplifying hydrological extremes"

10:30 AM to 12:00 PM: Panel Discussion

Richard Seager’s email comments regarding drought:

“The story of imminent greater aridity in SWern North America that Ed Cook will give on my behalf on Wednesday does not fit the first definition of abrupt change - a nonlinear jump - but does fit the second definition - a change that is faster than society can adapt. The model projections actually seem to quite linearly increase aridity in this region as GHGs rise but the change is quite large and rapid. It may not always have been the case that it happens faster - a decade or two - than society can adapt but the current political system and political fighting about the reality of climate change are preventing social responses on the timescales needed.”

Committee felt that Richard's treatment of imminent greater SW aridity does work with the new definition of abrupt climate change defined here.

“There is no evidence to date that either ENSO or the AO show regime-like behavior (see Newman and Stephenson respectively on this). However, as above, a GHG (or other external) forced change could be linear in the forcing but of sufficient amplitude to still cause trouble. An AO (or NAO) change could be behind the imminent further aridification of the Mediterranean region for example. Or it - and the SW drying too - could be just the result of overall warming and not directly linked into changes in the pdfs of existing modes of climate variability.”

Pat Barlein said that the observational record is not long enough. Short- or long-term memory processes a possible alternative to regime change.

Ed Cook said that here is a rich literature on fractional autocorrelation, including the Hirsh model, and studies of the Nile River record. Even a natural shift in the mean can take on the appearance of shifting regime because of autocorrelation.

The committee felt that this section needed a new title: “rapid changes to the hydrologic cycle” is not appropriate.

Pat Bartlein said that “hydrologic cycle” implies global water cycle and the oceans. This is really about the terrestrial aspects.

Konrad Steffen pointed out that this is like talking about “global” warming, when we are really interested in regional changes.

Andrew Weaver asked if we are talking about megadroughts in North America?

Pat Bartlein said that the different continents give you different monsoon expressions. It's useful to refer to the other Holocene monsoons. Amplification occurs in some places.

Shaun Marshall made the point that globally, the impacts of aridification are more severe in other places.

Andrew Weaver asked, what is our scope?

Jack McGeehin suggested that the focus should be on North America to address science policy relevant and national security issues. But scope can be global, as necessary, to make a more complete statement.

Andrew Weaver suggested that there are policy implications for all of North America (US may need water from Canada in the future).

Mark Micheleni asked if there will be an attempt to cover the global signature of drought?

Pat Bartlein said that there is a global monsoon. One mechanism with regional expression.

Ed Cook noted that he showed maps of global precipitation-evaporation from Richard's talk, it might be good to consider this to show the ways that things might move.

Konrad Steffen asked if subcommittee will address greenhouse gas forcing?

Ed Cook responded that this is what Richard Seager would suggest we do.

Dave Verardo asked if hydrologic variability will encompass floods as well as dry?

Ed Cook said that the discussion should cover broad wet periods and large scale pluvials. Floods would be difficult.

Tom Delworth said that models show predictions of future flooding. Paleorecord would be difficult. Thinks subcommittee should attempt to consider floods in their section.

Peter Clark noted that we may be getting into the realm of the Climate Extremes SAP. Public comment: Rick Rosen (NOAA) felt that floods fit into the scope of this study. Charge to committee is to determine if an abrupt event is already under way. May not be highly confident but an important underlying statement for this subcommittee.

Andrew Weaver asked if we should ask Martin Hoerling to contribute to this report.

Ed Cook said we should.

Pat Bartlein said that we should stay away from flood/drought designations because droughts are sustained and floods are like point data.

John Barron asked about the land use land cover component.

Pat Bartlein said there probably is a land cover feedback with plants, fire and urbanization.

Rick Rosen said that there are lots of definitions of drought. The committee needs to make sure the reader understands what definitions you are using.

Ed Cook said that he's been working with the PDSI, it's a soil balance model. Richard Seager has been working with estimates of soil moisture. We would like to work with the soil moisture index (and the PDSI), that is the direction we would like to stay with.

David Lawrence said that droughts can occur with small temperature increases.

Ed Cook agreed, stating that there is a tendency for hot droughts recently. Temperature has exacerbated drought.

Peter Clark noted that this topic differs from the other three because of repetition of events. Others are after single burps. How do we distinguish natural variability?

Pat Bartlein responded that it raises the regime change versus long-term change again.

Ed Cook said that it is hard to define abruptness versus variability. He would stay away from regime change.

Shawn Marshall asked if there should be a discussion of snow pack in this section? Maybe a box.

Pat Barlein said that net water supply is the term often discussed. Sometimes snow pack decreases but precipitation increases.

Ed Cook: Timing of melt is very important. Snow very important to reservoir recharge.

Konrad Steffen said that this is something the ski industry wants to know.

Bruce Molnia said that melting alpine glaciers also affect water supplies.

Pat Bartlein said that a hydrology-related issue is fire.

Ed Cook responded that fire could be treated as a box. Too much to take on in this section.

Ed Cook quoted Mark Twain: "Whiskey is for drinking, water is for fighting over." Water has such a huge impact- you cannot have a more important resource.

Ed Cook state that he wants to keep this section manageable, stick to natural variability, and what have we seen in the past.

Koni Steffen noted that the filter is the abrupt change.

Tom Delworth said that we need to consider what will happen in the next few decades. That is what people care about and why they will read the report.

Dave Verardo said that the committee should show the range of abruptness. There is a complexity. Some changes over years, some over decades.

John Barron pointed out that there is a regional difference in the impacts.

Ed Cook said that the main reason why the 2002 drought did not have a huge impact is because it occurred in the arid region of the west- not much going on there at the time. Now that the spatial patterns are changing, and it is beginning to affect food supplies, it is becoming important. Imagine if it affects ethanol production in the corn belt.

Carrie Morrill asked can we consider the oceans role not on drought but on floods and extreme events (hurricanes and storms)?

Ed Cook had difficulty with that approach.

Pat Bartlein: everything is connected. Tropical storms are a big part of the water supply of the southeastern US.

Dave Verardo suggested that this could be a box. Water is also an energy source.

Ed Cook noted that this feeds back into the greenhouse issue: will drought affect hydropower and ultimately cause more fossil fuel use?

Jack McGeehin established the subcommittee for rapid changes to the hydrologic cycle (new title not yet established).

Who is on this subcommittee:

- Richard Seager (not present at workshop)
- Ed Cook
- Pat Bartlein
- Robin Webb (not present at workshop)

Potential contributing authors:

- Martin Hoerling
- Upmanu Lall

Shaun Marshall asked what did the IPCC cover regarding drought? Is there a jumping off point?

Andrew Weaver said that they covered extremes, but not megadroughts.

Rick Rosen noted that IPCC treated trends of precipitation in Executive Summary.

Andrew Weaver said that the impacts will be covered in Working group 2. Out soon.

Peter Clark nominated Pat Barlein or Ed Cook as chapter lead. Ed Cook agrees to be chapter lead. Committee unanimously agrees.

Jack McGeehin discussed breakout sessions. As breakouts deliberate, please make notes of things that get removed, and reasons why. Offer up list of potential contributing authors.

Andrew Weaver noted that on the sea ice issue, the MOC subcommittee should include Marika Holland (NCAR) to contribute. As a box.

Konrad Steffen said that the subcommittee on Ice Sheets and Glaciers would also like to have Marika contribute.

Rick Rosen reminded everyone not to forget the questions listed in the prospectus. That is what we have committed to address. If you leave out questions, need to explain why. The prospectus has had CCSP Principals endorsement.

3:30 PM to 4:30 PM: Presentation of Outlines

After the breakout session, a representative of each of the four subcommittees presented a draft outline. These outlines and subsequent drafts of the outlines can be found here ([link](#)).

Summary of general discussion:

All outlines address the questions put forth in the prospectus.

Stick to the questions in the prospectus as written. Better to add a new question, if necessary, than change existing ones.

Format of each section may vary; some may want to organize the chapter around the prospectus questions, while other may want to incorporate questions into a different framework.

Each section should have some discussion of impacts and a summary box of important impacts.

All of the draft outlines were found to be acceptable by the committee.

Second drafts with more detail and names of proposed contributing authors are due two weeks after the workshop on Friday April 13, 2007.