When the Rain Stops: Drought on Subseasonal and Longer Timescales

FINAL REPORT

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Summary of Activities

The Aspen Global Change Institute hosted a technical science workshop, "*When the Rain Stops: Drought on Subseasonal and Longer Timescales,"* on September 9-14, 2018 in Aspen, CO. Gerald Meehl (NCAR), Roger Pulwarty (NOAA), and Angeline Pendergrass (NCAR) served as co-chairs for the workshop. The meeting included the participation of 25 scientists for a total of 125 participant days. The workshop resulted in agreement on definitions for both operational and research/prediction uses. Workshop participants are in the process of testing these definitions within their work on drought modeling, and impacts assessment, with the intention that these definitions can then be evaluated for CMIP6 (and incorporated into ESMValTool), as well as for the IPCC AR6 from observations, models, and impacts. Findings from the workshop and follow on experiments are in the process of being summarized and submitted for publication in a high profile peer-reviewed journal.

AGCI Workshop on Drought on Subseasonal and Longer Timescales

AGCI convened 25 experts on drought for a workshop: *When the Rain Stops: Drought on Subseasonal and Longer Timescales*, seeking to clarify some of the complexity that surrounds that particular weather and climate extreme. Drought is often difficult to characterize because of its diverse impacts (e.g., agricultural and hydrological), the associated variety of metrics by which it is defined, and the variety of timescales on which it can play out (from days to decades). These layered dimensions of drought often mean it is not adequately addressed in assessments of climate extremes.

This workshop examined drought across timescales and definitions, with special attention to seasonal to subseasonal (S2S) timescales. A particular goal was to chart what timescales, characterizations, and/or impacts uniquely define the more recently recognized phenomenon of

'flash drought'. Participants representing observational, modeling, and impact assessment perspectives, sought to answer key questions, such as:

1) How should we define or characterize 'flash drought,' and its impacts?
2) Where does it fit in with respect to existing drought types, and how does it interact with drought on various timescales?
3) What are current capabilities to predict 'flash droughts,' and what is needed to make progress?
4) How can and should 'flash droughts' be incorporated into early warning systems and risk management?
5) What is needed to improve monitoring?

Through presentations, extended discussions, and breakout groups, participants agreed that 'flash droughts' should be defined as rapid transitions in drought intensity. This means that flash droughts can both occur in isolation (rapid onset), and in connection with an existing drought (with rapid intensification). The term can be applied to both operational and research/prediction scenarios, though the definition should vary depending on the use case. In operational contexts, the rapid transition would be defined by a change of at least two US Drought Monitor intensity categories occurring in less than two weeks, and sustaining for at least another two weeks. In research and prediction contexts, rapid transition would be defined by a change of at least 50% in the Evaporative Demand Drought Index (EDDI) over one month, resulting in drought.

Participants concurred that while 'flash droughts' are possible in arid, snowpack-dependent areas, a separate category of "snow drought" should be applied to situations in which snowpack is rapidly depleted, for example by a rain-on-snow event. These definitions can however be applied to most recognized types of drought (meteorological, agricultural, ecological, hydrologic). The need for skillful, regionally specific, high-resolution predictions and forecasts was also identified as a key need by those in decision-making roles. Participants then conferred on what kinds of mechanisms would be most effective for communicating to the public that conditions are favorable for a 'flash drought,' and what kinds of impacts to prepare for given that information in specific regions. Next steps for participants will be to evaluate the proposed definition in different case studies (U.S., Australia, and elsewhere), to test how rare its occurrence is, and whether it is associated with impacts, and adjust accordingly.

Also as part of the workshop dialogue, participants engaged in a constructive conversation about the possible ethical implications of their research and its use in practical applications. This conversation served to push participants to identify how they can better engage stakeholders in the development and dissemination of information about drought, and 'flash drought' in particular. Participants recognized that often the extended time it takes to directly and meaningfully engage with stakeholder partners, is inherently at odds with time constraints and pressures to produce publications and meet other professional obligations and expectations. In addition to bolstering inclusivity with stakeholders, participants acknowledged the need for more inclusive and equitable workplace cultures, which will require both individual and institutional actions to become a reality.

Outcomes

The September 2018 workshop on Drought resulted in agreement on definitions for both operational and research/prediction uses. Workshop participants are in the process of testing these definitions within their work on drought modeling, and impacts assessment, with the intention that these definitions can then be evaluated for CMIP6 (and incorporated into ESMValTool), as well as for the IPCC AR6 from observations, models, and impacts. Findings from the workshop and follow on experiments will be summarized and submitted for publication in a high profile peer-reviewed journal.

Evaluation of 2018 Workshop

When the Rain Stops: Drought on Subseasonal and Longer Timescales (2018)

	Poor	Fair	Good	Very Good	Excellent	Totals
Session Theme Selection	0	0	1	8	10	19
	0%	0%	5%	42%	53%	
Quality of Presentations	0	0	0	2	17	19
	0%	0%	0%	11%	89%	
Logistical Support	0	0	0	1	18	19
	0%	0%	0%	5%	95%	
Personal Value	0	0	0.5	2.5	16	19
	0%	0%	3%	13%	84%	

Selected Comments from participants of the Drought workshop:
"Excellent topic that makes me think outside of my box. Robust exchange of ideas. Inspiring!"

"Timely and important and narrow enough to make progress."

"The small, well-selected group of people really brought their A-games, but also were able to bounce off each other and further add value."

"Hands down the best and most valuable workshops I've been to. The ample discussion time has allowed me to make a lot of contacts both in science and management areas."

"The scientific discussions as well as interactions with colleagues in the field (old and new) were rewarding and though provoking."

"AGCI is a true asset to global change research and application. No other program brings multi-disciplinary, small group convenings together as effectively as AGCI."

"AGCI seems to excel at bringing together the ingredients for fruitful and productive engagements on key issues facing society today."

"Perfect size and mix of people to allow deep thought."

Online Dissemination

AGCI makes the workshop description, roster, and agenda available on our website. Videos of publicly approved workshop presentations are in the process of being produced, and will be made available on the workshop website: agci.org/event/18s4

Appendix: Roster and Topical Agenda

Roster

When the Rain Stops: Drought on Subseasonal and Longer Timescales
ROSTER

Celine Bonfils
Lawrence Livermore National Laboratory

Ailie Gallant
Monash University

Peter Gleckler
Lawrence Livermore National Laboratory

Mike Hobbins
NOAA

Andy Hoell
NOAA

Marty Hoerling
NOAA

David Hoffman
Monash University

Laurna Kaatz
Denver Water

Flavio Lehner
UCAR

Dagmar Llewellyn
Reclamation Managing Water in the West

Jerry Meehl
NCAR

Philip Mote
Oregon State

Rich Neale
NCAR

Jonathan Overpeck
University of Michigan

Angie Pendergrass
NCAR

Roger Pulwarty
NOAA

Amanda Sheffield
NOAA

Kerstin Stahl
University Freiburg

Andreja Susnik
Slovenian Environment Agency

Mark Svoboda
University of Nebraska-Lincoln

Haiyan Teng
NCAR

Brad Udall
Colorado State University

Matthew Wheeler
Australian Government Bureau of Meteorology

Andy Wood
NCAR

Connie Woodhouse
University of Arizona

Agenda

When the Rain Stops: Drought on Subseasonal and Longer Timescales
AGENDA

SUNDAY, SEPTEMBER 9

Arrivals in Aspen

MONDAY, SEPTEMBER 10

Part 1. Welcome & Introductions

9:00 AM Welcome from John Katzenberger and AGCI staff

9:30 AM Extended introductions from participants

Part 2. Scene setting

11:00 AM **Roger Pulwarty, Jerry Meehl, and Angie Pendergrass –** Dimensions of drought and goals of the meeting
Discussion

Part 3. Characterizing drought, the S2S timescale, and where flash droughts fit
Chair: Angie Pendergrass

2:00 PM Definitions and features of flash droughts
David Hoffman – The sensitivity of drought variability to index and data selection

Ailie Gallant – Seasonal and sub-seasonal scale drought in southern Australia

Peter Gleckler – The need for drought metrics for model evaluation
Discussion

Part 4. Case studies highlighting the S2S timescale
Chair: Jerry Meehl

4:00 PM **Mike Hobbins** – Case 1 / Evaporative demand: dynamics and opportunities in drought early warning, monitoring, and S2S predictability

Andy Hoell – Case 2 / The predictability of northern Great Plains precipitation: Lessons learned from the 2017 Billion Dollar Drought

Andy Wood – *Case 3* / Western U.S. water prediction through the lens of hydrology: Examples and opportunities
Discussion

TUESDAY, SEPTEMBER 11

Part 5. Drought risk management and resource planning across timescales - Part I: US
Chair: Mark Svoboda

9:00 AM **Dagmar Llewellyn** – Where the rubber meets the road: Why we need (better) seasonal forecasts

Amanda Sheffield – Recent and future drought in California: Implications for S2S timescales within multiyear droughts

Laurna Kaatz – Preparing water utilities for drought on different timescales
Discussion

Part 6. Drought risk management and resource planning across timescales - Part II: International
Chair: Laurna Kaatz

11:00 AM **Matthew Wheeler *on behalf of Roger Stone*** – Drought and climate adaptation program: Northern Australia Climate Program – beef industry

Andreja Susnik – From drought watch to drought management at Drought Management Center for SouthEastern Europe (DMCSEE)

Kerstin Stahl – Potential of drought impact propagation patterns for early warning

Mark Svoboda – Including S2S timescale in early warming and risk management

Part 7. Breakout group 1

2:00 PM *Participants meet in breakout groups to discuss, "*How should we define or characterize flash drought, and its impacts? Where does it fit in? What is needed to improve monitoring?"
Group 1: Ailie Gallant and David Hoffman
Group 2: Peter Gleckler and Amanda Sheffield
Group 3: Mike Hobbins and Celine Bonfils

Walter Orr Roberts Public Lecture (Guests Welcome)

6:00 PM **Roger Pulwarty**
From Drought to Floods and Back Again? Learning and Adapting in an Uncertain Climate

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WEDNESDAY, SEPTEMBER 12

Part 8. Precipitation processes and timescale interactions
Chair: Rich Neale

9:00 AM **Celine Bonfils –** Mechanisms of changes in precipitation and droughts driven by natural variability and external forcings

Flavio Lehner – Paving new roads for the rubber to meet: Incorporating climate information into seasonal streamflow and drought forecasting

Philip Mote – When the rain DOESN'T stop: snow droughts in the western U.S.

Angie Pendergrass – The uneven nature of precipitation

Part 9. Breakout group 2

11:00 AM *Participants meet in breakout groups to discuss* Incorporating flash drought into early warning and risk management
Group 1: Dagmar Llewellyn and Andy Hoell
Group 2: Laurna Kaatz and Andreja Susnik
Group 3: Kerstin Stahl and Brad Udall

THURSDAY, SEPTEMBER 13

Part 10. Ethics of practice
Chair: Angie Pendergrass

9:00 AM Ethics of practice

Part 11. Predicting drought across timescales
Chair: Brad Udall

11:00 AM **Rich Neale** – Capturing timescale interactions: Clouds, forecasts, and drought

Haiyan Teng – Predictability sources for droughts associated with the midlatitude wave trains

Matthew Wheeler – Initial steps towards flash drought monitoring and prediction in Australia

Part 12. A case across timescales: The Colorado as a model basin
Chair: Roger Pulwarty

2:00 PM **Connie Woodhouse** – The effects of temperature on Colorado River drought over past centuries inferred from a runoff efficiency reconstruction

Jonathan Overpeck – The problem of near certain warming, aridification, and inevitable megadrought

Brad Udall – The Colorado River Millennium Drought: the relative impacts of higher temperatures vs. other potential causes

Marty Hoerling – Interpreting the Long-term Colorado River Drought - Implications for Anticipating Recovery

Part 13. Breakout group 3

4:00 PM *Participants meet in breakout groups to discuss* Flash drought and S2S prediction: Where are we on S2S prediction for flash drought, and what do we need to make progress?
Group 1: Jonathan Overpeck and Flavio Lehner
Group 2: Matthew Wheeler and Andy Wood
Group 3: Haiyan Teng and Philip Mote

FRIDAY, SEPTEMBER 14

Part 14. Breakout groups report

9:00 AM *Breakout groups report out in plenary*

Part 15. Pulling it all together and developing an action plan (DON'T LEAVE TOWN!)

11:00 AM *Whole-group discussion synthesizing what we have learned throughout the process*