CURRICULUM VITA

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Education:	
1988-1994	**University of Washington**, Seattle, Washington Ph.D. in Atmospheric Sciences, August 1994. Dissertation title: *Arctic Process and Climate Studies with the TOVS Satellite Sounder*.
1985-1988	**San Jose State University**, San Jose, CA. B.S. in Meteorology, May 1988.
1975-1978	**University of New Hampshire**, Durham, New Hampshire. Zoology major
Employment:	
2018-present	**Woods Hole Research Center** Senior Scientist
1994-2003	**Department of Marine and Coastal Sciences**, Rutgers University
2003-2007	Assistant Research Professor, member of Graduate Program faculty
2007-present	Associate Research Professor, member of Graduate Program faculty Research Professor I
2006-present	**Department of Environmental Sciences**, Rutgers University
1988-1994	Full member of Graduate Program in Atmospheric Sciences **Polar Science Center, Applied Physics Laboratory**, University of Washington Graduate Research Assistant (Advisor: Dr. Drew Rothrock)
Professional Activities:	
12/2018-present	Scientific American, Advisory Board member
1/2013-present	Metcalf Institute, U. of Rhode Island, Advisory Board member
1/2012-present	U. Mass. Lowell Env. Studies, Advisory Board member
10/2014-present	SEARCH Sea-Ice Action Team, co-leader
9/2011-2017	National Academy of Sciences Polar Research Board member
8/2011-2016	Study of Environmental Arctic Change (SEARCH) Obs. Change Panel member
2013-2014	NRC Study Committee, *The Arctic in the Anthropocene: Emerging Arctic Research Questions* (2014)
2011-2012	NRC Study Committee, *Seasonal-to-Decadal Predictions of Arctic Sea Ice: Challenges and Strategies* (2012)
1/2007- 4/2009	Co-Director Rutgers Climate and Environmental Change Initiative
10/2003-4/2009	NSF/Arctic System Science Program science committee and Executive Comm.
2006	NSF/Office of Polar Programs, Committee of Visitors (program review panel)
9/2000-2005	NSF/ HIAPER (NCAR's Gulfstream V research aircraft) Advisory Council
4/1999-2002	NSF/OFAP Review Panel, Vice Chair in 2000, Chair in 2001
10/1998	NSF/ HIAPER Review Panel
1/2004-1/2005	Program Chair of 2005 AMS Annual Meeting (4000+ attendees)
11/2003-2007	American Meteorological Society (AMS) Councilor and Exec. Committee
1/2007-1/2008	AMS Meetings Oversight Committee, Chair

1/1997-1/2003	AMS Committee on Polar Meteorology and Oceanog., Chair (2000-2003)
4/1996-2005	NASA Polar (NSIDC) DAAC Advisory Group
5/1996-2/2004	NASA Langley DAAC Advisory Panel
4/1995-1999	NASA Polar Pathfinder Working Group
10/2003-4/2009	Study of Environmental Arctic Change (SEARCH) Science Steering Comm.
1/2002	DOE Review Panel for Unmanned Aerial Vehicle Program.
4/1996-2001	Guest Investigator on NASA CERES Team
1990-1994	NASA TOVS Pathfinder Evaluation and Implementation Committees
3-4/1992	LeadEx Experiment, participant in airborne measurement component
Graduate Student Advisees	Ph.D. Students: Yonghua Chen (5/05), Natasa Skific (4/09), Michael Foster (10/08), Weihan Chan (12/14). M.S. Students: Linong Yan (10/03), Natasa Skific (11/05), Marc Chiacchio (1/01), David Groves (1/01, U. of WA). B.S. Honors Advisor: Weihan Chan (5/05)
Recent Selected Refereed Publications	Wu, B. and **Francis, J.A**, 2019: Summer Arctic cold anomaly dynamically linked to East Asian heat waves. J. of Climate, doi: 10.1175/JCLI-D-18-0370.1. **Francis, J.A**., Clarity and clouds: Progress in understanding Arctic influences on mid-latitude weather. A "Frostbites" essay in the 2018 Arctic Report Card, NOAA Arctic Program. **Francis, J.A.**, N. Skific, and S.J. Vavrus, 2018: North American weather regimes are becoming more persistent: Is Arctic amplification a factor? Geophys. Res. Lett., doi:10.1029/2018GL080252. Kapsch, M.-L., N. Skific, R.G. Graversen, M. Tjernstrom, and **J.A. Francis**, 2018: Summers with low Arctic sea ice linked to persistence of spring atmospheric circulation patterns. *Climate Dynamics*, accepted. Chen, L., **J.A. Francis**, and E. Hanna, 2018: The "Warm-Arctic/Cold-Continents" pattern during 1901-2010: a reanalysis-based study. *International J. of Climatology,* accepted. Cohen, J., K. Pfeiffer, and **J.A. Francis**, 2018: Warm Arctic episodes linked with increased frequency of extreme winter weather in the United States. *Nature Communications*, doi:10.1038/s41467-018-02992-9. **Francis, J.A.**, 2017: Why are Arctic linkages to extreme weather still up in the air? *Bull. Amer. Meteoro. Soc., 98,* 2551–2557. Wu, B., K. Yang, and **J.A. Francis**, 2017: A cold event in Asia during January-February 2012 and its possible association with Arctic sea-ice loss. *J. of Climate,* 10.1175/JCLI-D-16-0115.1. **Francis, J.A,** S.J. Vavrus, and J. Cohen, 2017: Amplified Arctic warming and mid-latitude weather: New perspectives on emerging connections. WIREs Climate Change, E474, doi:10.1002/wcc.474. Vavrus, S.J., F. Wang, J. Martin, **J.A. Francis**, Y. Peings, and J. Cattiaux, 2017: Changes in North American atmospheric circulation and extreme weather: Influence of Arctic amplification and northern hemisphere snow cover. *J. Climate, 30,* doi:10.1175/JCLI-D-16-0762.s1.

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Liu, J., Z. Chen, **J.A. Francis**, T. Mote, and Y. Hu, 2016: Has Arctic sea ice loss contributed to increased surface melting of the Greenland ice sheet? Journal of Climate, doi:10.1175/JCLI-D-15-0391.1.

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Recent Research Grants

Co-P.I.: NSF. Collaborative research: Research, synthesis and knowledge transfer in a changing Arctic. 2015-2017, $115,667.

Co-P.I.: NASA. An Integrated Observational/Modeling Assessment of the Effects of Recent and Future Arctic Change on Weather Systems in the United States, 2014 - 2017, $228,452.

P.I.: NSF, Collaborative Research: Trends in Extreme Weather Events Linked to Arctic Amplification, 2013 - 2016, $295,807.

P.I.: NSF, Collaborative Research: Roles of Clouds and Their Accomplices in Modulating the Trajectory of the Arctic System, 1/07-12/11, $205,170.

Co.I.: NSF, Collaborative Research: Improving remotely sensed surface fluxes over sea ice, 1/07 - 12/11, $154,616.

P.I.: NSF, Roles of Moist Static Energy Transport in the Changing Arctic System, 7/05 - 6/08, $256,769.

Co.I.: NASA: Improving Arctic Energy Budget Estimates by Combining New EOS-Era Products from Multiple Satellite Sensors, 4/15/04-4/14/07,
$248,342, P.I. Dr. Eugene Clothiaux, Pennsylvania State University.

Co.I.: Polar Winds from Satellite Imagers and Sounders, NASA, 4/1/04 - 3/31/07, $175,925, P.I. Dr. Jeffrey Key, NOAA/NESDIS.

P.I.: Interactions among Observations of Lateral Advection, Cloud, and Surface Properties in the Arctic, NSF, 6/03 - 5/07, $288,567.

P.I.: Correction of Systematic Errors in TOVS Radiances, NOAA/U. of AK, 8/ 03 - 7/06, $160,030.

Co.I.: NASA, An Improved GCM Simulation of the Arctic Hydrologic Cycle using

	Satellite-Derived Products, 2/02-12/06, $278,463.
Documentaries, media coverage, and various presentations	Please see full listing at *http://jenniferafrancis.com*

Testimony for Congressional Hearing
House Science, Space, and Technology Committee

10:00 am EST, 12 February 2019

by Jennifer Francis PhD, Senior Scientist at the Woods Hole Research Center, Falmouth, MA
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My name is Jennifer Francis. I'm an atmospheric scientist at the Woods Hole Research Center in Massachusetts. My research focuses on the connection between climate change and extreme weather events. Thank you, Chairwoman Johnson and members of the committee, for the opportunity to testify here today.

It's not your imagination: extreme weather events have become more frequent in recent decades. According to analysis by Munich Re, one of the foremost reinsurance companies in the world, the occurrence of extreme weather events around the globe has nearly tripled since the 1980s [**Fig. 1**].

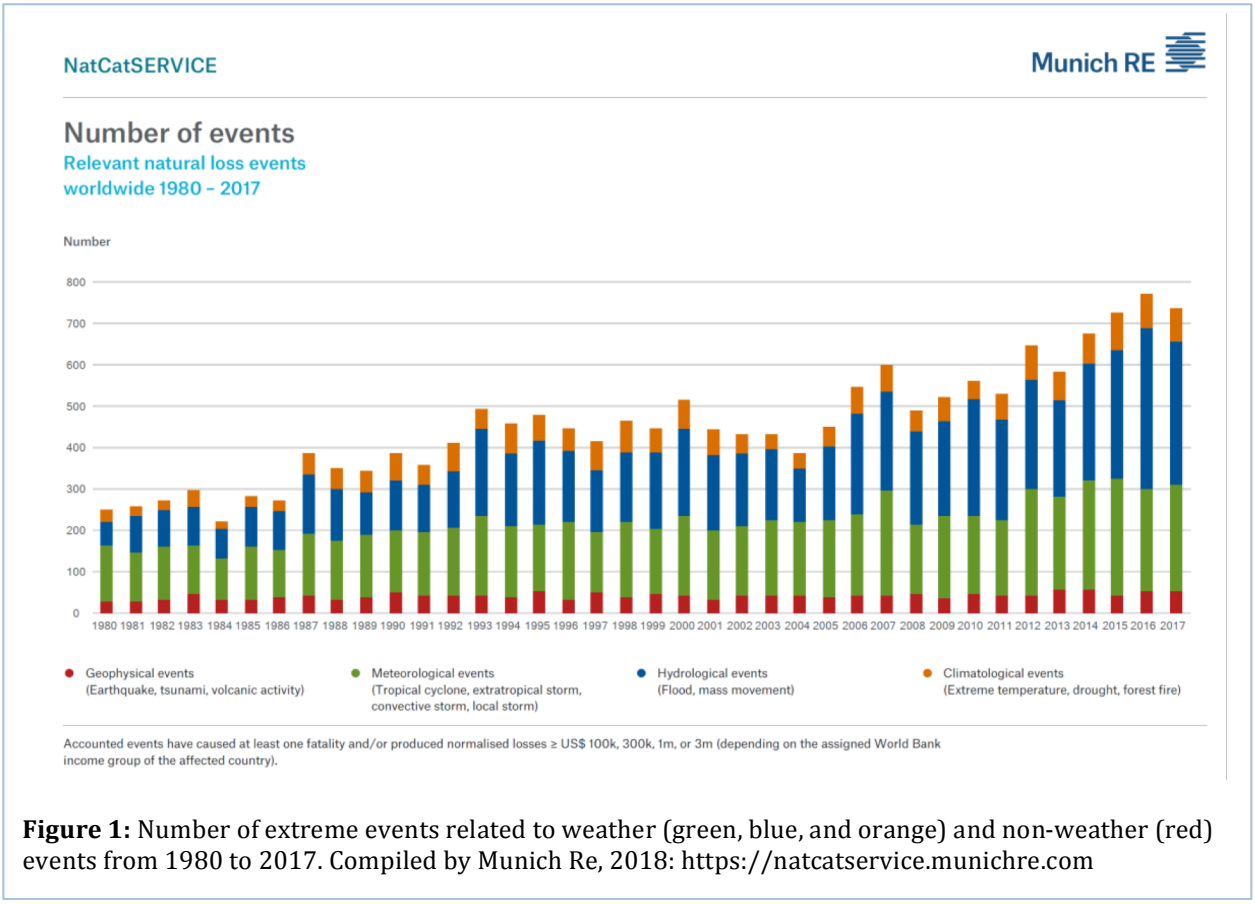

Figure 1: Number of extreme events related to weather (green, blue, and orange) and non-weather (red) events from 1980 to 2017. Compiled by Munich Re, 2018: https://natcatservice.munichre.com

Images of floods caused by feet of rain unleashed by hurricanes Harvey and Florence, docks sitting on dry soil in California's reservoirs, a sunken New Jersey roller coaster in the wake of Superstorm Sandy – to name only a very few – are forever etched in our memories. Yes, extreme weather has always happened, but there's no question that it's more vicious now, and all signs point to it getting worse as the globe continues to warm under a thickening blanket of greenhouse gases.

Before I go any further, let's clear up a few definitions that sometimes cause confusion. Climate change versus global warming: Climate change means all the ways that the climate system is changing, while global warming is just one of those ways. Climate versus weather: Climate is the average of all the weather that occurs at a particular location, while weather is the day-to-day swings in temperature and precipitation. Think of climate as your personality, while weather is your mood on any given day.

The links between climate change and extreme weather are a hot topic of scientific research. Some of the connections are straightforward and undisputed. For example, increasing global temperatures are making heat waves more intense and persistent, and therefore more deadly. As the air and oceans warm, evaporation also increases, which fuels an uptick in heavy precipitation events [**Fig. 2**].

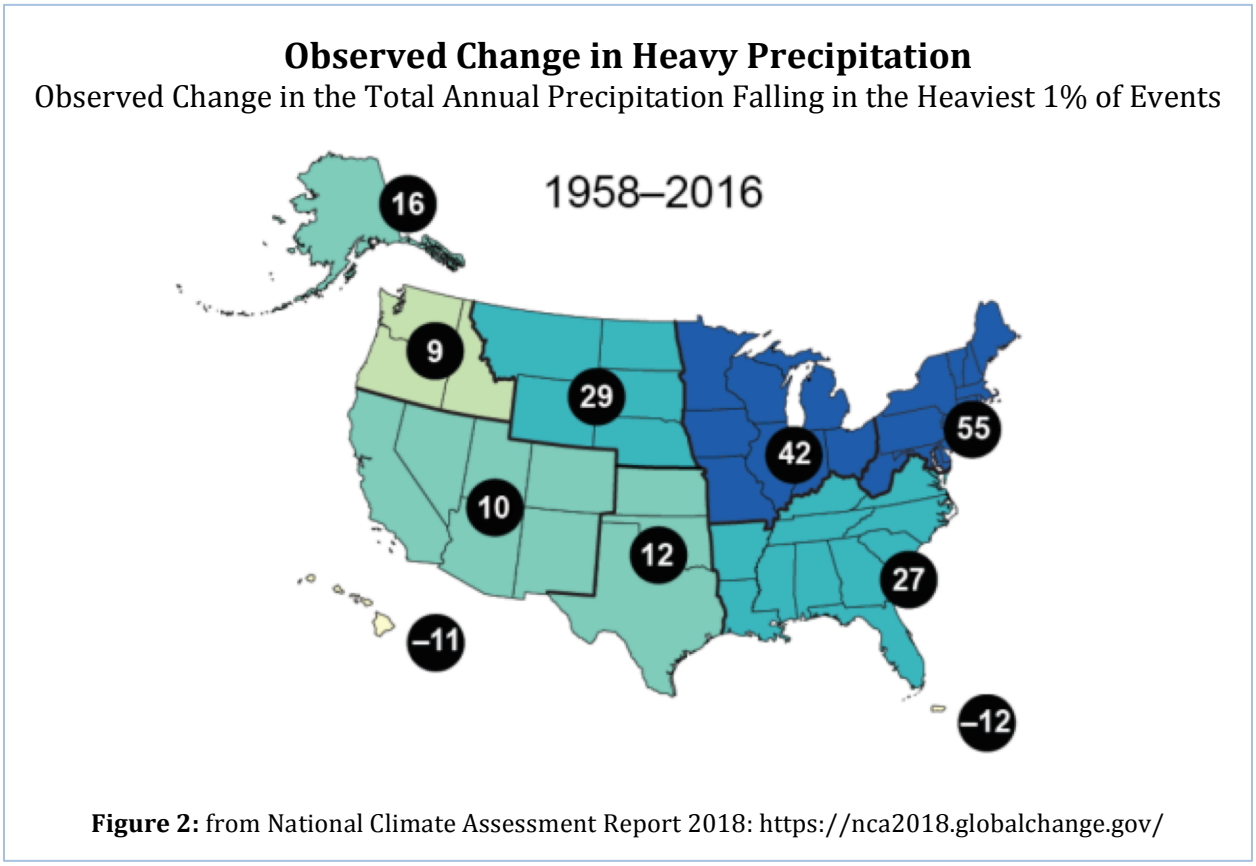

Figure 2: from National Climate Assessment Report 2018: https://nca2018.globalchange.gov/

The extra moisture and warmer oceans are also fueling rapid intensification of tropical storms. Storm surges are doing more damage because sea level is higher. On a happier note, though, fewer low-temperature records are being broken. Evidence of these changes is abundant and clearly tied to a warming planet owing to human influences [**Fig. 3**].

Recent studies are uncovering a myriad of other less straightforward connections, as well. The polar vortex has been in the news a lot lately, so let's start with winter extremes.

The true polar vortex is a pool of frigid air encircled by strong winds that sits about 30 miles above the Arctic during winter. Some evidence suggests it has been weakening and deforming more often lately[1], and when that happens, extreme cold AND hot temperatures strike areas in the northern hemisphere, as is clearly apparent in temperature anomalies during the severe cold snap two weeks ago [**Fig. 4**]. New research suggests that rapid Arctic warming is making these vortex splits more likely[2]. So even though cold records are being broken less often, severe and persistent cold spells will still happen.

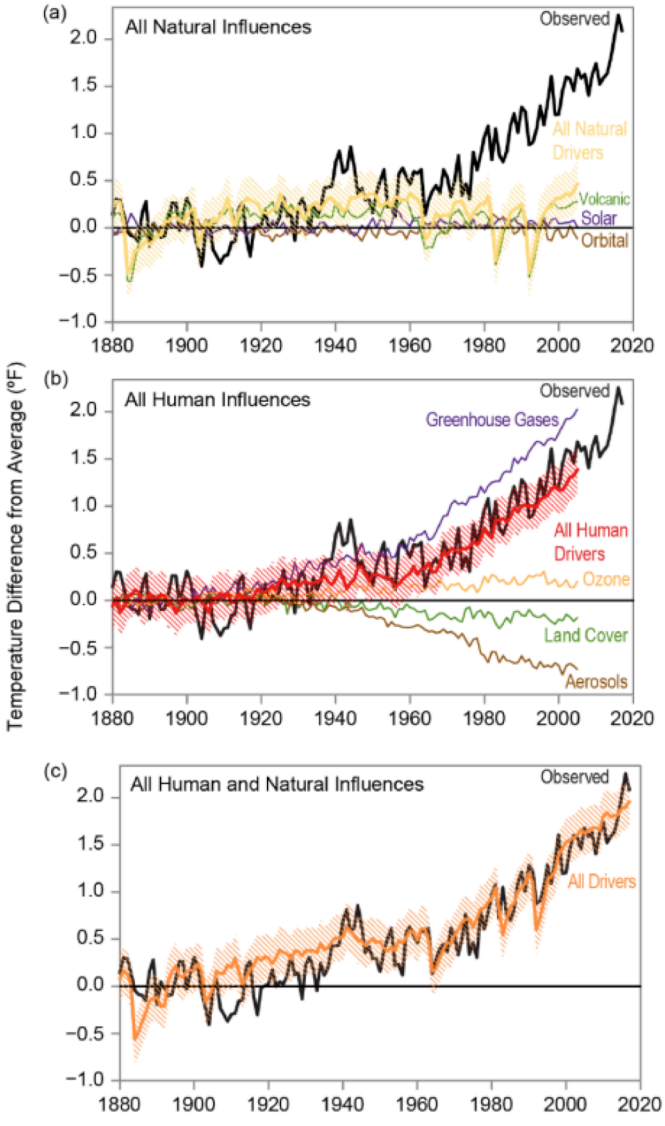

Figure 3: Climate model simulations illustrating the roles of various factors influencing global temperature changes since the late 1800s. Note that natural factors alone (top) would have caused the Earth to be in a gradual cooling cycle. From National Climate Assessment Report 2018.

Turning southward, global warming appears to be widening the tropical zone farther north and south. A symptom of this expansion is abnormal heat and drought in temperate regions such as Australia, southern California, and South Africa.

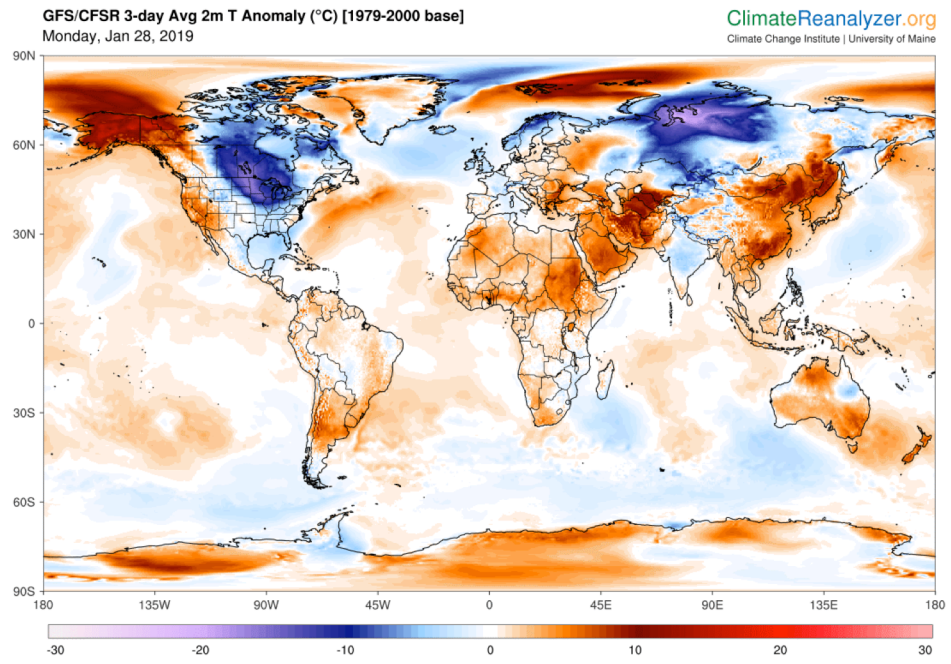

Figure 4: Global near-surface air temperature departures during the late January 2019 extreme cold spell in the Midwest. From the U. of Maine's Climate Reanalyzer http://www.climatereanalyzer.org

Another emerging hypothesis is related to the rapid loss of the spring snowcover over northern parts of continents. This earlier melt is causing high-latitude land areas to dry out and warm up faster, creating land temperature patterns that can trap summer weather systems in slow steering currents, making them stagnant. Studies have linked deadly summer heat waves and floods to this change in the climate[3].

Finally, a complex interplay between shifting ocean temperature patterns and a rapidly warming Arctic may be favoring weather regimes that exacerbate drought, heat, and wildfires in our western states while stacking the deck toward cool and stormy conditions in the east. Remember the parade of "bomb cyclones" that struck the eastern seaboard last winter? This west/east pattern was responsible.

In a nutshell, we know that climate change has made our atmosphere warmer and wetter, which alters every weather event that happens now. But assessing how climate change may affect the track and persistence of a weather system is still a challenge. It's relatively easy to determine that climate change made Hurricane Harvey's rainfall more intense[4], but it's much harder to say whether Harvey would have formed in the absence of climate change, or whether climate change caused it to stall over Houston. There's no doubt that the Arctic has warmed much faster than elsewhere, but whether Arctic air is surging southward more frequently now because of climate change is a cutting-edge research question.

This is just a sampling of the many topics being studied in our country's universities and research laboratories, the results of which are crucial to understanding climate change impacts that will help decision-makers and each of us prepare for a future with even more intense and destructive weather extremes. Clearly more work is needed to confirm or reject these complex relationships, though many are already coming into sharp focus.

Thank you again for the opportunity to participate in this hearing.

References

1. https://journals.ametsoc.org/doi/10.1175/BAMS-D-16-0259.1
2. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JD029222
3. https://www.nature.com/articles/srep45242
4. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018EF000825