

The GEWEX Challenge

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Extremes and Water on the Edge**

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Outline of this talk

- *Lessons from my history*
- **Some scientific illustrations**
- **Vision of GEWEX**
 - **Technical and system issues**
- **The moral and political challenges**
 - **Can we really separate science from all the “Policy Issues”?**
- **How do we support each other?**

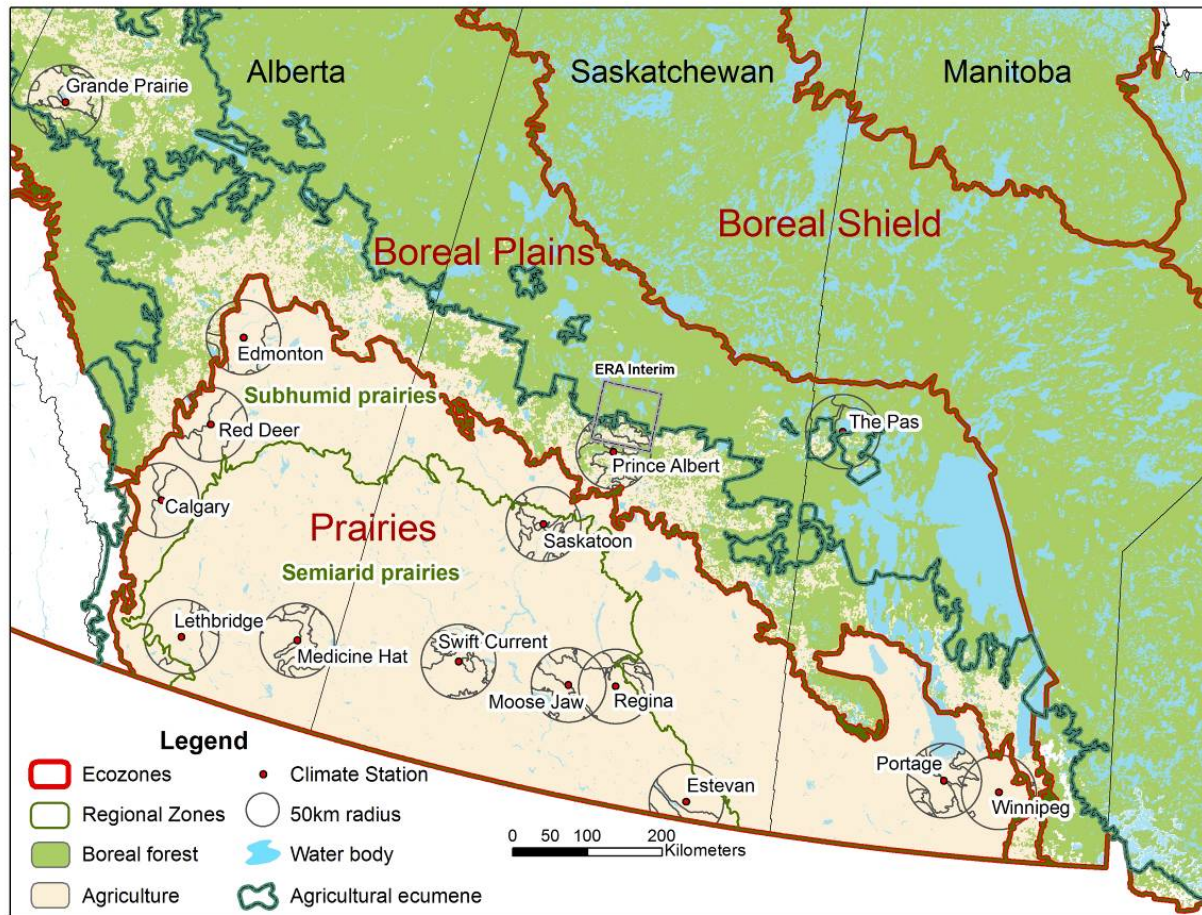
My History

- 1945-1970: UK education: Cambridge, London
- 1969: PhD student: *BOMEX and VIMHEX*
- 1970-78: Post-doc, faculty at Colorado State
- 1972: *VIMHEX-1972 (Venezuela)*
- 1974: *GATE Convection Scientist (Atlantic ITCZ)*
- 1978: Moved to Vermont: *“Independent scientist”*
- 1979-1989: Convection, parameterization, BL equil.
- 1990-2000: *FIFE, BOREAS*; ERA40 reanalysis
- 1998-2010: *GEWEX* river basins, *LBA*
- 2005-present: *VT Climate advisor/educator*
- 2010-present: Northern climate: VT, Prairies

Gratitude to many...

- **Global collaborators**
 - **GATE: US, Canada, Europe, USSR, W. Africa**
 - **ECMWF: 1983-present; evaluating reanalyses**
 - **BOREAS: Canada, US and UK**
 - **LBA: USP, Brazil**
 - **Prairie analysis: 2013-present; AG-Canada**
- **Stable funding (with no overhead!)**
 - **NSF: 1980-2012**
 - **NASA: 1985-2008**

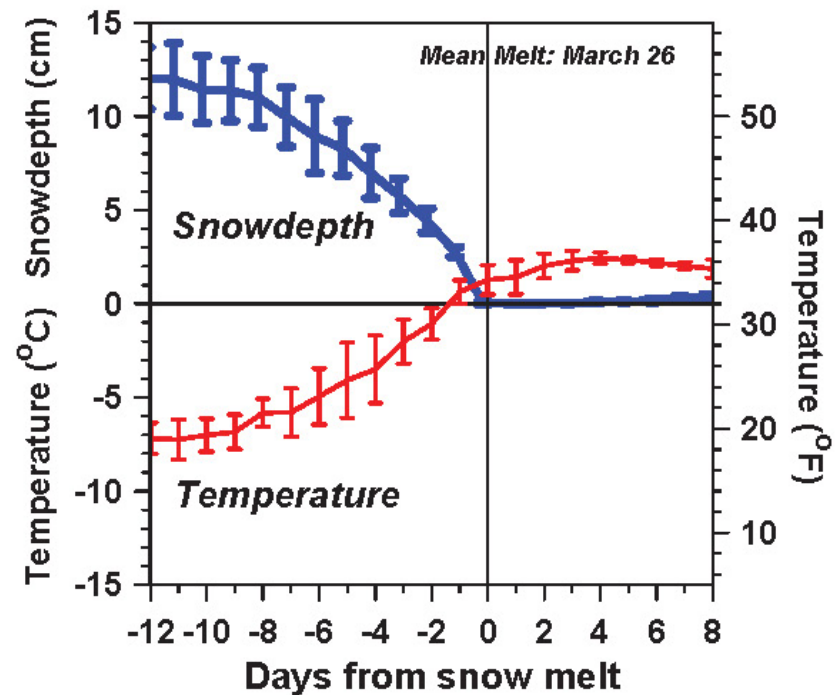
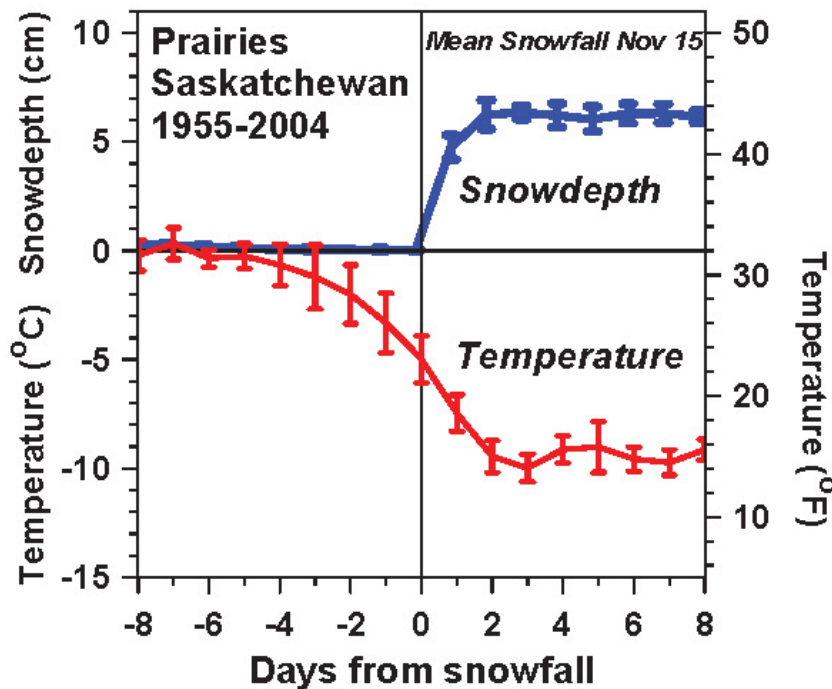
15 Prairie stations: 1953-now



- **Hourly** p, T, RH, WS, WD, **Opaque Cloud** (SW_{dn} , LW_{dn})
- **Daily** precipitation and snowdepth
- **Ecodistrict** crop data since 1955
- **Albedo** data since 2000

Snowfall and Snowmelt

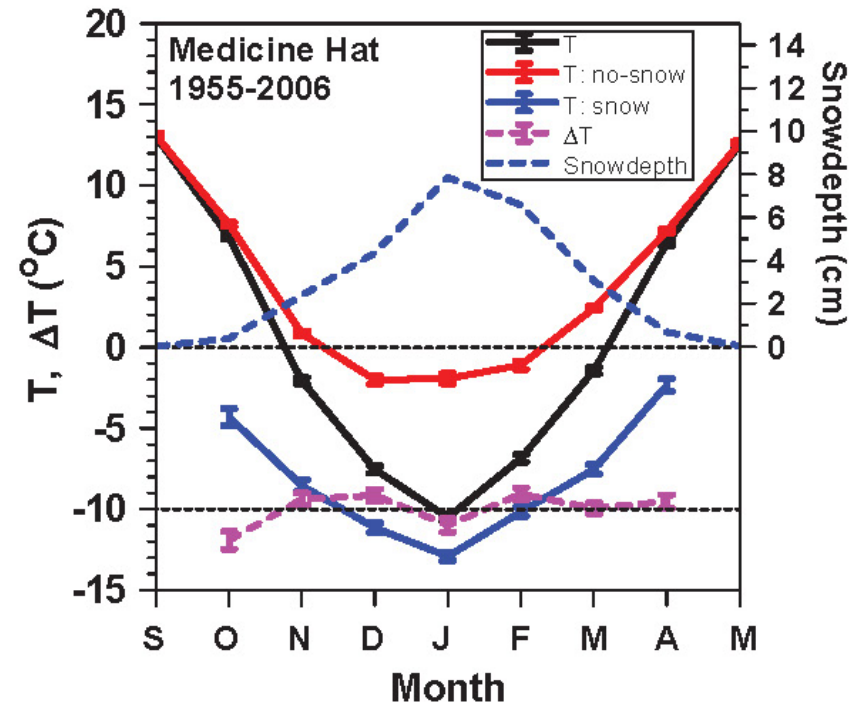
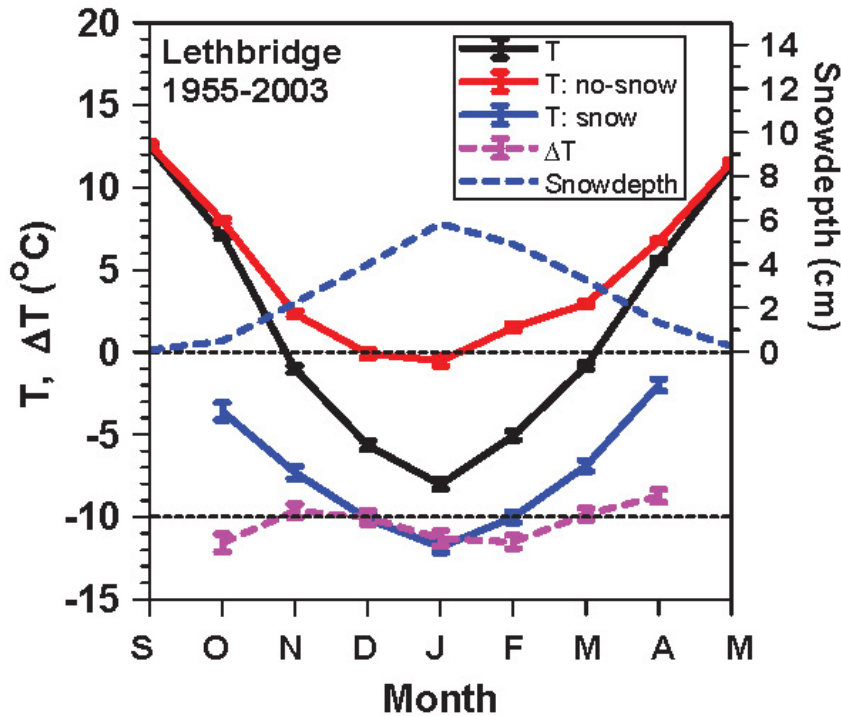
Winter and Spring transitions



- Temperature falls/rises about 10°C with first snowfall/snowmelt
- **Snow reflects sunlight; shift to cold stable BL**
 - Local climate switch between warm and cold seasons
 - Winter comes fast with snow

(Betts et al. 2014a)

Impact of Snow on Climate

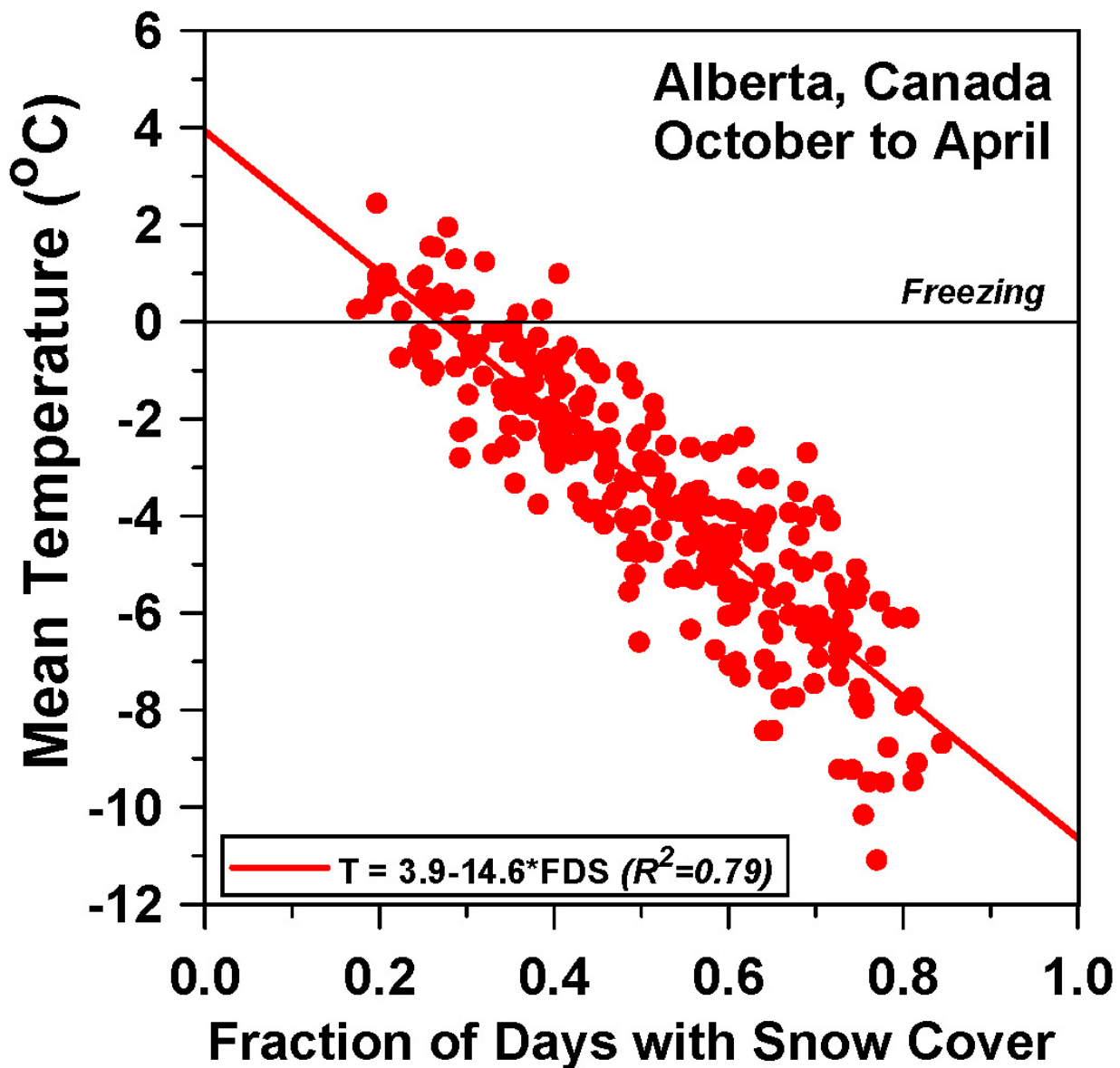


Separate mean climatology into days
with no-snow and Snowdepth >0

$$\Delta T = T:\text{no-snow} - T:\text{snow} = -10.2(\pm 1.1)^{\circ}\text{C}$$

Betts et al. (2016)

More snow cover - Colder temperatures



Winter is colder if more snow cover

Larger Slope
 14.6 ± 0.6 °C
(Seasonally coupled?)

Diurnal cycle: Clouds & Snow

Canadian Prairies 660 station-years of data

Winter climatology

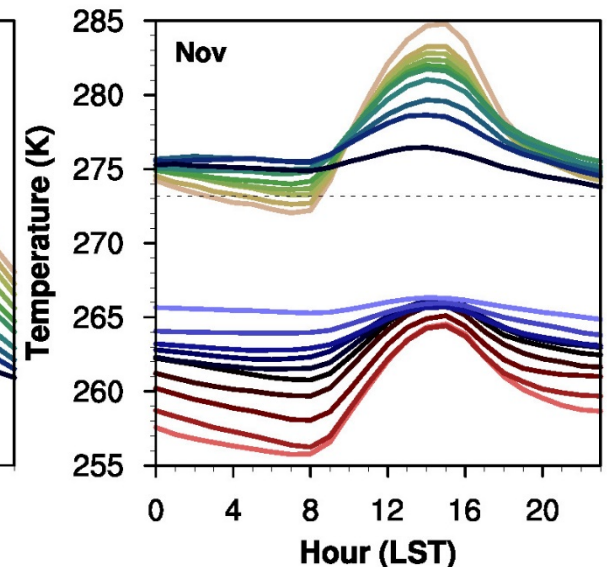
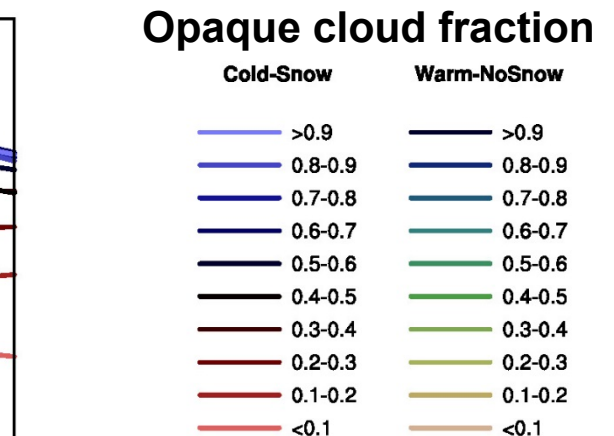
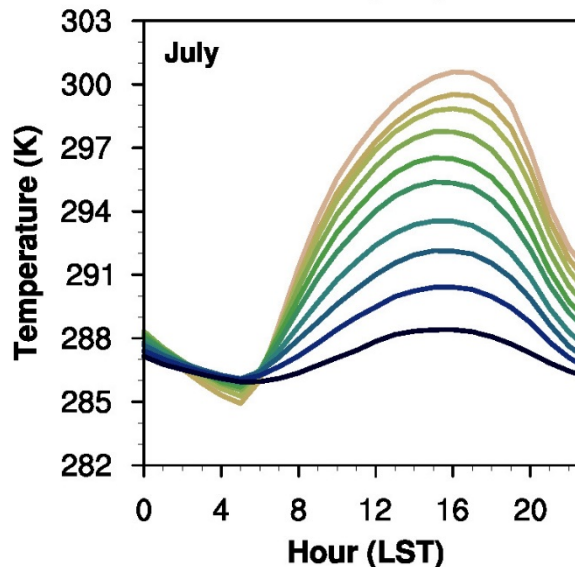
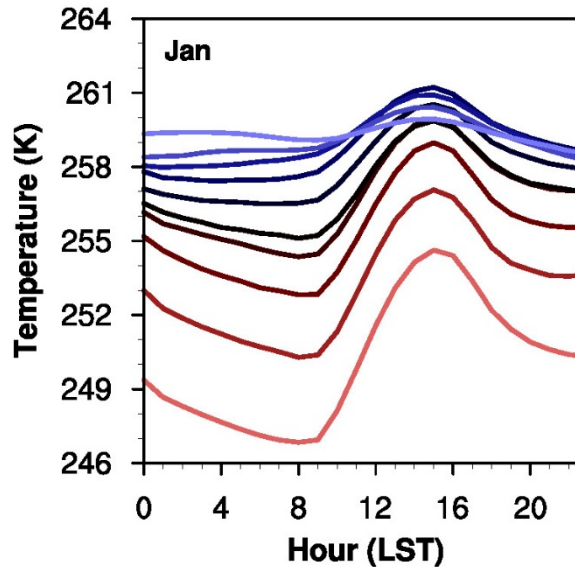
- Colder when clear
- LWCF dominant with snow
- Stable BL

Summer climatology

- Warmer when clear
- SWCF dominant: no snow
- Unstable daytime BL

Transition months:

- Show both climatologies
- With 11K separation
- Fast transitions with snow
- Snow is “Climate switch”



Lessons

- Long-term observations crucial for climate
- Hourly Prairie data superb
 - **First 40 yrs 'complete' (1953-1993)**
 - **99.5% days: have no missing hours**
 - **“Opaque cloud” gives SW cloud forcing to 10% and LW cloud forcing to $\pm 7 \text{ Wm}^{-2}$**
 - **Quantified decades-old questions**
 - **Historically not freely available: little analysis**
- *Open-access data - Moral imperative*

January 4, 2012: NASA GEOS-16

Earth's climate sustains life

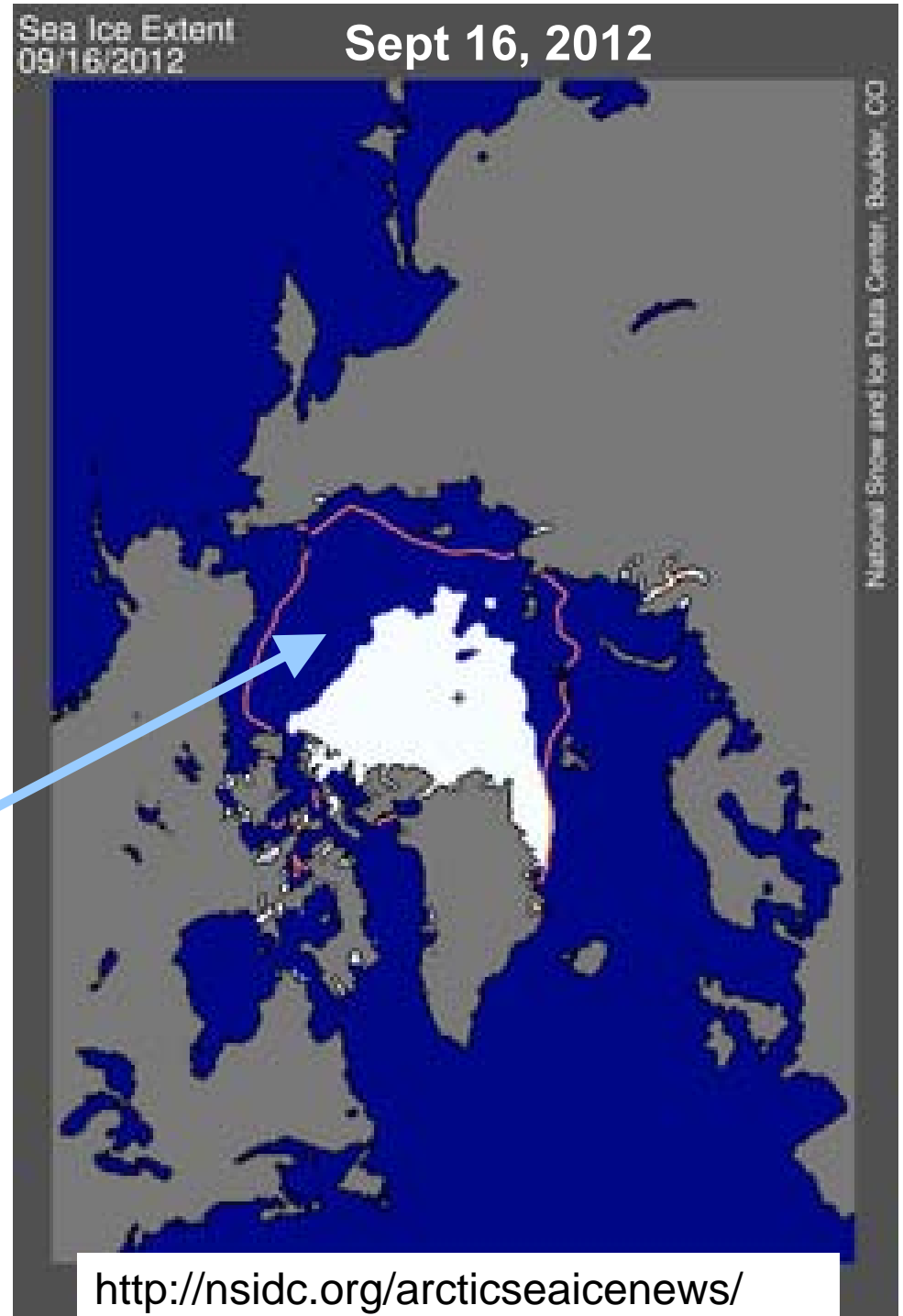
- Burning fossil fuels is increasing greenhouse gases
- **Climate is warming: ice is melting, extreme weather is increasing**
- Water plays crucial amplifying role
- Planetary modes changing



- Arctic warming twice as fast as globe
- Half the Arctic Sea Ice Melted in 2012

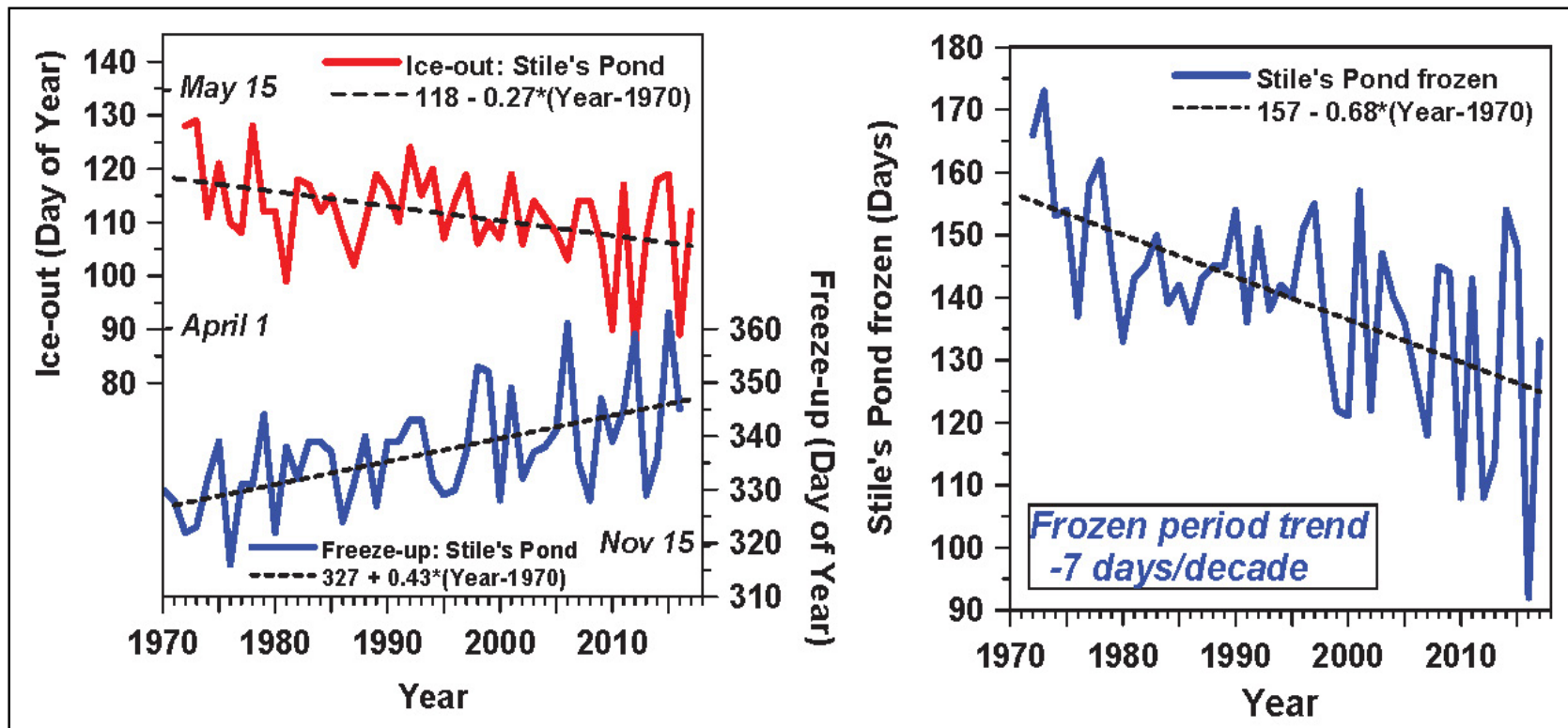
- Feedbacks amplify:
- *Less ice, less reflection of sunlight*
- *More evaporation, larger vapor greenhouse effect*
- NH winters have same feedbacks

- *Past 4 winters, Arctic sea-ice reached new record lows*
- *Arctic vortex weakening*



Vermont Lake: Freeze-up & Ice-out

Frozen Period Shrinking: variability huge



- Freeze-up later by **+4 days/decade**
- Ice-out earlier by **- 3 days/decade**
- Lake frozen period trend **- 7 days/decade**
- *Interannual variability ~ 45-y trend*

*Stiles Pond:
"Eye on the Sky"*

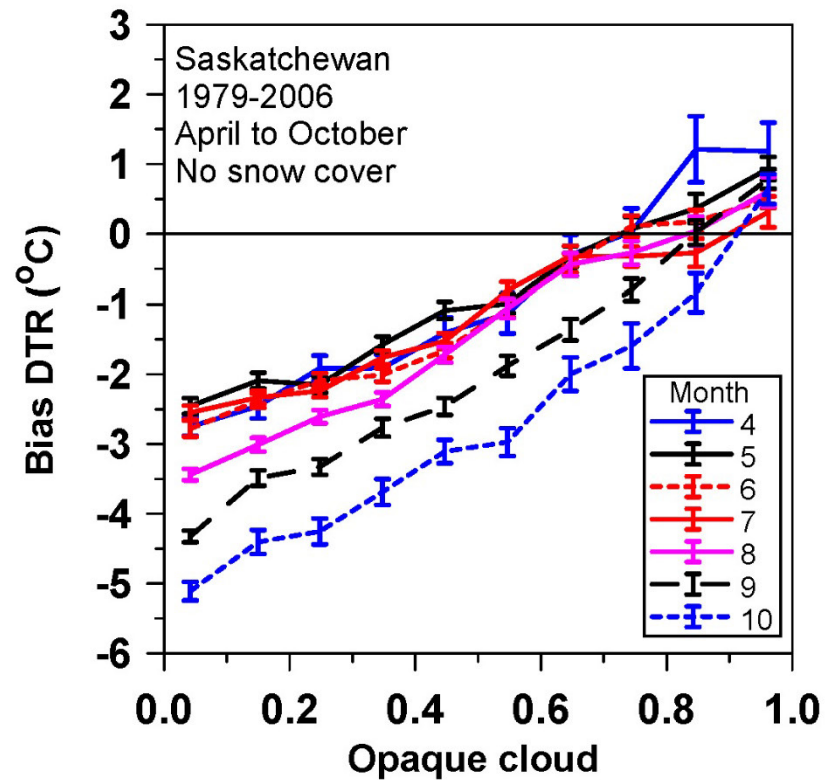
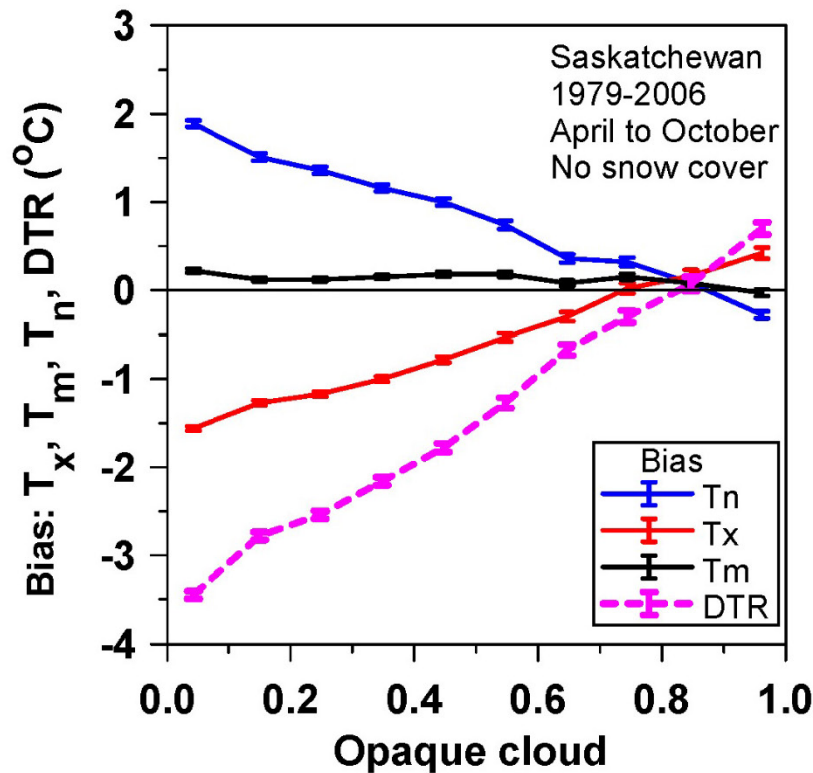
Vision of GEWEX

- **Address the scientific problems**
 - *Water and Extremes*
 - *Land-atmosphere interactions*
 - *Energy and water budgets*
 - *High-resolution modeling*
 - *Heat waves & extremes: past, present & future*
 - *Mountain water cycle*
 - *Weather & climate extremes*
 - *Cold-regions Earth system changes*
 - *Storms and high-impact weather*
 - *Irrigation & water cycle over breadbaskets*
- *Provide guidance to society and world*

Technical Issues

- *Global energy, water, carbon system*
 - *Inspiring ongoing work!*
 - **Global and regional complexity means dependence on models**
 - **Data needed to identify model biases**
 - **Improving models needs understanding**
 - *Example: Biases in ERA-Interim*

ERA-Interim Diurnal Cycle biases



ERA-Interim has warm season diurnal temperature biases related to cloud cover; with a negative DTR bias that increases from spring to fall *(Betts & Beljaars, 2017)*

Guidance: Social Responsibility

WAQAR HUSSEIN/EPA/CORBIS



Flooding in Pakistan in September 2012 affected millions of people, displacing them and damaging their homes, farms and supplies of food and water.

Webster (*Nature*, 2013) discusses the successes and challenges of providing Bangladesh and Pakistan with 10-day flood forecasts using the ECMWF global model precipitation forecasts

System Issues

- **Global Energy and Water coupled system**
 - Complex: Every month, new insights
 - Coupled to living systems: forests, agriculture
 - Critical for human welfare
- **Human waste streams are transforming the Earth's climate and natural ecosystems**
 - **Impacting water supplies, food system and human health; and changing the climate**
- **New mindset needed to mitigate, adapt and build resilience globally**
 - *Can we share what we know in near-real time?*
 - *Can we better manage our relation to the Earth?*

Can Science & Policy be kept separate?

- *Separation was the traditional frame*
 - How scientists are trained
 - It protects the integrity of science
 - Invaluable for global cooperation
 - Frame of GEWEX/International projects
- *Can we solve global challenges with this mindset?*
- *With docile acceptance of this model, the US has achieved full separation!*



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KEITH L. SEITTER, EXECUTIVE DIRECTOR
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30 January 2018

President Donald J. Trump
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

Dear President Trump:

In an interview with Piers Morgan on Britain's ITV News that aired Sunday, 28 January, you stated, among other comments:

“There is a cooling, and there's a heating. I mean, look, it used to not be climate change, it used to be global warming. That wasn't working too well because it was getting too cold all over the place”

Unfortunately, these and other climate-related comments in the interview are not consistent with scientific observations from around the globe, nor with scientific conclusions based on these observations. U.S Executive Branch agencies such as NASA and NOAA have been central to developing these observations and assessing their implications. This climate information provides a robust starting point for meaningful discussion of important policy issues employing the best available knowledge and understanding.

There is a wealth of comprehensive and accurate information on climate change available to you and your staff within government agencies, as well as from experts in academic institutions and other organizations. The American Meteorological Society stands ready to provide assistance in connecting Executive Branch staff with that knowledge and expertise to ensure that you and your staff are working with credible and scientifically validated information as you navigate the many difficult policy areas impacted by the Earth's changing climate.

Sincerely,



Keith L. Seitter
Executive Director

“Seek opportunities to communicate knowledge and technical skills” (AGU 2017)

But without an AMS check for \$100M – this was ignored!

***Not a ‘science communication’ problem
- a corruption problem & docile elites!***

Corruption not really new But now explicit in US

- ***For decades, stalling on climate change***
 - No fossil carbon tax in order to preserve value of fossil fuel assets
 - Only “cost-effective today” solutions
 - Shift 50X costs to our children and the Earth
 - Manipulation of public opinion
- ***Tacit acceptance by most scientists***

The Responsibilities and Rights of Scientists

- Adopted: **American Geophysical Union: April 2017**
- *The American Geophysical Union believes that **the free, open, and responsible practice of science is fundamental to scientific advancement for both human and environmental well-being**. Science requires freedom of movement, collaboration, and communication, as well as equitable access to data and resources. **It requires scientists to conduct and communicate scientific work for the benefit of society, with excellence, integrity, respect, fairness, trustworthiness, clarity, and transparency**. AGU rejects discrimination and harassment of any kind, including that based on such factors as ethnic origin, religion, citizenship, language, politics, sex, gender identity, sexual orientation, disability, or age.*

1. Responsibilities of All Scientists

a. Excellence in the Conduct of Research

b. Ethics

i. Communicate facts, conclusions, and uncertainty honestly, clearly, and transparently and disclose all conflicts of interest from any sources that would, or could be perceived to, bias conclusions whether addressing scientists, policy makers, or the general public.

iii. Seek opportunities to contribute knowledge and technical skills in support of the sustainability, resilience, health, and welfare of the environment and society.

v. Oppose any unethical or illegal actions, policies, procedures, or other directives that impact the conduct of science and actively work to correct them.

2. Rights of All scientists: c. Communication

iv. The right to respond to inaccurate portrayals of science by any individual or group including, government and institutional administrators, the media, private companies or industry representatives, and political entities.

My perception/values

- **Good solid definition and defense of traditional scientific values and integrity**
 - “Seek opportunities to contribute knowledge and technical skills in support of the sustainability, resilience, health, and welfare of the environment and society”
- **Does not address the ethical challenge of the responsibilities of earth scientists**
 - To the sustainability of human societies
 - To global equity
 - To the future of the Earth’s ecosystems

Challenges are growing

- **Short-term economic + financial interests**
 - Override science
 - Override human well-being across globe
 - Override preservation of ecosystems
 - Override all moral guidance (eg 2015 Encyclical)
- **Total mismatch in time-scales & trends**
 - Short-term economics discounts future
 - Earth's energy imbalance accumulates in oceans
- **System collapse approaching**
 - **Climate stability conflicts with 'business-as-usual'**

Traditional Solutions...

- **More Science, more solid ‘predictions’**
- ***Better communication of Science***
- **Hope that policy will catch up**
 - **But total mismatch of timescales, trends**
 - **In US, overt corruption increasing**
- ***Earth scientists have a responsibility for the Earth***

(Betts, BAMS 1976)

 - ***Accept this moral responsibility as a global community of scientists***

Paradigm shift for science

- **Great value of science is its honesty, integrity and its cooperative global vision**
 - It deals with the measurable world
 - It communicates openly and globally
 - Priceless to societies lost in corruption & deceit
- **Challenge is that humanity is embedded in a deeply interconnected living Earth system**
 - That cannot be separated and objectified
 - In fact the incompatibility of our social frames with the Earth system is driving climate change
 - ***Earth system limits need adaptive co-operative global governance***

Our Global Community

- **We face vast challenging issues that need close global collaboration**
 - *I work in the beautiful world of VT; dependent on the support of colleagues all over the world.*
 - *I have worked with ECMWF for 35 years exploring convection, BL, land surface processes and hydrology in the model.*
 - *E.g. At the time of the July 1993 Mississippi flood: the new 4 soil-layer scheme was being tested. Over one weekend, Martin Miller ran soil moisture sensitivity studies for precipitation. On Monday we saw that properly coupled SM improved the model precip. forecast skill from a few days out to a month.*
[GCIP science plan published in 1992]

- Yet last year, when a colleague at the European Centre said

‘For you Alan, we will do anything’

I was very humbled

- ***Then I realized it was an indicator of the depth of collaboration we will need in the years ahead***
- ***And I want to transform this into part of the GEWEX vision***

Expand the GEWEX vision

Come back to the theme of our global community of scientists, and our responsibilities to the Earth and its people

“Water, Energy: Life on Earth”
“For life on Earth we will do anything”

“Water, Energy: Life on Earth”
“For life on Earth we will do anything”

Thank-you

alanbetts.com
***(articles, talks,
research)***

