Proposal of the GEWEX/GHP Cross-Cut Project:

“Cold/Shoulder Season Precipitation Near 0°C”

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Research Team includes 16 scientists from 7 countries (Canada, China, France, Japan, Norway, Russia, and the United States) and is open to other collaborators

Objective: To improve our understanding of future changes in hazardous cold/shoulder season precipitation and storms, especially occurring near 0°C. This precipitation is a type of extreme that can be devastating and is subject to changing climate uncertainties.

FREEZING RAIN AFTERMATH

Toronto, Canada
December 2013

Hungary, early December, 2014 (actually in the past week)
~30,000 houses were damaged by ice storm

Possible reasons for contemporary and future changes

- Latitudinal shifts of climatic zones (areas that had “normal white winters” may get more frequent thaws, wet icy seasons, etc.)
- Increase in the cold season variability (blocking, unusually warm periods, etc)
- Direct impact of global warming (more atmospheric water vapor from Oceans are transported into the maritime continental areas

It is difficult to predict the phase of near 0°C precipitation events and when in frozen phase, this precipitation may become one of dangerous weather phenomena that can cause:

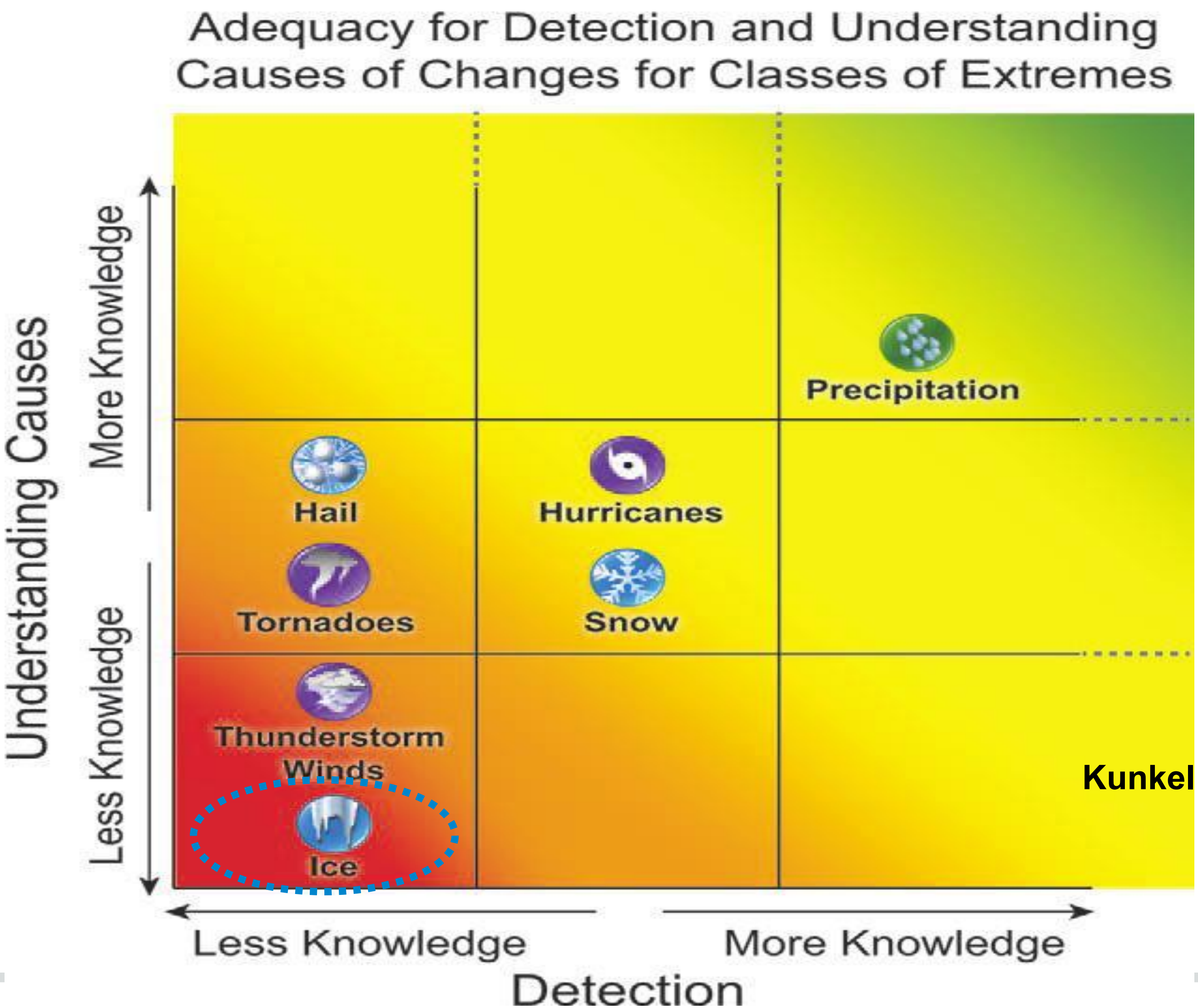
Interruptions in human activity affecting

- traffic
- communication
- housing and other man-made infrastructure
- high seas fleet operation
- impact on off-shore oil and gas production

including life threating events

These are relatively rare events but there are good reasons to expect that their frequency and strength may change with global warming

(In)Adequacy



Kunkel et al. (2013)

Regions most affected

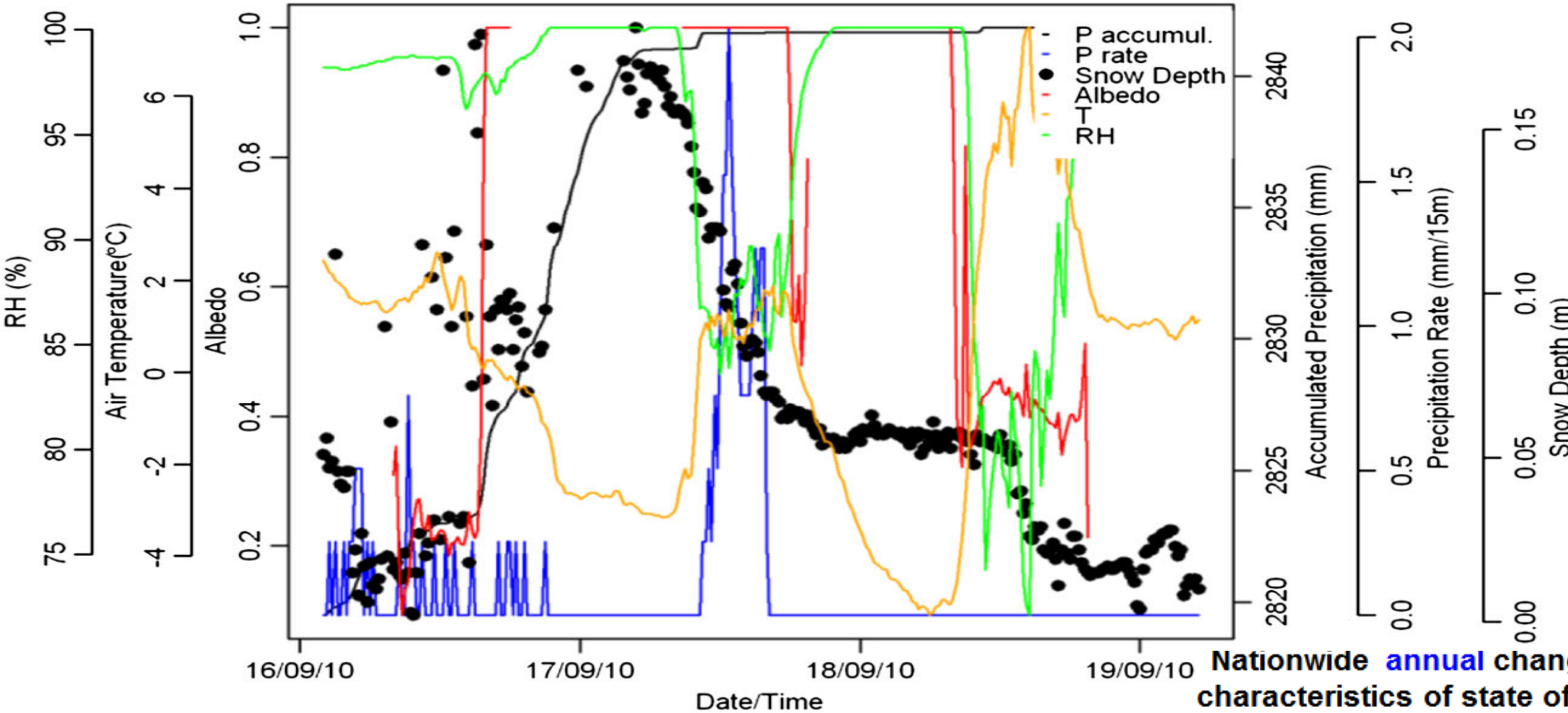
- **Arctic and Antarctic**
- **High Seas and corresponding coastal areas**
  - Northeastern North America
  - Northern part of Europe
- **Mountainous regions exposed to oceanic water vapor transport :**
  - Western coast of North America from California to Alaska
  - Russian Far East, Caucasus, Korea, Japan
  - Southern and Central China
- **Regions exposed to water vapor transport from large lakes and interior seas such as**
  - Great Lakes and Caspian Sea
  - Mediterranean, Black, and Baltic Seas

Specific Phenomena around °C

1. Heavy snowfall/rainfall transition
2. Large fraction of blizzards
3. Rain-on-snow events
4. Freezing rain and freezing drizzle
5. Ice load on infrastructure

Snowfall/rainfall transition

Phase transition of fallen precipitation impacts land surface conditions and the water cycle in a variety of ways. This is not a simple switch between wet snow and rain and requires thorough regional research (cf., Harder & Pomeroy 2013, *Hydrol. Process.*).

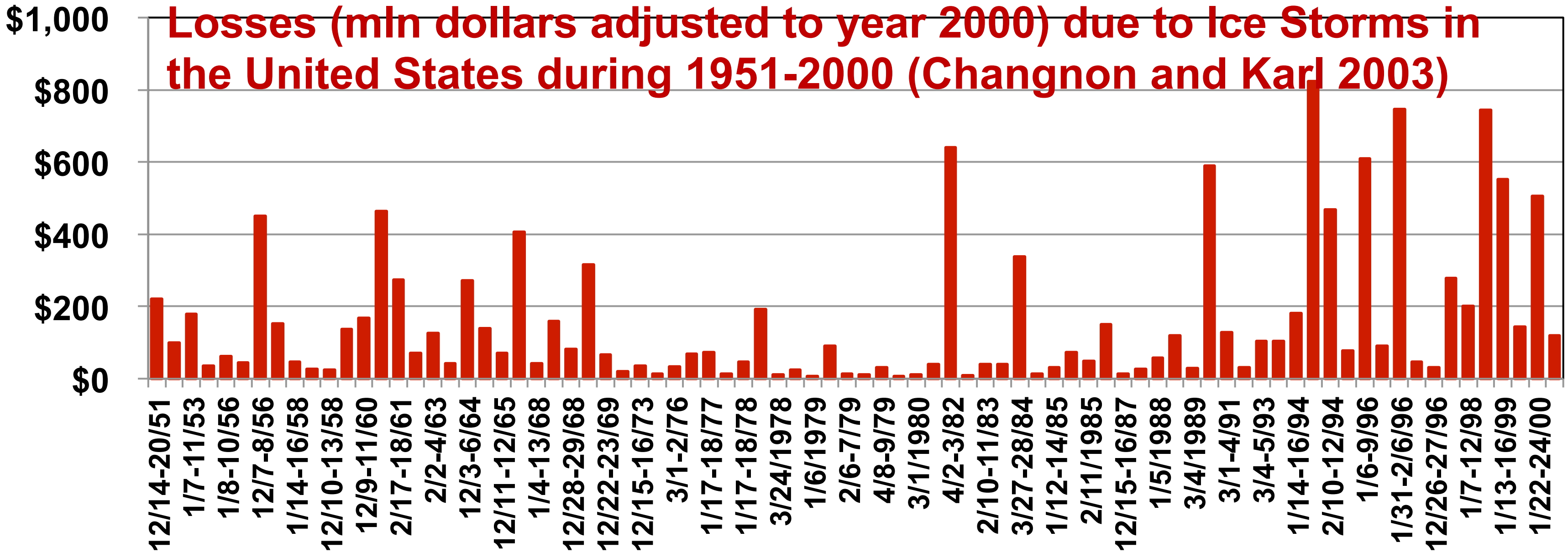


Currently we observe a substantial shifts in the 0°C isotherm across North America and Eurasia. Earlier spring onsets (by 1-2 weeks) are the most prominent feature of these shifts (cf., Groisman et al. 2006, *J. Climate*).

Nationwide annual changes in three major characteristics of state of the ground during the 1956-2004 period over Russia

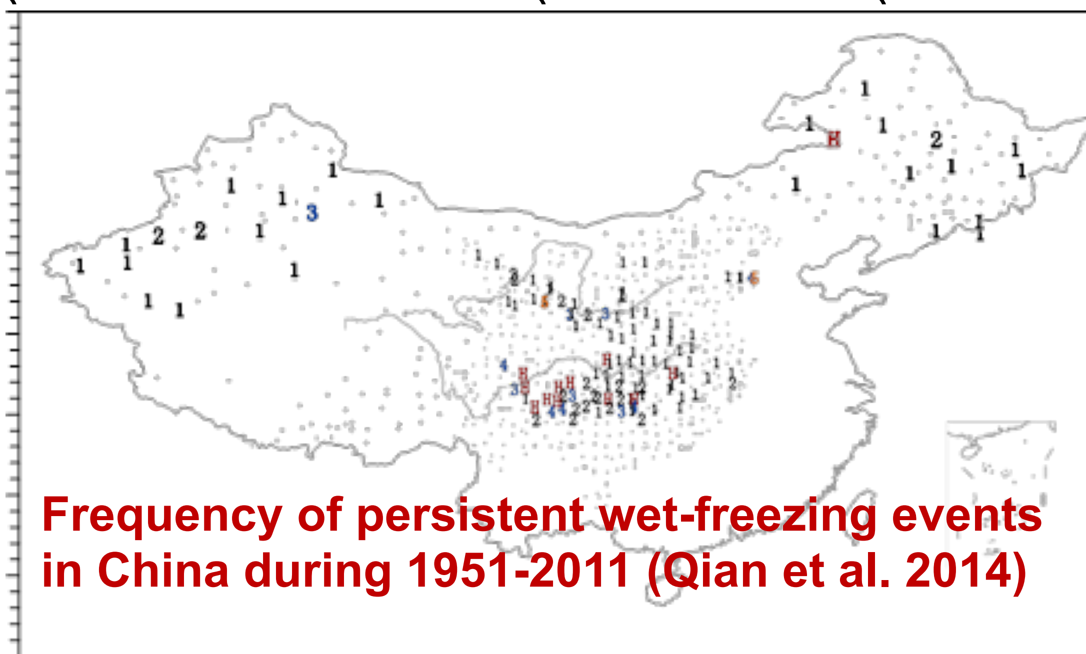
Element	Changes, days	Changes, %	R^2
Snow covered land	-2.1	-1	2
Unfrozen soil	5.0	3	14
Frozen ground, ice, remnants of snow cover	-3.0	-10	13

Freezing rain and freezing drizzle



Losses (mln dollars adjusted to year 2000) due to Ice Storms in the United States during 1951-2000 (Changnon and Karl 2003)

Freezing rains occur world-wide, are infrequent, but they cause heavy damage to infrastructure and may result in life losses. For many parts of the world their statistics have to be updated and tendencies in their frequency and intensities should quantified.



Frequency of persistent wet-freezing events in China during 1951-2011 (Qian et al. 2014)

Blizzards at the near 0°C temperatures

In the cold weather (with surface air temperatures below 1°C) a significant fraction of precipitation events with P ≥ 3 mm is accompanied with strong winds (blizzards) and when the precipitation totals are substantial (e.g., ≥ 10 mm) this fraction can well exceed 50%. Furthermore, a large fraction of these events occurs in a close proximity (±1°C) of the freezing point. **Table below show the mean percentage of these events for the 1966-2013 period area-averaged over the ~600 stations of the former USSR**. The total number of precipitation events with P ≥ 3 mm, N_p = 304,000, of them with blizzard, N_b = 124,300. When **P ≥ 10 mm**, N_p = 28,900, of them with blizzard,

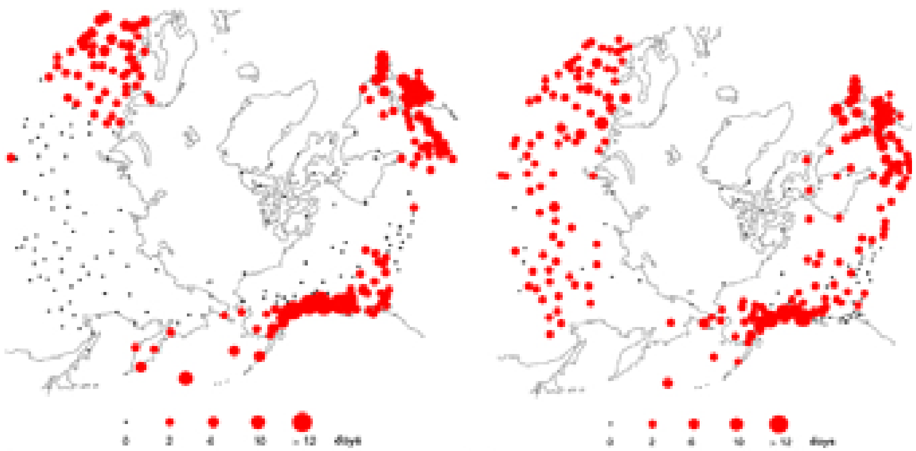
Percent of events	N_p	N_p & T∈[-1°C, 1°C]	N_b	N_b & T∈[-1°C, 1°C]	N_{pb}	N_{pb} & T∈[-1°C, 1°C]
T ≤ 1°C; P ≥ 3 mm	100	41	41	15.5	-----	-----
T ≤ 1°C; P ≥ 10 mm	9.5	5.2	4.3	2.2	100	55

N_{pb} = 13,100, **and 55% of these strong blizzards occur when surface air temperature ∈[-1°C, 1°C].**

Rain-on-snow events

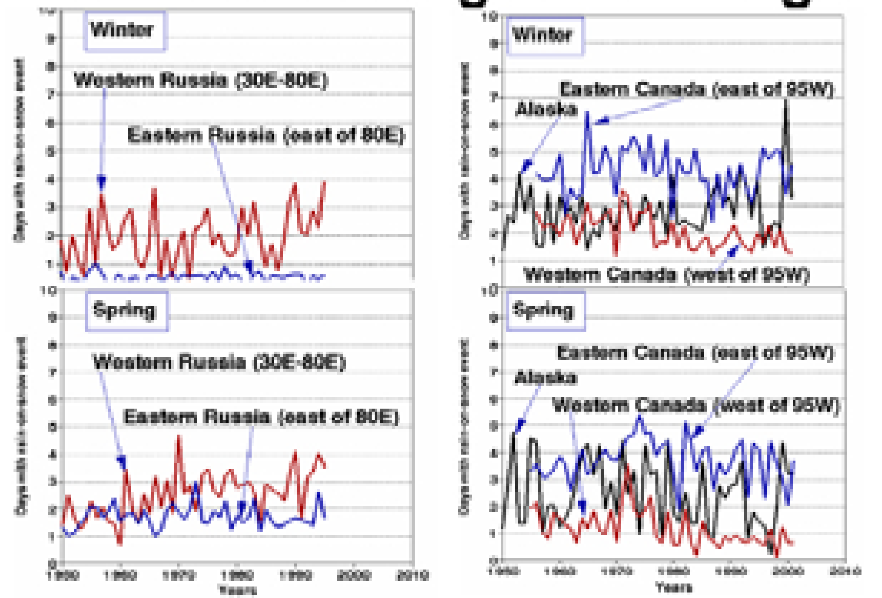
Rain on snow events: Climatology

Winter | **Spring**



- Number of days with rainfall = 1 mm when snow on the ground is = 3 cm

Rain on snow: Regional changes

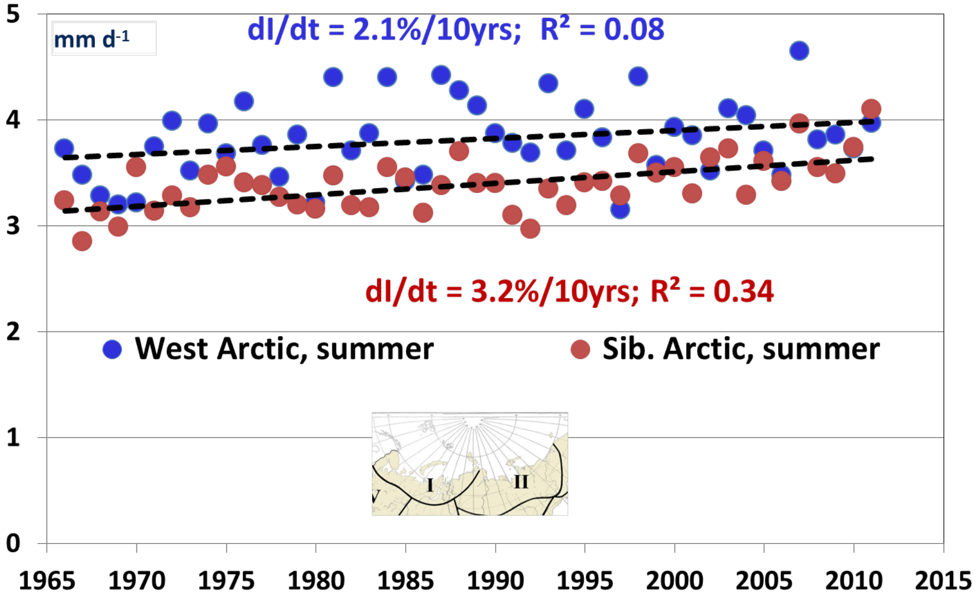


Increase over Russia (up to 50%/50yrs in winter over western Russia) and similar decrease over western Canada

Rain on snow climatology and regional changes of the event frequency (Archive of the Arctic Climate Impact Assessment, 2005)

The above analyses were made in the Arctic for the regions, where we had rainfall and snow cover data 10 years ago. Now, the information about frequency and intensity of rain-on-snow events has to be updated, expanded to other regions of the extratropics (the conterminous United States, Japan, China, and Fennoscandia), and thoroughly reassessed.

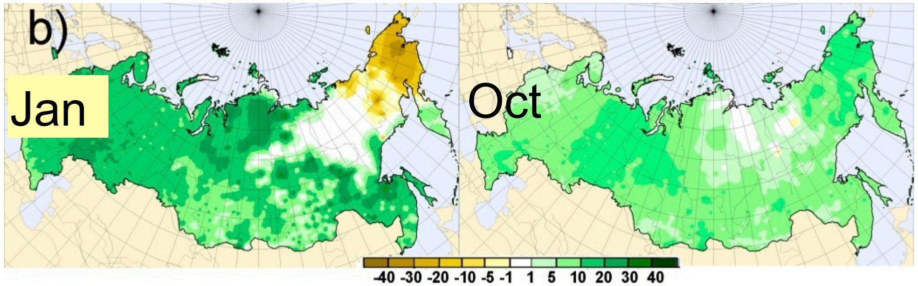
Ice load on infrastructure



Over Russia we observe: a nationwide increase in **precipitation intensity** over Russia even in the Arctic (Groisman et al. 2013) and an increase in mid-winter and autumn of the **near-surface water vapor pressure** (Bulygina et al. 2014)

Mean summer precipitation intensity over the Russian Arctic, mm d $^{-1}$

When temperatures are near 0°C, increases in near-surface water vapor pressure and precipitation intensity may lead to increase of maximum ice loads on terrestrial and off-shore infrastructure and ships in high seas

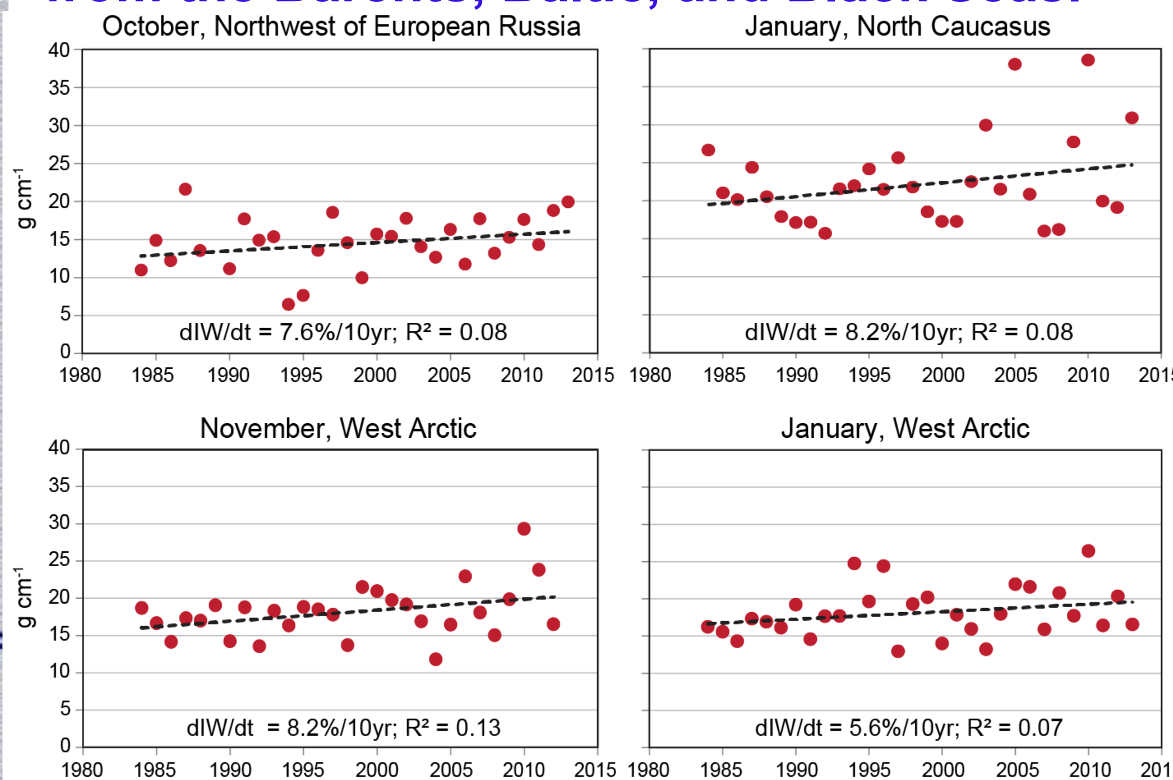


Long-term mean near-surface water vapor pressure changes (%) between the 1980-2010 and 1961-1990 periods

Changes in Icing Events (maximum monthly regional mean values); *Bulygina et al. (2014)*

Instrumental monitoring of icing and hoar frost

Dynamics of the monthly icing and hoar frost weight (IW) area averaged over meteorological stations of northernmost and southernmost regions of European Russia exposed to the water vapor transport from the Barents, Baltic, and Black Seas.



Proposed tasks

1. Prepare a review article for BAMS
2. Compile the relevant metadata and data worldwide
3. Study the physics of atmospheric processes associated with near 0°C precipitation events and establish their relationships with these events (in particular, the hazardous events)
4. Create contemporary climatology of each type of near 0°C precipitation phenomena
5. Improve the model representation of near 0°C precipitation phenomena and perform projections of their changes

谢谢!
Thank you!
Спасибо!

Finally

What's next?

- GHP December Meeting full proposal
- A discussion (review) paper with examples, science questions, and first results
- Release of the first products...

Research on this Issue

Types of studies carried out:

- Climatologies (North America, Europe …)
- Trend studies
- Case studies
- Basic precipitation science
- assessment of future conditions

What is a GHP cross-cut?

A focused scientific effort involving

- regional projects
- individual researchers
- at least one specific, doable action within 2-3 years (we have done some studies in Northern Russia and are going to continue it (a proposal to Belmont Forum has been submitted)

Possible regions of future studies:

- Western North America
- Norway, Japan, Russia, Canada
- Southern China