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 threatening 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

Adequacy for Detection and Understanding Causes of Changes for Classes of Extremes

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*).
Freezing rain and freezing drizzle

Freezing rains occur worldwide, 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 $P \geq 3$ mm is accompanied with strong winds (blizzards) and when the precipitation totals are substantial (e.g., $\geq 10$ mm) this fraction can well exceed 50%. Furthermore, a large fraction of these events occurs in a close proximity ($\pm 1°C$) 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 $P \geq 3$ mm, $N_p = 304,000$, of them with blizzard, $N_b = 124,300$. When $P \geq 10$ mm, $N_p = 28,900$, of them with blizzard,

<table>
<thead>
<tr>
<th>Percent of events</th>
<th>$N_p$</th>
<th>$N_p &amp; T \in [-1°C, 1°C]$</th>
<th>$N_b$</th>
<th>$N_b &amp; T \in [-1°C, 1°C]$</th>
<th>$N_{pb}$</th>
<th>$N_{pb} &amp; T \in [-1°C, 1°C]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T \leq 1°C; P \geq 3$ mm</td>
<td>100</td>
<td>41</td>
<td>41</td>
<td>15.5</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>$T \leq 1°C; P \geq 10$ mm</td>
<td>9.5</td>
<td>5.2</td>
<td>4.3</td>
<td>2.2</td>
<td>100</td>
<td>55</td>
</tr>
</tbody>
</table>

$N_{pb} = 13,100$, and 55% of these strong blizzards occur when surface air temperature $\in [-1°C, 1°C]$. 
Rain-on-snow events

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.
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.

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

Dynamics of the monthly icing and hoarfrost 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.

**Instrumental monitoring of icing and hoarfrost**

![Image of hoarfrost on branches]

- **October, Northwest of European Russia**
  - \( \frac{dW}{dt} = 7.6\%/10\text{yr}; R^2 = 0.08 \)

- **November, West Arctic**
  - \( \frac{dW}{dt} = 8.2\%/10\text{yr}; R^2 = 0.13 \)

- **January, North Caucasus**
  - \( \frac{dW}{dt} = 8.2\%/10\text{yr}; R^2 = 0.08 \)

- **January, West Arctic**
  - \( \frac{dW}{dt} = 5.6\%/10\text{yr}; R^2 = 0.07 \)
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