Supplementary material to "Assessing Changes in Eurasian Hydroclimatology"

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This meeting report's summary of findings is meant to be specific enough to help guide the participants, program managers, and other researchers in their research programs. This is also intended to build on the research priorities of existing efforts such as the International Polar Year (IPY), the Northern Eurasia Earth Science Partnership Initiative (NEESPI), the Global Energy and Water Cycle Experiment (GEWEX), Sustained Arctic Observing Networks (SAON), International Study of Arctic Change (ISAC), and Fresh Water Integration (FWI). Findings are organized as follows: 1) observations of change, 2) attribution, 3) recent progress, and 4) research priorities.

Observation of Change

Permafrost: no dramatic changes in active layer depth in the far North, though there is evidence of warming ground. Most changes in permafrost distributions are occurring on the warm margin of discontinuous permafrost.

Precipitation and snow: some evidence of increases in the far North and snow depth increases in the South from separate datasets. Changes in precipitation alone are subtle given strong interannual variability and cannot fully explain changes in river runoff. Errors in precipitation measurement, particularly for snow, are likely larger than the magnitude of the trend. The number of long-lived cyclones has appeared to increase, though the total number has decreased. Cyclone tracks have appeared to shift pole-ward with changes in the subpolar-polar atmospheric pressure gradient. Increased occurrence of rain on snow events may contribute to runoff trends. Snow cover extent in spring has declined.

Temperature: long-term warming trend is predominantly a winter phenomenon.

Runoff: increasing across Eurasia, runoff in North America appears closely tied to phase of North Atlantic Oscillation.

Clouds and Aerosols: shift in summertime cloud type from low to high from station data, decreasing incidence of fog, increase in number of summer fires and high rates of economic development in China are contributing to large amounts of atmospheric aerosols and soot.

Evapotranspiration (ET) and Vegetation: changes in vegetation (shrubs and boreal forest) suggest a northward shift in ecotones, evidence for a longer growing season which leads to an increase in annual ET, disappearance of large lakes in marginal permafrost zone maybe linked to talik formation and/or changes in ET, trend in small lakes largely unstudied.

Attribution

The question of the relative roles of regional land-atmosphere interactions versus large-scale atmospheric circulation is difficult to answer with direct observations or existing atmospheric reanlyses. High quality regional reanalyses using state-of-the-art models are necessary to tease apart these processes. Several new products should come online soon including the Arctic Regional Reanalysis by Bromwich, Walsh et al.

Despite the uncertainty about the relative roles of regional feedbacks and hemispheric circulation, it is clear that many processes including changes in surface air temperatures and precipitation are linked to large scale advection of air masses from lower latitudes, even deep in the interior of the Eurasian continent.

Long-term changes in precipitation and ET are likely contributors to changes in runoff, but detection is nearly impossible with biased gauge-based networks (precipitation) or sparse pan-evaporation records. Changes in subsurface storage are likely important contributors to changes in areas outside the continuous permafrost zone and are consistent with observed changes in aufeis distribution. Where subsurface storage has increased and is connected, it is likely contributing to river runoff. Where subsurface storage has increased via talik formation, but is not connected, it has little ability to contribute to baseflow runoff. Increases in active layer depth may enhance near surface water storage that could contribute to ET and influence runoff partitioning.

Impacts

Biological feedbacks may be dampening summer changes in the physical system. Vegetation appears to be changing. Land use change is an important factor, as well. Logging and silvaculture may impact regional climate in turn. Hydro-engineering has caused significant alteration to the natural hydrologic cycle and climate throughout Eurasia.

Increases in fire frequency have been an important impact of hydroclimate change in Siberia, as well as an agent of change in land cover and land-atmosphere interactions.

Changes to subsistence hunting and herding have been impacted by hydroclimate changes, particularly in snow cover extent/duration and rain-on-snow events.

Spatial shifts in and a decline in coastal fishery stocks are likely caused by a combination of temperature and salinity change as well as overfishing and pollution.

Despite major climate changes, economic opportunities are the main drivers in population shifts, changes in land use, hydrocarbon recovery (on land and offshore) as well as greenhouse gas, aerosol, and soot emissions. These changes are impacting the regional and global hydroclimate in turn.

Recent Research Progress

- Freshwater runoff from rivers may not be the crucial factor for meridional overturning circulation in the North Atlantic. Condition of Greenland ice cap is likely more important.

- University of New Hampshire/Roshydro Met product for unregulated river runoff in Eurasian basins is likely to be a key tool for separating the effect of hydropower engineering from runoff trends.

- Daily runoff product (R-Arctic-net 4.0) is also likely to be a useful product for determining shifts in the water cycle on the scale of days and weeks. Current monthly product limits detection of subtle trends in runoff timing.

- Detailed factor analysis suggests that changes in subsurface storage of water, hydro-engineering, and precipitation have differing relative influences over runoff in individual basins across Eurasia.

- Calculations using observed corrected-gauge precipitation and standard atmospheric reanalyses show inconsistencies between precipitation and runoff trends that are more likely the cause of errors in these products rather than changes in evapotranspiration or storage.

- Anomalies in Eurasian snow cover extent may contribute to troposphere-stratosphere couplings and large-scale circulation of the atmosphere.

- New Russian book (Georgiadi) published on the Lena basin geography is a strong synthesis of several decades of research on permafrost, climate, and vegetation.

- Russian hydrological GIS-based models have improved by using long-term field measurements for validation.

- Dynamic remote sensing algorithms show promise for better estimating snow water equivalent on the ground.

- New snowfall reconstructions may circumvent gauge-based measurement problems.

Priorities

- Russian-American exchange of ideas and data. Translating the Georgiadi book (2007) into English would be extremely valuable.

- Studies of change in the Active Layer Depth must include measures of subsidence.

- Better maps of permafrost distribution, taliks, and ice rich ground should be made.

- Regional dynamic remote sensing algorithms for the cryosphere should be further developed and implemented alongside ongoing ground validation.

- Better inventories of aufeis and lakes of all sizes should be made via remote sensing and ground surveys.

- Our understanding of groundwater pathways, hydrogeology, and the contribution of subsurface storage to river runoff should be improved, possibly using isotopes.

- Vegetation maps for Eurasia should be improved with remote sensing and ground validation.

- More accurate and higher resolution Digital Elevation Maps (DEMs) are necessary for simulating Eurasian hydrology.

- Expanded networks of soil moisture, evapotranspiration and eddy flux observations are important, particularly in the Siberian sector.

- Paleo hydrology and discharge from multiproxy reconstructions is necessary to put current hydroclimate change in perspective.

- Understanding natural change in river discharge will require detailed correction for hydropower engineering.

- Extensive field measurements should be made for NASA's Global Precipitation Measurement mission.

- The GEWEX/CEOP program in the Lena Basin should be expanded in scope and duration.

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List of the Workshop participants:
http://www.iarc.uaf.edu/workshops/2007/eurasian_hydro_07/participants.php

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