Use of International Polar Year data to improve attribution of long-term hydrologic changes in Arctic Eurasian land areas

Year 1 Progress Report

NASA Grant Number: NNX08AU68G

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Reporting Period: 30 June 2008 - 29 June 2009

During the reporting period, progress was as follows:

Task 1: Construct high quality gridded climatological forcing data for the VIC model for the study area.

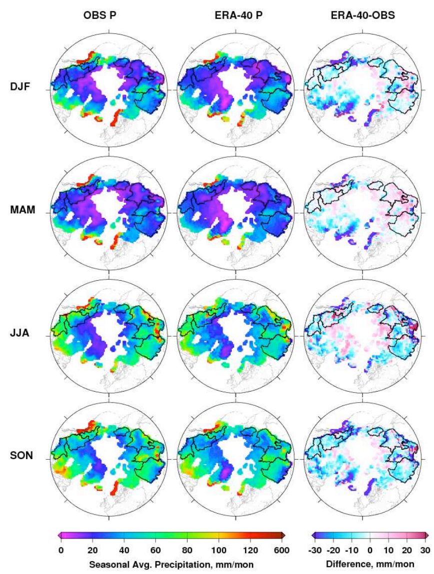

Figure 1. Spatial distribution of seasonal average precipitation from the gridded observations (OBS) and ERA-40 reanalysis, and the difference between the two fields for the Arctic drainage basins.

We proposed to construct a high quality data set for the VIC model and to produce estimates of surface water and energy fluxes over the pan-Arctic domain which will allow comparison with satellite and other (e.g. reanalysis) products. We constructed this high quality gridded product (1979-2007) using methods outlined in Adam et al. (2007). The data consist of daily time series of precipitation, maximum temperature, minimum temperature, and wind speed gridded to a 50-km EASE grid resolution.

We have compared the precipitation between the new data set and ERA-40. As shown in Figure 1 at left**,** the ERA-40 precipitation agree reasonably well with our gridded observations both in the timing and magnitude of the seasonal pattern. The distribution of seasonal precipitation is consistent between ERA-40 and observations. Significant differences are nonetheless evident in some areas. ERA-40 tends to underestimate precipitation in comparison with observations over southern Alaska, southeastern Greenland, and the Norwegian coast, where both ERA-40 and observations exhibit precipitation maxima. Along the Arctic coast, ERA-40 overestimates precipitation in the summer for North America, and in all seasons for Eurasia.

Task 2: Assemble and evaluate satellite-based water and energy data sets, and ancillary data, over the study domain.

We proposed to conduct a comprehensive review of data sets suitable for estimation of components of the surface water and energy budgets over the pan-Arctic domain. This work is in progress. To date, we have evaluated the surface incoming shortwave and longwave radiative fluxes from (1) VIC model, (2) International Satellite Cloud Climatology Project (ISCCP-FD), and (3) ERA-40 over the period 1984 to 2006. At the local scale, we are comparing these data sets with high-quality in situ measurements from the Global Energy Balance Archive (GEBA). At the regional scale, the consistency of the dominant spatial variability across different data sets is reasonably consistent as shown in Figure 2. All data sets reproduce the patterns associated with the annual mean, but they vary in their ability to capture patterns linked to spatial variability.

Task 3: Extend and interpret GRACE estimates of surface water storage changes over the major Arctic river basins.

We proposed to evaluate GRACE-based estimates of seasonal and inter-annual storage in the major arctic river basins, and to compare these estimates with estimates derived from the VIC model.

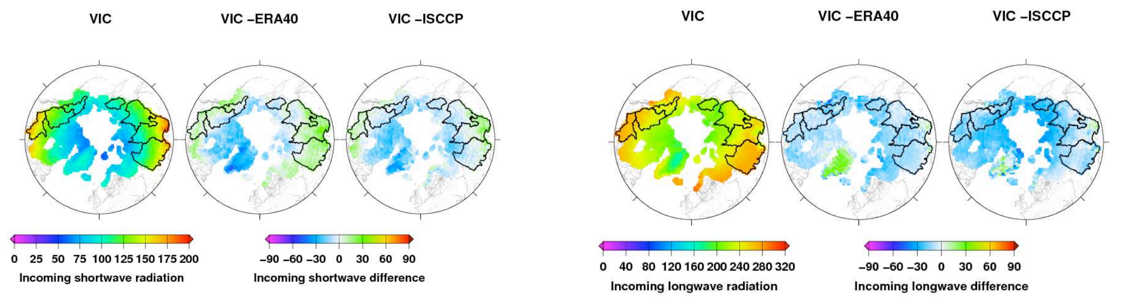

Figure 2. Spatial distribution of annual mean of a) incoming shortwave radiation, b) incoming longwave radiation from the VIC model, the difference between the VIC and ERA40, and the difference between the VIC and ISCCP for the pan-Arctic.

This task has been completed. The VIC model forced by GPCP observations and NCEP/NCAR reanalysis was used to evaluate GRACE-based estimates over the major Arctic river basins and the entire pan-Arctic for 2002-2007. Three GRACE-based datasets from different science processing centers (CSR, JPL, and OSU) were used. Figure 3 shows the monthly anomalies of basin-averaged terrestrial water storage (TWS) estimated from GRACE and VIC for the Lean, Yenisei, Ob, and Mackenzie River basins. The gray bands represent the range of GRACE estimates, and the green lines are the average of three GRACE estimates. The difference among the three GRACE data sets is much smaller than the difference between the GRACE estimates and the VIC model simulation. In general, the GRACE estimates of amplitude of seasonal variations in TWS are smaller than those from VIC. Possible reasons include:1) uncertainty from the VIC model input and the model itself, 2) the smoothing effects on the GRACE data (smoothing attenuates the real signals), 3) ocean "leakage" at the land-ocean boundary, which may effectively dilute the GRACE estimates.

Task 4: Evaluate effects of dams on the discharge of major rivers.

We proposed to use the recently developed VIC reservoir model to predict storage in major reservoirs in the pan-Arctic basins, and evaluate these prediction using a combination of satellite altimetry for reservoir stage and coincident estimates of reservoir surface area from

MODIS.

We have retrieved reservoir stage for major pan-Arctic reservoirs from the NASA/CNES Topex/Poseidon satellite missions and compared with the operational records from some large reservoirs to validate the feasibility of our method.

Task 5: Reconstruct past hydrologic changes over the study basins.

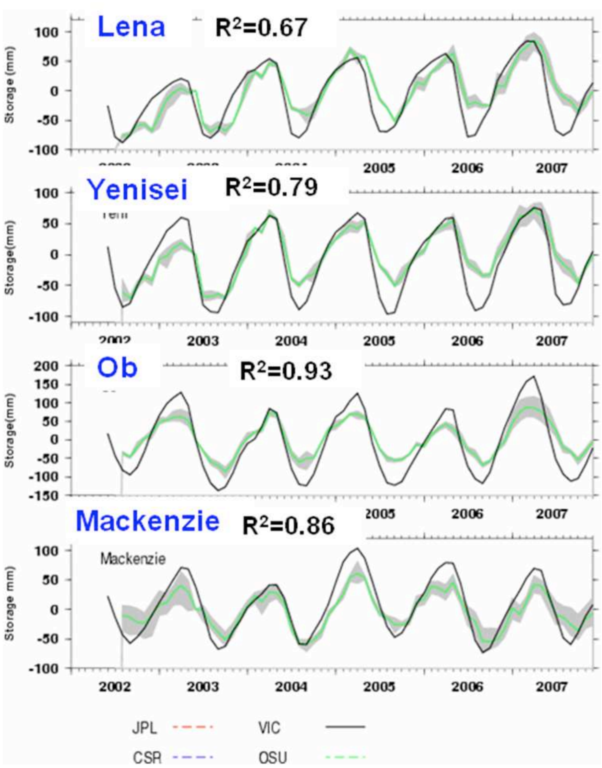

Figure 3. Monthly anomalies of basin-averaged TWS estimated from the GRACE and VIC

We proposed to reconstruct land cover, fire, and permafrost regimes, as well as reservoir effects, flows at the mouths of the rivers in the study domain and their major tributaries using the VIC model. Then, a series of sensitivity tests in which we will fix the various possible change agents (e.g., remove dams, prescribe a fixed annual cycle of permafrost active layer depth; fix vegetation – i.e., eliminate logging and fires) will be performed. **Work on this task has not yet started.**

Task 6: Comparison with other NEWS land surface data sets.

We proposed to compare the model forcing precipitation data set with remotely sensed precipitation data produced by NEWS PIs Adler and Sorooshian over that portion of the domain and compare the land surface water and energy cycle variables predicted by VIC with the same variables predicted by GLDAS over high latitude northern hemisphere land areas. **Work on this task has not yet started.**

References

Adam, J.C., and D.P. Lettenmaier, 2007. Application of new precipitation and reconstructed streamflow products to streamflow trend attribution in Northern Eurasia *J. Climate* 21(8): 1807-1828