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CONTROL ID: 1497802

TITLE: Terrestrial Arctic Amplification Due to Changes in the Eurasian Soil Thermal Regime

ABSTRACT BODY: The Arctic amplification phenomenon suggests that due to feedbacks largely involving sea ice, increases in surface air temperature in response to greenhouse gas forcing are most pronounced in the Arctic. As the Arctic warms in response to climate change, the summer melt season lengthens and intensifies, leading to less sea ice at the end of summer. Absorption of solar radiation during summer in expanding open water areas increases the heat content of the ocean, delaying ice formation and promoting increased upward heat fluxes. Loss of sea ice thus provides a positive feedback that exacerbates the warming observed in the Arctic.

The underlying premise of our study is that much like Arctic amplification due to the loss of sea ice, changes in the amount and distribution of frozen ground in Northern Hemisphere land areas represent a terrestrial analog to Arctic amplification. In response to climate warming we are observing increases in soil temperatures, deepening of the active layer, and talik formation in permafrost regions. This leads to delayed freeze-up of soils, decreased freeze depths in seasonally frozen ground regions, and earlier spring thaw. These changes in the soil thermal regime result in more and more heat storage in soils during the warm season, amplifying the frozen ground changes in high latitudes. The increased heat storage in the soil thermal regime results in a seasonal redistribution of energy, which leads to a substantially increased heat flux from the soil to the atmosphere during the cold season. It is this heat flux that represents our hypothesized feedback.

We use monthly historical soil temperature observations at 423 station locations in the Eurasian high latitudes combined with soil properties based on the Harmonized World Soil Database to provide estimates of this soil heat flux. We calculate the temperature gradient based on soil temperature and, for a generalized assessment, first use a constant, estimated thermal conductivity for frozen versus unfrozen soil to calculate soil heat flux. Next, we use the Variable Infiltration Capacity (VIC) land surface model to estimate soil moisture at each of the 423 sites, thereby providing a more robust estimate of site-specific thermal conductivity and hence soil heat flux. Finally, we use the thermal conductivity estimate provided by VIC itself, for a third estimate of soil heat flux. These various estimates are compared across the Eurasian high latitudes for a comprehensive validation of our hypothesized anomalous heat flux to the atmosphere in the transitional and cold seasons. We thereby present evidence for a previously unexplored land-atmosphere coupling, potentially capable of altering the large-scale flow of the atmospheric circulation.

CURRENT SECTION/FOCUS GROUP: Global Environmental Change

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AUTHORS/INSTITUTIONS: O.W. Frauenfeld, L. Chen, Geography, Texas A&M University, College Station, TX;
T. Zhang, CIRES/NSIDC, University of Colorado, Boulder, CO;

SPONSOR NAME: Oliver Frauenfeld

CONTACT (E-MAIL ONLY): oliverf@geog.tamu.edu

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