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Influence of Land Cover Change on Regional Water and Energy Field in Eastern Siberia

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According to IPCC AR4, Eastern Siberia is thought as an area of great future change in the environment compared with other area. However, environment change has already occurred, such as water surface expanding and forest area decrease. From meteorological stand points, land surface state can be written by land surface parameters: surface albedo, evaporative efficiency, roughness length, heat capacity and thermal conductivity. With land surface change, these parameters vary and water/energy balance also varies at the same time. Moreover, according to previous study on water recycling ratio, more than 60% of precipitation source is supplied by evapotranspiration from land surface and this trend becomes stronger in Eastern Siberia than Western Siberia. Water movement occurs between land surface and the atmosphere, thus three-dimensional model is required to make clear effect of land surface change on water and energy field.

Our study has two objectives:

1) to make clear what land surface parameter has strong impact on water and energy field

2) to estimate water and energy field change with land surface change.

To achieve first objective, above five land surface parameter impacts on water and energy field is investigated using three-dimensional atmospheric model (JMA-NHM). Using routine station precipitation data, calculation duration is set from 2000/07/07 to 2000/07/17. Here, defining parameter impact as ratio of perturbation of latent heat flux and perturbation of land surface parameter, surface albedo and evaporative efficiency were dominant parameters among five land surface parameters. Calculation duration was changed to June 2000, August 2000, July 2001 and July 2002 (from 7th to 17th) and parameter impact was derived for each durations. Parameter impact of surface albedo and evaporative efficiency took larger value among these durations and there was no dependency on season and year.

Based on first experiment result, water and energy field change with water surface expanding was analyzed. Considering water and grassland area distributes almost 20% of lowland Central Yakutia, water and energy field difference between grassland 20% run and water surface 20% run was investigated. Here, land surface distribution of grassland, water surface and original is denoted as (G, W, O). There was linear increase of latent heat flux with water surface expanding from (G, W, O) = (0.2, 0.0, 0.8) to (0.0, 0.2, 0.8) and degree of latent heat flux increase was 1.2 W m-2 (2.4%). To understand what parameter played important role for this result, each land surface parameter effect was estimated from parameter impact and parameter change. Surface albedo and evaporative efficiency were impactful parameter on water and energy field, however, surface albedo was not effective parameter for water surface expanding because degree of actual surface albedo change was not so large compared with other surface parameters. Surface albedo has higher parameter impact, but its actual parameter change was lower value. Thus it did not become impactful parameter. Similar discussion can be done for thermal conductivity; it had lower parameter impact and higher actual parameter change. On the other hand, evaporative efficiency had larger parameter impact and actual parameter change, thus it was dominant parameter with water surface expanding.

At last, latent heat flux and precipitation change with deforestation and water surface expanding was investigated using parameter impact and virtual land surface data. When all lowland area that was less than 250 m became grassland, latent heat flux increased 0.1 W m-2 from (G, W, O) = (0.2, 0.0. 0.8), however, it was 0.5 W m-2 from (G, W, O) = (0.2, 0.0, 0.8) to (0.0, 0.2, 0.8). Thus land surface change to grassland does not have strong impact to water and energy field, but land cover change that contains water surface enhances latent heat flux strongly.

Keywords: Eastern Siberia, Land Surface Change, Evapotranspiration, Precipitation, Heatbalance