Modelling of active layer dynamics and talik formation

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Active layer dynamics is assessed using the numerical model for thermal and hydrological processes in soil (Arzhanov et al., 2008; Mokhov et al., 2009) for geocryologival stations Marre-Sale (69ºN, 66ºE) and Yakutsk (129ºN, 62ºE). Atmospheric forcing needed by the model is taken either from the ERA-40 reanalysis data (Uppala et al., 2005) or from output from simulations with a coupled atmosphere-ocean general circulation model ECHAM5/MPI-OM . Figure 1 shows the comparison of simulated active layer thickness using ERA-40 reanalysis and observed active layer thickness for the Marre-Sale (Izrael et al., 2002; Pavlov and Moskalenko, 2002) and Yakutsk (Konstantinov et al., 2006) stations for the 1980s and 1990s.

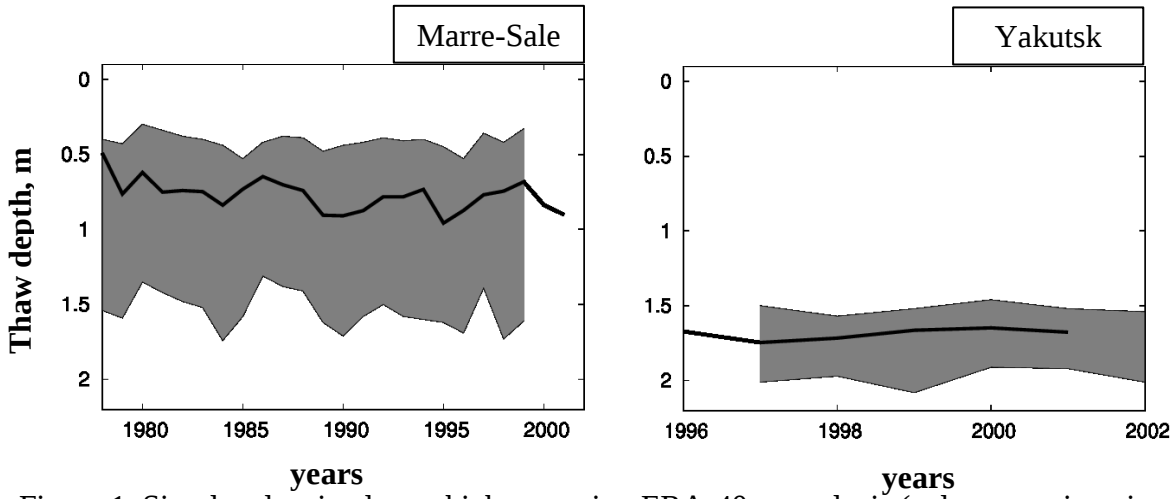

Figure 1. Simulated active layer thickness using ERA-40 reanalysis (values are given in black) and observations (values are given in gray) for the Marre-Sale and Yakutsk stations.

The simulated and observed active layer thickness are in reasonably good agreement for the both stations. For the Marre-Sale station, a general tendency for an increase the active layer thickness was observed in 1978-1995 (Pavlov and Moskalenko, 2002). The simulated active layer trend at the Marre-Sale station is about 0.007 m per year during the 1978-1995 period. Observed trends are about 0.005-0.011 m per year for this period (Izrael et al., 2001). The period from 1996 to 1999 was characterized by colder mean annual and summer temperatures. As a result, tendency for an increase in the thaw depth becomes less pronounced (Fig. 1).

To assess active layer dynamic for the Marre-Sale and Yakutsk stations during the 21st century the permafrost model was forced by the ECHAM5/MPI-OM atmospheric characteristics under SRES A1B and A2 scenarios. Summer air temperature increased by 4.8ºC at A1B scenario and 5.9ºC at A2 scenario for the Marre-Sale and increased by 4.0ºC and 5.3ºC, respectively, for the Yakutsk from 2000s to the 2090s (Fig. 2a). Thaw depth increased from the 2000s to the 2050s for the Marre-Sale station and from 2000s to the 2070s for the Yakutsk station (Fig. 2b). Since 2050s, the near-surface frozen ground thawed and talik depth increased for the Marre-Sale. The results also show that changes thawing regimes were different due to the summer air temperature (about 1.8ºC for the 2040-2060) under A1B and A2 scenarios. For the Yakutsk station the first talik formation occurred about 2073-2075 (Fig. 2b) and then talik depth increased since 2080s.

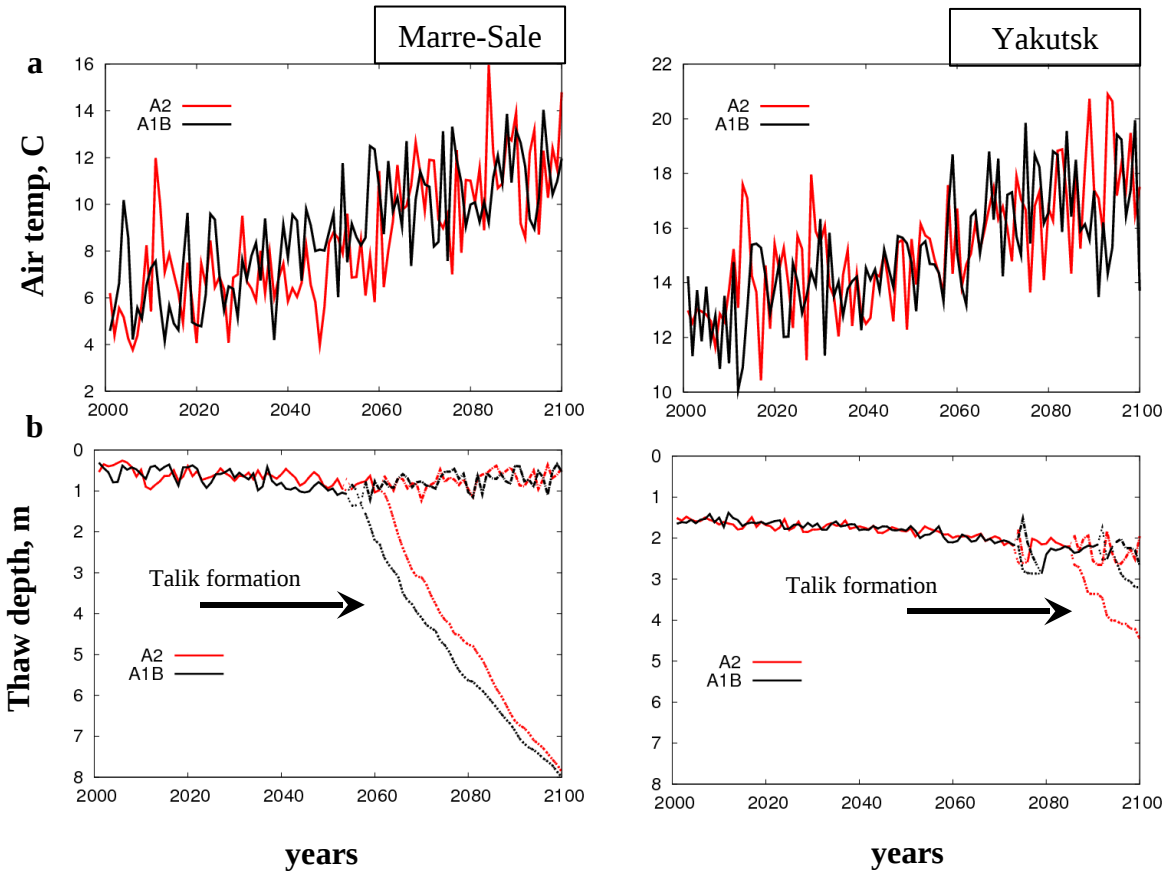

Figure 2. Summer air temperature under SRES A1B, A2 scenarios (a) and simulated thaw depths (b) for the Marre-Sale and Yakutsk stations.

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