Short-term climatic variability in the Okhotsk Sea during the past 15,000 years

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Today, a major challenge for paleoclimate research lies in understanding principle processes of interdecadal-centennial climatic changes ocurring rather rapidly during Holocene and the last deglaciation. However, for one of the world ocean's largest basins, the subarctic NW-Pacific, investigations so far have been hampered by an absence of Holocene high resolution marine records.

Our work in the Okhotsk Sea – within the framework of the joint russian-german BMBF-project KOMEX II – currently focuses on obtaining these records, disclosing short-term climatic shifts during the past 15,000 years. Within this Pacific marginal basin – and the adjacent Amur river hinterland – the humid SE-Asia monsoon transports the vast majority of moisture via precipitation into the drainage basin of the Amur in summer and thus directly influences the amount of fluvial discharge into the Okhotsk Sea. This regime is contrasted by cold, dry continental climate from NE-Siberia in wintertime exerting its influence on the lateral and temporal extent of the winter sea ice cover (Fig. 1). These two patterns show considerable variability in both strength and lateral extent on multifaceted timescales. Furthermore, the northern Sakhalin continental margin is the key region for the formation of Okhotsk Sea Intermediate Water (OSIW), flowing along the Sakhalin margin into the Pacific and ventilating the middepth North Pacific Intermediate Water (NPIW). Thus, we consider this region as crucial for the comprehension of complex changes and shifts of atmospheric and oceanographic systems in the subarctic Far East and western North Pacific region, but also focus on possible teleconnection patterns with a reference record of the northern hemisphere.

During the past expeditions, we recovered a suite of gravity cores along the continental margin of NE Sakhalin and W Kamchatka. (see. Fig. 1). At the former location (LV28-4-4 and LV29-79-3), both high biogenic productivity and terrigenous sediment supply by the Amur river drainage system are main contributors to the depositional environment. The latter location (LV29-108-5) mainly serves as as reference site for shallow intermediate water mass characteristics and variability close to the NW Pacific inflow through the deep passages between the Kurile islands. There, sediment composition is governed by changes in biogenic productivity and coastal upwelling.

Our pesent age models mostly consist of AMS radiocarbon control points from planktic foraminifera and benthic shell fragments. At the Kamchatka site our – still preliminary – age model is obtained by correlation of records of magnetic susceptibility to existing records confirmed by the occurrence of an ash layer (identified as K0~8000 yr BP, S. Gorbarenko, pers. comm., 2002) and additional AMS ^{14}C dates.

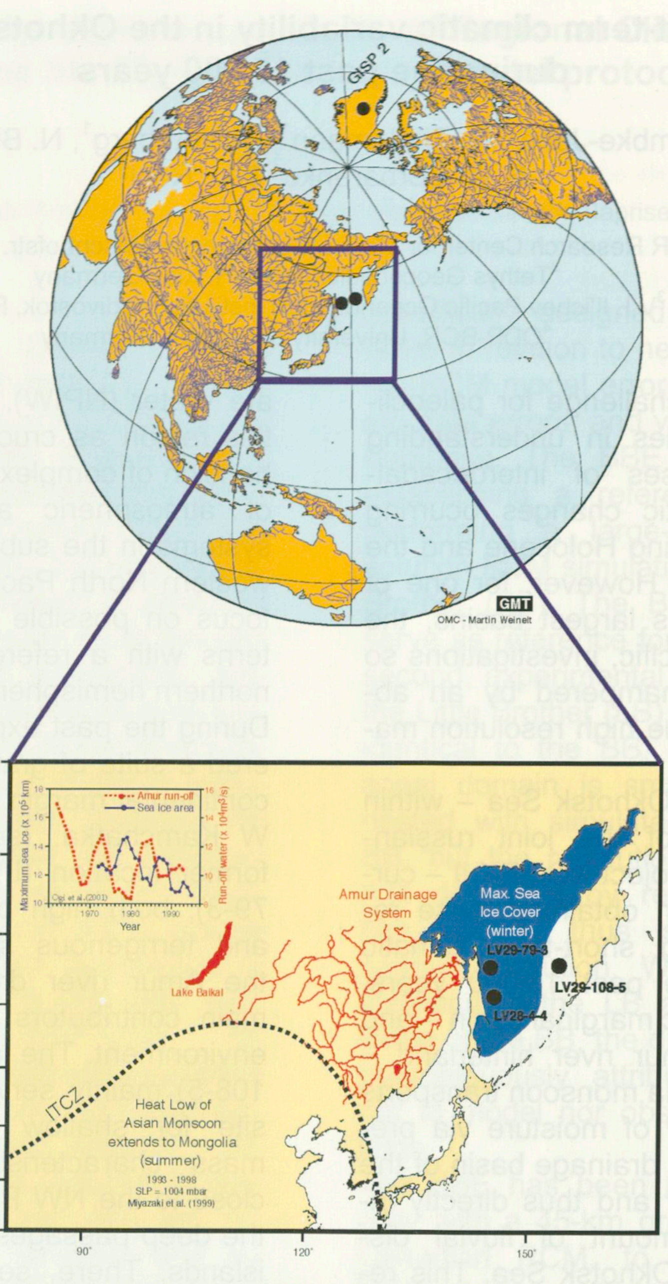

Fig. 1: Upper panel: Map with the locations of the study area in the Okhotsk Sea and the Greenland GISP 2 ice core used for correlation and depiction of teleconnection patterns between N Atlantic and NW Pacific. Lower panel: Location of sediment core locations in the Okhotsk Sea. Also shown is the maximum northward propagation of the ITCZ (simplified) and the Amur watershed. The insert shows observed negative feedbacks of the annual discharge into the Okhotsk Sea on buildup of winter sea ice (Ogi et al., 1996).

According to our age models, maximum sedimentation rates exceed 120 cm/kyr during the last 8000 years, though decreasing down to 20 cm/kyr in distal (southernmost) areas or older parts of the cores. Thus to date, our investigations gain an average temporal resolution of 20 - 100 years between discrete samples for the Holocene.

Based upon a multiproxy approach, we use content and accumulation rates of opal as a proxy for primary biogenic productivity while minor element distributions derived from XRF-core-scanning serve as indicators for riverine/terrestrial sediment supply. Whereas these datasets provide relatively high-resolution records, stable isotope data of benthic and planktic foraminifera supplement our results on a lower temporal scale revealing information about the evolution of OSIW and thus NPIW. Our results show high frequency oscillations in both Amur river discharge and biogenic productivity that can be correlated to oxygen isotope records of the Greenland GISP II ice core record. Beneath major incidents like the Younger Dryas with Termination Ib, we are confident to correlate these cyclic changes in sediment supply to the continental margins with the GISP 2 record, pointing towards large, presumably cross-pole, atmospheric teleconnection patterns. Spectral analysis reveals several millennial–interdecadal periodicities, with e.g. 940-year in the Holocene interval of 8500 – 4000 years BP. In the youngest interval of 0 – 4000 years BP, though, a transition towards a 1200-year cyclicity appears. The occurrence of cyclic changes within the same frequency spectra in either record substantiate a tight connection between our study area and the climate in the North Atlanitc during the past ca. 8,000 years BP. Within the observed cycles, we also recognize significant short-term events in the Okhotsk Sea, presumably attributable to the intervals known as the Medieval Warm Period or the Little Ice Age.