1. Summary of the research plan

The Anthropocene has seen unprecedented environmental change, and fundamental ecosystem services are increasingly at stake. This is particularly true for climate change and biogeochemical cycles. Interactions of both resulted, for instance, in global spread of anoxia in freshwater systems. However, a sound scientific assessment of such changes must rely on a long-term perspective. This information can be provided, for instance, by high-resolution quantitative diagnostic proxy records from varved lake sediments.

Recently, the applicant and his team have developed novel imaging methods (hyperspectral imaging in the visible/near-infrared range VNIR-HSI) for the biogeochemical analysis of lake sediments. We have established the "proof of concept" that VNIR-HSI data can be used (i) to quantify distributions and time-series of pigments that are diagnostic for **aquatic productivity** ({Chl *a* and chlorins}) and **meromixis** (bacteriopheophytin ***a***) and, (ii) to reconstruct annually resolved **season-specific quantitative climate variables**. This novel technology provides information at ultra-high resolution (45 µm); it is cost effective and very rapid. This work has been cited among the most innovative and promising future developments in the field.

Thus, the proposed research will develop along two thrusts (2 PhD projects):

1. Next level methodology: we propose (i) to extend laboratory-scale HSI of lake sediments to **SWIR (1000-2500 nm)**, which allows to detect important mineral groups (calcite, feldspars, clays, Fe-oxides) in biogenic varves and assess key-processes within the lake and the catchment (marl and metal-oxide precipitation, redox conditions, erosion/land cover); (ii) to improve data acquisition in the **450-500 nm range** (identification of carotenoids) and, (iii) separate **Chl *a* and chlorins** in the HSI-VNIR absorption band 650-700 nm.

2. Applications: The recently developed HSI-VNIR methodology (proof of concept) will be applied in three fields: (i) **Productivity/Meromixis**: we will establish the first annually resolved Holocene/Lateglacial long records of HSI-inferred aquatic productivity and meromixis from varved lake sediments in Switzerland and Poland and assess the driving processes by comparison with independent paleoclimate/paleoecolocical data. (ii) **Paleoclimatology**: using combined VNIR/SWIR/µXRF data we will explore how meteorological-scale phenomena and related limnological processes (fall algal blooms, multiple marl precipitation, phenology of anoxia etc.) are recorded in biogenic varves of NE Poland, and whether this could be used for 'Paleoweather ' reconstructions. (iii) We assess **SWIR-lithogenic components** in Holocene records from subantarctic islands (approved project ACE, Swiss Polar Inst.).