1 Summary of Research Plan

Substantial observational and experimental studies demonstrate the impact of climate change on ecosystems including the lengthening of the growing season during the past decades. With lowest uncertainty this trend towards a lengthening is largely attributed to the advancement of spring. Plant phenological records such as flowering dates or coloring dates of the leaves integrate the whole set of climate parameters, and can, thus, directly show the impact of a changing climate for plant species and ecosystems in the midlatitudes. Very precise long-term observations of Swiss observers reaching back to the 1700s offer the unique possibility to establish one of the longest and most significant phenological time series in the world. The calibration with climate variables and the projection of these data into the future with general circulation models (GCM) will additionally increase the value of the long-term historical observations.

Therefore, the proposed project focuses on the impact of changing large-scale climate on plants and aims at addressing the following scientific questions:

- **How did past climate determine the beginning of the growing season North of the Alps?**
- **What are the main climatic factors determining the phenological phases in Switzerland within the 20th century?**
- **How does the beginning of the growing season change in the 21st century under the expected continental warming?**

The beginning of the growing season will be derived from plant phenological observation data of fruit and deciduous trees such as cherry, apple, and beech, and vine. Swiss data were collected by the three applicants during the last three decades and are available as digitised and verified records until $\sim$1700. Additional data from southern Germany will be provided by the German weather service. Multivariate statistics such as canonical correlation analysis (CCA), will be applied to assess the major climate influences on the beginning of the growing season for the 20th century. Statistical reconstruction of the beginning of the growing season from climate parameters is carried out to assess the phenological time series. Future scenarios for the beginning of the growing season will be modeled in collaboration with partner institutes by using General Circulation Model (GCM) and downscaling. As an integrator of various environmental factors phenological time series not only yield information about the sensitivity to climate parameters but also indicate changes of the environment in general.

The significance of this project is expected to be

(1) the compilation of one of the world's longest phenological timeseries for the beginning of the growing season,

(2) the comparison of the independently observed and statistically reconstructed beginning of the growing season and, thus, the climate sensitivity of phenological observations,

(3) the calculation of future scenarios of the beginning of the growing season, and

(4) the establishment of an observational basis for further analysis and application of phenology in climate impact studies, environmental history, agronomy, and forestry.

Keywords: *climate change, climate impact, climate reconstruction, documentary proxy data, growing season, phenology, phenological networks, time series analysis, multivariate statistics, canonical component analysis (CCA), climate modeling, General Circulation Models (GCMs)*