Can remote sensing help citizen-science based phenological studies?

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Summary: Citizen science networks and remote sensing are both efficient to collect massive data related to phenology. However, both differ in their advantages and drawbacks for this purpose. Contrarily to remote sensing, citizen science allows distinguishing species-specific phenological responses to climate variability. On the other hand, large portions of territory of a country like Canada are not covered by citizen science networks, and the time series are often incomplete.

The mean mode of interaction between both types of data consists in validating the maps showing the ecosystem foliage transition times, such as the green-up date, obtained from high-resolution remote sensing with field observations, and in particular those collected by citizen scientists. Thus, the citizen science phenology data bring confidence to remote sensing based studies. However, one can merely find studies in which remote sensing is used to improve any one citizen science based study.

Here we present a case study data set between both types of data. We first use phenological data from the PlantWatch citizen science network to show that one remote sensing method green-up date relates to the leaf out date of woody species but also to the whole plant community phenology at the regional level, including flowering phenology. Second, we use a remote sensing time series to contextualize the analysis of citizen data to overcome the main drawbacks that is the incompleteness of time series. In particular we analyze the interspecies differences in phenology at the scale of so-called "phenoregions" delineated using remote sensing green-up maps.

Conclusion: from « comparing » to « combining »

Citizen science → evaluation of remote sensing green-up. Regional level : remote sensing matches community phenology. Medium resolution remote sensing → inter-annual variability of leafing and flowering phenology for plant community over large regions.

Citizen science : Inter-species differences in phenological variability. Impossible with remote sensing. Very long term for old networks. However, series can be incomplete → need for aggregate. Spatially discontinuous.

Despite some issues to be solved, remote sensing may help with a rational choice of observations to be aggregated : Fill in temporal gaps. Local scale observations provide regional scale information.

Fig. 1 : PlantWatch sites distribution across Canada.
Fig. 2 : Timing of ecosystem green-up date taken as the beginning of the NDVI increase (in day of year). NDVI : normalized difference infrared index. Input data : SPOT VEGETATION. Objective : no-effect of snowfall (Delbart et al. 2005).

Fig. 3 : Per-pixel validation of remote sensing by PlantWatch.
Fig. 4 : Regional time series of phenological events and of remote sensing green-up dates. Provinces (a) New Brunswick and Nova Scotia, (b) Quebec, (c) South Manitoba, South Saskatchewan.

Fig. 5 : Example of aggregation of time series called "phenoregions". New Brunswick - Nova Scotia region.

Fig. 6 : Example of aggregation of time series called "phenoregions". New Brunswick - Nova Scotia region.

Fig. 7 : Remote sensing data reprocessed and phenoregion delineation.

Fig. 8 : map of the 122 pheno-regions obtained from interannual variability in the green-up date (grey levels).

Fig. 9 : Phenology time series for the region including Eastern Newfoundland and Nova Scotia. In the legend, 0 stands for first bloom date, 1 for mid bloom date, 2 for leaf out date.

Factoring in phenological variability with satellite data can contribute to the development of climate change indicators. Remote sensing, especially with new satellite missions, offers the possibility of providing the necessary vegetation information to improve knowledge of phenological responses to climate variability. However, there is a need for detailed phenological maps of various regions to better understand the effects of climate change on vegetation phenology. Recent studies have shown that phenological responses to climate change can differ significantly between plant species, with some species showing earlier flowering and leafing dates while others show delayed phenological events. This heterogeneity in phenological responses has important implications for ecosystem function and biodiversity. Understanding these species-specific responses is crucial for developing effective strategies to adapt to climate change. Remote sensing can play a significant role in this context by providing spatially explicit phenological data that can be used to assess and predict the impacts of climate change on vegetation phenology.