Remote sensing and citizen science observatories: a promising partnership for phenology monitoring

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Phenology and Climate Change

Nature has its own rhythms, daily rhythms, seasonal rhythms... Plants and animals also present their own rhythms... migratory periods of birds, hibernation period for some mammals, or specific reproductive periods....
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These rhythms are driven by internal factors but also by environmental factors affected by climate change.

Changes in the rhythm of nature are recognized as a useful proxy for detecting climate change and a very interesting source of data for scientists investigating its effects on the natural ecosystems.
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phenology noun

The scientific study of periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions.
European policy indicator:

Leaf unfold is up to 1 day early per year!
Phenology

Traditional monitoring systems:

- Paper-based
- Reduced number of species
- Close to observers home
- Reduced number of observations
- Not representative across biomes
Phenology as Citizen Science

Not too long ago, some phenology monitoring networks appeared:

- **CATALUNYA**
  - FENOCAT initiative from the Catalan Meteorological Service
  - RitmeNatura Citizen Science observatory
    - RitmeNatura.cat

- **EUROPE**
  - Pan European PEP725 Phenology DataBase
• Citizen science observatory (H2020 Ground Truth 2.0) to collect phenological data in Catalunya
• Data stored in iNaturalist.org
• Monitors 12 species and specific phenophases
• Real-time searchable data for scientists, managers
• Correlated with the effects of climate change
Phenology

✓ Improve number of observations  ❌ Not representative across biomes

What can scientists do to increase the collection of vegetation phenology data at global level?

Use new technologies such as REMOTE SENSING
Phenology and Remote Sensing

Medium resolution optical satellites: (e.g. MODIS)

- Daily data
- Appropriate spectral configuration for vegetation monitoring
- Global coverage

✗ Spatial resolution too coarse

10 000 trees in one pixel!
Phenology and Remote Sensing

High resolution optical satellites:

LANDSAT:

✓ Appropriate spectral configuration for vegetation monitoring
✓ 30 m spatial resolution
✓ Global coverage

❌ Revisiting period too low (16 days)
Phenology and Remote Sensing

High resolution optical satellites:

SENTINEL 2A and 2B:

- Appropriate spectral configuration for vegetation monitoring
- 10 m spatial resolution
- Revisiting period between 3 and 5 days
- Global coverage

Still…..

IN SITU Observations

=/= METHODOLOGY

=/= REMOTE SENSING Observations

Hardly comparable
PhenoTandem Project

- PhenoTandem Project innovation approach:
  - co-designing a new observation protocol with citizen scientists
  - aiming at making in-situ observations interoperate with remote sensing products
  - by selecting the areas and habitats where traditional phenological in-situ observations done by volunteers can also be well monitored by Sentinel 2 images
  - Tested in Catalunya
PhenoTandem Approach

- Catalan Data Cube of Sentinel-2 data
  - Solution for storing big data products
  - Analysis ready data
  - Interoperable
  - Visualization and analysis through WMS
PhenoTandem Approach

- Co-designed selection of species of interest and definition of observable phenophases (in-situ and from space)
  - Leaf development
  - Flowering
  - Senescence
  - ....
PhenoTandem Approach

• Identification of large vegetation areas with clearly differentiated phenophases, such as Peach Trees
PhenoTandem Approach

- Time series analysis of Sentinel-2 data
  11-01-2019 07-03-2019 31-05-2019

In March 2019, S2 clearly captured the change in those areas
Time series analysis reveals the exact day blossoming occurs and, with this, we can track the blossoming dates over the years and monitor the effects of climate change.
PhenoTandem Approach

- Time series analysis of Sentinel-2 data
- Computation of phenology products and Ecosystem Functional Types
PhenoTandem approach

• Final selection of in-situ areas of interest to be visited by observers during spring and autumn campaigns

• Engagement of RitmeNatura.cat volunteers
PhenoTandem Approach

• Volunteers register observations through [iNaturalist.org](https://www.inaturalist.org) app

• After the campaign, in-situ observations and Sentinel-2 data will be combined to calibrate and validate remote sensing phenology products
Conclusions

• Monitoring vegetation phenology requires good coverage of data but also good quality specific in-situ information

• Remote sensing can provide the spatial, temporal and spectral resolutions suitable for vegetation phenology monitoring but...

• ...still need of in-situ data for calibration.
Conclusions

• Guided citizen science can be a useful approach to collect in-situ data for phenology monitoring

• Together, RS and CS, are a good partnership for powerful phenology monitoring
Thank you!

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