

Monitoring of Phenology to assess the climate change impacts in the Alps: *Phenoclim* and *PhenoAlp*



**Alpine Ecosystems
Research Center**

www.crea.hautesavoie.net

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Alpine Ecosystems Research Center

Centre de Recherches sur les Ecosystèmes d'Altitude



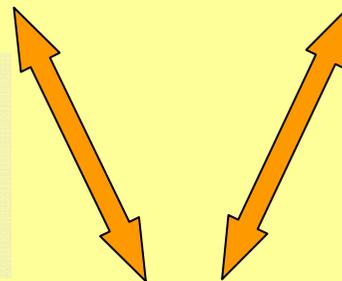
« Response of mountainous species to climate forcing »

**Scientific
Research**

*National
Scientific
Research Center
University...*

**Educational
activities**

*Non profit
organizations
Schools
...*



**Citizen
science**



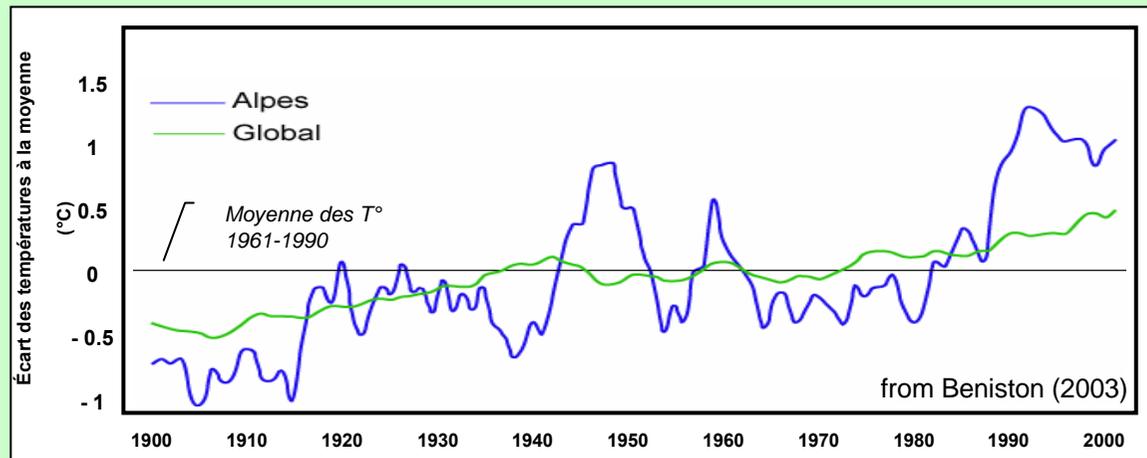
6 employees

Members nb : 72



Non profit org. located at
l'Observatoire du Mont-Blanc

Background

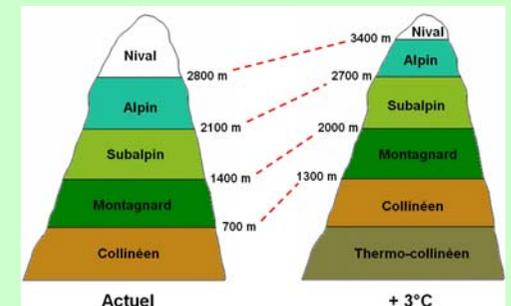


Increase of Air T°, especially during summer and at high elevation zones

↓ rainfall (summer)

↑ rainfall (winter)

- Precocity of the growth season
- Increase in duration of the growth season (9d)
- Migration of species to high elevation and latitude
- Shift of the vegetation belts (Lenoir et al., 2008)
- mismatching of biological cycles: prey-predator
- Loss of biodiversity and increase of invasive species



from Theurillat & Guisan (2001) Climatic Change

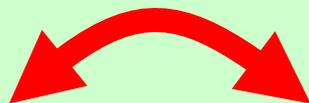


Phenology – the study of the timing of periodic biological events driven by environmental factor
First biotic indicator of climatic changes / A major component of species adaptation to climate variations



A scientific and educational program which invites the public to measure the impact of climate change on phenology of mountain vegetation. This ongoing program was launched in 2004.

Phenopiaf invites you to monitor the arrival (in the Alps) of five species of migratory birds.



EU co-funded Interreg project under the operational program for cross border cooperation France –Italy (Alps-Alcotra).

Aims

1. To create a standardized methodology for the monitoring and the study of climatic changes effects on alpine vegetation and animals using a phenological approach
2. To increase public awareness on the effects of global changes using a participatory science approach



10 species studied :



| Type of plants | Species | Scientific name |
|-------------------|----------------|--------------------------|
| <u>Trees</u> | Spruce | <i>Picea abies</i> |
| | European Larch | <i>Larix decidua</i> |
| | Silver Birch | <i>Betula pendula</i> |
| | Downy Birch | <i>Betula pubescens</i> |
| | Ash | <i>Fraxinus exelsior</i> |
| | Rowan | <i>Sorbus aucuparia</i> |
| <u>Shrubs</u> | Hazel | <i>Corylus avellana</i> |
| | Common Lilac | <i>Syringa vulgaris</i> |
| <u>Herbaceous</u> | Primrose | <i>Primula veris</i> |
| | Colt's foot | <i>Tussilago farfara</i> |

→ Common in the Alps and easily recognizable by non-specialists

→ Present on a large range of altitude

→ Studied as climate change indicators in Europe

3 species monitored per study sites with 3 labelled individuals

Phenological observations : 5 phenophases from the beginning to the end of the vegetation period

→ **Spring :**



Budburst



Flowering



Leaf unfolding

→ **Autumn :**



Leaf coloring



Leaf fall

Observations carried out **every 8 days**



Station T° N° 4
 Particulier
 74400 - Montroc
 Altitude : 1410 m

To see the curve

- 2 m above the ground
- 30 cm above the ground
- at ground level
- 5 cm under the ground

Submit

(c) CREA 2009 - Station N°4 , 203 and 234



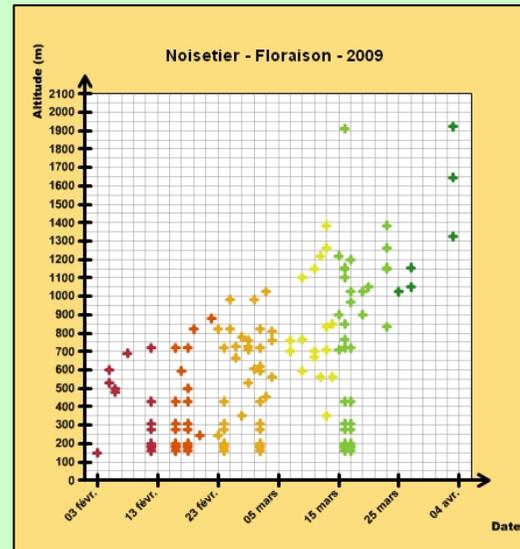
Station N° : N°4 - 74400 - Montroc - 1410m Month : 9 Year : 2009

Print Graph



Feedback to the participants (professionals from protected areas, individuals...):

- <http://www.crea.hautesavoie.net/phenoclim>
- Seminars, training courses, newsletters...



Phénoclim n° 18 - juin 2009

L'âge de maturité ?

Le coffre de la voiture déjà chargé et la crème solaire à portée de main, vous êtes sûrement fin prêts pour ce départ en vacances. N'oubliez pas de glisser dans votre sac la dernière lettre de Phénoclim pour agrémenter vos lectures de l'été...

Au sommaire, comme d'habitude, un peu de climat, une bonne dose de végétation et un saupoudrage d'actualités pour être au fait des dernières évolutions de Phénoclim. L'été sera-t-il décliné ? Tous ne pouvons pas vous le dire. En revanche, retrouvez un bilan détaillé de l'hiver et du printemps passés qui ont été très contrastés. Grand froid et gros coups de chauds auront alterné, entraînant des sécheresses très variées d'une espèce d'arbre à l'autre. C'est ce que vous constaterez en vous penchant de près sur les résultats de vos observations de noisetiers et de mélèzes.

Pour être le cinquième printemps de Phénoclim, nous essayons de prendre un peu de recul : les premières tendances de réponse au changement climatique sont-elles déjà visibles ? Au bout de combien de temps un tel programme scientifique aboutit-il la réalité scientifique pour être ses premiers résultats ? Pour le savoir, rendez-vous en page 106 !

L'équipe du CREA

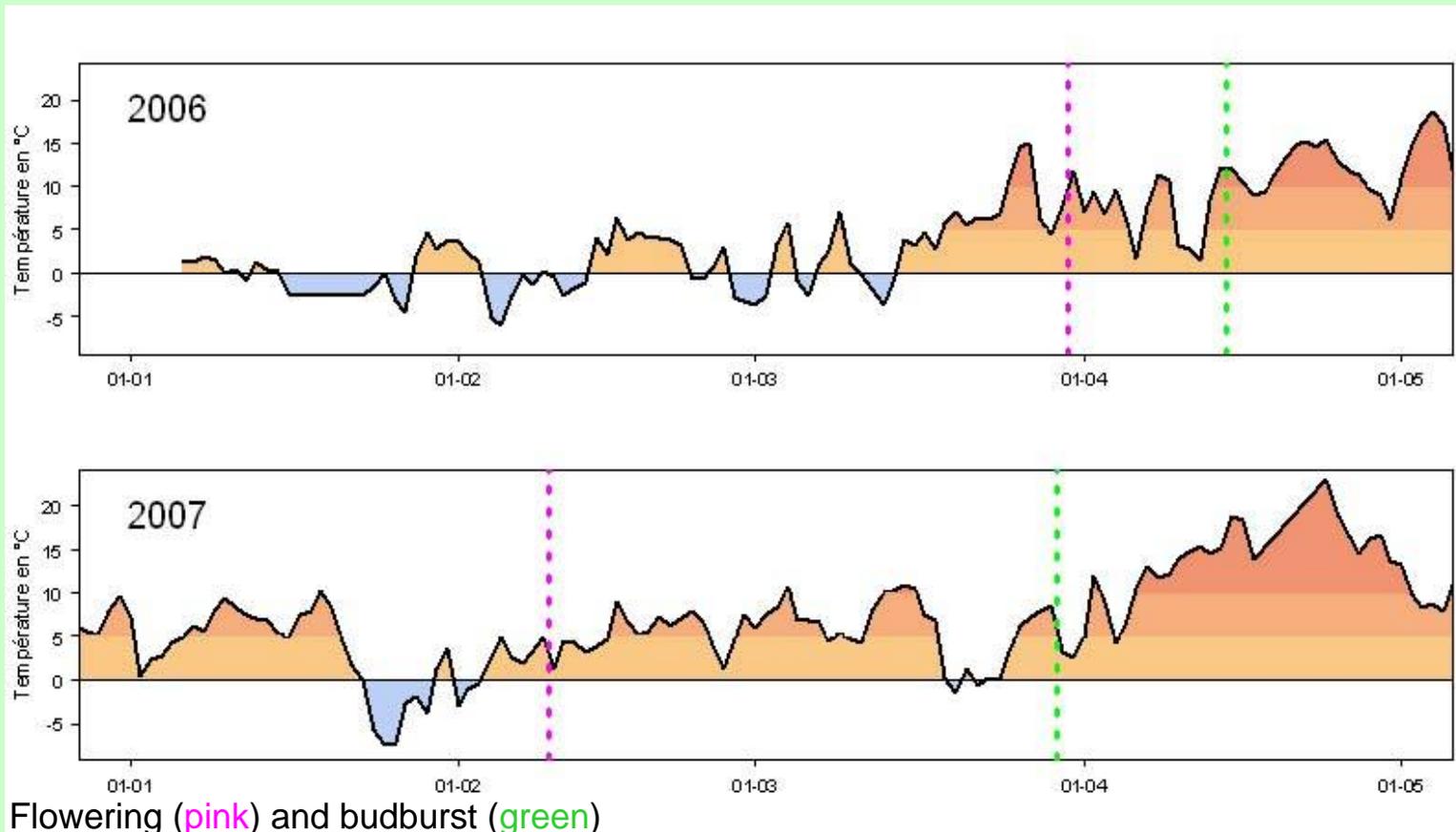
Phénoclim en chiffres

- 41 écoles, 56 particuliers et 17 structures associatives ou espèces protégées participent à Phénoclim
- Phénoclim est représenté dans 3 pays : la France, la Suisse et l'Italie et dans 6 massifs montagneux : les Alpes, le Jura, le Massif Central et les Vosges.
- 40 stations de température Phénoclim installées dans les Alpes
- 146 zones d'étude suivies, situées entre 150 m (Condrieu, Rhône) et 2136 m (Col du Lautaret, Hautes-Alpes)
- 14 avril : le premier débournement d'épave est enregistré à Sallanches à 560 m d'altitude. La fin de la saison est proche, car l'épave est l'espèce Phénoclim la plus tardive : ses bourgeons sont les derniers à s'ouvrir.
- 15 avril : alors que les premiers bourgeons d'épaves s'ouvrent à peine, le premier lilas fleurit déjà ! Il est situé à Annemey en Ardèche à 37 m d'altitude.

creA Centre de Recherches sur les Ecosystèmes d'Altitude Observatoire du Mont-Blanc 74400 Chamonix Tél 04 50 53 45 16 www.crea.hautesavoie.net

Retrouvez la lettre de Phénoclim sur le site internet du CREA, rubrique "Phénoclim - La lettre d'info"

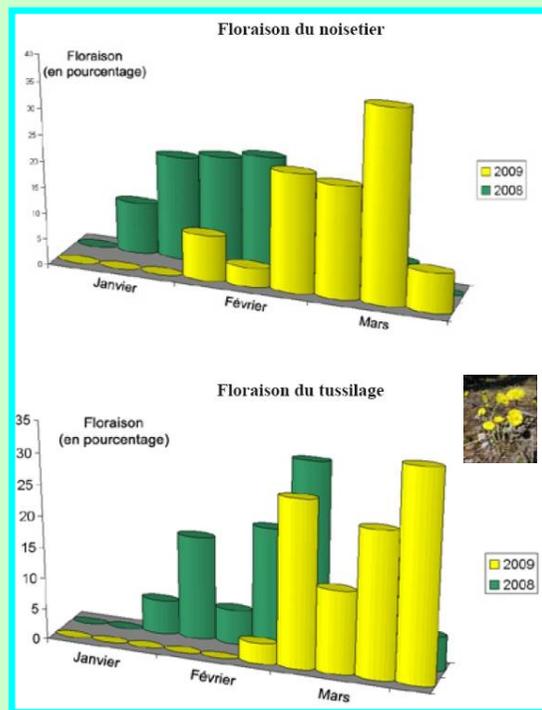
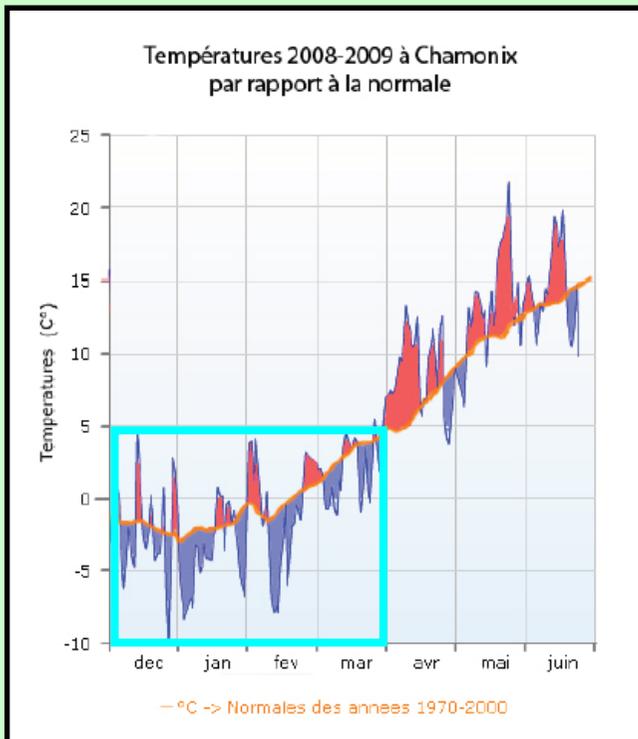
Hazel, an early species !!



T° Winter-spring 2006 < T° Winter-spring 2007 (2007 warmer)

Date flowering 2006 >> Date flowering 2007 (2007 earlier)

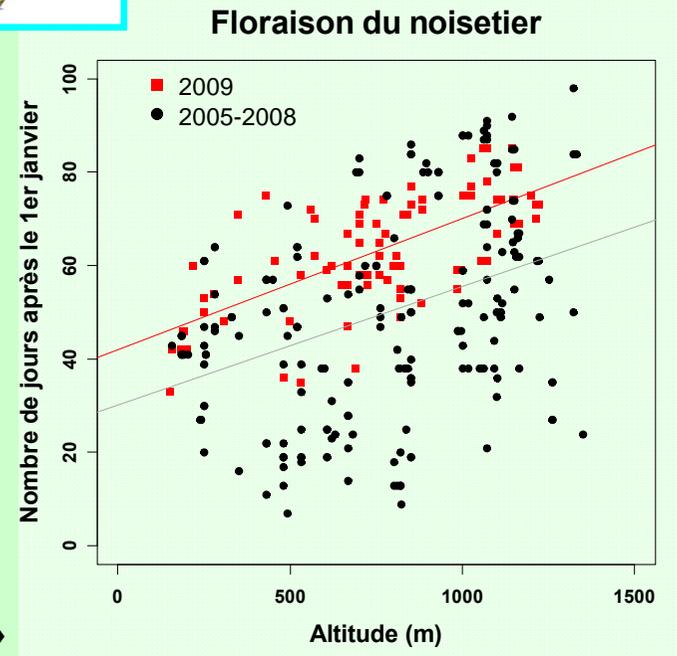
Small differences in budburst dates in 2006 and 2007

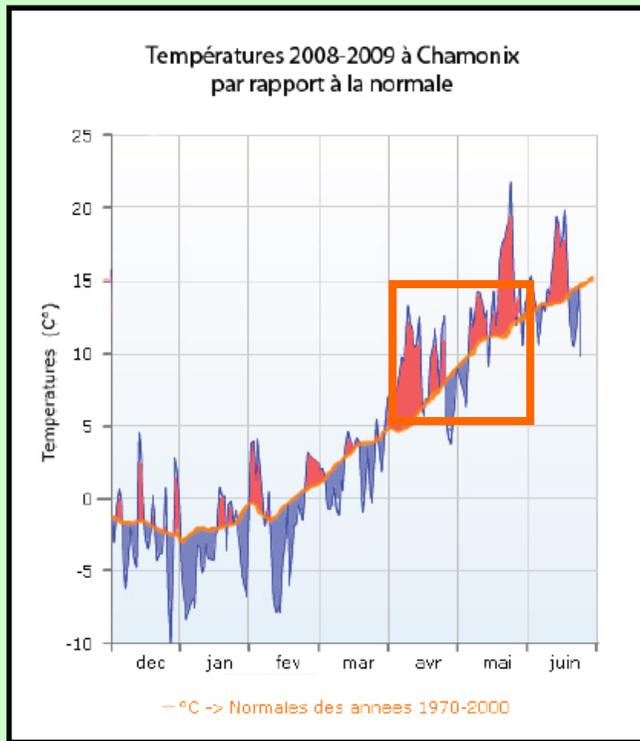


Cold winter

- A specific response along the altitude gradient (Hazel)...

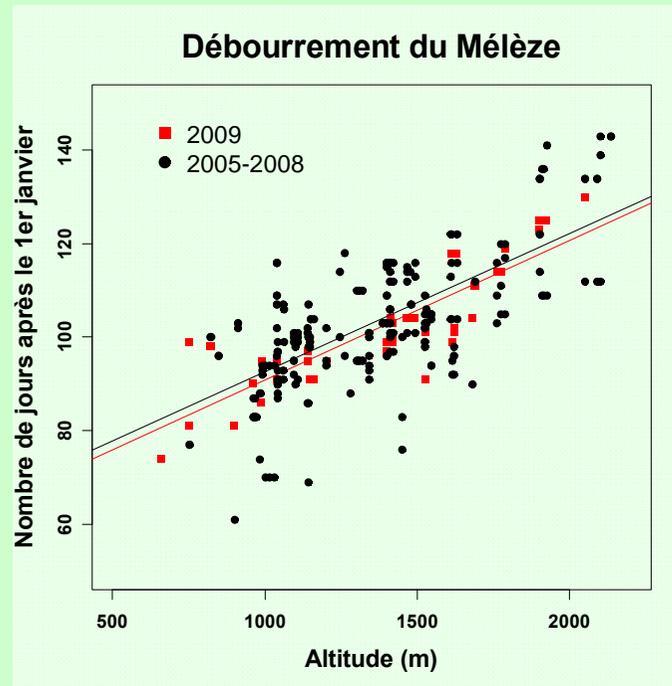
Early species
« delayed »



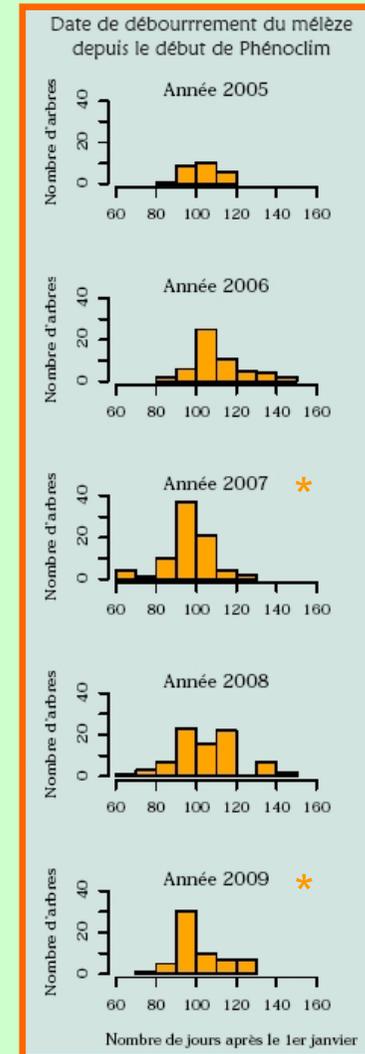


Cold winter
and
Warm spring

- A specific response along the altitude gradient...(Larch)



Late species
« adapted »



Deciduous species

Spring tree phenology in the Alps: effects of air temperature, altitude and local topography submitted to *International Journal of Biometeorology*

Maryline Pellerin et al., 2009



| Model | Parameter | Birch | Ash | Hazel | Spruce | Larch |
|----------------------------|---------------------------|-------|-------|-------|--------|-------|
| Altitude | n _{obs} | 47 | 60 | 52 | 43 | 37 |
| | k | 3 | 3 | 3 | 3 | 3 |
| | AIC _c | 374.2 | 468.4 | 437.7 | 367.9 | 334.3 |
| Temperature sum | r ² (adjusted) | 41.9 | 58.0 | 34.2 | 25.9 | 51.0 |
| | k | 3 | 3 | 3 | 3 | 3 |
| | AIC _c | 366.0 | 482.9 | 459.7 | 358.4 | 330.3 |
| Altitude + Temperature sum | r ² (adjusted) | 50.4 | 47.6 | 1.75 | 39.5 | 55.1 |
| | k | 4 | 4 | 4 | 4 | 4 |
| | AIC _c | 337.8 | 435.8 | 436.6 | 332.4 | 303.1 |
| | r ² (adjusted) | 72.2 | 75.1 | 36.9 | 66.2 | 76.2 |

Budburst

| Model | Parameter | Birch | Ash | Hazel | Spruce | Larch |
|----------------------------|---------------------------|-------|-------|-------|--------|-------|
| Altitude | n _{obs} | 46 | 57 | 46 | 37 | 36 |
| | k | 3 | 3 | 3 | 3 | 3 |
| | AIC _c | 352.7 | 467.7 | 360.0 | 300.9 | 315.9 |
| Temperature sum | r ² (adjusted) | 48.6 | 56.5 | 55.8 | 53.1 | 37.7 |
| | k | 3 | 3 | 3 | 3 | 3 |
| | AIC _c | 348.6 | 470.5 | 342.4 | 315.1 | 324.8 |
| Altitude + Temperature sum | r ² (adjusted) | 52.7 | 54.5 | 69.1 | 33.3 | 23.2 |
| | k | 4 | 4 | 4 | 4 | 4 |
| | AIC _c | 326.4 | 428.1 | 325.5 | 280.2 | 297.2 |
| | r ² (adjusted) | 71.1 | 77.5 | 78.7 | 73.0 | 60.9 |

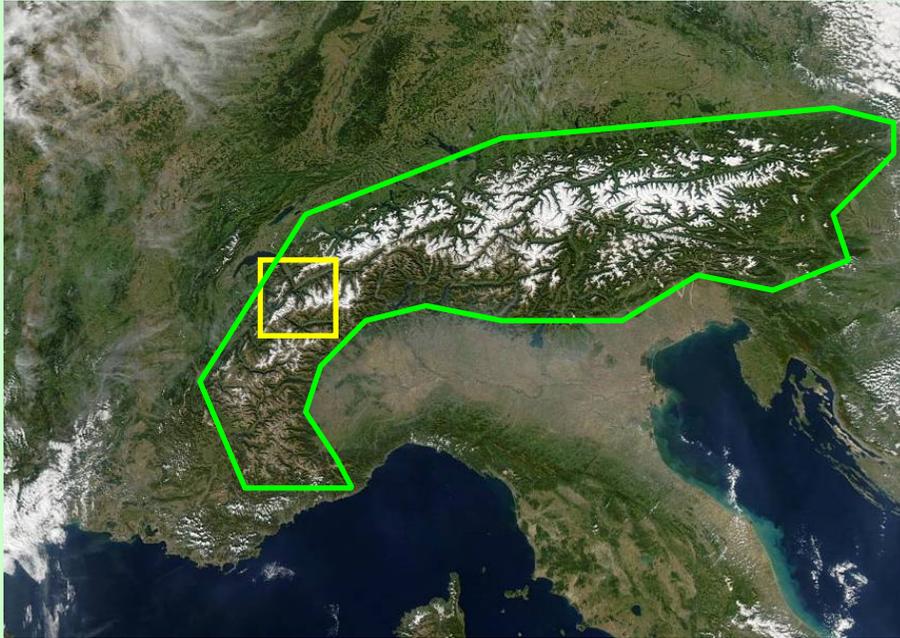
Unfolding

Akaike information criterion (AIC): low AIC, better model

The phenology is not only controlled by the T°sum. Topographic parameters like elevation, lat/long°, concavity and exposure control budburst and unfolding.

→ Physiological effects of elevation, phenotypic plasticity or adaptation to local conditions are **hypothesis** (1) probably because the T°soil and the snow cover limit the onset, (2) to « reduce » frost probabilities

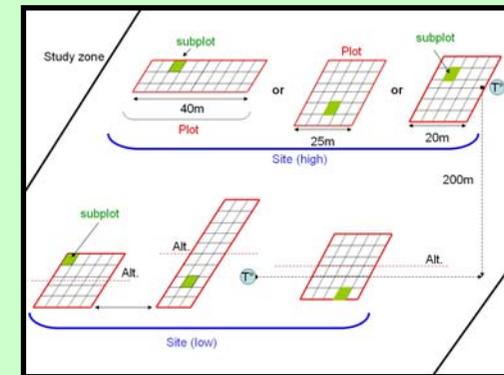
This effect could be observed for others plants or animals ?



The major goals are:

1- the implementation of an observatory network

2- the definition of a common observation strategy and common protocols



3- the involvement of local community in the observation to increase public awareness on the effects of global changes

PhenoPlantes: *developing climate changes indicators from plant phenology*

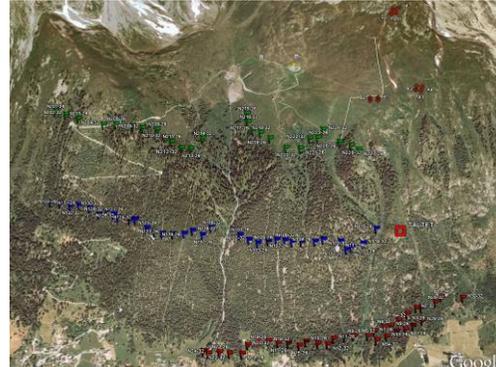
- based on Phénoclim protocol regarding forest species
- based on 7 growth life forms regarding alpine grasslands (evergreen, deciduous shrubs, grazed and non grazed poacea, leguminous...)



PhenoZoo: *developing climate changes indicators from animal phenology*

- monitoring of passerines and amphibian phenology (*Rana temporaria*) along an elevation gradient (dates of laying, brood and hatching)

⇒ ponds and nestboxes



InterPheno: *to analyse relationships between plants and animals phenology*

PhenoFlux: *to analyse relationships between inter-annual variability of plant phenology and productivity, measuring CO₂ fluxes by Eddy-Covariance technique*

MeteoReseau: *to create a network of temperature measurements stations in order to link phenological shift with T° trends*



Vallorcine 1910m (Fr)



Mont Avic Park 1150m (It)



PhenoDetect: *monitoring of the larch forests and alpine grasslands phenology*

- MODIS NDVI time series to retrieve phenological events linked with field measurements
- Continuous phenological observation by webcams



Field training day: PhenoPlantes 18-05-09
« Massif des Bauges » Natural Regional Park

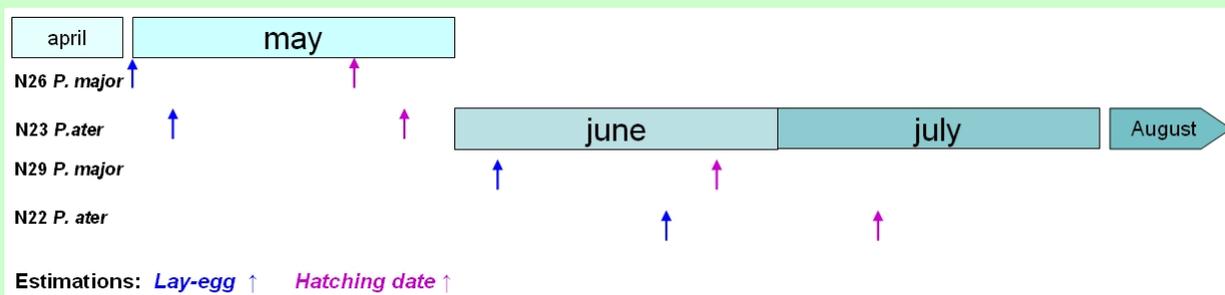
PhenoForm: *to create a network of partners in education promoting phenological observations to increase public awareness of CC in the Alps*



Field scholar visit (25-06-09), School of Yvoire (74)

PhenoZoo: first results

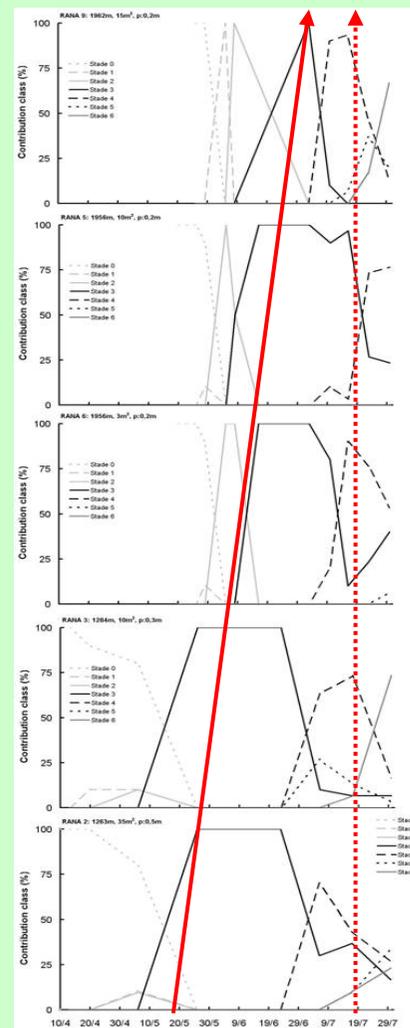
Monitoring of passerines:



- Breeding are observed only along the lower transect
- 4 nest boxes: 2 at the beginning of may and 2 during June
- Incubation period range: 11 and 15 days

Monitoring amphibian phenology (*Rana temporaria*) along an elevation gradient

- First spawns: one month delay between low and high ponds
 - Stage 3 : 11 days delay, Stage 4: 5 days delay
 - Total duration: 60 days at high elevation conditions and 90 at low conditions
- as expected, we observe a shorter cycle of development at 1900m than at 1300m.
- to go on the monitoring and extend the study sites distribution



ELEVATION

Main conclusions

- Huge efficiency of a network approach to collect data and educate the public : citizens or professionals of protected areas (Phenoclim or PhenoAlp programs)
- Interest to standardize protocols and common models (growth life forms, passerines, amphibians...): a common observation strategy
- Promising start of the PhenoAlp field campaign in France and Italy: adjustment of the protocol and first results

Outlooks

- To develop easier protocols from the PhenoAlp program to involve more and better local communities
- To create more educational tools
- To share experiences with similar projects about animal and vegetal phenology
- To find motivated partners to set-up Phenoclim sites at the Alpine regional scale: Alpine Phenology Observatory Network (APON !!!?!!!!?)
- To find financial supports: international, national, regional or local organizations

Centre de Recherches sur les Ecosystèmes d'Altitude

Assoc. Loi 1901 déclarée d'intérêt général

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Thanks





X CONGRESO LATINOAMERICANO DE BOTÁNICA

4 - 10 Octubre de 2010 La Serena Chile



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