1 Sites
   - sites and objectives
   - instrumental setup
   - some results

2 North Western Alps network

3 Image processing package
Sites

- alpine grassland - Tellinod
- larch forest - Tronchaney
- pinot gris vineyard - Winecam
Grassland: 1/3

- Tellinod (Torgnon - Aosta Valley)
- sub-alpine unmanaged grassland (2160 m asl)
- EC tower-phenology-radiometric vegetation indexes
- data since 2009
Larch forest: 2/3

- Tronchaney (Torgnon - Aosta Valley)
- Larch \( (L. \text{ decidua}) \) forest (2100 m asl)
- EC tower-phenology-radiometric vegetation indexes
- data since 2010
objectives

- **long term monitoring** of ecosystem processes phenology
- **phenology - carbon and water fluxes**
- understand the role of climate drivers with a special focus on **snow**
Vineyard: 3/3

- Vineyard (Aosta - Aosta Valley)
- Pinot gris (600 m asl)
- phenology-radiometric vegetation indexes (16 bands Cropscan)-field measures
- just started Apr 2014
Vineyard: 3/3

- Vineyard (Aosta - Aosta Valley)
- Pinot gris (600 m asl)
- phenology-radiometric vegetation indexes (16 bands Cropscan)-field measures
- just started Apr 2014
- obj: use webcam and radiometric indexes to infer canopy status and detect stresses
camera type overview

- campbell cameras logged to dataloggers (CC640, CC5MPX)
- "homemade" systems with Nikon D5000 and microcontroller (12MPx)
- "homemade" raspberry camera with microcontroller (5MPx)
- infrared cameras (NIR-R-G, Tetracam)
some issues ...

- spatial and radiometric resolution (i.e. camera quality)
- camera settings (exposure - white balance - raw vs. jpeg)
- camera control (computer vs. microcontroller vs. datalogger)
- communication (data transfer vs. manual download)
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some results: larch forest

- larch forest phenological cycle
some results: larch forest

- **Green Index (GCC)** and **phenophase** extraction
some results: larch forest

- comparison with field observations

<table>
<thead>
<tr>
<th>Spring Phases (SP)</th>
<th>Autumn Phases (AP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1 = unexpanded buds</td>
<td></td>
</tr>
<tr>
<td>SP2 = budburst $[B_{GS}]$, needles length &lt; 1 cm</td>
<td></td>
</tr>
<tr>
<td>SP3 = needles elongation, length: 1-3 cm</td>
<td></td>
</tr>
<tr>
<td>SP4 = needles unfolding, length &gt; 3 cm</td>
<td></td>
</tr>
<tr>
<td>SP5 = needles fully expanded</td>
<td></td>
</tr>
<tr>
<td>AP1 = yellow spot decolouration</td>
<td></td>
</tr>
<tr>
<td>AP2 = green to yellow</td>
<td></td>
</tr>
<tr>
<td>AP3 = yellow $[E_{GS}]$</td>
<td></td>
</tr>
<tr>
<td>AP4 = yellow to red</td>
<td></td>
</tr>
<tr>
<td>AP5 = red</td>
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$AP2-AP5$: decolouration spread on the whole crown
some results: larch forest

- comparison with field observations
some results: larch forest

- **Tracking IAV**: webcam GCC vs. ground based NDVI vs. carbon fluxes (EC)
some results: larch forest

- Tracking IAV: webcam GCC vs. ground based NDVI
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- Tracking IAV: webcam GCC vs. ground based NDVI
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- **Tracking IAV:** webcam GCC vs. carbon fluxes (NEE)
some results: grassland

- **grassland phenological cycle**
some results: grassland

- GCC seasonal course
some results: grassland

- **grid based analysis** (Julitta et al, 2014)
some results: grassland

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- Light use efficiency (LUE) models (Rossini et al, 2012, 2013)
- grassland phenology observation methods (Filippa et al, in prep)
some results: vineyard

- vineyard phenological cycle
North Western Alps phenological network
North Western Alps phenological network

• started in 2008

• Italy-France cooperation project (Interreg Alcotra)
  • PhenoAlp (2008-2011) www.phenoalp.eu
  • e-Pheno (2012-2014) www.epheno.eu

• Italy - Aosta Valley (ARPA, Parco Naturale Mont Avic, Parco Nazionale Gran Paradiso)

• France - (CREA, Parc National des Ecrins, LECA Grenoble, Parc des Bauges)

• field observations, sensor based observations (NDVI, webcam), schools engagement
North Western Alps phenological network

- Webcam and NDVI sensors (10 sites: 5IT, 5FR)
North Western Alps phenological network

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  - most sites installed in 2012-2013
- ecosystems: grasslands (1800-2400 m asl) and subalpine (< 2000 m asl)
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- storing and processing strategy under discussion
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NDVI database

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NDVI database
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Image Processing package
• R package for ROI definition, VIs computation, filtering, fitting, phenophase extraction and uncertainty estimation

• collaborative effort with Mirco’s and Andrew’s groups

• developed and tested on phenocam (phenocam.sr.unh.edu/webcam/) dataset: deciduous and evergreen forest, grassland and cropland

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ROI (Region of Interest) definition

- User can define ROIs on a reference image clicking on ROIs vertexes
VI’s computation

- VI’s (GCC, BCC, RCC, GEI, BRI, HSV, ...) are computed as mean ROI values for each image.
VI’s filtering

- most recently published filtering approaches are implemented: max (Sonnentag 2012), spline and MAD (Migliavacca 2011), clouds (Julitta 2014)

- filters can be applied in a default sequence or according to user’s needs

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VI’s filtering

**torgnon-ld**

**No cloud filtering**

**Only Max filter**

**Only max and spline**
VI's filtering

![Graphs showing the effect of different filtering methods on VIs over time.](#)
VI's filtering
filtered timeseries fitting:
  - spline

phenophases (i.e. start of season, end of season, ...) extraction:
  - fixed thresholds (e.g. half peak)
  - derivative approaches (inflection points of fitting functions)
  - breakpoint analysis

phenophase uncertainty estimation (residual bootstrap)
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**Figure:** Bartlett filtered data - Klosterman et al 2014 fitting and phenophases
Figure: Bartlett filtered data - Klosterman et al 2014 - Gu et al 2009 phenophases
Deciduous forest - Harvard Forest
Evergreen forest - Chibougamu Forest
Mixed forest - Canada OBS Forest
Sites North Western Alps network Image processing package

PhenoWebcam workshop
Grassland - Lethbridge Grassland

Lethbridge Grassland - NetCam SC IR - Fri Sep 05 06:01:10 2014
Temperature: 29.5 °C internal, 8.5 °C outside
RH: 0%, Pressure: 915.0 millibars
Exposure: 1300
Shrubland - Burnssagebrush
<table>
<thead>
<tr>
<th>Sites</th>
<th>North Western Alps network</th>
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</tr>
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### PhenoWebcam workshop

<table>
<thead>
<tr>
<th>Raw data</th>
<th>Spline</th>
<th>Elmore</th>
<th>Beck</th>
<th>Klos 1</th>
<th>Klos 2</th>
<th>Gu</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Raw data plots" /></td>
<td><img src="image2" alt="Spline plots" /></td>
<td><img src="image3" alt="Elmore plots" /></td>
<td><img src="image4" alt="Beck plots" /></td>
<td><img src="image5" alt="Klos 1 plots" /></td>
<td><img src="image6" alt="Klos 2 plots" /></td>
<td><img src="image7" alt="Gu plots" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spline ths</th>
<th>Deriv ths</th>
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</tr>
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<tbody>
<tr>
<td><img src="image8" alt="Spline ths plots" /></td>
<td><img src="image9" alt="Deriv ths plots" /></td>
<td><img src="image10" alt="Break points plots" /></td>
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</tbody>
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<thead>
<tr>
<th>Klos ths</th>
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<tr>
<td><img src="image11" alt="Klos ths plots" /></td>
<td><img src="image12" alt="Gu ths plots" /></td>
</tr>
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- release v0

- evaluate fittings performance and phenophase extraction on phenocam and european dataset

- future developments:
  - import external ROIs
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  - include grid based analysis
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  - multipeak phenological cycle (drought, crops, ...)

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