Environmental Protection Agency of Aosta Valley – ARPA VdA - Climate Change Unit

Agenzia Regionale per la Protezione dell'Ambiente della Valle d'Aosta – Effetti sul territorio dei cambiamenti climatici

SCORCHING ALPS: INSIGHTS FROM THE 2015 SUMMER HEATWAVE

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"Mountain regions are characterized by sensitive ecosystems, enhanced occurrences of extreme weather events, and natural catastrophes" **IPCC 2001**

"Climate change is affecting high mountains systems globally and in different ways" **IPCC2014**

with important resulting concerns for water resources availability, changes in vegetation phenology, biodiversity and the carbon cycle, agriculture, tourism and natural hazards.

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Phenology and carbon dioxide source/sink strength of a subalpine grassland in response to an exceptionally short snow season

M Galvagno, G Wohlfahrt, E Cremonese, M Rossini, R Colombo, G Filippa, T Julitta, G Manca, C Siniscalco, U Morra di Cella and M Migliavacca

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Stephan Gruber, Martin Hoelzle, Wilfried Haeberli

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Extreme events in gross primary production: a characterization across continents

J. Zscheischler, M. Reichstein, S. Harmeling, A. Rammig, E. Tomelleri, and M. D. Mahecha

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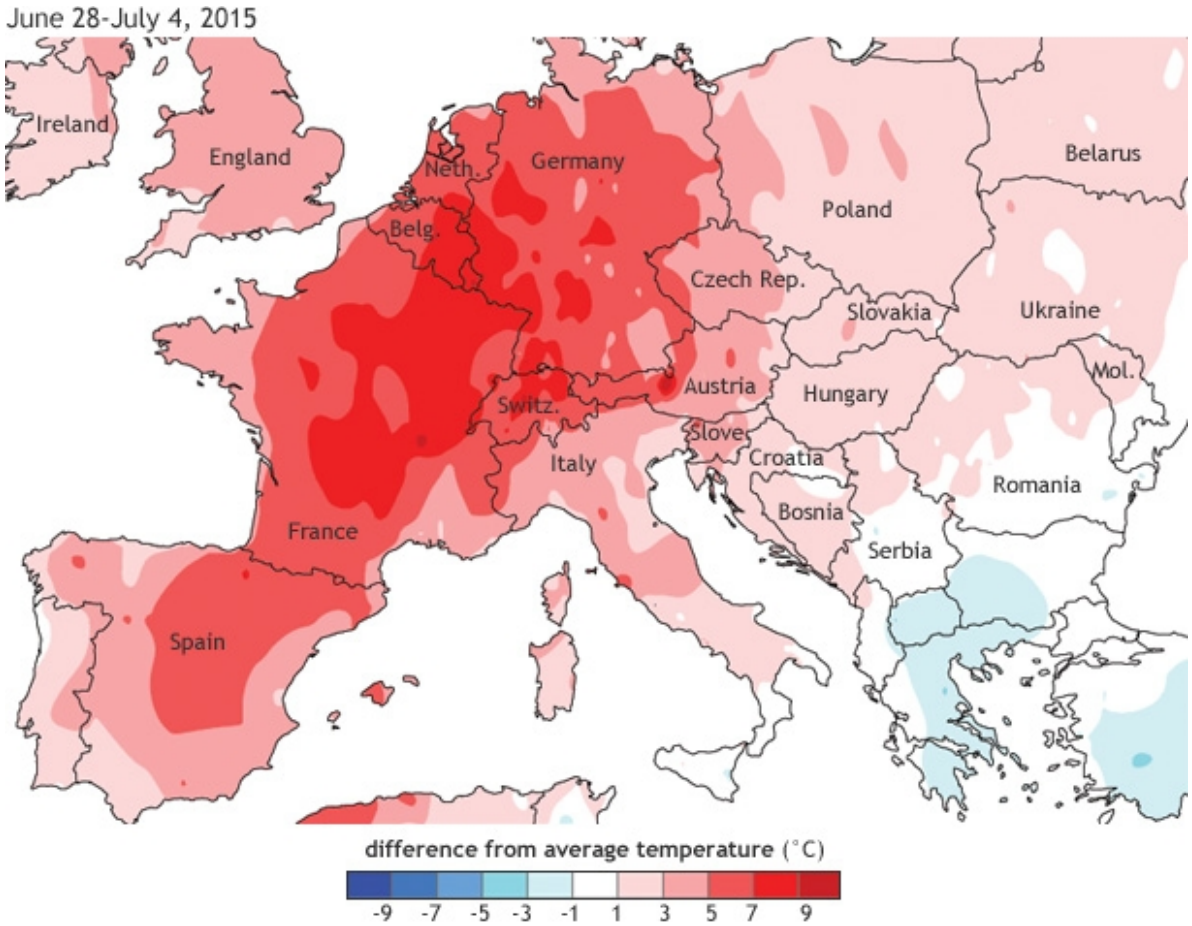
Permafrost model sensitivity to seasonal climatic changes and extreme events in mountainous regions

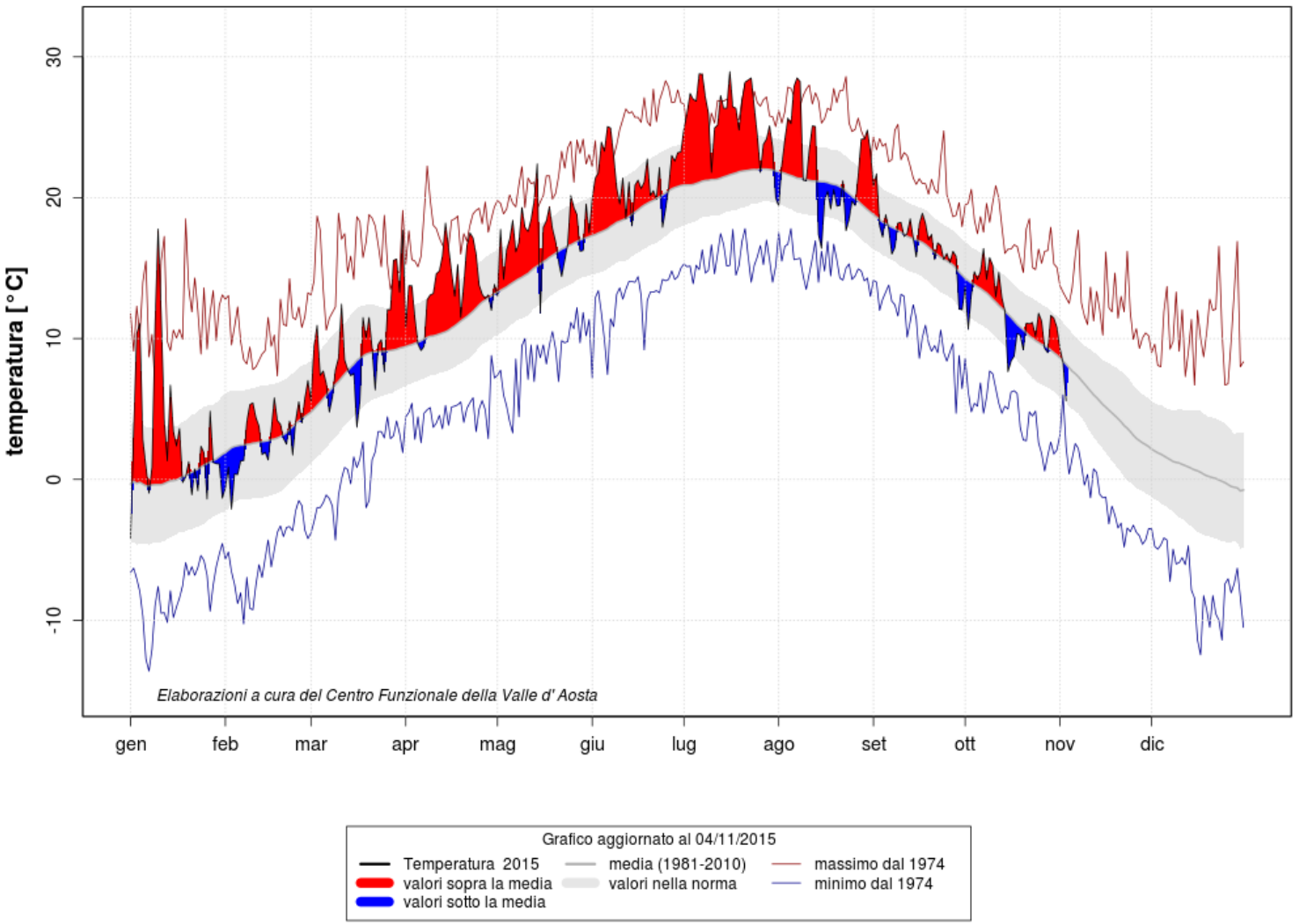
A Marmy, N Salzmann, M Scherler and C Hauck

2015 Heatwave in Europe

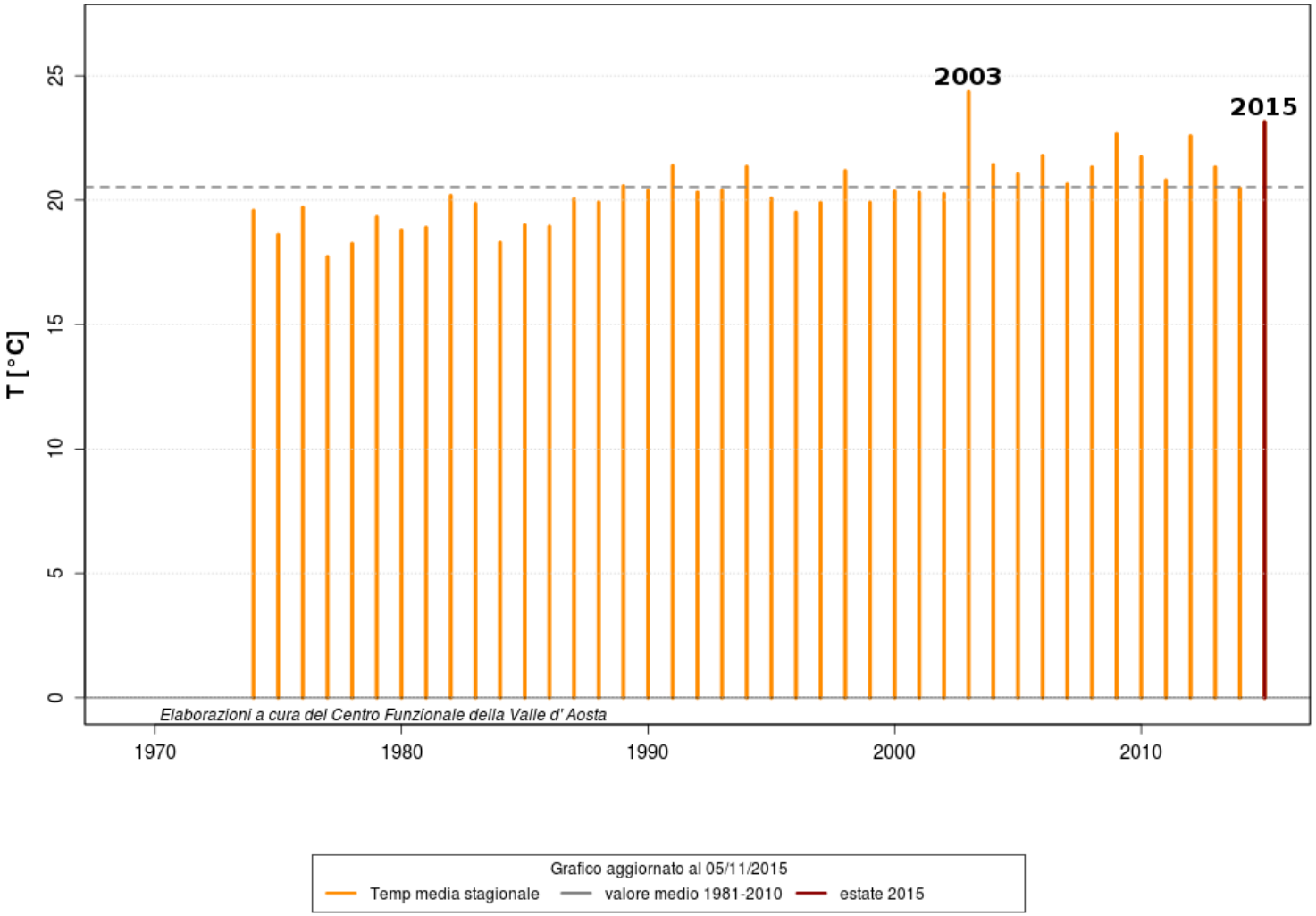


Average temperature anomalies (C) for Europe during June 28-July 4, 2015 based on preliminary global weather station data. A heat wave across the continent led to average temperature anomalies up to 7C in parts of western Europe. Image provided by NOAA's Climate Prediction Center.

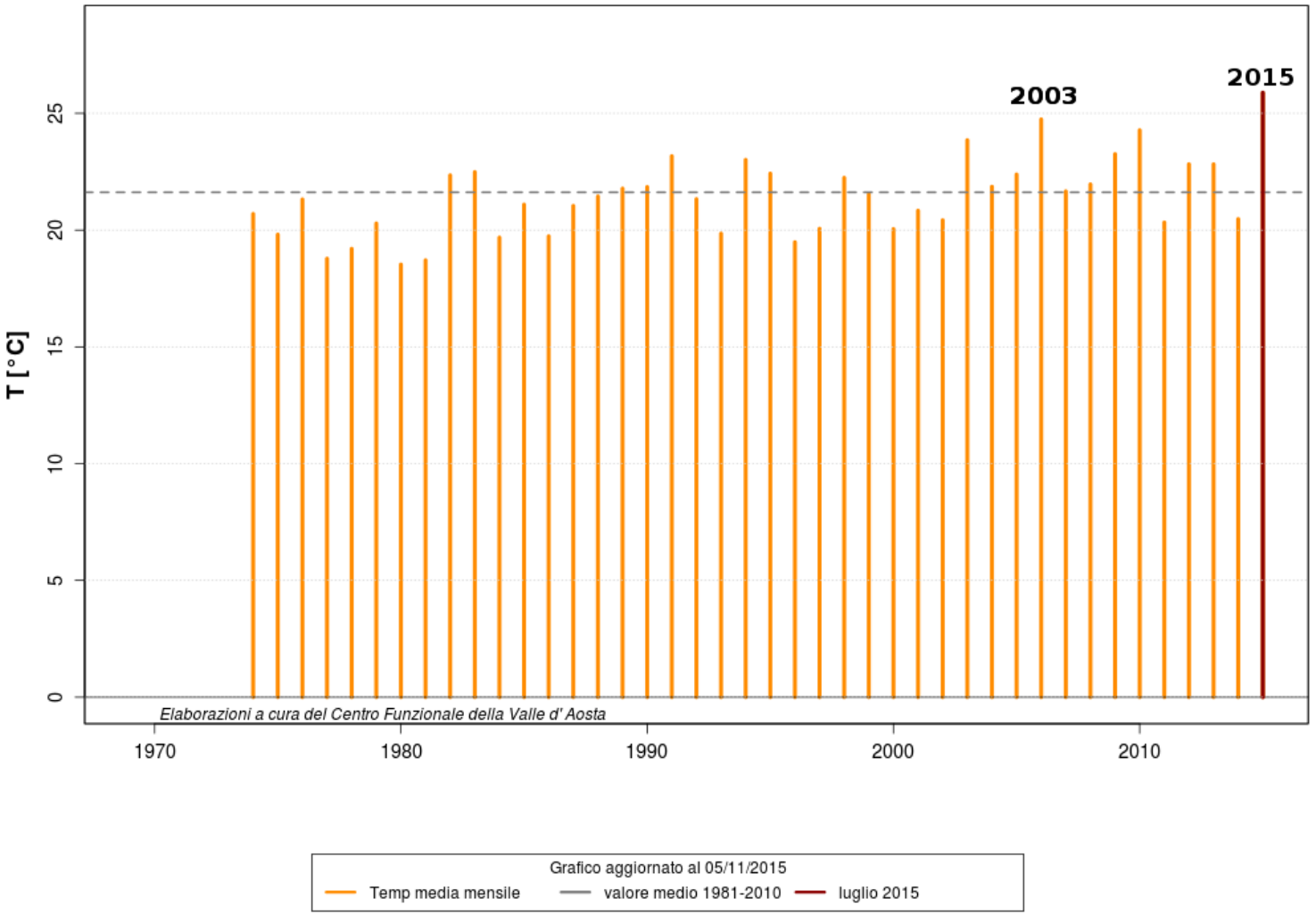
2015 Heatwave in Aosta Valley



2015 Heatwave in Aosta Valley - Summer

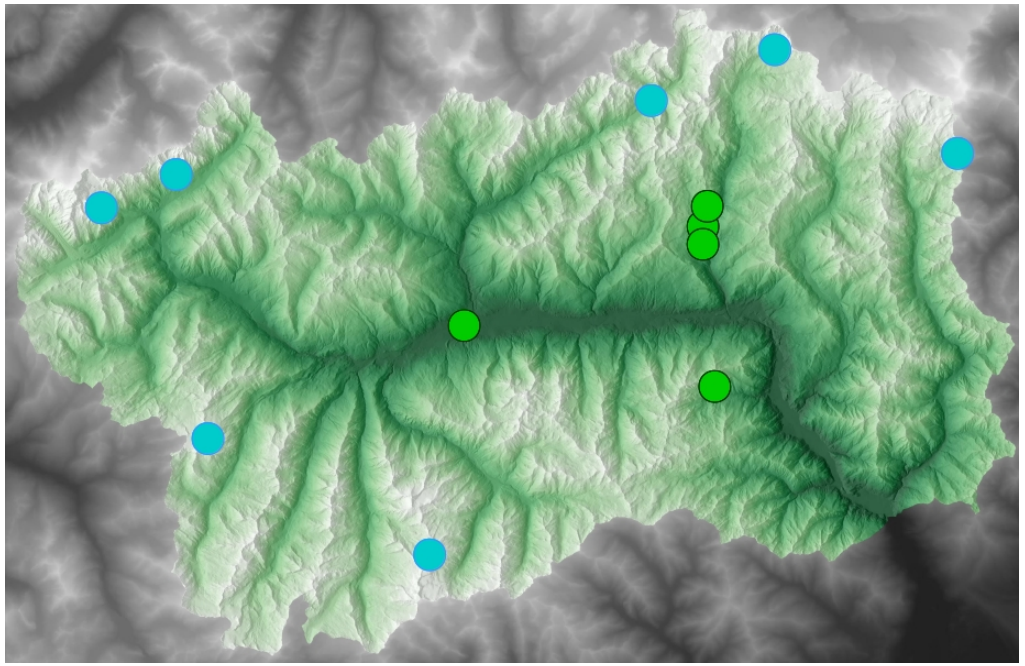


2015 Heatwave in Aosta Valley - July



Monitoring the heatwave impacts on the cryosphere and the biosphere

The aim of the study is to depict a synthesis of the global impact of the 2015 summer heatwave on the of the Aosta Valley



Cryosphere:

Glaciers

Permafrost

Snow

Biosphere:

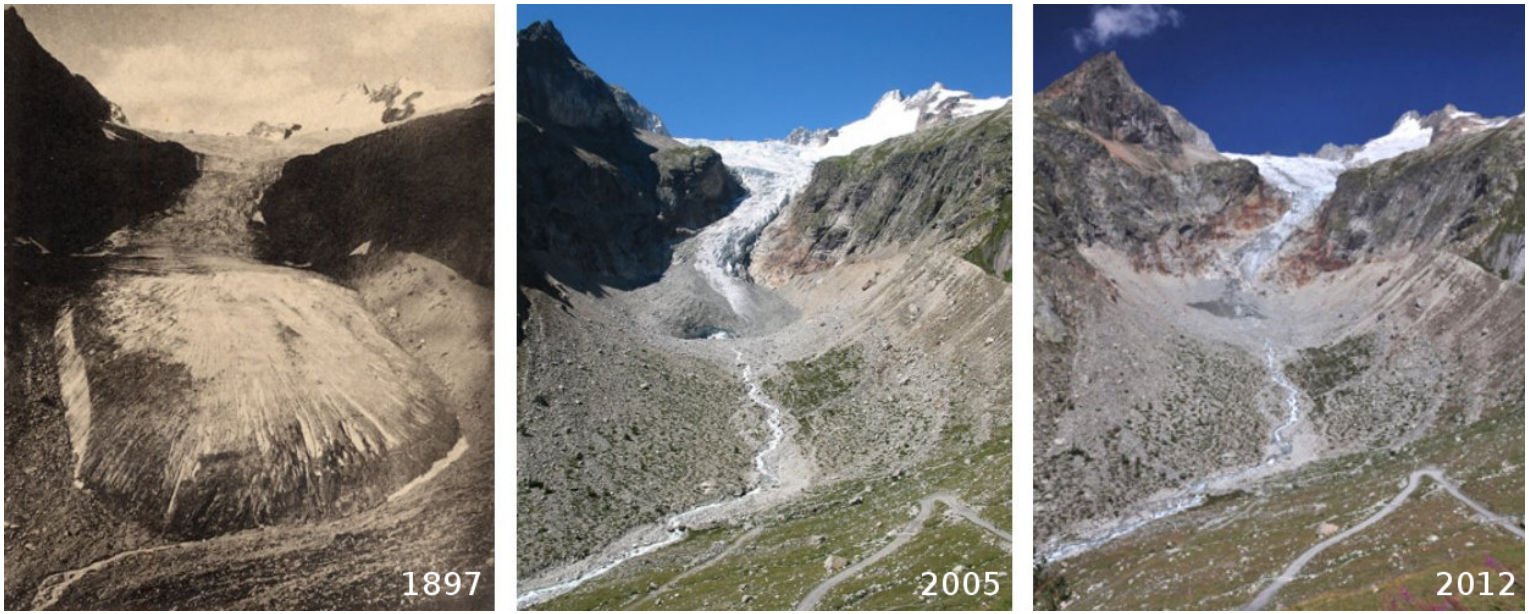
Phenology

Carbon cycle

Water Use

Glaciers

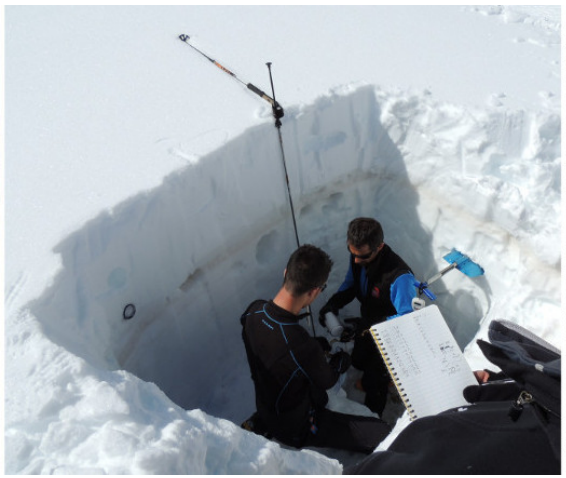
- Glaciers react quickly to climate warming losing mass and modifying their morphological characteristics and dynamics.
- Glacier shrinking affects water resources, hydropower production and water availability for irrigation purposes downvalley

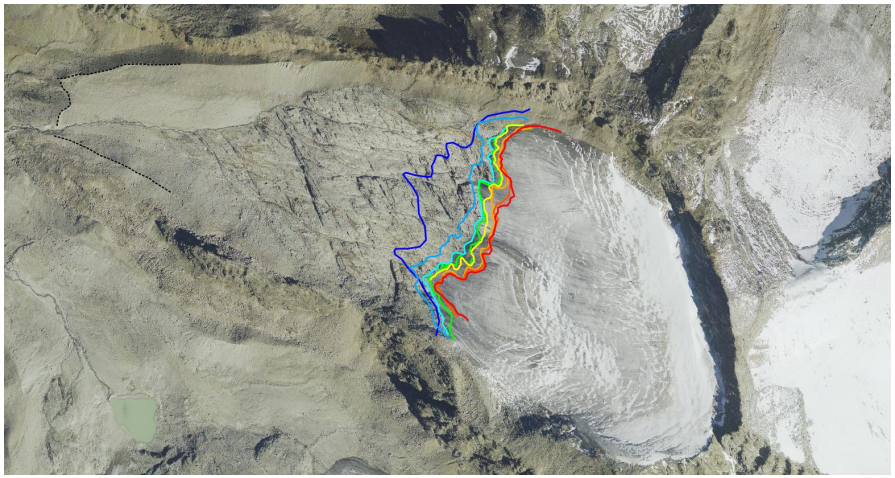


Credits: Fondazione Montagna Sicura

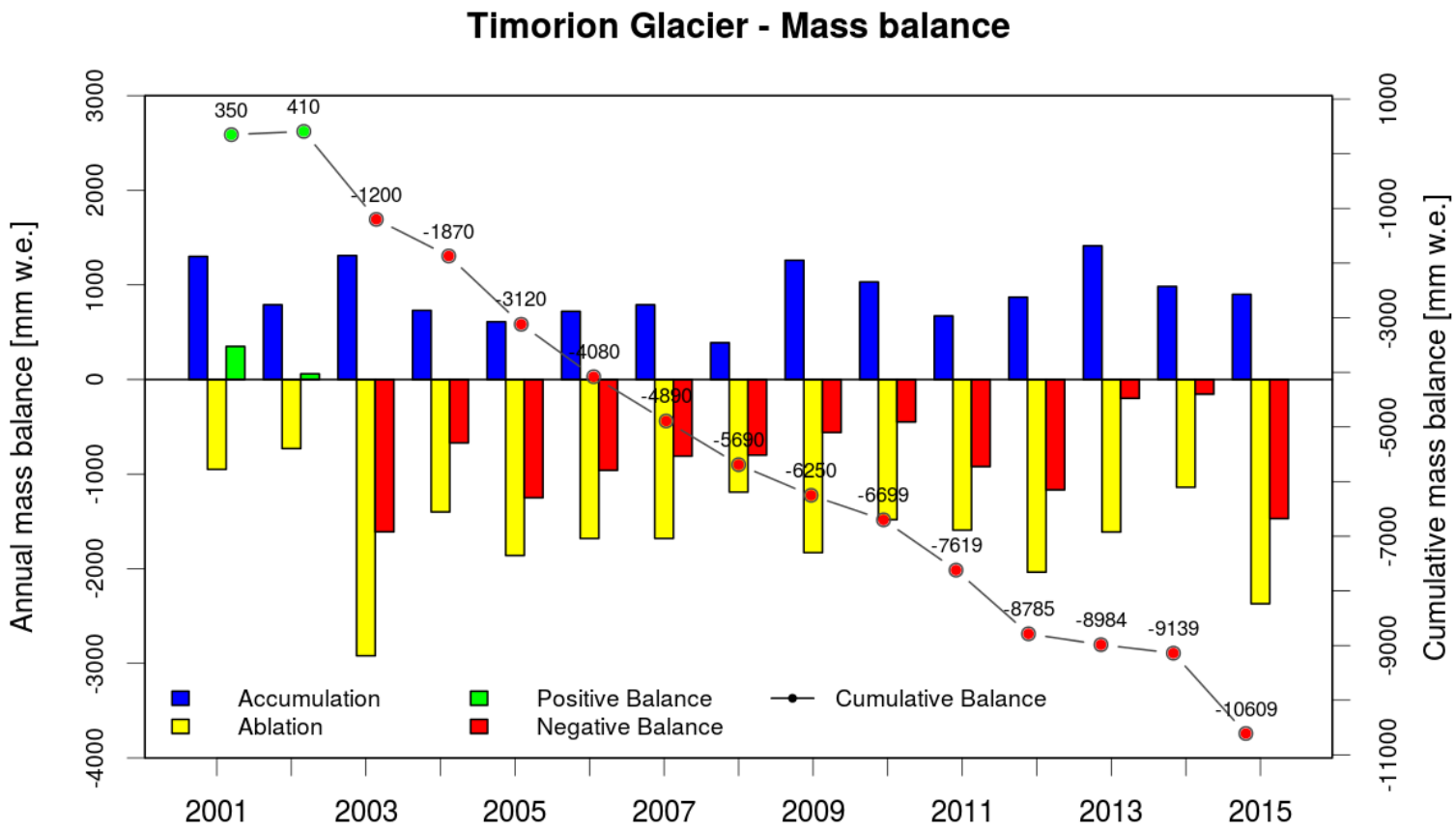
Glaciers: Measurements

- Mass balance measures
- Glacier front retreat observations and glacier thickness measures





Timorion mass balance



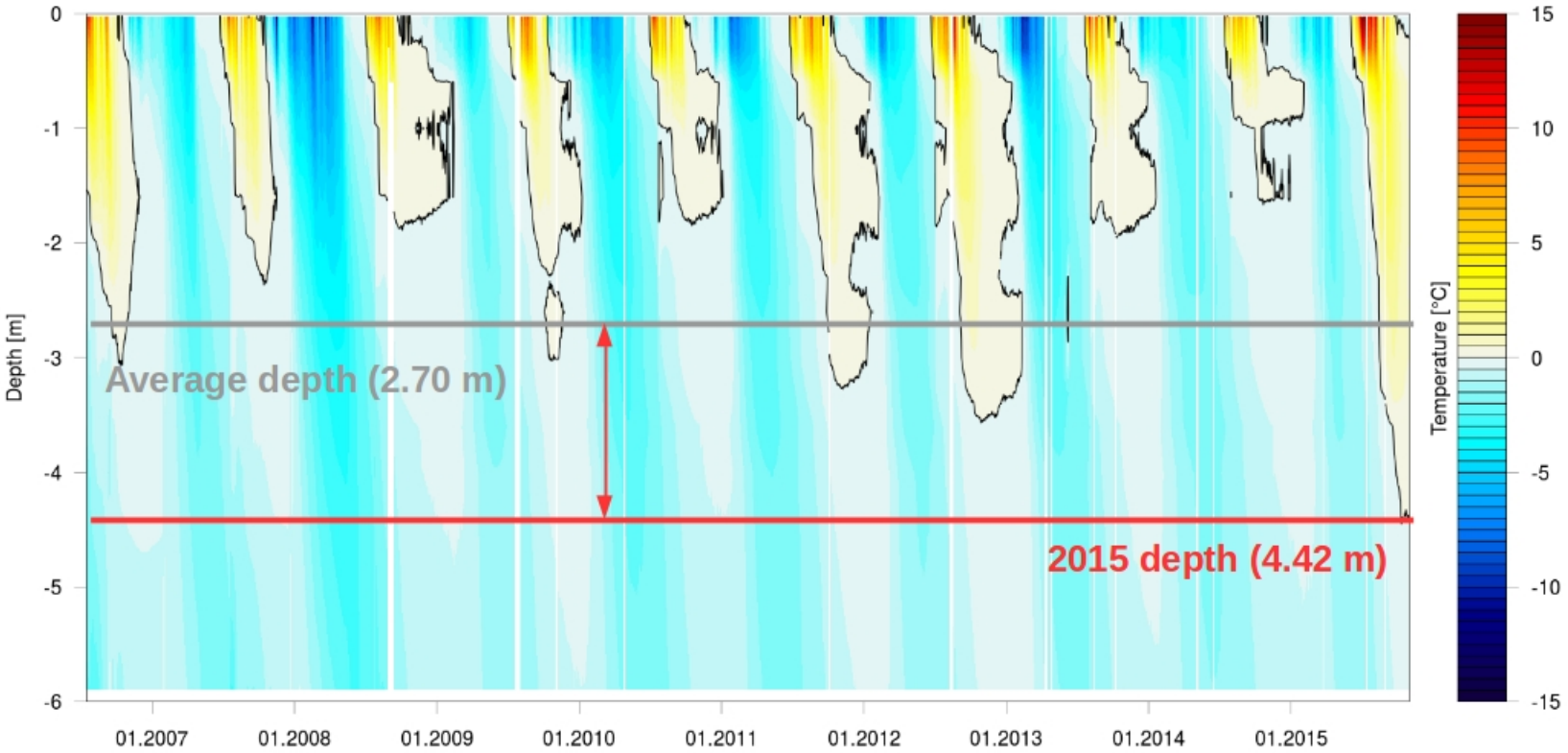
Permafrost

- Permafrost is a thermal state of the soil, debris or rocks, characteristic of cold climates
- The WMO has included the permafrost temperature and the active layer as one of the Essential Climate Variables useful to evaluate the climate change impacts at global scale

Permafrost: Measurements

- Ground surface and borehole temperatures on rockwalls and slopes to monitor and evaluate the thermal regime of mountain permafrost

Permafrost: Active Layer



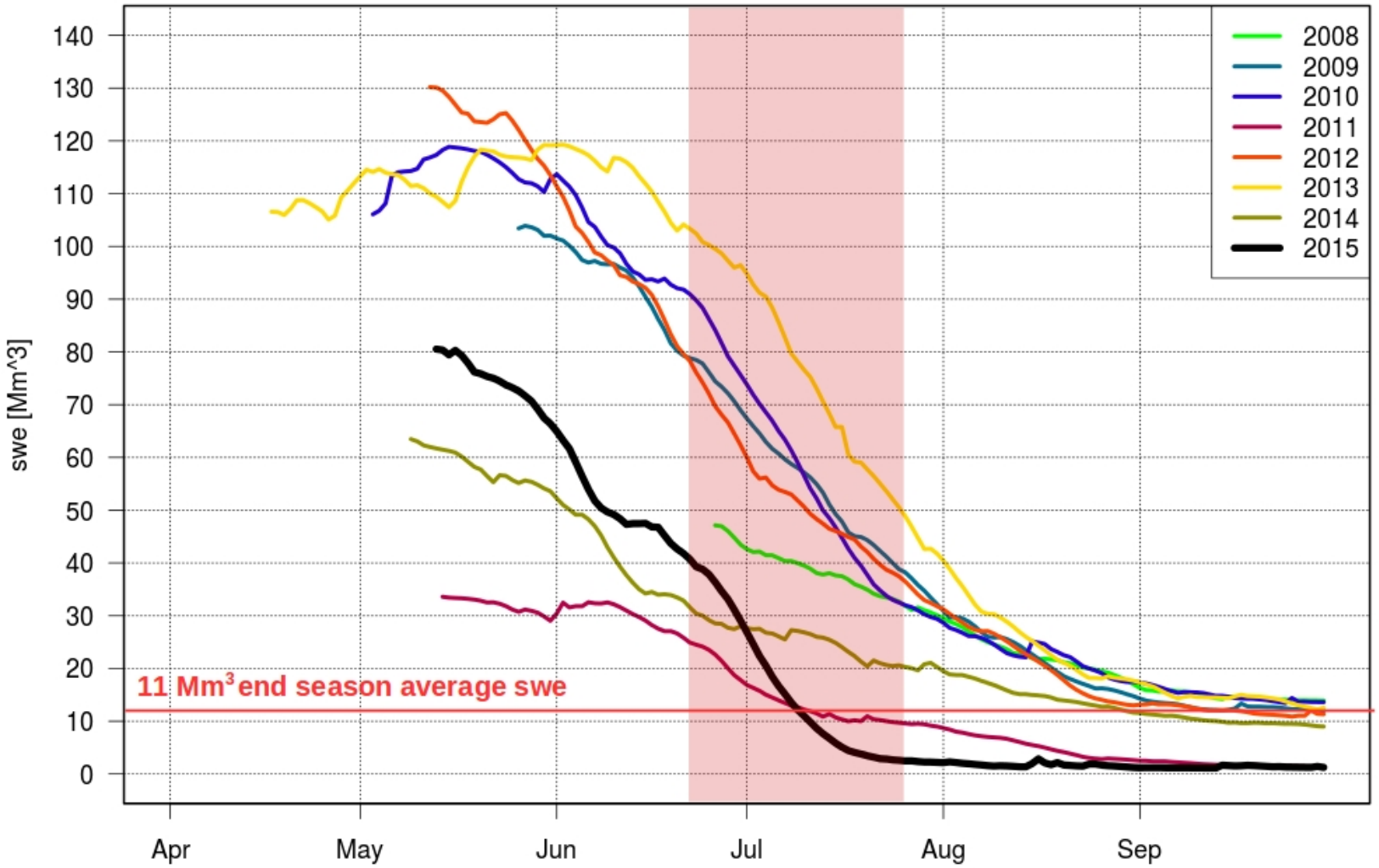
Snow

- Snow cover is crucial for the water balance of the Alps and the lowlands
- Snow cover has continued to decrease in extent in the last decades, altering hydrological systems, affecting water resources in terms of quantity and quality

Snow: Measurements

- Measurements and modeling of snow water content (SWE) at regional and watershed scale

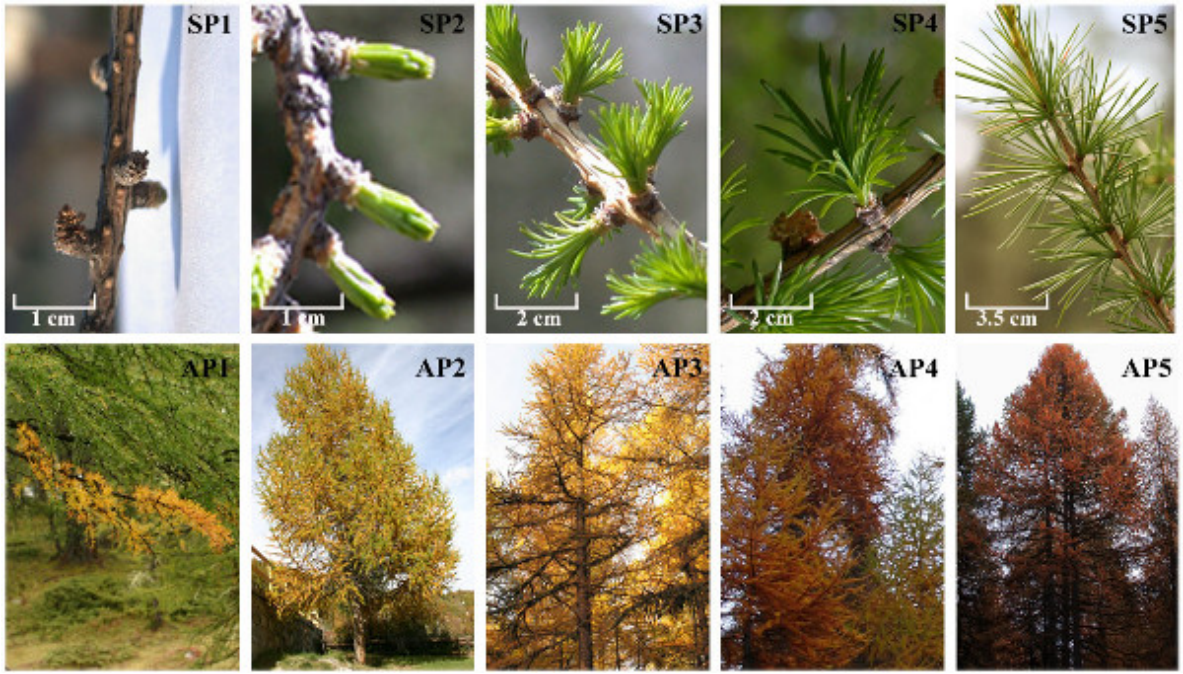
Snow water equivalent at an high elevation (4000 m asl) basin



- Climate extrems can affect the functioning of ecosystems via changes in phenology, photosynthetic capacity, respiratory processes of plants and soil microorganisms and water use efficiency
- Understanding the linkages between these processes is crucial to evaluate not only the impacts but also the feedbacks to the climate system

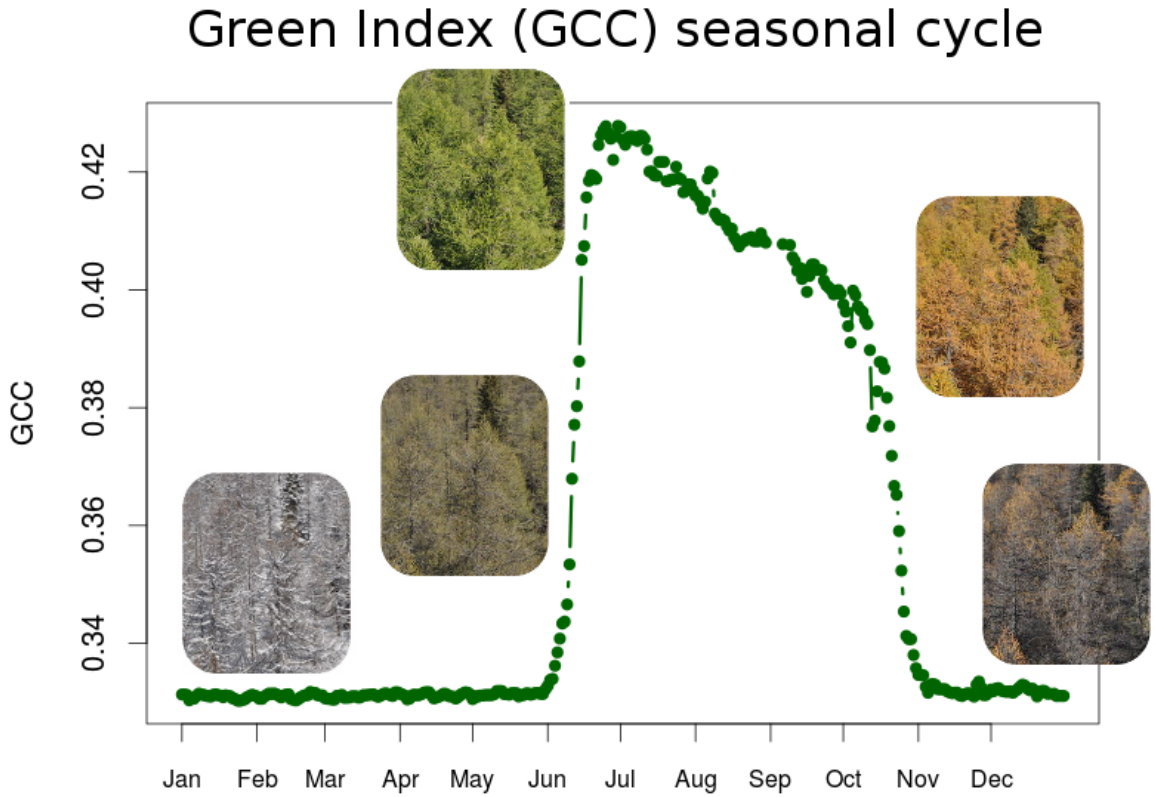
Phenology

- *"...is the study of the timing of recurrent biological events, the causes of their timing, and the interrelation among phases. (Lieth et al., 1974)"*
- Phenological response to climate change matches the warming pattern

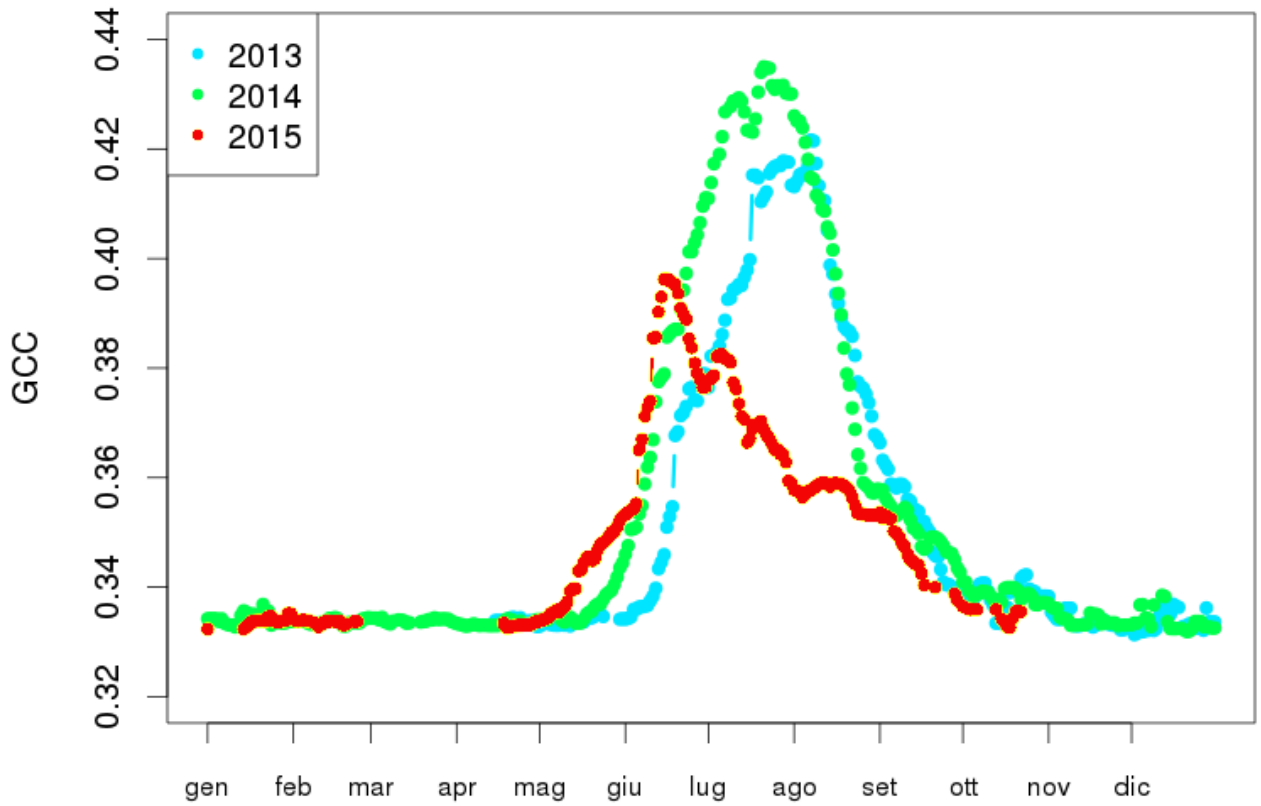


Phenology: How we measure it

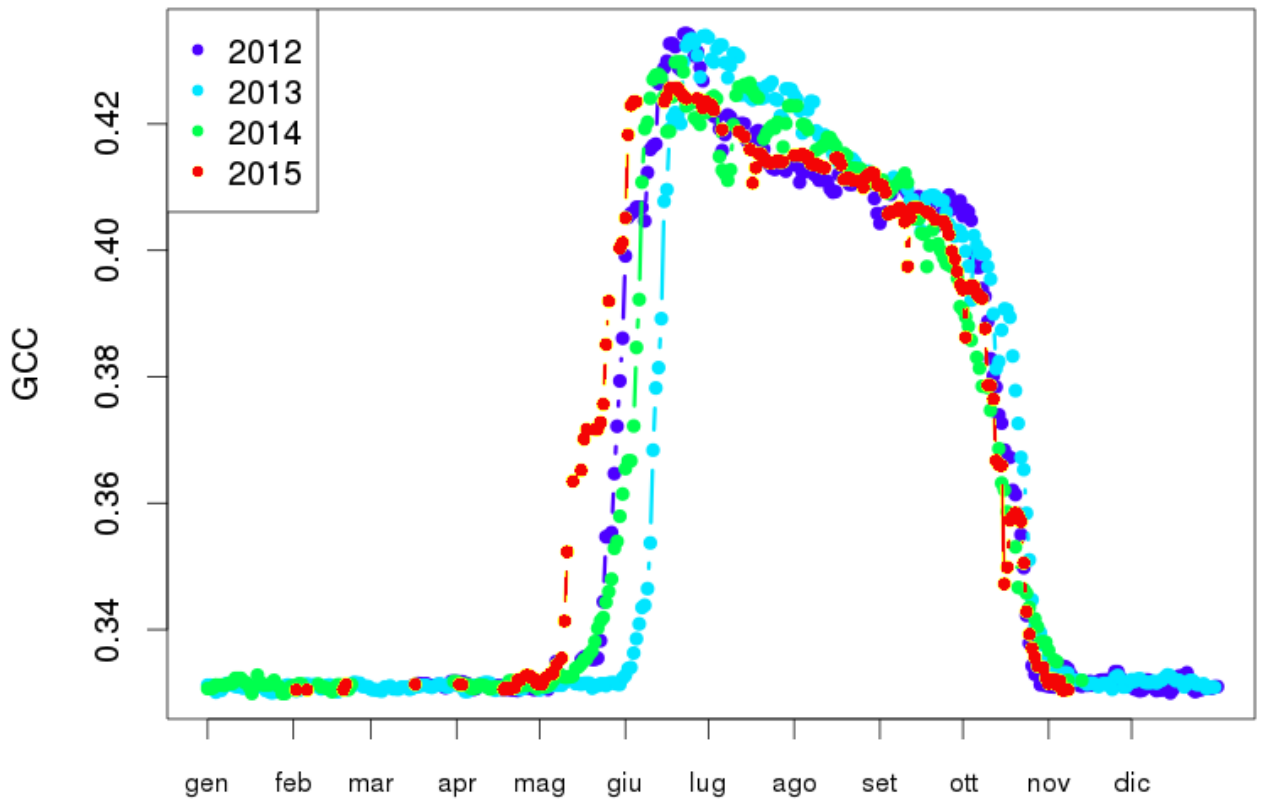
- We observe phenological development in a larch forest and a subalpine grassland, with both direct observations, digital cameras and proximal sensing



Phenology at Grassland: Greenness index

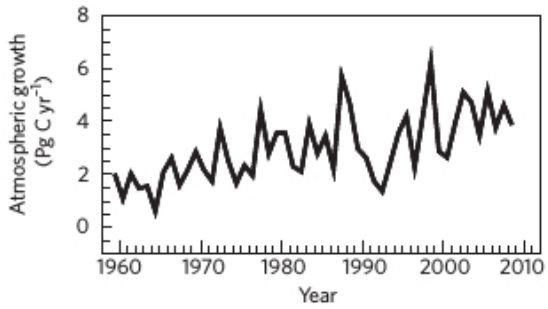


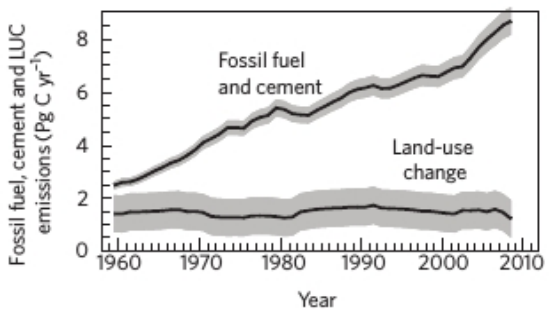
Phenology at Larch forest: Greenness index

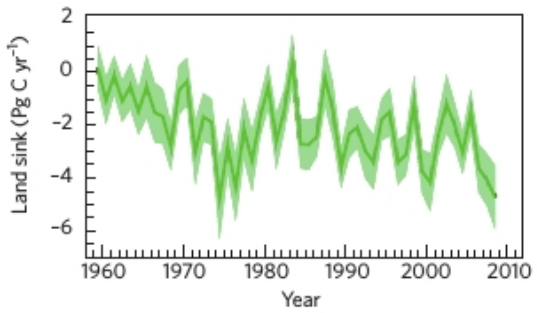


CO_2 exchanges between the ecosystem and the atmosphere

- Half of the man-made CO_2 remains in the atmosphere, the rest is absorbed by the oceans and land sinks
- Photosynthesis is the mechanism by which ecosystems uptake CO_2 from the atmosphere. A fraction of this carbon is released via ecosystem respiration back to the atmosphere. The small imbalance between these two large processes can be used to determine the role of an ecosystem to the global carbon cycle



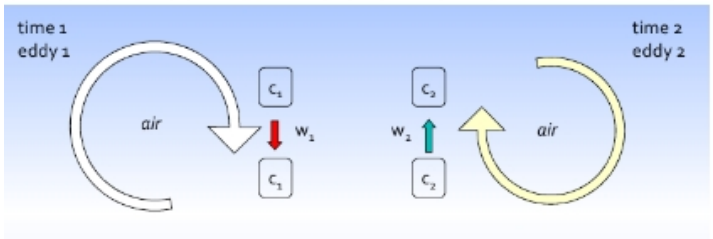




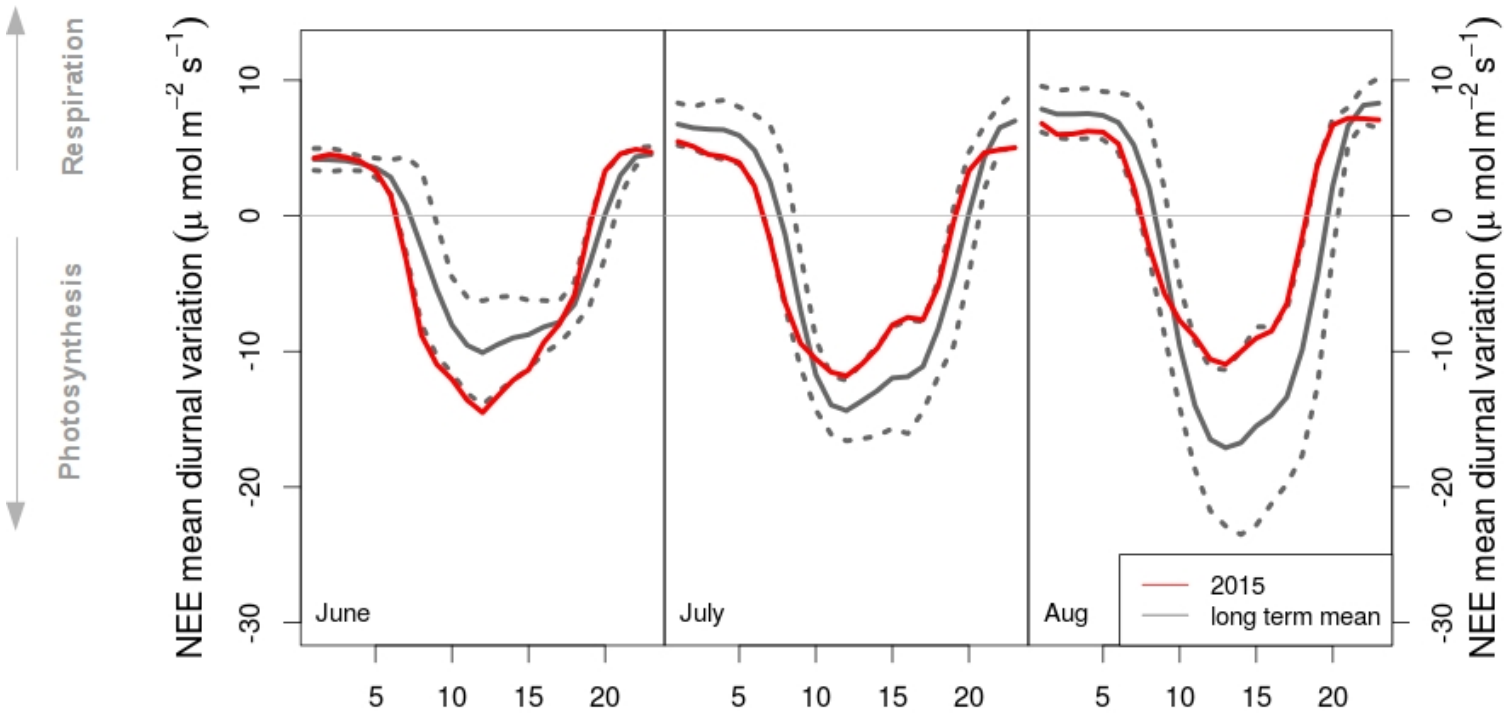
Le Quere et al., 2009 Nature Geoscience

CO_2 exchanges between the ecosystem and the atmosphere: Measurements

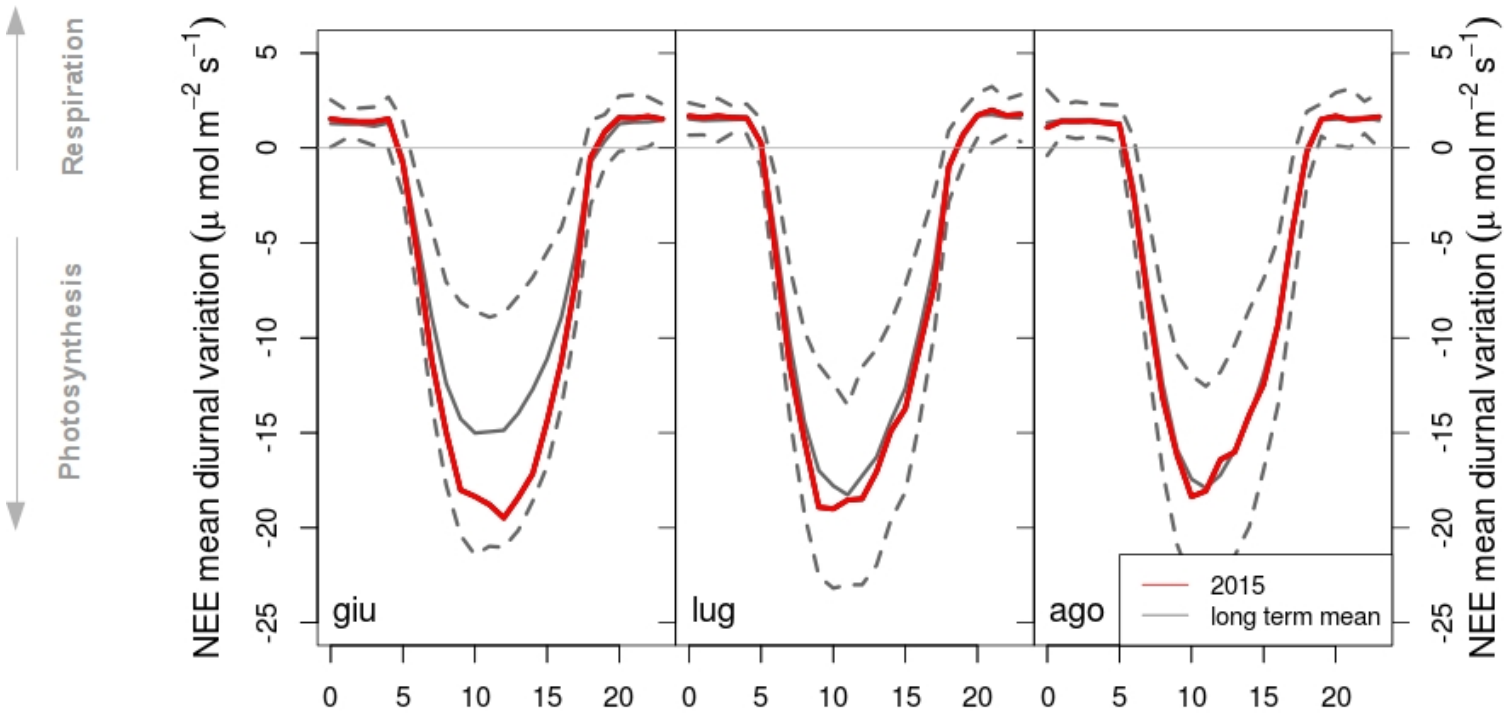
- Eddy covariance method
- Opaque and transparent ecosystem chambers



CO_2 exchanges: Diurnal photosynthetic rates at Grassland



CO_2 exchanges: Diurnal photosynthetic rates at Larch



Summary

The Cryosphere

In 2015 all the components showed anomalies compared to previous years:

- We observed the highest reduction in the **glaciers masss balance** since the hot summer of 2003: the mass loss was **110%** higher than the average
- The **permafrost** active layer has been **60%** deeper than the average
- The **snow** reached for the first time the **complete melting**, at the beginning of August. The average end of season conditions (11Mm^3 of SWE) occurred very early (beginning of July).

The Biosphere

Different effects were observed for alpine grassland and forest ecosystems:

- At the grassland, a strong reduction in the **green material** was reflected in less **productivity** and biomass.
- Conversely, at the larch forest **no significant changes** were observed with regard to both greenness and photosynthetic rates

Lessons learned...

- In Aosta Valley a severe heat wave occurred in summer 2015 resulting in air temperature anomaly close to 4-5 °C
- The several spells experienced by the Alps, had important impacts for water resource availability, the carbon cycle and agriculture, high mountains slope stability and tourism
- Although difficult to integrate, the different insights collected during summer 2015 represent a clear exemple of what it is expected by future increasing in extreme events in a alpine region and help to improve the knowledge base for the development, implementation and enforcement of EU climate change policies

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Thanks for your attention

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http://www.arpa.vda.it/en/climate-change-impacts/