The evidence of climate change in the Alps

The Aosta Valley is a small alpine region of about 3.300 km² located in the NW Italy, on the southern side of the Alps. Surrounded by the highest Alpine peaks, Monte Bianco (4810m), Monte Rosa (4634m) and Cervino (4478m), the Aosta Valley is characterised by a mountainous environment with more than 50% of the territory at an elevation above 2000 metres above sea level. This geography means the effects of climate change are a key issue for politicians and people working and living in the valley.

ARPA VdA is a technical agency of the Regional Administration, established in 1995. The first ARPA VdA climate change activities started in 1999. Since 2004, a specific department (OACC – Operational Area for Climate Change) was exclusively dedicated to the monitoring and study of climate change effects.

As global warming affects all the components of the alpine environment, an integrated monitoring approach to both the biosphere and the cryosphere is applied, with the main purpose of:

- getting a more comprehensive understanding of climate change effects in alpine environments;
- testing and developing methods for monitoring the effects of climate change;
- assuring long term monitoring; and,
- developing and updating reliable indicators of climate change.

Thanks to OACC participation in many European projects, a number of research lines have been developed together with a solid network of international collaborations.

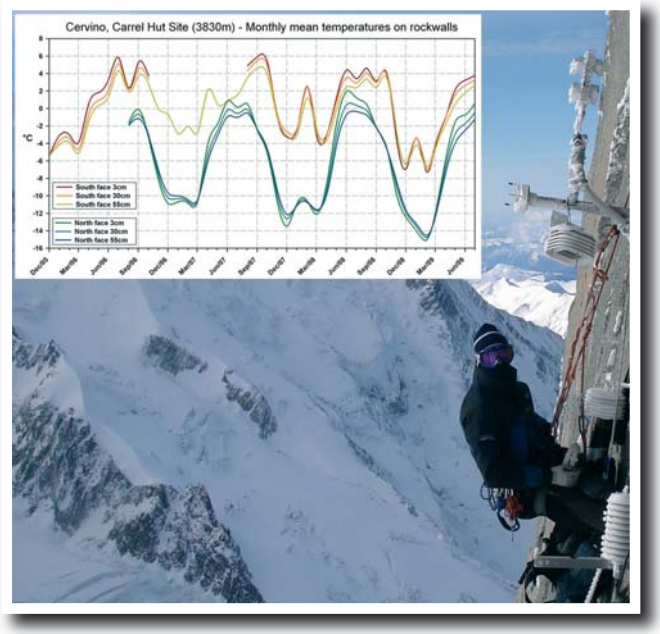

Fig 2: Timorion glacier: the results of mass balance monitoring (the bars indicate the balance between winter accumulation and summer melting of snow and ice)

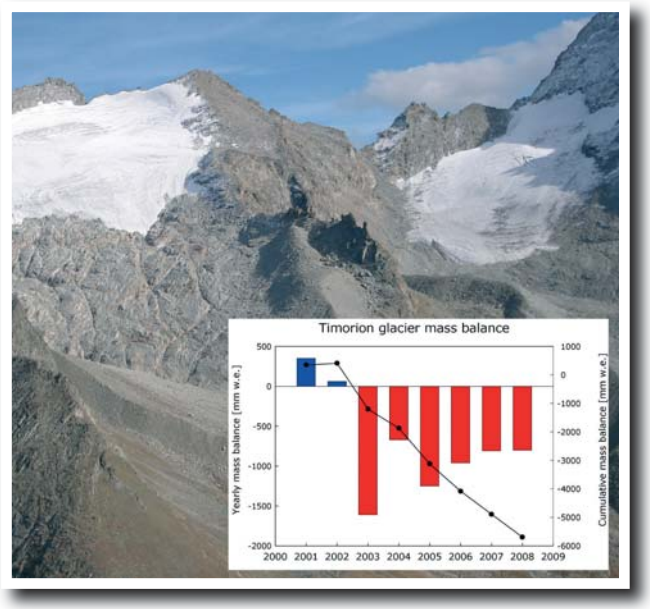

Fig 1: Measures of meteorological parameters in rock walls. The graph shows a time series of monthly mean rock temperature at different depths on the Matterhorn at 3880 m asl

Projects in the biosphere

Phenology is the study of plant life cycle events (budburst, flowering and senescence) and how these are influenced by climate. The phenological cycle of the Larix decidua has been monitored since 2005 through integration of field observations, remotely sensed data and phenological models. It is a very good indicator of both long-term and interannual climate variations. The collected data showed the strong effect of the warm 2007 winter which caused an anticipation of the growing season of about two weeks. These activities, started within the REPHLEX project, are currently being improved and developed in the framework of the European Union (EU) co-funded Interreg Project (ALCOTRA) PHENOALP, led by ARPA VdA.

Recent study has focused a great deal of attention on the carbon fluxes of alpine ecosystems, particularly on factors determining whether an ecosystem is a net source or sink of atmospheric carbon dioxide. The long-term monitoring of the net balance of an ecosystem can be done using the eddy covariance technique. Since 2008, ARPA VdA has been measuring the CO_2 fluxes of an alpine grassland (2160 m.a.s.l.). In 2009, a second eddy covariance tower was installed in a larch forest as a long-term monitoring of the carbon balance of these two important ecosystems.

Considering the cryosphere

The various cryosphere components have different sensitivity and reaction-time to global warming. The contemporary monitoring of snow, glaciers and permafrost is a way to get a comprehensive understanding of the ongoing processes.

Snow is a fundamental water reservoir and climate change will influence snow cover persistence and thus can negatively affect water availability. The knowledge of the amount of water stored in the snow, its spatial distribution and its temporal evolution dynamics, is an issue of increasing importance. For these reasons from 2006, ARPA VdA has developed modelling activities to monitor Snow Water Equivalent (SWE) distribution at the regional scale (3000 Km^2) for the Regional Hydrological Bulletin and at the medium basin scale (120 Km^2) for hydro-power production optimisation. On such topics OACC is a partner of the ACQWA project.

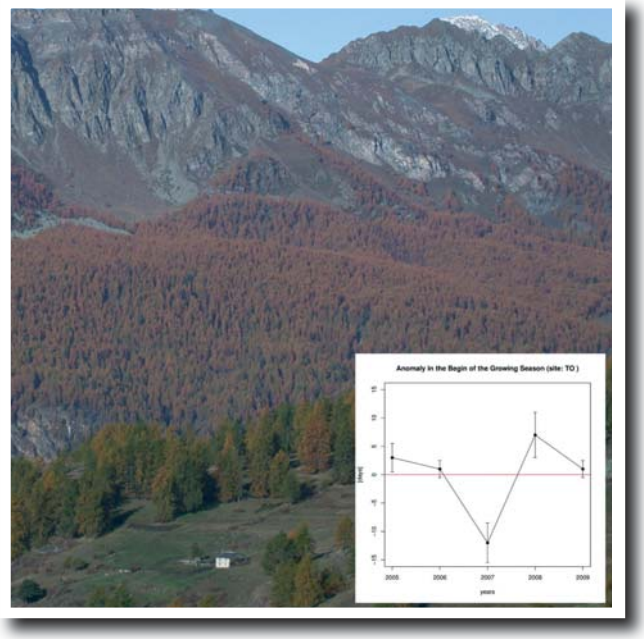

Fig 3: Autumn senescence in a larch population at 2100 m asl. The graph shows the results of five years of phenology observations: in red the mean date of the start of the growing season and in black yearly anomalies (negative values indicate an anticipation of the onset of spring)

Glaciers are an important water reservoir and their retreat is one of the most striking effects of global warming for the mountain environment. Since the glacier mass balance is determined by climatic condition, its long-term monitoring is a very reliable indicator. Mass balance is the difference resulting from the mass gained by the glacier through the winter/spring precipitations and the mass lost during the summer by snow and ice melting. For these reasons, ARPA VdA performs the yearly mass balance of some important glaciers that have lost significant mass since 2002.

Permafrost defines any earth's material that remains below 0°C for at least two consecutive years. Permafrost degradation in high mountain areas can cause slope instability and influence the occurrence and distribution of natural hazards. From 2004, ARPA VdA is monitoring the evolution of permafrost thermal state in many sites from flat terrains to near vertical rock walls. These data are fundamental for the construction, validation and calibration of permafrost distribution and evolution models. Starting from PERMAdataROC project, these activities are currently being improved within the PERMAnet and RiskNAT projects.

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