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X-Sense RTD 2010

FNSNF

Continous monitoring of alpine slope instabilites with GPS sensors

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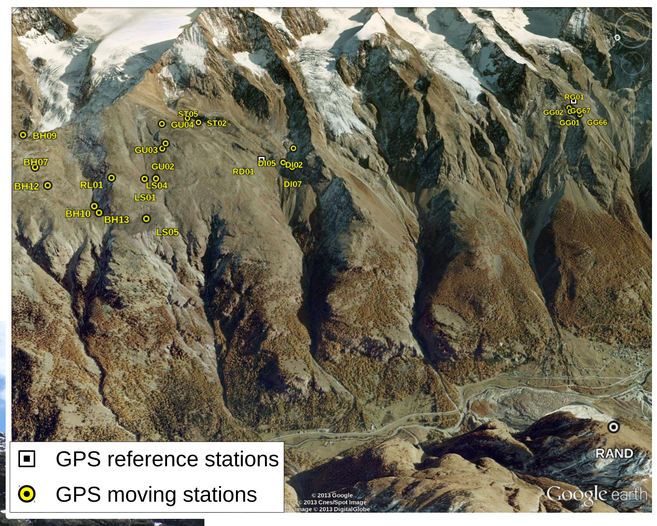
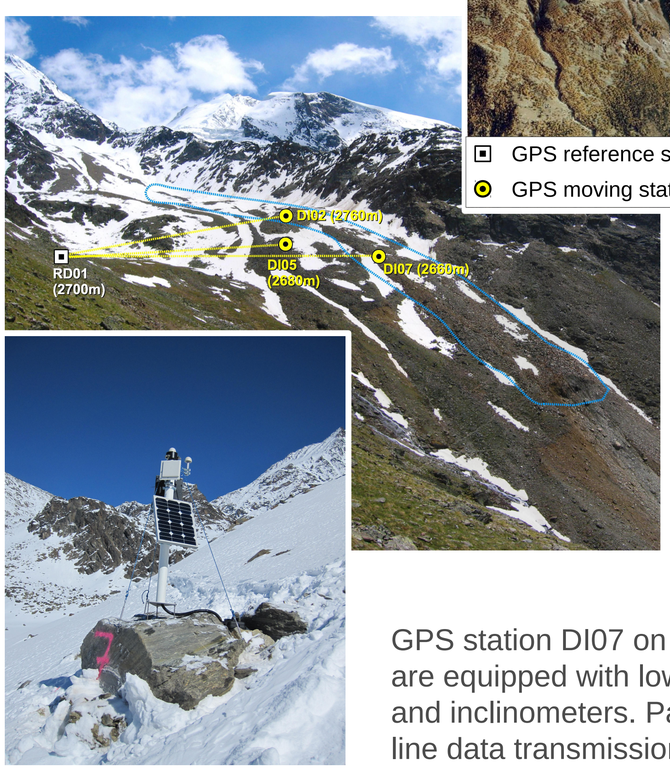
GPS Monitoring Network

- Network of permanent GPS stations operated in the Matter Valley (Swiss Alps) since winter 2010/2011, in the framework of the inter-disciplinary project *X-Sense*.
- Major goal: monitoring of alpine mass movements (e.g. rock glaciers).

Overview of the GPS monitoring network, currently totaling more than 20 GPS stations.





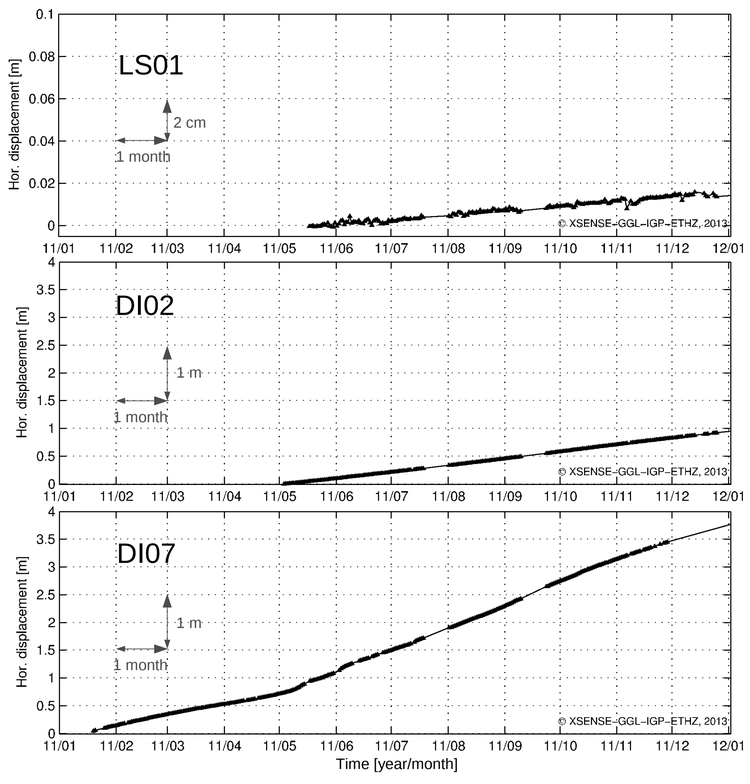
Subset of GPS network:

- reference station RD01 in stable area
- stations DI02, DI05, DI07 on a rock glacier (blue area)

GPS station DI07 on a rock glacier. The stations are equipped with low-cost L1 GPS receivers and inclinometers. Part of the stations have on-line data transmission.

Displacements from GPS

- GPS data processed in a fully automated processing chain
- GPS processing with Bernese GPS Software
- GPS processing based on differential L1 carrier phase techniques
- Computation of daily coordinates
- Computation of kinematic coordinates (30s sampling, not shown)
- Real-time RTK solutions are computed for online stations (not shown)



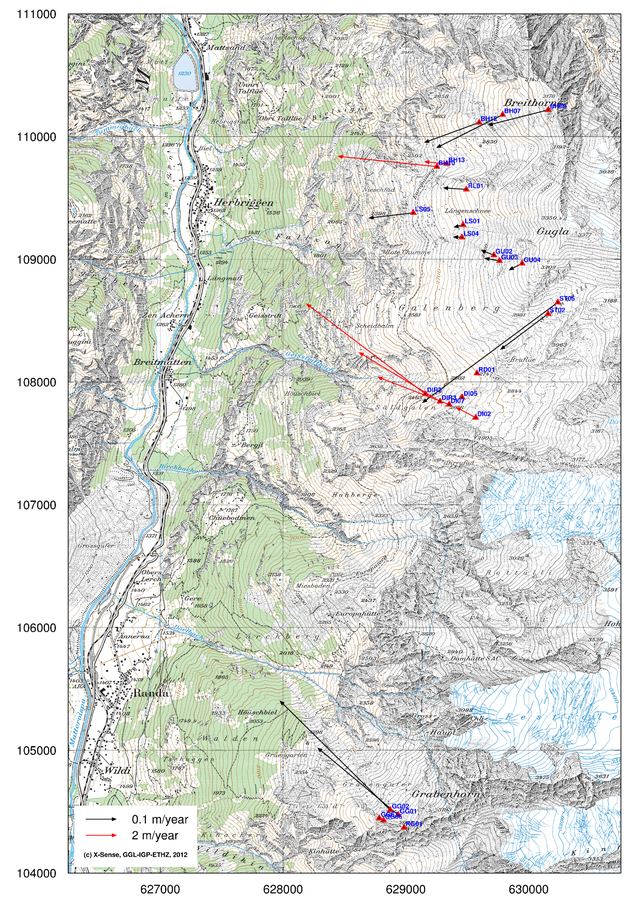
Horizontal displacements (daily solutions) of GPS stations LS01, DI02 and DI07 in 2011.

Velocities from GPS

- Mean velocities are computed from linear regression of GPS displacements.

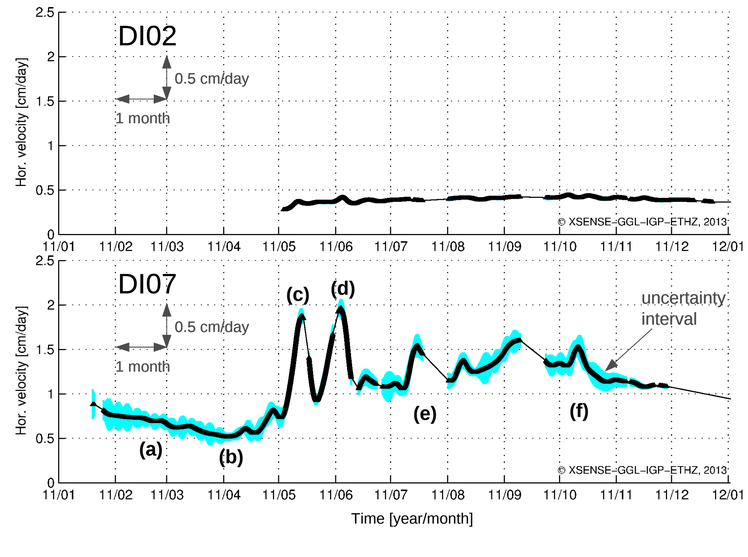
Station	Velocity [cm/day]	Velocity [m/year]
DI07	1.37 ± 0.020	4.97 ± 0.072
DI02	0.39 ± 0.002	1.44 ± 0.008
ST05	0.15 ± 0.004	0.55 ± 0.016
BH07	0.07 ± 0.002	0.24 ± 0.006
BH09	0.06 ± 0.004	0.20 ± 0.014
ST02	0.05 ± 0.002	0.19 ± 0.008
GU02	0.01 ± 0.002	0.05 ± 0.008
GU03	0.01 ± 0.001	0.05 ± 0.005
LS04	0.01 ± 0.001	0.03 ± 0.005
LS01	0.01 ± 0.001	0.03 ± 0.005

Mean 3D velocities of a subset of GPS stations from linear regression of displacements. The standard deviations reflect the degree of linearity of the observed displacements.



Map of mean 3D station velocities.

- Time series of surface velocities are computed from GPS displacements, based on least-squares smoothing spline parameterizations of displacements and their analytical derivatives.



Time series of horizontal velocities of stations DI02 and DI07 in 2011 (from GPS displacements). Station DI07 shows:

(a) velocity decrease from Jan. to April **(d)** velocity peak in June

(b) velocity minimum early April **(f)** velocity decrease from Sept. to Dec.

(c) velocity peak in May, during snow-melt **(e)** velocity increase from April to Sept.

Conclusions

- Monitoring stations equipped with low-cost L1 GPS provide:
  - continuous time series of displacements at cm-level accuracy
  - reliable observations of a wide range of mass movements, from cm/year to several m/year
  - detection of small short term and seasonal velocity variations
- Continuous observation of surface motion with GPS can contribute to understand processes linked to permafrost-related slope instabilities and prevent impacts on infrastructure and human life.