# Permafrost response to climate change in the Cervinia basin (Matterhorn, Italy)

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from process understanding to impacts and adaptation"
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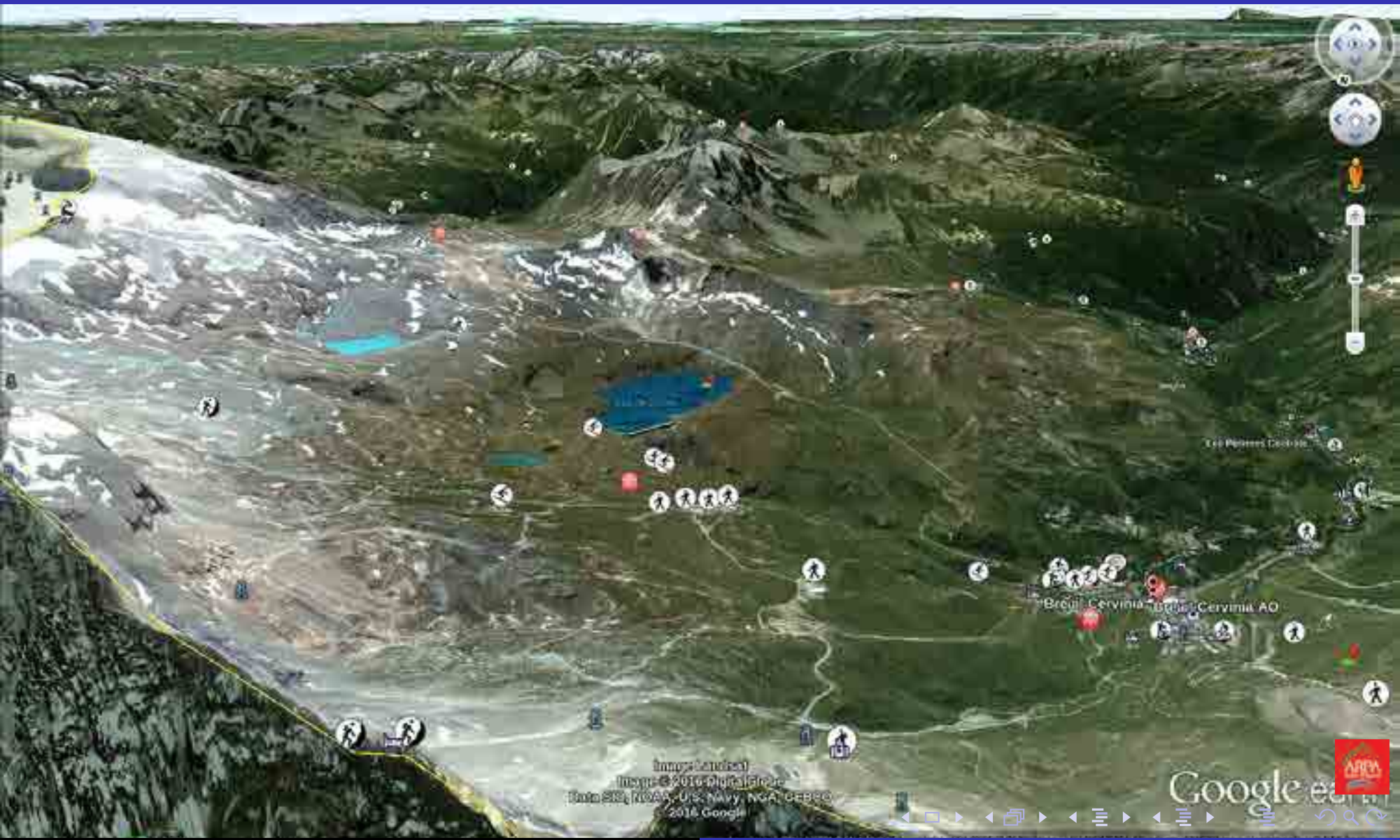
# Outline for section 1



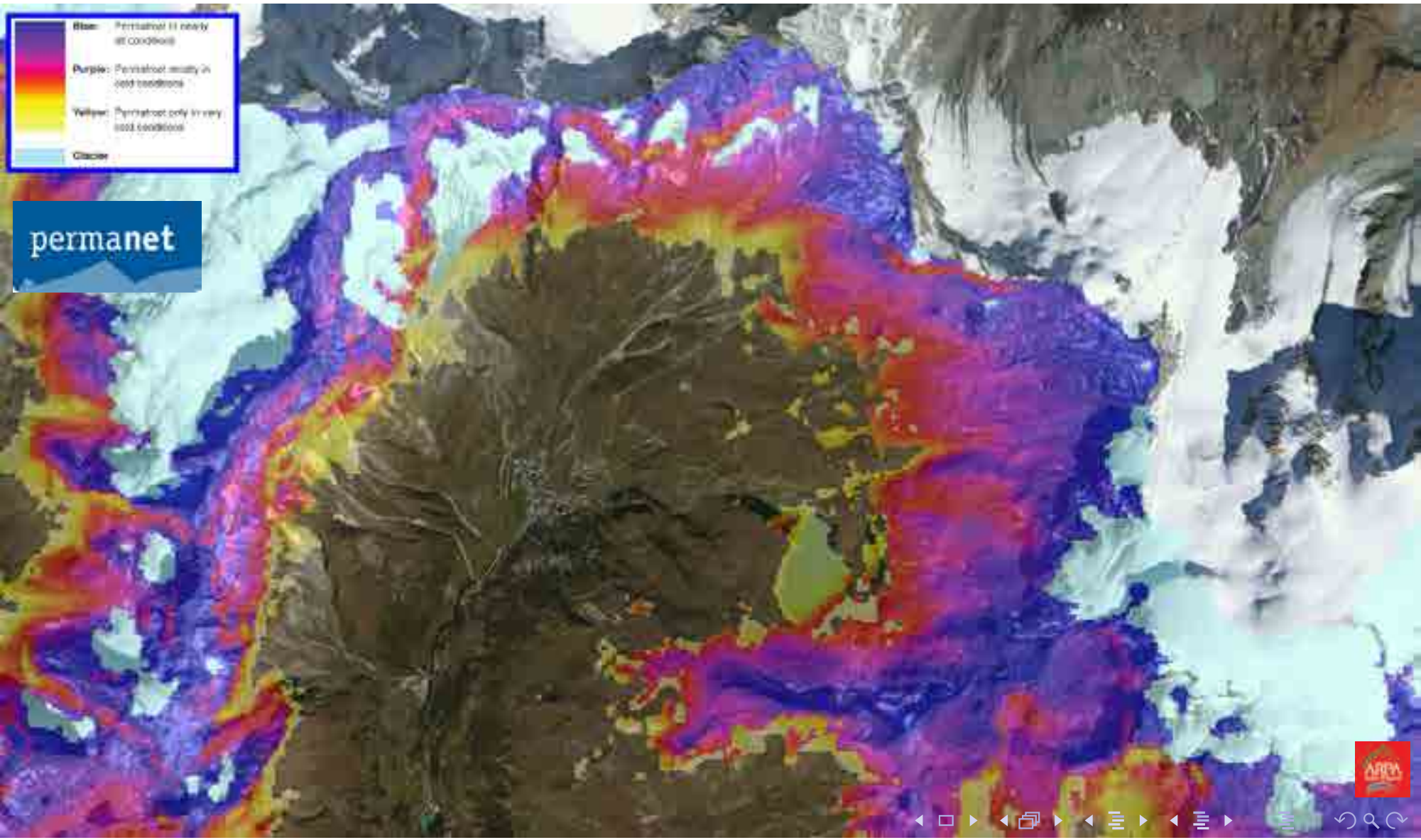
# The cervinia basin: view from Matterhorn

# The cervinia basin: human activities



# The cervinia basin: human activities

# The cervinia basin: potential permafrost distribution



# The cervinia basin: climate and topography

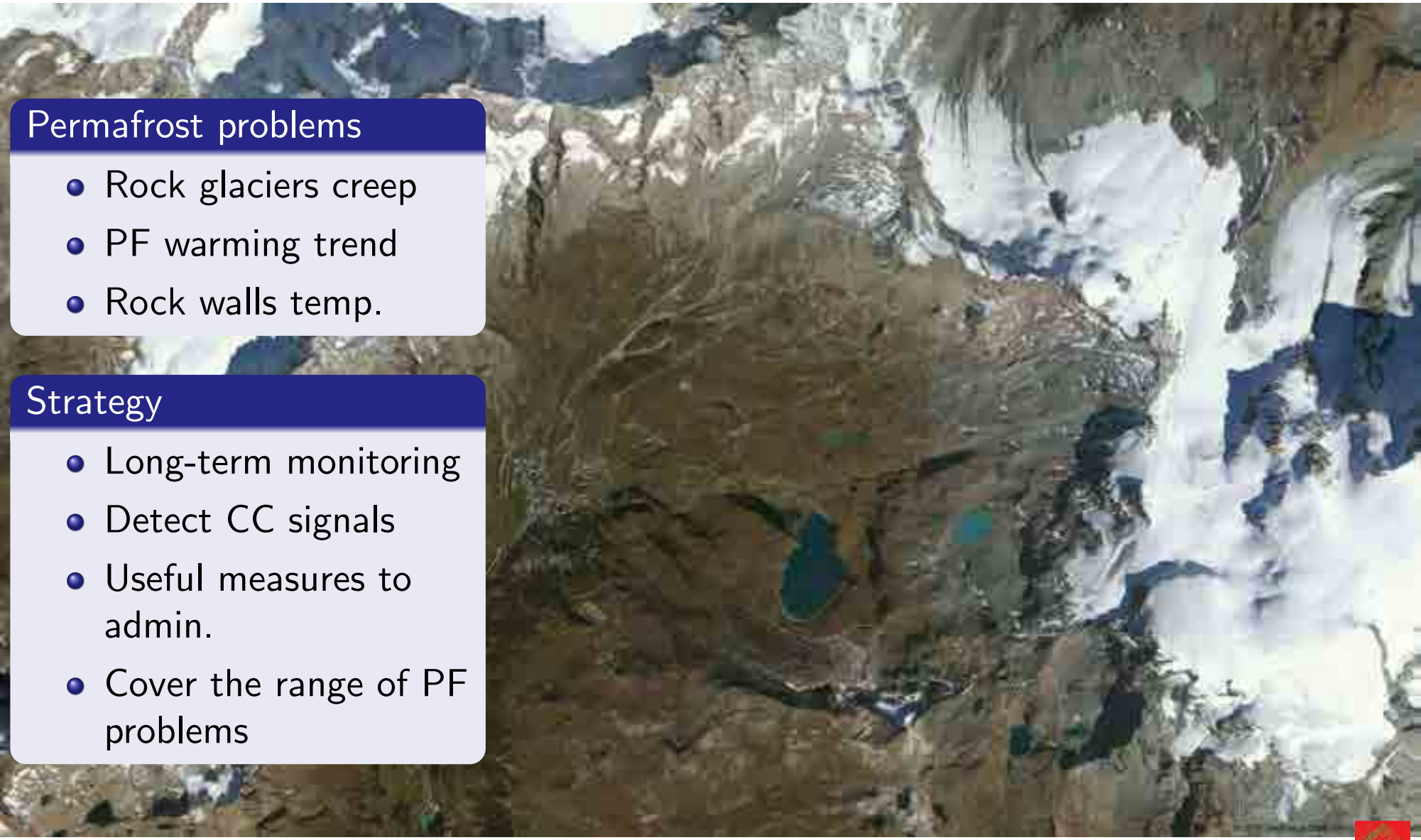
**Climate**
- MAAT:-3.2C
- Prec:1200 mm/y

**Morphology**
- Moraines
- Rock Glaciers
- Gelifluction Lobes
- High-elevation plateau
- Steep Rock walls

**Topography**
- Elev: 2000-4478
- Slope: all
- Aspect: all

# Outline for section 1



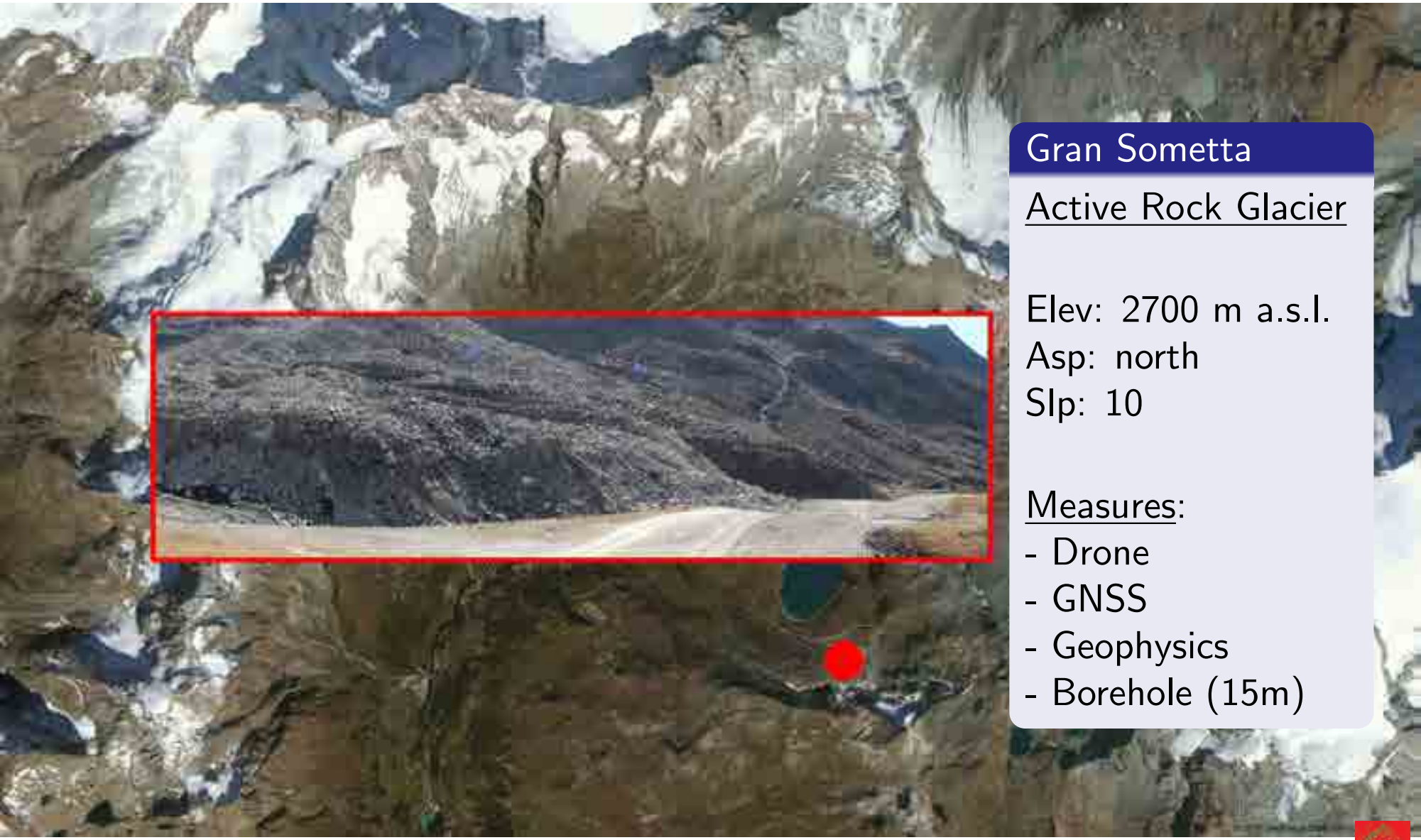


## Permafrost problems

- Rock glaciers creep
- PF warming trend
- Rock walls temp.

## Strategy

- Long-term monitoring
- Detect CC signals
- Useful measures to admin.
- Cover the range of PF problems



## Gran Sometta

Active Rock Glacier

Elev: 2700 m a.s.l.
Asp: north
Slp: 10

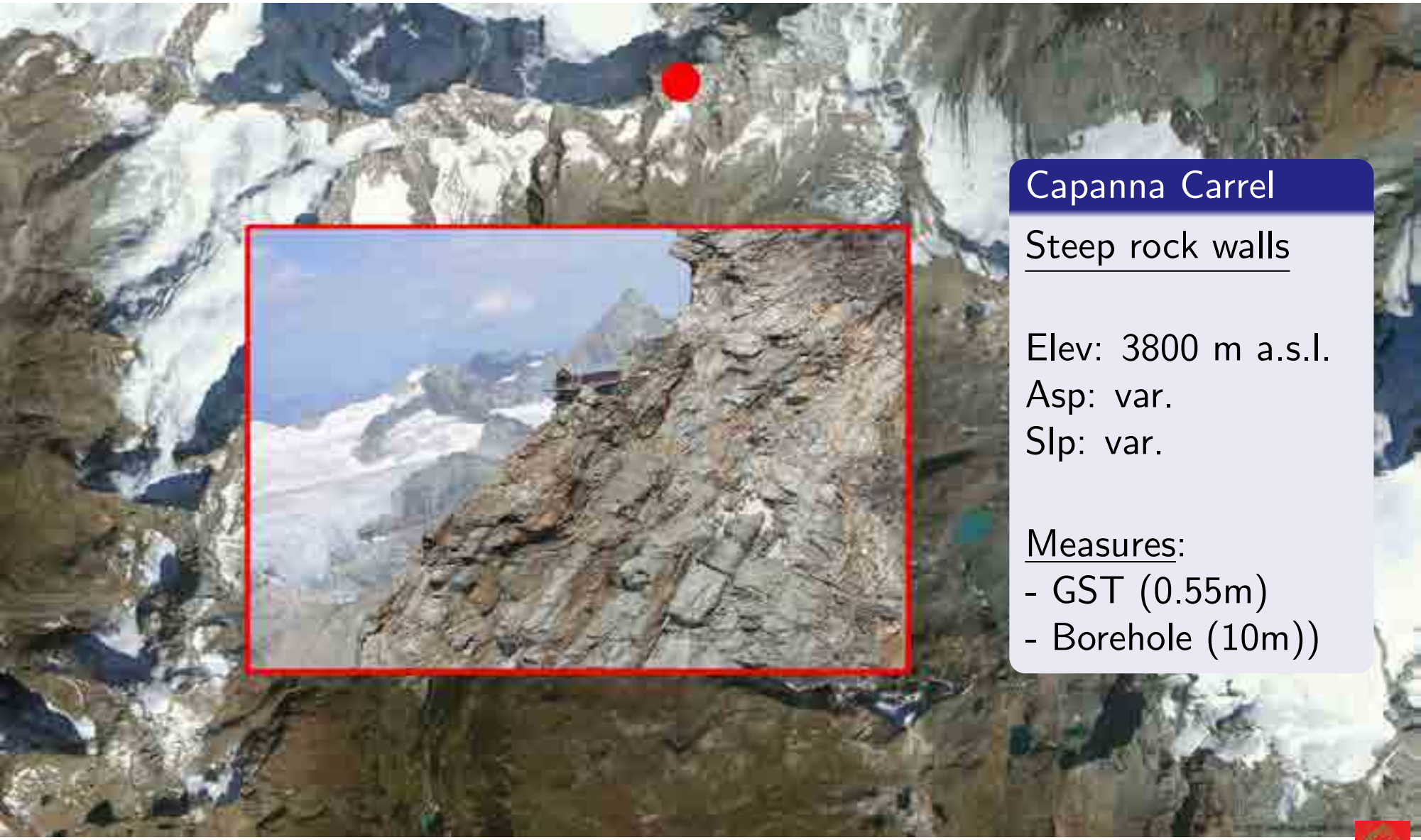
Measures:
- Drone
- GNSS
- Geophysics
- Borehole (15m)

## Cime Bianche

Plateau

Elev: 3100 m a.s.l.
Slp: 5
Asp: SW

Measures:
- Borehole (41m)
- Meteo
- OTT prec. gauge
- Soil water content
- Geophysics



## Capanna Carrel

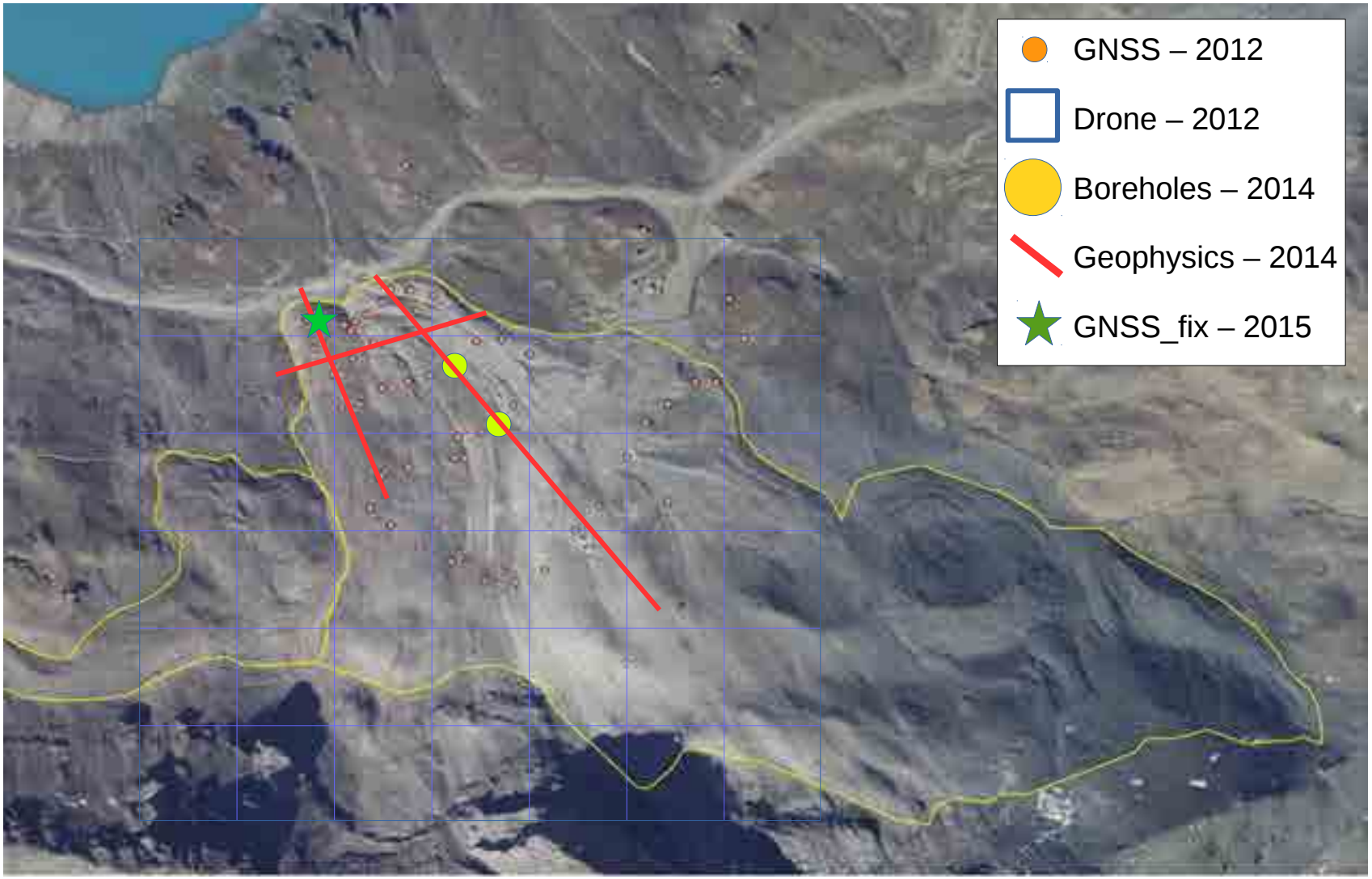
Steep rock walls

Elev: 3800 m a.s.l.
Asp: var.
Slp: var.

Measures:
- GST (0.55m)
- Borehole (10m))

# Outline for section 2



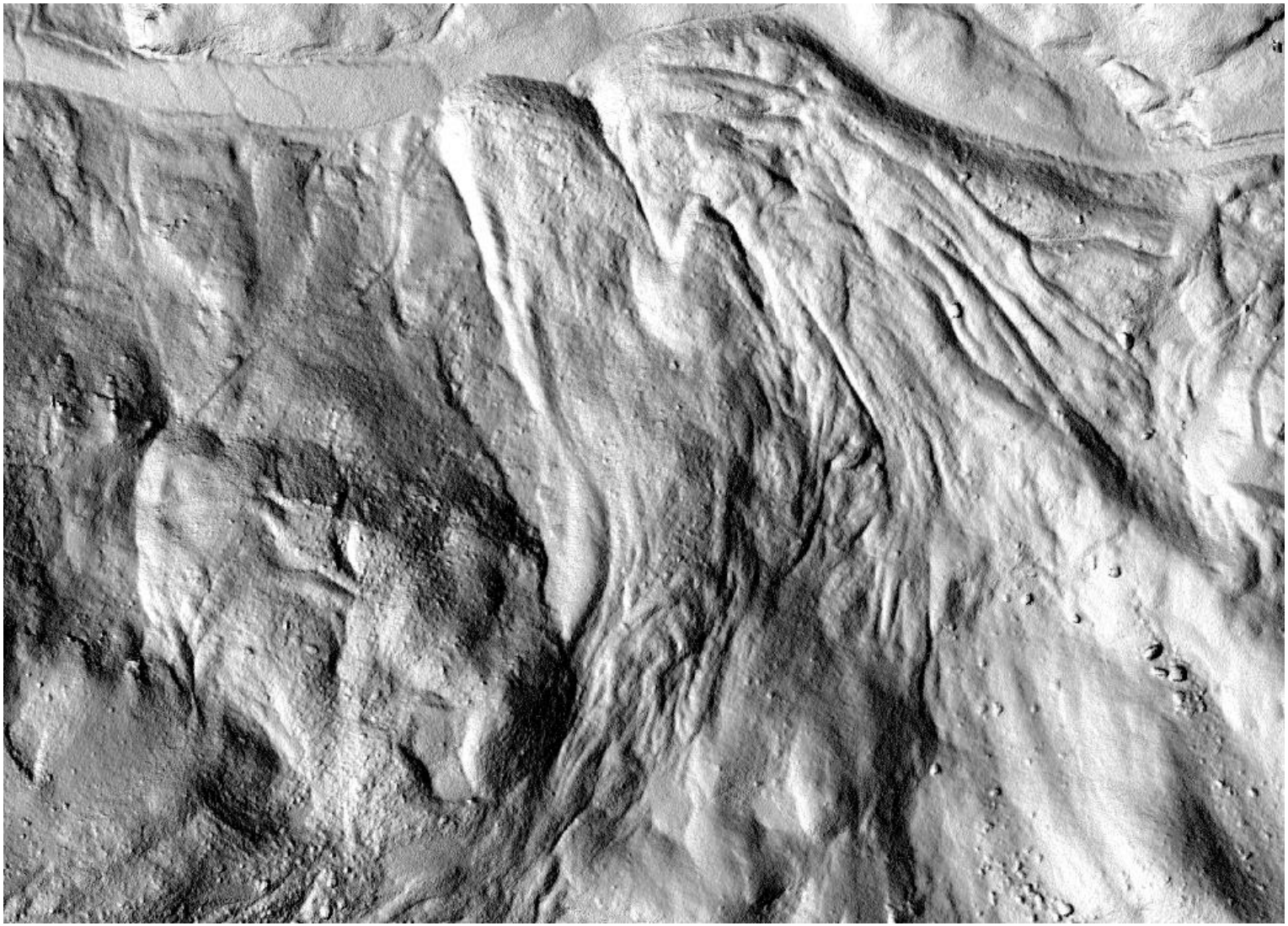

GNSS – 2012
Drone – 2012
Boreholes – 2014
Geophysics – 2014
GNSS_fix – 2015

# Drone intro

# Drone intro - 2012/10

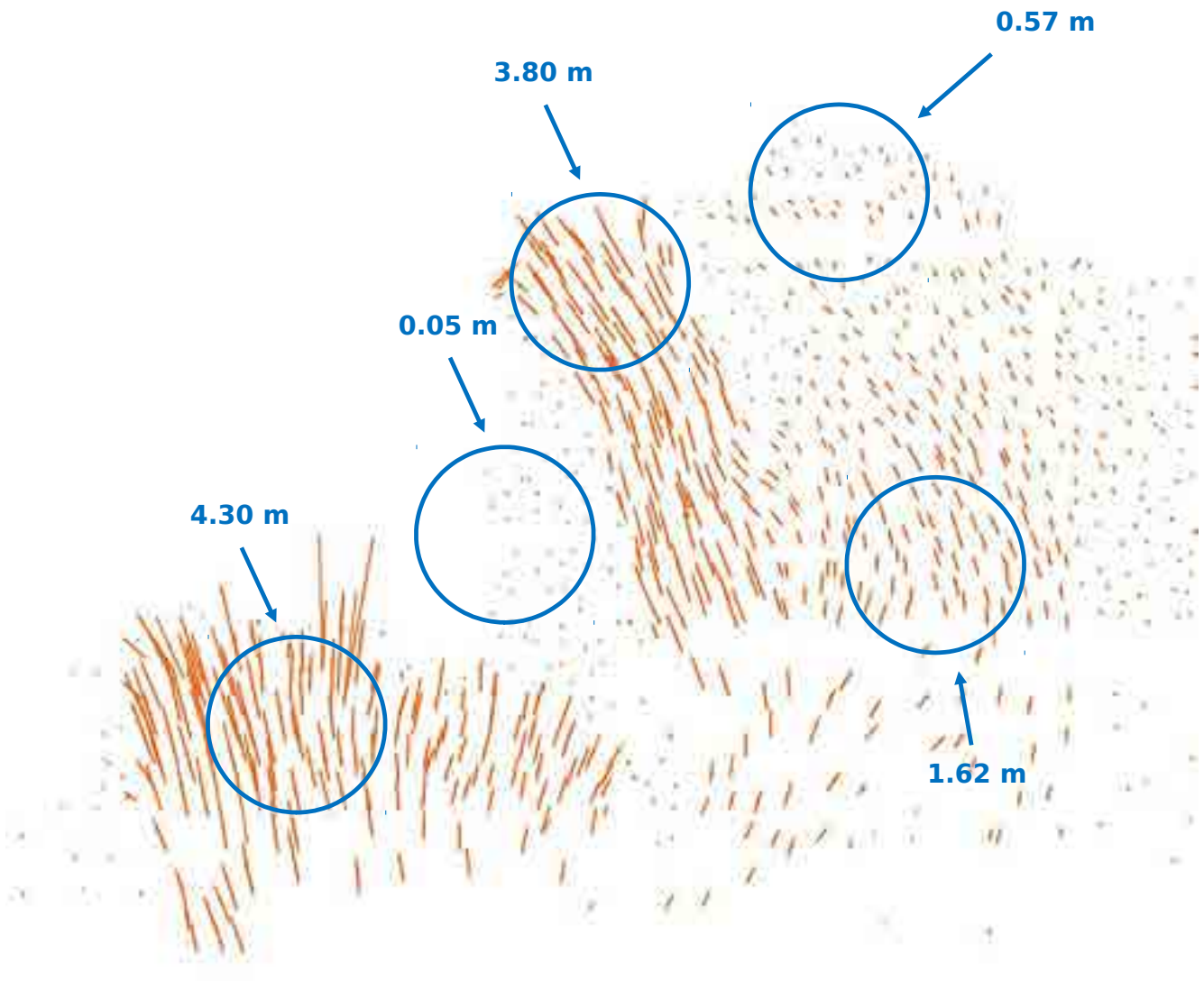
# Drone intro - 2014/10

# Drone intro - 2015/07

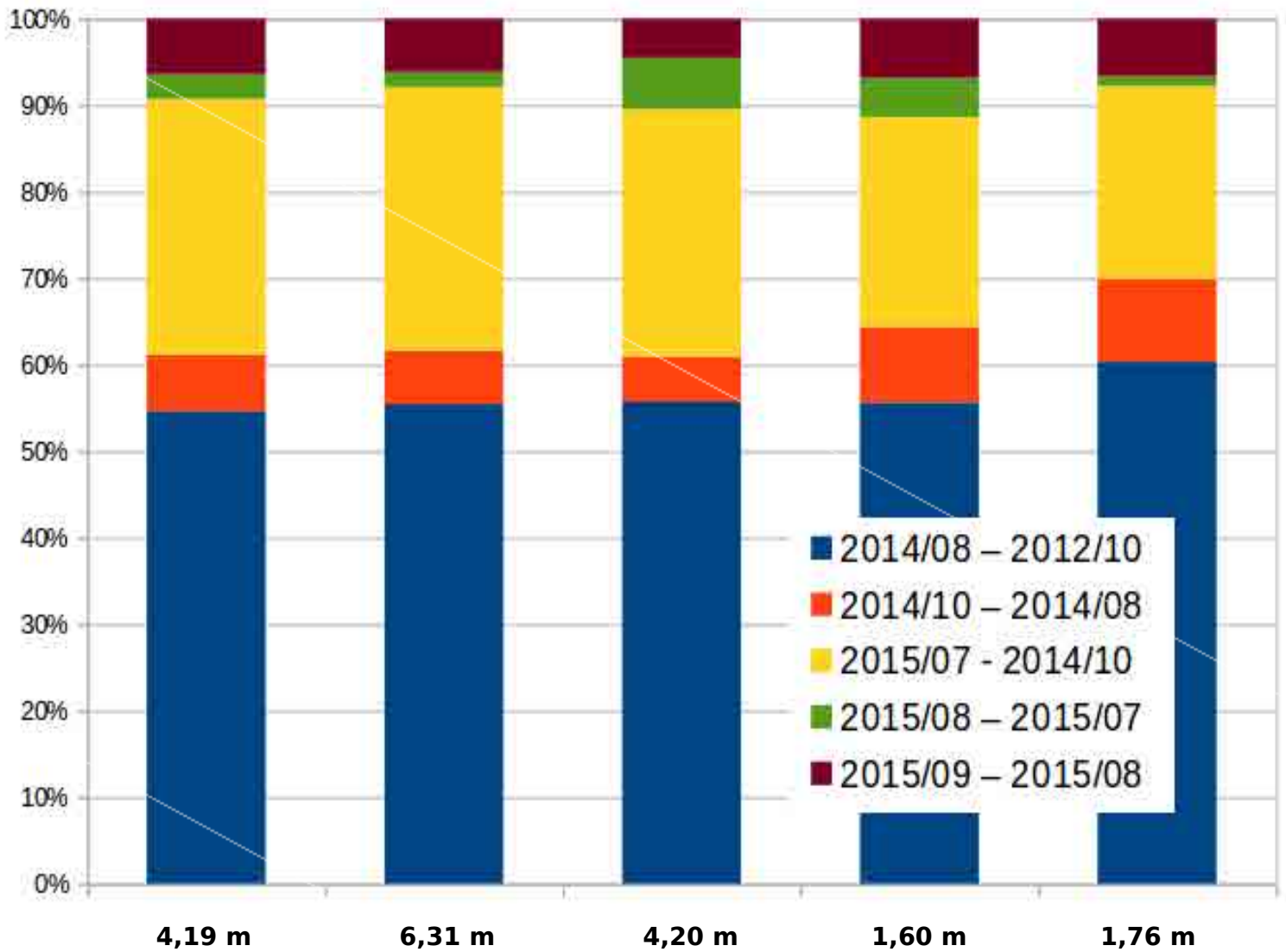


# Drone intro - 2015/08

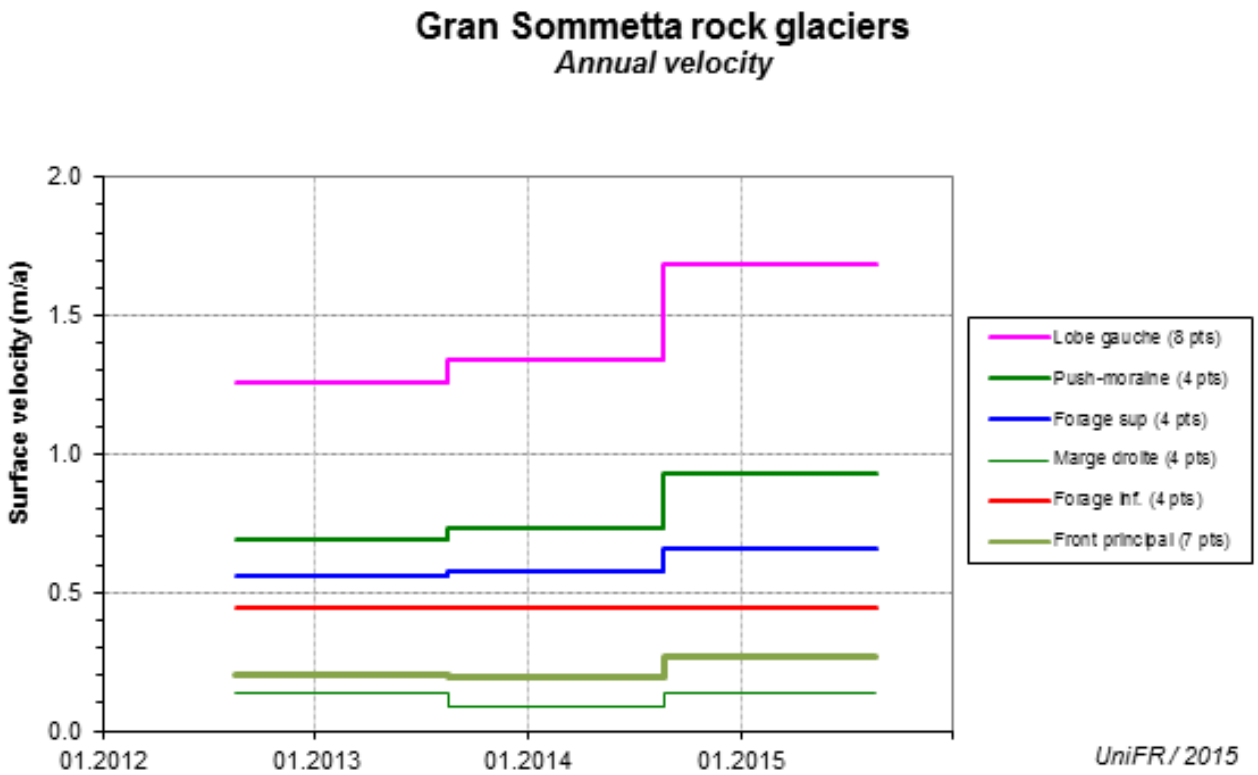
# Drone Surface Velocities



# Drone Surface Velocities

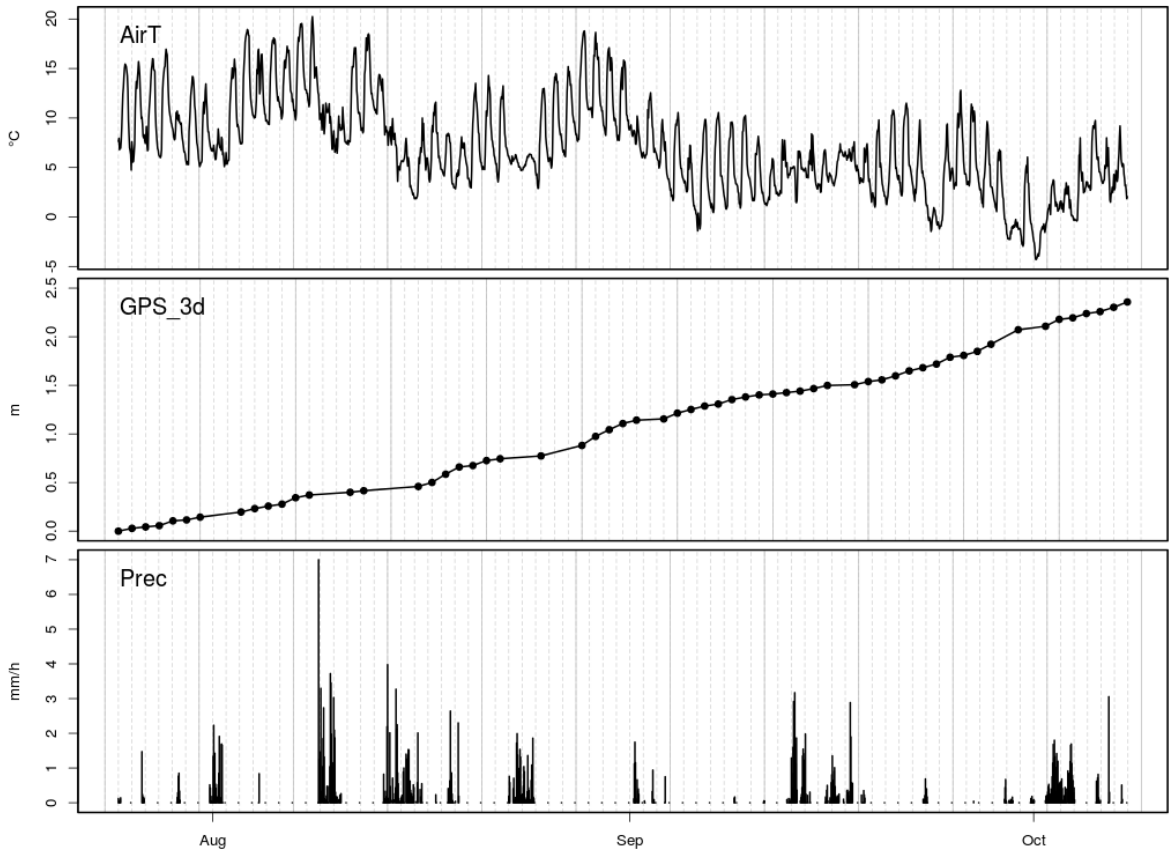


# GNSS velocities (by Uni.Fribourg)

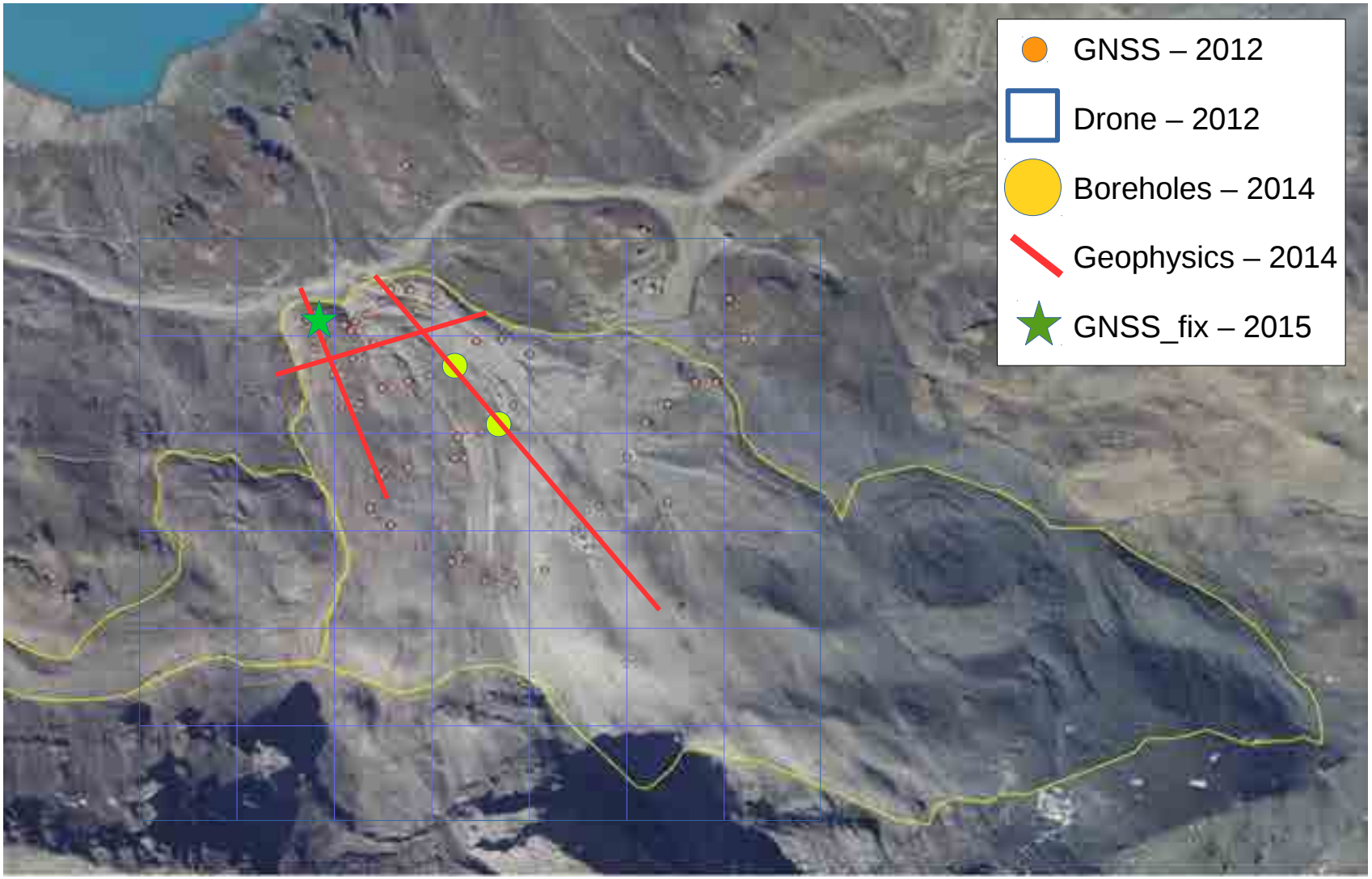


# Continuous GPS records

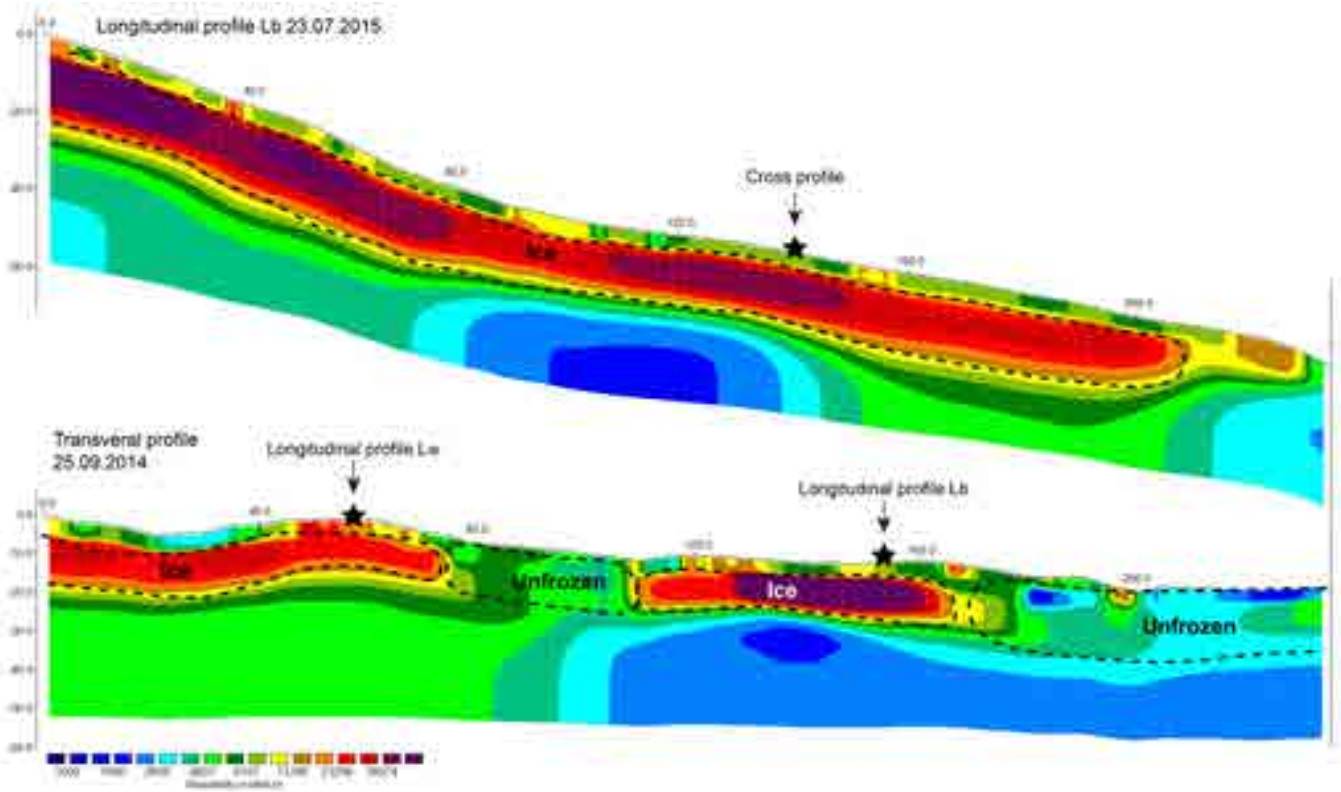
75 days



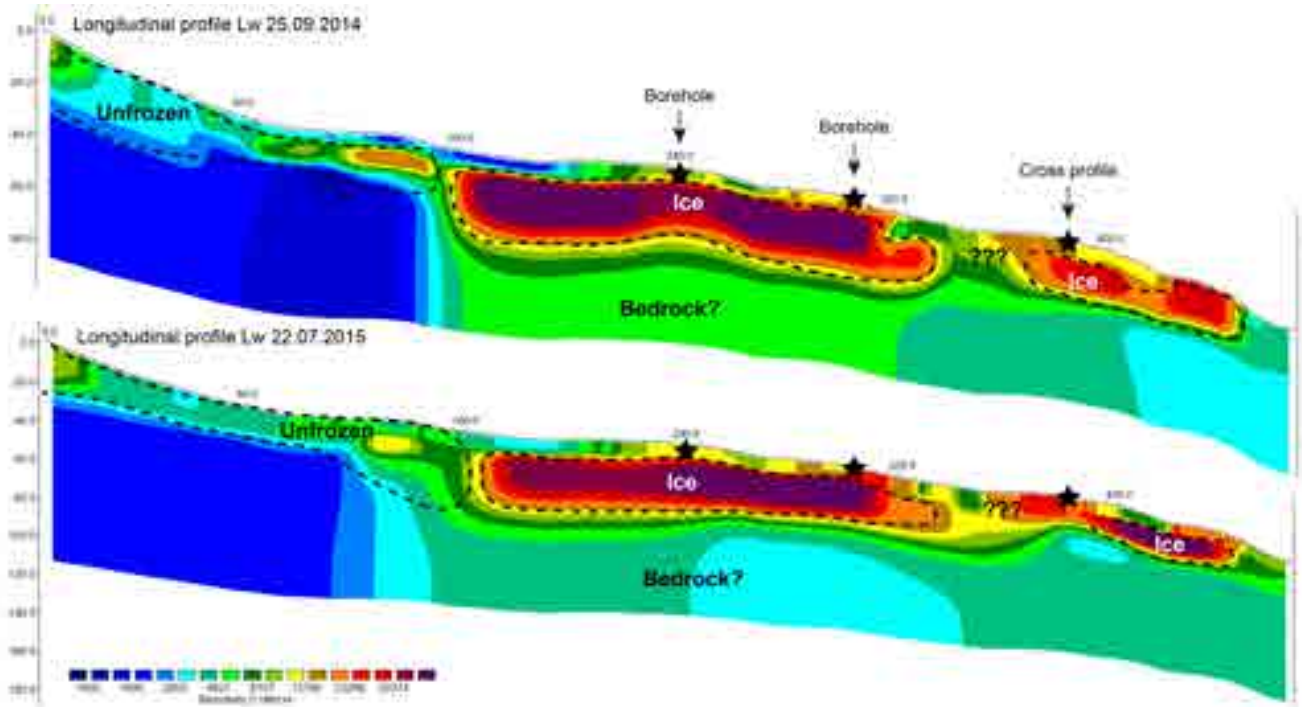

Mean velocity: 3.1 cm/day


GNSS – 2012
Drone – 2012
Boreholes – 2014
Geophysics – 2014
GNSS_fix – 2015

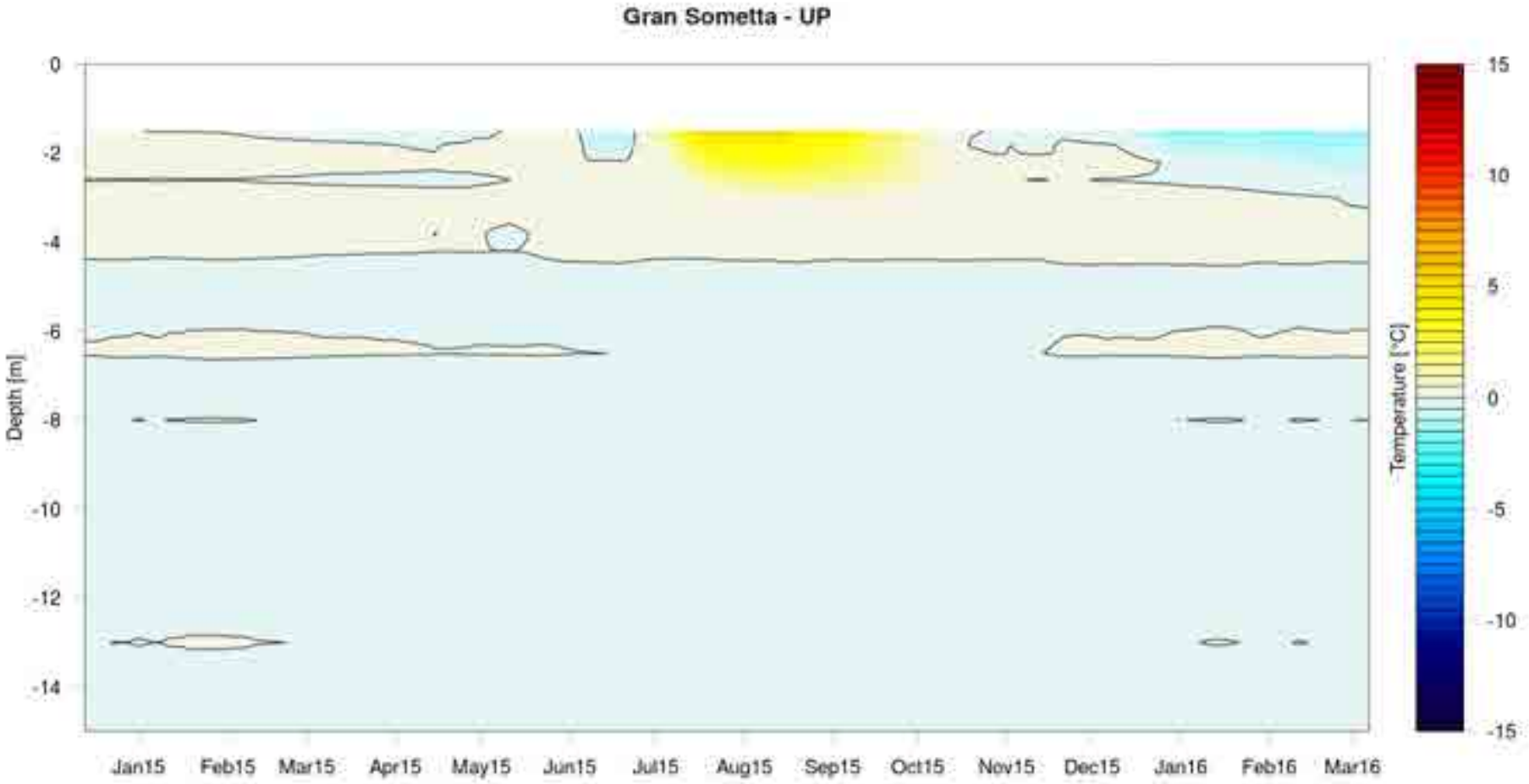
# Geophysics - Left Lobe (by Uni.Fribourg)



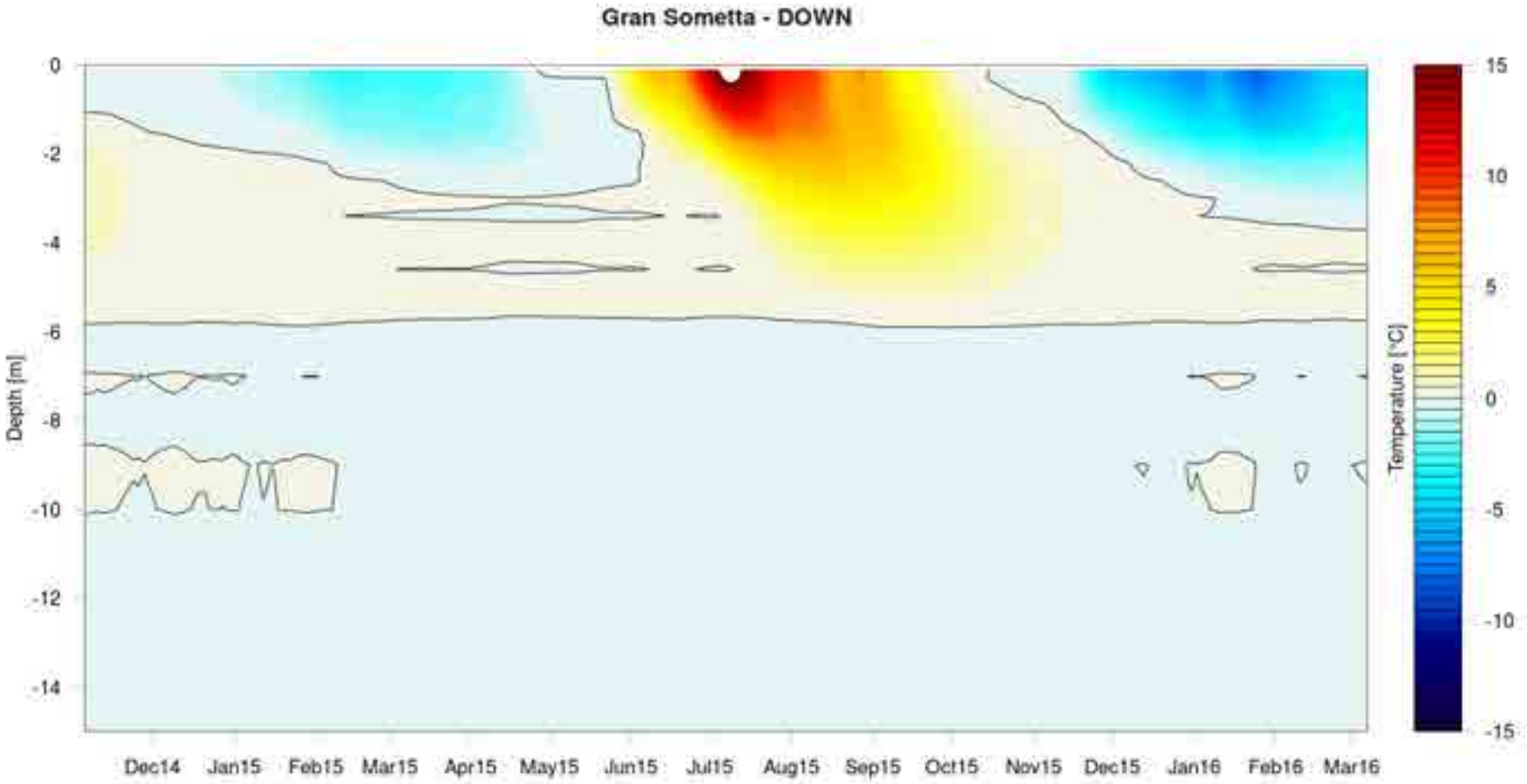
# Geophysics - White Lobe (by Uni.Fribourg)



# Borehole Temperatures - White Lobe



# Borehole Temperatures - White Lobe



# Gran Sometta

## Conclusions

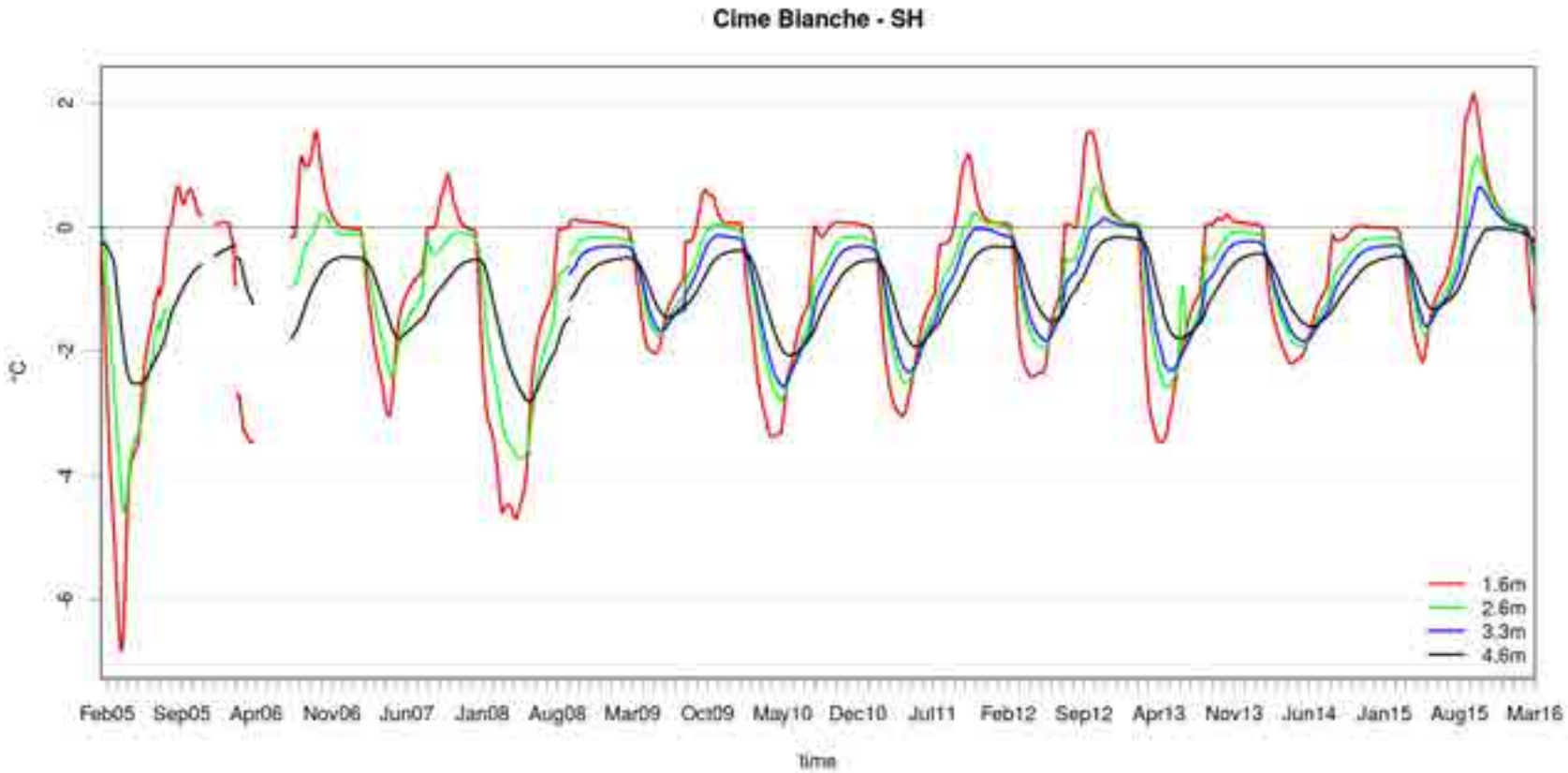
- The survey is producing useful data to quantify the creep velocity of the rock glaciers and its variation over time.
- The acceleration observed during the hot summer of 2015 suggest that this landform is highly unstable and reacts fastly to external forcing. Thus attention must be kept high.
- Nevertheless, the low slope angle should not allow the triggering of sudden dangerous phenomena.

# Outline for section 2

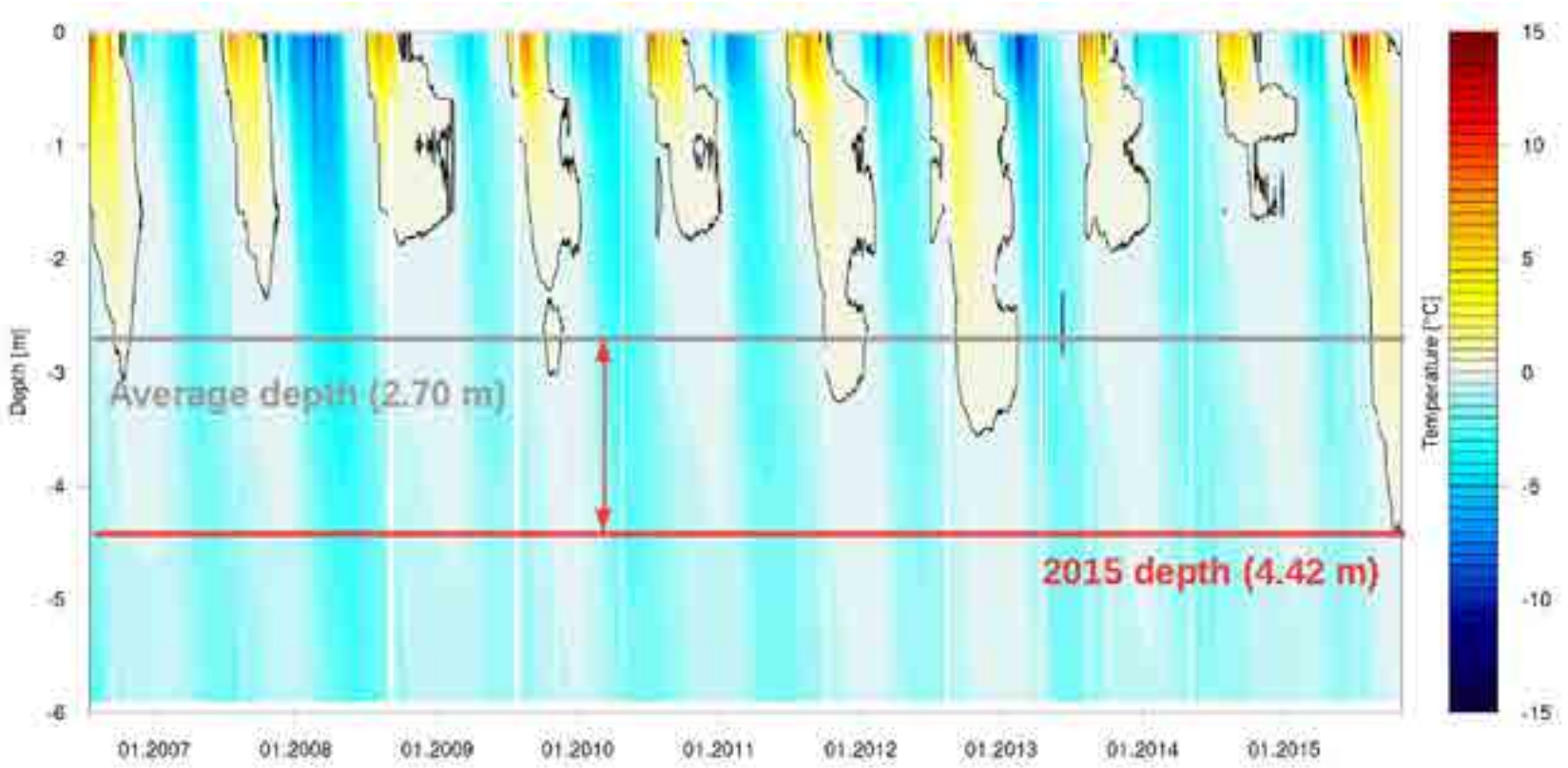


# Cime Bianche monitoring site (3100 m)

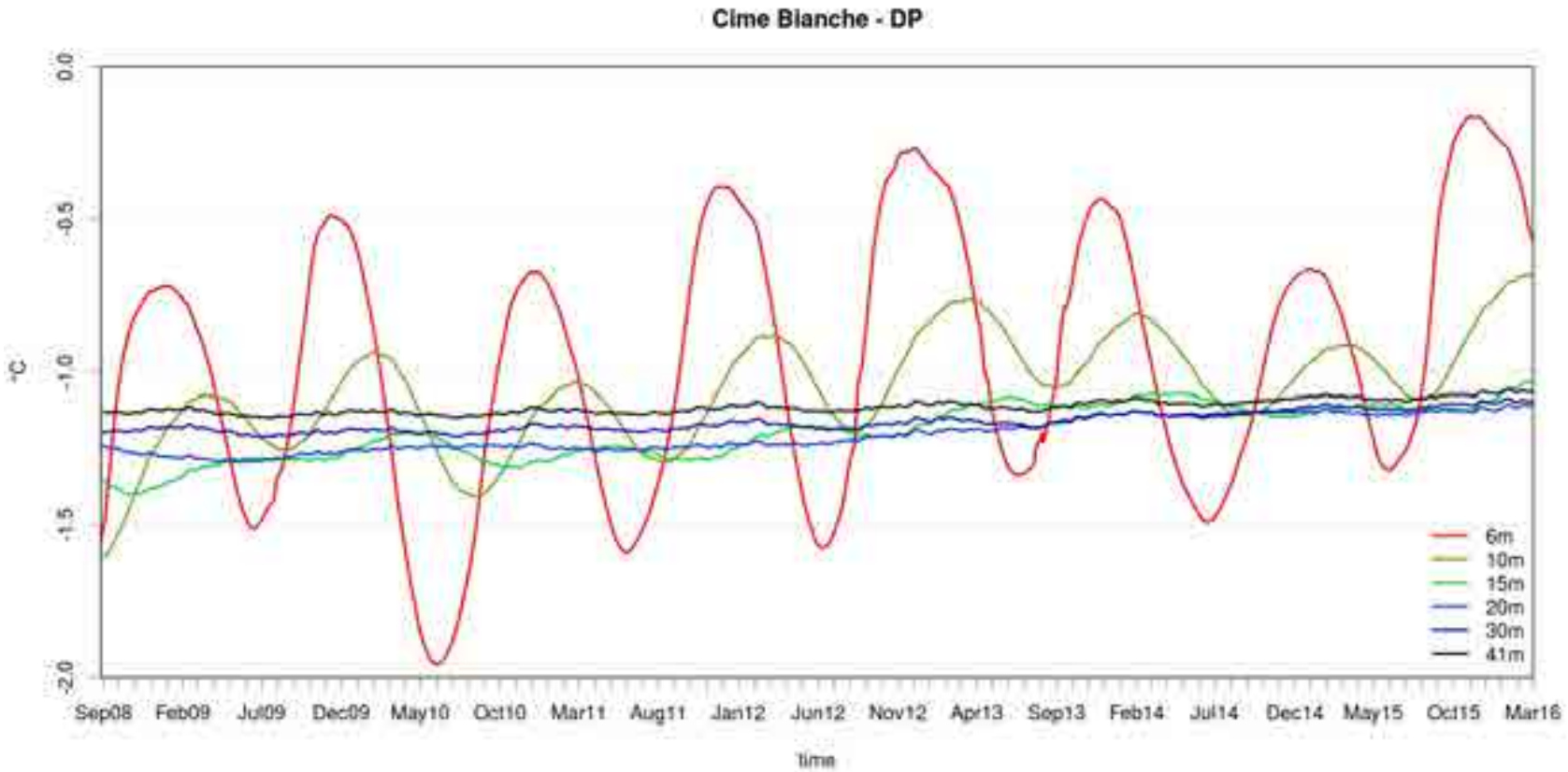
# Borehole SH (from 0 to 6 meters)



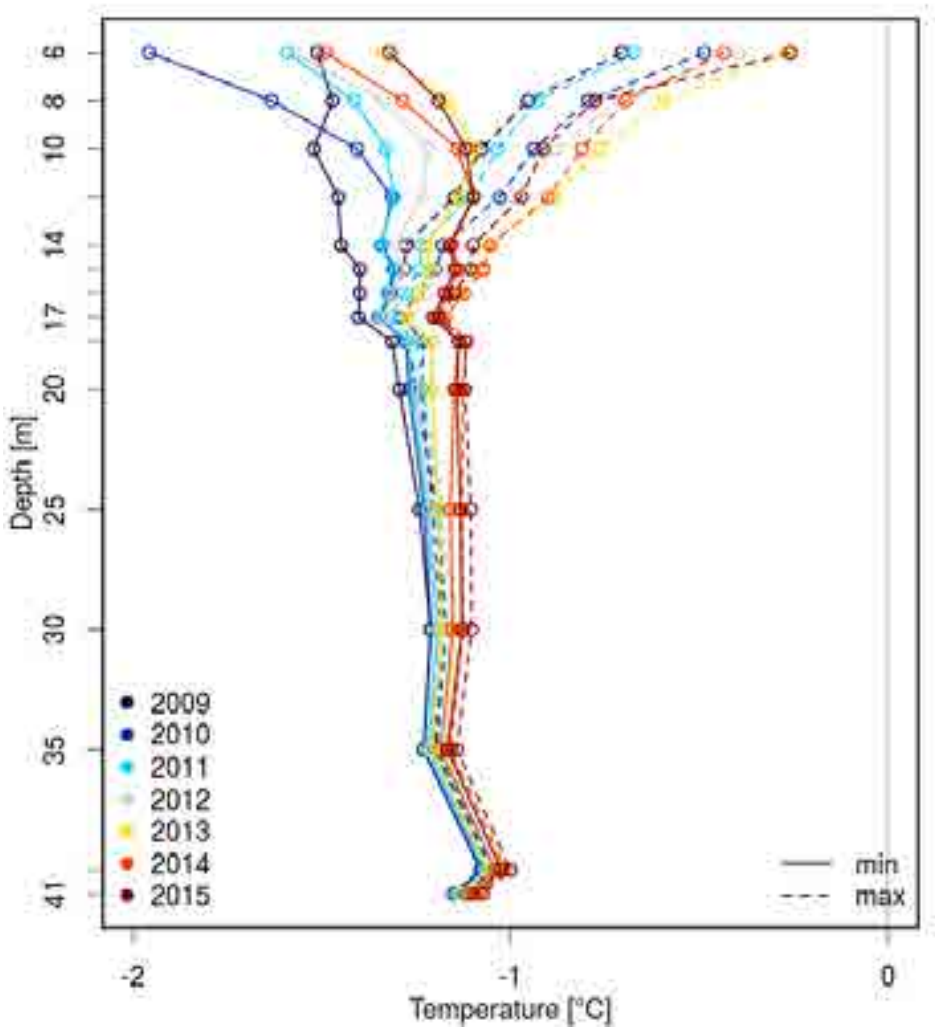
# Borehole SH (from 0 to 6 meters)



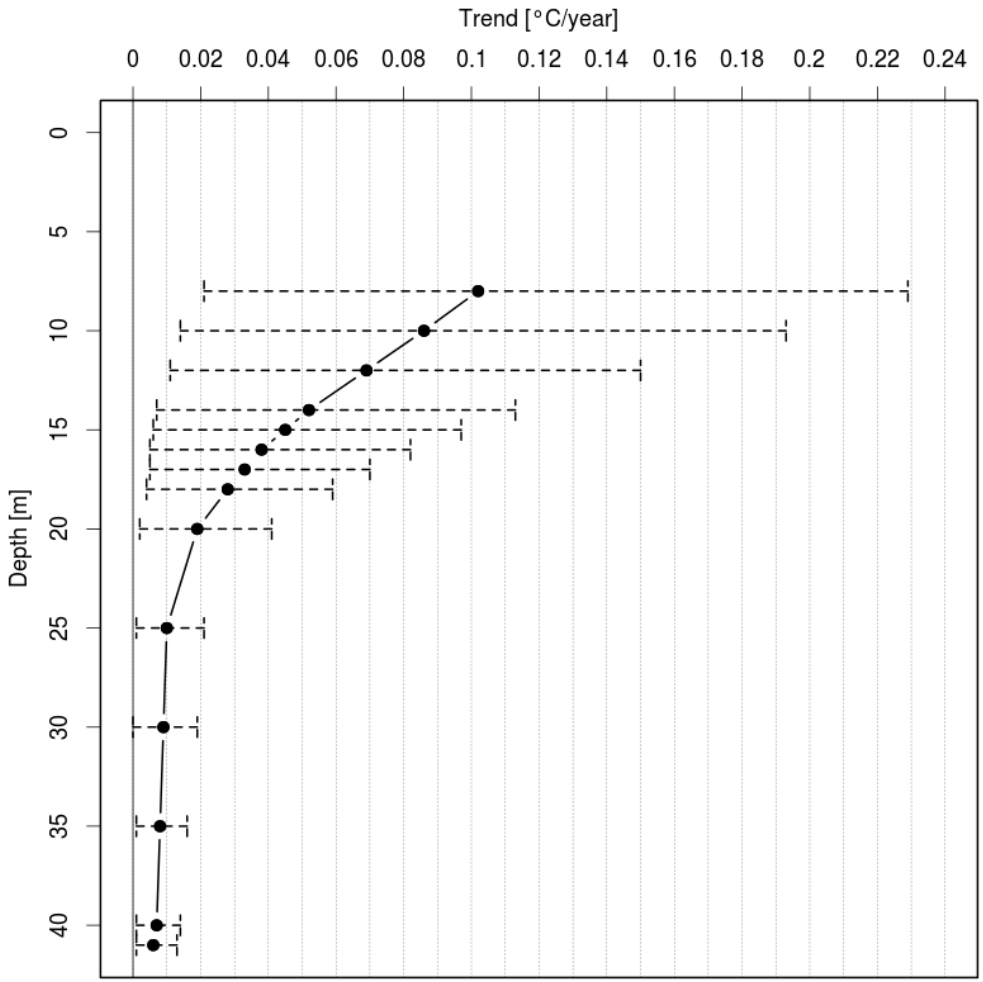
# Borehole DP (from 6 to 40 meters)



# Borehole DP (from 6 to 40 meters)



# Borehole DP (from 6 to 40 meters)



# Cime Bianche

## Conclusions

- The permafrost at Cime Bianche is degrading at significative rates below 8 meters.
- Warming trend decrease with depth then seems that heat comes from the top to the bottom of permafrost table
- If trend are confirmed to be real, after a re-calibration experiment planned for next summer, permafrost may retreat below 8/10m during the next 10 years.
- It is reasonable to assume that what we observe at Cime Bianche is happening at regional scale on the southern side of the Alps.

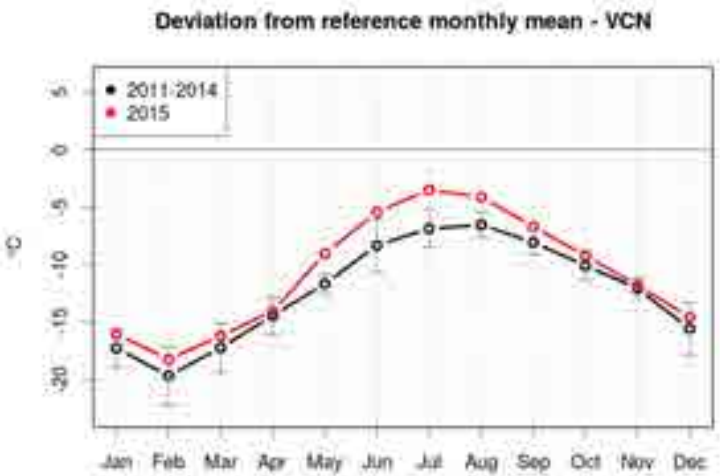
# Outline for section 2



# Capanna Carrel monitoring site (3800 m)

# Matterhorn Summit monitoring site (4450 m)

# GST monthly mean anomaly of 2015



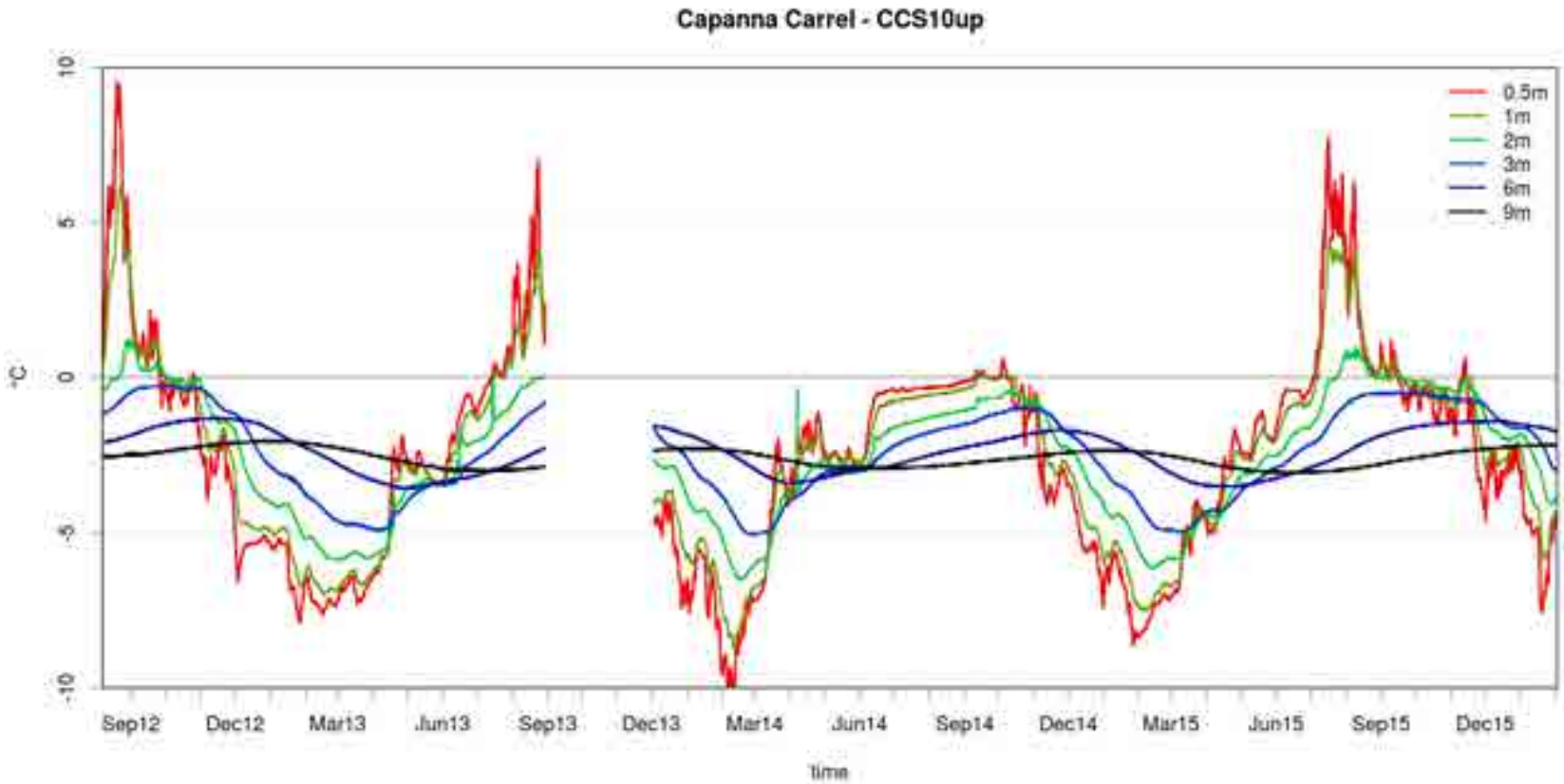



# Matterhorn - GST

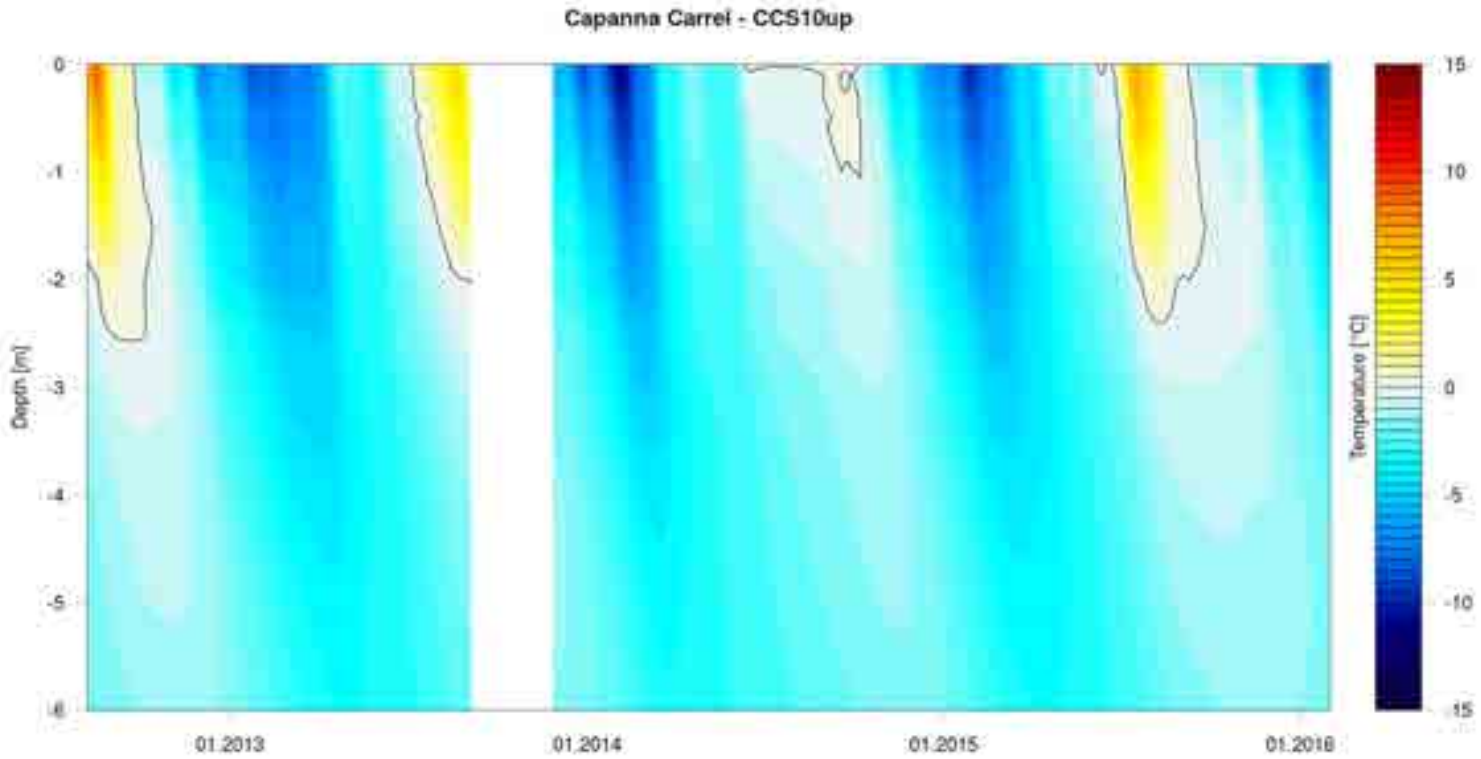
## Conclusions

- The GST are relatively simple measures that, given an observation base of some years, can provide useful indications on the real-time status of rockwall thermal regime.
- If the GST loggers are equipped with GPRS module for the daily data transmission, they may be used as support for decision making by the administrators.
- What we observed in 2015 on the logger CCW suggest that during heatwaves the altitudinal limit of the 0C isotherm on cold faces can rise significantly leading to critical situations for stability. This is exactly what have been observed during summer 2015 in the Mont Blanc massif by Ravanel: an increase in the elevation of rockfall trigger zone on cold faces.

# Deep Boreholes (10m) and ALT

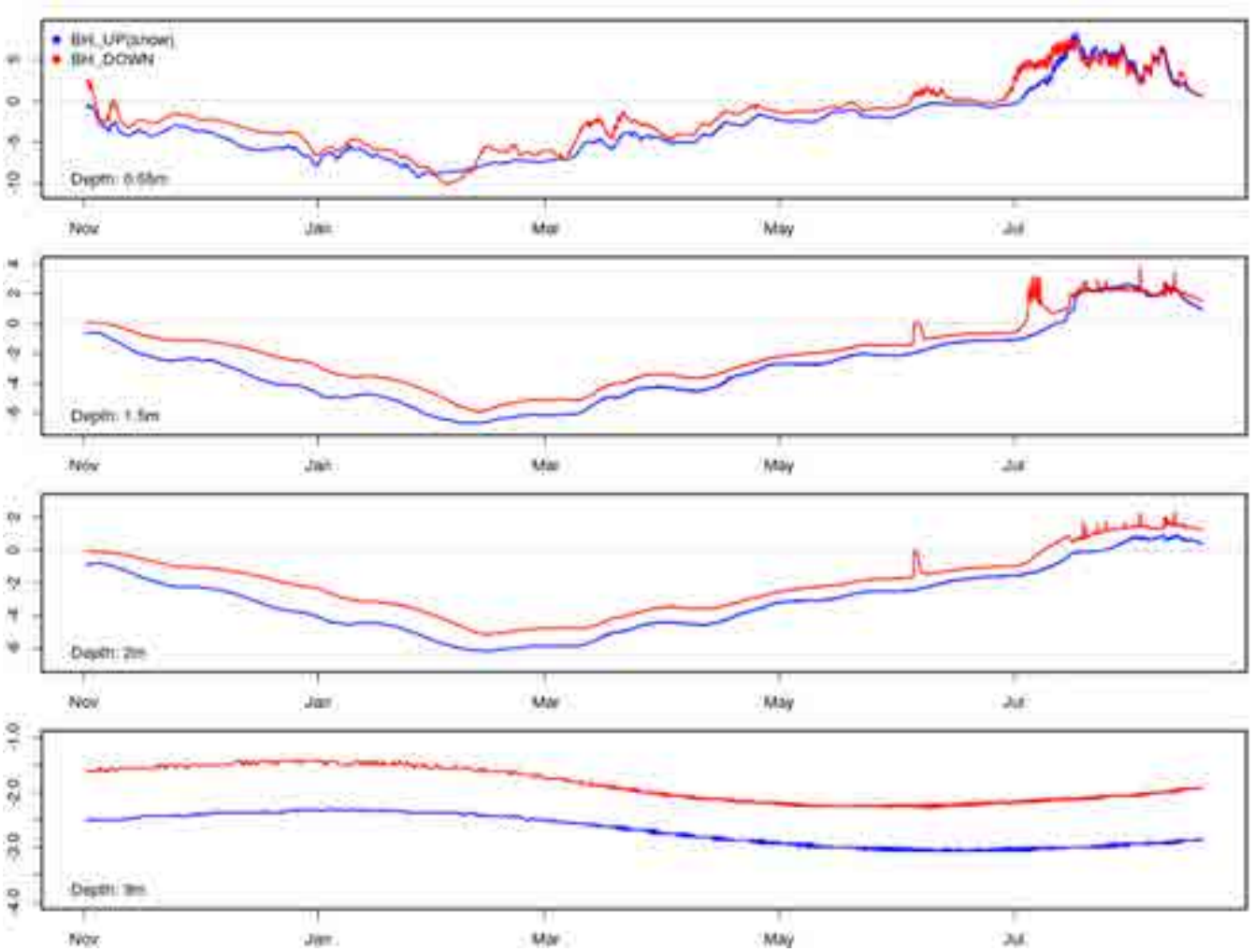


# Deep Boreholes (10m) and ALT




2012,2.5m
2013,2.0m
2014,1.0m
2015,2.4m

# Effect of thin and persistent snow cover



# Matterhorn - Boreholes

## Conclusions

- The experiment started in 2011 to explore the super-cooling effect of snow cover in steep rock walls is starting to show encouraging results.
- The instrumentation of the two boreholes on the west face will allow to quantify this effect also on a cold face.
- This findings have strong implications for the comprehension of permafrost distribution in steep rock walls as well as for modeling deep temperatures.

# Thanks for your attention!!

## Bibliography

- Pogliotti, Guglielmin, Cremonese, Morra di Cella, Filippa, Pellet, Hauck (2015).
Warming permafrost and active layer variability at Cime Bianche, Western European Alps.
The Cryosphere, 9(2), 647-661.

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Use of UAS in a High Mountain Landscape: the Case of Gran Sommetta Rock Glacier (AO).
The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 40(3), 391.