DRY ANDES RESEARCH

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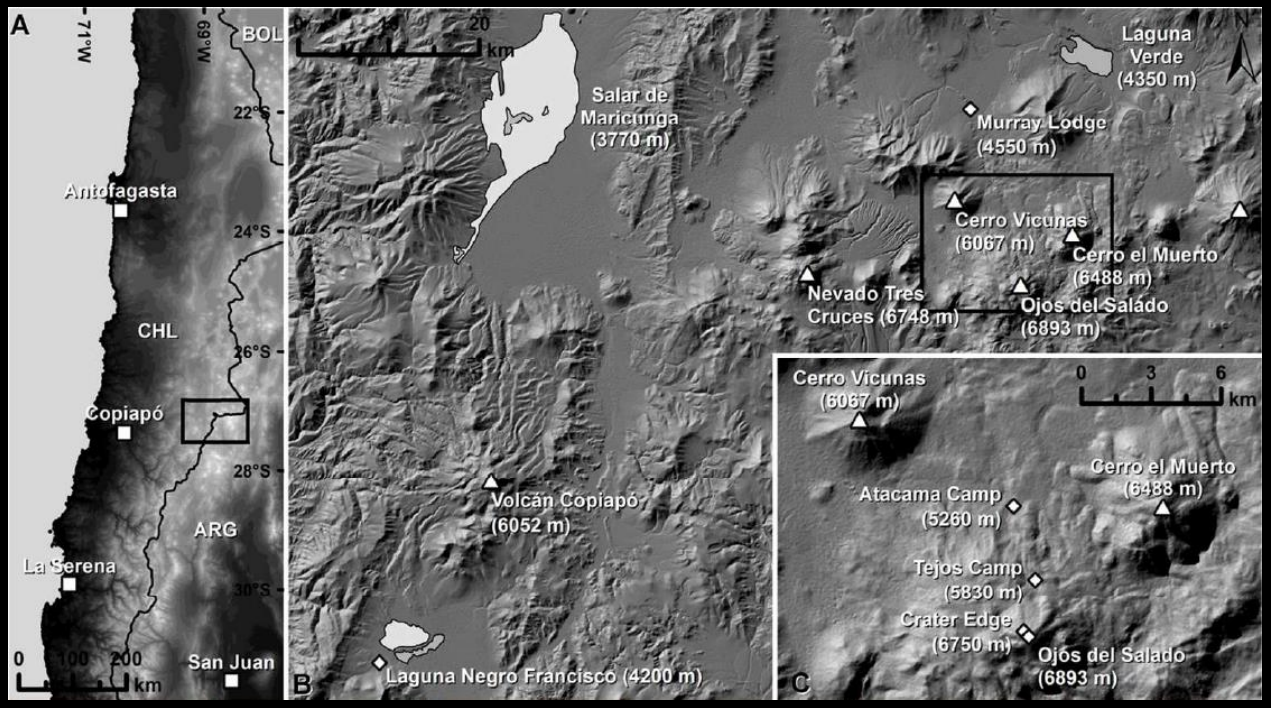
GROUND TEMPERATURE MONITORING IN THE EARTH'S HIGHEST MOUNTAIN DESERT

thermal regime and ground ice on the Ojos del Salado (6893 m) 2012 2018

- representative location for the arid Andes
- wide high-altitude section (4200-6893 m asl.)
- relatively good accessibility

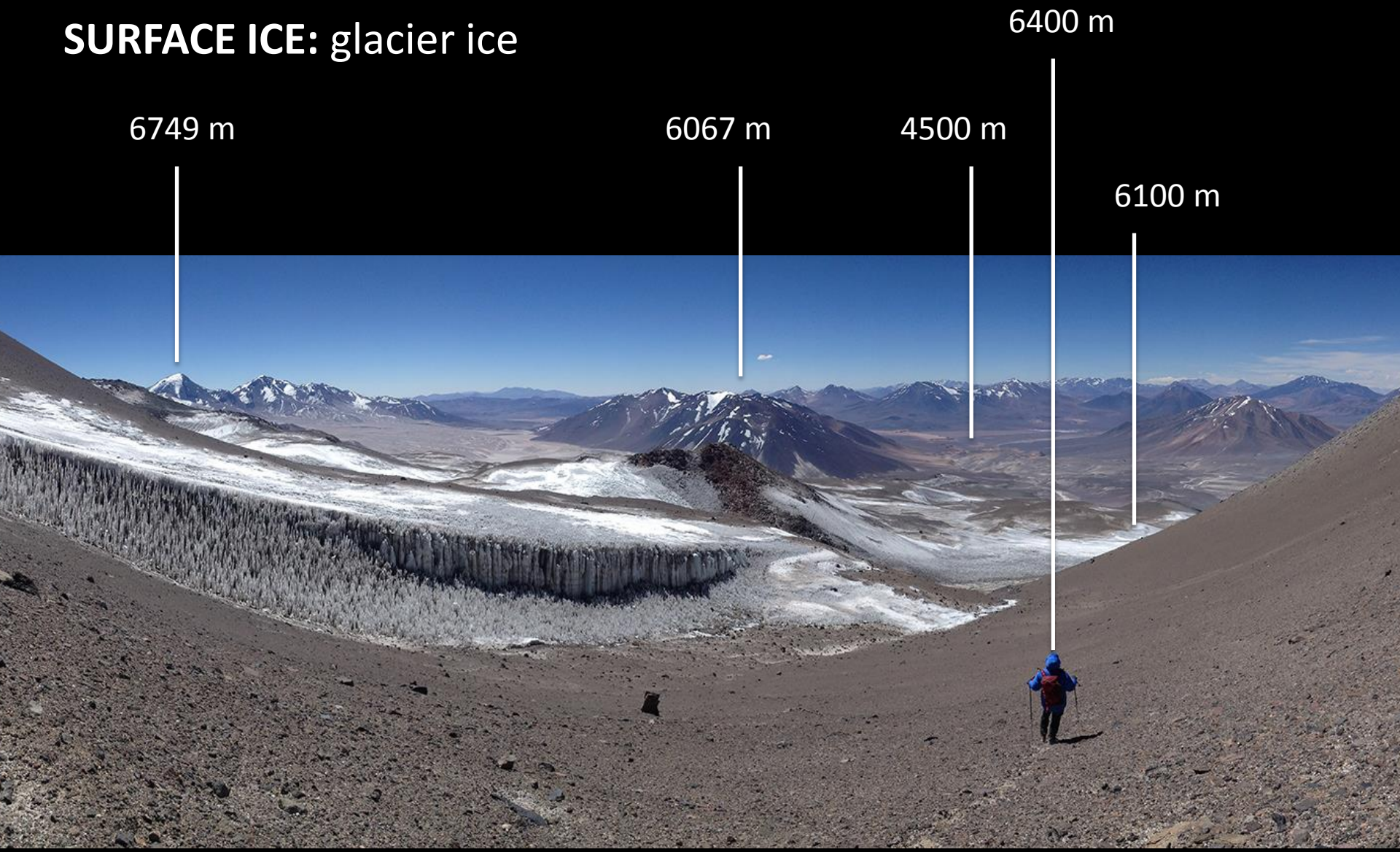
- high mountain massifs - “frozen water towers” of the desert
- water-reserves: in solid state, underground ice



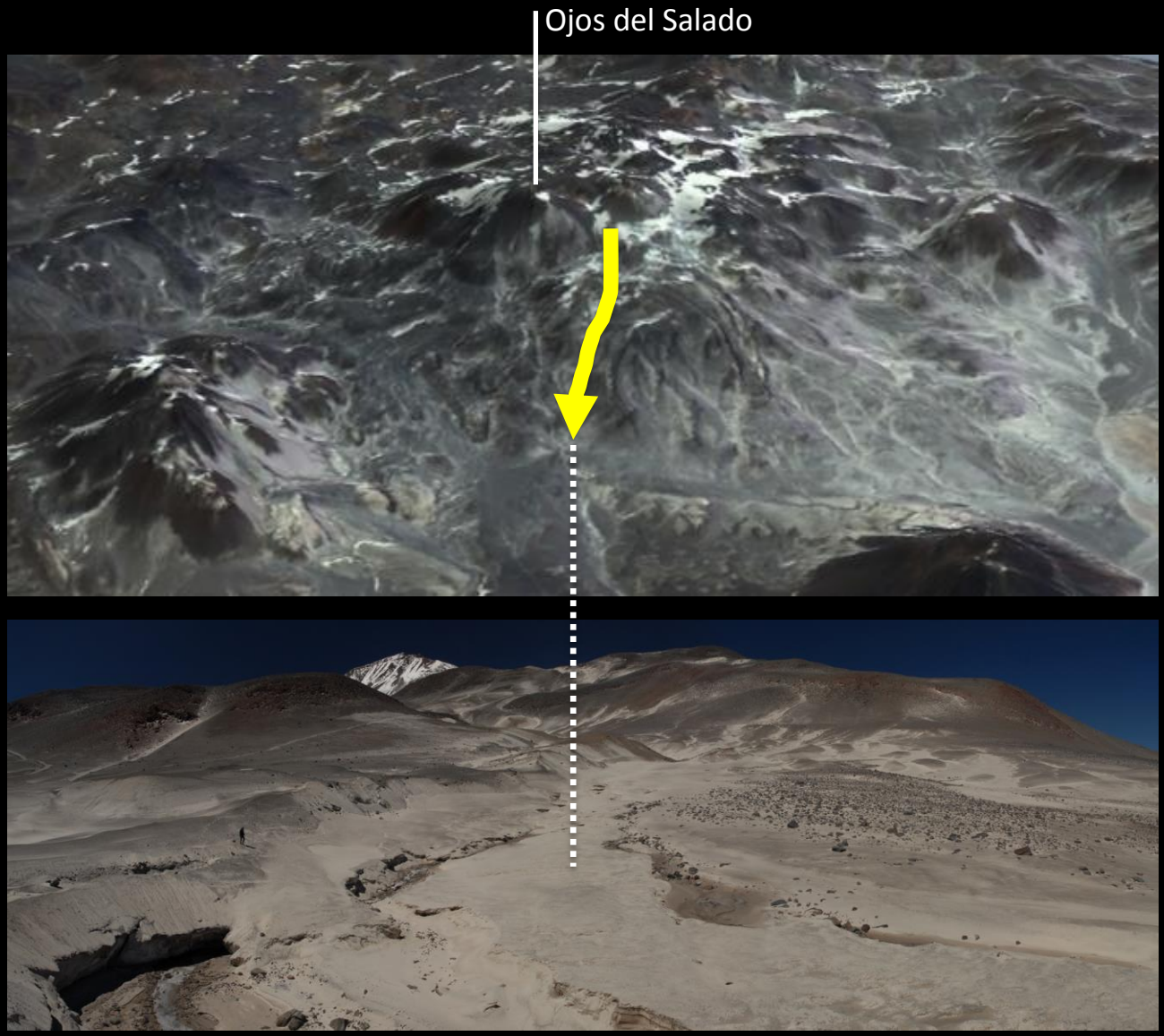
REPRESENTATIVE LOCATIONS – FIELD DATA COLLECTION – MONITORING – DATA ANALYSES – MODELLING – PREDICTING FUTURE PROCESSES

ICE IN THE MOUNTAIN DESERT

SURFACE ICE: glacier ice



Where are the moraines of the glacier-tongue?
When were the last advances of the local glacier?



METHOD: luminescence dating

- the post-IR IRSL-225 method was applied on coarse grained K-Fsp separates of the samples (grain size was mainly between 150-200 microm)
- the dose rate was measured by using a gamma-spectrometer

RESULTS (refinement is in progress)

- older moraines: 18.8 ± 1.0 ka
- younger moraines: 5.2 ± 0.3 ka

SURFACE ICE: lake ice


36 C
1 C
6500 m

GROUND ICE: buried ice

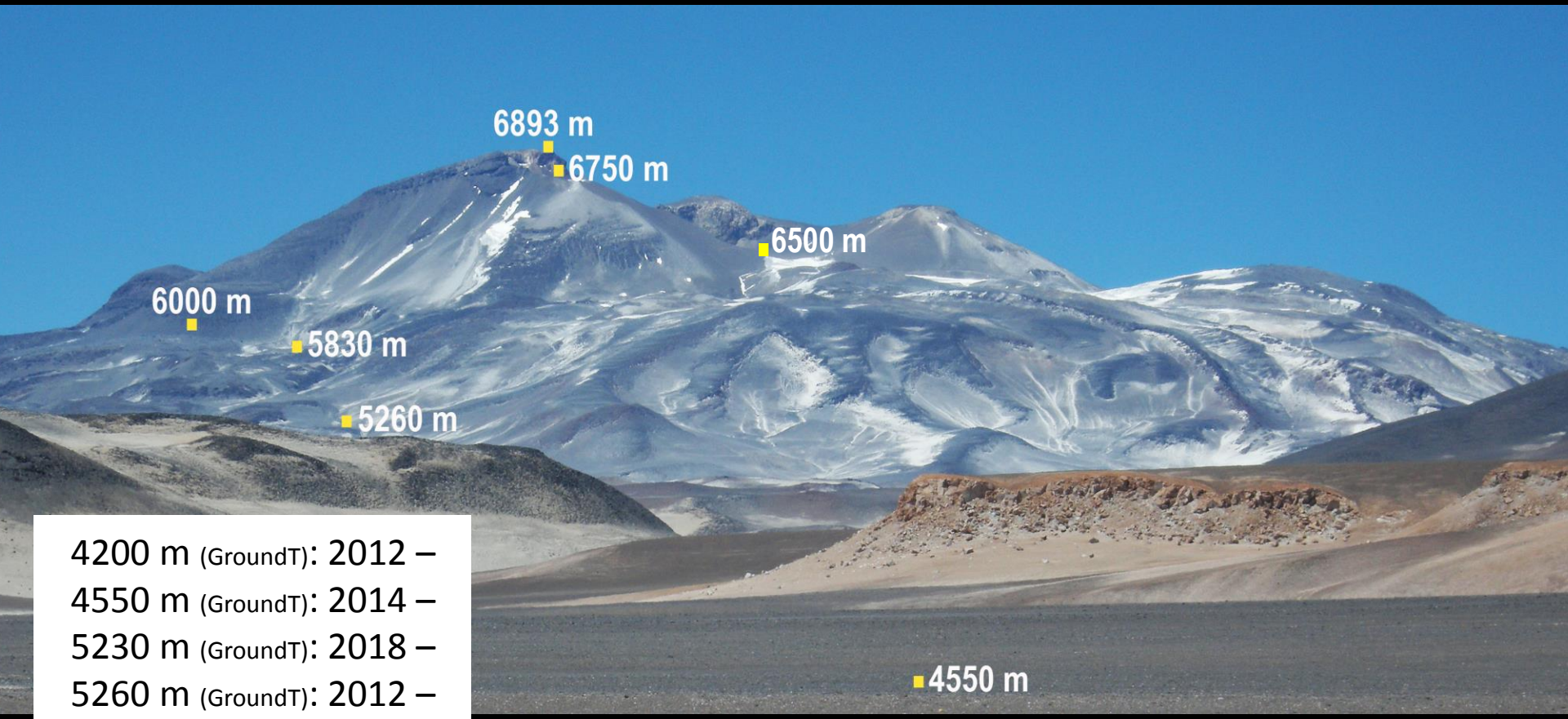
from buried snow, firn, frozen water

2014

2016

2018

GROUND ICE: pore ice (“ice cement”)



4200 m (GroundT): 2012 –
4550 m (GroundT): 2014 –
5230 m (GroundT): 2018 –
5260 m (GroundT): 2012 –
5830 m (GroundT): 2012 –
6000 m (AirT): 2014 –
6500 m (GroundT): 2016 –
6750 m (GroundT): 2012 –
6893 m (GroundT): 2012 –

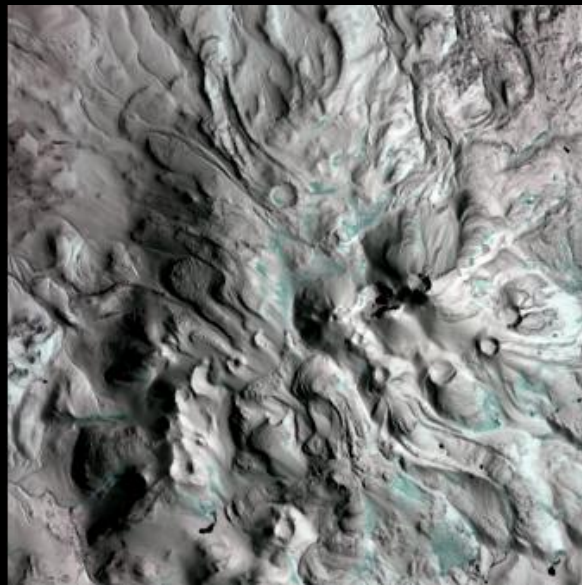
SHALLOW GROUND TEMPERATURE MEASUREMENTS (4200 – 6893m a.s.l.)

METEOROLOGICAL MEASUREMENT

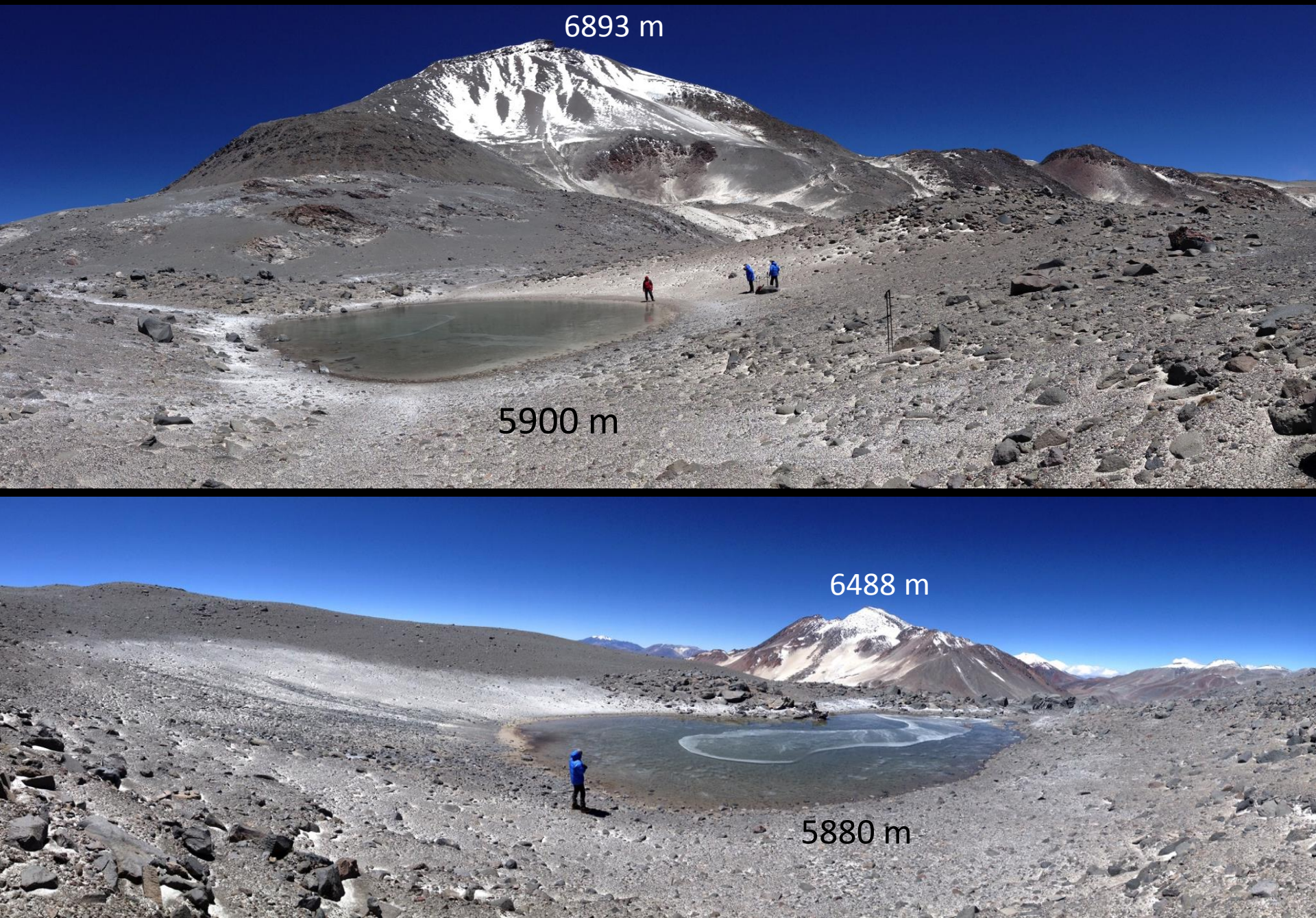
VERTICAL ELECTRIC SOUNDING

SEDIMENT SAMPLES

REMOTE SENSING



Importance of meltwater: high-mountain lakes

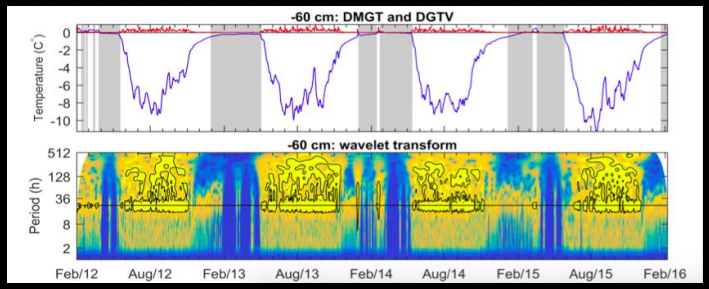


Importance of meltwater: streams + periglacial slope processes

Geostatistical data-analyses:

wavelet transformation

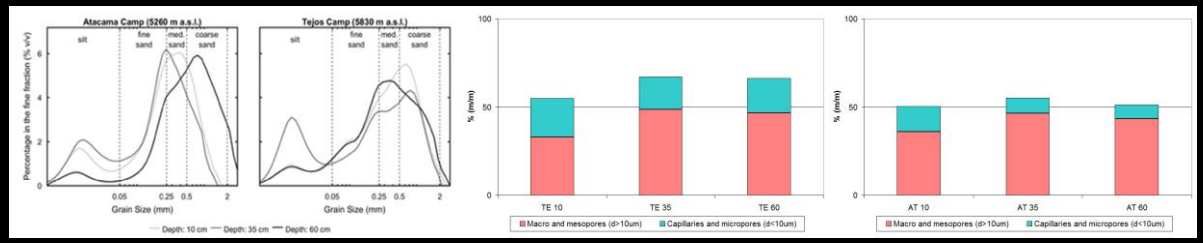
daily periodic behavior of ground temperature



Sediment-analyses:

particle size distribution, porosity, hygroscopicity

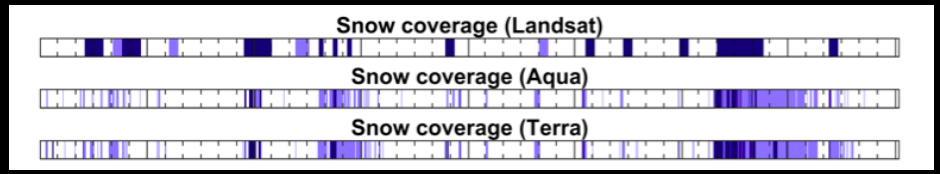
defining the water/ice retention capability and the flow of liquid water



Snowcover-analyses:

Landsat + MODIS

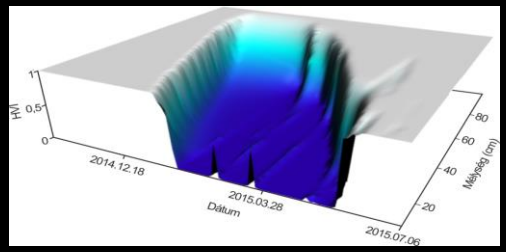
determination of insulating effect of local snow-cover



Model-development:

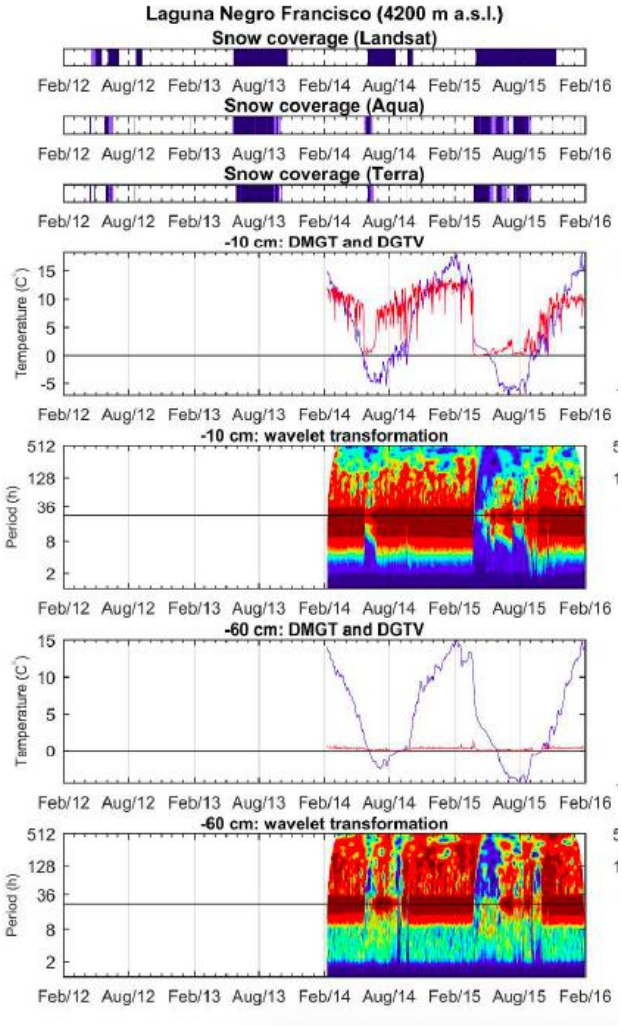
Comsol Multiphysics® finite-element modeling

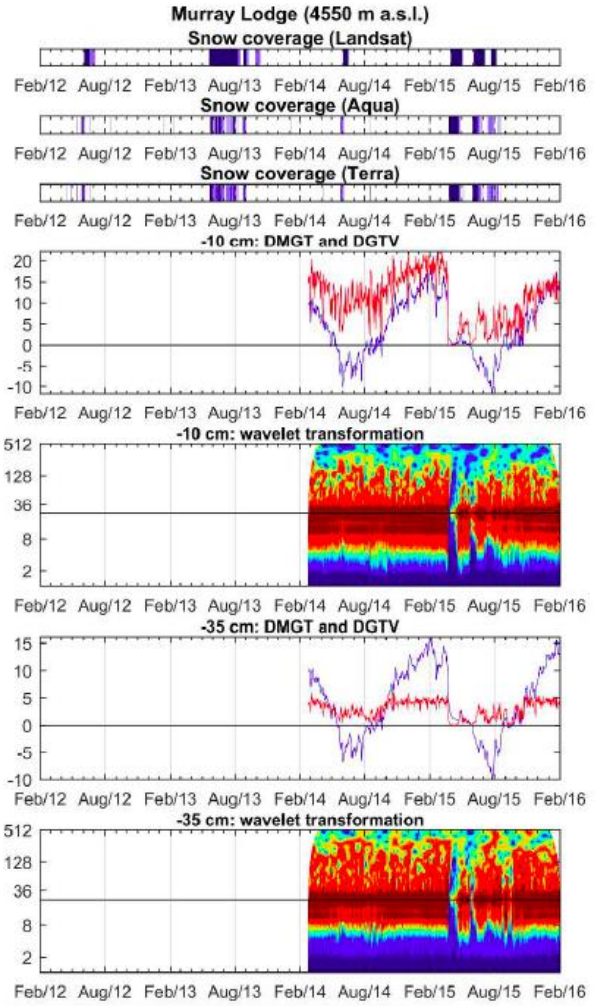
determination of the temporal changes of water/ice phases



4200 m

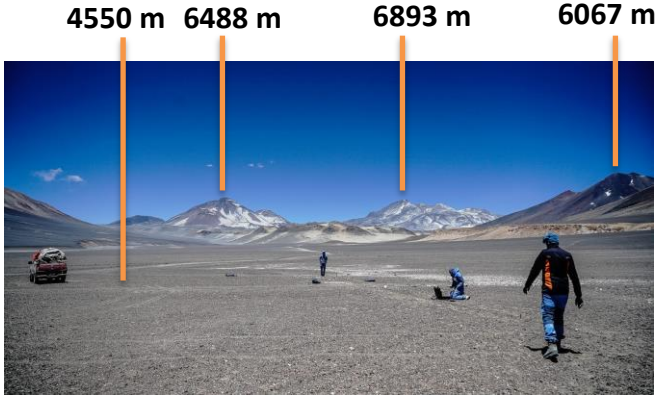
AMGT
-10 cm 6.3°C
-60 cm 5.9°C



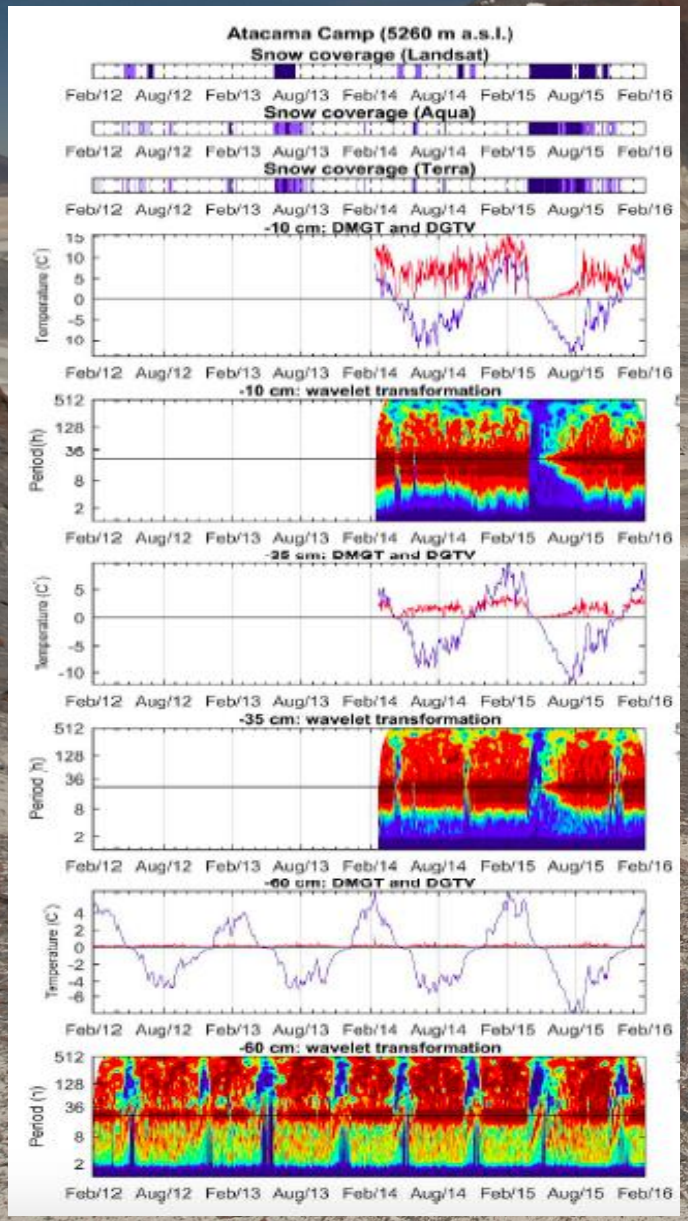


4550 m

AMGT
-10 cm 4.8°C
-35 cm 4.7°C



6067 m



5260 m

AMGT

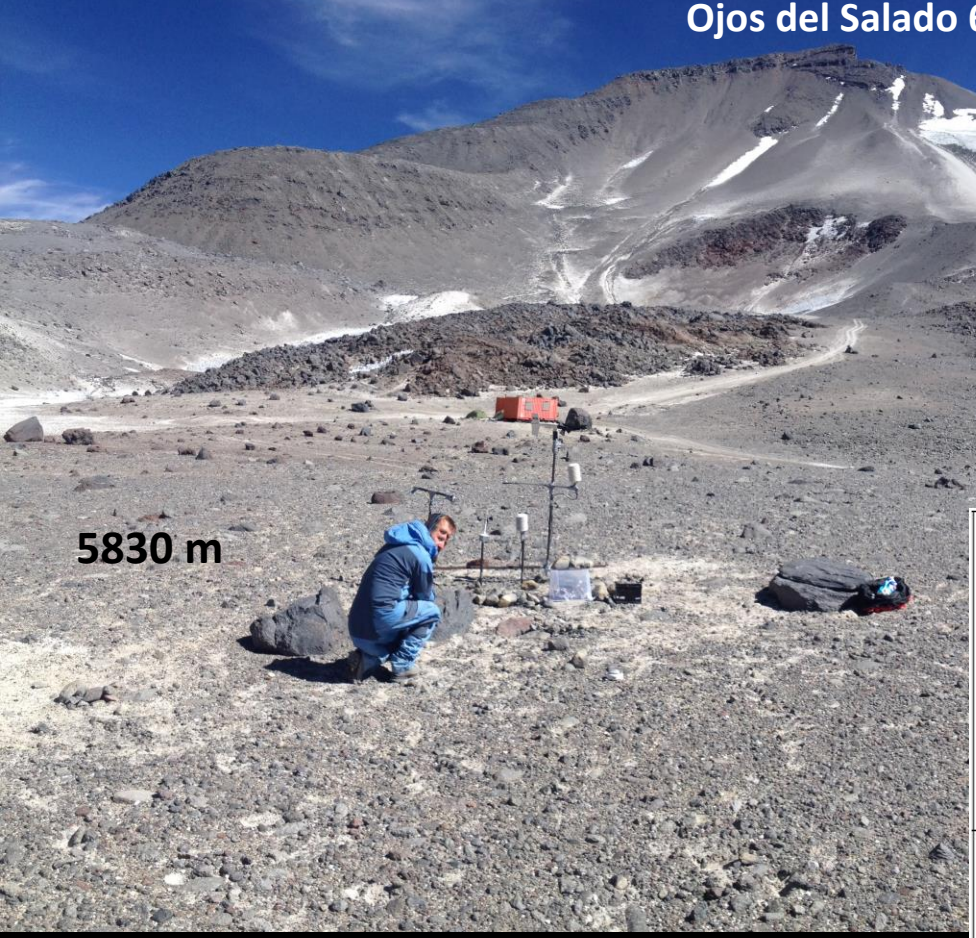
-10 cm: -0.7 °C

-35 cm: -0.4 °C

-60 cm: -0.38 °C

5260 m

Ojos del Salado 6893 m



5830 m

AMGT

-10 cm: -3.7 °C

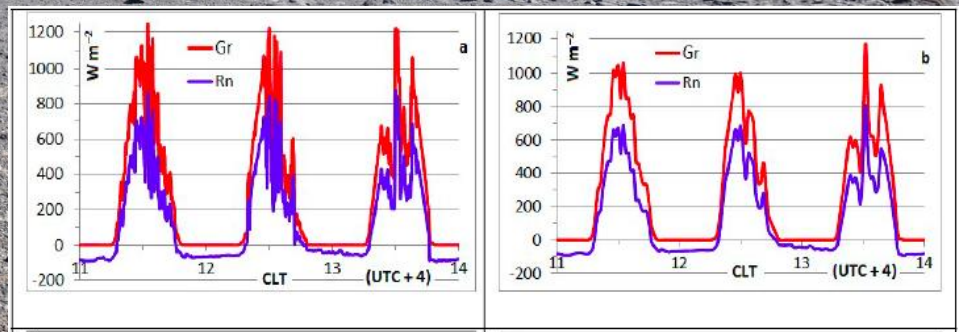
-35 cm: -3.5 °C

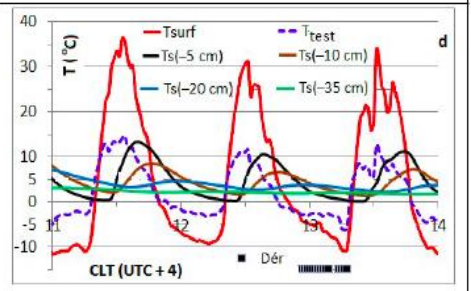
-60 cm: -3.3 °C

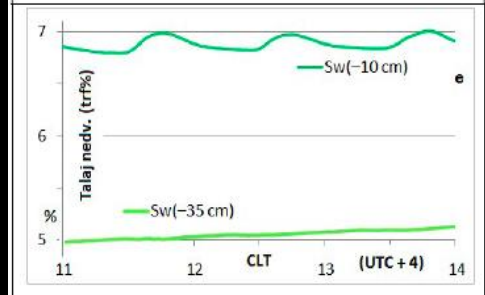
AMAT

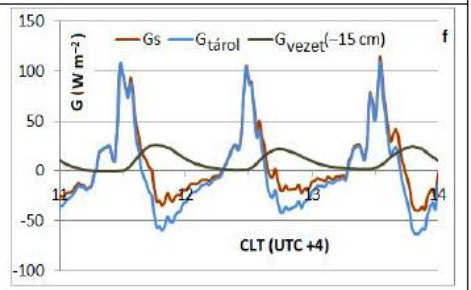
6000 m

200 cm: -10.2 °C

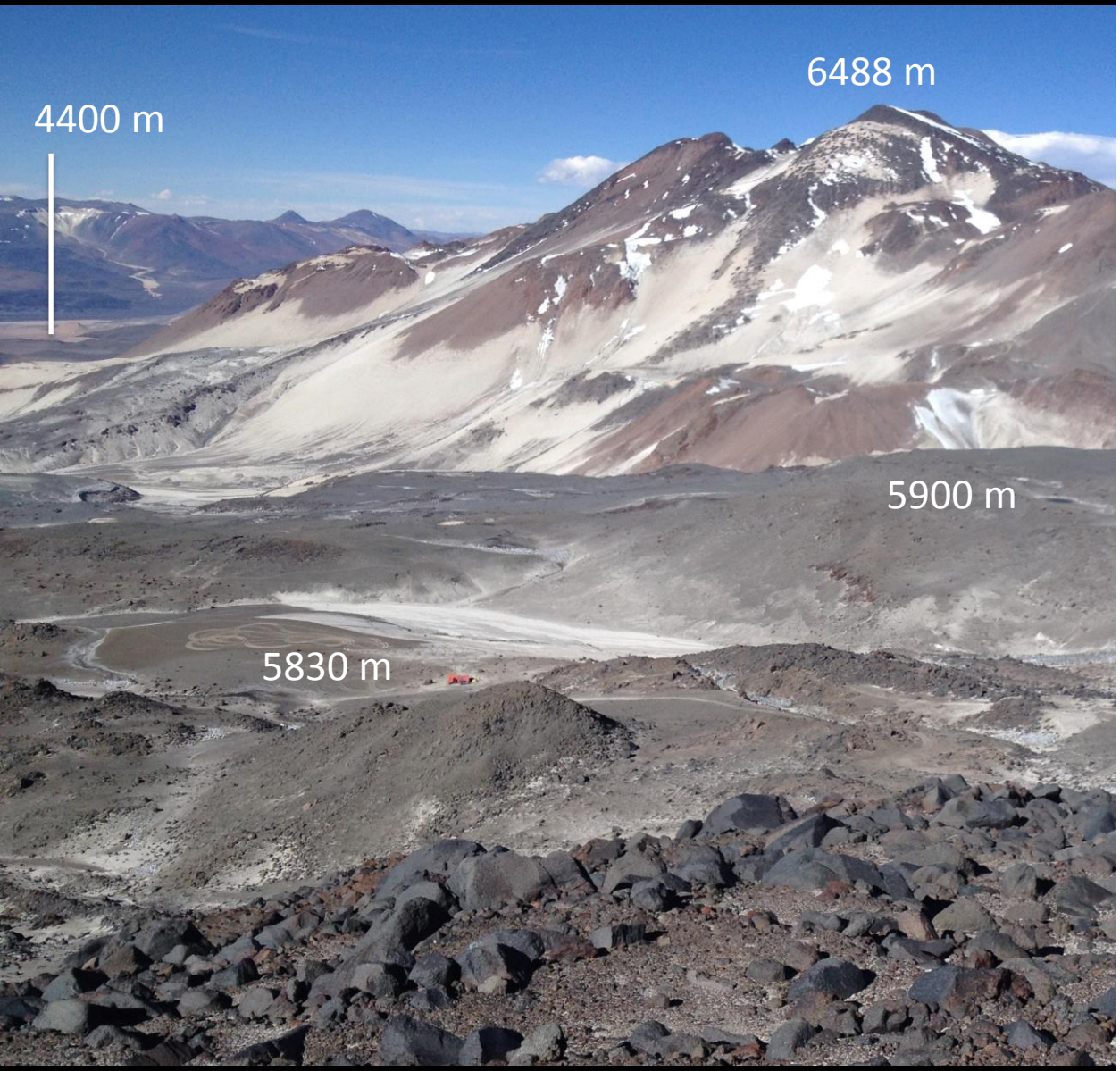


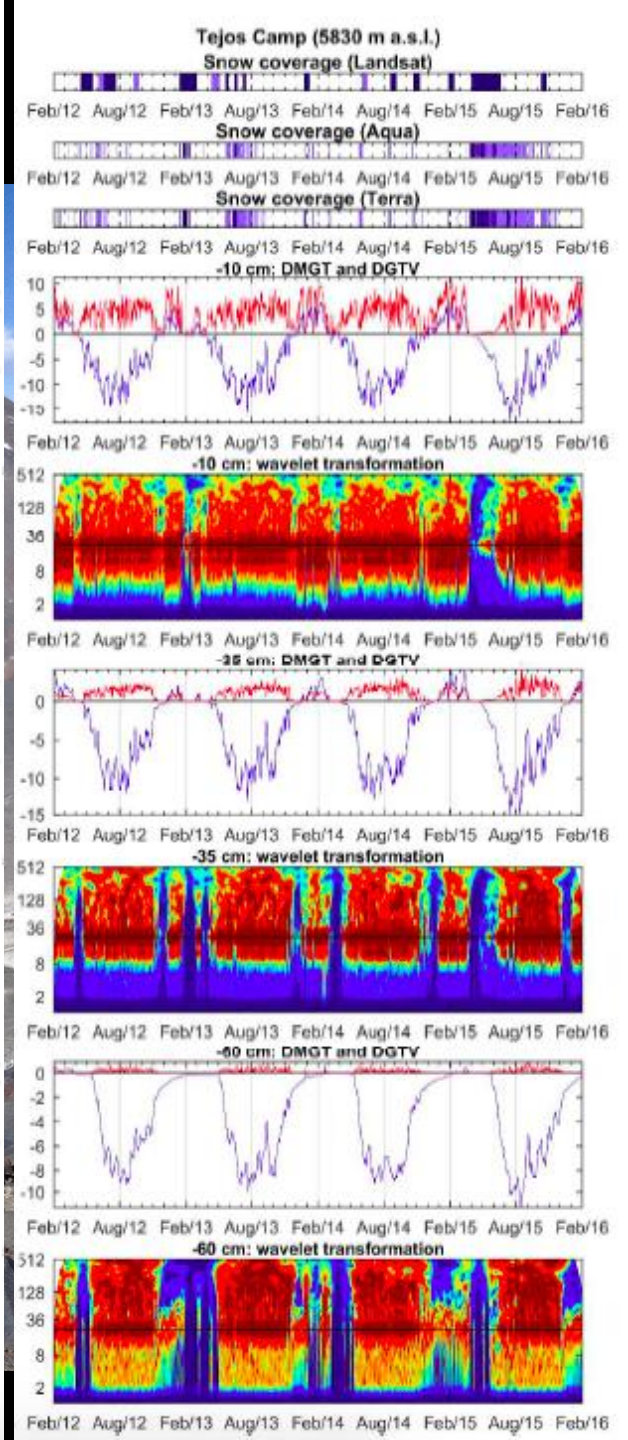




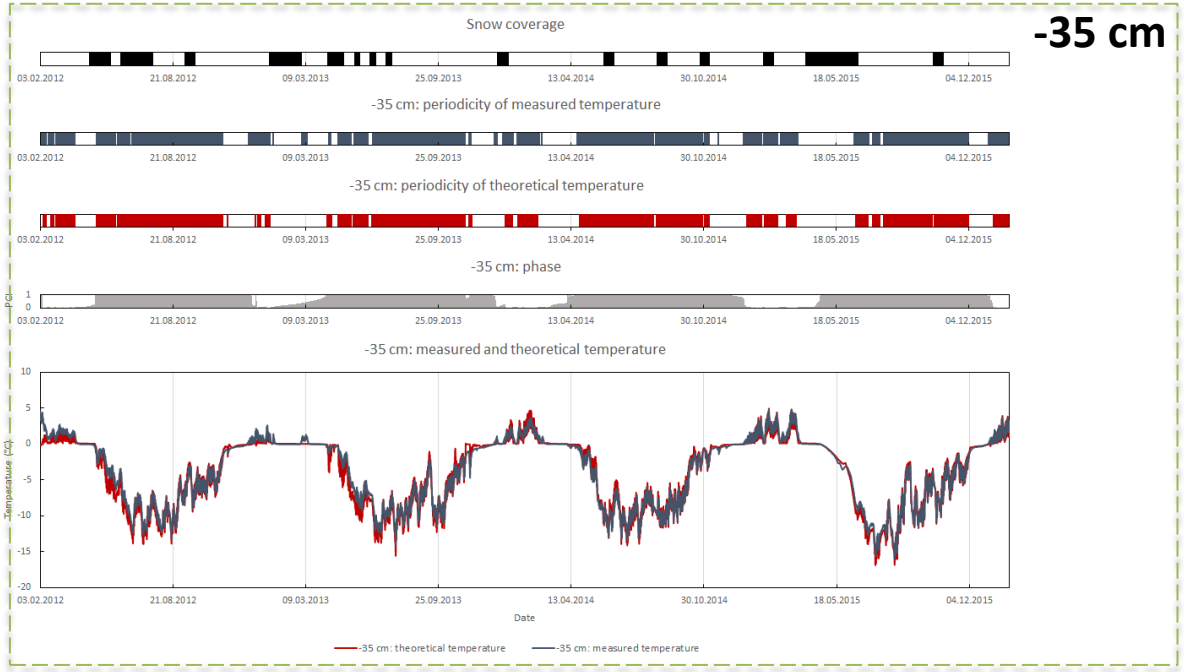


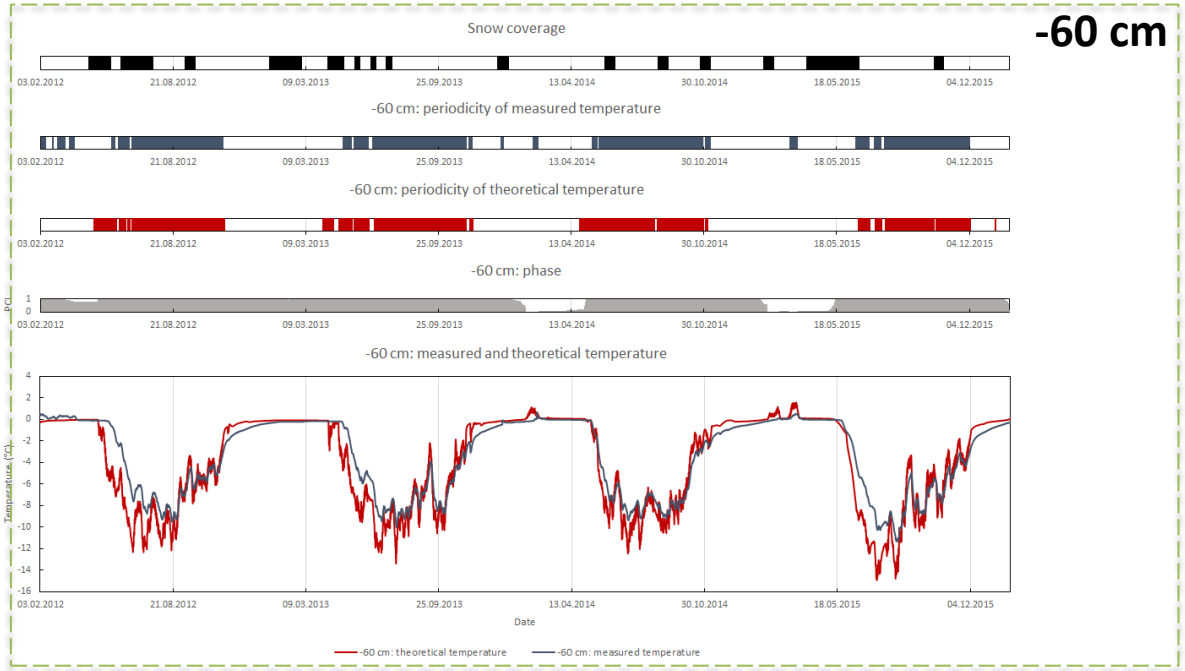
5830 m


6488 m
4400 m
5900 m
5830 m

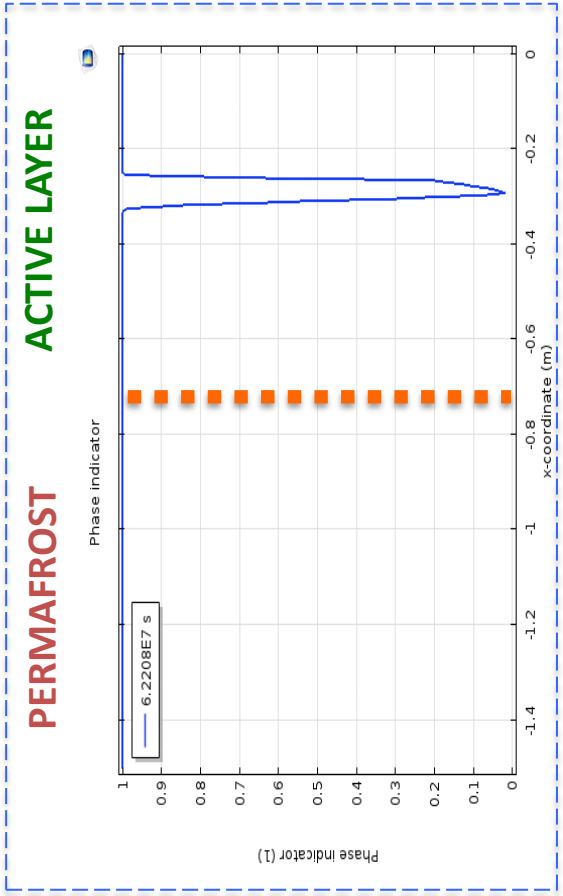

Tejos Camp (5830 m a.s.l.)
Snow coverage (Landsat)
Snow coverage (Aqua)
Snow coverage (Terra)
Feb/12 Aug/12 Feb/13 Aug/13 Feb/14 Aug/14 Feb/15 Aug/15 Feb/16
-10 cm: DMGT and DGTV
Temperature (C°)
-10 cm: wavelet transformation
Period (h)
-35 cm: DMGT and DGTV
-35 cm: wavelet transformation
-60 cm: DMGT and DGTV
-60 cm: wavelet transformation
Period (h)

5830 m

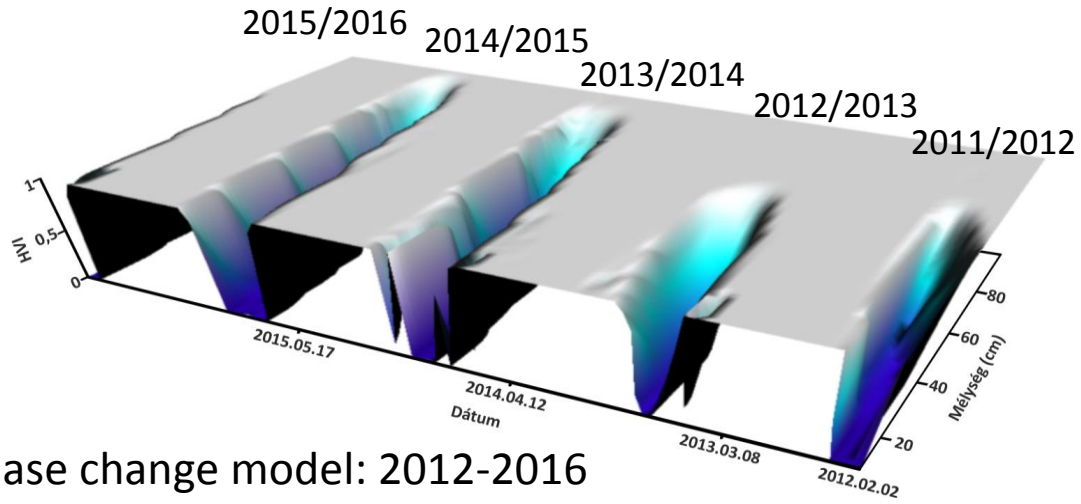




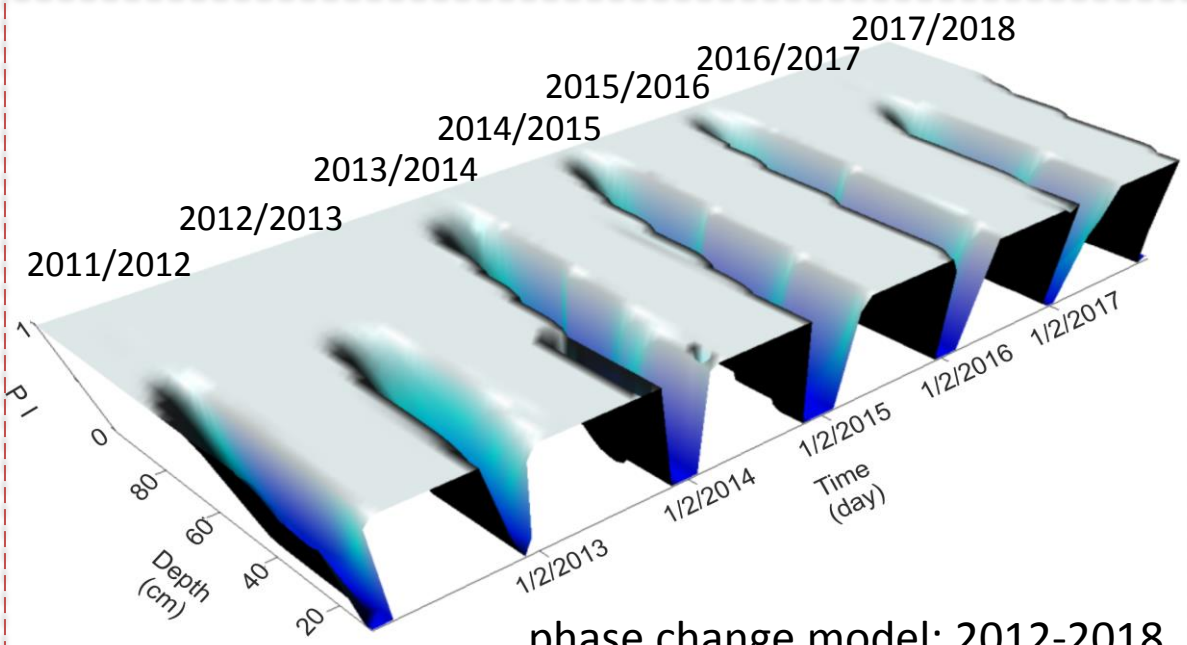
Model-development: temperature and phase changes



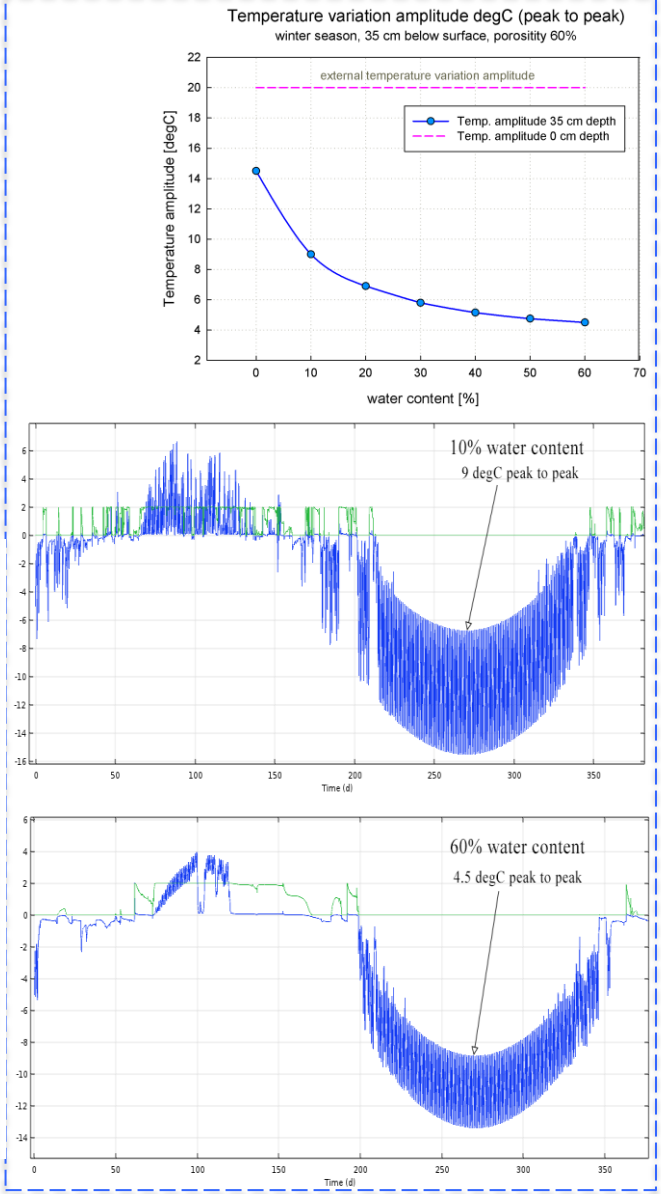
5830 m



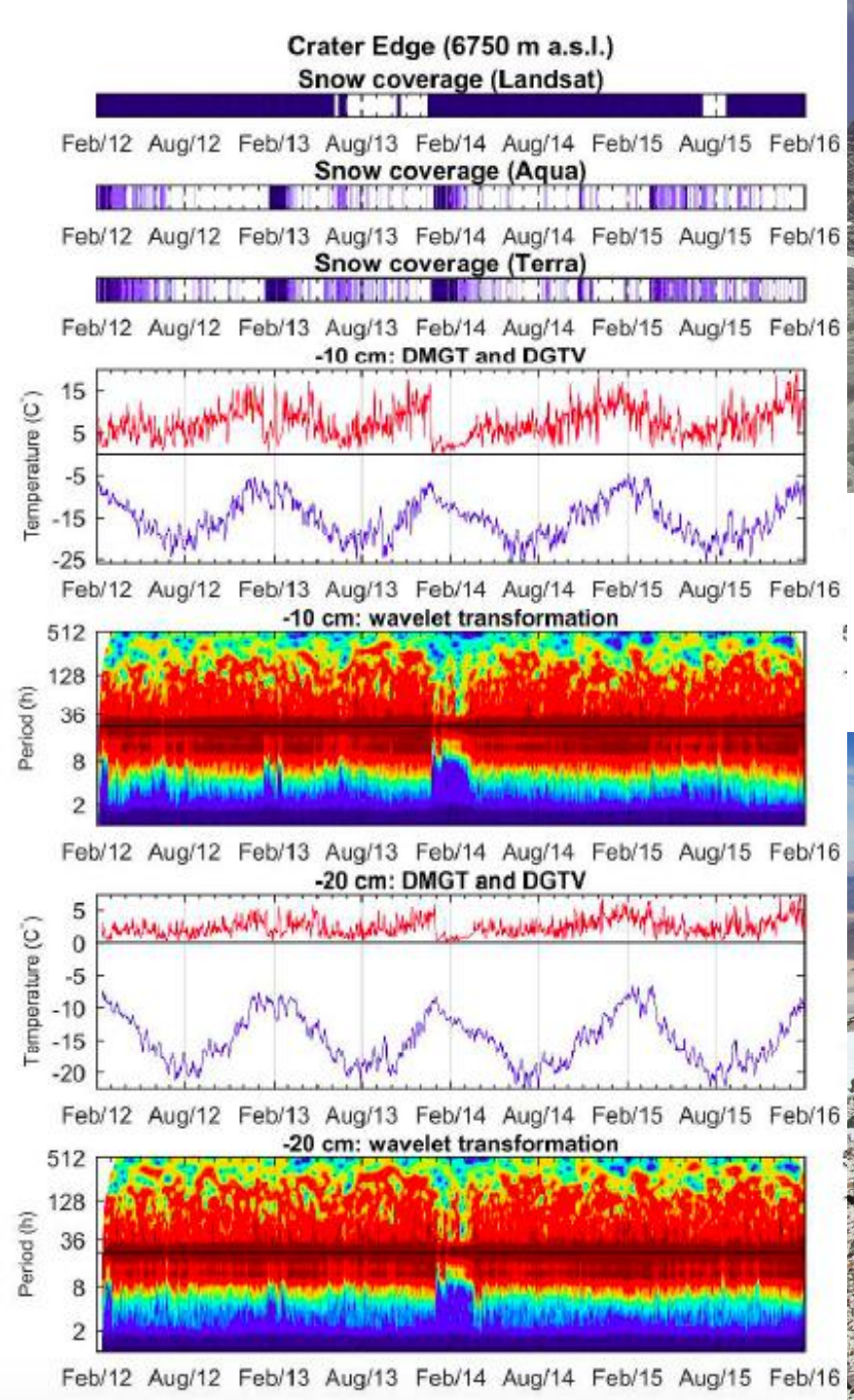
phase change model: 2012-2016



phase change model: 2012-2018

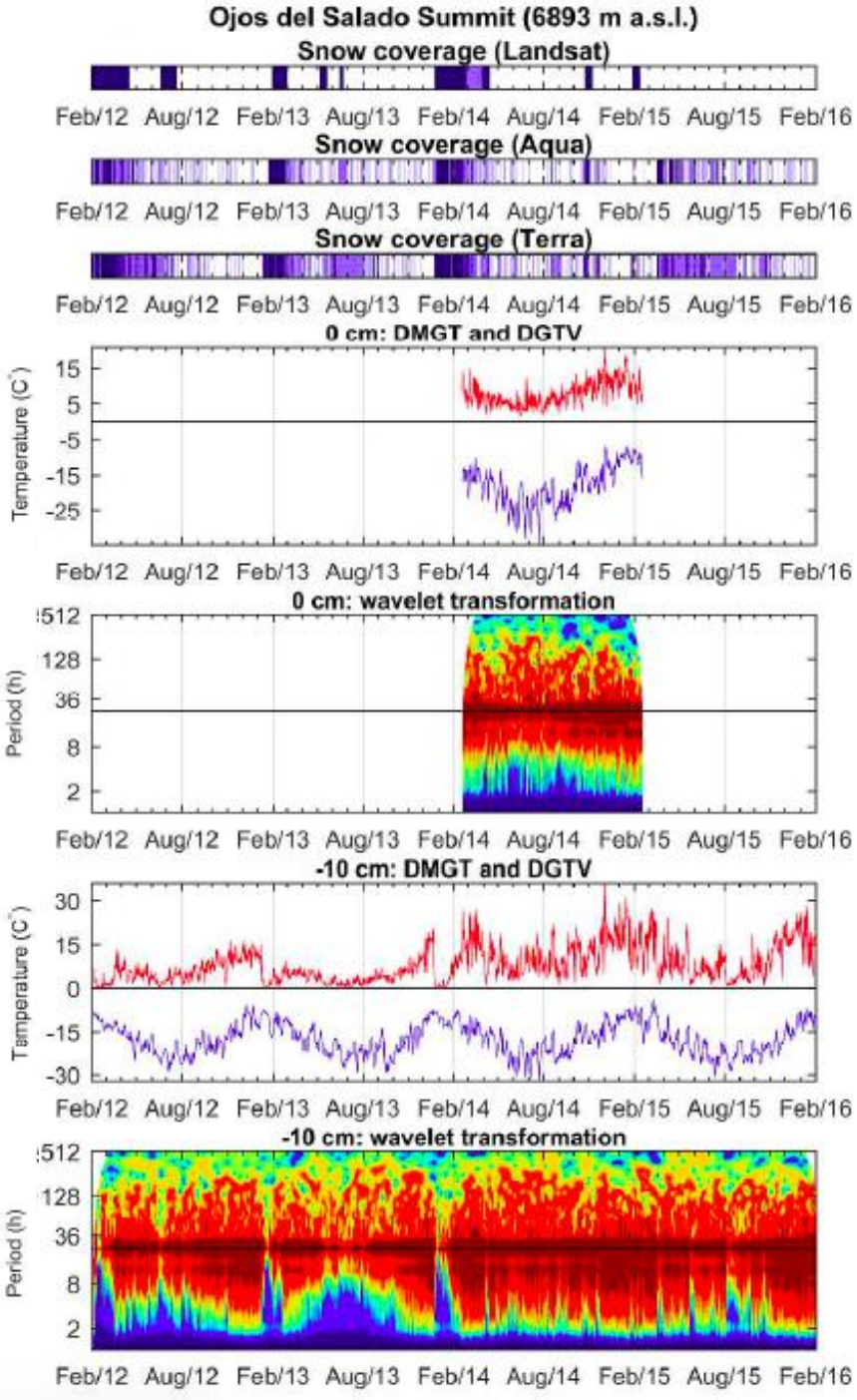


water content modelling



AMGT: -10 cm -15.2°C
-20 cm -14.8°C

6750 m



AMGT: 0 cm -18°C
-10 cm -17.6°C

6893 m

High mountain long term monitoring system:
works reliably from 4200-6893 m

Spatial distribution of the permafrost:
potential presence of ground ice
≤4550 m: unlikely
≥5260 m: possible
5860 m and above: detected

Potential moisture sources of the ground:
4200 m, 4550 m: melting snowpack
5260 m, 5830 m: thawing ground ice + melting snow
6750 m, 6893 m: melting is extremely limited

Thanks for the attention!

Wavelet transformation: new method for big data analysis in periglacial research
for the analysis of the active layer thermal processes
separate the role of snow cover and the phase changes

Thermal model: the analysis of the permafrost based “dry” regolith
for determining the ice/water phase changes of the active layer
the depth changes of the active layer
the length of the melting period
the water content of the active layer