

OSUG



# Evolution of snow melt-out date in the European Alps: what do we know about high elevations? First insights from optical imagery

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à l'Université de Genève

Atelier Neige OSUG  
« La neige vue du ciel »



**UNIVERSITÉ  
DE GENÈVE**

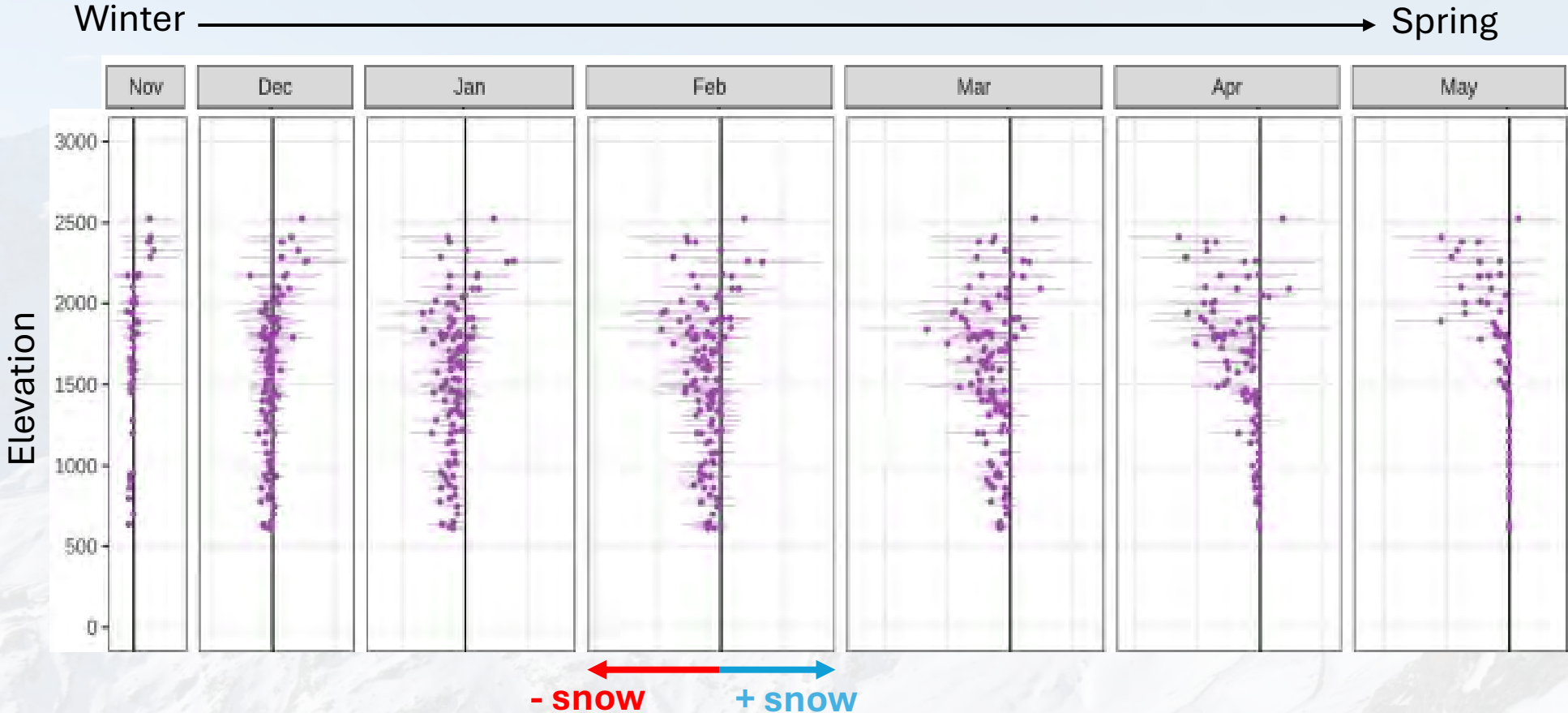




# Stating the obvious : Less snow in a warmer world ?



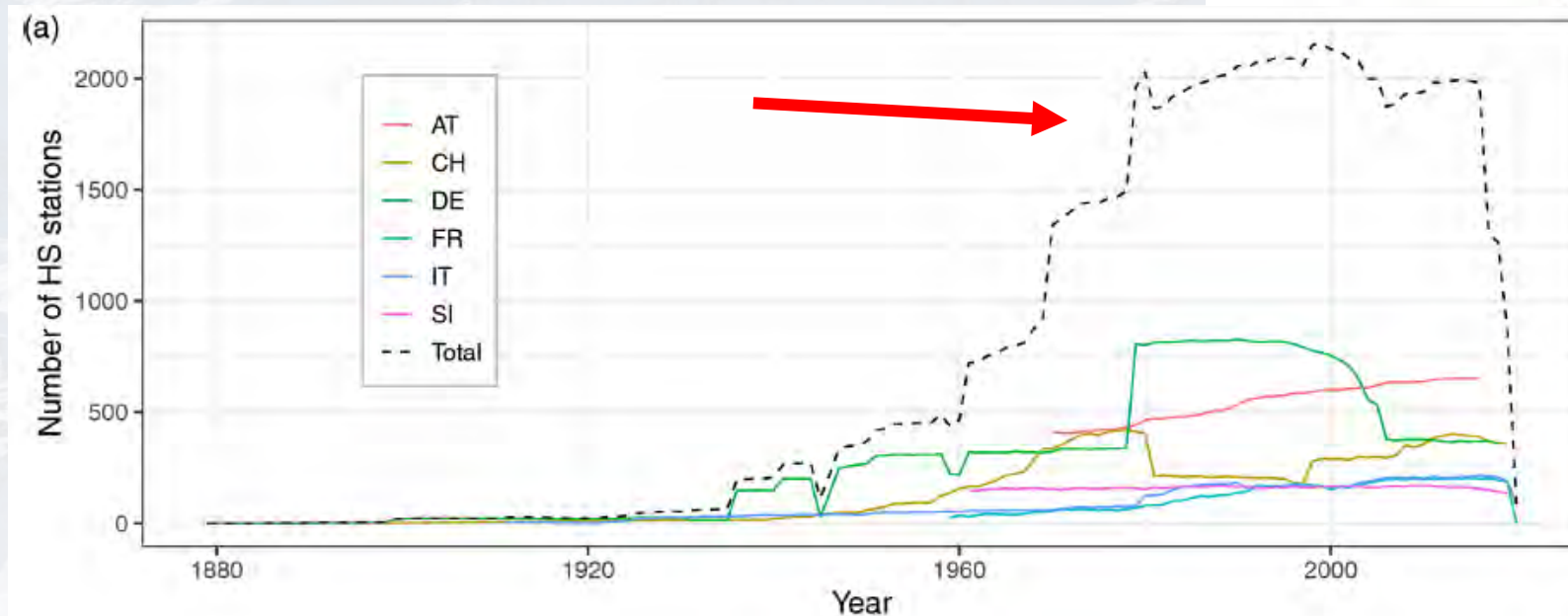
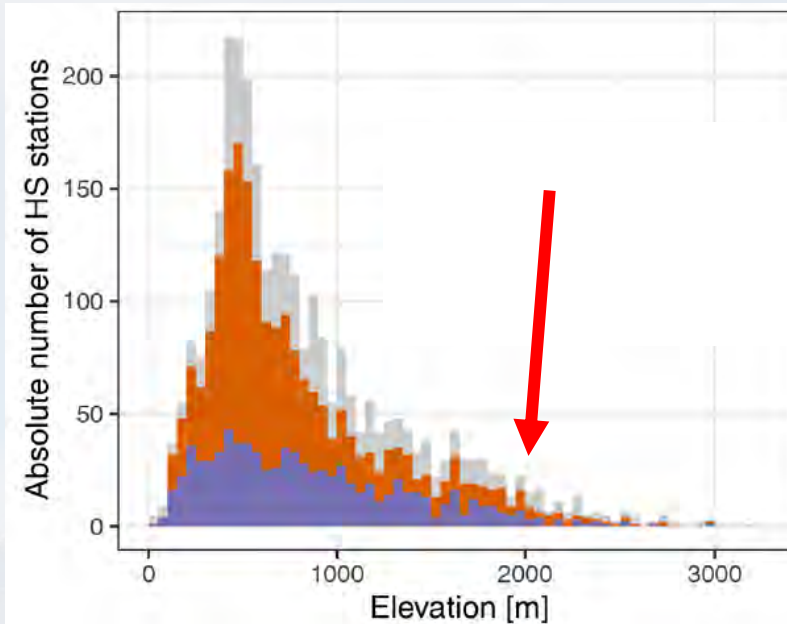
Increase in snow depth in midwinter, but significant decrease in spring



Change in snow depth over the period 1971 to 2019

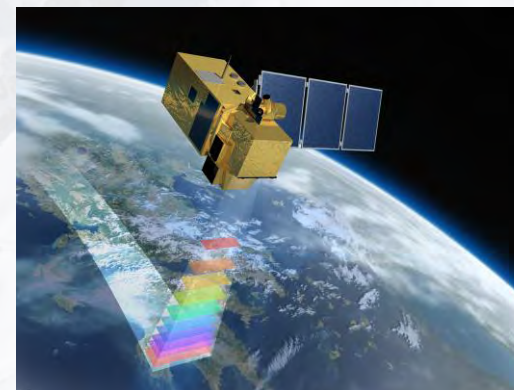
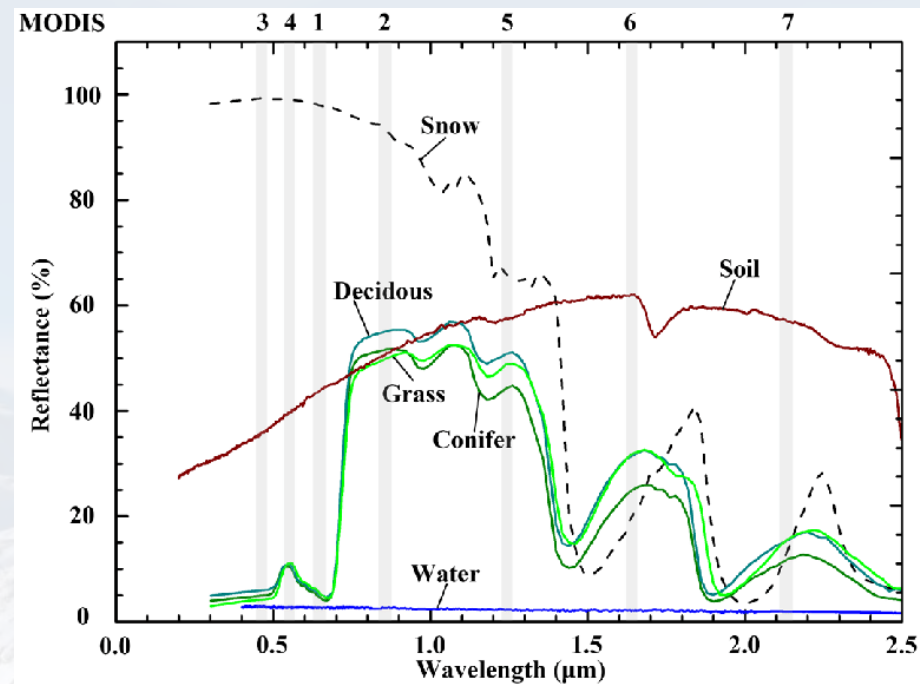
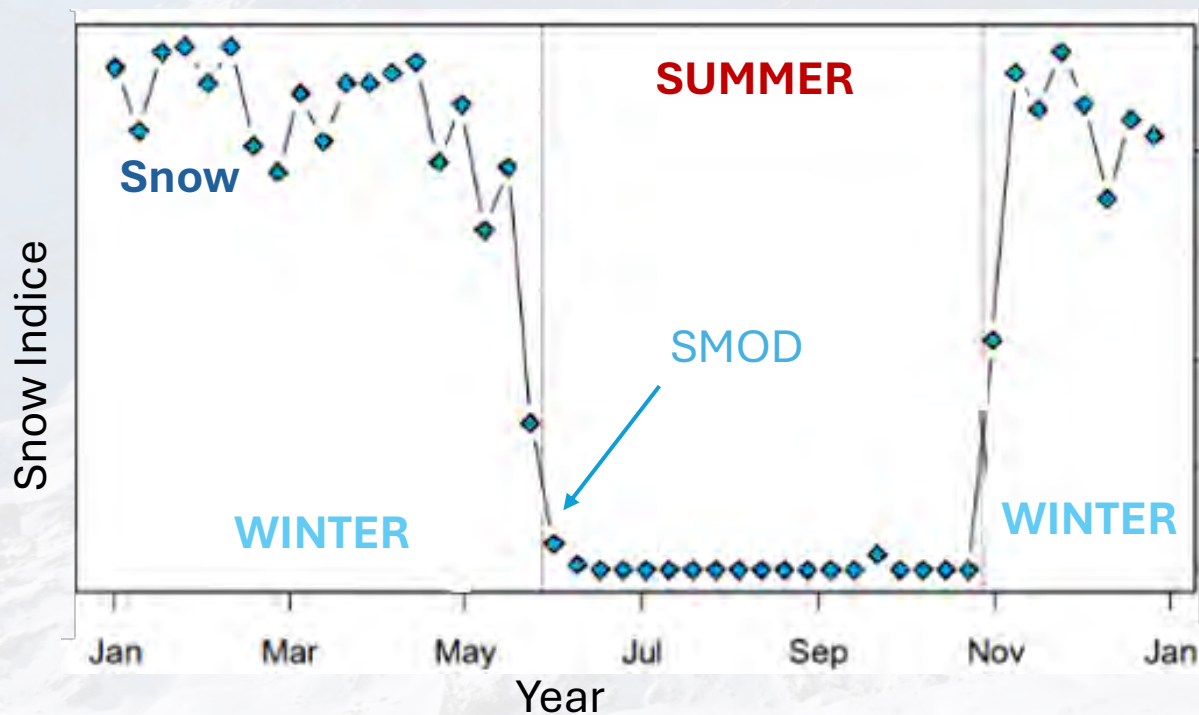
## Data representativeness

- Not a lot of stations across the Alps (**2000 stations across the European Alps**)
- Mostly between 0 and 2000 m
- Most are recording since the 1980s



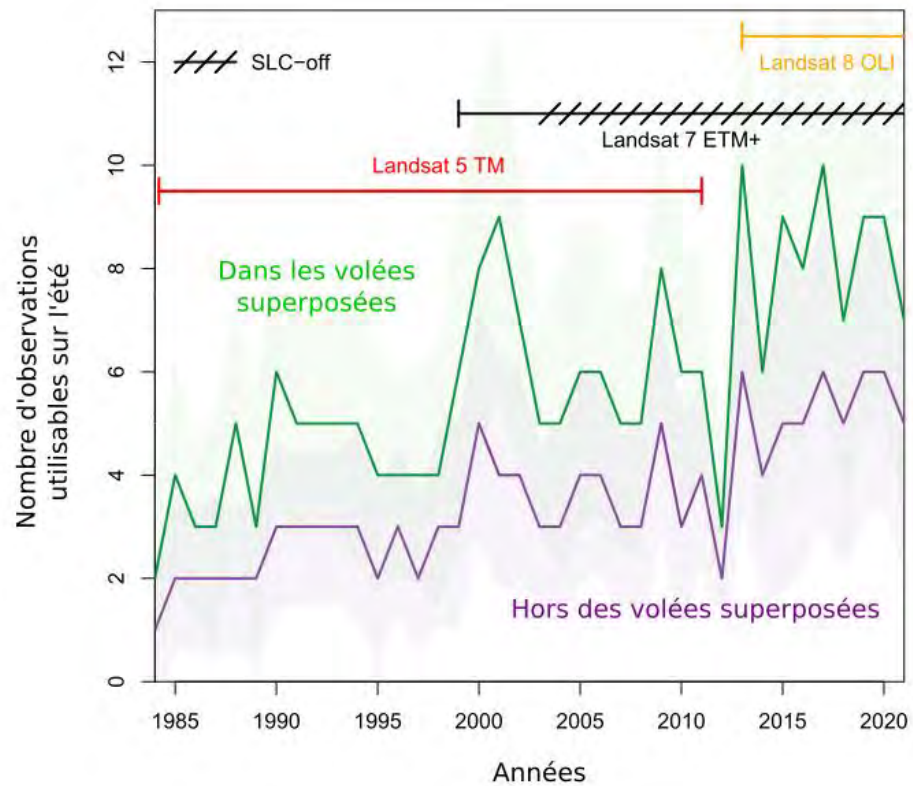
## Optical remote sensing as an alternative

- Unique spectral properties of snow with high reflectance in the visible range
- Satellites measuring the reflectance of the Earth's surface can be used to reconstruct snow cover.

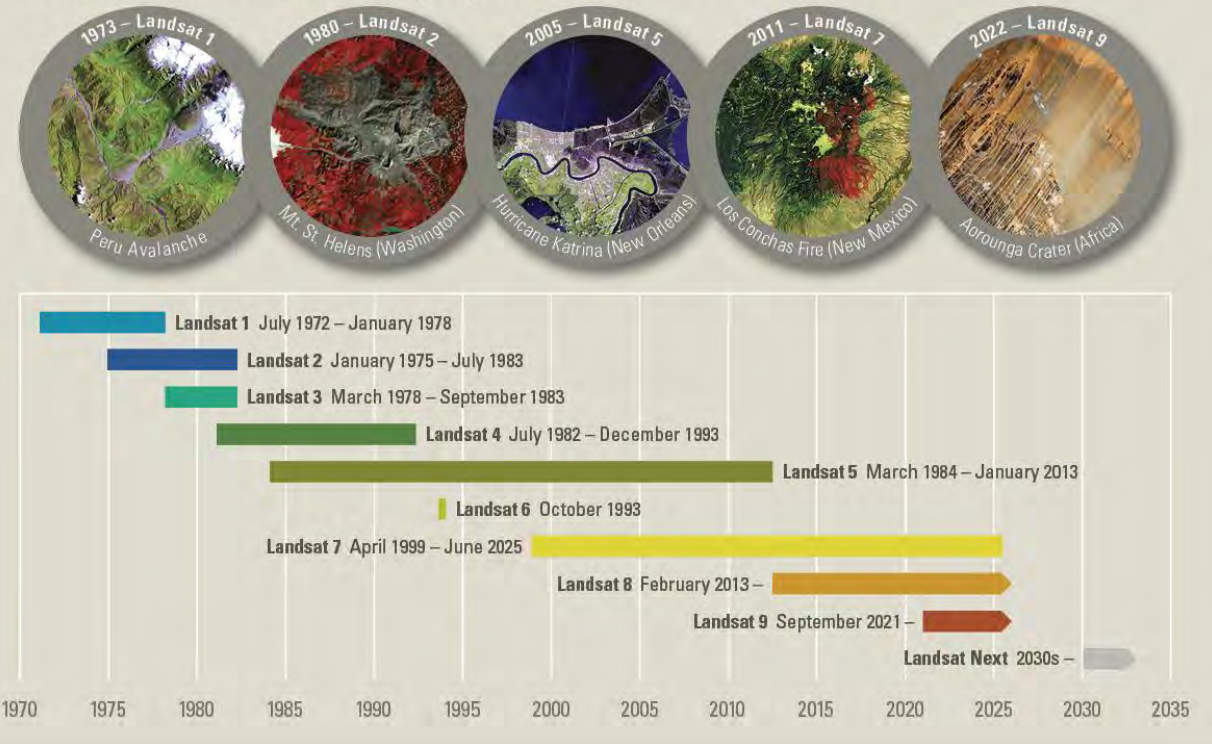


# The Landsat constellation

- 30 x 30 m
- Since 1984
- But... limited (and irregular) observation density

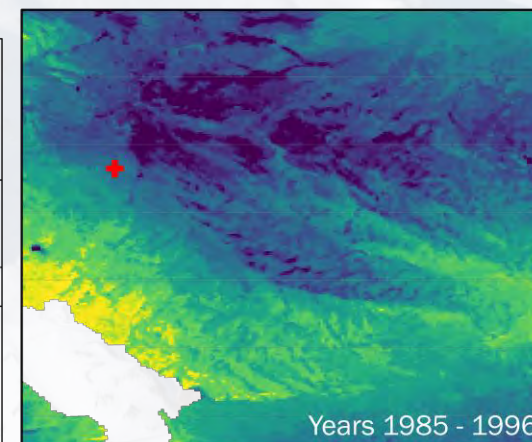
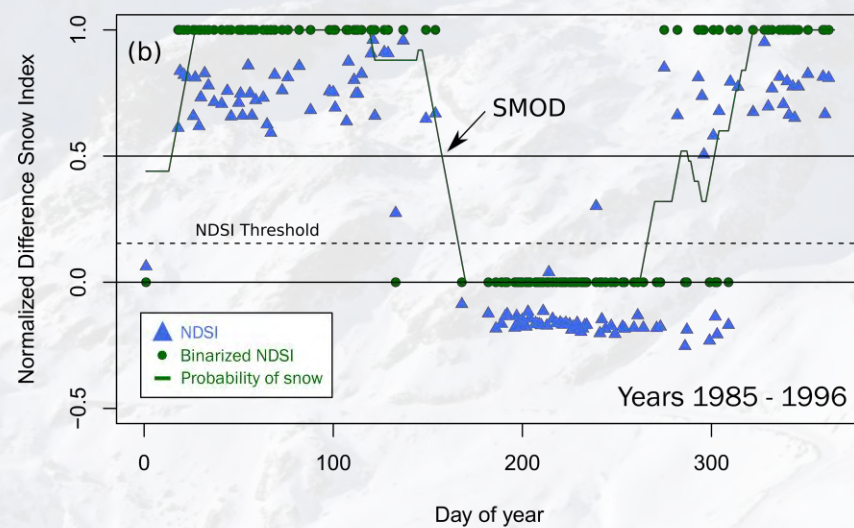
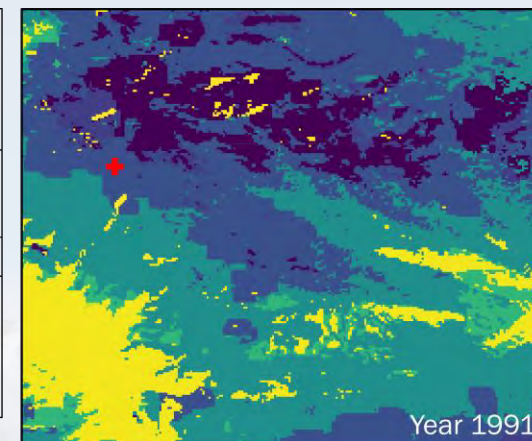
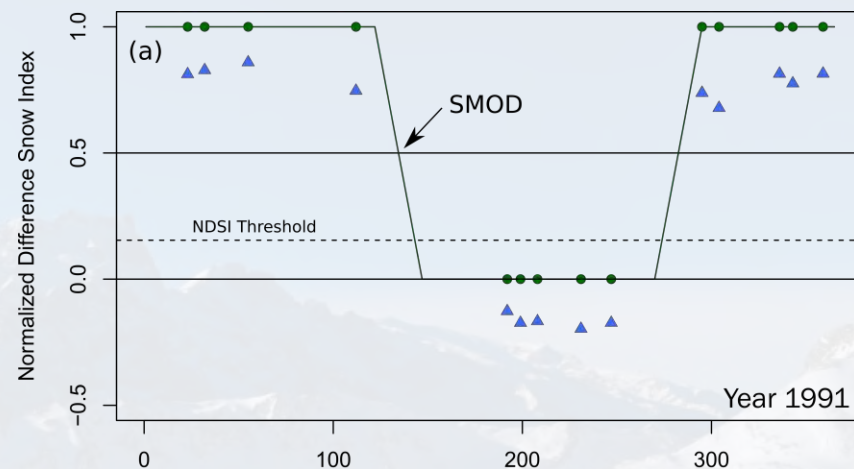
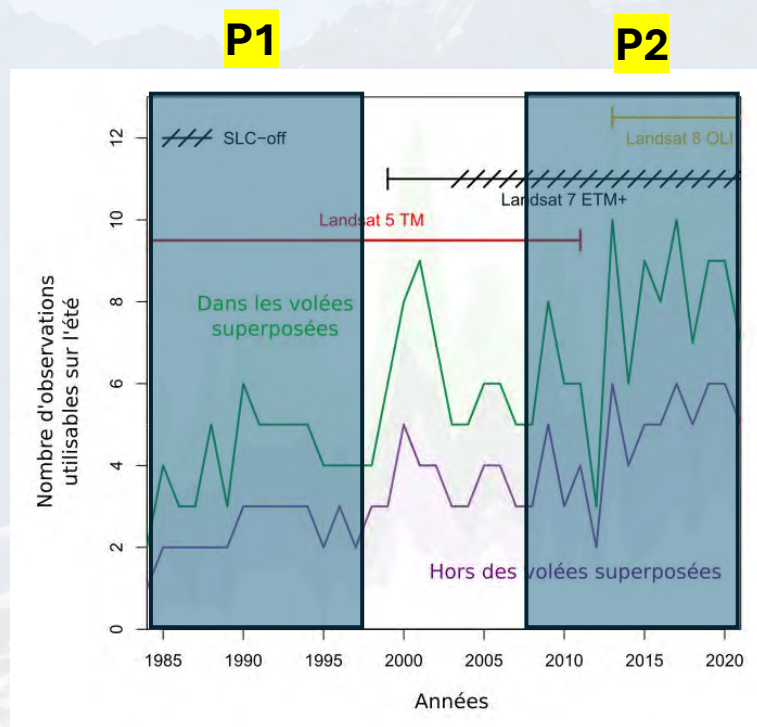


## Landsat Missions: Imaging the Earth Since 1972



# The Landsat constellation - SMOD

- 30 x 30 m
- Since 1984
- But... limited (and irregular) observation density



100 SMOD 240

# The Landsat constellation – A new approach

**Aim :** Annual estimates of SMOD at 30m from 1984 to present

**Method :** Use **weighted** information from year N-2, N-1, N+1 and N+2 to reconstruct SMOD of year N.

**It's a compromise !** Allows to densify the time series while conserving a portion of the annual signal

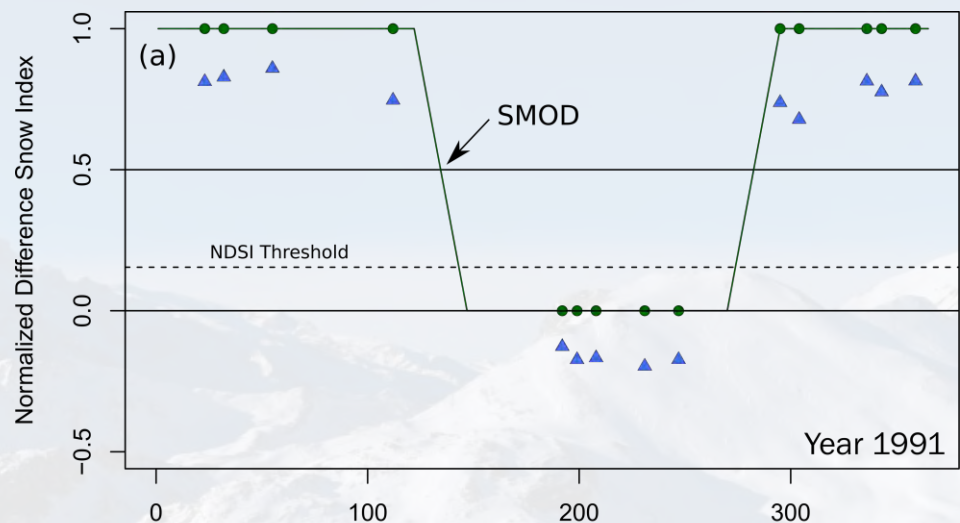
**In practice :**

I estimate SMOD using observations from N (**SMOD<sub>N</sub>**)

I estimate SMOD using observations from N-1 to N+1 (**SMOD<sub>N1</sub>**)

I estimate SMOD using observations from N-2 to N+2 (**SMOD<sub>N2</sub>**)

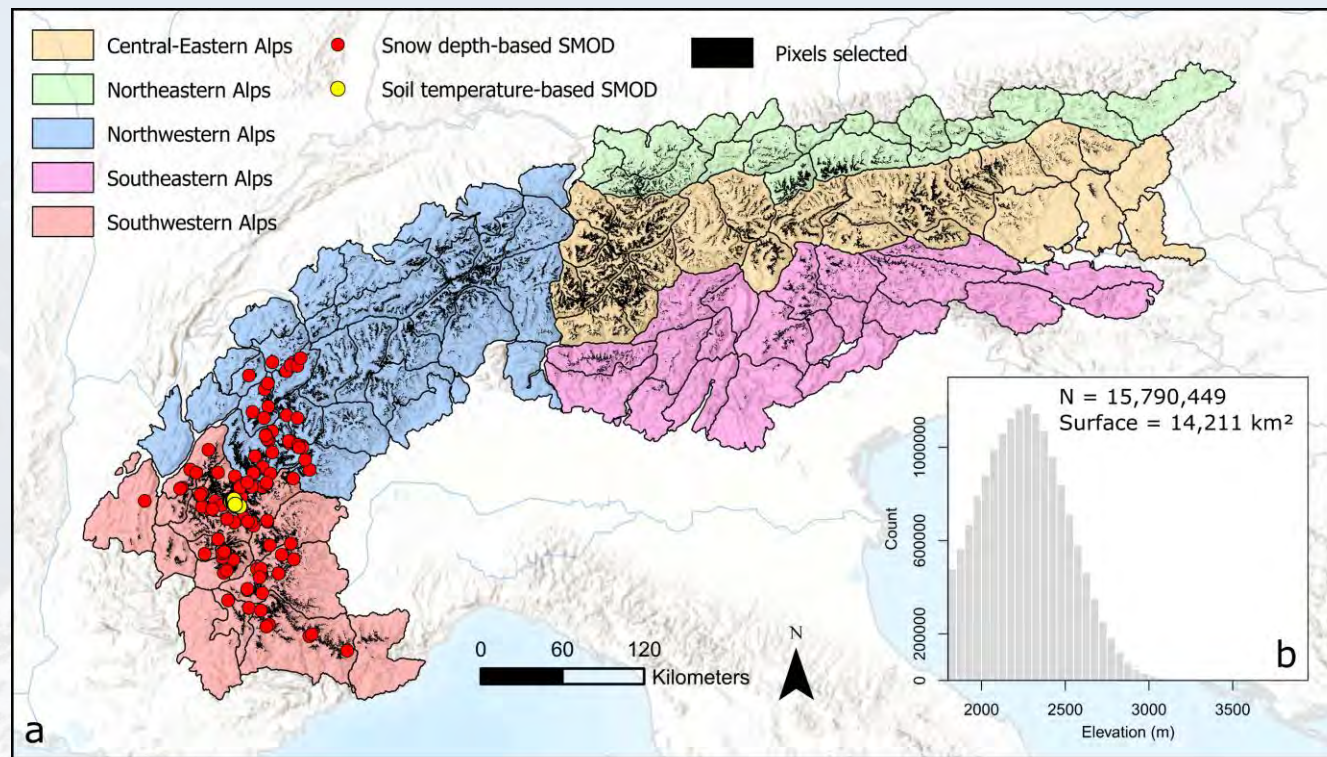
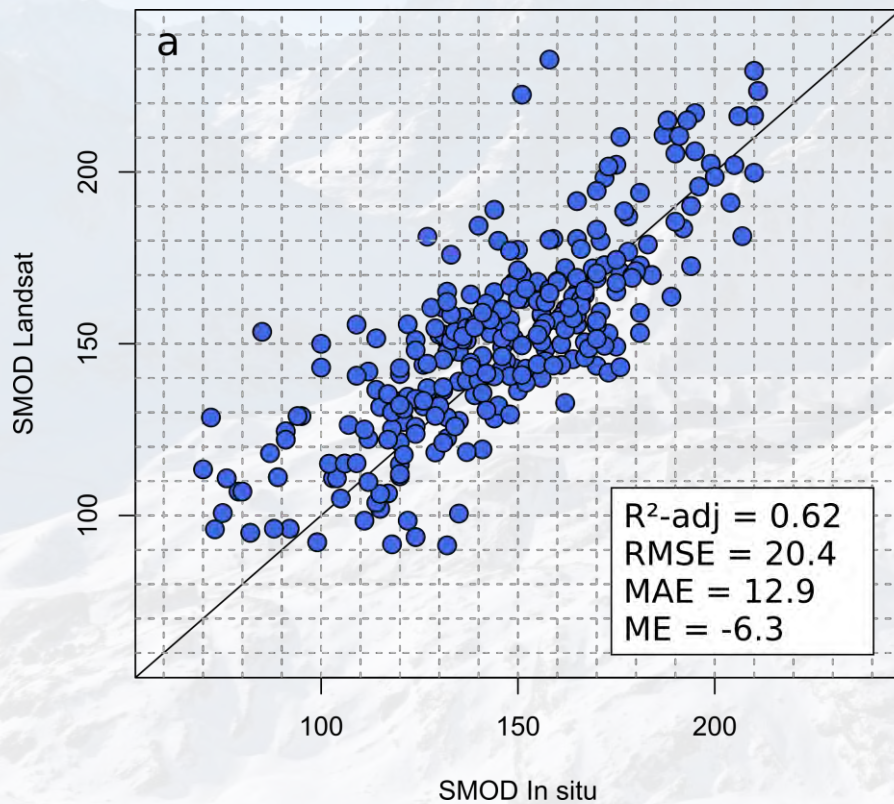
Then **SMOD** = mean(**SMOD<sub>N</sub>**, **SMOD<sub>N1</sub>**, **SMOD<sub>N2</sub>**)

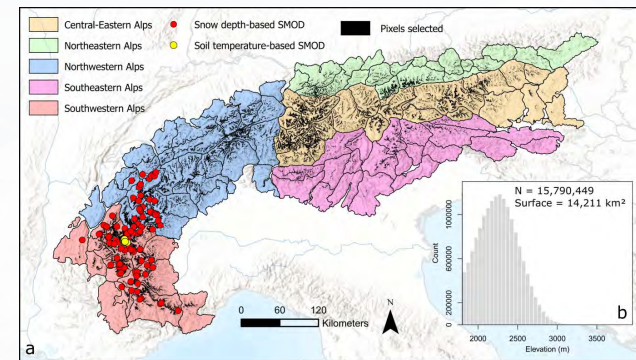
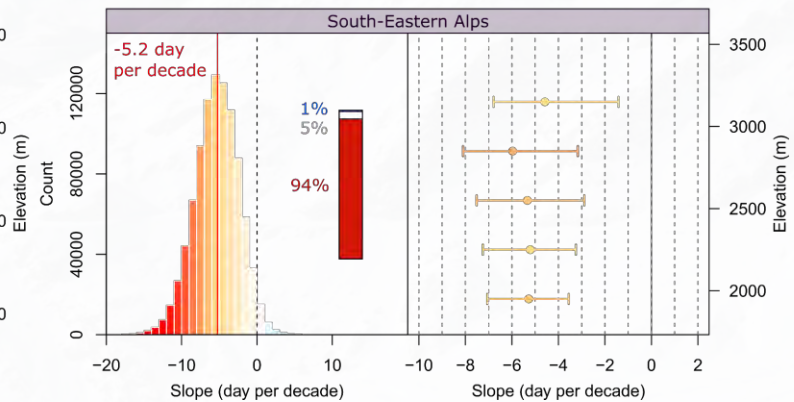
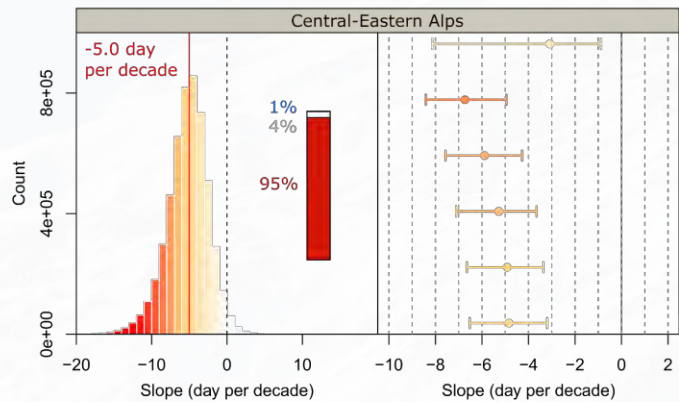
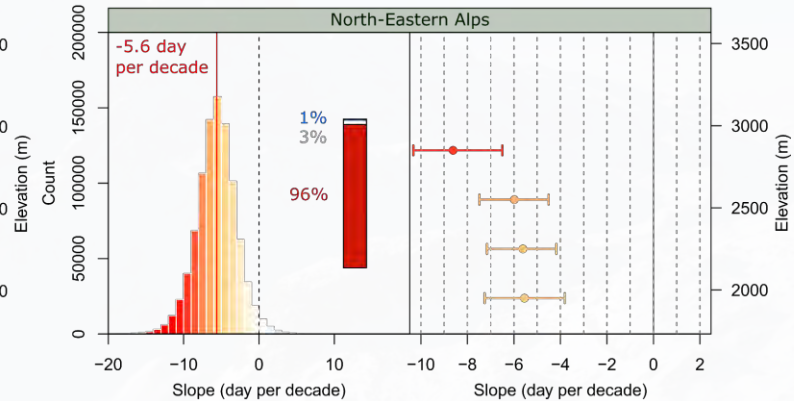
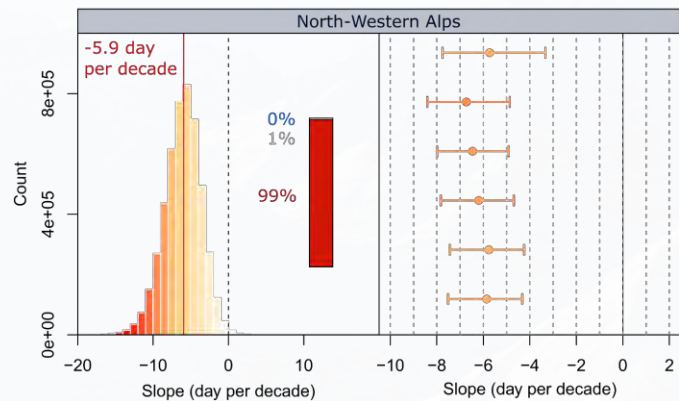
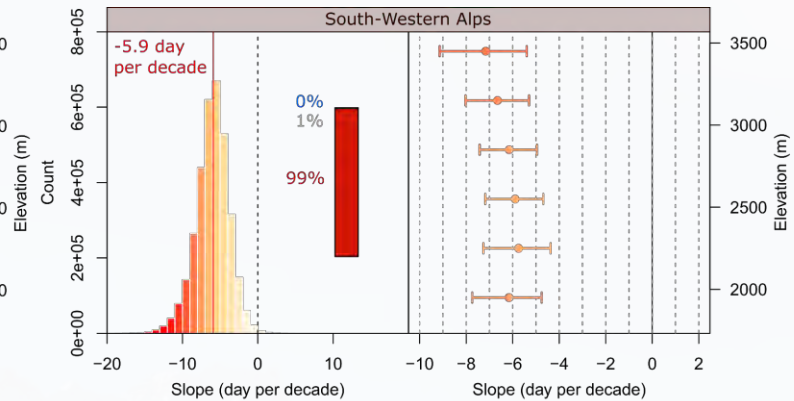
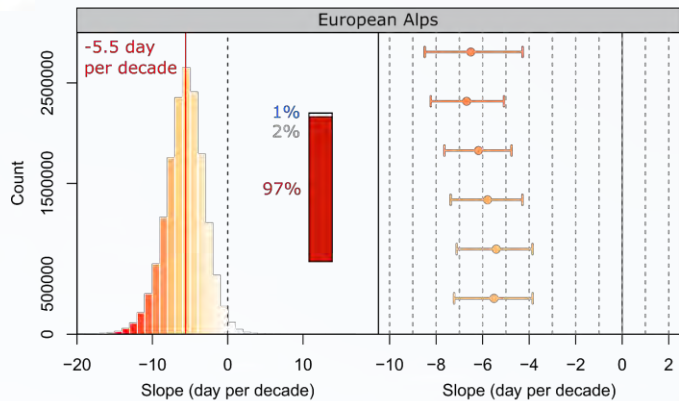


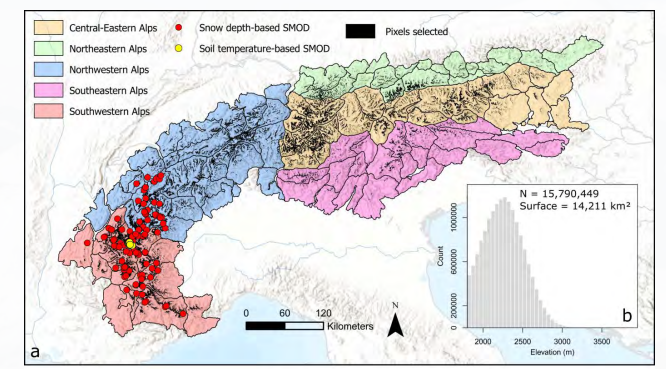
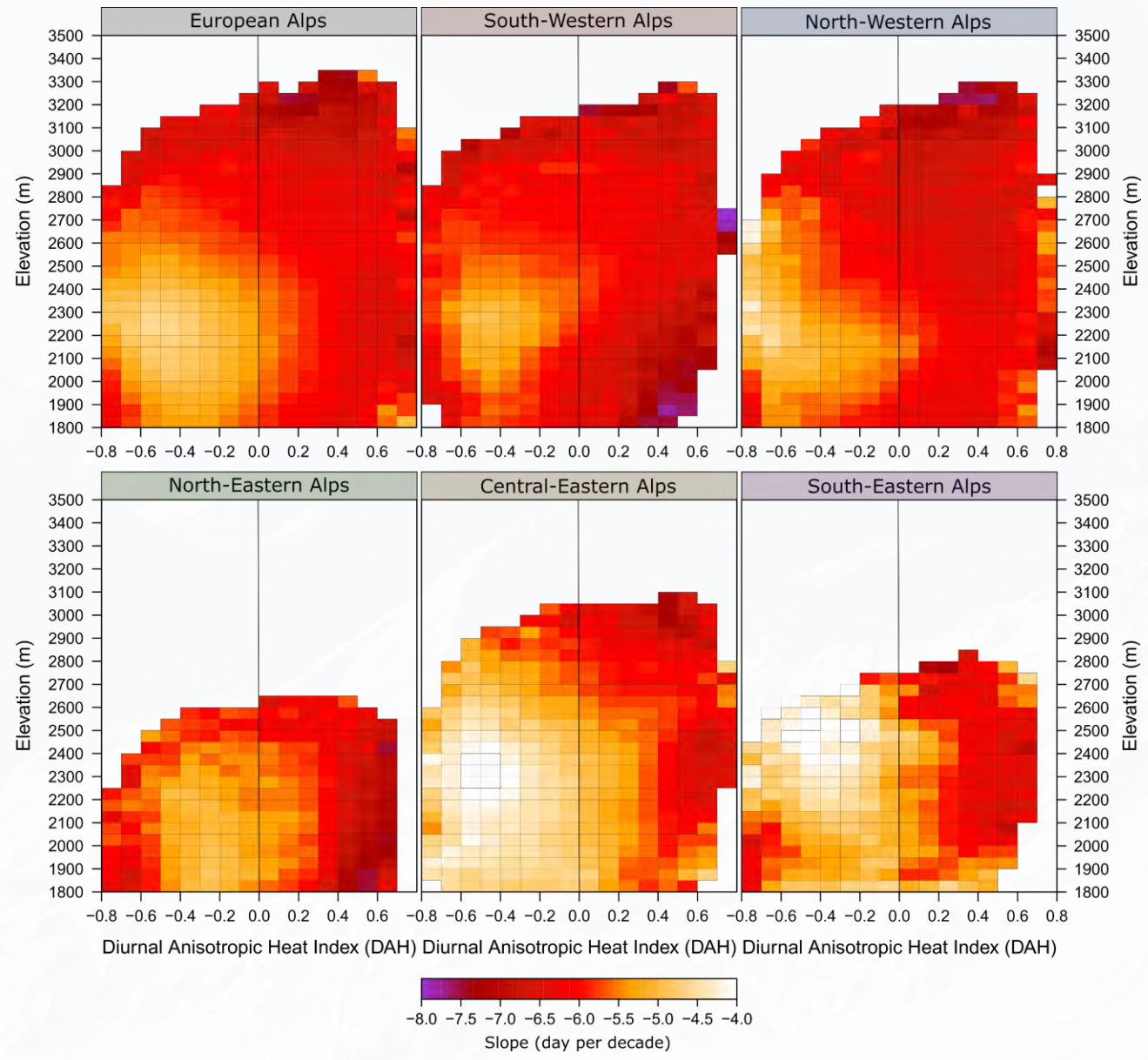
# Validation

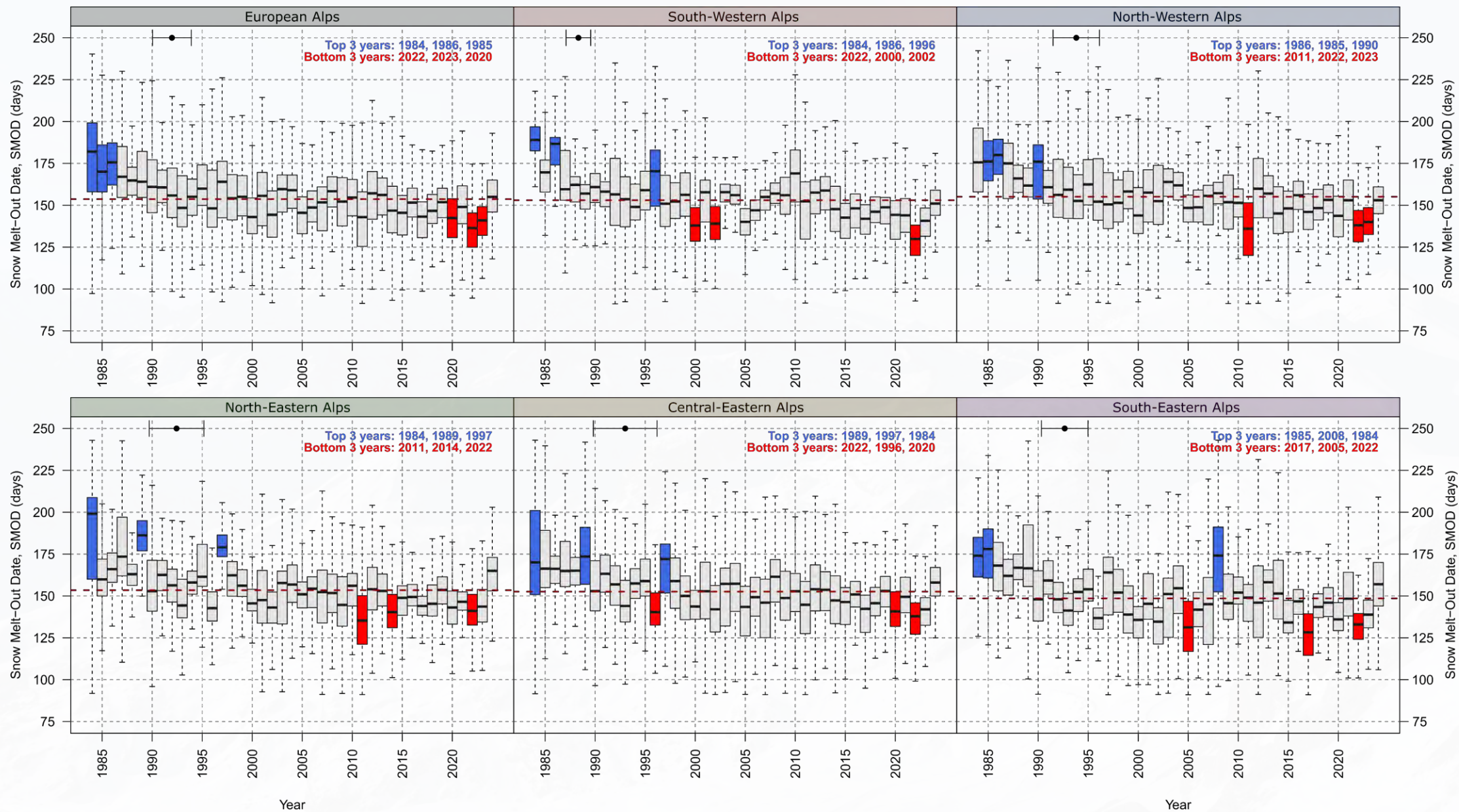
## Comparison between snow depth-based SMOD (French Alps) and Landsat-based SMOD

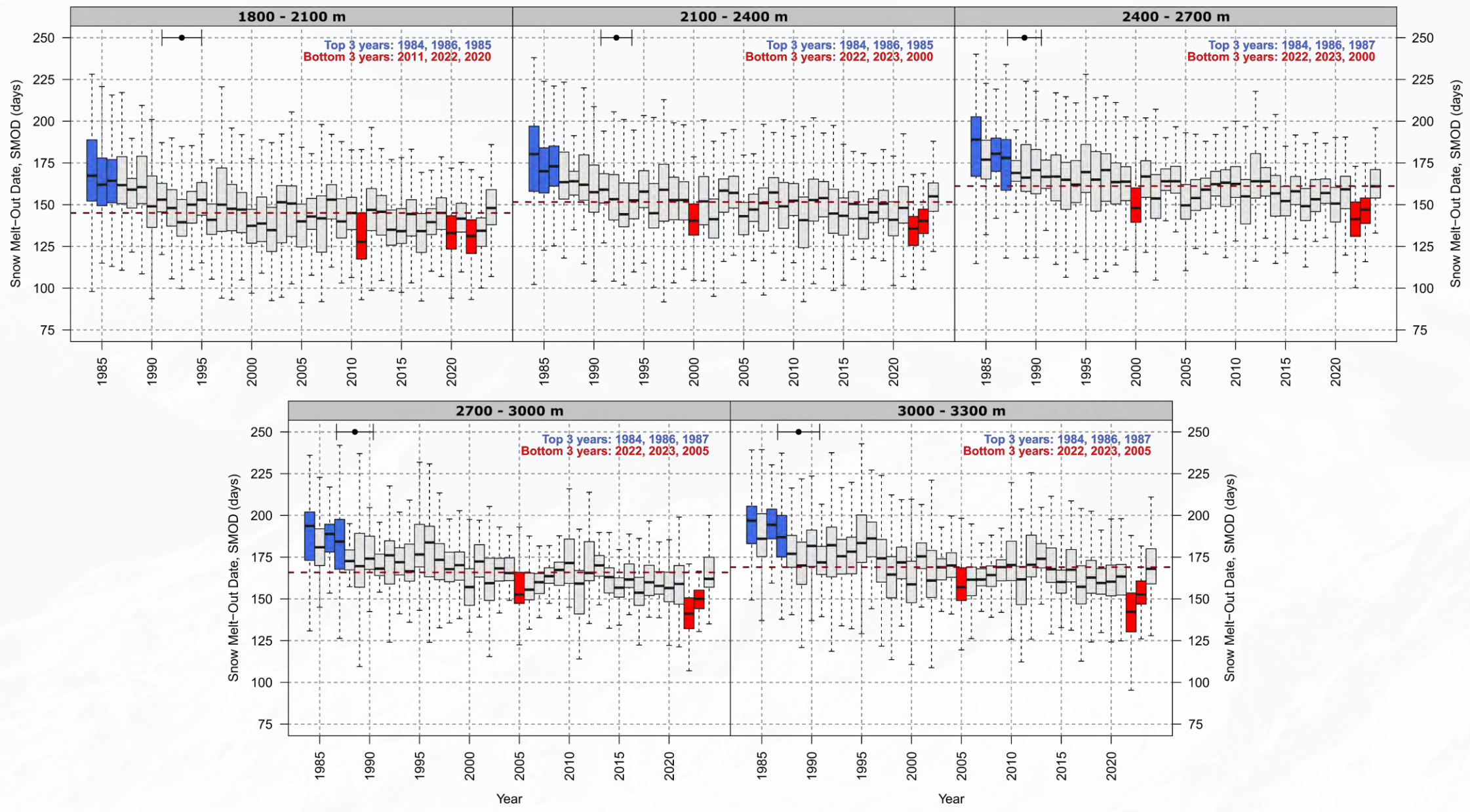
$R^2 = 0.62$

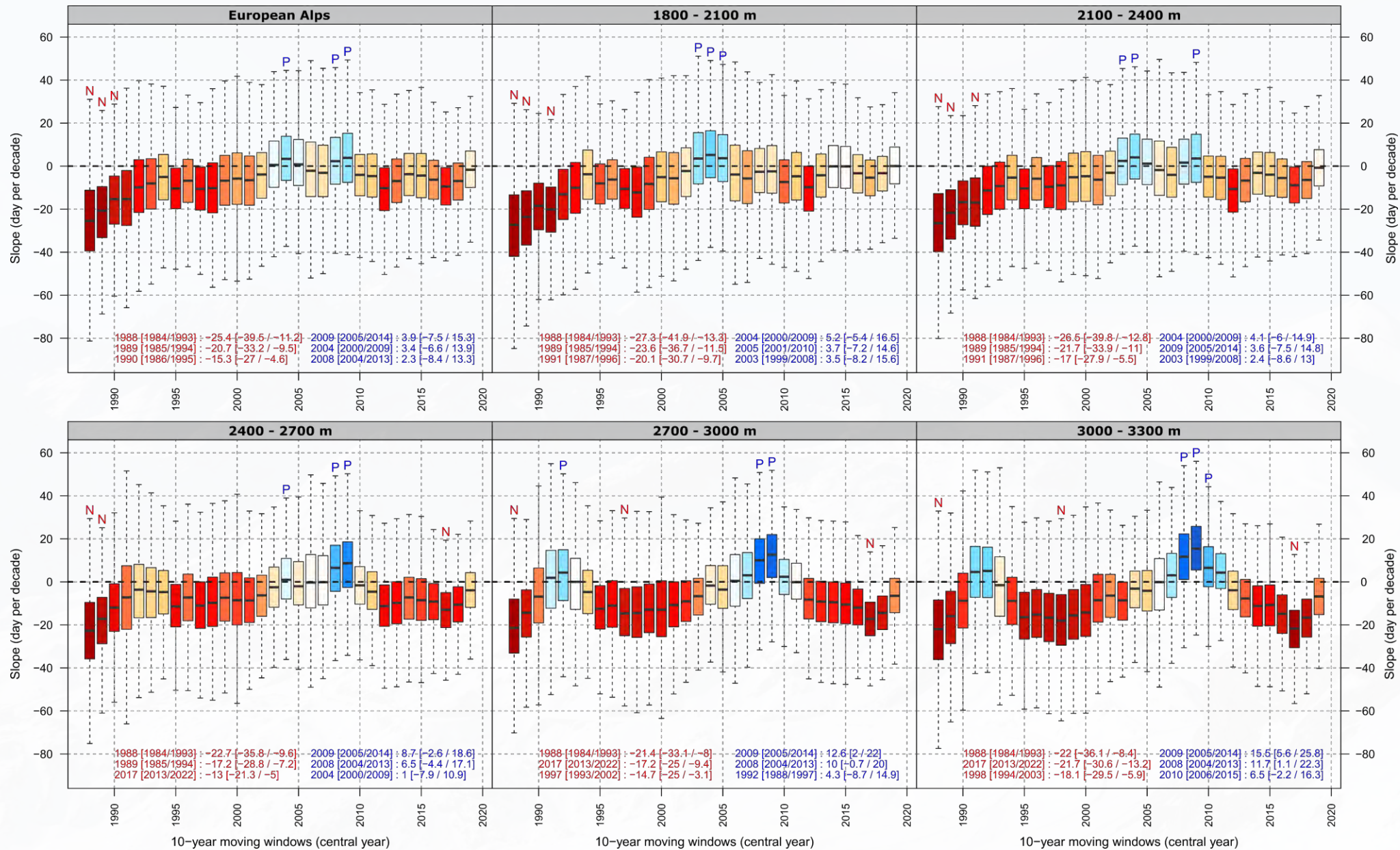












# Conclusion

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**Observation 1:** SMOD receding is faster at high altitudes ( $> 2800/3000\text{m}$ ) compared to lower altitudes

**Hypothesis:** Since SMOD occurs later in the season at high altitudes, does the increase in temperatures have a stronger effect? The earlier SMOD occurs, the less it is controlled by global warming?

**Observation 2:** At high altitudes, decadal oscillations in SMOD are observed.

**Hypothesis:** This reflects oscillations in precipitation. Precipitation still has a significant influence on the SMOD at high altitudes compared to low elevations where SMOD variability is mostly driven by temperature.