Modelling snow cover duration improves predictions of taxonomic and functional diversity of plant communities

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LECA Laboratoire d'Ecologie Alpine

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Grenoble - Col du Lautaret [2100 m]

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Introduction: context

Poa supina

Alchemilla pentaphyllea

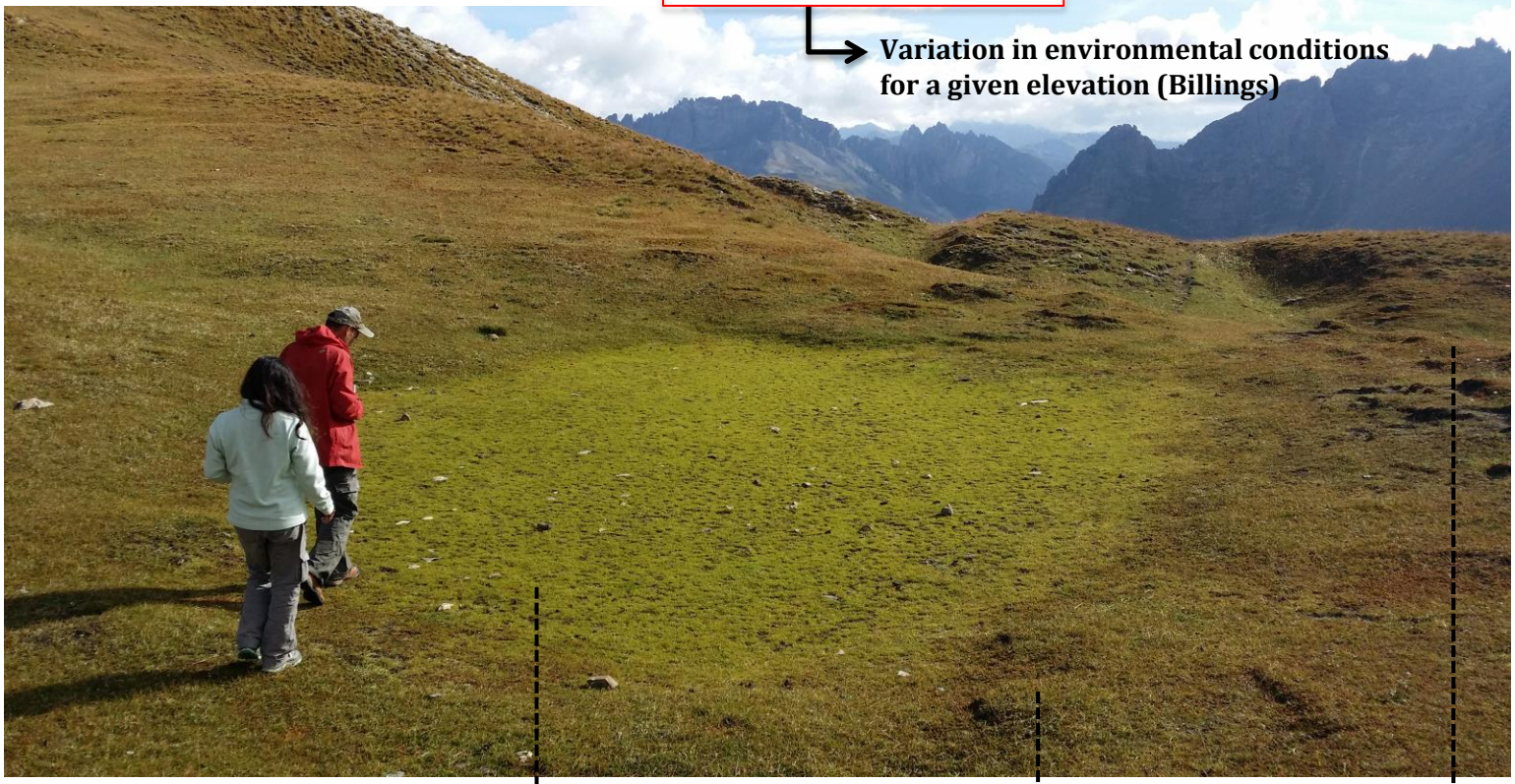
Salix herbaceae

Introduction: context

Arctic, Antarctic, and Alpine Research, Vol. 37, No. 4, 2005, pp. 444–453

Consistent Shifts in Alpine Plant Traits along a Mesotopographical Gradient

→ **Variation in environmental conditions for a given elevation (Billings)**



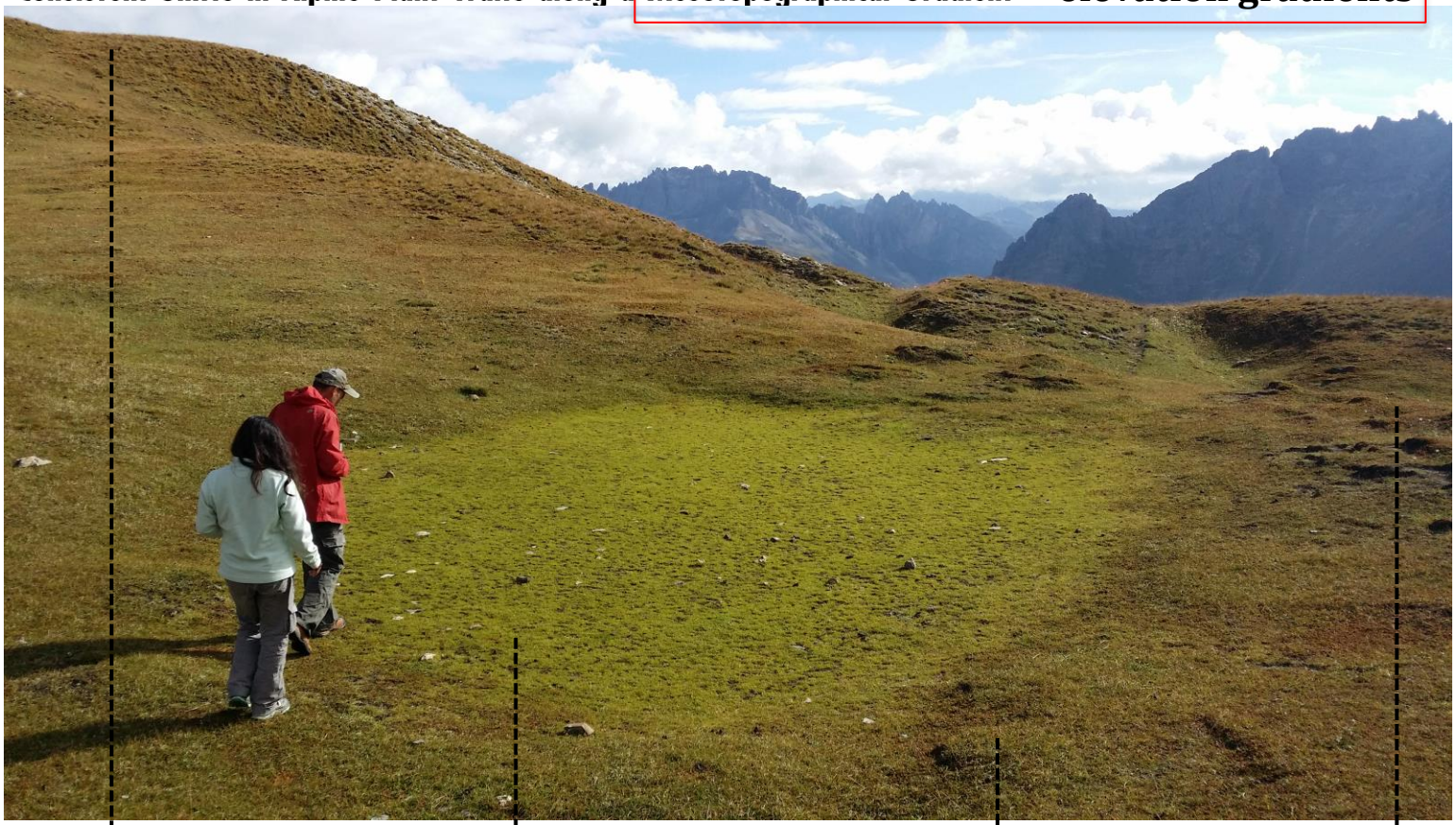
Poa supina — *Alchemilla pentaphyllea* — *Salix herbaceae*

Important taxonomic and functional variation relative to snow cover gradients

Introduction: context

Arctic, Antarctic, and Alpine Research, Vol. 37, No. 4, 2005, pp. 444–453

Consistent Shifts in Alpine Plant Traits along a Mesotopographical Gradient + elevation gradients



Helictotrichon sedenense — *Poa supina* — *Alchemilla pentaphyllea* — *Salix herbaceae*

Important taxonomic and functional variation relative to snow cover gradients

Introduction: Study aims

Main question:

- What are the statistical and ecological implications of accounting for snow cover duration for predicting patterns of alpine plant community diversity?

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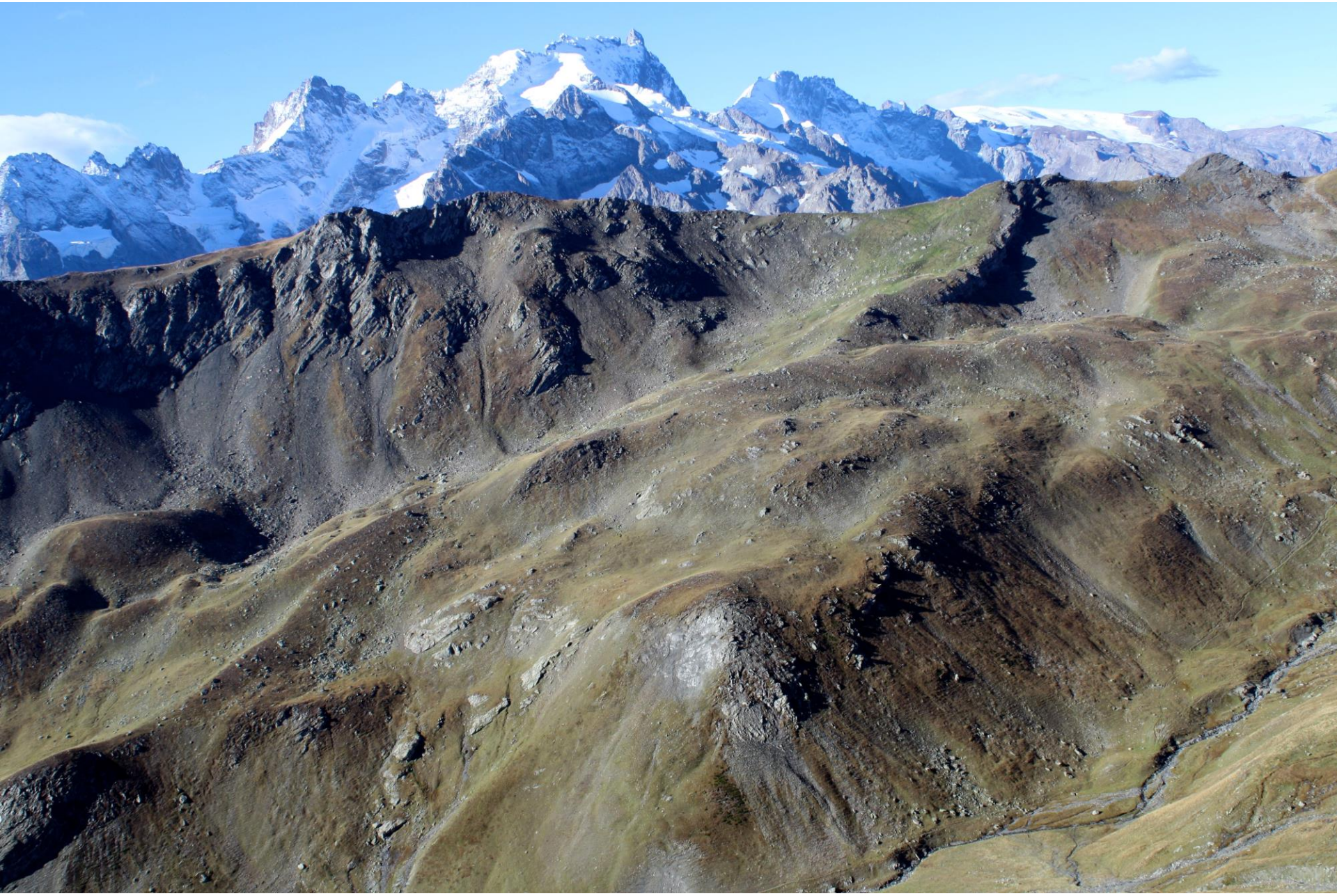
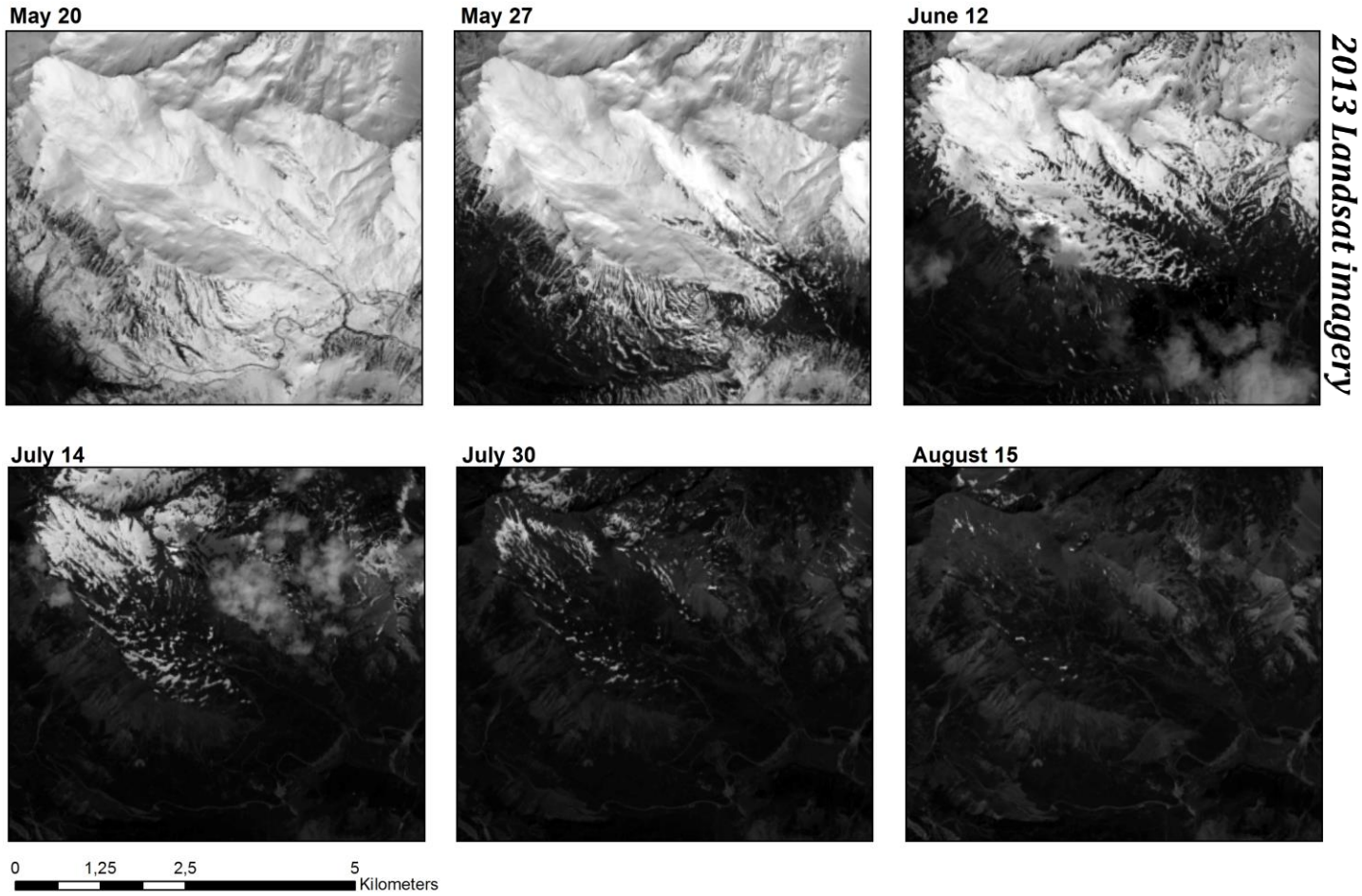
Remote sensing applications:

- **LiDAR DEM** resampled to 2m to quantify topographic variation (Elevation, Aspect, Slope and Topographic position index – TPI)
- **Landsat imagery** from 2000, 2001, 2002, 2013 & 2014 between March and mid-August classified into binary snow cover maps at 15 m resolution
- **Hyperspectral imagery** acquired in 2008 used to estimate leaf chlorophyll content (proxy for photosynthetic activity and leaf nitrogen content)



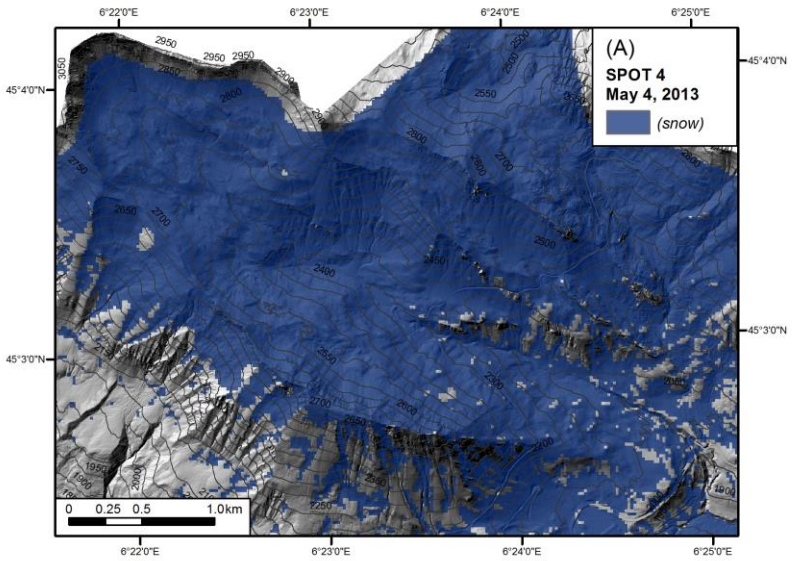
Methods: Snowmelt modelling

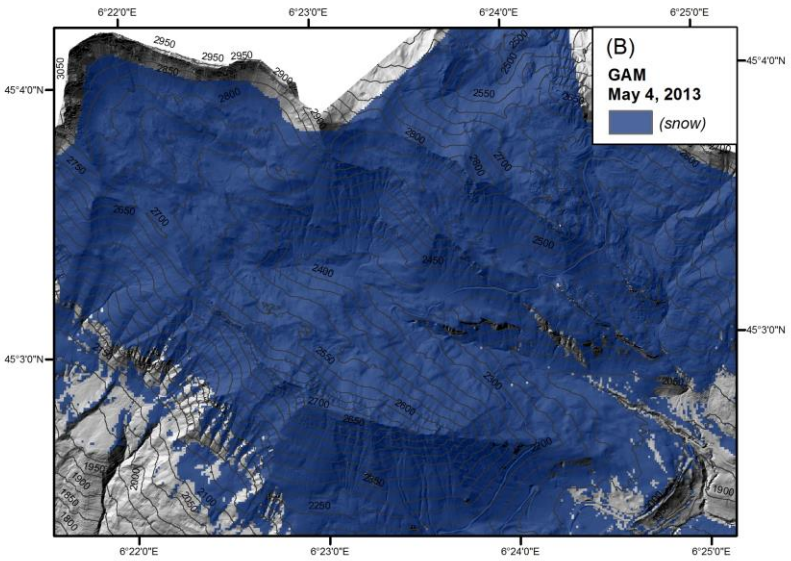


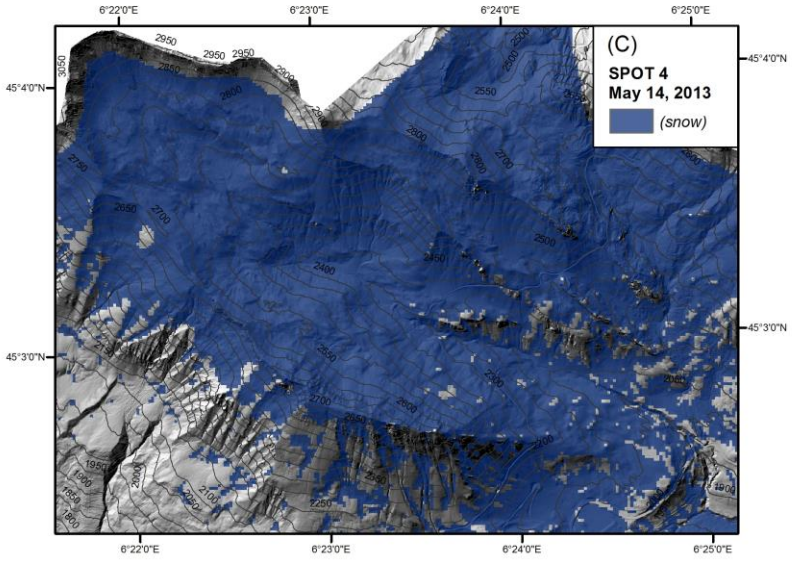
Generalized Additive Models (GAMs) fit for all five Landsat years and projected at a daily time step

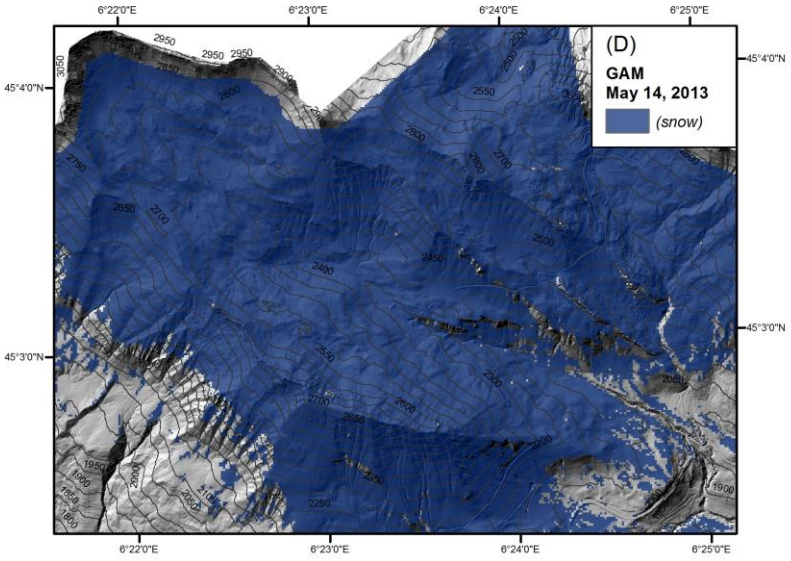
→ *Snow (0/1) ~ Date + Topography*

Methods: Snow modelling – Validation (SPOT 4 TAKE 5)









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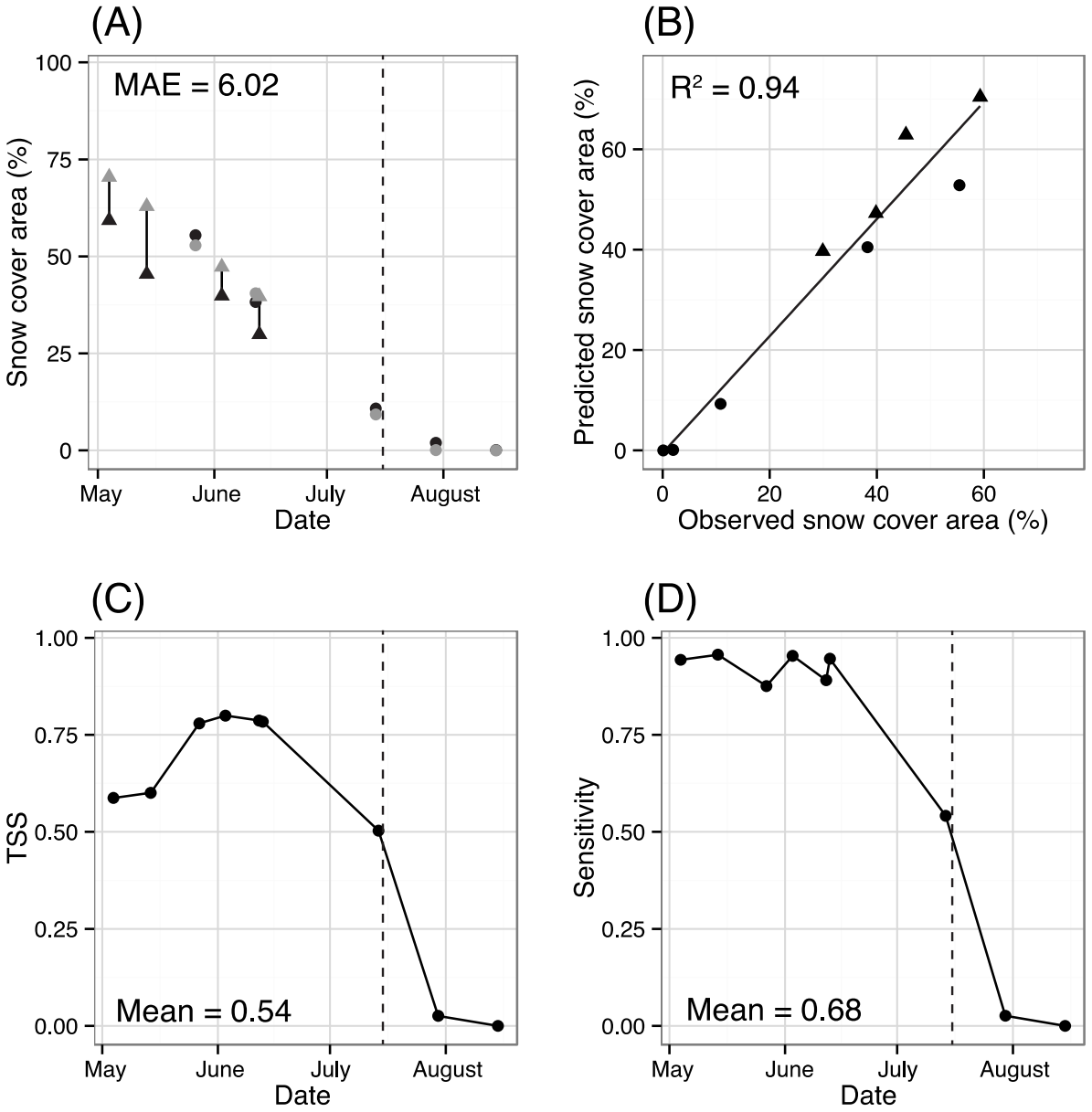


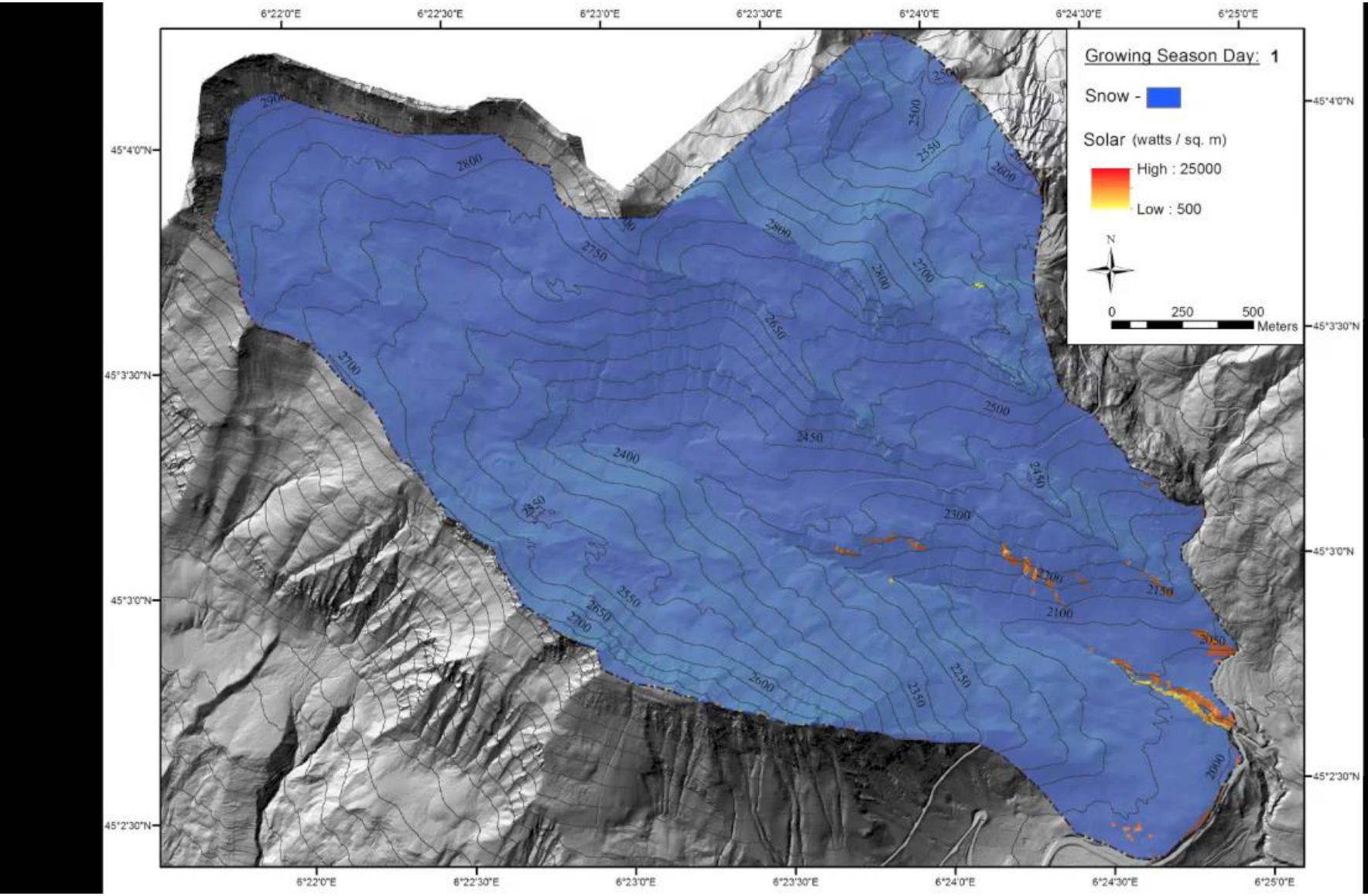
(A) Observed (black) and predicted (grey) snow cover area for 2013 Landsat and SPOT acquisition dates. MAE = mean absolute error; triangles correspond to SPOT 4 imagery, while circles correspond to Landsat 8.

(A) Observed and predicted snow cover area estimates for the nine image acquisition dates.

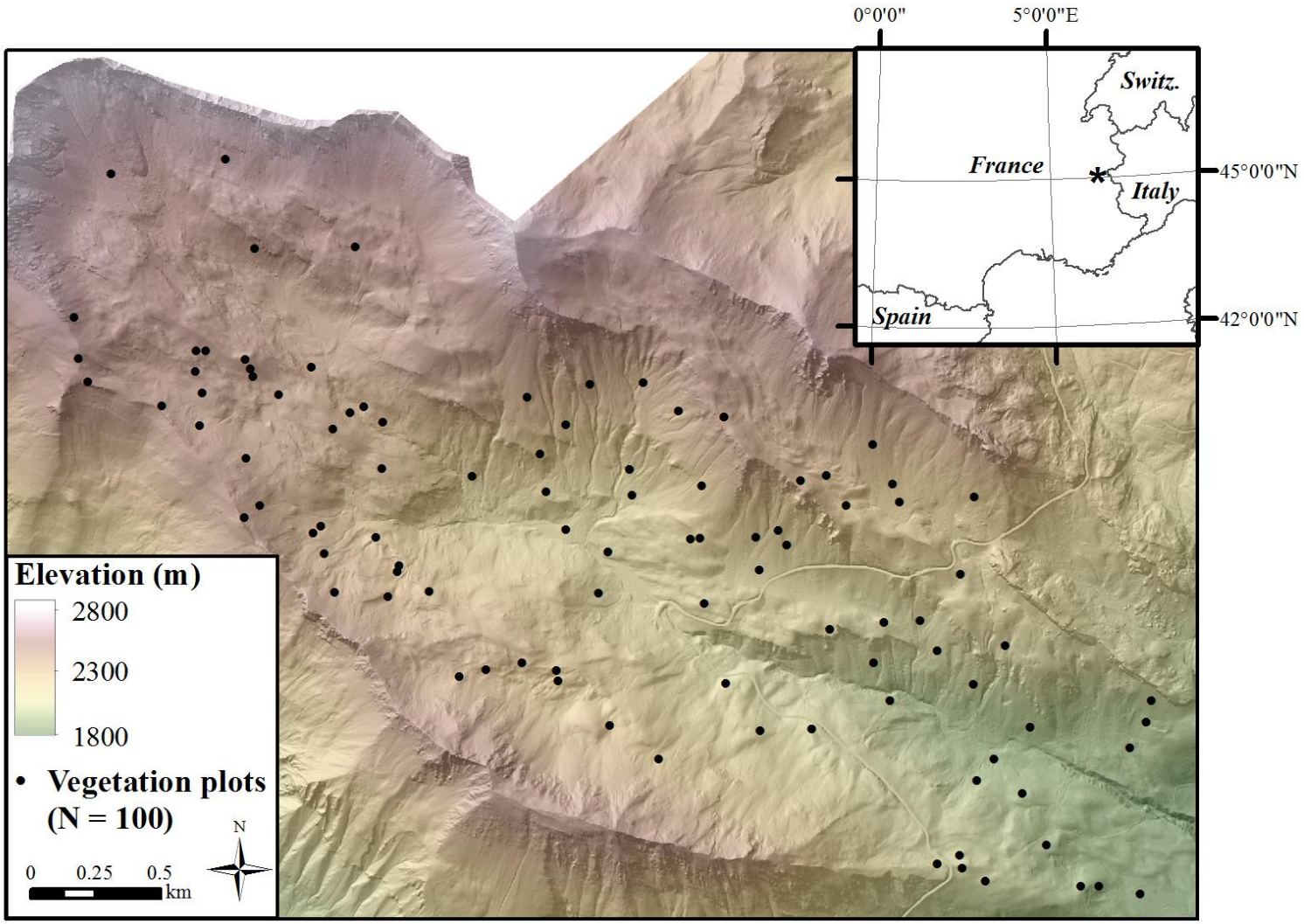
(B) Agreement, estimated by the True Skill Statistic (TSS), between observed and predicted snow cover area maps.

(A) Proportion of observed snow-covered pixels detected by the GAM model, as measured by Sensitivity. The dashed line in panels A, C and D corresponds with July 15.

Methods: Combining snow cover and energy gradients

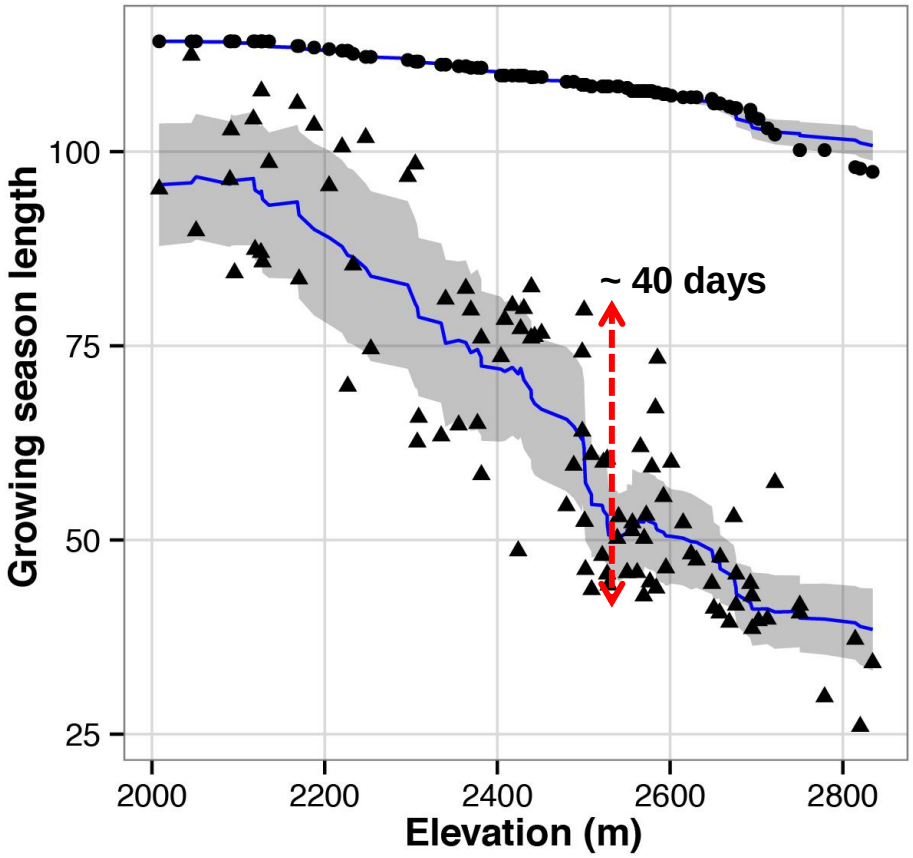


Methods: study area and vegetation data



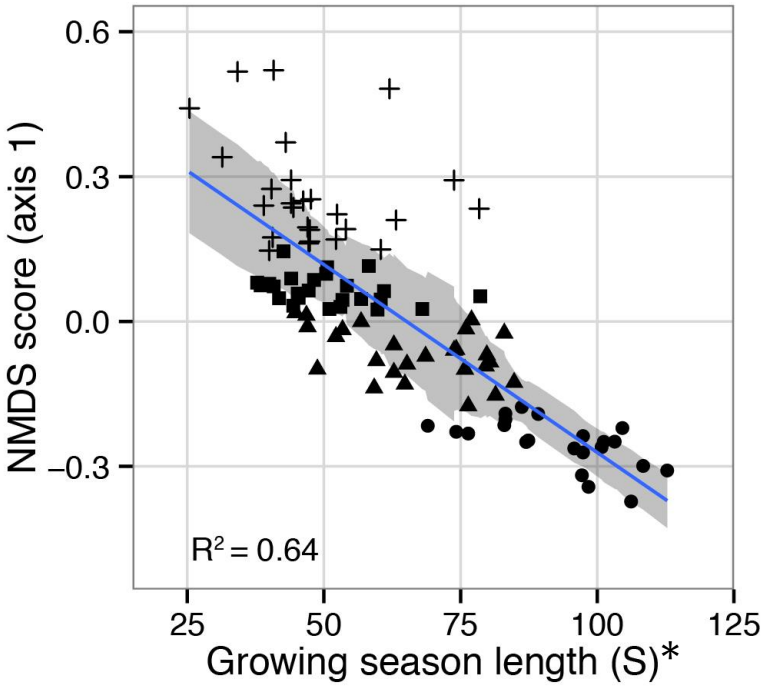
→ **For each plot:** Species Richness, Betadiversity (NMDS ordination), Community Weighted Mean Specific Leaf Area (SLA), Leaf Chlorophyll Content & Functional Diversity

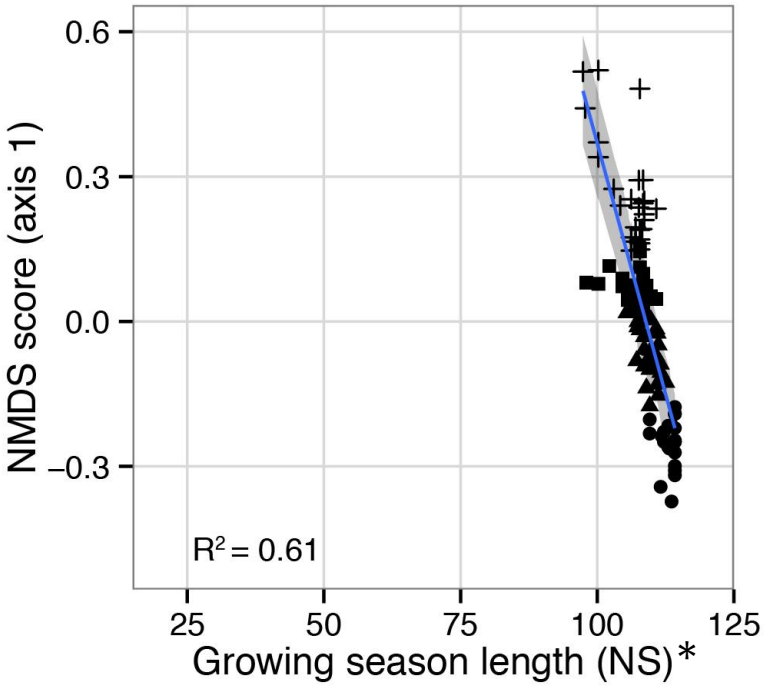
Results: Combining snow cover and energy gradients



→ Important variation in GSL introduced when snow cover duration is taken into account

Results: Linking energy gradients to biodiversity



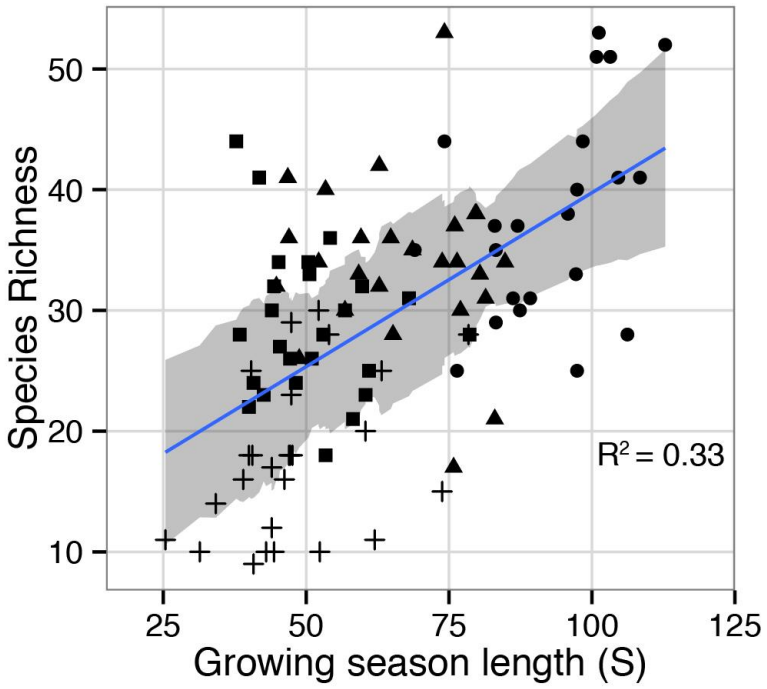


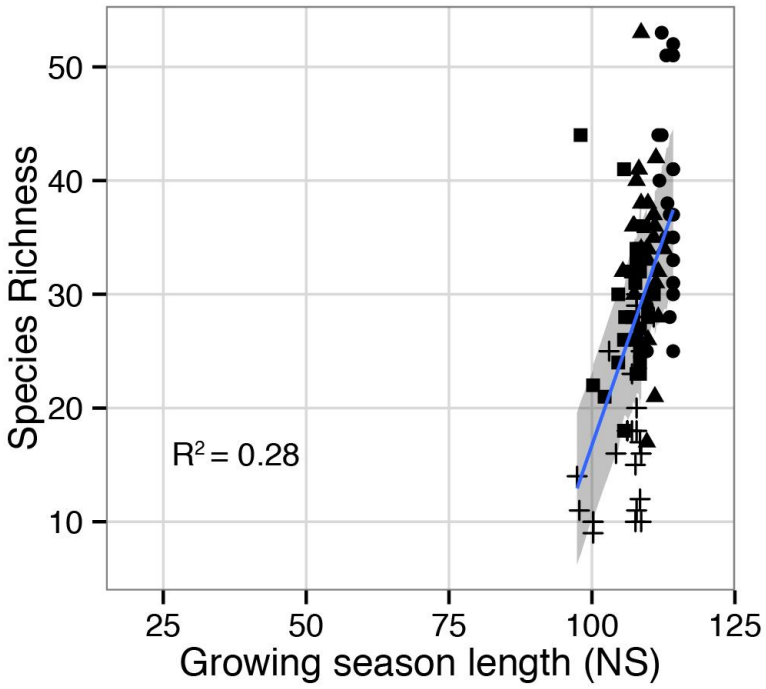
→ Turnover in species composition closely follows a snowmelt gradient

→ Environment/diversity relationship is compressed when only elevation is considered

* S = SNOW, NS = NO SNOW

Results: Linking energy gradients to biodiversity

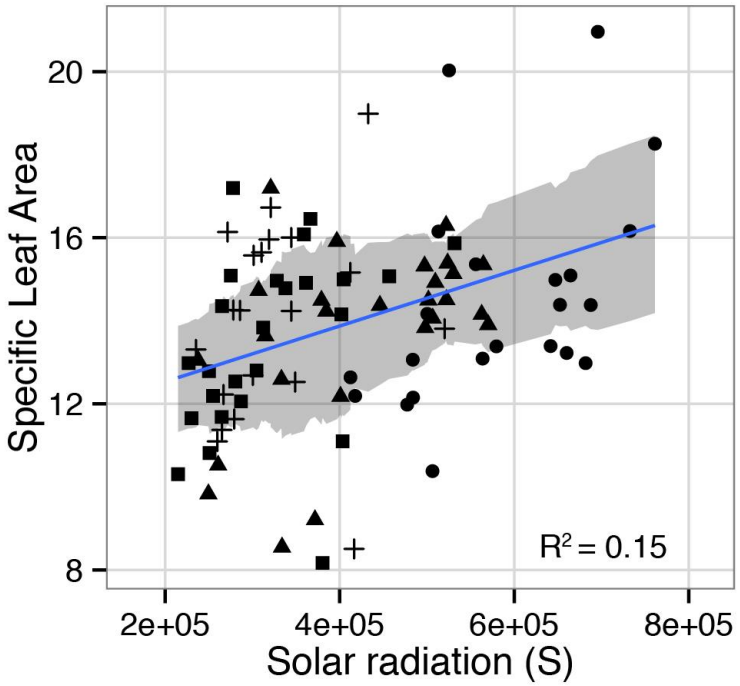


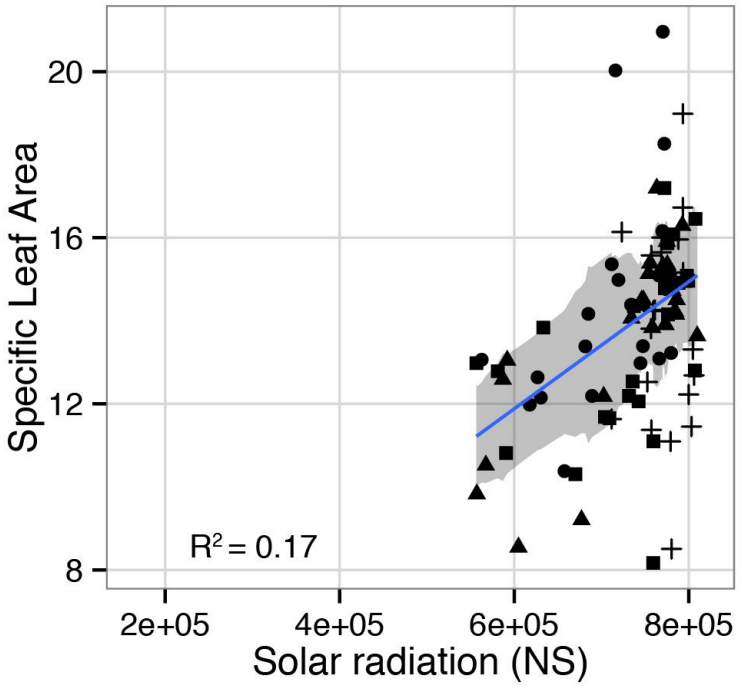


→ Similar pattern is observed for species richness

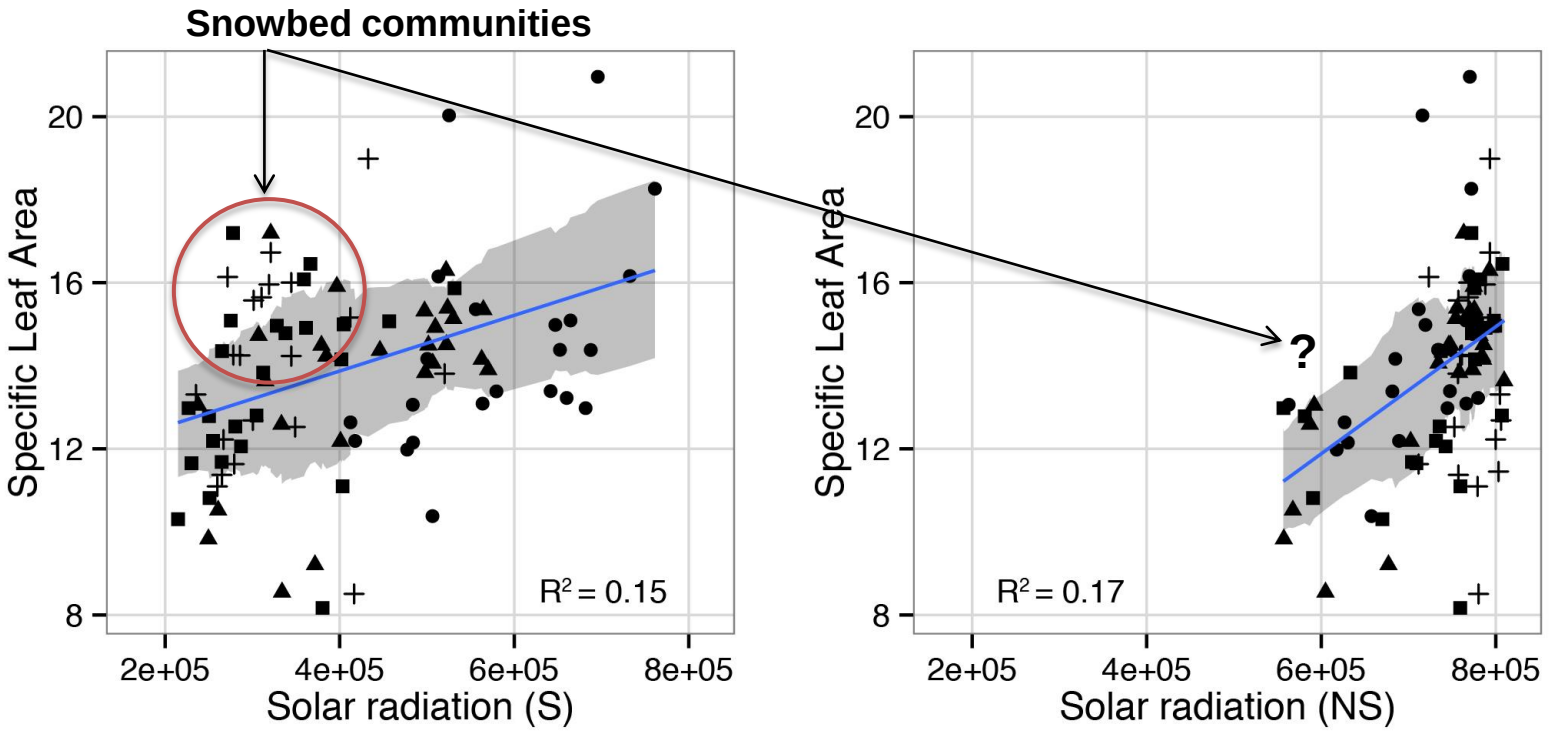
→ In addition to R^2, important to consider slope and intercept model parameters

Results: Linking energy gradients to biodiversity



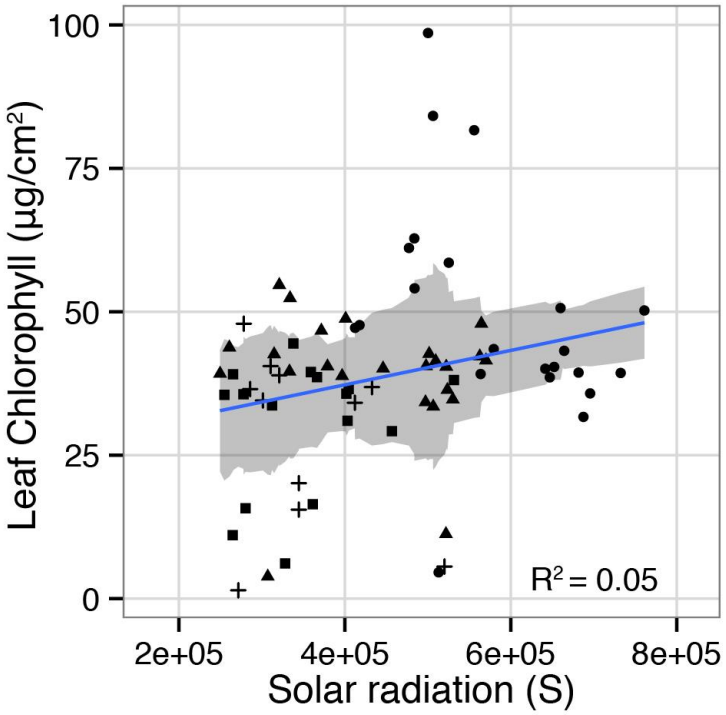


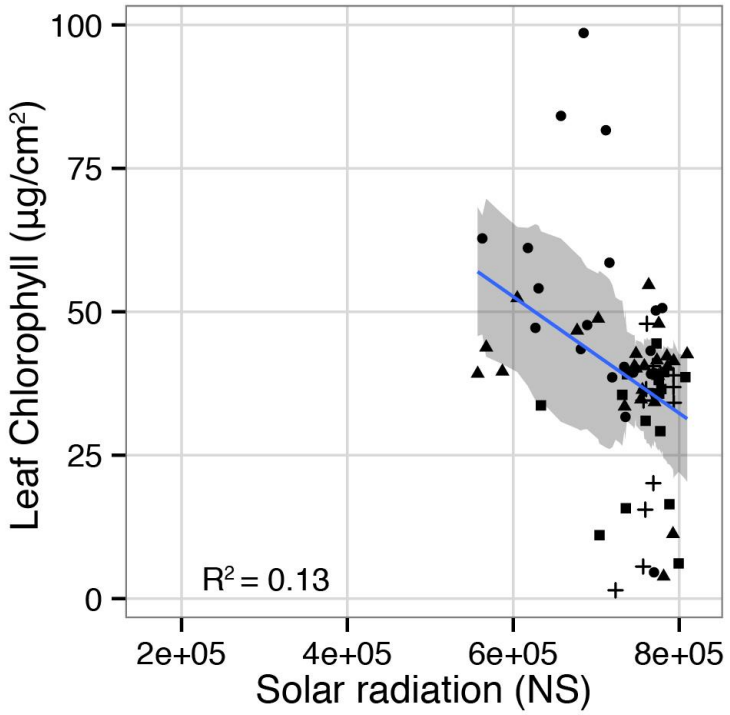
Results: Linking energy gradients to biodiversity



→ Snowbed communities characterized by **high SLA** and a **short growing season** are differentiated when snow cover is included

Results: Linking energy gradients to biodiversity

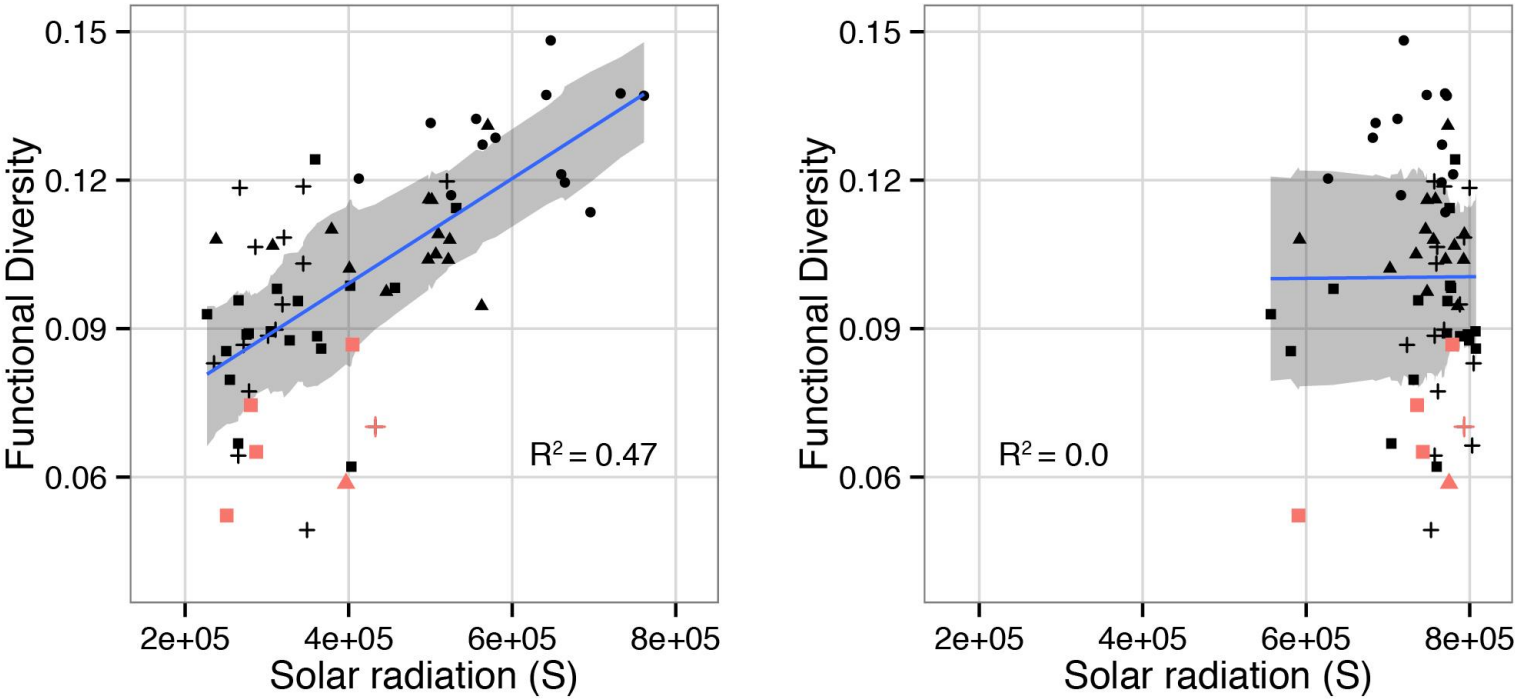




→ The slope direction changes to an intuitive relationship when snow cover duration is included

→ (!) Important to look at not only R^2

Results: Linking energy gradients to biodiversity



→ Functional convergence around optimal trait values is captured when solar radiation is filtered by snow cover

→ Validation of the Stress-Gradient Hypothesis (Bertness and Callaway 1994)

Conclusions & Perspectives

Main findings:

→ Quantifying an old idea: Snow is important in alpine systems!

→ Focus on developing ecologically meaningful predictors, rather than selecting variables on a statistical basis only

→ Efforts to predict the response of alpine plant communities to climate change need to consider future shifts in both temperature and snow regimes

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Main findings:

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Next steps and on going questions (in my PhD):

→ Estimate snow cover-mediated growing season length at the regional scale, maintaining high spatial resolution

- Process-based snow distribution model *vs.* Empirical distribution modelling approach

→ Test response of ecosystem productivity (NDVI) : Mont Blanc massif with M. CORONA LOZADA

→ SPOT 5 TAKE 5 project in collaboration with the CBNA and the IRSTEA

- Examine alpine plant community structure at the scale of the interior French Alps (Mercantour → Mont Blanc)

Thank you for your attention. Questions?

European Research Council

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