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It's time to go: drivers of migration phenology in a mountain ungulate, the Alpine ibex *Capra ibex*

V Chauveau, M Garel, C Toïgo, P Anderwald, B Bassano, M Beurier, Y Bunz, M Bouche, A Brambilla, F Cagnacci, M Canut, J Cavailles, I Champly, F Filli, A Frey-Roos, G Gressmann, I Herfindal, F Jurgeit, L Martinelli, L Maurino, R Papet, E Petit, M Ramanzin, P Semenzato, E Vannard, A Coulon, A Loison, P Marchand

CONTEXT & OBJECTIVES

- Climate change affects the phenology of biological events such as migrations⁽¹⁾.
- These effects are expected to be **amplified** in highly seasonal environments such as **mountains**⁽²⁾ but remain **less documented** for **short-distance migratory species** like the Alpine ibex, an emblematic species of the Alps.
- Understanding the **drivers of phenology** (environmental and individual) is therefore crucial to understand how individuals can respond to such rapid changes.

Our goals:

- To identify individual and environmental drivers of migration phenology in spring and autumn
- To assess behavioral plasticity in the timing of migration



METHODS

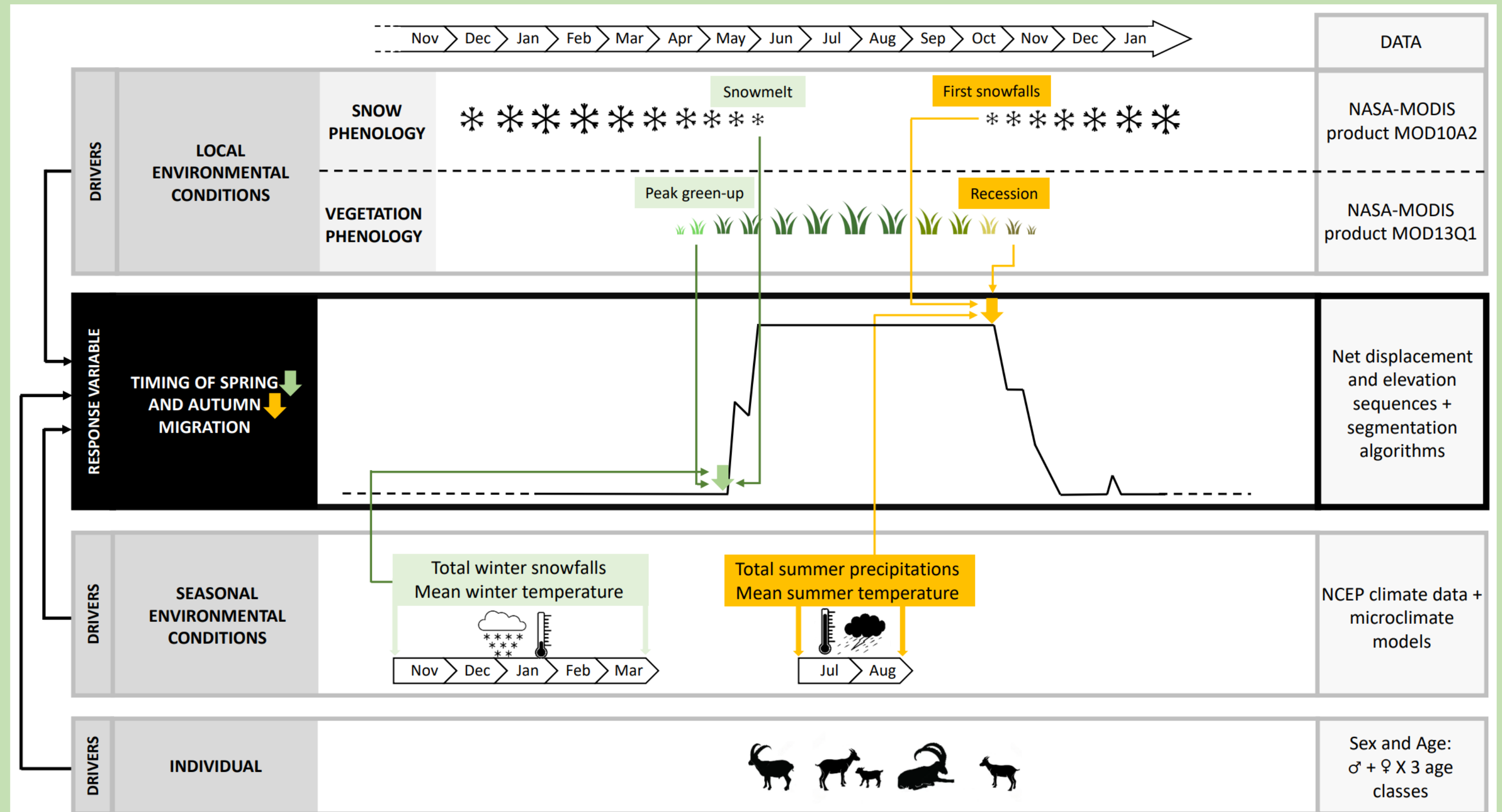
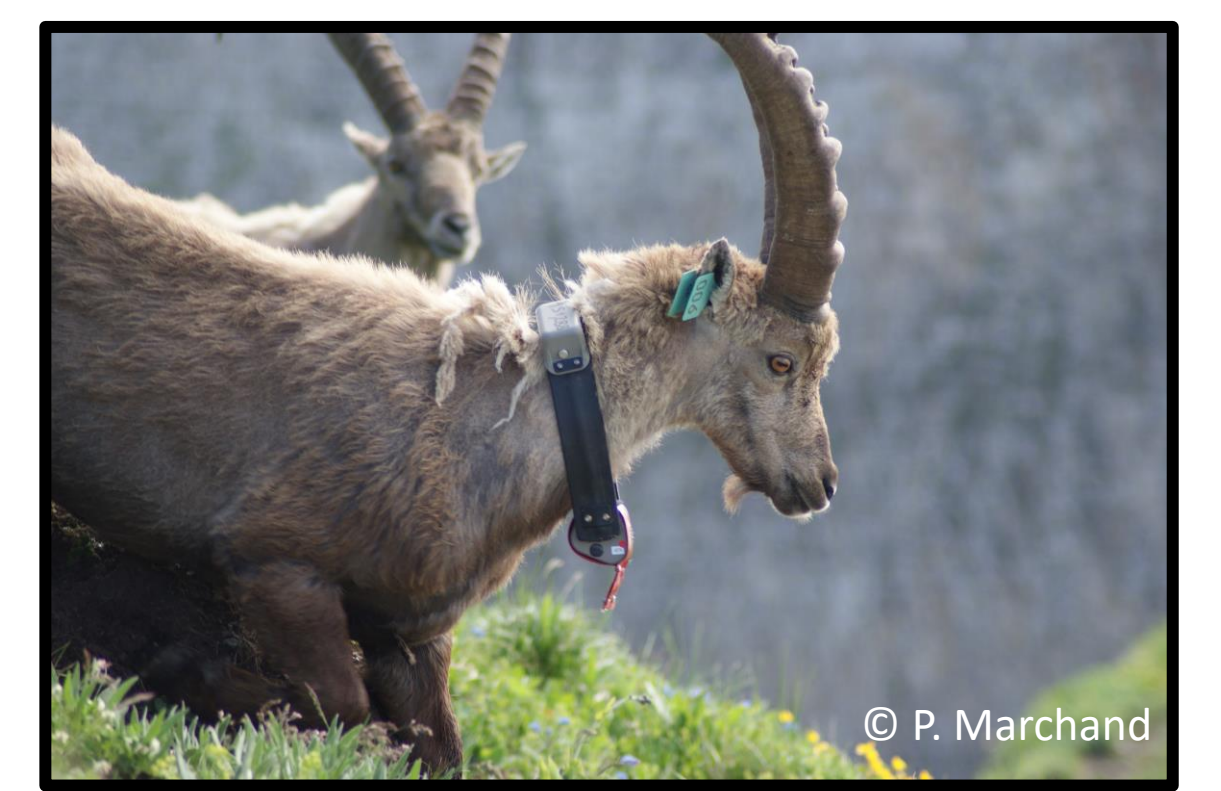
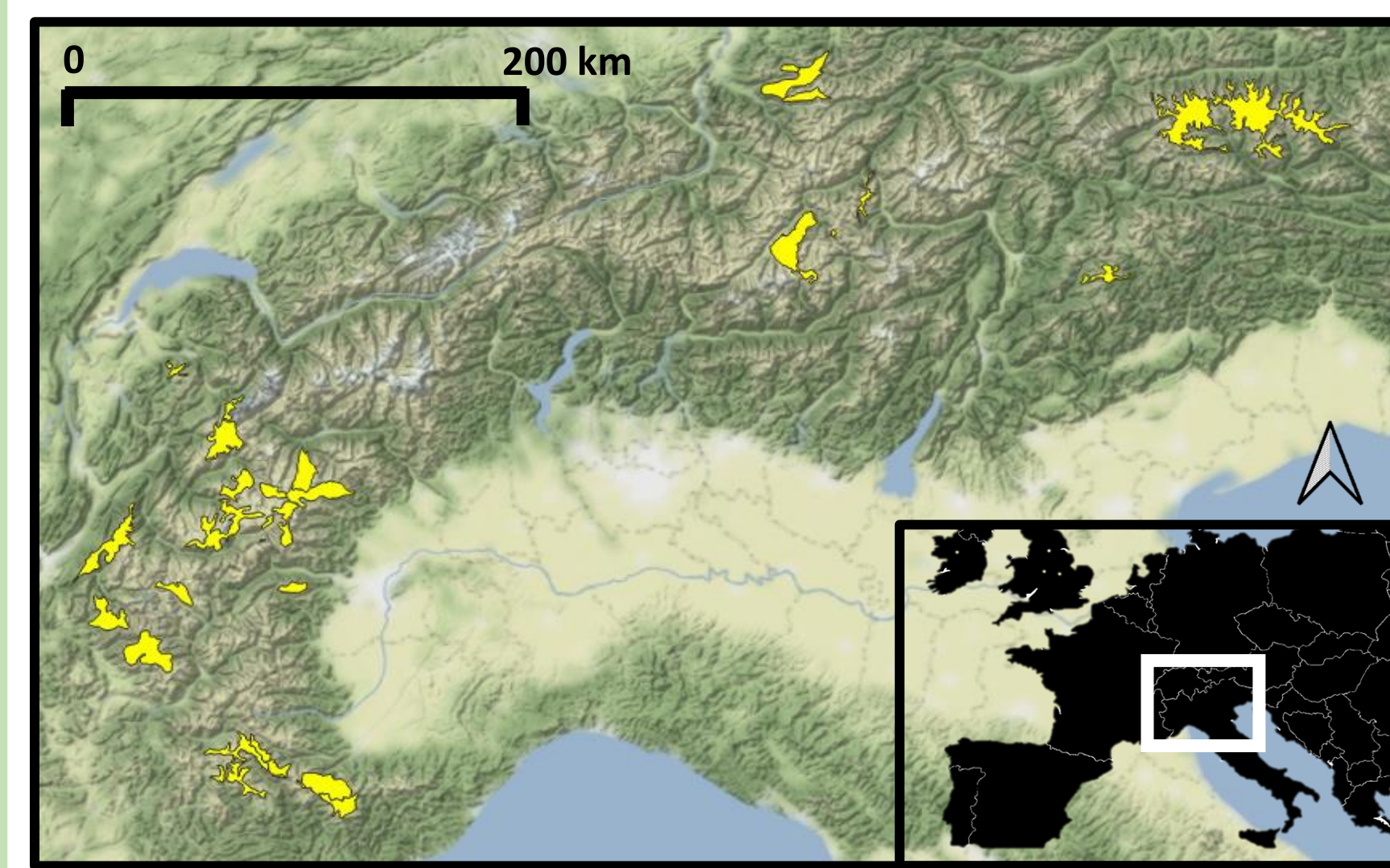


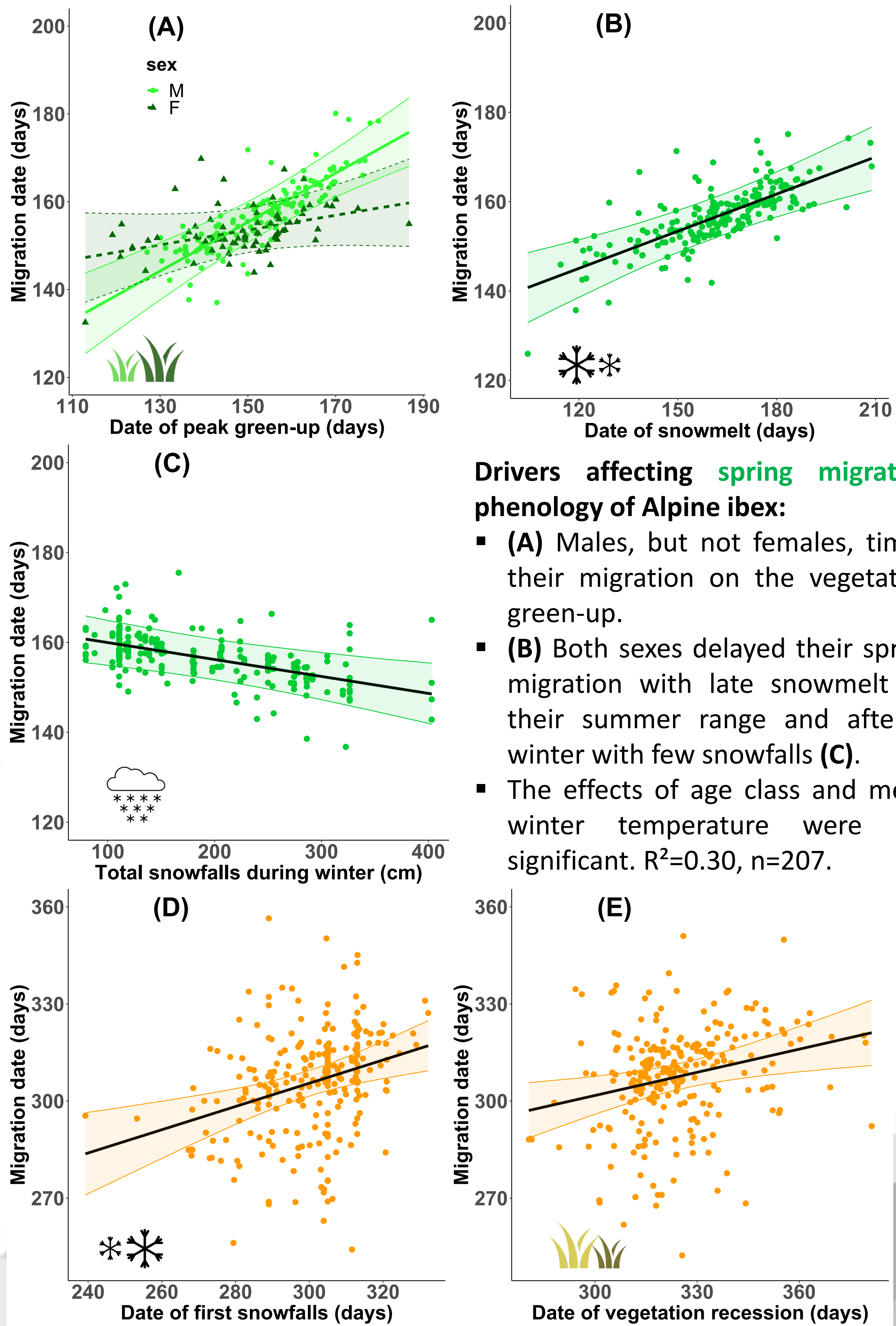
Illustration of possible environmental and individual drivers affecting the timing of ibex migration



407 ibex (218 M/189 F) tracked by GPS-collars from 17 populations (in yellow on the map, study period: 2003-2022)

- Linear mixed-effects models:** Drivers (Fixed effects) + Population/animal id (Random effects) -> Model selection based on AICc
- Assessing behavioral plasticity:** Animals migrating multiple years + interannual differences in drivers -> Δ migration dates \sim Δ drivers selected in best models

RESULTS

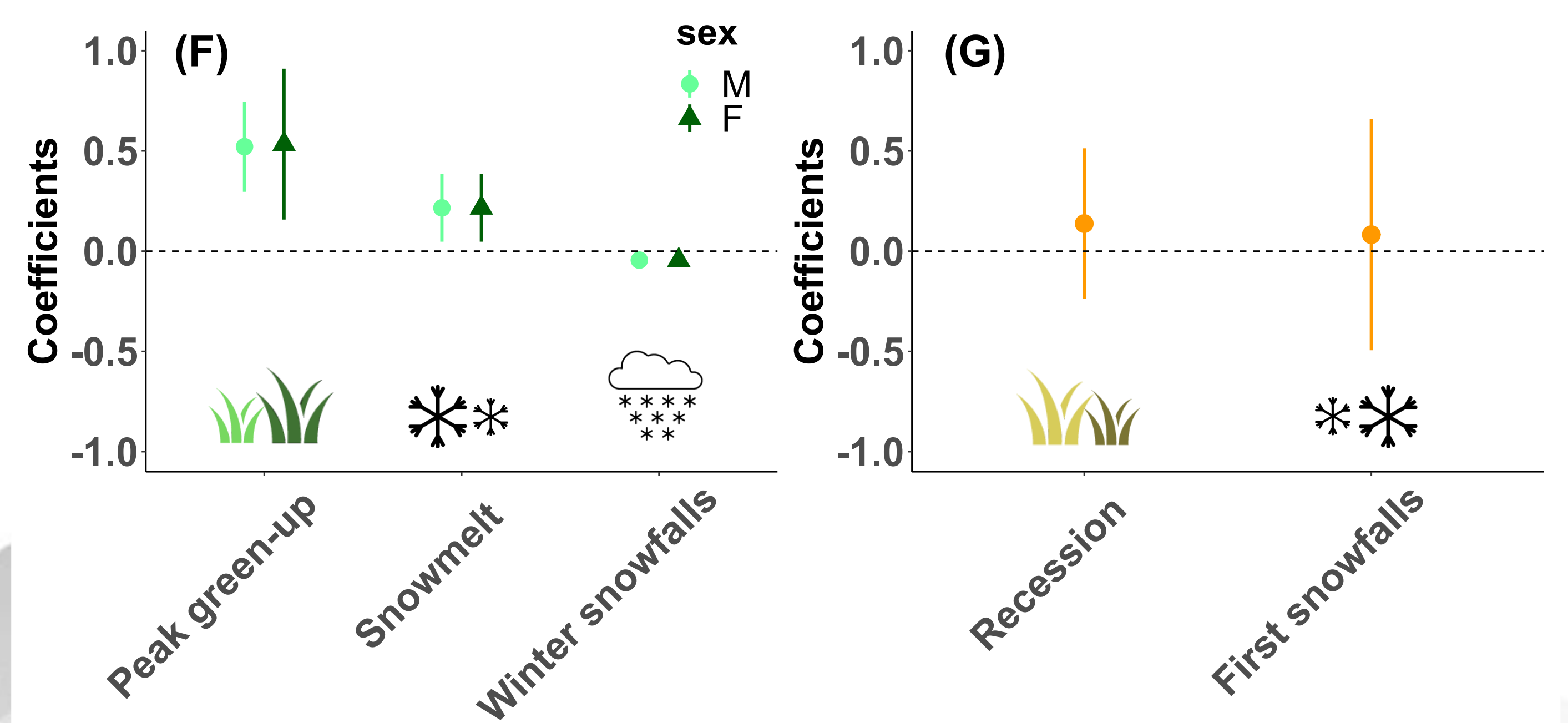


Drivers affecting spring migration phenology of Alpine ibex:

- (A) Males, but not females, timed their migration on the vegetation green-up.
- (B) Both sexes delayed their spring migration with late snowmelt on their summer range and after a winter with few snowfalls (C).
- The effects of age class and mean winter temperature were not significant. $R^2=0.30$, $n=207$.

Drivers affecting autumn migration phenology of Alpine ibex:

- (D) Migration date was positively correlated with the date of first snowfalls as well as the date of vegetation recession (E). These effects were similar for both sexes.
- The effects of age class and seasonal drivers were not significant. $R^2=0.11$, $n=247$.



Behavioral plasticity is limited

- In spring (F, $n=49$), both males and females displayed behavioral plasticity in response to interannual differences in date of peak green-up, snowmelt and winter snowfalls.
- However, this plasticity appeared limited with a shift of 5.2 and 2.2 days in migration dates for a shift of 10 days in vegetation growth peak and snowmelt, respectively. A difference of 1 meter in winter snowfalls led to a shift of 4.5 days in migration dates.
- In autumn (G, $n=38$), no behavioral plasticity in response to changes in phenological events was observed.

CONCLUSIONS

- Vegetation and snow phenology affects the timing of migration in Alpine ibex but differently between sexes in spring (females constrained by parturition?).
- Individuals display behavioral plasticity, but its extent appears limited (other important events such as the parturition and rut, possibly less plastic and potentially driven by other parameters, could constrain plasticity in migration timing).
- Onset of spring will be advanced by 30 days in 2100⁽³⁾. Ibex could possibly respond with a shift in migration timing but a mismatch of 15 days with the peak of green-up could be expected.
- Understanding how this trophic mismatch could change the benefits of migration and lead to demographic consequences is therefore crucial^(4, 5).