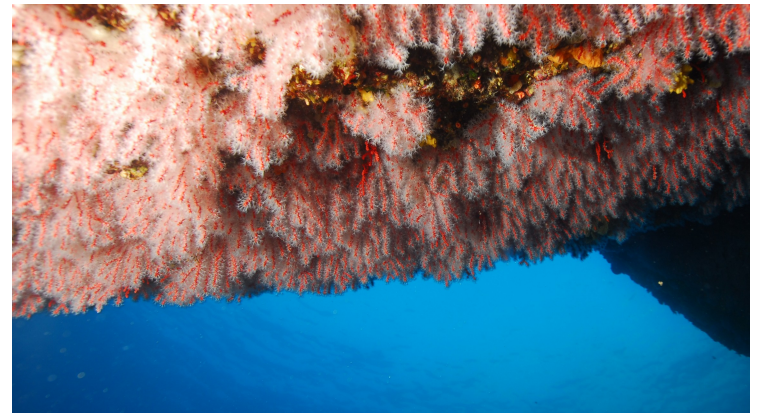


# Climate change and the evolutionary challenge of Mediterranean biodiversity



C. Pujos / ONF



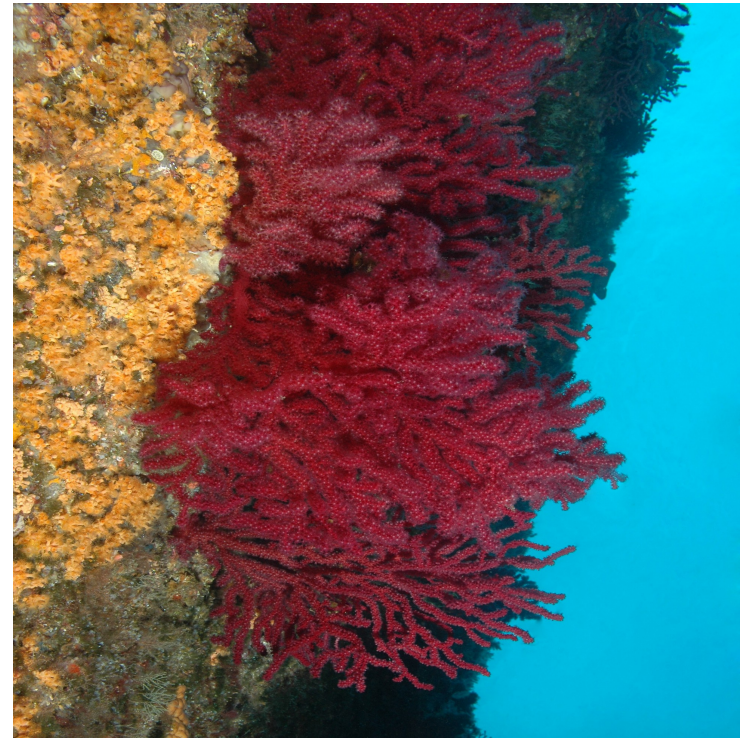
F. Zuberer / CNRS

B. Fady, M. Bally, A. Bondeau, F. Carlotti, A. Chenuil,  
W. Cramer, J-P. Féral, T. Gauquelin, A-C. Monnet,  
S. Thomas, F. Van Wambeke, D. Aurelle

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# Climate change and the evolutionary challenge of Mediterranean biodiversity



Ecological gradients and genetic adaptation to climate change in the Mediterranean

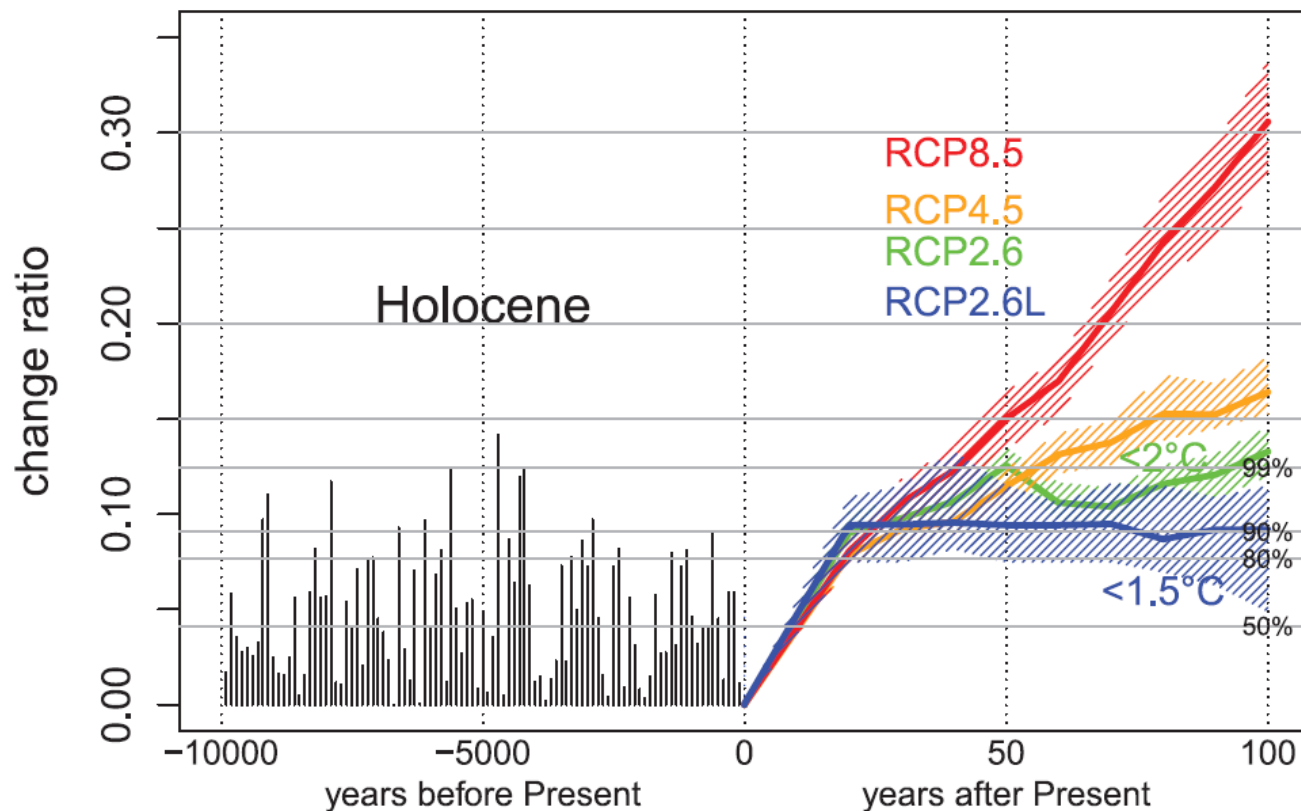
## **The Mediterranean paradox: High (taxonomic, genetic, functional) biodiversity despite long-term human pressure**

- ✓ Land: 1.8 % of earth's land mass; 20 % of flowering plants and ferns; 5,500 endemic plant species.
- ✓ Sea: 0.8% of the surface of the global ocean; 4 to 18% of the world biodiversity
- ✓ Birth of agriculture: 10-12,000 years ago
- ✓ Total current population: 500 millions + ~270 millions tourists annually



Current climate  
change pattern:  
~+0.2°C / decade  
2<sup>nd</sup> half 20<sup>th</sup> century,  
increased summer  
drought

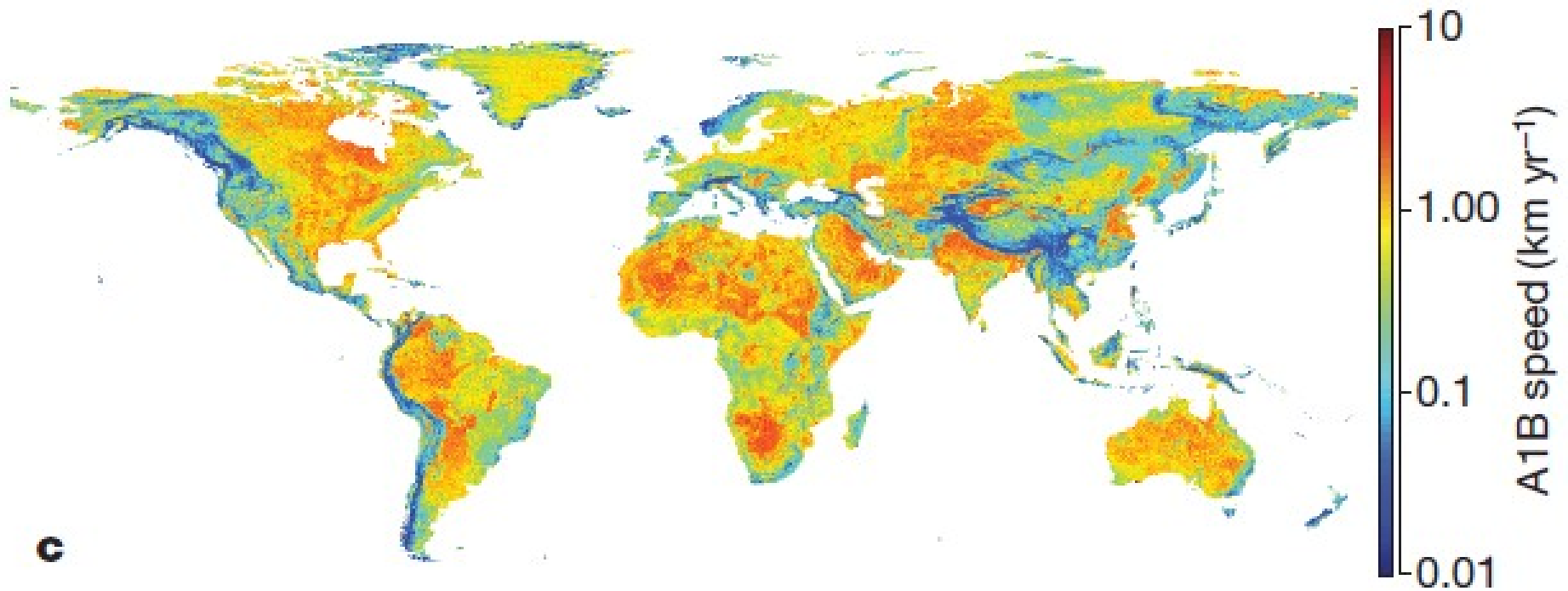
## Climate change in the Mediterranean: unprecedented biome composition change is expected



Left:  
Percentage of land that underwent a biome composition change during the Holocene based on pollen archives compared to present day composition.

Right:  
Biome composition change that can be expected under different climate change scenarios

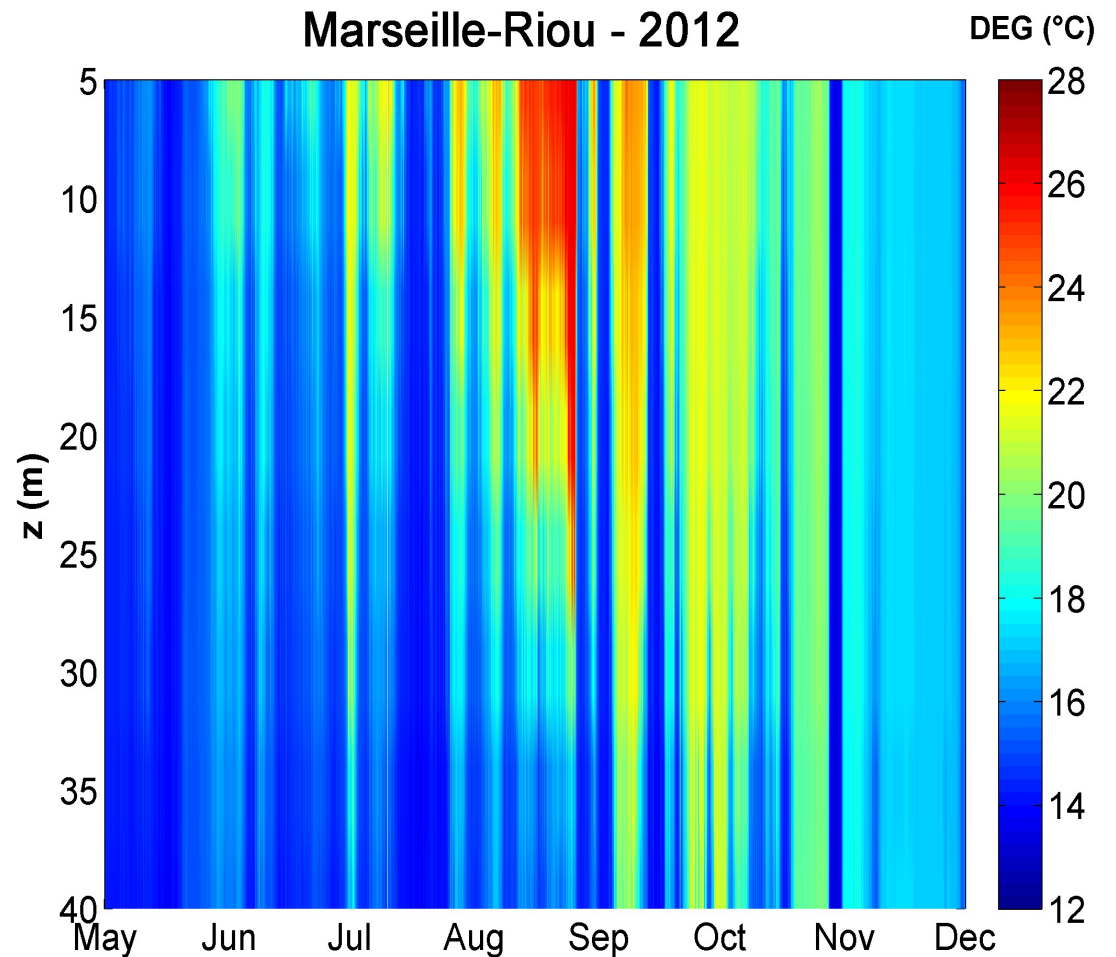
**Mediterranean terrestrial forests display one of the lowest velocity of climate change worldwide.  
=> a wealth of highly diverse landscapes and micro-habitats**



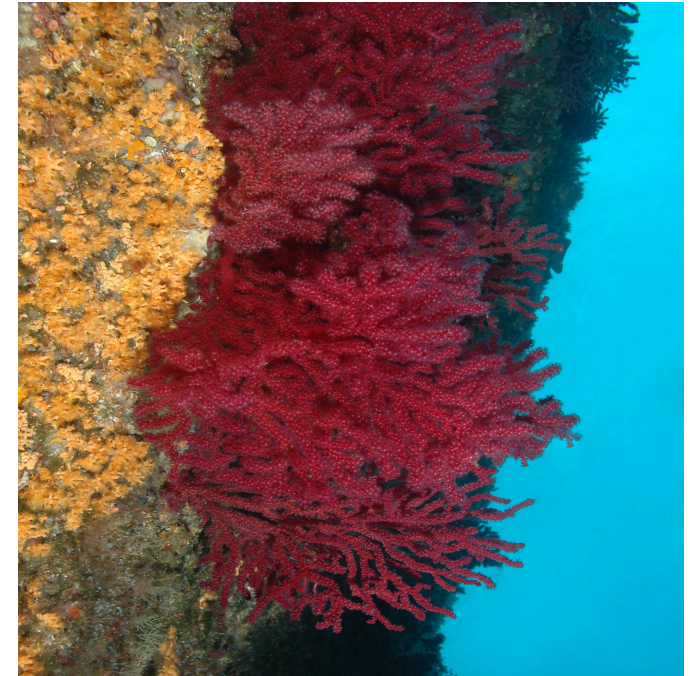
**c**, average of the global land surface. **c**, A global map of climate velocity calculated using the 2050–2100 Special Report on Emissions Scenarios (SRES) A1B emissions scenario temporal gradient.

## Steep habitat / ecological gradients: also in marine systems

Strong temperature stratification of shallow sea water during the summer in the north-western Mediterranean



## Looking for differentiation and signatures of selection in Mediterranean marine and terrestrial forests along ecological gradients



→ **Mediterranean ecological gradients = strong potential for local adaptation (temperature, light, drought, etc)**

## Similarities between Mediterranean marine and terrestrial forests:

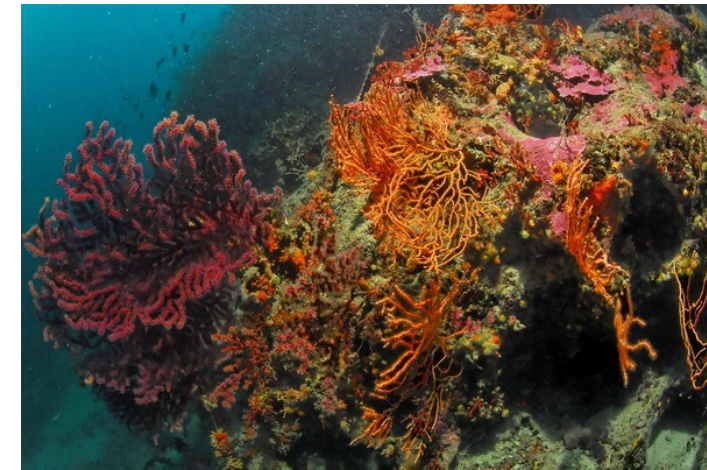
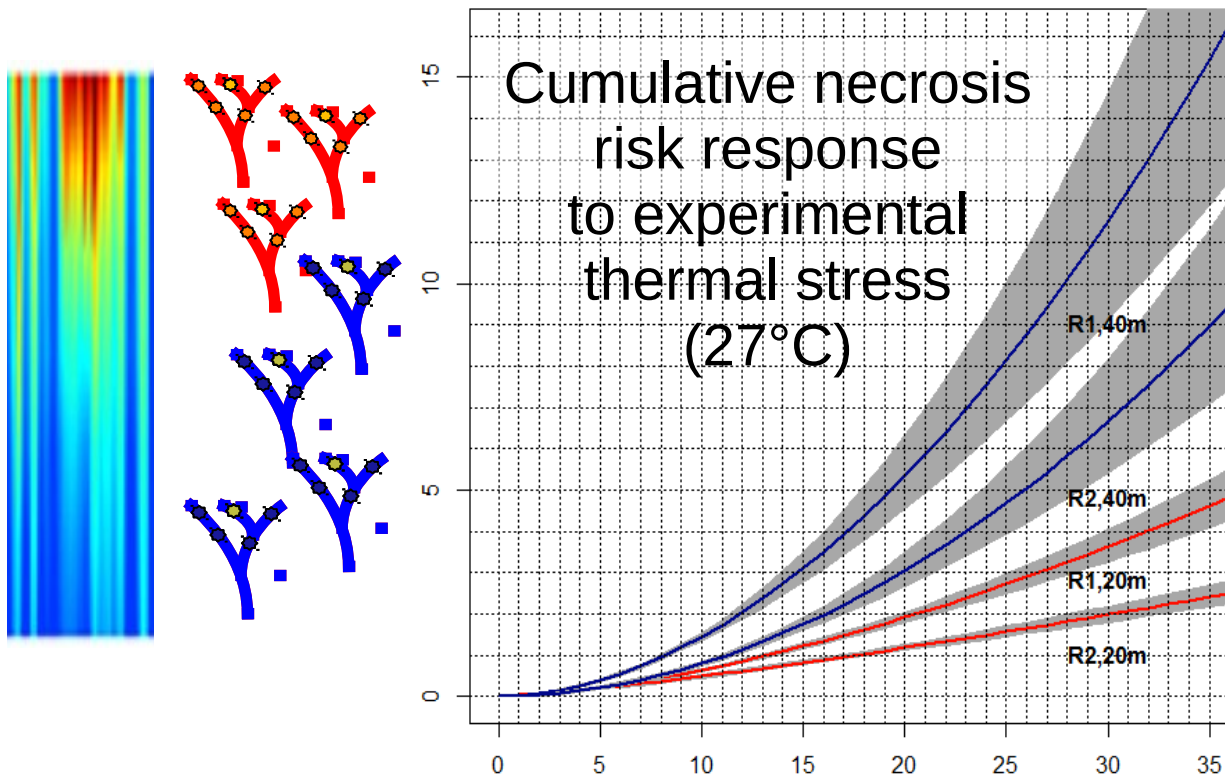
- **sessile** engineer species: long-lived anthozoans or algae, conifers and broadleaves
- “pulse like” recruitment;
- propagule dispersal possible across entire gradient;
- **range shift limitations** under climate change:
  - \* marine: no possibility of northward expansion;
  - \* terrestrial: no possibility of upward expansion on low mountains;
- **mortality** linked to heat wave events ( $T^{\circ} +$  pathogens).





## Mediterranean marine forests : gorgonians

- evolution along depth / temperature gradient
- thermotolerance differences (shallow > deep)
- variable differentiation between depths



40 m depth colonies



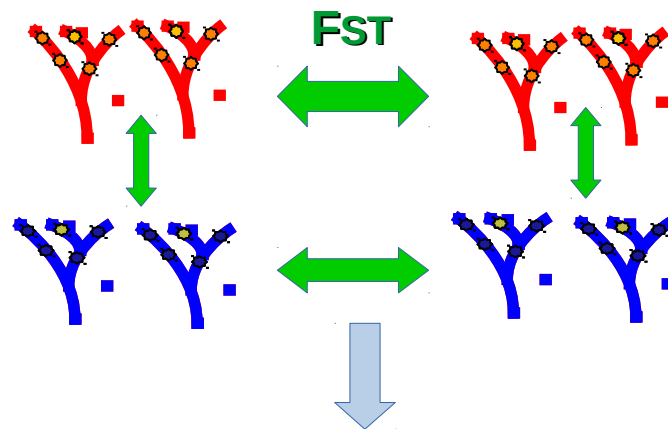
20 m depth colonies

*Eunicella cavolini*  
(Yellow gorgonian)

-> determinism / heritability of fitness differences?

## Mediterranean marine forests :

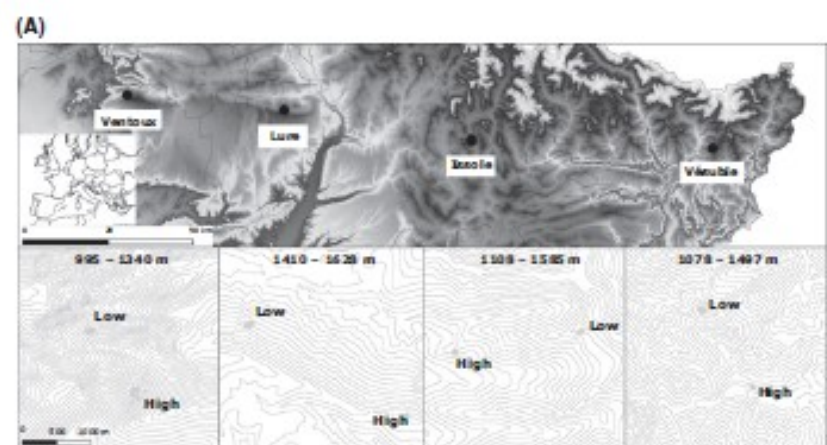
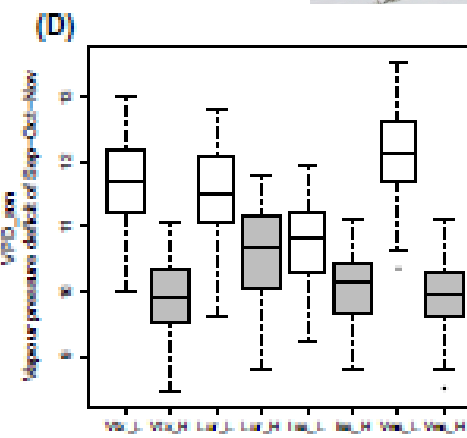
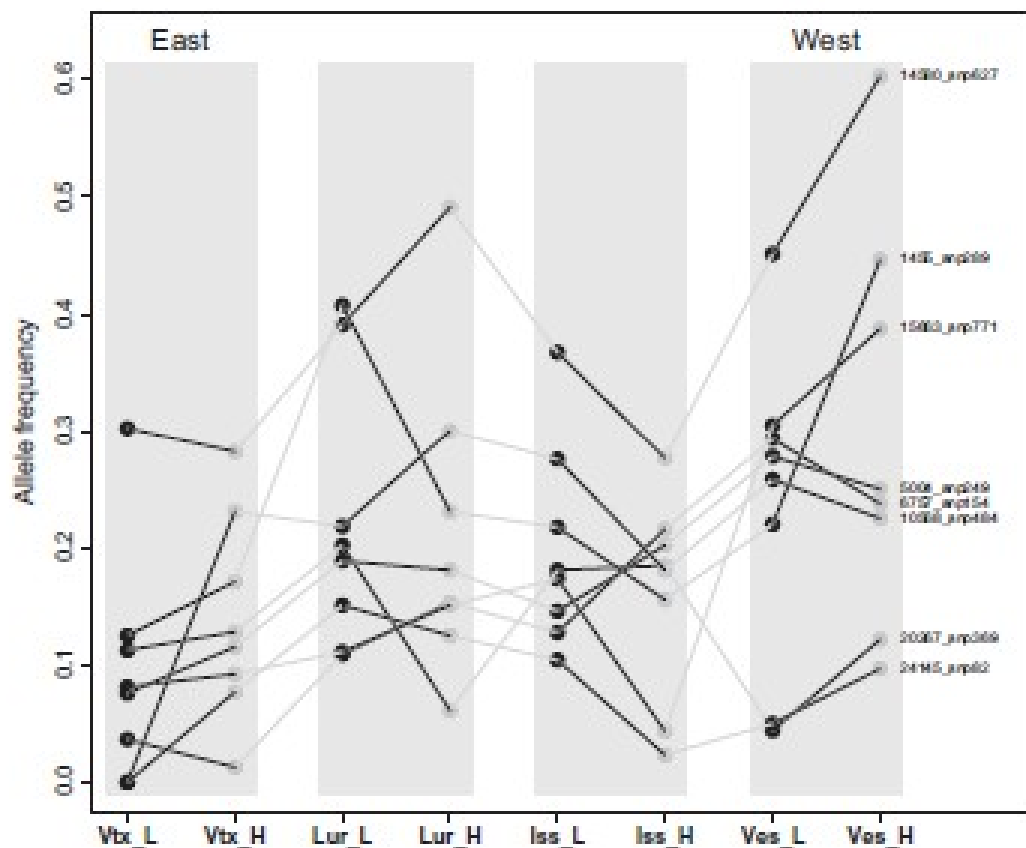
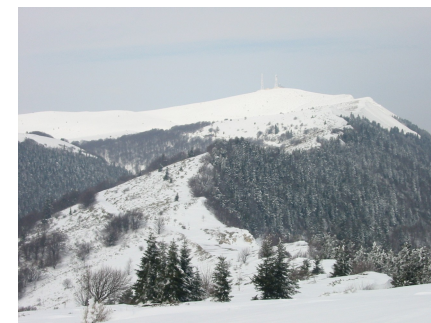
- genomic (RAD-Seq) structure along depth gradients (8-40 m) in *Corallium rubrum*;
- significant differentiation among sites (++) and different depths (+);
- Higher differentiation between shallow than between deep populations.



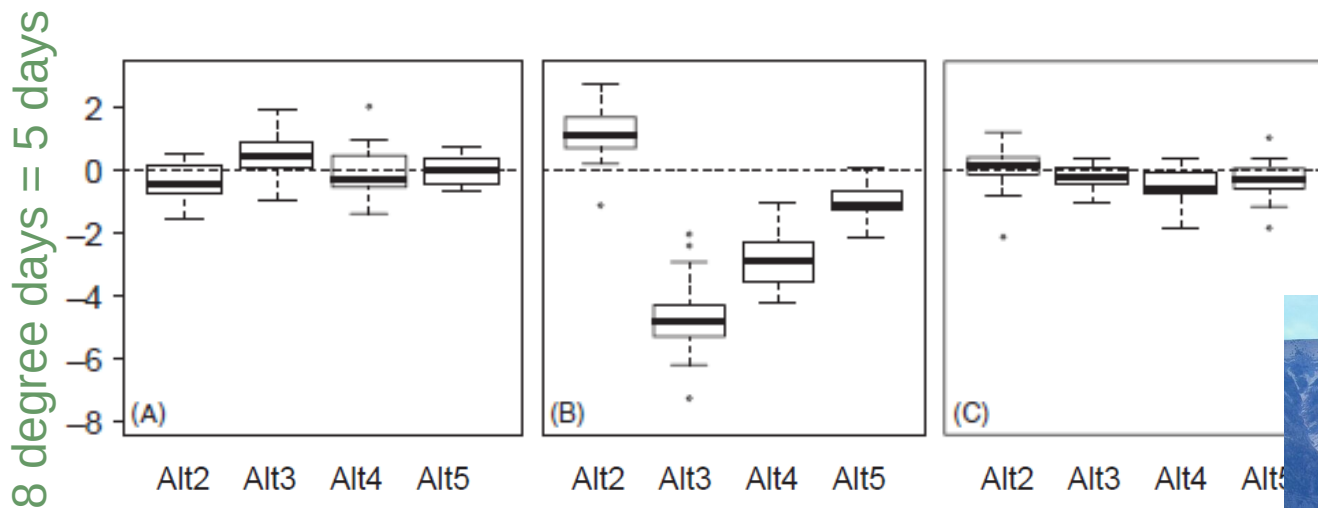
Outlier loci, see  
poster P-0585, S.  
66 (Aurelle et al.)  
on Sunday

=> Barriers to gene flow in shallow populations / cryptic species?

# Evidence of signature of selection for drought and frost along steep ecological gradients in the conifer tree *Abies alba* in southern France



## Modeling the rate of adaptive evolution of spring leaf unfolding after 5 generations along a steep altitudinal gradient (*Fagus sylvatica*)



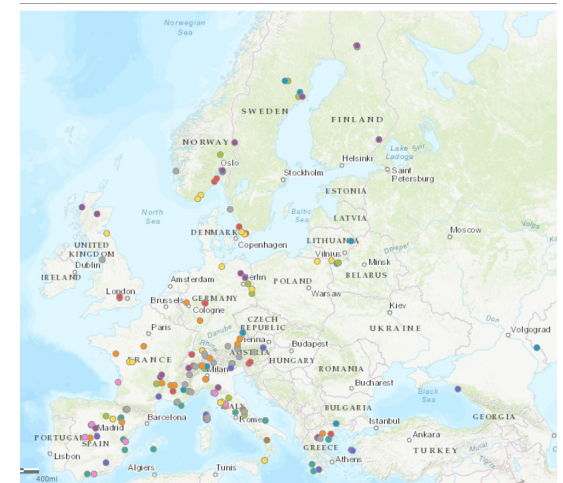
- (A): Neutral
- (B): adaptive evolution
- (C): adaptive evolution without mortality

## Conclusion (1) - implications for research:

Rapid local adaptation at short spatial scale is possible along steep ecological gradients.

Experimental design for detecting local adaptation: genome scan replicates *sensu* Lotterhos & Whitlock (MolEcol 2015) and reciprocal transplants.

See project GenTree:  
<http://www.gentree-h2020.eu/>



**Mediterranean = steep ecological gradients  
 = ideal biome for research on signatures of  
 selection and local adaptation!**

## Conclusion (2) – Evolutionary application for *in situ* conservation:

Conservation planning needs to focus on areas where there are **steep ecological gradients** which can foster natural selection and adaptation (e.g. coastal depth gradients; mountain sides).

**Include evolutionary thinking in conservation planning!**

See session S76. Evolutionary management of wild populations  
Wed, 22 August, starting 09:25 (Rabelais room)

