# *High alpine mountain facing climate change*

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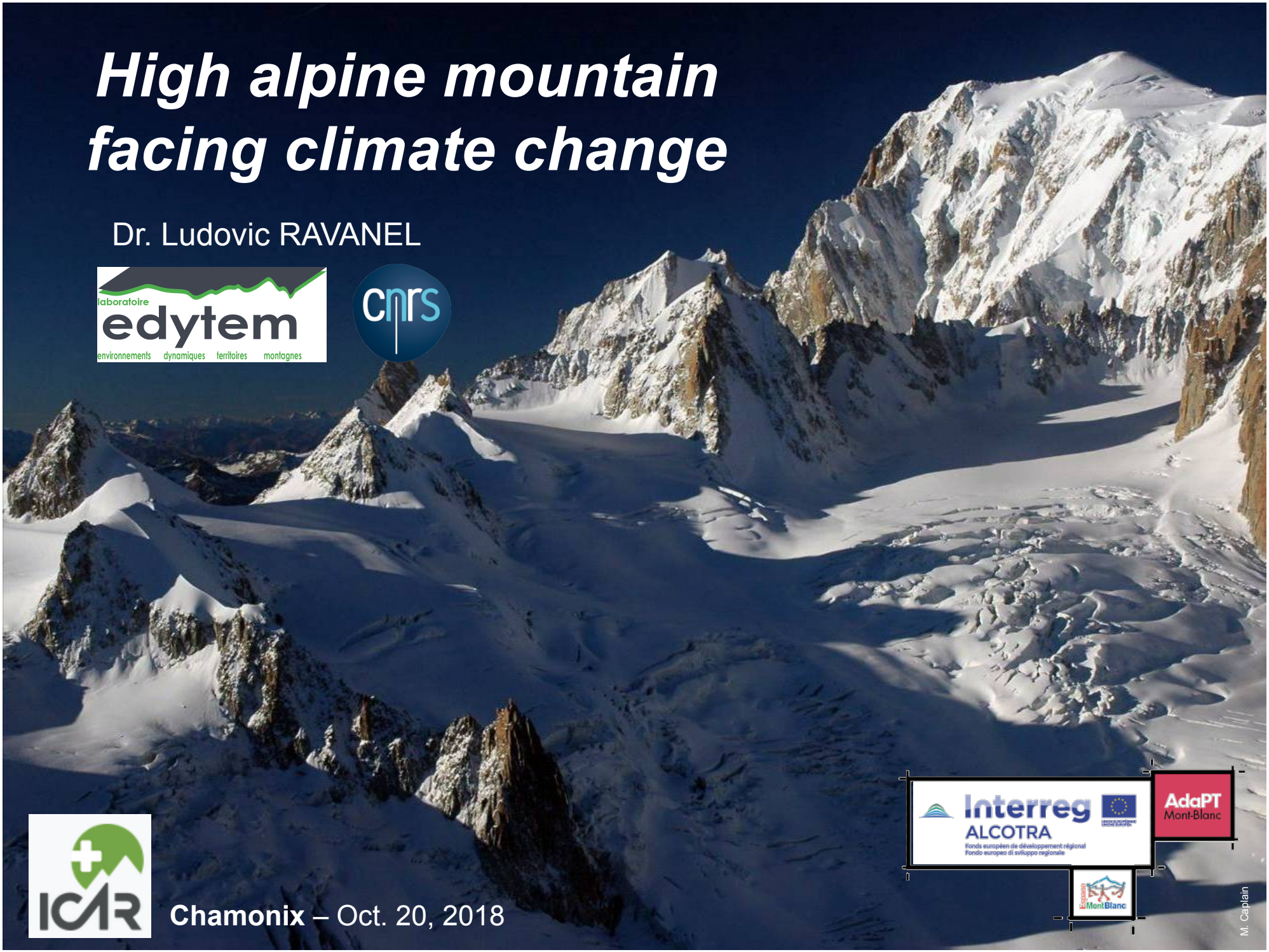
laboratoire edytem environnements dynamiques territoires montagnes

cnrs



Interreg ALCOTRA
Fonds européen de développement régional
Fondo europeo di sviluppo regionale

AdaPT Mont-Blanc

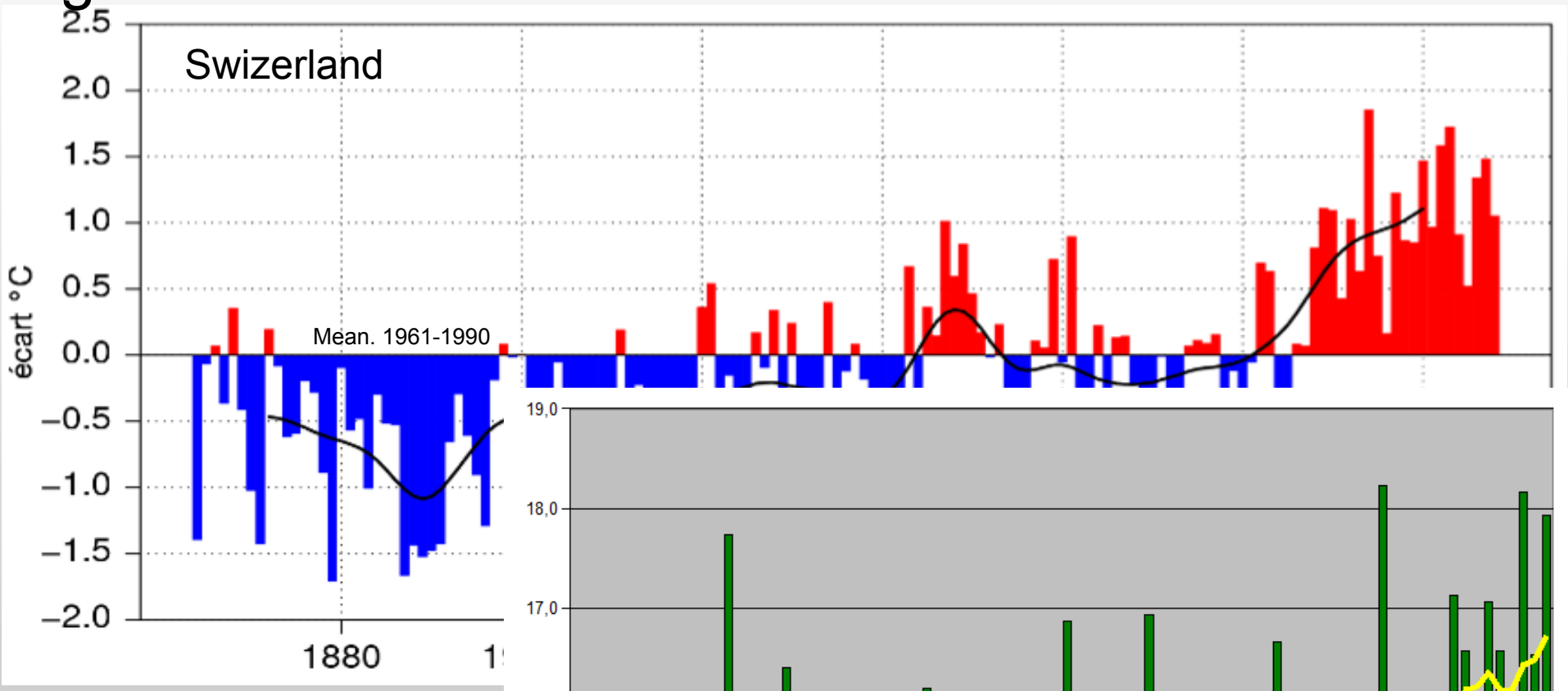
Espace Mont Blanc

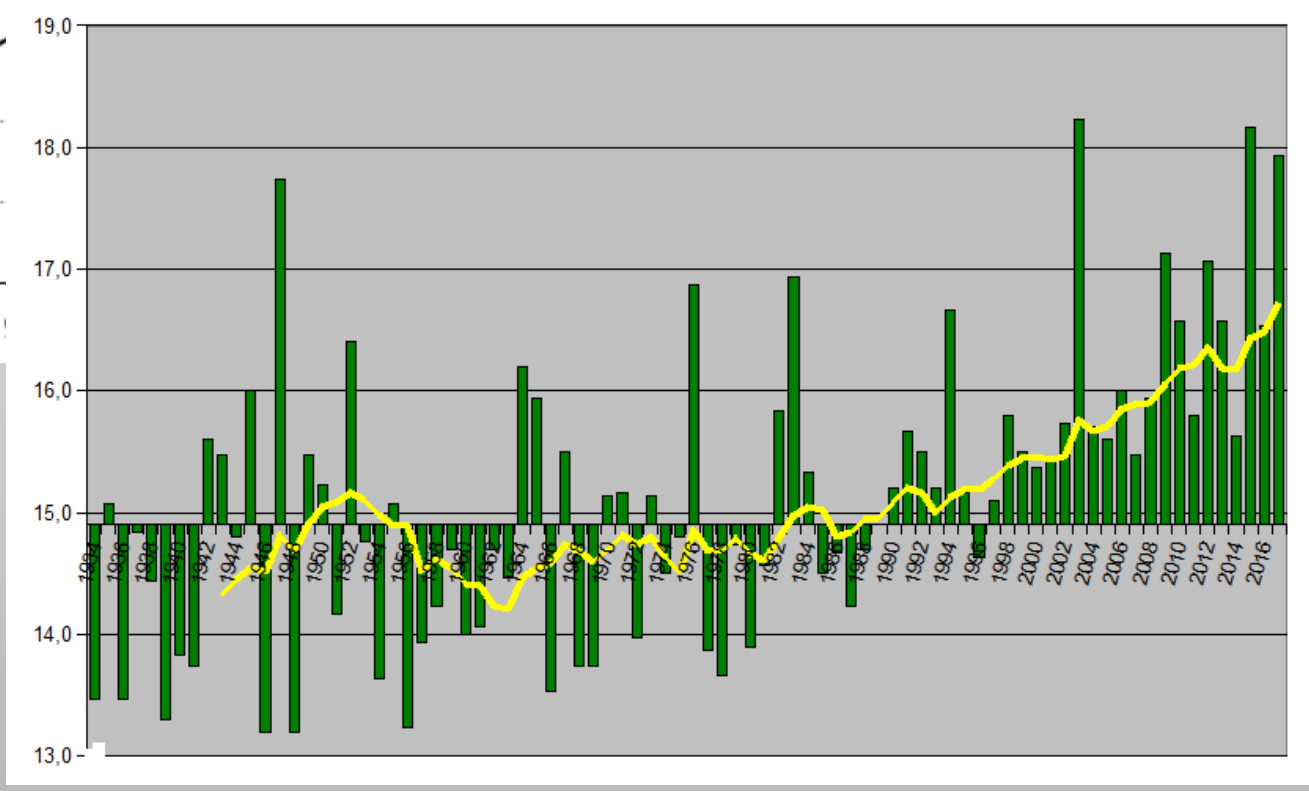
ICAR

**Chamonix** – Oct. 20, 2018

M. Caplain

# Alpine climate since the end of the Little Ice Age



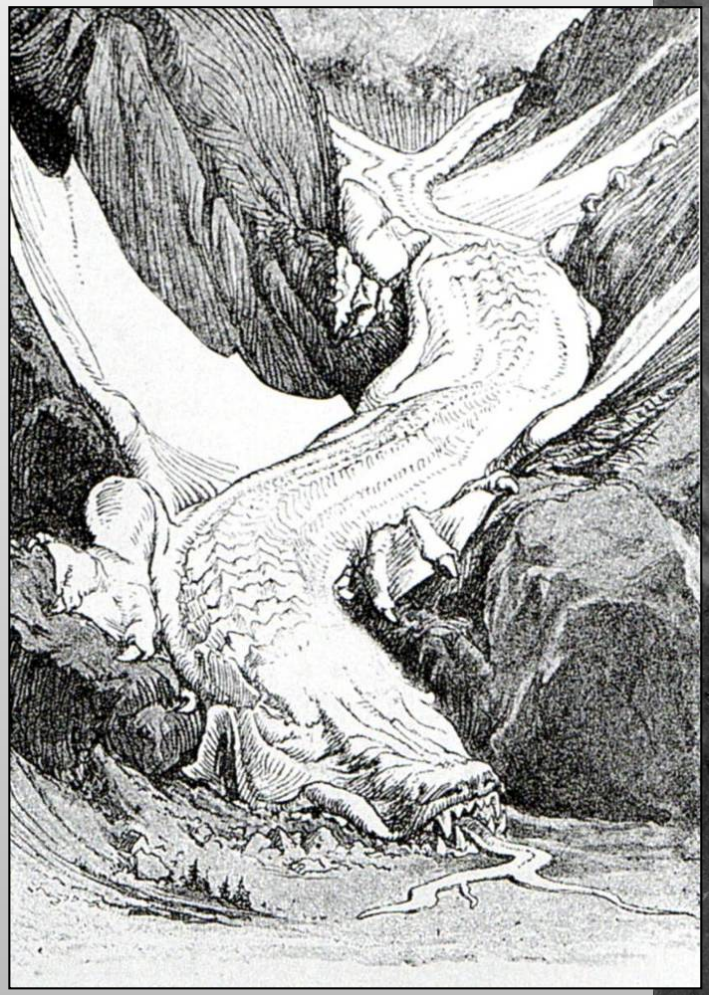




Chamonix 1936 - 2017:
+2,1°C !!!!!

Mean temp. in Chamonix
June / July / August

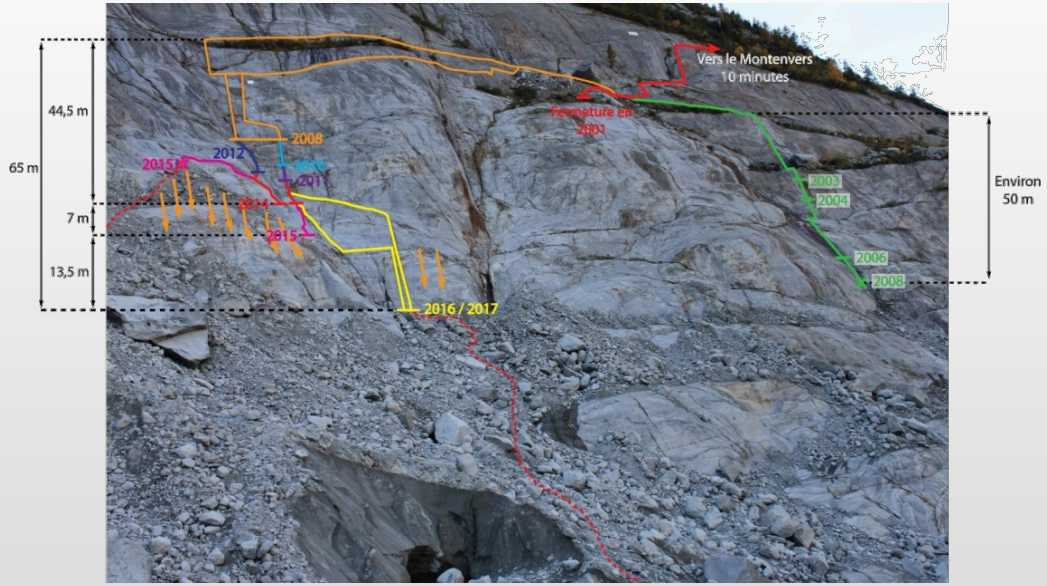

Mer de Glace
Chemin de fer du Montenvers
1042 - 1913 m
Chamonix
Mont-Blanc
CAISSE-CASH DESK
CAISSE-CASH DESK
CAISSE-CASH DESK
F. Louison

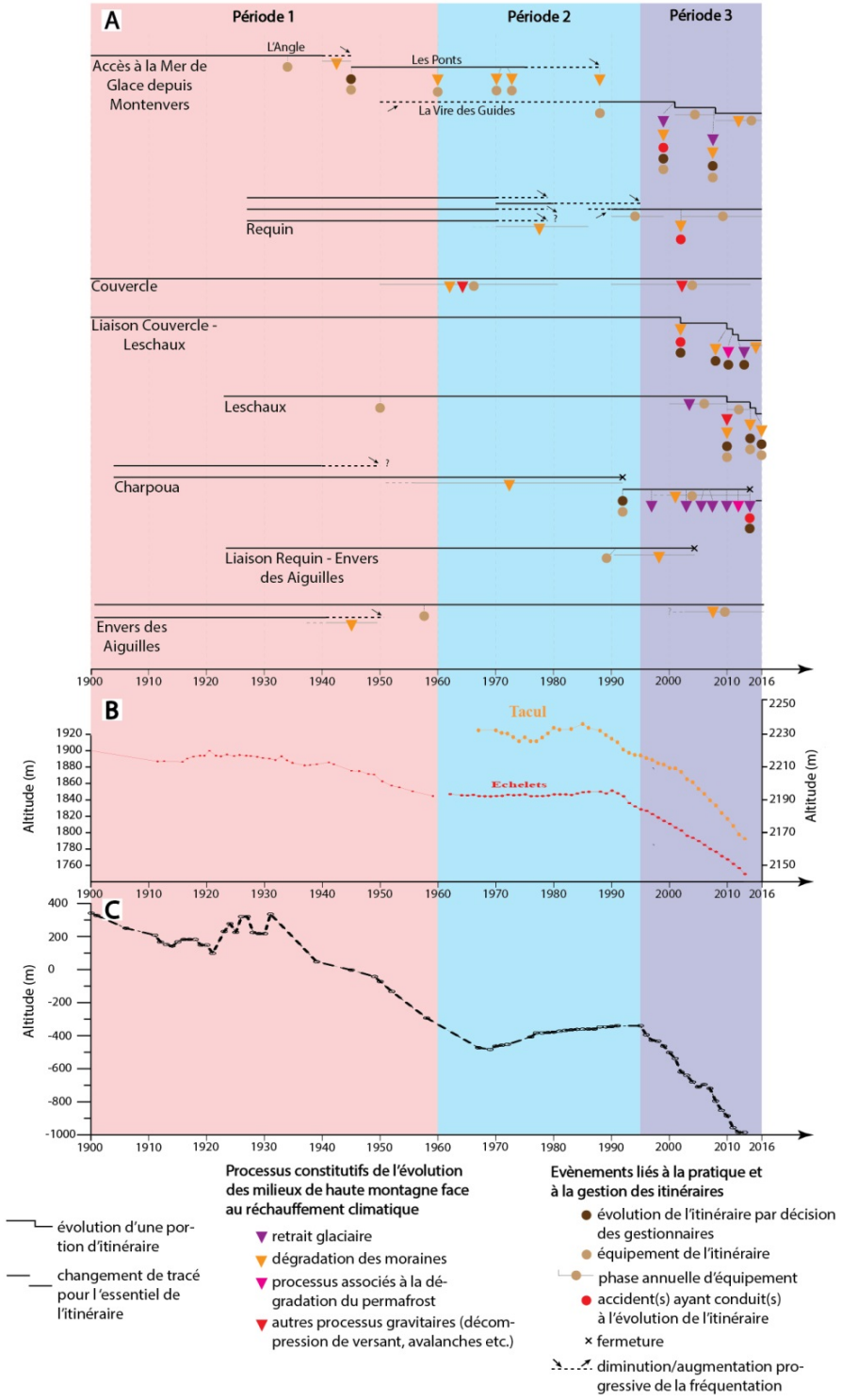
The Mer de Glace



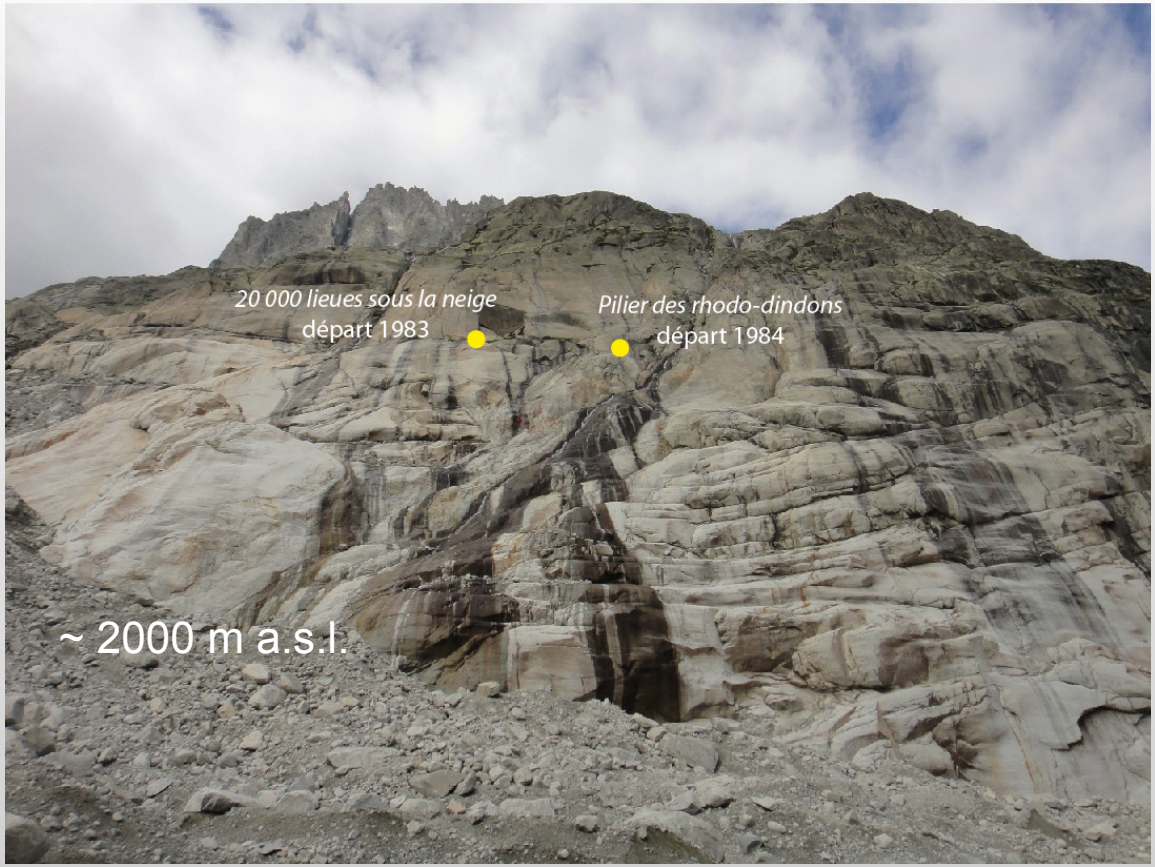

NIVEAU DU GLAC
LEVEL OF THE GLAC
1990

# Consequences on mountainee

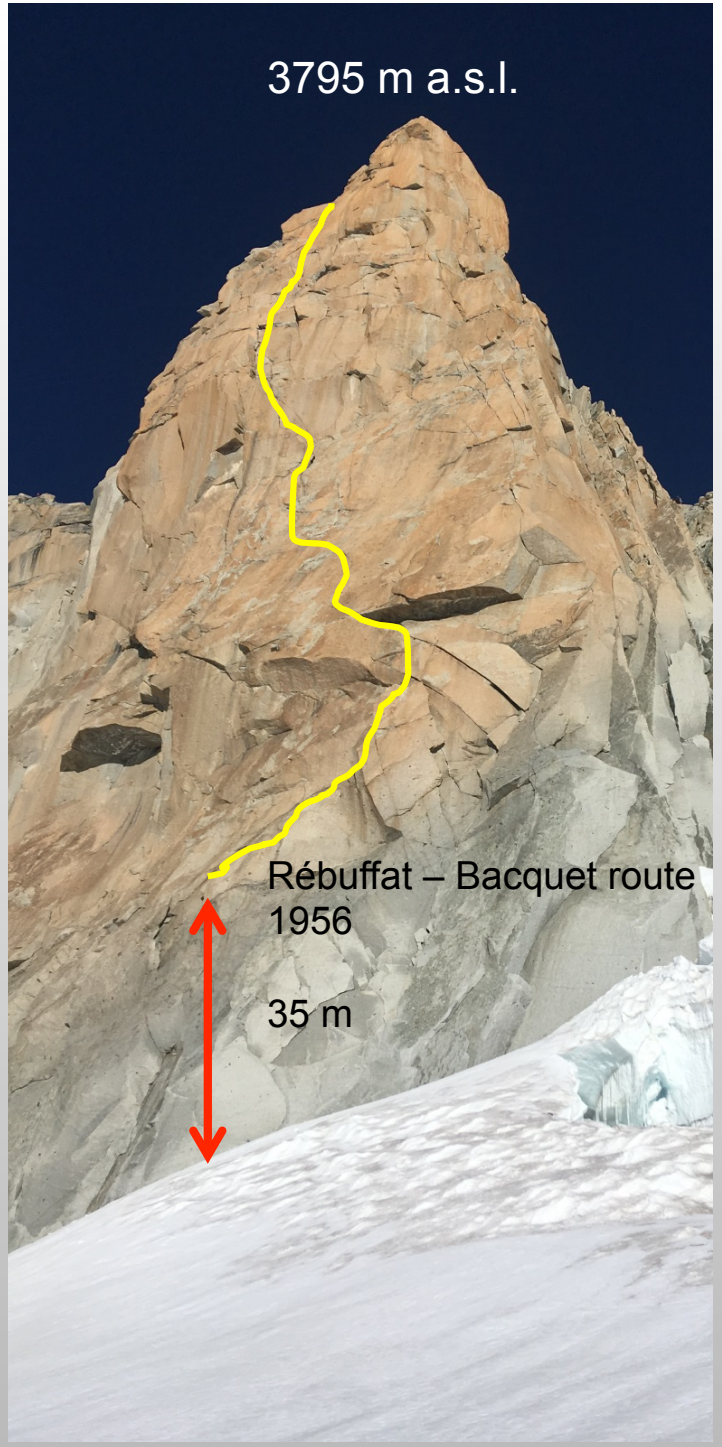


# → Access to climbing routes




*Sous l'Envers* slabs

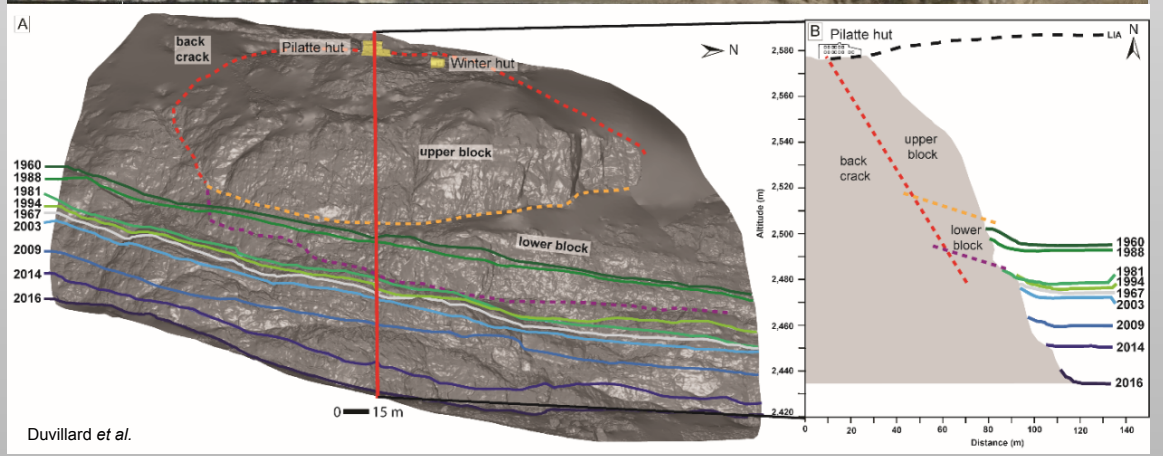



Aiguille du Midi south face

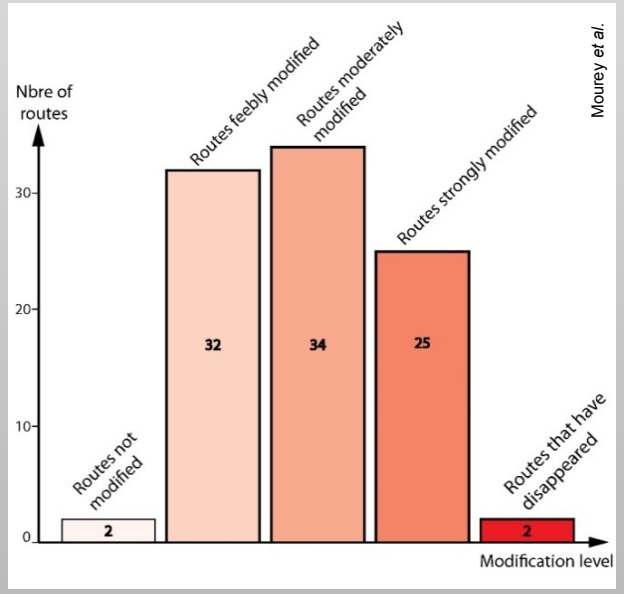
# At the hut…


Cosmiques hut (Mont Blanc), 1998, 600 m$^3$

Pilatte hut (Écrins), 400,000 m$^3$



# The route

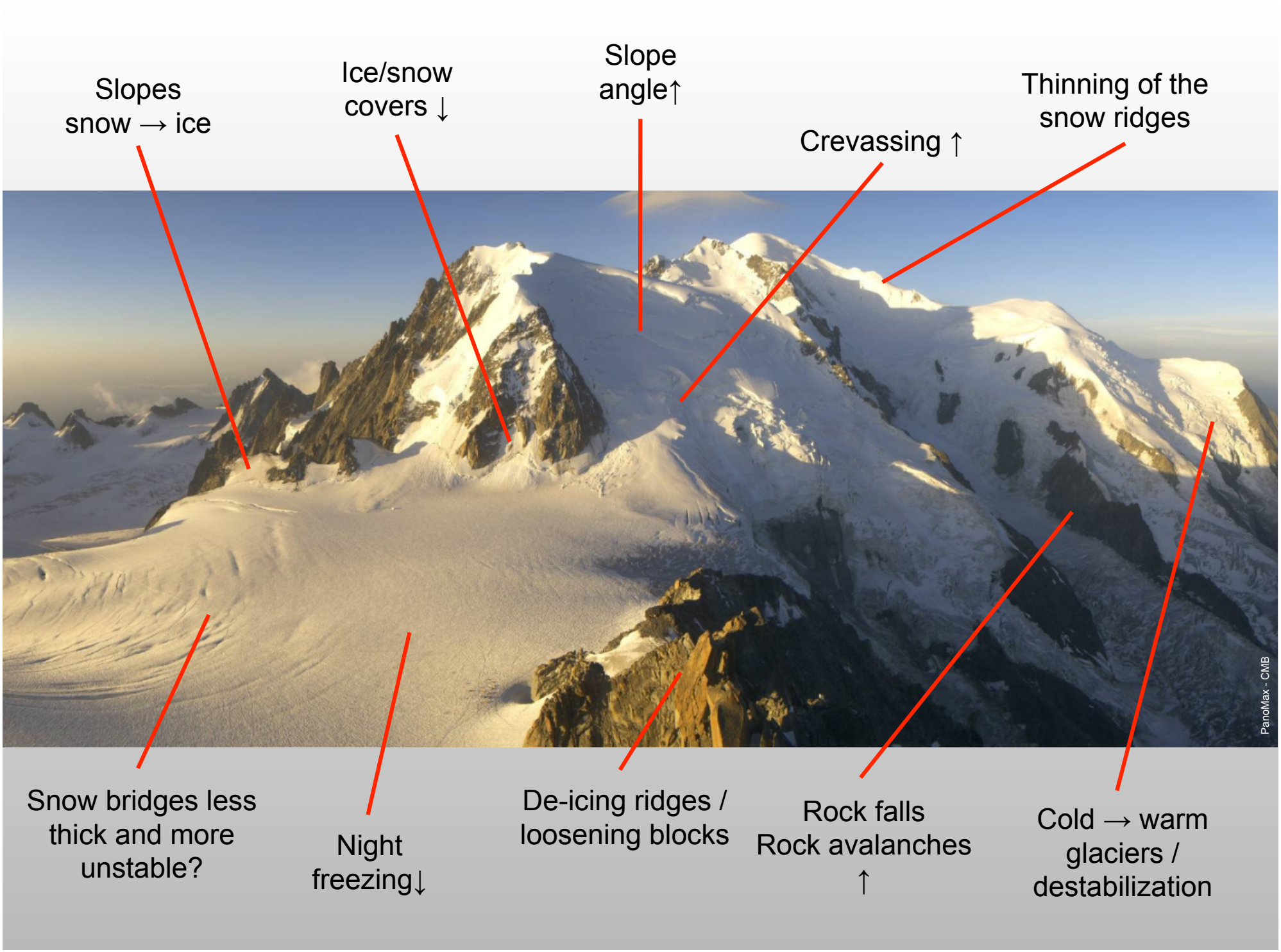




| Principaux effets du changement climatique sur les milieux de haute montagne | Processus affectant et modifiant les itinéraires | | Nombre d'itinéraires affectés (XX/95 - YY %) | Partie(s) des courses la (les) plus affectée(s) | Effets sur les conditions de fréquentation des itinéraires |
|---|---|---|---|---|---|
| Dégradation du permafrost | Eboulements / écroulements | | 28 - 27 | ↗ | ● ▲ |
| | Chutes de pierres (cryoclastie, ruissellement) | | 55 - 52 | ↗ | ● |
| Retrait des couvertures glacio-nivales et évolution des arêtes en neige | Couvertures glacio-nivales «en glace» plus tôt dans la saison éstivale (voire de manière quasi permanente) | | 58 - 55 | ↗ | ● |
| | Accroissement des angles de pente | | 53 - 50 | ↗ | ● |
| | Retrait des couvertures glacio-nivales; apparition du substratum rocheux en général très fracturé voire déstructuré | | 53 - 50 | ↗ | ▲ |
| | Arête de neige devenant plus étroites | | 25 - 24 | ↗ | ● |
| Retrait glaciaire | Processus paraglaciaires | Désenglacement et augmentation de la hauteur des moraines | 47 - 45 | ⇢ ↘ | ● ▲ |
| | | Accroissement des angles de pente des moraines | 47 - 45 | ⇢ ↘ | ● |
| | | Déstabilisation rocheuses (chutes de pierres, éboulements, écroulements, glissements) | 47 - 45 | ⇢ ↘ | ● |
| | | Développement de la torrentialité en zone proglaciaire | 3 - 3 | ⇢ ↘ | ● |
| | Désenglacement du substratum rocheux et apparition de dalles lisses | | 77 - 73 | ↗ | ● |
| | Désenglacement du substratum rocheux et apparition de blocs instables | | 30 - 28 | ↗ | ● ● |
| | Apparition de nouvelles zones de crevasses | | 47 - 45 | ⇢ ↘ | ● ● |
| | Crevasses et rimayes plus ouvertes | | 78 - 74 | ⇢ ↗ ↘ | ● ● |
| | Fragilisation des ponts de neige | | | | ● |
| | Rupture du front de glaciers froids | | 4 - 4 | ↘ | ● |
| | Chutes de séracs issues du front de glaciers froids | | 12 - 11 | ↗ | ● |
| | Chutes de séracs issues de la surface des glaciers | | 23 - 22 | ↘ | ● |
| | Rupture du front de glaciers tempérés | | 7 - 7 | ↘ | ● |
| | Modification de l'hydrologie supra-glaciaire (bédières plus nombreuses, larges et profondes) | | 4 - 4 | ⇢ ↘ | ▲ ● |
| | Accroissement de l'angle de pente de certains secteurs | | 73 - 70 | ↘ | ● |
| | Surface des glaciers plus souvent «en glace» | | 49 - 47 | ⇢ ↗ ↘ | ● |
| | Développement d'une couverture détritique à la surface des glaciers | | 24 - 23 | ⇢ ↘ | ▲ |
| | Chutes / glissement de matériaux rocheux à la surface des glaciers | | 11 - 10 | ⇢ ↘ | ● |
| | Regel nocturne moins fréquent | | | | ● |

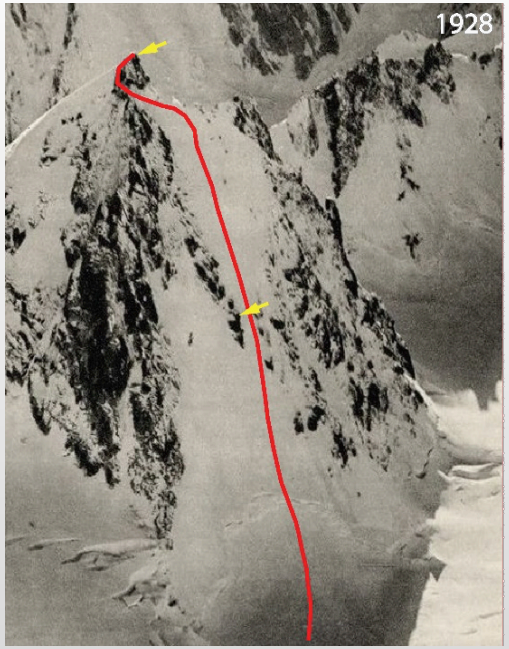
⇢ Approche
↗ Voie
↘ Descente

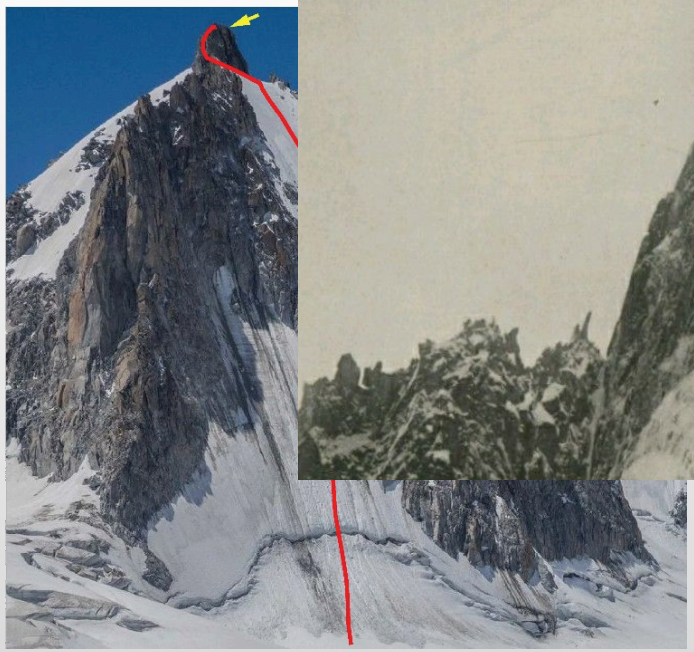
● Augmentation de la dangerosité
● Accroissement de la difficulté technique
▲ Allongement et plus grande pénibilité du cheminement
▲ Modification du tracé et des techniques de progression requises

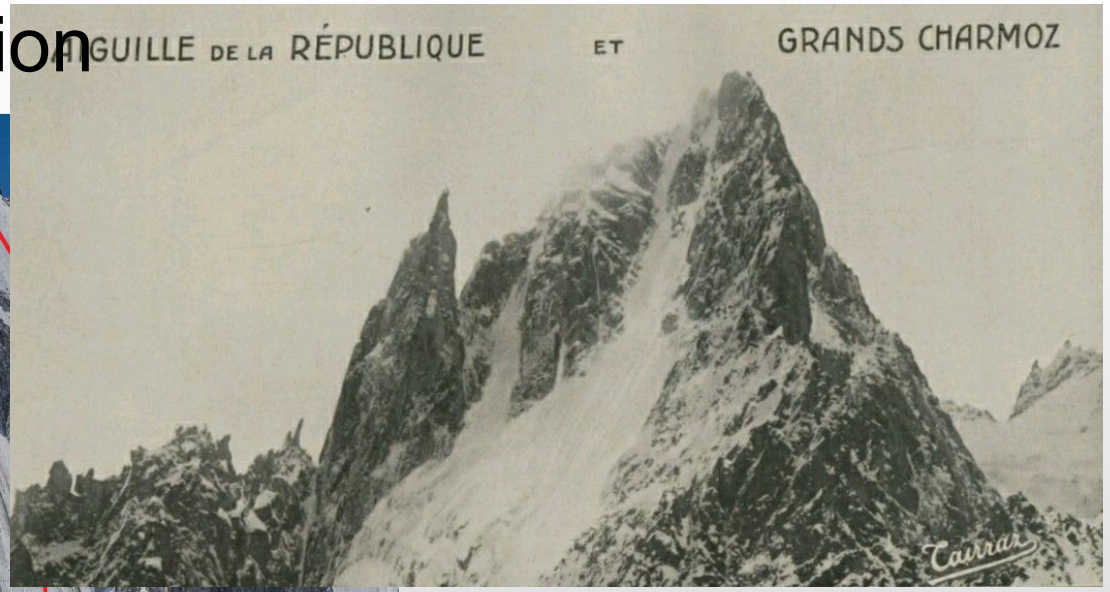
Mourey *et al.*

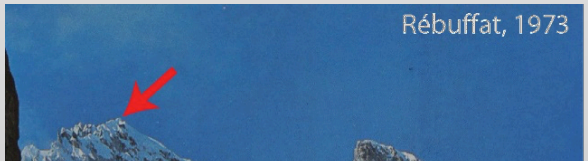

Slopes
snow → ice
Ice/snow
covers ↓
Slope
angle↑
Crevassing ↑
Thinning of the
snow ridges
Snow bridges less
thick and more
unstable?
Night
freezing↓
De-icing ridges /
loosening blocks
Rock falls
Rock avalanches
↑
Cold → warm
glaciers /
destabilization
PanoMax - CMB

# Snow/ice covers evolution

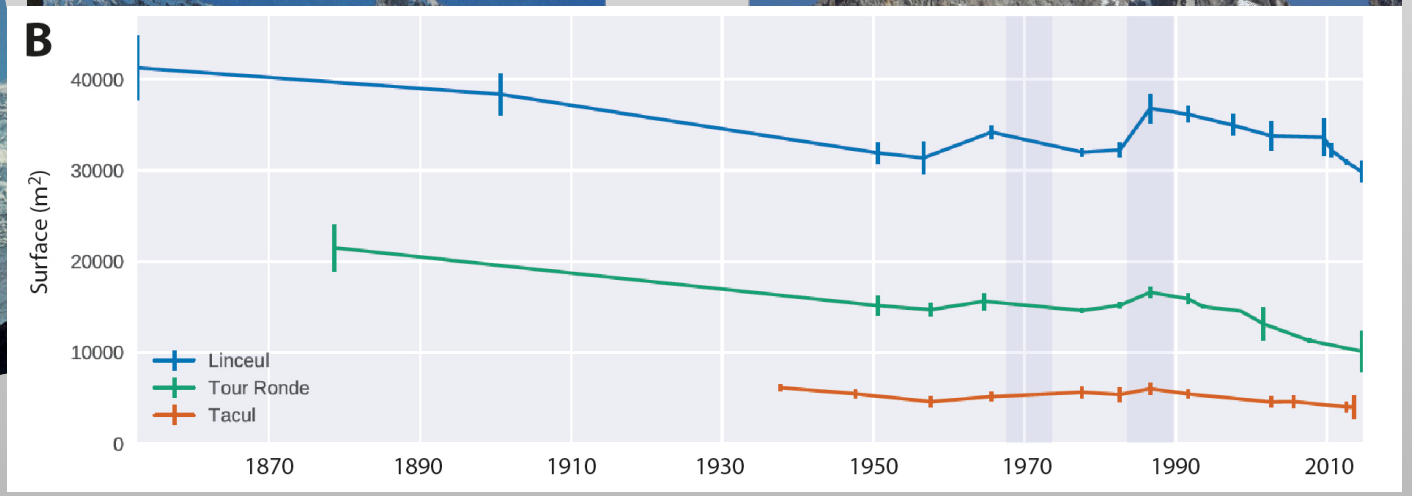






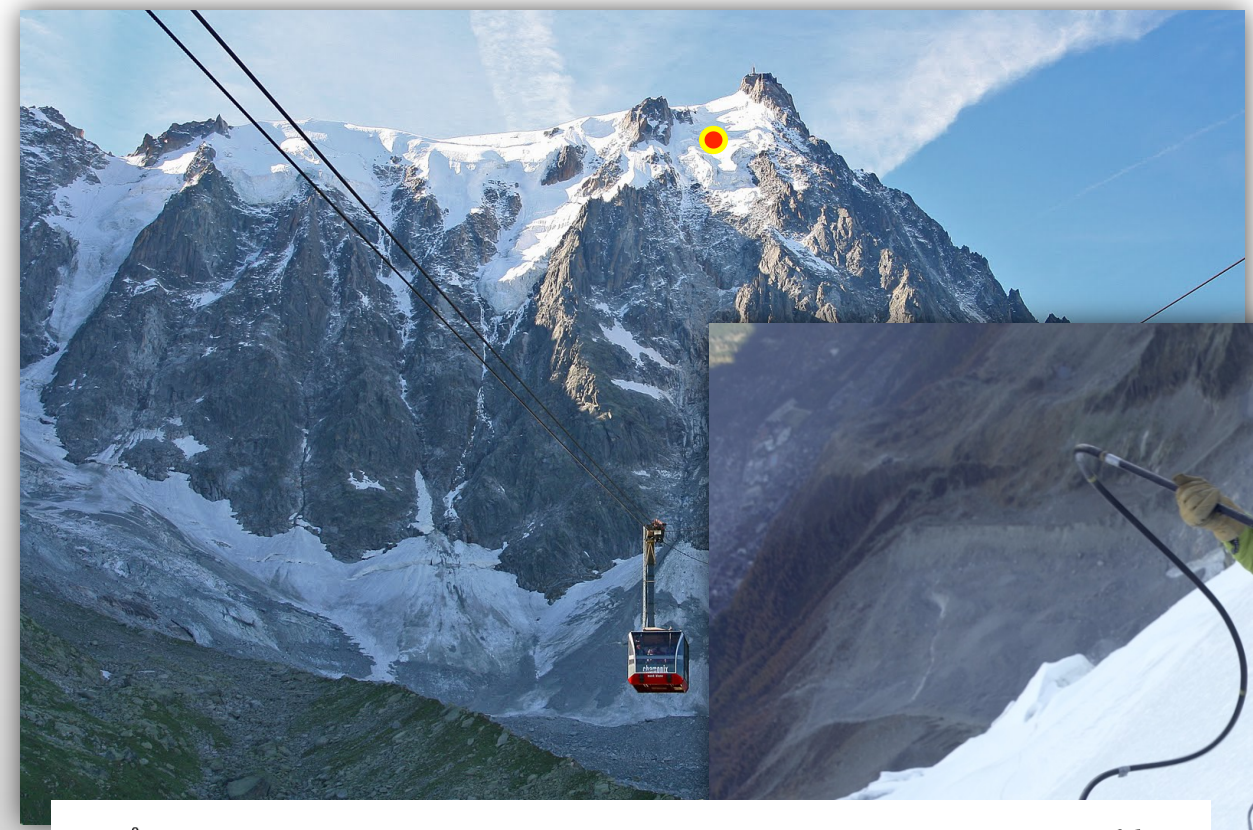



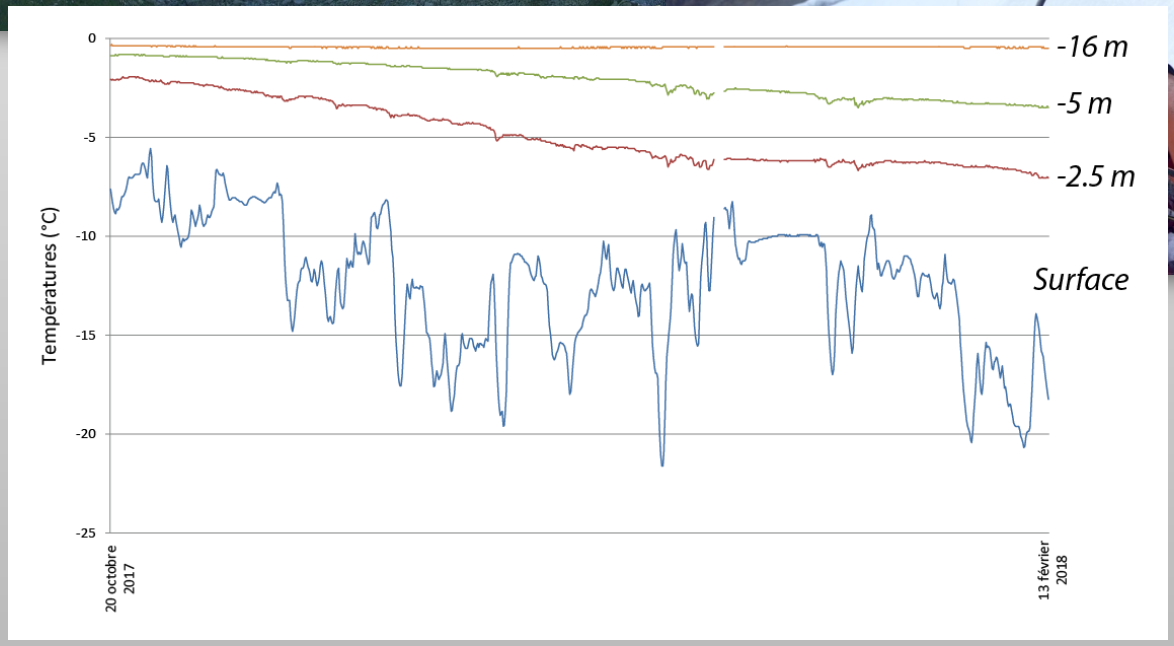
Triangle du Tacul

Summer 2017: - 70 cm

The ice that melts at present is **2650 years old**...

Aiguille du Midi (3842 m a.s.l.)






August 23, 2017 – SLF Davos
Bondo
Val Bondasca
Cap. di Sciora
Italy
1 km
Pizzo Cengalo

Piz Cengalo 3369 m a.s.l.

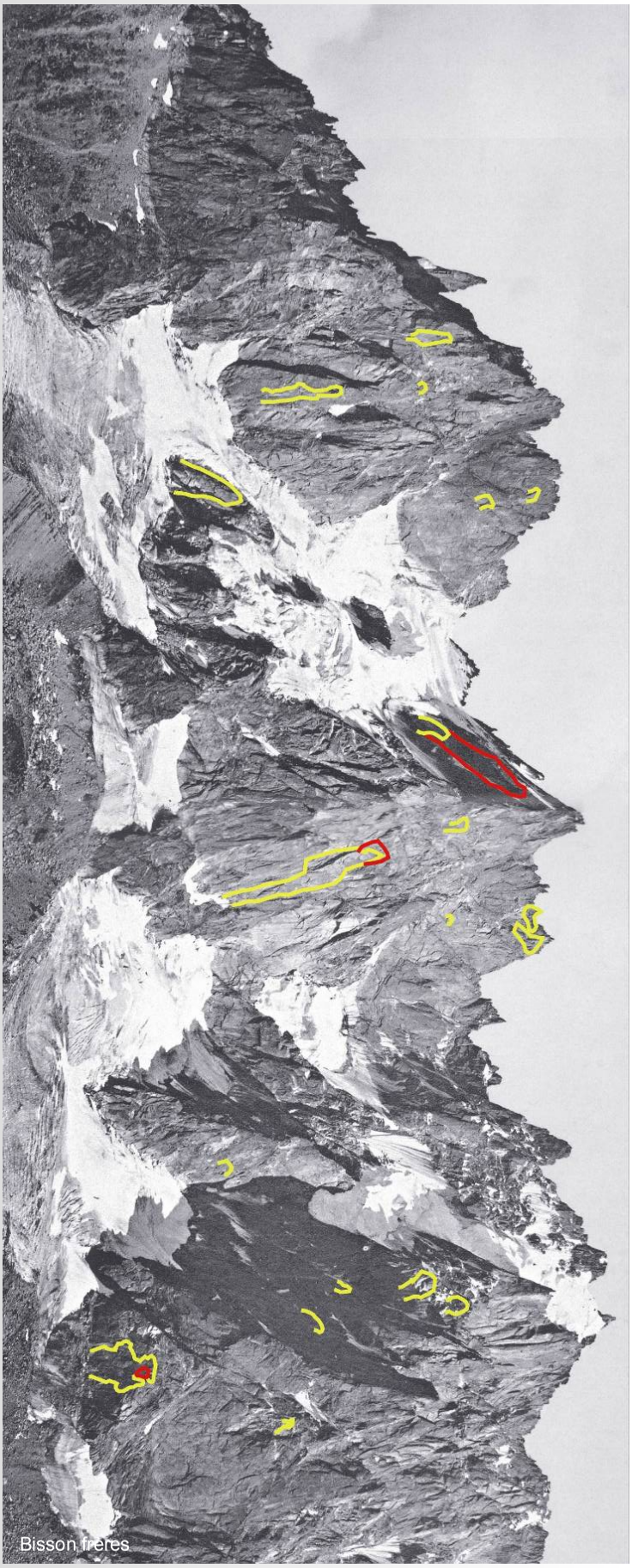

Val Bondasca, 1400 m a.s.l. (8 victims)


Bondo 800 m a.s.l. (99 infras. destroyed)

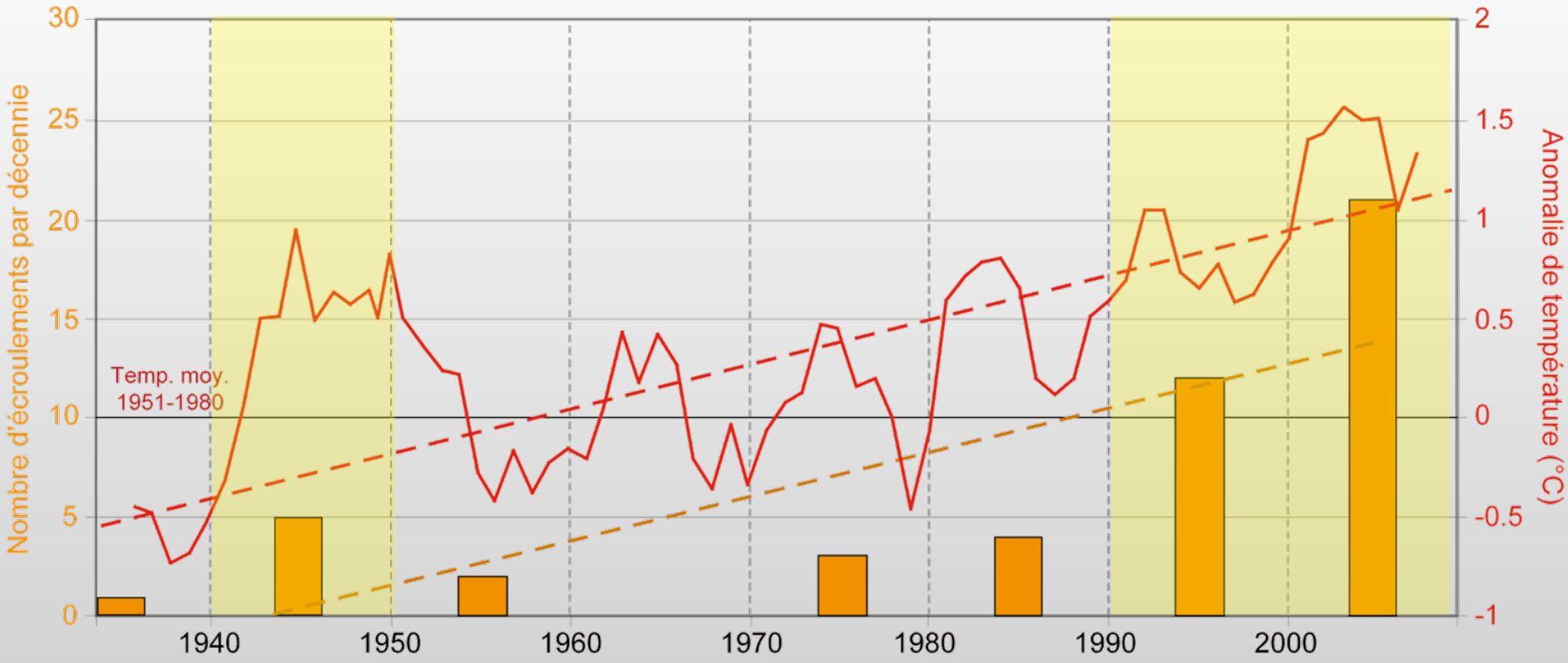

Real increase in volume / number of rockfalls or better observation?
Drus west face – 292,000 m3 – June 29-30, 2005

# Aiguilles de Chamonix


MLC, 2009


Bisson frères

# Drus + Aiguilles de Chamonix (1850-2009)




→ Very good correlation collapses / climate

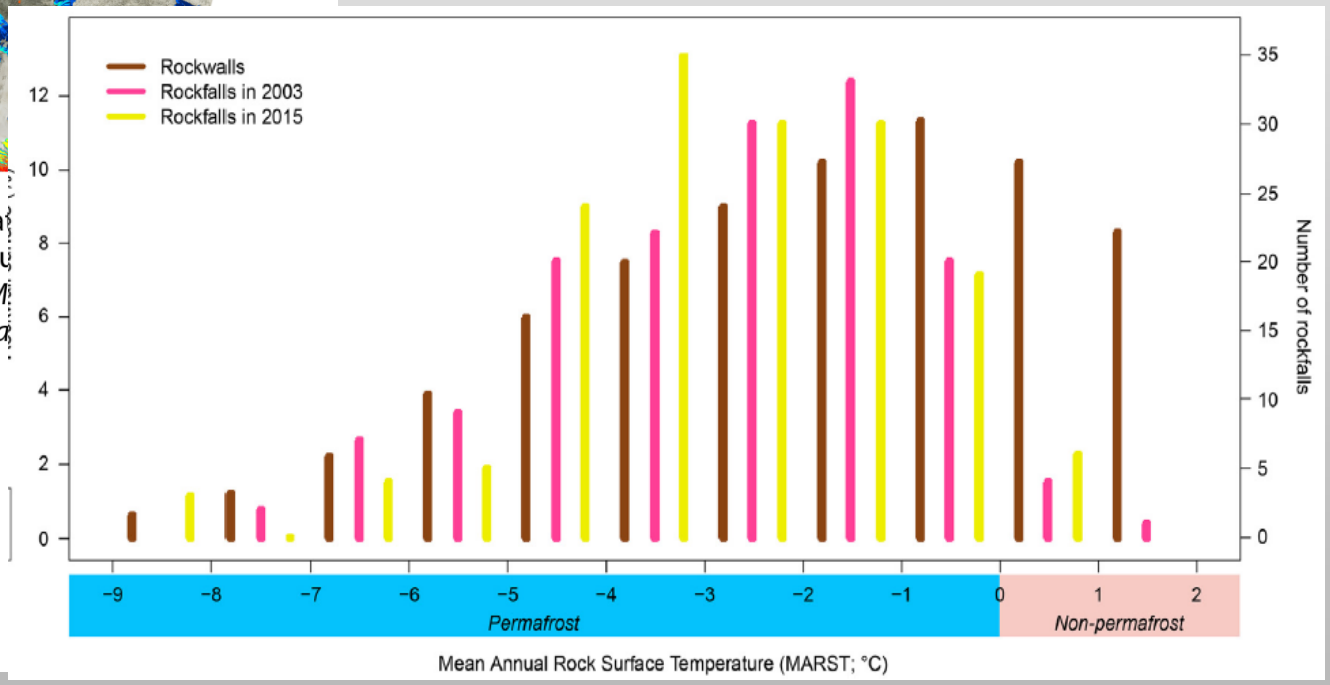
→ A “permafrost” issue

# The permafrost

= terrains whose temperature remains permanently negative







# An increasing hazard

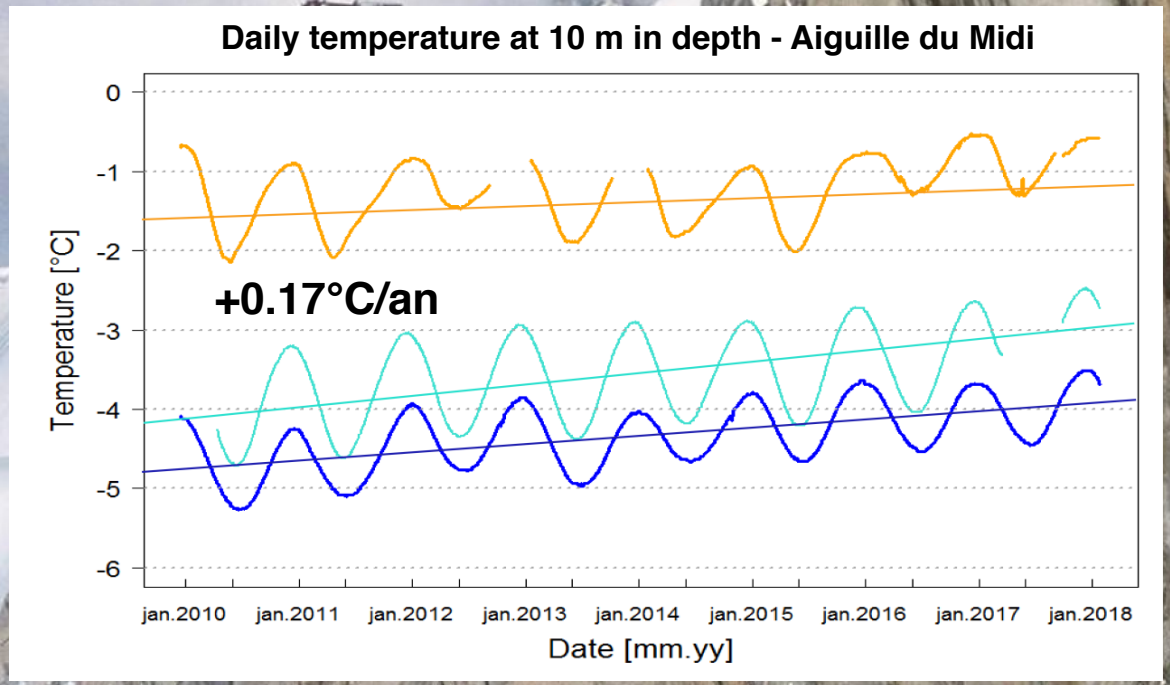


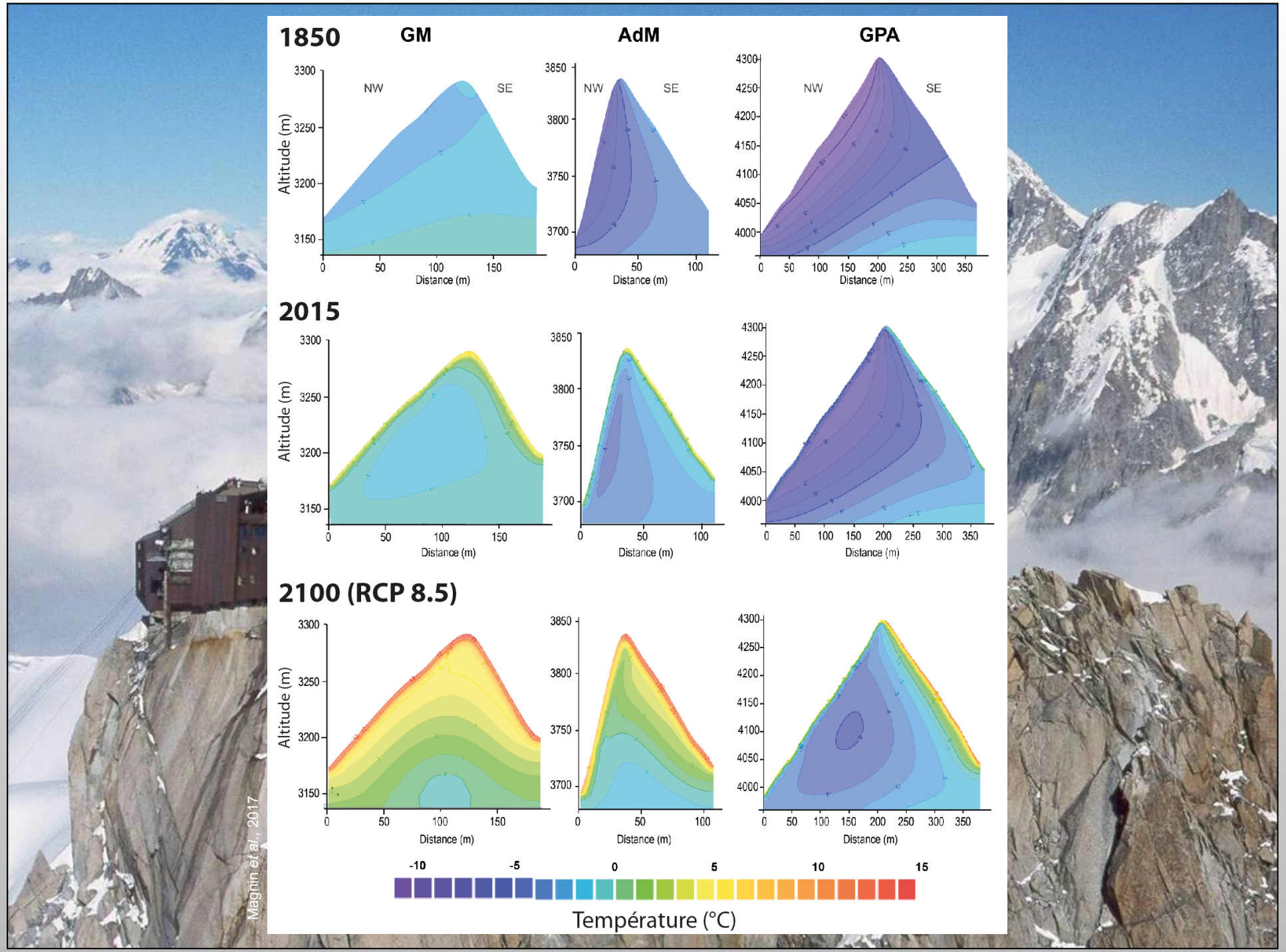


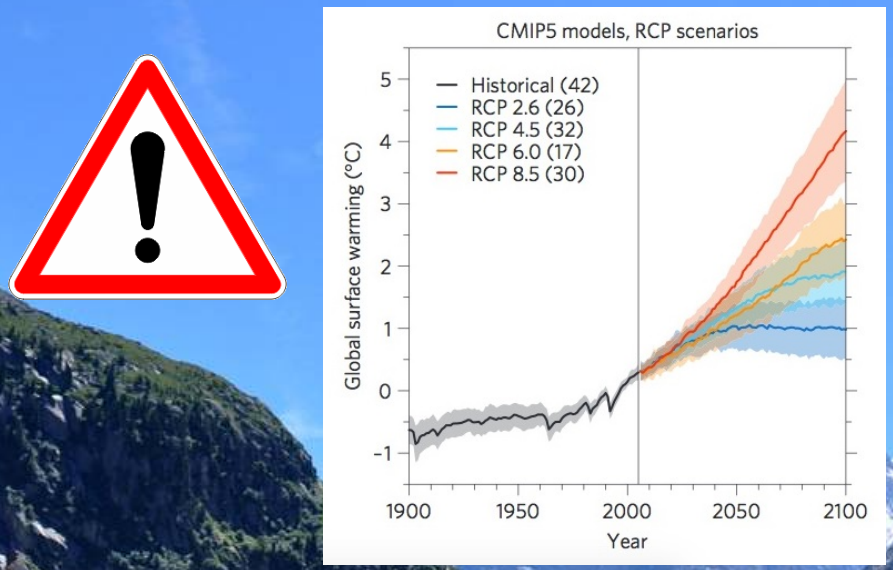

Between 1990 and 2017 :

- 102 dead
- 230 injured

# The Aiguille du Midi (3842 m a.s.l.), a permafrost laboratory...




1850
GM
AdM
GPA
NW
SE
Altitude (m)
Distance (m)
2015
2100 (RCP 8.5)
-10
-5
0
5
10
15
Température (°C)
Magnin et al., 2017




ARTICLE

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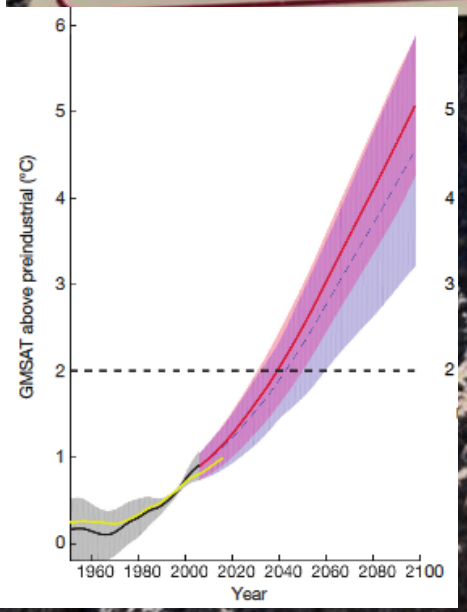
# Greater future global warming inferred from Earth's recent energy budget

Patrick T. Brown[1] & Ken Caldeira[1]

**Climate models provide the principal means of projecting global warming over the remainder of the twenty-first century but modelled estimates of warming vary by a factor of approximately two even under the same radiative forcing scenarios. Across-model relationships between currently observable attributes of the climate system and the simulated magnitude of future warming have the potential to inform projections. Here we show that robust across-model relationships exist between the global spatial patterns of several fundamental attributes of Earth's top-of-atmosphere energy budget and the magnitude of projected global warming. When we constrain the model projections with observations, we obtain greater means and narrower ranges of future global warming across the major radiative forcing scenarios, in general. In particular, we find that the observationally informed warming projection for the end of the twenty-first century for the steepest radiative forcing scenario is about 15 per cent warmer (+0.5 degrees Celsius) with a reduction of about a third in the two-standard-deviation spread (−1.2 degrees Celsius) relative to the raw model projections reported by the Intergovernmental Panel on Climate Change. Our results suggest that achieving any given global temperature stabilization target will require steeper greenhouse gas emissions reductions than previously calculated.**




F. Louison


Thanks!
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