Les glaces polaires et cryosphère continentale: vue de l'espace

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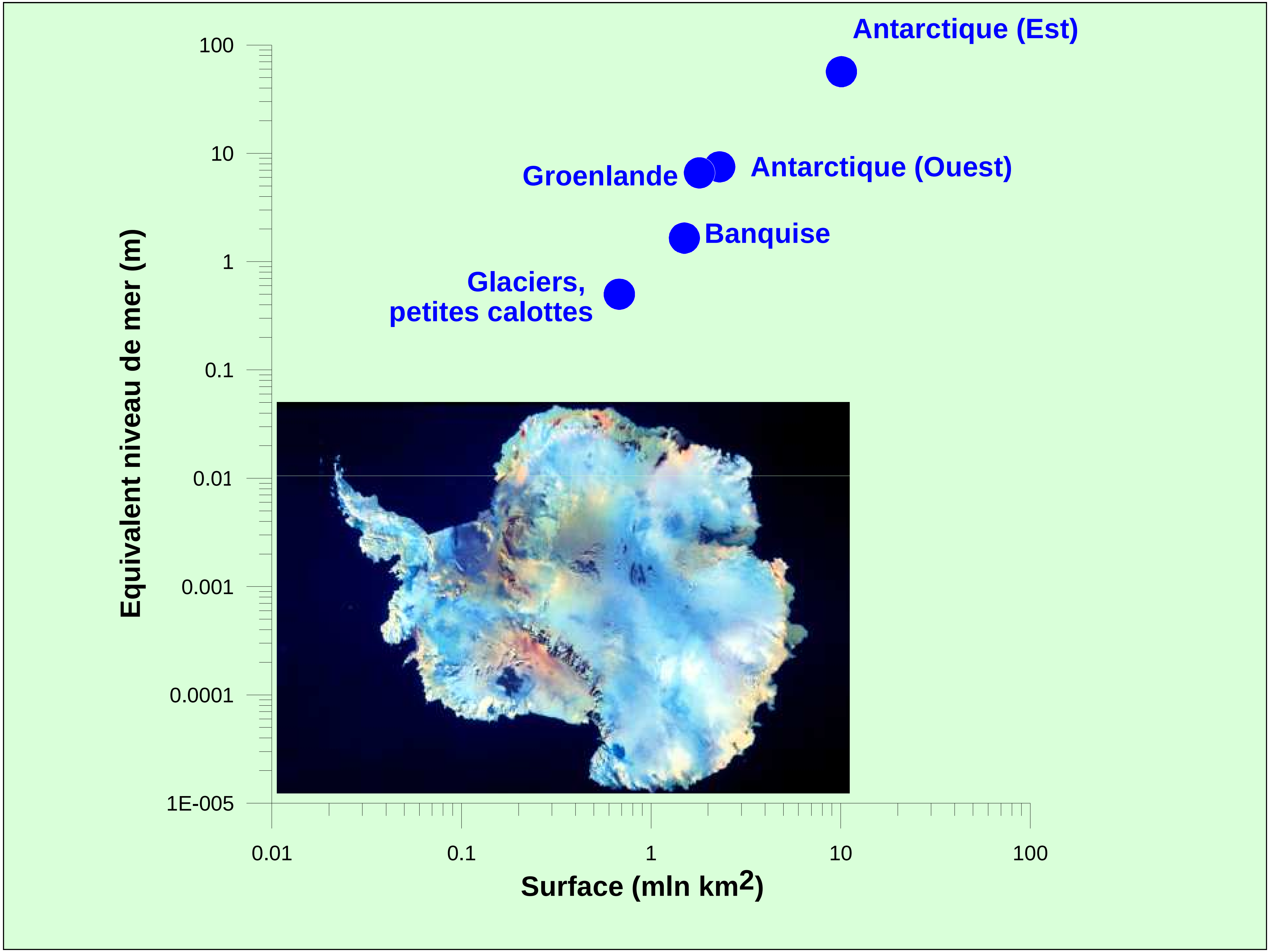
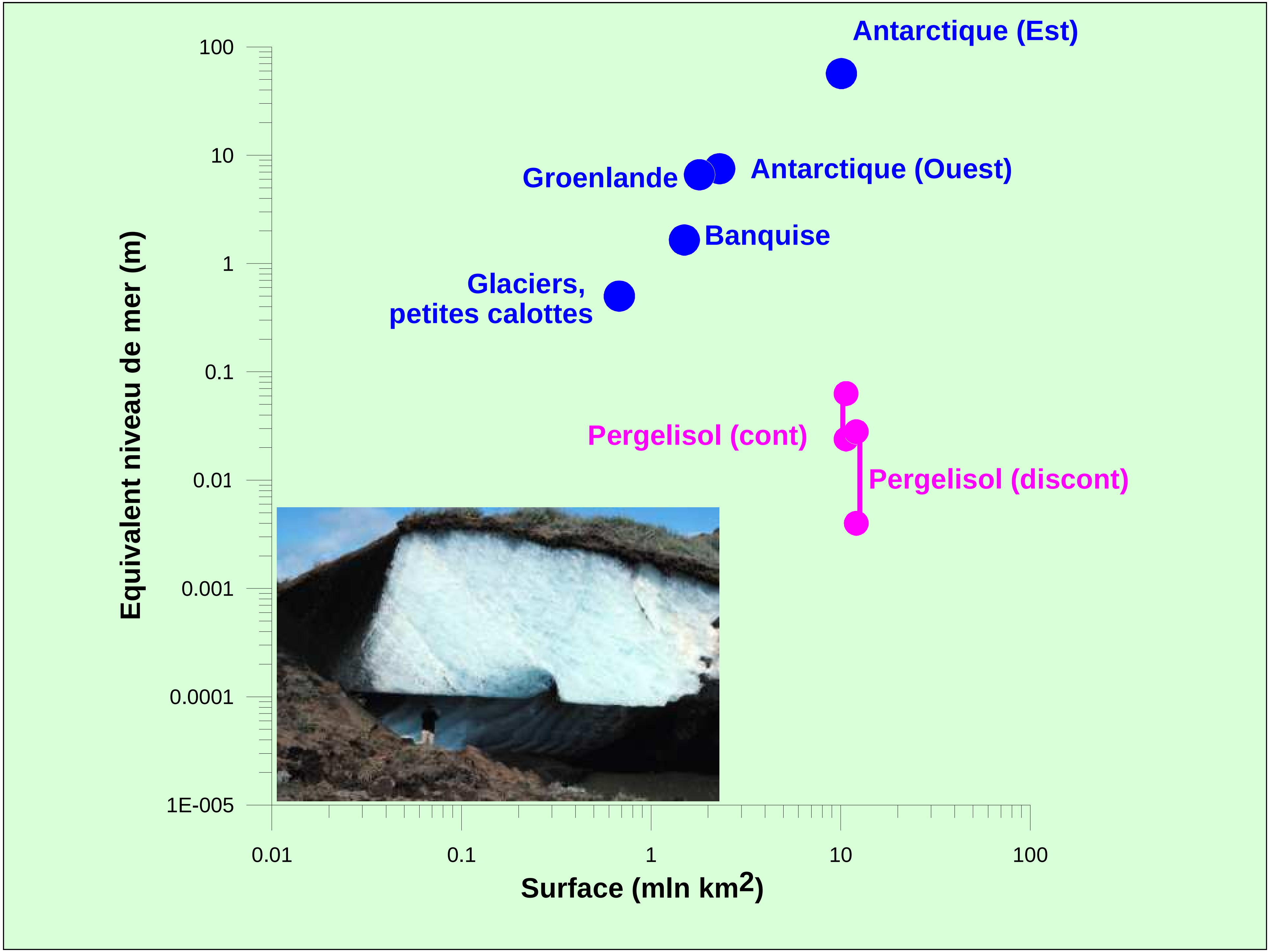
SMF - Journée scientifique 23/03/2011

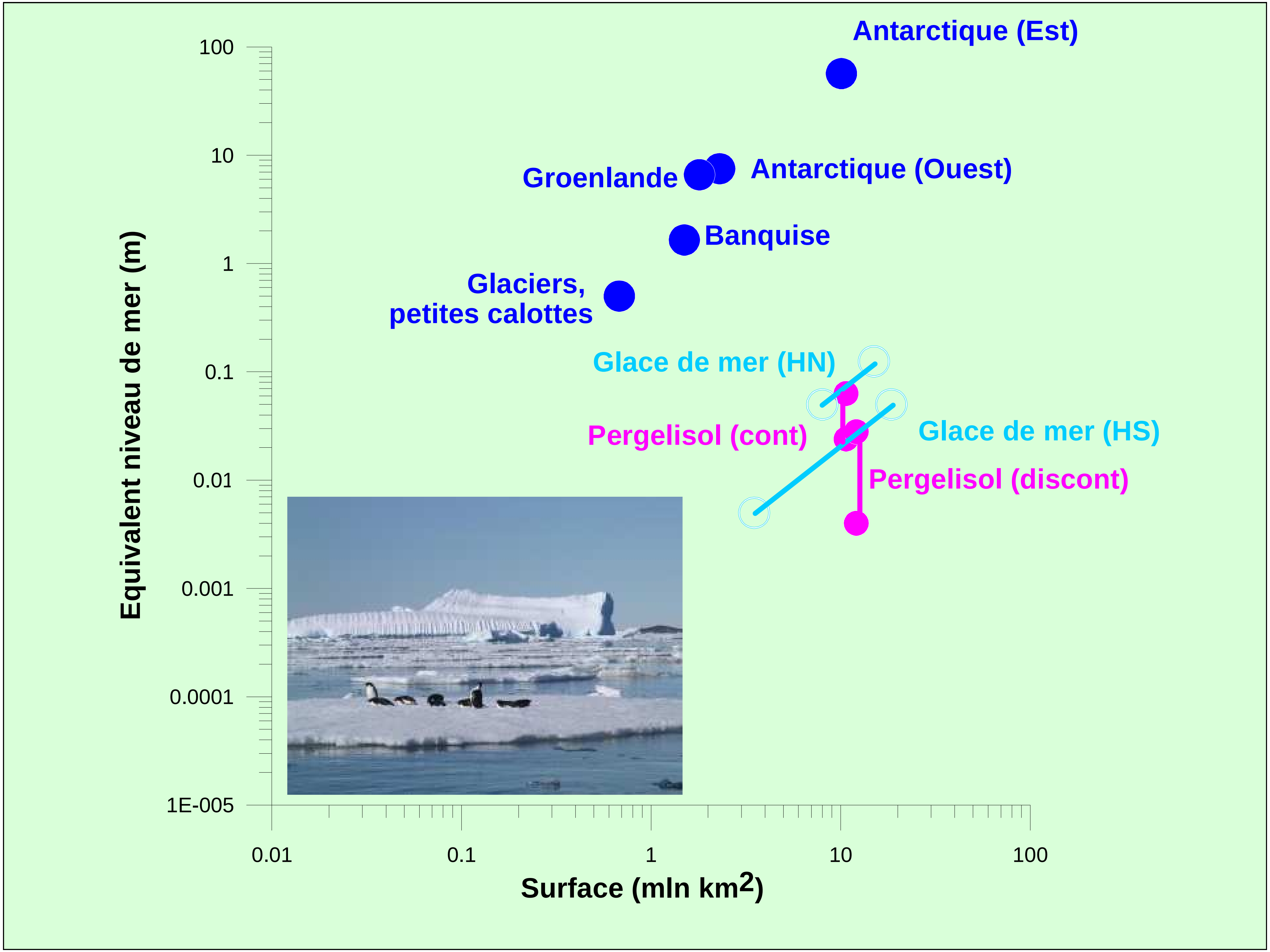
Quels sont les objets d'étude?



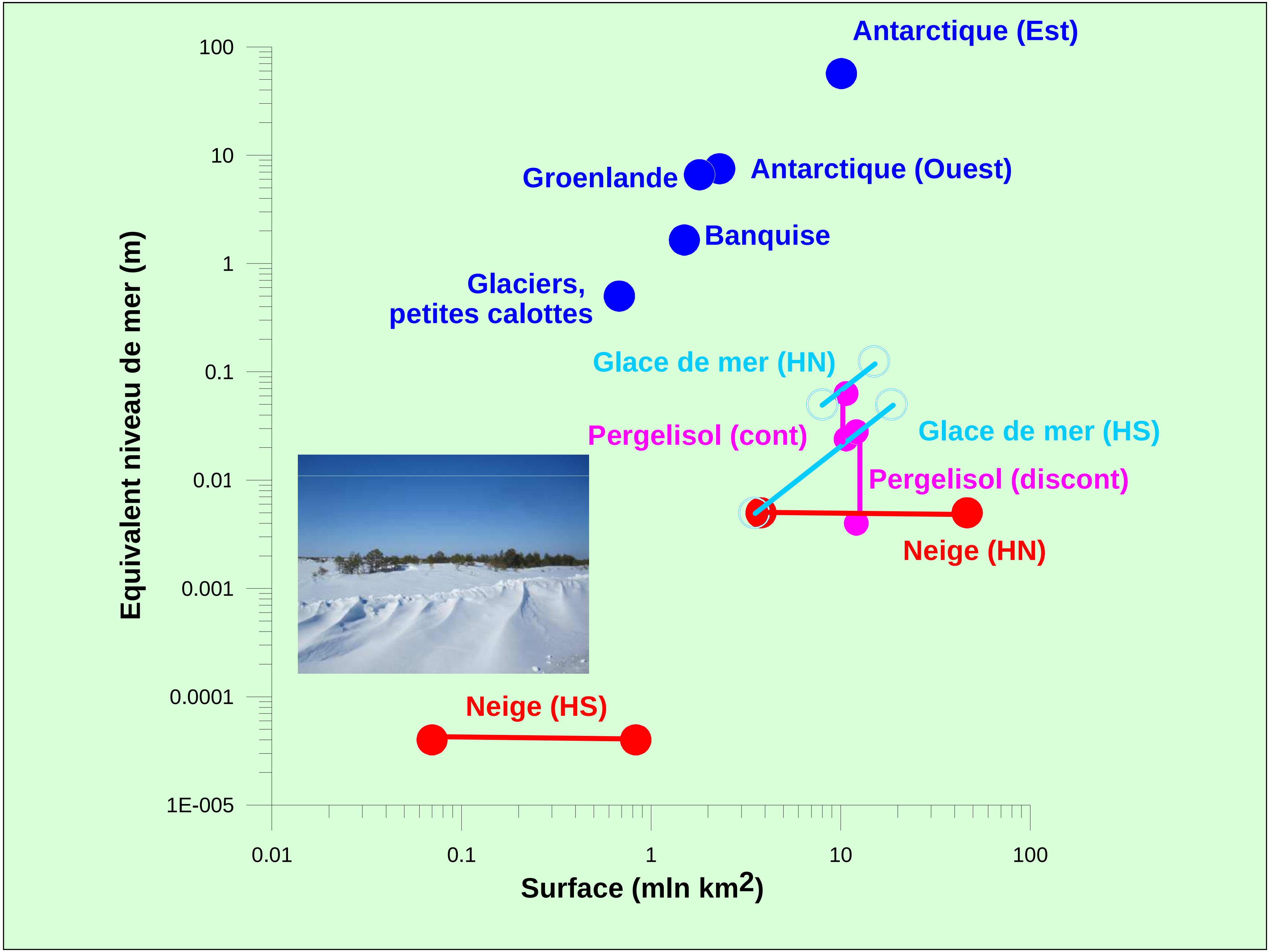
Antarctique (Est)
Groenlande
Antarctique (Ouest)
Banquise
Glaciers,
petites calottes
Equivalent niveau de mer (m)
100
10
1
0.1
0.01
0.001
0.0001
1E-005
0.01
0.1
1
10
100
Surface (mln km2)

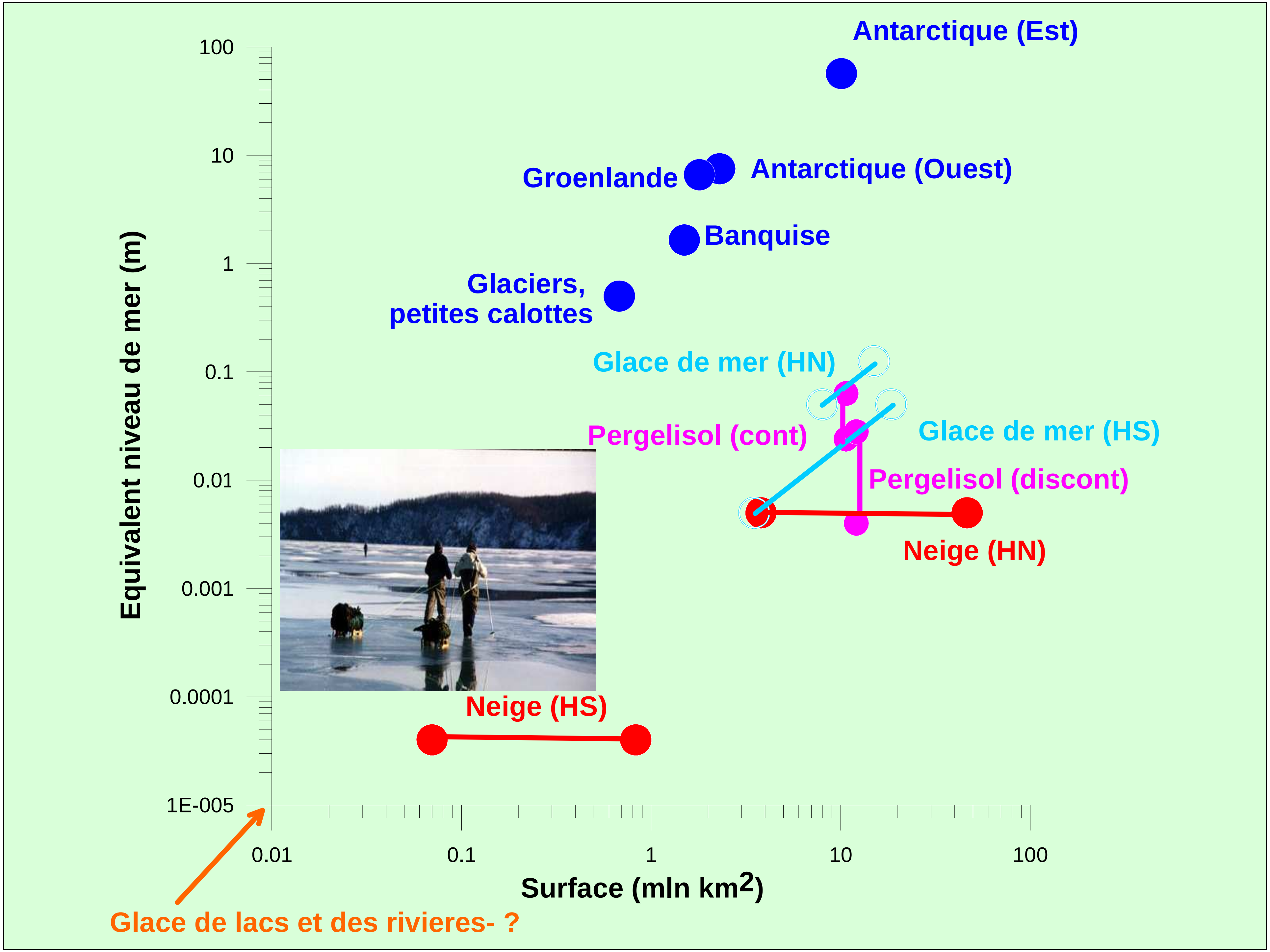


Antarctique (Est)
Groenlande
Antarctique (Ouest)
Banquise
Glaciers,
petites calottes
Pergelisol (cont)
Pergelisol (discont)
Equivalent niveau de mer (m)
100
10
1
0.1
0.01
0.001
0.0001
1E-005
0.01
0.1
1
10
100
Surface (mln km2)



Antarctique (Est)
Antarctique (Ouest)
Groenlande
Banquise
Glaciers,
petites calottes
Glace de mer (HN)
Glace de mer (HS)
Pergelisol (cont)
Pergelisol (discont)
Equivalent niveau de mer (m)
100
10
1
0.1
0.01
0.001
0.0001
1E-005
0.01
0.1
1
10
100
Surface (mln km2)


Antarctique (Est)
Groenlande
Antarctique (Ouest)
Banquise
Glaciers,
petites calottes
Glace de mer (HN)
Pergelisol (cont)
Glace de mer (HS)
Pergelisol (discont)
Neige (HN)
Neige (HS)
Equivalent niveau de mer (m)
100
10
1
0.1
0.01
0.001
0.0001
1E-005
0.01
0.1
1
10
100
Surface (mln km2)



Antarctique (Est)
Antarctique (Ouest)
Groenlande
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Glaciers,
petites calottes
Glace de mer (HN)
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Glace de mer (HS)
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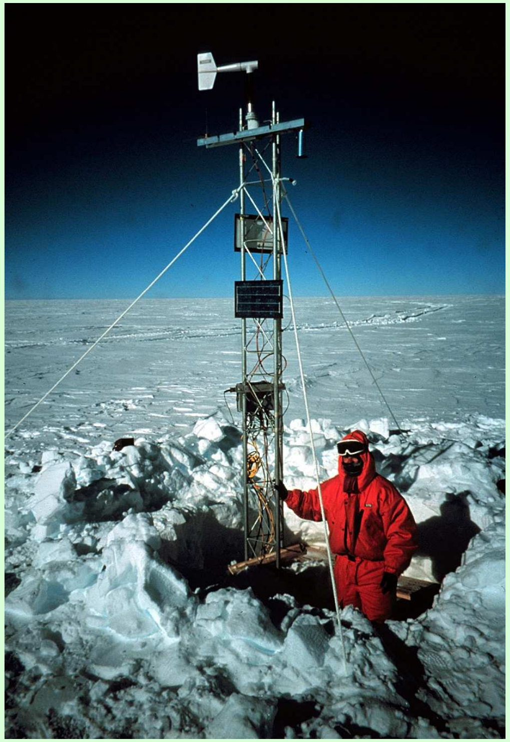
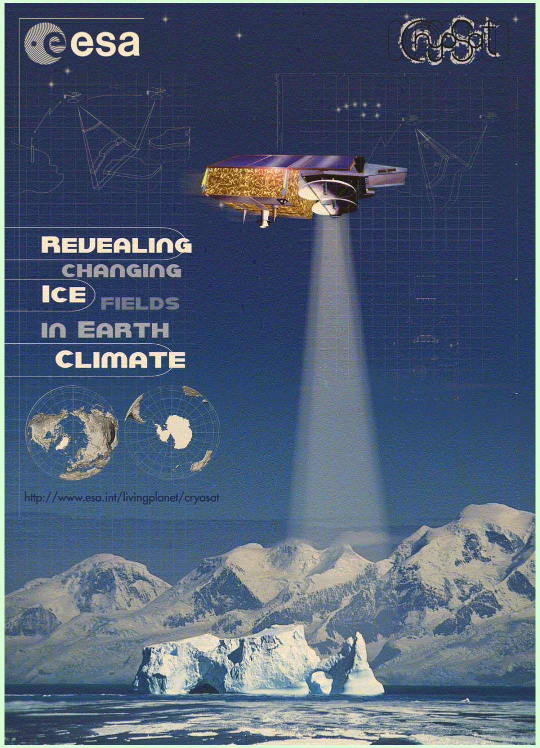
Neige (HN)
Neige (HS)
Equivalent niveau de mer (m)
100
10
1
0.1
0.01
0.001
0.0001
1E-005
0.01
0.1
1
10
100
Surface (mln km2)
Glace de lacs et des rivieres- ?

Est-ce qu'ils changent?

Est-ce important pour (moi)?

Mesures





Incertitudes:

échelle spatiale

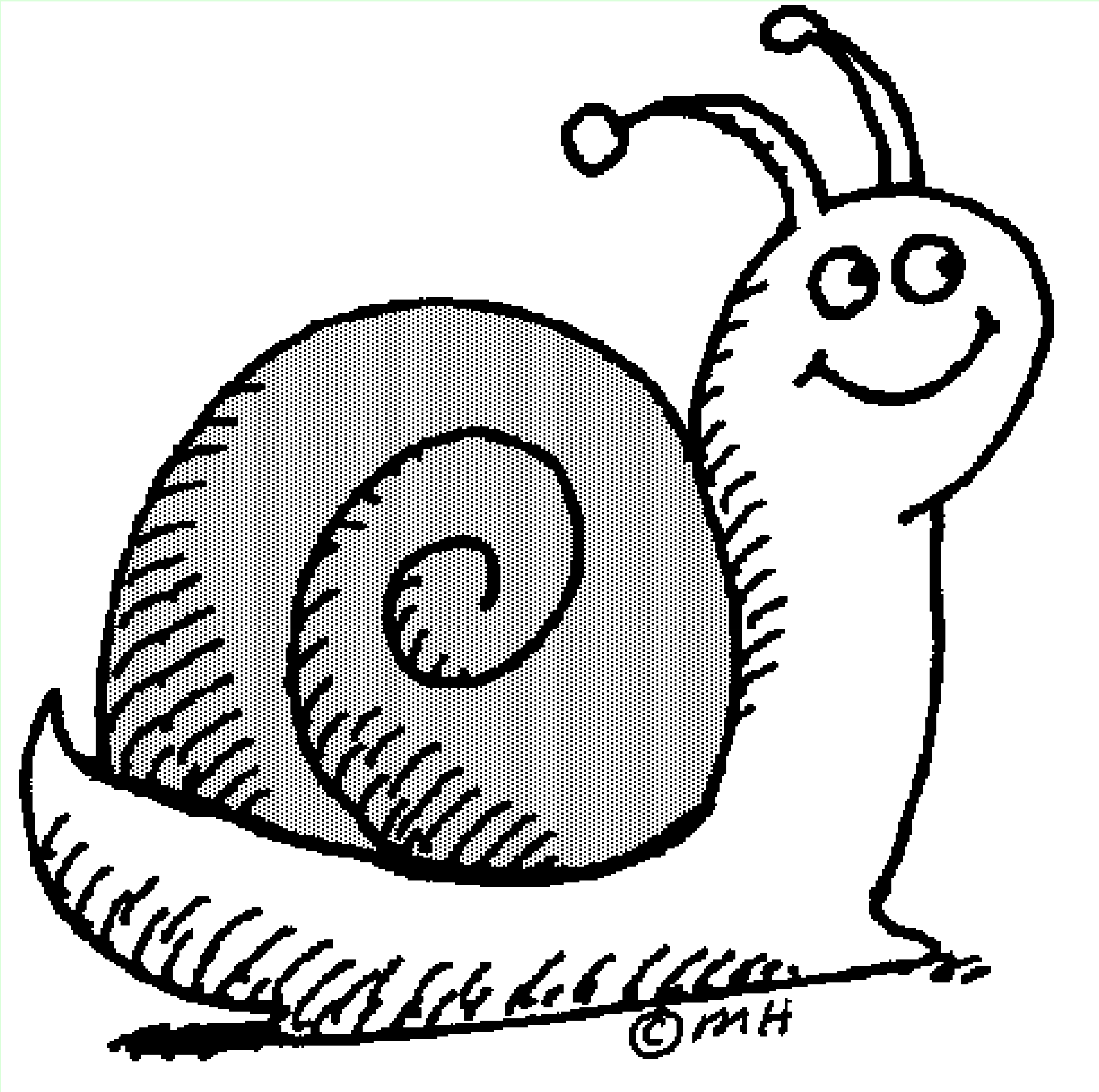
répétitivité

surface vs volume

interprétation

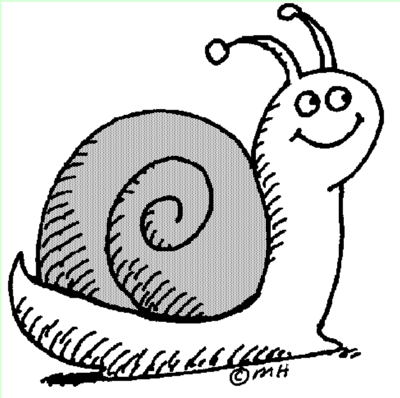
Etendue, profondeur, structure, volume, vitesse..

Deux types



Grand mais lent

Petit mais rapide



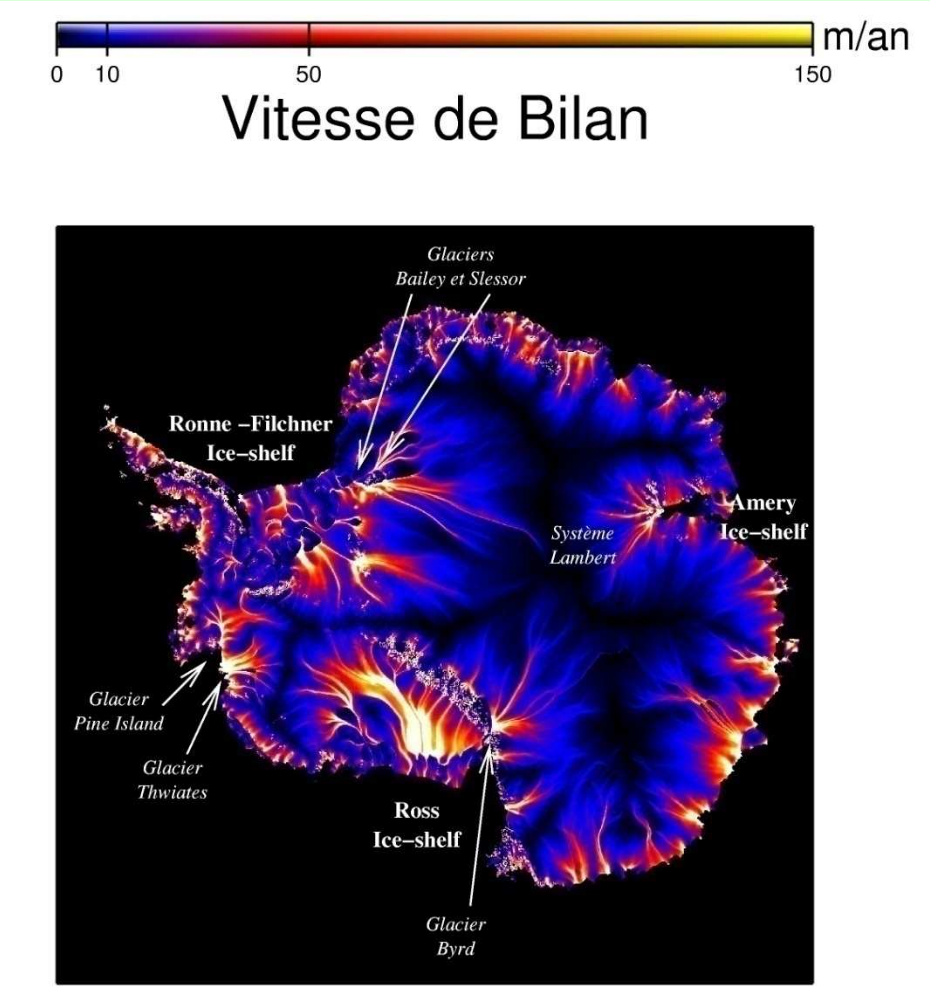
Calottes polaires

Glaciers

Pergélisol

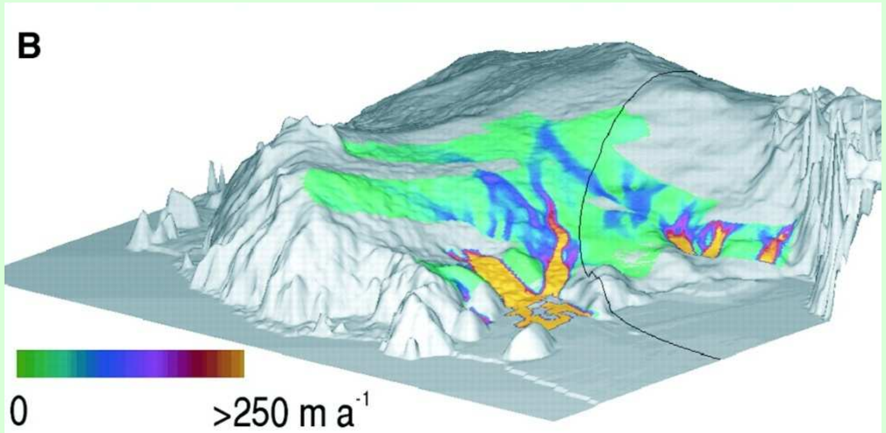
Vitesse d'écoulement de la glace: systèmes glaciaires côtiers

Antarctique

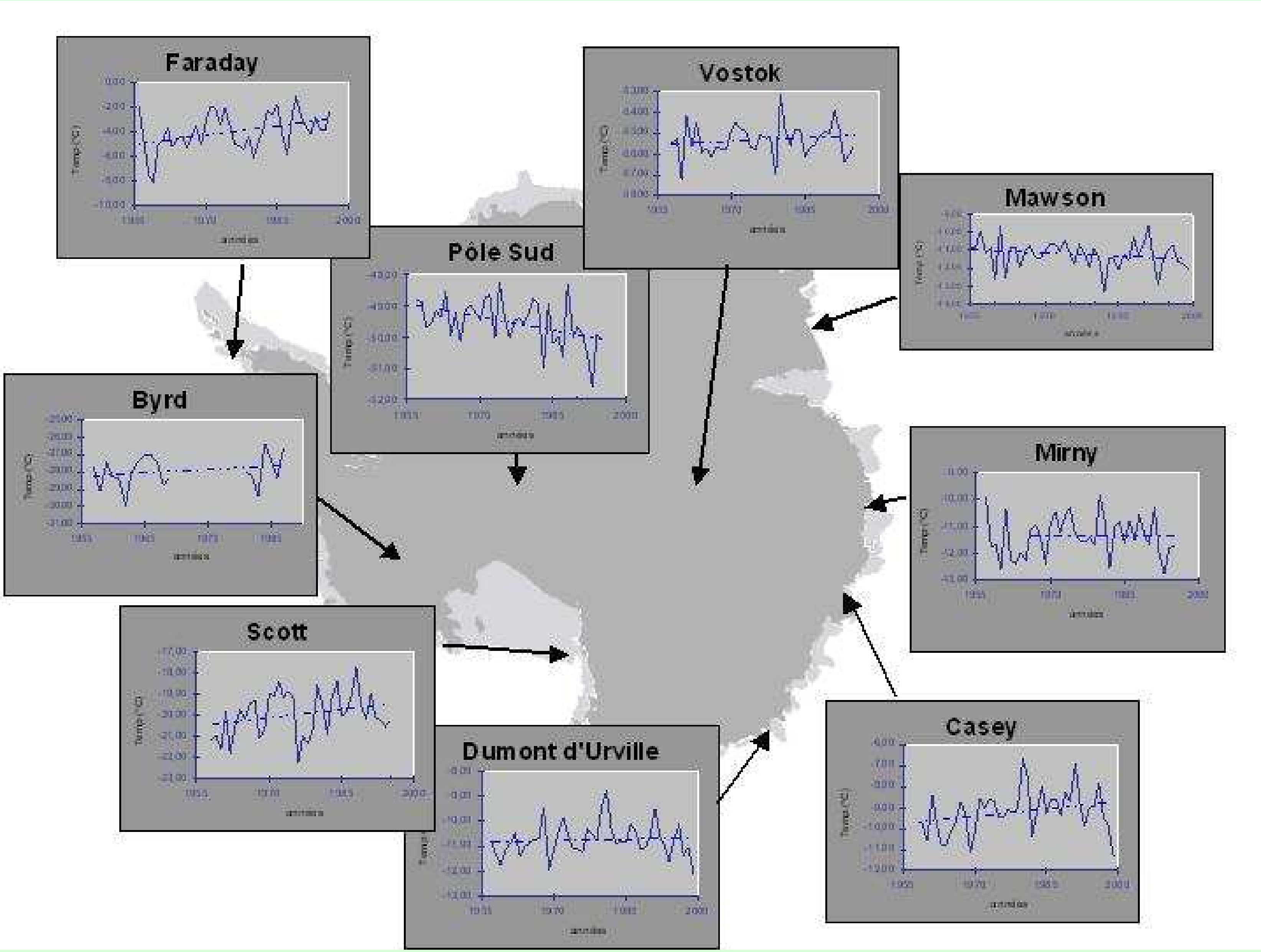


90% de la glace est évacuée par quelques dizaines de glaciers

Importance de leur suivi



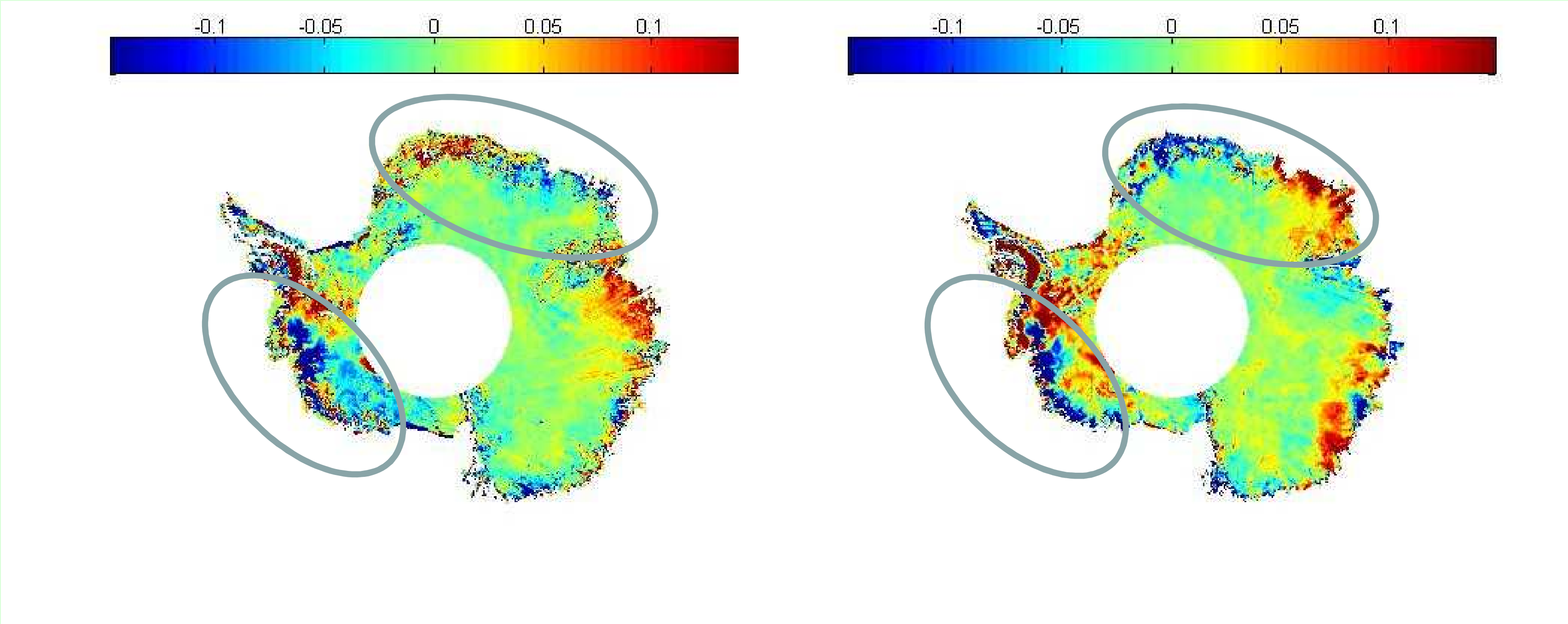
Températures (stations météo)



Variations de volume

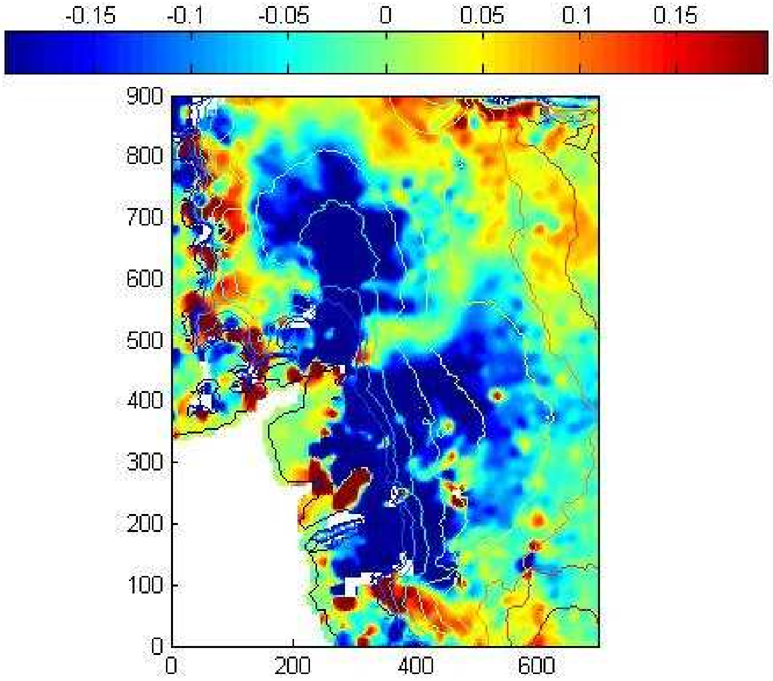
ERS (1995-2003)

Envisat (2002- 2007)

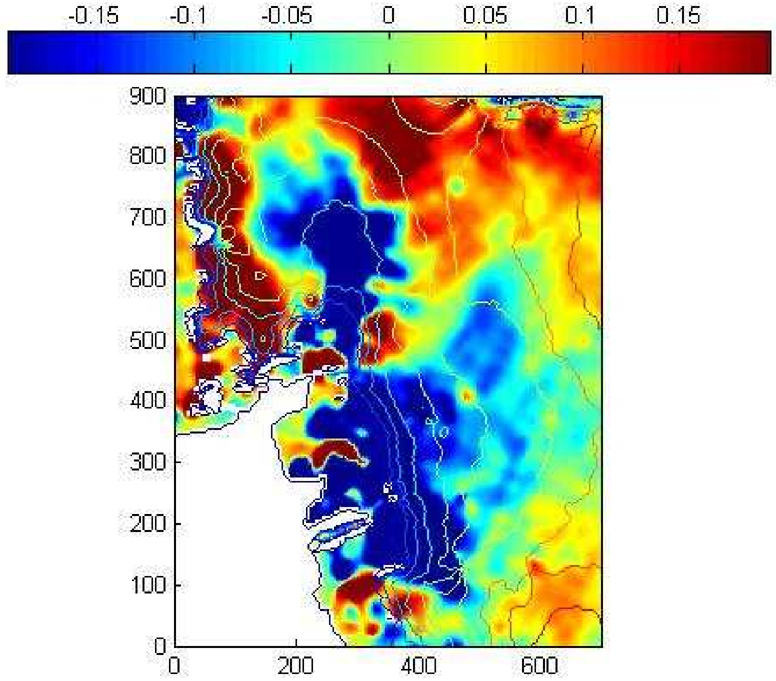


Pine Island Glacier

ERS 58 km^3/an de perte

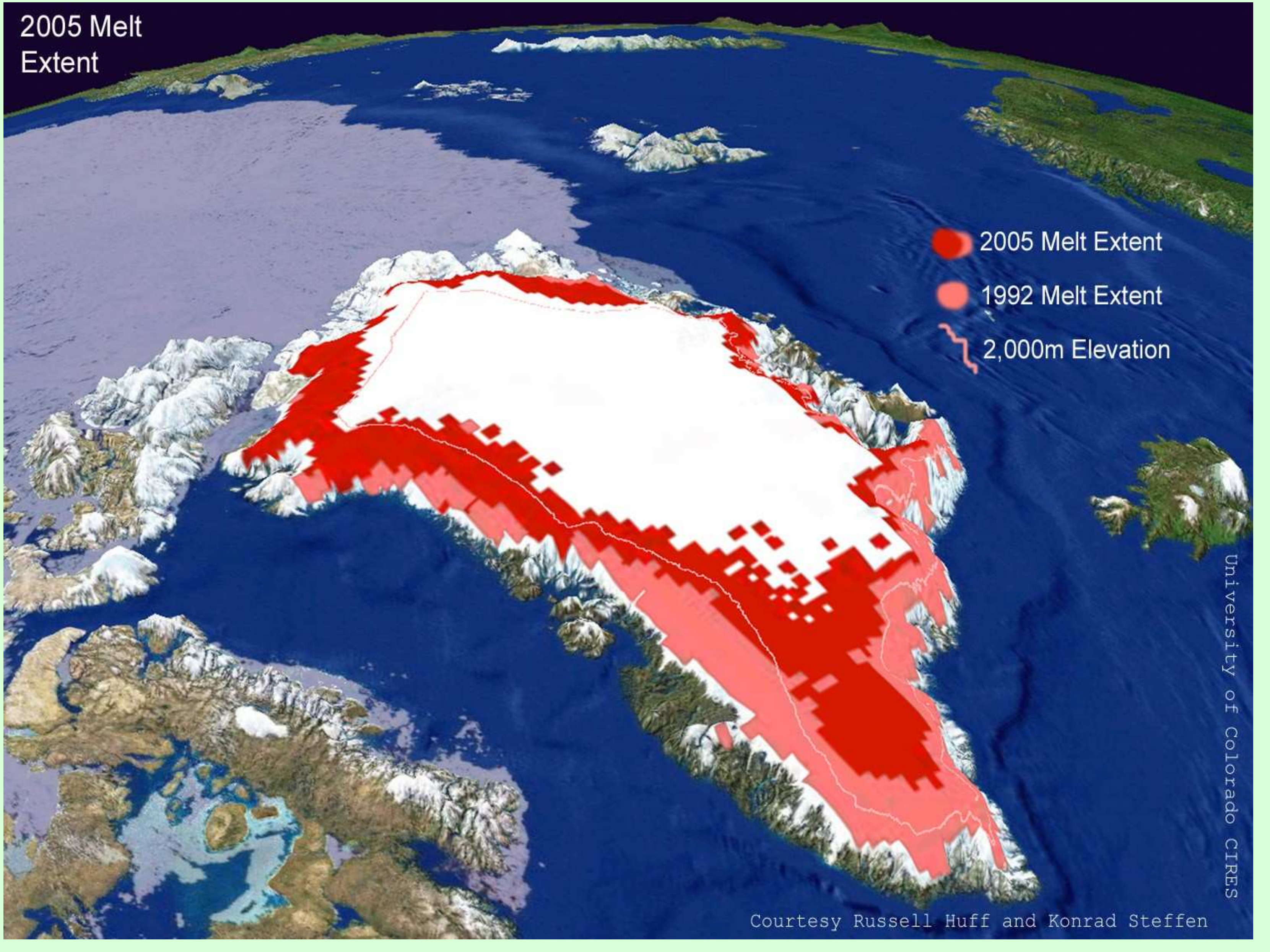


Envisat 53 km^3/an de perte



Antarctique en general: stable

Groenland


2005 Melt
Extent
2005 Melt Extent
1992 Melt Extent
2,000m Elevation
University of Colorado CIRES
Courtesy Russell Huff and Konrad Steffen

Evolution de la fonte

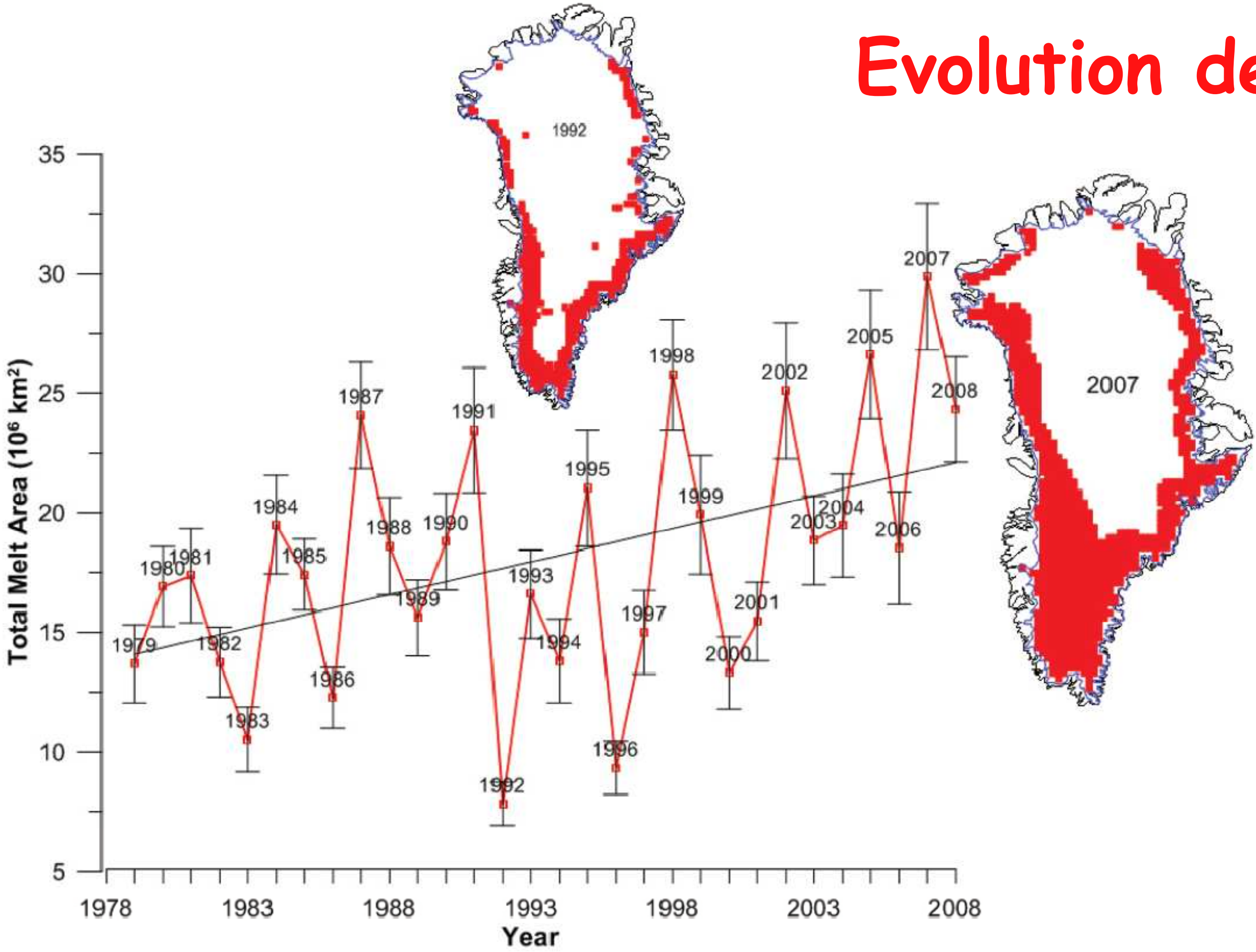
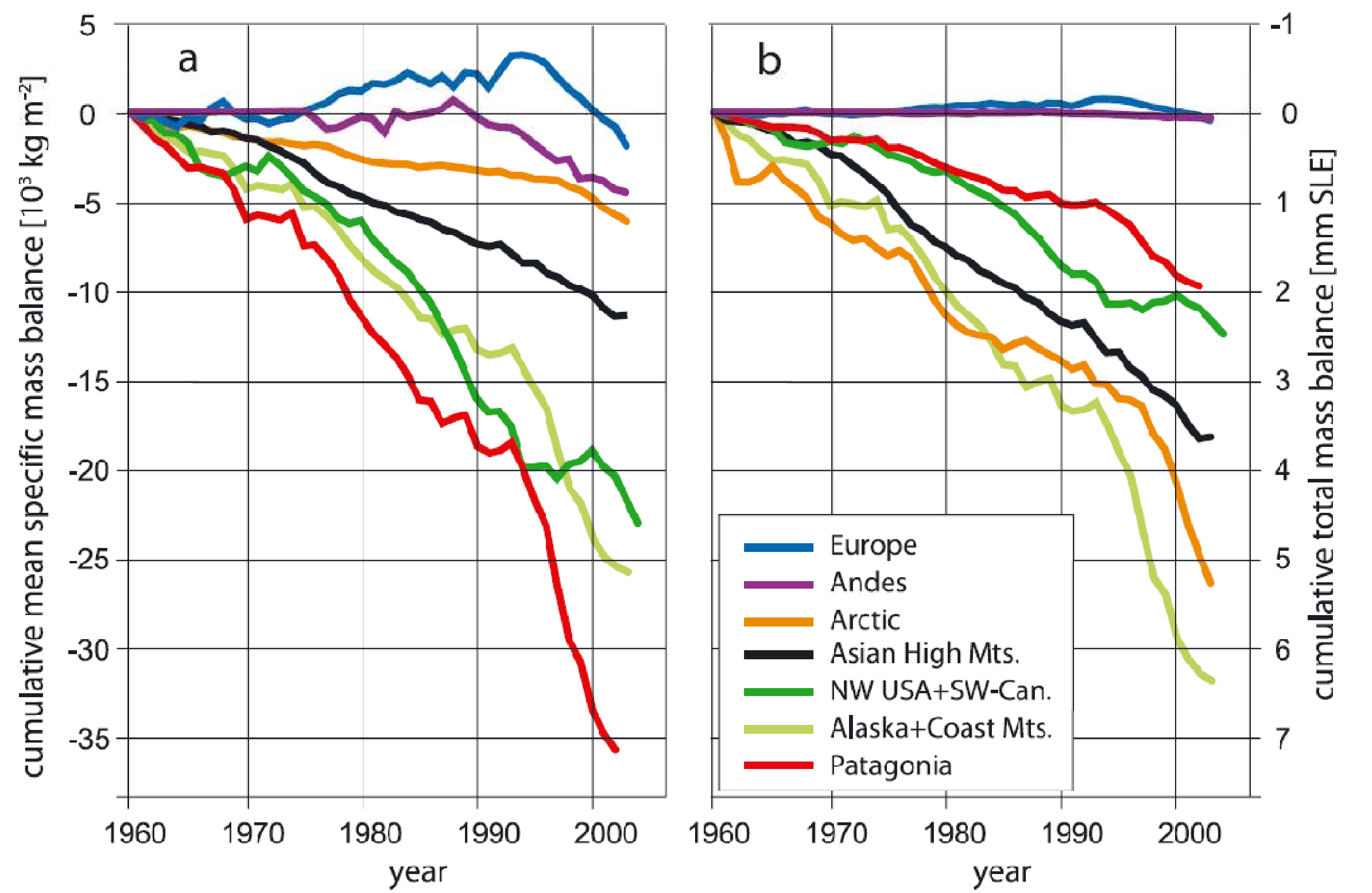


Figure 9. The total melt area of the Greenland ice sheet increased by 30% between 1979 and 2008 based on passive microwave satellite data, with the most extreme melt in 2007. In general 33-55% of the total mass loss from the Greenland ice sheet is caused by surface melt and runoff. For 2007, the area experiencing melt was around 50% of the total ice sheet area. The low melt year in 1992 was caused by the volcanic aerosols from Mt. Pinatubo causing a short-lived global cooling (updated from Steffen et al. 2008).

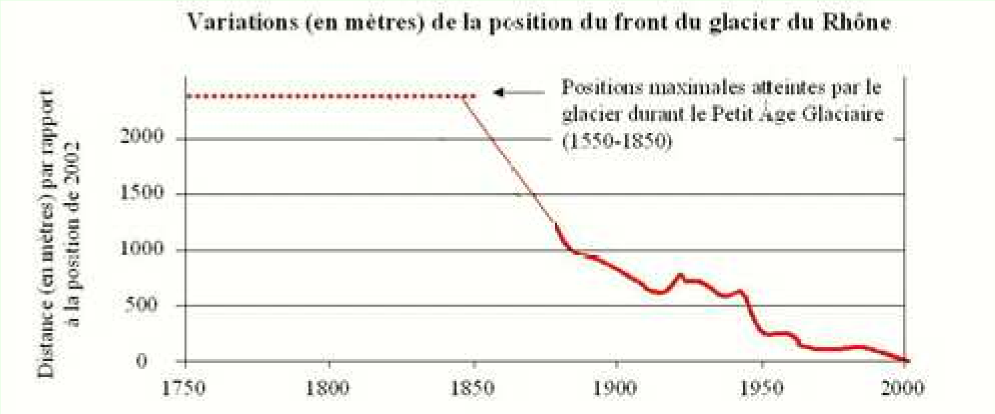
Groenland: augmentation des zones de fonte

Glaciers



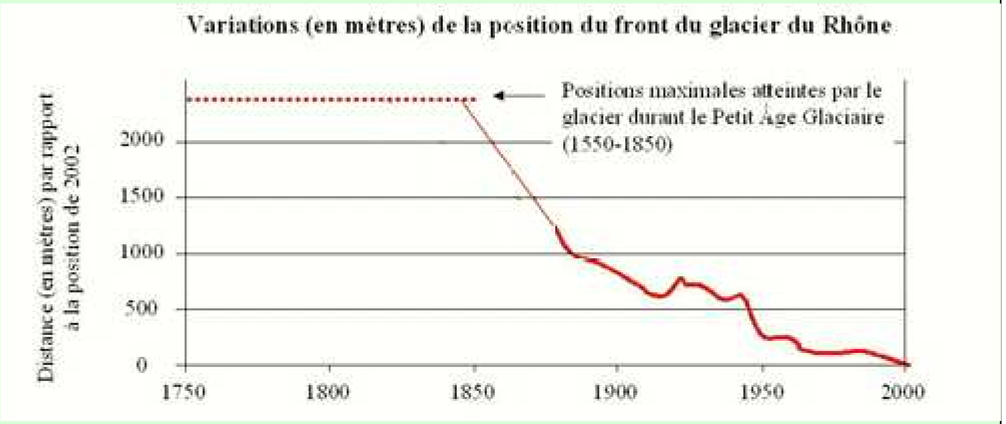
Cumulative specific mass balance (left, m/a water equivalent) and cumulative contribution to sea level rise (right, mm) of 7 large regions. Kaser & al., GRL, 2006

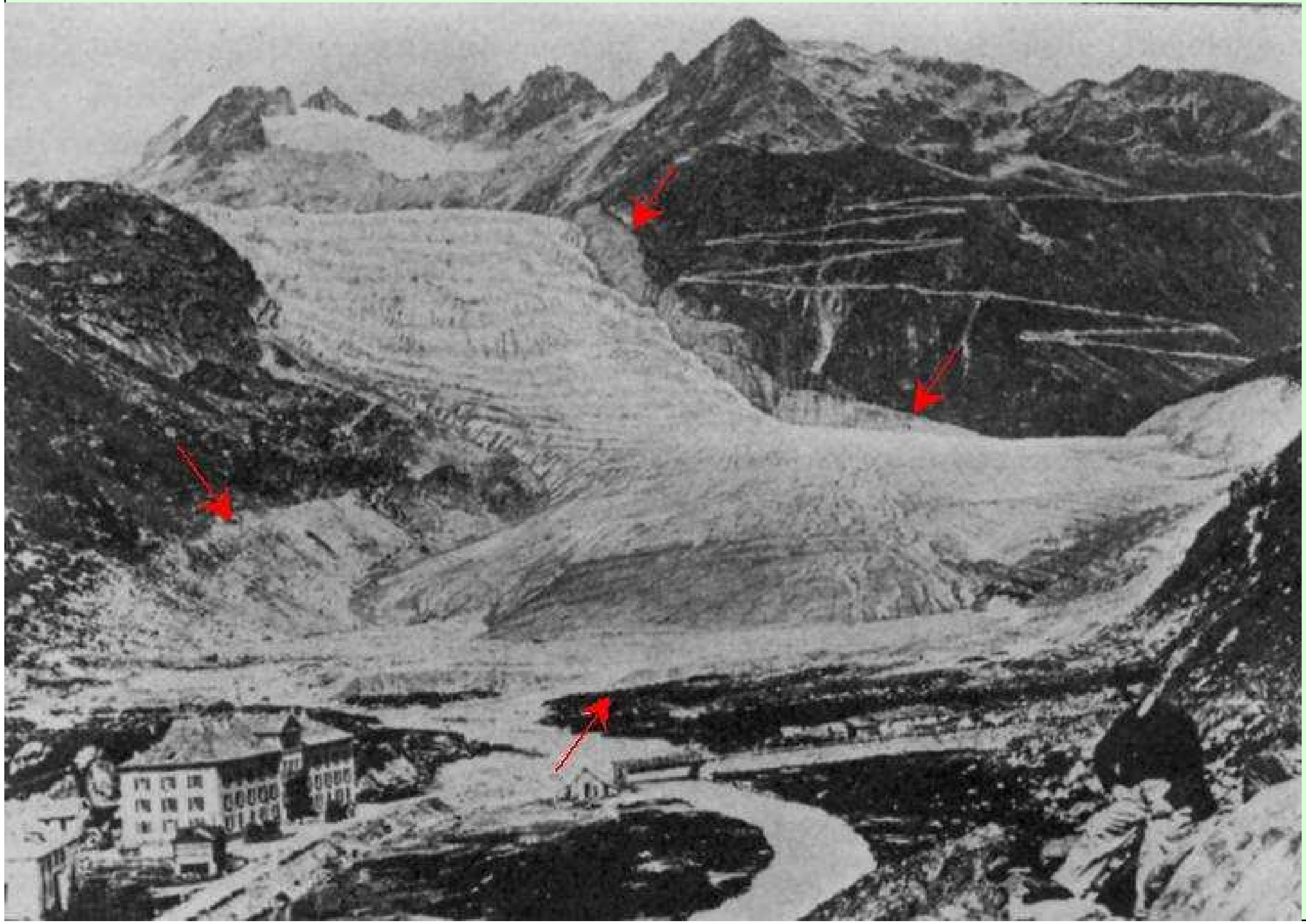
Le glacier du Rhône de 1850 à nos jours (9 km de recul)



1850

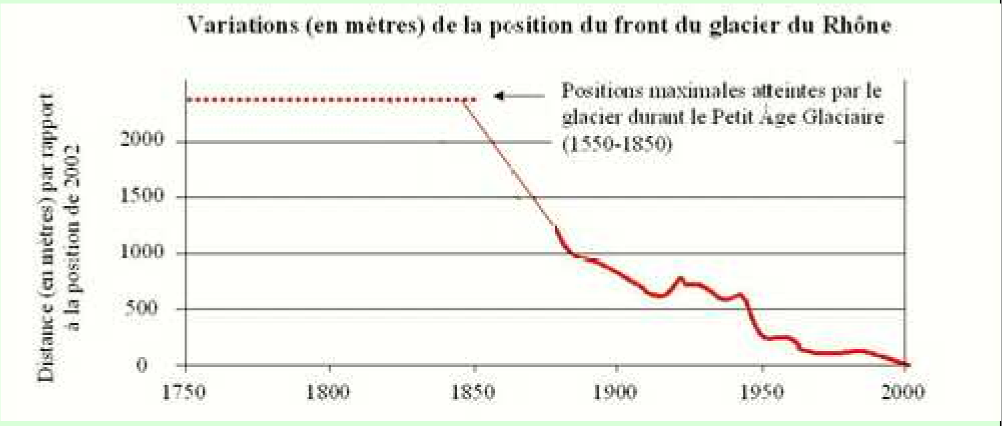
Flèches rouges: Position en 1850



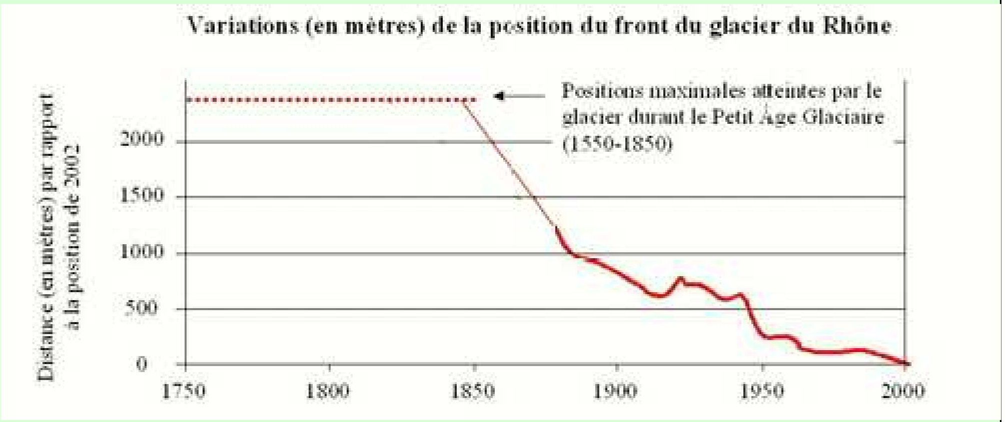


1870

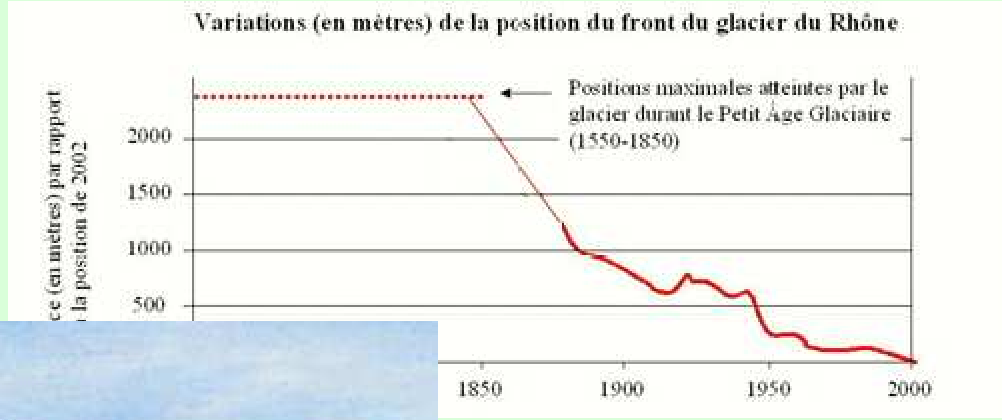
Flèches rouges:
Position en 1850



1914


Variations (en mètres) de la position du front du glacier du Rhône
Distance (en mètres) par rapport à la position de 2002
Positions maximales atteintes par le glacier durant le Petit Âge Glaciaire (1550-1850)
2000
1500
1000
500
0
1750
1800
1850
1900
1950
2000

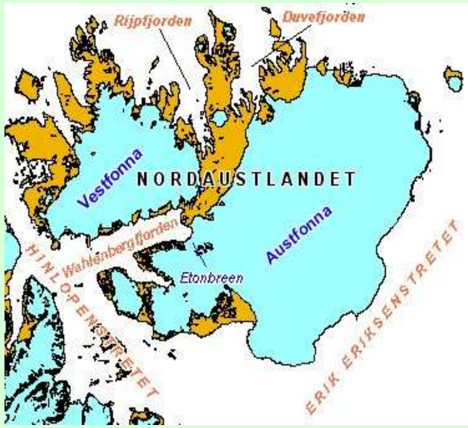
1925


Variations (en mètres) de la position du front du glacier du Rhône
Positions maximales atteintes par le glacier durant le Petit Âge Glaciaire (1550-1850)
2000
1500
1000
500
1850
1900
1950
2000

1985

2005

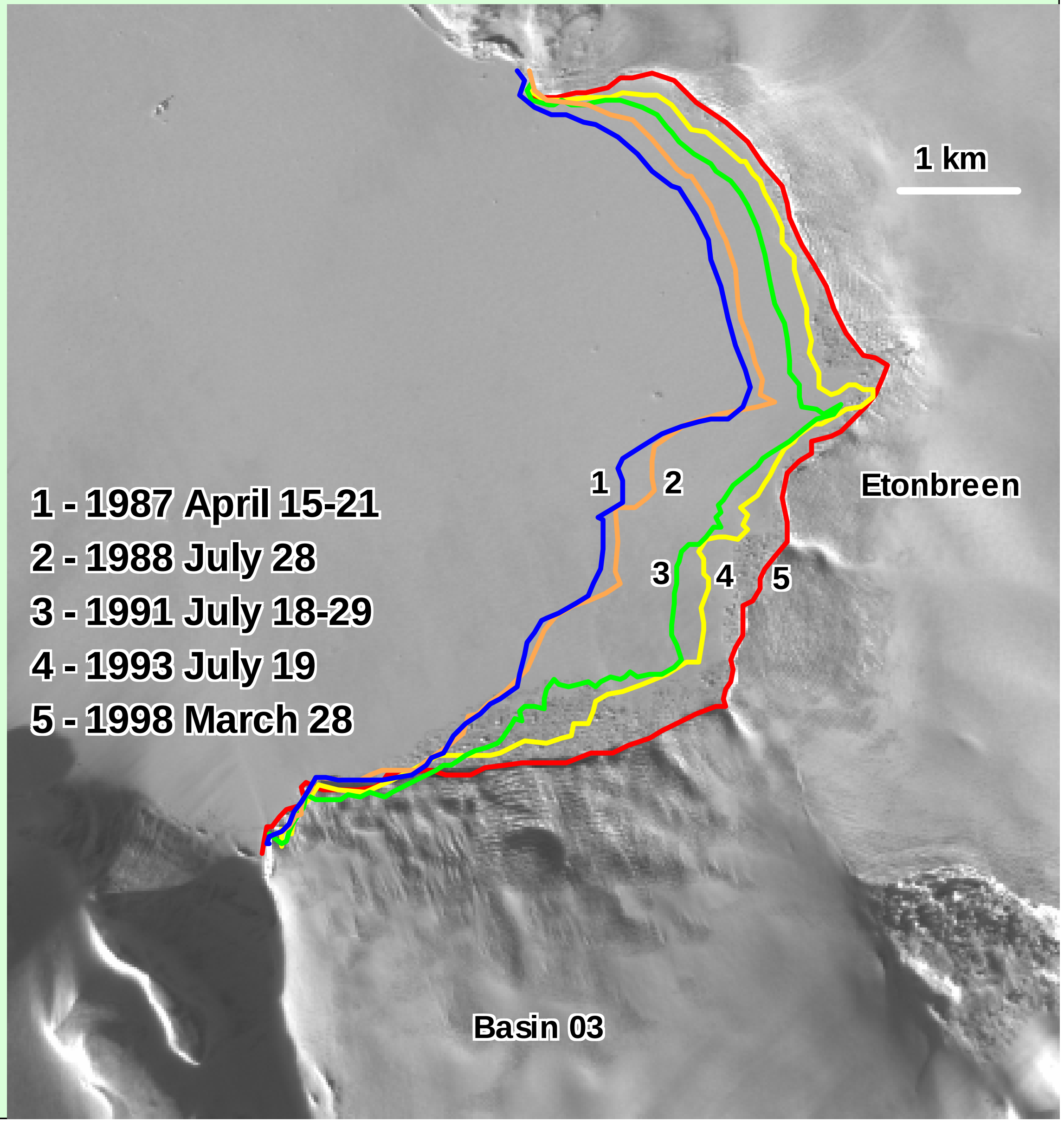
Etonbreen (Austfonna, Svalbard): 1987-1998



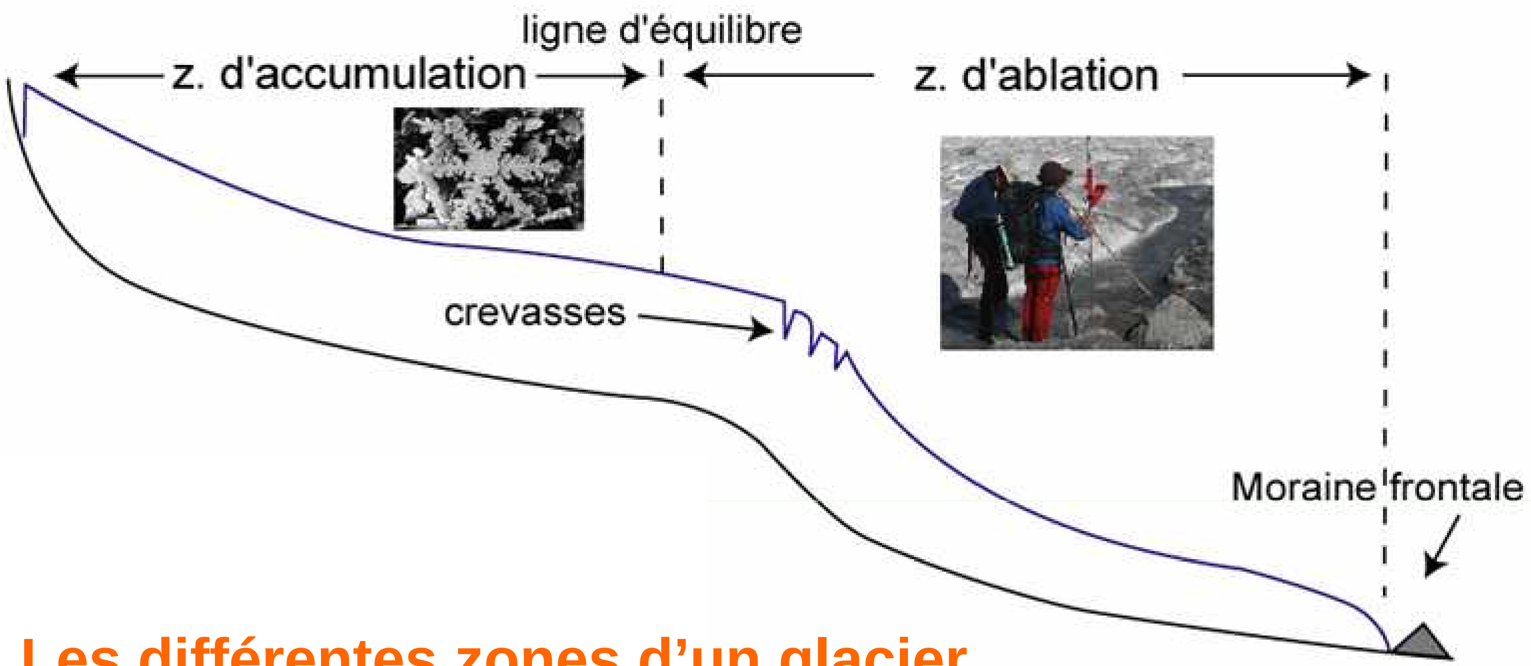
Surface changes of Etonbreen and Basin 03

Period	Change, km2	Rate, km2/yr
15/04/1987-28/07/1988	-0.75	-0.58
28/07/1988-29/07/1991	-3.04	-1.01
29/07/1991-19/07/1993	-1.42	-0.72
19/07/1993-28/03/1998	-2.25	-0.48

Background image: SPOT4, 28 March 1998

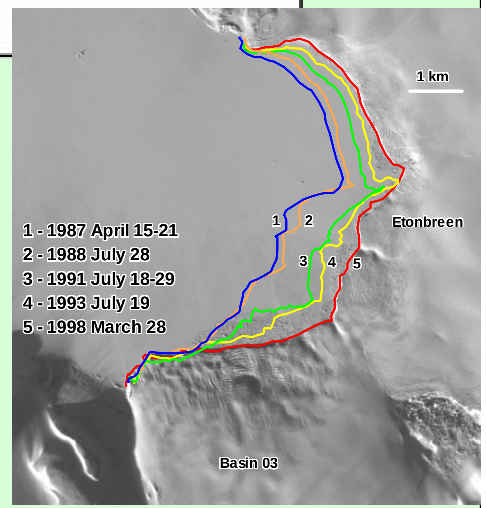


Fonctionnement d'un glacier



Les différentes zones d'un glacier

Glaciers à vidange



Importance d'interprétation correcte

Conséquences

Glaciers:
recul marqué

Lacs glaciaires:
danger de vidange

Eau potable

Bolivie, La Paz
avec glaciers: 12 %: 27%
sans: déficit de -9 : -25%

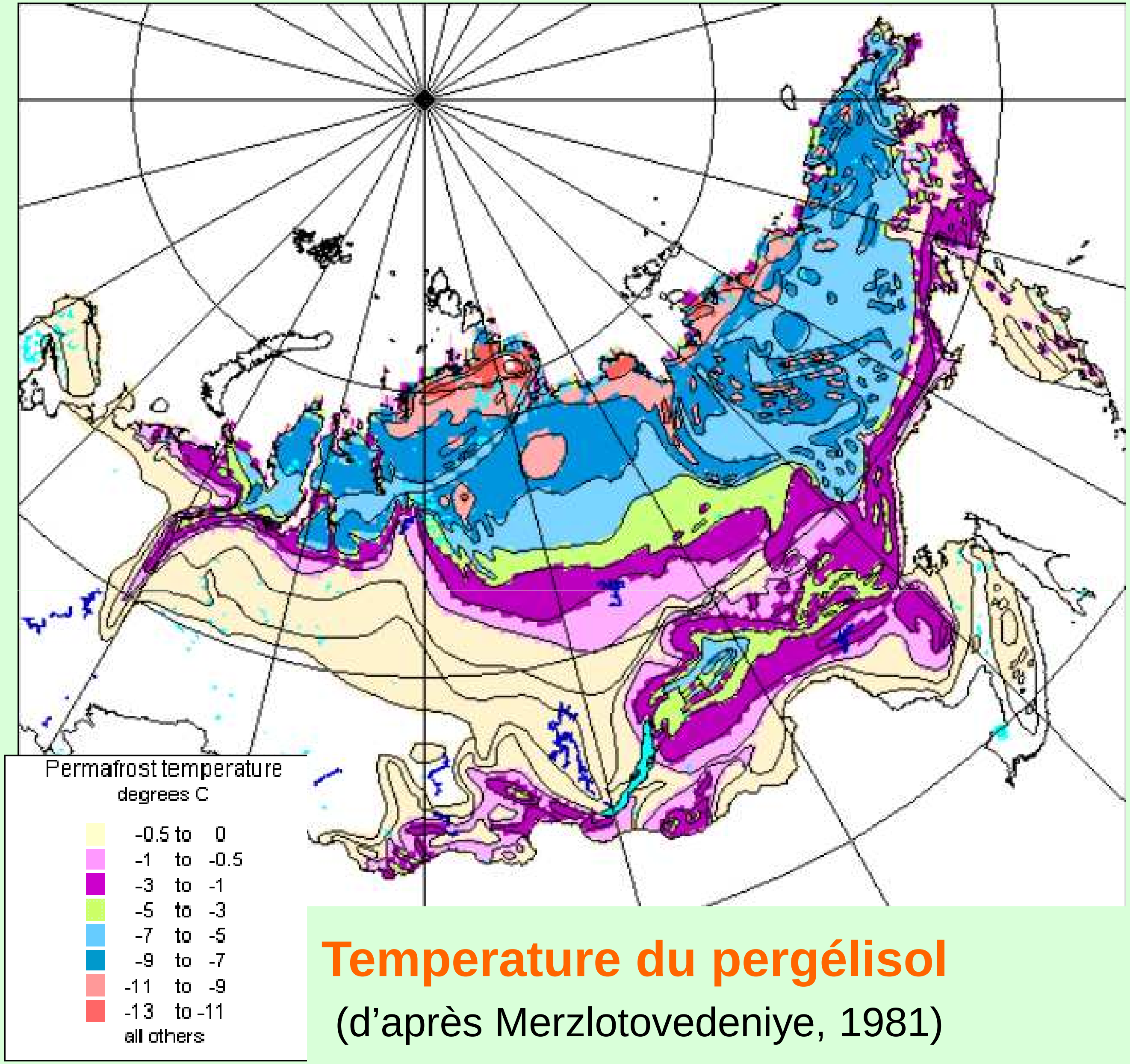
Niveau de l 'océan

Pergélisol

Plusieurs centaines de m de profondeur

Cycle du carbone

Difficile à quantifier par les satellites



Temperature du pergélisol

(d'après Merzlotovedeniye, 1981)

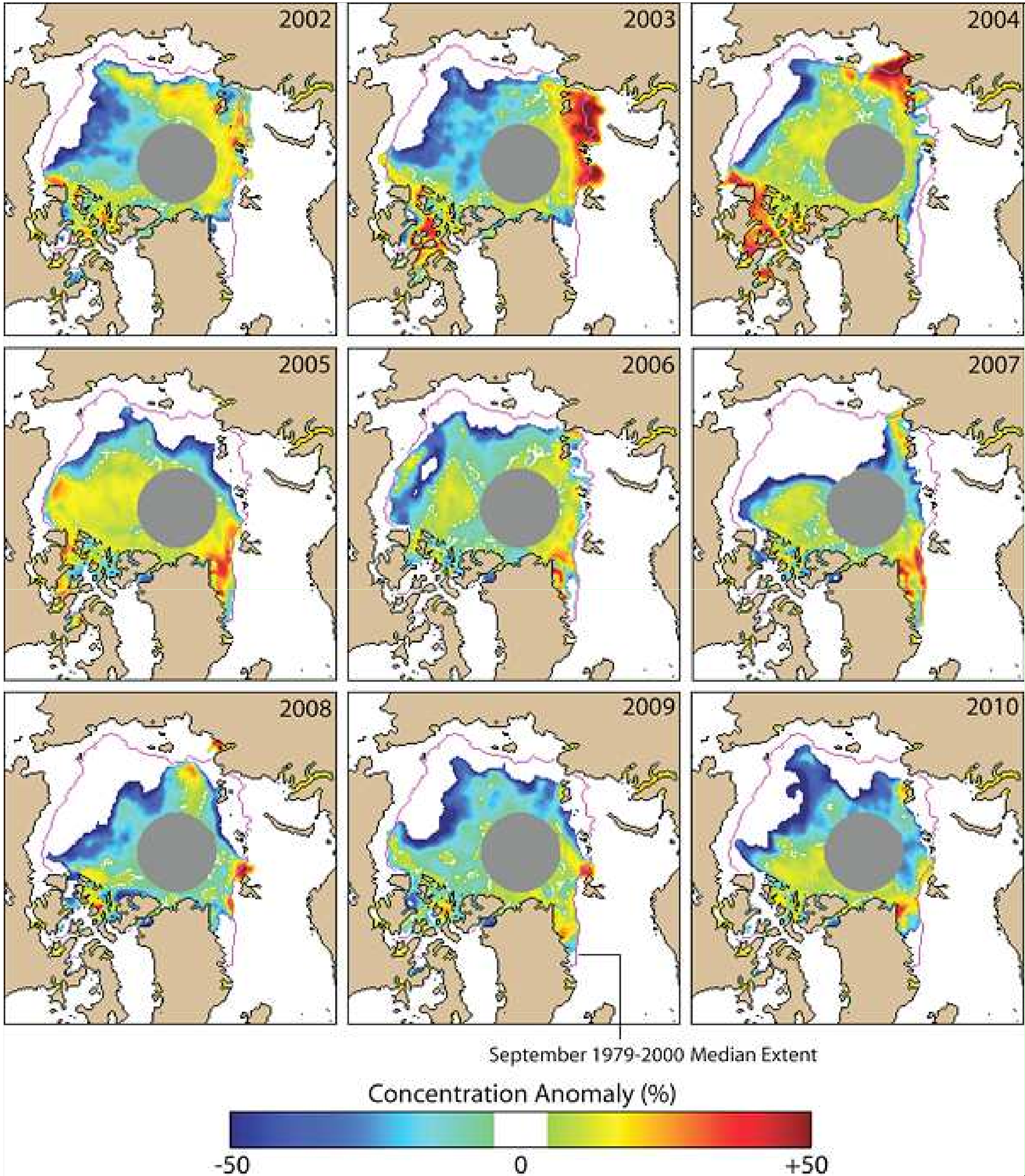
Mission de terrain 2010

Pergélisol: transport

Glace de mer

Neige

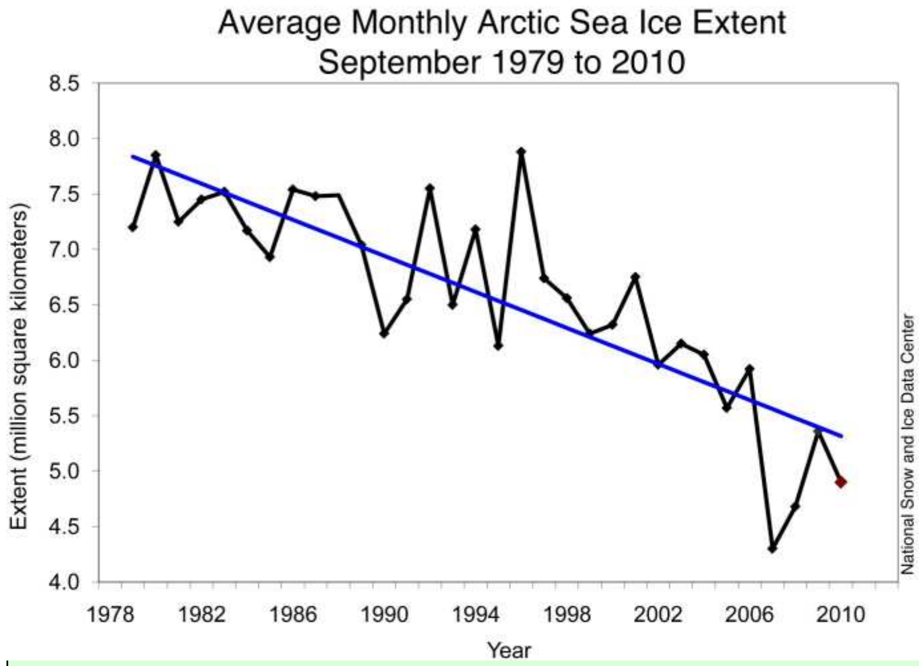
Glace de lacs et des rivières



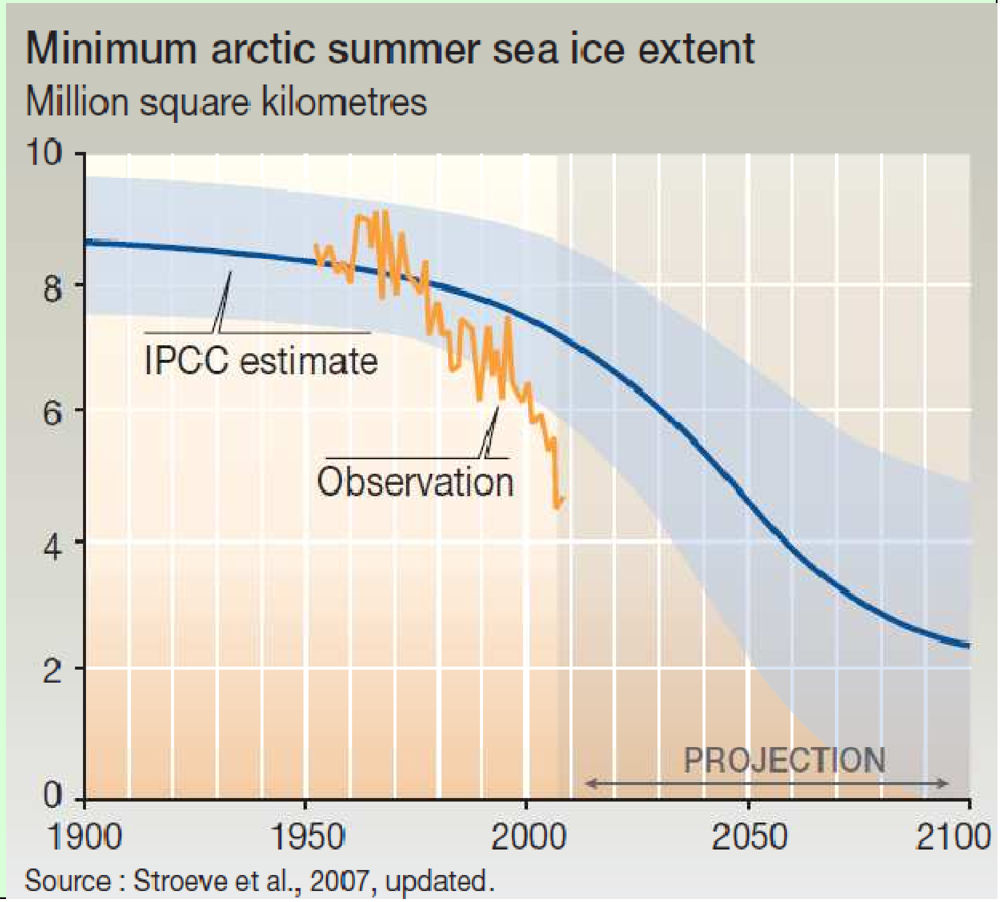
Glace de mer: Arctique

2007: surprenant recul difficilement explicable

Glace de mer: Arctique



Diminution de l'extension de la glace septembre (mesures satellitaires)

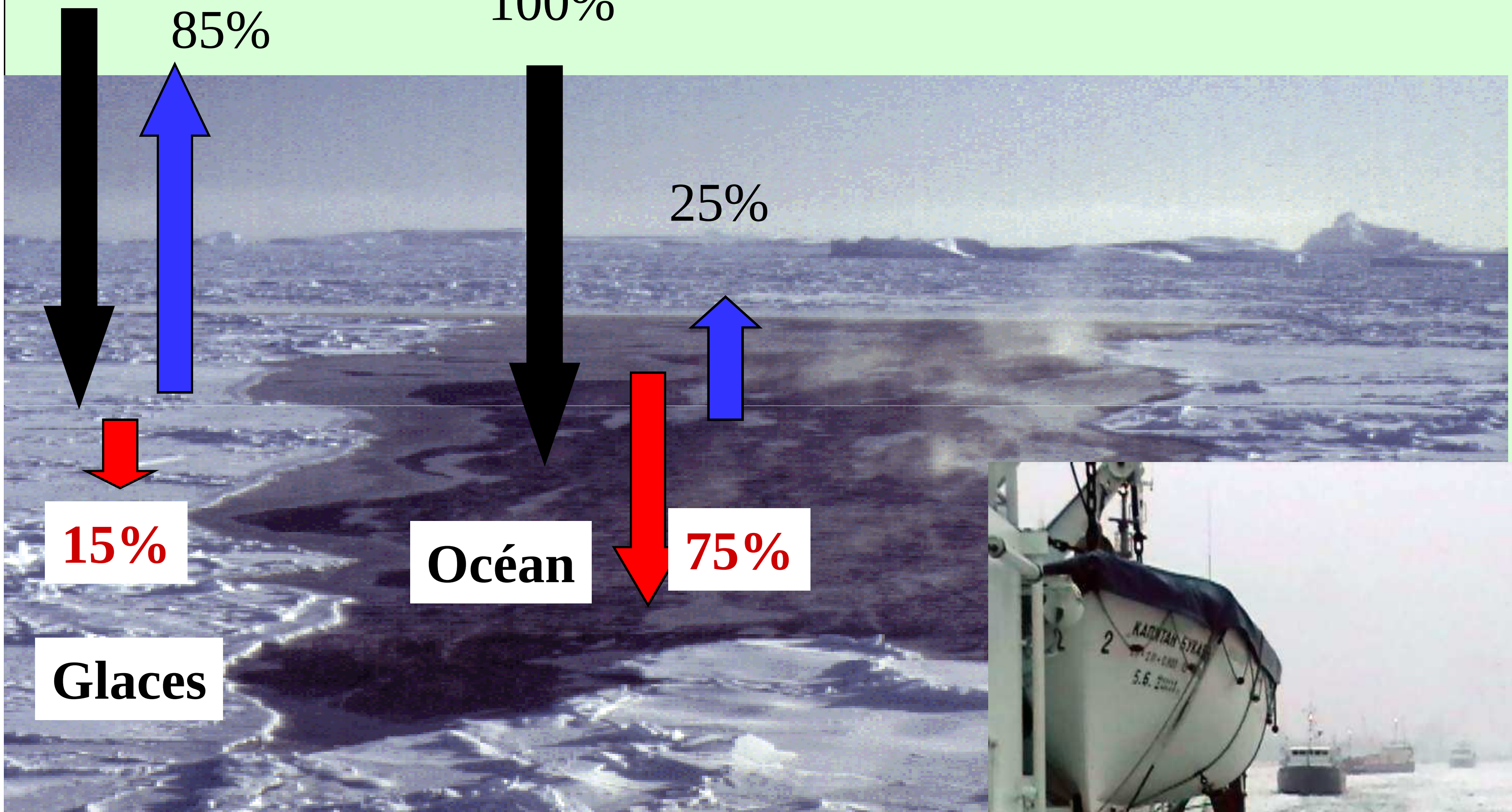


Les prévisions les plus pessimistes sont trop 'raisonnables'

Climat: Mécanisme d'auto-enchaînement = rétroaction positive

Conséquences

Niveau de l 'océan: NON

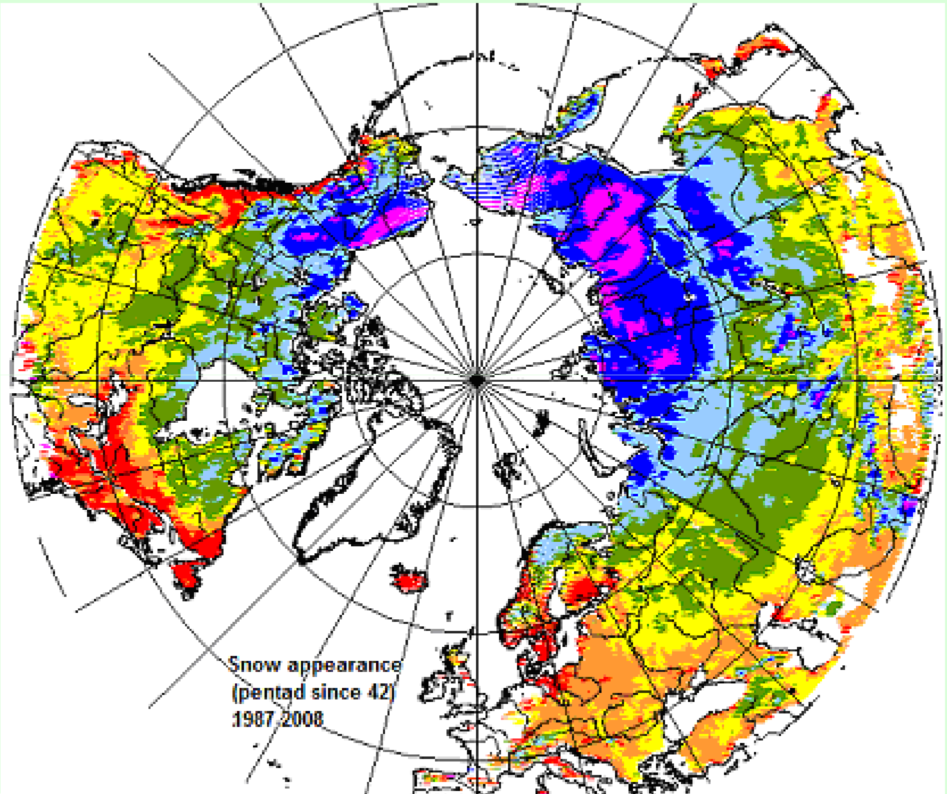


Transport, navigation

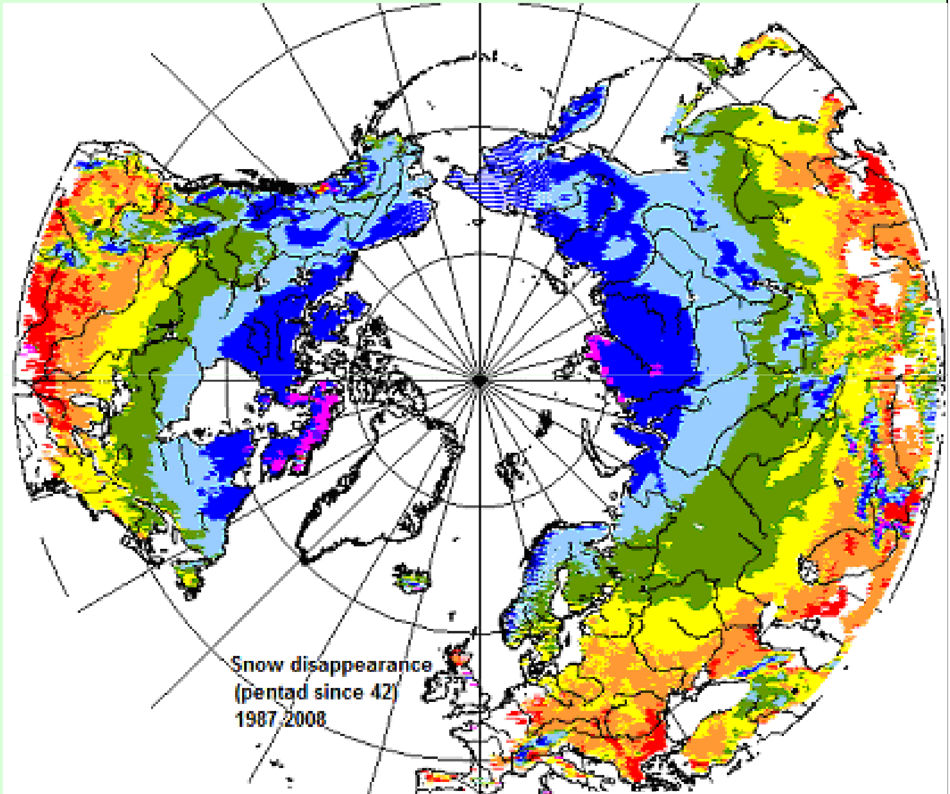
Climat - albedo, échange sol/atmosphère
Régime hydrologique, inondations

Neige

Etendue, timing - bien dévéloppé



Appearance pentad (dates)
- 1-15 (31 Jul - 9 Oct)
- 15-20 (9 Oct - 3 Nov)
- 20-25 (3 Nov - 28 Nov)
- 25-30 (28 Nov - 23 Dec)
- 30-35 (23 Dec - 17 Jan)
- 35-40 (17 Jan -11 Feb)
- 40-73 (11 Feb - 29 Jul)



Disappearance pentad (dates)
- 65-73 (16 Jun - 29 Jul)
- 60-65 (22 May - 16 Jun)
- 55-60 (27 Apr - 22 May)
- 50-55 (2 Apr - 27 Apr)
- 45-50 (8 Mar - 2 Apr)
- 40-45 (14 Feb - 8 Mar)
- 1-40 (31 Jul - 14 Feb)

Apparition et disparition de la neige (moyenne 1987-2008)

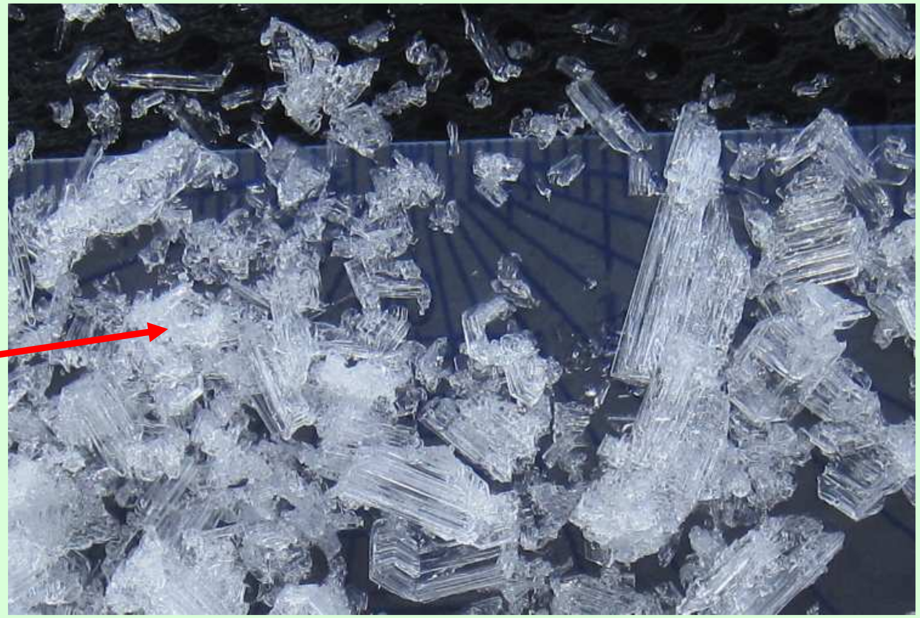
Profondeur, teneur en eau - beaucoup plus compliqué

Neige

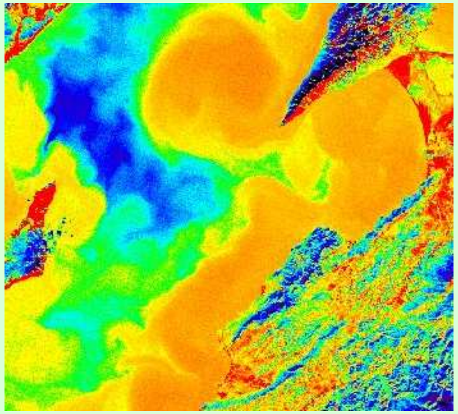
Satellite - mesure intégrale. Influence de la taille de grains
=> Validation par les mesures de terran

Mission de terrain 2011

2-15 mm



Glace de lacs - element dynamique



Champs hydrophysiques et hydrochimiques

Indicateur du changement climatique

Influence sur la productivité primaire

Caspian seal (Pusa Caspica)

Conditions de vie pour les mammifieres endemiques

Navigation, industrie, transport, peche, tourisme

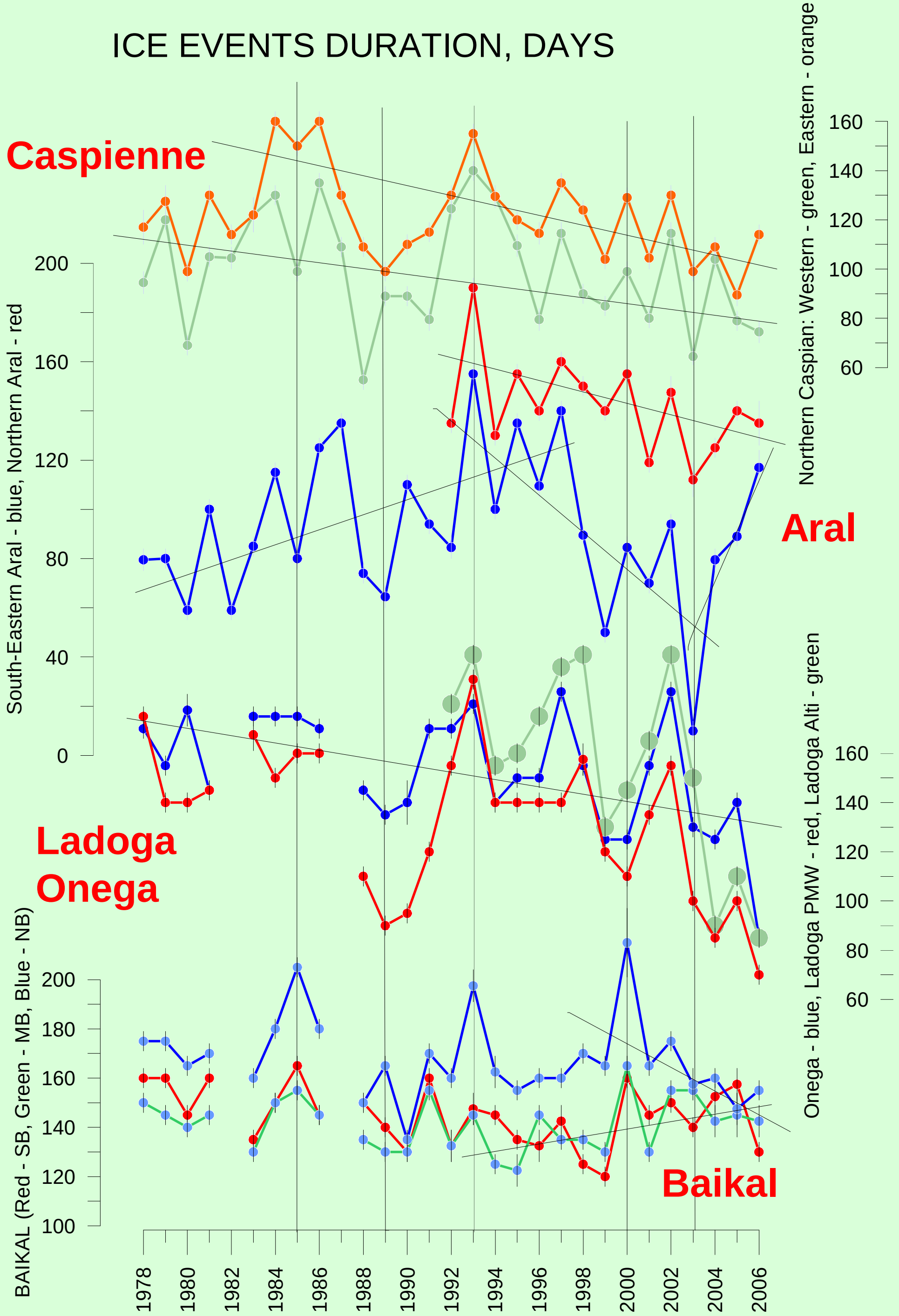
Brise-glace (mer Caspienne)

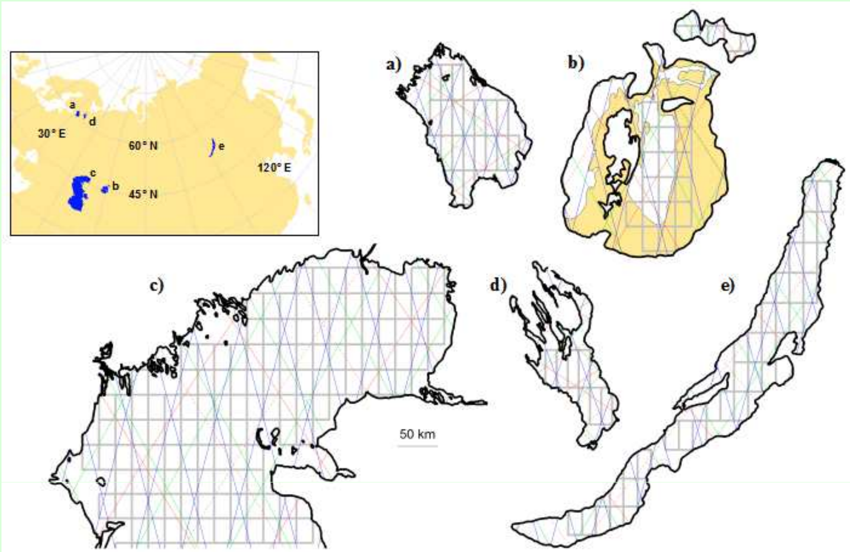
Plateforme petroliere, mer Caspienne

Ouverture de la route sur glace
Ol'khon, 11 Feb, 2004

Touristes sur la glace (lac Baikal)

Glace de lacs et mers interieurs



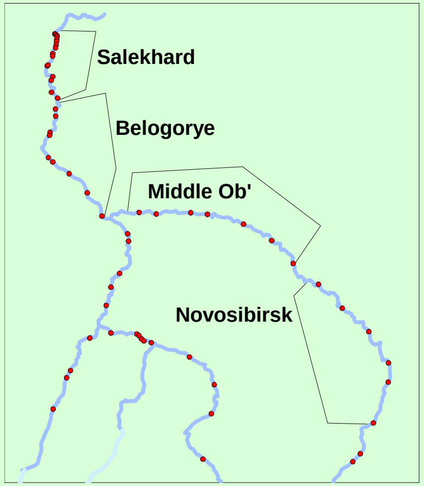


Technique multi-satellitaire: timing, éténdue

Bonne rélation avec les observations historiques

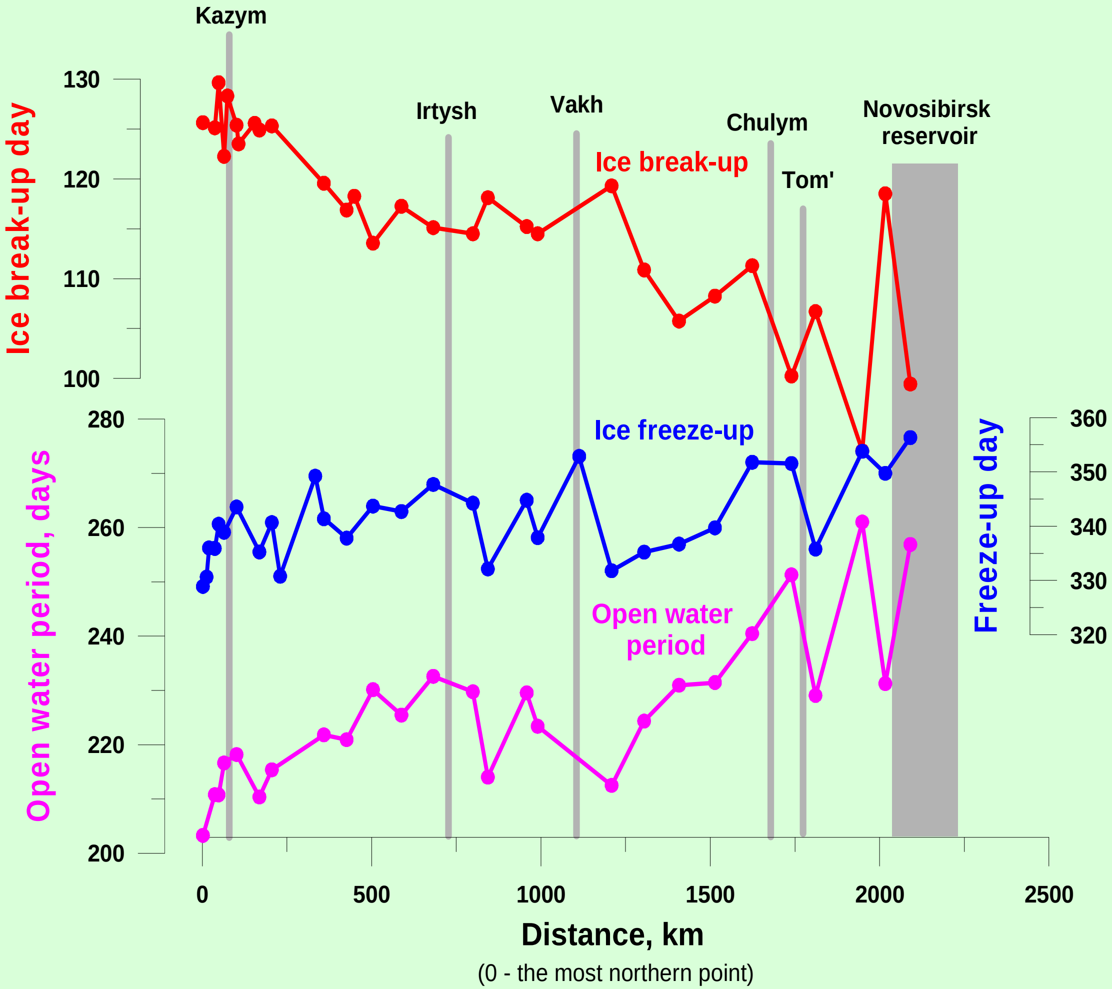
Extension/création des séries temporelles

Glace de rivieres



Influence de latitude

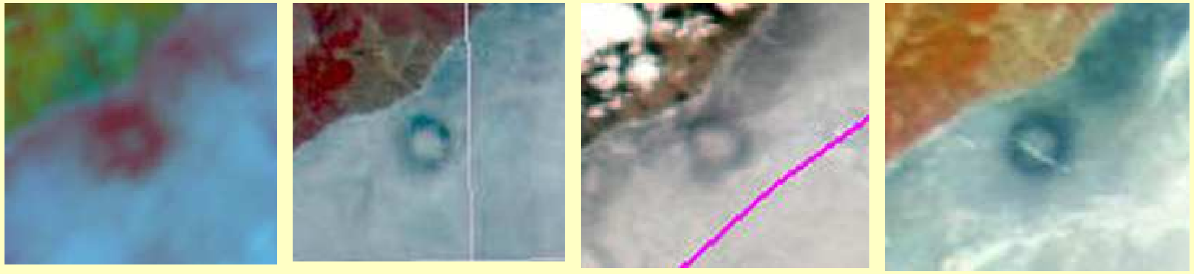
Mais aussi des reservoirs et confluents



Fleuve Ob' (T/P): dates de fonte et apparition de la glace, et la durée de la glace

Anneaux de glace

Krestovskiy Cape



1999 04 18 | 2003 04 20 | 2005 04 24 | 2008 04 22

Radius about 2.3 - 2.9 km

Nizhnee Izgolovye Cape

2009 04 15

2009 04 24

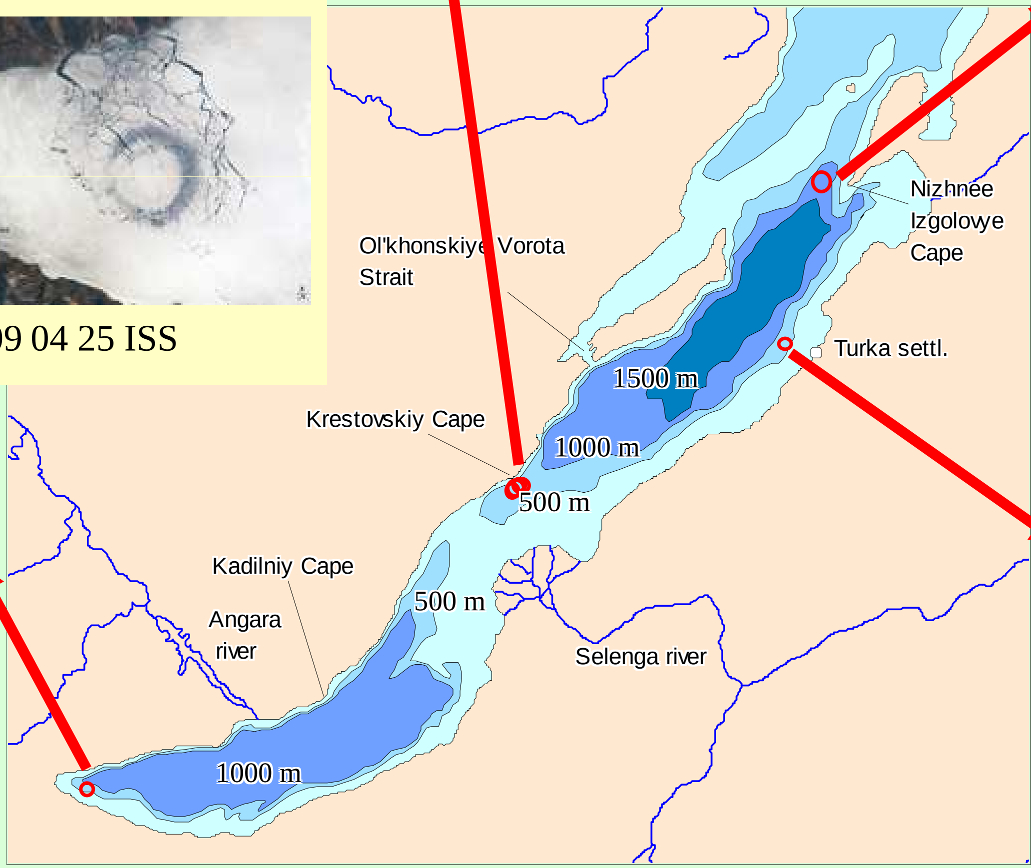
Radius about 2.8 km

Southern Baikal

2009 04 20 SPOT | 2009 04 25 ISS

2009 04 24

Radius about 2.1 km



Turka region

2008 04 22

Radius about 1.9 km

Beaucoup de changements, impact sur le climat et l ’homme

Continuer les observations, mieux comprendre les processus

Coopération internationale, multidisciplinaire