Surveillance des régions polaires par Envisat

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Collaboration:

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Glaces de mer:

- Région Arctique
- Région Antarctique

Calottes glaciaires

- Groenland
- Antarctique

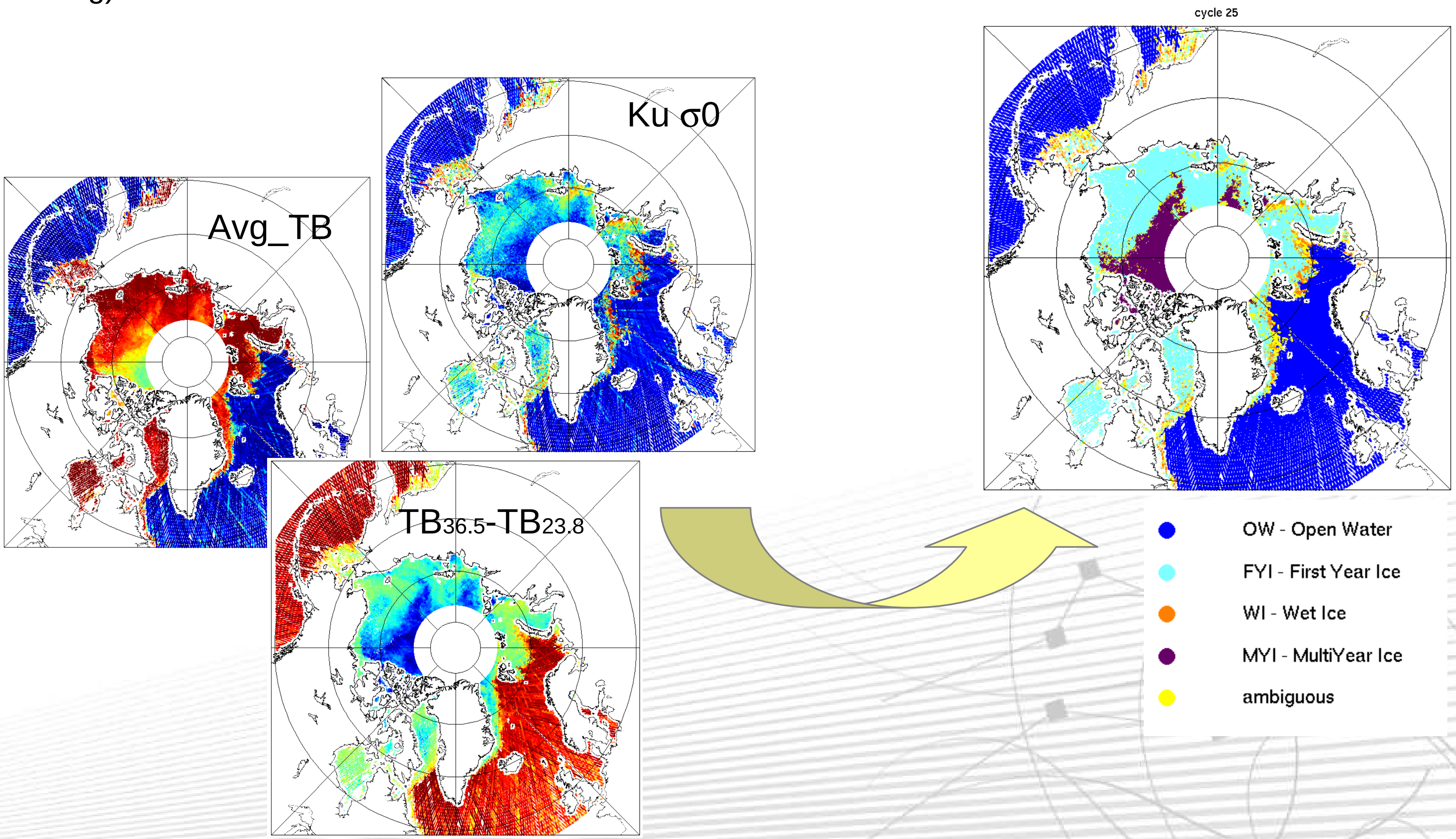
CLS COLLECTE LOCALISATION SATELLITES · LEGOS · Ifremer · UNIVERSITY of NEW HAMPSHIRE · esa

Glaces de mer & altimétrie

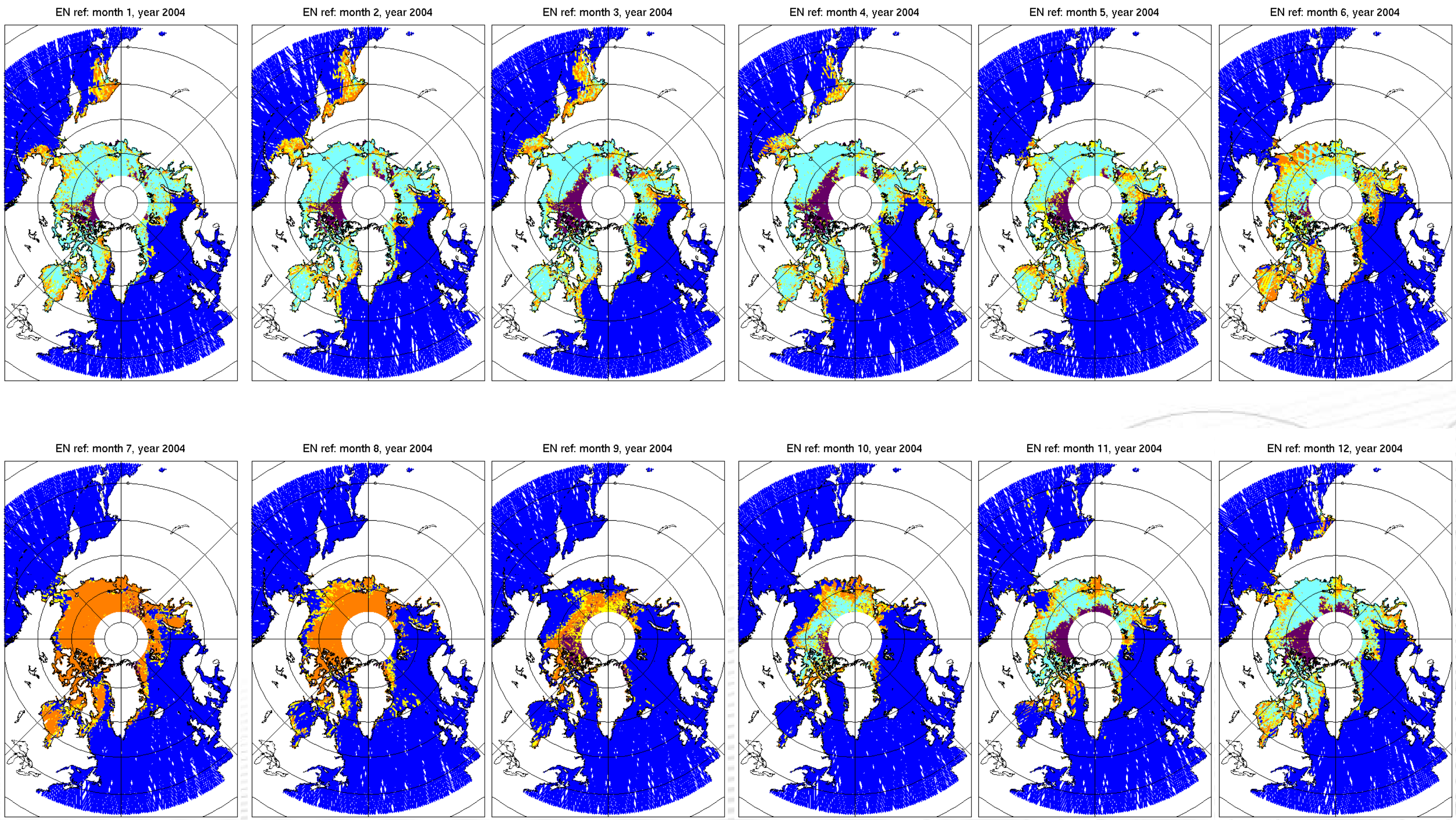
- ■ Limites des glaces / étendue de la banquise
- ☐ Épaisseur
  - augmente avec l'âge / temps de séjour 5-7 ans dans l'Arctique vs. 1-2 ans dans l'Antarctique
  - estimation à partir du freeboard et de l'épaisseur de la couverture de neige
- ■ Âge (classe) / approximation raisonnable de l'épaisseur moyenne
  - simplification en 2 catégories: jeune / saisonnière (FYI ~ 1 m) et pérenne (MYI ~ 3 m)
  - différence de température, salinité, constante diélectrique, rugosité (lisse / déformée), pénétration des ondes, …
- ■ Date de démarrage des périodes de fonte et de gel/regel
  - périodes de transition critique du développement
- ☐ Volume total de glace de mer dans chaque hémisphère
  - à partir de l'étendue et de l'épaisseur

Envisat ocean / sea-ice flag & Arctic region partition

- Detection of sea-ice corrupted sea surface height data within quality control processing for oceanography applications, but also provision of the sea-ice type for geophysical purpose (multi-state flag).



Over 2004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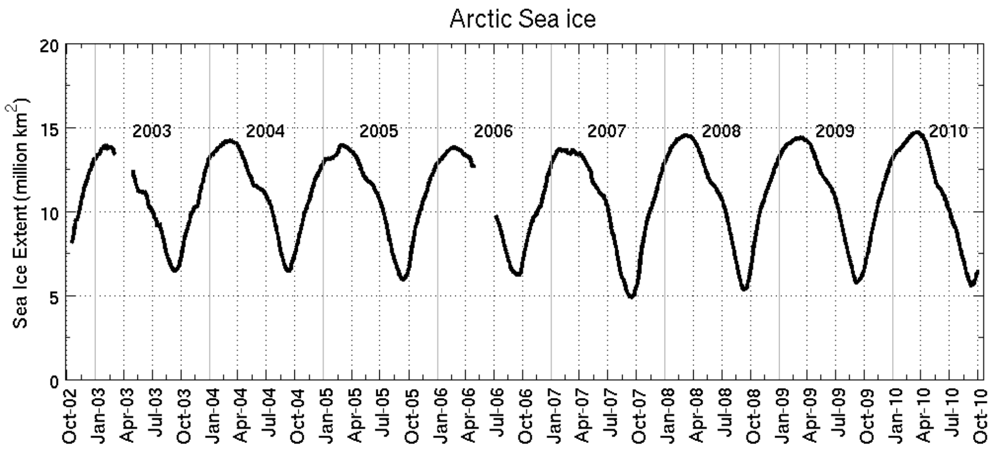
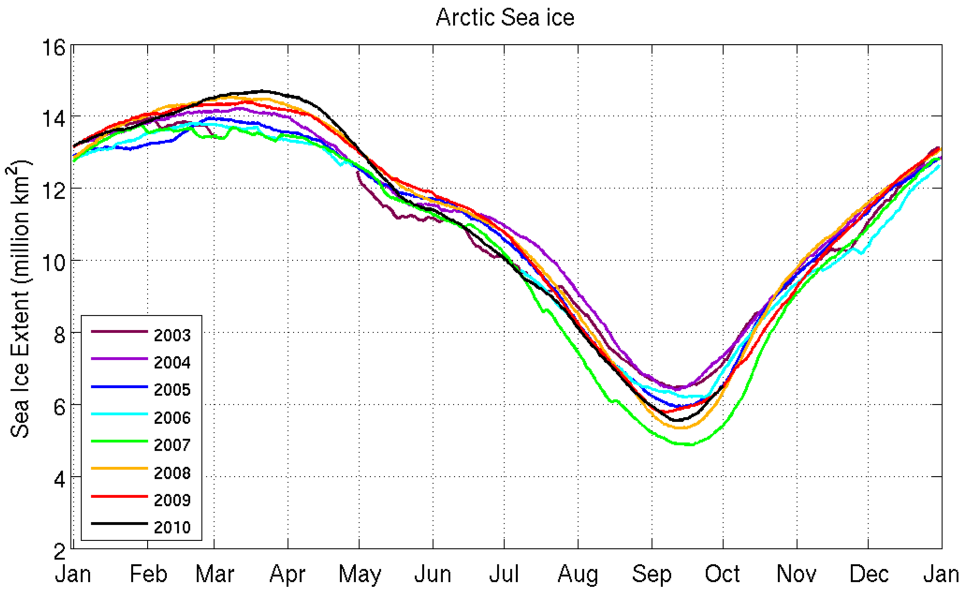
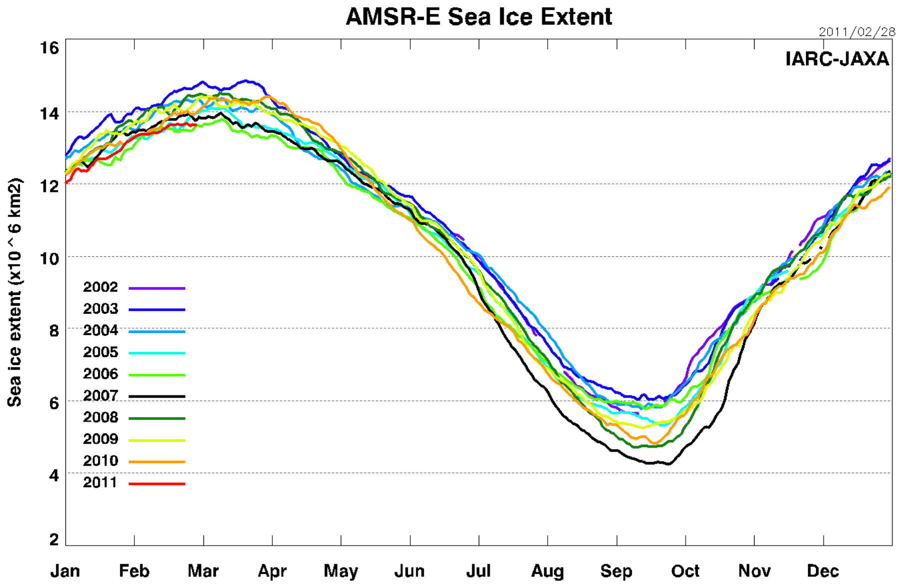
Seasonal & interannual variations of extent

(35-day running window + pole hole filled)

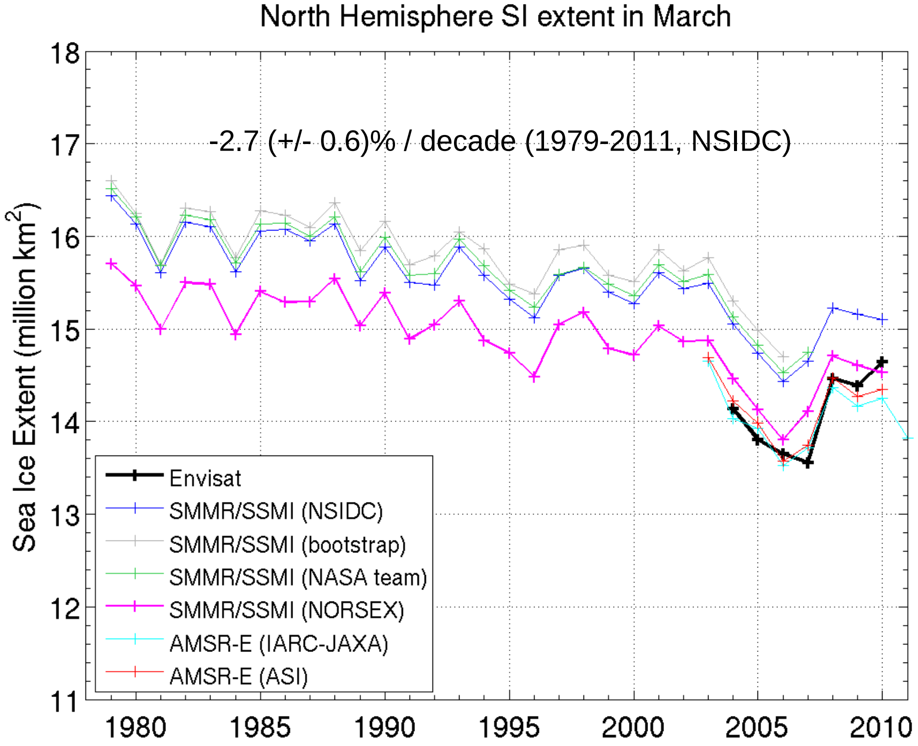


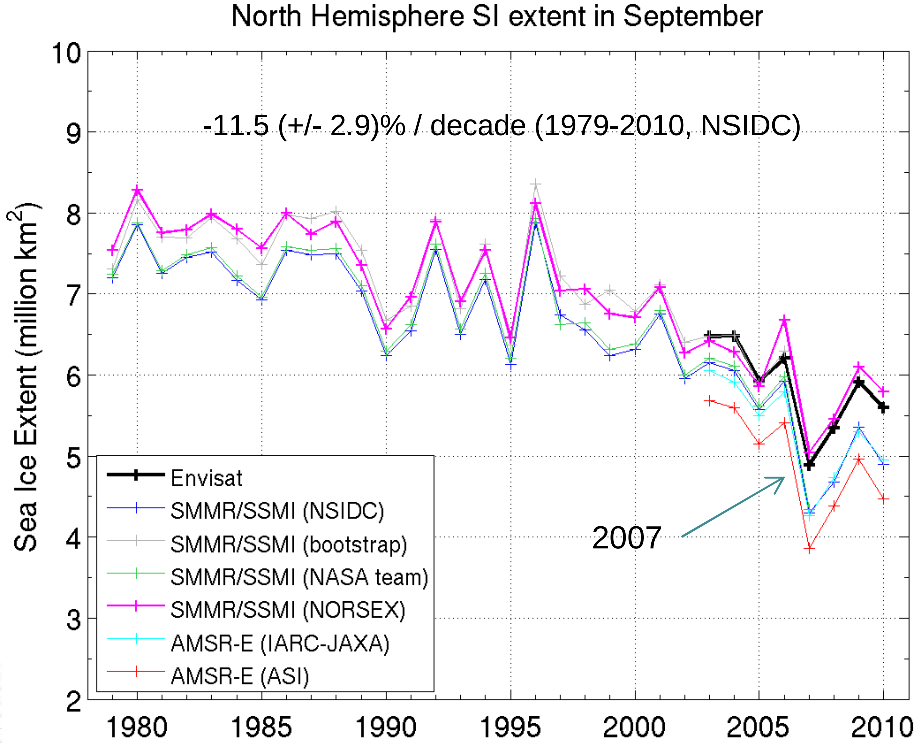
- pole hole ~2.6 million km²
- Each winter the ice cover grows as the sun sets for several months and intense cold ensues during the polar night. Some of the ice flow out of the Arctic.
- In the summer, wind and ocean currents cause some of the ice to flow out of the Arctic while much of it melts in place.





Monitoring of extents in March (maximum) and September (minimum) that define the annual cycle





- systematic underestimation because of altimeter sampling at mid latitudes

- large inter-annual variability in September
- possibility of overestimation for some years because of the assumption of pole hole completely filled with ice

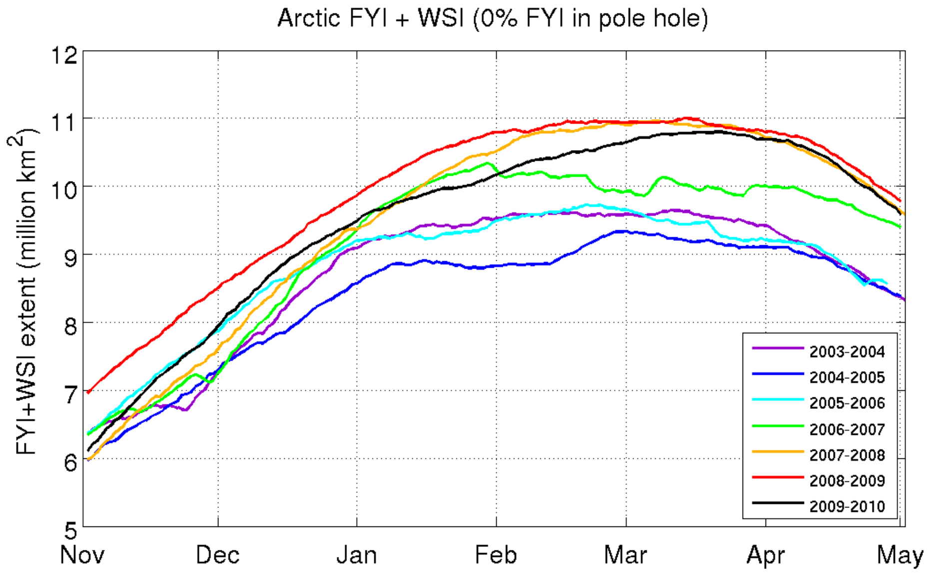
MYI and FYI extents variations during winter

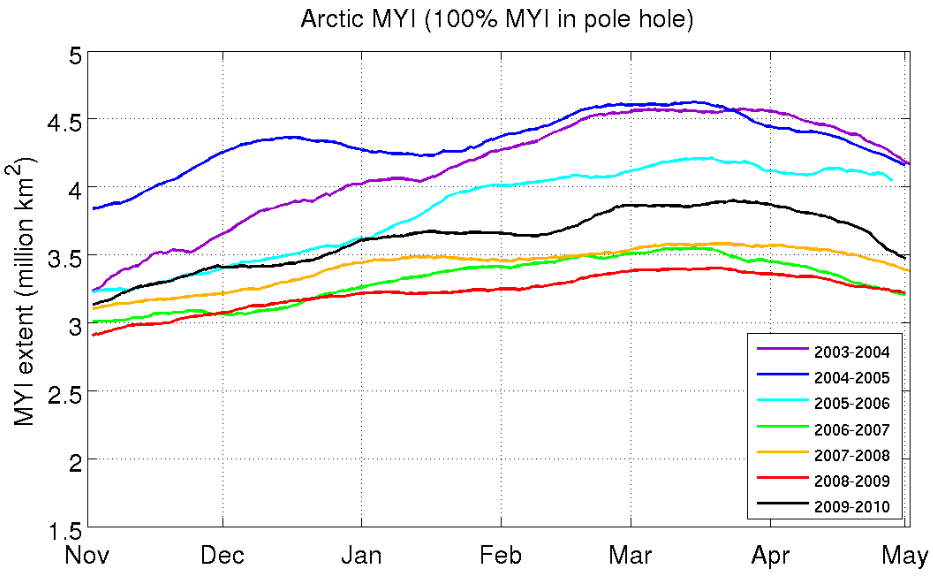
➢ knowledge of the partition between FYI and MYI zones provides another view of the ongoing transformation of the Arctic's ice cover

➢ gains:
   – ice growth (production by freezing of seawater and/or thickening) / compressed by collision and deformation

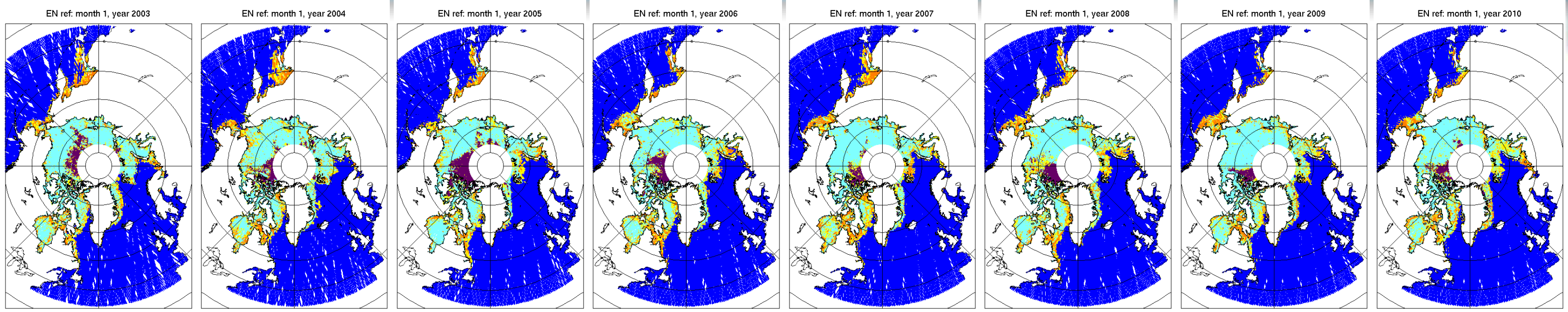
➢ losses:
   – export and melting in warmer water
   – change of class

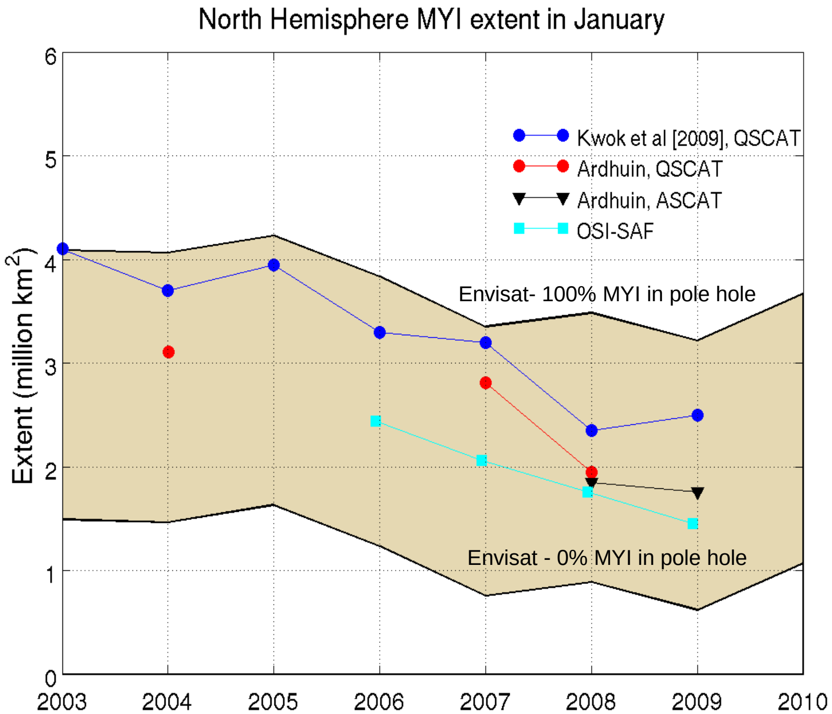
➢ Seasonal ice replaces thick older ice as the dominant type (~50% MYI coverage (1980s) -> less than 30%)





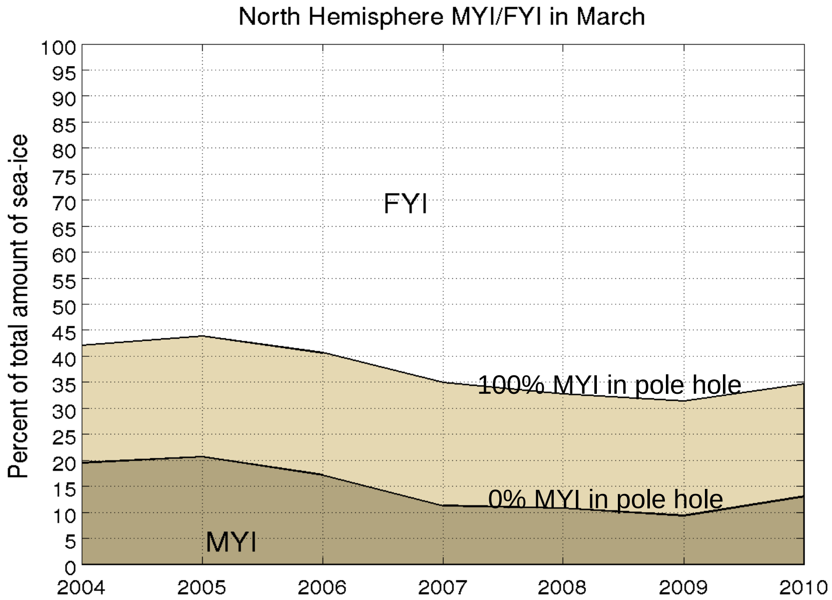
Comparison of MYI extents in January



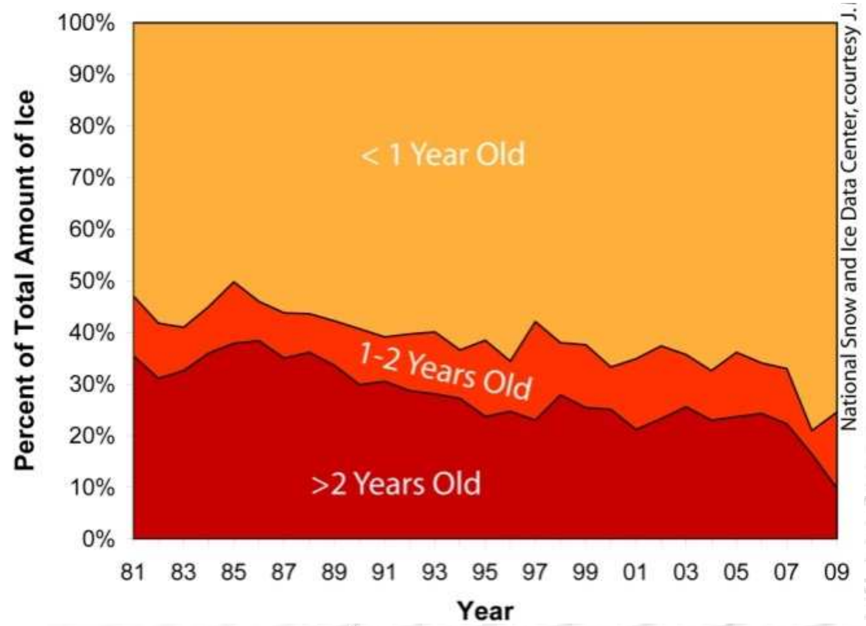


- -3% per decade for total sea ice extent
- -10, -7% per decade in MYI cover

MYI / FYI distributions



From Fowler , Maslanik and NSIDC
(http://www.sciencedaily.com/releases/2009/04/)

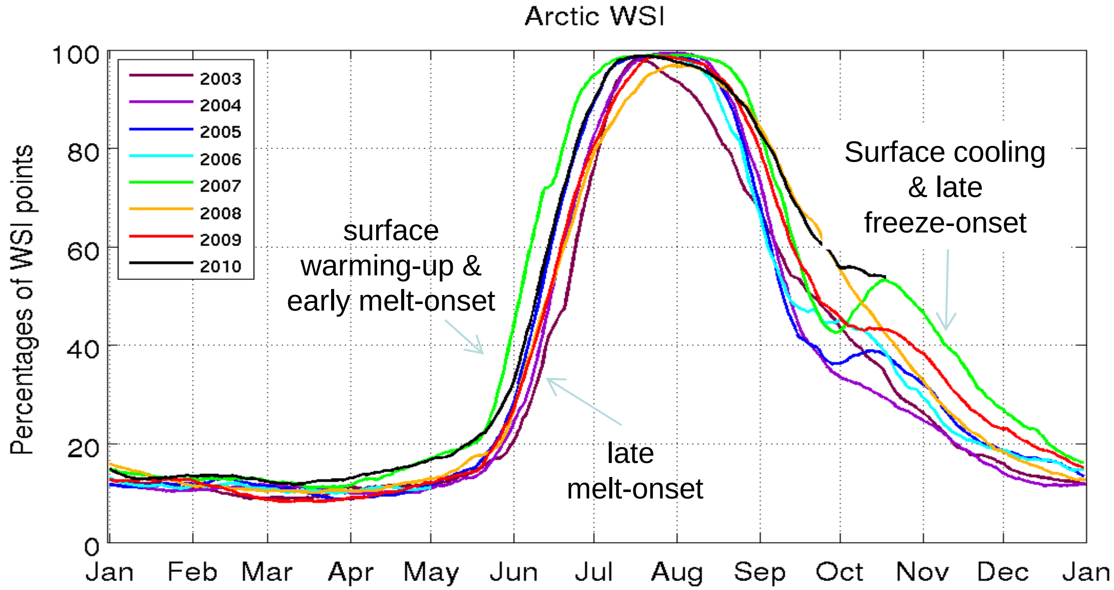


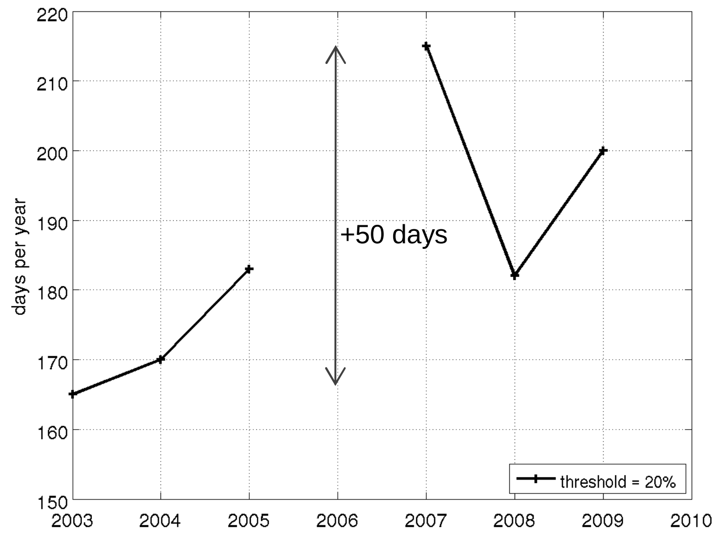
- lower extent in MYI and decrease in MYI thickness lead to near reversal in the volumetric contribution of the two ice types to the total volume of the Arctic Ocean ice cover

[Kwok, 2009]:from ICESat data

- 2003: 62% in MYI
  38% in FYI
- 2008: 32% in MYI
  68% in FYI

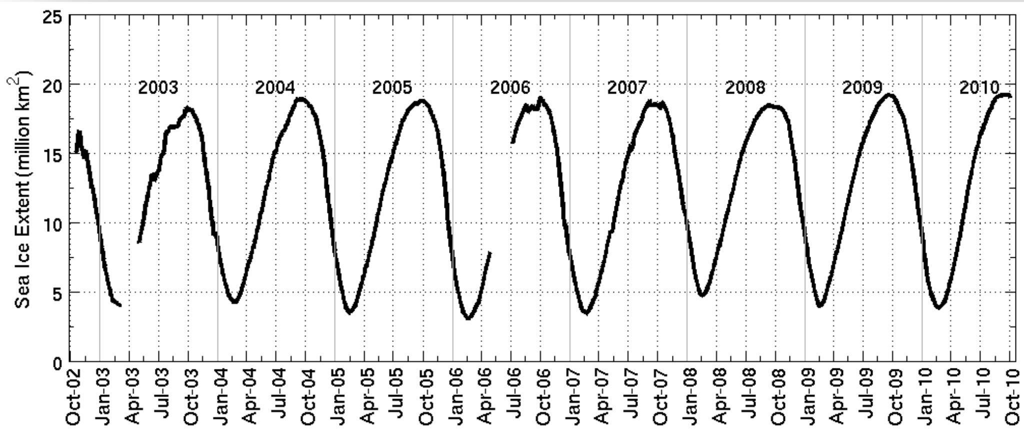
Melt-onset / freeze-onset / summer melt duration

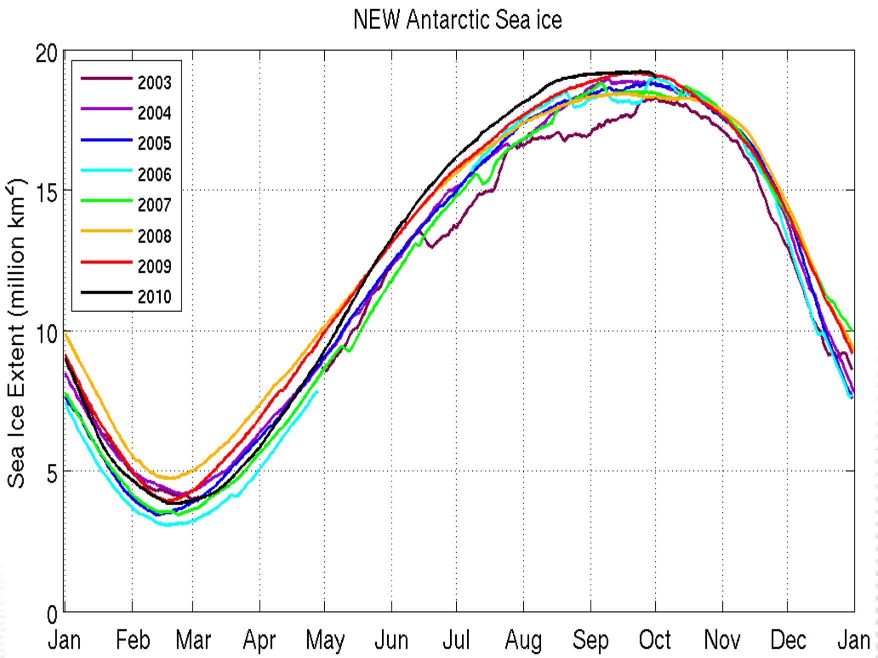


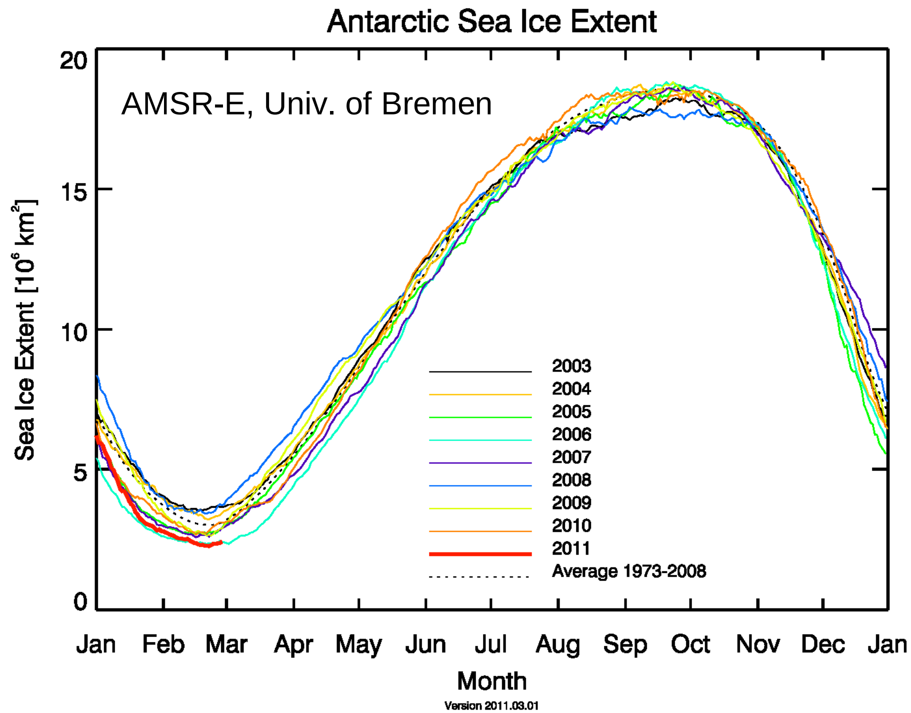


- for 2007 (record-low minimum in September):
  - warmer winter / early warming-up of the sea-ice surface / early melt-onset
  - warmer summer and warmer seawater / delay in the onset of freeze-up
  - longer melting season / more intense thinning of MYI by melting at the surface and below
  - anomalies in patterns of atmospheric and sea ice circulations / higher loss by ice export during summer outside the Arctic basin

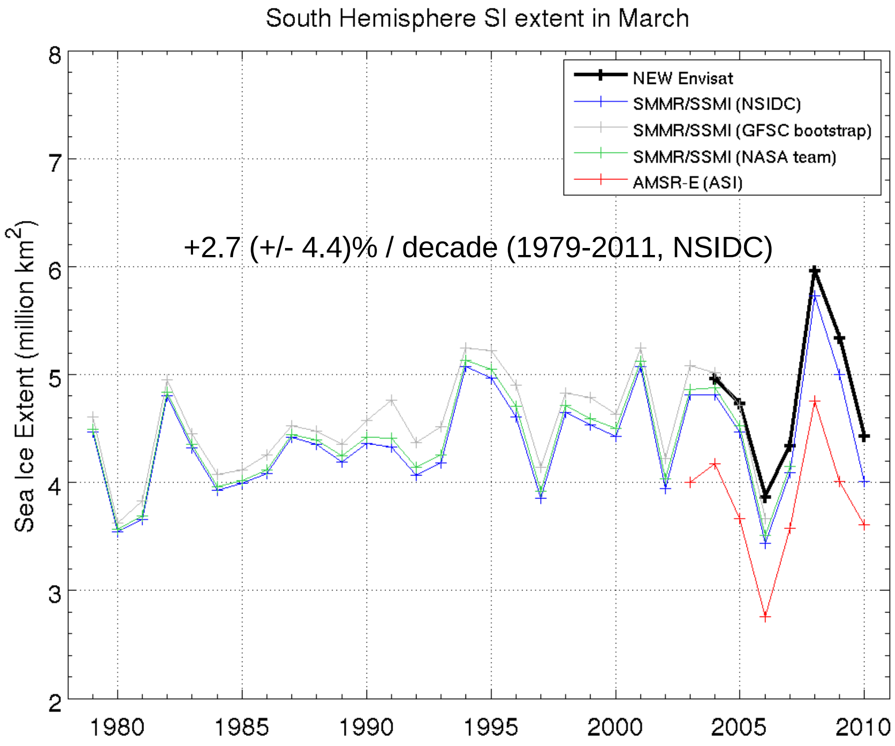
Antarctic region

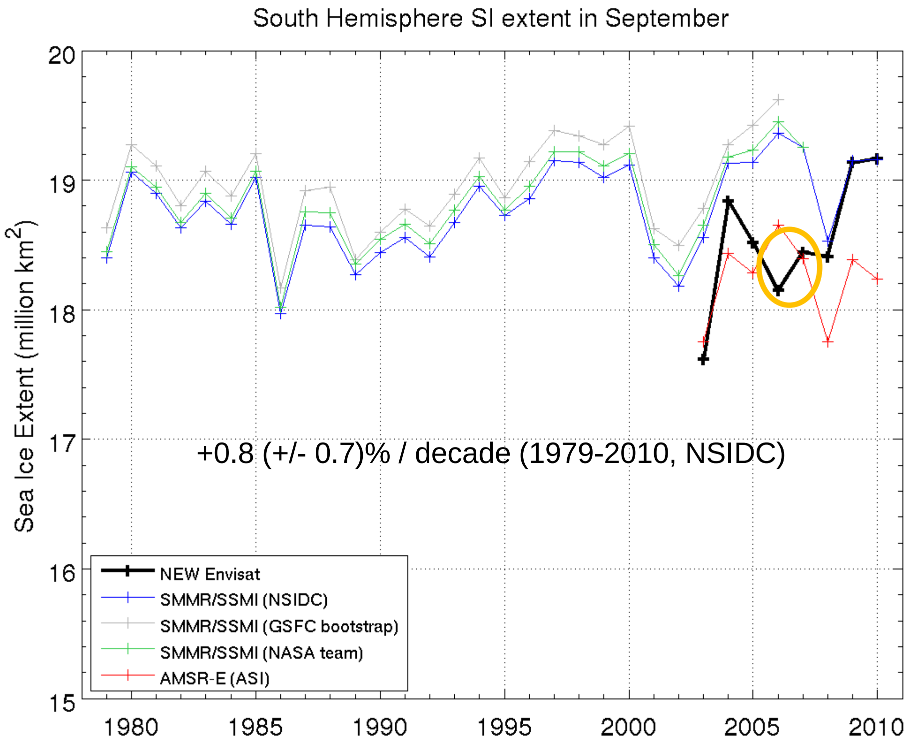






Monitoring of extents in March (minimum) and September (maximum)





- Larger problem of missing data (2006 & 2007)

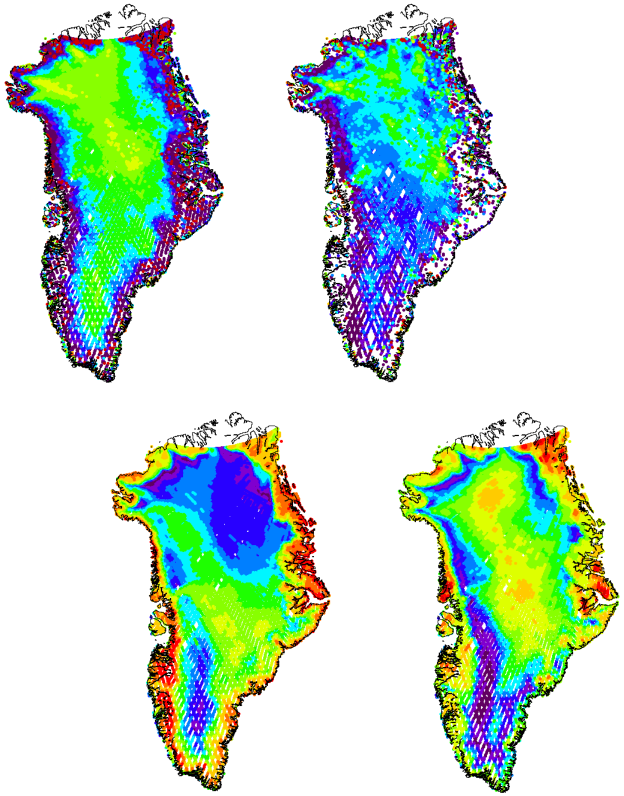
Sea-Ice: Conclusions and Perspectives

- Most dramatic signals of the general Arctic-wide warming trend in recent years are
  - the continued significant reduction in the extent of the summer sea ice cover
  - the decrease in the amount of multi-year ice
  - key question (from climate change perspective): how fast the total volume of sea ice is changing ?
- Good potential of altimetry for use within a sea-ice monitoring system
  - sea-ice extent
  - inter-annual variation of ratio between MYI & FYI contributions to total ice cover during winter
  - provision of information on Arctic sea-ice surface warming for evaluation of the melt season duration
- Test to be done within WOOPI project
  - development of an improved algorithm to distinguish Arctic perennial and seasonal sea-ice during the summer melt season
- Perspectives
  - application to Altika, Sentinel-3 records
  - monitoring of multi-mission time-series to improve surface sampling
  - use of CryoSat-2 (2° pole hole), CFOSAT data (combination of SWIM & SCAT)
  - ice-thickness estimation (application for Altika) from improved freeboard retrieval

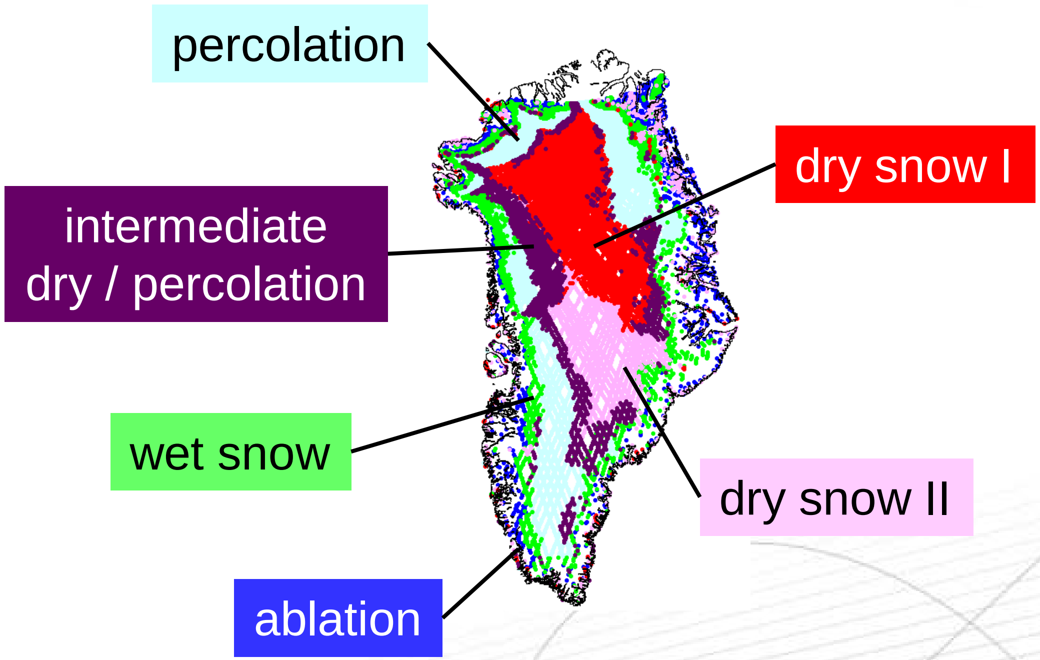
Calottes glaciaires & classification de la neige/glace

- There are uncertainties in estimating the correct height over ice sheet because of the radar wave penetration within the cold and dry snow medium. They display dependencies on snowpack characteristics which vary seasonally and spatially.
- Partition of ice sheet into different homogeneous regions can help for the interpretation of altimetry data.
- The monitoring of the extent changes of these regions would be a good indicator of the climate change effects on Greenland and Antarctica.

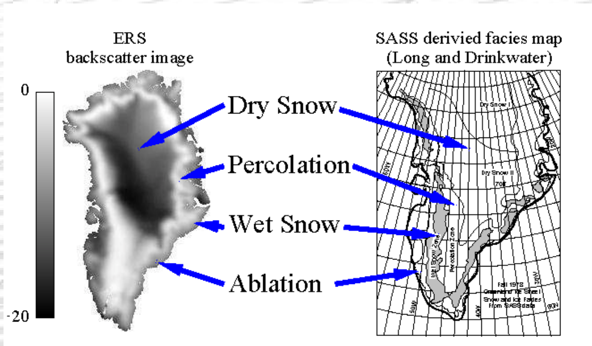
Greenland partition



(Ku σ0, Ku-S σ0, Avg_TB, ratio_TB)

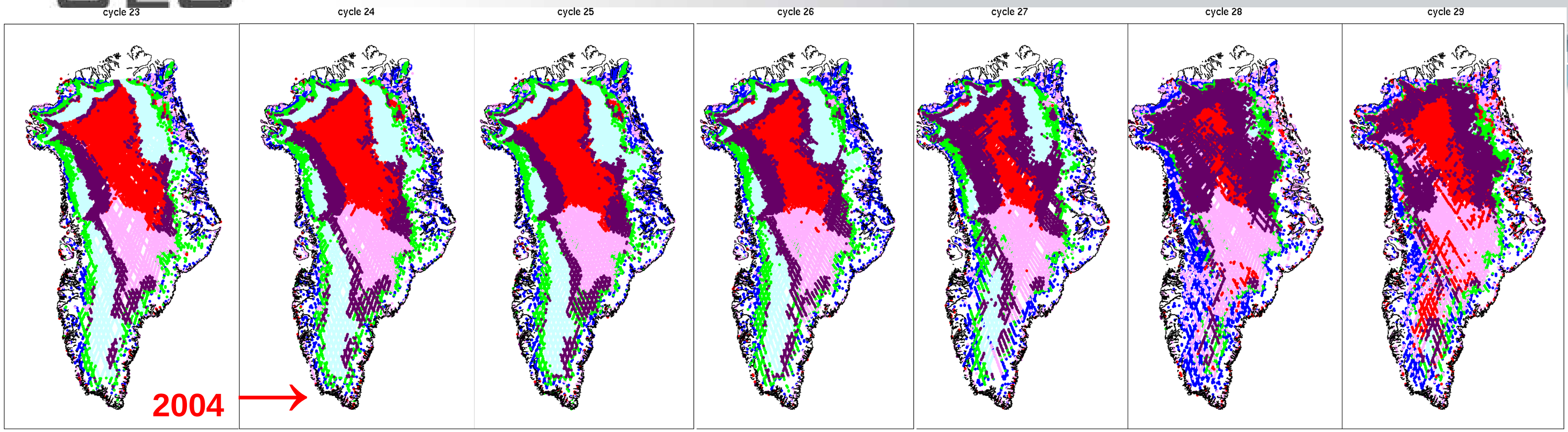


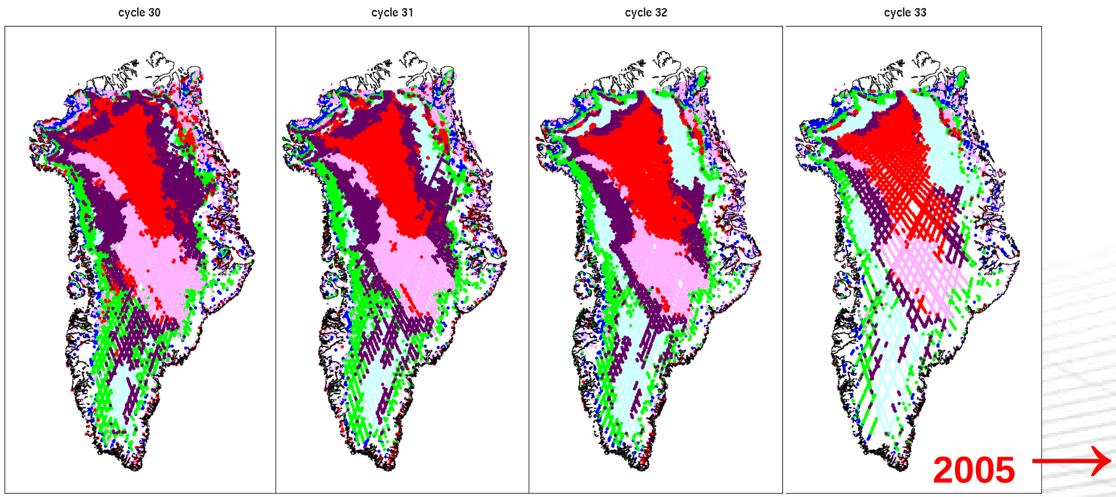
Related to accumulation patterns, snow layering as a consequence of the topographically - influenced wind regime, temperature and local melt effects.

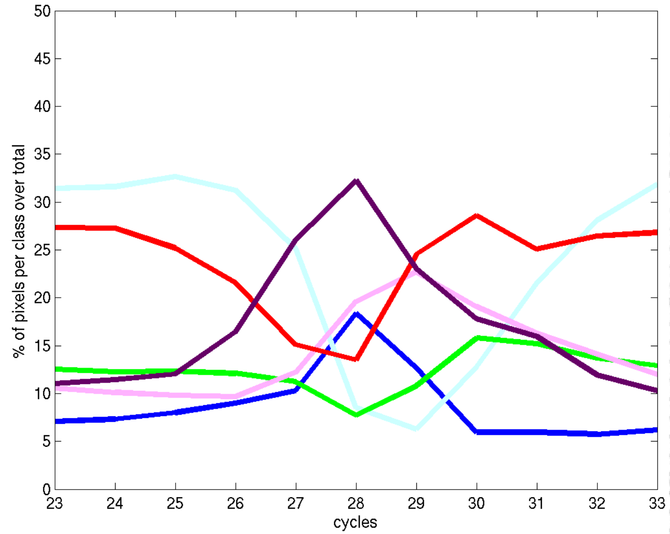


From Ashcraft (2004) & Benson (1962)

Seasonal variation





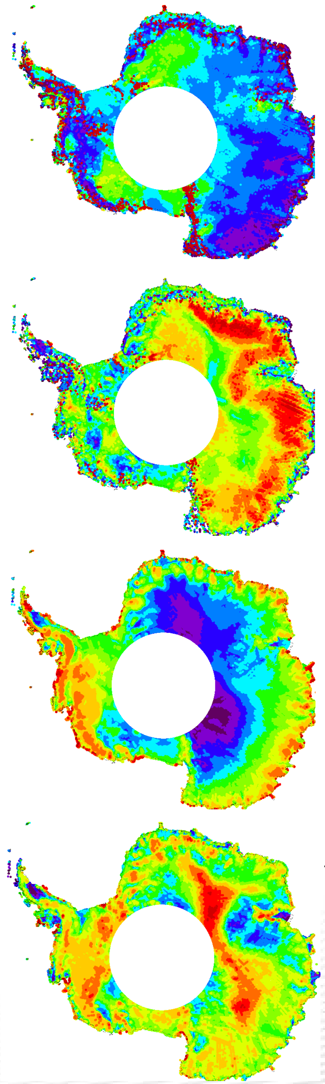


⟶ decrease of the percolation (light blue), dry snow I (red) zones during summer period due to wet snow

⟶ Increase of the ablation zone (dark blue) and intermediate dry/percolation zone (purple) during summer

⟶ surface melting possible within dry snow zone as delimited by Benson.

Antarctica partition



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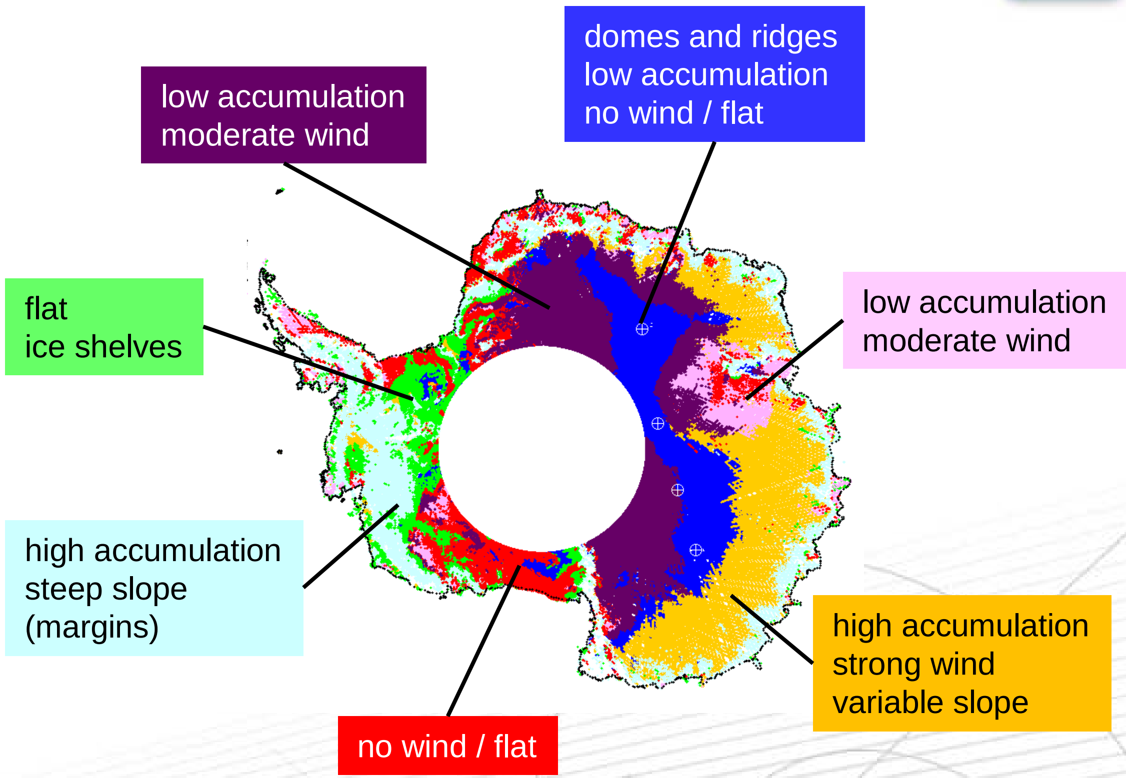

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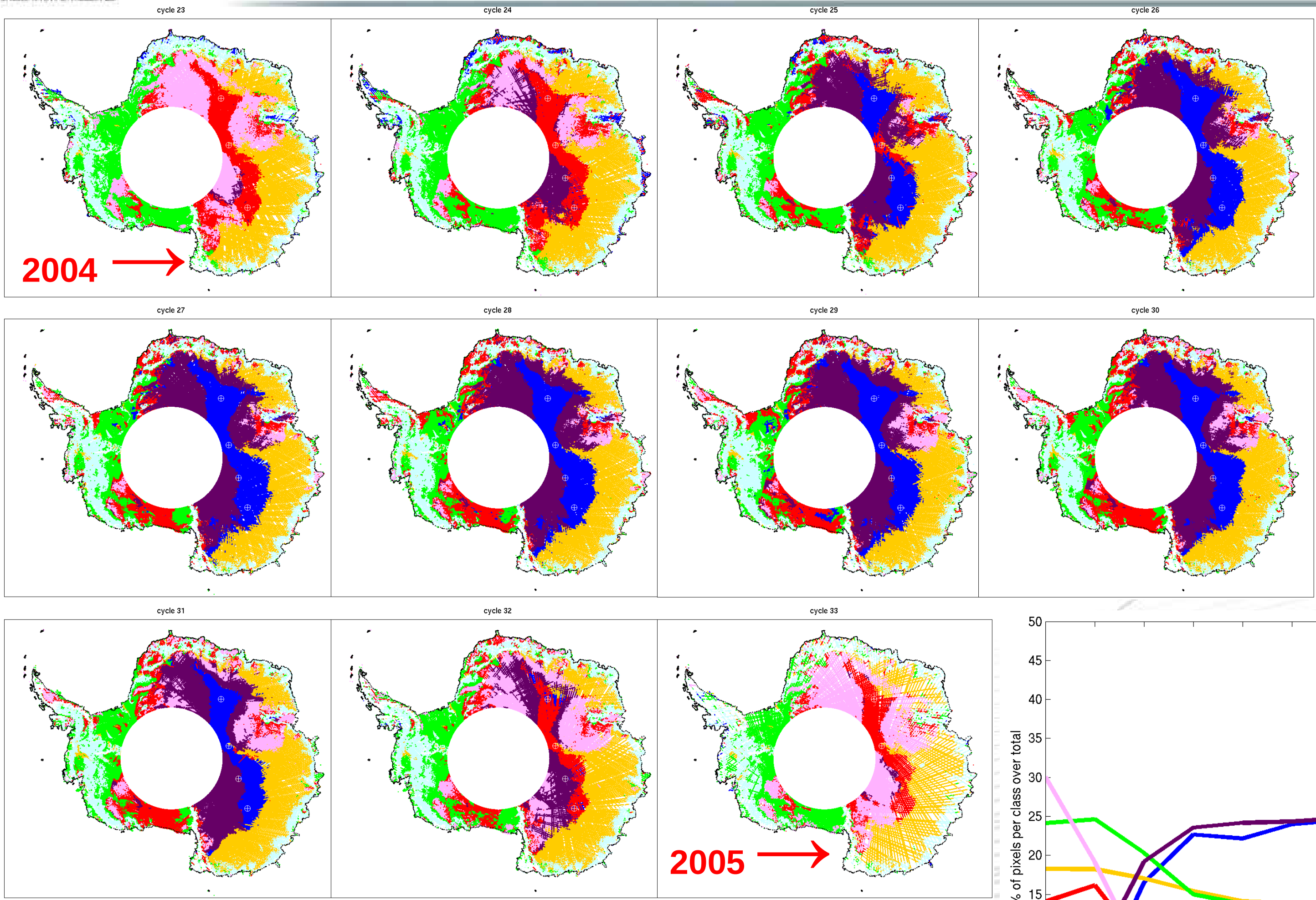
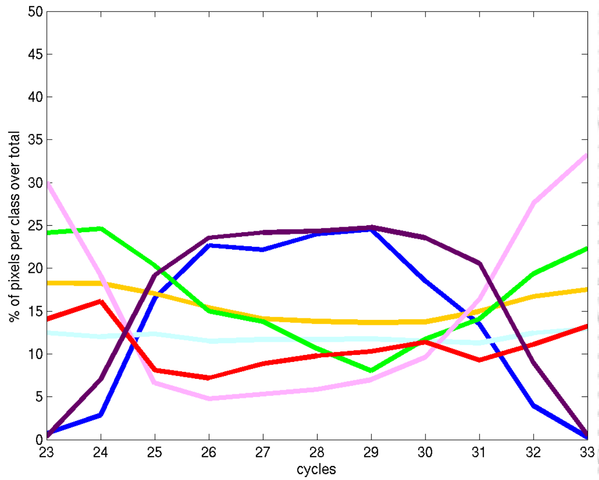
Seasonal variation





⟶ seasonal changes in class distribution (region in dark blue becomes red during summer, switch between regions in pink and purple)

⟶ contrast between the 2 ice shelves in winter while they are in the same class in summer period

Ice sheets: Conclusions and Perspectives

- The snow facies classifiers partition the 2 ice sheets into regions with similar microwave signatures.
  - The difference in snow morphology is due to variable conditions in local climate (accumulation rate, air temperature, wind) which is governed by topography.
  - Presence of surface liquid water changes also the microwave signatures.

- A partition into 7 classes looks interesting over Antarctica while a 6-class solution is preferred for Greenland.

- Observations of the effects of climate change through change in the microwave signal behavior might be more easily detected via the classification of the signatures.
  - This approach defines a tool for monitoring long-term spatial variations over the ice sheets.
  - Coming soon from WOOPI: application to the Envisat time-series 2003-2010.

- Perspectives:
  - Application to Sentinel-3 records
  - Test of Altika data
  - Test of Cryosat-2 and CFOSAT data (combination of SWIM & SCAT)


Thanks !