Sea-ice and snow facies classification

Ngan Tran (CLS)

Frédérique Rémy (LEGOS) , Fanny Girard-Ardhuin (IFREMER),
Hui Feng (UNH), Pierre Féménias (ESA)

Contents:

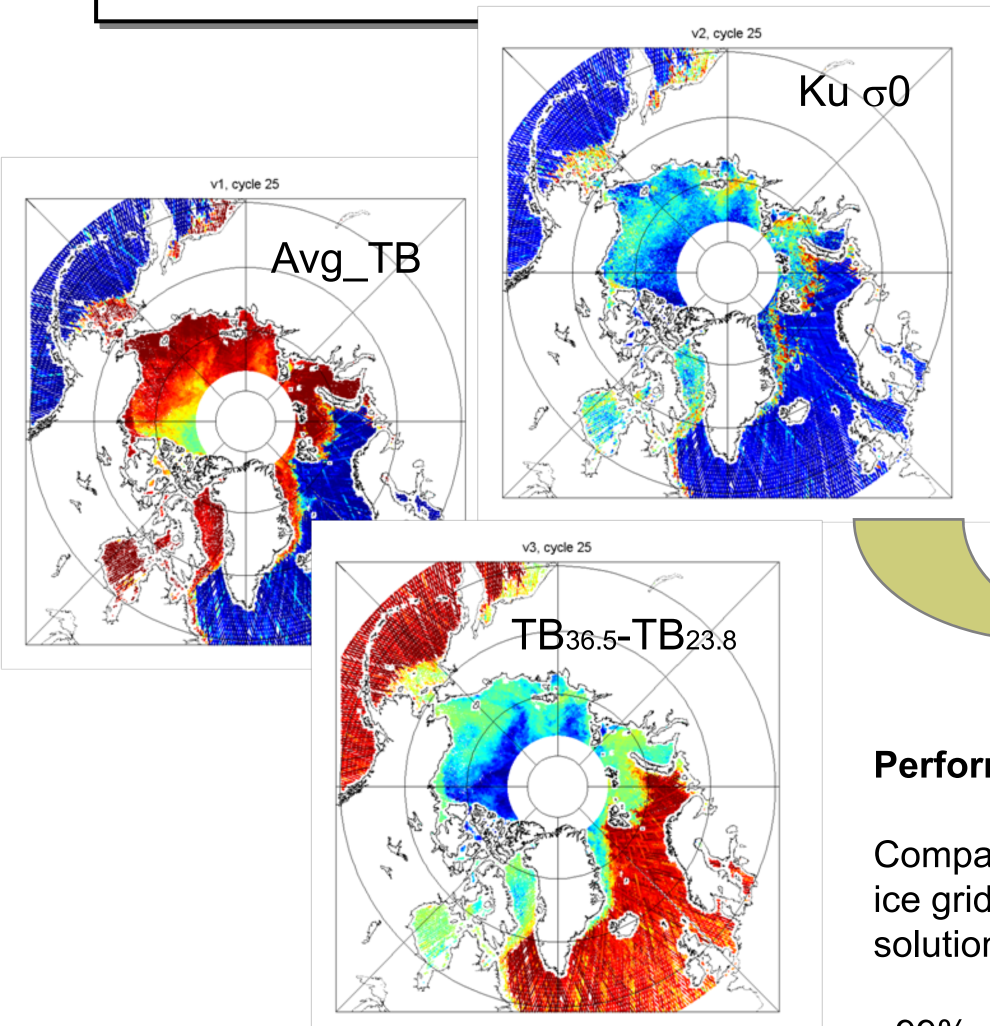
Image: © S. White

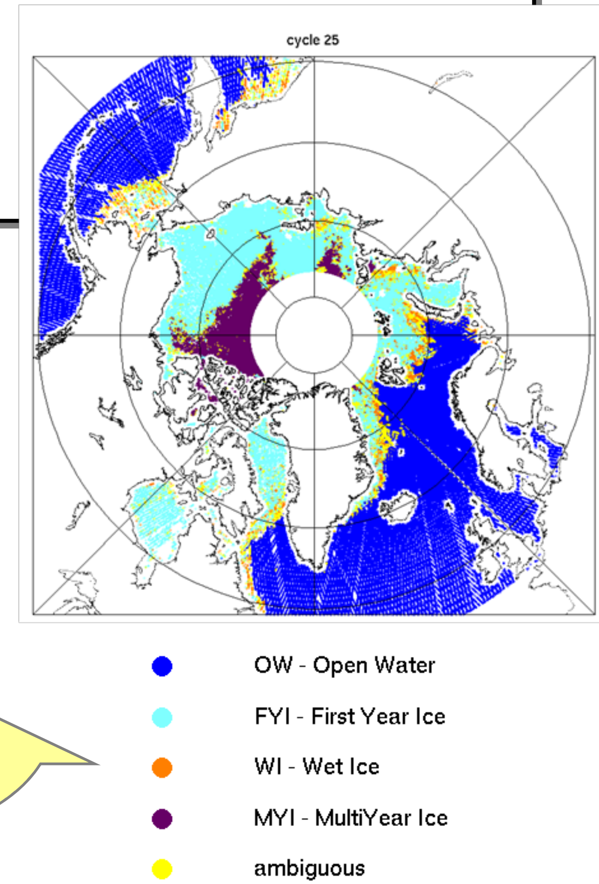
Part I : Sea-Ice

- Detection of sea-ice corrupted sea surface height data within quality control processing for oceanography applications, but also provision of the sea-ice type.
- The developed algorithm took advantage of the availability of both passive and active microwave data on the same platform.
- Choice of parameters in order to make such development applicable to all past and future altimetry missions (i.e. combination of mono-frequency altimeter and dual-frequency radiometer). Peakiness parameter is currently only available in Envisat products.

Image: © S. White

Arctic sea-ice partition

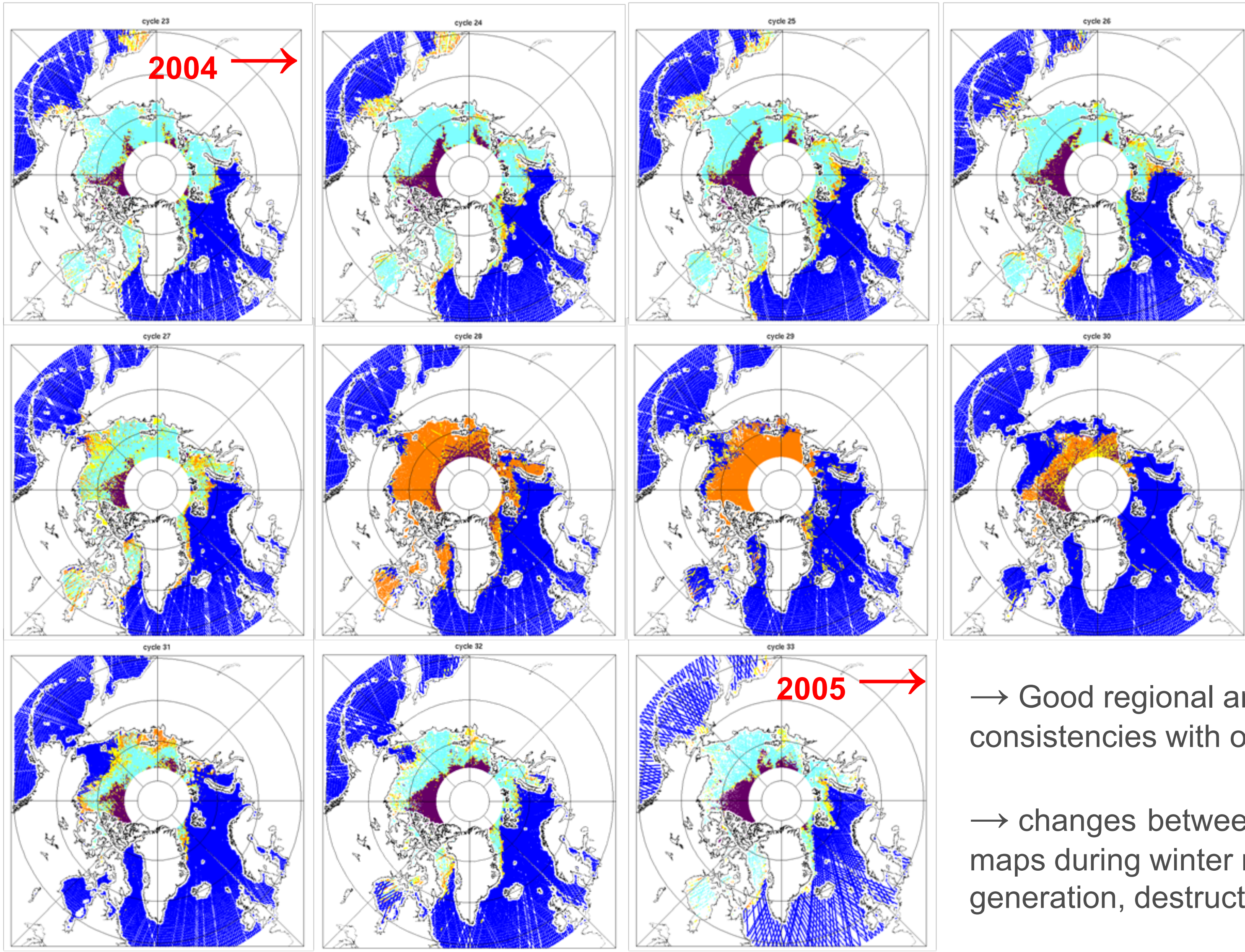




Performances in class retrieval

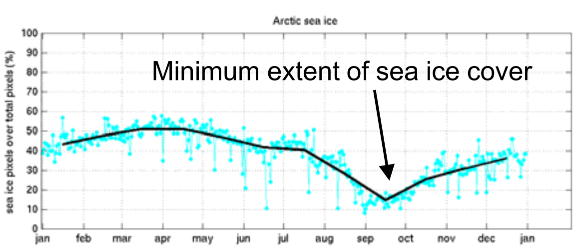
Comparison with collocations from daily level 3 polar sea ice grids derived from SSMI and SeaWinds (3-class solution vs. 5-class solution):

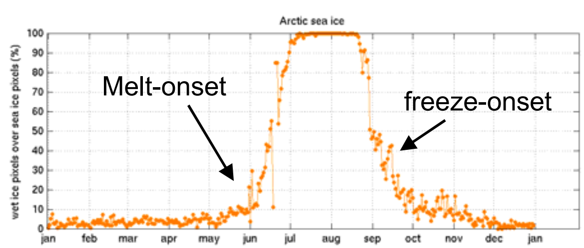
~99% of good identification of both OW and global SI
~90% of good identification of MYI

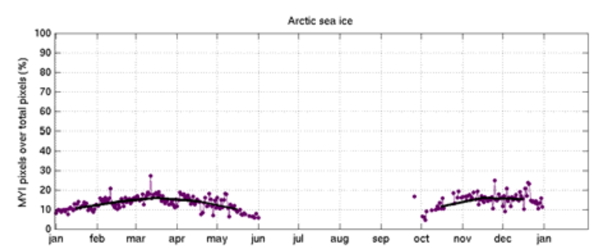


→ Good regional and seasonal consistencies with other works

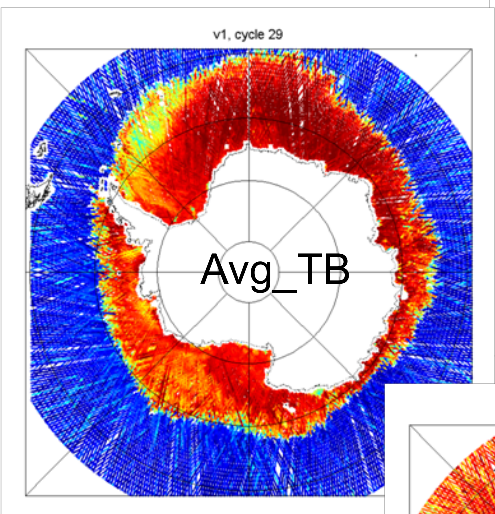
→ changes between contiguous maps during winter related to sea-ice generation, destruction or motion

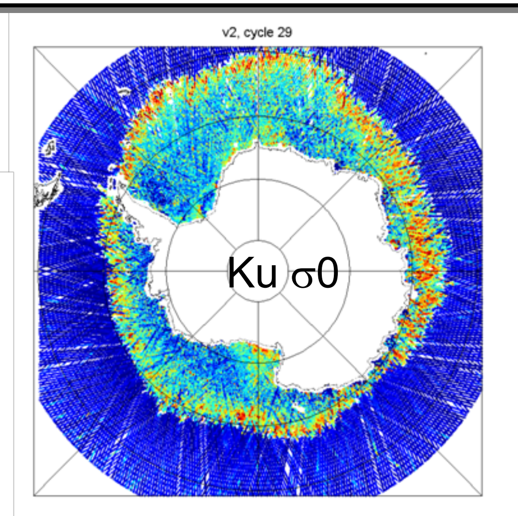


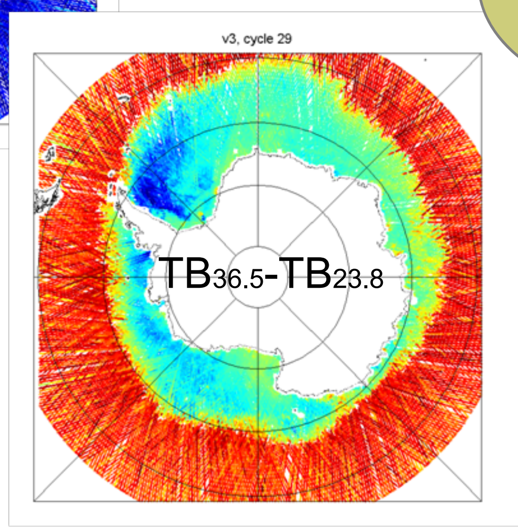


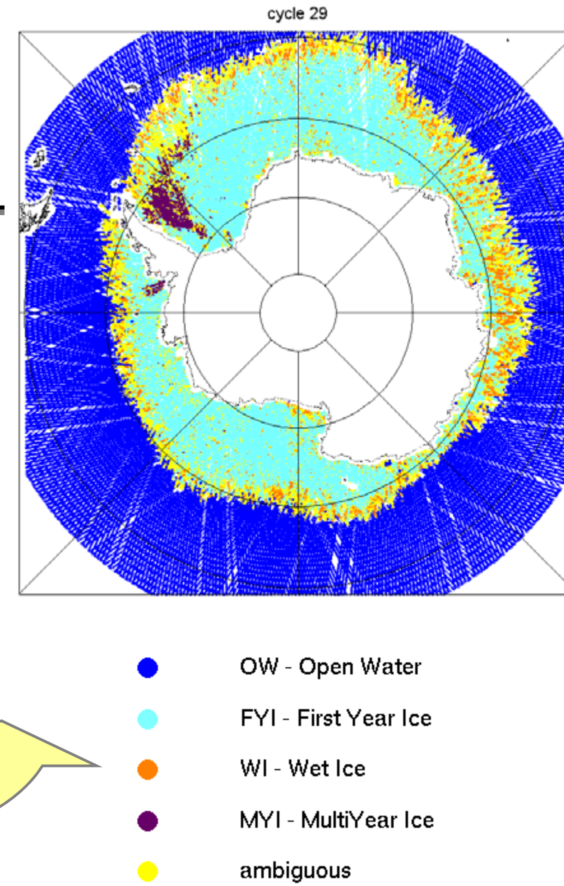


Antarctic sea-ice partition





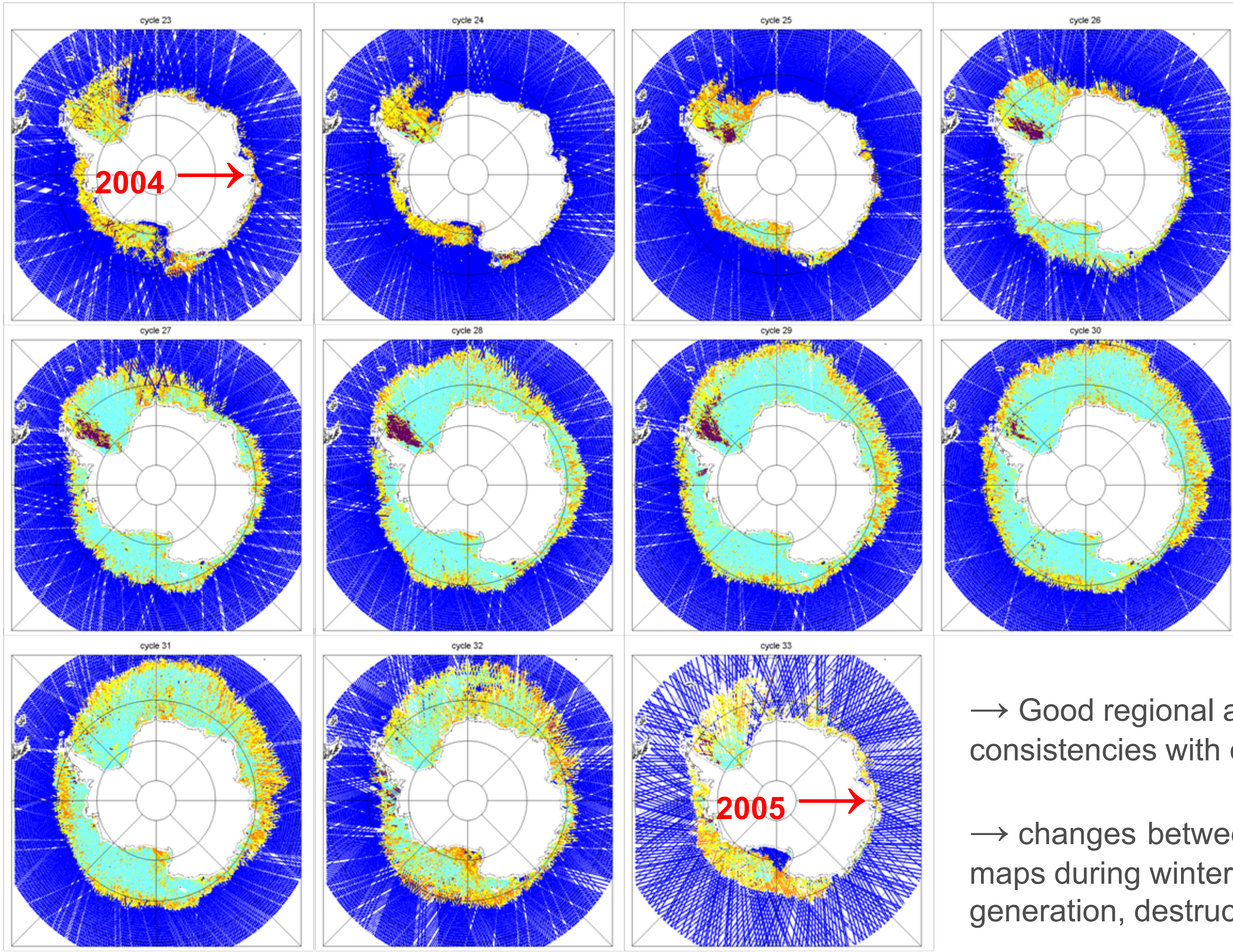




Performances in class retrieval

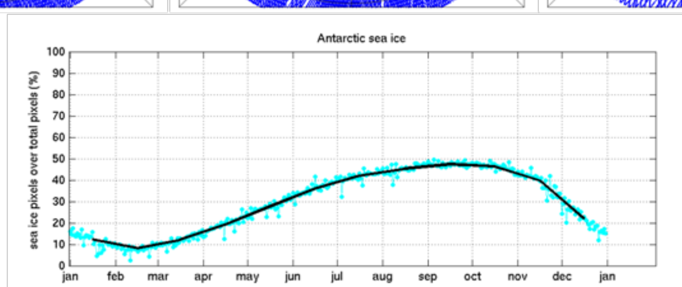
Comparison with collocations from daily level 3 polar sea ice grids

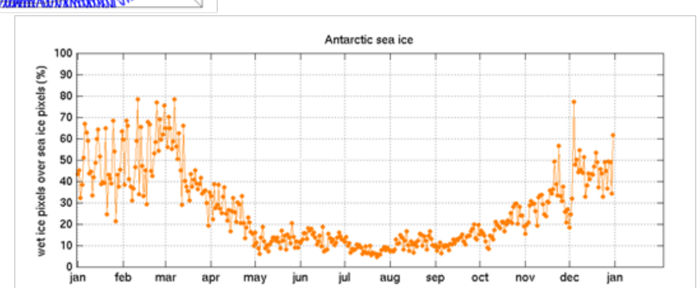
~99.8% of good identification of OW
~99% of good identification of global SI



→ Good regional and seasonal consistencies with other works

→ changes between contiguous maps during winter related to sea-ice generation, destruction or motion





Summary

- The sea-ice classifier accounts for 4 distinct surface types + 1 class of mixed types noted as ambiguous.
- It provides very good discrimination of open water / global sea ice over polar regions.
- It represents an ice flag for oceanographic applications but also a new application of altimetry data with climate change monitoring issue.
- It can help for monitoring phenomena such as:
  - Increase of the surface melting cover or duration during summer
  - Delayed formation of seasonal sea-ice
  - Gradual disappearance of multi-year sea-ice that is replaced by seasonal sea-ice
  - Accumulation of MYI along Greenland and Canadian coasts and in Fram Strait region due to sea-ice drift

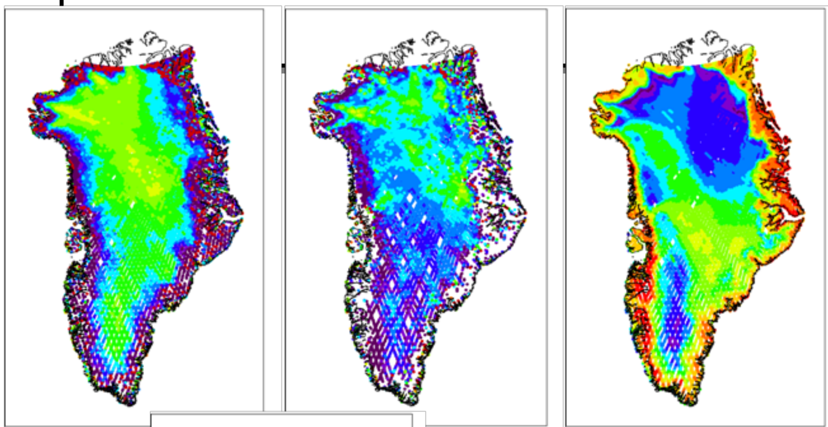
Part II: Snow facies

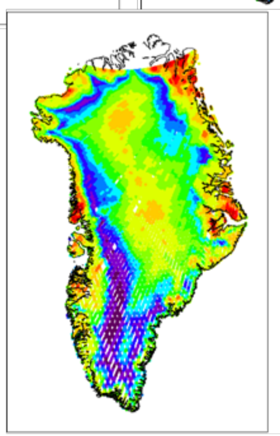
- Uncertainties in estimating the correct height over ice sheet because of the radar wave penetration within the cold and dry snow medium. They display dependencies on snowpack characteristics which vary seasonally and spatially.

- Partition of ice sheet into different regions can help for the interpretation of altimetry data and provides a tool to monitor more easily the effects of climate change on Greenland and Antarctica.

Image: © S. White

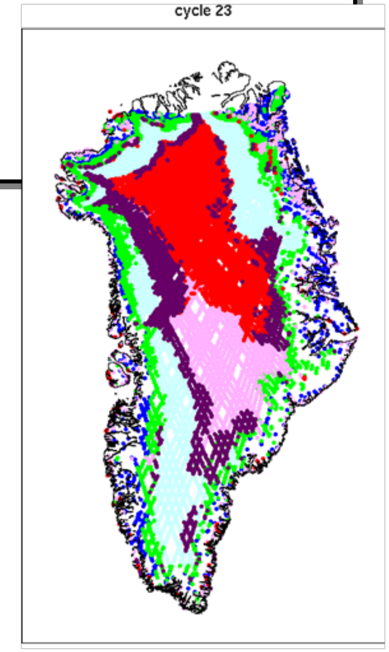
6-class partition of Greenland snow facies





(Ku σ0, Ku-S σ0, Avg_TB, ratio_TB)

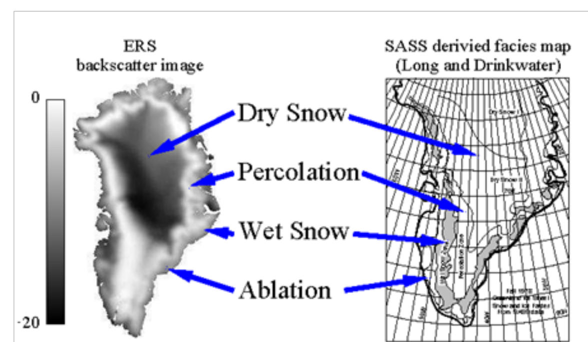
Related to accumulation patterns, snow layering as a consequence of the topographically - influenced wind regime and local melt effects.



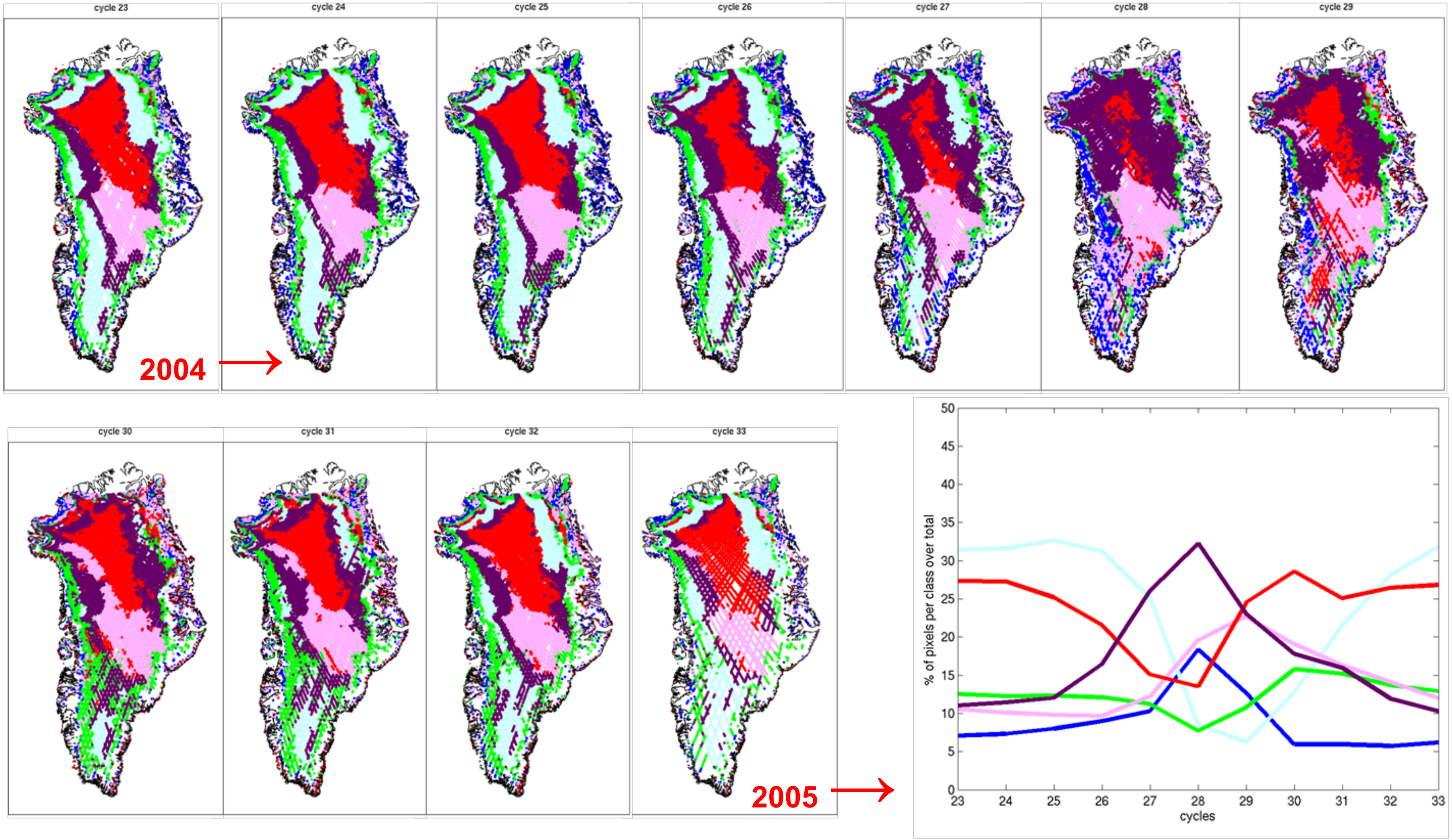
Class 1	Dark blue	Ablation zone	mainly during summer
Class 2	Light blue	Percolation	disappears during summer
Class 3	Green	Wet snow	variable
Class 4	Pink	Dry snow zone II	yearlong
Class 5	Red	Dry snow zone I	diminishes during summer
Class 6	Purple	Intermediate dry / percolation	Increases during summer

Benson's classification (1962):

<u>Dry snow zones I / II</u> : difference in accumulation, wind patterns and air temperatures, no summer melting
<u>Percolation zone</u>: meltwater forming ice pipes or glands
<u>Wet snow zone</u>: intense surface melting, snow is damp throughout the summer season
<u>Ablation zone</u>: all winter snow accumulation melts exposing the underlying ice



From Ashcraft (2004)

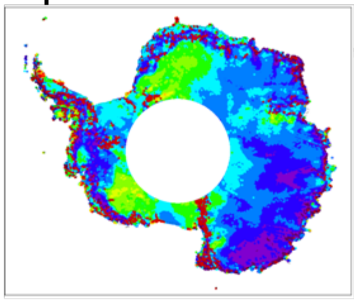


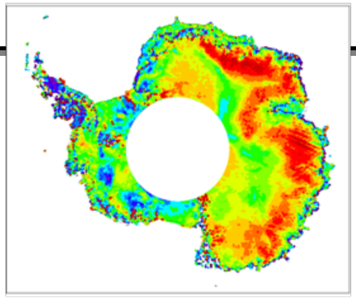
⟶ decrease of the percolation (light blue), dry snow I (red) zones during summer period

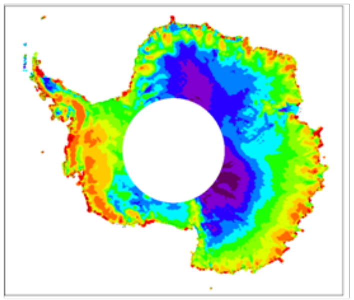
⟶ surface melting possible within dry snow zone as delimited by Benson.

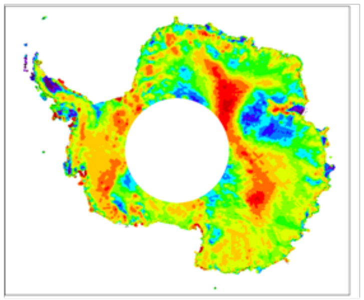
⟶ Increase of the ablation zone (dark blue) and intermediate dry/percolation zone (purple) during summer

7-class partition of Antarctica snow facies



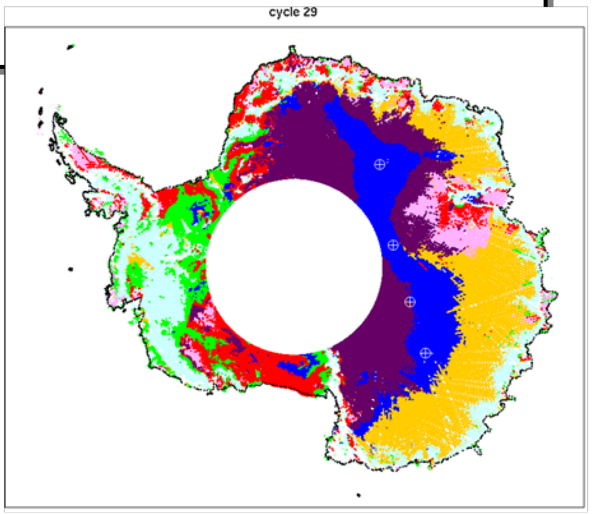




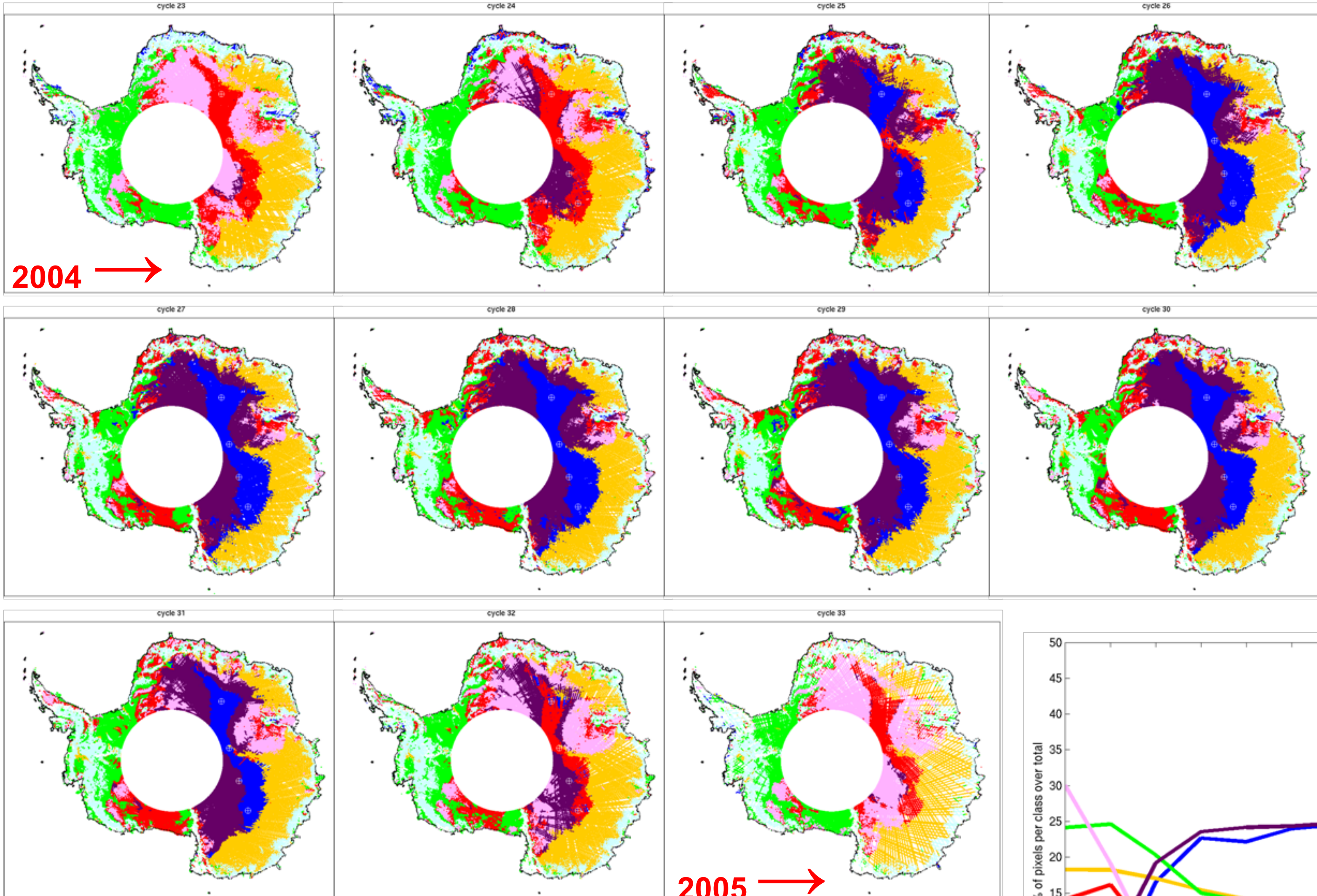


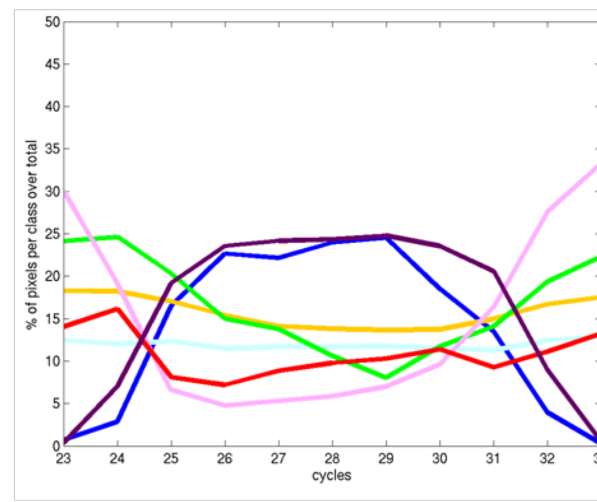
(Ku σ0, Ku-S σ0, Avg_TB, ratio_TB)

Related to accumulation patterns and snow layering as a consequence of the topographically-influenced wind regime.



Class 1	Dark blue	domes and ridges low accumulation no wind / flat	only during winter
Class 2 Class 3	Orange Ligth blue	high accumulation strong wind / variable slope high accumulation steep slope (margins)	yearlong yearlong
Class 4	Green	ice shelves / flat	yearlong for Filchner-Roone Ross in summer only
Class 5	Pink	low accumulation Moderate wind	only during summer becomes class 7 in winter
Class 6	Red	no wind / flat	change in geographic location between winter and summer
Class 7	Purple	low accumulation Moderate wind	only during winter becomes class 5 in summer





→ 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

Summary

- 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 and temporal variations over the ice sheets by comparing with the 2004 reference classification.


Thank you !
Image: © S. White