Investigations of the inter-annual variations of polar Ice surface characteristics using altimetric observations

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BACKGROUND

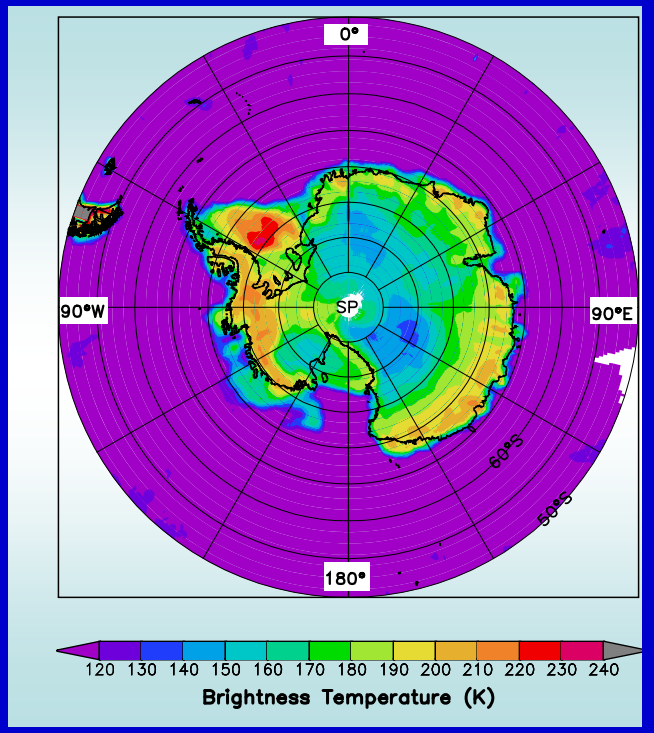
- Sea Ice Extent and concentration using IRS-P4 MSMR
- 18GHz data was utilised

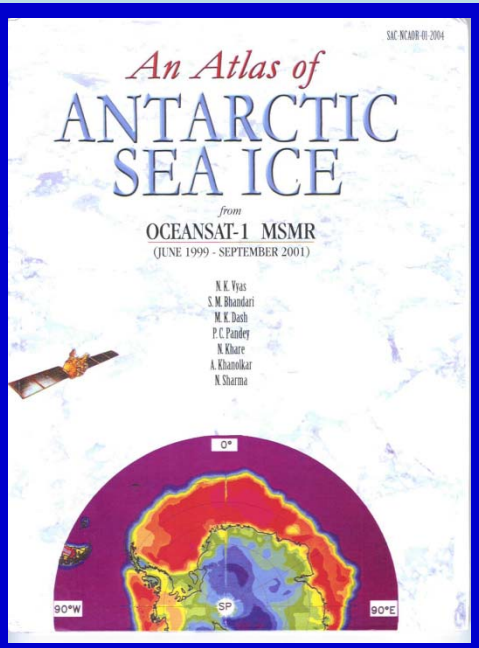
- A boundary between ice and water was derived from Scatter plot of brightness temperature of Ice & Ocean. Which was found at TB = 130 K

- Inter-calibration of MSMR radiometric brightness temperatures with that of SSM/I onboard DMSP satellite.

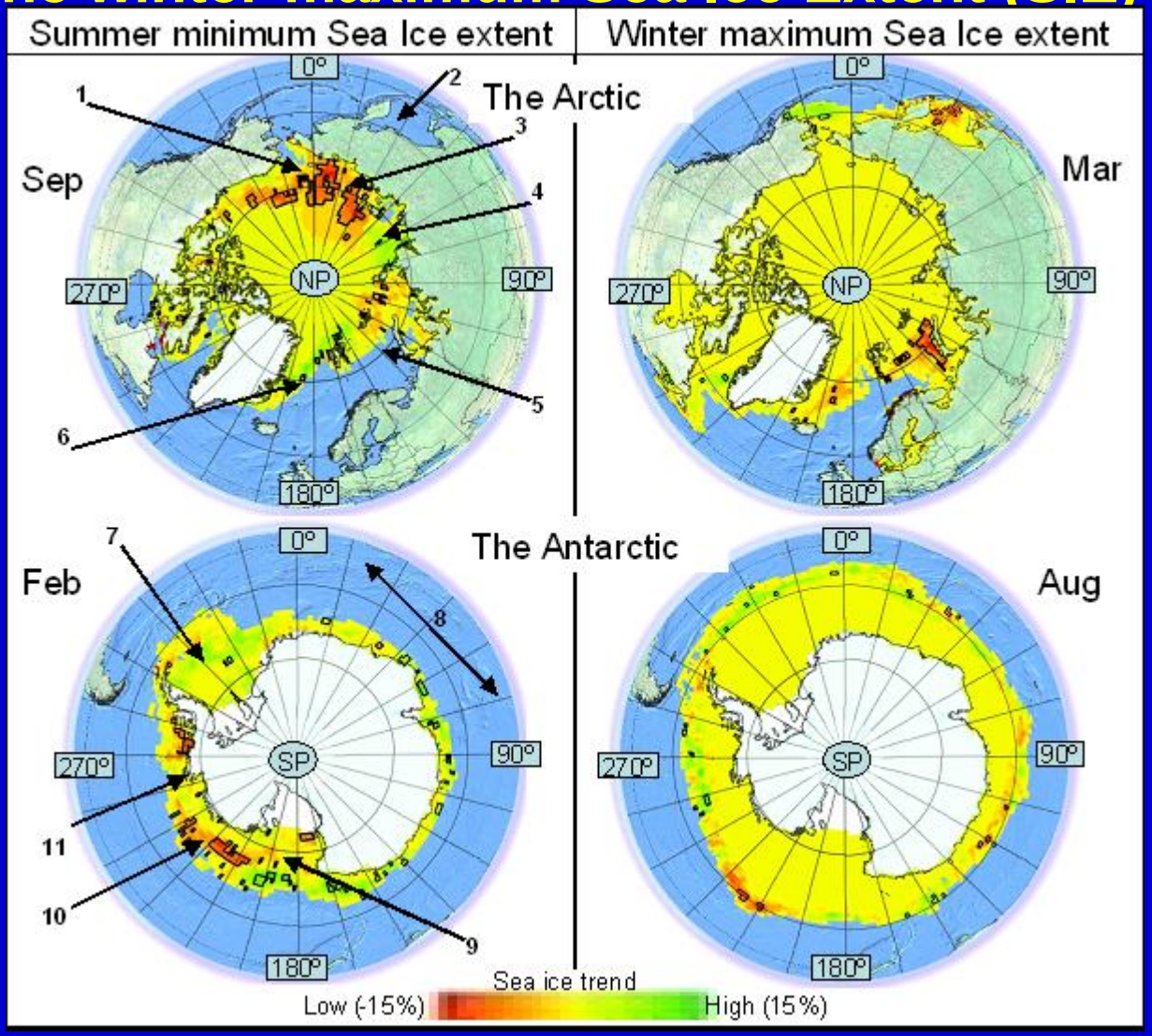
- Sea ice concentration algorithm of SSM/I was tuned for MSMR data

- An Atlas of Antarctic Sea Ice from Oceansat-1 MSMR (June 1999- September 2001) has been prepared and published in collaboration with NCAOR





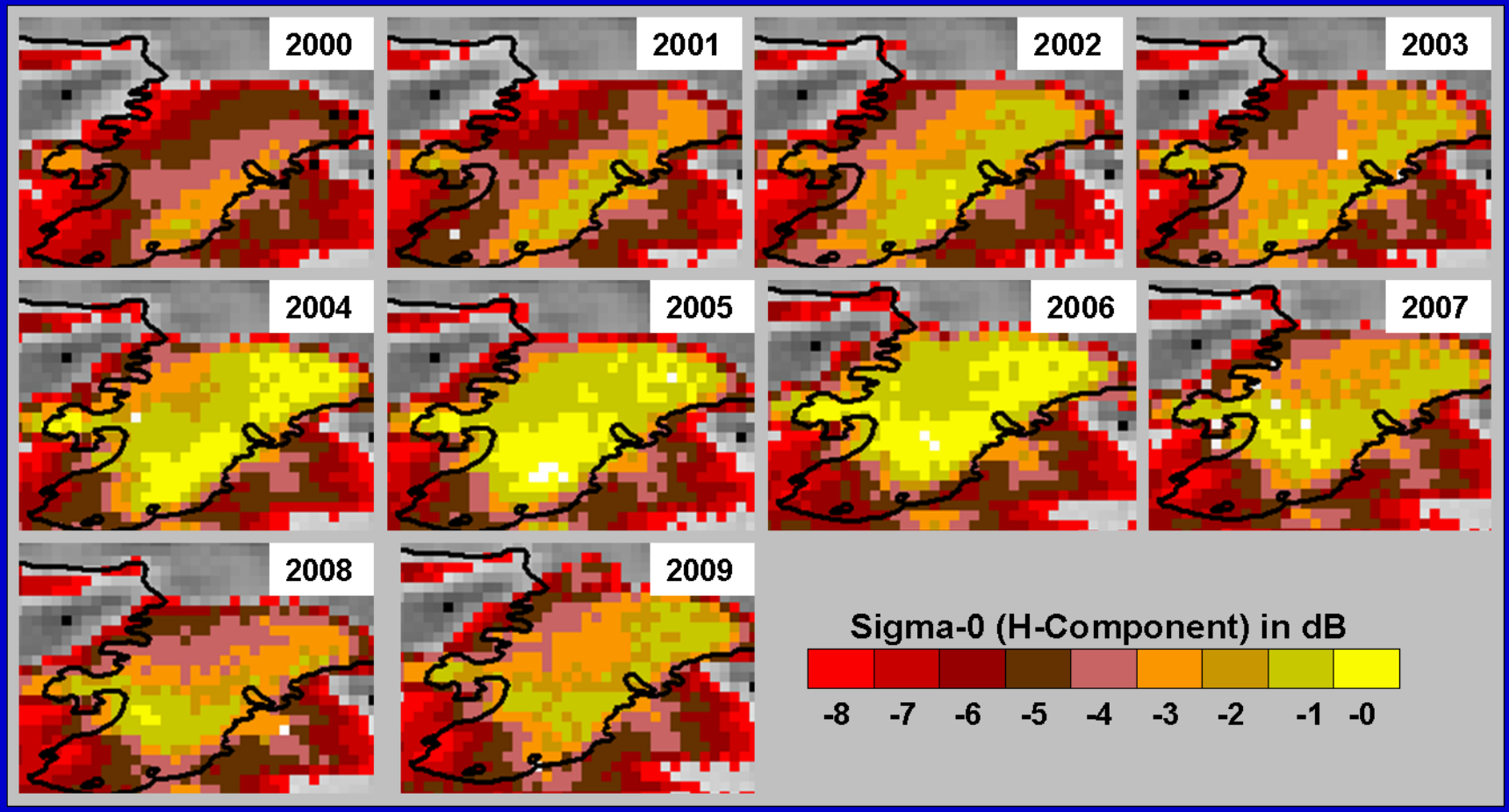
Recent trends in the summer minimum and the winter-maximum Sea Ice Extent (SIE)



Data Used: QuikSCAT data for the period from 1999-2009 (Entire life cycle of QuikSCAT)

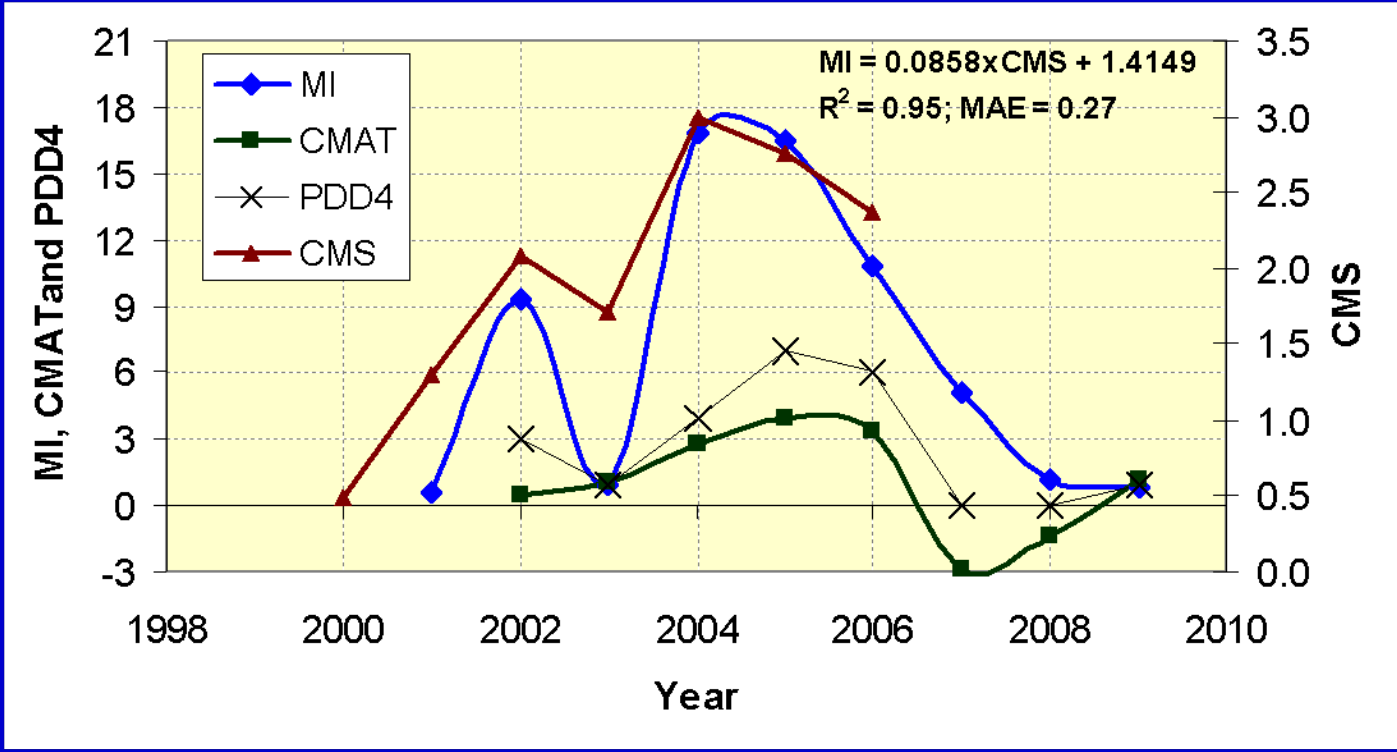
(1) Chukchi, (2) Okhotsk, (3) East Siberian, (4) Laptev, (5) Barents, (6) East Greenland, (7) Weddell, (8) Indian Ocean sector, (9) Ross, (10) Amundsen, (11) Bellingshausen

Evolution of mid-winter (June) Sigma-0 for H-component for Amery Ice Shelf



- Changes in Sigma-0 values during winter indicates the variation in volume scattering component from dry snow pack

Inter-comparison of Melting Index (MI), Cumulative Surface Melting (CMS) and Cumulative Mean Air Temperature (CMAT) for the month of January

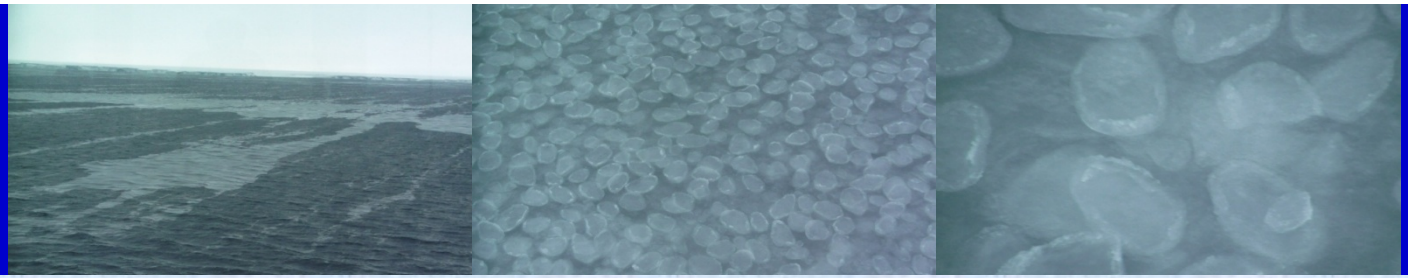


-Melting Index (MI) is the cumulative effect of drop in Sigma-0 from the previous winter average (indicator of melting effect)

-Passive microwave based CMS Index data was obtained from Picard and Filly (2006)

- CMAT and Positive Degree Days having temp. greater than 4ºC (PDD4) are derived from the Davis station data obtained from Australian Antarctic Centre Database

Sea-Ice seasonality: RADAR Variations



The condition in which sea-ice is formed is important because it determines the roughness of the surface, to which the RADAR is sensitive.

- Ice that has frozen under calm conditions will be very smooth and give an almost specular reflection with no return signal to the RADAR.
- On the other hand, ice-sheet formed in turbulent seas, the border between every consolidated pancake will be rough on scales equal to the radar wavelength, which result in stronger backscatter spread over a wider solid angle.
- Snow-cover above ice will also alter the RADAR-signatures of sea-ice.

Results from Preliminary Analysis

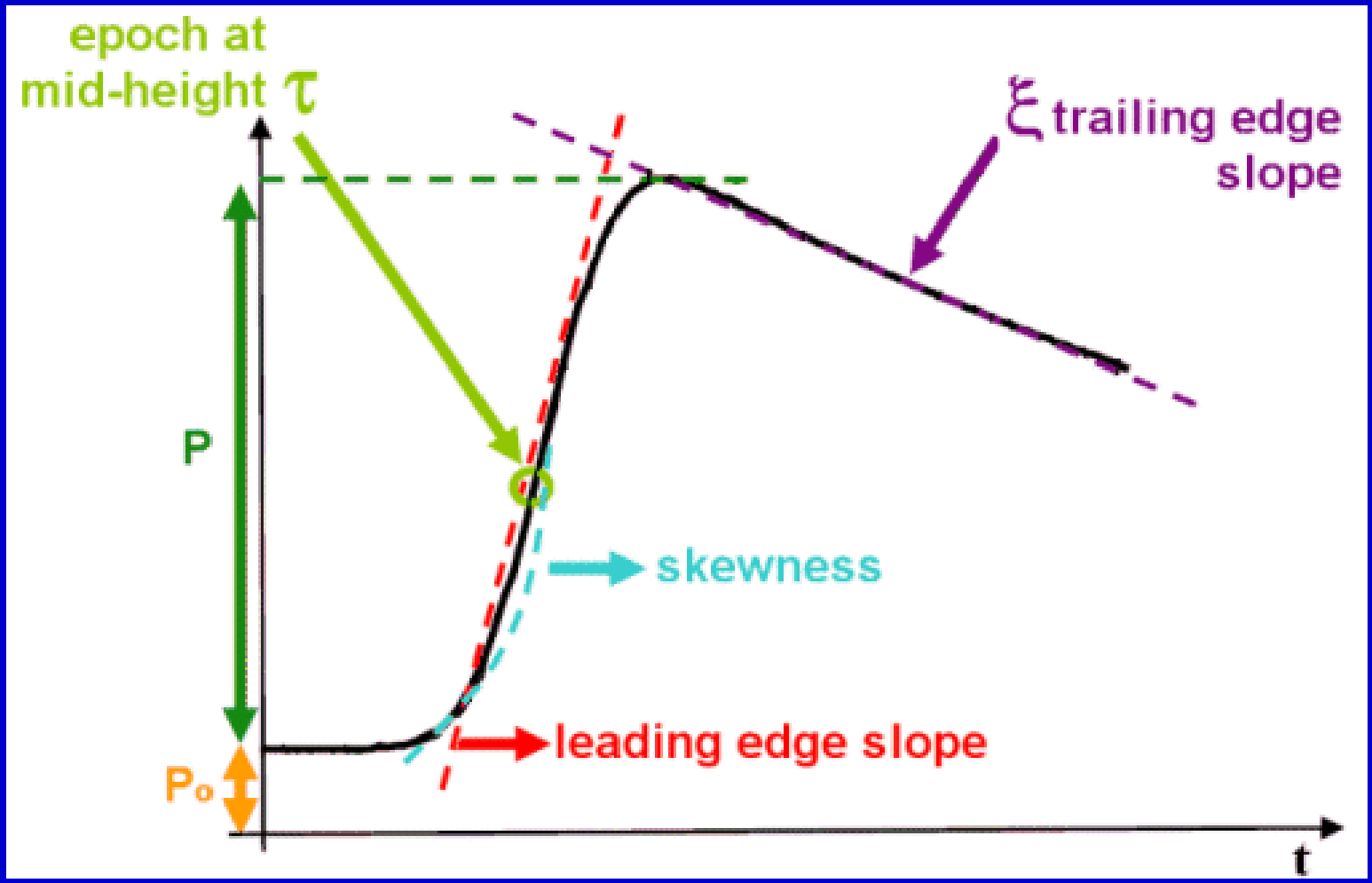
Study Area: Antarctic Sea Ice

Data: PISTACH Coastal product

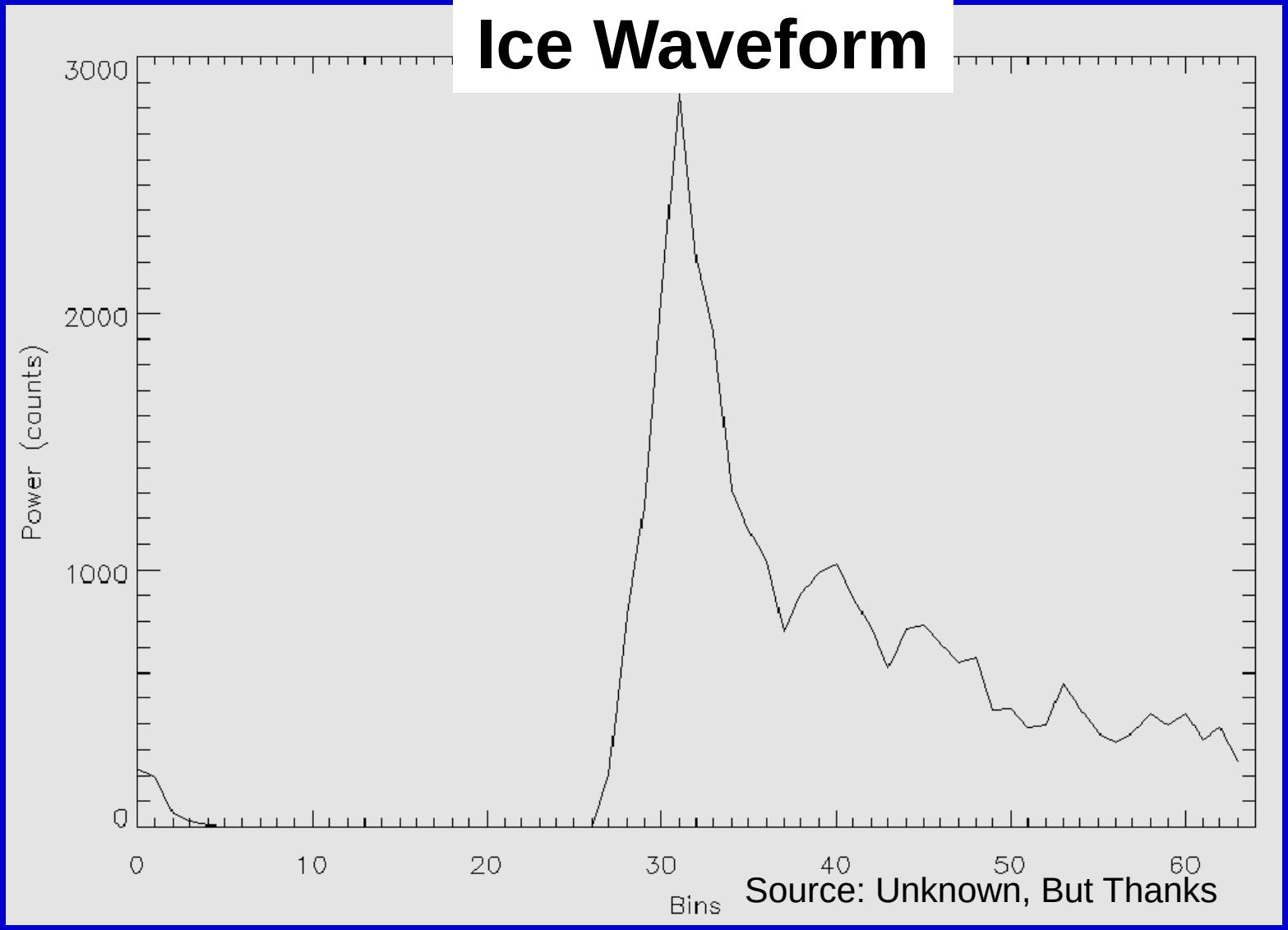
Cycle 49 & Cycle 85 (Nov 2009 & Nov 2010)

Pre-processed Altimeter data

Typical Ocean waveform



Ice Waveform



Source: Unknown, But Thanks

The distinguishing characteristics of ice waveforms are that they are often narrow-peaked in shape, taper off quickly with incidence angle, have high backscatter coefficients at nadir, and are widely variable.

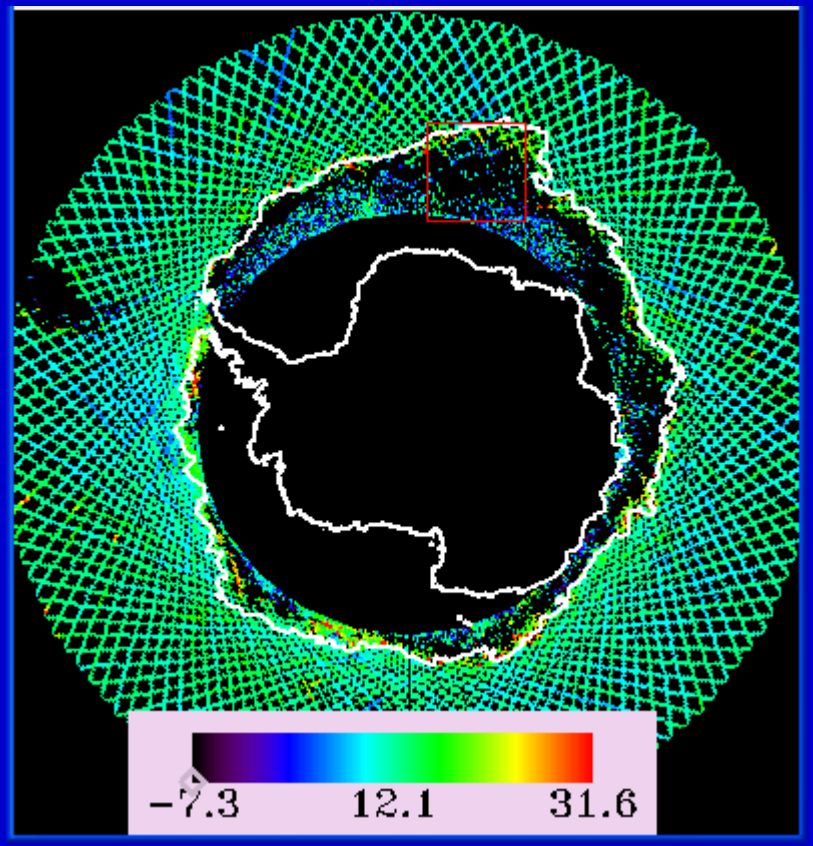
Requirement for Waveform Retracking

- Generally, in pre-retracked waveforms available from the standard altimeter products assumes that return is coming from the ocean surface and it processes accordingly.

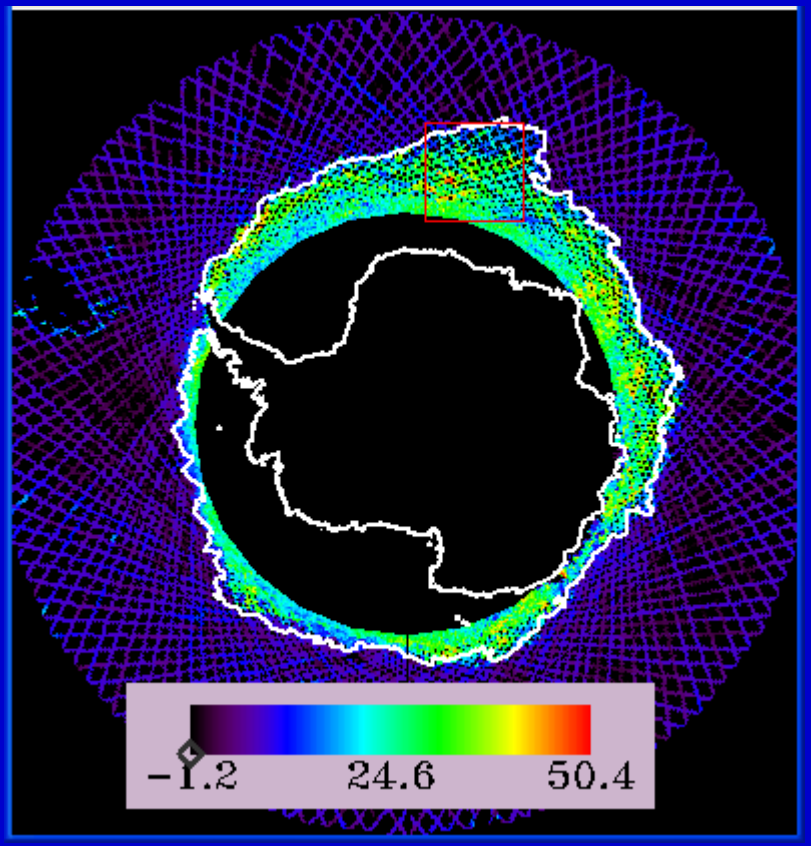
- However, for non-ocean surfaces the assumption “Ocean” fails due to different waveform shape.

- This emphasize that for better eastimates from altimetry, knowledge of earth surface class and associated waveform shape is required for the re-tracking.

Waveform Retracking



Sigma-0 (Ku)



Ice - Sigma-0 (Ku)

Data: PISTACH Coastal Product – Cycle49 – Oct 31, 2009 to Nov 9, 2009

Pulse Peakiness (PP)

Assuming waveform is roughly centered in the altimeter range window the Pulse Peakiness parameter is effectively measure of the ratio of the peak and average power in the return.

Pulse Peakiness (PP)

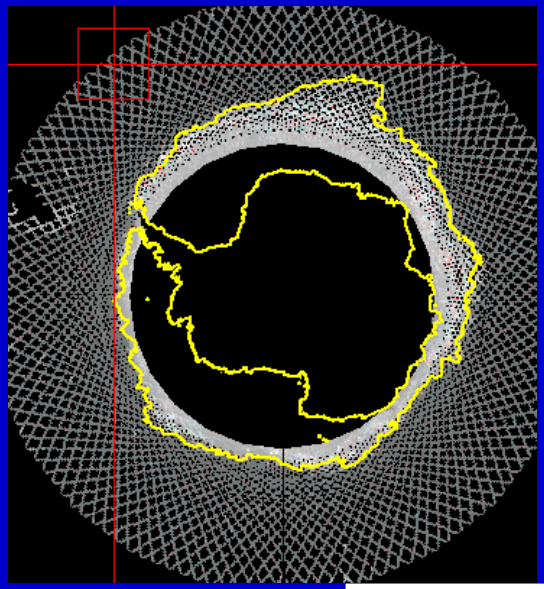
Over the ocean this value is approximately 1, although noise, resulting from the speckle in the altimeter return, will result in a value closer to 1.5-1.7. while higher values are observed for specular returns from sea ice. However, these values changes from sensor-to-sensor due to difference in system configuration.

PP is observed to near constant over the open ocean
Gradual increase in PP values as altimeter moves from Ocean to ice pack, suggesting a possibility of correlation with ice concentration.

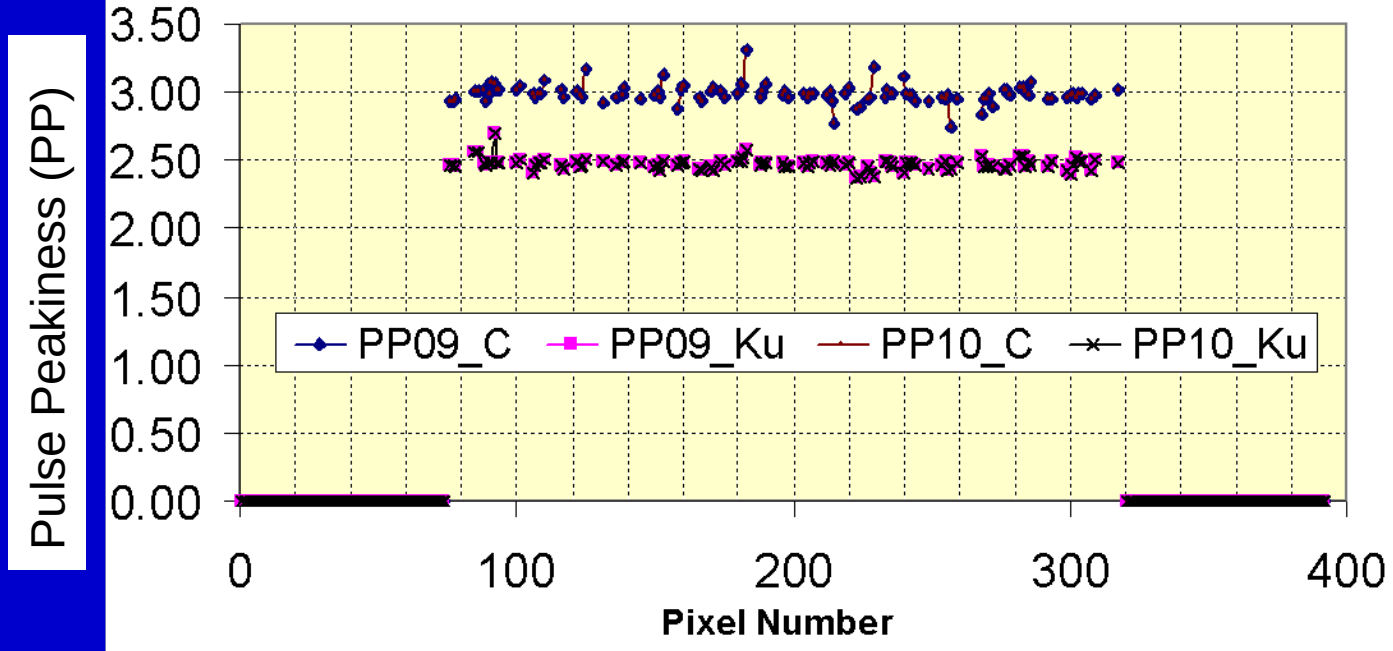
This may be useful in determining the ice compactness, it is also subject to the prevailing wind and wave conditions.

What is the PP range in PISTACH data?

Pulse Peakiness (PP)- Open Ocean surface

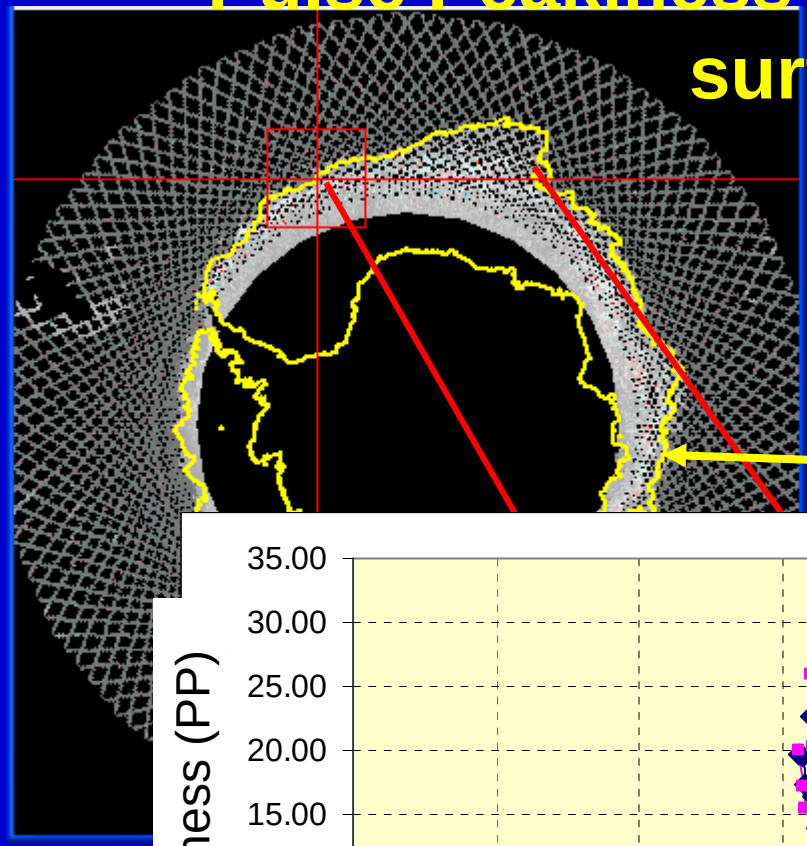


	PP_C	PP_Ku
AVG	2.98	2.44
SD	0.053	0.035
MAX	3.32	2.53
MIN	2.76	2.28

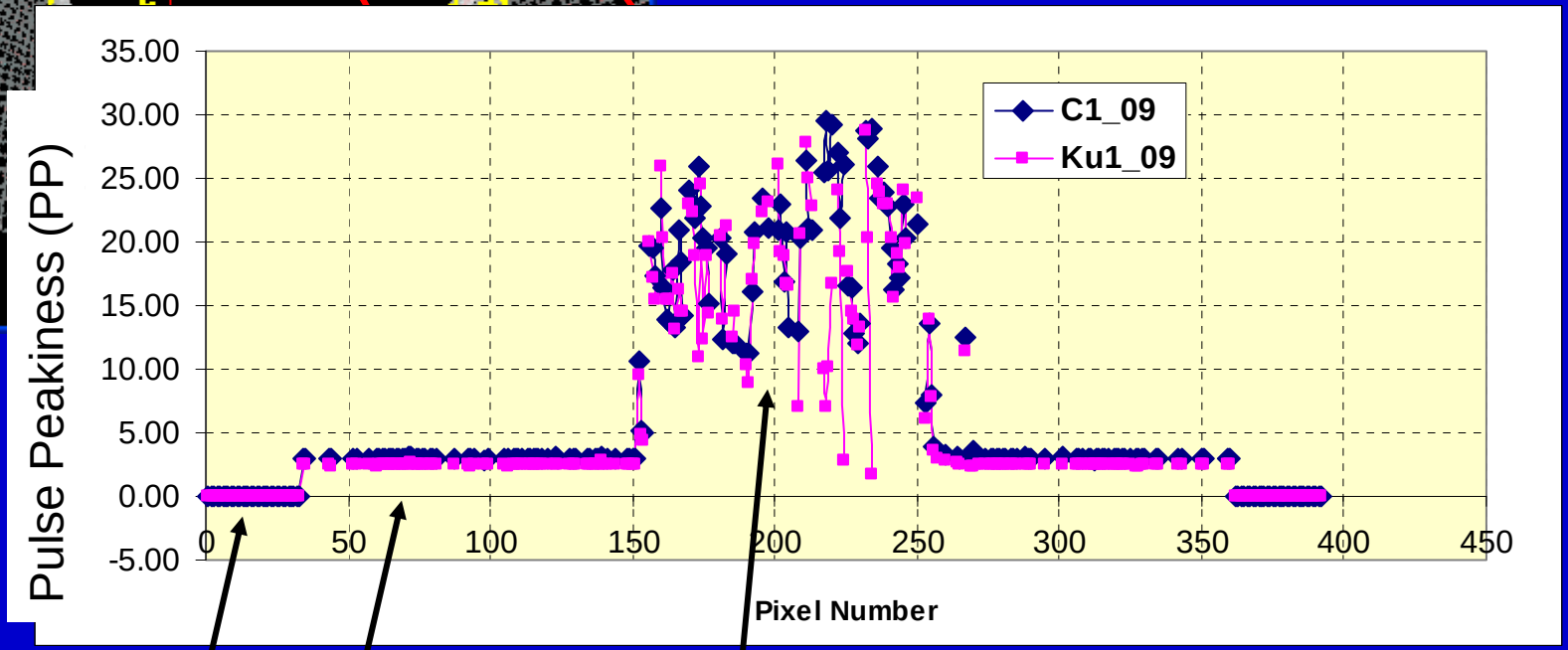


Pulse Peakiness (PP)- Ocean & Ice surface

PISTACH – Coastal Product – Cycle49 – Oct29-Nov9, 2009



Sea Ice Mask Obtained from BYU site; derived from 4.45km enhanced resolution QuikSCAT data

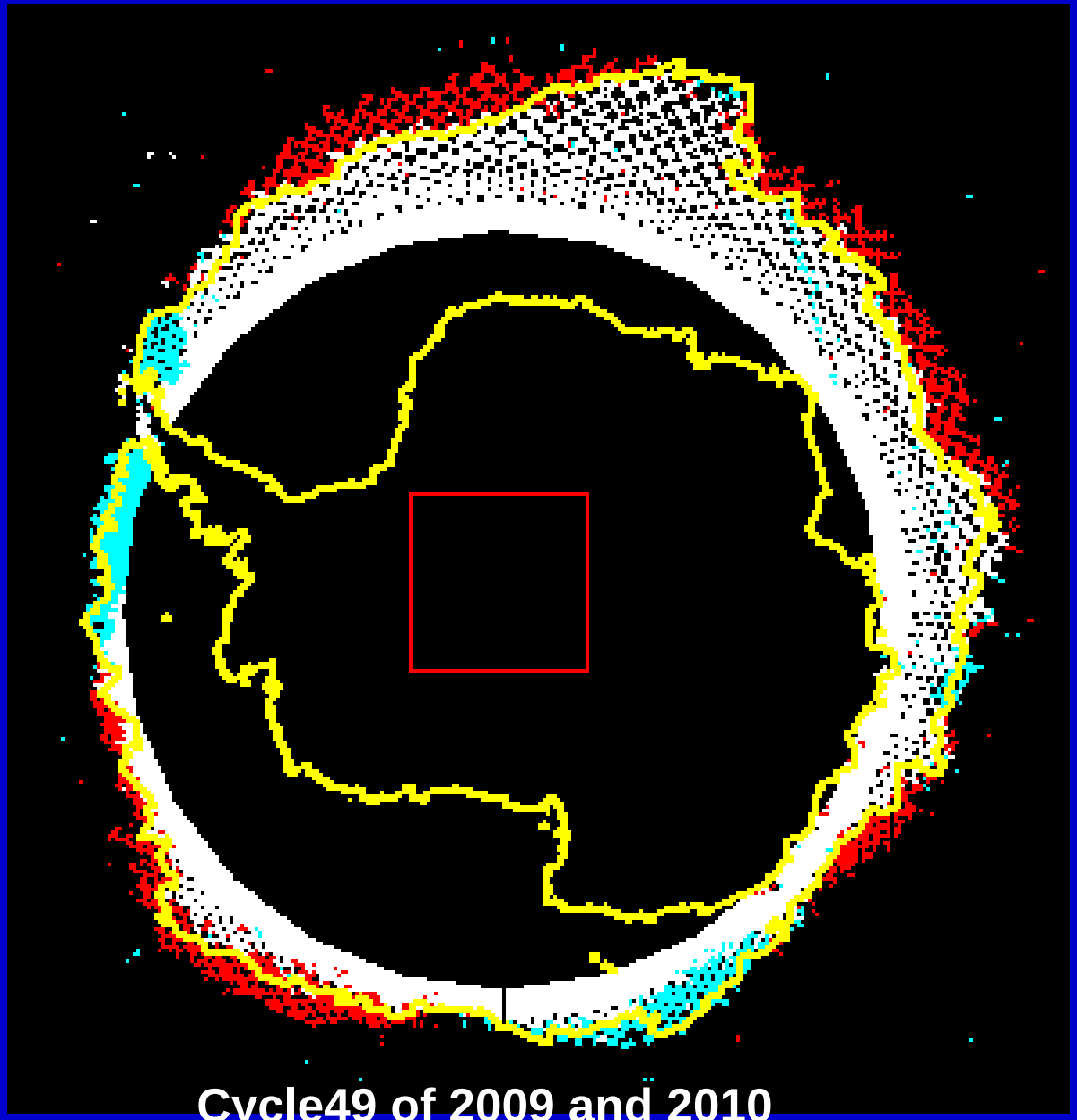


No-Data

Open Ocean

Sea Ice

Year-to-Year Variation in Winter Sea Ice cover



Cycle49 of 2009 and 2010

Ice in 2009 & 2010

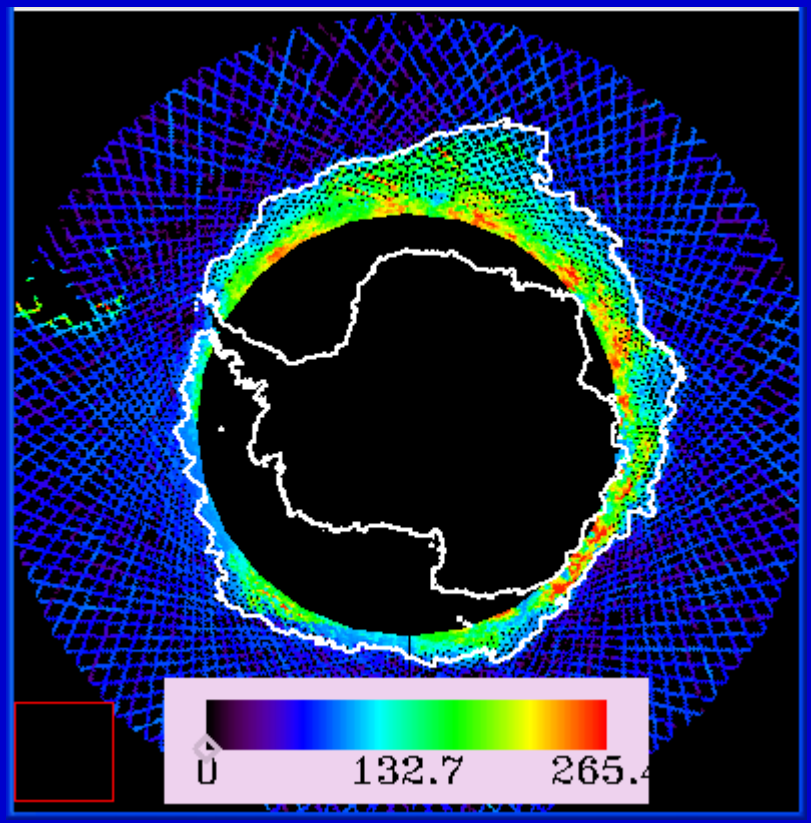
Ice in 2009

Ice in 2010

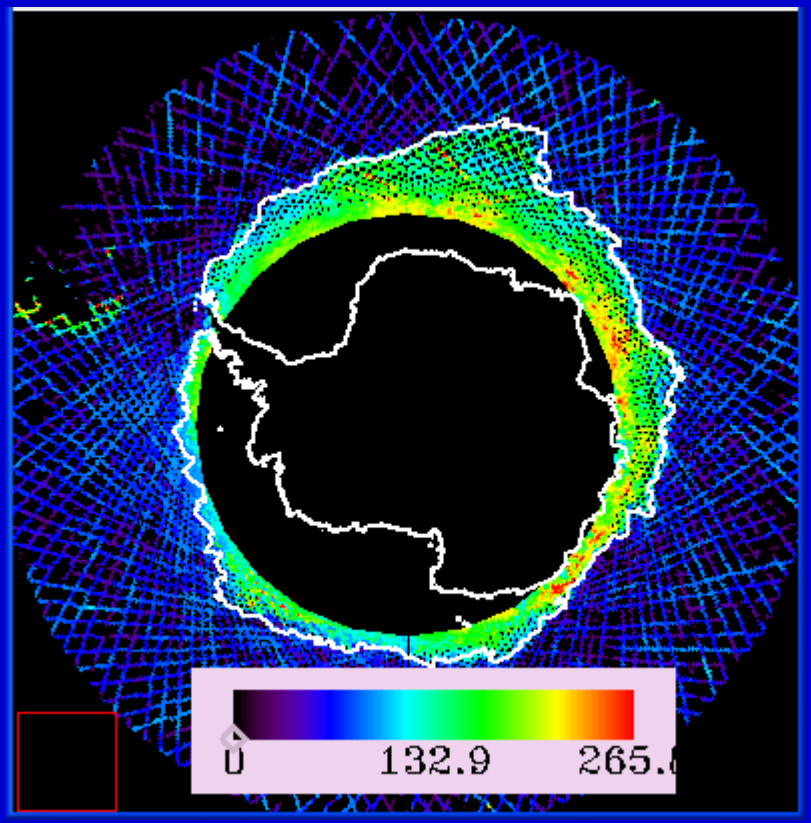
Criteria:

Ice if PP(C) > 3.32

Brightness Temperatures at 18.7 & 34 GHz

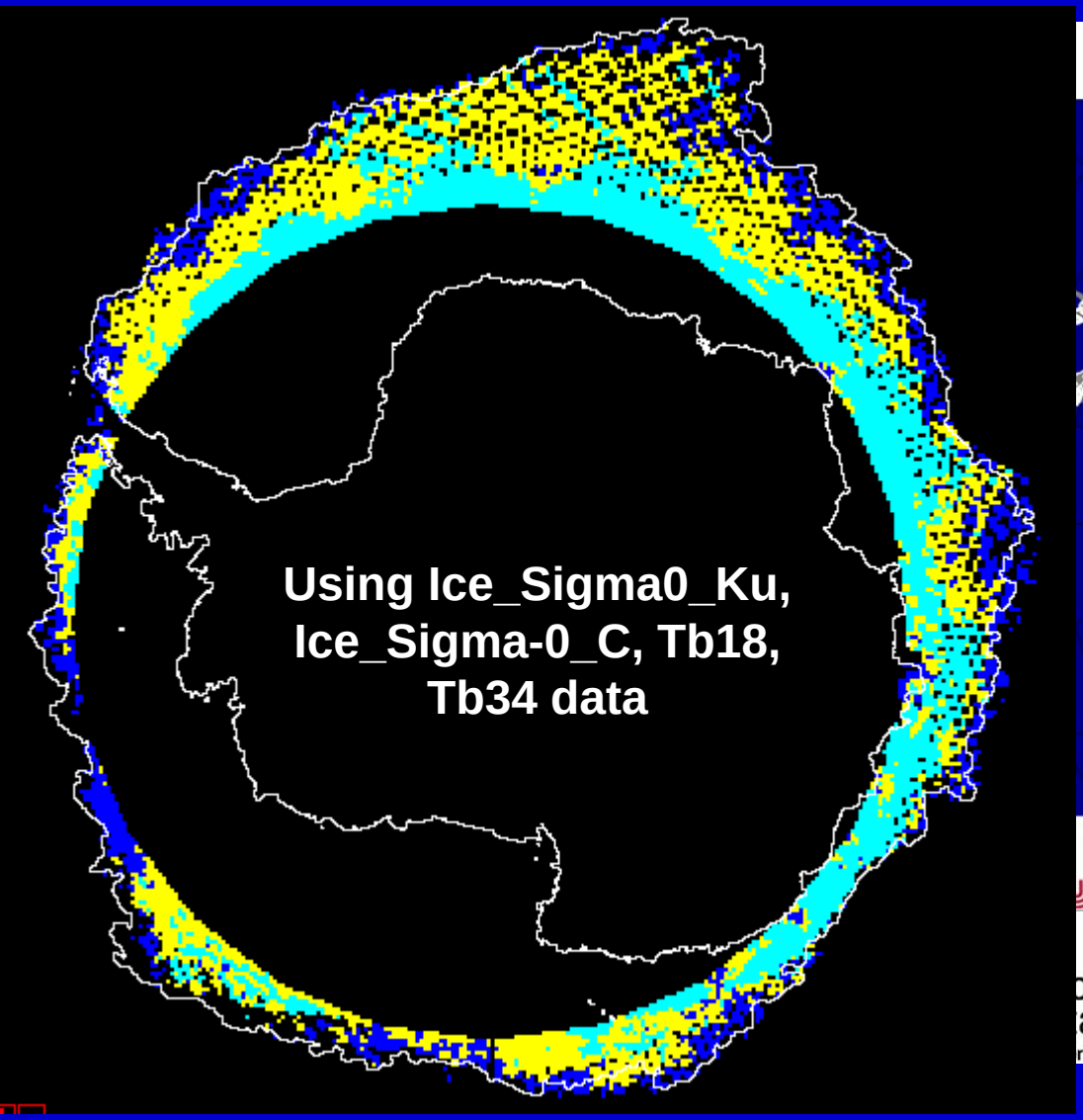


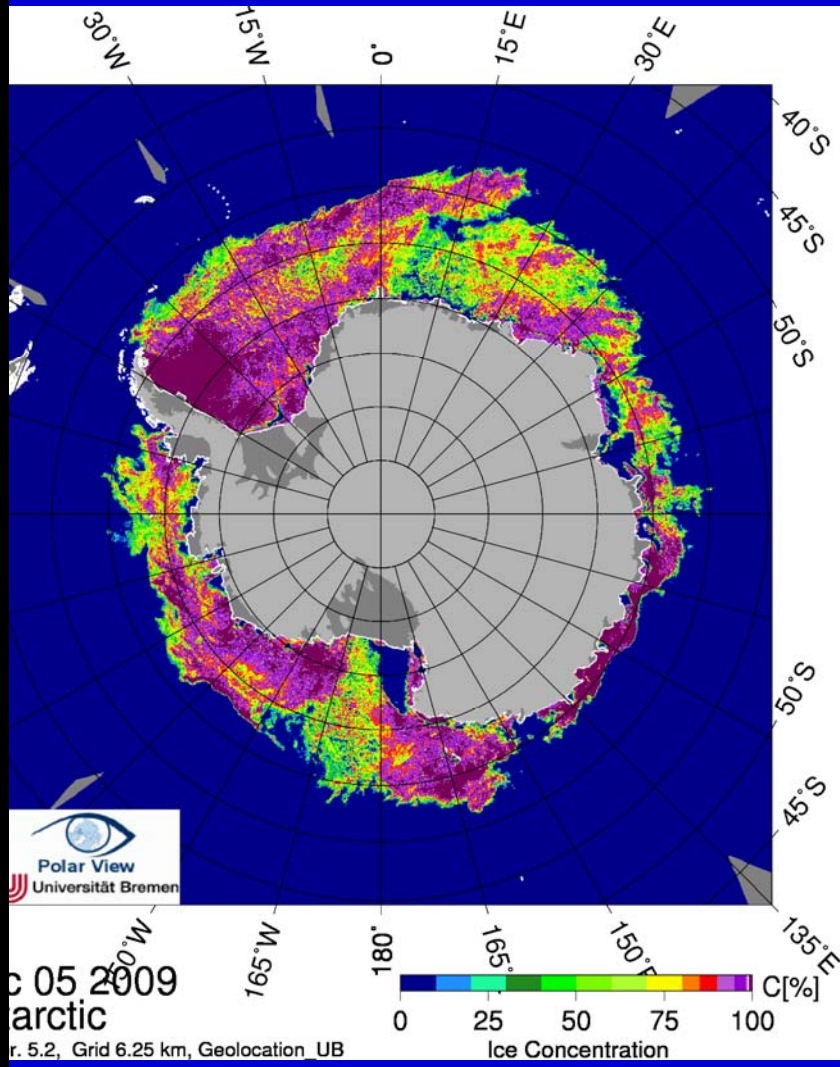
Tb 18.7



Tb 34.0

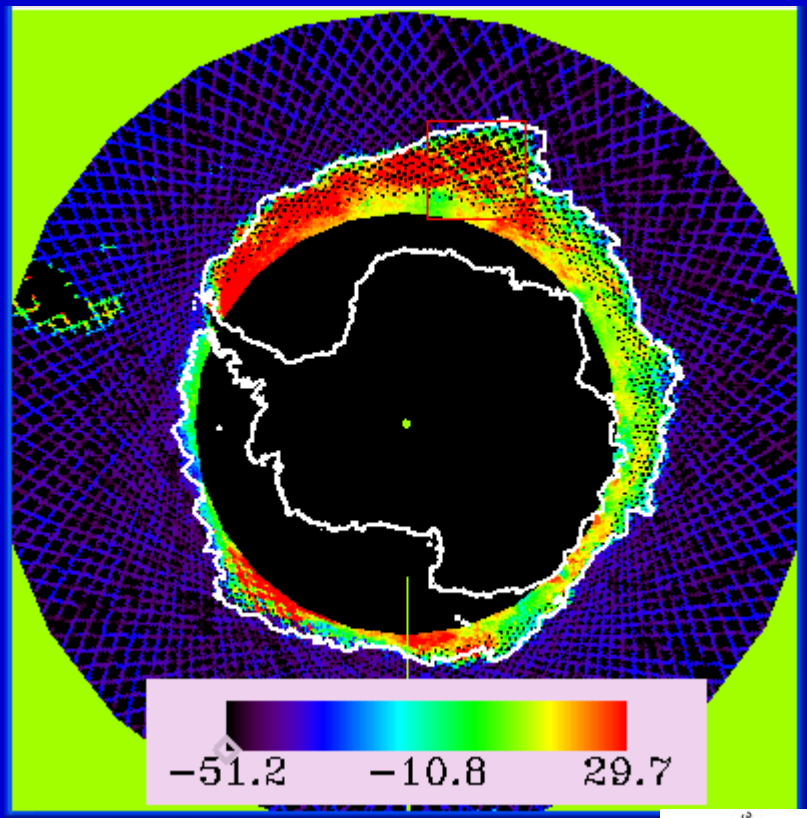
K-means clustering of sea ice cover



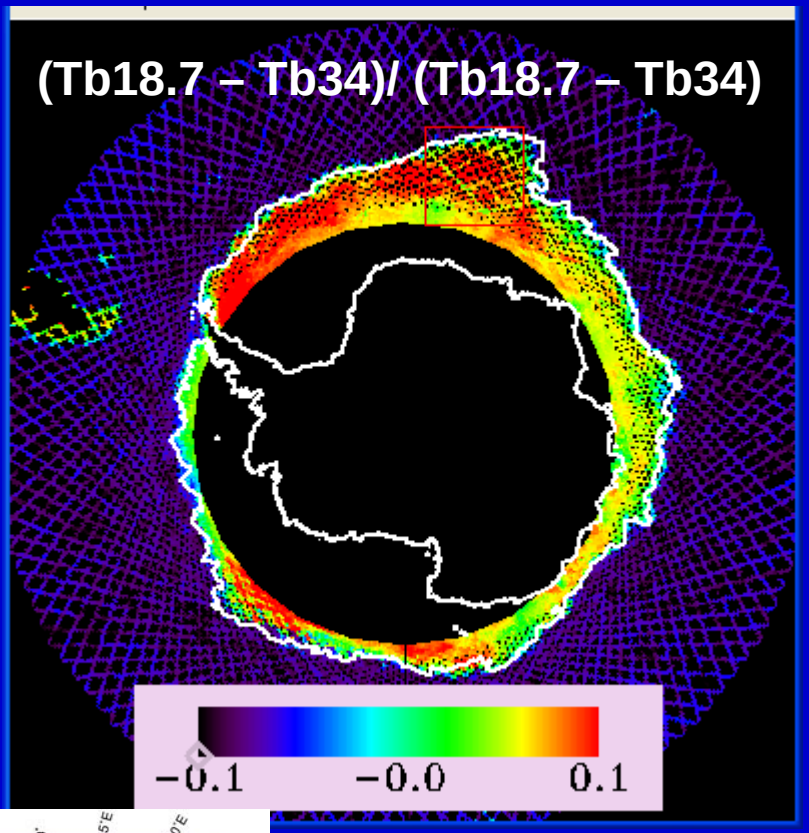


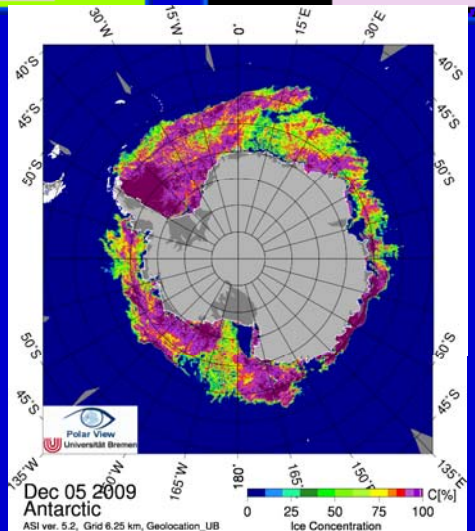
ASI Sea Ice concentration data (6.25 Km)

Possible use of Microwave Indices



Tb18.7 – Tb34





ASI Sea Ice concentration data (6.25 Km)

Future Work: Sea Ice

Snow depth, snow density and ice density have a strong impact on the sea ice buoyancy and ice freeboard.

The basic technique of computing sea ice thickness by satellite altimetry is to measure freeboard (that is the height of the ice or snow surface above water) from the difference between the surface height of the larger ice floes, and the height of the thin ice or water surface in the major leads.

The ice freeboard measurements are then converted to ice thickness by assuming hydrostatic equilibrium and using fixed densities of ice, sea water and snow, as well as snow depth [Laxon et al., 2003].

Long Term Goal

Assessment of seasonal and inter-annual changes in sea ice and ice sheet/shelf surface characteristics

Assessment of the long-term change in surface elevation of polar ice sheets/shelves

Conclusion

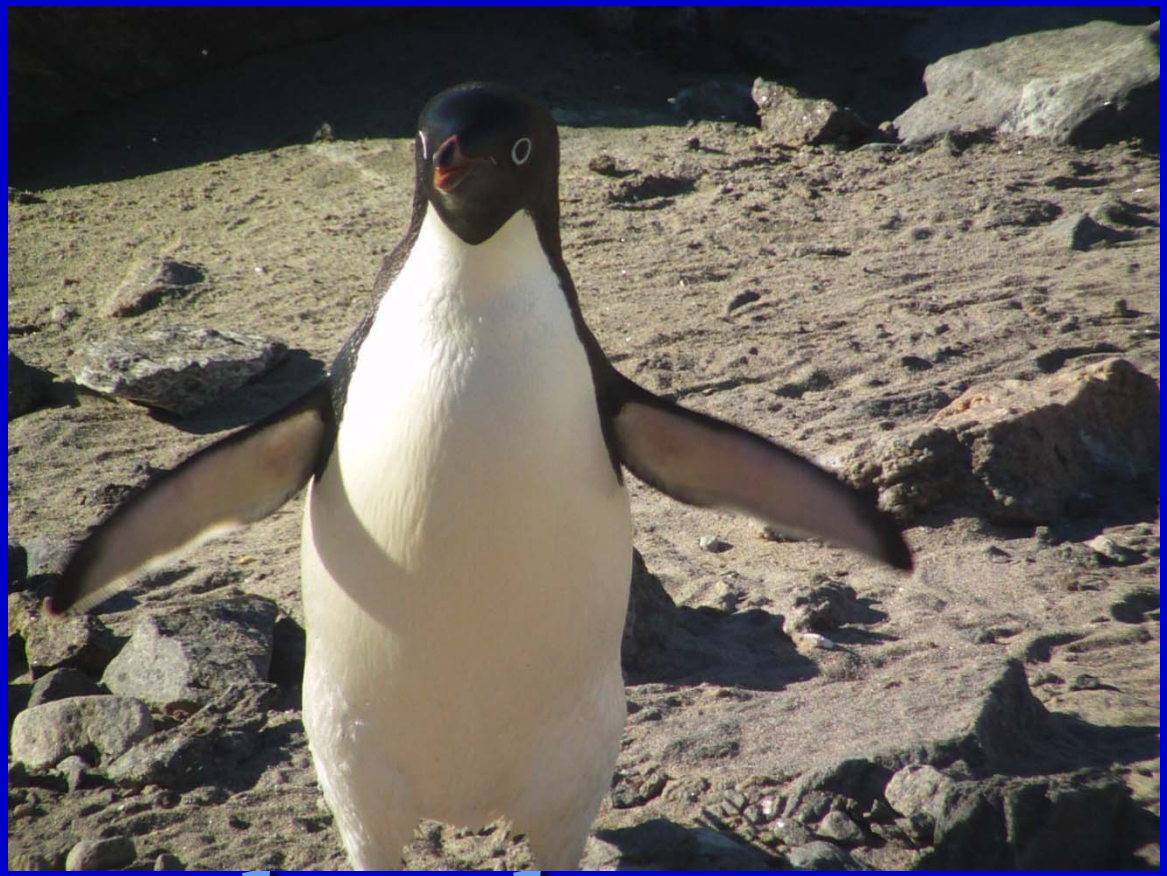
Potential of PISTACH Coastal product in winter sea ice identification and analysis in the Antarctic has been investigated

Pulse Peakiness (PP) parameter found to be useful in delineation of the sea ice from open ocean.

The ice-ocean boundary values for PP at C- and Ku-band were obtained from the data and used to observe the inter-annual variation of sea ice cover during 2009 and 2009.

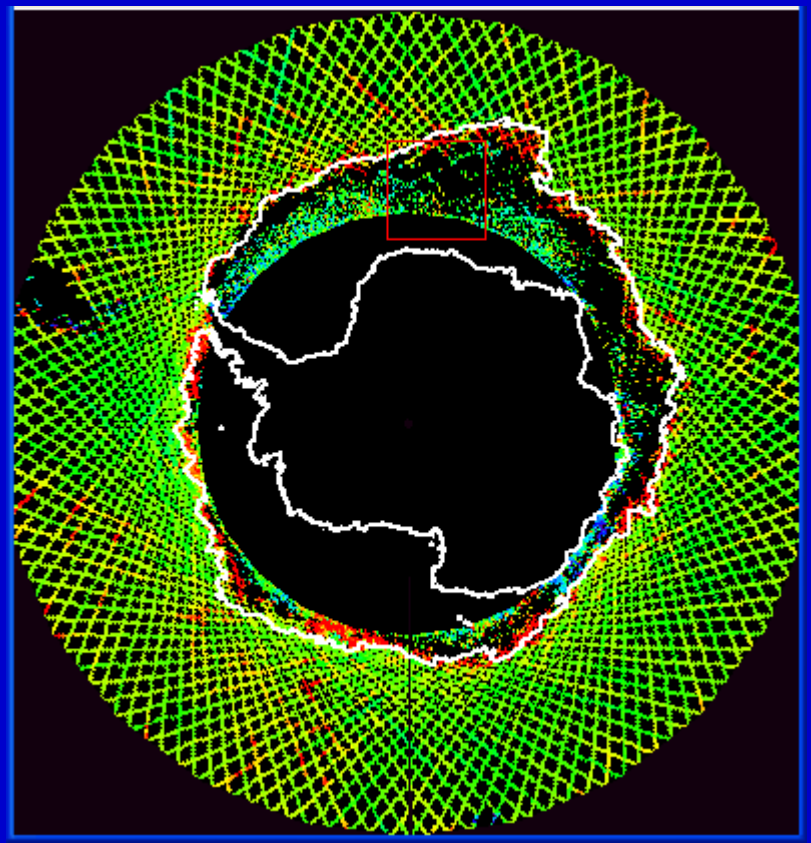
Brightness temperature provided in the product and microwave indices derived from them, can provide additional information to assess the sea ice characteristics.

Further studies are being initiated for the retrieval of sea ice thickness and long term assessment by synergetic use of altimeter data along with scatterometer and Radiometer data

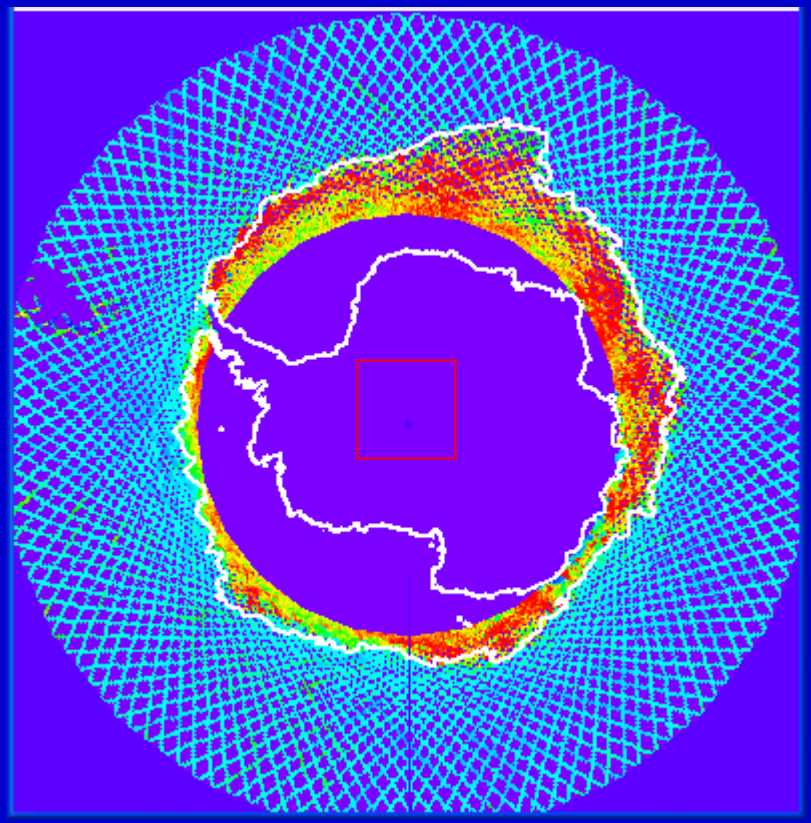


Thank You…

Waveform Retracking



Sigma-0 (Ku)



Ice - Sigma-0 (Ku)

Data: PISTACH Coastal Product – Cycle49 – Oct 31, 2009 to Nov 9, 2009