

An aerial photograph of sea ice in Antarctica. The ice is a mix of white and light blue, with numerous dark, jagged cracks and leads. There are several distinct patches of snow or thicker ice, appearing as lighter, more uniform areas. The overall texture is rough and fractured.

Changes in Snow Depth Over Sea Ice

Antarctica

Michael Lewis
EES 5053
Fall, 2005

Background



- Antarctica Land Mass – 14 million km²
 - 98% covered with ice sheet, 2% barren rock
- Sea Ice Extent Varies
 - minimum in January (about 2.5 million km²)
 - maximum in October (about 20 million km²)
- Antarctica is a desert
 - mean monthly precipitation less than 4 mm

Area of Interest

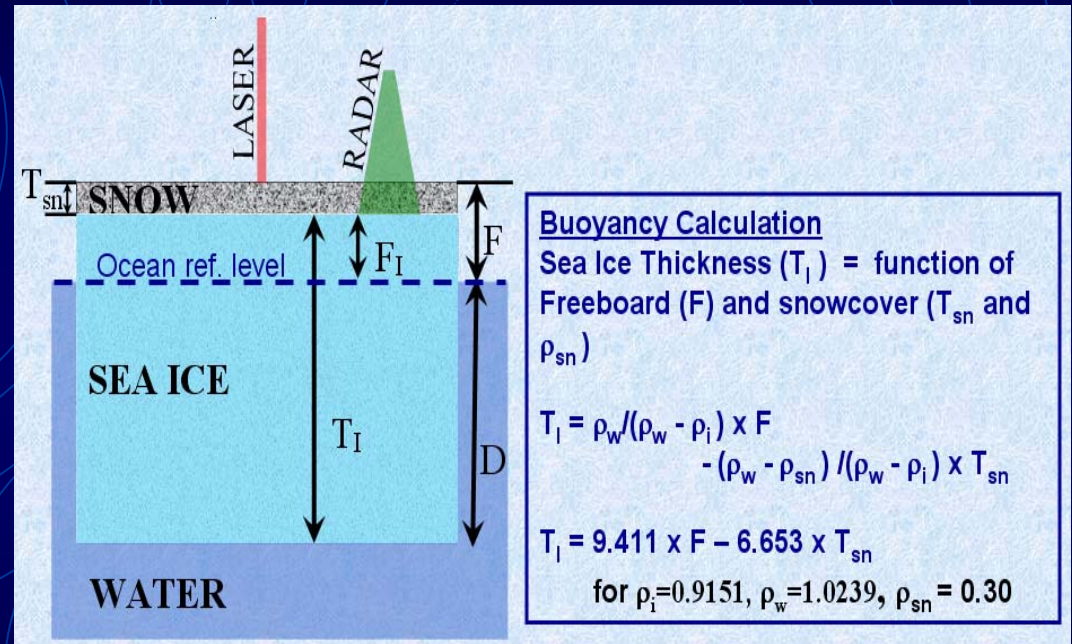


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Significance

- Evaluate changes in snow cover on sea ice using remote sensing
- Improve sea ice models for global climate studies



after Zwally, 2004

Objectives

- Examine temporal changes in the extent and depth of snow cover on the sea ice of Antarctica
- Analyze changes related to maximum and minimum occurrence of snow cover on sea ice

Advanced Microwave Scanning Radiometer- Earth Observing System (AMSR-E)



NASA

- Aqua Satellite, Joint Japan/USA
- Horizontal and Vertical polarized Brightness Temperatures (T_b)
- 6.9, 10.7, 18.7, 23.8, 36.5, and 89 GHz frequencies
- Spatial resolution varies from 5.4 km (89 GHz) to 56 km (6.9 GHz)

Snow Depth Algorithm

NSIDC- Cavalieri and Comiso, 2004



- Level 3 data product
- AMSR-E Brightness Temperature (T_b) corrected to account for variations in sea ice concentration (T_{bi}) is a Level 2 data product
- Snow depth (SD) calculated using T_{bi} at 37V GHz and 19V GHz using the following:

$$SD = -2.34 - 771 (T_{bi37V} - T_{bi19V}) / (T_{bi37V} + T_{bi19V})$$

- Snow Depth (SD) provided in centimeters
- Provides running average over past 5-days

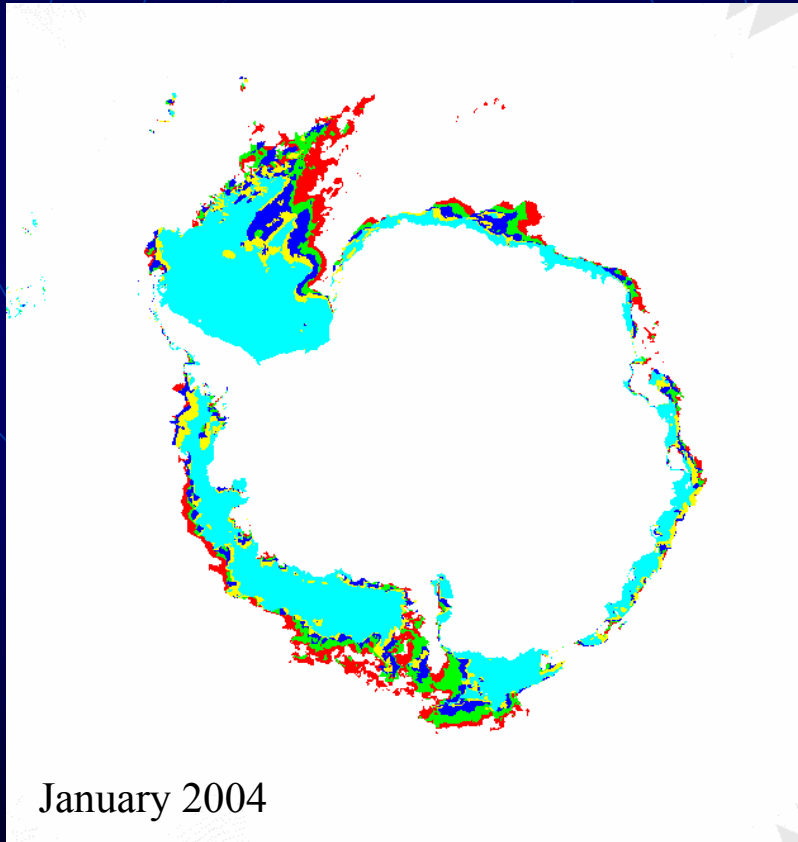
Data Product



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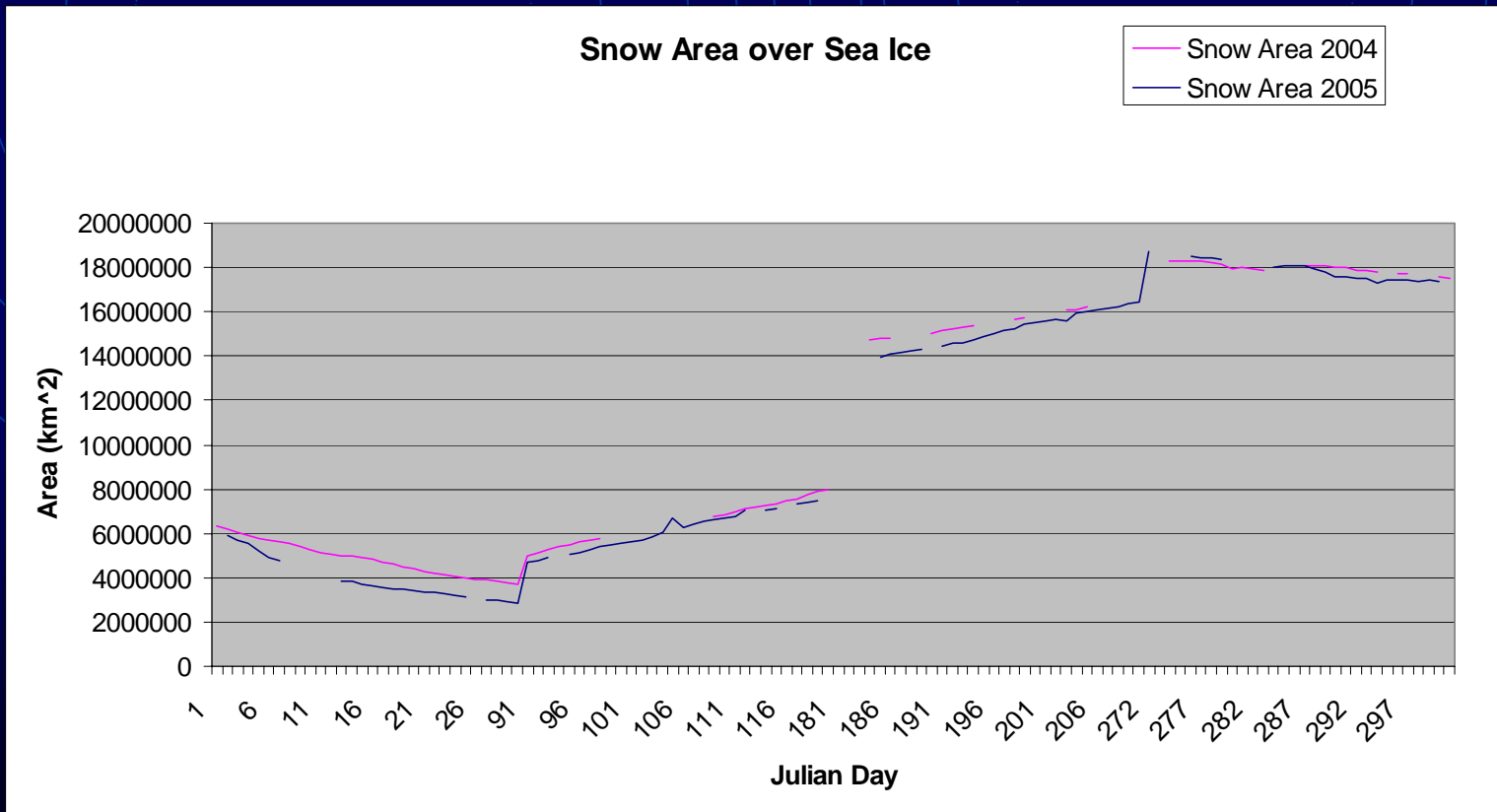
- AMSR-E/Aqua Daily L3 12.5 km Tb, Sea Ice Conc., & Snow Depth Polar Grids
- Ordered data through EOS Data Gateway
- Downloaded from National Snow and Ice Data Center (NSIDC) in HDF format
- Years 2004 and 2005
- Austral Seasonal Intervals: January (summer), April (Fall), July (winter), and October (spring)
- Over 200 images (12.5 km x 12.5 km pixel size)

Process

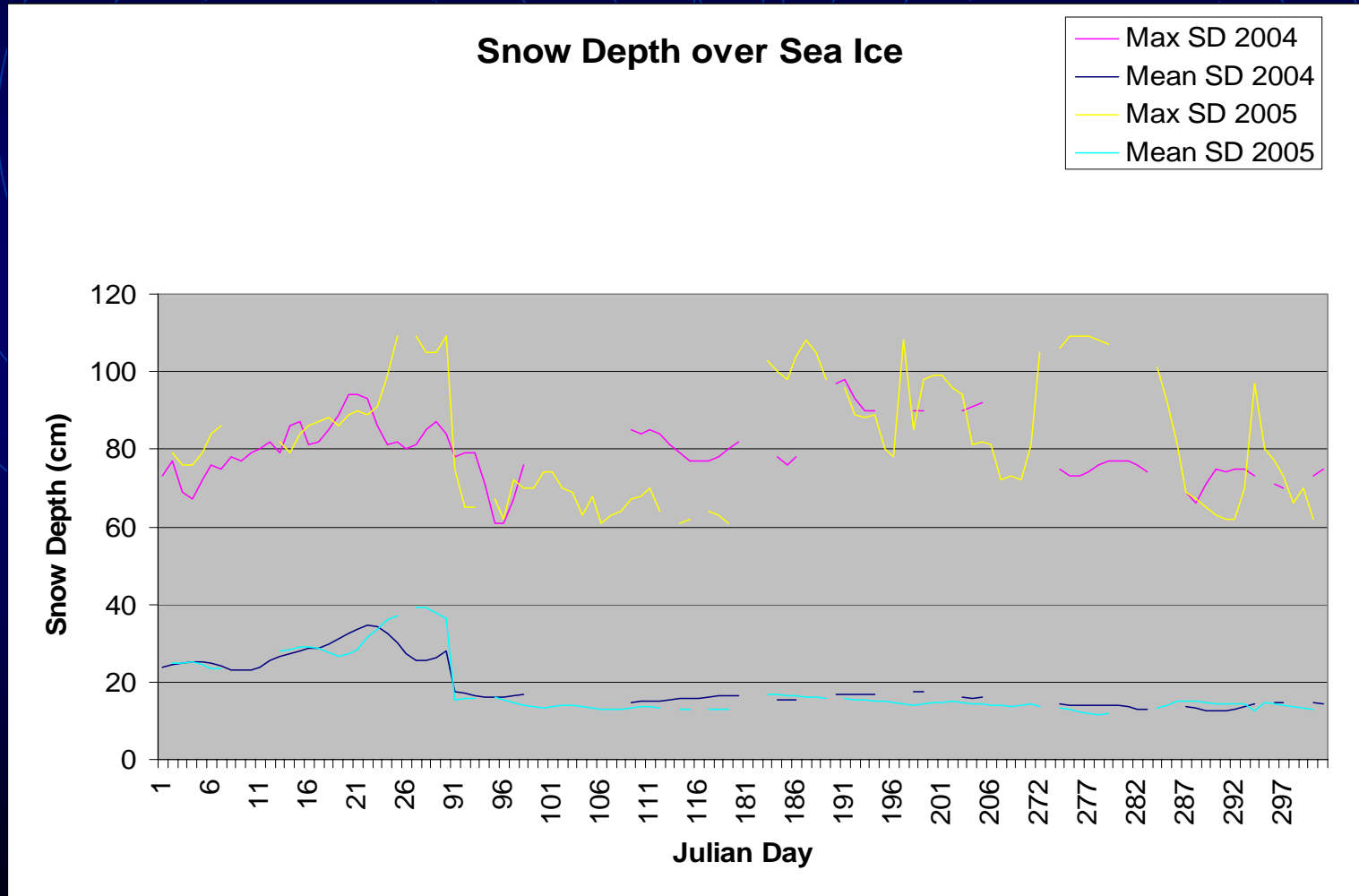


- Combined data into monthly composite ENVI images
- Used threshold ROIs to remove all background data except Snow Depth
- Computed Statistics on all daily SD for the ROI
- Determine monthly Grand Mean (mean of daily SD means)
- Find min and max thresholds as $\pm 2 \sigma$

The total AREA of snow cover present on sea ice generally decreased from 2004 to 2005, especially in summer

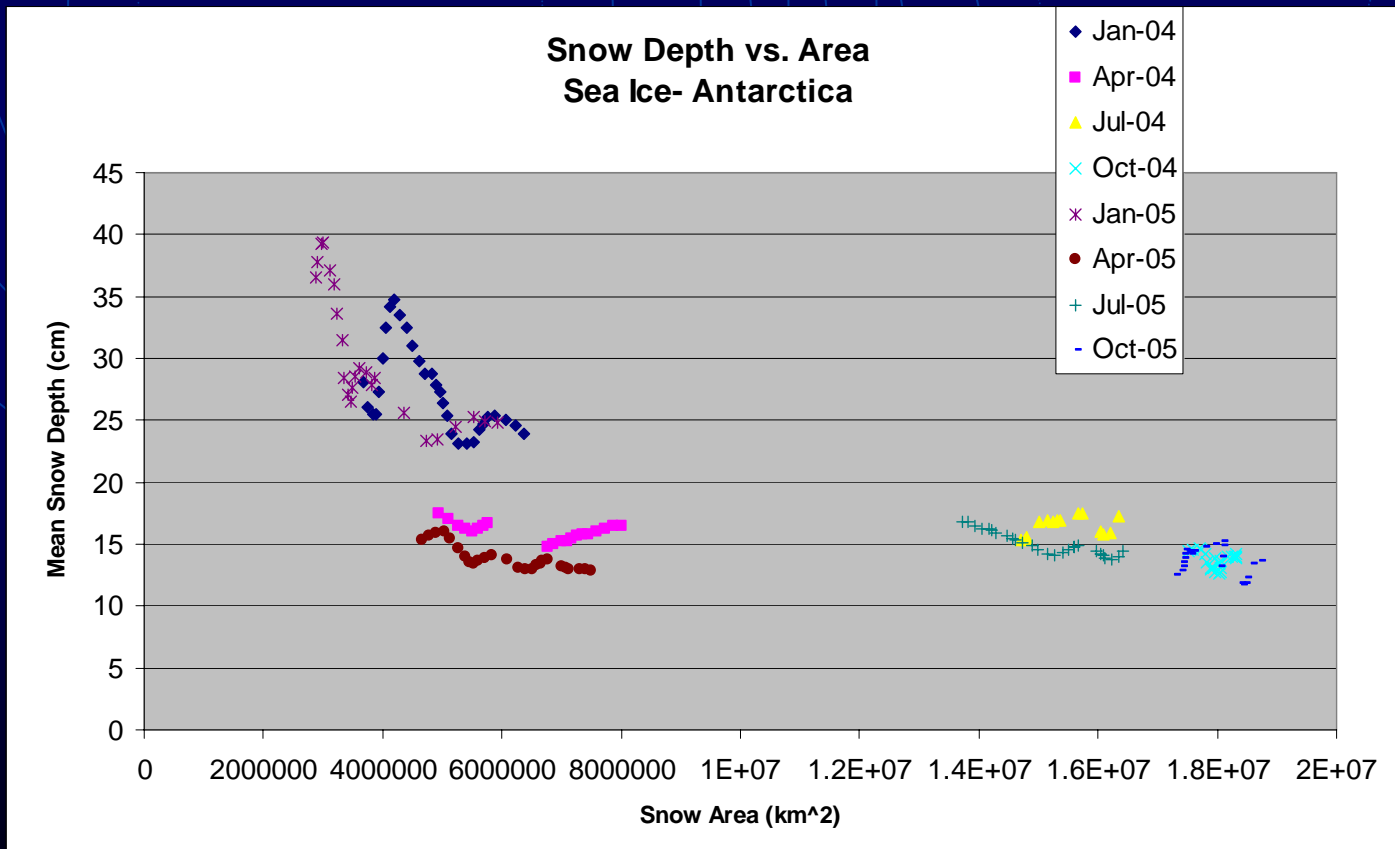


Mean Snow Depth appears relatively consistent with exception of a later snow event in January 2005
Maximum Snow Depth generally appears greater in 2005



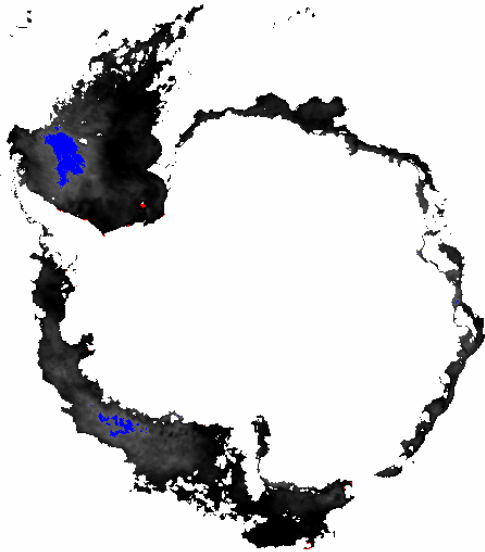
Summer time has greater Mean Snow Depth over a smaller Ice Area (wet season)

Winter time has less Mean Snow Depth over a greater Ice Area (dry season)

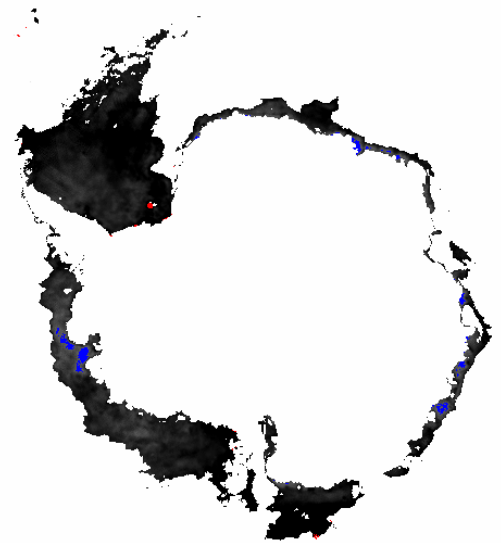


January
2004

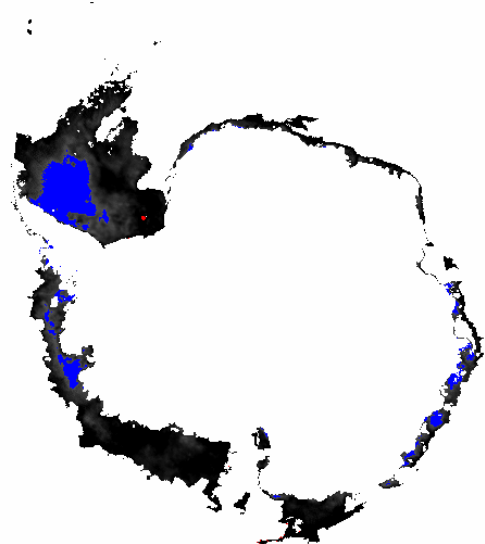
Intra Month
Comparison
Of Min. And
Max. Areas



Jan 01, 2004



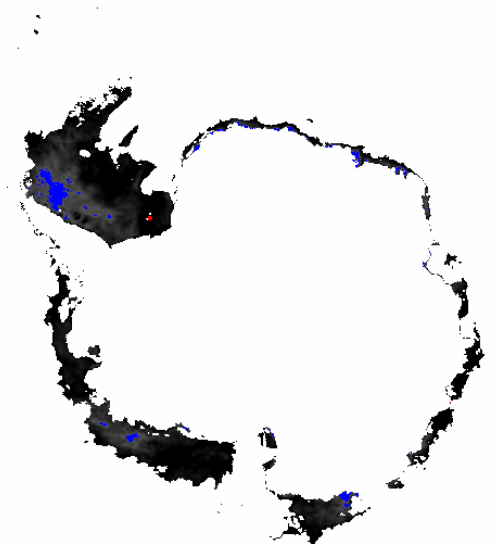
Jan 10, 2004



Jan 20, 2004

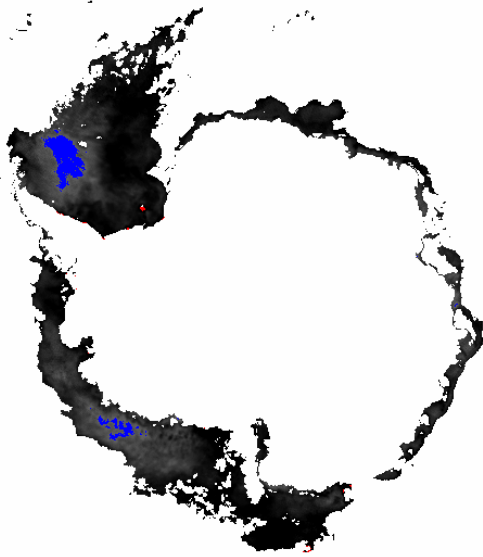
Blue = Max.
 2σ above the
Monthly Grand
Mean

Red = Min.
2 cm Snow
Depth or
less

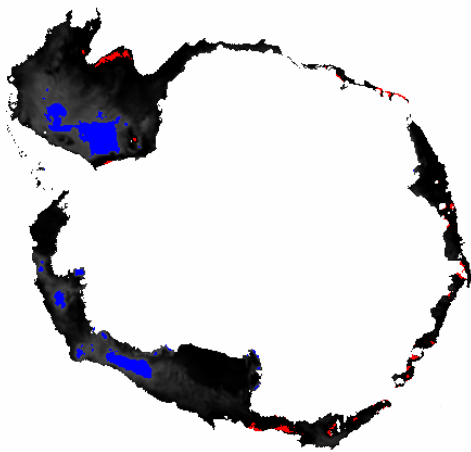


Jan 30, 2004

**Intra Year
(Seasonal)
Comparison
Of Min. And
Max. Areas**



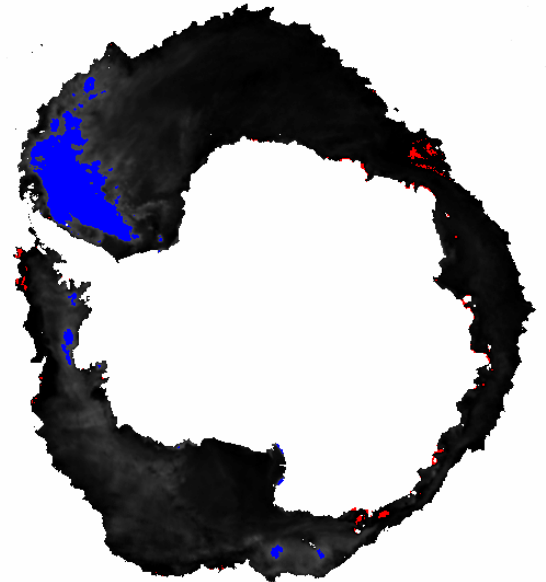
Jan. 1, 2004



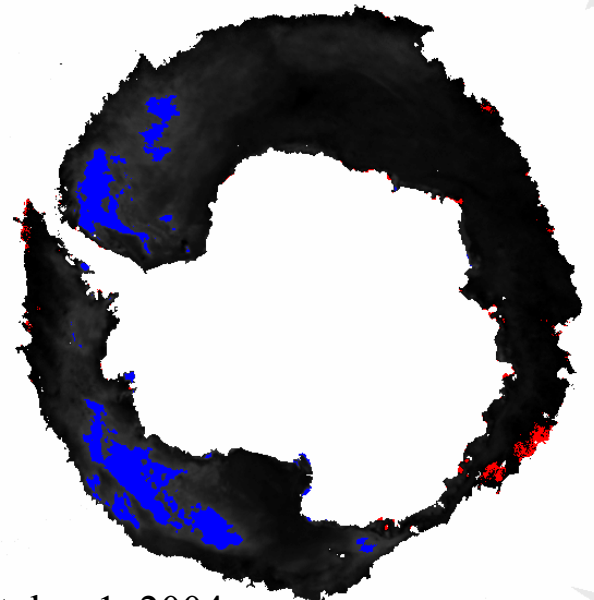
April 1, 2004

Blue = Max.
2 σ above the
Monthly Grand
Mean

Red = Min.
2 cm Snow
Depth or
less



July 3, 2004

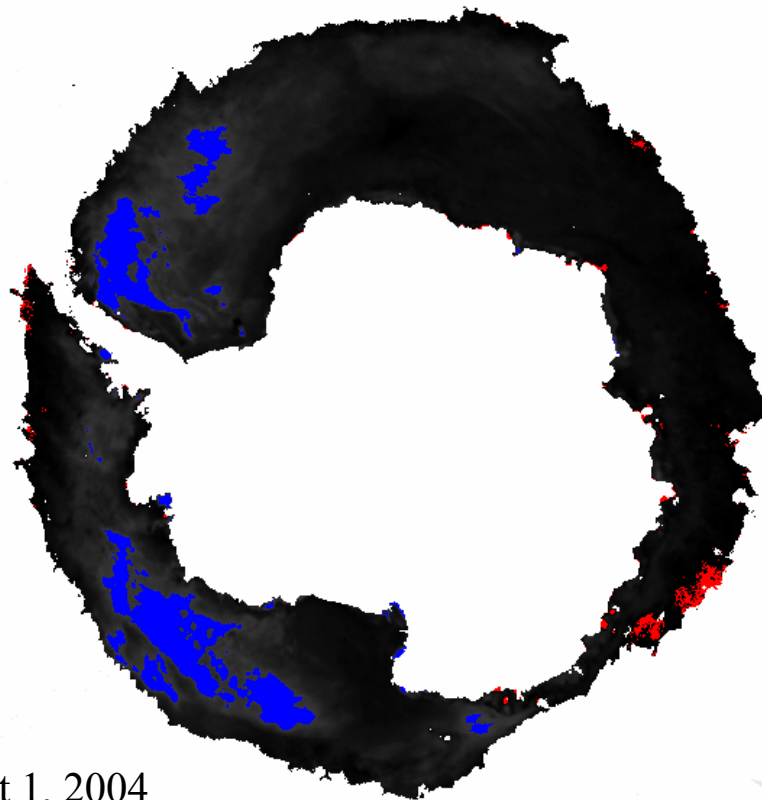


October 1, 2004

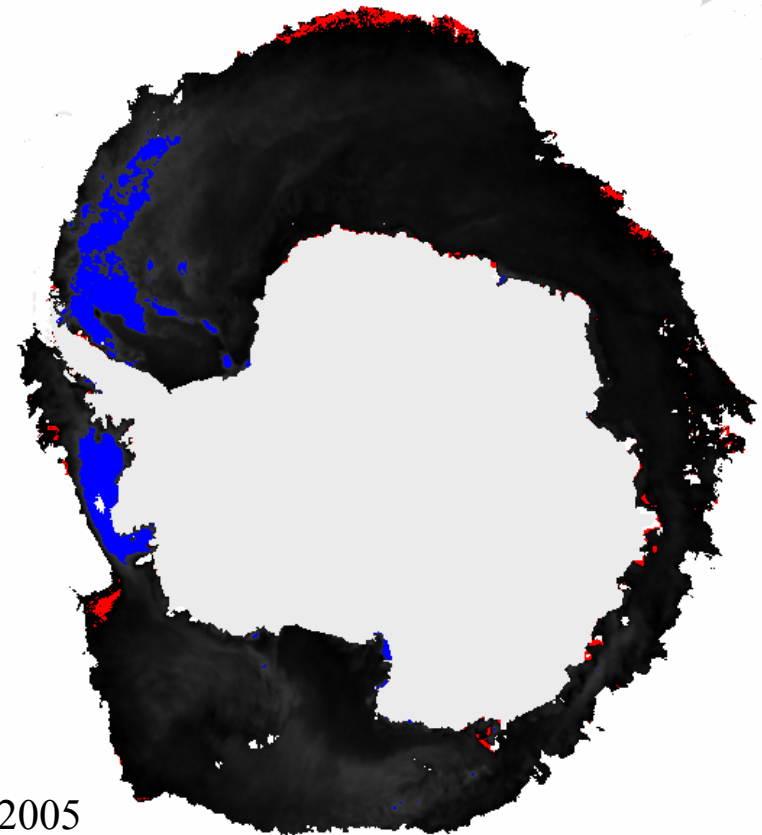
Inter Year Comparisons 2004 to 2005

Blue = Max.
2 σ above the
Monthly Grand
Mean

Red = Min.
2 cm Snow
Depth or
less

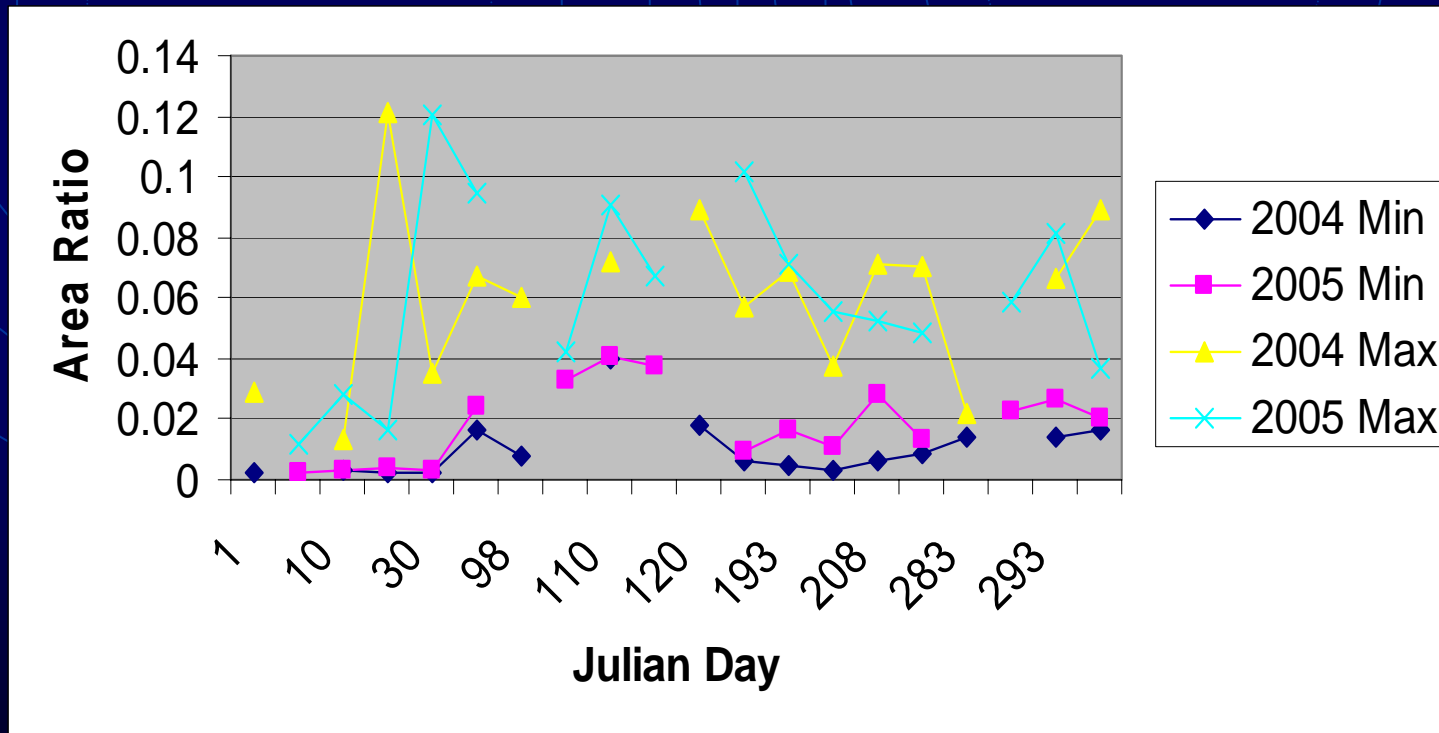


Oct 1, 2004



Oct 1, 2005

Area Ratio is (Min or Max) / (Total Area)



Conclusions

- Minimum area of snow over sea ice occurs at the end of the Austral Summer (January)
- Maximum area of snow over sea ice occurs in October (Austral Spring)
- There is generally a decrease in total area between 2004 and 2005
- Mean snow depth is relatively consistent between 2004 and 2005



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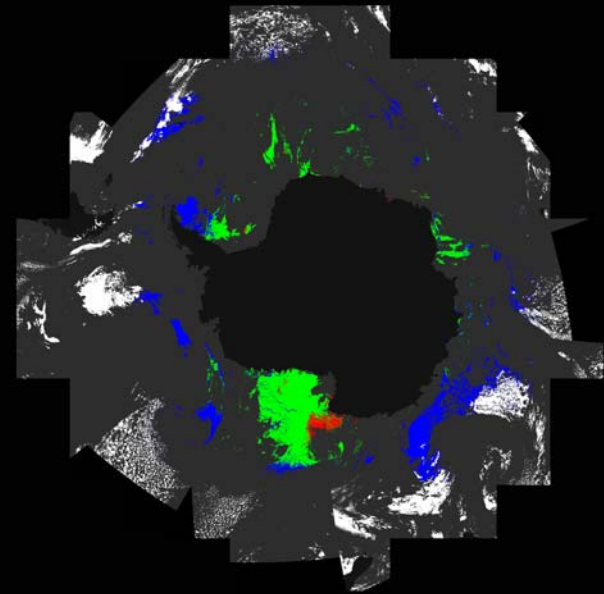
Conclusions (cont.)

- Summer time has greater Mean Snow Depth over a smaller Ice Area which implies that this is the wet season
- Winter time has less Mean Snow Depth over a greater Ice Area which implies that this is the dry season
- Temporal comparison of Minimum and Maximum areas not conclusive



Additional Study

- Compare data with Ice Surface Temperature data from MODIS
- Compare data with precipitation records of Antarctica
- Apply to Sea Ice buoyancy calculations



MODIS Ice Surface Temperature (Daily, Global 4 km)
October 1, 2005