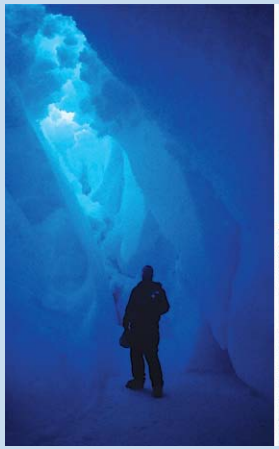
National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976



Creation and Preservation of a Sea Ice Climate Data Record

Walt Meier
F. Fetterer, R. Duerr, J. Stroeve

walt@nsidc.org
303-492-6508

NOAA CDR Meeting
14 September 2010

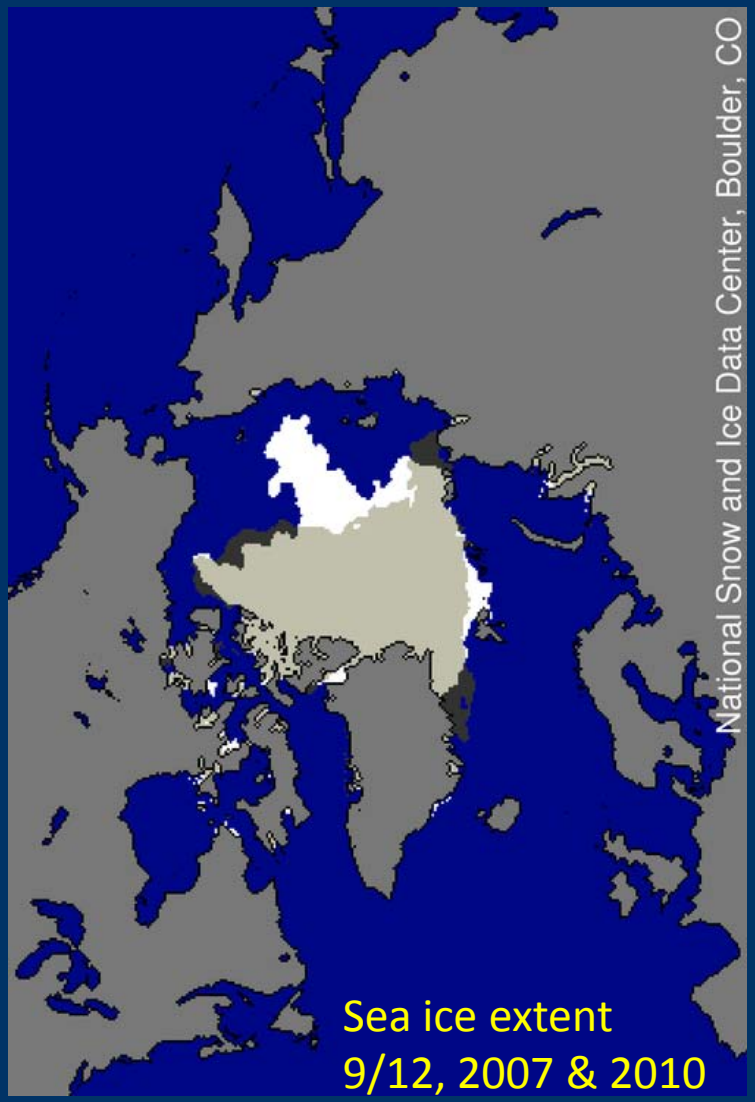
Project Overview

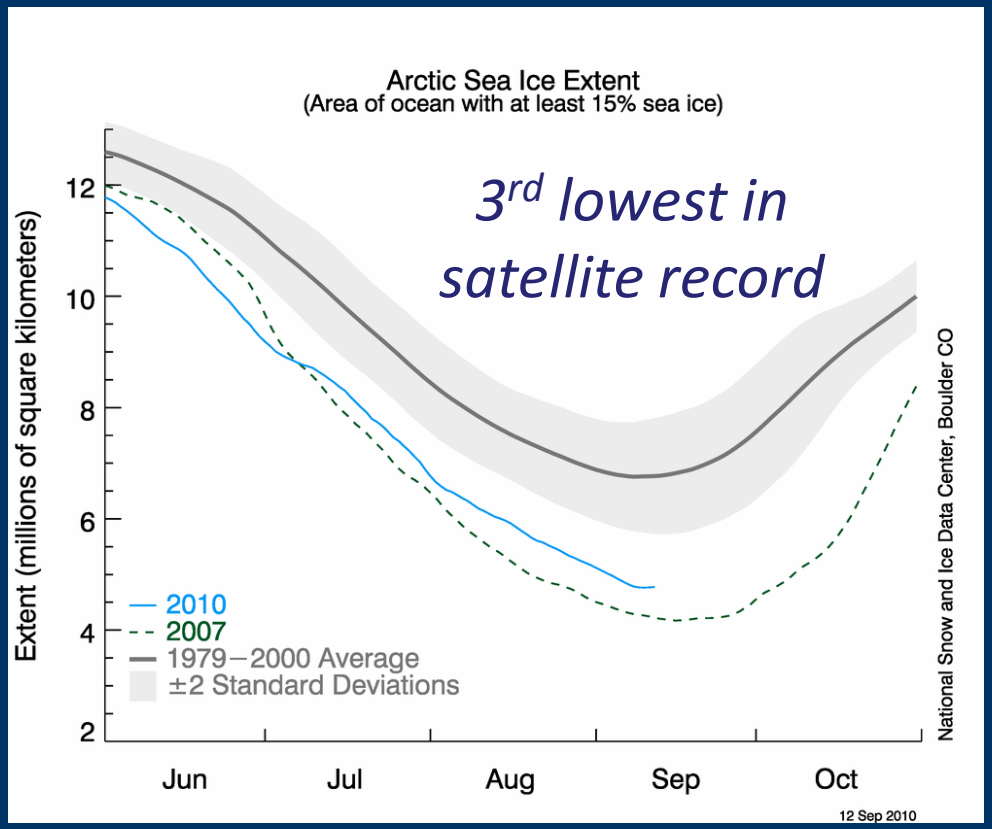
- Project Goals: Work toward upgrading sea ice concentration products to CDR level by:
  - Improve metadata
  - Develop data quality estimates
  - Improve intersensor calibration where possible
- Performance Baseline:
  - Intersensor calibration for F17 SSMIS – F13 SSM/I: first time done for NRT sea ice products
  - Metadata developed, awaiting implementation
  - Data quality parameters developed
  - Bootstrap algorithm product implemented at NSIDC
  - Collaboration with several groups
    - NOAA snow and ice CDR product development team (J. Key, PI)
    - NOAA snow CDR team (D. Robinson, PI)
    - Remote Sensing Systems, Inc. (calibrated TBs)
    - NASA Goddard (intercalibration coefficients)
    - WCRP Climate and Cryosphere
    - ESA Ocean and Sea Ice Satellite Application Facility
  - Delays in completion of some tasks due to data delays and resource availability; no-cost extension approved

Project Overview

- Deliverables
  - Sea ice concentration/extent/area estimates, 1979-present
  - Data quality/error estimation (grid cell level)
  - Metadata (product, granule level)
- ECVs:
  - Gridded sea ice concentration
  - Total sea ice extent and area
  - Ultimately, also sea ice drift, age, etc. (NOAA CDR, J. Key, PI)
- User community:
  - Cryosphere, climate modeling, ocean, atmosphere, biology
  - Fisheries, native communities, shipping, natural resources
  - Policymakers, national defense (e.g., U.S. DoD NORTHCOM)
  - Educators, students, media, blogosphere, general public

Arctic Sea Ice News and Analysis (NASA Team)





- Ice in 2010 only
- Ice in 2010 and 2007
- Ice in 2007 only

5-day avg. extent:

9/10: 4.76×10^6 sq km

9/11: 4.77×10^6 sq km

http://nsidc.org/arcticseaicenews/

Algorithm/product maturity

- NRT Tbs → "Near-real-time sea ice" (NASA Team)
  - Previously F13, F15 SSM/I from NASA Marshall
  - June 2009: F17 SSMIS from CLASS
  - Sea ice processed at NSIDC
- Processed Tbs → "Preliminary sea ice" (NASA Team and Bootstrap)
  - Tbs from Remote Sensing Systems (RSS)
  - Sea ice processed at NSIDC
- Processed Tbs → NASA Goddard –> "Final sea ice" (NASA Team and Bootstrap)
  - Tbs from RSS
  - Sea ice processed at NASA Goddard, archived at NSIDC
  - NSIDC to eventually take over final processing?
- Sea ice processing almost completely consistent
- Only "Final" sea ice stored in permanent archive

Product maturity

- Metadata
  - Architecture developed to produce granule-level metadata meeting ISO-19115 standard
  - Final coding and implementation awaiting resources at NSIDC; target to complete by early next year
- Data quality estimates
  - Multiple concentration estimates – NASA Team and Bootstrap initially (others possibly added later)
    - OSI SAF, AMSR-E, NOAA IMS
  - Grid cell level data quality
    - Melt state (D. Robinson et al., snow CDR)
    - Concentration difference/range
    - Coastal proximity (land-ocean spillover error)
    - Latency (new ice)

Algorithm/Product Maturity

- SMMR-SSM/I-SSMIS
  - NASA Team (NTA) – NRT and final QC-ed
  - Bootstrap (SBA) – final QC-ed only
    - Originally run only at NASA Goddard
    - NSIDC in final stages of implementing → will allow NRT processing
- AMSR-E – part of NASA EOS standard products
  - NASA Team 2 (NT2)
  - AMSR Bootstrap (ABA)
- There are also several algorithm products available from various international groups

Algorithm/Product Maturity

- Using F17 SSMIS TBs for NRT sea ice
  - Obtained from CLASS
  - NRT intercalibration done in 2009 to assure continuity – manuscript currently in review
- Final TB intercalibration: awaiting data from RSS
  - Long delay due to several issues, including TB quality
  - Expected by the end of the month
- NSIDC will work with NASA Goddard on final sea ice intercalibration
  - Requires 2007 pre-release F17 SSMIS data, which was not initially made available
  - RSS was able to obtain earlier SSMIS thanks to several efforts including by NOAA (thanks H. Semunegus!)
- Eventually, need for full reprocessing using most advanced TB version and new intercalibration baseline

Product maturity

Maturity	Sensor Use	Algorithm stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none
2	Research Mission	Some changes expected	Research grade (extensive)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing
3	Research Missions	Minimal changes expected	Research grade (extensive); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
4	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD, Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators

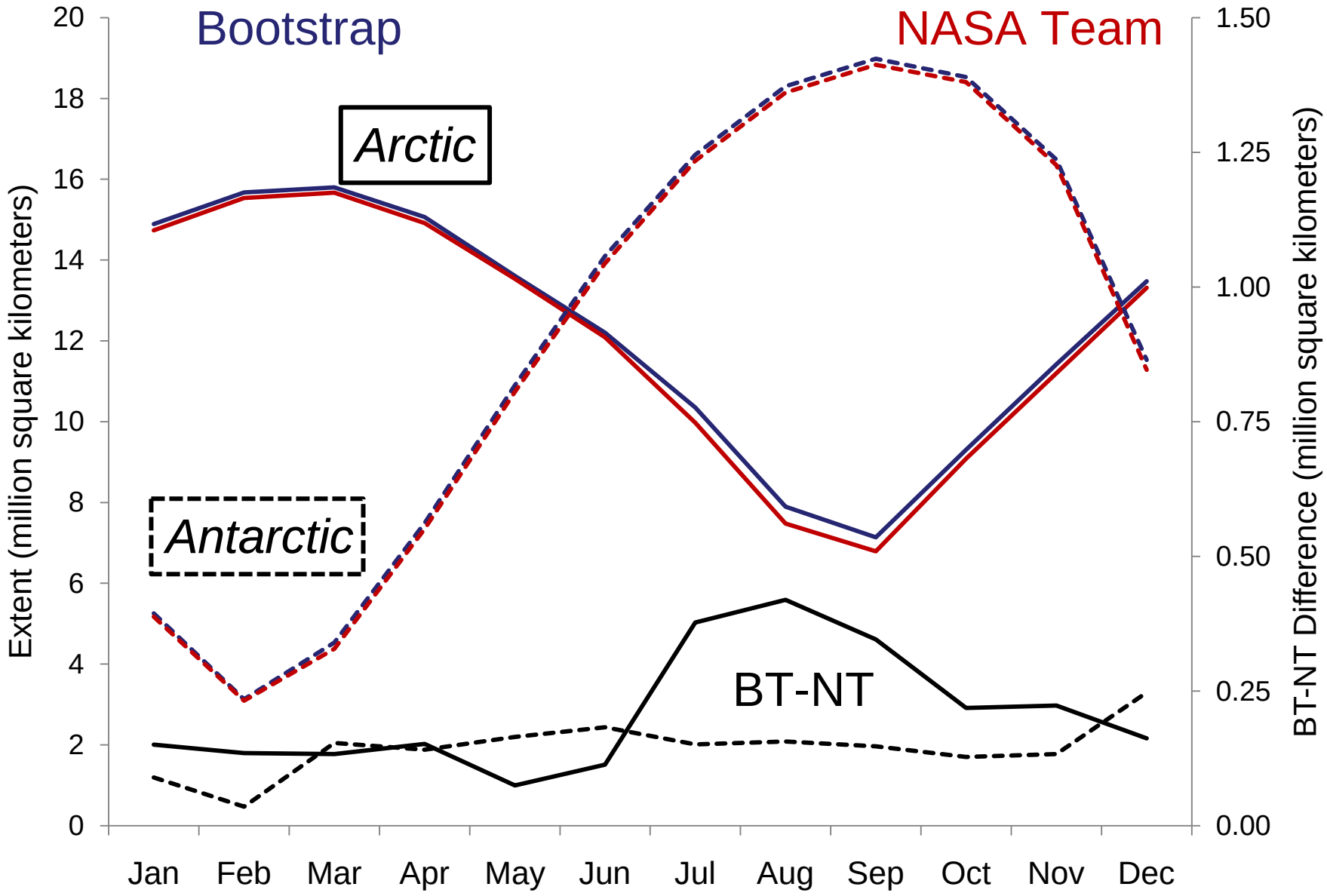
CIRES

NSIDC
National Snow and Ice Data Center

Research-to-Operations Results

- Deliverable: sea ice concentration climate data record with associated metadata and data quality estimates
- Post-award plans: continue development through Snow and Ice CDR Product Development Team
  - Final implementation of metadata and QC fields
  - WCRP CliC sea ice algorithm workshop
  - Update processing through present when F17 TBs arrive from RSS
  - Integrate with other snow and ice products
  - Eventual full reprocessing, when/if resources allow
- NOAA Collaborators: J. Key

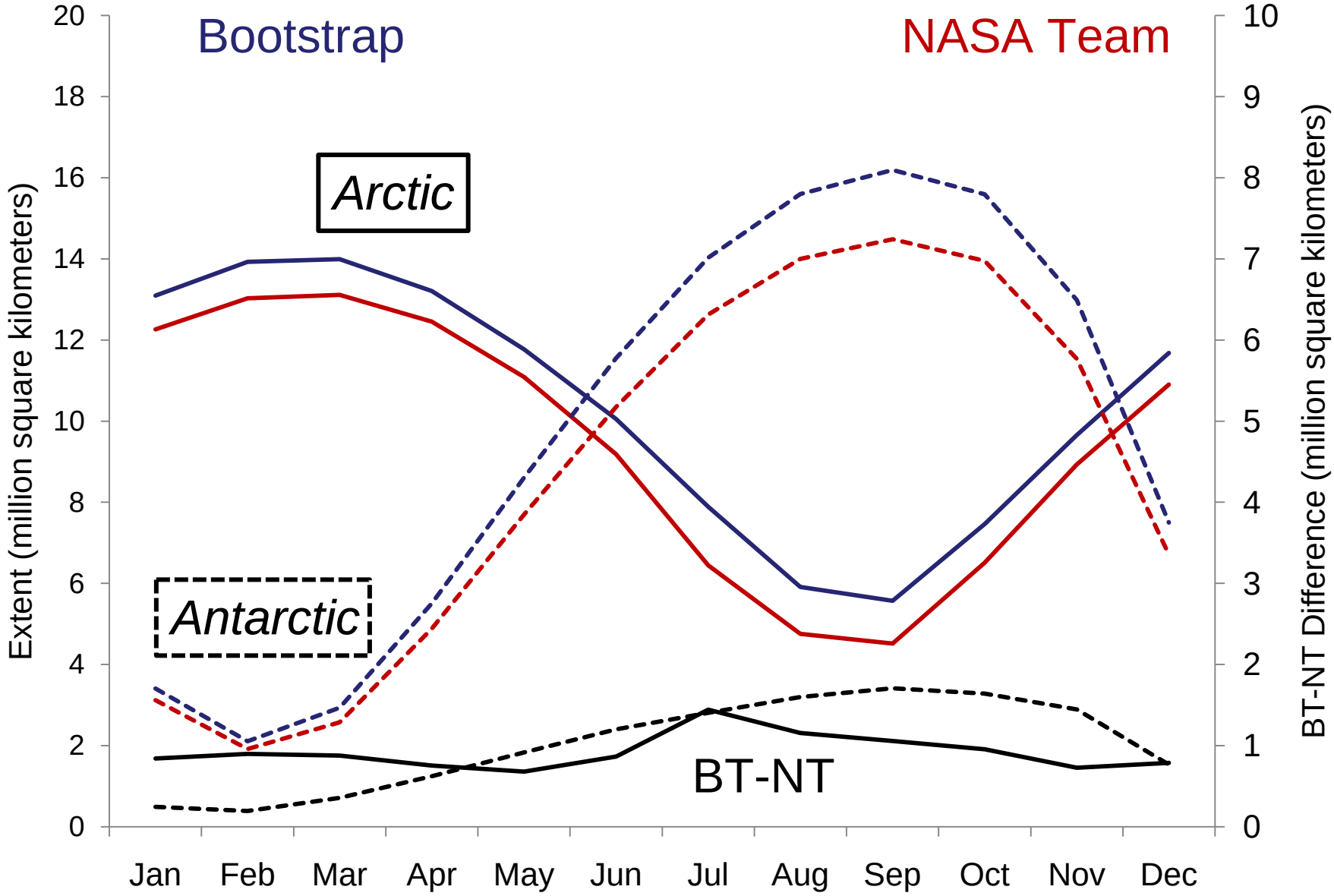
Sea Ice Monthly Average Extent, 1979-2007



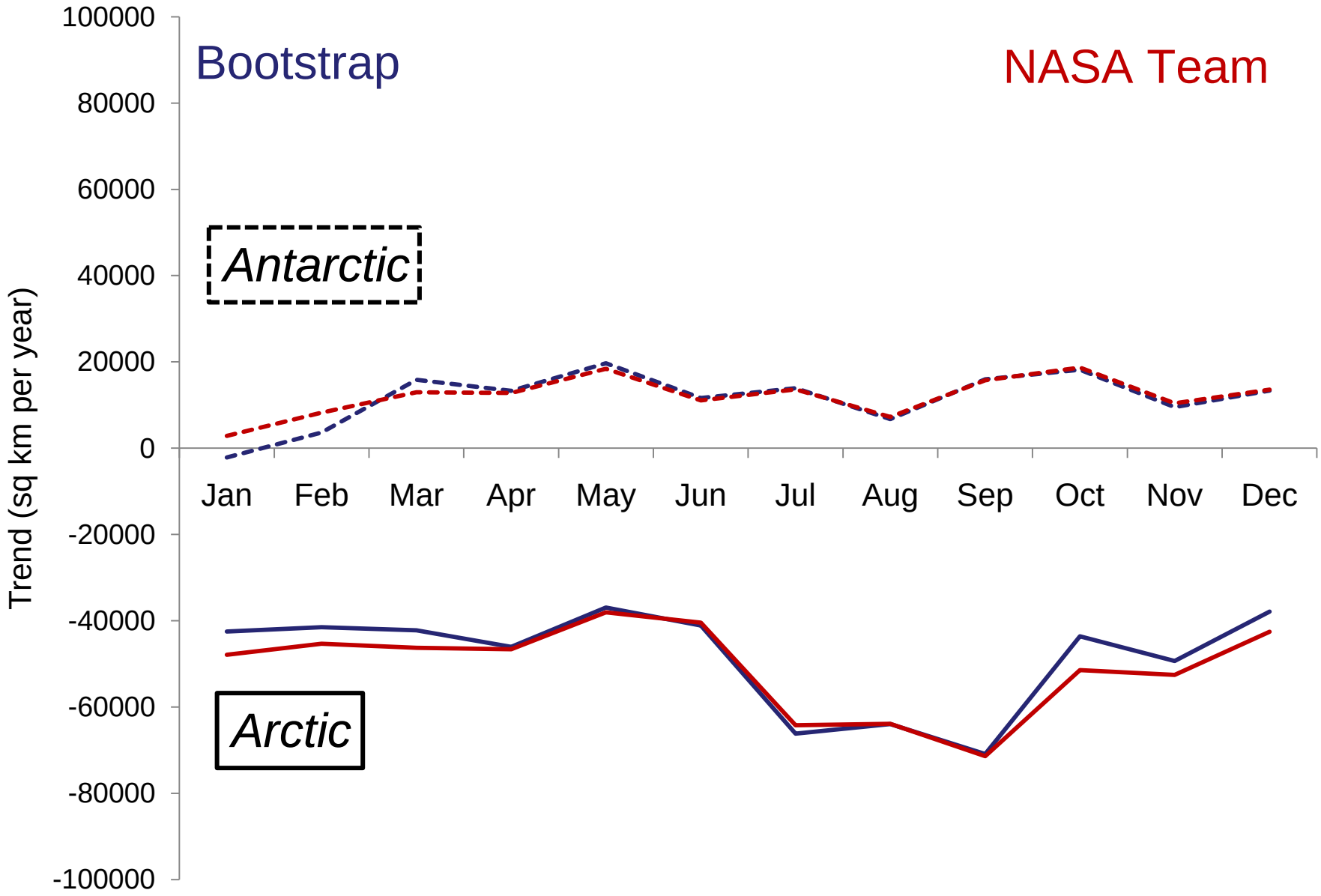
CIRES

NSIDC
National Snow and Ice Data Center

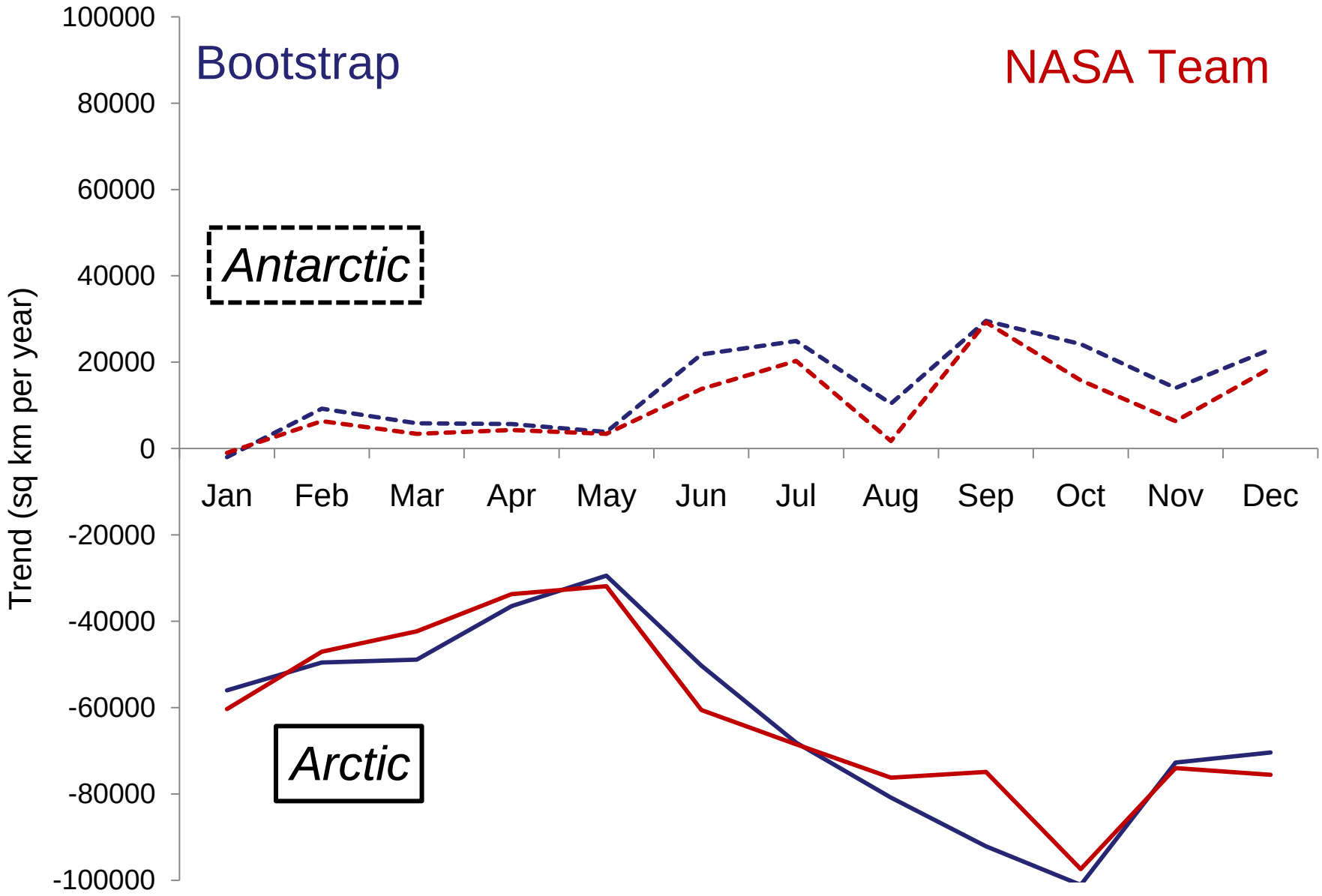
Sea Ice Monthly Average Area, 1987-2007



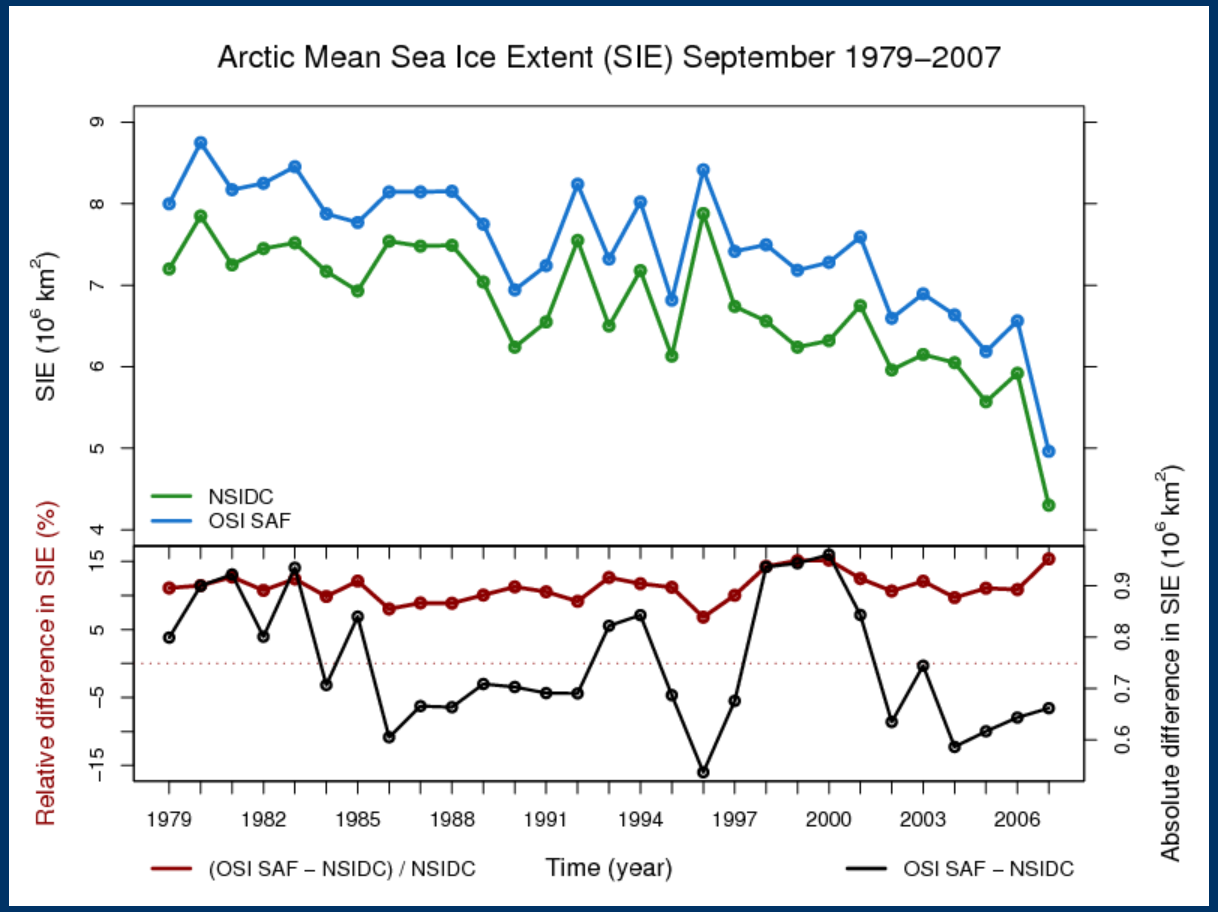
Sea Ice Monthly Extent Trend, 1979-2007



Sea Ice Monthly Area Trend, 1987-2007



Results – Comparison with ESA EUMETSAT Ocean & Sea Ice Satellite Application Facility (OSI SAF)



SAF algorithm is a hybrid Bootstrap/Bristol algorithm

Comparison with NSIDC NASA Team

Research-to-Operations

- WCRP Climate and Cryosphere (CliC) group interested in deciding on an overall “standard” sea ice concentration product – i.e., a climate data record
- CliC is supporting a sea ice algorithm workshop
  - Late-winter, early-spring, Washington, DC
  - Invite algorithm developers and users
  - NSIDC/NOAA’s CDR will be presented and discussed
    - Feedback on data quality fields, metadata, and algorithms

Lessons Learned/Recommendations

- Difficult to overcome entrenched user communities
  - Hard to settle on only one algorithm
  - WCRP CliC workshop to help solve
  - Offer multiple estimates, with differences clearly explained
- Reliance on operational DMSP data is risky
  - Errors not quickly caught, corrected, or reported
  - No reprocessing of bad data
- Fully-reprocessed dataset with latest TB version and upgraded intercalibration would be useful

Source Data – brightness temperatures (Tb)

	SMMR	SSM/I	SSMIS	AMSR-E	AMSR2	MIS
Years of operation	1978-1987	1987-2009	2002-	2002-	2011/2012	2016
Freq. (GHz)	6.9, 19, 22, 37	19, 22, 37, 85	19, 22, 37, 91, +	6.9, 19, 22, 37, 89	6.9, 19, 22, 37, 89	
IFOV 37 GHz (km)	~40	~40	~40	~15	~15	
Gridded Res. (km)	25	12.5/25	12.5/25	6.25/12.5	6.25/12.5	
Selected Algs.	NT BT	NT BT	NT BT	NT2 ABT Bremen	??	??

+ = higher frequency sounding channels, potential for atmospheric characterization
6.9 GHz can provide ice surface temperature for better sea ice
85-91 GHz provides higher spatial resolution and better ice surface and atm. characterization

CIRES

NSIDC
National Snow and Ice Data Center