



A Product Development Team for Snow and Ice Climate Data Records

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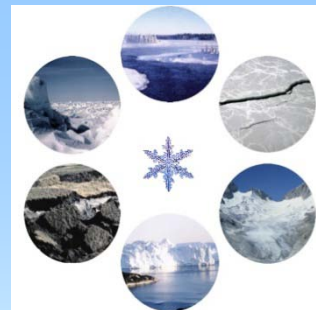


CDR Team Meeting
2-4 Aug 2011

Outline

- Brief Project Overview
- Approach (1-2 slides)
- Results/Accomplishments (1-3 slides)
- Validation Strategy/Results (1-2 slides)
- Algorithm/Product Maturity
- Issues/Risks & Work-Off Plans
- Schedule
- Transition Plan
- Societal Benefits (2 slides)
- Resources (1-2 slides)

Overview: Goals

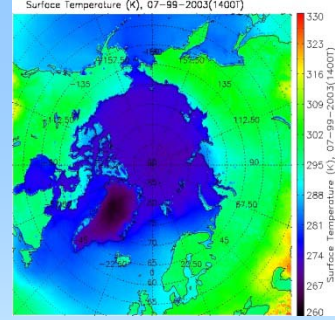


The cryosphere product development team is coordinating the generation, validation, and archival of fundamental and thematic snow and ice climate data records, building on existing products and efforts as appropriate.

Our goal is to refine, extend, validate, document, and archive visible, infrared, and passive microwave cryosphere products. We are merging the existing data into consistent time series, and using these series as a basis for transitioning to NPP/JPSS products. We are building on existing efforts, coordinating with other funded products, as appropriate.

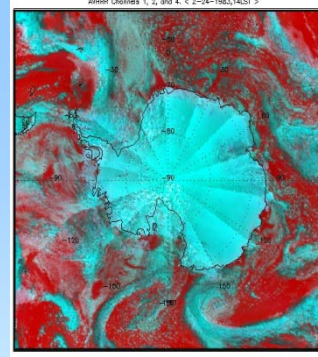
Note: This is the beginning of the 3rd and last project year.

Overview: Deliverables and Source Data



- Sea ice concentration and extent (SSM/I and SSMIS)
- Sea ice motion (AVHRR, SMMR and SSM/I or AMSR-E)
- Sea ice thickness/age (AVHRR, SMMR, MODIS, SSM/I and AMSR-E)
- Ice/snow surface temperature (AVHRR and MODIS)
- Ice/snow surface broadband albedo (AVHRR and MODIS)
- Surface shortwave and longwave radiation (AVHRR and MODIS)
- Snow cover/extent (AVHRR, SSM/I, AMSR-E, MODIS)
- Surface ice melt onset/freeze-up (SMMR, SSM/I, AMSR-E)

Overview: ECVs

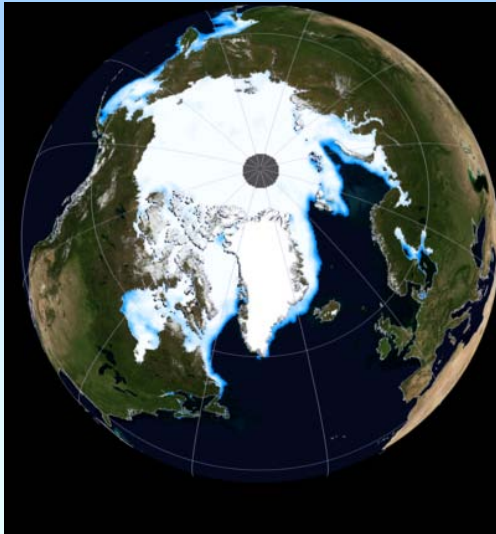


- GCOS ECVs addressed
 - Sea ice
 - Surface temperature
 - Surface albedo
 - Snow cover
 - Cloud properties
 - Surface radiation budget
- User communities
 - Climate modeling and prediction, satellite product validation, energy, transportation, fisheries, wildlife management

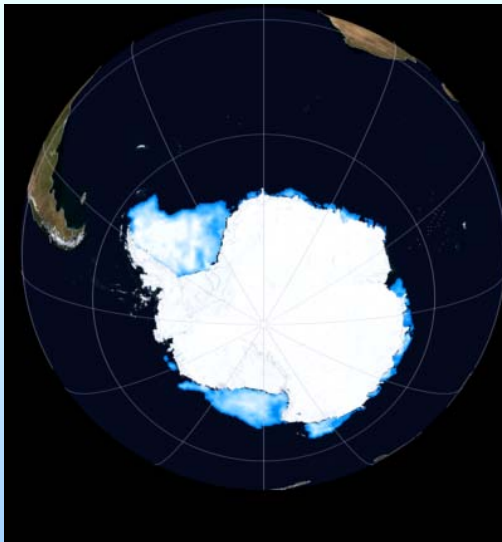
Personnel

- **Jeff Key**, NOAA/NESDIS
- **Xuanji Wang**, University of Wisconsin
- **Yinghui Liu**, University of Wisconsin
- **James Maslanik**, University of Colorado
- **Walt Meier**, University of Colorado
- **Charles Fowler**, University of Colorado
- **Julienne Stroeve**, University of Colorado
- **William Emery**, University of Colorado
- **Mark Tschudi**, University of Colorado
- **Dorothy Hall**, NASA/GSFC

Sea ice concentration/extent products



14 March 2010



- 30+ year record from several sensors
 - Nimbus-7 SMMR (1978-1987)
 - DMSP SSM/I-SSMIS series (1987-present)
 - NASA EOS AMSR-E (2002-present)
 - JAXA GCOM-W AMSR2 (2011)
 - SMMR-SSM/I-SSMIS intercalibrated
- Several algorithms
 - NASA Team
 - Bootstrap
 - NASA Team 2
 - Bristol, Norsex, Cal/Val, ARTIST, etc.
- No clearly superior algorithm
 - Combined algorithms?

Archived at NSIDC
(NT2 for AMSR-E only)

Current NSIDC Sea Ice Concentration Products

NASA Team (NT)

- 1-byte integer array
- Flat binary format
- Concentration scaled 0-250 (quarter %)
- Land, coast, pole, missing flag values
- 300-byte header w/ limited metadata
- No quality/error information
- NT Antarctic landmask

Bootstrap (BT)

- 2-byte integer array
- Flat binary format
- Concentration scaled 0-1000 (tenth %)
- Land, pole/missing flag values
- No header, no file level metadata
- No quality/error information
- BT Antarctic landmask

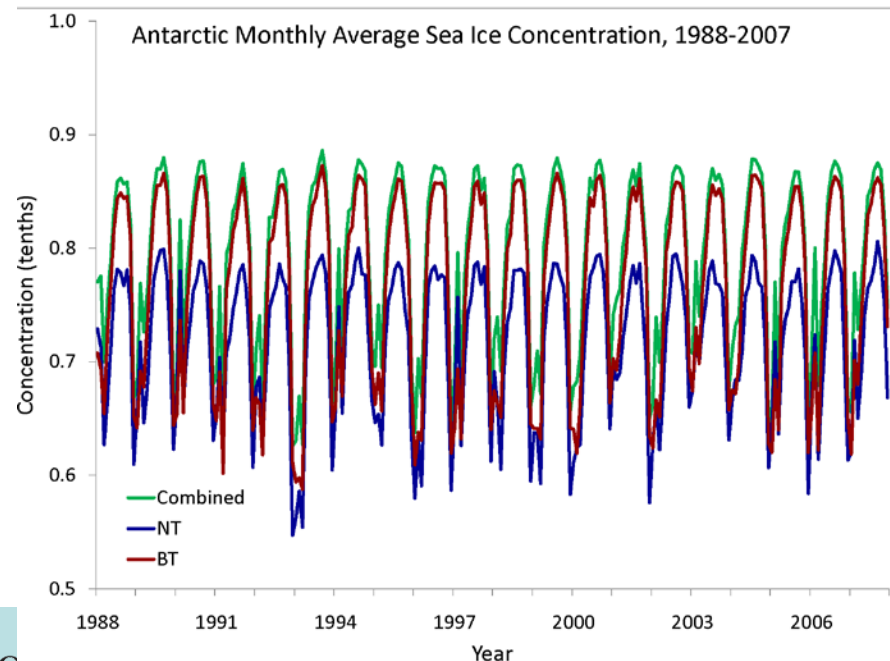
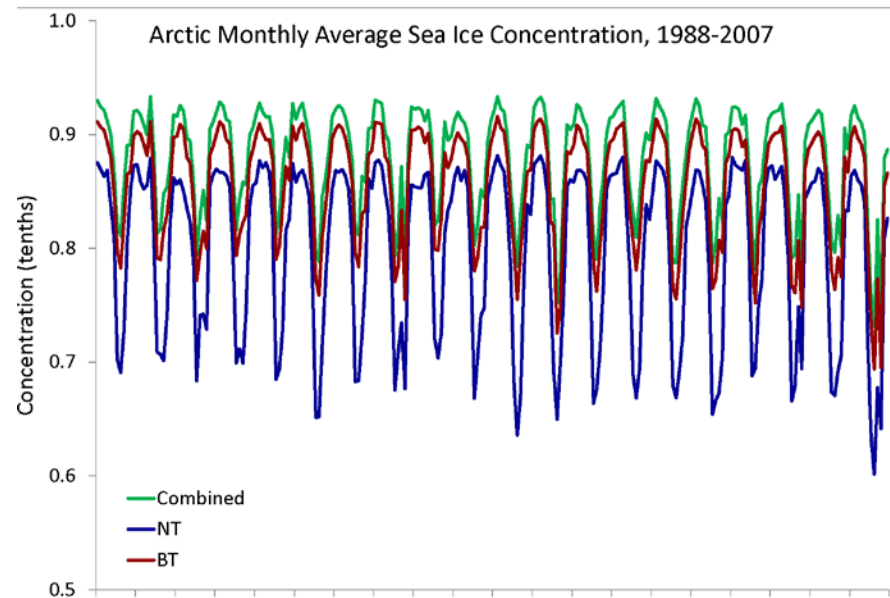
Sea Ice Concentration CDR

Sea Ice Concentration CDR

- Suite of 1-byte integer array for NT, BT and a combined field
- NetCDF format
- Concentration 0-100%
- Land, coast, pole, missing, lake flag values
- Consistent landmask in Antarctic
- St. Deviation (uncertainty indicator) and QA field
- 1987-present at CDR quality, older data provided also

Sea ice concentration CDR

1. Concentration (combined NT & BT)
 - A. BT ice edge
 - B. $\text{Max}(\text{BT} | \text{NT})$ for each grid cell
 - PM concentration generally biased low
 - NT for thin ice and melt
 - BT for interior cold temps.
2. St. Dev. field
3. QA field (melt, etc.)
4. Original NT and BT (Goddard) included for long-time users and a combined Goddard for extension of CDR to include SMMR
 - Goddard fields include manual QC that is not reproducible, thus do not meet CDR standards



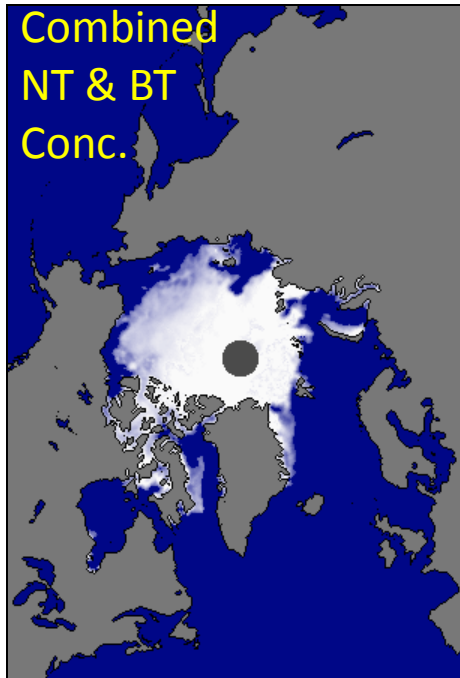
Concentration CDR Product Suite

*Original NASA
Team (NT) and
Bootstrap products
also included in same
format and scaling*

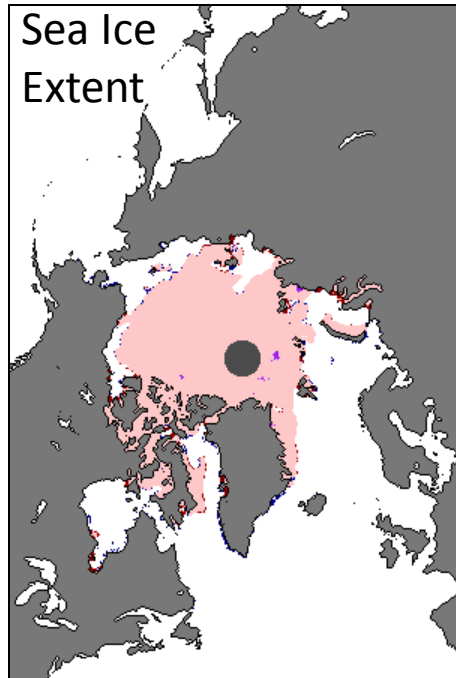
15 July 2007

% Concentration
100
0

Combined
NT & BT
Conc.

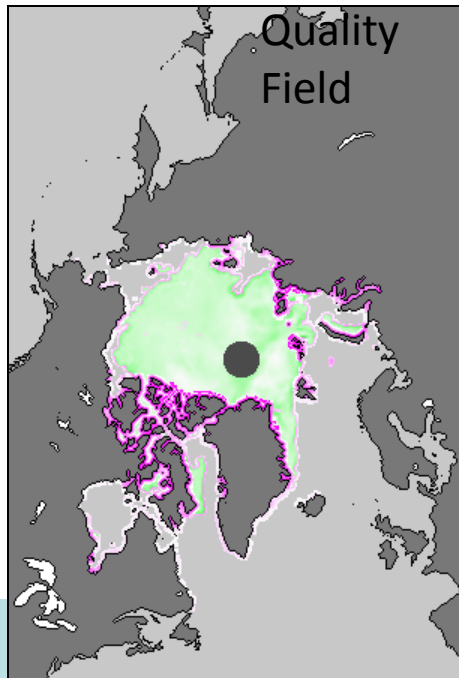


Sea Ice
Extent

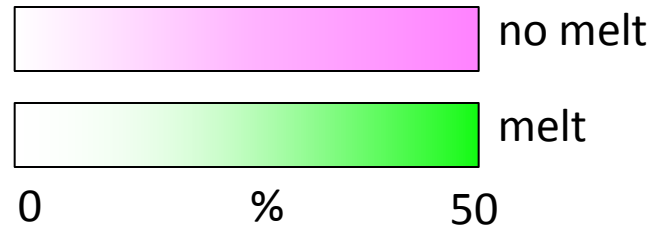


- BT Only
- NT Only
- NT > BT
- BT > NT
- BT = NT

Quality
Field



NT & BT 3x3 St. Dev.

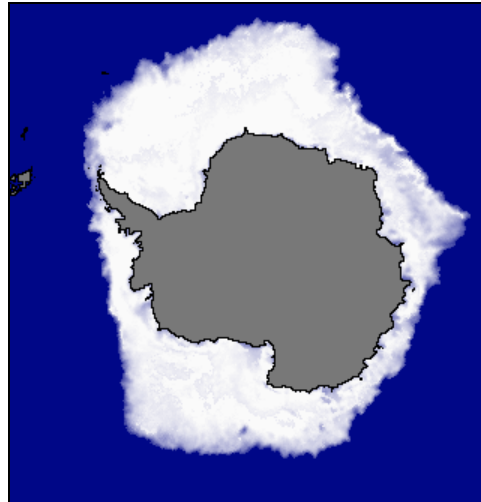


Concentration CDR Product Suite

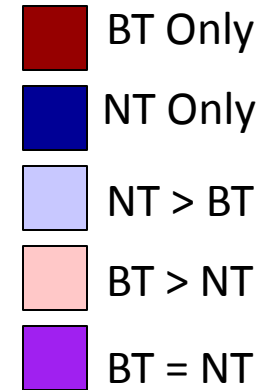
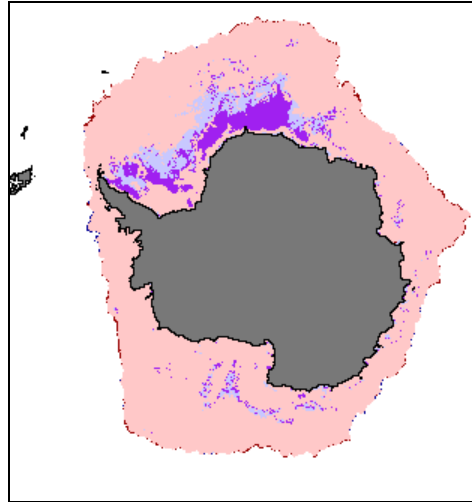
*Original NASA
Team (NT) and
Bootstrap products
also included in same
format and scaling*

Combined NT & BT
Concentration

% Concentration
100
0

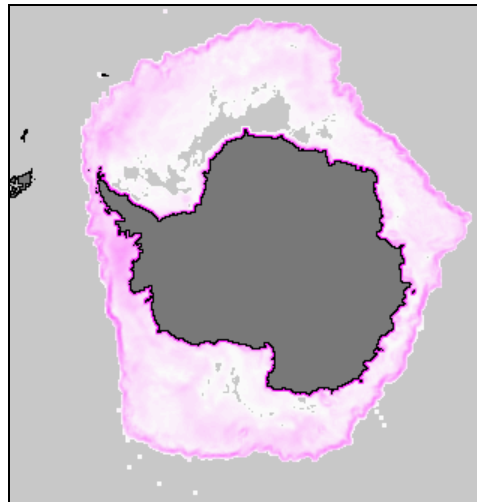


Sea Ice Extent

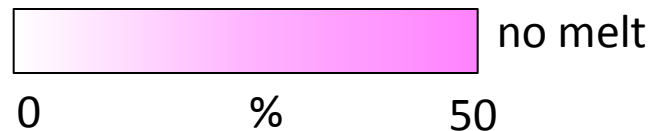


15 Sep 2007

Quality Field



NT & BT 3x3 St. Dev.



(no melt algorithm for Antarctic sea ice)

Ice Concentration and Ice Mask from vis/IR

Algorithm:

- Ice mask: Group threshold tests
- Ice concentration: tie-point algorithm
- GOES-R algorithm. Similar algorithm used for JPSS.

Sensors:

- AVHRR (MODIS) near visible and near infrared channel data, and surface temperature retrieved.

Area coverage:

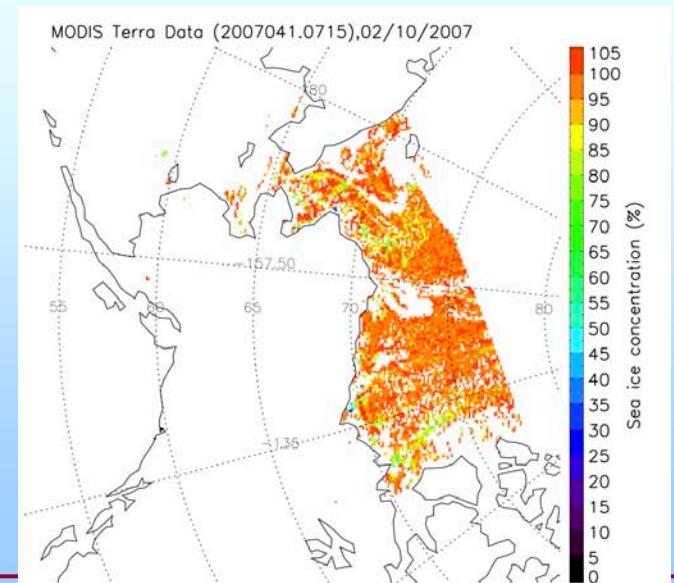
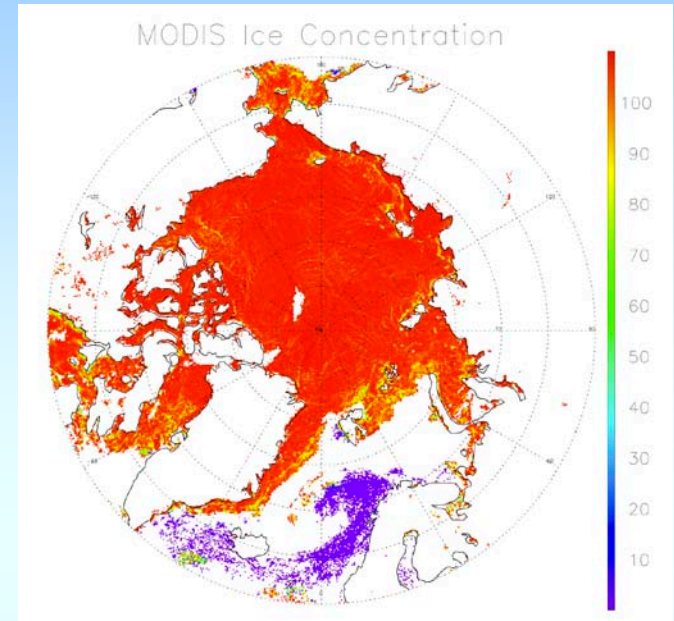
- Arctic and Antarctica.

Time Period:

- 1982~2004, currently.

Spatial Resolution:

- 25 km (can be up to 1km).



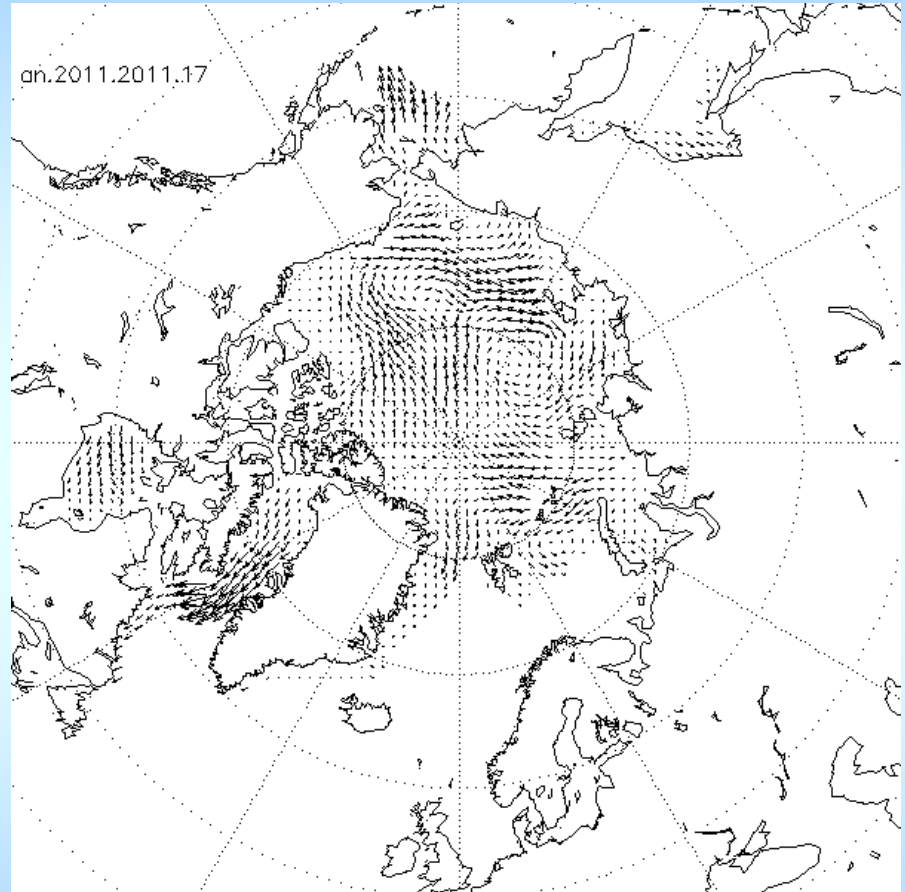
Ice Motion

Algorithm:

- Ice motion based on Maximum Cross Correlation computations from SMMR, SSM/I, AMSR-E and AVHRR have been computed and are available on a daily and weekly composite basis back to 1979.

Sensors:

- The latest version of this product uses AMSR-E as the primary sensor starting in 2002 and will utilize the NPP ATMS when operational.
- The product has been merged with NPRB ice buoy trajectories over the same time period.



Sea ice thickness/age - Energy budget method

Sea Ice Thickness

Algorithm:

- One-dimensional Thermodynamic Ice Model (OTIM) based on the surface energy budget at the equilibrium state.
- Algorithm for GOES-R. Similar algorithm for JPSS.

Sensors:

- Uses other derived products.

Area coverage:

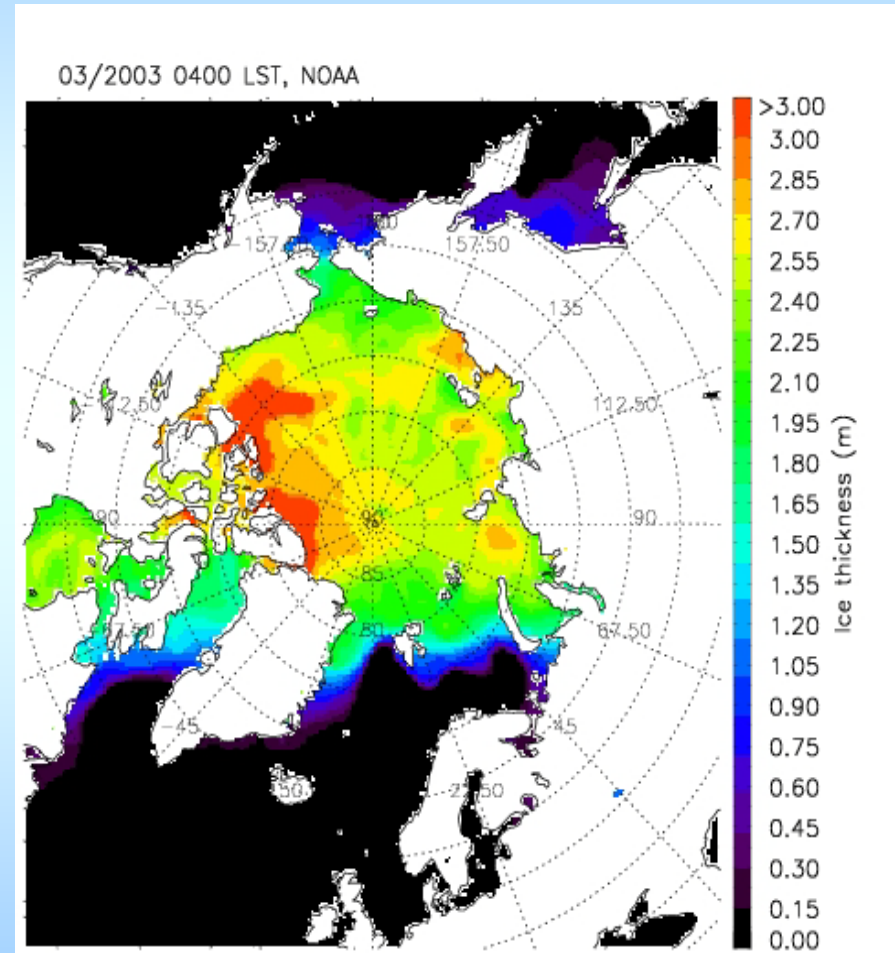
- Arctic and Antarctic

Time period:

- 1982~2004, currently

Spatial resolution:

- 25 km



Ice Age - Lagrangian Tracking

Algorithm:

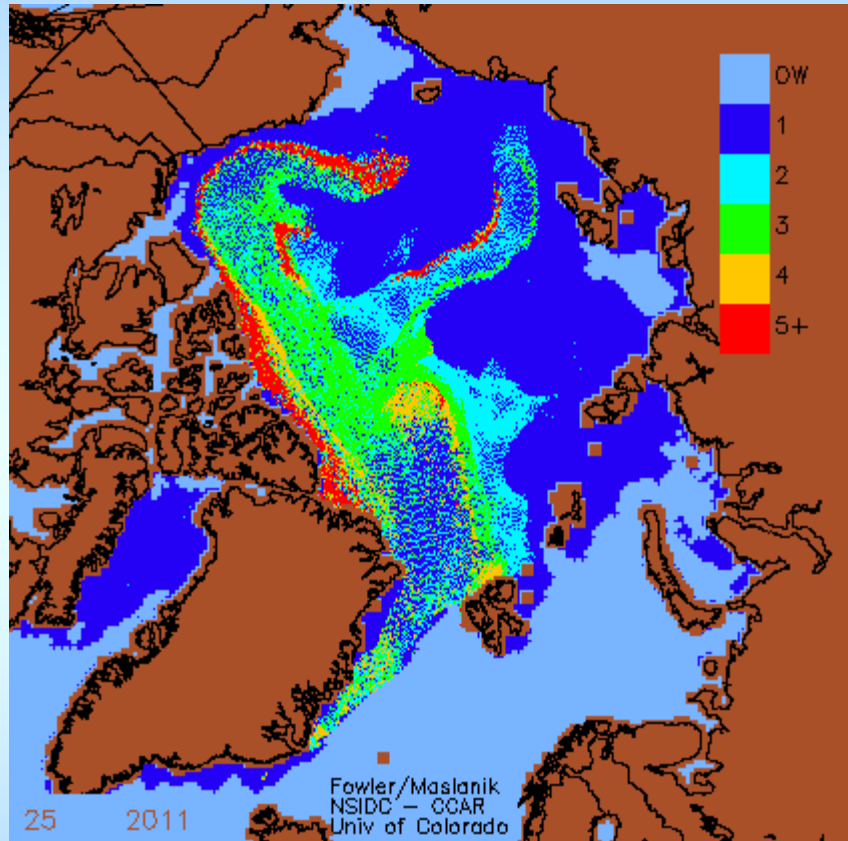
- Lagrangian tracking of ice to determine age. Empirical relationship between ice age and thickness.

Sensors:

- APP ice motion fields

Time period:

- 1980-July 2011, updated monthly



Ice/snow surface temperature

Algorithm:

- Split window technique using AVHRR channel 4 and 5 with cloud adjustment for cloudy sky condition for snow and ice surface.
- Similar method used for JPSS.

Sensors:

- AVHRR channel 4 & 5 or equivalent sensors with near-infrared and atmospheric window channels.

Area coverage:

- Arctic and Antarctic

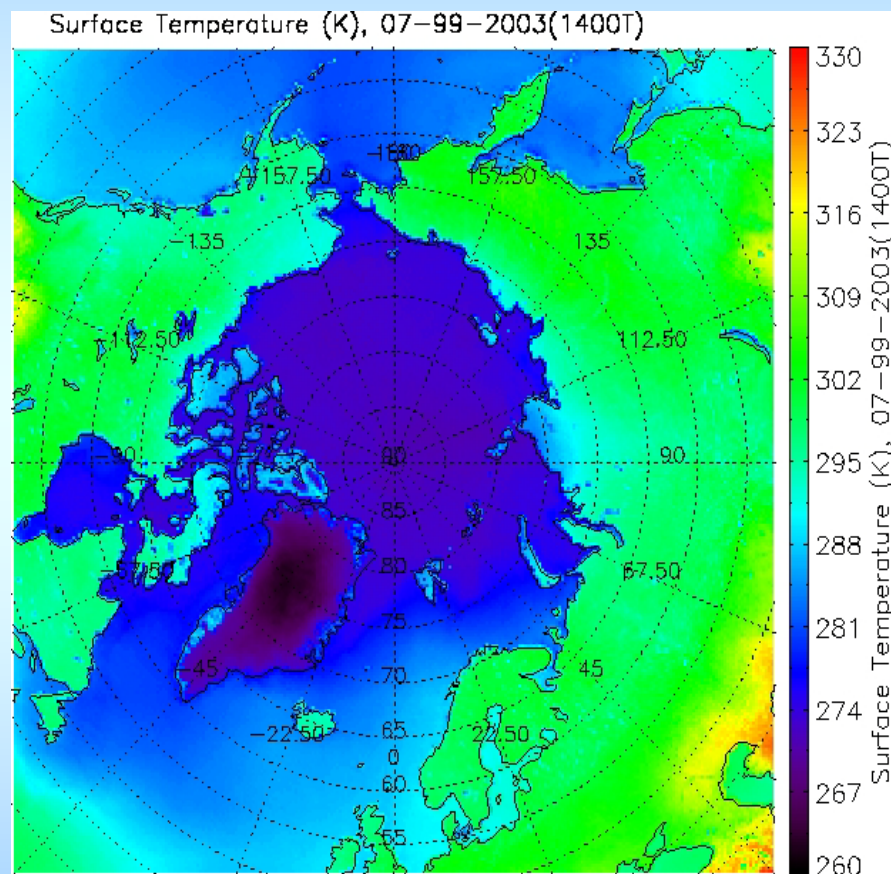
Time period:

- 1982~2004 (being updated through 2010 now)

Spatial resolution:

- 25 km for APP-X products (5 km for basic APP temperature and reflectance products)

Surface Skin Temperature



Greenland clear- sky surface temperature

Algorithm:

- Split window technique using MODIS bands 31 & 32

Sensors:

- MODIS Terra & Aqua

Area coverage:

- Greenland

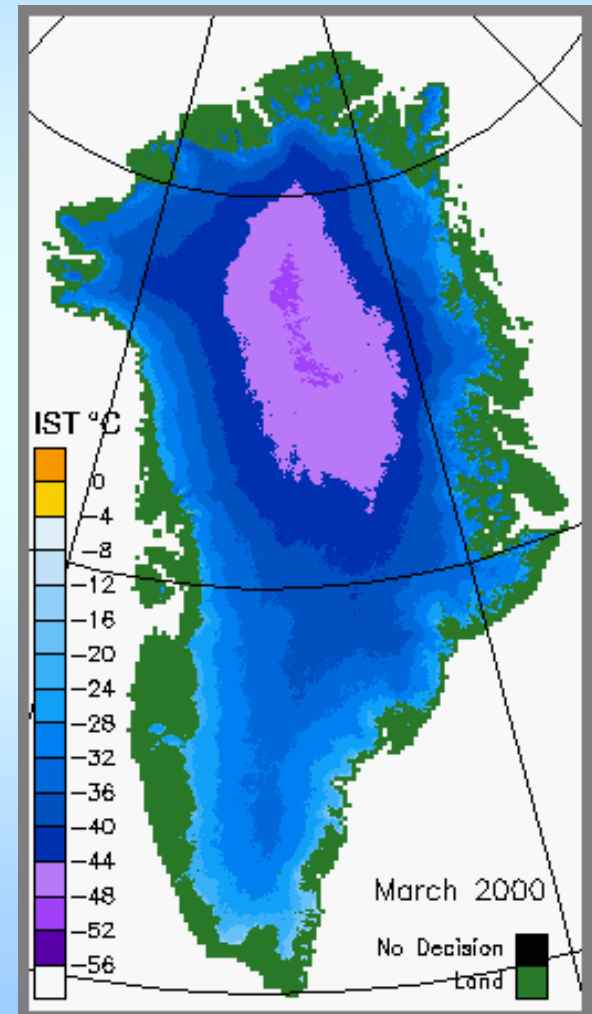
Time period:

- 2000-present, daily & monthly maps

Spatial resolution:

- 6.25 km, polar stereographic grid

Surface Skin Temperature



Ice/snow surface broadband albedo

Algorithm:

- Using AVHRR channel 1 and 2 with cloud adjustment for cloudy sky condition.

Sensors:

- AVHRR channel 1 & 2 or equivalent sensors with optical channels.

Area coverage:

- Arctic and Antarctic

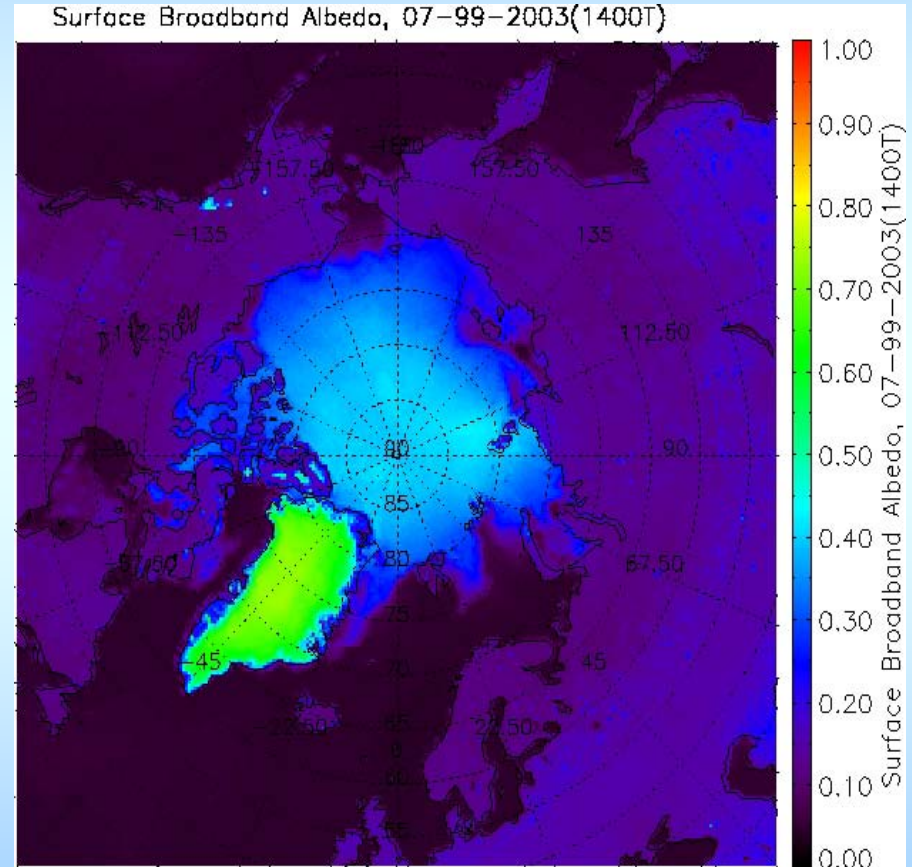
Time period:

- 1982~2004, currently

Spatial resolution:

- 25 km

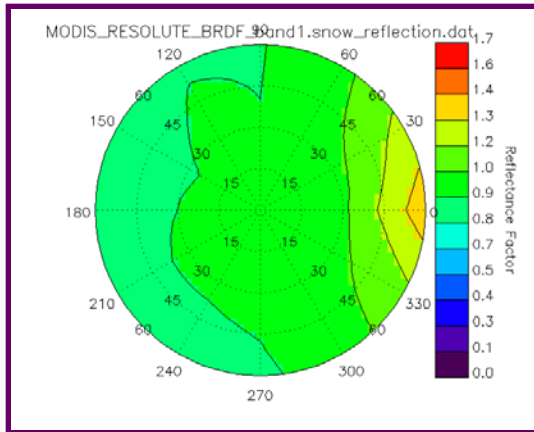
Surface Broadband Albedo



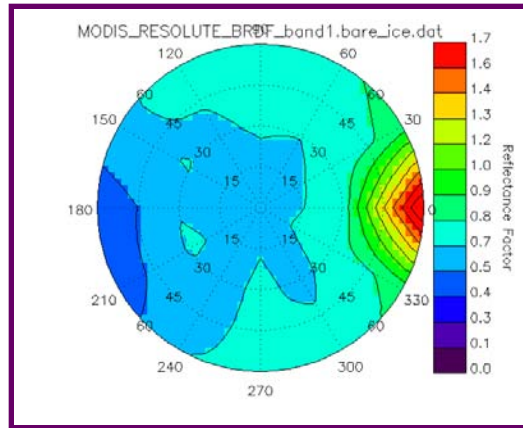
Examples of Sea Ice HDRF

MODIS Band 1 Integrated HDRF

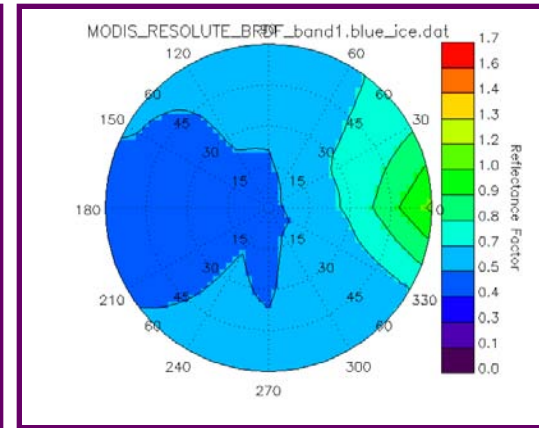
Snow



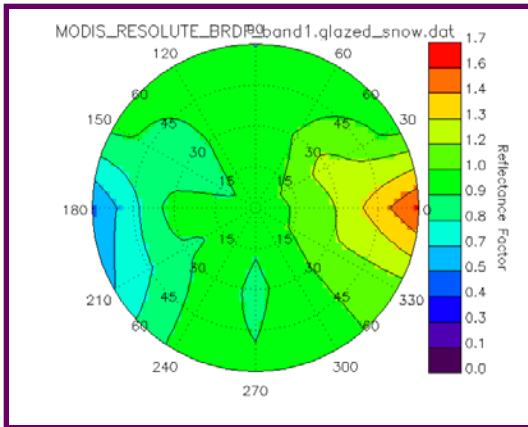
Bare Ice



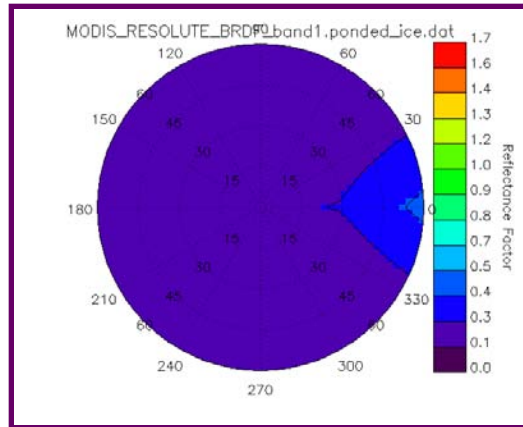
Blue Ice



Measurements near Resolute, AK



Glazed Snow



Ponded Ice

Strength of forward scattering peak depends on ice type.

Surface shortwave and longwave radiation

Algorithm:

- Forward radiative transfer calculation using a neural network version of radiation transfer model and derived products for clouds and surface properties.

Sensors:

- All AVHRR channels

Area coverage:

- Arctic and Antarctic

Time period:

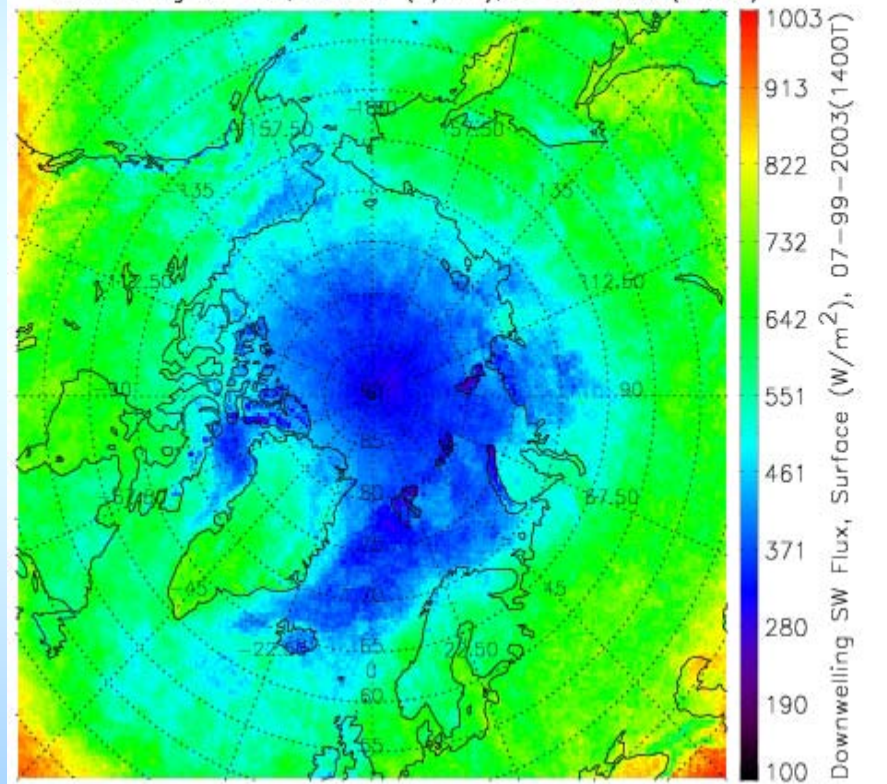
- 1982~2004, being updated through 2010 now

Spatial resolution:

- 25 km

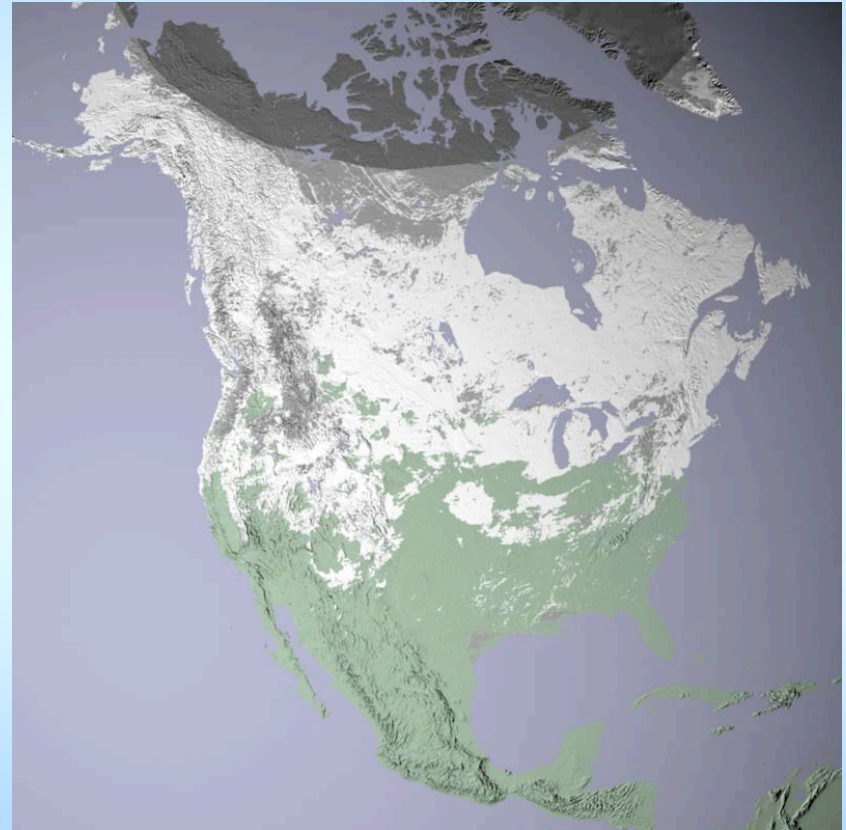
Surface shortwave radiation flux, downward

Downwelling SW Flux, Surface (W/m^2), 07-99-2003(1400T)



Northern Hemisphere Snow Extent Earth System Data Records

- Assess compliance of current NH snow cover products over land, sea ice and the Greenland ice sheet with NRC Climate Data Record (Earth System Data Record) characteristics
- Blend data records using statistical measures to develop enhanced, ESDRs of NH snow conditions
- Make the ESDRs and associated products available to the user community via an existing web site (<http://climate.rutgers.edu/snowcover/>) and encourage their use.
- Use MODIS snow products for validation of enhanced ESDR, and for snow mapping since 2000



Melt Onset

Drobot-Anderson Algorithm:

- Passive microwave temperature difference between 19 and 37 GHz channels

Sensors:

- SMMR, SSM/I (future: SSMIS, AMSR-E)

Time period:

- 1982-2007, currently

Smith, Markus, Miller Algorithm:

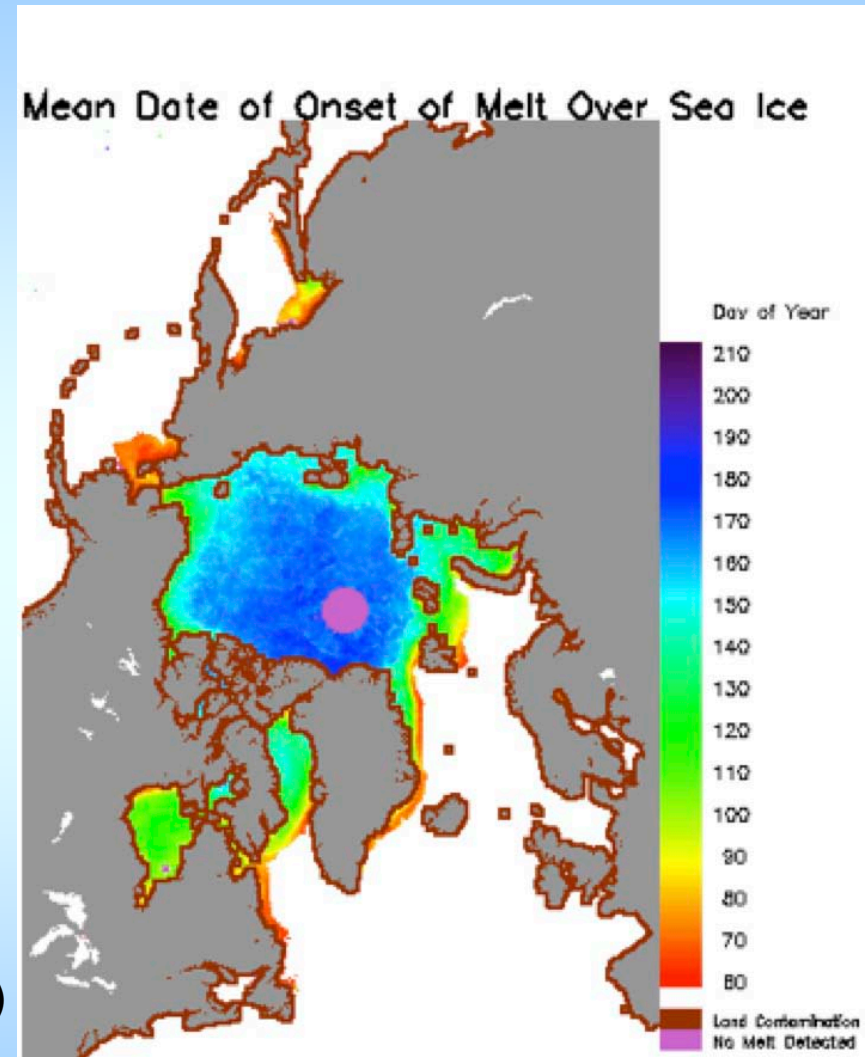
- Passive microwave temperature difference between 19 and 37 GHz channels. Includes “early melt” and freeze-up parameters as well.

Sensors:

- SMMR, SSM/I (future: SSMIS, AMSR)

Time period:

- 1982-2008, currently



Results/Accomplishments (1)

- *Scientific discovery:* Listed on the “Benefits to Science Community” slide.
- *Daily data quality fields are being implemented in the passive microwave ice concentration CDR.* The fields will include data values (e.g., concentration difference between algorithms) and quality flags. Metadata fields have now been developed, based on ISO 19115-2.
- Near-real-time sea ice products are being produced from *the newest DMSP sensor, the F17 SSMIS.*
- *Ice motion vectors have been calculated from AMSR-E* and compared to those from SSM/I, with the intent of generating motion vectors for the full AMSR-E time series.
- *The sea ice motion time series has been and continues to be updated.*
- The passive microwave sea ice concentration products provide the basis for regular scientific analysis of conditions at the NASA and NOAA funded “NSIDC Arctic Sea Ice News and Analysis” (ASINA) website. The passive microwave sea ice products also provide input and a baseline for evaluation for the ARCUS/SEARCH Sea Ice Outlook.

Results/Accomplishments (2)

- The *Lagrangian tracking ice age product has been updated through the present* and continues to be updated monthly, with the improved vectors used for age calculation. An accuracy/quality assessment of the ice age data has been completed.
- *The entire (1979-2010) ice age time series was re-processed* using 15% ice concentration values, vs. 40% used previously to improve consistency with other data sets (e.g., NIC charts). After evaluation of this new threshold and updating the ice age software to correct for introduced error, we are now proceeding with using the 15% concentration in the standard product.
- *APP-x has been reprocessed. Many algorithm refinements have been made* for the extended AVHRR Polar Pathfinder (APP-x), *including the addition of ice concentration and thickness/age*. Validation efforts have provided quantitative error assessments.
- *Improvements to calibration and composite processes of APP* have been made for a more consistent dataset. Extension of APP-x to the present is underway.

Results/Accomplishments (3)

- *A comparison of surface temperature over Greenland from AVHRR and MODIS* has shown that APP-x underestimates the temperature relative to MODIS, with a lower bias observed during the summer months, however, the products agree well under clear skies. A comparison of the APP-x temperature data with drifting buoy temperatures show good agreement during the non-melt period, with a slight bias during melt.
- Field measurements of the directional reflectance of snow, exposed ice, ponded ice, and combinations of the above are being processing in order to lay the framework for improving the albedo retrieval by improving the angular dependence model (ADM) used to convert the directional measurement to an albedo.
- *A comparison between Northern Hemisphere snow cover using NOAA and Rutgers snow maps* from 1966 through the MODIS era (2000 – present) has begun.

Results/Accomplishments (4)

- *A WCRP workshop that focused on essential climate variables, including sea ice, was held in Frascati, Italy, in May (2011). Key was a co-organizer; Meier attended and discussed sea ice CDRs. It was decided that an inventory of ECV data sets will be developed. It is likely that the inventory will be established at the NOAA Global Observing Systems Information Center (GOSIC), and the admission of new datasets into the inventory will be managed by the GCOS Panels.*
- The WCRP Climate and Cryosphere (CliC) project funded a *workshop on sea ice concentration products* in early 2011 (DC area). W. Meier organized the workshop.
- *A project web site has (just) been established that includes an online forum (<http://stratus.ssec.wisc.edu/cdrcryo>)*

PM Sea Ice Concentration Validation Approach

- Several independent validation case-studies over many years, e.g.:
 - Andersen et al., JGR, 2007: intercompared six algorithm products
 - Meier, IEEE TGRS 2005: compared four algorithms against AVHRR
 - Cavalieri et al., IEEE TGRS, 2003: AMSR-E with Landsat and airborne imagery
 - Steffen et al., AGU Geophys. Monograph 68: comparison with Landsat
- General uncertainties 5-10% concentration, but higher biases under many conditions (melt, thin ice, near ice edge)
 - Validation conclusions depend on location and season of case studies
 - Relative performance of algorithms varies with conditions and no one algorithm clearly superior
- Best approach for internal, NRT validation is running secondary algorithms and ancillary products (e.g., melt onset) to provide a data uncertainty/quality estimate at each grid cell
 - Key ancillary parameters selected and will soon be implemented and made available for review by users
 - Algorithm workshop planned for spring 2011 to bring algorithm producers and users together to evaluate algorithms and data quality parameters

Ice Age/Thickness Validation Approach

Lagrangian Ice Age

- Compare spatial patterns of ice age to aircraft data from multiple existing efforts (NASA AMSRice03, NASA AMSRice06 validation campaigns, IceBridge flights (imagery and LIDAR profiling), recent Characterization of Arctic Sea Ice Experiment UAS flights (imagery, LIDAR, radar).
- Examine temporal and spatial consistency compared to complementary satellite data (ICESat, QuikSCAT, AMSR-E, ENVISAT).
- Evaluated the effects of using AMSR-E derived ice motion fields to test sensitivity to variations in ice motion accuracies. Less RMS differences with buoys.

Energy Budget Ice Thickness:

- OTIM retrieved ice thickness with AVHRR, MODIS and SEVIRI were validated with in-situ observations, e.g., from submarine, mooring, and meteorological stations (Wang, Key, and Liu (2010), A thermodynamic model for estimating sea and lake ice thickness with optical satellite data, J. Geophys. Res.)

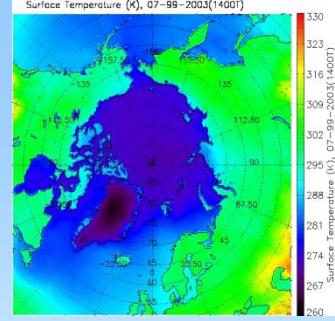
IST, Albedo, Radiation Validation Approach

- APP-x products were validated with in-situ observations, e.g., from SHEBA and meteorological stations (Xuanji Wang and Jeffrey R. Key, 2005, Arctic Surface, Cloud, and Radiation Properties Based on the AVHRR Polar Pathfinder Data Set. Part I: Spatial and Temporal Characteristics, J. Climate, Vol.18, No.14, 2558-2574, 2005.)
- Sea ice concentration from vis/IR was validated with ice products from microwave observations, and retrieved sea ice motion was validated with in-situ buoy data. This is ongoing in GOES-R and NPP cal/val projects.
- MODIS Greenland ISTs for the winter of 2008-09 at Summit, Greenland, were compared with ground measurements showing ~3K lower temperatures under clear sky conditions than in-situ measurements; further validation using AWS data is ongoing (see Hall et al., submitted to J. Climate).

Sea Ice Motion Validation Approach

- Product has been validated vs. various data sets by multiple investigators. These efforts will continue.
- The effects of loss of tracking during parts of the summer (due to surface melt) on ice motion errors is being evaluated.
- Comparisons to modeled surface winds.

Maturity Index: Summary



(Qualitative average. Details on following slides)

Sea ice concentration and extent: **5**

Sea ice motion: **5**

Sea ice age – Lagrangian: **3**

Sea ice thickness/age – energy budget: **4**

Ice/snow surface temperature: **4.5**

Ice/snow surface broadband albedo: **4.5**

Surface shortwave/longwave radiation: **4.5**

Snow cover/extent: **5**

Surface ice melt onset/freeze-up: **4**

CDR Maturity Matrix – Sea Ice Concentration (as of October, 2011)

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
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	ATBD Review
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.	NOAA Operations Review
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.	Source code released; 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	Source code portable and released; Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators	CDR Certification Review
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	Source code portable and released; Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators	

CDR Maturity Matrix – Sea Ice Motion

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none	
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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.	Source code released; 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	Source code portable and released; Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators	CDR Certification Review
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	Source code portable and released; Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators	

CDR Maturity Matrix – Lagrangian Ice Age

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
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	ATBD Review
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CDR Maturity Matrix – Energy Budget Ice Thickness

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
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	ATBD Review
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CDR Maturity Matrix - Ice/Snow Surface Temperature

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none	
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CDR Maturity Matrix - Ice/Snow Surface Albedo

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none	
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CDR Maturity Matrix – Surface Radiative Fluxes

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none	
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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.	NOAA Operations Review
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Issues/Risks & Work- Off Plans

- Current or possible future problems:
 1. Many difference passive microwave sea ice concentration products – not complete consistency with NASA Goddard products.
 2. Ice age from Lagrangian tracking is less mature, but potentially valuable.
 3. Extending APP (hence APP-x) in time beyond 2009 is not funded.
 4. Combining IST data from APP/APP-x and MODIS over Greenland has proven to be difficult (and not entirely successful).

- Approaches to work around or mitigate the problem(s):
 1. Continue to compare ice concentration products. Possibly include differences in quality fields.
 2. Continue validation efforts for ice age. New version of ice age product will be delivered to NSIDC/NOAA.
 3. Implement APP processing at CIMSS (underway).

Schedule

Year 2

- *Reprocess APP-x* products from 1982 to present. Update and extend APP-x *metadata* and documentation; compare with MODSI ISTs over Greenland.
- Passive microwave: Complete the development of *data quality fields* and request feedback from the community, host a CliC-funded *workshop* on sea ice concentration products, and implement metadata fields and produce for the current sea ice products. Investigate *other sea ice algorithms* methods for possible inclusion in the concentration CDR and/or data quality fields.
- *Update ice age* products and continue validation.
- Work with Rutgers (D. Robinson) in *combining MODIS and Rutgers snow cover*.

Year 3

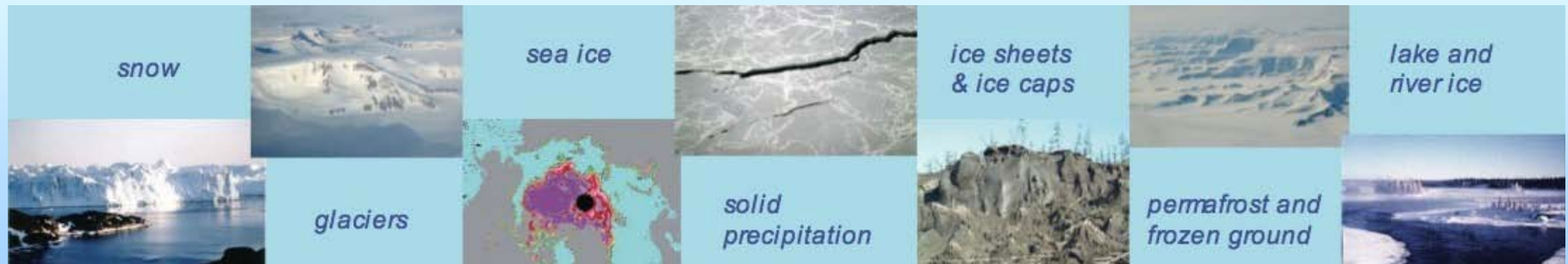
- Extend APP-x and passive microwave products through 2011 and implement routine updating. *In progress*
- Deliver products and documentation to the appropriate data center. *In planning stage*
- Transition APP-x algorithms to NPP VIIRS product processing, and evaluate the performance for NPP VIIRS products. *In progress*

Transition Plan

- DOCUMENTATION (~July 2012)
 - Climate Algorithm Theoretical Basis Document (C-ATBD)
 - See CDR web site: <http://www.ncdc.noaa.gov/cdr/guidelines.html>
 - C-ATBD template is listed under “Development Guidelines”
 - Data Flow Chart and Maturity Matrix: Matrices are done; flow charts TBC
 - See CDR web site: <http://www.ncdc.noaa.gov/cdr/operationalcdrs.html>
 - Examples are in the right column
- DATA SET(S) (~July 2012)
 - Format: netCDF
 - Quality of Metadata: Good; needs to be better
 - Size of data set: TBD; APP-x: ~6 GB; ...
- SOURCE CODE (~July 2012)
 - Level of Documentation: Good
 - Language: Some C, some Fortran
 - README: To be added
- CONCERNS (Risks): *Next slide*

Transition Plan, cont.

- CONCERNS (Risks):
 - Does NCDC want to/need to host all products? Some datasets are better left at elsewhere, e.g., passive microwave sea ice concentration at NSIDC; MODIS snow cover at GSFC. This needs to be discussed (Donna Scott from NSIDC is at this meeting.)
 - From the original program announcement: “Over the longer term, NOAA may seek to consolidate some or all routine production activities around its operational Centers and/or NOAA Cooperative Institutes. Applicants should consider any CDR, proposed in response to this Announcement, as eligible for such migration and transition. However, no funds awarded under this competition can be used for CDR migration and transition to NOAA.”
 - The Cryosphere Team is addressing the major cryosphere elements (snow cover, sea ice concentration, sea ice thickness and age), but not all of the cryosphere. This is not an issue, just a clarification.



Benefit to the Science Community

- User communities: Climate scientists, modelers (for verification), remote sensing scientists, Global Cryosphere Watch (GCW)
- Scientific discovery:
 - *The loss of the oldest, thickest Arctic sea ice continues at a record pace through mid-2011.* Viewed along with model estimates of low ice volume at the start of the melt season, it is likely that ice extent for September 2011 will continue the recent history of extreme seasonal minima. *The thinner ice cover is responding more dramatically to synoptic-scale variation both in the winter and summer (e.g., Maslanik, et al. Geophys. Res. Lett., July 2011).*
 - *Changes in sea ice concentration and cloud cover played major roles in the magnitude of recent Arctic surface temperature trends.* Significant surface warming associated with sea ice loss accounts for most of the observed warming trend. In winter, cloud cover trends explain most of the surface temperature cooling in the central Arctic Ocean.
 - *The APP-x product was recently used to study of controls on snow albedo feedback (SAF), which is important for assessing the validity of feedbacks in global climate models.*
 - An analysis of passive microwave sea ice concentration and MODIS cloud amount quantifies the effect of changes in sea ice extent and concentration on cloud amount. *A 1% decrease in sea ice concentration corresponded to 0.14~0.34 percent increase in cloud amount in different seasons.*
 - Surface-temperature measurements of the Greenland Ice Sheet can be used to study temperature and melt trends.

Benefit to Society

- **Climate science**
 - Understanding climate change; scientific discovery (previous slide)
- **Weather forecasting and climate prediction**
 - Snow cover and ice concentration products are used to improve weather forecasts and in climate prediction.
- **Transportation**
 - Government and private industry can use the sea ice data to evaluate regional changes and assess the potential impacts on infrastructure (e.g., oil rigs), navigation, marine safety and security, recreation, hunting, and wildlife.
- **Water resource management**
 - Snow cover data can be used to assess the variability in water supply for agriculture, hydropower, and potable water.
- **Wildlife management**
 - The ice age product has been used to assess potential long-term survival of polar bears and for research aircraft flight planning (<http://content.usatoday.com/communities/sciencefair/post/2010/12/ic-e-refuge-may-be-polar-bears-last-stand/1>).

Resources

- Number of personnel employed for project
 - CIMSS & STAR: 3 (~1.2 FTE)
 - CU/CCAR & NSIDC: 5 (~2.0 FTE)
 - NASA GSFC: 1 (~0.1 FTE)
- Key equipment or observatories used
 - None
- Key collaborating projects or personnel
 - NSIDC, MODIS & Rutgers snow cover projects, GOES-R and NPP/JPSS snow/ice, WMO Global Cryosphere Watch, EUMETSAT SAF, WCRP CliC,
- NOAA points-of-contact or collaborators, as applicable
 - Jeff Key, NOAA/NESDIS/STAR, Madison, WI
 - NASA: Dorothy Hall, GSFC, Greenbelt, MD
- Target NOAA Data Center:
 - NCDC, NSIDC