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Snow and Ice Gridding Status and Recommendations

May 14, 2014

Robert Mahoney (NGAS)
Rich Dworak (UW/SSEC)
Paul Meade JPSS Cryosphere JAM
Marina Tsidulko (NOAA STAR/AIT)

Overview

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- Current Status – Monthly Manual Updating of Gridded Snow/Ice Rolling Tiles with NOAA Global Automated Multi-sensor Snow/Ice (GMASI)
- Near Term Plan – Daily Automated Updating of Gridded Snow/Ice Rolling Tiles with GMASI
- Gridding Tests Performed using VIIRS Snow/Ice with GMASI as Fallback
- Recommendations

(1) Current Status – Monthly Manual Updating of Gridded Snow/Ice Rolling Tiles with NOAA Global Automated Multi-sensor Snow/Ice (GMASI)

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Current Status – Monthly Manual Update of the Gridded Snow/Ice Rolling Tiles (IVGSC)

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- **Monthly Fast Track** updating of the Snow/Ice Cover Rolling Tiles is currently being performed
  - – Based on the "NOAA AutoSnow" 4 km, Global Multisensor Automated Snow/Ice cover (GMASI) product
  - – Based on NOAA AutoSnow for 15th of each month
  - – Manual processing to generate IDPS Sinusoidal Gridded Snow/Ice Rolling tiles (IVGSC)
  - – Delay of 1 to 2 weeks after the 15th of each month for the update to become operational
    - time required for manual tile generation, AERB FastTrack process and IDPS implementation
  - – Operational Snow/Ice Rolling tiles are 5 to 6 weeks old by the time of the next update
  - – Need more frequent (daily) updates for downstream product quality

(2) Near Term Plan – Daily Automated Updating of Gridded Snow/Ice Rolling Tiles with GMASI

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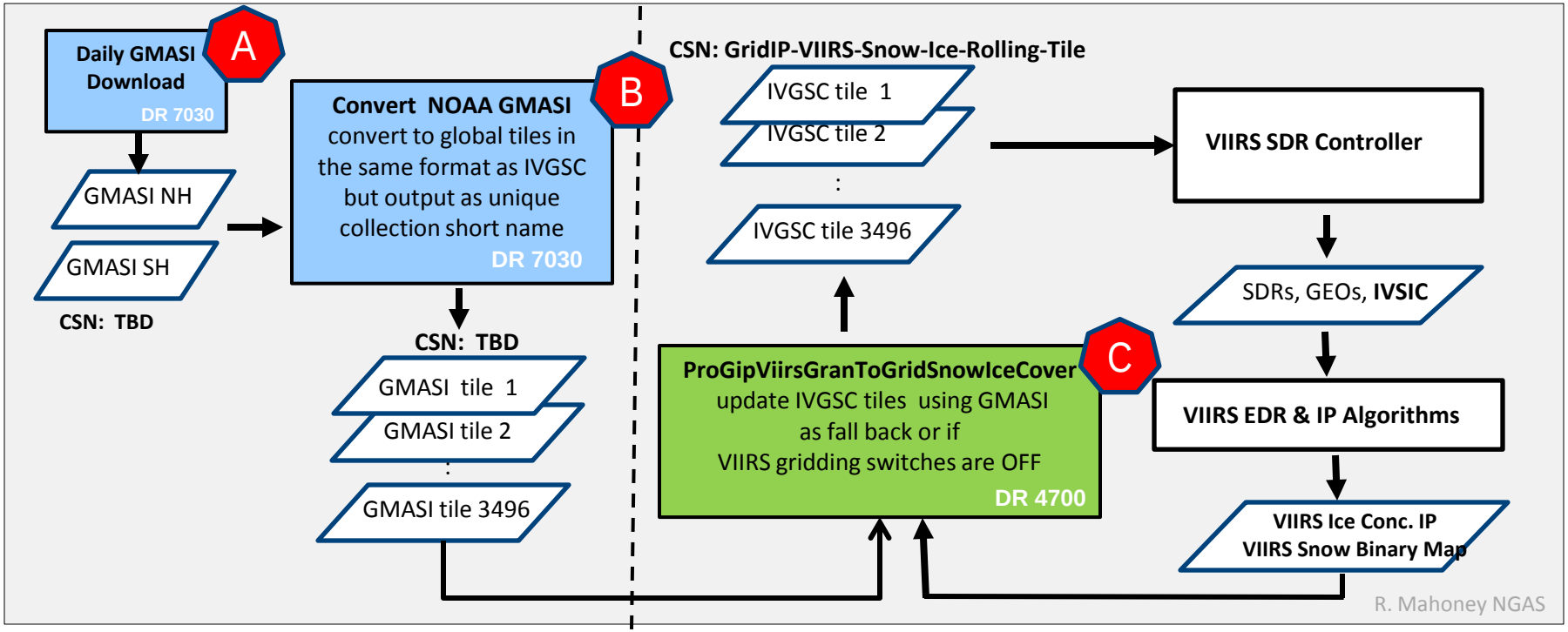
Near Term Plan - Daily Automated Updating of IVGSC Tiles with NOAA GMASI Data



- **Stage A: CCR 13-1082 (ADR 7030**) implements daily automated acquisition of North and South Hemi. NOAA Global Multi-sensor Automated Snow/Ice (GMASI NH and SH) data files
- **Stage B: CCR 13-1082 (ADR 7030**) implements IDPS conversion of GMASI NH and SH files to global sinusoidal tiles in the same format as the NPP IVGSC tiles as a new collection short name entity
- **Stage C: CCR 13-1043 (ADR 4700**) implements code changes to the ProGipViirsGranToGridSnowIceCover routine to allow updating of IVGSC tiles using VIIRS Snow/Ice with GMASI as fall back **or** to **perform daily updating with only GMASI data if VIIRS snow/ice gridding switches are set to OFF**

GMASI Implementation Stage A

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- NOAA OSPO Produces Daily Snow/Ice Data
  - NH: 4 km IMS (Interactive Multisensor Snow product)
  - SH: 2 km AutoSnowIce
- NOAA OSPO delivers Daily Snow/Ice Data to NOAA TOC
  - 2 Files: NH, SH
- File Transfer from NOAA TOC to IDPS
  - Same as for other ODAD

GMASI Implementation Stage B

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- IDPS Conversion: IMS/AutoSnowIce 

GMASI
  - GMASI Format / Data Values Homologous to IVGSC (Snow/Ice Rolling Tiles)
  - 3436 Tiles, Sinusoidal Projection

- *Example* Conversion Scripts Provided by VIIRS Cryosphere Cal/Val Team (CCR 13-1082)
  - ~ 800 MatLab SLOC (including I/O and whitespace)
  - Technical Guidance Memo titled "NG_TechMemo_Conversion of_NOAA_IMS_and_AutoSnow_to_SinGrid.doc" (R. Mahoney/NGAS)

GMASI Implementation Stage C

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- Modified IDPS & Algorithm Code Provided by Cryosphere Cal/Val Team (CCR 13-1043)
  - M. Tsidulko (NOAA STAR AIT) / R. Mahoney (NGAS)/P. Meade (Cryospshere JAM)
  - C++ Source:
    - 11 Modified Files, ~340 SLOC modified
    - 2 New Files, ~400 SLOC total
  - XML Source (configuration):
    - 2 Modified Files, ~140 SLOC modified
    - 1 New File, ~200 SLOC total
  - Approved by AERB

Near Term Plan for Daily Updating of the Snow/Ice Rolling Tiles with GMASI– Key Points

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- Modified Snow/Ice GranToGrid code (ADR 4700) introduces **two gridding switches** (VIIRS Snow and Ice gridding switches) that allow activation of the Snow/Ice GranToGrid in four possible states:

  1. Gridding Switches for VIIRS Snow and Ice both set to **OFF** results in:
     - Snow/Ice Rolling Tiles updated daily, globally with GMASI
  2. Gridding switches for VIIRS Snow and Ice both set to **ON** results in:
     - Snow/Ice Rolling Tiles updated using VIIRS Snow and Sea Ice and GMASI as fallback
  3. Gridding switches for VIIRS Snow set to **ON** and VIIRS Ice to **OFF** results in
     - Snow/Ice Rolling Tiles updated based on VIIRS Snow Cover EDR and GMASI as fallback over land and GMASI only over oceans
  4. Gridding switch for VIIRS Snow set to **OFF** and VIIRS Ice set to **ON** results in
     - Snow/Ice Rolling Tiles updated based on VIIRS Sea Ice Concentration and GMASI as fallback over oceans and GMASI only over land

- VIIRS Cryosphere Cal/Val Team recommends daily updating *initially* with GMASI data ONLY (VIIRS snow and ice gridding switch both set to “OFF”)

Note: Algorithm switches allows for testing of VIIRS Snow and Ice gridding separately

(3) Gridding Tests Performed using VIIRS Snow/Ice with GMASI as Fallback

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Gridding Tests for Updating Snow/Ice Rolling with VIIRS Snow/Ice + GMASI

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- Gridding Tests Performed to Determine Additional Quality Controls Required for Activation of VIIRS Snow/Ice Gridding (with GMASI as Fallback)
  - Goal to determine whether a set of VIIRS based quality criteria, shown below, can allow VIIRS Snow/Ice Gridding to be activated or whether additional climatology based quality control measures such as used in the production of the NOAA AutoSnow product are required
- Gridding Tests Performed for Two 1 Week Periods in Aug, 2013
  - Aug 11-18, 2013 (Pre-MX 7.2) and Aug 21-27, 2013 (Post- MX7.2) periods
  - Stand alone Ice Concentration IP and Snow Cover EDR off-line gridding test implemented by Rich Dworak UW/SSEC for more flexible and efficient prototyping of gridding tests
- Quality Control Criteria Applied for Gridding Tests (VIIRS Based Q/C Tests)

	Quality Control Criteria	Comment
1	VCM confidently clear	Cloud confidence from IVIQF for Sea Ice Concentration IP Cloud confidence from VSCMO cloud confidence quality flag
2	No thin cirrus	Based on VCM thin cirrus flag
3	Solar Zenith angle threshold to mitigate cloud shadows	SZA < 85° Pre MX7.2 gridded SZA < 80° Post MX7.2 gridded
4	Standard VCM cloud adjacency (no cloud adjacency)	**Applied to Snow Cover EDR** (VSCMO) and Ice Concentration IP (IVIIC) based on the VCM cloud adjacency flag
6	Extended cloud adjacency filter	**Applied to Sea Ice Concentration IP** (pixels with more than 15% clouds in a 31x31 sliding window screened)
6	**ForceDayThreshold**	Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days (changed "**forceDayThreshold"** from 10day threshold)

VIIRS Snow/Ice Gridding Test – Post MX 7.2
No Extended Cloud Adjacency Filter

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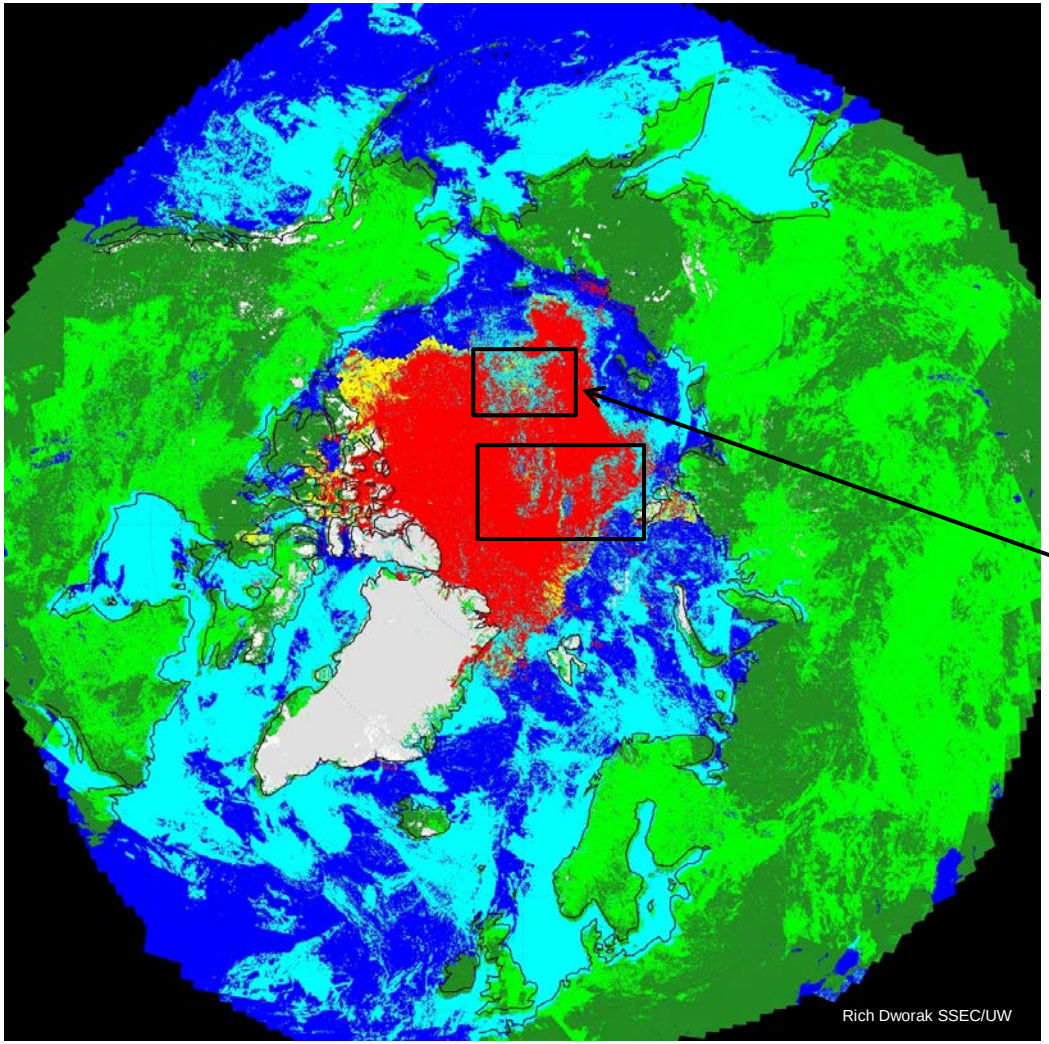

GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Missing Ice regions

Gridding Quality Criteria

1. **No Extended Cloud Adjacency**:
2. **Only SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

Gridding test results after a one week gridding period (Aug. 21-27, 2013). Regions of missing ice still appear in the grid (boxed regions) based on gridding using the standard VCM cloud adjacency quality control

NOAA AutoSnow Used as Reference VIIRS Snow/Ice Gridding Test – August 27, 2013

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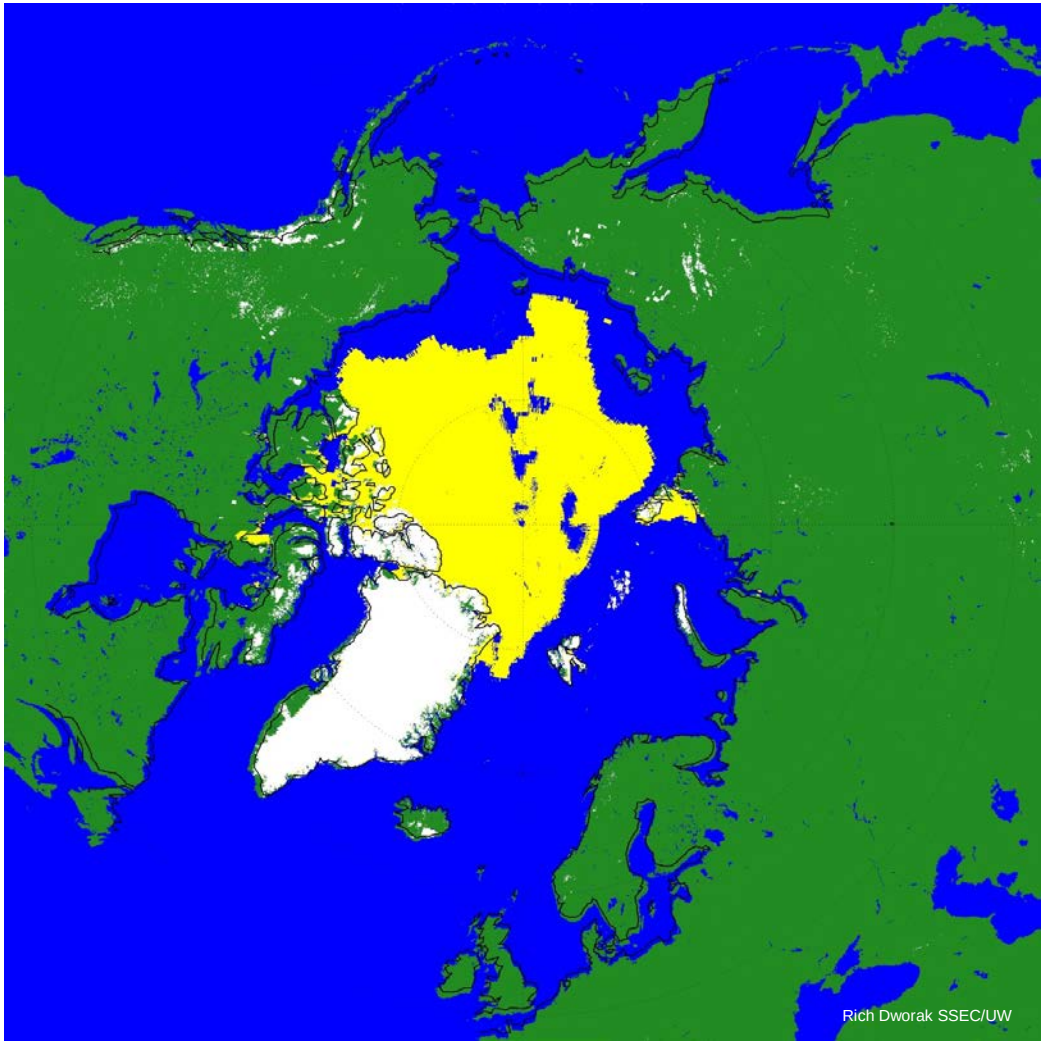

Ice over water
Snow over land
No Snow over land
No Ice over water

NOAA AutoSnow reference for the end of day of Aug 27 for the one week gridding period August 21-27, 2013

VIIRS Snow/Ice Gridding Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter

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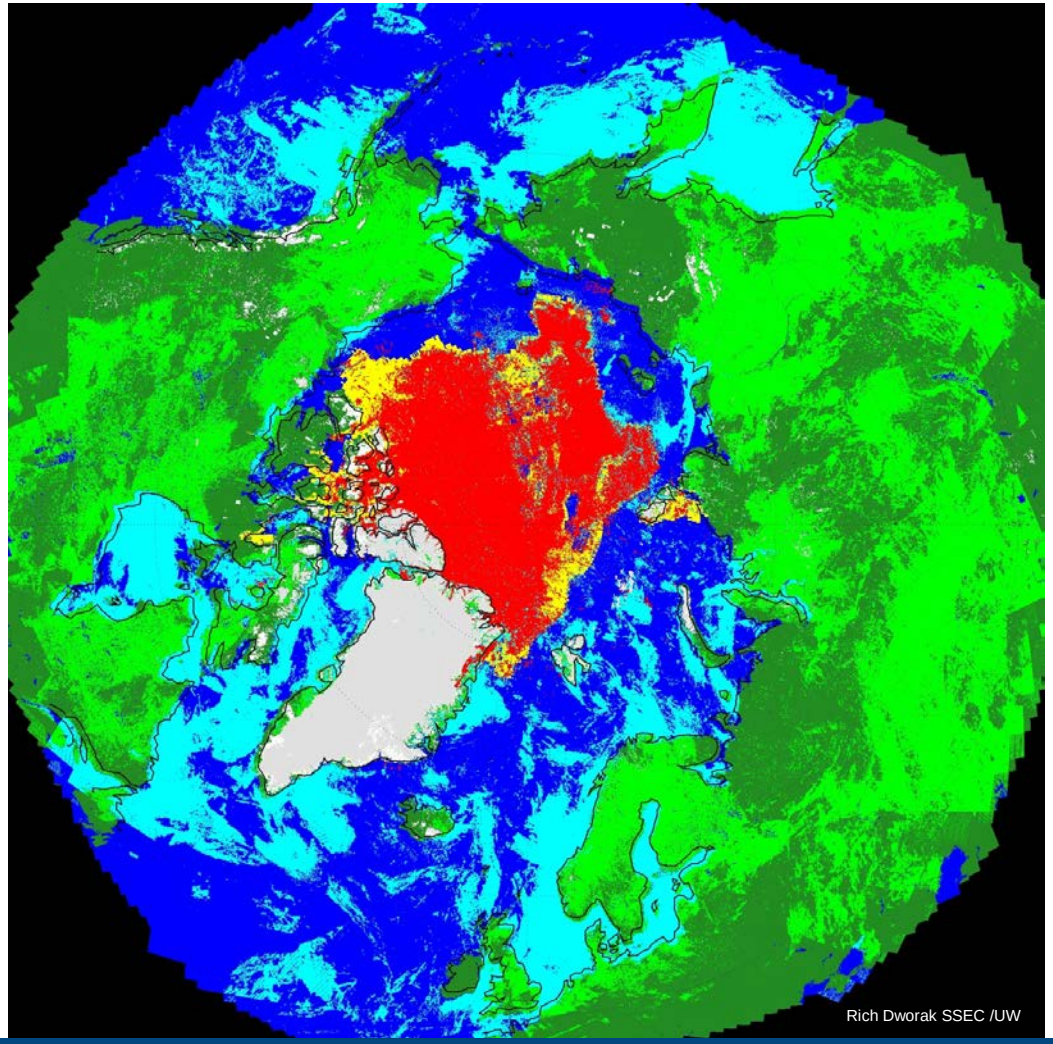


GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

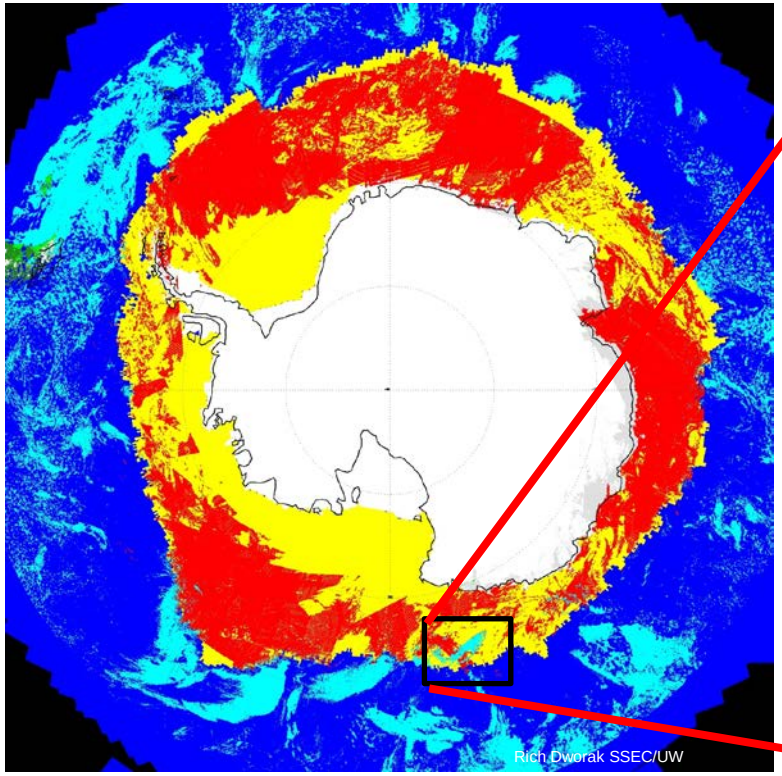
Gridding Quality Criteria

1. **Extended Cloud Adjacency**:
   - flag pixels with more than 15% clouds in a 31x31 sliding window
2. **SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

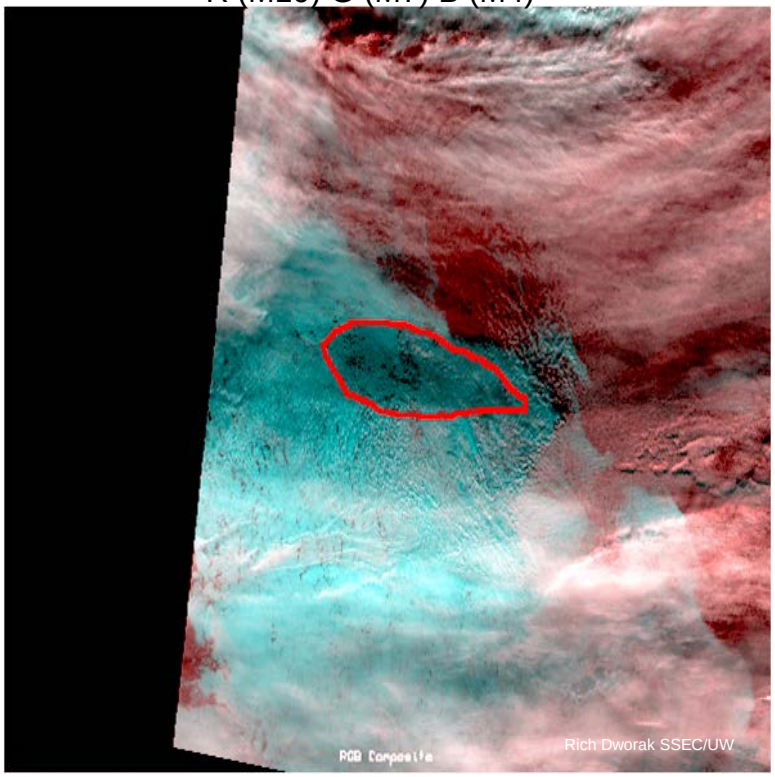
After application of an extended cloud adjacency filter to the Sea Ice Concentration IP, the gridded Snow/Ice at the end of the Aug. 21-27 gridding period is consistent with the NOAA AutoSnow reference for Aug. 27 but significant regions were not updated by VIIRS data even after the 7 day gridding test period . Standard VCM cloud adjacency is applied to Snow Cover EDR

Example of Missing Ice Due to Cloud Shadows

Antarctic August 18, 2013 Pre-MX 7.2



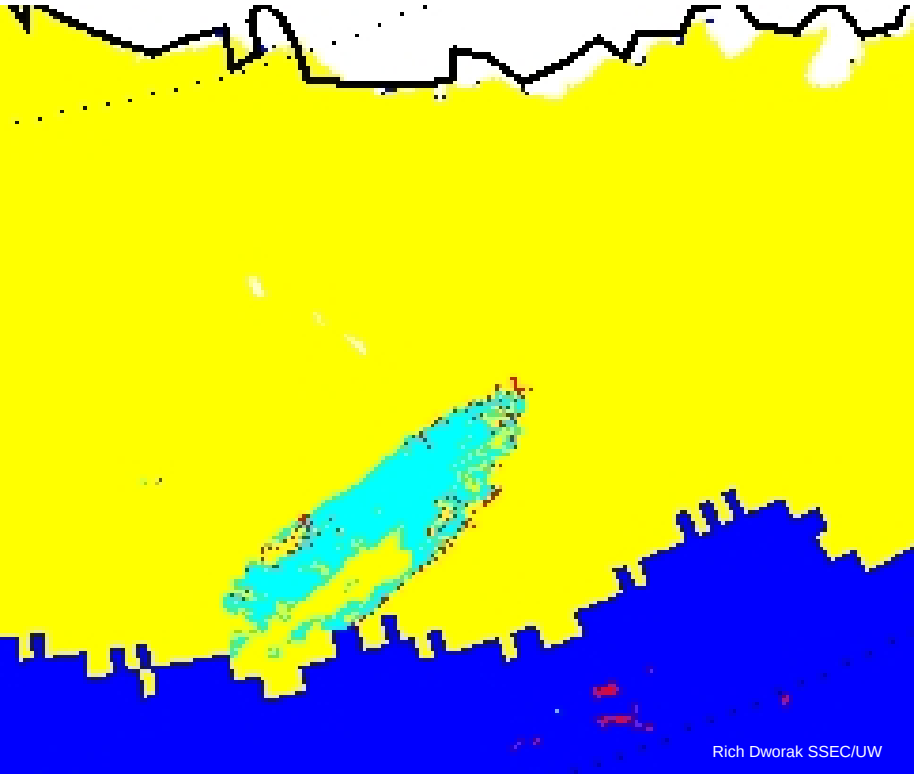
False Color SDR Reflectance for Region of Interest
R (M10) G (M7) B (M4)



A region of missing sea ice was detected in the gridding test for Aug. 11-18, 2013. Cloud shadow seen in the enhanced false color image. The missing ice in the box region over the Antarctic (left) is due to the Ice Concentration algorithm erroneously retrieving “No Ice” in the region of lower reflectance due to undetected cloud shadows.

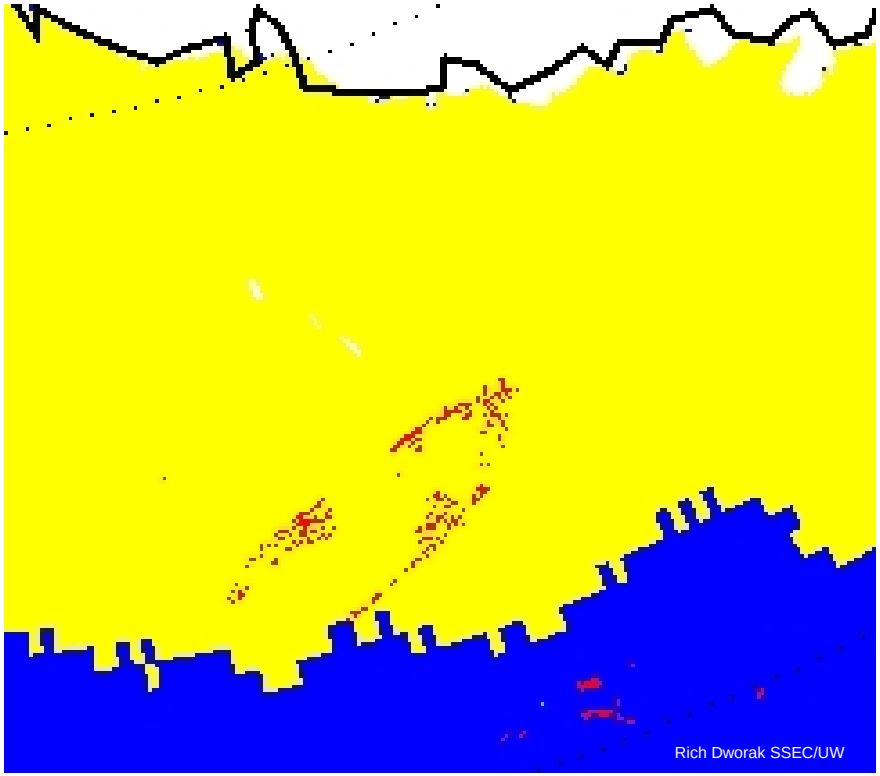
Antarctic Missing Ice Traced to 08/18/13 Orbit

Before



Missing Ice (light blue region) appears in the gridding test result for gridding for day only VIIRS data (Sol. Zen < 85°)

After



All missing ice detects removed with Sol. Zen. > 80 removed

Application of solar zenith angle threshold of 80° removed the missing ice associated with the cloud shadow. Although a solar zenith angle of 80° has been used for this gridding test it is recommended that the solar zenith angle threshold for gridding be tied to the VCM Cloud Shadow max solar zenith angle threshold (currently 75°) if VIIRS Snow/Ice Gridding is activated

Quantitative Comparison with GMASI Reference (NOAA AutoSnow) Snow/Ice Grid

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	Probability of Detection For VIIRS Updated Pixels		False Alarm Rate For VIIRS Updated Pixels	
	Sea Ice	Snow	Sea Ice	Snow
Northern H.	87.2 % (78.4%)	(87.8%)	6.6% (8.7%)	(10.0%)
Southern H.	94.4 % (92.8%)	(96.5%)	4.9% (5.6%)	(3.2%)

PoD = 100 x nSnowIceMatch/(nSnowIceMatch + nSnowIceMissing + nSnowIceFalse)

FAR = 100 x (nSnowIceFalse)/(nSnowIceFalse + nSnowIceMatch)

- Probability of detection and false alarm rate are shown for VIIRS updated pixels with all additional QC criteria applied
- Values shown in parenthesis have had No extended cloud adjacency filter applied
- PoD and FAR as defined here are relative to the NOAA AutoSnow product which used as the reference or derived truth

Probability of Detection (PoD) and False Alarm Rates (FAR) , shown above. Even after application of an Extended Cloud Adjacency filter, gridding only day pixels with Sol. Zen < 80° and all cloud mask elements confidently clear errors remain for VIIRS gridded sea ice.

Gridding Test Summary

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- Improvement in VIIRS gridded Snow/Ice due to MX 7.2 VCM update and application of additional quality control criteria which included:

    1. Extended cloud adjacency applied to Sea Ice Concentration IP
    2. Standard cloud adjacency applied to Snow Cover EDR
    3. Confidently clear pixels only
    4. No thin cirrus
    5. Solar zenith angle limited to angles less than 80°
    6. Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days

- Sea Ice PoD and FAR relative to NOAA AutoSnow for VIIRS gridded Sea Ice are approximately 87% and 7% respectively after testing with the proposed quality control criteria

- Significant regions were not updated by VIIRS Snow/Ice even after a 7 day gridding test period

- Cloud shadows result in missing snow/ice in the Snow/Ice Rolling Tile grid. A solar zenith angle threshold of 80° used in the gridding tests appeared to mitigate cloud shadow errors.

- Gridding tests did not include Northern Hemi. Winter which is important for testing snow cover gridding

- Further reduction in Snow/Ice gridding errors will require significant effort to implement climatology based quality control criteria used for the production of the NOAA AutoSnow and additional quality control criteria

(4) Recommendations

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Recommendations

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- Implement Near Term Plan to Update the Snow/Ice Rolling Tiles Daily with GMASI
  - Activate Snow/Ice GranToGrid with VIIRS Snow and Ice Gridding Switches OFF
- Daily updating with GMASI is most likely adequate for downstream product quality
  - After daily GMASI updating becomes operational downstream products should be evaluated to determine whether further improvements are needed
  - Activation of VIIRS Snow or Ice gridding requires additional quality controls such as those used in the production of the NOAA AutoSnow product and should be tested only after being determined as necessary due to the significant level of effort associated with implementing such controls

Backup Slides

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Gridding Tests Based on Post MX 7.2 Improved VCM

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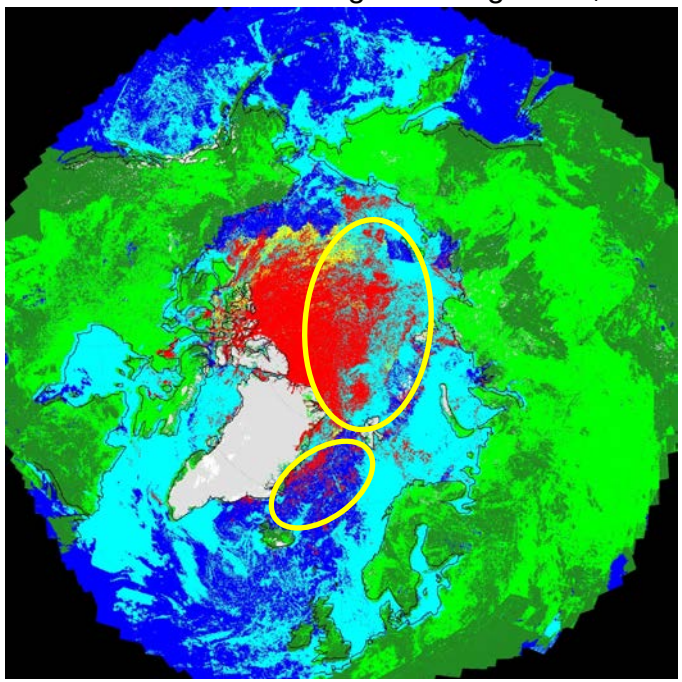
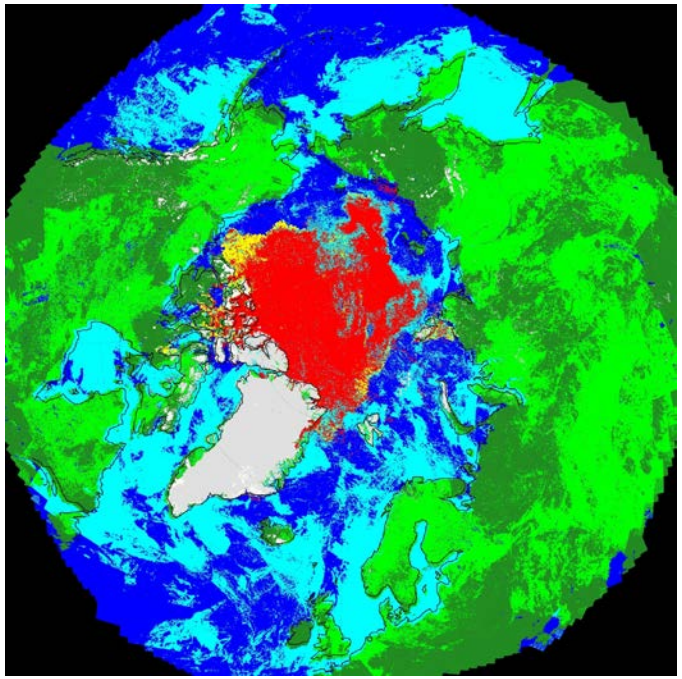
- MX 7.2 VCM Updates – Implemented at IDPS on Aug. 20, 2013
  - –Significant improvement to snow/ice/cloud differentiation in daytime scene (ADR 7018)
  - – Added thresholds for the gross nighttime Infrared (IR) and Mid-Wave IR difference cloud detection test (ADR 7018). Also corrected logic for cloud shadows (ADR 7028)

VIIRS Gridded Snow/Ice – Pre MX 7.2
End of 1 Week Gridding Test August 18, 2013



VIIRS Gridded Snow/Ice – Post MX 7.2
End of 1 Week Gridding Test August 27, 2013



GMASI

- Ice over water
- Snow over land
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VIIRS Updated

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- Snow over land
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- No Ice over water

Gridding Quality Criteria

1. **No Extended Cloud Adjacency**:
2. **Only SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

Gridding tests performed with Post MX 7.2 data (right) showed significantly less missing ice and false ice over the Northern Hemisphere. Circled regions in the Pre-MX 7.2 gridding test result show large regions of false ice and missing ice (left).

VIIRS Snow/Ice Gridding Test – Post MX 7.2
No Extended Cloud Adjacency Filter

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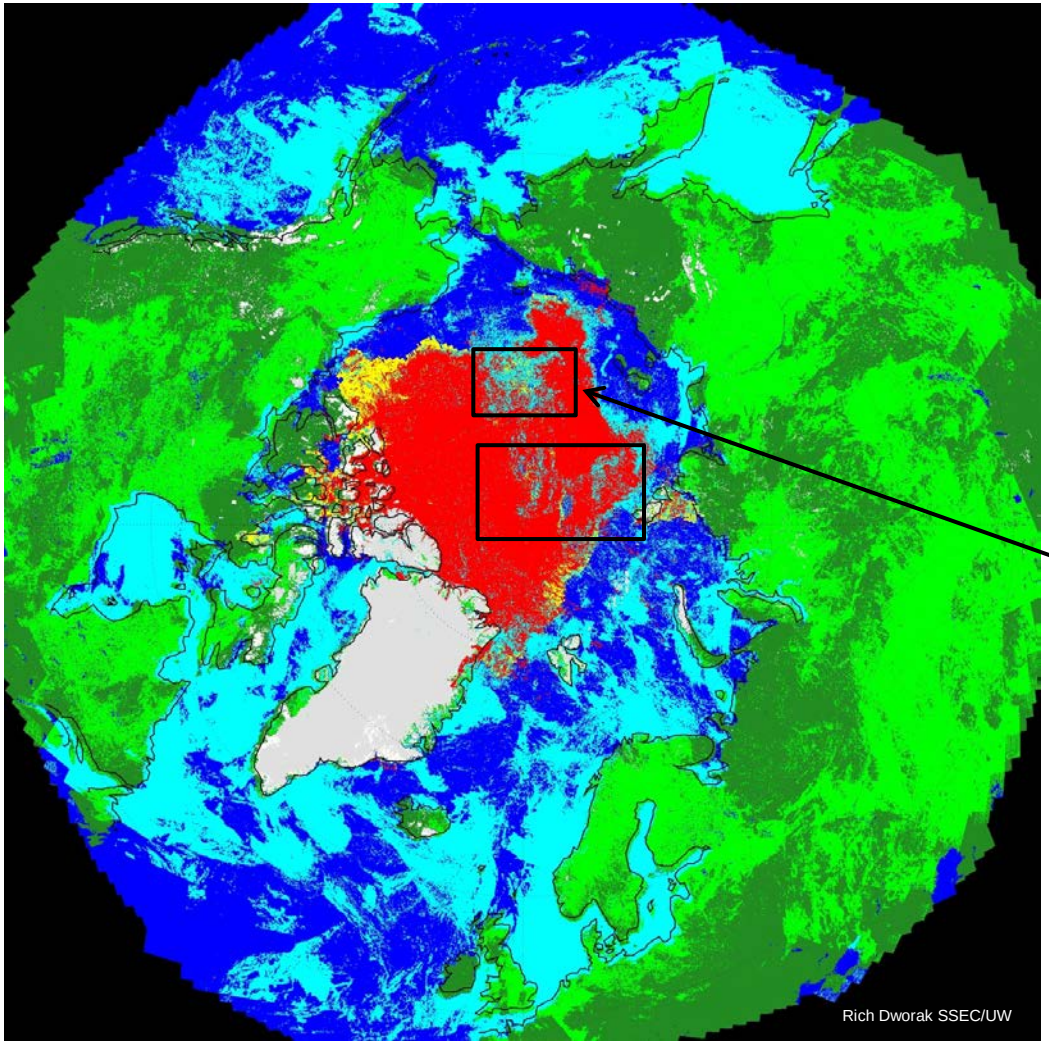

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Missing Ice regions

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NOAA AutoSnow Used as Reference VIIRS Snow/Ice Gridding Test – August 27, 2013

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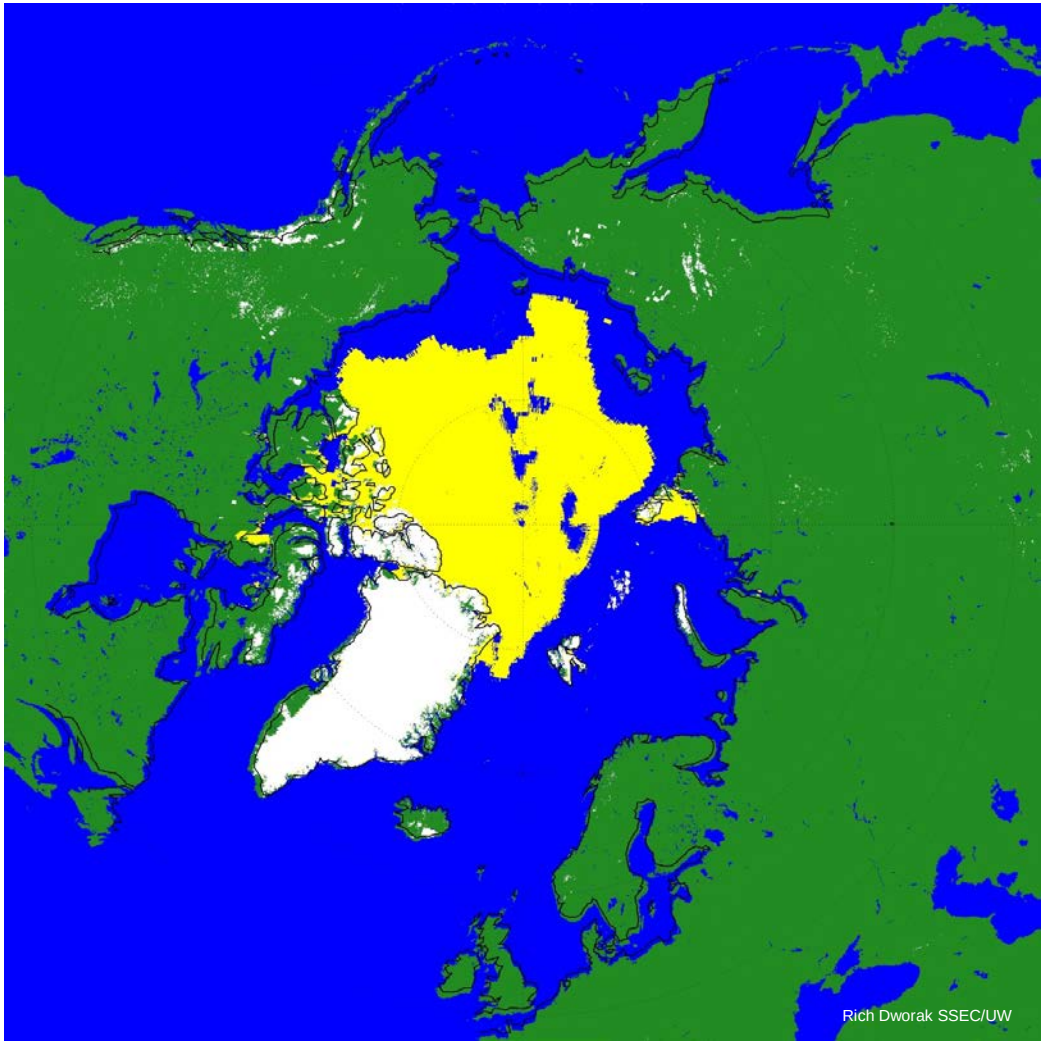

Ice over water
Snow over land
No Snow over land
No Ice over water

NOAA AutoSnow reference for the end of day of Aug 27 for the one week gridding period August 21-27, 2013

VIIRS Snow/Ice Gridding Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter

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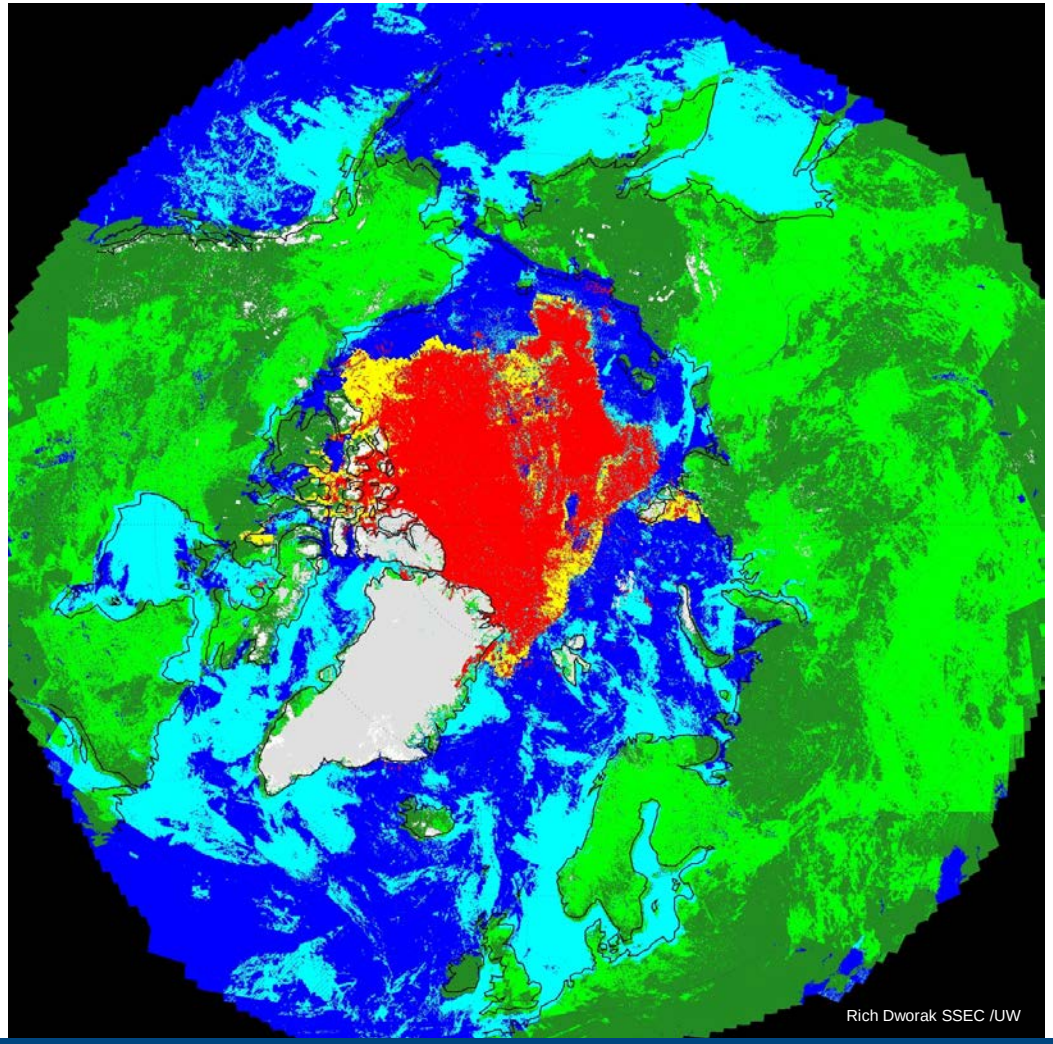

GMASI

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VIIRS Updated

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Gridding Quality Criteria

1. **Extended Cloud Adjacency**:
   - flag pixels with more than 15% clouds in a 31x31 sliding window
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3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

After application of an extended cloud adjacency filter to the Sea Ice Concentration IP, the gridded Snow/Ice at the end of the Aug. 21-27 gridding period is consistent with the NOAA AutoSnow reference for Aug. 27 but significant regions were not updated by VIIRS data even after the 7 day gridding test period . Standard VCM cloud adjacency is applied to Snow Cover EDR

VIIRS Gridded Snow/Ice Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter Applied

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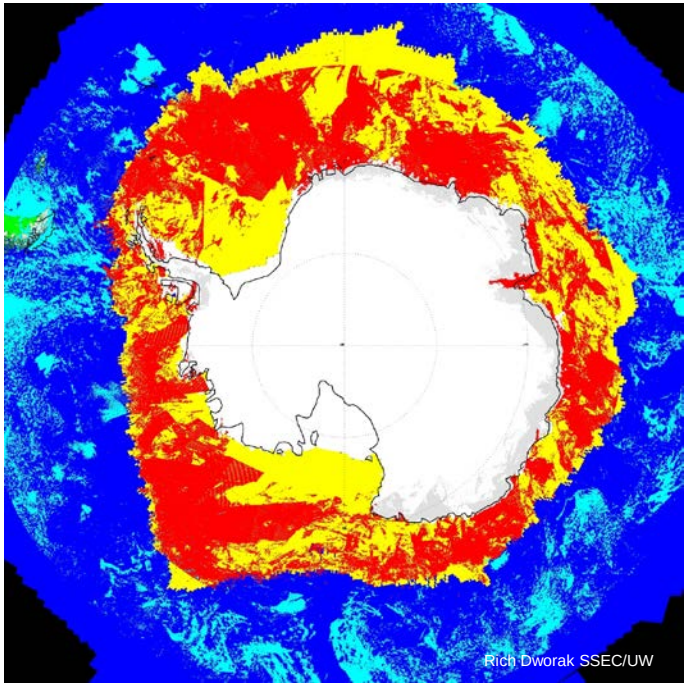
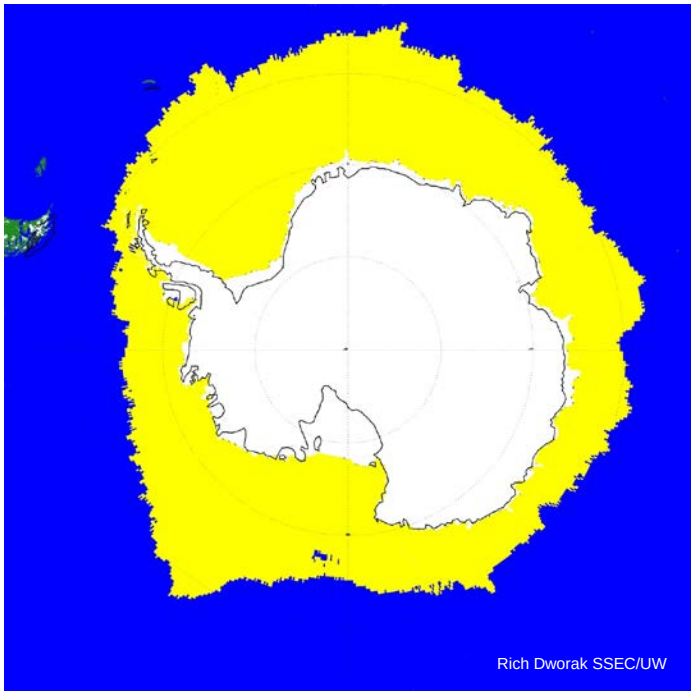
Gridded Snow/Ice Antarctic Aug. 27, 2013



NOAA AutoSnow Antarctic Aug. 27, 2013



GMASI

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VIIRS Updated

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- No Ice over water

Gridding Quality Criteria

1. Extended Cloud Adjacency:
- flag pixels with more than 15% clouds in a 31x31 sliding window

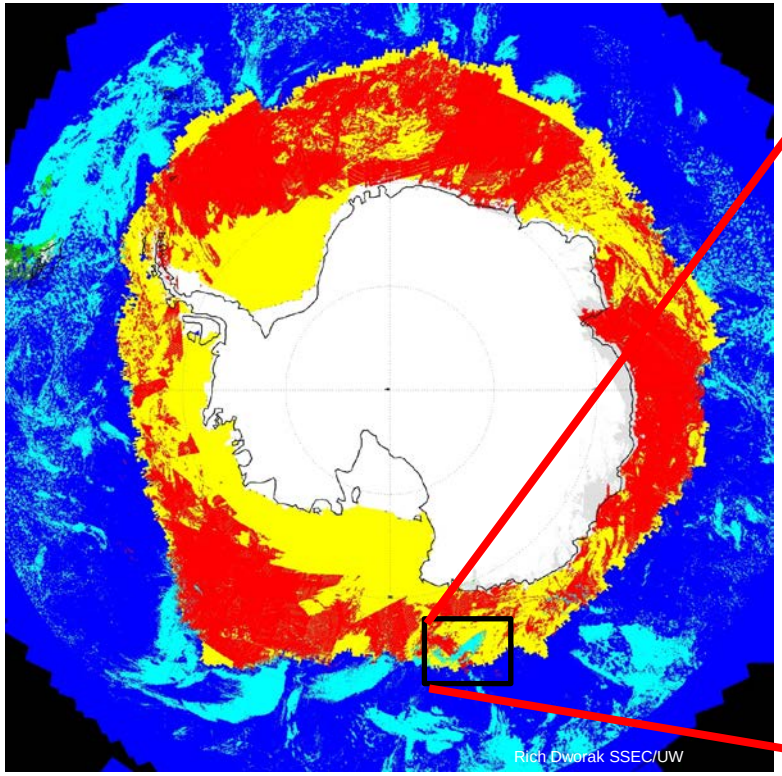
2. SZA < 80° gridded

3. Cloud Confidence
- confidently clear only
- no thin cirrus
- no VCM cloud adjacency

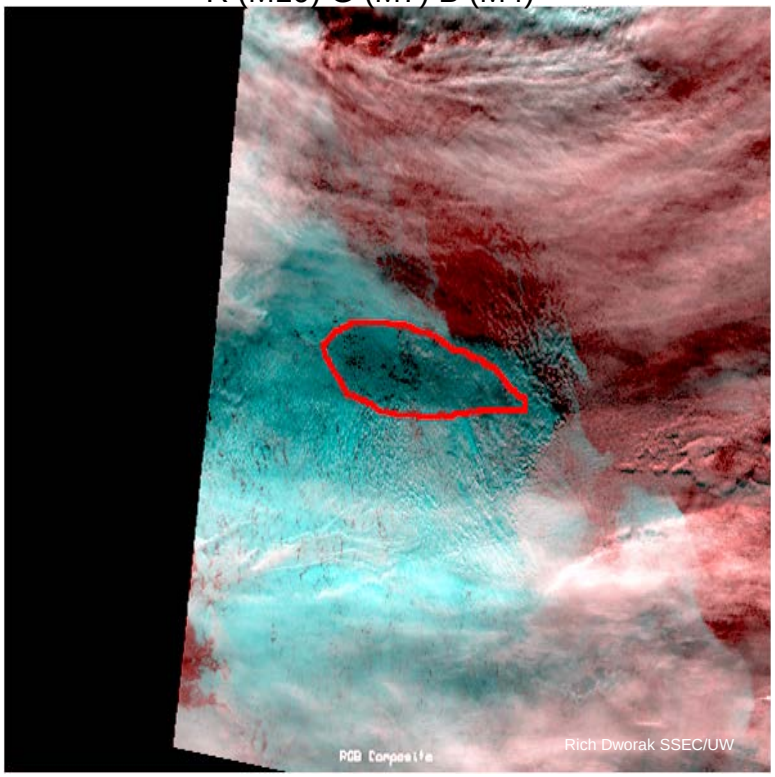
After one week gridding test period (Aug. 21-27) Snow/Ice in the VIIRS Snow/Ice gridding test grid (left) is consistent the GMASI (NOAA AutoSnow) but significant regions were not updated by VIIRS data even after the 7 day gridding test period.

Example of Missing Ice Due to Cloud Shadows

Antarctic August 18, 2013 Pre-MX 7.2



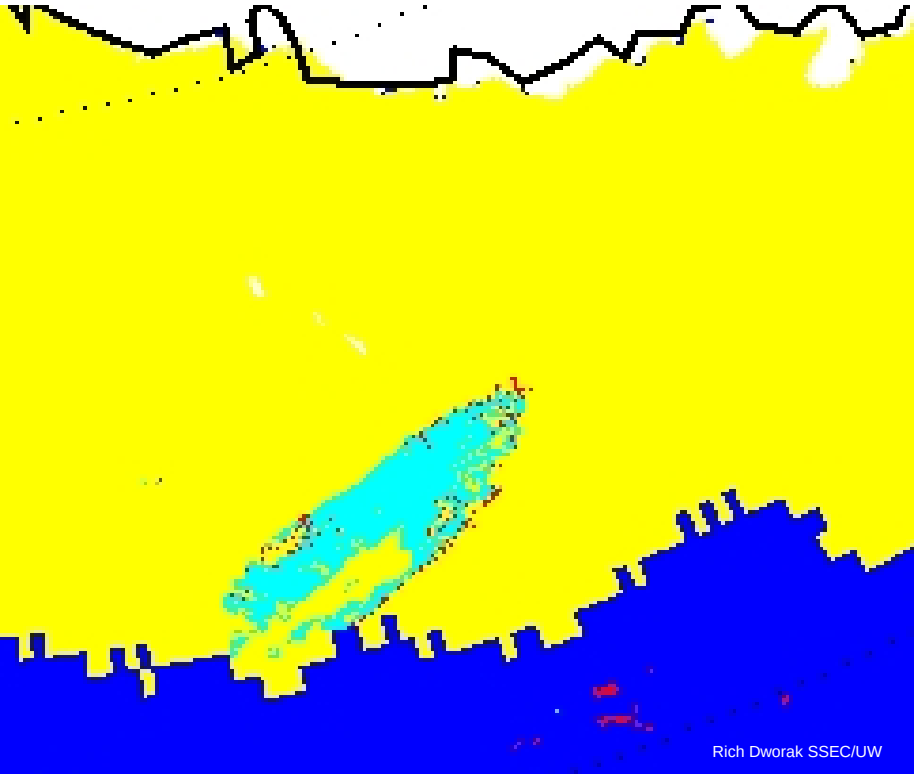
False Color SDR Reflectance for Region of Interest
R (M10) G (M7) B (M4)



A region of missing sea ice was detected in the gridding test for Aug. 11-18, 2013. Cloud shadow seen in the enhanced false color image. The missing ice in the box region over the Antarctic (left) is due to the Ice Concentration algorithm erroneously retrieving "No Ice" in the region of lower reflectance due to undetected cloud shadows.

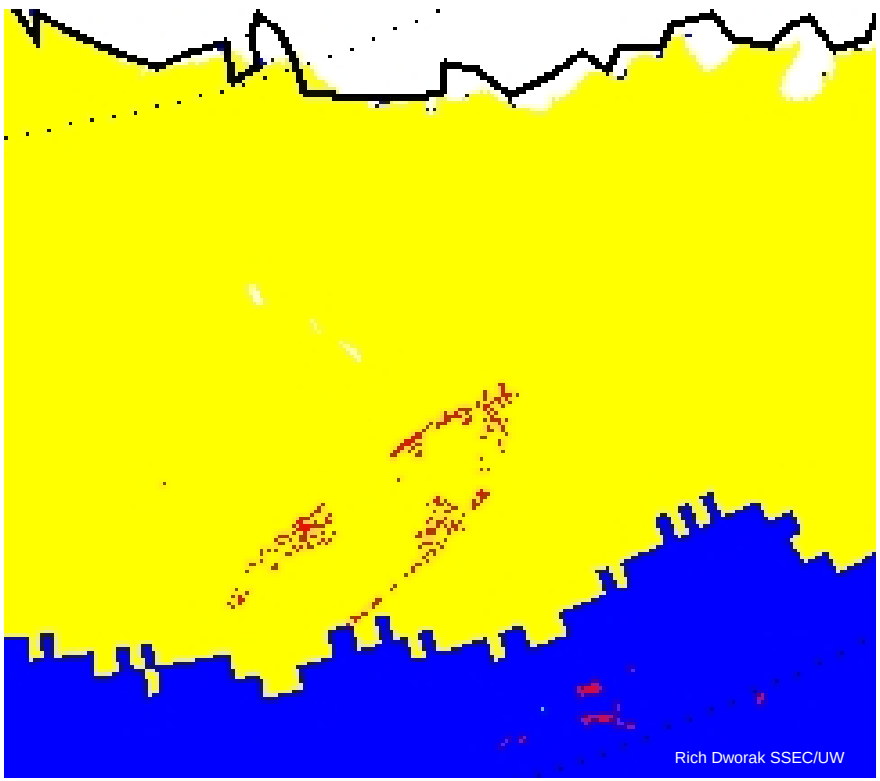
Antarctic Missing Ice Traced to 08/18/13 Orbit

Before



Missing Ice (light blue region) appears in the gridding test result for gridding for day only VIIRS data (Sol. Zen < 85°)

After



All missing ice detects removed with Sol. Zen. > 80 removed

Application of solar zenith angle threshold of 80° removed the missing ice associated with the cloud shadow. Although a solar zenith angle of 80° has been used for this gridding test it is recommended that the solar zenith angle threshold for gridding be tied to the VCM Cloud Shadow max solar zenith angle threshold (currently 75°) if VIIRS Snow/Ice Gridding is activated

Long Term Plan – Step 3: Activation of VIIRS Snow and Sea Ice Gridding with Climatology Based and Other Checks

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- Duplicate all NOAA AutoSnow Q/C criteria checks
- Substantial level of effort that requires new climatology ancillary data and updates to the GranToGrid SnowIceCover, Snow Cover and Sea Ice Concentration IP routines.

Long Term Plan – Higher Impact: Activate VIIRS Snow/Ice Gridding after implementation of Additional Quality Climatology Based Quality Control Criteria			
ADR	ADR Title	Description	Action
Not yet	Sea Ice Concentration IP Additional Quality Control Criteria	Apply additional surface temperature and climatology based surface temperature checks	•Identify NOAA AutoSnow tests and climatology data • Relative Azimuth test for high solar zenith angles •Prototype proposed tests, format conversion for new ancillary data Identify/submit ADRs
Not Yet	Snow Cover EDR Additional Quality Control Criteria to prevent false snow	Apply additional surface temperature, climatology and terrain height tests to screen false snow	•Identify NOAA AutoSnow tests and climatology data •Relative Azimuth test for high solar zenith angles • Extended Cloud Adjacency added to Snow Cover •Prototype proposed tests, format conversion for new ancillary data Identify/submit ADRs