

VIIRS Sea Ice Concentration IP Status

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

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- Status of Algorithm Changes/Updates
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Sea Ice Concentration IP Algorithm and Product - Description

• Algorithm Description

Tie point based retrieval of ice concentration at VIIRS imagery resolution (375 m @nadir). Ice and water tie points are determined for the visible TOA reflectance (VIIRS I1 band), near infrared TOA reflectance (VIIRS I2 band), and Surface Temperature.

– Tie points are established from the local distribution of reflectance and temperature within a sliding search window centered on each VIIRS Imagery resolution pixel.

– Ice/water thresholds are derived from the local minimum of the distribution of reflectance and temperature. Derived tie points are specific to the local region contained within the search window.

– Transition to Surface Temperature IP thermal tie points only for night is controlled by quality weights. De-weighted reflective quality weights for VCM cloud shadow flagged pixels favor thermal tie point based ice fraction retrievals

– VIIRS Surface Temperature IP is determined using the VIIRS I5 (11.5 μm), M15 (10.8 μm) and M16 (12.0 μm) bands

• **Heritage:** No Vis/IR operational heritage. AVHRR research heritage (Comiso & Massom, 1994). Microwave heritage NASA Bootstrap and Team tie point based ice concentration retrieval algorithms.

• **Inputs:** TOA reflectances (VIIRS I1 and I2 bands) and Surface Temperature IP at imagery resolution, Ice Quality Flags IP, Ice Weights IP

• **Outputs:** Ice Reflectance/Temperature IP, Ice Concentration IP

• **Product Description:** The VIIRS Sea Ice Concentration IP consists of retrieved ice concentration at VIIRS Imagery **resolution (375 m @ nadir)** and is **produced both day and night**, over oceans **poleward of 36° N and 50° S latitude**.

– It is currently a retained Cal/Val IP (non-deliverable) product for NPP with quality flags provided separately in the Ice Quality Flags IP

Status of Algorithm changes/updates

Date	Update/DR#	Reason	Status
04-09-2013	7139	Correct Sea Ice Conc. OAD flow chart figure	Request closure with Beta Maturity 474-CCR-13-0945
12-13-2012	5017	RTN Sev2 PCR Ice IPs Maneuver	Closed (Raytheon PCR 032616)
11-27-2012	4987	Sea Ice Quality/Ice Concentration IP: Additional quality checks for identifying regions with potential VCM cloud leakage	Open
10-17-2012	4959	Sea Ice Conc. Tie Point Fill Fix	Open
01-19-2012	4524	OAD for VIIRS Sea Ice Concentration (SIC) Intermediate Product (IP) Mx6 Updates (ECR-ALG-0034) (CDRL A031)	Canceled (minor edits)
12-08-2010	4129	Ice concentration weights not initialized before final ice concentration calculation	Closed – Fix date unknown, verified by code inspection
07-17-2009	2863	Latency impact due to valid point count methodology	Deferred for re-evaluation
07-17-2009	2936	Ice Surface Temp and IST use different emissivities for ice	Closed CCR 474-CCR-14-1521 with delivery of updated Surface Temperature IP coefficients.

- Evaluation Approaches

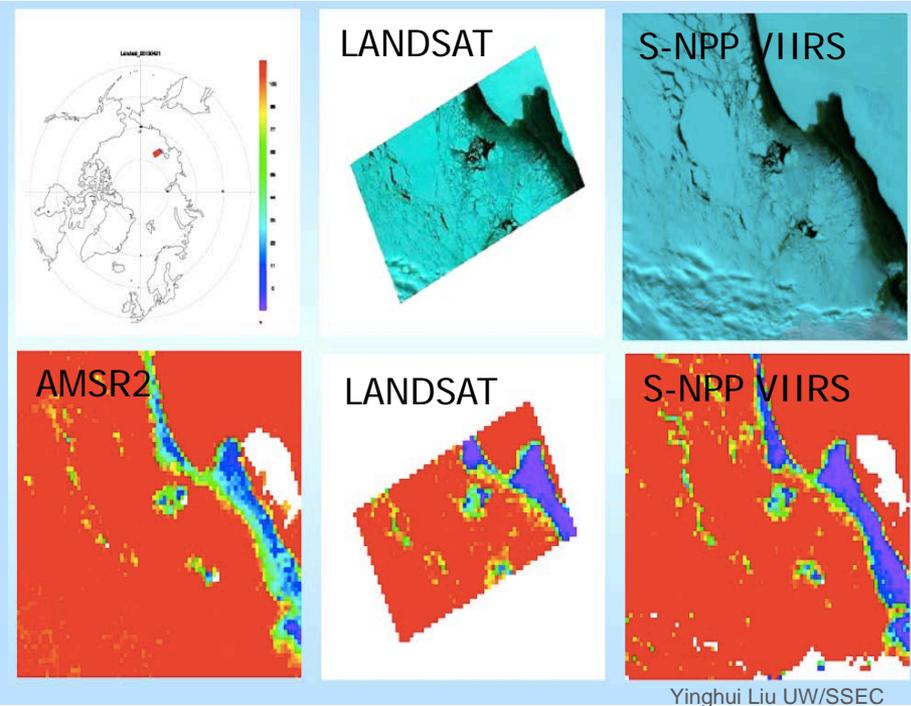
1. LANDSAT 8 and AMSR2 derived ice concentration, quantitative comparisons to VIIRS SIC for 25 clear LANDSAT scenes
2. Daily, global hemispheric VIIRS Sea Ice Concentration (SIC) and SSMIS passive microwave ice concentration visual and quantitative comparisons
3. Visual comparison of NIC Weekly Ice Charts, VIIRS SDR false color reflectance imagery, MODIS Aqua MYD29 product for 30+ S-NPP/Aqua Simultaneous Nadir Overpass (SNO) scenes that span 1 year and both hemispheres
4. Visual comparison of NOAA AutoSnow product with global, hemispheric Snow/Ice gridding test results

- Notes:

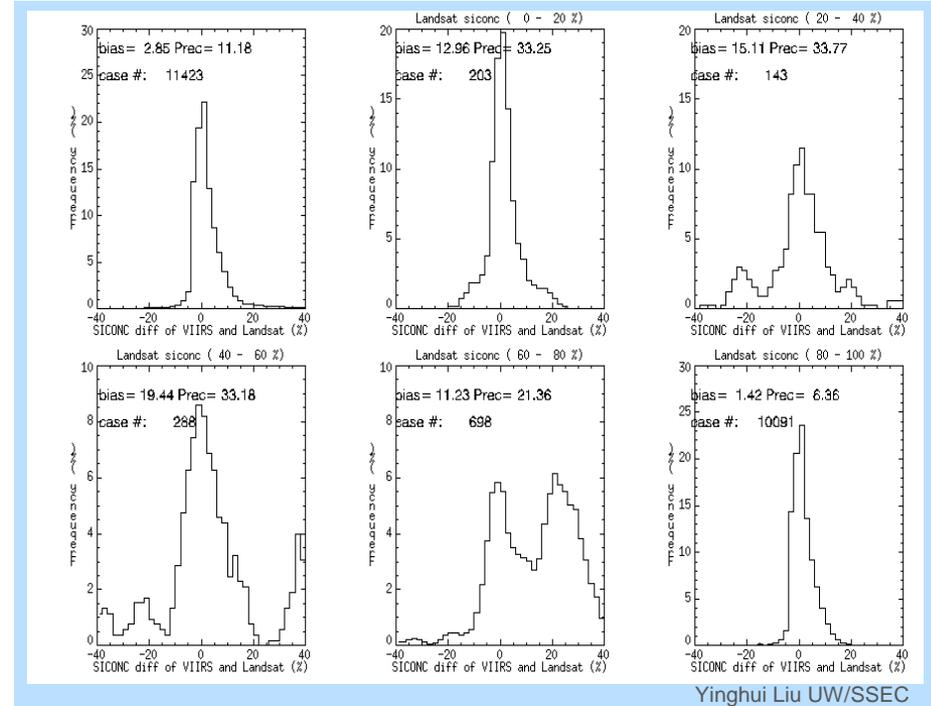
- Leveraging the 30+ S-NPP/MODIS Aqua SNO matchup scenes for IST EDR evaluation for Ice Concentration golden granules. (plan to extend the dataset)
- Plan to extend the SSMIS comparisons performed for the Provisional Maturity to span golden granule scene dates
- Leveraged the Snow/Ice gridding test results to identify occurrences of false and missing sea ice
- Plan to use additional LANDSAT and AMSR2 ice concentration and other data sets as available

(1) Comparison of VIIRS Sea Ice Concentration to LANDSAT and AMSR2 (example)

Panel A



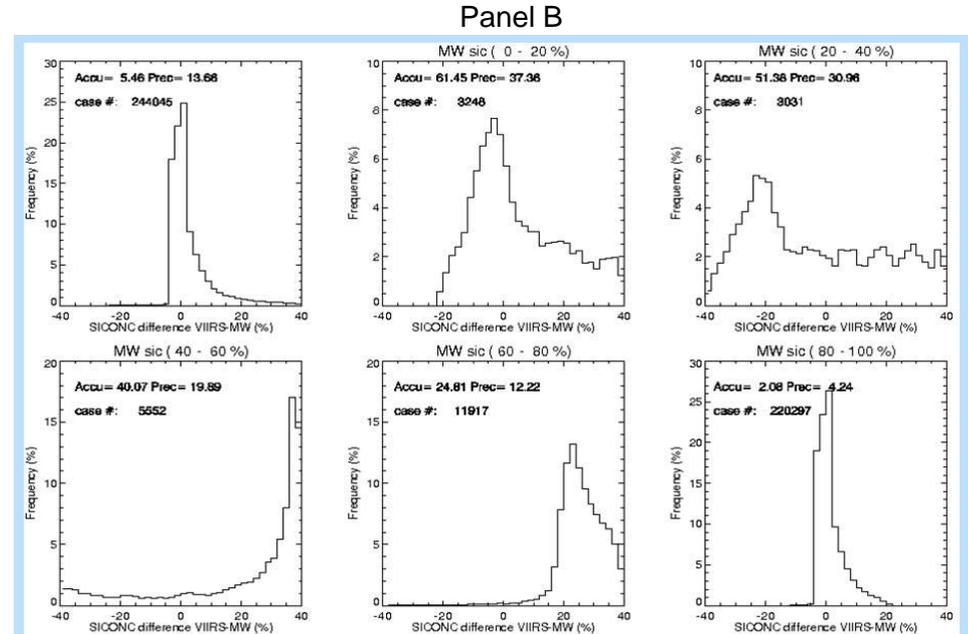
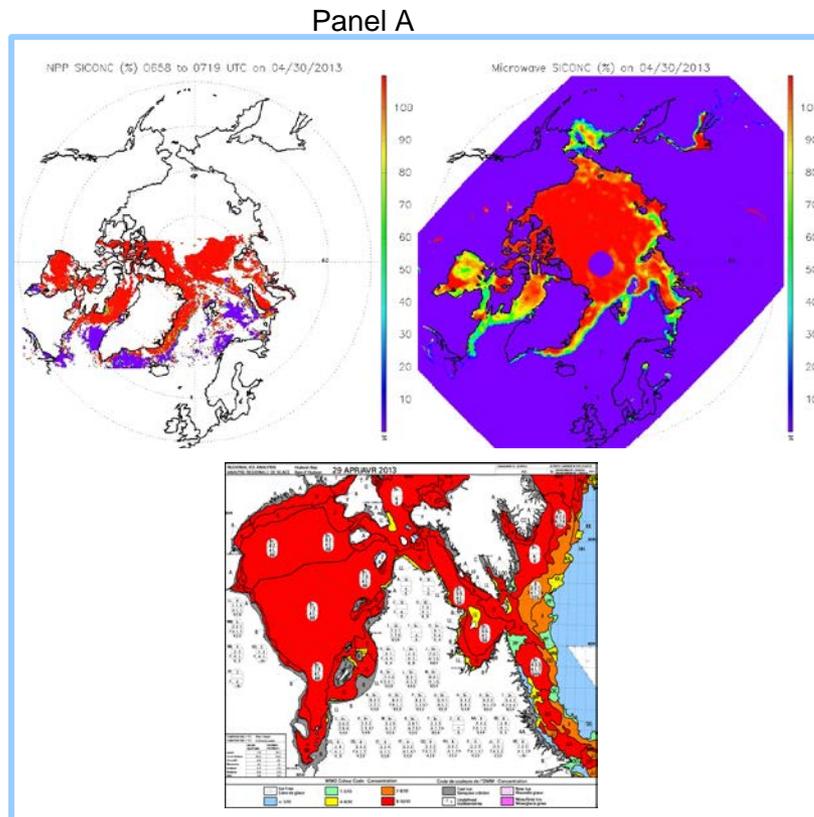
Panel B VIIRS vs. LANDSAT Ice Concentration



Panel A: upper image left to right: location of the scene, LANDSAT and VIIRS SDR false color image; Panel A, lower image left to right: Sea Ice Conc. from AMSR2, LANDSAT, and the Suomi NPP VIIRS on 4/21/2013 .

Panel B: Ice concentration differences between VIIRS and LANDSAT for all cases (top left) and cases with LANDSAT sea ice concentration in the ranges 0–20%, 20–40%, 40–60%, 60–80%, and 80–100%. Measurement accuracy (bias) and measurement precision (Prec) are indicated for each bin.

(2) Comparison of VIIRS Ice Conc. to Passive Microwave and NIC Ice Chart (example)



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Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Accuracy	5.46	61.45	51.38	40.07	24.81	2.08
Precision	13.66	37.36	30.96	19.89	12.22	4.24

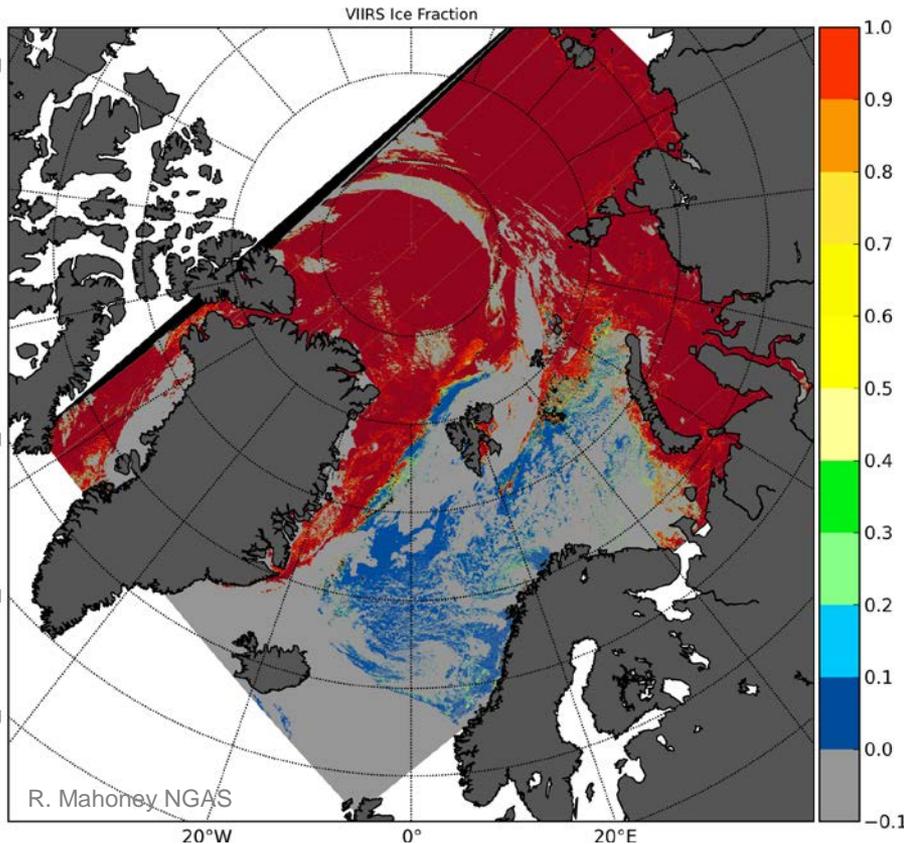
Panel A: Ice Concentration from S-NPP VIIRS Sea Ice Concentration IP (top left), SSMIS using NASA team algorithm (top right) on April 30, 2013, and from the weekly ice chart on April 29th 2013 from the Canadian Ice Service (bottom right).

Panel B: Accuracy and precision and ice concentration difference histograms for total, 0-20%, 20-40%, 40-50%, 0-80% and 80-100% ice fraction range.

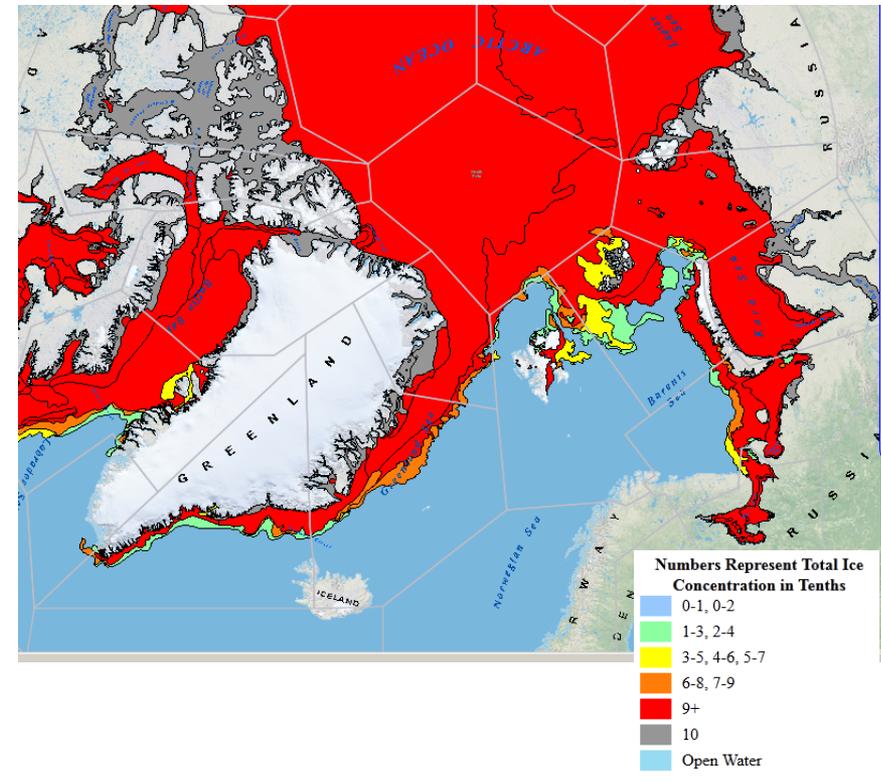
Further VIIRS Ice Concentration IP comparisons to SSMIS Ice Concentrations for dates corresponding to the 30+ golden granule scenes are planned

(3) Comparison of VIIRS Ice Concentration IP to National Ice Center Ice Charts (night scene example)

VIIRS Ice Concentration IP Feb. 20, 2014 (04:39-04:46 UTC)

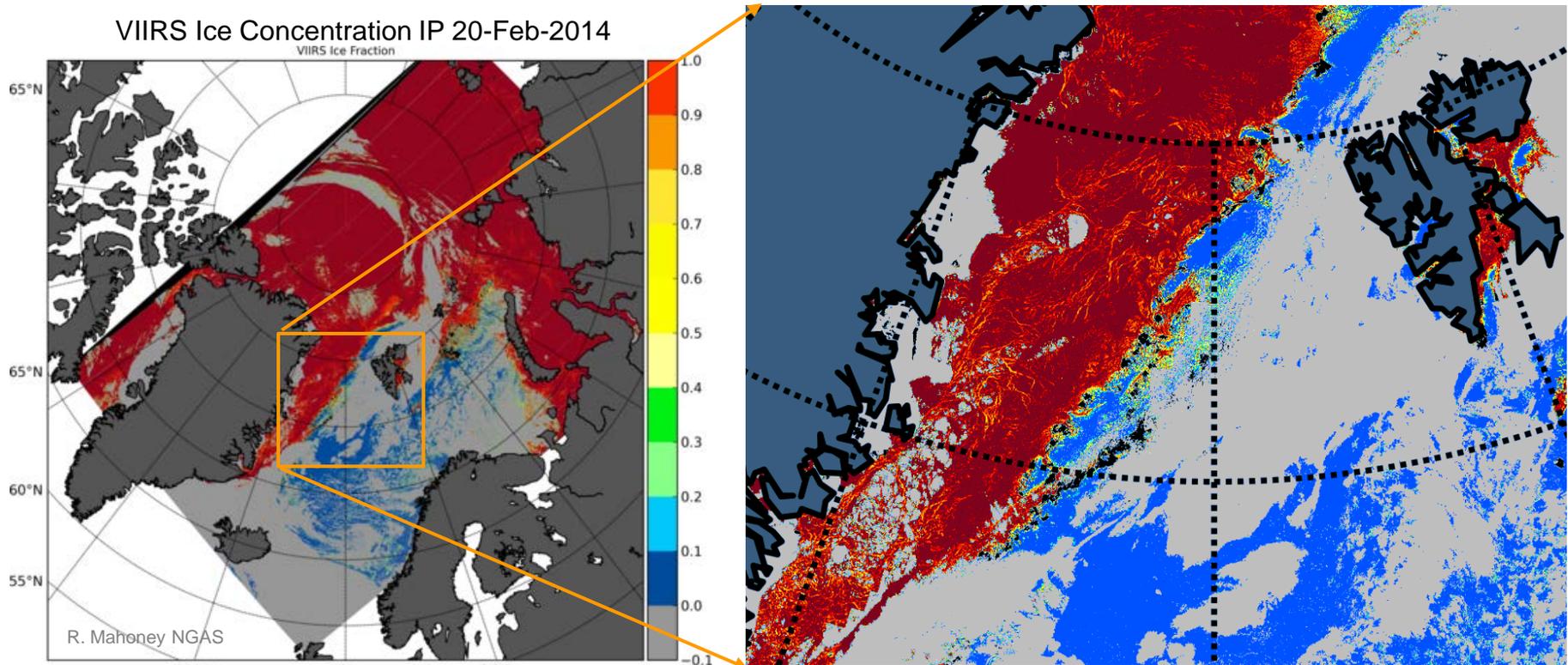


Reference: <http://www.natice.noaa.gov/ps/javascriptproductviewer/index.html>



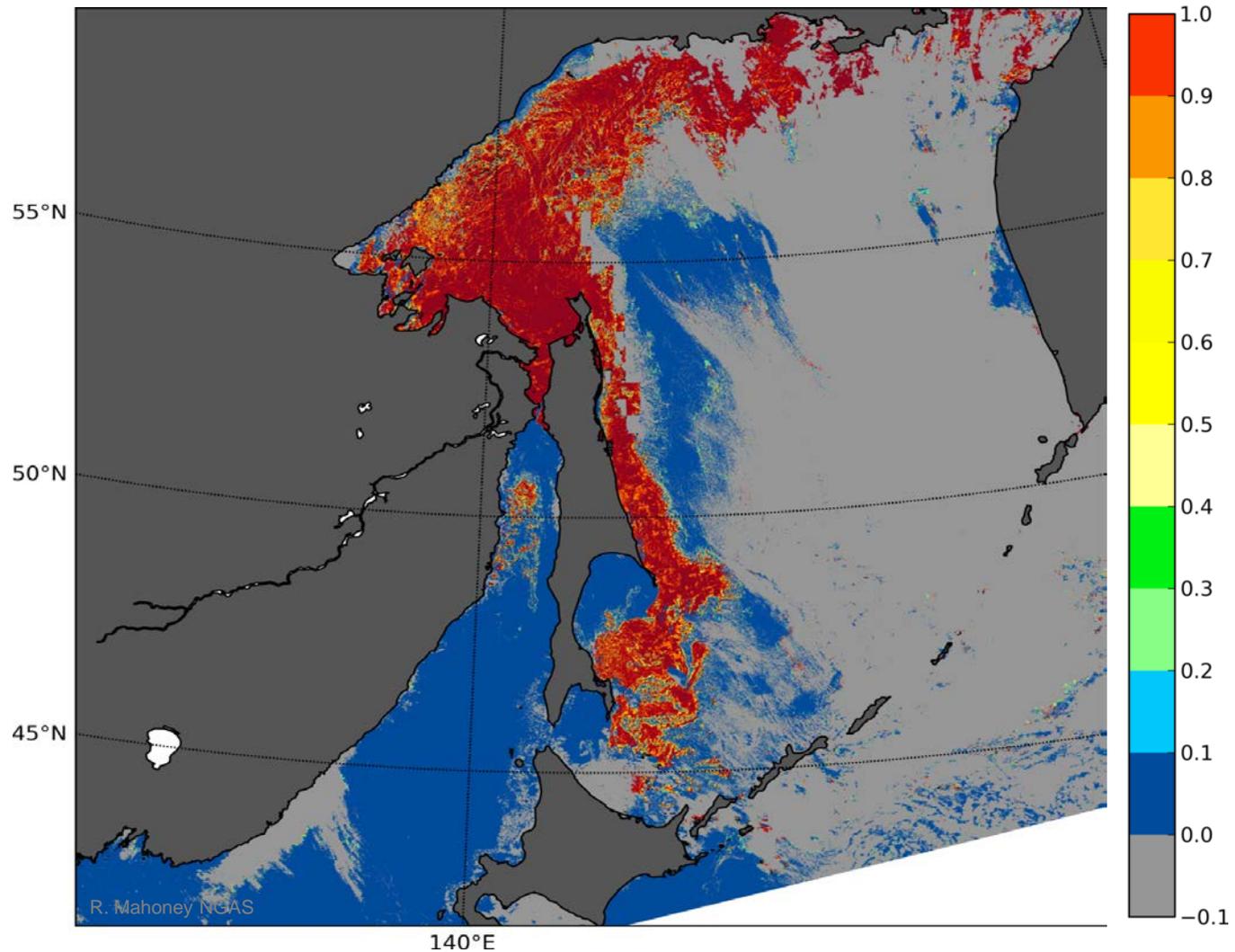
VIIRS Ice Concentration IP for Feb. 20, 2014 night scene is consistent with that of the corresponding National Ice Center weekly ice chart for Feb. 20, 2014 and the ice extent matches extremely well

VIIRS Ice Concentration IP Shows Detailed Structure of Ice Edges and Leads



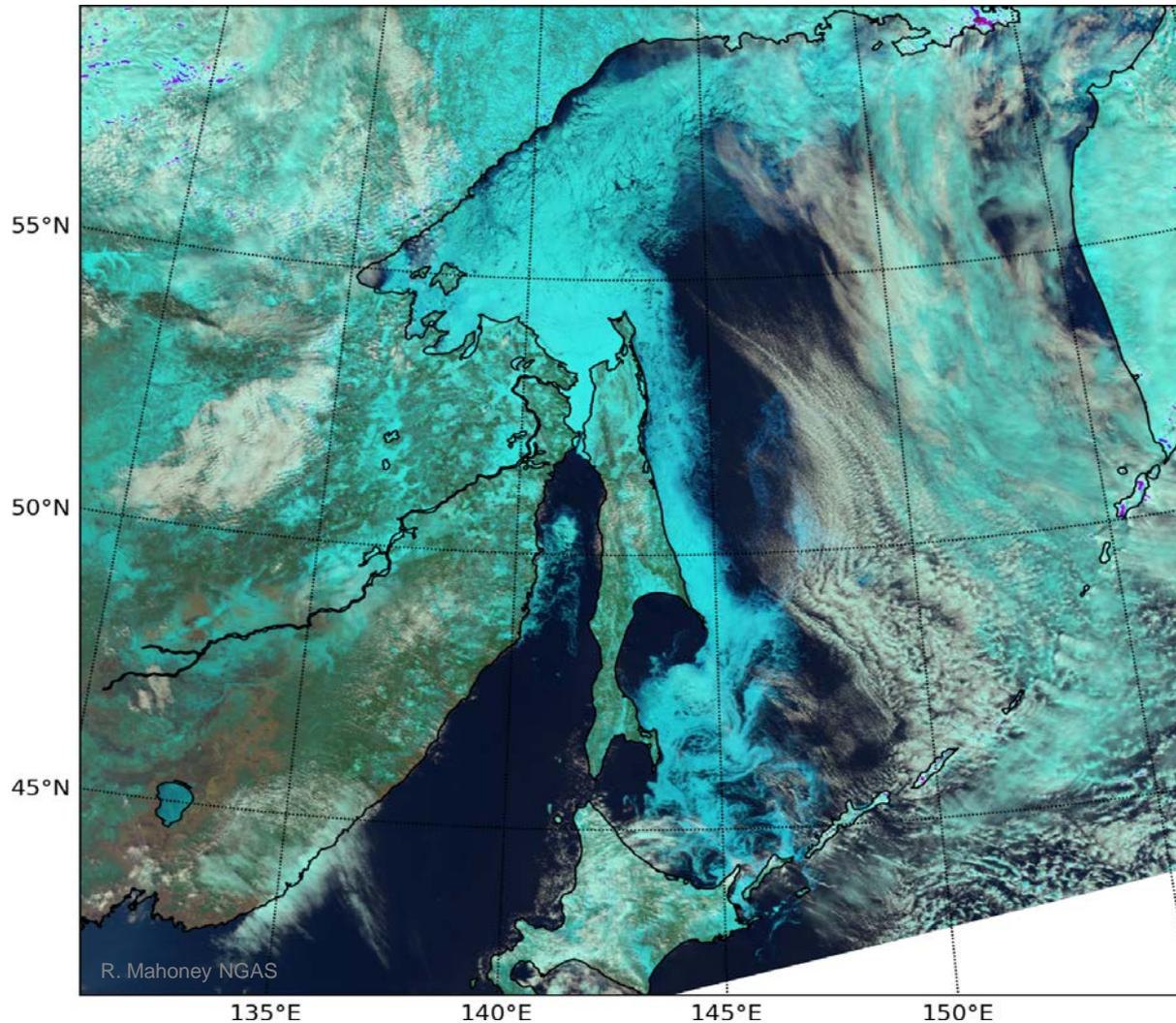
Detailed structure of the ice edge and leads can be seen in the Ice Concentration IP as shown in the zoomed subset region in the right figure. The current Ice Concentration IP if produced as a product should allow users to identify ice edges more accurately. The Ice Concentration IP is currently only a retained, non-deliverable Cal/Val IP

Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scene



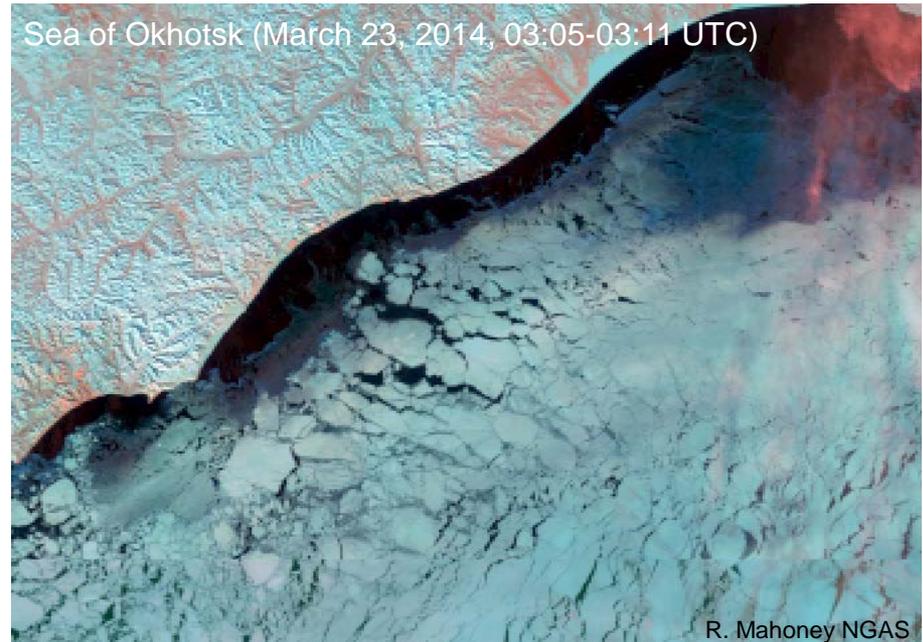
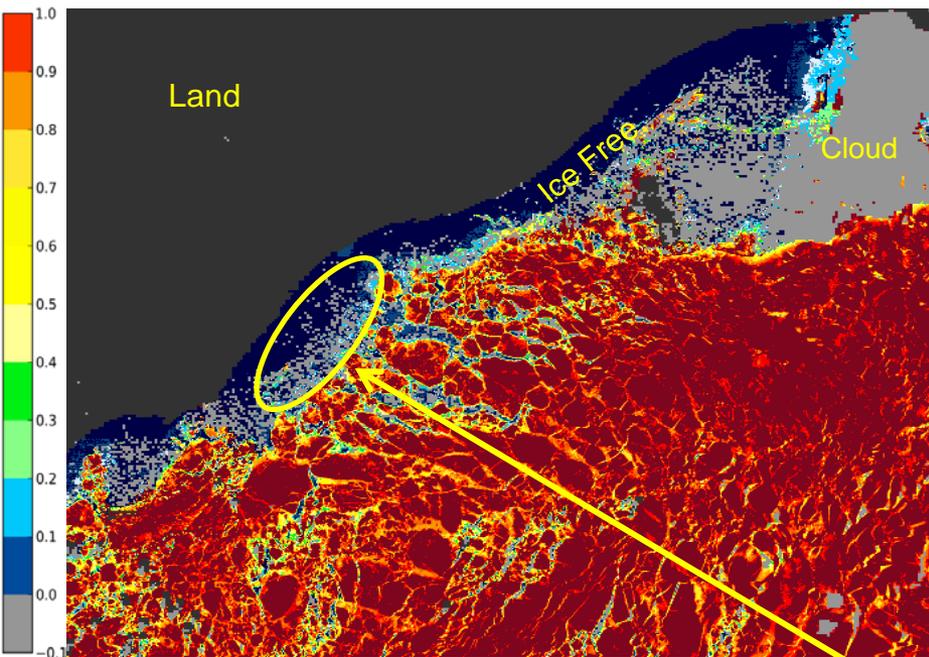
The ice edges seen in the VIIRS Ice Concentration IP typically closely match ice edges seen in false color SDR reflectance band imagery as in this day case of melting sea ice in the Sea of Okhotsk (March 23, 2014, 03:05-03:11 UTC)

Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes



Reference false color VIIRS SDR reflectance band imagery showing melting sea ice over the Sea of Okhotsk for March 23, 2014.

Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes – Full Resolution Zoom

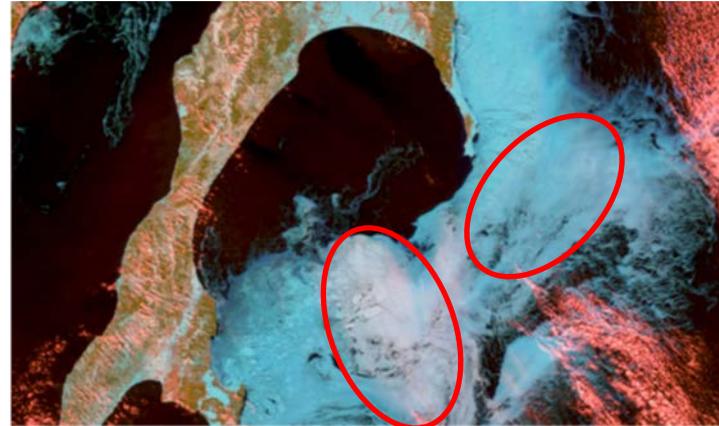
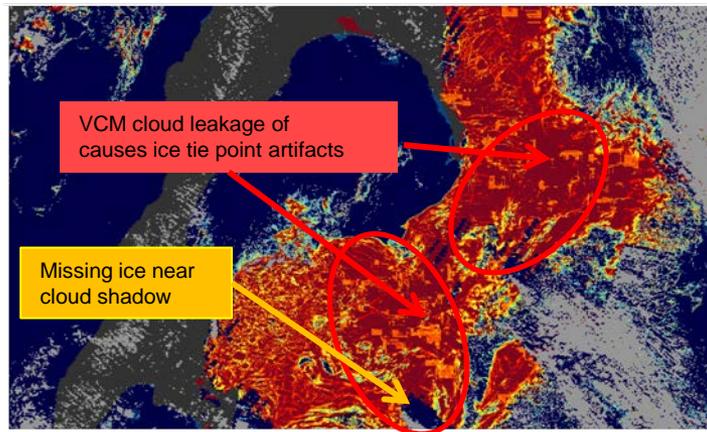
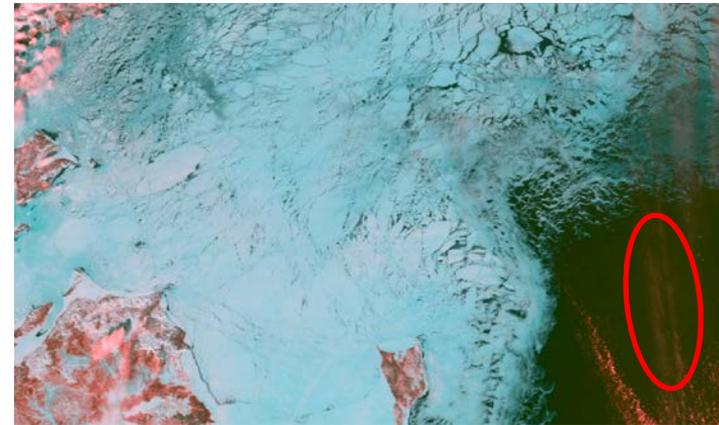
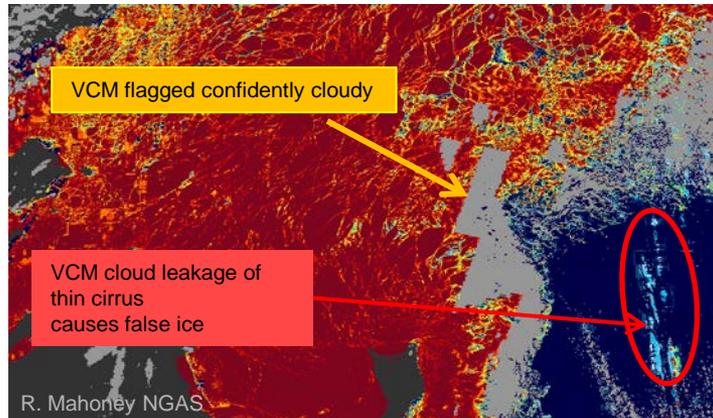


Many pixels near ice edges are flagged by VCM as confidently cloudy are clear in the corresponding false color SDR image

VIIRS Ice Concentration IP (left) shows fine detail of ice edge and lead features. An ice fraction threshold of 0.1 yields an ice extent that very closely matches the ice edges seen in the corresponding VIIRS SDR reflectance band imagery zoomed at full VIIRS imagery resolution (right).

Many ice edge pixels however, are flagged as confidently cloudy by the VCM and are not retrieved by the ice concentration algorithm.

Comparison of VIIRS Ice Conc. to Zoomed VIIRS False Color SDR for Day Scenes – Issues



(1) Rectangular fill values are associated with VCM positive M7 and M1 threshold test triggered by out of date manually updated GMASI snow/ice (top left). (2) False ice is seen in the product (top left) corresponding undetected thin cirrus (red circle, top right). (3) Rectangular and linear artifacts seen within the circled regions in the VIIRS Ice Concentration IP (bottom left) are thought to be associated with ice tie point window fall back to default values. This often occurs over regions with ill defined ice tie point histogram peaks such as regions with undetected clouds as shown within the red circled regions in the false color SDR reflectance image (lower right). A possible fix is to fall back to a running mean ice tie point in instead of a global default.

- **Detailed structure of Ice edges and ice leads are observable in the VIIRS Sea Ice Concentration IP** at VIIRS Imagery resolution for both day and night, out to edge of scan based on visual comparisons
 - Ice extent compares well with VIIRS SDR False color imagery, National Ice Center Ice Charts, MODIS Aqua/MYD29 (see backup slide) reference data and full resolution zoomed VIIRS SDR reflectance imagery
- Quantitative performance based on comparison with LANDSAT ice fractions show relatively small bias and good precision for the total (2.9% and 11%) and high ice fraction range (1.42% and 6.36%) but reduced performance for mid range ice fractions based a set of 25 scenes
- Some artifacts, rectangular lowered ice concentrations, were observed for regions associated with undetected thin clouds. ADR 4959 has been submitted and implementation running mean ice tie point will likely mitigate this problem
- Cloud shadows can result in missing ice. Tunable quality weight parameters may mitigate the problem for VCM cloud shadow flagged pixels.
- Ice edges under clear sky conditions are often flagged by VCM as confidently cloudy. Examples will be provided to the VCM team since ice edges are the regions of primary importance to users
- The VIIRS Ice Concentration IP is currently a non-deliverable retained cal/val IP. The JPSS system spec. defines a measurement range requirement but has no other performance spec.

VIIRS Sea Ice Concentration IP Issues & Proposed Solutions

- In general, issues identified for the Ice Concentration IP are not severe in nature and most issues have technical solutions that can be tested. Some improvements however, depend on further improvements to VIIRS Cloud Mask cloud confidence and cloud shadow detection

Issue	Description	Proposed Solution
Ice Tie Point Fix		ADR 4959 to implement use of a running mean ice tie point as fall back for windows with ill conditioned and can water tie point distribution
False Ice Near Cloud Edges	False ice is frequently observed near cloud edges due to undetected clouds	ADR 4987 opened to implement additional quality check for extended cloud adjacency/ partly cloudy conditions within the ice tie point search window
Missing ice due to cloud shadow	Occasional occurrences of missing ice been observed to be associated with lowered reflectance due to cloud shadows.	<ol style="list-style-type: none"> Investigate algorithm tuning of quality weights for VCM cloud shadow flagged pixels (increase weight for thermal band retrieval) Need to submit ADR Request VCM team to improve and extend the VCM cloud shadow algorithm
VCM false cloud detection near ice edges	Ice edges in clear sky conditions are often flagged by VCM as confidently cloudy thus obscuring the ice edge	Request VCM team to improve VCM cloud confidence performance near ice edges
Ice Concentration IP conversion to deliverable product	The VIIRS Sea Ice Concentration IP is currently a retained Cal/Val, non-deliverable IP. Quality flags are not provided with the product. Conversion to a deliverable product requires implementation of product quality flags	Define and implement a set of Ice Concentration IP product quality flags to Ice Concentration IP prior to being promoted to a deliverable product
Detection of low reflectance thin ice	Newly forming (dark) ice with low reflectance (<0.2) might not be detected by the current ice concentration algorithm day reflectance base retrieval algorithm branch	Investigate potential ice concentration algorithm failures to detect newly forming (dark) ice during day. Explore use of increasing thermal algorithm branch retrieval quality weight for ice temperatures over pixels with reflectance < 0.2

- Observed performance of the VIIRS Ice Concentration IP is such that this product has high potential to become an extremely useful JPSS product due to its ability to **provide detailed views of ice edge and lead features at VIIRS Imagery resolution (375 m @ nadir) for both day and night out to VIIRS edge of scan**
- Performance evaluation based on visual comparisons indicate that the VIIRS Ice Concentration IP in its current state may already be an extremely useful product for identifying ice extent for both day and night for clear sky conditions
- The VIIRS Ice Concentration IP for NPP is a currently non-deliverable Retained Cal/Val IP. Promotion to a deliverable product will require minor level of effort for addition of product quality flags, implementation of extended cloud adjacency quality flagging and correction of minor defects