Request for
VIIRS Sea Ice Concentration IP
Beta Maturity

DR # 7132
CCR # 474-CCR-13-0945
DRAT discussion: April 19, 2013
AERB presentation: April 24, 2013

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VIIRS Sea Ice Concentration IP Product Users

- U.S. Users
  - NSIDC, National Snow Ice Data Center
  - NIC, National/Naval Ice Center
  - OSPO, Office of Satellite and Product Operations
  - STAR, Center for Satellite Applications and Research
  - GSFC, NASA/Goddard Space Flight Center Hydrological Sciences Branch
  - NWS, National Weather Service, including the Alaska Ice Desk
  - CLASS, Comprehensive Large Array-data Stewardship System

- User Community
  - Navigation
  - Emergency Management
  - Operational Weather Prediction
  - Climate Research
  - DOD

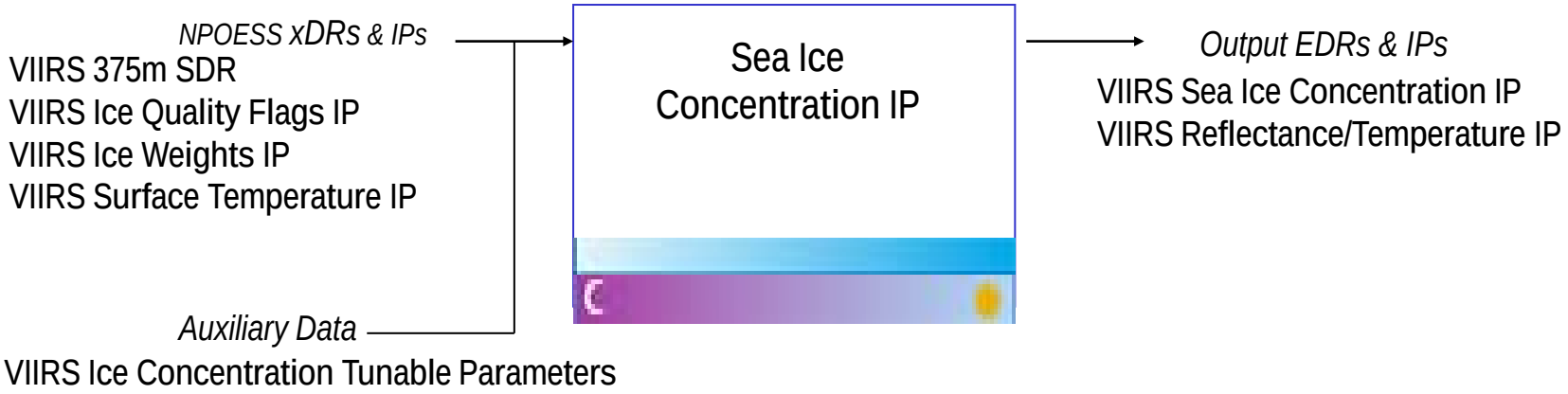
Beta EDR Maturity Definition

- Early release product.
- Minimally validated.
- May still contain significant errors.
- Versioning not established until a baseline is determined.
- Available to allow users to gain familiarity with data formats and parameters.
- Product is not appropriate as the basis for quantitative scientific publication studies and applications.

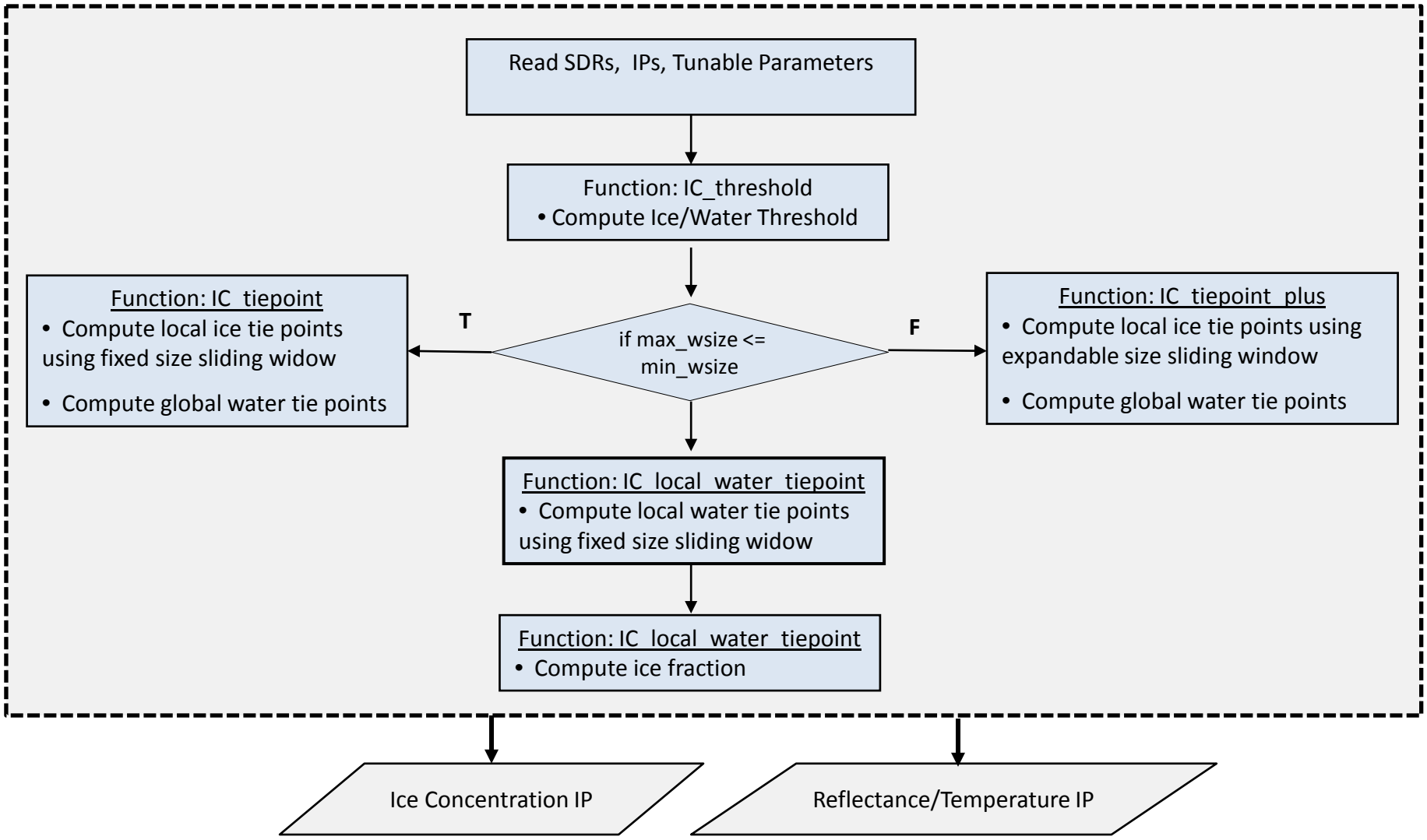
Summary of the VIIRS Sea Ice Conc. IP

- The VIIRS Sea Ice Concentration IP consists of retrieved ice concentration at VIIRS Imagery spatial resolution (375 m @ nadir), for both day and night, over oceans pole ward of 36^{o} N and 50^{o} S latitude.
- The Ice Concentration algorithm computes ice fractions based on ice and water tie points determined from VIIRS I1 (0.64 μm and I2 (0.865 μm) reflectance and VIIRS I5 band (11.5 μm) based retrieved surface temperature from the VIIRS Surface Temperature IP.
- Ice/water thresholds are determined from the local minimum of the distribution of reflectance and temperature. Ice and water tie points are derived from the local maxima of the reflectance and temperature distribution within a sliding search window centered on each pixel.
- Inputs are TOA reflectance (VIIRS I1 and I2 bands) and Surface Temperature IP at VIIRS imagery resolution. Cloud and quality information input are provided by the Ice Quality Flags and IP, Ice Weights IP
- Outputs Ice Concentration IP and Reflectance/Temperature IP

Summary of the VIIRS Sea Ice Conc. IP Algorithm Inputs



Summary of VIIRS Sea Ice Conc. IP Processing Flow



VIIRS Sea Ice Characterization L1RD Requirements

Sea Ice Characterization (SIC)

“Sea ice age is defined as the time that has passed since the formation of the surface layer of an ice-covered region of the ocean. The sea ice characterization EDR provides an ice age class. Sea ice concentration, which is the fraction of a horizontal cell covered by ice, is an intermediate product (IP).”

VIIRS Sea Ice Characterization L1RD Requirements (Continued)

Sea Ice Characterization Requirements from L1RD version 2.4

EDR Attribute	Threshold	Objective
a. Vertical Coverage	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Clear** **2. All weather**	 1.0 km No capability	 0.5 km 1 km
c. Mapping Uncertainty, 3 sigma **1. Clear** **2. Cloudy**	 5 km No capability	 0.5 km 1 km
d. Measure Range **1. Ice Age** **2. Ice Concentration**	 Ice Free, New Young, all other ice 0/10 to 10/10	 Ice free, Nilas, Gray White Grey, White, First Year Medium, First Year Thick, Second Year, Multiyear, Smooth and Deformed Ice 0/10 to 10/10
e. Measurement Uncertainty **1. Probability of Correct Typing (Ice Age)** **2. Ice Concentration**	 70% Note 1	 90% 5%
f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	6 hrs
g. Geographic coverage	All Ice-covered regions of the global ocean	All Ice-covered regions of the global ocean

Notes:
1. VIIRS produces a sea ice concentration IP in clear sky conditions, which is provided as an input to the ice surface temperature calculation

History of Algorithm changes/updates

Date	Update/DR#	Reason	Status
04-09-2013	DR 7139	Correct Sea Ice Conc. OAD flow chart figure	Request closure with Beta Maturity 474-CCR-13-0945
12-13-2012	DR 5017	RTN Sev2 PCR Ice IPs Maneuver	open
11-27-2012	DR 4987	Sea Ice Quality/Ice Concentration IP: Additional quality checks for identifying regions with potential VCM cloud leakage	open
10-17-2012	DR 4959	Sea Ice Conc. Tie Point Fill Fix	open
01-19-2012	DR 4524	OAD for VIIRS Sea Ice Concentration (SIC) Intermediate Product (IP) Mx6 Updates (ECR-ALG-0034) (CDRL A031)	open
12-08-2010	DR 4129	Ice concentration weights not initialized before final ice concentration calculation	open
07-17-2009	DR 2863	Latency impact due to valid point count methodology	Deferred for re-evaluation

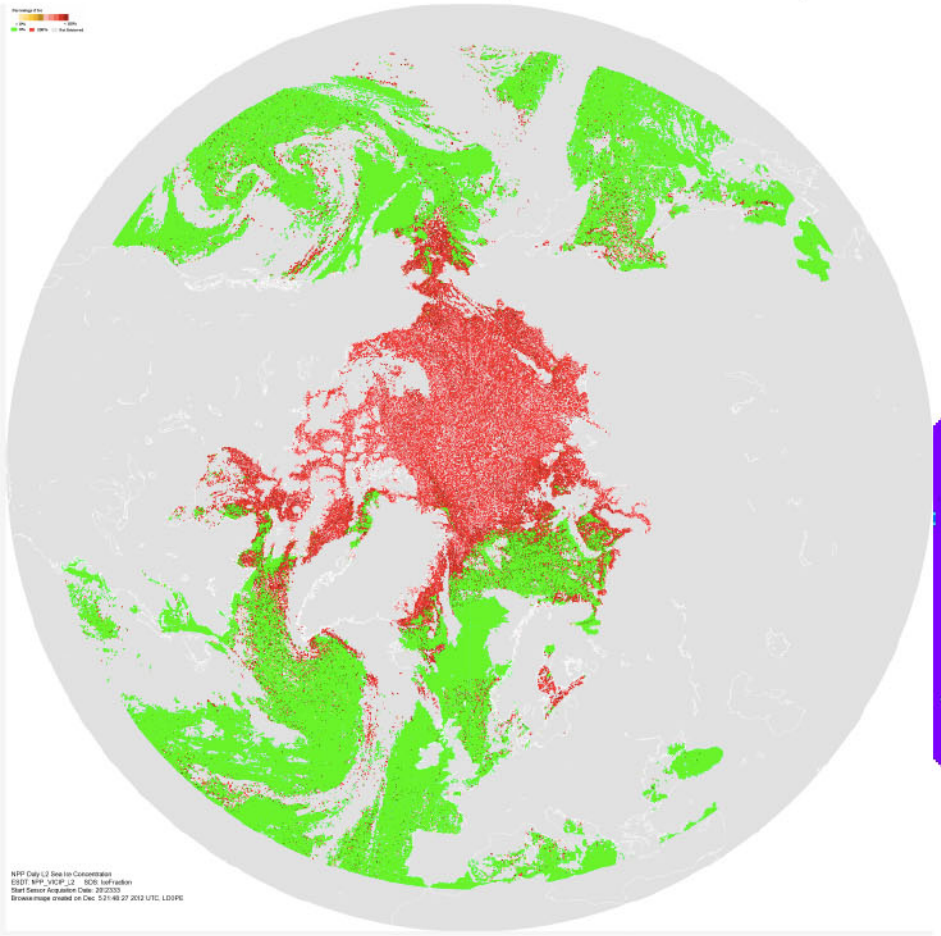
Beta Maturity Evaluation

- Beta Maturity Evaluation Approaches
  - Visualizations of daily global VIIRS Sea Ice Concentration and comparison with passive microwave ice concentration
- Criteria: Minimally validated
  - Evaluation is based on a limited number of focus days (hemispheric comparisons for retrieval products)
    - NH data: 1/29/2012, 2/1/2012, 2/27/2012
    - Antarctica: 10/12/2012
  - Some detailed analysis has been done on other days with a limited set of granules focused on a region
    - Beaufort Sea: 1/29/2012, 2/9/2012, 4/5/2012, 6/8/2012, 7/23/2012
    - Gulf of Alaska: 12/17/2012
    - Terra Nova Bay: 10/12/2012

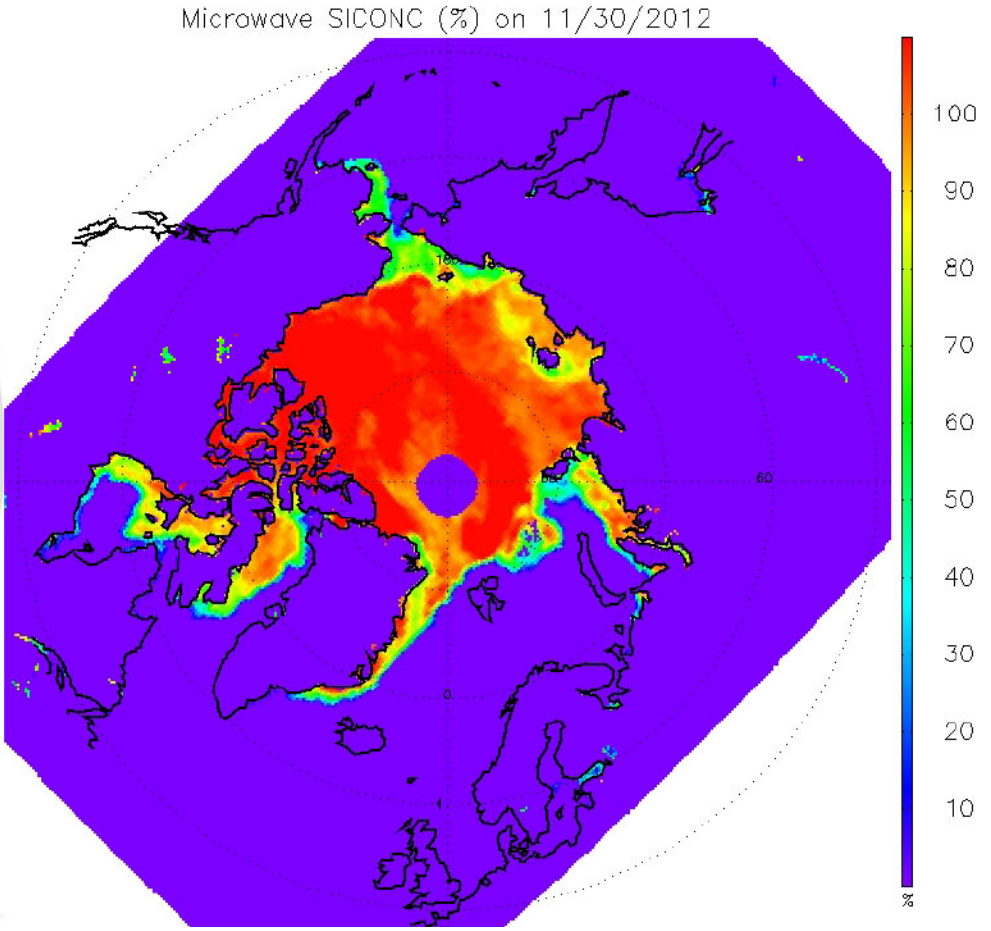
Beta Maturity Evaluation – Comparison of VIIRS Ice Conc. to Passive Microwave

VIIRS sea ice concentration IP is retrieving false sea ice over lower-latitude ocean areas.

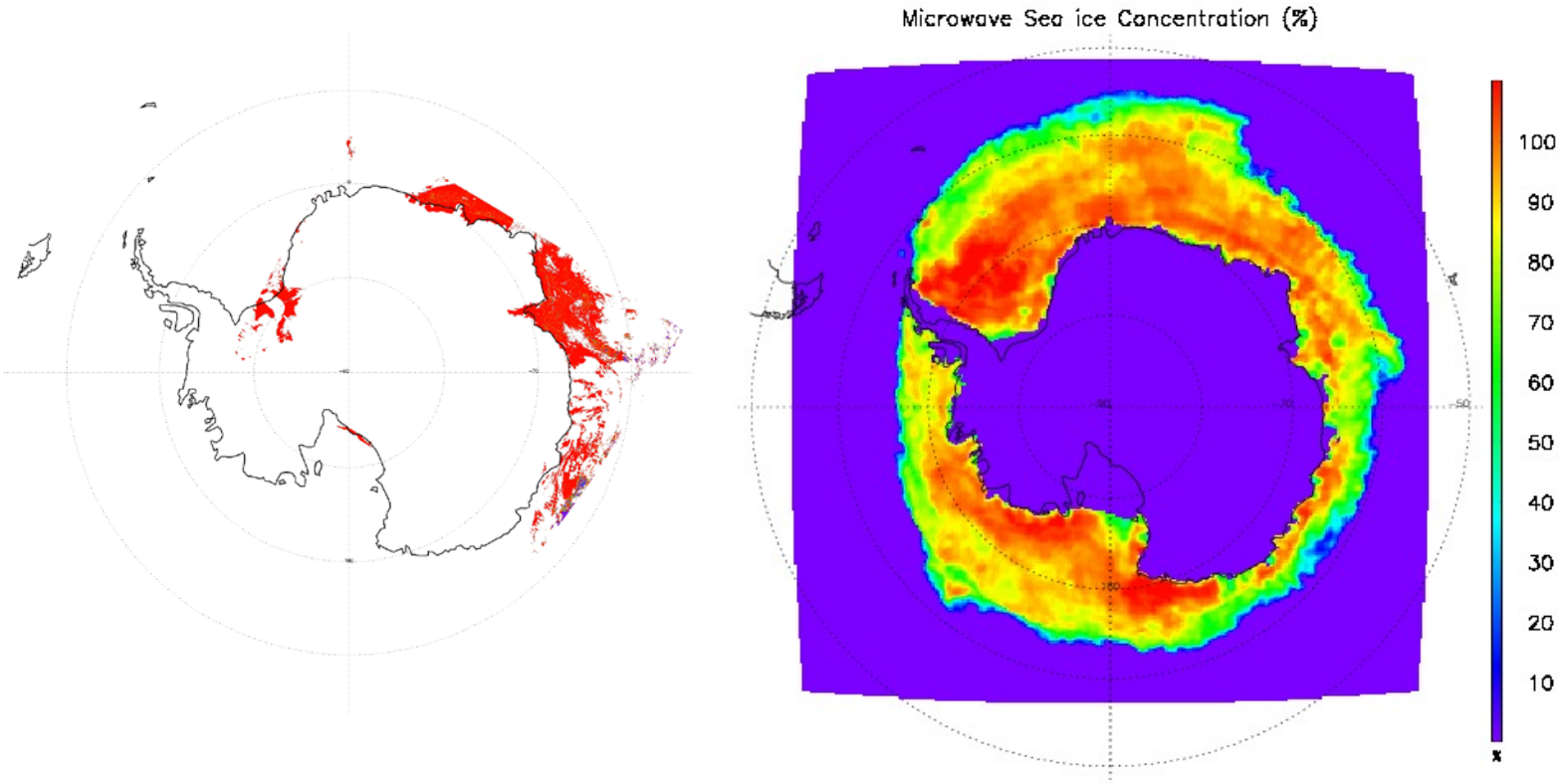
VIIRS Sea Ice Fraction (from Land PEATE)



Sea Ice Concentration from SSMIS passive microwave



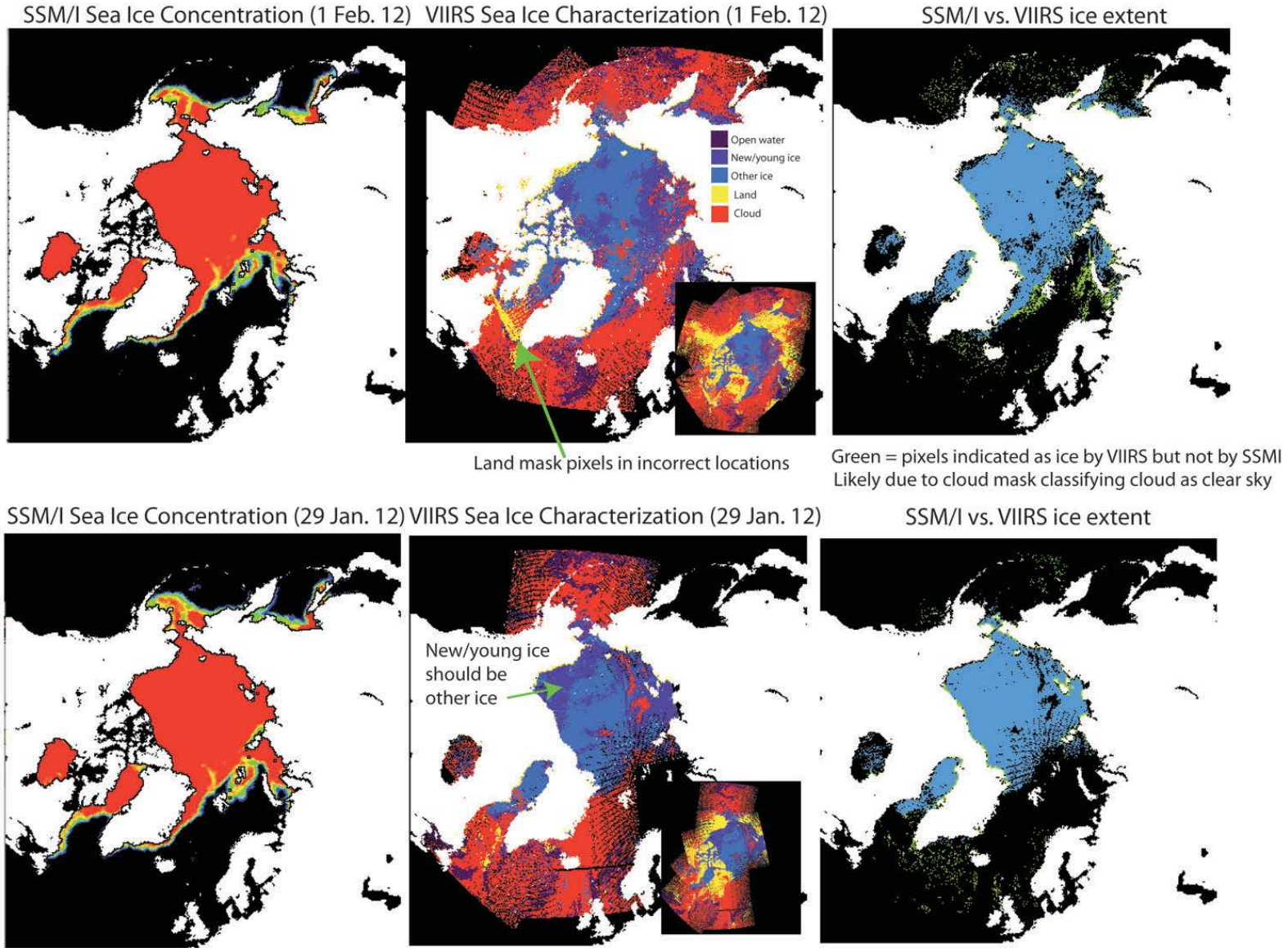
Beta Maturity Evaluation – Comparison of VIIRS Ice Conc. to Passive Microwave



VIIRS Sea Ice Concentration IP (left) vs. SSM/I Ice Concentration (right) for 10/12/2012, Antarctica.

Beta Maturity Evaluation – Comparison VIIRS Ice Conc. Passive Microwave

Sea ice extent is realistic, but with some false ice over open water, misclassification of new/young vs. other ice (in SIC EDR), and some misplacement of land values



Beta Justification Summary

- Criteria: Early release product
  - Ice Concentration IP performance is directly dependent on VIIRS Imagery resolution SDRs and the VIIRS Surface Temperature IP. It is also dependent on the VIIRS Cloud Mask IP, and AOT IP through the Ice Quality Flags IP and Ice Weights IP
    - VIIRS SDR Cal and Geo products reached provisional maturity in March, 2013.
    - VIIRS Cloud Mask IP reached provisional maturity in February, 2013
    - VIIRS Aerosol Optical Thickness reached beta maturity in September 2013
    - VIIRS Surface Temperature IP beta maturity pending approval

Beta Justification Summary

- Criteria: Available to allow users to gain familiarity with data formats and parameters
  - Cryosphere team has evaluated IDPS EDR products available from CLASS
    - Users can access and read the products and the product compares reasonably with the heritage satellite snow map products
  - Beta release will allow other users within the community to gain experience with the data formats and parameters.
    - This is important to allow users to complement the validation activity.

Beta Justification Summary

- Criteria: Product is not appropriate as the basis for quantitative scientific publication studies and applications
  - The product has known flaws (see caveats slides later in this presentation), but these products are of sufficient quality to justify use by a broader community
  - Most of the issues
    - VIIRS Sea Ice Concentration IP contains retrievals over false ice. The SST team has reported instances of missing ice. Some of the false ice retrieved by the VIIRS Sea Ice Concentration IP has been linked to a cloud leakage from a VIIRS Cloud Mask (VCM) which is still maturing and out of date (not update daily) Grid-VIIRS-Snow-Ice-Cover-Rolling Tiles that affects the VCM performance.
    - Significant discontinuities false and missing ice have been observed transitioning from day to night. Nighttime performance is poorer than daytime.
    - Ice Concentration performance bias exists but is expected to improve with additional quality checks, algorithm quality checks and maturation of the VCM and updated Surface Temperature IP regression coefficients

Caveats for Operational VIIRS Ice Concentration IP (additional issues)

- Known problems and proposed technical solutions
  - False ice frequently observed near cloud edges.
    - Implementation of additional quality checks in the Sea Ice Concentration IP for future builds beyond MX 8.0 should mitigate this problem
  - Significant discontinuities in ice concentration evident at 85 deg SZA transition between day/night for VCM and Ice Concentration to thermal based retrievals.
    - Such errors may be reduced with subsequent VIIRS Cloud Mask updates. However, such discontinuities will always remain.
  - Ice Concentration biases
    - Investigate and adjust tunable parameters associated with computation of ice tie points
  - Minor discontinuities related to ice tie points evident in the ice concentration
    - DR 4959 implementation of running mean based fallback tie points are likely to mitigate this problem

Caveats for Operational Ice Concentration IP
False Ice Observed near scattered clouds

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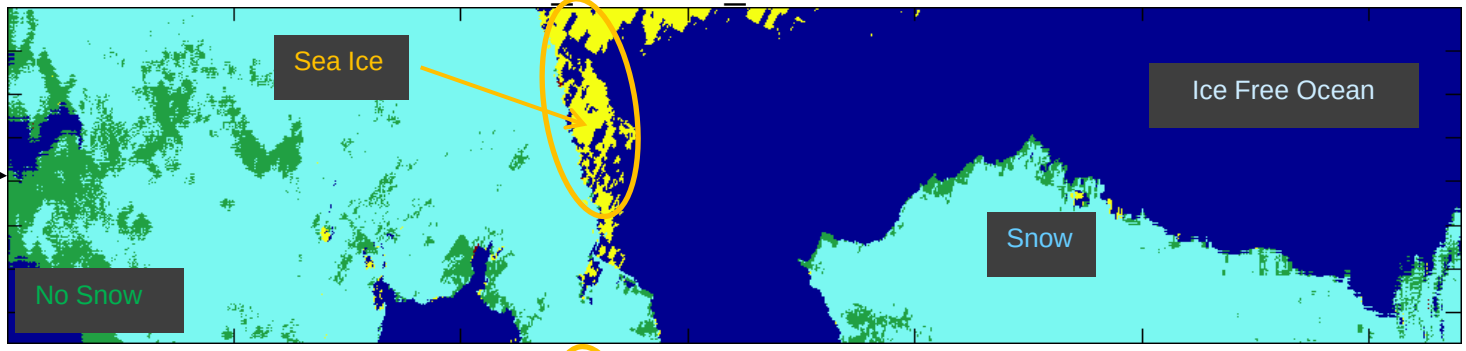
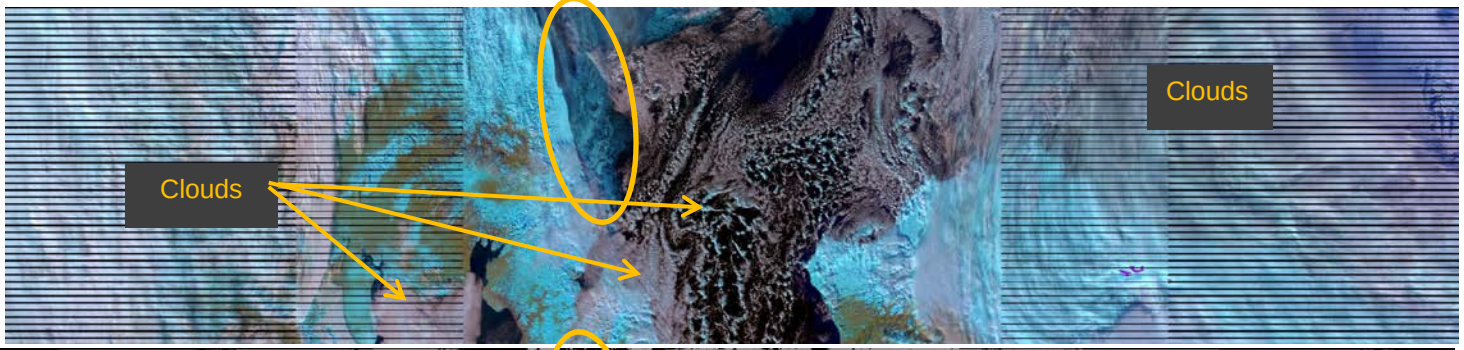
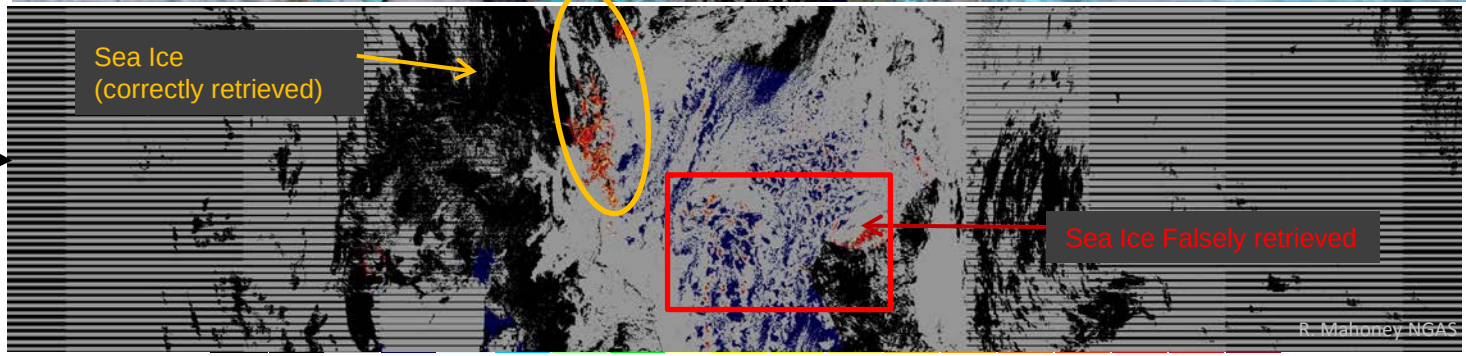
NOAA Global Automated Multisensor Snow/Ice



False Color VIIRS SDR Imagery



VIIRS Sea Ice Conc. IP



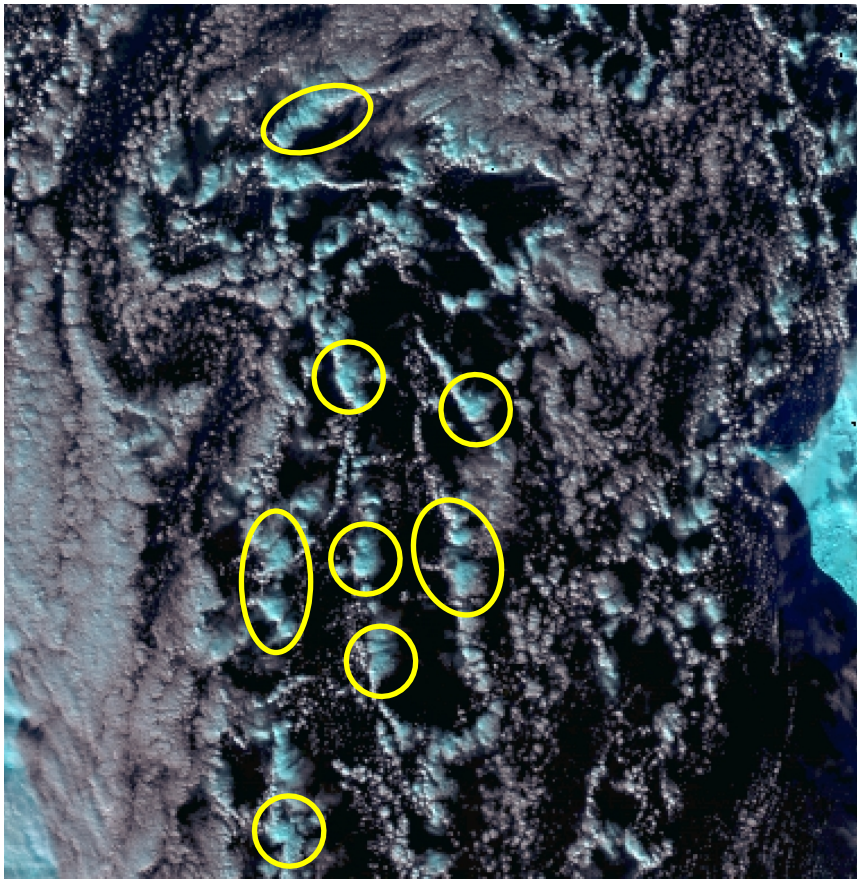
Fill Land Cloud 0.0 0.01 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.85 0.9 0.95 0.96 0.98 0.99 1.0

ice fraction

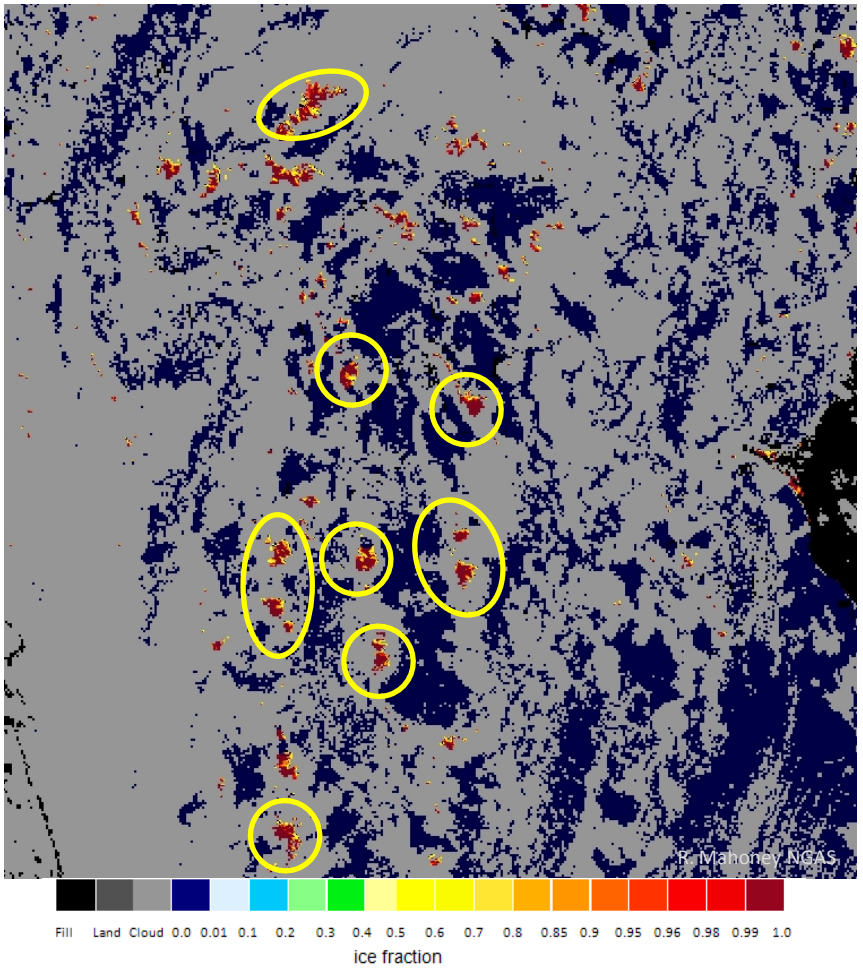
False ice is observed in regions with scattered clouds for Chukchi Sea/Beaufort Sea scene.

Caveats for Operational Ice Concentration IP False Ice Observed near scattered clouds

False color VIIRS SDRs

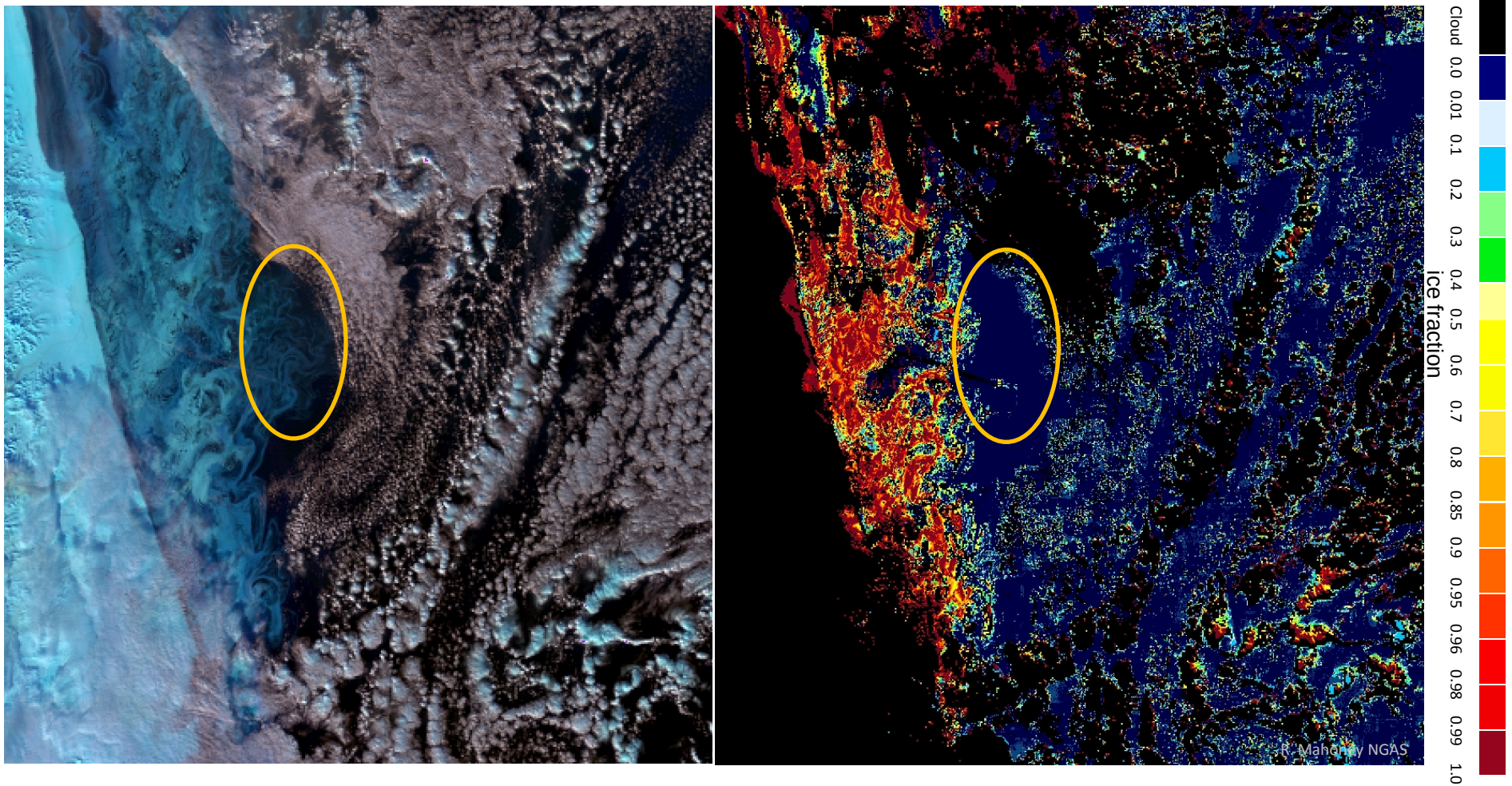


VIIRS Sea Ice Conc. IP



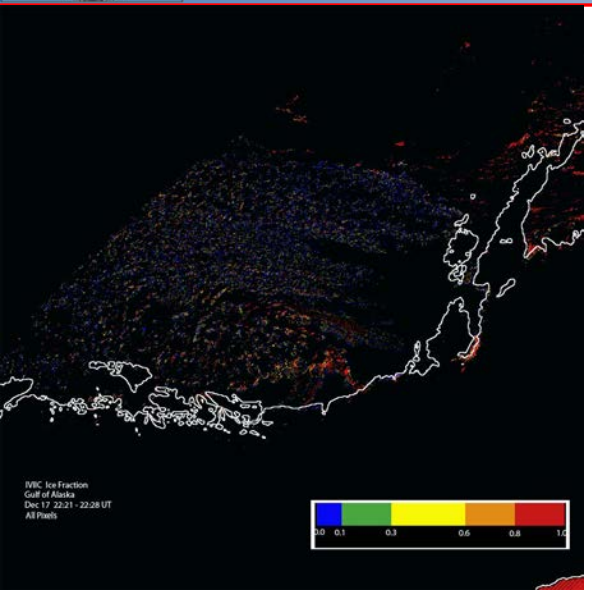
False color of VIIRS SDR reflectance (Red: M10, Green: M7, Blue: M5) for zoomed region (left). False ice shown by the yellow circled regions (right) correspond to clouds misclassified as confidently clear by the VCM and suggests additional quality checks are required in the Ice Concentration IP for extended cloud adjacency and significant partial cloudy regions.

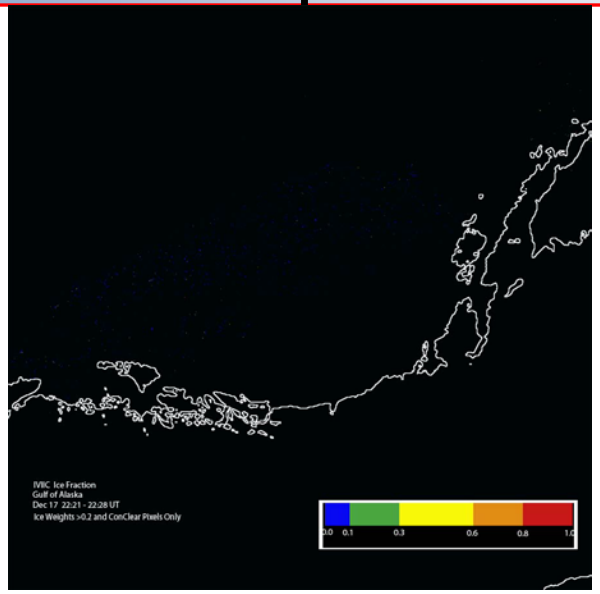
Caveats for Operational Ice Concentration IP Observed Missing Sea Ice

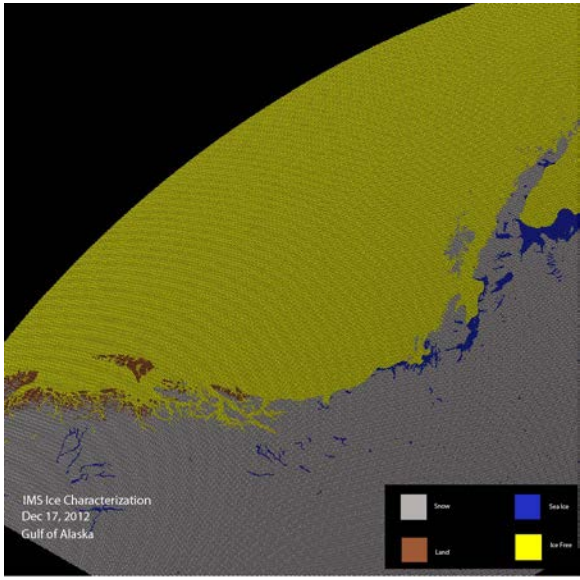


Some regions of missing sea ice have been observed in the VIIRS Ice Concentration IP for thin ice as shown in the circled region. False ice near clouds area also seen and for low ice fractions

Beta Maturity Evaluation - test to improve SIC IP

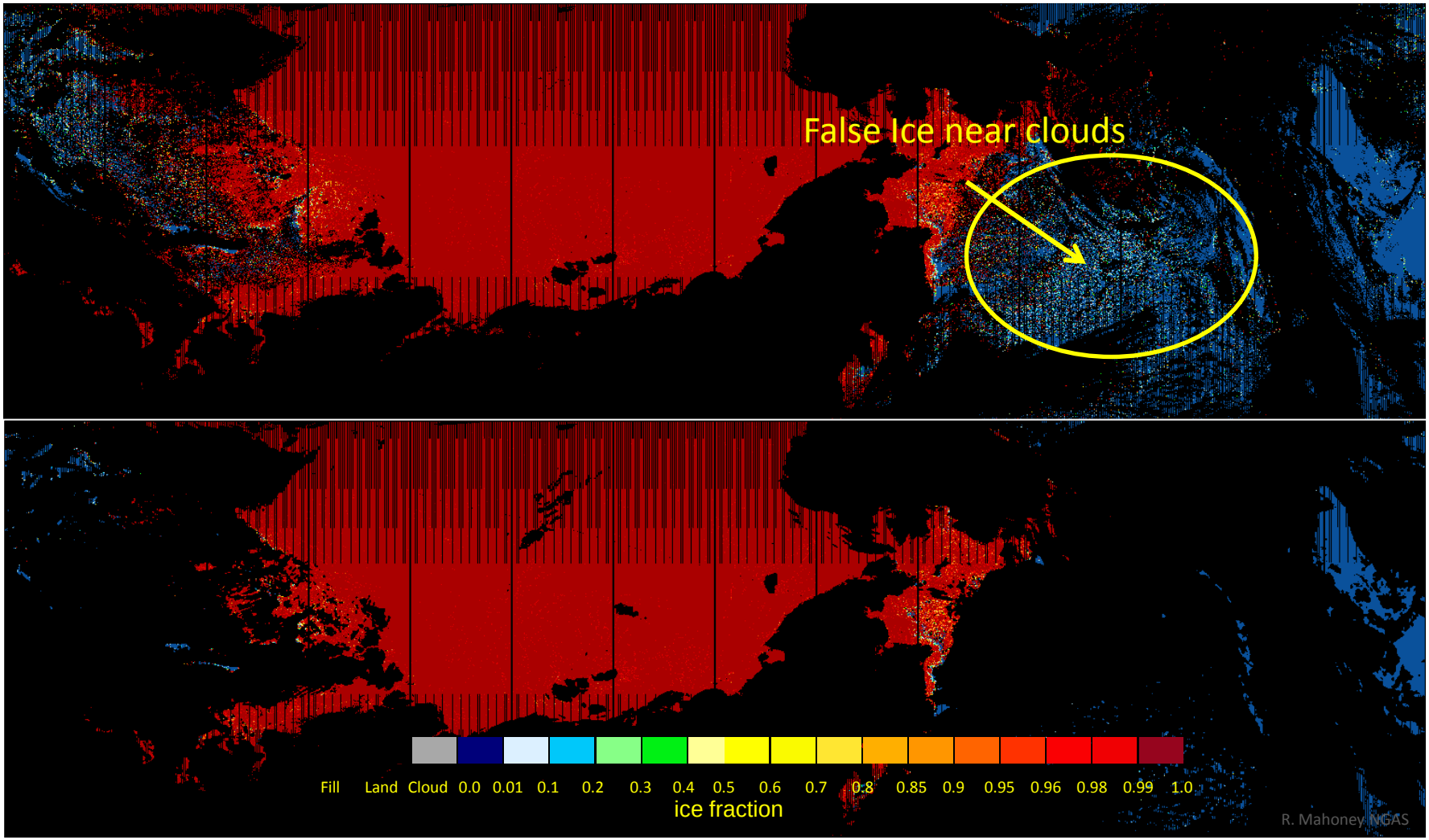






12/17/12: False ice (left) in Gulf of Alaska, removed (center) in local test after applying threshold for ice concentration weights. IMS ice data (right), showing absence of sea ice in this region (all ice-free).

Beta Maturity Evaluation
- Sliding Window Cloud Filtering Test



Results of partial cloudy filter tests for mosaic of VIIRS Sea Ice Concentration IP granules for Arctic 12-18-2012. Upper figure shows unfiltered ice concentration IP and lower figure shows results after application of a 15% non-confidently clear tie point search window filter. Further tests are required to determine the benefits and drawbacks of such an approach as an additional quality check in the Ice Concentration IP.

Additional Supporting Documentation

- TIM Meetings and Presentations
  - Cal/Val Team Meeting, April 2012
  - DR 4987 Sea Ice Concentration IP: Poor Performance Near Cloud Edges, January 3, 2013
- Monthly/weekly reports
  https://groups.ssec.wisc.edu/groups/jpss/cryosphere/reports
- NPP Science Team, Land Report, 12/12/2013

Future Plans and Issues

- We are working to get these changes into the IDPS
  - DR 7139, 4959, 4987, 4129, 7139
- Detailed performance characterization requires:
  - Further qualitative and quantitative comparisons with independent ice concentration sources
- Major actions for the provisional maturity justification and schedule
  - Implementation of additional quality checks and associated quality flags (MX 9.0)

Conclusion

- VIIRS Sea Ice Concentration IP has met the beta maturity stage based on the definitions and the evidence shown
  - It exceeds the definition of beta in most cases
  - Off-line IP product performance appears to be of sufficient quality for use by the Sea Ice Age EDR to identify ice to be classified as well as for Ice Surface Temperature EDR to identify sea ice for retrievals
- Some issues have been uncovered during validation and solutions are being evaluated.