VIIRS Cloud Mask Issues Observed by the Cryosphere Team

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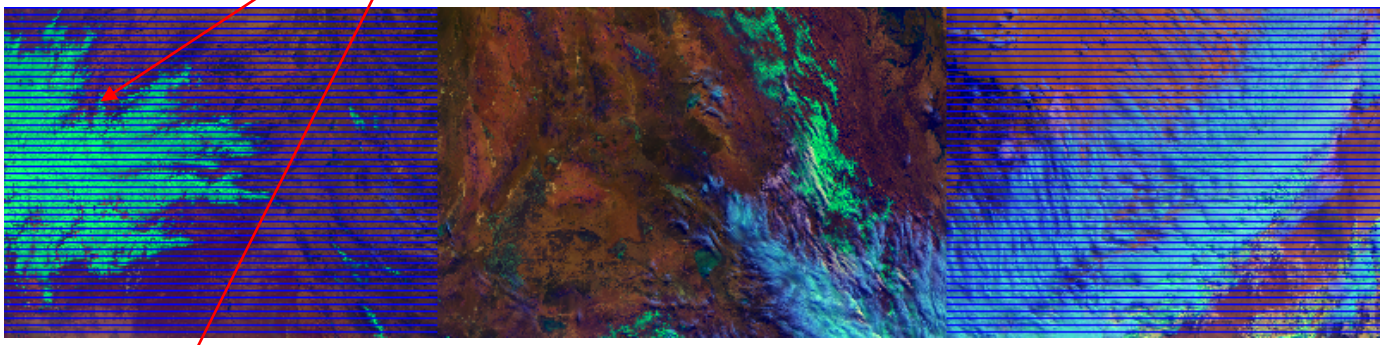
Introduction

- VCM cloud confidence errors (leakage and false alarms) directly impact the performance of the Cryosphere EDR products primarily through errors in snow/ice detection
- IST EDR performance can additionally be affected by errors due to undetected thin cirrus, particularly a problem for night regions
- Snow detection errors have been observed in the post MX 7.2 Build Snow Cover EDR associated with VCM cloud leakage (undetected clouds) and cloud shadows
- Sea Ice detection errors have been observed in pre-MX 7.2 Build Sea Ice Concentration IP related to VCM cloud leakage and undetected cloud shadows
- The VCM is being continuously improved and several recent improvements are directed toward mitigating cloud leakage and improvements to performance at night

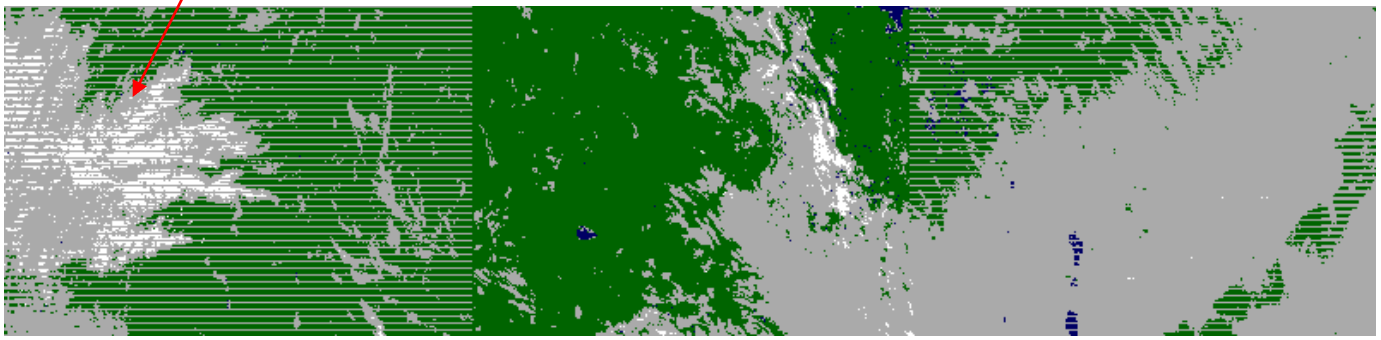
VIIRS Binary Snow Cover: Overestimated cloud extent

Clear snow-covered pixels are often labeled as cloudy. Most often this occurs along the snow cover boundary and in the mountains.

No clouds seen in false color imagery
Clouds are mapped in the VIIRS snow product



VIIRS RGB granule image



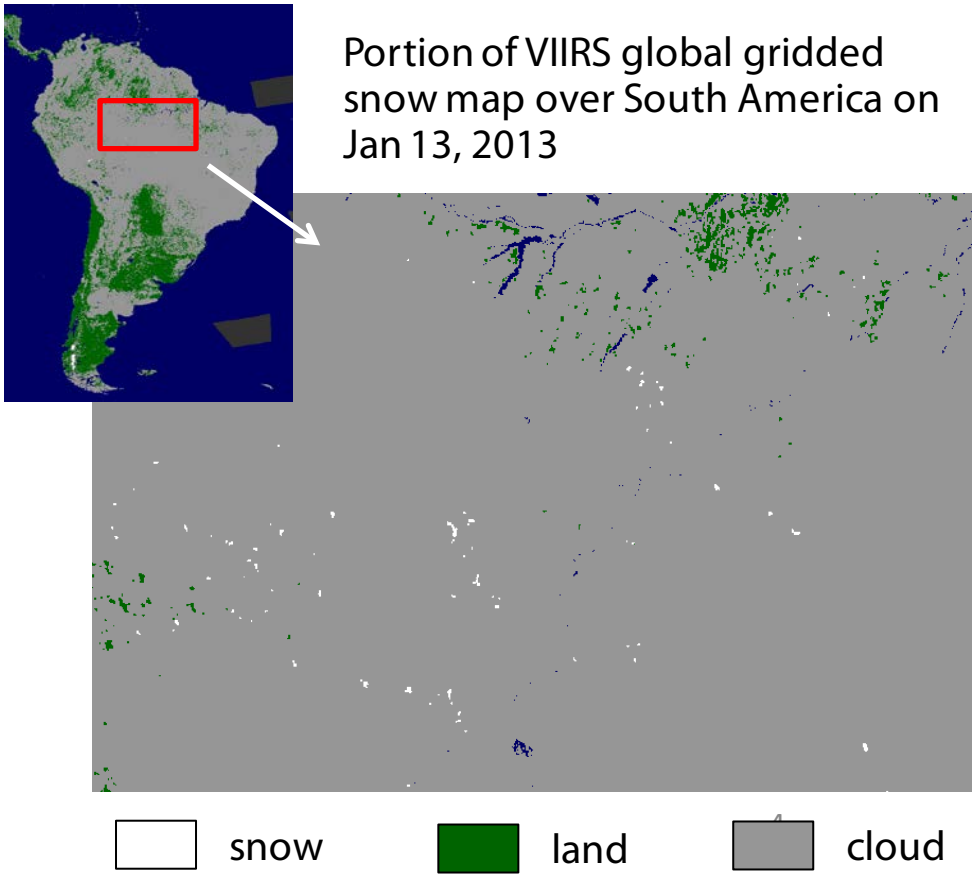
VIIRS granule snow product

snow land cloud No data / not processed

VIIRS Binary Snow Cover: False Snow

Some clouds are missed by the VIIRS cloud mask (VCM). Missed clouds are more often interpreted as snow and thus may appear in the snow product as spurious snow.

On the global scale the extent of spurious snow cover is small, 1-2%, compared to the extent of correctly identified snow.

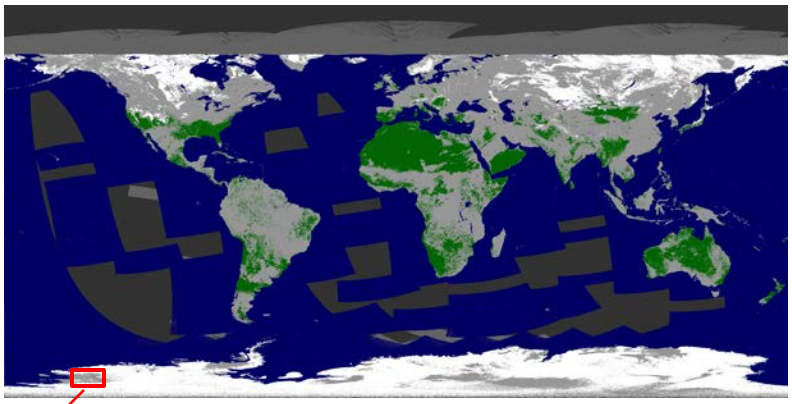


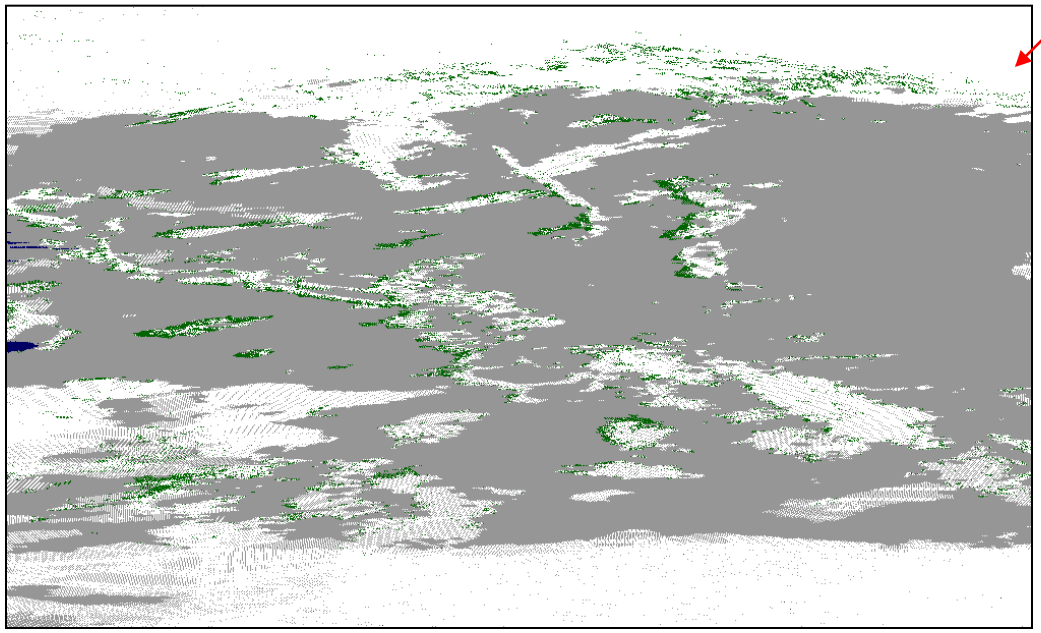
Portion of VIIRS global gridded snow map over South America on Jan 13, 2013

VIIRS Binary Snow Cover: Missed Snow due to Cloud Shadows

Occasional failures to detect snow shadowed by clouds were noticed in the VIIRS snow product

VIIRS snow cover, January 31, 2013 (day 2013031)





snow

land

cloud

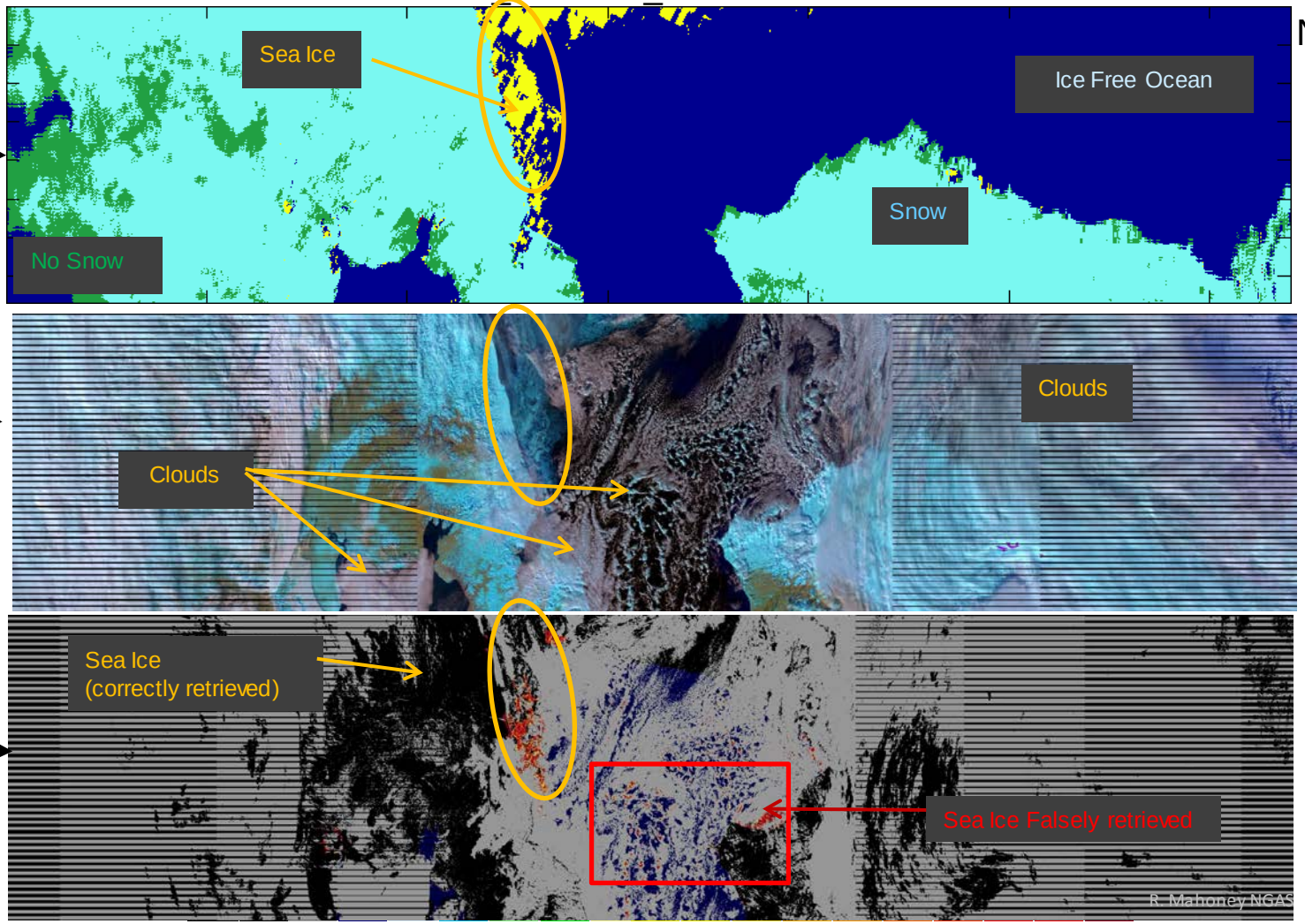
Caveats for Operational Ice Concentration IP
False Ice Observed near scattered clouds

d20121017_t2311272_e2312514

NOAA Global Automated Multisensor Snow/Ice

False Color VIIRS SDR Imagery

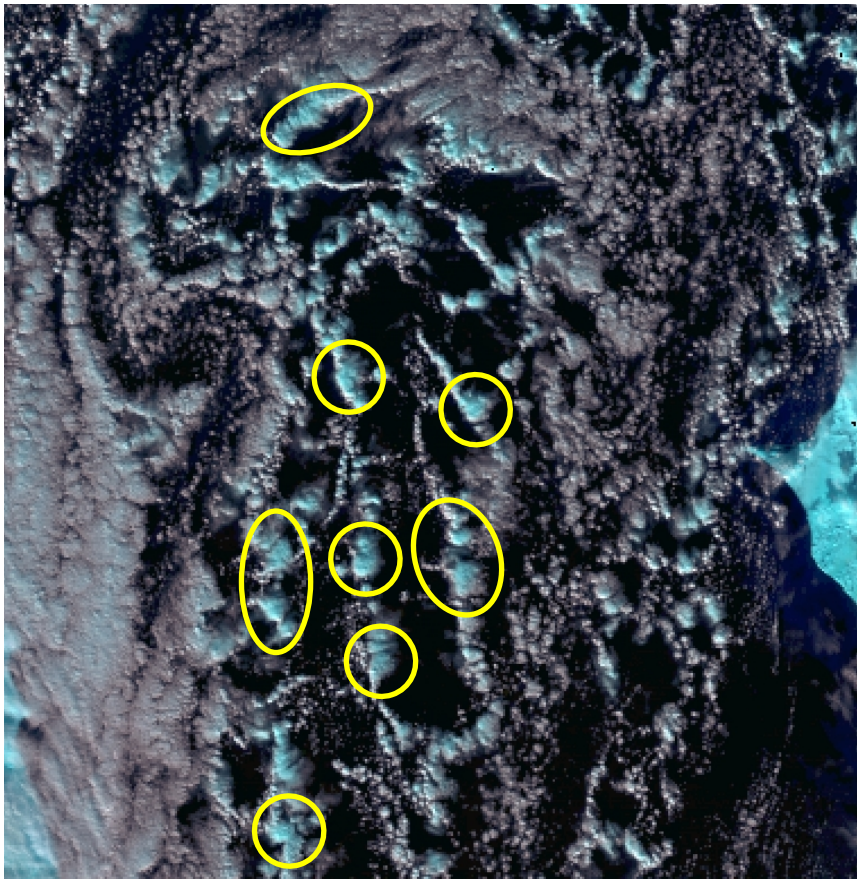
VIIRS Sea Ice Conc. IP



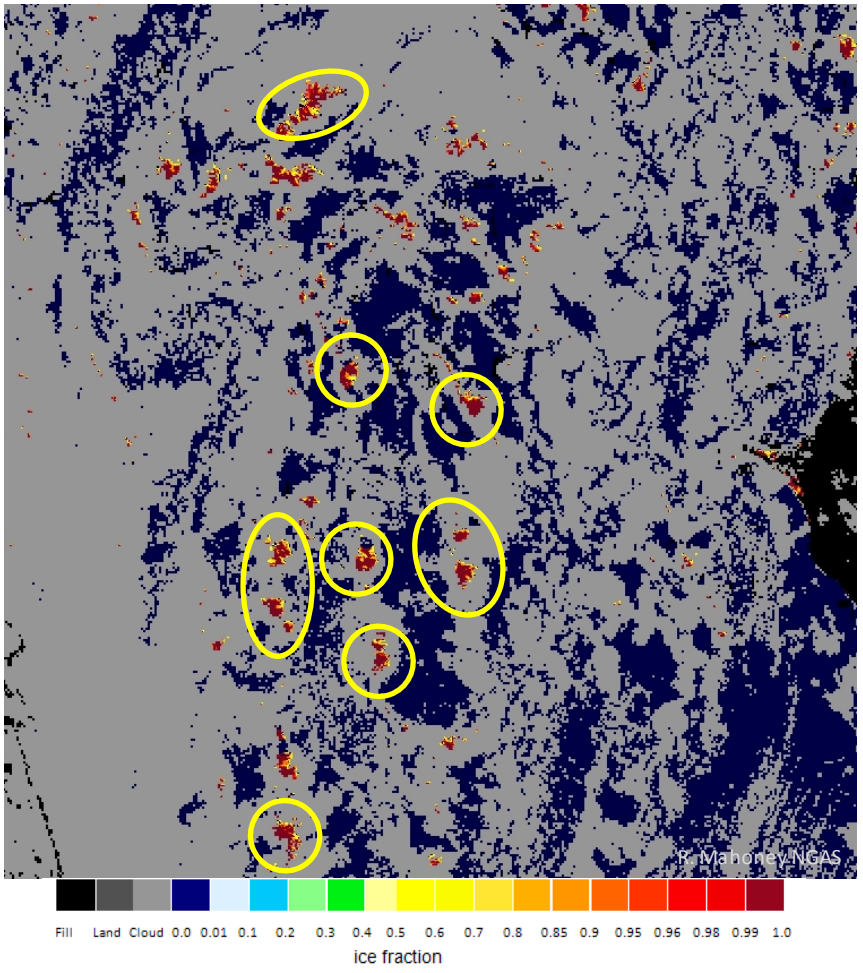
False ice is observed in regions with scattered clouds for Chukchi Sea/Beaufort Sea scene. A VCM improvement implemented on Aug. 20, 2013 (MX 7.2) was designed to mitigate this problem. Post MX 7.2 impacts on cryosphere products require further analysis

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

False color VIIRS SDRs

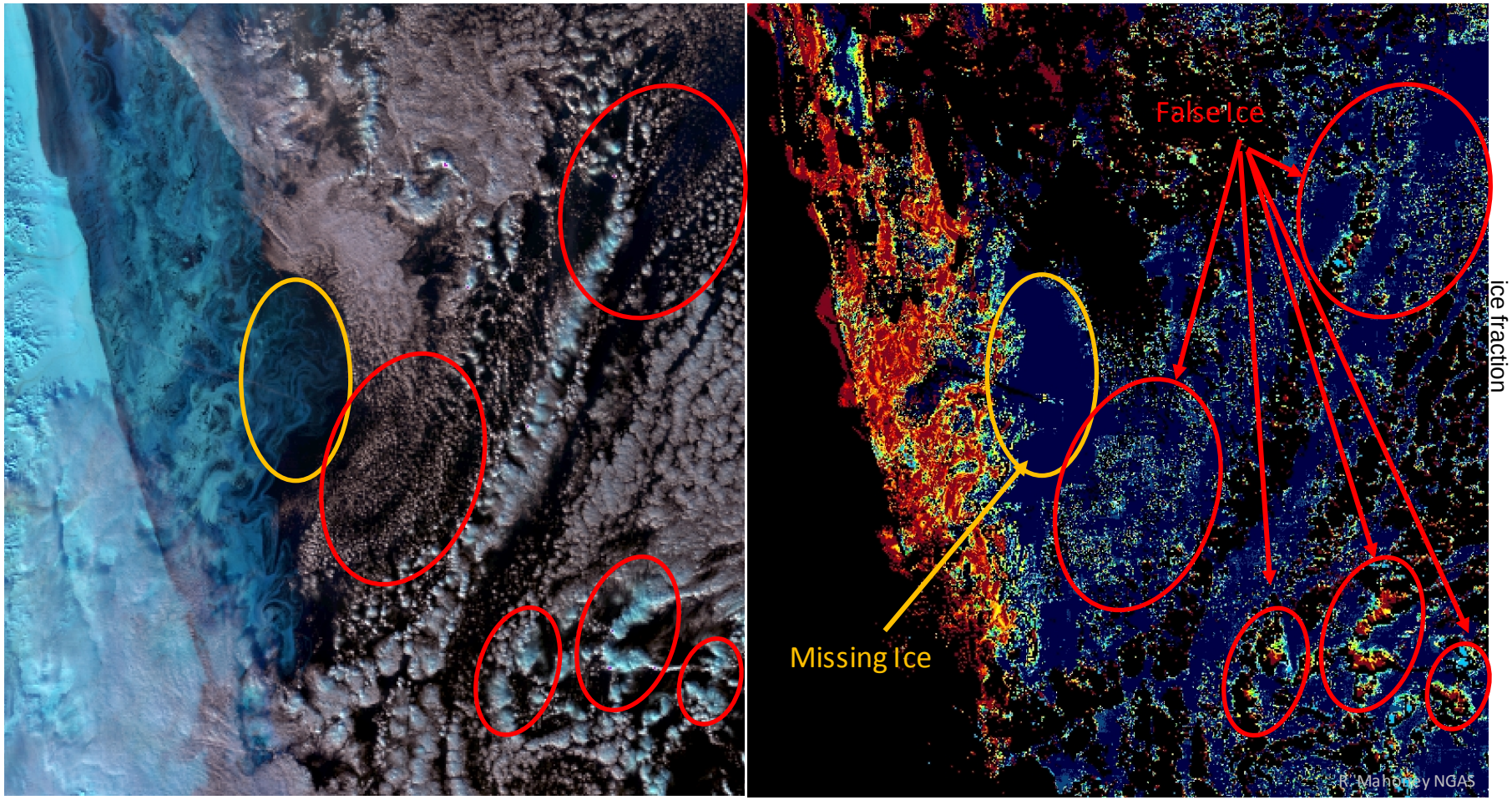


VIIRS Sea Ice Conc. IP



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.

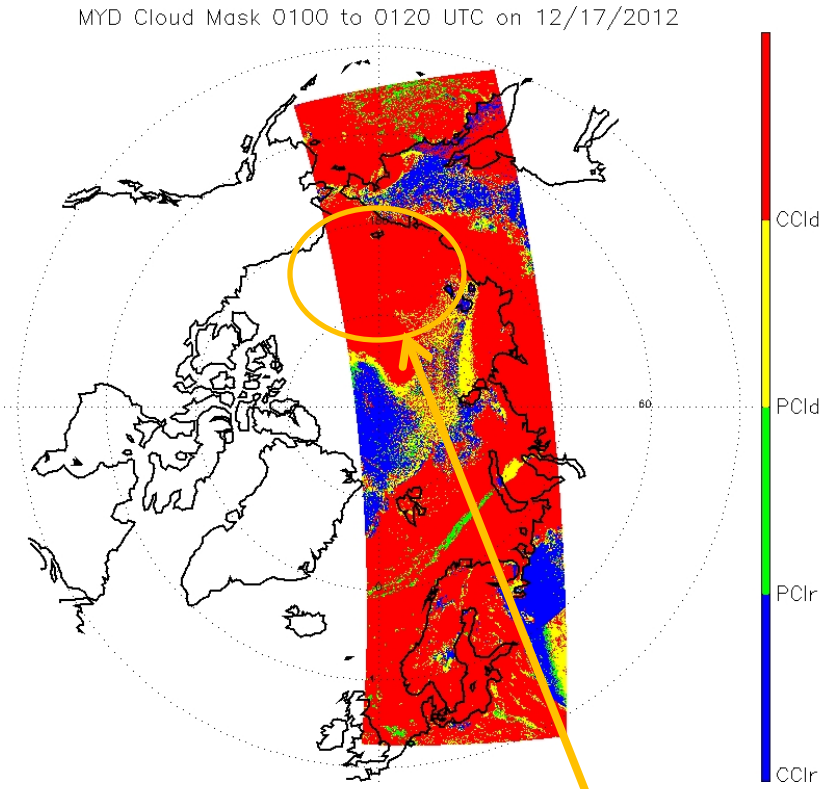
Caveats for Operational Ice Concentration IP Observed Missing Sea Ice



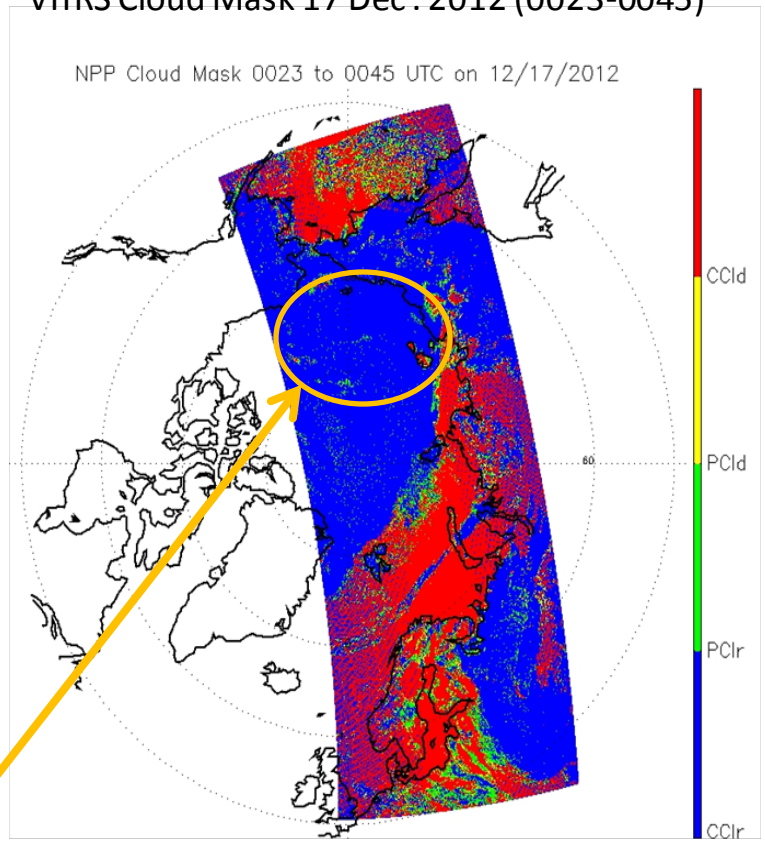
Some regions of missing sea ice have been observed in the VIIRS Ice Concentration IP (IVIIC) for thin ice as shown in the yellow circled region. Some cases of missing ice correspond to regions of depressed reflectance due to cloud shadows. Further examples of VCM cloud leakage resulting in false ice in the IVIIC are shown in the red circled regions and occurs more frequently as false ice with low ice fractions.

VIIRS/MODIS Cloud Confidence Discrepancy Observed in Night Arctic Scenes

MODIS Cloud Mask 17 Dec . 2012 (0100-0120)



VIIRS Cloud Mask 17 Dec . 2012 (0023-0045)

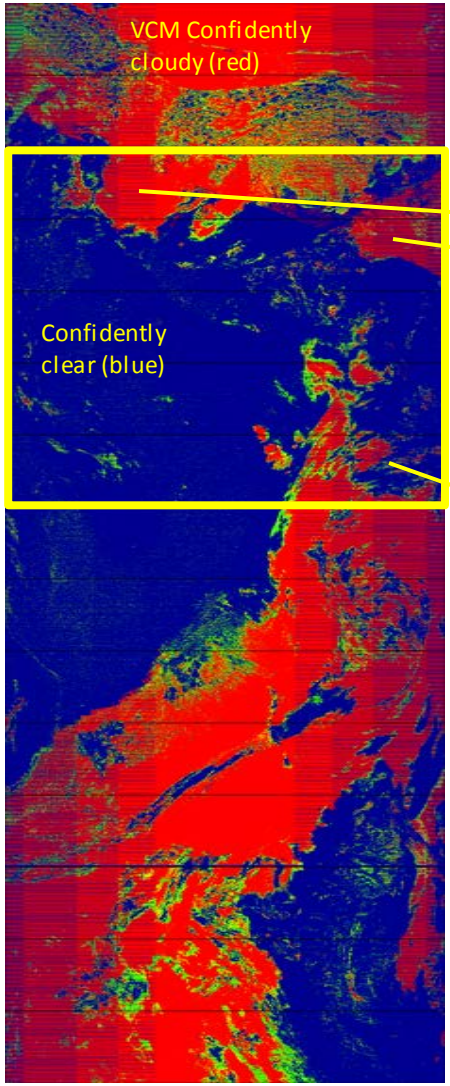


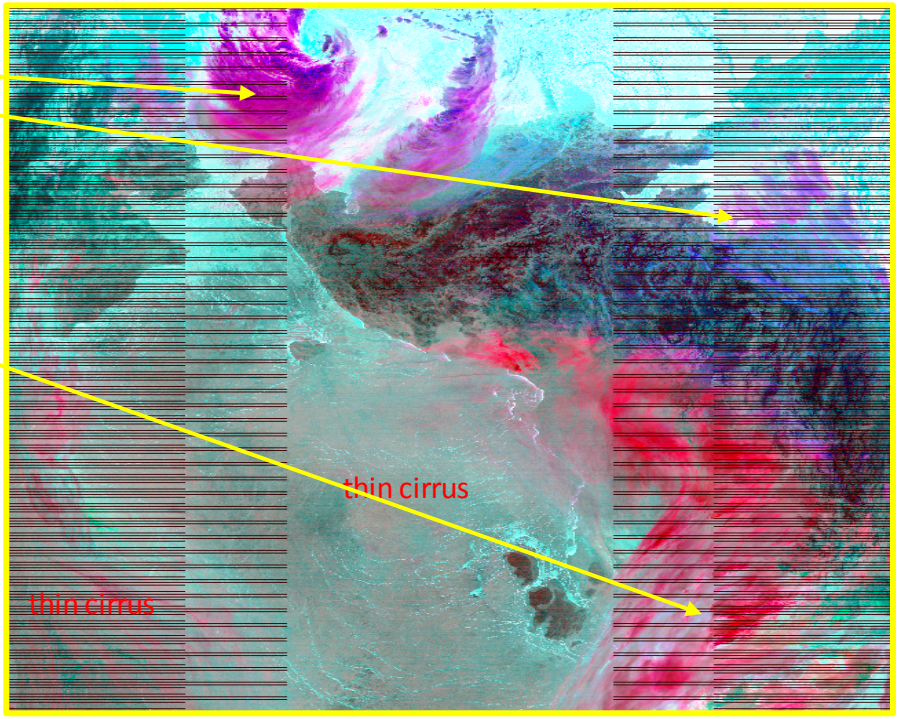
Confidently Cloudy = Red
Confidently Clear = Blue

Region of discrepancy

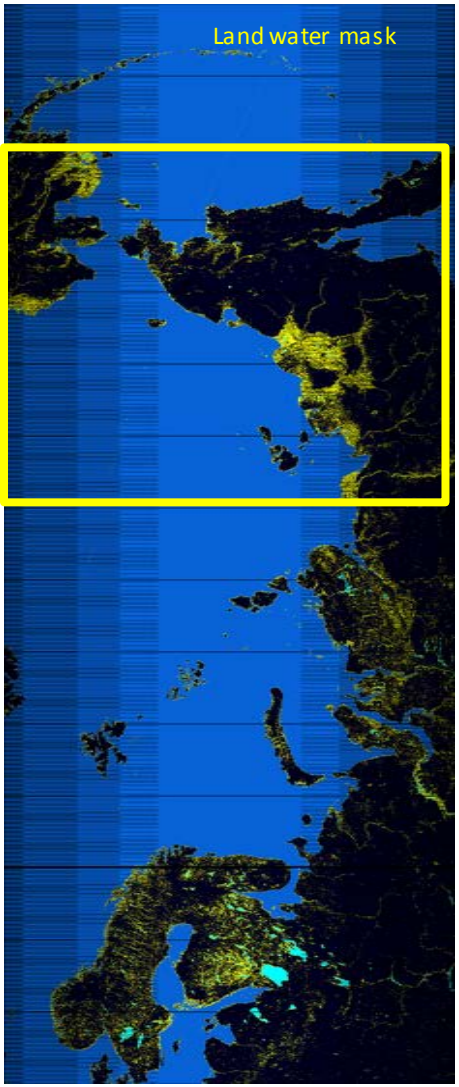
Large region shown by MODIS cloud mask as confidently cloudy is shown as confidently clear by the VCM. This region is inspected in detail on (slide 10)

VIIRS SDR False Color Brightness Temperature Difference and Brightness Temperatures





(Red: M15-M16, Green: M16, Blue: M12)



VCM misses extensive areas of cloud in this night scene but appears to correctly identify some clear regions compared to MODIS cloud mask. Clouds identifiable in thermal band difference imagery above suggests VCM night performance improvements may be possible based on IR thresholding techniques.

VCM Post Provisional Updates

Several updates to the VCM implemented in 2013 are relevant to the Cryosphere Algorithms. These improvements addressed thin cirrus detection, mitigation of missing clouds (leakage) for day and improved detection of clouds night:

- Build 7.1 (July 10, 2013) included:
  - ✓ Adding a PW variable in the algorithm for detecting (thin) cirrus
- Build 7.2 (August 20, 2013)included:
  - ✓Significant improvement to snow/ice/cloud differentiation in daytime scene
  - ✓Added thresholds for the gross nighttime Infrared (IR) and Mid-Wave IR difference cloud detection test
  - ✓Corrected logic for cloud shadows

While Validation Level 1 analysis of Snow Cover EDR has involved examination of some post Build MX 7.2 scenes, analysis of the IST and Sea Ice Characterization EDRs performance has not.

Summary

- Analysis of Snow Cover EDR based on post MX 7.2 Build data indicates that occurrences of false snow are often associated with VCM cloud leakage and occurrences of missing snow often associated with VCM false alarms that occur frequently near edges of snow fields and mountainous regions. Missing snow was also found to be associated with cloud shadow regions.

- Analysis of pre-MX 7.2 Build data detected occurrences of false ice associated with cloud leakage and missing ice associated with undetected cloud shadows particularly near terminator regions.

- Currently the VCM cloud shadow algorithm is limited to performing shadow detection up to a Solar Zenith Angle (SZA) threshold of 75°. Extending shadow detection capability up to the day/night limit is desirable but may require significant effort beyond extending the SZA threshold.

- Validation Level 2 efforts will include analysis of the post MX 7.2 Build VCM update impacts on the IST and Sea Ice Characterization EDRs to confirm mitigation of the observed problems related to false and missing ice detection.