Retrieval of Sea Ice Age and Concentration Using The VIIRS Sea Ice Characterization Algorithm: Preliminary Tests with MODIS Proxy Data

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Introduction

Abstract:

The VIIRS Sea Ice Characterization algorithm performs retrieval of ice age classification (New/Young, First Year, Multiyear) at 2.4km spatial resolution and ice concentration at 375m resolution at nadir using the VIIRS 640nm (I1) and 865nm (I2) reflectance bands and the 11.5um (I5), 11um (M15) and 12um (M16) thermal infrared bands. Retrieval of New/Young from thicker First Year and Multiyear ice is based on application of a reflectance threshold model for daytime pixels and an energy balance model for night time pixels. Discrimination of First Year ice from that of Multiyear ice is performed using a filtered distribution of ice reflectance or ice temperature. Retrieval of sub-pixel sea ice concentration is based on reflectance and thermal tie point methods. An overview is provided of the current status of the NPOESS/NPP VIIRS Sea Ice Characterization algorithm and preliminary results based on functional chain testing using MODIS proxy data are presented.

Background:

The VIIRS Sea Ice Characterization algorithm is designed provide day/night retrievals of ice age class and ice concentration. Ice concentration is retrieved as an intermediate product for use by sea ice age EDR classification algorithm. Key requirements are summarized in the following table derived from the NPOESS/NPP System Specifications for the Sea Ice Age EDR.

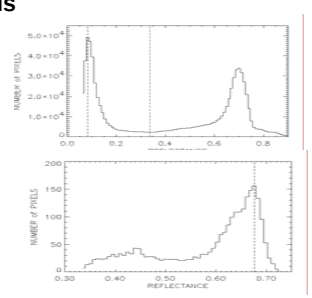
Paragraph	Attribute	Value
40.7.8-1	Horizontal Cell Size (Ice Age)	
40.7.8-1a	1. Clear	2.4 km
40.7.8-3	Horizontal Coverage	Oceans
40.7.8.4	Measurement Range	
40.7.8-4a	1. Ice Age Classes, Clear	New/Young, First Year, Multi-year
40.7.8-6	Probability of Correct Typing (Ice Age)	
40.7.8-6a	1. First Year from Multi-year	80%
40.7.8-6b	2. New/Young from First Year	70%
40.7.8.6c	3. New/Young from Multi-year	70%

Preliminary chain testing of the sea ice algorithm have thus far been conducted for several scenes based on MODIS derived proxy data. Results have been qualitatively compared against partial concentration data derived from National Ice Center Ice Chart data[(1)].

Algorithm Basis

Sea Ice Concentration:

- Ice concentration is derived from a tie point equation
- Ice and water tie points are determined for the visible TOA reflectance (VIIRS I1 band), near infrared TOA reflectance (VIIRSI2 band), and surface temperature
- Ice/water thresholds are derived from the local minimum of the distribution of reflectance and temperature (dashed lines in top figure show the water peak and the ice/water threshold)
- Tie points for a VIIRS imagery resolution pixel are established from the local distribution of reflectance and temperature within a sliding search window centered on that pixel (dashed line in bottom figure shows the local ice tie point)
- Derived tie points are specific to the local region contained within the search window, providing global operational capability



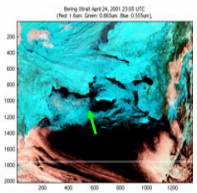
Sea Ice Age:

- Ice is classified as one of three types, New/Young, First Year, or Multi-Year
- New or Young ice is discriminated from thicker ice (First Year or Multi-year) by a threshold ice thickness of 30 cm.

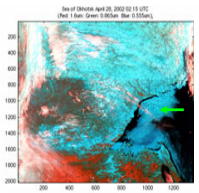
- Discrimination of New/Young ice from thicker First Year and Multi-year ice is achieved by two independent methods (algorithms)
  1: At nighttime and for low sun angle conditions, an energy balance derivation of ice thickness from ice temperature.
  2: At daytime, application of a reflectance/thickness relation obtained from a LUT.

- Multi-year ice is discriminated from First Year ice by analysis of the spatial distribution of ice reflectance or temperature in scene subsets :Classification algorithm is based on using application of a spatial filter, identification of peaks in probability densities, and segmentation

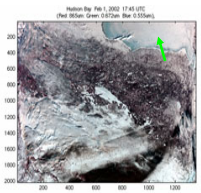
MODIS Proxy Test Scenes



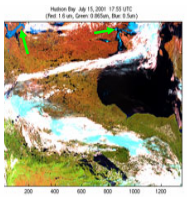
Bering Strait
April 24, 2001 23:05 UTC



Sea of Okhotsk
April 28, 2002 02:15 UTC



Hudson Bay
Feb. 1, 2002 17:45 UTC

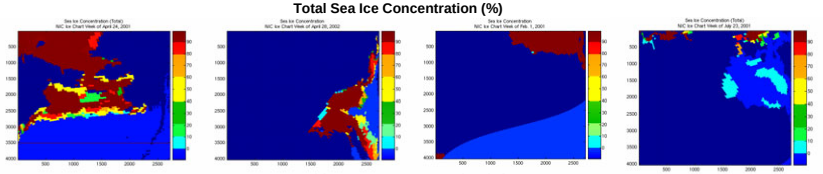


Hudson Bay
July 15, 2001 17:55 UTC

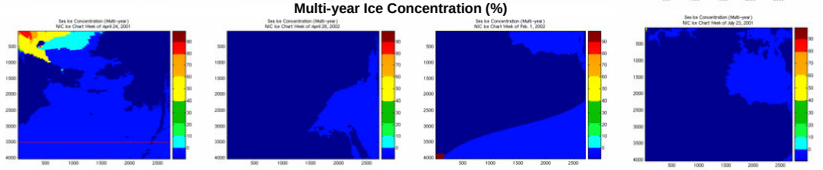
Enhanced (RGB) reflectance images corresponding to MODIS proxy data scene. Sea ice regions are indicated above by arrows.

Digitized Ice Chart Ice Concentration Data

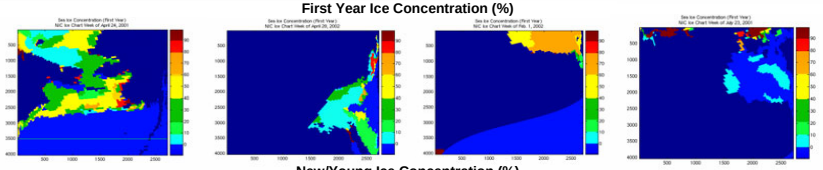
Total Sea Ice Concentration (%)



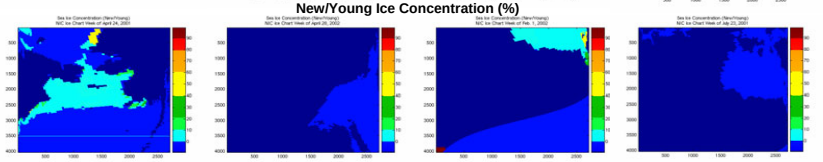
Multi-year Ice Concentration (%)



First Year Ice Concentration (%)



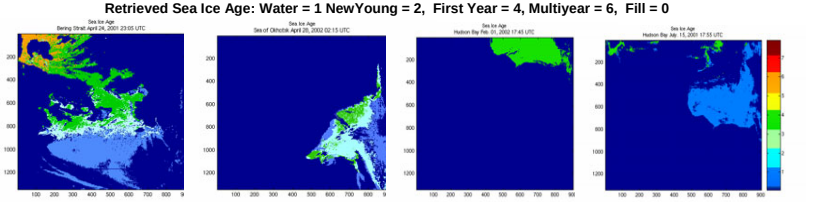
New/Young Ice Concentration (%)



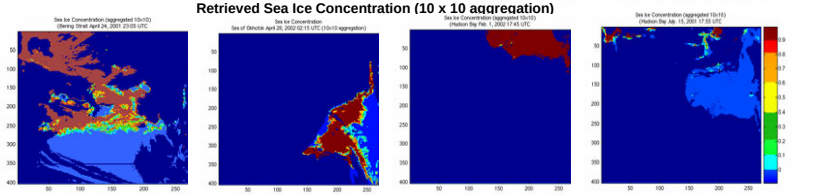
Ice concentrations derived from digitized ice charts[(1)] provided on a Lambert Azimuthal Equal Area projection (EaseGrid) have been remapped to satellite swath and are shown for comparison with retrieved sea ice age and concentrations shown in the next frame. Note the inconsistency between partial concentrations the total concentration. These therefore should be interpreted as a qualitative indicator of presence of ice age types and relative concentration.

Sea Ice Age Ice and Concentration Results

Retrieved Sea Ice Age: Water = 1 NewYoung = 2, First Year = 4, Multiyear = 6, Fill = 0



Retrieved Sea Ice Concentration (10 x 10 aggregation)



Conclusions

Preliminary results retrieved sea ice age and ice concentration produced from the VIIRS Sea Ice Algorithm show qualitative agreement with of gross features visible in enhanced MODIS reflectance imagery and partial ice concentration data derived from NIC ice chart data. Presence of Multi-year ice indicated in the the NIC ice chart for the April 24, 2001 Bering Strait scene is captured in the sea ice age retrieval. Ice age classes for Hudson Bay and Sea of Okhotsk properly capture the predominant ice types. Further comparisons are required utilizing AMSR-E, SSM/I, MOD29 Sea Ice concentration data and National Ice Center ice chart data for performance of objective comparisons.

(1) National Ice Center. 2006. National Ice Center Sea Ice Charts and Climatologies in Gridded Format. Edited by F. Fetterer and C. Fowler. Boulder, CO: National Snow and Ice Data Center. Digital media.