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Intercomparison of MODIS and VIIRS Results for Mapping Summer Minimum of Snow and Ice (MSI) Extent Over Canadian Landmass

Alexander P. Trishchenko, Calin Ungureanu

Canada Centre for Remote Sensing, Natural Resources Canada

Objective

- **The final goal**: To continue MODIS time series generated by the Canada Centre for Remote Sensing (CCRS) over Canada landmass since 2000 with compatible and advanced products generated from **Visible/Infrared Imaging Radiometer Suite** (VIIRS) imagery;
- VIIRS currently operates onboard the NOAA Suomi National Polar-orbiting Partnership (SNPP) satellite. SNPP orbit: sun synch. (1:30pm), H=830km, VIIRS swath – 3040km ;
- SNPP is the first satellite of future US/NOAA Joint Polar Satellite System (JPSS) that will include JPSS-1 & 2 satellites etc. all equipped with VIIRS.

CCRS product features: MODIS vs VIIRS

- **MODIS imagery** includes three types of spatial scales: 250m, 500m, 1000m (@nadir)
  - 250m – B1 (red) and B2 (NIR)
  - 500m – all solar bands B1 (blue) to B7 (SWIR -2.2mm)
  - 1000m – all bands B1(blue) to B36 (TIR-14.2mm)
    - Standard MODIS image output formats: swath and sinusoidal projection
    - Standard MODIS compositing period – 1-day and 16-day
- **VIIRS imagery** includes two types of spatial scales:
  - 375m (I-bands) – 5 bands
  - 750m (M-bands) -16 bands + DNB
  - Additional enhancement along the scan direction (3-sample, 2-sample and 1-sample aggregation) to compensate for the growth of pixel size with increase of the Viewing Zenith Angle (VZA)
- **CCRS MODIS processing** features:
  - Lambert Conic Conformal Projection (LCC) over Canada, Lambert Azimuthal Equal Area (LAEA) over the North America and Arctic circumpolar region
  - 10-day compositing intervals
  - Enhanced spatial resolution for all solar bands B1-B7 to 250m scale*
    - 250m is a requirement for spatial resolution for several terrestrial ECVs: GCOS-154 (2011). "Systematic observation requirements for satellite-based data products for climate. 2011 Update. Supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)".
  - Product is generated directly from swath images, i.e. no extra re-projection steps
  - In-house scene ID mask: clear, cloud, cloud shadow
  - Two-value (Forward and Backward Scattering) in-house compositing scheme
- **CCRS VIIRS processing** features
  - LCC (and potentially LAEA) projections compatible with CCRS MODIS format
  - 10-day compositing intervals
  - Spatial resolution (re-mapping) for output products
    - 250m for I-bands
    - 500m for M-bands
  - In-house re-projection tool
  - In-house scene ID-mask
  - In-house compositing scheme

Current VIIRS processing chain at CCRS



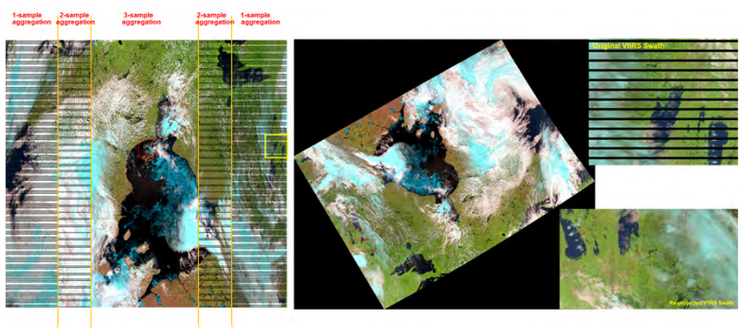
Code currently consists of
- > 60 modules
- > 12,000 lines

- Input data
  - ✓ I-band SDRs + geo
  - ✓ M-band SDRs + geo
  - ✓ VIIRS Cloud Mask (VCM) EDR

- Processing is defined by **CONFIG**uration file
- Various intermediate outputs can be generated for debugging, testing and QC purposes
  - ✓ Input images and geo-files
  - ✓ Gradients employed in re-projection
  - ✓ GCP chips and Correlation Matrices
  - ✓ GCP statistics
  - ✓ LOG-file with a record of all operations

VIIRS re-projection scheme at CCRS

VIIRS image re-projection is based in MODIS concurrent gradient search method developed at CCRS by Khlopenkov and Trishchenko, IEEE TGRS, 2008, 46 (7), pp. 2016-2027. The geolocation quality control in implemented to ensure high geolocation accuracy and compatibility with MODIS



References:

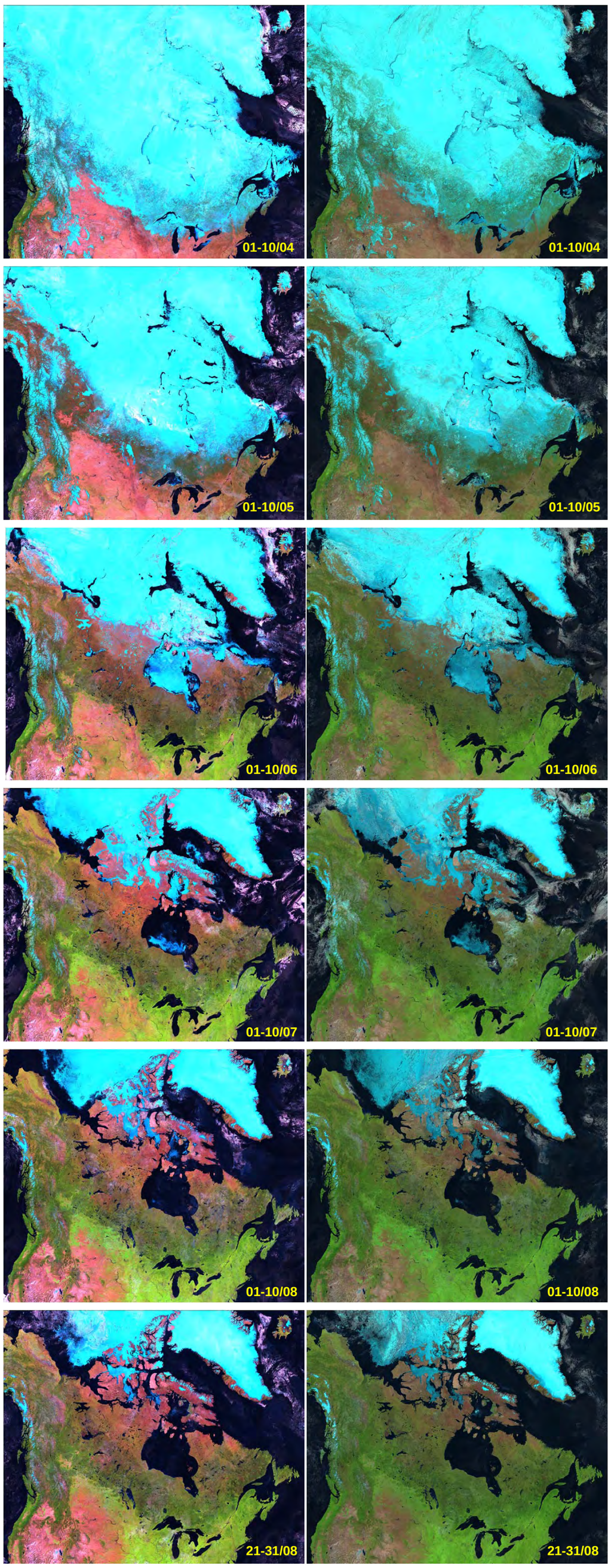
Khlopenkov K.V., A.P.Trishchenko, 2008: Implementation and evaluation of concurrent gradient search method for reprojection of MODIS level 1B imagery. *IEEE TGRS*. 46 (7), art. no. 4538199, pp. 2016-2027

Luo, Y., A.P.Trishchenko, K.V. Khlopenkov, 2008: Developing clear-sky, cloud and cloud shadow mask for producing clear-sky composites at 250 m spatial resolution for seven MODIS land bands over Canada and North America. *Rem. Sensing Environ.* 112 (12), pp. 4167-4185.

Trishchenko,A.P., S.G.Leblanc, S.Wang, J.Li, C.Ungureanu, Y.Luo, K.V.Khlopenkov, F.Fontana, 2016: Variations of annual minimum snow and ice extent over Canada and neighboring landmass derived from MODIS 250m imagery for 2000-2014 period. *Can. J. Rem. Sens.*. Vo. 42(3), pp.: 214-242

Trishchenko, A.P., Y.Luo, K. Khlopenkov, W.M.Park, S.Wang, 2009: Arctic circumpolar mosaic at 250m spatial resolution for IPY by fusion of MODIS/TERRA land bands B1–B7. *Int. J. Rem. Sensing.* 30, 1635-1641.

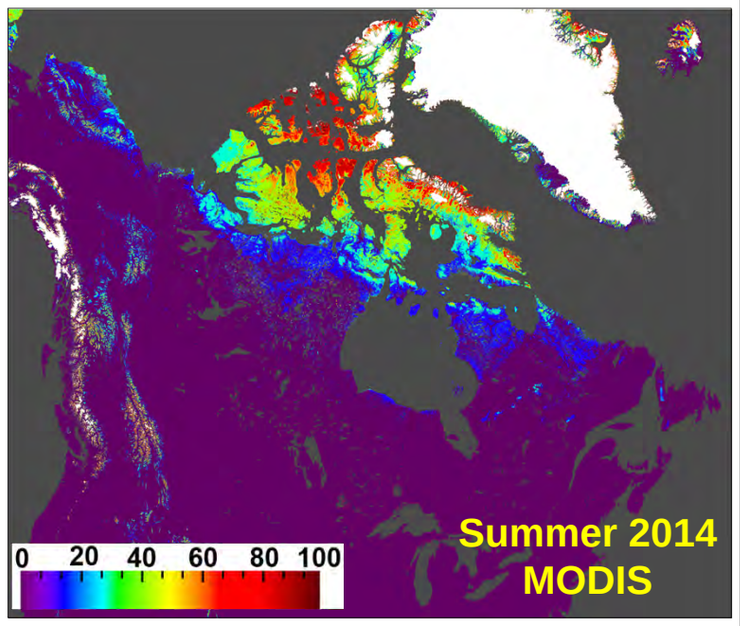
Examples of MODIS and VIIRS imagery for summer 2014: 10-day composites at the beginning of each month

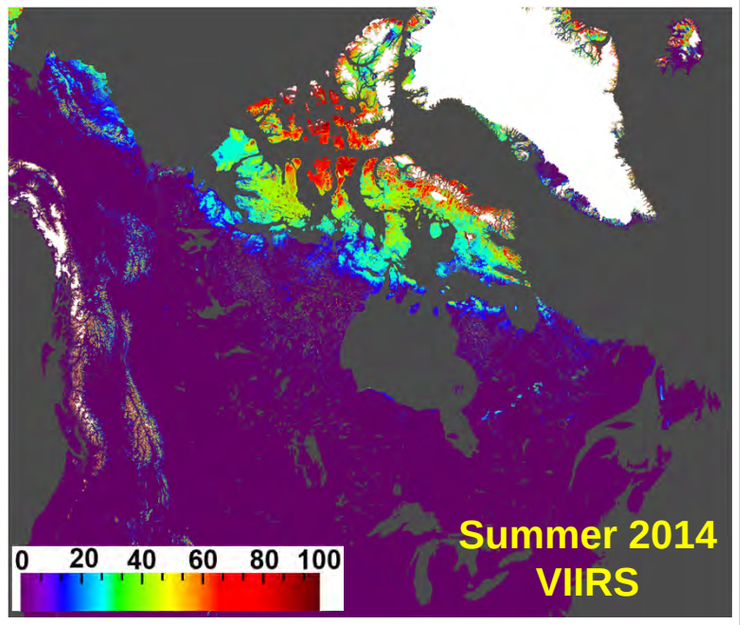


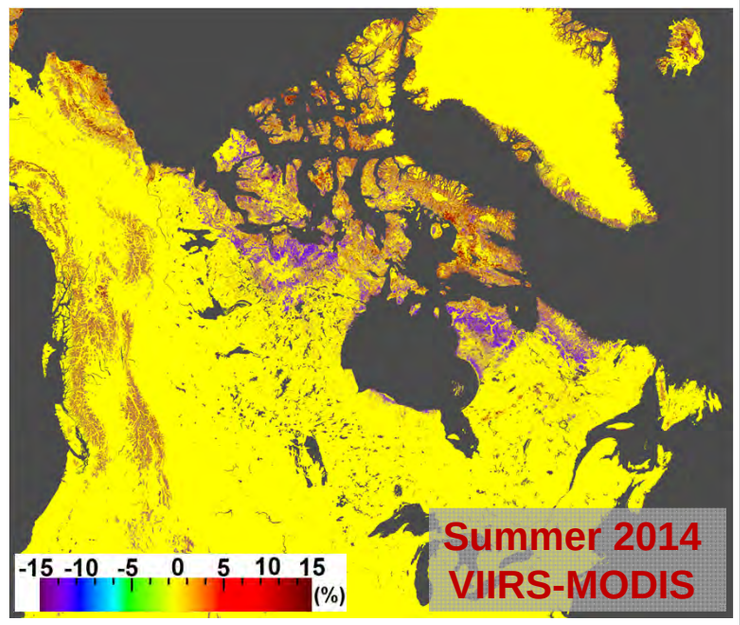
False color composites are created for
- MODIS pictures: from bands B1 (as blue), B2 (as green), B6 (as red),
- VIIRS pictures: from band I1 (as blue), I2 (as green), I3 (as red)

Some visual differences are caused by the different software utilized to generate the color images and different color enhancing schemes that are hard-coded in the processing chains for MODIS (Luo et al. 2008) and Trishchenko and Ungureanu (this work).

Warm season probability maps over land

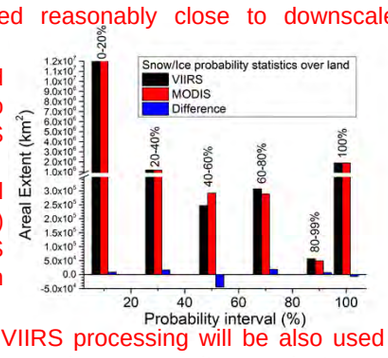






Conclusions

1) The VIIRS processing system has been developed at CCRS to continue MODIS-compatible time series generated over Canada since 2000;
2) VIIRS data products are generated at the map grid compatible with 250-m MODIS imagery for VIIRS I-bands, and nested as 2x2 pixels, i.e. 500-m grid for VIIRS M-bands;
3) Preliminary comparison conducted for summer 2014 shows that rescaled I-bands performed reasonably close to downscaled MODIS 250-m imagery;
4) VIIRS cloud screening and compositing scheme also performs close to MODIS one;
5) Difference in seasonal minimum snow/ice (MSI) extent between MODIS and VIIRS is less than 0.4%;



6) We anticipate that CCRS VIIRS processing will be also used to generate the Arctic circumpolar composite products once sufficient resources are allocated.

Acknowledgments

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- VIIRS data are acquired from NOAA CLASS archive

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