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VTT

Optical Products from Sentinel-2 and Suomi-NPP/VIIRS

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enveo

GAMMA REMOTE SENSING

SYKE

VTT

SEVENTH FRAMEWORK PROGRAMME

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Structure of Presentation

- **High-resolution data**
  - Sentinel-2 pre-processing/ingestion
  - Atmospheric corrections for high-resolution images
- **Low-resolution data**
  - Suomi-NPP/VIIRS pre-processing/ingestion
  - Atmospheric corrections for low-resolution images

- **The optical Sentinel products – both high-resolution and low-resolution – are available as surface reflectance in a user-specified projection**

Sentinel-2/Introduction

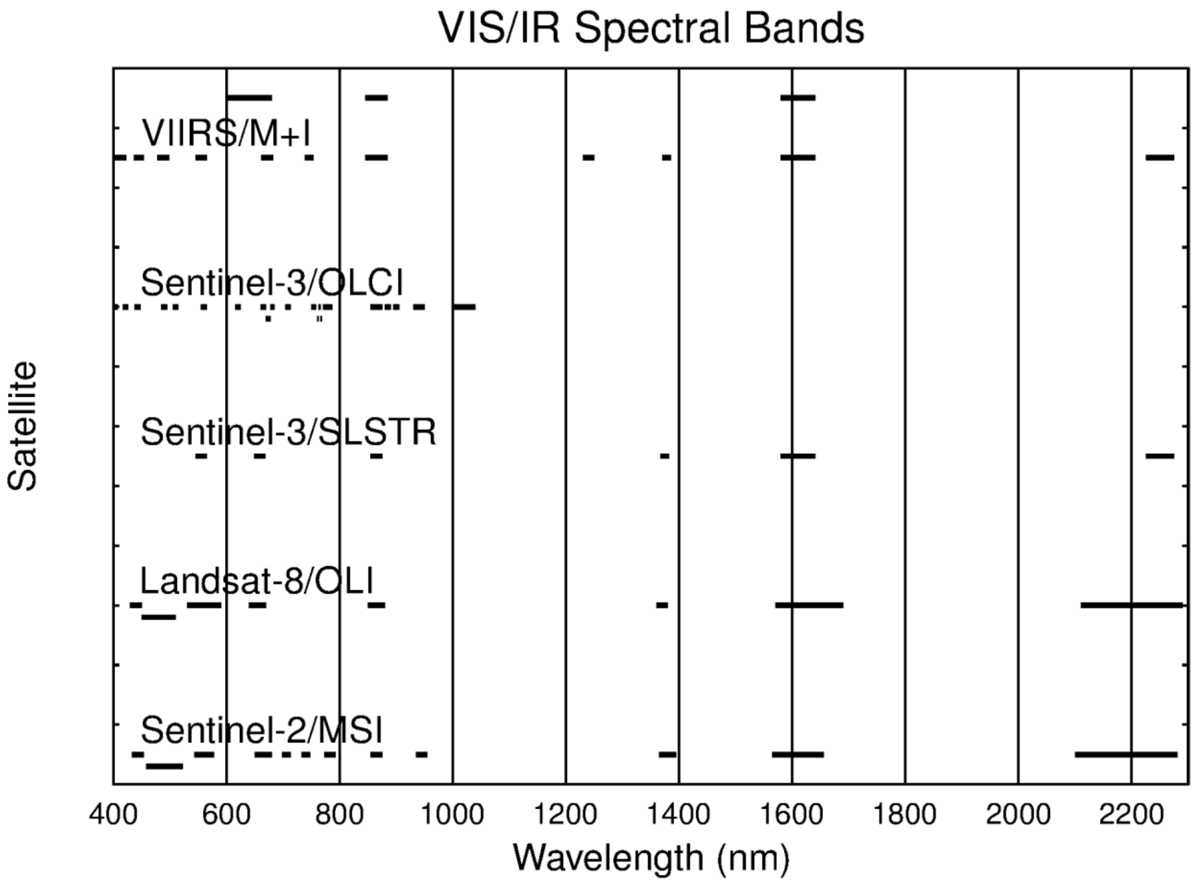
- The new high-resolution optical remote sensing satellite by the European Space Agency ESA
- A follow-on mission to the French Spot satellites
- Increases the image dimension of Spot (60 km by 60 km) and Landsat (185 km by 185 km) to 280 km by 280 km
- Improves the Resolution of Landsat-8 (30 m) to 10 m (in the most important spectral bands)
- Improves the number of spectral bands from the 5 of Spot to the level of Landsat
- Free data distributed by ESA
- The data volume of one image is about 25 Giga bytes

Sentinel-2 Bands

Band	Wave Length (nm)	Bandwidth (nm)	Pixel
2	490 (blue)	65	
3	560 (green)	35	10 m
4	665 (red)	30	
8	842	115	
5	705	15	
6	740	15	
7	783	20	20 m
8a	865	20	
11	1 610	90	
12	2 190	180	
1	443	20	
9	945	20	60 m
10	1 375	30	

- Sentinel-2 data are compressed with JPEG-2000 algorithms when transmitted from the satellite to ground receiving stations
- The data products come as JPEG-2000 compressed files

Spectral Bands of Optical Sentinel Satellites



Sentinel-2/Status 16.11.2015

- **Sentinel-2 was launched in June 2015**
- **Still in commissioning phase**
- **Sample images published by ESA**
- **Nine sub-images in Europe (on 16.11.2015)**
- **The largest sub-image is 2 by 2 tiles (100 km) while a whole image should be 4 by 4 tiles**

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Sentinel-2 Image of the Venezia … Lago di Garda area, acquired on 13.8.2015
Natural colour image (blue = band 2, green = band 3, red = band 4)

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Atmospheric Correction of High-Resolution Satellite Data with Variable Atmospheric Optical Density

- For Landsat-8 and Sentinel-2 type data
- Algorithm based on dark dense vegetation and experimental observations on surface reflectance ratio between 2.2 µm (short wave infrared) and blue visible light at 0.49 µm
- Uses the SMAC software by the French space agency CNES
- SMAC models the atmospheric scattering and absorptance of light and computes the surface reflectance when given the top-of-atmosphere reflectance and angles for the satellite and the sun
- Iterative approach:
  - Compute surface reflectance with SMAC
  - Increase AOD until the target ratio reached in surface reflectance
- Land cover map Corine-2012 (25-m raster version) used as a mask for dark dense vegetation
- NDVI thresholding to avoid new cleared areas and infrastructure

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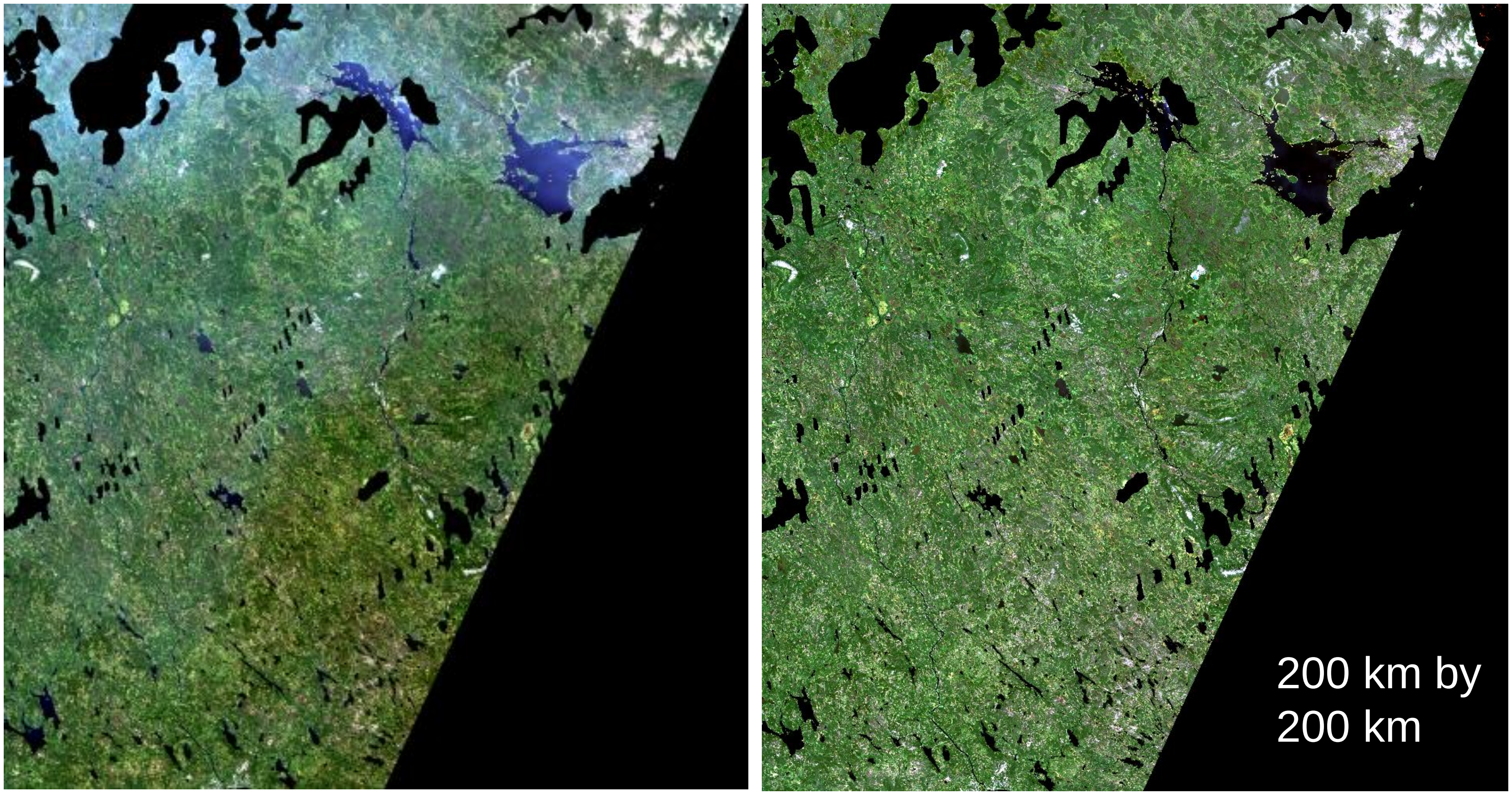
Sample Atmospheric Correction



- Original left (aerosol in northern part), corrected right, area: Sodankylä
- The correction makes this Landsat-8 image of 6.8.2014 (the best cloud-free image of summers 2013 and 2014) usable in numerical analysis methods

Suomi-NPP/VIIRS

- Suomi-NPP is an American follow-on satellite to MODIS and NOAA/AVHRR satellites
- Resolution:
  - M-bands: 750 m
  - I-bands: 375 m
- Image swath width: 3000 km
- Received in Sodankylä by Finnish Meteorological Institute
- Suomi-NPP is used as a replacement satellite for Sentinel-3, whose launch is planned in December 2015

Band	Central(nm)	Width(nm)
M1	412	20
M2	445	18
M3	488 (blue)	20
M4	555 (green)	20
M5	672 (red)	20
M6	746	15
M7	865	39
M8	1240	20
M9	1378	15
M10	1610	60
M11	2250	50
M12	3700	180
M13	4050	155
M14	8550	300
M15	10763	1000
M16	12013	950
I1	640	80
I2	865	39
I3	1610	60
I4	3740	380
I5	11450	1900

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Suomi-NPP/VIIRS Processing line

- VIIRS data come in HDF5 (Hierarchical Data Format 5) files, including latitude and longitude for every pixel
- Data ingestion modules for 1) Suomi-NPP/VIIRS data received in Sodankylä and 2) the CLASS archive of NASA
- Rectification modules for supported projections, nearest-neighbour and weighted-average resampling
- Atmospheric correction with the SMAC algorithm:
  - Correction with constant Aerosol Optical Density (AOD) implemented using the SMAC software
  - Correction with variable AOD (work in progress)

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Use of the SMAC Program for Suomi-NPP/VIIRS Data

- **No coefficient files are provided at the SMAC website for VIIRS bands**
- **The closest bands from MODIS and all other supported sensors were used to fill-in the missing VIIRS coefficient files**

VIIRS Band	Sensor	Band
M1	Modis	8
M2	Modis	9
M3	Modis	10
M4	Landsat-8	3
M5	MISR	3
M6	Modis	15
M7	Modis	2
M8	Modis	5
M9	Modis	26
M10	Landsat-8	6
M11	Aster	7
I1	NOAA-18	1
I2	Modis	2
I3	Landsat-8	6

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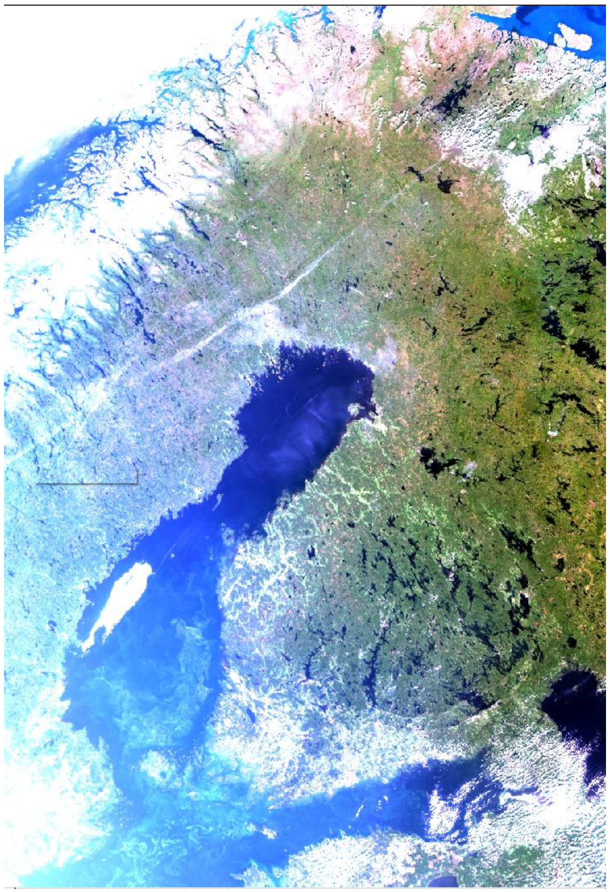
Sample Atmospheric Correction/VIIRS

Top of Atmosphere reflectance



Constant AOD/SMAC

Variable AOD/SMAC

18.8.2015, natural colour (red = M5, green = M4, blue = M3)

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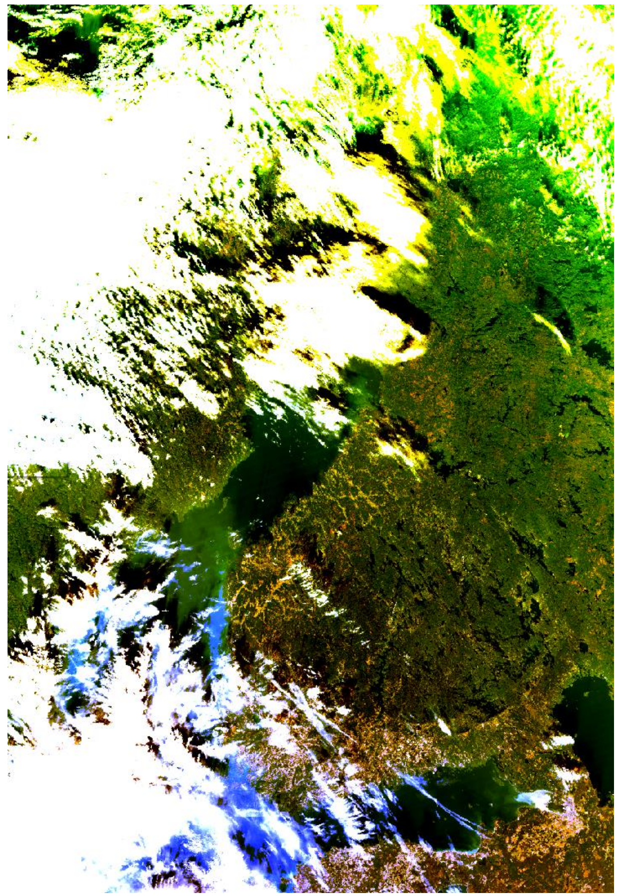
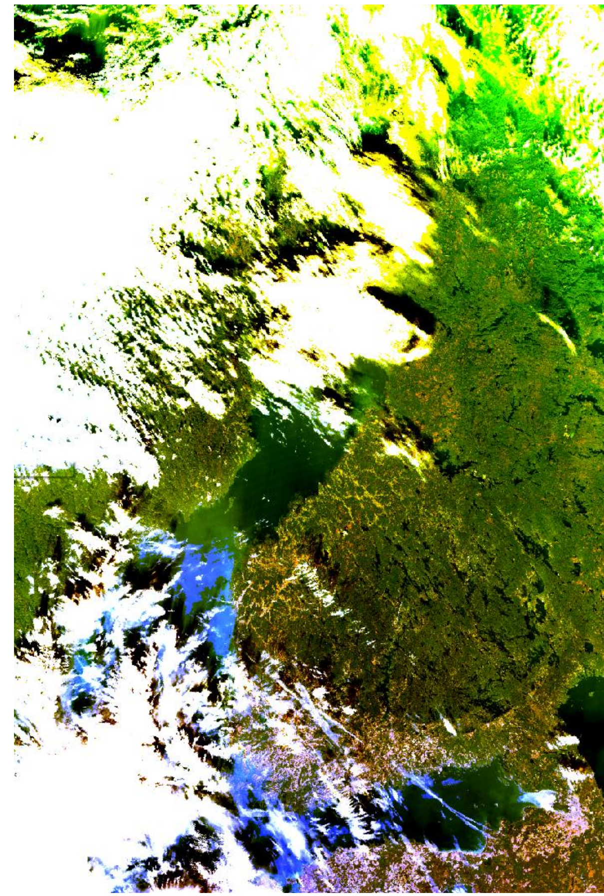
Sample Atmospheric Correction/VIIRS

Top of Atmosphere reflectance

Constant AOD



Variable AOD



3.11.2015, natural colour (red = M5, green = M4, blue = M3)

Observations from Atmospheric corrections

- **Problems – undetected clouds and cloud shadows – cause artefacts in estimated atmospheric optical densities**
- **More reliable cloud and cloud shadow detection is needed in order to make variable AOD corrections reliable in automatic processing chains**

Cloud detection from Suomi-NPP VIIRS data

- **60 VIIRS images from August 2014 to October 2014**
- **Five methods tested for cloud and shadow mapping from reflectance data**
  - Blue/Green ratio > 0.3
  - Red/SWIR ratio > 0.5
  - LUO[1] method (without shadow projection), several thresholds for Blue, Red, NIR and SWIR and their ratios
  - comp_cloud — Blue,Green,Red > 15% and Red/SWIR < 1.3
    Shadow if MaxReflectance from NIR
  - cloud_mask, threshold for every channel, except M9

[1] Luo, Y., Trishchenko, A.P., Khlopenkov, K.V. Developing clear-sky, cloud and shadow masks for producing clear-sky composites at 250-meter spatial resolution for the seven MODIS land bands over Canada and North America. Remote sensingof environment 112 (2008), pp. 4167-4185

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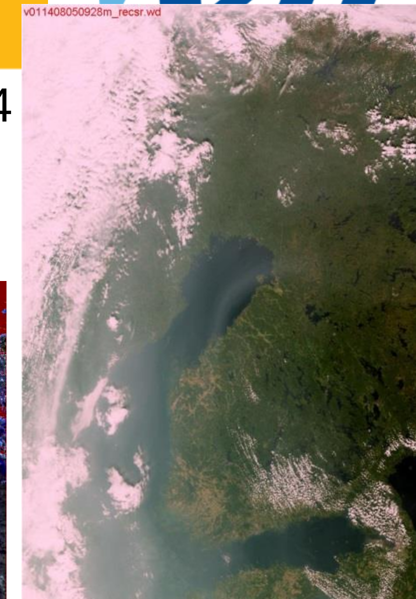
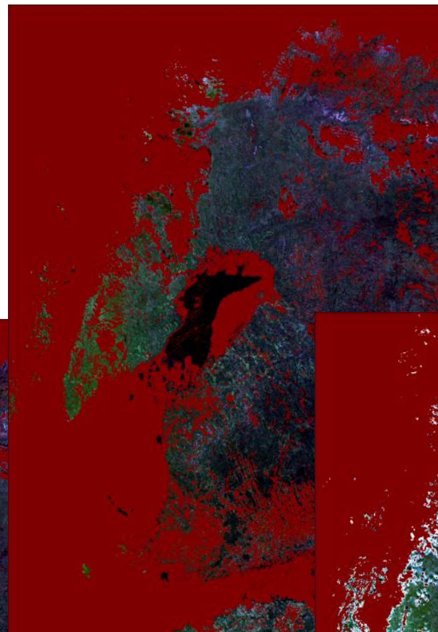
VIIRS image 5.8.2014

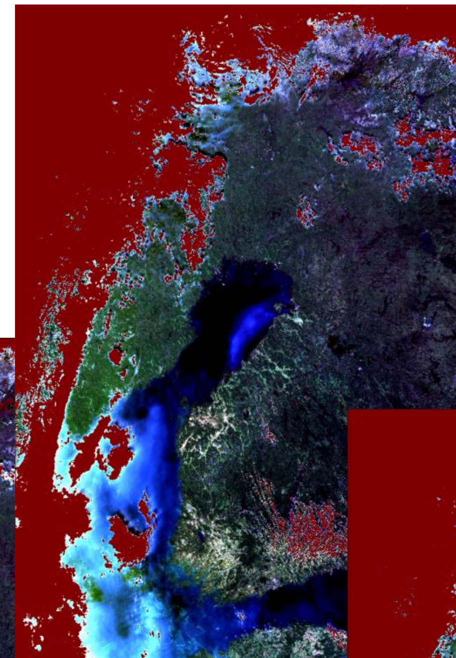


Examples

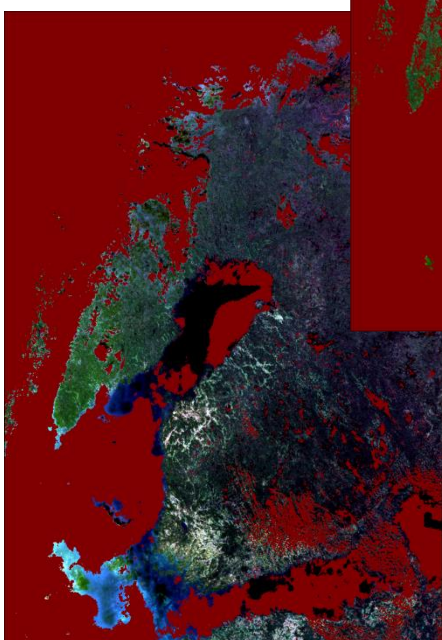
Red/SWIR



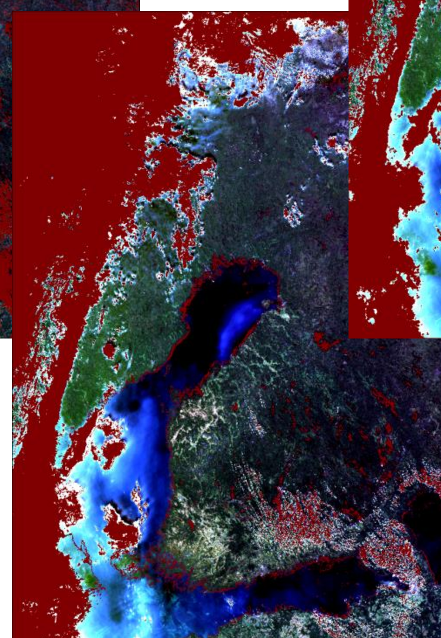
comp_cloud



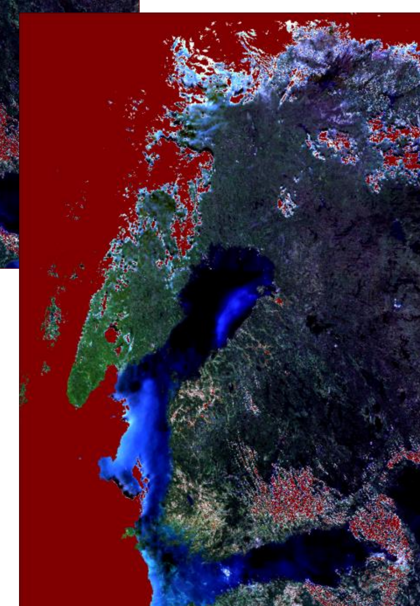
Blue/Green



LUO



cloud_mask



Red: Cloud and cloud shadow class

Conclusions from cloud and shadow detection

- **Ratio images Blue/Green and Red/SWIR good for cloud and cloud shadow. Find highest proportion of clouds and shadows. One threshold.**
- **However, also water areas go to cloud and shadow class. With Red/SWIR ratio also built area and non-vegetated fields go to cloud and shadow class**
- **Comp-cloud, LUO and cloud_mask give comparable results. Cloud borders and shadows are problematic. Need several thresholds.**

Next

- **Further elaboration of B/G ratio with water mask input**
- **Comparison with SYKE method**