A METHOD FOR COMPOSITING MODIS SATELLITE IMAGES TO REMOVE CLOUD COVER

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1. ABSTRACT

This abstracts briefly presents details of techniques for generating thermal infrared and visible composite images from cloud-free portions of MODIS (MODerate resolution Imaging Spectroradiometer) images closely spaced in time, with a focus on studies of landfast sea ice along the East Antarctic coast. Composite image inclusion criteria are based on modified MODIS EOS cloud mask product results. The compositing process presented places emphasis on retaining maximum spatial resolution while minimizing computing storage space requirements. Composite images can be produced either as a regular product (e.g., on a 10-day grid), or dynamically (whenever enough information is acquired to produce a new output image). The techniques presented are applicable at any latitude, are available for all MODIS channels at their native resolution, can combine Aqua and Terra images, and can produce maps in any output projection. However, due to the polar orbit of NASA's Terra and Aqua satellites which host the MODIS instrument, more frequent coverage is produced at higher latitudes. Thus, the techniques presented are particularly applicable to polar research. An example of summertime (visible) composite image generation of the landfast sea ice around the Mertz Glacier region, East Antarctica, is included.

2. IMAGE ENHANCEMENT AND DATA PREPARATIONS

The concept behind the composite image generation process is to use cloud-free portions of visible-thermal infrared images closely spaced in time to build a composite cloud-free image. MODIS granules were cloud-masked using a modified EOS Level 2 MOD35 cloud mask product [1]. For each pixel in the level 1B granule, a mask value was assigned if that pixel had not been classified as "confident clear" (confidence greater than 0.99) or "probably clear" (confidence greater than 0.95). In the interest of retaining only high resolution data for image analysis, all original swaths were trimmed at a cross-track look angle of $\pm$ 35 $^\circ$, resulting in an output resolution range of 1-2 km for 1 km granules.

Following cloud masking and swath trimming, the MODIS images were reprojected to a common grid using the ms2gt (MODIS Swath-To-Grid Toolbox) [2]. As part of the gridding process, bowtie corrections were also computed. The ms2gt software was found to produce excellent output from the centre to the extreme edge of the swath.

To aid in fast ice detection, the Antarctic continent was masked using the MOA (Mosaic Of Antarctica) coastline product [3] after image georegistration. Simple solar zenith angle (SZA) corrections were computed at this point for shortwave images, by dividing the original reflectance by the cosine of the SZA.

3. COMPOSITING ALGORITHM AND RESULTS

After all image pre-processing, composite images were generated. The algorithm averages "useful" pixels from several component images on a per-pixel basis until a full composite is generated (i.e. there are no more "holes" in the image), or no

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component images remain to be assimilated into the composite. For the purposes of this paper, composite images were generated from component images acquired over 10 consecutive days.

Close manual examination reveals that no cloud is visible in the composite image (see figure 1). Due to its spatially-static nature, the fast ice edge is very well defined over these 10 day periods, whereas the dynamic pack ice becomes blurred, as expected). The sharply-defined edge of the fast ice is an indication of the accuracy of both the MODIS satellites' ephemeris data and ms2gt's geolocation and bowtie-correction algorithms.

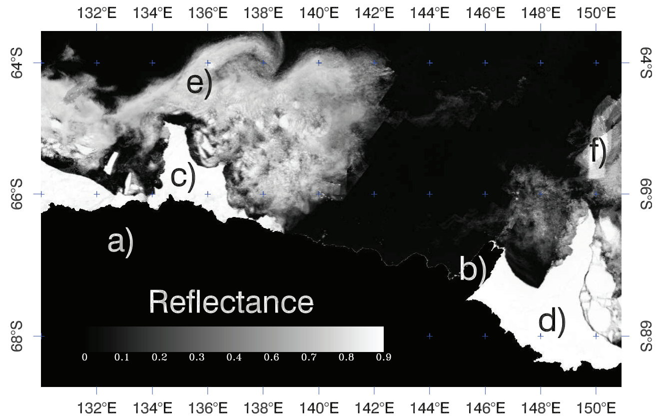

Fig. 1. Visible (channel 1) composite of the Mertz Glacier region, generated from 27 summertime MODIS images (December 1 - 9, 2005). a) The Antarctic continent (masked to aid fast ice detection). b) The Mertz Glacier Tongue (also masked). c) Seasonally recurring fast ice buttress. d) Extensive summertime fast ice to the east of the Tongue. e) Summertime pack ice (much less extensive than the wintertime pack). f) A massive tabular iceberg which has rotated during the 10-day period covered by the 27 MODIS images comprising the composite.

4. CONCLUSION

This paper describes a new algorithm and techniques for compositing MODIS satellite imagery to remove cloud cover over polar regions. 10-day compositing periods were found to be often sufficient to produce almost-complete composites both during the winter (using IR wavelength imagery) and summer (using visible wavelength imagery). The techniques described here can produce composite images of any MODIS channel, can combine component images from both MODIS platforms (Aqua and Terra), can be used at any latitude, and can produce output maps in many projections whilst maintaining the highest possible resolution.

Though these techniques were developed to aid in landfast sea ice detection, alternative potential applications exist, including high resolution ice concentration retrieval; cloud-free Normalised Difference Vegetation Index (NDVI), Sea Surface Temperature (SST) and land surface temperature composites; and cloud-free spectral land usage retrieval. Additionally, with minor modifications, the gridding and compositing procedures described here could be applied to several MODIS level 2 (swath-level) products to produce climatologies - e.g. the MODIS cloud mask product (MOD35) itself could be composited to produce a high-resolution cloud climatology - this is a work underway.

5. REFERENCES

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