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First space-borne high-spatial-resolution optical imagery of the Antarctic from Formosat-2

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Coordinating and collecting satellite data of changing polar environments is one of the prime activities of International Polar Year (IPY) 2007–08 (Rapley *et al.* 2004). Within this framework, the requirements to obtain spaceborne snapshots of the Polar Regions and key high latitude processes have been prepared by the international cryospheric community under the auspices of the approved IPY project titled the Global Inter-agency IPY Polar Snapshot Year (GIIPSY). Earlier efforts in manoeuvring Radarsat-1 in a special mode provided radar images with a spatial resolution of 30 m over the entirety of Antarctica during September–October 1997 (Jezek *et al.* 1998). Limited to their altitude (AL), swath (SW) and pointing capability (PC), however, the operation of optical satellites with high-spatial-resolution sensors is generally restricted to certain latitudes. For example, Landsat (AL:705 km/SW:185 km/PC:0°) mission has been able to provide high-spatial-resolution optical imagery only to ~81°N to ~81°S since the 1980s. The coverage is now extended to ~86° by ASTER (AL:705 km/SW:60 km/PC:24°) (Kargel *et al.* 2005), but there has been no availability of space-borne optical image of the polar regions with a resolution equivalent or higher than Landsat type sensors with latitudes higher than 86°, until the successful operation of Formosat-2 (AL:891 km/SW:24 km/PC: ± 45° across and along track). Equipped with two-axes high torque reaction wheels, Formosat-2 is able to point not only to ± 45° across track, but also to ± 45° along track (Liu *et al.* 2007). Figure 1 shows the accessible areas (longer lines: along track ± 0°, across track ± 45°; shorter lines: along track ± 0°, across track ± 30°) and the corresponding ground tracks (solid curves) of Formosat-2 in the Polar Regions. Note that the accessible areas would be even greater if the pointing direction is also set to ± 45° along track. The detailed comparison of Formosat-2 with other similar sensors, including the multi-spectral bands and imaging repeat period, can be found in table I in Liu *et al.* (2007). To support IPY 2007–08, the National Space Organization (NSPO) of Taiwan launched a Polar Imaging Campaign (PIC) in March 2006. Up to September 2007, a total of 1 131 624 km^2 in the North Polar Region and a total of 57 408 km^2 in the South Polar Region had been imaged by Formosat-2. All Formosat-2 images taken during the NSPO PIC are available from the authors.

Image processing

Through the Formosat-2 terminal developed by NSPO and Tatung System Technologies Inc (Liu *et al.* 2004), the daily raw data from Formosat-2 is first processed by applying basic radiometric calibration (level-1A) and then is processed by projecting the raw image onto a spheroid using the ephemeris data onboard to correct for the satellite orbit and altitude (level-2). Note that the level-1A and level-2 products both suffer from the problem of band-to-band misregistration (Liu *et al.* 2007). The level-2 images

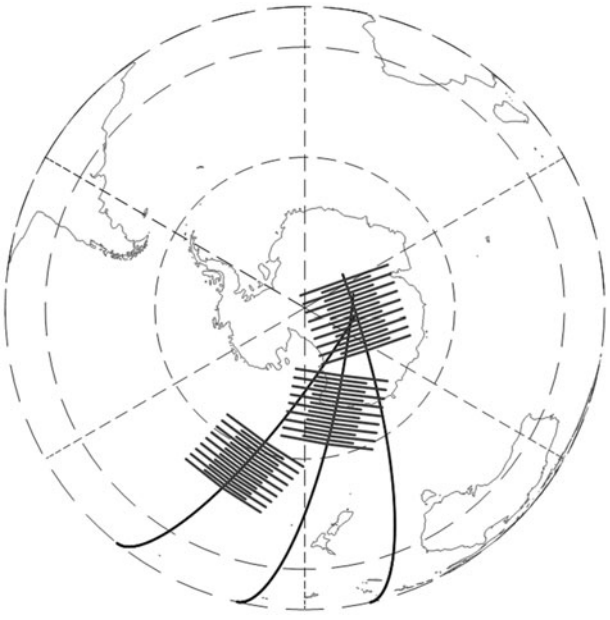

Fig. 1. Areas covered by Formosat-2 (longer lines: along track ± 0°, across track ± 45°; shorter lines: along track ± 0°, across track ± 30°) and the corresponding ground tracks (solid curves).

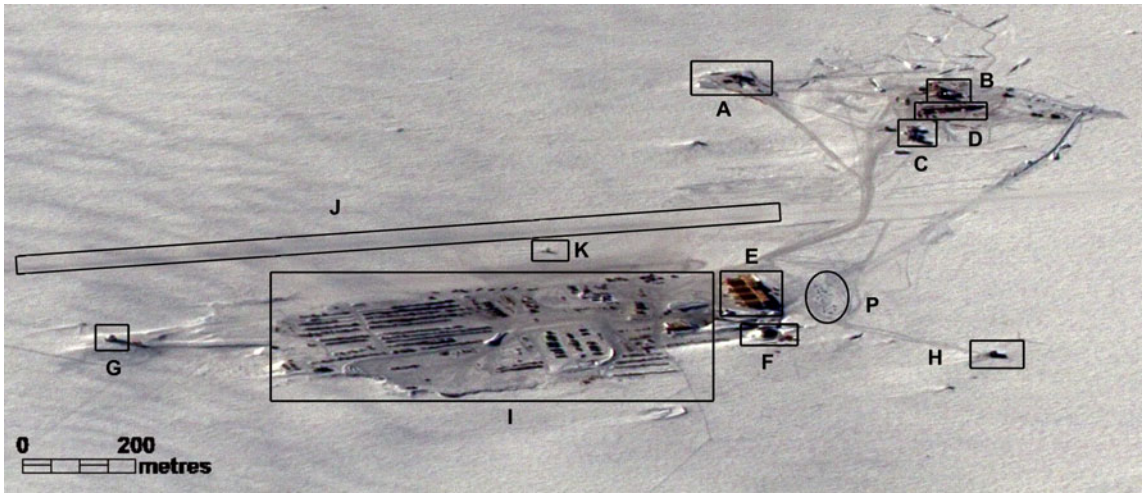

Fig. 2. The first space-borne optical image of the Amundsen-Scott South Pole Station with high spatial resolution (2 m) and multi-spectral bands taken by Formosat-2 on 18 December 2006. A = Ice Cube, B = Dark Sector Lab (South Pole Telescope), C = Poemerantz Observatory (Cosmic microwave Background imager), D = IceCube drill camp, E = the Elevated Station (the new Amundsen-Scott Station), F = the Dome (NSF Amundsen-Scott Station) and the SkyLab in the right within the rectangle, G = GEOSAT/MARISAT Radar, H = Atmospheric research Observatory, I = summer camp, J = ski way, K = PAX terminal, P = Geographic South Pole.

are further processed by the automatic Formosat-2 image processing system (F2-AIPS), including band-to-band coregistration, spectral preserved pan-sharpening and multi-temporal imagery matching, as described in Liu (2006). It takes approximately two hours to process one standard scene of Formosat-2 imagery (12×12 km^2).

Figure 2 shows the first space-borne optical image of the Amundsen-Scott South Pole Station with high-spatial-resolution (2 m) and multi-spectral bands taken by Formosat-2 on 18 December 2006, which can be compared to the earlier radar image taken by Radarsat-1 on 14 September 1997 (http://www.space.gc.ca/asc/img/rsat1_southpr1.tif, browsed on 5 October 2007). Such high spatial resolution optical images could be a very useful data source for monitoring the environment anywhere in Antarctica.

The successful operation of Formosat-2 launched on 21 May 2004 enables us to acquire both high-spatial- and high-temporal-resolution optical imagery for the entire Polar Regions. This imagery could be used to observe more rapidly changing features at the margins of the Antarctic continent, such as sea ice conditions, monitoring the daily changes in ice shelves, and tracking floating ice with sizes of tens of metres for consecutive days. It would also benefit the field logistics planning where imagery or air photography is not available. To support IPY 2007–08, NSPO provides access to all of its Formosat-2 imagery collected during PIC. Since characterizing rapid dynamic changes in the Polar Regions is a major challenge in assessing the ice contributions to sea-level change (Alley *et al.* 2005), these images could be a very useful data source with immediate impact on the research in Polar Regions.

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References

Alley, R.B., Clark, P.U., Huybrechts, P. & Joughin, I. 2005. Ice-sheet and sea-level changes. *Science*, **310**, 456–460.

Jezek, K.C., Cars, F., Crawford, J., Curlande, J., Holt, B., Kaupp, V., Lord, K., Labelle-Hammer, N., Mahmood, A., Ondrus, P. & Wales, C. 1998. Snapshots of Antarctica from Radarsat-1. *In Proceedings IGARRS'98*, *Seattle, Washington*. New York: *IEEE*, 1428–1430.

Kargel, J.S., Abrams, M.J., Bishop, M.P., Bush, A., Hamilton, G., Jiskoot, H., Kaab, A., Kieffer, H.H., Lee, E.M., Paul, F., Rau, F., Raup, B., Shroder, J.F., Soltesz, D., Stainforth, D., Stearns, L. & Wessels, R. 2005. Multispectral imaging contributions to global land ice measurements from space. *Remote Sensing of the Environment*, **99**, 187–219.

Liu, C., Wu, S.-C., Hwang, F.-T., Wu, A.-M. & Chen, H. 2004. Radiometric and geometric calibration of ROCSAT-2 image. *In The 25th Asian conference on remote sensing*, vol. 1. Chiang Mai: Asian Association on Remote Sensing, 465–470.

Liu, C.-C. 2006. Processing of FORMOSAT-2 daily revisit imagery for site surveillance. *IEEE Transactions on Geoscience and Remote Sensing*, **44**, 3206–3214.

Liu, C.-C., Liu, J.-G., Lin, C.-W., Wu, A.-M., Liu, S.-H. & Shieh, C.-L. 2007. Image processing of FORMOSAT-2 data for monitoring South Asia tsunami. *International Journal of Remote Sensing*, **28**, 3093–3111.

Rapley, C., Bell, R., Allison, I., Bindschadler, R., Casassa, G., Chown, S., Duhaime, G., Kotlyakov, V., Kuhn, M., Orheim, O., Pandey, P.C., Petersen, H.K., Schalke, H., Janoschek, W., Sarukhanian, E. & Zhang, Z. 2004. A framework for the International Polar Year 2007–2008. Paris: ICSU, 57 pp.

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