CNES status on optical satellite activities supporting International Polar Year

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Direction for Strategy and Programs - CNES
CNES contribution to IPY activities

- support scientific community through usual or dedicated AOs
- contribute to in-situ campaigns (buoys, balloon campaigns,...)
- perform satellite time series of observations on polar areas (in particular SPOT5)
Time series of observations with optical satellites

- Sensors/satellites used for IPY:
  - VGT1/SPOT4
  - Formosat2 (cooperation with Spot Image & NSPO)
  - HRS/SPOT5 (cooperation with Spot Image)
VGT1/SPOT4
VEGETATION : The Instrument

SPOT 4 launch: March 24 1998
First VEGETATION image: March 31 1998

VEGETATION
on-board SPOT 4 satellite
Geometry

Spatial resolution:
≈ 1 km at nadir
minimum variation for off-nadir

Field of view:
2250 km (101°) compatible with 1 day coverage

Multispectral registration:
better than 0.2 pixel

Location accuracy:
better than 1000 m

Multitemporal registration:
better than 500 m (expected)

Colocation with HRVIR:
better than 300 m

Radiometry

Spectral bands:

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength</th>
<th>Reflectance range</th>
</tr>
</thead>
<tbody>
<tr>
<td>blue (B0)</td>
<td>0.43 - 0.47 µm</td>
<td>up to 0.5</td>
</tr>
<tr>
<td>red (B2)</td>
<td>0.61 - 0.68 µm</td>
<td>up to 0.5</td>
</tr>
<tr>
<td>NIR (B3)</td>
<td>0.78 - 0.89 µm</td>
<td>up to 0.7</td>
</tr>
<tr>
<td>SWIR</td>
<td>1.58 - 1.75 µm</td>
<td>up to 0.6</td>
</tr>
</tbody>
</table>

Radiometric resolution:
better than 0.003

Calibration:

absolute: 5%
interband: 3%
multitemporal: 3%
HRVIR cross cal.: 3%
VGT1 Programming

- New Programming for the International Polar Year since April 2007

- The goal is to realize 2 syntheses a year for each pole, without any cloud

- It will last at least 2 years
VGT1 programming for IPY: specific zones

- Area to cover North Pole (zenithal angle < 80°)
- Areas to get GCP on lands
- Areas of interest for image quality
- Area to cover South Pole (zenithal angle < 80°)
Programming-3

- VGT1 programming for IPY: summer solstice
  - Complete cover of North pole, but none for South pole
VGT1 programming for IPY: autumn equinox

- For both poles, only borders are covered
VGT1 programming for IPY: winter solstice

- Complete cover of South pole, but none for North pole
VGT1 programming for IPY: spring equinox

- For both poles, only borders are covered (same as autumn equinox)
Example: changes in North Pole (melting and floating) during June 2007.
Example: decadal synthesis in Antarctica (3 decades of January + first decade of February, 2008)
For data policy & access, see: http://www.spot-vegetation.com/

(Extracts from the data policy)

The following standard VEGETATION products are available to customers:

- **P or Primary products**: zone extracted from a single orbit, geometrically, and radiometrically corrected.
- **S or Synthesis products**:
  - **$S_1$ or daily synthesis**: synthesis of all data acquired over a 24 hour period.
  - **$S_{10}$ or 10-day synthesis**: a result of the merging of data strips from 10 consecutive days.
  - **D10**: 10-day synthesis based upon a bi-directional reflectance distribution function.
  - **S-NDVI products**: contain only the NDVI index. S-total products consist of the NDVI index, all spectral bands, and acquisition parameters.

Scientific users and programme partners can obtain all S and P products upon payment of the cost of medium, packaging, and shipping. All requests however are subject to approval by the VEGETATION Programme and orders are processed according to availability of production capacity. **P products older than 3 months** are available on SDLT and DVD only. Other products can be downloaded via FTP.
Formosat2
Special cooperation for IPY between NSPO, Spot-Image, Cnes & Legos: repeated (at least monthly) observations of selected glaciers

- First validation on Kronebreen glacier in Svalbard

- First North series of observations during summer, 2007

- First South series of observations during winter, 2007-2008

- New series of observations planned in Arctica during spring-summer, 2008.
Example: Kronebreen Glacier (Svalbard) displacement from March to May, 2007
Partial results of F2 2007 campaign (1/3)

Name (#acquisitions)
Catalog date

Note: catalog date is not significant
Partial results of F2 2007 campaign (2/3)

Name (#acquisitions)
Catalog date
Partial results of F2 2007 campaign (3/3)

Name (#acquisitions)
Catalog date

10 IMAU K Transect - Margin (3) 24 jul, 2007
9 IMAU K Transect Inland_Green... (18) 24 jul, 2007
8 Jakobsbaen Ishrae Inland_Gr... (10) 24 jul, 2007
7 Jakobsbaen Ishra Greenland (16) 24 jul, 2007
6 Helheim_Greenland (16) 24 jul, 2007
5 Kangerdlugssuaq Greenland (42) 24 jul, 2007
3 Breidamerkurjokull_iceland (16) 24 jul, 2007
2 Skeidararjokull_iceland (45) 24 jul, 2007
Some results of F2 2007 campaign

Helheim (Greenland)
Kangerdlugssuaq (Greenland)
Otto (Canada)
2007-2008 South & North Campaigns

- IPY Cryospheric Target F2 South
  - Stereo pair for DEM
    - Cock Ice Cap - Kerguelen Island
    - Heard Island
  - Glacier velocity field - Exact repeat pair
    - Glacier San Valentini
    - Glacier San Rafael - Tidewater
    - Glacier HPA - non Calving
    - Glacier San Guinlin - Freshwater
    - Perito Moreno - Patagonia
    - Cock Ice cap - Kerguelen island
    - RALLENGUHE - Kerguelen Island
    - Heard Island
    - Ross Bay & Island
    - Drygalski Glacier
    - Helheim Glacier
    - Crane Glacier - Peninsula
    - Flash Glacier
    - Scarp Inlet Shelf
    - Byrd Glacier
    - Transantarctique
    - Transantarctique2
    - Transantarctique3
    - Transantarctique4
    - Transantarctique5
    - Astrolabe
    - Merz Glacier - Crack
    - Mortz Glacier - OL
    - Pine Island Glacier
    - Foundation Ice Stream
    - Queen Fabiola Ice Stream
- Monitoring subglacial lake activity - Exact repeat pair with large incidence angle
  - Recovery Lake 1
  - Recovery Lake 2
  - Recovery Lake 3
  - Engelhardt Lake
  - Mercer Lake
  - Mac Ayeal Lake

- IPY Glacier F2 North New in 2008
  - Greenland - Daugmard Jansen
  - Greenland - Hayes Glacier
  - Svalbard - Hansbreen
  - Alaska - Tasu Glacier

- IPY Glacier F2 North updated in 2008
  - Greenland - Krenbrenn - Svalbard
  - Slettermarja - Iceland
  - Grimsvót - Gjáí - Iceland - High Incidence Angle
  - Kangauruggssuaq - Greenland
  - Helheim - Greenland
  - Jakobsbaen Isbree - Margin
  - Jakobsbaen Isbree Island
  - NIMA - K Transect - Margin
  - NIMA - K Transect - Island
  - Belcher Glacier - Devon Ice Cap
  - Otto Glacier - Ellesmero
  - Bering - Alaska
  - Hubbard Glacier - Alaska
  - Columbia Glacier - Alaska
  - KasavukGaluk - Yukon - Canada
  - Kluikish Glacier - Canada
HRS/SPOT5
Goal: obtain an archive of stereo imagery in order to have DEM capabilities:

- at a given time, for use as an absolute reference
- for climatic change applications (margins, glaciers, …)

CNES will fund the full archiving process (acquisition of data, quick-looks, catalog), in cooperation with SPOT IMAGE, IGN, and LEGOS.

CNES will fund DEM production on selected, prioritary areas; after processing, DEMs will be accessible free of charge to the worldwide scientific community.

Name of the project: SPIRIT (SPOT 5 stereoscopic survey of Polar Ice: Reference Images and Topographies).

Production of DEM on other areas can be studied with other partners.
SPOT5/HRS program

- **HRS**: high-resolution stereo-imager:
  - images: 120km x up-to 600km
  - resolution: up to 5x10m
  - B/H: 0.8 (0.4 also possible with HRG)
  - absolute height accuracy: ~1 to 10m (without any tie point)

- Dedicated acquisitions for polar regions (up to +/- 82°):
  - low-gain acquisition (high signal!)
  - choice of a DEM resolution of typ. 40 m (tests with 15 to 50m)
  - limited to relief areas (no DEM possible in perfectly uniform white areas...)
  - ok for margins & most glaciers
  - validation activities from 2004 to 2006
HRS 2004-2006 validation program on Antarctica Peninsula & Alaska:
Mosaic activities on Antarctica
The SPIRIT product

Contents

- 2 DTM{s}, assuming different sets of correlation parameters
- 2 reliability masks
- 1 HRS orthoimage (SPOTView)

DTMs Characteristics

- 40m posting interval
- DTM “no hole”: the non correlated pixels are interpolated
- DIMAP Geotiff format
- 10m vertical accuracy
- Absolute horizontal precision evaluated to 30m rms

Masks specificities

- Register the correlation score from 0 to 100%
- Interpolated pixels are reported with 0% score
- Point-to-point superimposable with the corresponding DTM{s}

HRS Orthoimage

- Computed from one of the HRS images
- 5m ground resolution
- Same absolute horizontal precision as the DTM{s} (30m rms)
Examples of 3D Images from HRS products

Jakobshavn Isbrae Glacier
Greenland, West Coast
Last evolutions due to change climate

www.spotimage.com
Continuation of evaluation of the SPIRIT DTMs

(From E. Berthier et al. work, submitted to ISPRS J. Photogrammetric & Remote Sensing)
(a) 24 July 2007 SPIRIT ortho-image with the ICESat 3H track overlaid in blue.
(b) Histogram of the elevation difference between the 24 July 2007 SPIRIT DTM and ICESat elevation profiles.
(c). Histogram of elevation differences between the 24 July 2007 SPIRIT DTM and ICESat elevation profiles after excluding pixels with anomalous elevation differences (due to clouds).
(a) 4 August 2007 SPIRIT Ortho-image with the ICESat track overlaid in blue.
(b) Histogram of the elevation difference between the 4 August 2007 SPIRIT DTM and ICESat elevation profiles.
Validation of DTM with ICESAT data

Root mean square elevation errors in the different SPIRIT DTMs as a function of the surface slope. The rms has been estimated in two cases when ice and non-ice pixels are mixed (square symbols) or distinguished (rounded symbol). All interpolated or cloudy pixels in the SPIRIT DTMs have been excluded before computing these statistics.
Programming zones: North Hemisphere
SPIRIT areas of interest: Northern hemisphere

Target areas

679,518 km²
SPRINT coverage: Arctic campaign 2007

- Percentage covered: 44.5% (0.302 Mkm²)
- Additional (priority #4) area: 0.528 Mkm²
- Total cloud-free covered area: 0.830 Mkm²
2008 Arctic campaign plan (to be confirmed)

- Remaining areas not acquired in 2007

- Few additional areas (Canada, Norway, ...)

IPY Space Task Group Meeting, May 5-6, 2008
SPIRIT areas of interest: Southern hemisphere

Target areas
1,950,038 km²
• Percentage covered: 77.2% (1.479 Mkm²)

• Additional (priority #4) area: 1.920 Mkm²

• Total cloud-free covered area: 3.399 Mkm²
Accumulation area of Lambert Glacier, Antarctica (quick-look)
Prince Albert Mountains, Antarctica (quick-look)
Byrd Glacier, Antarctica (quick-look)
Knox Coast, Antarctica (quick-look)
How to get HRS Glaciology Products?

- Ask for a login: provided by request at hrs_ipy@cnes.fr
- Browse the Polar DALI HRS pairs archive
- Fill an order form
- The order form is analysed to check its eligibility
- An acknowledgement of receipt is given once the order form is validated.
- The HRS Glaciology product is delivered through a FTP server.
Polar DALI: Visualizing quick looks with Google Earth
In the frame of IPY, CNES, in cooperation with partners, is continuing an intensive acquisition campaign with optical satellites (VGT1/SPOT4, HRS/SPOT5, plus F2)

- VGT1 & HRS data are available for the scientific community

- HRS programming may be adapted to other requests/proposals