Geometric and Radiometric Pre-processing of CHRIS/Proba over Mountainous Terrain

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Outline of the talk

Site description
- field data / Goniometer measurements

CHRIS acquisitions
- multi-temporal CHRIS data acquisitions

Geometric Processing

Atmospheric Correction
- Vicarious Calibration

Conclusion and Outlook
Site description

Test Site is located in the Swiss National Park

- boreal vegetation type dominated by mountain pine trees
- species: pinus montana spec., Larix
- height range of 1800 - 2400 MSL
Field data

Spectrodirectional measurements (FIGOS)
  • alpine meadow
  • snow surface (Davos)

Spectro-radiometric characterization of different targets
  • meadow, gravel, asphalt, snow

Biophysical and biochemical forest parameters
  • LAI
  • Fcover
  • Leaf water content, Leaf chlorophyll content

Additional data:
  • Airborne Imaging spectrometer data: DAIS, ROSIS (2002)
  • Airborne small footprint LIDAR data (2002)
Spectrodirectional measurements

HDRF (Hemispherical Directional Reflectance Factor) measurements from RSL’s FIGOS.

Alpine meadow

HDRF measurements performed on June 26, 2004.

Spectrodirectional Measurements of an Alpine Meadow I

- Date: June 26, 2004 (1 day prior to overflight)
- Time: 10.00 UTC (1h prior to overflight time)
- Problem: not typical grass HDRF (forward scatter effects visible)

551nm
895nm
Field spectra corresponding to CHRIS view geometry
Spectroradiometric Measurements

Field measurements of different targets with the ASD fieldspec
meadow and river gravel

[Graphs showing reflectance vs. wavelength for meadow and gravel targets]
Core Plots of field measurements

Stratified sampling scheme:
- Four intensive test sites, each with 9 subplots (A-O)
- Covering different densities and the dominating species
- Assessment of the crown and understory in separate strata

Structure of a core plot
Field campaign: ground measurements I

Canopy Structure
- LAI2000 (LAI/LAD)
- Hemispherical photographs (fcover, wood/foliage fraction)
- Tree geometry: coordinates, height, crown shape, DBH

Canopy biochemistry
- Leaf water content
- Leaf chlorophyll content
- Leaf dry matter

Spectroradiometric measurements
- Characterization of landcover types
- Leaf optical properties
1. Tree climber and branch cutting (WSL)
2. CO2 gassing experiment (WSL)
3. Needle, bark, and branch reflectance measurement
4. Needle transmission measurement
5. Hemispherical photo (Gap fraction)
6. Hemispherical photo (fCover, LAI)
CHRIS acquisitions

multi-temporal Data takes: Swiss National Park
- 7 data takes (5 in winter, 2 in summer)
  06.12.03 / 23.12.03 / 23.01.04 / 17.01.04 / 26/27.6.04 / 22.11.04

Mode 3:
- spatial resolution: 18 m
- 18 Bands, 400-1050 nm
- 5 view angles

Winter

Summer
## CHRIS Image Acquisition Geometry (June 27, 2004, SNP)

<table>
<thead>
<tr>
<th>CHRIS file name</th>
<th>Chronological image order</th>
<th>FZA [°]</th>
<th>Observation zenith angle [°] (HDF 4.1)</th>
<th>Observation azimuth angle [°] N=0° (HDF 4.1)</th>
<th>Accross track angle [°] (Geomatica)</th>
<th>Along track angle [°] (Geomatica)</th>
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<tr>
<td>42AC</td>
<td>1</td>
<td>+55</td>
<td>+51.15</td>
<td>177.01</td>
<td>3.70 (E)</td>
<td>51.11 (to S)</td>
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<tr>
<td>42AA</td>
<td>2</td>
<td>+36</td>
<td>+33.33</td>
<td>161.17</td>
<td>11.98 (E)</td>
<td>31.90 (to S)</td>
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<td>0</td>
<td>+21.21</td>
<td>135.20</td>
<td>15.34 (E)</td>
<td>15.34 (to S)</td>
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<tr>
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<td>4</td>
<td>-36</td>
<td>-37.76</td>
<td>36.02</td>
<td>24.49 (E)</td>
<td>32.07 (to N)</td>
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<tr>
<td>42AD</td>
<td>5</td>
<td>-55</td>
<td>-54.59</td>
<td>28.88</td>
<td>34.19 (E)</td>
<td>50.93 (to N)</td>
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</tbody>
</table>

Solar zenith: 24.3°, solar azimuth: 161°
Parametric Geocoding
Use of a 3D physical model (parametric approach) [Toutin 1985, 1992] as implemented in PCI / Geomatica

A physical model can mathematically describe all distortions of
- the platform (position, velocity, orientation)
- the sensor (view angles, IFOV, panoramic effect)
- the Earth (ellipsoid, relief)
- the cartographic projection

Needs orbit and sensor information and a small number of GCP’s to compute / refine the parameters of the mathematical model

Number of GCP’s depend on orbit and sensor information availability, GCP accuracy and final expected accuracy (iterative least-square method)
Typical information required for parametric geocoding approach

• Orbit and sensor information
  • Sensor altitude (637 km)
  • Orbital period (96.77 min) [Barnsley et al., IEEE Trans. Geosc. & RS Vol. 42(7), 2004]
  • Eccentricity (0.0084) [Barnsley et al.]
  • Actual inclination (97.84°) [Barnsley et al.]
  • Across track angle, along track angle (calculated from CHRIS HDF4.1 information)
  • IFOV

• Image Information
  • Pixel spacing (18 m at nadir)
  • Approx. scene centre
  • Ellipsoid (DEM)
### GCP Selection for Parametric Geocoding

#### GCP’s selected within the whole CHRIS scene

<table>
<thead>
<tr>
<th>RMS [pixels]</th>
<th>+55°</th>
<th>+36°</th>
<th>0°</th>
<th>-36°</th>
<th>-55°</th>
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</thead>
<tbody>
<tr>
<td>total</td>
<td>1.12</td>
<td>2.91</td>
<td>0.76</td>
<td>2.85</td>
<td>1.58</td>
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<tr>
<td>X</td>
<td>0.91</td>
<td>2.15</td>
<td>0.42</td>
<td>2.37</td>
<td>1.13</td>
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<td>Y</td>
<td>0.65</td>
<td>1.96</td>
<td>0.64</td>
<td>1.59</td>
<td>1.11</td>
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<td>Number of GCP’s</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>10</td>
<td>9</td>
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</table>

#### GCP’s selected within the CHRIS region of interest

<table>
<thead>
<tr>
<th>RMS [pixels]</th>
<th>+55°</th>
<th>+36°</th>
<th>0°</th>
<th>-36°</th>
<th>-55°</th>
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</thead>
<tbody>
<tr>
<td>total</td>
<td>0.88</td>
<td>0.58</td>
<td>0.76</td>
<td>0.90</td>
<td>0.36</td>
</tr>
<tr>
<td>X</td>
<td>0.56</td>
<td>0.18</td>
<td>0.42</td>
<td>0.51</td>
<td>0.22</td>
</tr>
<tr>
<td>Y</td>
<td>0.64</td>
<td>0.55</td>
<td>0.64</td>
<td>0.74</td>
<td>0.28</td>
</tr>
<tr>
<td>Number of GCP’s</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>
Geometric Correction: Validation

- geo-corrected View angles overlaid with Vector layers
Geometric Correction: Validation

geo-corrected Nadir view overlaid with Vector layers

QuickTime™ and a None decompressor are needed to see this picture.
Atmospheric Processing

Atmospheric correction of the CHRIS radiance data is performed using ATCOR2/3 [Richter, 2005], which is based on MODTRAN-4.

CHRIS Land Mode 3 newly implemented in ATCOR2/3

ATCOR3 is a radiative transfer code for atmospheric correction of optical spaceborne sensors, including the option to process tilted sensors (accounts for varying path length and transmittance)

ATCOR3 supports atmospheric correction over rugged terrain by including digital elevation models (elevation, slope, aspect, sky view factor, cast shadow)
Atmospheric Processing: Validation

- Comparison of corrected CHRIS spectra vs ground measurements (gravel, meadow) or ROSIS (forest)
- Atmospheric correction within uncertainties of ground measurements
- Calibration errors in band 1, 17-18
Vicarious Calibration

VC relative to an alpine meadow
HDRF measurements: ground vs spaceborne

- Goniometer field measurements of a meadow target in VIS same trend for back / forwards scattering angles

FIGOS

CHRI$S$
Geometric and atmospheric corrected scenes

June 27, 2004

+36

-36

+55

+21 (0)

-55
42AC (+55)
42AA (+36, exactly in solar principle plane)
42A9 (0, (+21))
42AB (-36)
42AD (-55)
Conclusions

A 3D physical model (parametric geocoding approach) has been successfully applied to a CHRIS / PROBA scene over rugged terrain.

Atmospheric processing of a CHRIS data set has been performed using ATCOR3. ATCOR3 is adapted to account for tilted angles, illumination effects (DEM), varying path lengths and transmissions.

HDRF measurements using a goniometer have been performed close to a CHRIS data take. In the VIS, same trends can be seen for forward / backward scattering angles between field- and CHRIS data.

CHRIS calibration errors may be observed in channels 1, 17 and 18.
Outlook

Effects of changing background reflectance to HDRF of a forest canopy (understory vs. snow surface)
  • comparison of winter and summer CHRIS acquisitions
  • Effects of **heterogeneity** on HDRF bowl/bell shape

biophysical/chemical forest parameter retrieval:
  • based on 3D-Radiative Transfer Model
  • RTM inversion exploiting the **directional and temporal** dimension

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Pinty et al. 2002

3-D Bell-shape

k=1.18