TÜBİTAK Space Technologies Research Institute

QA4EO Workshop

Tuz Gölü Radiometric Calibration Test Site

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30 September 2009
Outline

• TÜBİTAK UZAY
• Why do we need calibration?
• Tuz Gölü Test Site Establishment Steps
• Tuz Gölü Reference Test Site Characteristic
• 2008 Calibration Campaign
• 2009 CEOS Pilot Calibration Campaign
• Conclusions
TÜBİTAK UZAY

- TÜBİTAK UZAY (The Scientific and Technological Research Council of Turkey, Space Technologies Research Institute) is a governmental institute.

RASAT

- It will be launched on 2010.
- Funded by State Planning Office as a development project for a LEO EO satellite with GSD = 7.5 m
- Main imaging system was procured from Korea
- By successful completion of this project:
  - New payloads will have been tested in space
  - First LEO EO satellite designed and manufactured totally in Turkey will have been launched
  - Infrastructure and skills about LEO satellites will have been improved
TÜBİTAK UZAY Calibration Activities

• Data processing software for radiometric and geometric calibration of BILSAT data.

• Improving data processing software for RASAT data radiometric, geometric calibration and basic image processing tools.

• Establish a new absolute radiometric calibration test site on Tuz Gölü (Salt Lake).

• Contribution on IVOS and QA4EO activities.
Why do we need calibration?

- For reliability of optical satellite data to make it compatible with the other optical satellite data and derive accurate knowledge, information.

What do we have?
- Satellite Data
- Reference Test Site
- Methodology
- Software

What is the end user fundamental requirement to use the satellite data?

Calibrated Data

Reliable/Suitable Calibrated Data

QA4EO
• TÜBİTAK UZAY decided to establish a new reference test site and maintain it to help in achieving QA4EO strategy.

• Tuz Gölü test site is used for determining key issues on vicarious calibration.

• Two calibration campaigns were completed successfully.
  
    • 2008 Campaign with NPL
    • 2009 CEOS European pilot campaign supported by ESA.

• 2010 CEOS Campaign
• …
What is vicarious calibration?

- Ground measurements (spectroradiometer, BRDF, met. station)
- Atmospheric Measurements (Sun Photometer)
- 6S Successive Order MODTRAN
- Radiative Transfer Function
- TOA
- DN values from satellite
- Absolute Calibration
1. Define the intended application and subsequent requirements driving the characteristics for the reference test site
   - sensor spatial resolution, (all sensors, only high, only medium, one particular sensor)
   - sensor view orientation,
   - accuracy required,
   - regularity of use,
   - spectral range to be covered
   - spectral resolution

Tuz Gölü

- Suitable test site for high and medium resolution satellites
- Easy accessible to Europe
- Convenient for cross comparison exercises, developing methodologies for reflectance based vicarious calibration.

*Tuz Gölü Establishment Steps slides are the summary of ESA supported CONTROLS Project Deliverable prepared by NPL and TÜBİTAK UZAY thanks to experiences gained from Tuz Gölü studies.*
2. **Preliminary identification of a candidate test site**
   - Refer to the parameters in the “*Template for information regarding the prime Committee on Earth Observation Satellites (CEOS) Working Group on Calibration & Validation (WGCV) Cal/Val site*”
   - Refer to the QA4EO “*Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain*”
   - Google Earth images can be used for the first look.
   - Available local data can give idea about the site.

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**Tuz Gölü**

- Using MODIS and Landsat images, the first spatial homogeneity analysis were performed by statistical methods and including local data both mentioned documents were prepared.
3. Preliminary study to choose the measurement area and time
   - Best availability duration for the candidate site in terms of accessibility, weather
   - Define whether there is any obstacles to use the site in any time
   - Logistics issues
   - Determine the target area

Tuz Gölü

- Tuz Gölü is a salt lake, which dries to a salt surface for about three months during a year. Considering weather conditions, the optimum months were determined as July and August by analyzing the local data between 1987 and 2007.

- First of all, spatial autocorrelation methods are used to determine the suitable site. After visiting the site according to this analysis, the measurement area and optimum access way to the target area are determined.
4. **Site Characterisation**
   - **Field Campaign**
     - Determine the aim, methodology to be used (The size of the area, sampling strategy, frequency of reference panel measurements, usage of spectroradiometer, RTC program etc.), equipment
   - Radiometric Characterisation including surface radiance/reflectance data on different time and location and BRDF of the surface
   - Atmospheric Characterisation (aerosol, ozone loading, temperature, wind, water vapour, pressure etc.)
   - Data Analysis

**Tuz Gölü**

- First data is available from 2008 campaign. 2009 field campaign data are still being analysed.
- The reflectance based methodology that is proposed by Arizona University Remote Sensing group is used.
- The main instruments are ASD Spectroradiometer, CIMEL sun photometer, automatic weather station, DGPS.
- Data analysis are performed in cooperation with NPL.
Tuz Gölü Test Site Establishment Steps

5. Demonstration of site suitability
   – Comparison to existing established test sites
   – Well prepared template and questionnaire prepared by CEOS community.
   – Reports
   – Comparison to CEOS general criteria

Tuz Gölü

• Tuz Gölü site data was compared with the calibrated UK-DMC-1 and Landsat images. These images had been calibrated using the Railroad Valley, Nevada (N38.497°, W115.690°) test site, which has a long-standing history.
6. *Submission for endorsement*
   - Once the site has been evaluated this information should be formally recorded on the “reference standard template” by following procedure QA4EO-WGCV-IVO-CSP- 001. This procedure then indicates that the template should be submitted to CEOS WGCV IVOS for review.

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**Tuz Gölü**

- Tuz Gölü reference standard template is available on http://calval.cr.usgs.gov/PDF/QA4EO-WGCV-IVO-CSP-008_TG.pdf
References for potential site criteria:

  “Template for information regarding the prime Committee on Earth Observation Satellites (CEOS) Working Group on Calibration & Validation (WGCV) Cal/Val site”
  “Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain “
Tuz Gölü Characteristics

- Tuz Gölü is spatially uniform with RMS of the deviation from the mean smaller than 2 % for a 300 * 100m target
Tuz Gölü Characteristics

- Tuz Gölü has high reflectance values about ~0.40-0.58 for VNIR

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<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Mean</th>
<th>StDev %</th>
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<tbody>
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<td>0.42631</td>
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</tr>
<tr>
<td>Green (520-630)</td>
<td>0.52318</td>
<td>1.5%</td>
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<tr>
<td>Red (630-760)</td>
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<tr>
<td>NIR (760-900)</td>
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<th>Green (520-630)</th>
<th>Red (630-760)</th>
<th>NIR (760-900)</th>
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<td>0.52±0.03</td>
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<td>0.53±0.02</td>
<td>0.59±0.02</td>
<td>0.59±0.02</td>
</tr>
</tbody>
</table>
Tuz Gölü Characteristics

• Spectral characteristics over range 350 – 2500 nm
The site is uniform in terms of six days period, 2008 field campaign.
Tuz Gölü Characteristics

- BRDF of the surface will be determined after analysing the multi-angular measurements of the site performed by NPL GRASS.
Tuz Gölü Characteristics

- No vegetation exists over this site.
- The elevation of the site is 907 m
Tuz Gölü Characteristics

- In July and August, most of the days are cloud-free according to the data collected during 24-28 August 2008 and Archived Data of Turkish State Meteorological Service.

(a) Average Monthly Insolation (hours) (b) Average Monthly Rainfall (mm)
(Turkish State Meteorological Service, 2007 data)
• Tuz Gölü is located near main highroads and easily accessible. It is located about 150 km southeast of Ankara approximately 2 hours drive.

• It is located in the central part of Turkey at about 300 km from the Mediterranean Sea, 350 km from the Black Sea, and 580 km from the Aegean Sea.
Aerosol optical thickness at 550 nm as calculated from Terra-MODIS data over 2001-2008 period.
Tuz Gölü Characteristics

- An initial screening to identify suitable target areas was conducted using the MODIS satellite images of July and August (2004-2006), which is the most suitable time period for the sites use.

- The red region is 324.026 km² and indicates the homogenous area available throughout July-August. The yellow region has an area of 195.092 km² and gives an indication about areas, which are likely to be dry, during this period.
Tuz Gölü Characteristics

- The site will be temporarily instrumented with the main equipment as meteorological weather station, ASD Spectrometer, CIMEL sunphotometer.
2008 Field Campaign with NPL

- Field campaign was performed during 18 – 24 August 2008
- Surface radiance/reflectance measurements with ASD Spectrometer
- BRDF measurements with GRASS designed by NPL
- AOT and water vapour measurements with Microtops Sunphotometer loaned from NERC
- Temperature, Pressure, wind, humidity measurements with automatic weather station
2009 CEOS Pilot Field Campaign

Tuz Gölü, Turkey was proposed and accepted to serve as a host for both comparisons as it is in relatively easy reach of all participants and particularly those in Europe who will take part in the pilot comparison.

It was agreed to perform pilot 2009 CEOS field campaign before 2010 CEOS Field Campaign. These studies are supported by ESA.

National Physical Laboratory (NPL), UK – Pilot
TÜBİTAK Space Technologies Institute (TÜBİTAK UZAY), Turkey – Host

Participants:
French Aerospace Research Center (CNES/ONERA), France
German Aerospace Center (DLR), Germany
TÜBİTAK Space Technologies Institute (TÜBİTAK UZAY), Turkey
2009 CEOS Pilot Campaign

The objectives are:

- Evaluate differences in field instrument primary calibrations
- Evaluate differences in methods for characterising and assigning “radiometric value” to a site
- Establish formal traceability of Tuz Gölü reference site based on an evaluation of all comparison results.
- Identify the minimum and ideal specifications for characterisation/instrumentation for a CEOS “reference standard”
Establish “best practice” guidance for above and/or knowledge of variance between methodologies.

A multi-sensor (satellite and aircraft) comparison linked to the ground calibration derived from the multi-team comparison.

**Measurands:**

1. Spectral reflectance factor of the site surface
2. Projected Top Of the Atmosphere radiance for the site appropriately integrated to enable a calibration of a satellite sensor with both high and medium spatial resolution
3. Spectral radiance measurements by the spectroradiometer
### 2009 CEOS Pilot Campaign

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Measurement</th>
<th>Institute</th>
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<tbody>
<tr>
<td>GRASS</td>
<td>BRDF</td>
<td>NPL</td>
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<tr>
<td>CIMEL Sun Photometer</td>
<td>AOT, water vapour, ozone data</td>
<td>CNES</td>
</tr>
<tr>
<td>Meteorological Station</td>
<td>Temperature, wind, humidity, pressure, irradiance, UV index</td>
<td>TÜBİTAK UZAY</td>
</tr>
<tr>
<td>Microtops II Sun Photometer</td>
<td>AOT</td>
<td>DLR</td>
</tr>
<tr>
<td>Microtops II Ozonometer</td>
<td>Ozone content</td>
<td>DLR</td>
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<tr>
<td>ASD Spectrometers</td>
<td>Radiance/Reflectance</td>
<td>DLR, TÜBİTAK UZAY, ONERA, NPL</td>
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<tr>
<td>KT19 Heitonics thermoradiometers</td>
<td>Spectrum measurements over thermal region.</td>
<td>ONERA</td>
</tr>
<tr>
<td>HYMAP</td>
<td>Hyperspectral measurements</td>
<td>DLR</td>
</tr>
</tbody>
</table>
CEOS Campaign – What we have?

1. Cross Comparison via TSARS
   23/08/2009 ----- data from ONERA, DLR, TU & NPL
   29/08/2009 ----- data from ONERA, DLR, TU & NPL

2. Cross comparison via reference panel
   26/08/2009 ----- data from ONERA, DLR, TU & NPL
   27/08/2009 ----- data from ONERA, DLR, TU & NPL
### 3. Ground Measurements

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<tr>
<td>DLR</td>
<td>Camp Preparation</td>
<td>1km*1km</td>
<td>No site measurements</td>
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<td>100m*300m (M3)</td>
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<tr>
<td>TU</td>
<td>100m*300m (M2)</td>
<td>100m*300m (M3)</td>
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### 4. Satellite Data

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<tbody>
<tr>
<td>SPOT4</td>
<td>10m-1band + 20m 4bands</td>
<td></td>
<td></td>
<td>08:38:18 (UTC)</td>
<td></td>
</tr>
<tr>
<td>MERIS</td>
<td></td>
<td></td>
<td>08:10:48 (UTC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing 1</td>
<td>07:22:48 (UTC)</td>
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<tr>
<td>Proba</td>
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<tr>
<td>Terra</td>
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<td>UK DMC</td>
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<td>06:31:11 (UTC)</td>
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<td>UK DMC2</td>
<td>07:45:00 (UTC)</td>
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<td></td>
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<tr>
<td>Deimos1</td>
<td></td>
<td></td>
<td></td>
<td>07:46:42 (UTC)</td>
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</table>
5. Airborne measurements with HYMAP taken on 1st September 2009
Conclusions

• Tuz Gölü is a new radiometric calibration test site proposed and maintained by TÜBİTAK UZAY.

• It has an important role on defining “best practices” thanks to ESA and CEOS community.

• Tuz Gölü CEOS field campaign is a key practical exercise on implication of QA4EO in space-related projects. It proves the importance and requirement of these studies.

• These kind of studies would be more to prepare guides more detaily and answer the requirements. It provides sharing knowledge, discussions which are the most important issues.

• The reports written by the experiences from practical exercises will guide the cal/val users.
Thank You!

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UZAMŞAL HOMOJENLİK (Uydu Verileri)

- Getis Ord

\[ G_i^* (d) = \frac{\sum_{j} w_{ij}(d)x_j}{\sum_{j} x_j} \]

- Moran’s I

\[ I_i = \frac{\sum_i x_i}{\sum_i x_i^2} \sum_j w_{ij}x_j \]

- \( w_{ij}(d) \) = Uzamsal ağırlık matrisi
- \( x_j \) = j koordinat indeksli pikselin sayısal değeri
- \( i \) = Hedef pikselin koordinat indeksi
One Problem!

• Tarpaulins?
• We are open to alternatives?
Conclusions

Refer to QA4EO Guides and follow them

- Yes
  - Accessibility/Availability
    - Yes
    - Suitability/Reliability
      - Yes
      - Achieve QA4EO strategy
        - Facilitate interoperability of GEO systems
  - No
    - Refer to QA4EO Guides and follow them

Achieve QA4EO strategy
Facilitate interoperability of GEO systems