TÜBİTAK Space Technologies Research Institute

QA4EO Workshop

Tuz Gölü Radiometric Calibration Test Site

Selime GÜROL

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

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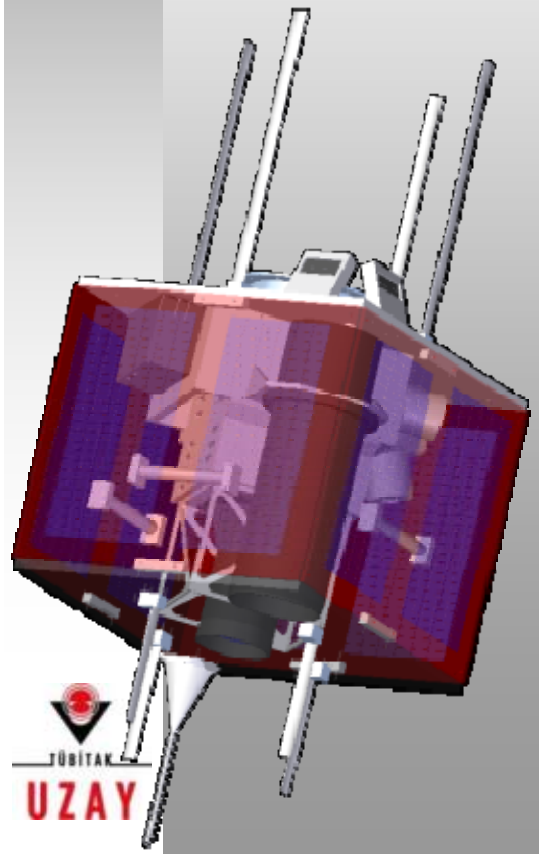
• TÜBİTAK UZAY (The Scientific and Technological Research Council of Turkey, Space Techologies Research Institute) is a governmental institute.

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 successfull 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.

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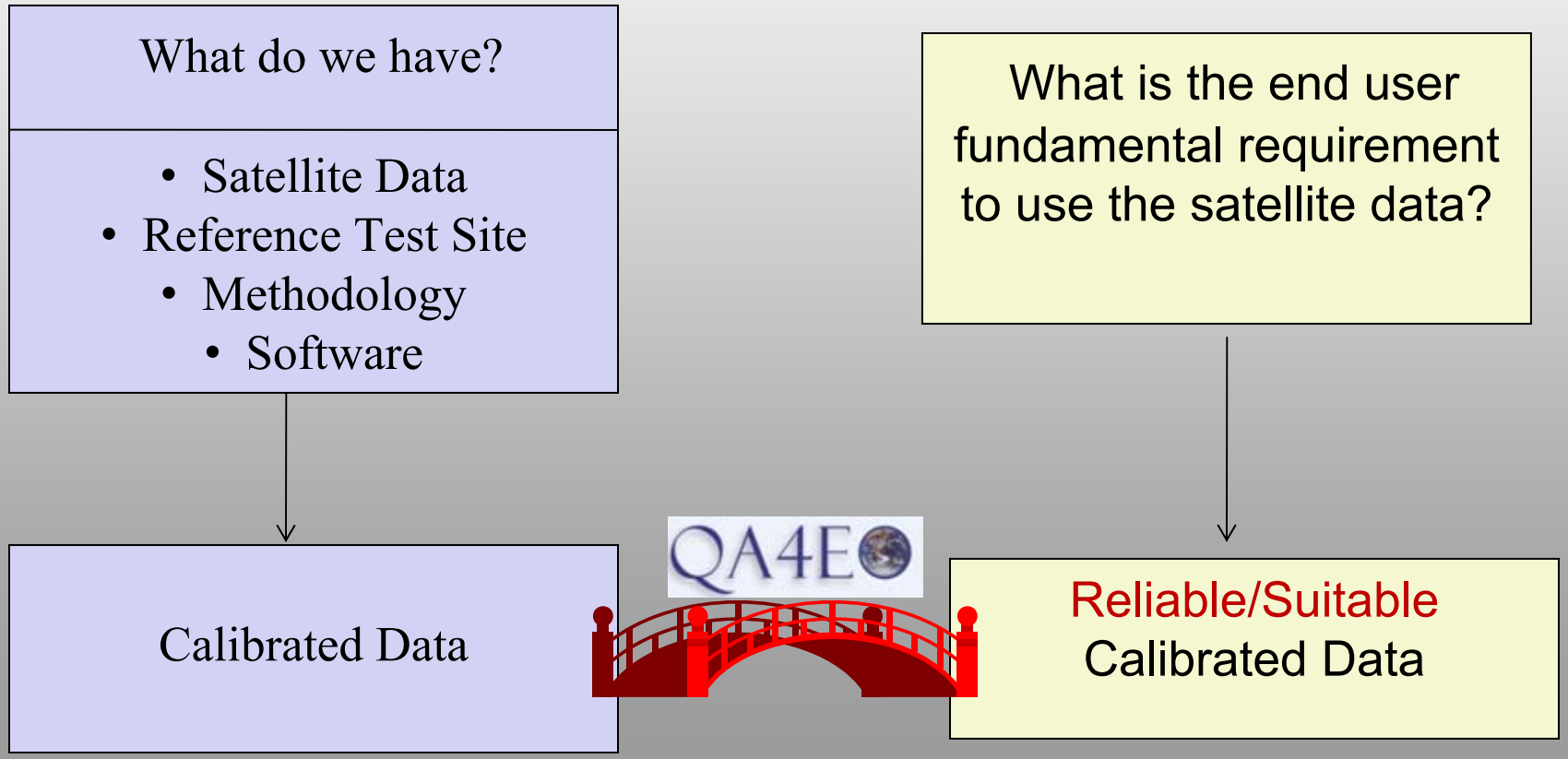
Why do we need calibration?

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



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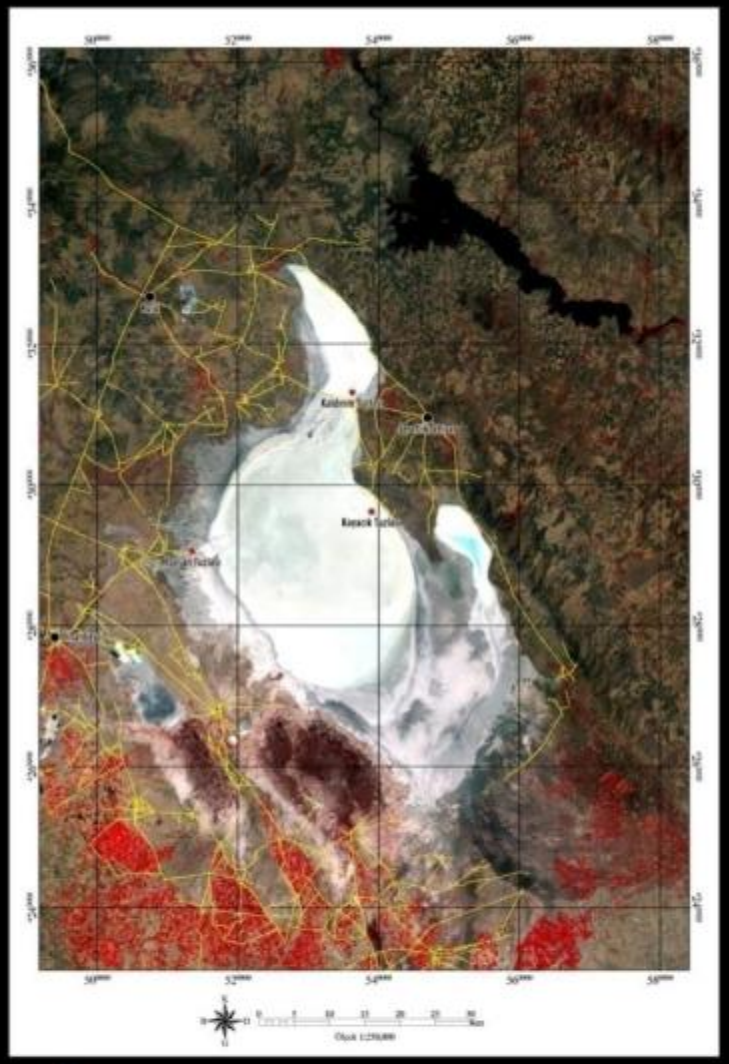
Tuz Gölü Reference Test Site



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

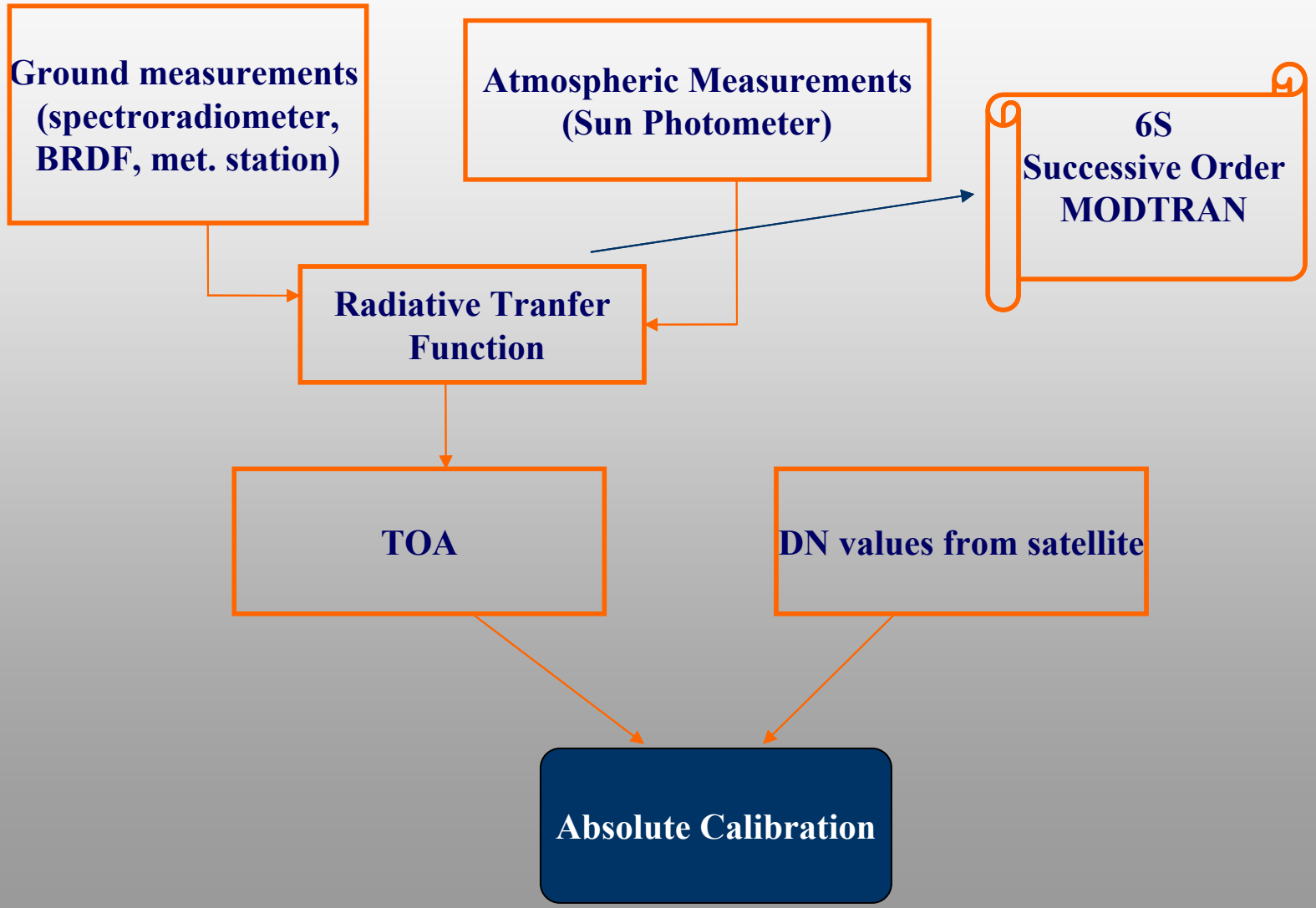
- Tuz Gölü test site is used for determining key issues on vicarious calibration.

- 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?



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Tuz Gölü Test Site Establishment Steps*

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.

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* 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.

Tuz Gölü Test Site Establishment Steps

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.*

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.

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Tuz Gölü Test Site Establishment Steps

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 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 target area are determined.

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Tuz Gölü Test Site Establishment Steps

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.

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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.

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Tuz Gölü Test Site Establishment Steps

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

Tuz Gölü

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

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Tuz Gölü Characteristics

References for potential site criteria:

- Morain S., and Budge M. A., 2004. *Post-Launch Calibration of Satellite Sensors, ISPRS Book Series,* Volume 2, pp.181-187.
- Teillet, P.M., Barsi, J.A., Chander, G., and Thome, K.J. Prime candidate earth targets for the post-launch radiometric calibration of space-based optical imaging instruments. *Proceedings of SPIE, vol. 6677, 66770S, 2007.*
- Thome, K., 2002. Paper on the ISPRS Commission I Mid-Term Symposium in conjunction with Pecora 15/Land Satellite Information IV Conference "Ground look radiometric calibration approaches for remote sensing imagers in the solar reflective", Denver, CO USA. http://www.isprs.org/commission1/proceedings02/paper/00039.pdf .
- Scott, K. P., Thome, K., Brownlee, M. R., 1996. Evaluation of the Railroad Valley playa for use in vicarious calibration. *Proceedings of SPIE, vol. 2818, pp. 158-166*
- "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 "

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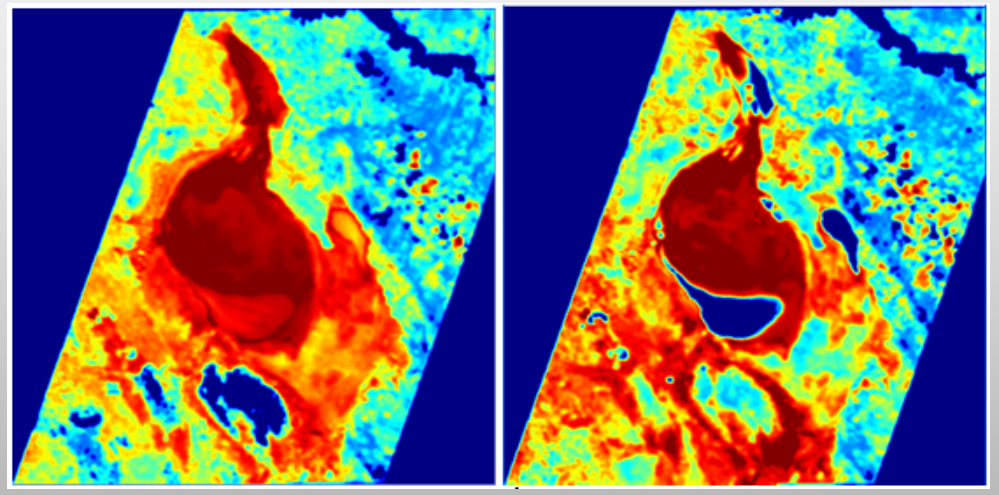
Tuz Gölü Characteristics

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



10.07.2006 MODIS red band

10.07.2006 MODIS NIR band

Low DNs

High DNs

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Tuz Gölü Characteristics

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

Wavelength (nm)	Mean	StDev %
Blue (420-520)	0,42631	2%
Green (520-630)	0,52318	1.5%
Red (630-760)	0,58385	1.37%
NIR (760-900)	0,57597	1.56%

Date	Blue (420-520)	Green (520-630)	Red (630-760)	NIR (760-900)
19.08.2008	0.43±0.03	0.52±0.03	0.58±0.03	0.58±0.03
20.08.2008	0.45±0.02	0.55±0.03	0.60±0.03	0.59±0.03
21.08.2008	0.43±0.03	0.52±0.03	0.58±0.04	0.58±0.04
22.08.2008	0.41±0.02	0.51±0.02	0.57±0.02	0.57±0.03
23.08.2008	0.42±0.02	0.51±0.02	0.58±0.02	0.57±0.02
24.08.2008	0.43±0.02	0.53±0.02	0.59±0.02	0.59±0.02

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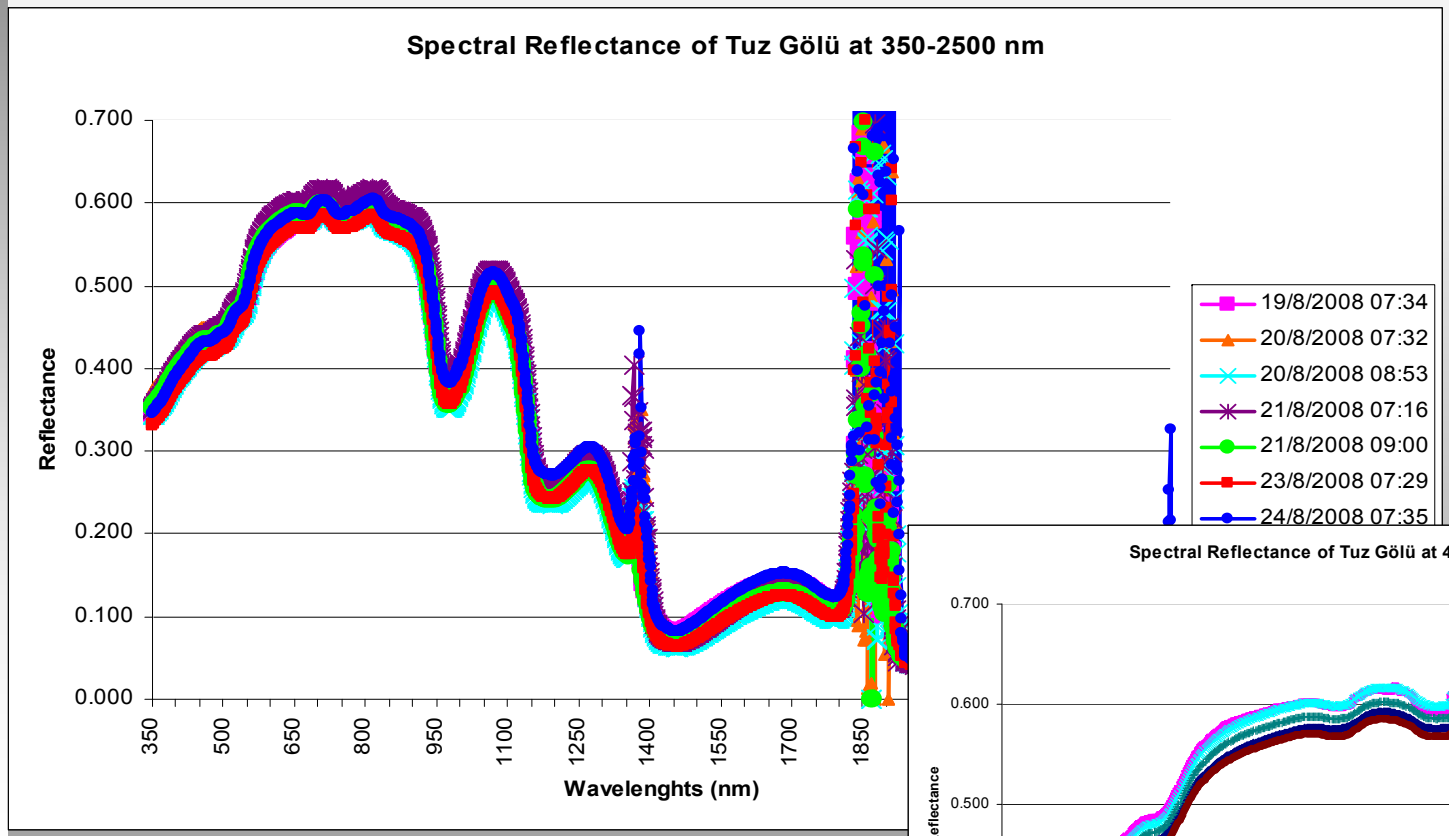
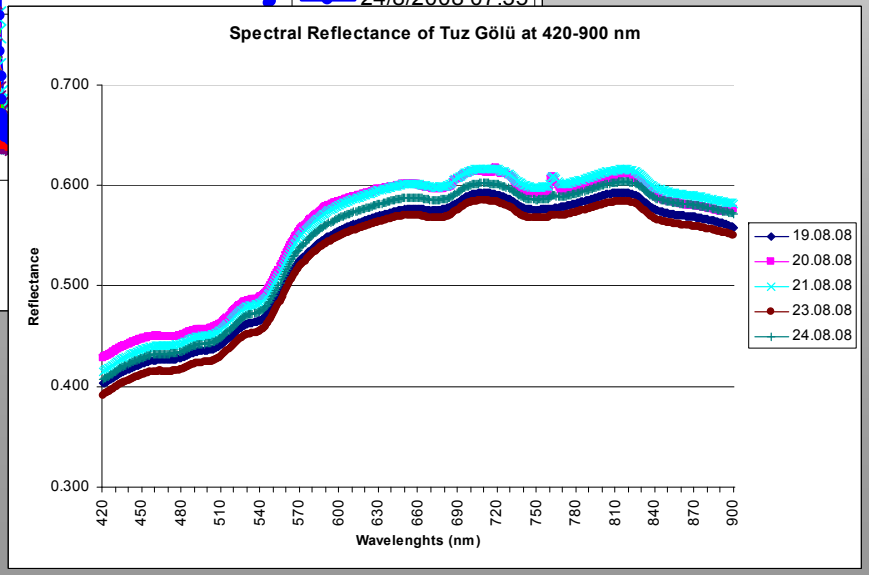
Tuz Gölü Characteristics

- Spectral characteristics over range 350 – 2500 nm





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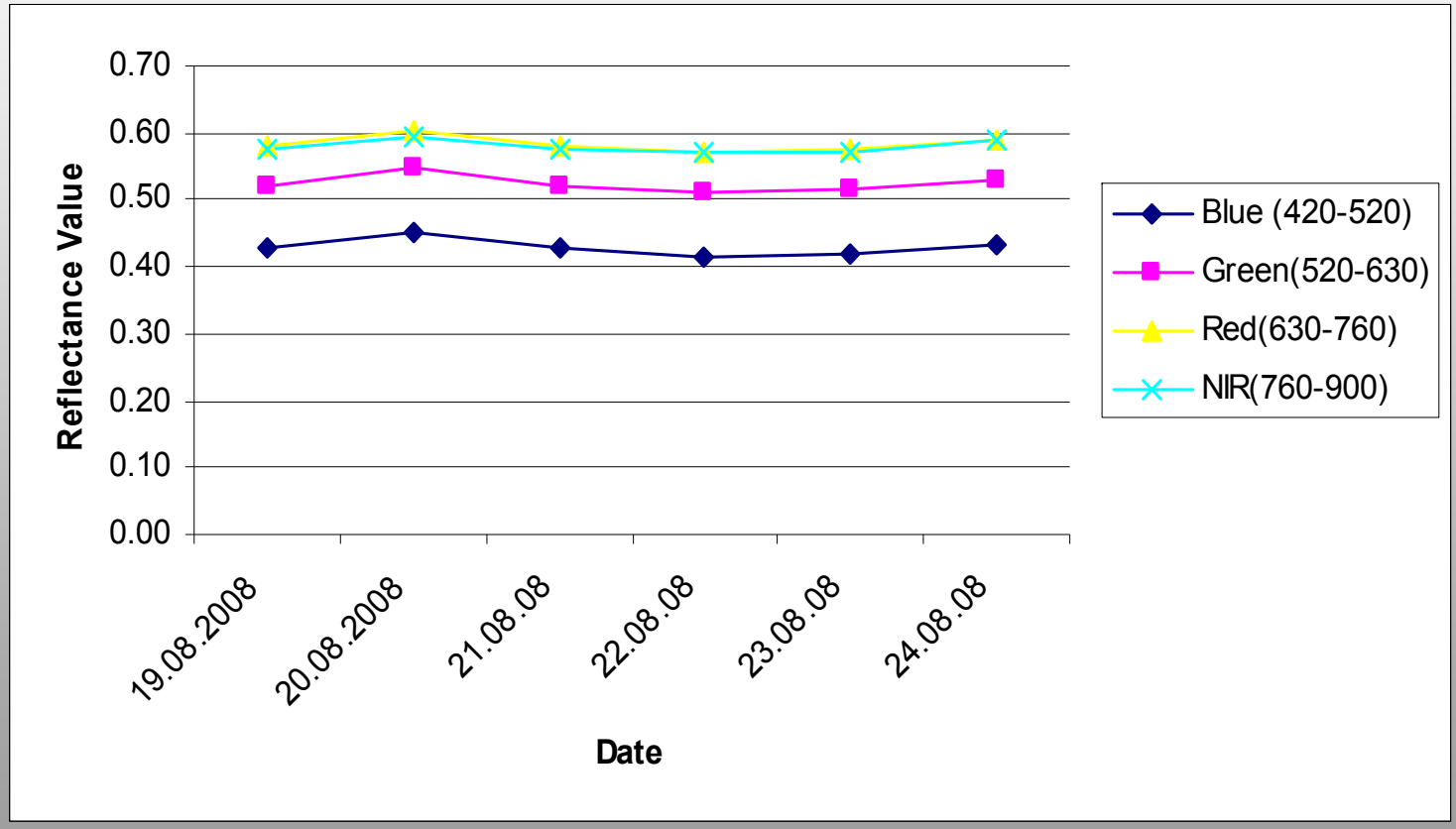
Tuz Gölü Characteristics

- The site is uniform in terms of six days period, 2008 field campaign



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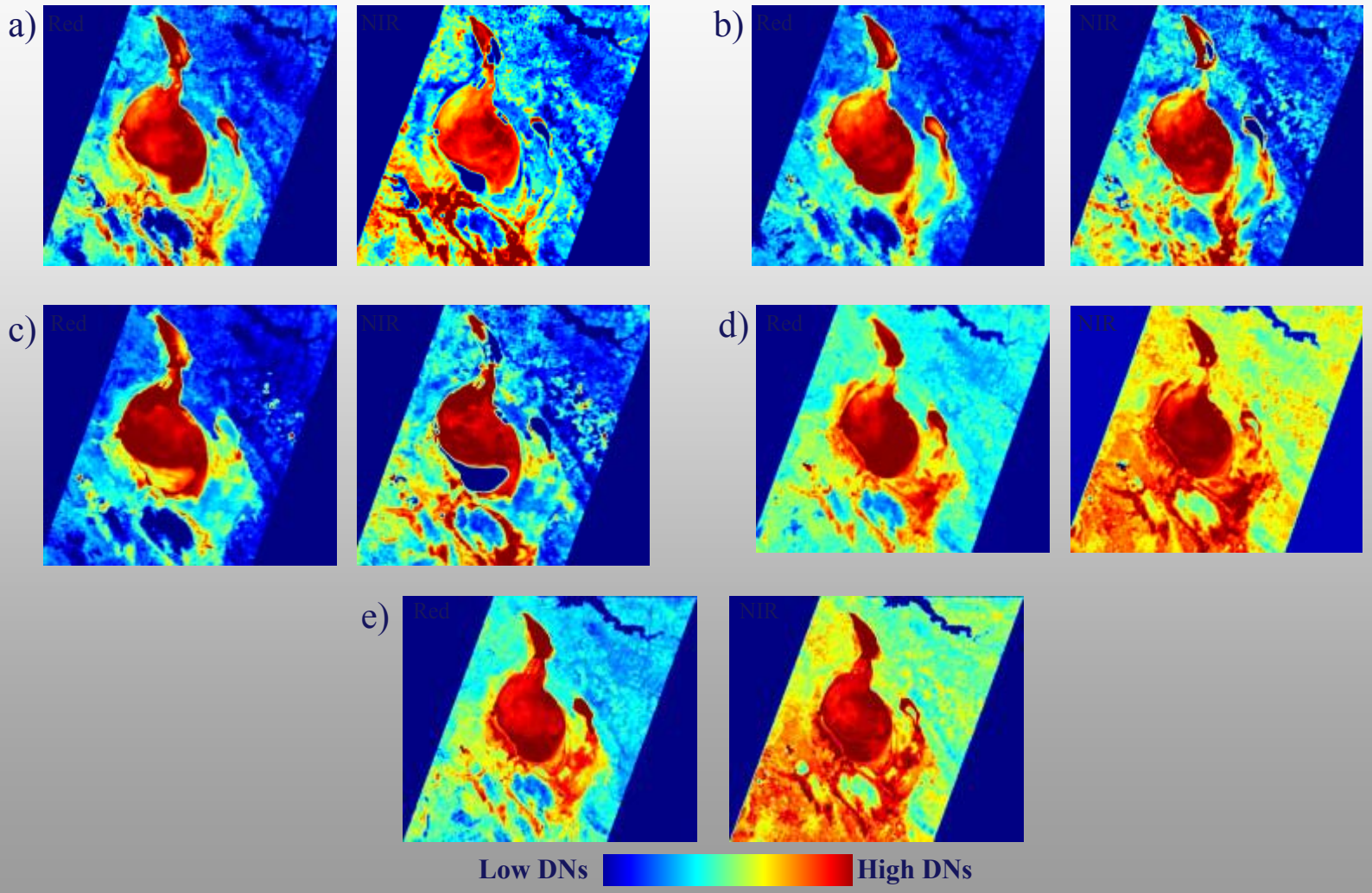
Tuz Golu Characteristics



Getis-Ord Gi indices Red and NIR bands of MODIS (LPDAAC) satellite images of a) 10.07.2004, b) 10.08.2005, c) 10.07.2006, d) 20.07.2007, e) 21.08.2008

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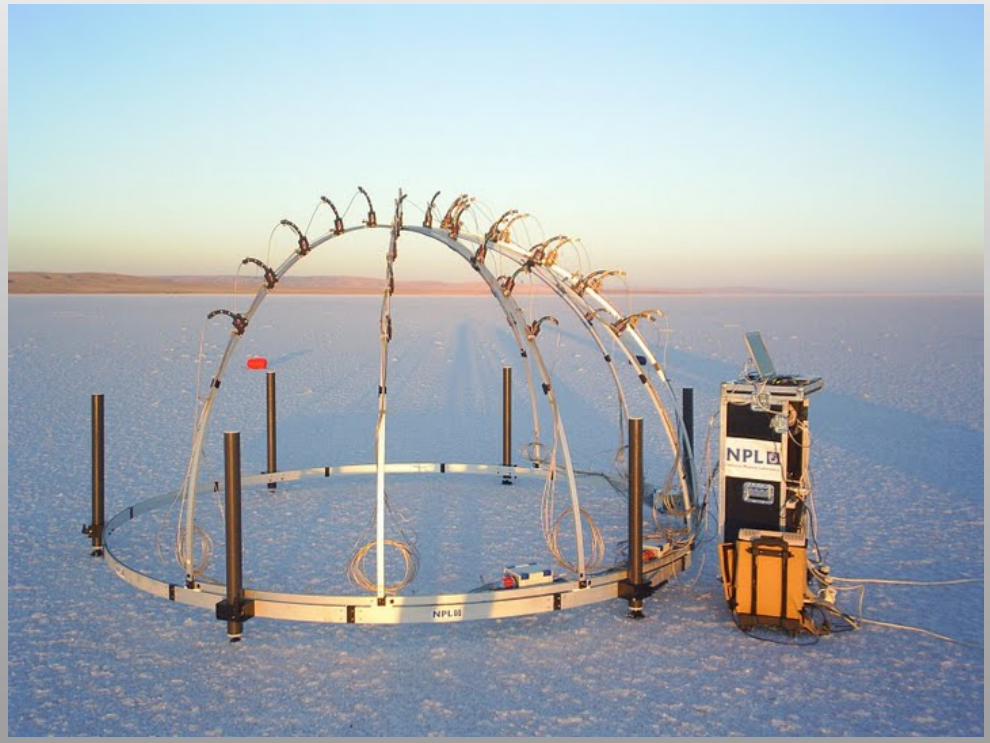
Tuz Gölü Characteristics

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



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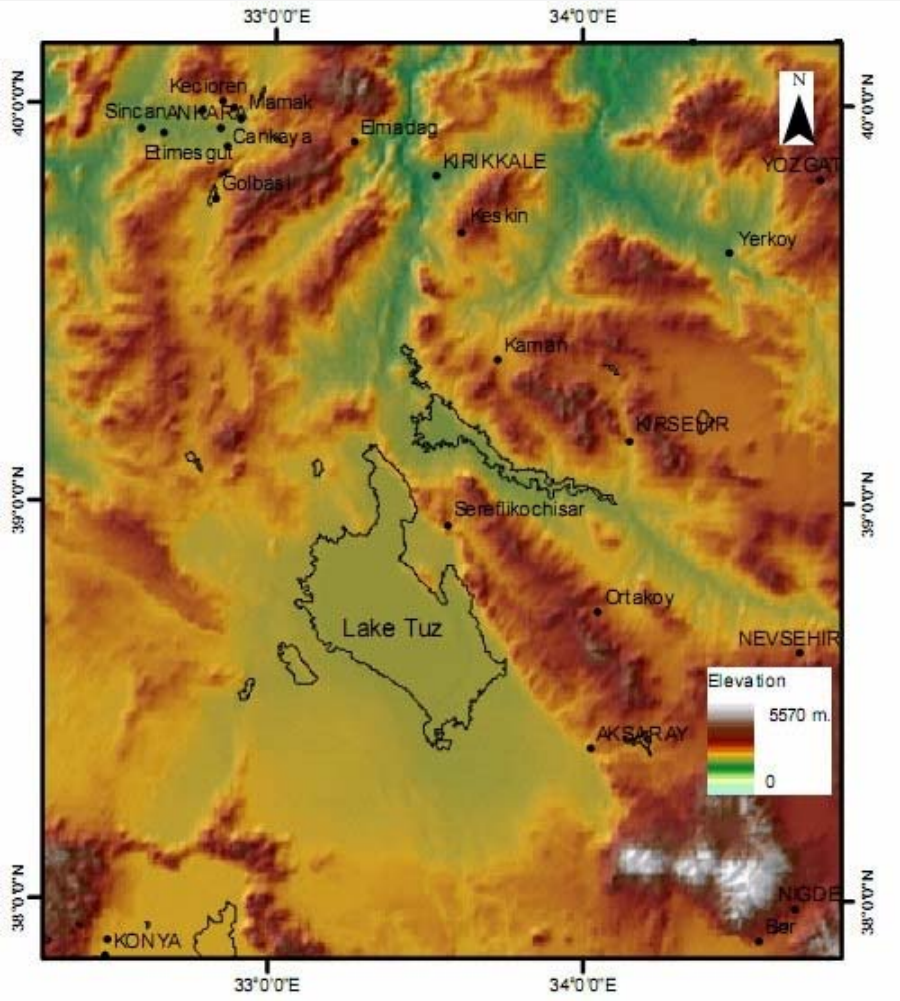
Tuz Gölü Characteristics

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



SRTM DEM of the region

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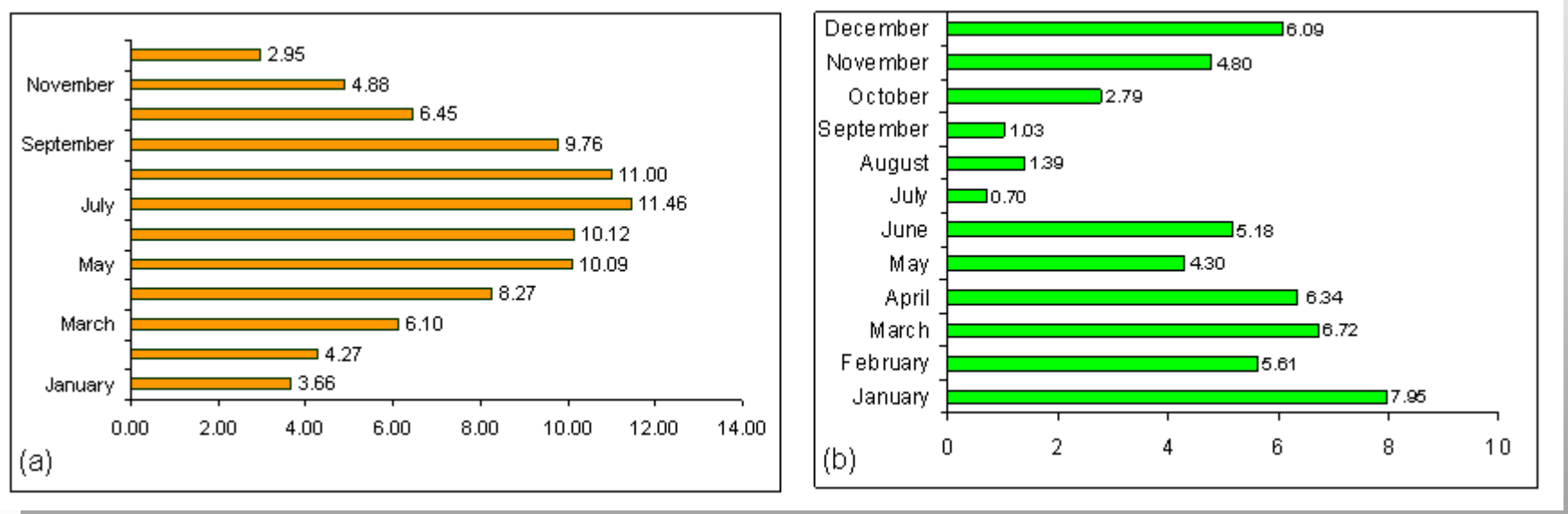
Tuz Gölü Characteristics

- 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)

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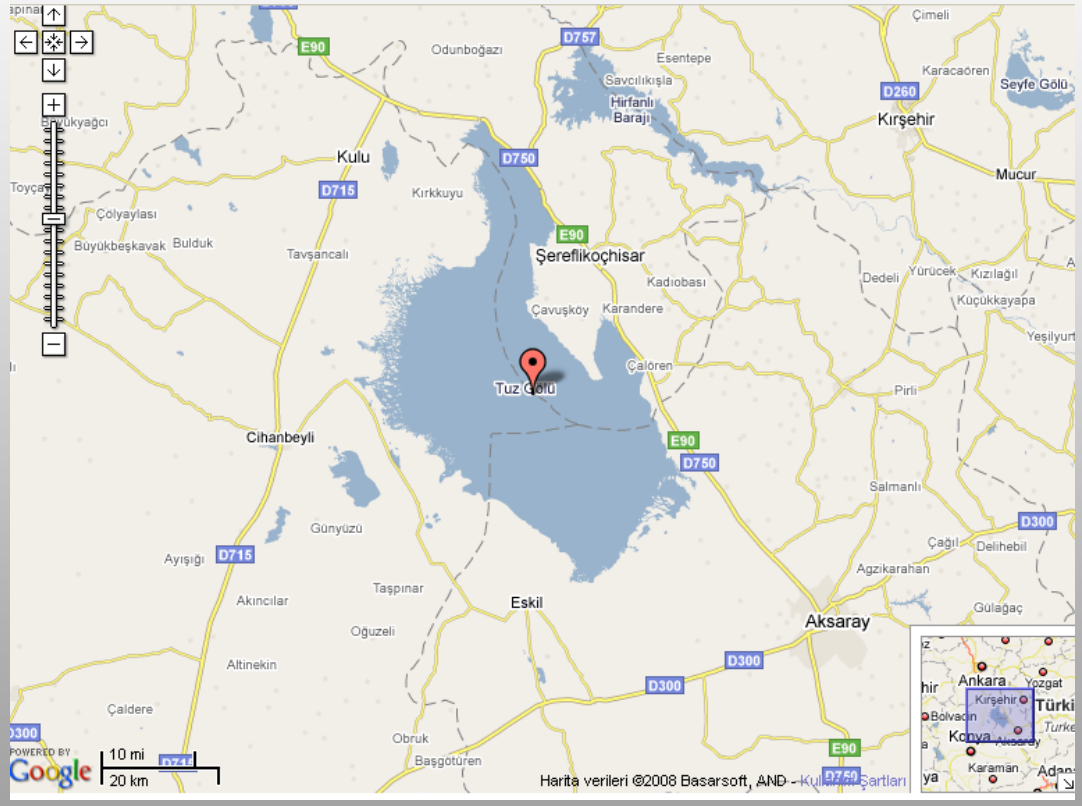
Tuz Gölü Characteristics

- 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.

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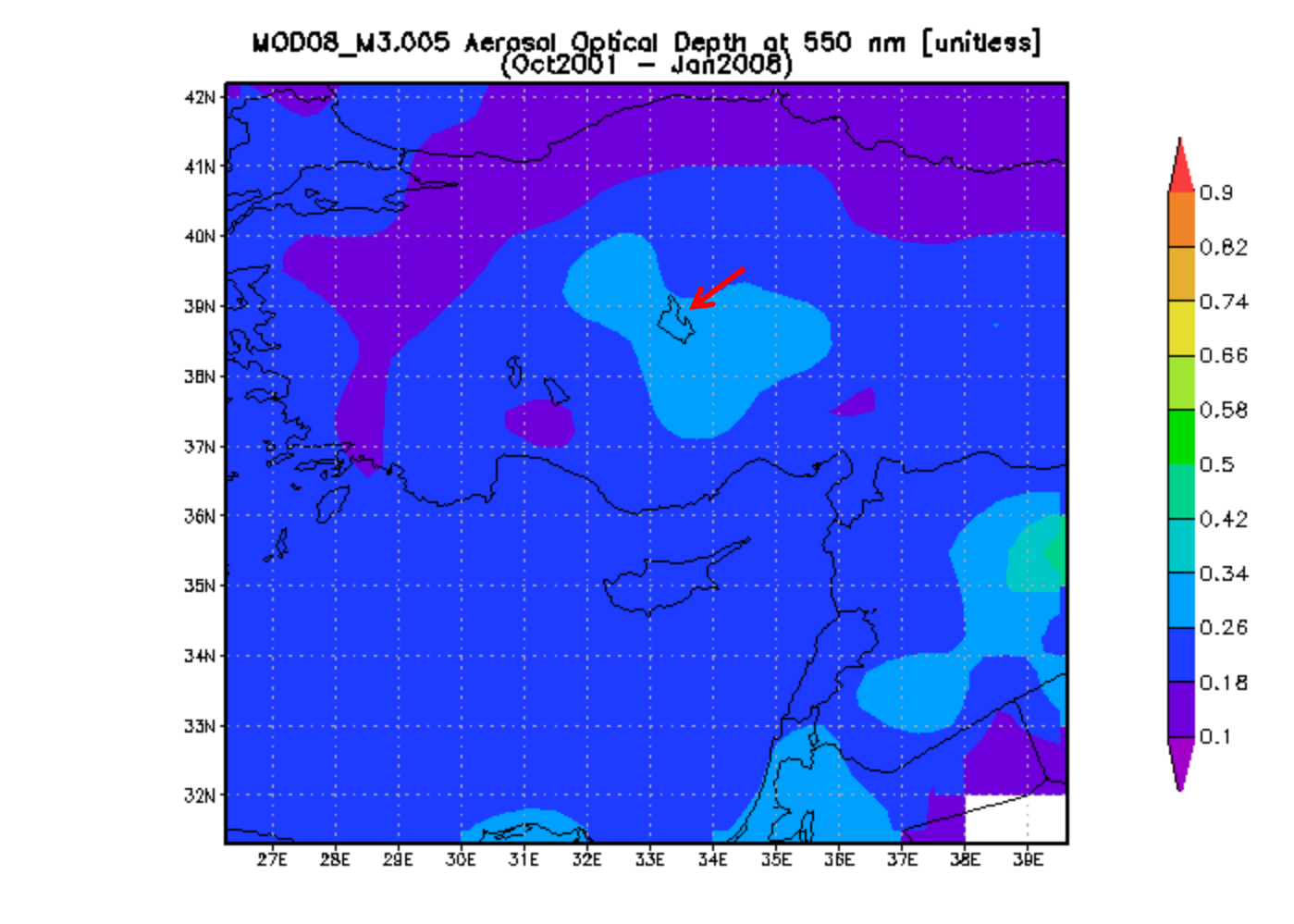
Tuz Gölü Characteristics



Aerosol optical thickness at 550 nm as calculated from Terra-MODIS data over 2001-2008 period.

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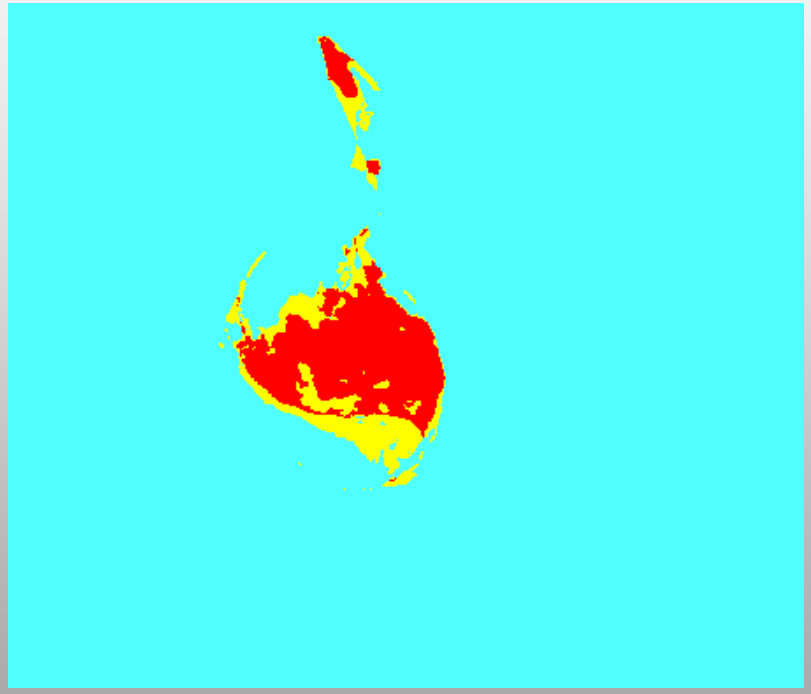
Tuz Gölü Characteristics

- 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.

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Tuz Gölü Characteristics

• The site will be temporarily instrumented with the main equipment as meteorological weather station, ASD Spectrometer, CIMEL sunphotometer.

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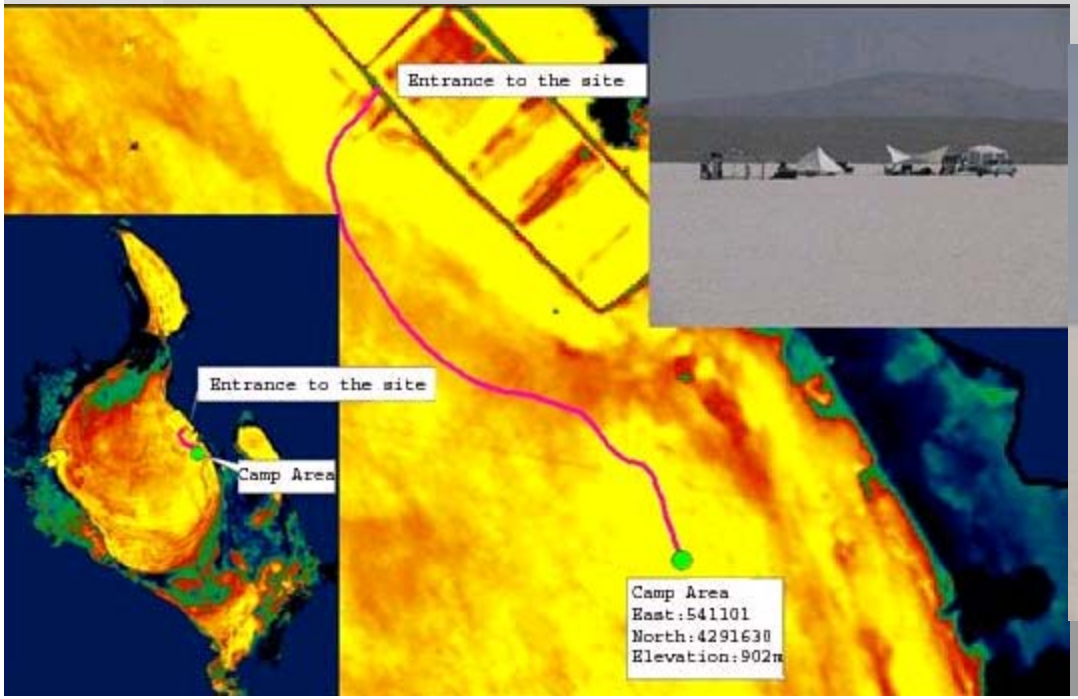
2008 Field Campaign with NPL

- 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 in relatively easy reach of all participants and particularly those in Europe who will take part in the pilot comparison.

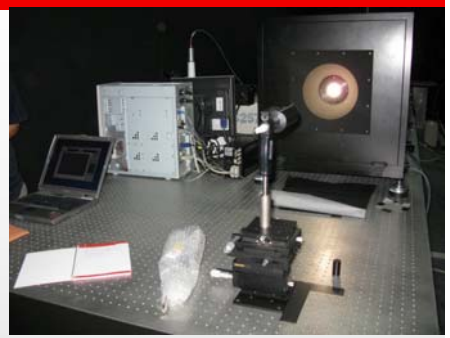
It was agreed to perform pilot 2009 CEOS field campaign before 2010 CEOS Field Campaign. These studies are supported by ESA.

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:

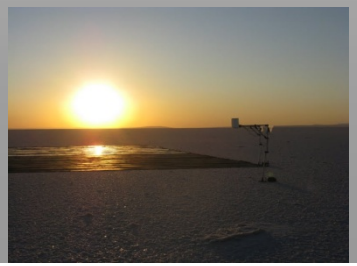


- Evaluate differences in field instrument primary calibrations

- 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”



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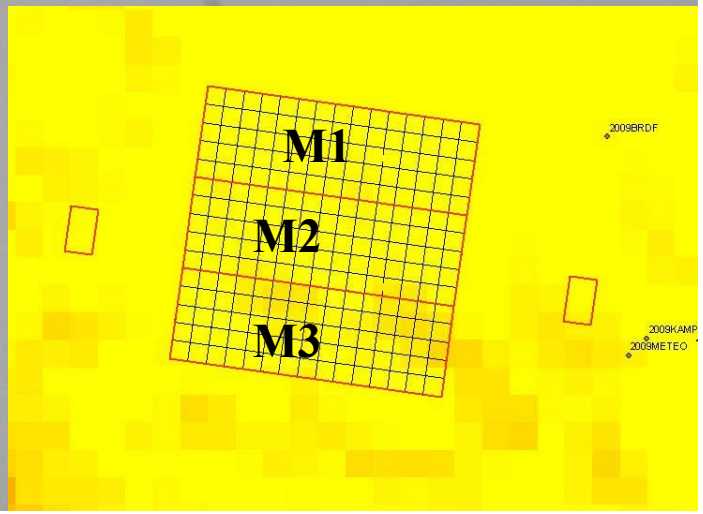
2009 CEOS Pilot Campaign

- 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

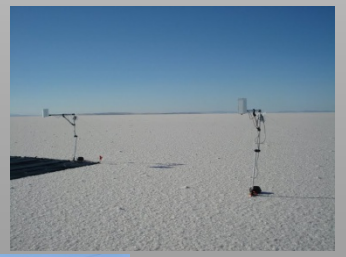


2009 CEOS Pilot Campaign

Equipment	Measurement	Institute
GRASS	BRDF	NPL
CIMEL Sun Photometer	AOT, water vapour, ozone data	CNES
Meteorological Station	Temperature, wind, humidity, pressure, irradiance, UV index	TÜBİTAK UZAY
Microtops II Sun Photometer	AOT	DLR
Microtops II Ozonometer	Ozone content	DLR
ASD Spectrometers	Radiance/ Reflectance	DLR, TÜBİTAK UZAY, ONERA, NPL
KT19 Heitronics thermoradiometers	Spectrum measurements over thermal region.	ONERA
HYMAP	Hyperspectral measurements	DLR



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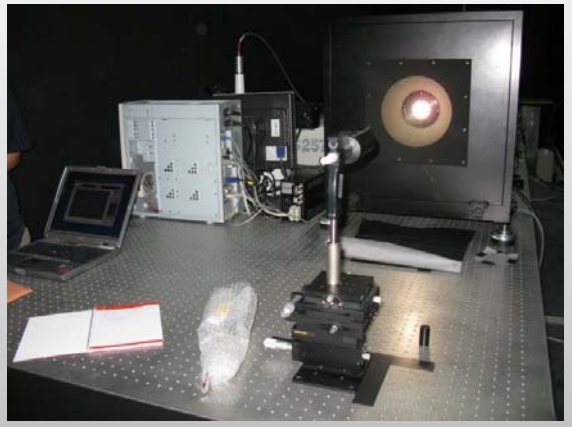
CEOS Campaign – What we have?

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

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CEOS Campaign – What we have?

3. Ground Measurements

Institute	*24/08/2009*	*25/08/2009*	*26/08/2009*	*27/08/2009*	*28/08/2009*
DLR	Camp Preparation	1km*1km	No site measurements	100m*300m (M1)	100m*300m (M3)
ONERA		100m*300m (M1)		100m*300m (M2)	100m*300m (M3)
TU		100m*300m (M2)		1km*1km	100m*300m (M3)

4. Satellite Data

Sensors	*24/08/2009*	*25/08/2009*	*26/08/200*	*27/08/2008*	*28/08/2009*
SPOT4	10m-1band + 20m 4bands				08:38:18 (UTC)
MERIS			08:10:48 (UTC)		
Beijing 1		07:22:48 (UTC)			
Proba		07:46:26 (UTC)			
Terra		08:33:07 (UTC)			
UK DMC		06:18:00 (UTC)			06:31:11 (UTC)
UK DMC2		07:45:00 (UTC)			
Deimos1				07:46:42 (UTC)	

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CEOS Campaign – What we have?

5. Airborne measurements with HYMAP taken on 1st September 2009

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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.

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Thank You!

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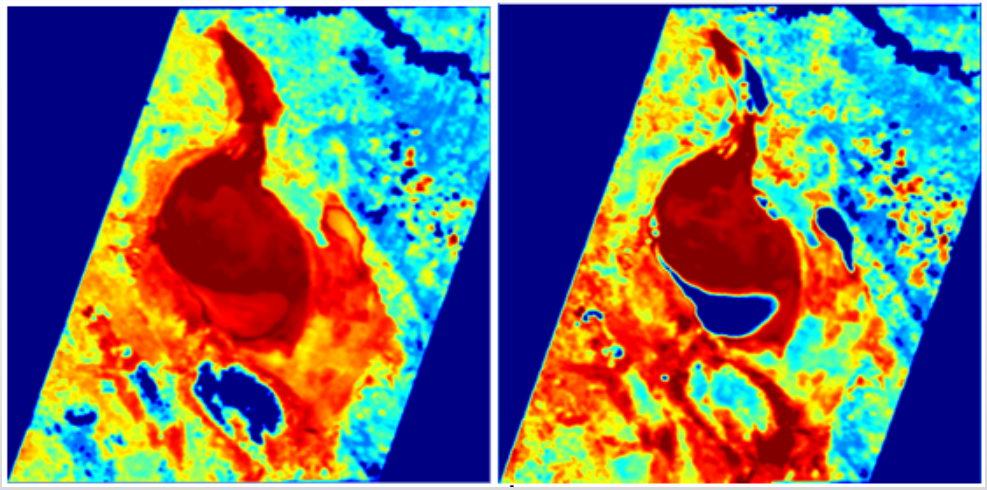
UZAMSAL HOMOJENLİK (Uydu Verileri)

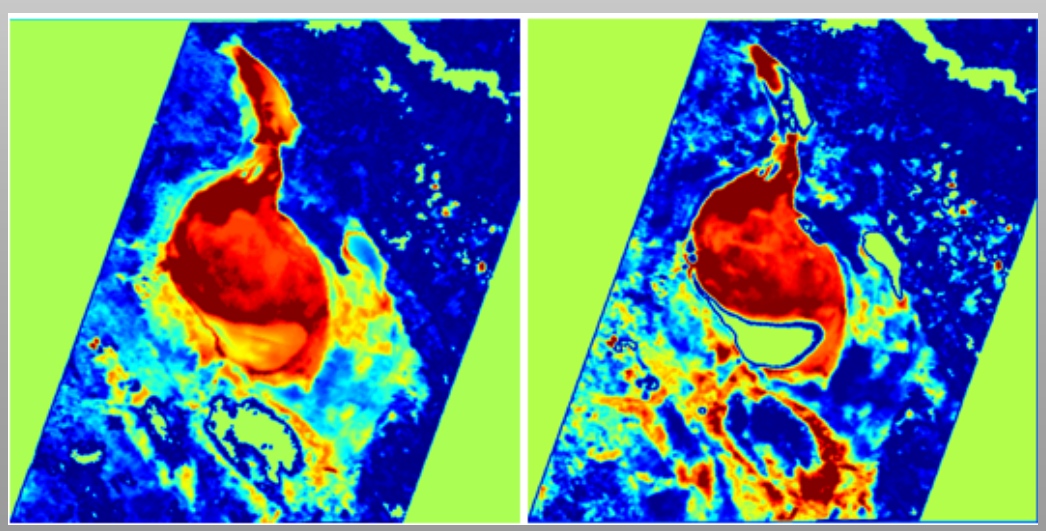
- Getis Ord

$$G_i^*(d) = \frac{\sum_j w_{ij}(d) x_j}{\sum_j x_j}$$



10.07.2006 MODIS kırmızı bant 10.07.2006 MODIS NIR bant

Düşük SD  Yüksek SD



Yakın olmayan değerler  Yakın değerler

- Moran's I

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

$w_{ij}(d)$ = Uzamsal ağırlık matrisi

x_j = j koordinat indeksli pikselin sayısal değeri

i = Hedef pikselin koordinat indeksi

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One Problem!

- Tarpaulins ?
- We are open to alternatives?

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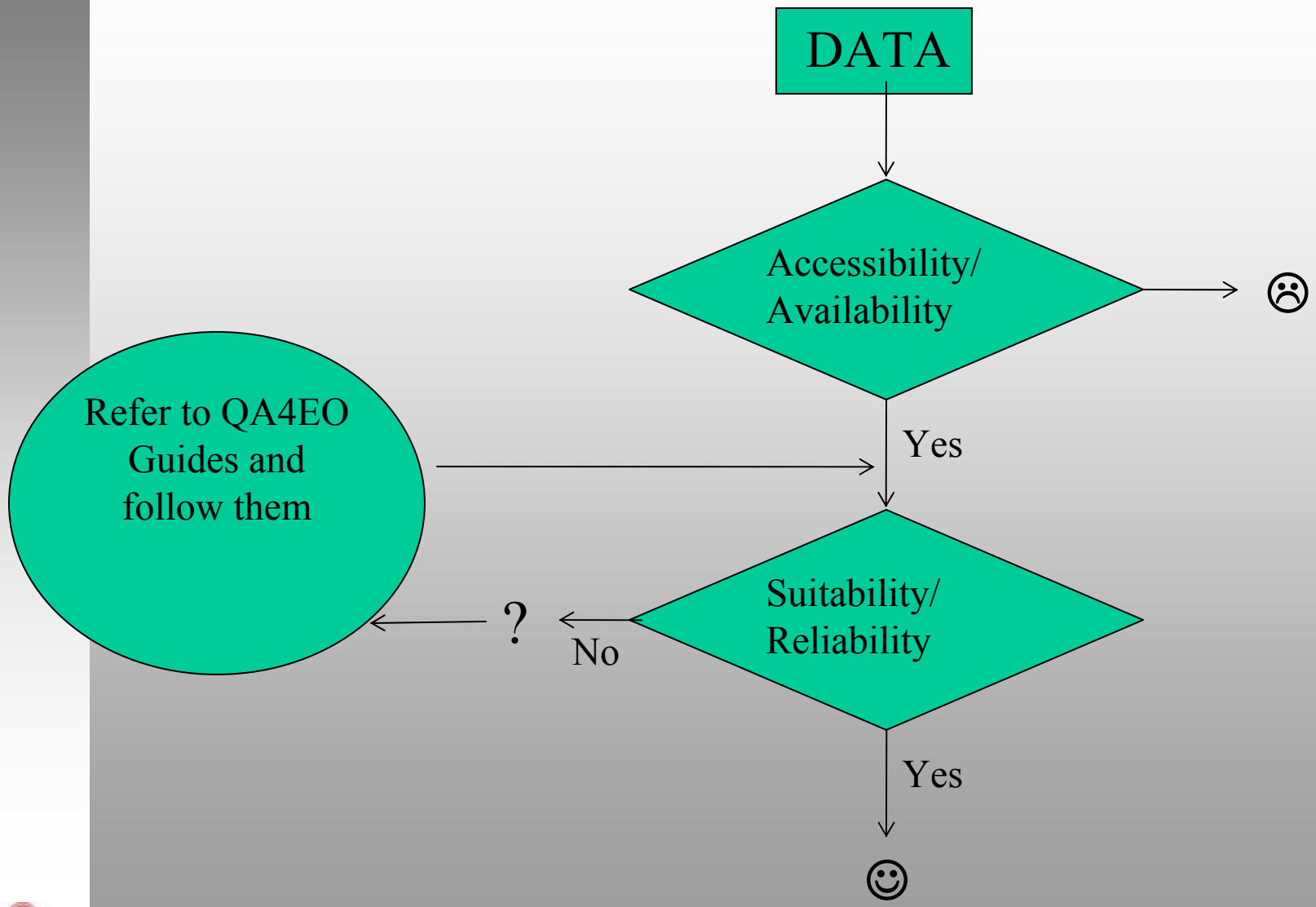
Conclusions



Achieve QA4EO strategy
Facilitate interoperability of GEO systems

TÜBİTAK UZAY