Recent developments in Lybia-4 spectral and directional characterization

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The original idea to use TOA simulated radiance over Libya-4 as an absolute calibration reference dated back to the early 2000s and is still in use since then at EUMETSAT
The × symbol is for ATSR-2, △ for SeaWiFS, + for VEGETATION and □ for MERIS.
Use of simulated reflectances over bright desert target as an absolute calibration reference

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This letter presents the improvements of an absolute calibration reference system based on simulated top-of-atmosphere bidirectional reflectance factor time series over bright desert targets. The current work highlights a case study performed over Committee on Earth Observation Satellites (CEOS) calibration target Libya4, demonstrating that it is possible to achieve a mean accuracy of 3% when simulation is compared with calibrated observations acquired by polar orbiting satellites.
LIBYA-4 : SPECTRAL SIMULATIONS

Latest improvements

Comparison of 3 RTMs in the VIS spectral range over Libya-4 wrt MODIS, MERIS, GOME-2 data;

6SV: RTE -> Successive Order of scattering. Widely used in the “land” community for atmospheric correction (HITRAN96)

RTMOM: RTE -> MOM (HITRAN96)

LibRadTranV2beta: RTE -> MC (REPTRAN, HITRAN 2004)
Comparison between RTM simulations and observations over Libya-4

**RED**: ~600 MODIS observations

**BLUE**: ~350 MERIS observations
Simulation of 350 MERIS DATA with:

RTMOM
SIXSV
LibRadTranV2
GOME-2 DATA

- Provided by EUMETSAT
- Extraction of one “pixel” centered over Libya-4
- SZA and VZA restricted to 0-30 degrees
- ~70 observations, band-3 and -4
Missing NO$_2$ absorption in RTMOM and SIXV (HITRAN96)
Missing $O_4$ absorption in RTMOM and SIXV (HITRAN96)
SIXSV includes polarization
RTMs agree within 1% where gas transmittance is close to 1.
Monte-Carlo effects in LibRadTran
LIBYA-4 : BRF SIMULATIONS

OBJECTIVE:
Analyze surface reflectance azimuthal dependencies due to sand dune organization for different regions-of-interest (ROIs) sizes using a 3D Monte Carlo ray-tracing RTM.

The global 30m digital elevation model (DEM) derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) observations has been used for this analysis.
Article

Sand Dune Ridge Alignment Effects on Surface BRF over the Libya-4 CEOS Calibration Site

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Libya-4 morphology

ASTER DEM over the Libya-4

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</table>
Libya-4 morphology

ASTER DEM over the 20km x 20 km ROI
Libya-4 morphology

Sand dune repose angle distribution

10 km
20 km
50 km
100 km
Libya-4 morphology

Sand dune azimuth angle distribution

- 10 km
- 20 km
- 50 km
- 100 km
Simulation performed with Raytran, a 3D ray-tracing Monte-Carlo radiative transfer model;

Surface topography represented with ASTER DEM;

Sand reflectance is assumed Lambertian (0.3), i.e., BRF effects are only due to the topography.
Example of nadir-looking Raytran surface reflectance simulation over the 100 km × 100 km ROI acquired with a 250 m pixel resolution CCD camera for a sand reflectance value of 0.3

SZA = 50°
SAA = 270°

The ROI size has limited impact on the mean reflectance value
Sand reflectance = 0.3
Comparison of morning and afternoon overpasses
Raytran surface reflectance simulation in the principal plane over the 20 × 20 km ROI for SZA = 50°.
Morning pass: solid line
Afternoon pass: dashed line
Surface reflectance relative difference in the principal plane between morning and afternoon overpasses.

ROI: 10 km  20 km  50 km  100 km
The new required RTM accuracy driven by vicarious calibration of Sentinel satellites better than 3% will necessitate the development of a new generation of RTM:

- Non flat earth;
- 3D effects of any complexity and scales;
- Accurate simulation over land surfaces, water bodies and atmospheric media;
- Full radiative coupling between these media;
- Polarization and IR emission;
- Moon.
CONCLUSIONS (1)

The major simulated TOA BRF differences between RTMs over Libya-4 are due to the way gas transmittance is handled;

In the 350nm – 500nm spectral interval, the exact contribution of polarization is yet to be estimated;
CONCLUSIONS (2)

- Analysis of the effects of sand dune ridge alignments and ROI size on surface BRF over CEOS PICS Libya-4;
- 3D scene construction relies on the 30-m resolution ASTER DEM;
- ROI size has a pretty limited impact on the mean BRF averaged over a large number of illumination and viewing conditions;
- 50 km ROI has the most homogeneous surface reflectance.
CONCLUSIONS (3)

- Relative difference of surface reflectance in the principal plane between morning and afternoon illumination can exceed 1%
- It is recommended to account for these effects when comparing these two illumination conditions with a required accuracy better than 3%
- Future works should include sand BRF for accurate TOA BRF simulations and would necessitate the development of a new generation of RTM.