

MODIS-Aqua Calibration as seen by Alternative

Statistical Methods over Natural Targets

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Introduction

Reminder for calibration approaches

Results :

- over Desert sites
- over Rayleigh
- over Sunglint
- trending analysis

• Synergic analysis

Further analysis and Conclusion



Introduction - What's behind "Calibration"

NC = A.MI

• Calibrate a sensor = estimate the A or $\triangle A$ coefficients

- NC = digits
- MI = Measured radiance
- CI = Estimated radiance = reference
- → any difference between MI and CI is assumed to be a calibration error on A
- → but can also be explained by :
 - existing errors on CI : i.e. the calibration method accuracy
 - +many contributors, other than A, could explain why MI is not predictable by CI
 - +general formulation for a radiometric model (sometimes very complex)





What's behind "Calibration"

• What appends in the instrument (MI) VERSUS What is assumed (CI)

- + error in dark current, straylight, non linearity : bias on A derived from bright/dark targets
- + error in polarisation : bias on A derived from polarized/unpolarized targets
- + error in the inter-pixel, or in FOV : bias on A derived from different geometries
- + error in the spectral response knowledge : bias on A derived from different targets

• Interest to combine multiple calibration targets 1.0

- from dark to very bright
 - in VIS, and/or NIR, and/or SWIR
- very different spectral shapes
 - + from Rayleigh (λ-4)
 - to white spectrum
 - to desert spectrum
- other characteristics
 - from polarized to unpolarized
 - from Lambertian to directional



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The CNES's Operational Arsenal





Reminder - Calibration Approaches

• Absolute calibration over Rayleigh (Hagolle et al., 1999, Fougnie et al., 2010)

- Rayleigh scattering predictable
- reference = Rayleigh scattering (~90% of TOA signal after selection)
- selected oceanic sites
- calibration of all geometries (exc. sunglint) for VISIBLE range
- Cross-calibration over desert (Lachérade et al., 2013)
 - Use of pseudo-invariant sites
 - reference = one sensor or one date
 - 20 desert sites
 - 2 main steps : geometrical matching (no simultaneity req.) + spectral interpolation
- Interband calibration over sunglint (Hagolle et al., 2004)
 - use of the "white" reflection of the sun over ocean reflective range
 - reference = one spectral band
 - selected oceanic sites
 - sunglint not predicted but estimated using one band









Reminder - Calibration Approaches

• Absolute calibration over Rayleigh (Hagolle et al., 1999, Fougnie et al., 2010)

- Rayleigh scattering predictable
- •re <u>Here MODIS</u>, but see also other applications :
 - Pleiades in Lachérade et al.

Cross

C

- SPOT6 in Gamet et al.
- PARASOL in Fougnie et al.

Interb

- u ...all in CALCON 2013
- reference = one spectral band
- selected oceanic sites
- sunglint not predicted but estimated using one band





nterpolation



→ All are statistical approaches



Cross-calibration over Desert sites

Cross-calibration with MERIS

- MERIS = good radiometric reference + rich spectral coverage (VISNIR)
- MODIS archive 2003-2011 :
 - Level-1 from Collection 5
 - saturation for OC bands
- Good accordance within 1%

Band	DESERT
412	0.999
443	0.998
469	1.008
488	1.001
531	
551	
555	0.999
645	0.984
667	
678	
748	
858	1.015
869	





Cross-calibration over Desert sites

Consistency of the cross-calibration with parameters

Band#1- 645nm 2002-2011





Calibration over Rayleigh Scattering

• Ratio observed / computed reflectances – absolute evaluation for VIS bands

- MODIS : all bands from 412 to 678nm
- Ievel-1 from Collection 6
- +consistency within 2%

bias for B1-645nm

+significant







Calibration over Sunglint

Ratio observed / computed – interband for the whole reflective spectral range
MODIS : all bands from 412 to 2130nm – using a reference band (645nm)
level-1 from Collection 6 – saturation for some OC bands
consistency within 2% but significant bias for B01-645nm





Validation of the trending

• Time series of Quarterly mean TOA reflectance



- Mean over desert sites = pseudo-invariant targets
- No significant trend detected seasonal variations due to geometry
- Interband perfectly stable within 1%



bands are arbitrarily shifted up/down for clarity



Validation of the trending

• Time series of Yearly ratio Measured to Predicted Radiances



- Yearly mean over calibration results
- No significant trend detected

Interband perfectly stable within 0.5%



bands are normalized to 1 for clarity





Comparison of results from all methods

- DESERT, RAYLEIGH
- Sunglint normalized by <443,469,555>
- OC Vicarious Cal = cal adjustment + residual atmospheric correction





Synergy

Comparison of results from all methods – Normalized results by <443,469,555>
DESERT, RAYLEIGH

- Sunglint normalized by <443,469,555>
- OC Vicarious Cal = cal adjustment + residual atmospheric correction (from SEADAS)
- Very good consistency for VIS bands
- Discrepancy for B1-645nm : DESERT known to be less accurate for B1 in this case
- Agreement for NIR band

Relevancy of OC Vic Cal

for "Land" bands







Polarization

• Preliminary analysis: impact of the polarization on Rayleigh calibration

- All results are averaged into 4°(VZA) bins
- Sunglint region 0°<VZA<30°</p>

+ Is the directional signature linked to the polarization sensitivity of the instrument ?

+ To be investigated ...



according Sun and Xiong, 2007



Conclusion

• Calibration of MODIS-Aqua has been implemented for :

- Rayleigh absolute calibration
- Sunglint interband calibration
- In addition to the existing cross-calibration over desert sites

• Synergic analysis :

- + generally, a good consistency is observed, mainly for VIS bands
- Iight biases identified for B1-645 and B2-858 Land bands
- + relevancy of OC Vicarious calibration for "Land" bands, B1 to B4 (645, 858, 469, 555), and for B8 (412)
- no residual temporal trending was detected

On-going investigation :

- + desert : compare to other sensors to confirm conclusion for B1 and B2 bands
- how the polarization sensitivity impacts Rayleigh scattering results



Thank you for your attention !

If you want more : Back up slides \rightarrow

CALCON'13

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Gaseous absorption

• Typical gaseous absorption :

	Tot	O 3	WV	02	CO2	CH4	NO2
412	1	1	1	1	1	1	1
443	0,997	0,997	1	1	1	1	1
469	0,993	0,993	1	1	1	1	1
488	0,984	0,984	1	1	1	1	1
555	0,924	0,924	1	1	1	1	1
645	0,918	0,940	0,978	0,998	1	1	1
858	0,975	1	0,975	1	1	1	1
1240	0,984	1	0,988	0,997	0,999	1	1
1640	0,980	1	0,996	1	0,983	0,988	1
2130	0,877	1	0,901	1	0,974	0,999	0,994