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Sensor to sensor cross-comparison uncertainty assessment techniques

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Introduction

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The evaluation of the uncertainty in cross-calibration by using techniques to fully propagate the error/uncertainty.

Two contributors as examples:

- Spectral response uncertainty
- AOT effect

Spectral response effect

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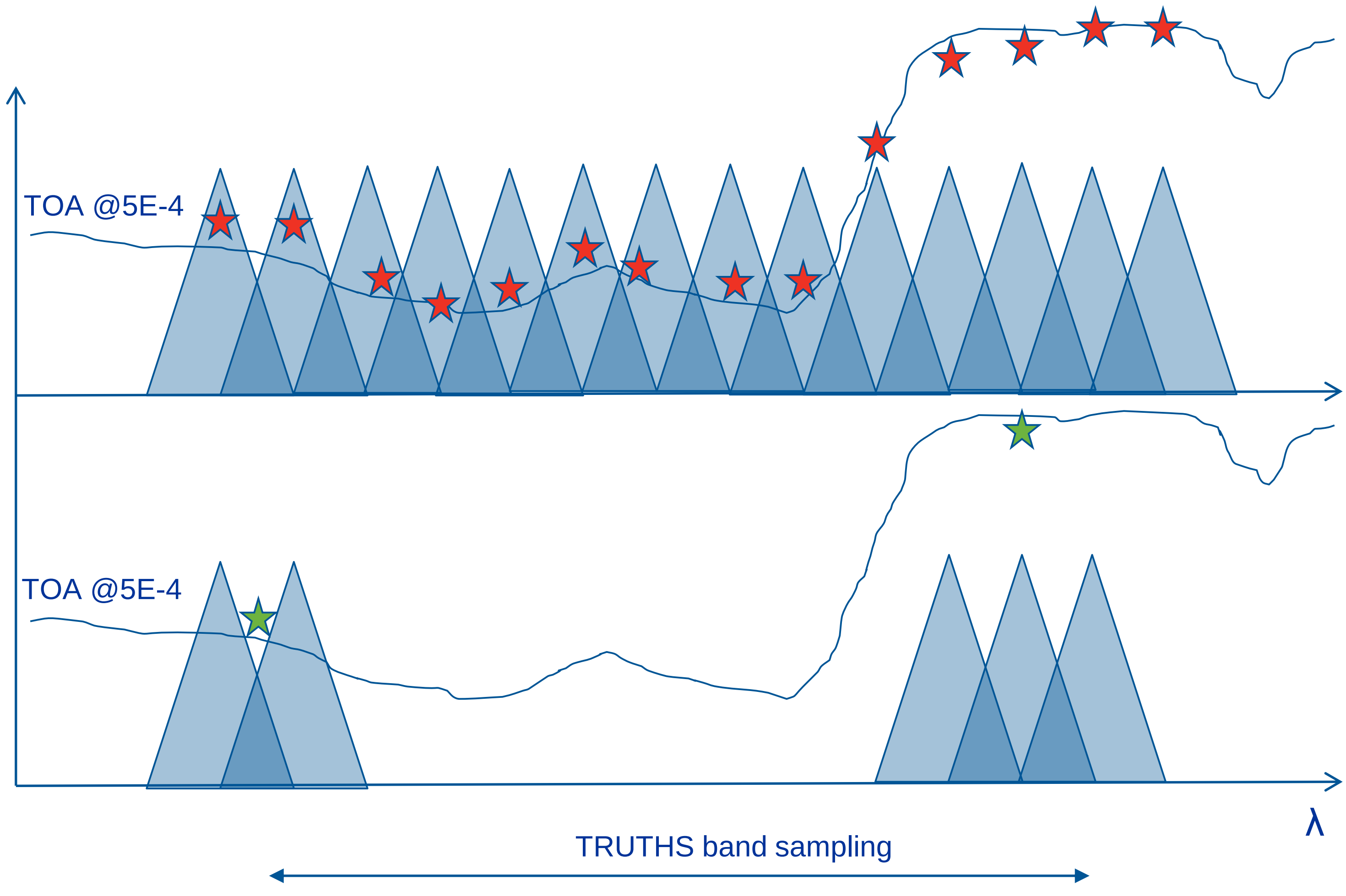
1. TRUTHS spectral response triangular shape:

   design has a low aberration and the slit width and the pixel width match

2. SRF is then convolved with the TOA reflectance of a selected site (★)→ here I used DIMITRI Libya-4 resampled at 0.0005 nm
3. This is further binned to estimate the TOA measurement of the TRUTHS bands (★).
   - Binning based on design to achieve specified SNR
   - TRUTHS bands (binned) specified at a sampling distance (here 5nm)
4. The measurements of the TRUTHS bands are interpolated at the same sampling as the TOA scene (0.0005 nm) to reconstruct the full TOA response.

Spectral response effect

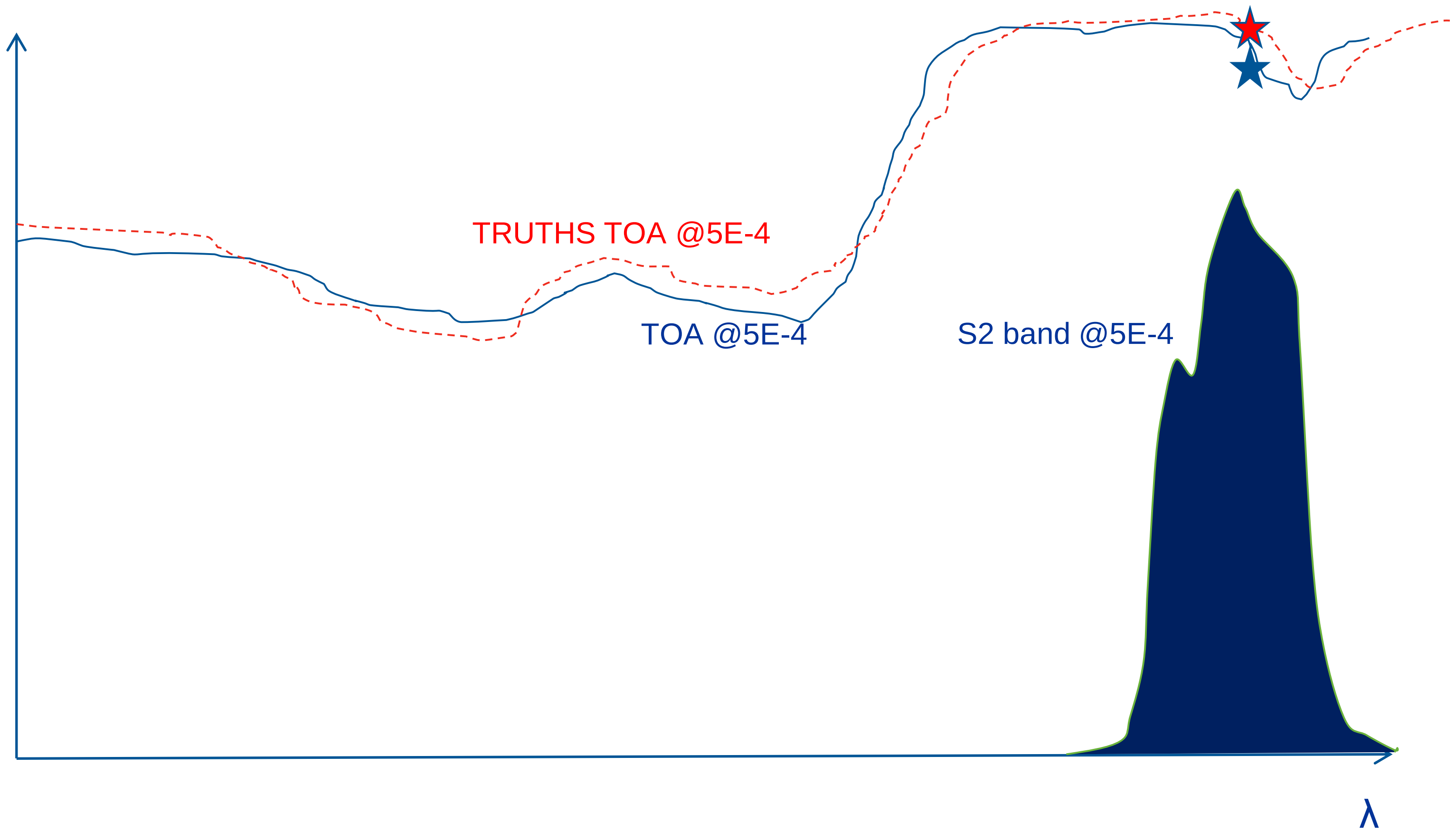


Spectral response effect

- Two effects to study:
  Sampling/resolution
  Spectral response knowledge

- The first effect (sampling/resolution of the TRUTHS bands) is studied by
  1. convolving the target instrument response with the TOA reference reflectance and
  2. convolving the target instrument response with the TOA reflectance reconstructed from TRUTHS (★)
  3. then comparing them (bias/ systematic error).

Spectral response effect



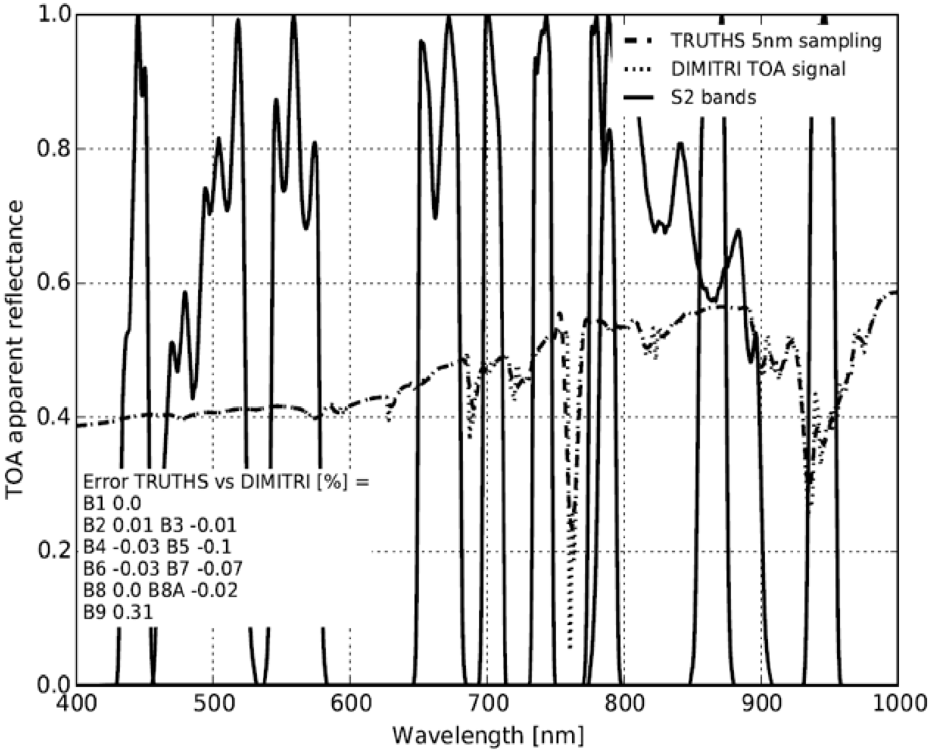
Spectral response effect

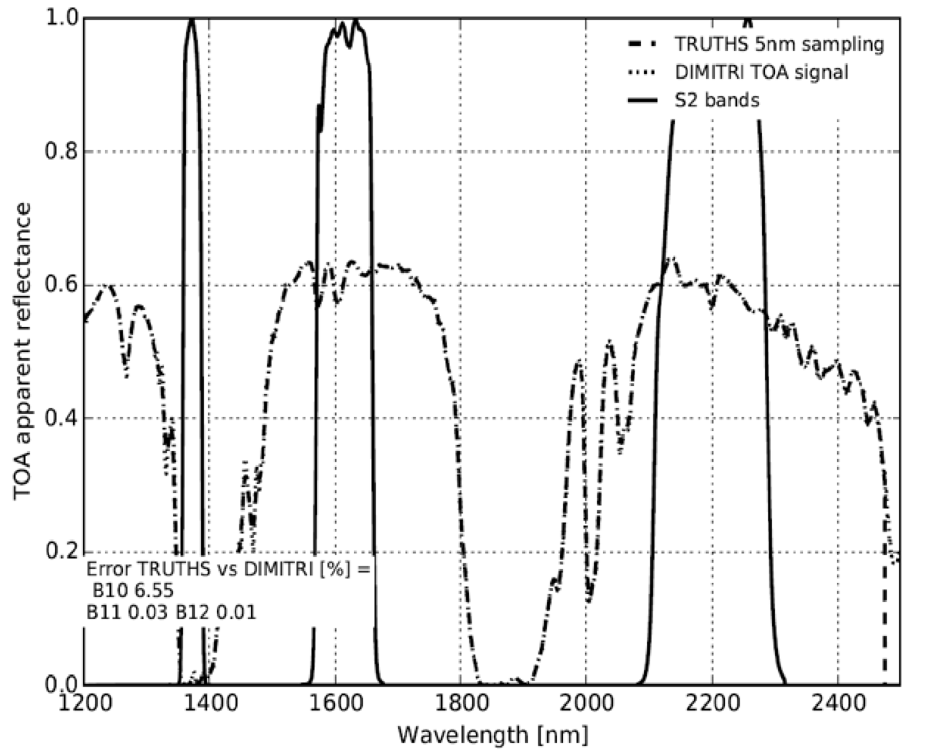
Convolution of Sentinel 2 Multi-Spectral Imager (MSI) bands difference between:

- Libya-4 TOA reflectance reference and
- TRUTHS simulation with 5 nm sampling bands

Differences (biases/errors) produced are below 0.1 %.

Band 9 and 10 are detection bands (water vapour absorption)





Spectral response effect

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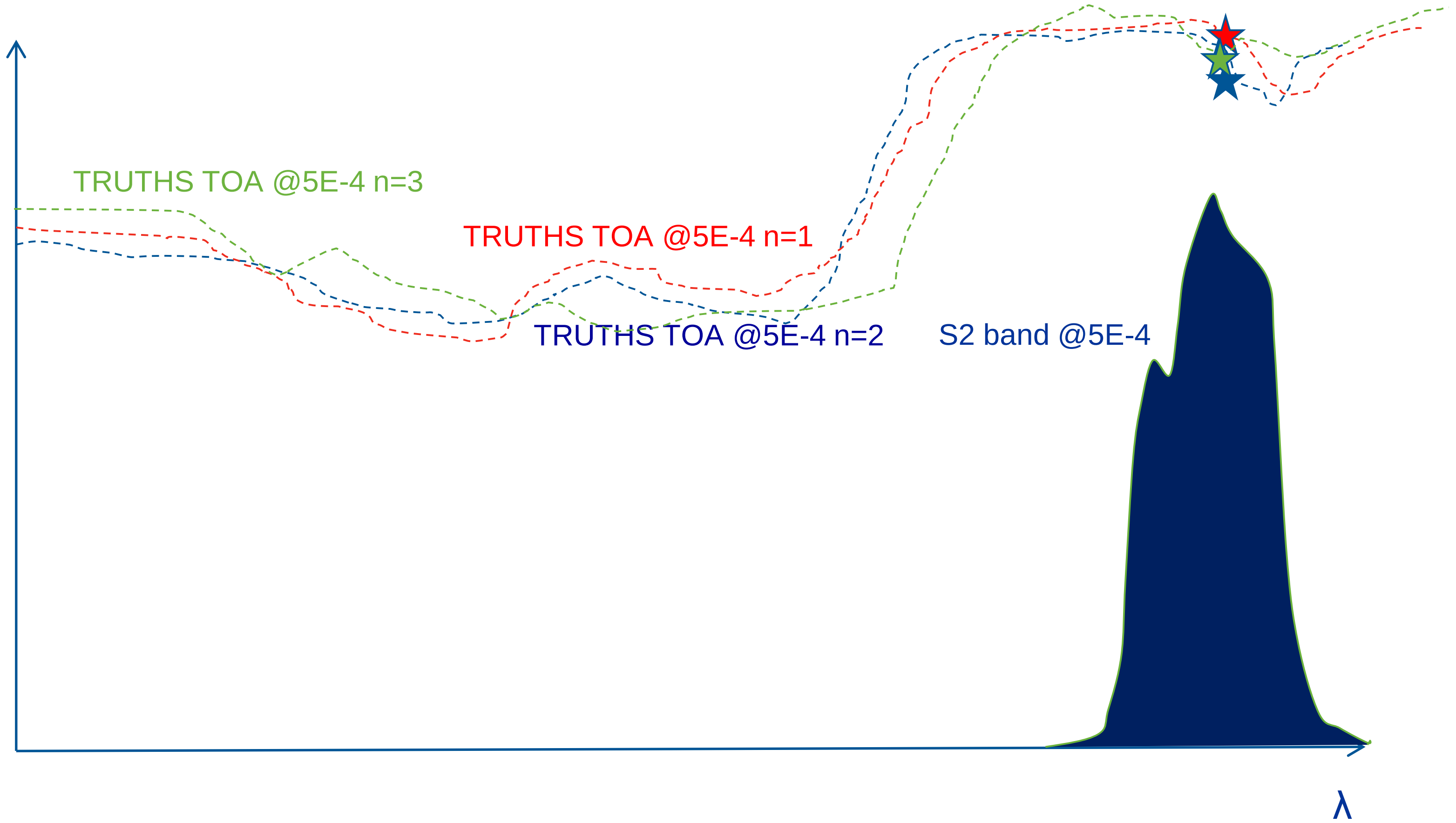
- The second effect is studied
  1. by reconstructing the TOA reflectance spectrum n times (dashed lines of colours)
  2. and convolving it with a Sentinel 2 band (parallel processing) (★★★).
- The central wavelength and bandwidth are modelled as a normal distribution. This, results in a dispersion of TOA reflectance values for the Sentinel 2 band convolution.

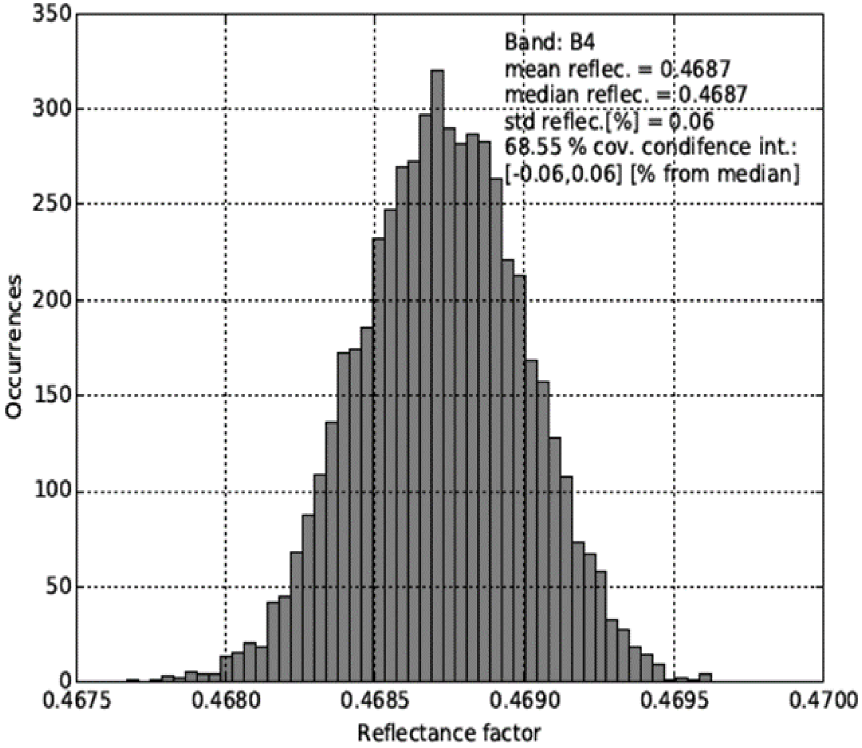
- This needs the use of parallel processing (JASMIN): each iteration takes 5 minutes.
- The modelling of the spectral changes is preliminary (more in next steps)

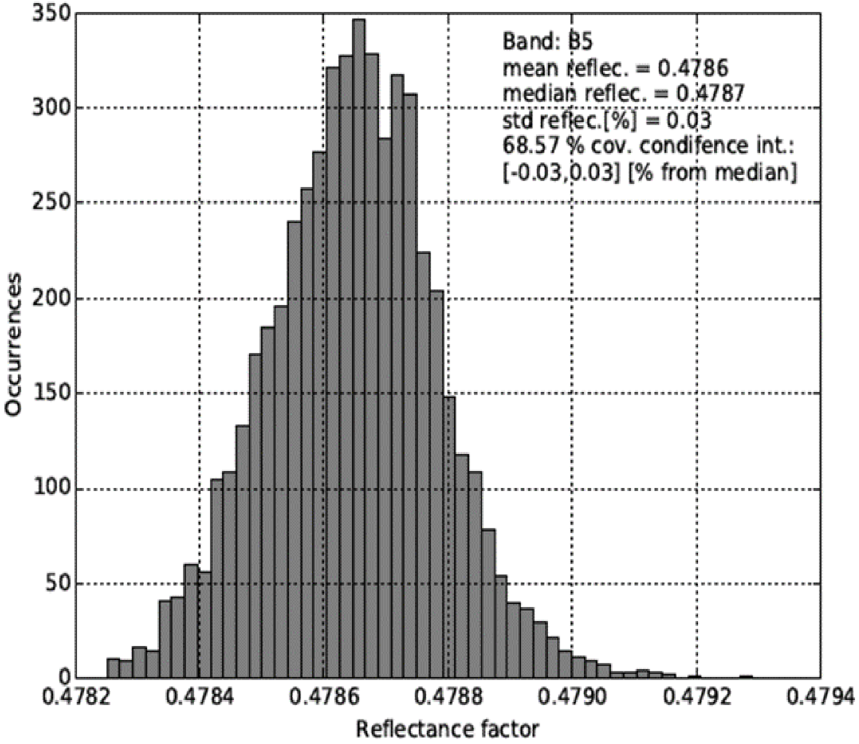
Spectral response effect



Spectral response effect

- For the Sentinel 2 band 4 and 5 over Libya-4 with an associated central wavelength and bandwidth knowledge uncertainty of 0.2 nm (k=1), the result shows an effect below 0.1 % (k=1) in the TOA reflectance spectrum





Aerosol effect

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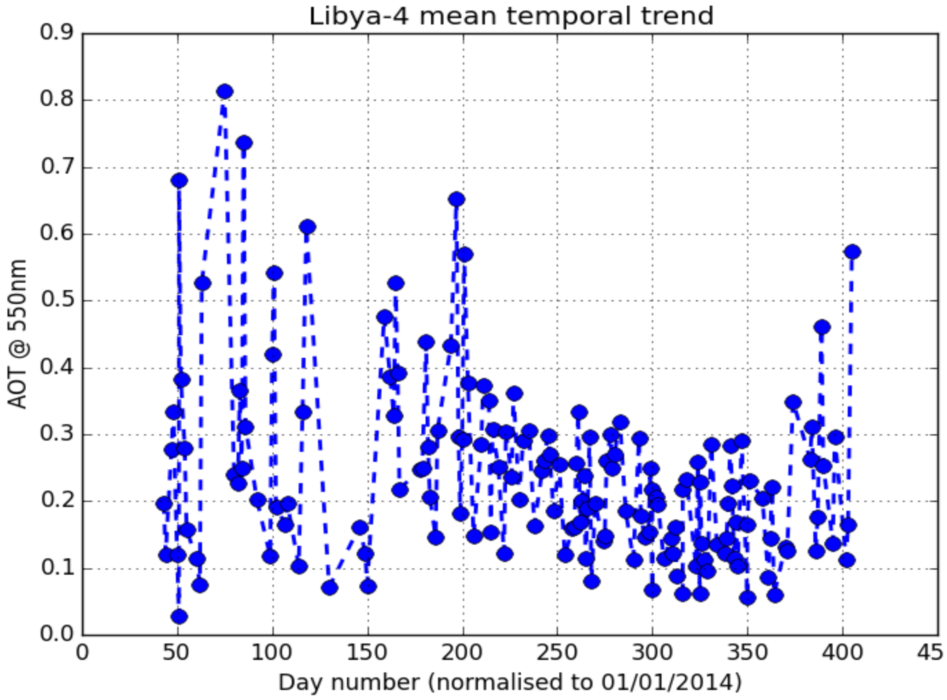
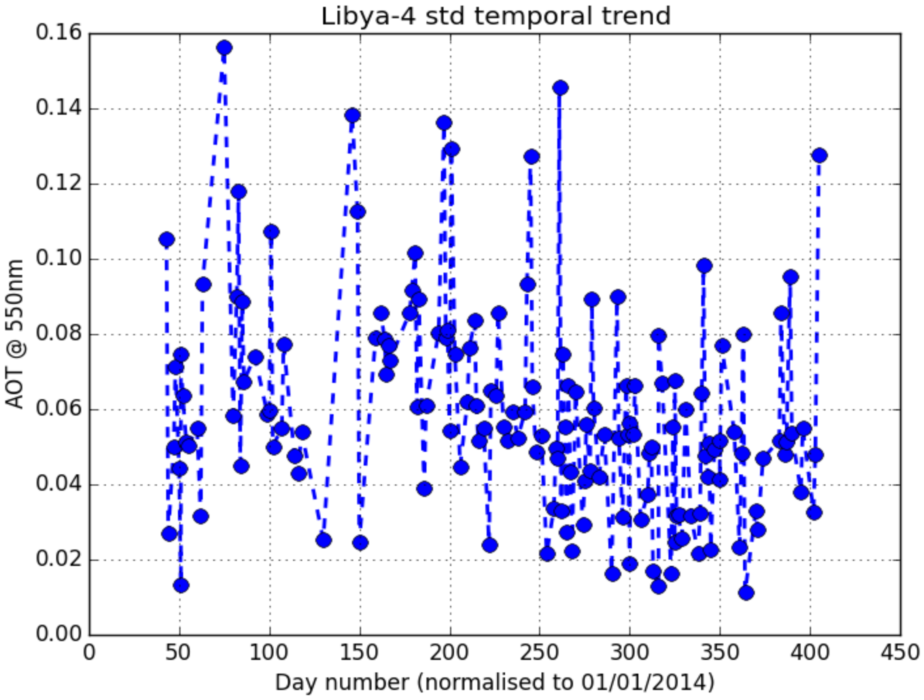
- The impact of Aerosol Optical Thickness (AOT) can be approximated by the short-term variations of aerosols in the spatial variations of neighbourhood pixels. This is justified by considering transportation of aerosol particles by the wind → Spatial variations = short temporal variations

- This effect has been studied by processing DATA: MODIS Deep Blue Aerosol Optical Depth 550 Land 10 km resolution.
- Libya-4 site and 4ºx4º latitude and longitude, for a period of one year (2014).
- Selected ROI of 100x100 km (100 pixels) of 'Deep Blue Aerosol Optical Depth 550 Land' with best confidence flag (QA=3).
- Repeated for each image and discarded if 1)<90 valid pixels(QA=3) 2) the mean is higher than 1 (dust storm).
- The resulting AOT distribution is propagated to the TOA reflectance by using the 6SV1 code and RPV surface model. The sun angles are calculated from the time-stamping of the product.

Aerosol effect

- Evolution of the mean (left), and standard deviation (right) of the AOT at 550nm using MODIS L2 AOT deep blue products over Libya-4 100x100km area for the period from 12-02-2014 to 09-02-2015.





Aerosol effect

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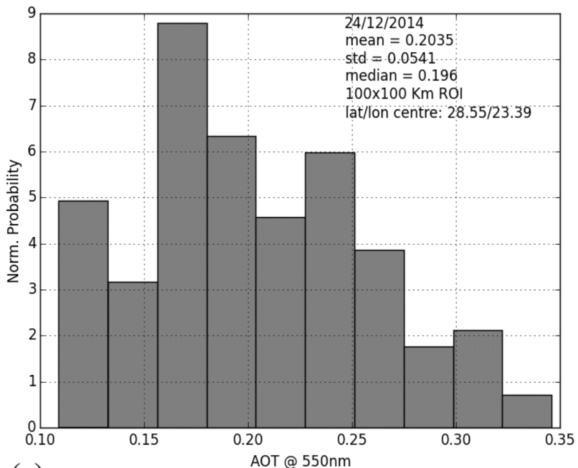
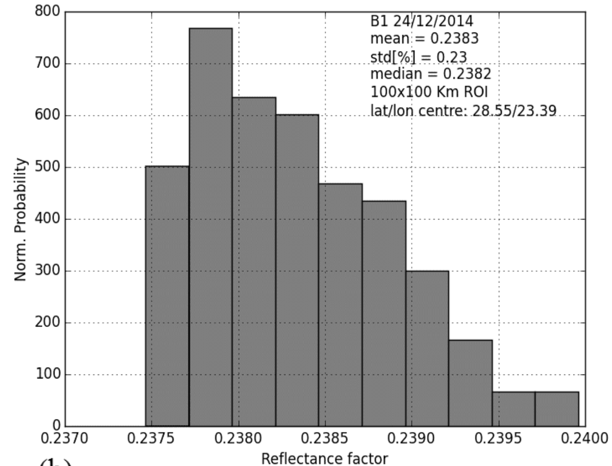
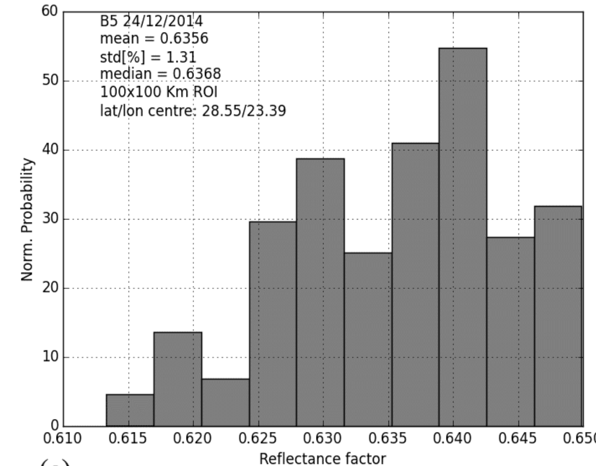


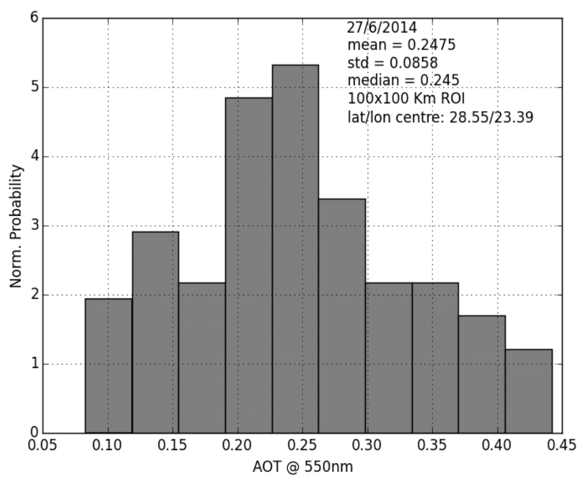
(a)



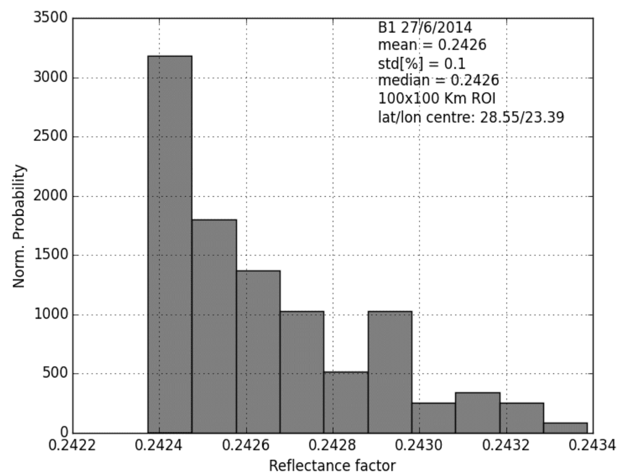
(b)



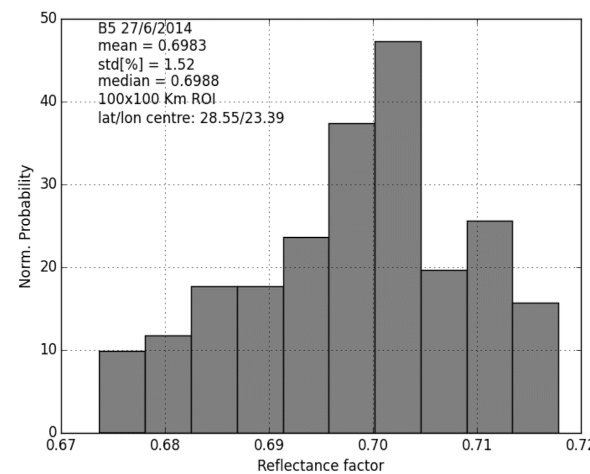
(c)



(d)



(e)



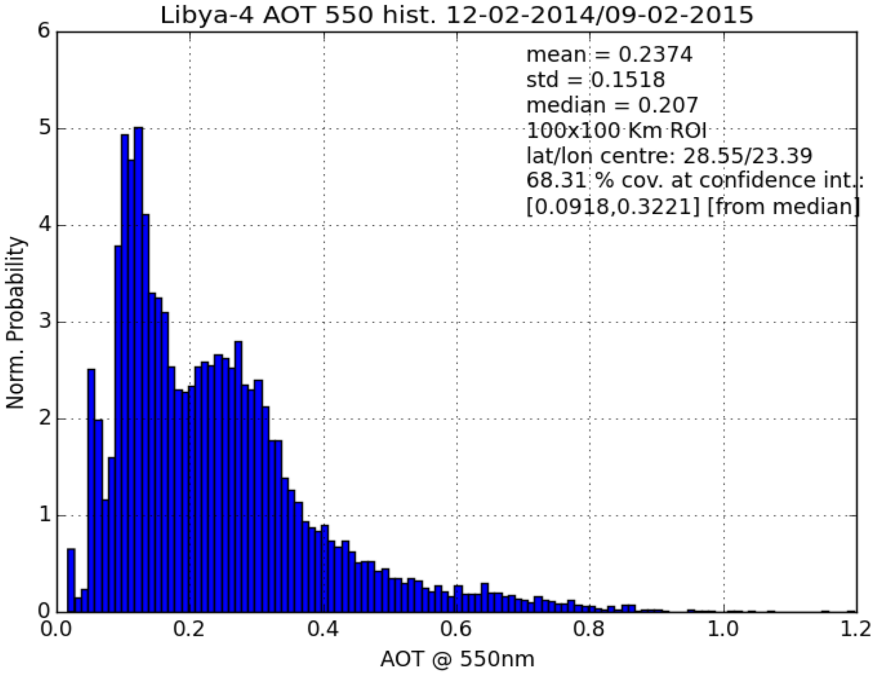
(f)

Aerosol effect

- The “real” impact is indeed lower:

  Typical ROI 50km→ std of the mean reduction factor 5 (if fully uncorrelated)

  L2 aerosol product uses several aerosol micro-physical models (4 at least visible in the figure). Similarly to [Govaerts,2010], a fix aerosol class at each ROI acquisition would be beneficial→



  The mode is the best estimate of the year attending at the distribution and SMACAA ~0.11 [Mishra, 2014]

Conclusions

- There is the possibility to fully propagate the uncertainty contributions in a cross-calibration!

- Possibilities of refinement in next steps:

1. Spectral response: model correctly the systematic/random contributions and its change across the spectral range.
2. Aerosol: reprocess the data for the specific site. Sort of PIC AOT products with spatial resolution.