Systematic Long Term Intercomparison of SCIAMACHY and MERIS radiances on global scale and over ground sites

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EOP/GMQ
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Outline

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2. Dataset and Algorithm Overview
3. Target Selection Criteria
4. 1st processing with no Correction for M-Factors (Sciamachy)
5. 2nd processing scenario (M-Factors Applied)
6. Results over global scale
7. 3rd processing scenario: Results for Libya 4 Pseudo Invariant Site
8. 4th processing scenario: Processing of SCIA V8
9. Conclusions

Objectives and Challenges

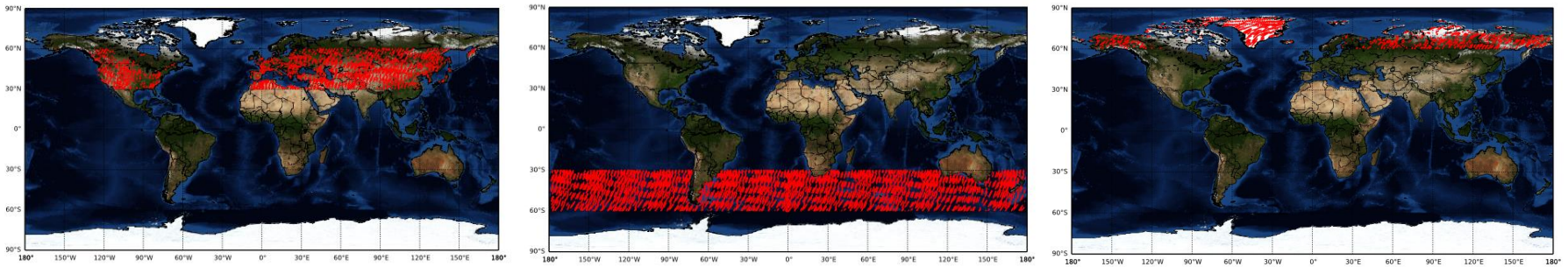
1. Extraction of SCIAMACHY spectra over Test Sites (in support to CEOS WGCV)
2. Intercomparison of MERIS and SCIAMACHY (long term)
3. Development of SNO technique to be applied to future/current missions
4. Intercomparison of MERIS and SCIAMACHY over test sites (e.g. Libya4)
5. Quantification of differences and trends

Some challenges:

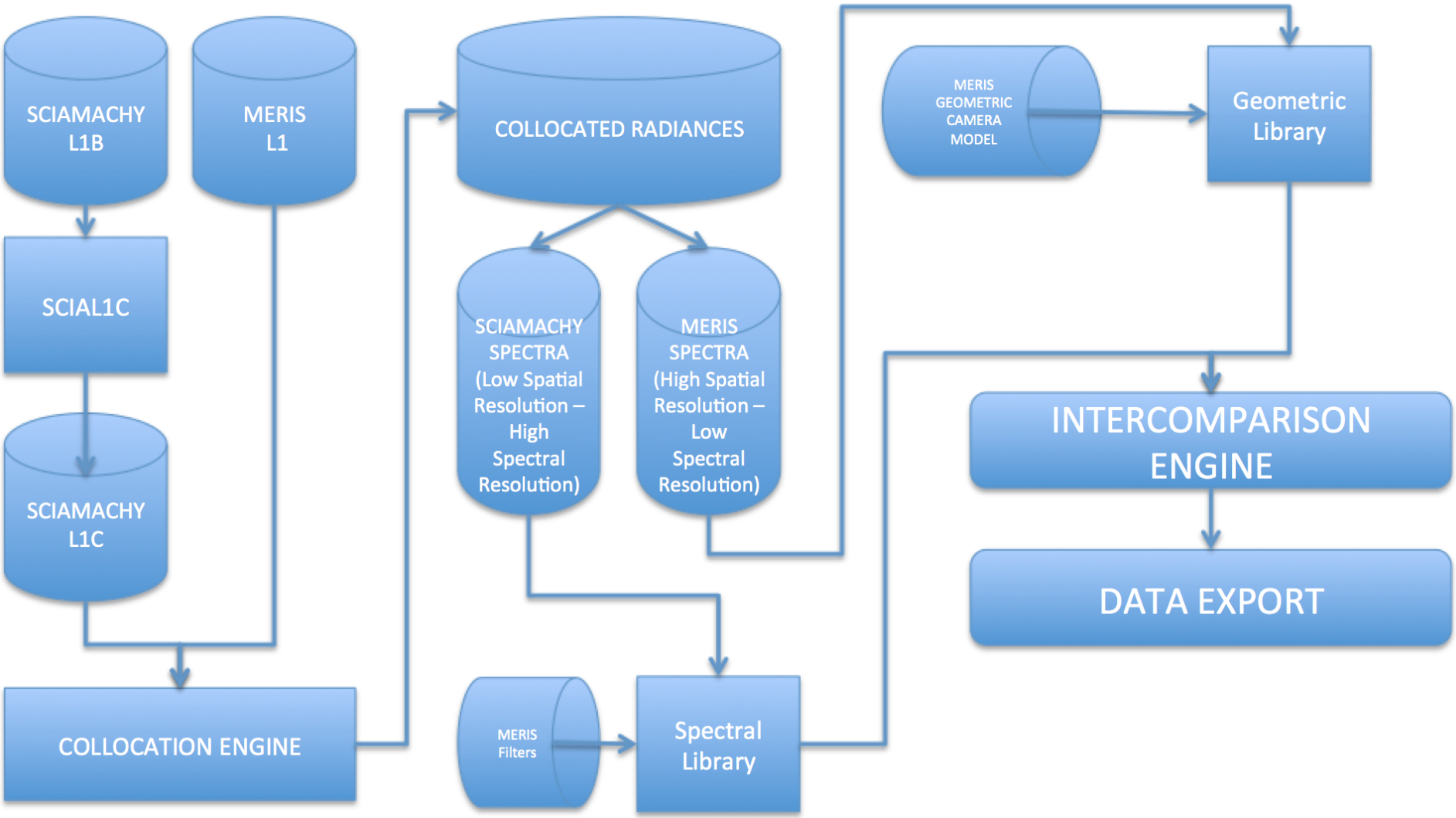
- Access to data (Very Large Dataset)
- Different "logic" organisation of data – how to handle them? (SCIAMACHY is "spectrally" oriented and organized, MERIS is image oriented)
- Calibration and understanding of SCIAMACHY is not trivial
- Some processing issues have to be addressed (parallelization?)
- No external information: let's try to understand what's in the data

Dataset and Scenarios

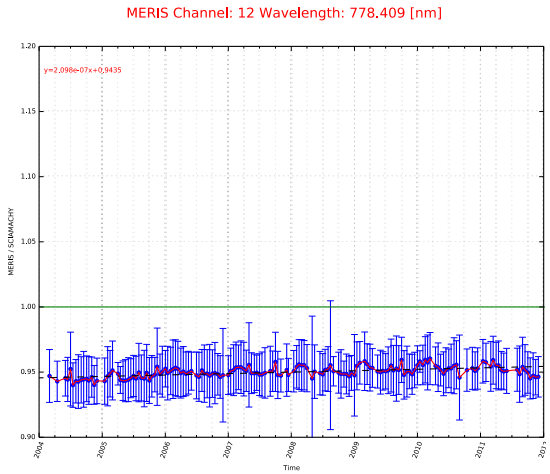
1. Dataset:
    a. SCIAMACHY V7.04 (L1B) (radiance and reflectance)
    b. SCIAMACHY V8.0X (L1B) (radiance)
    c. MERIS MEGS-PC 8.0 (L1) (radiance and reflectance)
    d. 1st and 15th of each month, from 2003 to 2012 (> 3000 orbits)
    e. Output in Netcdf (CF convention where possible), so results can be easily shared and processed
2. Processing on Target Area (Tunable by Land/Water/Mixed Mask or by Region of Interest)
3. Spectral Library handles general spectra
4. Sensors are modeled by "Filter Functions" (config file) and Camera



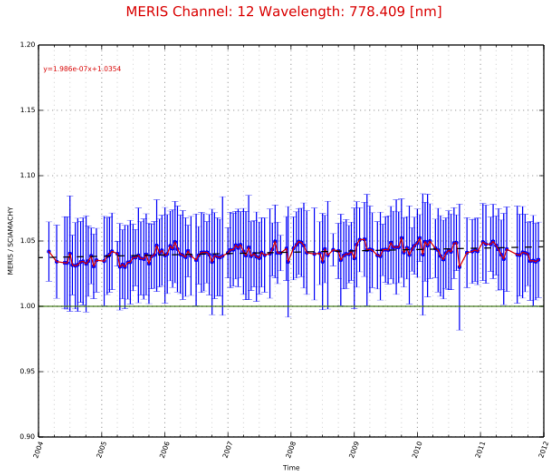
Processing Flow



Some considerations on Radiance/ Reflectance and Geometric and Spectral organization



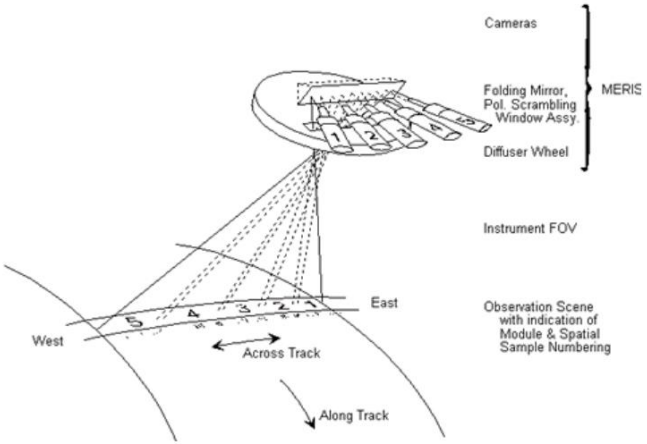
Radiance

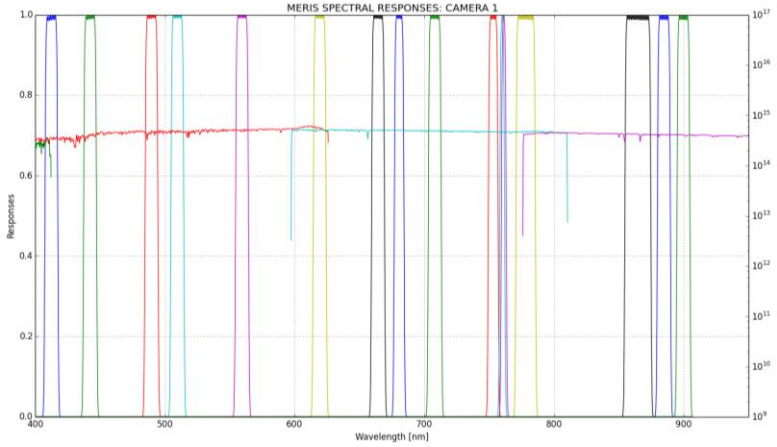


Reflectance

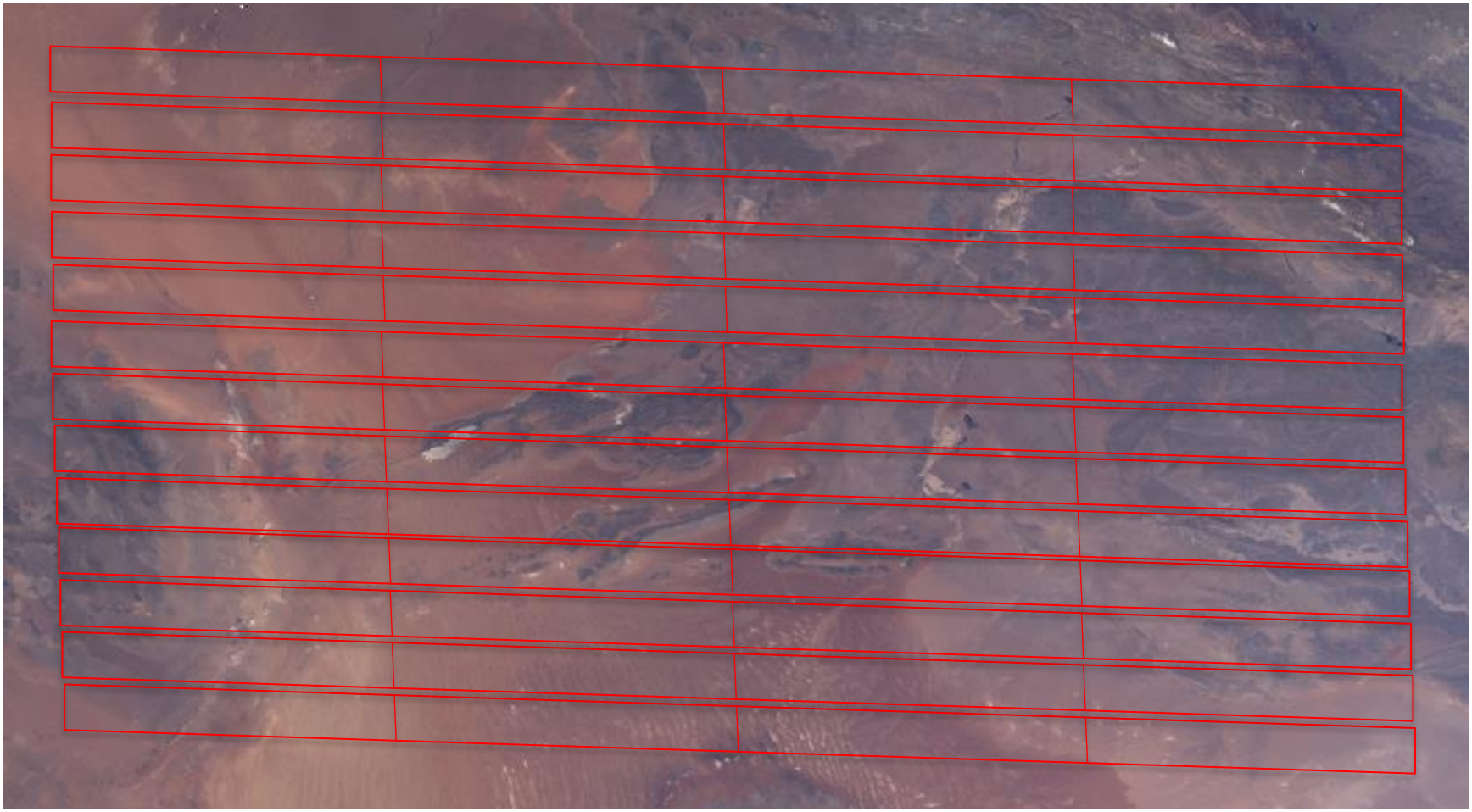
The tool can handle radiance / reflectance intercomparison, extraction of Solar Flux. This helped to highlight sostantial differences between the radiance and reflectance.

MERIS is made of 5 identical cameras: each camera has its own spectral filters. The algorithm model the geometric and spectral organisation of the cameras. Each SCIAMACHY observation is convoluted with the actual MERIS Spectral Function, depending on position within the swath



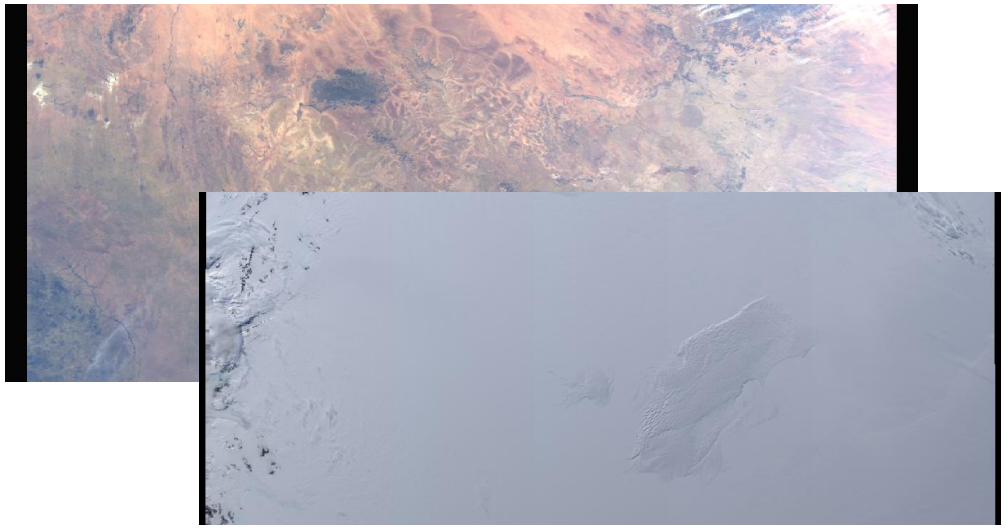


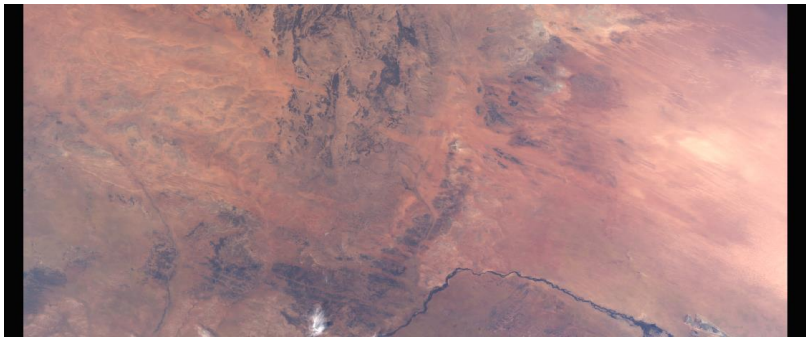
MERIS Target with SCIAMACHY Footprint overlay

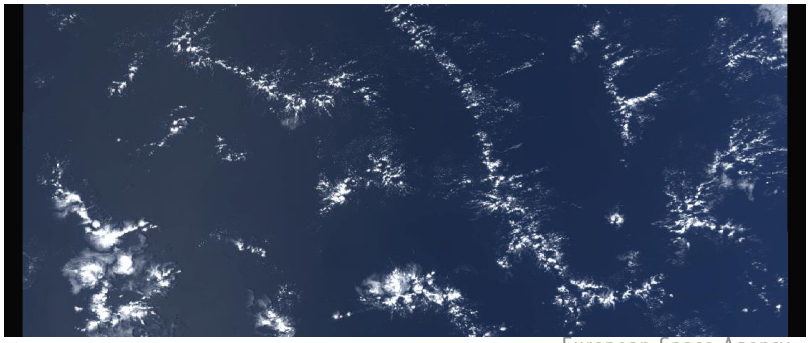


Selection Criteria 1/2

1. Matches have been selected under the following criteria:
    a. Solar Zenith Angle < 70
    b. High Spatial Homogeneity. (Relative STD <10%. MERIS radiances contained into a SCIAMACHY pixel)

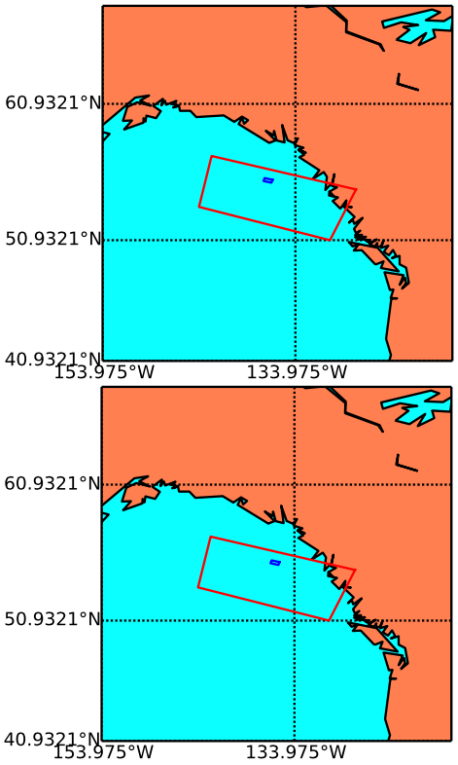


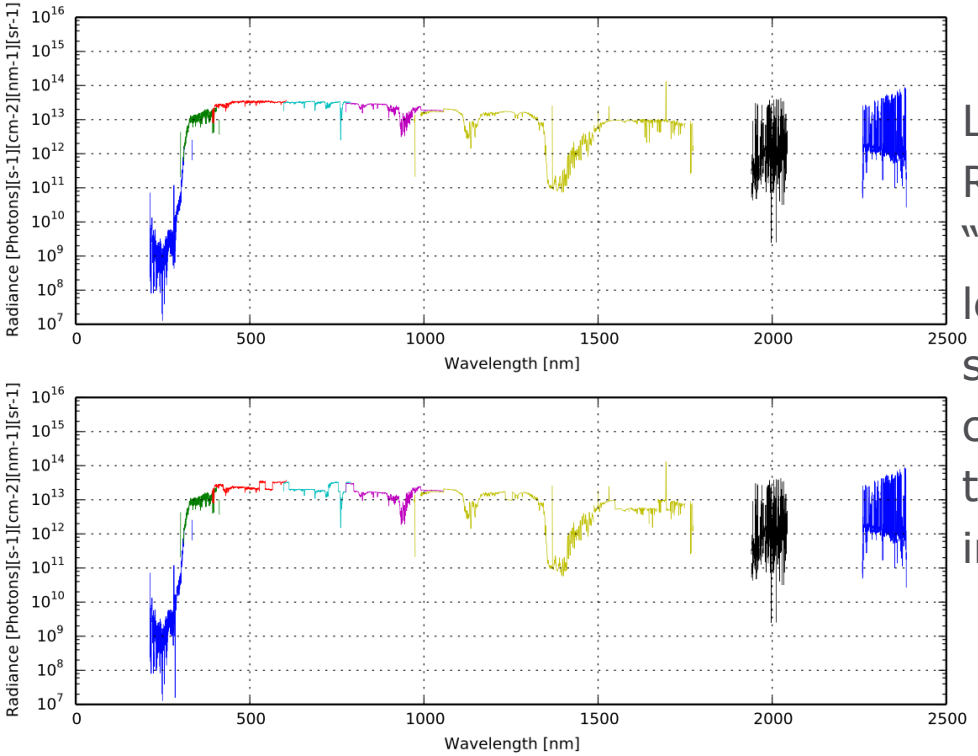




Selection Criteria 2/2

1. High Spatial resolution (lowest Integration Time) leads to “discontinuous” spectra due to different integration time for each cluster. The figure shows two adjacent observation over the ocean at high resolution: “jumps” within the spectra can be noticed.

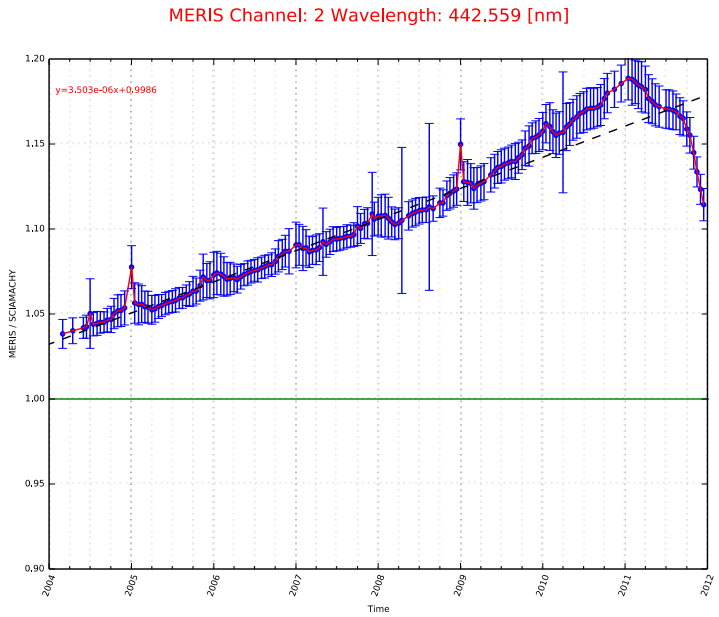




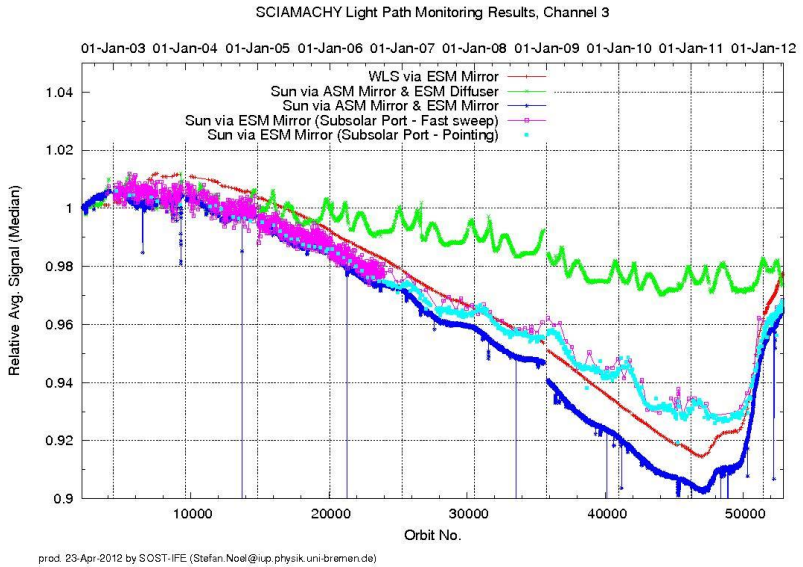
Low Spatial Resolution and “flat” spectra lead to the selection of clean random targets for the intercomparison

Full Time Series Analysis (2004-2012)

Result for band 2



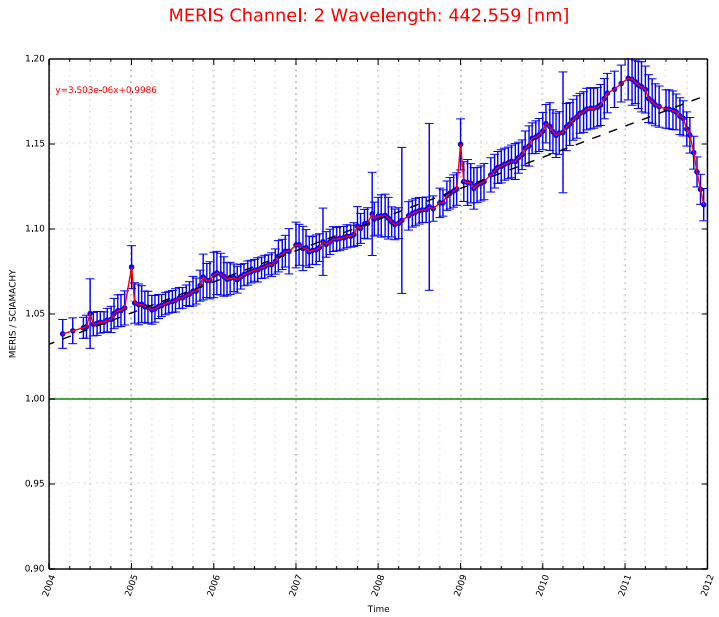
SCIAMACHY Light Path Monitoring (Univ. of Bremen)



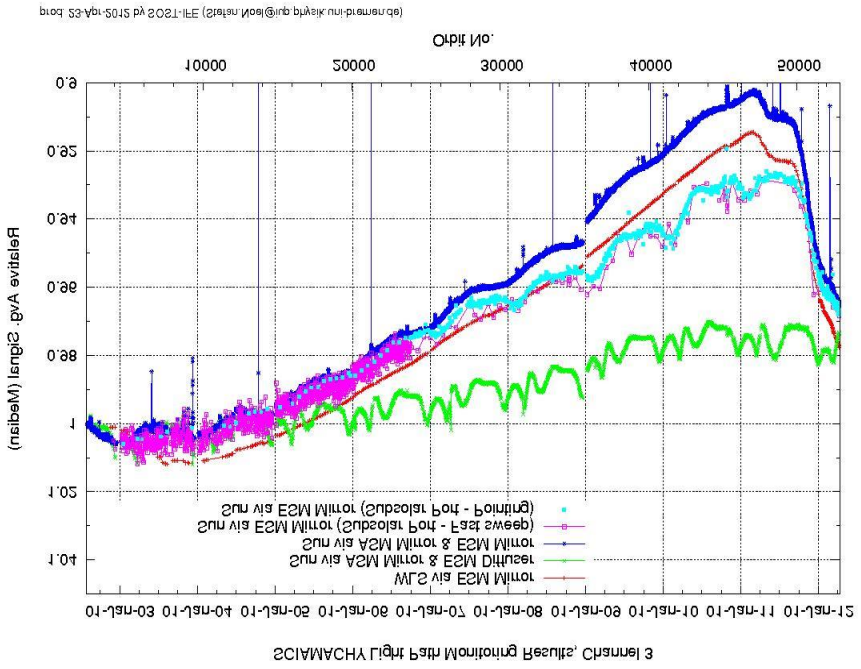
http://www.iup.uni-bremen.de/sciamachy/LTM/LTM.html

Full Time Series Analysis (2004-2012)

Impetus Result for band 2



SCIAMACHY Light Path Monitoring (Univ. of Bremen) FLIPPED



What does it happen if M-Factors are applied?

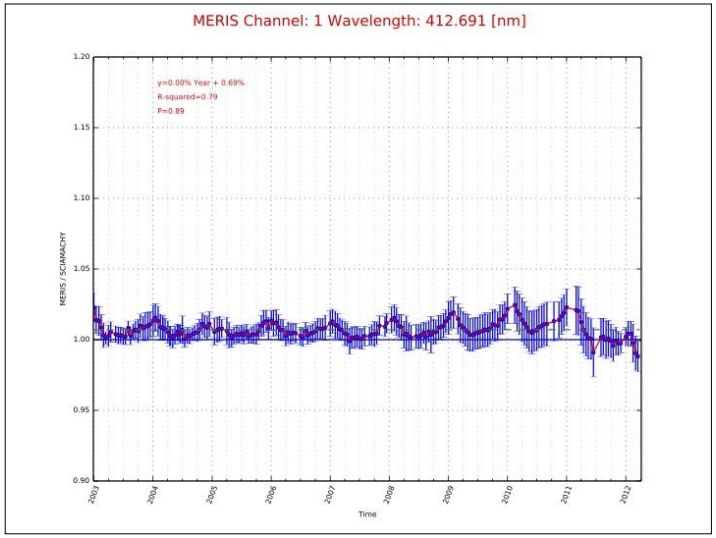
Results with no M-Factor Correction (2004-2012)

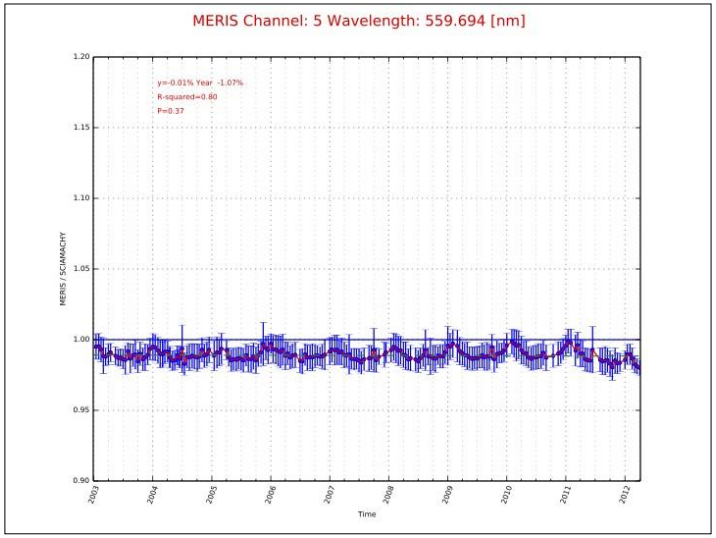
		Trend/Year	Bias
Detector 3	Band 1	2.26%	0.06%
	Band 2	1.82%	3.12%
	Band 3	1.15%	1.28%
	Band 4	1.11%	3.87%
	Band 5	0.92%	1.16%
Detector 4	Band 6	0.45%	-0.37%
	Band 7	0.42%	-0.36%
	Band 8	0.40%	-0.48%
	Band 9	0.42%	1.08%
	Band 10	0.37%	1.18%
	Band 12	0.55%	-4.72%
Detector 5	Band 13	0.36%	0.62%
	Band 14	0.35%	0.69%
	Band 15	0.34%	-0.23%

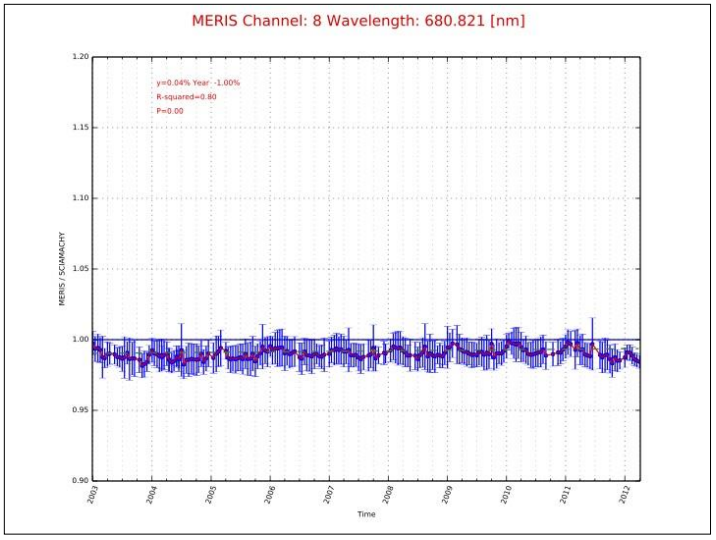
Results M-Factor Correction (2003-2012)

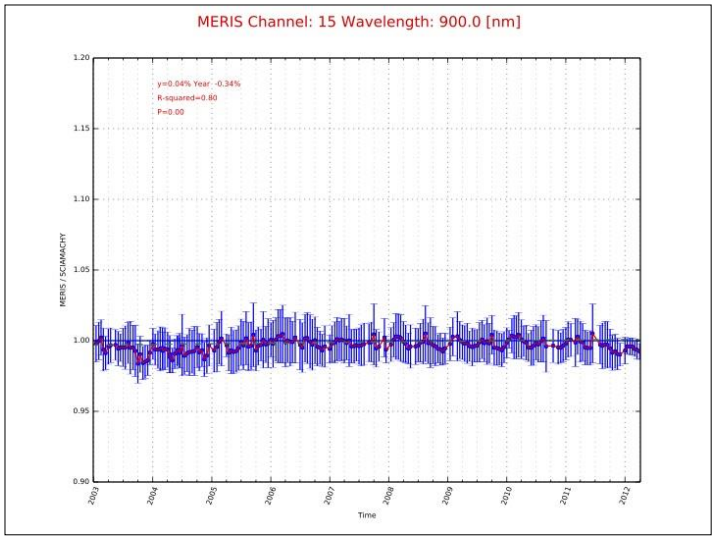
		Trend/Year	Bias
Detector 3	Band 1	0.01%	0.69%
	Band 2	0.03%	3.63%
	Band 3	0.03%	3.49%
	Band 4	0.03%	1.60%
	Band 5	0.01%	-1.07%
Detector 4	Band 6	0.02%	-0.31%
	Band 7	0.03%	-0.40%
	Band 8	0.04%	-1.00%
	Band 9	0.06%	1.51%
	Band 10	0.08%	1.22%
	Band 12	0.12%	-5.01%
Detector 5	Band 13	0.09%	1.06%
	Band 14	0.08%	0.65%
	Band 15	0.04%	-0.34%

Results M-Factor Correction (2003-2012) – Some Plots



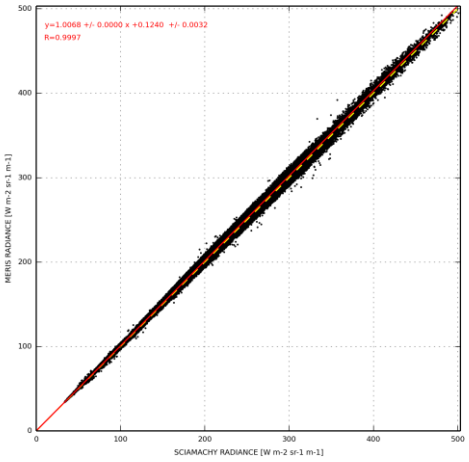




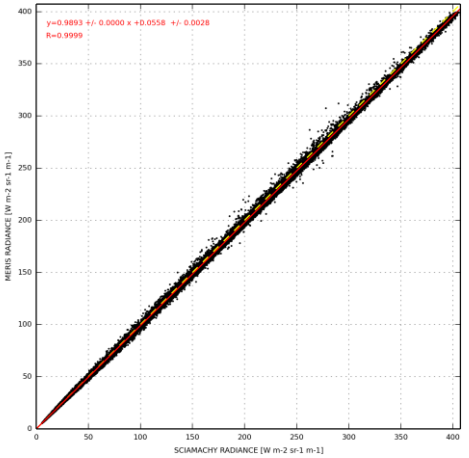


Scatter Plots over Global Scale

MERIS Channel: 1 Wavelength: 412.691 [nm]

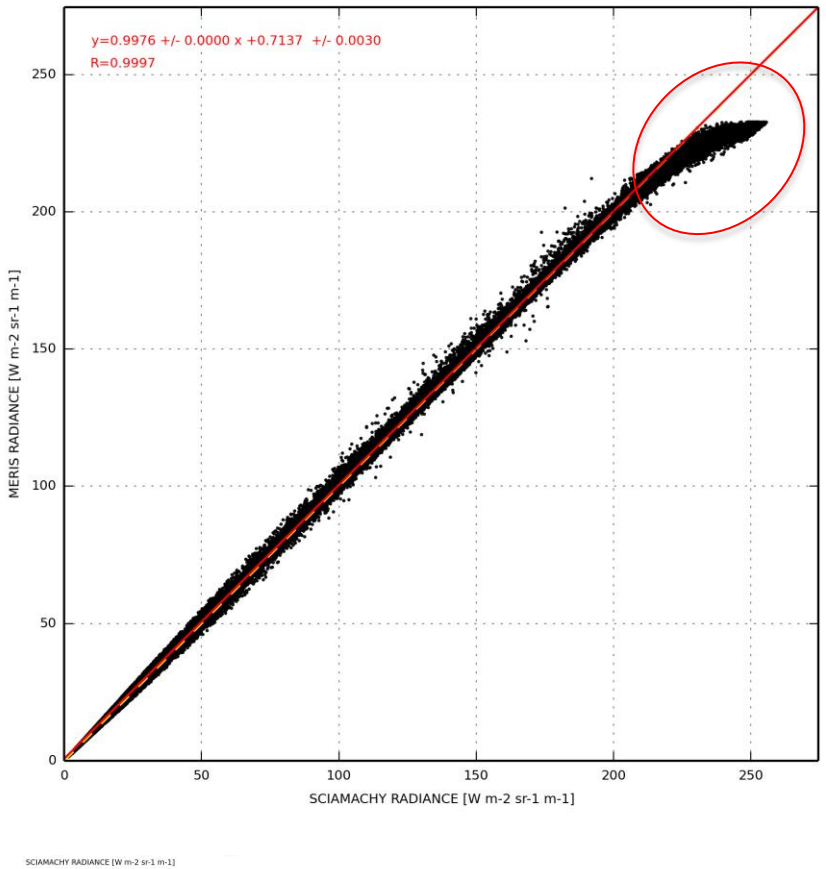


MERIS Channel: 8 Wavelength: 680.821 [nm]

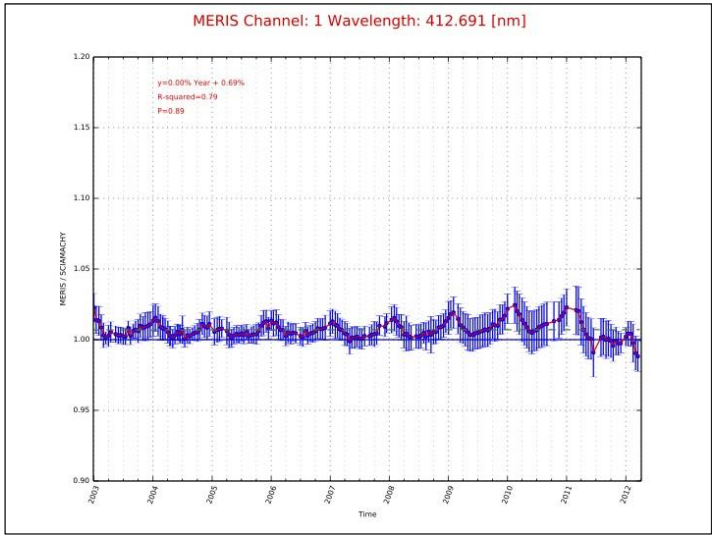


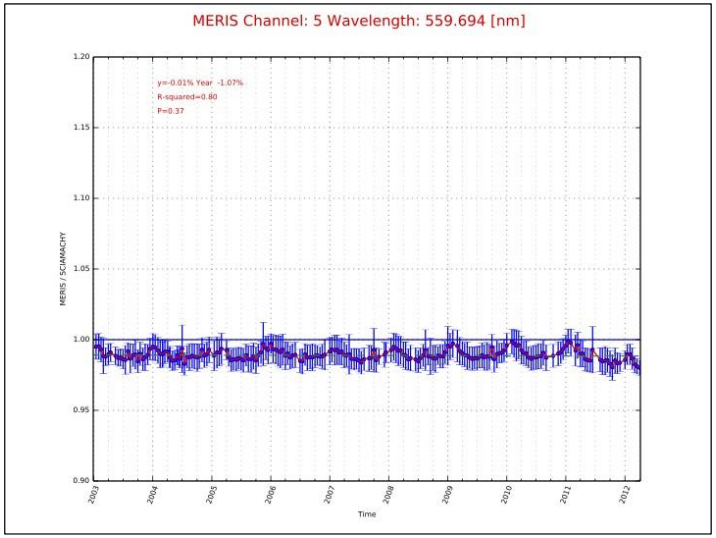
MERIS Channel: 5 Wavelength: 559.694 [nm]

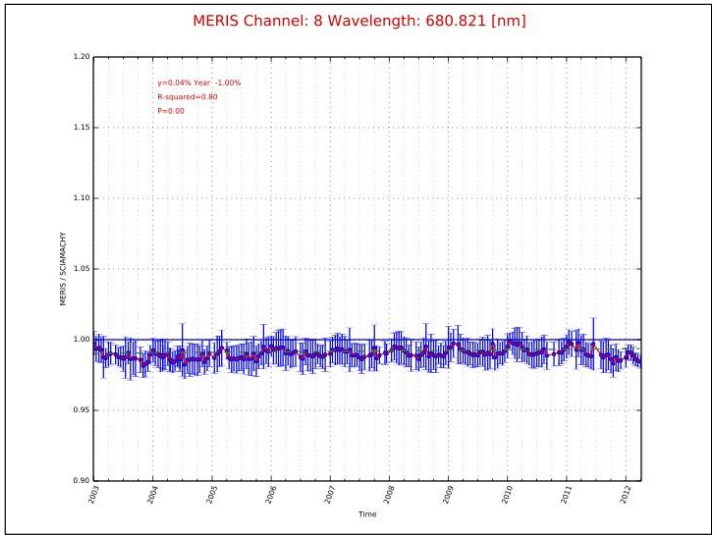
MERIS Channel: 13 Wavelength: 864.876 [nm]

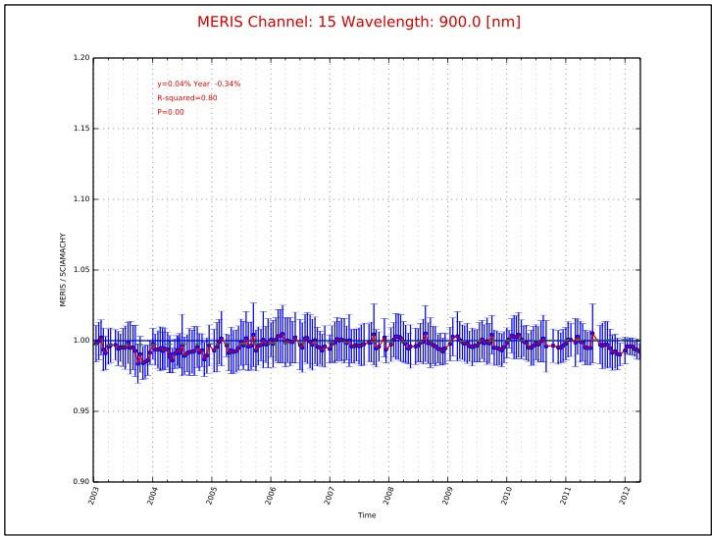


Results M-Factor Correction (2003-2012) – Some Plots over Libya4



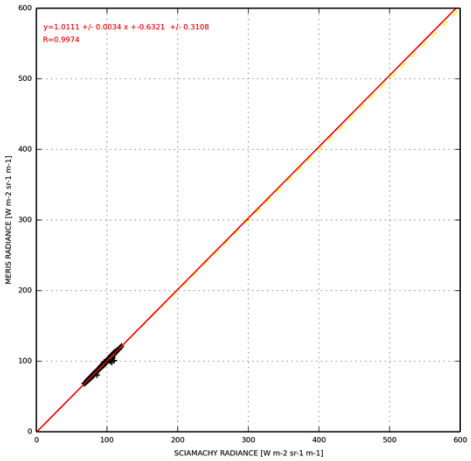




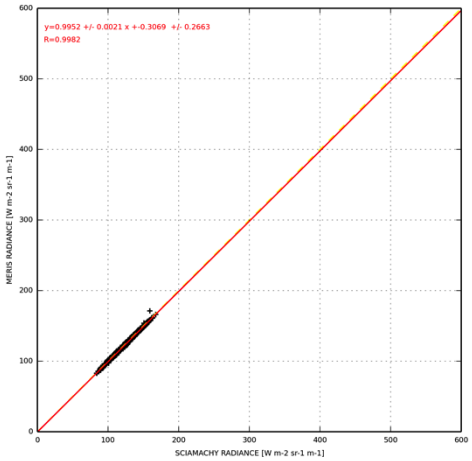


Scatter Plots for Libya 4

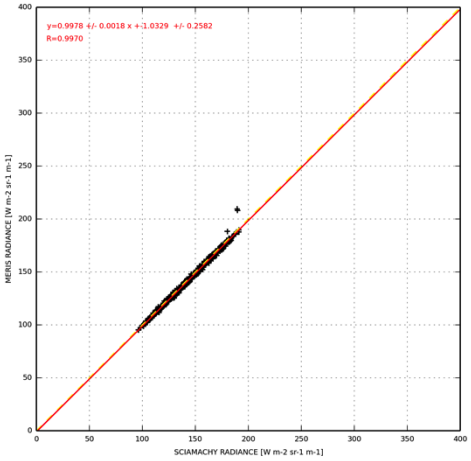
MERIS Channel: 1 Wavelength: 412.691 [nm]



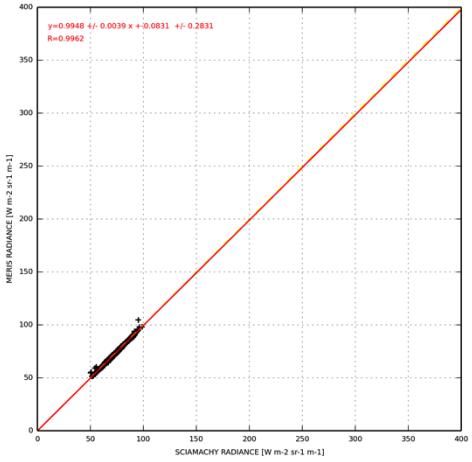
MERIS Channel: 5 Wavelength: 559.694 [nm]



MERIS Channel: 8 Wavelength: 680.821 [nm]



MERIS Channel: 15 Wavelength: 900.0 [nm]



Results M-Factor Correction (2003-2012) over Libya4

		Trend/Year	Bias
Detector 3	Band 1	0.16%	0.53%
	Band 2	0.07%	3.43%
	Band 3	0.08%	3.55%
	Band 4	0.07%	1.72%
	Band 5	0.07%	-1.01%
Detector 4	Band 6	0.10%	-0.32%
	Band 7	0.11%	-0.51%
	Band 8	0.13%	-1.11%
	Band 9	0.15%	1.30%
	Band 10	0.18%	0.97%
	Band 12	0.19%	-5.30%
Detector 5	Band 13	0.19%	0.67%
	Band 14	0.18%	0.20%
	Band 15	0.13%	-0.72%

Results M-Factor Correction (2003-2012) over Libya4 and Global

		Trend/Year	Bias
Detector 3	Band 1	0.16%	0.53%
	Band 2	0.07%	3.43%
	Band 3	0.08%	3.55%
	Band 4	0.07%	1.72%
	Band 5	0.07%	-1.01%
Detector 4	Band 6	0.10%	-0.32%
	Band 7	0.11%	-0.51%
	Band 8	0.13%	-1.11%
	Band 9	0.15%	1.30%
	Band 10	0.18%	0.97%
	Band 12	0.19%	-5.30%
Detector 5	Band 13	0.19%	0.67%
	Band 14	0.18%	0.20%
	Band 15	0.13%	-0.72%

	Trend/Year	Bias
Band 1	0.01%	0.69%
Band 2	0.03%	3.63%
Band 3	0.03%	3.49%
Band 4	0.03%	1.60%
Band 5	0.01%	-1.07%
Band 6	0.02%	-0.31%
Band 7	0.03%	-0.40%
Band 8	0.04%	-1.00%
Band 9	0.06%	1.51%
Band 10	0.08%	1.22%
Band 12	0.12%	-5.01%
Band 13	0.09%	1.06%
Band 14	0.08%	0.65%
Band 15	0.04%	-0.34%

Analysis of Time series: being ready for V8

1. When V7 and V8 have been analysed and compared to MERIS, trends came out
2. In order to better understand the behavior of 3 datasets (MERIS, SCIA-V7, SCIA-V8), data have been separately analysed.

$$TS(t) = Tr(t) + S(t) + n(t)$$

Time Series

Trend

Seasonality
(Periodic Signal)

noise

By estimating *S(t),* it is possible to isolate the Trend component

$$Tr(t) + S(t) + n(t) - \bar{S}_e \approx Tr(t) + n(t) + \varepsilon$$

Analysis of Time series

$$Tr(t) + S(t) + n(t) - \bar{S_e} \approx Tr(t) + n(t) + \varepsilon$$

By integrating the equation within a fixed time interval we can reduce the Noise contribution (Integration of noise within an interval is zero by definition)

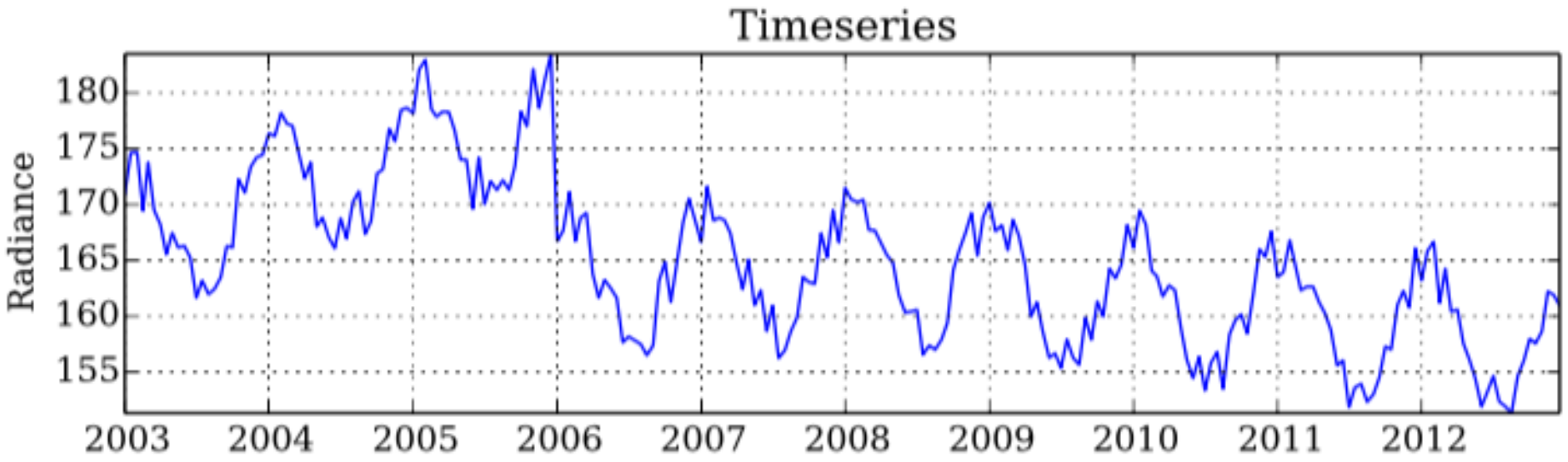
$$\int_{t0}^{t1} Tr(t) + n(t) + \varepsilon = \int_{t0}^{t1} Tr(t) + \int_{t0}^{t1} n(t) + \varepsilon$$

$$\approx F[Tr(t)]|_{t0}^{t1} + \varepsilon_n$$

If the trend is a linear function, the primitive function will be a quadratic function (easy to understand and calculate)

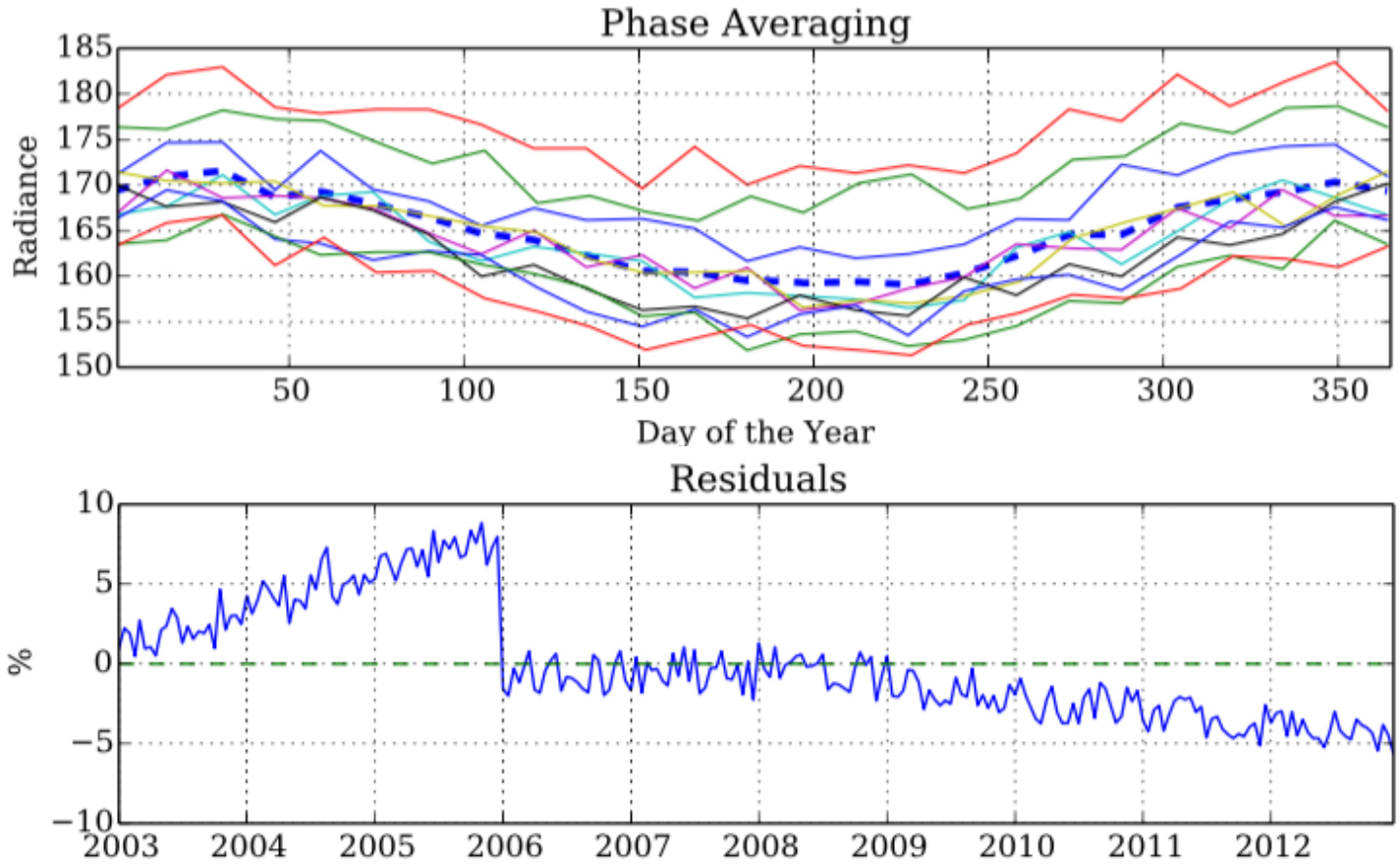
Analysis of Time series - Simulation

1. Synthetic time series has been created (2003-2012). The time series is made by a 3 different trends, a periodic signal (composition of sin and cos) and a noise component (uniform distribution)



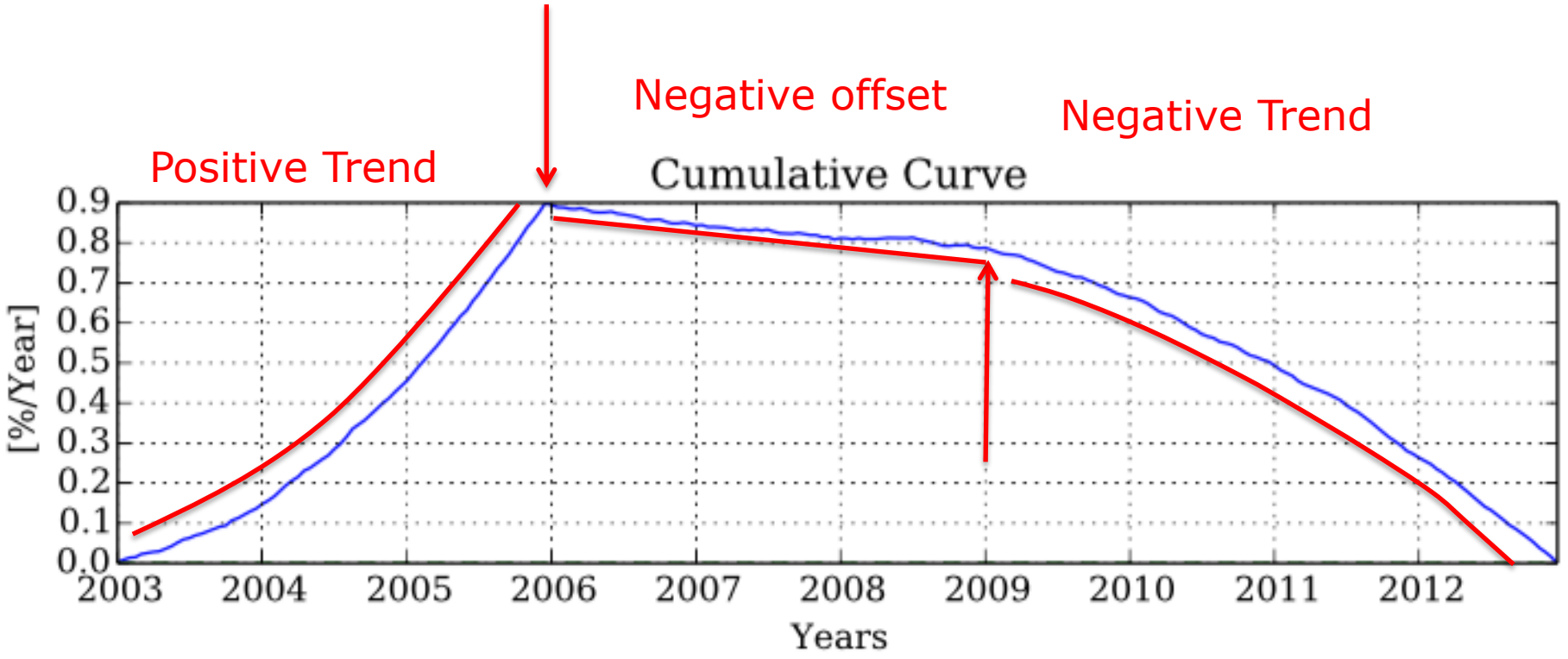
Analysis of Time series - Simulation

1. Estimation of Seasonal Signal and Calculation of Residuals

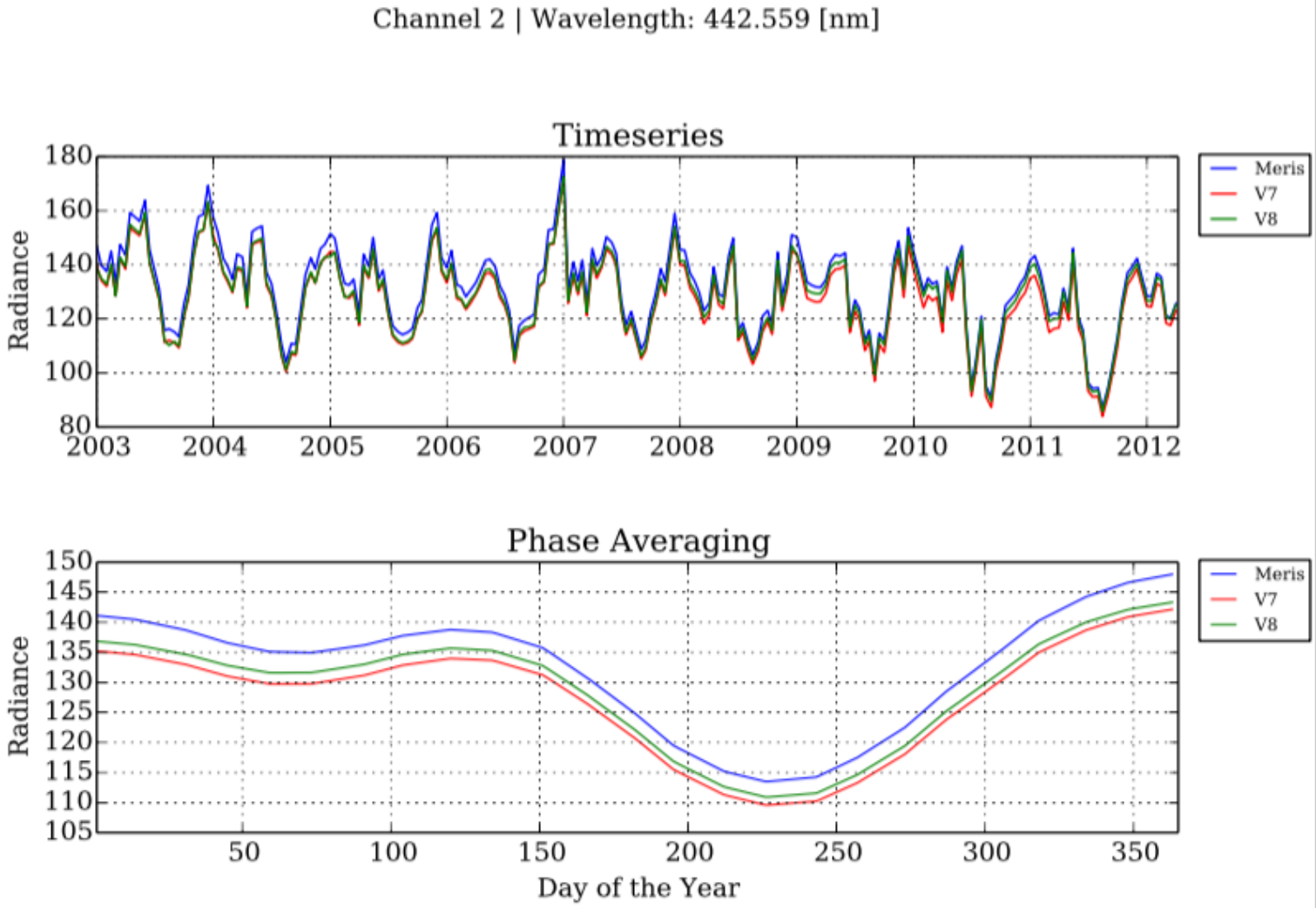


Analysis of Time series - Simulation

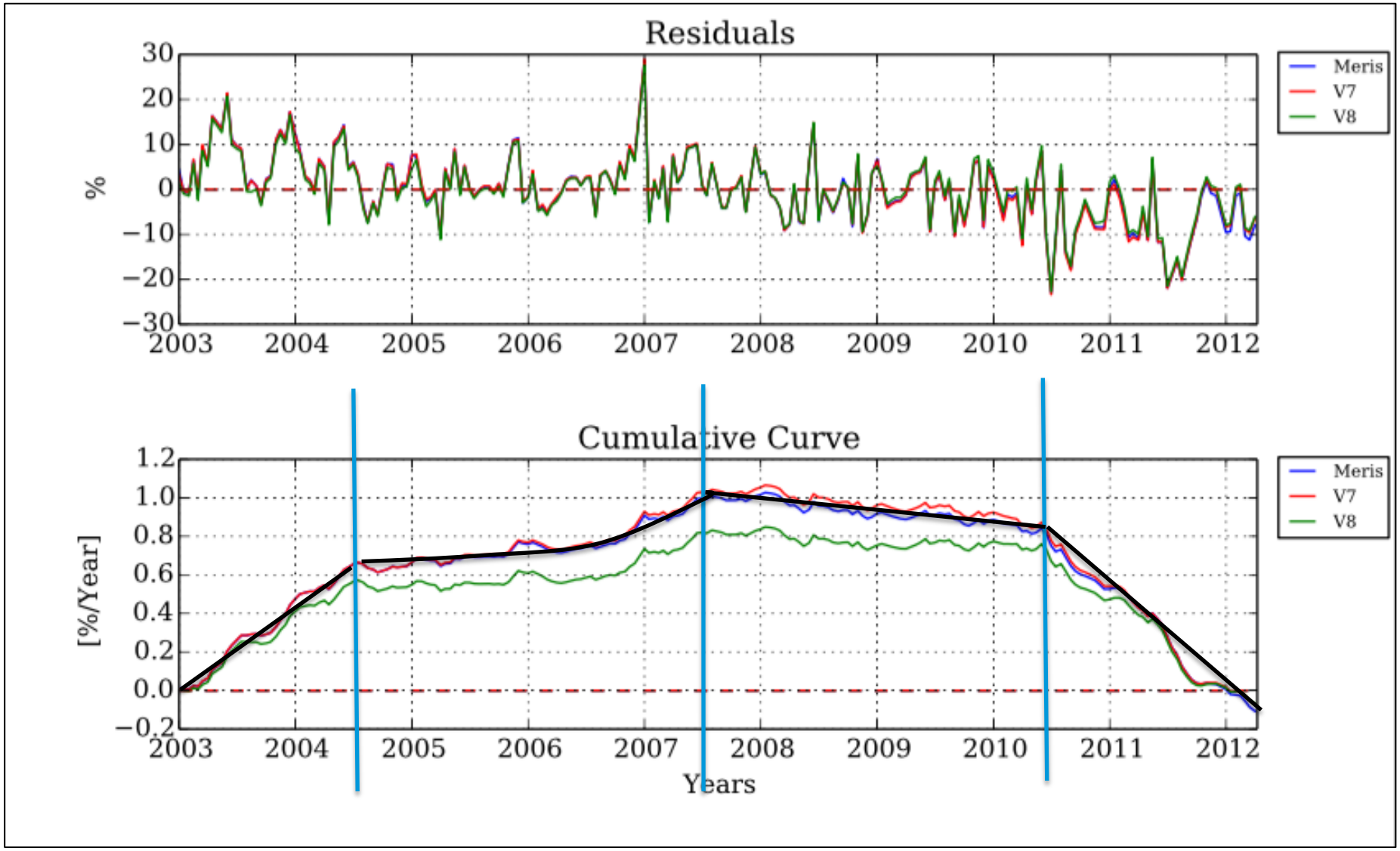
1. Cumulative Curve – Detection of Trends and major events



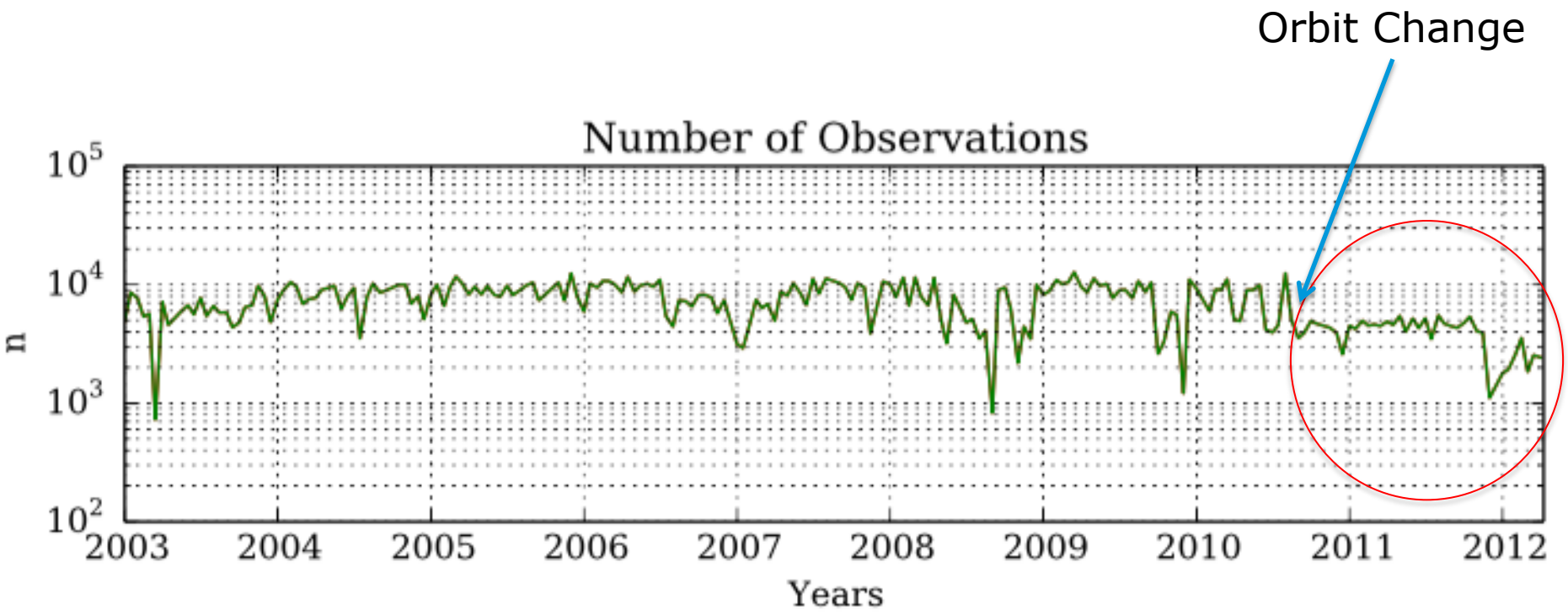
Analysis of Time series – Actual Data



Analysis of Time series – Actual Data

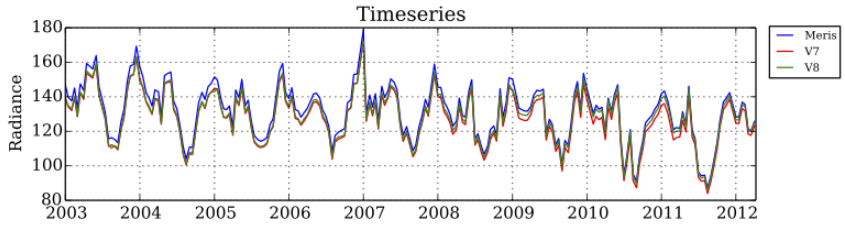


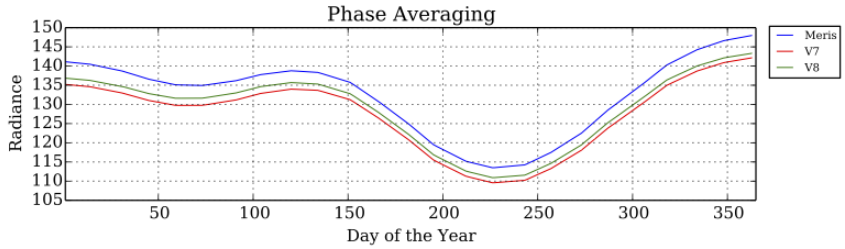
Analysis of Time series – Number of Collocations

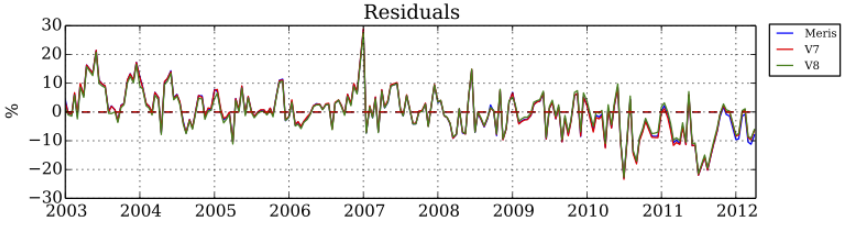


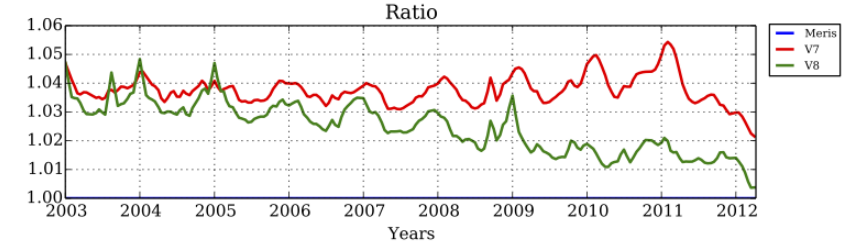
V7 vs V8 – Intercomparison by ratio

Channel 2 | Wavelength: 442.559 [nm]

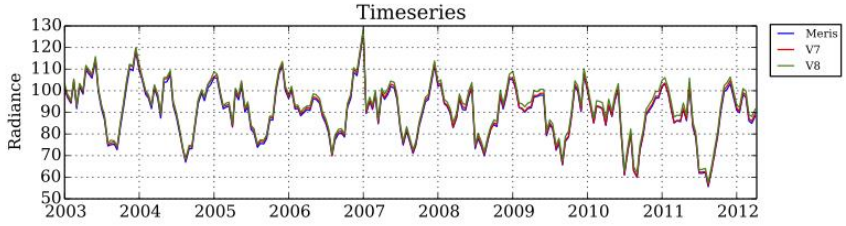


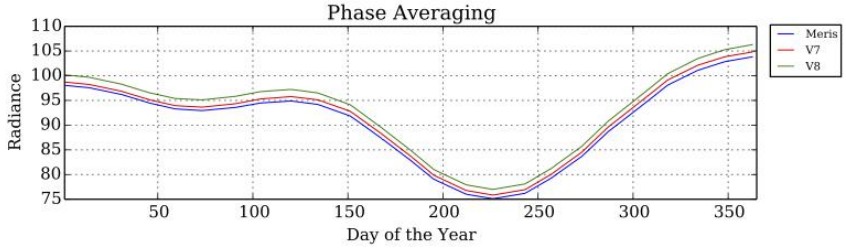


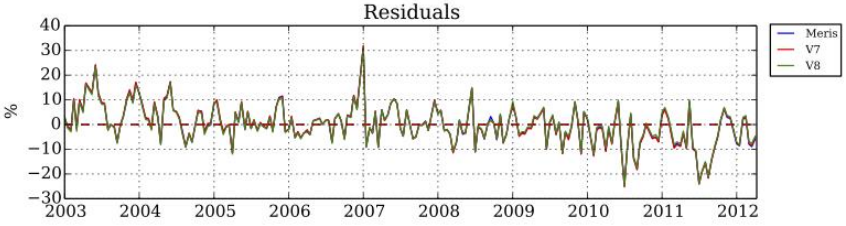


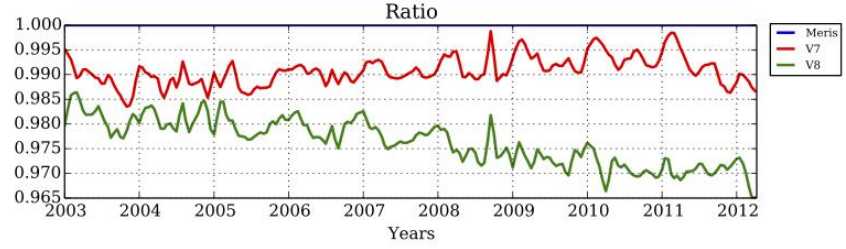


Channel 8 | Wavelength: 680.821 [nm]



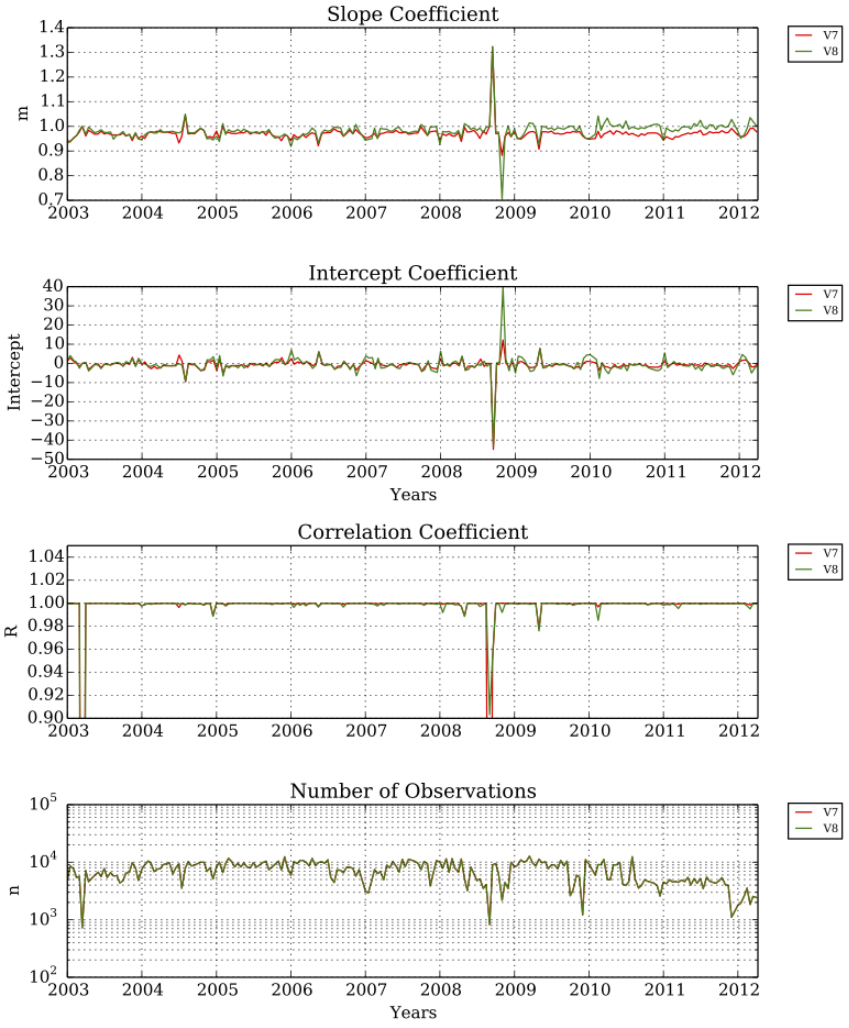




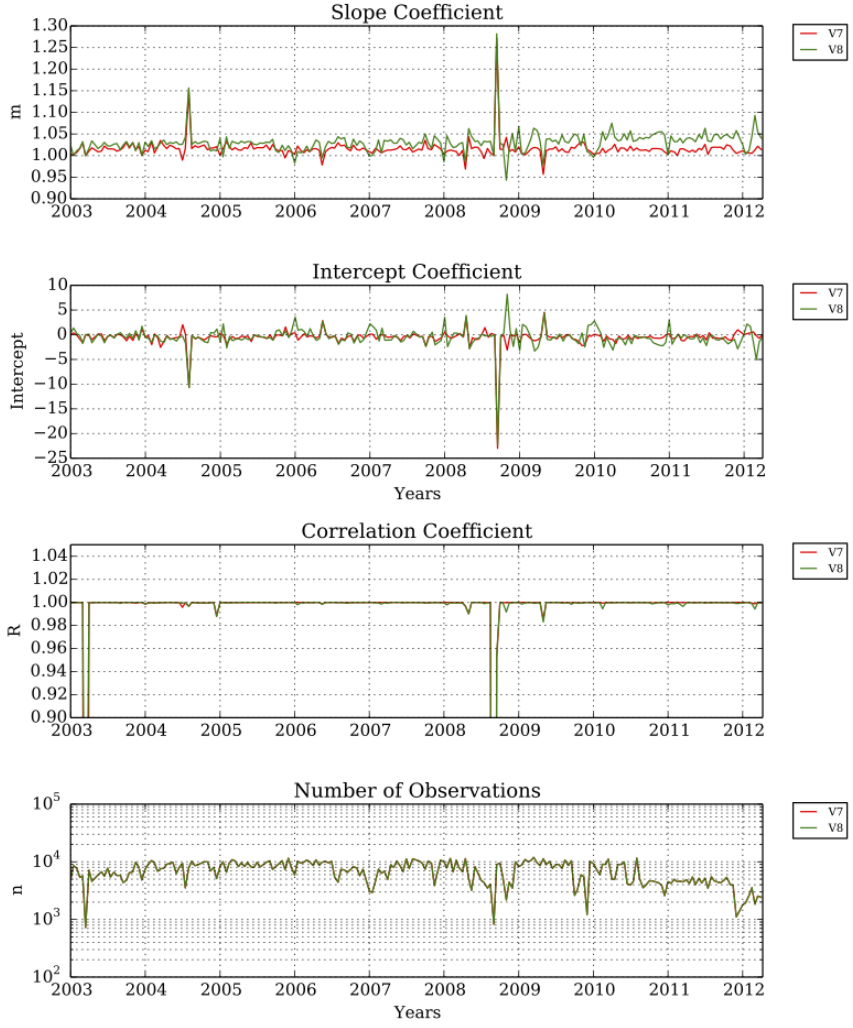


V7 vs V8 – Intercomparison by monitoring linear regressions parameters

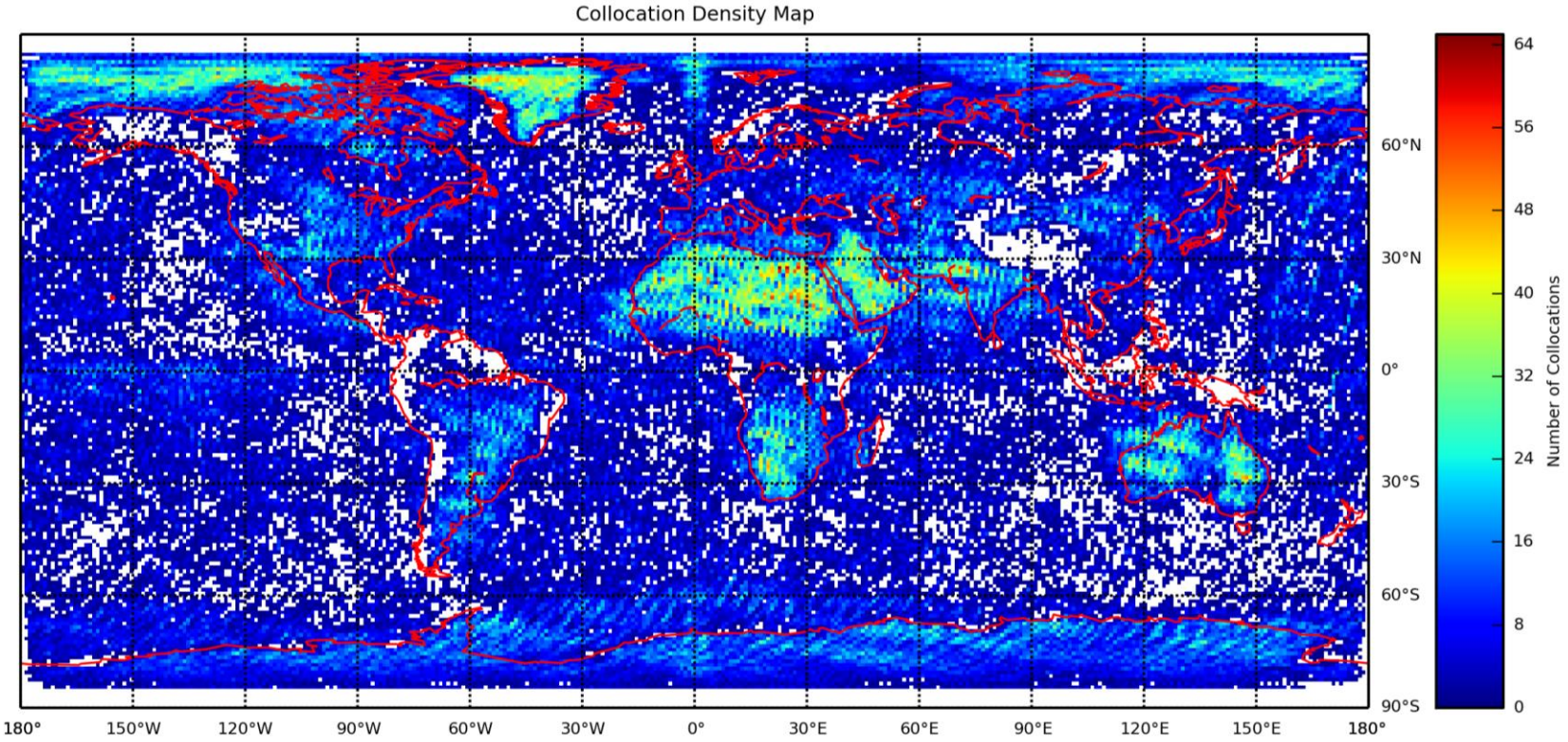
Channel 2 | Wavelength: 442.559 [nm]



Channel 8 | Wavelength: 680.821 [nm]



Geographic Distribution of Data



Conclusions

1. A robust algorithm for the **systematic intercomparison of MERIS/SCIAMACHY Observation** has been implemented and tested over a large dataset [**THANKS TO GPOD TEAM FOR THE KIND SUPPORT**]
2. M-Factors correction is crucial to obtain calibrated and stable SCIAMACHY radiances
3. The intercomparison showed a stable and flat behavior of the two sensors (some biases) and seasonality is still present for short wavelengths (Blue).(Radiances)
4. Intercomparison over Libya4 confirmed the trend for the global intercomparison
5. The use of Libya4 did not show the saturation for band 12. Dynamic range is not fully explored.
6. The geographic distribution of data showed how particular areas are suitable for the intercomparison (Sahara and Arabia, Greenland, Australia, Thar Desert, South Africa) and other have never been taken into account (Himalaya, Andes, Papua New Guinea, Alaska)

Conclusions

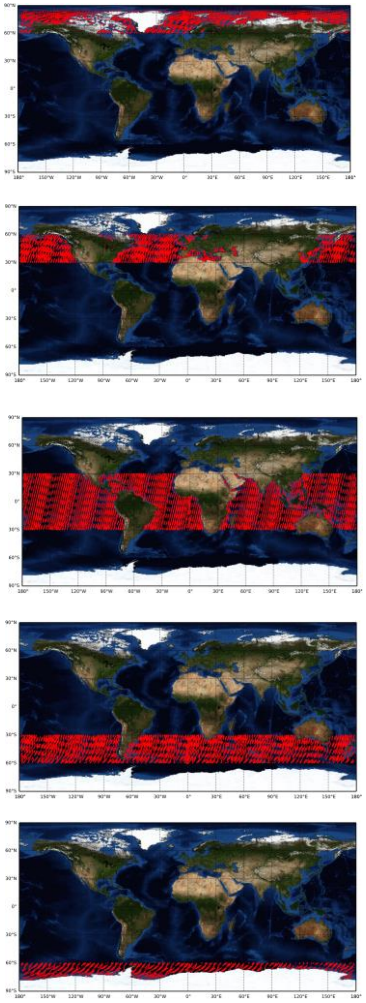
1. SCIA V8 has M-Factor correction embedded into the files (good!)
2. Analysis of V8 showed trends with respect to MERIS. This lead to a deeper analysis of the 3 datasets.
3. The trend analysis showed a strong “correlation” between V7 and Meris. V8 showed a more independent behavior from MERIS, V8 is more stable along the entire mission life
4. Analysis of trends has been done with two techniques: Ratio and Monitoring of linear regression. The last techniques does not show any sensitivity to trends (it can be easily demonstrated).
5. V7 and V8 intercomparison has been conducted on the target points.

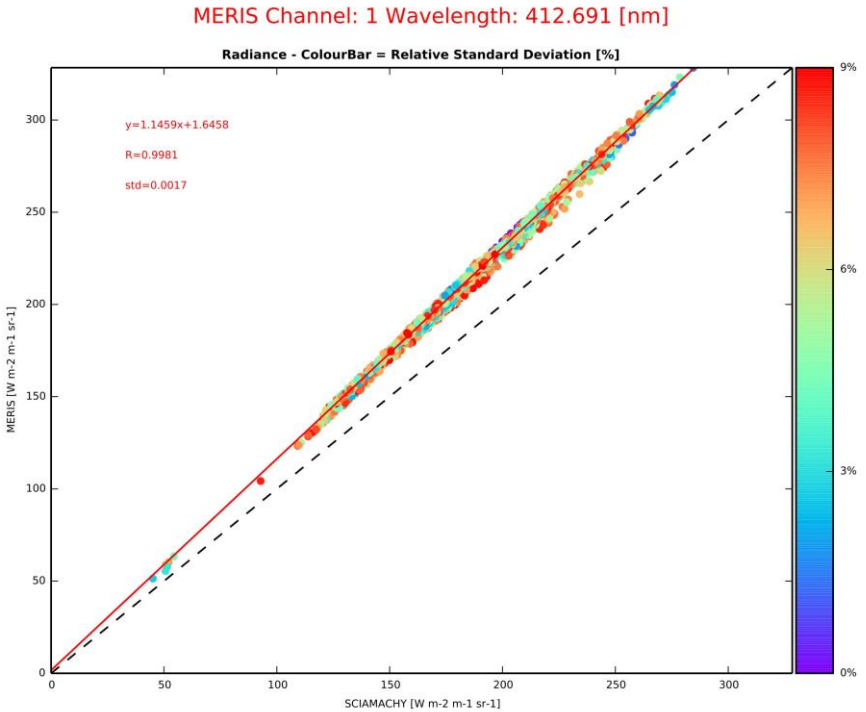
Thanks for the attention and…

Auf Wiedersehen!!

(arrivederci)

A first approach, from the north to the south!





~2.5% travelling from North to South! Y: 2009 Polarization?

Considerations on Polarisation

1. 1st processed dataset (2009) has been used to test the robustness, performances and reliability of the algorithm [so called IMPETUS].
2. SCIAMACHY data have been calibrated but NOT corrected with m-factors (monitoring factors)
3. Differences are wavelength dependent and affect more the visible bands (1-5, 3rd SCIAMACHY detector)
4. MERIS has a "scrambler" right before the camera optic assembly (to minimize the effect of polarization). SCIAMACHY is actually using polarization for some of its measurements.