International Ocean Colour Science Meeting 2015

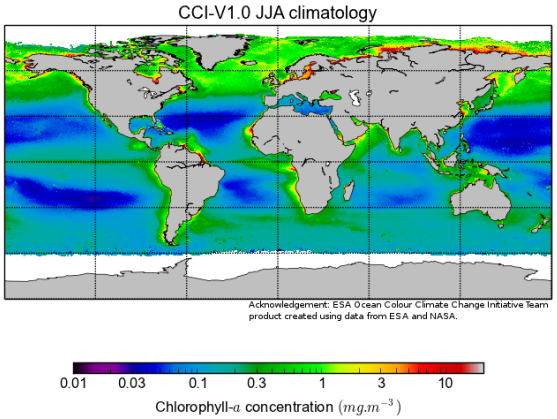
Advancing Global Ocean Colour Observations

Challenges of System Vicarious Calibration for non-standard atmospheric correction

Constant Mazeran[(1)], Carsten Brockmann[(2)], François Steinmetz[(3)], Marco Zühlke[(2)]
& the ESA OC-CCI consortium

[(1)]Solvo, [(2)]Brockmann Consult, [(3)]Hygeos

Context: ESA OC Climate Change Initiative



Long-term global EO archive of Ocean Colour ECV: ρ_w, chl, IOP

Phase 2 started in February 2014: continuous update of data products following review of climate researchers + extension to new sensors

Past and in-flight sensors currently considered: SeaWiFS, MODIS, MERIS, VIIRS. OLCI planned for 2016

Two types of atmospheric corrections (AC) considered:

- "Standard/historical AC ", e.g. NASA-l2gen $\rho_w(\lambda_{VIS}) = \frac{\rho_{gc}(\lambda_{VIS}) - \rho_{atm}(\text{from } \lambda_{NIR})}{t_d(\text{from } \lambda_{NIR})}$
- "Non standard AC", based on a marine model and full spectrum inversion
  e.g. HYGEOS-POLYMER, HZG-NN, FUB-SIACS $\rho_w(\lambda_{VIS}) = \frac{\rho_{gc}(\lambda_{VIS}) - \rho_{atm}(\text{from all } \lambda)}{t_d(\text{from all } \lambda)}$

System Vicarious Calibration (SVC): post-launch mean to harmonise OC radiometry across all missions

What does SVC tell us?

SVC formalism considers {sensor+algorithms} as a whole and is thus a very pragmatic way to:

- Specify requirements on L1 radiometry (system input) by requirements on ρ_w (system output)
- Detect (or at least validate) any sensor drift at ρ_w level, through analysis of long-term time series

Most generic formulation of the SVC problem, for a given algorithm, observation and reference is:

With $\rho_w = F(\rho_{TOA})$, find g such that $F(g * \rho_{TOA}) = \rho_w^{REF}$ for all bands

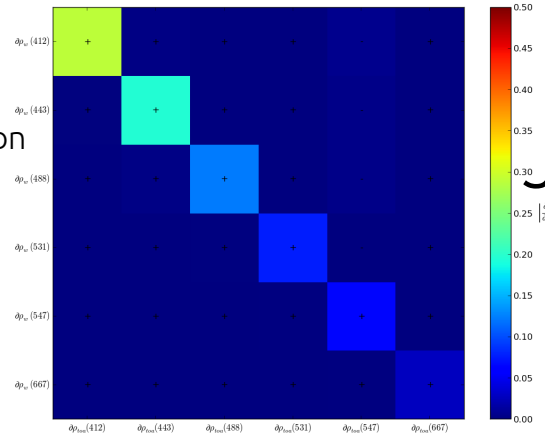
→ SVC = sensitivity to TOA = assessing how much do we need to (vicariously) calibrate

l2gen

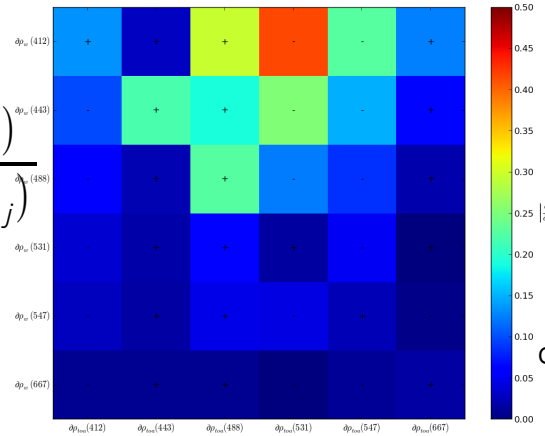
Band per band calibration

Sensitivity in 1/t(λ)

Need a SVC further to instrument calibration



$$J_{ij} = \frac{\partial \rho_w(\lambda_i)}{\partial \rho_{TOA}(\lambda_j)}$$



POLYMER

Coupled calibration

Non-intuitive sensitivity

Need for SVC – but maybe different calibration requirements?

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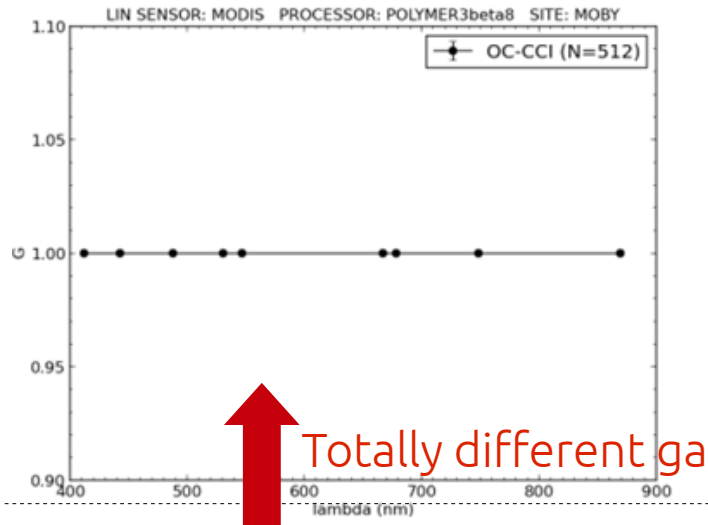
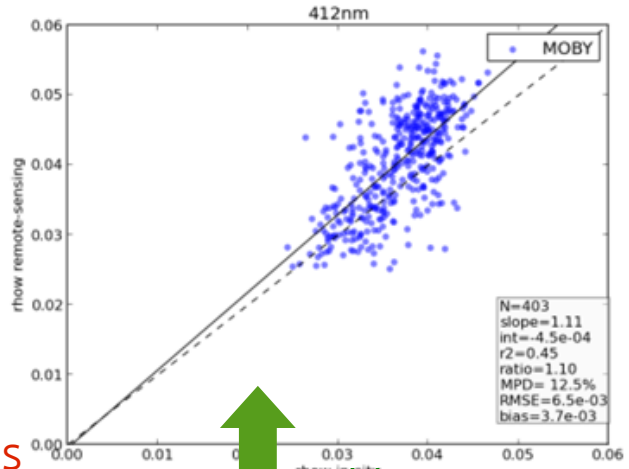
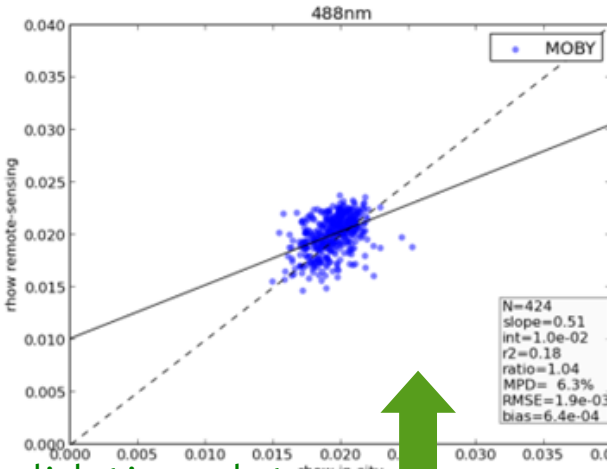
Specificity of spectral matching AC

By construction POLYMER inversion is invariant to any calibration following $g(\lambda) = 1 + \frac{c_0 T_0(\lambda) + c_1 \lambda^{-1} + c_2 \lambda^{-1}}{\rho_{GC}(\lambda)}$

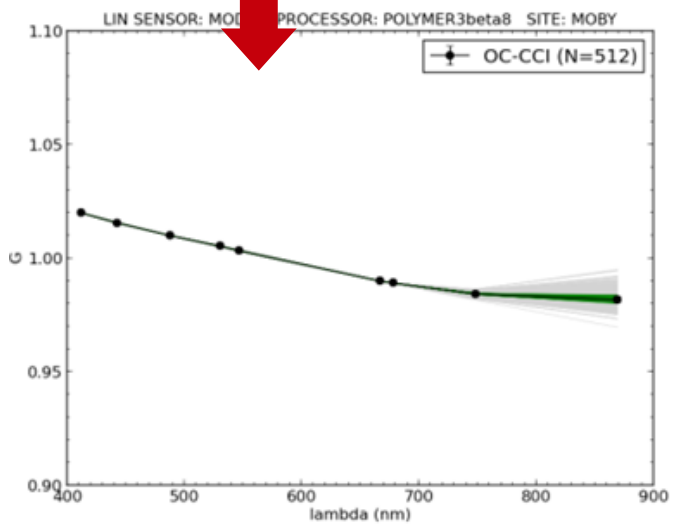


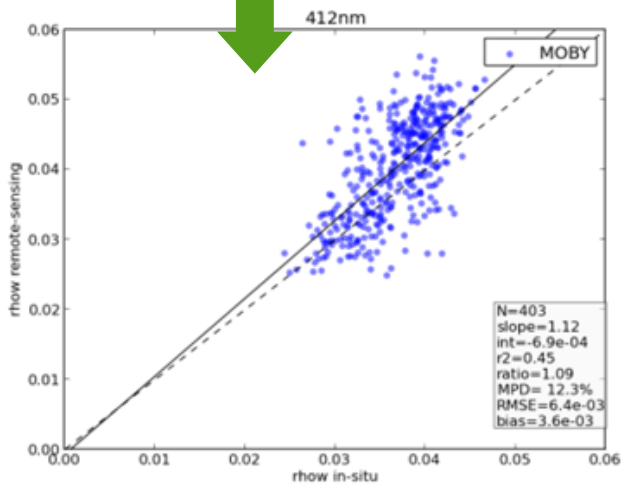


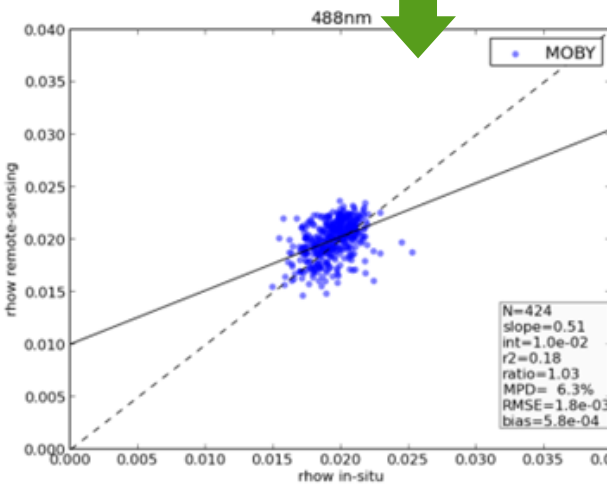


Totally different gains

Very same ρ_w and validation plots





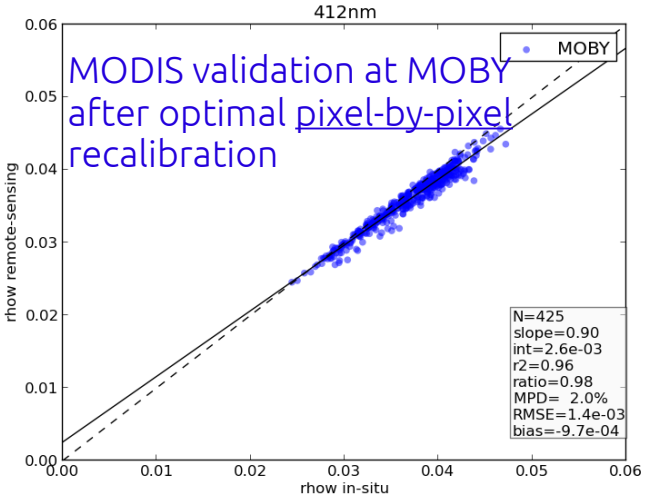


Feasibility of SVC ?

The strict SVC problem cannot be solved, unless there exists IOPs such that $\rho_w^{REF}(\lambda)=\rho_w^{MOD}(\lambda, IOPs)$ for all λ

The best we can do is a SVC in a *least-square sense*:

With $\rho_w = F(\rho_{TOA})$, find g to minimise $\|F(g*\rho_{TOA})-\rho_w^{REF}\|$



Standard AC

- Gains always exist
- Gains are unique after NIR calibration
- Gains can be computed explicitly at each band
- Gains yield to a perfect match with reference data, at all bands

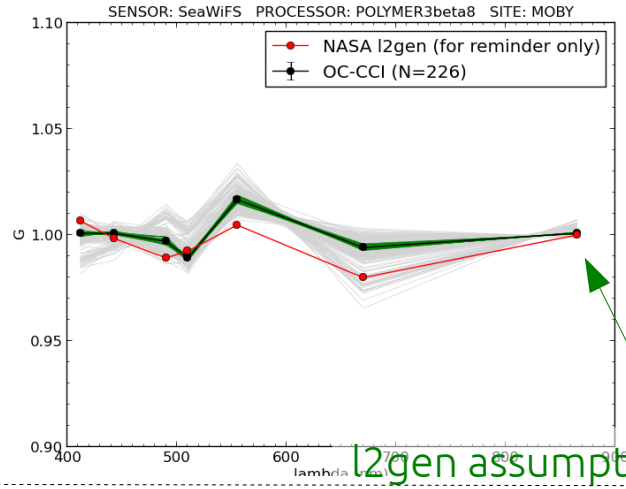
Spectral matching (POLYMER)

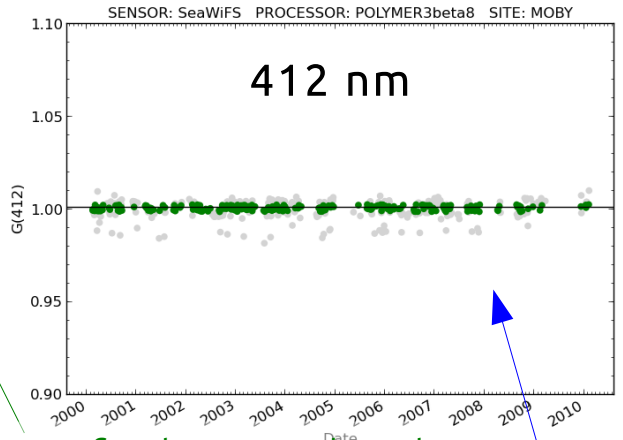
- "True" gains exist only if ρ_w^{MOD} fit reference data
- Infinity of gains are possible
- Gains are computed by a non-linear spectrally coupled system
- Gains only yield to an approximate match with reference data, in a least-square sense. Errors vary with bands

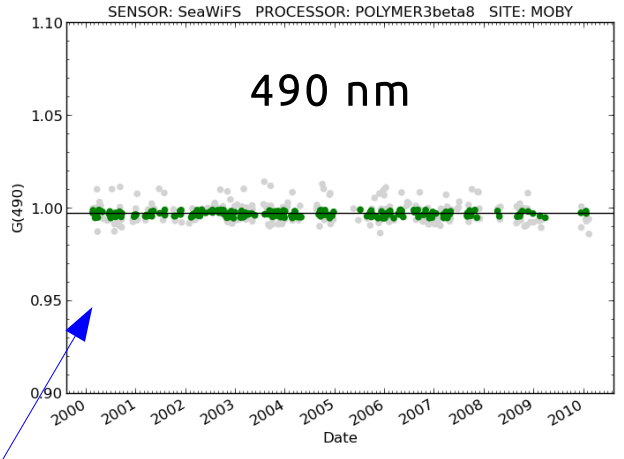
Findings from POLYMER SVC at MOBY

SVC gains have no meaning per se, but comparison between two algorithms can provide information

SeaWiFS



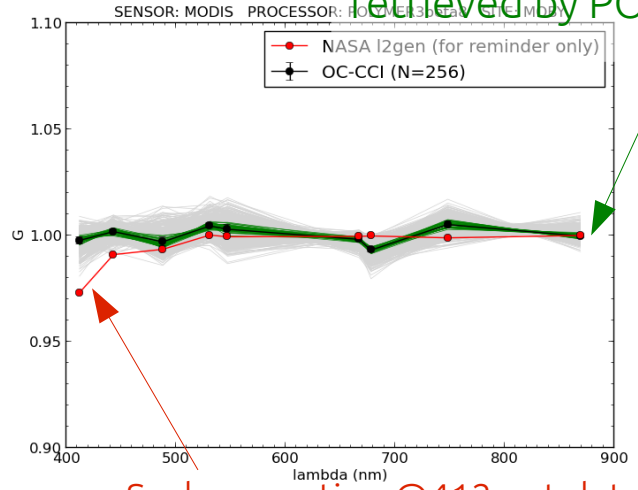


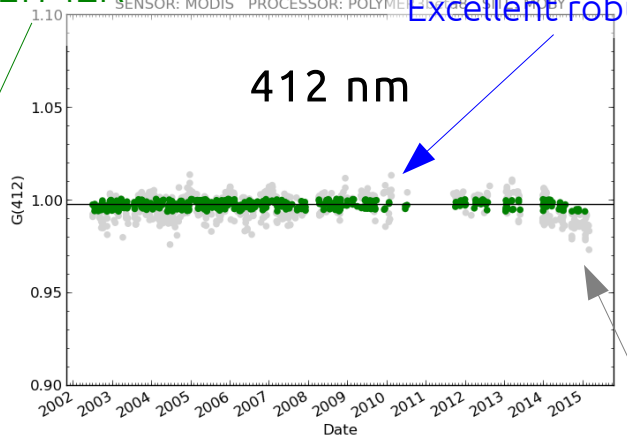


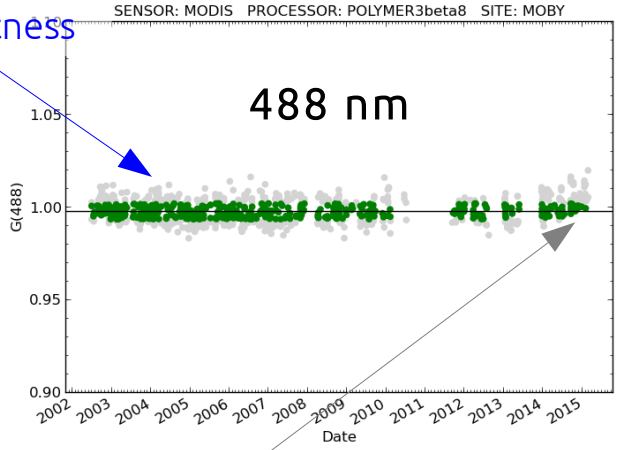
l2gen assumption in farthest NIR band retrieved by POLYMER

Excellent robustness

MODIS

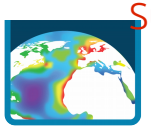






Such correction @412 not detected by POLYMER

Temporal degradation after 2013?



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Conclusion

- Spectral matching ACs are more and more used by the OC community, cf. OC-CCI
- Such algorithms ask new questions in term of calibration requirements (interband vs absolute)
- System Vicarious Calibration can bring answers but needs a new perspective:
  - Link between TOA and BOA does not follow classical OC formulation – cf. Jacobian matrix
  - Gains are spectrally coupled and cannot be computed by the standard method
  - Gains are not always unique
  - The strict SVC problem is not solvable → define *SVC in a least square sense*
- SVC of spectral matching AC remains meaningful and useful to bring an extended number of data

Acknowledgements

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