ASSESSMENT OF THE UNCERTAINTY OF ATMOSPHERIC SCATTERING FUNCTIONS USED IN MERIS ATMOSPHERIC CORRECTION OVER WATER

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Par Bleu technologies

Motivations

- Contribute to the MERIS validation of L2 optical parameters
- Consolidate the validation of the aerosol product
- Propose an atmospheric alternative for the validation of the marine reflectance:
  - Clear waters: Check consistency with Vicarious Calibration (VCAL)
  - Coastal waters: Spatial & temporal stability of atmosphere is higher than that of marine signal

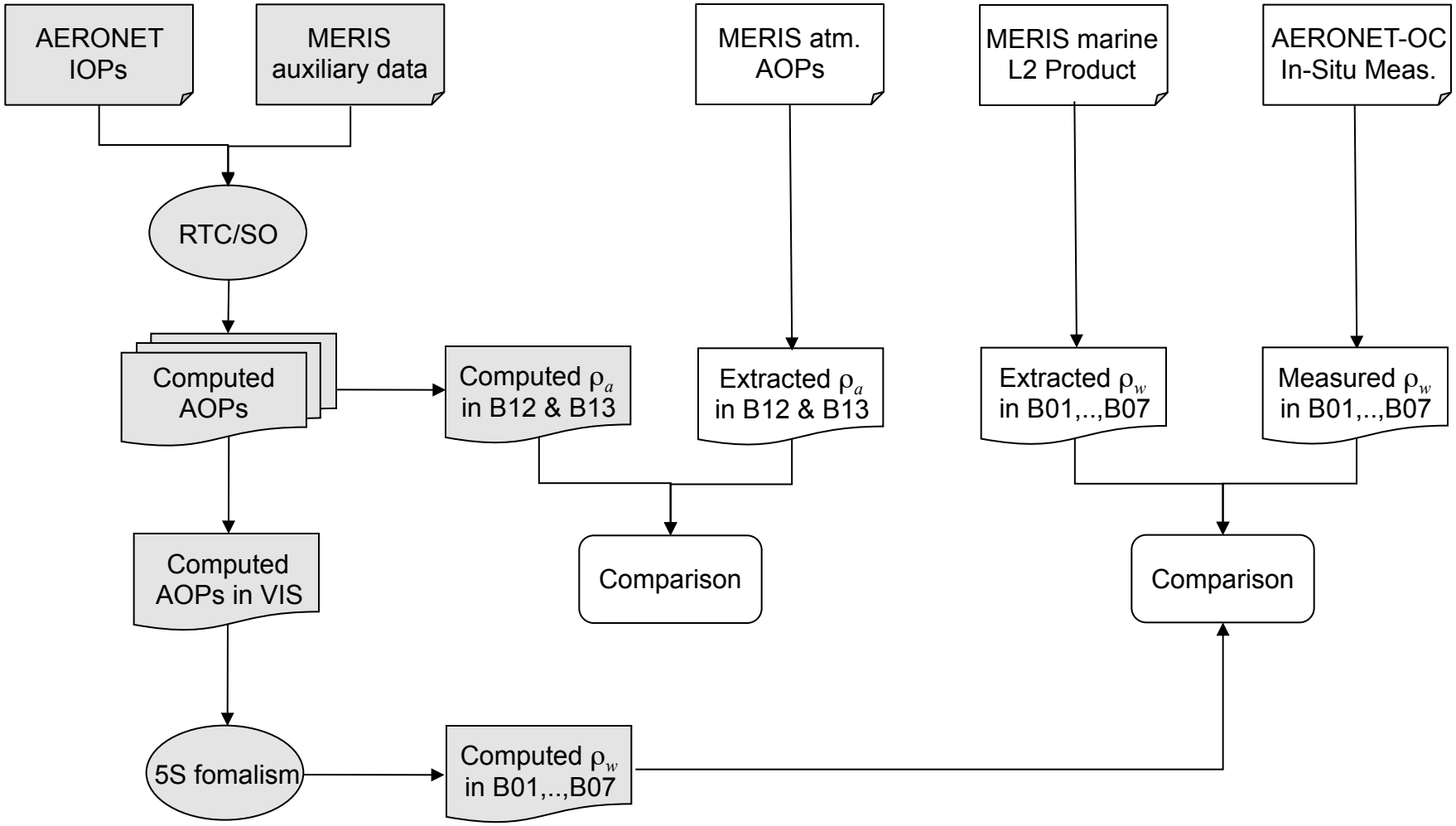
Context

- Aerosol optical thicknesses (AOTs) are used to validate the MERIS L2 aerosol product
- AOTs from AERONET Ocean Colour are proposed in MERIS Matchup In situ Database (MERMAID)
- MERIS water reflectances (ρ_w) result from the atmospheric correction (AC)
- AC relies on the knowledge of the aerosol inherent optical properties (IOPs)

Methodology

- Aerosol IOPs: AOT(λ) + SSA(λ) + Paer(Θ,λ) at 440, 675 & 870 nm
- IOPs are provided by AERONET inversions
- Compute the required atmospheric scattering functions with these IOPs for the AC in the MERIS conditions
- Compare the aerosol reflectance (ρ_{aer}) in NIR for validating BPAC + Sun glint correction
- Use the 5S formalism of the TOA reflectance for extracting ρ_w and to compare it with the MERIS derived one

Flow Chart of the Methodology to Validate MERIS Atmospheric Scattering Functions



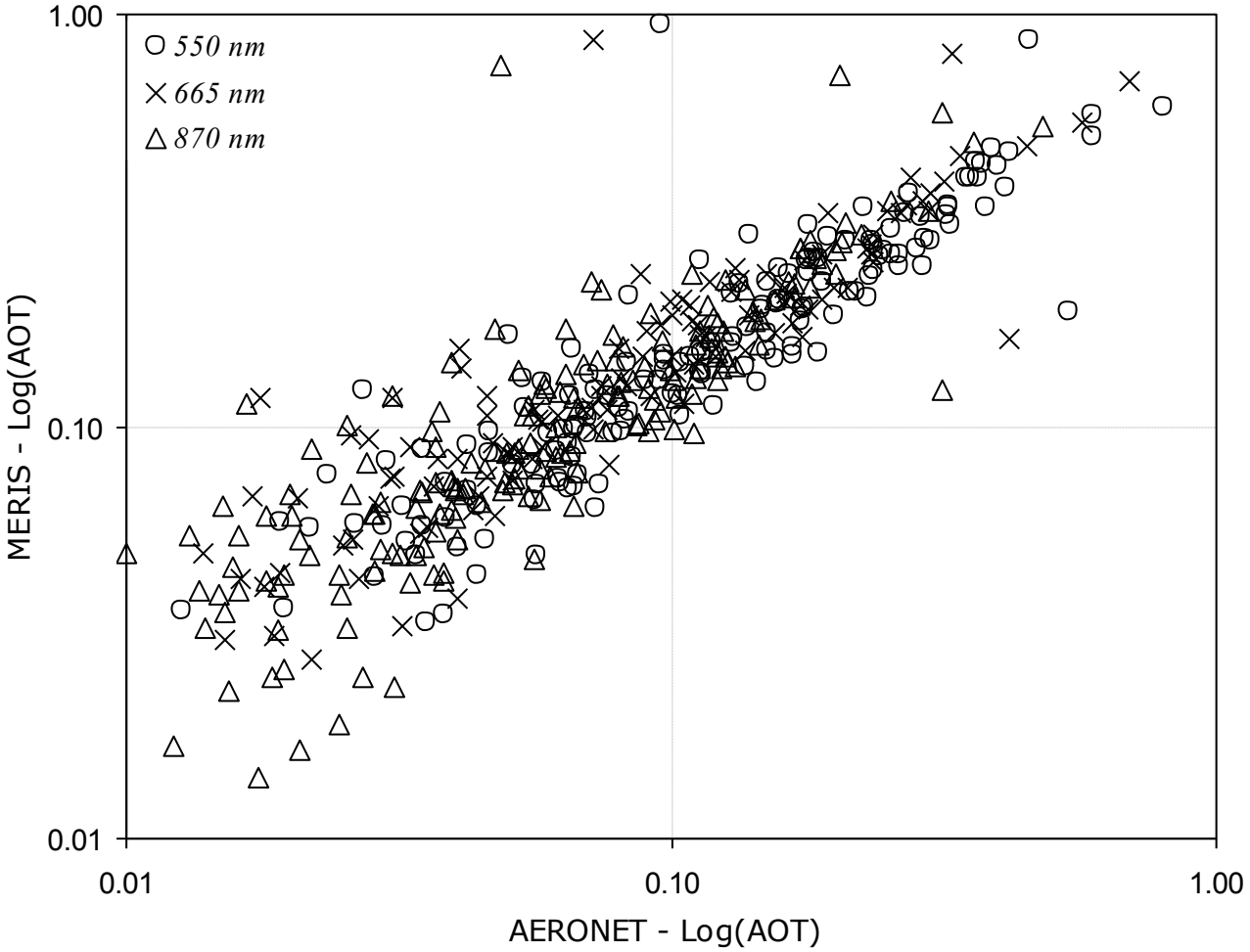
RTC/SO

- Vector code (polarization)
- Vertical discretization: 100 sub-layers
- Black water body
- Fresnel reflection (Cox & Munk model)
- Angular integration: Gauss quadrature (24 angles)
- RTE solved using the *Fourier* series expansion (Is) of radiance
  - + Transmittances: nadir view and Is = 0
    (Principle of reciprocity)
  - + Radiances: Is = 80 terms

Aerosols (MERIS-3RP)

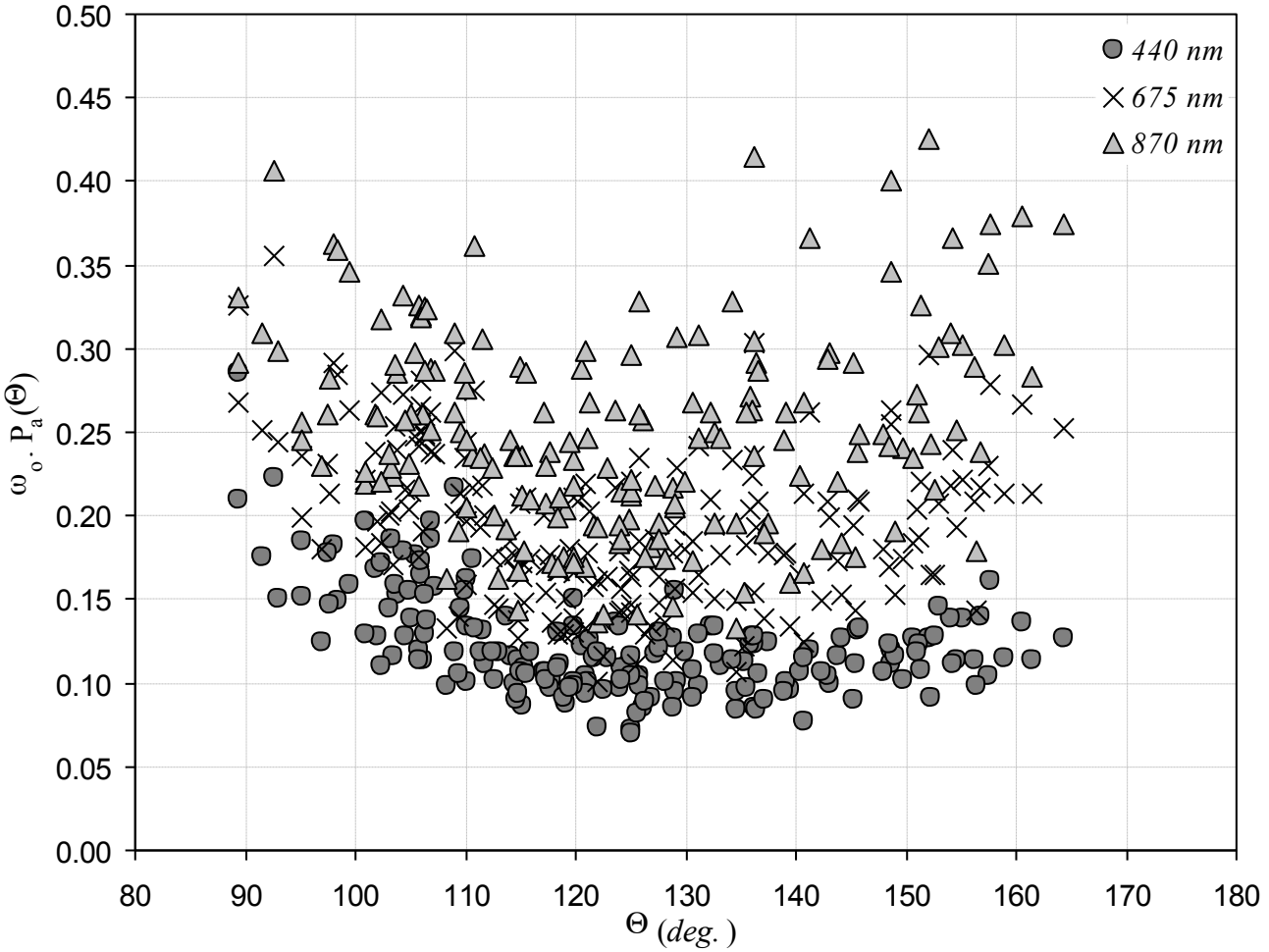
- Heritage: 12 SAMs (Fern & Shettle)
  - ⇨ Maritime, Coastal & Rural (RH=50, 70, 90, 99%)
- Additional models:
  - ⇨ Model #0 (Whiter than white)
  - ⇨ 3 IOPA blue aerosols (including a spectral dependence extracted from an approach combining micro-physical properties of small particles with IOP's derived from CIMEL measurements
- Exotic models:
  - ⇨ 18 absorbing DUSTs (Moulin et al., 2001)

AOT: MERIS vs AERONET



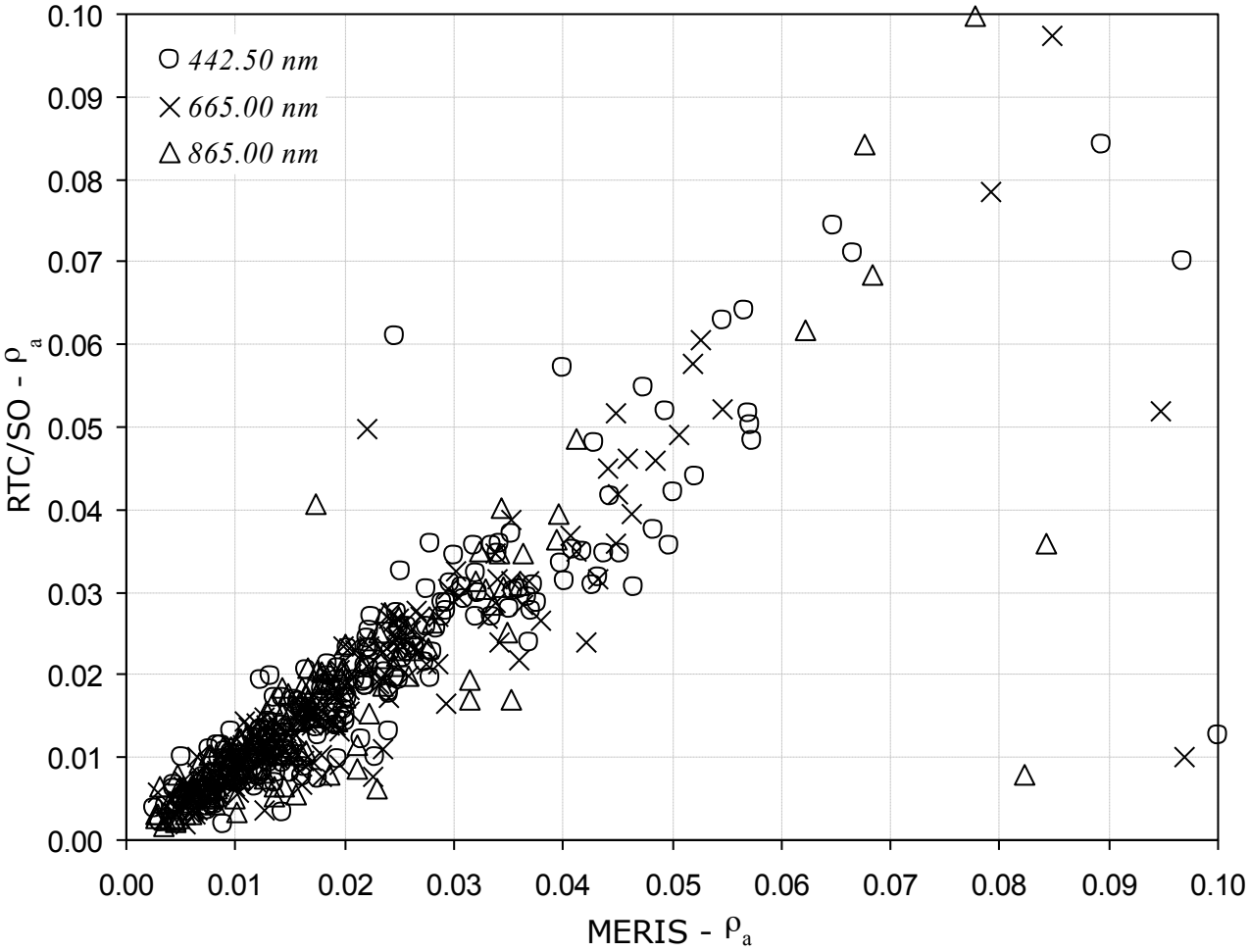
AOTs at 560, 665 and 865 nm over the AAOT site (Venice, Italy).
Comparison between the MERIS retrievals and the AERONET extractions.

AERONET - Aerosol Phase Function



Aerosol phase function times single scattering albedo, $\omega_o(\lambda).P_a(\Theta,\lambda)$

Evaluation of Aerosol Reflectance



Aerosol reflectances (ρ_a) in MERIS B02 (442.5 *nm*), *B07* (665 *nm*) *and B13* (865 *nm*). *Comparison between the MERIS extractions and the RTC/SO computations.*

Conclusions on ρ_{aer}

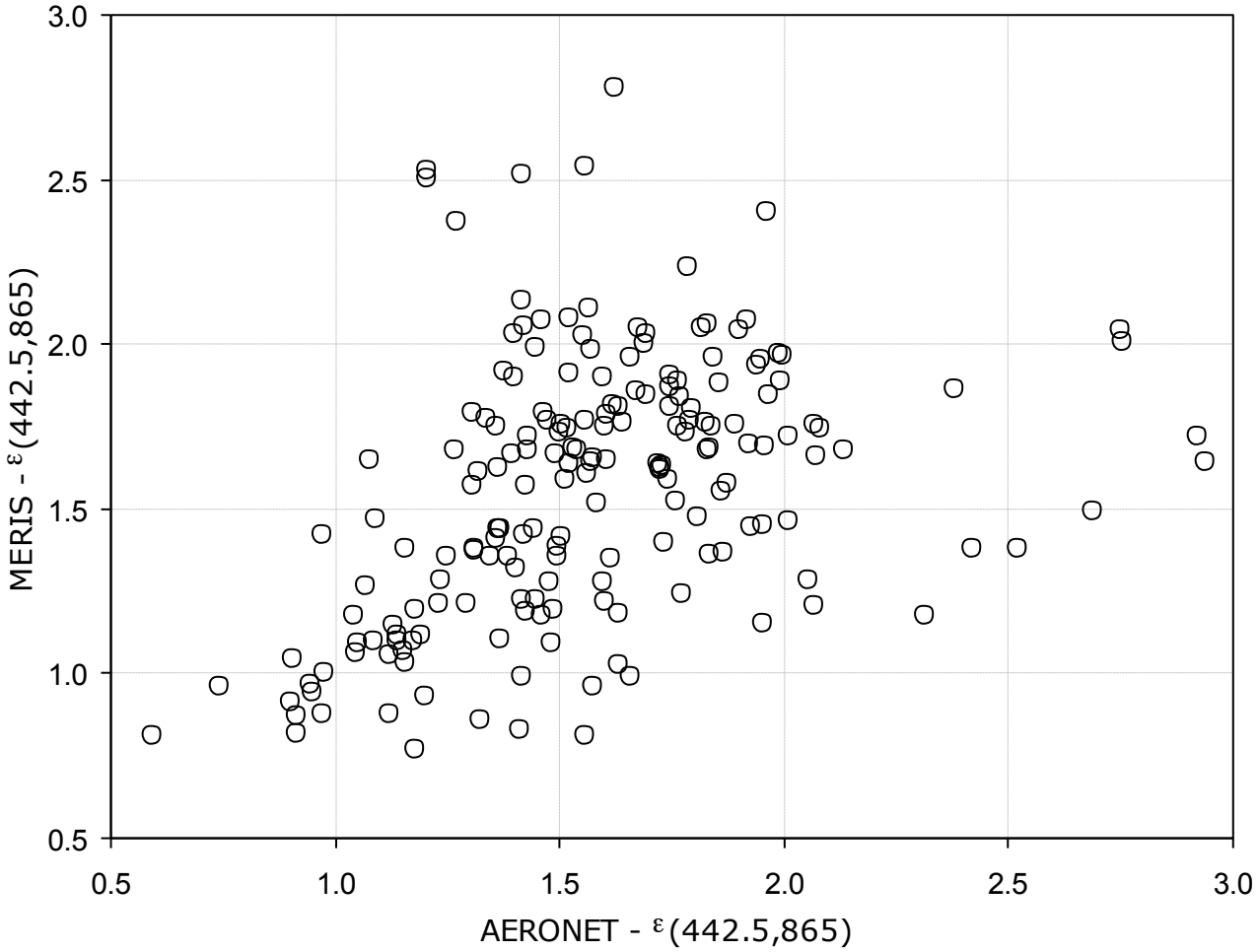
- Not so bad:
  - ✓ MERIS Calibration in the NIR is OK !
  - ✓ BPAC as well
- MERIS APF (P_a) is underestimated
  - ⇔ MERIS AOT overestimated !

*Ref.: Aznay, O., and R. Santer, 2009. "MERIS atmospheric correction over coastal waters: validation of the MERIS aerosol models using AERONET", International Journal of Remote Sensing, **30** (18), pp. 4663-4684.*

Retrieval of Water Reflectance

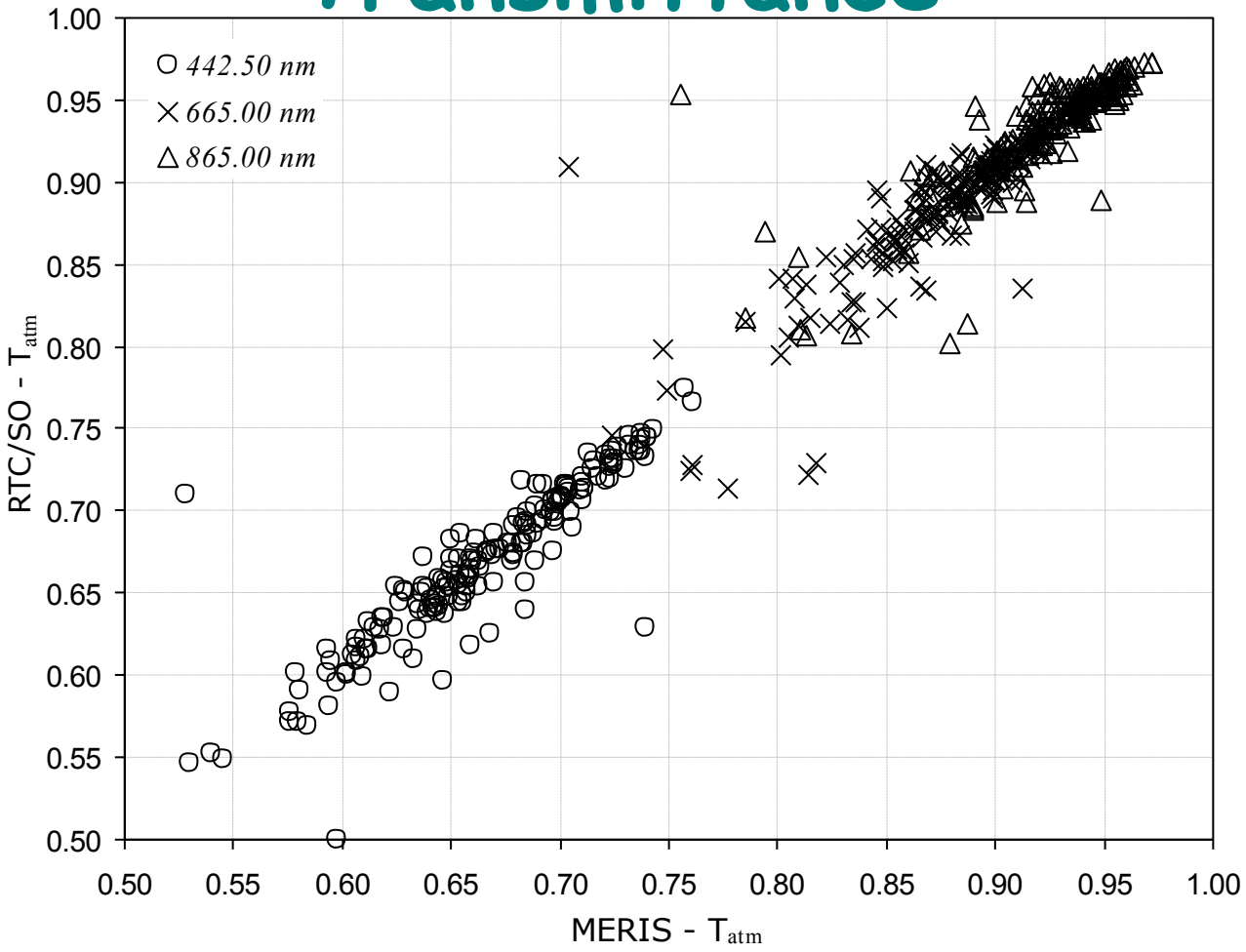
- 5S formalism: $\rho_w = \dfrac{\rho_{ng} - \rho_{atm}}{T(\mu_s) \cdot .T(\mu_v)}$
- AOT and P_a are interpolated in all the MERIS spectral bands from the 3 AERONET bands
- ρ_{atm} and T are from MERMAID break-points
- Validation of ρ_{atm} through ρ_{aer}

ρ_{aer} : From MERIS B_{13} to B_{02}



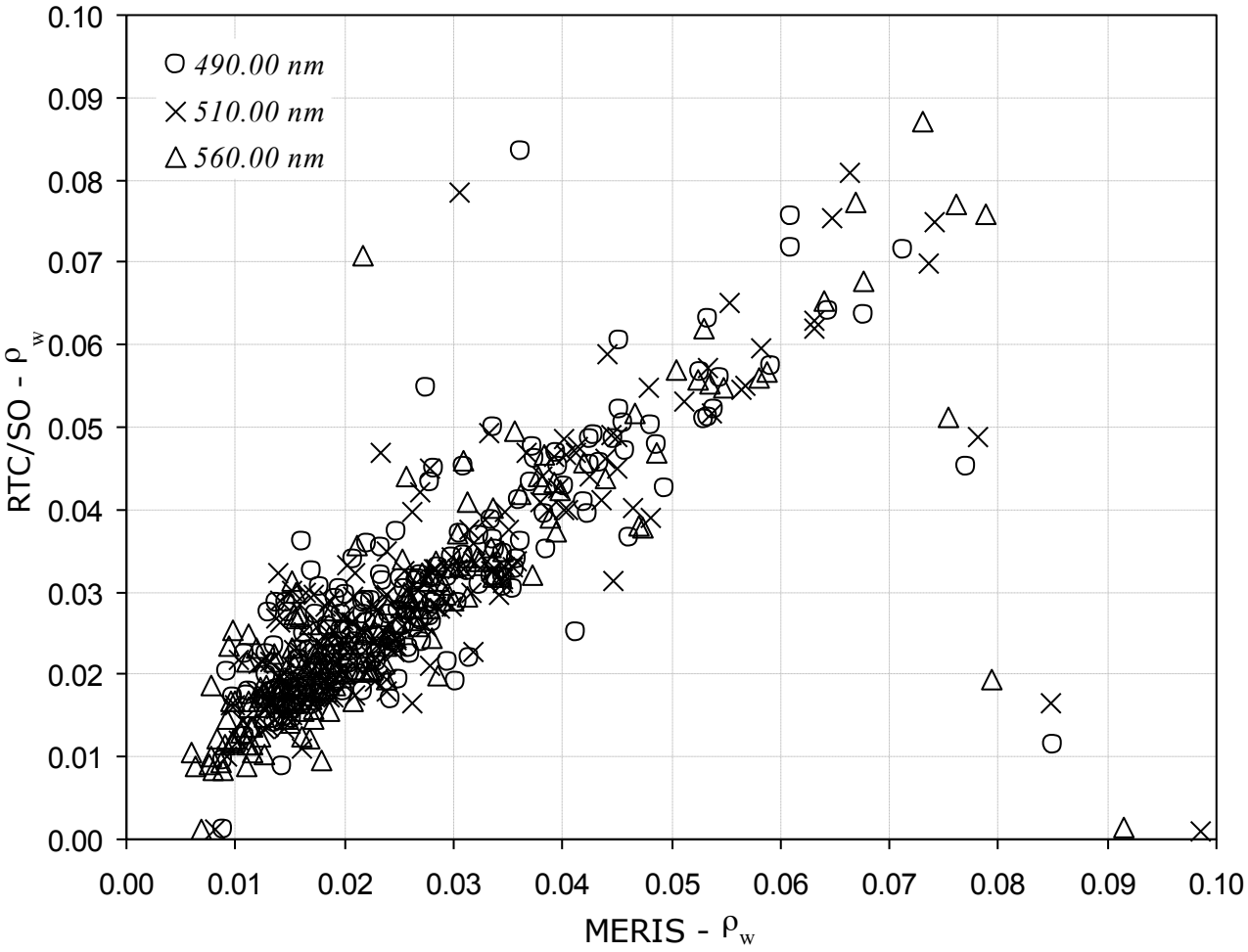
Spectral dependence factor of the aerosol reflectance (ε) *computed between* B_{02} *and* B_{13}*: MERIS versus AERONET*

Evaluation of Atmospheric Transmittance



Atmospheric transmittances (T_{atm}) in B_{02} (442.5 nm), B_{07} (665 nm) and B_{13} (865 nm). Comparison between MERIS extractions and RTC/SO computations.

Evaluation of Marine Reflectance



Marine reflectances (ρ_w) in B_{03} (490 nm), B_{04} (510 nm) and B_{05} (560 nm). Comparison between MERIS retrievals and RTC/SO simulations.

Conclusions-1

- Illustration of an alternative approach to validate AC
- Not an evaluation of the MERIS L2 product
  - Only one site: AAOT
  - Only 110 matchups

*Ref.: Aznay, O., R. Santer, and F. Zagolski, 2014. "Validation of the atmospheric scattering functions used in the atmospheric correction over the ocean", International Journal of Remote Sensing, **35** (13), pp. 4984-5003.*

AERONET Sites

- Alta Acqua Oceanographic Tower (AAOT, Venice's offshore platform) in the Adriatic Sea

  (coastal waters + coastal atmosphere)

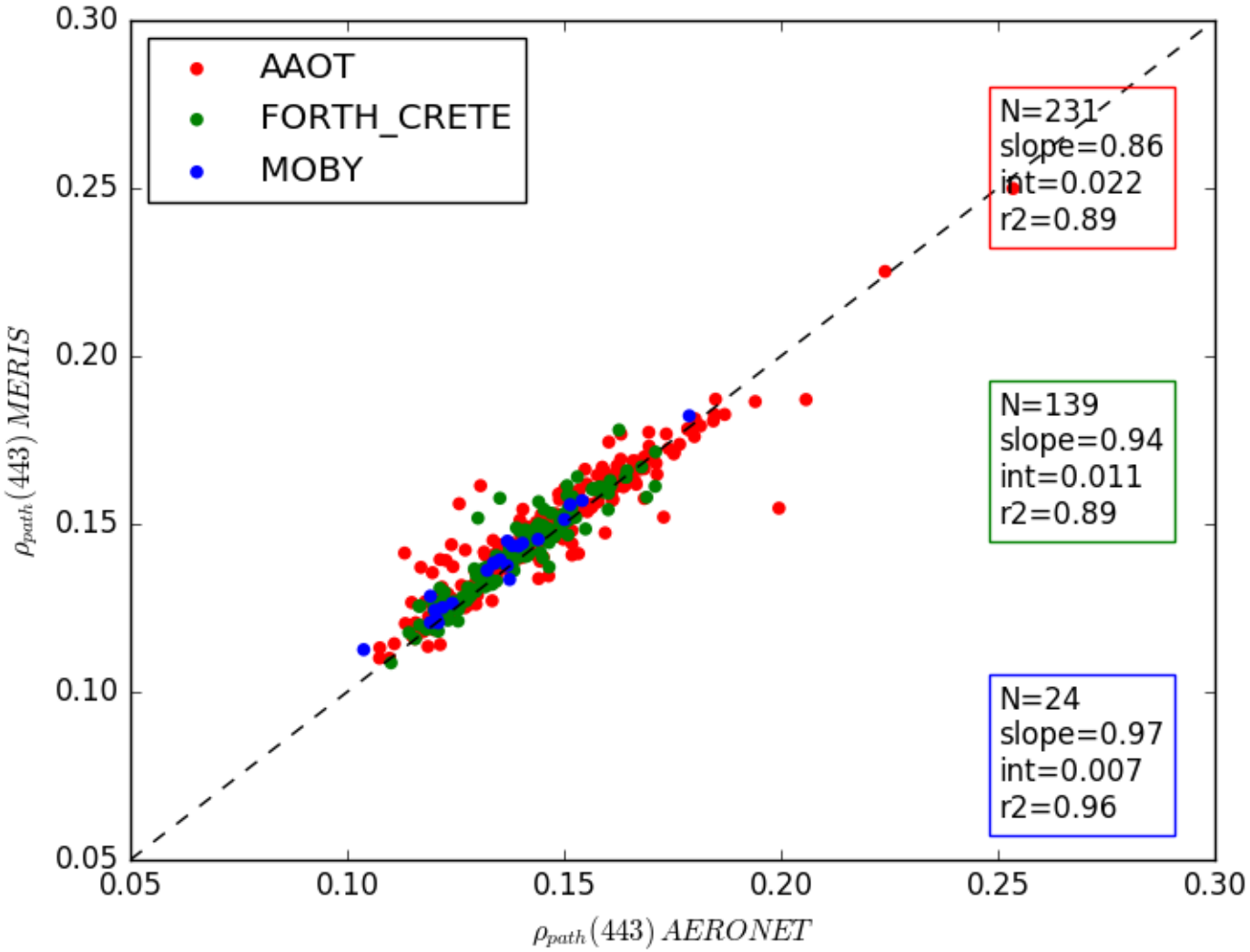
- Forth Crete (station located on the coastline in the North of Crete)

  (oligotrophic waters + clear atmosphere)

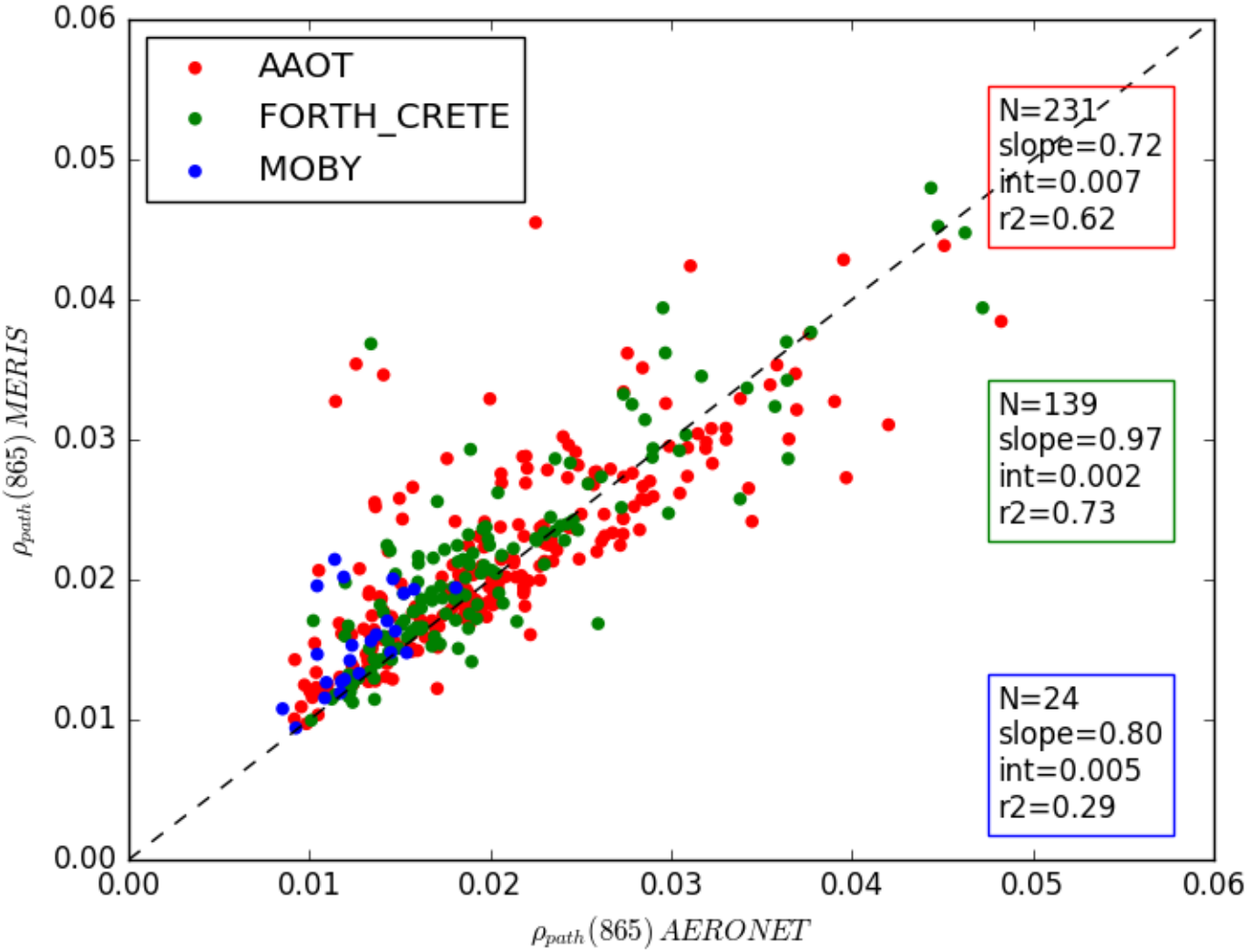
- Marine Optical BuoY (MOBY, Lanaii) in the Pacific Ocean

  (oligotrophic waters + very clear atmosphere)

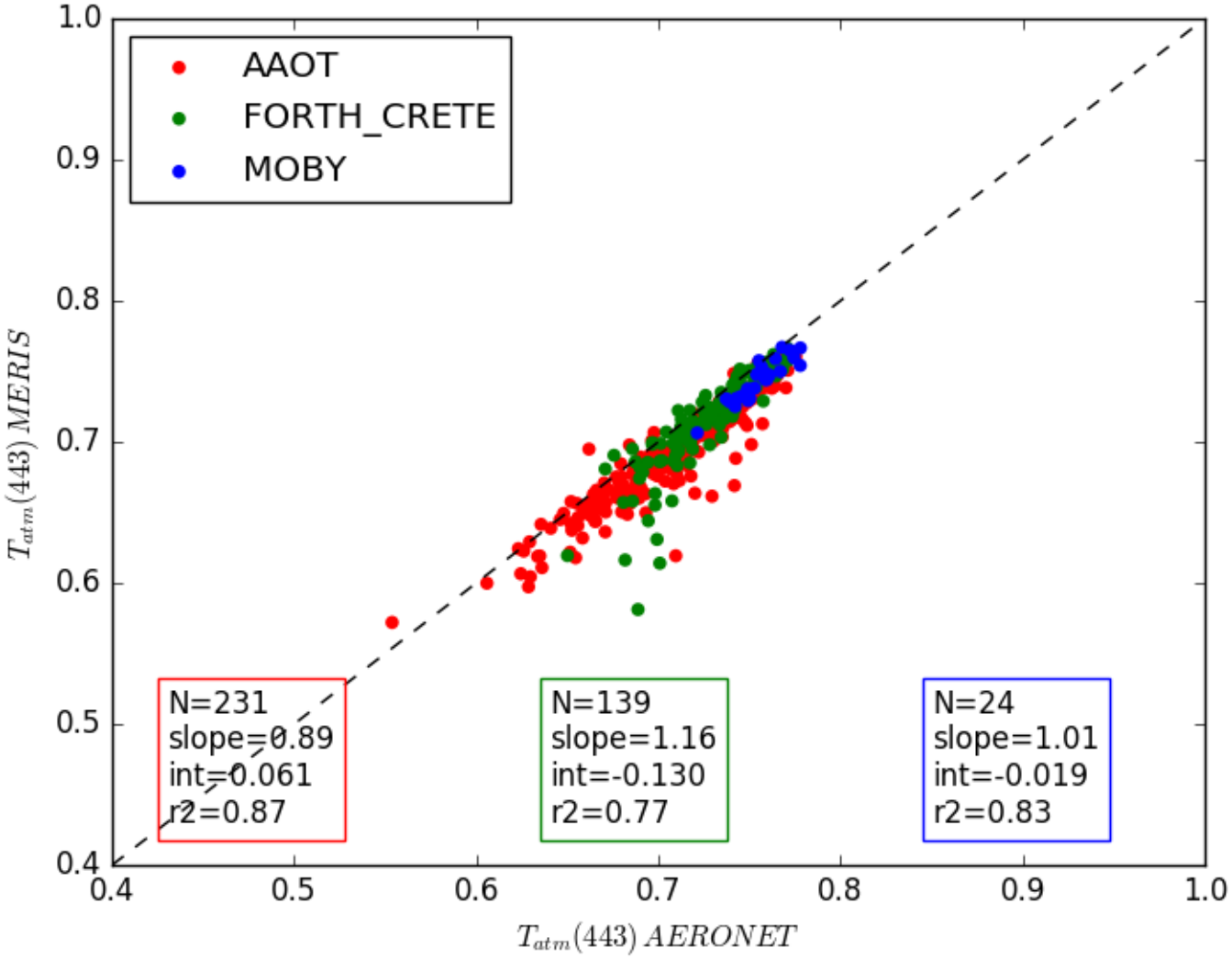
Atmospheric Reflectance (443nm)



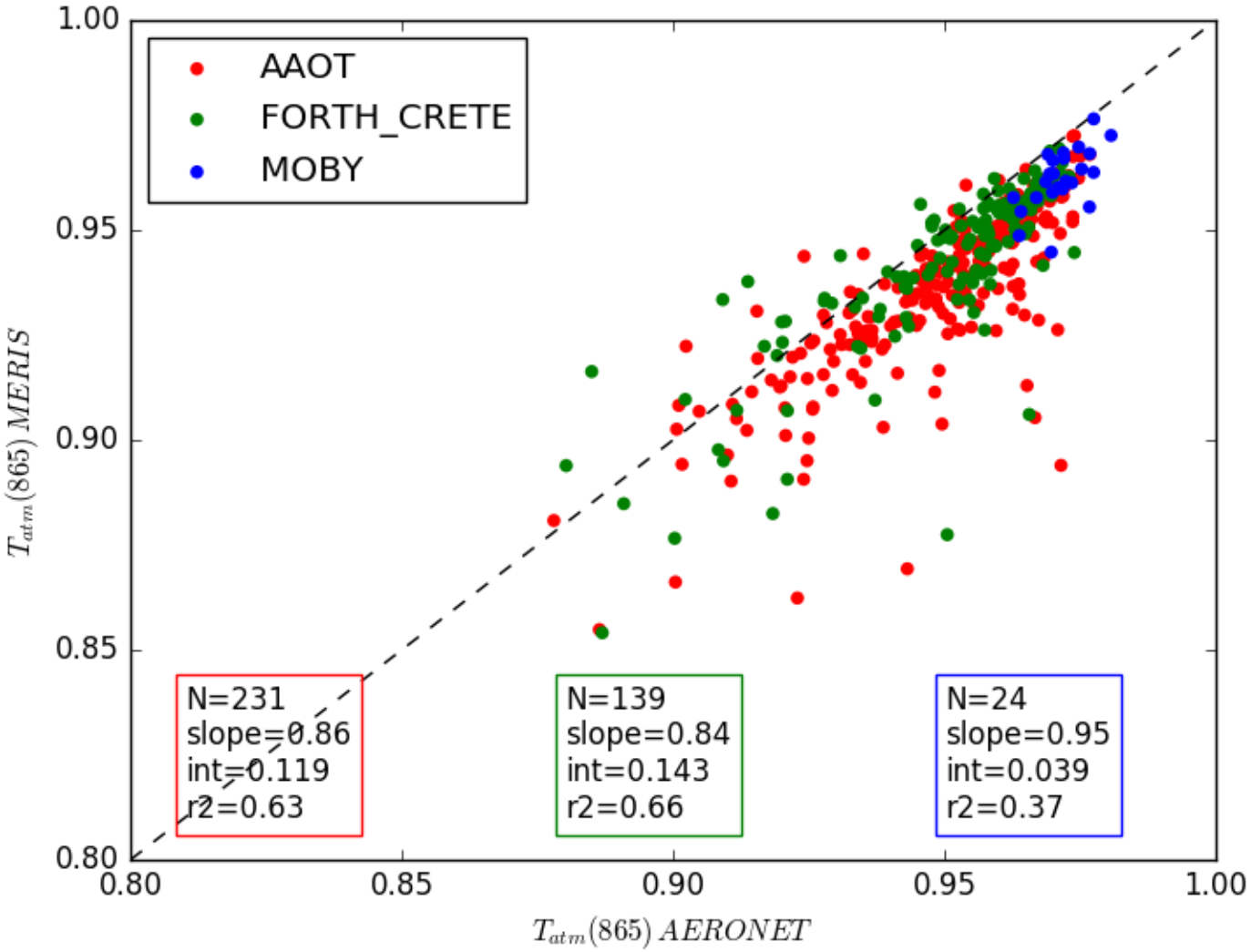
Atmospheric Reflectance (865nm)



Atmospheric Transmittance (443nm)



Atmospheric Transmittance (865nm)



Preliminary Conclusions-2

- Uncertainty around 3% on the atmospheric reflectance at 443nm
- Uncertainty around 1% on the atmospheric transmittance at 443nm
- This contributes to about 3% uncertainty on the vicarious calibration gains in the blue region

Perspectives

- MERIS-4RP (NASA/GSFC Climatology)
- Add 2 other AERONET sites
  - ⇨ Gustav-Dalen Tower (Baltic Sea) + Gloria (Black Sea)
- Use L2 quality flags in the statistical analysis
  - ⇨ PCD19, PCD1_13, …
- Assess the temporal variability of aerosols using the AERONET data bracketing the time of MERIS overpass
- Assess the spatial variability of aerosols by inspecting MERIS data over few kilometers around the site

Thank You !