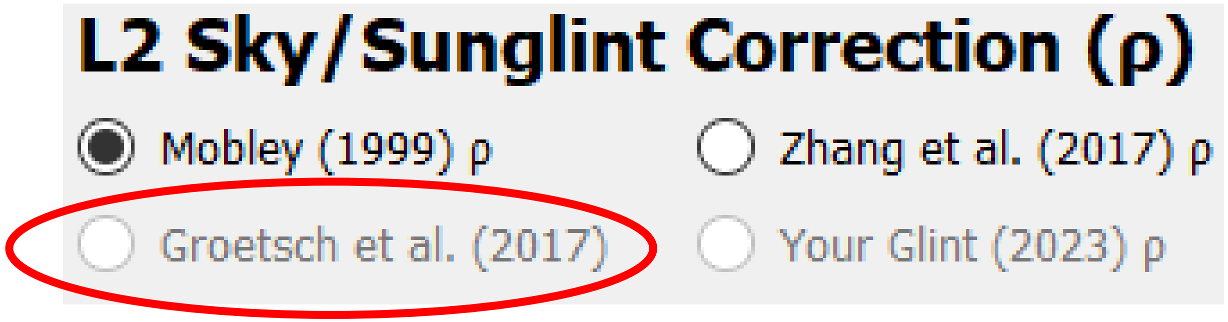
The 3C method for glint removal from above-surface radiometry

A summary and an update

HyperCP



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Validation of a spectral correction procedure for sun and sky reflections in above-water reflectance measurements

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Determination of the remote-sensing reflectance from above-water measurements with the "3C model": a further assessment

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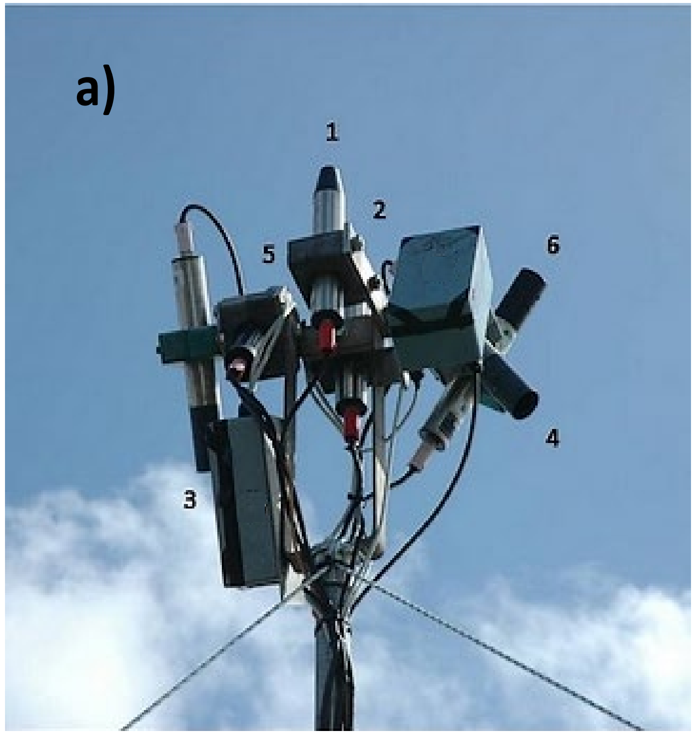
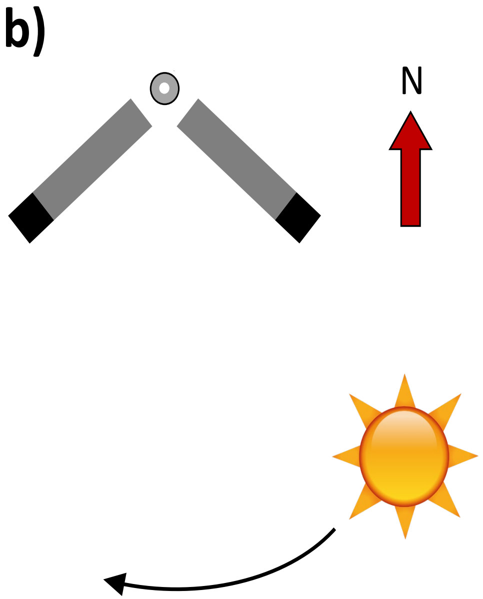
DISCLAIMER

- Not suitable for satellite validation
- Potentially harmful
- Use at your own risk

You have been warned!


GLINT
N





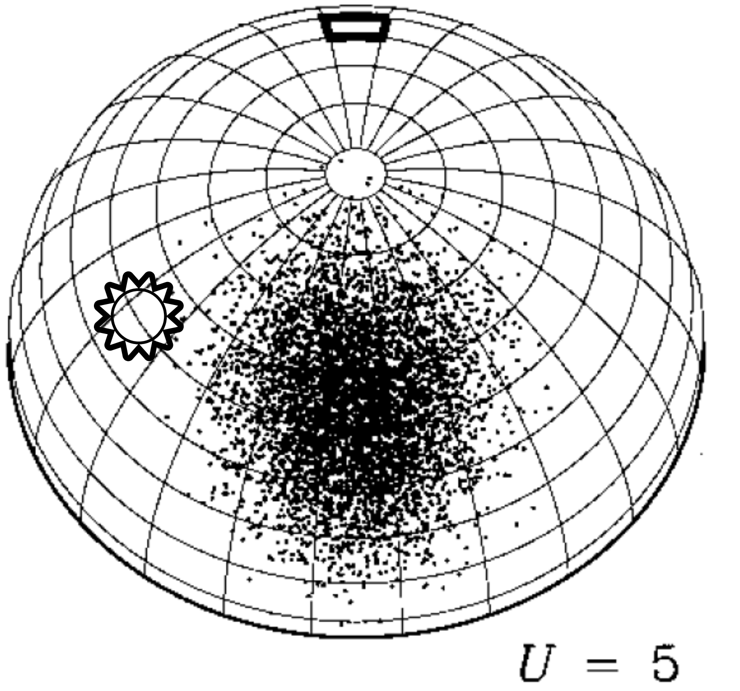
Measuring every 15 min since 2008

Protocol used at NIOZ before me

- Single radiance acquisitions
- Use the direction orientation (east or west) that has less $\frac{L_t}{E_s}$
- $R_{rs} = \frac{L_t - \rho L_i}{E_s}$

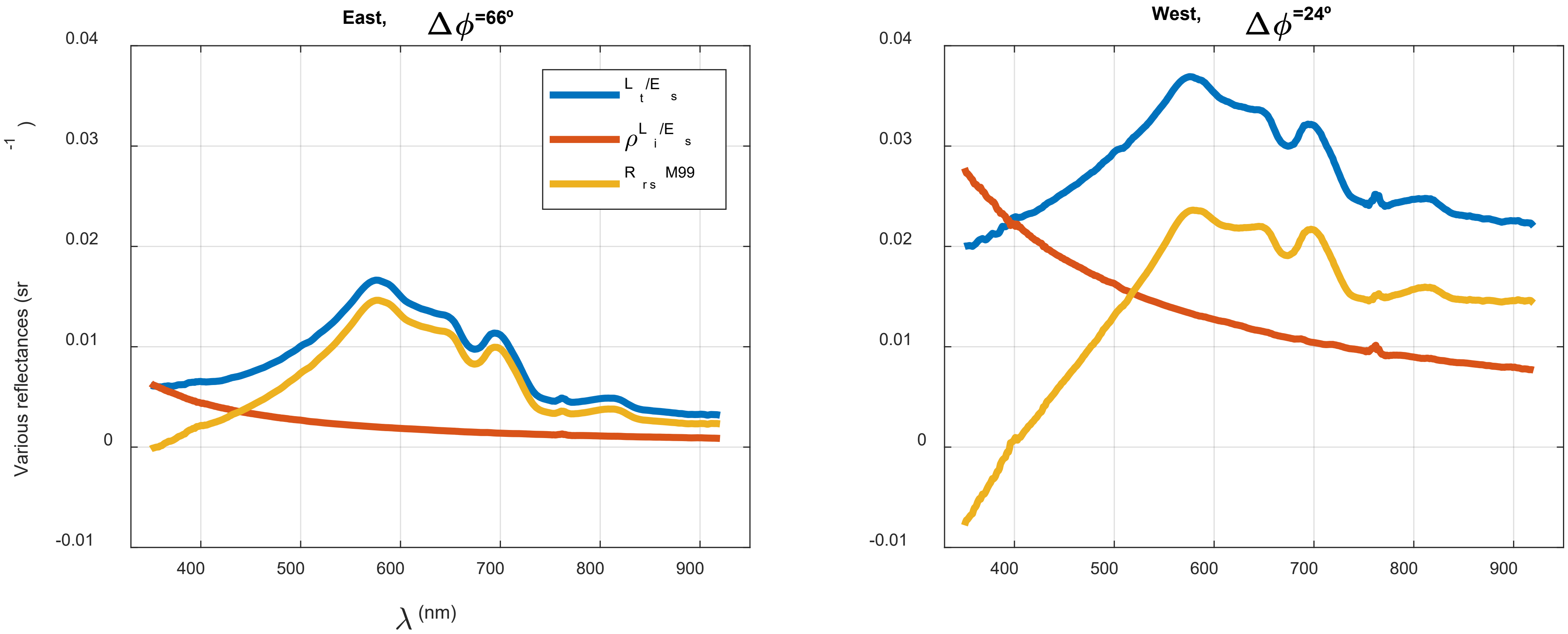
On statistical representativeness of the radiances involved in the correction

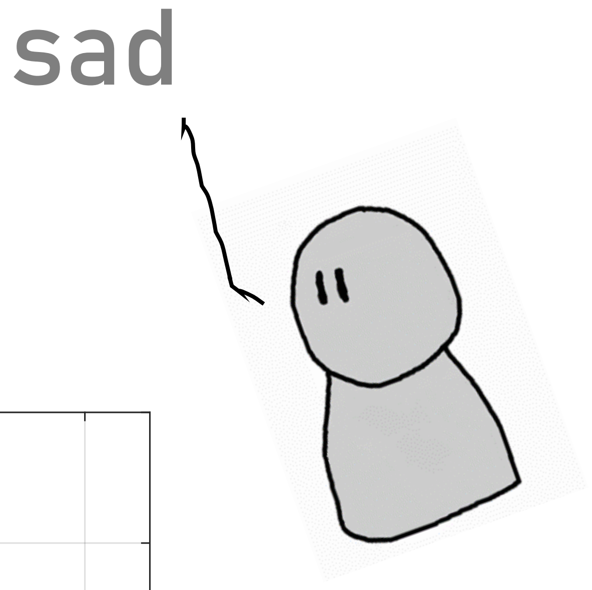
- We know: $\mathrm{L_w} = L_t - \rho L_i$
- But what is ρ?
- ρ is the result of Monte Carlo calculations over a large number of realizations for the PDF of the sea state given the wind speed
- Single acquisitions of L_t are an instantaneous sampling of that PDF → it needs multiple acquisitions
- Better written: $\mathrm{L_w} = \langle L_t \rangle - \rho \langle L_i \rangle$
- Not possible for NIOZ data



Case study
08-May-2008 12:30 UTC

- $\theta_s = 37°$, sunny, $w = 6\ m/s$



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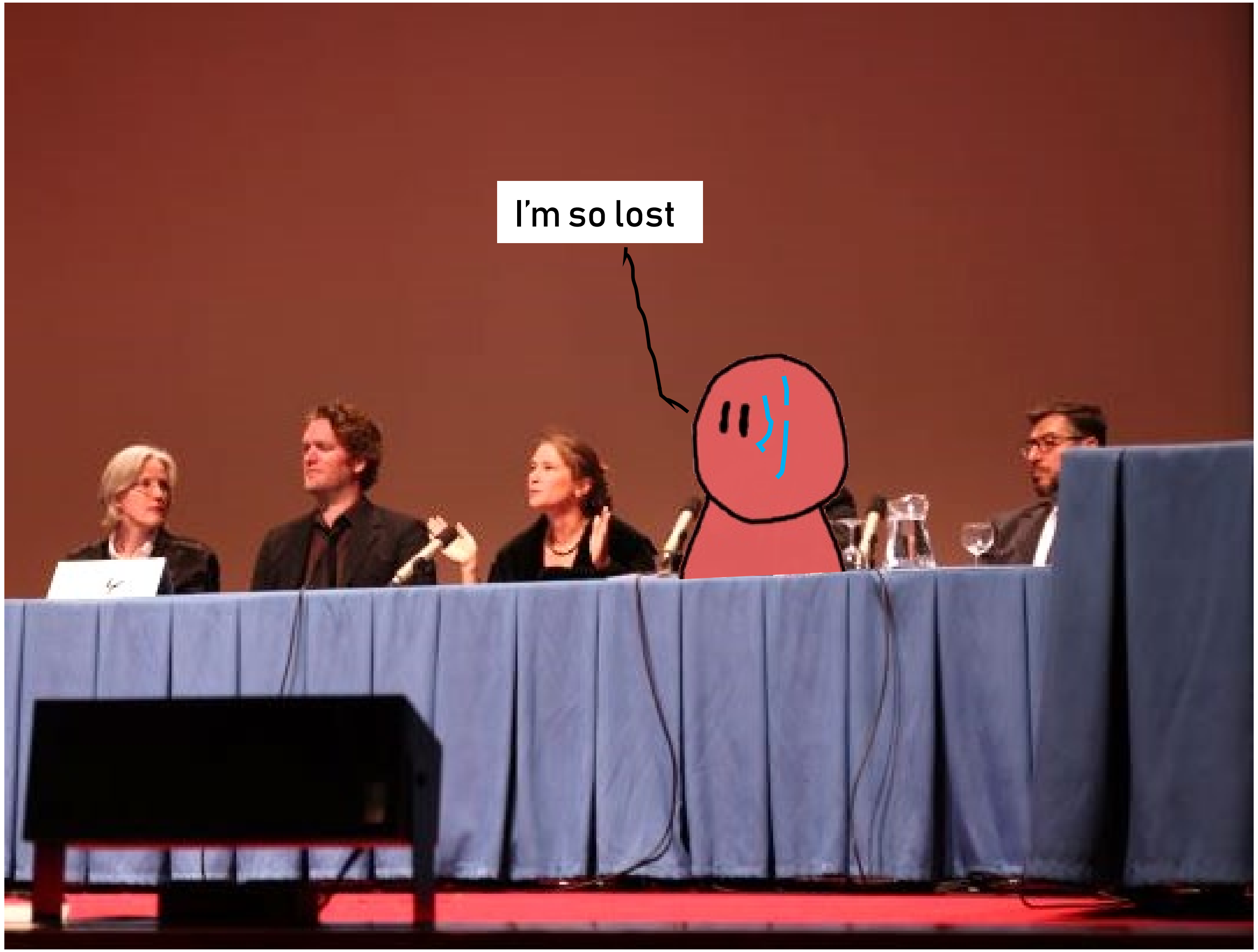
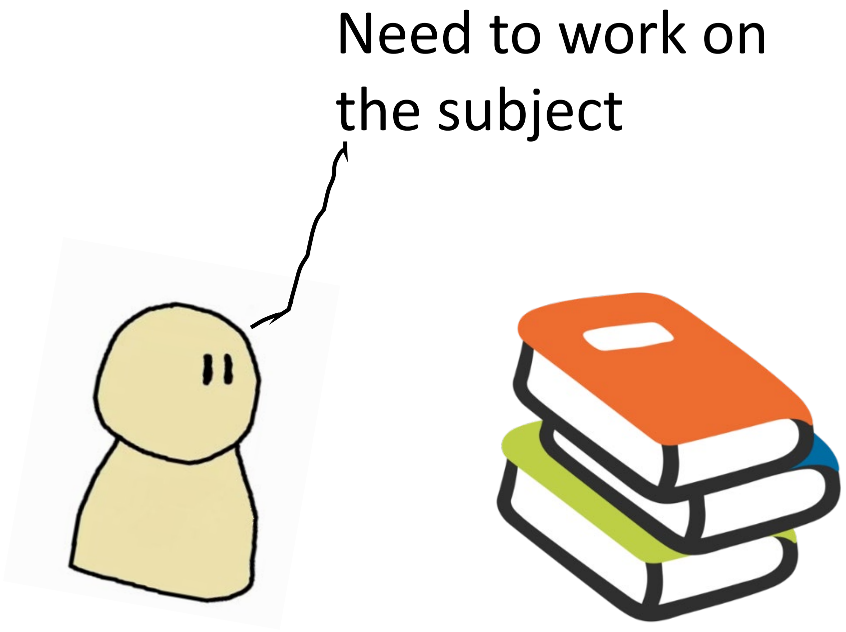

I'm so lost


Need to work on the subject

$$\mathrm{R}_{rs} = \frac{L_t}{E_s} - \rho_f \frac{L_i}{E_s} - \Delta(\lambda)$$

→ A term $\Delta(\lambda)$ is introduced (needs to be calculated)

$$\frac{L_t}{E_s} = \mathrm{R}_{rs} + \underbrace{\rho_f \frac{L_s}{E_s} + \Delta(\lambda)}_{\text{Glint}}$$

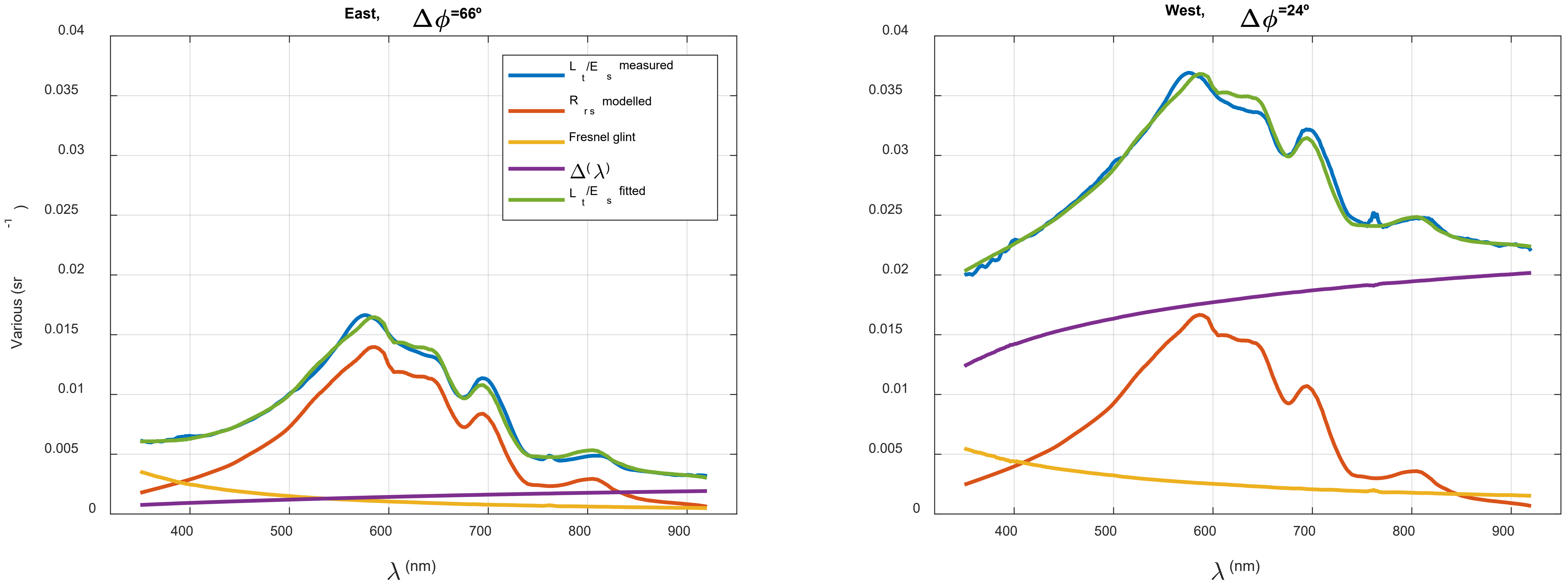
Glint

More generally:

$$\frac{L_t}{E_s}(\theta_s, \theta_v, \Delta\phi) = \mathrm{R}_{rs}(\theta_s, \theta_v, \Delta\phi) + R_g(\theta_s, \theta_v, \Delta\phi)$$

$$\frac{L_t}{E_s} = \mathrm{R}_{rs} + \rho_f \frac{L_i}{E_s} + \Delta(\lambda)$$

- The "$\Delta(\lambda)$" term should account for the missing glint after $\rho_f \frac{L_i}{E_s}$
- $\Delta(\lambda)$ is synthetic
- $\Delta(\lambda)$ is found by optimization of $\frac{L_t}{E_s}$



Let's dig a bit on the analytical models

- Groetsch et al. (2017) models R_{rs} using Albert and Mobley (2003)

$$R_{rs} = p_1\left(1 + p_2 x + p_3 x^2 + p_4 x^3\right) \times \left(1 + p_5 \frac{1}{\cos\theta_s}\right)\left(1 + p_6 u\right) \times \left(1 + p_7 \frac{1}{\cos\theta_v}\right) x$$

$$x = \frac{b_b}{a + b_b}, \mathrm{u} \rightarrow \text{wind speed}$$

- How can you model R_{rs} without taking into consideration the azimuth?
- …you don't
- → I shift to Lee et al. (2011)

Lee et al. (2011) model

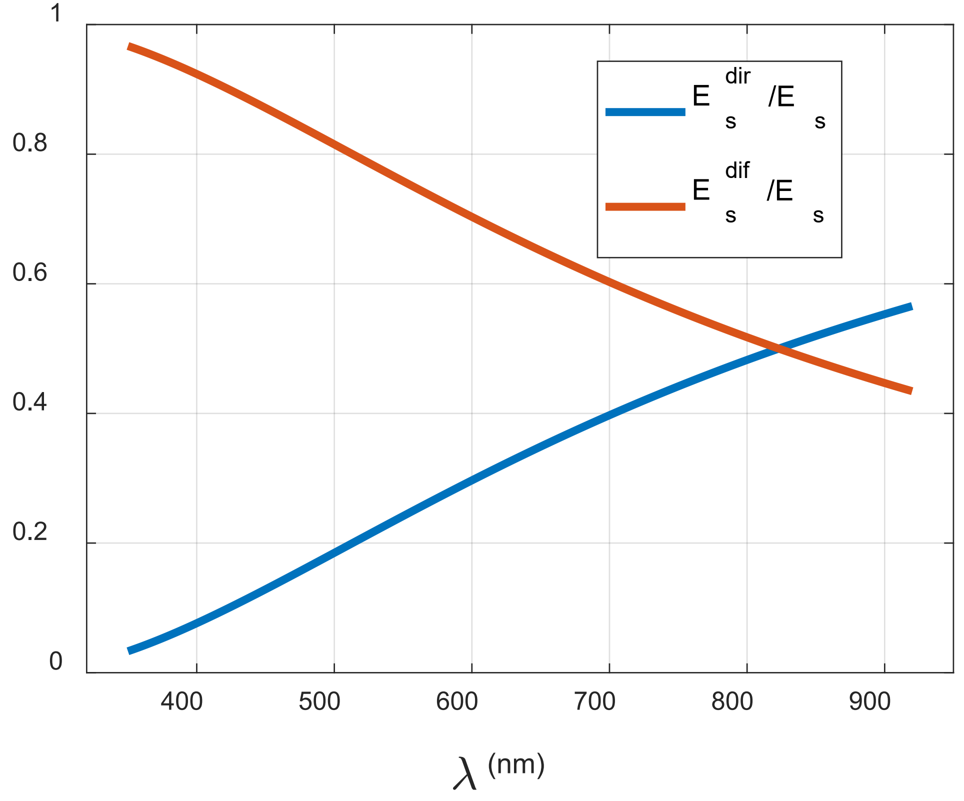
$$R_{rs}(\theta_s, \theta_v, \Delta\phi, IOPs) =$$

$$[G_0^w(\theta_s, \theta_v, \Delta\phi) + G_1^w(\theta_s, \theta_v, \Delta\phi)\omega_{bw}]\omega_{bw}$$
$$+\left[G_0^p(\theta_s, \theta_v, \Delta\phi) + G_1^p(\theta_s, \theta_v, \Delta\phi)\omega_{bp}\right]\omega_{bp}$$

- CHL, CDOM and TSM are guessed, determining ω_{bw} and ω_{bp}
- See that the influences of the geometry $(\theta_s, \theta_v, \Delta\phi)$ and the IOPs are clearly separated in the analytical expresión
- The model is invertible for the IOPs → modified QAA

$$\Delta = f_{sd}\rho_{sd}\frac{1}{\pi}\frac{E_s^{dir}}{E_s} + f_{ss}\rho_{ss}\frac{1}{\pi}\frac{E_s^{dif}}{E_s}$$

Direct — Diffuse



$\frac{E_s^{dir}}{E_s}, \frac{E_s^{dif}}{E_s}$ are **basis functions** for the glint

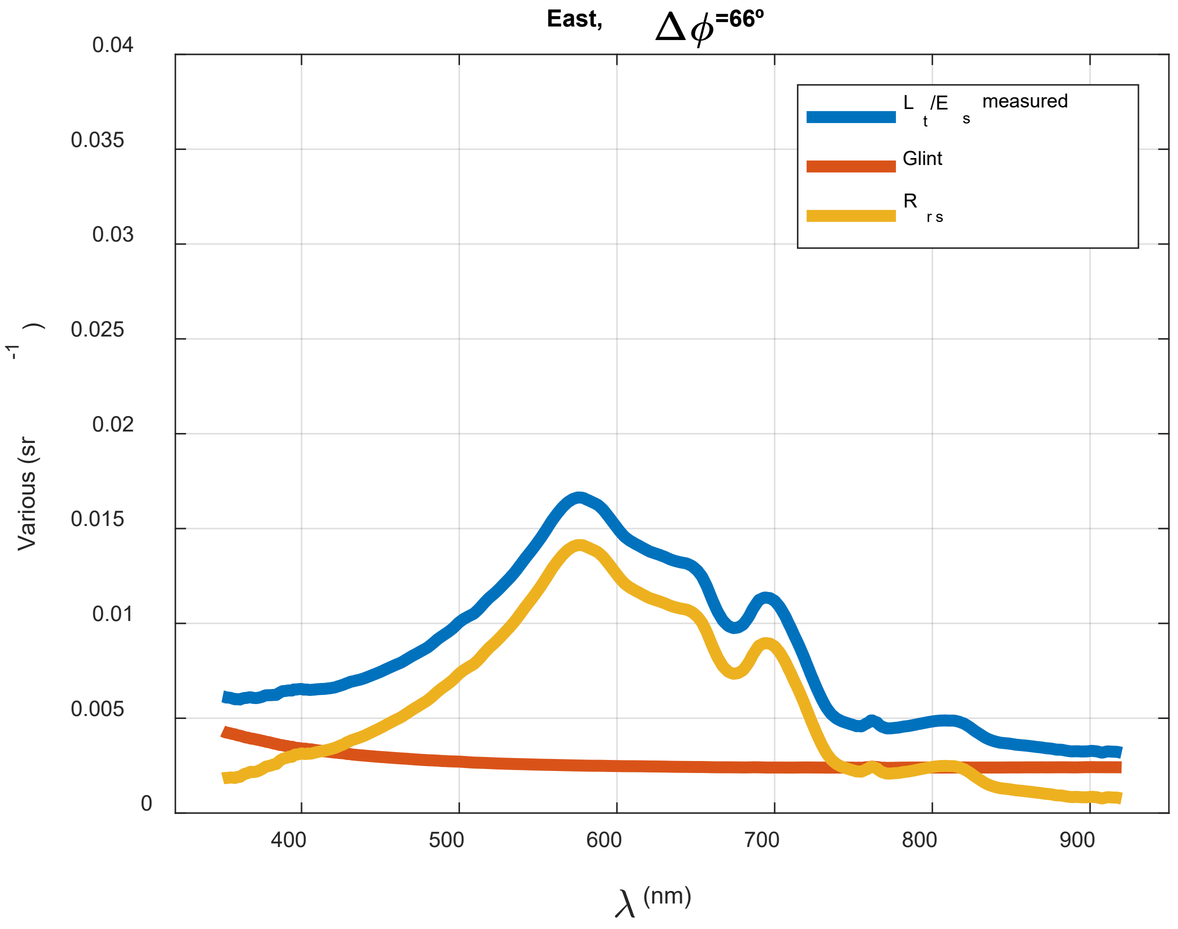
They can be…

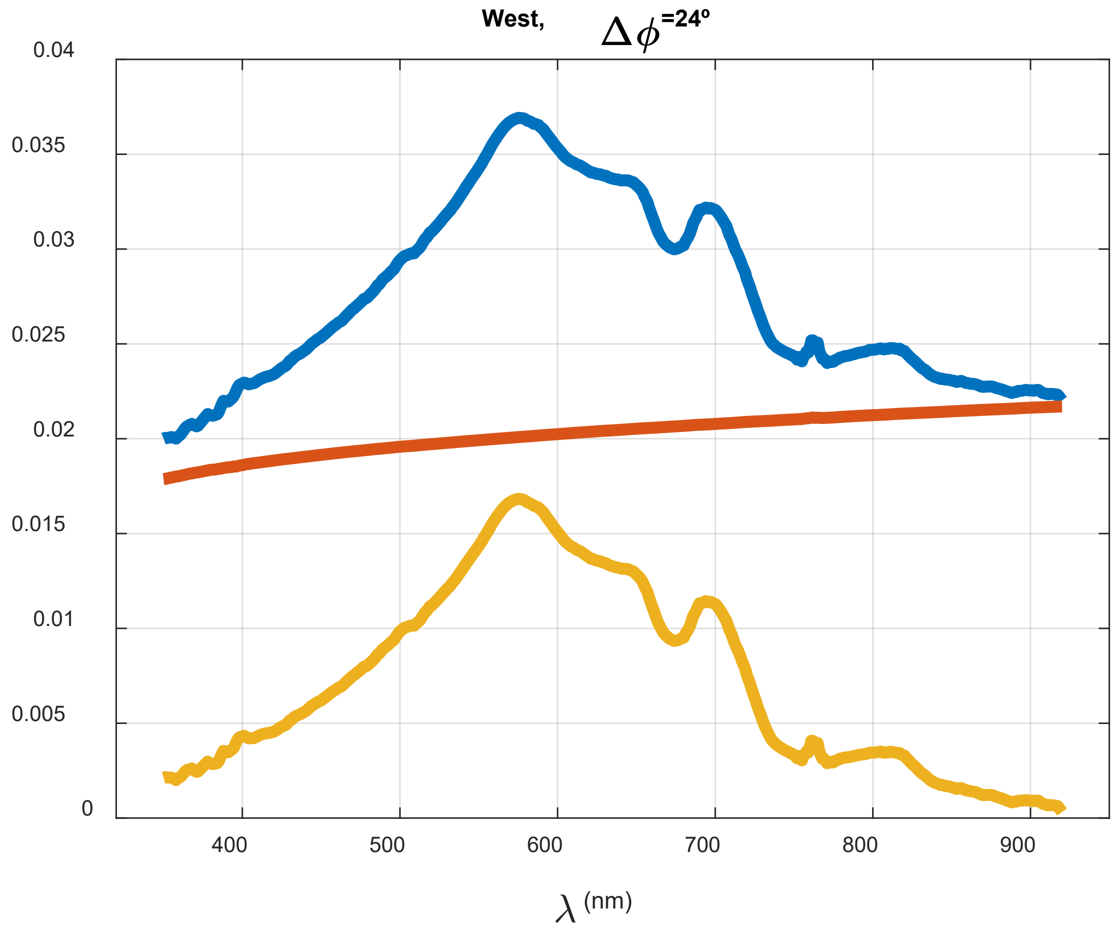
- Measured directly
- Guessed from atmospheric data + RTE
- Guessed by fitting $\frac{L_t}{E_s}$ with Gregg and Carder, 1990)

- ρ_{sd}, ρ_{ss} → Surface reflectance factors, KNOWN (Gege, 2012)
- f_{sd}, f_{ss} → Fractions of the reflected direct and diffuse irradiances contributing to L_u, UNKNOWN

Results

- Low glint in the east sensors, dominated by the $\frac{L_i}{E_s}$ term
- High glint in the west sensors, dominated by direct radiation





Summary

- The 3C model guesses the glint that is embedded in $\frac{L_t}{E_s}$
- Glint is expressed as diffuse and direct components
- 3C naturally simplifies to Mobley's method for sunny skies and high azimuths
- Likely reliable for some azimuthal range $\Delta\phi < 90°$
- Ruddick's "similarity" method can be assumed implicit
- Operational 3C model is bugged
- https://gitlab.com/pgroetsch/rrs_model_3C in python
- https://gitlab.com/jaipipor/rrs_model_3c_matlab to be updated

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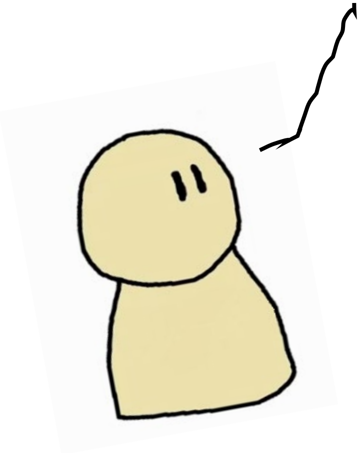
Read our paper



Thank you!