Marine Reflectance in the Short Wave Infrared (1000-3000nm, esp. 1000-1150nm)

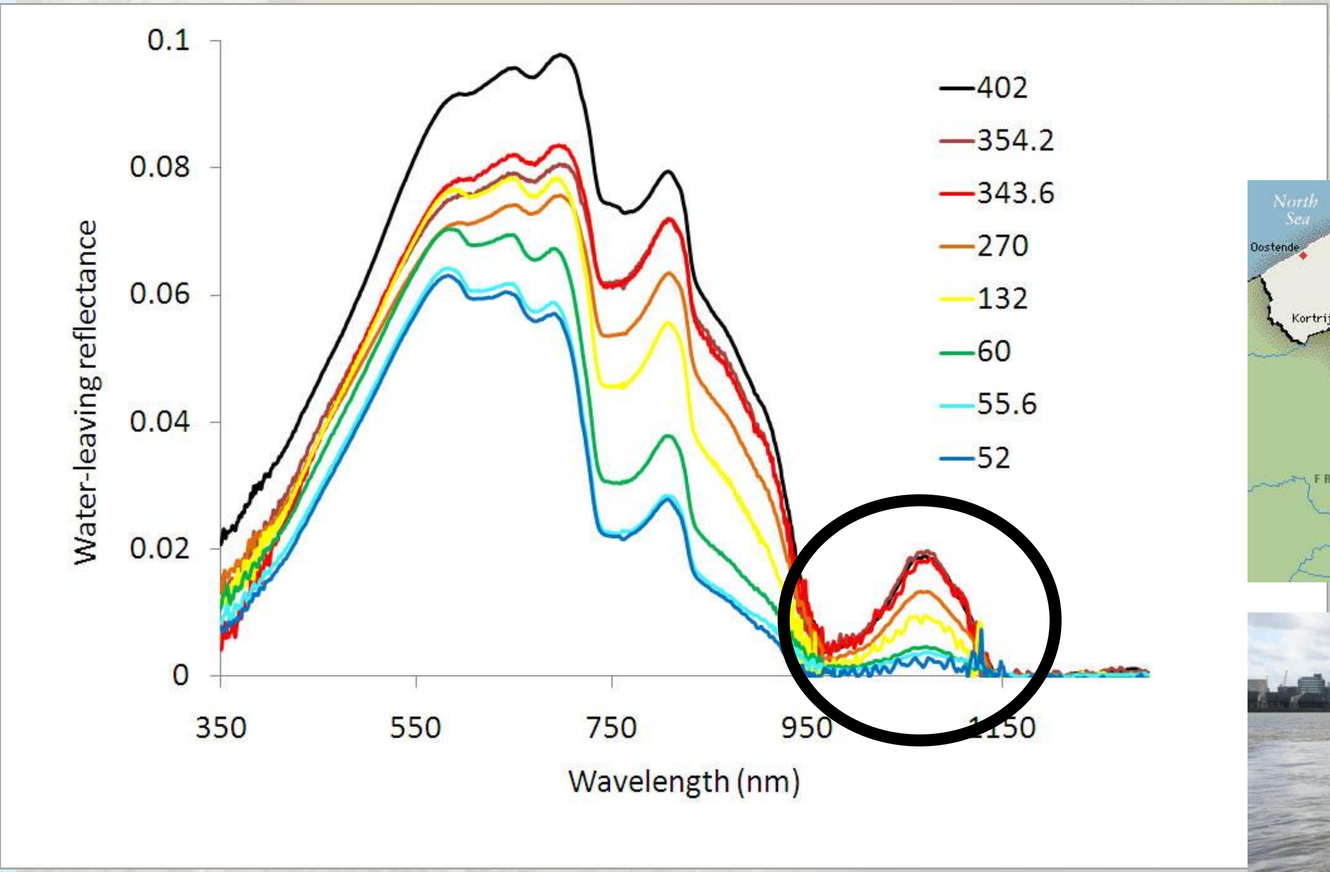
For extremely turbid waters

Belcolour – MICAS heritage

SeaSWIR

Knaeps, E., Raymaekers, D., Sterckx, S, Ruddick, K., Dogliotti, A.I.. 2012. In situ evidence of non-zero reflectance in the OLCI 1020nm band for a turbid estuary, *Remote Sensing of Environment*, *Sentinel special issue*, 112

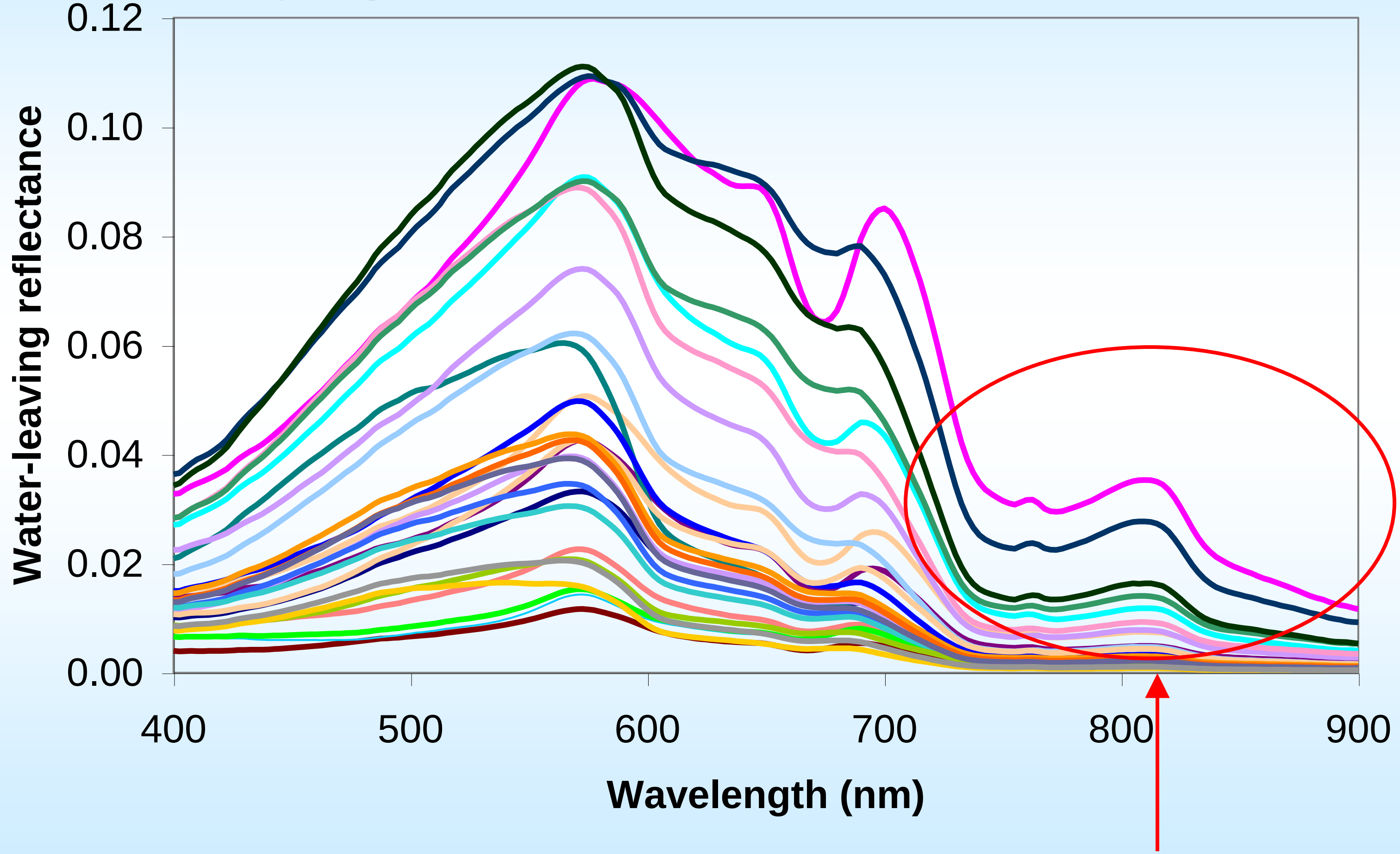
Pure water absorption coefficient (Pope & Fry, 1997; Kou *et al.*, 1993)



Background: Near Infrared (700-900nm) reflectance

[Ruddick, De Cauwer, Park and Moore. Seaborne measurements of near infrared water-leaving reflectance: The similarity spectrum. Limnol. Oceanogr., 51(2), 2006, 1167–1179]

« Similarity spectrum » – what does that mean?



All reflectance spectra have the same shape here

Theory: Near Infrared (700-900nm) reflectance

SeaSWIR

[Ruddick, De Cauwer, Park and Moore. Seaborne measurements of near infrared water-leaving reflectance: The similarity spectrum. Limnol. Oceanogr., 51(2), 2006, 1167–1179]

- Gordon/Morel reflectance models give:

$$\rho_w(\lambda) \equiv \pi \frac{L_w^{0+}}{E_d^{0+}} = \frac{\pi \Re f'}{Q} \frac{b_b(\lambda)}{a(\lambda)+b_b(\lambda)}$$

- Supposing for the near infrared (700-900nm):

$$\gamma = \frac{\pi \Re f'}{Q} \text{ indepedent of wavelength, } \lambda$$

$$b_b >> a \quad \text{and} \quad \frac{b_b}{a+b_b} \approx \frac{b_b}{a}$$

$$b_b(\lambda) = b_{b0} \text{ independent of wavelength}$$

$$a(\lambda) \approx a_w(\lambda)$$

$$\Rightarrow \rho_w(\lambda) \approx \gamma \frac{b_{b0}}{a_w(\lambda)}$$

Reflectance spectral shape depends on $a_w(\lambda)$, magnitude on b_{b0}

Theory: Near Infrared (700-900nm) reflectance

[Ruddick, De Cauwer, Park and Moore. Seaborne measurements of near infrared water-leaving reflectance: The similarity spectrum. Limnol. Oceanogr., 51(2), 2006, 1167–1179]

- Simple model for Water Reflectance in NIR (700-900nm) is:

$$\rho_w(\lambda) = \gamma b_{b0*} * TSM * \frac{a_w(780nm)}{a_w(\lambda)} \left(\frac{\lambda}{780nm}\right)^{-n}$$

TSM=>Magnitude

Pure water absorption =>Shape

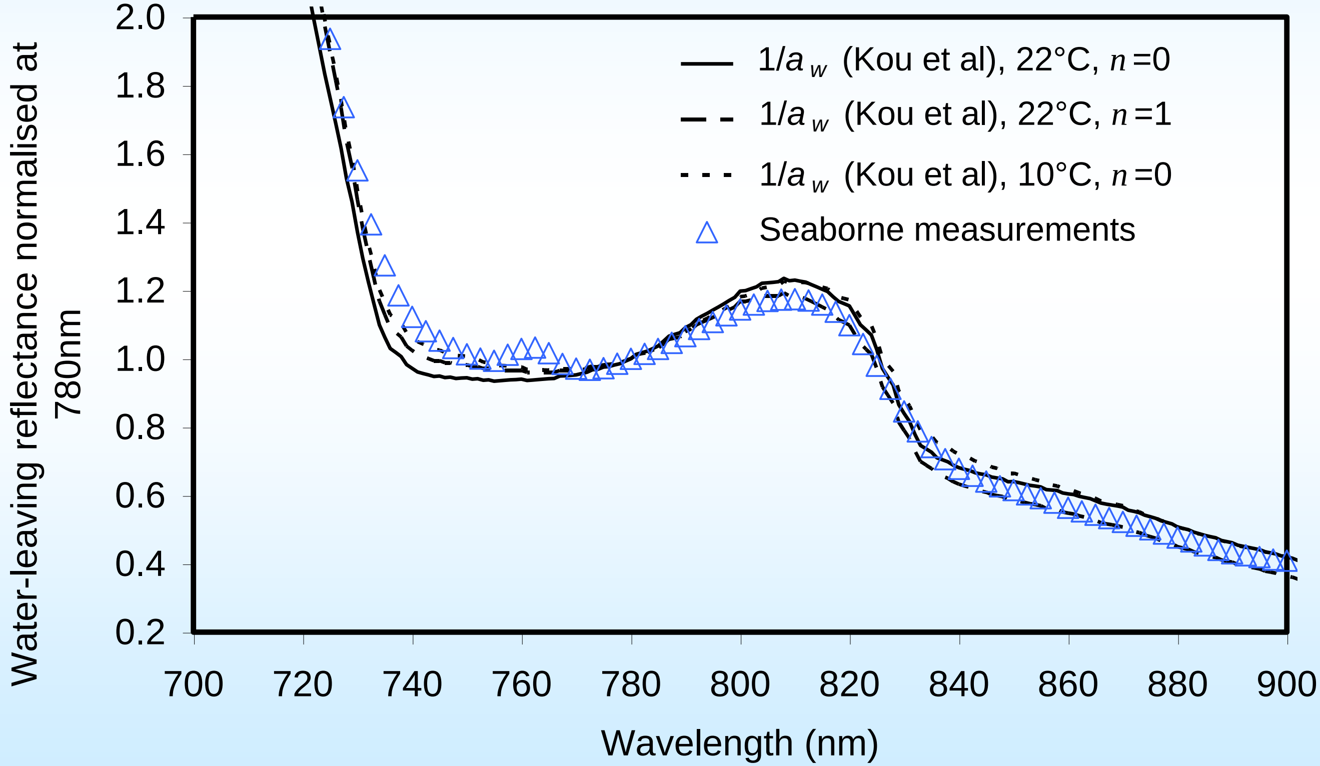
Particulate backscatter slope =2nd order

High refl non-linearity, BRDF, etc =2nd order

Validation of simple NIR theory

[Ruddick, De Cauwer, Park and Moore. Seaborne measurements of near infrared water-leaving reflectance: The similarity spectrum. Limnol. Oceanogr., 51(2), 2006, 1167–1179]

- Comparing seaborne reflectance data (average of 27 measurement) with optical theory and lab water absorption (temp=10°, 22°C and b_b spectrum *n*=0,1)



Validation: Near Infrared (700-900nm) reflectance

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- TSM=>Magnitude
- Pure water absorption =>Shape
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- High refl non-linearity, BRDF, etc =2nd order

- LIMITATIONS:
  - High reflectance non-linearity [Doron et al, 2011; Wang et al, 2012]
  - Pure water absorption variation with temperature
  - BRDF (viewing and sun angles)

Theory: SWIR (1000-3000nm) reflectance

- Simple model for Water Reflectance in SWIR (1000-3000nm) is:

$$\rho_w(\lambda) = \gamma b_{b0*} * TSM * \frac{a_w(780nm)}{a_w(\lambda)} \left(\frac{\lambda}{780nm}\right)^{-n}$$

TSM=>Magnitude

Pure water absorption =>Shape

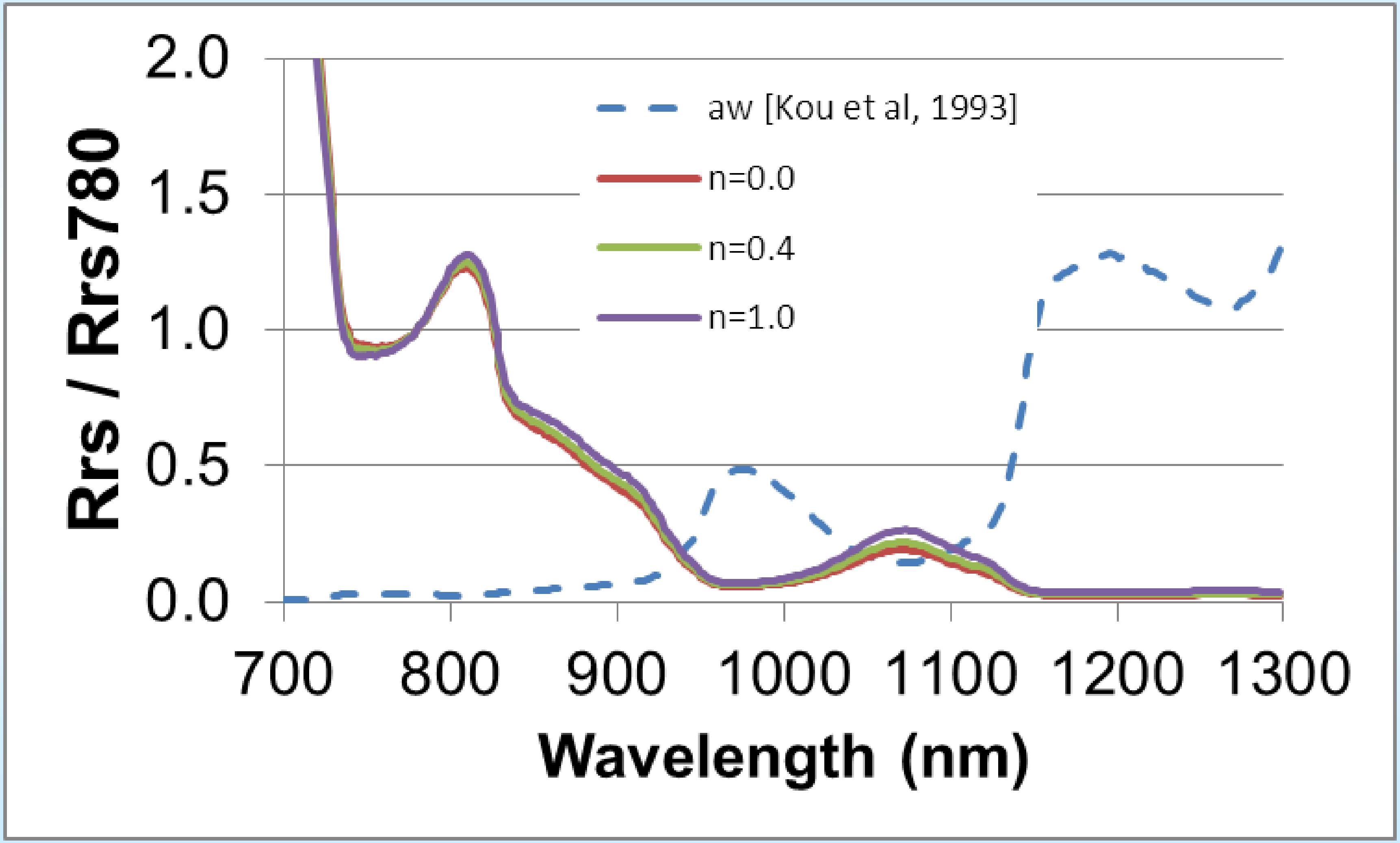
Particulate backscatter slope =2^{nd} order

High refl non-linearity, BRDF, etc =2^{nd} order

- Data needed for:
  - Pure water optical properties [Röttgers et al, 2011]
  - Spectral Particulate backscatter : new SeaSWIR BB instrument
  - Reflectance measurements for validation: ASD, CIMEL/SeaPRISM

NIR/SWIR Rrs simple model – aw and n_bbp

$$\rho_w(\lambda) = \gamma b_{b0*} * TSM * \frac{a_w(780nm)}{a_w(\lambda)} \left(\frac{\lambda}{780nm} \right)^{-n}$$



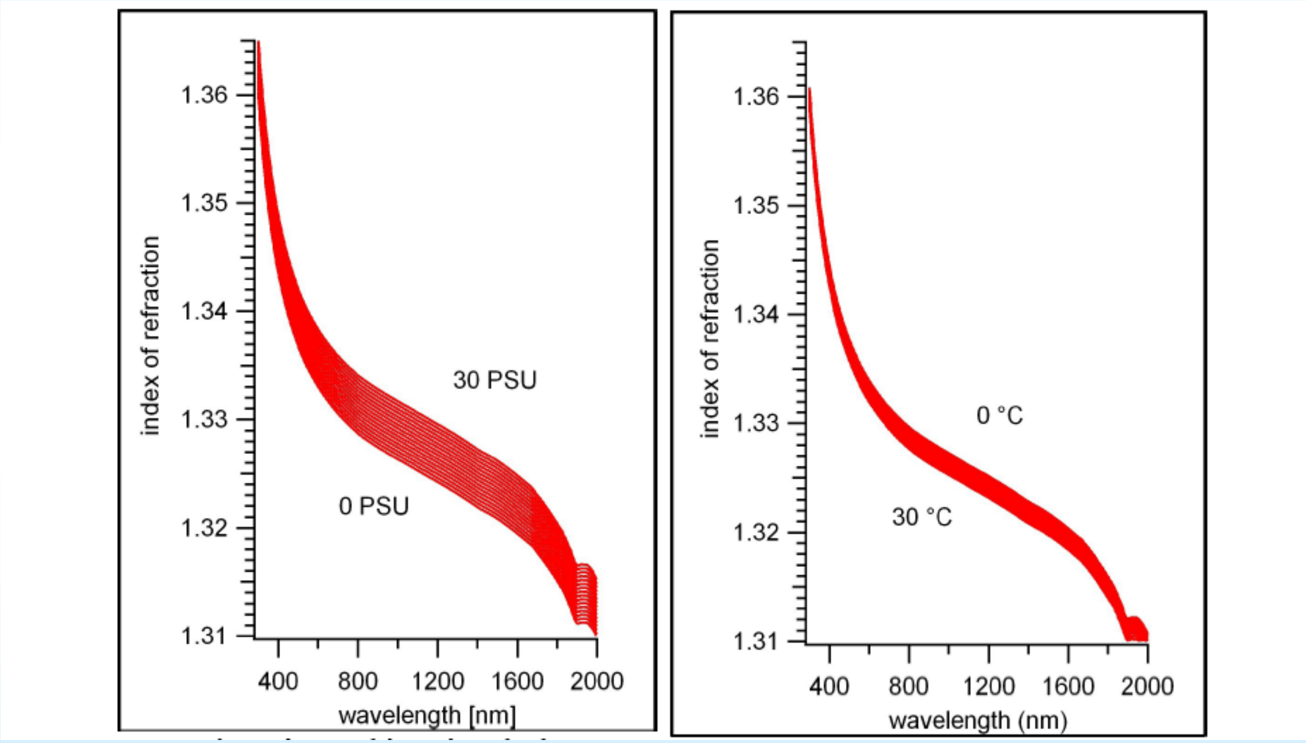
Conclusions

- Marine reflectance in the SWIR will be:
  - Proportional to bbp (or TSM)
  - Shaped by pure water absorption and bbp spectrum exponent
- SeaSWIR project is acquiring cal/val data:
  - Particulate backscatter (700-1040nm)
  - Marine Reflectance (ASD: 400-2000+nm, CIMEL: 1020nm)
  - Total Suspended Matter, turbidity
  - Other bio-optical properties (ap, etc.)
- … and running Hydrolight, more accurate than simple theoretical model

Acknowledgement: Belgian Science Policy Office SeaSWIR project funding

Theory (II) – Sunglint in the SWIR

- For AATSR processing there is a salinity-correction for the sea surface Fresnel coeff. in the SWIR [Röttgers et al, 2011]:



- … so can sunglint reflection be used as a basis for a high resolution (10m!) Coastal Zone Salinity Scanner ?