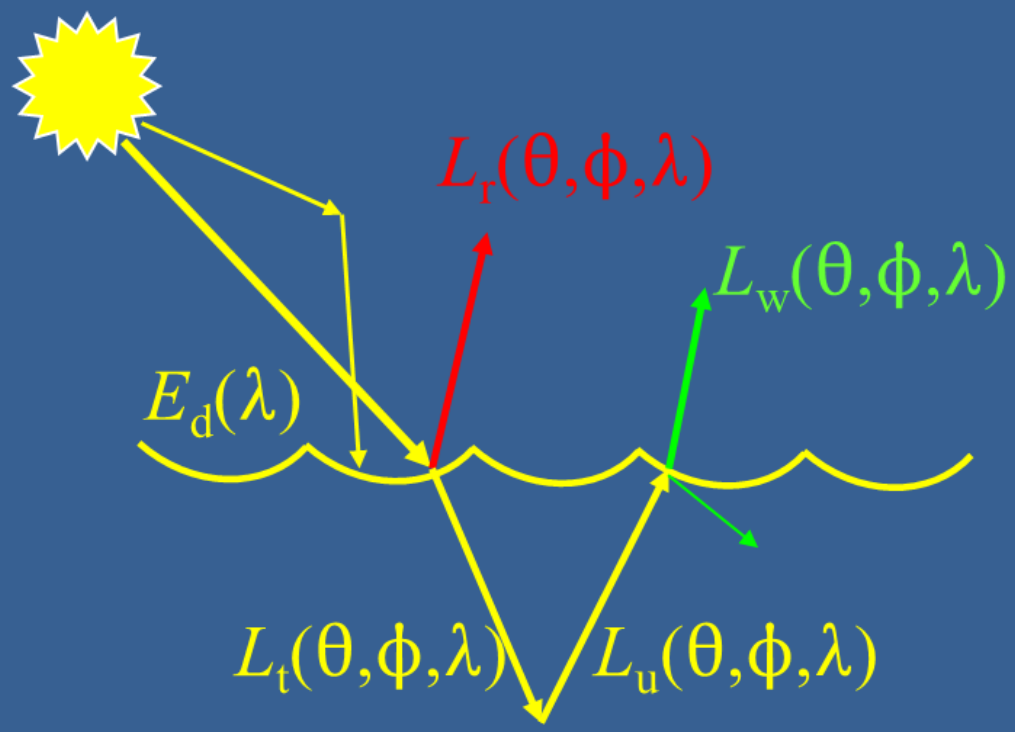
Multiple Choice Exam
on
Chlorophyll Fluorescence

(allowing you to show off all that you have learned this week)

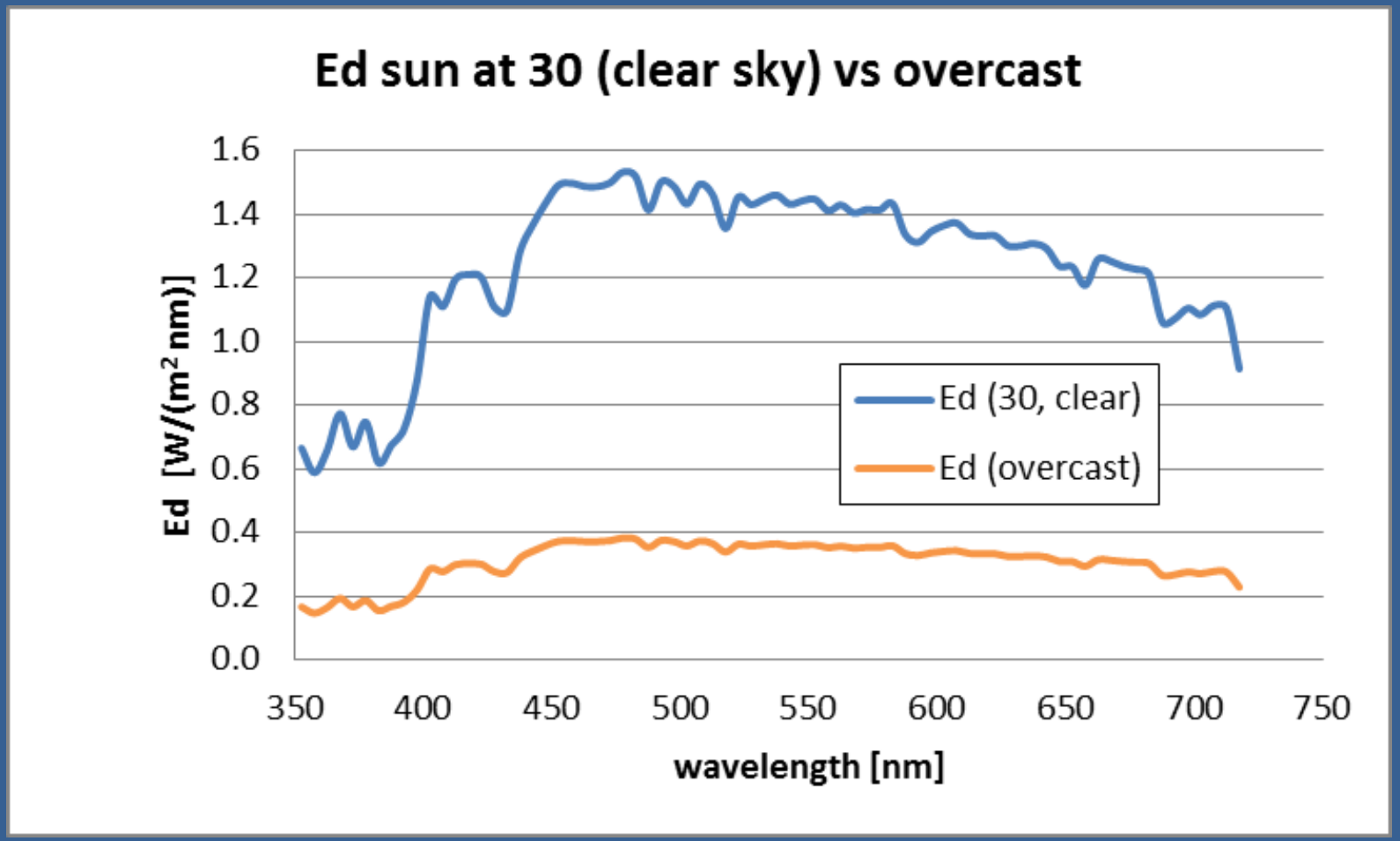
Quick review of R_{rs}: The apparent optical property (AOP) used for remote sensing



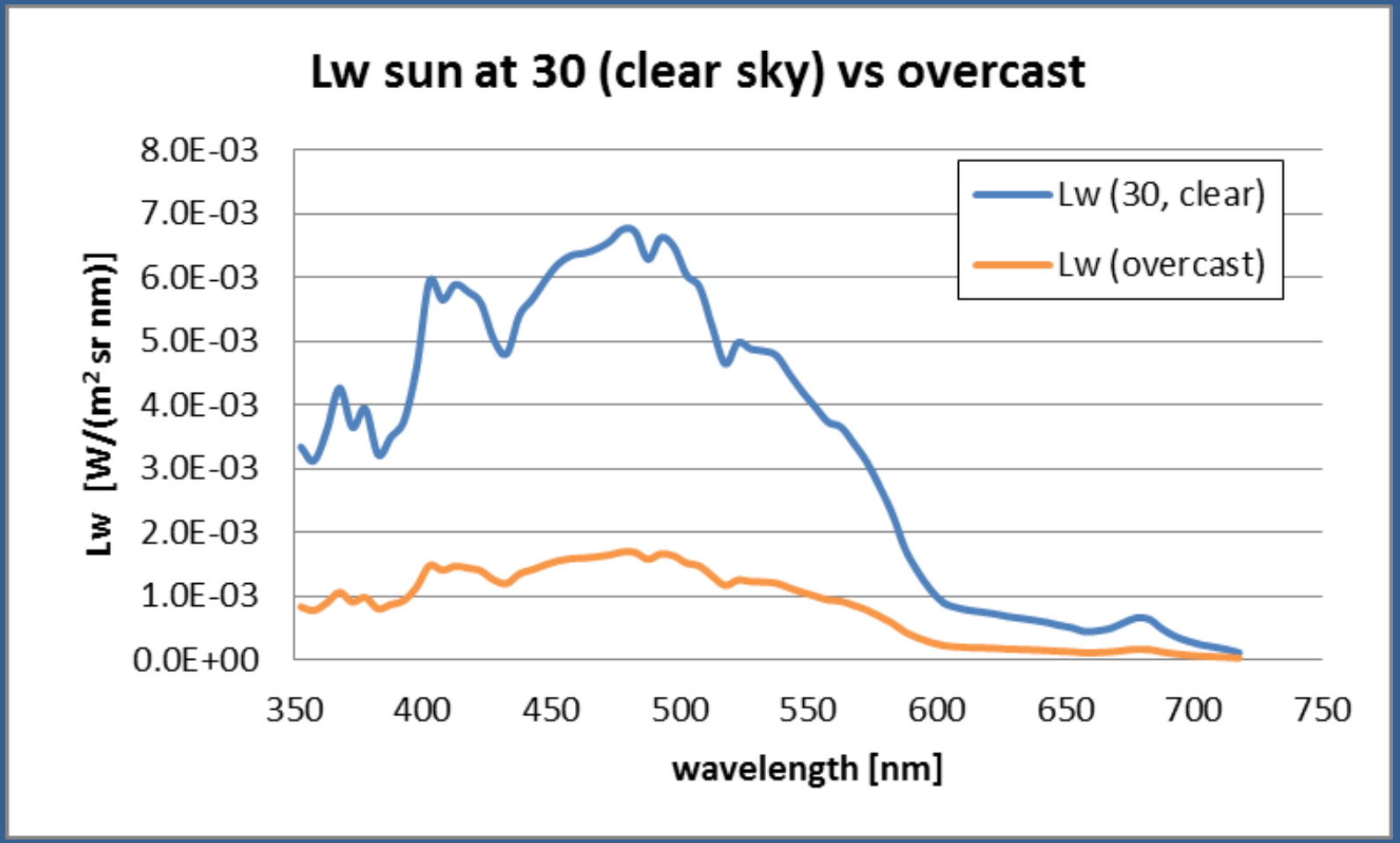
$$R_{rs}(\theta,\varphi,\lambda) = \frac{\text{upwelling water-leaving radiance}}{\text{downwelling plane irradiance}}$$

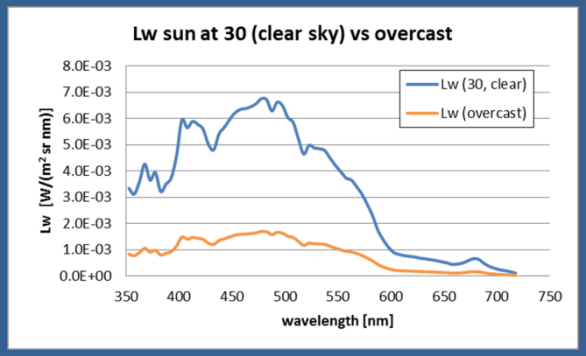
$$R_{rs}(\text{in air},\theta,\varphi,\lambda) \equiv \frac{L_w(\text{in air},\theta,\varphi,\lambda)}{E_d(\text{in air},\lambda)} \qquad [\text{sr}^{-1}]$$

HydroLight run with sun at a 30 deg zenith angle in a clear sky vs an overcast sky (5 nm resolution, U = 5 m/s, RTE solved to 30 m, etc.)



HydroLight run with sun at a 30 deg zenith angle in a clear sky vs an overcast sky




Lw sun at 30 (clear sky) vs overcast
Lw (30, clear)
Lw (overcast)
Lw [W/(m² sr nm)]
8.0E-03
7.0E-03
6.0E-03
5.0E-03
4.0E-03
3.0E-03
2.0E-03
1.0E-03
0.0E+00
350 400 450 500 550 600 650 700 750
wavelength [nm]

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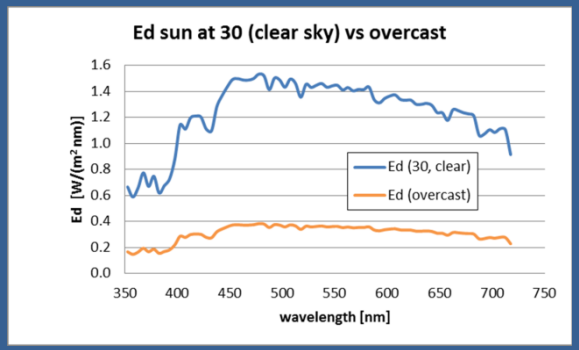
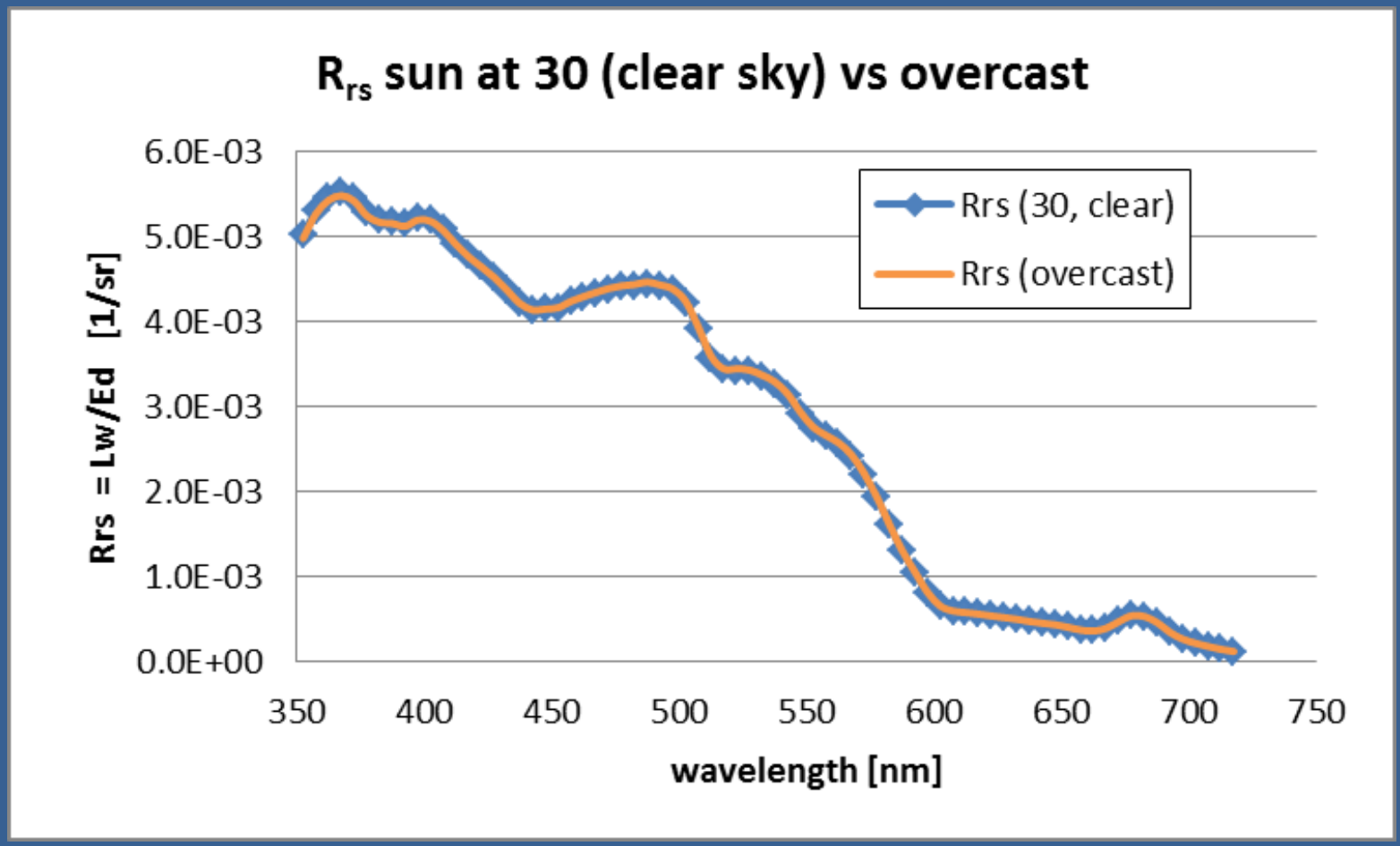
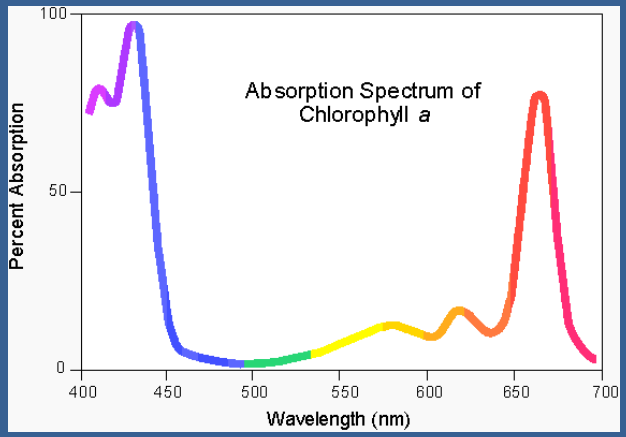

Ed sun at 30 (clear sky) vs overcast
Ed (30, clear)
Ed (overcast)
Ed [W/(m² nm)]
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
350 400 450 500 550 600 650 700 750
wavelength [nm]

=


Rrs sun at 30 (clear sky) vs overcast
Rrs (30, clear)
Rrs (overcast)
Rrs = Lw/Ed [1/sr]
6.0E-03
5.0E-03
4.0E-03
3.0E-03
2.0E-03
1.0E-03
0.0E+00
350 400 450 500 550 600 650 700 750
wavelength [nm]

Remember that Chl fluorescence is proportional to

- How much chlorophyll there is to absorb light
- How much light is available to be absorbed
- How efficiently the chlorophyll re-emits photons (the quantum efficiency)

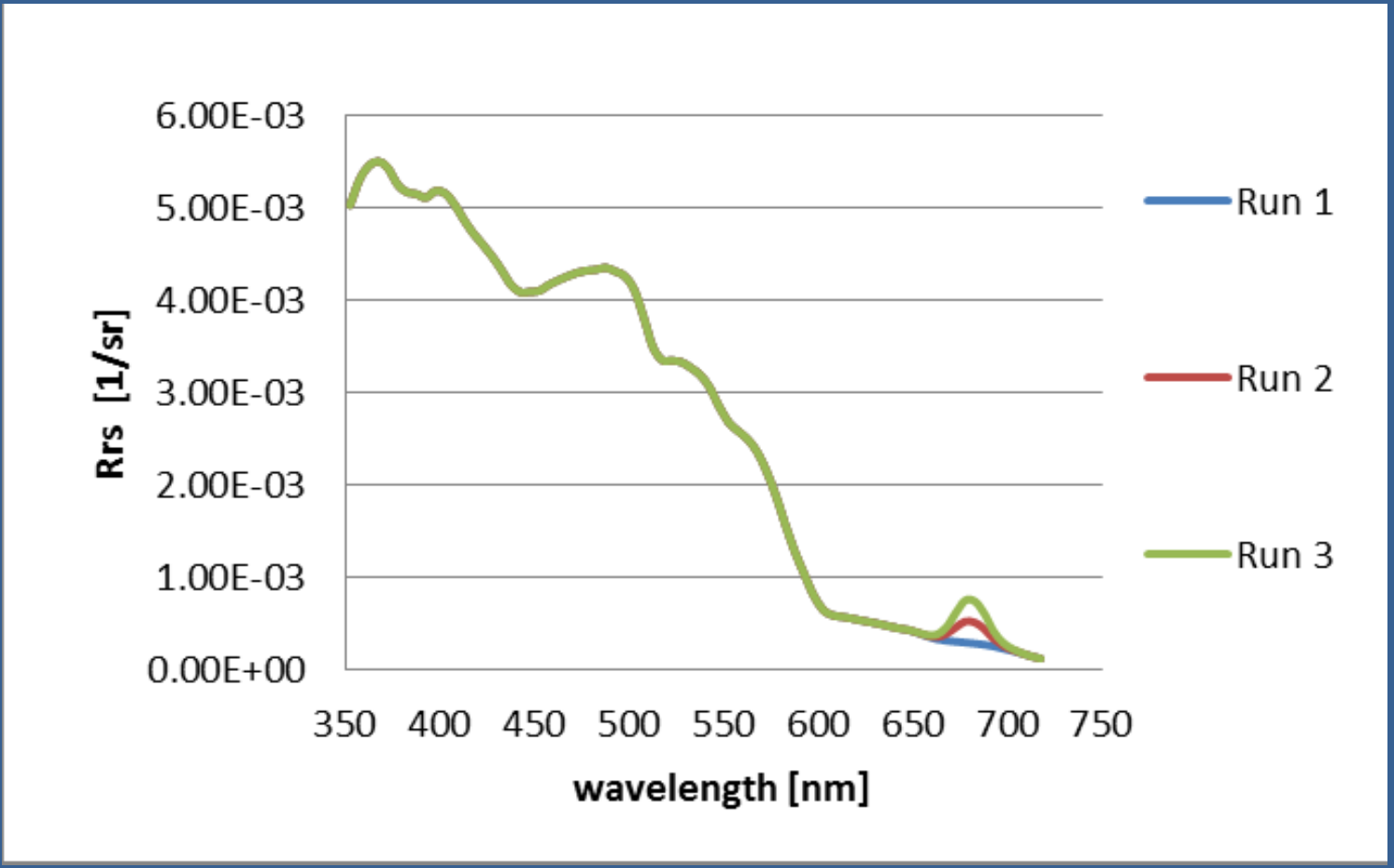


From MJP

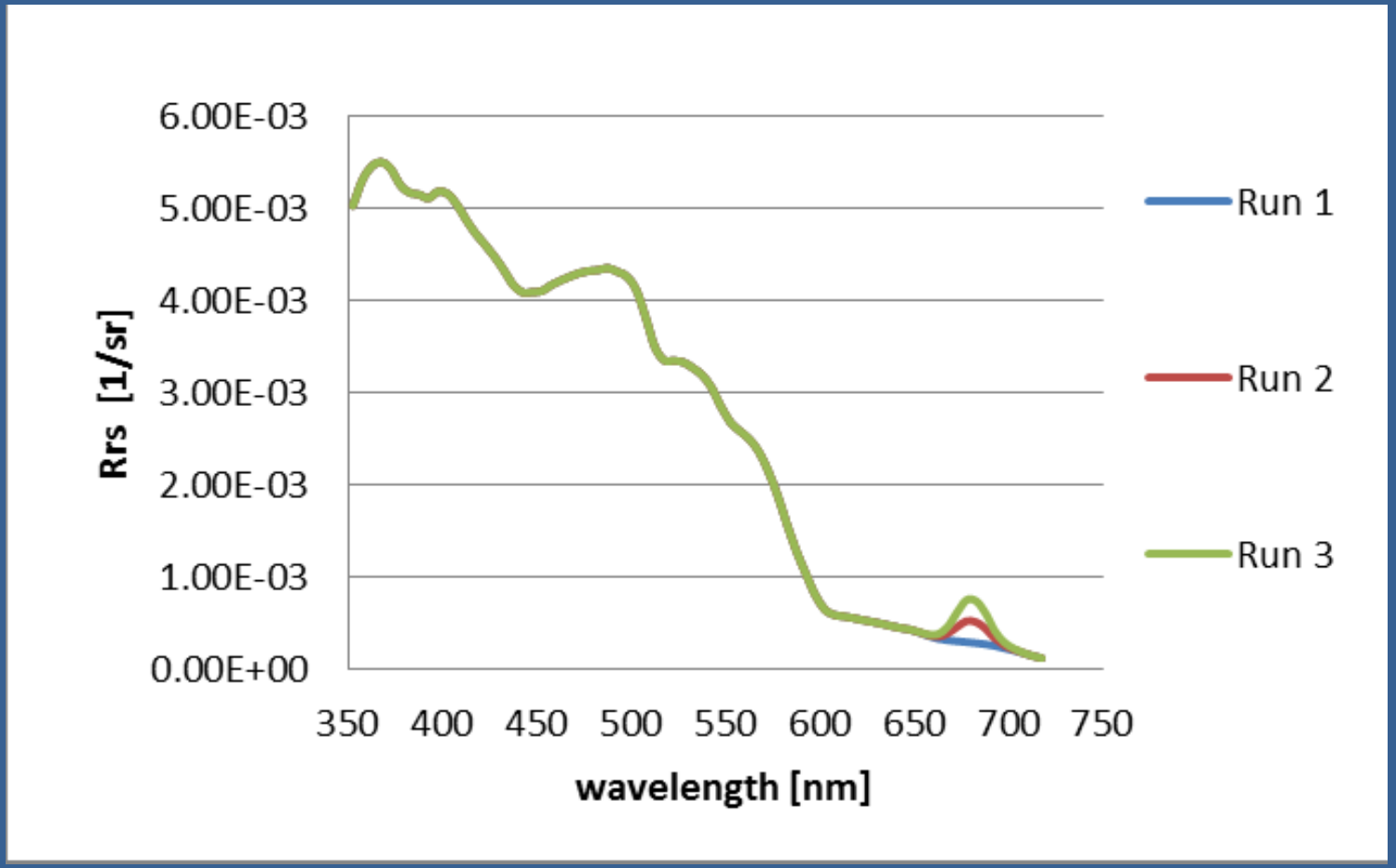
Now you explain the following R_{rs} spectra. Your choices are

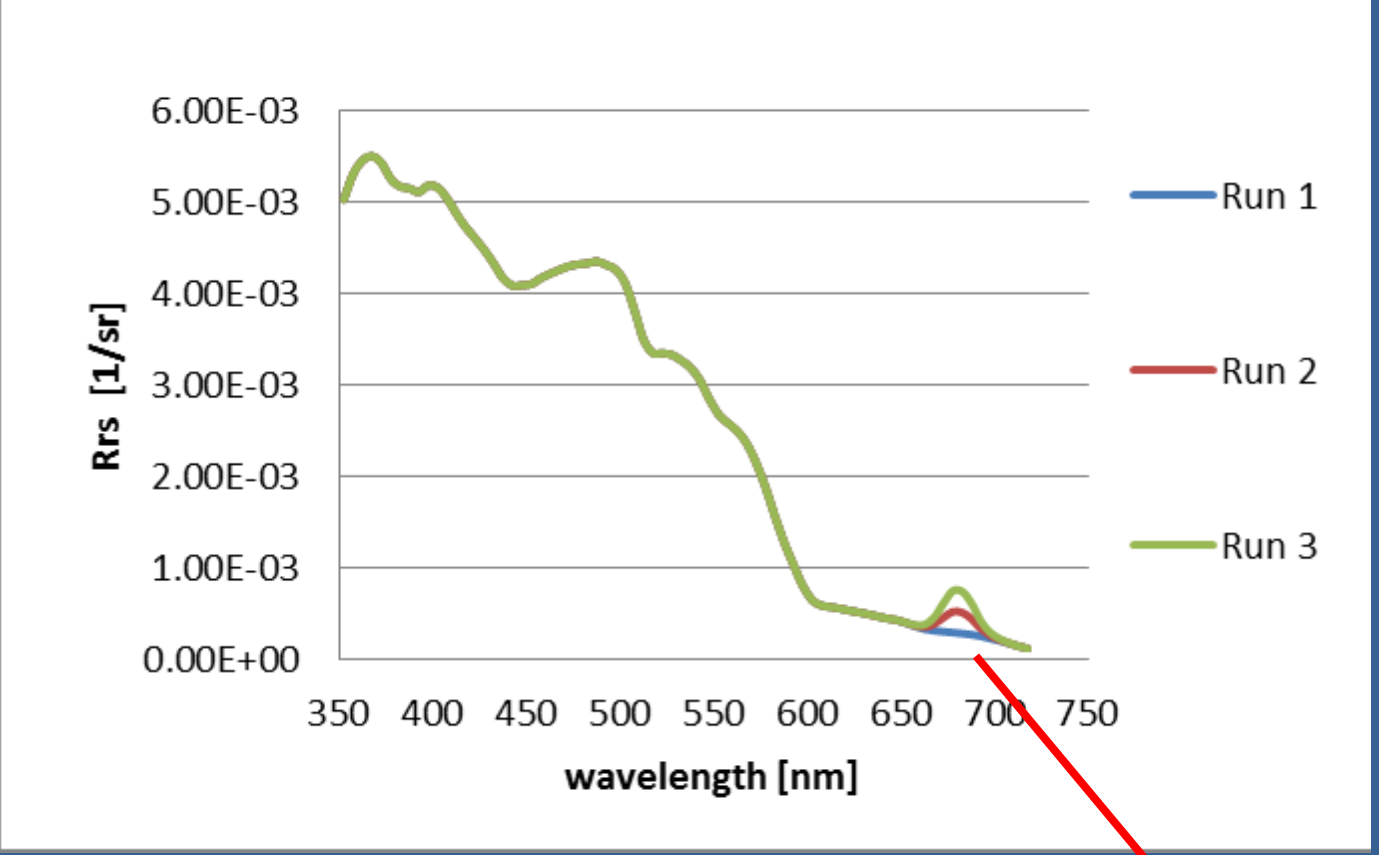
- Chl = 1 mg m^{-3} vs 5 mg m^{-3}
- Quantum Efficiency Φ_{Chl} = 0 (no chl fl) vs 0.02 vs 0.04
- Sun zenith angle = 0 vs 60 deg

What is the Chl value : 1 or 5?

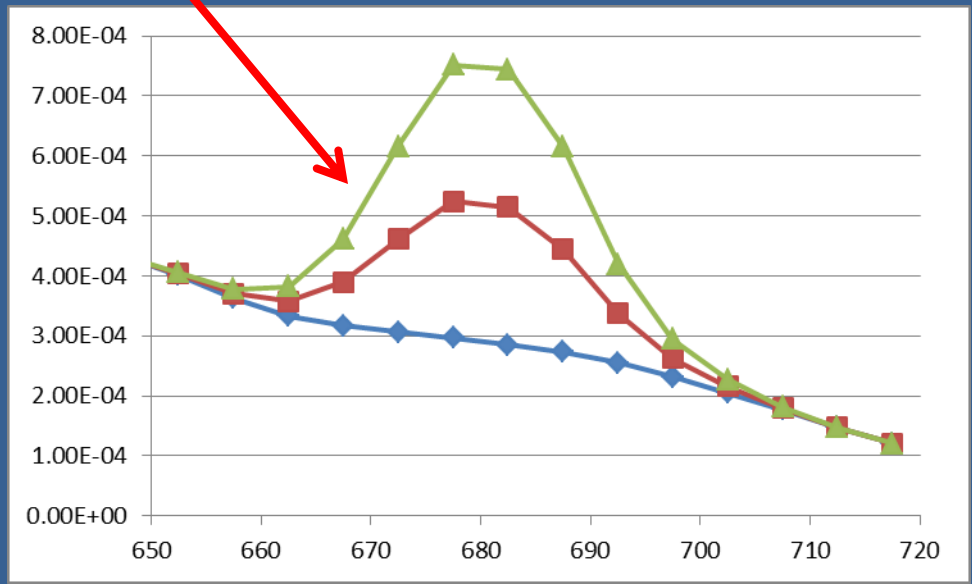


What is the sun zenith angle: 0 or 60 deg?





What causes these differences?



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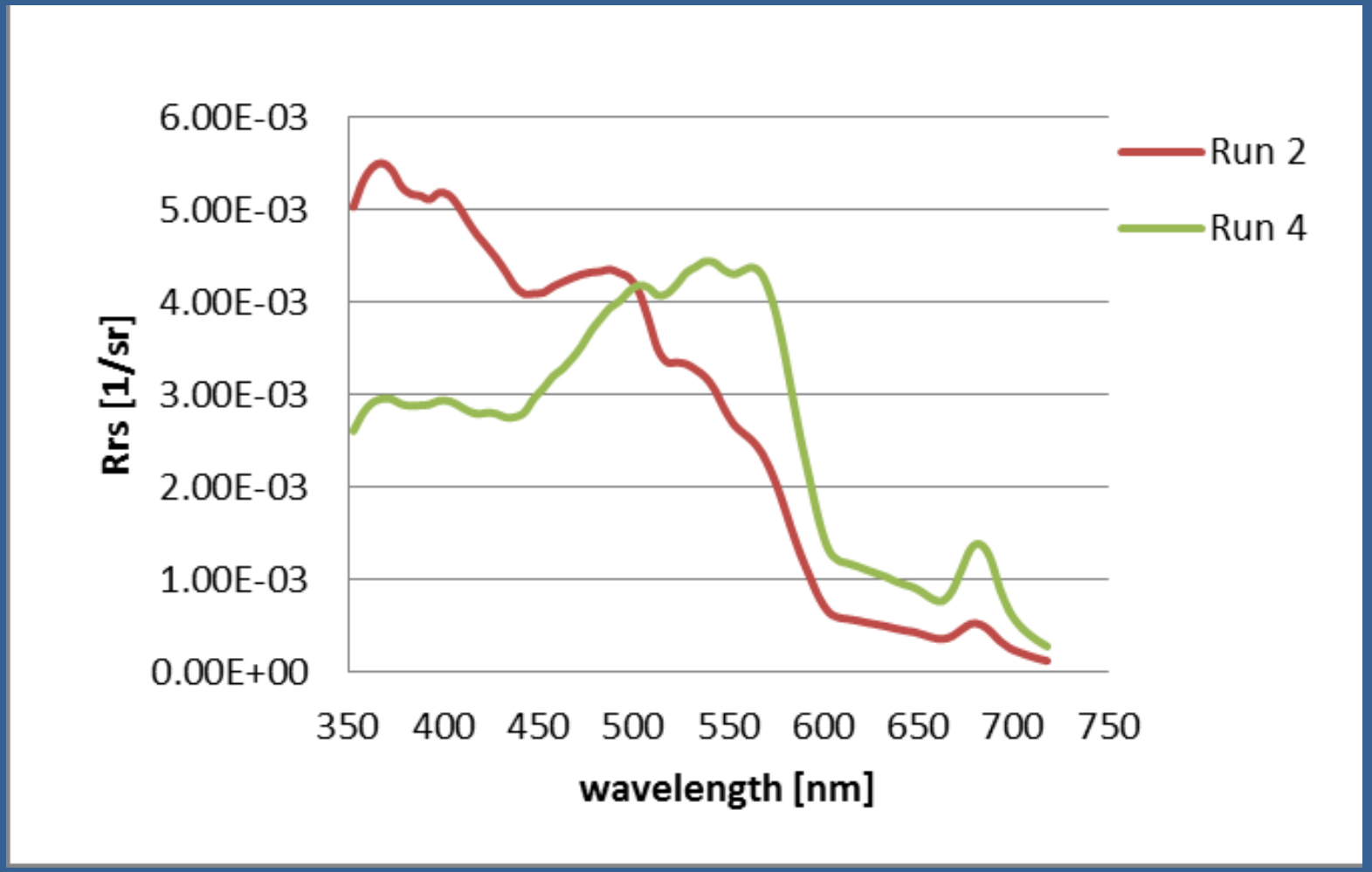
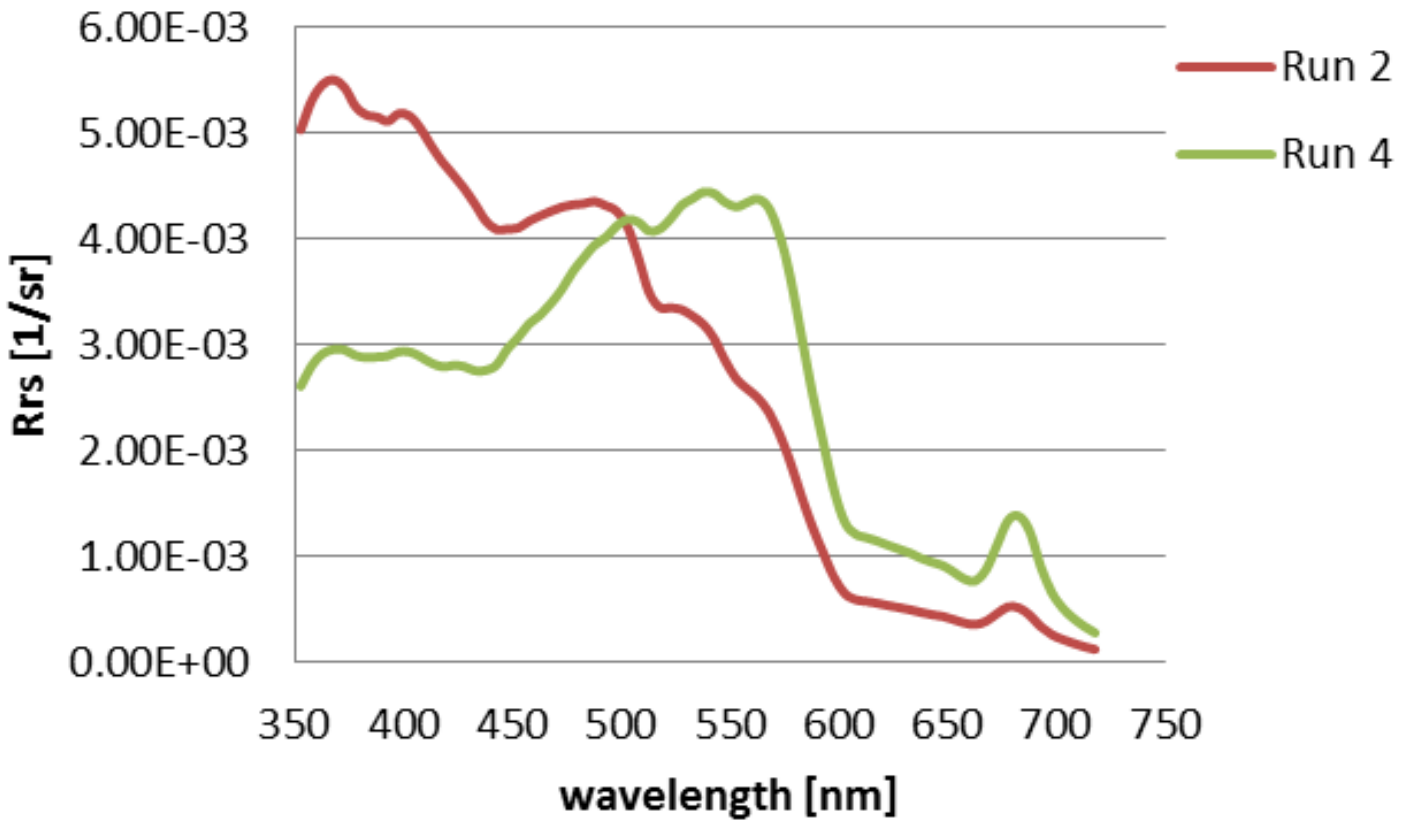
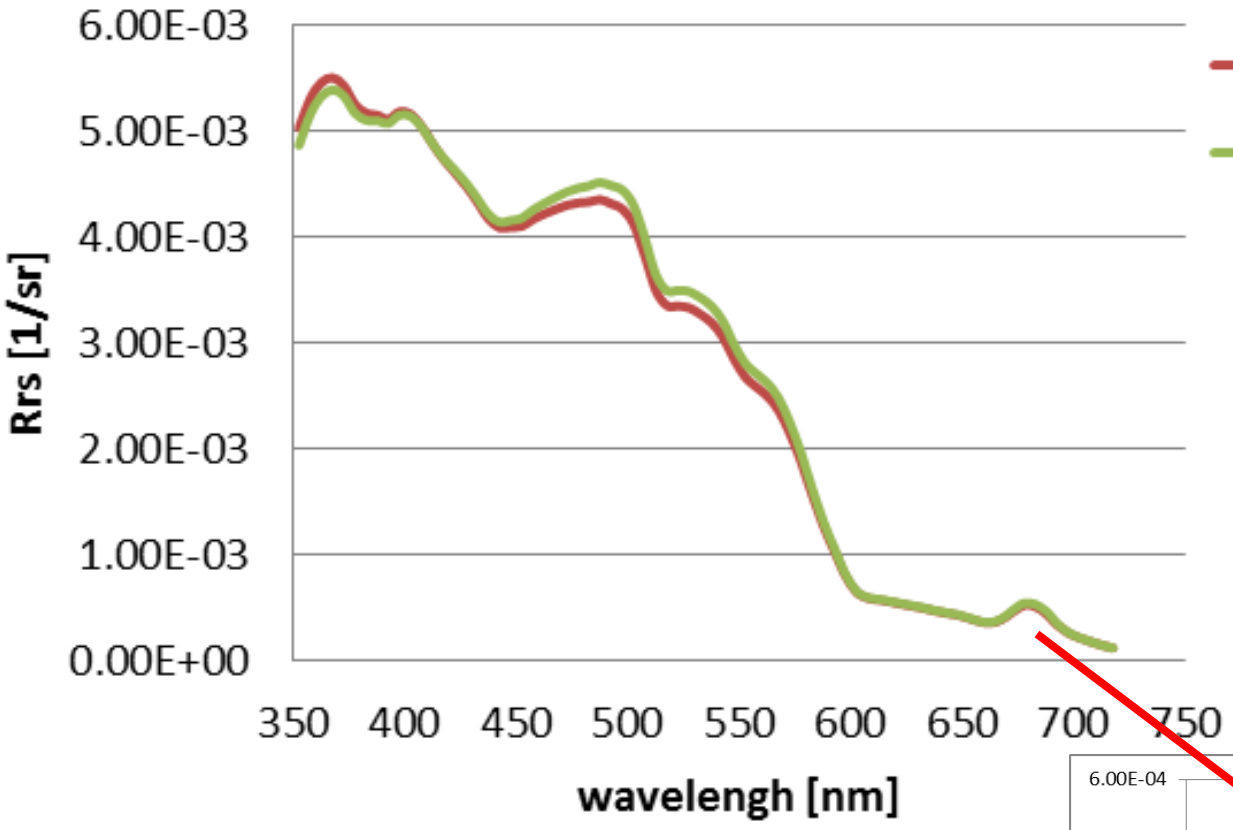
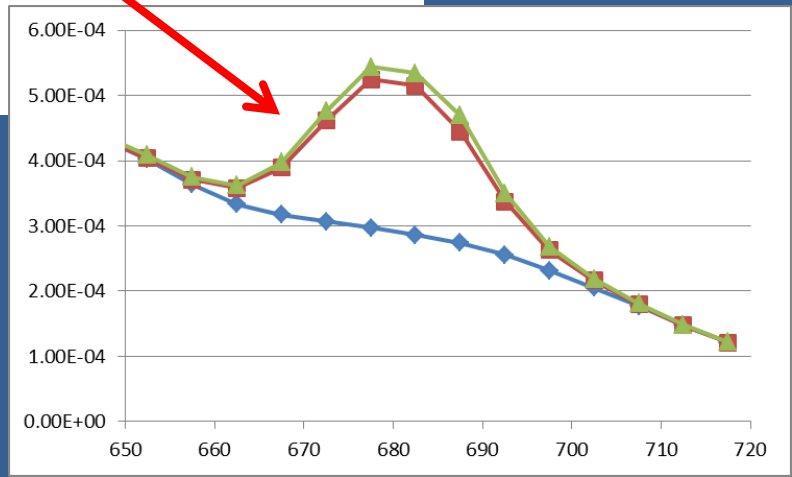


What is the value of Φ_{Chl}?



What causes these differences?





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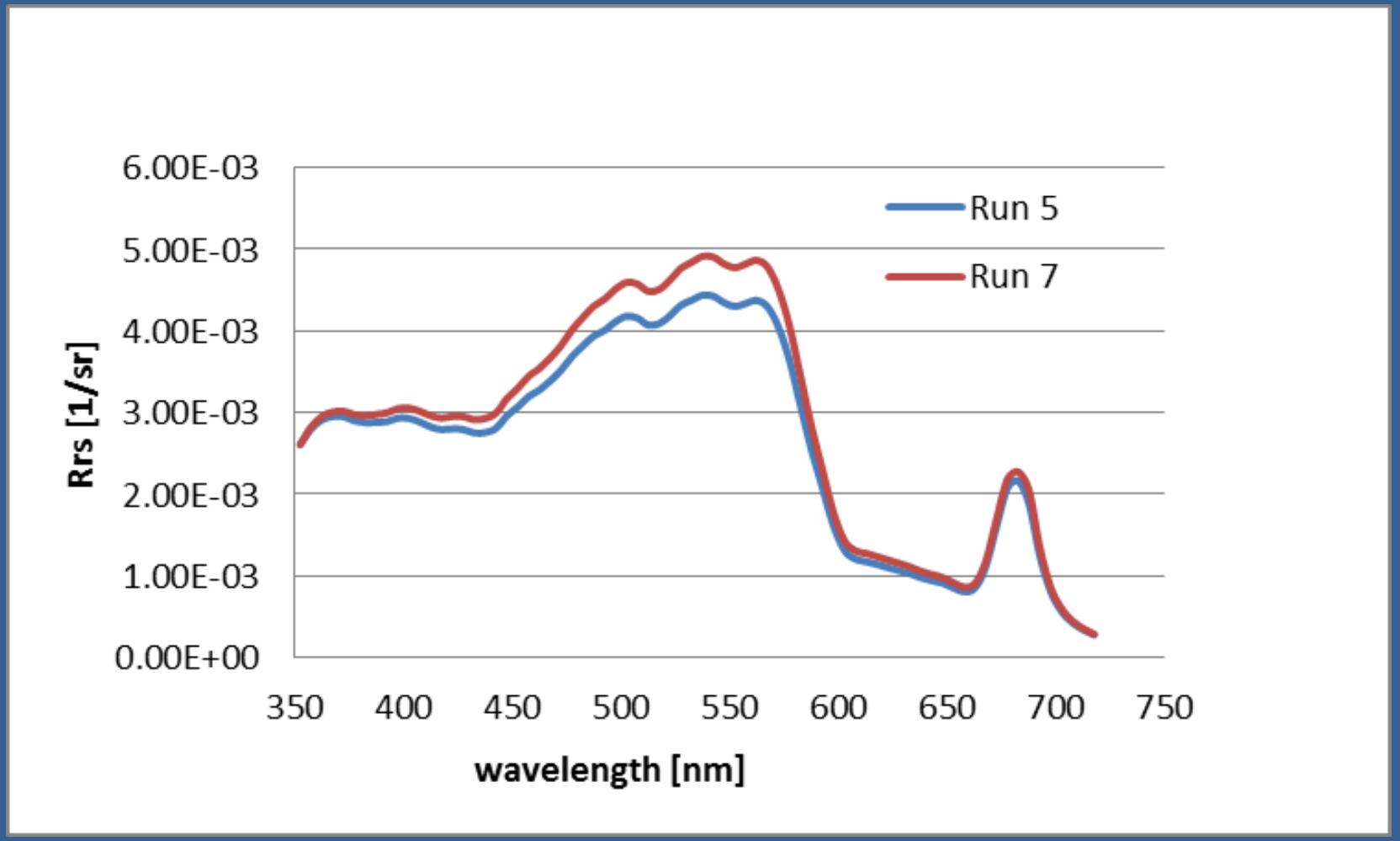

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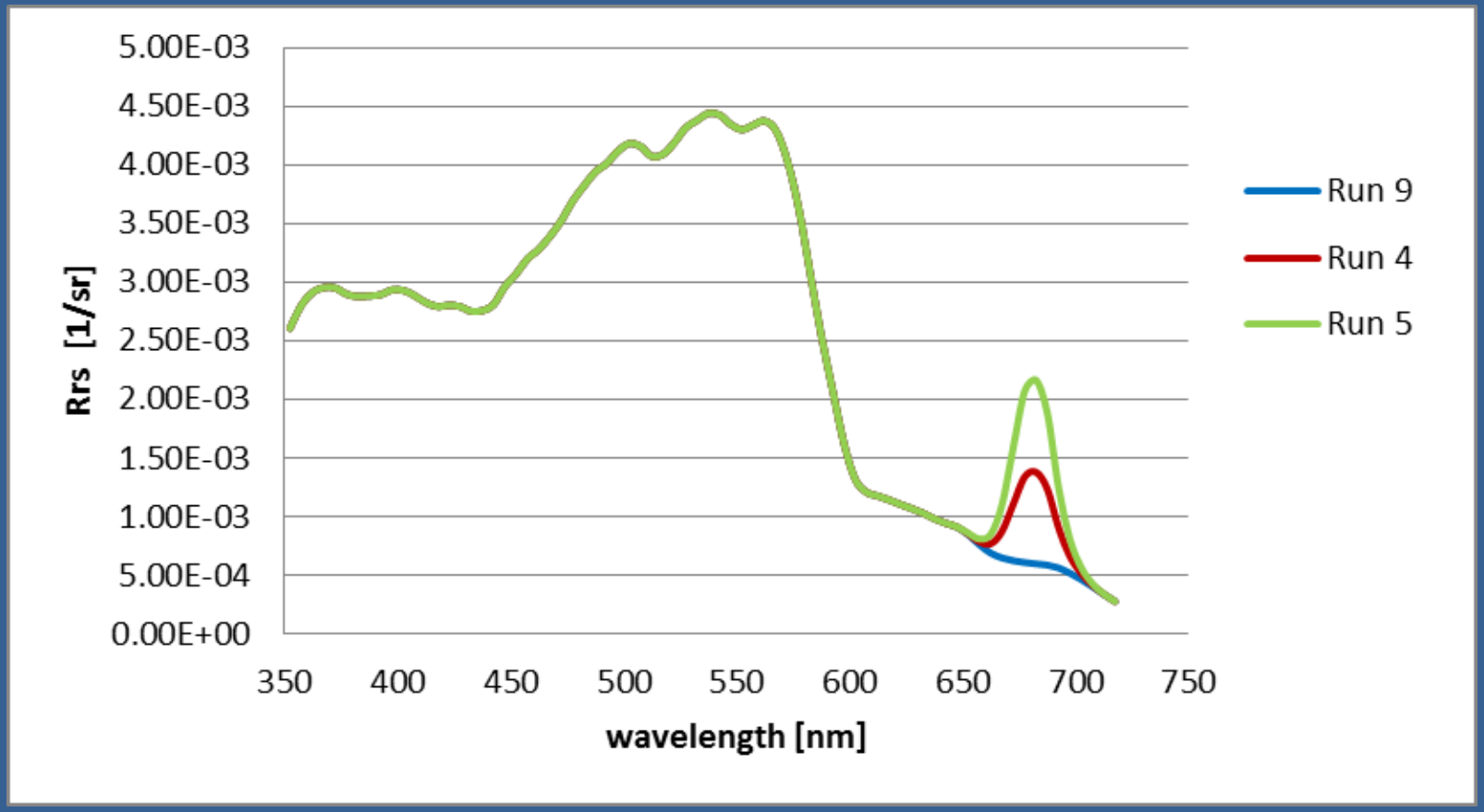
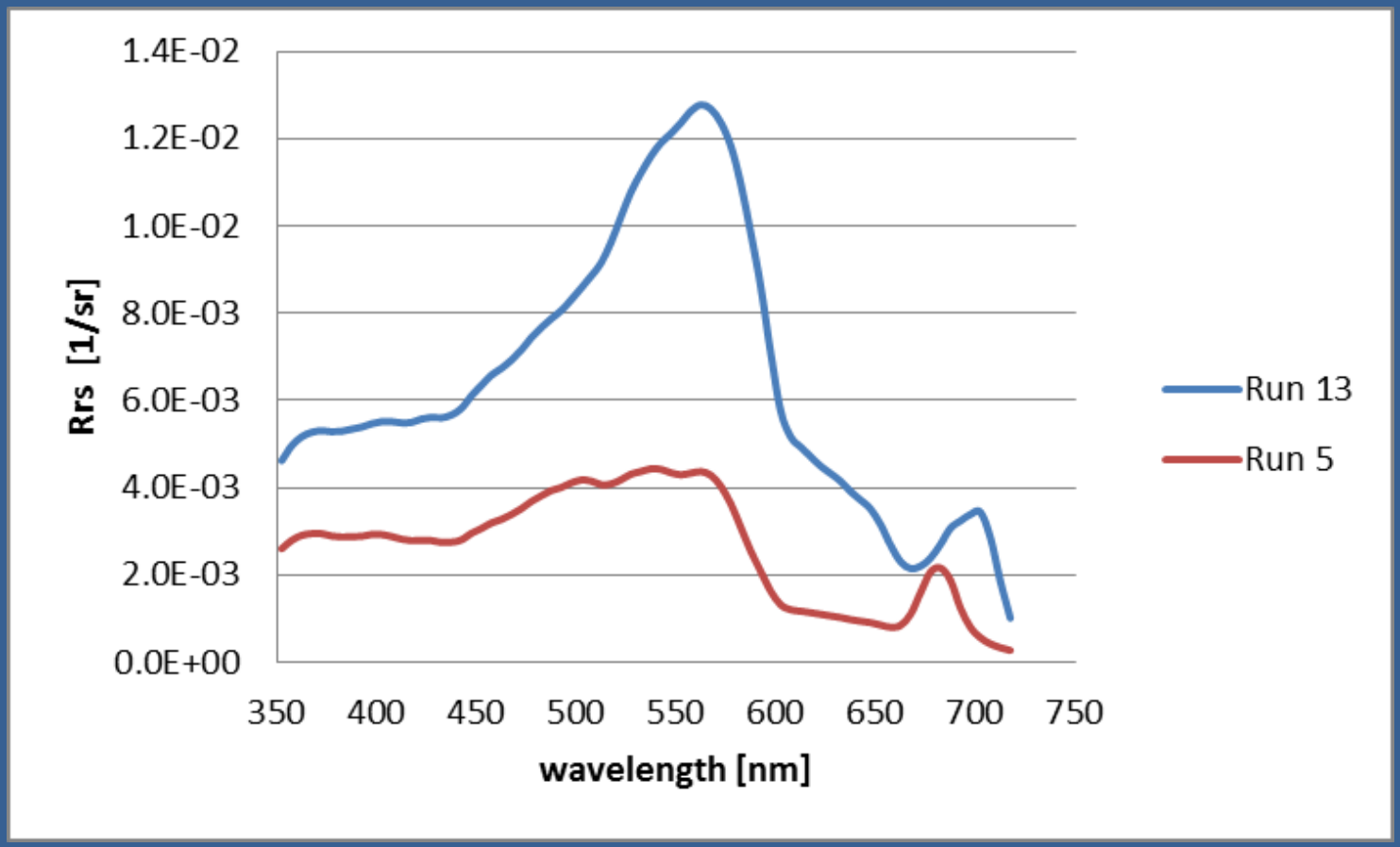


Extra credit question: Explain the blue curve (red is Chl = 5, Φ_{Chl} = 0.04; sun at 0)



The rising “red edge” reflectance of the sea grass bottom at 2 m starts the rise in R_{rs}, which is then suppressed by the increasing water absorption