Answers

Answer 1.1: *Increasing non-algae particle concentration increases absorption for the blue spectral region, and for the green region if sufficiently high. Backscatter increases at all wavelengths, giving an increase in reflectance at all wavelengths at first, but when the increased blue absorption takes effect the blue reflectance increases no further while the green and red reflectances continue to increase rapidly at first, then more and more slowly as maximum reflectance is reached.*

Answer 1.2: *For low NAP and CDOM and CHL=1 mg/m*^{3}*, the reflectance spectrum has a maximum at 400nm and a local maximum at about 460nm. If CHL increases further to CHL=30 mg/m3 the reflectance at 400nm decreases, because phytoplankton absorb strongly in the blue, but the reflectance maxima around 490nm and 570nm increase because the total absorption is lower there. As CHL increases the water colour goes from blue to green.*

Answer 1.3: *Input of CHL=0.1 mg/m*^{3}*, NAP=0.01 g/m*^{3} *and CDOM=0.004 /m were used to generate the "blue curve" reflectance spectrum.*

Answer 1.4: *Input of CHL=10.0 mg/m*^{3}*, NAP=0.01 g/m*^{3} *and CDOM=0.04 /m were used to generate the "green curve" reflectance spectrum.*

Answer 1.5: *Input of CHL=12.6 mg/m*^{3}*, NAP=50.1 g/m*^{3} *and CDOM=1.58 /m was used to generate the "brown curve" reflectance spectrum.*

Answer 1.6: *When the brown curve in question 1.5 is well-fitted variation of CHL has little effect on the reflectance spectrum. It is only near 670nm that a difference can be seen when varying CHL. This implies that the blue and green spectral regions are not useful in algorithms for CHL retrieval in such high NAP and CDOM waters. The red curve is lower reflectance (so lower backscatter, so lower NAP) and has a clearer local minimum at 670nm (so has higher CHL). CHL=19.9 mg/m*^{3}*, NAP=50.1 g/m*^{3} *and CDOM=1.58 /m was used to generate the red curve.*

Answer 2.1: *This is a broad question with no simple, unique answer. However, an example of what is lost with the SeaWiFs bands is that the local minimum near 670nm for high CHL can no longer be distinguished because neighbouring bands are spectrally too far away. As a consequence different triplet values (especially with different CHL) seem to fit reasonably well, indicating that the solution is less well-constrained than when the same spectrum was fitted previously in Question 1.5, but with hyperspectral data.*

Answer 2.2: *The MERIS 709nm band helps constrain better the CHL solution for this problem. The presence of such is band is very advantageous for CHL retrieval in turbid waters.*

Answer 2.3: *This question and other similar questions relating to uniqueness of solutions are being considered by various research groups internationally but no clear answer has been provided yet. It is suspected that if we have too many "unknown" variables to retrieve then there could be multiple solutions that are* *equally possible. i.e. optical remote sensing cannot give a single answer but gives potentially more than one answer which is completely coherent with the available data. In such cases extra data, e.g. from in situ measurements or from knowledge of parameters such as SCDOM (which can then be accepted as fixed), is needed to determine which solution corresponds to the reality. An interesting discussion of possible multiple solutions to the optical remote sensing problem is given by [Sydor, Applied Optics, vol 43, no 10, 2004]. The problem of possible existence of multiple solutions is much more severe when less spectral information is available (e.g. SeaWiFs bands instead of hyperspectral). In the extreme case of very limited spectral information (e.g. AVHRR bands 1 and 2) there is no way of distinguishing between non-algae and algae particles.*

***Answer 2.4**: There is an interesting discussion of this "reflectance saturation" phenomenon in [Luo, Y., Doxaran, D., Ruddick, K., Shen, F., Gentili, B., Yan, L. and H. Huang (2018). Saturation of water reflectance in extremely turbid media based on field measurements, satellite data and bio-optical modelling. Optics Express, 26, 10435-10451.* https://doi.org/10.1364/OE.26.010435*]*

***Answers 2.5 and 2.6**: We don't give all the answers!*