

The Light and Radiometry chapter showed how various physical and mathematical quantities such as energy and solid angle can be combined to describe light in terms of radiance. The Overview of Optical Oceanography chapter showed how various inherent optical properties (IOPs) are used to describe the optical properties of the medium through which light propagates. This chapter now develops the radiative transfer equations that tie together those two sets of properties and thereby provide the theoretical framework for all of optical oceanography and ocean-color remote sensing. The "organization chart" seen in Figure figure1 shows the central role of radiative transfer theory and the radiative transfer equation. In essence, IOPs and boundary conditions go into the equation, and radiance comes out.

There is actually a hierarchy of radiative transfer equations (RTEs). At the top is a very general equation (Eq. 2 of the The General Vector Radiative Transfer Equation page) capable of describing polarized light propagation in matter that is directionally non-isotropic, that can absorb light differently for different states of polarization, and that contains scattering particles of any shape and random or non-random orientation. Although very general in its ability to simulate any situation encountered in optical oceanography, the full set of IOP inputs to this equation is never measured in the oceanographic setting.

The IOP inputs to the most general equation become considerably simpler if the medium has mirror symmetry, as explained on the The VRTE for Mirror-symmetric Media page. The resulting equation is suitable for computation of polarized radiative transfer in the oceanic setting, especially after restriction to a plane-parallel geometry (Eq. 3 of that page).

The vector-level equations can be further simplified as shown on the The Scalar Radiative Transfer Equation page to obtain the equation shown in Fig. figure1. That equation for the total radiance is only approximate, but the inputs are simple enough to measure and model, so this equation finds wide use in oceanography.

These vector and scalar RTEs are derived on the Level 2 pages referenced above.

The radiance-level RTEs yield further equations involving the irradiances. One example is the two-flow equations for the plane irradiances E_d and E_u seen in Light and Water Section 5.11. However, those equations cannot be solved for the irradiances unless *ad hoc* assumptions are made about the angular shape of the radiance distribution.

Solution of the vector and scalar RTEs must be done numerically except for a few trivial cases such as non-scattering media. Approximate analytical solutions for the radiance can be obtained under very restrictive (and unphysical) conditions such as a sun in a black sky and only single scattering within the water. These single-scattering solutions are developed on pages The Single-Scattering Approximation and The Quasi-Single-Scattering Approximation.

There are also irradiance-level "solutions" of the scalar RTE such as Gershun's Law.

These topics are all discussed in the Level 2 material of this chapter.

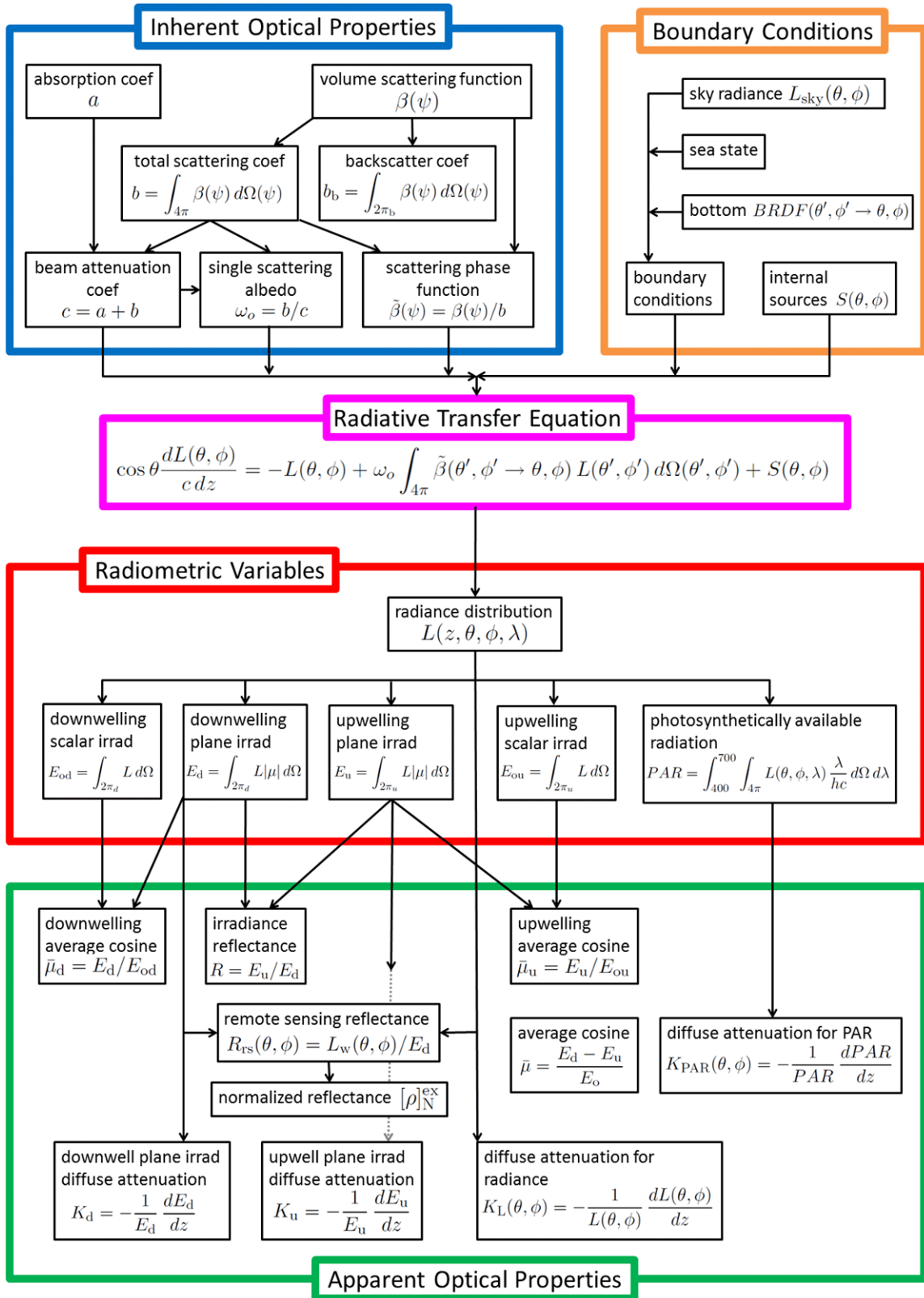


Figure 1: Organization chart for optical oceanography.