

SLOPE: A radiative transfer model for leaves incorporating fluorescence

Stefan W Maier

Objectives

- **deterministic model based on physical laws**
- **not too complex**
- **input variables have to be readily available**
- **take into account relevant properties (e.g. clumping of pigments → sieve effect, vertical inhomogeneity)**
- **does not have to be invertible analytically**
- **reasonably fast to be able to do many simulations**
- **leaf level measurements only for validation, not for model development (e.g. tuning)**
- **specific absorption coefficients determined independent of the model**
- **include fluorescence (any light source: Laser, sun, lab)**

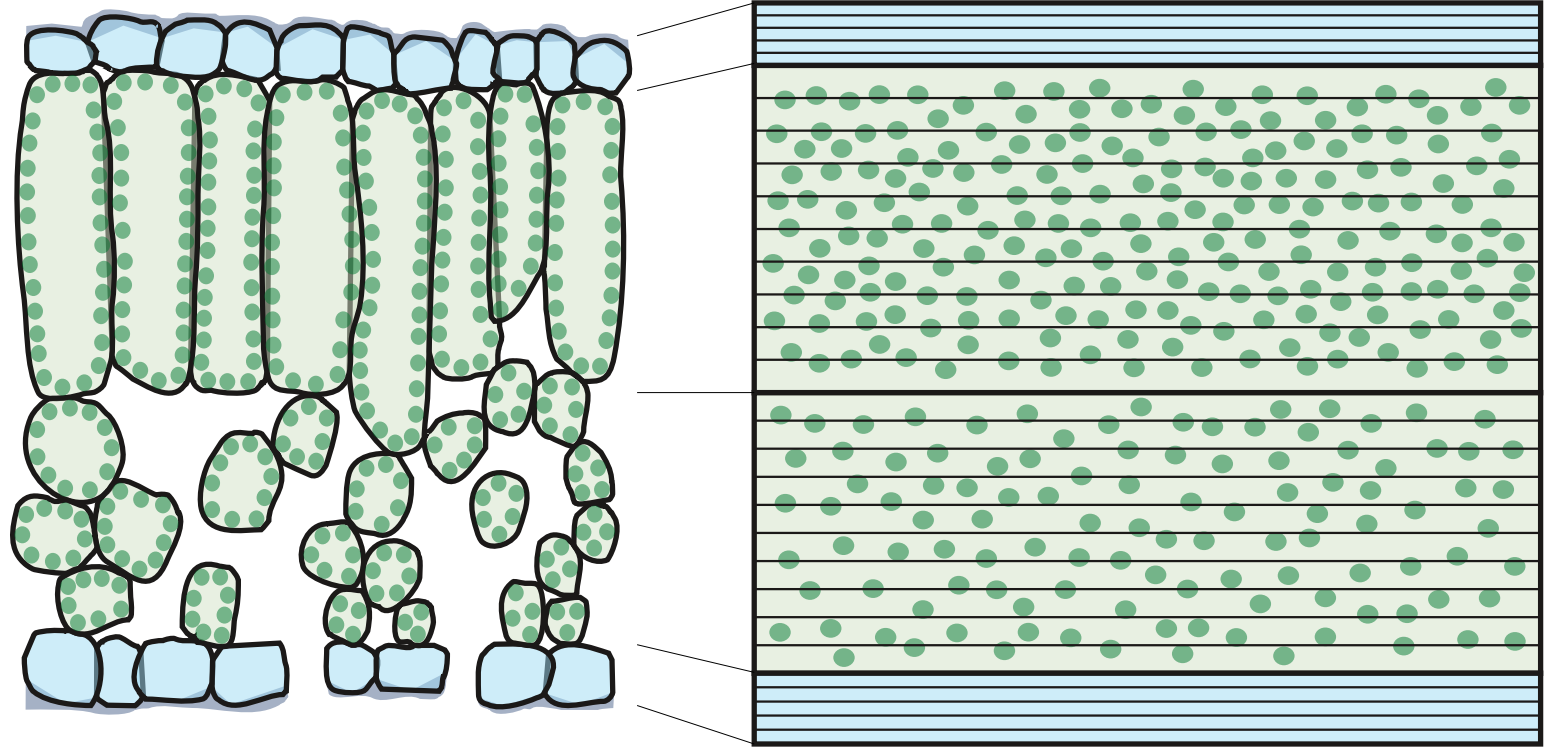
Structure of SLOPE (1/2)

upper epidermis

palisade parenchyma

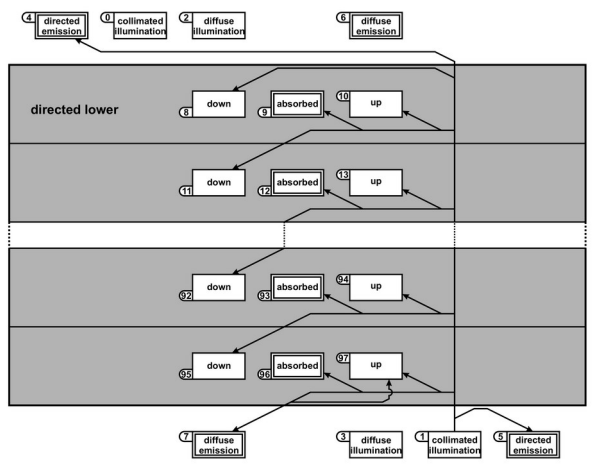
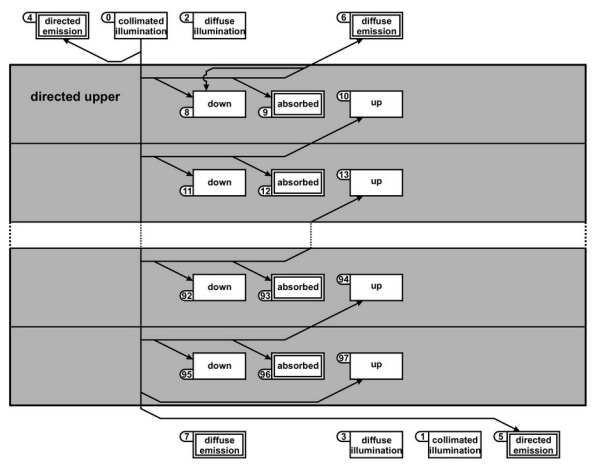
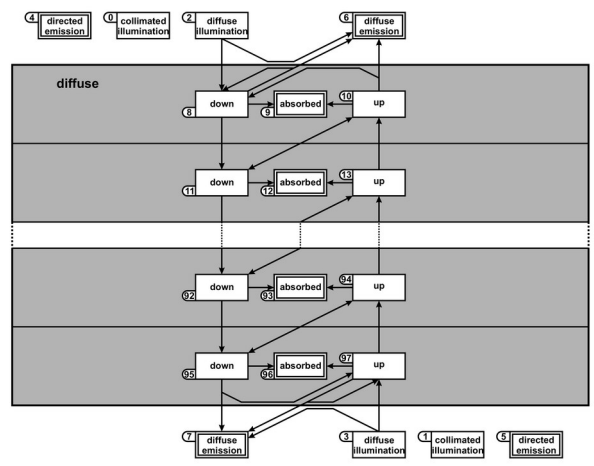
spongy parenchyma

lower epidermis



Structure of SLOPE (2/2)

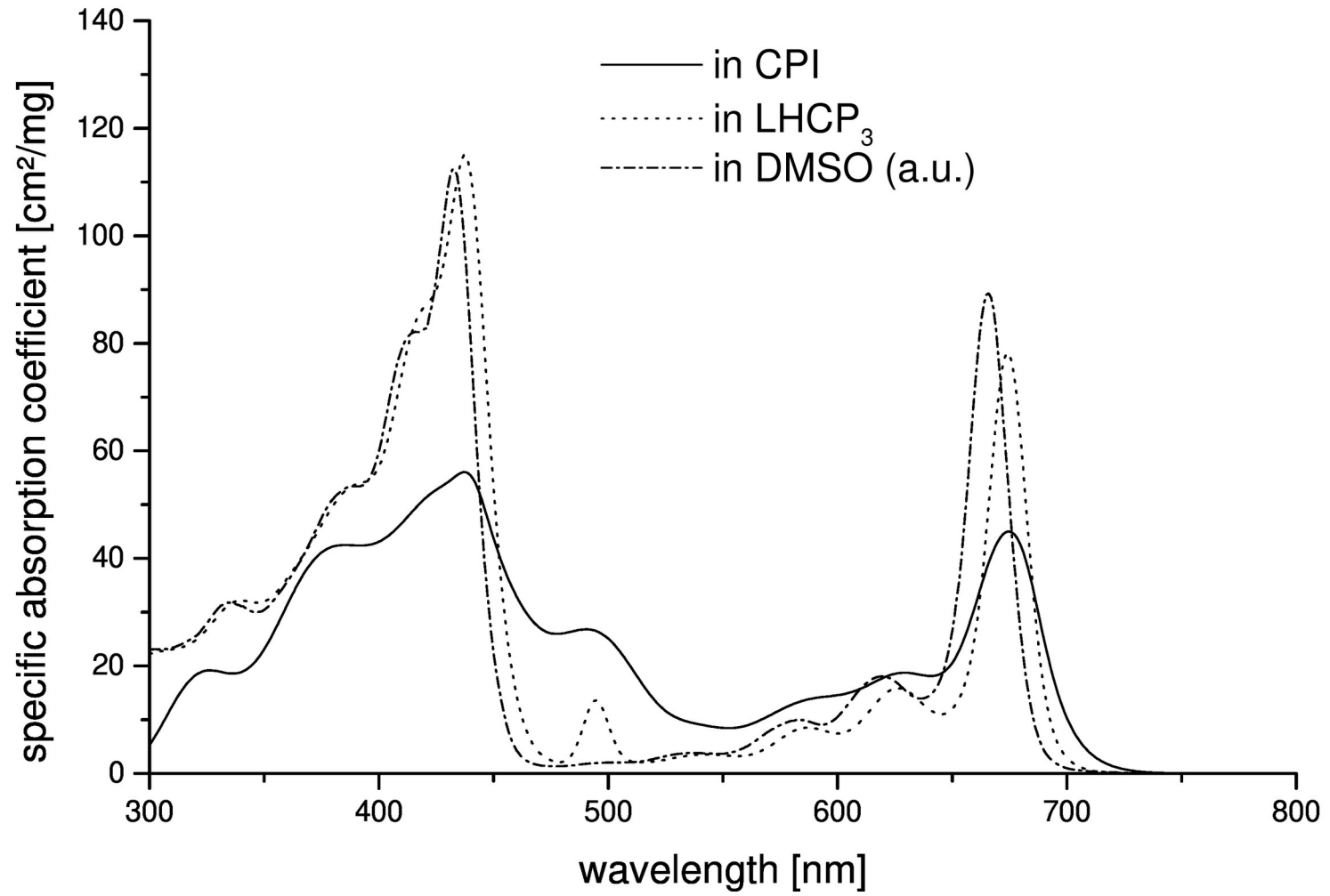
light states



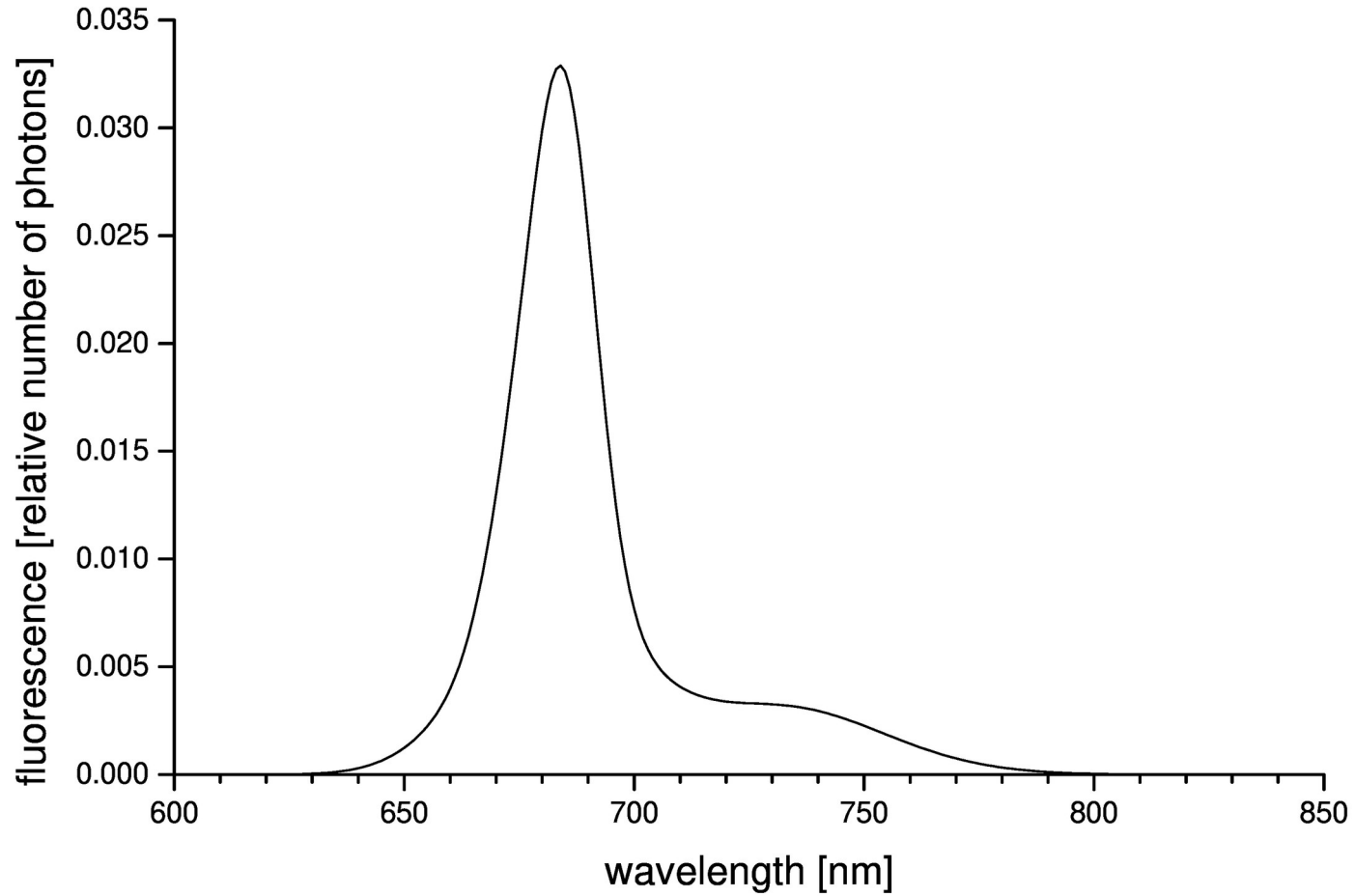
transition probability between states described by physical laws (mostly Beer's law)

- light states are described by vector
- transition probabilities are elements of matrix
- radiative transfer modelling is a series of matrix multiplications
- done wavelength by wavelength
- fluorescence transfers light in 'absorbed' states to 'up' / 'down' states at longer wavelengths

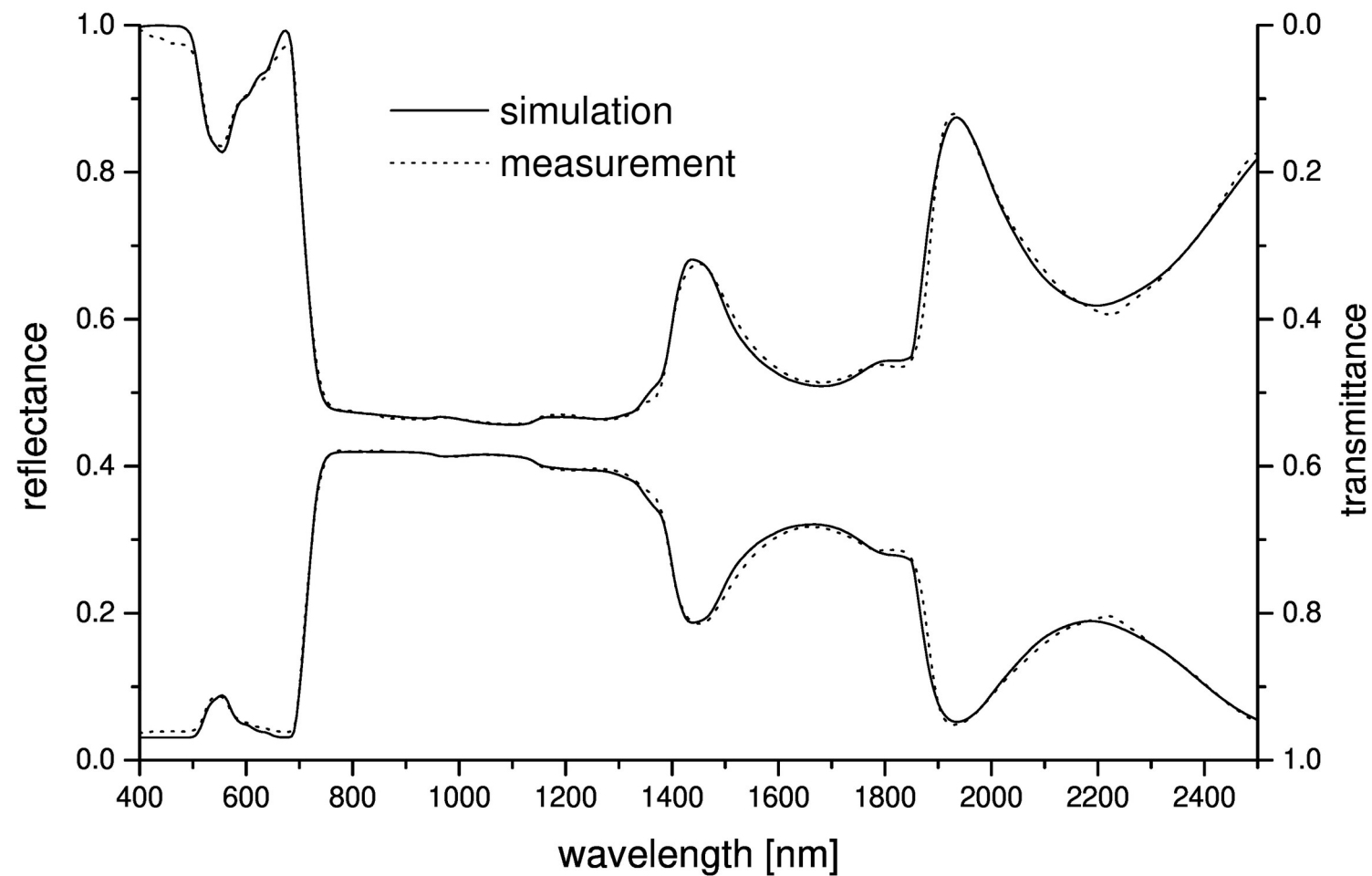
Specific Absorption Coefficient (Chlorophyll a)



Fluorescence Spectrum

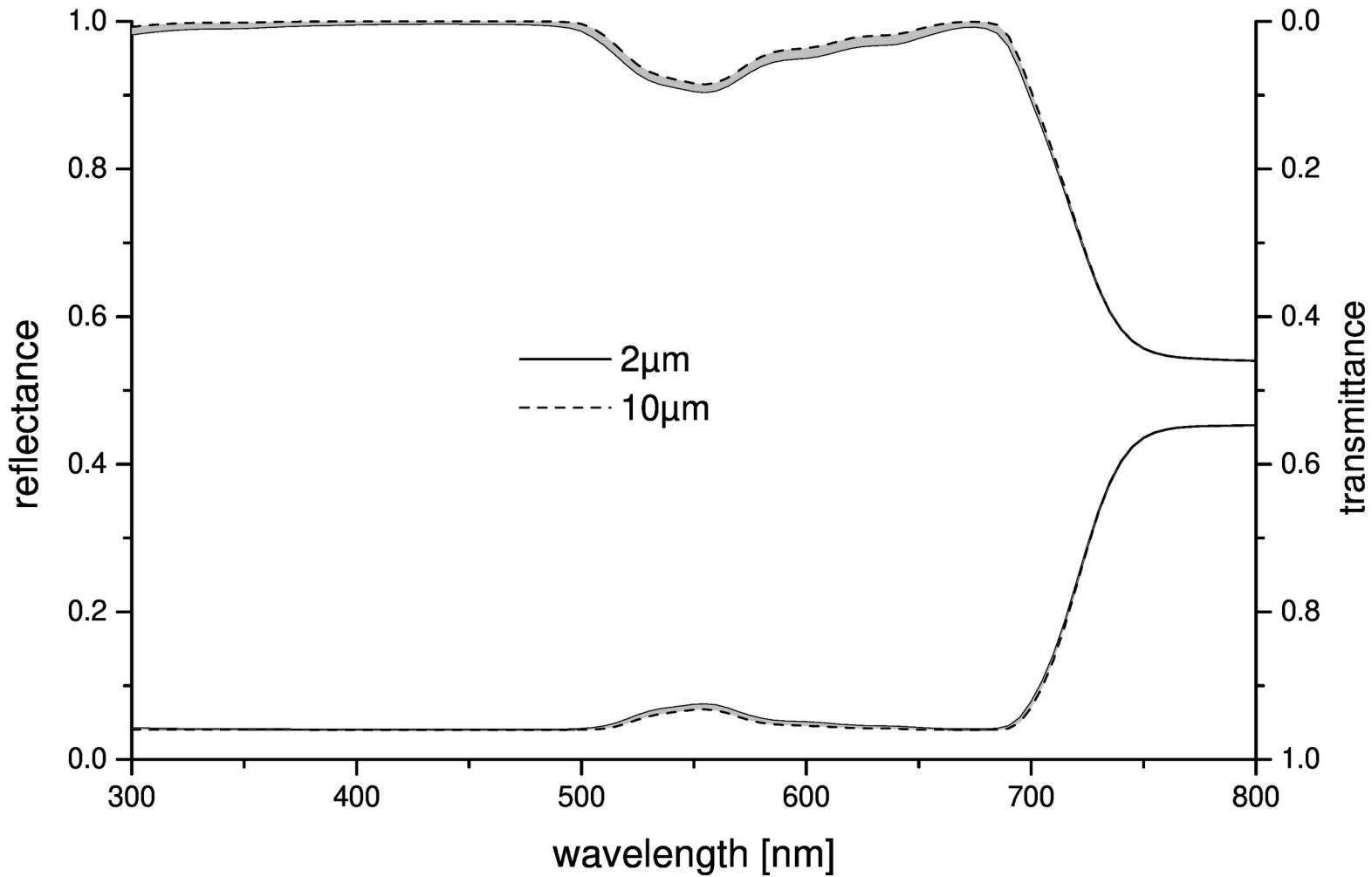


Comparison with Measurements

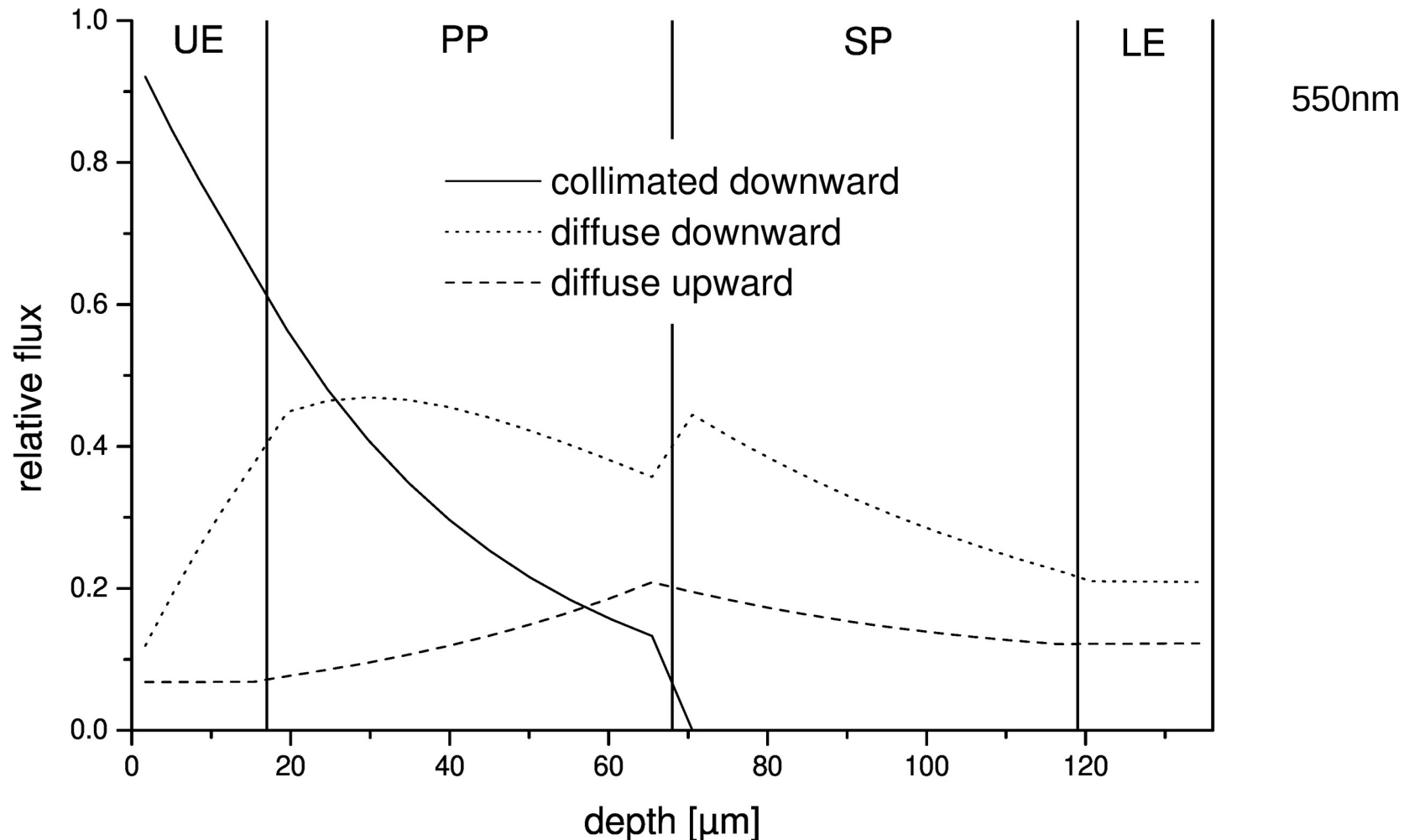


maple leaf - Hosgood et al. (1995) Leaf Optical Properties Experiment 93 (LOPEX93). European Commission, Joint Research Centre, Institute for Remote Sensing Applications.

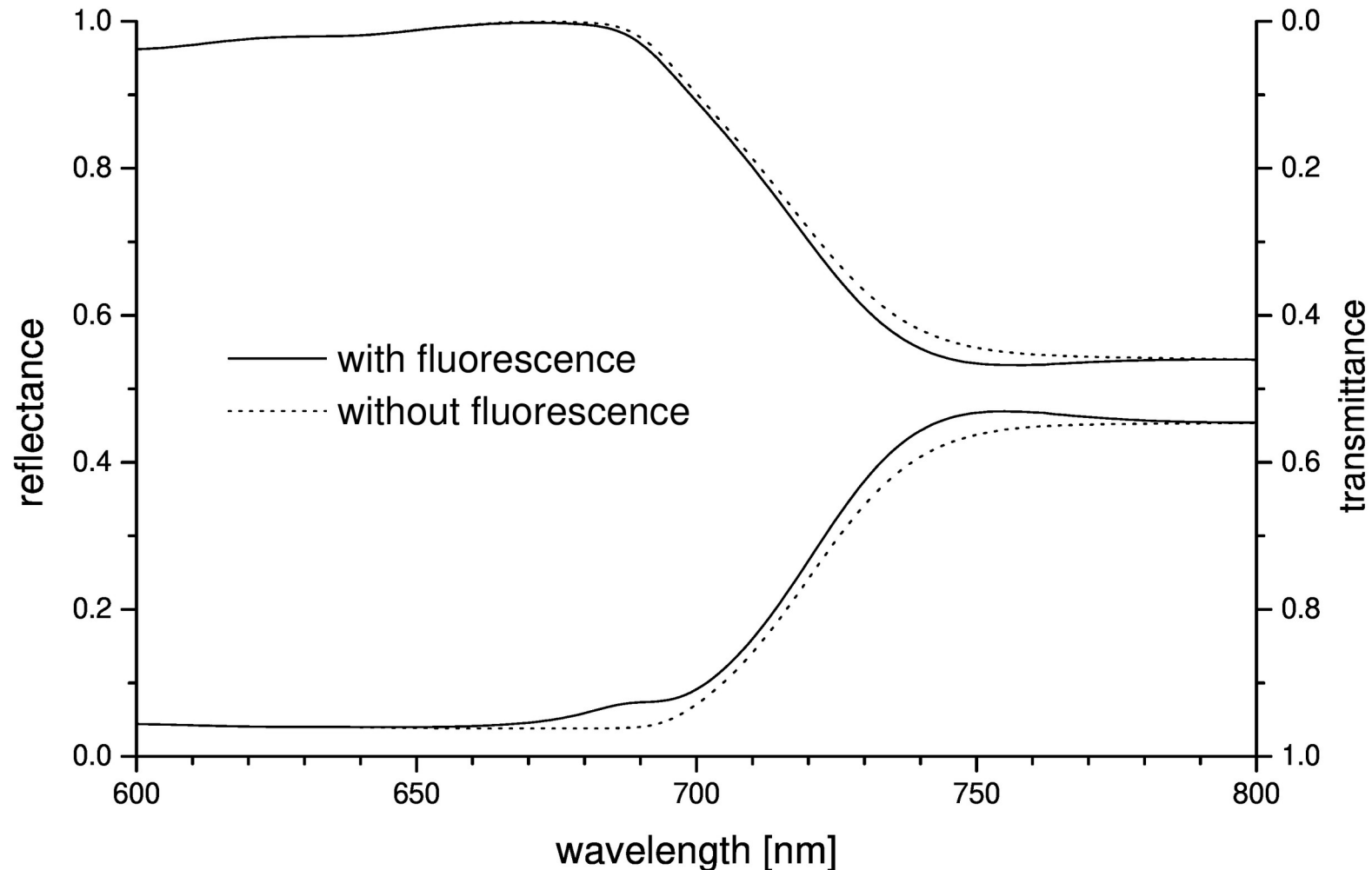
Impact of Chloroplast Orientation



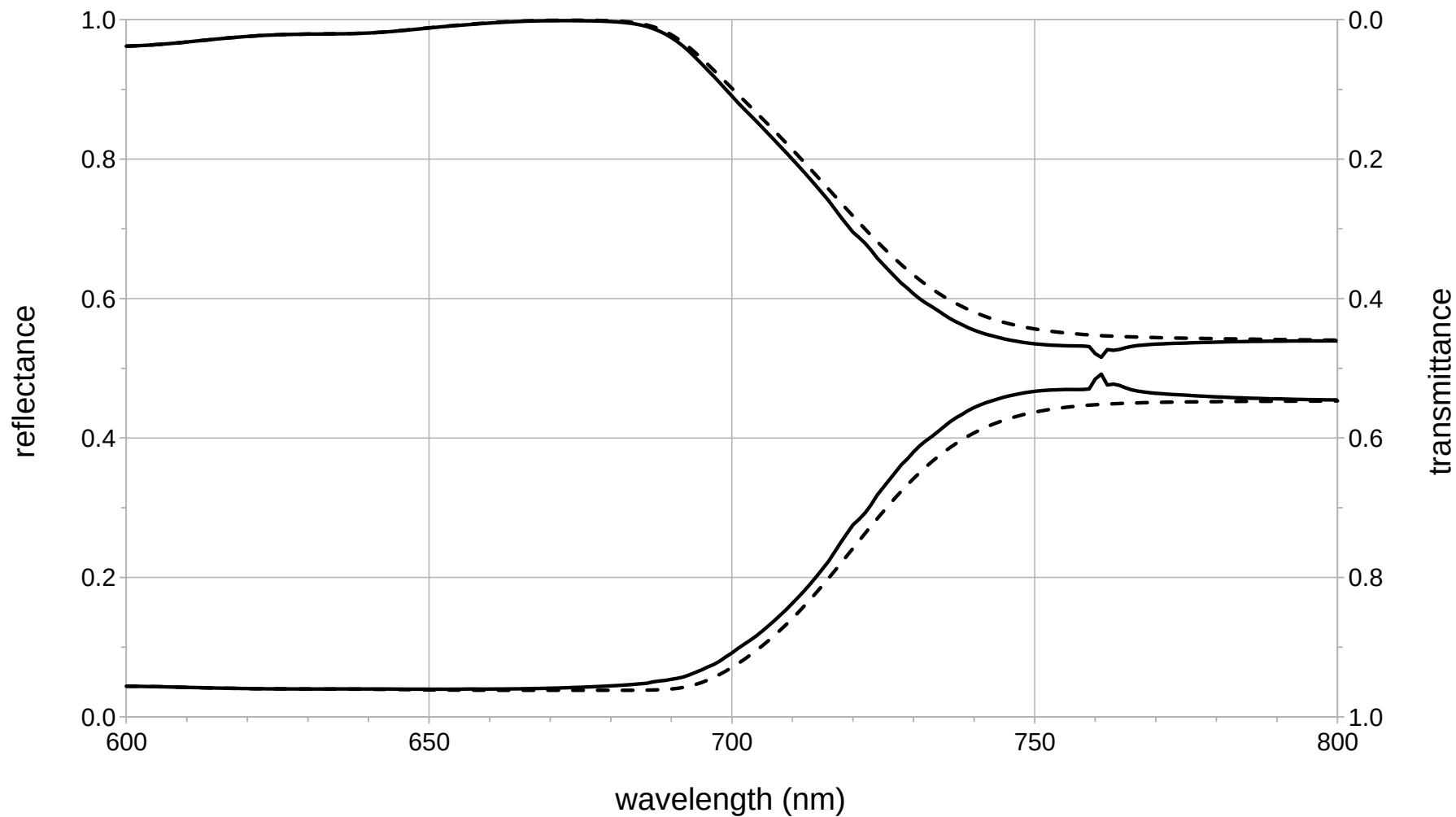
Light Fluxes within a Leaf



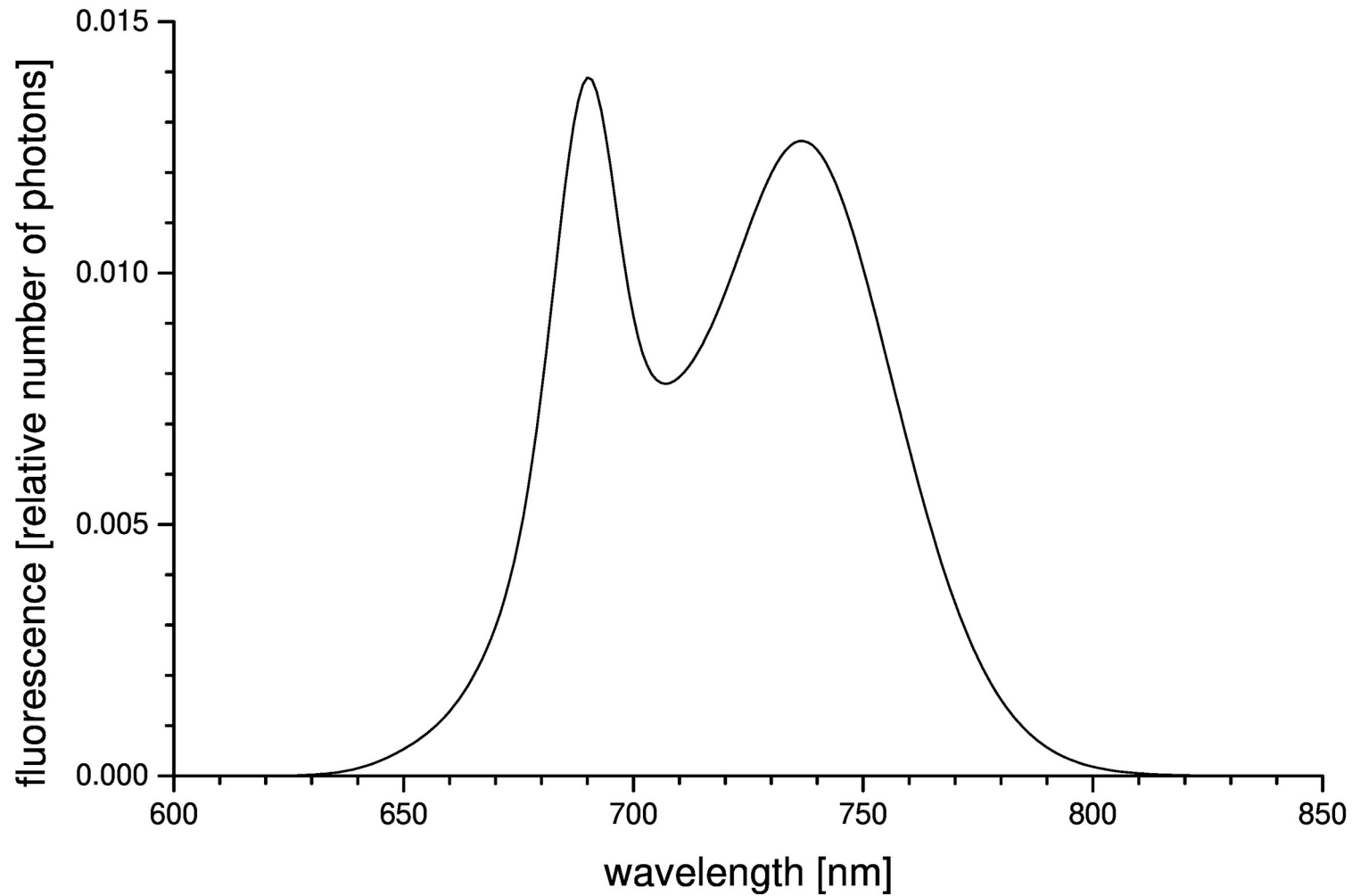
Impact of Fluorescence on Apparent Reflectance (light source: halogen lamp)



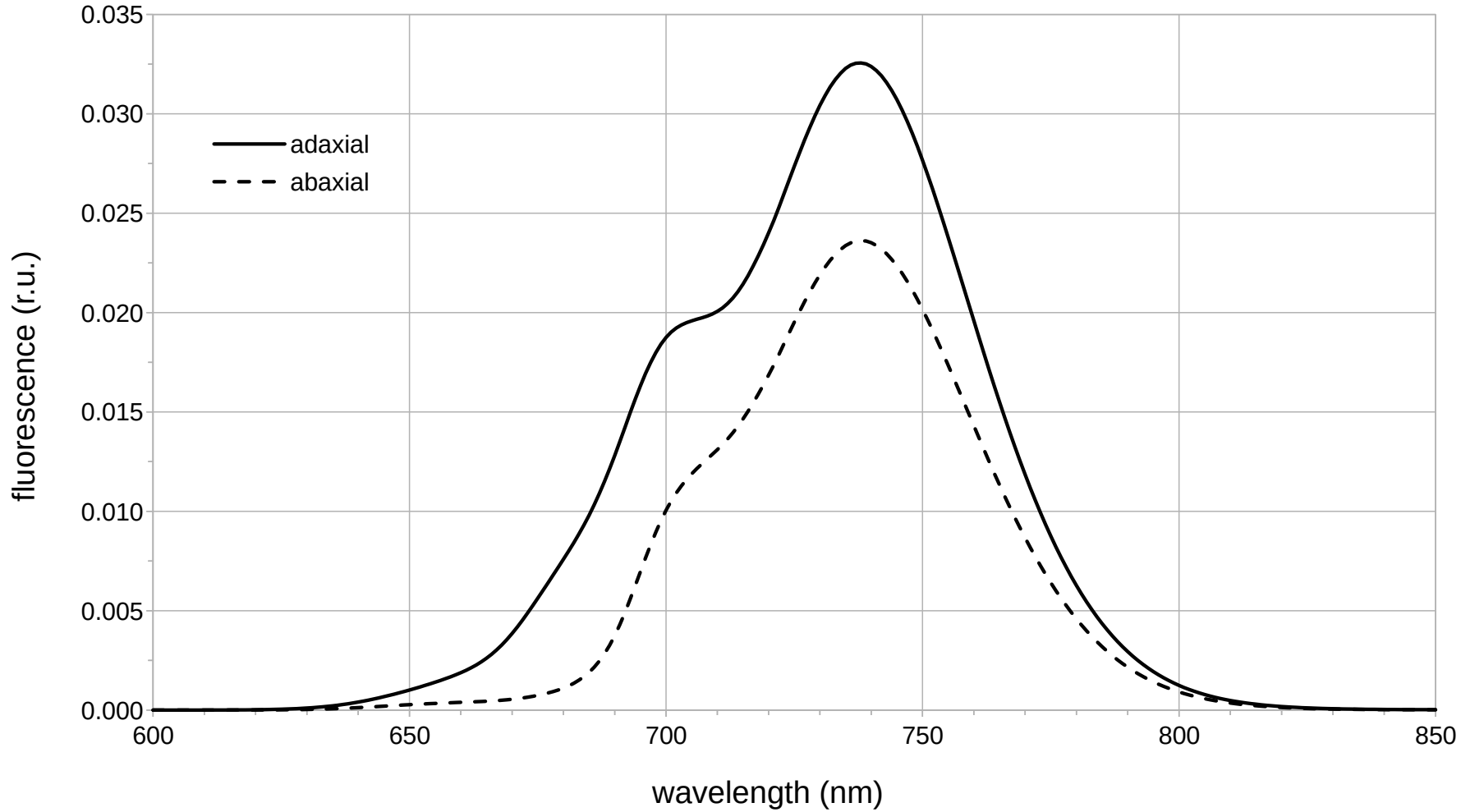
Impact of Fluorescence on Apparent Reflectance (light source: sun)



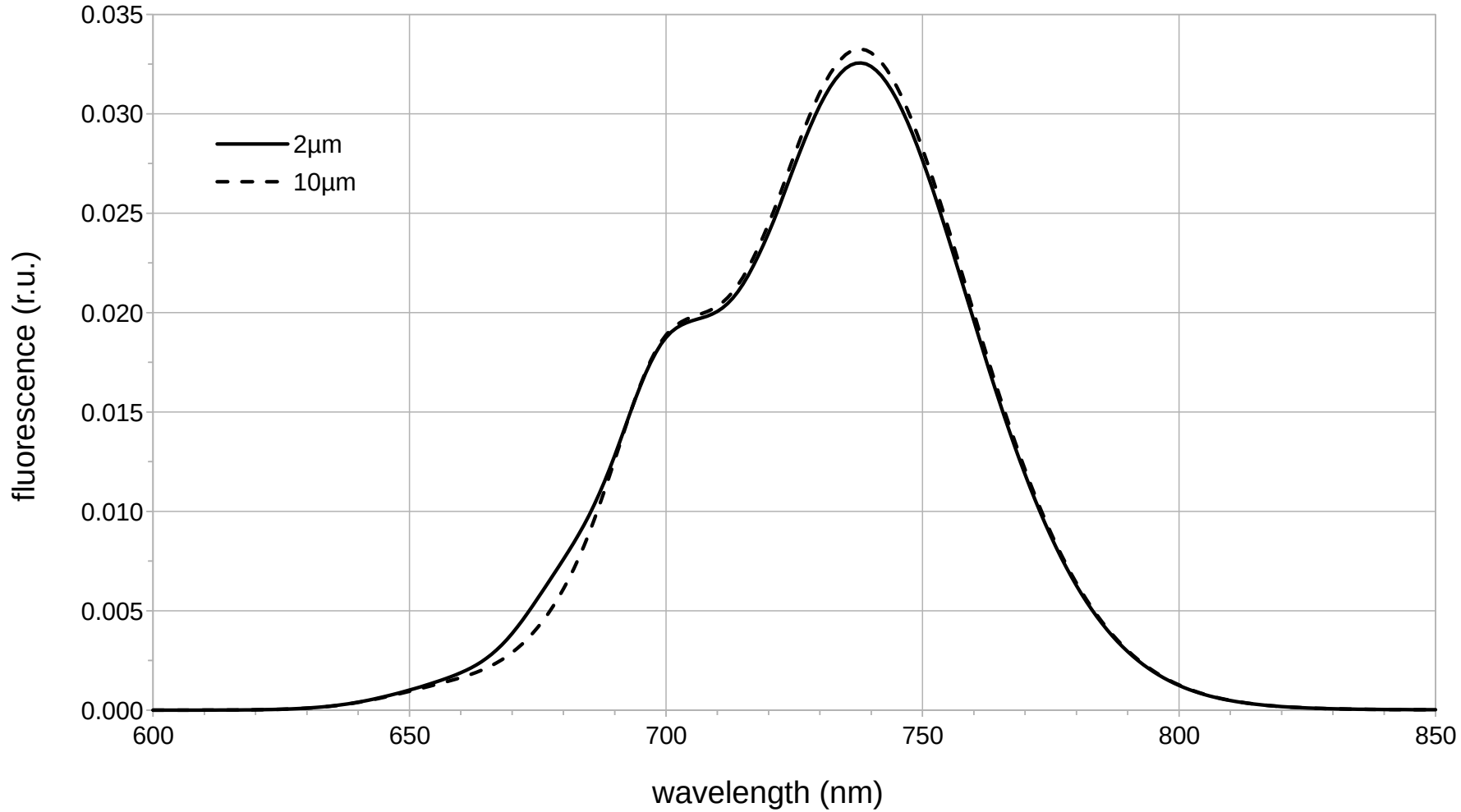
Laser Induced Fluorescence



Solar-Induced Fluorescence Adaxial vs Abaxial Side



Impact of Chloroplast Orientation on Solar-Induced Fluorescence



- **re-implement in Python (currently C)**
- **make available on GitHub**
- **seeking collaboration for further validation of fluorescence**

stefan.maier@maitec.au / stefan.maier@maitec-sec.de