Blue light and near infrared: Protecting the eyes from potentially harmful radiation

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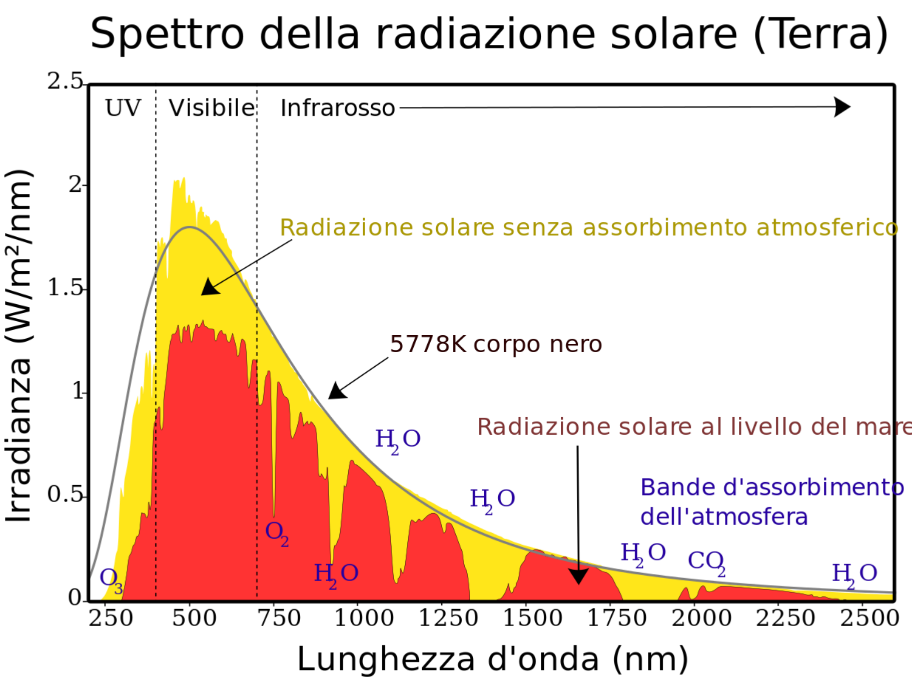
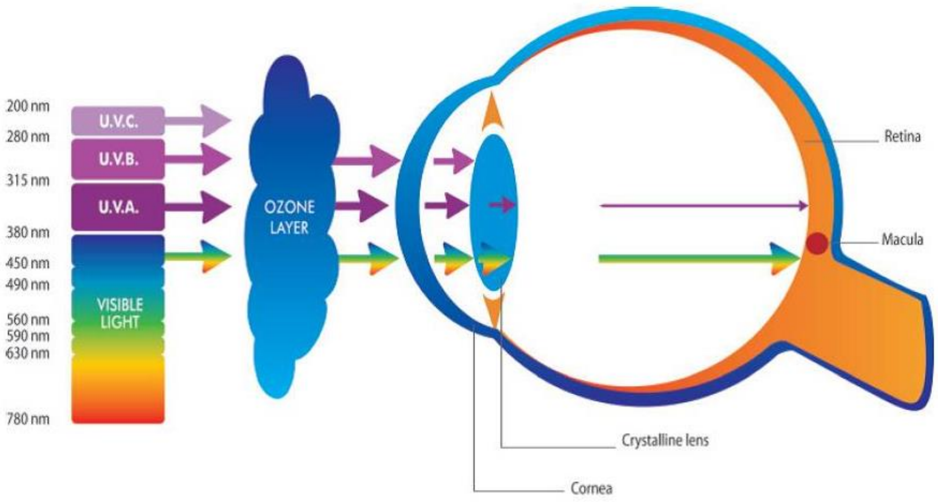
The importance of light filtering





Excessive exposure to UV light can induce:

- Pinguecola, Pterygium, and other conjunctival diseases
- photokeratitis
- cataracts
- solar retinopathy

Short-wavelength visible radiation (blue light):

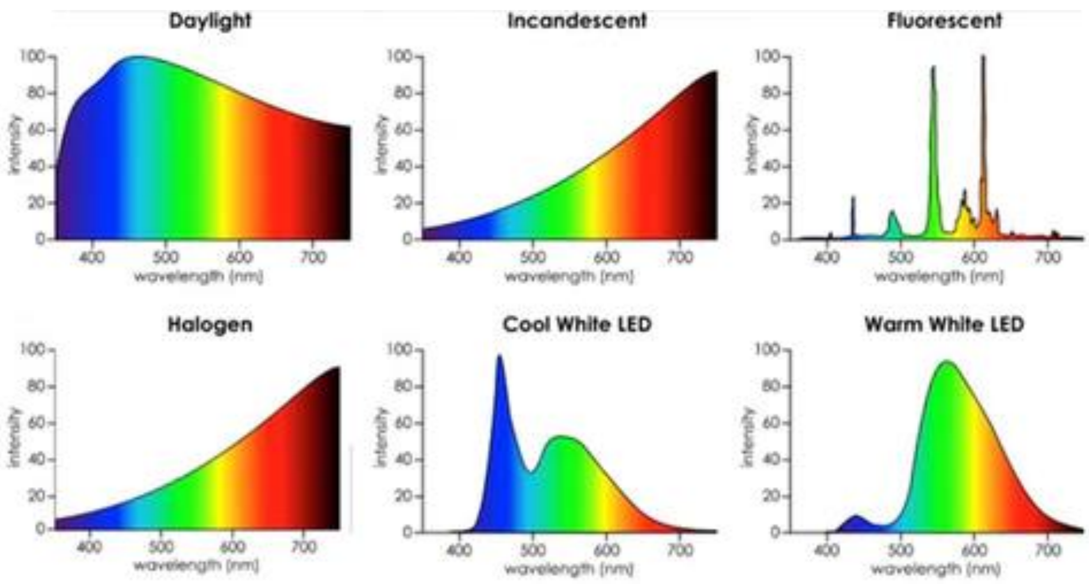
- can interfere with sleep-wake circadian cycle (melanopsin production at 480 nm)
- promotes age-related macular degeneracy (AMD)
- solar retinopathy

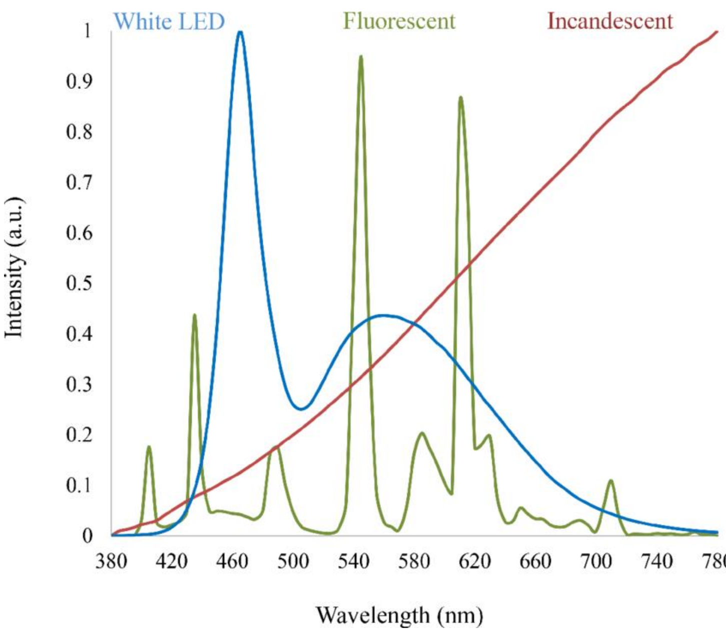
Additional light filtering is recommended for the eye safety!

Artificial sources of light

The introduction of LED lamps and digital devices has dramatically increased human exposure to blue light. LEDs replaced standard light sources (e.g., incandescent and halogen) and they are massively adopted for screens of the electronic devices which we use every day, such as PCs, TVs, smartphones, and tablets.

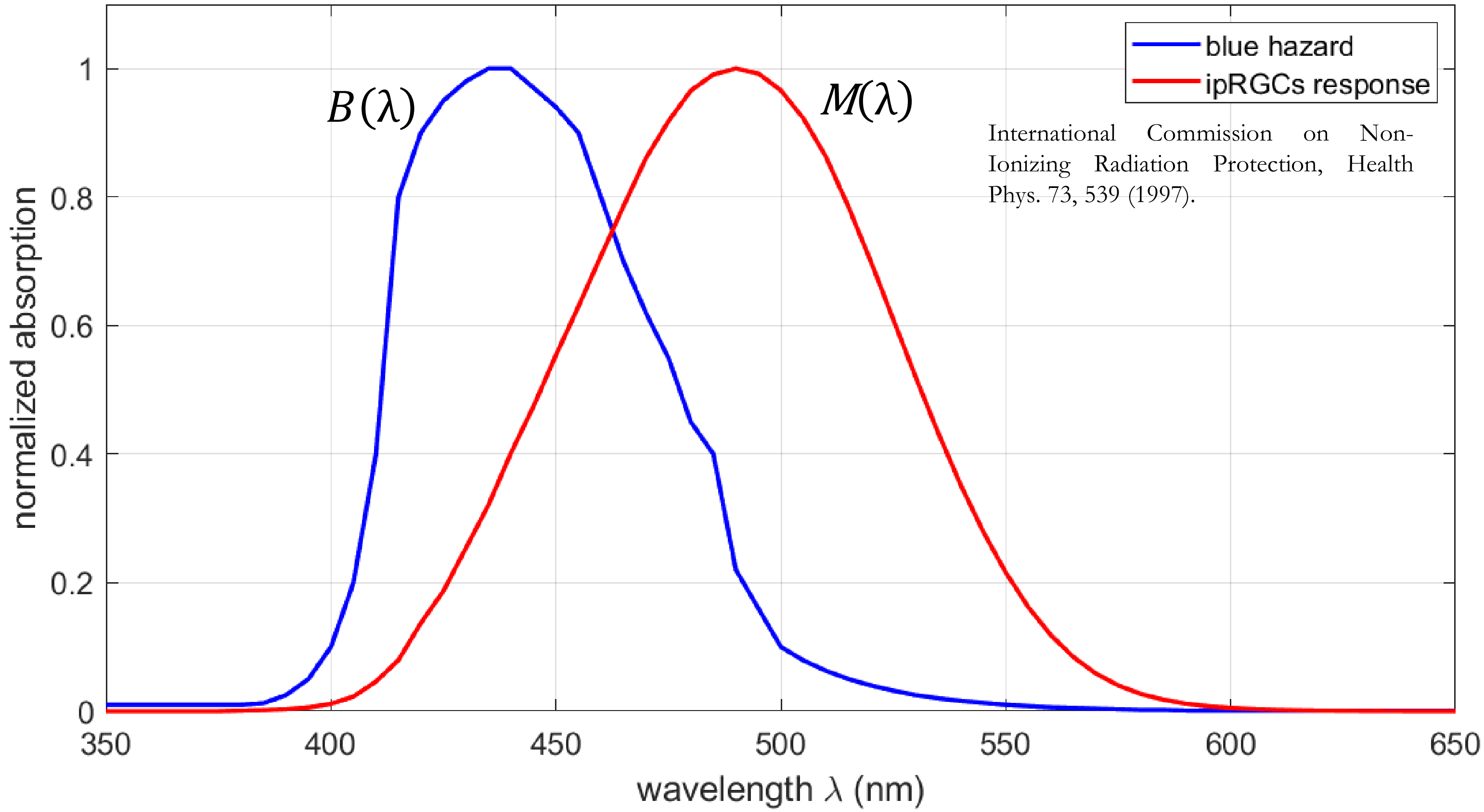
A particularity of the commonly used white LED is its significant emission of short-wavelength blue light.





Estimating the filtering action

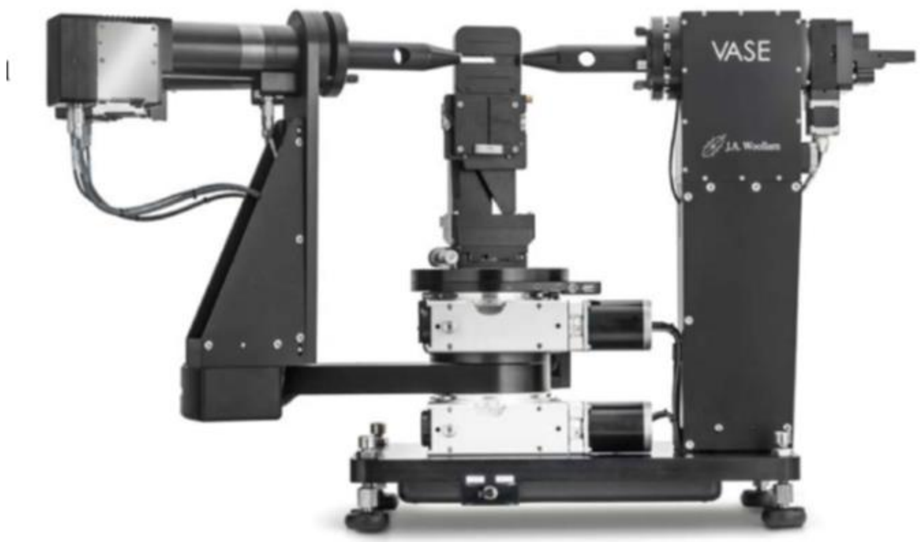
We consider the curves describing the blue hazard and the response of intrinsically photosensitive retinal ganglion cells (ipRGCs),. There is a clear overlap between the two functions.



International Commission on Non-Ionizing Radiation Protection, Health Phys. 73, 539 (1997).

Is it possible to mitigate blue hazard without affecting melanopsin excitation?

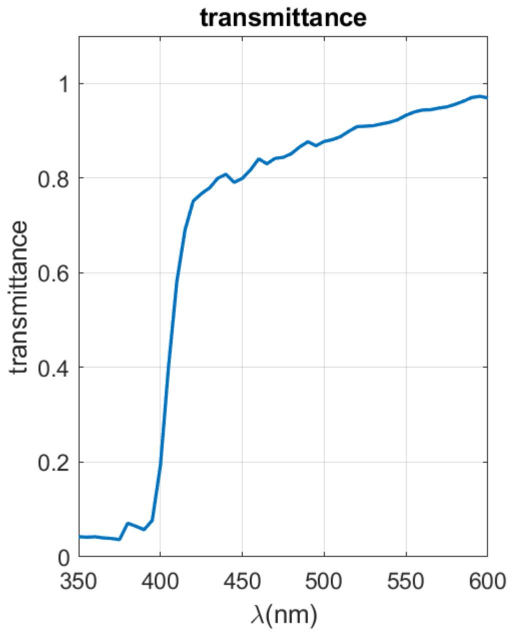
Spectroscopic ellipsometer (VASE)

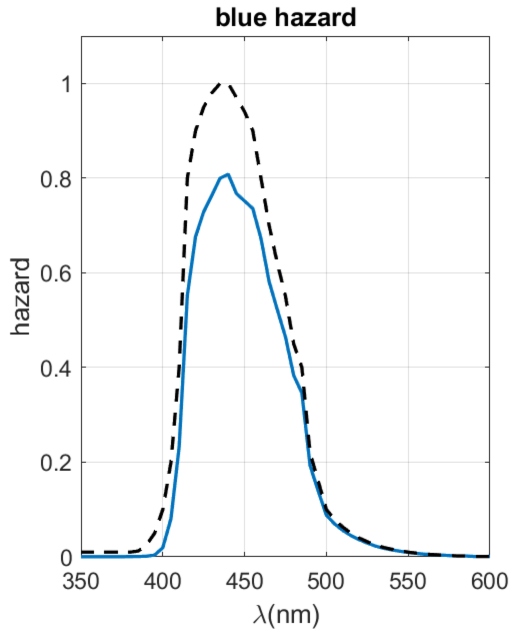


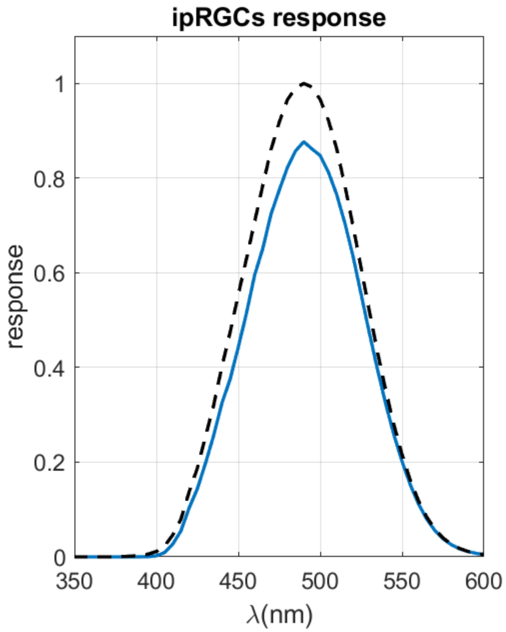
- Variable wavelength and angle of incidence enable flexible measurement capabilities
- Multifunctional: spectroscopic ellipsometry, scatterometry, reflectivity/transmittance analyses
- Wavelength range: 320-2400 nm, resolution 0.3 nm

We performed transmission analyses in the range 350-800 nm, step 5 nm, for blue-filtering lenses, and 350-1500 nm, step 5 nm for infrared-filtering investigations

Estimating the filtering action of a lens



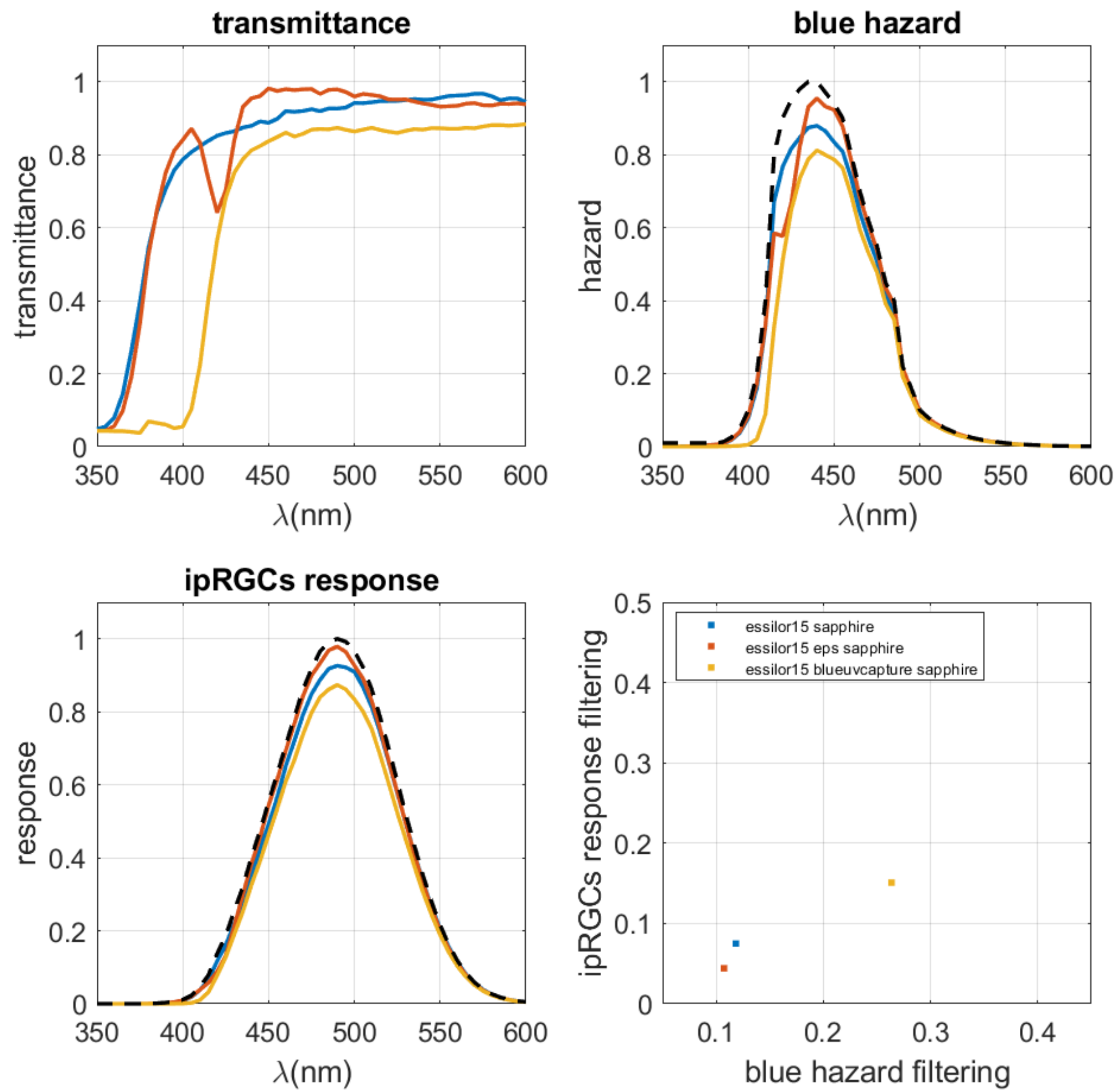




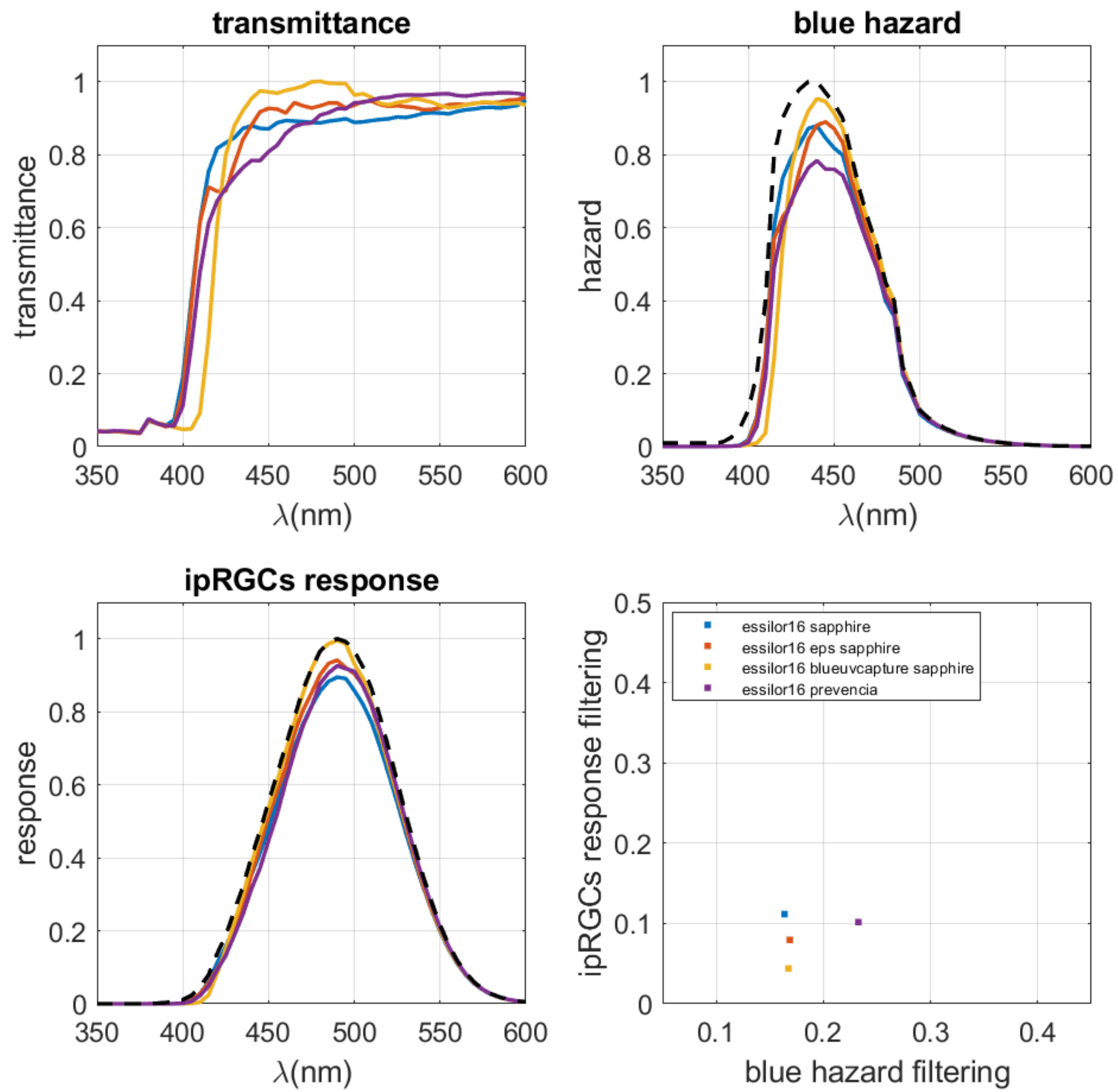
$BF = 0.22$ $\qquad$ $MF = 0.14$

$$BF = 1 - \frac{\int_{350}^{650} B(\lambda)T(\lambda)d\lambda}{\int_{350}^{650} B(\lambda)d\lambda} \qquad MF = 1 - \frac{\int_{350}^{650} M(\lambda)T(\lambda)d\lambda}{\int_{350}^{650} M(\lambda)d\lambda}$$

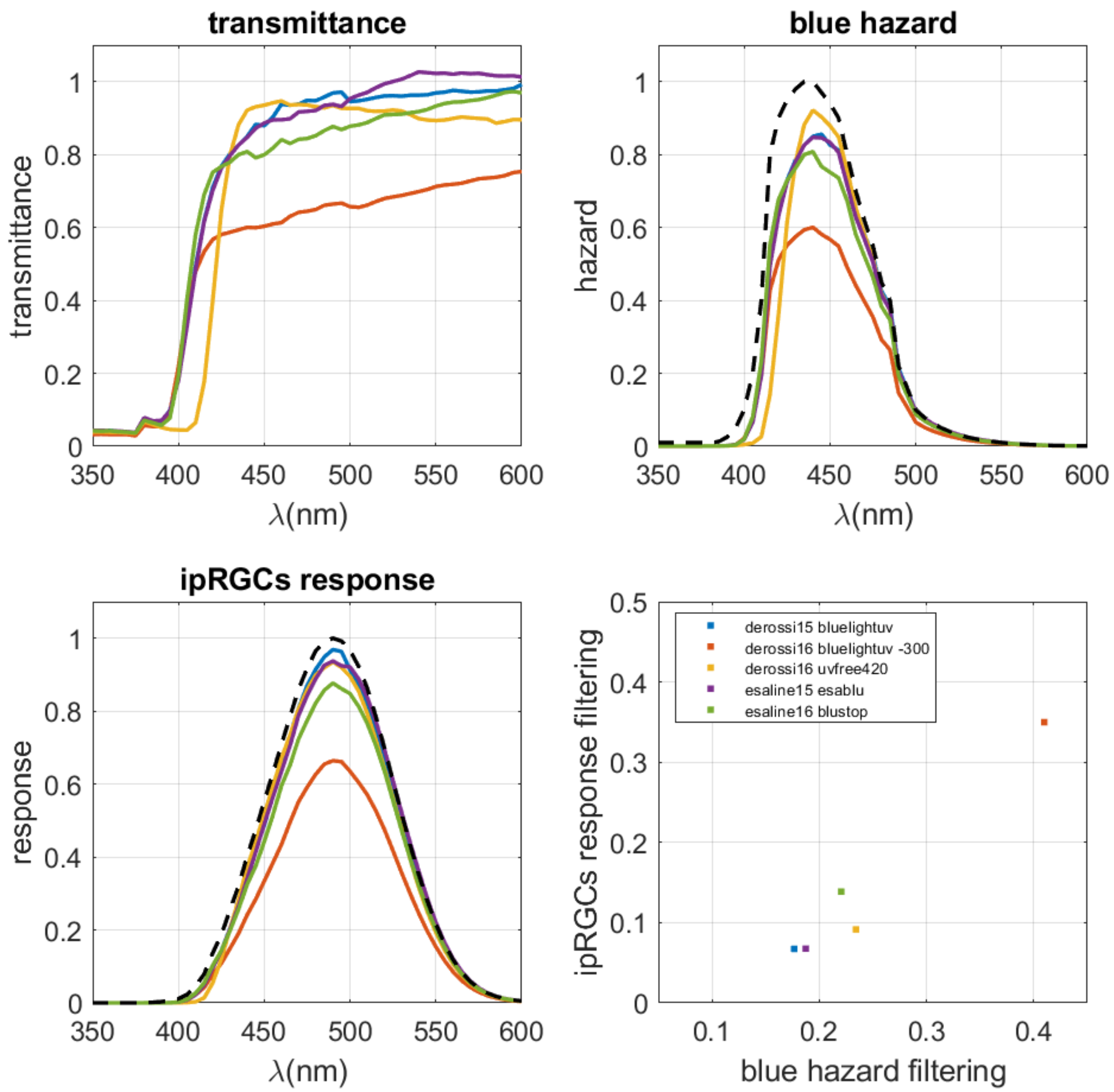
Blue-filtering lens analysis - 1



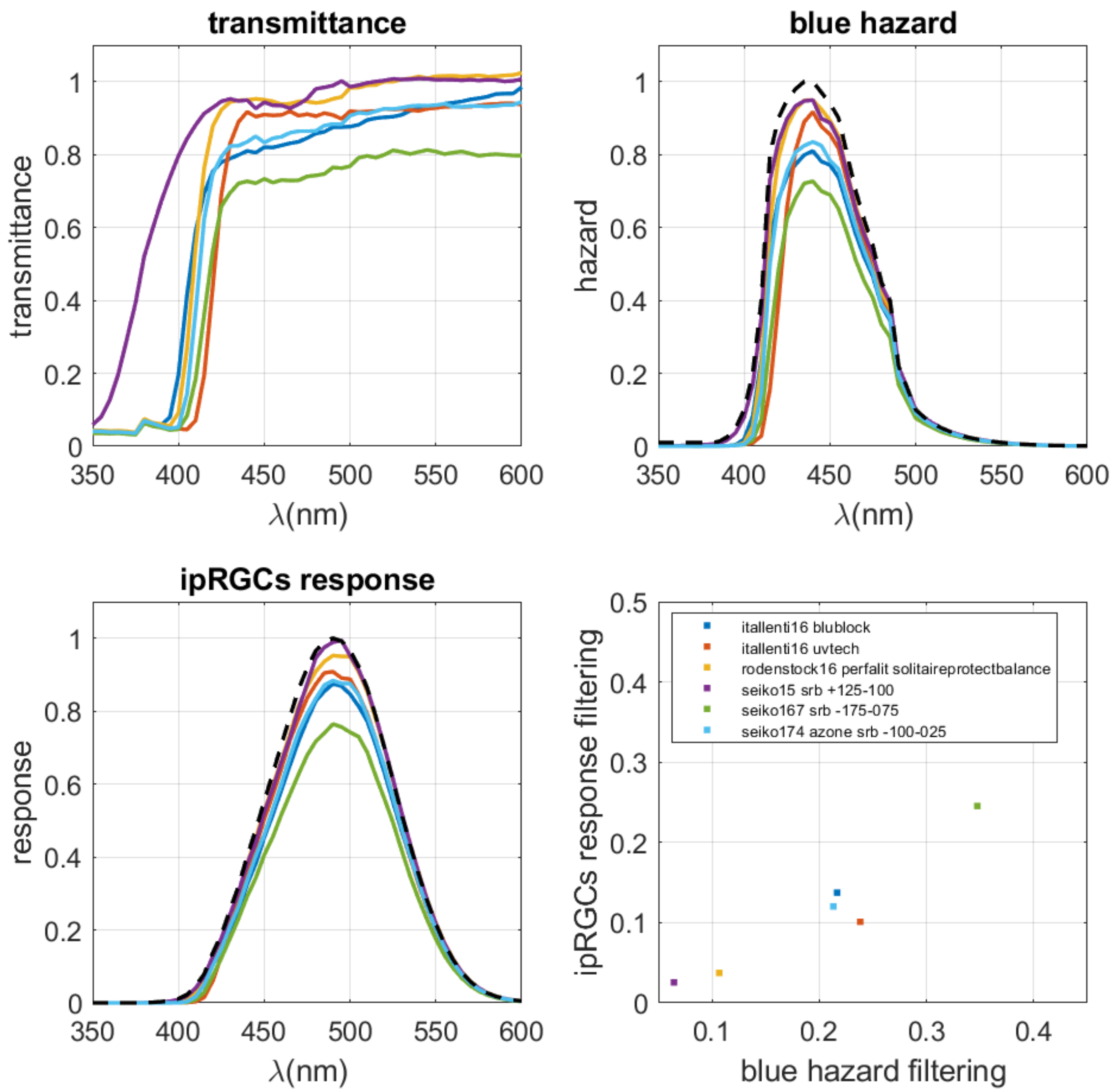
Blue-filtering lens analysis - 2



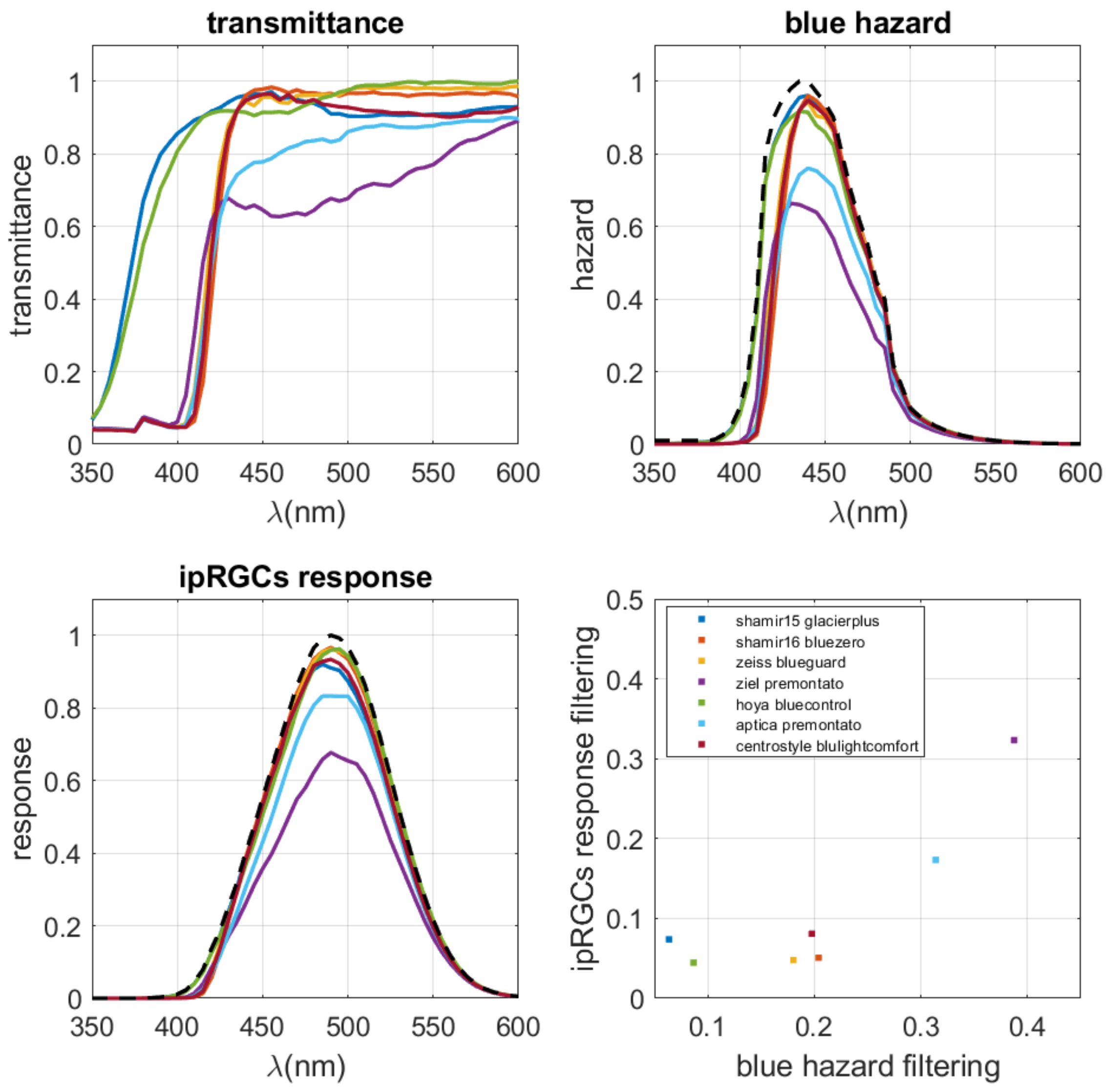
Blue-filtering lens analysis - 3



Blue-filtering lens analysis - 4

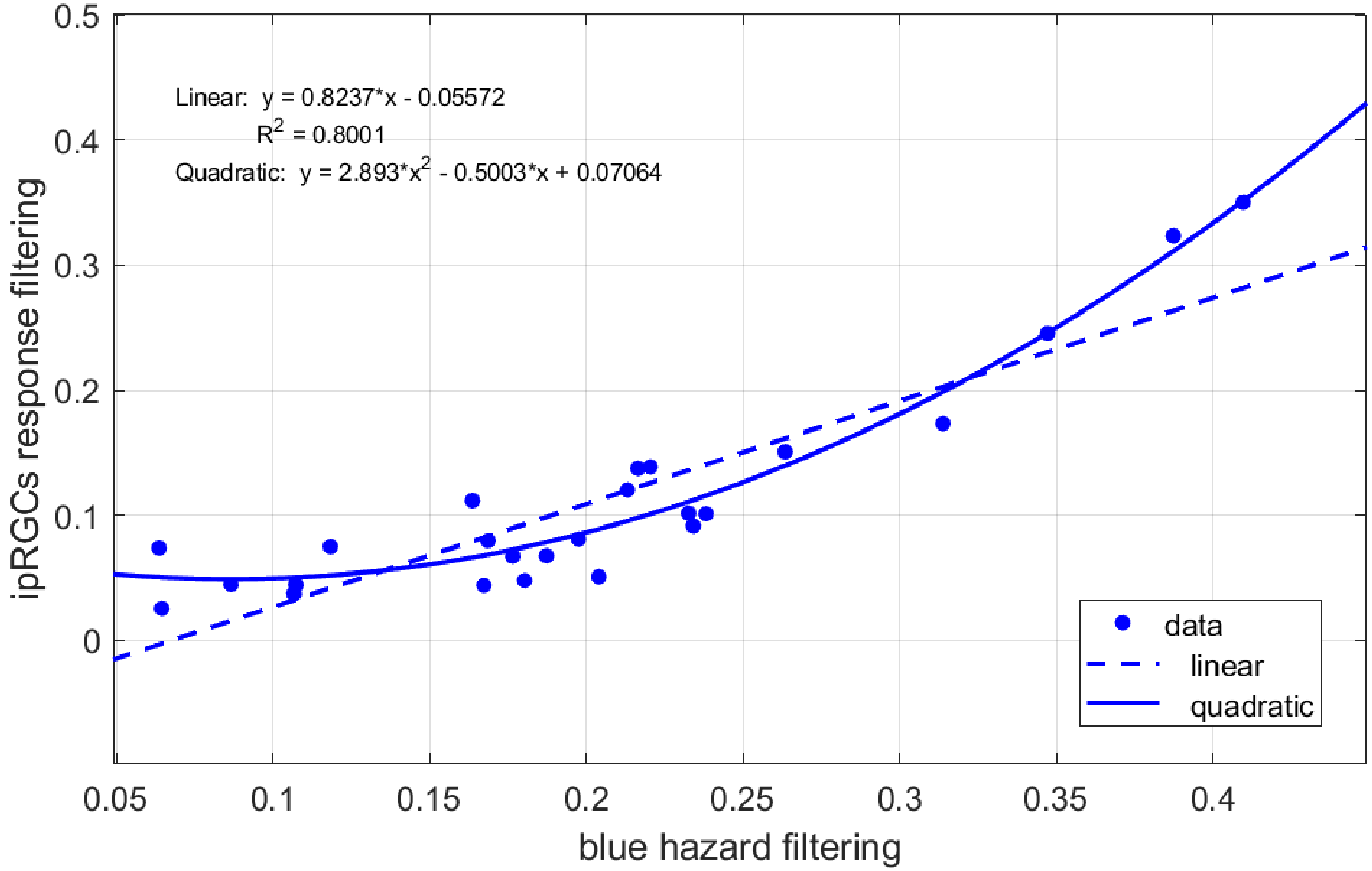


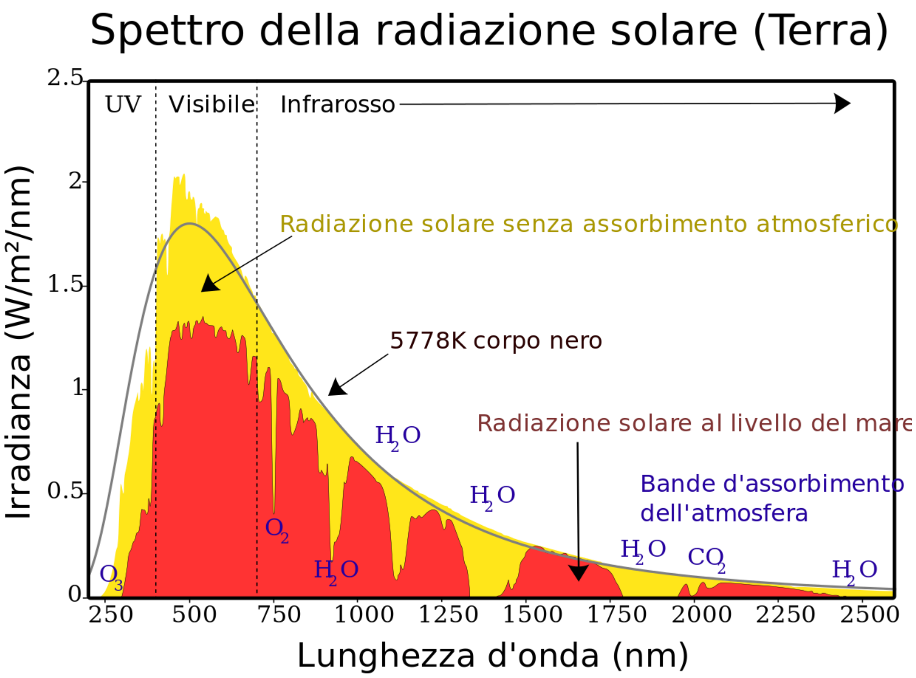
Blue-filtering lens analysis - 5

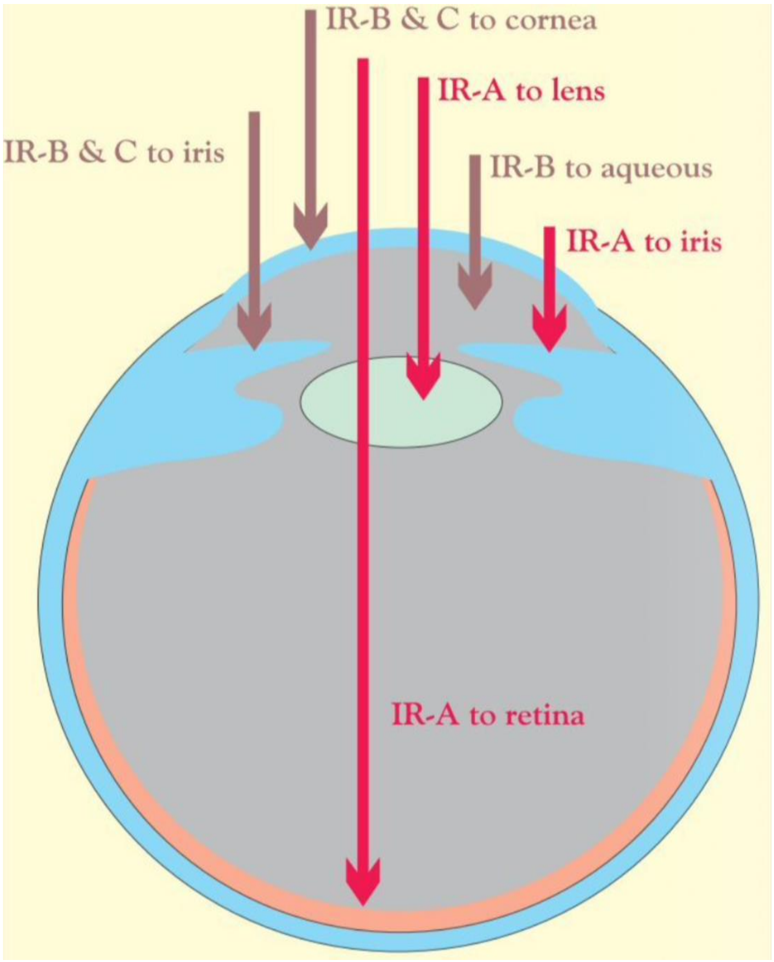


Strong correlation

Strong correlation between blue hazard mitigation and filtering of the ipRGCs response curve







Exposure to high IR intensity can induce local warming and tissue damage.

Protection is recommeded during specific activities outdoor (e.g., skiing) and particular jobs.

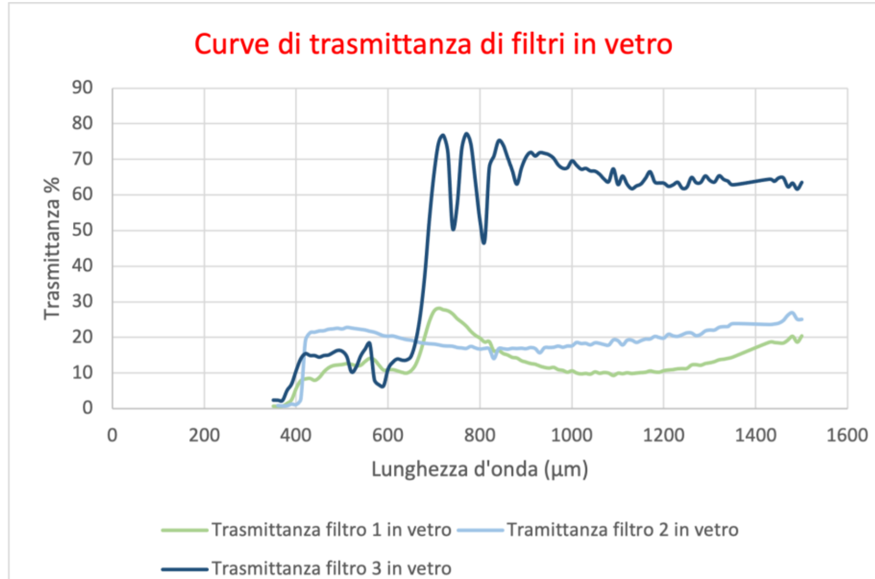
IR filtering analysis

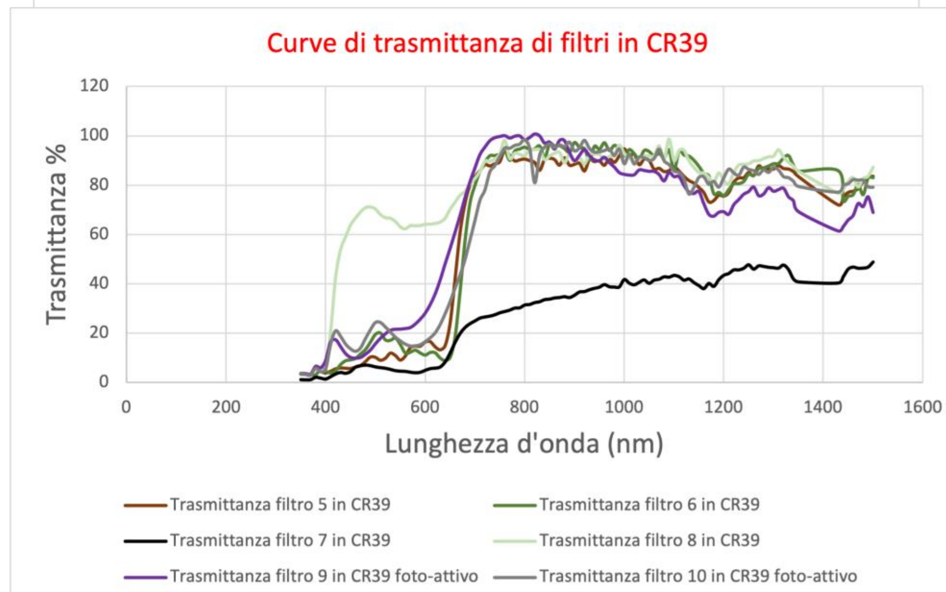
CARATTERISTICHE TECNICHE DEI FILTRI SOLARI ANALIZZATI

	MATERIALE	COLORAZIONE	CATEGORIA	TRATTAMENTI
FILTRO 1	Vetro	Verde g15	3	Nessuno
FILTRO 2	Vetro	Grigio- Azzurro	2	Antiriflesso, specchiata
FILTRO 3	Vetro	Dark Blu	3	Nessuno
FILTRO 4	Vetro	Dark Green	3	Polarizzata
FILTRO 5	CR39	Marrone 75%	3	Nessuno
FILTRO 6	CR39	Verde g15 75%	3	Nessuno
FILTRO 7	CR39	Nero	4	Nessuno
FILTRO 8	CR39	Grigio-Verde	1	Nessuno
FILTRO 9	CR39	Transition Ametista	Variabile	Antiriflesso, Fotocromatico
FILTRO 10	CR39	Grigio	Variabile	Antiriflesso, Fotocromatico
FILTRO 11	Policarbonato	Grigio 75%	3	Nessuno
FILTRO 12	Policarbonato	Rosso-Viola	3	Specchiato
FILTRO 13	Policarbonato	Viola scuro	3	Polarizzata

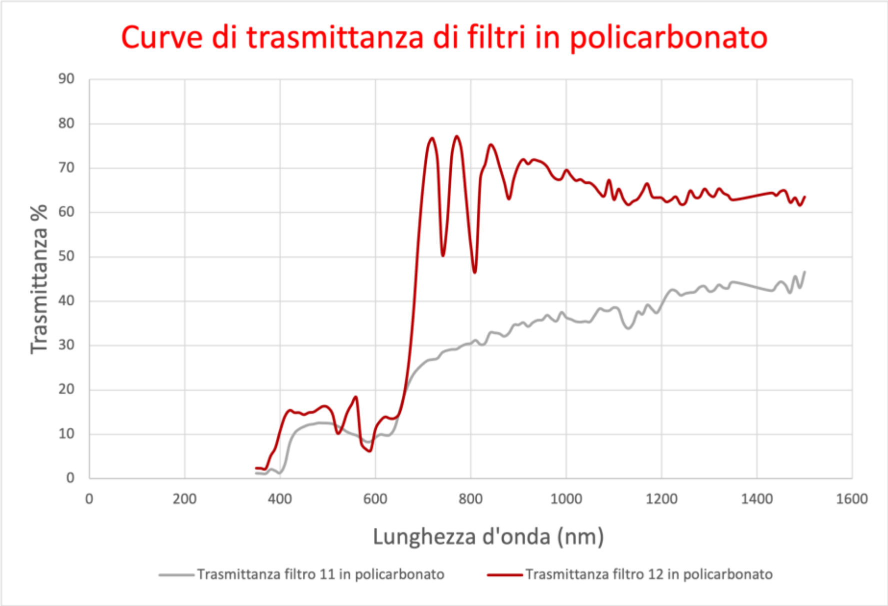
LEGGENDA

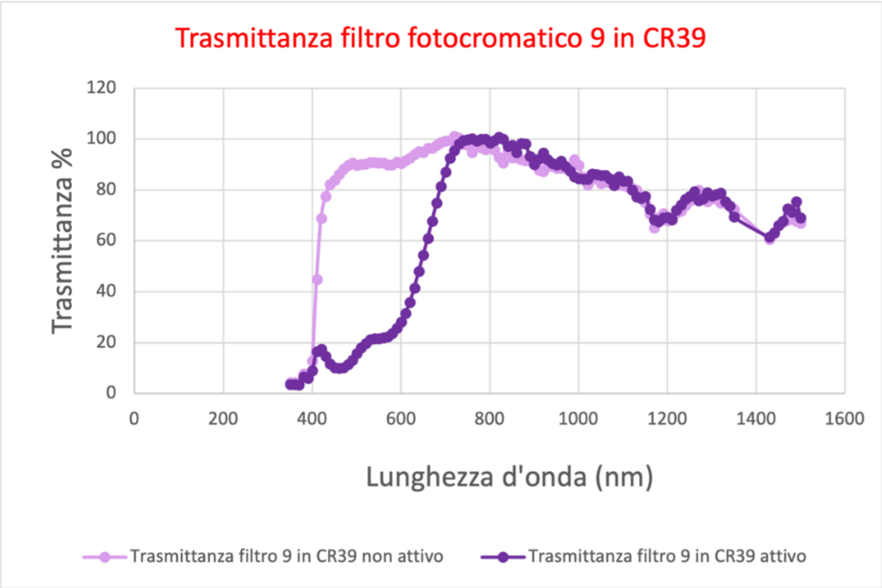
(azzurro)	FILTRO POLARIZZATO
(giallo)	FILTRO FOTOCROMATICO

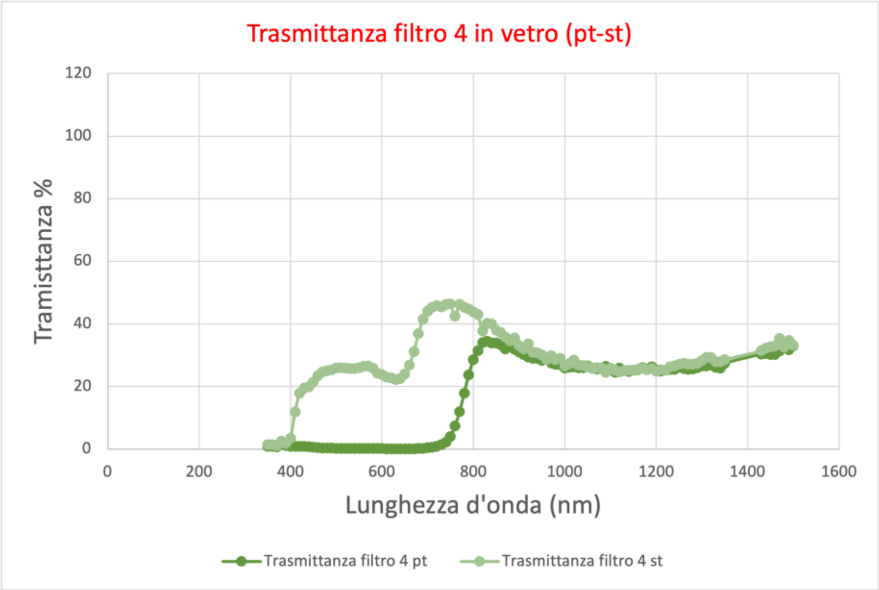




IR filtering analysis



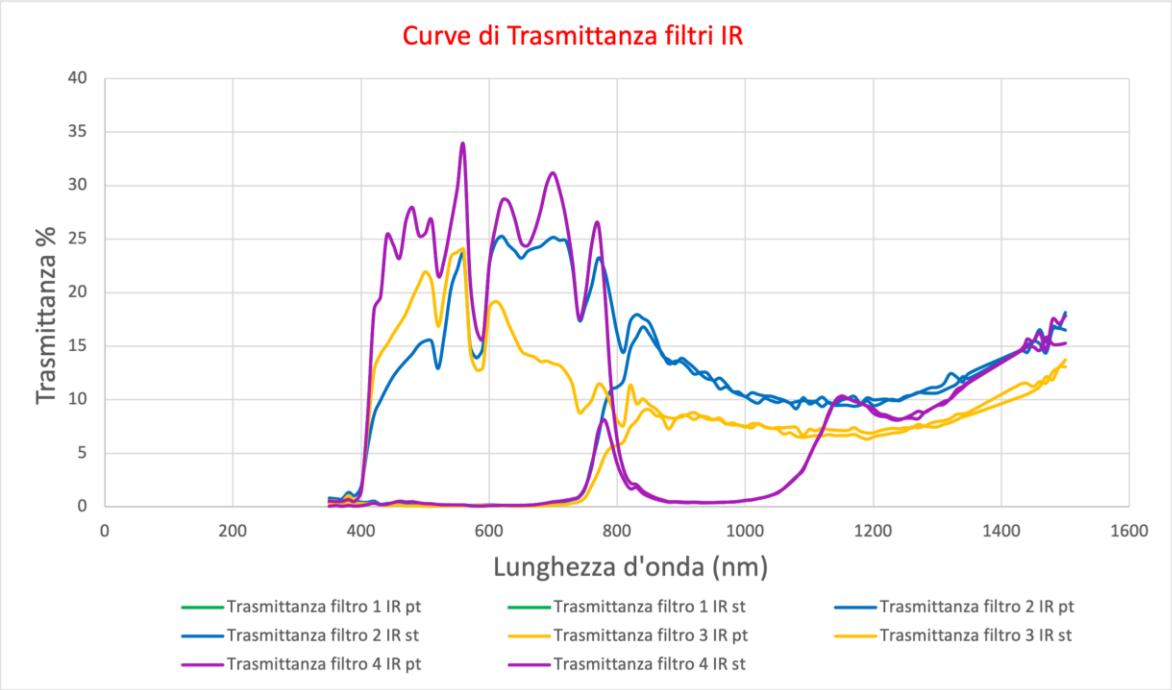




IR filtering analysis

CARATTERISTICHE TECNICHE DEI FILTRI IR SOLARI ANALIZZATI

	MATERIALE	COLORAZIONE	TRATTAMENTI
FILTRO 1	Vetro	Verde	Polarizzato
FILTRO 2	Vetro	Blu	Polarizzato
FILTRO 3	Vetro	Giallo-Dorato	Polarizzato
FILTRO 4	Vetro	Blu Viola	Polarizzato



Conclusions and perspectives

- To prevent damage and alterations it is important to protect the eye from solar radiation also considering UV, blue range, and IR
- It is also fundamental to verify filtering aids and their real effectiveness
- Blu light filters were not found to be effective in minimizing blue hazard and maximizing ipRGCs response at the same time, then a selective filter between 400-420 and 460 nm would be needed
- Specific IR filters perform better than common ones, but most filters do not provide high absorption of IR radiation
- The sensation of heat is usually sufficient to induce the subject to stop exposure and wear the proper protection

Thanks for your kind attention!

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