Update 2021: Environmental Effects Assessment Panel

33rd Meeting of the Parties to the Montreal Protocol
23-29 October 2021
Location: Global

Environmental effects of stratospheric ozone depletion, UV radiation, and interactions with climate change

EEAP Co-chairs:
Janet F. Bornman (Australia)
Paul Barnes (United States)
Krishna Pandey (India)

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EEAP work plan

- The EEAP Updates contribute to the full Quadrennial Assessments
- The 2021 Update was revised and refined during the EEAP online meeting (9 – 17 September 2021)
- A final version for UNEP/Ozone Secretariat will be provided in December 2021

Collaboration and engagement

- Representatives from WHO and WMO attended on one of the EEAP meeting days; and also Sophia Mylona (Ozone Sec)
- Ongoing TEAP and SAP communications to augment and streamline our common activities

Terms of Reference

Environmental Effects Assessment Panel

To request the Environmental Effects Assessment Panel, in drafting its **2022 report**, to pay particular attention to the most recent scientific information together with future projections and scenarios, **to assess the effects from changes in the ozone layer and ultraviolet radiation**, and **their interaction with the climate system,** as well as **the effects of breakdown products** of controlled substances and their alternatives on:

a) The biosphere, biodiversity and ecosystem health, including on biogeochemical processes and global cycles;

b) Human health;

c) Ecosystem services, agriculture and materials, including for construction, transport, photovoltaic use and microplastics

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EEAP Working Groups and main areas for the Quadrennial Assessment

	Interactive effects of stratospheric ozone and climate change on:
	Solar ultraviolet radiation
	Human health
	Terrestrial ecosystems & Biogeochemical cycles
	Aquatic ecosystems
	Composition of the troposphere and air quality
	Natural and synthetic materials
Quad Format	Summary of highlights Executive Summary Main text FAQs

Environmental Effects Assessment Panel

Timetable overview: Quadrennial Assessment

November 2021	Draft outlines; feedback meetings with Co-Chairs
Dec 2021 - Jan **2022**	Working Group drafts
1 Feb	Internal review of initial drafts
7 –18 Feb	EEAP Quadrennial Assessment meeting 1 (online) Refining and revising of drafts
19 Feb – 18 Mar	Refining and revising of drafts, continued
18 Mar – 15 Apr	Internal reviewing; invitations to reviewers
6 -12 May	Revisions incorporated; revised drafts to reviewers
24 - 30 Jun	Reviewer comments received and compiled
30 June – 12 Aug	Working groups respond to reviewer comments; revisions
6 Sep	Online EEAP pre-meeting
19 – 27 Sep	EEAP Quadrennial Assessment meeting 2 (Sweden, on-site) with reviewers
21 Oct	Revisions completed; presentation at 34th MOP: 31 Oct-4 Nov

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The Update highlights the contribution of the Montreal Protocol to environmental and societal sustainability, and mitigation of climate change

aligning with

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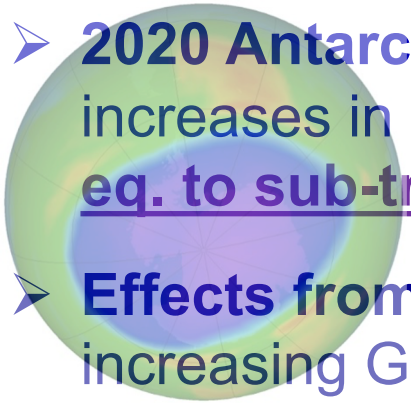
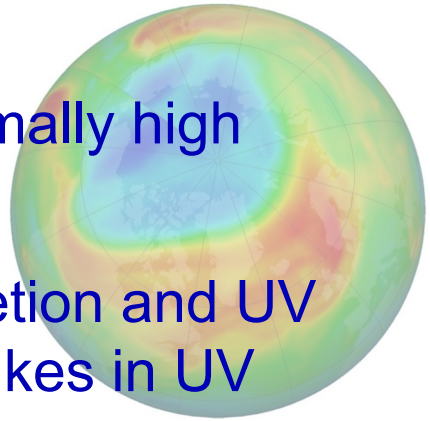
UV radiation and climate

HIGHLIGHTS



- **2020 Antarctic ozone 'hole'** of record duration; record-breaking increases in UV-B radiation (UV index (UVI) of 7.8 & **12** recorded - **eq. to sub-tropic summer max**) but still indications of recovery
- **Effects from expected cooling of the polar stratosphere** from increasing GHGs during the 21st century are projected to dominate atmospheric circulation (affecting temperature and rainfall), while effects from ODS decrease



- **2020 Arctic ozone depletion** contributed to abnormally high springtime temperatures across Asia and Europe

Projected large springtime variability in ozone depletion and UV radiation throughout the 21st century with larger spikes in UV radiation if GHGs and stratospheric water vapour continue to increase throughout this century despite decreasing ODSs.

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HIGHLIGHTS

Human health

Role of the Montreal Protocol

- **The Montreal Protocol has reduced damaging health effects** of excessive exposure to solar UV radiation by protecting the ozone layer
- **By avoiding large increases in DNA-damaging UV-B radiation**, humans can safely tolerate time outdoors, thereby gaining the benefits of moderate sun exposure
- **Benefits**:

✓ Vitamin D production in the skin

✓ Possible reduced risk/severity of a number of diseases

Examples: those related to immune function - multiple sclerosis and COVID-19

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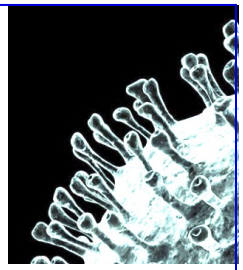
HIGHLIGHTS

Human health



COVID-19 pandemic - evidence suggests that vitamin D, UV radiation, and other aspects of climate may play a role

Two mechanisms influencing COVID-19

1) Inactivation of the SARS-CoV-2 virus by ambient UV radiation *and/or*
2) Vitamin D and nitric oxide produced by exposing the skin to UV radiation could have beneficial effects on immunity and metabolism

- **Skin cancer** continues to be a considerable burden, but some evidence of declining melanoma incidence in certain populations in younger age groups
- **Eye diseases** related to exposure to UV radiation continue to be a major cause of vision impairment globally

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Extreme climate events (ECEs) HIGHLIGHTS

- **Extreme climate events** are increasing in severity & frequency. ECEs change exposure of terrestrial ecosystems to solar UV radiation, during and after:

  - severe drought (++ UV) or catastrophic floods (-- UV)
  - temperature extremes (++ UV)
  - wildfires (++ UV), (-- UV)
  - cyclones/hurricanes (++ UV), (-- UV)
  - rapid snow/ice-melt (++ UV)

- **Consequences** – negative effects for ecosystem stability and productivity, biodiversity, GHG emissions, and seasonal timing of exposure to UV radiation, and carbon storage*

- **Potential ECEs by technological intervention (geoengineering)** *Rapid changes*: temp, rain, ozone depletion, air quality, ecosystems

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Extreme climate events (ECEs) HIGHLIGHTS

Additional connectivity among evolving climate systems:

- **ECEs are superimposed upon ongoing trends** of increasing global temperatures & atmospheric carbon dioxide concentrations

Climate change affects stratospheric ozone depletion and UV radiation, and stratospheric ozone depletion affects climate change

Environmental effects/consequences

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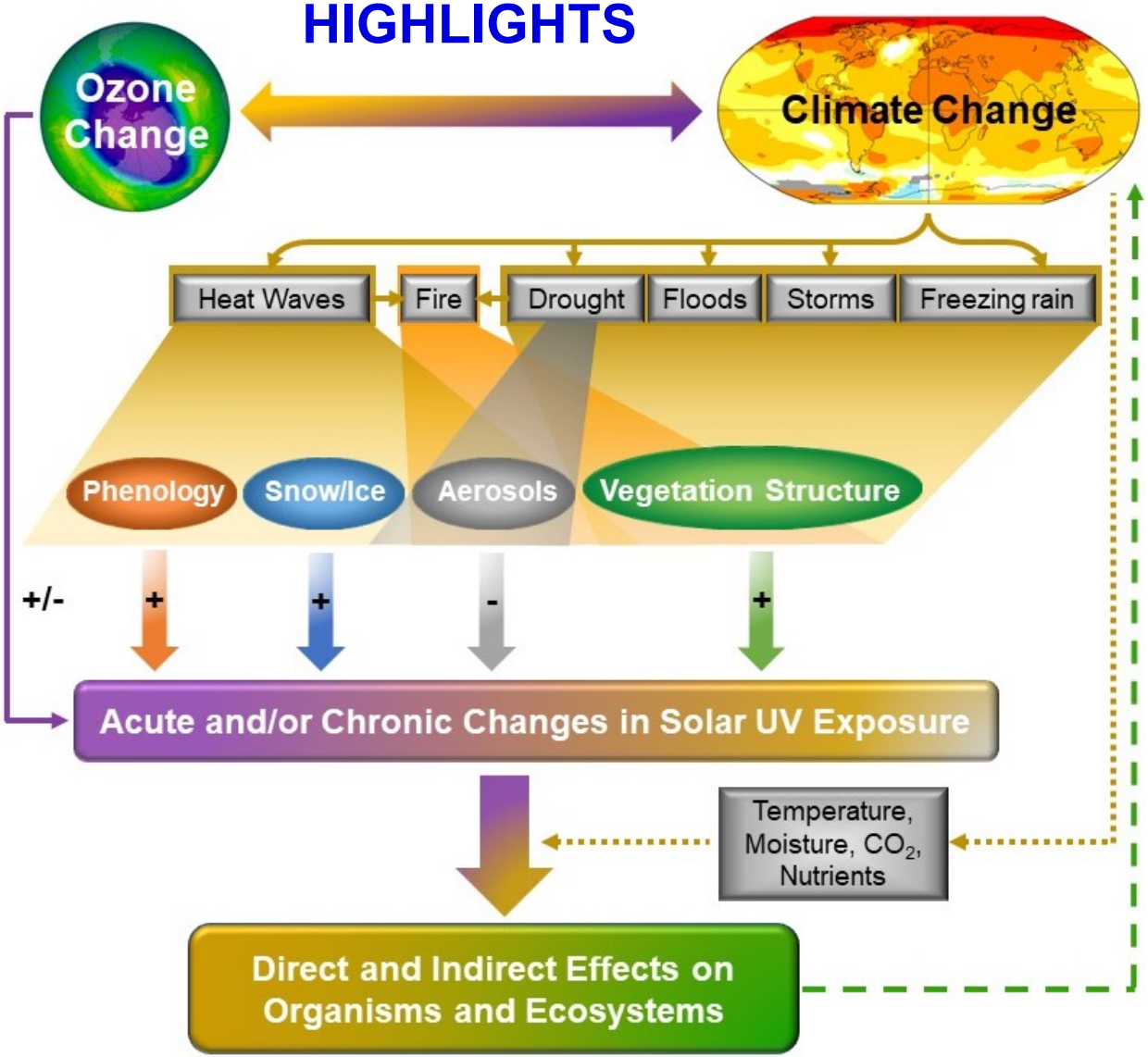
Extreme climate events (ECEs)

Terrestrial ecosystems

HIGHLIGHTS



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Extreme climate events
Aquatic/terrestrial ecosystems

HIGHLIGHTS

- **Interactive effects from increased rainfall and runoff** (dissolved organic matter, DOM) into aquatic systems

  Problem with increasing DOM:

  - **undesirable parasites and pathogens** are shielded from disinfection by UV-B radiation → food security and disease risk

  - at the surface, **UV radiation photodegrades/breaks down DOM**, releasing the GHG, methane; micro-organisms then further break down the DOM, releasing carbon dioxide

- **UV radiation also increases toxicity of some contaminants**, e.g., polycyclic aromatic hydrocarbons (**PAHs**) found in oil spills, some pesticides, etc (cancer risk)

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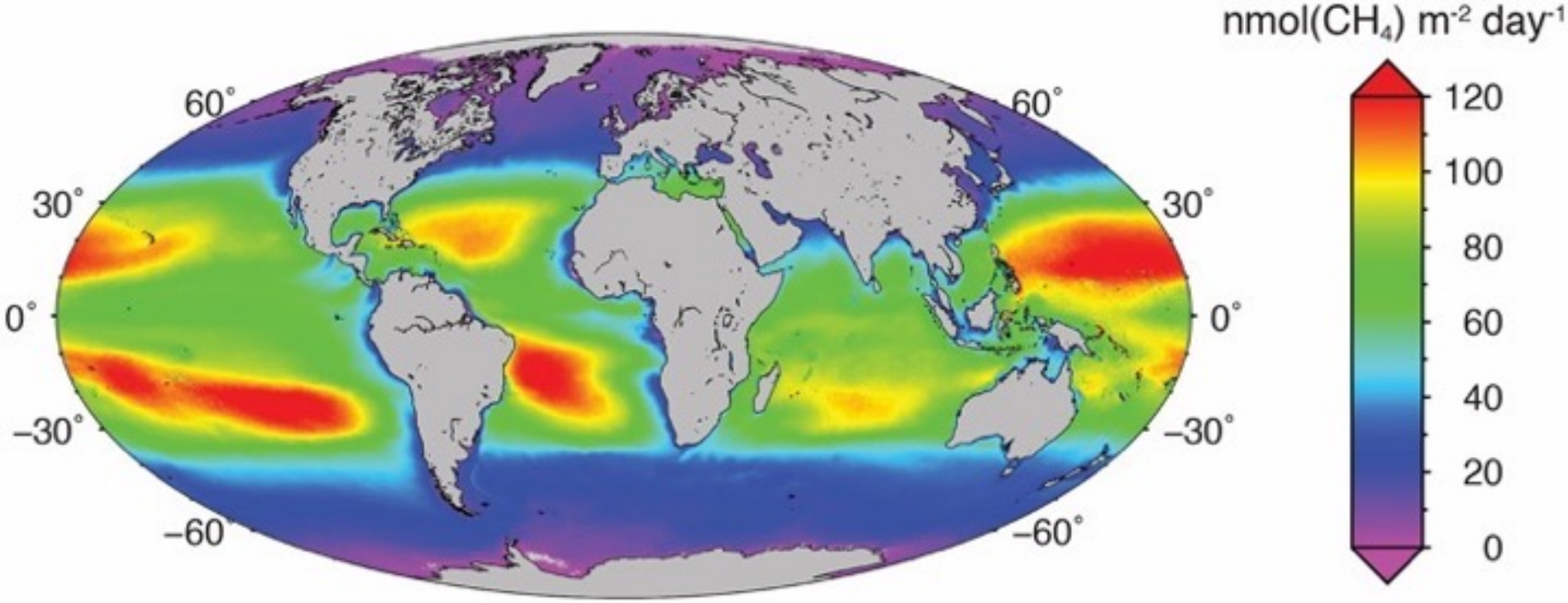
Extreme climate events
Aquatic/terrestrial ecosystems

HIGHLIGHTS



Photoproduction rate of methane from dissolved organic matter (DOM) at the ocean surface (top 150 m). (Figure by Rachele Ossola)

Adapted from Li et al. 2020. *Geophys. Res. Lett., 47*(14), e2020GL088362

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Breakdown products

HIGHLIGHTS

Breakdown products by the action of UV radiation of controlled substances and their alternatives

- **Photodegradation** of per- and polyfluoroalkyl substances (PFAS) into more toxic perfluorocarboxylic acids (**PFCAs**)
- **Trifluoroacetic acid (TFA)**, an example of PFAS, is a widespread contaminant, and a breakdown product (photodegradation) of hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), and hydrofluoroolefins (HFOs) in the atmosphere
- TFA: recently detected in surface waters, beer, tea, herbal infusions, and indoor dust; but not in toxic concentrations

  Risk assessments will continue to be useful

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Natural & synthetic materials

HIGHLIGHTS

Montreal Protocol and innovation

Implications of effects of UV radiation and climate change:

- **Decreased useful lifetime of natural materials** (e.g., wood) and synthetic plastics used outdoors and in textiles (polyester, nylon)

  To counter this decrease, higher levels of UV stabilisation are needed (more costly; increased persistence & leaching)

- **Degradation of plastic debris and litter is accelerated** with high amounts of UV radiation and high temperatures: environmental consequences ↓

  accelerated production rate of microplastics and microfibres
  Two studies found microplastics (by inhalation) in human placenta and on the foetal side. Foetal translocation not yet demonstrated

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HIGHLIGHTS

Natural & synthetic materials

- UV radiation: mainly responsible for plastic degradation, forming microplastics in the environment
- Microfibres from textiles: often account for 80-90% of sampled microplastics in the ocean (polyester and nylon fibres) – UV and mechanical breakdown

Montreal Protocol and innovation

New innovations to protect the environment & human health:

Replacements for plastic and *other* contaminants (such as *polycyclic aromatic hydrocarbons, PAHs*)

- Novel, scalable & optically-clear, solar UV-blocking wood *composites* (*i.e.,fillers/additives inserted into wood*)
- Graphene and its oxides (nanoscale); block UV; electrical and anti-microbial properties; environmental contamination?
- Titanium oxide blocks UV transmission through textiles by absorption, reflection and/or scattering of the UV radiation (protects skin from UV)

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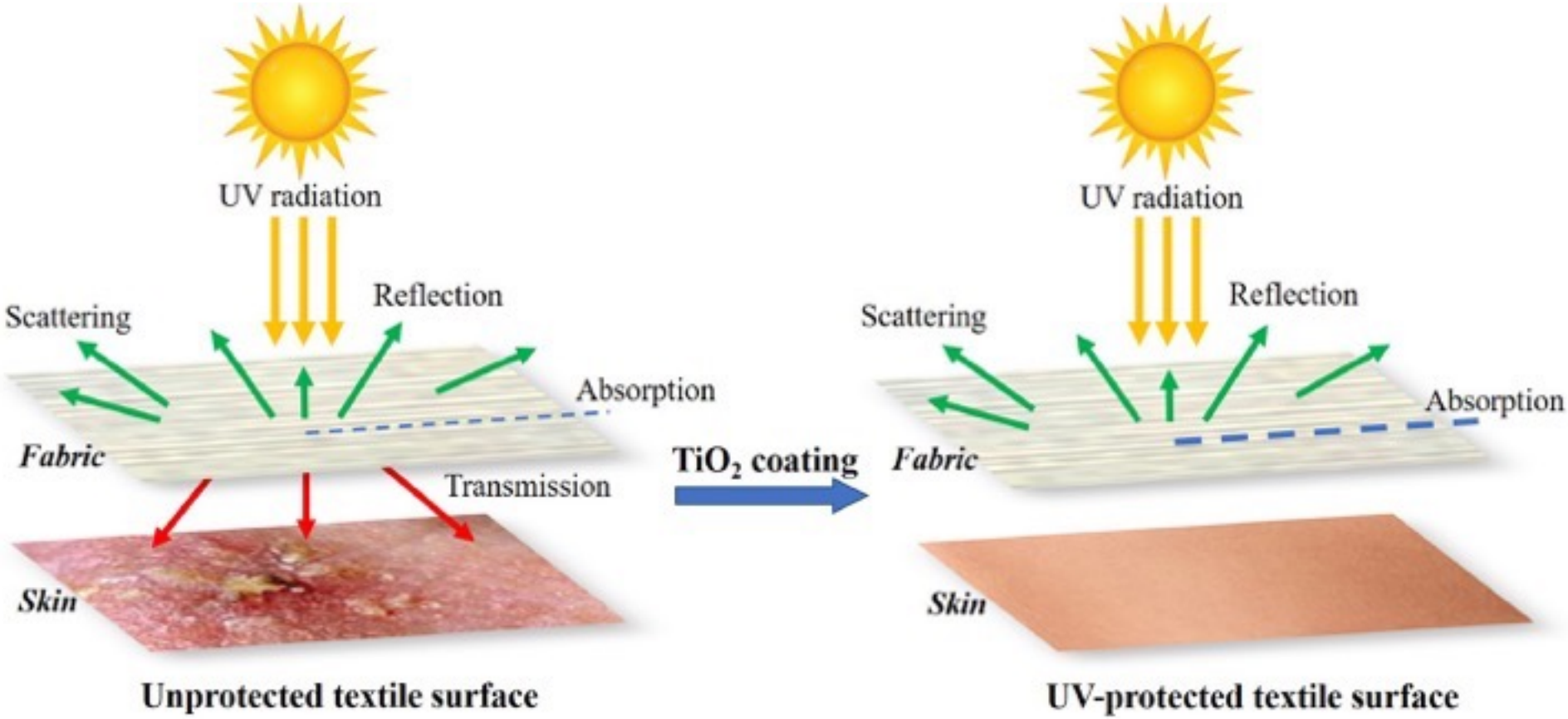

Modified textile protecting skin by reflection, scattering, and absorption of UV radiation; TiO_2 also has anti-microbial properties

Courtesy Rashid, M.M., et al. (2021) *Surfaces and Interfaces*, 22, 100890

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Carbon storage by plants

HIGHLIGHTS

Ongoing benefits of the Montreal Protocol

Recent modelling study: Young, P. J., A. B. Harper, C. Huntingford, N. D. Paul, O. Morgenstern, P. A. Newman, L. D. Oman, S. Madronich, and R. R. Garcia (2021), The Montreal Protocol protects the terrestrial carbon sink, Nature, 596 (7872), 384-388.

The study brings important high-level messages of the significance of the Montreal Protocol, although with large uncertainties in the estimations and the problem of extensive heterogeneity/non-uniformity among plants and their wide range of response to climate and UV radiation.

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Carbon storage by plants

HIGHLIGHTS

Ongoing benefits of the Montreal Protocol

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Without the Montreal Protocol, estimated:

Increase in UV-B (280–315 nm) radiation by ca 400% over the 21st century without control of the ODSs

Decrease of 325–690 billion tonnes carbon held in plants by end of century

Additional 115–235 parts per million of carbon dioxide in the atmosphere

Additional rise in global mean surface temperature of 0.5–1.0 °C

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The assessment of environmental effects, including health, continues to reinforce the multiple benefits of the Montreal Protocol in reaching the SDG targets