

Review: The relationship between exposure of ultraviolet radiation and vitamin D status

Ola Engelsen

*Norwegian Institute for Air Research
(NILU)*

Ann R. Webb

University of Manchester

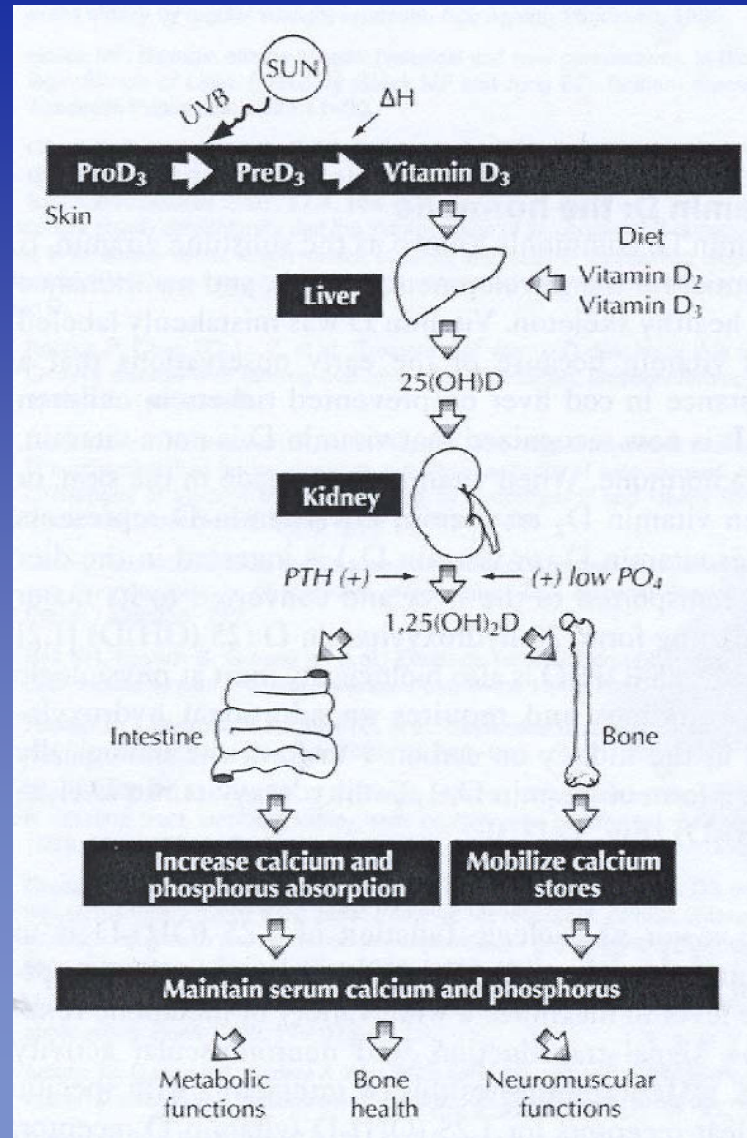
Outline

- Health effects of vitamin D
- Formation of vitamin D
- Desirable vitamin D levels
- Factors which affect vitamin D synthesis
- How much do we know?
- Indicative UV exposure times
- Erythema vs. vitamin D exposure

Health effects of vitamin D

- **Healthy skeleton (bone metabolism, calcium and phosphorous homeostasis)**
- **May prevent cancer and autoimmune diseases**
- **May have many other health benefits, e.g. lower blood pressure.**

Formation of vitamin D



Optimal levels of vitamin D status

Recommendations based on leveling out of PTH.

25(OH)D levels (nmol/L)

- **>50-80 satisfactory**
- **25-50 suboptimal**
- **12.5-25 deficiency**
- **<12.5 serious deficiency**

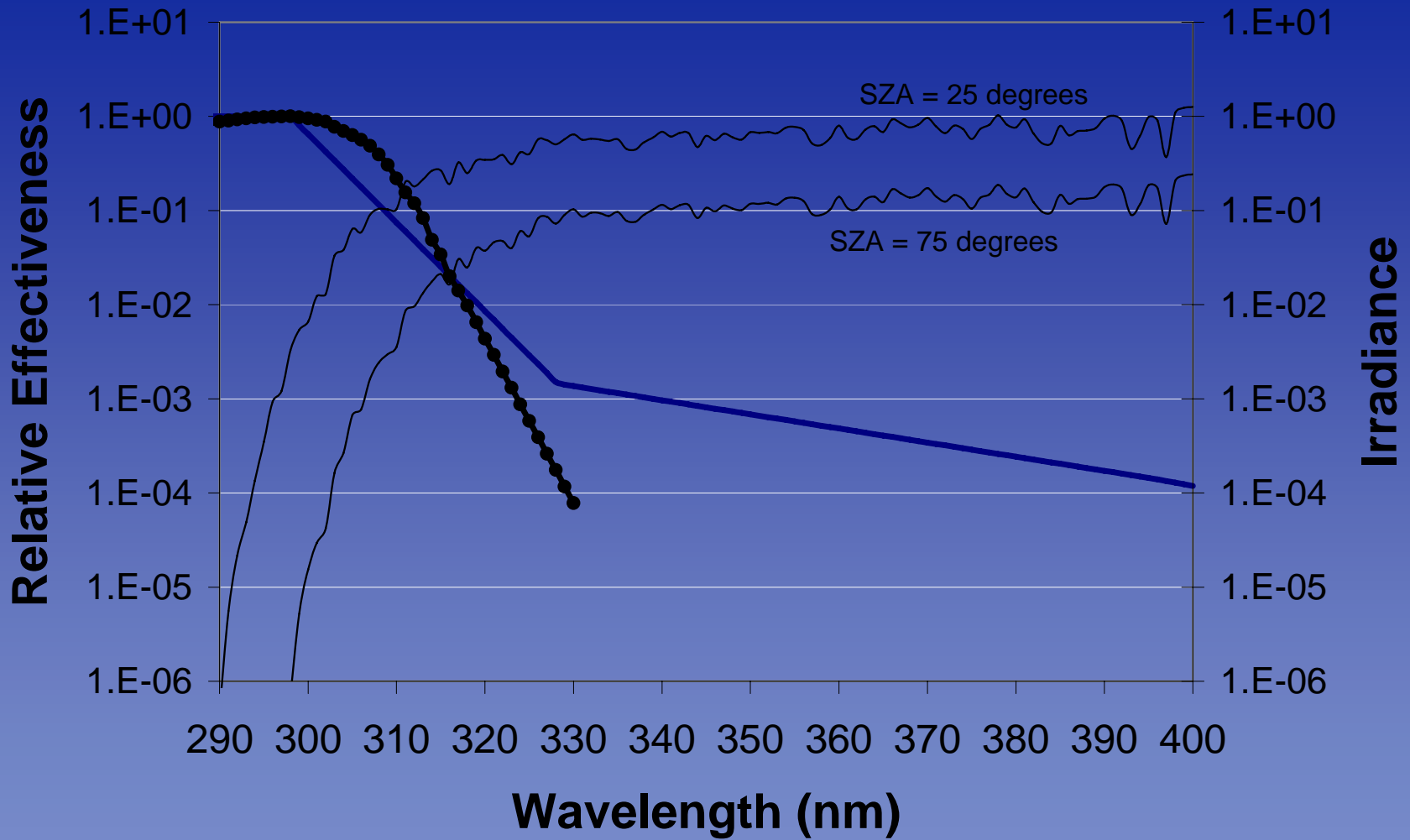
Main factors driving UV exposure

- **wavelengths,**
- **clouds,**
- **solar zenith angle (season and latitude),**
- **ozone,**
- **surface reflection (snow),**
- **sunscreen,**
- **outdoor behaviour,**
- **skin type,**
- **obesity,**
- **age,**
- **sunbeds,**
- **clothing (temperature)**



Ola Engelsen, NILU
ESP Meeting, Sept 07





Vitamin D synthesis from UVR

- In vitro models (Galkin, Obi-Tabot)
- Some in vivo studies (Holick, Matsuoka)
 - *Lamp characteristics unclear*
- Depends on time and location (Webb, Holick)
- Atmospheric conditions

Laboratory exposure studies

Best available study: Walk in chamber experiments showed that 1 full body MED = 10000 – 25000 IU. This relationship has been confirmed by at least 4 studies, also under natural exposure.

- **Weakness: Lab experiments apply fixed broadband UV lamps, assimilation to the solar spectrum is difficult due to uncertainties in vitamin D action spectrum**

Relationship of dietary intake and vitamin D status

Extensive literature review (Vieth, 1999).

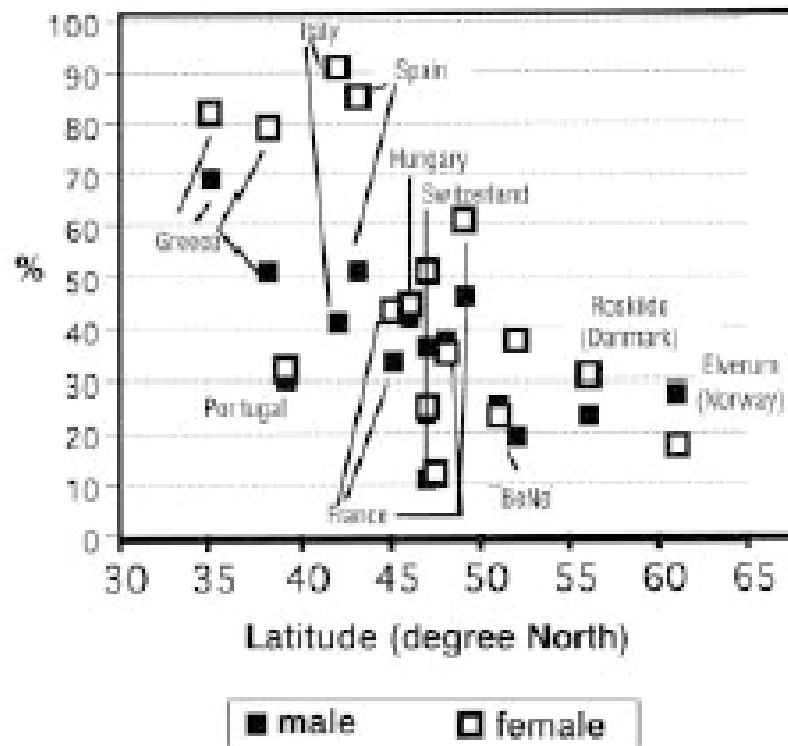
Formulas (Heaney, 2004).

Not straightforward, depends on initial 25(OH)D level and calcium intake.

Vitamin D status

- **Negative gradient of vitamin D status in Europe wrt. latitude due to diet and skin complexion (Sharla, 2000), converse elsewhere.**
- **Vitamin D status is seasonally dependent with a late wintertime low, except some coastal communities.**
- **Suboptimal levels are widespread at mid- and high latitudes.**
- **Extremely low vitD levels in darker skin individuals.**

Figure 2: The percentage of the population with vitamin D deficiency (25-hydroxyvitamin D < 12 ng/ml) is plotted against the latitude. Data from reference [24].



Daily duration of VitD synthesis

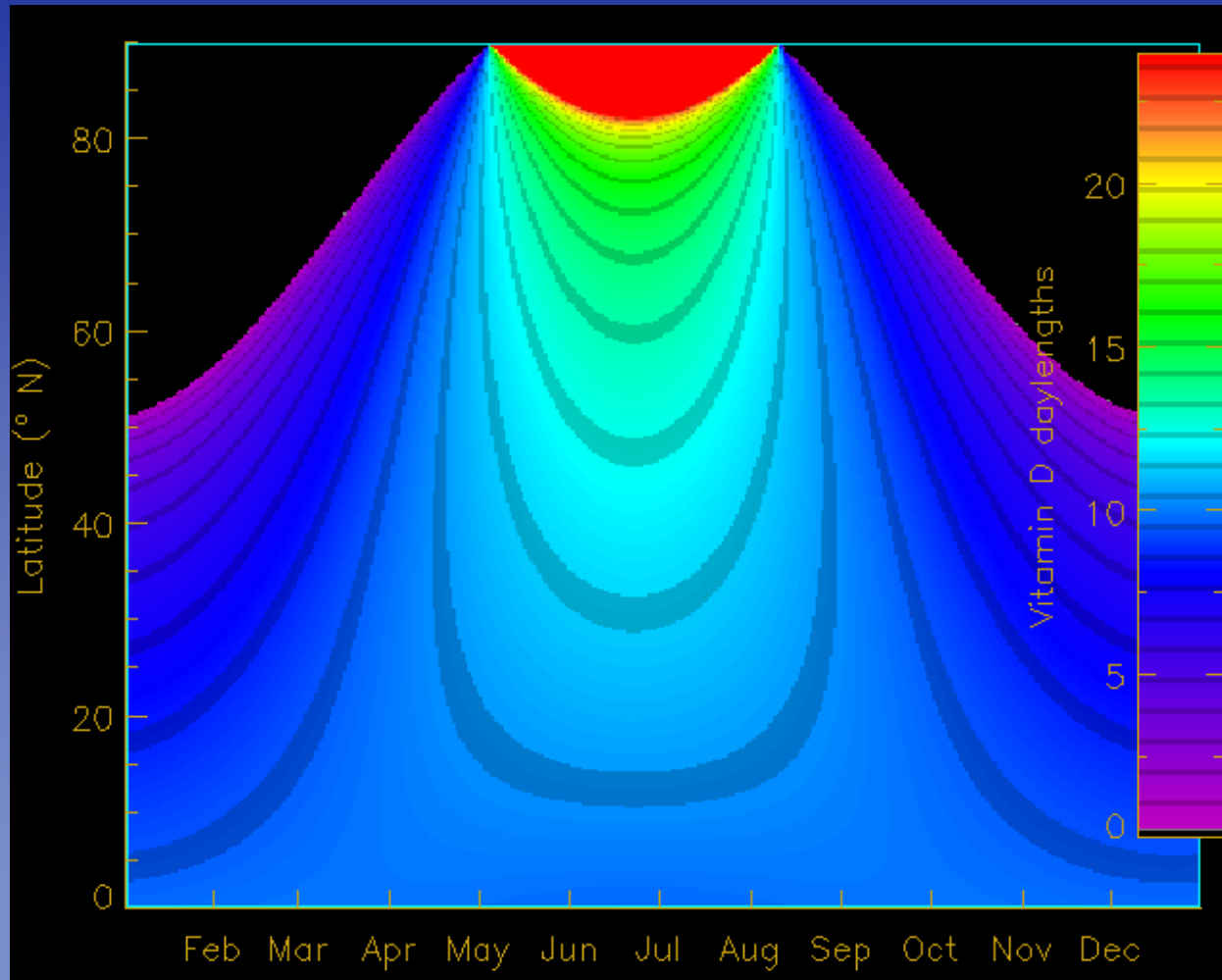
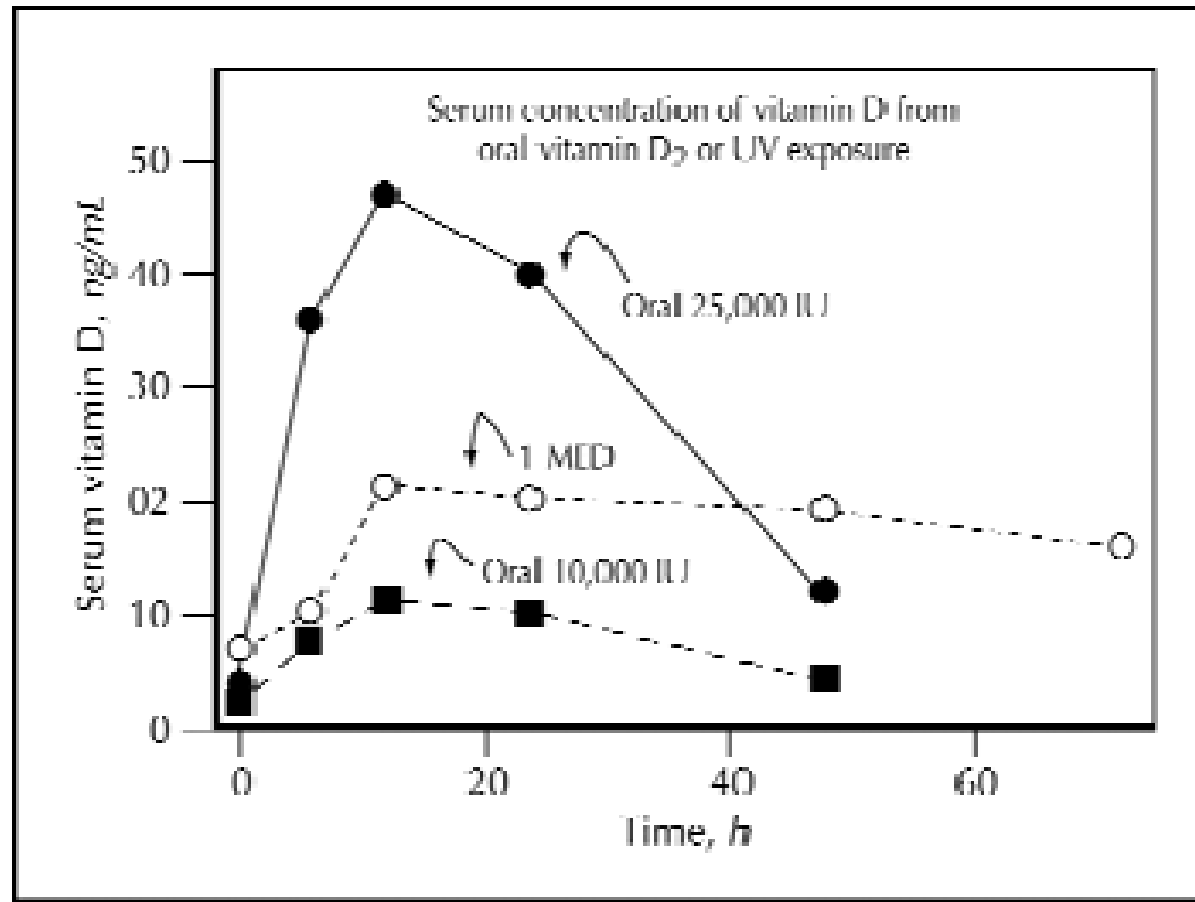
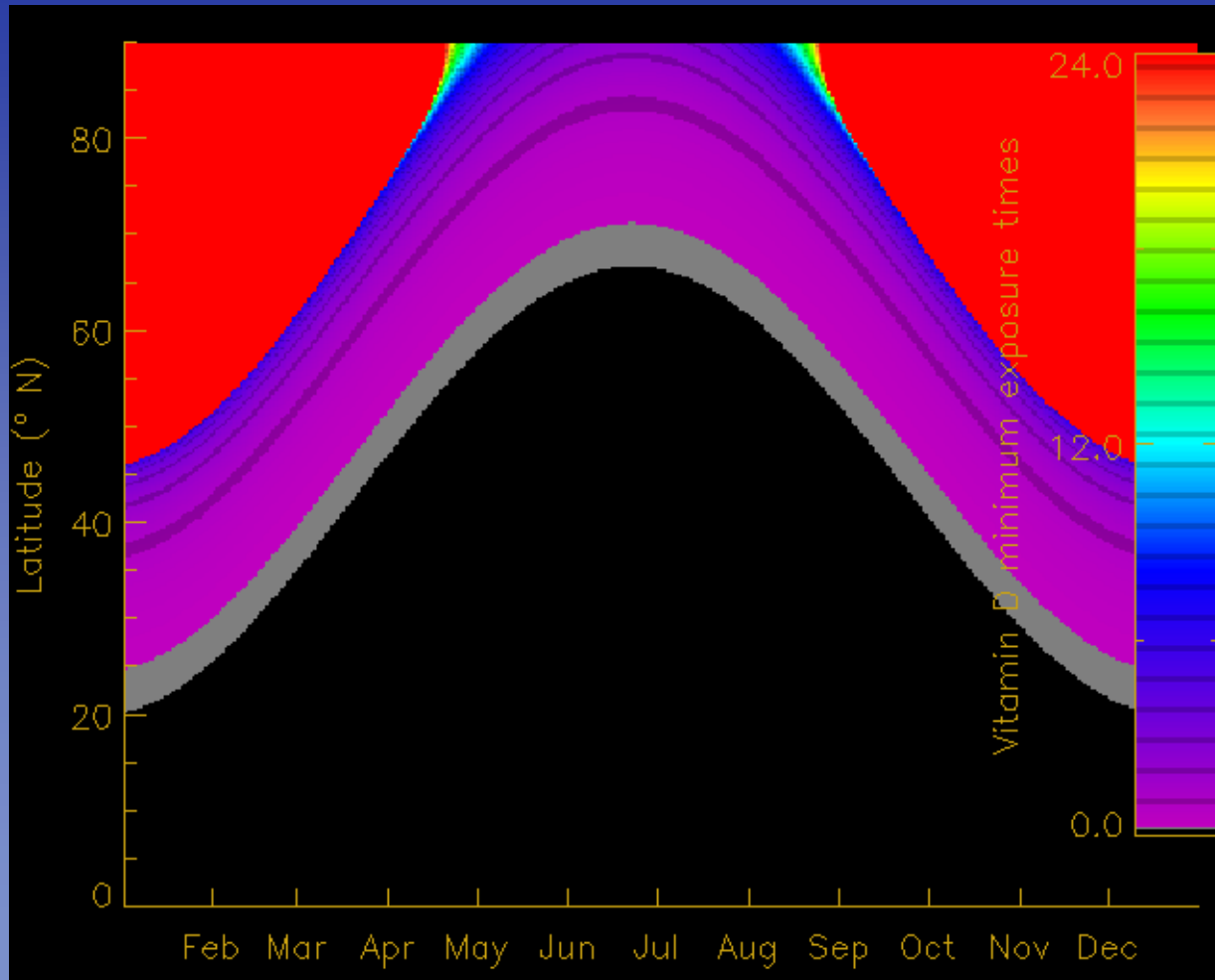


Figure 7. Comparison of oral vitamin D and ultraviolet B irradiation on serum vitamin D

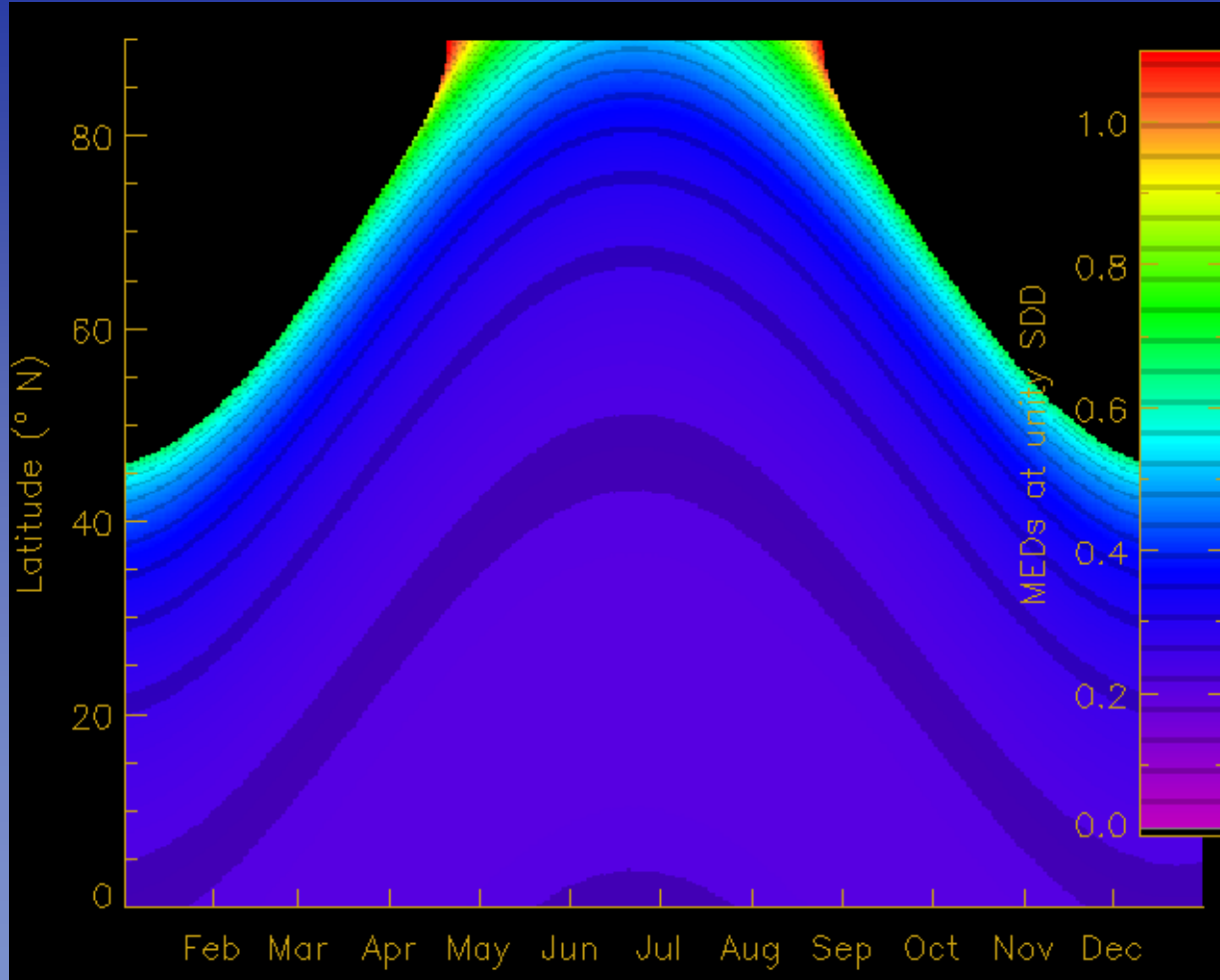


Comparison of serum vitamin D levels after a whole-body exposure to 1 minimal erythemal dose (MED) of simulated sunlight compared with a single oral dose of either 10,000 or 25,000 IU of vitamin D₂. Reproduced with permission [61].

Recommended solar exposure (hours)



MEDs at unity SDD



Exposure time, hours (Minimal Erythematol Dose, fraction) for Boston at the spring equinox

Vit. D >	400 IU		1000 IU		4000 IU	
Skin	2	5	2	5	2	5
Type>						
Area v						
F,N,H	0.15	0.35	0.36	0.89	1.49	3.95
(11.5%)	(0.21)	(0.21)	(0.54)	(0.54)	(2.16)	(2.16)
F,N,H,A	0.07	0.16	0.17	0.40	0.67	1.62
(25.5%)	(0.09)	(0.09)	(0.24)	(0.24)	(0.97)	(0.97)
F,N,H,A,L	0.03	0.07	0.07	0.18	0.29	0.70
(57.5%)	(0.04)	(0.04)	(0.10)	(0.10)	(0.43)	(0.43)

User-operated online internet model simulations

<http://nadir.nilu.no/~olaeng/fastrt/VitD.html>

http://nadir.nilu.no/~olaeng/fastrt/VitD_quartMED.html

<http://nadir.nilu.no/~olaeng/fastrt/fastrt.html>

See FastRT poster (Engelsen et al.)

Conclusions

- **Dermal UV synthesis is inadequately understood**
- **Good qualitative understanding of processes**
- **Quantitative modelling is possible but is incomplete and is based on limited cohort experiments**
- **Erythema if high doses of vitamin D should be obtained by normal skin exposure (face, neck, hands)**
- **Unrealistically long exposure times are sometimes required to obtain recommended vitamin D doses through skin.**
- **Desirable vitamin D doses and erythemal doses more similar for low solar elevations**

Thanks to collaborators

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