



A.W. Schmalwieser

Unit of Biophysics

University of Veterinary Medicine, Vienna, Austria

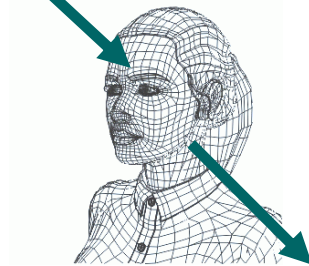
Impact of Climatic and
Environmental Factors on
Personal UV Radiation Exposure
and Human Health

Impact of UVR

Solar
UV

Climate: Total Ozone – Clouds – Aerosols- Albedo

1. Radiation (Measurements, Modelling)



2. Receiver: age, gender, ...
behaviour, ...
environ,

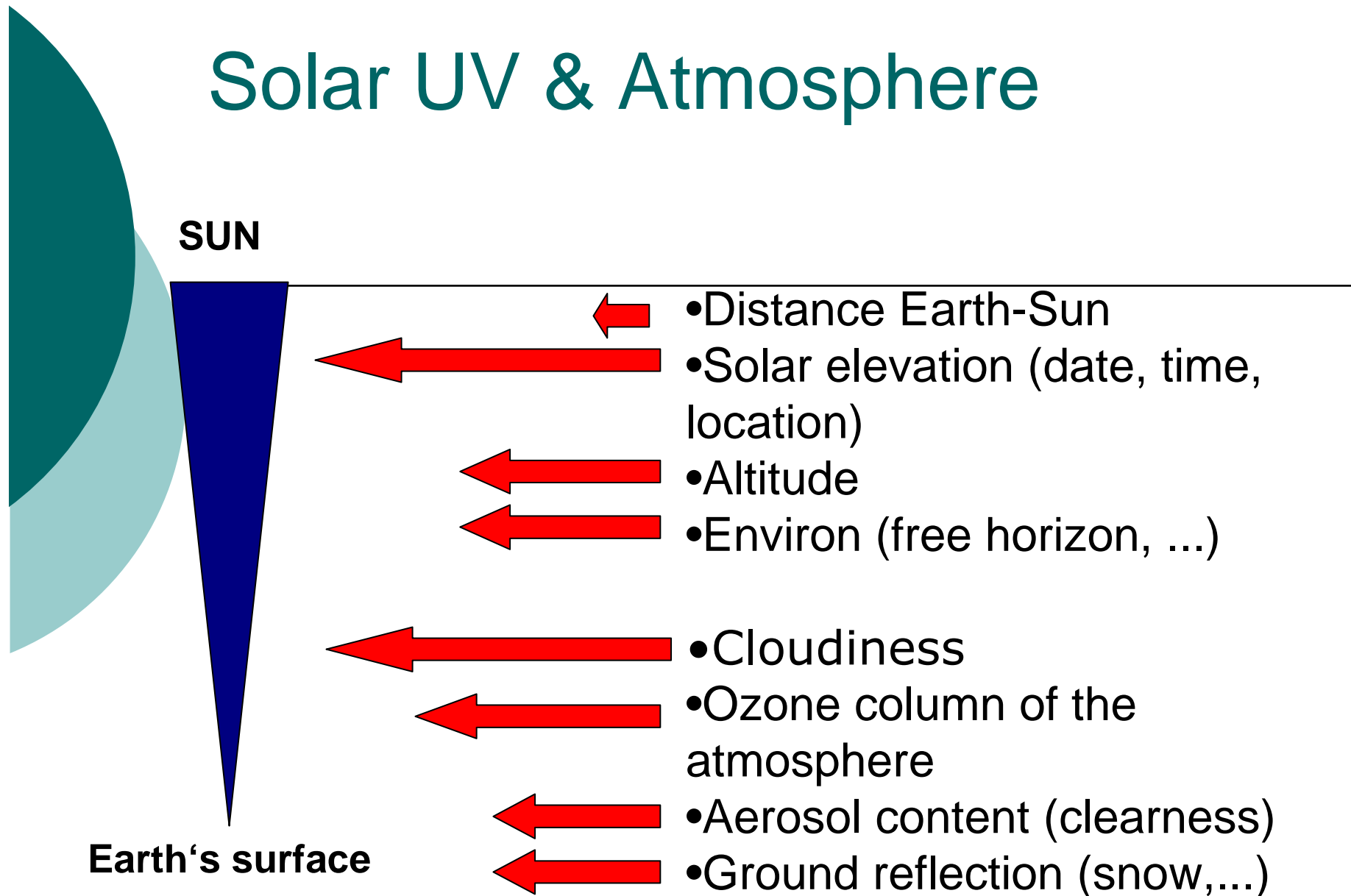
Climate

3. Surface: skin color, pigmentation,...

4. Effect inside the body: vitamin D,
DNA-damage, immunosuppression
(blood, urine, skin biopsy)

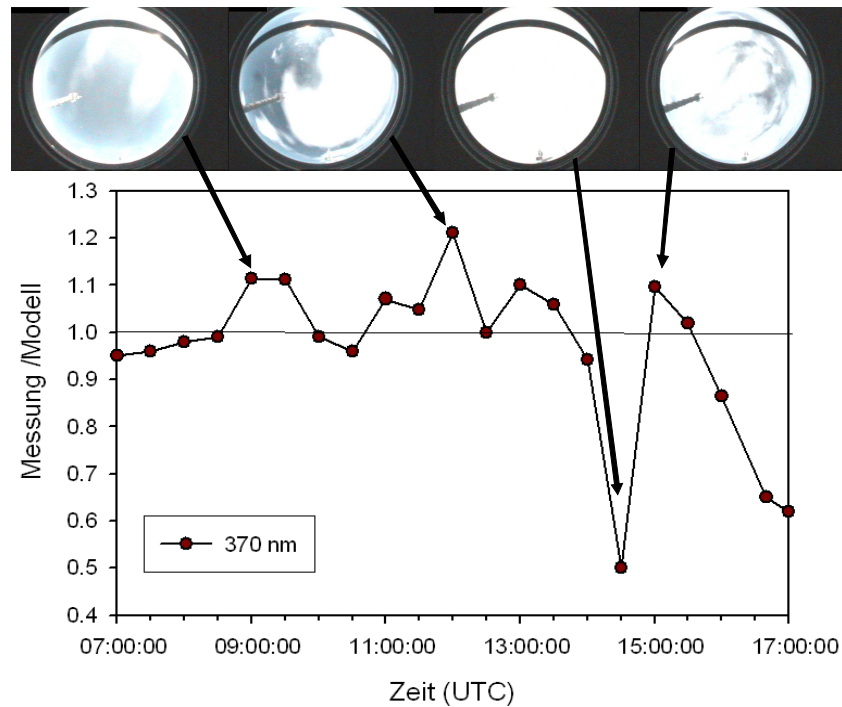
5. Exposure, effect ->Risk

Solar UV & Atmosphere

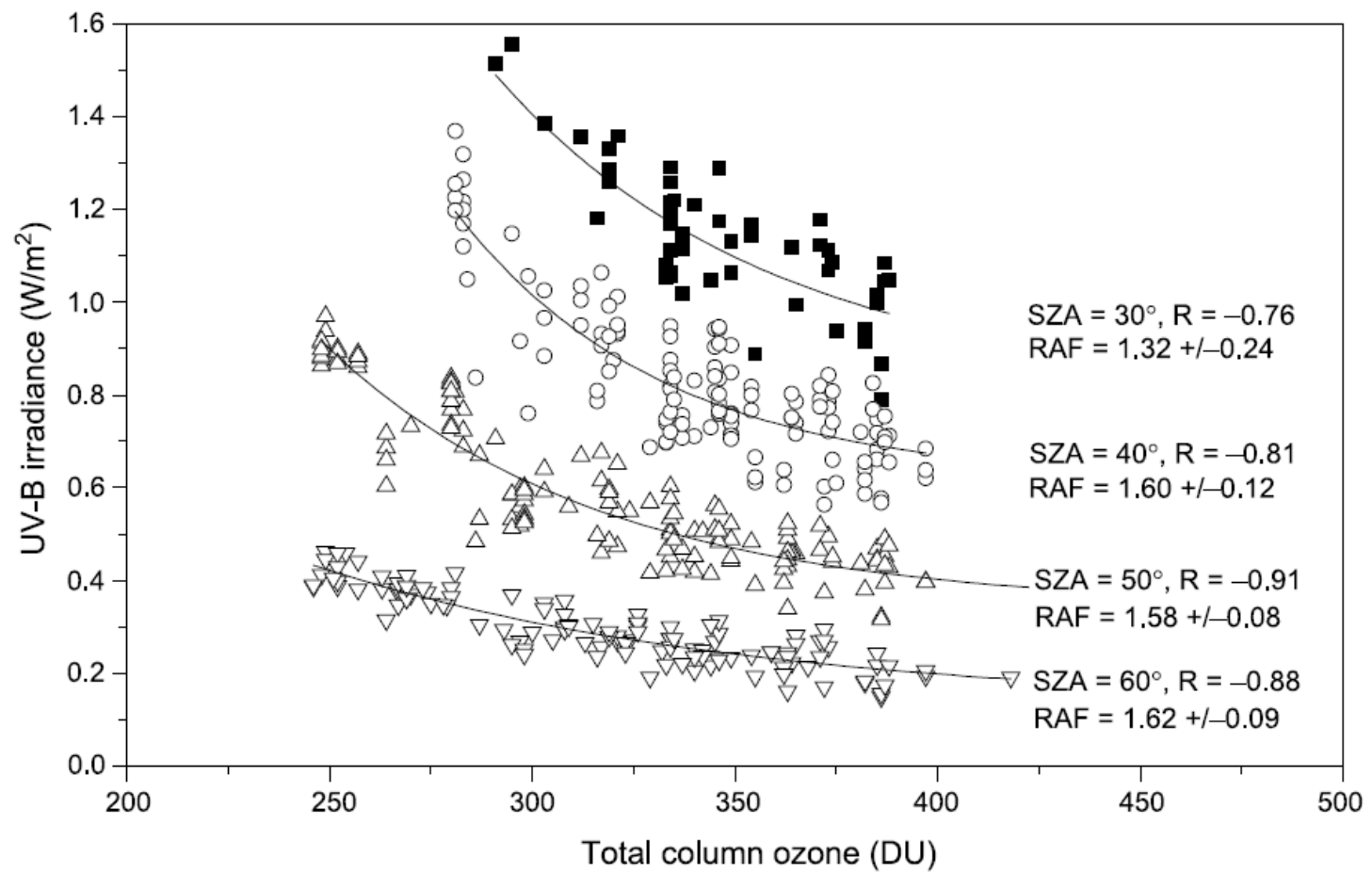


Atmosphere: Clouds

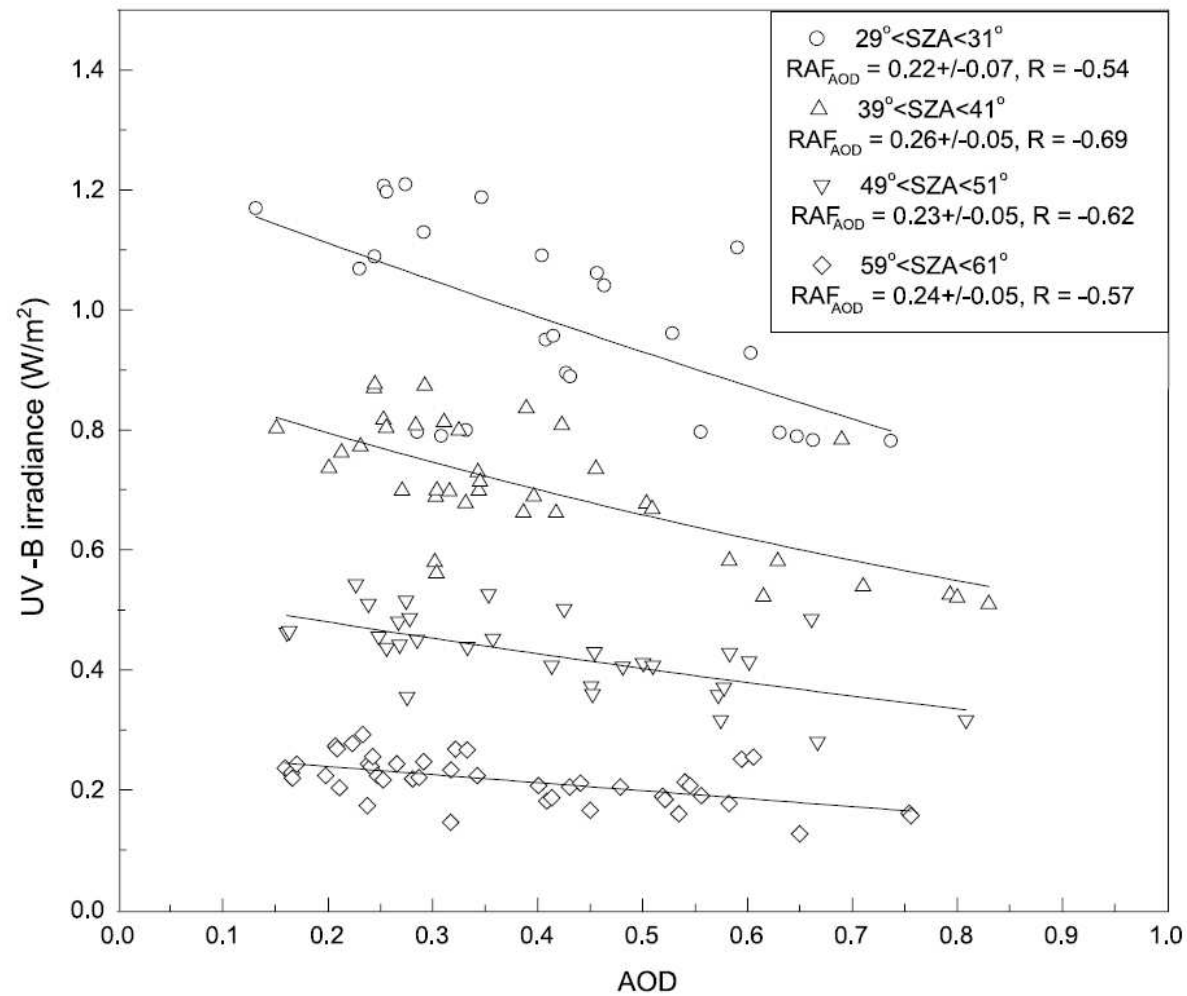
Enhancement
Cloudless sky
Attenuation



Ozone

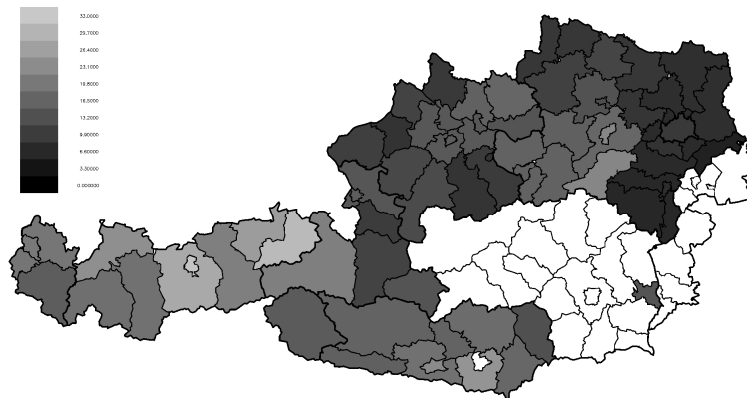


Aerosols

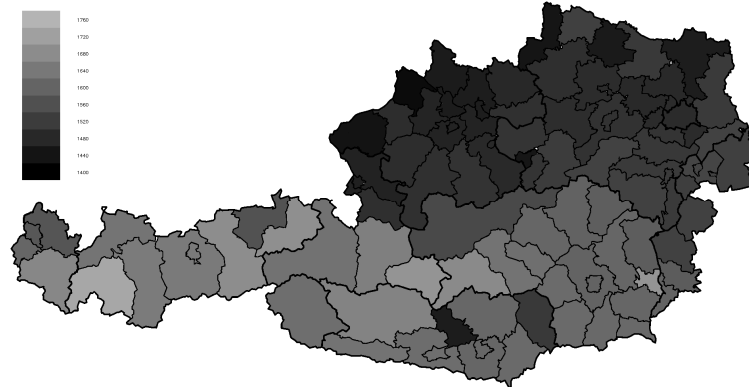


Spatial resolution of atmosph. IP

Melanoma Incidence rates



UV (90%-percentile)



1 district ~20x20km

www.cost726.org

(It: A.M.Siani, G. Zipoli)

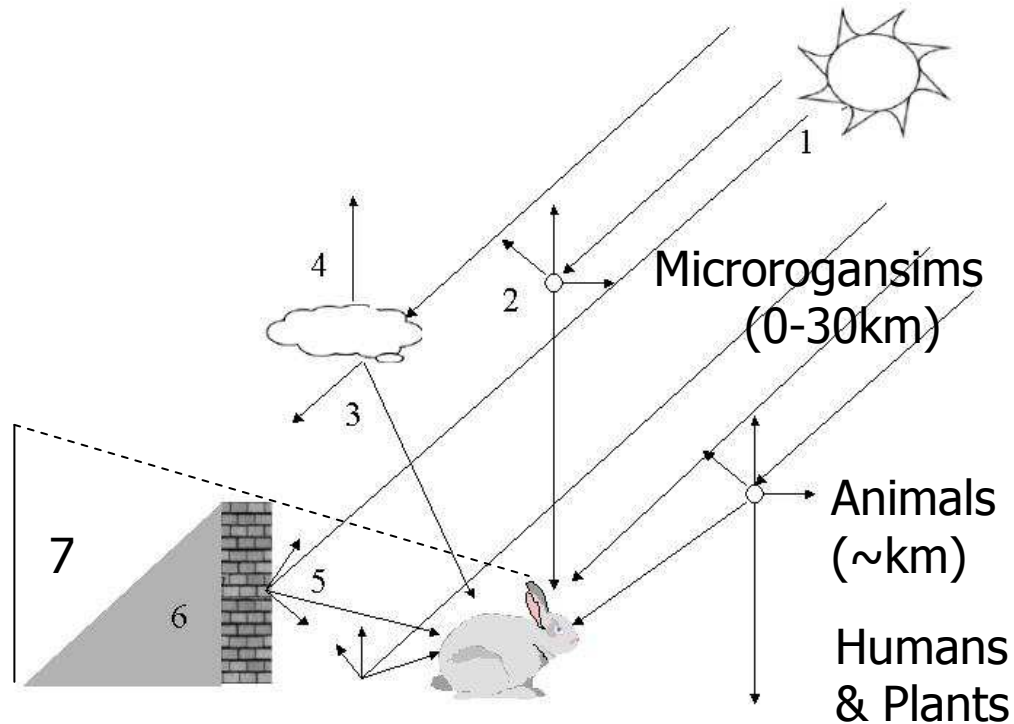
Atmospheric input parameters

Changes compared to 1976-1985

Station	Season	UV		TOC		SD	
		1986-1995	1996-2005	1986-1995	1996-2005	1986-1995	1996-2005
Vienna 150 m	Winter	+29% (1.7%)	+18% (4.7%)	-5%	-4%	+20%	+10%
	Spring	+9% (1.1%)	+20% (4.1%)	-4%	-6%	+2%	+13%
	Summer	+12% (0.9%)	+8% (3.9%)	-2%	-4%	+11%	+14%
	Autumn	+10% (1.2%)	+10% (4.2%)	-2%	-1%	+2%	±0%
Sonnblick 3105 m	Winter	+14% (2.7%)	+22% (2.2%)	-5%	-4%	+18%	+17%
	Spring	+7% (2.5%)	+19% (2.0%)	-4%	-6%	-2%	+10%
	Summer	±0% (2.3%)	±0% (1.7%)	-2%	-4%	+5%	+8%
	Autumn	-1% (2.7%)	+10% (2.2%)	-2%	-1%	-6%	-3%



Atmosphere & Environ



1 direct beam irradiance $\sim 50\%$

2 radiation scattered by molecules and aerosols

3 radiation scattered by clouds

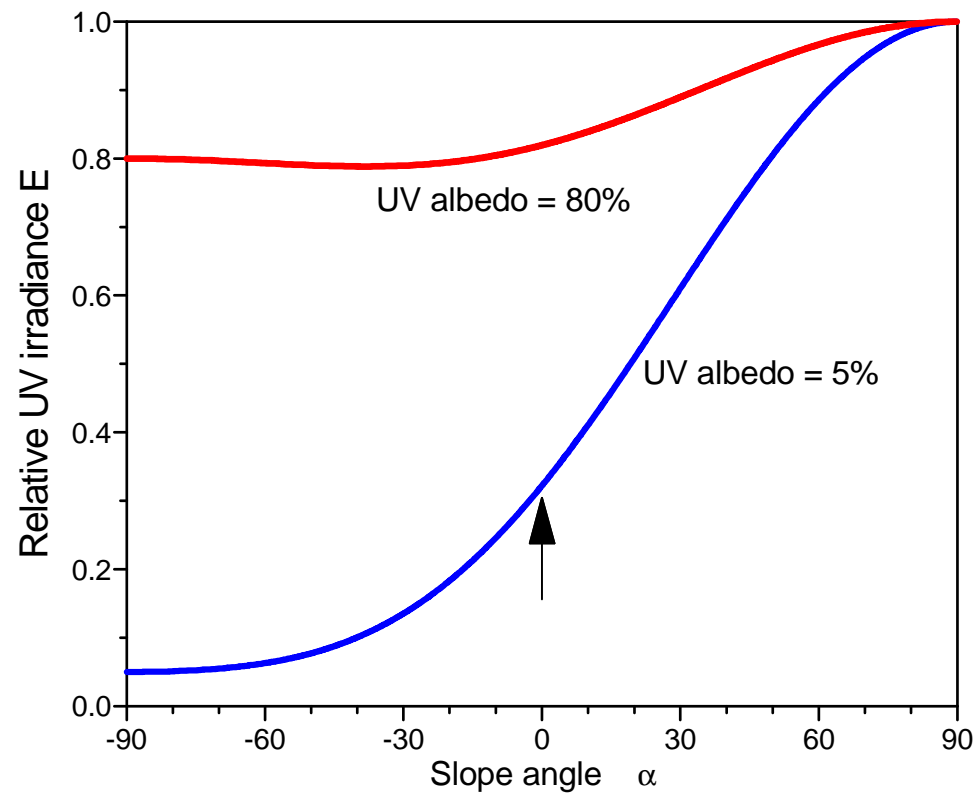
4 radiation reflected by clouds

5 reflection by the surroundings

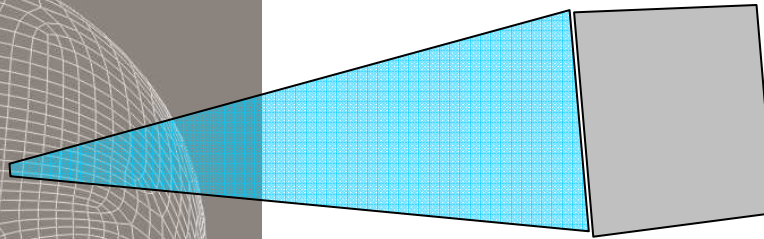
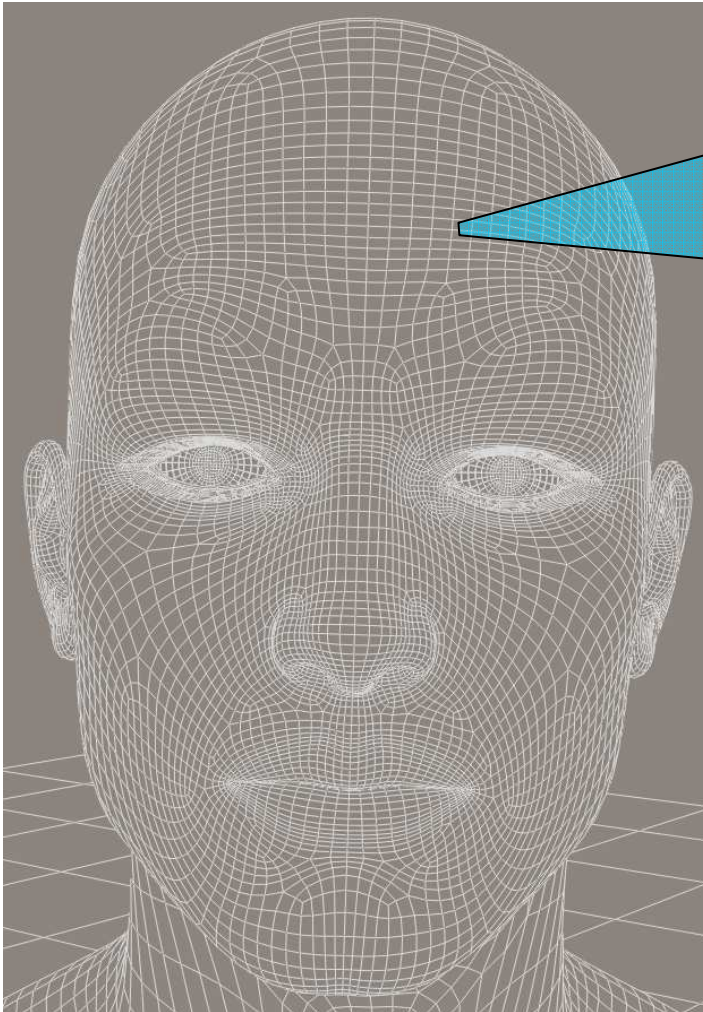
6 shading

7 obstruction of the sky

Albedo



2. Receiver



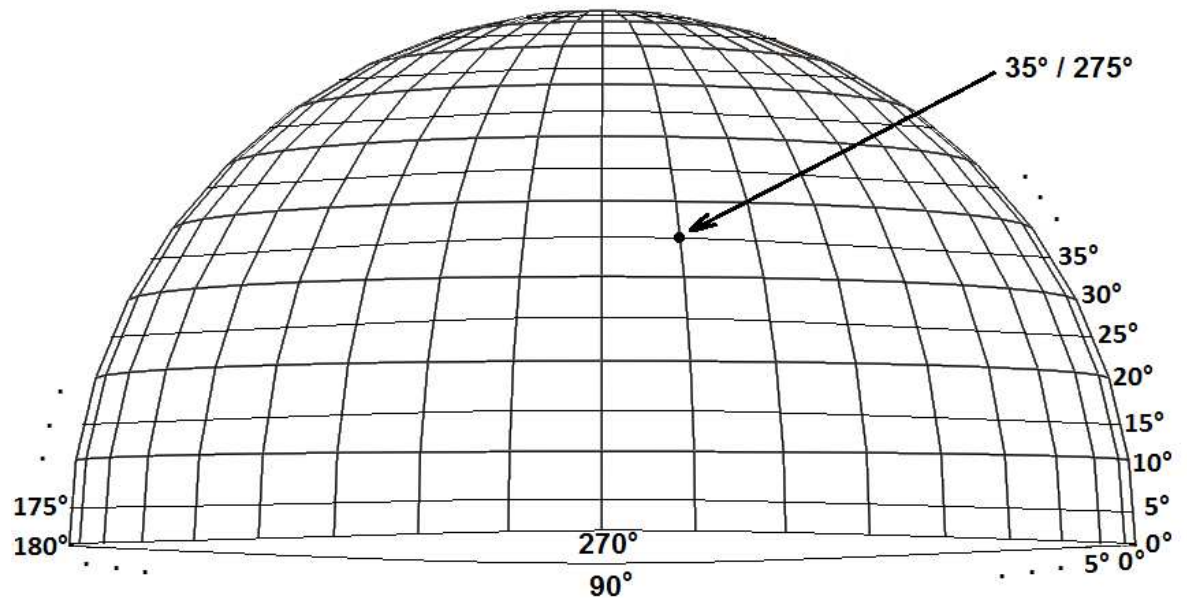
?

Measuring & modeling the UV distribution over a human body



Measured sky distribution

9-head device, University of Veterinary Medicine
Vienna, Austria

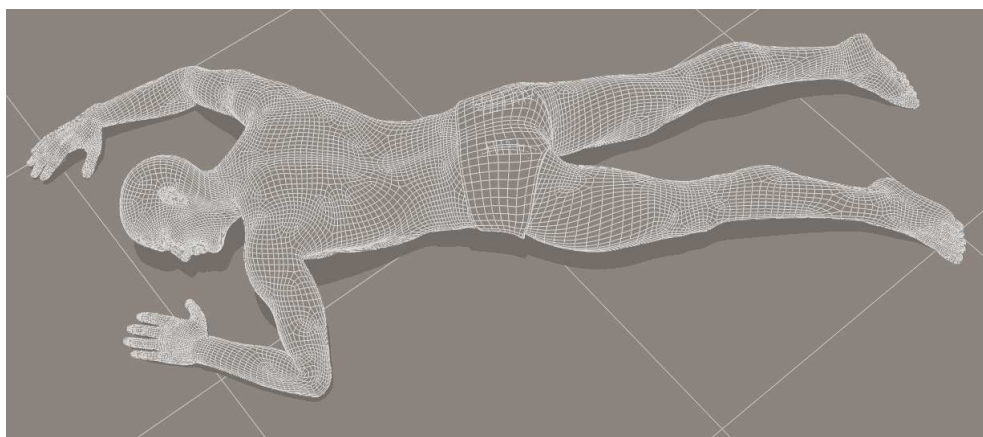
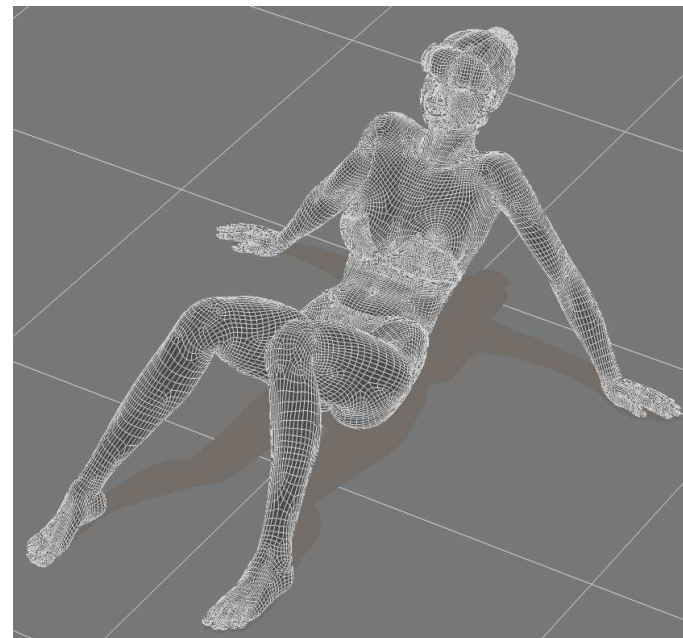


Modelled sky Distribution

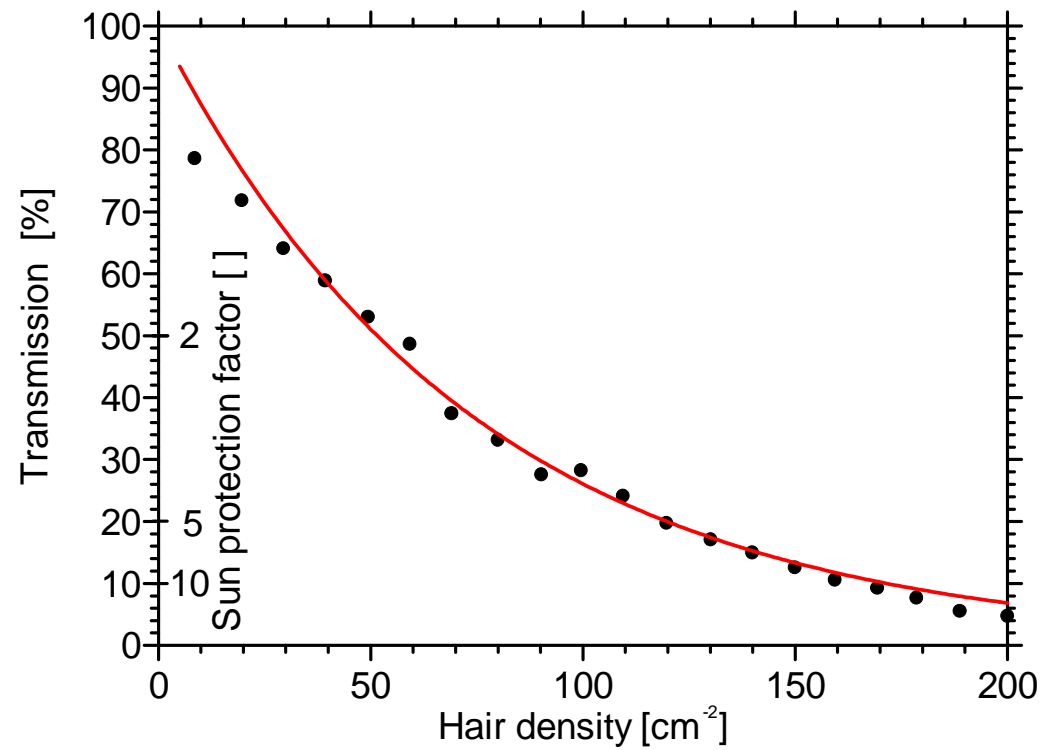
(IP: atmospheric parameters
Measured ambient UV)



Poses



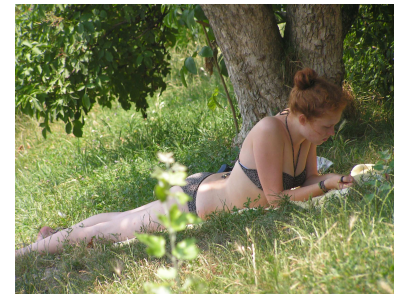
Hair density



Short hair

Personal Exposure

- Inclination body part – sun
- Local environment
- Duration of exposure
- Protection by fabrics
- Protection by sun screen
- Protection by shadow



River Danube, 20m distance



Behaviour



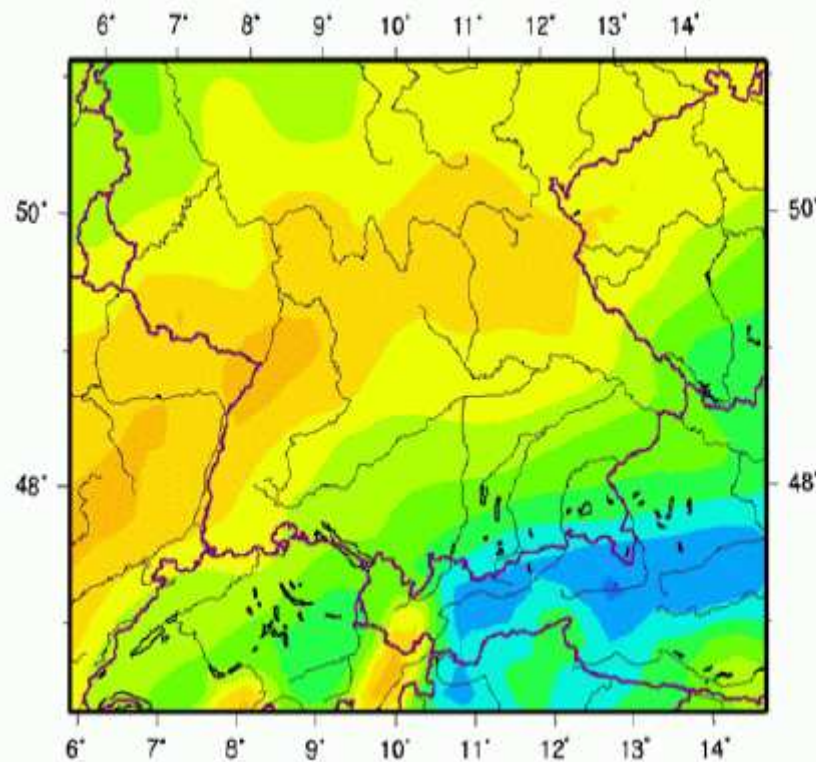
Behaviour: 50 to >1000 SED/yr

- Occupation (10-95%)
- Unintentional exposure (5%)
- Personal sun feeling (10-90%)
- Spare time activity (10-90%)
- Holiday up to 50%
 - destination (e.g. altitude for skiing, skiing vs. overseas summer temp., lakes,...)
- Personal feeling (temperature, wind, humidity and,...)

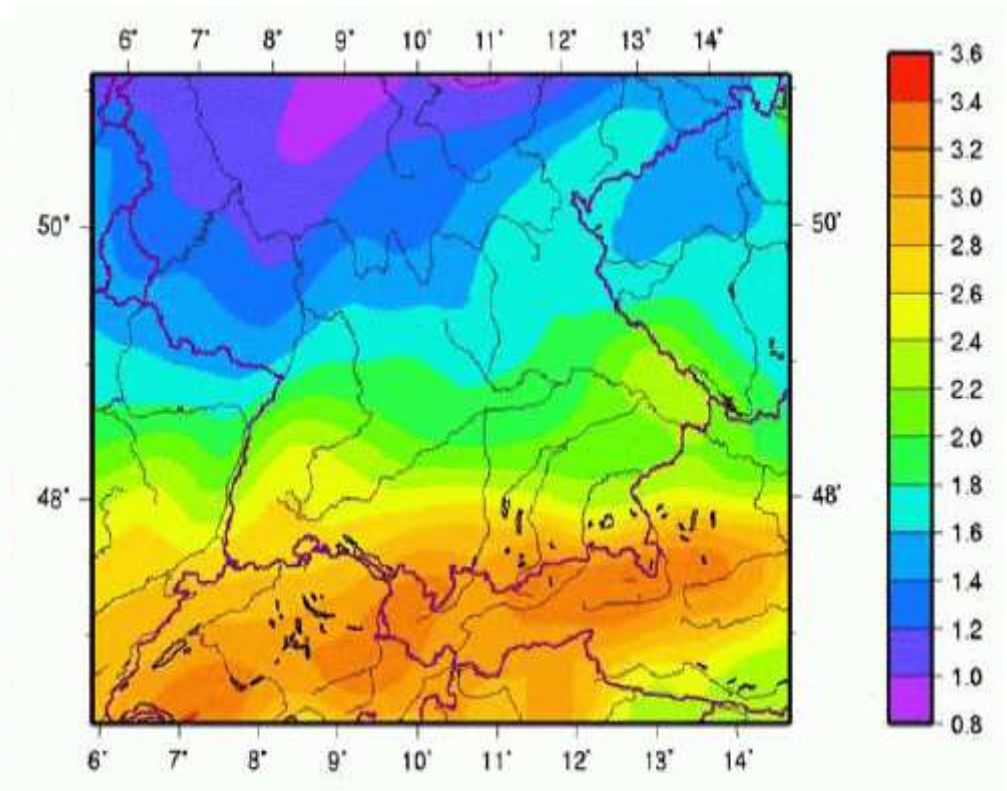


Climate

Temperature change to 2030

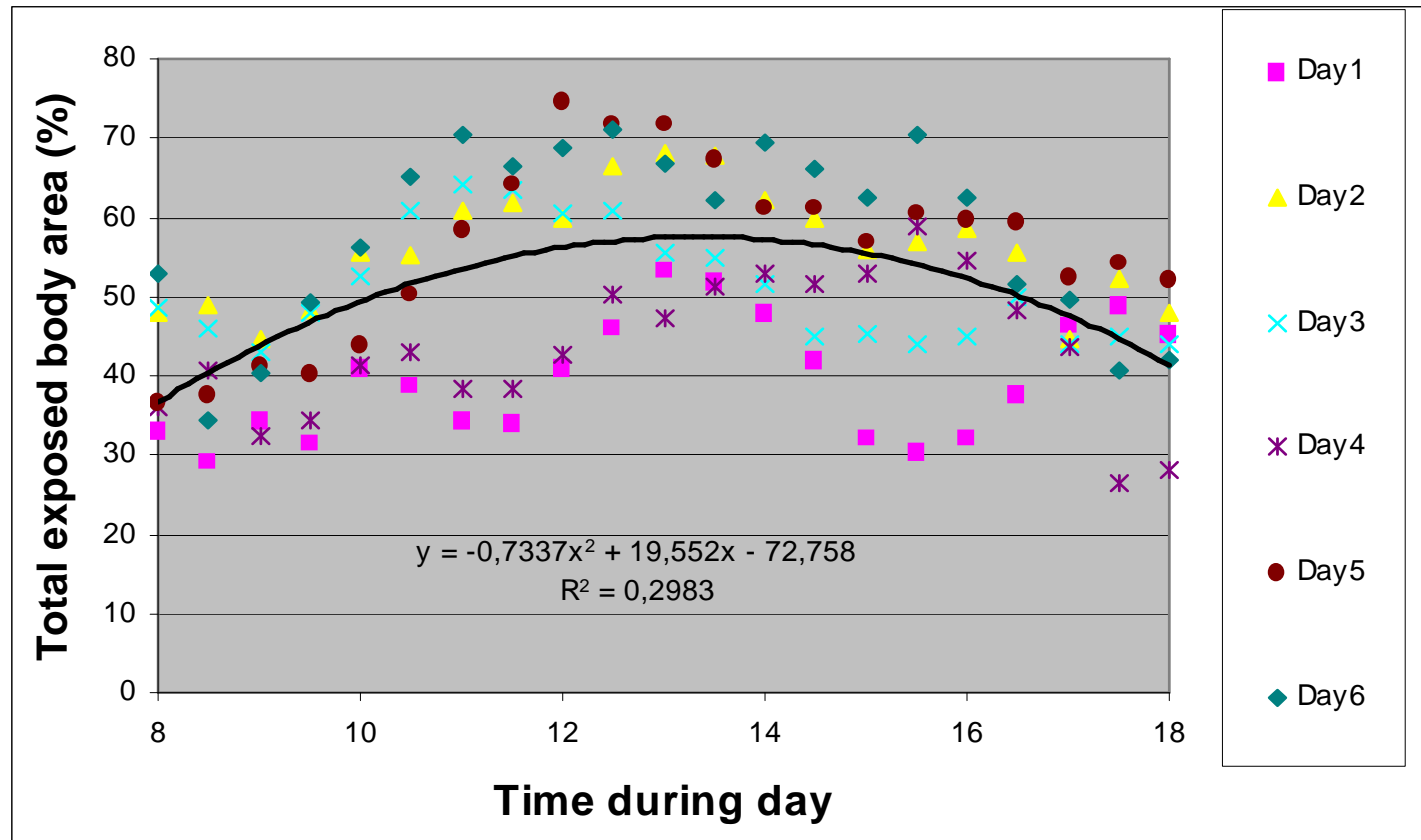


Summer

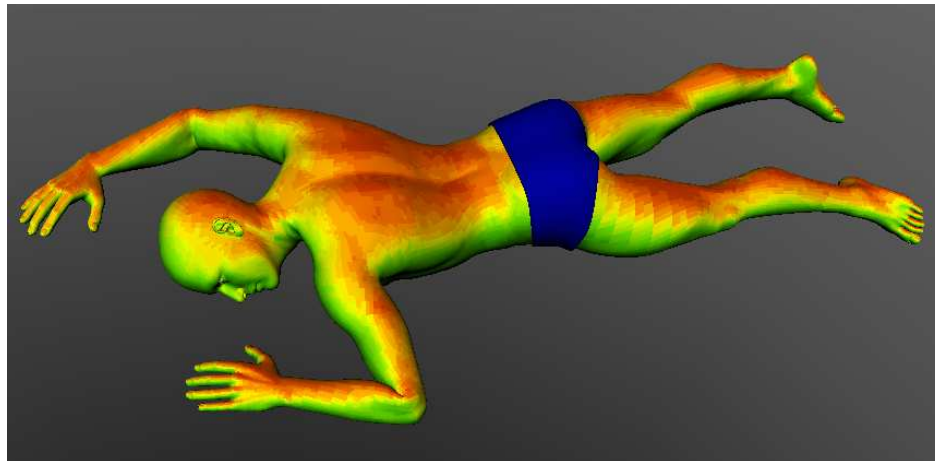
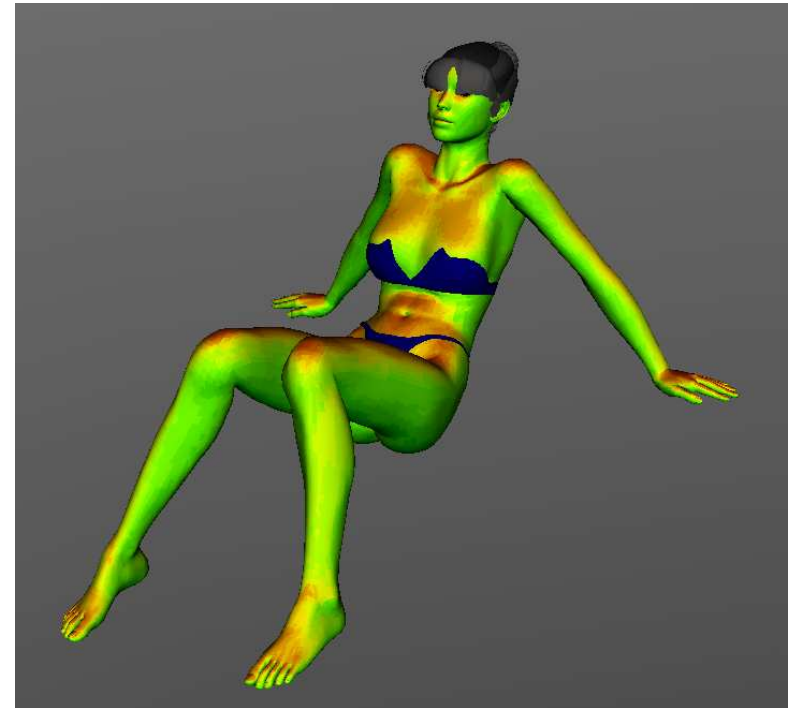
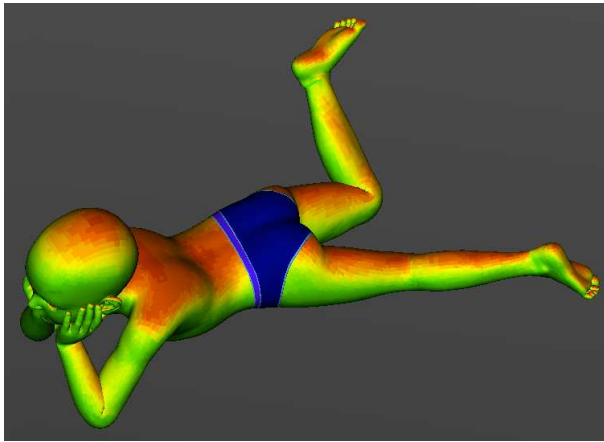


Winter

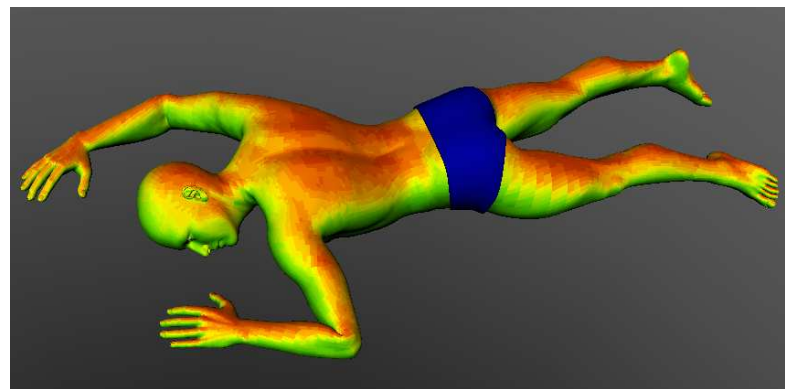
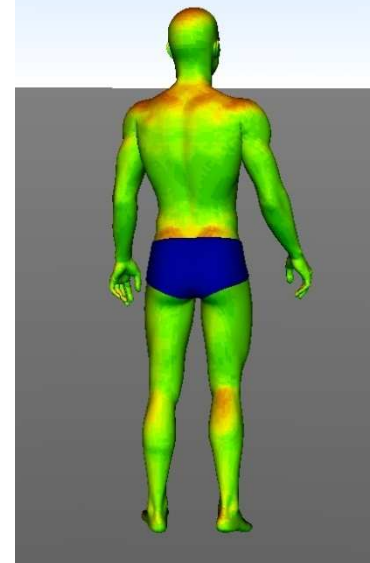
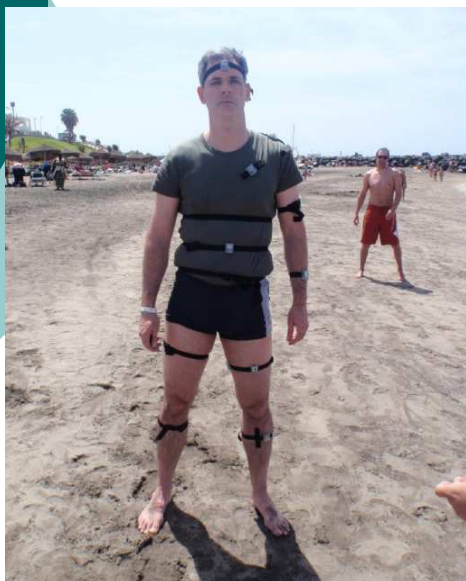
Beach holiday: exposed body area



Beach holiday: UV - Exposure

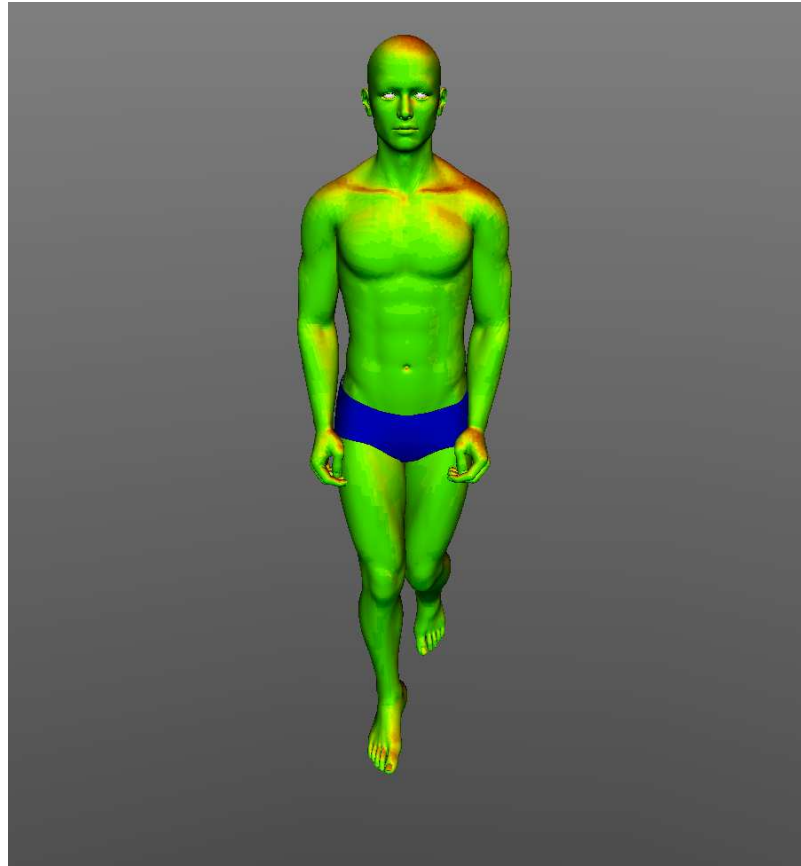


Model vs. personal dosimeter data



Tenerife, Spain, March, 2011

Beach walk





3. Biological Effects

- Vital: Vitamin D₃, mental health, internal clock,...
- Adaption: pigmentation, skin thickening,...
- Damage: DNA, RNA, cells,...
cancer, sun burn, photoaging,...
- Photorepair (counter acting)

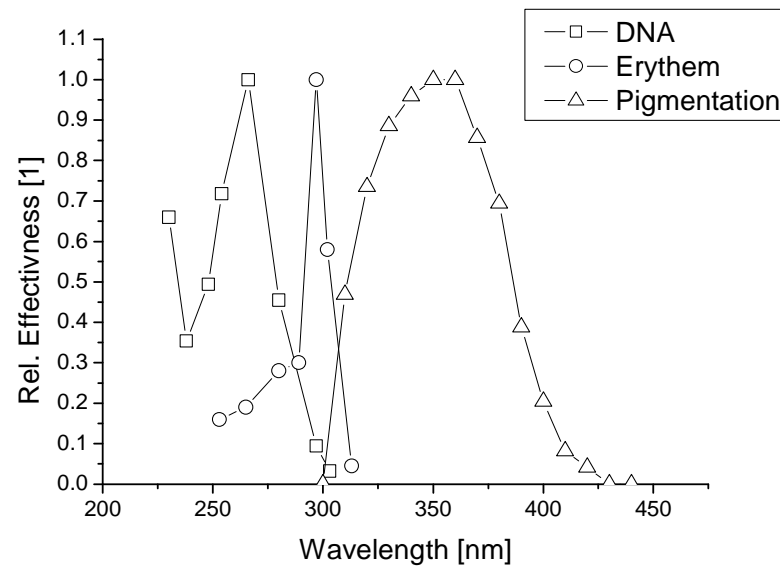


Biological Effects

- Reversibility:
 - Reversible (erythema, pigmentation,...)
 - Irreversible (photoaging, risk of skin cancer,..)
- Latent time:
 - Immediate (erythema, immediate pigmentation,...)
 - Delayed (persistent pigmentation,...)
 - Long term (skin cancer, cataract,...)
- Cumulation:
 - non-cumulative (sunburn,...)
 - overexposure cumulative (melanoma,...)
 - permanent cumulative (skin thickening, skin cancer, photoaging,...)

Biologically effective UV

- Action Spectrum = Wavelength dependence of response
- Recent collection: +400 AS



DNA Setlow et al. 1990
Ery: CIE 1998
Pigm: DIN5050

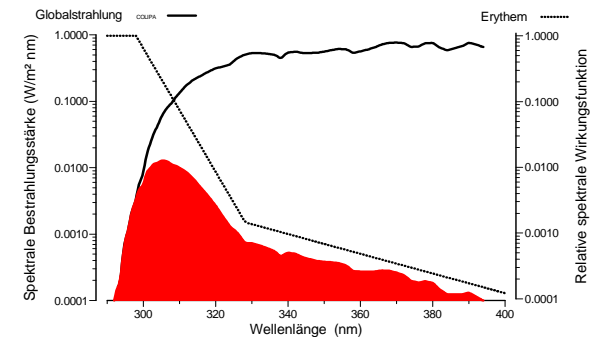
Biol. effective UV radiation

Biologically effective Irradiance E_{biol} :

$$E_{biol} = \int_{280nm}^{400nm} E_{\lambda} \sigma_{\lambda} d\lambda$$

spectral irradiance E_{λ}

Action spectrum σ_{λ} : wavelength dependent effectiveness in causing a certain effect, spectral sensitivity of an organism/effect to U\



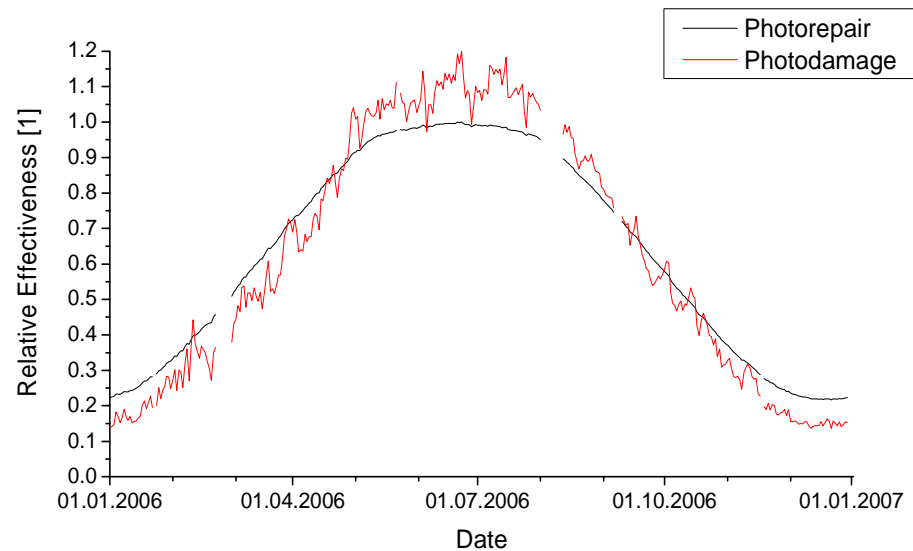
Biologically-effective dose (radiance):

$$D_{biol} = E_{biol} \cdot t$$

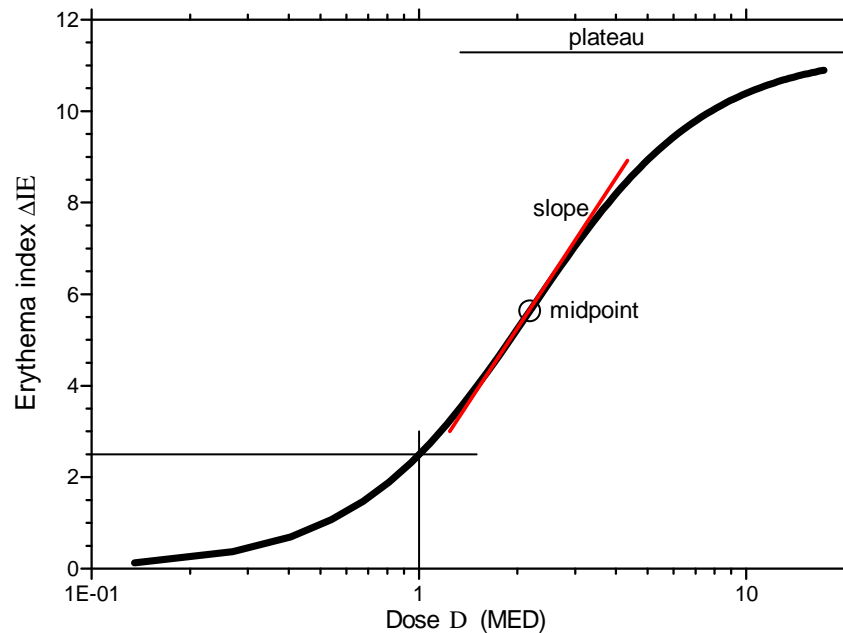
(biologically-effective irradiance E_{biol} , the time of exposure t)

Seasonal changes

Effective solar radiation (Vienna)



Dose Response Relationship



Plateau dose
(no further effect)

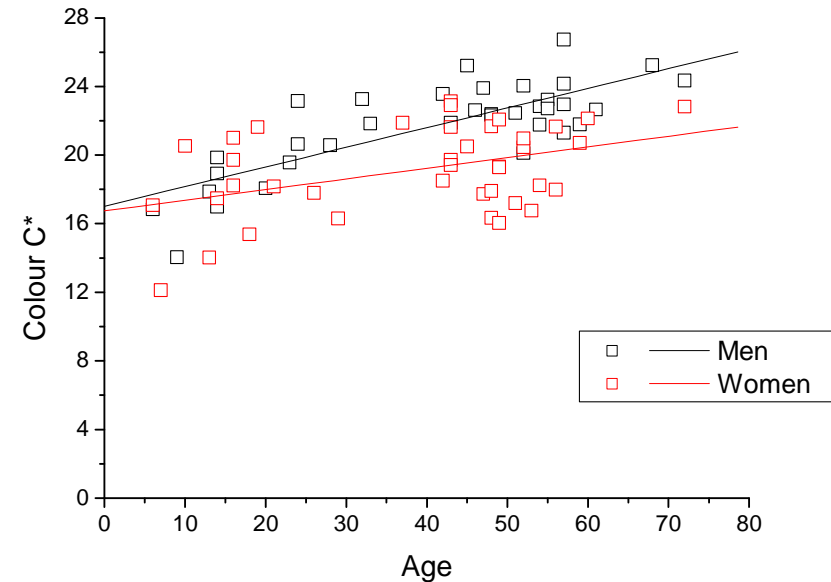
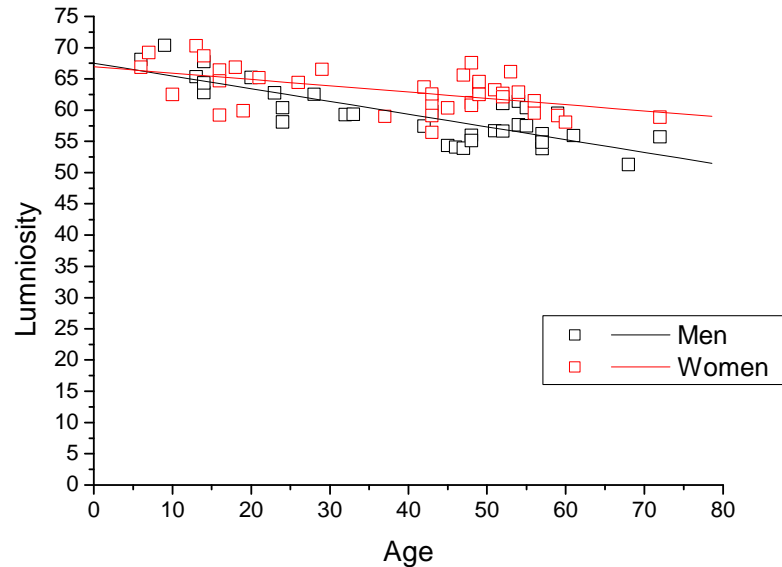
Linear dose response
(Dose \sim Response)

Threshold dose
(no effect)

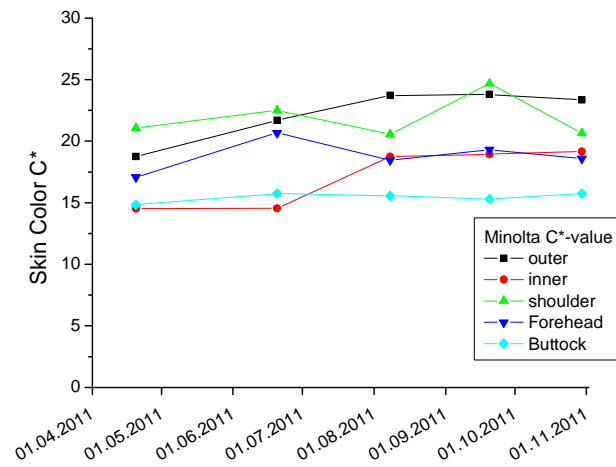
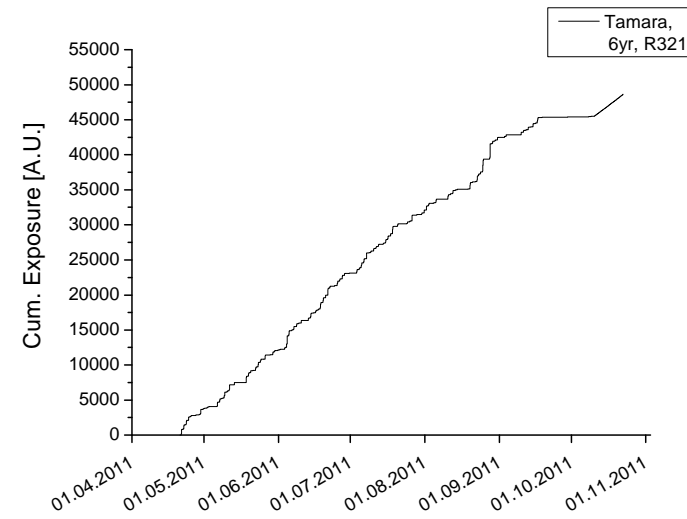
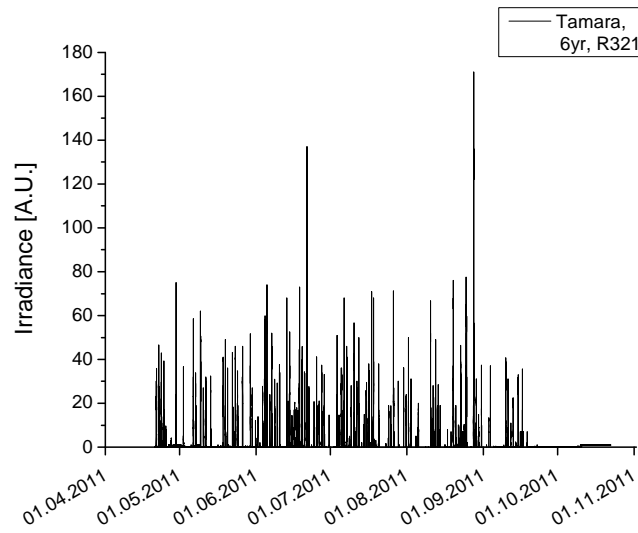
Dose response relationships must be available!!!
Measurements of dose / measurements of response

Pigmentation

- Skin colour of forehead (winter) increases with age, increase differs by gender ($p < 0,05$) but not inner side of arms, shoulder, forearms, buttocks



Exposure and skin colour





Sun burn: Skiing holiday

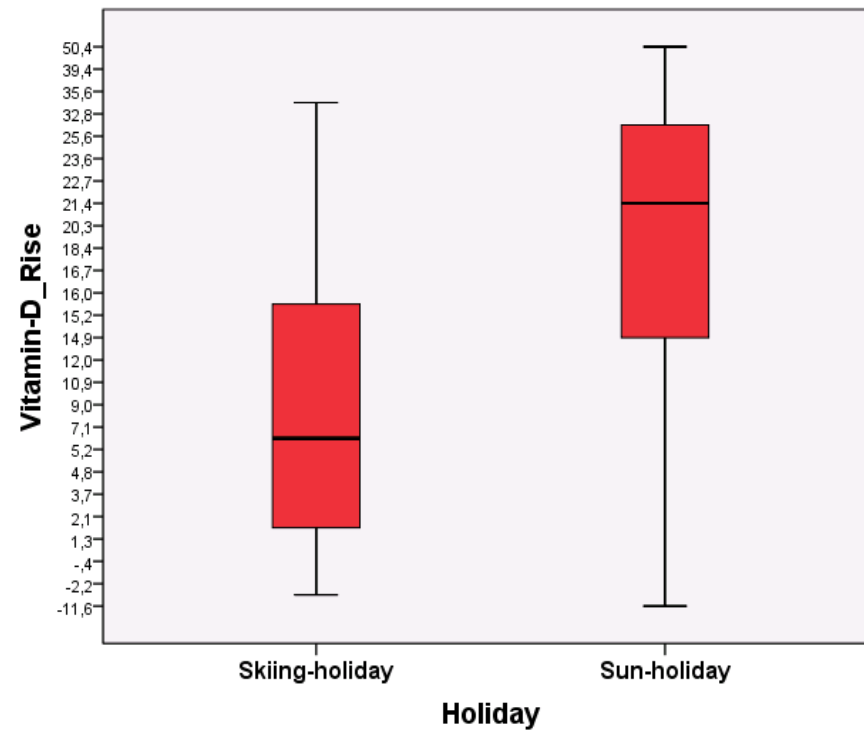
Skin site	Frequency
Nose	63 %
Cheeks	62 %
Chin	28 %
Neck	19 %
Forehead	14 %
Other	14 %
Ears	5 %



Sun burn: Beach holiday 1 week

Skin site	Frequency
Chest / Belly	43 %
Back/ Shoulder	30 %
Head	27 %
Arms	22 %
Legs	13 %

Vitamin D rise

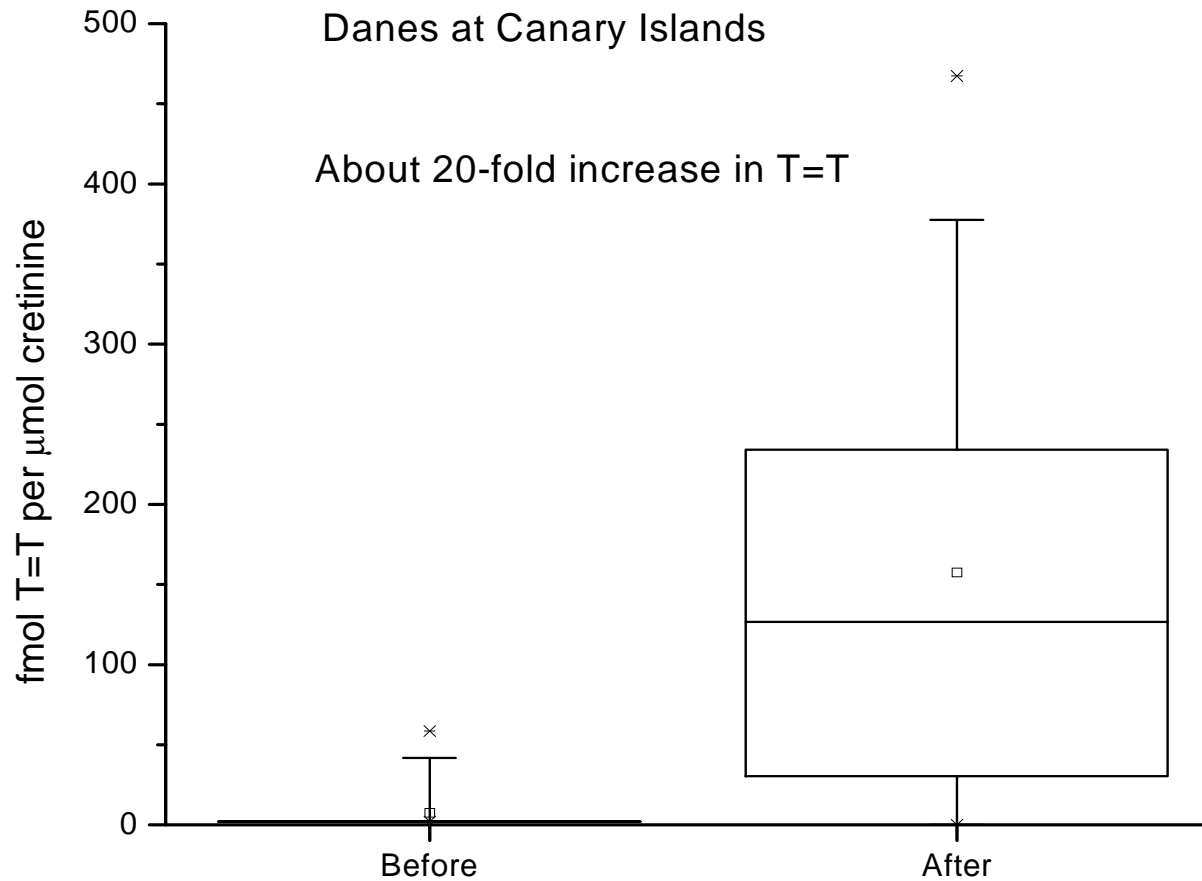


wide variation
(behaviour,..)

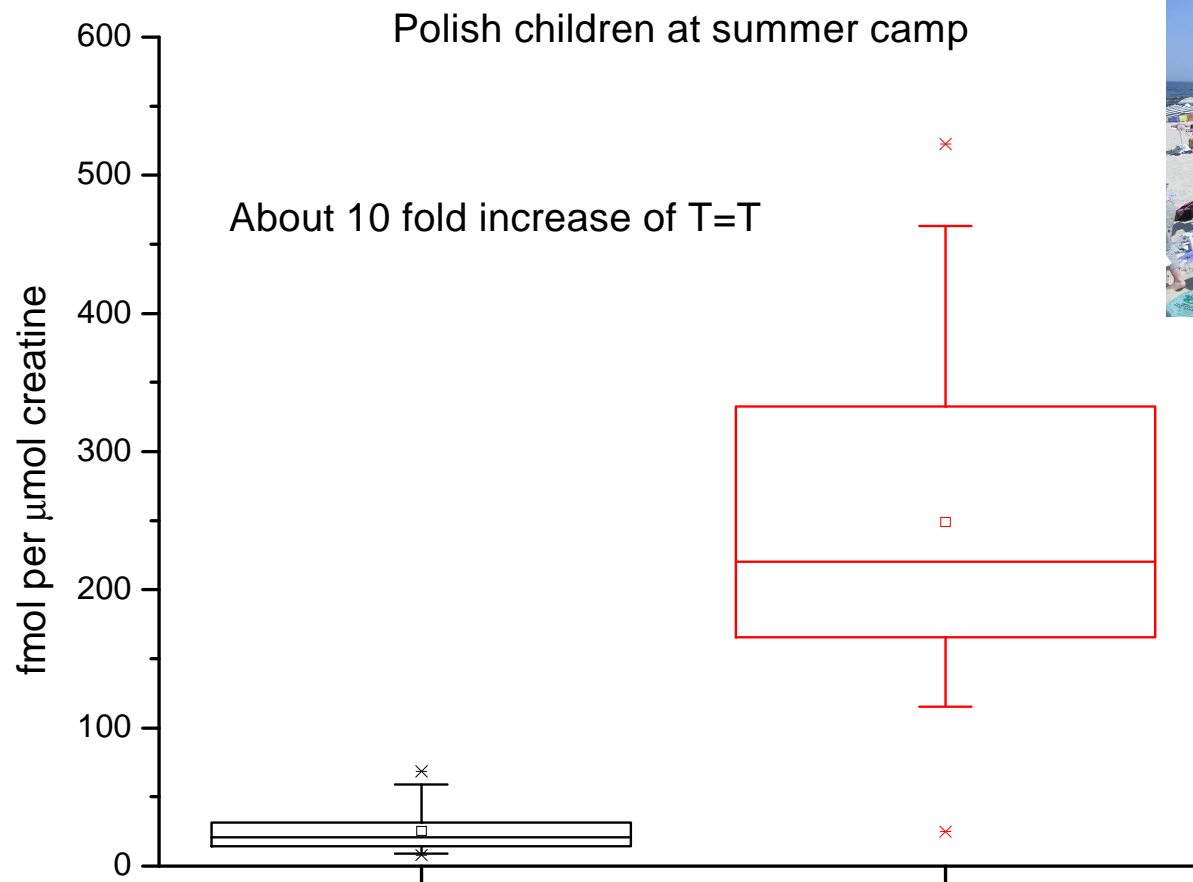
Face
Austria
March

Large part of the body
Teneriffe
March

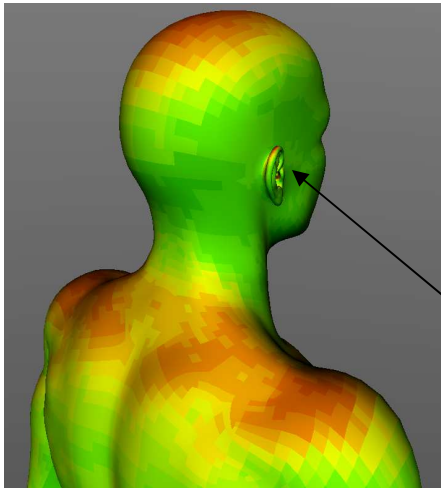
DNA-damage (T=T urine)



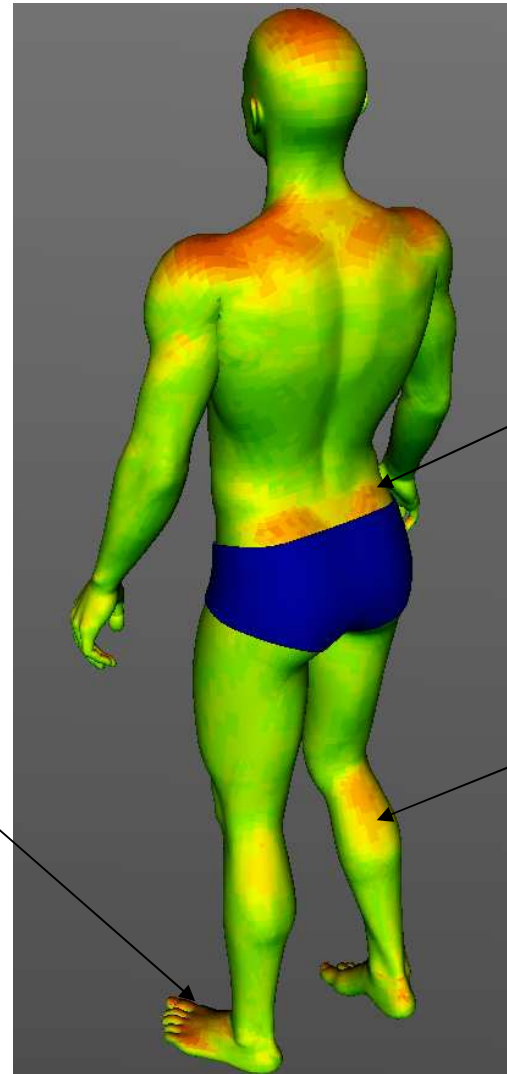
DNA-damage (T=T urine)



Body parts of risk



NM
Skin
cancer



Pigmentation
Children
Young adults

Pigmentation
sunburn

Melanoma
women



Risk: Sun screen use

	Beach	Skiing
Days with application of sunscreen	85 %	91 %
SPF	18 [Range: 2 - 50]	22 [Range: 4 -50]
Average number of applications	1.8 times [Range 1-6]	1.5 times [1-4]
Applying sunscreen the day before a sunburn	82 %	81 %
Sunburns on body areas without sunscreen use	18 %	16 %
Sunburns on body areas with sunscreen use	30 %	36 %



Risk & demographic structure of the population

- Age increases -> skin cancer increases
 $i \sim D^3$
- Mother holiday (30 month)
- Working time per week (42)-40-38.5 hr
- Holiday entitlement (5 wk, 6wk elderly)
- Age of retirement 55/60 -> 62/65
- Rest/nursing home
- Socio-economic status (increasing SC rate in young women with high s-e-s.)
- Outdoor sport trends,



Expectation for the Future

- Climate change: no significant change of ambient UV
- Behavioural trends from climate change
- Behavioural trends: more risk for overexposure and more risk for underexposure
- Demographic structure: detto
- !!! Lack in Dose-Response function for several important effects !!!



Thanks for audience!

EU Project **ICEPURE** (Impact of Climatic and Environmental
Factors on Personal UV Radiation Exposure and Human Health)
2009-2013, www.icepure.eu