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Integrated Assessment of Health Risks of Environmental Stressors in Europe

Integrated Project
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D28 Climate Assessment Protocol

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1 The assessment issue

Climate is both a hazard and resource. The effects of climate and weather on a range of health outcomes have been known since the time of Hippocrates. Seasonal patterns in mortality were described as soon as routine data on deaths became available in the 19th Century. Since at least the 20th century, when infectious disease mortality was greatly reduced, populations in temperate regions have patterns of deaths higher in winter than in the summer. Occasionally, during the summer months, episodes of very high temperatures will cause peaks in mortality (sometimes also partly due to the concurrent presence of air pollution).
It is only recently, however, that the health effects of heat, cold, ultraviolet radiation (UVR) have been subject to risk assessment and risk management, partly also for reasons of climate change mitigation and adaptation strategies. It is also now accepted that human activities are affecting the climate system leading to severe and possibly irreversible impacts.

WP3.7 aims to enhance methods for assessment of current and future impacts of climate, and how these can by modified by policies, strategies and measures. Climate variability and change have a range of impacts on health, but this protocol will only address the following mechanisms:

- Heat
- Cold
- Ultraviolet radiation (UVR)
- Anthropogenic climate change

Climate is a large-scale phenomenon and impacts occur across a range of different temporal and spatial scales. Policies to reduce or prevent global environmental changes, such as changes in radiative forcing factors (due to e.g. CO_2-emissions) and stratospheric ozone depletion, even if implemented now, do not achieve the benefits to health for decades, or further, into the future. The assessment of climate change impacts will need to take into account future baseline mortality and morbidity, changes is exposure factors like temperature and UVR, as well as changes in the sensitivity of population to climate factors. The assessments related to 'heat', 'cold' and 'UVR' will be the primary focus in this document.

Climate change and its impact on health are both surrounded with considerable uncertainties. At least to some extent, there is uncertainty with which climate change and its impacts take place as different probabilities. This may lead to substantially different conclusions on what would be the best option to implement. For impact assessment protocols it is necessary to use various climate baseline scenarios like those for general temperature rise, strengths and frequency of extreme hot and cold episodes, and precipitation characteristics, and use the range of estimated changes on their main indicators as given. IPCC scenarios and their predicted outcomes may very well be used in this respect (IPCC 2007). For cities specific indicator values may be used if available.

Assessments based on various internationally agreed policy protocols (Kyoto - greenhouse gases; Montreal - ozone-depleting (organic) substances) indicate that climate change will take place despite the mitigation strategies that are going to be implemented come into compliance with these protocols. This stresses the need for more research on and analysis and assessment of current situations as well as policy options, their costs, and their possible health benefits. This also calls for short-term and long-term adaptation strategies in order to reduce the human vulnerability to climate change.

Key stakeholders include Health Ministries, civil protection, local governments, local health authorities, health care providers, social services/voluntary associations, NGO's, advocacy groups (e.g. for the elderly), and researchers (see WP 3.7 scoping).

2 The risk assessment framework

The WP3.7 assessment procedure consists of ten steps (see below). Step 1-6 focus on the description/assessment of exposure and impact characteristics (exposure, mortality and morbidity baseline rates, exposure-response relationships for given health endpoints, demographic data, population vulnerability data) corresponding to the status-quo scenarios as well as the different policy scenarios. The comparative health impacts of the policy options considered will be assessed using a prototype model, which utilizes Excel as a platform. The model is based on a common framework, beginning with input specific to a policy option and ultimately producing a measure of its overall health impact. The assessment will be conducted for different population groups: 5-year age groups, males/females.

We will implement this framework for heat and cold burdens on health. Climate scenarios will then be applied to this framework to estimate future impact on health for a range of emission scenarios (related to mitigation policy) and adaptation options. Secondly, the framework will be implemented for the assessment of UVR impacts, and scenarios of ozone depletion and adaptation.

2.1 Multi-step process

Step 1: Scoping framework
The evidence relevant to climate and health was reviewed during the scoping phase of the work package. Two major 'pathways' have been identified for the WP3.7 risk assessment: the direct effects of (ambient) temperature) and the impacts of ultraviolet radiation. Accordingly assessment frameworks were developed for heat/cold, UVR and ozone depletion and future climate change (focusing on heat/cold).

Step 2: Policy scenarios
a) Identify and describe baseline scenarios (exposure, morbidity/mortality rates, population)
b) Identify and describe mitigation policies and/or specific adaptation (intervention) measures/responses;
c) Setting time horizons

Step 3: Exposure assessment
a) Identification and characterization of exposure
b) Assess baseline exposure characteristics
c) Assess exposure characteristics under selected policy scenarios

Stratification: 5-year age groups, males/females.

Step 4: Health outcomes
a) Identification and characterization of health outcomes. These may range in severity from, for example, cold-related discomfort to a cold induced fatal cardiac event. The possible health outcomes are grouped by relative severity and extent of impacts (in line with WP3.2 housing).

b) Baseline event rates (mortality and morbidity) in population (groups) according to different scenarios.

Stratification: 5-year age groups, males/females.

Step 5: Estimation of exposure-effect relationships

a) Estimation of baseline (status-quo) exposure-response relationships (relative risks, RR) for given health end points
b) Estimation of exposure-response relationships (RR) under selected policy scenarios (compared to baseline).
c) Identify effect duration and disease weighing factors to allow burden of disease estimations (DALYs)
d) Identify population life tables in order to allow estimation of life years lost (YLL) or loss of life expectancy (LLE)

Stratification: 5-year age groups, males/females.

Step 6 Data needs/collection

a) Refine data needs based on steps 1-5. Please note that demographic data and population vulnerability data is required as well.
b) Data collection

Step 7: Estimation of population attributable risk

- Population attributable fraction (PAF): proportional reduction in disease/deaths that would occur if exposure to the risk factor were reduced to zero. PAF is calculated using the relative risk (RR) of exposure. The exposed population may itself be divided into multiple categories based on level of exposure each with its own relative risk (if available). WHO methodology for PAF assessment is recommended.
- It is possible to consider the attributable risk in specific population groups by obtaining baseline event rates for each group of interest. Additionally, group specific relative risks may be available, or alternatively, it may be assumed that this varies little between groups but acts in the context of differing baseline risks. Whichever decision is made – to assess group-specific or whole population impacts – it is necessary to obtain corresponding population figures to calculate the potential health impact.

Step 8: Health impact assessment

a) Calculation of attributable health impact of baseline exposure for different population groups. This uses two figures: the baseline event rate in the population of interest (i.e. in exposed and unexposed), and, PAF; PAF*baseline event rate.
b) Calculation of attributable health impact of policy scenario (compared to baseline). Note: Burden observed due to baseline conditions (status quo) in a population compared to exposure/RR according the different policy scenarios.

Step 9: Uncertainty assessment

a) Identification and characterization of major sources of uncertainty (building on training by WP1.5); e.g. uncertainties in climate change characteristics and outcome (use range of outcomes under various climate change projections)
b) Sensitivity analysis. In a situation where information is limited (data gaps), informed decisions can be based on assumptions or extrapolations. Sensitivity analysis offers a practical way of dealing with such uncertainties as it provides a method of

examining model function and behaviour by measuring the variation in outputs resulting from changes to its inputs.

Step 10: Risk characterization and policy appraisal
Translation into impact and policy relevant indicators (# people, DALYs, YLLs, LLE, other weighing of different health effects, costing), building on SP1 training.

a) *Assessment of burden of disease using standard DALY methodology (training by SP1)*
b)
c) *Assessment of YLL and LLE using standard life table analysis (training by SP1 or through using the IOMLIFET method)*

Table 1: WP3.7 first pass assessment scope

Hazards	**Exposure**	**Health impacts**	**Sub-groups**	**Geograph area**	**Policy scenarios** (time span: from 2010 up to 2050)
Heat and Cold	Outdoor temperature, min, max), Apparent temperature (min, max)	Mortality and morbidity (hospital admissions)(total, cardiovascular, respiratory, cerebrovascular)	Male/ female; 5-year age groups	Rome, London, Helsinki, EU	Heat plans, housing, IPCC climate change (policy) incl. adaptation & acclimatization
UV	Annual erythemally weighted UVR	Skin cancer morbidity, mortality, DALYs: BCC, SCC, melanoma	Male/ female; 5-year age groups	Rome, London, Helsinki, EU	Ozone depletion (incl. mitigation), behavioural changes, cloud cover changes

2.2 Iterative process

We envision an iterative process. We will start with a simple version, conducting steps 1-10 focusing on, for example, only one policy scenario and one or two health outcomes. Consequent iterations will build upon previous assessment, adding elements were required/possible. Lessons learned in the first pass assessment will be used to refine and complete the assessment in the second pass assessment.

2.3 General data needs

The following indicates information and data requirements for the risk assessment. The information requirements are location specific and for several time periods.

Population data
- *Population data:* Population size estimates by age, sex, region, etc. For UK this information is available from the Office of National Statistics (ONS). UN data from the Global Burden of Disease (GBD) studies is available for EU.
- *Life tables:* For both all-cause and cause-specific mortality data, for 10 year age groups (ONS). Need to control for cohort effects (simulations/modelling).
- Stratification to be considered in first pass: age groups, male/female

Health outcomes: event rates

- Baseline rate of outcomes of interests in the population, disaggregated into specific age groups and distinguishing between men and women.
- Severity: Baseline information needed classified by severity of disease: Class I = death (ONS); Class II = hospitalisation (Hospital Episode Statistics –HES); Class III = primary care consultation (General Practice Research database, HES outpatient, National Health Service (NHS) direct); Class IV = mild symptoms (NHS direct, other?). All of the data for Class I to III can be collected by routine sources. For Class IV this may be more complicated?? These classes only serve as a guide, and final groupings may use another classification system. In any case, each of the classes will be assigned a weight indicative of its relative severity: Class I may be weighted at 10 000, Class II at 1000, etc.
- We also need information on exposure-specific disease rates (from routine data sources and/or from case-studies).
- For longer range outlooks, baseline trends are required.

Exposures

The proportion and nature of the population currently exposed to the exposures of interest.

Relative risk

Relative risk of a health outcome in the exposed population, perhaps by group of interest (age-groups, male/female). To be determined from data collected and previous studies.

Disability-adjusted and quality-adjusted life years (DALYs and QALYs)

As well as the above data, diseases specific disability weights are needed in the assessment of QALYs/DALYs. These are available from the European Disability Weight Project, the Dutch Public Health Status and Forecast and the GBD study. Information on effect duration is required as well.

Years of Life Lost and Loss of Life Expancy (YLL and LLE)

Data on population life tables in cities (or countries) and Europe.

Policy scenarios

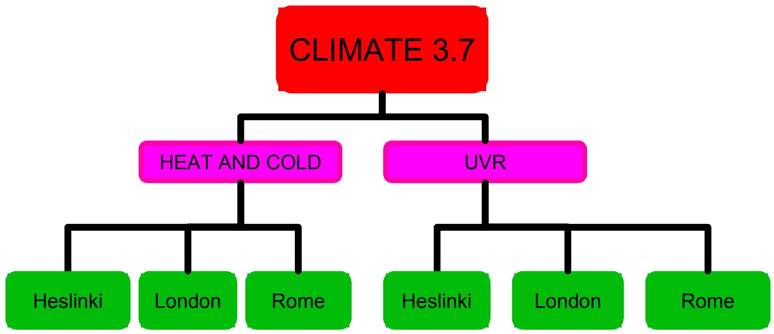
The effects of the policy scenarios on exposure/sensitivity to exposure has to be derived from other (European) projects, literature review or expert judgment.

Uncertainty

In case of major uncertainties, we have to work with various climate change and adaptation projections (in case of policy scenarios) and lower and higher exposure and risk estimates (in case of exposure and health impacts). Make use of, for example, confidence intervals and standard errors, to the extent possible.

2.4 Cases

The first pass assessment will focus on several case studies/ European cities (see figure). These case studies will consider a range of European climates. In the second pass protocol, it will be explored whether an EU-wide assessment is possible as well.



2.5 Step 1: Scoping framework

Figures 1 and 2 show the assessment frameworks developed in the scoping phase. And assessment of the burden of heat and cold deaths will be undertaken- as well as in the context of climate change and integrating assumptions on the possible reduction of adaptation (policies).

Case studies regarding heat/ cold and climate change will focus on 3 European cities, representing different climate zones:

1) Cold zone – Helsinki/Finland
2) Temperate zone - London/UK
3) Mediterranean zone – Rome/Italy

Europe-wide assessment of the burden of heat and cold mortality and morbidity should be undertaken in a later phase (as well as in the context of climate change and integrating assumptions on the possible reduction of impact\policy). In doing so, we need the be very explicit about how we translate information/data from other scale levels to city-level.

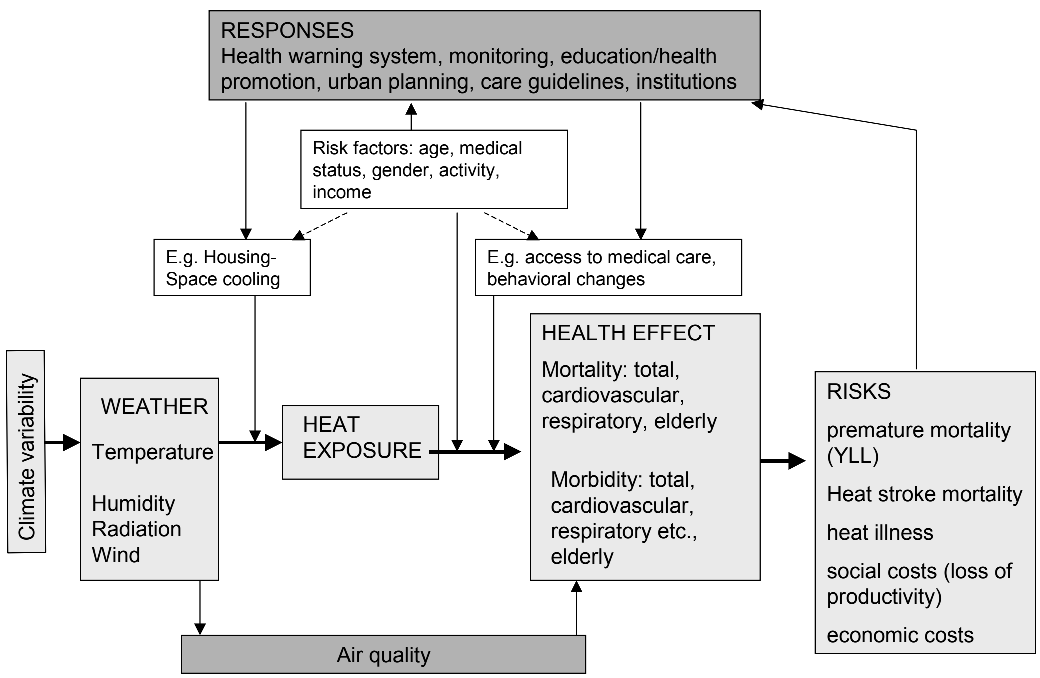


Figure 1: Full-chain framework for ‘HEAT’.

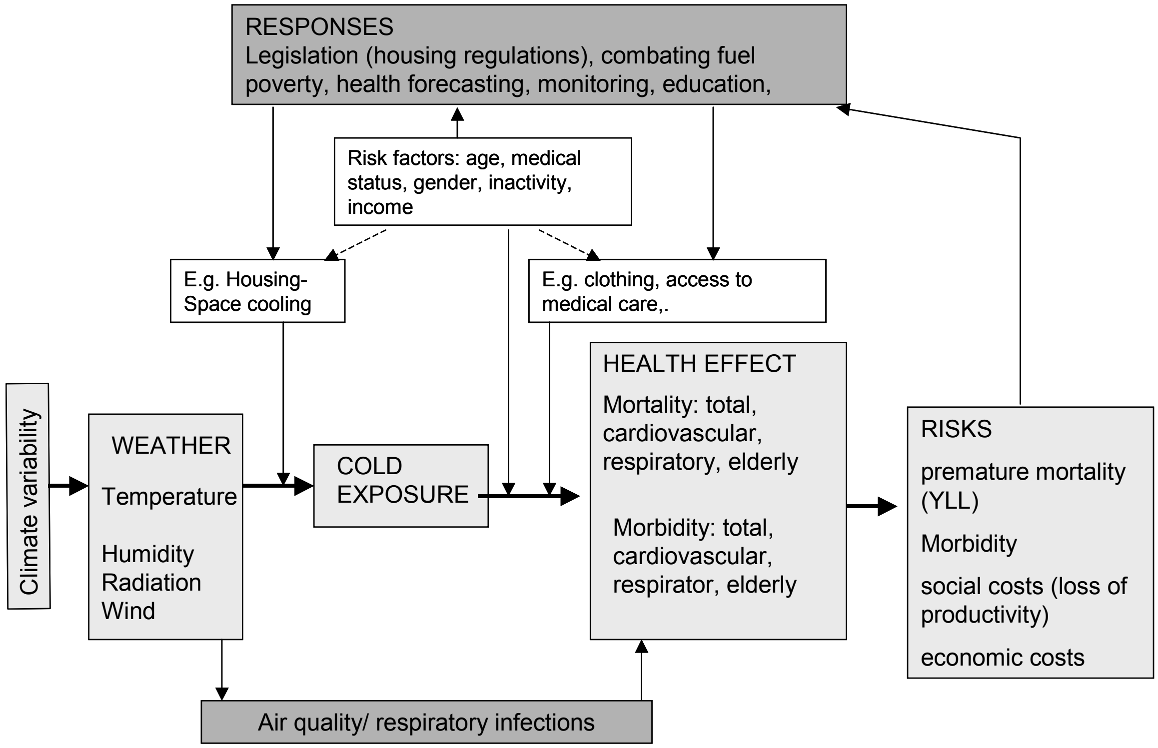


Figure 2:. Full-chain framework for 'COLD'.

2.6 Step 2: Policy scenarios

a) Identify baseline scenario.

The INTARESE baseline year is 2001. Baseline scenario is based upon:

- status quo exposure (based on PHEWE and EUROHEAT)
- status quo exposure-effect relationships, i.e. prior to 2003 (based on PHEWE and EUROHEAT). Research shows changing heat-mortality relationship after 2003. The cause of this observation is still unclear; it could be an indication of the effect of interventions/awareness (or merely is an indication of uncertainty involved).
- estimated future baseline event rates, incorporating population growth and ageing (e.g. to avoid cohort effect of ageing). Population scenarios are available at European level, and for some countries (UK, Finland).

b) Identify and describe (effect of) policy scenarios

Policy scenarios can have an influence on sensitivity to temperature and/or temperature exposure. We have identified the following policy scenarios

- Housing (e.g. space cooling, heating, insulation). Link with WP3.2 Housing.
- Heat Health Warning Systems.
- Climate change (policy). Climate change is defined as the change in mean climate states, for decades or longer. A minimum 30-year period is required to define the climate of a given location. Average seasonal or monthly temperatures are used to define the climate of a particular place.
- Urban planning: the second pass assessment might also include policy scenarios on urban planning.

Detailed description of each scenario will be developed, quantifying their implications on exposure and/or dose-response relationships as adequate as possible (for selected cities) with assumptions/uncertainties made explicit. Quantitative estimates of the benefit of Heat-health warning systems are not yet available -but may be become available for Rome and London in next 12 months

An integrated assessment of future climate change impacts on health needs to address the following components:

- Applying the knowledge of current temperature-health associations
- Exploring future climate-heat associations in Europe using the output of regional or global climate models.
- Exploring specific adaptation (intervention) measures aimed to reduce the climate-health risk indicator value (like housing plans and heat plans).
- Exploring health futures in Europe to understand the context in which climate change effects will be realized, with specific focus on future changes in "adaptive capacity" and acclimatization.

The IPCC scenarios: SRES scenarios are presented in four "storylines" which represent mutually consistent characterizations of future states of the world during the 21st century, including demographic and economic development, energy use and greenhouse gas emissions, together with associated changes in climate and sea level. Regional differences and interactions, especially between developing and industrialised countries, are also assessed (IPCC 2000).

Please note that we know that populations are changing in sensitivity to temperature (not necessarily in response to climate change). Scenarios can be developed regarding possible changes in the adaptive capacity of the community of interest.

Climate policy scenarios incorporate the estimated effects of mitigation. Mitigation refers to the policies for the control of greenhouse gas emissions or enhance carbon sinks and thereby reduce future radiative forcing of the climate system. The SRES scenarios are non-interventionist, and therefore are not linked to policies. The EU policy target is set on limiting global climate change to 2 degrees Celsius [EC 2007].

Individual countries also have their voluntary targets (UK climate change bill that is now in debate] but hard to linked to changes in temperature. Stabilisation scenarios are preferred, and these currently constitute a few and many have not been run on climate models. Scaled models that are more policy relevant include the COSMIC programme which runs a range of scenarios and emissions policies at the national and global level, and other IAM have also been undertaken but they are not publicly available (IMAGE, etc.].

Two types of adaptations can be distinguished:

- What is likely (changes in adaptive capacity)
- What is recommended (policy for responding to climate change).

Adaptation covers a very wide range of policy activities that may or may not be explicitly linked to climate change. In this assessment, the policy interventions that reduce heat and cold deaths are considered as adaptation.

The majority of health models in fact make no estimate of future changes in important modifying influences. A main uncertainty in estimates of the impact of climate change on heat-related mortality and morbidity is the extent to which, even without specific adaptation strategies, physiological adaptation and factors such as behavioural changes in hot weather will reduce impacts in the general population. Physiological acclimatization to hot environments can occur over a few days, and can explain why the impact of the first heat wave on mortality and morbidity is often greater than that of subsequent heat waves in a single summer. The rate at which infrastructural changes will take place without specific advice is likely to be much slower. Neither the magnitude nor the time course of the various modifying factors can be predicted with any confidence. It is clear that preventive measures will be needed to counter the substantial initial adverse effects of heat, and long-term changes are required to housing and urban infrastructure (Kovats and Koppe 2005). Scenarios can be developed regarding possible changes in the adaptive capacity of the community of interest.

Table 2: Main determinants of the future heat and cold deaths in the UK.

Determinants	**Changes over time (decadal trend)**	**Effect on future heat deaths**	**Effect on future cold deaths**
Population growth	Increase	↑	↑
Population ageing	Increase proportion of >65s	↑	↑
Health status	Declines in rates of cardio-respiratory disease	↓	↓
Public health	Improved public health activities to reduce heat and cold related mortality		
Housing	Houses	↔	↔
Acclimatisation	Physiological and behavioural adaptation to warmer climate	↓	↑

Source: Kovats, Lachowycz and Hunt, forthcoming.

c) Setting time horizons

- The time scale of the adaptations needs to be considered, as public health measures (HHWS) can be implemented quickly but housing measures may take longer. Long-term changes are required to housing and urban infrastructure (Kovats and Koppel 2005). Time horizon for housing and heat plan scenarios is set on 2010 (in line with WP3.2 Housing)
- For climate change scenarios the time horizons are set on 2020, 2030 and 2050 [use single years- but based on average climate]

2.7 Step 3: Exposure assessment

a) Identification and characterization of exposure

Regarding the parameterization of outdoor temperature exposures, a range of indices are available (see scoping report). The epidemiological studies primarily use data from outdoor weather stations. In order to link the exposure assessment with outcomes from epidemiological studies, we will focus on ambient temperature (min, max, average) and Apparent Temperature. The epidemiological evidence base is from time series studies and episode analyses.

b) Baseline exposure

Current climate (and housing conditions) (e.g. prior to 2001?)

c) Exposure under policy scenarios

Data on the impacts of different climate change (policy) scenarios is required in order to compare policy scenarios with the baseline exposure. Several scenarios are available (gridded data- city level- available?).

Stratification: 5-year age groups, males/females.

2.8 Step 4: Health outcomes

a) Identification and characterization of health outcomes.
These may range in severity from, for example, cold-related discomfort to a cold induced fatal cardiac event. The possible health outcomes are grouped by relative severity (in line with WP3.2 housing).

Table 3. Health outcomes for HEAT and COLD (Outcomes are categorized by severity with I being most severe).

Severity health outcome	Cat I	Cat II	Cat III
Heat	Mortality: heat-related deaths- total, and through cardiovascular, respiratory, cerebrovascular causes	Morbidity: hospital admissions- total, and through cardiovascular, respiratory, cerebrovascular causes	Others: *GP consultation – all causes, respiratory causes*
Cold	Mortality: cold-related deaths- total, and through cardiovascular, respiratory, cerebrovascular causes	Morbidity: hospital admissions- total, and through cardiovascular, respiratory, cerebrovascular causes	Others: *GP consultation – all causes, respiratory causes*

b) Baseline event rates in whole population
Data on baseline event rates are required (e.g. asthma mortality per age group, baseline prevalence). Data is available from PHEWE and EUROHEAT projects, and SP2.3. output. For longer-term outlooks (e.g. climate change) information on the trends in baseline event rates is required (due to changes in age structure and population growth).

Stratification: 5-year age groups, males/females.

2.9 Step 5: Estimate exposure effect relationships

a) Estimation of baseline exposure-response relationships (RR)
Separate analysis for summer and winter (based on PHEWE and EUROHEAT):

- Summer; e.g. city-specific thresholds and percent variation in mortality to 1°C increase in apparent temperature above the threshold. Harvesting effect observed! Small effect on respiratory hospital admissions for few cities.
- Winter: e.g. Combined exposure-response curve of apparent temperature (lags 0-15) and the total daily number of deaths, all ages. Delayed effect up to 20 days! Small effect on cardiovascular hospital admissions in elderly in northern continental cities. Significant effect up to two weeks on respiratory hospital admissions.

Note: we will use the results from PHEWE and EUROHEAT for the elderly, while for age groups which have not been analyzed in detail in these projects (e.g. small children results from other studies might be used, preferable multi-center studies

b) Estimation of exposure-response relationships (RR) under different policy scenarios
Data on the impacts of different adaptations scenarios is required in order to compare policy scenarios with the baseline. A literature review will be undertaken and possibly expert elicitation.

d) Identify effect duration and disease weighing factors to allow burden of disease estimations (DALYs).

e) Identify population life tables in order to allow estimation of life years lost (YLL) or loss of life expectancy (LLE)

Stratification: 5-year age groups, males/females.

2.10 Step 6: Data needs/collection

a) and b) Refine data needs and data collection (covering all data needs)

Please note that the exposure and health indicators should be consistent with the indicators used to establish the RR. Stratification: 5-year age groups, males/females.

Exposure data
Exposure indicators: ambient max./min. temp, max./min. apparent temperature.
Time span: (1960-1990, 2001), future climate (based on climate scenarios up to 2050)
Time resolution: daily, monthly
Geographical scale: Rome, London, Helsinki, EU
Population groups: Male/female needed, overall population, in 5-years age groups
Data sources: PHEWE and EUROHEAT dataset, (national) meteorological databases, SP2.1 review of climate data. Regarding climate change: use national datasets or the GCM output [HadCM3]. Take into account the uncertainty around the projections- particularly if looking at grid cell data or from a single models.

Health outcome data
Mortality (total, cardiovascular, cerebrovascular, respiratory),
Morbidity/hospital admissions (total, cardiovascular, cerebrovascular, respiratory),
Time span: baseline (2001) and baseline trends (up to 2050?)
Time resolution: annual, monthly, (possibly summer/winter?)
Geographical scale: Rome, London, Helsinki, EU
Population groups: Male/female needed, overall population, in 5-years age groups
Data sources: PHEWE and EUROHEAT dataset, (national) databases, SP2.3 efforts

Other data:
- life expectancy tables
- population data (e.g. to calculate trends, baseline rates up to 2050), lifetables
- air quality, housing (what indicators, time spans, sources etc.?)
- information on relationships between variables, i.e. exposure-effect relationships, data on the effects of adaptation and policy scenarios.

2.11 Step 7: Estimation of exposure attributable risk

The PAF needs to be estimated for both heat and cold exposure. According to WHO methodology and INTARESE guidelines/tool. Based on:
- status quo exposure/RR
- the exposure/RR under different policy scenarios.

Stratification: 5-year age groups, males/females.

2.12 Step 8: Health impact assessment

a) *Calculation of attributable health impact of baseline exposure for different population groups.* Based on steps 1-7.
b) *Calculation of attributable health impact of policy scenario (compared to baseline).* Based on steps 1-7.

It is possible to consider the attributable risk in specific population groups by obtaining baseline event rates for each group of interest. Additionally, group specific relative risks may be available, or alternatively, it may be assumed that this varies little between groups but acts in the context of differing baseline risks. Whichever decision is made – to assess group-specific or whole population impacts – it is necessary to obtain corresponding population figures to calculate the potential health impact. A general INTARESE tool will be developed by SP1/SP4.

Stratification: 5-year age groups, males/females.

2.13 Step 9: Uncertainty assessment

a) Identification and characterization of major sources of uncertainty.

Guidance on how to specify and assess uncertainties is being developed by WP1.5, and the classification of uncertainties that this has identified should be followed as far as possible. Important uncertainties are, for example, related to the estimation of RR, prevalence rates, success of interventions etc. The aim is to find innovative ways of dealing with these uncertainties and to be transparent on the assumptions made.

b) Sensitivity analysis

Sensitivity analysis will be conducted to indicate which uncertainties have major impacts on outcomes and thus require further research in the future.

2.14 Step 10: Risk characterization and policy appraisal

Translation into policy relevant indicators: Years of Life Lost, Loss of Life Expectancy, weighing of different health effects (DALYs), costing. Depends on input from SP1.

a) *Assessment of burden of disease using standard DALY methodology (training by SP1)*
b) *Assessment of YLL and LLE using standard life table analysis (training by SP1 or through using the IOMLIFET method).*

2.15 Iterative process

The first pass assessment will consist of two stages:
Stage 1 June –October 2007 (cases= Rome and London)

- Baseline: estimating heat and cold attributable mortality for baseline year for Rome and London (We will use a normal year and extreme year for the baseline, following the method of Kosatsky, but baseline mortality will refer to 2001, to be consistent with other work packages).
- Policy issues: Estimate the avoided heat/cold deaths from implementing a) housing policies or b) heat plans (to be decided which policy scenario will be addressed first). We will use a 10 year time frame, in accordance with WP3.2 (i.e. 2001 compared to 2010).
- Climate change burdens. Standard approach is, for a given time slice [e.g 2020], cc impact = burdens under climate change - burdens under baseline climate [2001 or 1960-1990 period] [with assumptions about adaptation and acclimatization]. This does address climate policy issues if we select the relevant emissions scenarios. I.e. compare impacts in SRES-A2 (high emissions) vs SRES-B2 (low emissions).

Stage 2: Nov 2007-April 2008

- Baseline: also include estimating heat and cold attributable mortality for baseline year for Helsinki, if data is already available.
- Policy issues: estimate avoidable burden for both housing policies and heat plans
- Climate change burdens: also include climate change policy by including (emission) stabilization scenario

At the end of the first pass assessment period, the assessment process will be evaluated and the most important lessons learned will be identified. This will form the bases for the second pass assessment protocol. In the second pass protocol, it will be explored whether: 1) an EU-wide assessment is possible as well and 2) whether morbidity can be included as well.

2.16 Expected challenges in the assessment process

- Part of cold/heat mortality is possibly due to forward displacement of deaths
- Geographical differences in sensitivity and threshold temperatures (i.e. different perceptions of ‘cold’ and ‘heat’).
- Effect modification/ confounding: air quality.
- No robust assessments of the effectiveness of response measures (e.g. behaviour, housing, HWWS) available yet.
- Link with morbidity (hospital admissions) not well established.

- How to organize linkages with Housing WP. We want to match the geographical regions to the Housing case study – to improve integration. Match on country/city across case studies. In addition, we want to match policy options regarding housing interventions. How do we link outdoor apparent temperature to indoor temperature? Make use of what you got and be transparent about critical uncertainties (sensitivity analysis) and assumptions.
- In case of data gaps: Indicate that we did not forget certain aspects in our analysis. Specify what needs to be developed: research needs and critical priorities.
- Besides linear relationships (e.g. PHEWE results), how do we deal with heat wave episodes -> difficulties with probability. Cannot address extreme events outside the projected changes in daily variability of Temperature. Difficulties with definition and future probability of heat waves
- Costs of interventions? Only use information that is available – second pass, ask SP1.
- Extrapolation of current epidemiological response functions to risk assessment models (extrapolating long-term effects from short-term associations. A particular problem arises from extrapolating observed weather-health relationships to risk assessment models. Time series methods have been developed to estimate the proportion of disease in a population that is attributable to weather, that is, the short-term variation in meteorological exposures (day-to-day or week-to-week). Strong associations have been found between temperature and daily mortality, and between temperature and cases of bacterial diarrhoea. There has been much discussion on whether it is appropriate to extrapolate long term effects from a short-term association.
- No robust assessments of the effectiveness of adaptation strategies available yet.
- Future changes in response capacity, and acclimatization.
- WHO is asked for advice to make proper estimates on missing health-related data, maybe through expert judgement.

Cross linkages with other work-packages:
- Climate emissions –
    - Energy Efficiency in Housing
    - GHG emissions in Transport
    - Drivers – Land use Workpackage?
- Impacts changed by CC
    - Transport [Air quality]

3 Ultraviolet Radiation

3.1 Step 1: Scoping framework

Figure 3 shows the assessment frameworks developed in the scoping phase. And assessment of the burden of UVR health impacts will be undertaken- as well as in the context of climate change and integrating assumptions on the possible reduction of adaptation (policies).
Case studies regarding changes in UVR will focus on 3 European cities, representing different UVR zones:

1) Cold zone- Helsinki/Finland
2) Temperate zone; London/UK
3) Mediterranean zone- Rome/Italy

Europe-wide assessment should be undertaken in a later phase (as well as in the context of ozone depletion and integrating assumptions on the possible reduction of impact\policy). In doing so, we need to be very explicit about how we translate information/data from other scale levels to city-level.

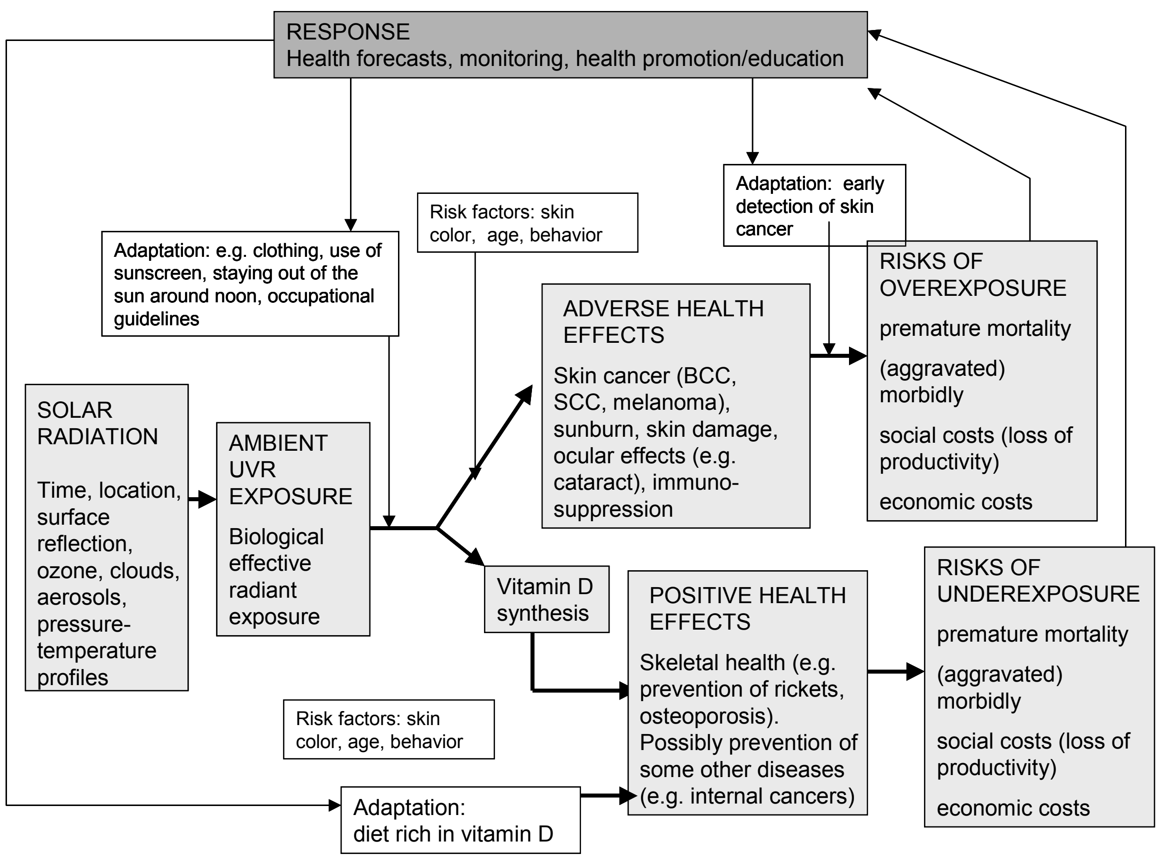


Figure 3 Full-chain framework for 'UVR'.

3.2 Step 2: Policy scenarios

a) Identify baseline scenario.
The baseline year is 2000. Baseline scenario is based upon:
a) status quo exposure (based on current UVR climate and behavioural patterns)
b) status quo exposure-effect relationships, i.e. prior to 2000 (based on epidemiological data pre-2000).
c) estimated future baseline event rates, incorporating population growth and ageing (e.g. to avoid cohort effect of ageing). Population scenarios are available at European level, and for some countries (UK, Finland).

b) Identify and describe (effect of) policy scenarios
<u>Changes in ambient UVR:</u>

a) (Mitigation of) ozone depletion: Illustrates the effects of policies to control emission ozone depleting substances. Future ozone predictions: At least Oslo CTM2 Global Ozone fields years 2000, 2030, 2050, 2070, 2100 for IPCC 2001 scenarios A2 and B1 (http://www.ipcc.ch/pub/spm22-01.pdf) are available. More recently updated scenarios will be considered, if available. Candidates are the ozone and UVR time series being developed within the ongoing EU project SCOUT-O3. Currently there are only data until year 2020.
b) Climate change and cloud cover: Cloud cover can be a key factor in ambient UVR levels. . A search for future projections will be done. We will consult the forthcoming IPCC report, and its data material. With global warming, there is a trend toward thicker clouds.

<u>Changes in exposure behaviour</u>

c) Outdoor behaviour:_EPA exposure factors handbook for USA, 1997. This is a rigorous study and we will for this reason assume this is relevant for Europe. We will facilitate for risk assessments for future variations in outdoor habits, although the trend is heading for more indoor activities.
d) Climate change and clothing:_There are rigorous publications on comfortable clothing levels (thickness and cover) with respect to temperature and humidity (e.g., Steadman, 1979). However for UV radiation, only skin exposure is relevant, and such complex models are not necessary. We expect to define simple rules for skin coverage by clothing for 3-4 temperature ranges. We plan to link this to the projected changes in heat and cold as discussed above.
e) (Improved) implementation of health forecasts and health education/promotion focused on behavior The effect of UVR protection programmes is uncertain because there are no uniform or systematic intervention campaigns throughout Europe (CHEAPE report on children's health and the environment in Europe, 2007, WHO, in print).). We will consider the Occupational guidelines for outdoor-workers (e.g. currently exposure of outdoor workers often exceeds these guidelines; what will be the implication of stricter monitoring/enforcement)

Detailed description of each scenario will be developed, quantifying their implications on exposure and/or dose-response relationships as adequate as possible (for selected cities) with assumptions/uncertainties made explicit. Future scenarios on changes in diet are beyond the scope of the risk assessment.

c) Setting time horizons

- Baseline: We plan to do risk assessments for year 2000/2001.
- Policy scenarios: We will select years which have significant changes in ozone levels. The time horizons are set on 2000, 2030, 2050 (and possibly 2070 and 2100).

3.3 Step 3: Exposure assessment

a) Identification and characterization of exposure

This assessment will look at the health impacts of ambient UVR exposure (from solar radiation only). Ideally, a risk assessment considers the biological effective dose for the health outcomes under investigation. However, exposure assessment needs to be linked to health impact assessment, so the exposure indicators should match the indicators used in establishing exposure-response relationships. In epidemiological studies, the ultraviolet radiation index (UVI) or the erythemally effective dose types are by far the most popular and common, so the selected dose-response relationships should be based on those UV dose metrics.. The study by Lucas uses the annual ambient erythemally weighted UVR as indicator of ambient UVR exposure. Please note that estimates of ground level UVR are not the same as personal UVR exposure. Ambient UVR can only give an indication of possible UVR exposure distribution of a population.

b) Baseline exposure

Current UVR climate (baseline year 2000) and behavioral patterns.

c) Exposure under policy scenarios

Data on the impacts of different scenarios is required in order to compare policy scenarios with the baseline exposure. A literature review will be undertaken (combined with expert judgment where necessary)

Stratification: 5-year age groups, males/females.

3.4 Step 4: Health outcomes

a) Identification and characterization of health outcomes.

According to the UVR Global Burden of Disease (GBD) study by Lucas, McMichael et al (2006), there is strong evidence of causality regarding the following negative effects of overexposure to UV (Lucas et al. 2006): skin cancer (BCC, SCC and melanoma), solar keratoses (chronic skin damage), acute effects on the skin (sunburn), chronic effects on the eye (cataract, pterygium, SCC), acute effects on the eye (e.g. solar retinopathy), activation of latent herpes labialis infection due to immune effects

The first pass assessment will primarily focus on the effects on skin cancer (estimated global burden of disease and the attributable fraction are relative high compared to other health outcomes):

- Morbidity: (annual) <u>incidence</u> from skin cancer (BCC, SCC and melanoma)
- (Annual) mortality from skin cancer, particularly melanoma

Please note that UVR exposure also yields positive effects, such as the prevention of Vitamin D deficiency and associated health effects. It is estimated that the disease burden associated with zero-exposure is relatively high. These positive effects are beyond the scope of the first pass assessment.

b) Baseline event rates in whole population
Data on baseline event rates are required, e.g. baseline SCC incidence or baseline melanoma mortality. For longer-term outlooks (e.g. ozone depletion) information on the trends in baseline event rates is required (due to changes in age structure and population growth).

Stratification: 5-year age groups, males/females.

3.5 Step 5: Estimate exposure effect relationships

a) *Estimation of baseline exposure-response relationships (RR)*
Exposure-health effective dose-response functions will most likely come from Lucas et al. [2006], However, some dose-response functions for some selected diseases will be derived from other parts of the literature after a closer review. For SCC and BCC such curves are given in Figures A3.3 and A3.5 in Lucas et al. [2006] for different age groups.

b) *Estimation of exposure-response relationships (RR) under different policy scenarios*
Data on the impacts of different adaptations scenarios is required in order to compare policy scenarios with the baseline. A literature review will be undertaken and possibly expert elicitation.

c) *Identify effect duration and disease weighing factors to allow burden of disease estimations (DALYs).*
It is decided that this case study will use the UVR Global Burden of Disease (GBD) study by Lucas, McMichael et al (2006) as one of the main sources of input regarding on the exposure-health relationships. This study already performed meta-reviews and expert judgements. The report also provides input to calculate DALY's. Use disease models from WHO. See for example the figure below illustrating the disease model for BCC.

d) Identify population life tables in order to allow estimation of life years lost (YLL) or loss of life expectancy (LLE)

Stratification: 5-year age groups, males/females.

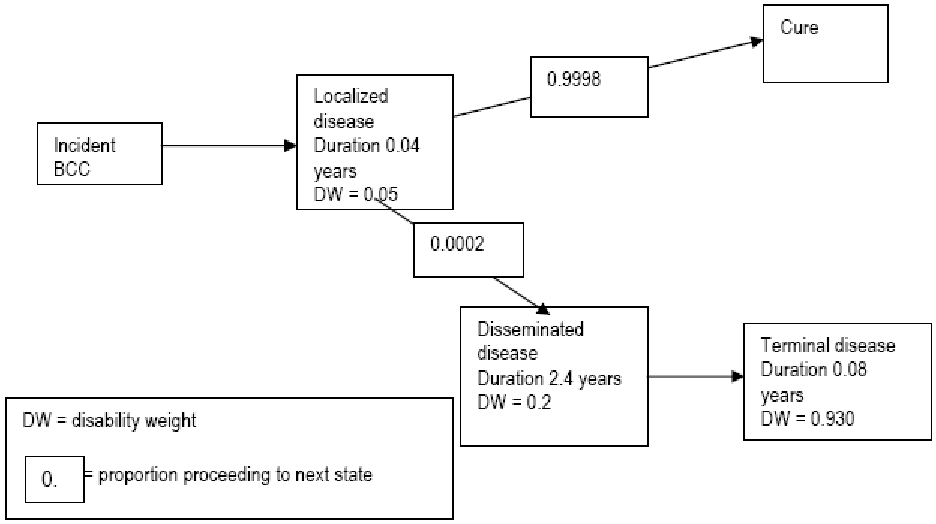


Figure 4: Example disease model (Lucas et al 2006)

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3.6 Step 6: Data needs/collection

a) and b) Refine data needs and data collection (covering all data needs)

Please note that the exposure and health indicators should be consistent with the indicators used to establish the RR. Stratification: 5-year age groups.

Exposure data
Exposure indicators: monthly erythemal doses 1997-2003. Compute corresponding clear-sky erythemal doses from TOMS ozone columns. We will compute effective cloud/aerosol modification factors. For future UVR we will use future ozone predictions (see below) to compute clear sky erythemal doses. we will compute real doses using the above modification factors. If readily available, we compute future modification factors for available future cloud predictions. The ozone and UVR times series from the ongoing SCOUT-O3 project will be considered. Currently this project only has projections on ozone and cloudiness until 2020. It is difficult to assess personal exposure accounting for outdoor behaviour, clothing, etc. For each age group and region, assume UV-index/erythemal dose is a good relative indicator. There are data on outdoors behaviour in an EPA exposure factors report, but not for the same age groups as in the WHO report (Lucas et al., 2006). we assign weights to the UV-indices on the basis of outdoor behaviour data for each age group.
Time span: 1997-2003, 2030, 2050 (and possibly 2070 and 2100)
Time resolution: monthly, annual.
Geographical scale: Rome, London, Helsinki, EU
Population groups: Male/female needed, overall population, in 5-years age groups, and possibly vulnerable groups (e.g. outdoor workers, skin type)
Data sources: model results based on TOMS ozone columns (available).

Health outcome data
Health indicators: annual mortality and incidence rates for melanoma, SCC, BCC. Other health outcome possibly to be included in second pass assessment.
Time span: baseline (2001) and baseline trends up to 2050
Time resolution: annual
Geographical scale: Rome, London, Helsinki, EU
Population groups: Male/female needed, overall population, in 5-years age groups, (e.g. outdoor workers, skin type)
Data sources: National and regional data registries available in some countries (e.g. UK) EUCAN database, ENCR.

Other data:
- life expectancy table
- population data (e.g. to calculate trends, baseline rates up to 2050), lifetables
- information on relationships between variables, i.e. exposure-effect relationships, data on the effects of adaptation and policy scenarios.

3.7 Step 7: Estimation of exposure attributable risk

The PAF needs to be estimated for UVR-exposure. According to WHO methodology and INTARESE guidelines/tool. Based on status quo exposure/RR and the exposure/RR under different policy scenarios.

Stratification: 5-year age groups, males/females.

3.8 Step 8: Health impact assessment

a) *Calculation of attributable health impact of baseline exposure for different population groups.* Based on steps 1-7.
b) *Calculation of attributable health impact of policy scenario (compared to baseline).* Based on steps 1-7.

It is possible to consider the attributable risk in specific population groups by obtaining baseline event rates for each group of interest. Additionally, group specific relative risks may be available, or alternatively, it may be assumed that this varies little between groups but acts in the context of differing baseline risks. Whichever decision is made – to assess group-specific or whole population impacts – it is necessary to obtain corresponding population figures to calculate the potential health impact. A general INTARESE tool will be developed by SP1/SP4.

Stratification: 5-year age groups, males/females.

3.9 Step 9: Uncertainty assessment

a) *Identification and characterization of major sources of uncertainty.*

Guidance on how to specify and assess uncertainties is being developed by WP1.5, and the classification of uncertainties that this has identified should be followed as far as possible. Important uncertainties are, for example, related to the estimation of RR, prevalence rates, success of interventions etc. The aim is to find innovative ways of dealing with these uncertainties and to be transparent on the assumptions made.

b) Sensitivity analysis

Sensitivity analysis will be conducted to indicate which uncertainties have major impacts on outcomes and thus require further research in the future.

3.10 Step 10: Risk characterization and policy appraisal

Translation into policy relevant indicators: e.g. DALYs, costing. Depends on input from SP1.

a) Assessment of burden of disease using standard DALY methodology (training by SP1)

b) Assessment of YLL and LLE using standard life table analysis (training by SP1 or through using the IOMLIFET method).

3.11 Iterative process

The first pass assessment will consist of two stages:

Stage 1 June –October 2007 (cases= Rome and London)

- Baseline: estimating UVR attributable morbidity/mortality/DALYs for baseline year for Rome, London and Helsinki (depending on data availability), focusing on SCC and BCC only.
- Policy issues: Estimate the avoided UVR effects related to a specific behavioural changes (e.g. outdoor behaviour) (to be decided which policy scenario will be addressed first).
- Ozone depletion: Standard approach is, for a given time slice [e.g. 2020], impact = burdens under future ozone depletion (mitigation) scenarios - burdens under baseline climate (with assumptions about adaptation).

Stage 2: Nov 2007-April 2008

- Baseline: also include estimating morbidity/mortality/DALY's for baseline year for melanoma, if data is already available.
- Policy issues: estimate avoidable burden for several behavioural changes, if required.
- It will also be explored how to address climate change impact on cloud cover and clothing behaviour.

At the end of the first pass assessment period, the assessment process will be evaluated and the most important lessons learned will be identified. This will form the bases for the second pass assessment protocol. In the second pass protocol, it will be explored whether an EU-wide assessment is possible as well.

3.12 Expected challenges in the assessment process

- Ambient UVR does not easily translate to actual population exposure distribution; however, ambient UVR is our current best measure of population UVR exposure.

- For many diseases there are a long lag-period between exposure and health effect; there are difficulties in estimating past exposures (often based on recall of number of sunburns, estimated accumulated hours in the sun).
- Estimated dose-response relationships are often based on ecological studies or case-control studies (with a significant risk on recall bias). There is probably a dose-response relationship between cumulative dose and risk of NMSC, but there is no simple dose-effect relationship for melanoma.
- Ideally, ambient UVR is translated into biologically effective radiant exposure (for several health outcomes)
- For some diseases (e.g. BCC, melanoma) the relationship might involve an accumulated UVR dose threshold as well as critical life stage of exposure (e.g. childhood exposure). The latter is difficult to obtain accurate information about because ozone and UV data are relatively scarce before the 1980's
- Most studies are conducted in fair skinned populations.

4 Reporting and communication

The methods and results derived from WP3.3 will be made available (in accordance with the deliverable deadlines) within the INTARESE project team to facilitate further refinement of the framework, toolbox design and methodologies for integration across policy scenarios. Relevant developments and results from WP3.3 will be published in the scientific literature in a timely manner.

An interim report of the results of the first-pass assessment (month 18 – month 30) will be prepared in month 24 (November 2007). This will be distributed to all SP3 work packages and to SP1.

The first draft of the water assessment protocol will be completed by March 2007 for distribution to WP3.7 partners. A revised draft will be sent to other relevant WPs/SPs by April. Upon receipt of their comments and suggestions, a complete final draft of the document will be submitted to the Project Co-ordinator (David Briggs) by 15th May 2007 (project month 18), for evaluation and reconsideration of the protocol for second pass.

In the first pass user consultation will primarely focus on the those INTARESE sub-projects that will use the assessment results (e.g. SP2, SP5 & SP4). A more comprehensive user consultation will be conducted in the (beginning of the) second pass assessemt. The minimum requirement would be to provide the results to the stakeholders involved in the assessment framing and protocol development, along with members of the project (including the Advisory Group). A guidance document to be issued by SP1 is expected on how to involve stakeholders.