

UV-radiation and skin cancer in Norway

I. Medhaug, J.A. Olseth, and J. Reuder

Geophysical Institute, University of Bergen, Norway

Introduction

A distinct increase in skin cancer incidence has been observed since the cancer registration started in Norway in the 1950s (Fig 1). As exposure to UV-radiation is assumed to be the main risk factor for skin cancer, hourly UV values of UVA, UVB and erythemal UV are reconstructed for the time period 1957-2005 for the counties in Norway (58-70°N) (Fig 2). These data can be used for a statistical correlation analysis. In addition, the reconstructed UV data set provides a Norwegian UV climatology for the past 5 decades that can be used for a wide range of biological investigations.

For the UV reconstruction, the neural network version of the radiation transfer model STAR has been used. Model simulations are based on measured total ozone amount and synoptic observations of cloudiness and snow cover.

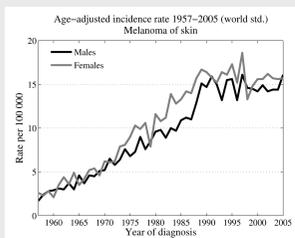


Fig 1: Age adjusted incidence rate of Cutaneous Malignant Melanoma for Norway in the period 1957-2005 (Data provided by the Cancer Registry of Norway).



Fig 2: Reconstruction sites / synoptic measurement stations.

Model / Data

UV modeling

UV data were reconstructed by running the neural network version of the System for Transfer of Atmospheric Radiation (STAR_{neuro}), developed at the Meteorological Institute, University of Munich, Germany (Schwander et al., 2002). STAR calculates spectral irradiances that can be integrated over wavelength by using user-defined weighting functions. In the presented study integral UVA (315-400 nm), UVB (280-315 nm) and erythemally weighted UV radiation ERY (McKinlay and Diffey, 1987) have been estimated.

The cloud effect in STAR_{neuro} is described by a cloud modification factor (CMF), determined by a neural network algorithm using the type and amount of low-, medium- and high-level clouds as input. Snow cover and depth and the total ozone amount have been used as additional input parameters. The reconstructions were done on an hourly basis, with a subsequent integration into daily, monthly and yearly values for further analysis.

Model input data from measurements and observations had to be preprocessed for the model simulations:

- Ozone data for each reconstruction site were interpolated between 20 stations from the WUOUC database, limited by 55-80°N, 10°W-40°E.
- Routine cloud and snow observations performed by the Norwegian Meteorological Institute (met.no) were processed to determine the required cloud and albedo information for STAR (for details see Medhaug, 2007).

UV measurements

UV-measurements at 4 stations have been used to validate the reconstructed data. All measurements have been performed by multi-channel GUUV (Ground-based Ultra Violet radiometer) 541 from Biospherical Instruments (Fig 3). The instruments are part of the Norwegian UV monitoring network, operated by the Norwegian Radiation Protection Authority (NRPA) and the Norwegian Institute for Air Research (NILU).

Due to co-allocation with synoptic observation sites of the Norwegian Meteorological Institute, the following 4 stations have been selected for an UV-intercomparison:

- Tromsø
- Bergen
- Oslo
- Landvik / Kjevik



Fig 3: GUUV 541

UV reconstruction

Reconstructed vs measured:

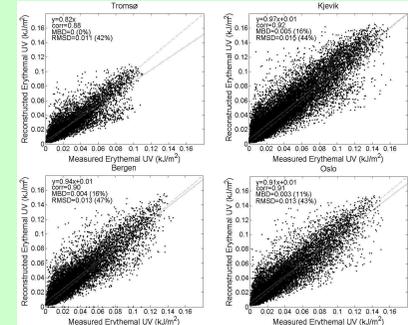


Fig 4: Reconstructed vs measured hourly erythemally weighted UV radiation

- Overall: - 0 % deviation for the northernmost station (Tromsø).
- 11-16 % overestimation for the southern stations.
- Clear sky: Slight overestimation of 1-7 % at all stations.
- Overcast: Overestimation of 10-20 % for all but the northernmost station.

Cancer vs UV:

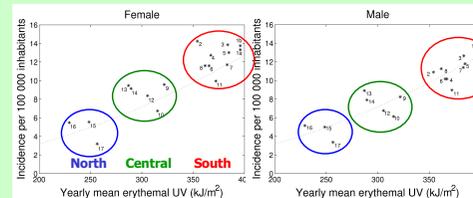


Fig 5: Mean incidence rate of malignant melanoma vs mean erythemal UV during 1957-2005 (period April-August) for 18 counties in northern, central, and southern Norway. Dotted line shows the quadratic fit.

- Increase of cancer incidence with increasing erythemal UV.
- Best correlation with quadratic fit.

UV climatology:

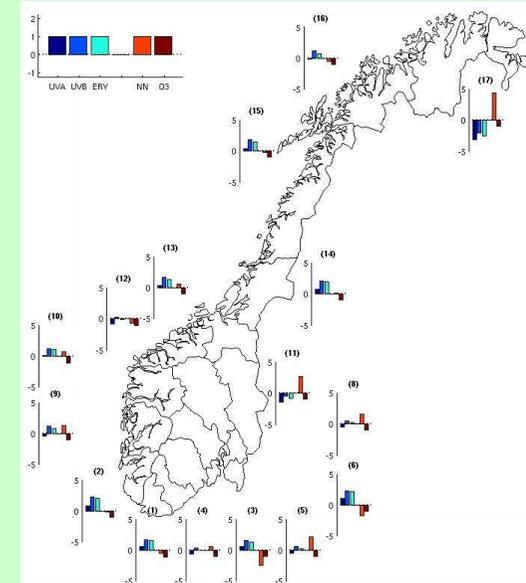


Fig 6: Decadal trends in UVA, UVB, erythemal UV (ERY), total cloud cover (NN) and total ozone column (O3) in % for all counties /stations for the period 1957-2005. Station numbers as in Fig 2.

- Weak positive and negative trends in UVA, showing mainly the variable cloud effect on UV irradiance.
- Predominantly positive trends in UVB and ERY due to uniform total ozone reduction over the whole area.

Summary

- Hourly UVA, UVB and erythemal UV for all Norwegian counties, representing the North-South and East-West extension of the country.
- Deviations from measurements under all sky conditions varies between 0% for the northernmost site to 11-16% overestimation for the other locations.
- For clear sky cases, a reasonable agreement is found between reconstructed and measured data for all stations.
- North-South gradient - mostly due to the latitudinal solar elevation decrease towards north.
- East-West variation - due to differences in cloud optical thickness and total cloud amount.
- No uniform trend in UVA, but predominantly positive trend in ERY over the period 1957-2005.

References:

- McKinlay, A.F. and B.L. Diffey (1987). A reference action spectrum for ultraviolet induced erythema in human skin. *CIE J.* 6, 17-22
- Medhaug, I. (2007). Reconstruction of UV-radiation and its potential implications on development of skin cancer. http://1115srv.vu-wien.ac.at/uv/COST726/COST726_Dateien/Results/Masterthesis_Iselin_Medhaug.pdf
- Schwander, H., P. Koepke, A. Kaifal, and G. Seckmeyer (2002). Modification of spectral UV irradiance by clouds. *J. Geophys. Res.* 107(D16), AAC7-1 to AAC7-12

Acknowledgements:

Thanks to Bjørn Johnsen at Norwegian Radiation Protection Authority for providing the UV data, and Trude Eid Robsahm at the Cancer Registry of Norway for contributing with cancer data.

