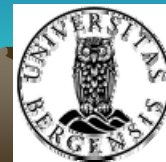


# UV-radiation: Examples from Bergen on Measurements Reconstruction and Applications

**Iselin Medhaug  
Brynhild Berge Sjølingstad  
Ottar Sætre**

***Jan Asle Olseth & Joachim Reuder***  
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*Geophysical Institute  
University of Bergen*





# Geophysical Institute (45 m.a.s.l.) University of Bergen

## Radiation Observatory



# Geophysical Institute (45 m.a.s.l.)

## Shortwave (solar) radiation

1. Sunshine duration
2. Total (global) solar radiation
3. Diffuse solar radiation
4. Direct normal radiation

1



4



3



2

# Geophysical Institute (45 m.a.s.l.)

Shortwave (solar) radiation

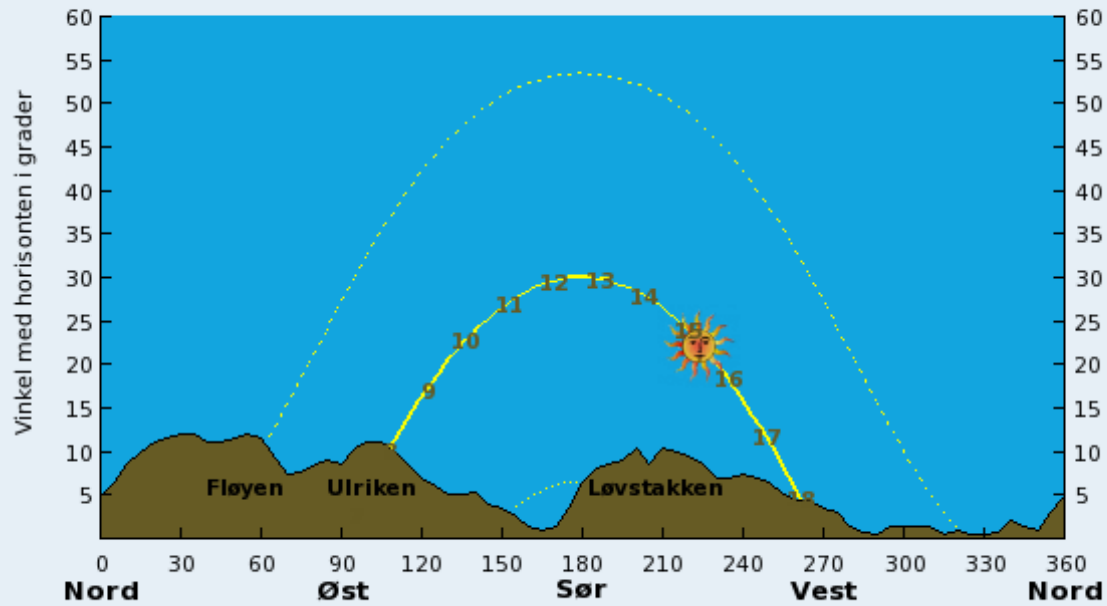
5. UV radiation

Longwave (terrestrial) radiation

6. Atmospheric radiation



### Solposisjon på himmelen sett fra Geofysisk institutt 21.03.2007



# Recent master theses on UV-radiation at Geophysical Institute



**Iselin Medhaug:**

**UV-radiation and its effect on skin cancer in Norway**  
*(finished summer 2007; Cancer Registry)*

**Brynhild Berge Sjølingstad:**

**The effect of UV-radiation on Arcto Norwegian cod**  
*(finished summer 2007: Institute for Marine Research)*

**Ottar Sætre:**

**Observed and modelled UV-radiation in Bergen**  
*(finished spring 2006)*

**Thomas Carlson:**

**UV-radiation in Norway**

**Satellite estimates, model estimates and ground observations**  
*(finished summer 2005)*

**Iselin Medhaug:**

## **UV-radiation and its effect on skin cancer in Norway**

**Reconstruction of UV-radiation at one station in each county in Norway 1957 - 2005 (total of 17 sites)**

**Model:  
STARneuro**

**Input:**

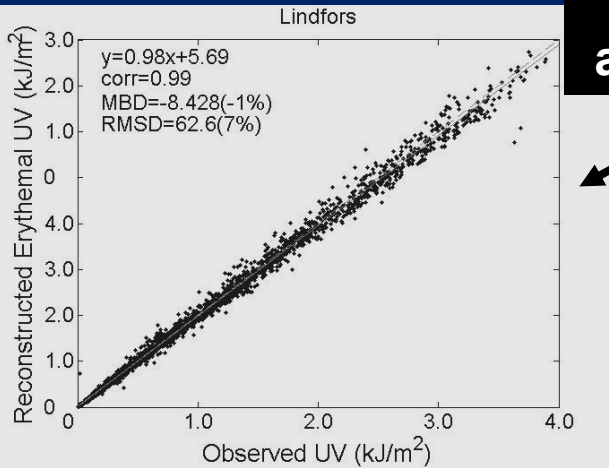
- **Solar elevation**
- **Ozone**
- **Cloud information**
- **Turbidity**
- **Ground albedo**



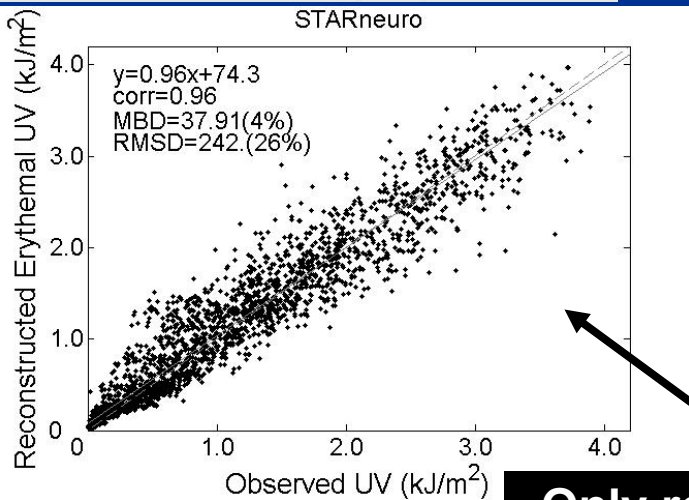


### Bergen

#### Daily values

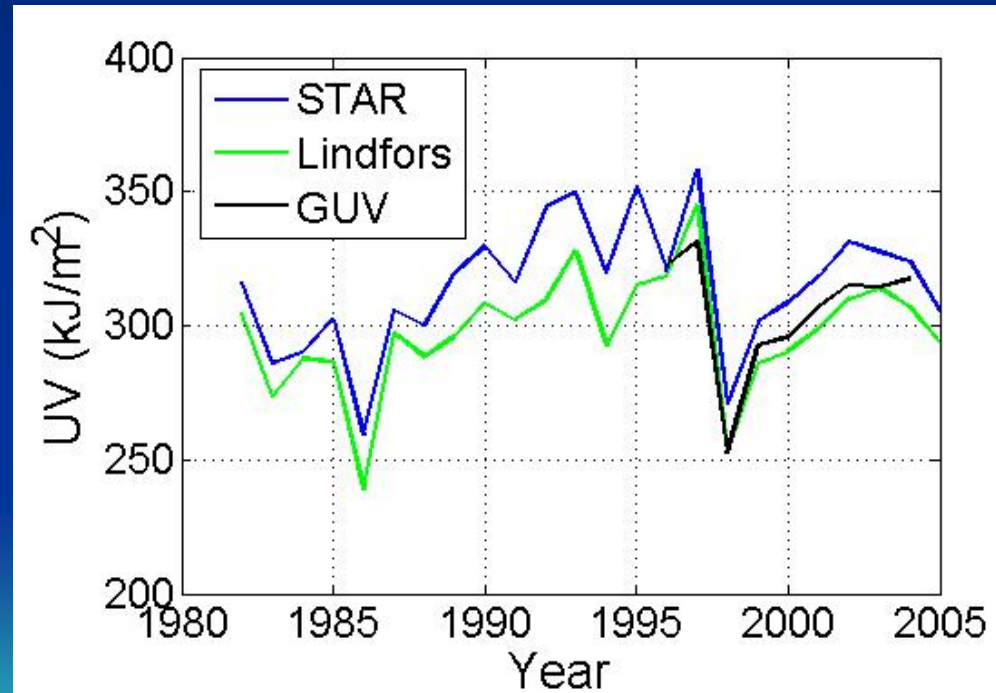


**Global radiation  
as additional input**



**Only regular cloud  
Info as input**

#### Annual values



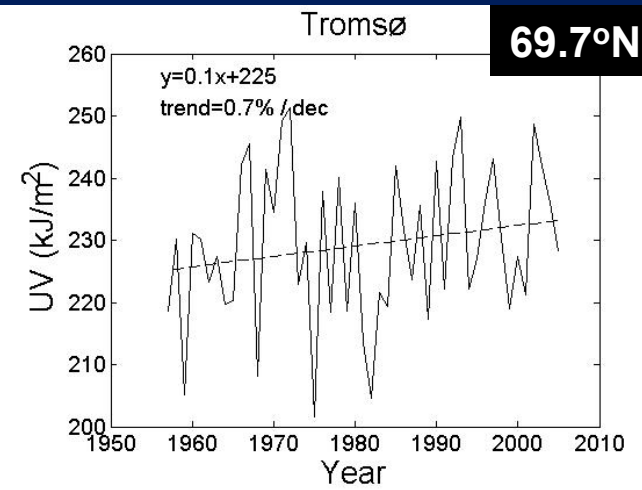
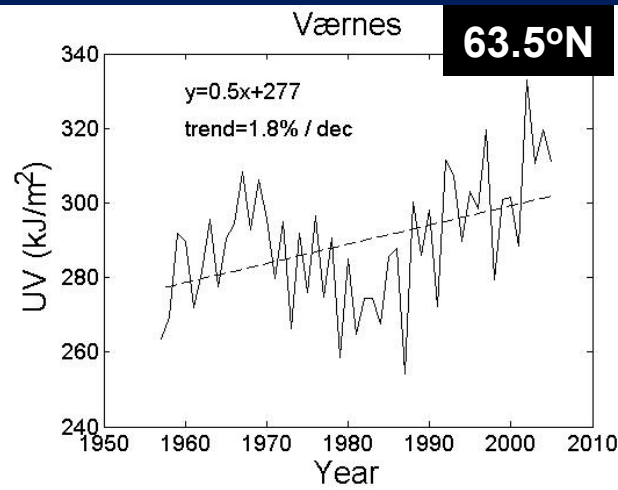
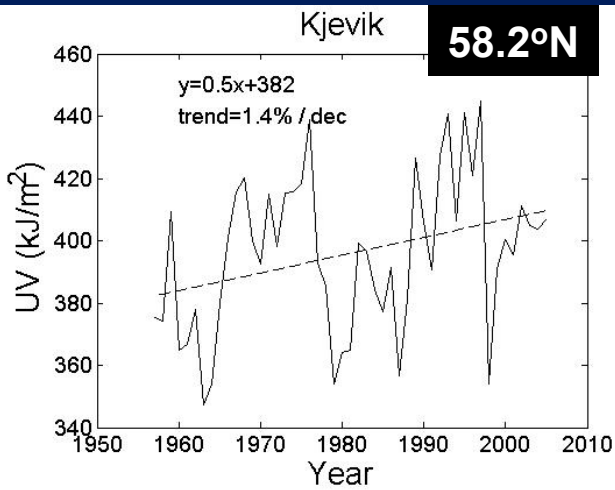




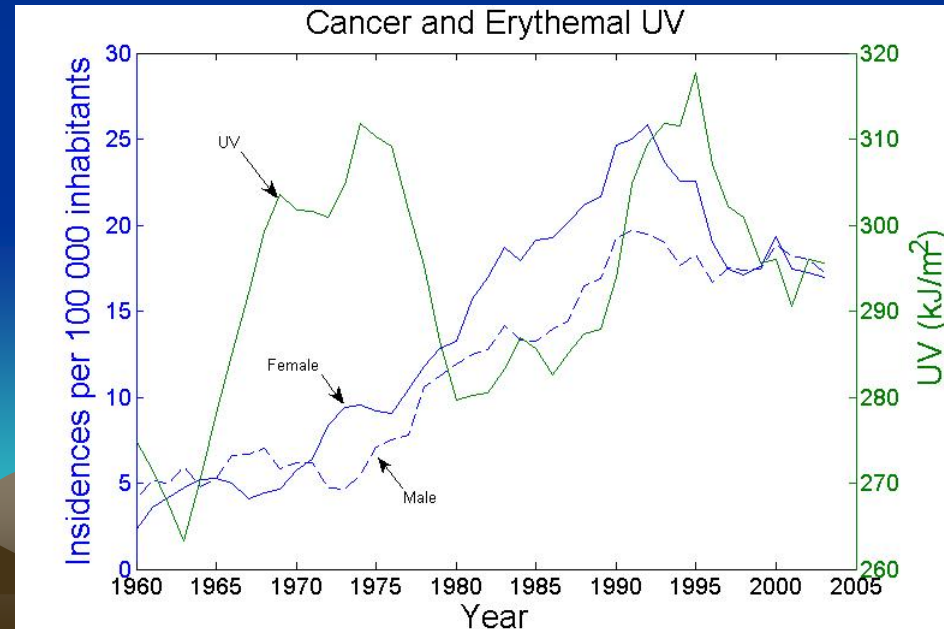
# Iselin Medhaug:

## UV-radiation and its effect on skin cancer in Norway

### Latitudinal variation



### Cancer and Erythemal UV ( 5 year moving average ) Kjevik (58.2°N)



**Brynhild Berge Sjølingstad:**



## **The effect of UV-radiation on Arcto Norwegian cod**

**Cod-eggs are passively drifting in the ocean**

**Method for investigating UV effect on cod eggs:**

- **Reconstruction of UV (*STARneuro weighted with UV- sensitivity*) at sea surface at the spawning areas (March – May)**
- **Development of a cod UV-index dependent on:**
  - **UV radiation on the surface**
  - **Transmission of UV radiation through the water column**
  - **Mixing of eggs in the water column (depends on wind speed)**

**Investigation of the relationship  
between cod UV-index and the stock of cod**

# Brynild Berge Sjølingstad:

## The effect of UV-radiation on Arcto Norwegian cod

Spawning areas  
Synoptic stations

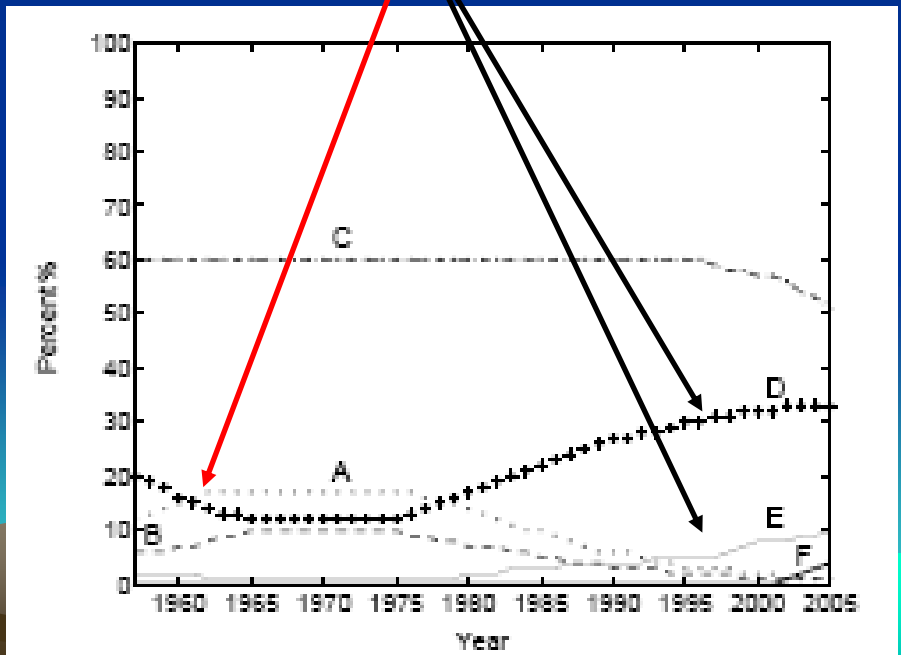
Relative weight  
of the spawning areas

Shift towards north with time  
(caused by increasing temperature)



Figure 3.1: Geographically placement of the current SYNOP stations. The grey fields indicate the spawning areas, this will be further discussed in section 3.6.

Southern area      Northern area





**Brynhild Berge Sjølingstad:**

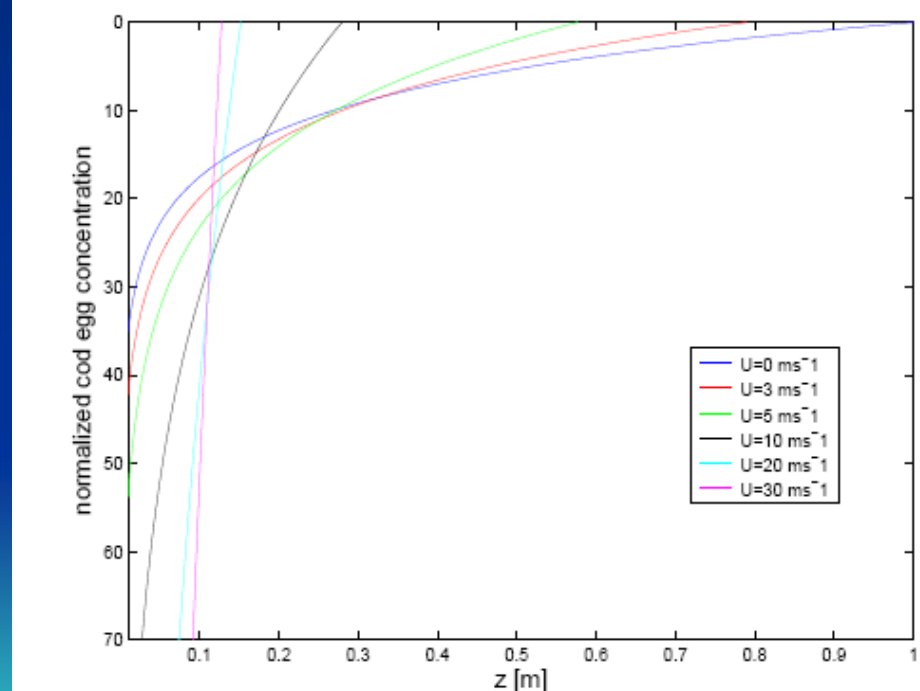
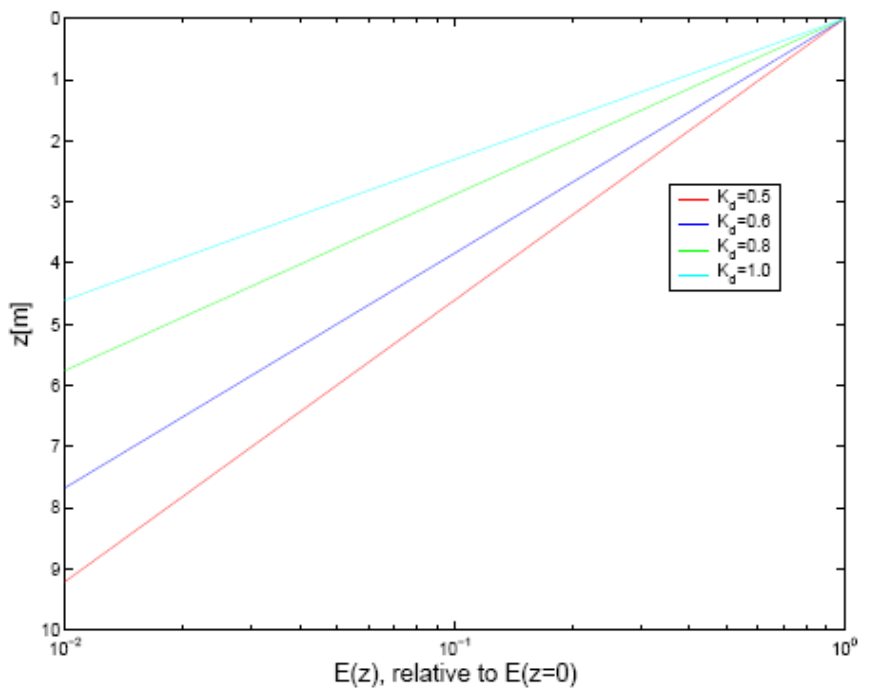
# The effect of UV-radiation on Arcto Norwegian cod

**UV-radiation at sea surface**

+

**Vertical distribution of cod-eggs  
as a function of wind speed**

**UV-transmission in ocean**

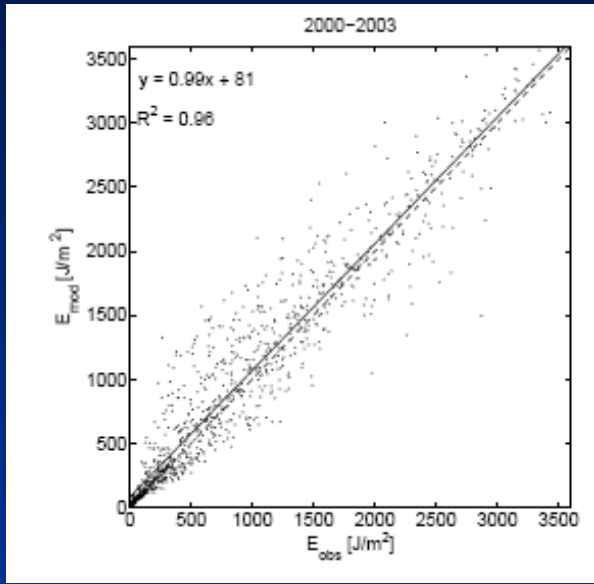


**Cod UV-index**



# Brynhild Berge Sjølingstad:

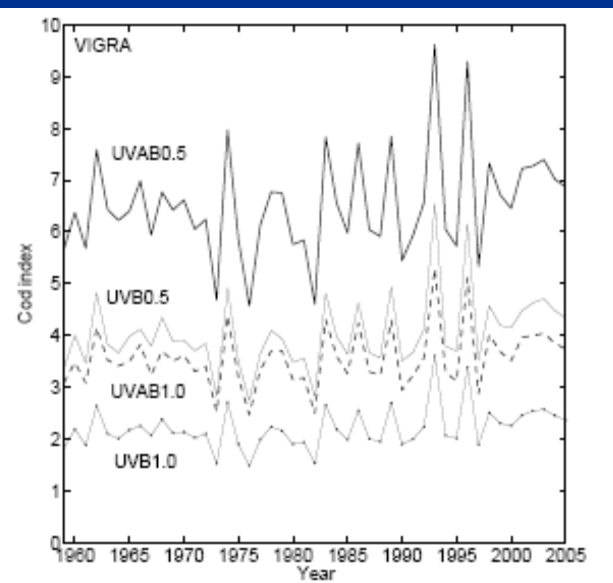
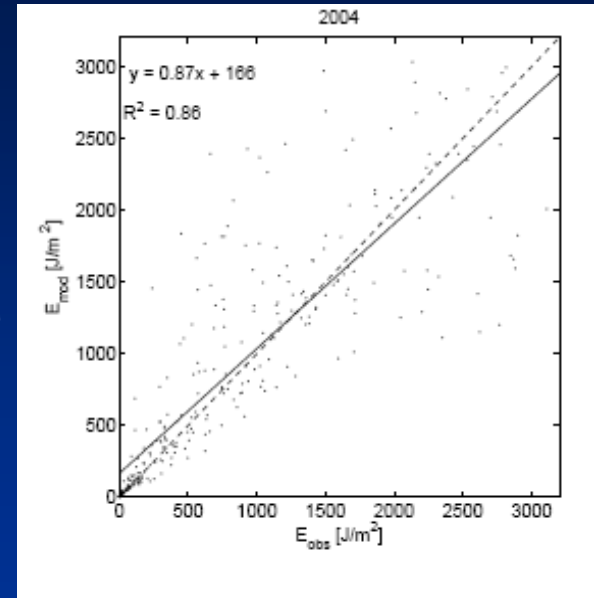
## The effect of UV-radiation on Arcto Norwegian cod



### Daily UV Andøya

2000-2003

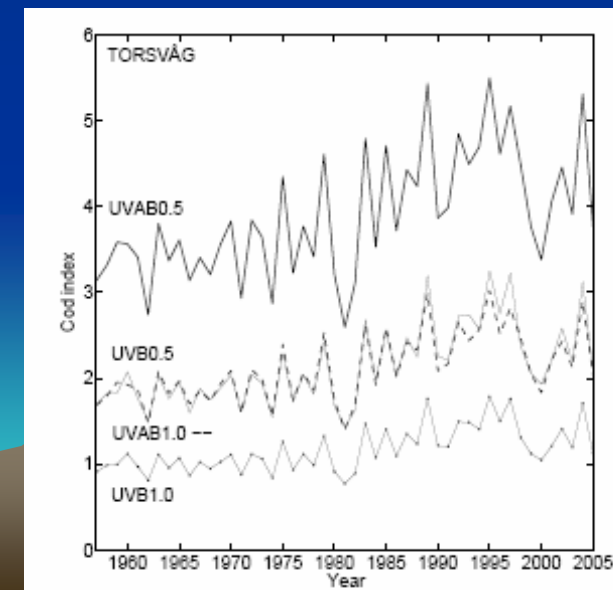
2004  
Leakage  
of water



### Cod UV-index

Southern  
area

Northern  
area



Ottar Sætre:

## Observed and modelled UV-radiation in Bergen



- Estimation of erythemal UV in Bergen
- Comparison between modelled and observed values
- Comparison with observed UV in Norrköping, Sweden





Ottar Sætre:

## Observed and modelled UV-radiation in Bergen

### Model:

#### STAR – two versions:

- STARsci for clear sky
- STARneuro under actual cloud cover
  - “Trained” on data from Garmisch-Partenkirchen

#### Variable input for STAR:

- Solar elevation
- Cloud amount
- Global irradiance
- Ozone
- Air pressure

#### Non-variable input for STAR:

- Average continental atmosphere
- Aerosol optical depth (AOD) 0.20
- Albedo 0.03





# Comparison ground measurements - model results

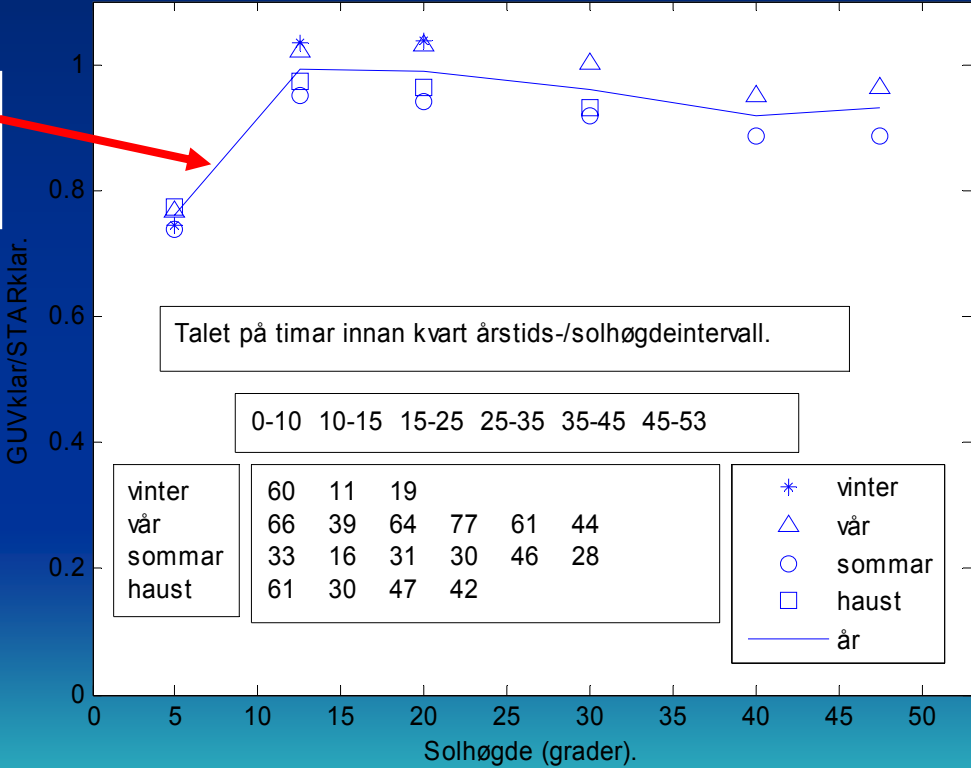
## Clear sky

**GUV / STAR**  
as a function of solar elevation for  
- the whole year  
- different seasons

• Low sun – low ratio  
– mountains affects GUV

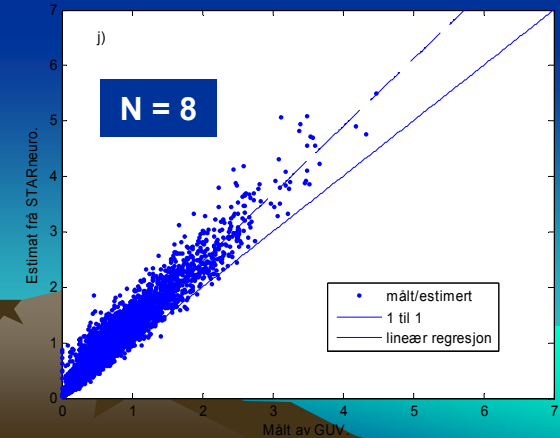
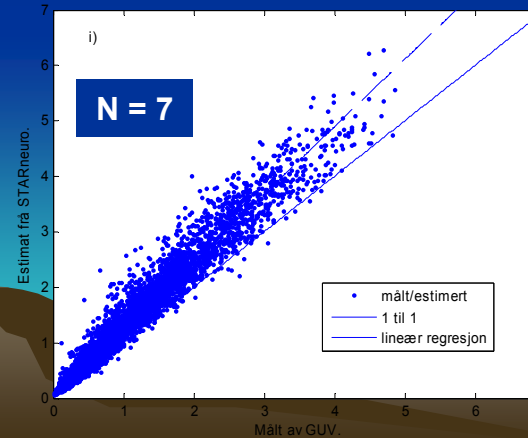
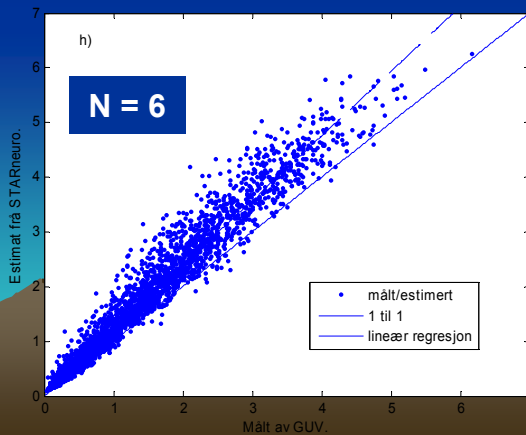
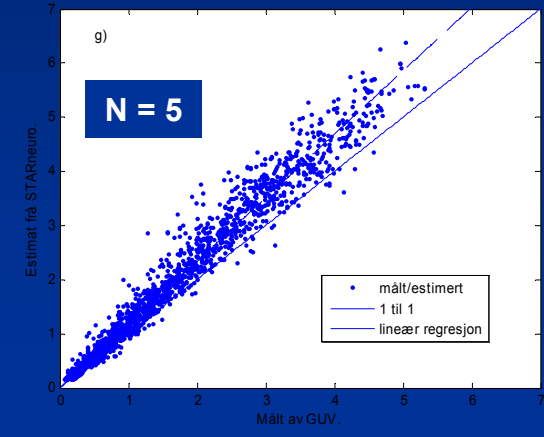
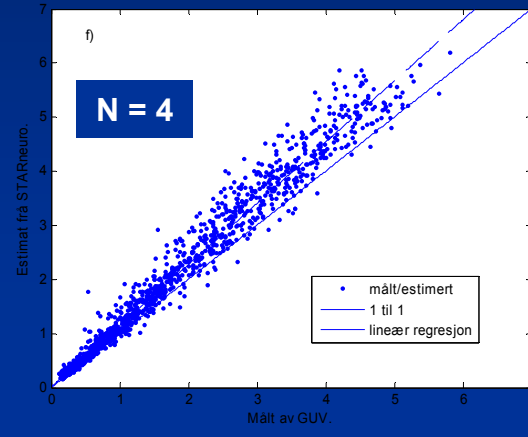
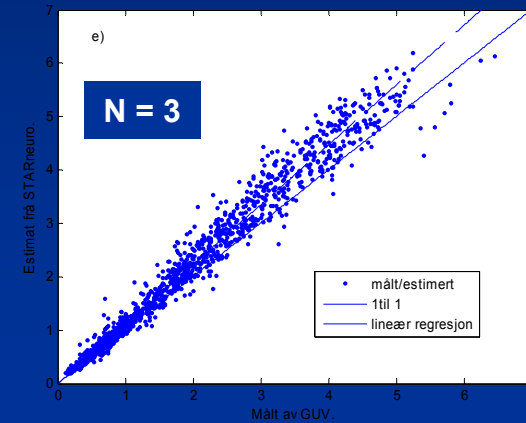
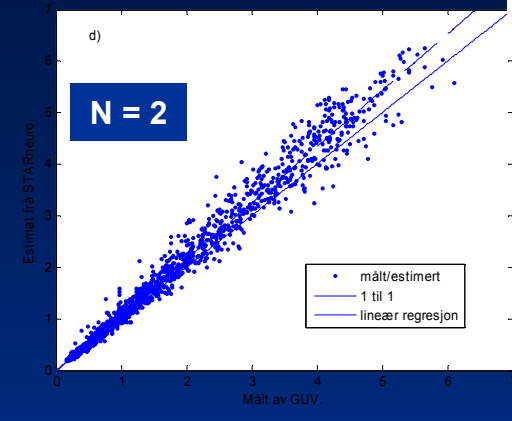
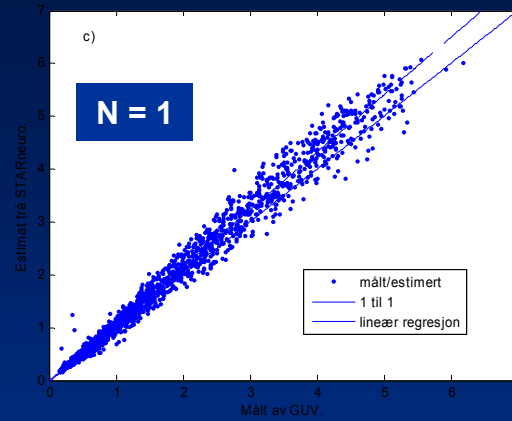
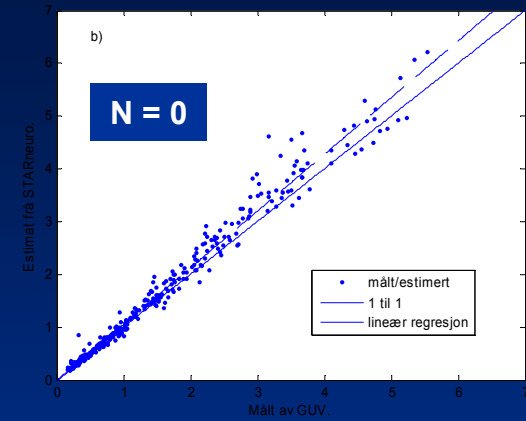
• Fixed turbidity as input  
→ seasonal variation

• Small solar elevation variation  
for each season





# Comparison ground measurement – model results





Ottar Sætre:

## Observed and modelled UV-radiation in Bergen

### Measurements (GUV) – model results (STAR)

#### At clear sky

- Turbidity → seasonal variations
- Small solar elevation dependency for each season



Mean ratio GUV / STAR:

- Winter 1.04
- Spring 0.97
- Summer 0.89
- Autumn 0.94

#### At arbitrary cloud amounts

Small seasonal variation in the ratio GUV / STAR (for cloud amount > 2 octa)  
except at snow - covered ground



Cloud amount (N)	0	1	2	3	4	5	6	7	8
GUV/STAR (March-Nov.)	0.94	0.94	0.92	0.90	0.86	0.84	0.81	0.79	0.74
GUV/STAR (Year)	0.94	0.94	0.92	0.90	0.86	0.84	0.81	0.79	0.74

Mean ratio GUV / STAR for different cloud amounts.

# The effect of clouds

## Comparison between Bergen and Norrköping

### High

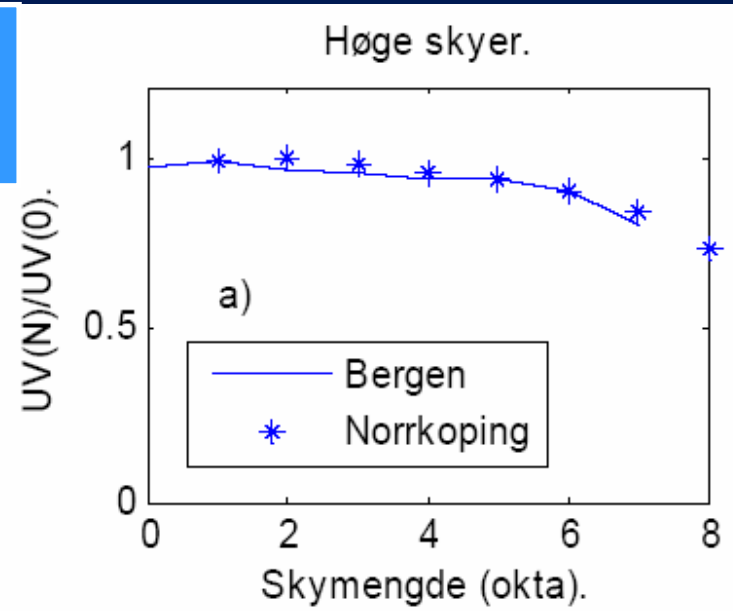
- Small differences (High clouds universal?)

### Low / medium high (no precipitation)

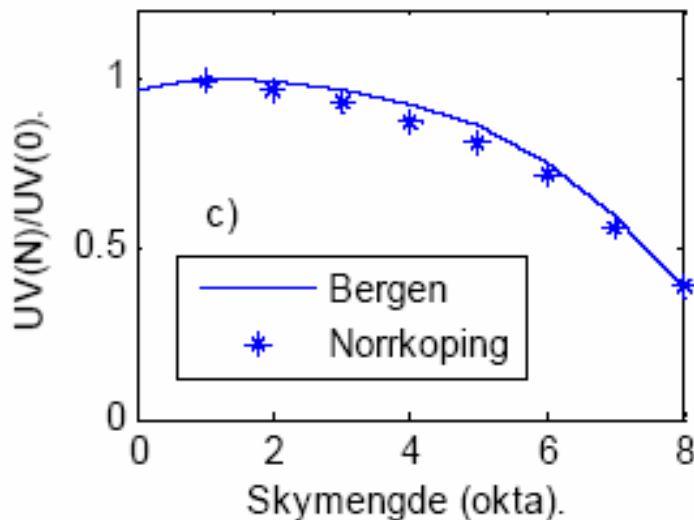
- Bergen higher for  $N \leq 4$  octa (Clouds in east / northeast?)

### Low / medium high (precipitation)

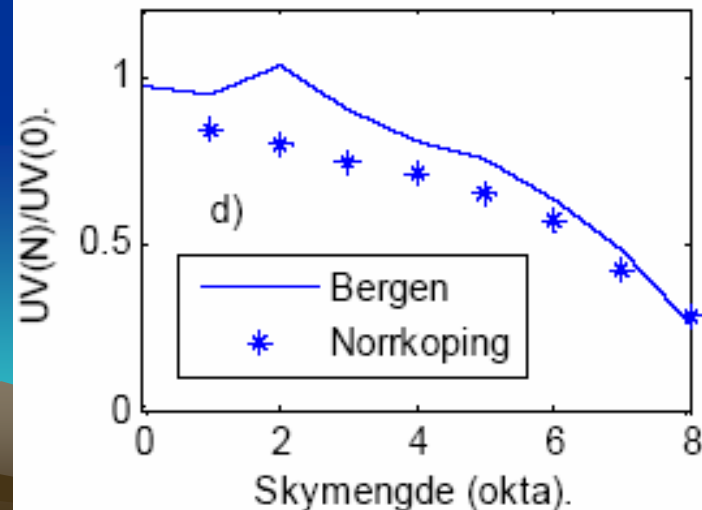
- Bergen lower for  $N = 8$  octa (Thick precipitating clouds?)



Mellomhøge og låge skyer utan nedbør



Mellomhøge og låge skyer med nedbør.





Thank you !

