



First case studies of 3-D-Radiative Transfer Calculations in mountainous terrain in the UV

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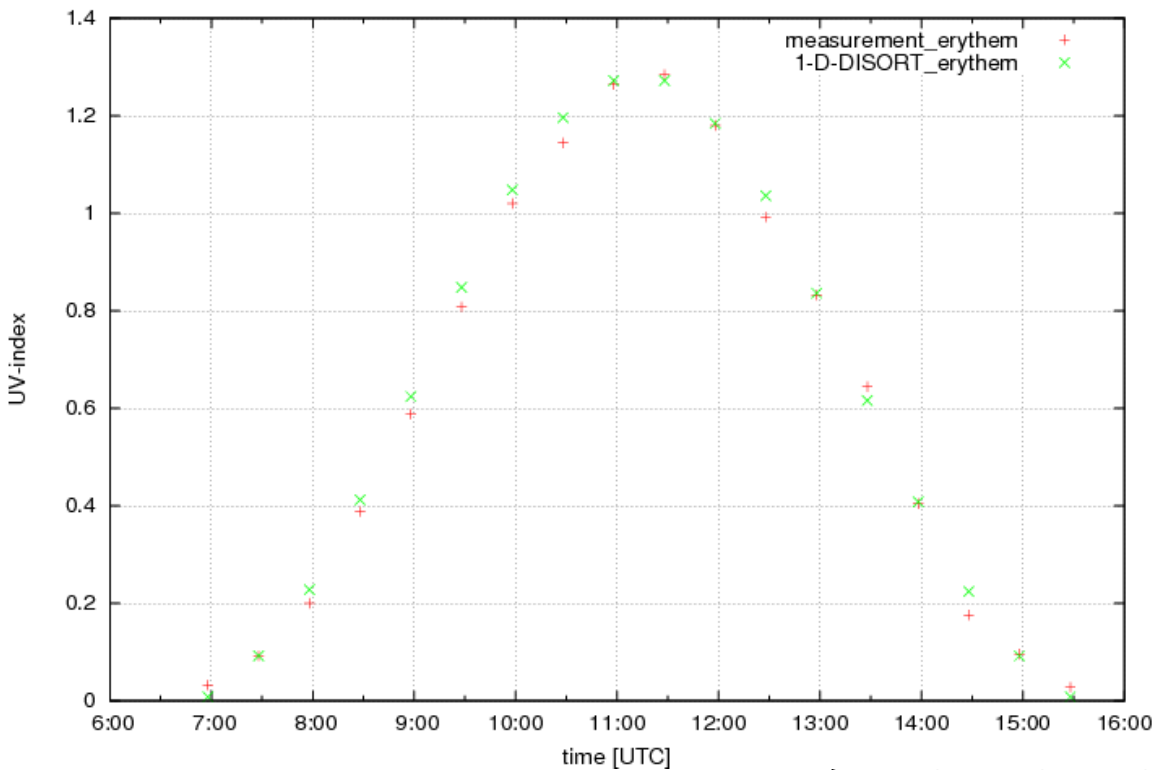
Outline

- Comparison of a 1-D-model with measurements
- Why use 3-D-models ?
- Presentation of the 3-D-model
- Spatial distribution of radiation
- Conclusions and Outlook

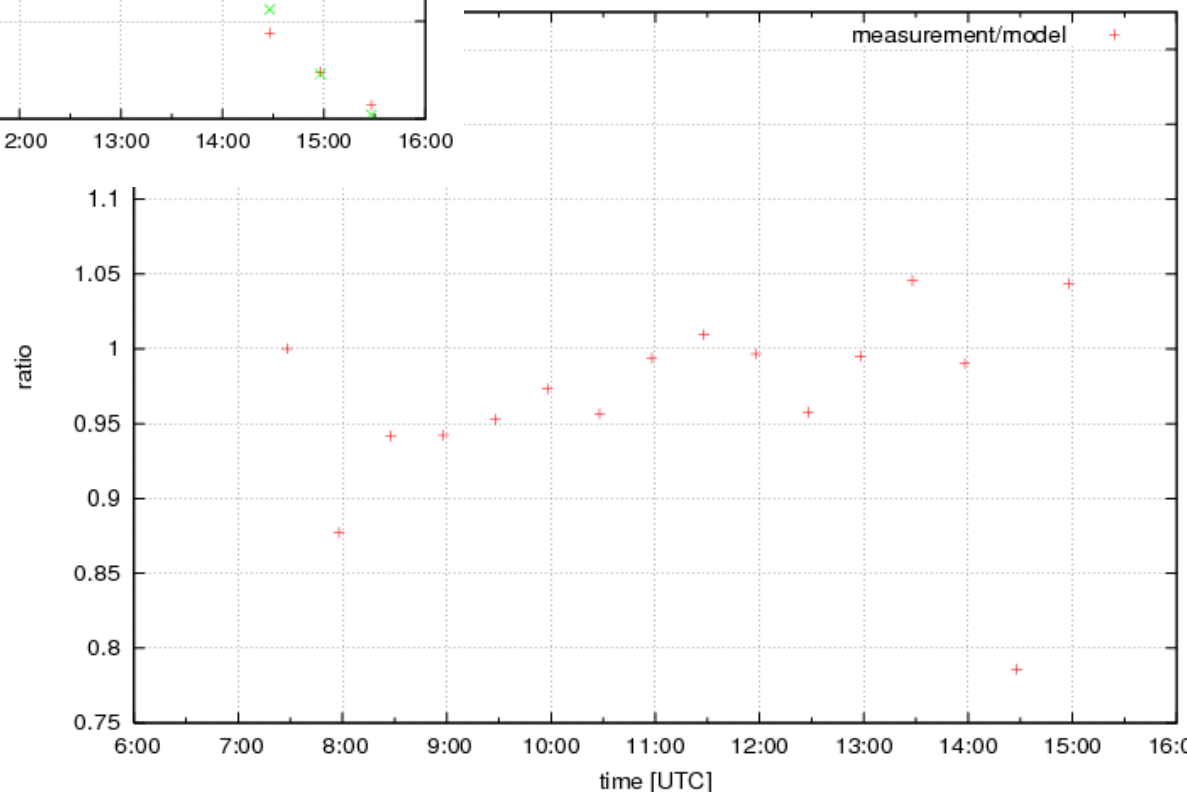
Bentham and Brewer on top of Sonnblick



Calculated and measured erythem-irradiance at January 11th at Sonnblick

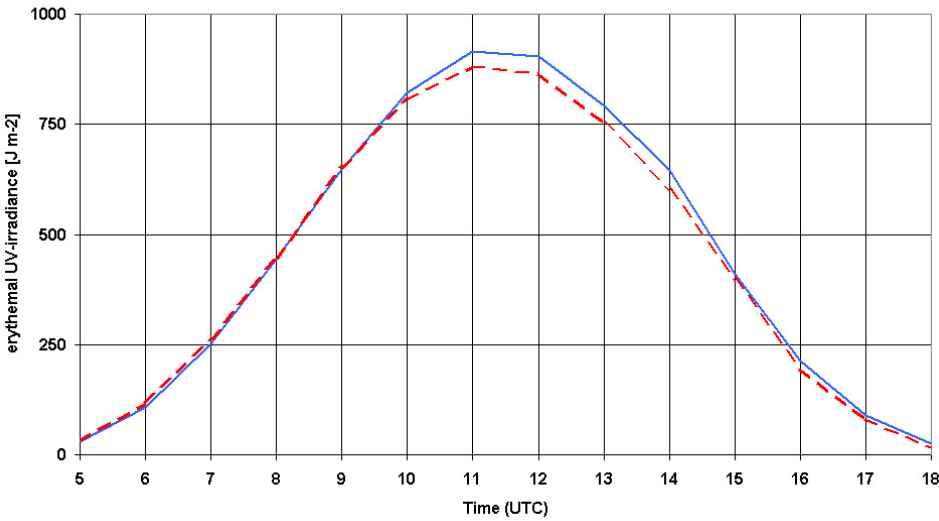


I measured erythem-irradiance at January 11th at Sonnblick



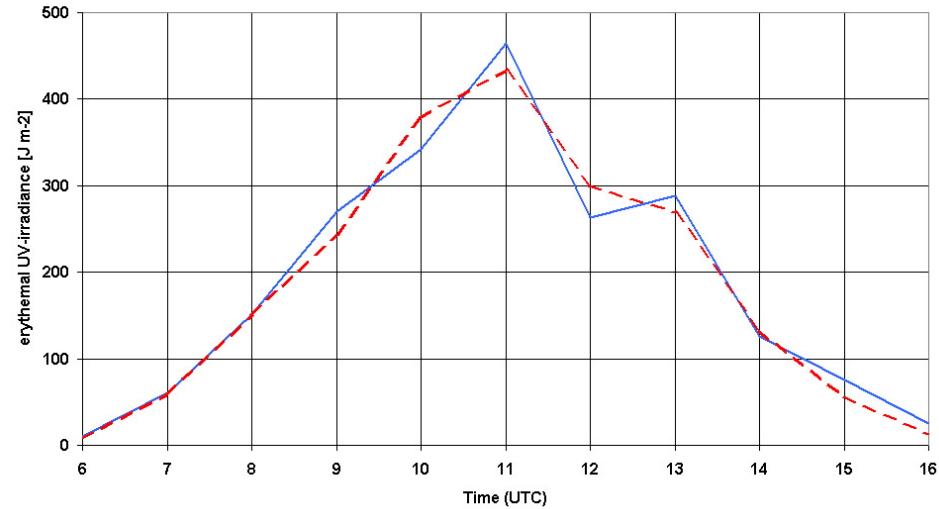
Clear - sky

22. 6. 2003



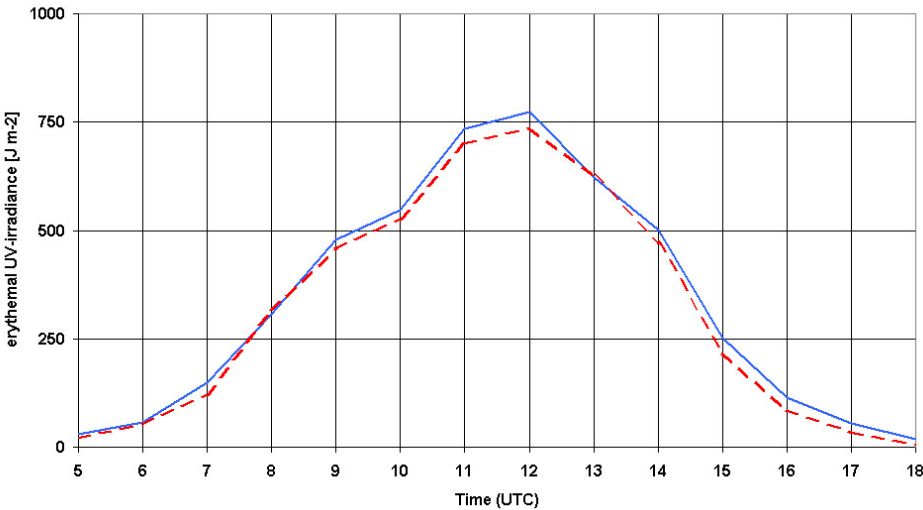
Broken clouds

28. 9. 2003



Overcast

12. 7. 2000



— measurement
 - - - 1-D-model (with CMF)

Good agreement even for cloudy situations (with CMF)

Range	±5%	±10%	±15%	±20%	±25%	±30%	±35%	±40%
Daily data	36%	62%	76%	86%	93%	95%	98%	99%
Monthly data	67%	96%	100%					

H. Rieder, 2007

3-D effects in mountainous regions

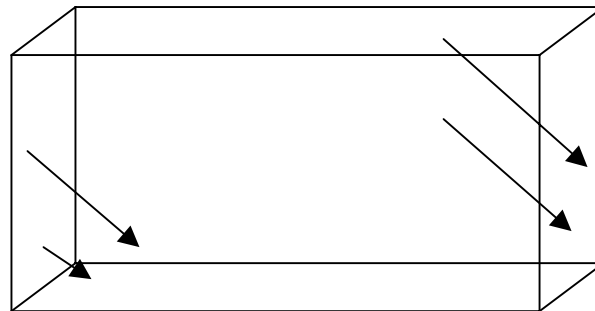
- increase of radiation with altitude
- shadowing effects
- reflection on inclined (snow covered) surfaces
- surface increase in comparison to flat surfaces (16 % in our model domain)
- calculation of irradiance with regard to the orientation and slope of the surface



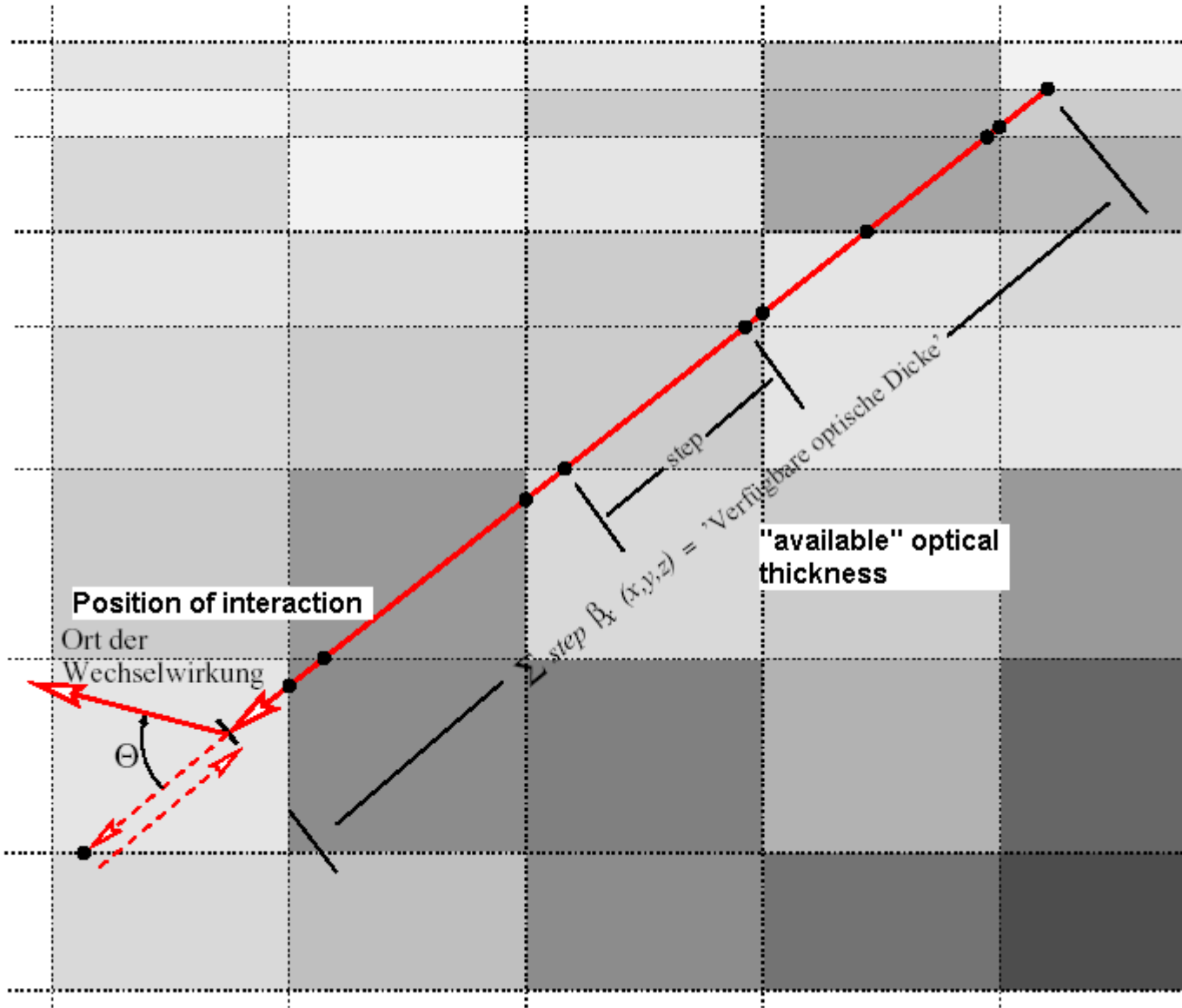
Presentation of model

- For this study a 3-D Monte Carlo model is used.
- The Monte Carlo model used is the modified model Grimaldi (Scheirer and Macke).
- The 3-D model includes a digital elevation map of the 21.75 x 24.1 km surroundings of Sonnblick Observatory in Austria, therefore altitude, slope and orientation of the surface are taken into account
- Rayleigh scattering and ozone absorption (according to Molina & Molina) are incorporated
- Individual snow cover derived from satellite data (algorithm from R. Becker) is allocated to each pixel

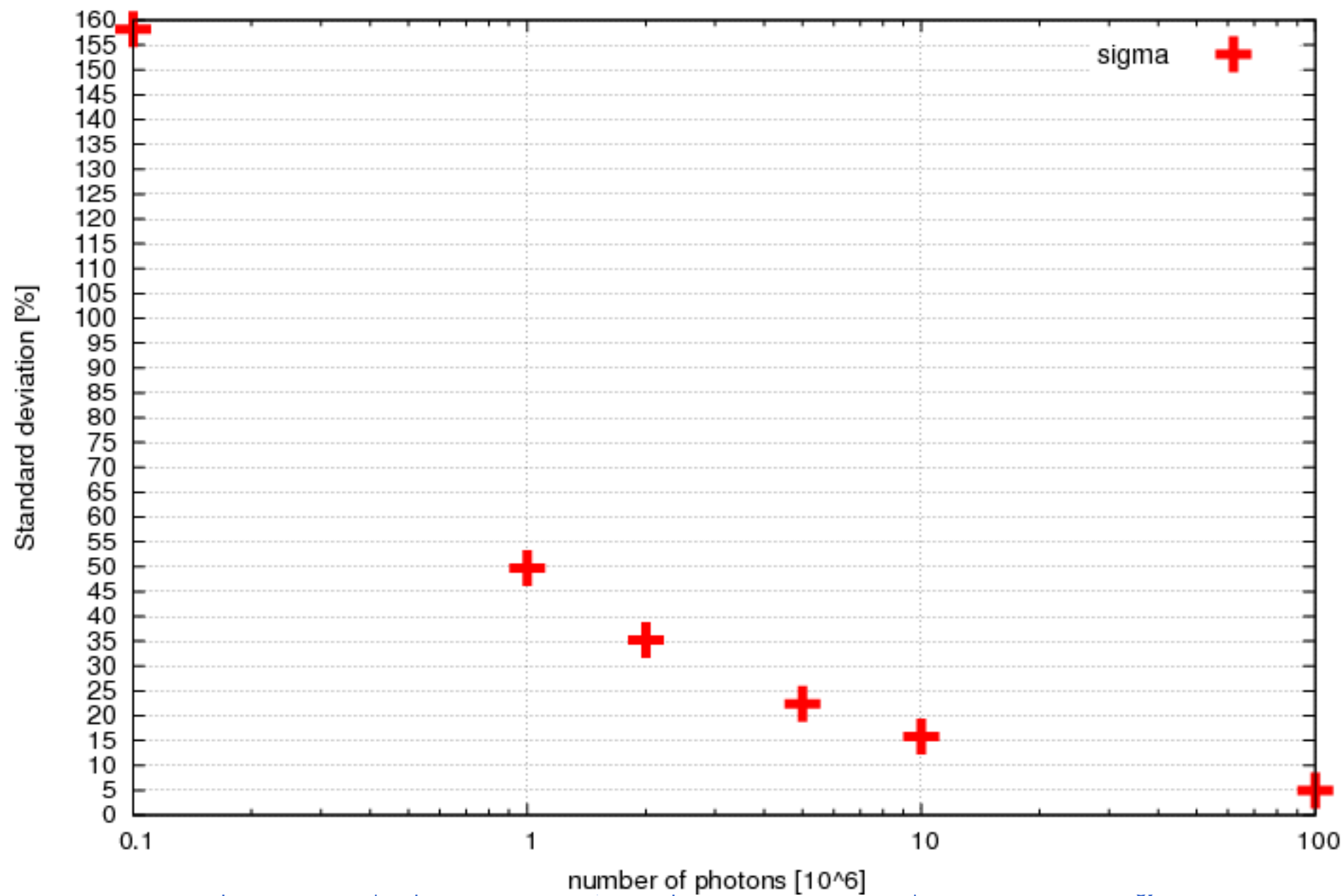
- Altitude, inclination and orientation of each pixel are considered.
- Periodic conditions are assumed - on the edges of grid box photons leaving the box come in from other side.



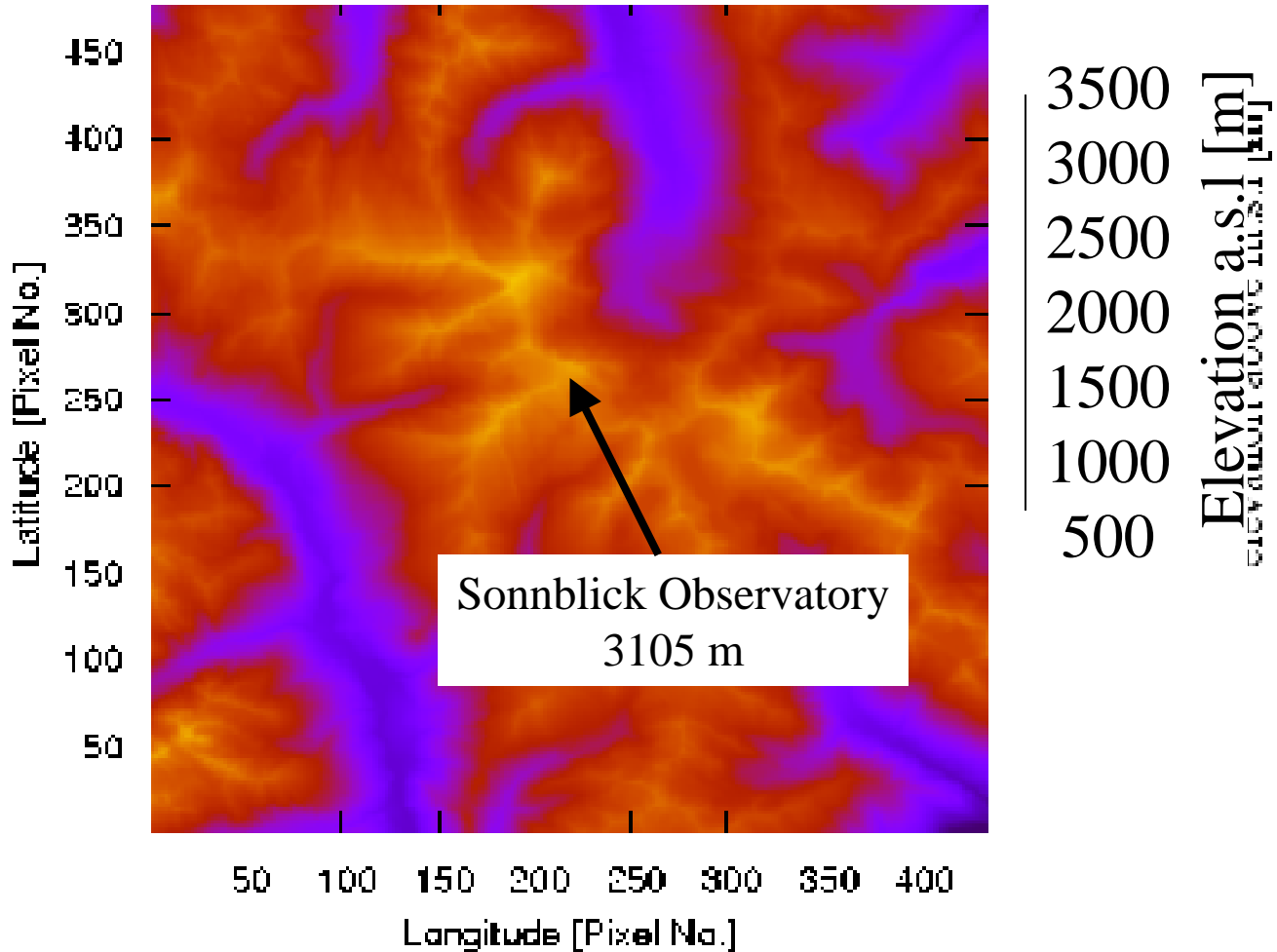
Path of a swarm of photons in the model



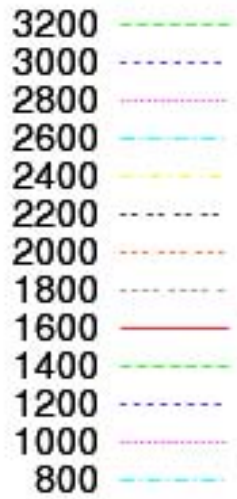
Accuracy of Monte Carlo Simulations



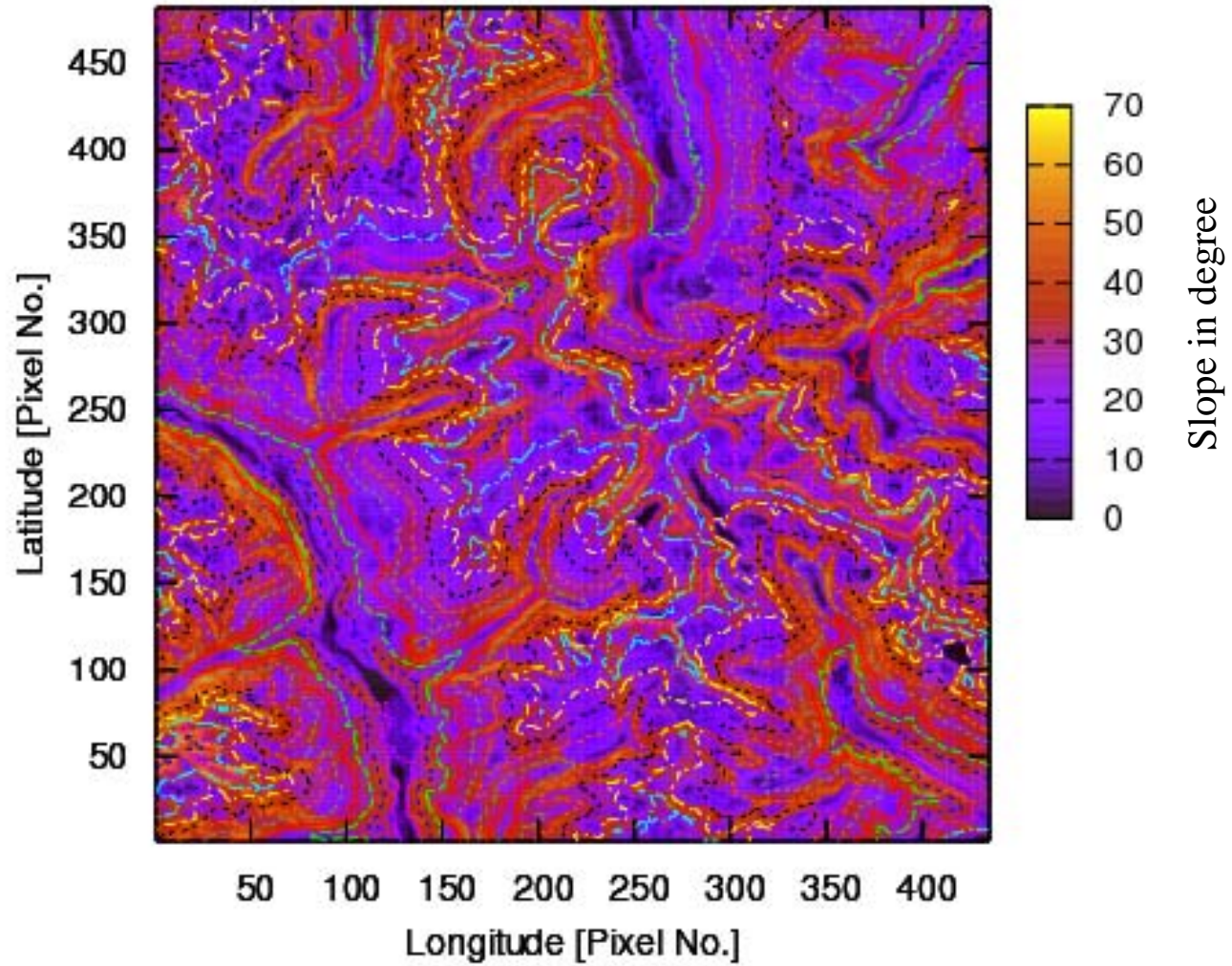
Digital elevation map (50 m resolution)



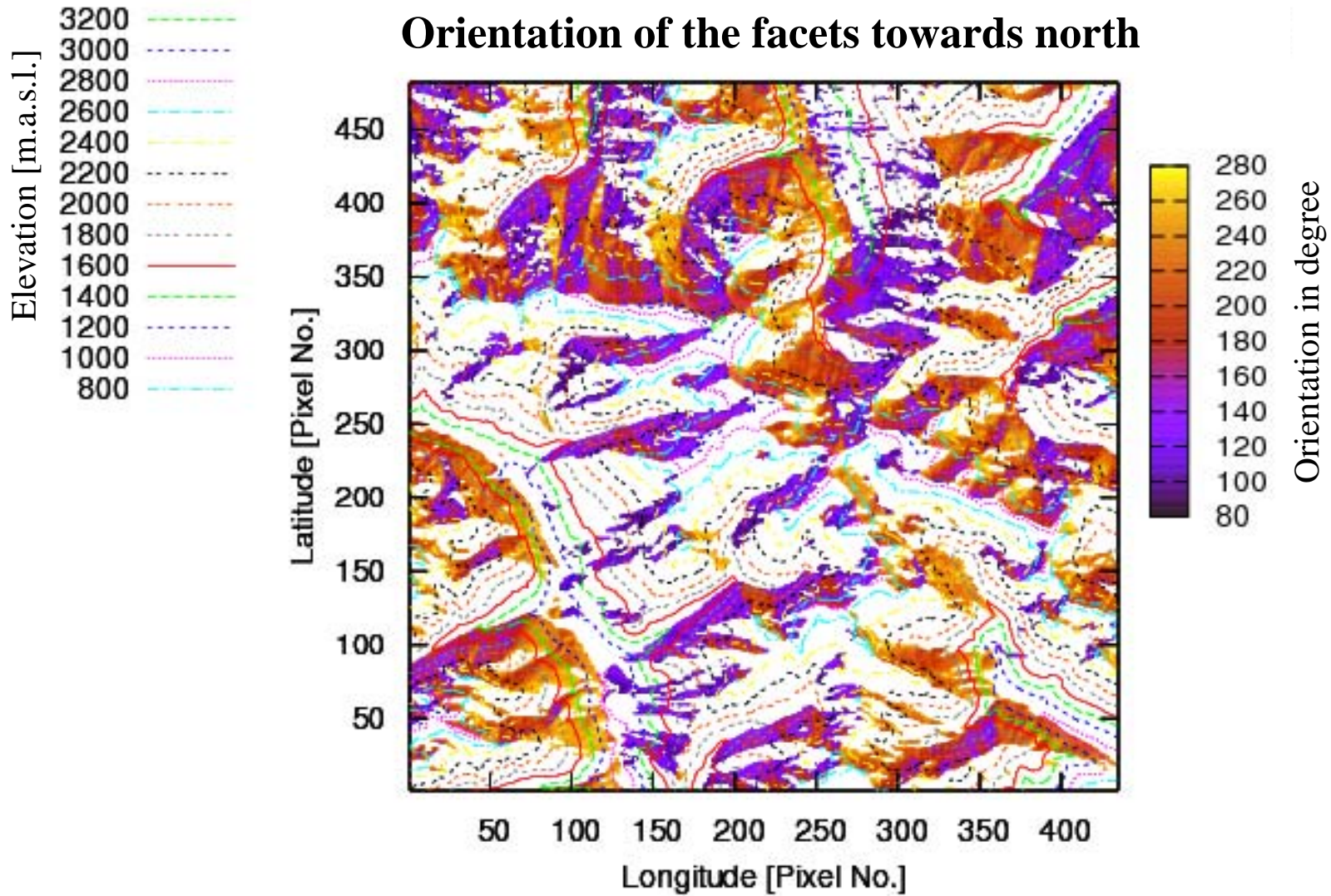
Elevation [m.a.s.l.]

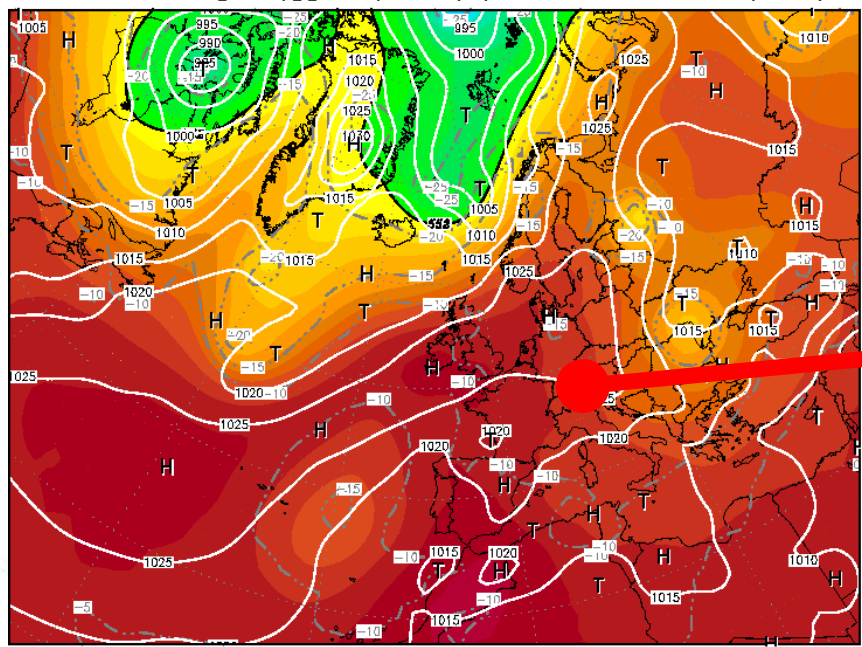
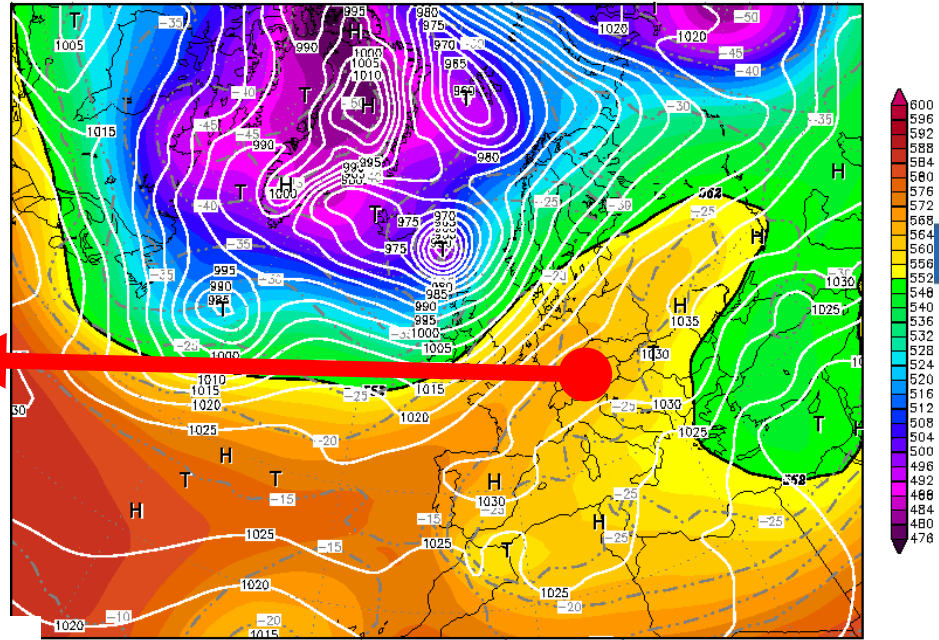
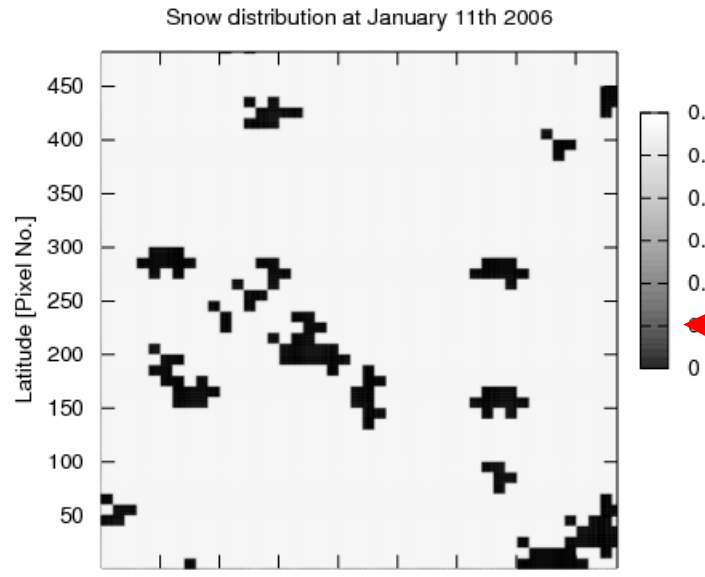


Slope of the facets (ul)

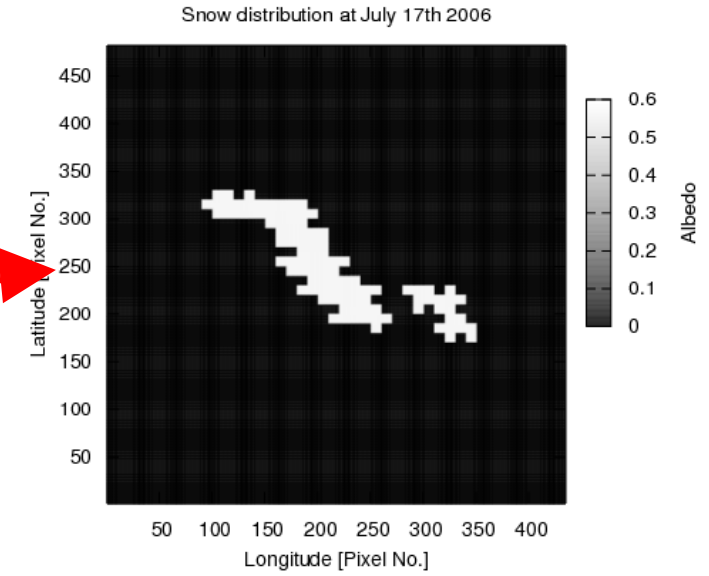


Orientation of the facets towards north





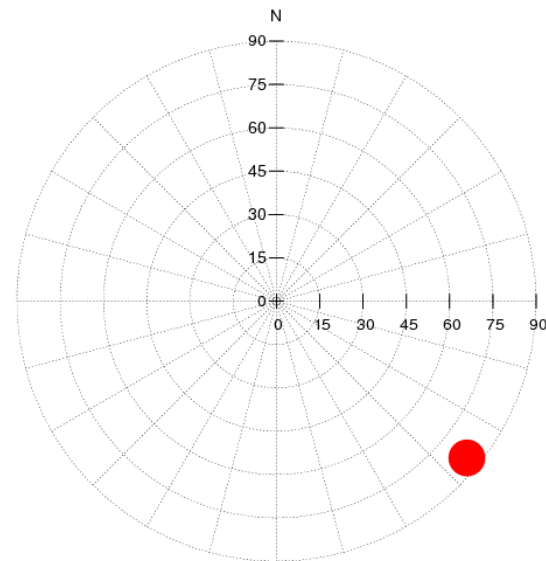
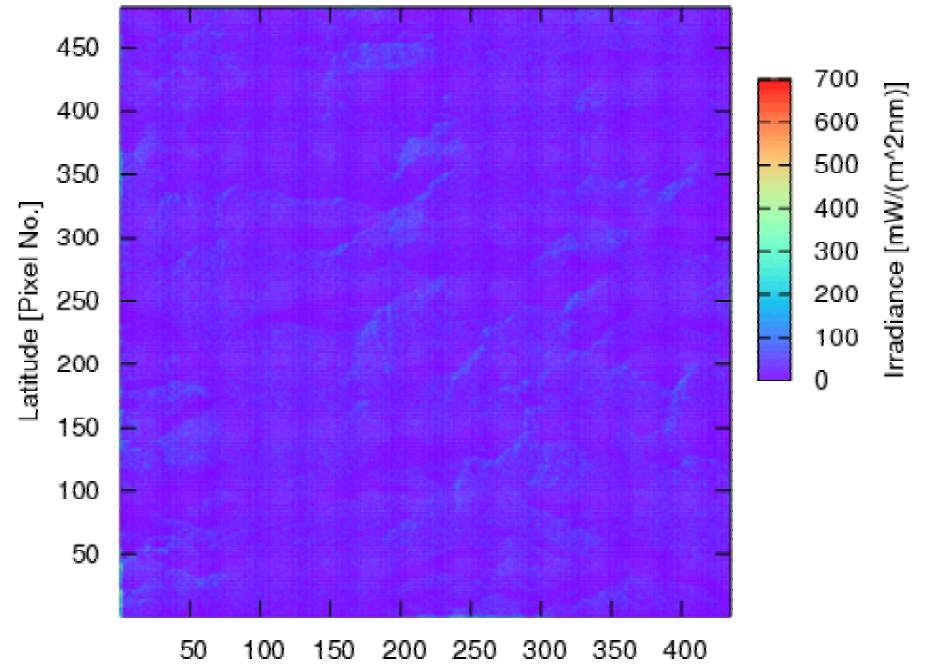
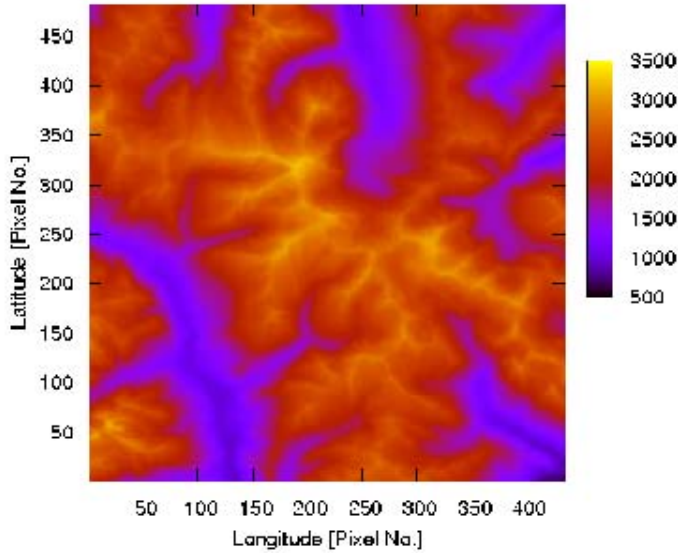
Daten: GFS-Modell des amerikanischen Wetterdienstes
 (C) Wetterzentrale
 www.wetterzentrale.de



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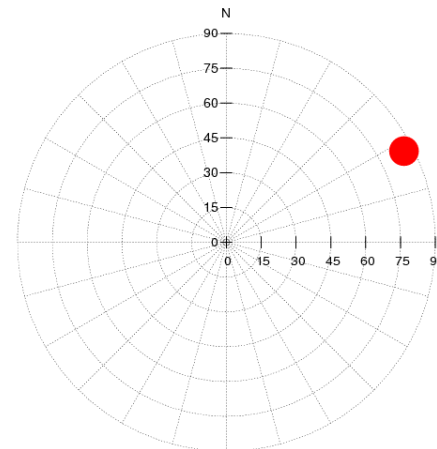
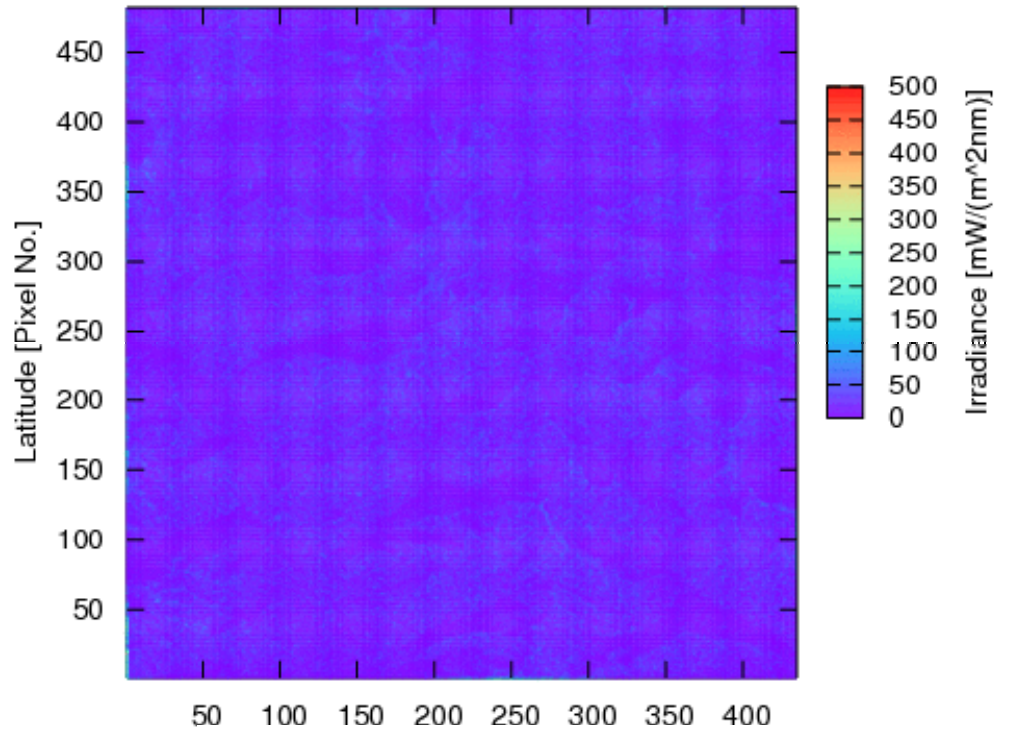
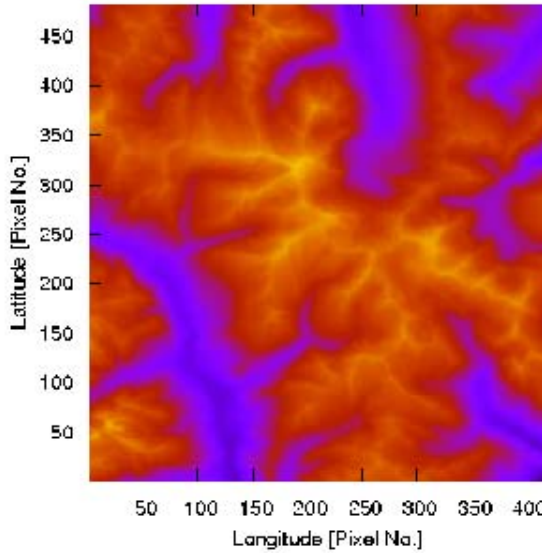
Direct + Diffuse Irradiance at 360nm at _20060111_ zenith: 85.4 azimuth: 309.4

Digital elevation map (50 m resolution)



Direct + Diffuse Irradiance at 360nm at _20060717_ zenith: 86.0 azimuth: 242.8

Digital elevation map (50 m resolution)





Summary and Conclusions

- 3-D-models in combination with measurements are very useful to study UV in mountainous terrain
- The main features of UV radiation in the mountains (shadowing effects, attenuation due to ozone, rayleigh scattering, [Mie scattering within clouds]) are well reproduced in the model
- Some more tests with variable ozone columns (and profiles) are required
- The influence of aerosols in the model should be further tested as well

Outlook

- Spatial distribution of actinic flux and irradiance will be further investigated
- Data from the measurement campaign in Innsbruck will be analysed
- Input parameter like ozone column, aerosol optical depth and extinction coefficient, single scattering albedo (with LIDAR) derived during the campaign will give more accurate information of the optical properties of the air
- Model comparison with measurements of actinic flux with a high accuracy



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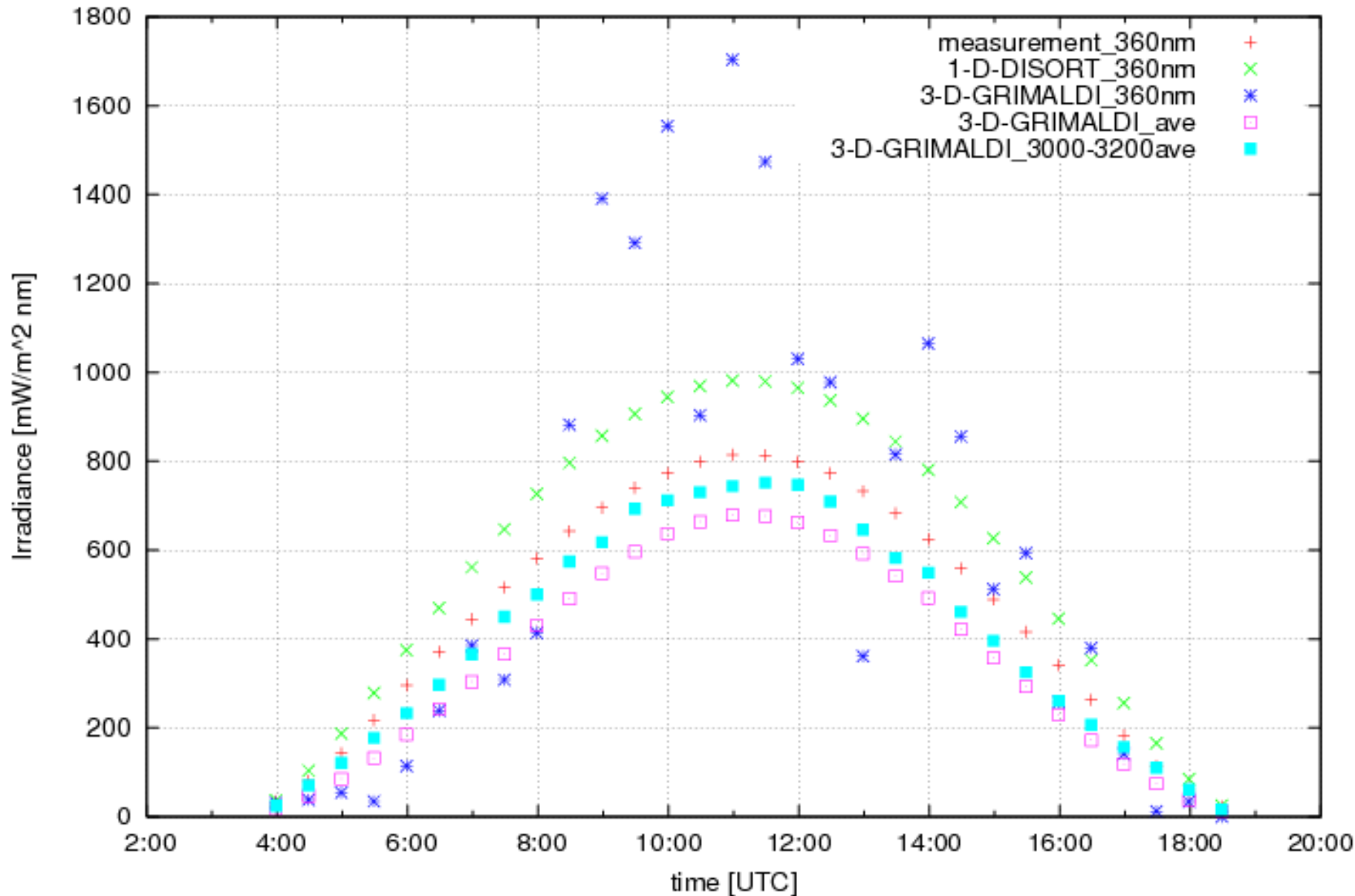
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Thank you for your attention !

Calculated and measured irradiance at July 17th at Sonnblick



altitude effect

Calculated actinic flux at January 11th at Sonnblick

