Validation of the block Radiation_on_Inclined_Surface

TABLE OF CONTENTS

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Complete path of the block in the Carnot Library

Carnot/weather/radiation_on_inclinded surface

Changes in the document

11/04/2012 created

19/04/2012 added incidence angles verification

1 Software versions

Meteonorm Version 6.1

Version of Model, Carnot, Matlab and Operation system

surfrad.c (V 5.1.0), Carnot 5.2, Matlab R2010b, Windows XP

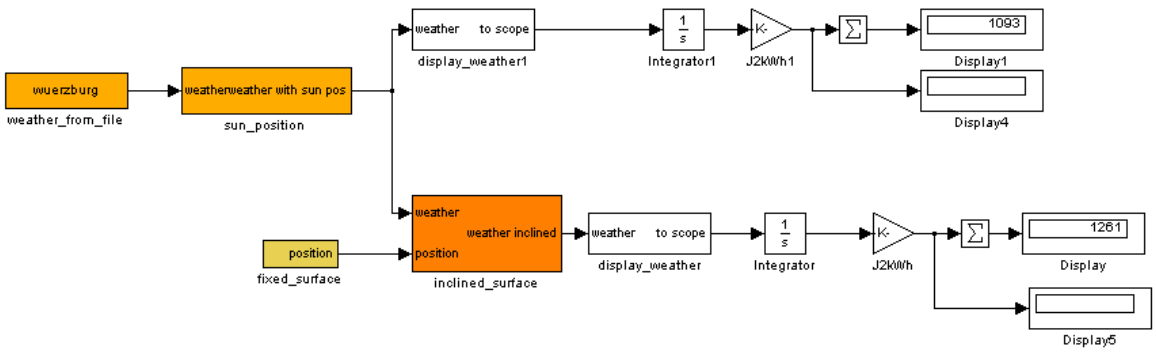
surfrad.c V 7.0 , Carnot 7.0, Matlab R2018b, Windows 10

2 Description of the model

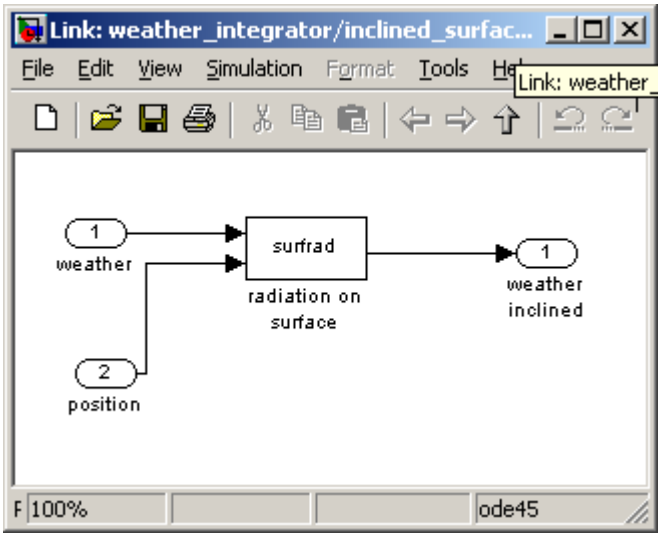
2.1 Block

Detailed description of the equations is given by Duffie (2006).

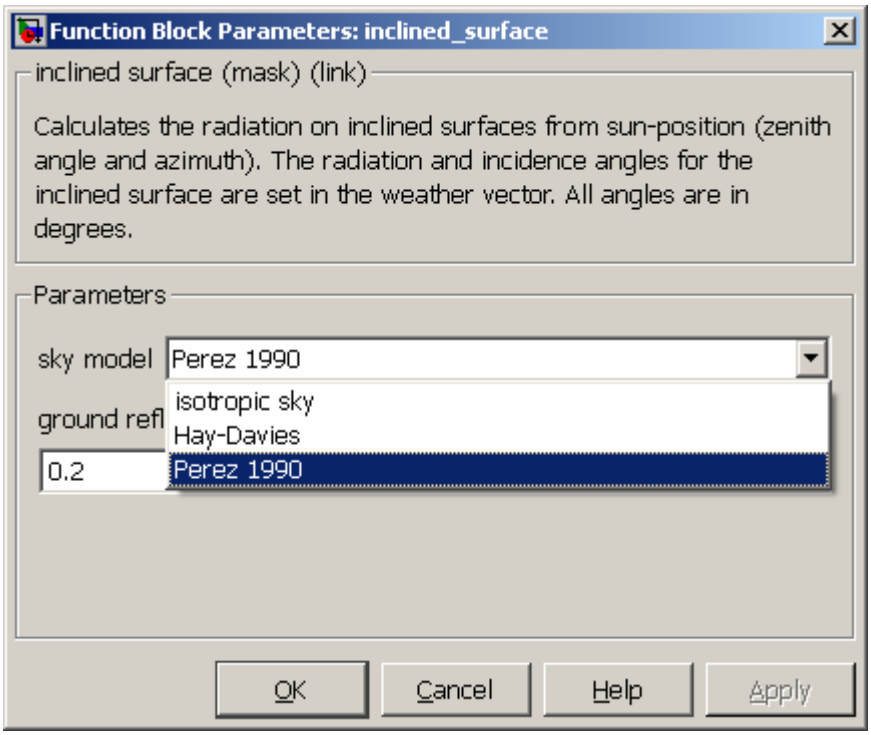
Model for the comparison:



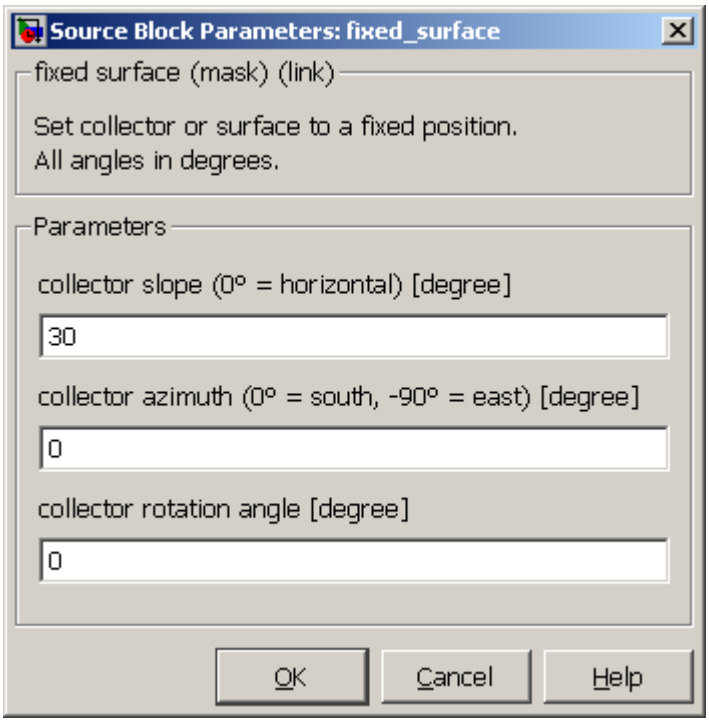
“Look under Mask” of the Block:



Block parameters:



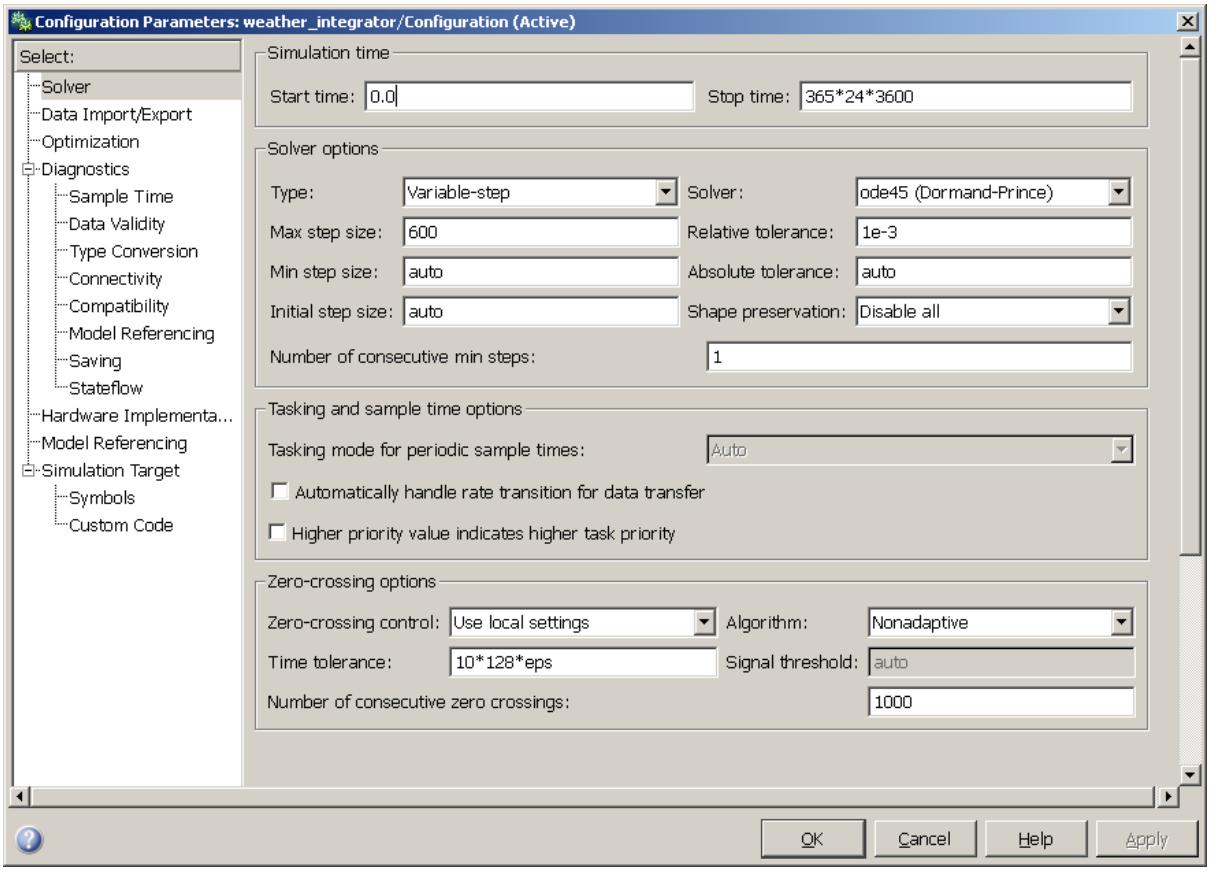
The Position is varied:



2.2 Model File

Comparison of horizontal and inclined solar radiation for the location Wuerzburg (Germany), results of Meteonorm and Carnot are compard. The input for Carnot is the Meteonorm weather data file generated for the same location using the 5.x Carnot weather data format (including direct normal radiation).

Solver parameters:



2.3 Incidence angles

According to ISO 9806:2017 the longitudinal and transversal incidence angles are:

$$\theta_{\mathrm{L}}(\theta,\gamma) = \tan^{-1}\left(\frac{\sin(\theta)\cos(\gamma)}{\cos(\theta)}\right)$$

$$\theta_{\mathrm{T}}(\theta,\gamma) = \tan^{-1}\left(\frac{\sin(\theta)\sin(\gamma)}{\cos(\theta)}\right)$$

With

γ	Solarazimutwinkel	°
θ	Einfallswinkel	°

The calculation of the incidence angle θ can be taken from literature (e.g. Duffie, Beckmann: Solar Engineering of Thermal Processes, 2006).

The validation was done with the calculation results of Meteonorm.

3 Results

3.1 Annual Solar Radiation

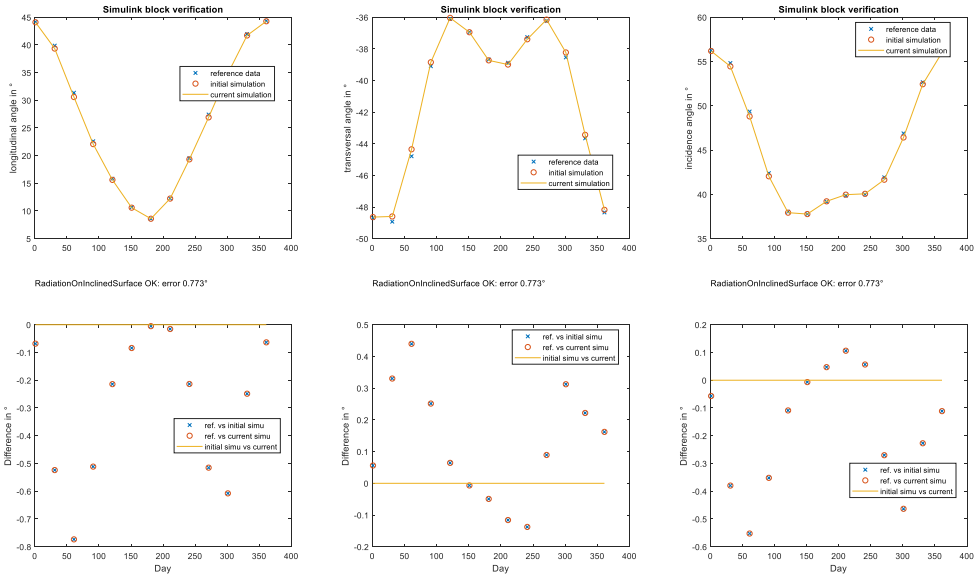
Annual sum of solar radiation in kWh/m²

Perez Sky Model, ground reflectance 0.2

Azimut	Inclination	**Meteonorm Global**	CARNOT Global	**Meteonorm Diffuse**	CARNOT Diffuse
0	0	**1093**	1092	**594**	593
0	30	**1257**	1255	**628**	629
0	60	**1178**	1178	**583**	585
0	90	**882**	883	**471**	474
45	30	**1192**	1190	**614**	614
45	60	**1102**	1101	**565**	567
45	90	**846**	846	**461**	464
-90	30	**1041**	1044	**574**	576
-90	60	**906**	912	**511**	516
-90	90	**699**	707	**421**	427
120	30	**903**	901	**545**	544
120	60	**715**	715	**470**	471
120	90	**547**	548	**388**	391
-180	30	**775**	774	**512**	512
-180	60	**484**	486	**414**	415
-180	90	**373**	376	**350**	351

3.2 Incidence angles

Results of verify_RadiationInclinedSurface



4 Literature

Duffie, J., Beckman, W.: Solar Engineering of thermal processes, John Wiley & Sons Inc, 2006

ISO 9806:2017 Solar energy – Solar thermal collectors – Test methods (ISO 9806:2017)