Comparison of monthly satellite, modelled and in situ surface radiation data over Hungary

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Alapítva: 1870

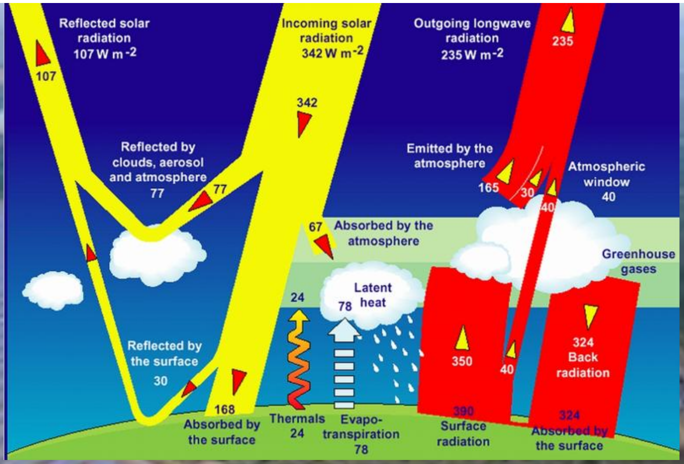
Importance of radiation data

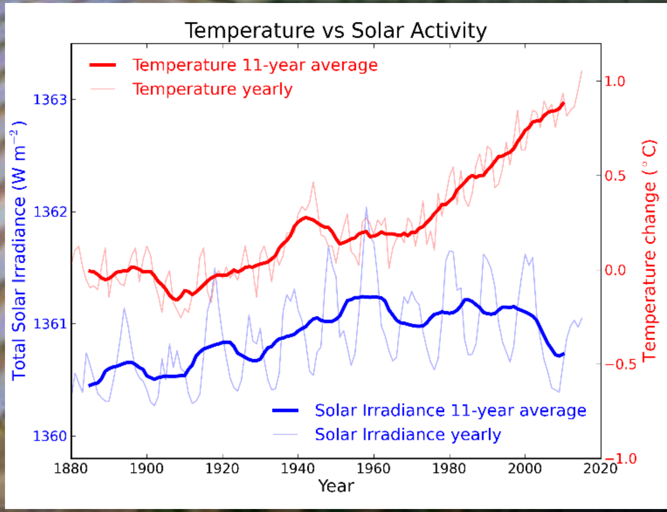
Climate studies:

- solar budget
- long term trend

Solar powers:

- feasibility and resource assement
- system siting
- system design
- finantial assessment
- performance check
- grid managment
- elekcricity market
- development and testing of technology

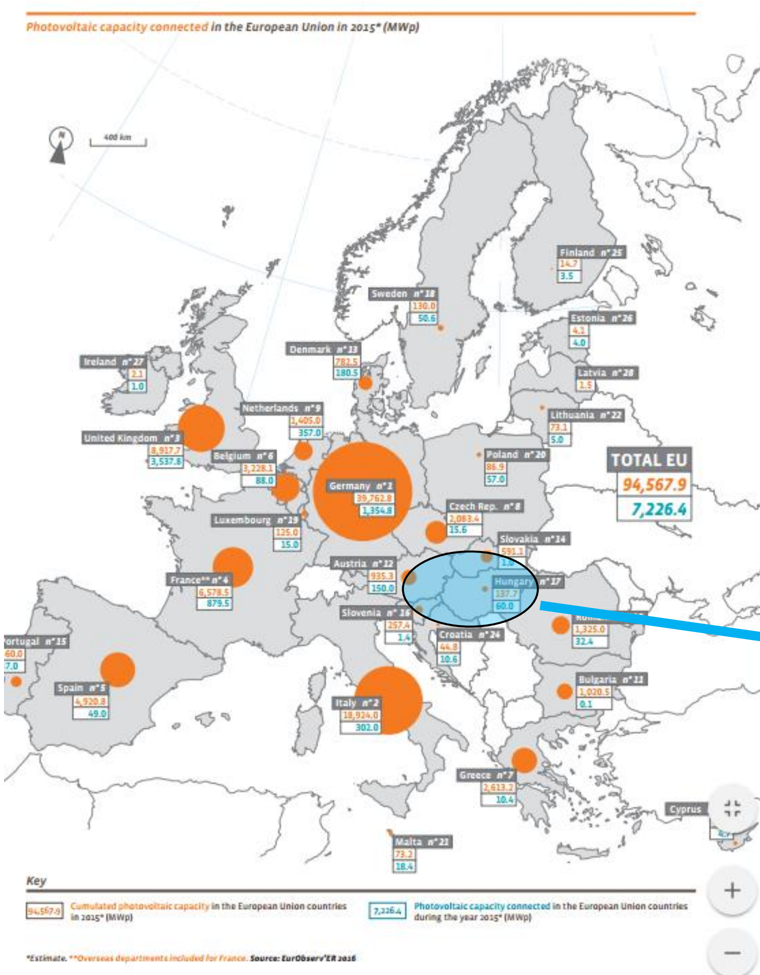


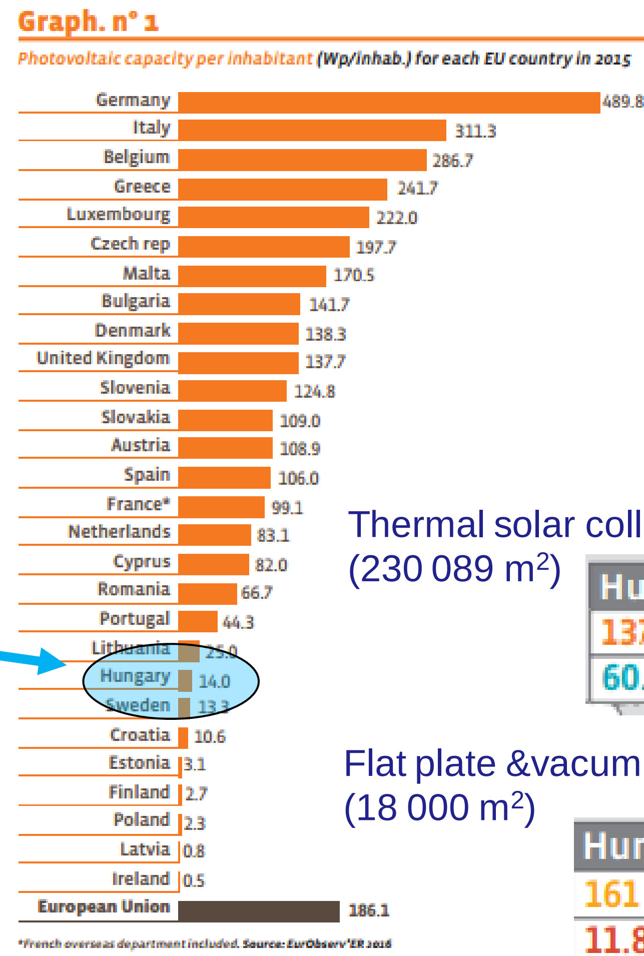


Source: https://www.quora.com/

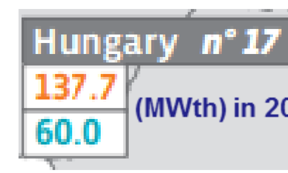
Solar PV (and collector) capacity in EU

EUROBSERVER,2016



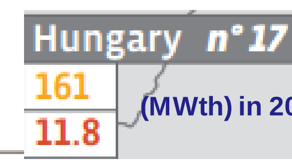


Thermal solar collectors
(230 089 m^2)



(MWth) in 2015

Flat plate &vacum collectors
(18 000 m^2)



(MWth) in 2015

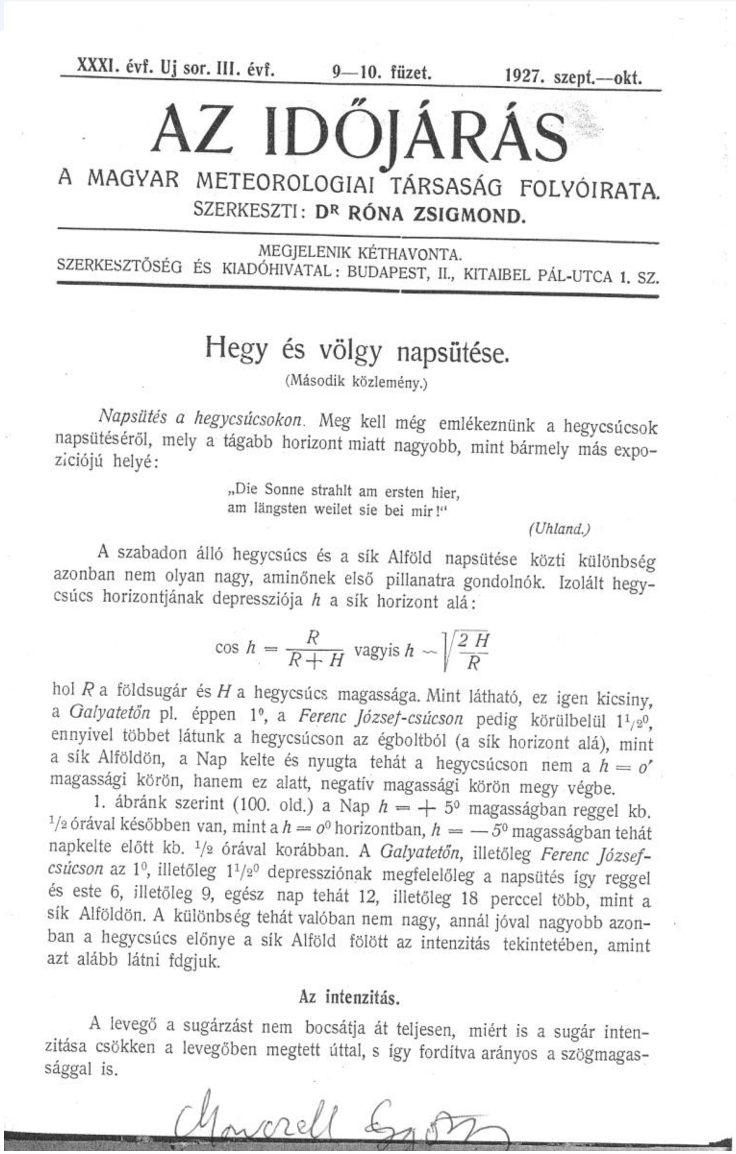
Hungary

Total energy consumption (2015) 42,5 *10^9 kWh

Solar energy theoretical potential 1,16*10^{14}KWh/year (~3000*)

Solar energy technical potential: 486*10^{19} kWh (~10*)

OMSZ long tradition on solar R+D



XXXI. évf. Uj sor. III. évf. 9—10. füzet. 1927. szept.—okt.

AZ IDŐJÁRÁS

A MAGYAR METEOROLOGIAI TÁRSASÁG FOLYÓIRATA.
SZERKESZTI: DR RÓNA ZSIGMOND.

MEGJELENIK KÉTHAVONTA.
SZERKESZTŐSÉG ÉS KIADÓHIVATAL: BUDAPEST, II., KITAIBEL PÁL-UTCA 1. SZ.

Hegy és völgy napsütése.

(Második közlemény.)

Napsütés a hegycsúcsokon. Meg kell még emlékeznünk a hegycsúcsok napsütéséről, mely a tágabb horizont miatt nagyobb, mint bármely más expozíciójú helyé:

„Die Sonne strahlt am ersten hier,
am längsten weilet sie bei mir!"
(Uhland.)

A szabadon álló hegycsúcs és a sík Alföld napsütése közti különbség azonban nem olyan nagy, aminőnek első pillanatra gondolnók. Izolált hegycsúcs horizontjának depressziója h a sík horizont alá:

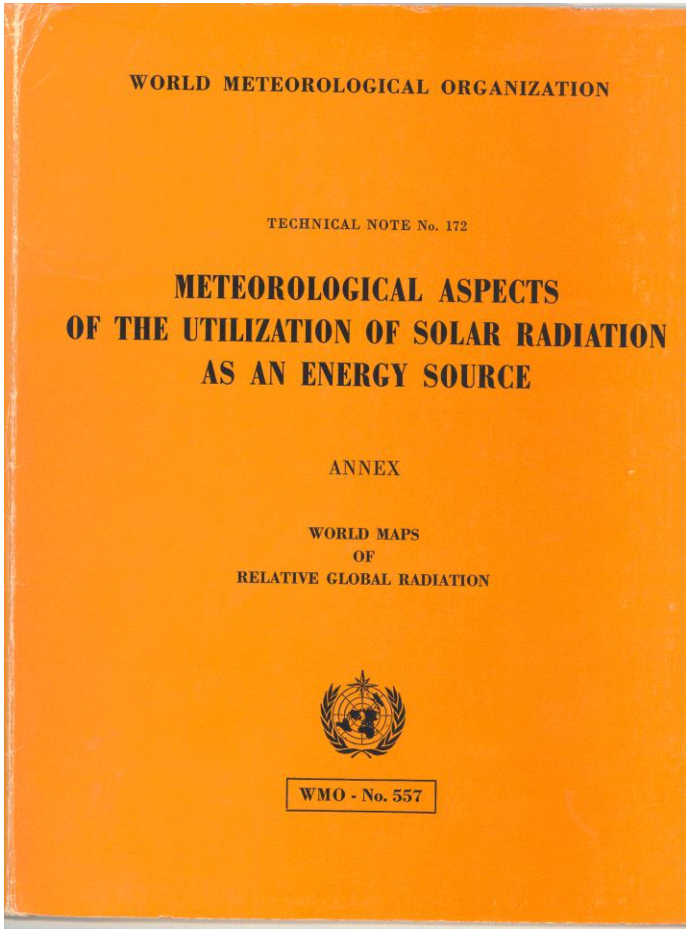
$$\cos h = \frac{R}{R+H} \text{ vagyis } h \sim \sqrt{\frac{2H}{R}}$$

hol R a földsugár és H a hegycsúcs magassága. Mint látható, ez igen kicsiny, a *Galyatetőn* pl. éppen 1°, a *Ferenc József-csúcson* pedig körülbelül $1^1/_2{}^0$, ennyivel többet látunk a hegycsúcson az égboltból (a sík horizont alá), mint a sík Alföldön, a Nap kelte és nyugta tehát a hegycsúcson nem a $h = o'$ magassági körön, hanem ez alatt, negatív magassági körön megy végbe.

1. ábránk szerint (100. old.) a Nap $h = +5^0$ magasságban reggel kb. $^1/_2$ órával későbben van, mint a $h = o^0$ horizontban, $h = -5^0$ magasságban tehát napkelte előtt kb. $^1/_2$ órával korábban. A *Galyatetőn*, illetőleg *Ferenc József-csúcson* az 1^0, illetőleg $1^1/_2{}^0$ depressziónak megfelelőleg a napsütés így reggel és este 6, illetőleg 9, egész nap tehát 12, illetőleg 18 perccel több, mint a sík Alföldön. A különbség tehát valóban nem nagy, annál jóval nagyobb azonban a hegycsúcs előnye a sík Alföld fölött az intenzitás tekintetében, amint azt alább látni fogjuk.

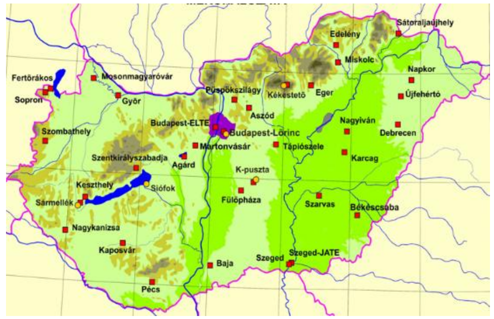
Az intenzitás.

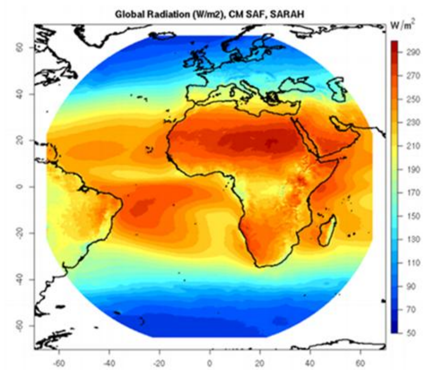
A levegő a sugárzást nem bocsátja át teljesen, miért is a sugár intenzitása csökken a levegőben megtett úttal, s így fordítva arányos a szögmagassággal is.



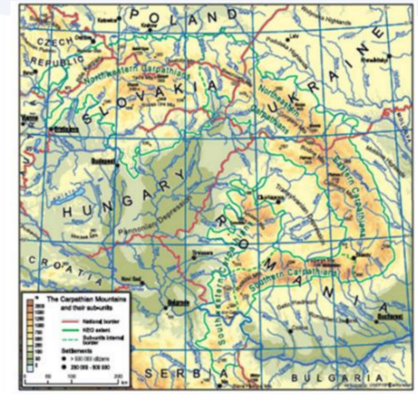
1981
Major Gy. (ed),
Miskolczi F., Putsay M., Rimóczi-Paál A.,
Takács O., Tárkányi Z.

Global radiation data for Hungary





http://www.cmsaf.eu/EN/Home/home_node.html



	Ground measurements	Satellite data	Modelled data
Data Set	**OMSZ Network**	**EUMETSAT CM SAF** http://wui.cmsaf.eu/s	**CarpatClim** www.carpatclim-eu.org/
Abbr.	**OBS**	**SIS**	**CC**
Parameters	Global radiation	Surface Incoming Shortwave radiation	Globan radiation from sunshine duration
Spatial resolution/ number of stations	40	0.05^o x 0.05^o	0.1^o x 0.1^o
Lengt of record	pyranometers Kipp&Zonen (1972-)	1983-2013 SARAH data set	1961-2010

Advantages - disadvatages

	Ground measurements	Satellite data	Modelled data
Advantages	• high accuracy • high time resolution	• high spatial resolution • long term data (>30y) • no soiling	• in case of no data
Dis-advantages	• soiling of the sensors • sensor failures	• lover time resolutions • lower accuracy	• dependency on model

Comment on units:

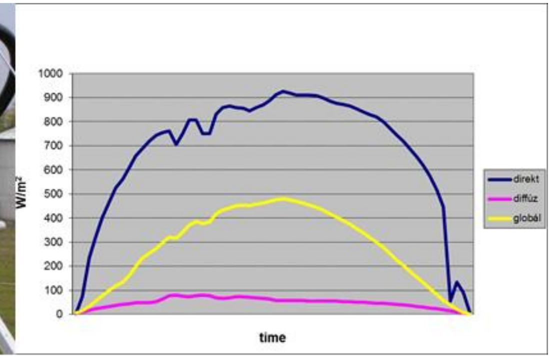
Irradiation is the energy received per area ($MJ/m^2/day$)

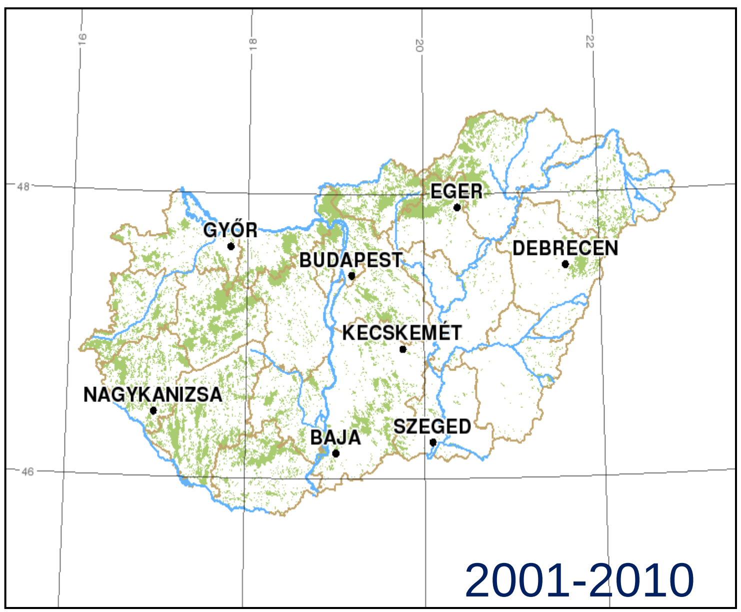
preferd by met community

Irradiance is defined as a power (or flux) received per area (W/m^2)

preferd by energetic community

Ground measurements





GHI – Global Horizontal Irradiance

(total solar irradiance)

GHI= DNI * Cos (SZA) + DHI

SZA – solar zenit angle

DHI – Diffuse Horizontal Irradiance

(diffuse sky radiation)

DNI – Direct Normal Irradiance

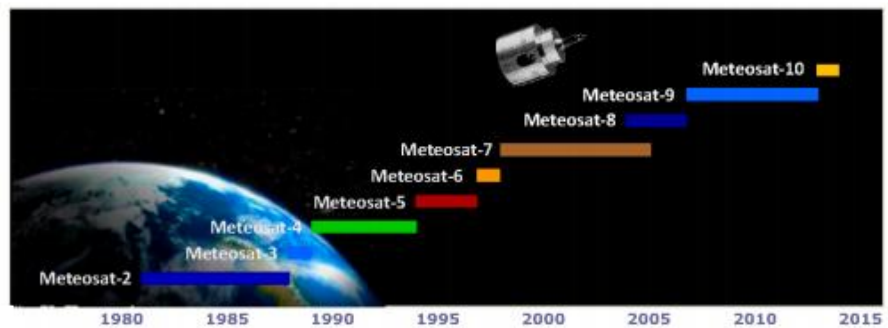
(beam irradiance)

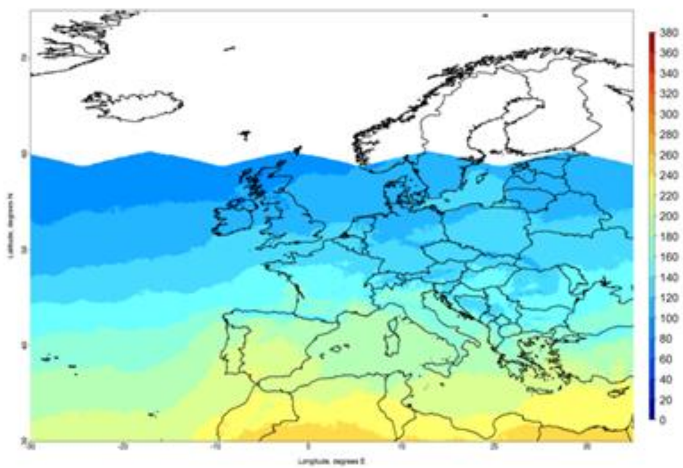
for CSP (Concentrating Solar Power)

EUMETSAT Clima SAF

Surface Solar Radiation Data Set –Heliosat (SARAH):

- MFG. MSG
- 31 year. monthly
- 1983.01-2013.12
- 0.05° x 0.05°





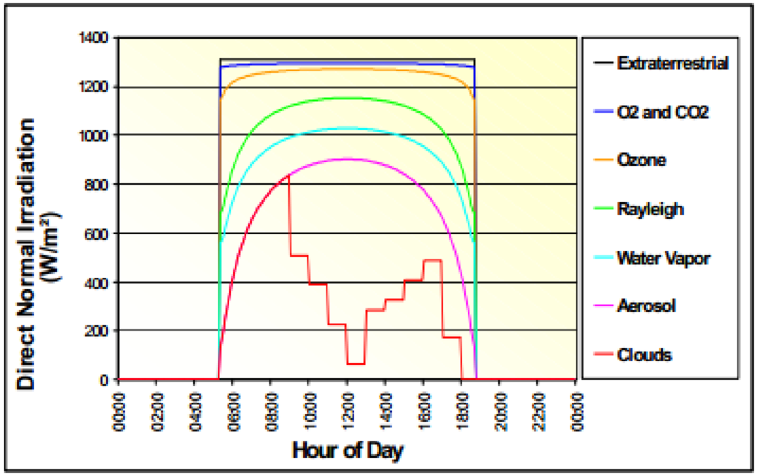
Parameters (W/m²)

- **SIS (Surface Incoming Solar radiation)**
- SID (Surface Direct Irradiance)
- DNI (Direct Normal Irradiation)

Satellite derived data

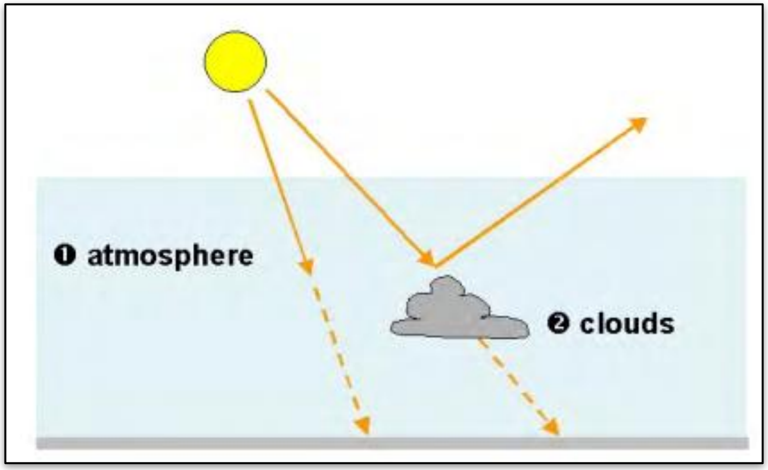
1. **Atmosphere:**

Gather satellite information of atmospheric composition (**ozone, water vapor, aerosol**) apply ‚**clear sky**' method to calculate fraction of direct and diffuse irradiance.



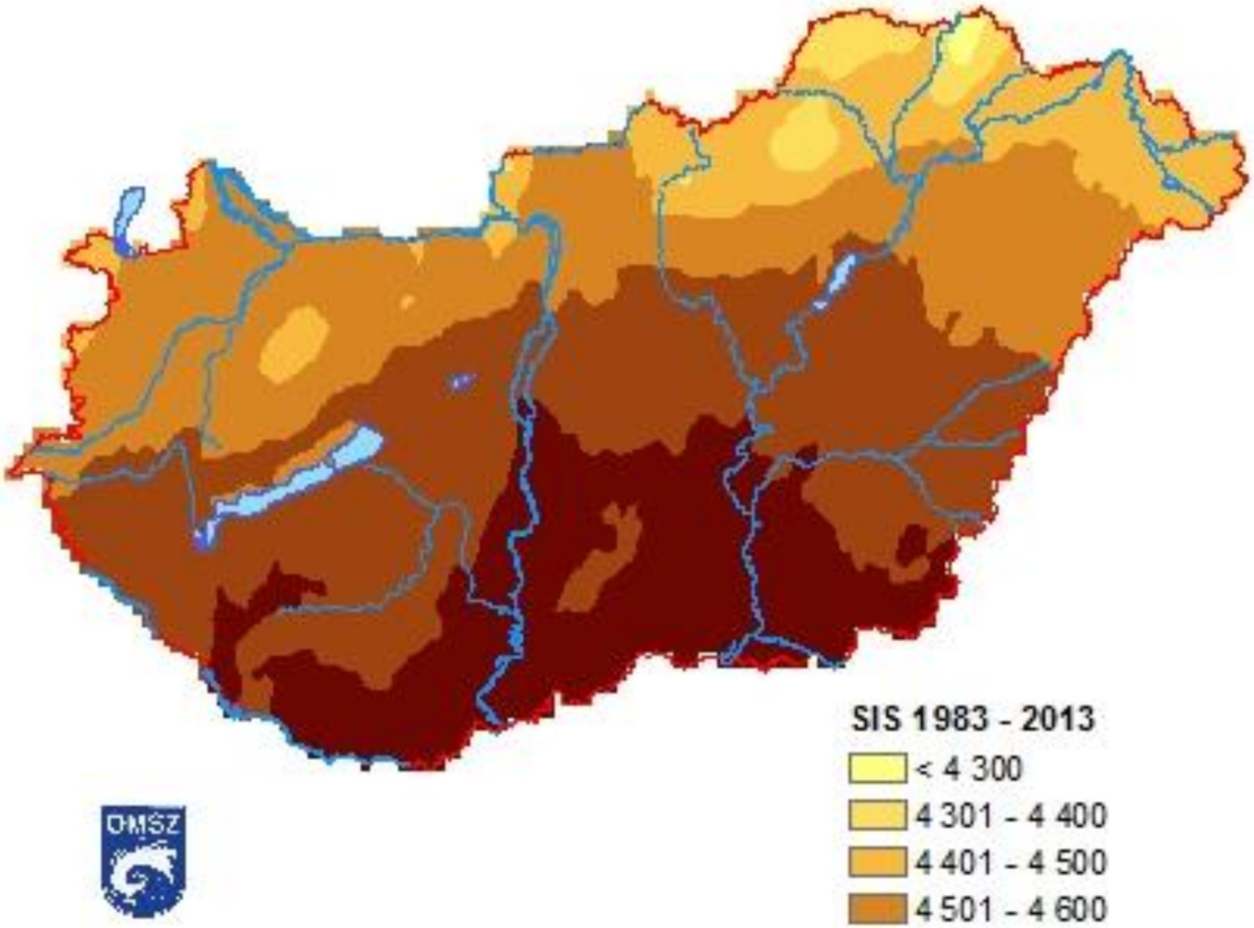
2. **Clouds:**

Calculate the cloud index as the difference between **actual reflectivity** of the earth as it is seen by the satellite and a **reference image** which only includes reflectance of the ground.



www.solemi.de/method.html

Radiation maps: SIS (1983-2013)



Carpatclim radiation data

Calculation methodology

Input:

- accumulated daily records of sunshine duration [hours] at meteorological station level;
- latitudes of the stations (ϕ in radians);

In CARPATCLIM project where observed global radiation was available at station level, it was used. In the case where only sunshine duration was available, global radiation was calculated using the equation postulated by Ångström (1924) and modified by Prescott (1940) which relates global radiation to extra-terrestrial radiation R_a (known as Angot radiation) and relative sunshine duration n/N. The two constants in this equation depend on the geographic location.

$$R_s = \left(0{,}25 + 0{,}50\frac{n}{N}\right)R_a \quad , (1)$$

where:

R_s global radiation [MJ m^{-2} d^{-1}],

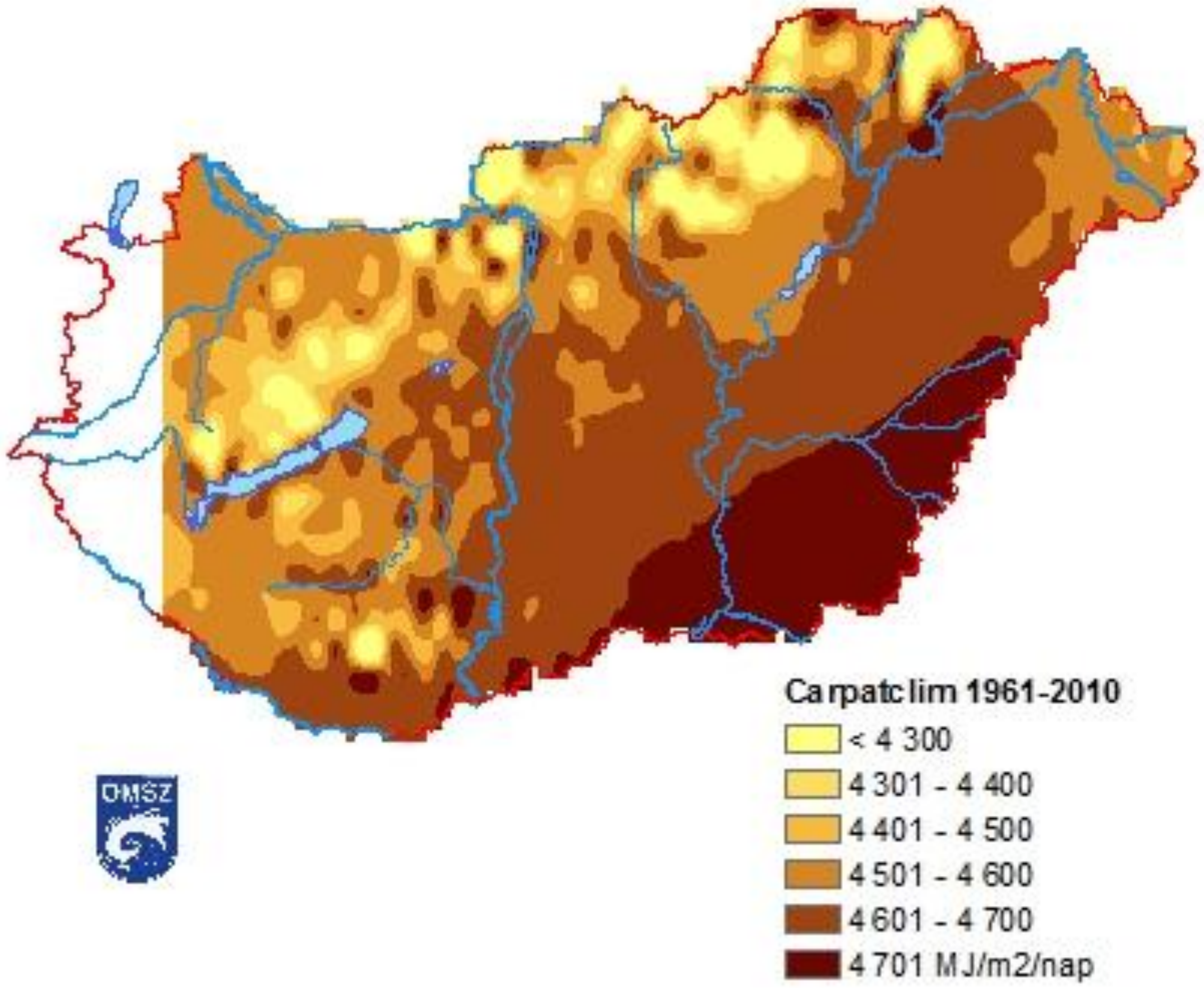
n/N relative sunshine duration [-],

n actual duration of sunshine [hour],

N maximum possible daily sunshine duration (daylight hours) [hour] (2),

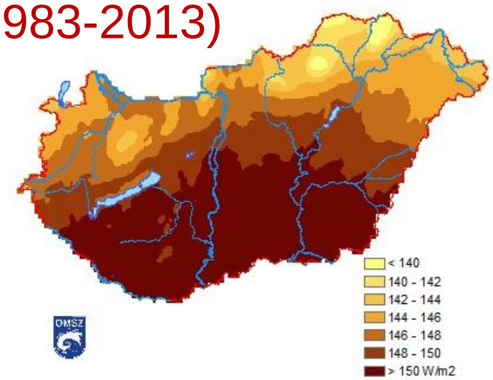
R_a extra-terrestrial radiation [MJ m^{-2} d^{-1}] (5).

Radiation Maps: CarpatClim (1961-2010)

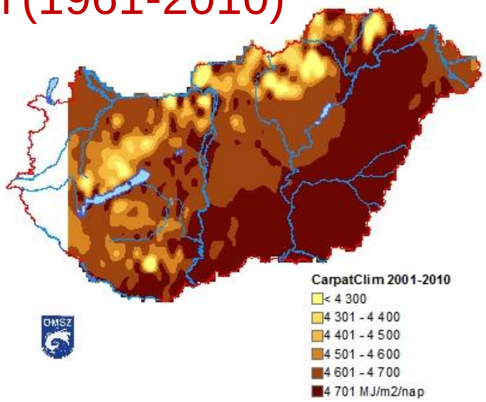


Comparison of SIS and CarpatClim global radiation maps

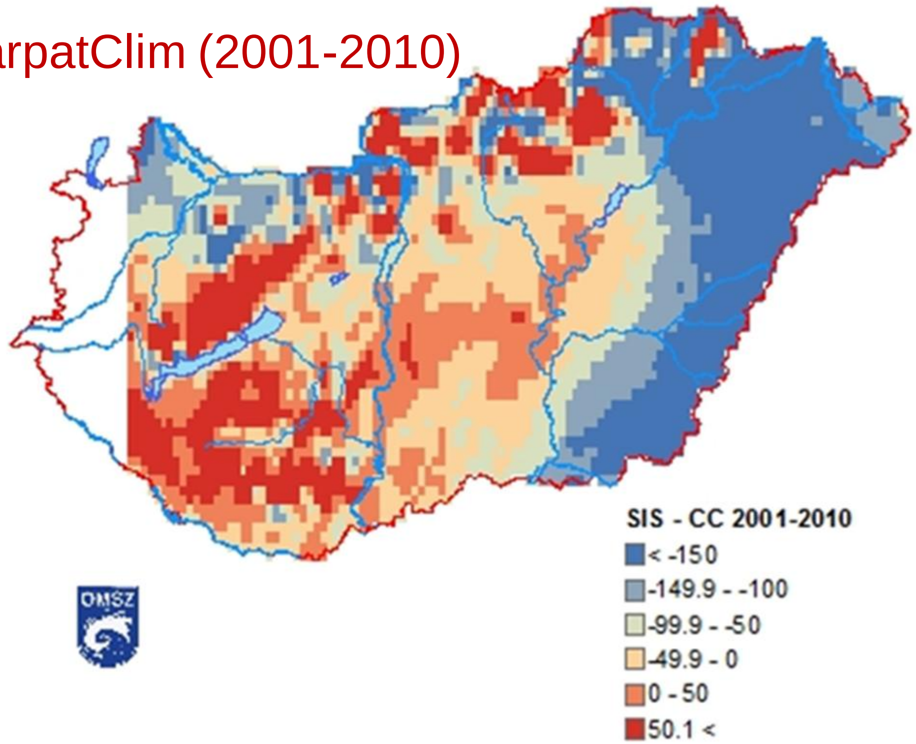
SIS (1983-2013)



CarpatClim (1961-2010)



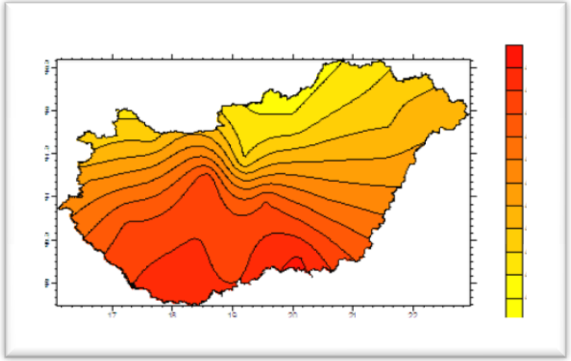
SIS minus CarpatClim (2001-2010)



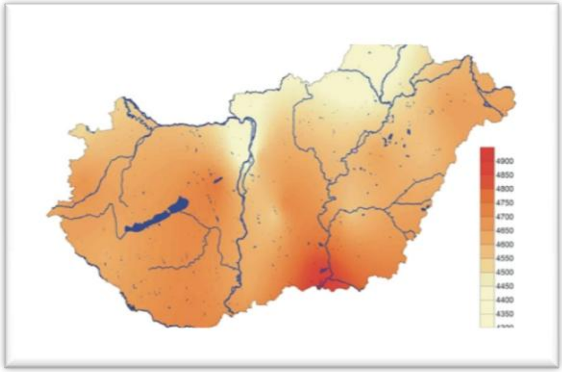
Solar radiation Atlases

OMSZ Network

1951-80 (David és mtsai.)
13 stations

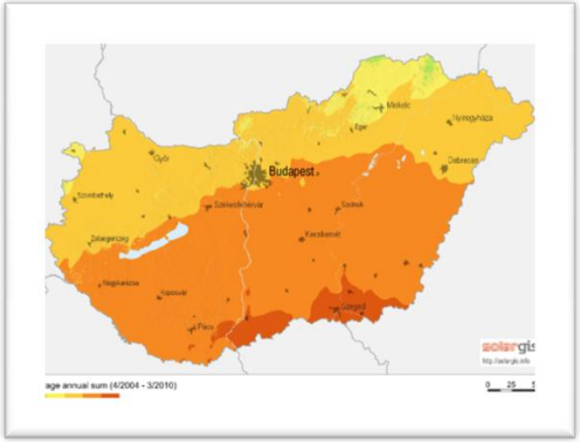


1997-2002 (Bella és mtsai)
15 stations

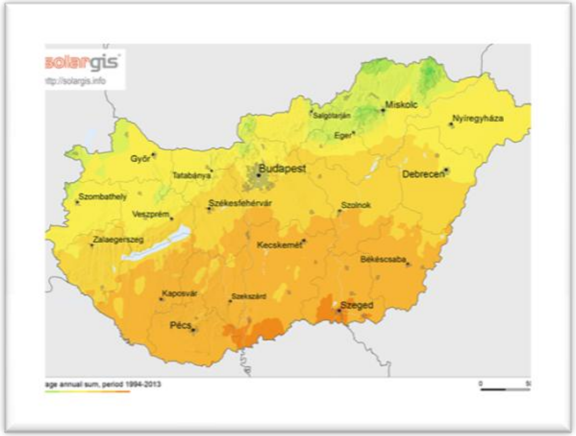


2000-2009 (met.hu)
13 stations

Satellites



2004-2010 (SolarGIS)

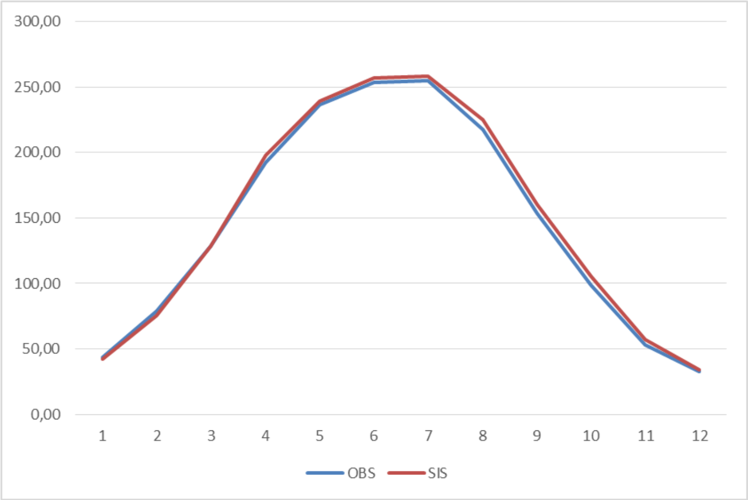


1994-2013 (SolarGIS)
*4*4 km MSG,GOES,MTSAT*

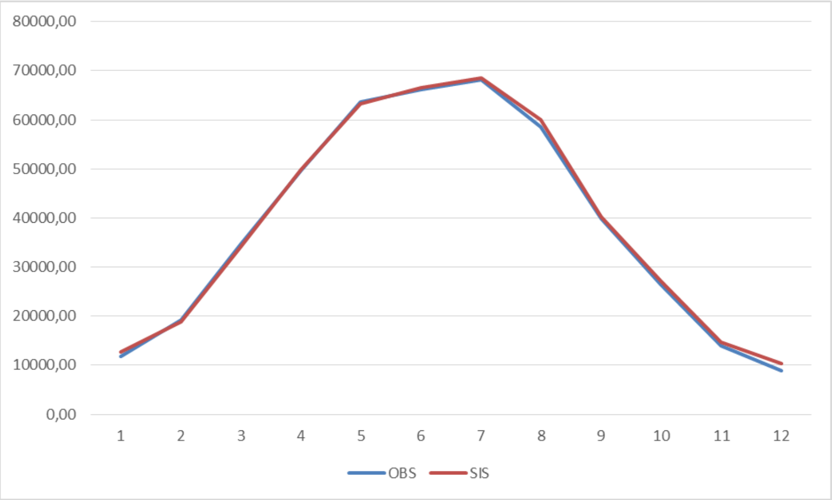
PVGIS © European Union. 2001-2012
1998-2011 (PVGIS)
WRDC. Meteosat. 1^0*1^0

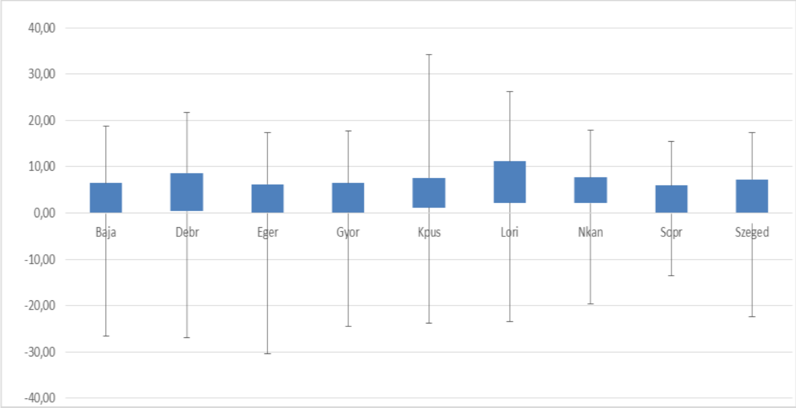
Verifications

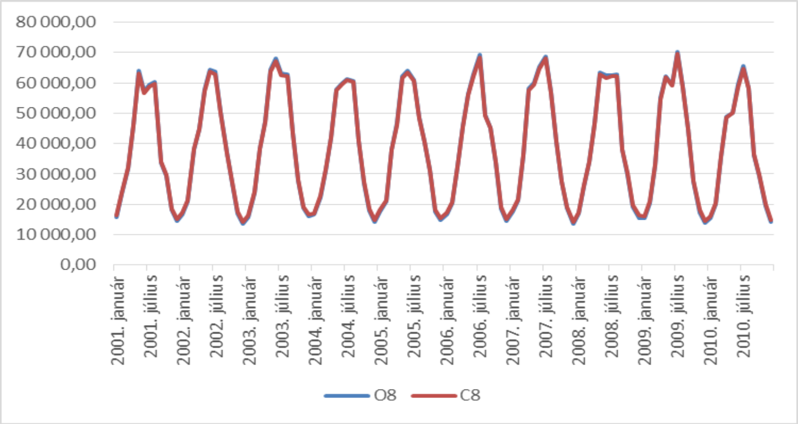
Satellite & Observed



CarpatClim & Observed







Monthly verification

Data 1	Data 2	N	BIAS	MAB	SD	AC	Frac> 15W/m2
SIS	**OBS**	**1038**	**3.17**	**5.96**	**7.11**	**0.90**	**5.60**
SIS	**CarpatClim**	**959**	**0.92**	**6.54**	**8.37**	**0.97**	**7.51**
CarpatClim	**OBS**	**945**	**1.69**	**5.37**	**6.90**	**0.99**	**5.00**
Müllet et all., 2015	BSRN	1672	1.27	5.46	7.34	0.92	5.60
Riihalä et. all. 2015	FMI, 18 stations		-	6.23	8.32	0.89	
Sanches-Lorenzo et all, 2013	GEBA, 47 stations		5.2	8.2	9.5		
LVGMC				6-9			

- Bias < 3.2 W/m^2
- Mean Absolut Bias 5.5-6.5 W/m^2
- Test results are similar to literature

Future plans

Verification on daily data

Radiation Atlas of Hungary from CM SAF (SARAH)

Thank you for your attention!

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