

Recent Trends and Solar Radiation Outlook for the USA

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Contents

- Analysis of historic and future trends
- Two parameters:
 - Global radiation (GHI)
 - Direct normal radiation (DNI)
- Two periods:
 - Global radiation trends within USA of last 14 years
 - Future scenarios of global radiation based on IPCC AR 4 (2007)

Data

Ground data: Surfrad / Univ. OR

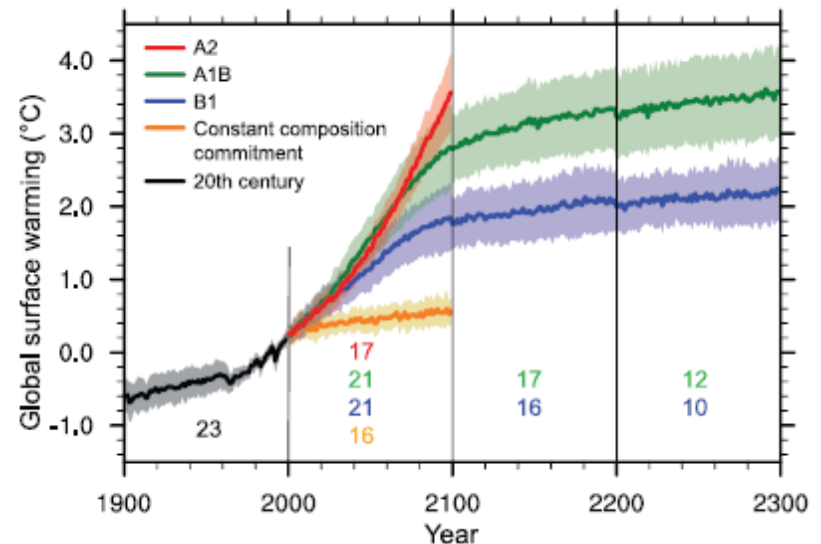
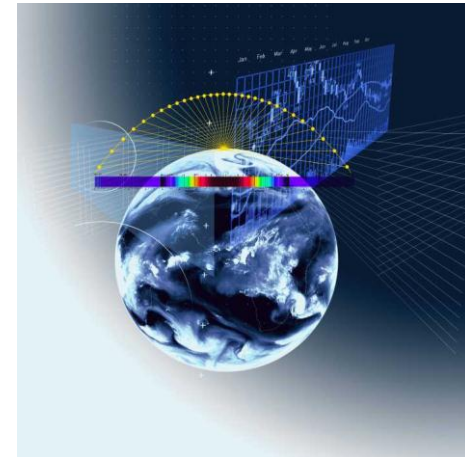
- 8 sites in USA: 1997 – 2012

Future data: IPCC

- 4th report, 2007
- Anomalies B1, A1B, A2
- 18 model mean, 1° resolution

Tool: meteonorm version 7.0

- Climate normals 1986 – 2005
 - WMO, WRDC, GEBA, NREL
- IPCC 2007 data
- Stochastic generator

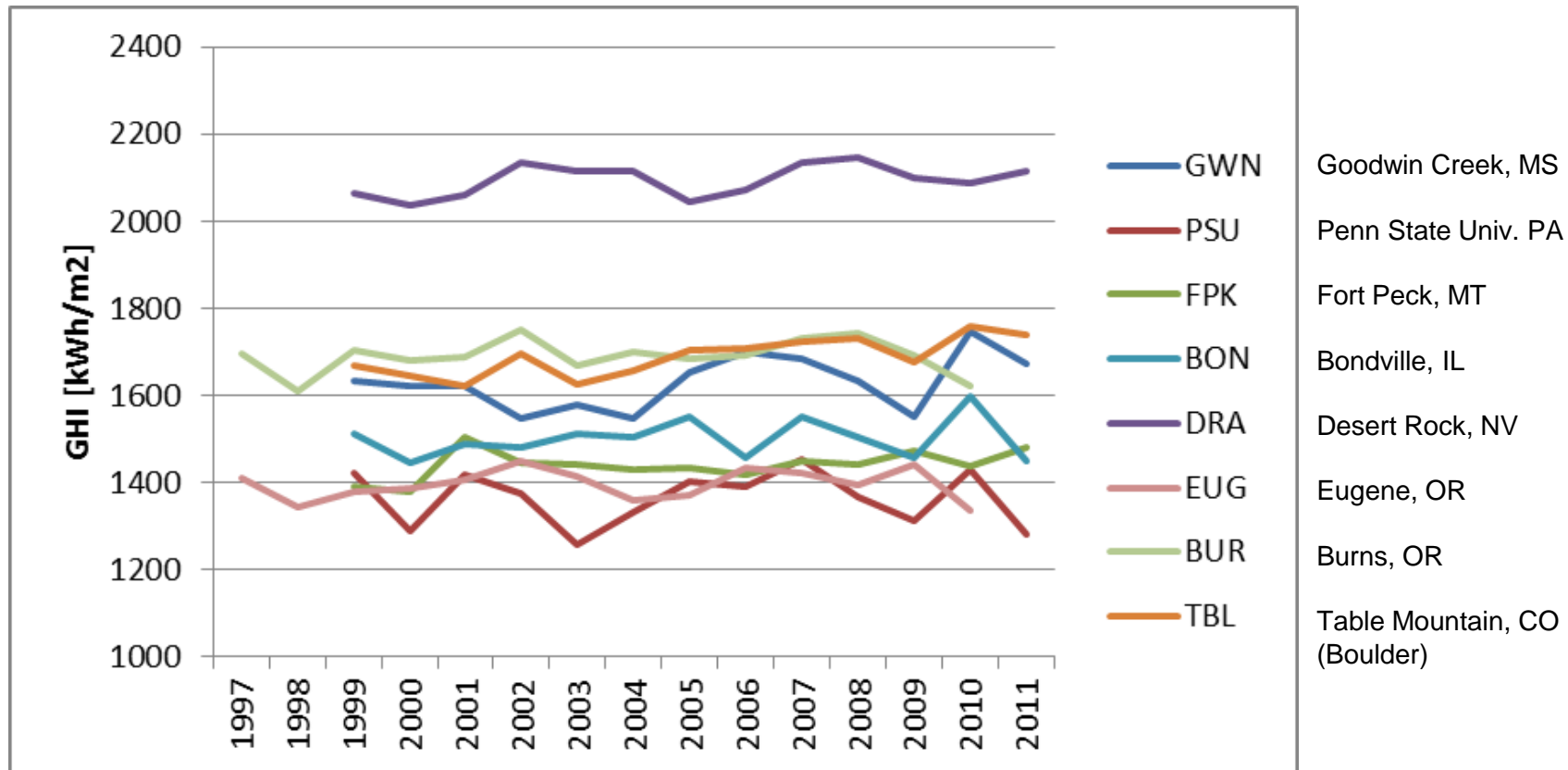


Recent trends: Stations

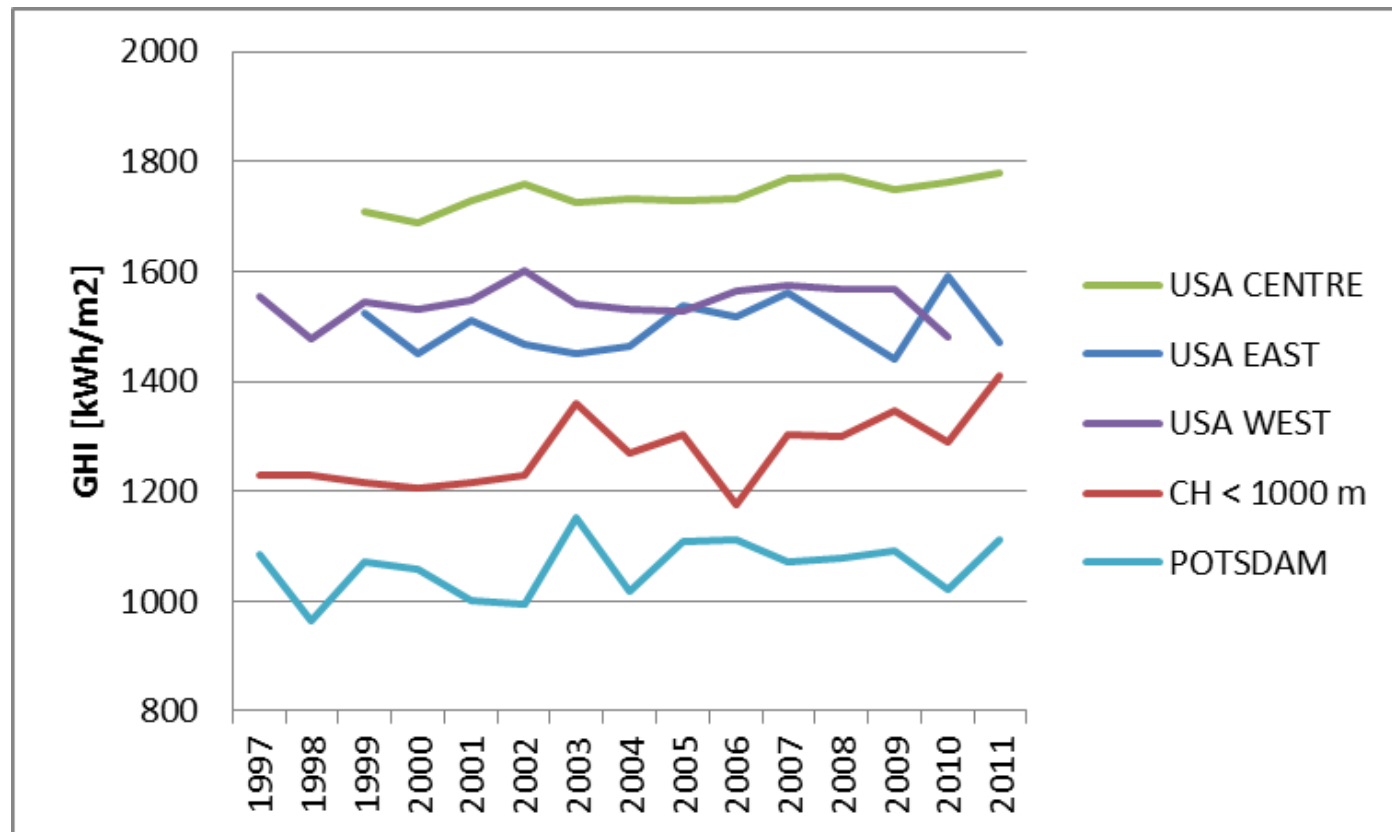


- 8 stations are used for trend analysis. Networks: Surfrad/BSRN, Univ. Oregon
- 1997 – 2011, DNI and GHI
- Problem: there is no real long time series (> 40 years without breaks) in the USA

Recent trends: station trends



Recent trends: regional means



- USA: Only trend for Centre is significant (3% increase per decade)
- For comparison: CH low land has 9% increase

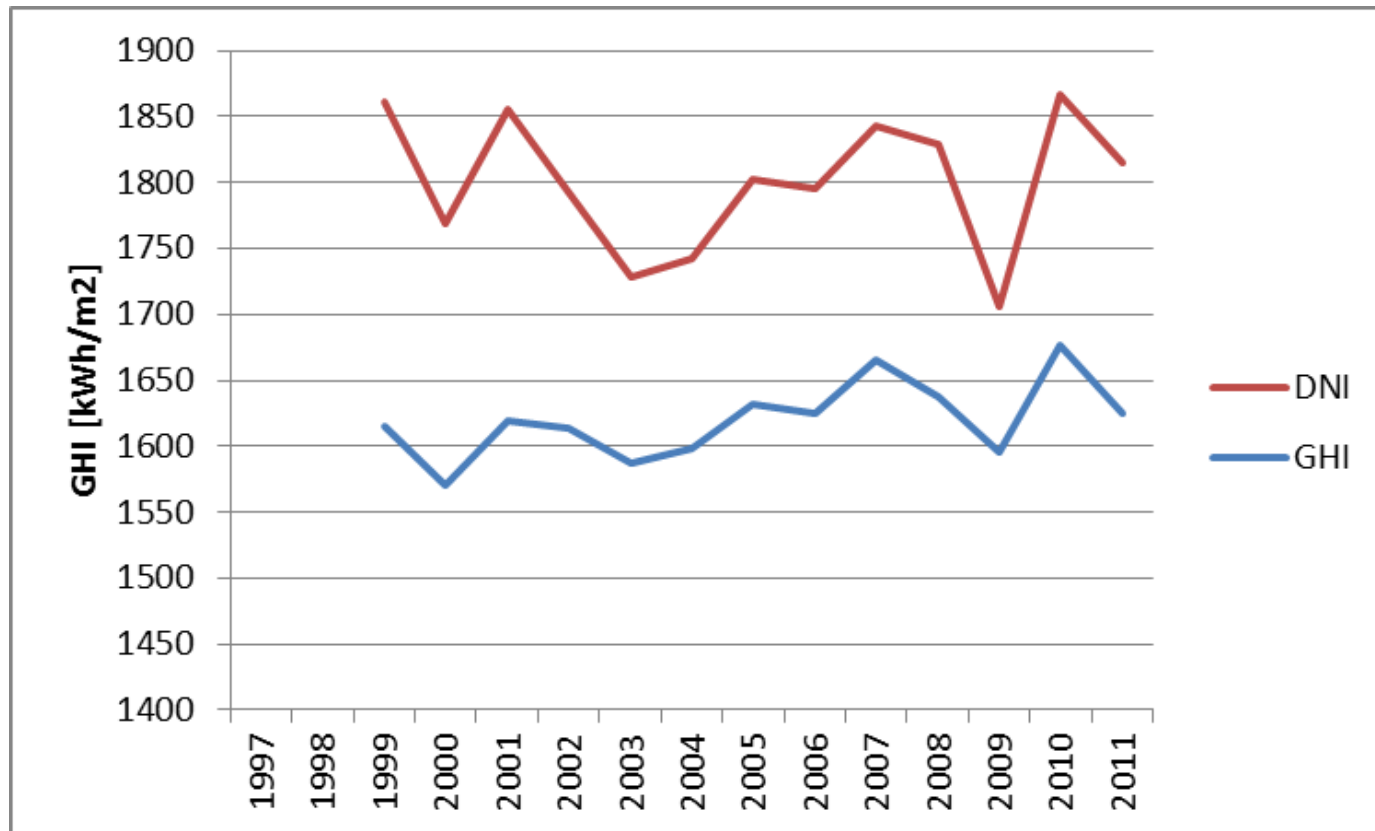
Recent trends



Site	Trend GHI [%/decade]	Significant	Trend DNI [%/decade]	Significant
Bondville, IL (BON)	1.3%	no	-3.1%	no
Boulder, CO (TBL)	5.0%	yes	2.8%	no
Burns, OR (BUR)	-0.9%	no	-1.5%	no
Desert Rock, NV (DRA)	2.0%	no	0.9%	no
Eugene, OR (EUG)	-0.2%	no	-1.8%	no
Fort Peck, MT (FPK)	2.7%	no	-4.5%	no
Goodwin Creek, MS (GWN)	4.1%	no	7.0%	no
Penn State, PA (PSA)	-0.5%	no	-5.5%	no
CH low land	9.2%	yes	-	-
Potsdam	3.2%	no	-	-

- Most USA trends are not significant
- For comparison: Swiss low land sites have a big and significant trend

Recent trends: DNI and GHI



- Average DNI and GHI trends are not significant (they are slightly positive)

Future trends: method

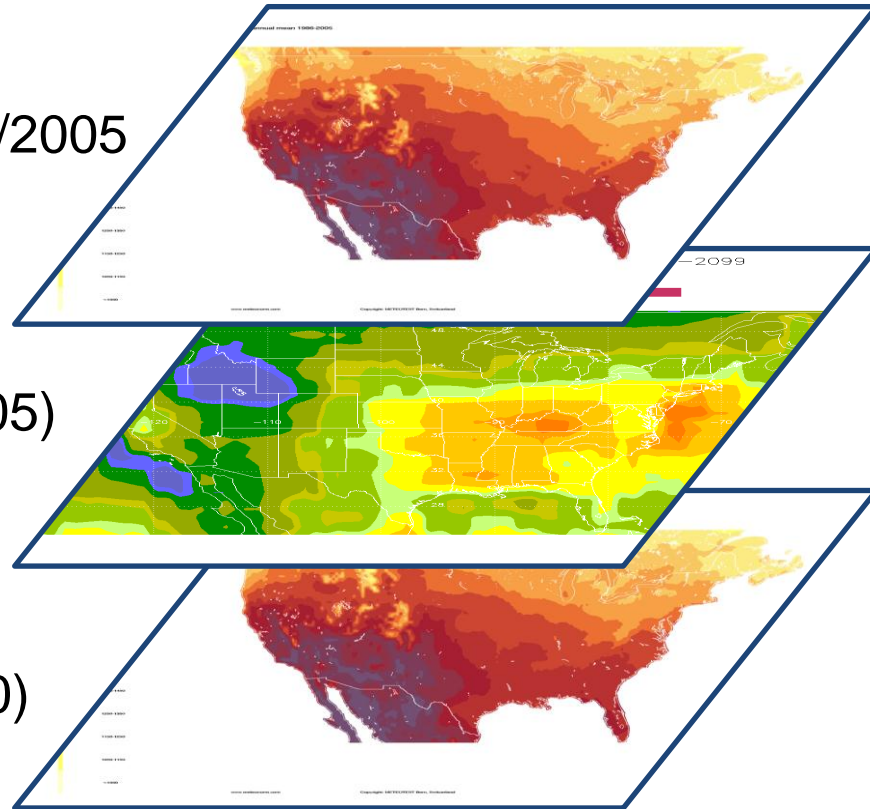
Global radiation map 1986/2005

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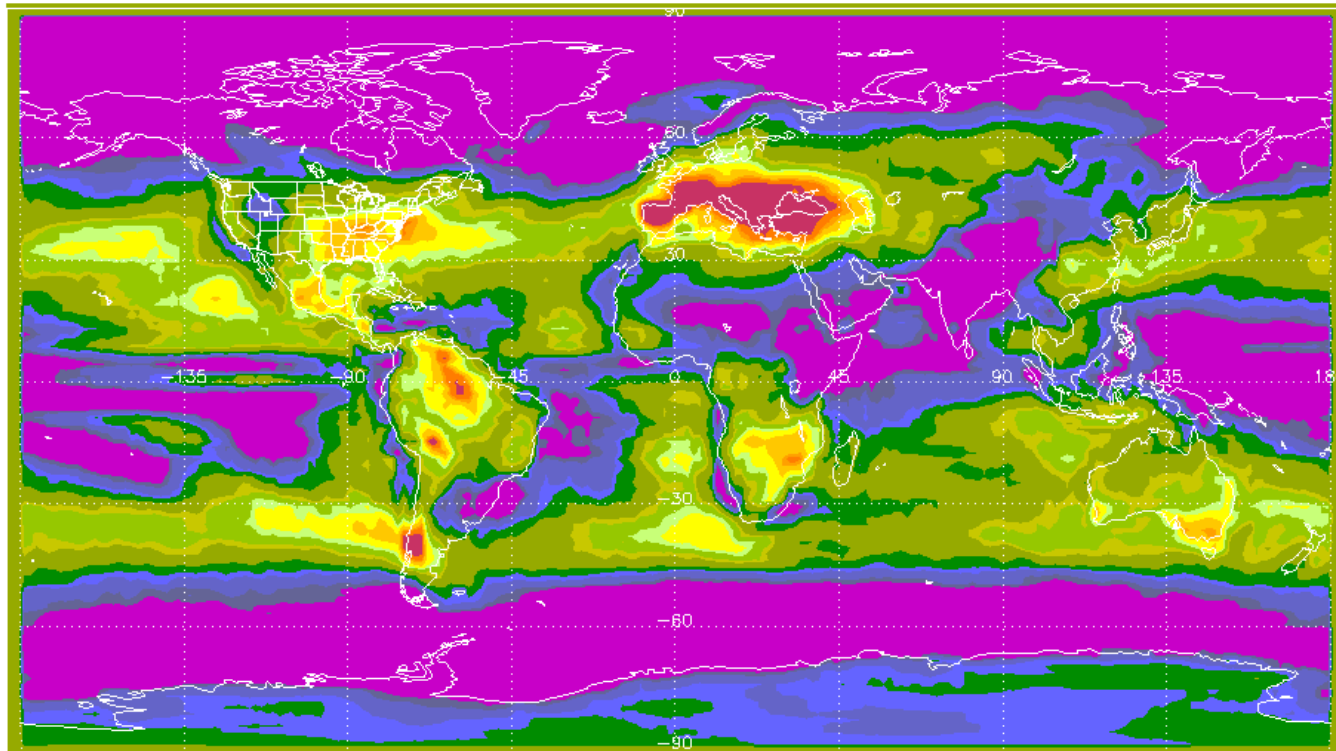
Anomaly (2090 – 1986/2005)

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Global radiation map (2090)

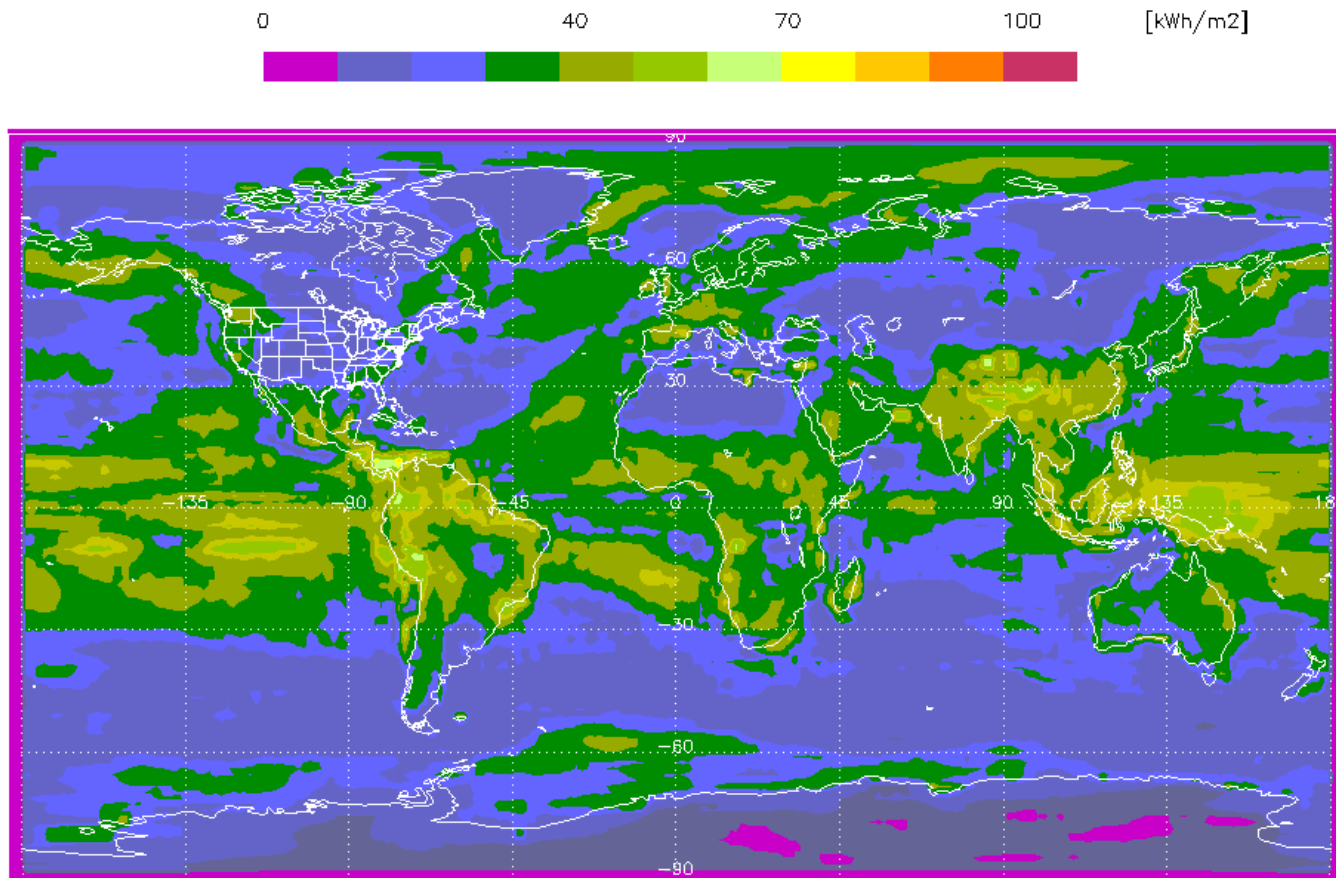


Anomalies 2080-99: A1B worldwide



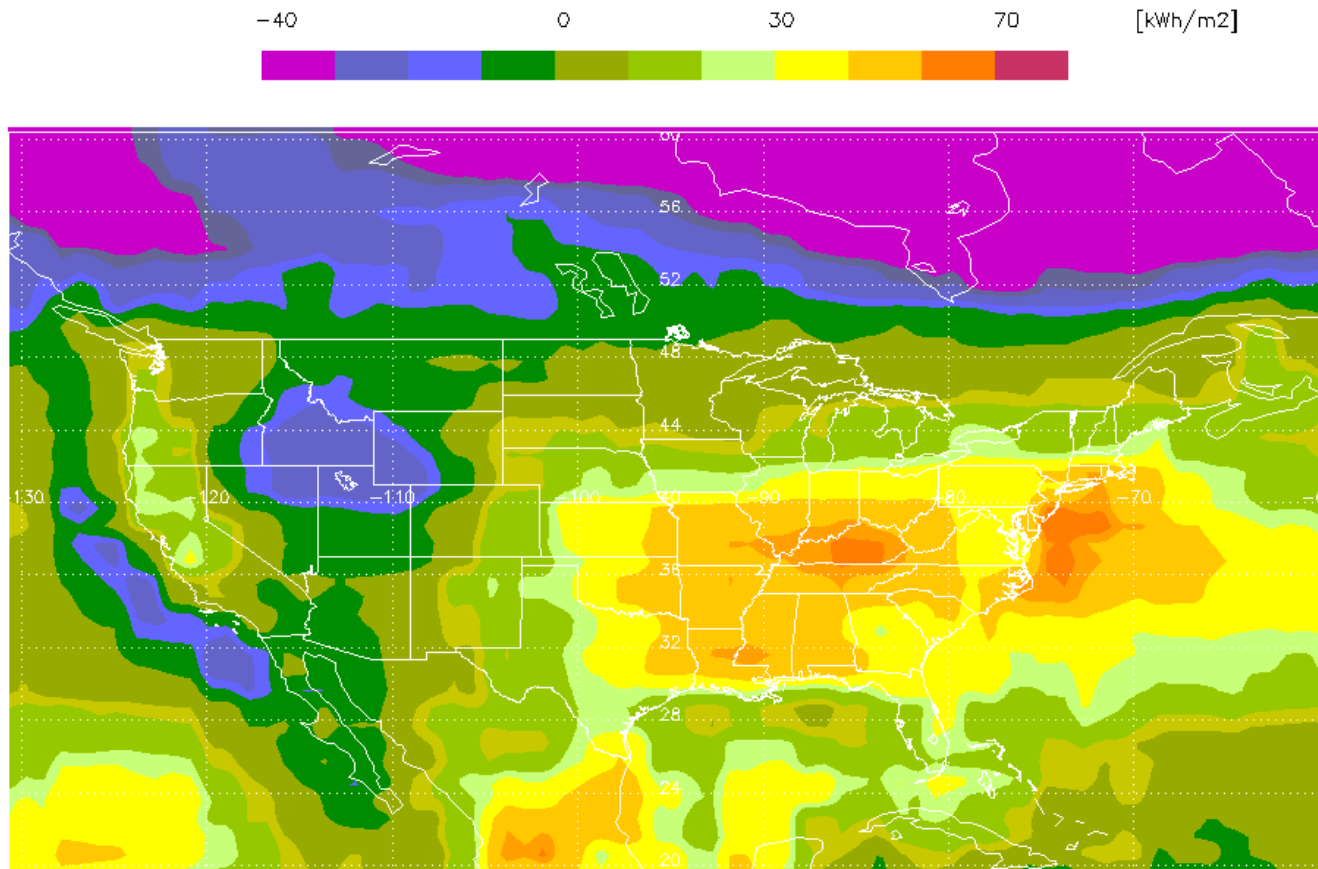
- Small relative changes
- General small decrease
- Increase: Southern Europe

Standard deviation of 18 models



- Many regions with non significant anomalies (standard dev. \approx average)

Anomalies 2080-99: USA



- USA: Small relative changes
- Increase: South-East
- Decrease: Great Basin

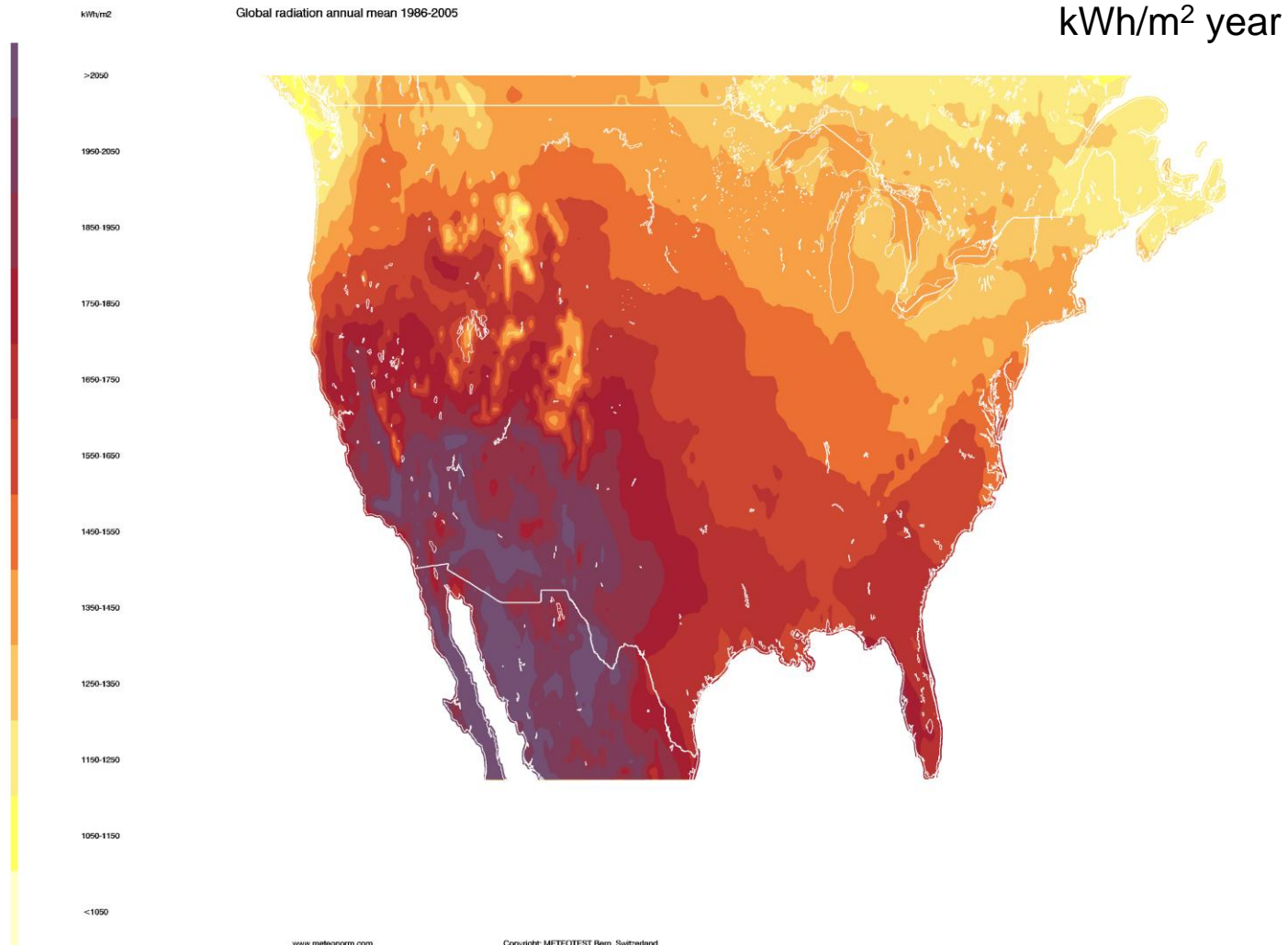
Future changes: big cities (2050)



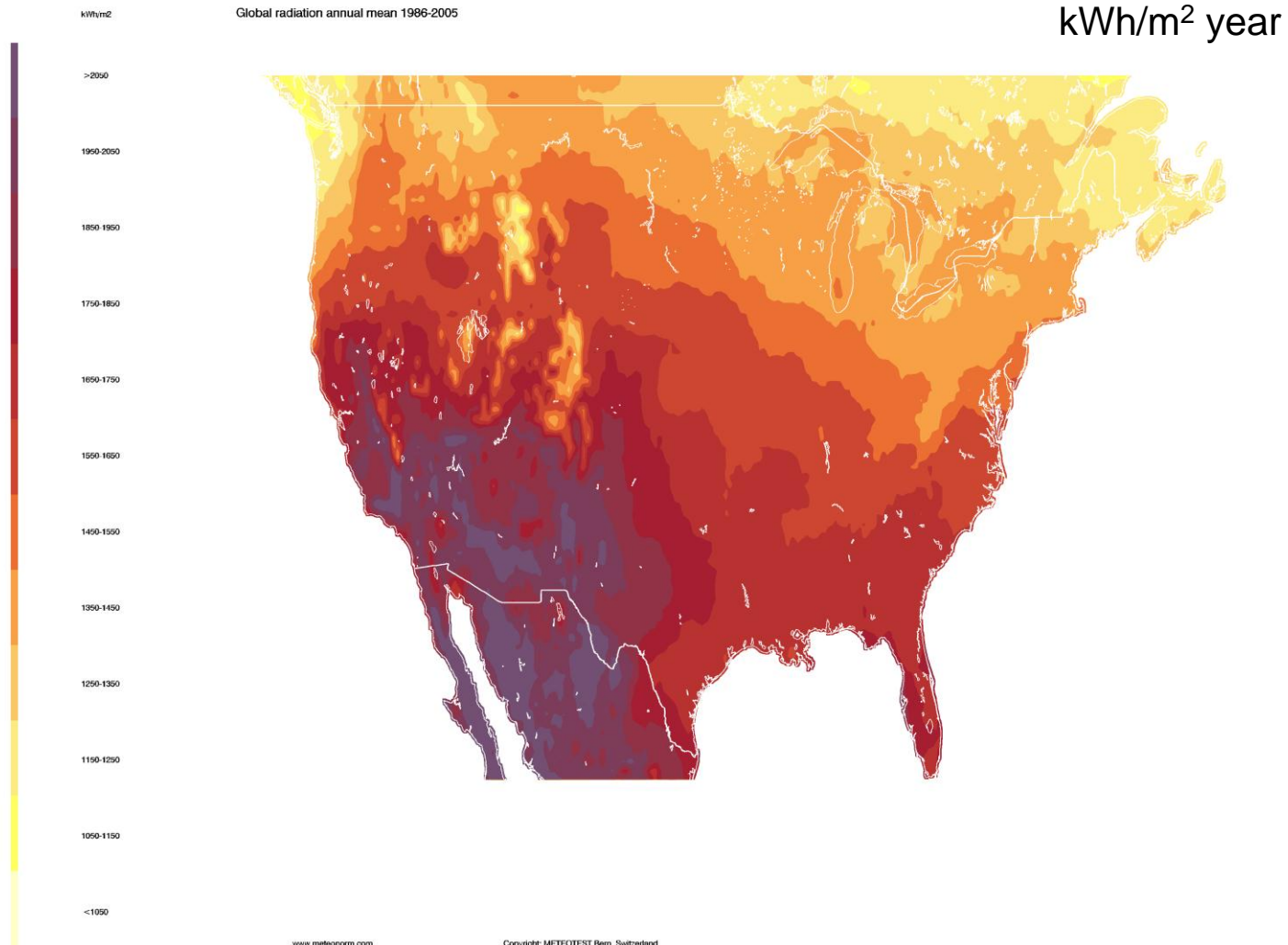
Site	GHI 1986-05 [kWh/m ²]	GHI 2050 [kWh/m ²]	GHI Delta [%]	DNI 1986-05 [kWh/m ²]	DNI 2050 [kWh/m ²]	DNI Delta [%]	Ta Delta [C]
Chicago, IL	1406	1433	1.9%	1363	1446	6.1%	2.8
Denver, CO	1652	1665	0.8%	1893	1906	0.7%	2.8
Las Vegas, NV	2026	2021	-0.2%	2550	2546	-0.2%	2.6
Los Angeles, CA	1816	1827	0.6%	1905	1951	2.4%	2.0
Miami, FL	1750	1762	0.7%	1519	1544	1.6%	1.5
New Orleans, LS	1628	1662	2.1%	1335	1423	6.6%	2.1
New York, NY	1430	1459	2.0%	1373	1388	1.1%	2.5
Seattle, WA	1193	1210	1.4%	1091	1140	4.5%	1.9

- Calculation based on meteonorm version 7
- Most trends are small

Global radiation map 1986 - 2005

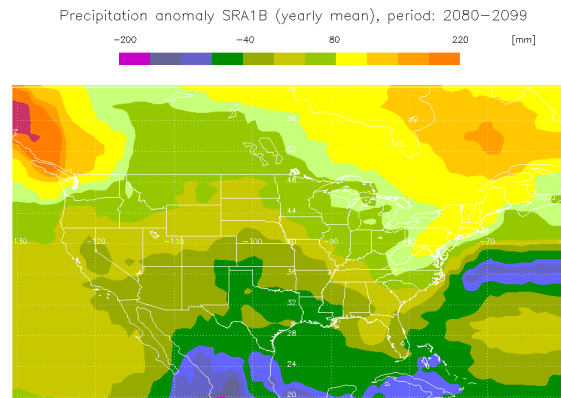
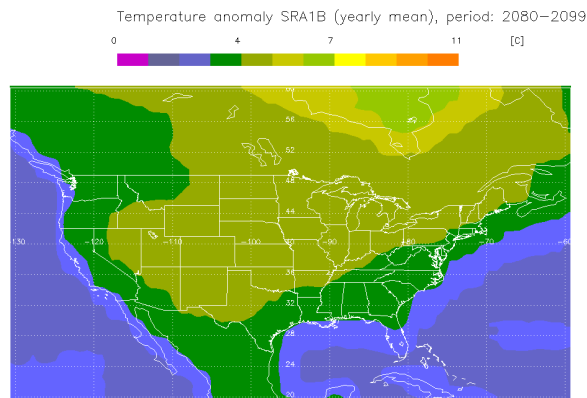


Global radiation map 2080 - 2099



Conclusions

- Small recent and future changes for solar radiation in the USA
 - Changes within climate variability
 - No signals about strong decline or increase
 - Relatively small changes between scenarios
- Climate change on radiation is dependent on region:
 - Other regions show much higher trends (e.g. Southern Europe)
- Strong significant trends of other parameters (e.g. temperature and precipitation) do have big effects also in the USA.



**Thank you for you
attention**

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