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UV-history in Europe: A comparison of UV-Reconstruction Models

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Part of SCOUT-O3 EC project

Objectives

- Reconstruction of past UV beyond onset of UV-measurements

Driven by

- Recognition that long-term exposure is key parameters for adverse health effects
- Understanding current and development of UV-burden

Phase 1

- Model intercomparison and model ⟷ measurement, 4 sites

Phase 2

- Establish best approach, and final reconstruction at 8 sites

UV reconstruction Models

5 models: Neural Networks(2) & Physical-Emperical(3)

Neural Network:

Input: SZA, ozone, global radiation, aod, ground albedo, visibility, sunshine duration
Delivarable: daily UV-dose cloudy sky
Required: training period for each site

Physical-Emprical:

Input: SZA, ozone, global radiation, aod, ground albedo, visibility, sunshine duration, total water vapor column
Delivarable: daily UV-dose cloudy sky & clear sky
Required: established correlation for global radiation <-> UV (once)

Training	Validation
2000-2004	rest of available UV-data

Used data

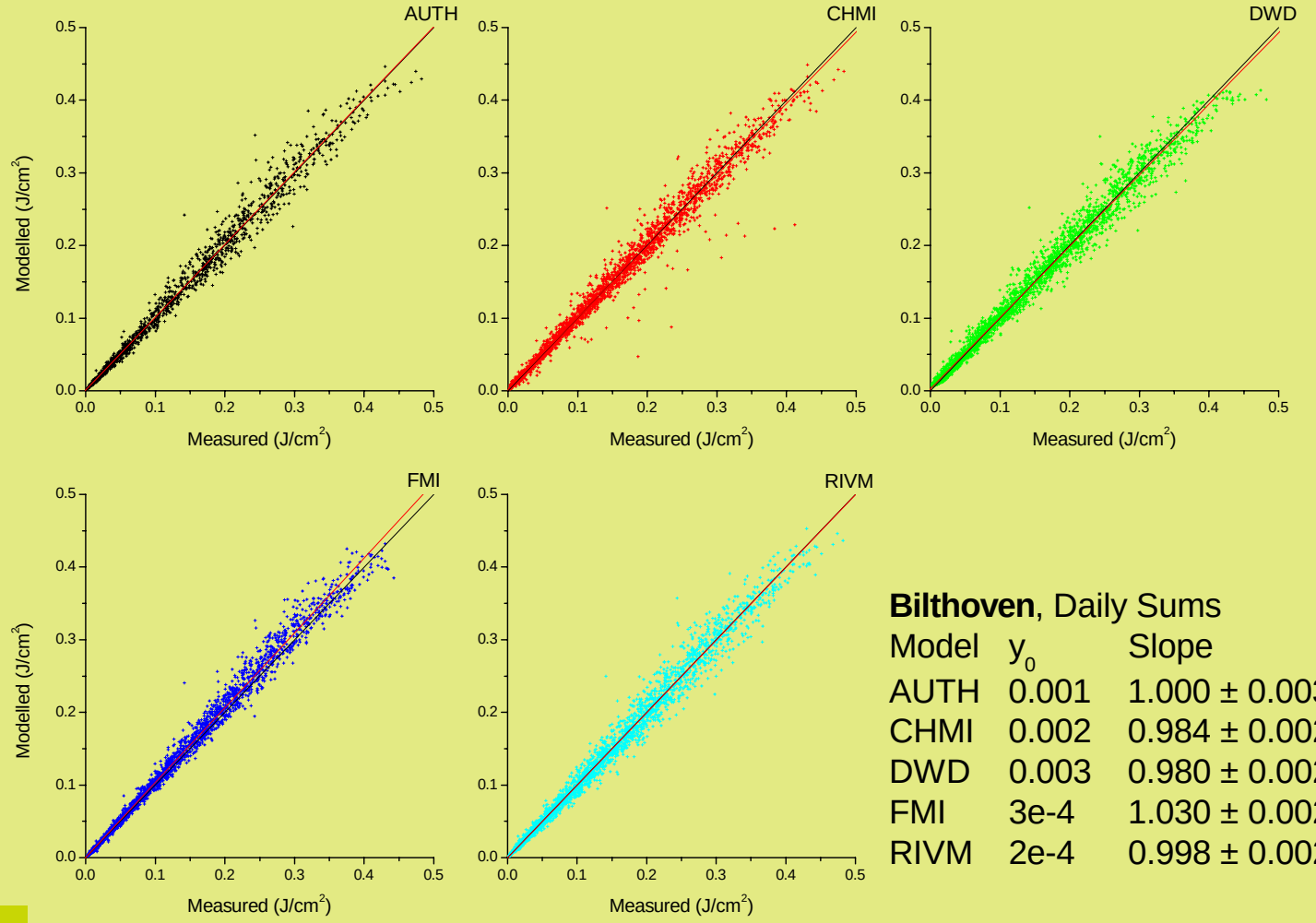
Available Spectral UV data: validation and training

	Thessaloniki	Potsdam	Bilthoven	Jokioinen
Daily doses	1992-2005	1995-2003	1996-2005	1995-2005
Hourly doses	1992-2005			
Momentary dose rates			1996-2005	1995-2005

Available auxiliary data; possible model input

	Thessaloniki	Potsdam	Bilthoven	Jokioinen
Global solar radiation	1992-2005	1937-2003	1965-2005	1981-2005
Diffuse solar radiation		1937-2003		
Total ozone	1982-2005	1964-2003	1972-2005	1994-2005
Aerosols	1997-2006	1994-2003		
Visibility	1974-2002	1950-2003		1981-2005
Total Cloud cover	1982-2002	1950-2003		1981-2005
Sunshine duration	1974-2002	1893-2005		1951-2005
albedo		1984-2003		
Snow depth				1959-2005

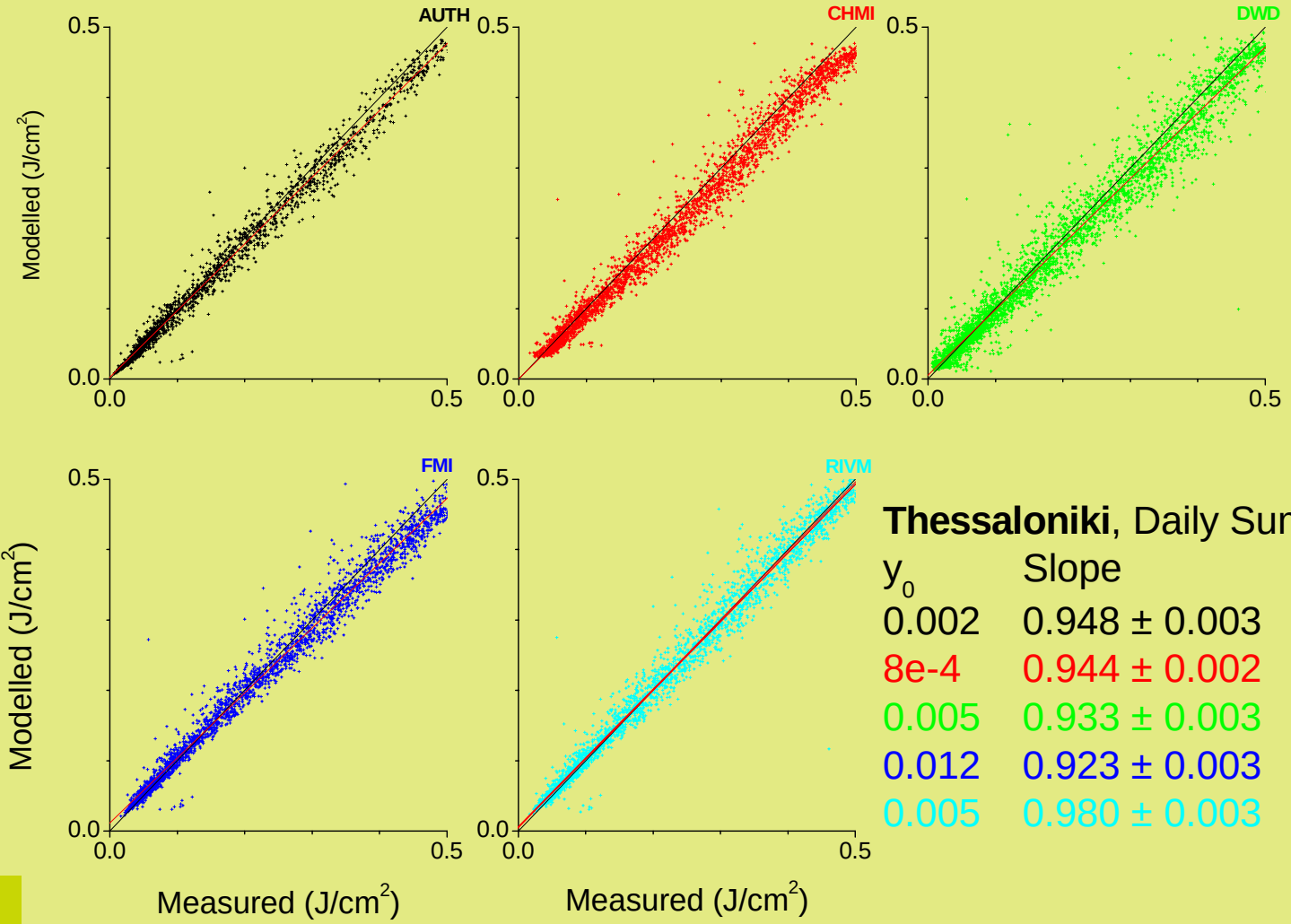
Results Bilthoven, direct correlation



Bilthoven, Daily Sums

Model	y_0	Slope	N
AUTH	0.001	1.000 ± 0.003	1485
CHMI	0.002	0.984 ± 0.002	3043
DWD	0.003	0.980 ± 0.002	3199
FMI	3e-4	1.030 ± 0.002	2737
RIVM	2e-4	0.998 ± 0.002	3200

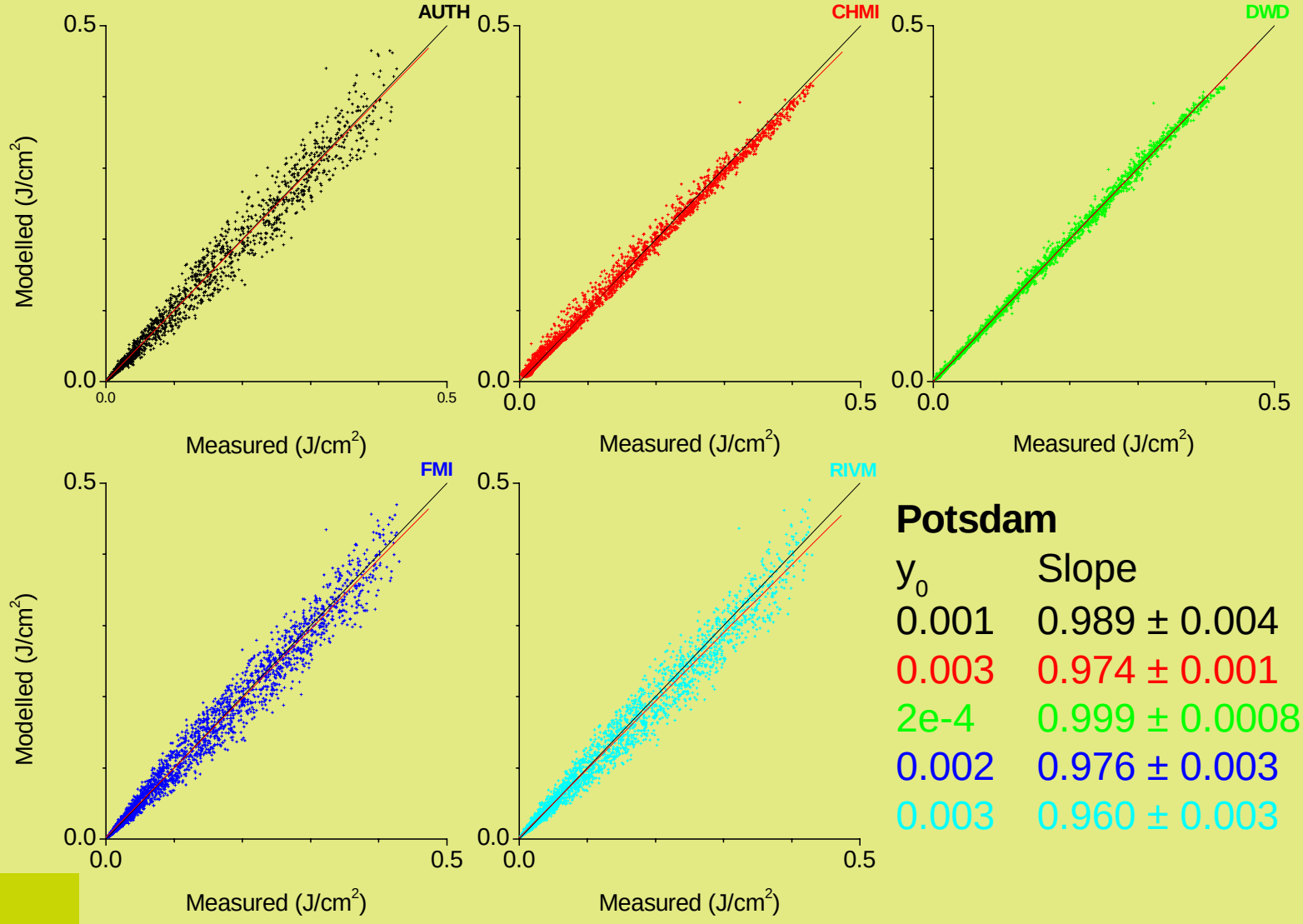
Results Thessaloniki, direct correlation



Thessaloniki, Daily Sums

y_0	Slope	N
0.002	0.948 ± 0.003	1626
8e-4	0.944 ± 0.002	2738
0.005	0.933 ± 0.003	2946
0.012	0.923 ± 0.003	2508
0.005	0.980 ± 0.003	2547

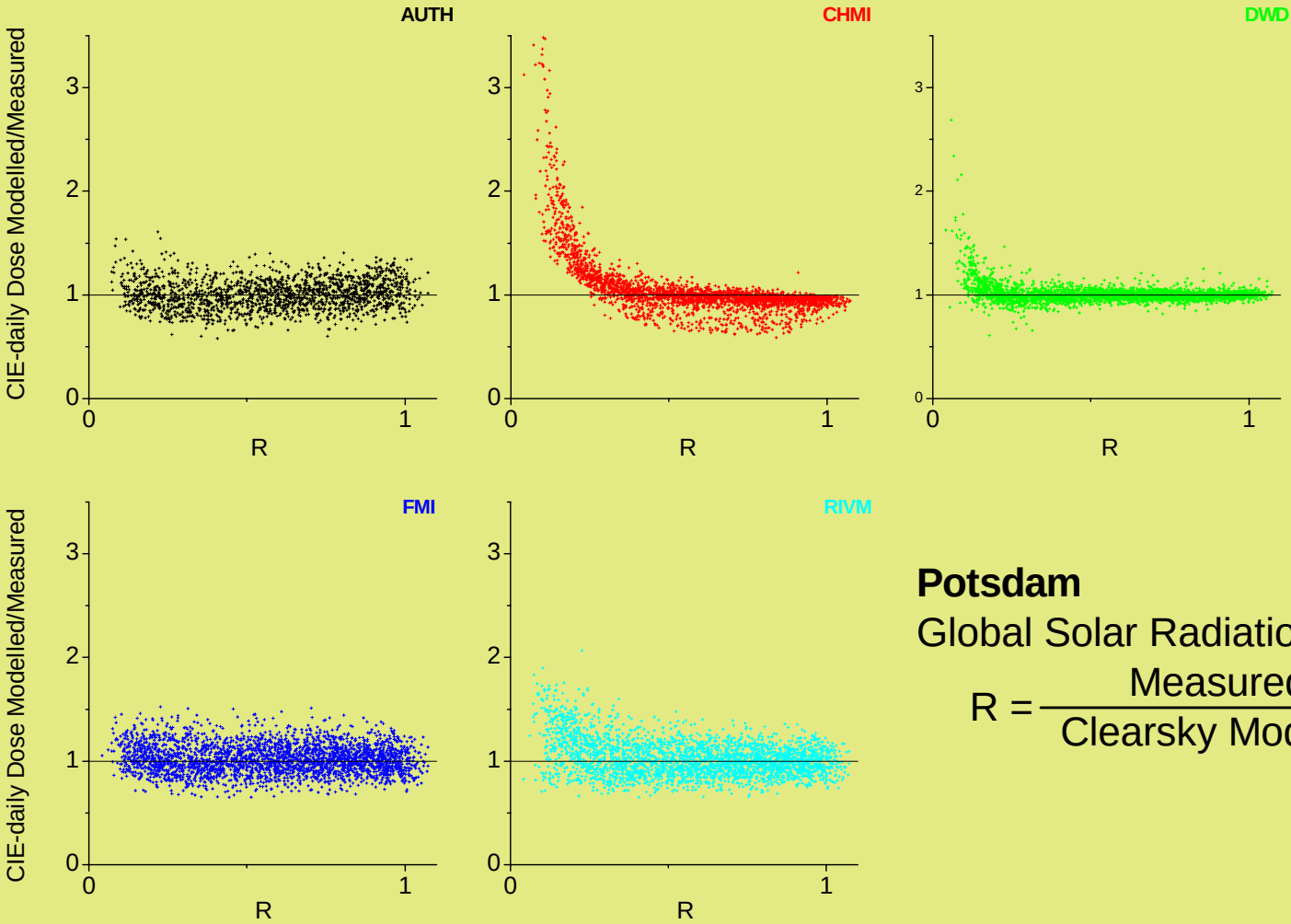
Results Potsdam, direct correlation



Potsdam

y_0	Slope	N
0.001	0.989 ± 0.004	1655
0.003	0.974 ± 0.001	3043
2e-4	0.999 ± 0.0008	2946
0.002	0.976 ± 0.003	2728
0.003	0.960 ± 0.003	2728

Results Potsdam, cloudiness

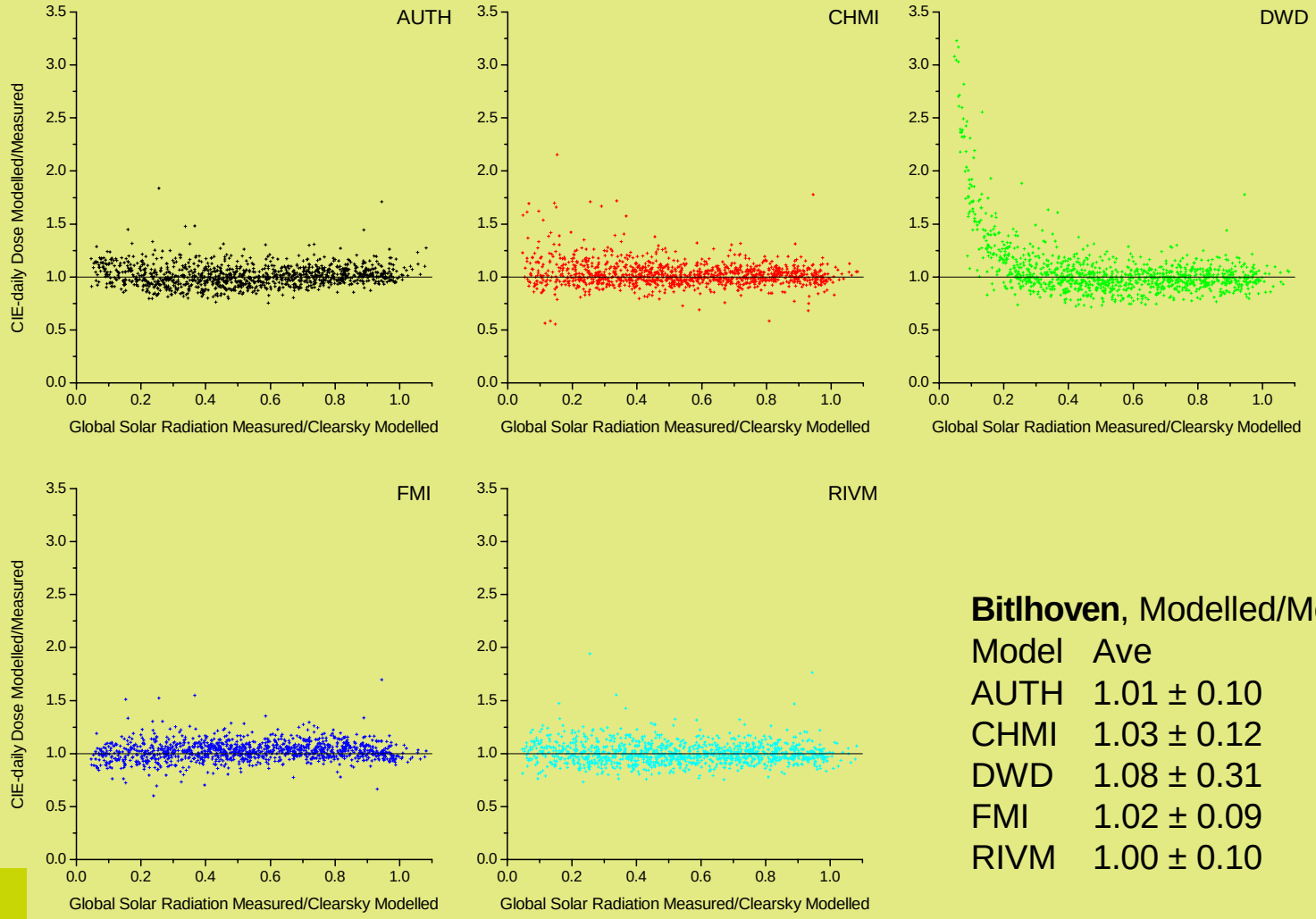


Potsdam

Global Solar Radiation

$$R = \frac{\text{Measured}}{\text{Clearsky Modelled}}$$

Results Bilthoven, cloudiness



Bitlhoven, Modelled/Measured

Model	Ave	N
AUTH	1.01 ± 0.10	1156
CHMI	1.03 ± 0.12	1156
DWD	1.08 ± 0.31	1156
FMI	1.02 ± 0.09	1156
RIVM	1.00 ± 0.10	1156

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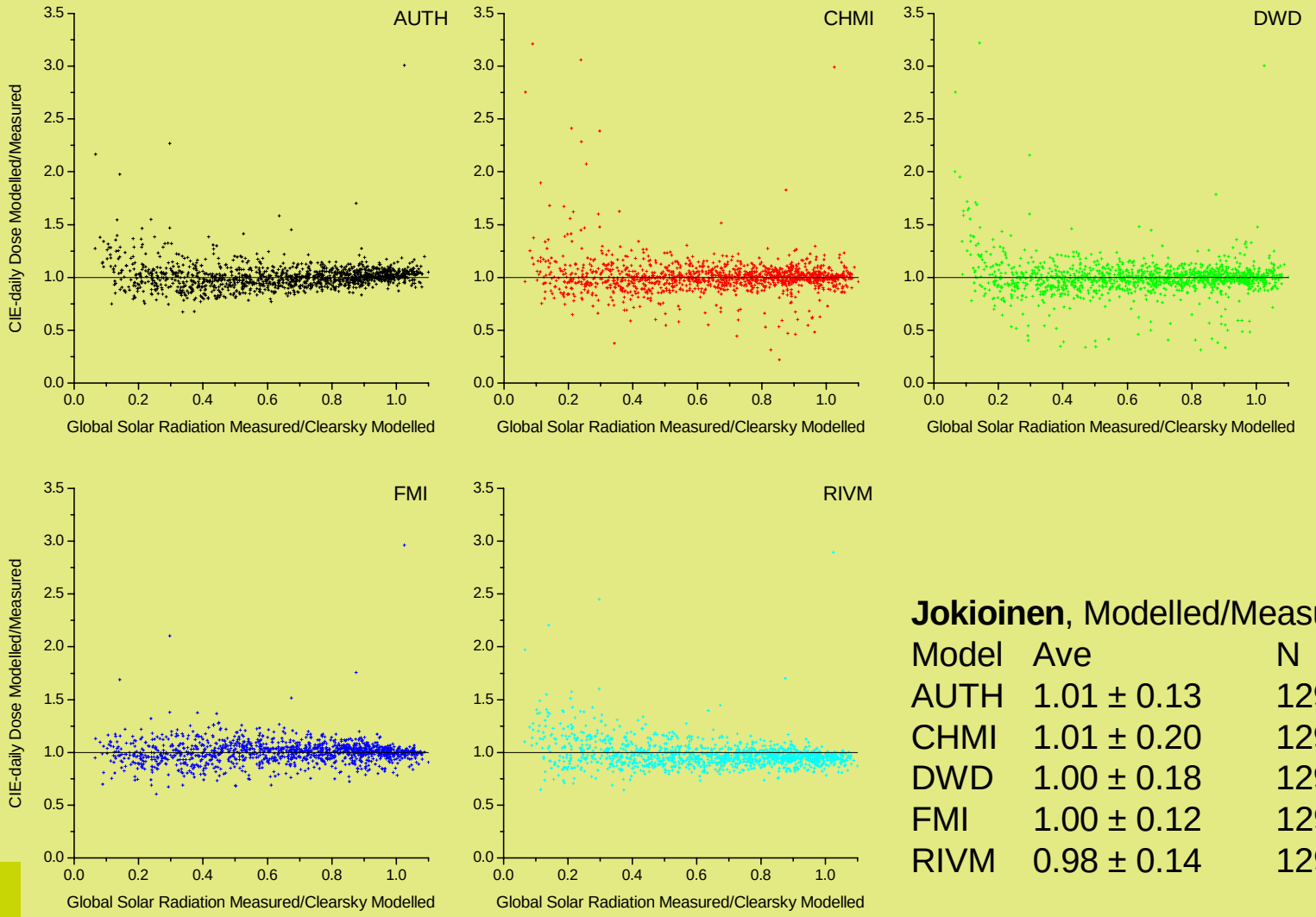
Results Jokioinen, cloudiness



Jokioinen, Modelled/Measured

Model	Ave	N
AUTH	1.01 ± 0.13	1299
CHMI	1.01 ± 0.20	1299
DWD	1.00 ± 0.18	1299
FMI	1.00 ± 0.12	1299
RIVM	0.98 ± 0.14	1299

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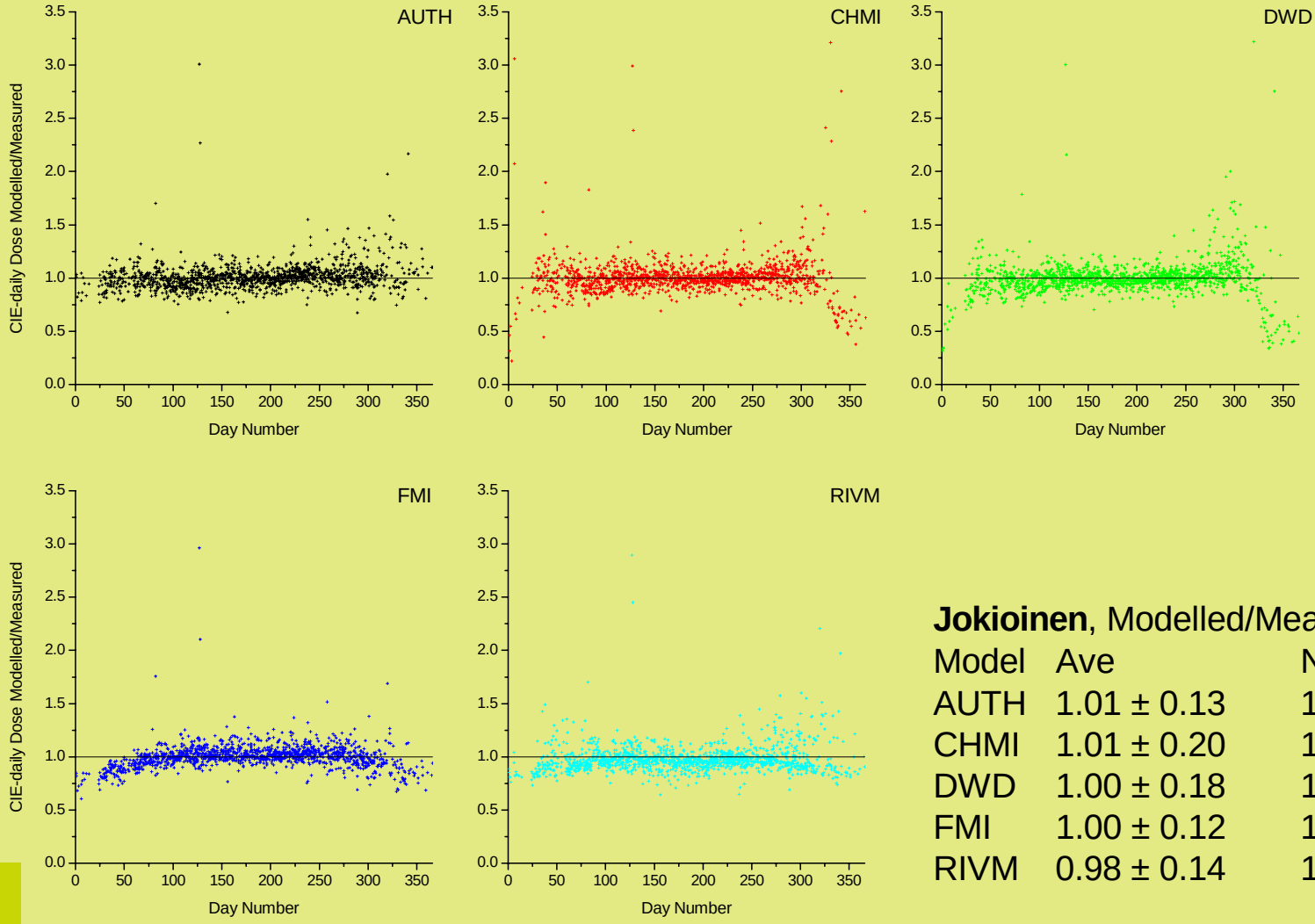
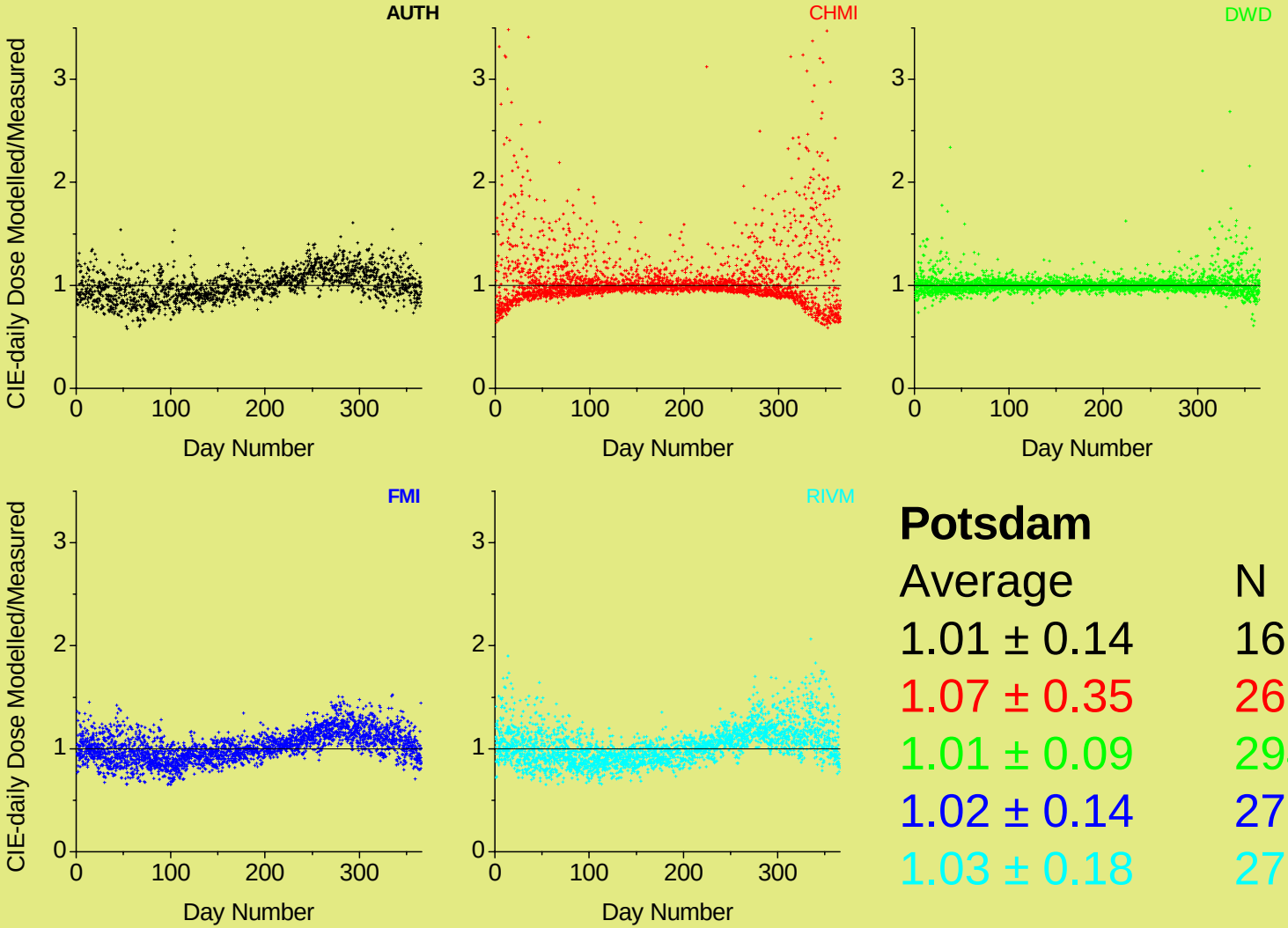
Results Jokioinen, day number



Jokioinen, Modelled/Measured

Model	Ave	N
AUTH	1.01 ± 0.13	1299
CHMI	1.01 ± 0.20	1299
DWD	1.00 ± 0.18	1299
FMI	1.00 ± 0.12	1299
RIVM	0.98 ± 0.14	1299

Results Potsdam, day number



Potsdam

Average	N
1.01 ± 0.14	1655
1.07 ± 0.35	2696
1.01 ± 0.09	2946
1.02 ± 0.14	2728
1.03 ± 0.18	2728

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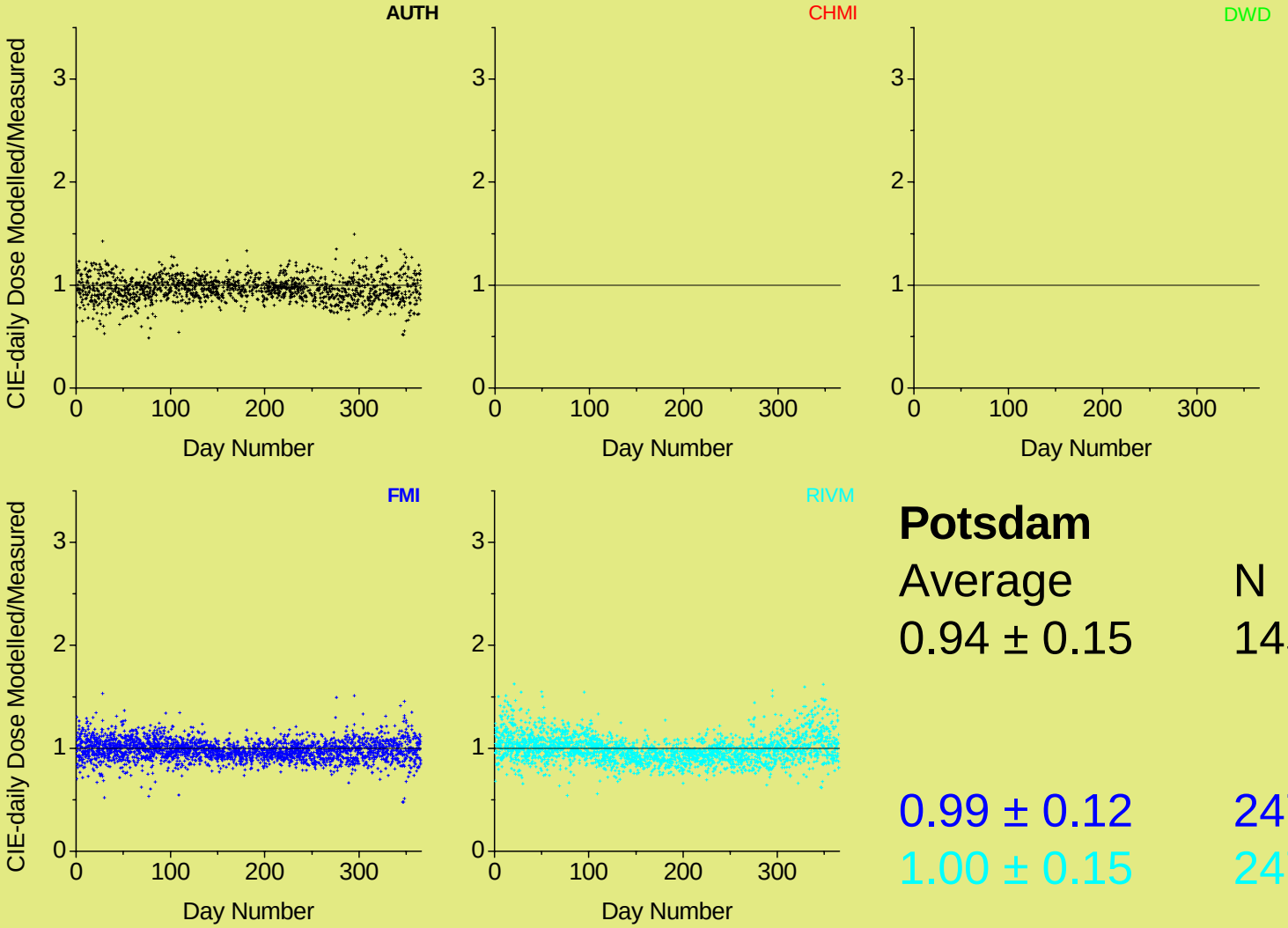
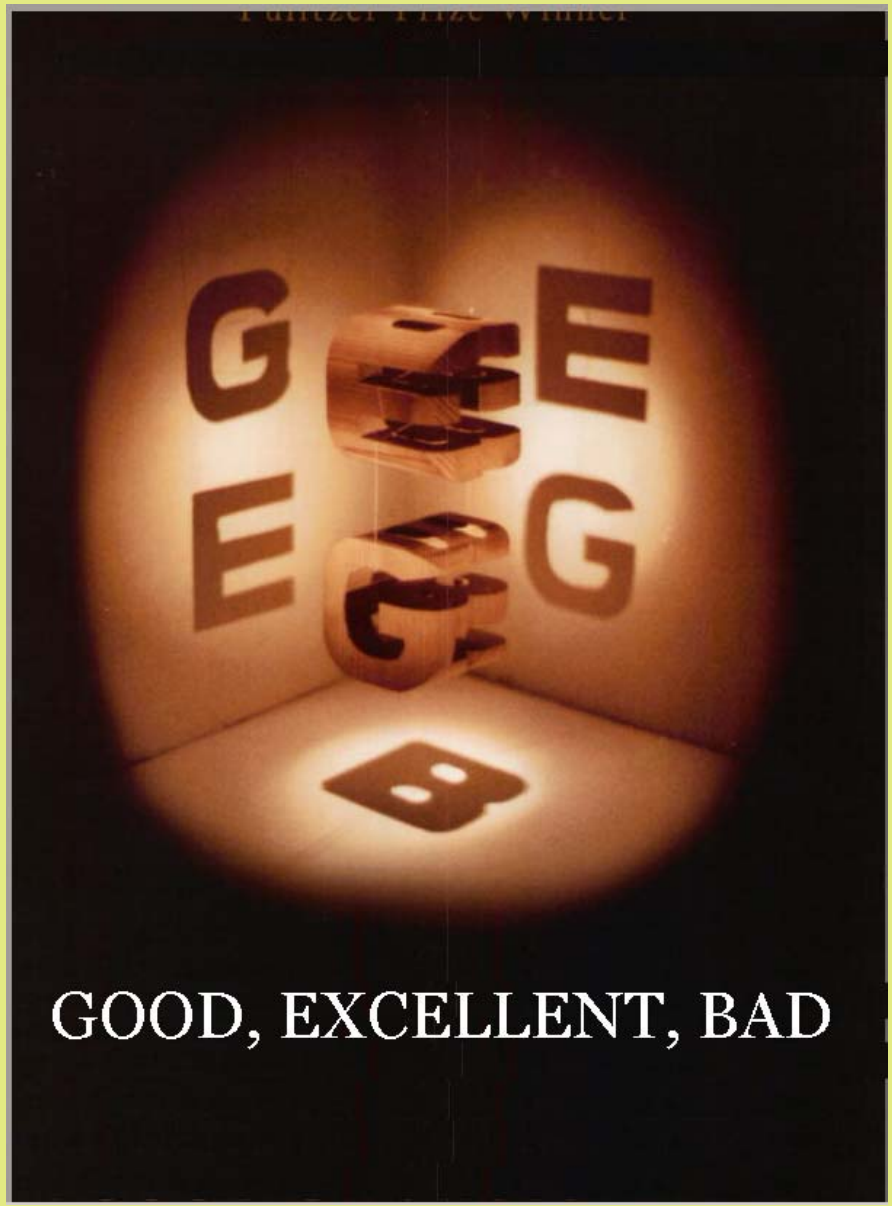
Results Potsdam, uv-data updated



Potsdam

Average	N
0.94 ± 0.15	1451
0.99 ± 0.12	2472
1.00 ± 0.15	2472

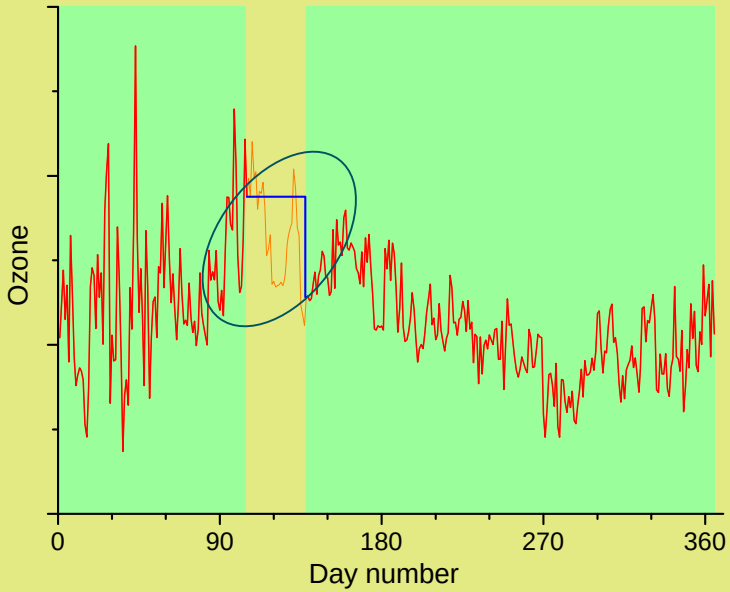
Conclusion



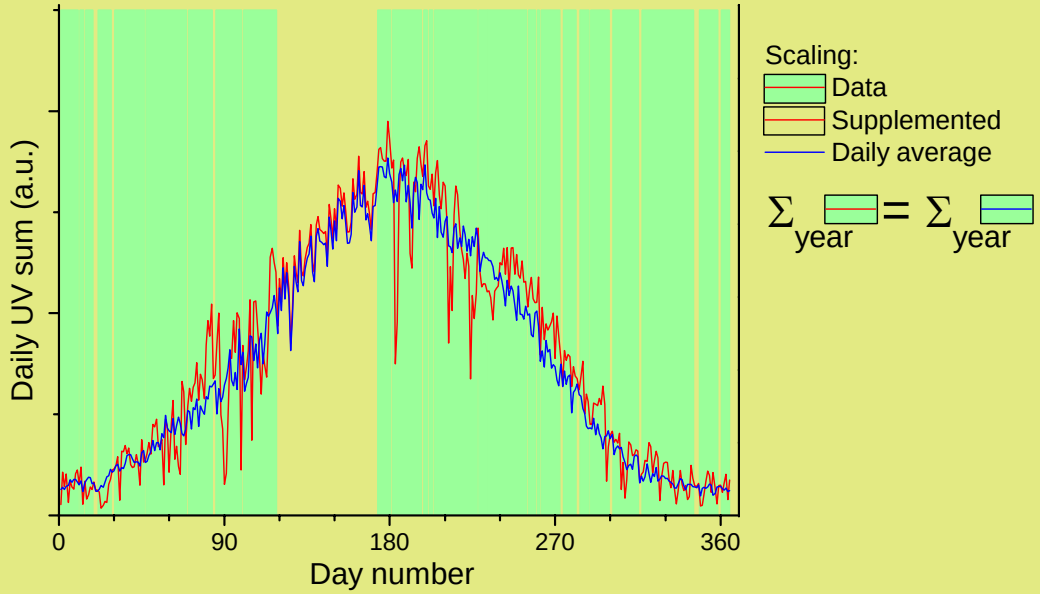
Construction of Month and Year Sums

➡ requires supplementation of input data sets

repetition last measurement

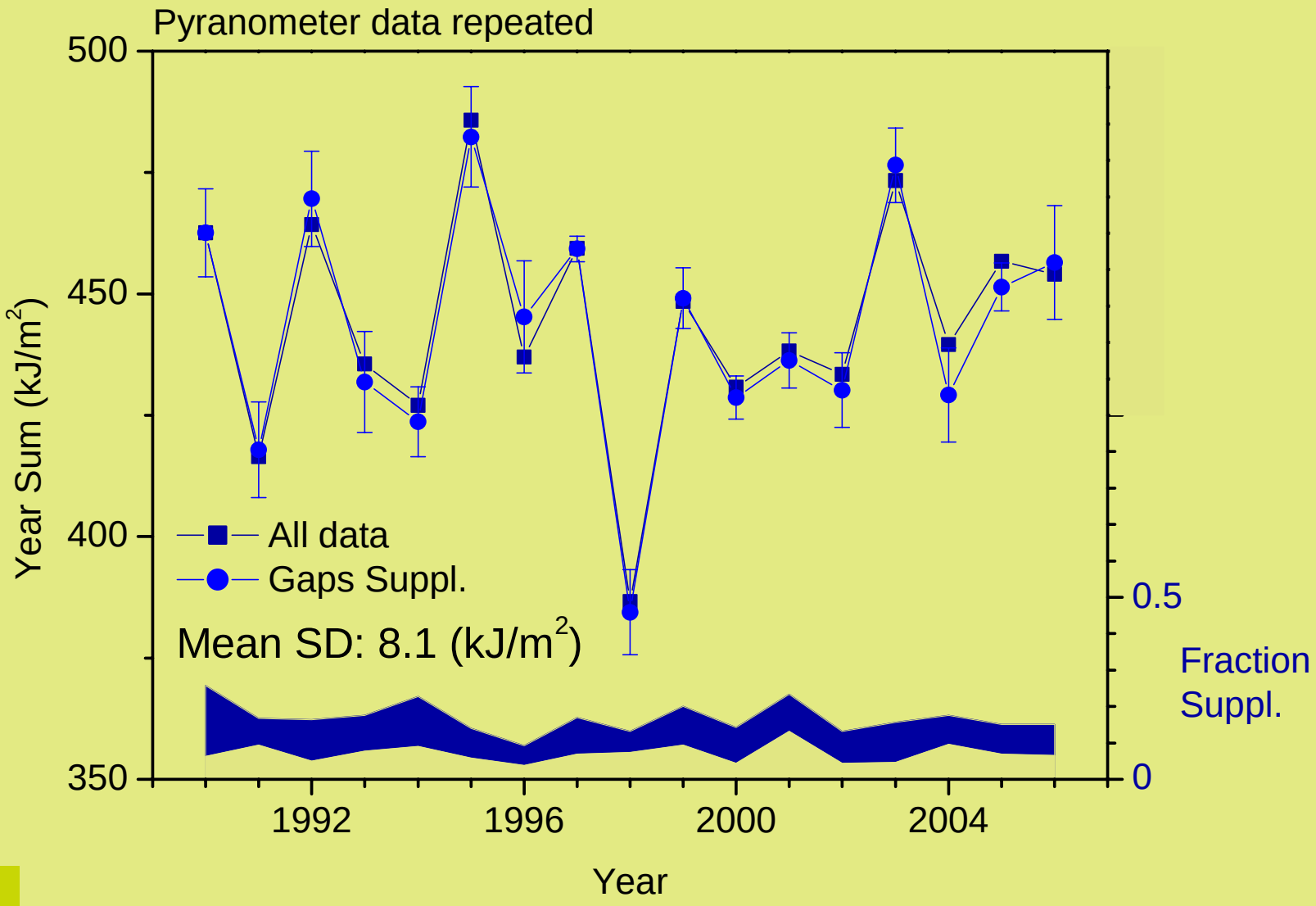


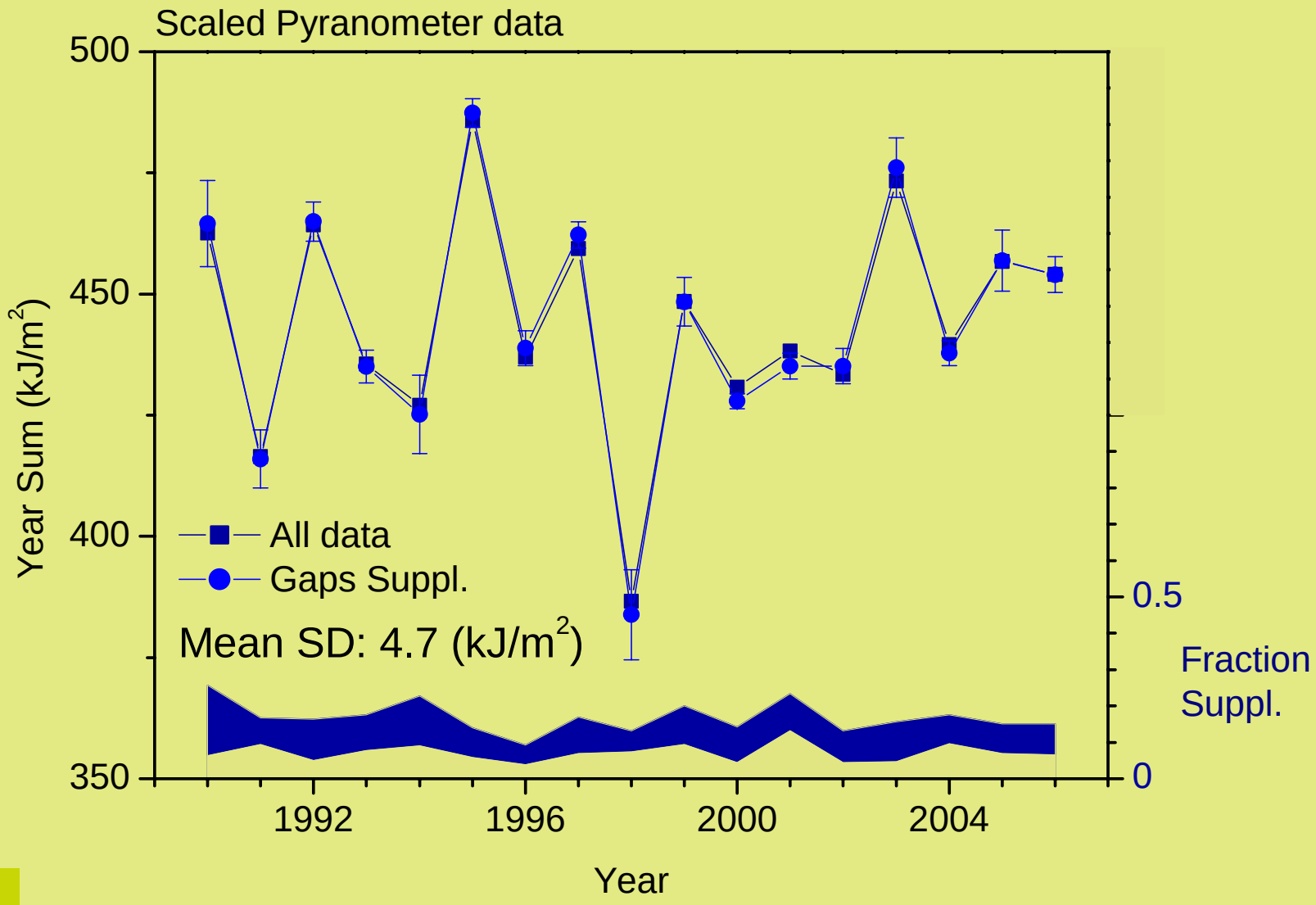
scaling annual pattern

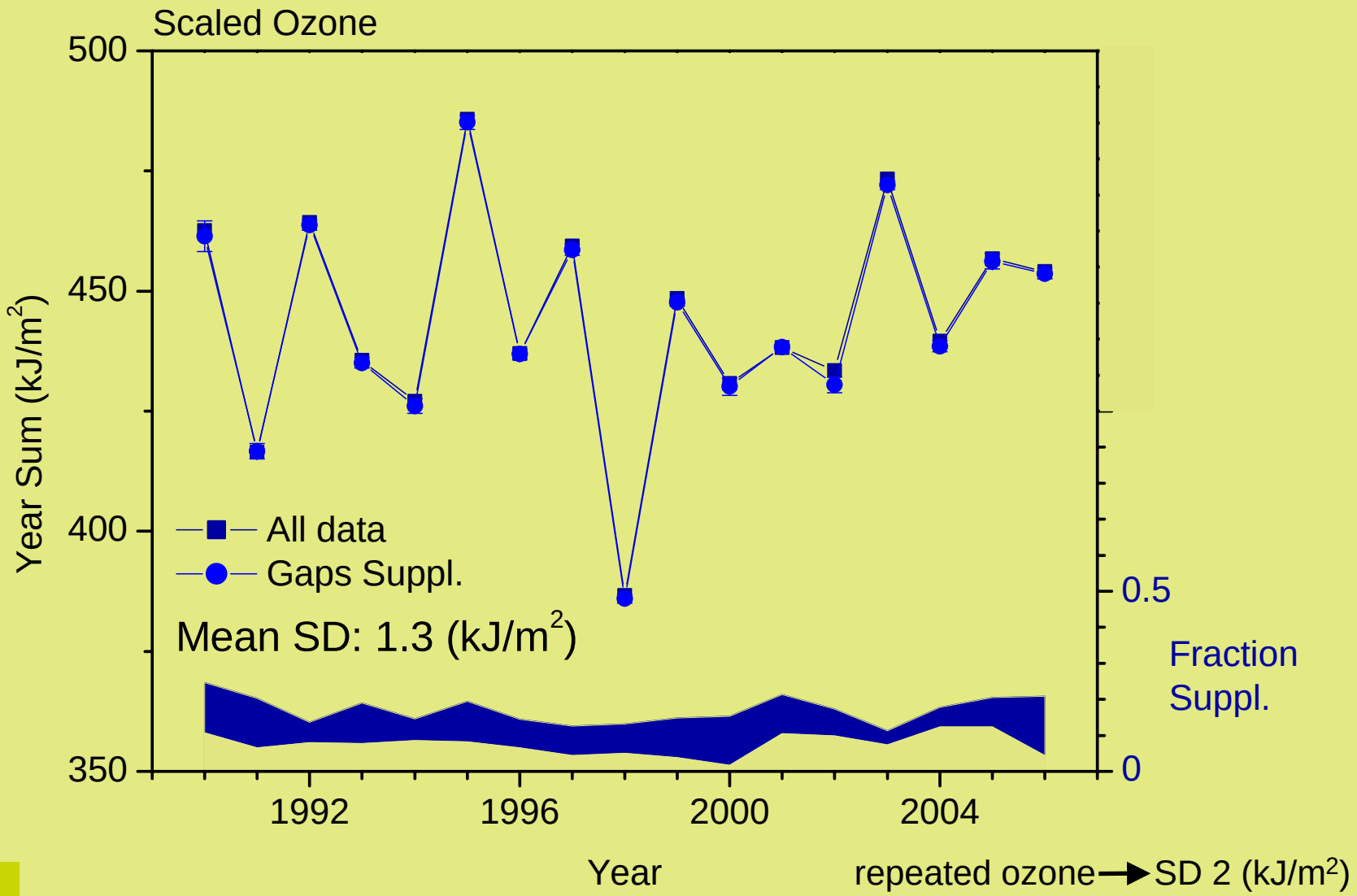


INITIAL take out sets of 10 connected days randomly

TEST ➡ supplement ➡ construct year sums


Pyranometer data repeated
500
450
400
350
Year Sum (kJ/m2)
All data
Gaps Suppl.
Mean SD: 8.1 (kJ/m2)
0.5
0
Fraction Suppl.
1992
1996
2000
2004
Year


Scaled Pyranometer data
500
450
400
350
Year Sum (kJ/m2)
All data
Gaps Suppl.
Mean SD: 4.7 (kJ/m2)
0.5
0
Fraction Suppl.
1992
1996
2000
2004
Year



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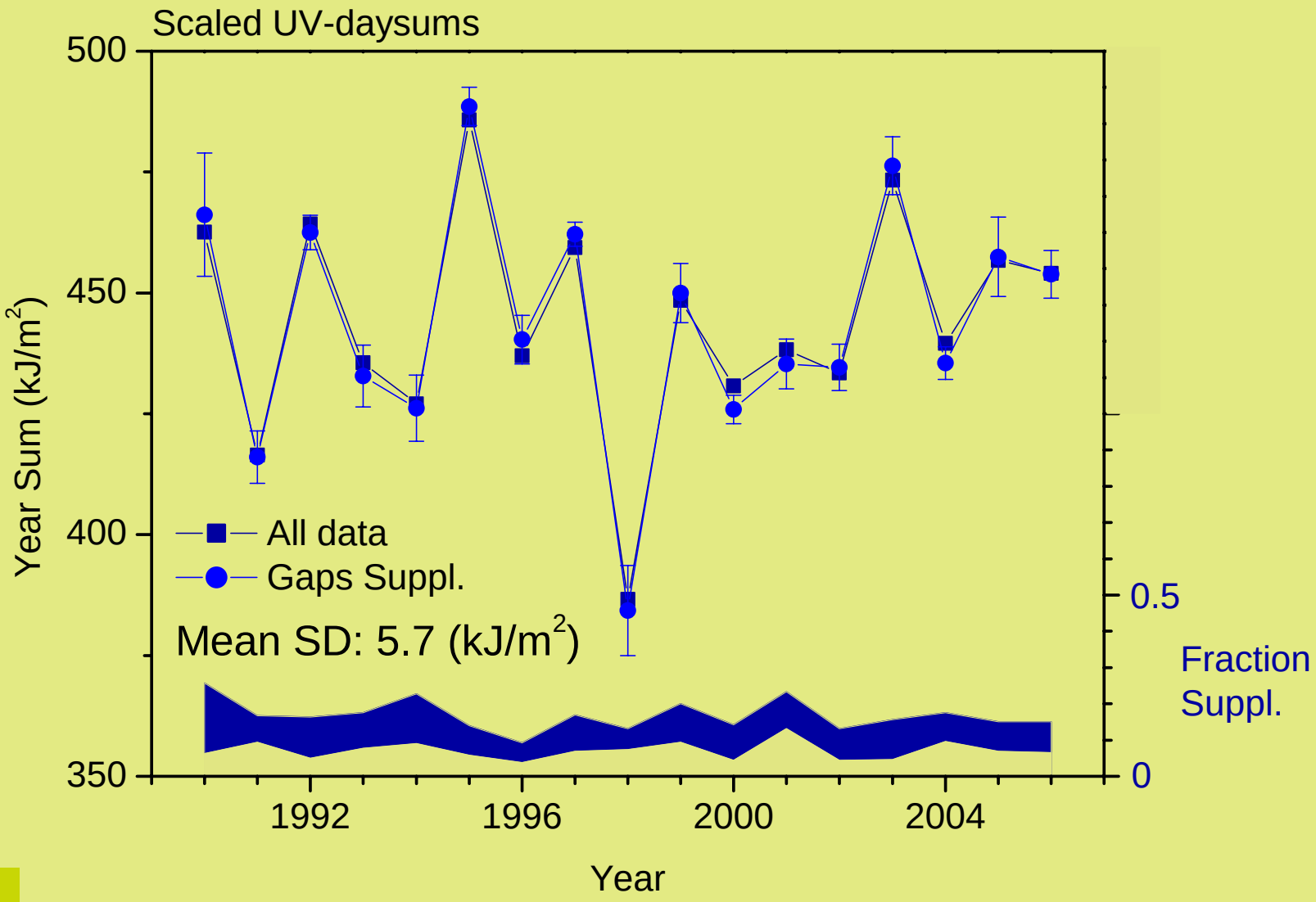
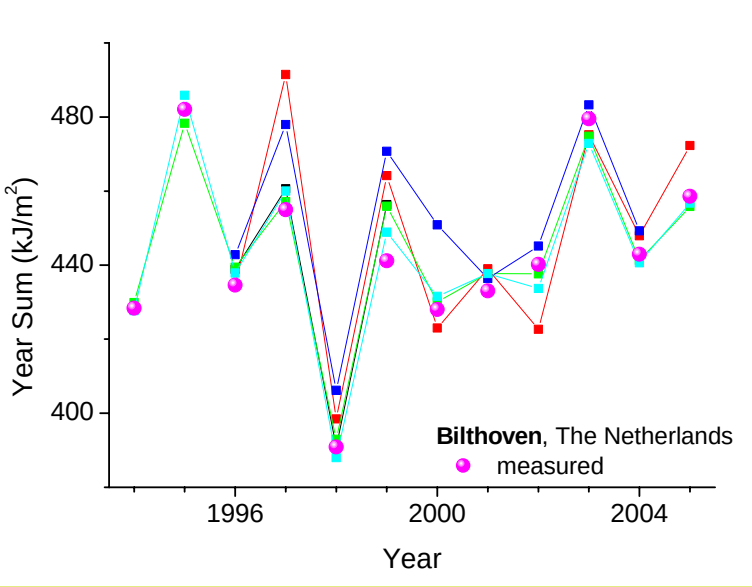
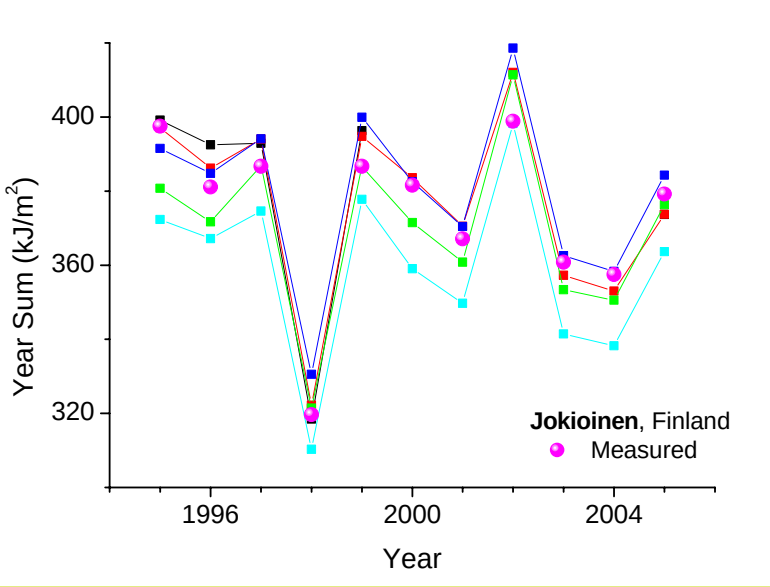

Scaled UV-daysums
500
450
400
350
Year Sum (kJ/m2)
All data
Gaps Suppl.
Mean SD: 5.7 (kJ/m2)
0.5
0
Fraction Suppl.
1992
1996
2000
2004
Year

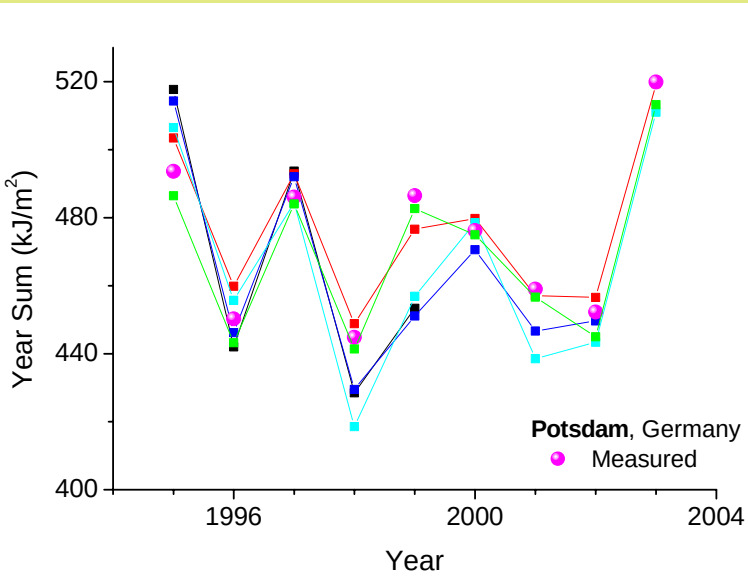
Conclusion

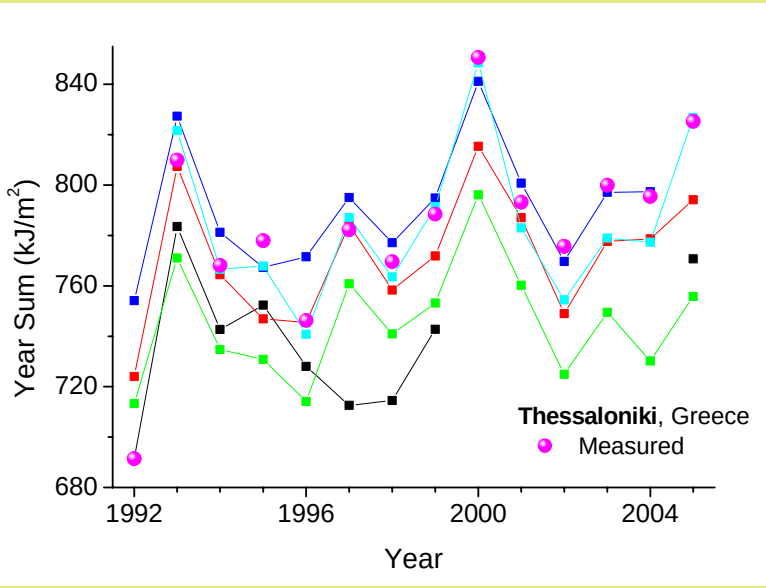
- Auxiliary data should be supplemented
- Errors: 1% per 10% supplemented cloud proxy data, ozone 0.3%
- Supplementation of UV-day sum's is good alternative, 1.3%

Year Sums









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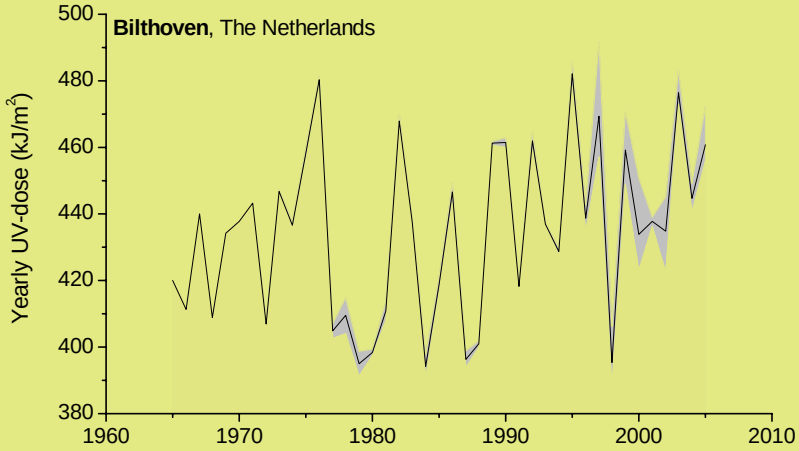
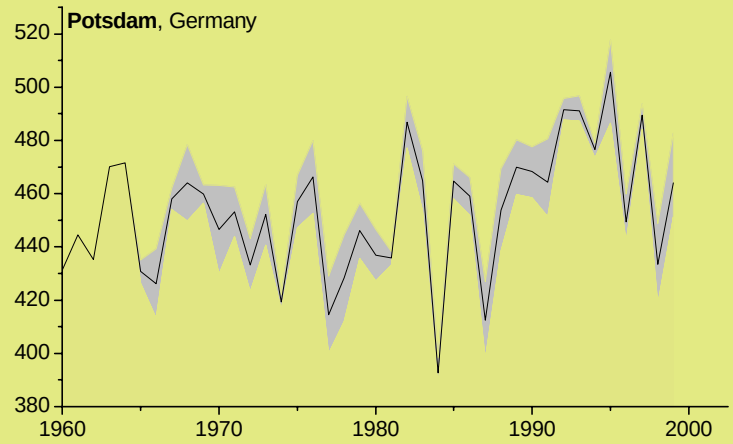
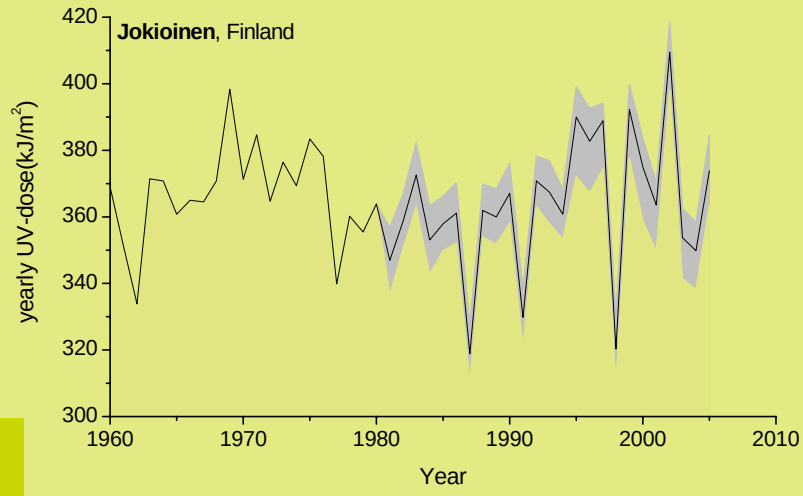
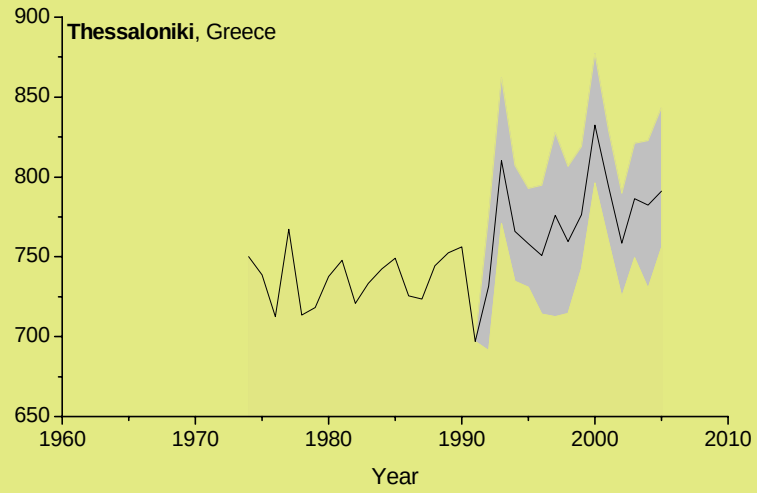
Reconstruction

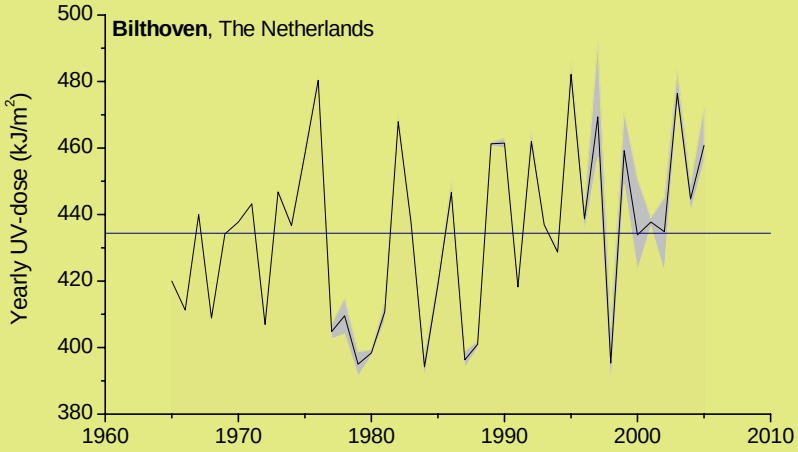


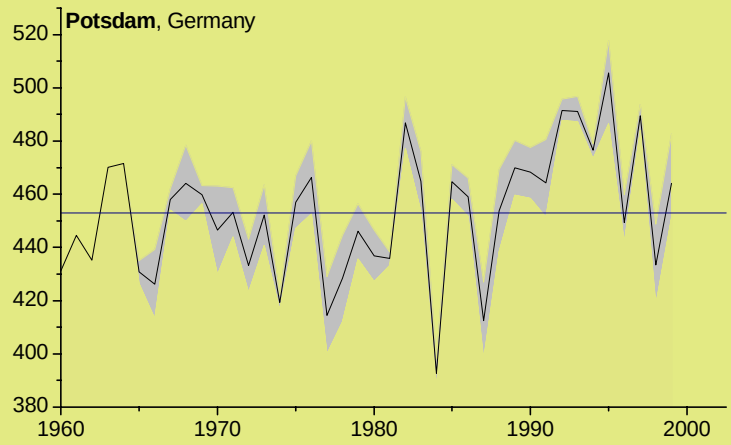


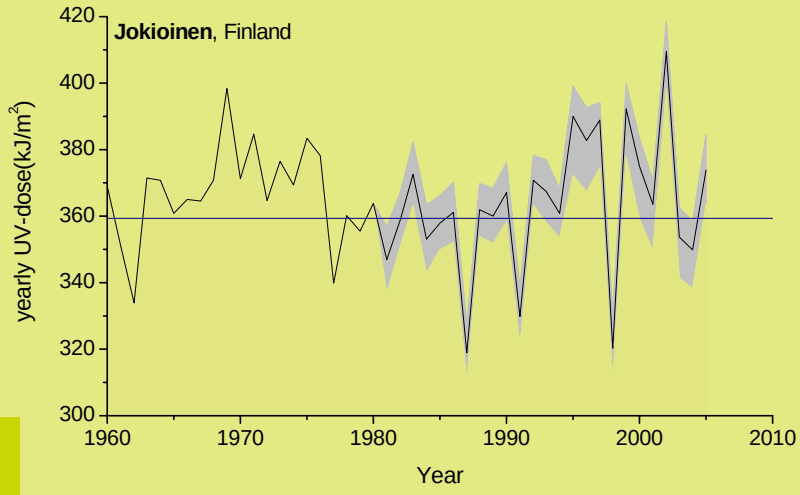


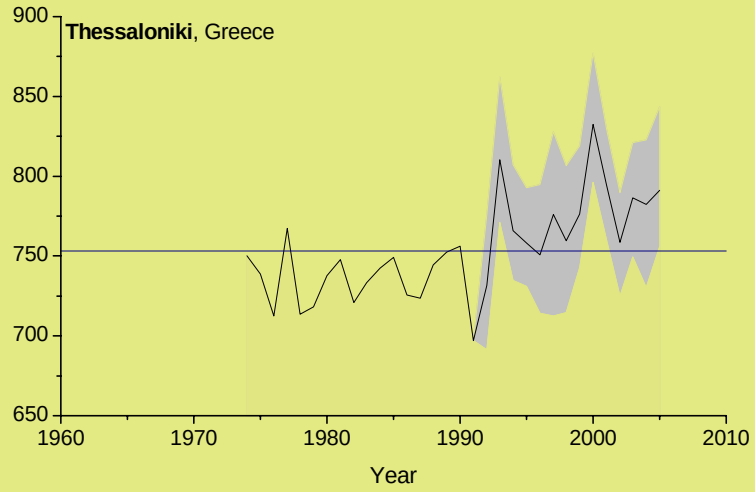


Reconstruction









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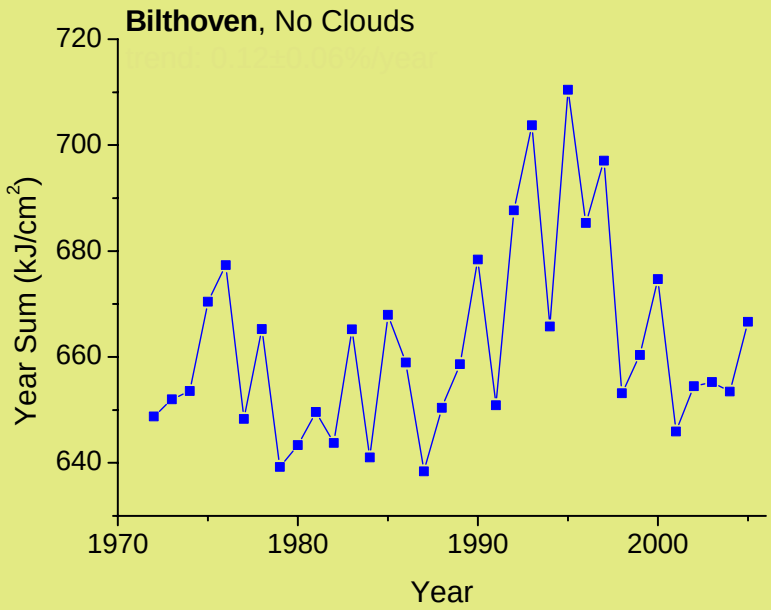

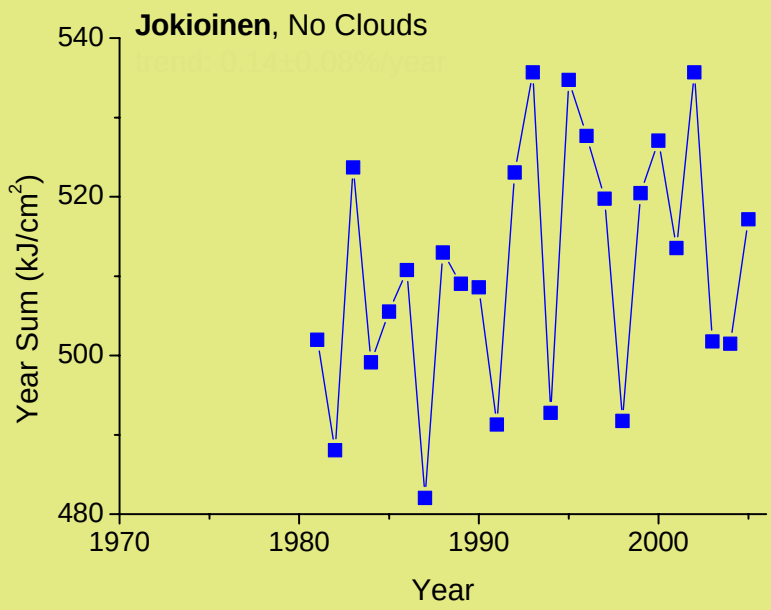

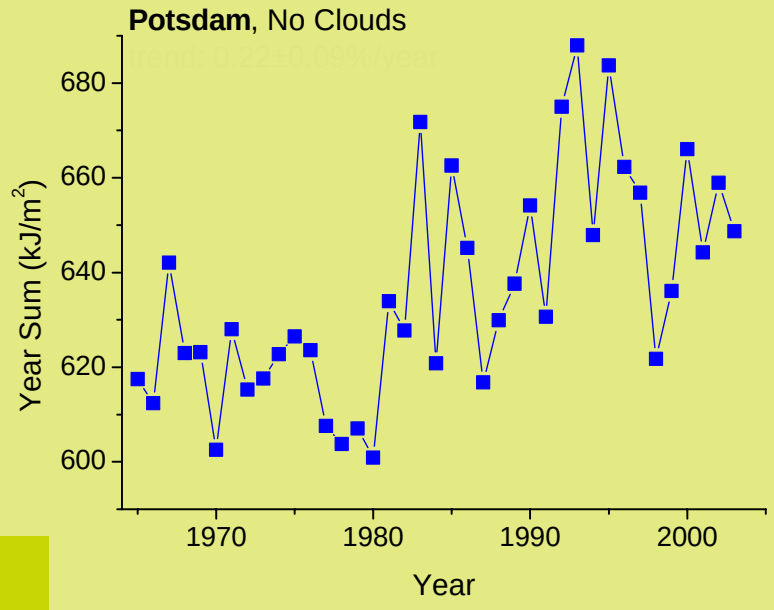

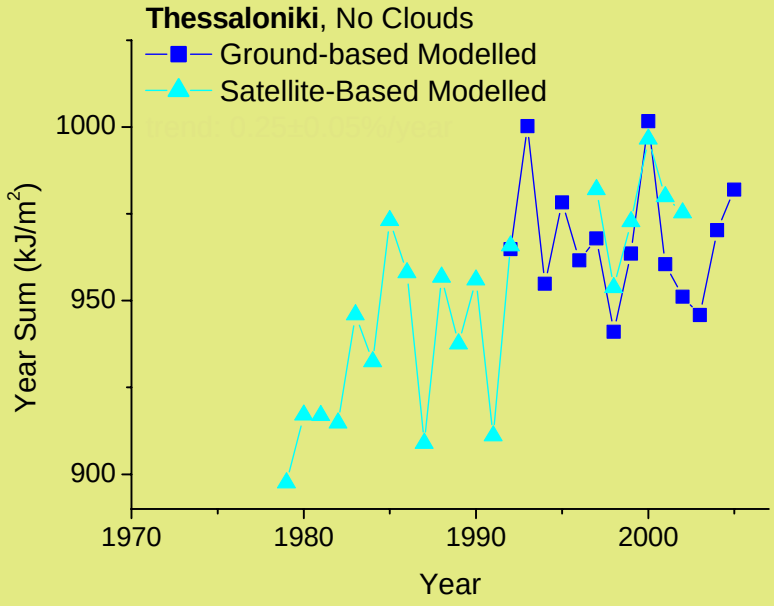

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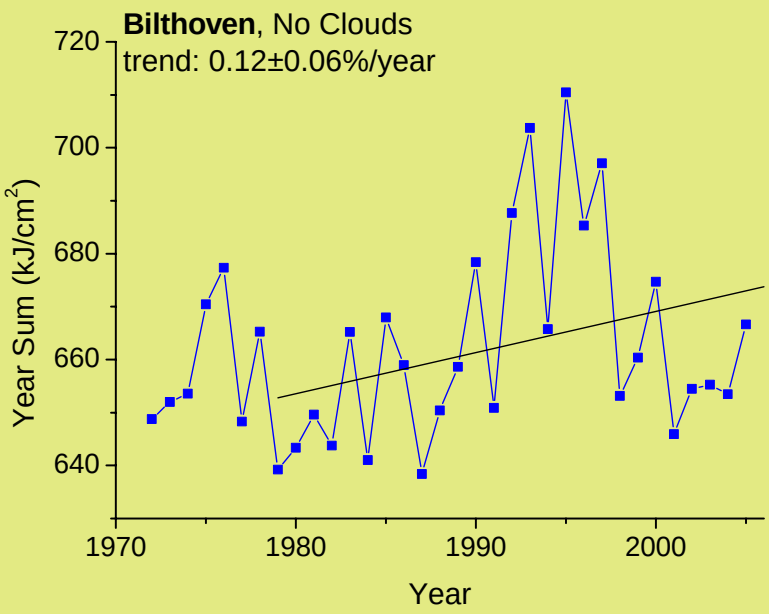

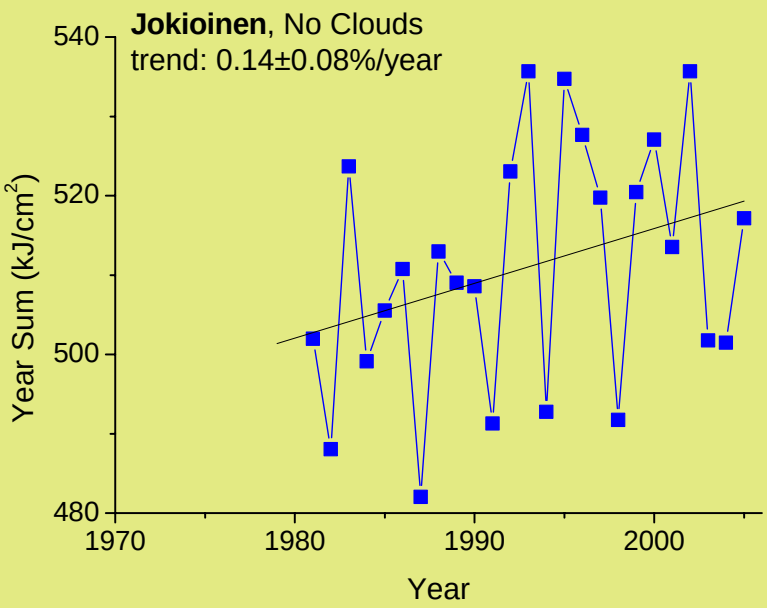

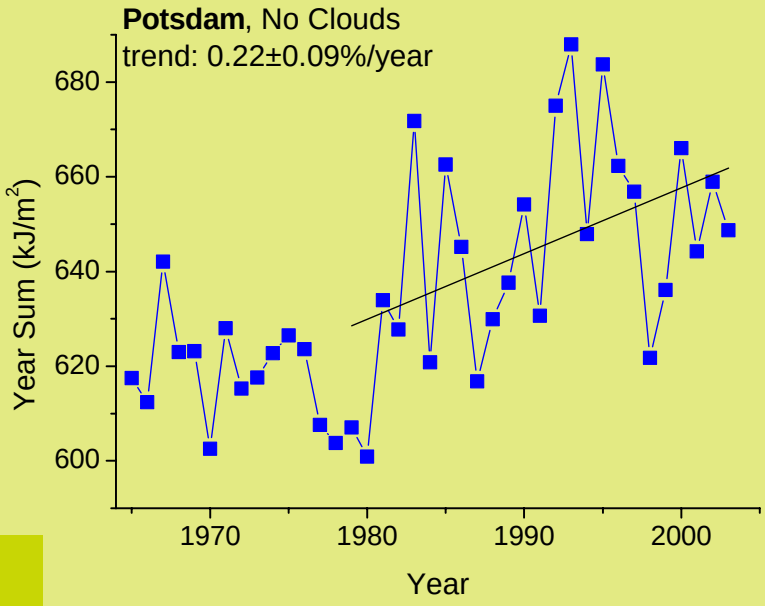

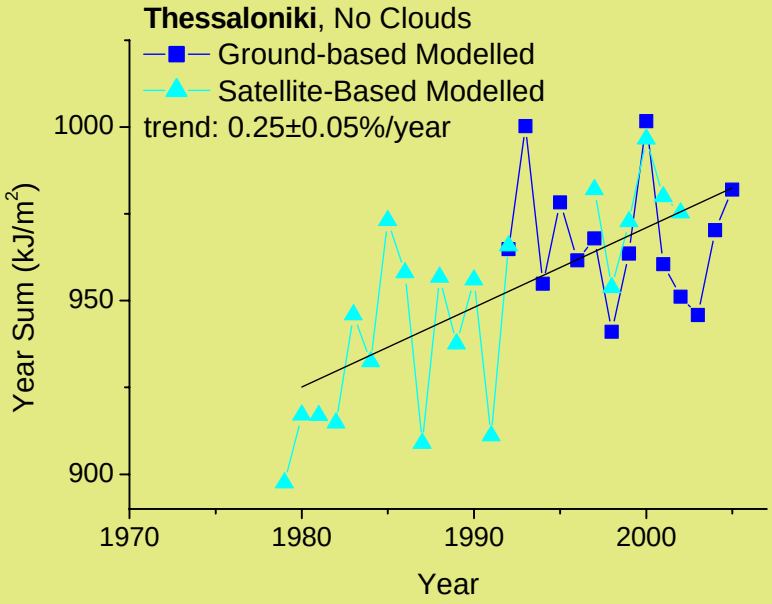

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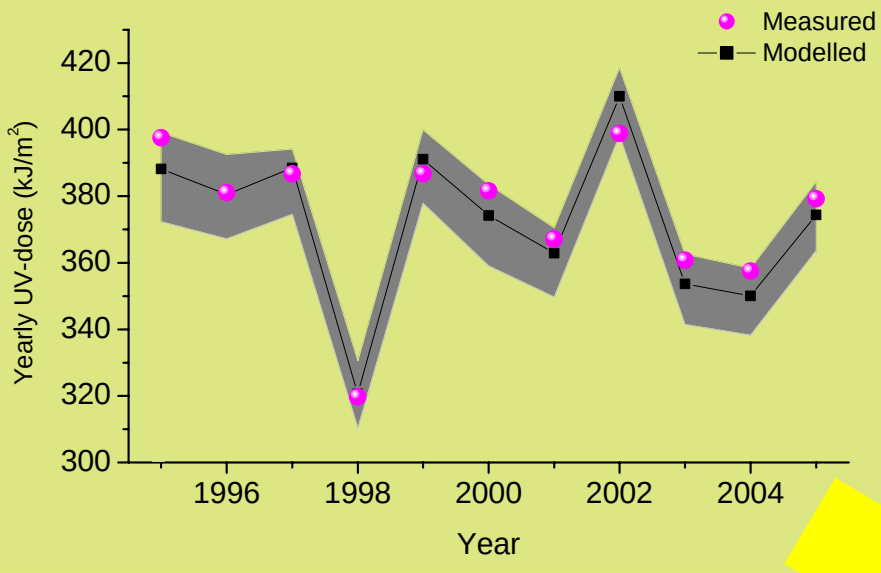
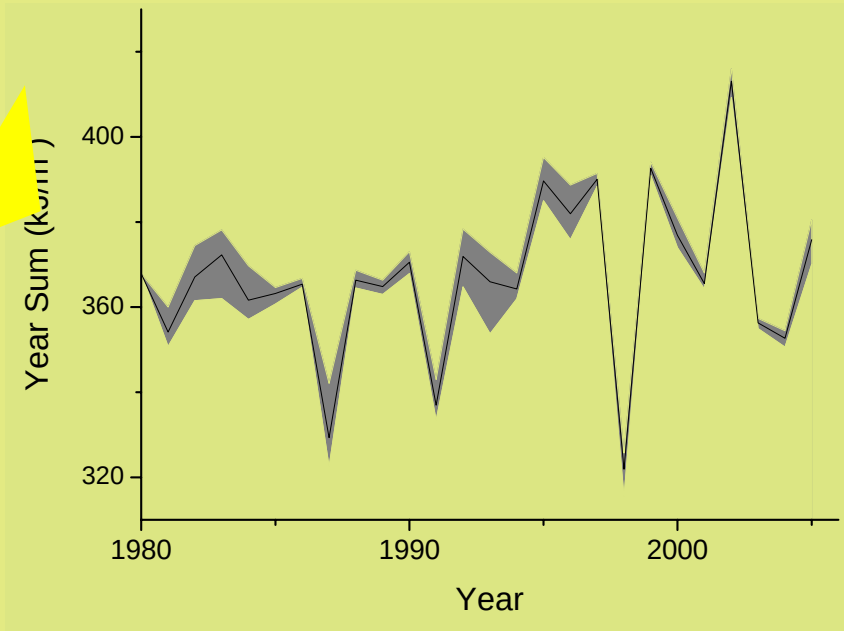

Measured
Modelled
Yearly UV-dose (kJ/m2)
420
400
380
360
340
320
300
1996
1998
2000
2002
2004
Year

Final


Year Sum (kJ/m²)
400
360
320
1980
1990
2000
Year

Summary

- UV reconstruction Models agree well M-M & M-Meas., but also problems identified
- Two model types give distinguishable results
  - NN excellent, require training, local, no meas. validation
  - PE good, general applicable, measurement validation
- Best results obtained with annual pattern supplemented auxiliary data
- Reliable reconstruction is feasible

Based on modeled results:

- Clear sky UV shows increase since eighties, cloudy sky UV less obvious (large year-to-year variability)