Algorithm-development strategies for retrieving the downwelling longwave flux at the Earth's surface

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Models

CRM: Column Radiation Model from CCM3

MODTRAN 3.7

Data

ARM SGP: 15 IOPs from April 1994 to April 1998

ARM TWP: Manus Island for six months during 1997 (JAN, FEB, JUL, AUG, SEP, OCT)

Surface measurements are half-hourly means.

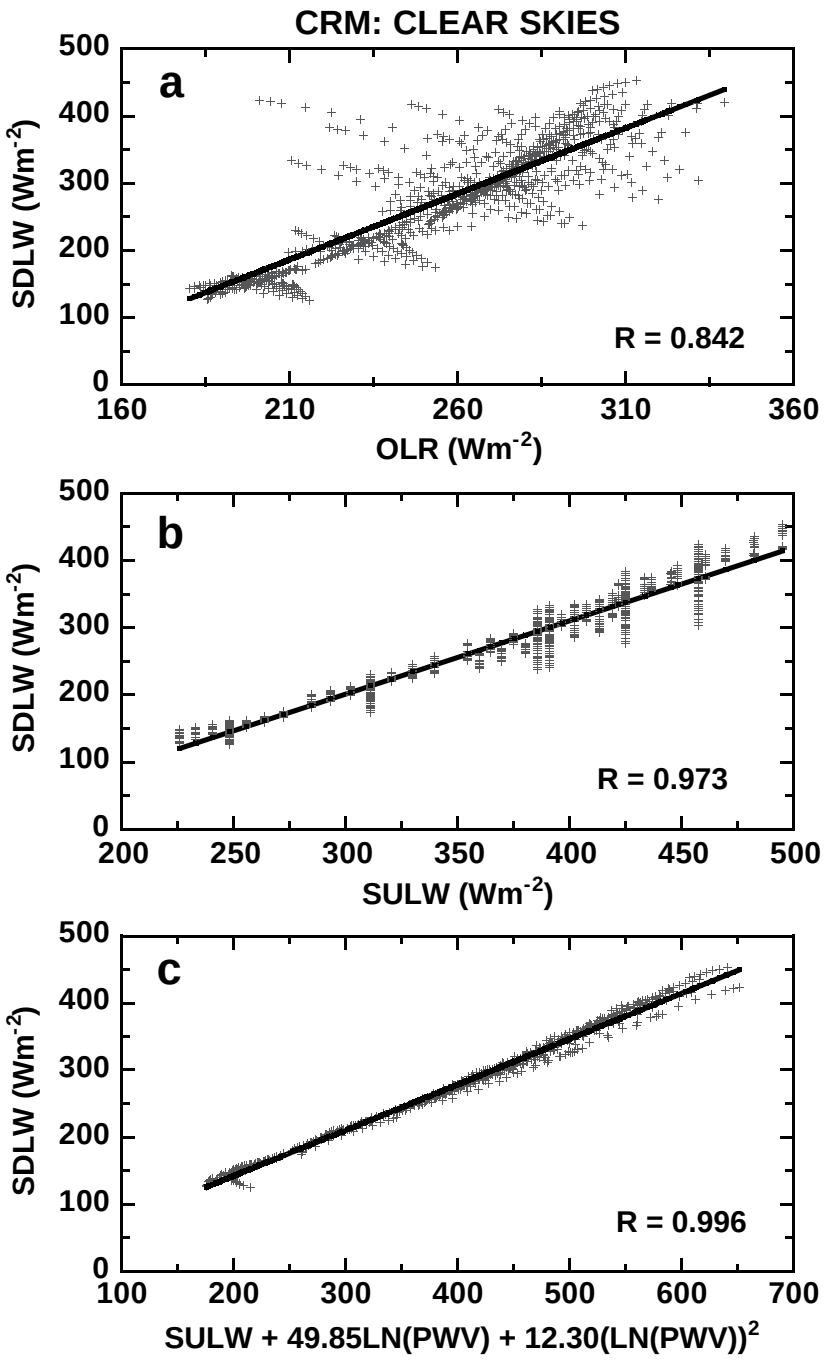
CRM: CLEAR SKIES
a
R = 0.842
SDLW (Wm-2)
OLR (Wm-2)
b
R = 0.973
SDLW (Wm-2)
SULW (Wm-2)
c
R = 0.996
SDLW (Wm-2)
SULW + 49.85LN(PWV) + 12.30(LN(PWV))2

Figure 1

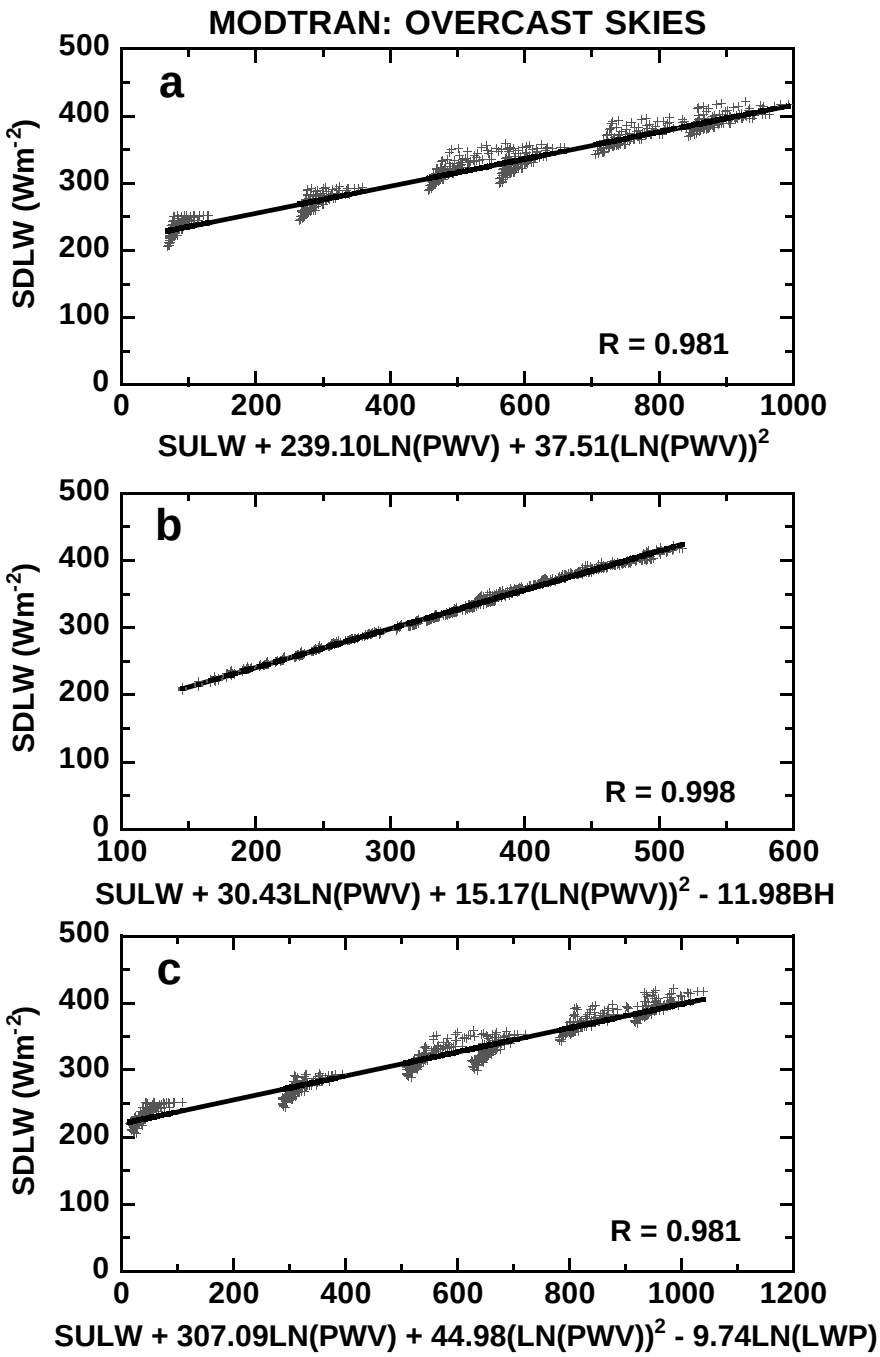
MODTRAN: OVERCAST SKIES
a
SDLW (Wm-2)
R = 0.981
SULW + 239.10LN(PWV) + 37.51(LN(PWV))2
b
SDLW (Wm-2)
R = 0.998
SULW + 30.43LN(PWV) + 15.17(LN(PWV))2 - 11.98BH
c
SDLW (Wm-2)
R = 0.981
SULW + 307.09LN(PWV) + 44.98(LN(PWV))2 - 9.74LN(LWP)

Figure 2

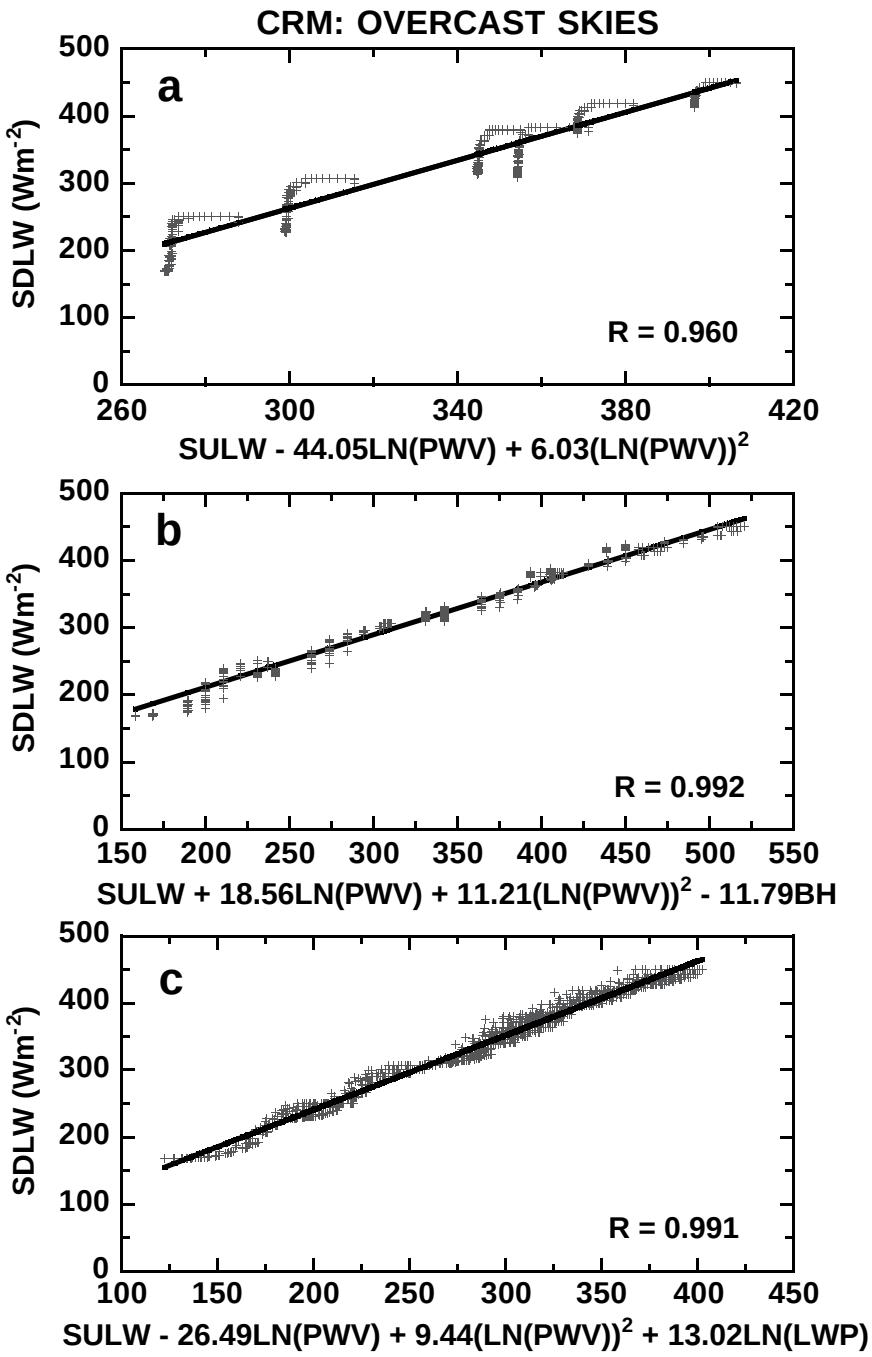
CRM: OVERCAST SKIES
a
SDLW (Wm-2)
R = 0.960
SULW - 44.05LN(PWV) + 6.03(LN(PWV))2
b
SDLW (Wm-2)
R = 0.992
SULW + 18.56LN(PWV) + 11.21(LN(PWV))2 - 11.79BH
c
SDLW (Wm-2)
R = 0.991
SULW - 26.49LN(PWV) + 9.44(LN(PWV))2 + 13.02LN(LWP)

Figure 3

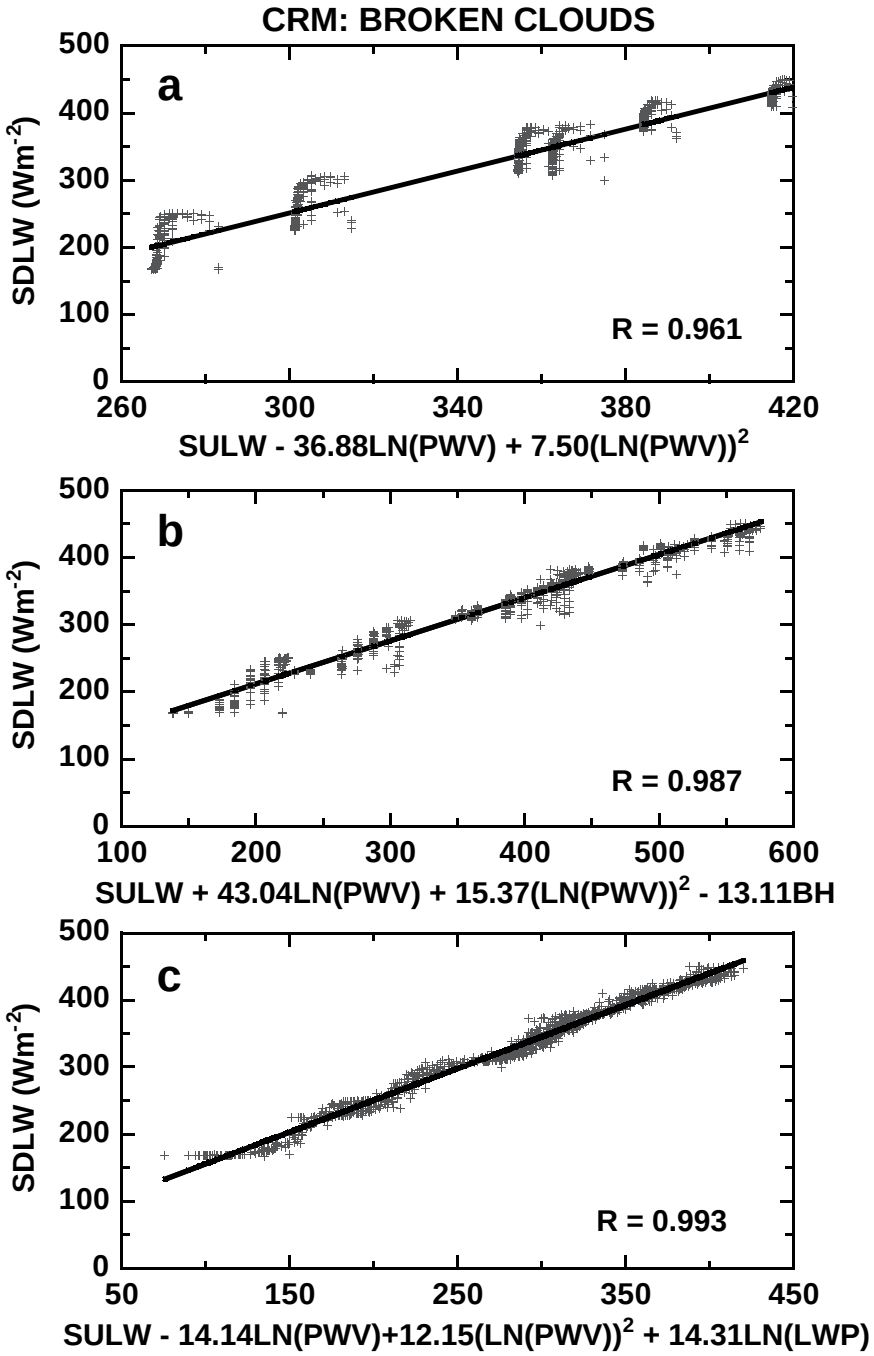
CRM: BROKEN CLOUDS
a
SDLW (Wm-2)
R = 0.961
SULW - 36.88LN(PWV) + 7.50(LN(PWV))2
b
SDLW (Wm-2)
R = 0.987
SULW + 43.04LN(PWV) + 15.37(LN(PWV))2 - 13.11BH
c
SDLW (Wm-2)
R = 0.993
SULW - 14.14LN(PWV)+12.15(LN(PWV))2 + 14.31LN(LWP)

Figure 4

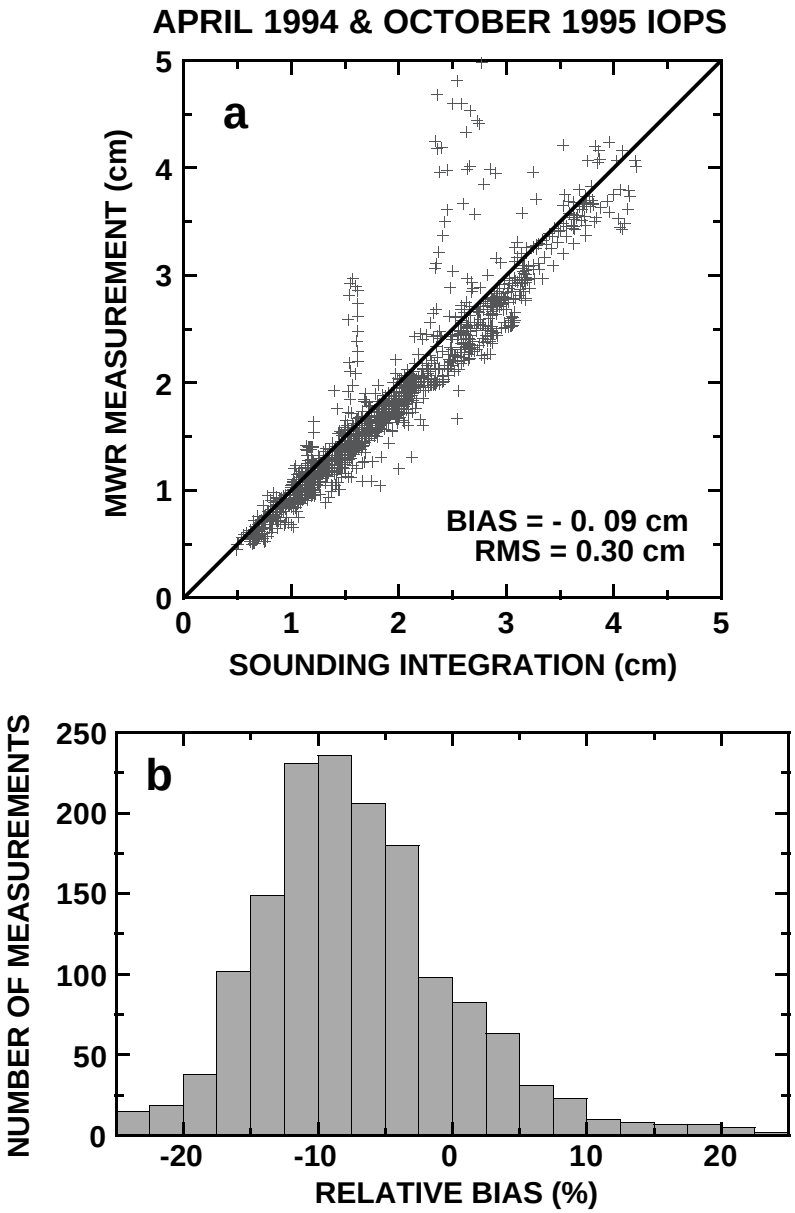
APRIL 1994 & OCTOBER 1995 IOPS
a
MWR MEASUREMENT (cm)
SOUNDING INTEGRATION (cm)
BIAS = - 0. 09 cm
RMS = 0.30 cm
0
1
2
3
4
5
b
NUMBER OF MEASUREMENTS
RELATIVE BIAS (%)
250
200
150
100
50
-20
-10
10
20

Figure 5

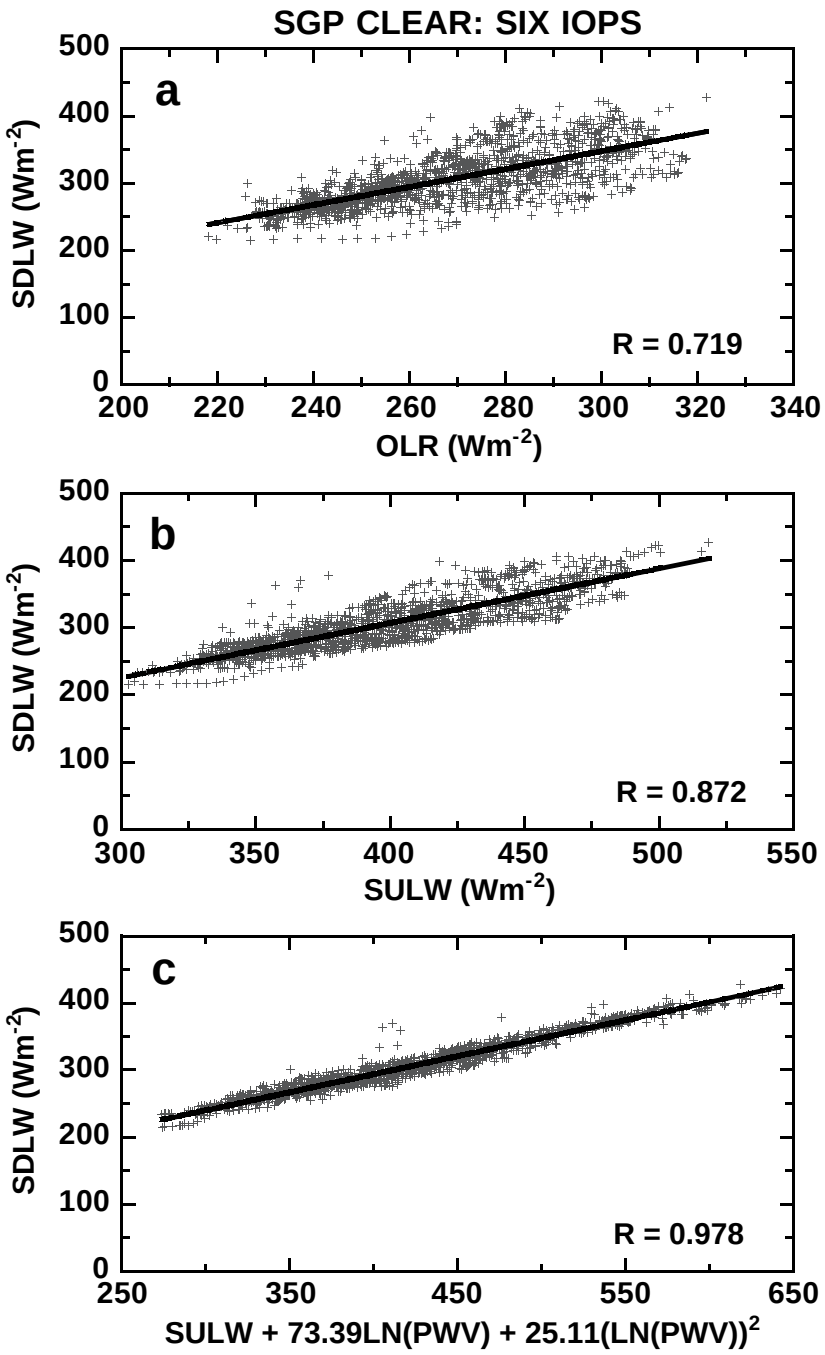
SGP CLEAR: SIX IOPS
a
SDLW (Wm-2)
OLR (Wm-2)
R = 0.719
b
SDLW (Wm-2)
SULW (Wm-2)
R = 0.872
c
SDLW (Wm-2)
SULW + 73.39LN(PWV) + 25.11(LN(PWV))2
R = 0.978

Figure 6

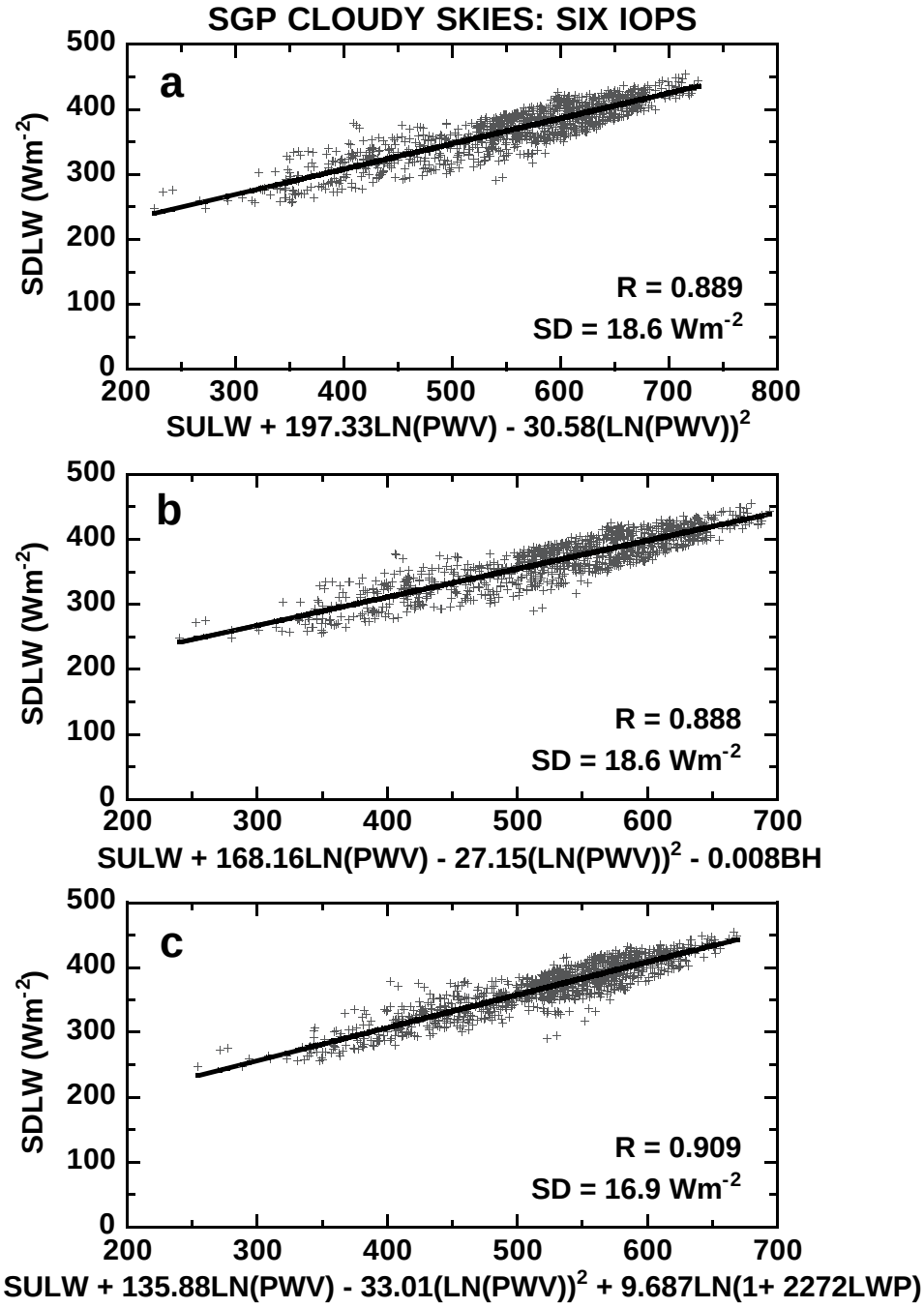
SGP CLOUDY SKIES: SIX IOPS
a
SDLW (Wm-2)
R = 0.889
SD = 18.6 Wm-2
SULW + 197.33LN(PWV) - 30.58(LN(PWV))2
b
SDLW (Wm-2)
R = 0.888
SD = 18.6 Wm-2
SULW + 168.16LN(PWV) - 27.15(LN(PWV))2 - 0.008BH
c
SDLW (Wm-2)
R = 0.909
SD = 16.9 Wm-2
SULW + 135.88LN(PWV) - 33.01(LN(PWV))2 + 9.687LN(1+ 2272LWP)

Figure 7

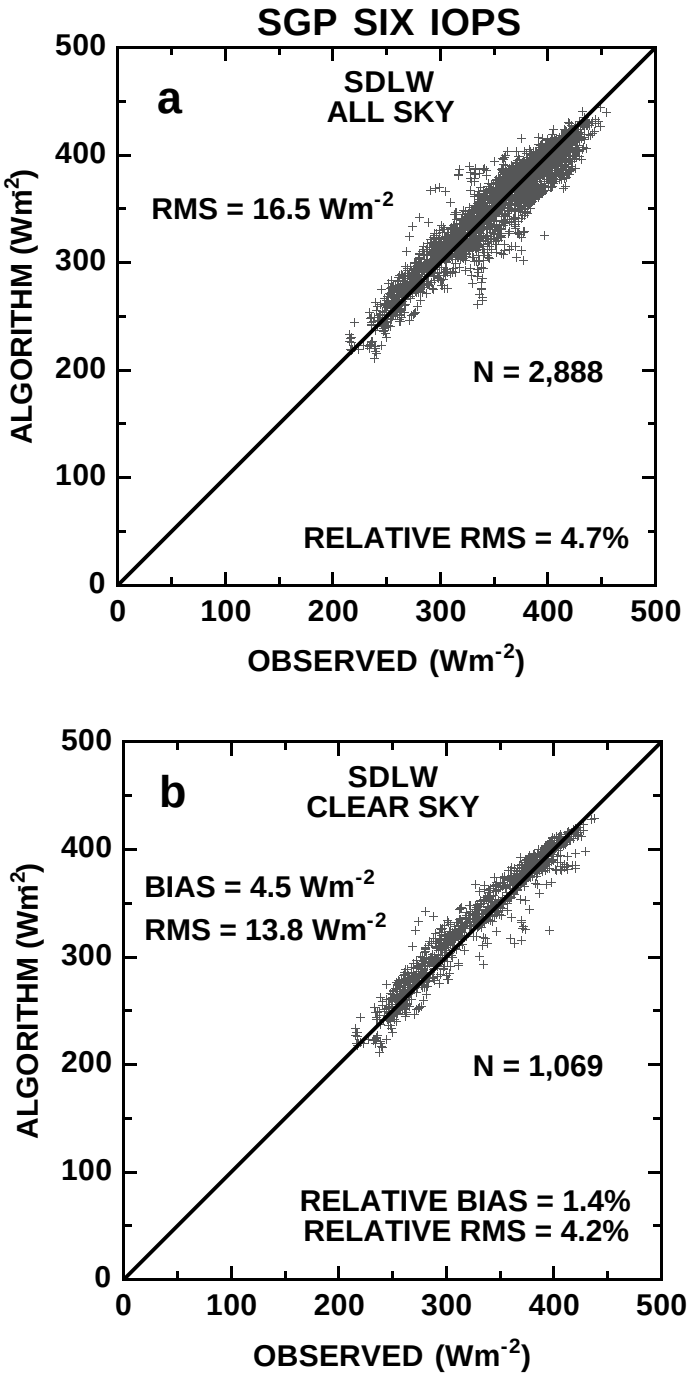
SGP SIX IOPS
a
SDLW
ALL SKY
RMS = 16.5 Wm-2
N = 2,888
RELATIVE RMS = 4.7%
ALGORITHM (Wm-2)
OBSERVED (Wm-2)
0
100
200
300
400
500
b
SDLW
CLEAR SKY
BIAS = 4.5 Wm-2
RMS = 13.8 Wm-2
N = 1,069
RELATIVE BIAS = 1.4%
RELATIVE RMS = 4.2%
ALGORITHM (Wm-2)
OBSERVED (Wm-2)

Figure 8

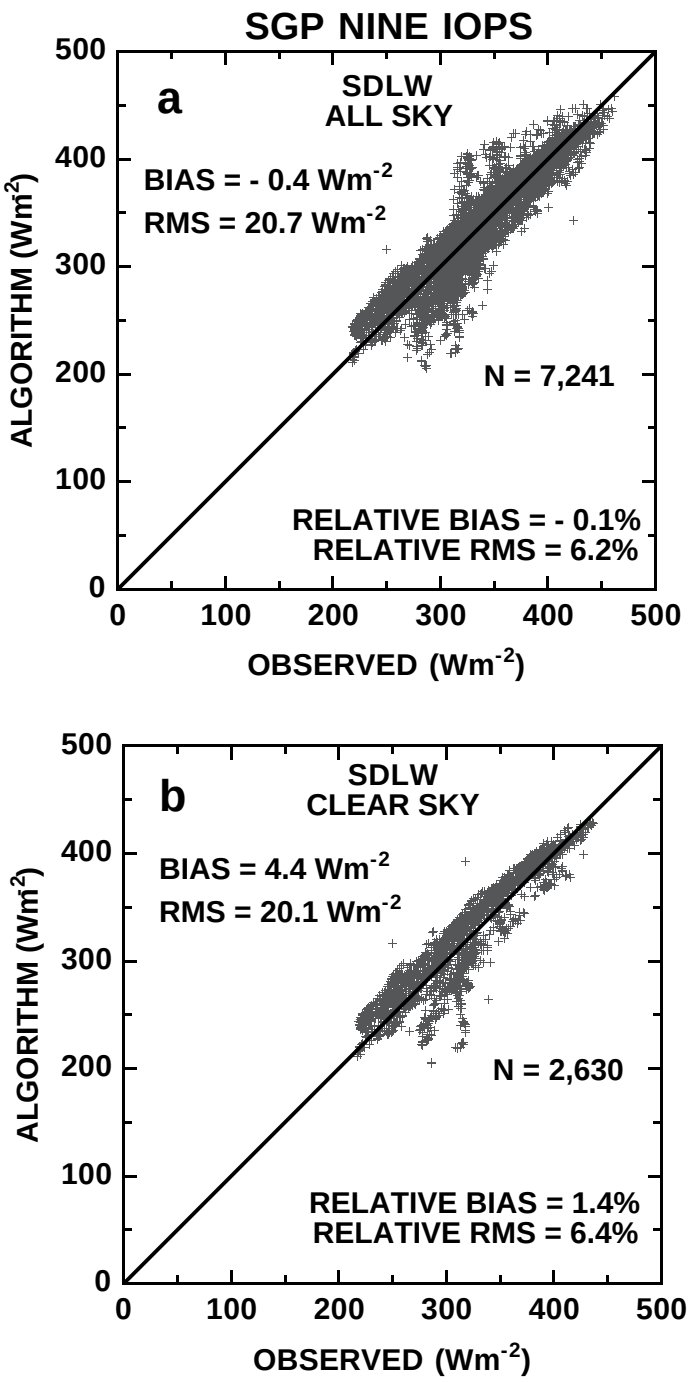
SGP NINE IOPS
a
SDLW
ALL SKY
BIAS = - 0.4 Wm-2
RMS = 20.7 Wm-2
N = 7,241
RELATIVE BIAS = - 0.1%
RELATIVE RMS = 6.2%
ALGORITHM (Wm-2)
OBSERVED (Wm-2)
0
100
200
300
400
500
b
SDLW
CLEAR SKY
BIAS = 4.4 Wm-2
RMS = 20.1 Wm-2
N = 2,630
RELATIVE BIAS = 1.4%
RELATIVE RMS = 6.4%
ALGORITHM (Wm-2)
OBSERVED (Wm-2)

Figure 9

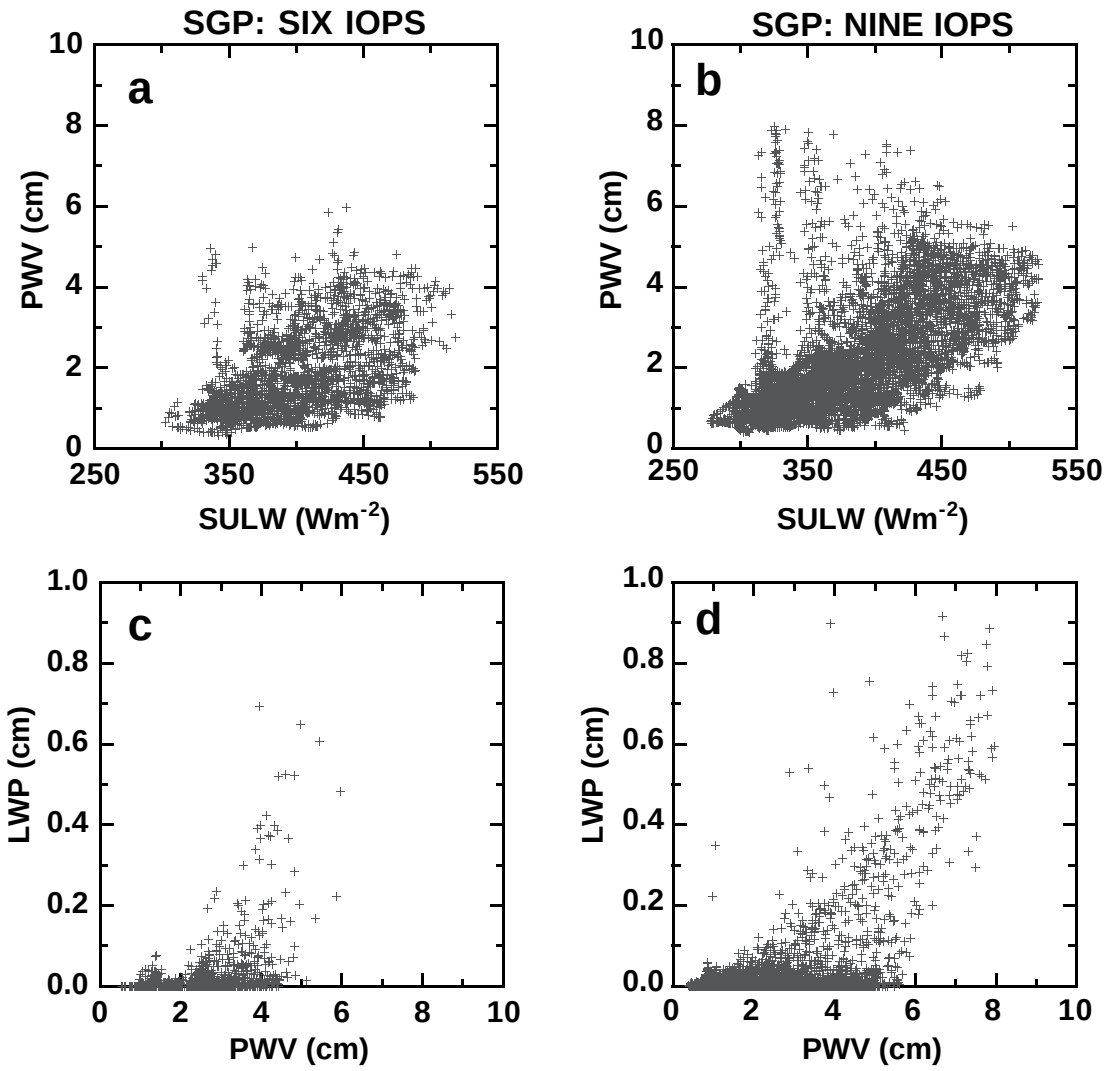
SGP: SIX IOPS
SGP: NINE IOPS
a
b
c
d
PWV (cm)
SULW (Wm-2)
LWP (cm)
PWV (cm)
0
2
4
6
8
10
250
350
450
550
0.0
0.2
0.4
0.6
0.8
1.0

Figure 10

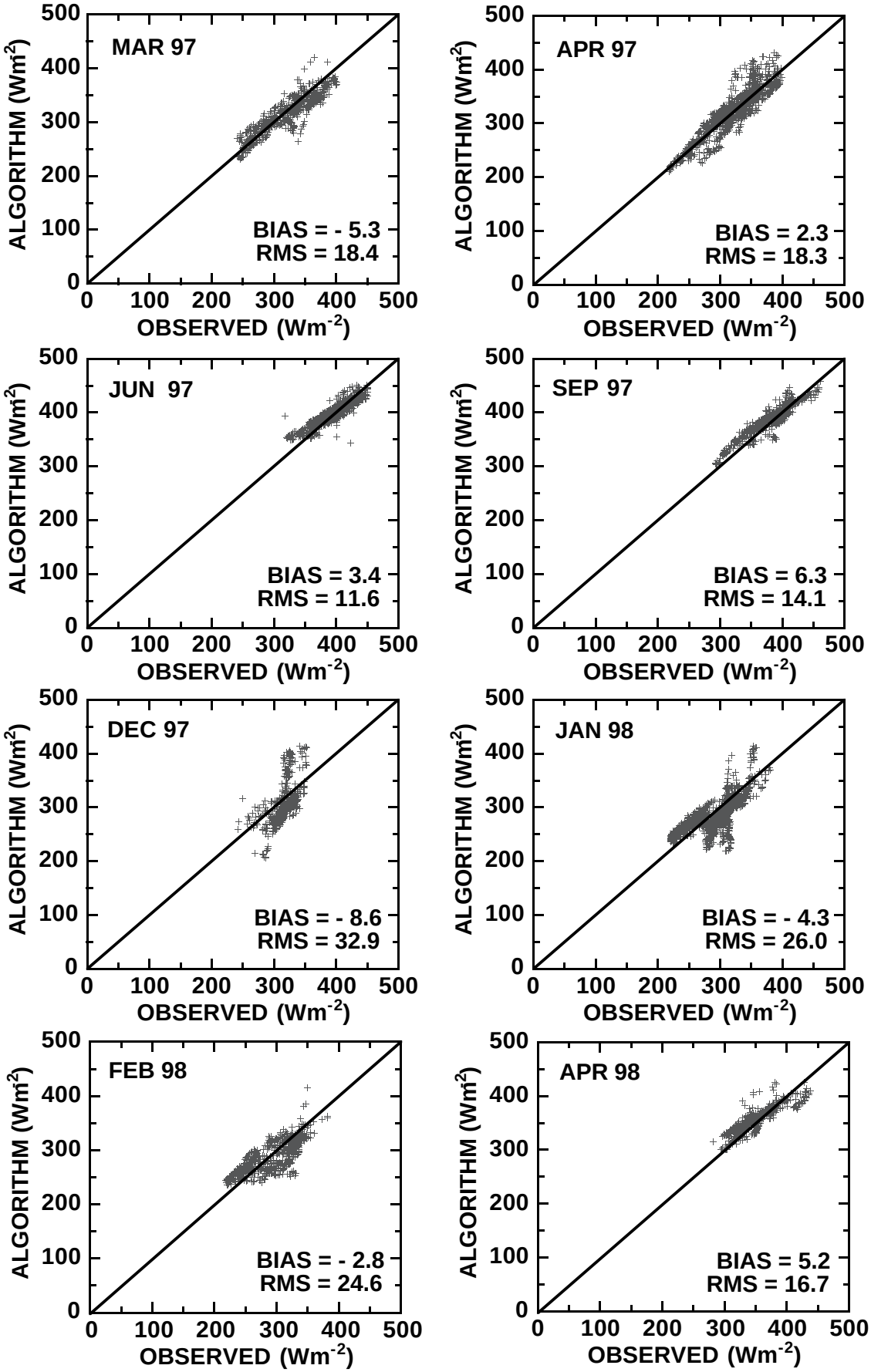
MAR 97
BIAS = - 5.3
RMS = 18.4
APR 97
BIAS = 2.3
RMS = 18.3
JUN 97
BIAS = 3.4
RMS = 11.6
SEP 97
BIAS = 6.3
RMS = 14.1
DEC 97
BIAS = - 8.6
RMS = 32.9
JAN 98
BIAS = - 4.3
RMS = 26.0
FEB 98
BIAS = - 2.8
RMS = 24.6
APR 98
BIAS = 5.2
RMS = 16.7
ALGORITHM (Wm-2)
OBSERVED (Wm-2)
0
100
200
300
400
500

Figure 11

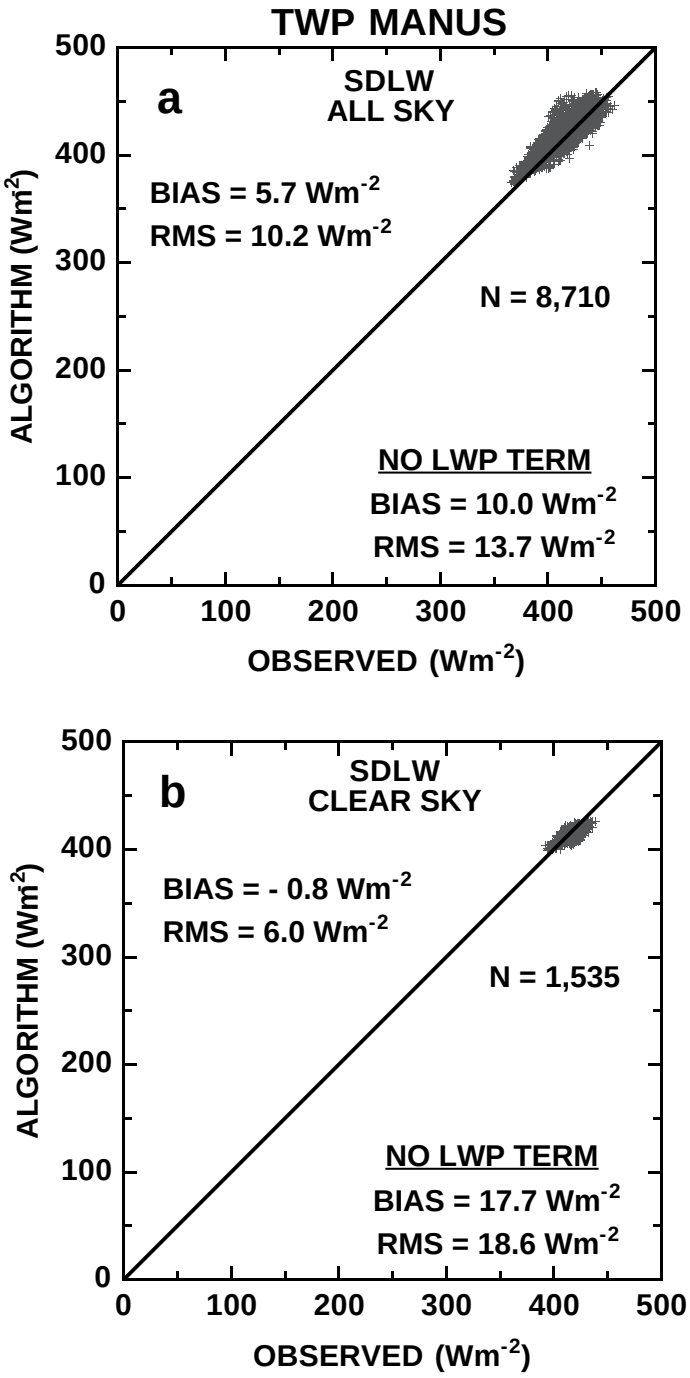
TWP MANUS
a
SDLW
ALL SKY
BIAS = 5.7 Wm-2
RMS = 10.2 Wm-2
N = 8,710
NO LWP TERM
BIAS = 10.0 Wm-2
RMS = 13.7 Wm-2
ALGORITHM (Wm-2)
OBSERVED (Wm-2)
0
100
200
300
400
500
b
SDLW
CLEAR SKY
BIAS = - 0.8 Wm-2
RMS = 6.0 Wm-2
N = 1,535
NO LWP TERM
BIAS = 17.7 Wm-2
RMS = 18.6 Wm-2
ALGORITHM (Wm-2)
OBSERVED (Wm-2)

Figure 12

Conclusions

- **Both the model sensitivity studies and the data correlations suggest that cloud-base height might not be a useful grid-averaged input parameter.**
- **Although SDLW should not depend upon cloud liquid water, this does appear to be a useful input parameter in the context of serving as a surrogate for cloud-base height.**
- **A simple parameterization for SDLW in terms of PWV and LWP might be geographically invariant except for regions where there are low-level ice clouds.**