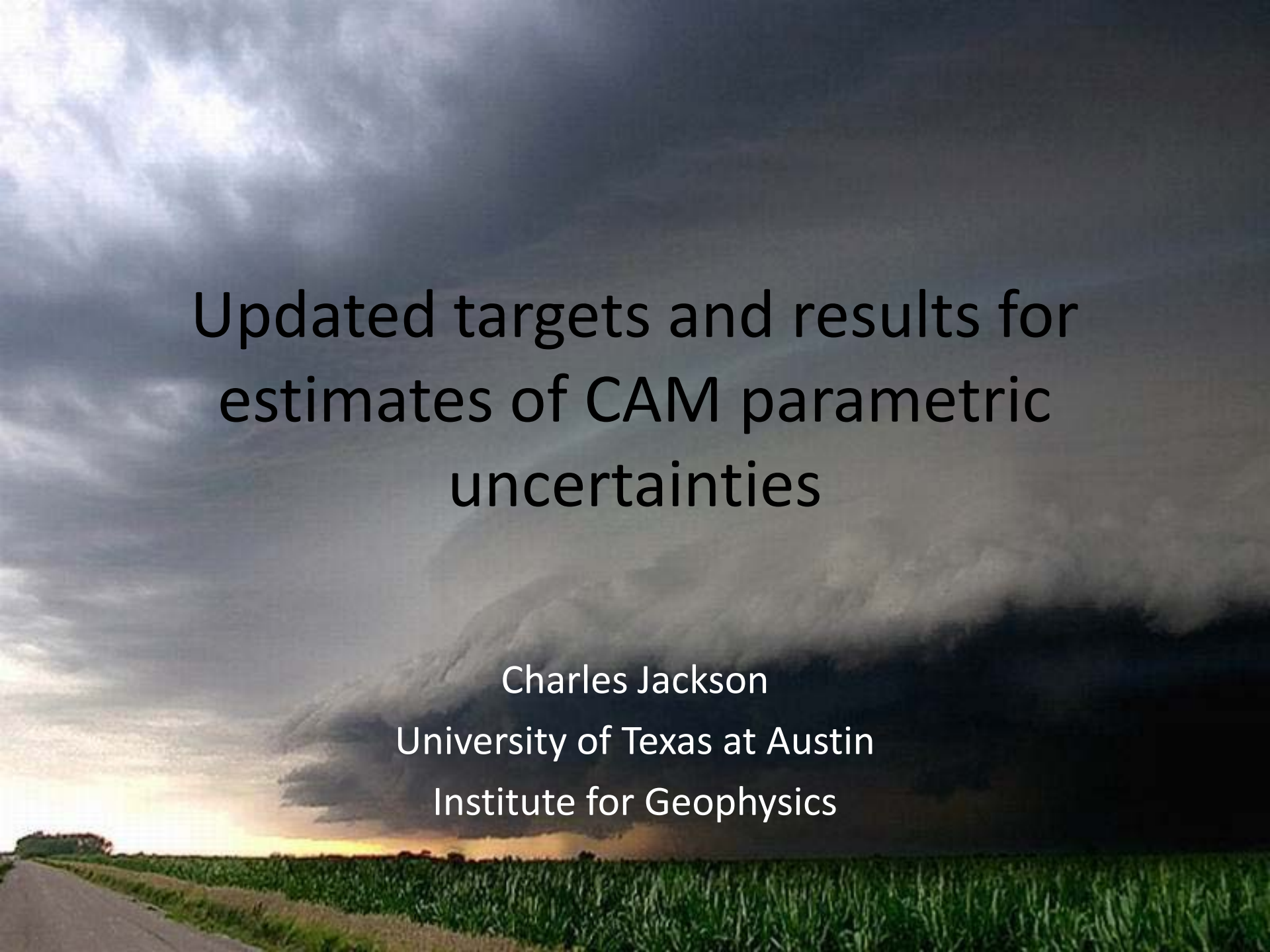

Updated targets and results for estimates of CAM parametric uncertainties

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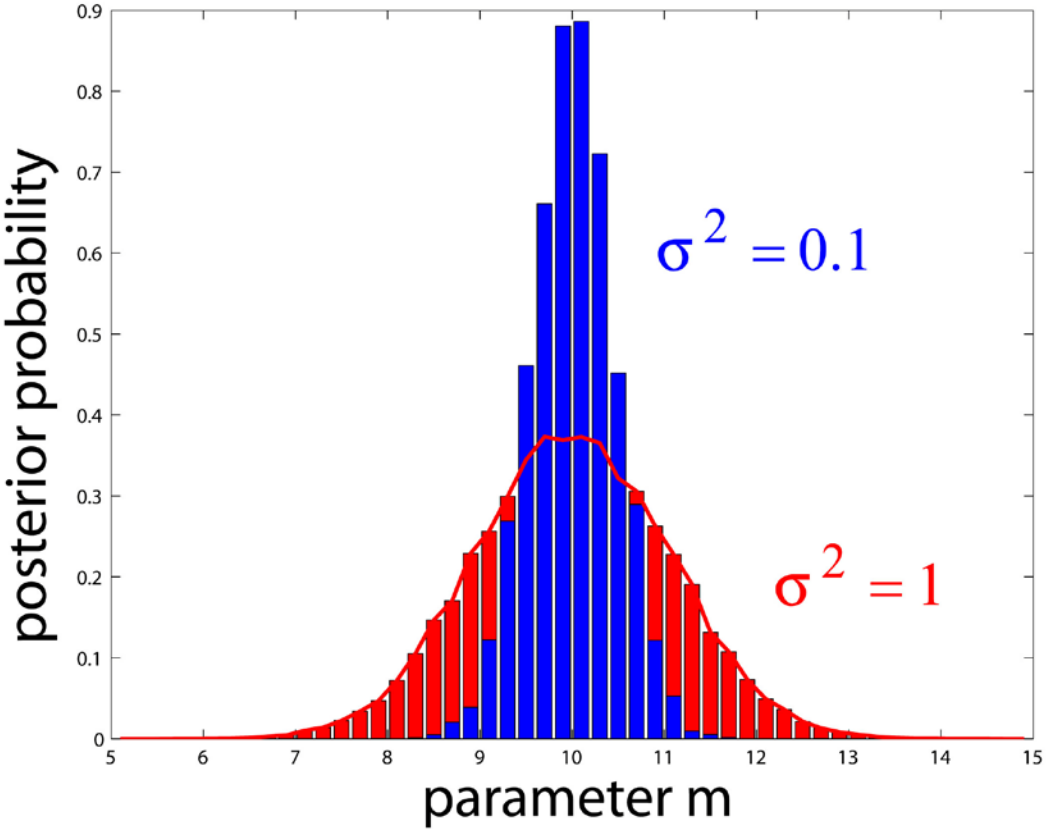
University of Texas at Austin
Institute for Geophysics

Near-term goals for uncertainty quantification and data directed model development

- Improve codes that manage calculation on hpc resources for open source release.

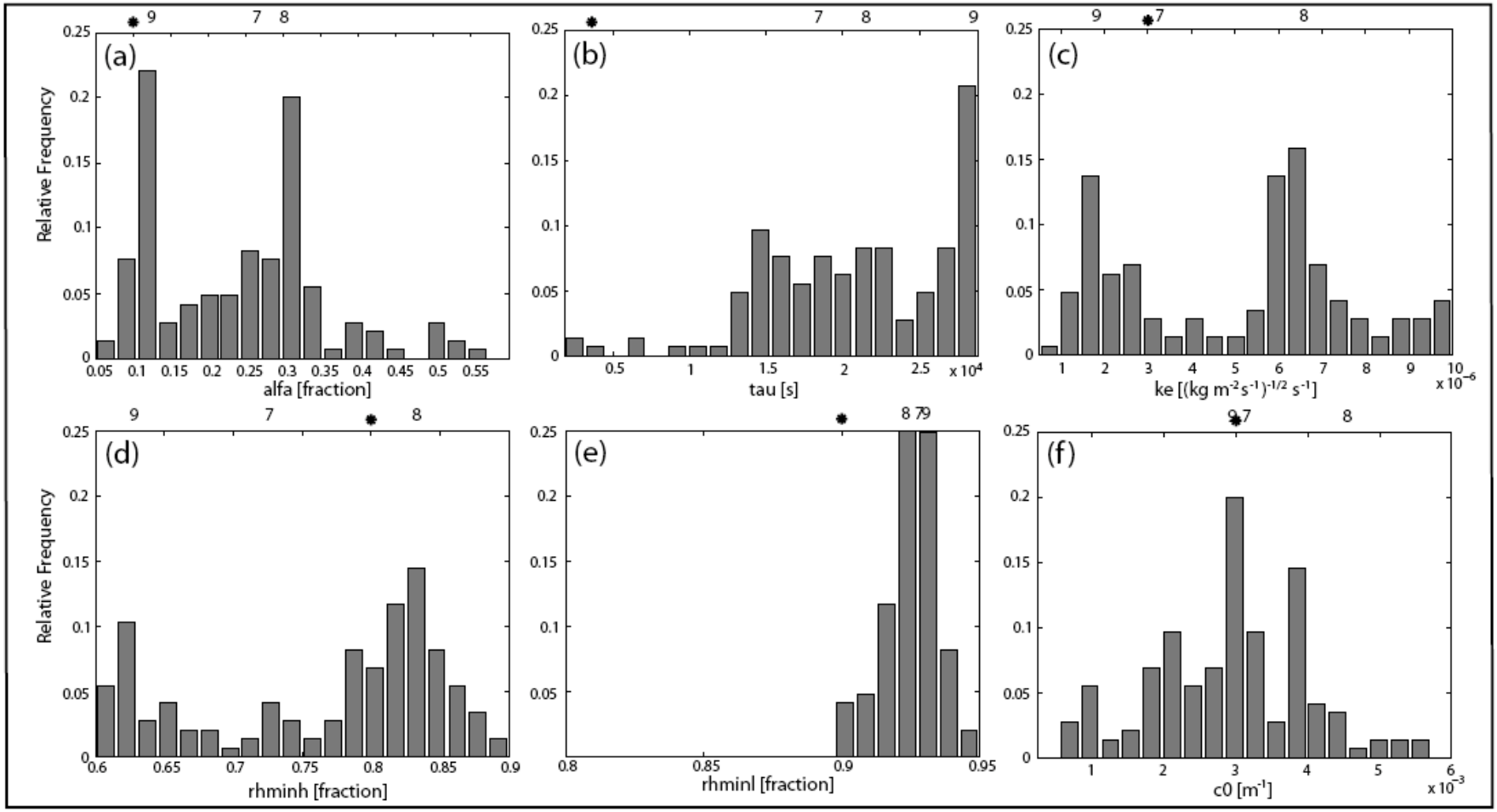
- Better communicate relevance of approach to model development, i.e. target the AMWG web diagnostics Taylor metrics.

$$PPD(\mathbf{m}\,|\,\mathbf{d}_{obs}, g(\mathbf{m})) \propto \exp\left[-\frac{1}{2}\left(g(\mathbf{m})-\mathbf{d}_{obs}\right)^{T}\mathbf{C}_{noise}^{-1}\left(g(\mathbf{m})-\mathbf{d}_{obs}\right)\right]\cdot prior(\mathbf{m})$$

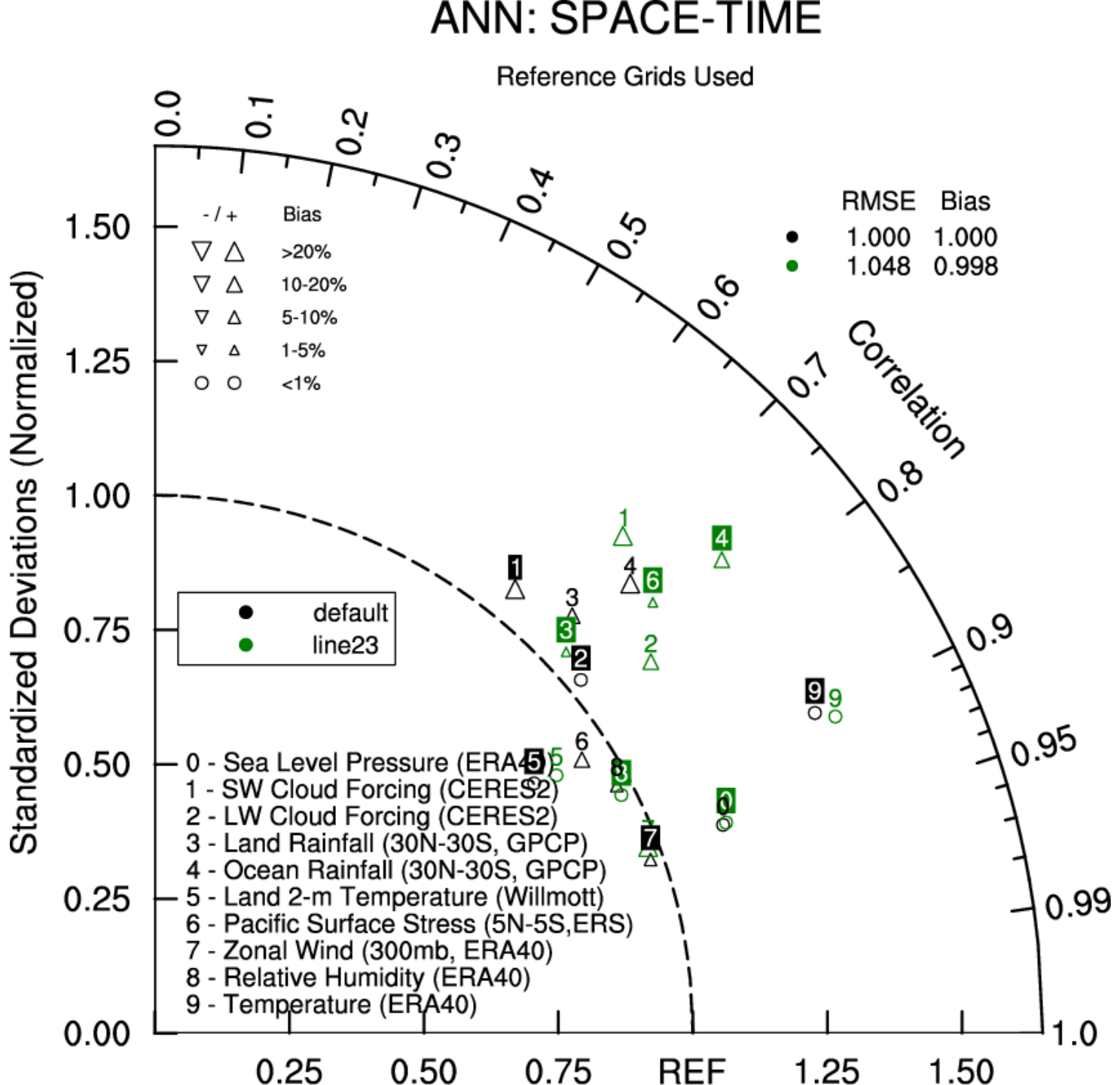


$$E(m) = \frac{(m-10)^2}{2\sigma^2}$$

Posterior Probability Density
(NCEP-based cost function, 6 parameters)



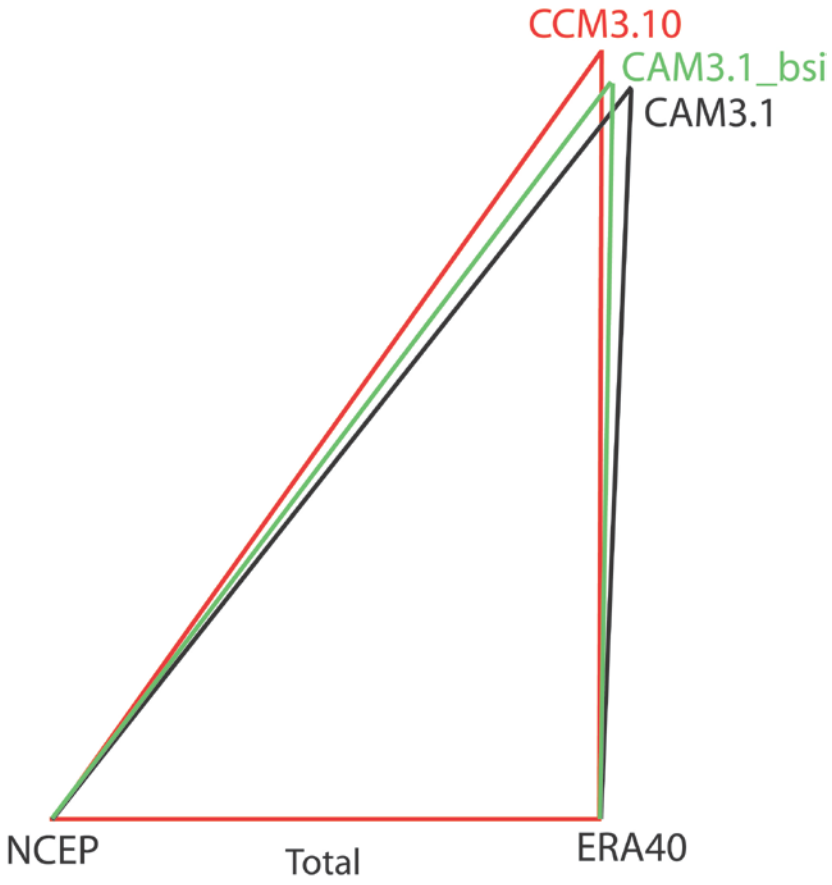
Discussed (but not shown) in Jackson et al., (2008)

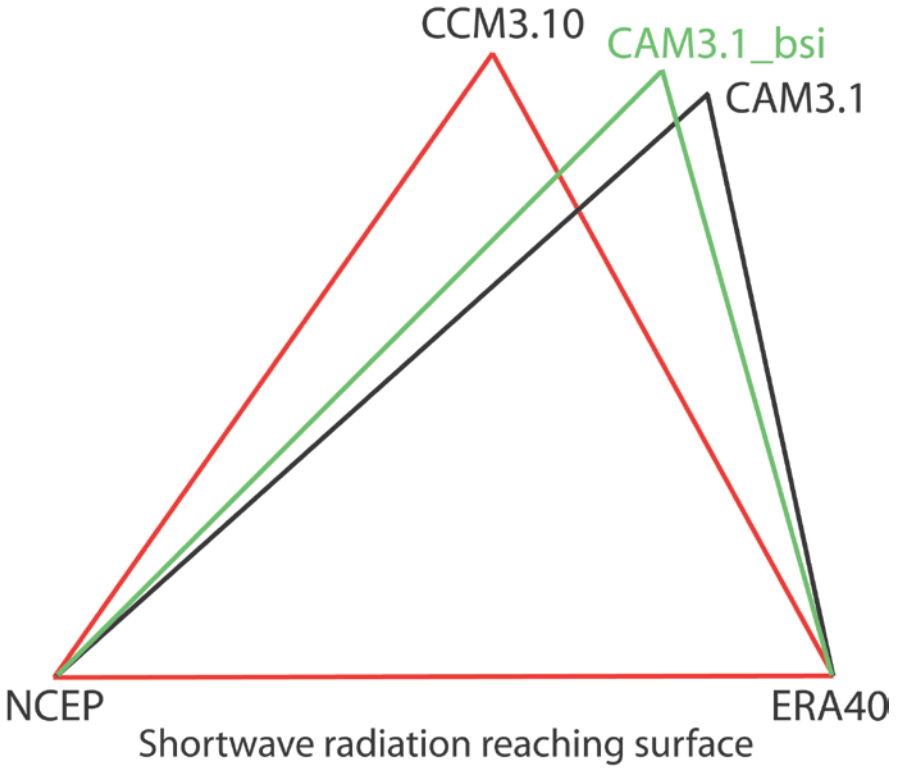

ANN: SPACE-TIME
Reference Grids Used
Standardized Deviations (Normalized)
Correlation
RMSE Bias
1.000 1.000
1.048 0.998
- / + Bias
>20%
10-20%
5-10%
1-5%
<1%
default
line23
0 - Sea Level Pressure (ERA40)
1 - SW Cloud Forcing (CERES2)
2 - LW Cloud Forcing (CERES2)
3 - Land Rainfall (30N-30S, GPCP)
4 - Ocean Rainfall (30N-30S, GPCP)
5 - Land 2-m Temperature (Willmott)
6 - Pacific Surface Stress (5N-5S,ERS)
7 - Zonal Wind (300mb, ERA40)
8 - Relative Humidity (ERA40)
9 - Temperature (ERA40)
REF

Model-Data Comparison of:

1. **Low-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
2. **Mid-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
3. **High-level clouds**, 1990-2001, ISCCP satellite observations (Rossow et al. 1991)
4. **Net shortwave top**, 1985-1989, ERBE satellite observations (Barkstrom et al. 1989)
5. **Net longwave top**, 1985-1989, ERBE satellite observations (Barkstrom et al. 1989)
6. **Global radiative balance top**, 0.3 Watts/m2, imposed.
7. **Shortwave radiation to surface**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al.2001)
8. **2m air temperature**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
9. **Surface sensible heat flux**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
10. **Surface latent heat flux**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
11. **Relative humidity (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al.2001)
12. **Air temperature (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
13. **Zonal winds (zonal mean)**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
14. **Sea level pressure**, 1990-2001, NCEP reanalysis data (Kalnay et al. 1991, Kistler et al. 2001)
15. **Precipitation**, 1990-2001, CMAP instrumental record (Xie and Arkin 1996, 1997)

NCEP reanalysis ‘obs’ ≠ ECMWF ‘obs’





AMWG-inspired analysis

- CAM3.1
- Use “top 10” Taylor metrics
- 2-year model integration, climatological sst, use last year for analysis
- Same 6 parameters
- 2020 experiments completed
- Optimal configurations ~5% better than default
- http://web.me.com/csj/CAM_Stochastic_Inversion/Welcome.html

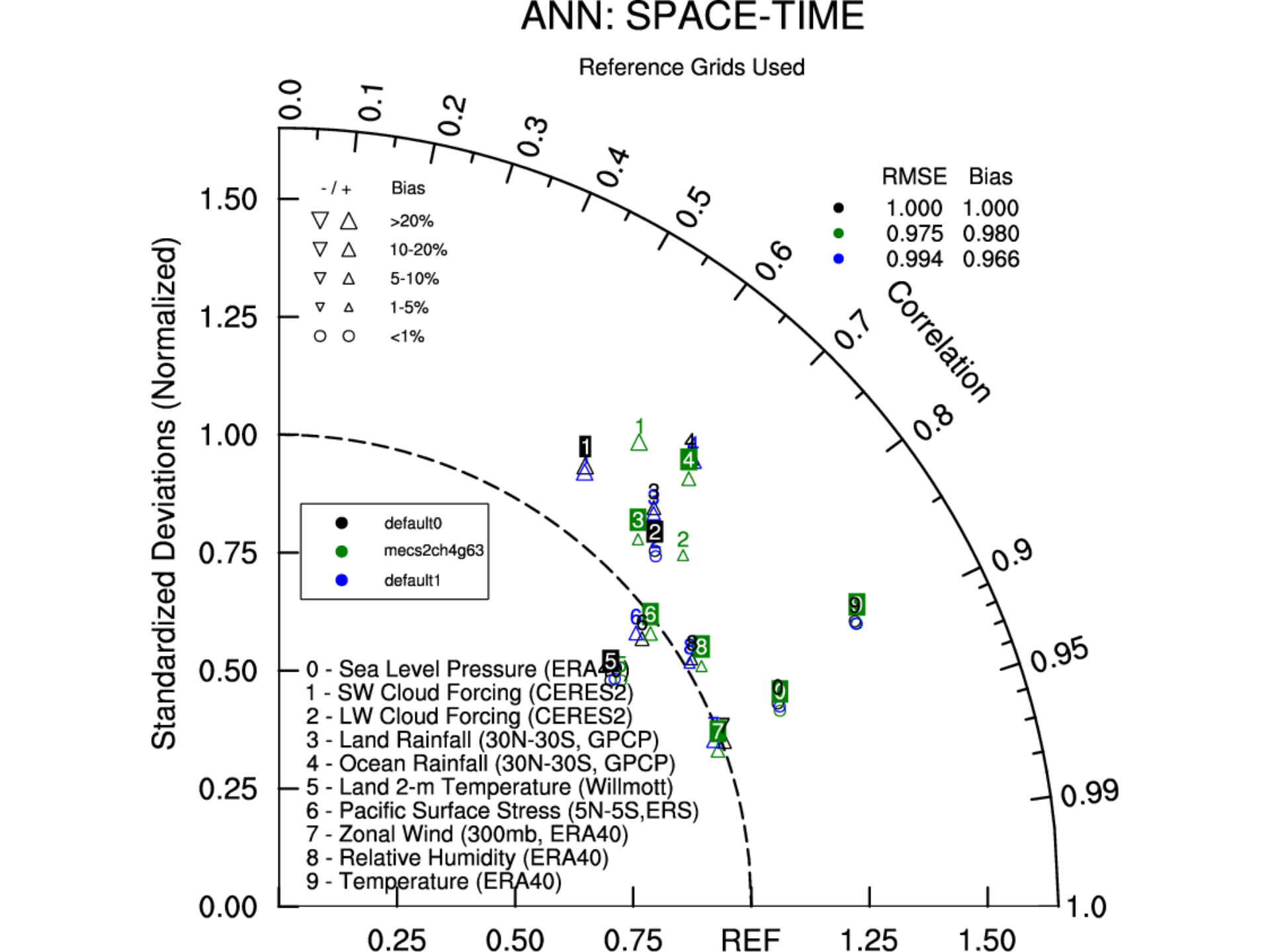
User name: cam

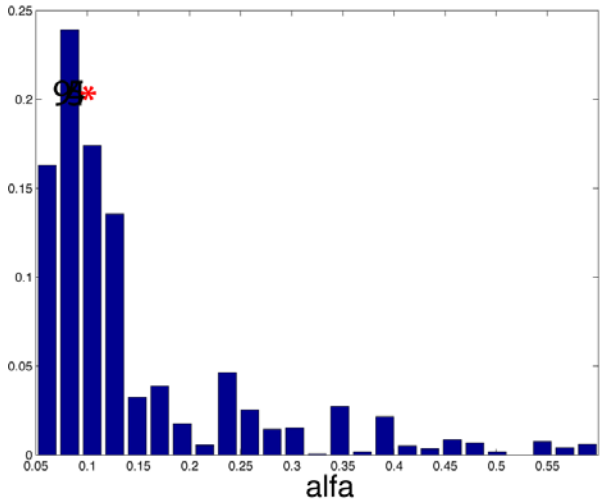
Password: tuning

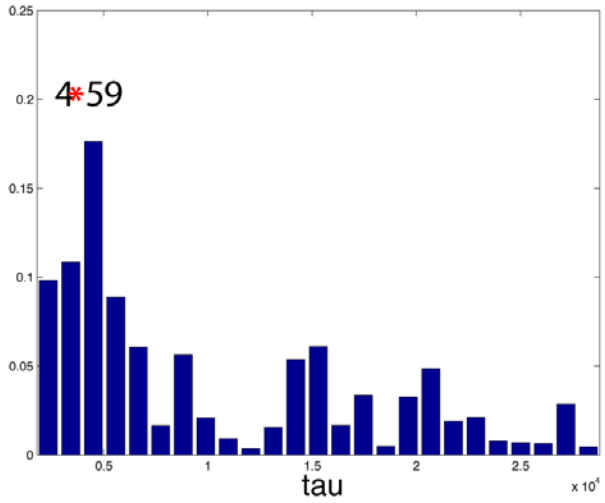
Top “10” Taylor metrics + …

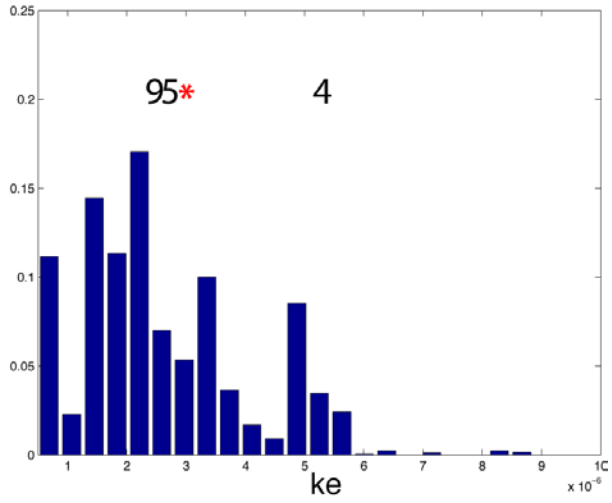
(all 30S to 30N, DJF, MAM, JJA, SON, unless otherwise noted)

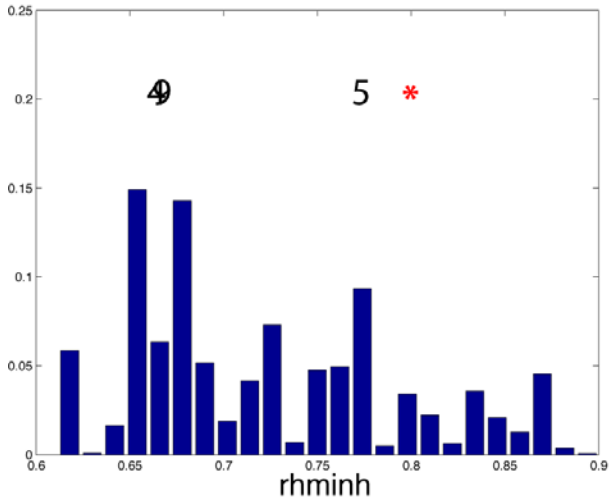
1. Land 2-m air temperature (Willmott) 2. Vertically averaged (mass weighted) air temperature (ERA 40) 3. Latent heat fluxes over ocean (WHOI) 4. Zonal winds at 300 mb (ERA40) 5. Longwave cloud forcing (CERES2) 6. Shortwave cloud forcing (CERES2) 7. Precipitation over land (GPCP) 8. Precipitation over ocean (GPCP) 9. Sea level pressure (ERA40) 10. Vertically averaged (mass weighted) relative humidity (ERA40) 11. Global mean annual mean radiative balance (= 0.5 W/m^2) Left out: pacific ocean wind stress along equator (Is now available for future experiments, but originally we were having difficulty with this field)

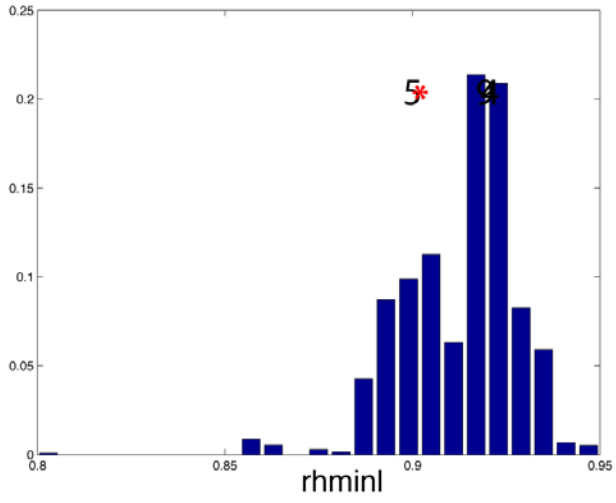

ANN: SPACE-TIME
Reference Grids Used
Standardized Deviations (Normalized)
Correlation
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.95
0.99
1.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
0.25
0.50
0.75
REF
1.25
1.50
- / + Bias
>20%
10-20%
5-10%
1-5%
<1%
RMSE Bias
1.000 1.000
0.975 0.980
0.994 0.966
default0
mecs2ch4g63
default1
0 - Sea Level Pressure (ERA40)
1 - SW Cloud Forcing (CERES2)
2 - LW Cloud Forcing (CERES2)
3 - Land Rainfall (30N-30S, GPCP)
4 - Ocean Rainfall (30N-30S, GPCP)
5 - Land 2-m Temperature (Willmott)
6 - Pacific Surface Stress (5N-5S,ERS)
7 - Zonal Wind (300mb, ERA40)
8 - Relative Humidity (ERA40)
9 - Temperature (ERA40)

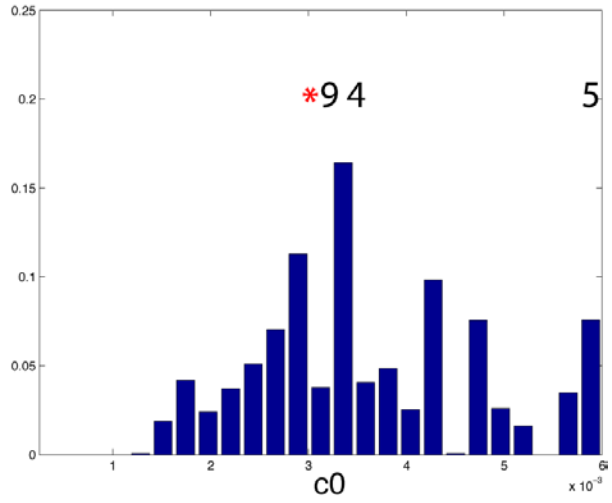

alfa


tau


ke

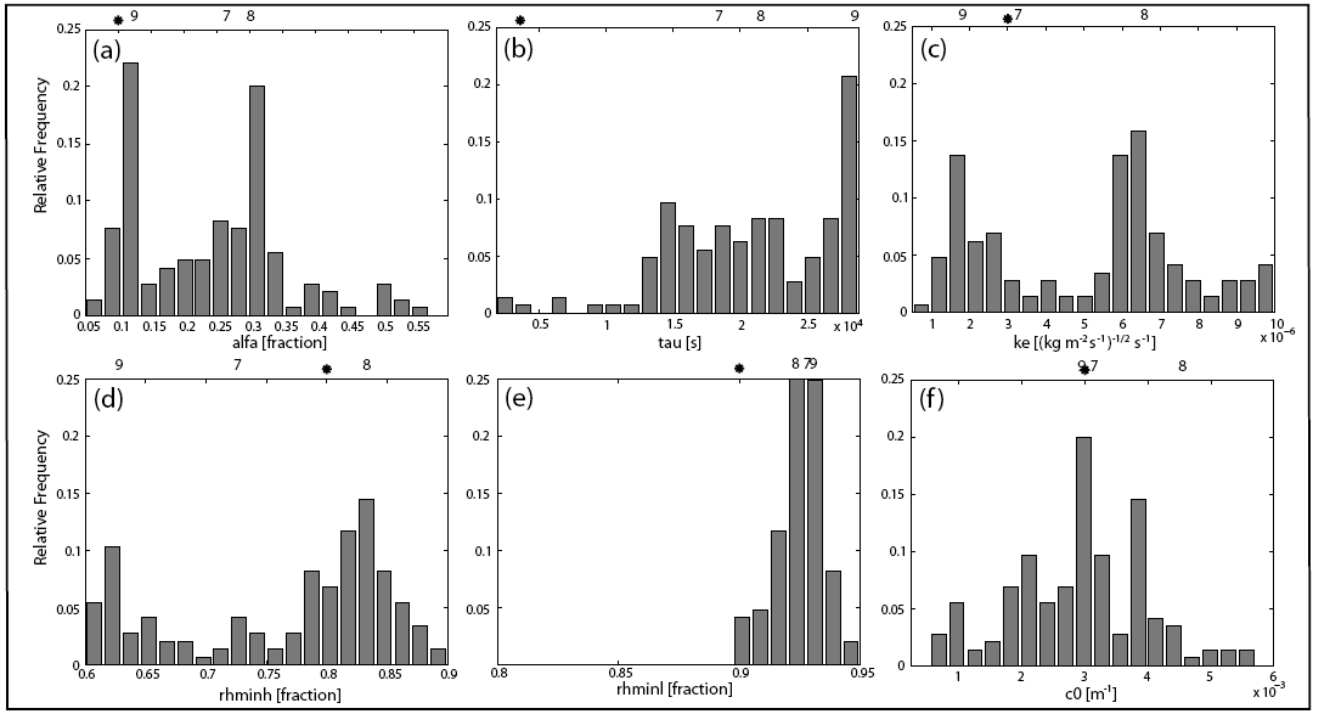

rhminh

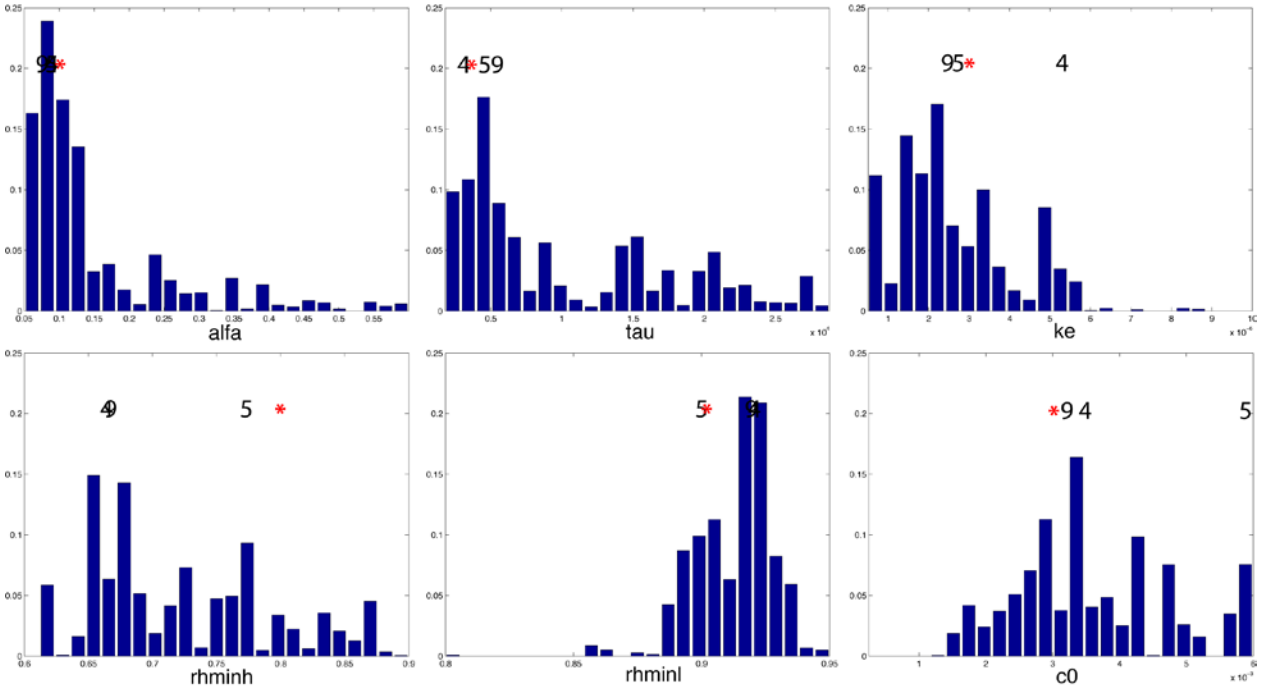

rhminl

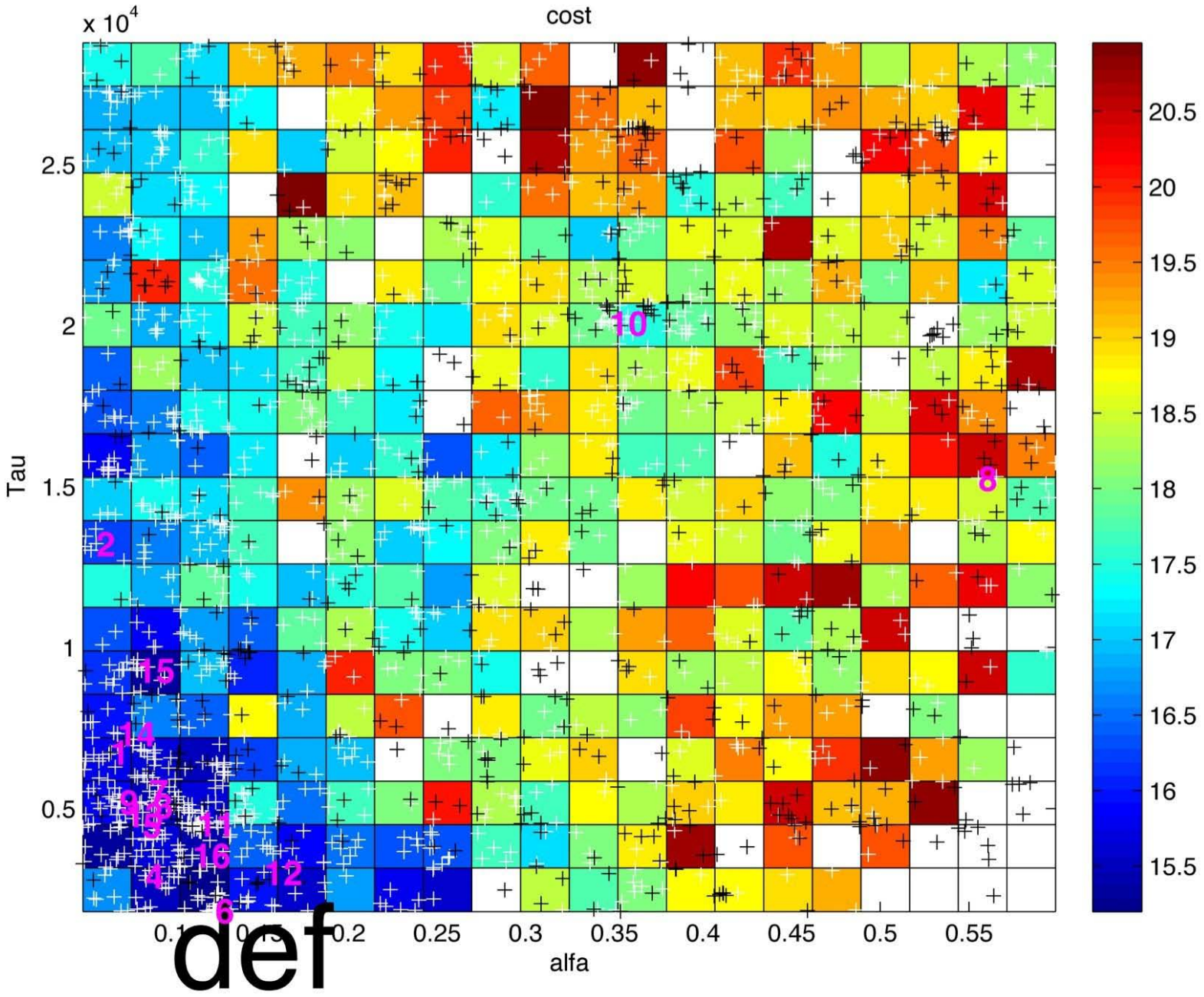

c0

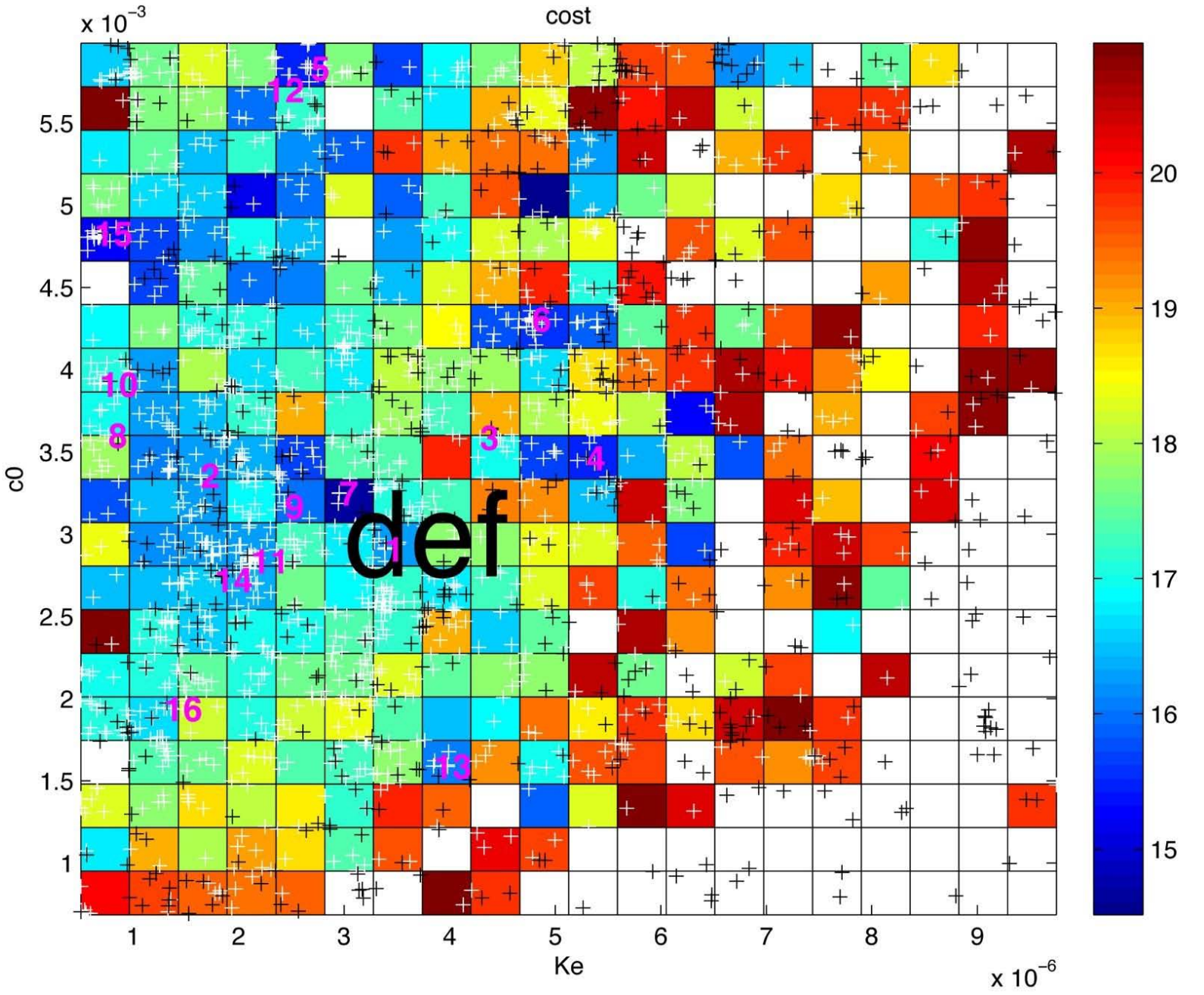
Old cost function

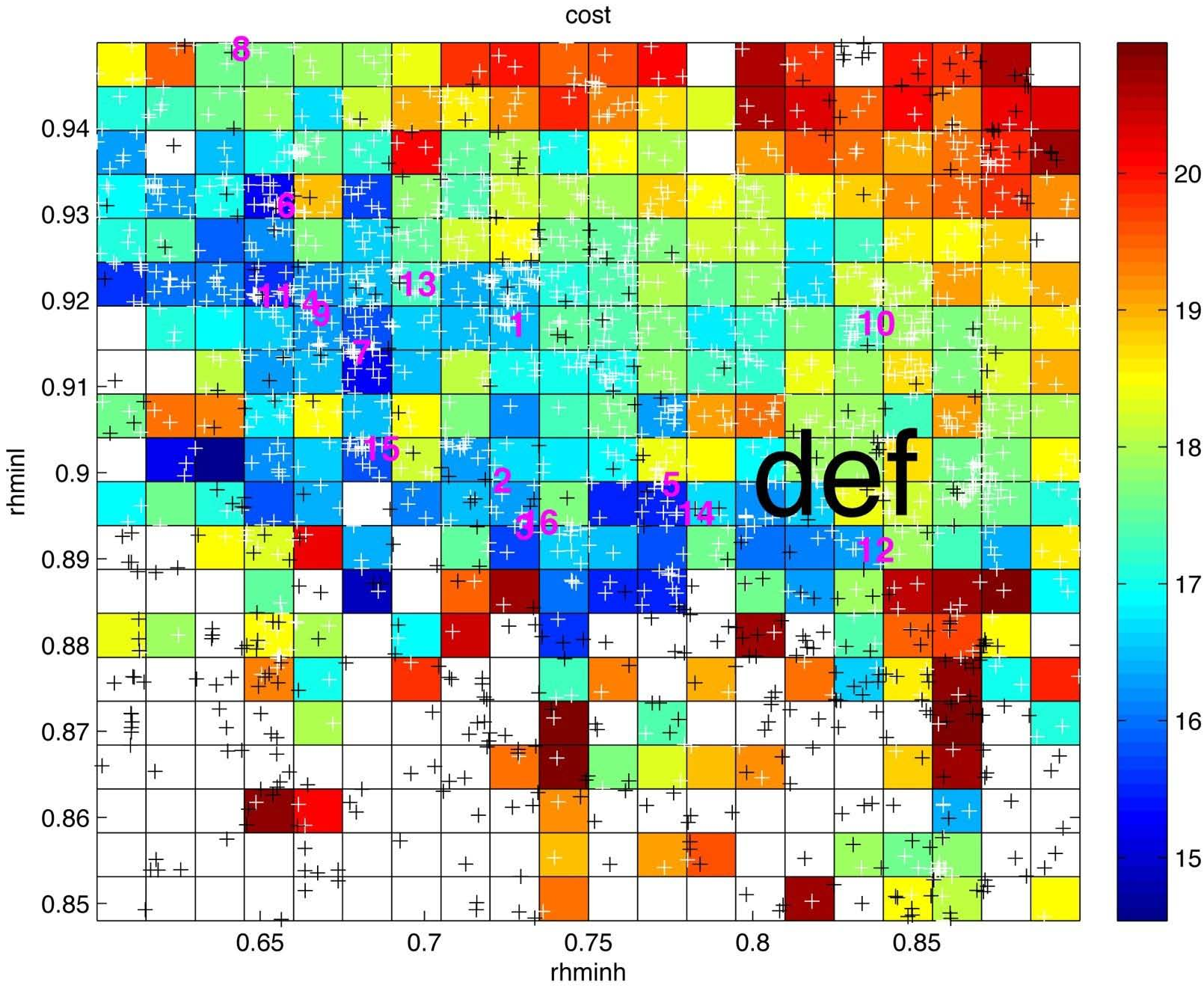
AMWG-inspired Cost function

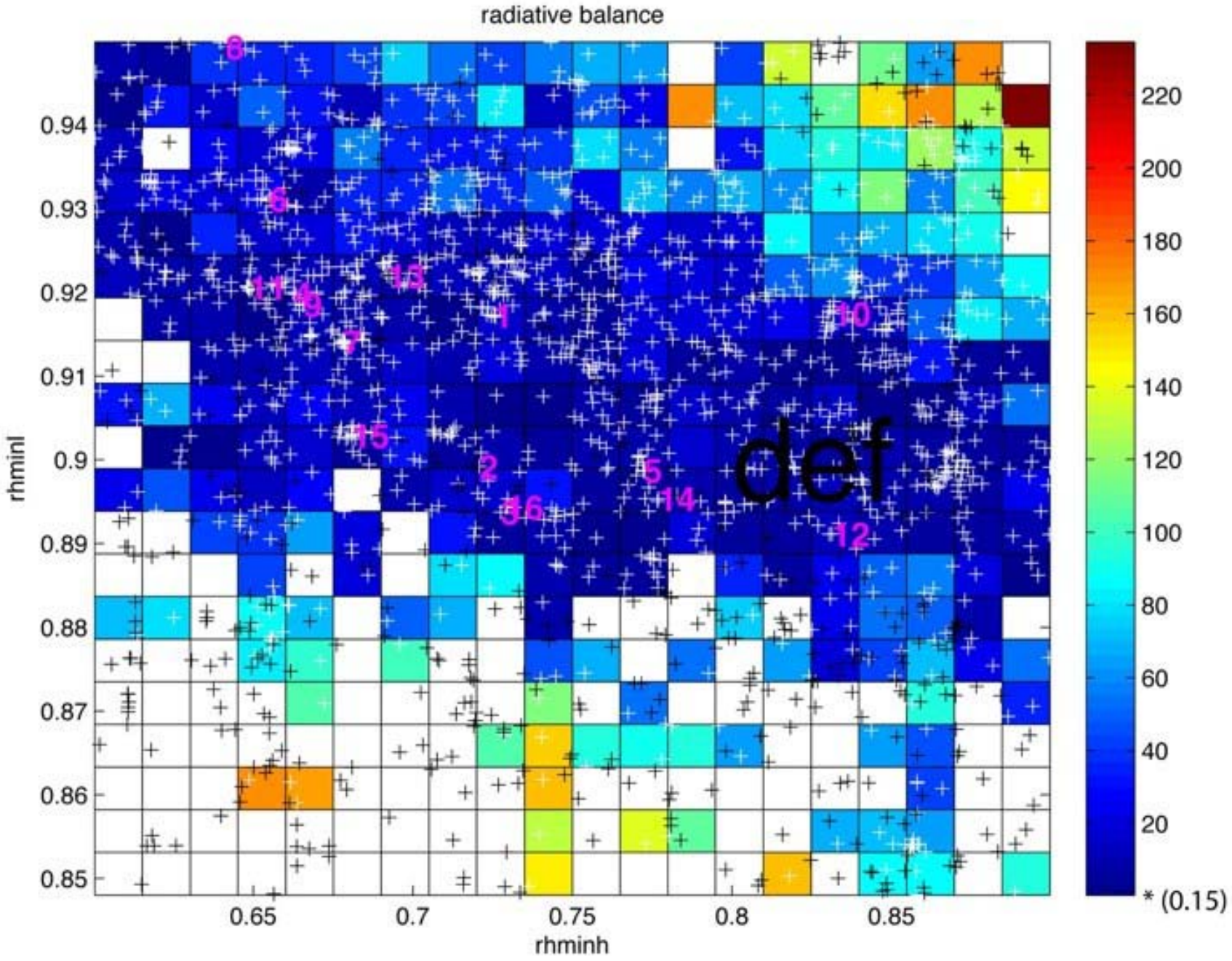


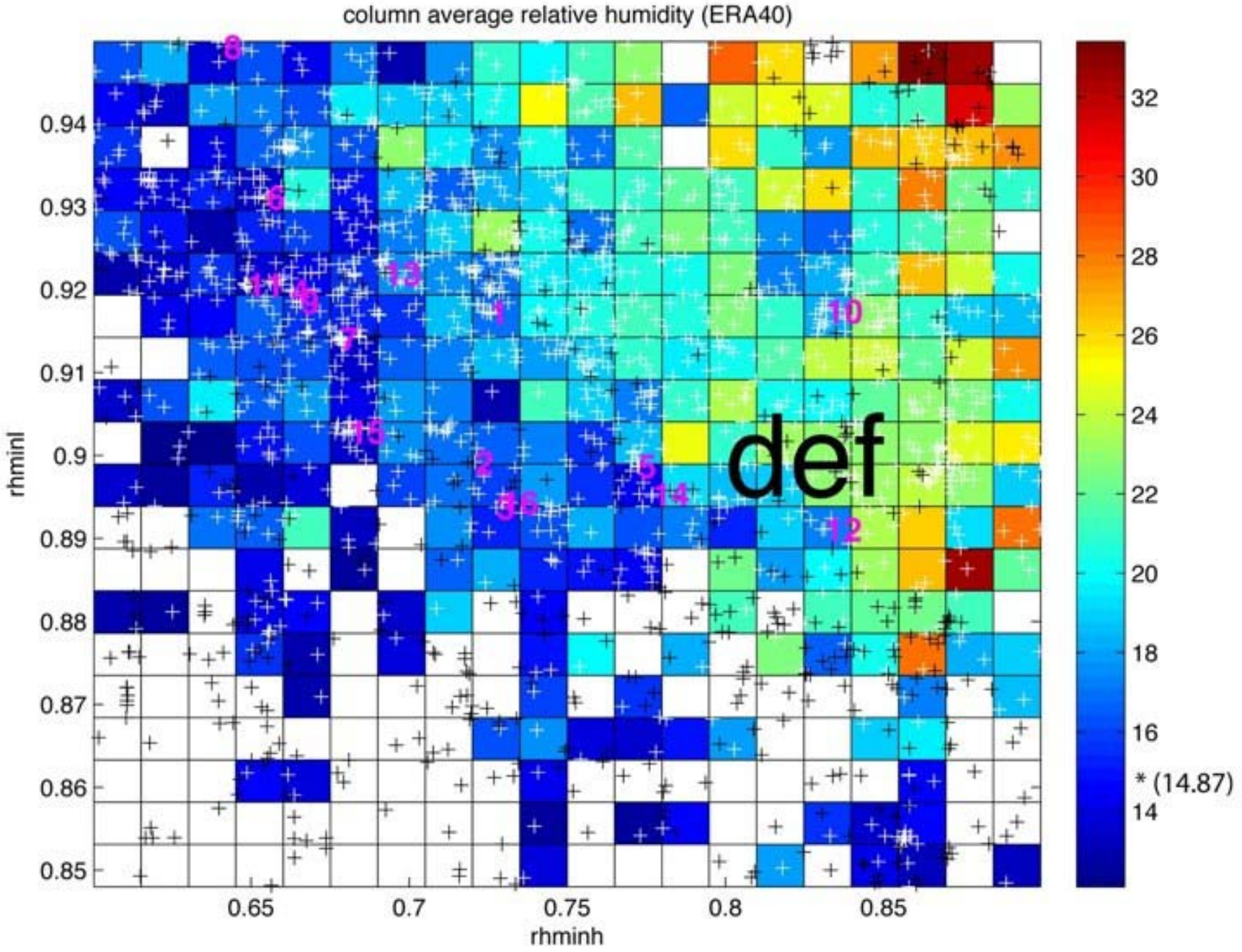


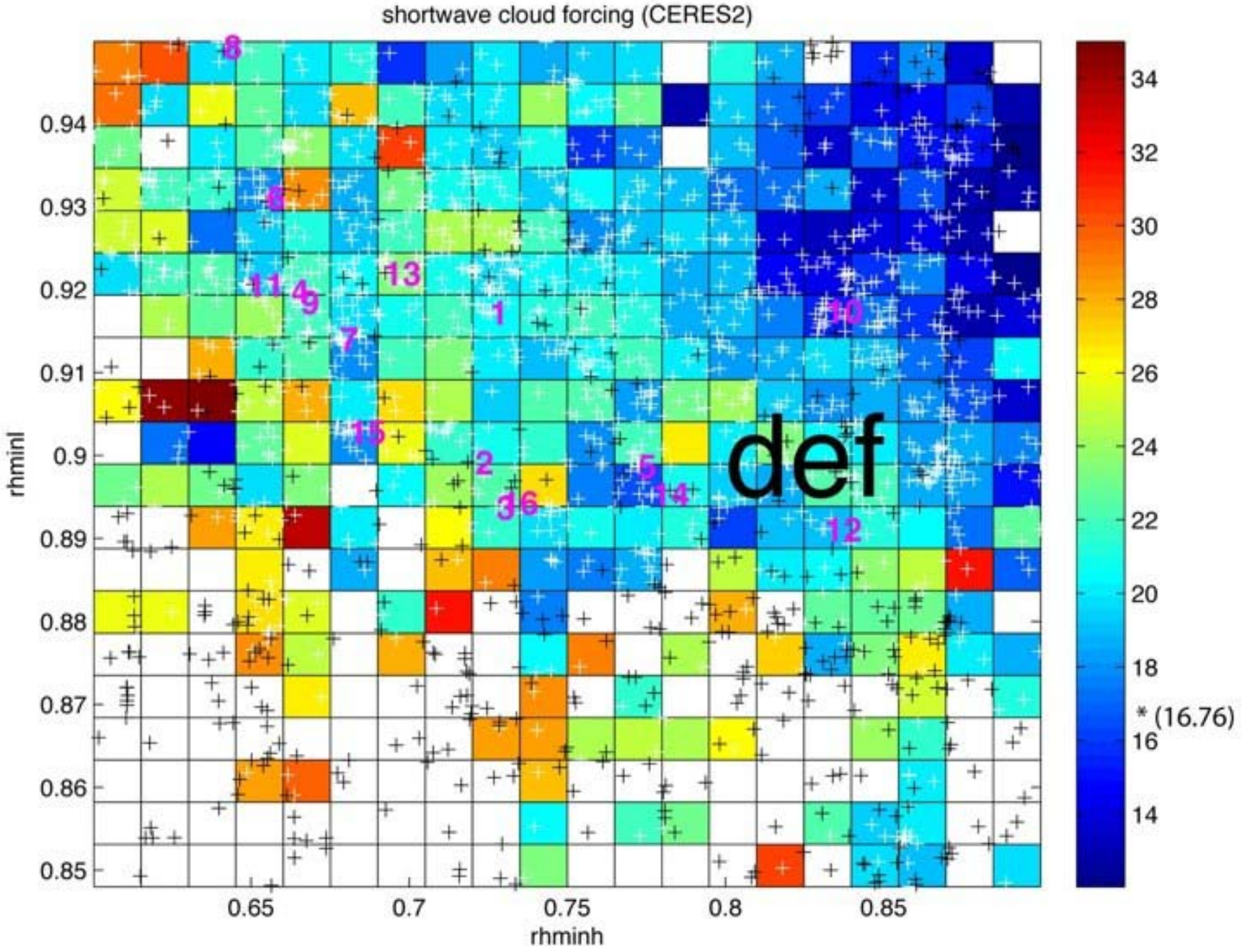

cost
x 10^4
Tau
alfa
2.5
2
1.5
1
0.5
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
10
8
2
15
14
1
9
3
13
11
16
4
12
6
def

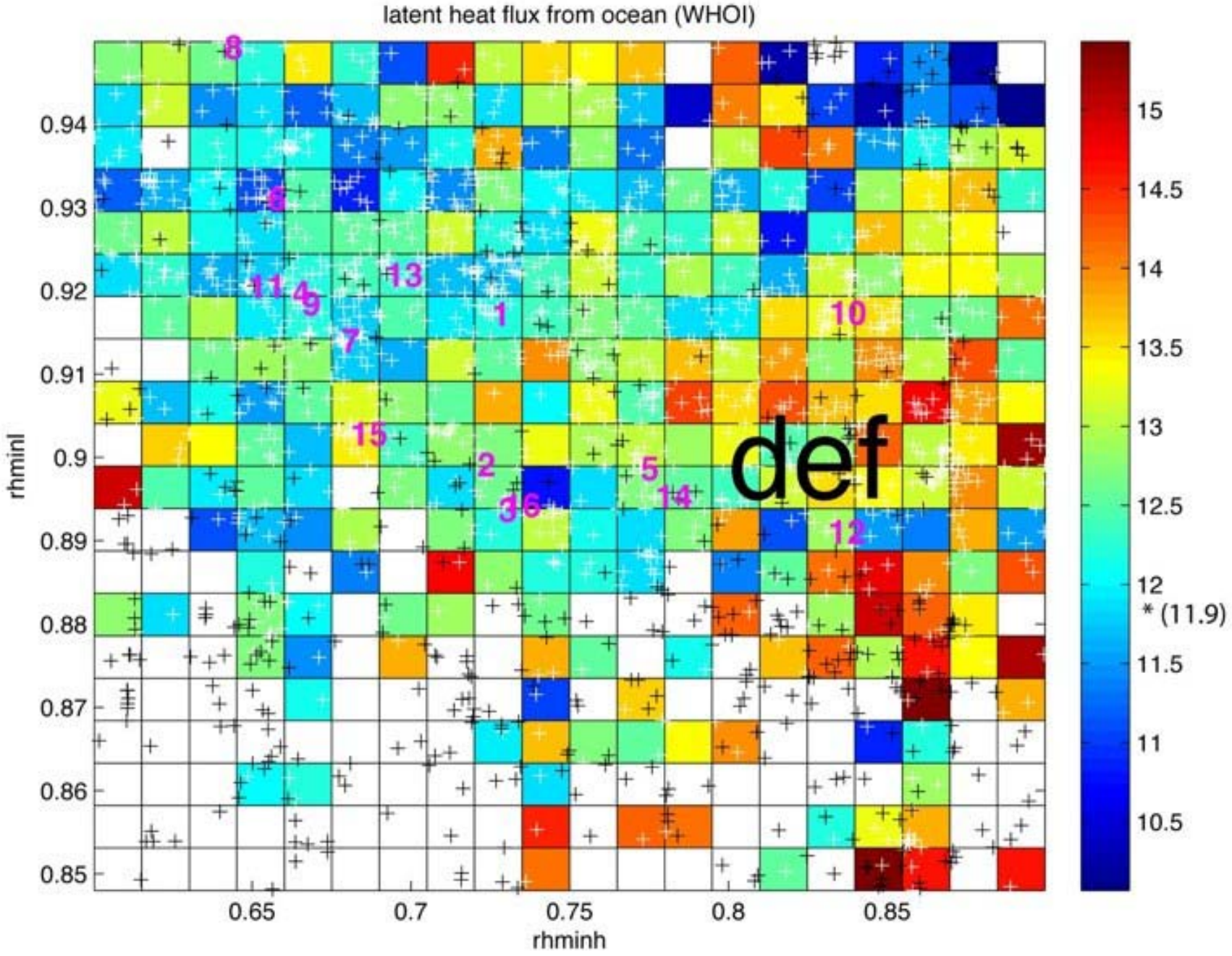

cost
x 10^-3
c0
Ke
x 10^-6
def
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
1
2
3
4
5
6
7
8
9
20
19
18
17
16
15

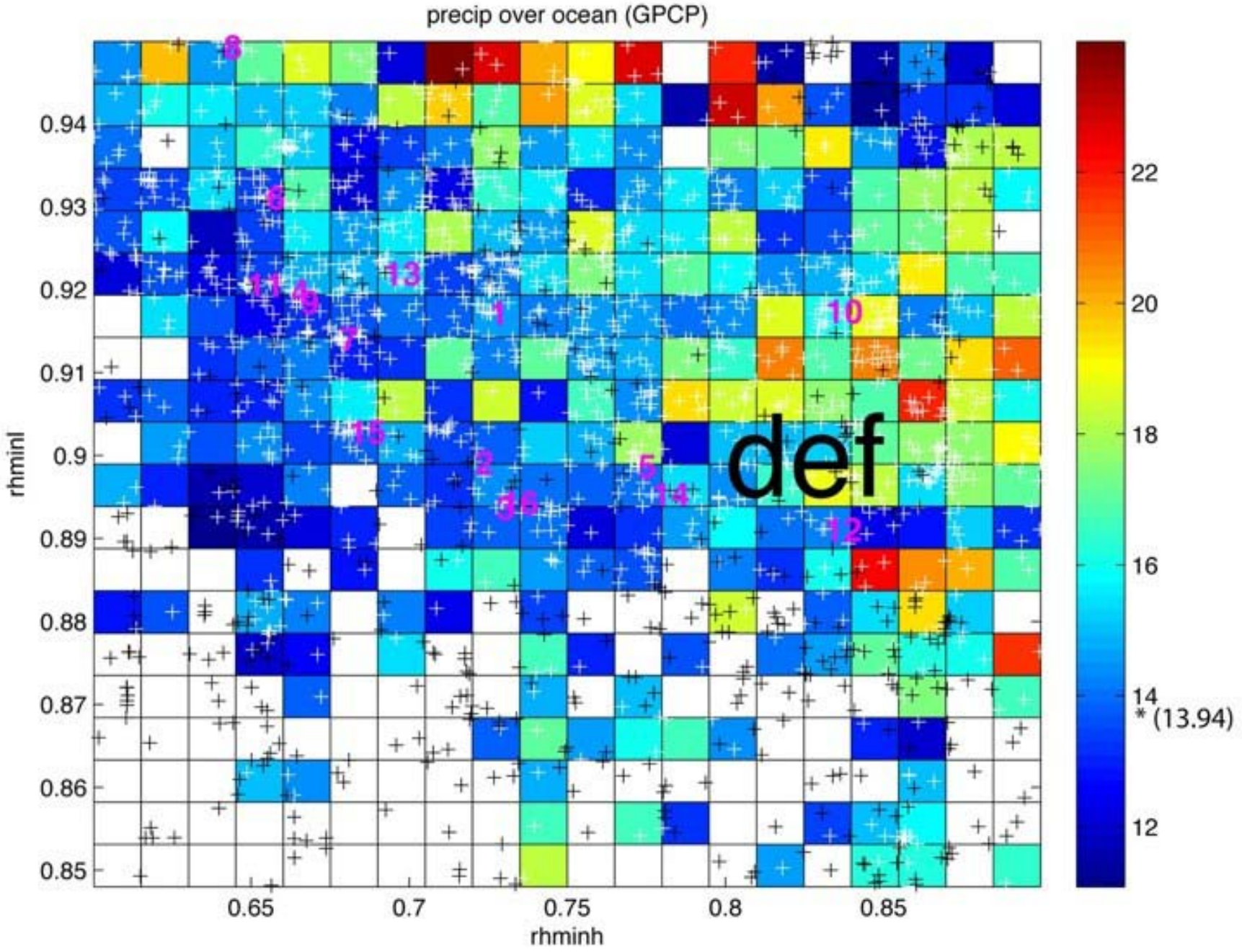

cost
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
20
19
18
17
16
15
def
8
6
11
4
3
13
1
7
10
15
2
5
14
16
12


radiative balance
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
def
8
6
11
4
9
13
1
7
10
15
2
5
14
16
12
220
200
180
160
140
120
100
80
60
40
20
* (0.15)


column average relative humidity (ERA40)
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
def
8
6
13
11
4
3
1
10
7
15
2
5
14
16
12
32
30
28
26
24
22
20
18
16
* (14.87)
14


shortwave cloud forcing (CERES2)
def
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
34
32
30
28
26
24
22
20
18
* (16.76)
16
14
8
6
11
4
9
13
1
7
10
15
2
5
14
3
16
12


latent heat flux from ocean (WHOI)
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
8
6
11
4
9
13
1
7
10
15
2
5
14
3
6
12
def
15
14.5
14
13.5
13
12.5
12
* (11.9)
11.5
11
10.5


precip over ocean (GPCP)
def
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.65
0.7
0.75
0.8
0.85
22
20
18
16
14
12
* (13.94)

More ambitious AMWG-inspired uncertainty/optimization

- Similar “top 10” Taylor metrics
- 4-year model integration, climatological sst, use last 3 years for analysis
- 15 parameters
- 1150 experiments completed (ongoing)
- So far, only a few have reached skill score similar to default model

9 new parameters

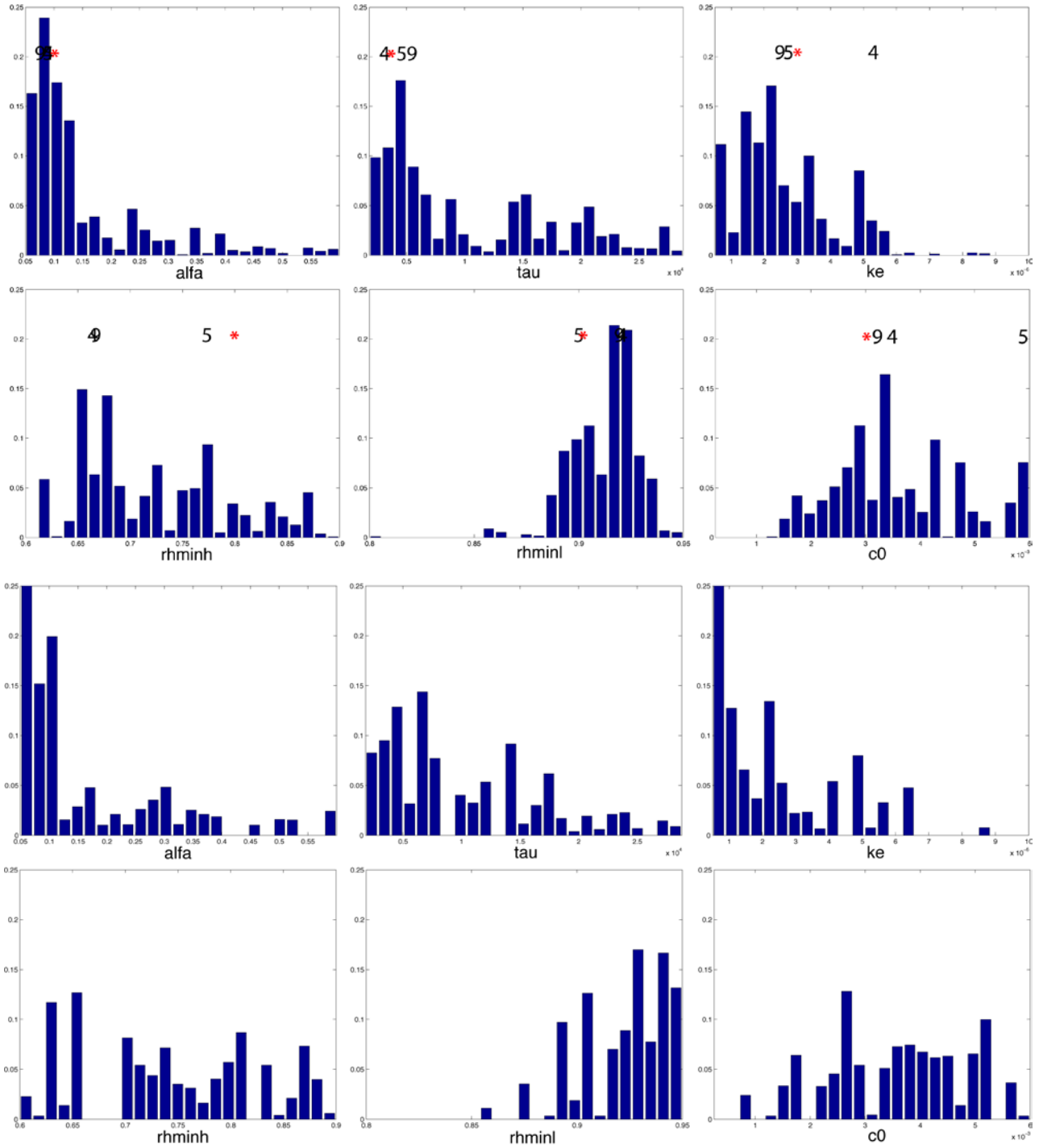
Same 6 parameters as before plus:

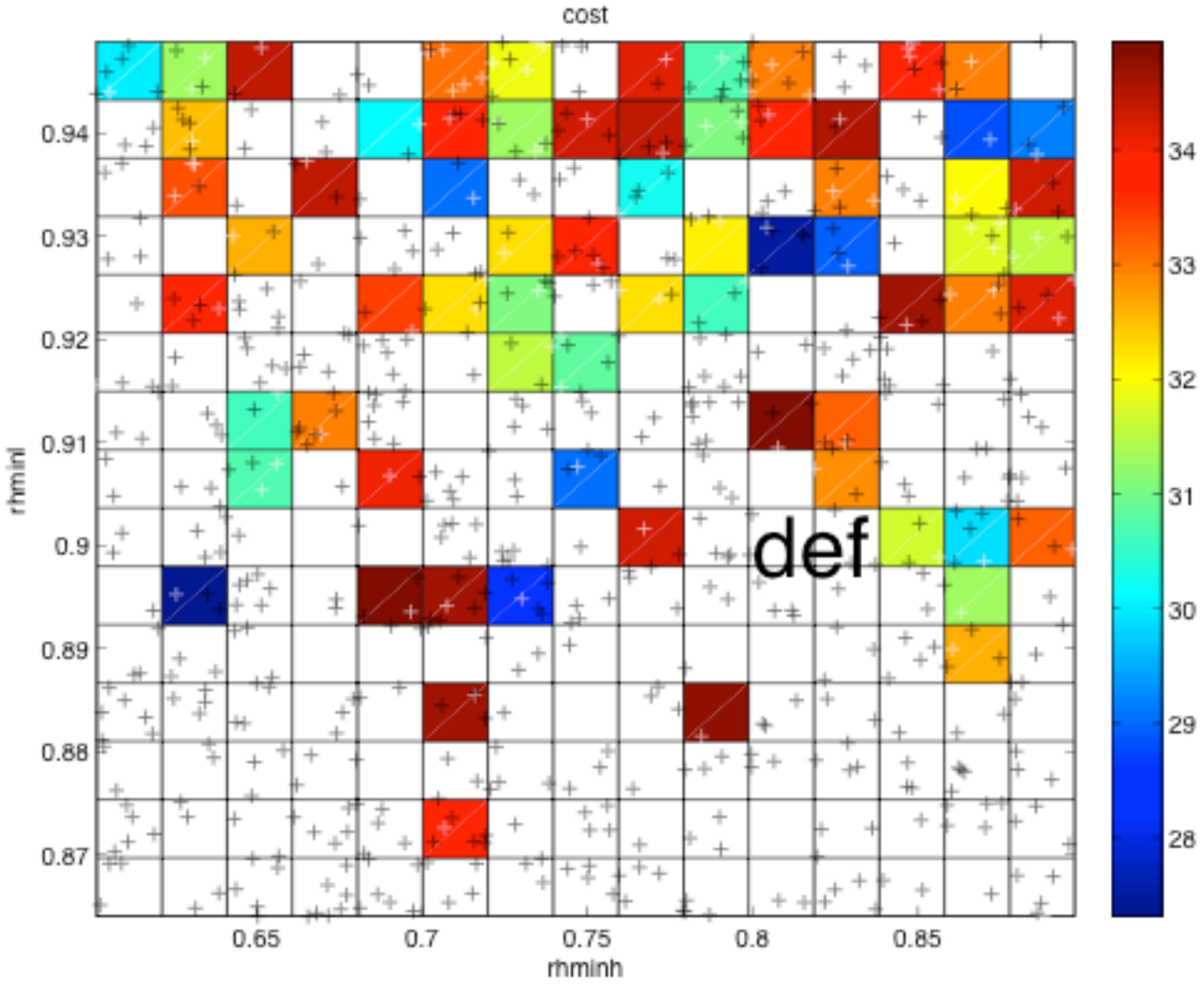
- icritc/w auto-conversion for cold/warm ice
- vice_small (ice fall velocities)
- rliq (ocean,land, ice) cloud droplet size
- capn(w,c,si) cloud droplet number

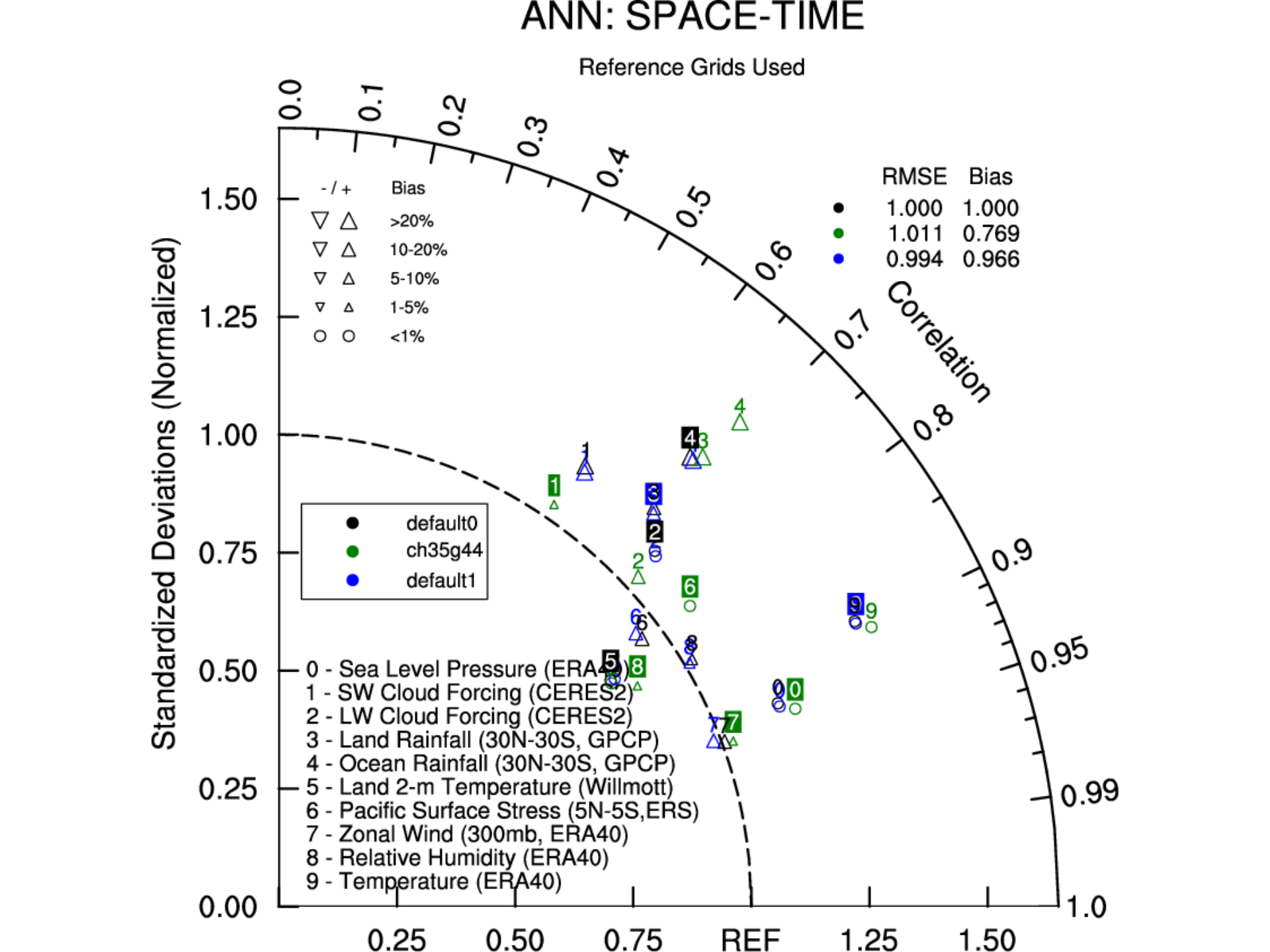
6 params
2020 exp

AMWG-inspired Cost function

15 params
1150 exp




cost
rhminl
rhminh
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.65
0.7
0.75
0.8
0.85
34
33
32
31
30
29
28
def


ANN: SPACE-TIME
Reference Grids Used
Standardized Deviations (Normalized)
Correlation
RMSE Bias
1.000 1.000
1.011 0.769
0.994 0.966
- / + Bias
>20%
10-20%
5-10%
1-5%
<1%
default0
ch35g44
default1
0 - Sea Level Pressure (ERA40)
1 - SW Cloud Forcing (CERES2)
2 - LW Cloud Forcing (CERES2)
3 - Land Rainfall (30N-30S, GPCP)
4 - Ocean Rainfall (30N-30S, GPCP)
5 - Land 2-m Temperature (Willmott)
6 - Pacific Surface Stress (5N-5S,ERS)
7 - Zonal Wind (300mb, ERA40)
8 - Relative Humidity (ERA40)
9 - Temperature (ERA40)
REF