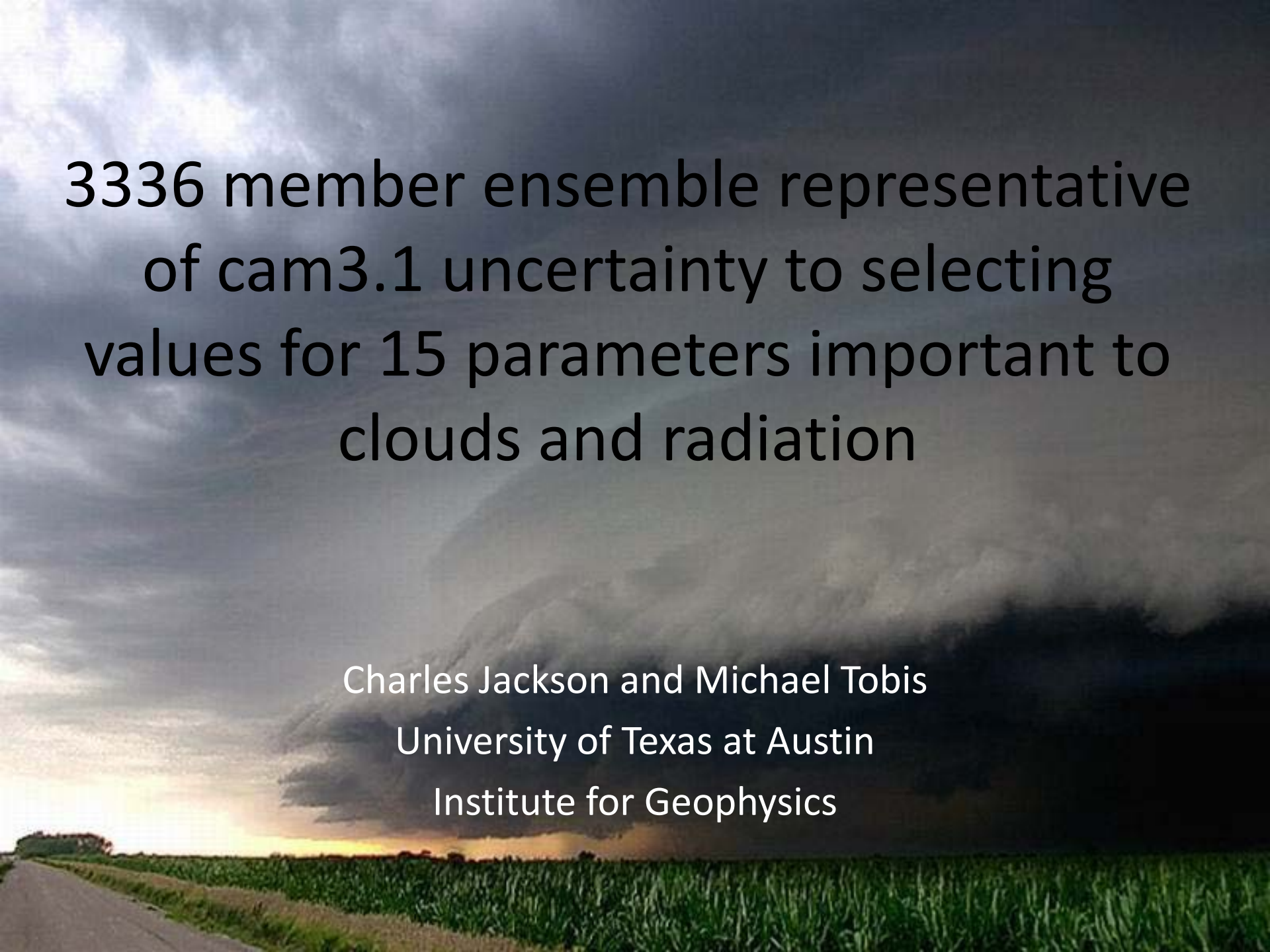
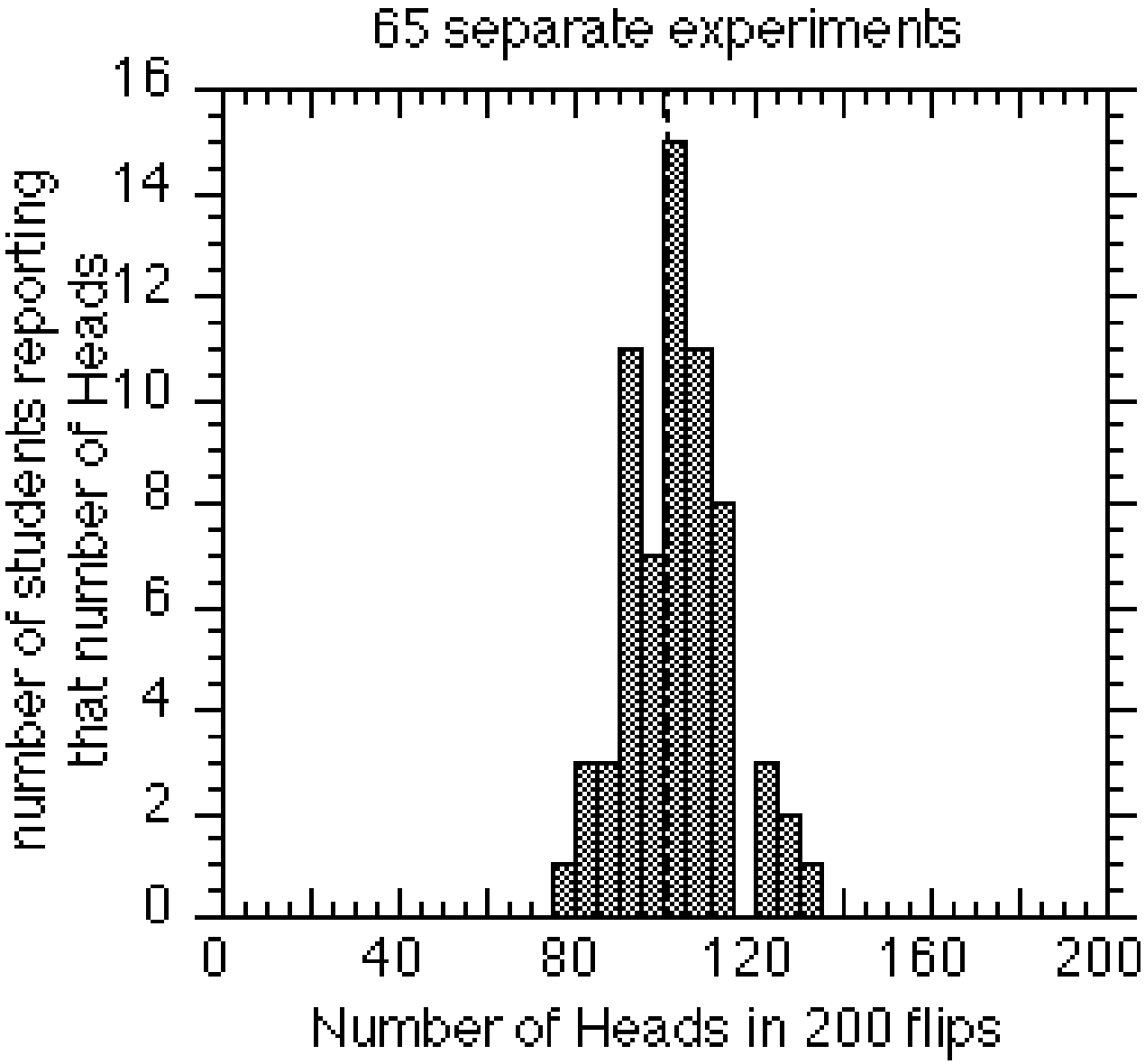


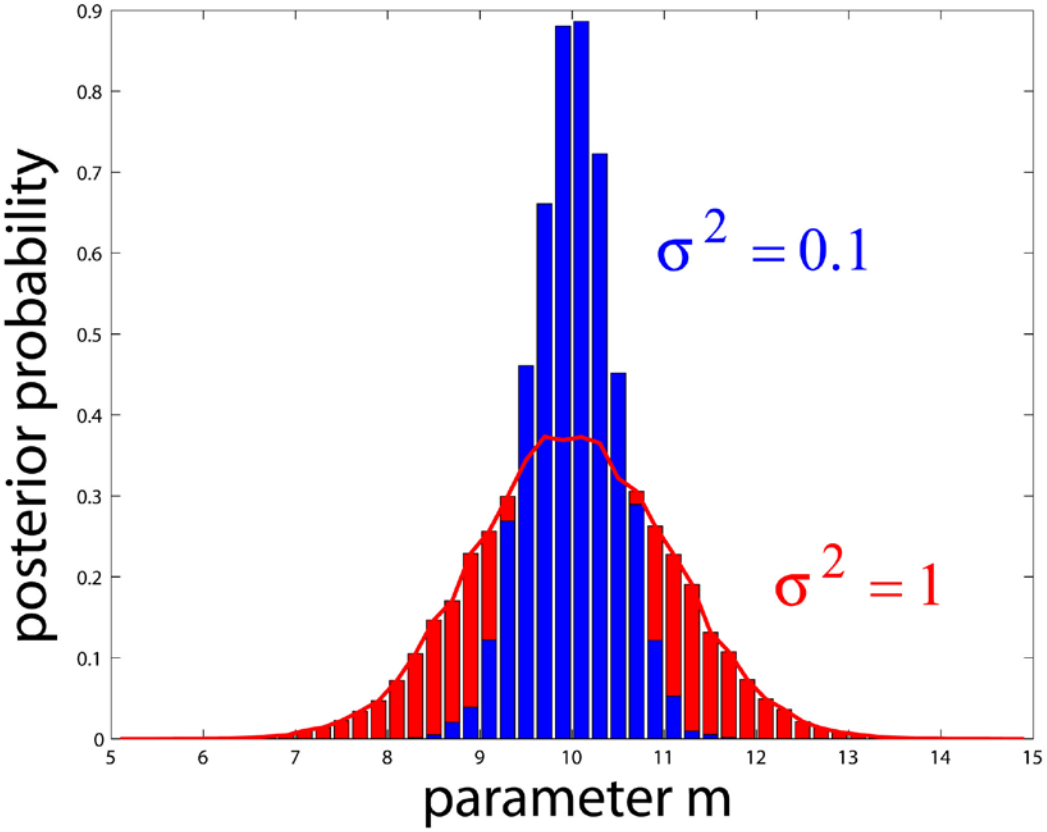
3336 member ensemble representative of cam3.1 uncertainty to selecting values for 15 parameters important to clouds and radiation

Charles Jackson and Michael Tobis
University of Texas at Austin
Institute for Geophysics



http://muller.lbl.gov/teaching/physics10

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



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

More ambitious AMWG-inspired uncertainty/optimization

- Similar “top 10” Taylor metrics now w/ pacific wind stress
- 4-year model integration, climatological sst, use last 3 years for analysis
- 15 parameters
- 3336 experiments completed
- Using a Markov sampling strategy

Updated 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) 12. pacific ocean wind stress along equator

Parameter	Definition	Value Ranges
RHMINL [%/100]	Low cloud critical relative humidity	
RHMINH [%/100]	High cloud critical relative humidity	
ALFA [fraction]	Initial cloud downdraft mass flux	
TAU [hours]	Consumption rate of CAPE	
ke $[(\text{kg m}^{-2}\ \text{s}^{-1})^{-1/2}\text{s}^{-1}]$	Environmental air entrainment rate	
c0 $[\text{m}^{-1}]$	Precipitation efficiency	

For more information about experiment see Jackson et al., 2008, J. Climate.

9 new parameters

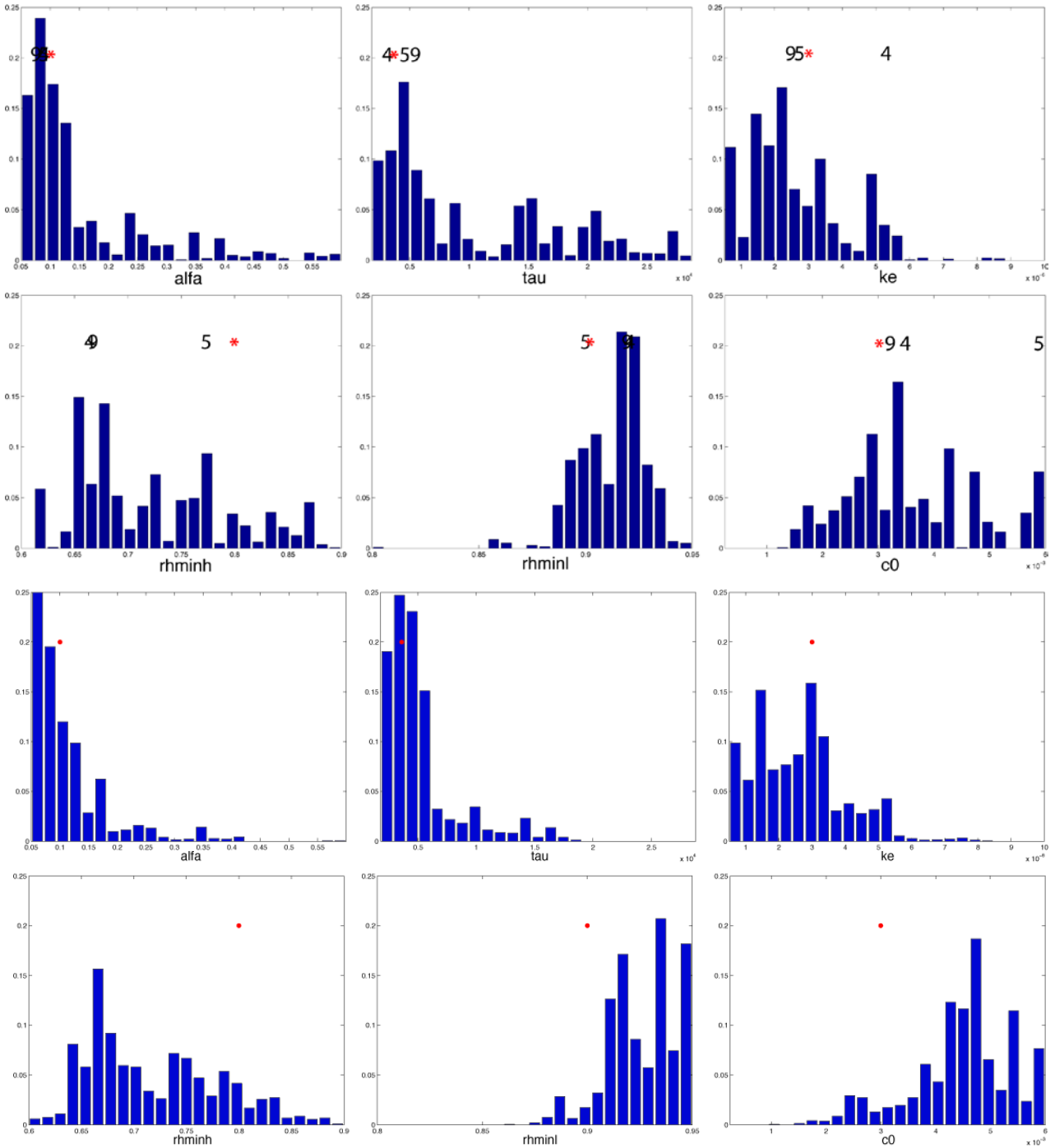
Same 6 parameters as before plus:

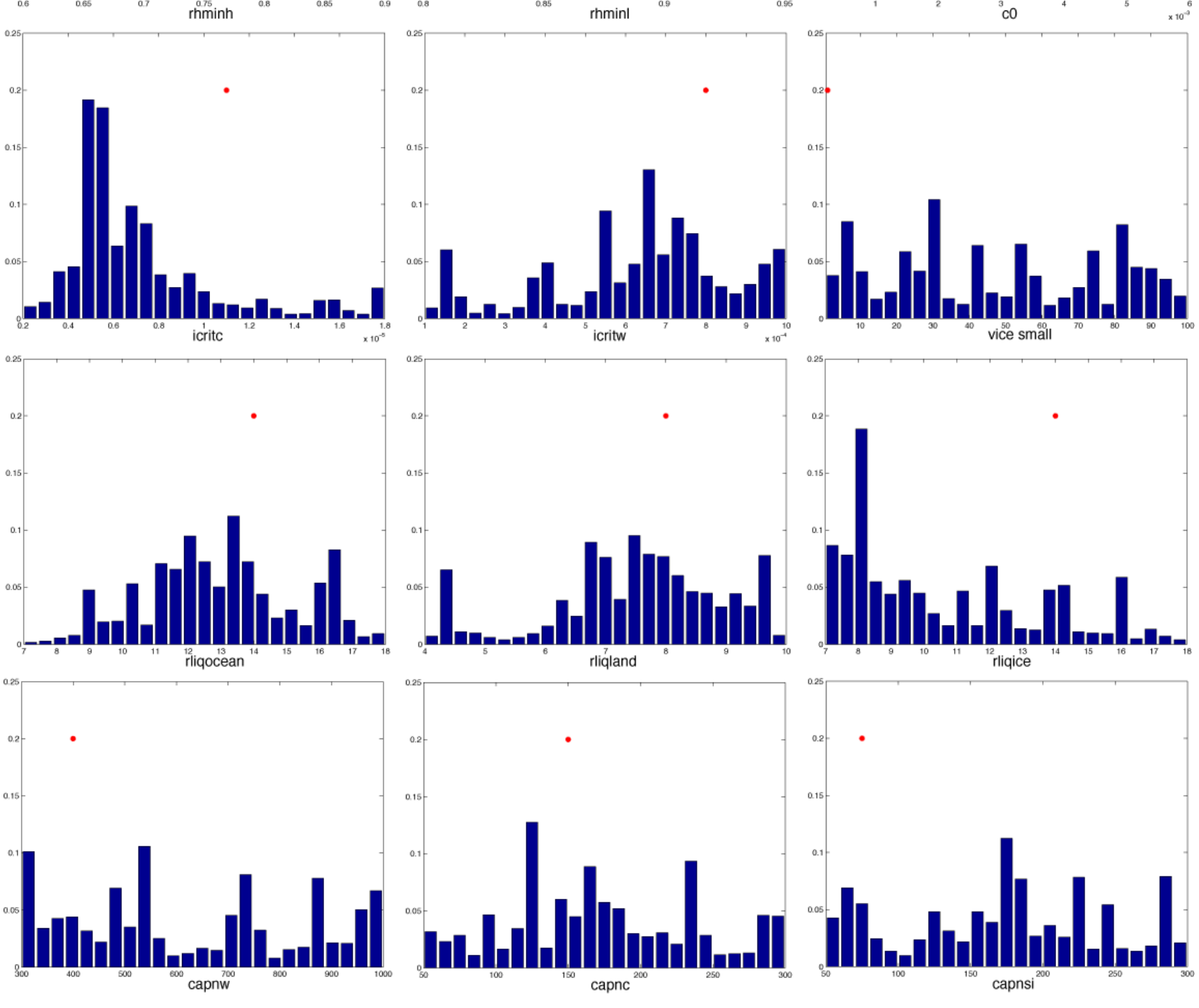
- icritc/w auto-conversion for cold/warm ice
- vice_small (ice fall velocities)
- rliq (ocean,land, ice) cloud droplet size
- capn(w,c,si) cloud droplet number

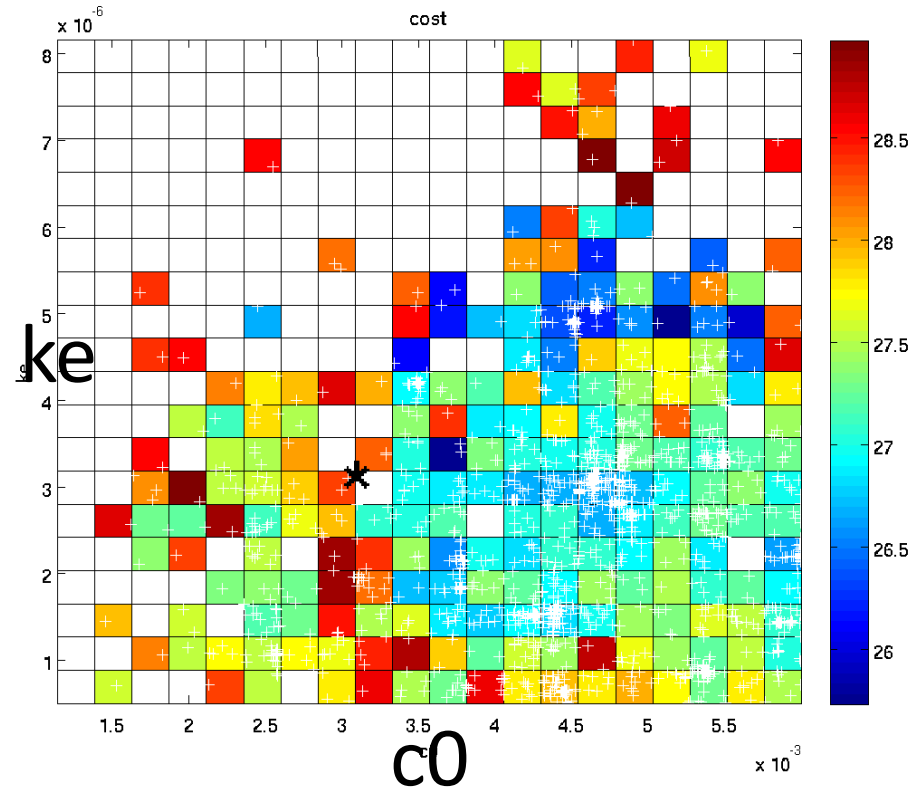
6 params
2020 exp

AMWG-inspired Cost function

15 params
3336 exp
(~1800 acceptable)



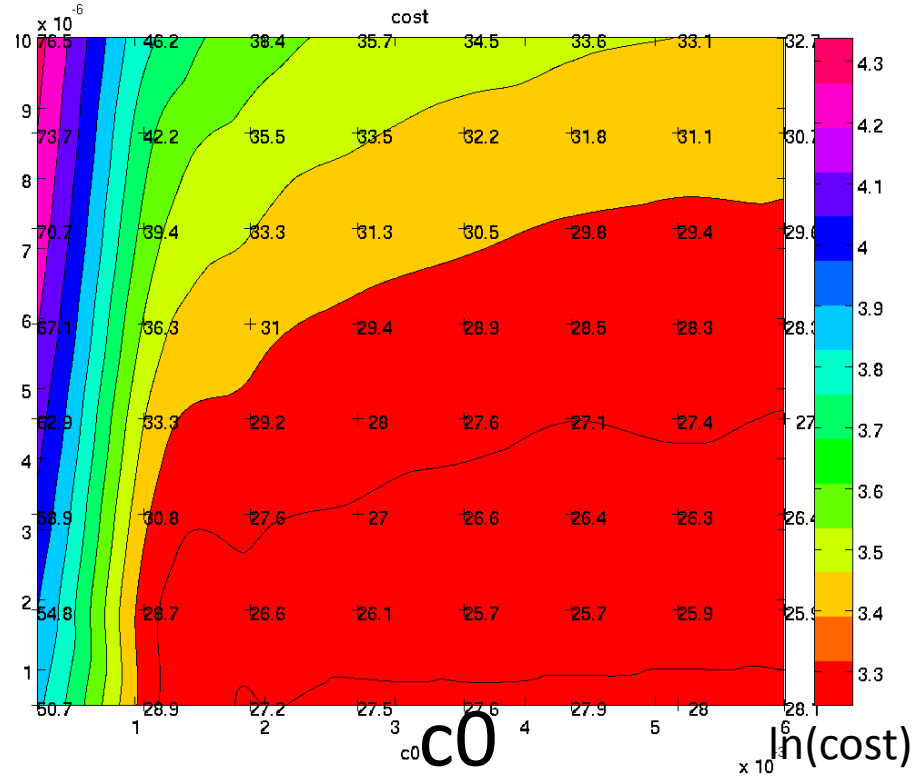

rhminh
rhminl
c0
x 10^-3
icritc
x 10^-5
icritw
x 10^-4
vice small
rliqocean
rliqland
rliqice
capnw
capnc
capnsi



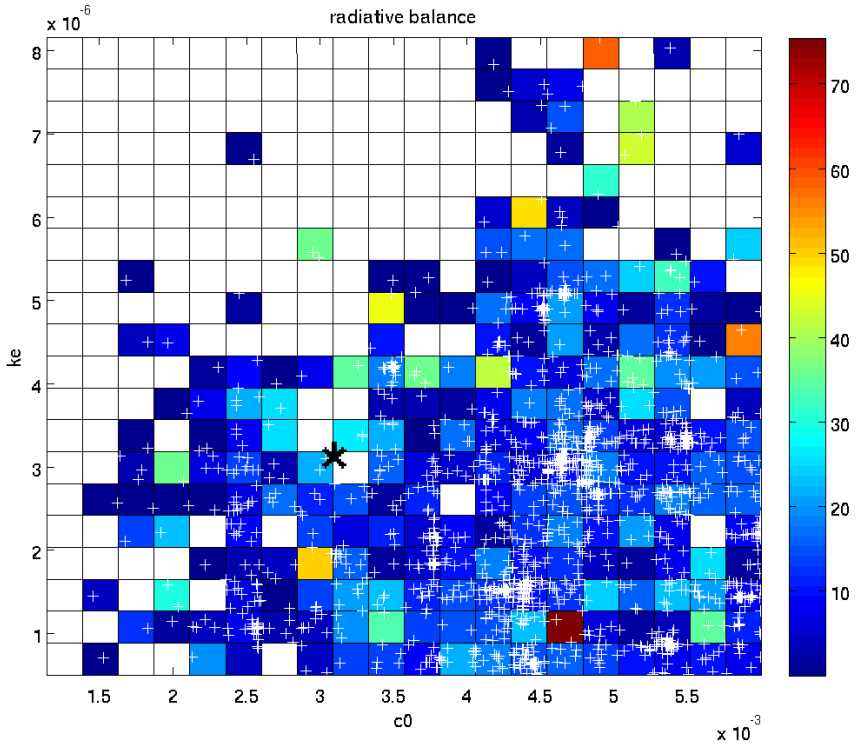
Stochastic sampling
1800 samples, 3-year averages

$$\overline{\text{cost}}(p1,p2) = \frac{\sum_{i=1}^{\text{nexp}} \text{cost}(p1,p2)_i \exp\left[-\bar{S}\cdot\left(\text{cost}(p1,p2)_i - \text{cost}(p1,p2)_{\min}\right)\right]}{\sum_{i=1}^{\text{nexp}} \exp\left[-\bar{S}\cdot\left(\text{cost}(p1,p2)_i - \text{cost}(p1,p2)_{\min}\right)\right]}$$

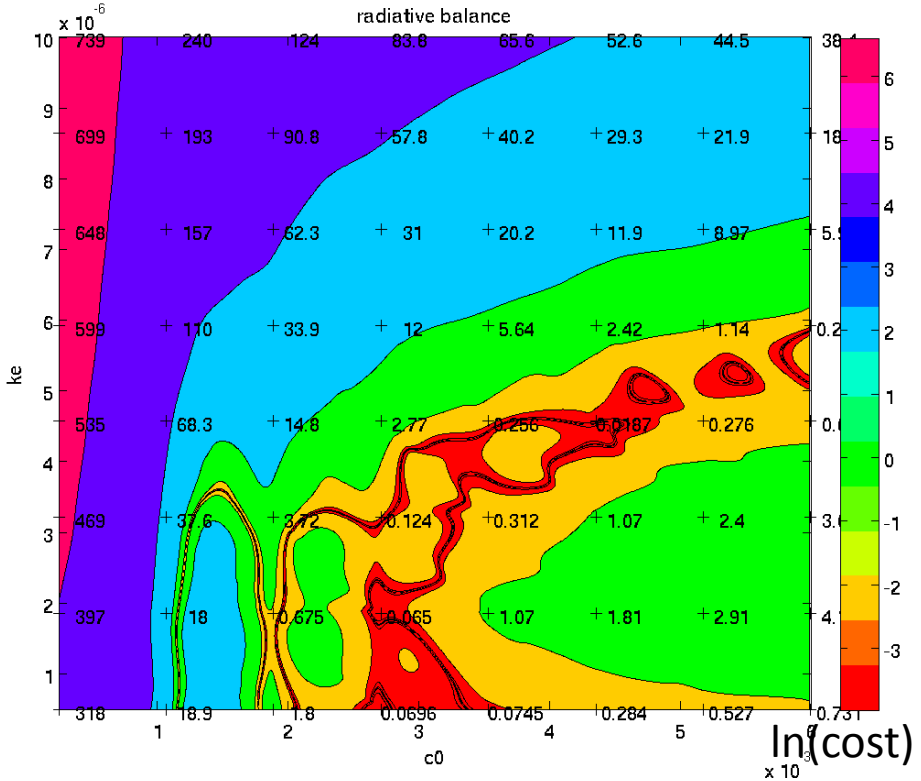
Total "cost"

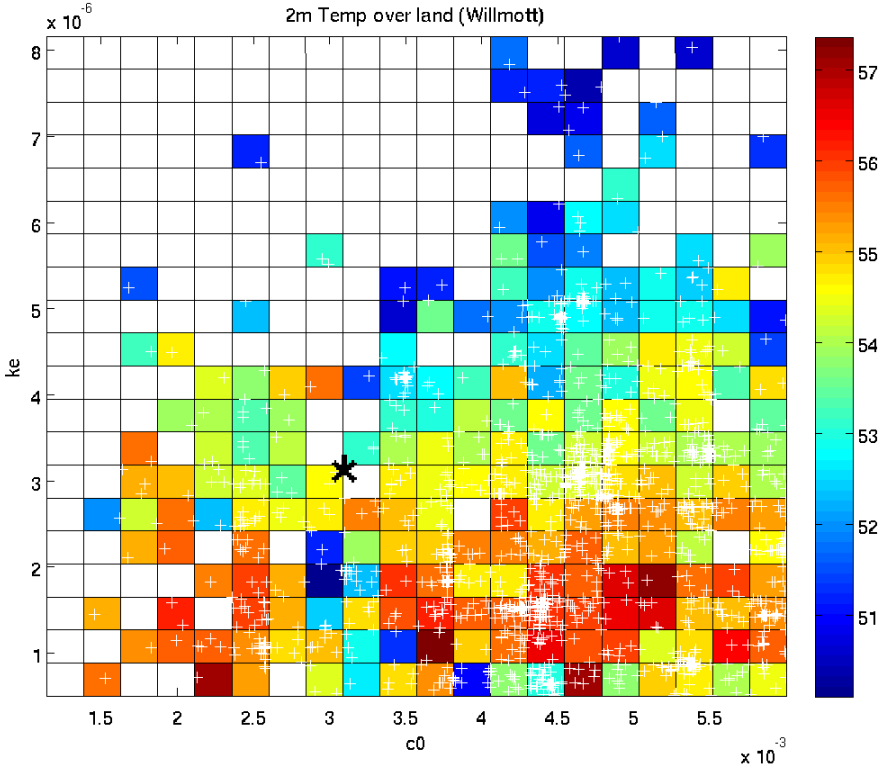


8x8 Grid of experiments
32 year averages

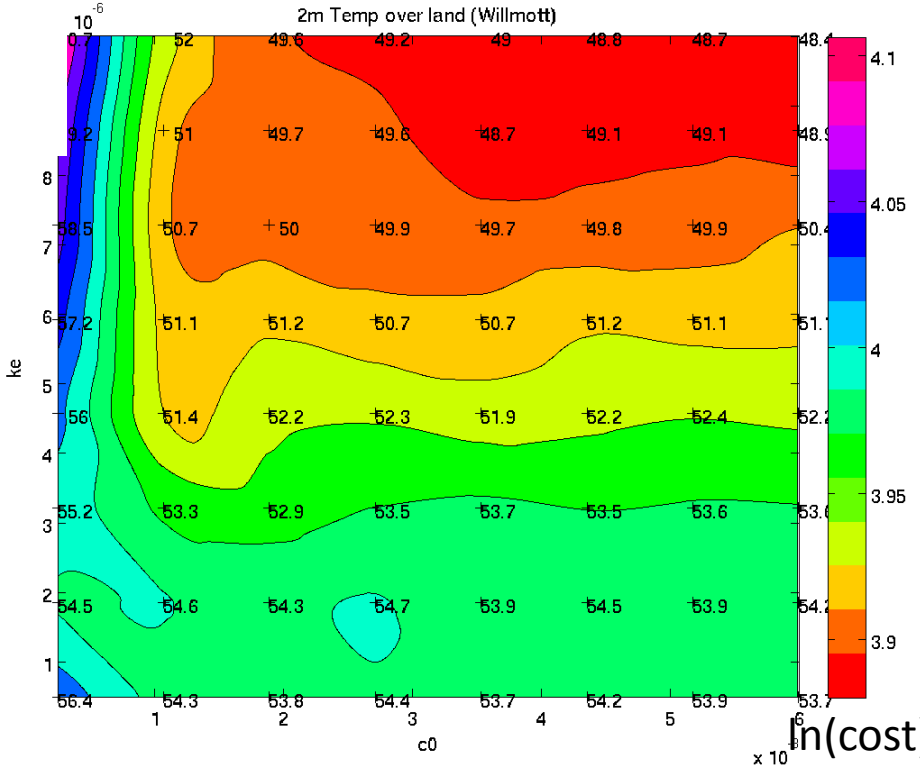


Radiative balance

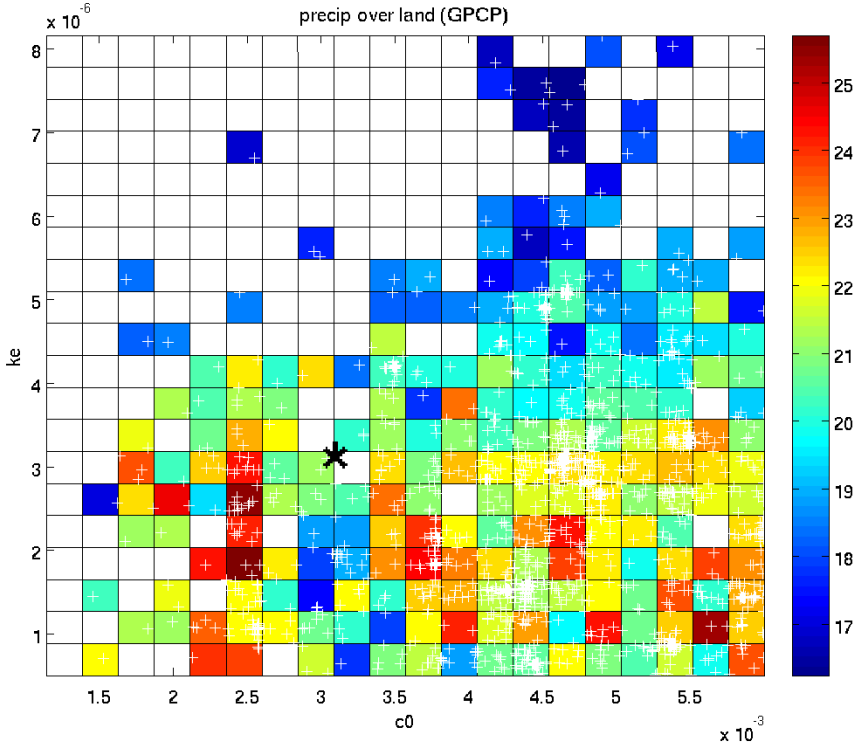




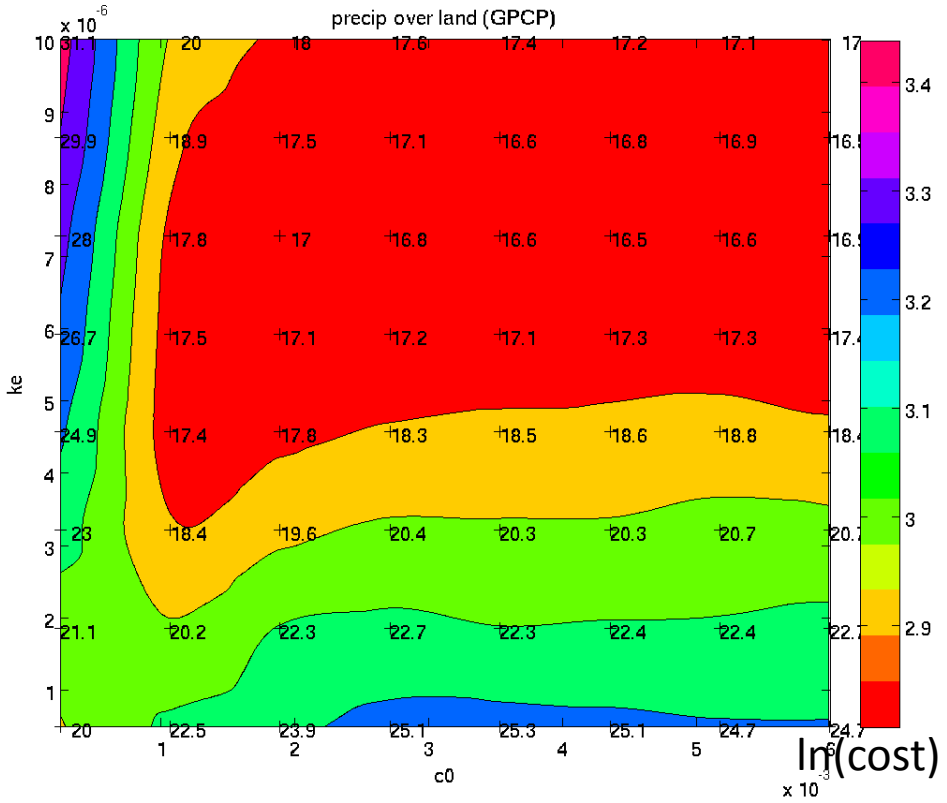
2m Temperature over land (Willmott)



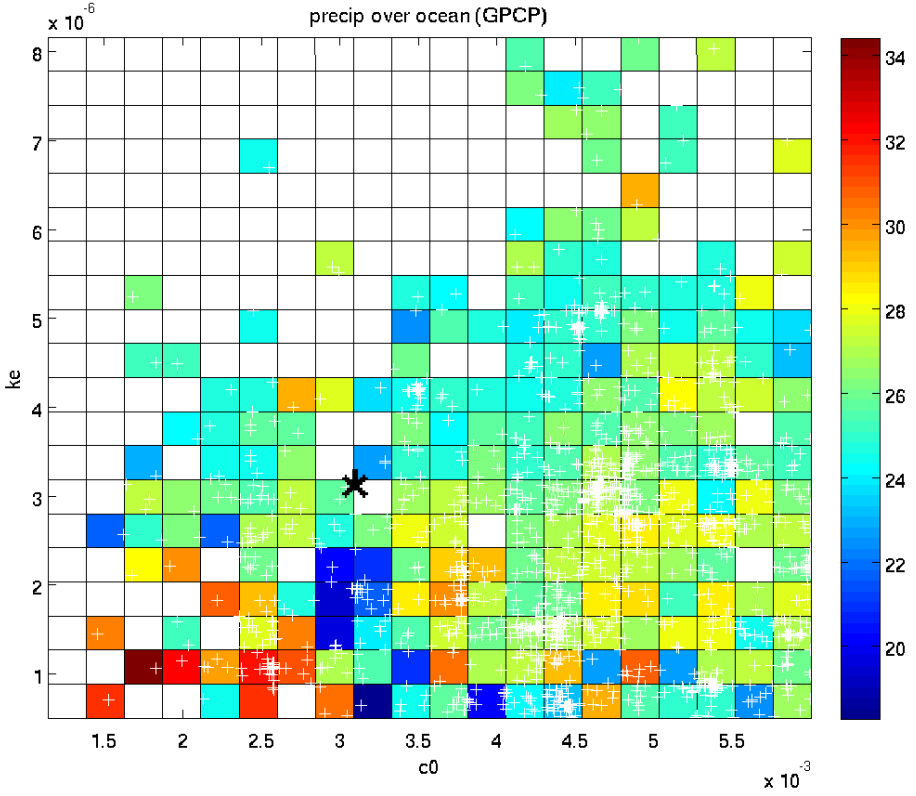
ln(cost)



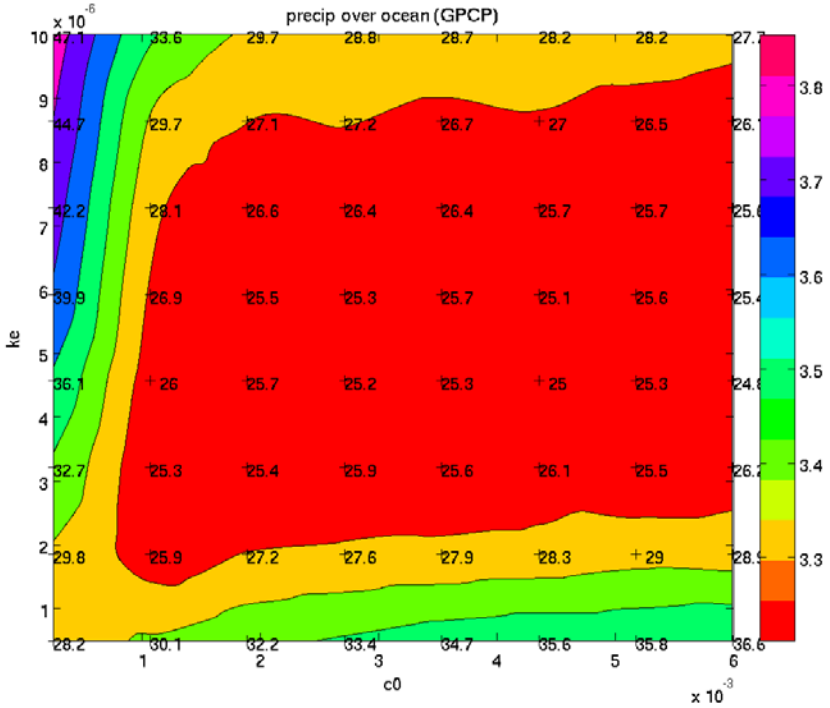
Precipitation over land (GPCP)

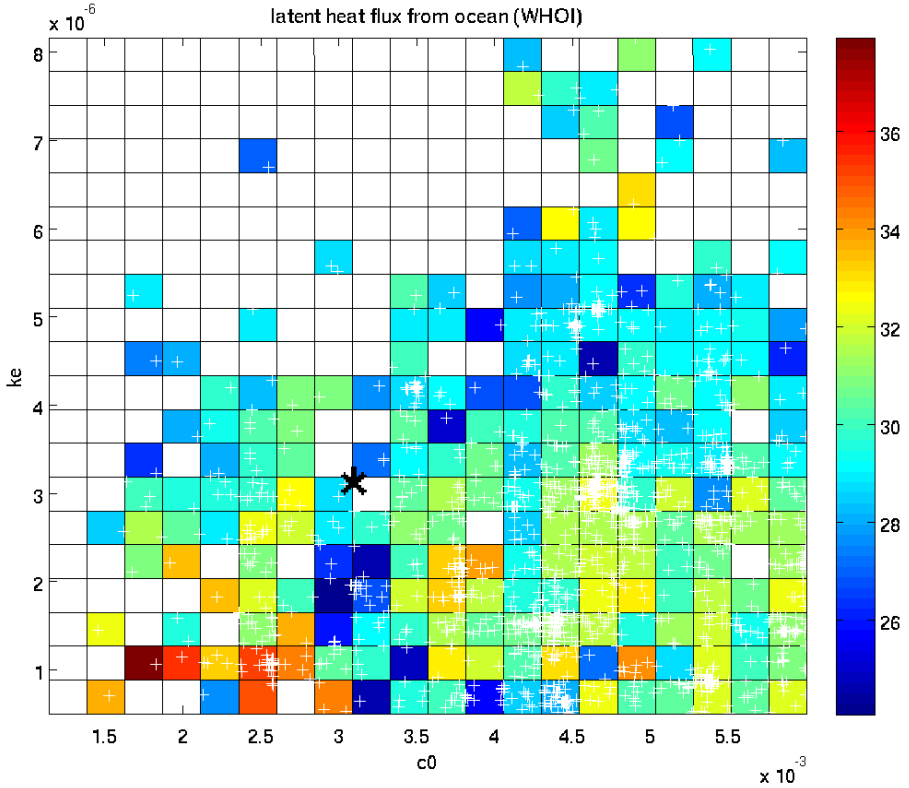


ln(cost)

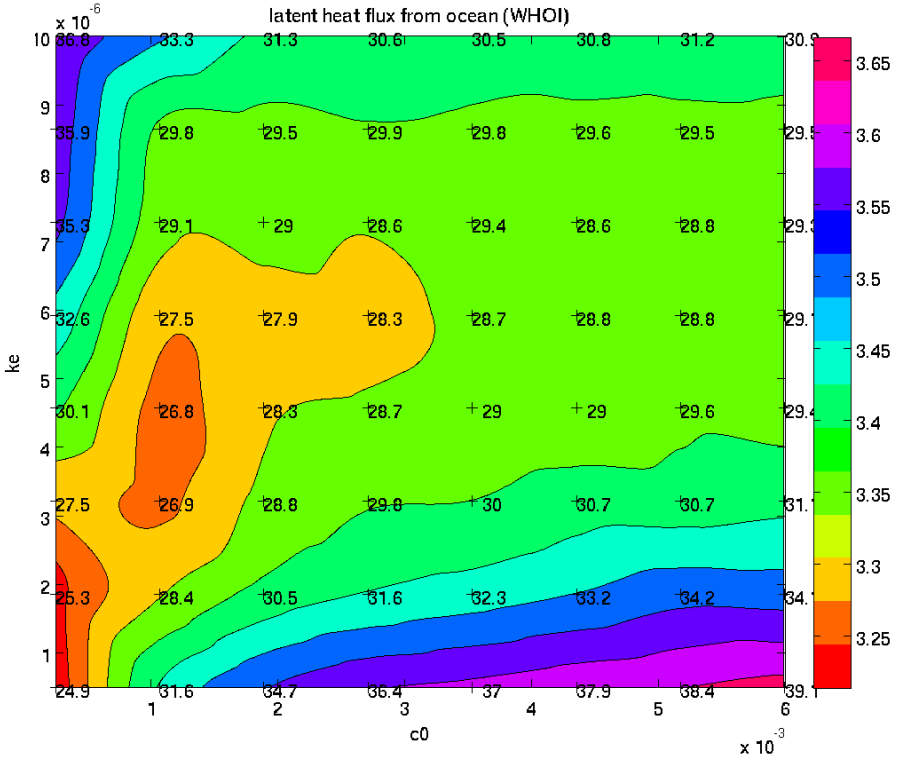


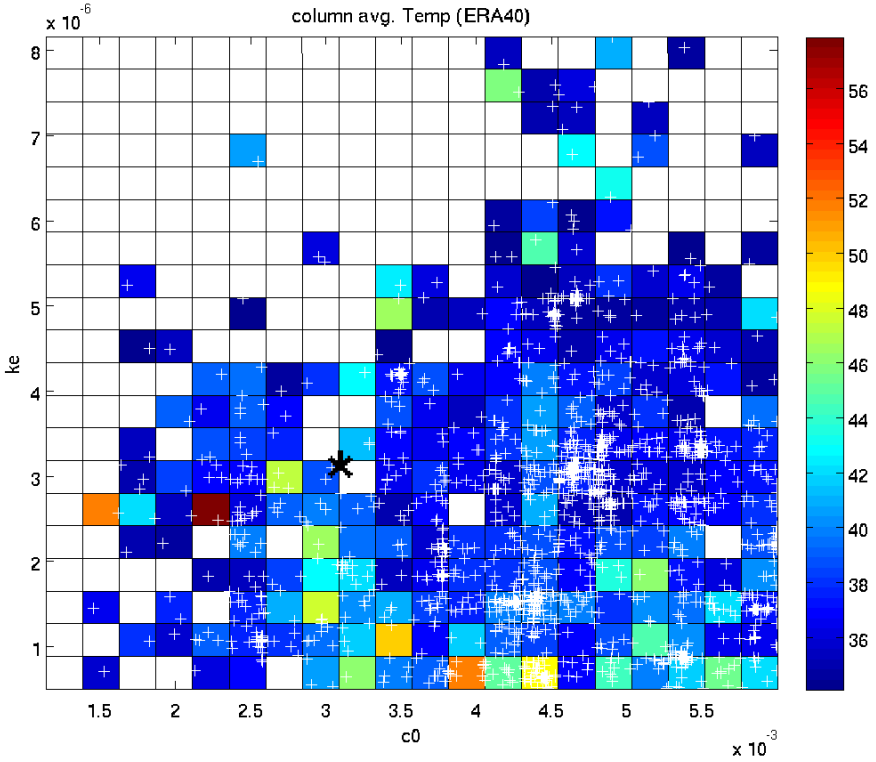
Precipitation over ocean (GPCP)



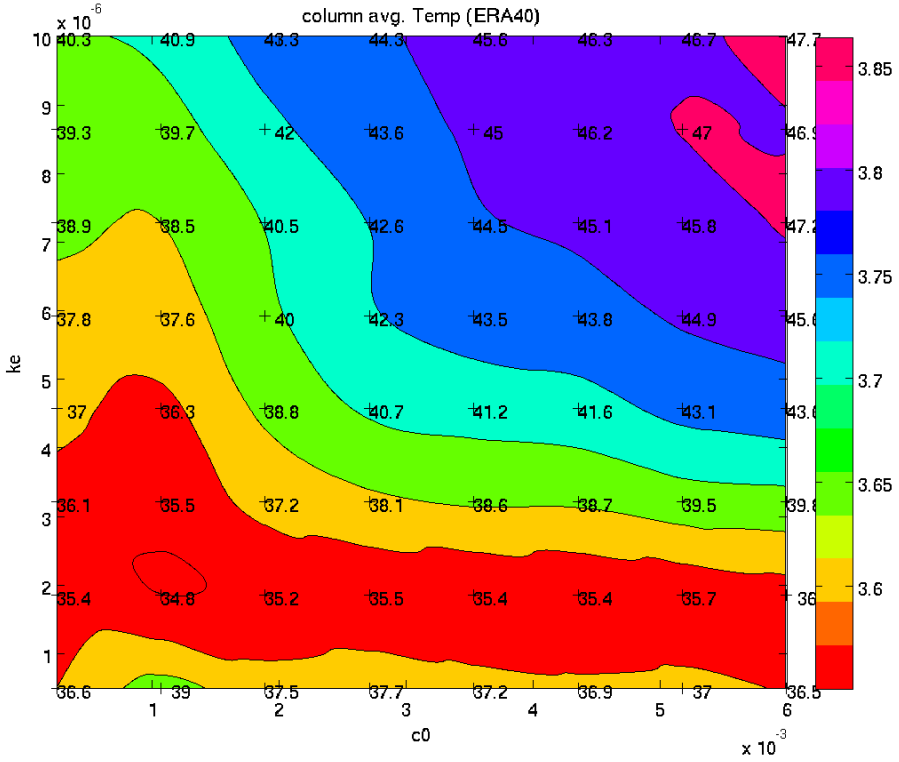


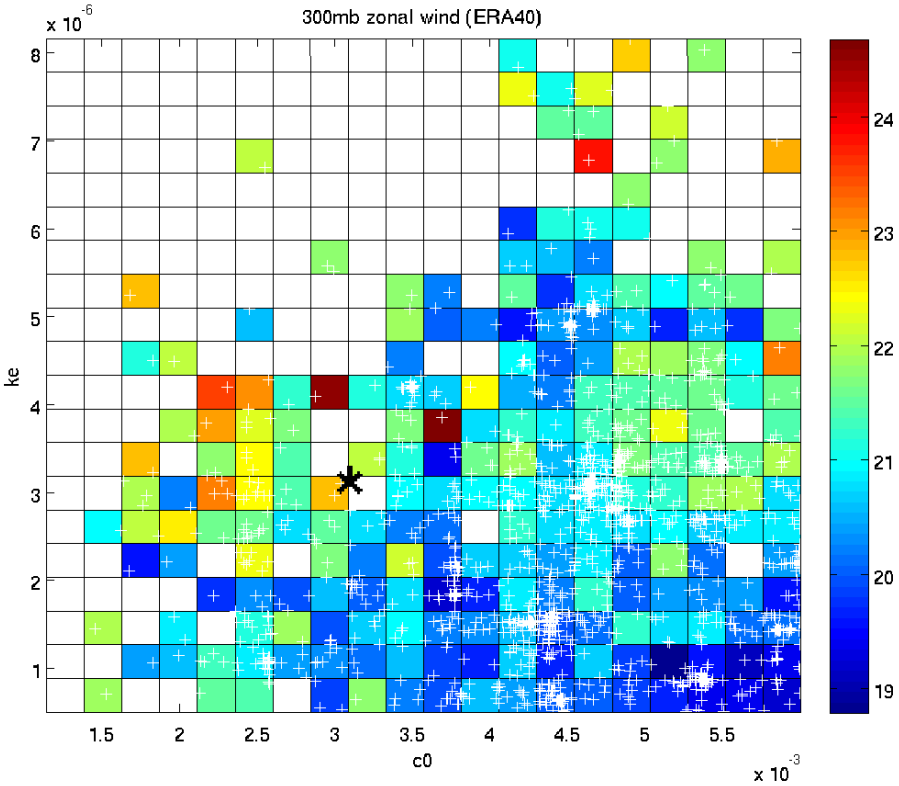
Latent heat flux from ocean (WHOI)



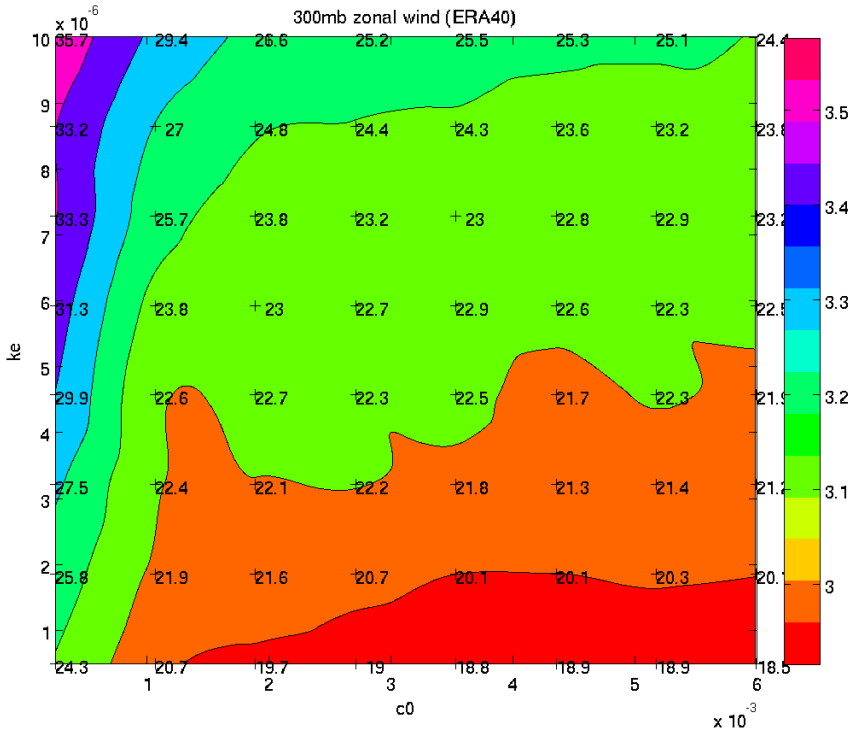


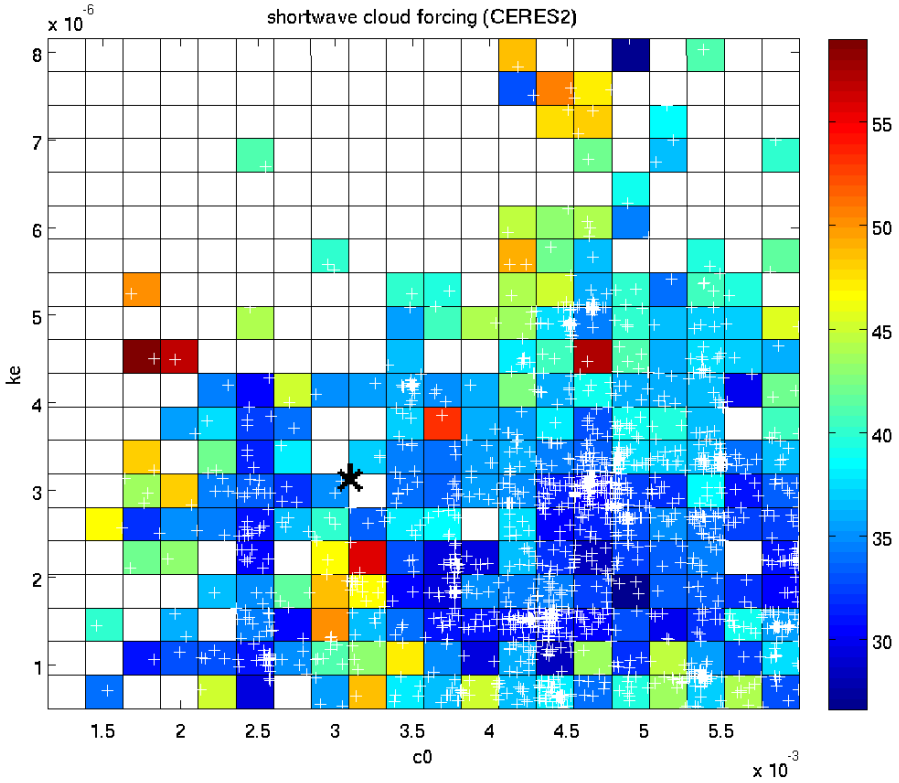
Column average Temperature (ERA40)



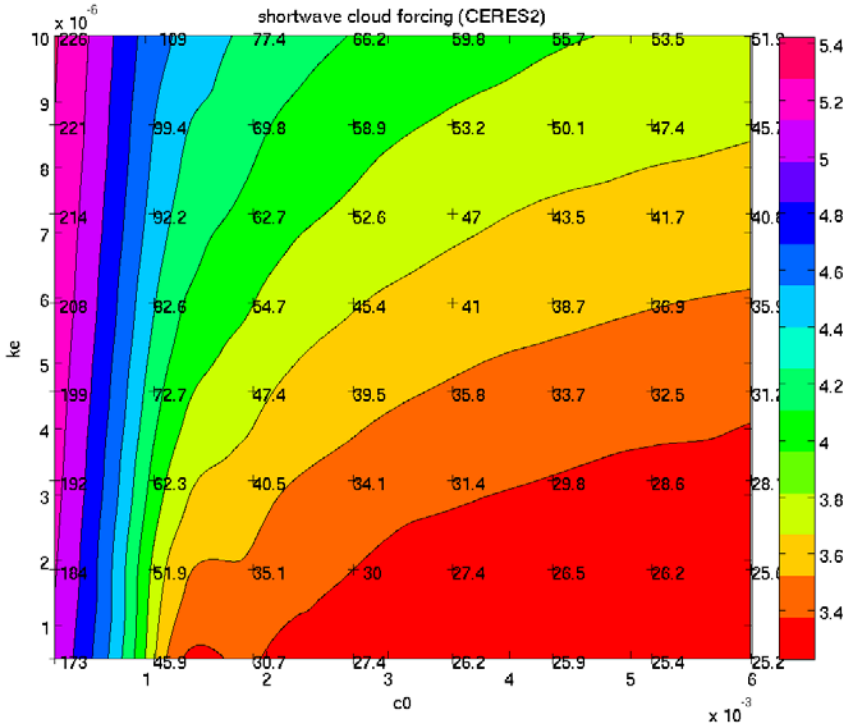


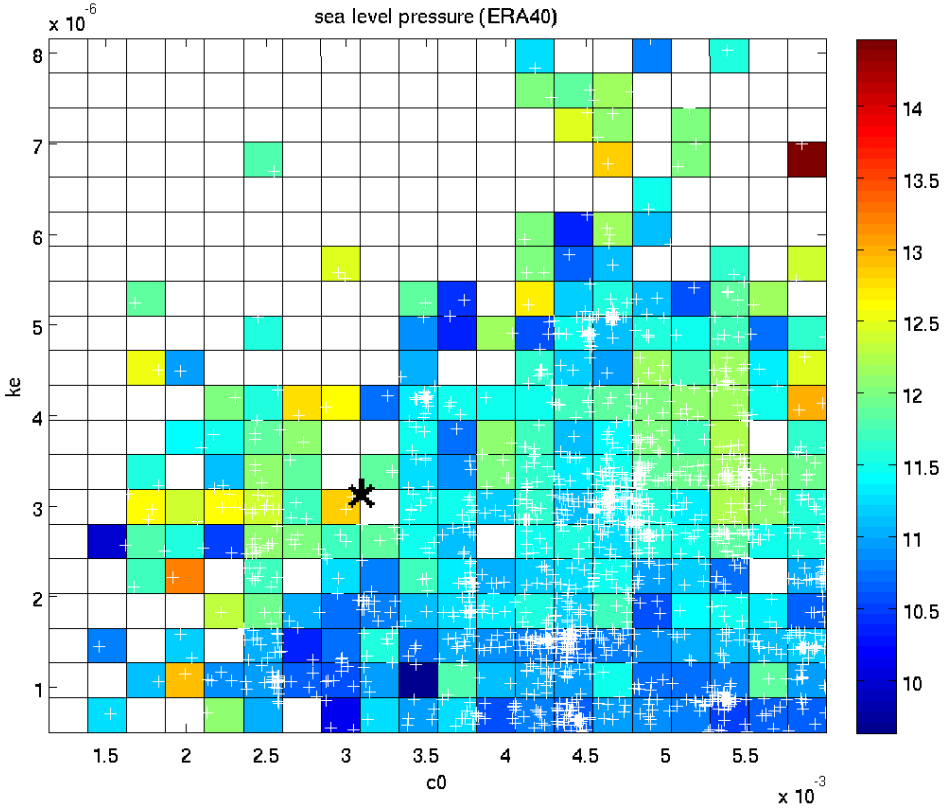
200mb zonal wind (ERA40)



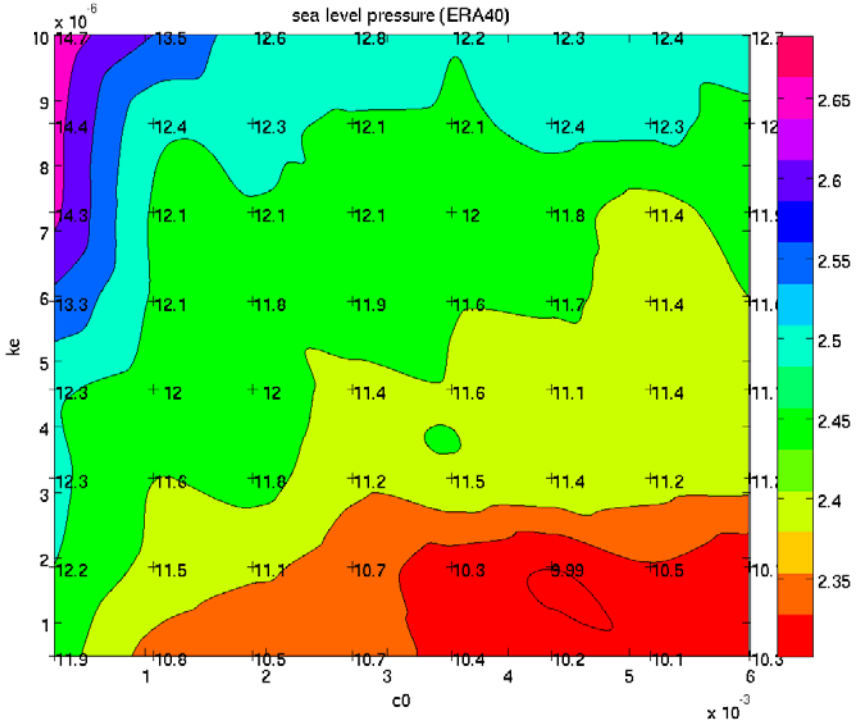


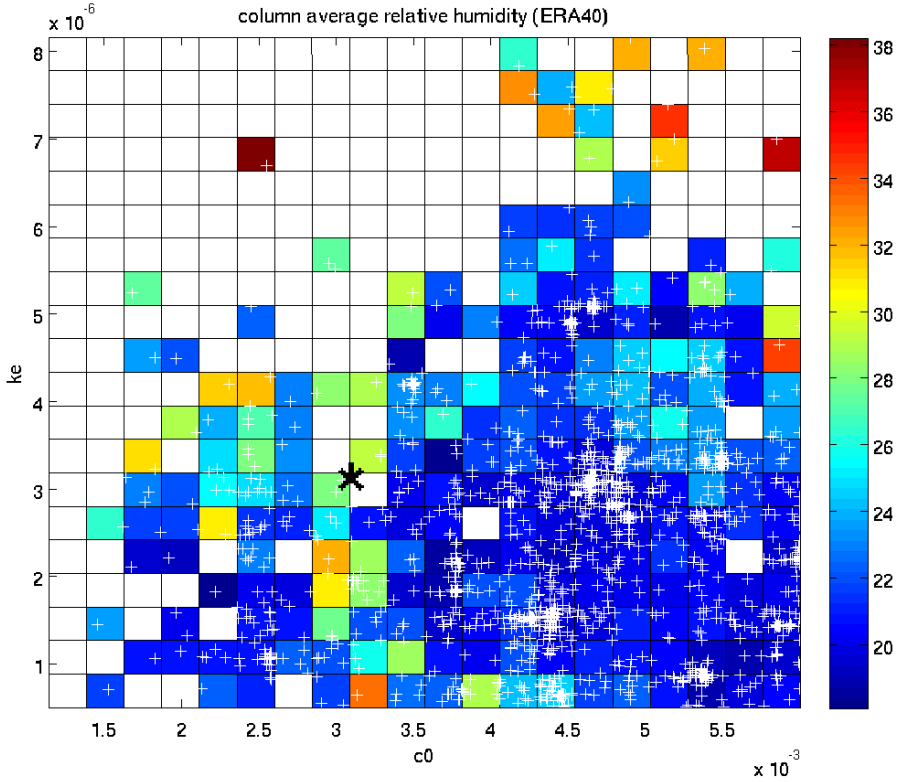
Shortwave cloud forcing (CERES2)



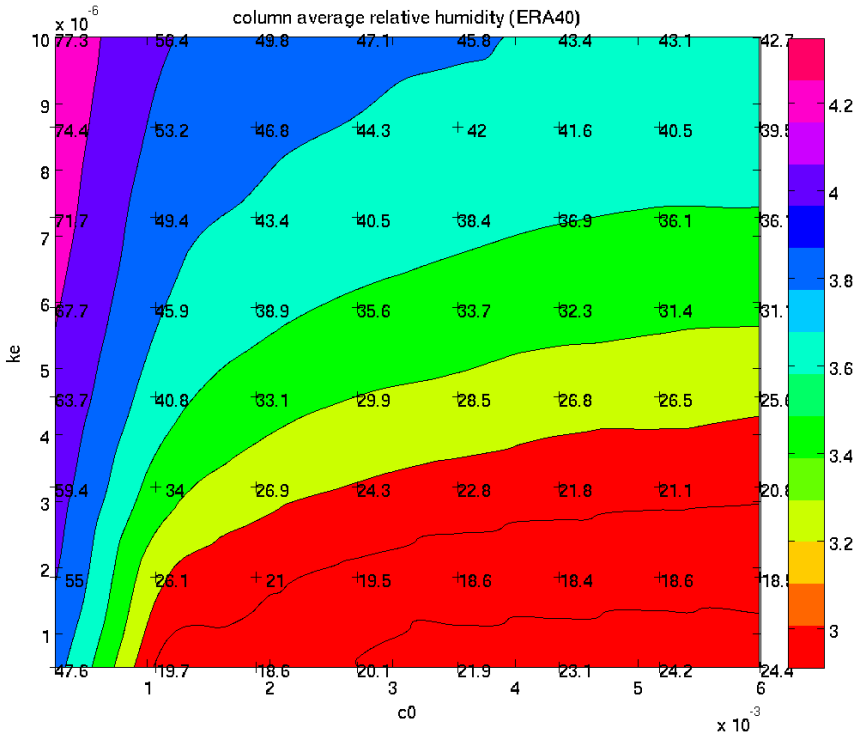


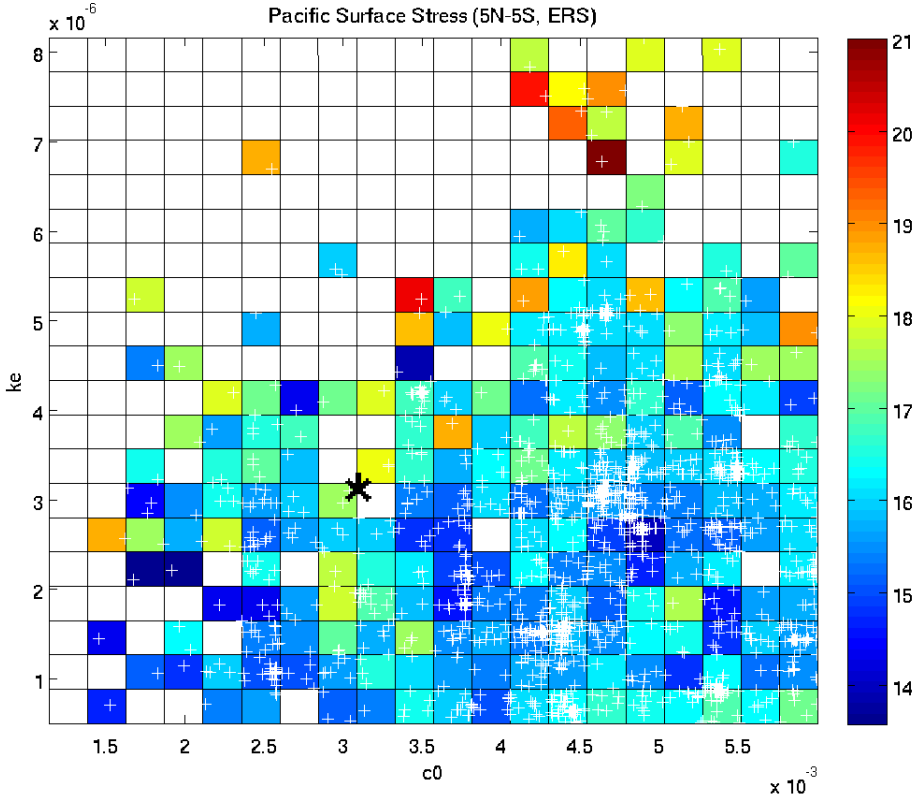
Sea level pressure (ERA40)



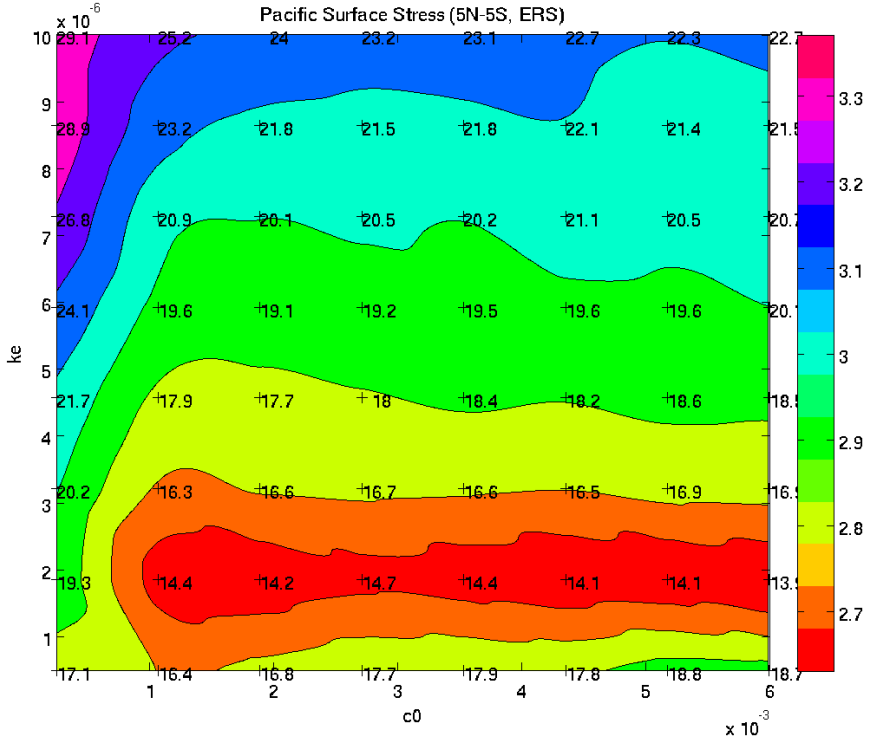


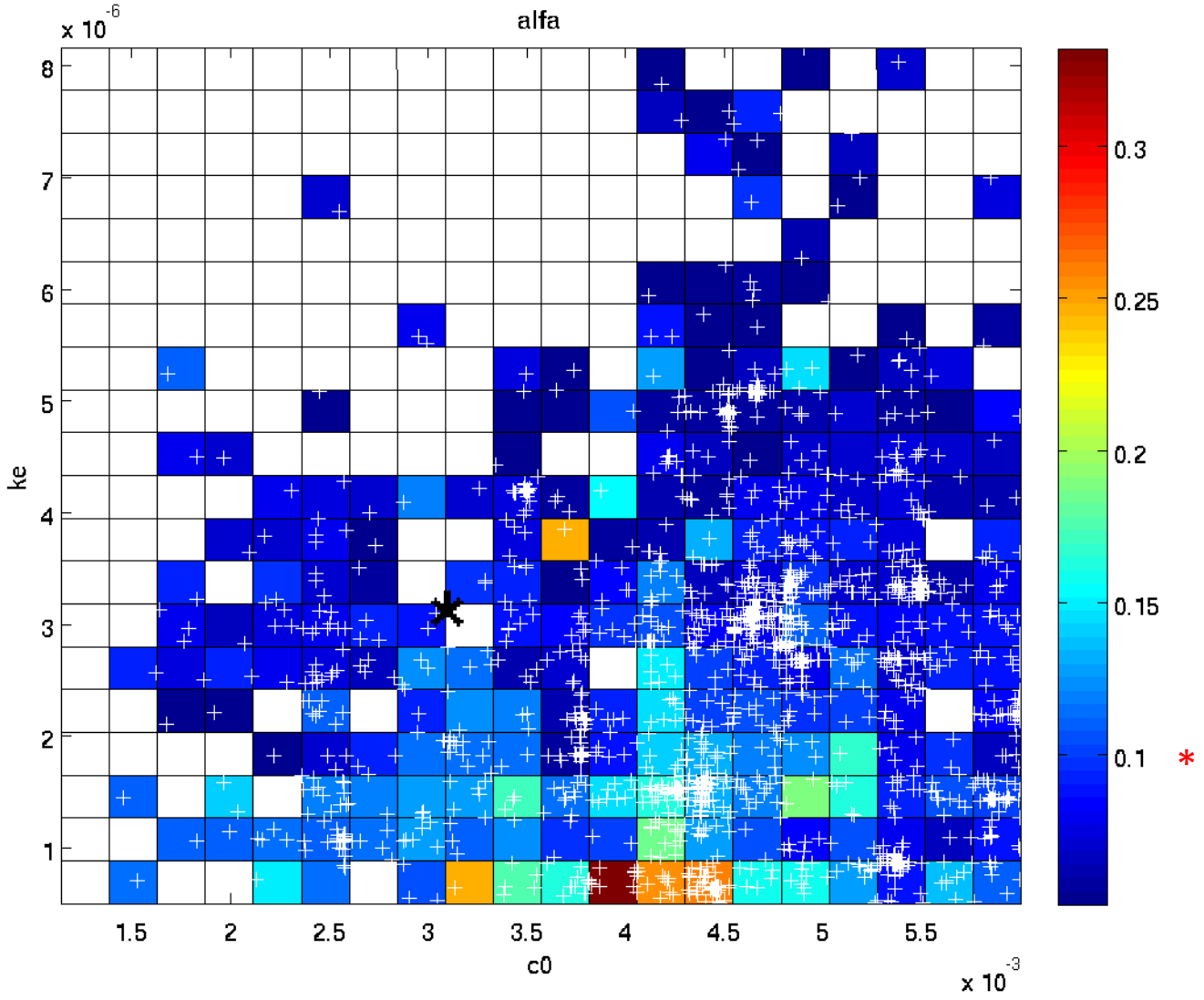
Column average relative humidity (ERA40)



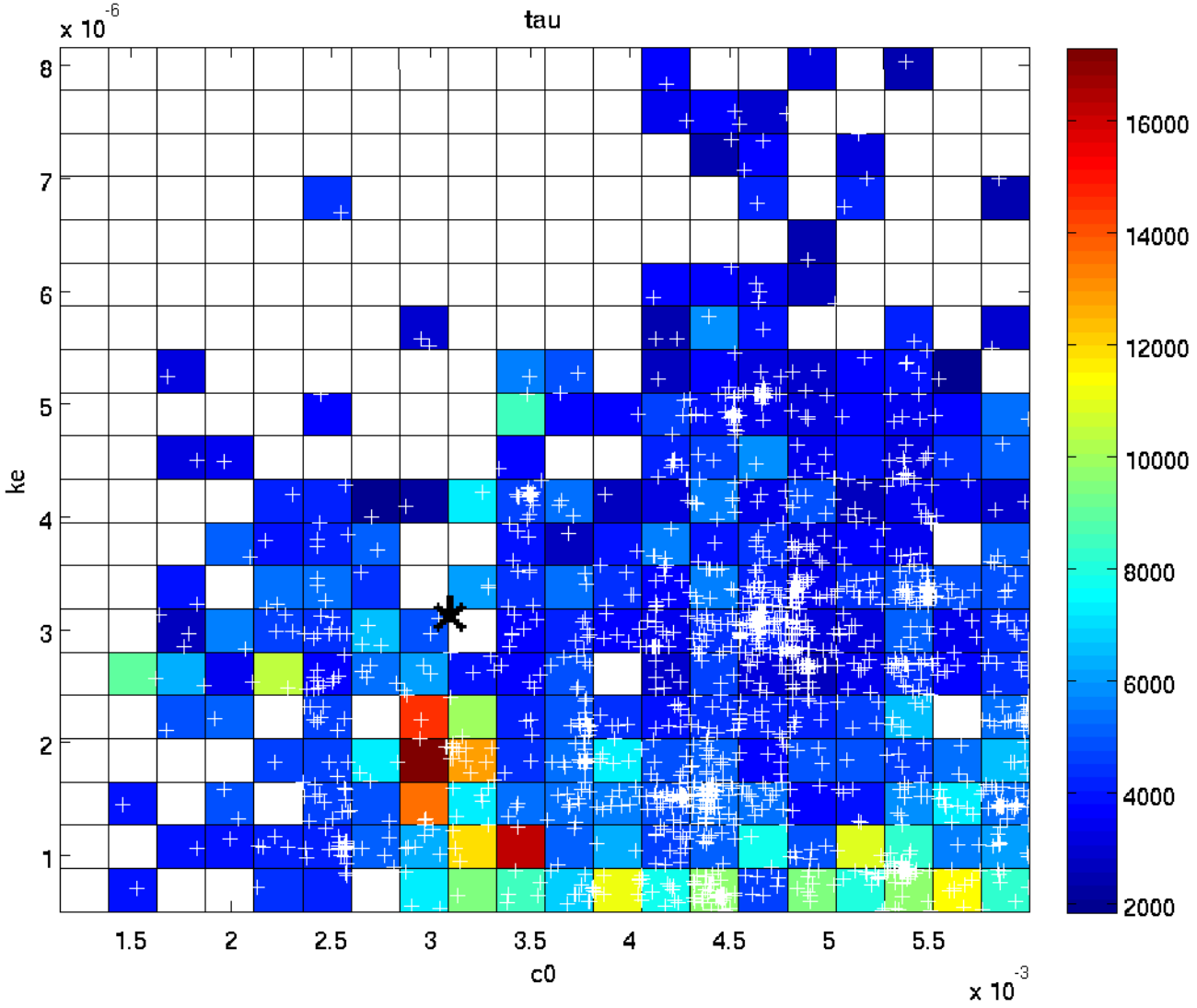


Pacific surface stress 5N-5S (ERS)




alfa
x 10^-6
8
7
6
5
4
3
2
1
ke
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
0.3
0.25
0.2
0.15
0.1
*

ALFA


tau
x 10^-6
ke
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7
6
5
4
3
2
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
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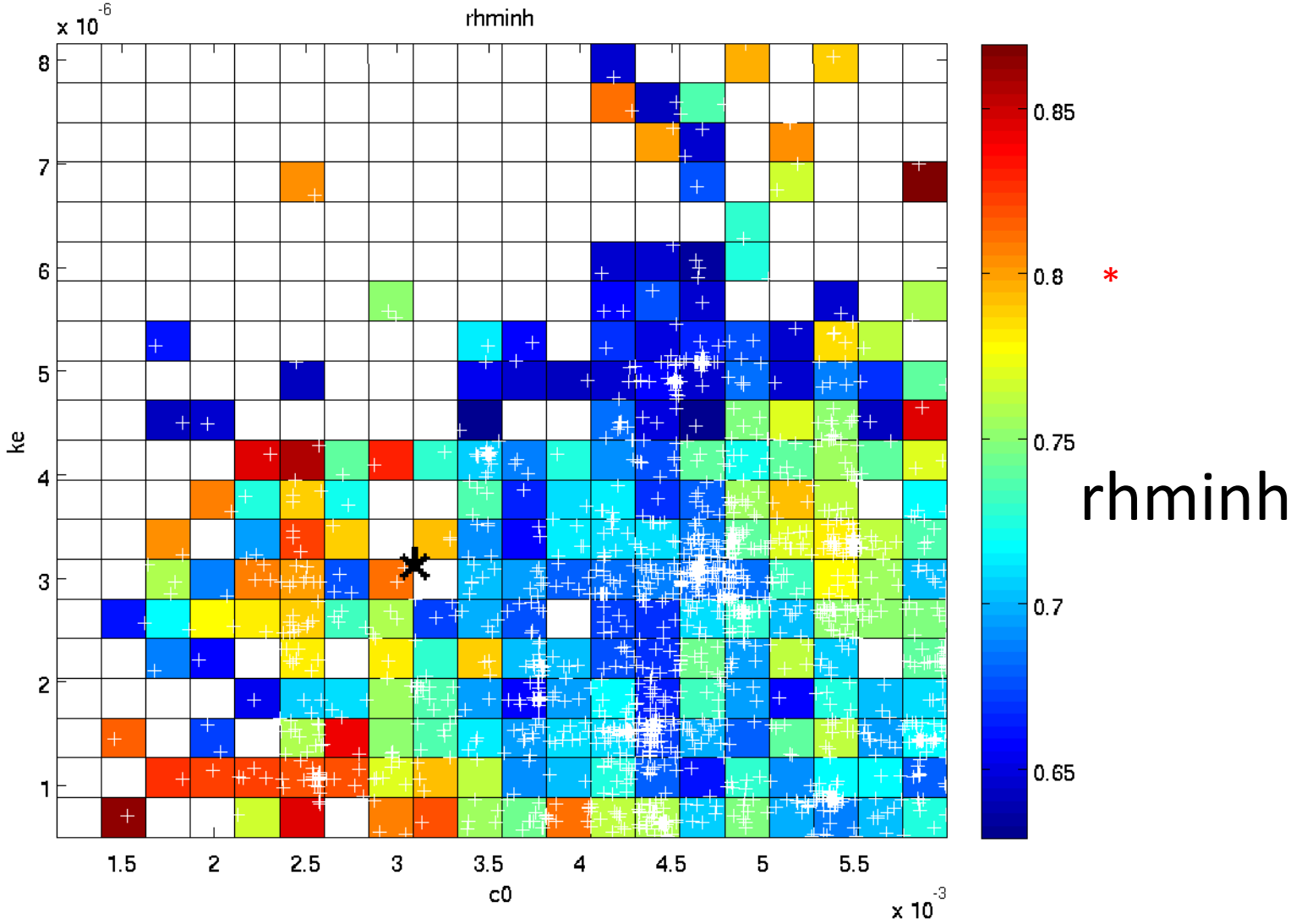
16000
14000
12000
10000
8000
6000
4000
2000

tau

*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x 10^-6
8
7
6
5
4
3
2
1
ke
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
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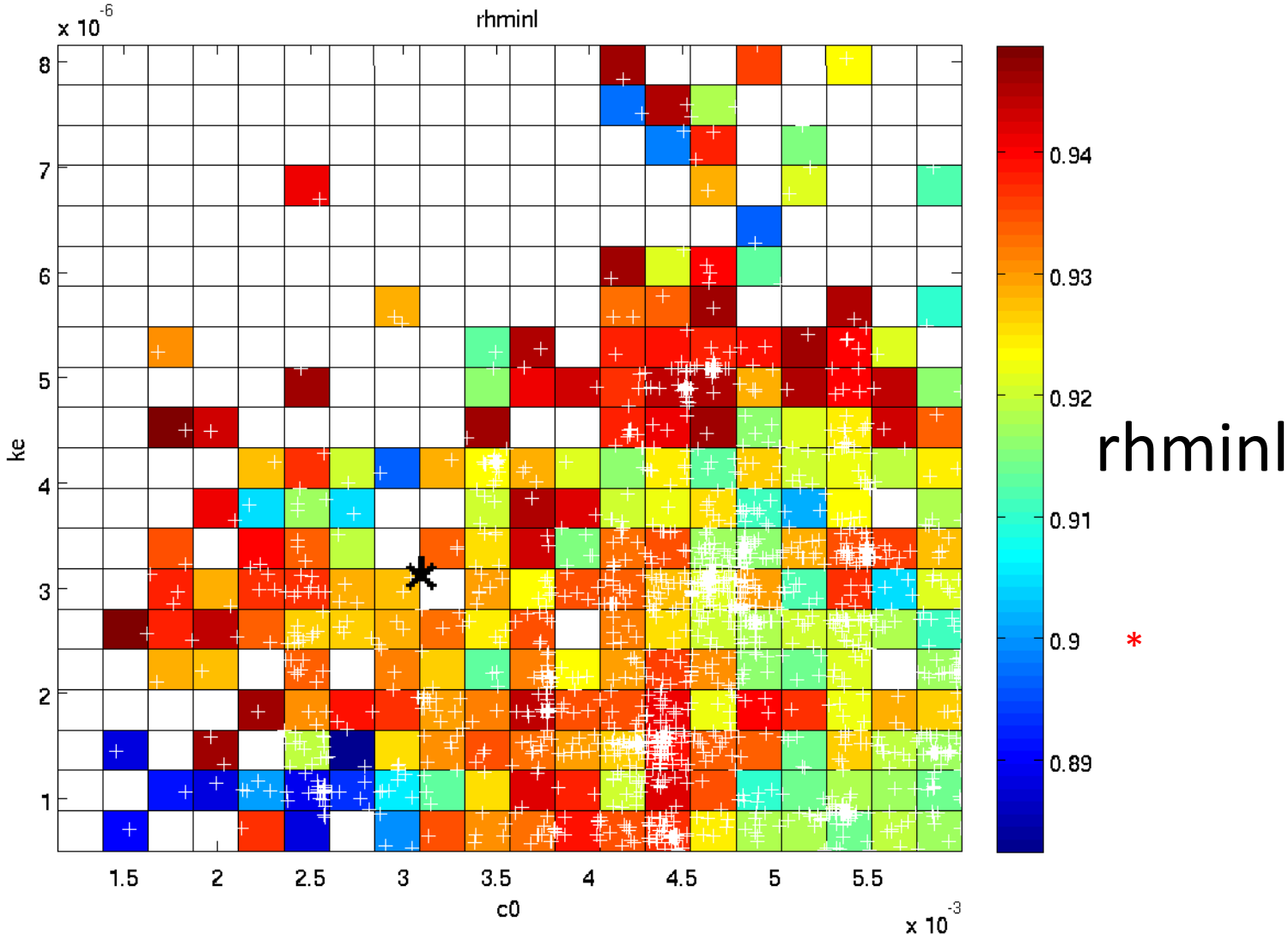
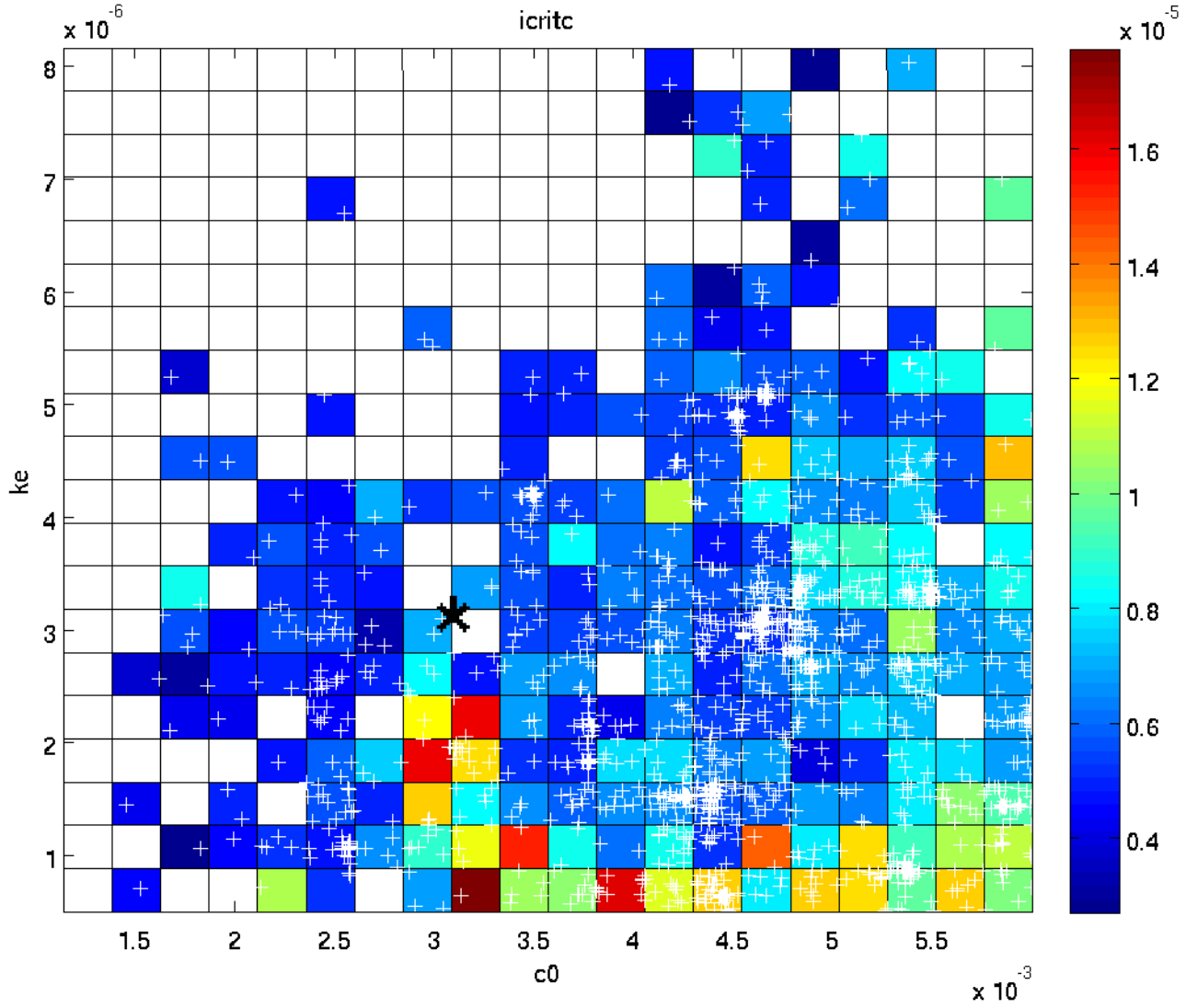
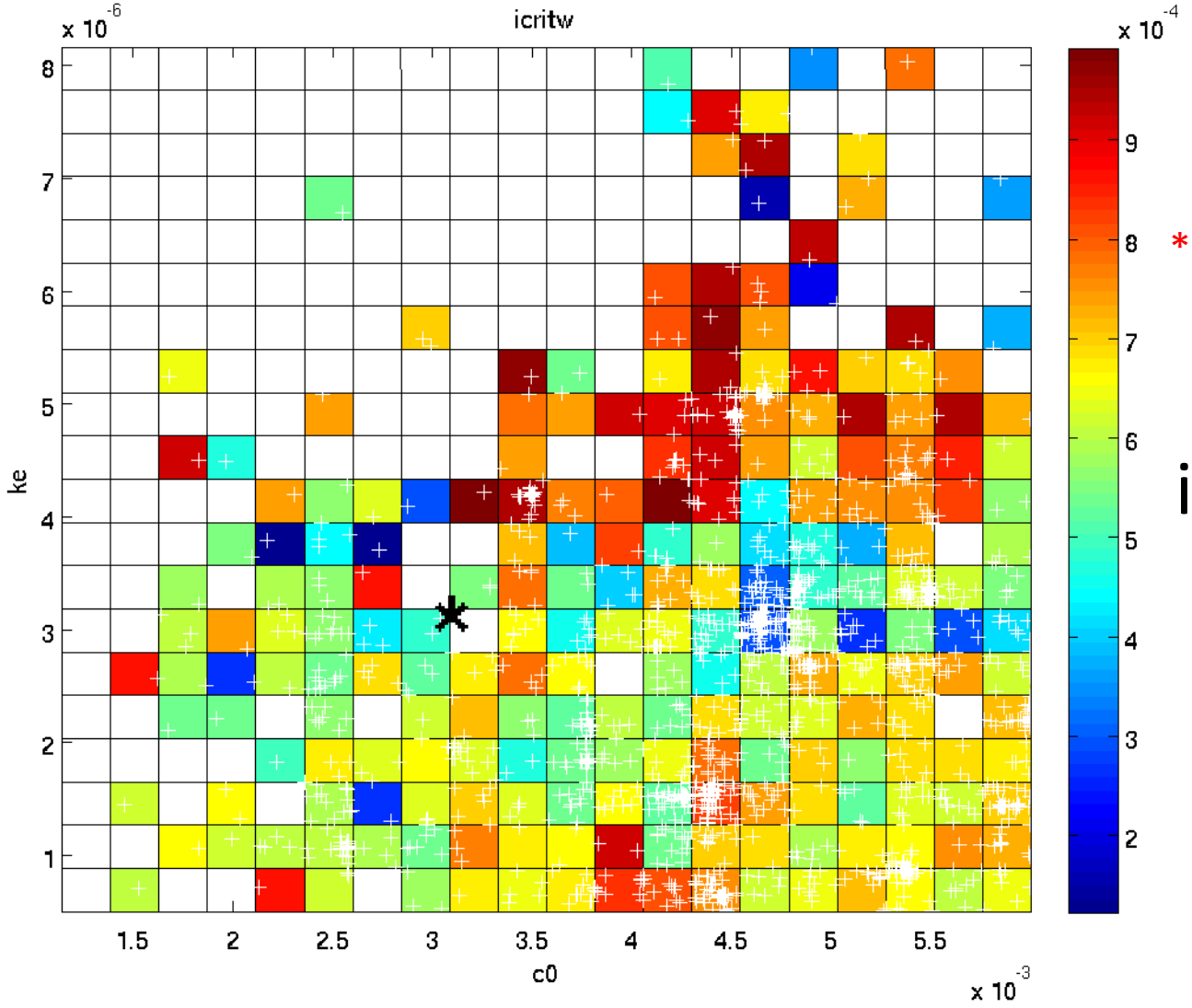
0.8
0.75
0.7
0.65
rhminh


rhminl
x 10^-6
8
7
6
5
4
3
2
1
ke
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
0.94
0.93
0.92
0.91
0.9
0.89
rhminl
*

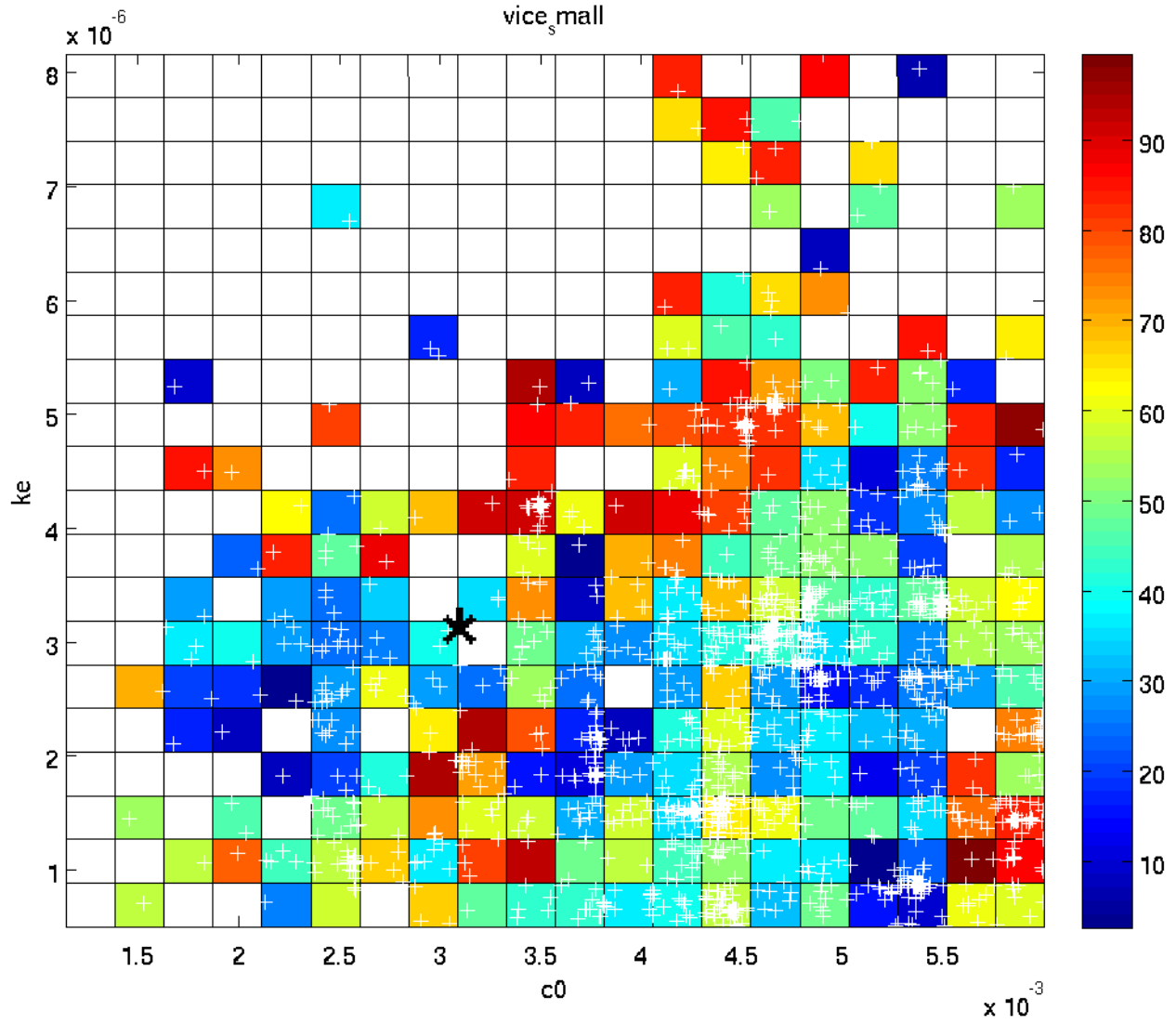

icritc
x 10^-6
x 10^-5
ke
c0
x 10^-3
1.5
2
2.5
3
3.5
4
4.5
5
5.5
1
2
3
4
5
6
7
8
0.4
0.6
0.8
1
1.2
1.4
1.6

*

icritc



icritw


vice_small
x 10^-6
ke
c0
x 10^-3
1.5
2
2.5
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4
4.5
5
5.5
1
2
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6
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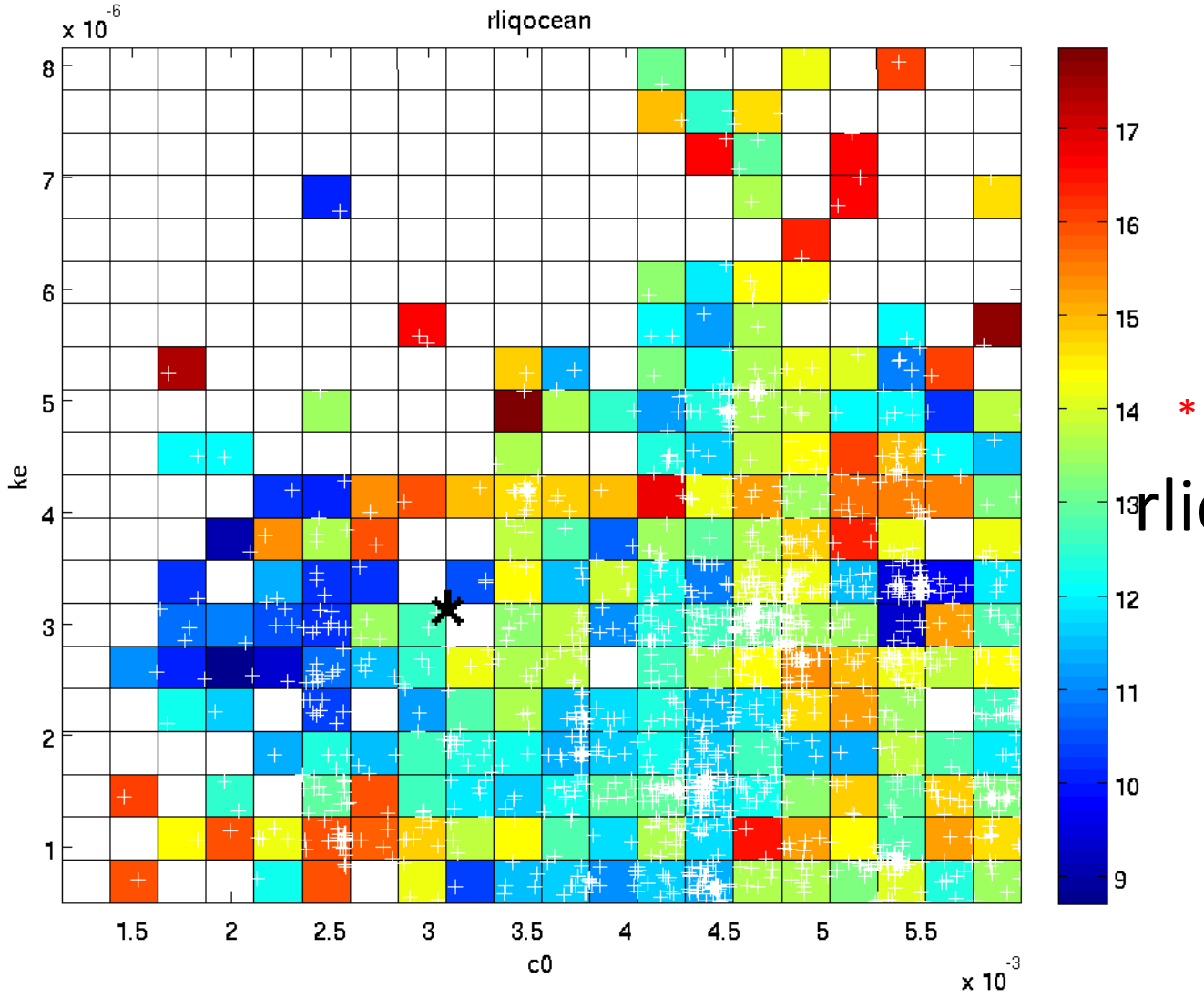
8
10
20
30
40
50
60
70
80
90

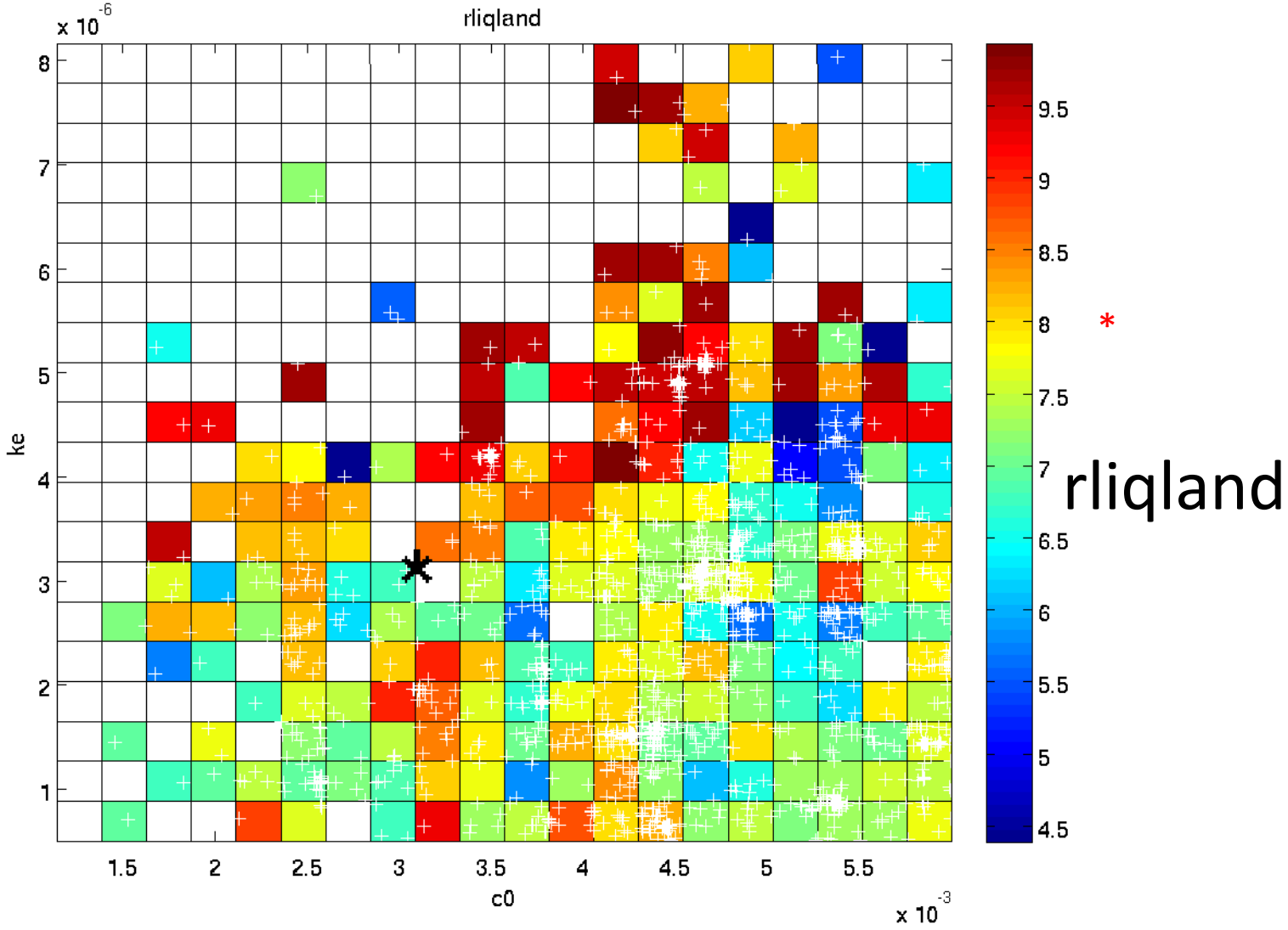
Vice small

*


rliqocean
x 10^-6
8
7
6
5
4
3
2
1
ke
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
17
16
15
14
13
12
11
10
9

*

rliqocean


rliqland
x 10^-6
ke
8
7
6
5
4
3
2
1
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2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
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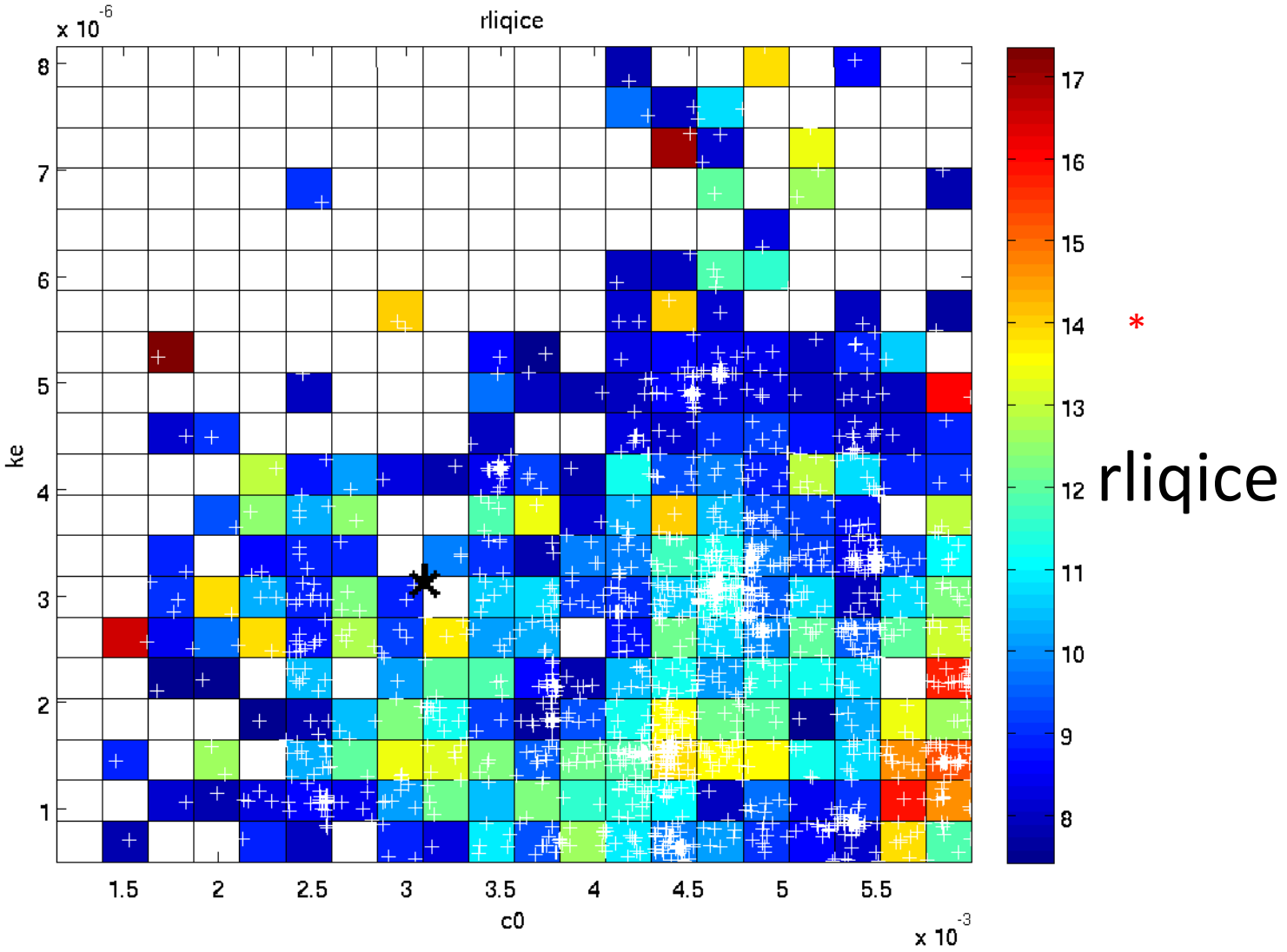
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
*
rliqland


rliqice
x 10^-6
ke
c0
x 10^-3
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2
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3.5
4
4.5
5
5.5
1
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7
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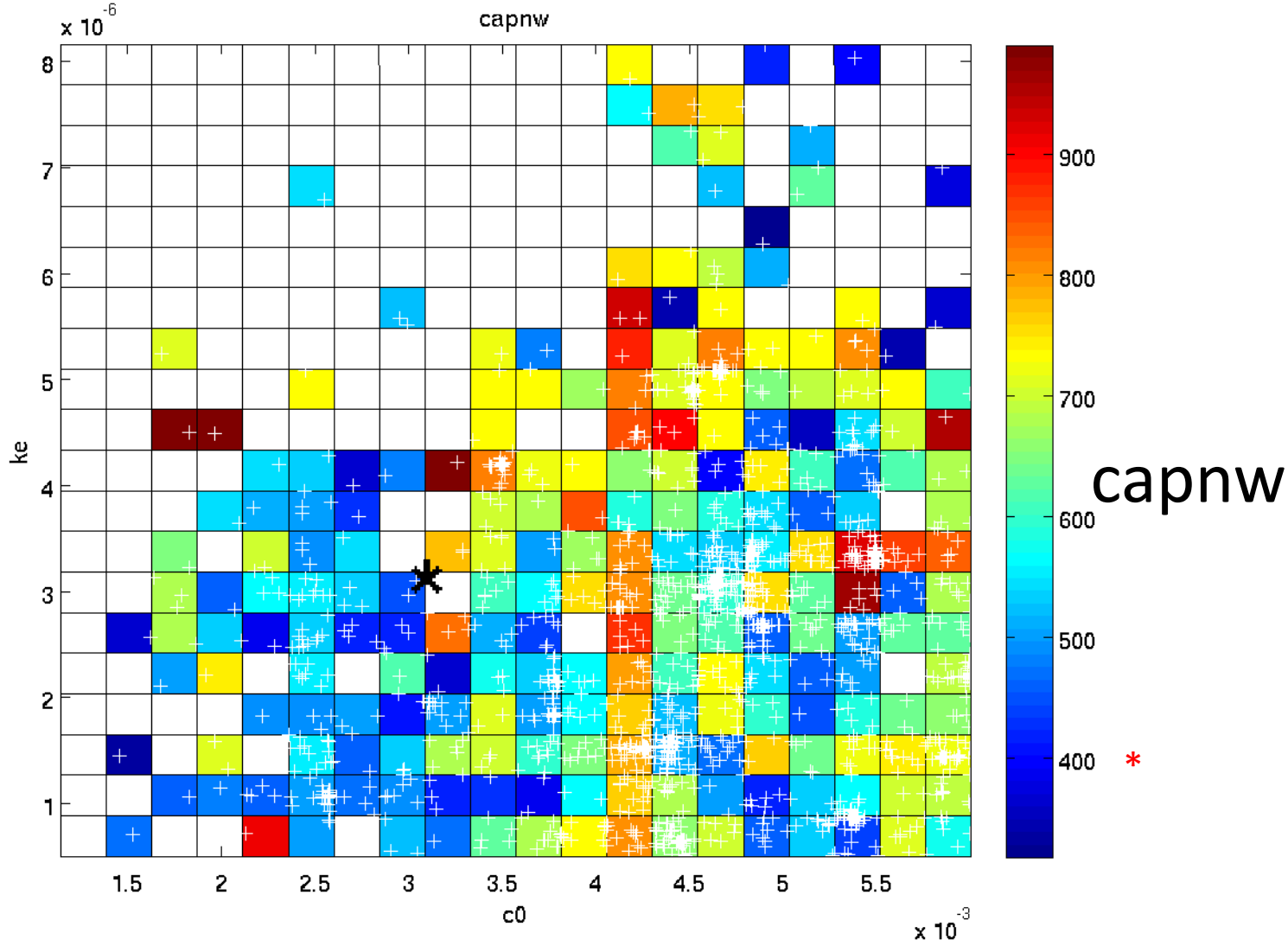
8
9
10
11
12
13
14
15
16
17
*
rliqice


capnw
x 10^-6
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7
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3
2
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ke
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2
2.5
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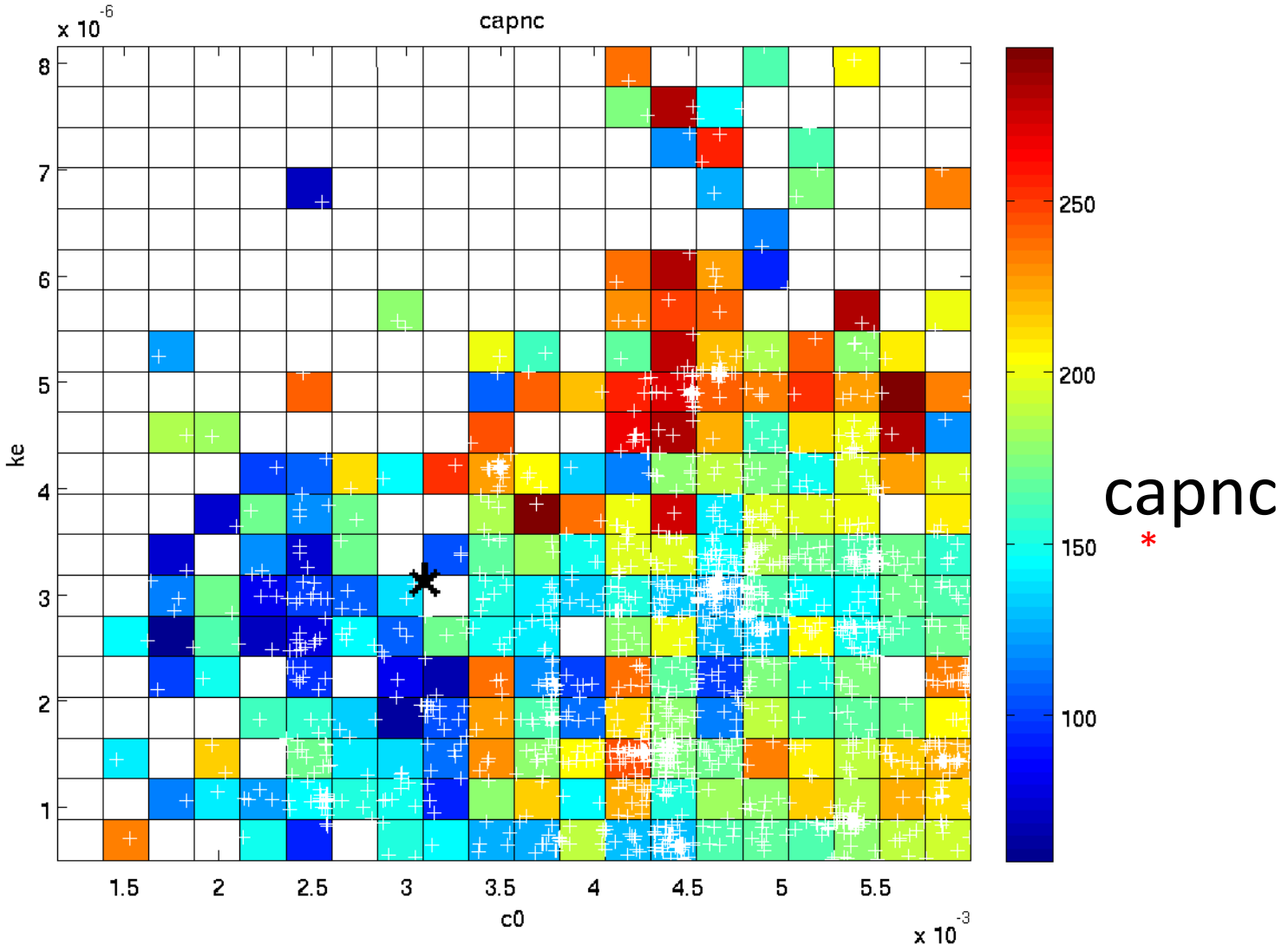
4.5
5
5.5
c0
x 10^-3
900
800
700
600
500
400
capnw
*


capnc
x 10^-6
ke
8
7
6
5
4
3
2
1
1.5
2
2.5
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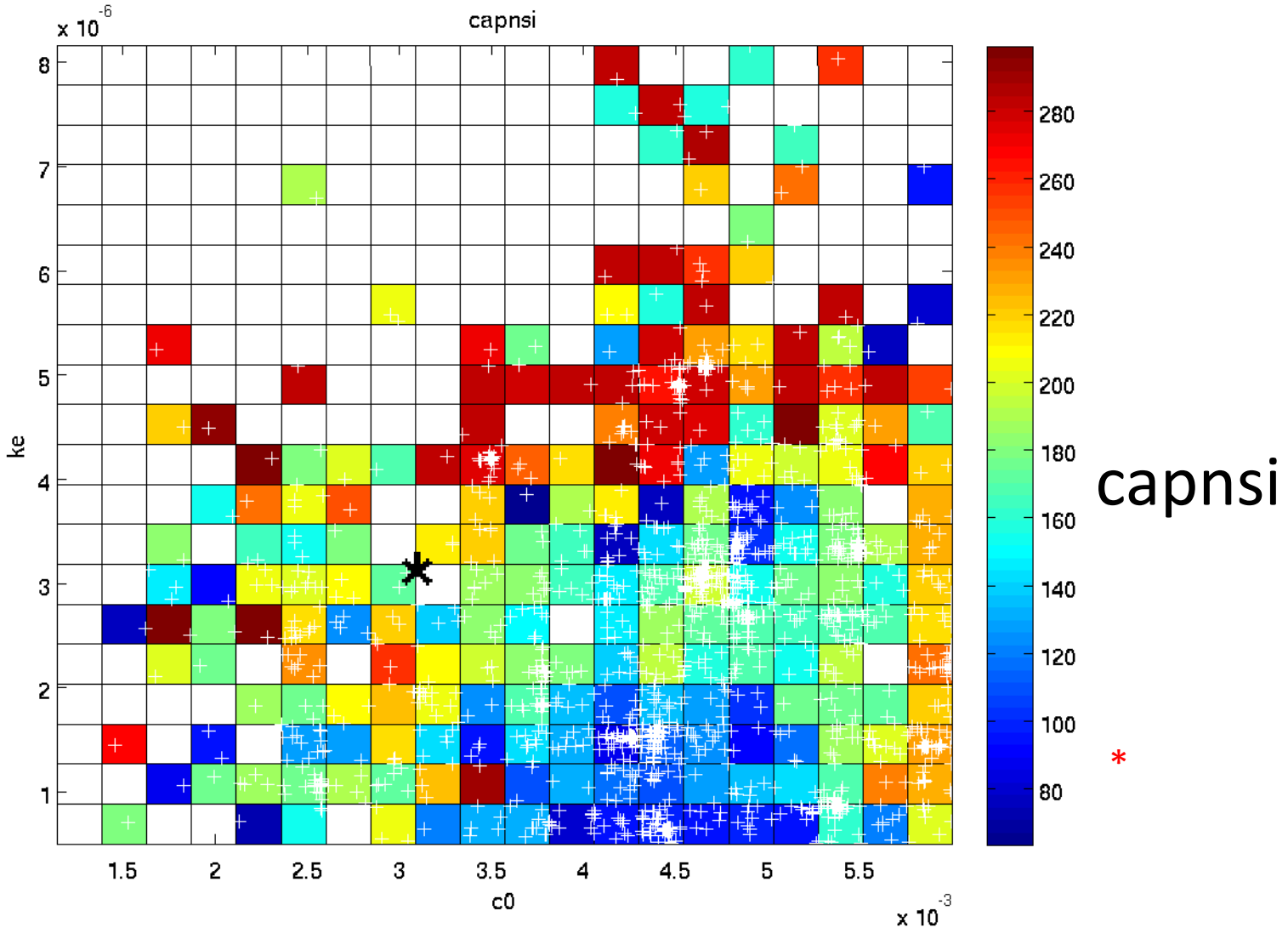
3.5
4
4.5
5
5.5
c0
x 10^-3
250
200
150
100
capnc
*


capnsi
x 10^-6
ke
8
7
6
5
4
3
2
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
c0
x 10^-3
280
260
240
220
200
180
160
140
120
100
80
capnsi
*

Summary

- Maximum likelihood means that the model will be similar to observations in most respects.
- Best performing model configuration is not the most likely choice.
- Models have difficulty matching all constraints simultaneously
- There are strong dependencies among model parameters selected