Understanding the distribution of tropical low cloud albedo in CFMIP2 models

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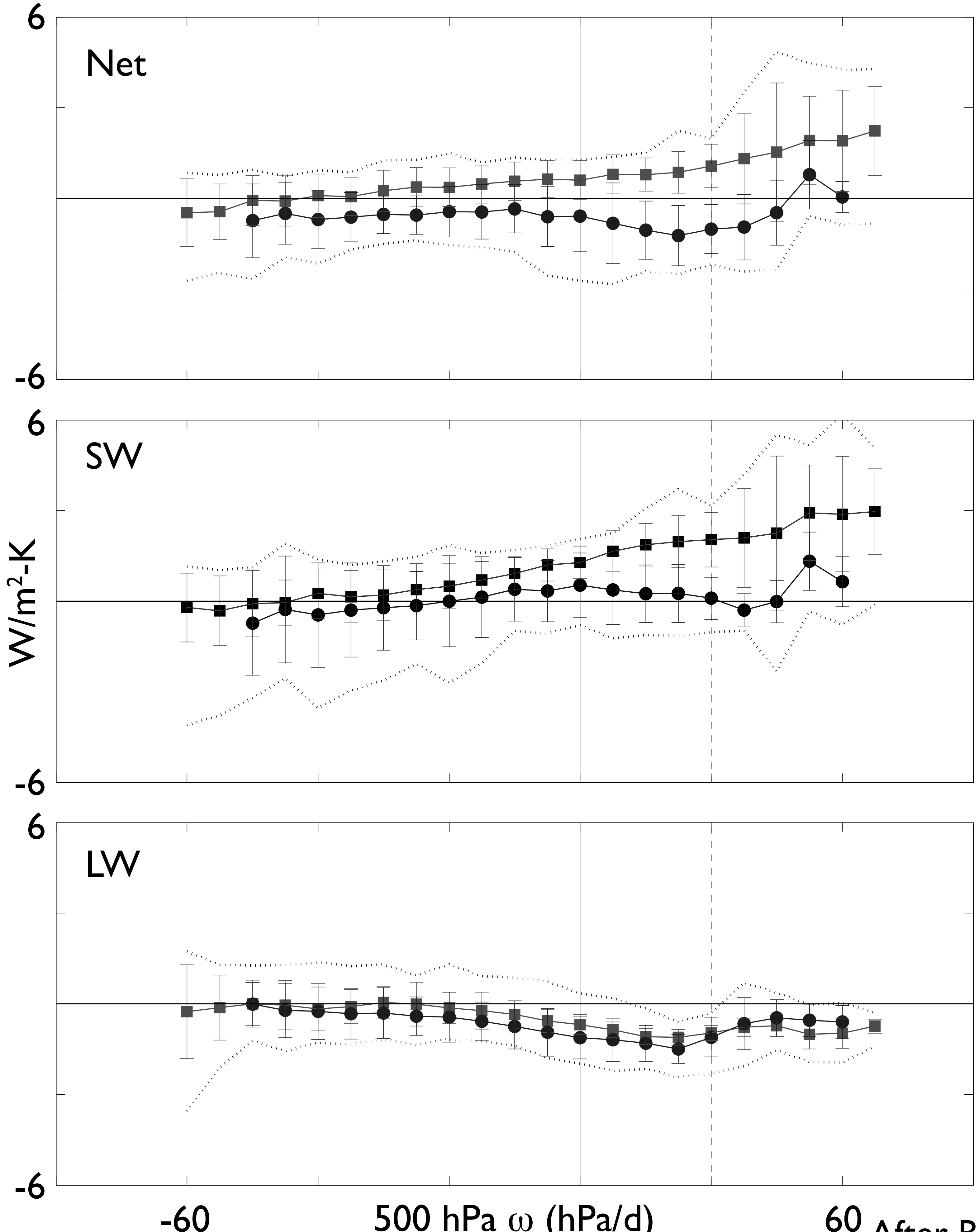
University of Colorado



After Bony and Dufresne 2005

We hypothesize that

- differences between parameterizations, rather than between large-scale states, are responsible for this diversity

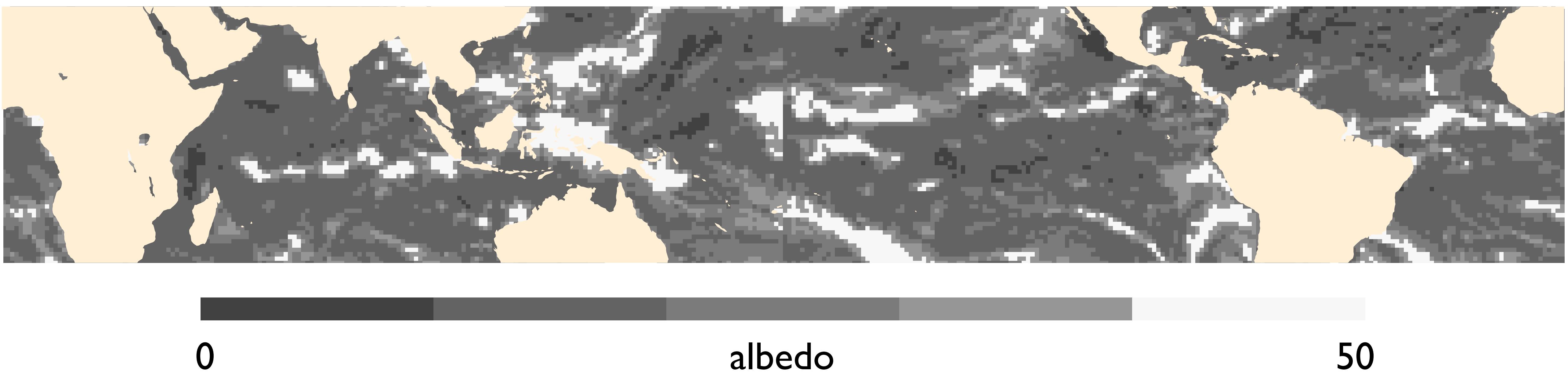
- better (or even more uniform) parameterizations would lead to narrow distributions of predictions

Corollaries: differences between parameterization should be

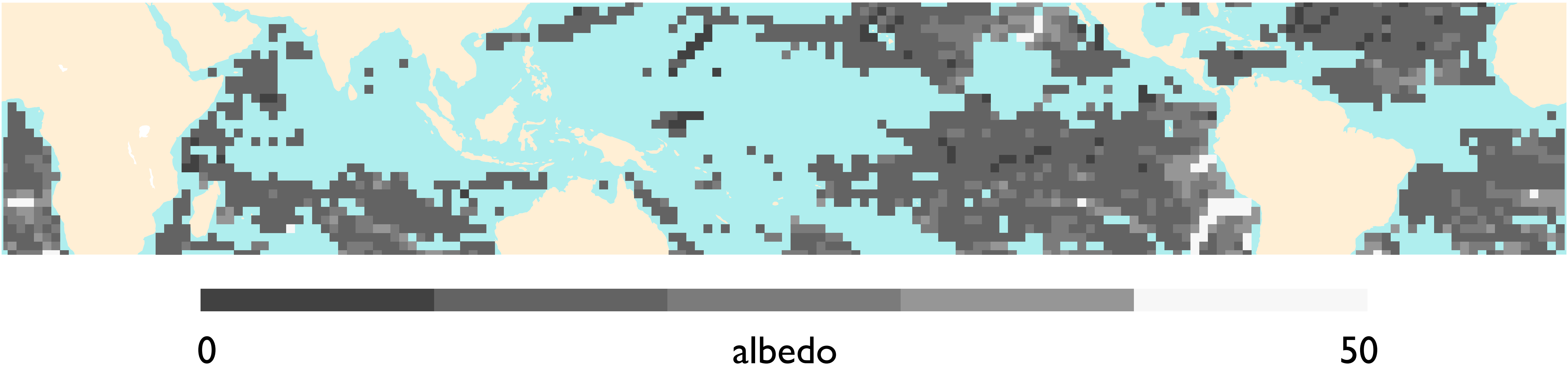
- evident in present-day simulations

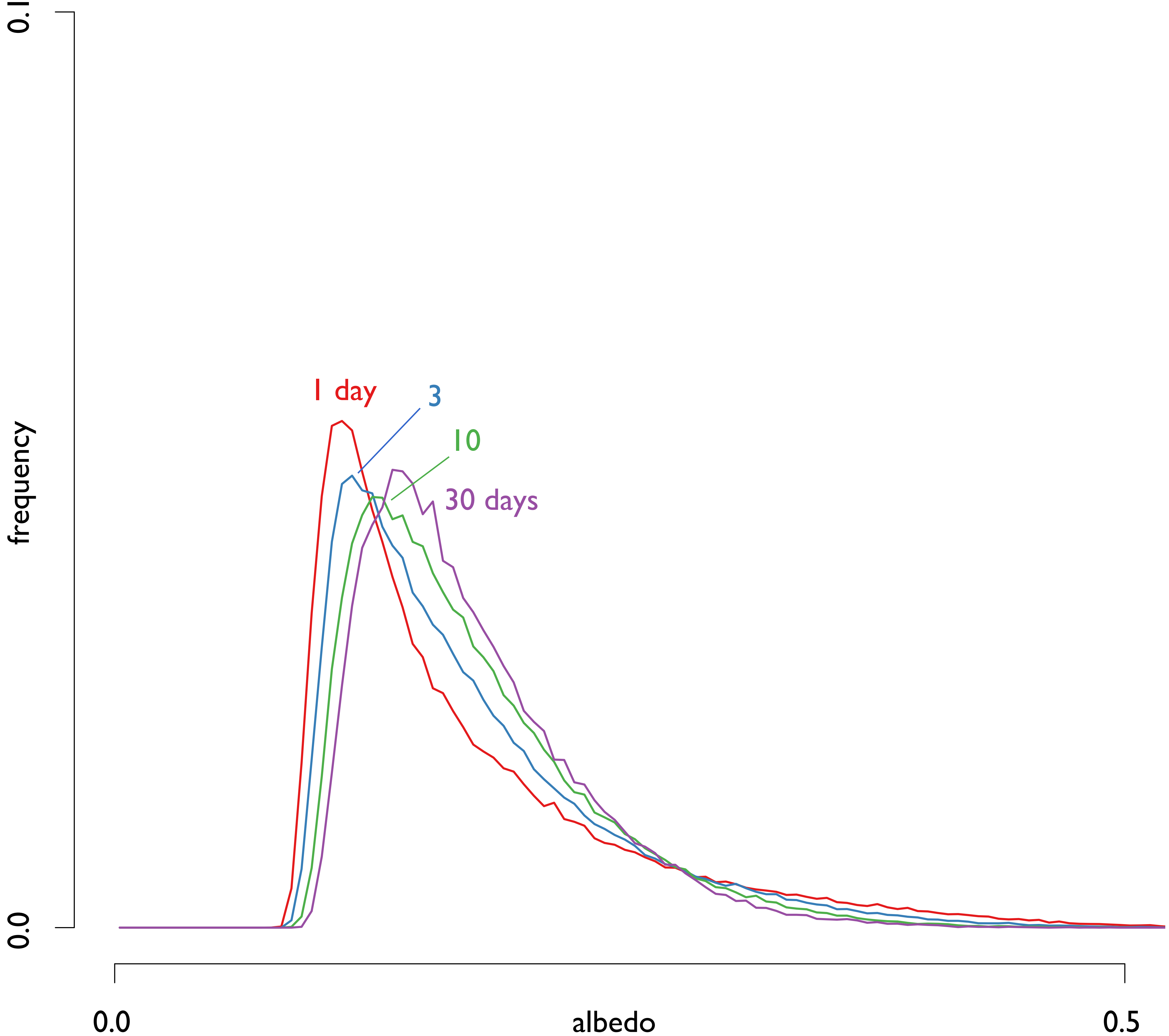
- evident at short time scales

Diurnally-averaged CERES albedo

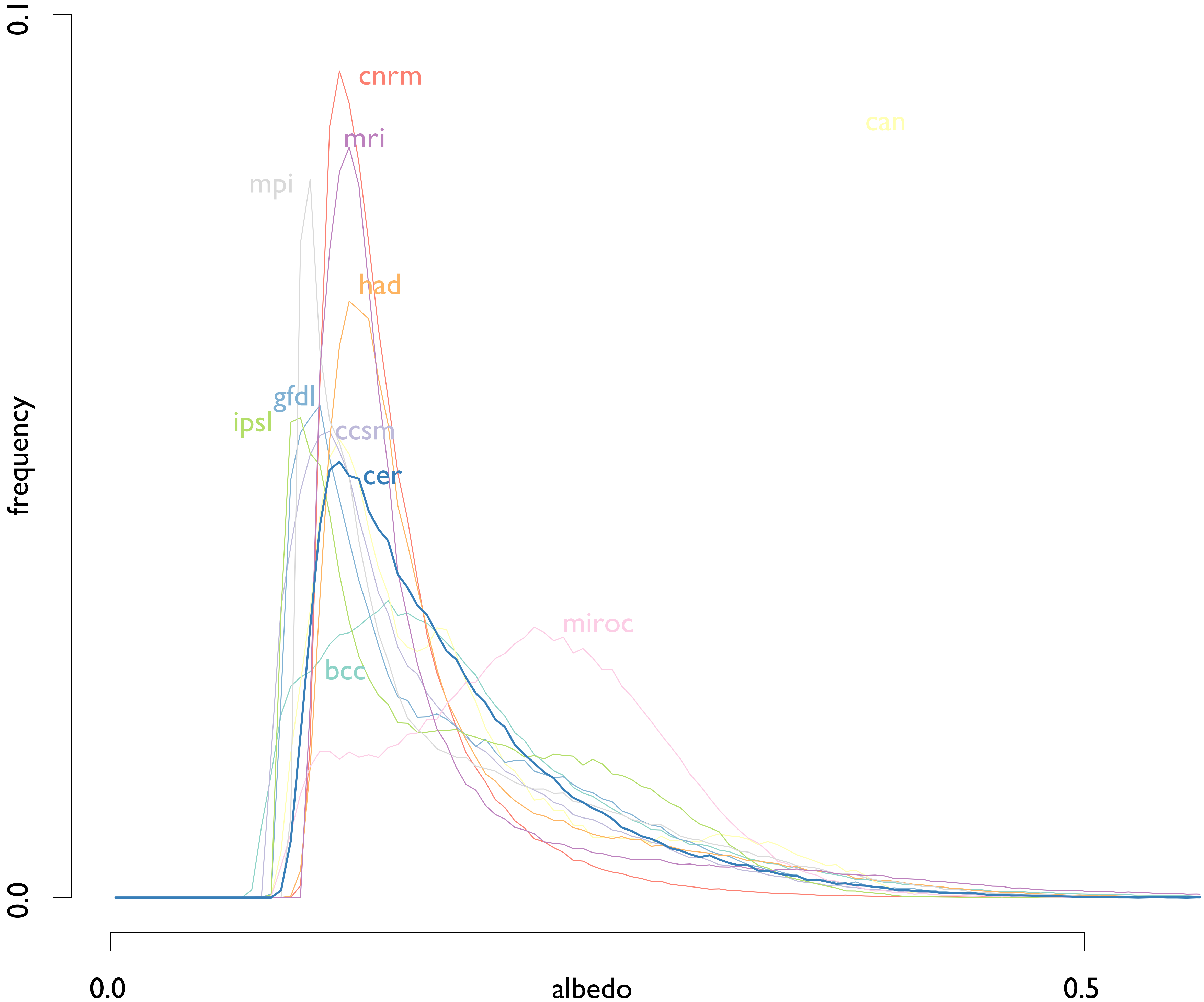


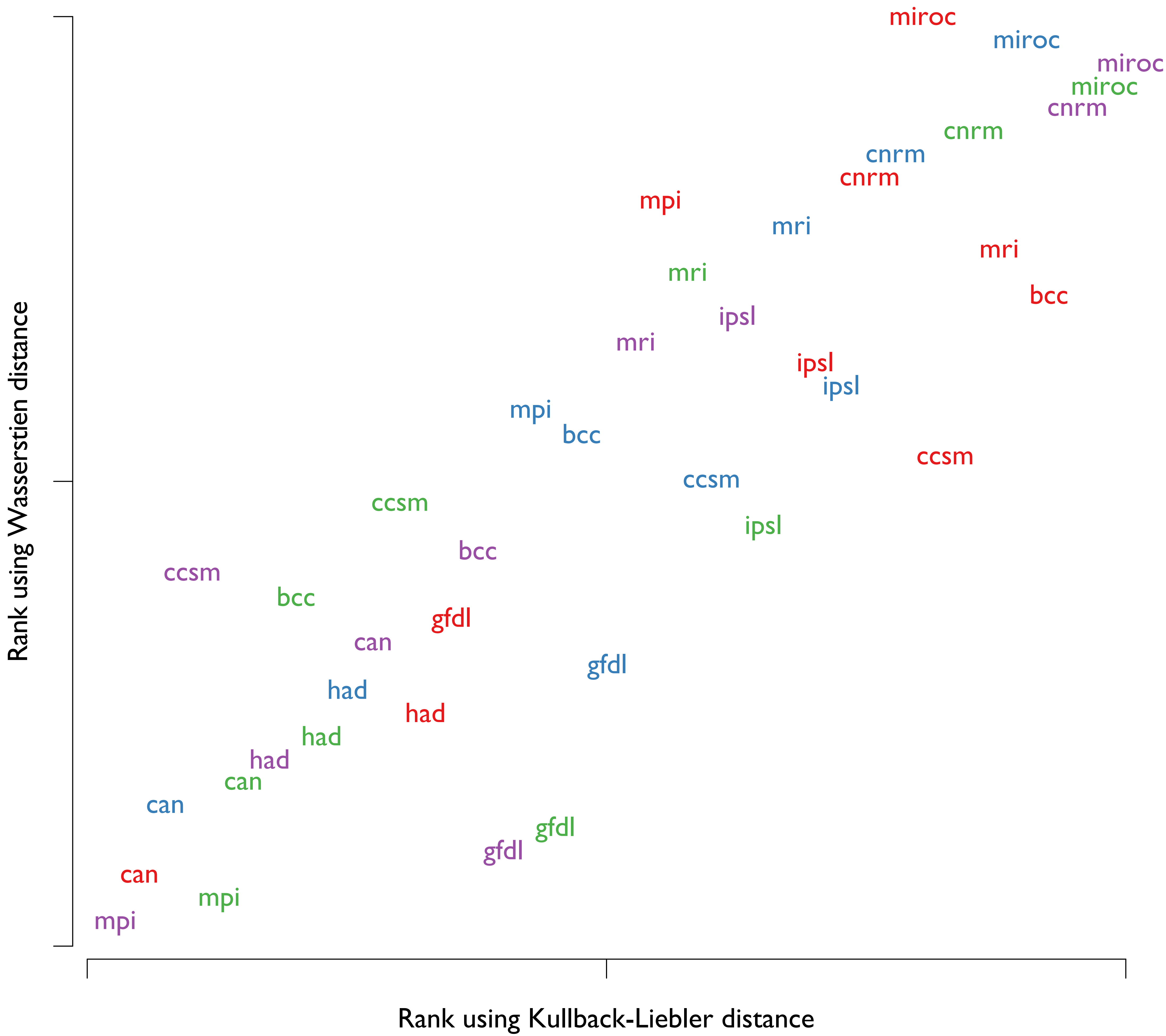
Diurnally-averaged CERES low cloud albedo



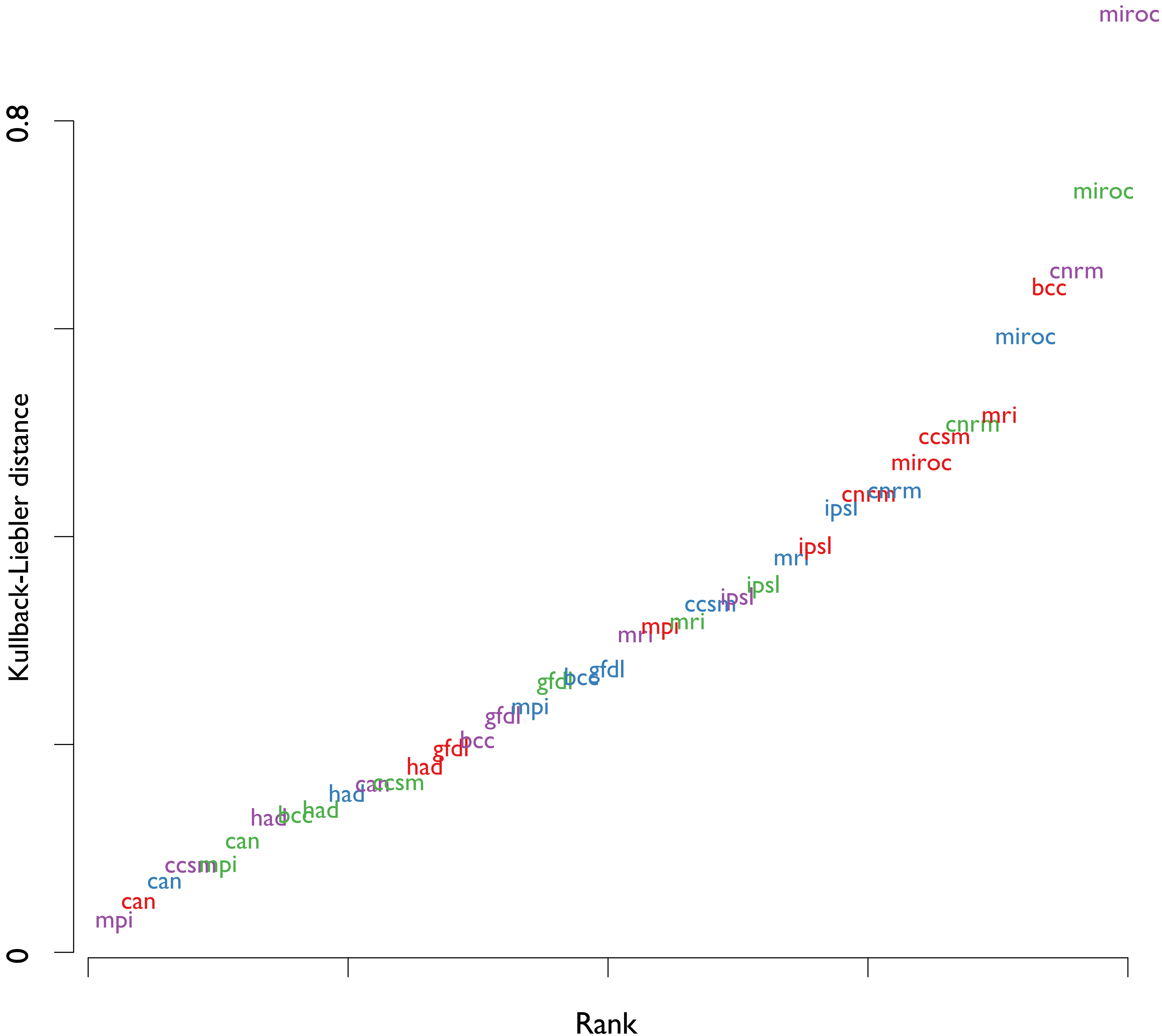


0.1
0.0
frequency
1 day
3
10
30 days
0.0
albedo
0.5


0.1
0.0
frequency
cnrm
mri
mpi
had
gfdl
ipsl
ccsm
cer
miroc
bcc
can
0.0
albedo
0.5



miroc
miroc
miroc
miroc
cnrm
cnrm
cnrm
cnrm
mpi
mri
mri
mri
bcc
ipsl
mri
ipsl
ipsl
mpi
bcc
ccsm
ccsm
ccsm
ipsl
bcc
ccsm
bcc
gfdl
can
gfdl
had
had
had
had
can
can
gfdl
gfdl
can
mpi
mpi
Rank using Wasserstien distance
Rank using Kullback-Liebler distance



Kullback-Liebler distance
0
0.8
Rank
mpi
can
can
ccsm
mpi
can
had
bcc
had
had
can
ccsm
had
gfdl
bcc
gfdl
mpi
gfdl
bcc
gfdl
mri
mpi
mri
ccsm
ipsl
ipsl
mri
ipsl
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cnrm
cnrm
miroc
ccsm
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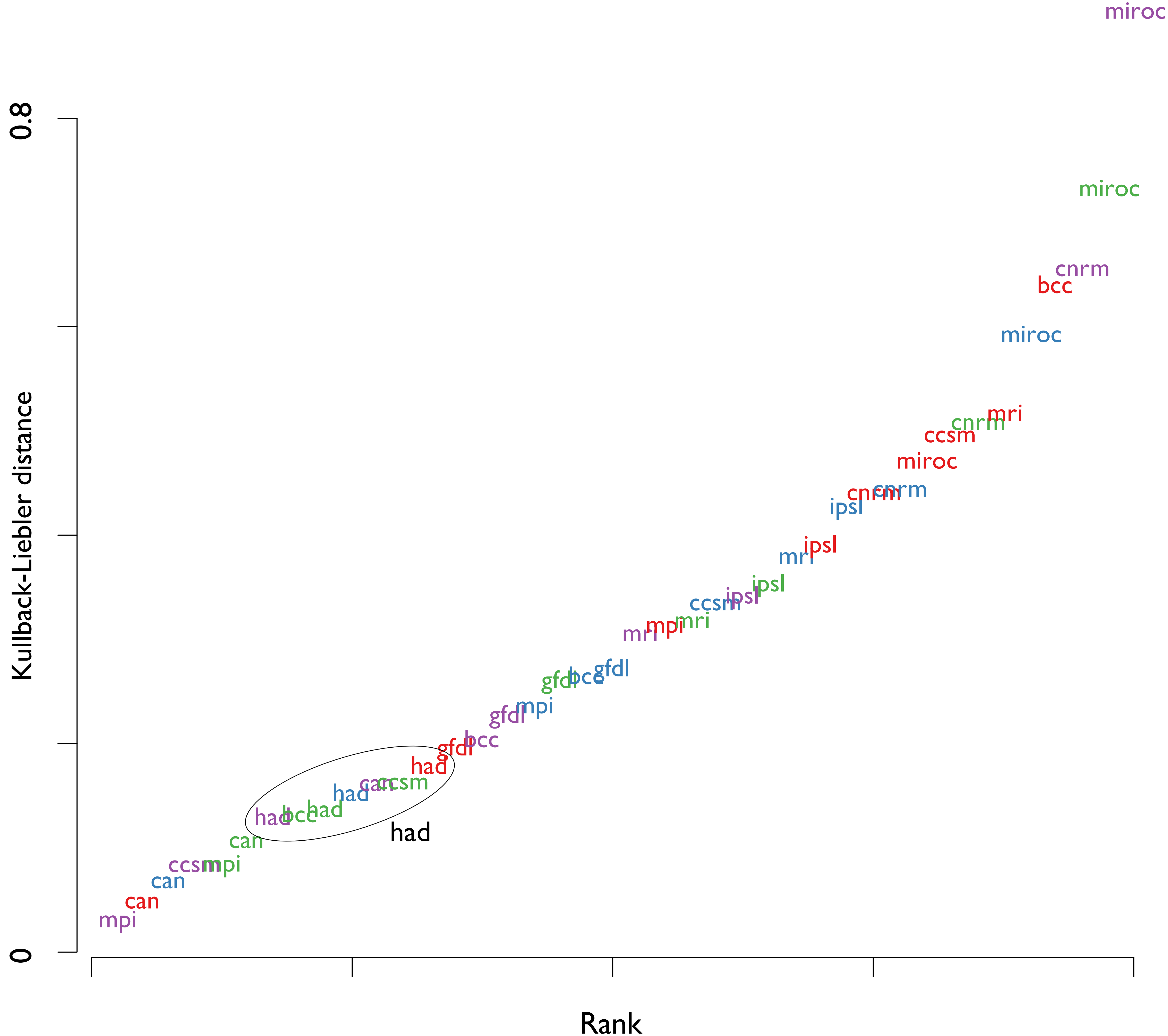
mri
miroc
bcc
cnrm
miroc
miroc



0.8
0
Kullback-Liebler distance
Rank
had
miroc
miroc
cnrm
bcc
miroc
mri
cnrm
ccsm
miroc
cnrm
cnrm
ipsl
ipsl
mri
ipsl
ipsl
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had
ccsm
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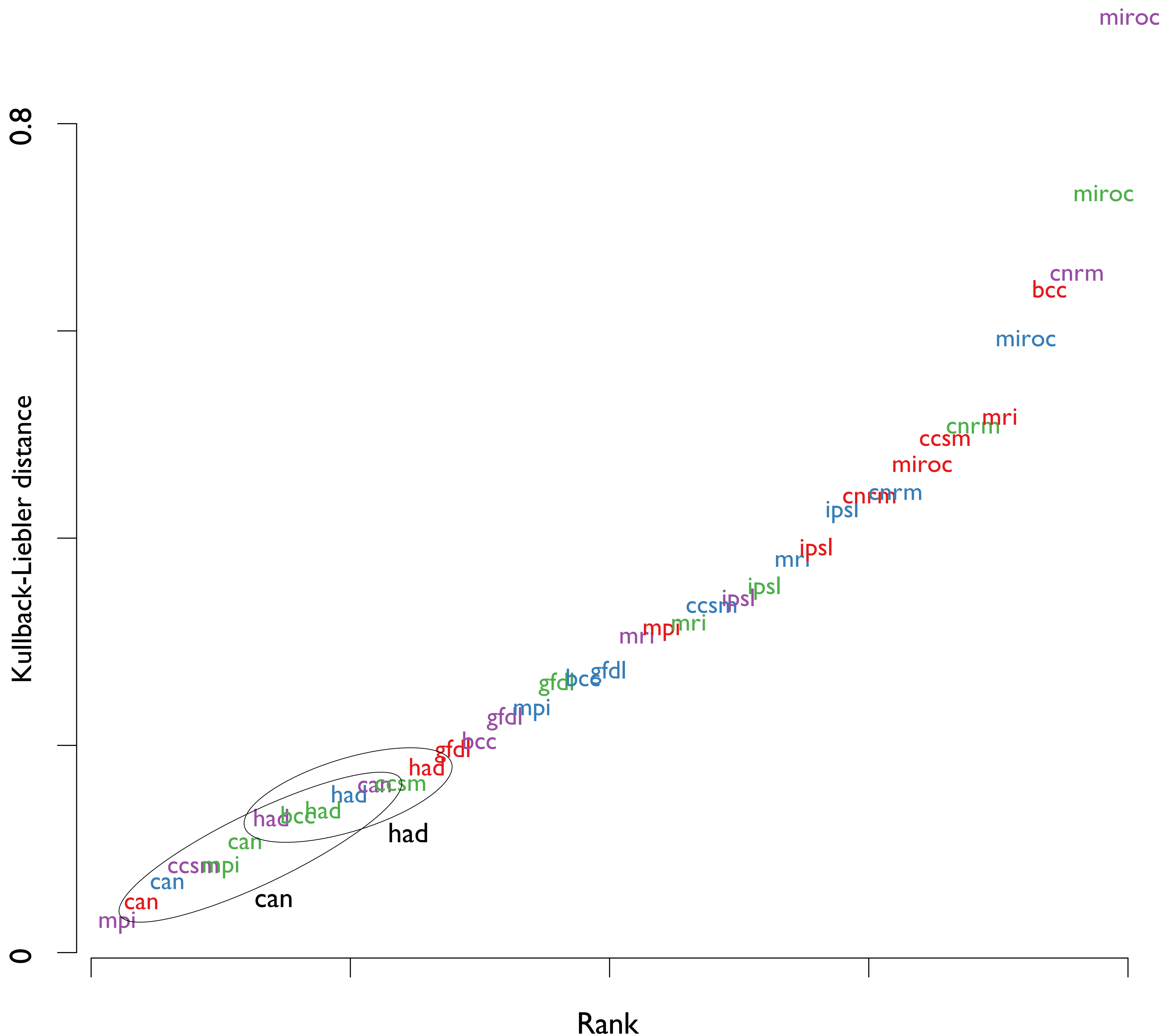
ccsm
mpi
can
can
mpi



Kullback-Liebler distance
0.8
0
Rank
miroc
miroc
cnrm
bcc
miroc
mri
cnrm
ccsm
miroc
cnrm
cnrm
ipsl
ipsl
mri
ipsl
ipsl
ccsm
mri
mpi
mri
gfdl
bcc
gfdl
mpi
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ccsm
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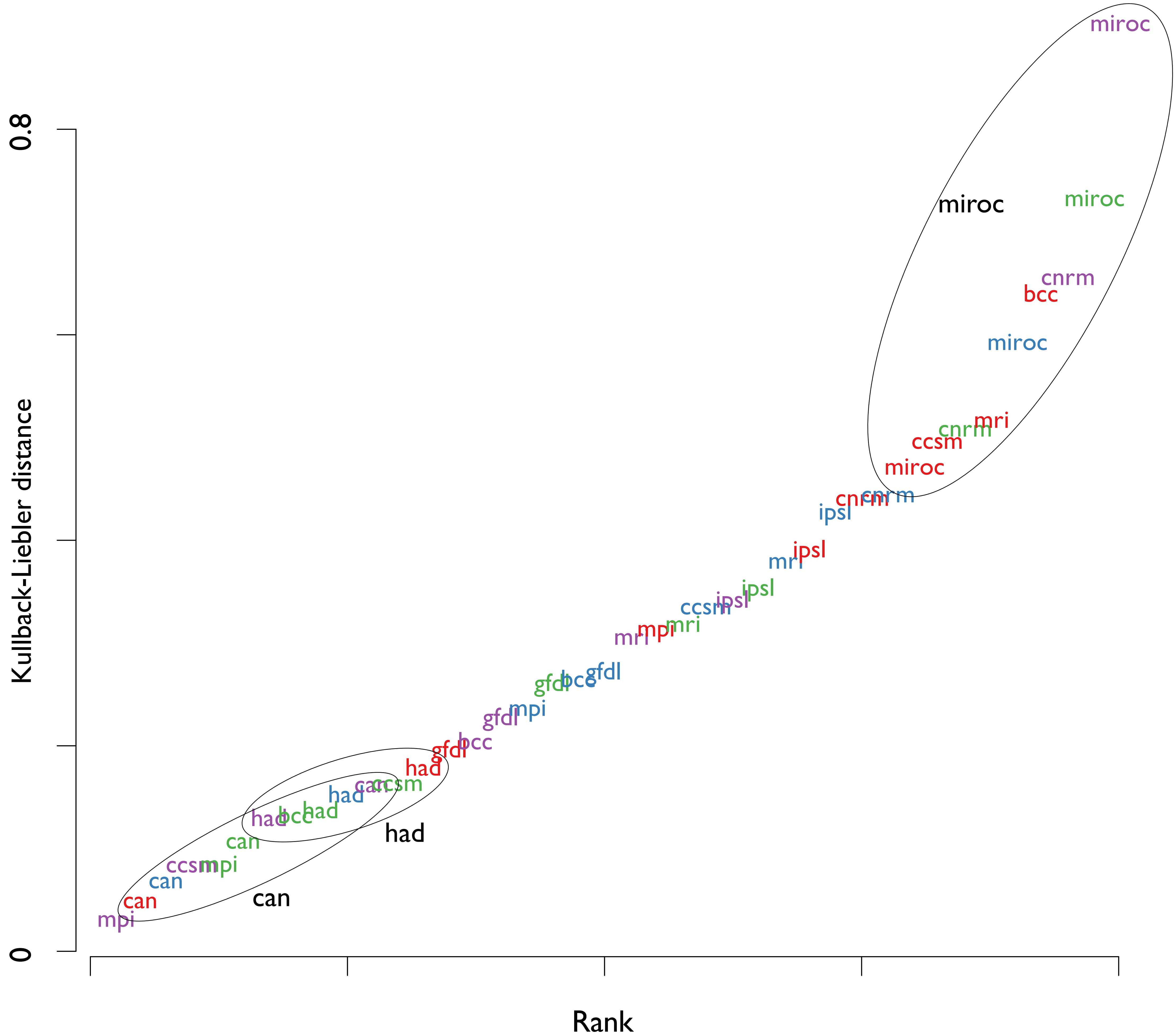
mpi
can
can
can
mpi


Kullback-Liebler distance
0.8
0
Rank
miroc
miroc
miroc
cnrm
bcc
miroc
mri
cnrm
ccsm
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cnrm
cnrm
ipsl
ipsl
mri
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ccsm
mri
mpi
mri
gfdl
bcc
gfdl
mpi
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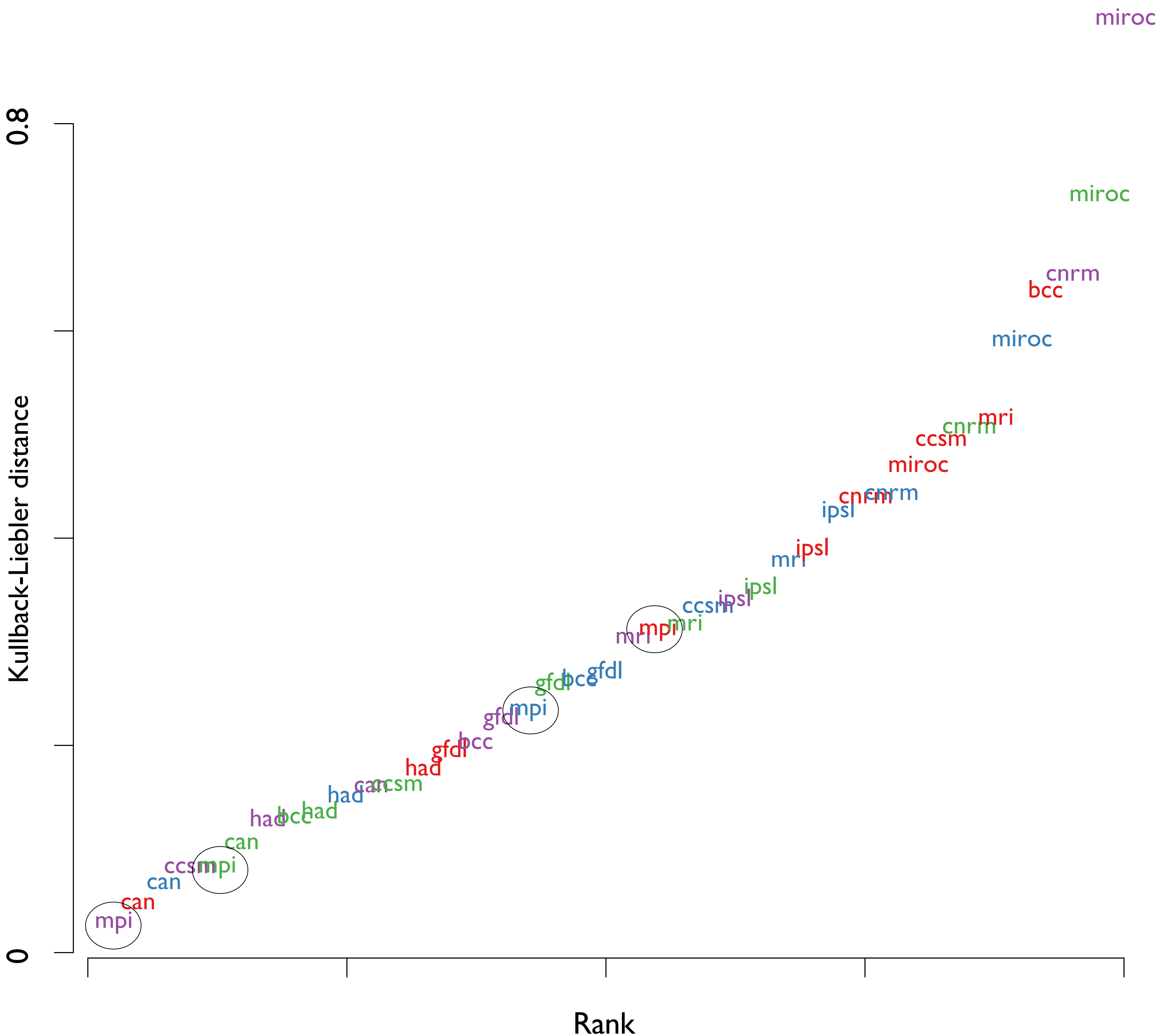
had
ccsm
can
had
had
bcc
had
had
can
ccsm
mpi
can
can
can
mpi



Kullback-Liebler distance
0.8
0
Rank
miroc
miroc
cnrm
bcc
miroc
mri
cnrm
ccsm
miroc
cnrm
cnrm
ipsl
ipsl
mri
ipsl
ipsl
ccsm
mri
mpi
mri
gfdl
bcc
gfdl
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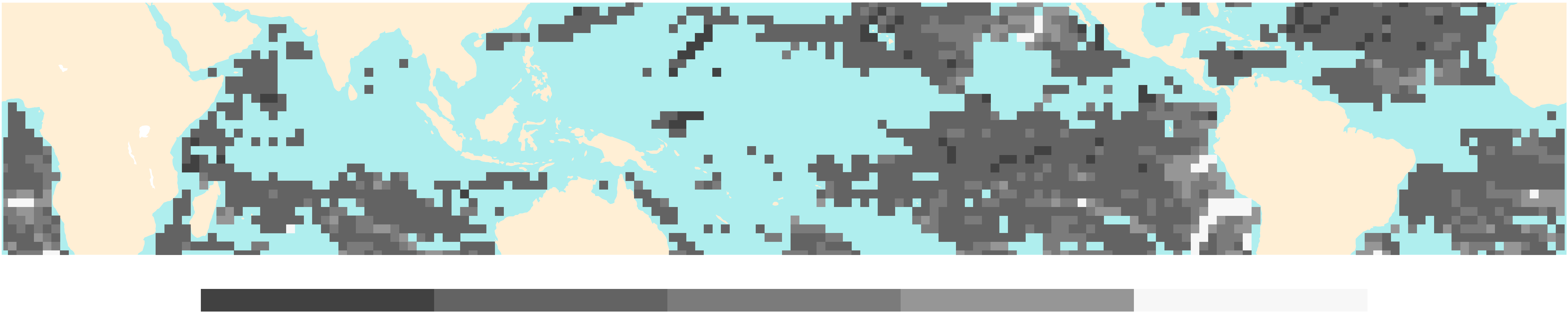
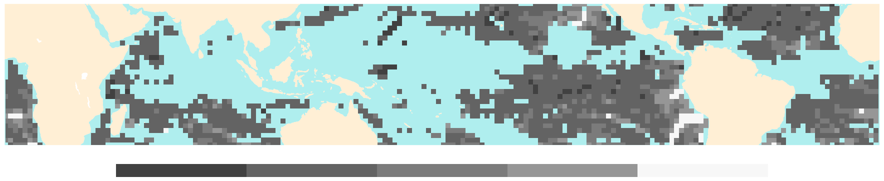
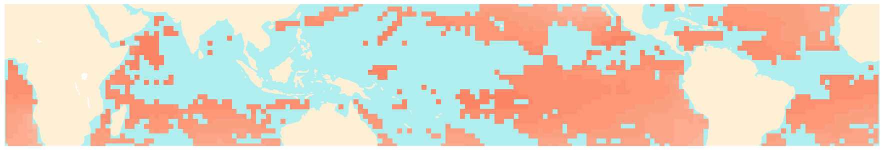
bcc
had
can
ccsm
mpi
can
can
mpi

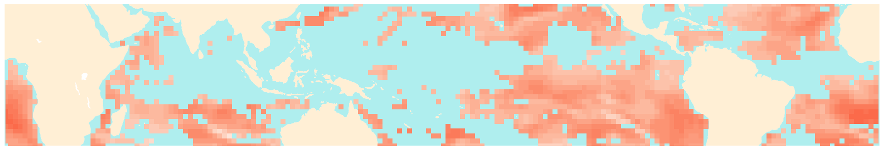


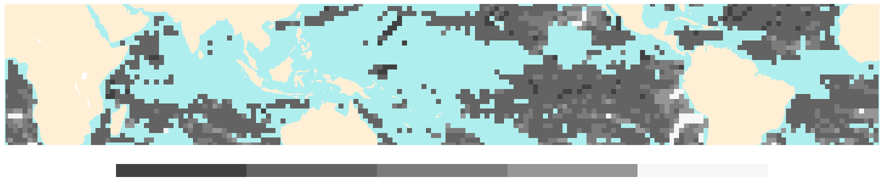


SST



EIS





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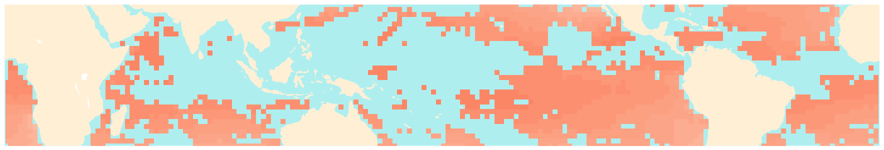

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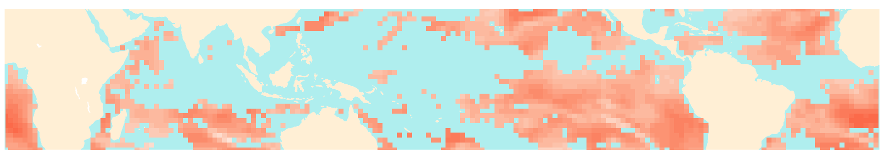
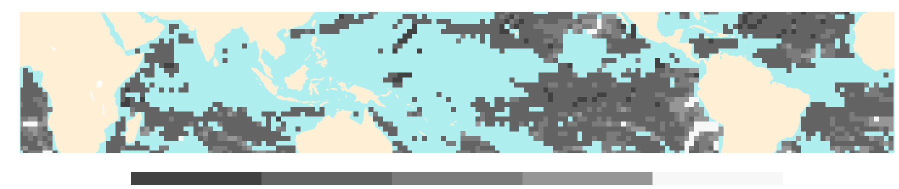
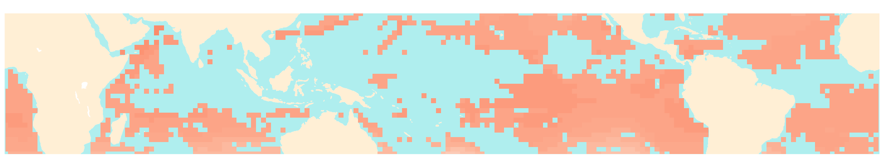
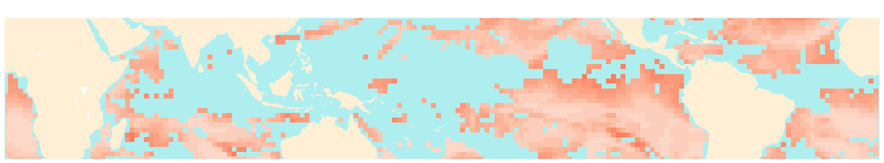




T 700



RH 700



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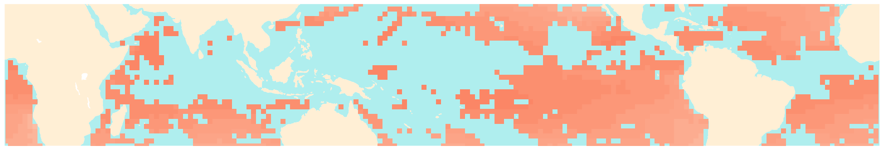

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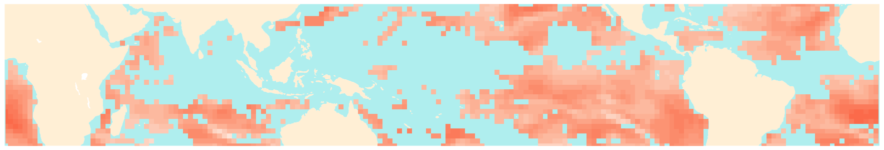
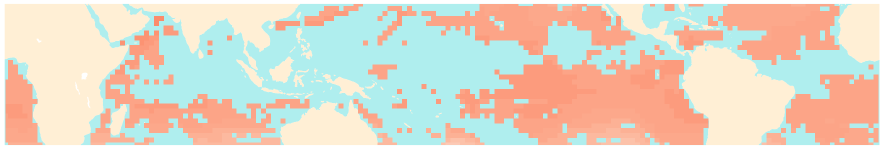


T 700



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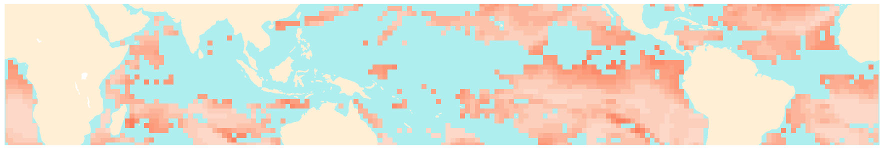
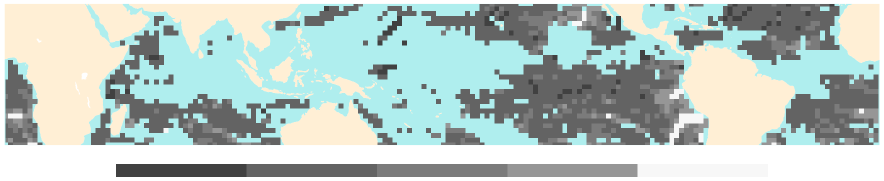


etc...



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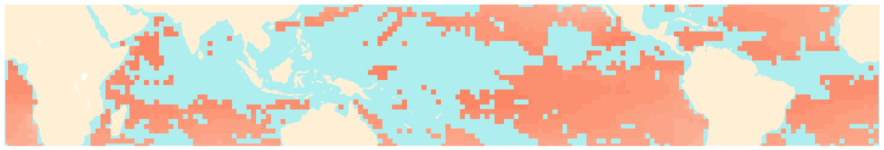

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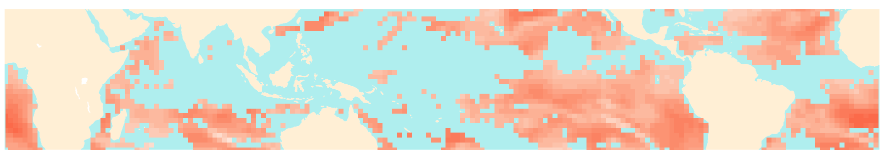

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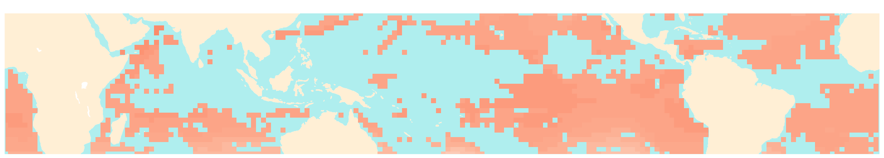
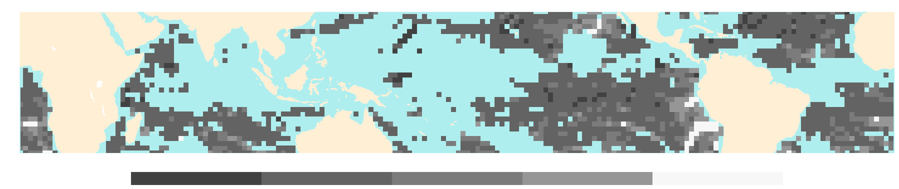
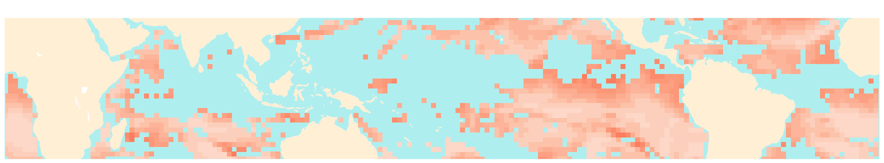


$$P_m(a_m|\mathbf{S}_{j,m}) = \ldots$$

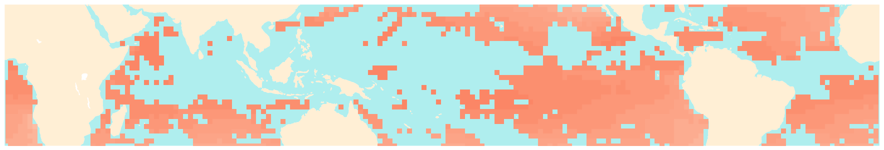


RH 700

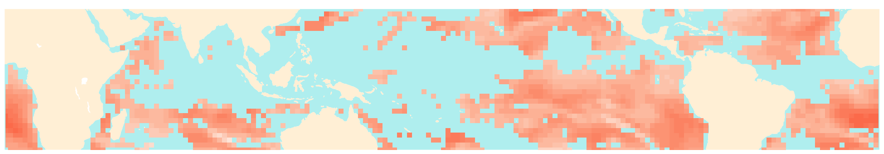


etc...

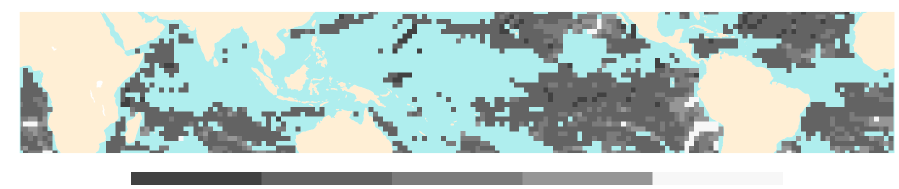
SST



EIS



$$P_m(a_m|\mathbf{S}_{j,m}) = \ldots$$



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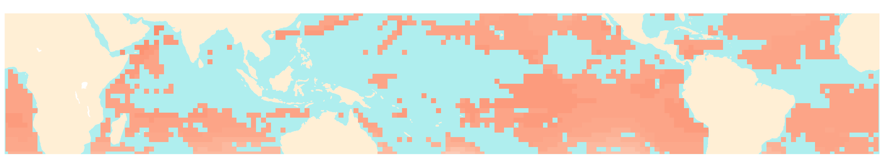

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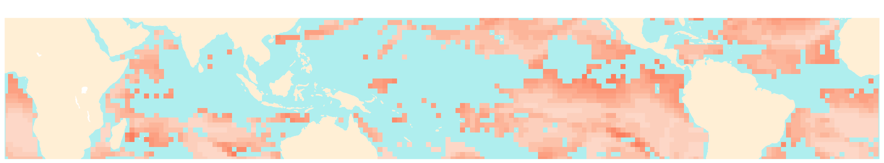
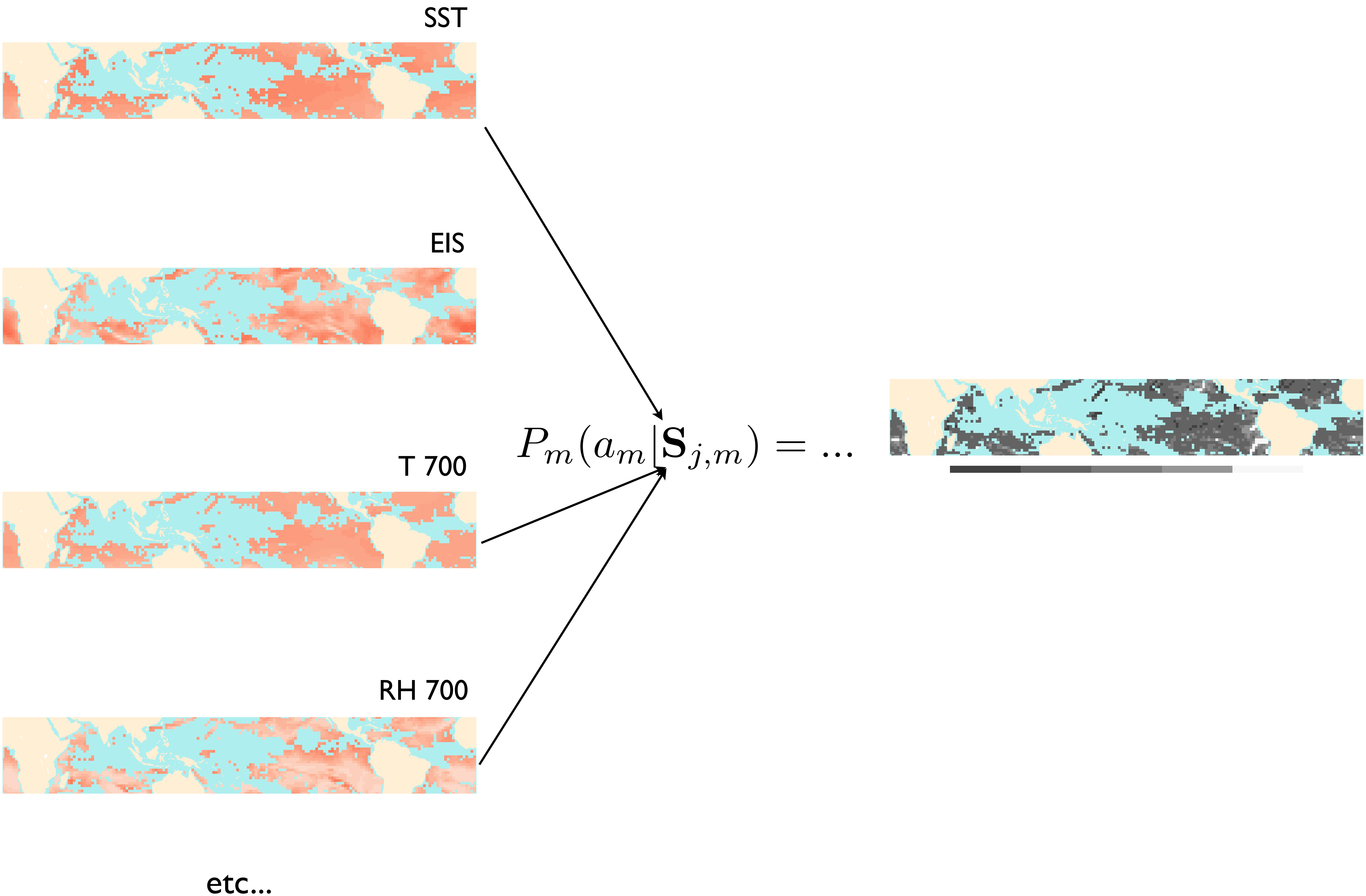


etc...

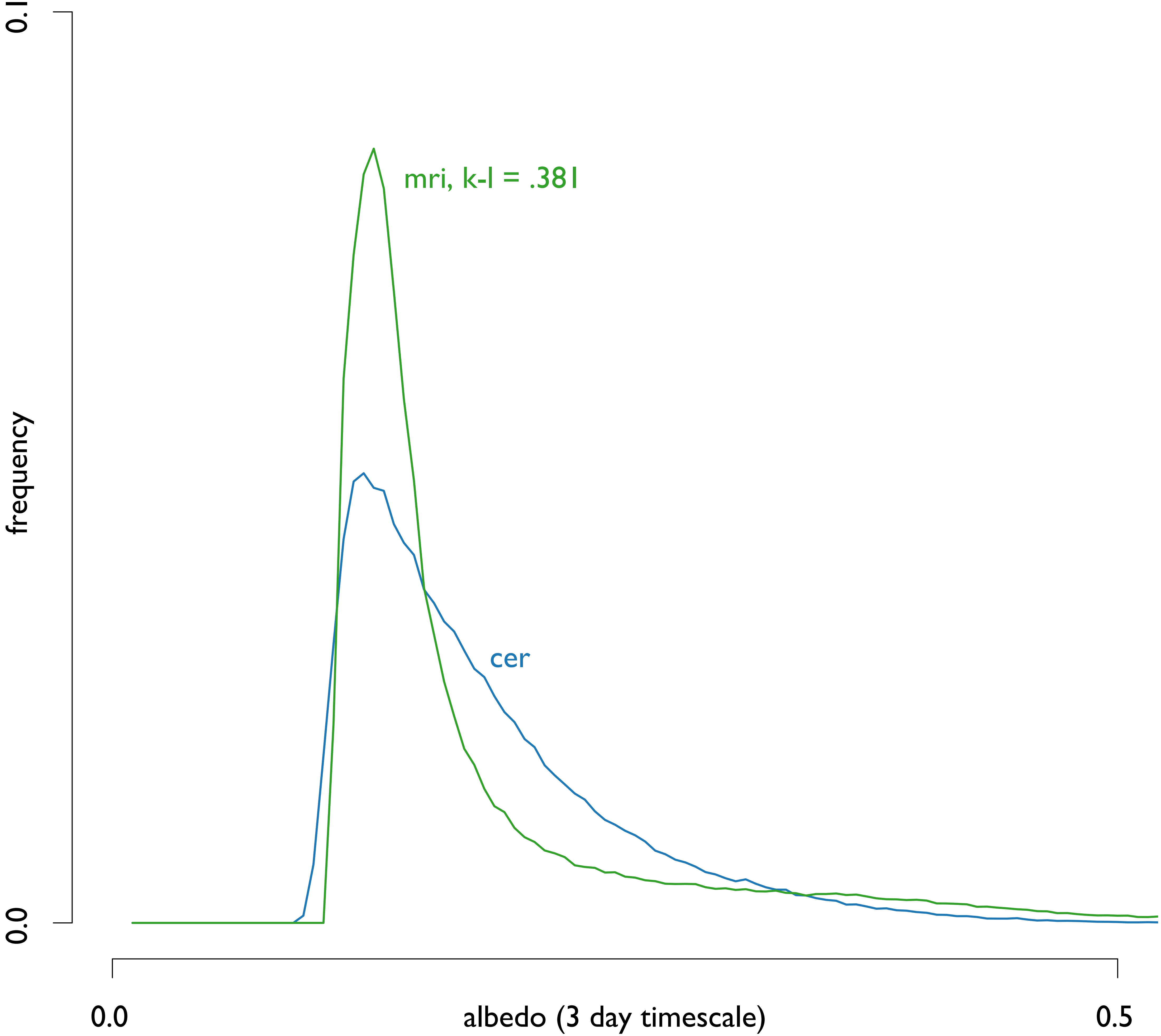

SST
EIS
T 700
RH 700
etc...
$P_m(a_m|\mathbf{S}_{j,m}) = \ldots$

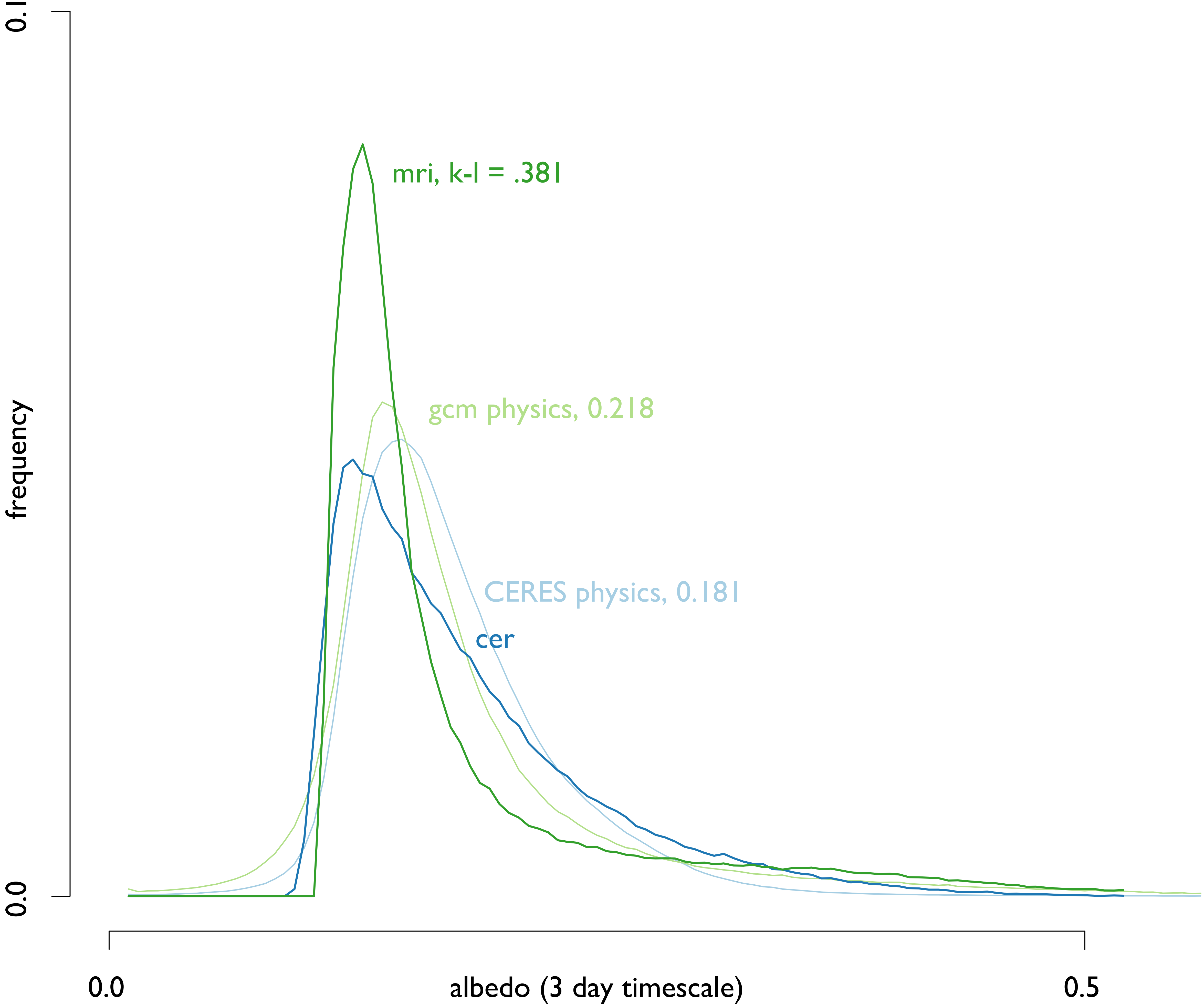
We predict low cloud albedo from time-averaged environmental state with (nonlinear, multivariate) Baysesian neural networks

The skill of the fit generally increases with
the number of variables used in the prediction
the averaging time scale

We make separate statistical models for CERES/ERA and each GCM at each time scale

This lets us assess the degree to which error can be reduced by using (more) realistic physics or environmental states


0.1
0.0
frequency
mri, k-l = .381
cer
0.0
albedo (3 day timescale)
0.5


0.1
0.0
frequency
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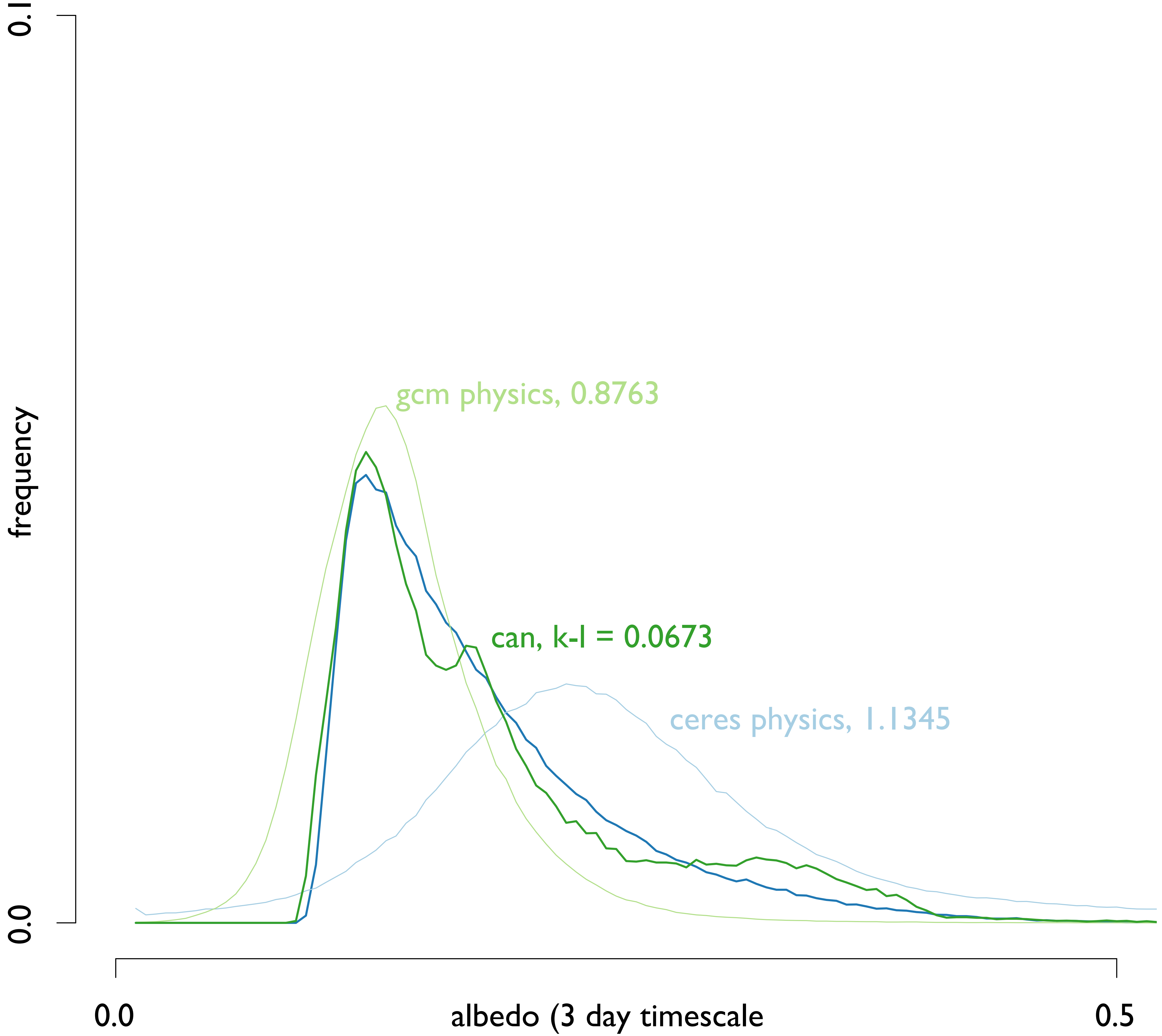
gcm physics, 0.218
CERES physics, 0.181
cer
0.0
albedo (3 day timescale)
0.5


0.1
frequency
0.0
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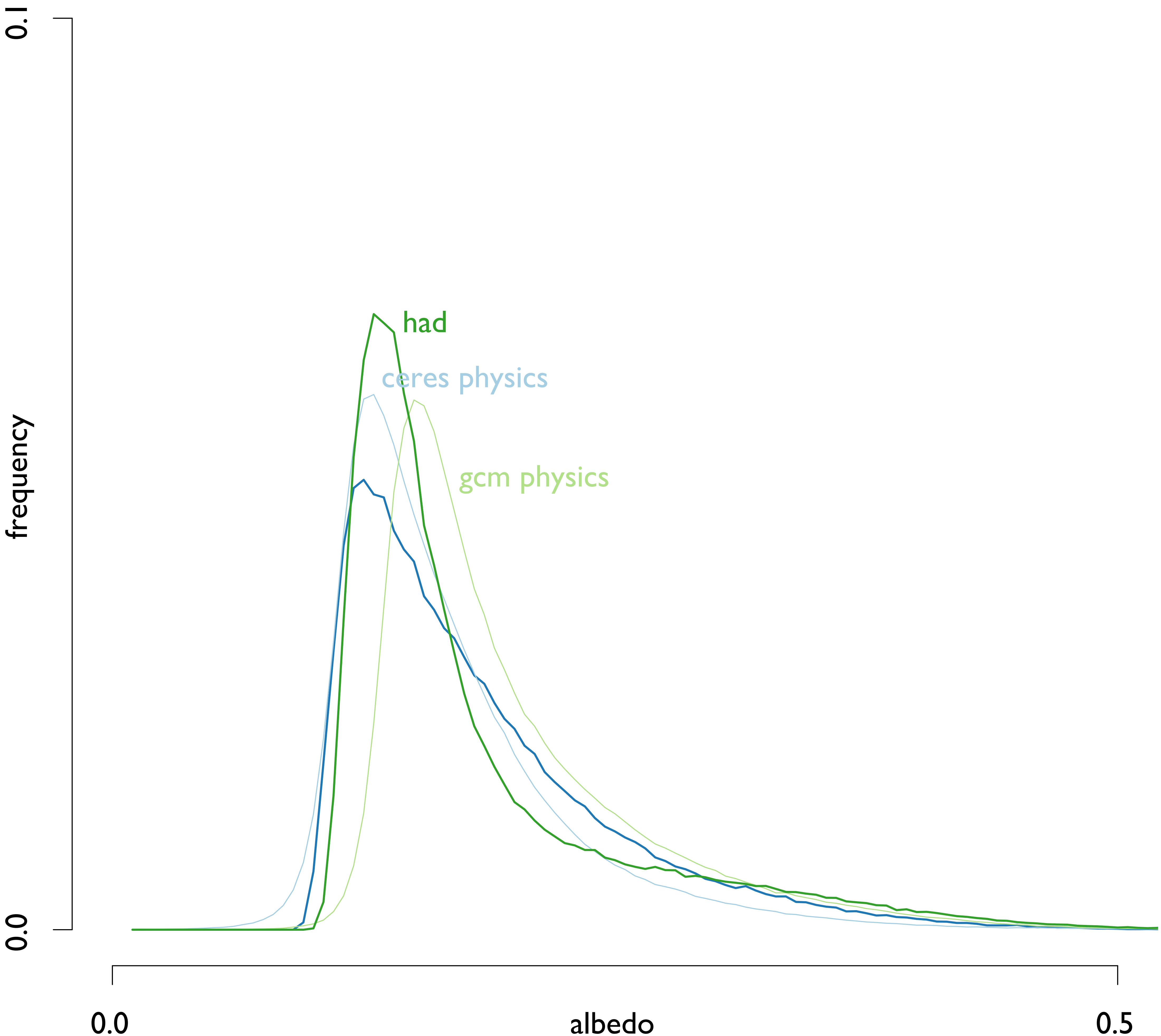
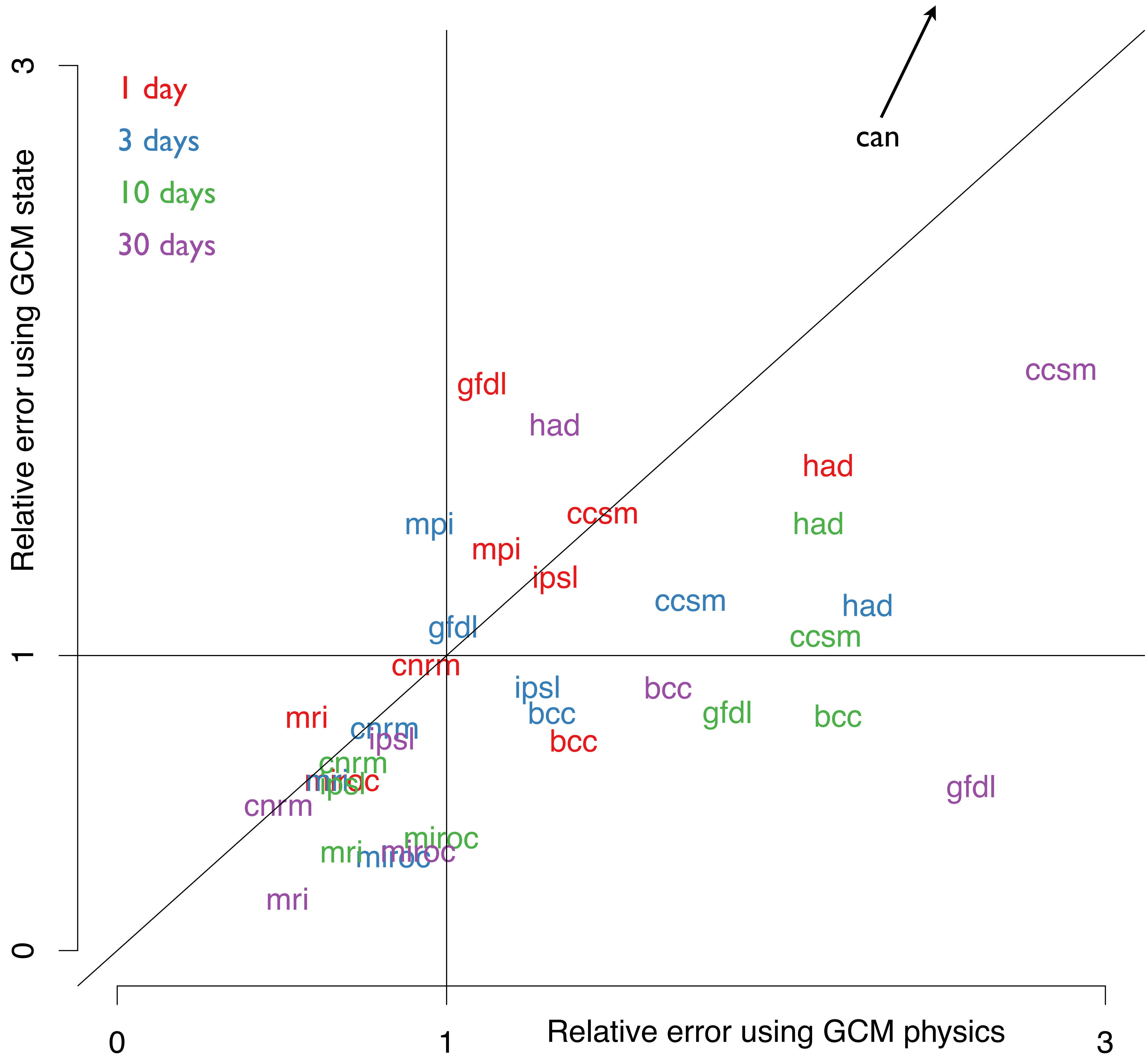
can, k-l = 0.0673
ceres physics, 1.1345
0.0
albedo (3 day timescale
0.5



0.1
0.0
frequency
had
ceres physics
gcm physics
0.0
albedo
0.5



1 day
3 days
10 days
30 days
can
Relative error using GCM state
Relative error using GCM physics
0
1
3
ccsm
gfdl
had
mpi
ipsl
cnrm
mri
miroc
bcc

The news so far

(Measuring distances between environmental states is difficult)

Distributions of tropical low cloud albedo are more sensitive to physics than to dynamics...

... but simply replacing parameterizations with “better” physics won’t necessarily make predictions more uniform

in part because models contain compensating errors