Barbados and Beyond:

Trade-wind boundary layer structure and cloud properties in observations and climate models

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NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

U.S. DEPARTMENT OF ENERGY | Office of Science

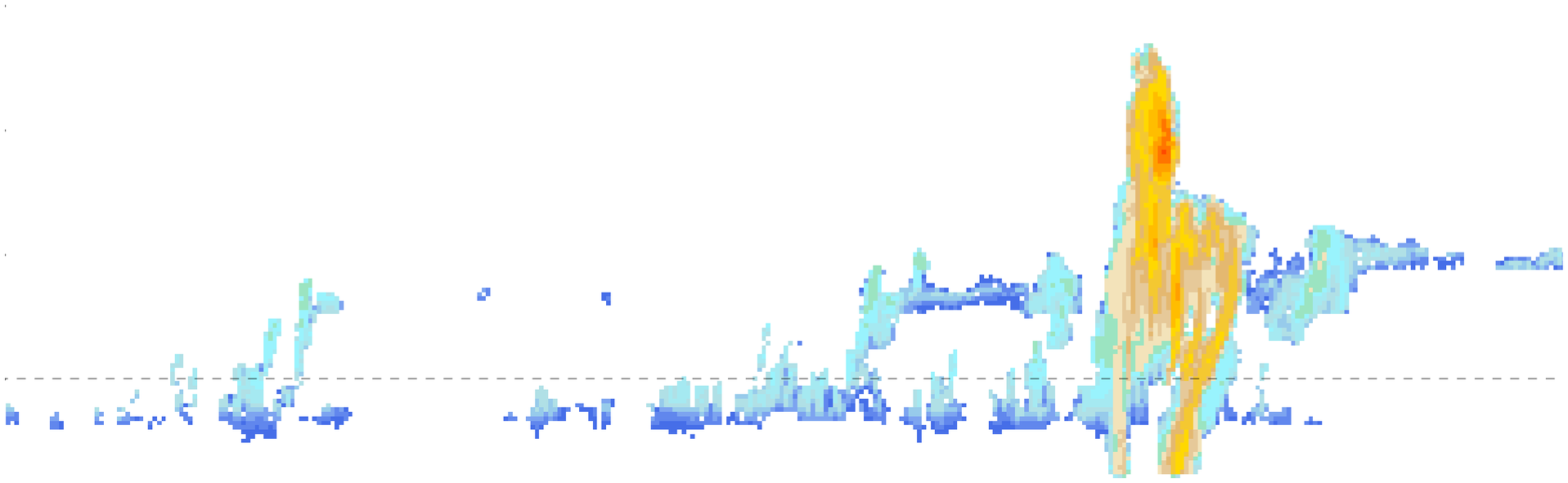
NCAR is sponsored by the National Science Foundation

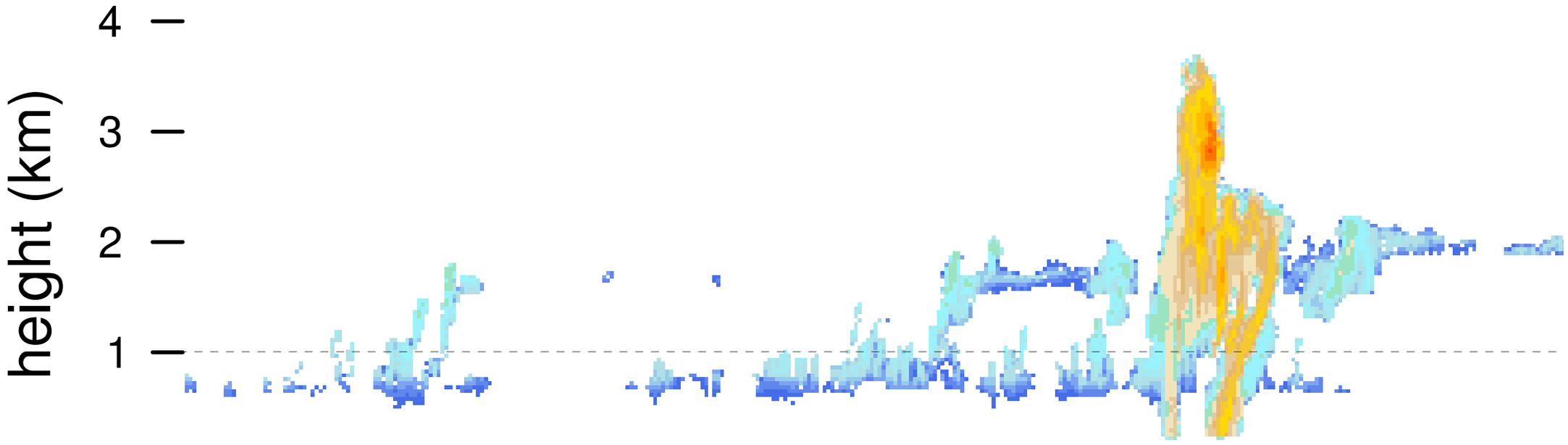
- Assessment of trade-wind clouds in CMIP5/CFMIP models (+IFS)
- Mean cloud properties
- Cloud variability
- Co-variability with environment
- Does Barbados region represent broader trades?

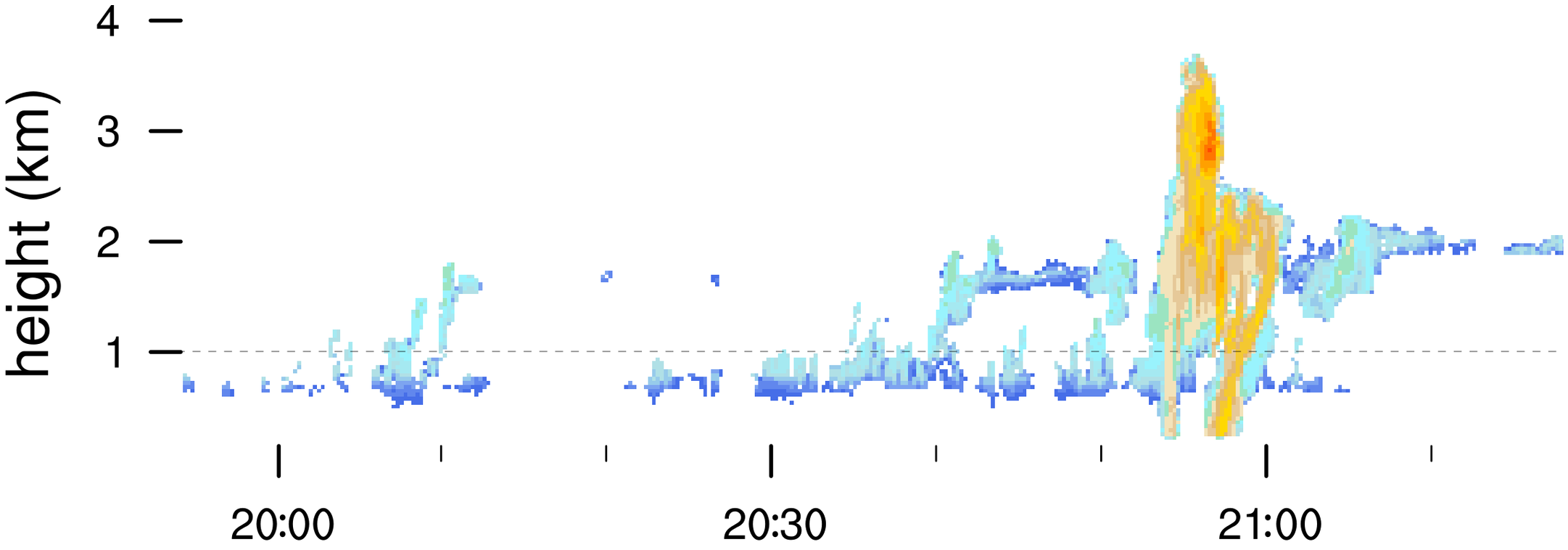
Nuijens et al. 2015: The behavior of trade-wind cloudiness in observations and models: The major cloud components and their variability.
JAMES / doi:10.1002/2014MS000390

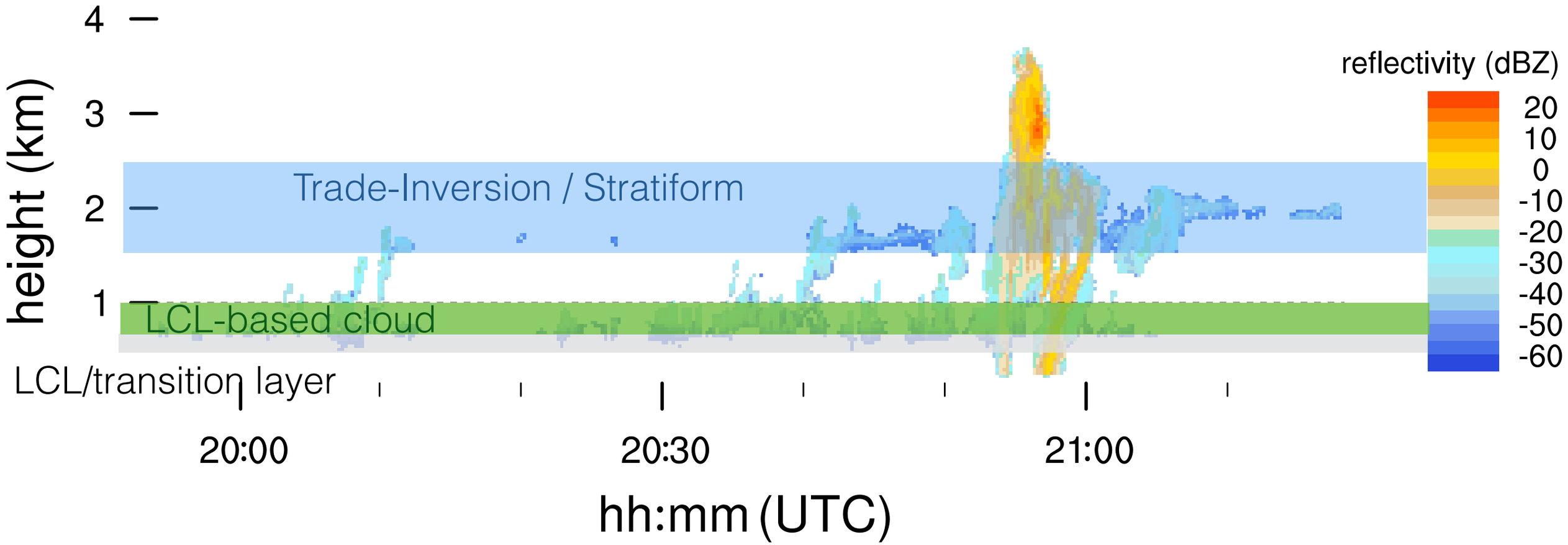
Nuijens et al. 2015: Observed and modeled patterns of co-variability between low-level cloudiness and the structure of the trade-wind layer.
JAMES, submitted.

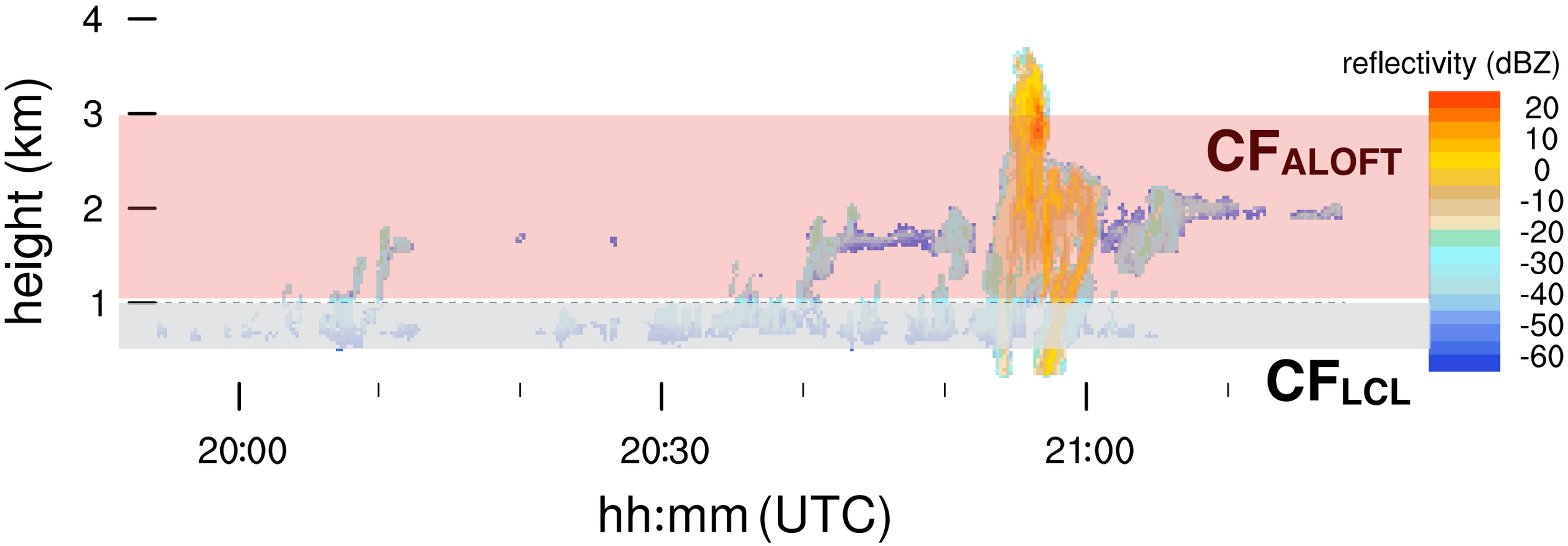
Medeiros & Nuijens, in prep.

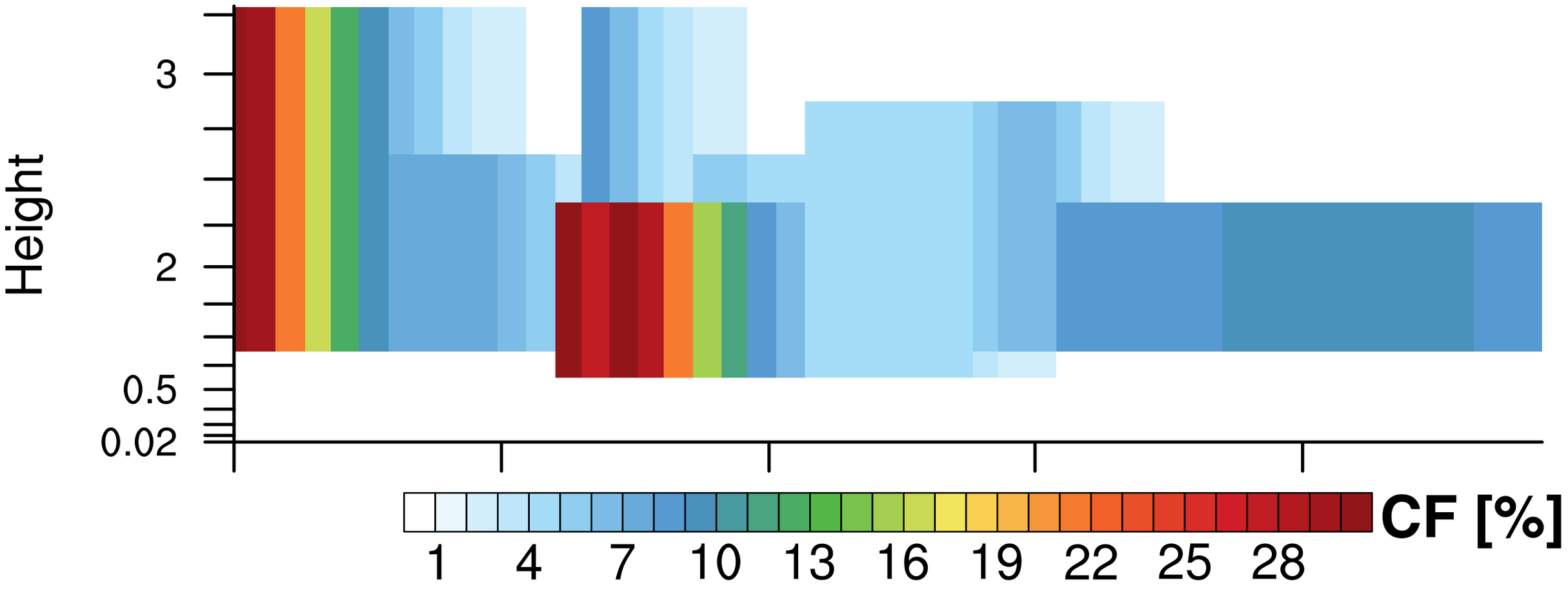



height (km)
4
3
2
1

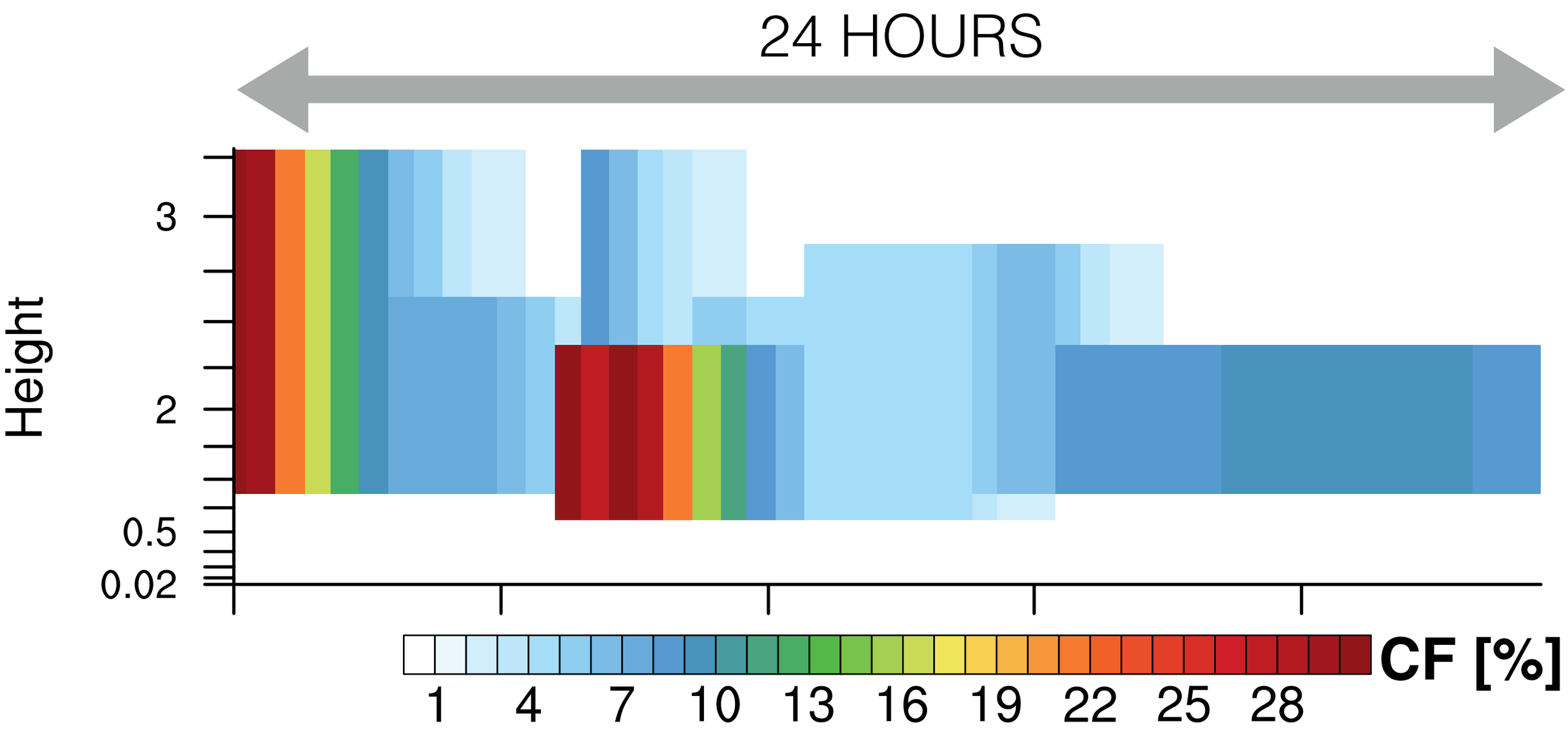

height (km)
4
3
2
1
20:00
20:30
21:00


4
3
2
1
height (km)
Trade-Inversion / Stratiform
LCL-based cloud
LCL/transition layer
reflectivity (dBZ)
20
10
0
-10
-20
-30
-40
-50
-60
20:00
20:30
21:00
hh:mm (UTC)


height (km)
4
3
2
1
reflectivity (dBZ)
20
10
0
-10
-20
-30
-40
-50
-60
CF ALOFT
CF LCL
20:00
20:30
21:00
hh:mm (UTC)



*Note: Nuijens et al. ***does*** average the obs to account for difference in resolution.



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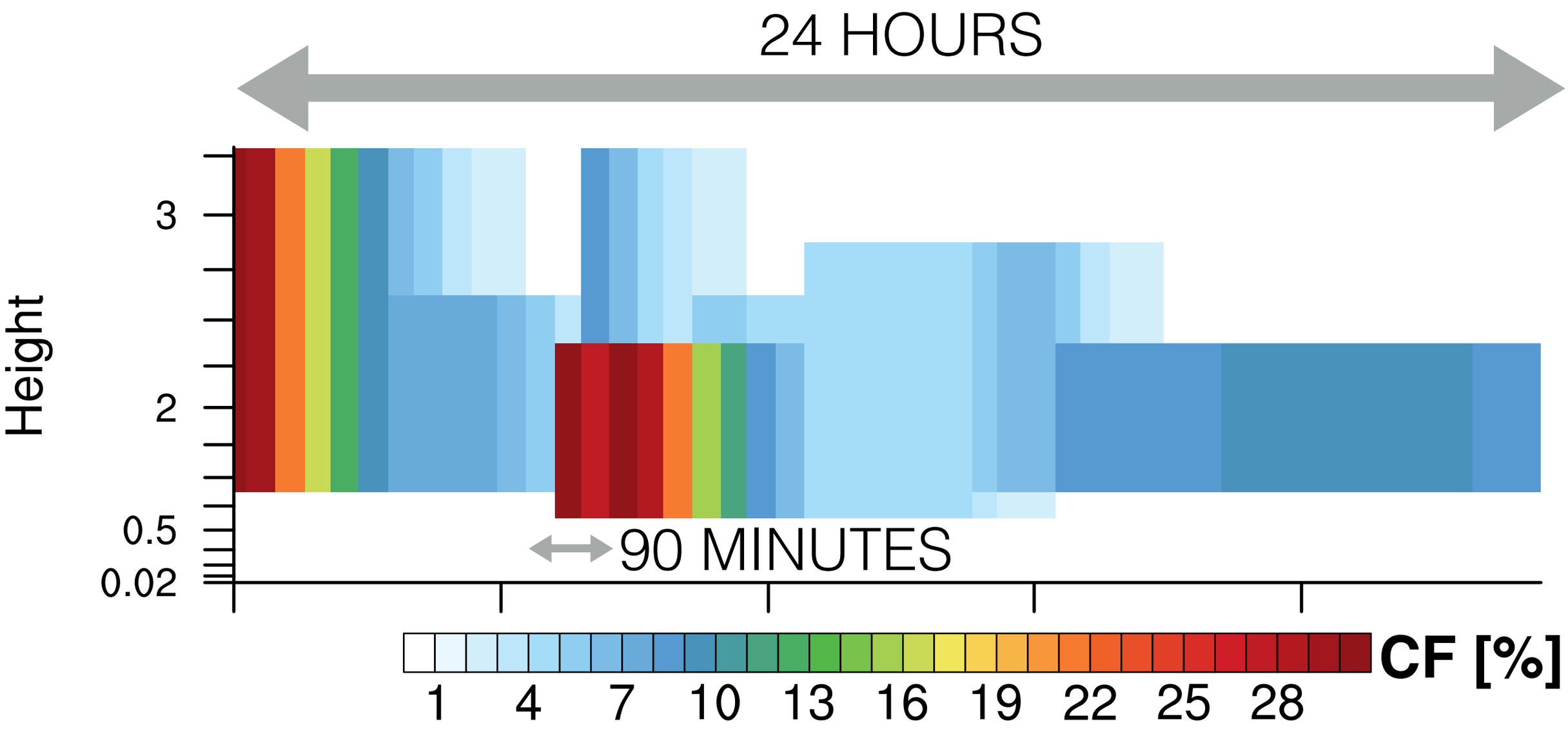

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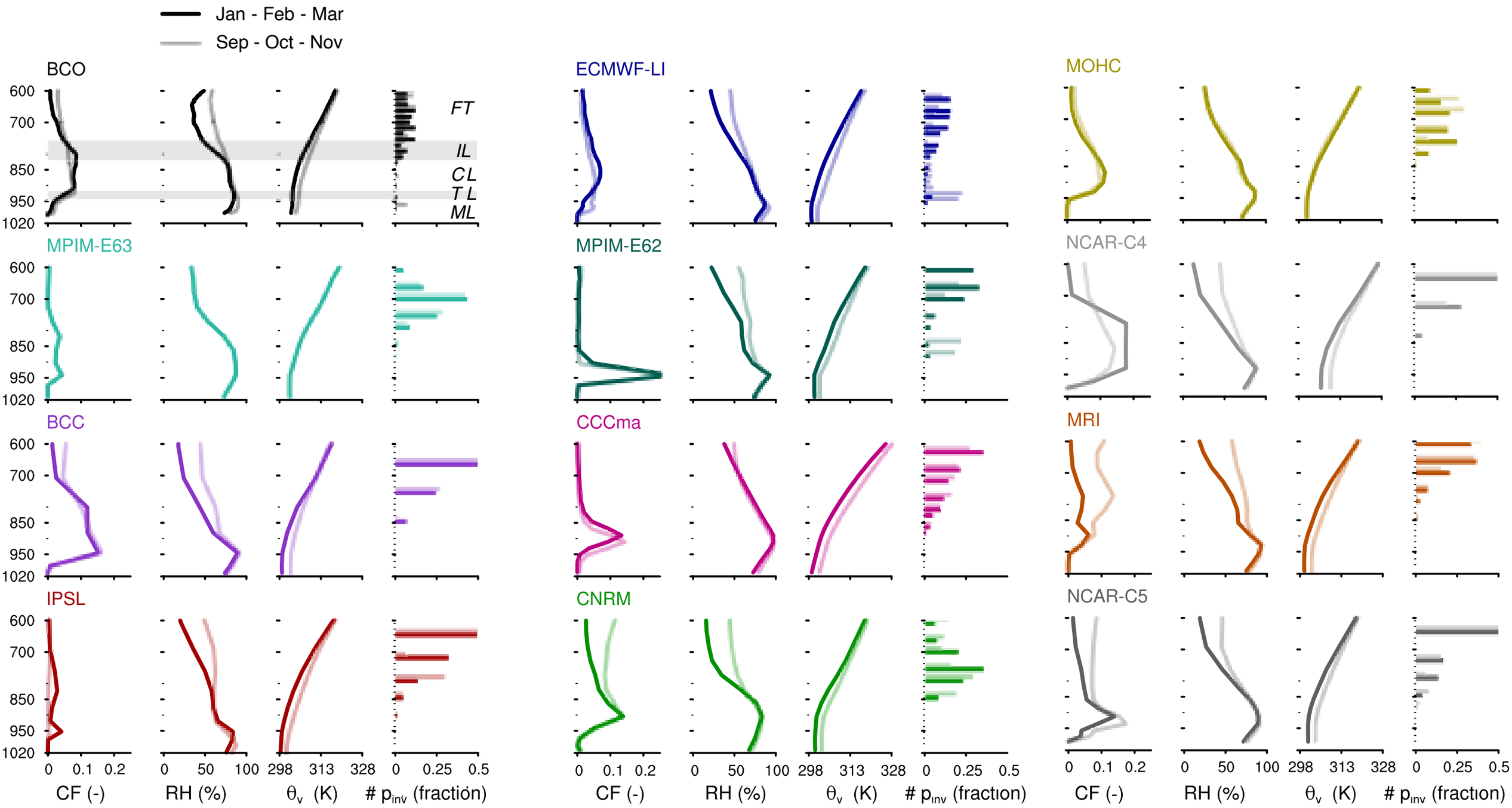
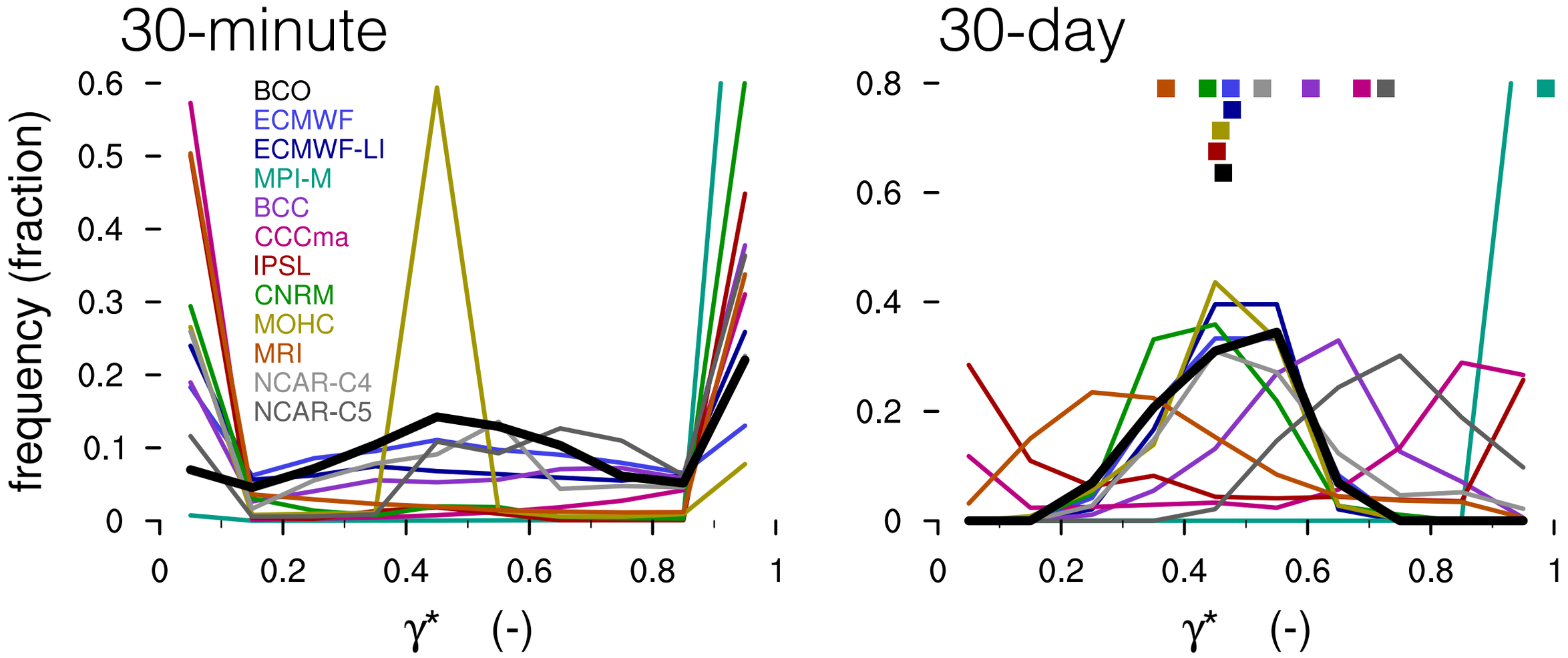
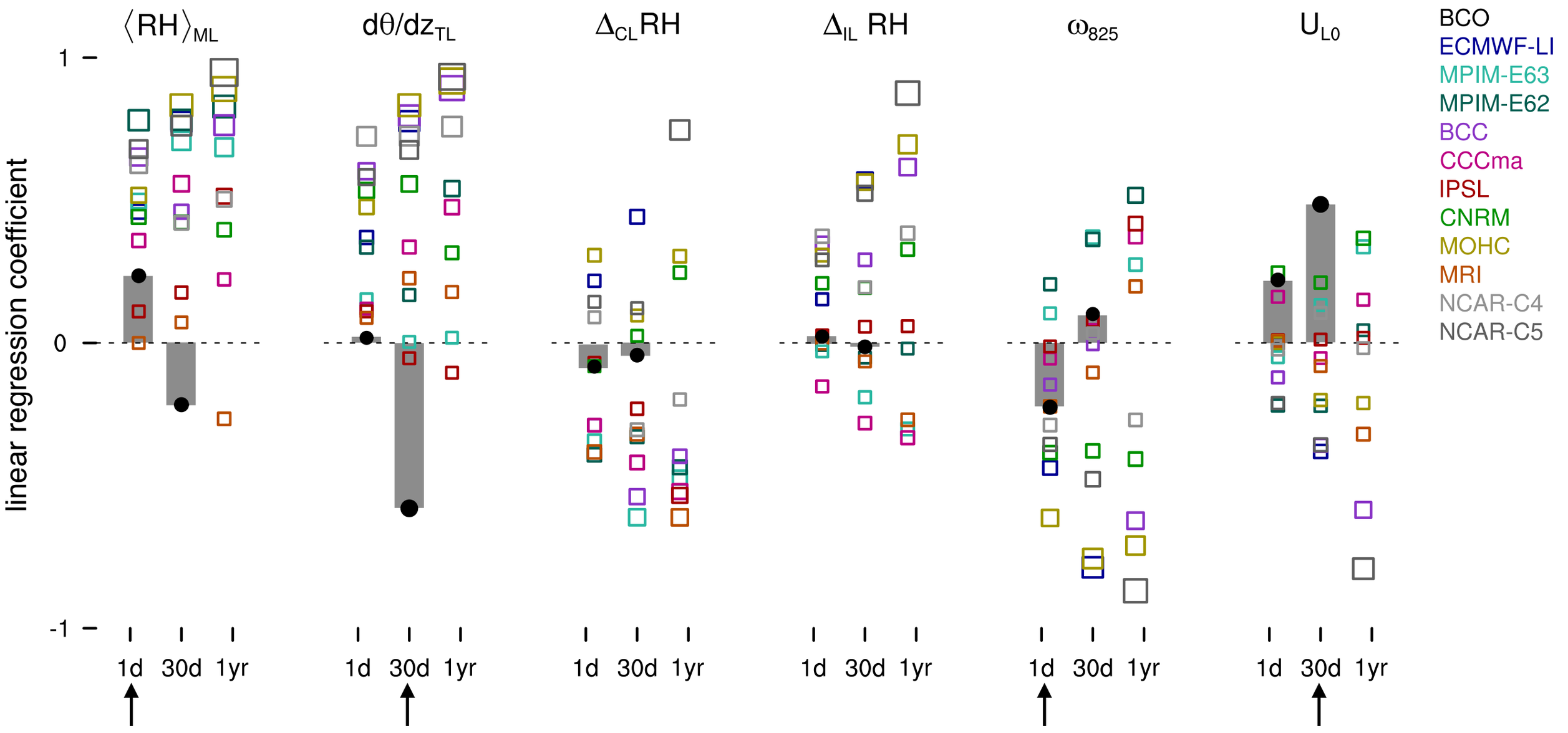

Jan - Feb - Mar
Sep - Oct - Nov
BCO
ECMWF-LI
MOHC
MPIM-E63
MPIM-E62
NCAR-C4
BCC
CCCma
MRI
IPSL
CNRM
NCAR-C5
600
700
850
950
1020
FT
IL
CL
TL
ML
0 0.1 0.2
0 50 100
298 313 328
0 0.25 0.5
CF (-)
RH (%)
θv (K)
pinv (fraction)



$$\gamma = \frac{\mathrm{CF}_{925}}{\mathrm{CF}_{925}+\mathrm{CF}_{850}}$$

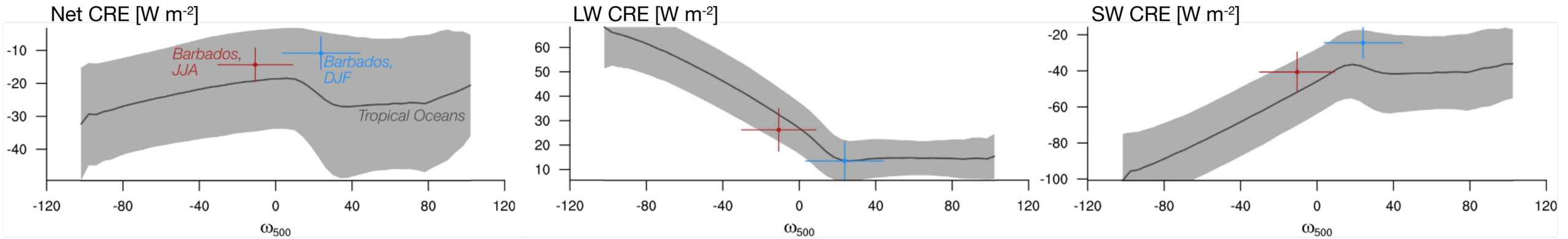
Most models also show CF = 0 at both levels often, BCO shows that only happens 3% of the time. Contributes variance of low-level clouds.

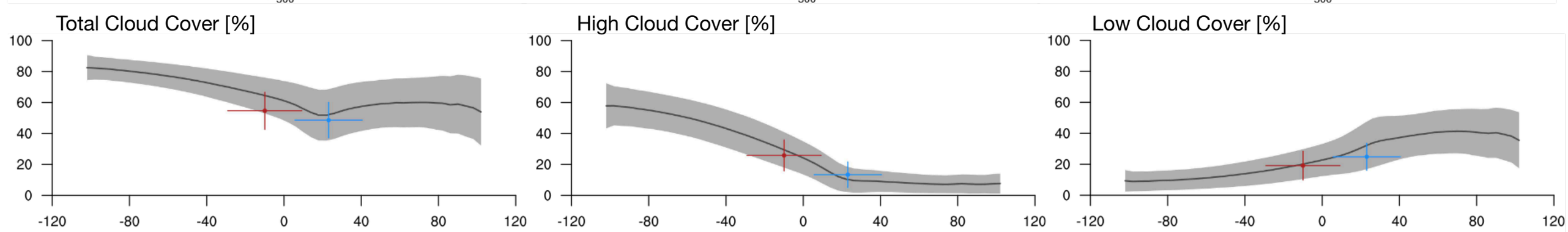
Co-variability of clouds near LCL with their environment



Same thing for CFaloft shows DcIRH is important for short timescales, ML RH and inversion strength more important at longer timescales.

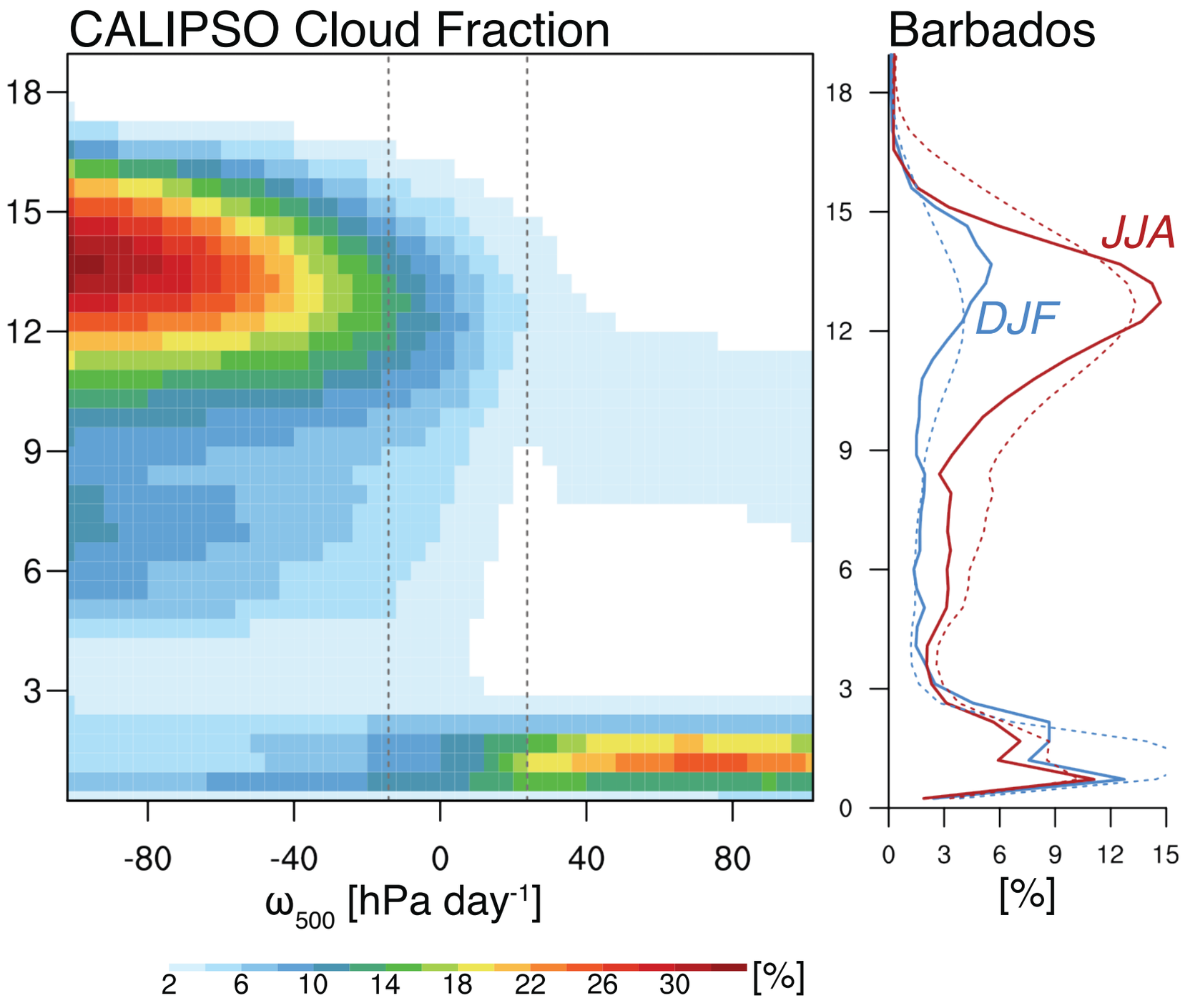
Do the results from single Caribbean grid points generalize to the broader trades?



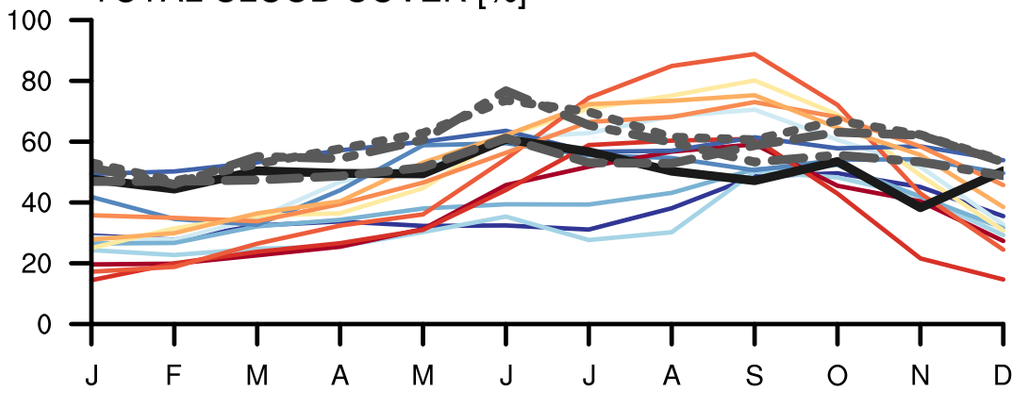


ω_{500}

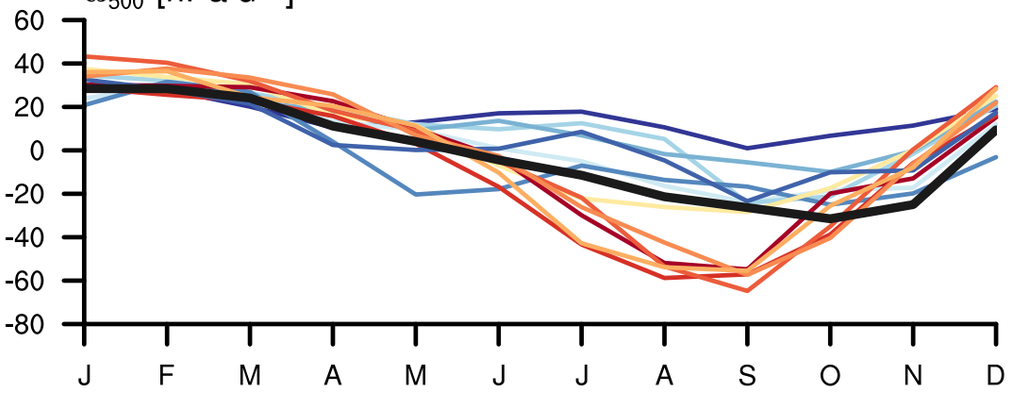
rising sinking


CALIPSO Cloud Fraction
18
15
12
9
6
3
-80
-40
0
40
80
ω500 [hPa day-1]
2
6
10
14
18
22
26
30
[%]
Barbados
18
15
12
9
6
3
0
0
3
6
9
12
15
[%]
JJA
DJF

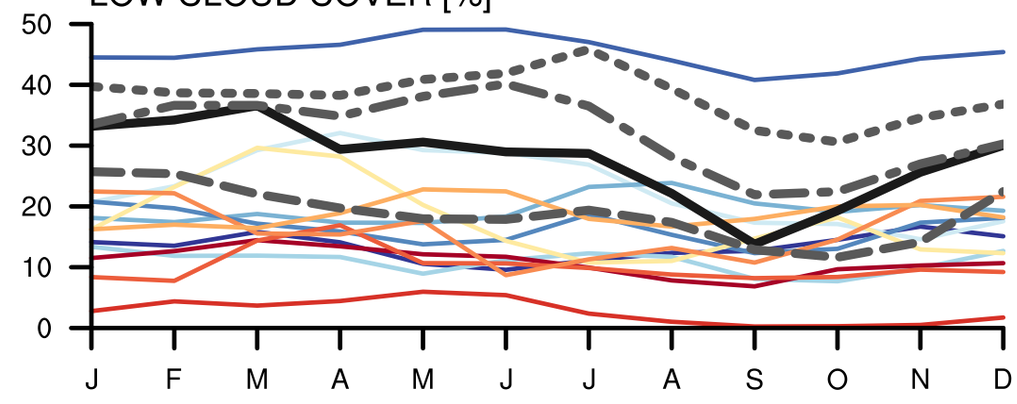
TOTAL CLOUD COVER [%]



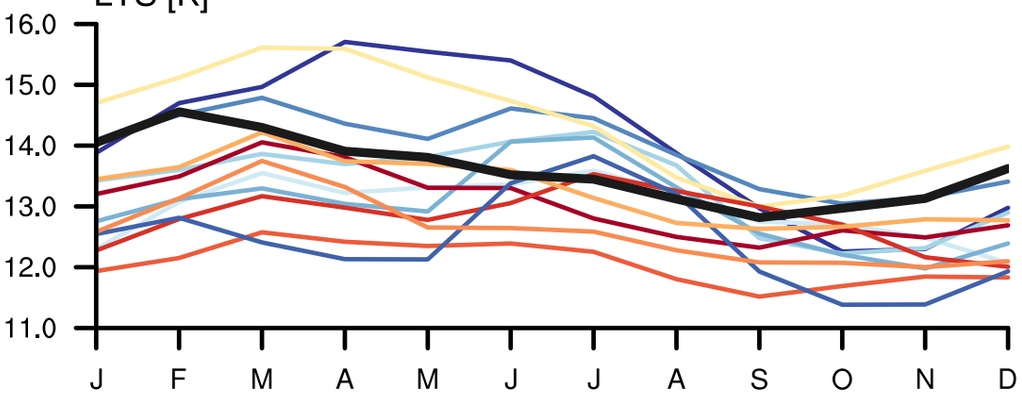
ω_{500} [hPa d^{-1}]



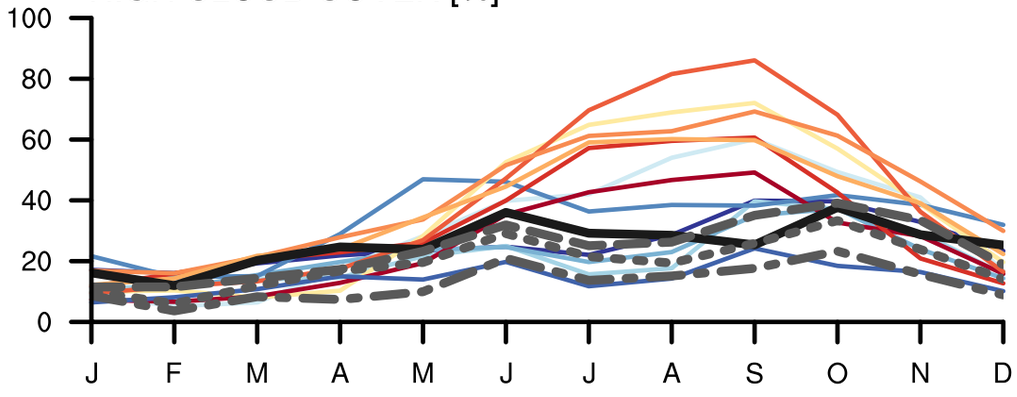
LOW CLOUD COVER [%]



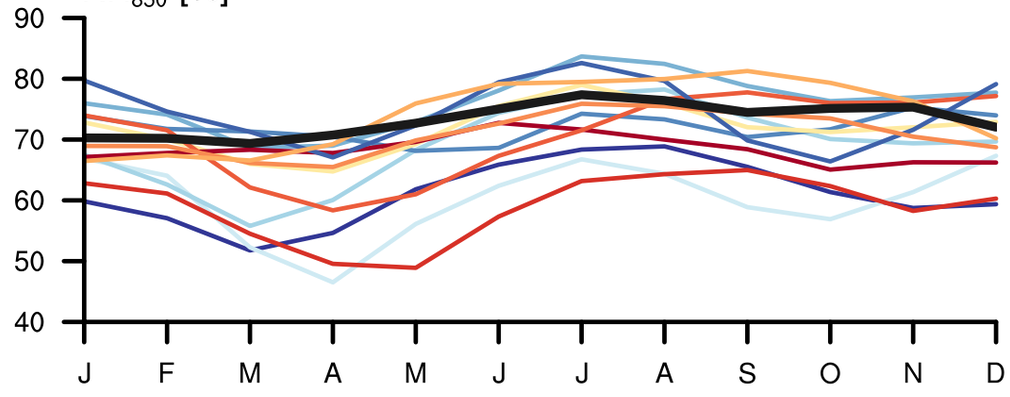
LTS [K]



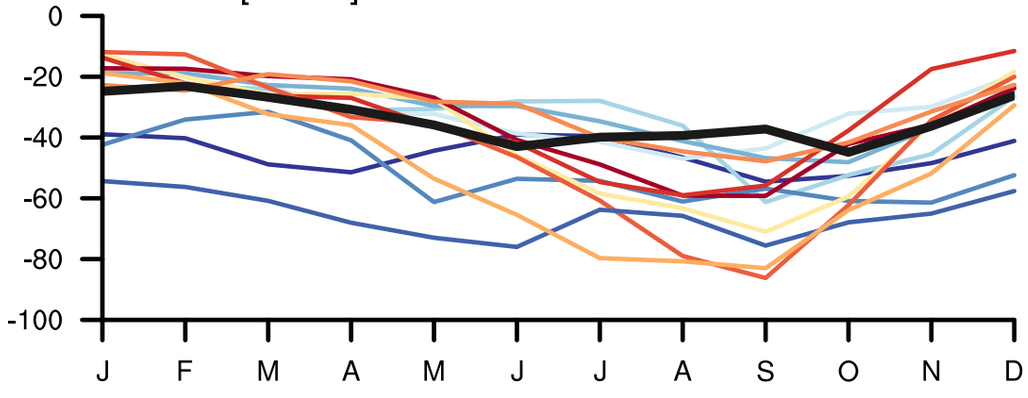
HIGH CLOUD COVER [%]

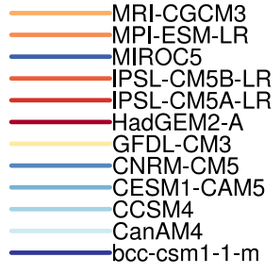


RH_{850} [%]

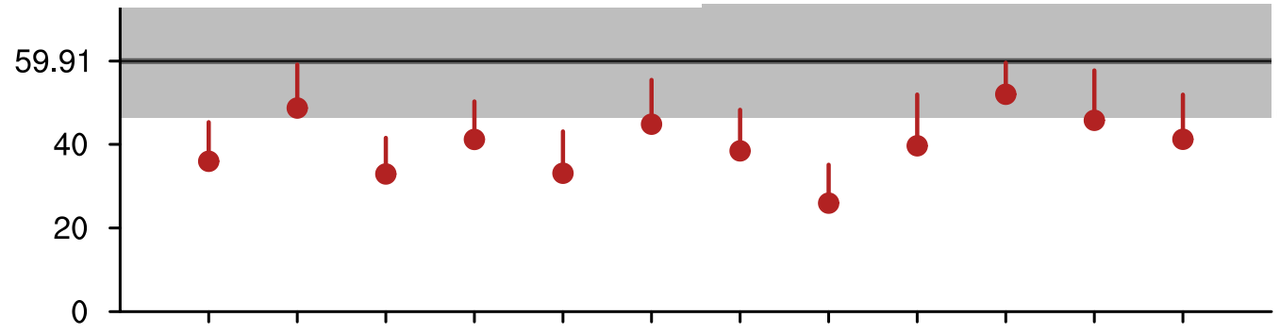


SWCRE [W m^{-2}]

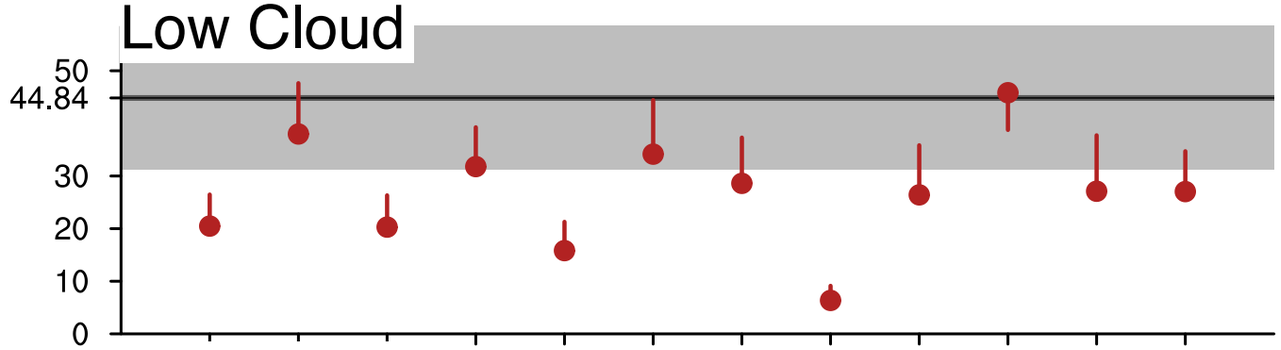




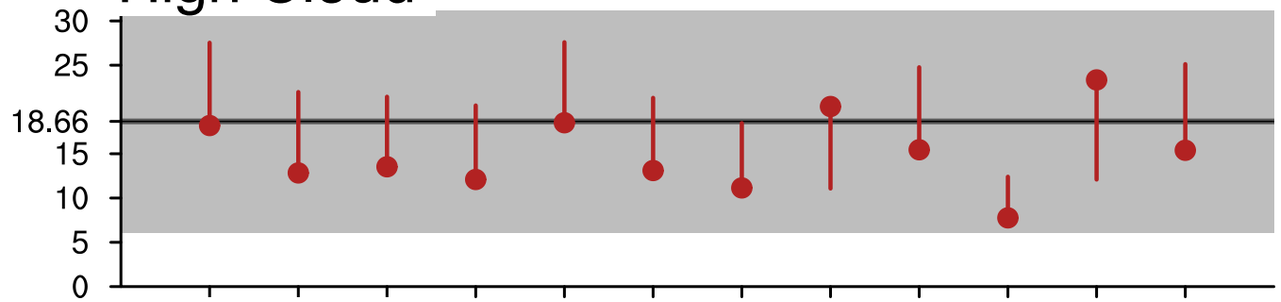
Total Cloud



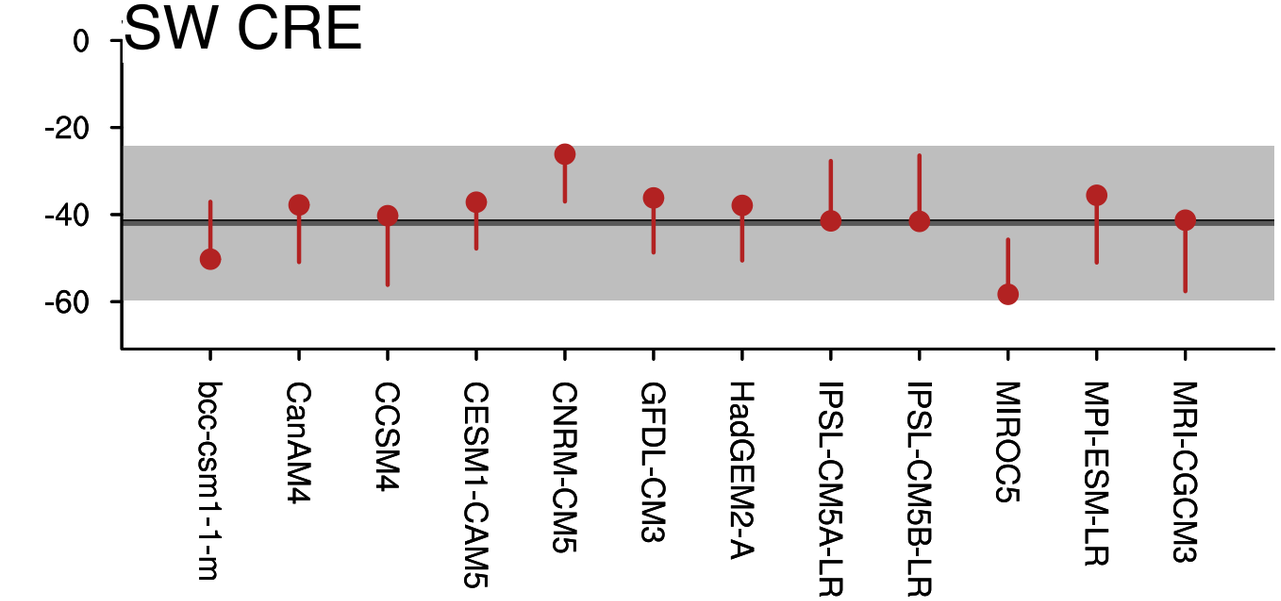
Low Cloud



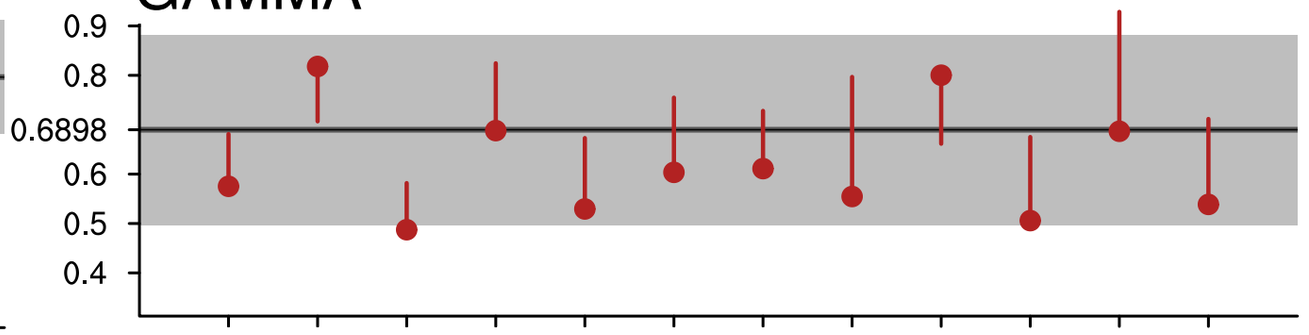
High Cloud



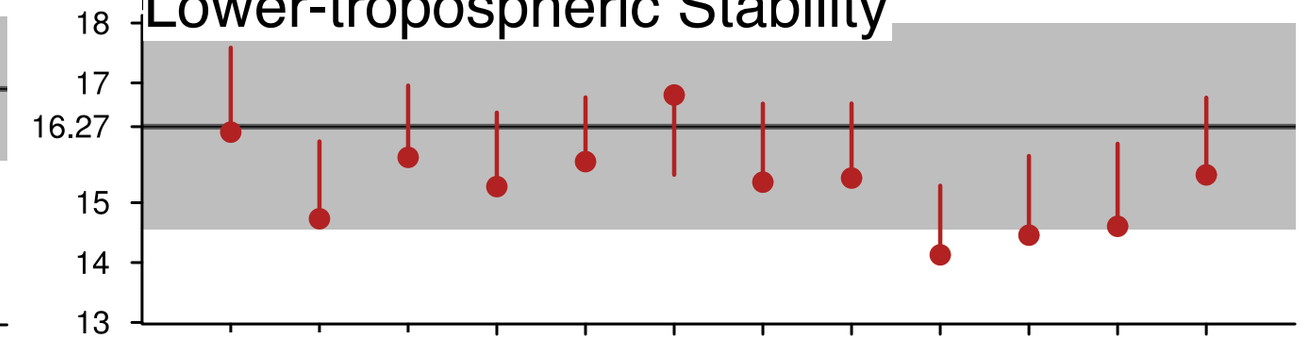
SW CRE



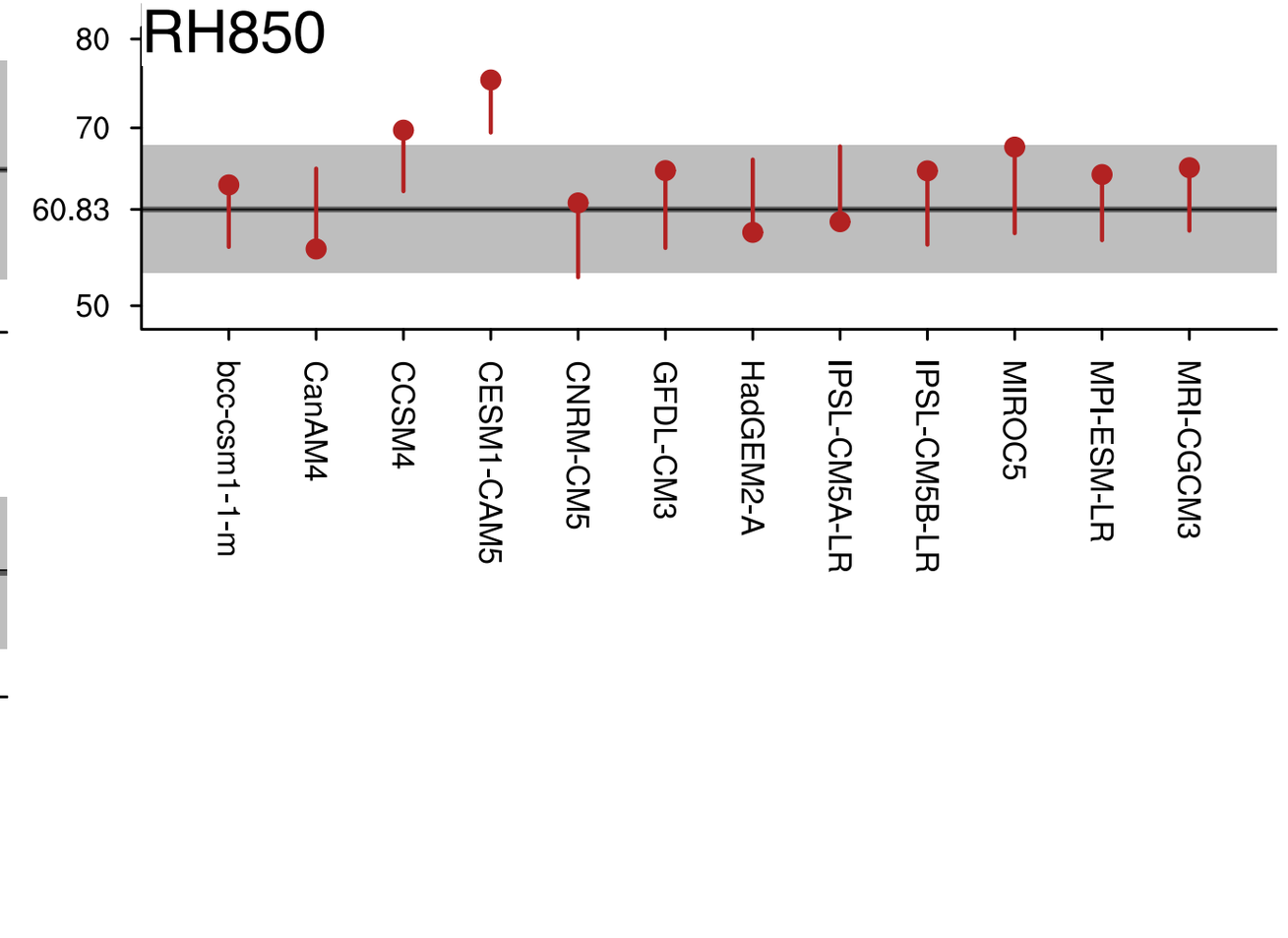
GAMMA

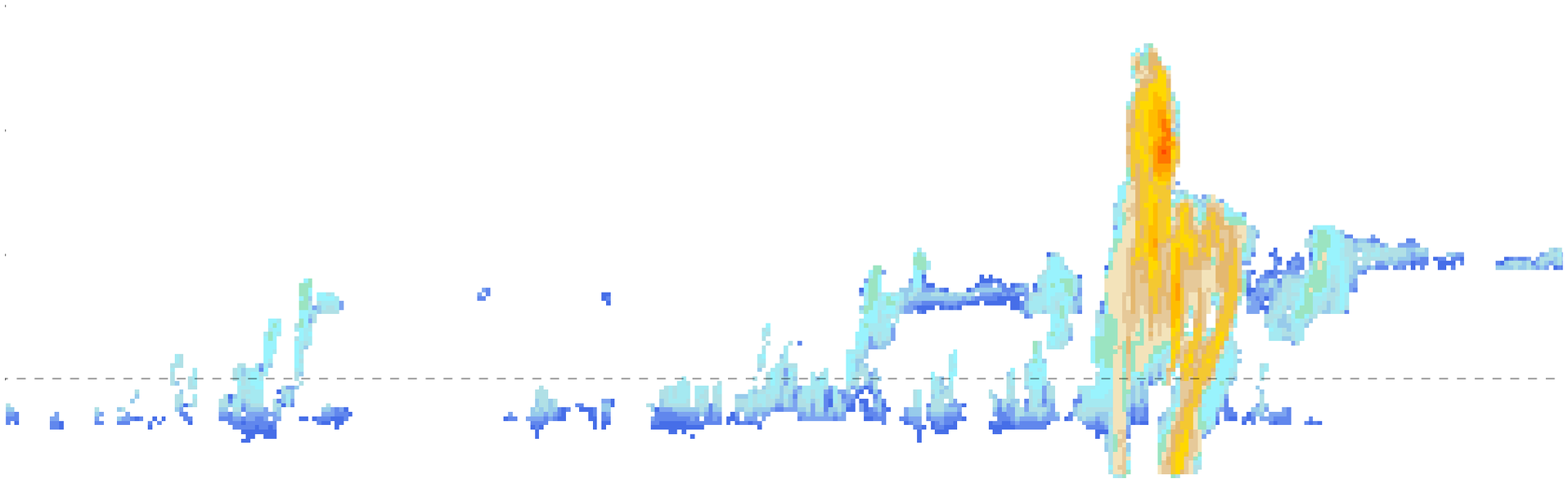


Lower-tropospheric Stability

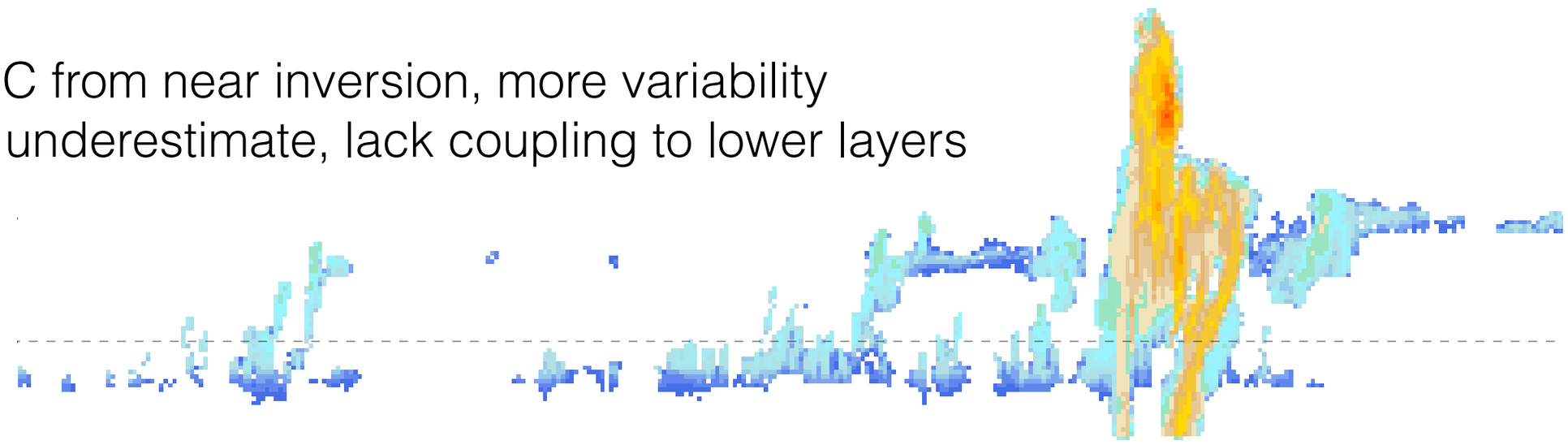


RH850





1/3 of CC from near inversion, more variability
models underestimate, lack coupling to lower layers



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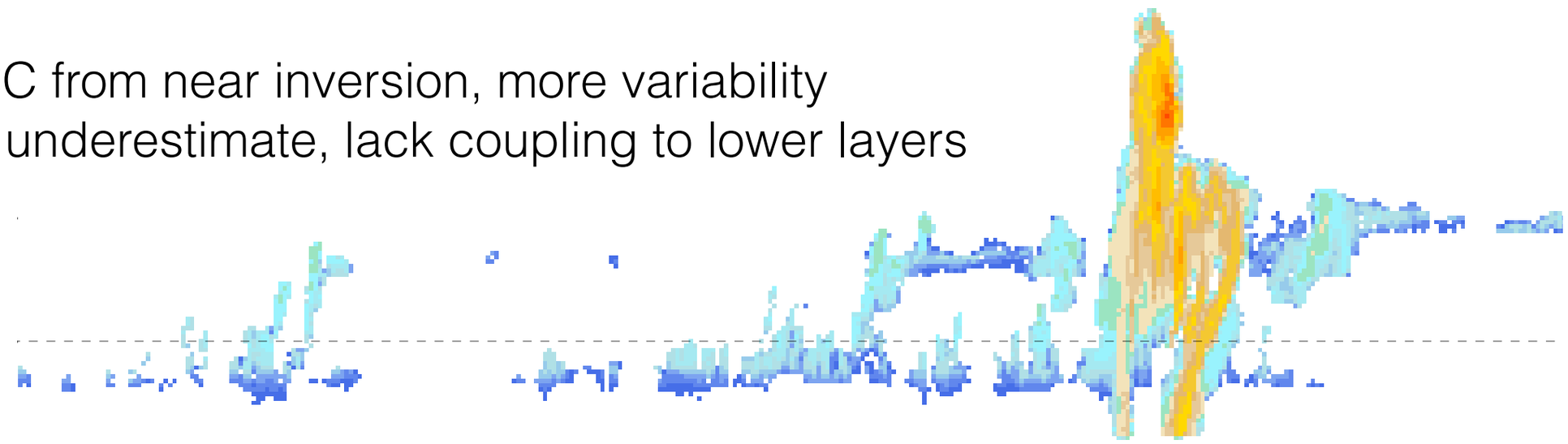

2/3 of CC from low-level (small variability)
models underestimate cloud, contain too much variability
variability related to low-level RH and omega (high freq.)
& low-level winds (low freq.)

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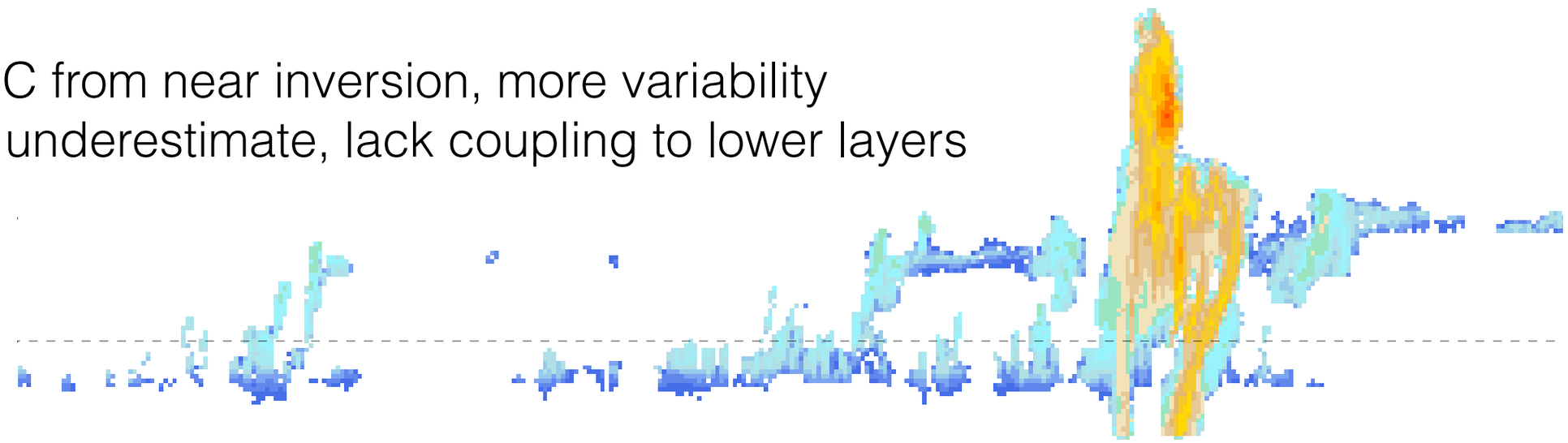

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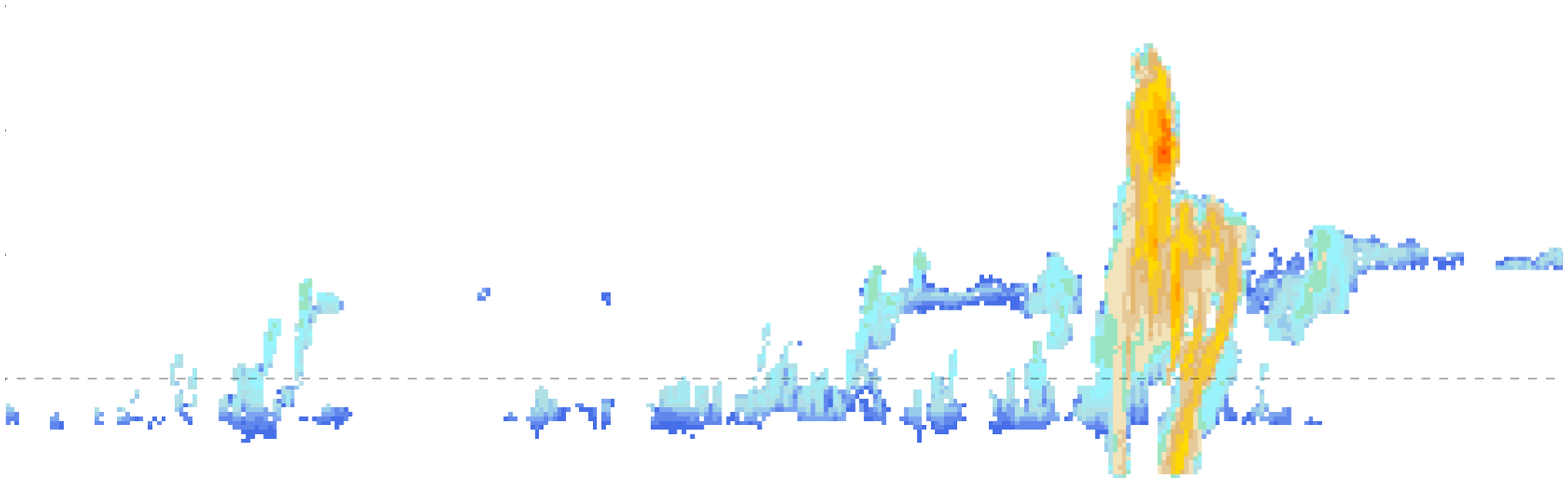
Satellite+Reanalysis shows Barbados similar to broader tropical regimes.
AMIP regimes show similar biases to Barbados winter (subsidence).

Thanks