# The day-to-day co-variability between mineral dust and cloud glaciation: A proxy for heterogeneous freezing.

## Supplement information

Diego Villanueva[1], Bernd Heinold[1], Patric Seifert[1], Hartwig Deneke[1], Martin Radenz[1], Ina Tegen[1]
[1]Leibniz Institute for Tropospheric Research, Leipzig, 04318, Germany
*Correspondence to*: Diego Villanueva (ortiz@tropos.de)

For figures S.1 to S.14:

a) Time average at -15°C (averaged in a 12 K range), 2007-2010.
b) Time-zonal average, 2007-2010.
c) Zonal average at -15°C (averaged in a 12 K range), 2007-2010.

S 1-S 3: Frequency phase ratio (FPR) variables.

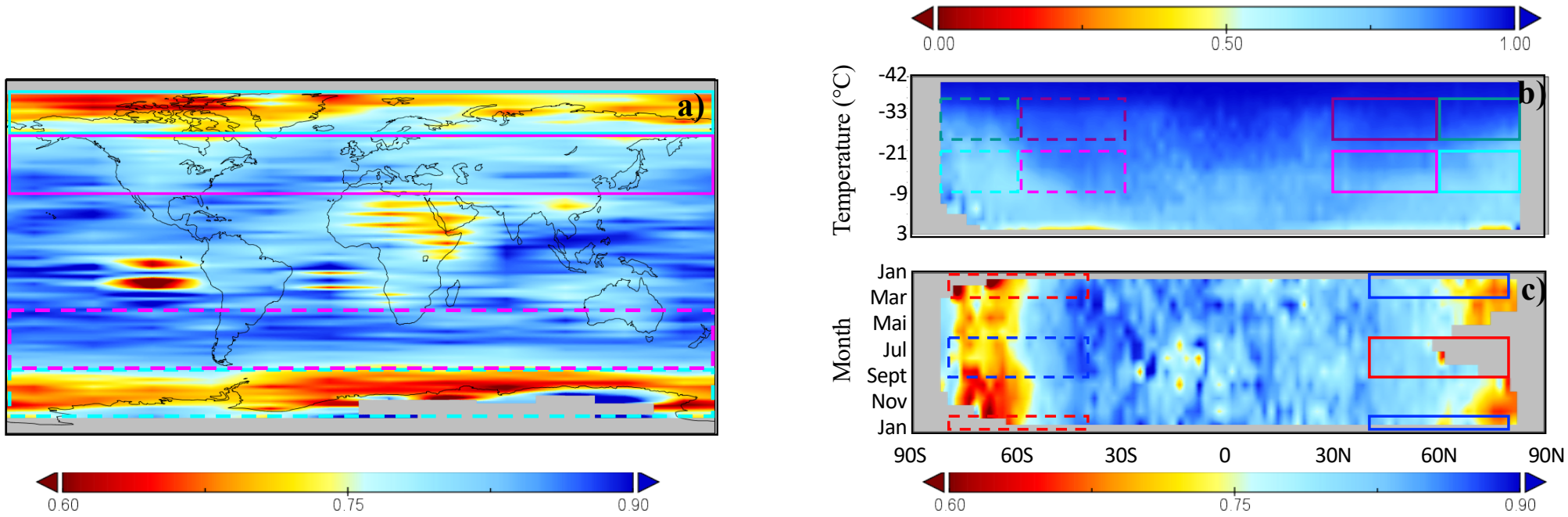
S 4-S.7: Dust aerosol data from MACC reanalysis.

S.8-S.9: Cloud volume fraction of all and stratiform clouds (CALIPSO-GOCCP).

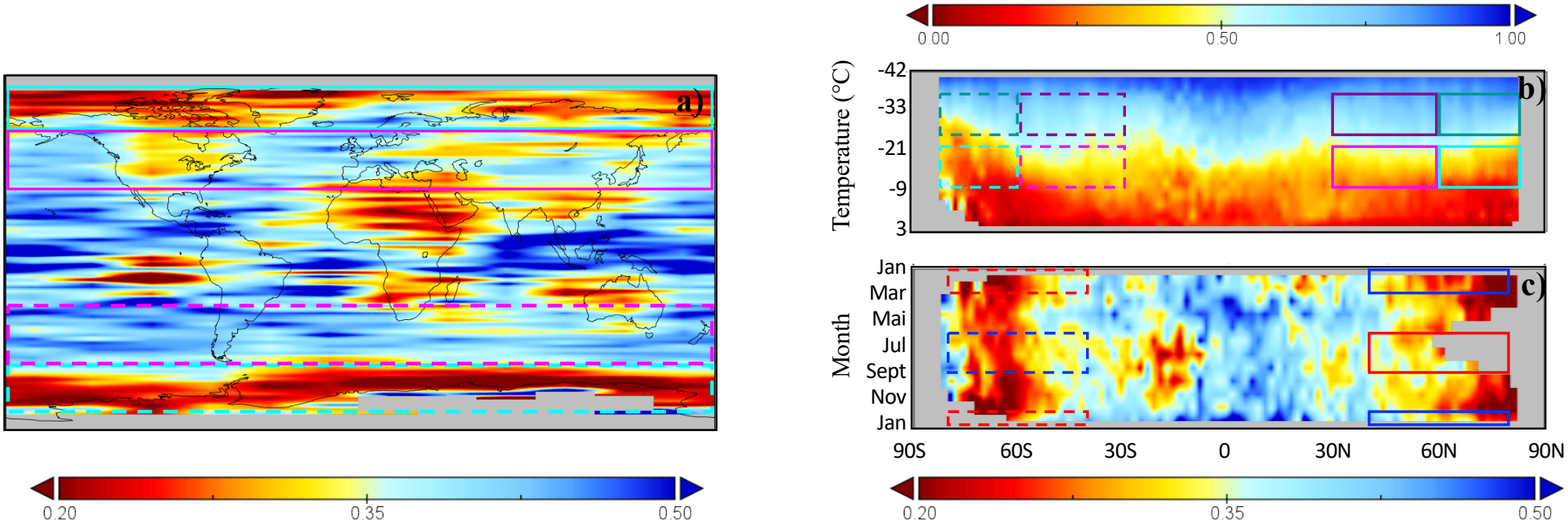
S.10-S.13: Vertical velocity (MACC), relative humidity (ERA-Interim), isotherm height and temperature (ECMWF-AUX).

S.14-S.16: Sample size distribution.

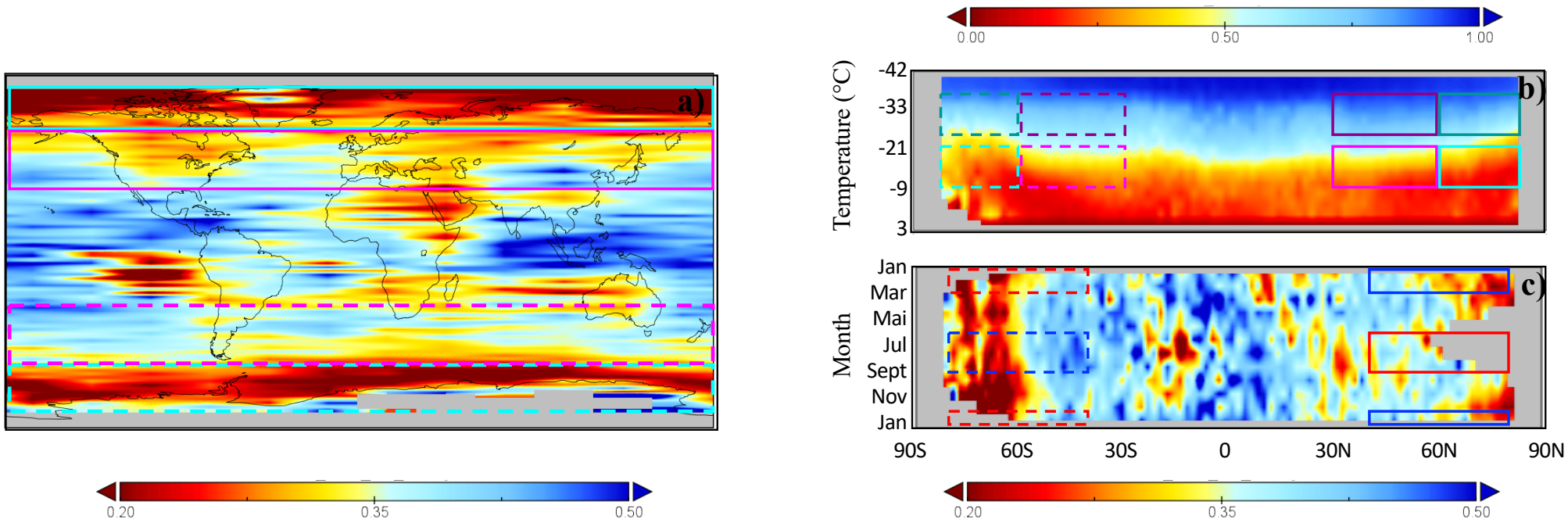
S.17-S.20: Day-to-day dust-ice statistics without meteorological constraints.



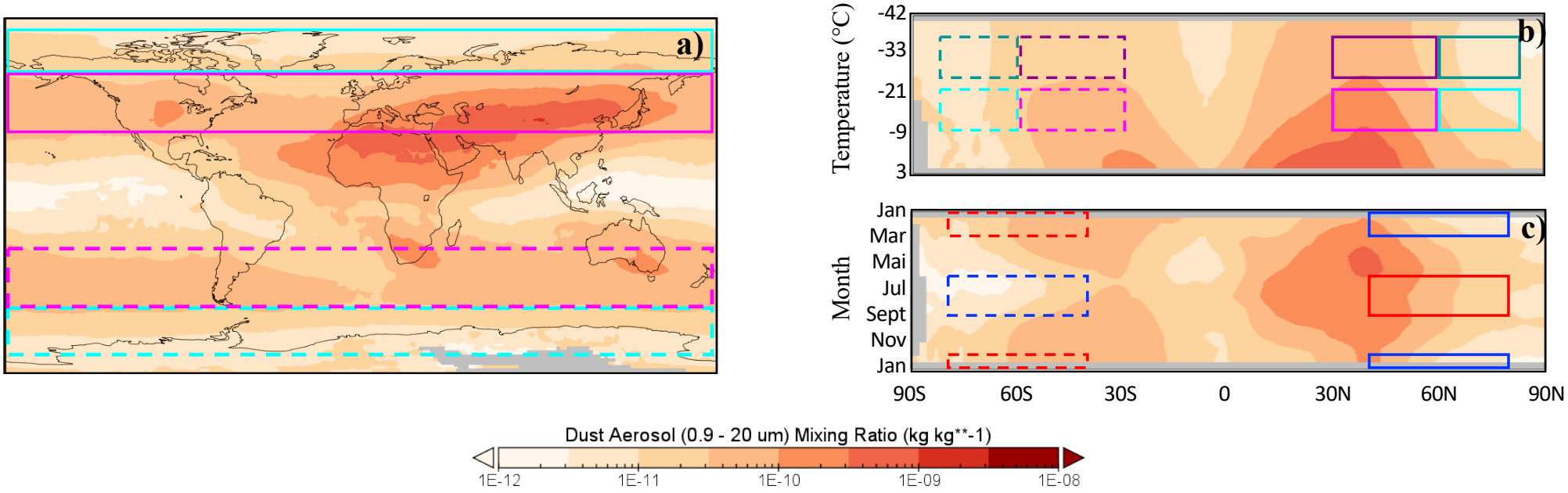

S1. $FPR_{DARDAR}$ [%]



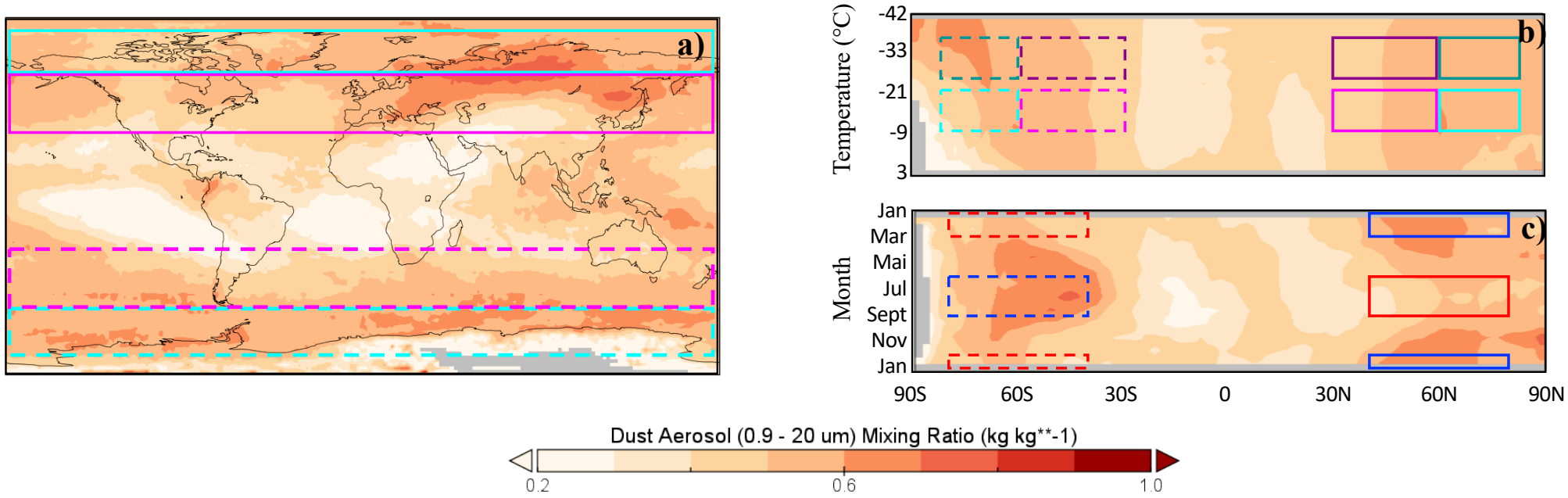

S2. $FPR_ALT_{DARDAR}$ [%]


a)
0.20
0.35
0.50
0.00
0.50
1.00
Temperature (°C)
-42
-33
-21
-9
3
b)
Month
Jan
Mar
Mai
Jul
Sept
Nov
Jan
c)
90S
60S
30S
0
30N
60N
90N
0.20
0.35
0.50

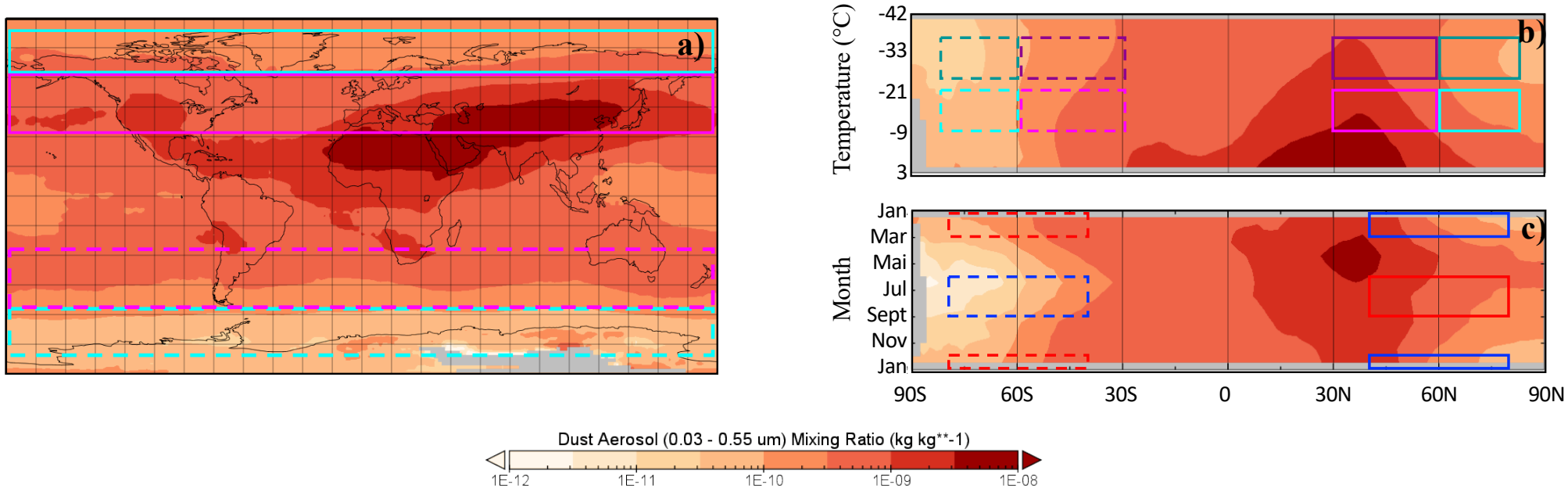
S3. $FPR_{GOCCP}$ [%]



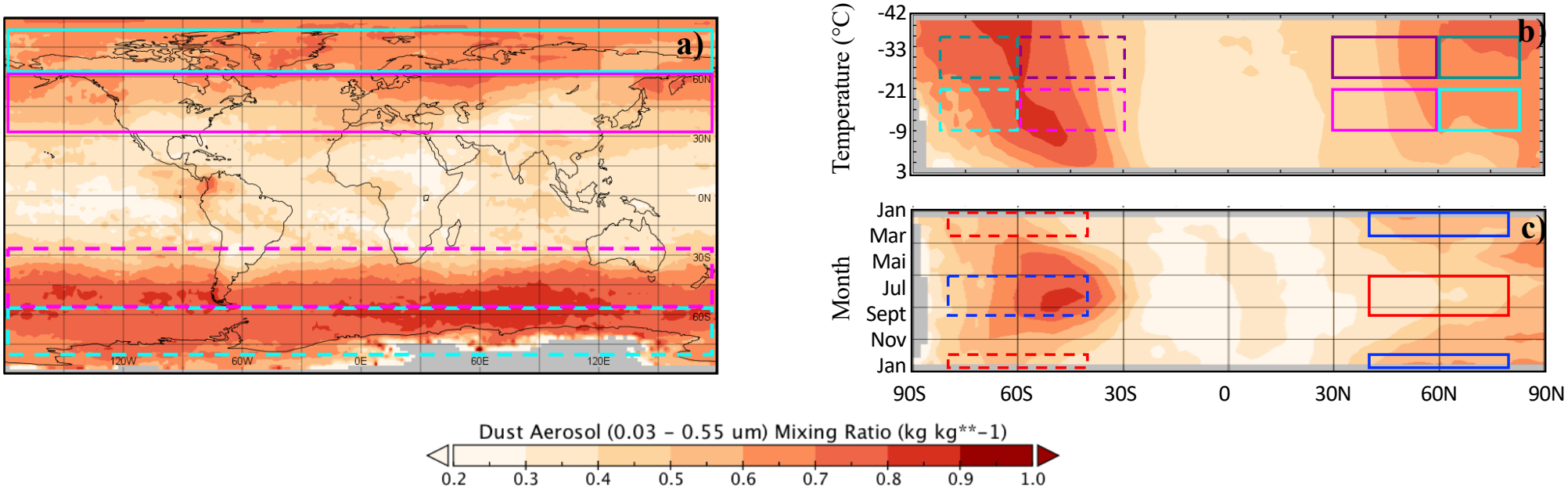

S4. MACC coarse dust [kg/kg].



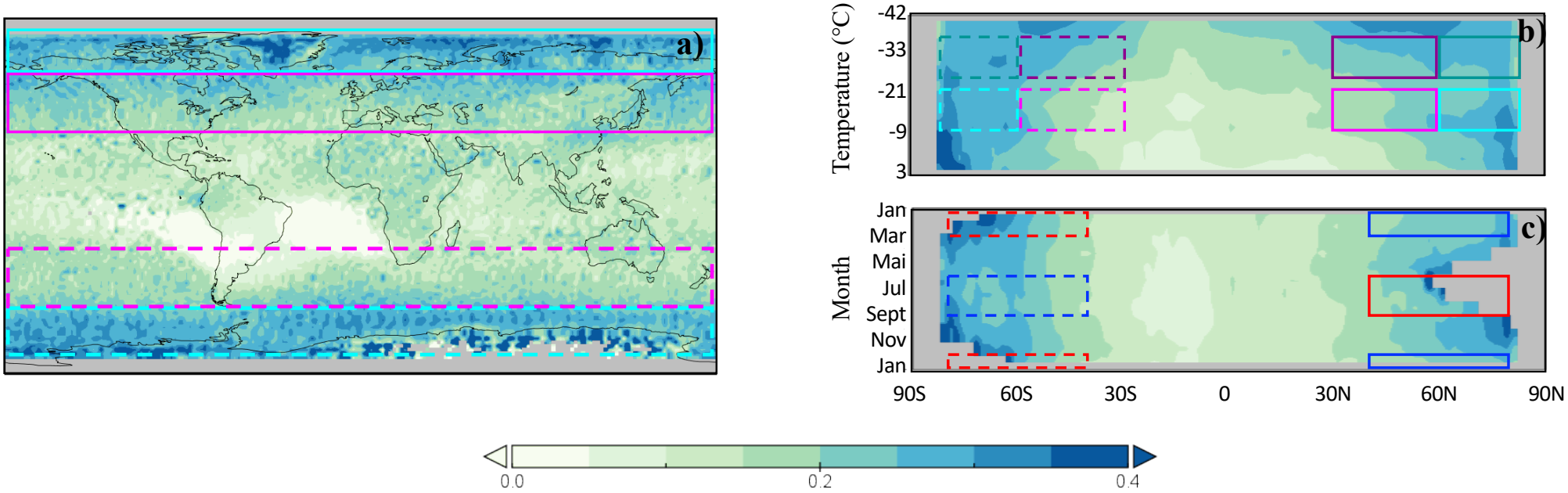

S5. Standard deviation of coarse log (dust) MACC [log(kg/kg)].



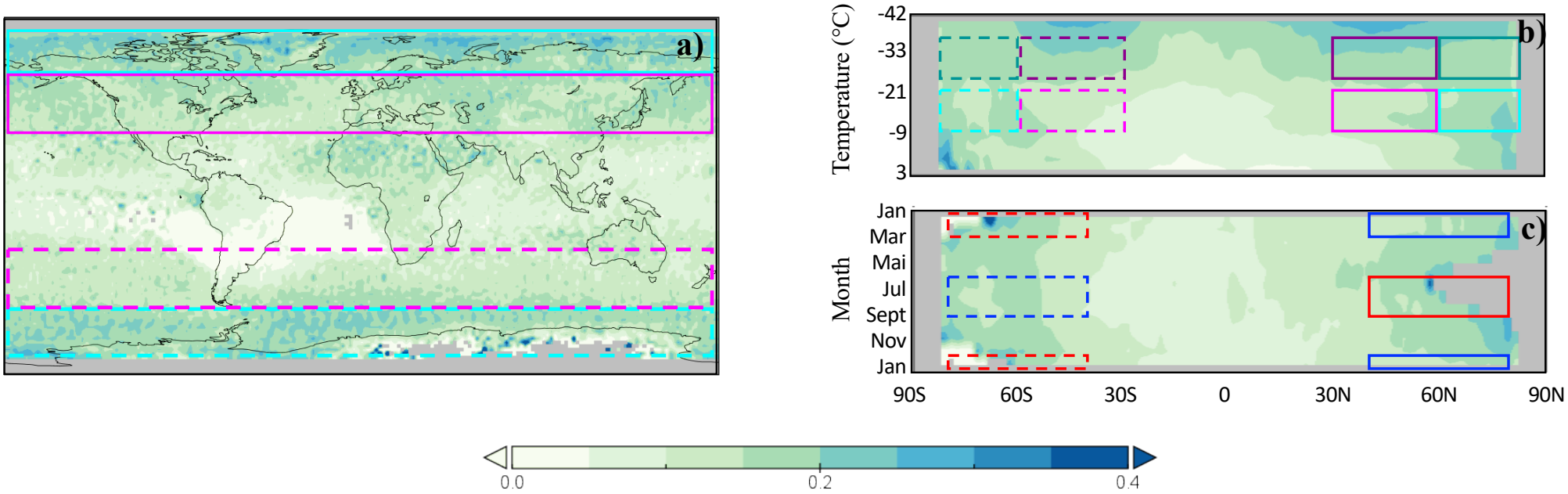

S6. MACC fine dust [kg/kg].



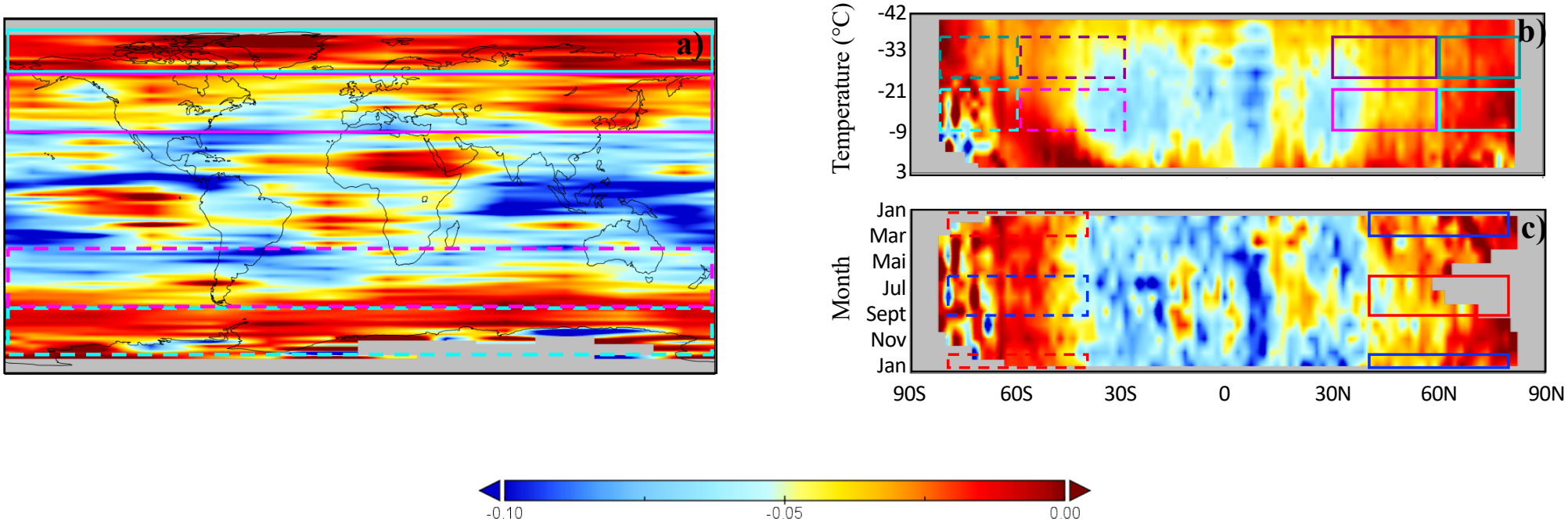

S7. Standard deviation of fine log (dust) MACC [log(kg/kg)].



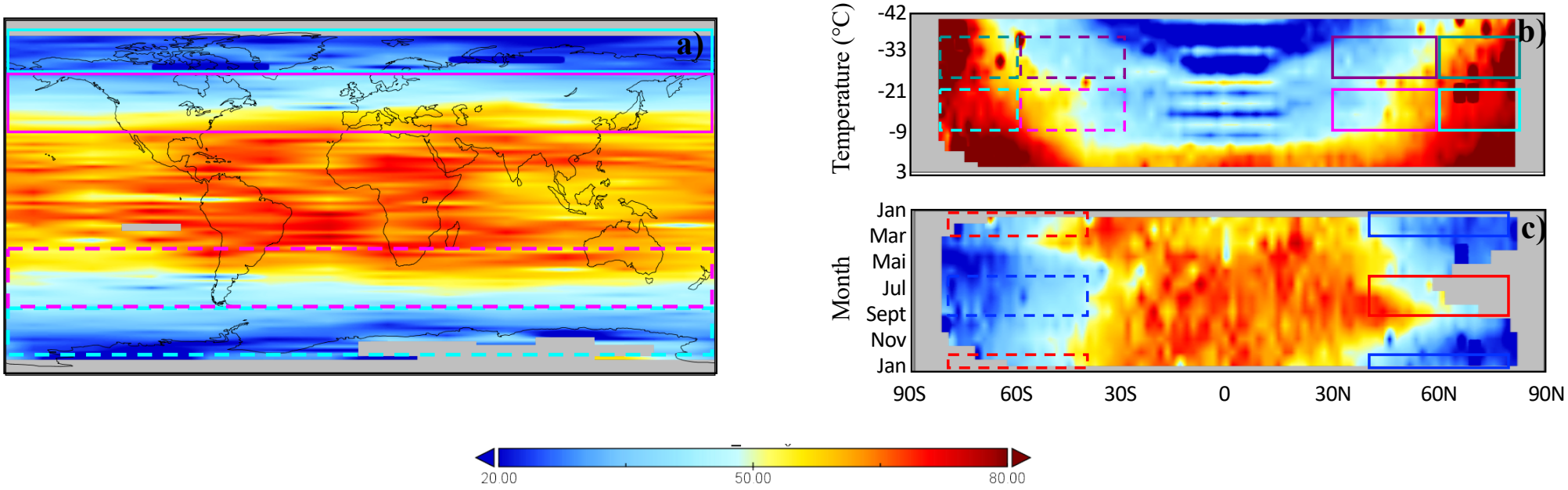

S8. Cloud volume fraction [%].



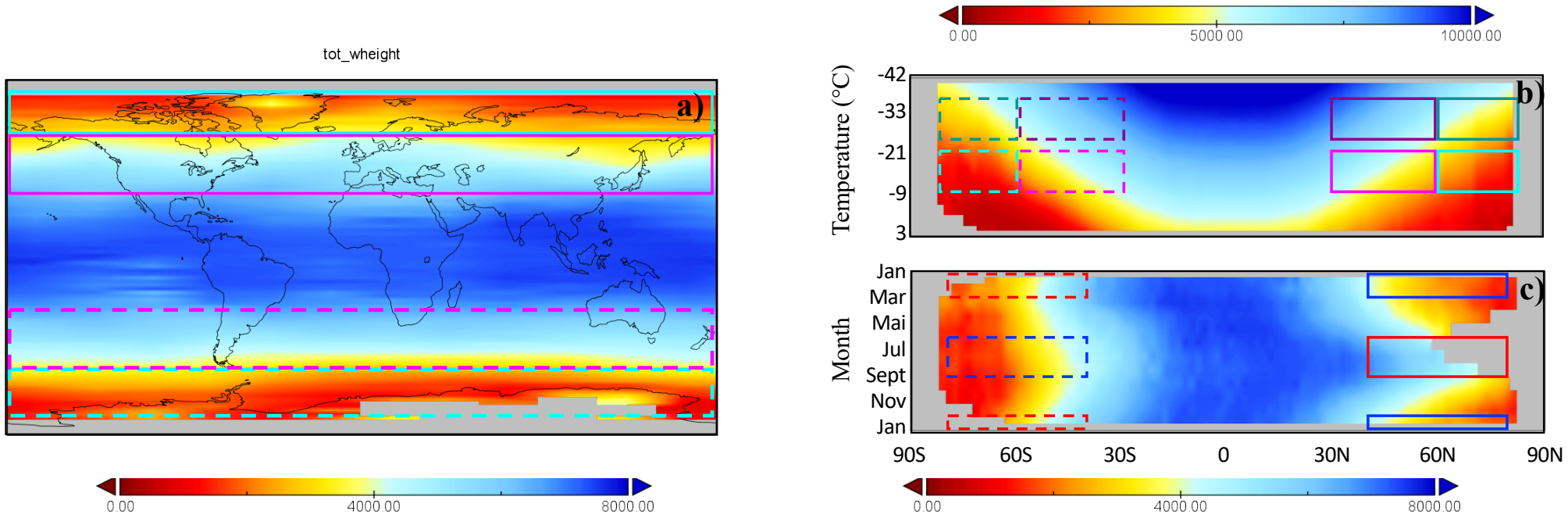

S9. Stratiform cloud volume fraction [%].



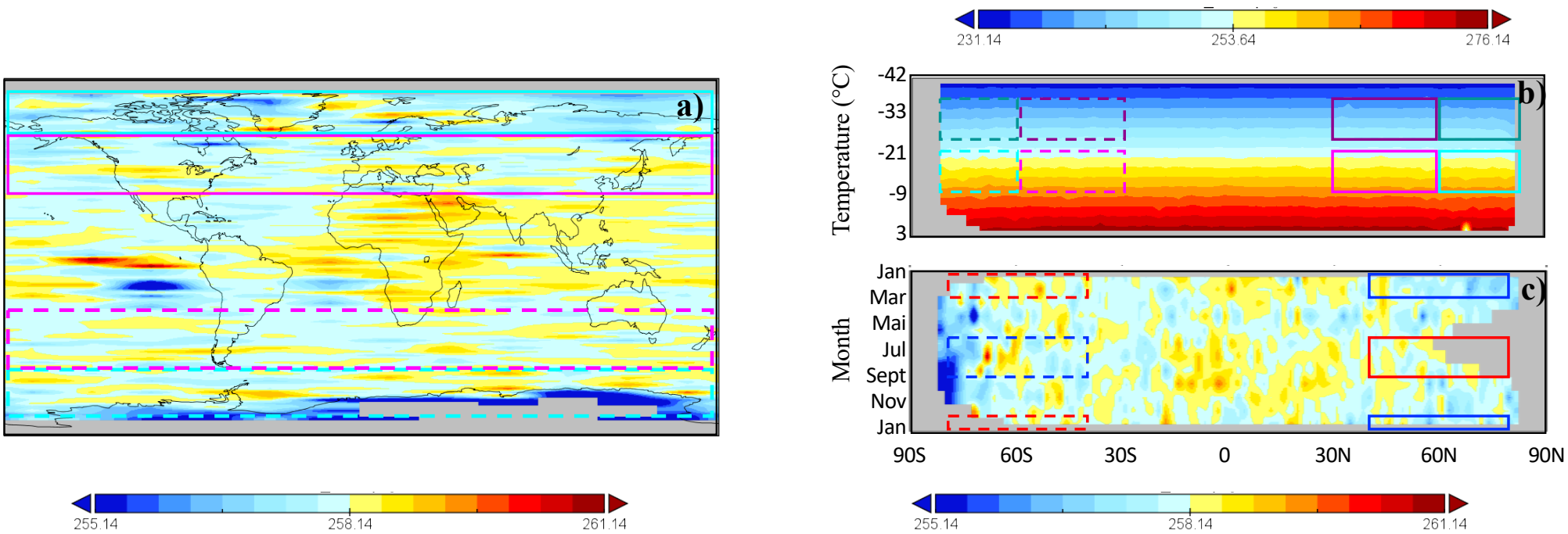

S10. MACC vertical velocity [Pa/s] for stratiform clouds.



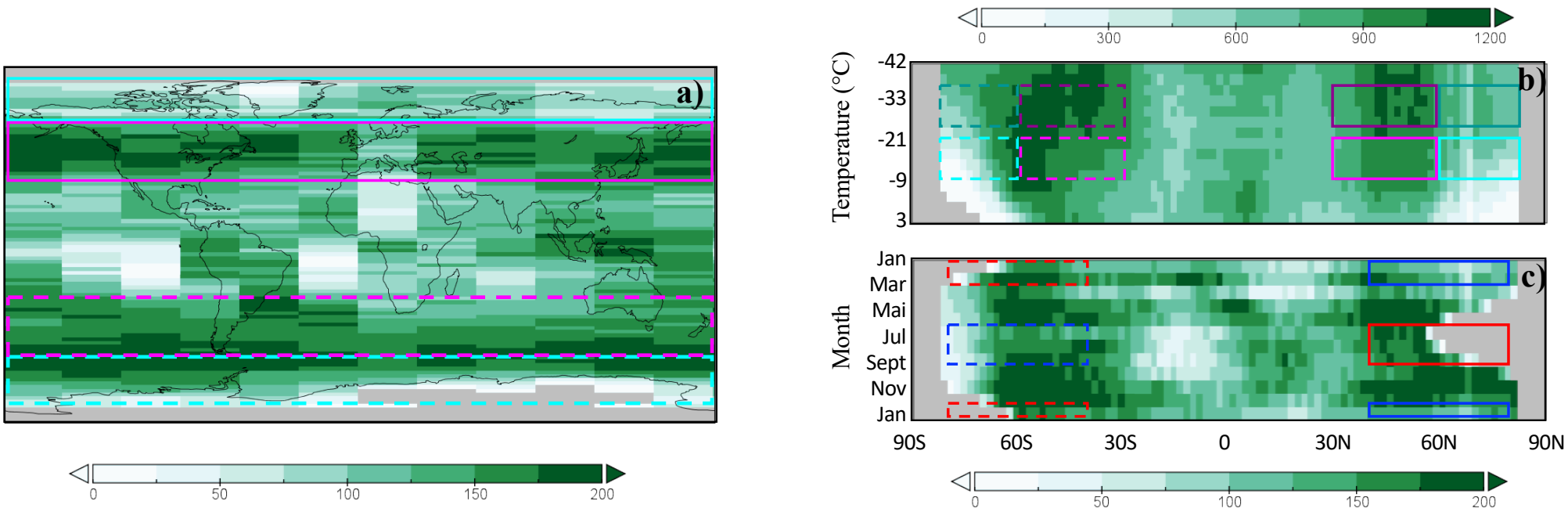

S11. MACC relative humidity [%] for stratiform clouds.



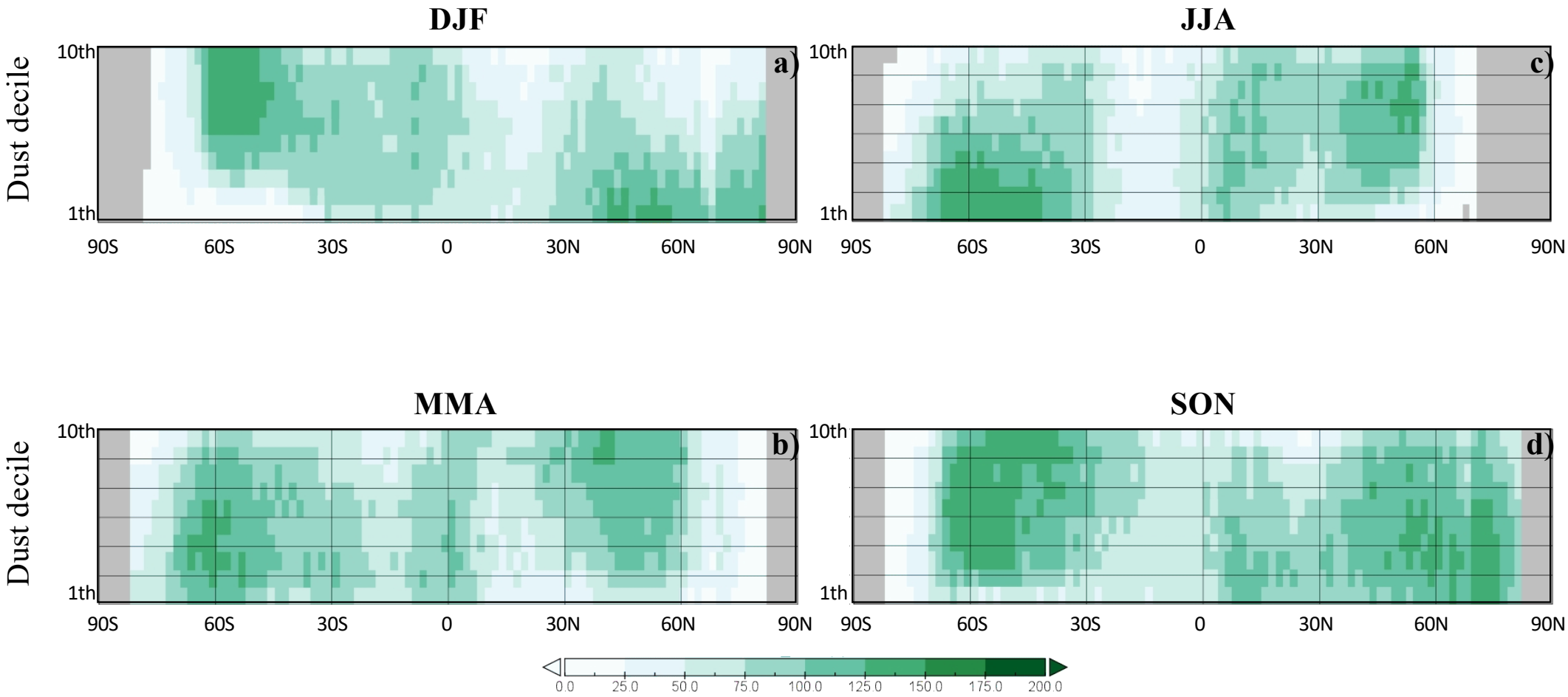

S12. ECMWF-AUX isotherm height [m] for stratiform clouds.



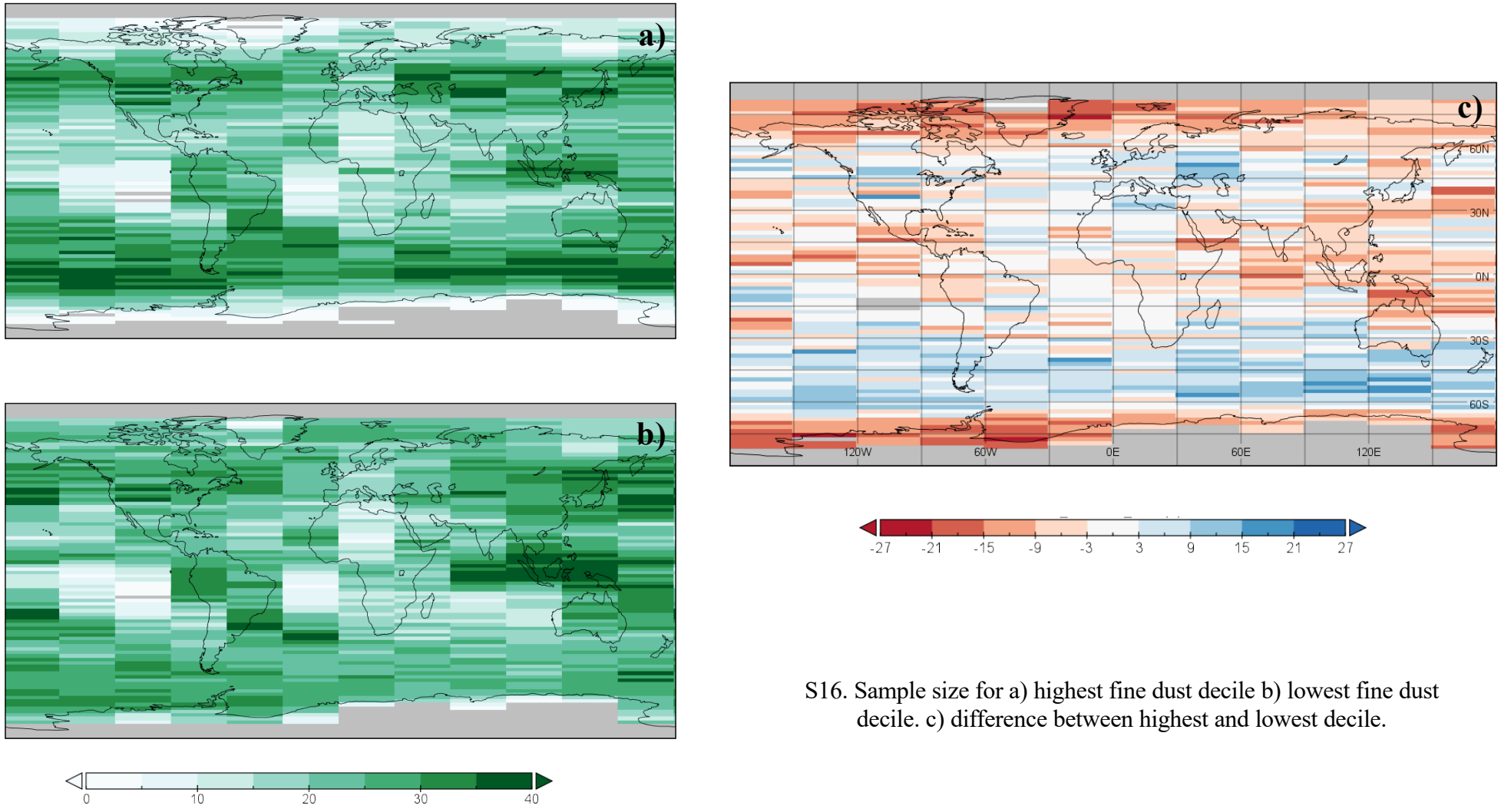

S13. ECMWF-AUX temperature [K] for stratiform clouds.



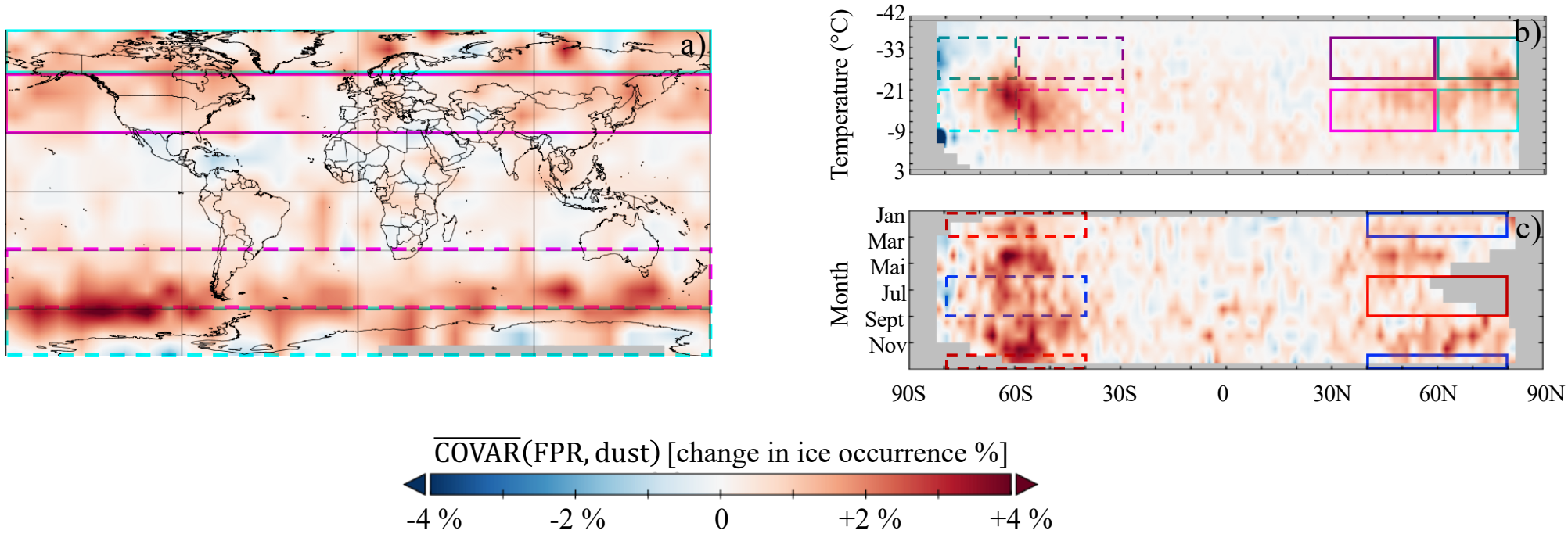

S14. Sample size of stratiform clouds [#gridboxes(month, dust decile, temperature, latitude, longitude)].



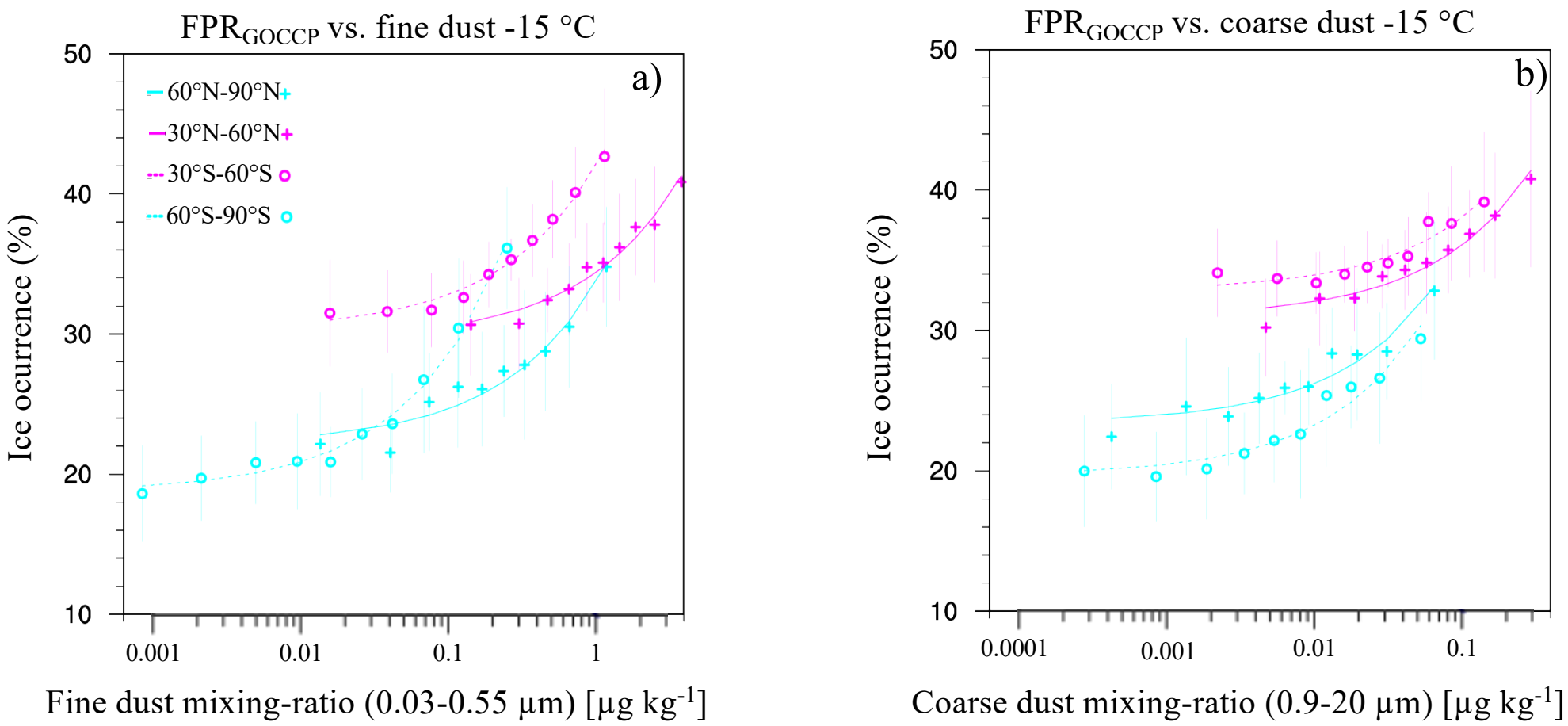

S15. Sample size of stratiform clouds [#gridboxes(month, dust decile, temperature, latitude, longitude)] for different seasons.



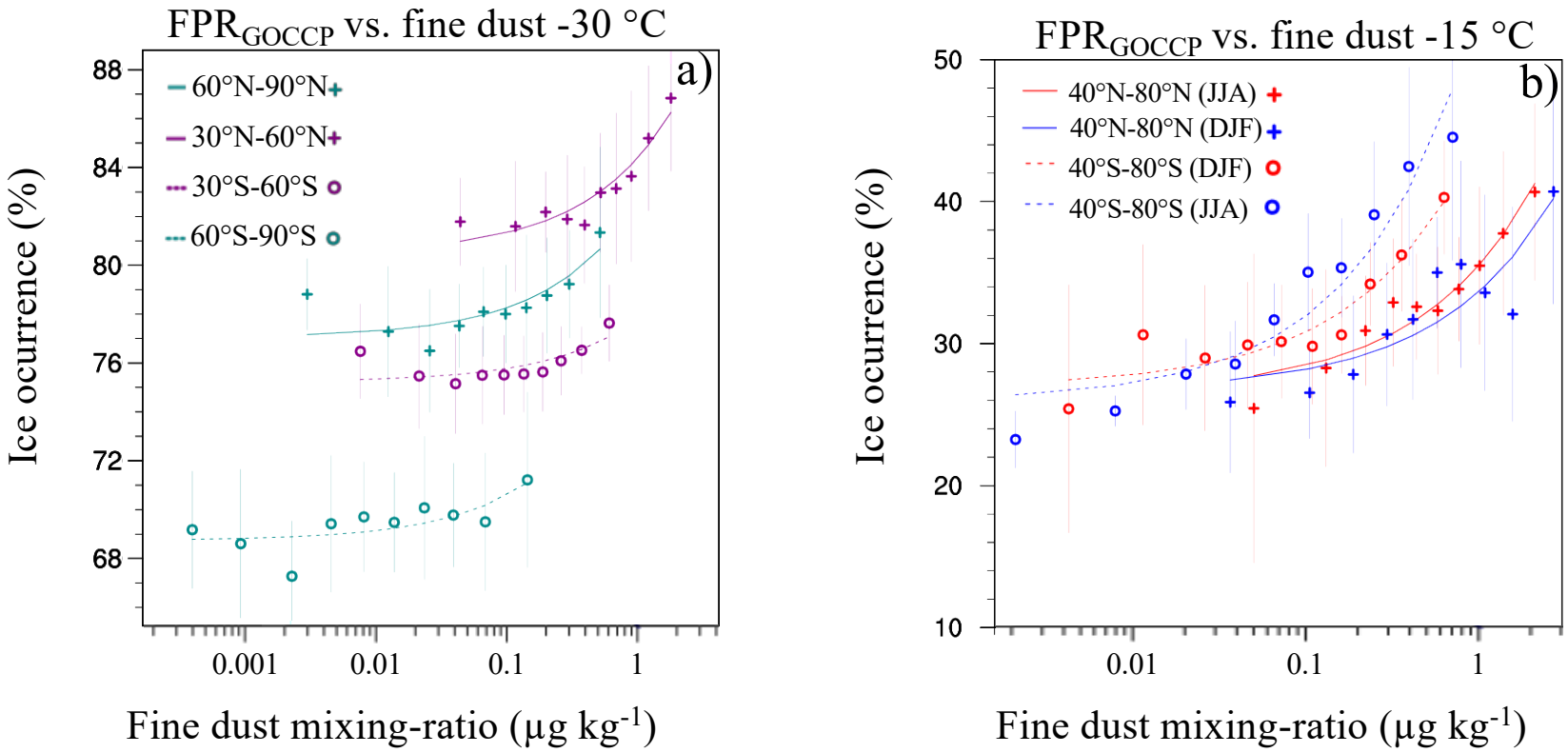

S16. Sample size for a) highest fine dust decile b) lowest fine dust decile. c) difference between highest and lowest decile.



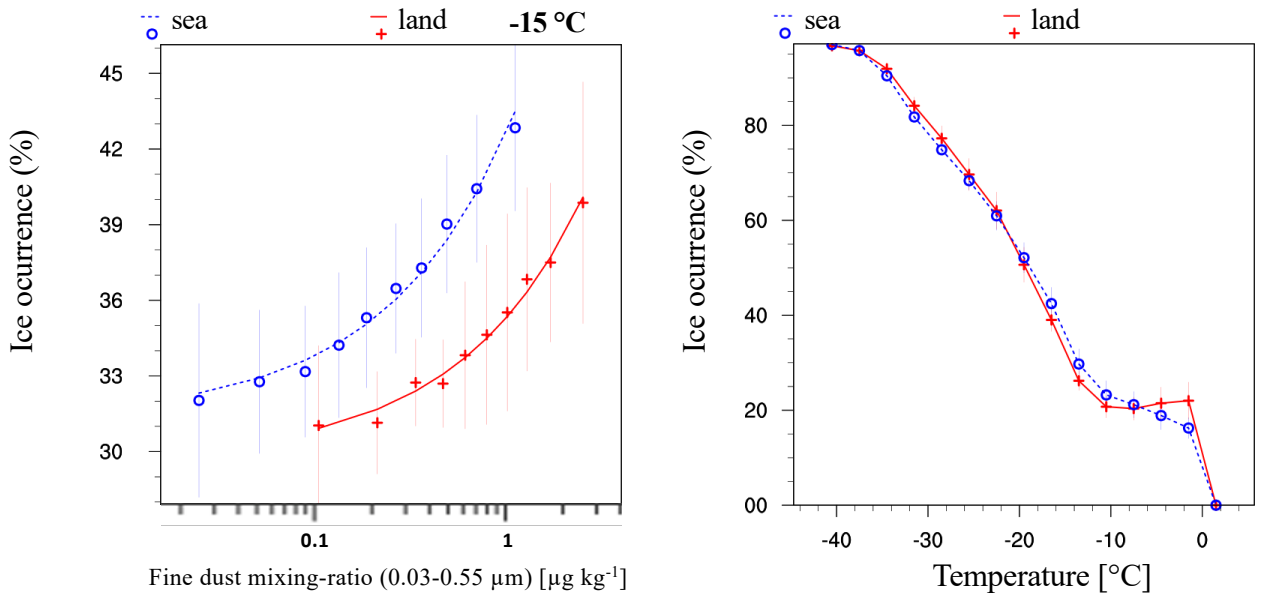

S17. Day-to-day covariance of fine dust mixing-ratio (MACC) and $FPR_{GOCCP}$ 2007-2010. The covariance is normalized by the fine dust standard deviation. a) Time mean covariance between 12 monthly covariance values at -15°C (averaged in a 12 K range). b) Time-zonal mean covariance. c) Monthly-zonal mean covariance at -15°C. Red colours denote a high correlation between day-to-day fine dust and ice occurrence. The colour and pattern of the boxes correspond to the regression lines in S 18 and S 19.




S18. Average cloud phase for the mid-latitude and high-latitude bands for -15 °C (range -21 °C to -9 °C) in the period 2007-2010. The horizontal axis corresponds to the different time deciles (day-to-day variability) of fine (a) and coarse (b) dust mixing-ratio (MACC), calculated for each each 3°C temperature bin and gridbox (1.875°x1.875°) and averaged along each 12 °C temperature range and latitude band (30°x360°). The vertical bars are positioned at each dust decile and show the mean zonal standard deviation within each latitude band. The lines represent the linear regressions ($FPR=A\cdot m^{2/3}+FPR_0$ ). Only stratiform and non-precipitating clouds were included.




S 19. Same as Fig 7.a but for a) -30 °C (range -36 °C to -24 °C) and b) winter (blue) and summer (red) seasons for the 40-80°N/S latitude bands.




S 20. Average sea/land cloud phase (CALIPSO-GOCCP) a) at -15 °C (range -21 °C to -9 °C) against the MACC deciles of fine dust mixing ratio and b) against temperature for 2007-2010. The vertical lines correspond to the standard deviation between a) Longitudes and b) Months of the year.