How efficiently to TTL cirrus dehydrate air?

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ATTREX-3 Science Team Meeting

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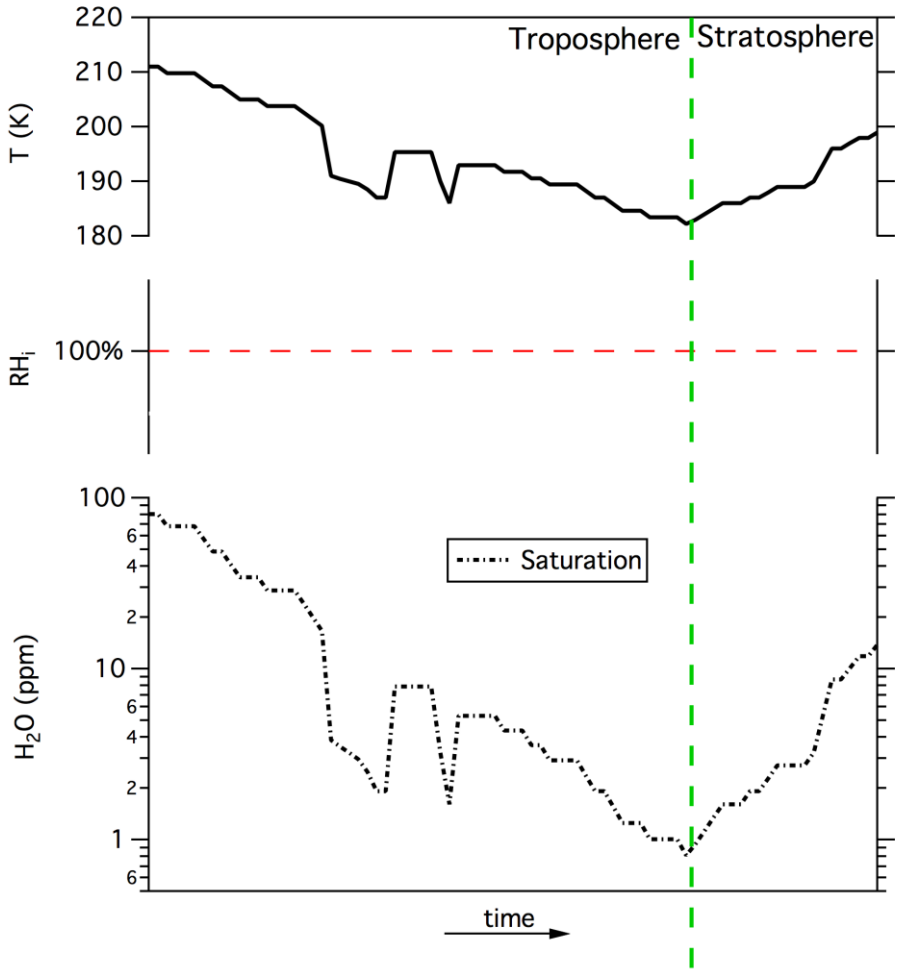
CIRES

NOAA

How efficient is dehydration in TTL? Complete efficiency would imply that the stratospheric entry WV is equal to 100% RH_i at Lagrangian dry point (LDP = lowest saturation mixing ratio encountered on path to stratosphere).



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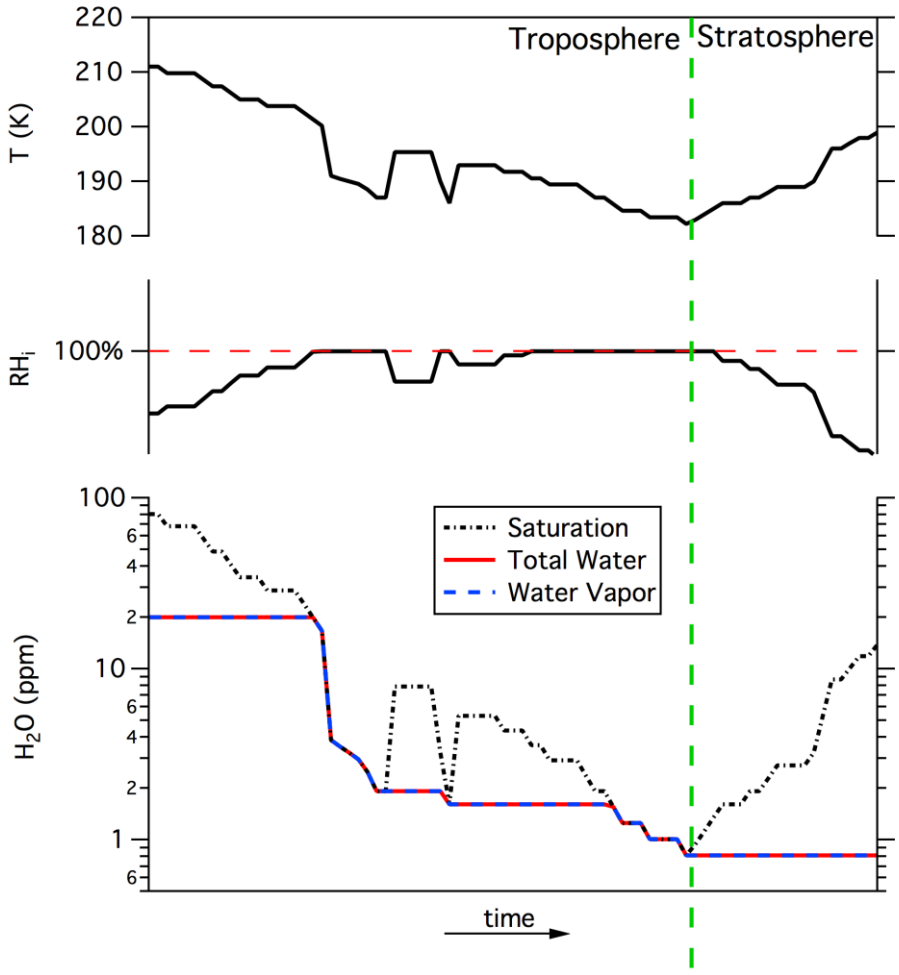

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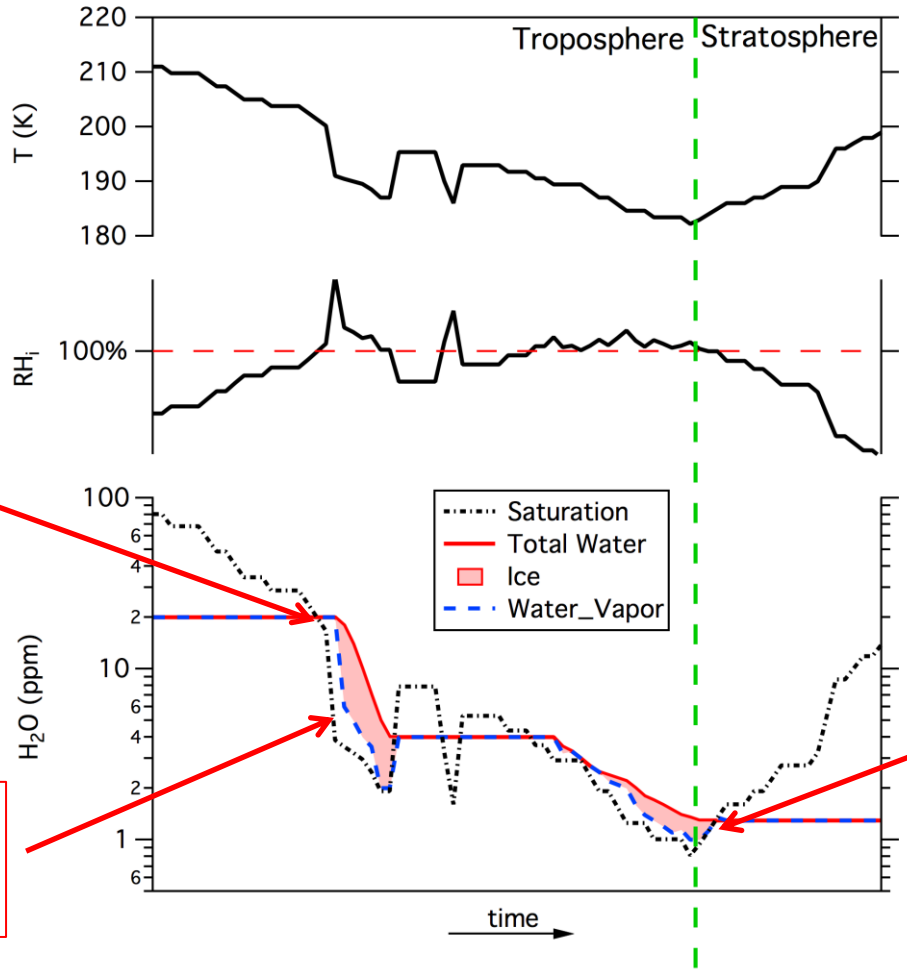
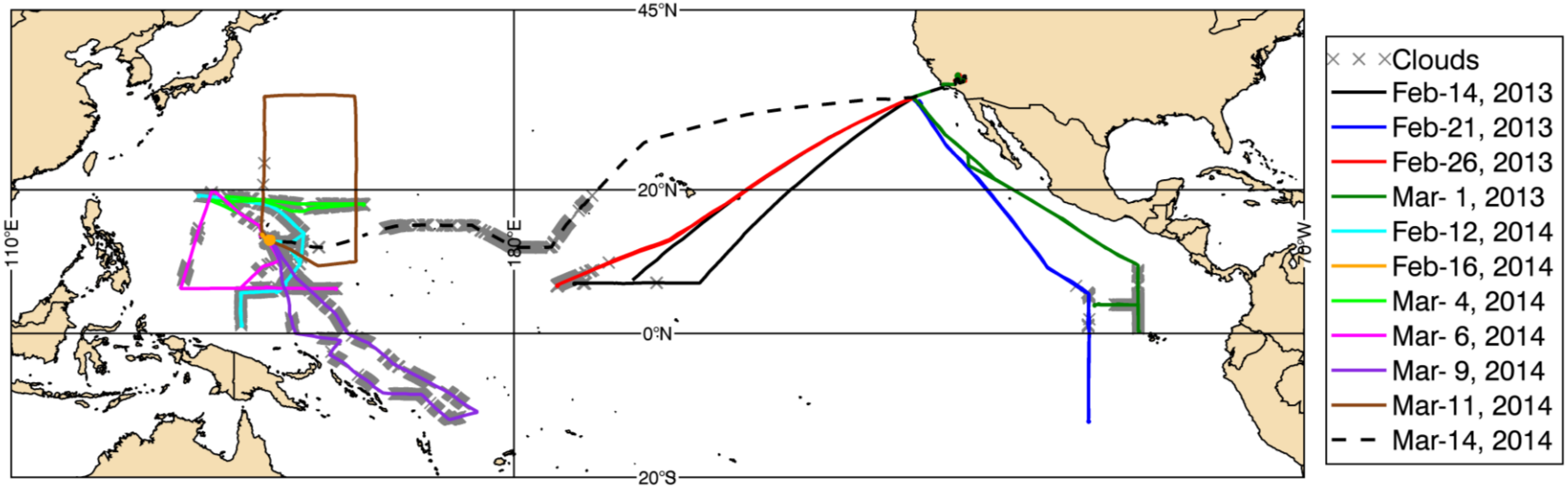


Nucleation requires significant supersaturation

Ice crystal growth can be slow

Ice crystals can be small with low terminal velocity, incompletely removing ice

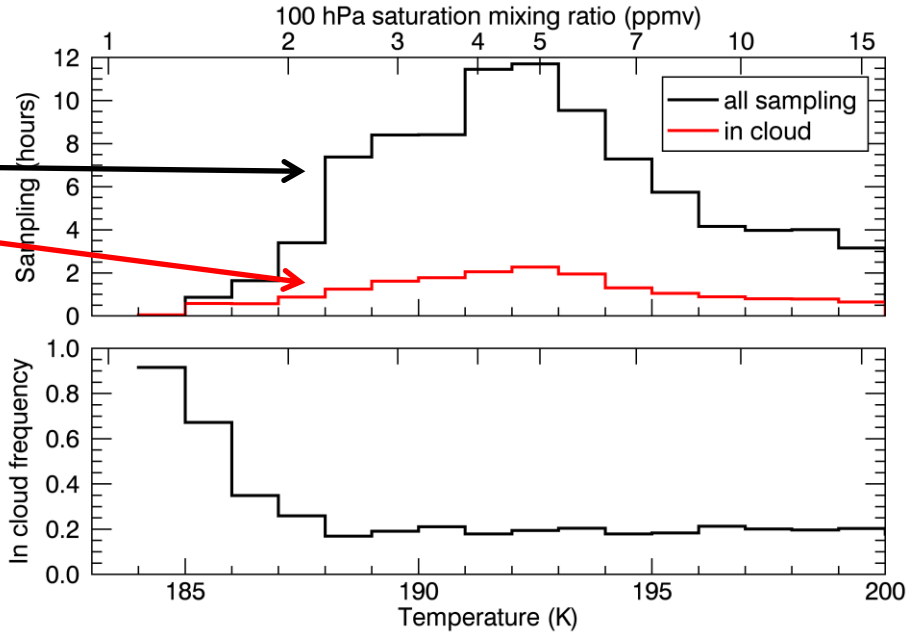
ATTREX TTL Domination



182 hours sampling < 200 K

37 hours inside clouds < 200 K

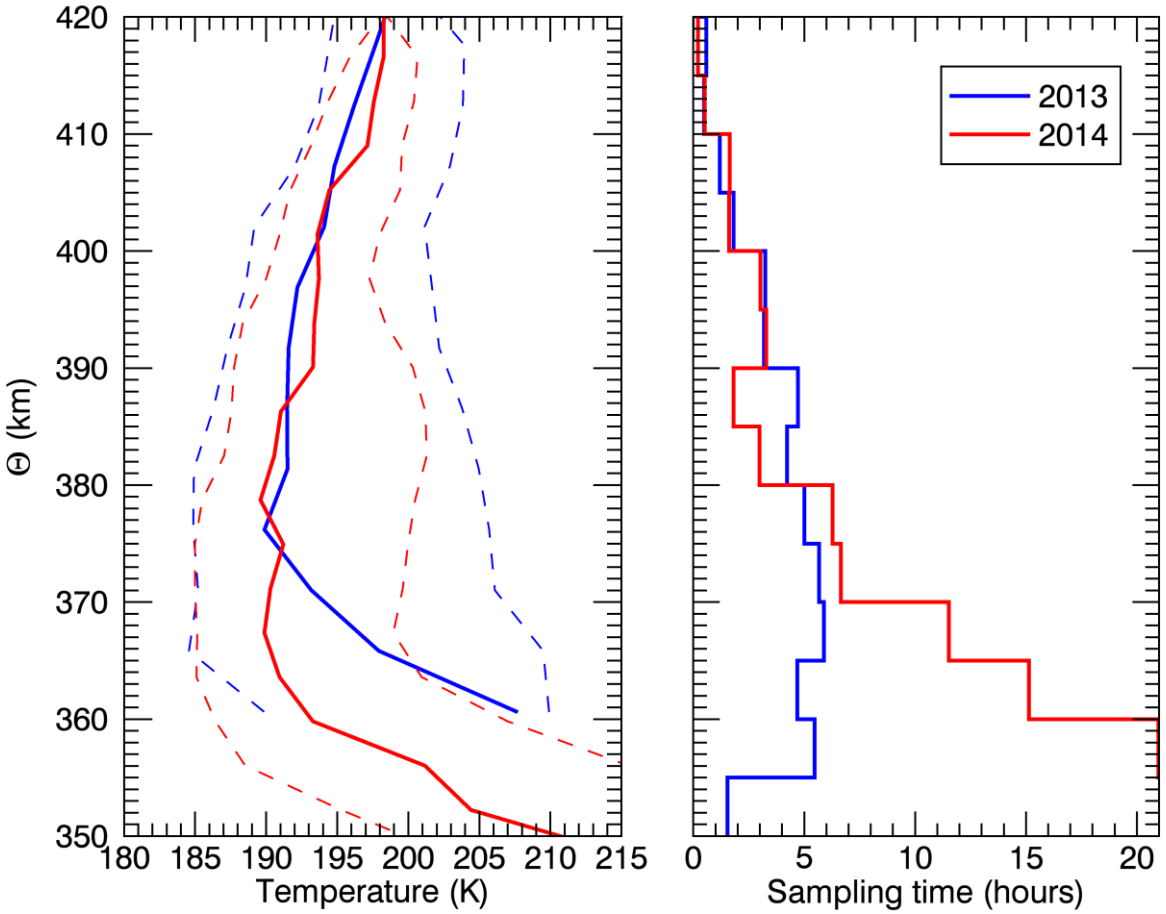
Use data to statistically understand/parameterize dehydration efficiency



Ice water content ‘climatology’

(at least) 2 problems:

- Possibly biased sampling / incomplete climatology.
- Convectively detrained cirrus.



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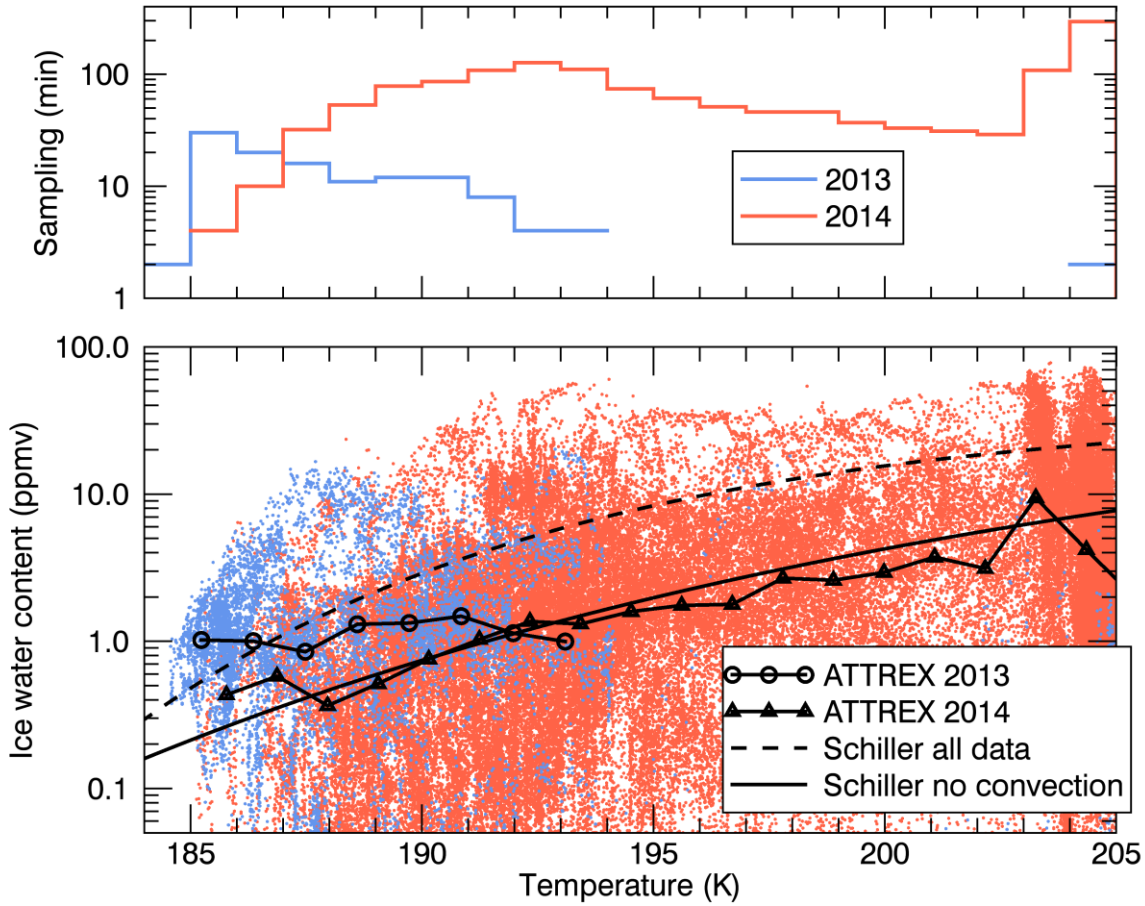
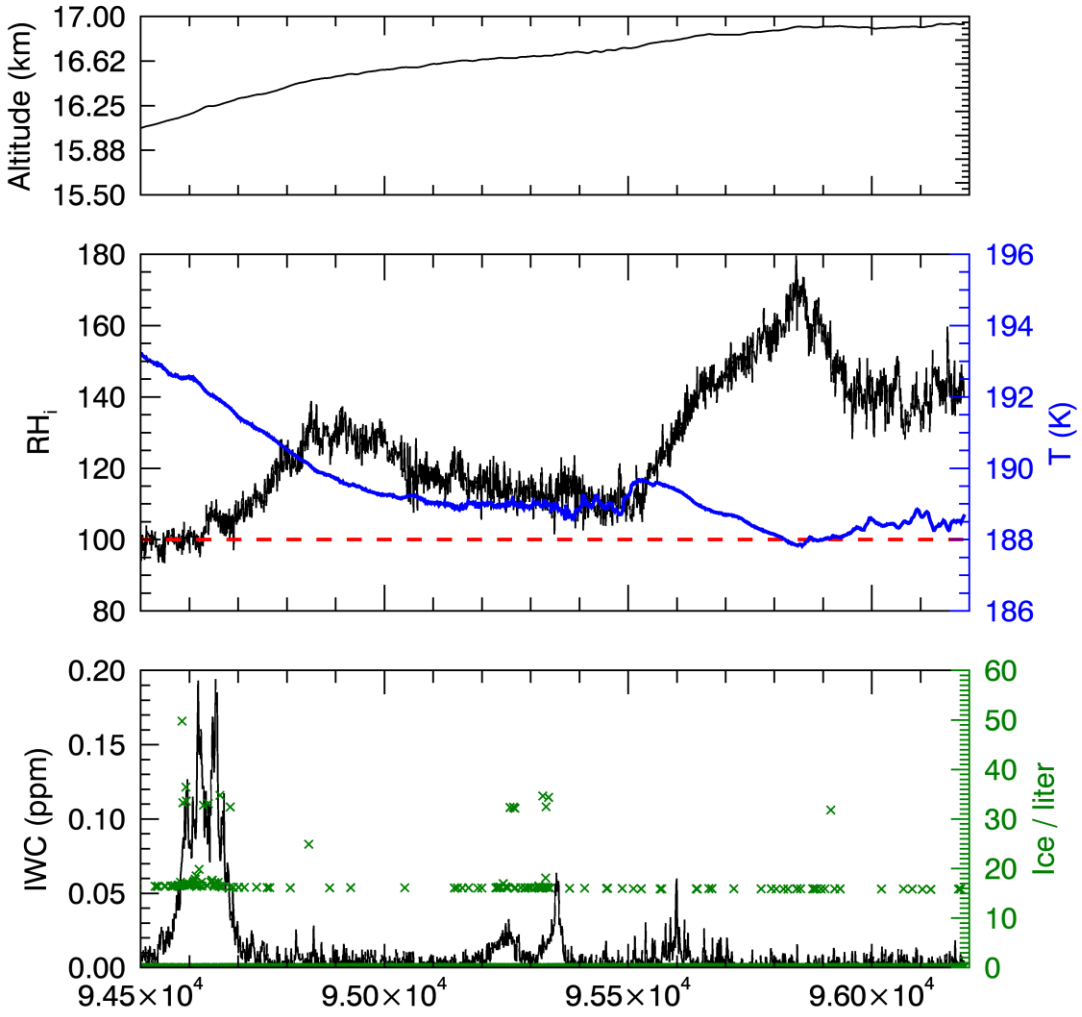


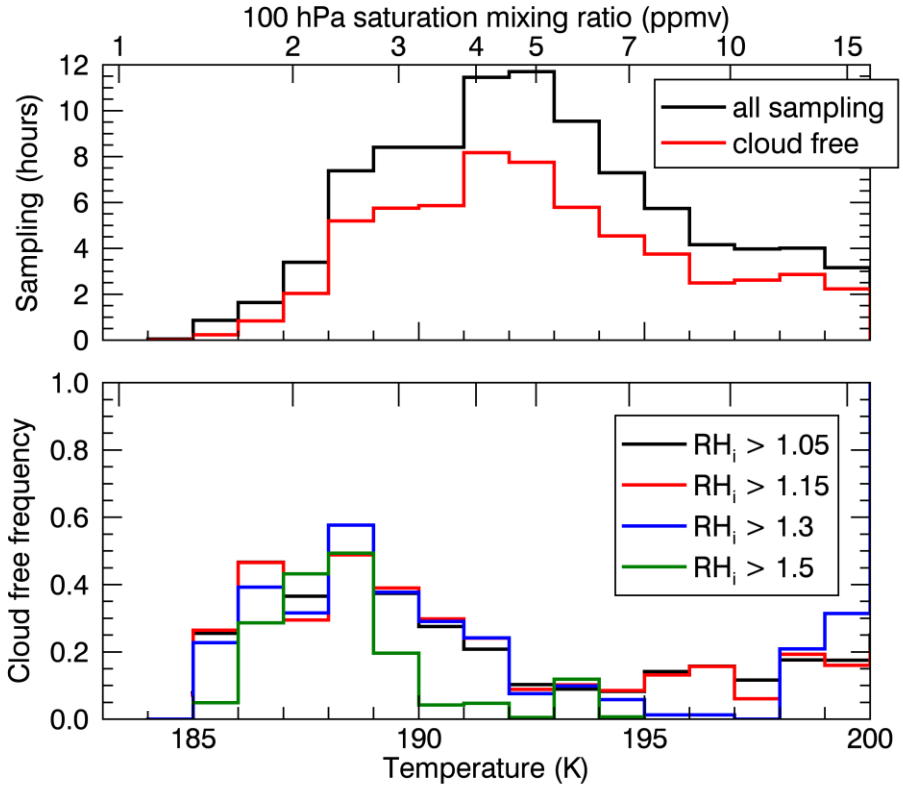
How frequently is supersaturated air free of ice?

Example from Feb. 12, 2014
Near 10N, 150W



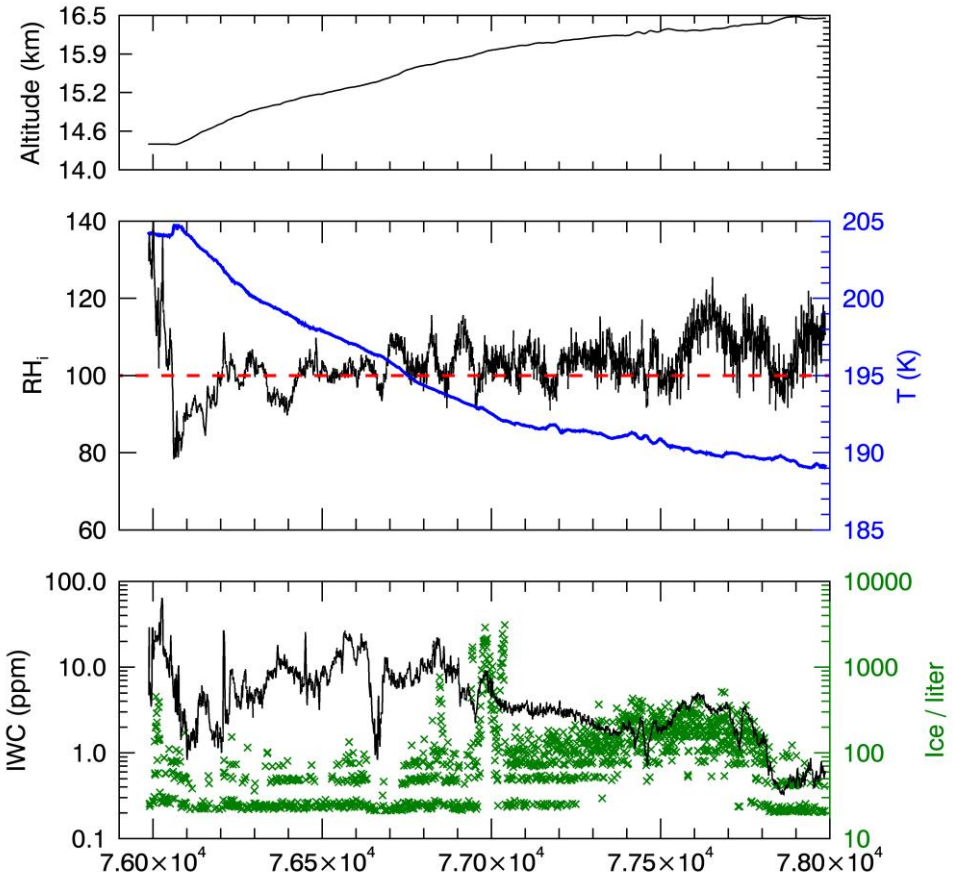
How frequently is supersaturated air free of ice?

Probability of supersaturation occurring in cloud free region increases below 195 K.

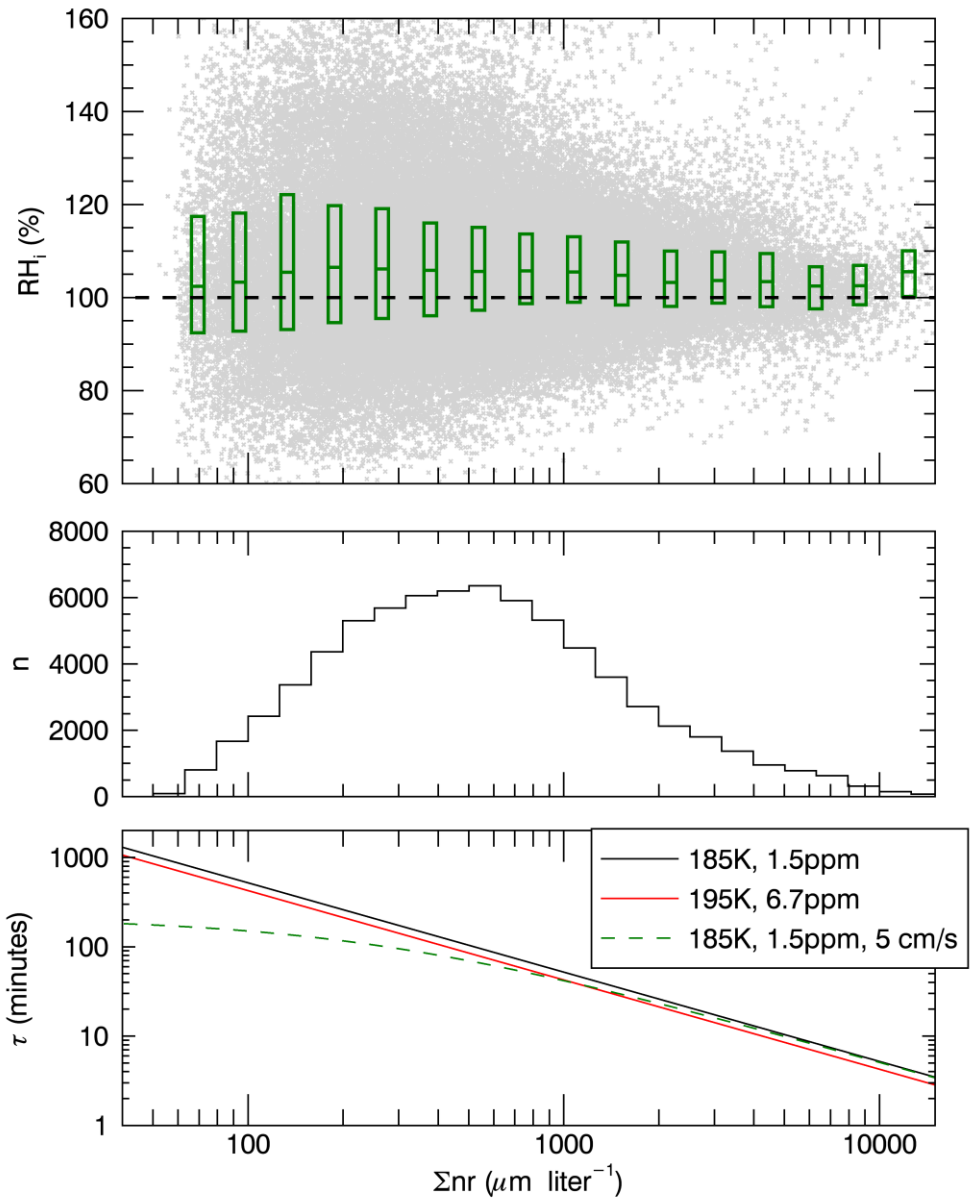


How frequently are clouds supersaturated?

Example from Feb. 16, 2014
Near 13N, 146W

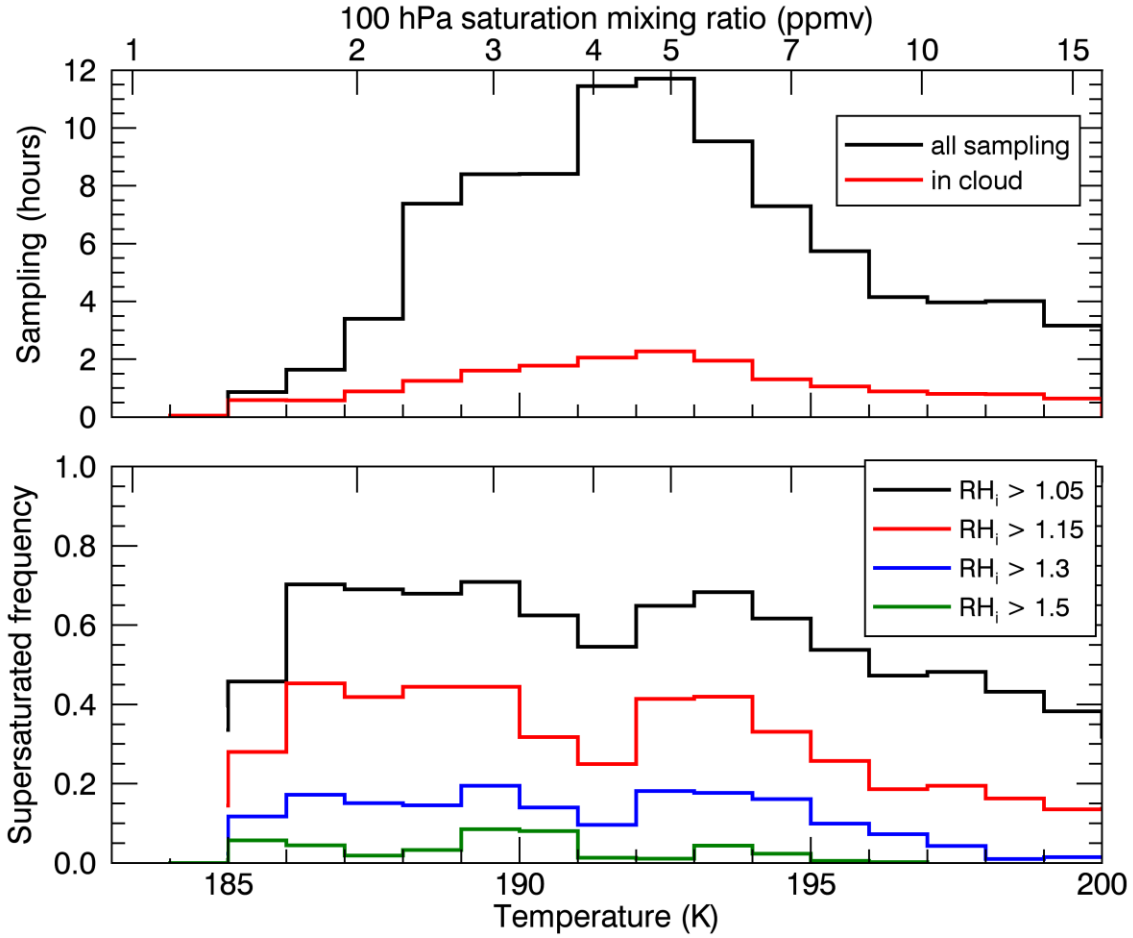


How frequently are clouds supersaturated?

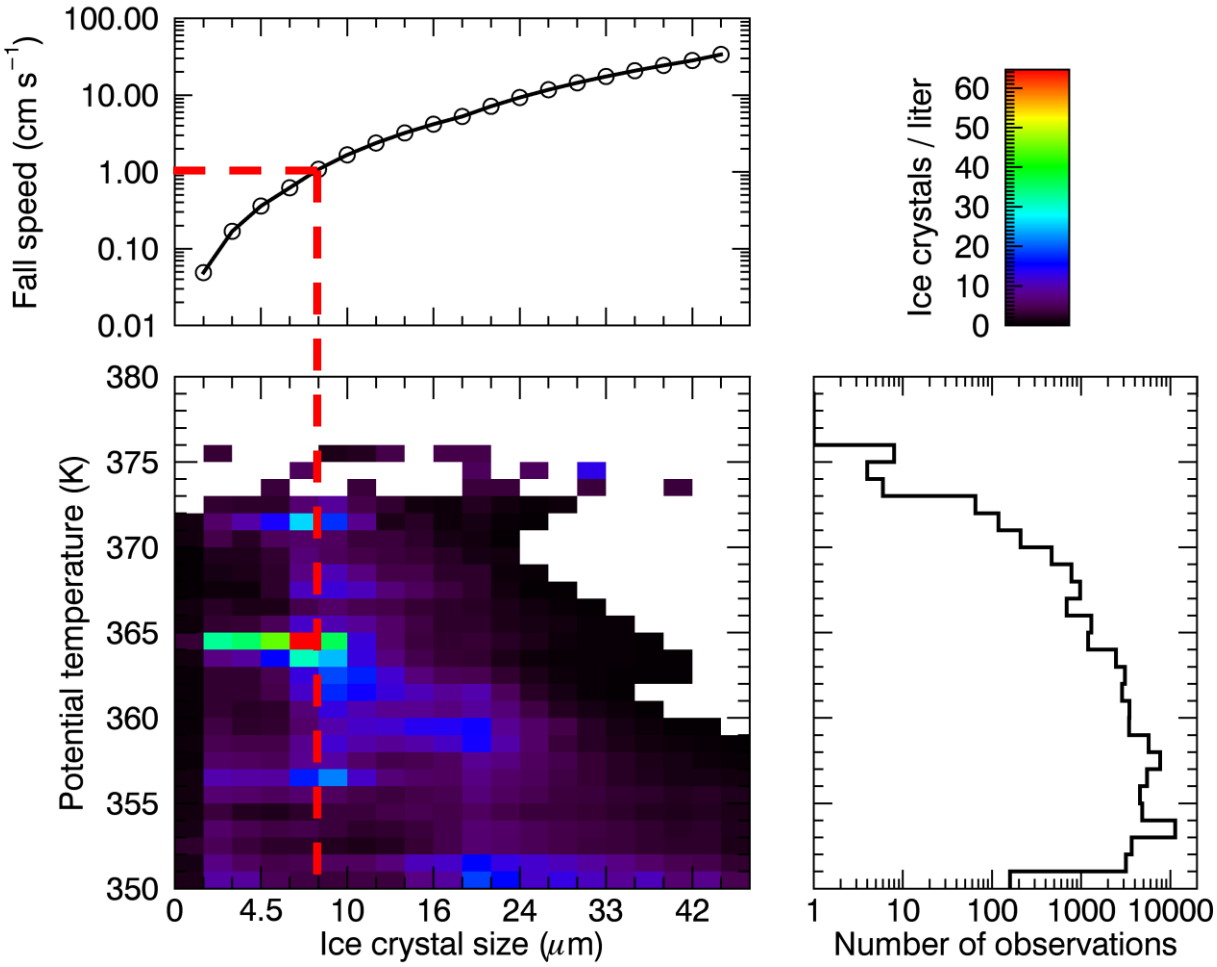


How frequently are clouds supersaturated?

Supersaturation Relaxation time increases with decreasing T.



How efficiently is ice removed?



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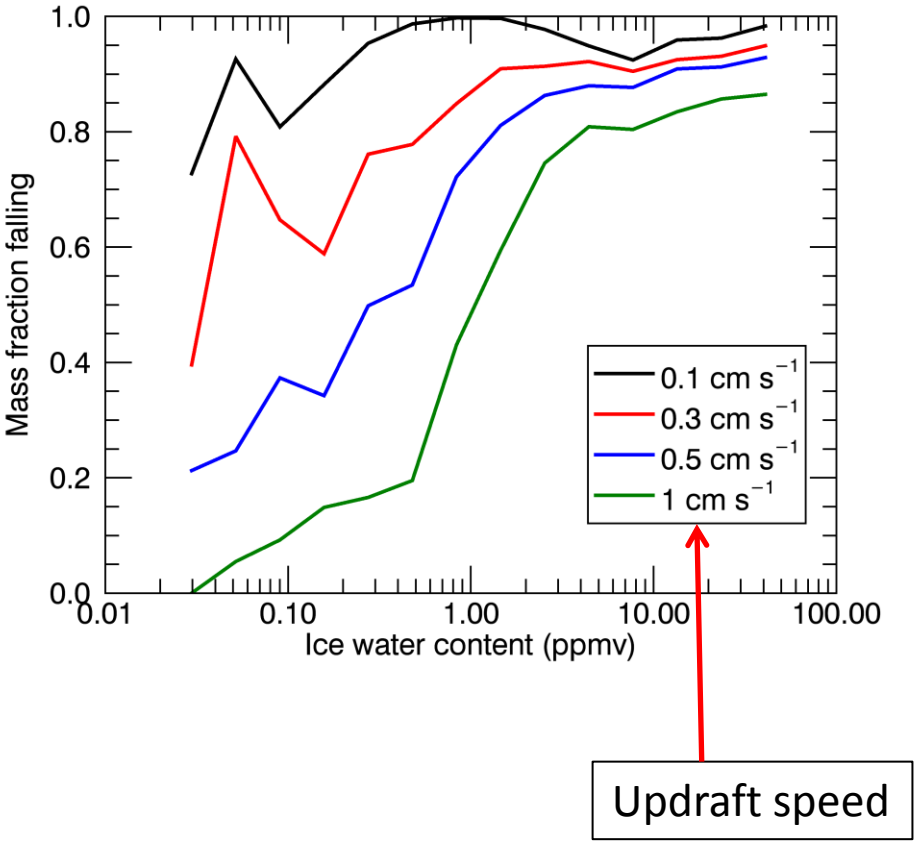

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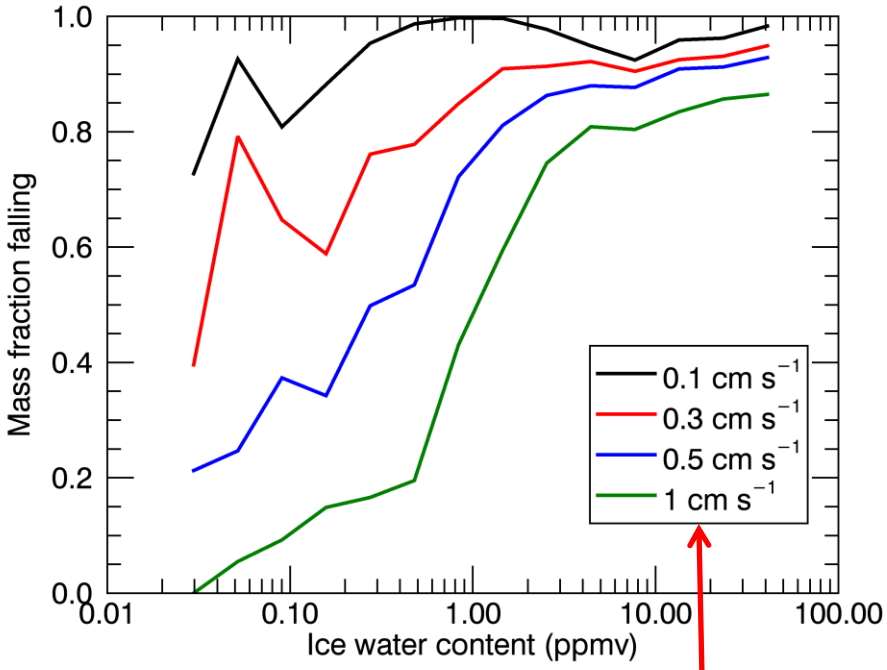
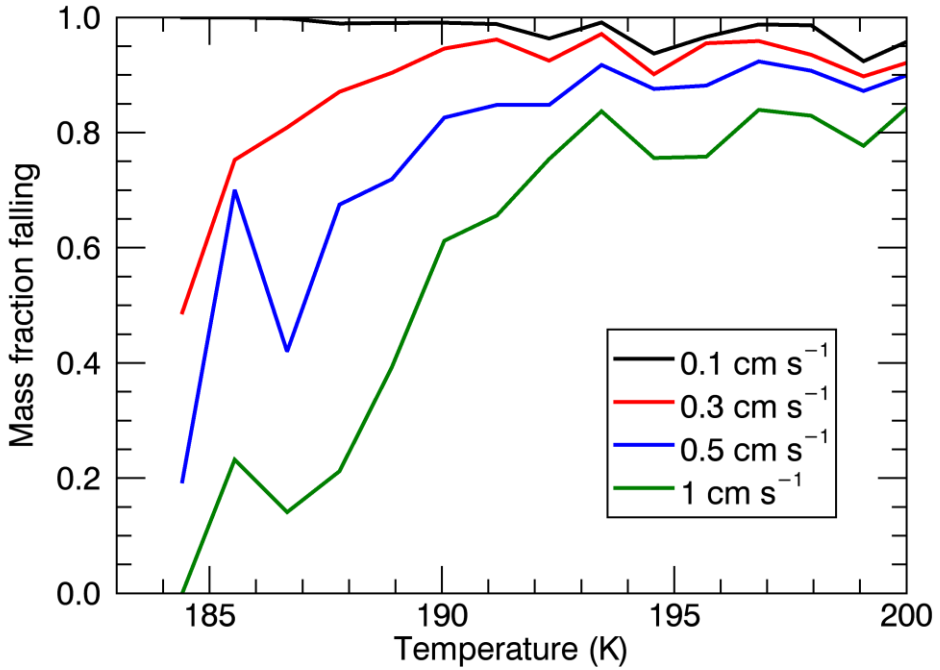


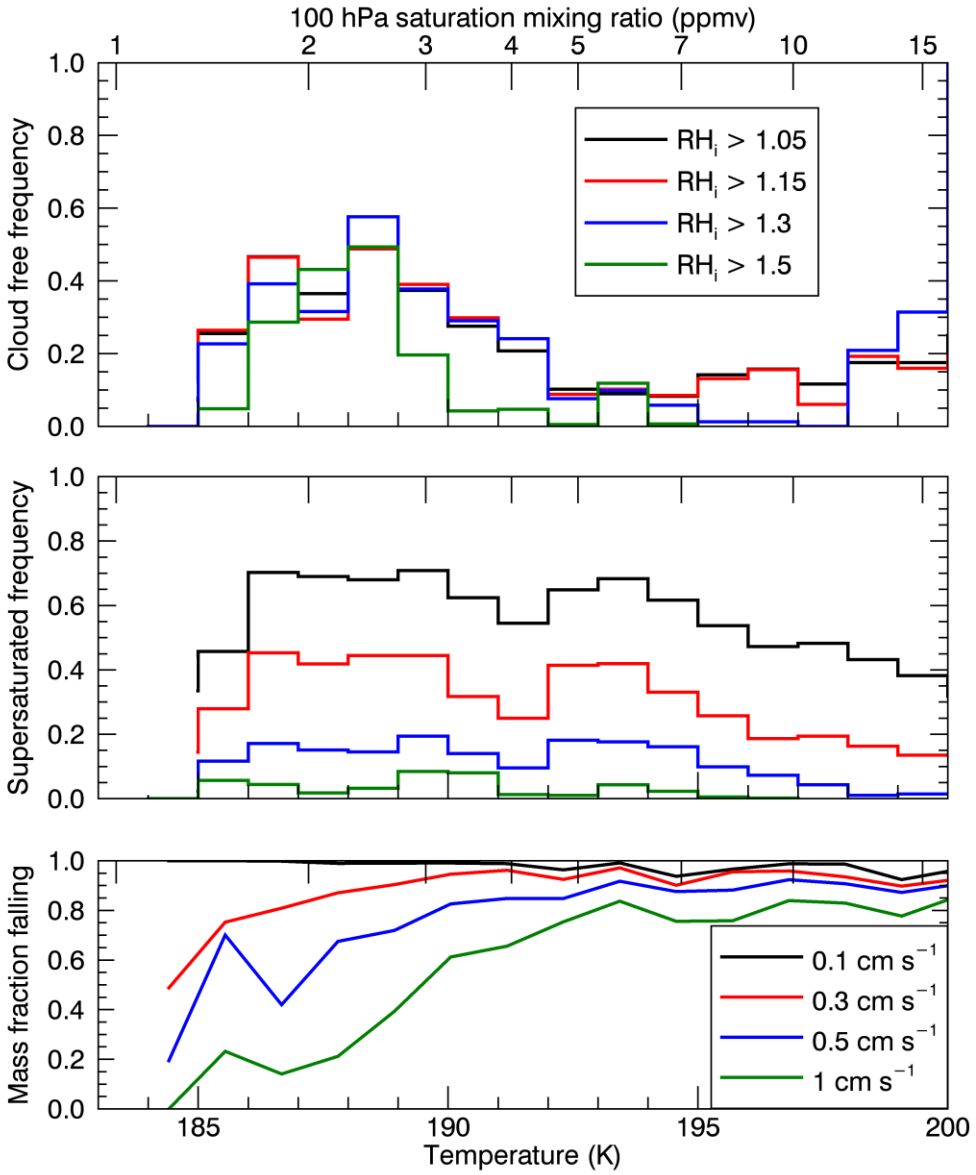


Updraft speed

Nucleation

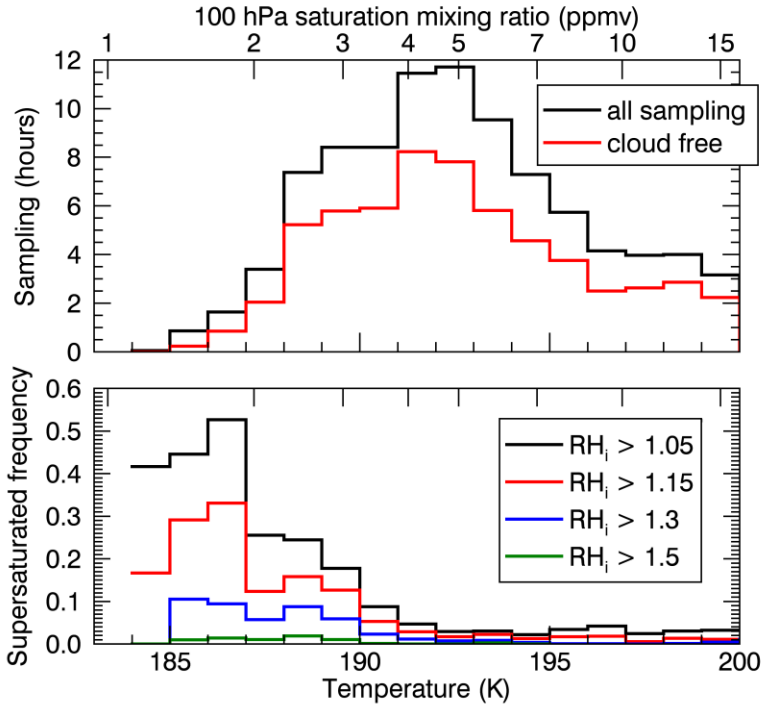
Deposition

Sedimentation



Summary

- IWC is comparable to Schiller et al., suggesting our measurements are somewhat representative of climatology.
- Significant supersaturations observed inside and outside of clouds, in agreement with our expectations. Supersaturated frequencies increase with decreasing T.
- Ice settling efficiency decreases significantly below IWC ~ 1-3 ppm, T ~ 190 – 195 K.
- All three mechanisms suggest that dehydration will be less efficient as temperatures decrease below ~ 195 K.
- More measurements < 185K needed.


100 hPa saturation mixing ratio (ppmv)
1
2
3
4
5
7
10
15
Sampling (hours)
0
2
4
6
8
10
12
all sampling
cloud free
Supersaturated frequency
0.0
0.1
0.2
0.3
0.4
0.5
0.6
RHi > 1.05
RHi > 1.15
RHi > 1.3
RHi > 1.5
185
190
195
200
Temperature (K)