Cloud properties of arctic boundary-layer stratus: impacts on surface radiation

Greg McFarquhar and Gong Zhang

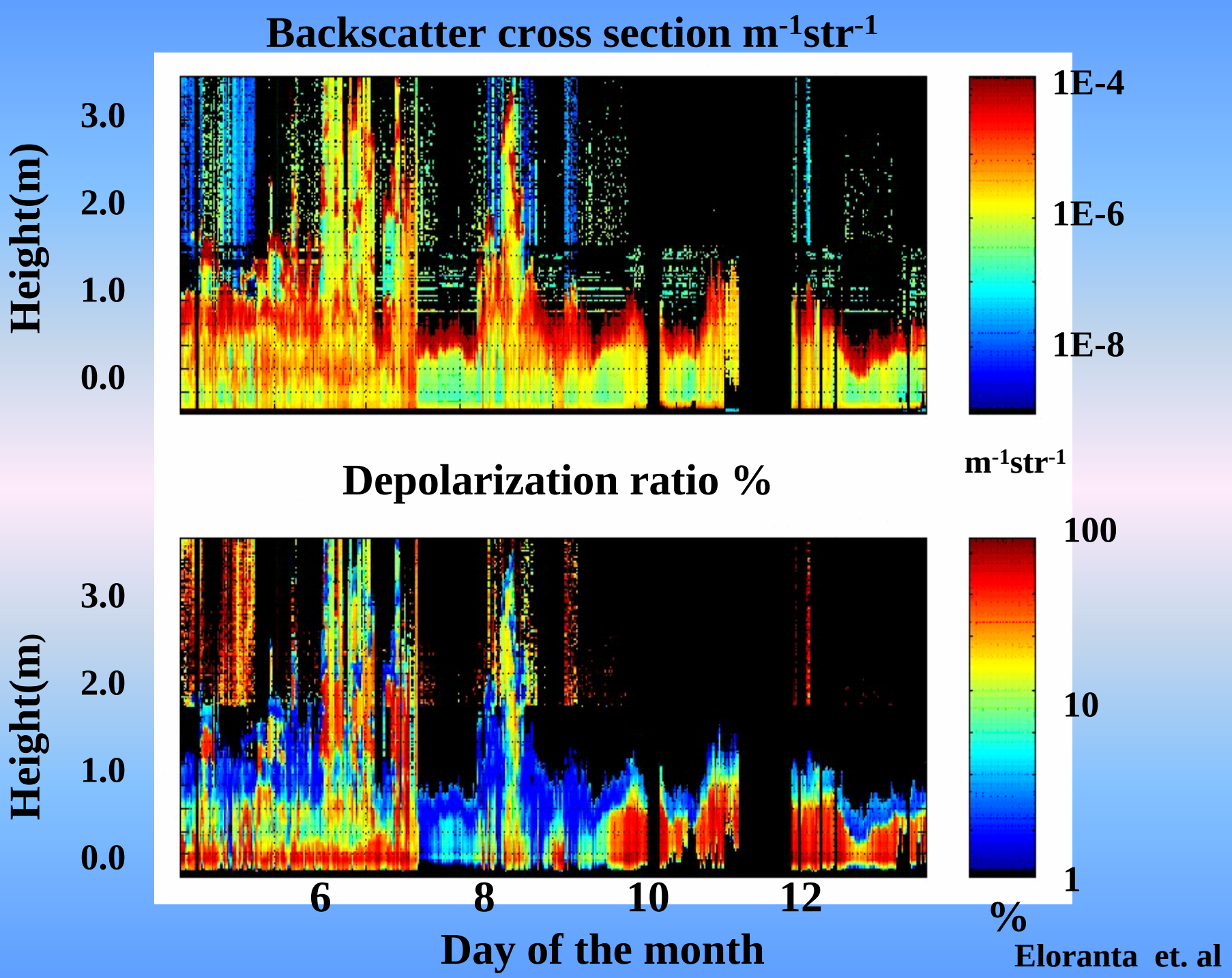
University of Illinois at Urbana-Champaign

Cloud Properties Working Group:

Mixed-Phase Breakout 12 Nov. 2008

Motivation

- **Examine impact of mixed-phase stratus observed during M-PACE on surface LW radiance by determining:**
  - **whether LW surface radiance calculated using the LBLRTM initialized with M-PACE cloud observations is consistent with AERI observations**
  - **sensitivity of LW surface radiance to cloud microphysical and macrophysical properties**



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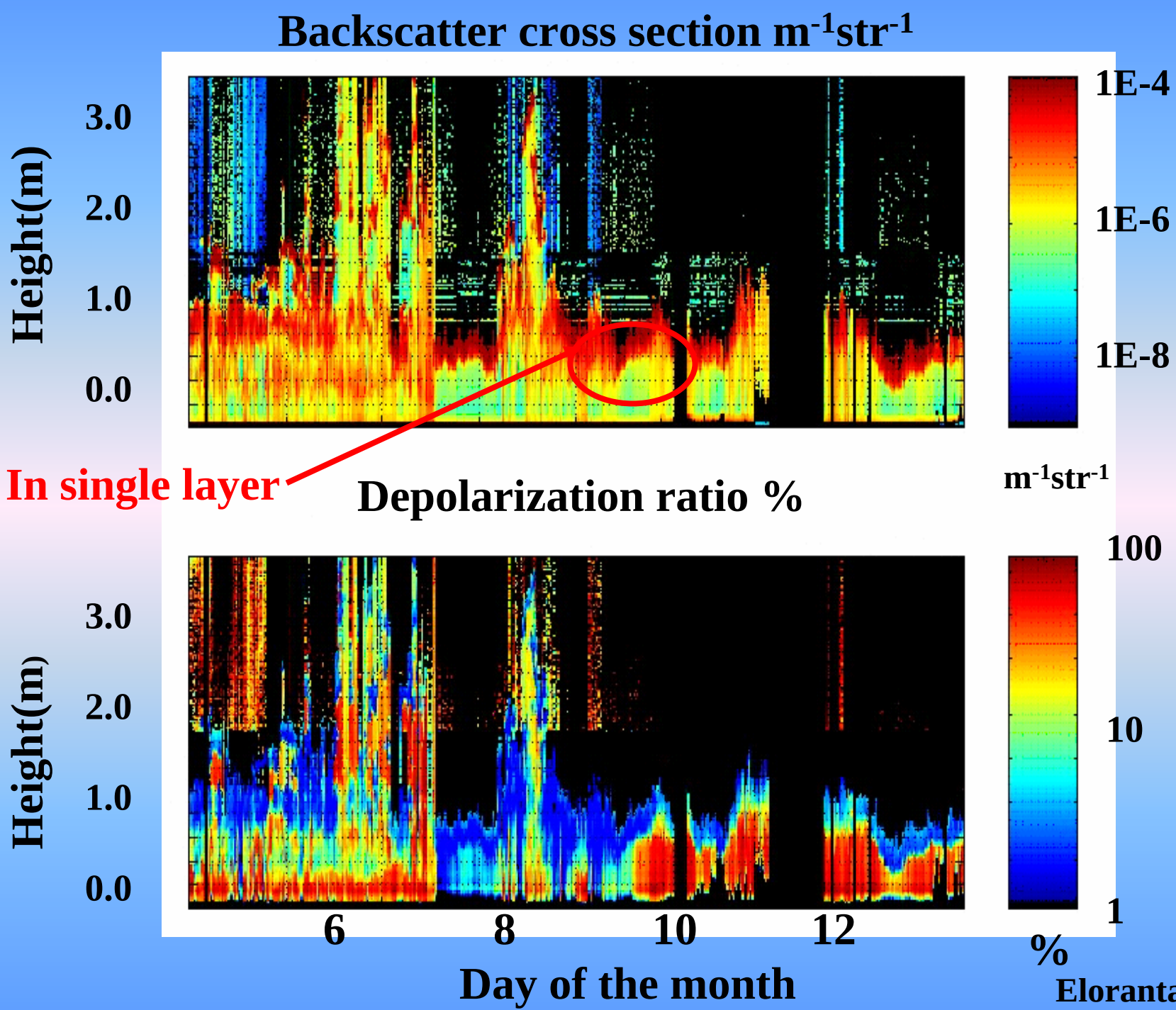
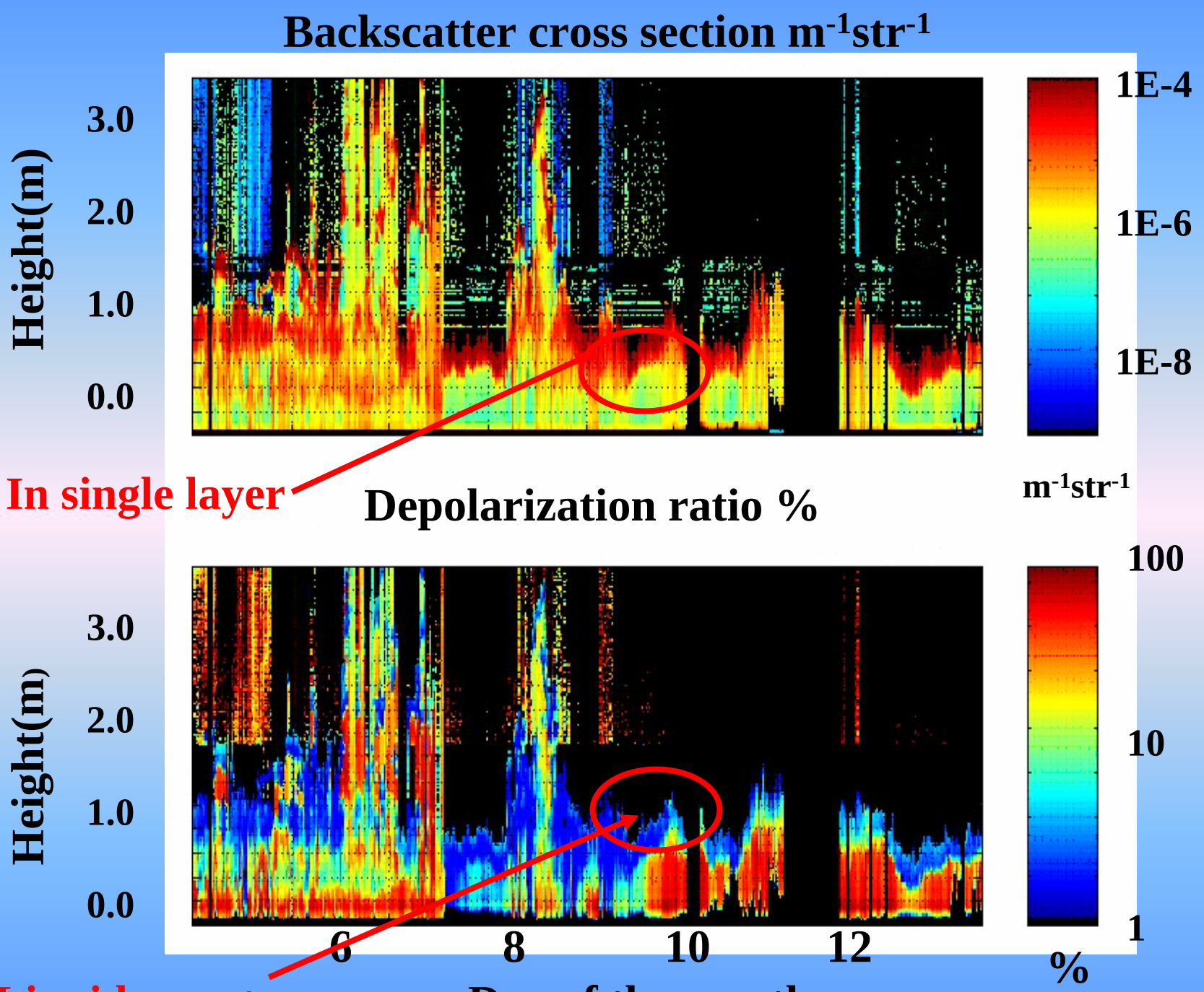


Eloranta et. al


Backscatter cross section m-1str-1
Height(m)
3.0
2.0
1.0
0.0
1E-4
1E-6
1E-8
m-1str-1
In single layer
Depolarization ratio %
100
10
1
%
6
8
10
12
Day of the month
Liquid near top
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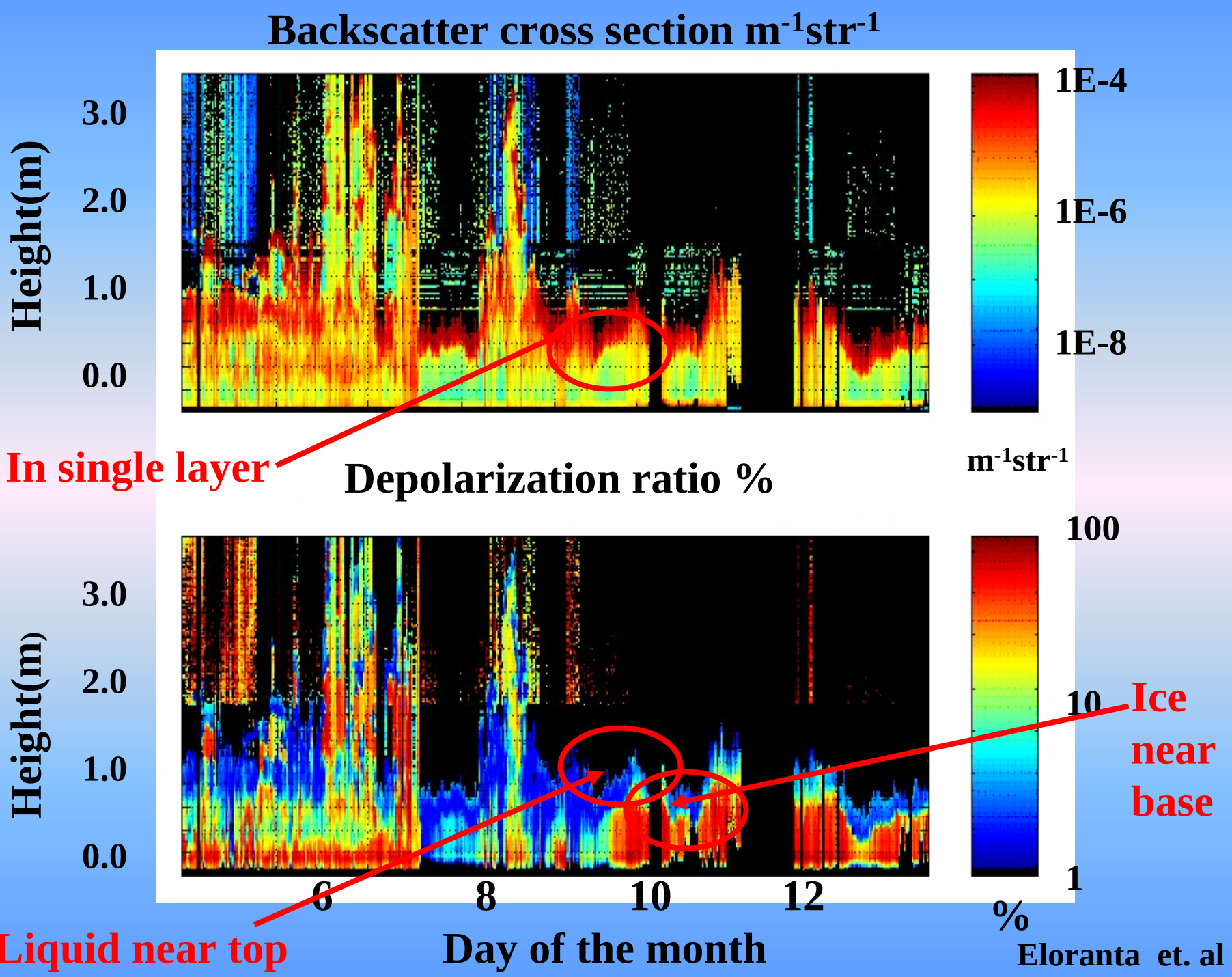
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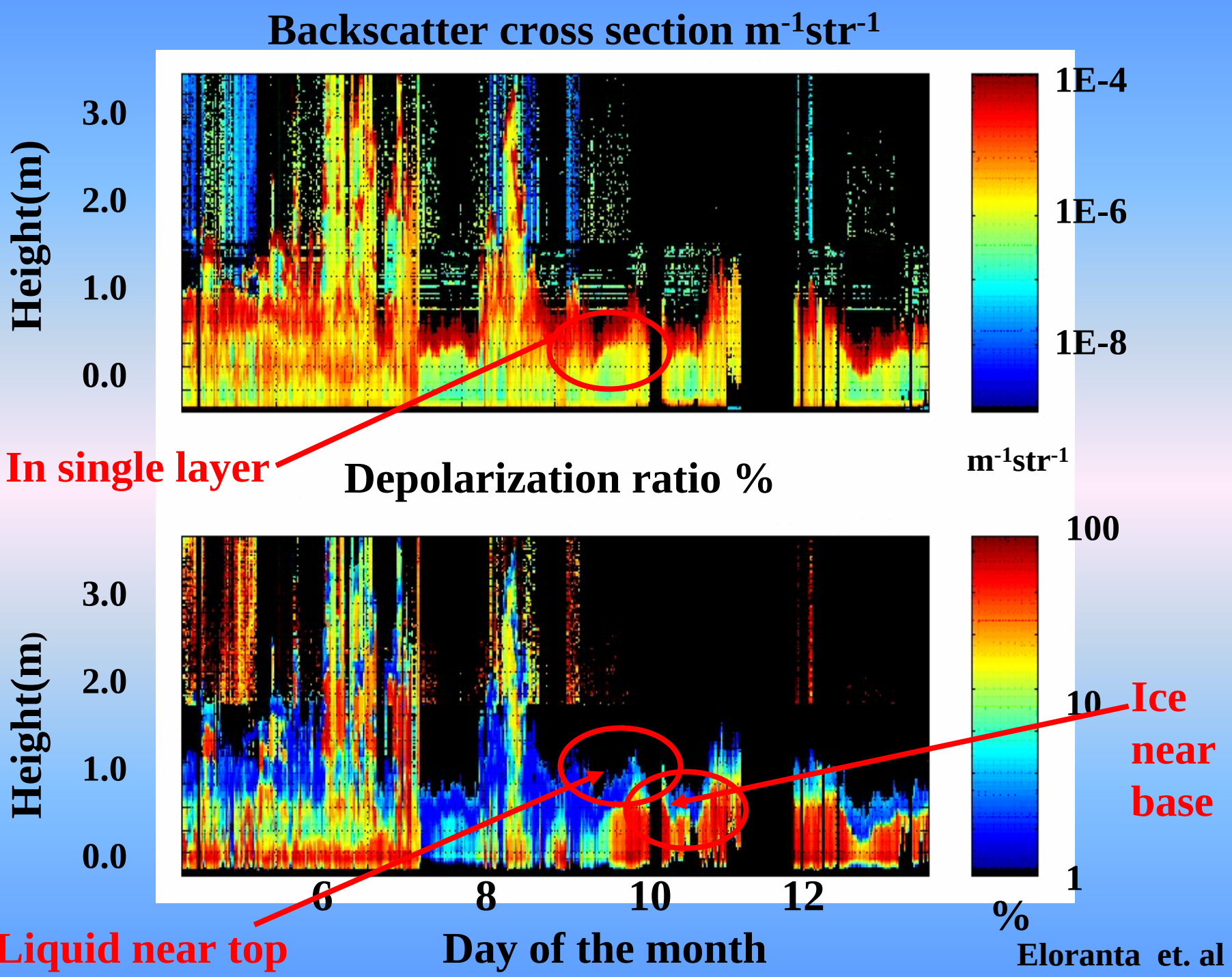
Eloranta et. al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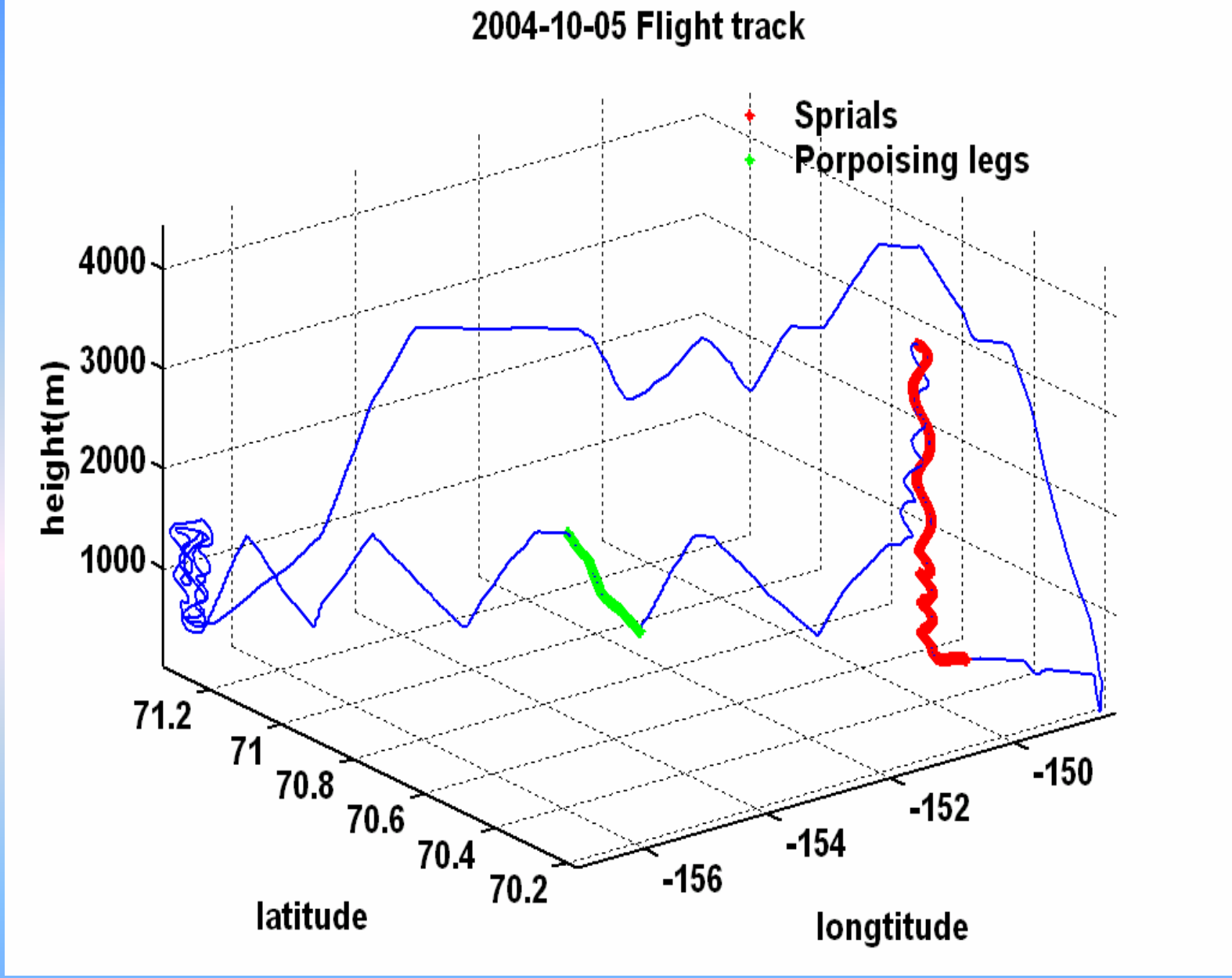
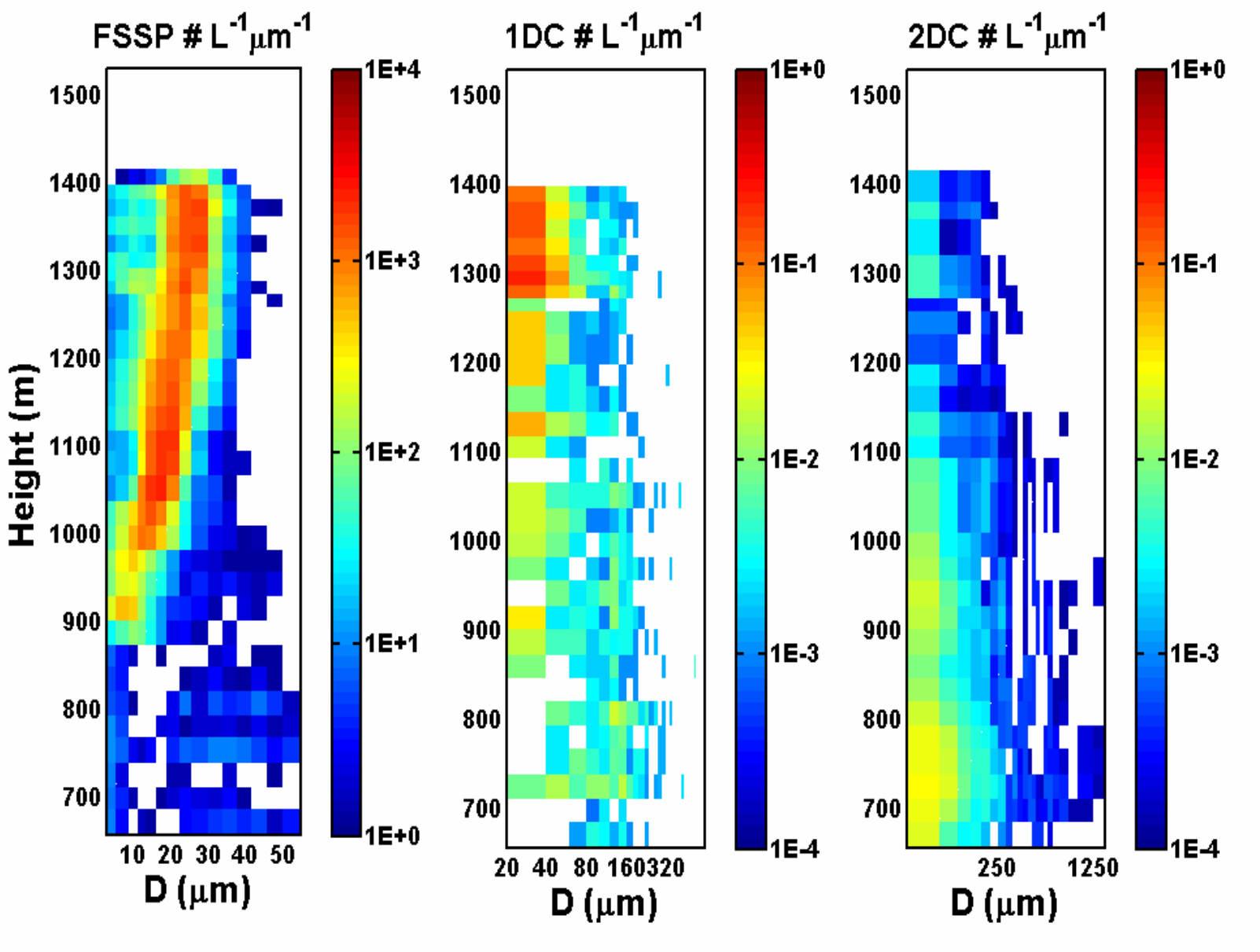
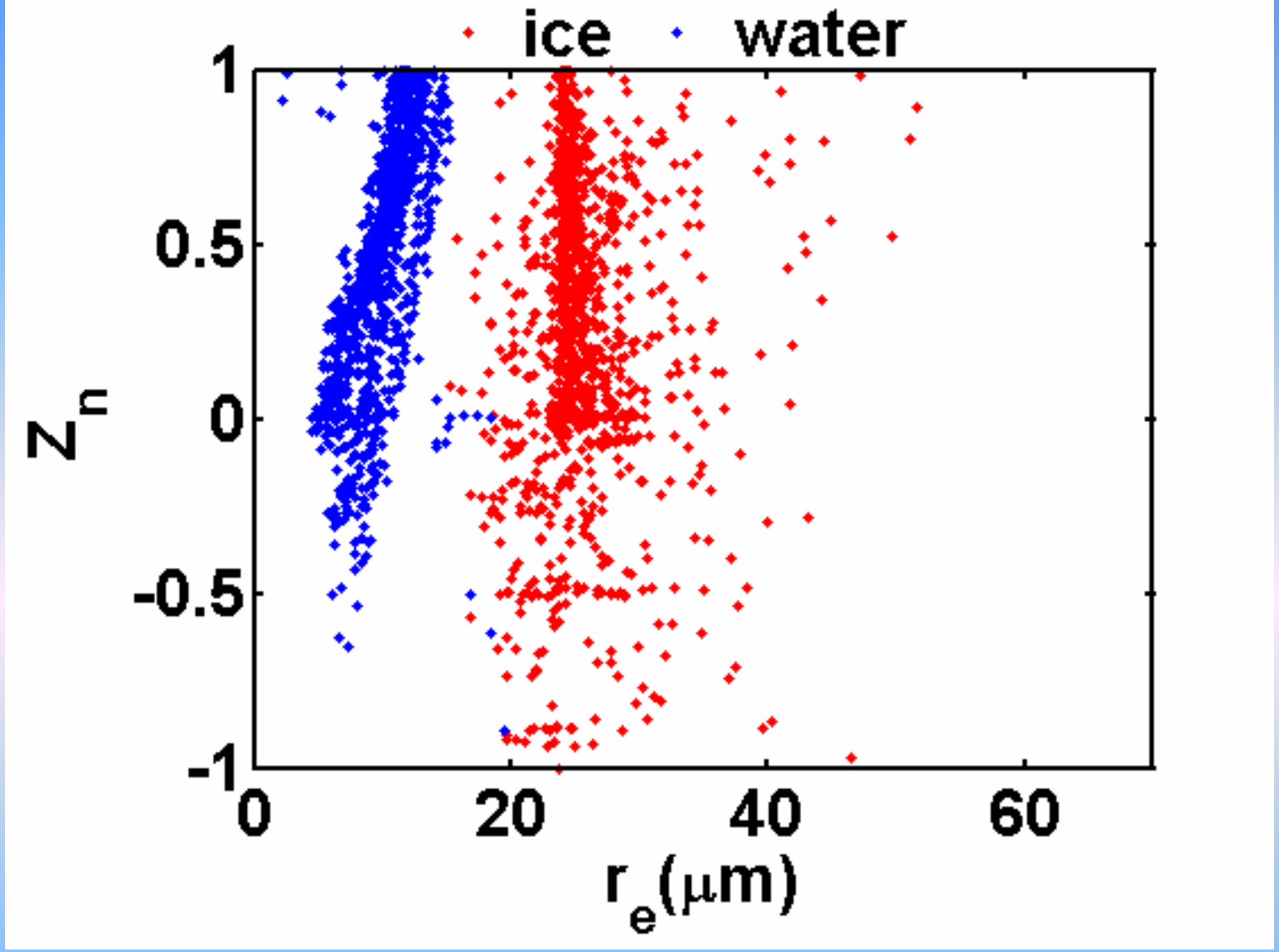


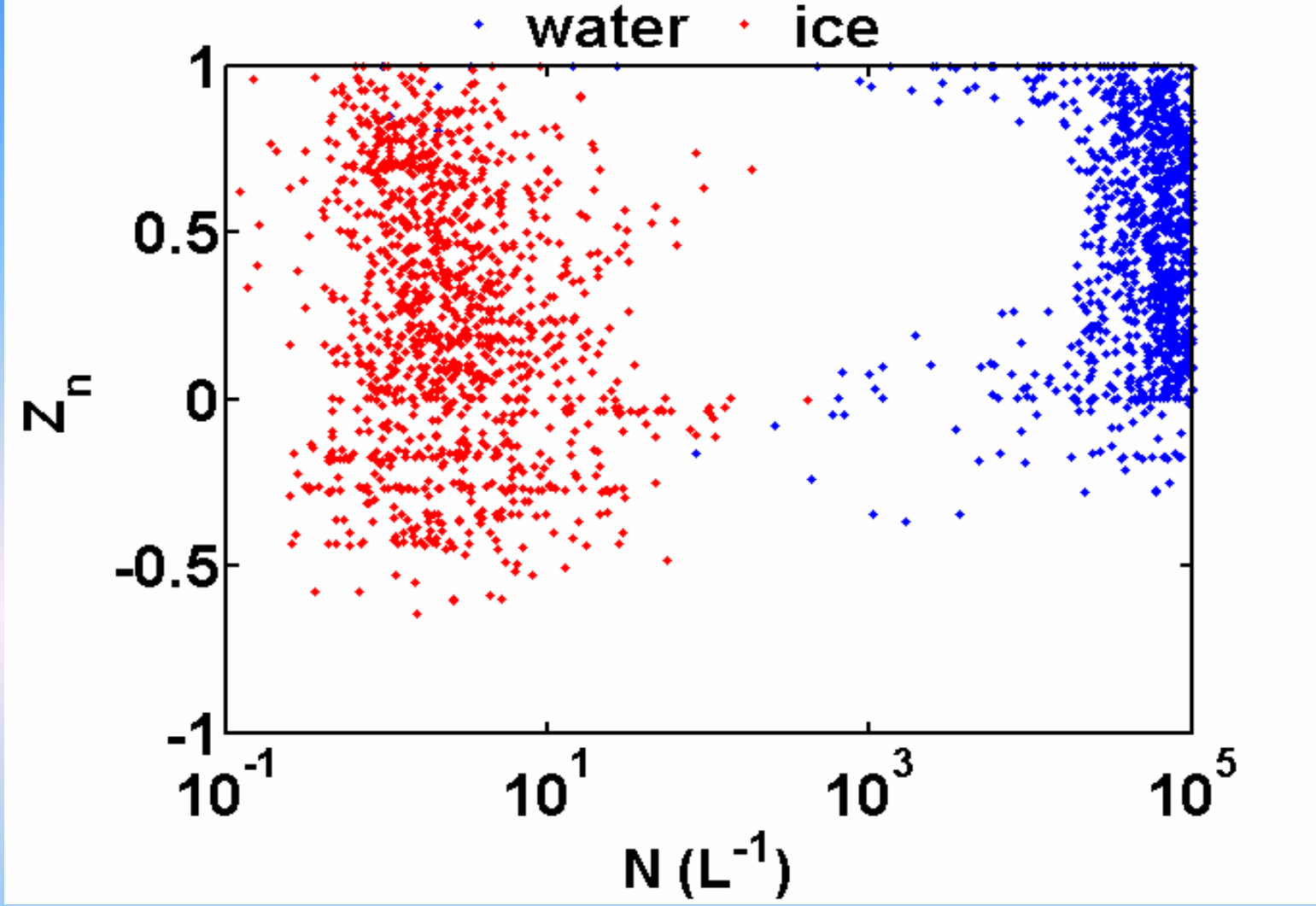
Input to LBLRTM come from aircraft data collected over AERI at Oliktok Pt



Data from multiple probes on Citation give size & phase distributions covering all particle sizes

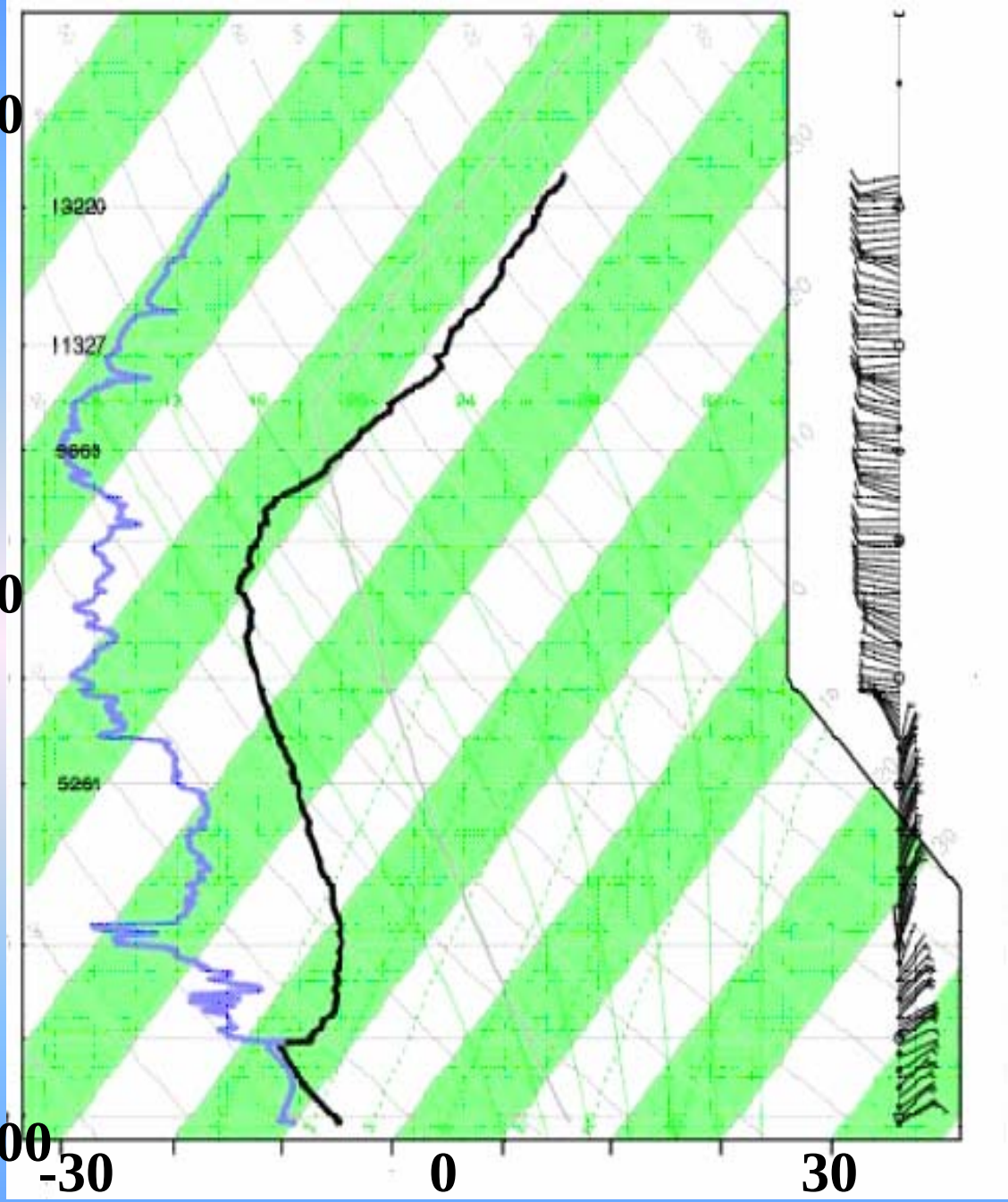


From size distributions, $r_{ei}(z)$, $r_{ew}(z)$ calculated and input to LBLRTM



$N_i(z)$ and $N_w(z)$ also calculated and input to LBLRTM

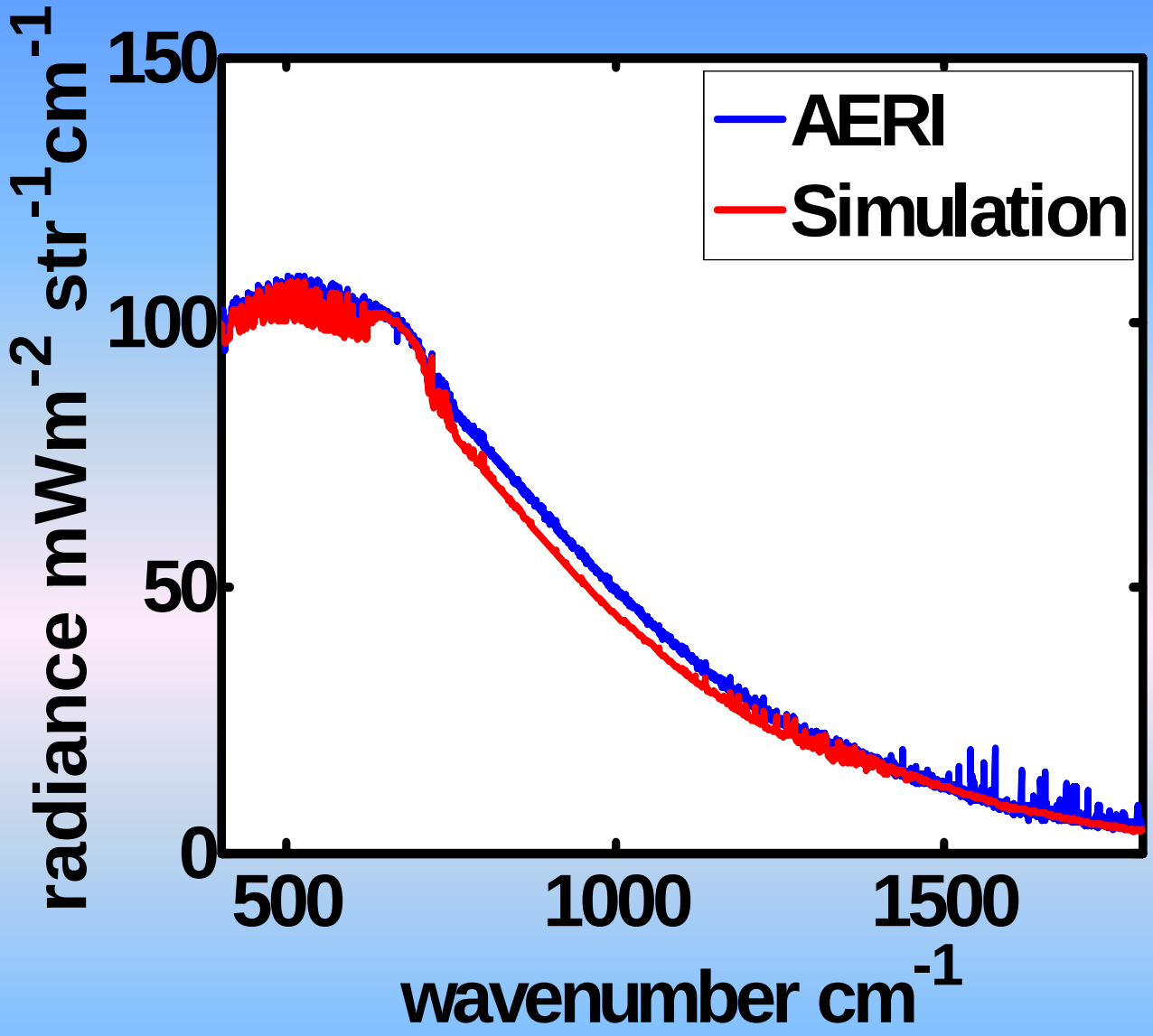
NOTE: Crystals with D < 50 μm not included in N_i

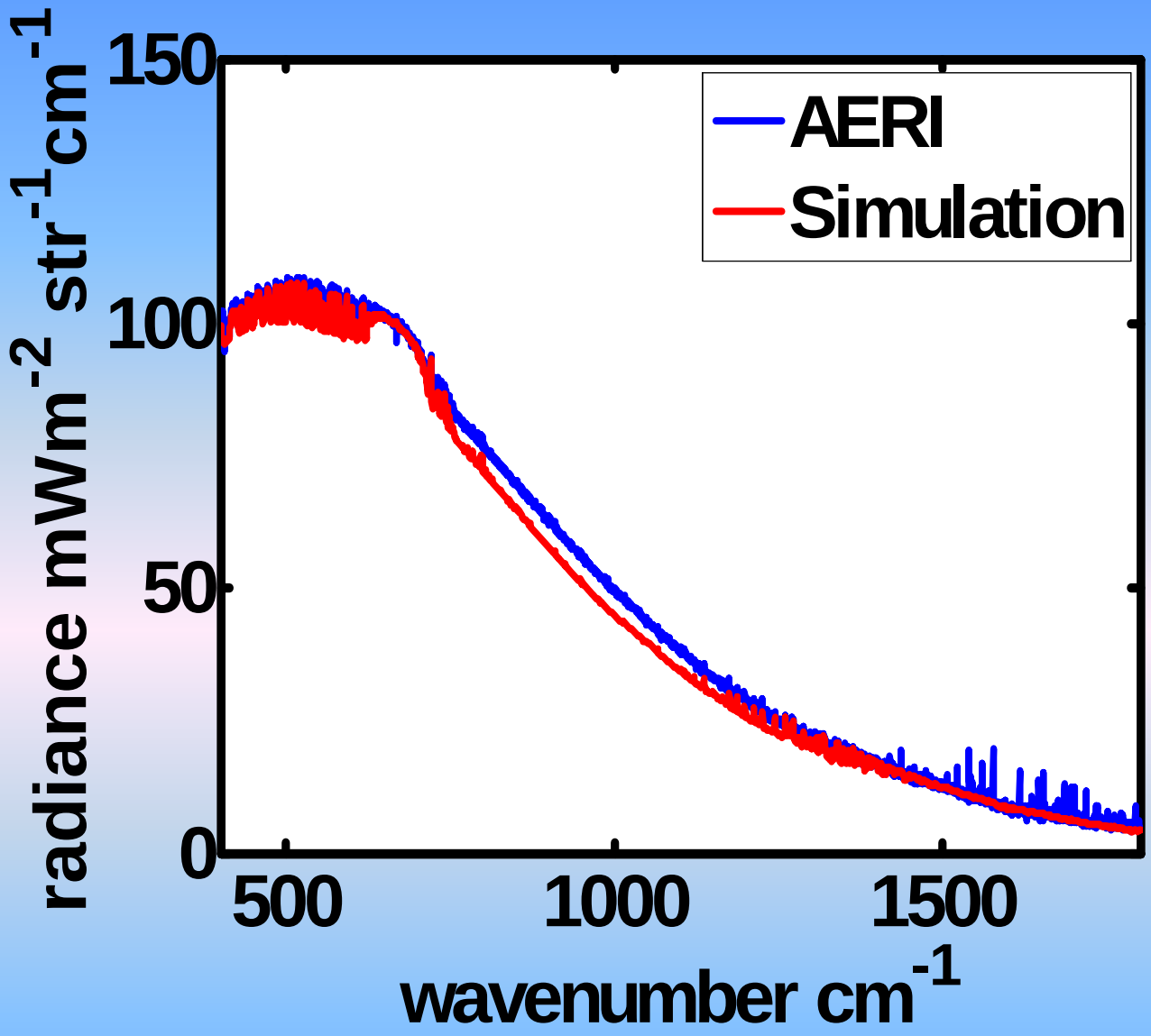


Soundings at Oliktok give T(z) and $T_d(z)$

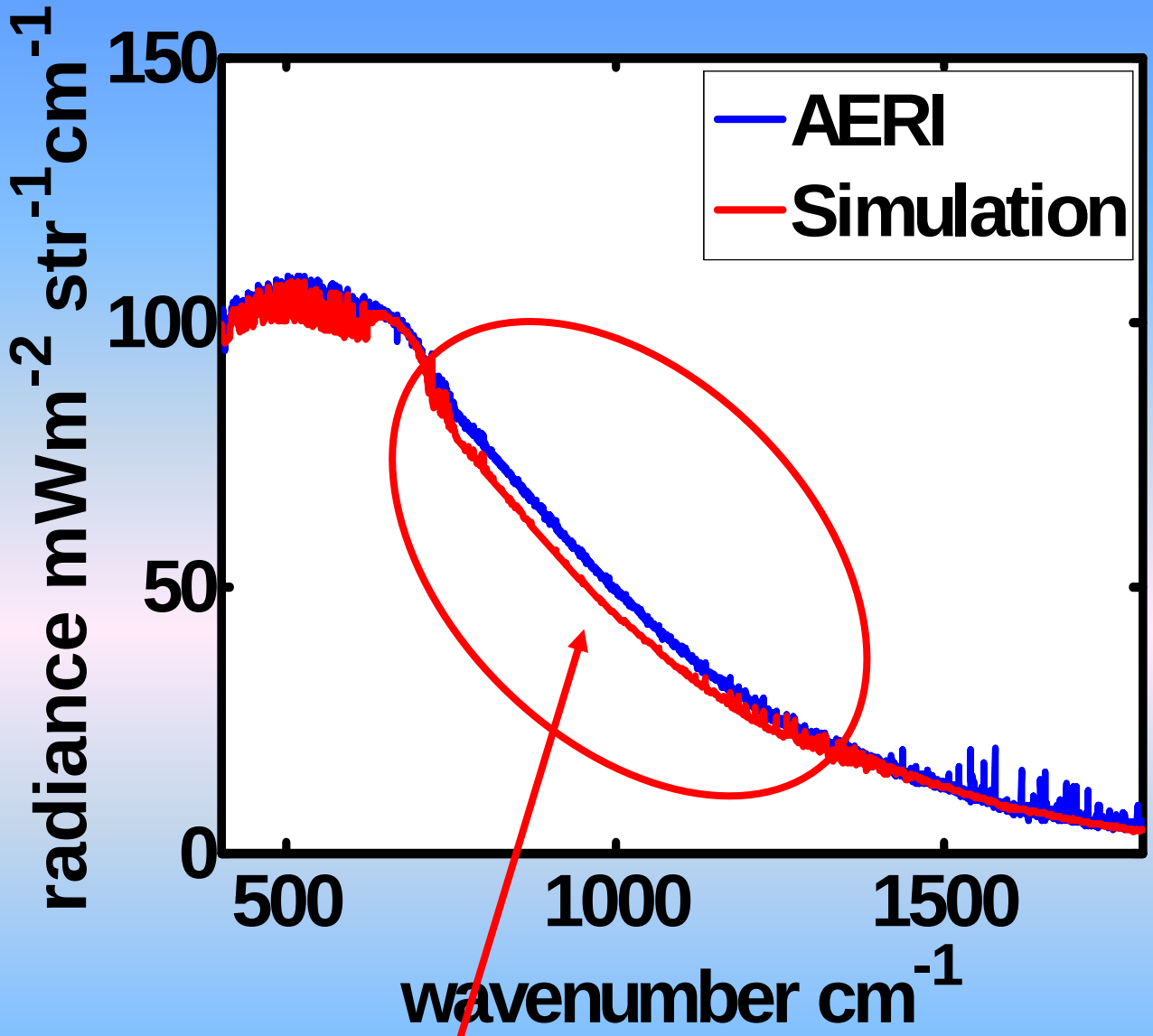
Inputs required by LBLRTM

Inputs	Source
$T(z)$, $T_d(z)$	Closest sounding in time released at Oliktok
Aerosol number concentration	Use climatological averages
Surface albedo	Assumed as new snow covered ground (emissivity 0.985)
N_i and N_w	Derived from in-situ data
r_{ei} and r_{ew}	Derived from in-situ data

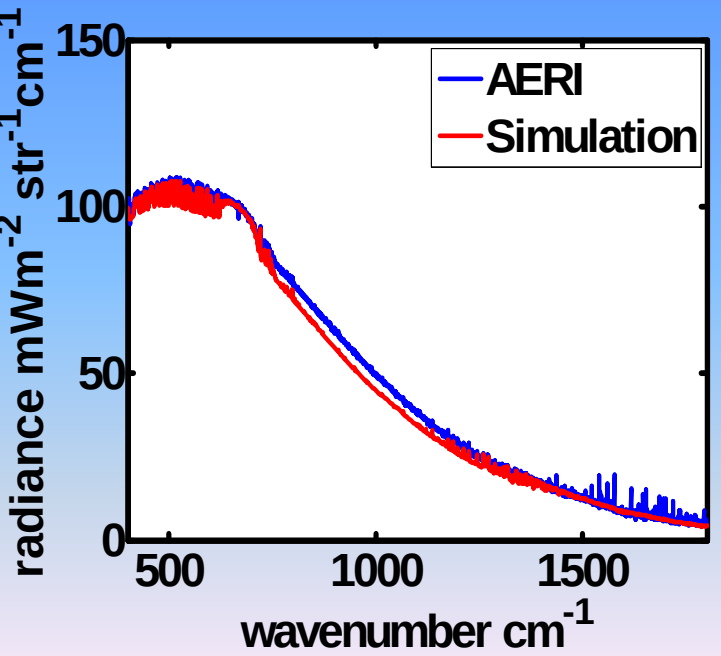

radiance mWm-2 str-1cm-1
150
100
50
0
500
1000
1500
wavenumber cm-1
AERI
Simulation

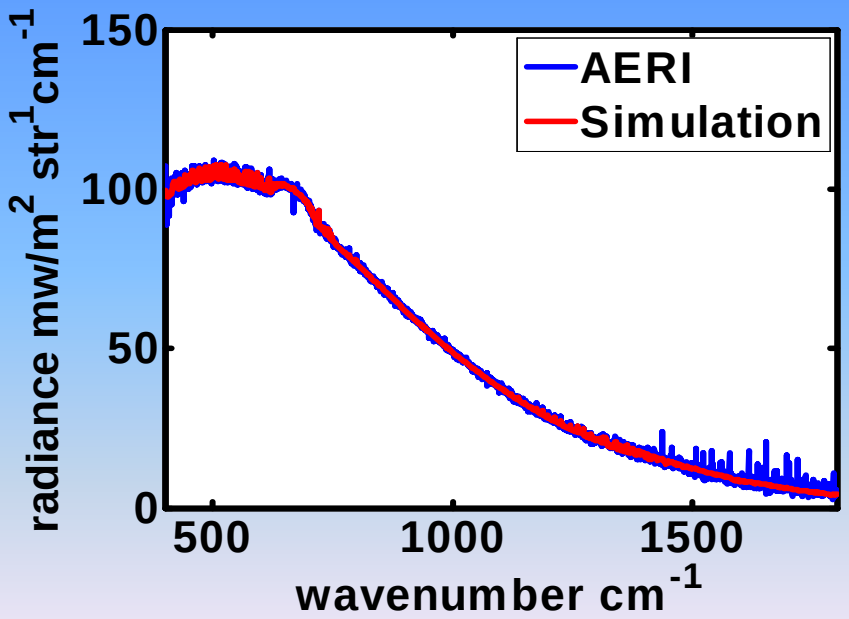


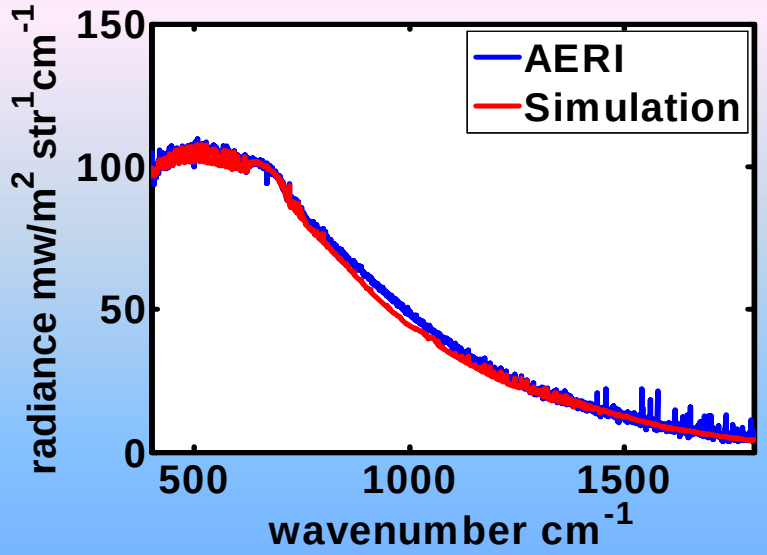
Simulated and observed radiance differ by 3.1 W m^{-2} str^{-1} on 10 Oct. 2004, less than 5% of total radiance

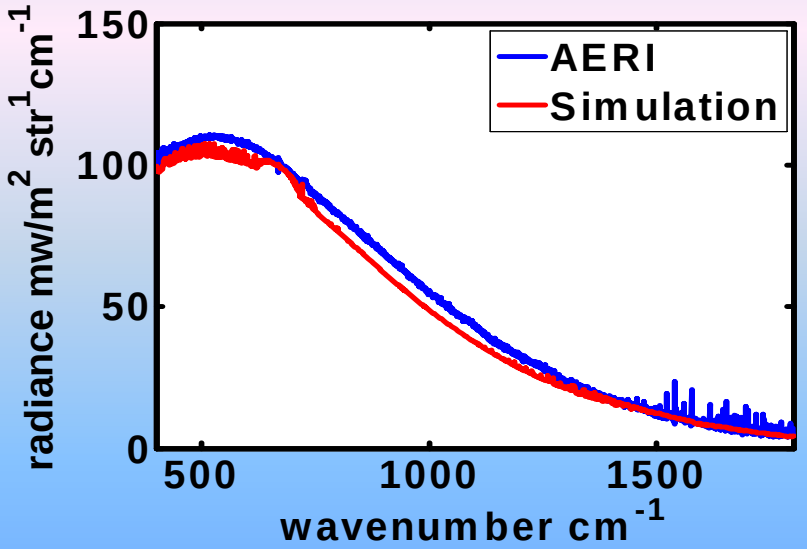


Difference mainly from 700 to 1200 cm^{-1}

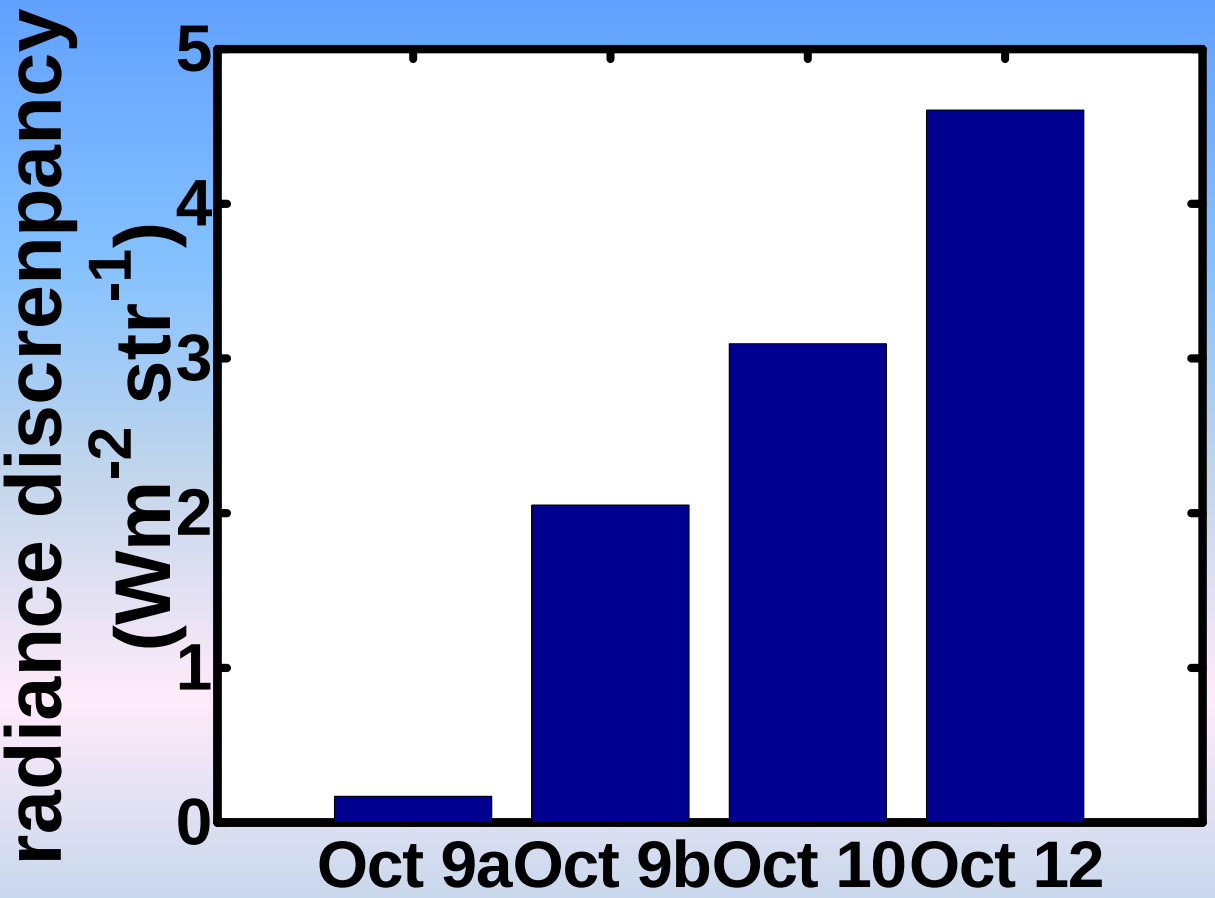






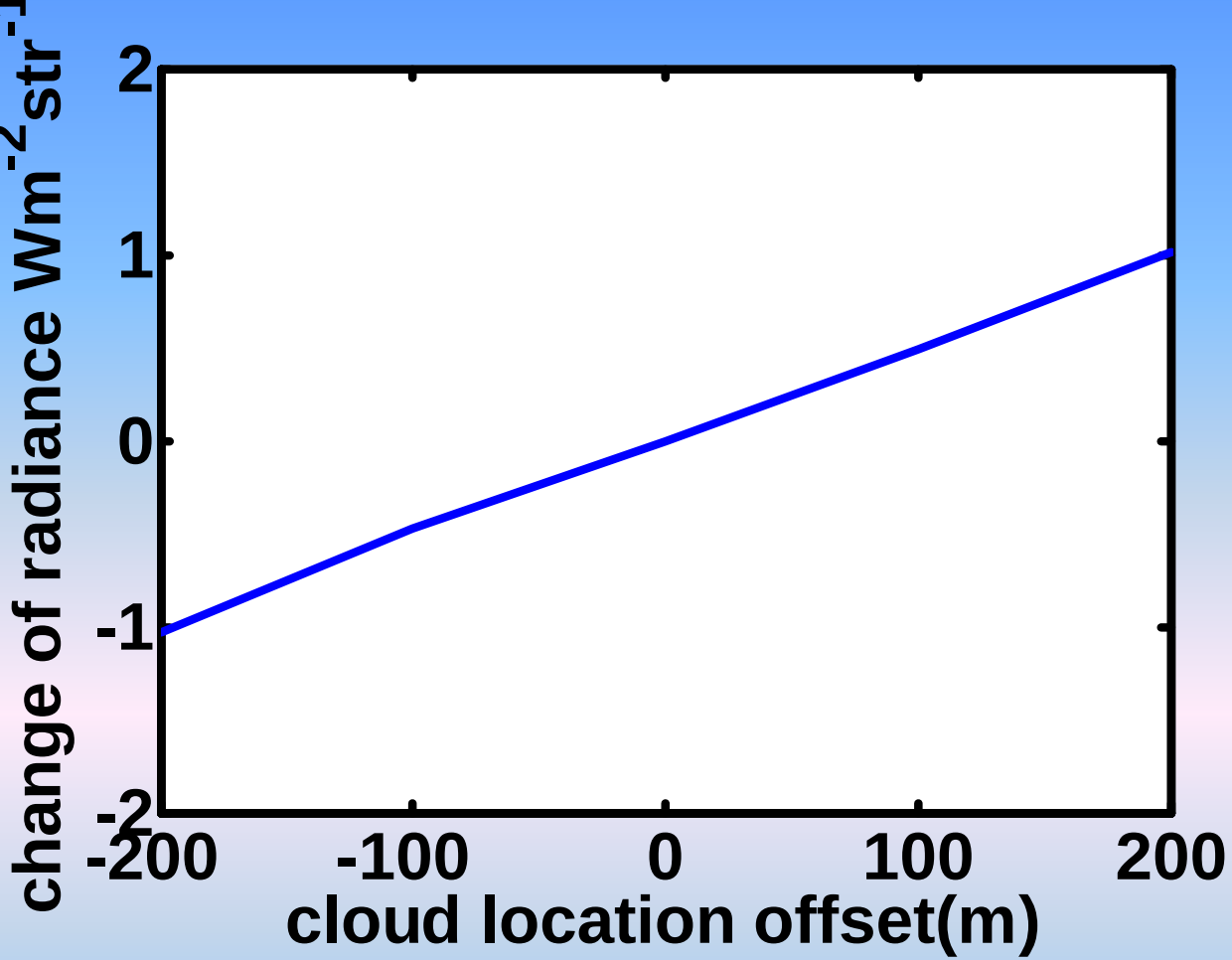


Other dates (Oct. 9, Oct. 12a and b) show similar agreement between observed & simulated radiance

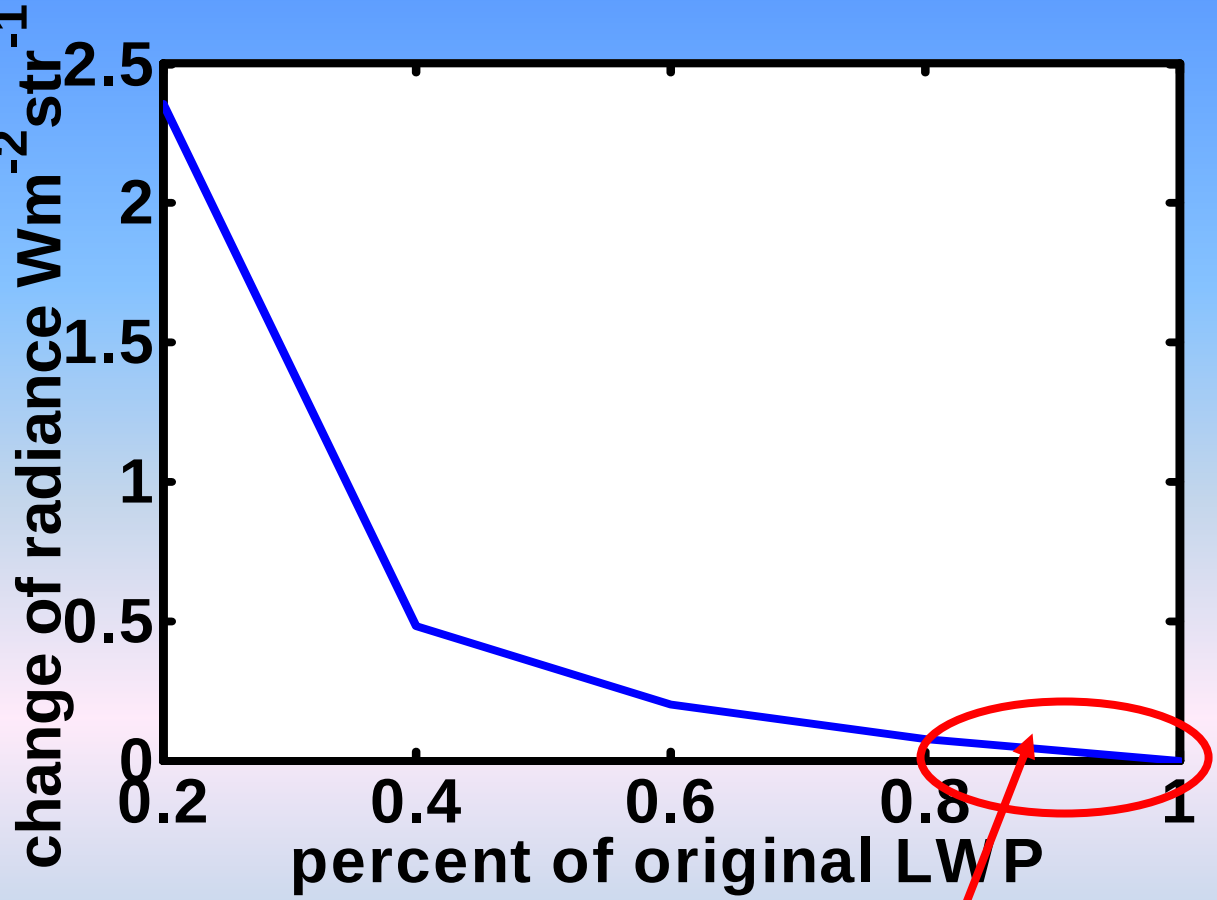


Simulated radiance consistently biased low compared to observations

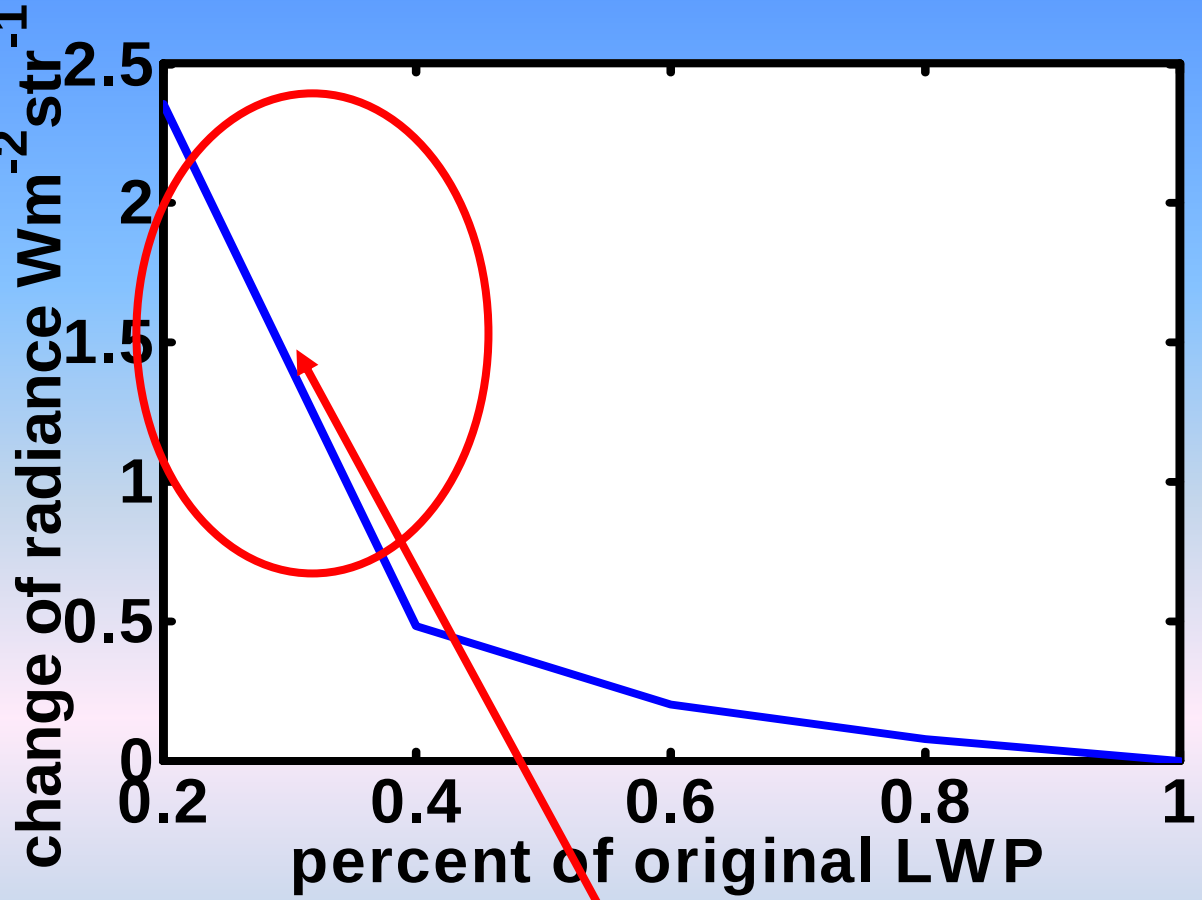
Citation did not reach cloud bottom on Oct. 12, explaining larger difference



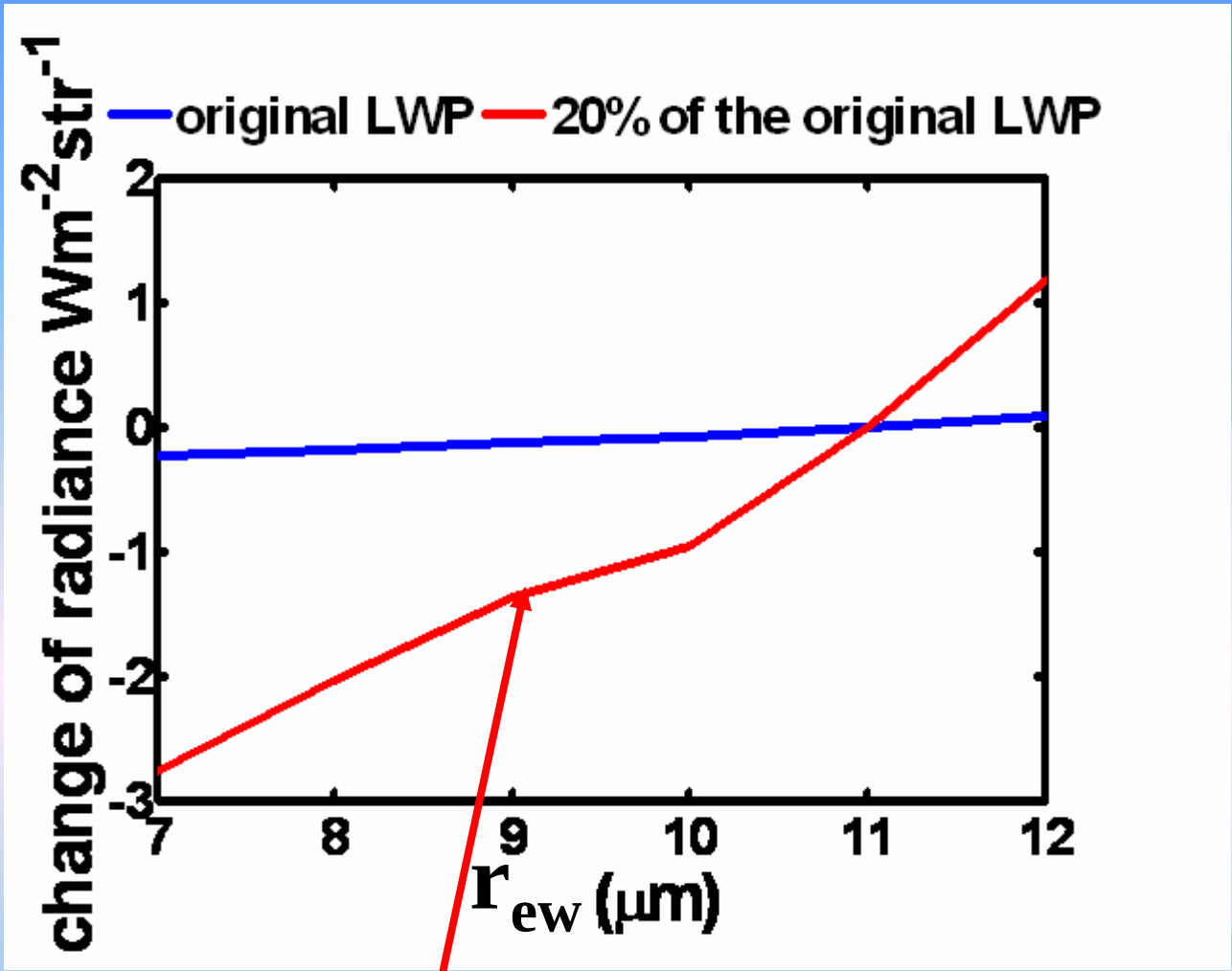
Sensitivity test varying cloud location showed ~100 m shift in cloud location caused ~ 0.5 W m^{-2} str^{-1} change in radiance



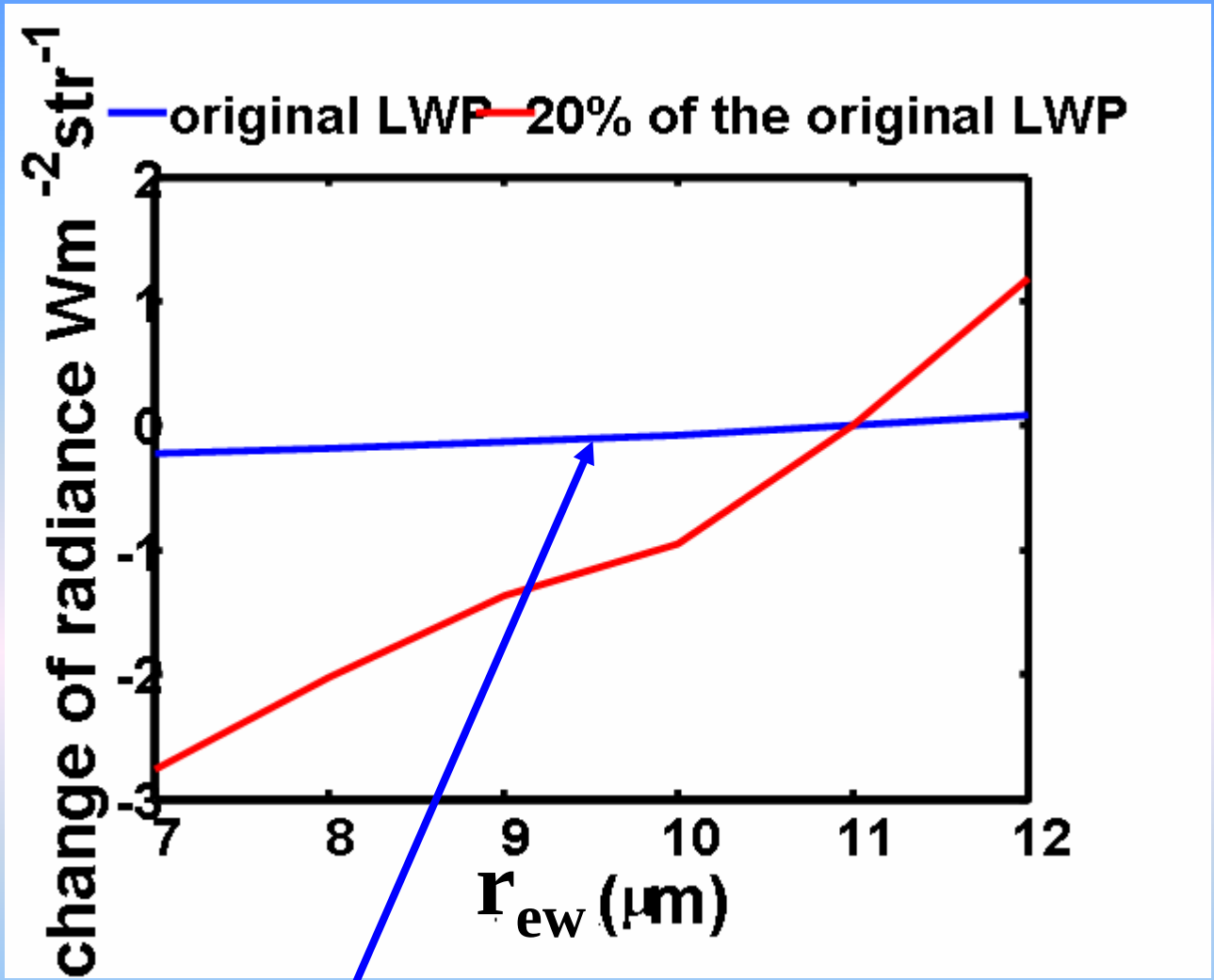
Changing LWP from 100 gm^{-2} to 80 gm^{-2} introduces only 0.08 W m^{-2} str^{-1} change of surface radiance



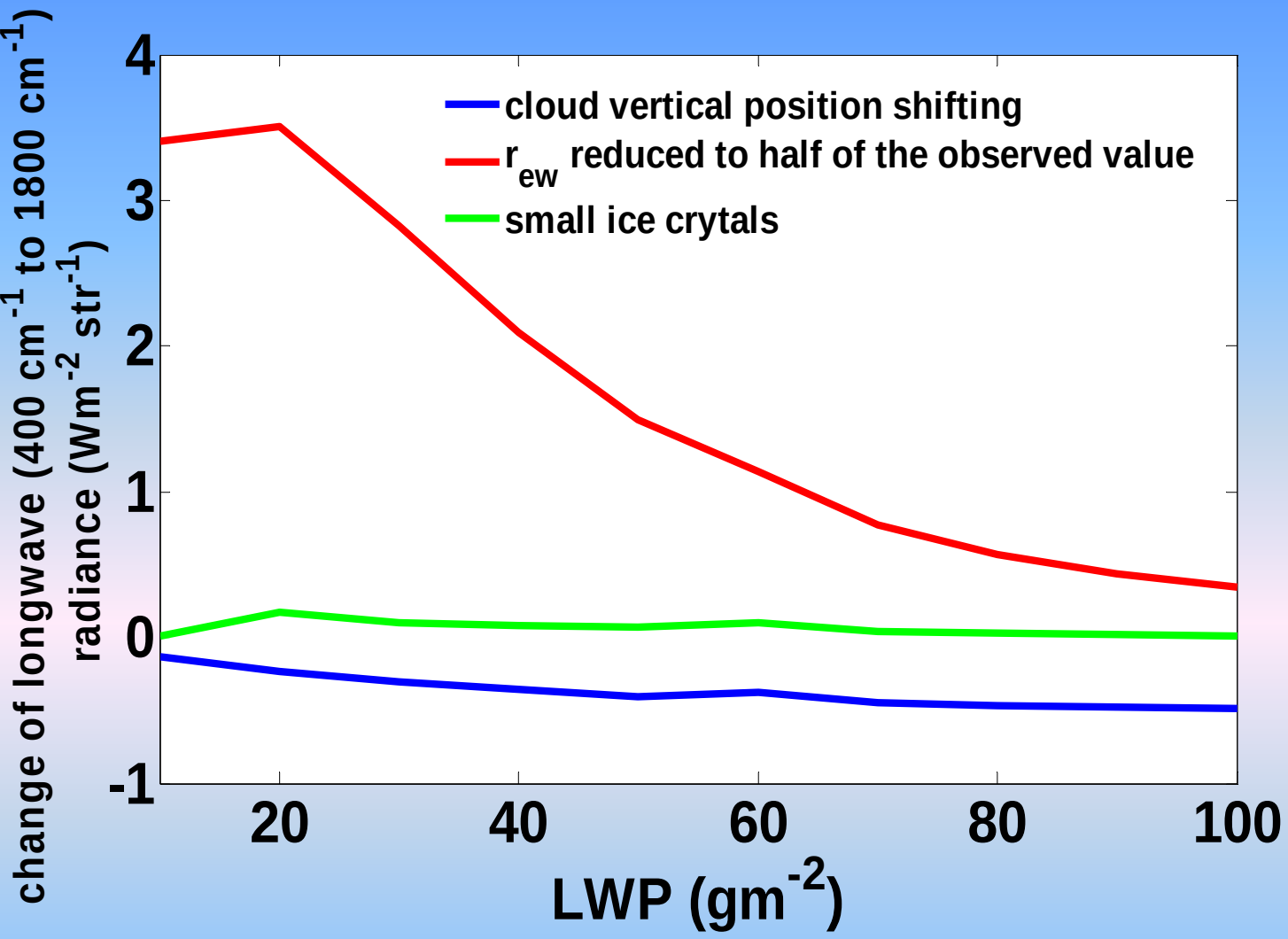
BUT, changing LWP from 40 gm^{-2} to 20 gm^{-2} introduces only 1.88 W m^{-2} str^{-1} change of surface radiance



Changing r_{ew} from 7 μm to 12 μm introduces 3.96 W m^{-2} str^{-1} radiance difference when LWP is 20 g m^{-2}



Changing r_{ew} from 7 μm to 12 μm introduces 3.96 W $m^{-2}str^{-1}$ radiance difference when LWP is 20 gm^{-2} but only 0.31 W $m^{-2}str^{-1}$ when LWP is 100 g m^{-2}



Assuming small particles are ice instead of water does not have big impact on radiance field compared to changing r_{ew} or cloud position

Conclusions

- Simulated LW surface radiance averages 2.4 W m^{-2} str^{-1} lower than AERI observations.
- LW surface radiance changes by ~ 0.5 W m^{-2} str^{-1} when shifting cloud location by 100 m
- LWP changes from 100 to 80 gm^{-2} introduce 0.08 W m^{-2} str^{-1} radiance change; 40 to 20 g m^{-2} change introduces 1.88 W m^{-2} str^{-1} radiance change.
- Microphysical properties of thin stratus (LWP 20 g m^{-2}) have more impact on LW radiance than those of thick stratus (LWP 100 gm^{-2})
- Treating small particles as ice instead of water has minimal impact on LW radiance