Building a Multi-Channel Hail Climatology in the GPM Domain

Dr. Sarah D. Bang

NASA Postdoctoral Program, Marshall Space Flight Center

Dr. Daniel J. Cecil

NASA Marshall Space Flight Center

Huntsville, AL USA

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EGU General Assembly ● Vienna, Austria

全球降水観測計画 GPM GLOBAL PRECIPITATION MEASUREMENT

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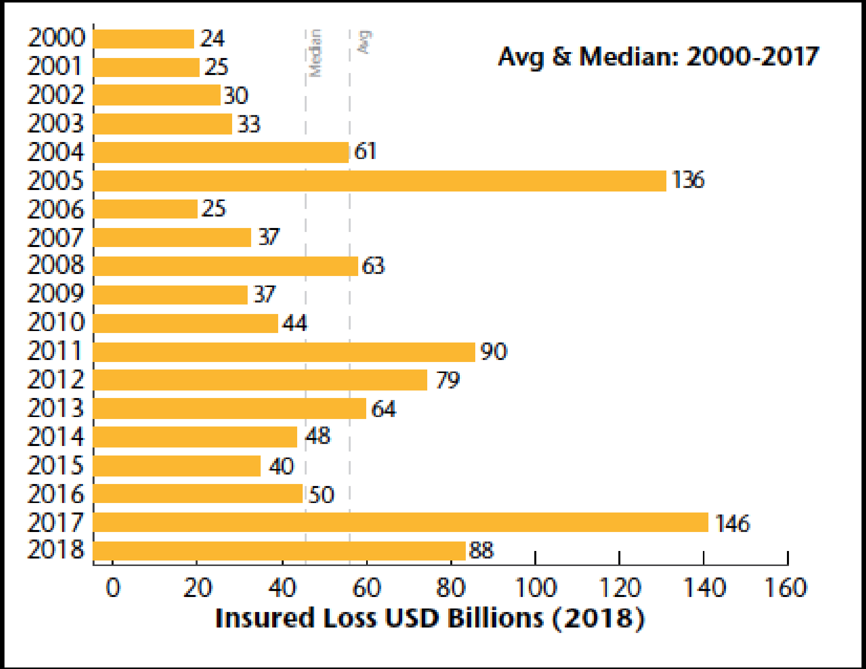
Hail Damage and Threat

Annual insured losses due to severe weather average at $66 Billion (€58Billion) since 2008

- (in the US) Hail accounts for ~70% of this loss



Aon, Weather, Climate, and Catastrophe Insight (2018 Annual Report)

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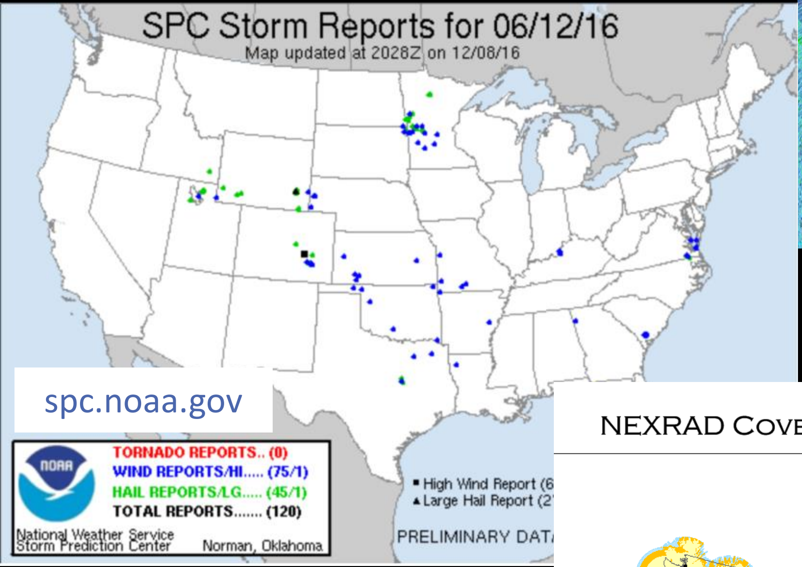
Observing Hail



spc.noaa.gov

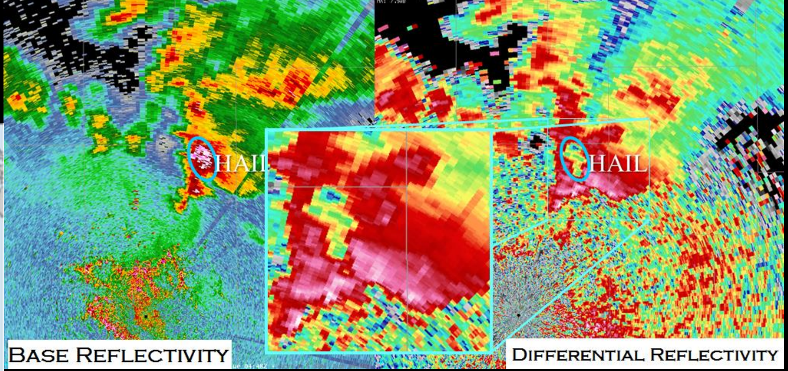
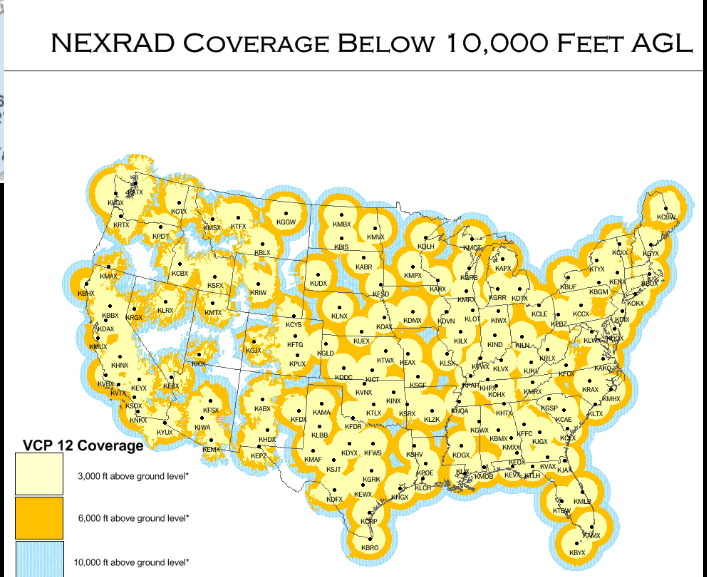
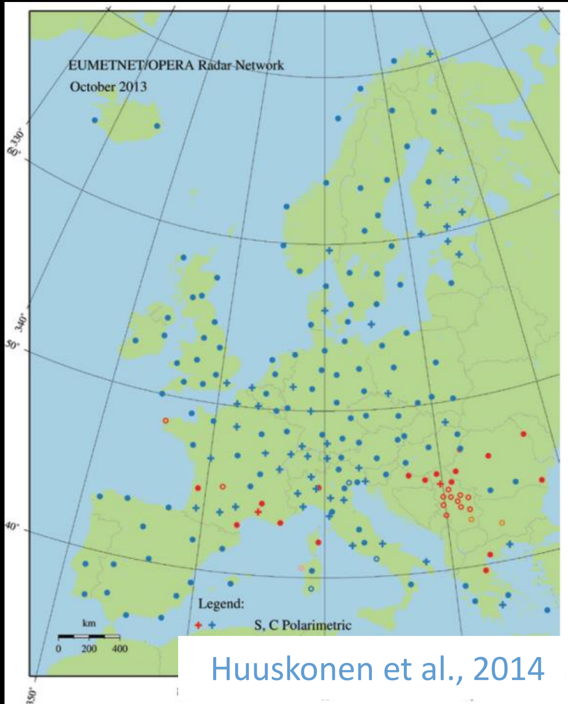


Image courtesy of NWS Birmingham and the Warning Decision Training Branch





Huuskonen et al., 2014

9 April 2019

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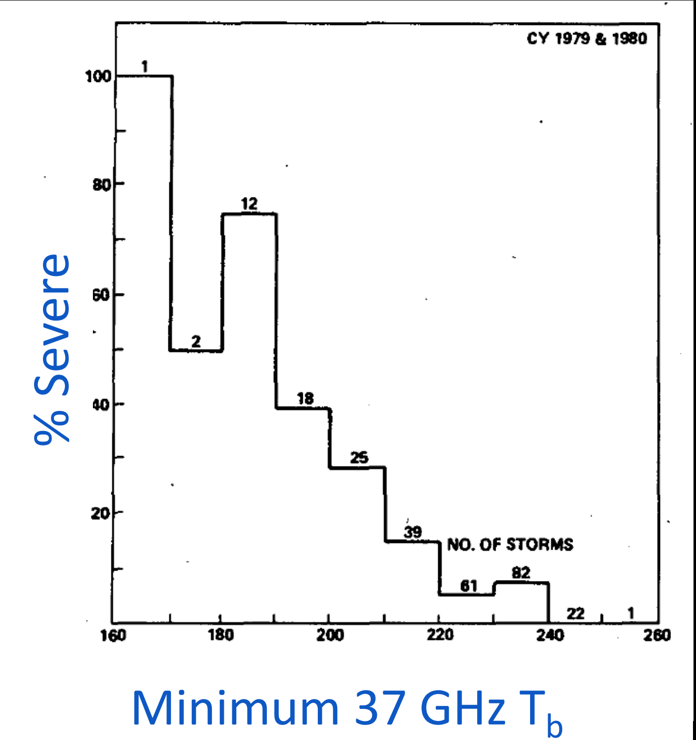
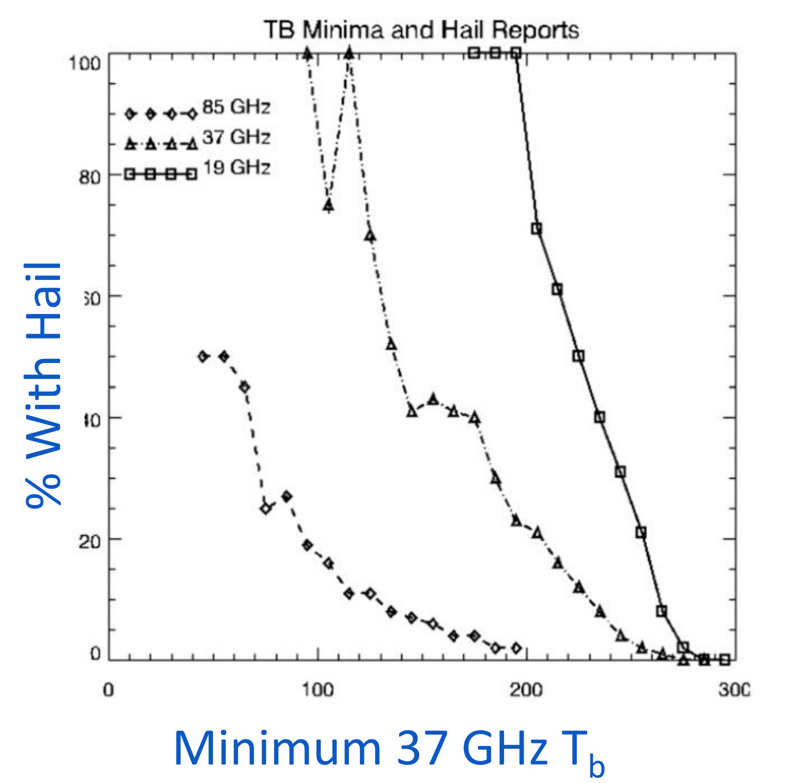
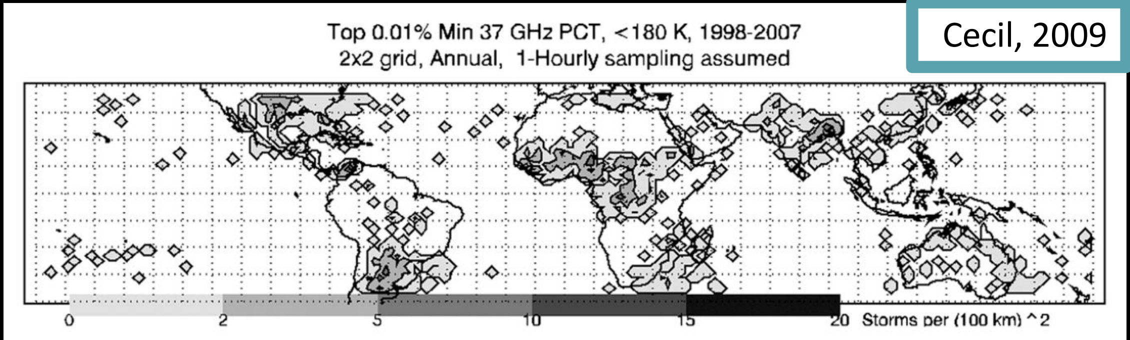


Spencer et al., 1987

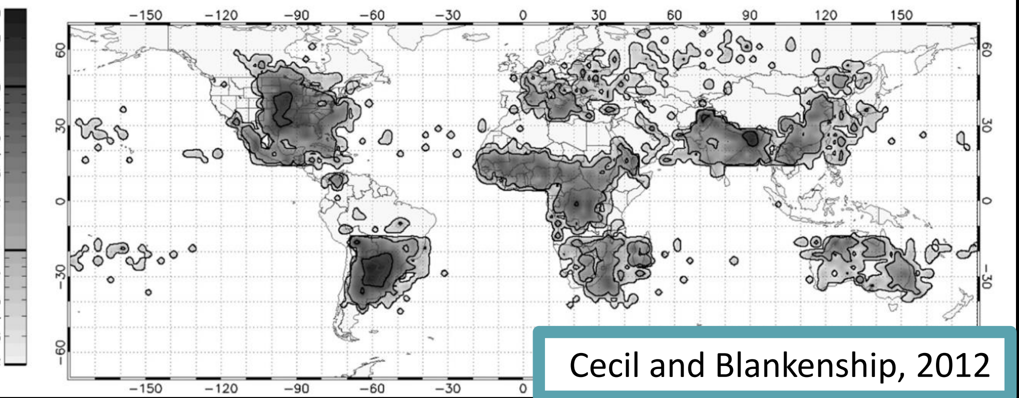


Cecil, 2009

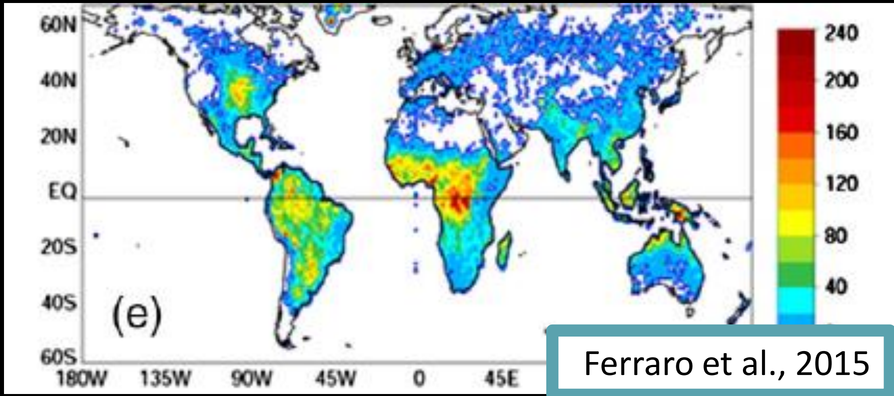
Satellite-Based Hail Climatologies



Cecil, 2009



Cecil and Blankenship, 2012



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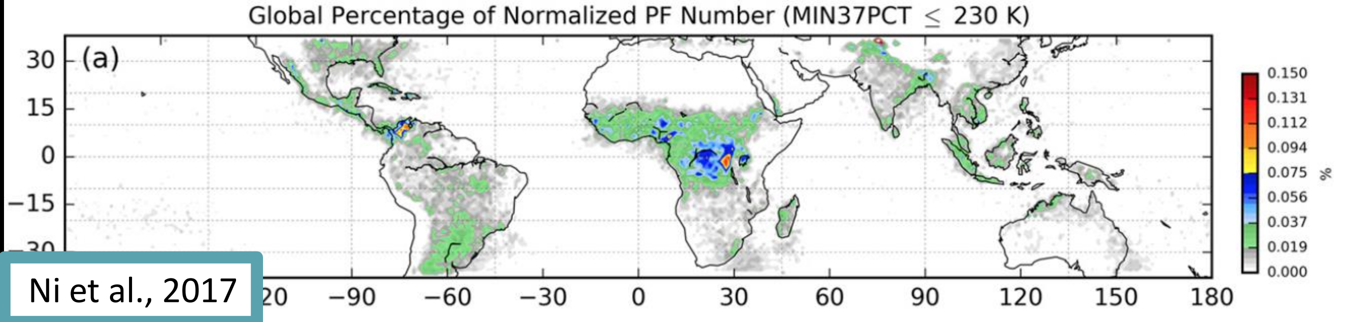

Ni et al., 2017

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NASA's TRMM & GPM Missions

Tropical Rainfall Measuring Mission

- TRMM Precipitation Radar (PR)
  - Ku-band (13.8 GHz)
- TRMM Microwave Imager (TMI)
  - 9-channels, 10-85 GHz

Global Precipitation Measurement

- Dual-frequency Precipitation Radar (DPR)
  - Ka-/Ku-band (35.5/13.6 GHz)
- GPM Microwave Imager (GMI)
  - 13-channels 10-183 GHz

Hou et al., 2014

Summary provided by
Stephanie Wingo, NASA MSFC

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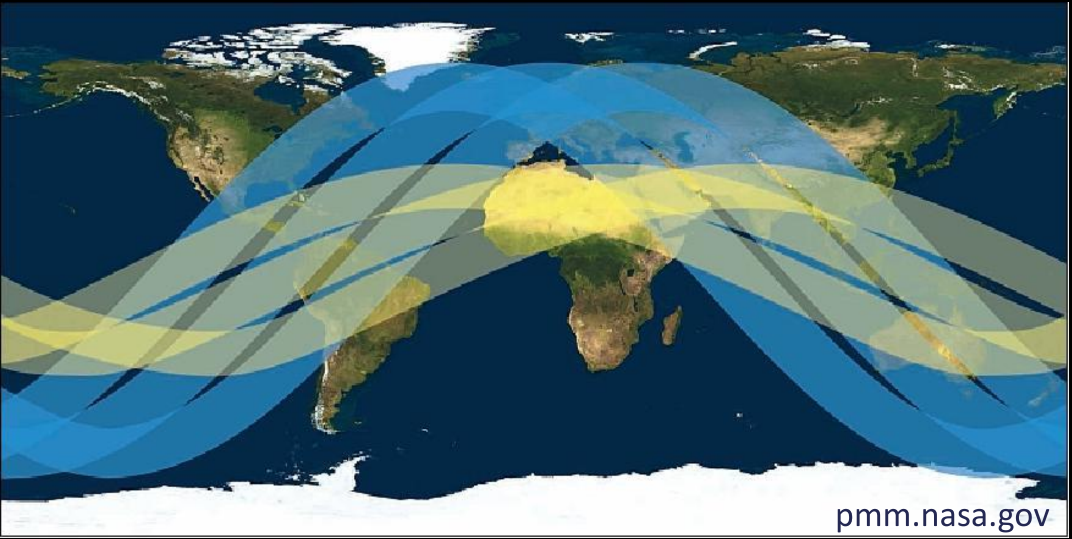

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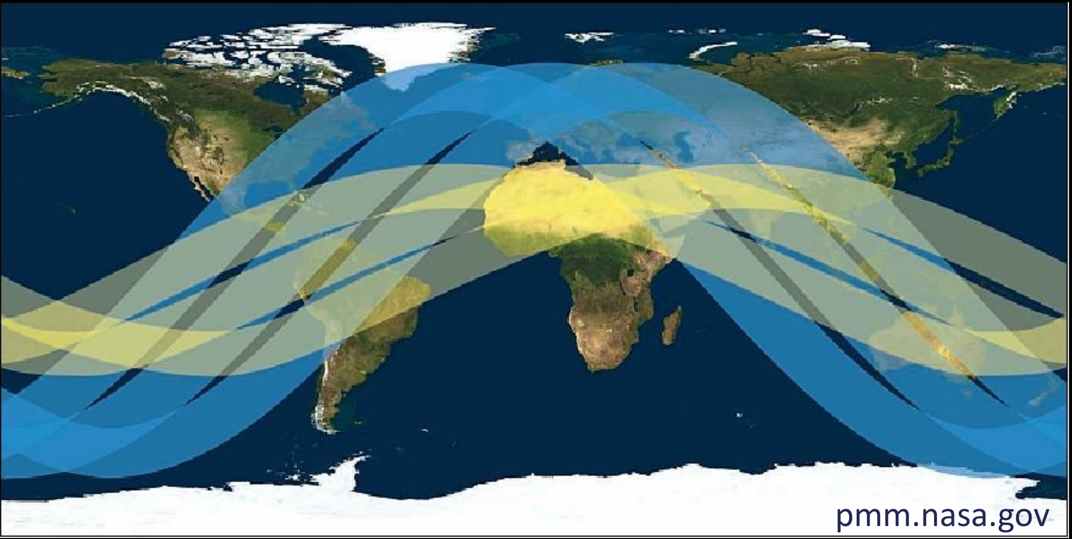
- Constellation Partners:
  - JAXA, NOAA, DOD, EUMETSAT, CNES, ISRO
  - Cross-calibrate passive microwave observations
- <4 hourly global resolution?

Hou et al., 2014



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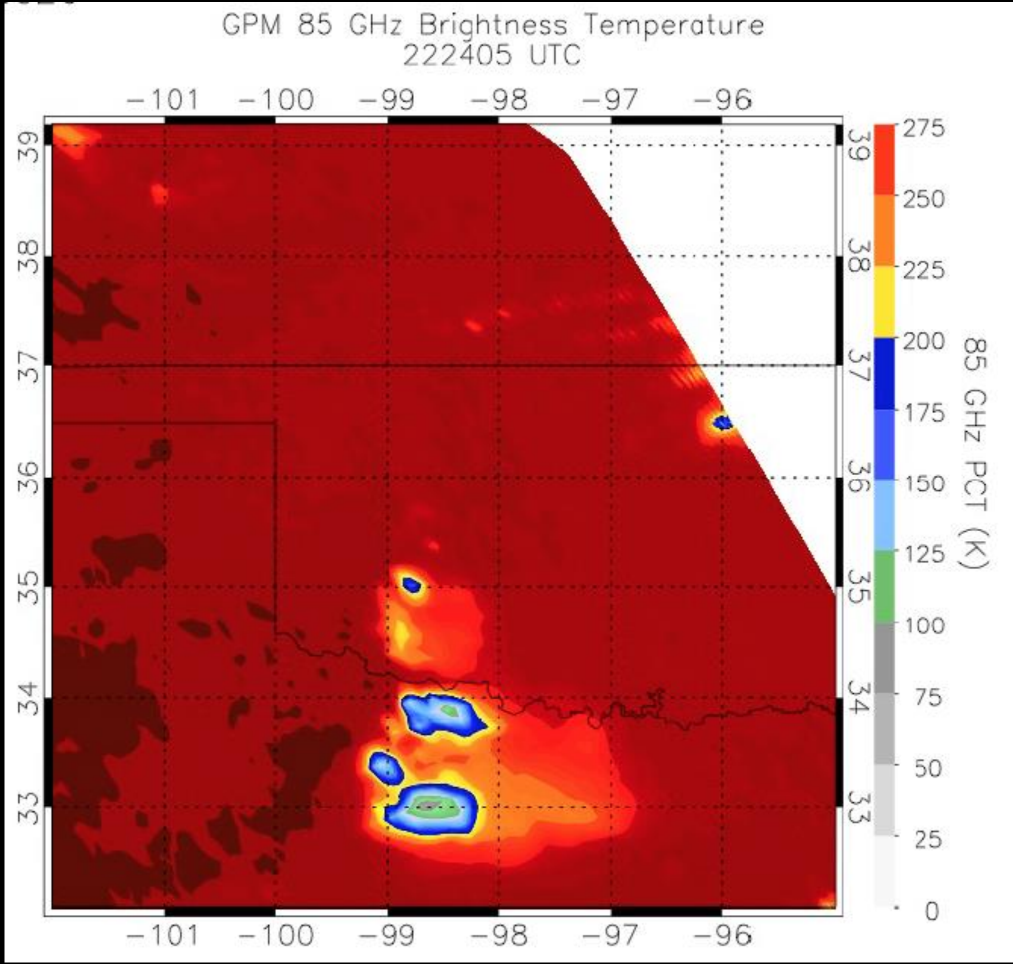
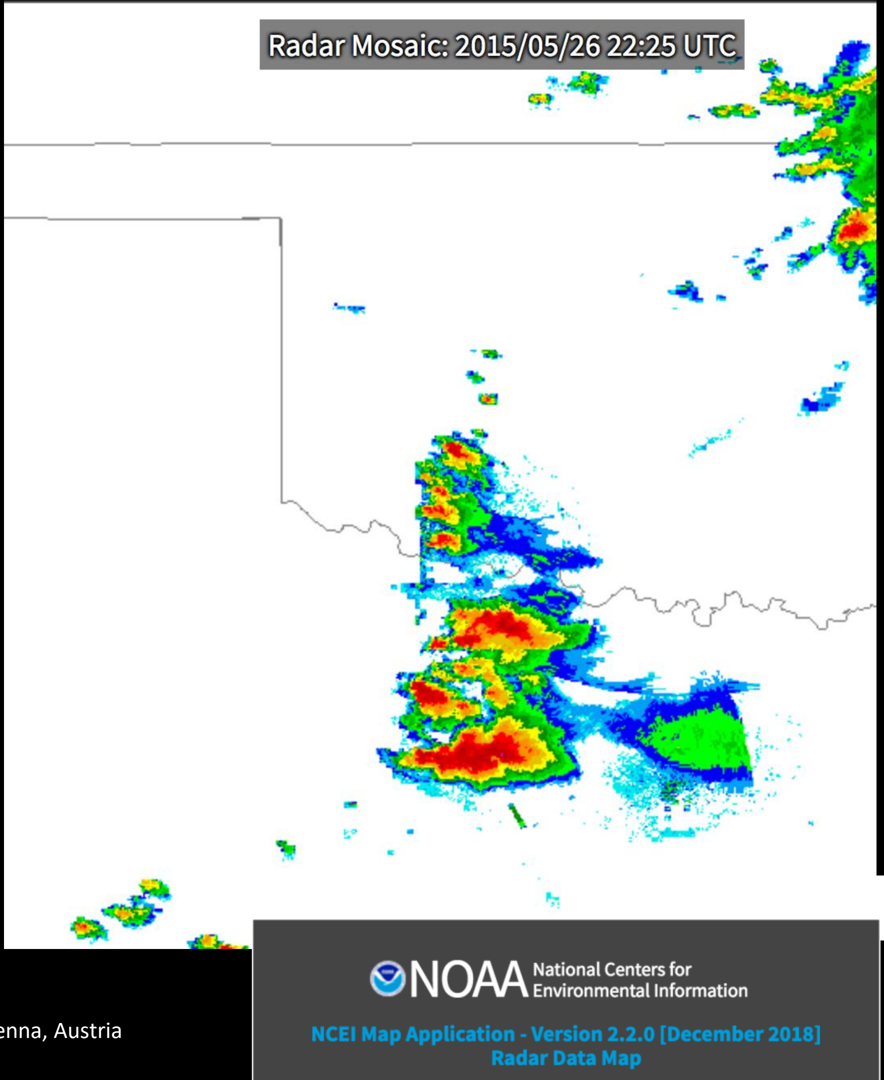
TRMM PCTFs





ienna, Austria

37GHz Minimum T_b (PCT) and Hail

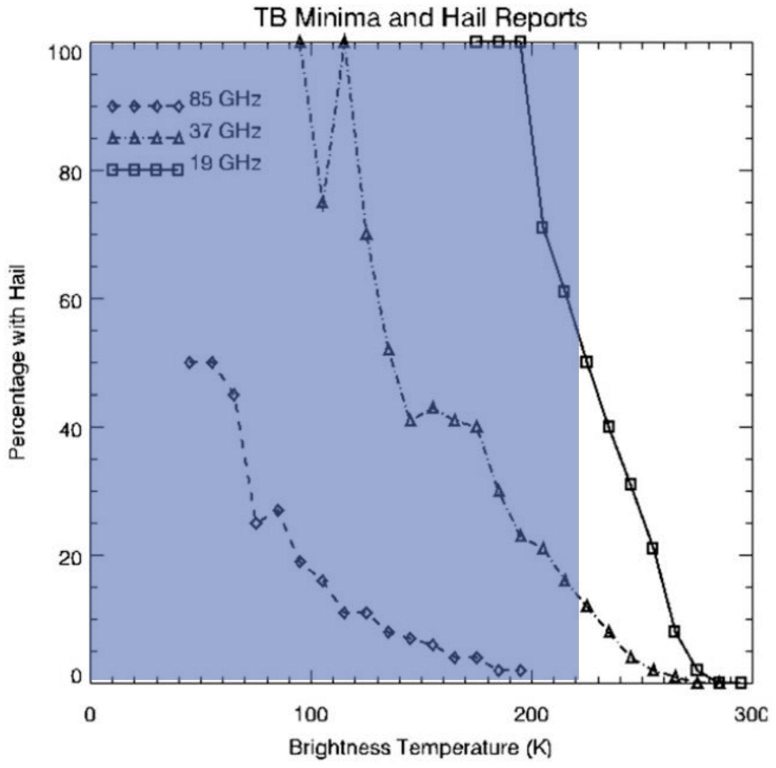


FIG. 2. Percentage of brightness temperature local minima associated with hail reports.

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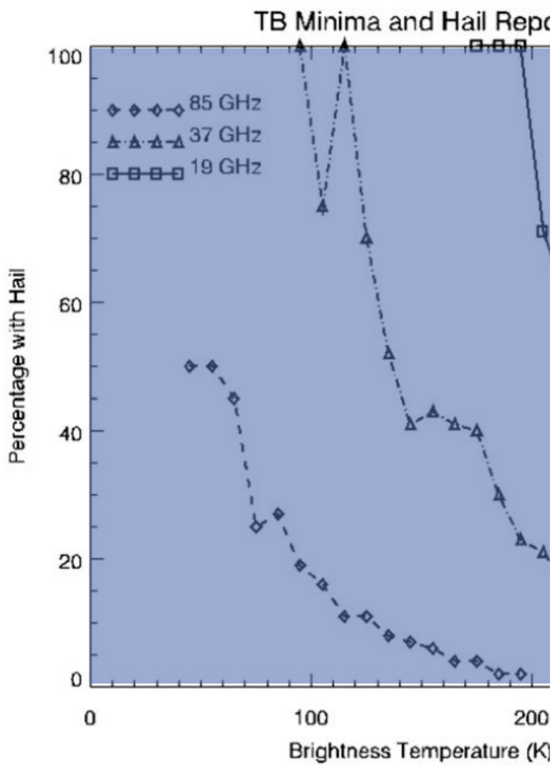

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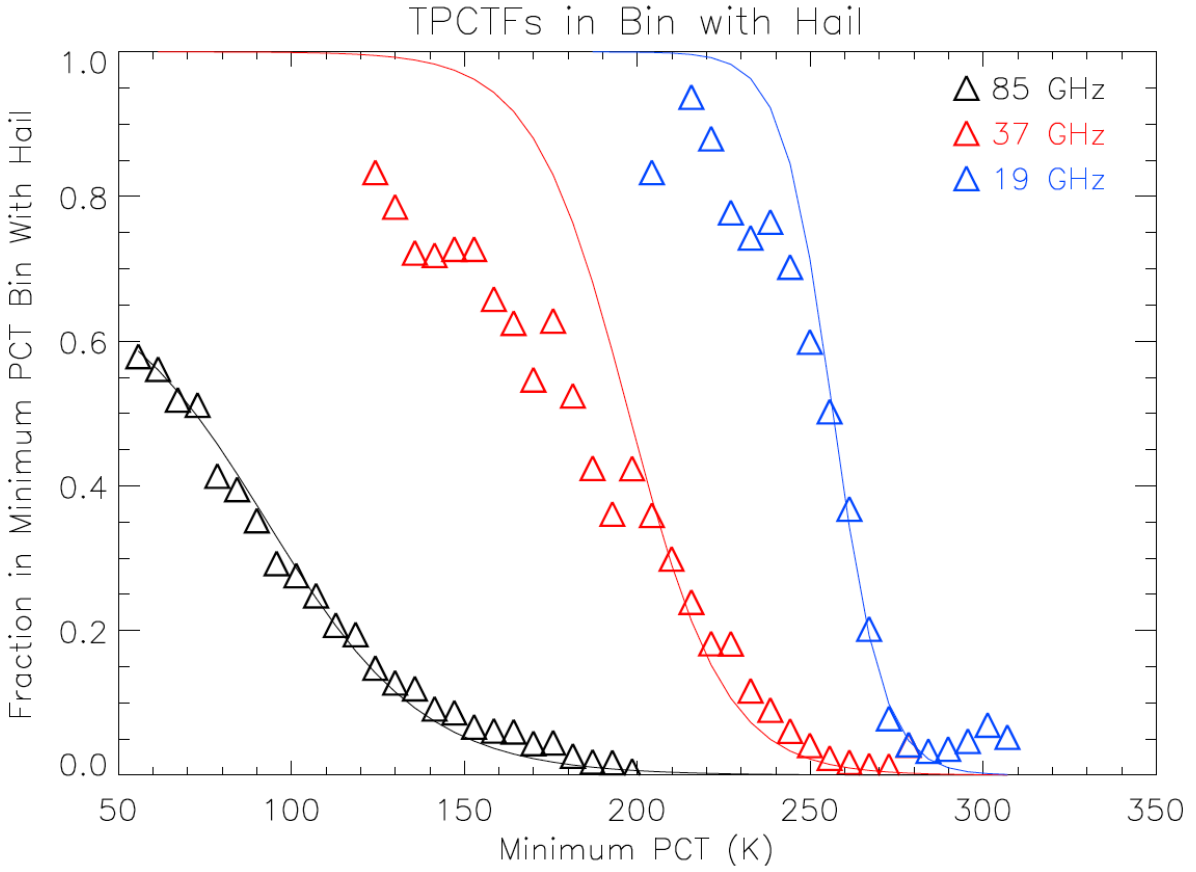

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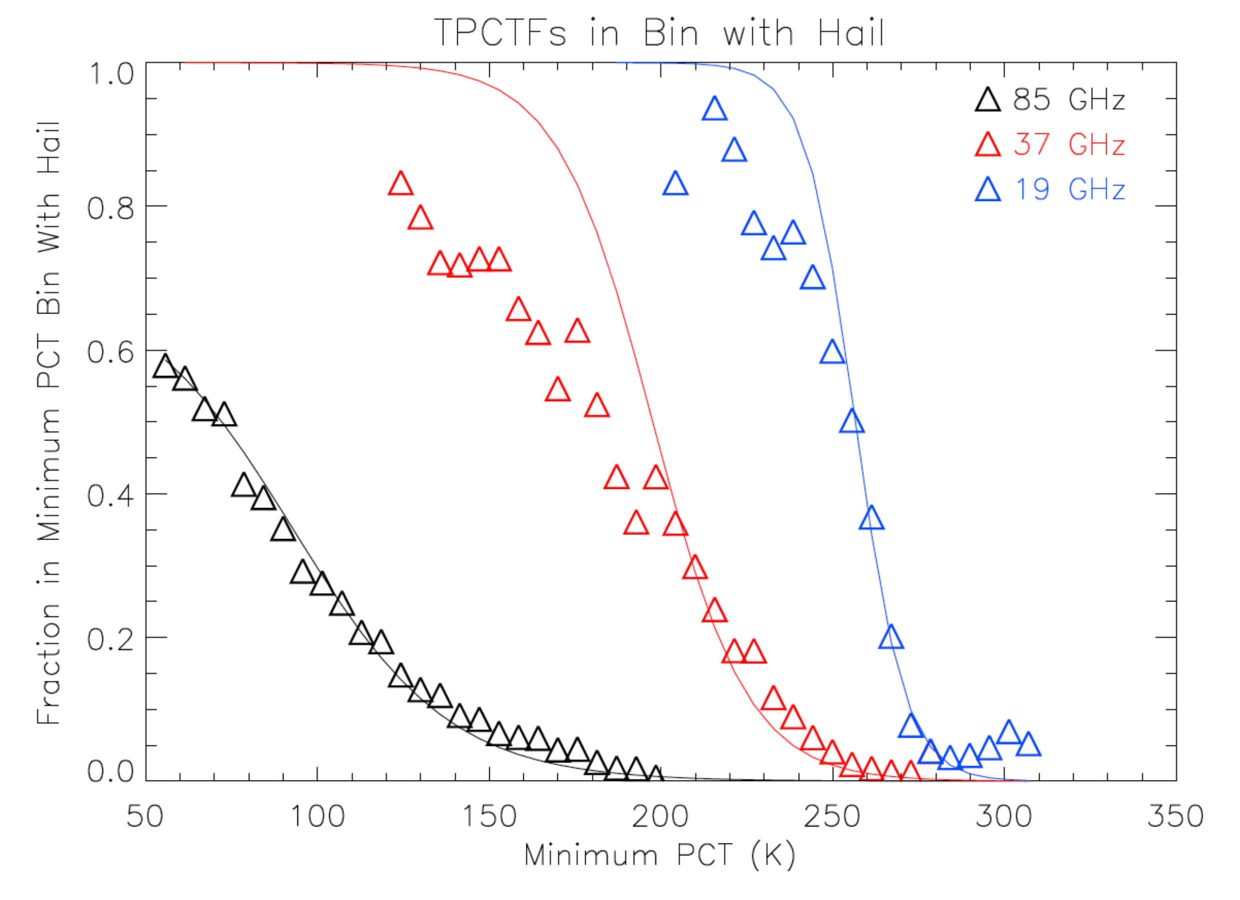

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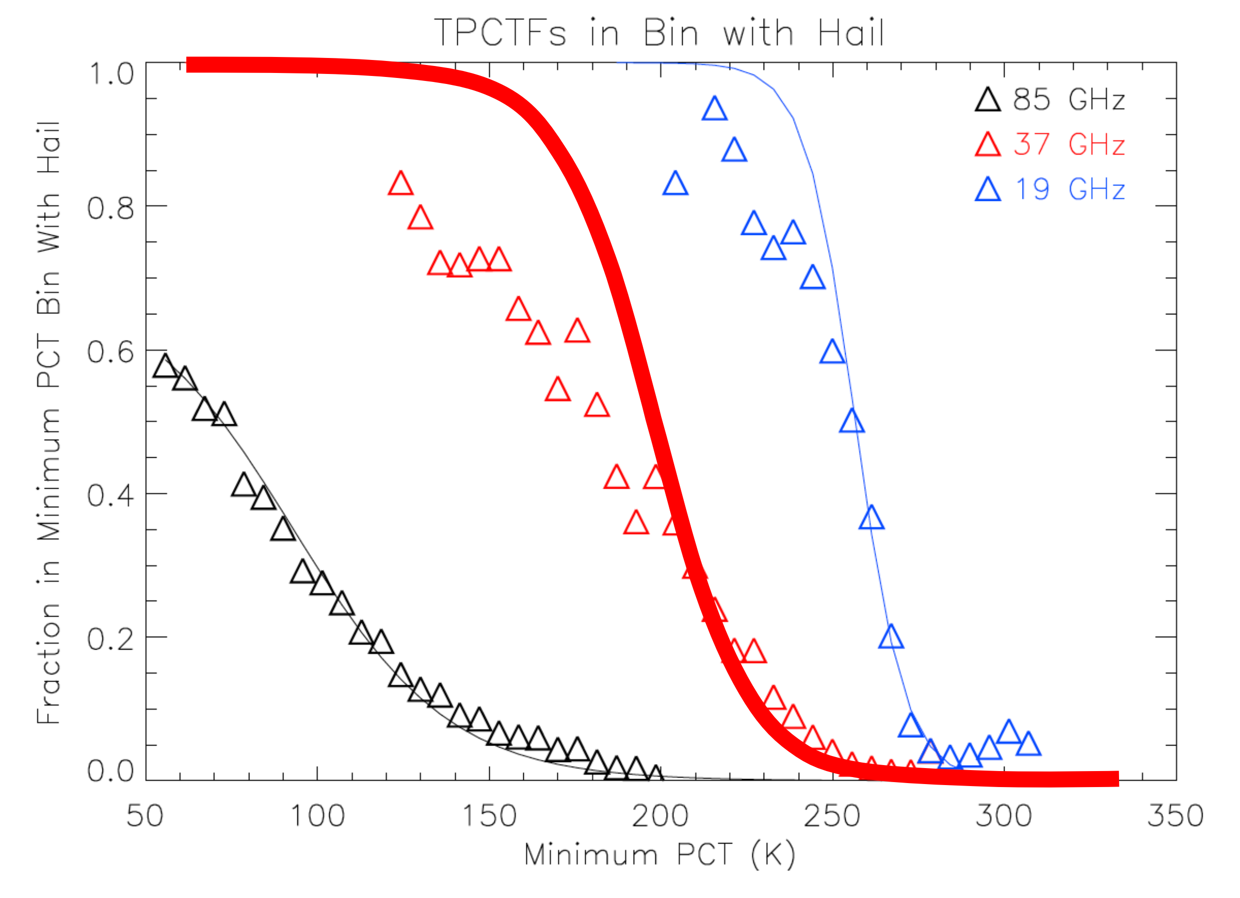

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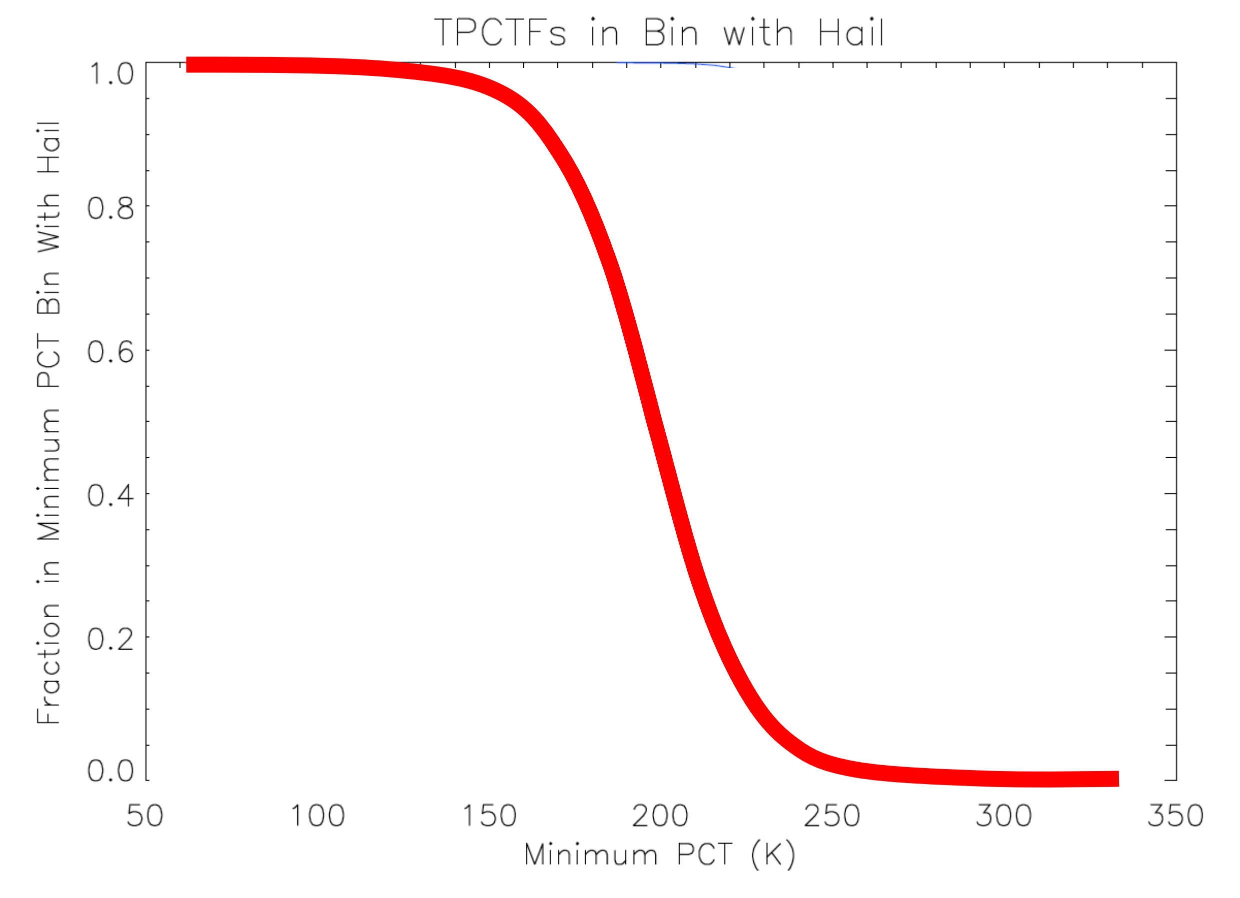
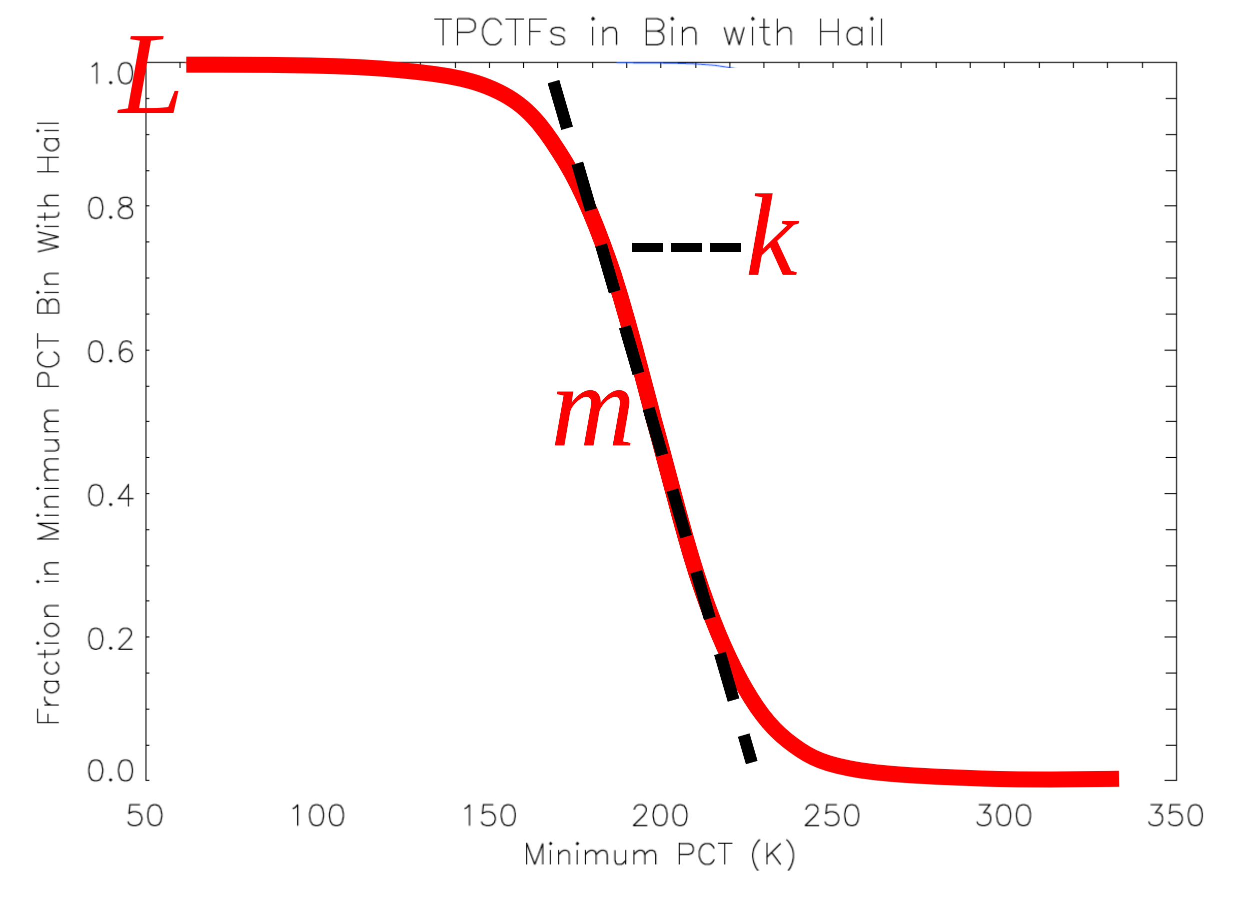


$$f(x) = \frac{L}{1+e^{-k(x-m)}}$$

37GHz Minimum T_b and Hail



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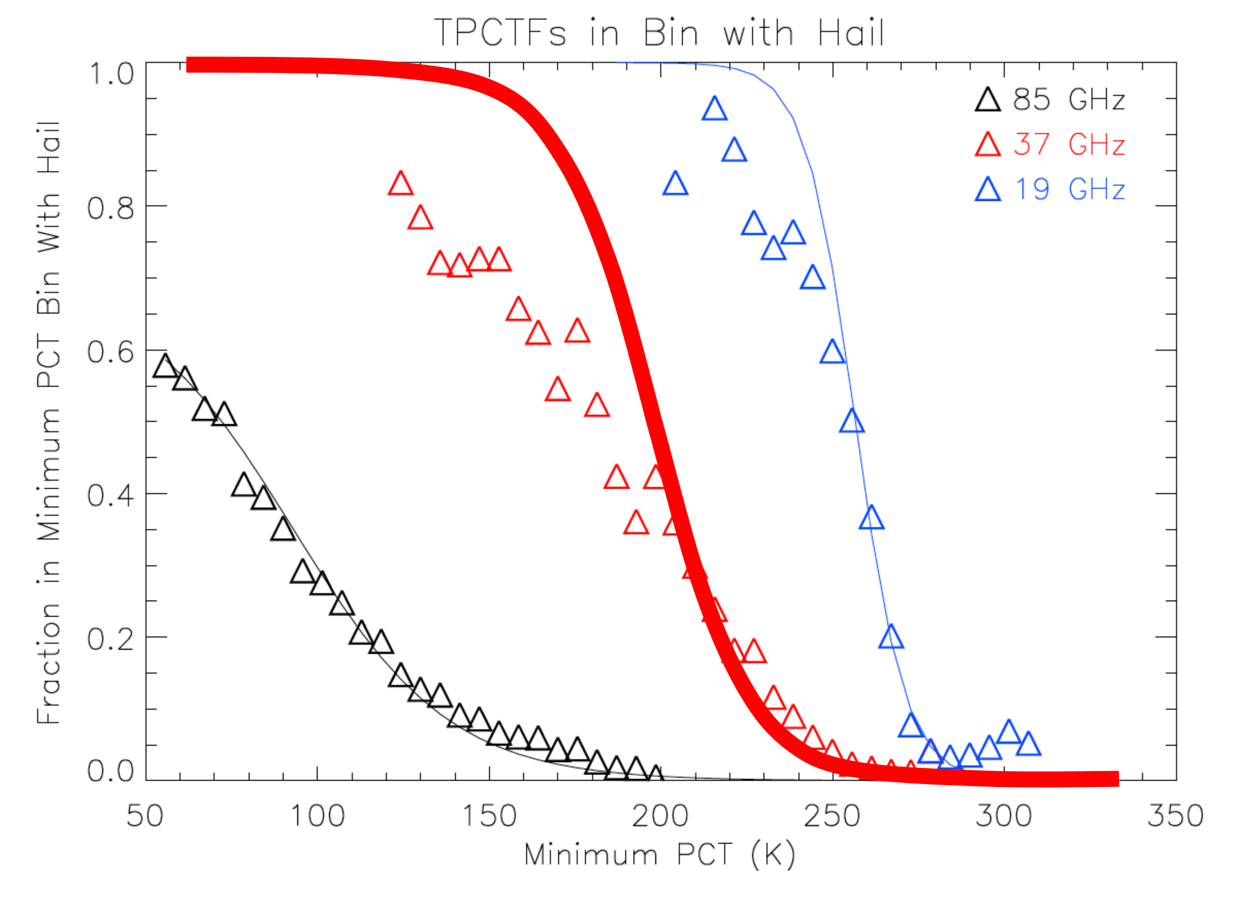

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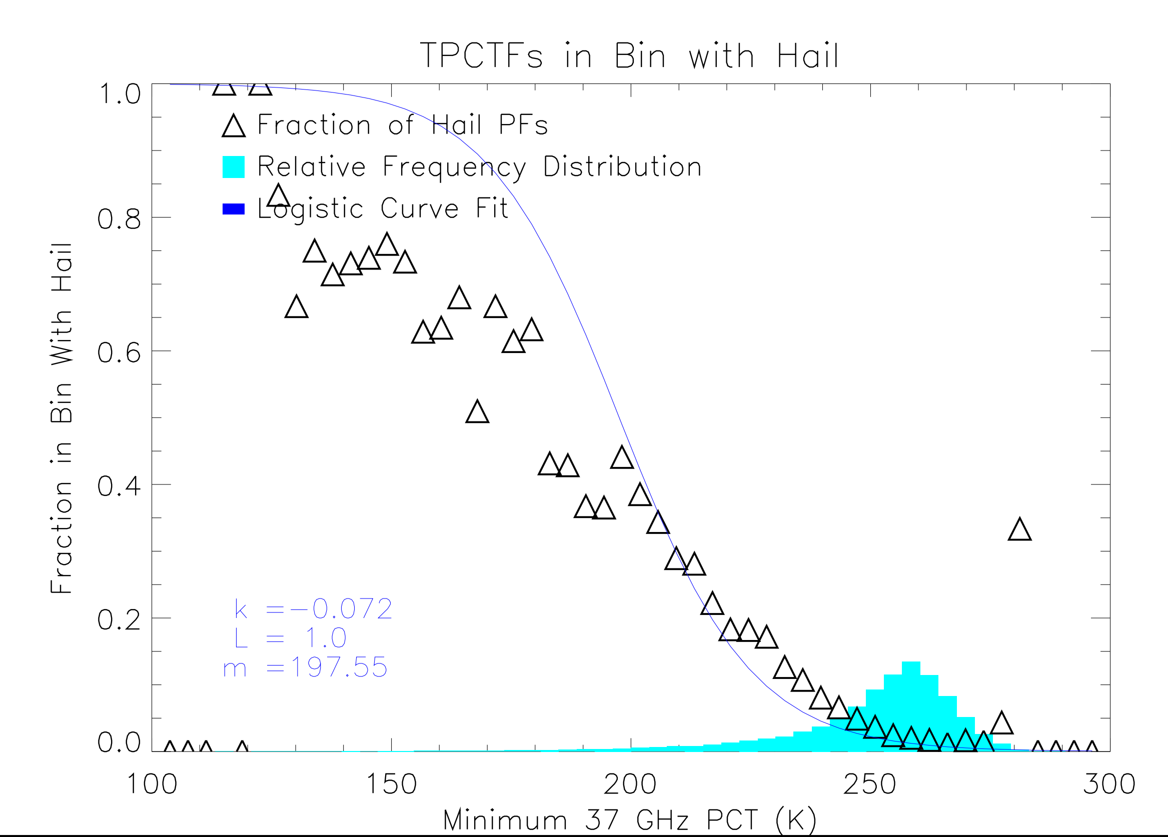
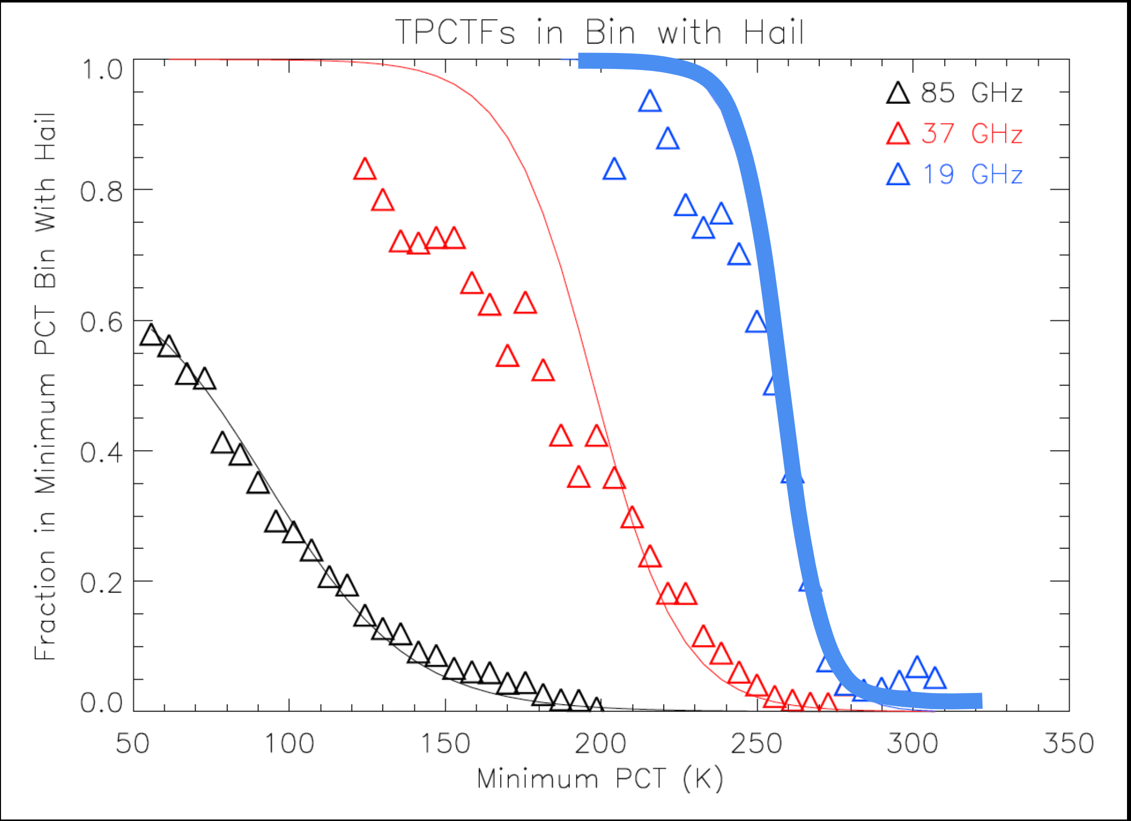
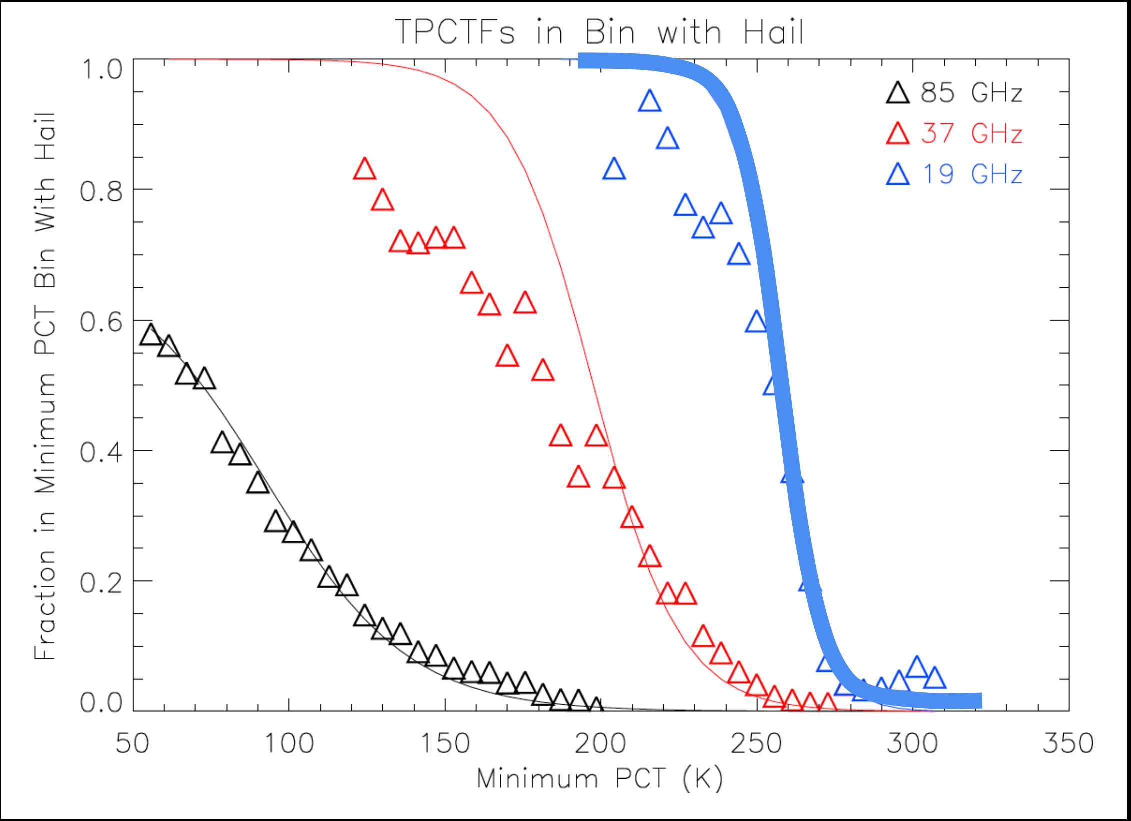
Probability of Hail with Minimum 37 GHz PCT

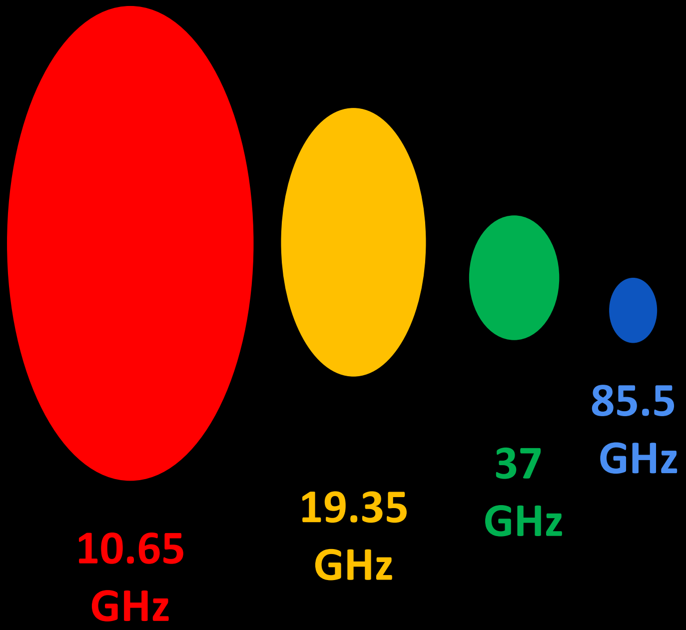


19GHz Minimum T_b and Hail

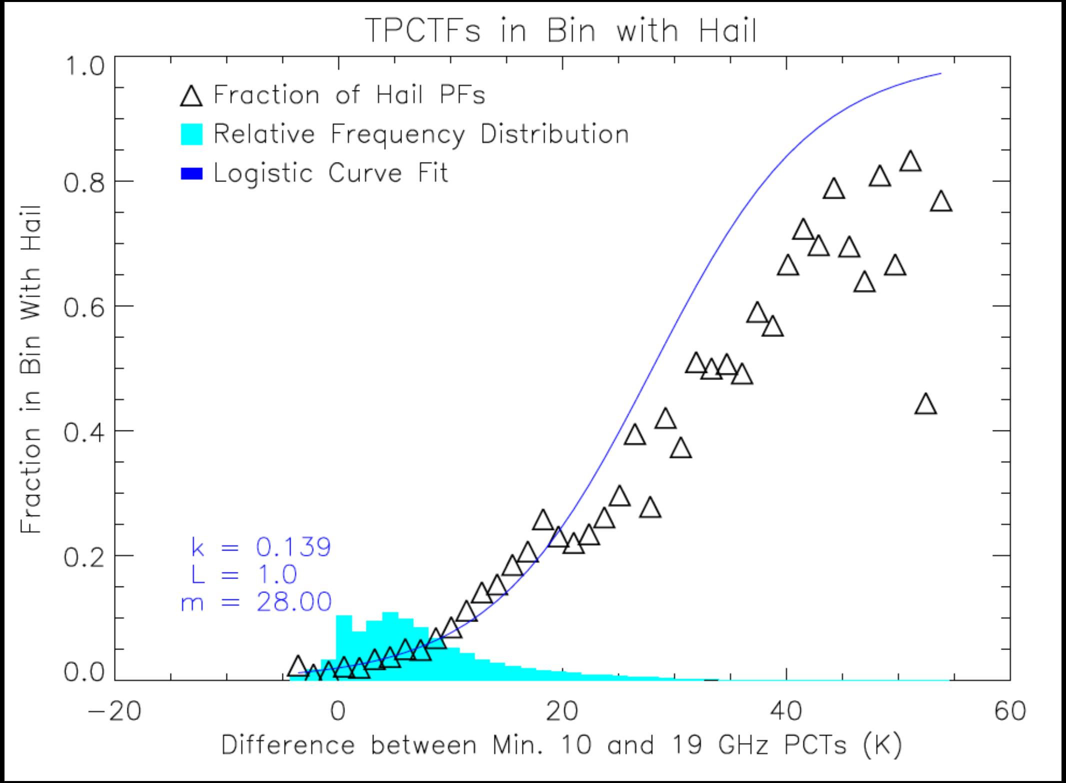


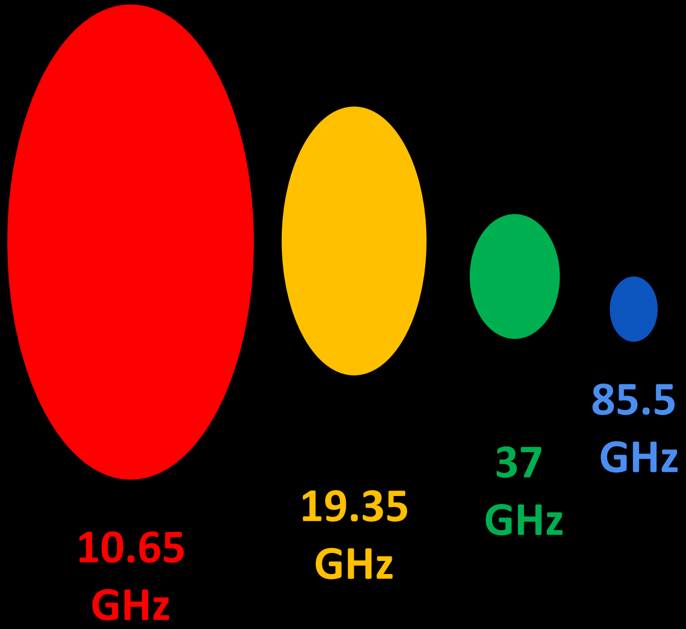
19GHz Minimum T_b and Hail



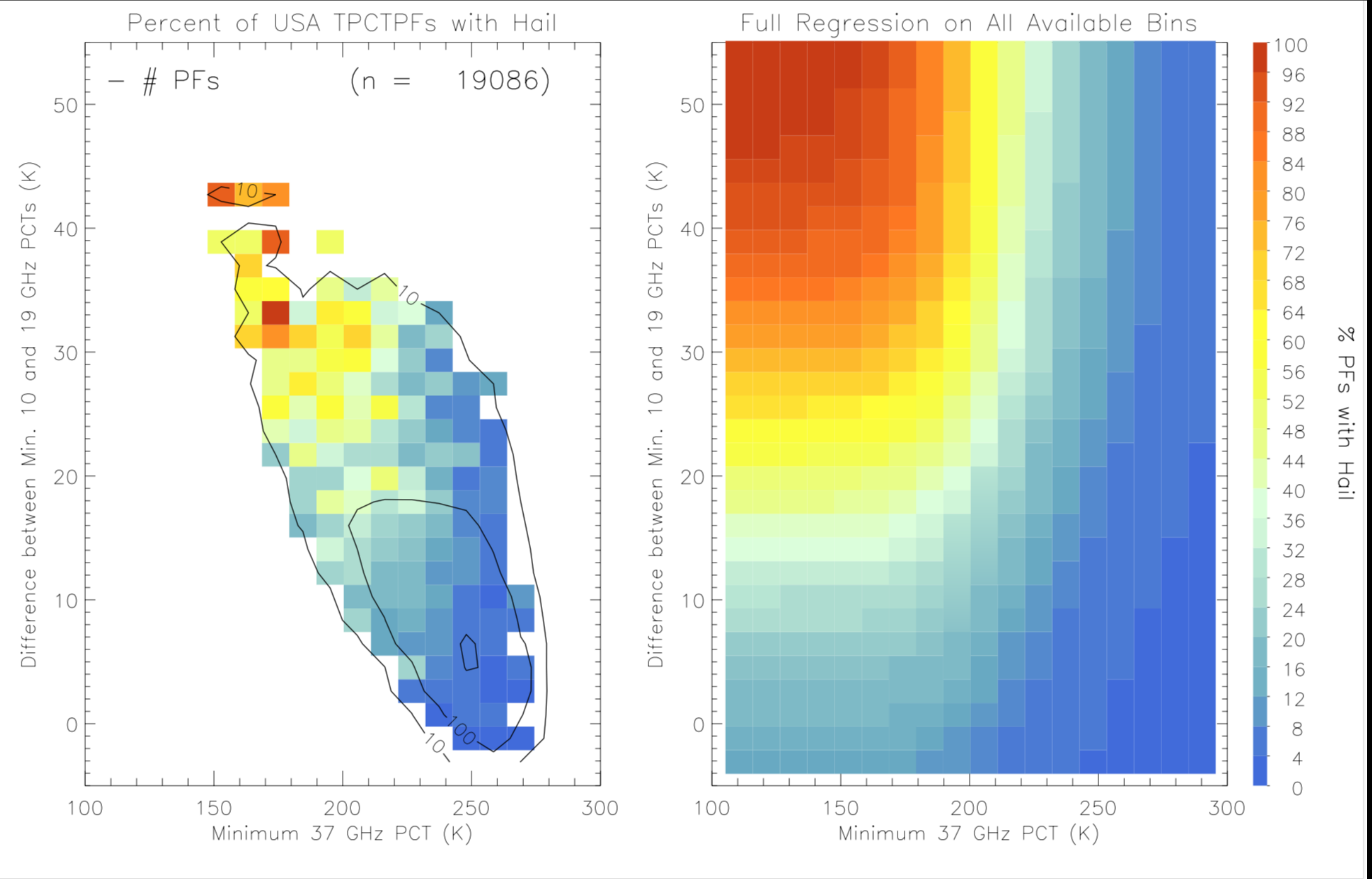


Probability of Hail with 10 - 19 GHz Difference





Two Dimensions of Hail Probability



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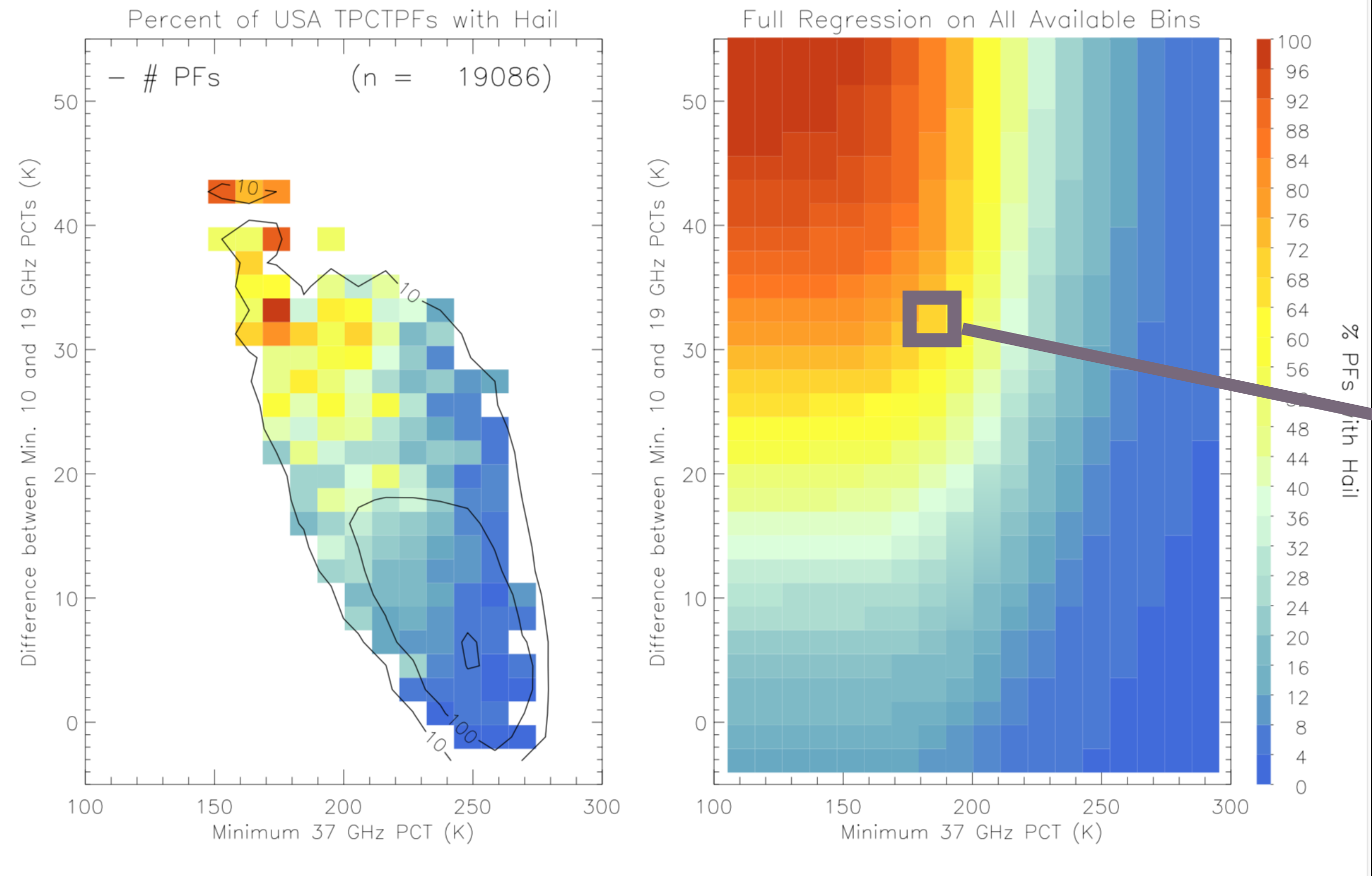
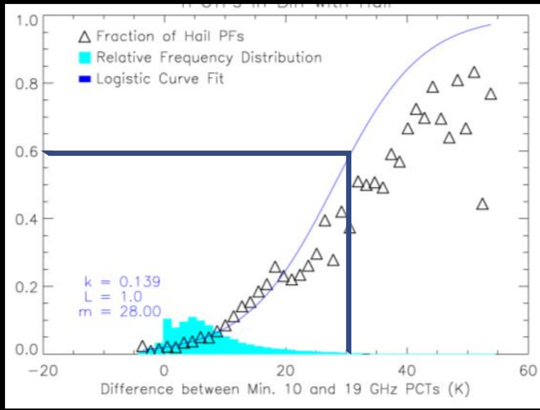
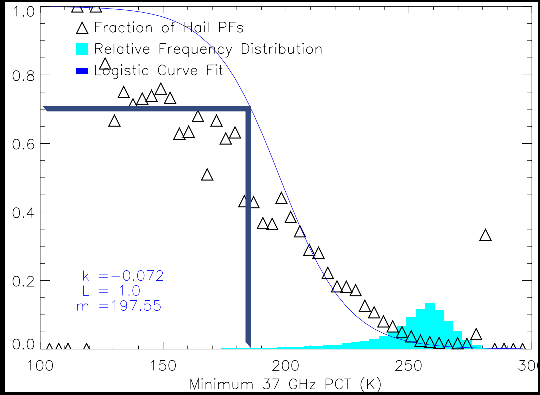




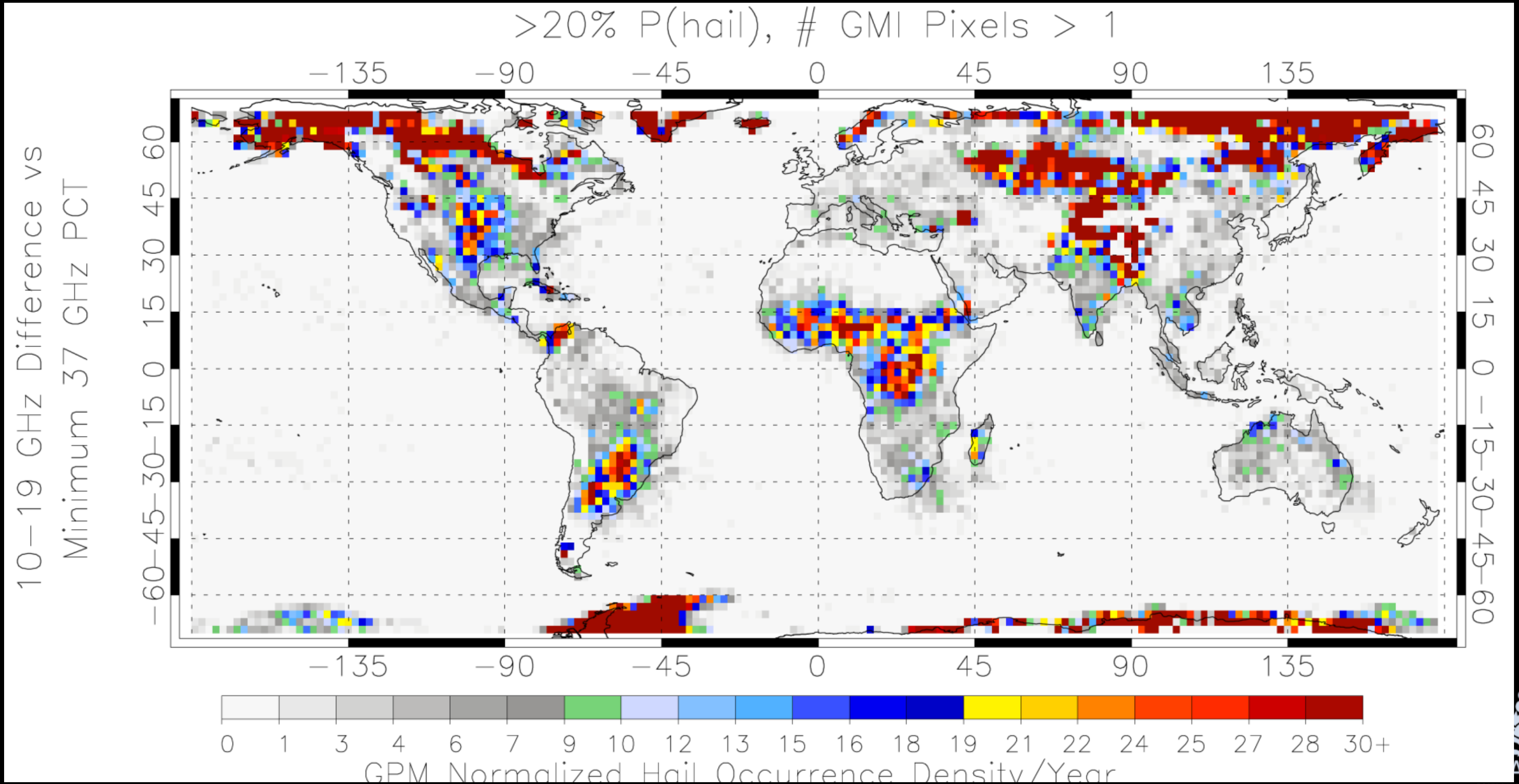
$P_{hail(}$ (10-19) = 0.6

P_{hail} (Min 37) = 0.7

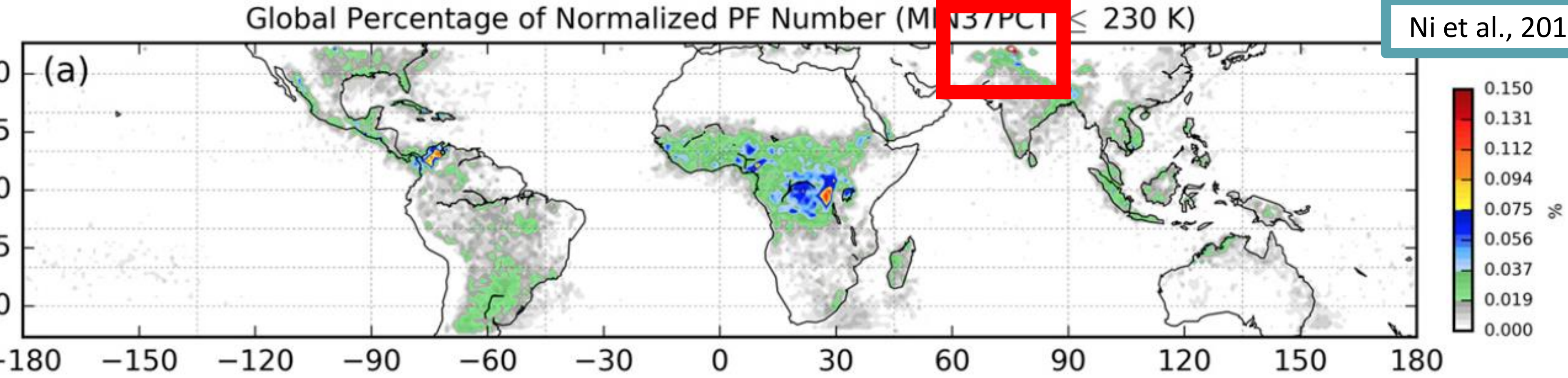
$\surd(0.6*0.7) = P_{hail} = 0.648$



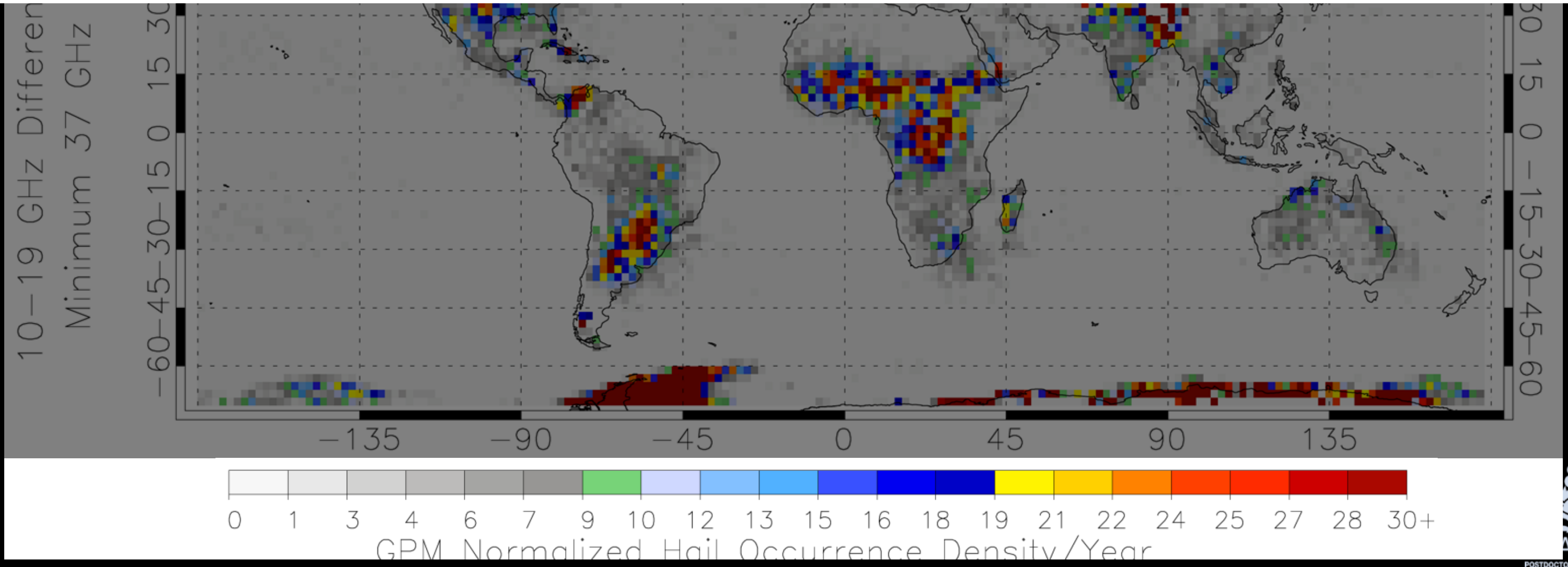
GPM Hail Climatology, Minimum 37 GHz PCT



Ni et al., 2017

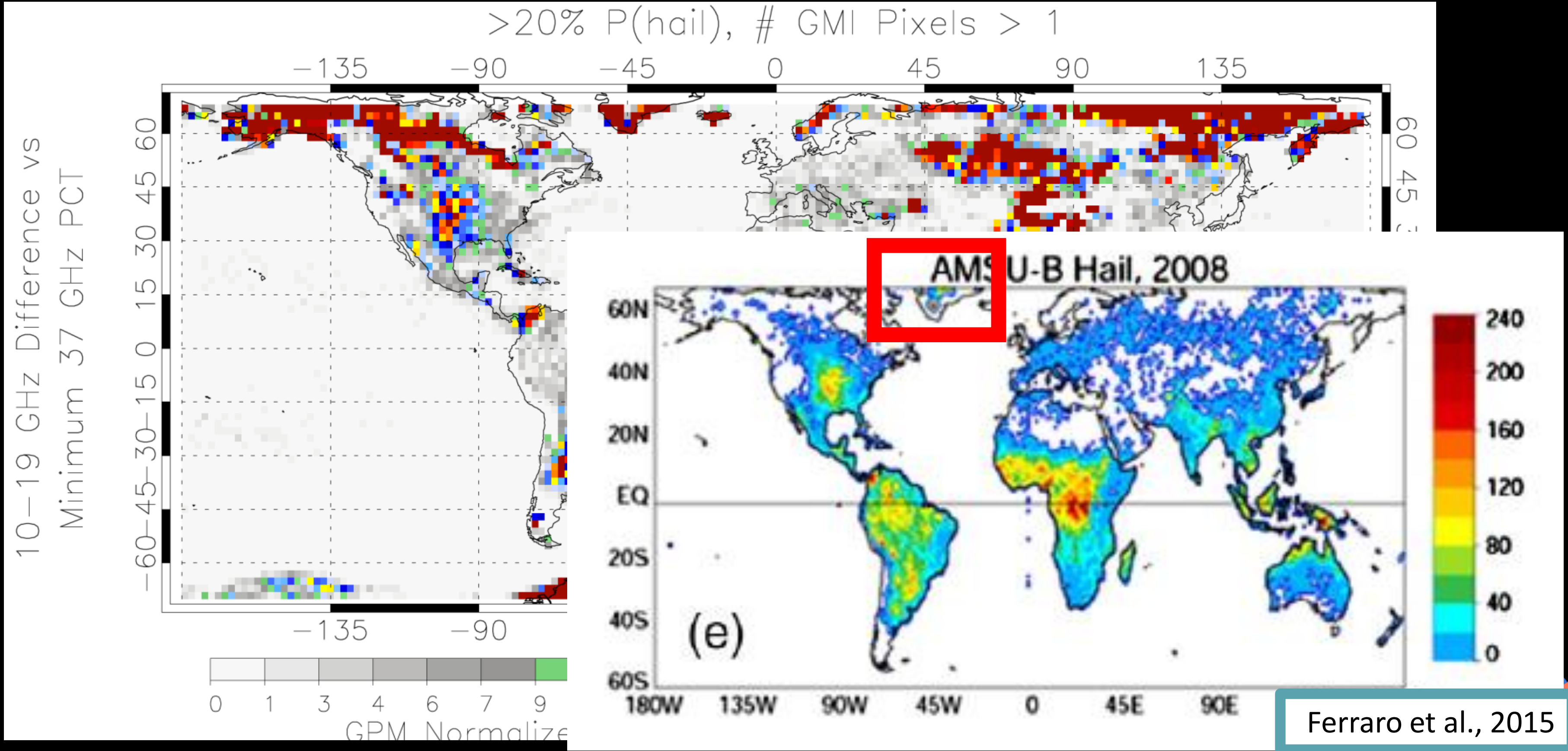


Global Percentage of Normalized PF Number (MIN37PCT ≤ 230 K)
(a)
0.150
0.131
0.112
0.094
0.075
0.056
0.037
0.019
0.000
%
-180
−150
−120
−90
−60
−30
0
30
60
90
120
150
180



10−19 GHz Differen
Minimum 37 GHz
−60 −45 −30 −15 0 15 30
−135
−90
−45
0
45
90
135
0
1
3
4
6
7
9
10
12
13
15
16
18
19
21
22
24
25
27
28
30+
GPM Normalized Hail Occurrence Density/Year

GPM Hail Climatology, Minimum 37 GHz PCT



Ferraro et al., 2015

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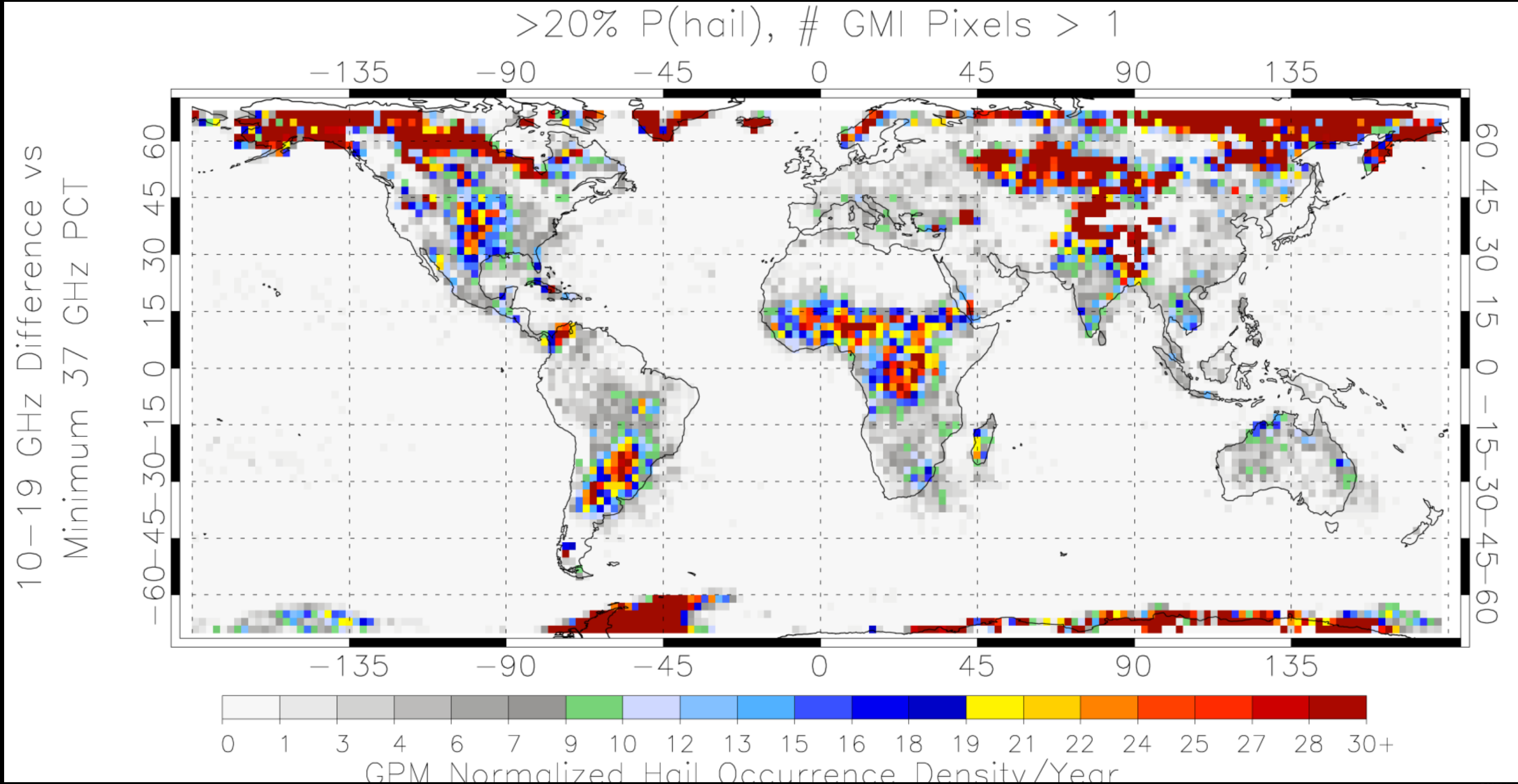
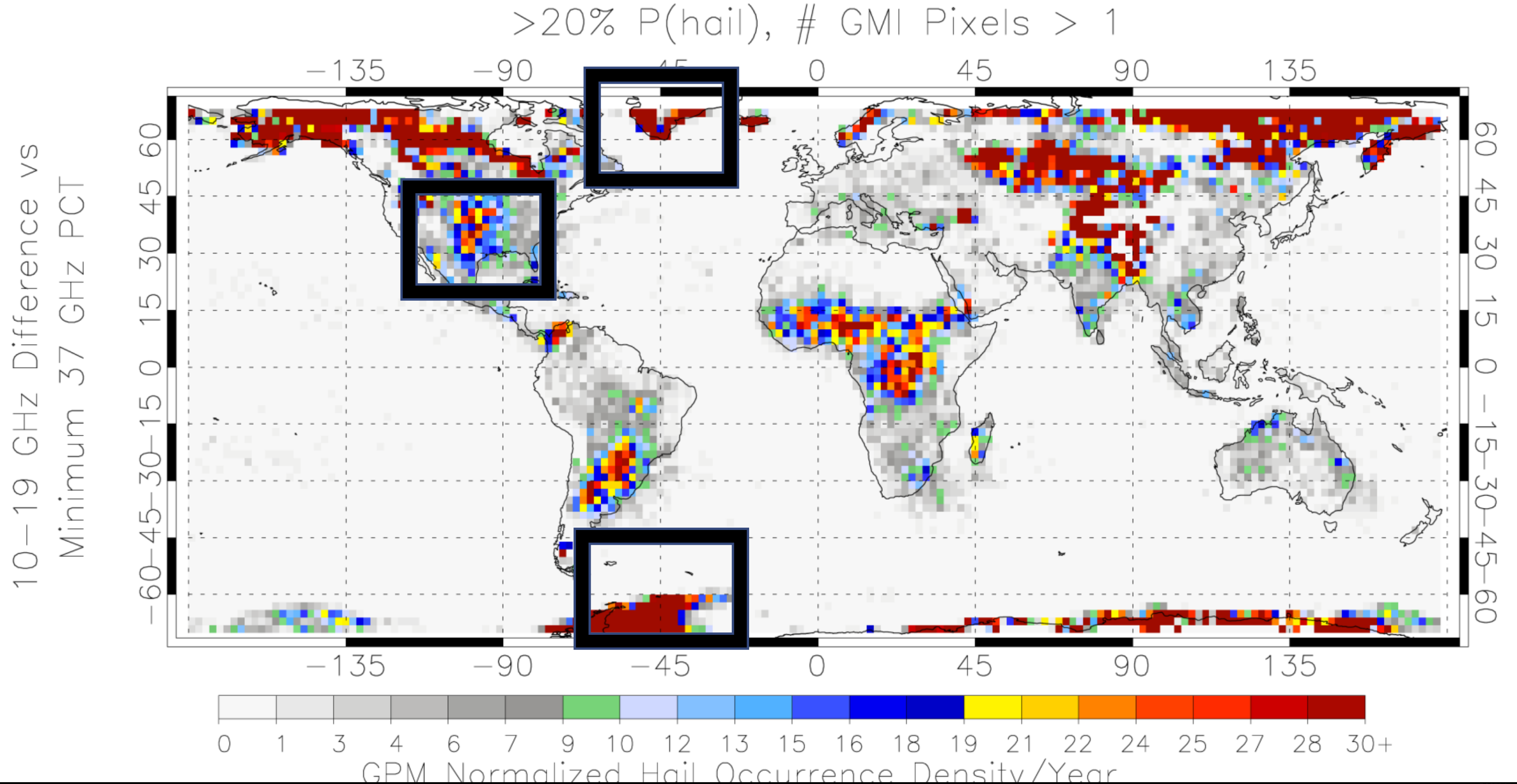
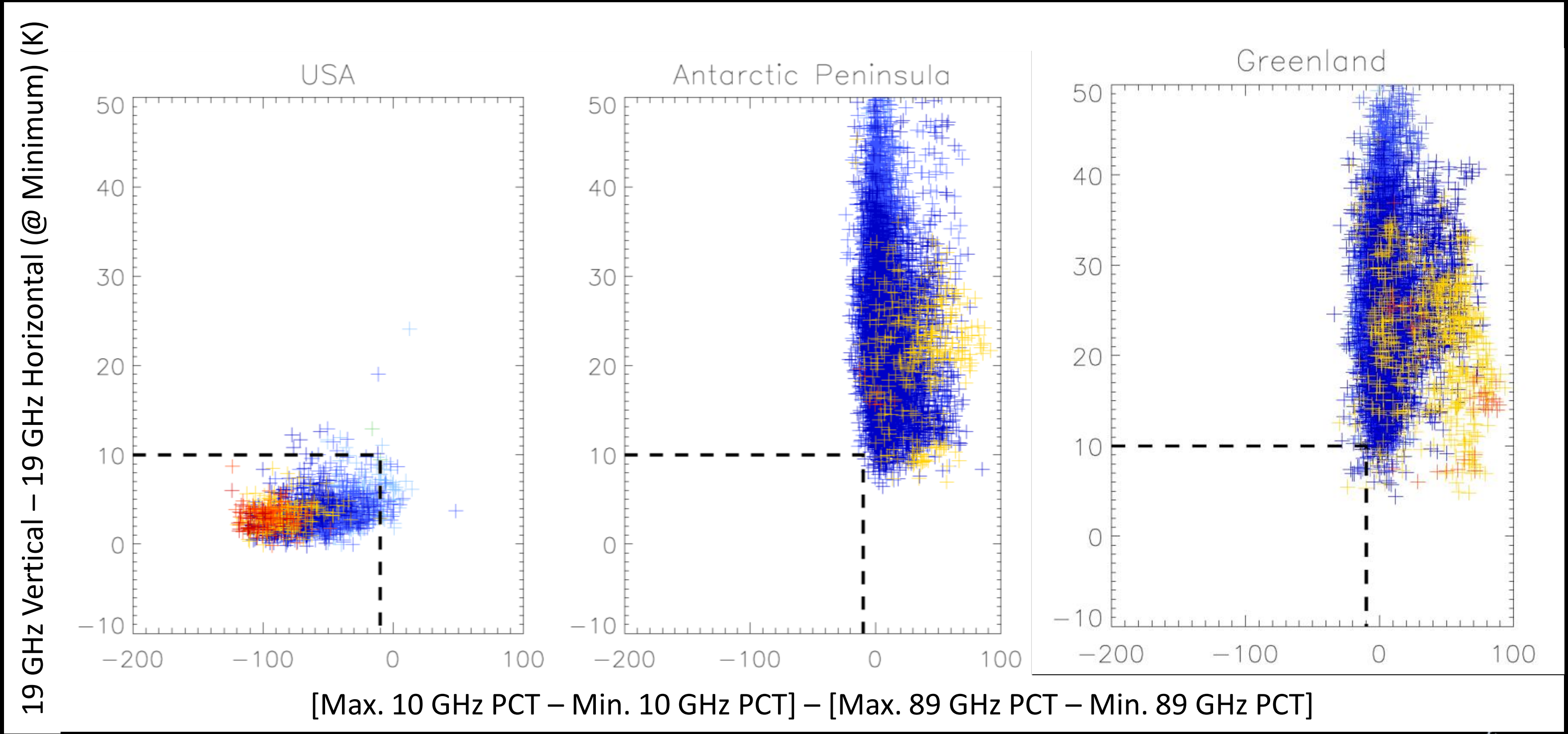


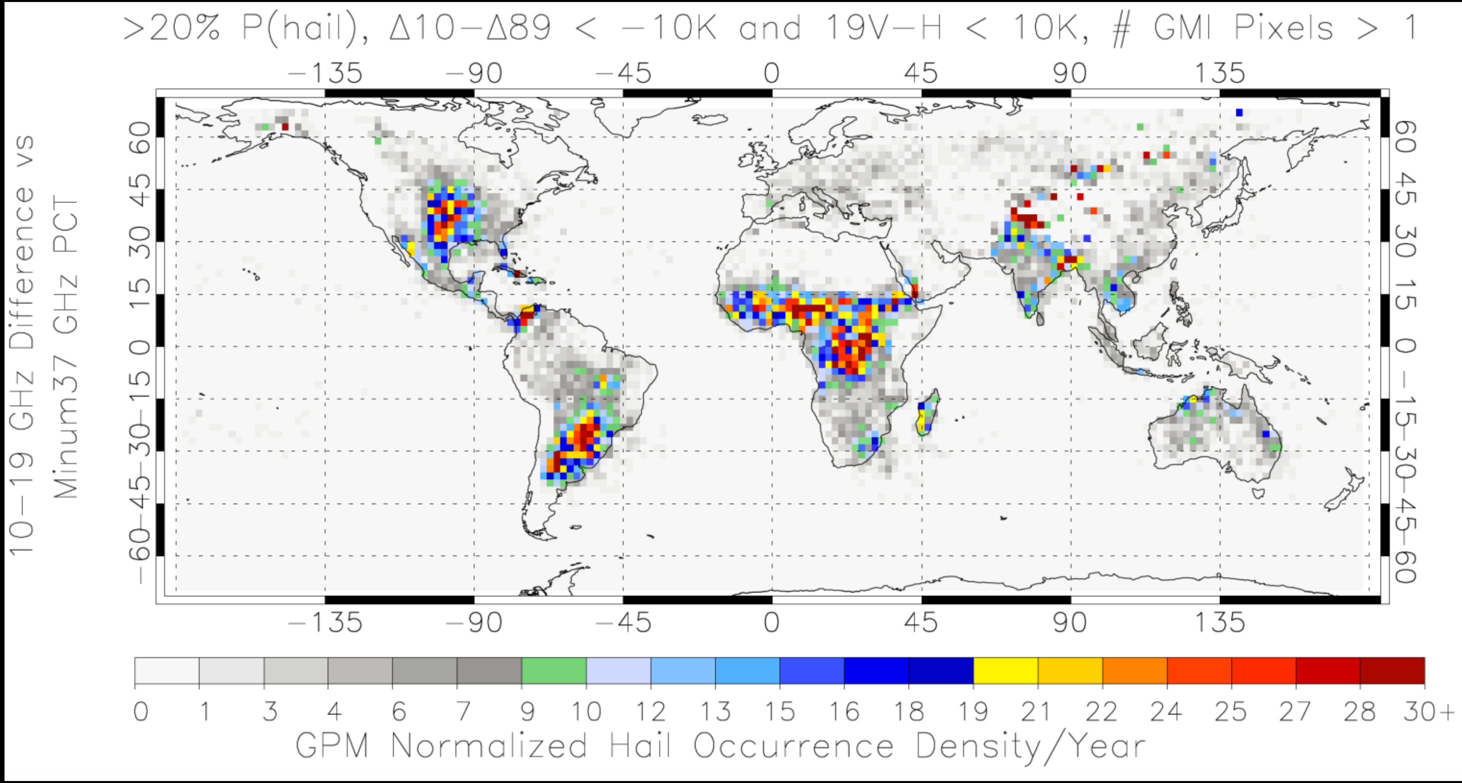
GPM Hail Climatology, Minimum 37 GHz PCT



Snow/Ice Filter



GPM Hail Climatology, Minimum 37 GHz PCT + Snow/Ice Filter



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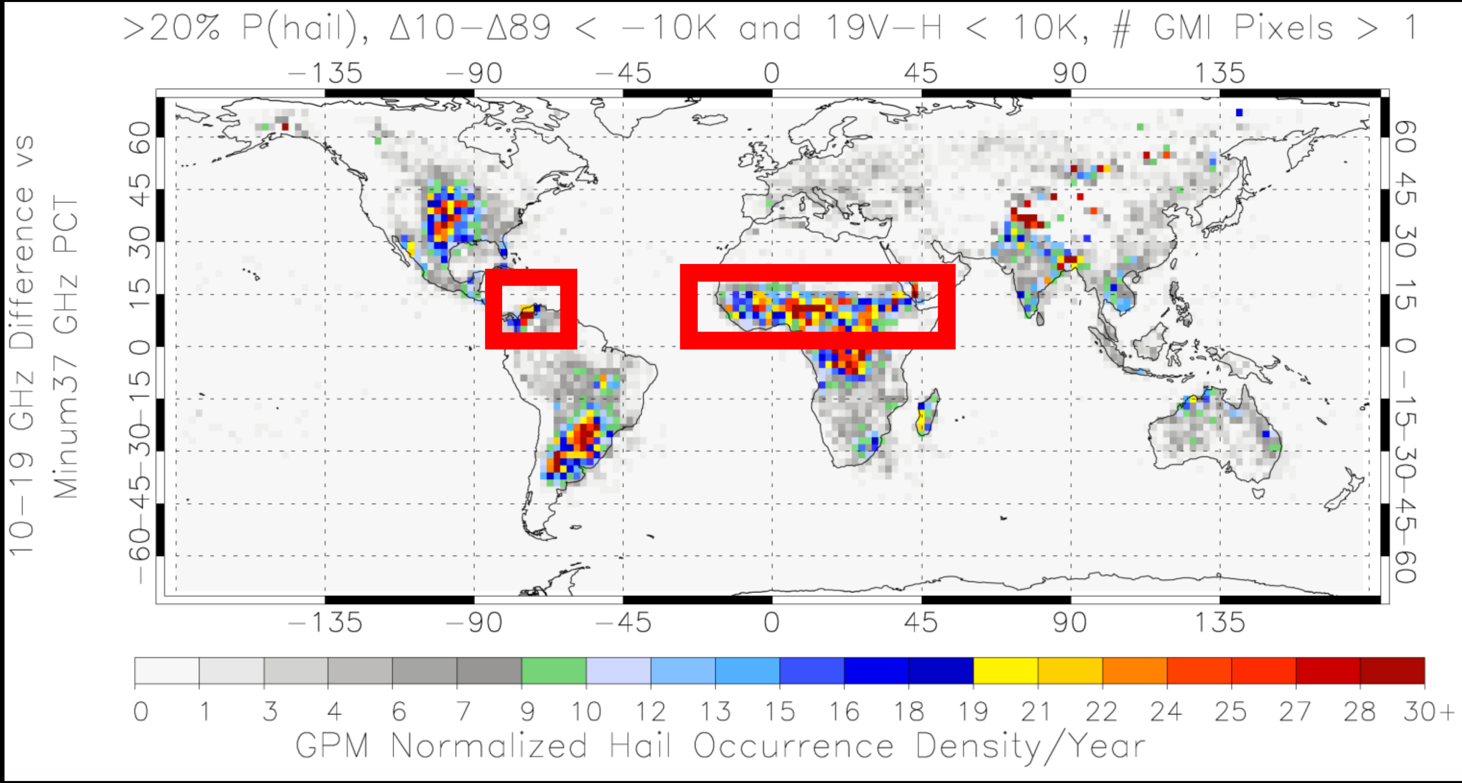
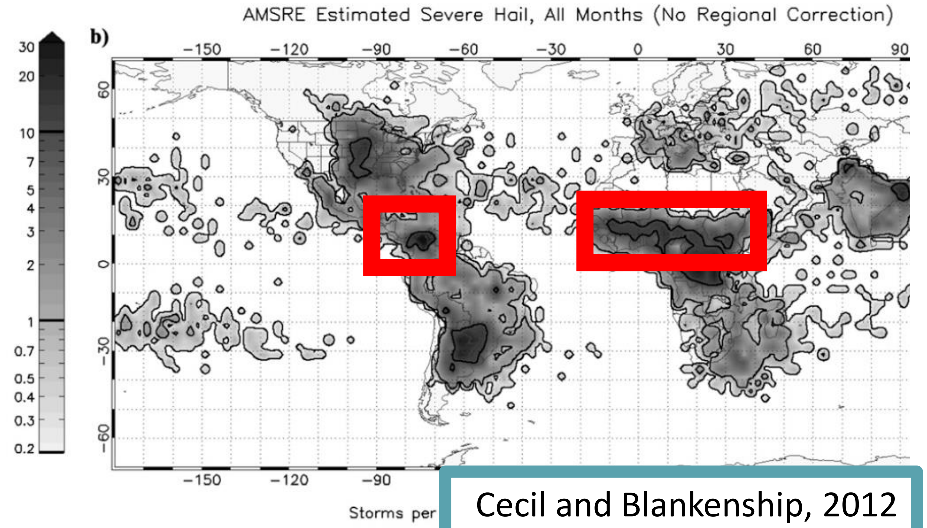
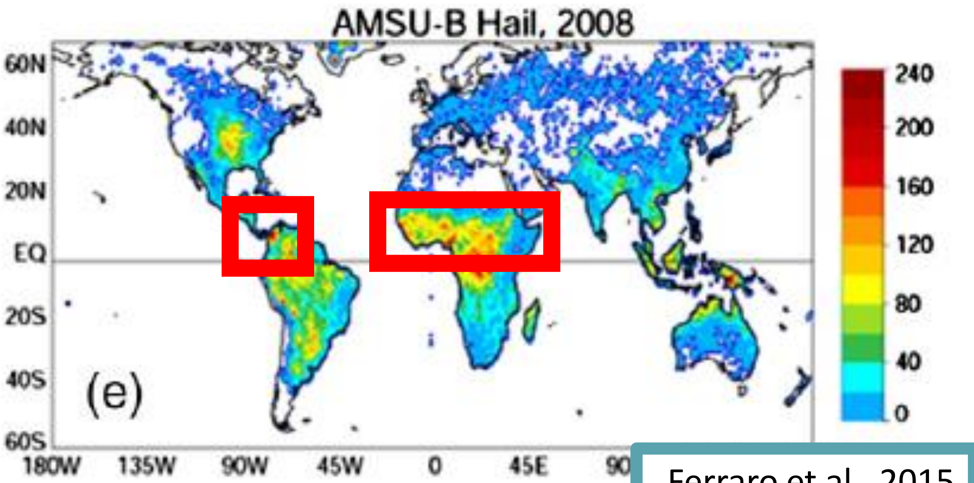




Cecil and Blankenship, 2012



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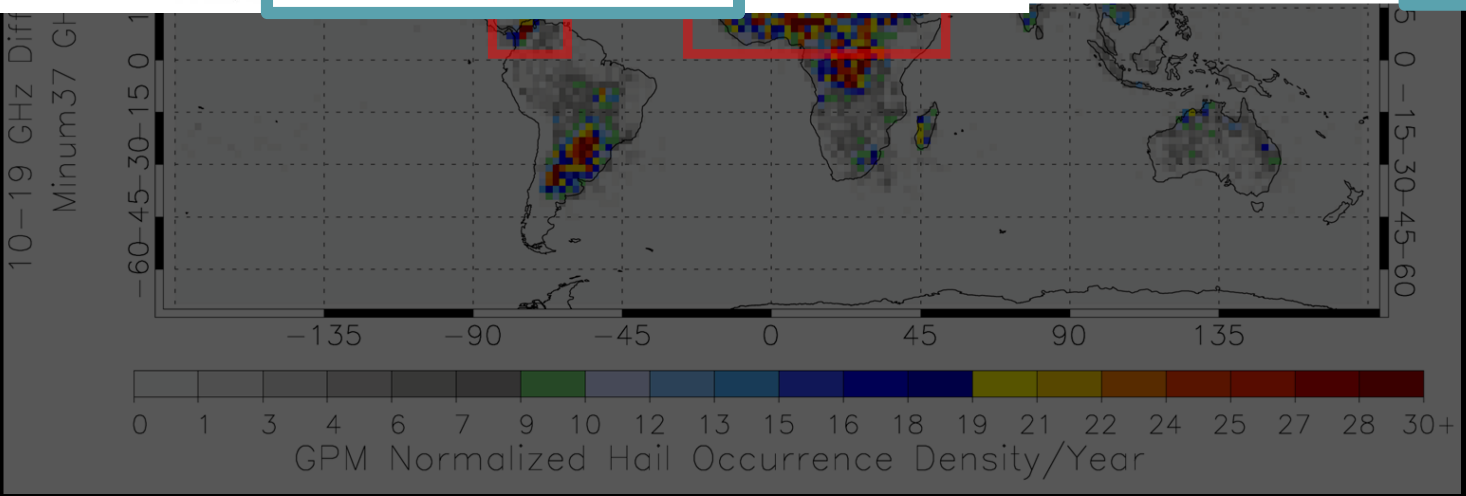

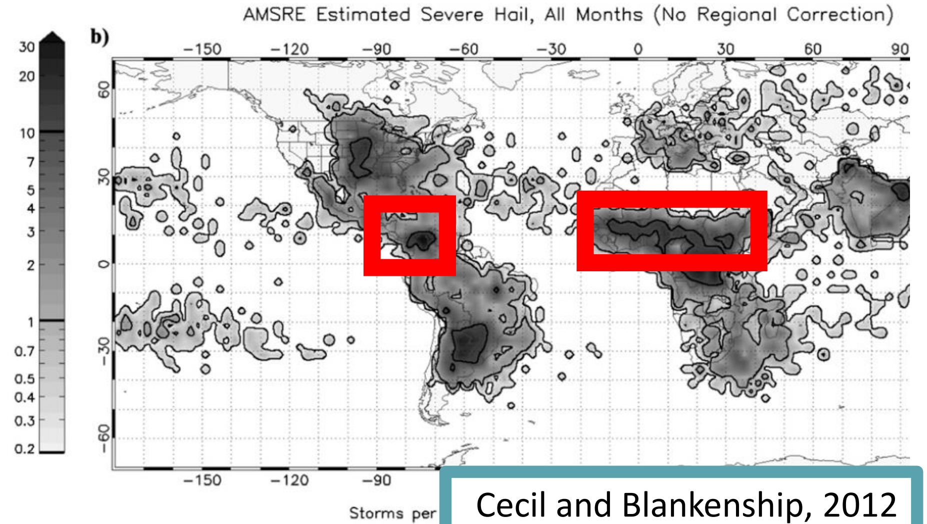

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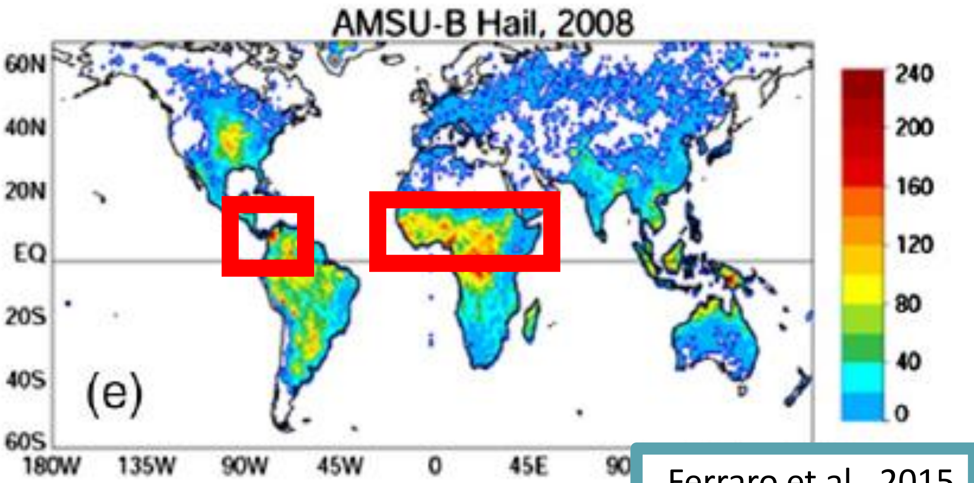

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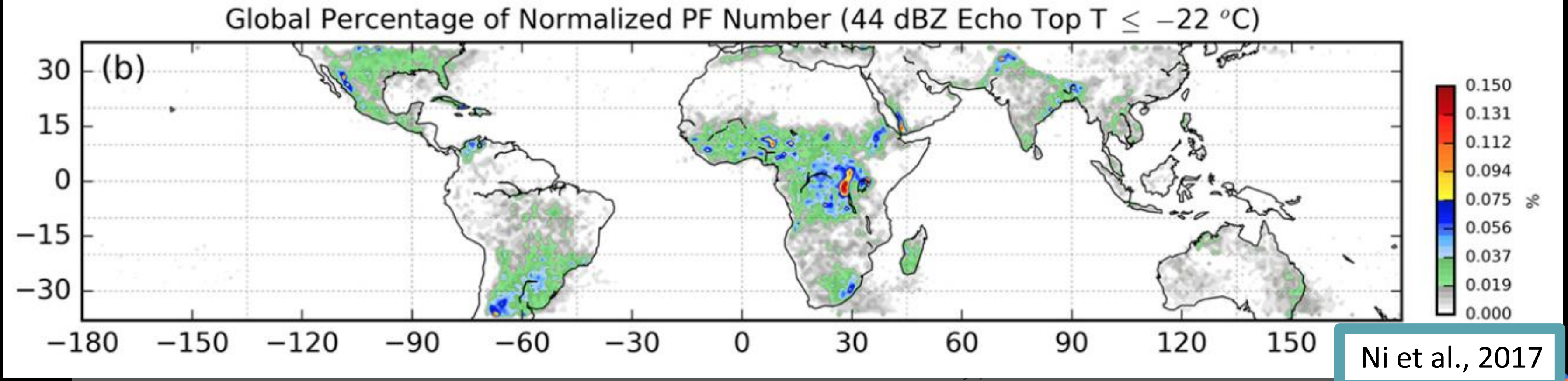
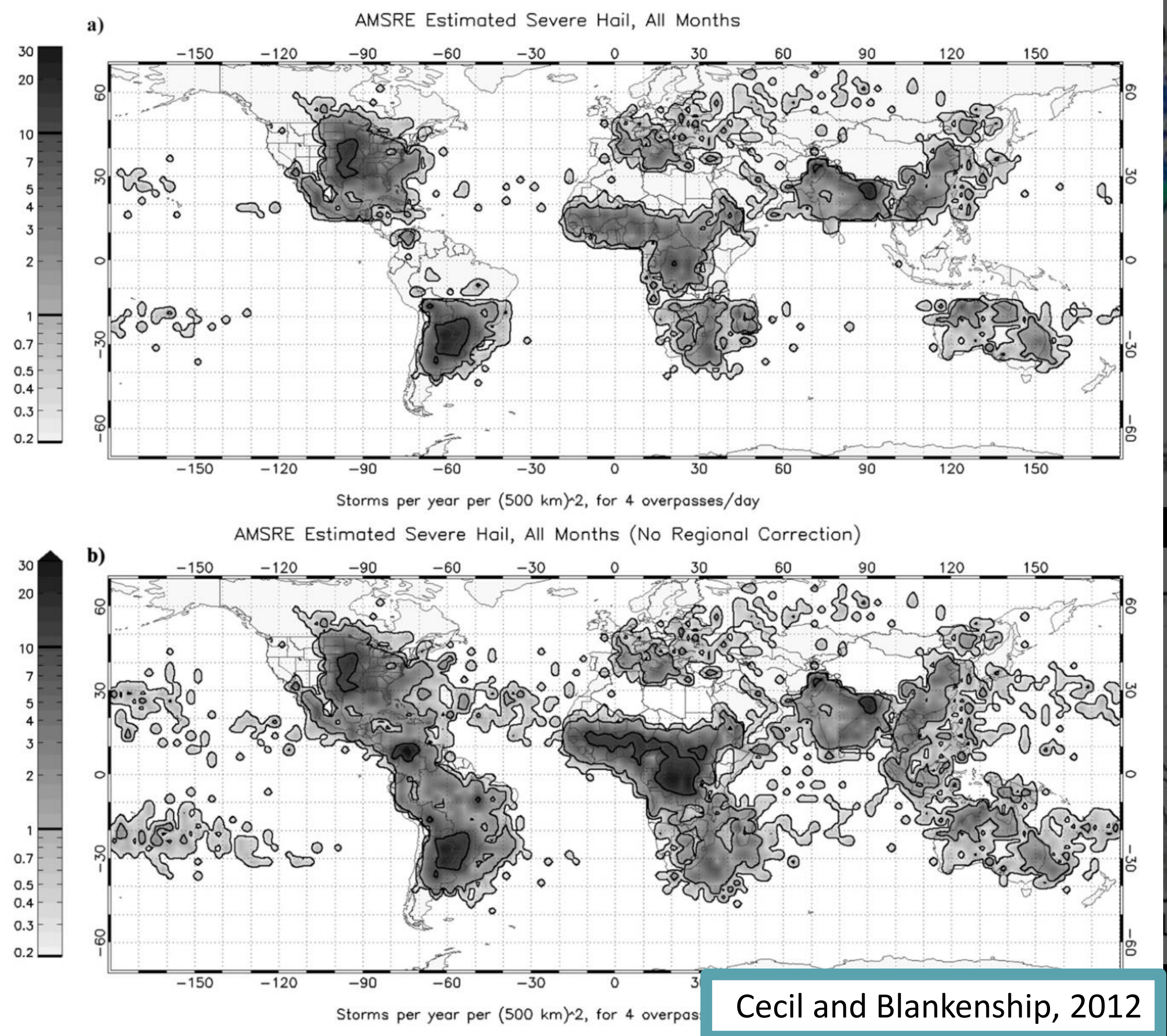
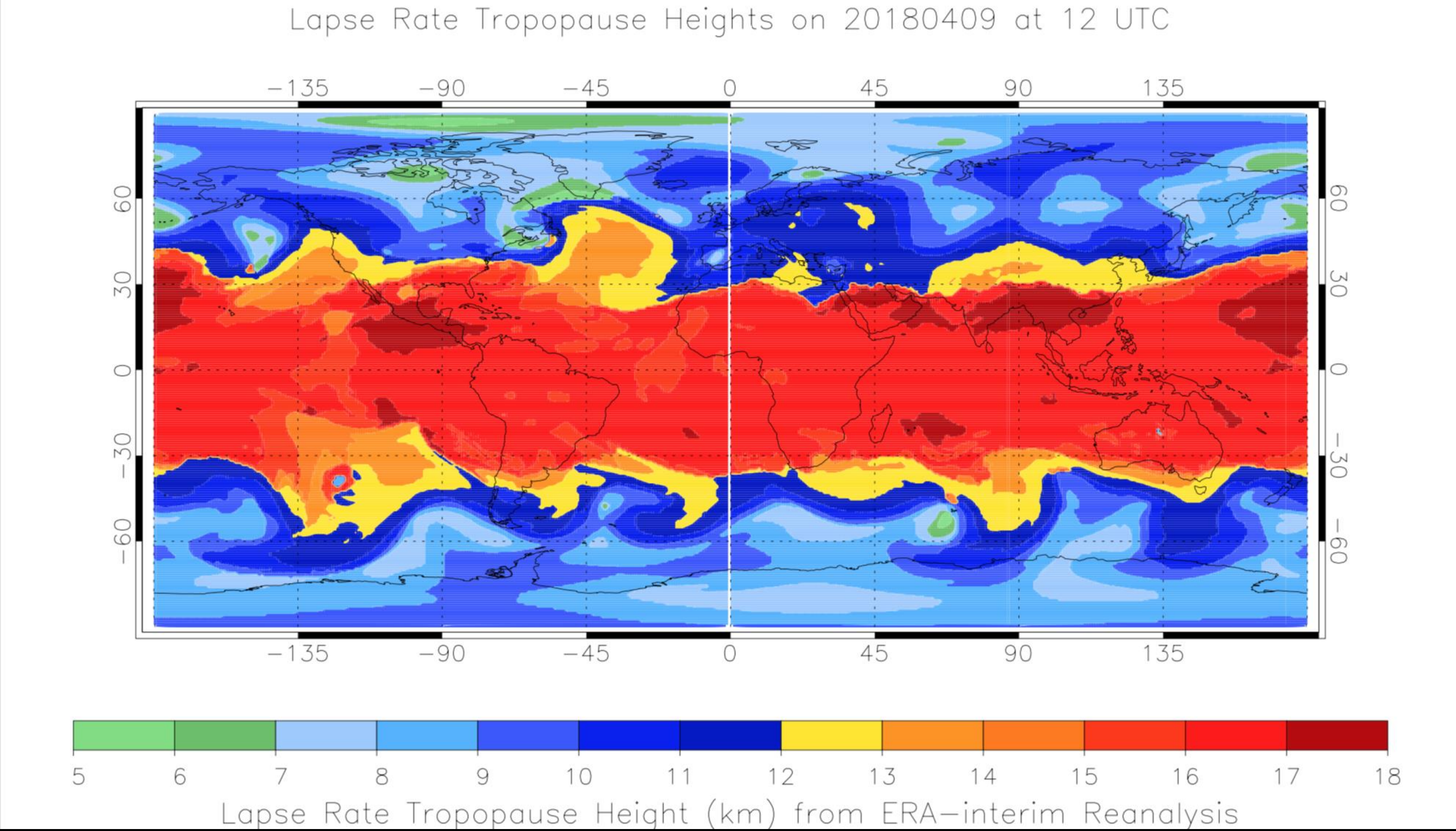


Ni et al., 2017



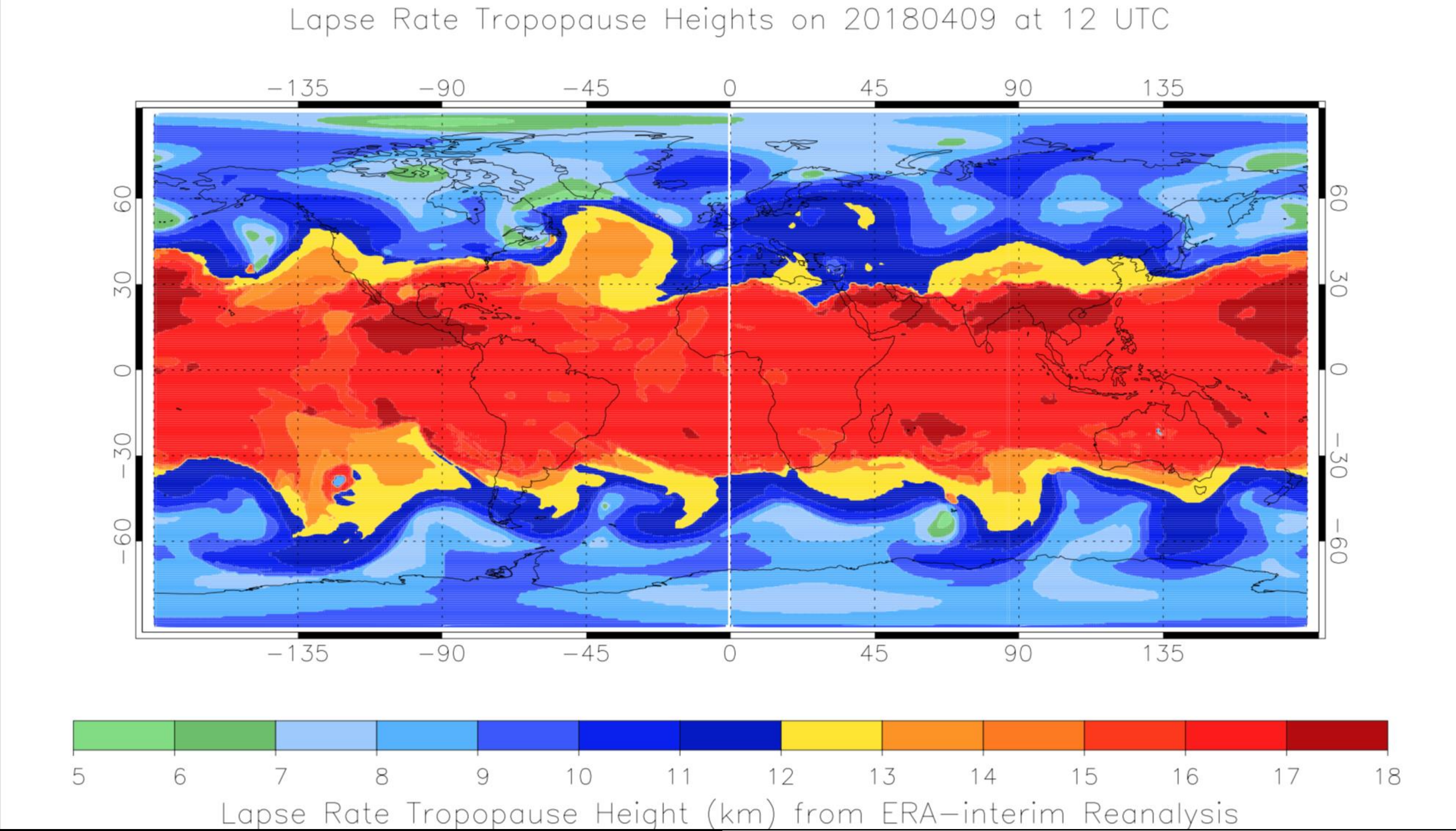
Cecil and Blankenship, 2012

Normalizing by Tropopause Height



LRT calculation performed by Nana Liu at Texas A&M Corpus Christi,
see Liu and Liu, 2018

Normalizing by Tropopause Height



LRT calculation performed by Nana Liu at Texas A&M Corpus Christi, see Liu and Liu, 2018

$$\text{Normalized 37 GHz PCT Depression} = \frac{MAX37PCT - MIN37PCT}{(1 + LRT - \overline{LRT}_{USA})}$$

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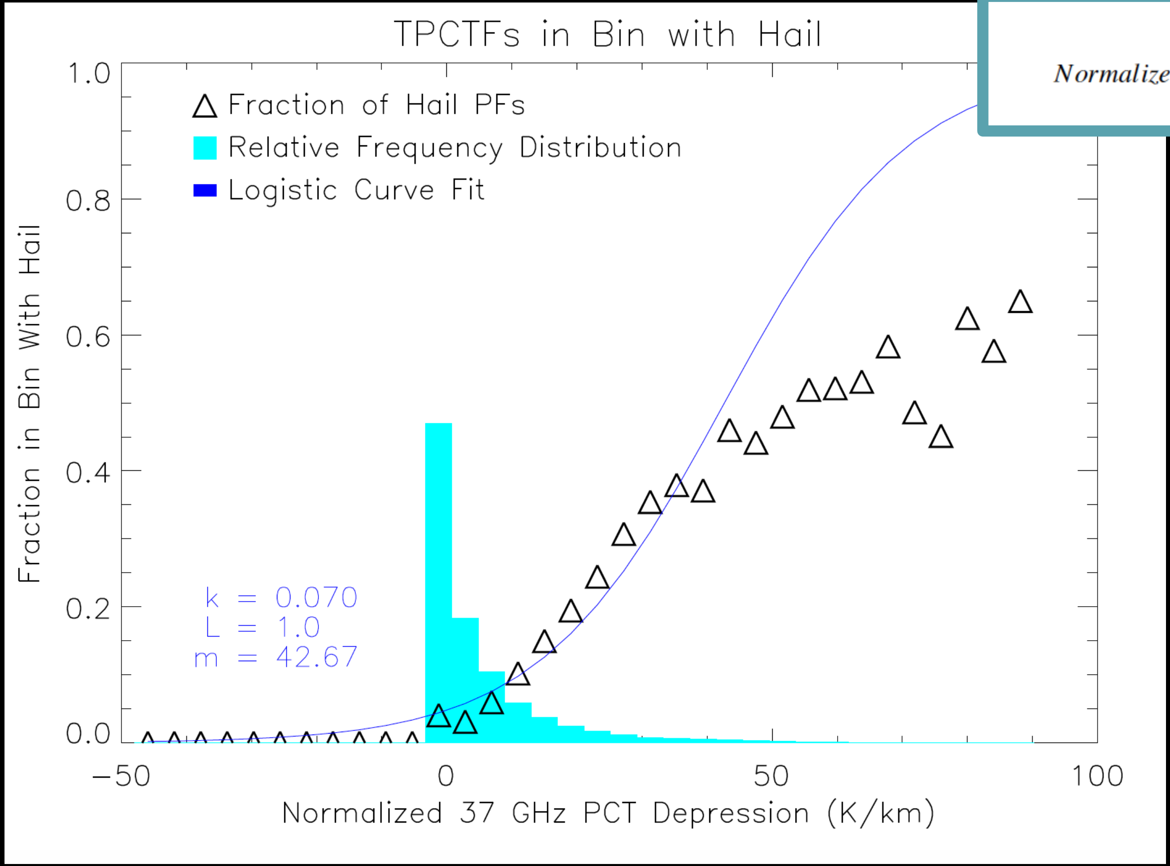

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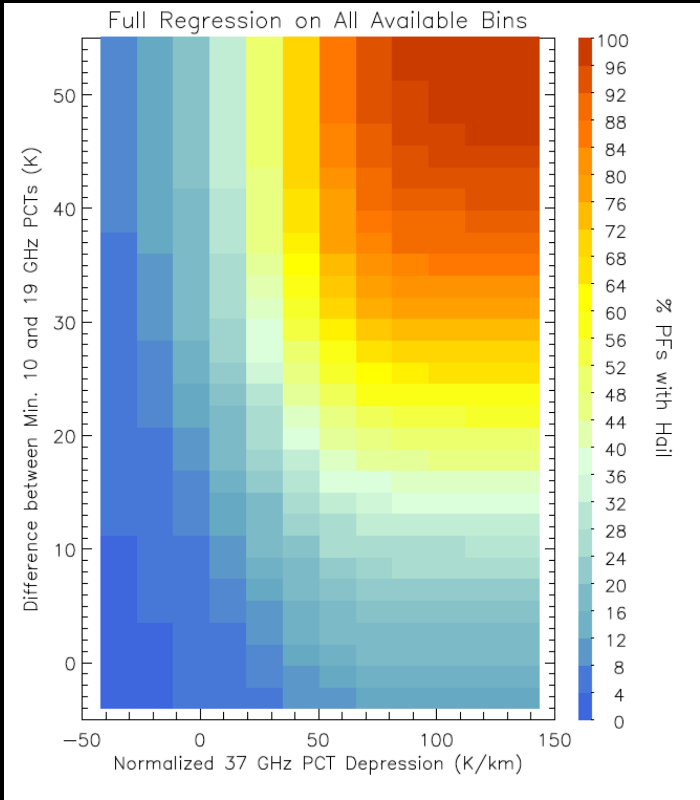
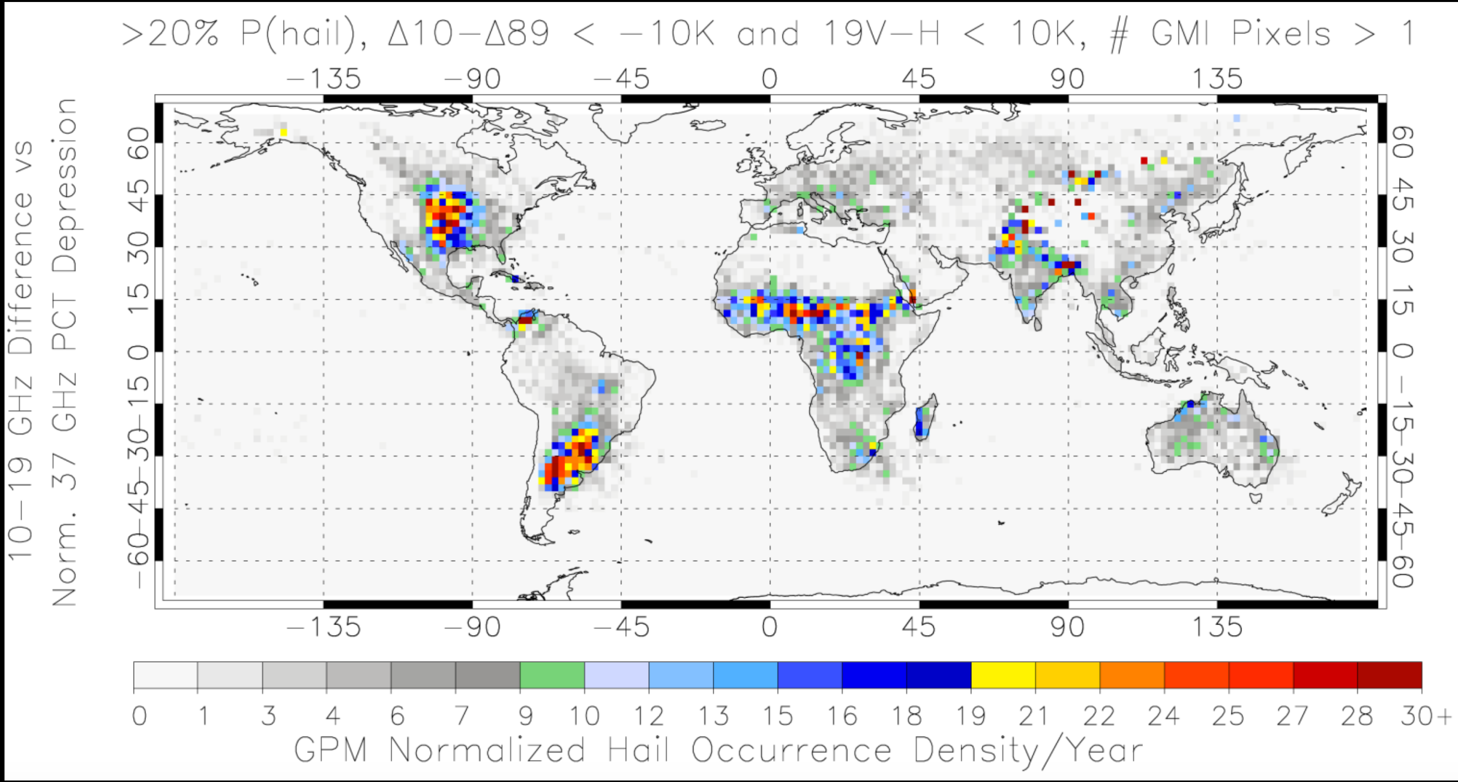
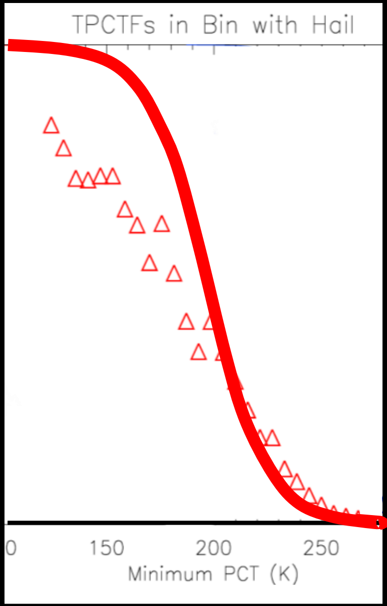
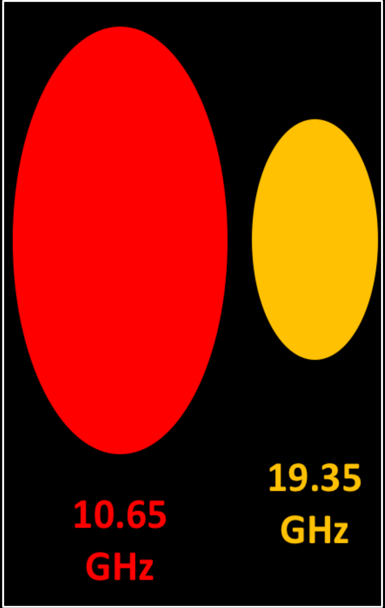


GPM Hail Climatology, Normalized 37 GHz PCT Depression + Snow/Ice Filter

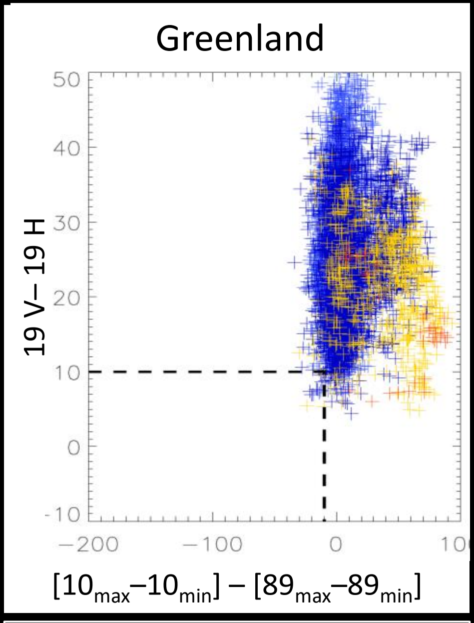




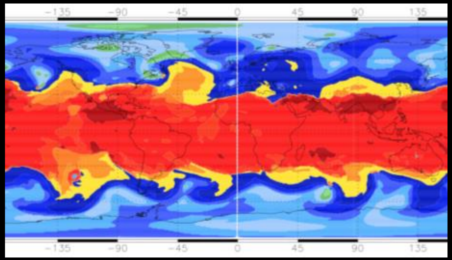
We fit logistic curves to the probability of hail for given TRMM/GPM microwave quantities, instead of assuming a threshold brightness temperature

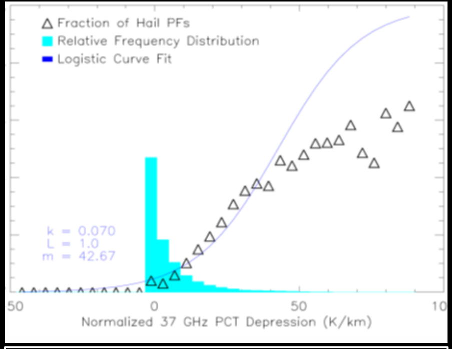


We create a new microwave variable, leveraging the minimum 19 GHz PCT (relative to a background state captured by the 10 GHZ PCT)



We propose a new microwave-based filter to remove features we suspect are over snowy and icy regimes, by leveraging the 19 GHz V-H difference and the difference between the 10-89 GHz PCT depressions.





We estimate hail probability using not only 10-19 GHz PCT difference, but also we normalize the 37 GHz PCT Depression by the height of the troposphere.

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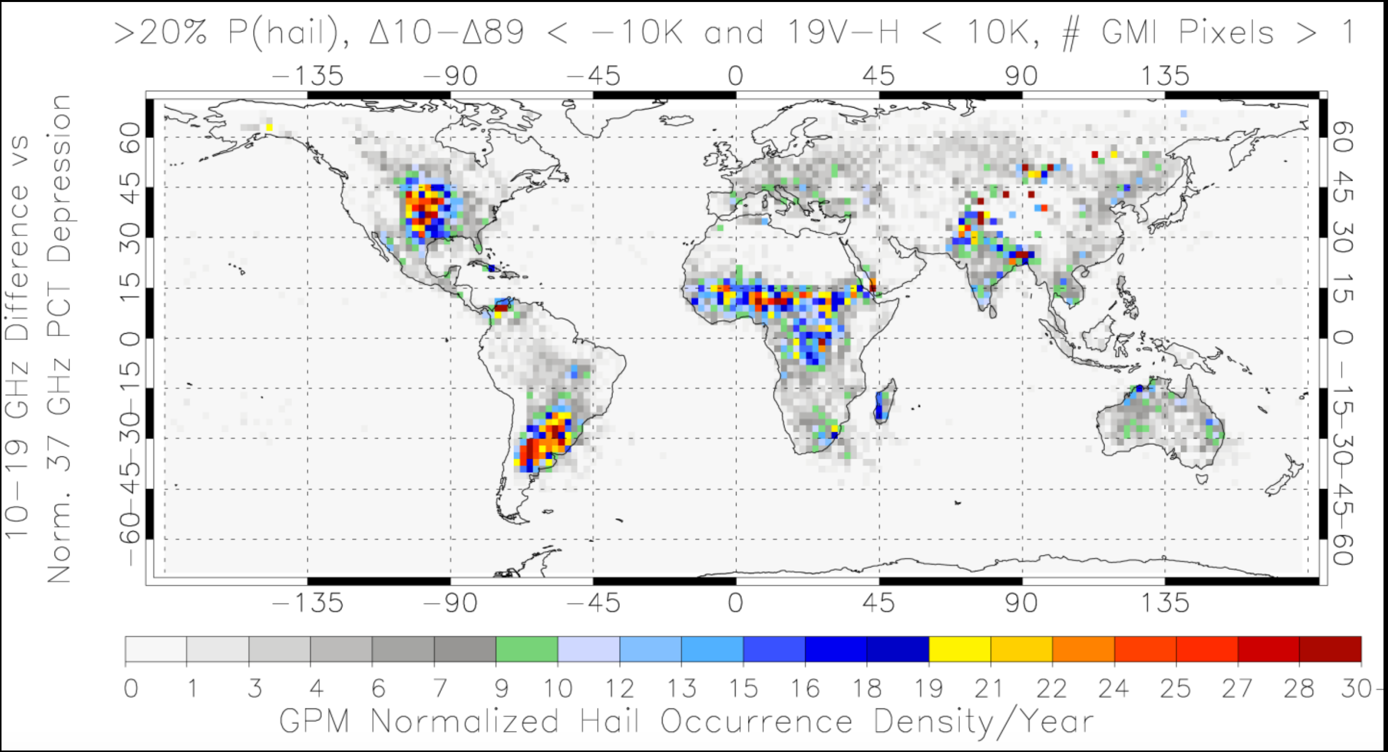
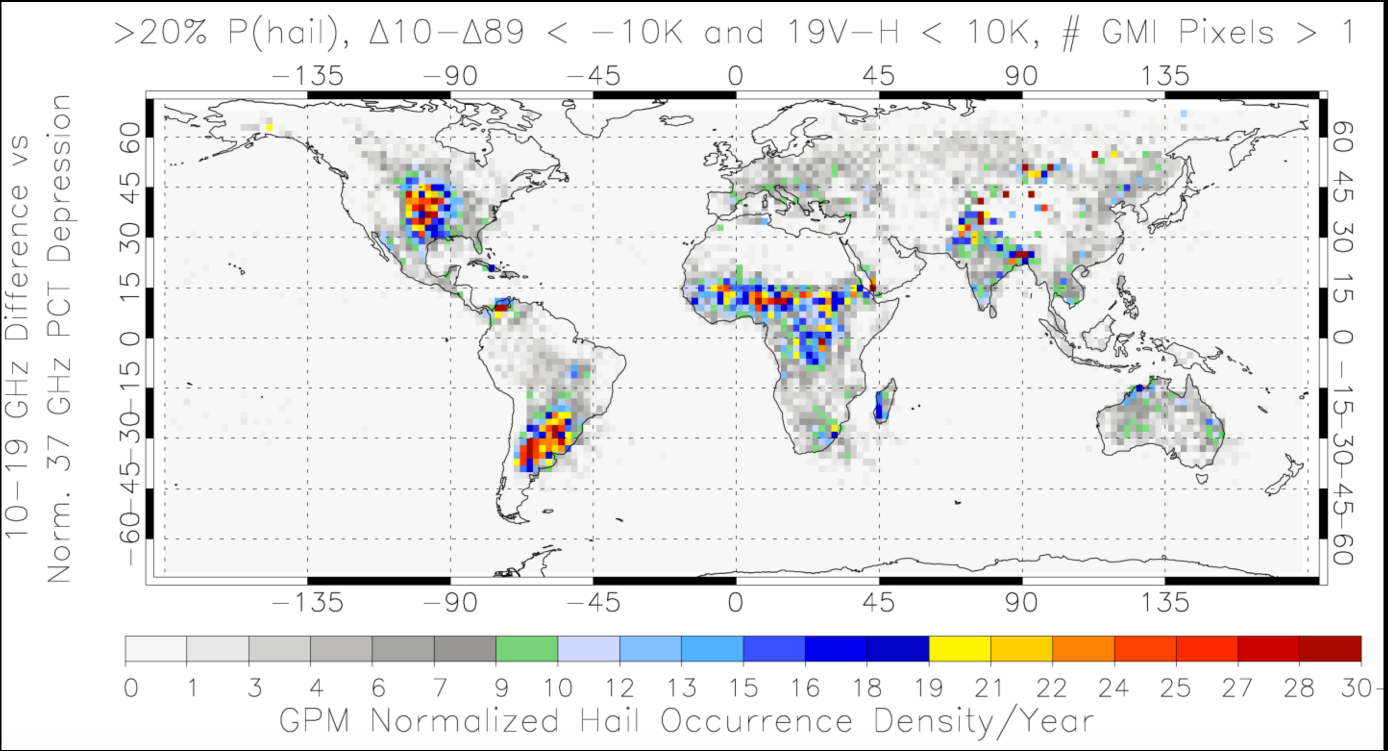


>20% P(hail), Δ10−Δ89 < −10K and 19V−H < 10K, # GMI Pixels > 1
10−19 GHz Difference vs Norm. 37 GHz PCT Depression
−135 −90 −45 0 45 90 135
60 45 30 15 0 −15 −30 −45 −60
0 1 3 4 6 7 9 10 12 13 15 16 18 19 21 22 24 25 27 28 30
GPM Normalized Hail Occurrence Density/Year



Contact us at:

Sarah.D.Bang@nasa.gov

Daniel.J.Cecil@nasa.gov

Thank You!

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