Extremely Low Passive Microwave Brightness Temperatures Due To Thunderstorms

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Data Sources

- SSMI data from NCDC, calibrated by Colorado State University
  - ➢ *SSMI grouped into precipitation features by Chuntao Liu, TAMU-CC*
- AMSR-E data from NSIDC, calibrated by AMSR-E science team
  - ➢ *AMSR-E grouped into precipitation features by Clay Blankenship, USRA*
- TMI data from NASA PPS, grouped into precipitation features
- GMI data V03B from PPS, grouped into precipitation features by Chuntao Liu, TAMU-CC

Objectives

1) document the lower limits on brightness temperatures from previously observed storms

- From TMI, SSMI, AMSR-E, GMI

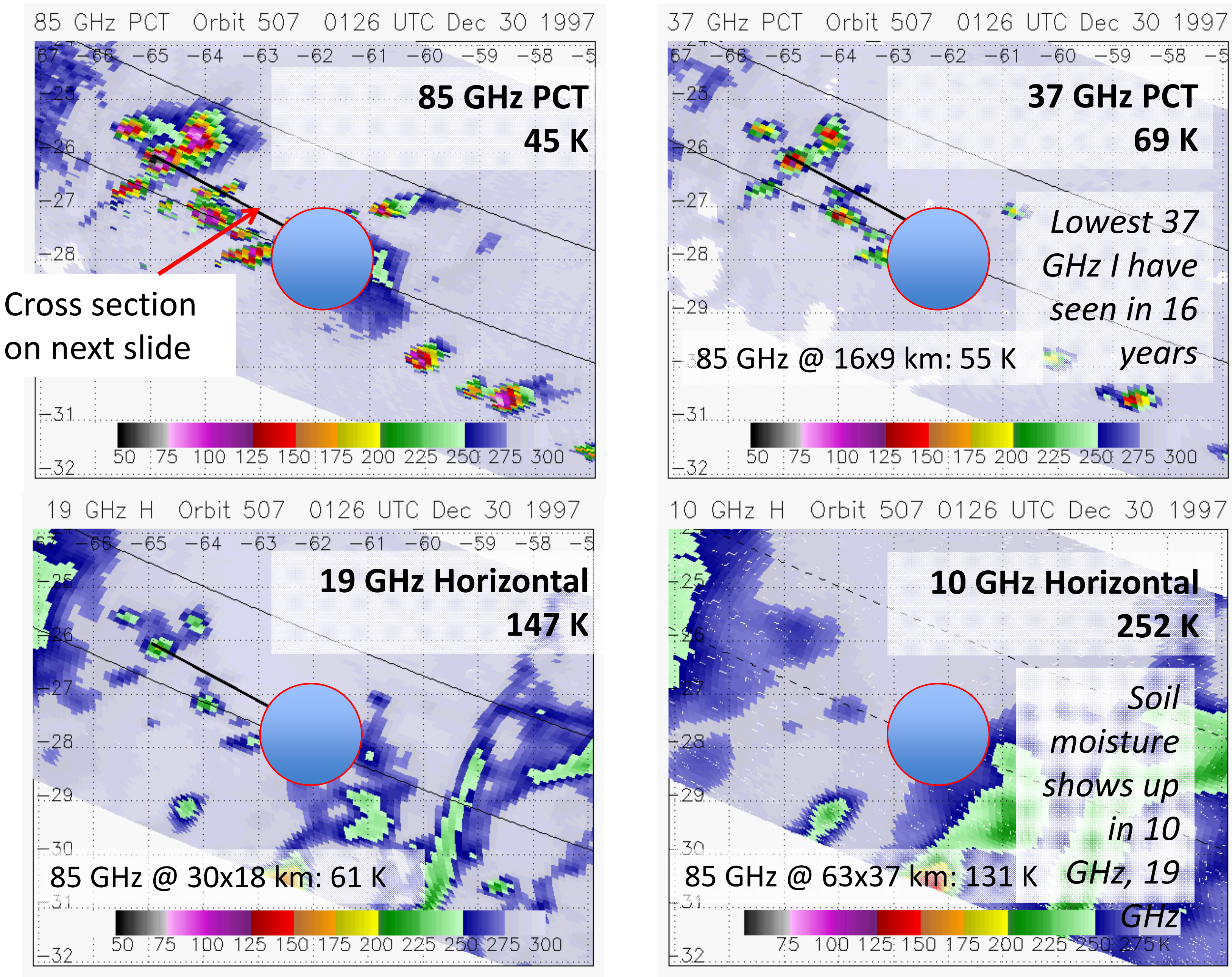
    Spoiler Alert: ~40 K @ 85 GHz, ~70 K @ 37 GHz

2) map the locations where the "strongest of the strong" storms do occur.

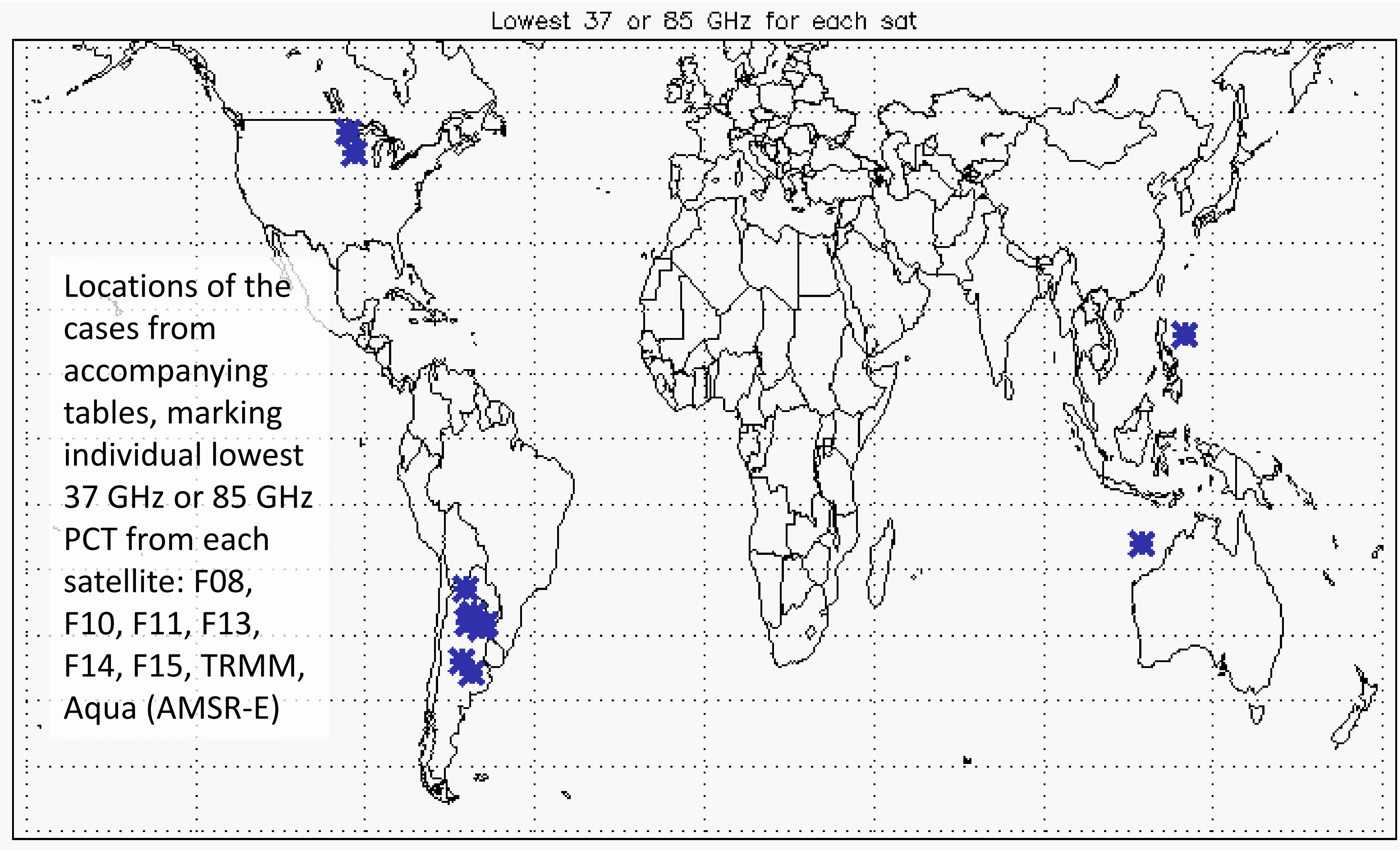
    Spoiler Alert: mostly northern Argentina

3) describe objective methods for identifying valid measurements of extreme storms and separating out the measurements likely compromised by noise (*filtering at the storm-level, not pixel-level)*

TRMM case with lowest 37 GHz; northern Argentina



Most extreme cases from each satellite



Sensors Used

SSMI data from CSU; AMSR-E from NSIDC; TMI from TSDIS/PPS

Sensor / Platform	Period of record	37 GHz footprint	85 GHz footprint	mode time of day
SSMI / F08	Jul 1987 Dec 1988	37 x 29 km	15 x 13 km	5-7 am; 5-7 pm 5 am NH; 5 pm SH
SSMI / F10	Dec 1990 Nov 1997	37 x 29 km	15 x 13 km	8-11 am; 8-11 pm 10 am NH; 10 pm SH
SSMI / F11	Dec 1991 Mar 2000	37 x 29 km	15 x 13 km	5-8 am; 5-8 pm 7 am NH; 7 pm SH
SSMI / F13	May 1995 Nov 2009	37 x 29 km	15 x 13 km	5-7 am; 5-7 pm 5 pm NH; 5 am SH
SSMI / F14	May 1997 Aug 2008	37 x 29 km	15 x 13 km	7-10 am; 7-10 pm 8 pm NH; 8 am SH
TMI / TRMM	Dec 1997 Oct 2014	16 x 9 km	7 x 5 km	any
AMSR-E / Aqua	Jul 2002 Feb 2010	14 x 8 km	6 x 4 km	~2 AM and PM
GMI	Mar –Oct 2014	14 x 9 km	7 x 4 km	any

Lowest 85 GHz PCT

SSMI Min 85 GHz generally in 50's K for 13x15 km footprint

Note: F08 SSMI 85 GHz became too noisy to search beyond March 1988.

Sensor / Platform	Date	Time UTC / LST	Lon	Lat	Min 37	**Min 85**	Location	Notes
SSMI F08	09 Mar 1988	2153 / 6 pm	64.56 W	34.01 S	182.4	**77.0**	Cordoba, **Argentina**	-
SSMI F10	30 Dec 1996	1455 / 11 pm	116.11 E	16.07 S	187.4	**60.8**	Eastern Indian Ocean	Cyclone Phil (sheared, weakening)
SSMI F11	28 Jun 1998	0026 / 9 pm	92.67 W	43.78 N	119.1	**63.4**	Minnesota, **USA**	Same as F11 case for 37 GHz
SSMI F13	16 Nov 1998	2205 / 6 pm	63.46 W	23.01 S	129.2	**51.0**	Salta, **Argentina**	Same as F13 case for 37 GHz
SSMI F14	30 Dec 1997	0046 / 9 pm	62.22 W	27.93 S	129.4	**58.3**	Santiago del Estero, **Argentina**	Same as TMI case for 37 GHz
SSMI F15	13 Nov 2009	2152 / 6 pm	59.37 W	28.70 S	124.4	**53.6**	Santa Fe, **Argentina**	Same as F15 37 GHz case

Lowest 85 GHz PCT

Higher resolution sensors see Min85/89 GHz ~40 K

Sensor / Platform	Date	Time UTC / LST	Lon	Lat	Min 37	**Min 85**	Location	Notes
TMI TRMM	14 Nov 2009	0109 / 9 pm	58.14 W	28.15 S	123.0	**39.4**	Corrientes, **Argentina**	
AMSR-E Aqua	18 Nov 2005	0502 / 1 pm	127.33 E	15.90 N	109.7	**41.1**	**Philippine Sea**	Typhoon Bolaven
GPM GMI	9 May 2014	1509 / 9 pm	92.16 E	24.84 N	116.6	**46.3**	**Bangladesh**	

GMI initial analysis limited to 8 March – 31 October 2014

Lowest 37 GHz PCT

Min 37 GHz generally in the 120's K for 37x29 km SSMI footprint

Sensor / Platform	Date	Time UTC / LST	Lon	Lat	**Min 37**	Min 85	Location	Notes
SSMI / F08	12 Dec 1988	2202 / 6 pm	62.78 W	27.84 S	**146.9**	88.7	Santiago del Estero, **Argentina**	
SSMI / F10	22 Dec 1991	0104 / 9 pm	61.25 W	26.72 S	**120.9**	64.5	Chaco, **Argentina**	
SSMI / F11	28 Jun 1998	0026 / 6 pm	92.67 W	43.78 N	**119.1**	63.4	Minnesota, **USA**	1.75" hail, 81 kt wind
SSMI / F13	16 Nov 1998	2205 / 6 pm	63.46 W	23.01 S	**129.2**	51.0	Salta, **Argentina**	
SSMI / F14	04 Jul 1999	1507 / 9 am	94.22 W	47.02 N	**123.8**	64.9	Minnesota, **USA**	"Boundary Waters Derecho". Tornado, hail, wind damage reported.
SSMI F15	13 Nov 2009	2152 / 6 pm	59.23 W	28.76 S	**124.4**	53.6	Santa Fe, **Argentina**	Same as F15 85 GHz case

Lowest 37 GHz PCT

Higher resolution sensors see Min37/36 GHz below 100 K, down to 68 K *so far*

Sensor / Platform	Date	Time UTC / LST	Lon	Lat	**Min 37**	Min 85	Location	Notes
TMI / TRMM	30 Dec 1997	0127 / 9 pm	62.05 W	27.67 S	**68.1**	44.1	Santiago del Estero, **Argentina**	40 dBZ radar echo above 19 km. See Zipser et al. (2006 and Table 3)
AMSR-E / Aqua	05 Jan 2010	1824 / 2 pm	61.78 W	35.69 S	**79.6**	56.8	Buenos Aires, **Argentina**	153 K 18-GHz
GMI	28 Oct 2014	2059 / 5 pm	59.94 W	34.14 S	**91.1**	46.4	Buenos Aires, **Argentina**	Tornado, hail, flood

GMI initial analysis limited to 8 March – 31 October 2014

Filters for distinguishing storms from noise

Storms have spatially coherent TB patterns that help distinguish them from "noise"

"Precipitation Features"(PFs) are clusters of pixels with 85 GHz < 250 K

Basic statistics from the PFs objectively screen much of the noise

Snow/Ice: Very large areas of 85 GHz < 250 K are from snow/ice cover, not storms.

Npixels > 5000 → snow

Small Storms: Noise often occurs in isolated pixels. Storms that occur in isolated pixels are usually too weak to be of interest here. If a storm really has 85 GHz < 100 K, it probably has a few adjoining pixels below 150 K and several more below 250 K.

Nlt150 < 3 or nlt250 lt 4 → possible noise

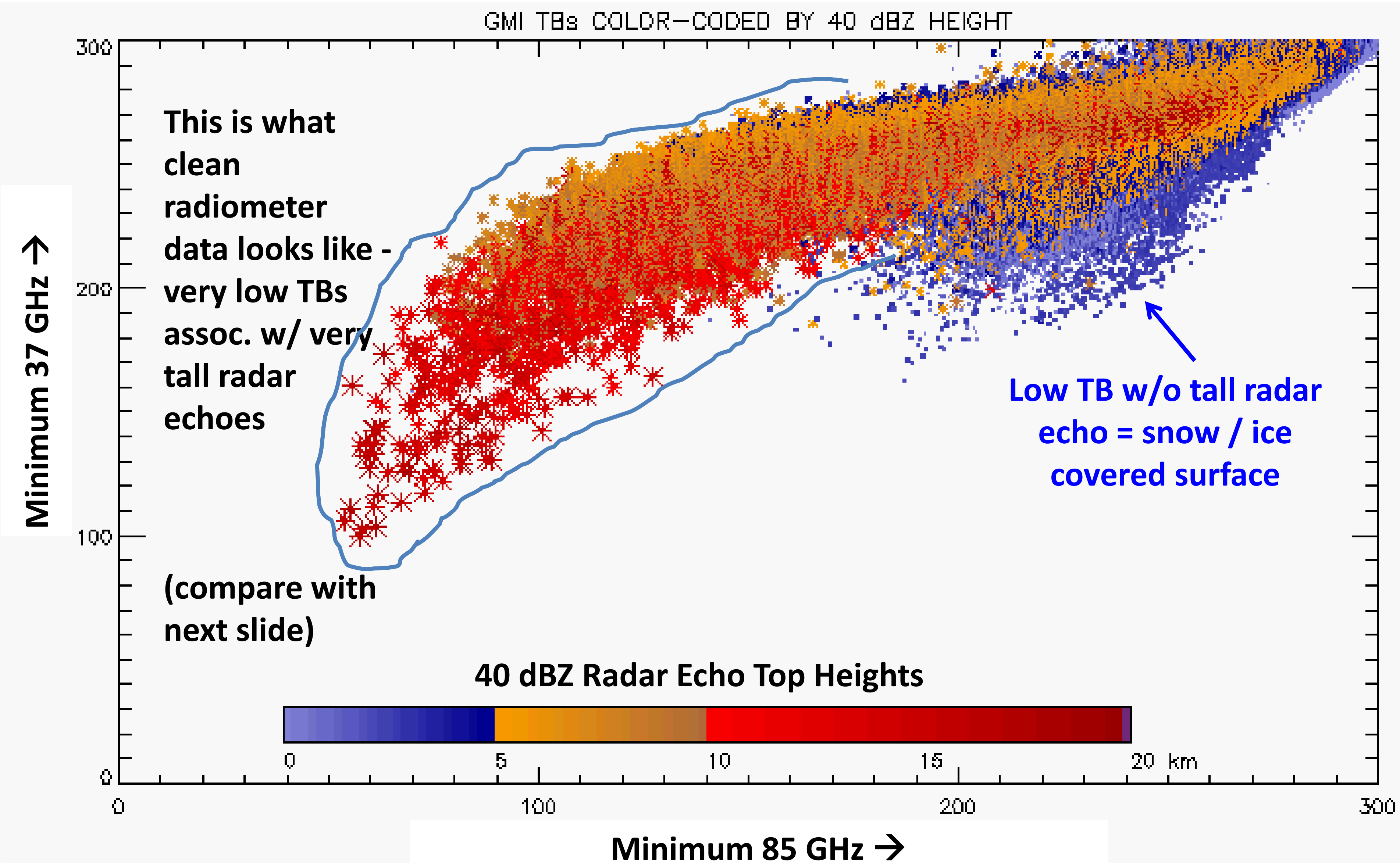
All Pixels <150 K: If there is a cluster of pixels below 150 K without any adjoining pixels < 250 K, that is very likely instrument noise.

Nlt150 = nlt250 → very likely noise

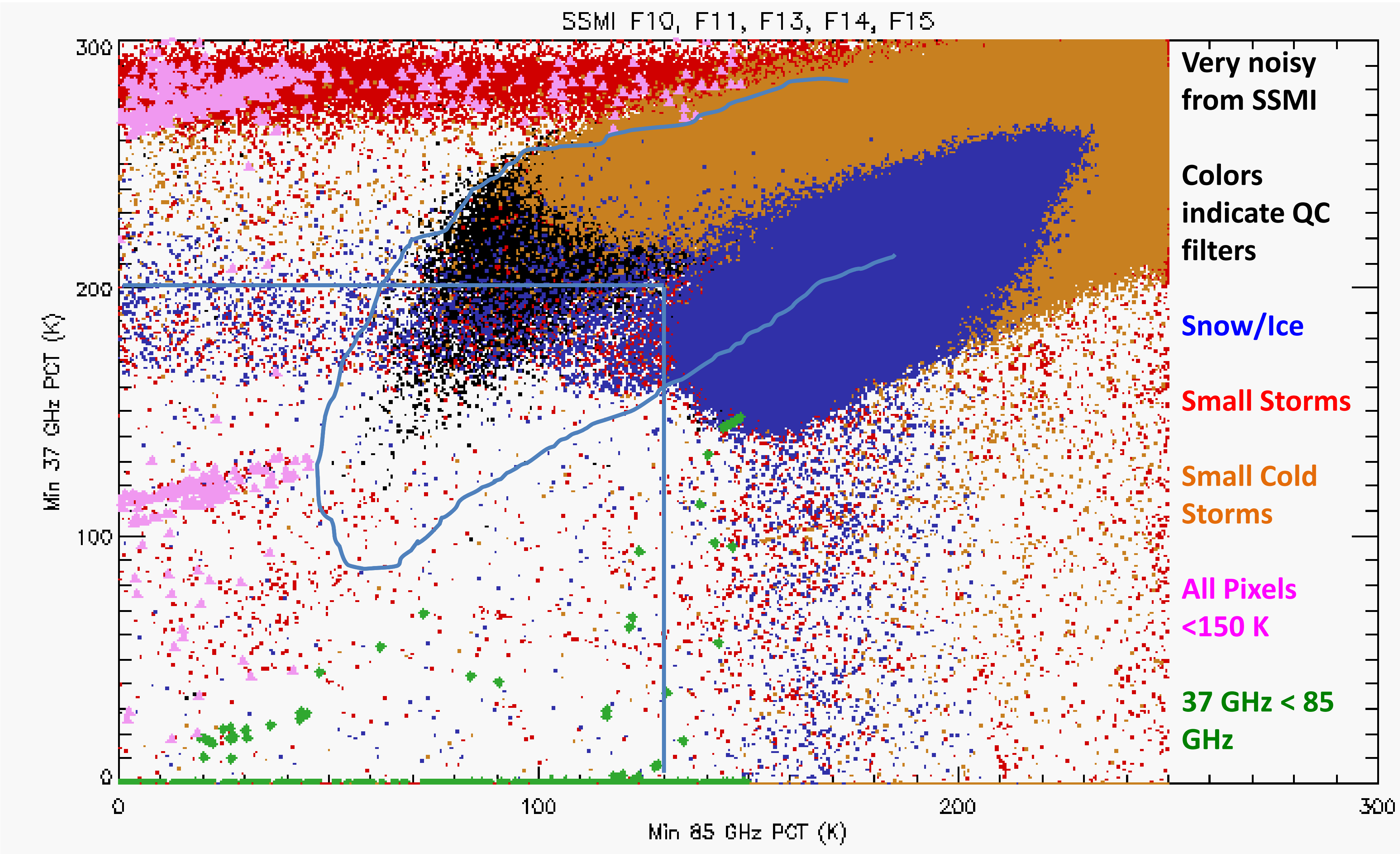
37 GHz < 85 GHz: Not a physical result of strong thunderstorms at current footprint sizes.

Min37 = Min85 → definitely noise

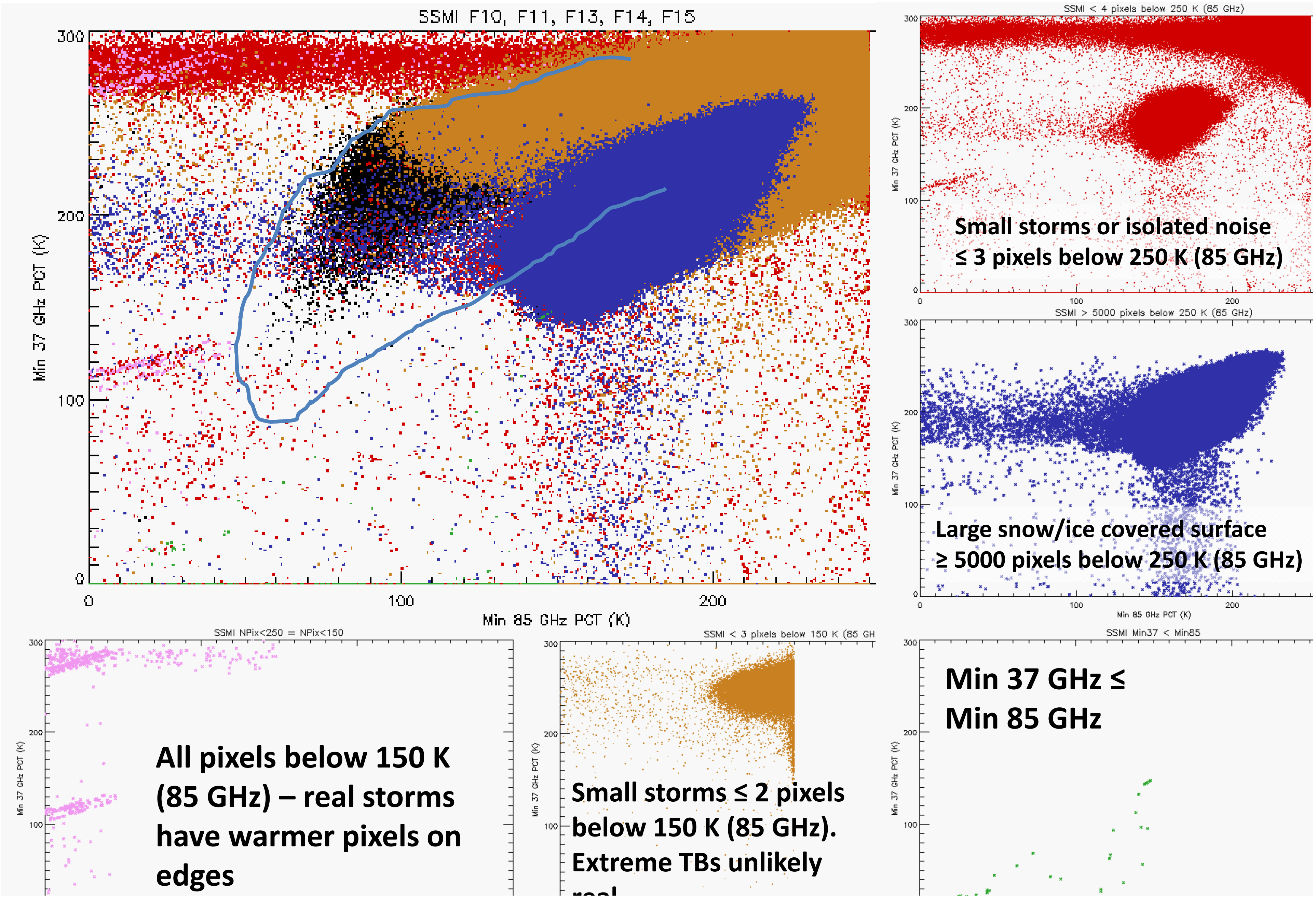
85 vs 37 GHz from GMI



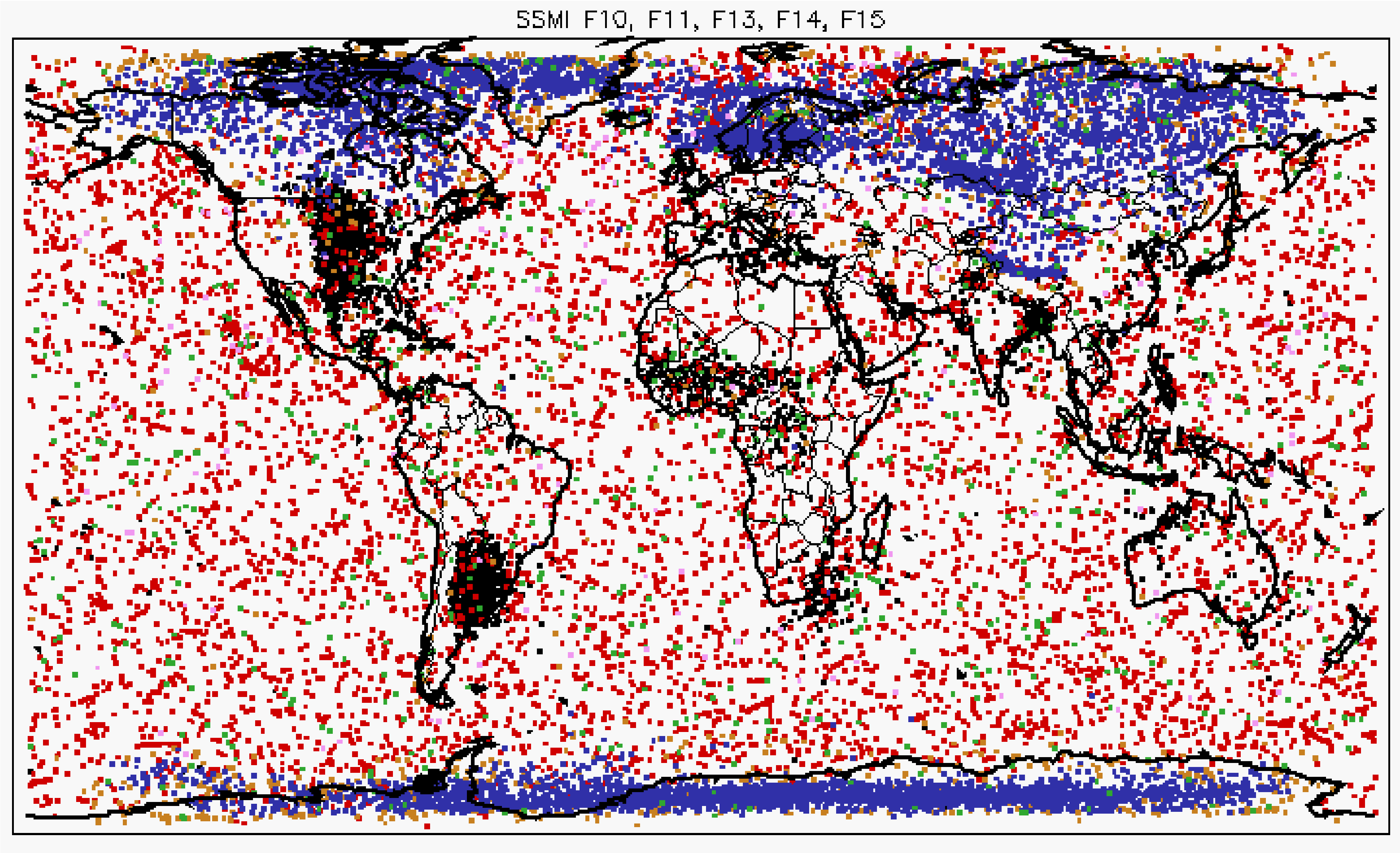
85 vs 37 GHz from SSMI



Statistical filters for Precip Features



SSMI “storms” with 85 GHz < 130 K & 37 GHz < 200 K

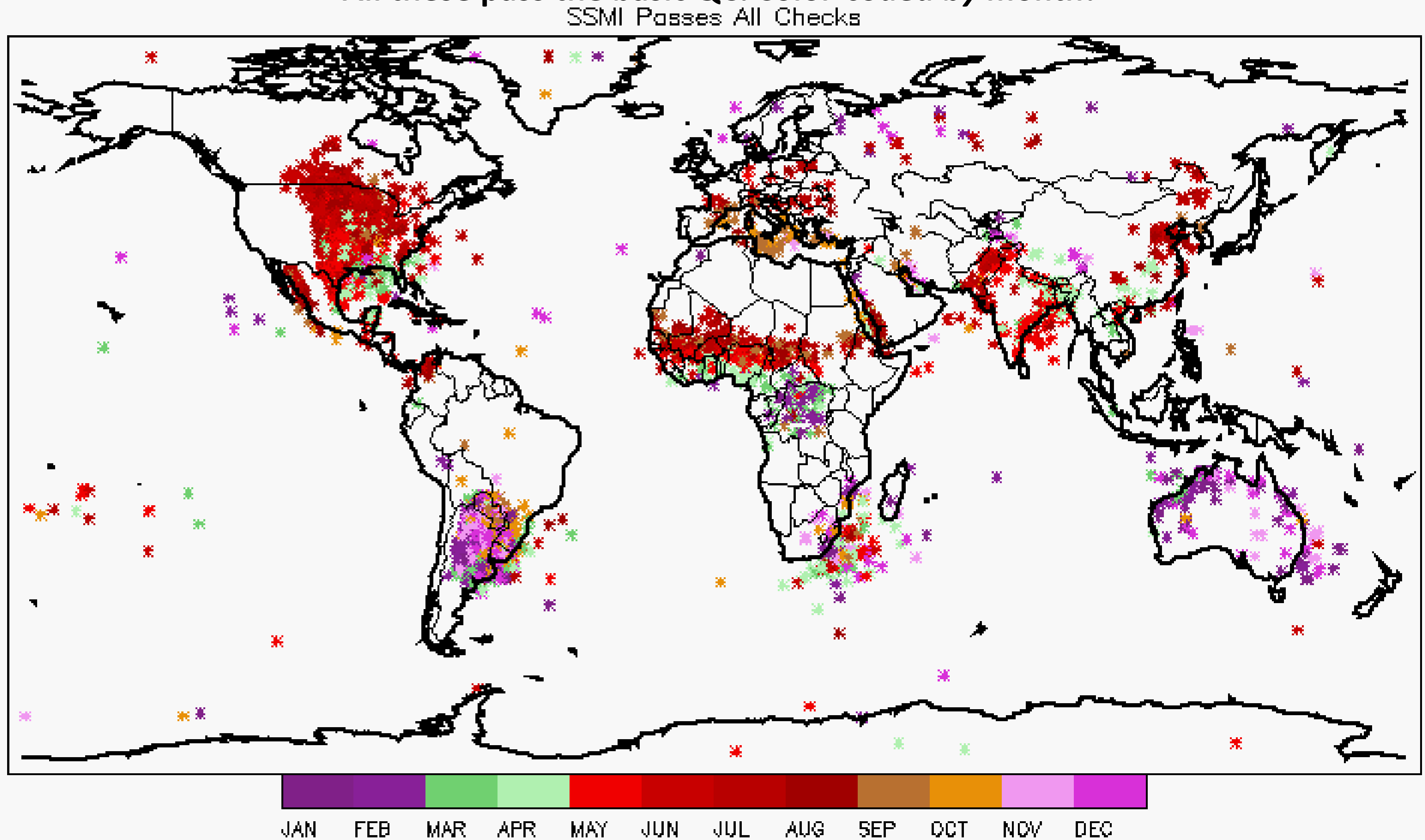


Blue = Snow/Ice   Red/Orange = Small storms / isolated noise   Green/Pink = Other noise

Black = Real Storms

SSMI “storms” with 85 GHz < 130 K & 37 GHz < 200 K

All these pass the basic QC. *Color-coded by month*.



Summary of Statistical Filters

Precipitation features with intense convection tend to have recognizable statistical properties:

- They are clusters of several adjacent pixels with low brightness temperatures.
- Their total size is larger than the area of intense convection itself.
- The 85 GHz PCT is substantially lower than the 37 GHz PCT.

Can be filtered somewhat effectively at *Precipitation Feature level, instead of pixel level*:

- **npixels gt 3**: Removes isolated bad pixels (pixel size ~200 km^2)
- **npixels lt 5000**: Removes enormous snowpacks (~1 million km^2)
- **min37pct gt min85pct**: Removes problematic channel combinations
- **nlt150 gt 2**: From experience, intense storms are large enough for multiple pixels
- **npixels gt nlt150**: If all the pixels have low TB, something is probably wrong.
- **min85pct lt 130 and min37pct lt 200**: Helps to remove snowpack
- ***min85pct gt 40 and min37pct gt 80 (FOR SSMI RESOLUTION)****: From examination of cases satisfying the above criteria– anything that looks like a real storm has values well above these for SSMI.*

Summary - Lowest observed TBs associated with convection

85 GHz:
~40 K (Hi-Res – TMI, AMSR-E, GMI – 5x7 km)
~50-60 K (Lo-Res – SSMI – 13x15 km)

37 GHz:
~70-90 K (Hi-Res – TMI, AMSR-E, GMI – 9x16 km)
~120 K (Lo-Res – SSMI – 29x37 km)

Mostly in Argentina, Central USA, a few scattered elsewhere

Values are low enough they seem like outliers – would be easy to just throw them out as noise via automated filters that do not expect "real" brightness temperatures to be this low.