Extremely Low Brightness Temperatures with Deep Convection - Discriminating Signal From Noise

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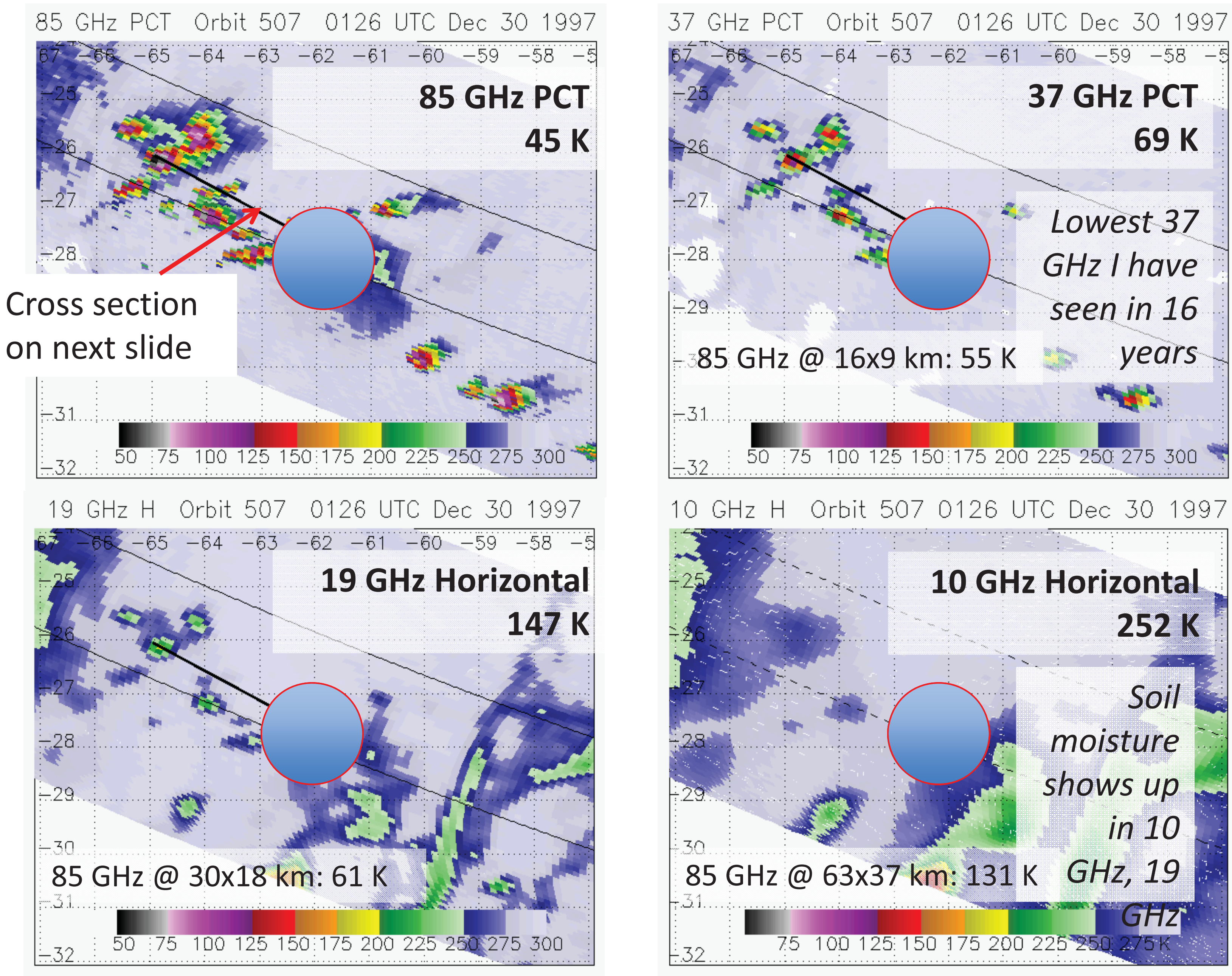
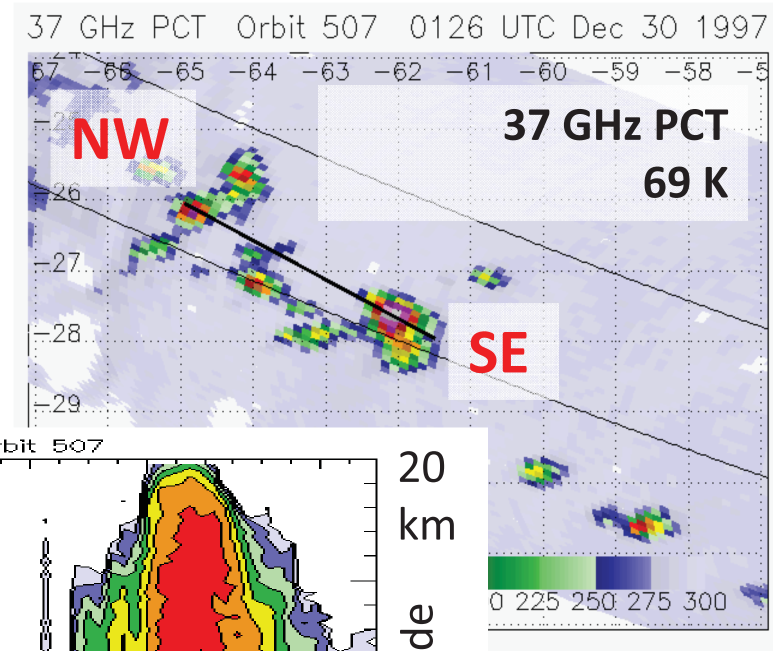
TRMM case with lowest 37 GHz; northern Argentina



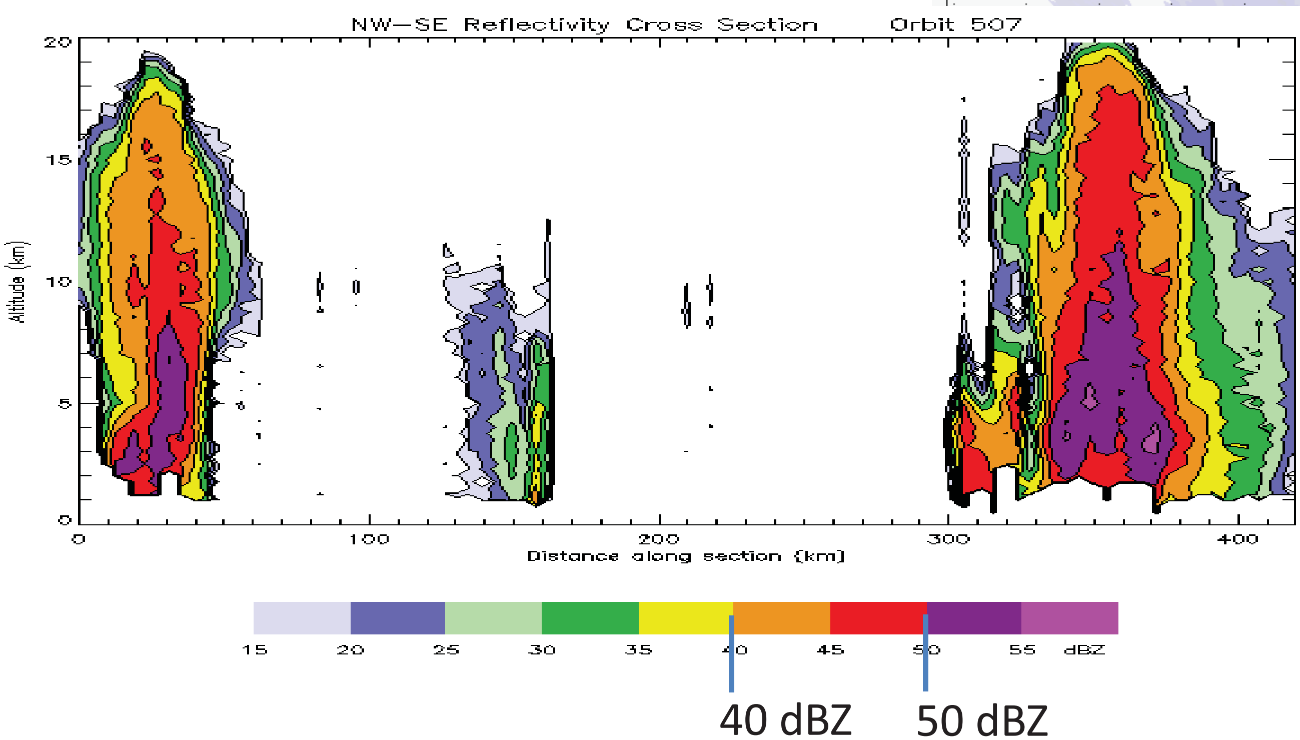
Radar Reflectivity Cross Section – 30 Dec 1997

Without corroborating radar data, such low TBs would seem suspicious

50 dBZ @ ~12 km
45 dBZ @ ~18 km



NW



20 km altitude

SE

Objectives

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

- From TMI, SSMI, AMSR-E; to be extended to GMI

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

2) describe objective methods for identifying valid measurements of extreme storms and separating out the measurements likely compromised by noise

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

   Spoiler Alert: mostly northern Argentina

Sensors Used

SSMI data from CSU; AMSR-E from NSIDC; TMI from TISDIS/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 Feb 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

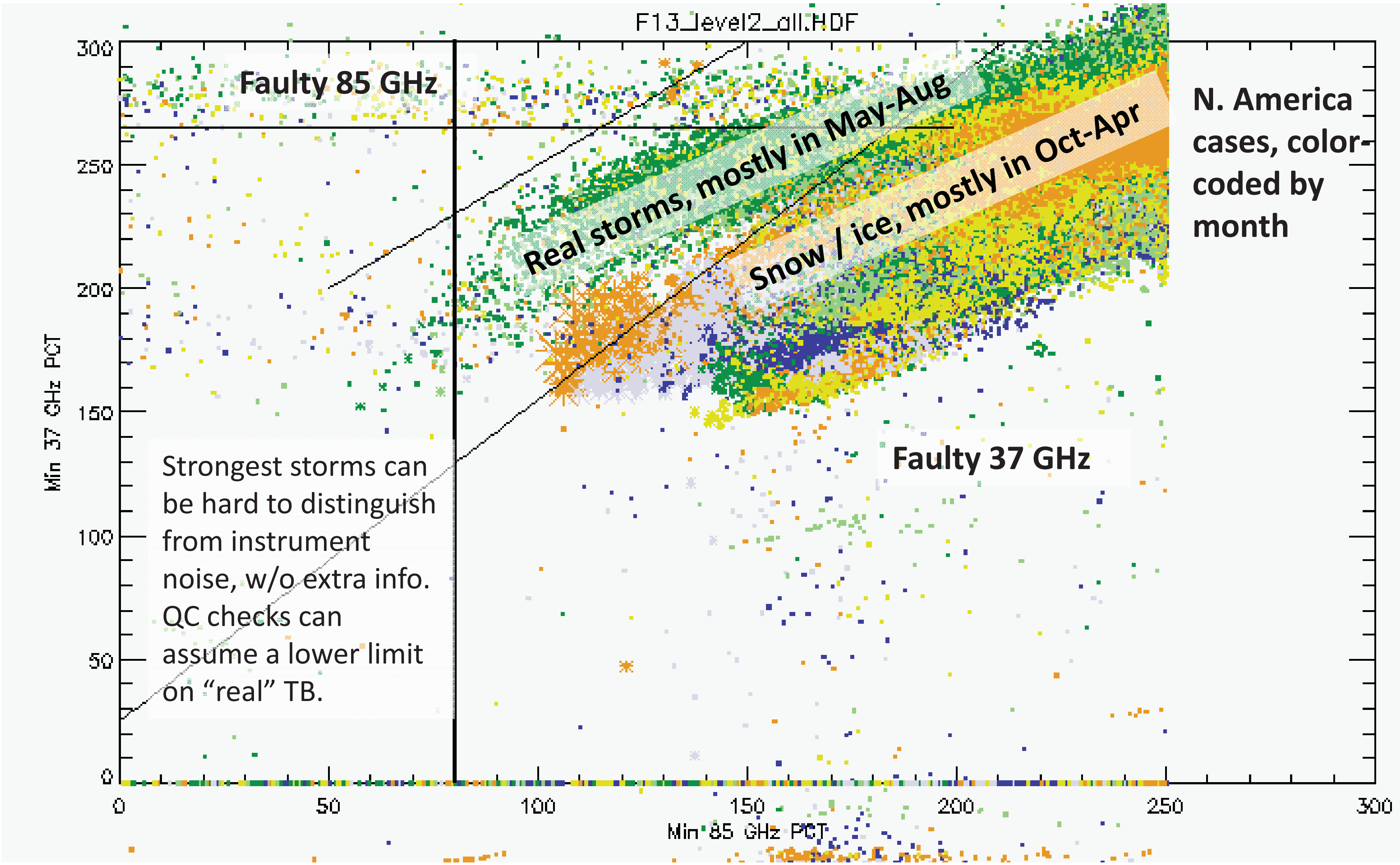
Lowest 85 GHz PCT

Sensor / Platform	Period of record	Date	Time UTC	Time LST	Lon	Lat	Min 37	**Min 85**	Location	Notes
SSMI F08		-	-	-	-	-	-	**-**	-	-
SSMI F10	Dec 1990 Nov 1997	30 Dec 1996	1455	11 pm	116.11 E	16.07 S	187.4	**60.8**	Eastern Indian Ocean	dubious
SSMI F11	Dec 1991 Mar 2000	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	May 1995 Nov 2009	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	May 1997 Aug 2008	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
TMI TRMM	Dec 1997 Feb 2014	14 Nov 2009	0109	9 pm	58.14 W	28.15 S	123.0	**39.4**	Corrientes, **Argentina**	
AMSR-E Aqua	Jul 2002 Dec 2010	18 Nov 2005	0502	1 pm	127.33 E	15.90 N	109.7	**41.1**	**Philippine Sea**	Typhoon Bolaven

Lowest 37 GHz PCT

Sensor / Platform	Period of record	Date	Time UTC	Time LST	Lon	Lat	**Min 37**	Min 85	Location	Notes
SSMI / F08	Jul 1987 Dec 1988	12 Dec 1988	2202	6 pm	62.78 W	27.84 S	**146.9**	88.7	Santiago del Estero, **Argentina**	
SSMI / F10	Dec 1990 Nov 1997	22 Dec 1991	0104	9 pm	61.25 W	26.72 S	**120.9**	64.5	Chaco, **Argentina**	
SSMI / F11	Dec 1991 Mar 2000	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	May 1995 Nov 2009	16 Nov 1998	2205	6 pm	63.46 W	23.01 S	**129.2**	51.0	Salta, **Argentina**	
SSMI / F14	May 1997 Aug 2008	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. Price and Murphy (2002 GRL)
TMI / TRMM	Dec 1997 Feb 2014	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	Jul 2002 Dec 2010	05 Jan 2010	1824	2 pm	61.78 W	35.69 S	**79.6**	56.8	Buenos Aires, **Argentina**	153 K 18-GHz

SSMI – Sorting Signal from Noise

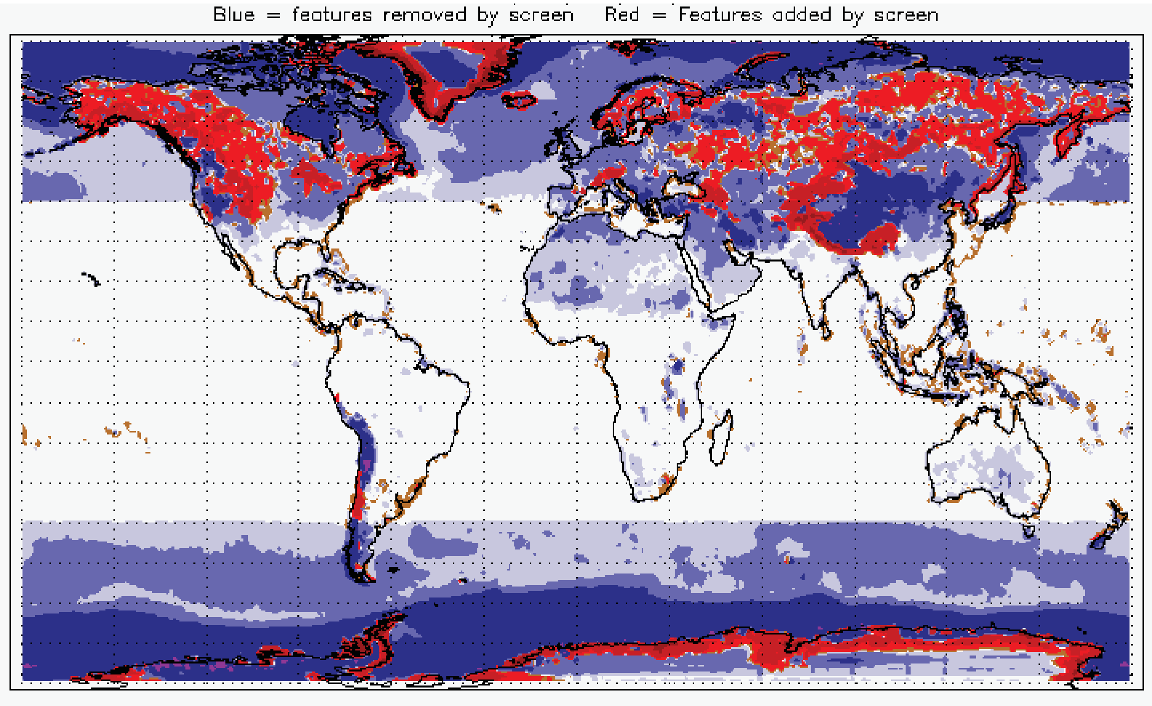


Using a Snow Screen

Using a basic snow screen applied to individual pixels should eliminate much of the noise.

In practice, it splits up many features by removing some pixels and leaving others. So instead of having a few ridiculously large features due to snow (blue in the plot), the screen leaves many small features (red in the plot).

The ridiculously large features are easier to filter out statistically, so in some ways we are better off not screening the individual pixels before filtering the precipitation features.



Statistical filters for Precip Features

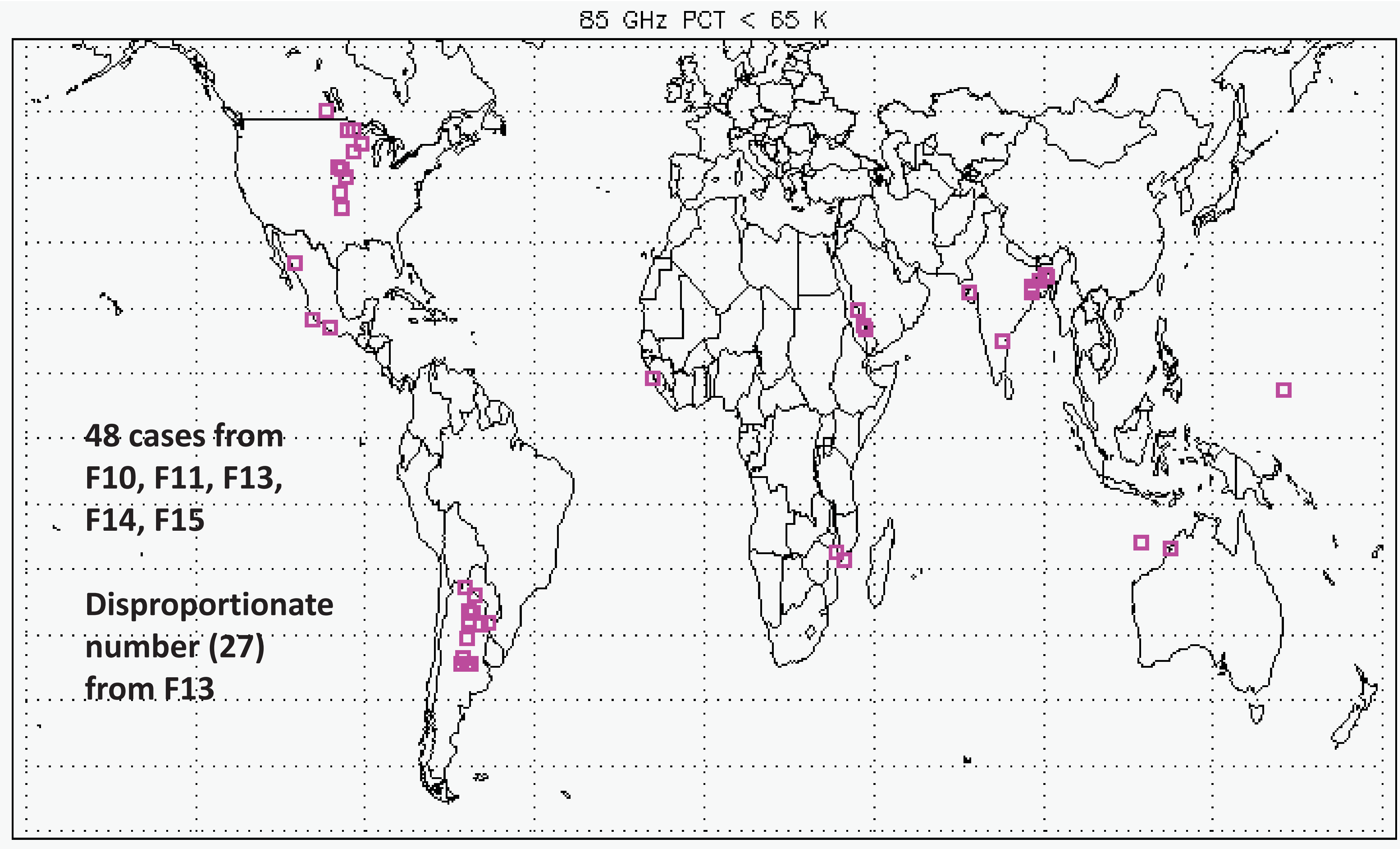
Precipitation features with intense convection tend to have recognizable statistical properties:

- 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.

These criteria are used for the current filtering, applied to *SSMI* data:

npixels gt 3: Removes isolated bad pixels (pixel size ~200 km^2)
npixels lt 5000: Removes enormous snowpacks
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: From examination of cases satisfying the above criteria– anything that looks like a real storm has values well above these

SSMI 85 GHz PCT ≤ 65 K



SSMI 37 GHz PCT ≤ 150K