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**CATÁLOGO DE ESPECTROS DINÂMICOS DE EXPLOSÕES
SOLARES DECIMÉTRICAS REGISTRADAS PELO
BRAZILIAN SOLAR SPECTROSCOPE (BSS): 1999**

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BRAZILIAN SOLAR SPECTROSCOPE - BSS**

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1 - O PROJETO BRAZILIAN SOLAR SPECTROSCOPE (BSS)

1.1 - Breve Histórico

Em 1990, a Linha de Pesquisa e Desenvolvimento de Física do Meio Interplanetário (FMI), da Divisão de Astrofísica, do INPE iniciou a primeira etapa do projeto de desenvolvimento do espectrógrafo solar. Inicialmente, foi instalado, em São José dos Campos, SP, um refletor parabólico de 9 metros de diâmetro, com um alimentador de banda estreita, operando no foco da antena na faixa de frequência de (1600 ± 100) MHz. A aquisição digital de dados teve início em 1992 (Sawant e Rosa, 1990; Sawant et al., 1991; Fernandes, 1992; Sawant et al., 1992; Sawant et al., 1993; Sawant et al., 1996). Este instrumento esteve em operação regular até o final de 1994, e registrou cerca de 350 grupos de explosões solares.

A partir de 1995, teve início a nova etapa do projeto, com a instalação de um alimentador de banda larga composto de duas antenas log-periódicas cruzadas e com a modificação de todo equipamento para operação na faixa de frequência de 200 a 2500 MHz, incluindo o software de aquisição. O espectrógrafo de banda larga entrou em operação em maio de 1996, com observações iniciais principalmente para testes do funcionamento do sistema, incluindo a aquisição digital dos dados e aquisição do código de tempo do GPS (“Global Position System”). Desde abril de 1998, está em operação regular, o instrumento batizado de **Brazilian Solar Spectroscope (BSS)** (Fernandes, 1997; Faria, 1999; Fernandes et al., 2000; Sawant et al., 2000; Sawant et al., 2001; Fernandes et al., 2001). O sistema de aquisição digital dos dados tem sido aprimorado, junto com o desenvolvimento dos programas para visualização e tratamento dos dados digitais (Faria, 1999; Martinon et al., 2000).

1.2 - Descrição Geral do Instrumento

O sistema receptor do BSS é constituído pela antena parabólica de 9 metros de diâmetro, do alimentador de banda larga (200 - 2500 MHz) composto por um par de antenas log-periódicas cruzadas, que permitem a recepção das componentes ortogonais (vertical e horizontal) do sinal recebido da fonte (Sol). A saída do alimentador está conectada a dois pré-amplificadores de baixo ruído, ligados a um circuito somador de banda larga. Depois de somado, o sinal é introduzido em um analisador de espectros (HP8559A), depois os sinais de variação de tensão na saída do analisador seguem para os sistemas de aquisição e monitoramento. O dados coletados pelo sistema receptor são digitalizados no microcomputador de aquisição e armazenados e visualizados num segundo microcomputador, conforme mostra a Figura 1. A Tabela 1 mostra as principais características do BSS.

O BSS é o único espectrógrafo dedicado às observações solares na faixa decimétrica, com alta resolução e alta sensibilidade em operação no hemisfério ocidental terrestre, de modo que, entre 16 e 19 UT, este é o único espectrógrafo digital a monitorar o Sol, preenchendo uma lacuna entre as observações realizadas na Europa e na América do Norte.

1.3 - Visualização e Análise de Dados

Para visualização e tratamento dos dados digitais do BSS é utilizado um programa desenvolvido na linguagem IDL (“Interactive Data Language”) batizado de BSSView (Faria, 1999). Este programa permite visualizar em tempo quase-real o espectro dinâmico das observações e obter representações gráficas dos dados digitalizados (perfis temporais de múltiplos canais de frequência, imagens 2D e 3D em escalas de cores e mapas de contorno).

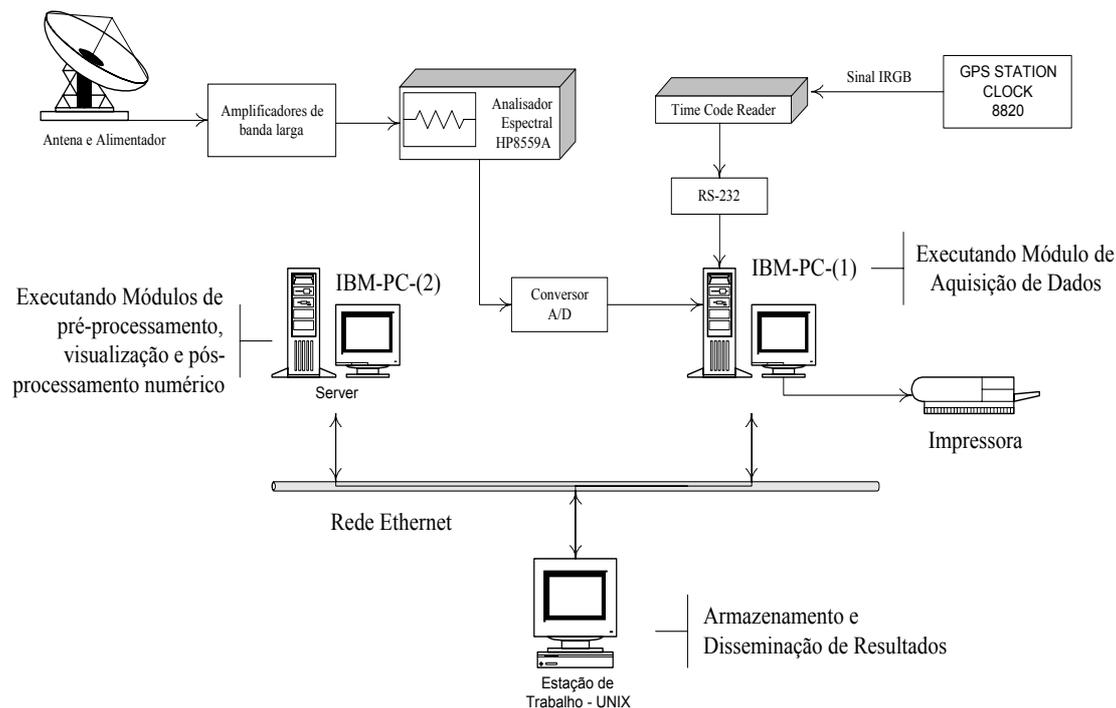


FIGURA 1 - Diagrama de blocos representando o Brazilian Solar Spectroscope (BSS).

TABELA 1 - Principais características do BSS.

Diâmetro da Antena	9 metros
Montagem	polar
Alimentador	log-periódico cruzado
Frequência	200-2500 MHz
Resolução temporal	0,01; 0,02; 0,05; 0,10; 0,20; 1 s
Resolução espectral	1; 3 MHz
Precisão tempo absoluta	0,003 s
Sensibilidade	~2-3 sfu
Número de canais	25; 50; 100
Visualização	tempo real
Campo de visada	todo o disco solar
Observações diárias	11:00-19:00 UT

Para a determinação de parâmetros das observações, foi desenvolvido um programa base, batizado de BSSData (Martinon et al., 2000; Martinon et al., 2002), contendo ferramentas para destacar as explosões, para determinar visualmente os parâmetros das explosões, para manipular as cores do espectro dinâmico e para organizar os dados em projetos distintos.

2 - OBSERVAÇÕES SOLARES DECIMÉTRICAS: 1999

Devido à grande incidência de tempestades elétricas no verão na região de São José dos Campos, SP, que podem danificar a eletrônica do sistema do BSS, e principalmente às férias coletivas dos funcionários do INPE, os meses de janeiro e fevereiro são escolhidos para manutenção e reparos mecânicos na antena e no sistema de rastreamento, não ocorrendo observações neste período. Assim, as observações solares sistemáticas utilizando o BSS ocorrem entre os meses de março e dezembro. As observações são realizadas diariamente, de segunda a sexta, aproximadamente das 8:30 às 15:30 horas, horário local (11:30 - 18:30 UT). A Tabela 2 mostra o resumo das observações realizadas pelo BSS em 1999 e a Figura 2 a distribuição mensal dos dias de observação e eventos registrados. A lista completa das explosões solares observadas é apresentada na Tabela 3.

TABELA 2 – Observações solares com o BSS em 1999.

Dias	Horas	“Flares” solares registrados
190	1140	87

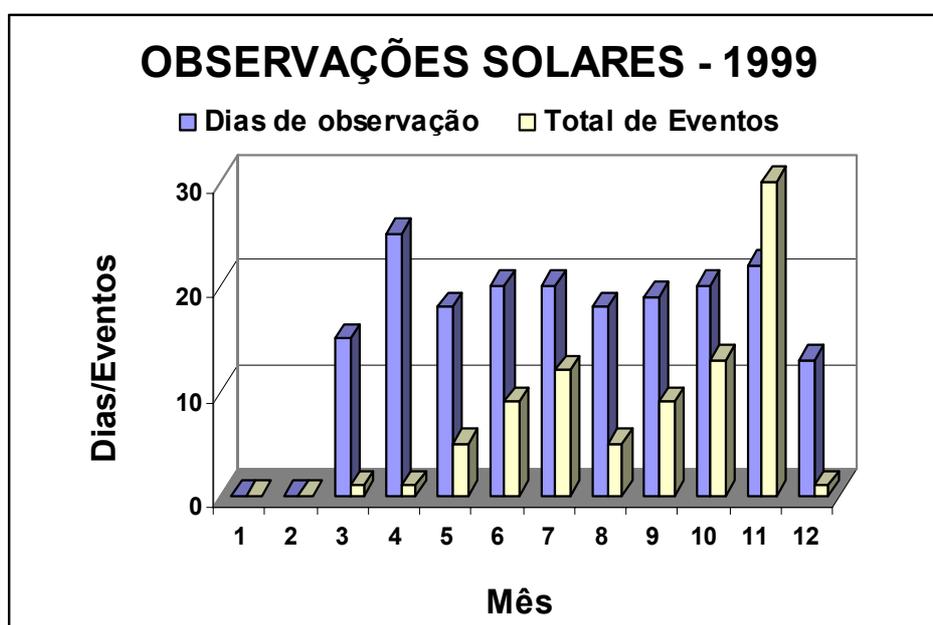


FIGURA 2 - Distribuição mensal do total de dias de observações solares realizadas pelo BSS em 1999 e do número de eventos registrados no mesmo período.

TABELA 3 - Lista de explosões registradas pelo BSS em 1999.

Dia	Hora (UT)	Tipo de atividade*	BSS Arq.	GOES	Atividade Associada**
MARÇO					
19	15:19:15-15:26:45	Zebra	B5	-	< 15:32 EPL
ABRIL					
07	13:25:01	Fraco CNT	B7	-	-
MAIO					
07	14:26:47-14:27:06	Fraco ghost RS	D1	C7.4	RBR1415-15400 14:26 SF
08	14:23-14:26	Gradual fraco	C9	M4.6	RBR 245-15400 RSP V
18	18:06:05-18:06:14	TIII-like G	H3	-	RNS 245
30	16:05:50-16:06:02	Fraco patch G nb	F0	-	RBR 245 16:05 RNS
JUNHO					
17	16:51	CNT bb (>1min)	F3	M3.6	-
22	18:31	Gradual	G8-G9	M1.7	-
22	18:34	Fracas EF + CNT	H0	M1.7	RBR 1415 18:27
24	16:44-17:17	Puls. + EF	F0-F3	-	RBR 245 17:14
24	18:02	EF	G3	-	RBR 245 18:01
26	13:45-13:56	Gradual	C2-C3	-	RSP CTM/2
26	15:40	Fraca EF G bb RS	E1	-	-
27	17:21:46-17:21:58	TIII G ib	F7	-	-
28	12:21:02-12:21:11	TIII nb drift chain	A6	C1.6	SF 12:19 RSP III/2 12:13
JULHO					
02	15:14:45-15:15:55	Ghost	D6	M1.6	-
02	15:15:07	EF ISO	D6	M1.6	15:16 FLA
05	16:39:24-16:39:31	TIII nb	E9	-	RSP
12	15:30:50	EF LBxfreq	D9	-	RBR 15:31 RSP
16	15:45:51	EF ISO	E1	M3.1	FLA
19	15:08:42-15:09:15	TIII-like G	D4	-	15:08 FLA
23	12:45:02	Fracas EF J	B0	C5.9	-
24	12:02:56	Par EF	A3	-	RBR 1415 12:03
24	12:03:20-12:03:40	Fracos ghosts	A3	-	RBR 1415 12:03
24	12:03:47	EF nb	A3	-	RBR 1415 12:03
24	12:03:48-12:03:51	Patch complexo	A3	-	RBR 1415 12:03
25	13:09	Gradual	A9-B0	-	-
AGOSTO					
17	12:43-18:34	Noise + EF	B0-H0	C2.6	C5.9 14:28
20	18:27-18:37	Gradual	G6-G7	M1.2	RBR 245-2695
23	17:58-17:59	Patches	G3-G4	-	-
23	18:04	Zebra	G4	C5.7	18:03
30	17:50-17:59	Gradual+ghost+puls.	G0-G1	M3.8	-
SETEMBRO					
02	17:39:40	Faixa clara-escura	D1	-	-

(Continua)

... Continuação

03	18:04:38	Intermitente	F2	-	-
09	14:22-17:14 ?	Gradual+EFlentadfd t	B0-B3	C3.3	-
13	16:27:30-16:27:59	Fracas EF + dots	E9	C2.6	< 16:02 DSF
13	16:57:17	TIII-like ib ISO	F4	C2.6	-
13	17:02:26	Drift dots	F4	-	-
13	17:43:50-17:44:11	TIII G	G2	-	-
14	13:57	Fracas TIII-like+EF	A2-A3	C1.8	-
22	13:30	Gradual + ghost	C0	C5.2	1F RBR 245-2695 RSP V/3 III/1

OUTUBRO

01	14:58:47-14:59:08	3 picos fortes bb	D8	C6.0	RBR 245-880
07	15:52:31	Dots normal drift	E9	-	-
18	16:26:25	Dots + zebra nb	F5	-	-
19	17:02:19-17:04:44	Zebra bb	D3	-	-
19	17:27:57-17:28:45	Zebra bb	D8	-	-
19	17:56:44	Zebra bb + dots	E3	C1.0	SF
20	16:19	Fraca zebra + dots	E2	-	-
21	11:53:39	Dots nt	A6	-	-
28	17:56:55	EF TIII-like nb ISO	H1	-	-
28	18:01:36	EF TIII-like ISO	H2	-	-
28	18:04:26	Line of Dots	H3	-	-
28	18:05:43	EF TIII-like nb ISO	H3	-	-

NOVEMBRO

09	11:53:47-11:54:17	Fraca EF + CNT	A7	-	-
09	12:06:25-12:06:37	EF TIII-like G CNT	A9	-	RBR 1415
09	12:07:40-12:07:49	CNT	A9	-	-
09	12:08:01	EF	A9	-	-
09	12:09:06-12:09:06	EF TIII-like	A9	-	RSP III/2
09	12:10:21	EFT ib ISO	B0	-	-
09	12:11:08-12:11:16	Fracas EF (~1s)	B0	-	-
09	12:52:22-12:52:57	EF+CNTib dfdchain	B7	C5.6	RBR 245-8800 RSP III/3
09	12:56:24-12:56:59	CNT	B8	C5.6	RBR 245-8800 RSP III/3
09	12:57:37-12:58:08	Fraco CNT	B8	C5.6	RBR 245-8800 RSP III/3
09	12:58:33	EFT	B8	C5.6	RBR 245-8800 RSP III/3
09	14:33	EF in	D0	-	-
09	15:15:10	EFT TIII G + patch	E3	-	RBR 245-410 RSP III/3
09	16:24:51	EF TIII-like nb drift / patch nb split	F6	C4.6	-
10	15:44-15:46	CCNTfraco	E7	-	-
10	15:46-15:51	EF TIII-like RSdfdt	E8	M1.5	SF RBR 245-15400
10	16:46:00-16:46:02	EF TIII-like G fracos	F8	-	-
18	14:40	Fraco CNT nt	D6	-	-
18	17:12	TIIIG	G3	C2.7	-
19	15:01	Fraca EF	F2	-	-
20	14:34:42	Fraca TIII-like ISO	D2	-	-

21	18:13	EF + Gradual CNT	H4-H6	M3.4	2N RBR 606-15400
22	12:13	EF TIII-like nb	B0	C8.9	-

(Continua)

... Conclusão

25		CNT nt	E7...H3	-	-
26	13:41	CNT nt	C3	M6.0	2N RBR 2695-15400
26	14:15	CNT	C9	-	-
26	16:26:44-16:28:12	EF GG	F3	-	-
27	12:08:22	EF Dots cutoff drift	A1	X1.4	2B RBR 1415-15400
27	12:09-12:22	Gradual	A1-A3	X1.4	-
29	14:02	EF nb	D0	-	RSP 14:02 CTM/1
29	15:23	Fracos ghost	E3	-	SF 15:32 – 16:05
29	16:01	EF bb frac	F0	-	-

DEZEMBRO

01	13:17 -	Fracos ghost	B0...C8	-	SF 13:47-07:32 ERU
02	11:58:-35-11:58:40	EF frac	A7	-	-
09	17:50-17:55	EF frac	F8	-	-

* Abreviações das estruturas finas: CNT: emissão contínua; EF: Estrutura Fina; EFT: Estrutura Fina em Tempo; TIII: Tipo III; G: Grupo de < 10 estruturas; GG: Grupo de > 10 estruturas; ISO: estrutura isolada; RS: “Reverse Slope” – taxa de deriva inversa; nb: banda estreita; ib: banda intermediária; bb: banda larga; NT: curta duração; dfdt: taxa de deriva em frequência; Puls.: Pulsações; Osc.: Oscilações; U: na forma de U; U inv.: na forma de U invertido; J: na forma de J; int. var.: com variação da intensidade com a frequência.

** As siglas para a atividade associada (eventos em raios-X e rádio em diversas frequências) são as mesmas adotadas pelo “Space Environment Center” (gopher://solar.sec.noaa.gov).

3 - CATÁLOGO DAS EXPLOSÕES SOLARES REGISTRADAS

Este Catálogo é composto de uma seqüência de figuras representando os registros de todas as explosões solares observadas pelo instrumento Brazilian Solar Spectroscopie durante o ano. Os registros das explosões solares são apresentados na forma de **espectro dinâmico** (a variação da intensidade da emissão em função do tempo e da freqüência). A Figura 3 mostra um exemplo ilustrativo de um espectro dinâmico gerado a partir de dados de explosões solares apresentando estruturas finas.

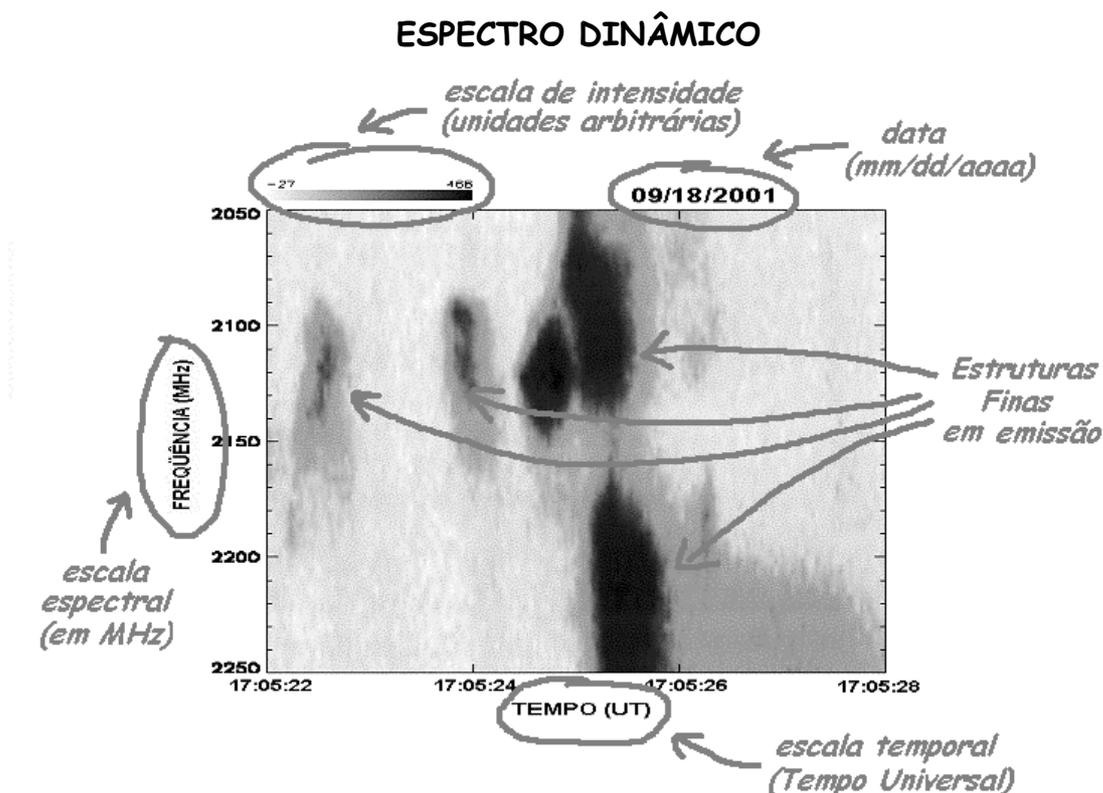
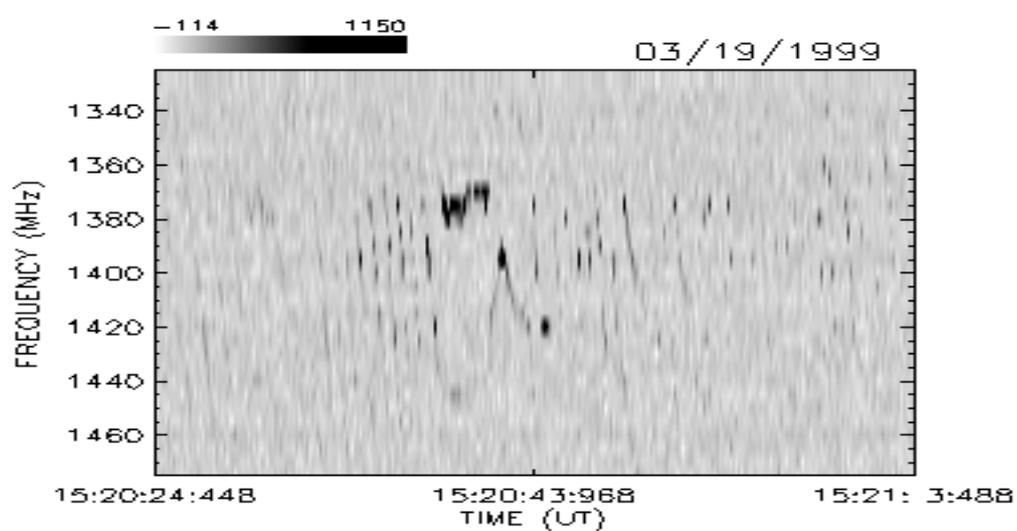
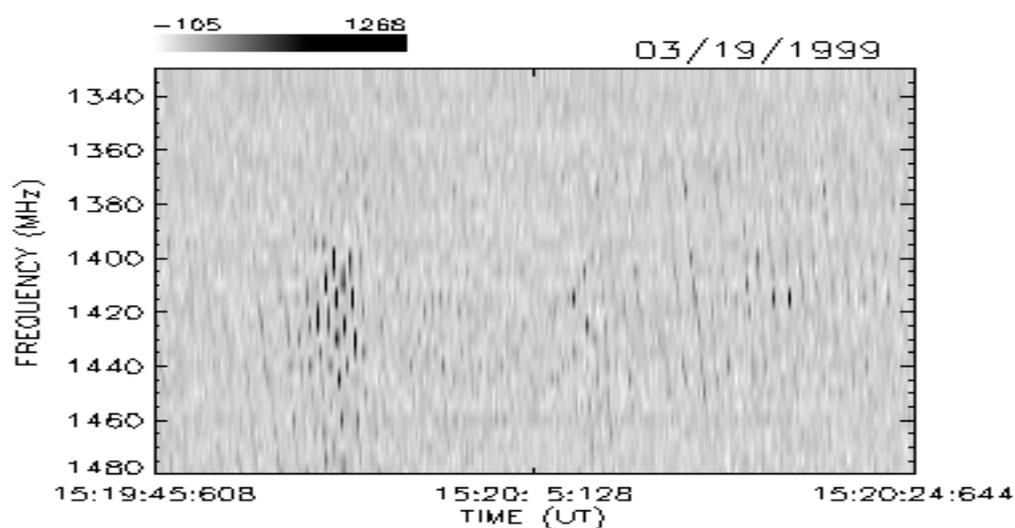
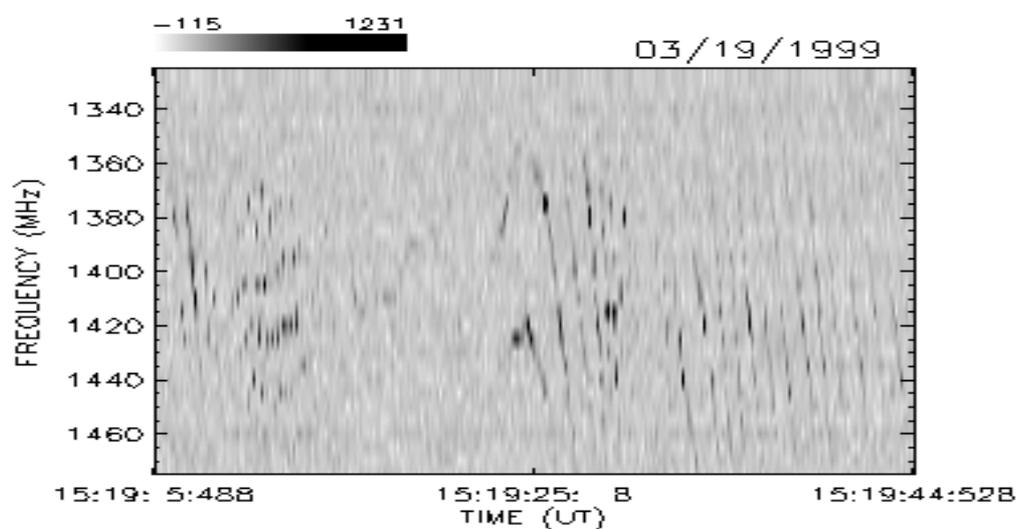


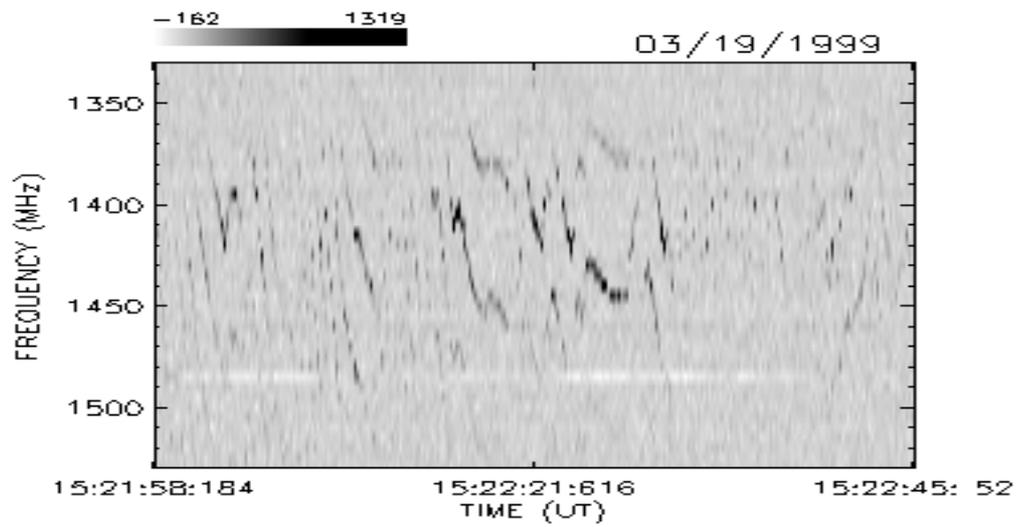
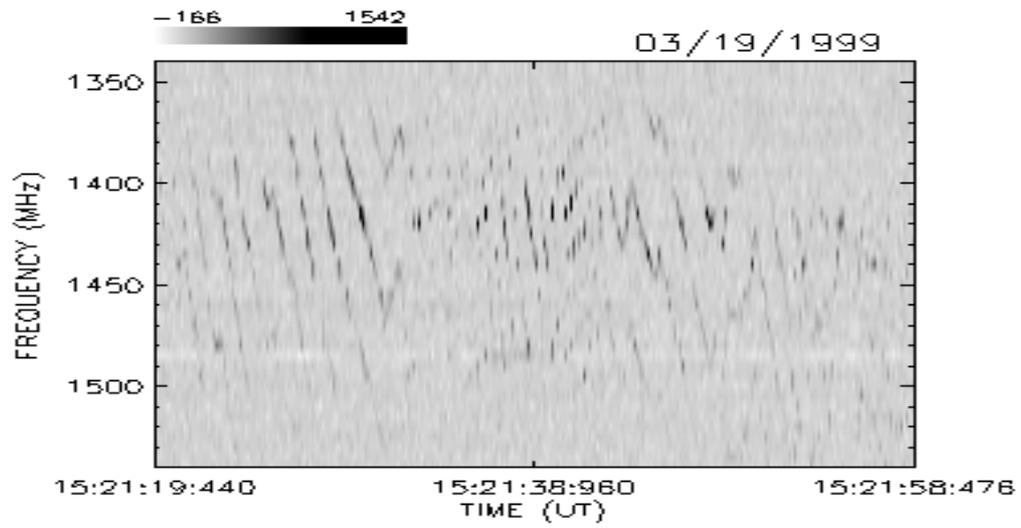
FIGURA 3 – Exemplo de espectro dinâmico gerado a partir dos dados de explosões solares observadas pelo BSS. Na parte superior da figura, são representadas uma escala de intensidade (em unidades arbitrárias) e a data da explosão na forma (mm/dd/aaaa); os eixos vertical e horizontal representam, respectivamente, os intervalos em freqüência (em MHz) e em tempo (em Tempo Universal) em que foram registradas as emissões. Nota-se que os valores da freqüência no eixo vertical crescem para baixo, conforme convenção adotada internacionalmente.

O Catálogo completo dos espectros dinâmicos das explosões registradas pelo BSS ao longo do ano de 1999 é apresentado a seguir. Cabe ressaltar que neste Catálogo não houve preocupação em apresentar as explosões de acordo com qualquer tipo de classificação morfológica ou fenomenológica. Os espectros dinâmicos estão dispostos em ordem puramente cronológica. Uma catalogação das explosões baseada em aspectos morfológicos pode ser encontrada em Fernandes et al. (2003).

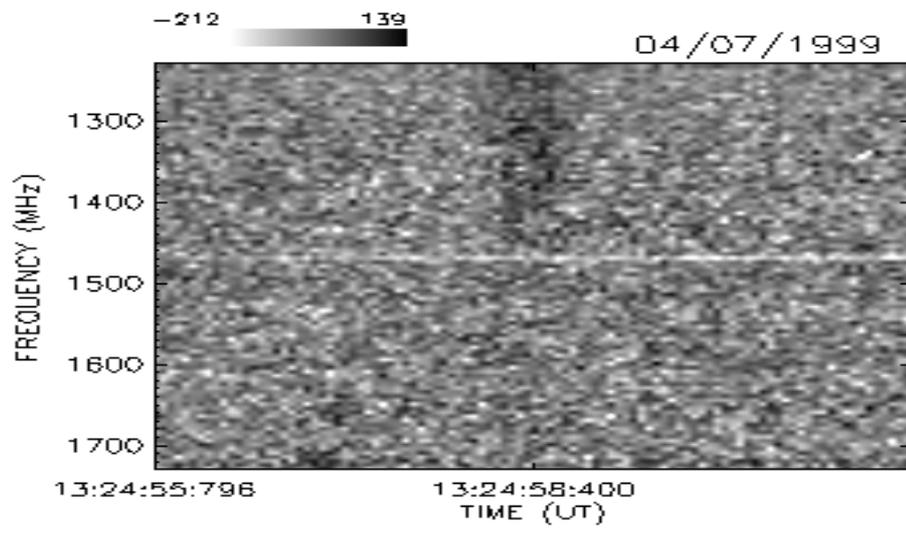
MARÇO / 99



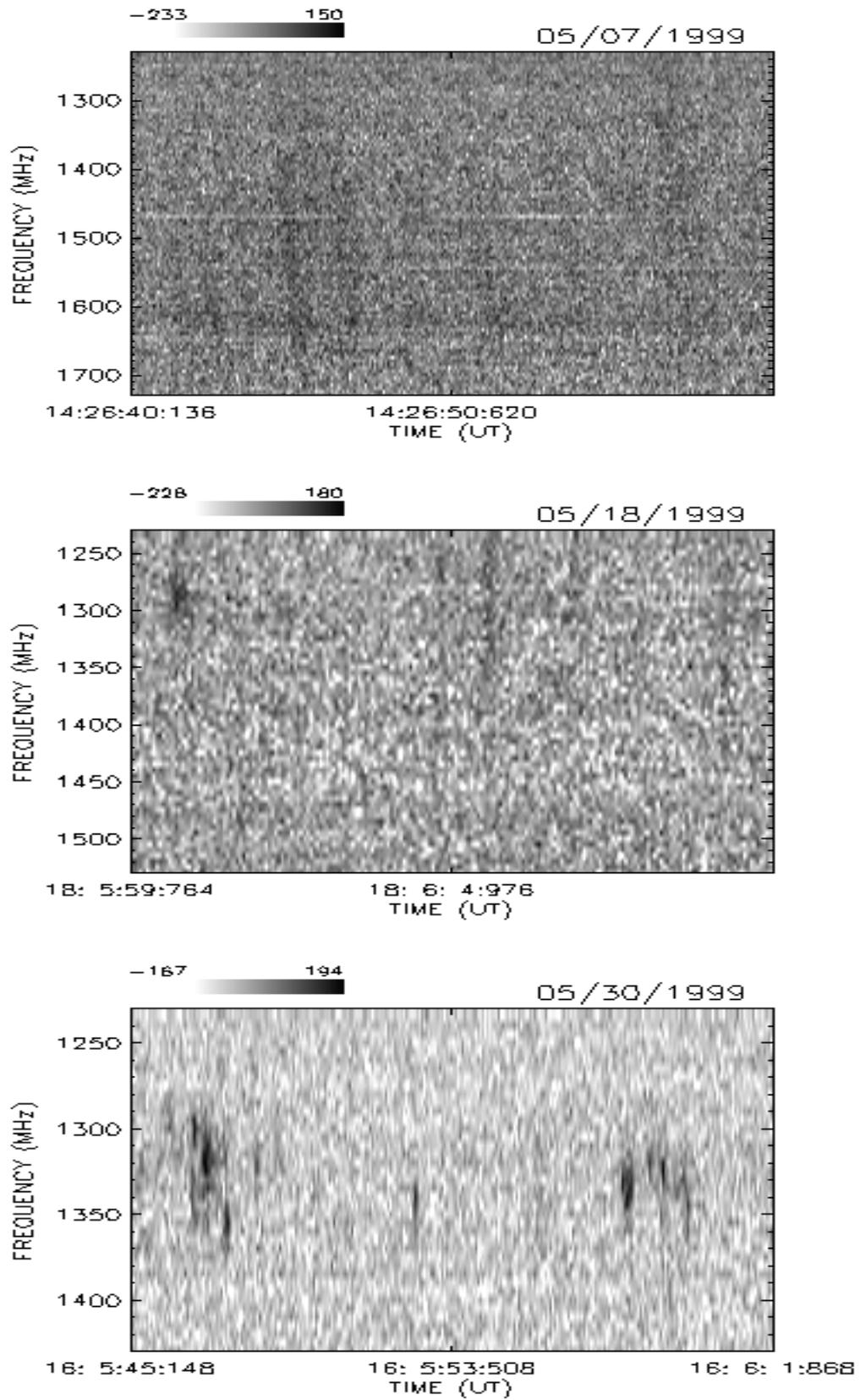
MARÇO / 99



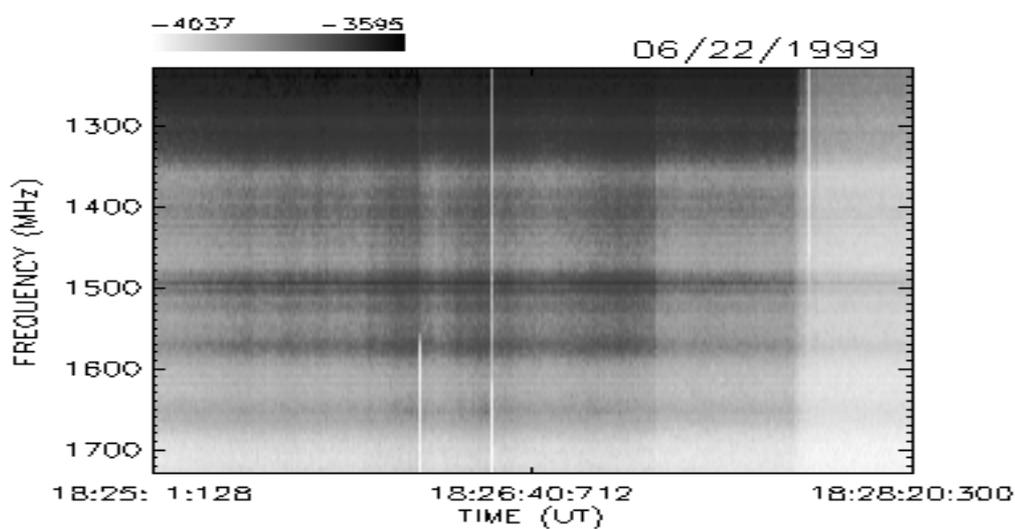
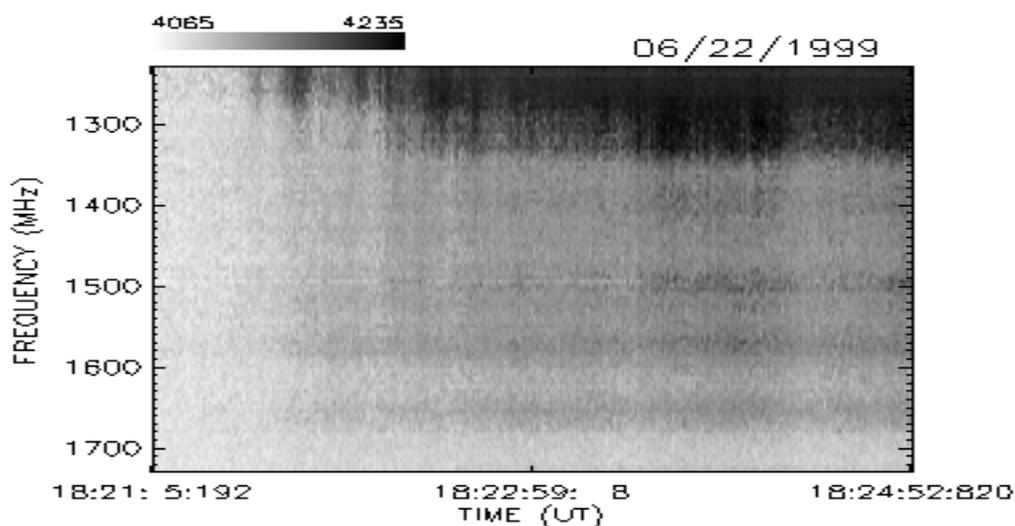
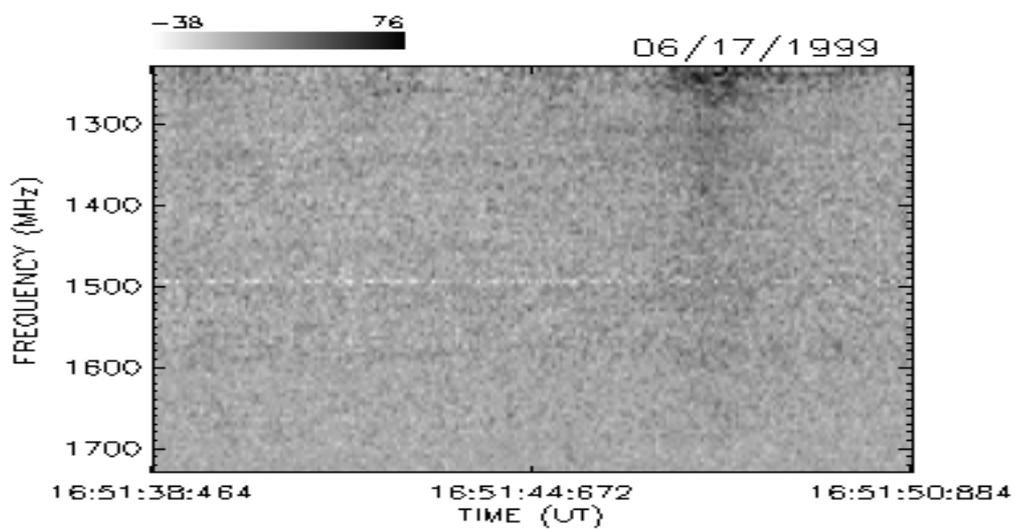
ABRIL / 99



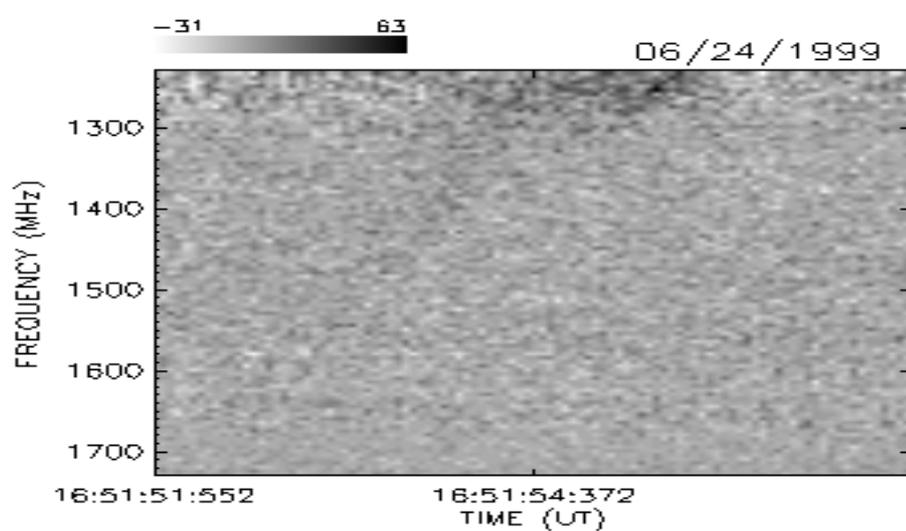
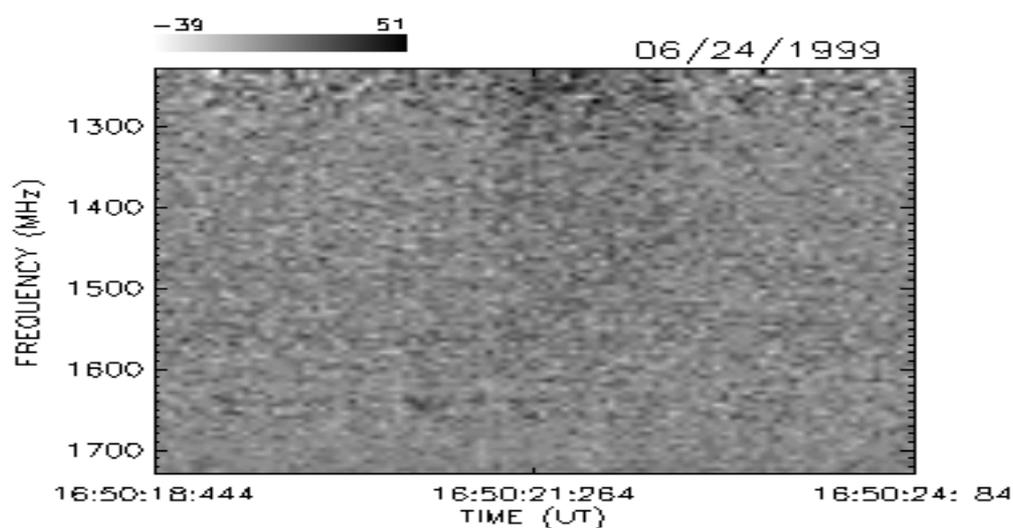
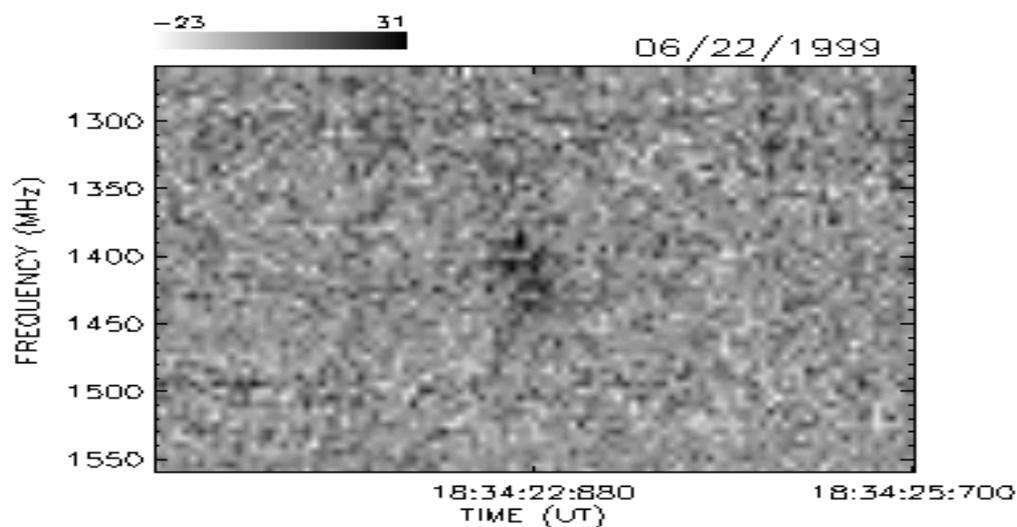
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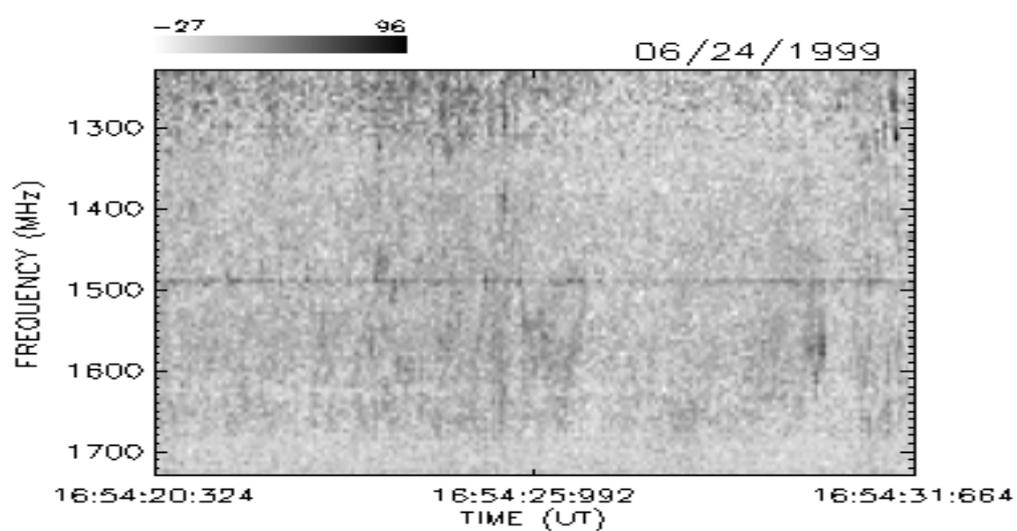
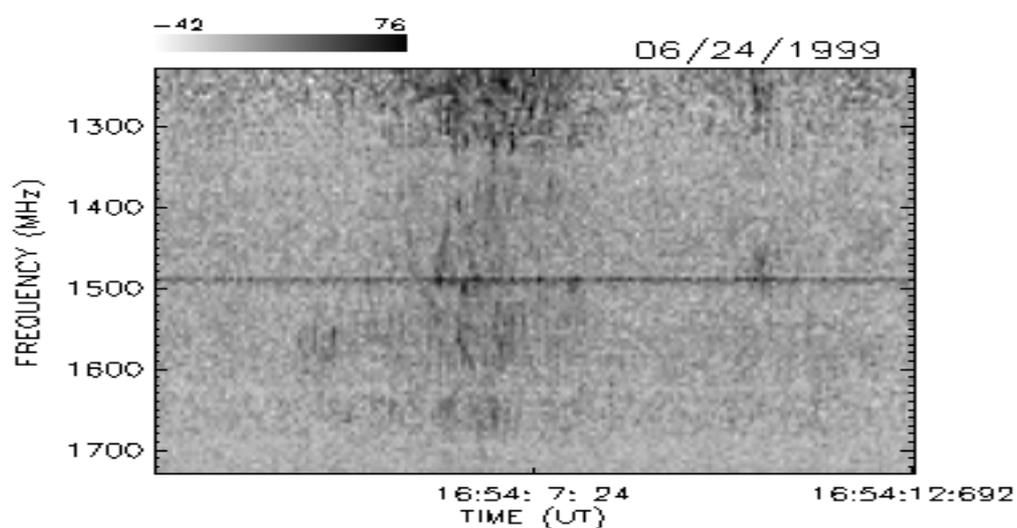
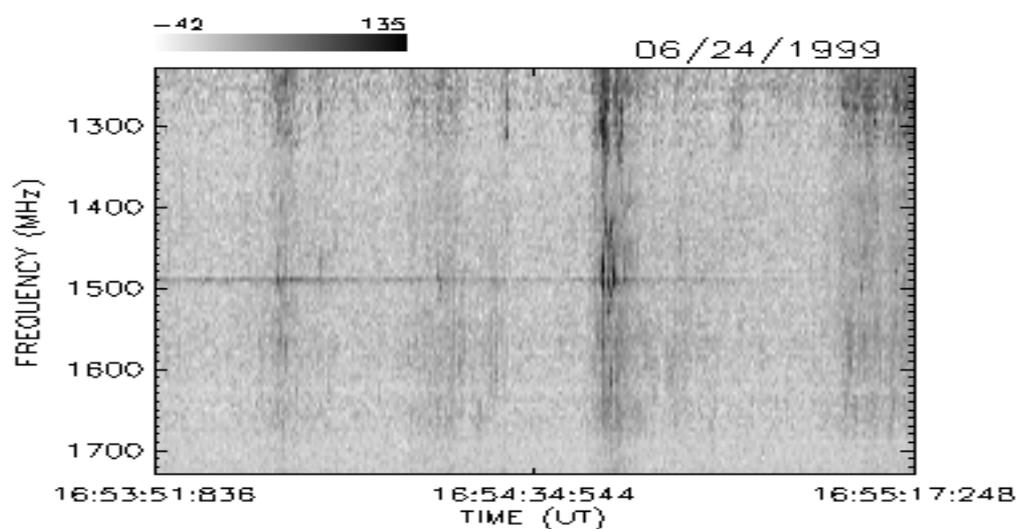
JUNHO / 99



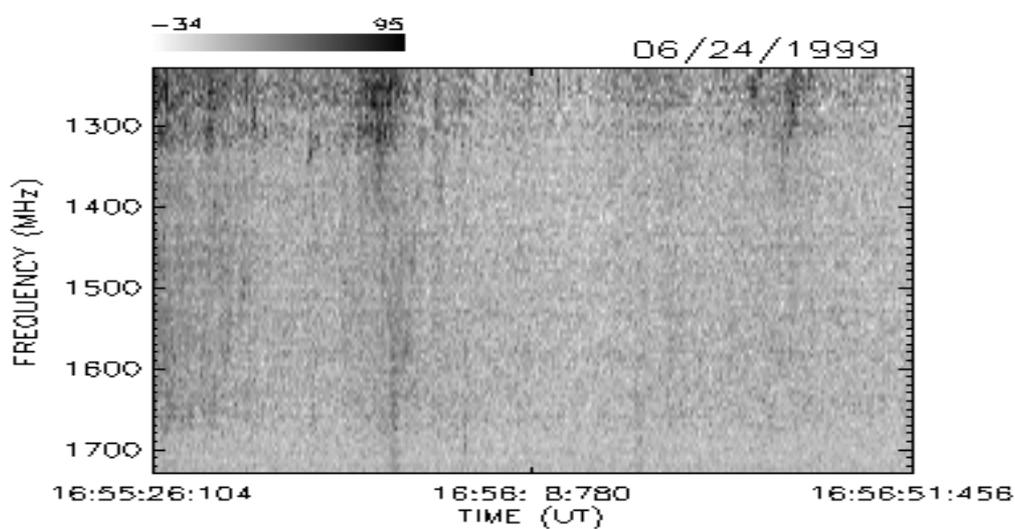
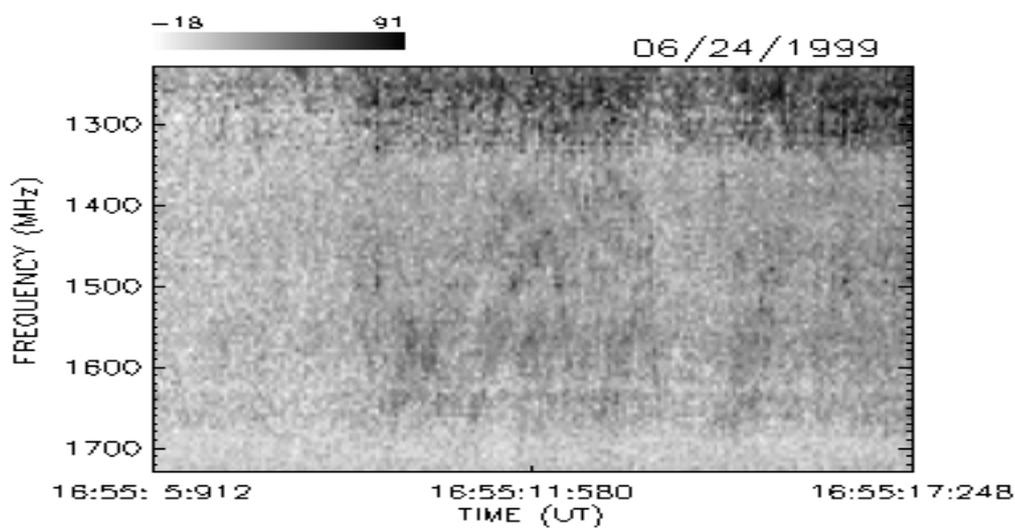
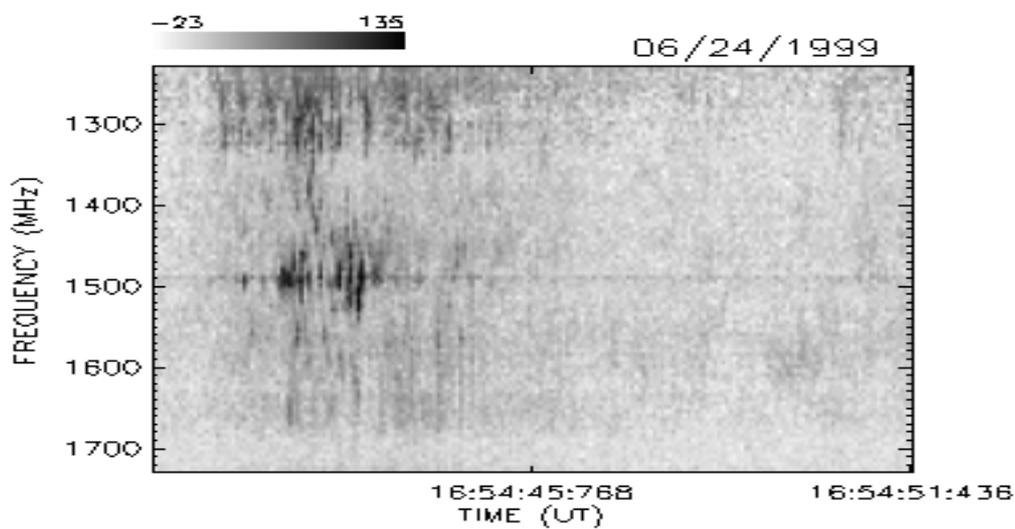
JUNHO / 99



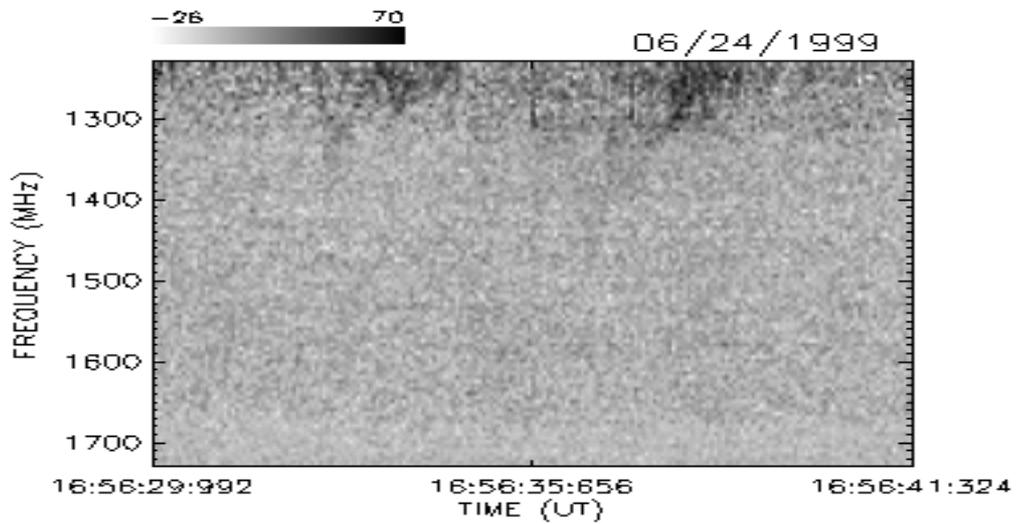
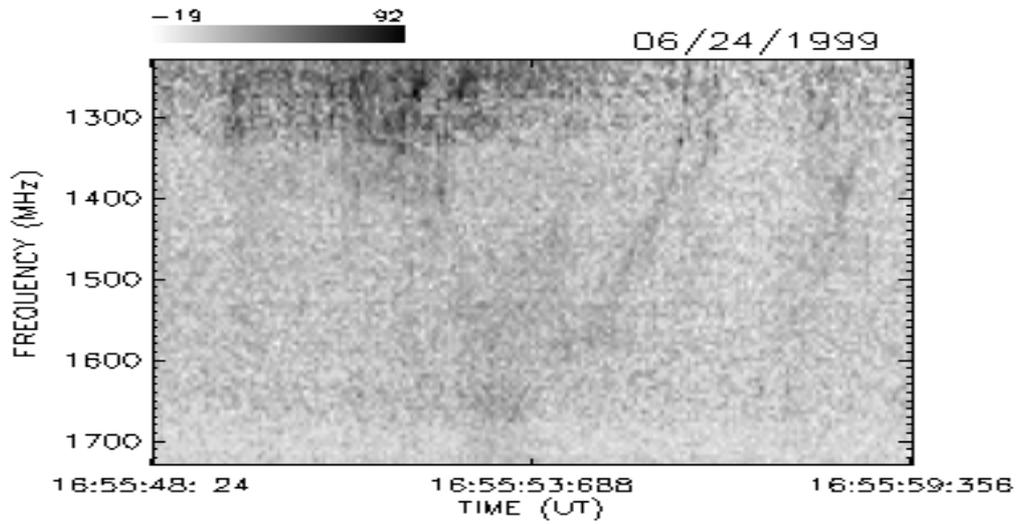
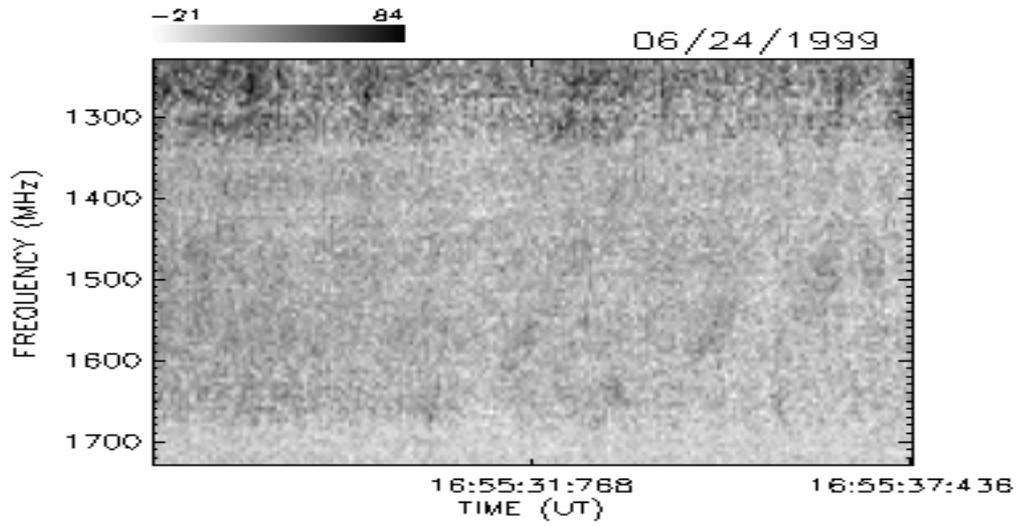
JUNHO / 99



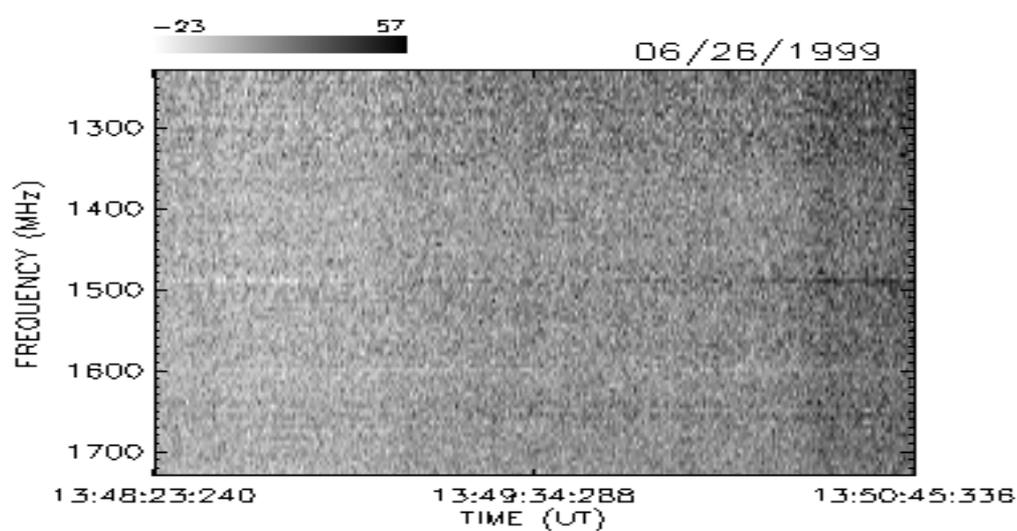
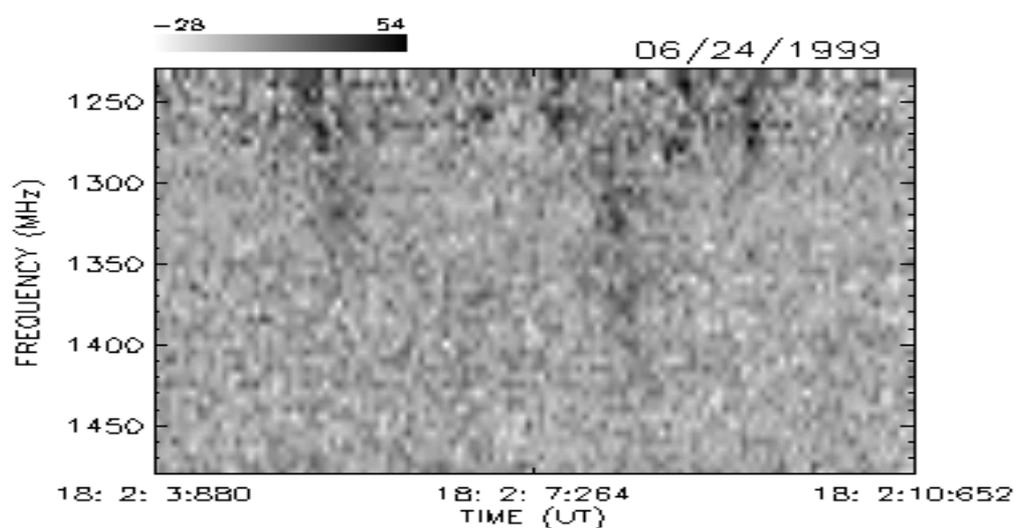
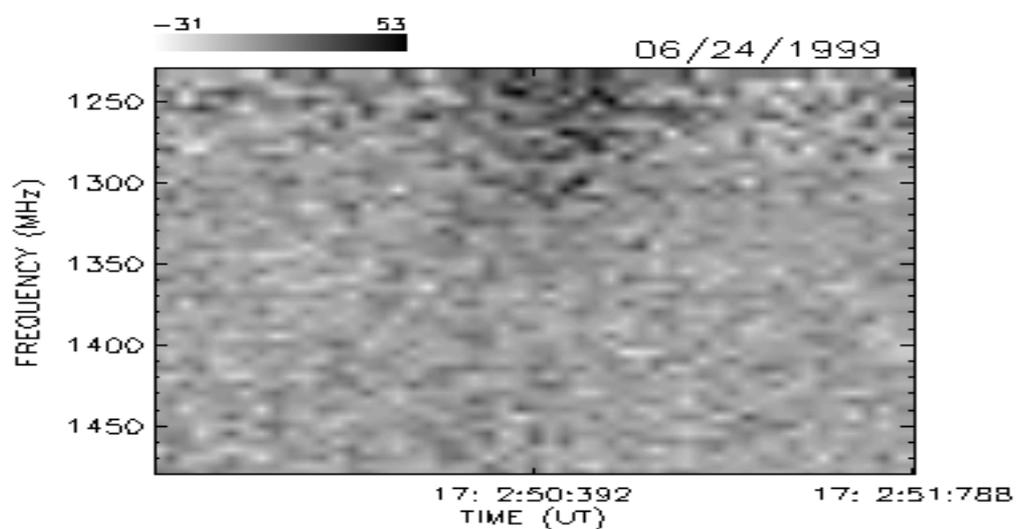
JUNHO / 99



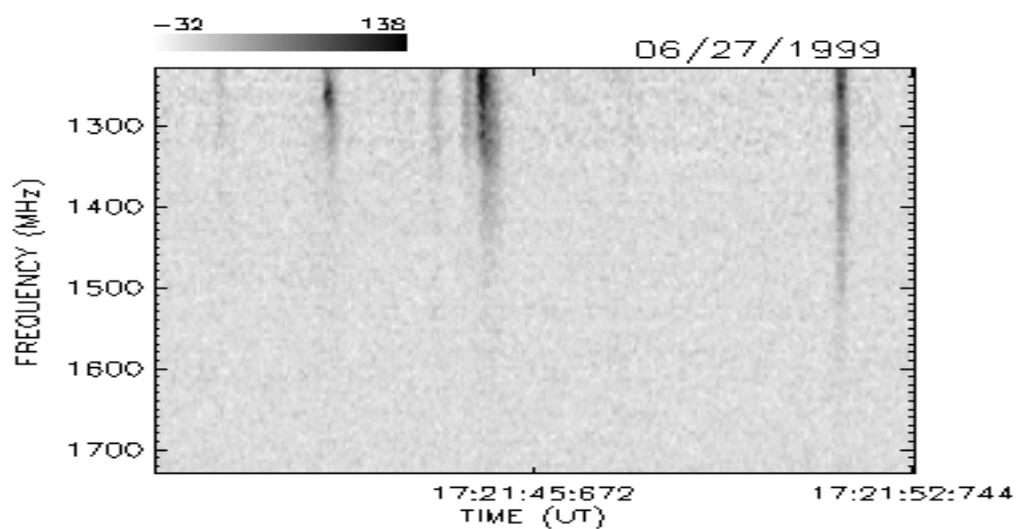
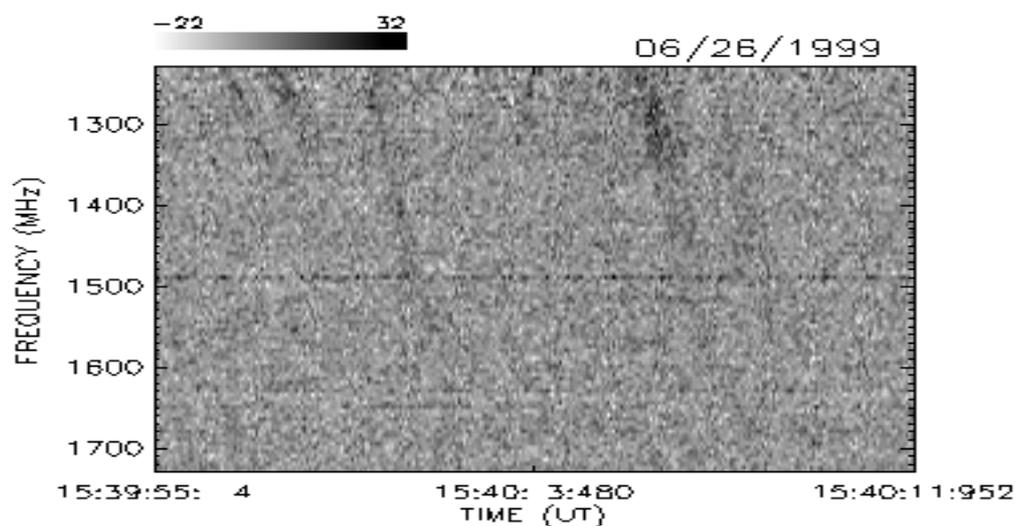
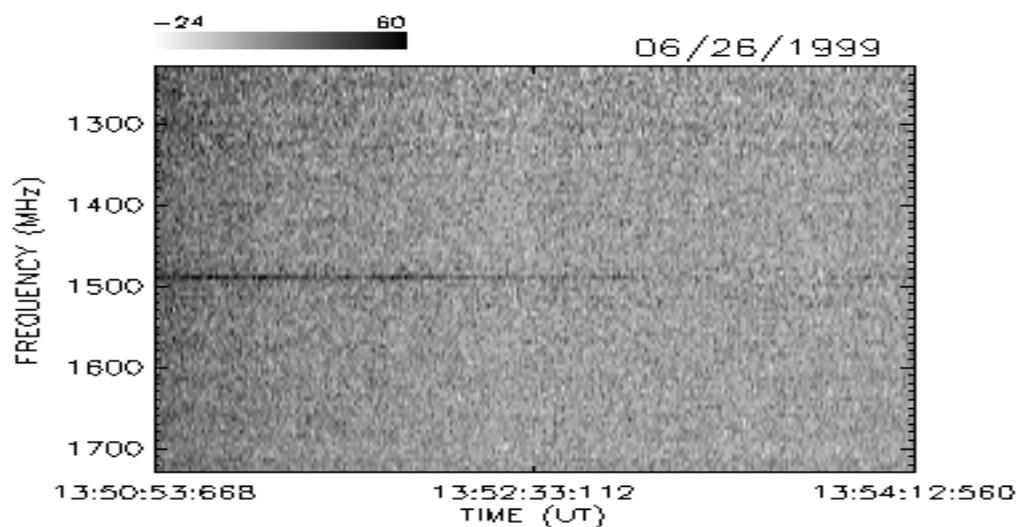
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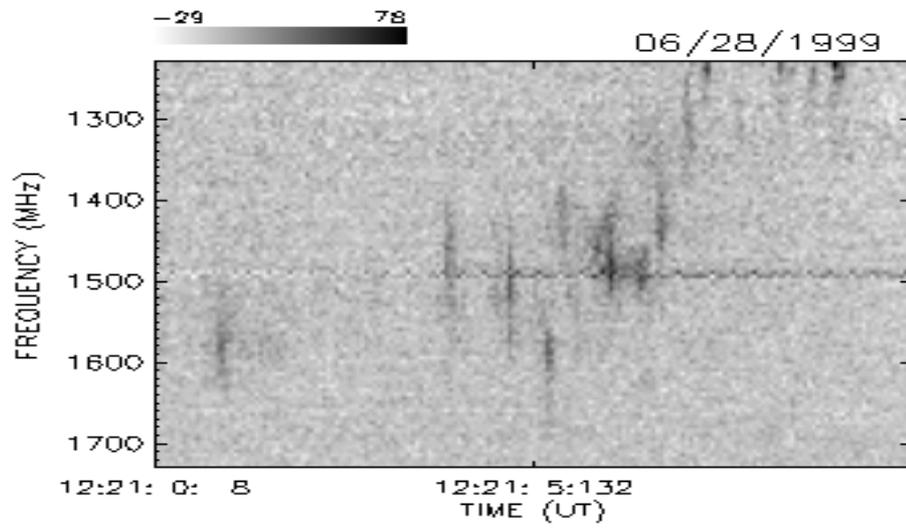
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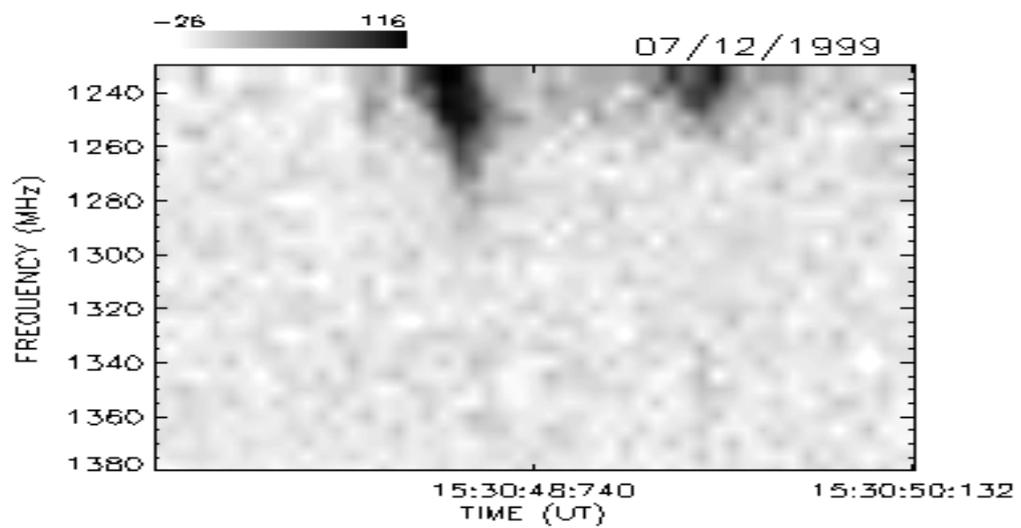
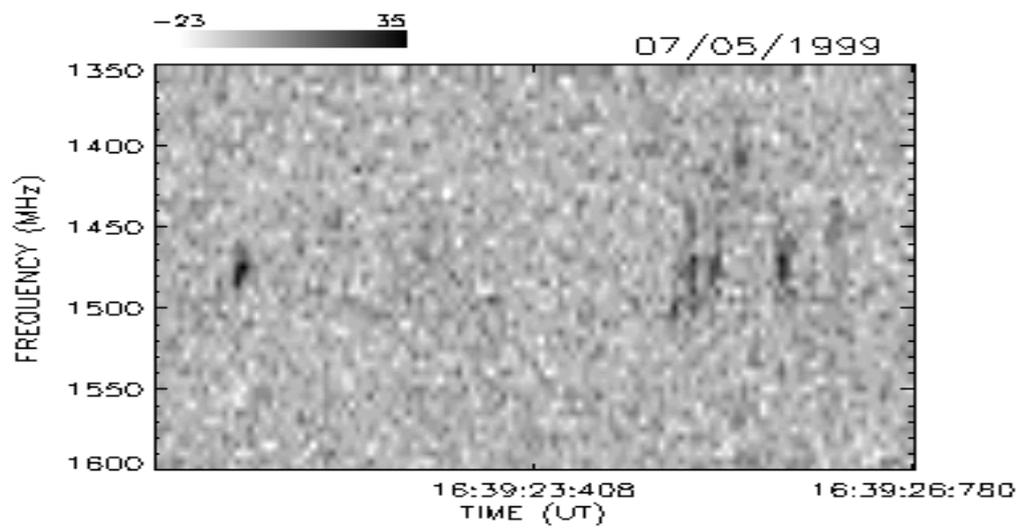
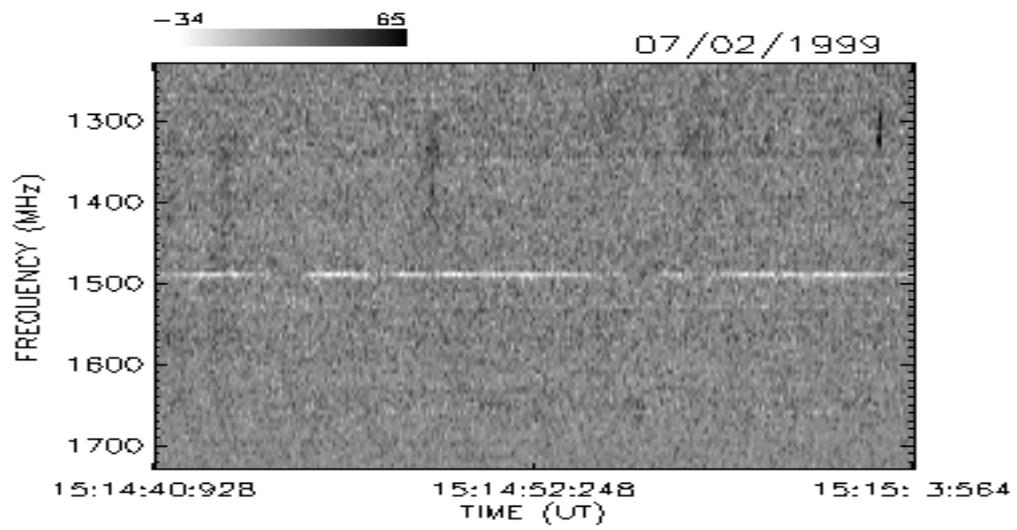
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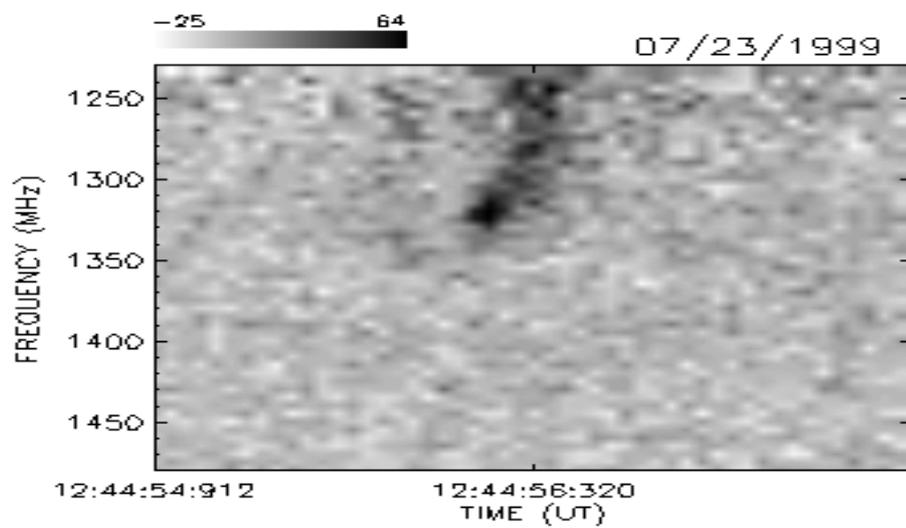
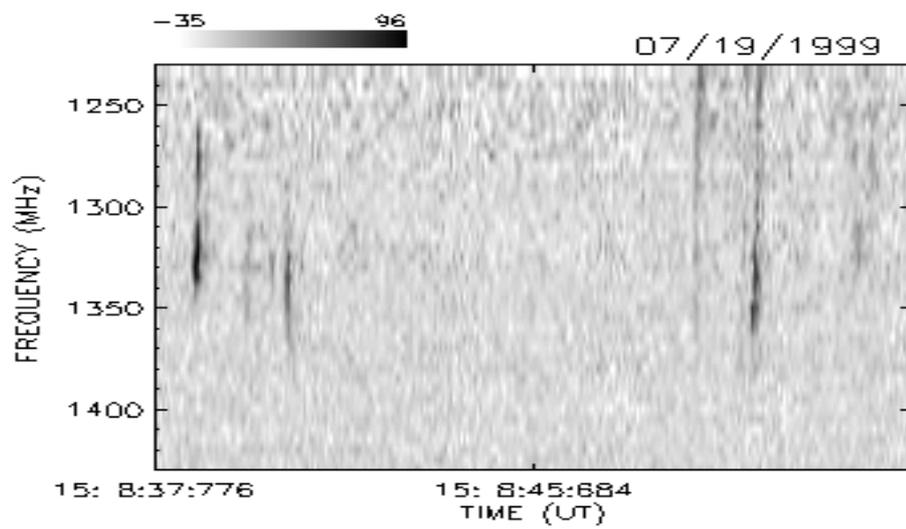
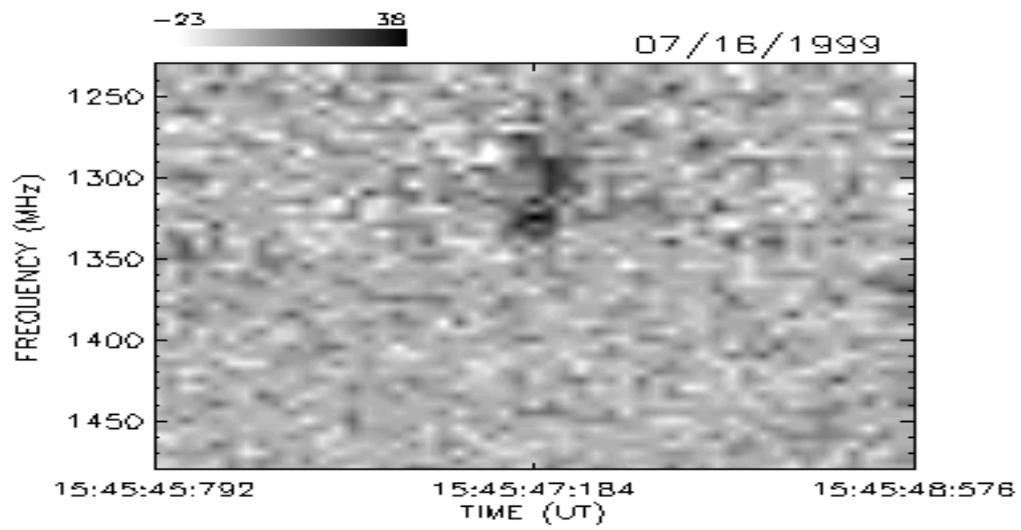
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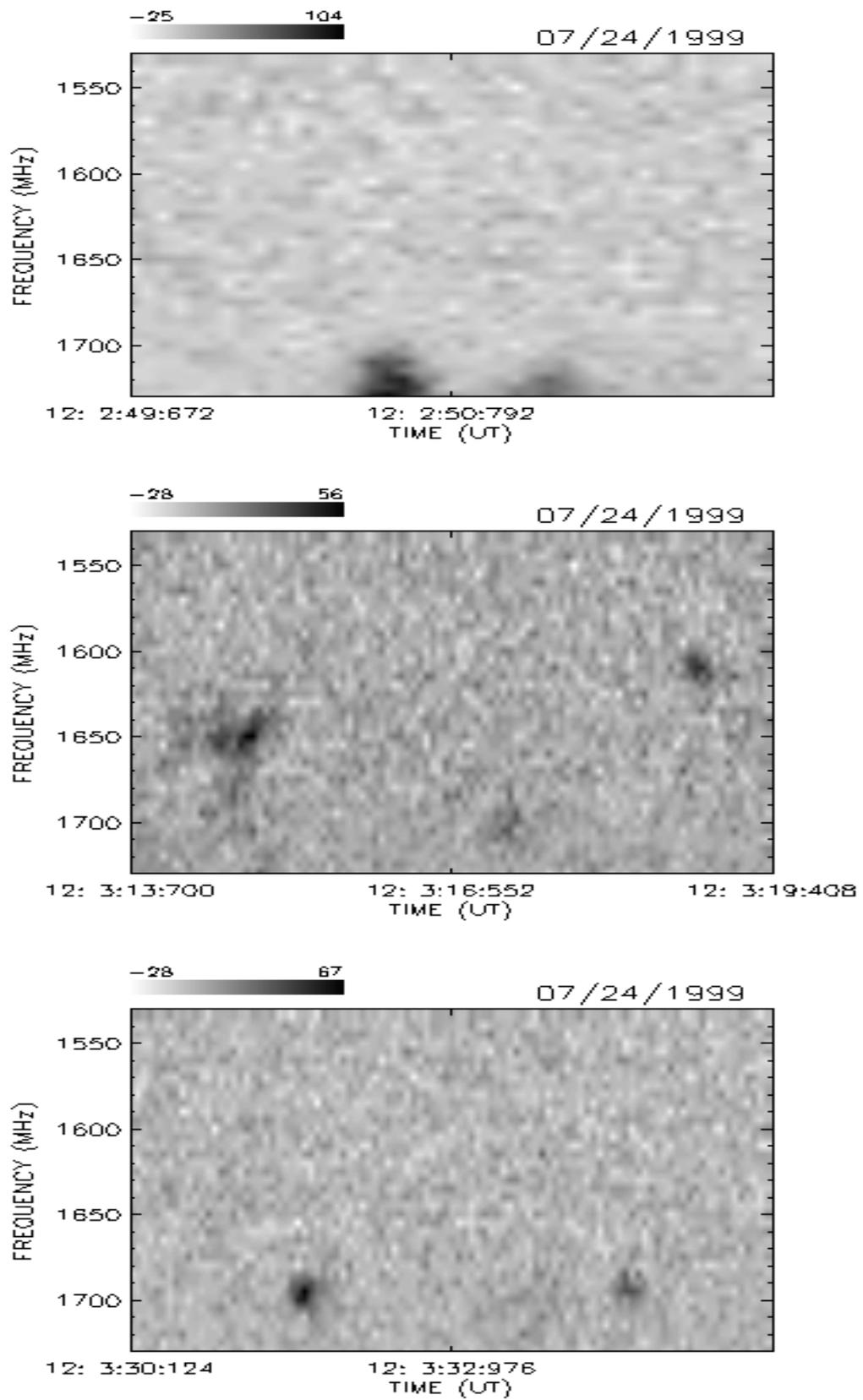
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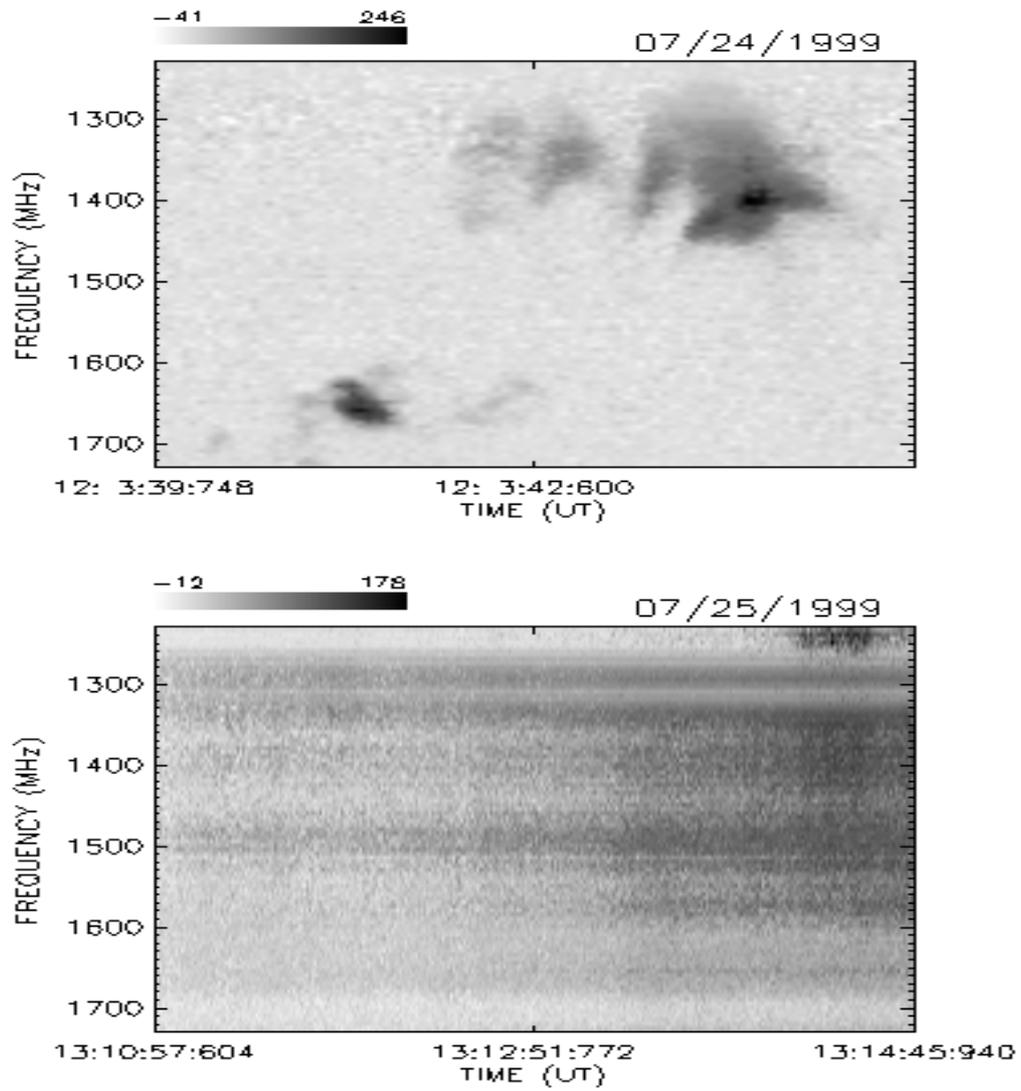
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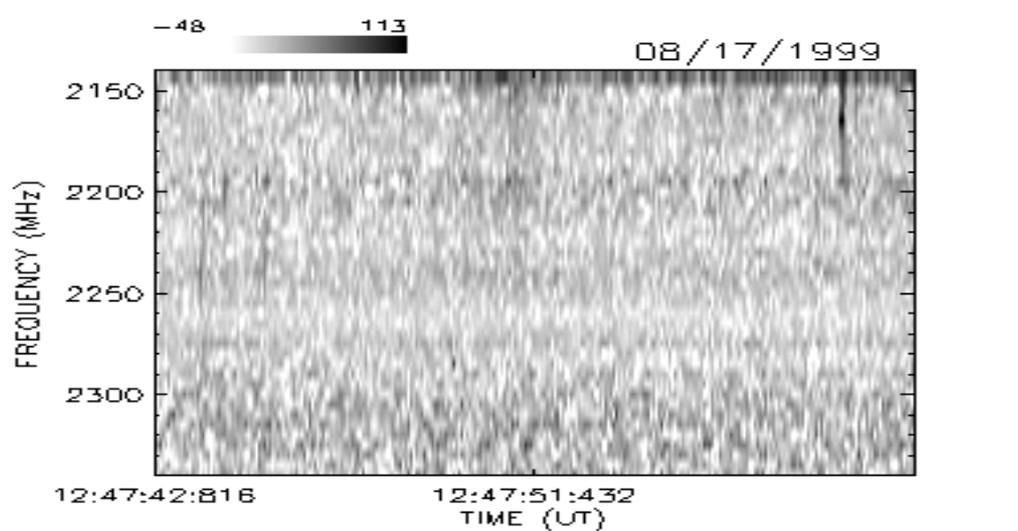
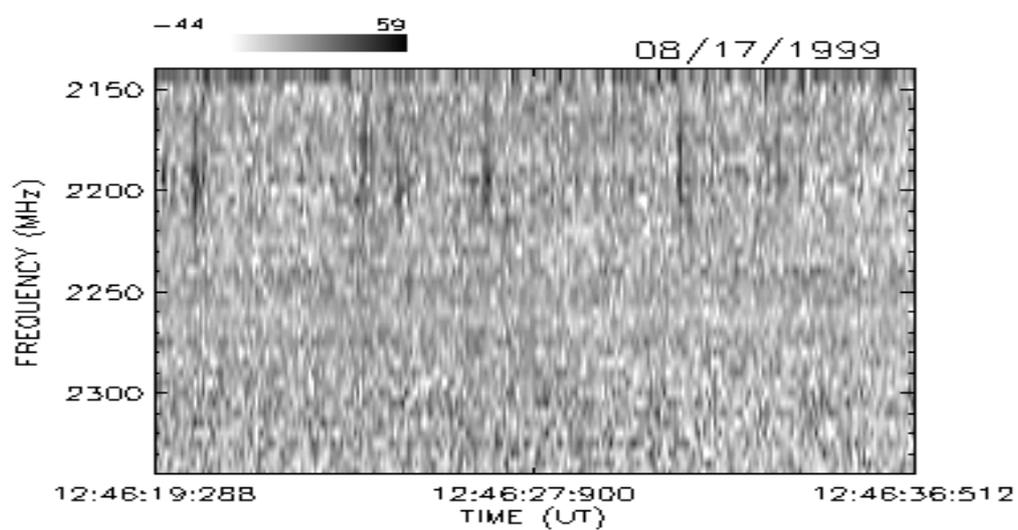
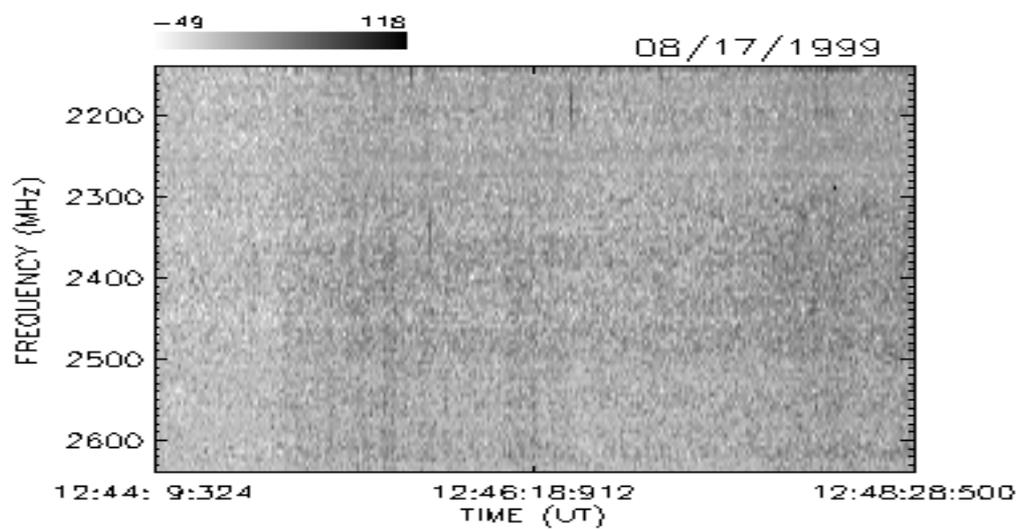
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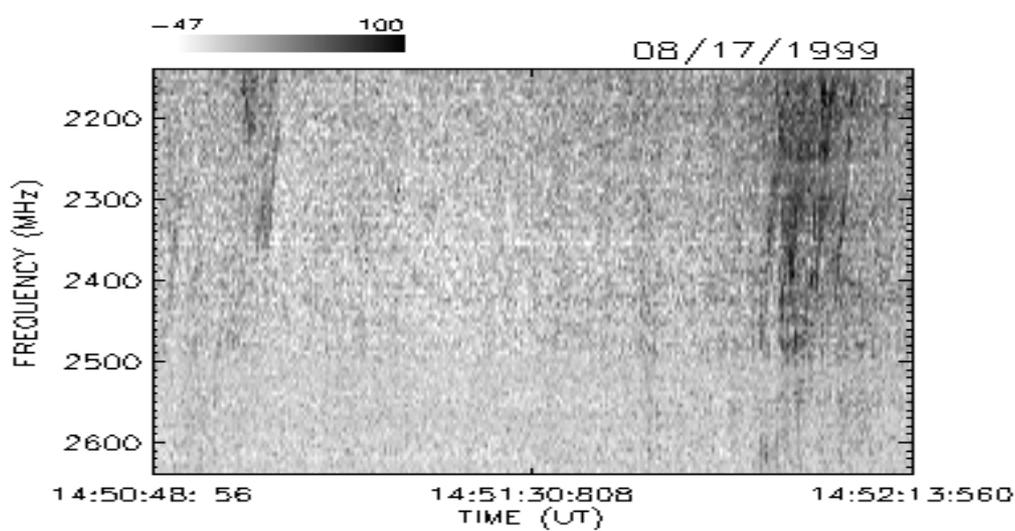
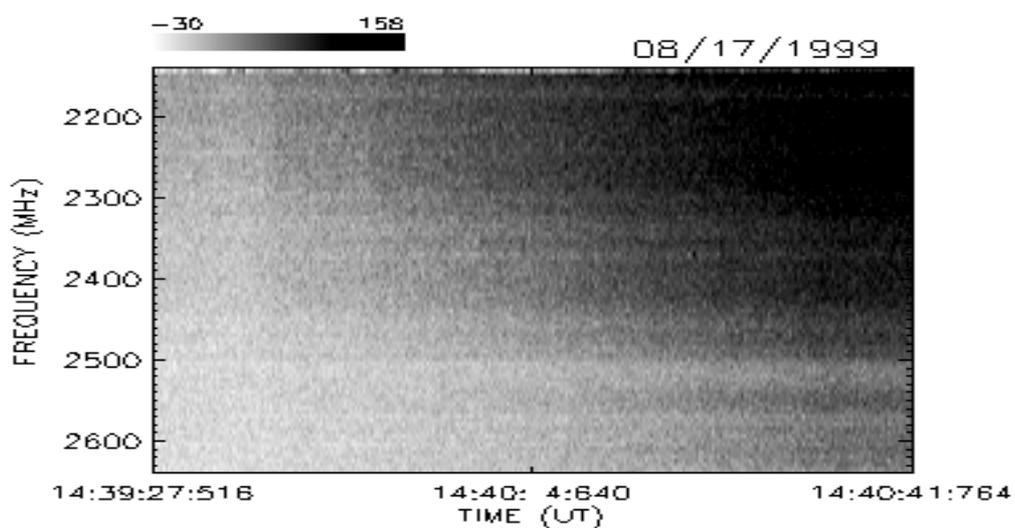
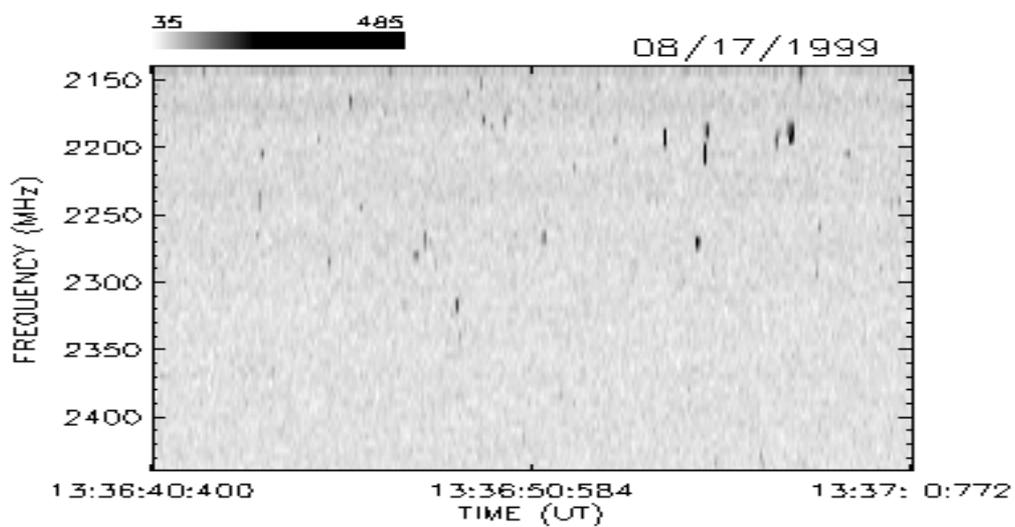
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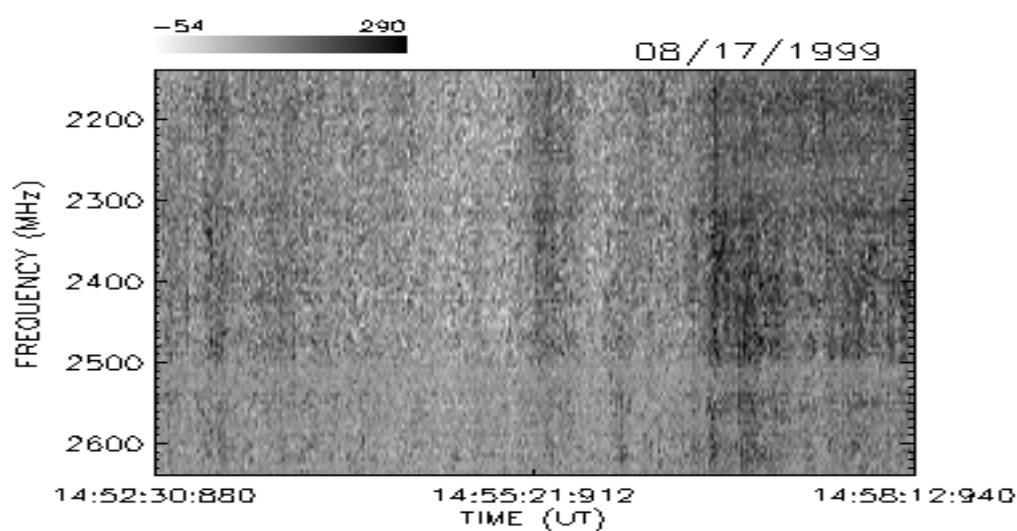
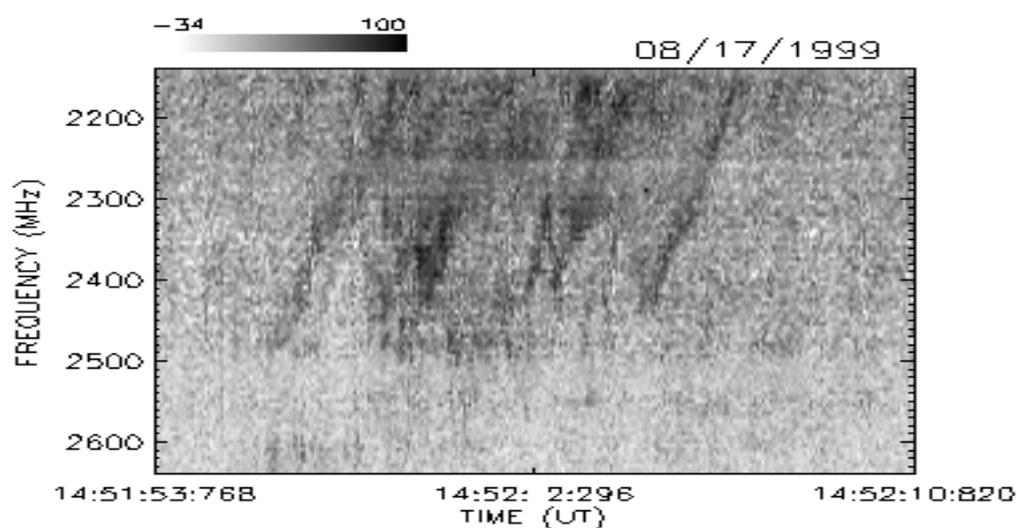
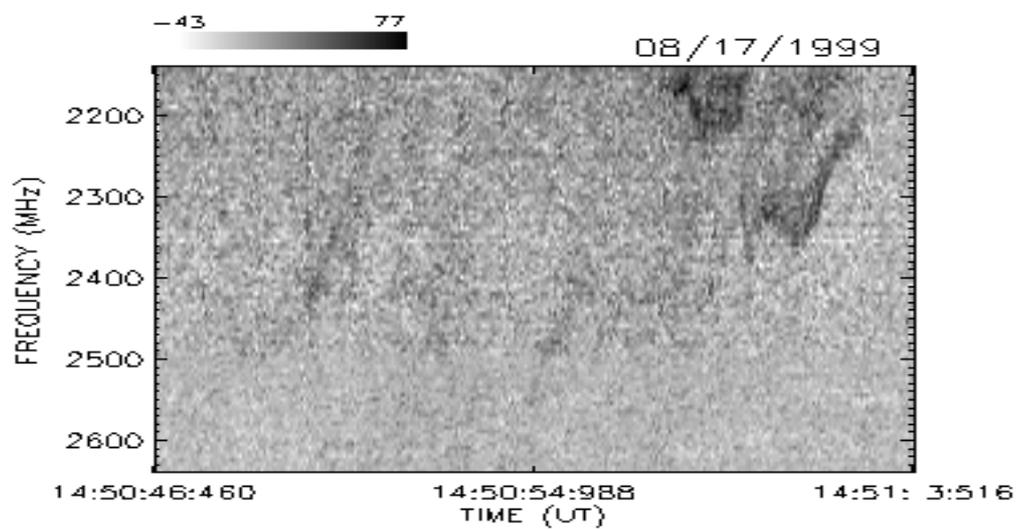
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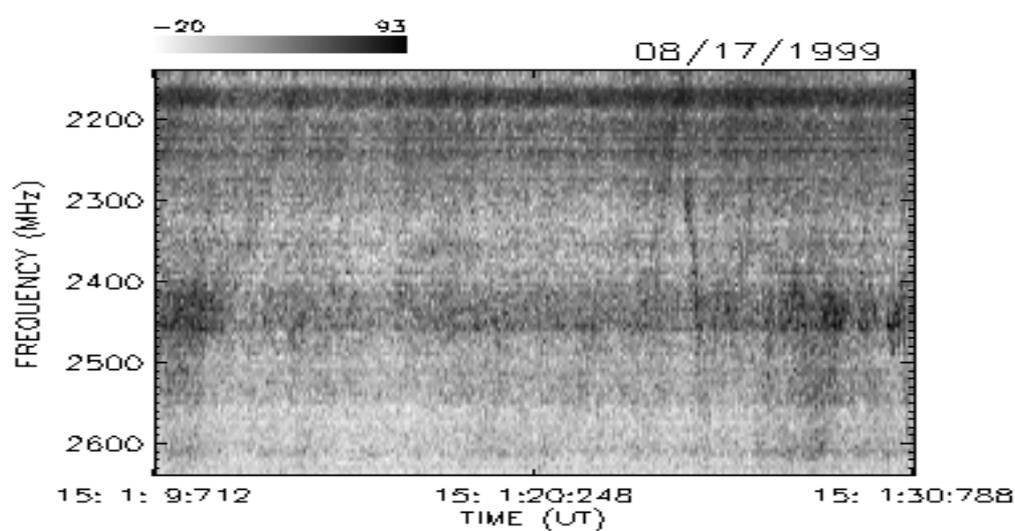
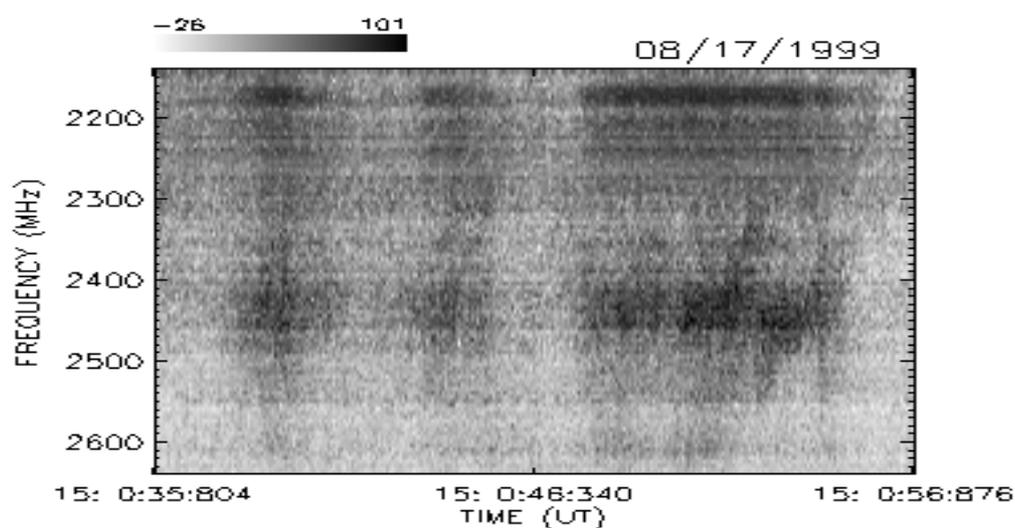
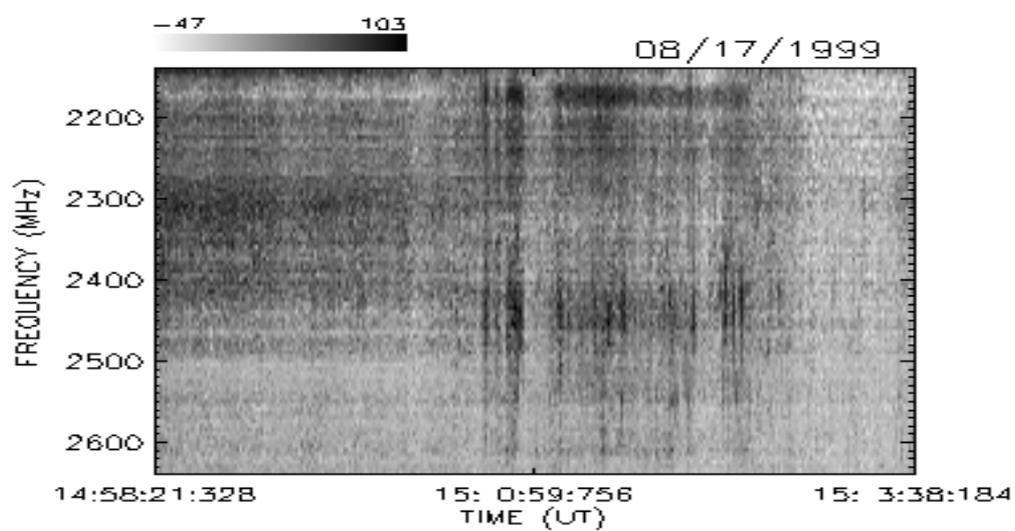
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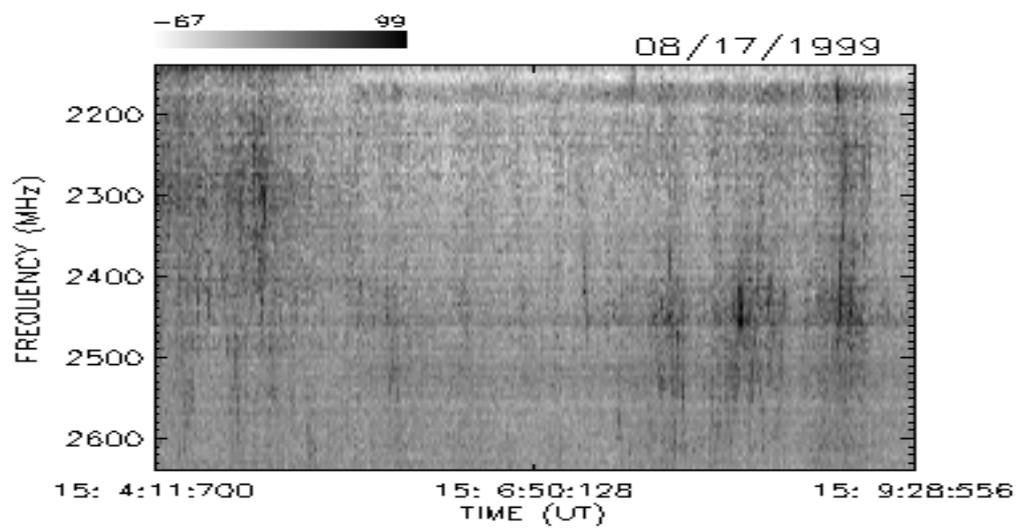
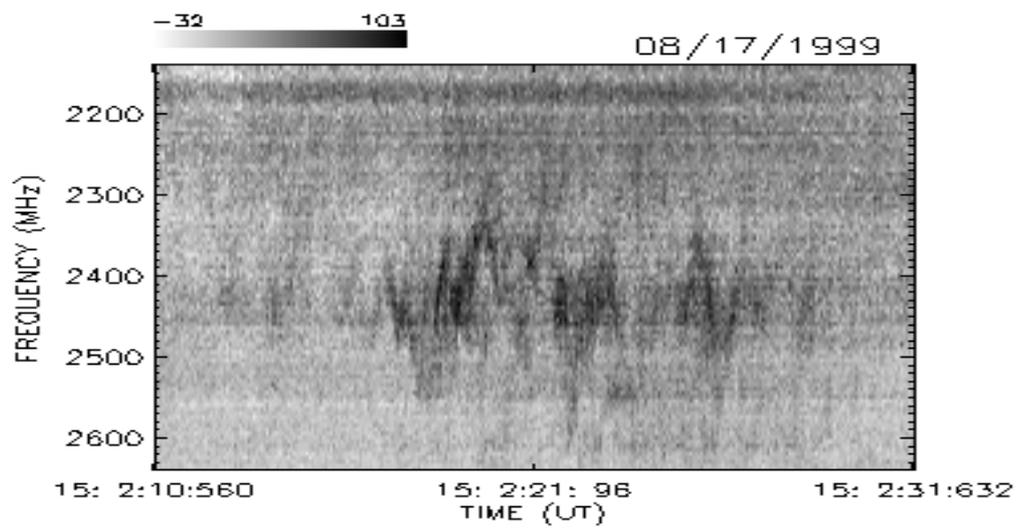
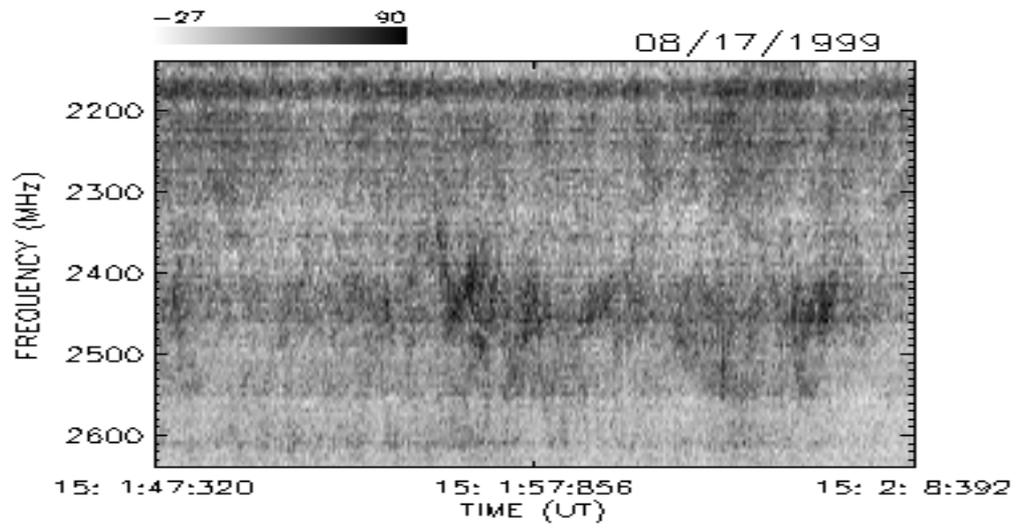
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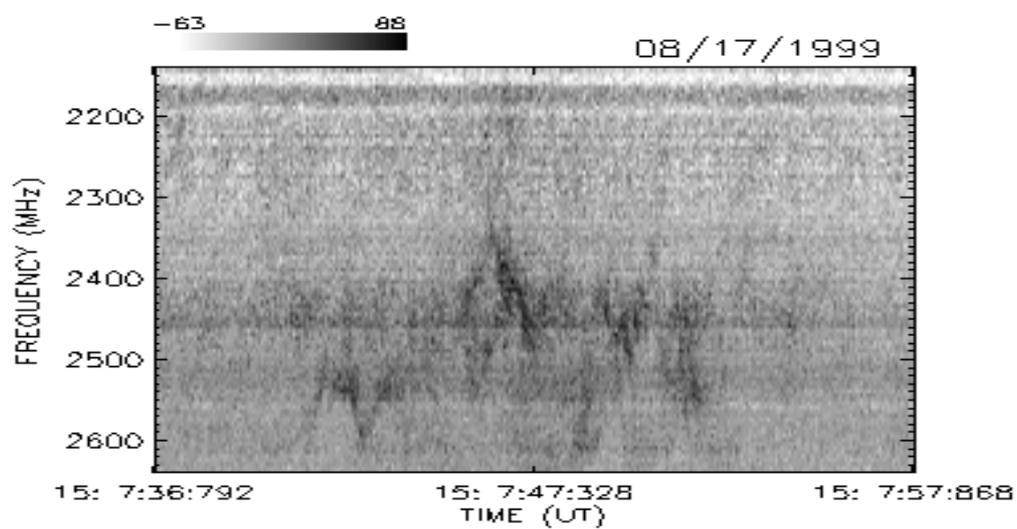
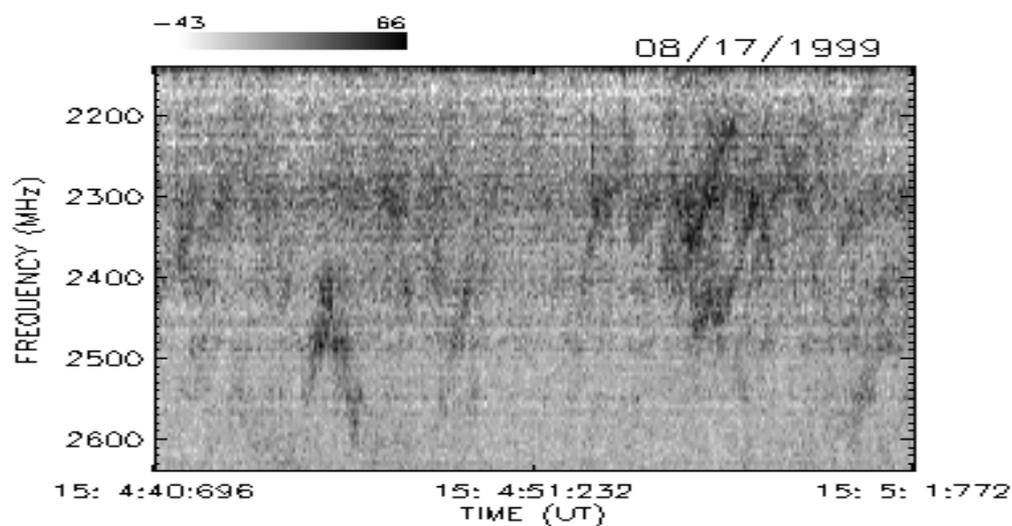
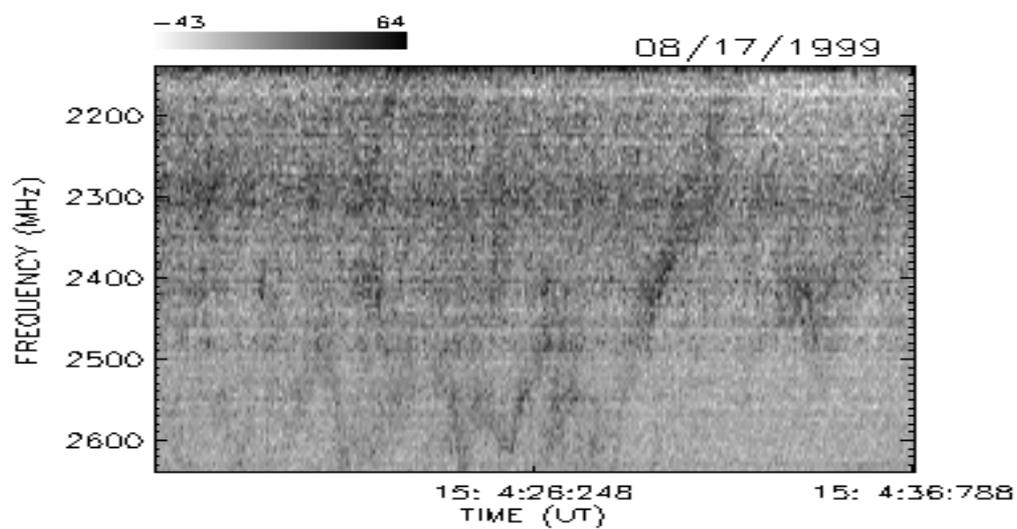
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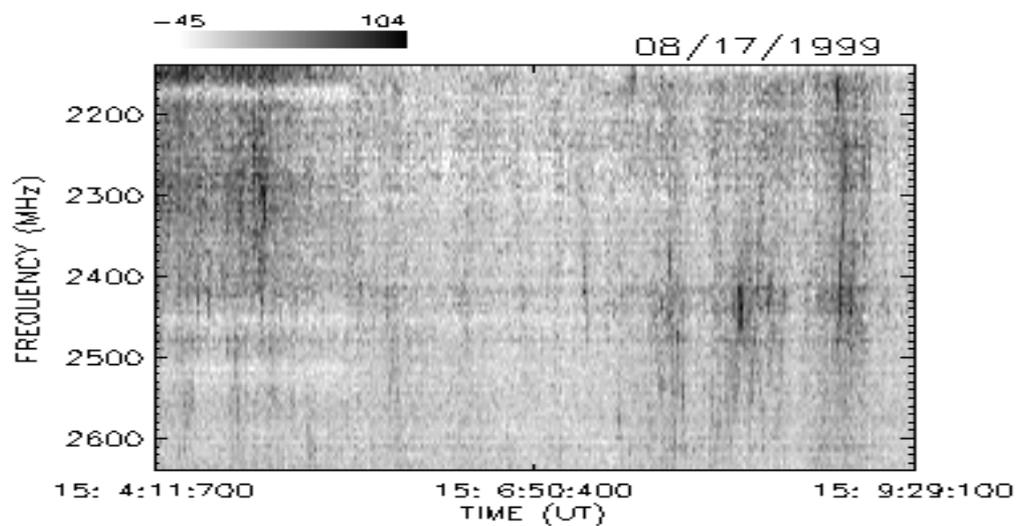
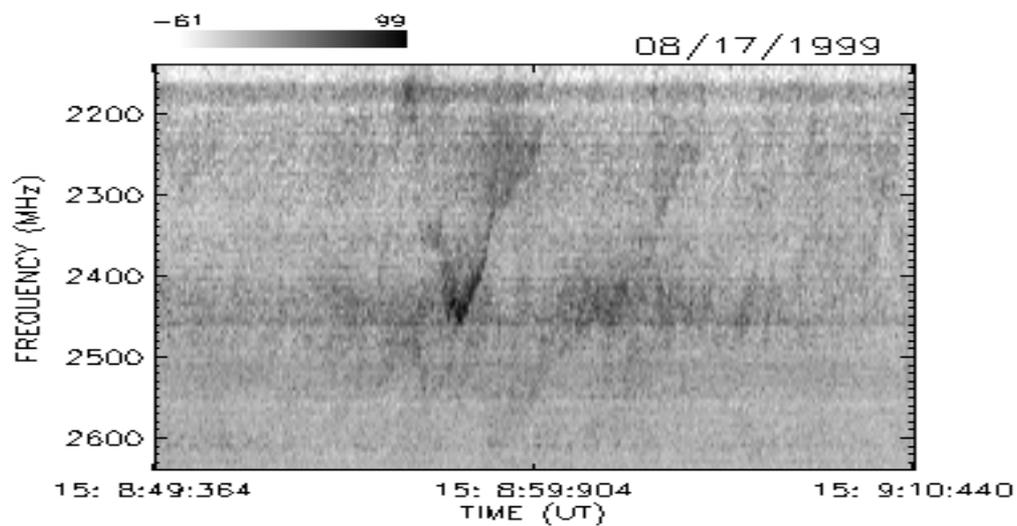
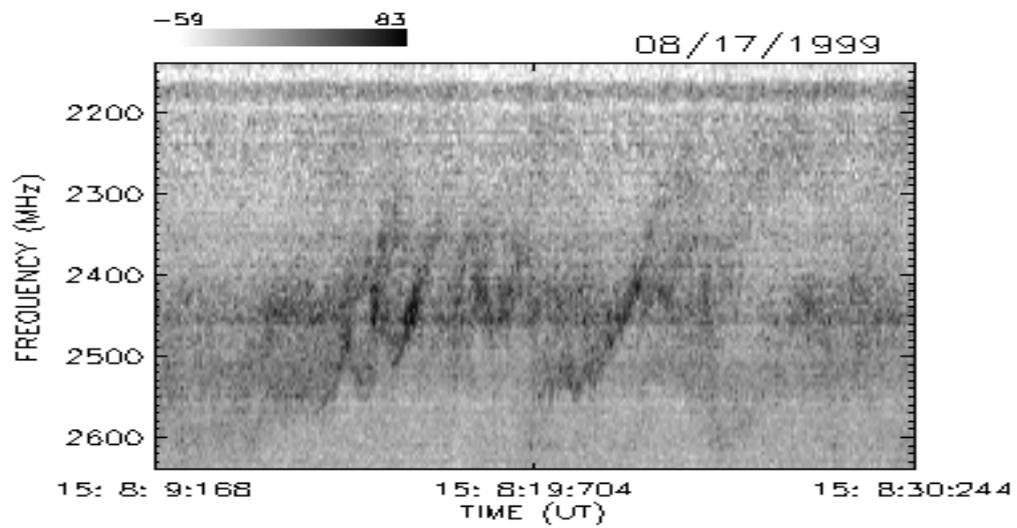
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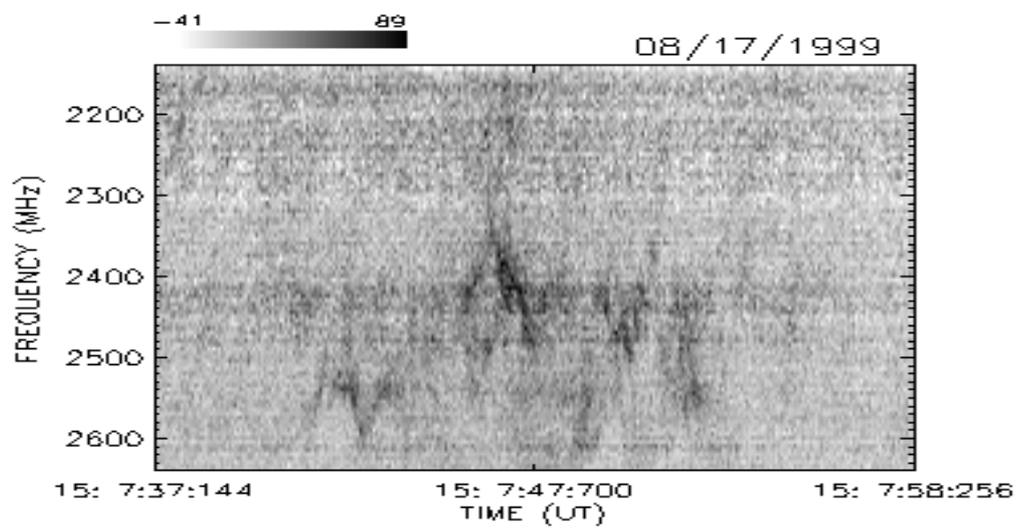
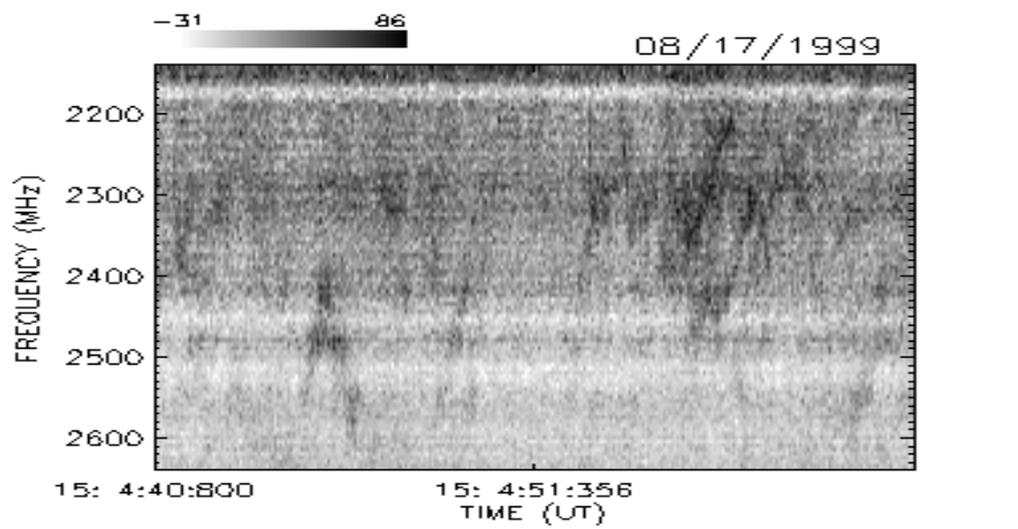
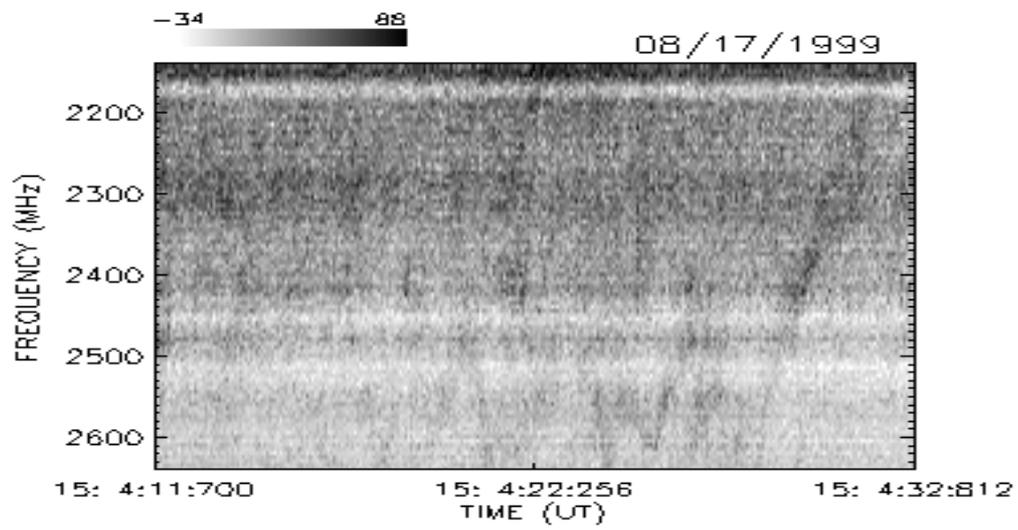
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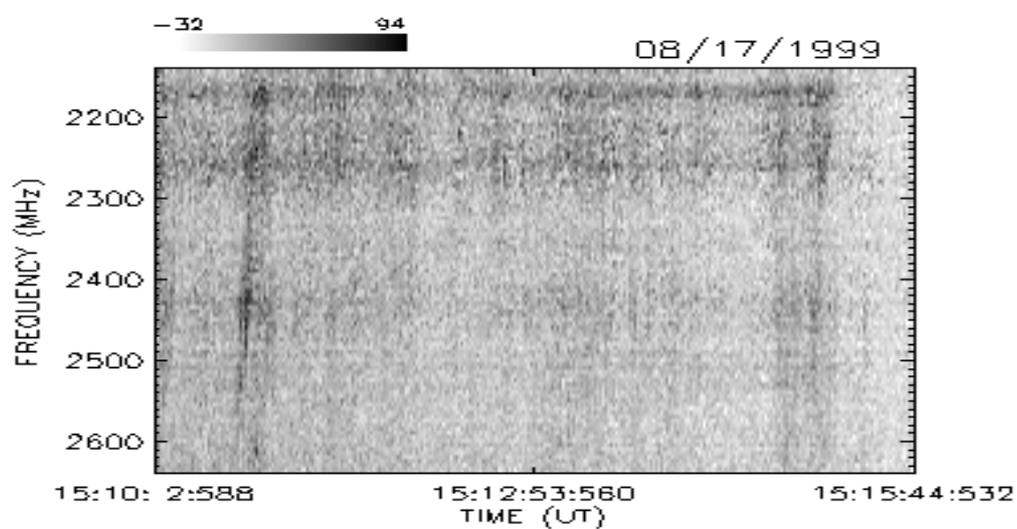
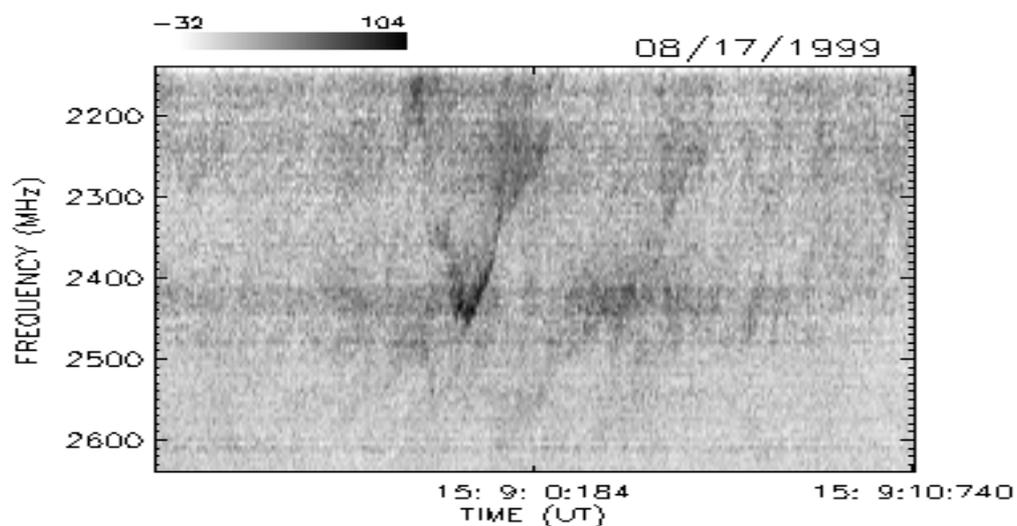
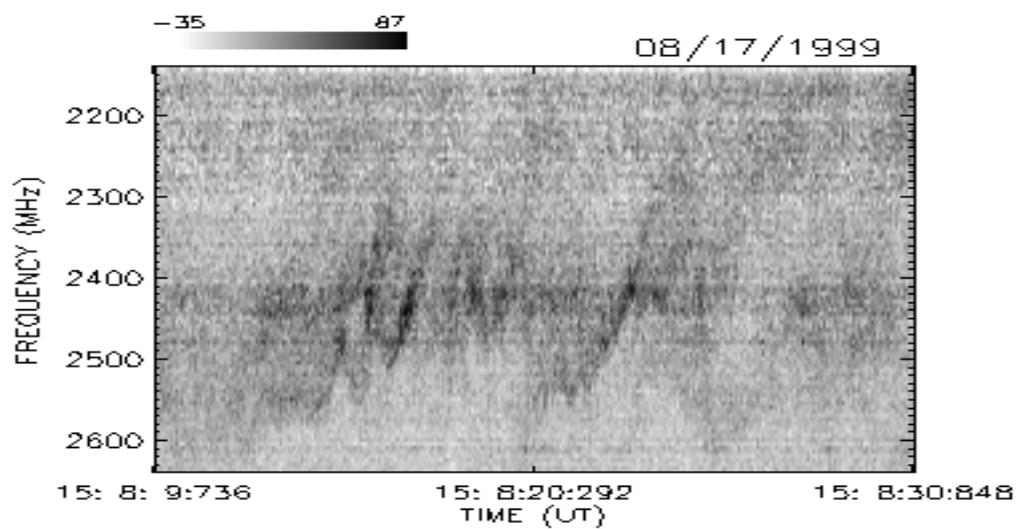
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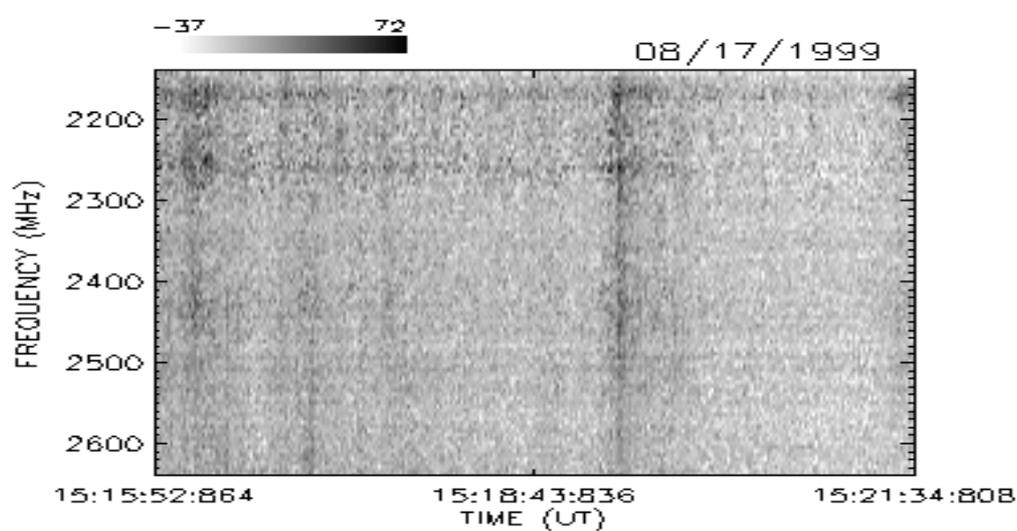
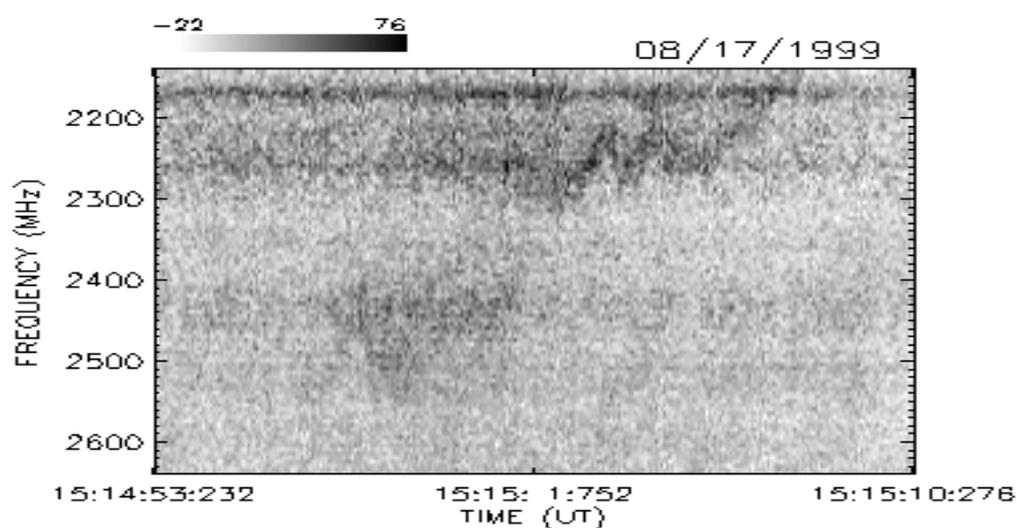
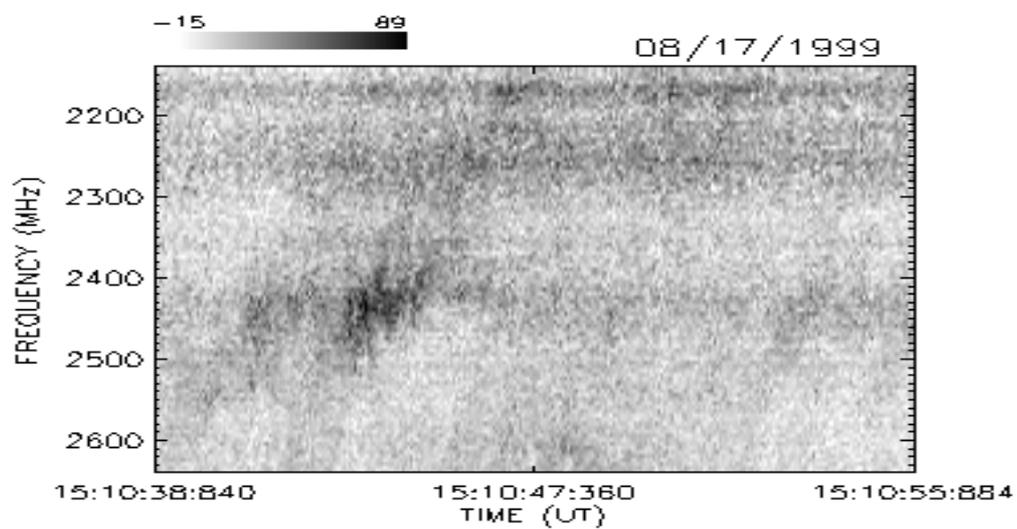
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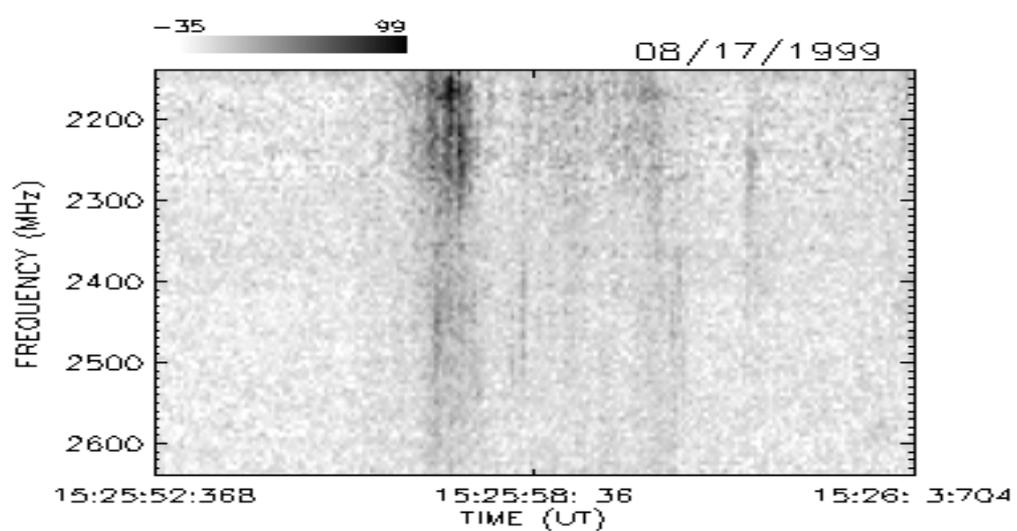
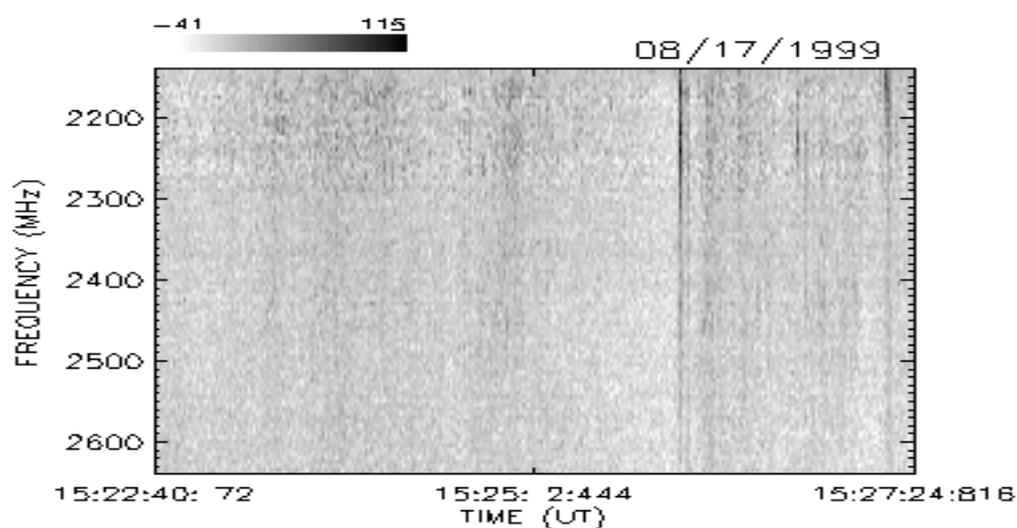
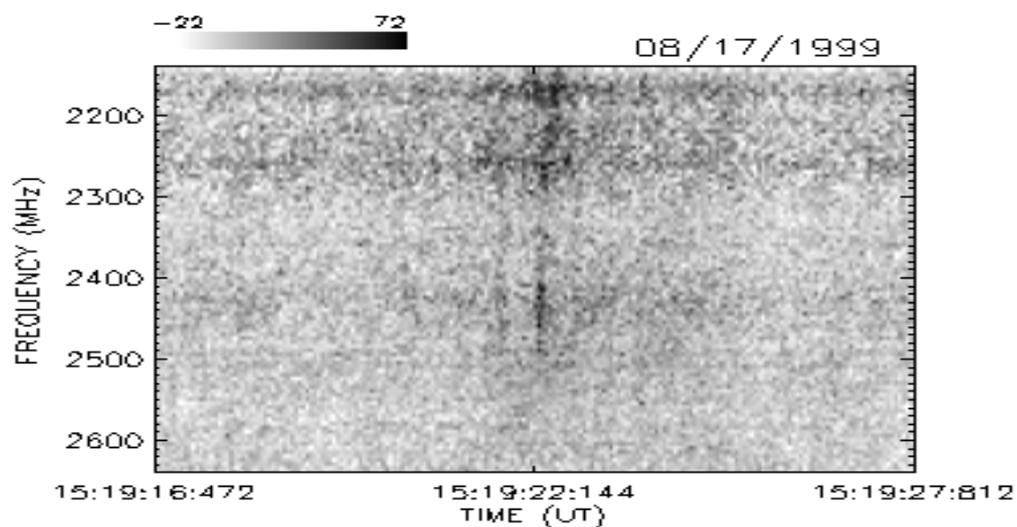
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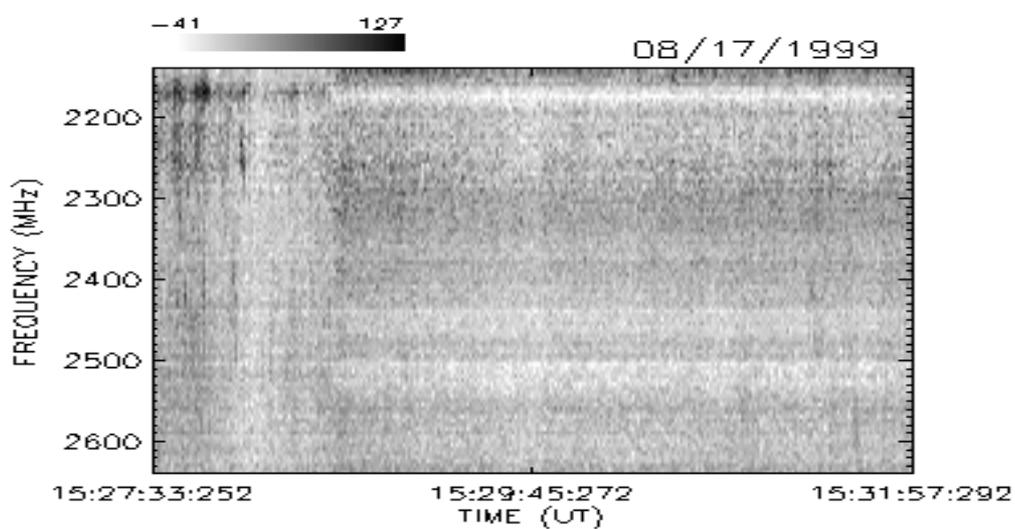
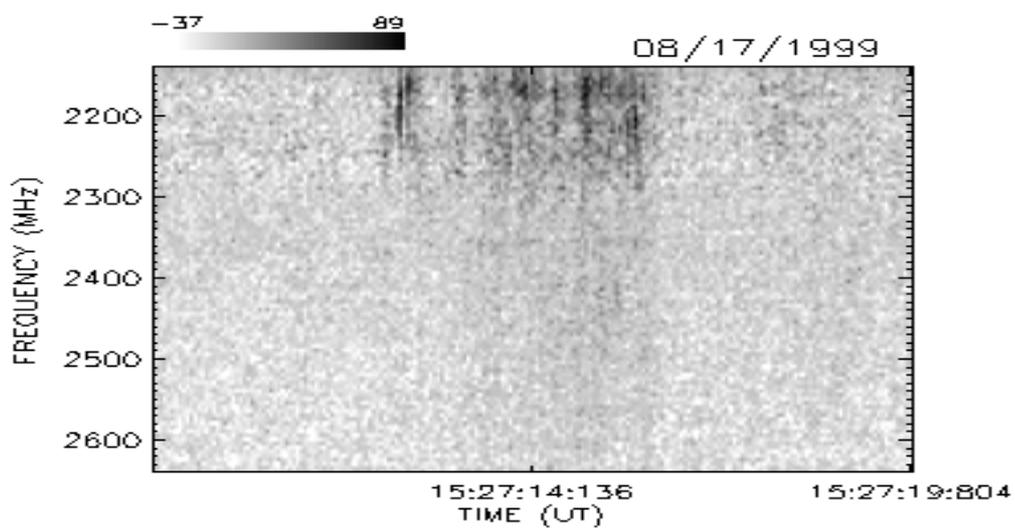
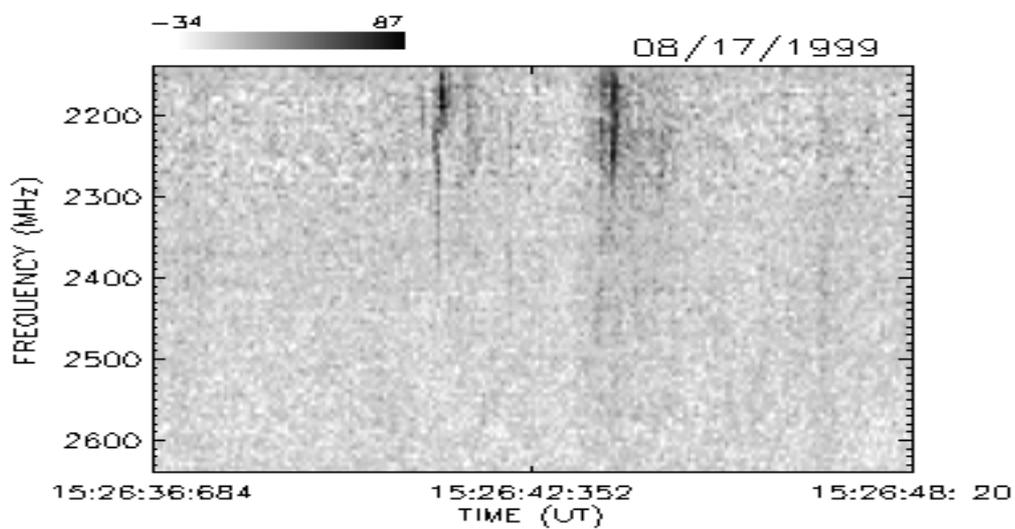
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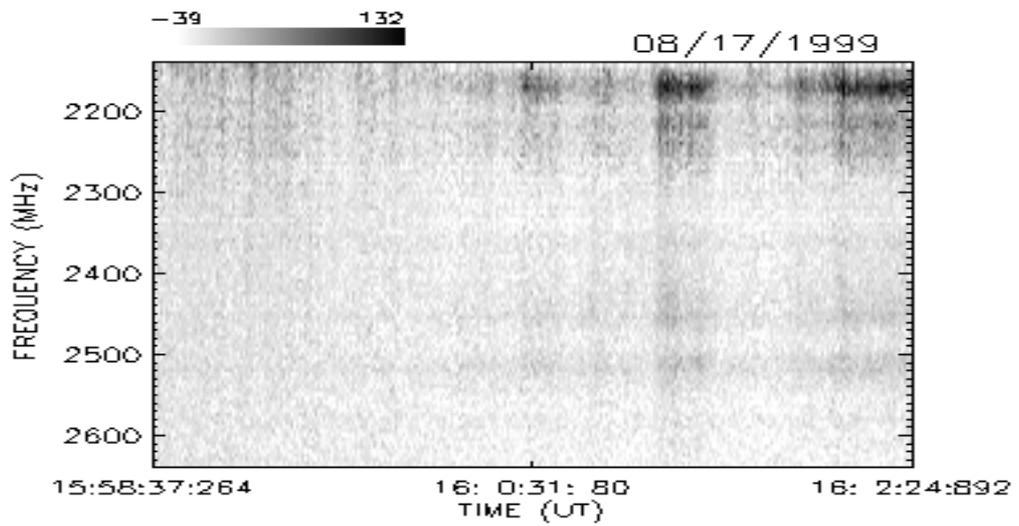
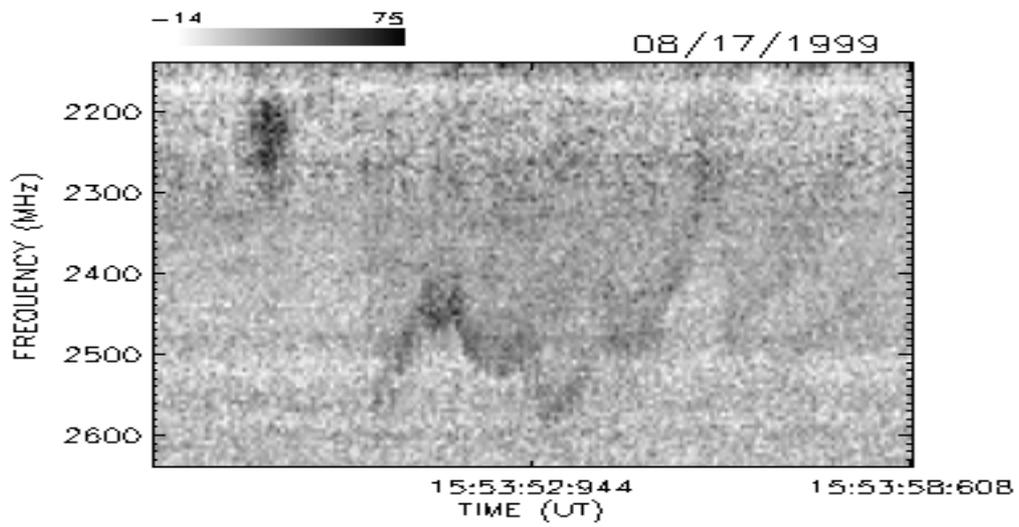
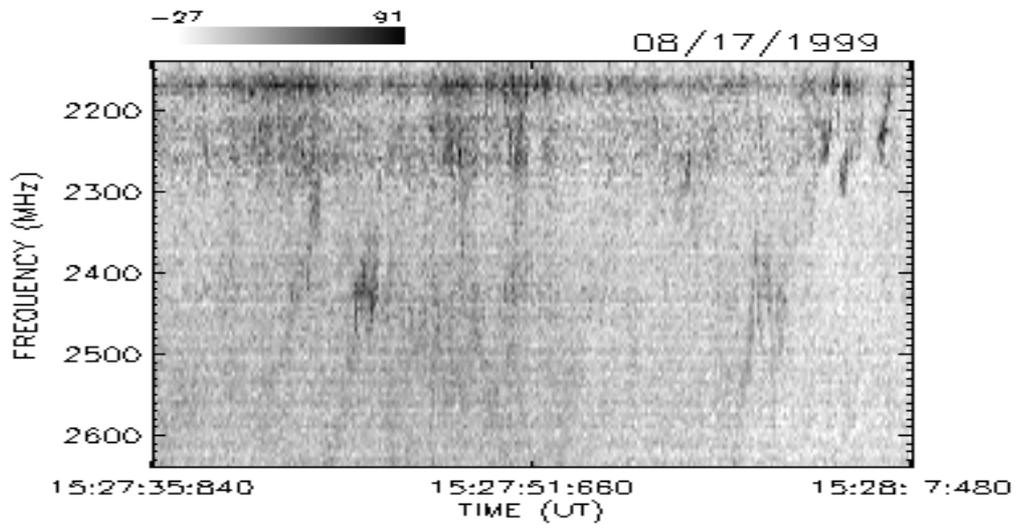
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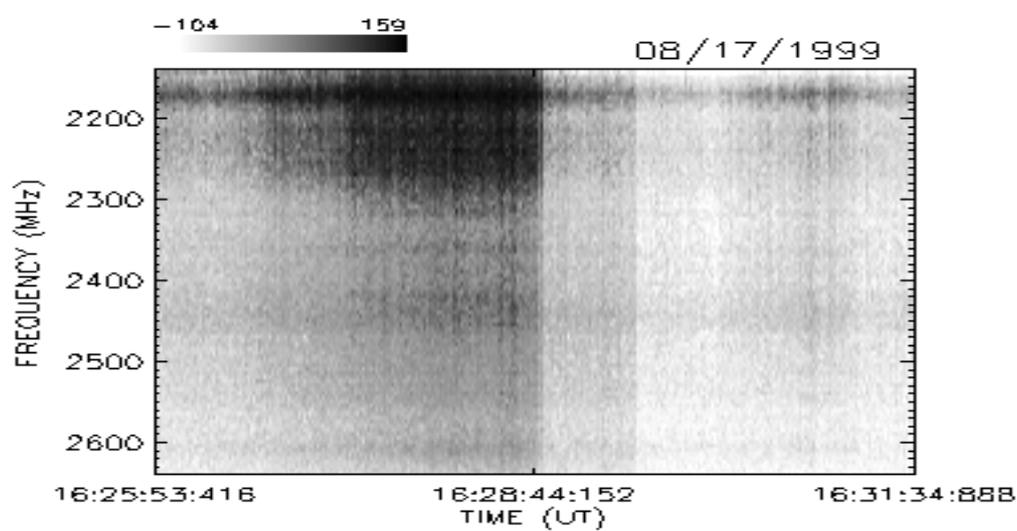
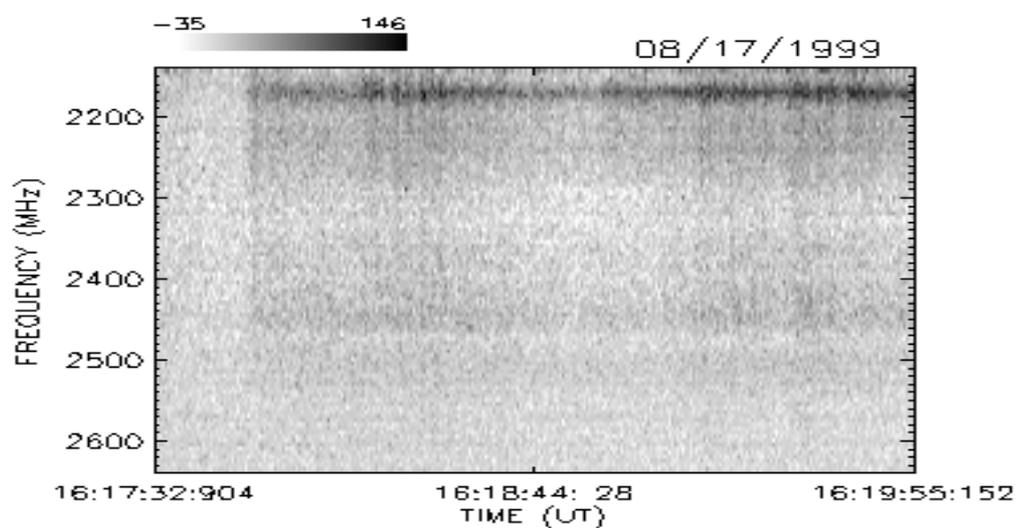
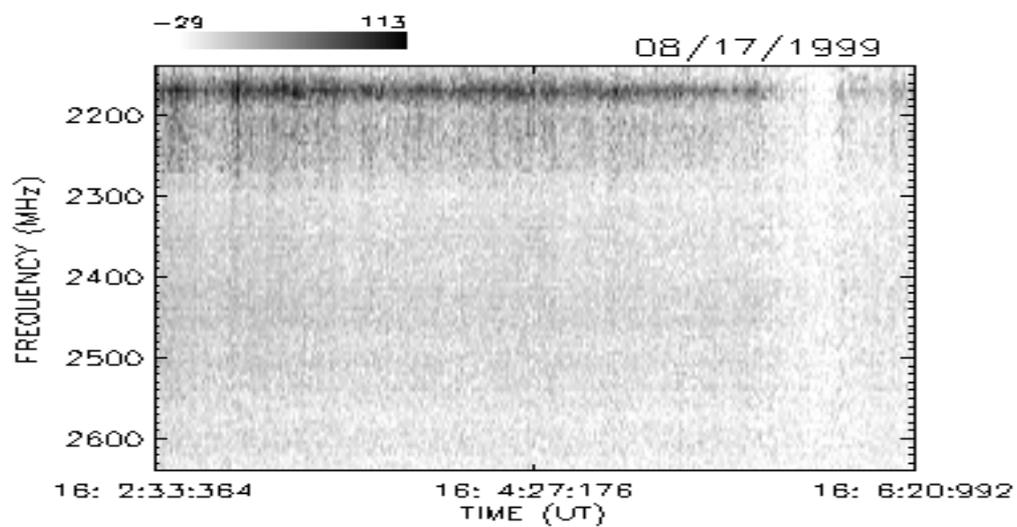
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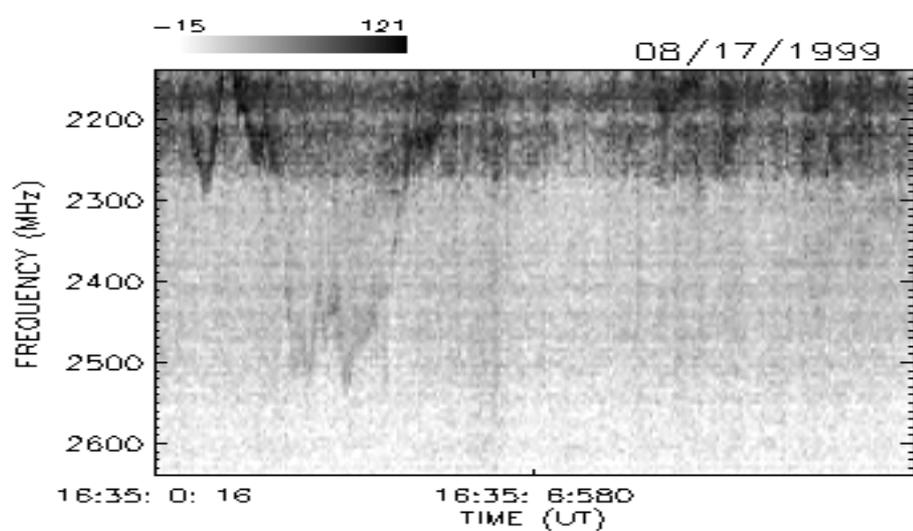
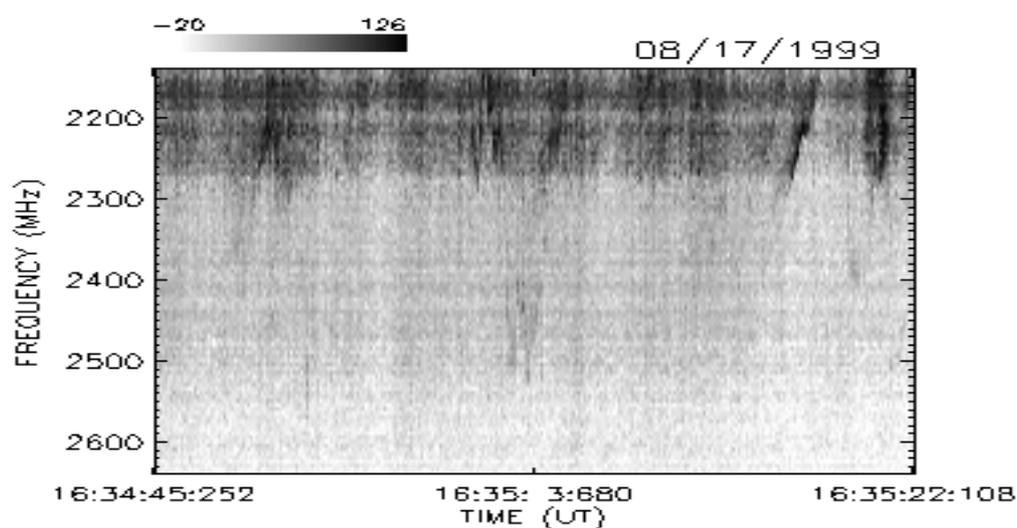
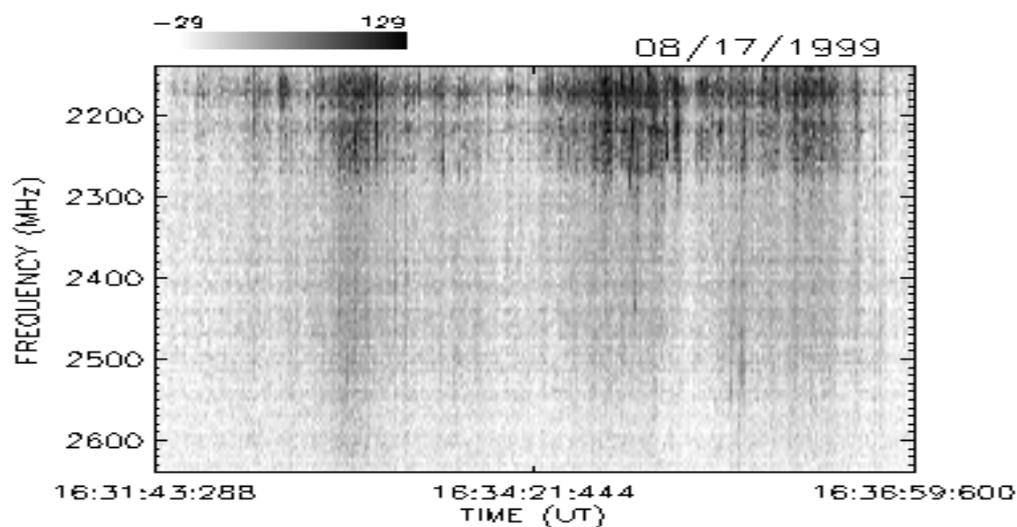
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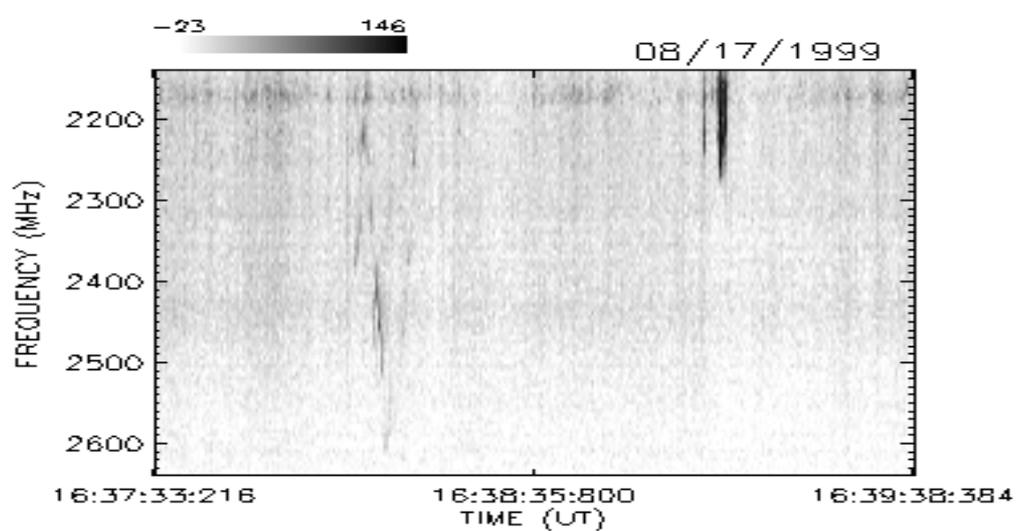
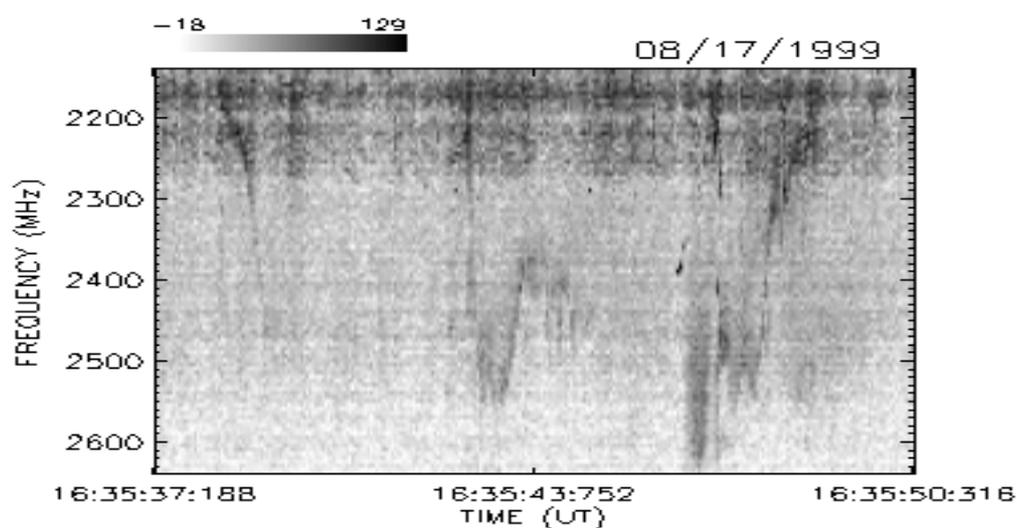
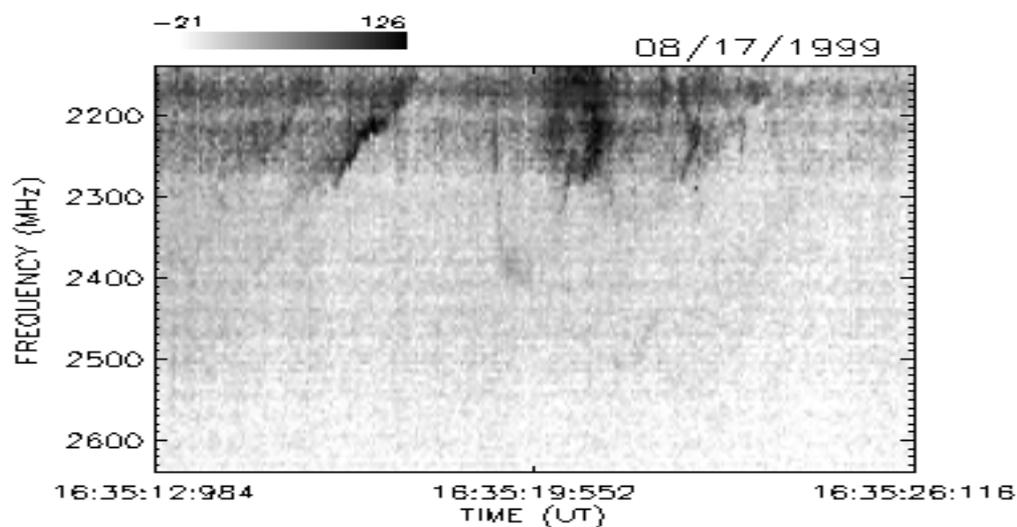
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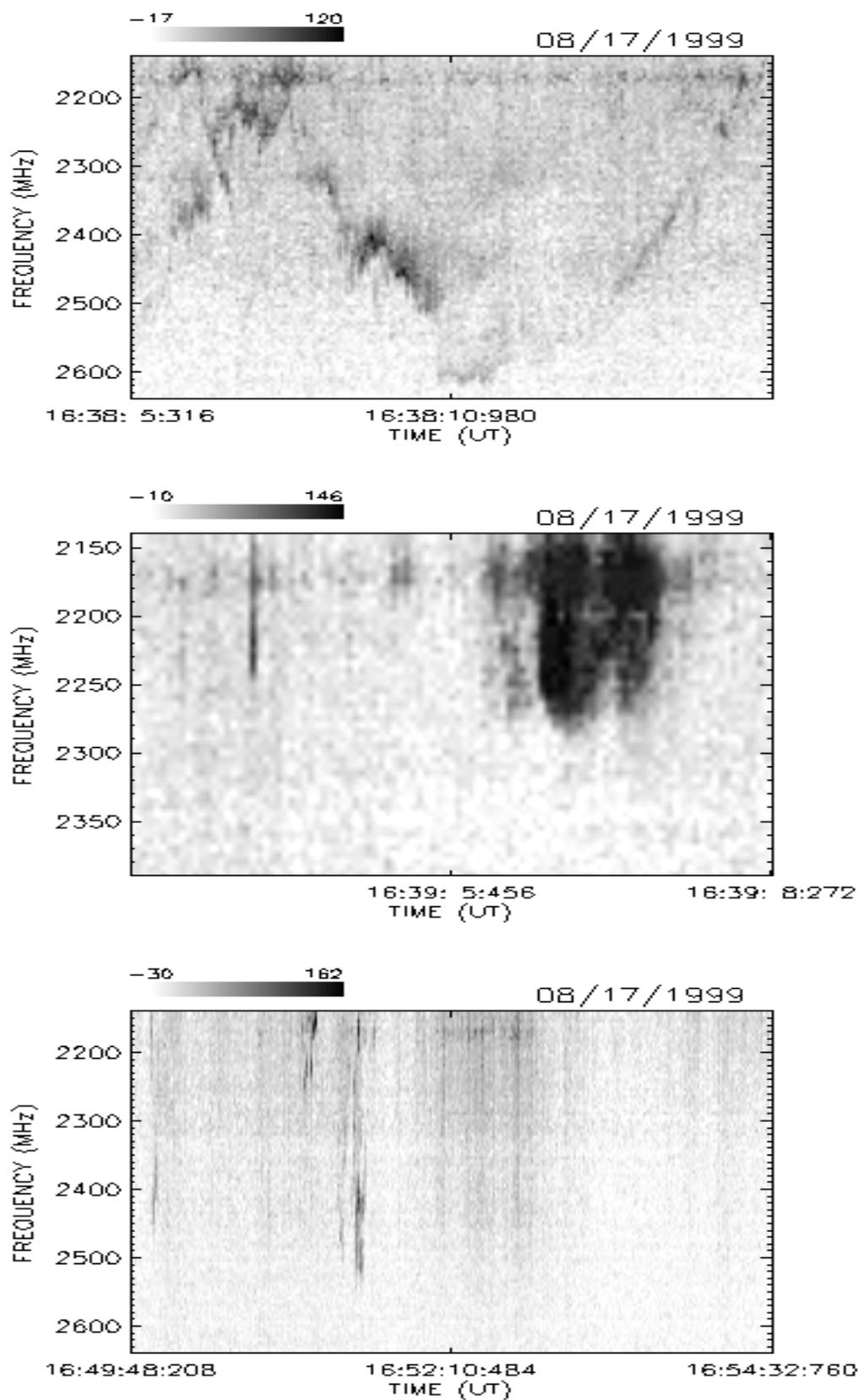
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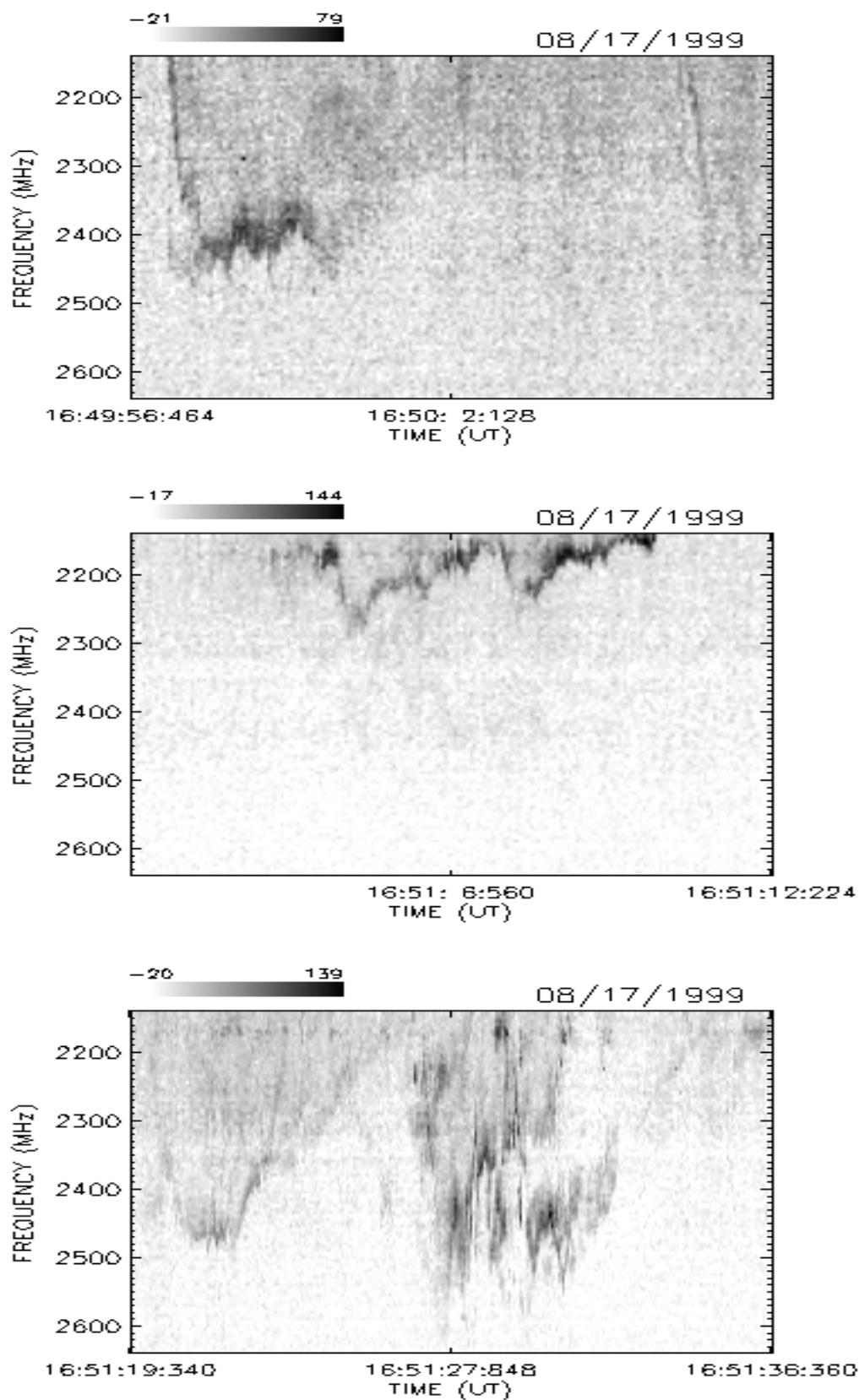
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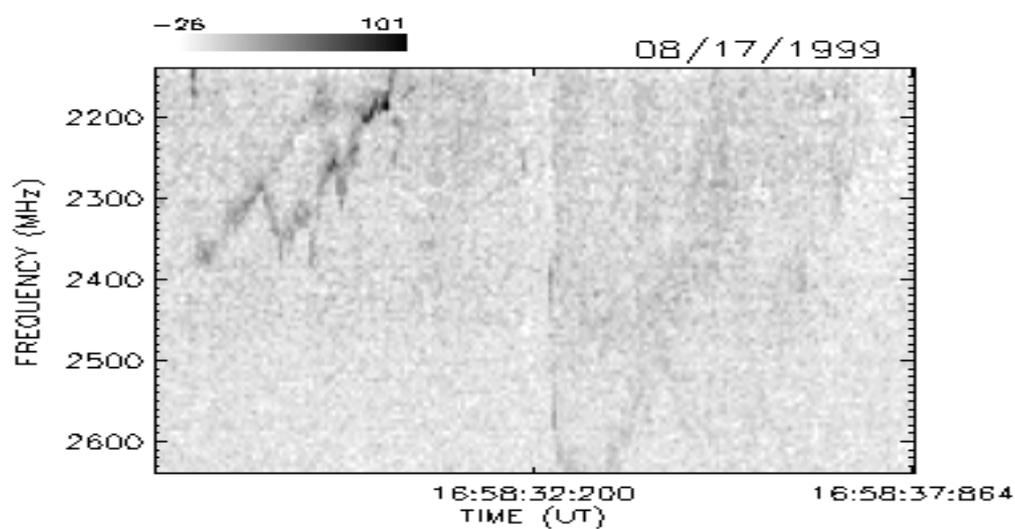
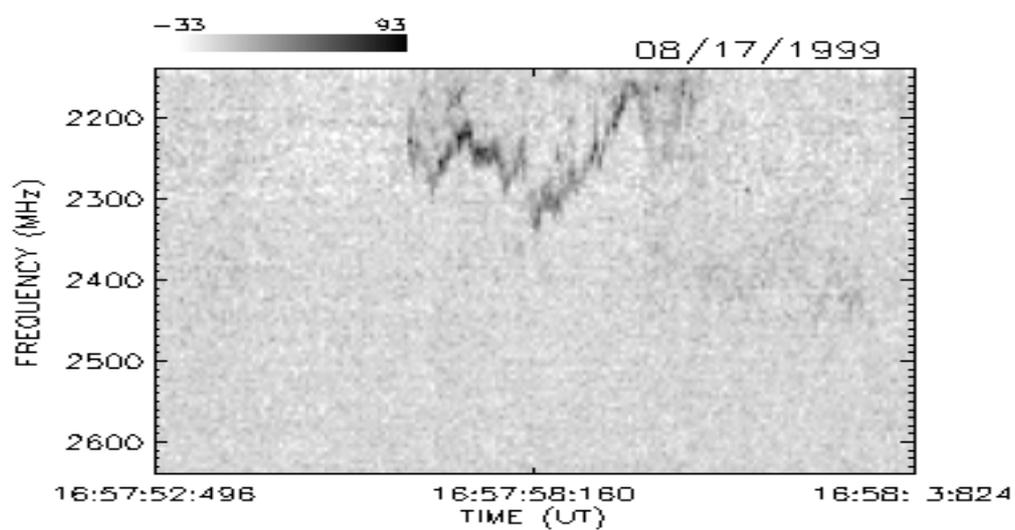
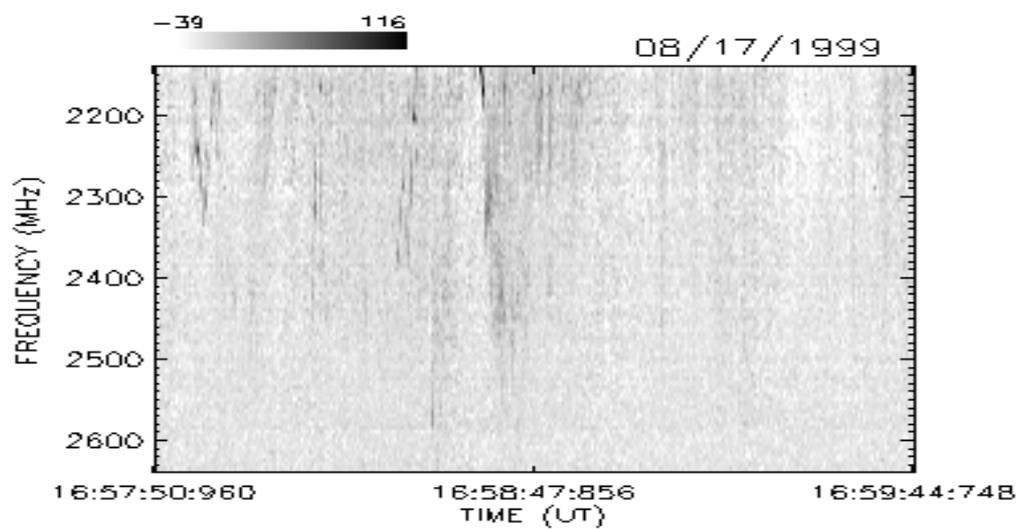
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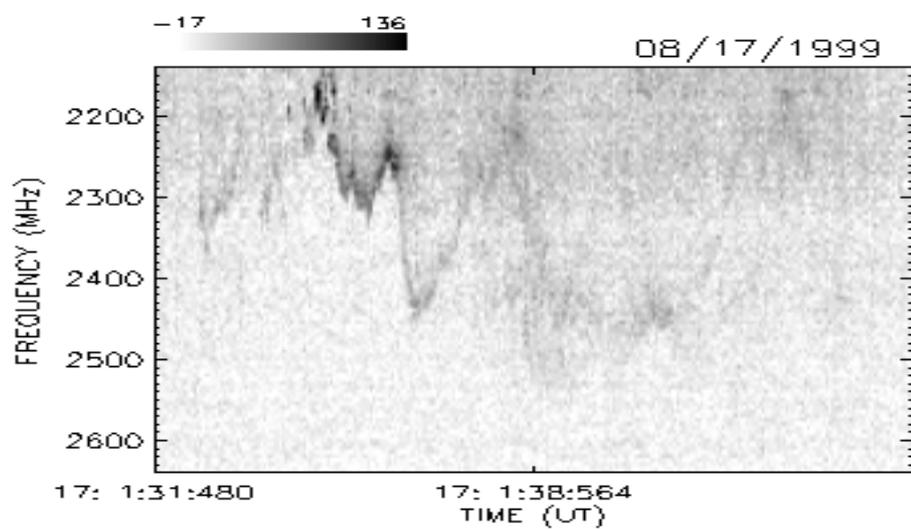
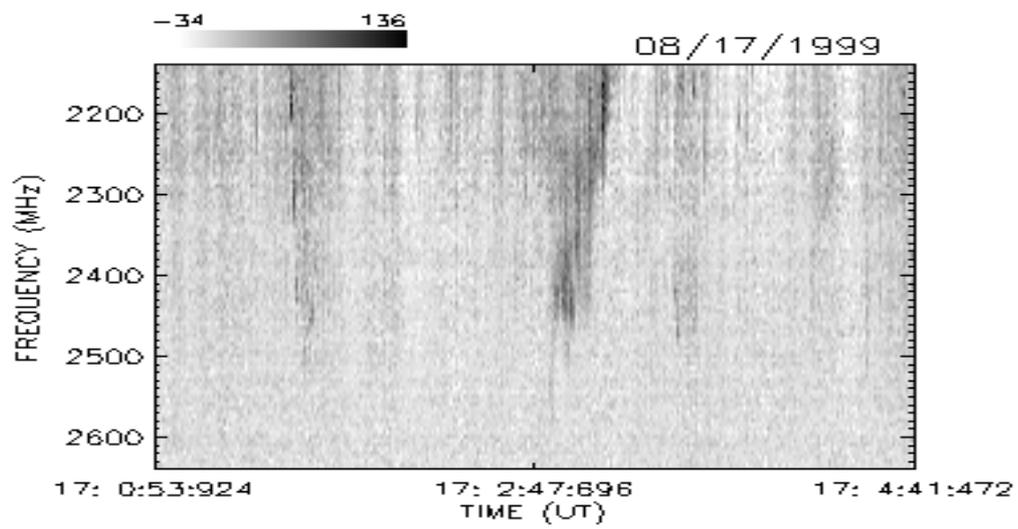
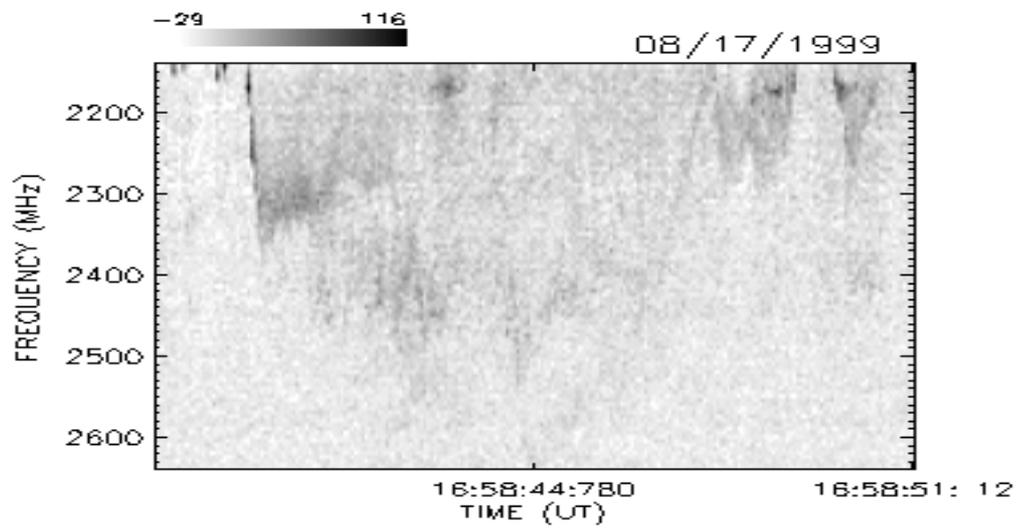
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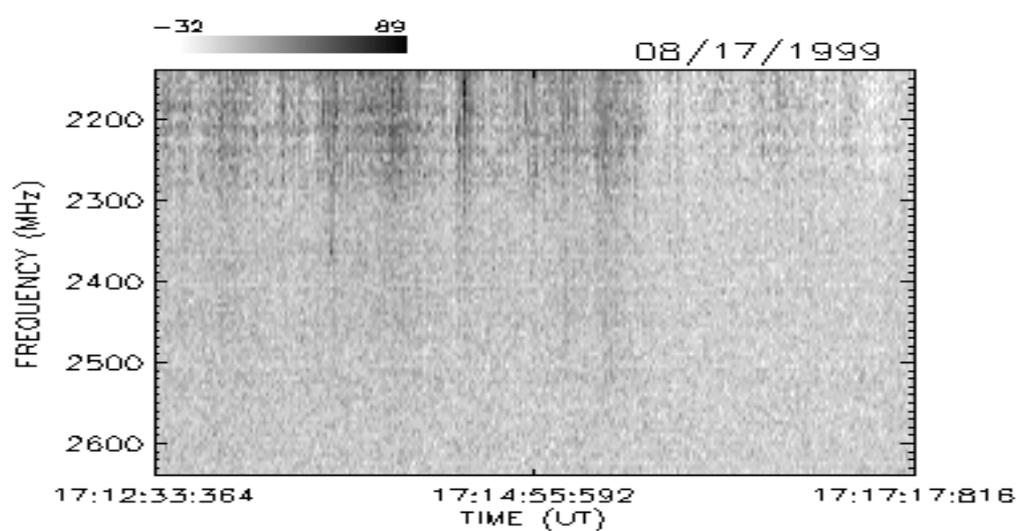
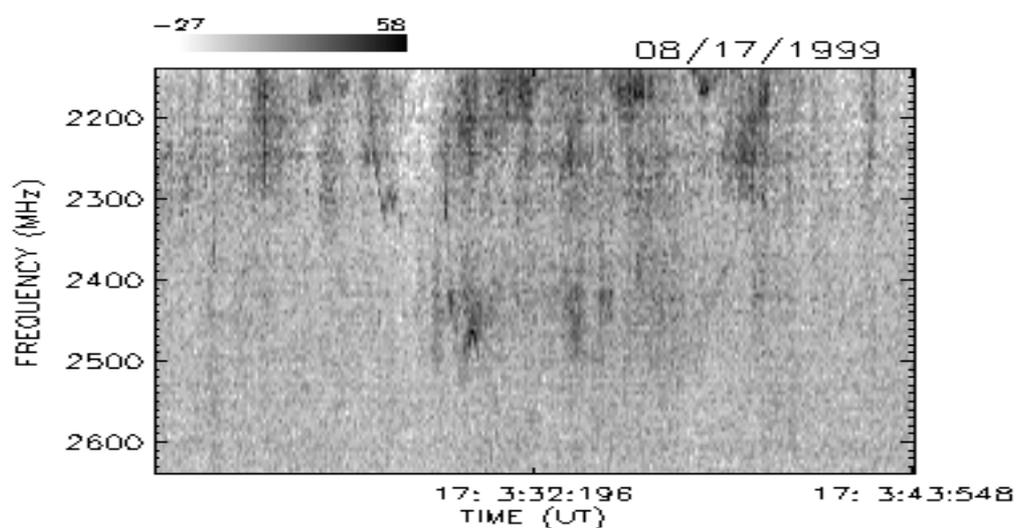
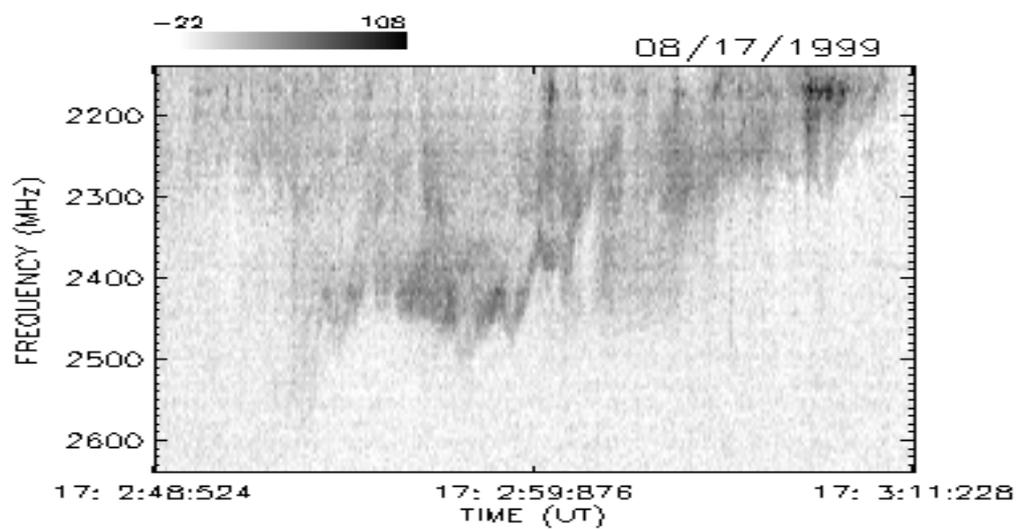
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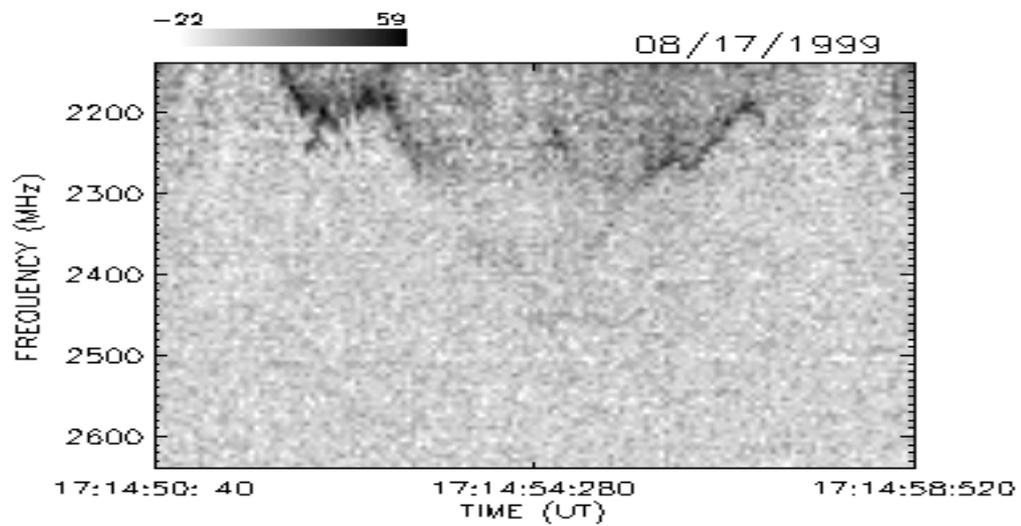
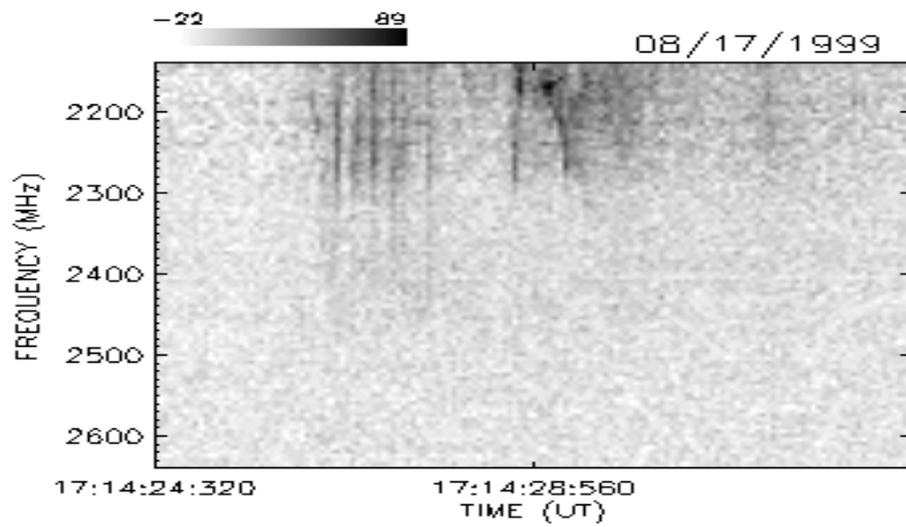
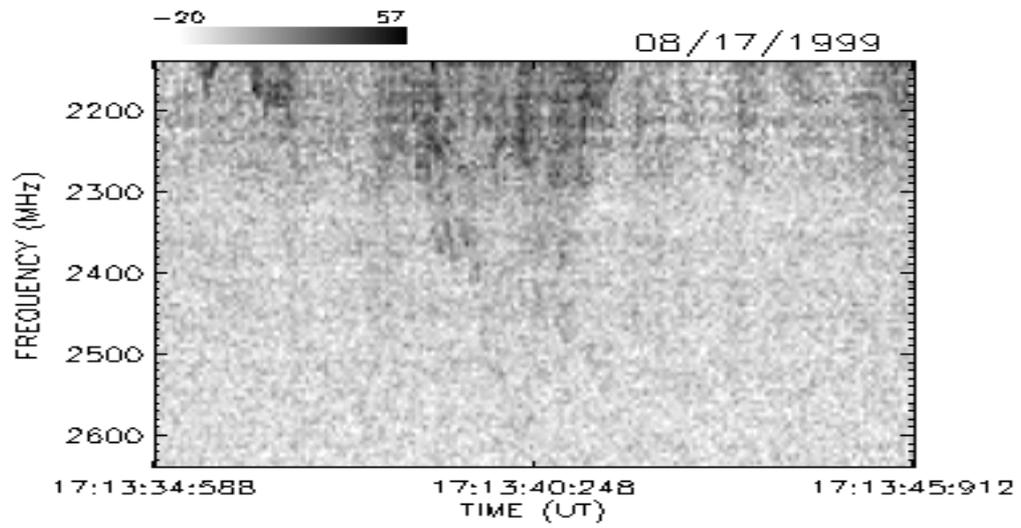
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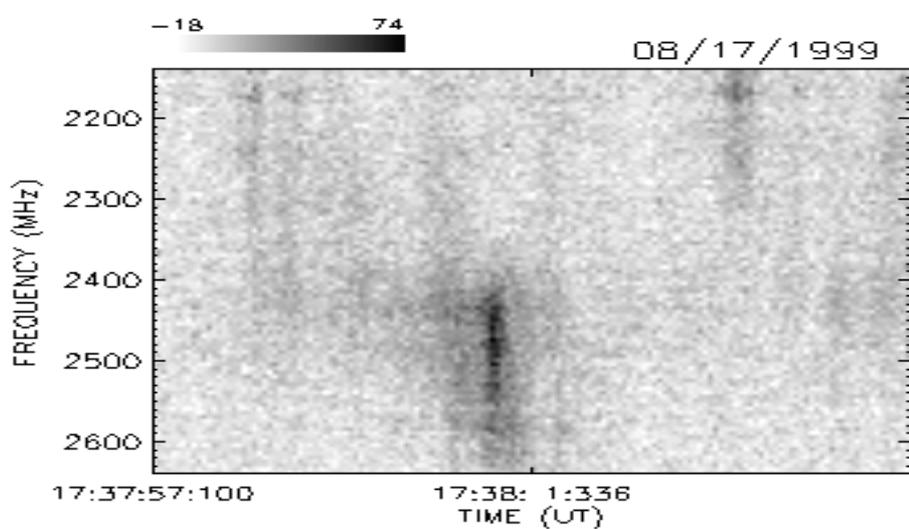
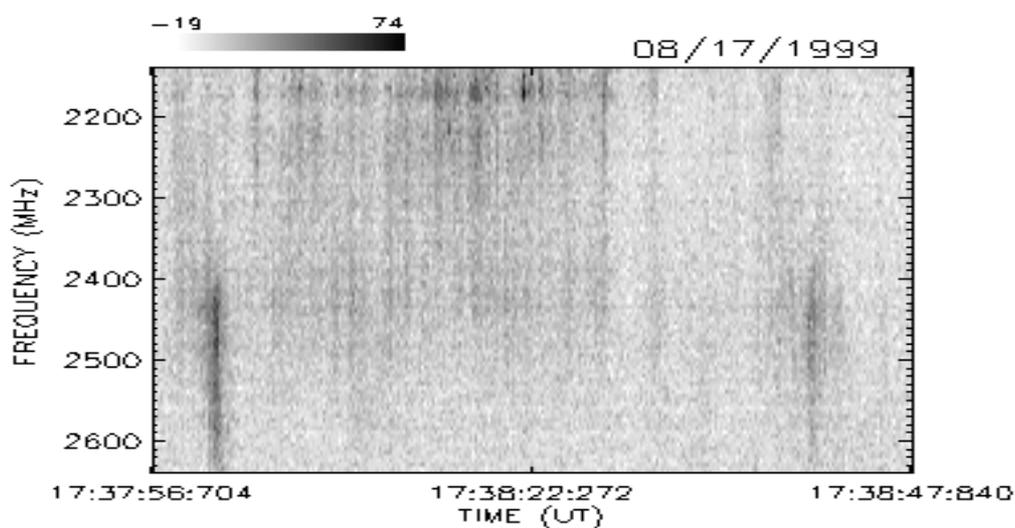
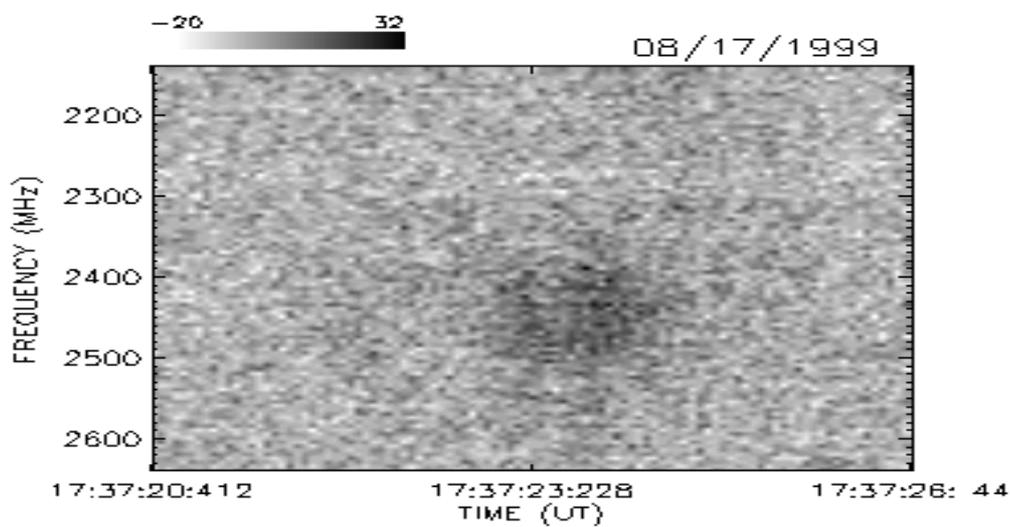
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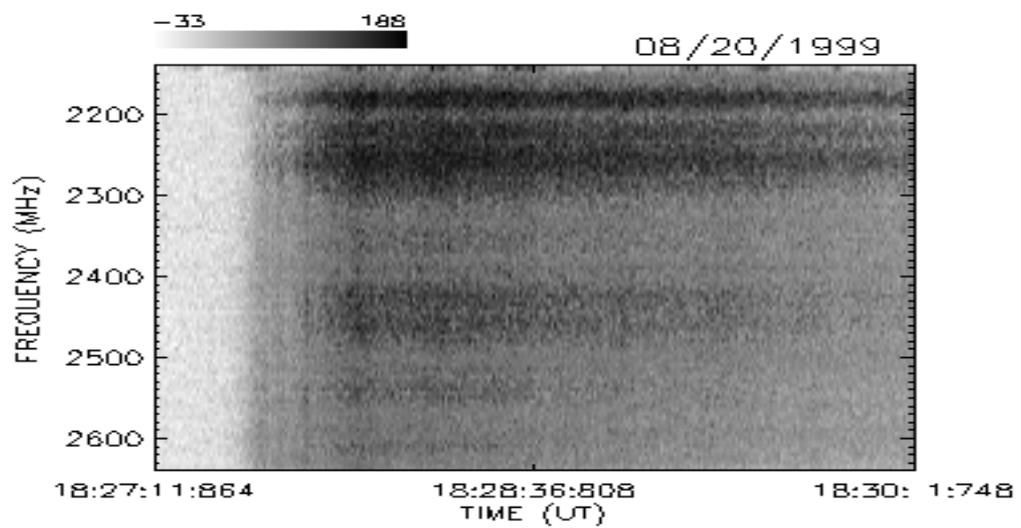
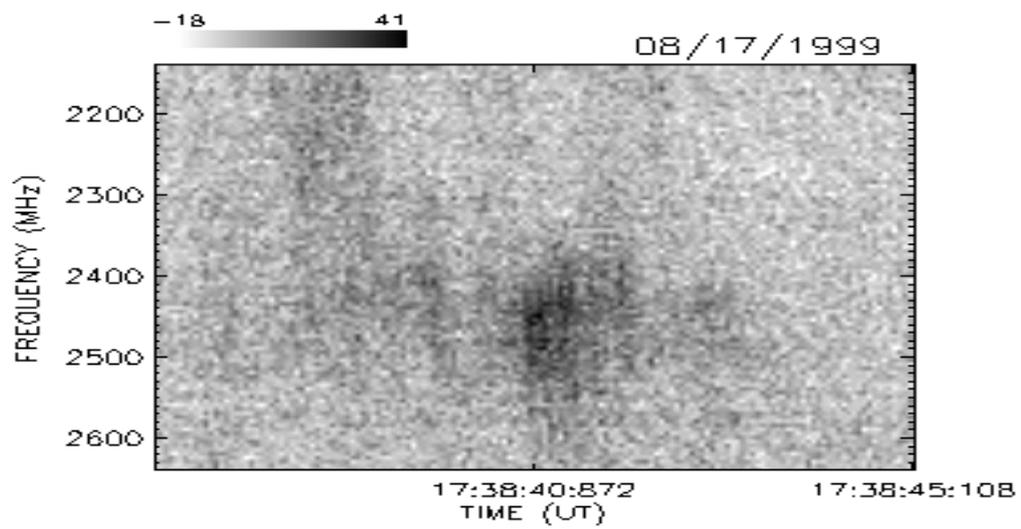
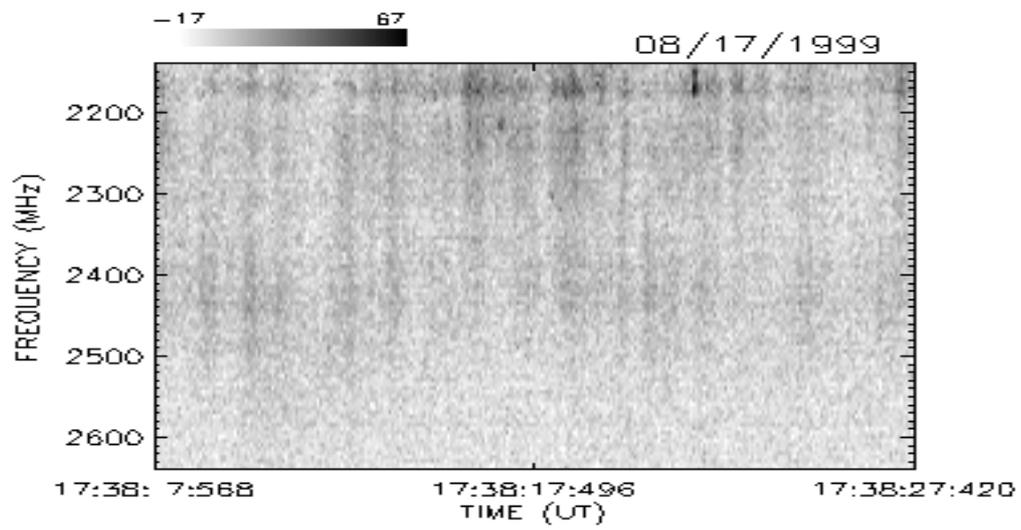
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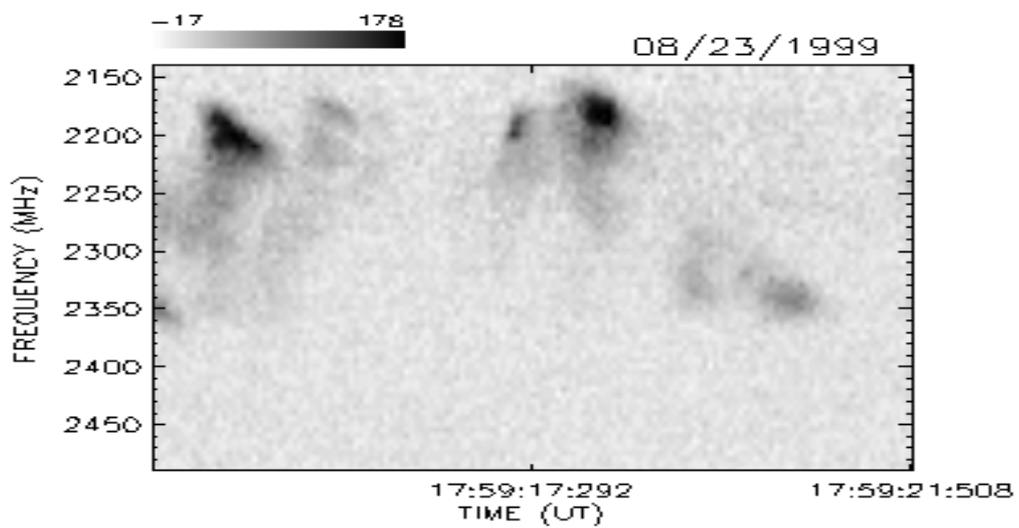
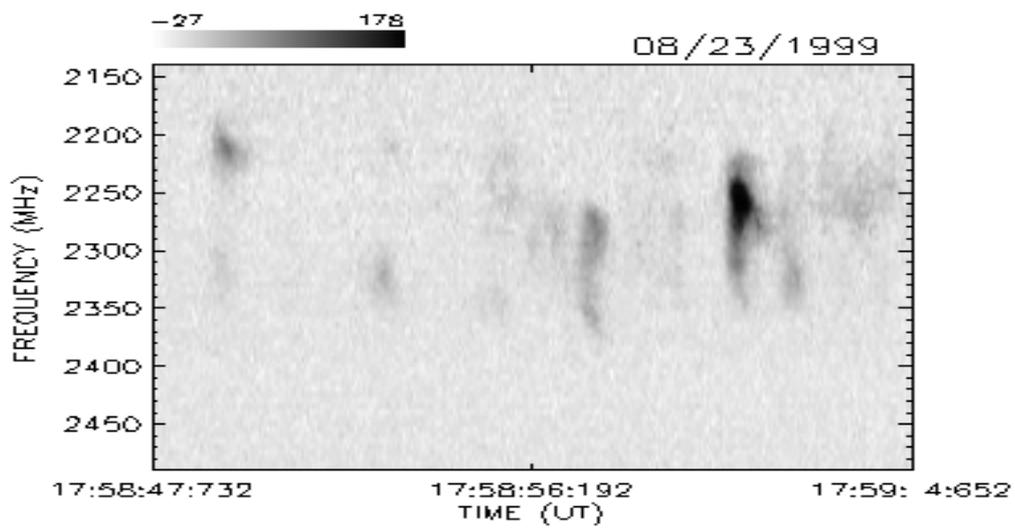
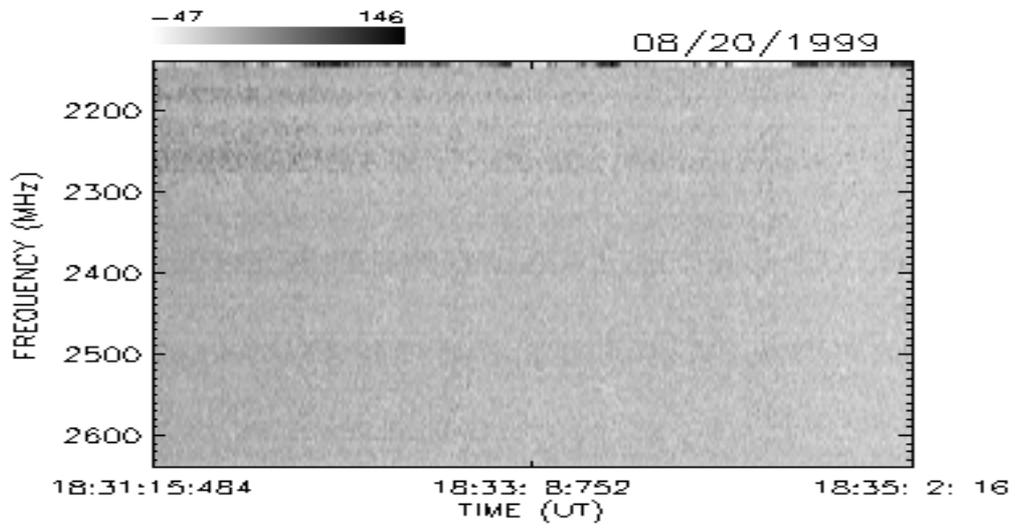
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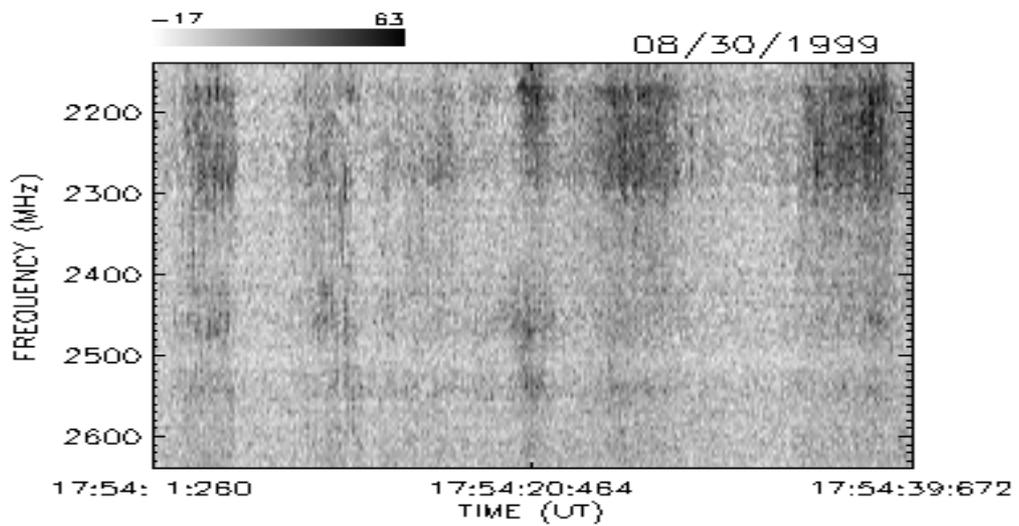
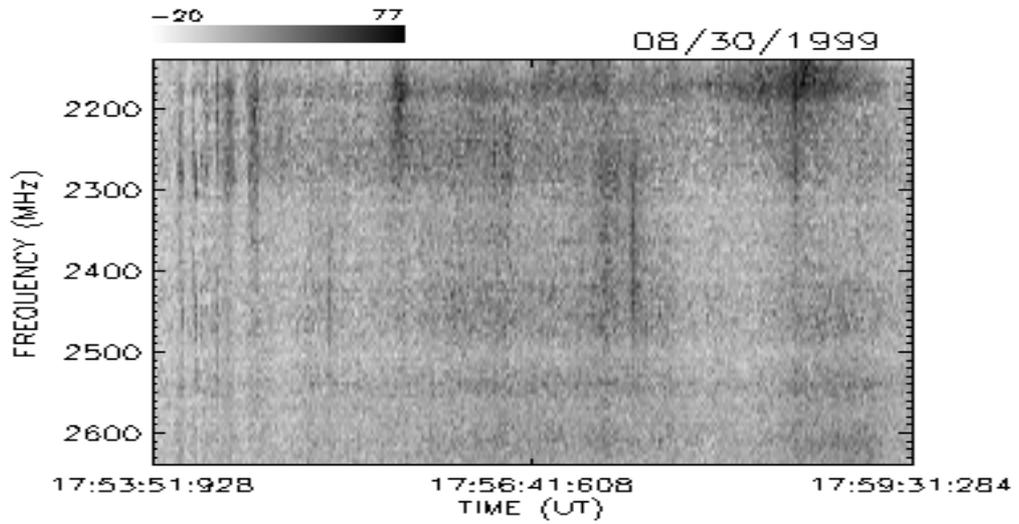
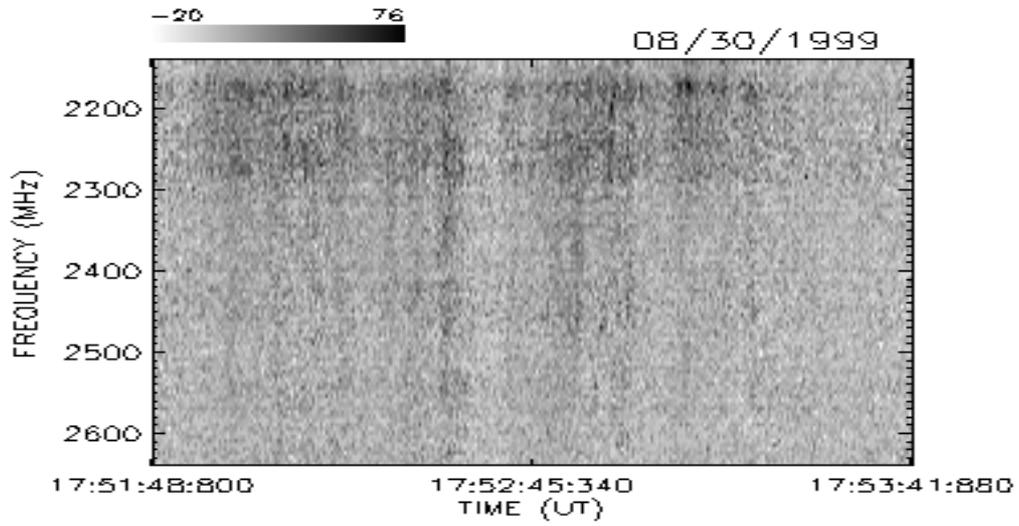
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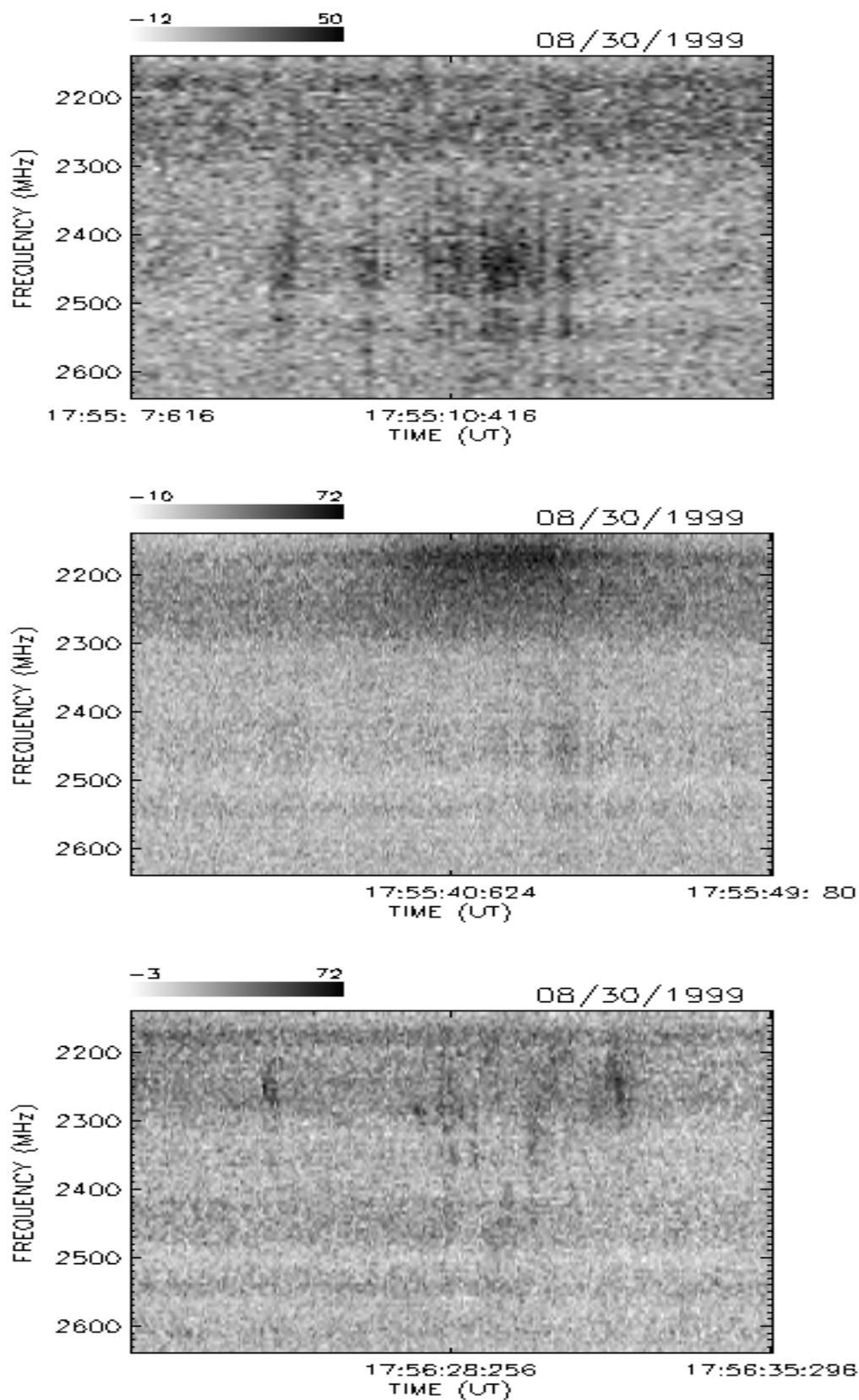
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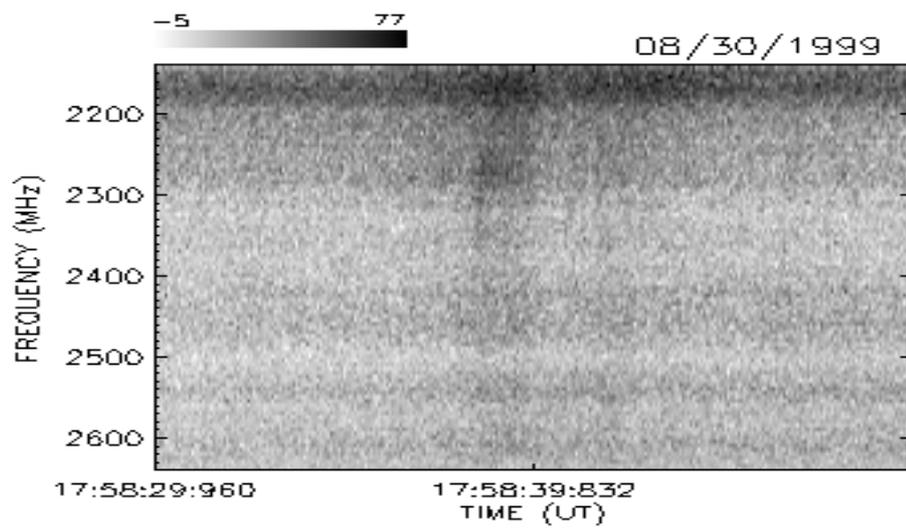
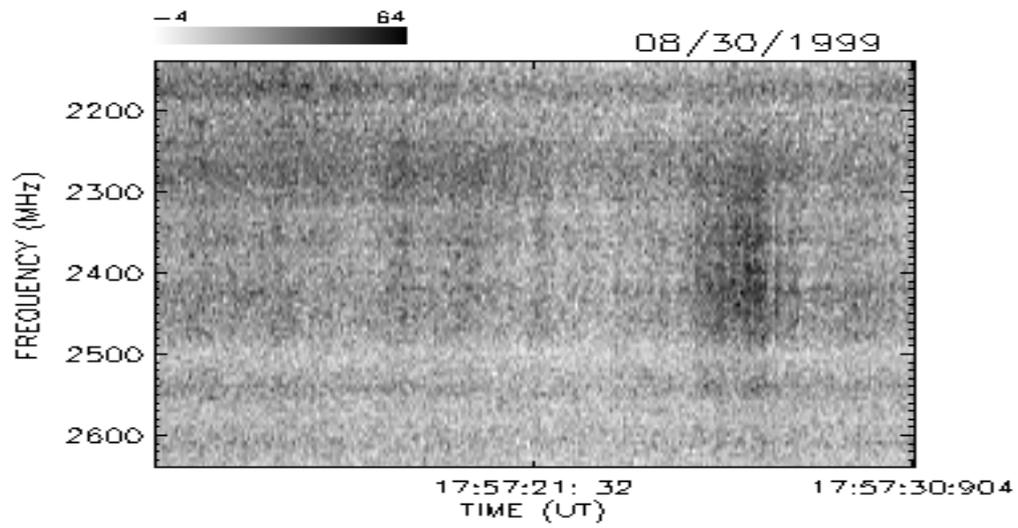
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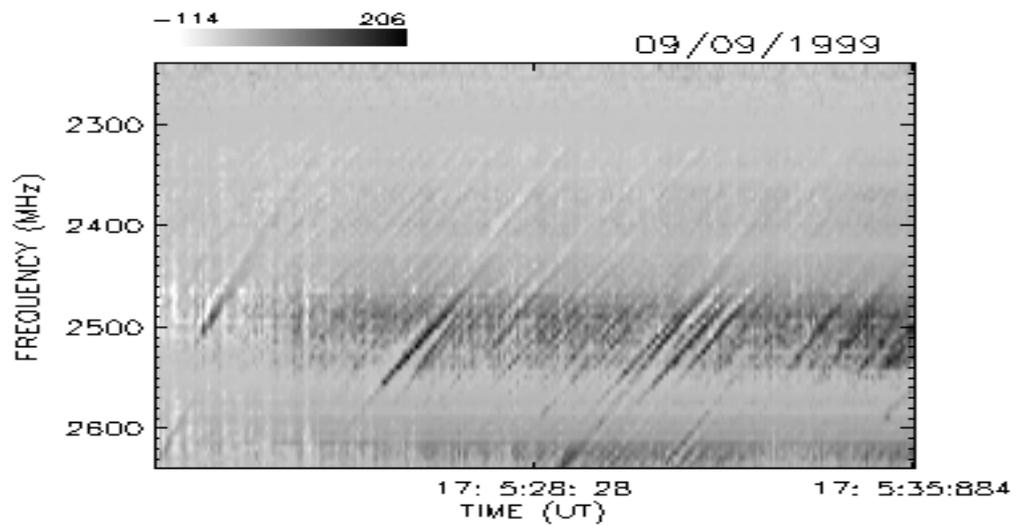
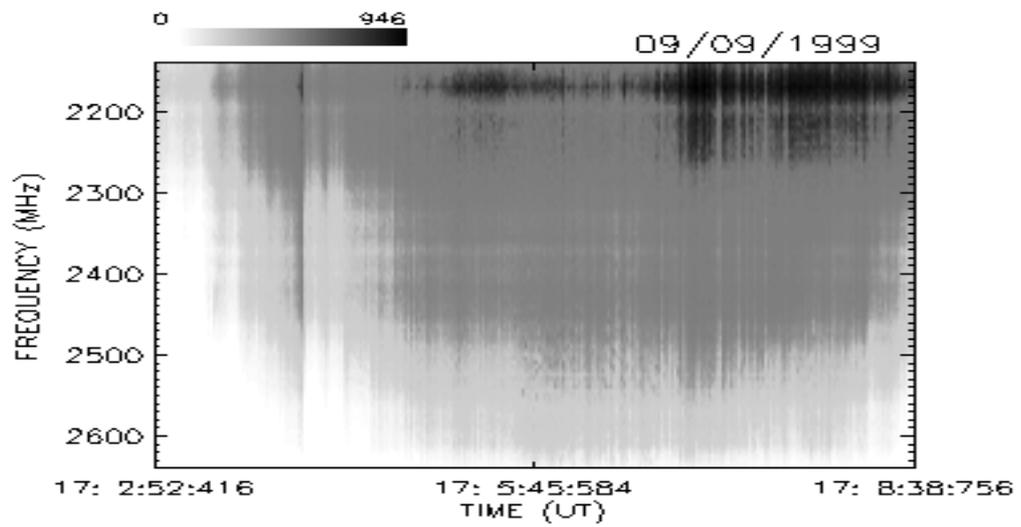
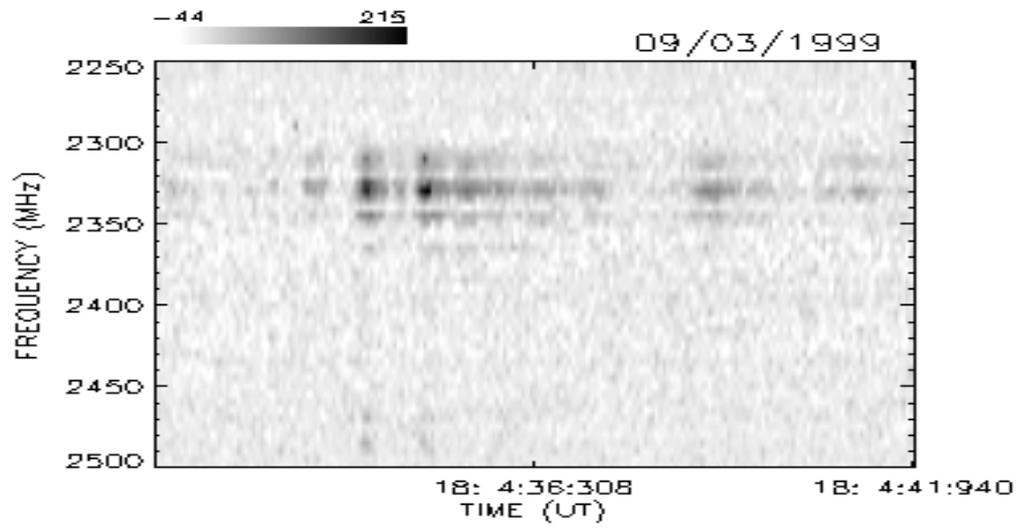
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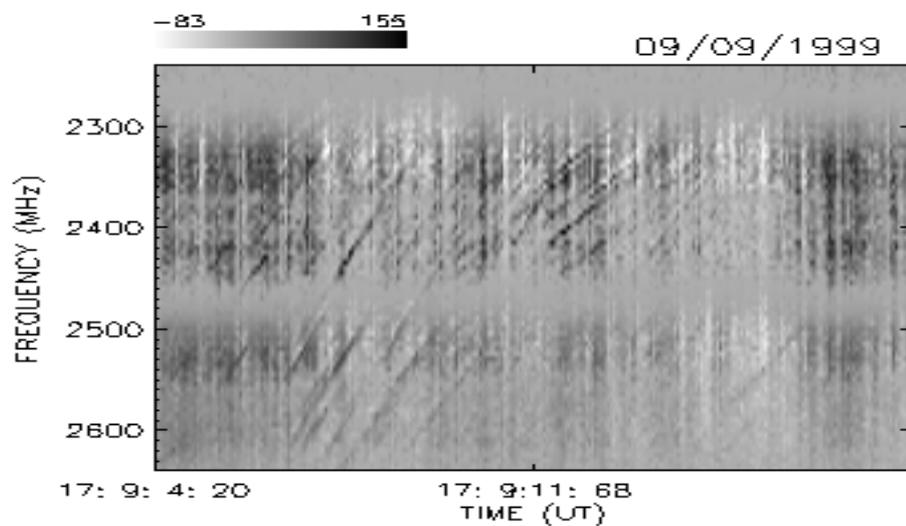
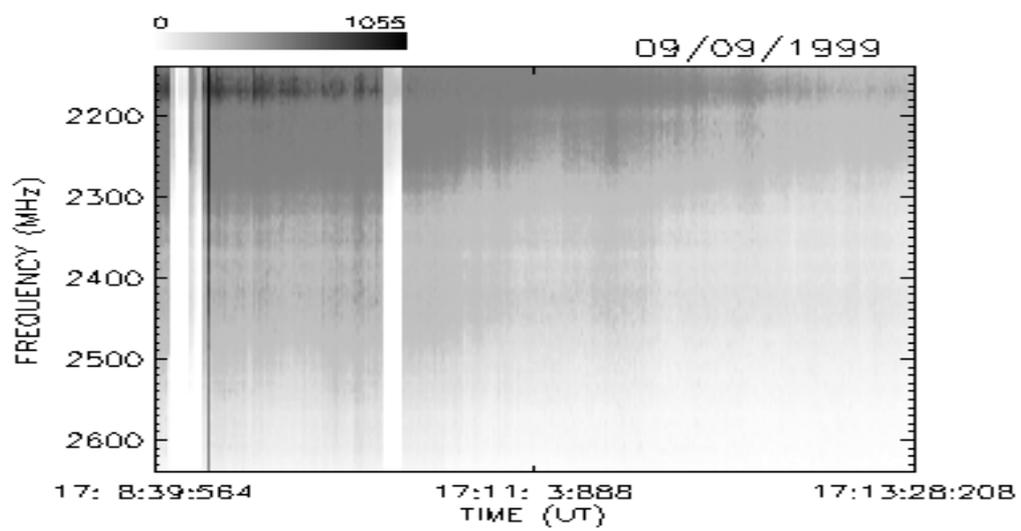
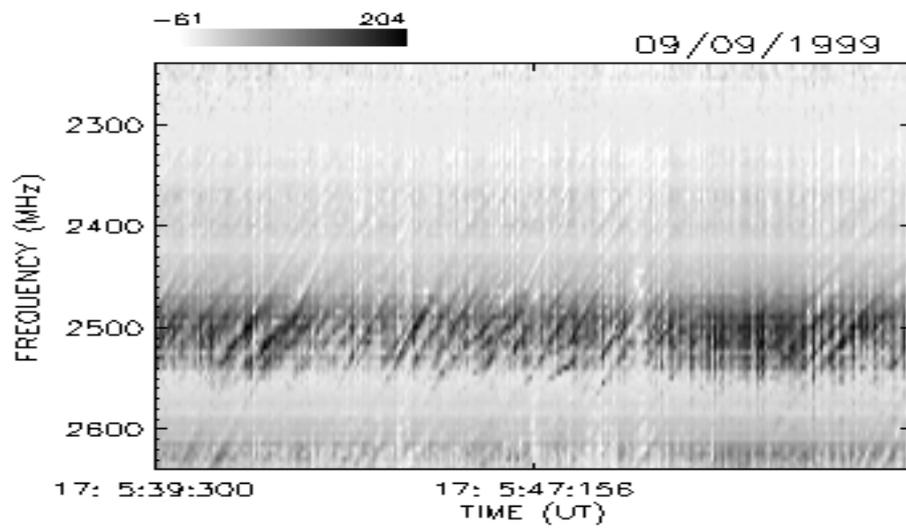
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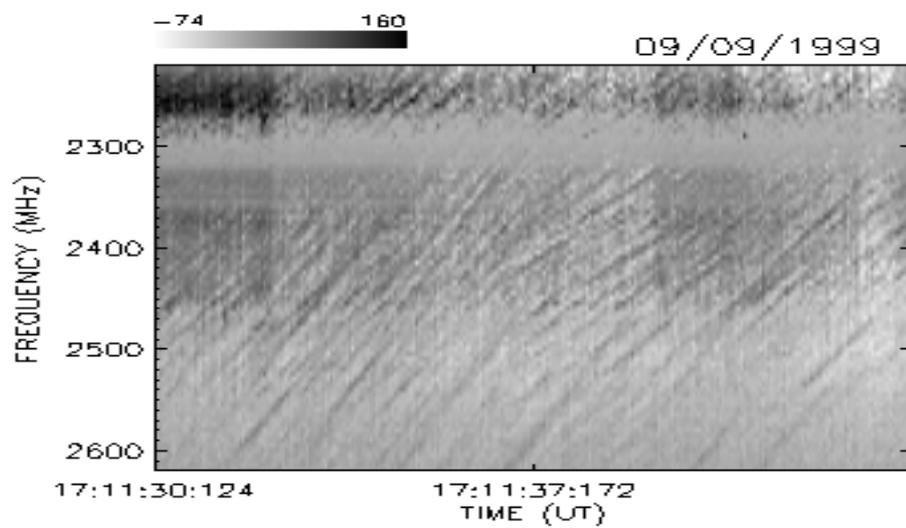
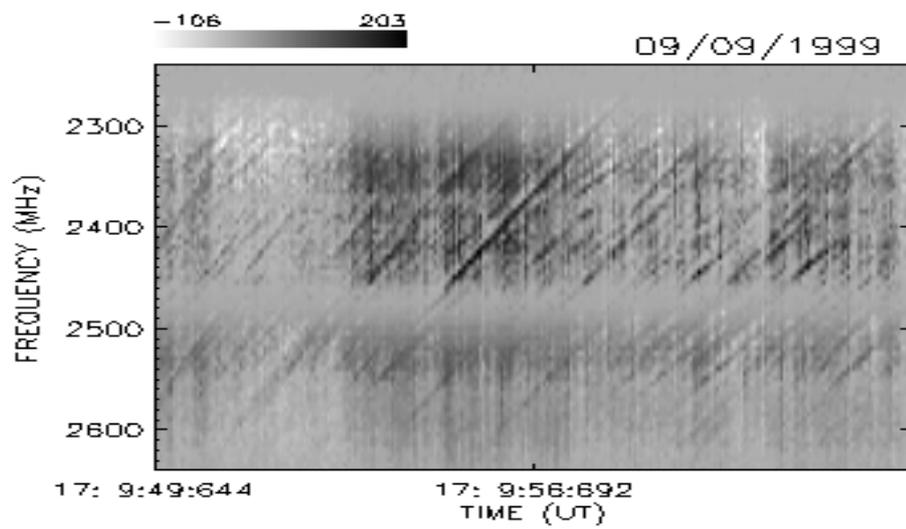
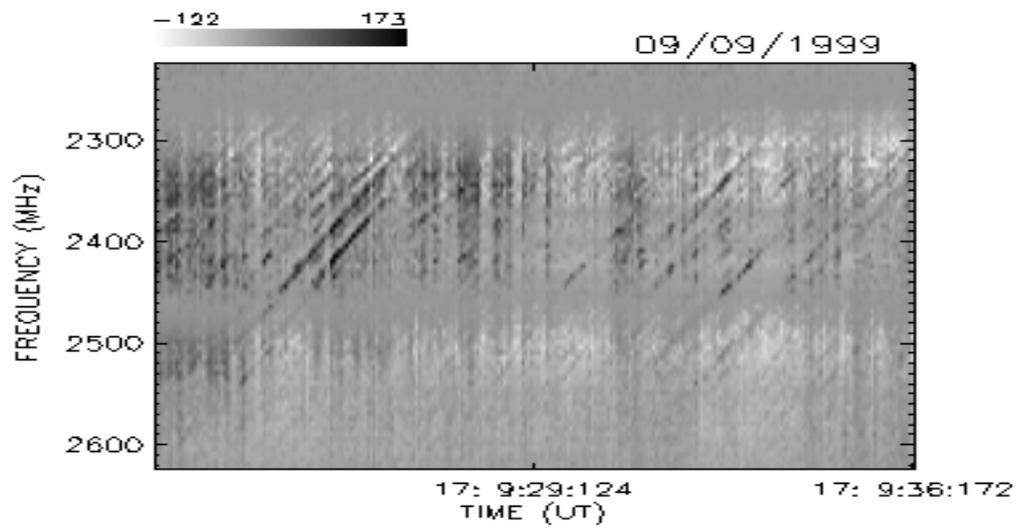
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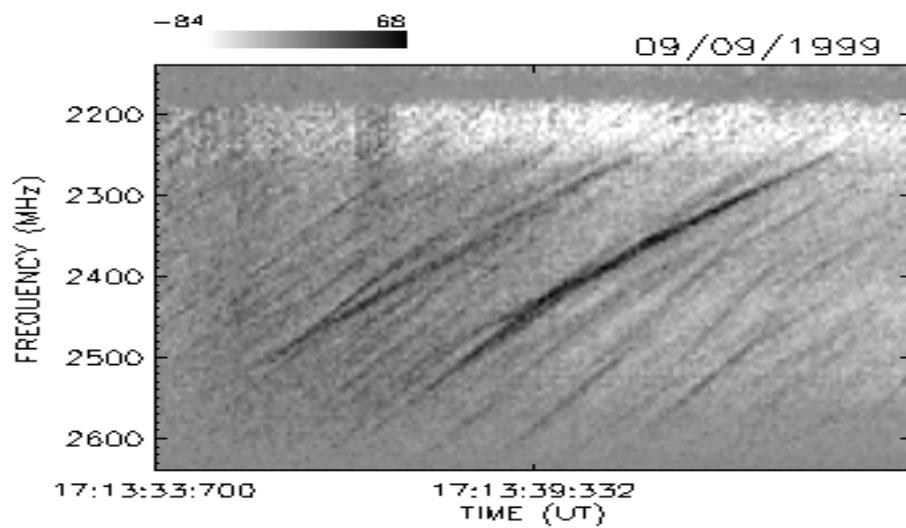
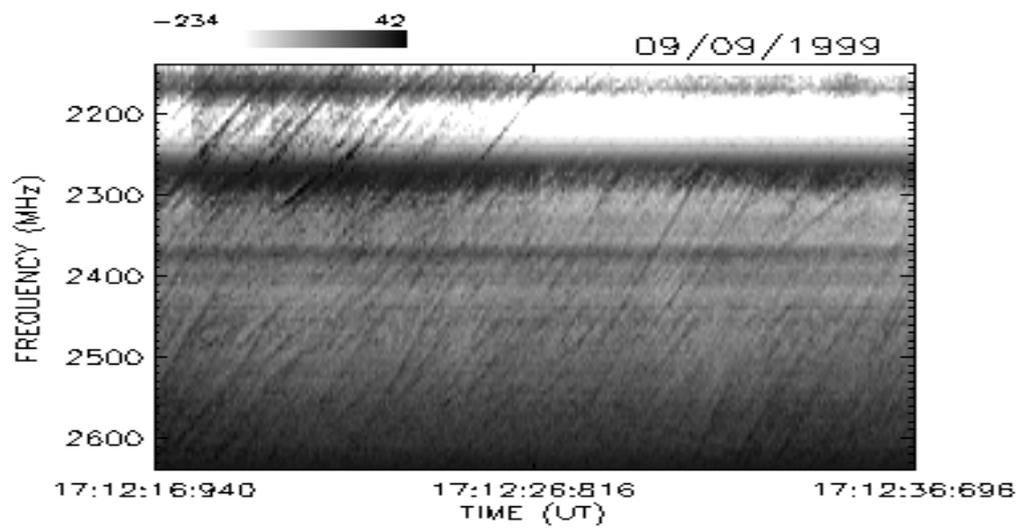
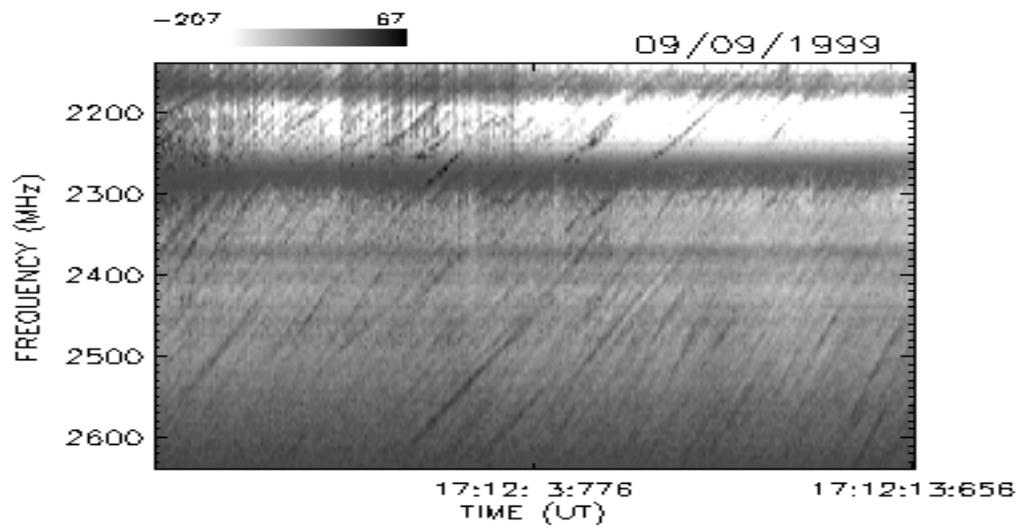
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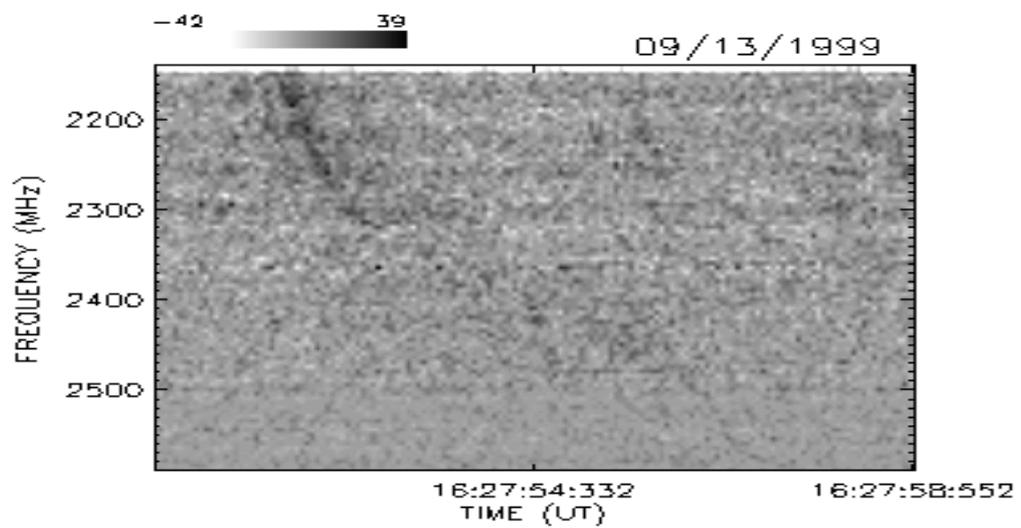
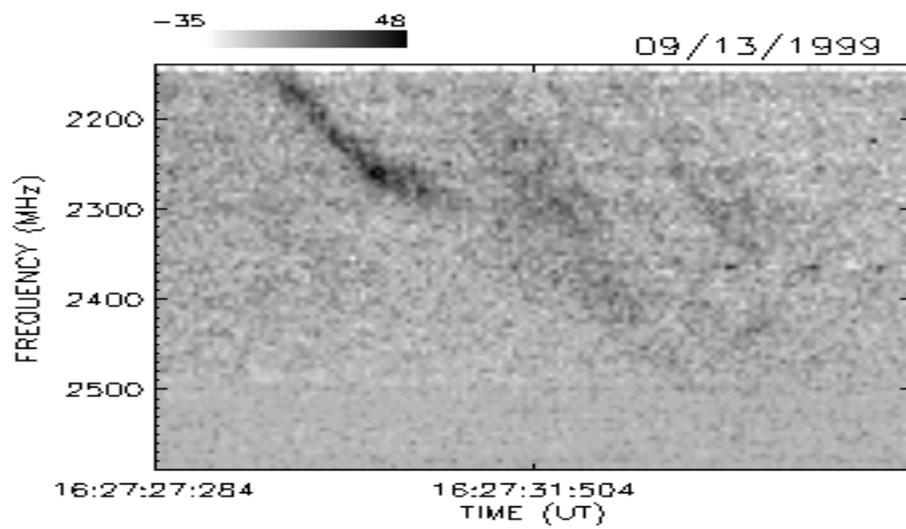
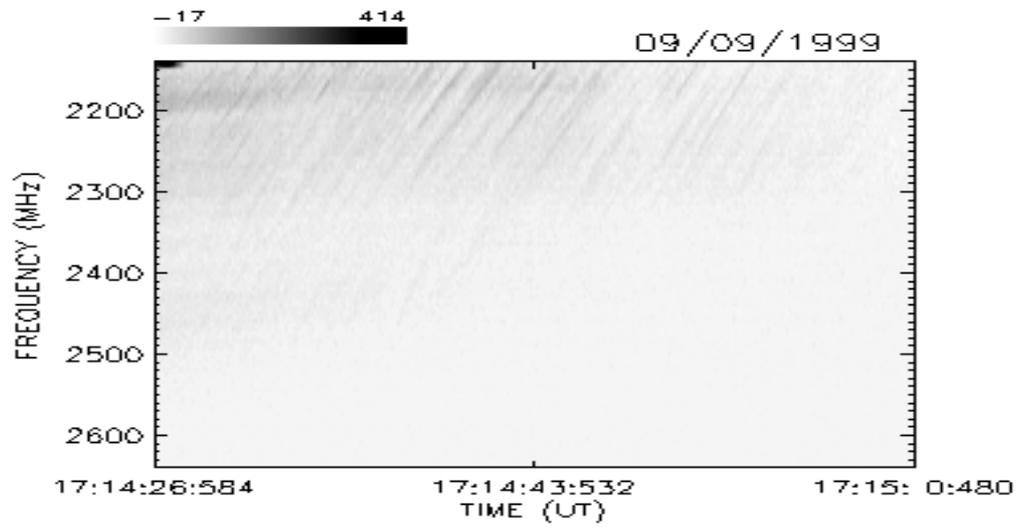
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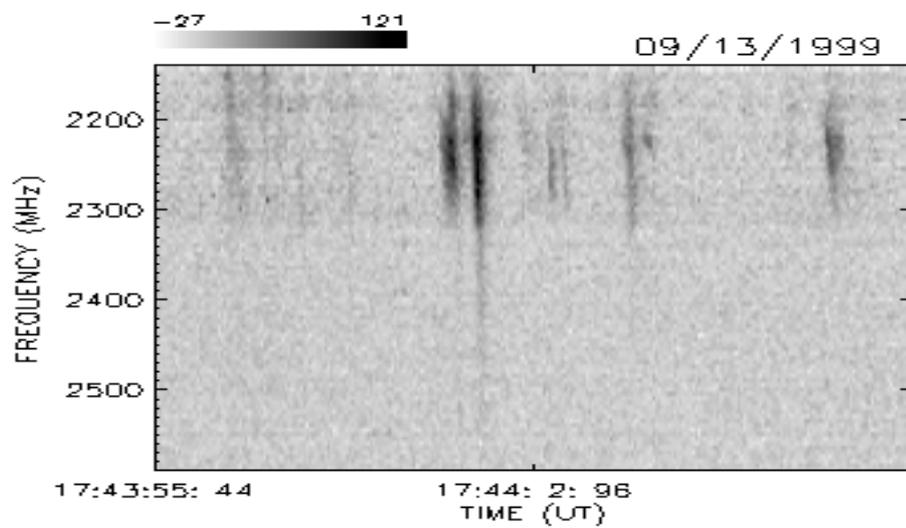
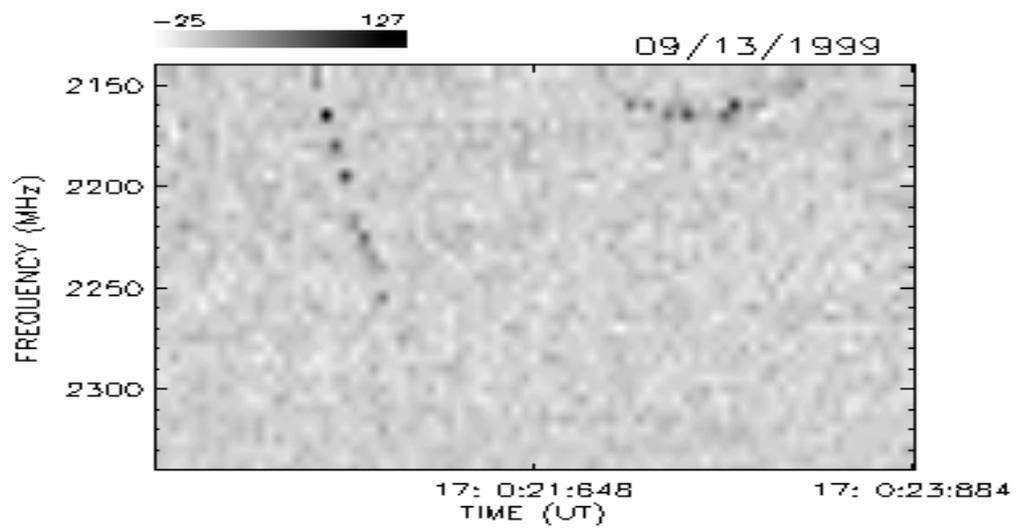
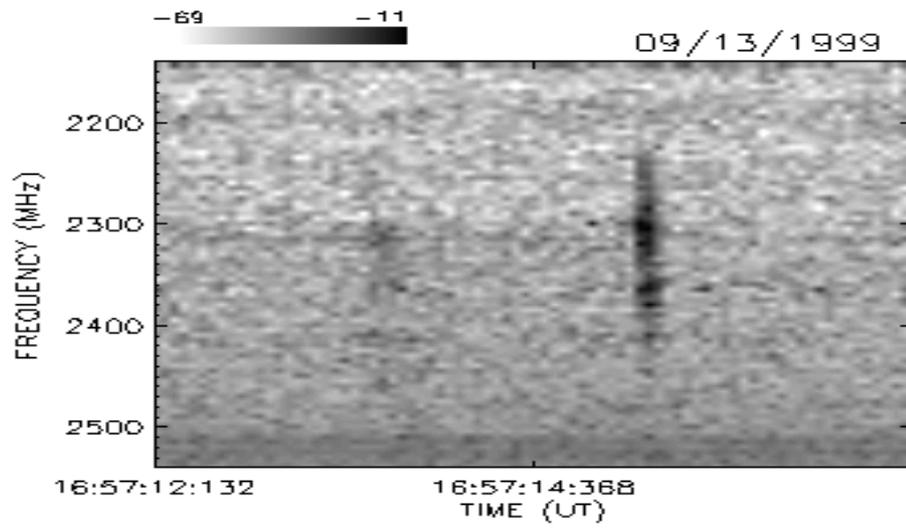
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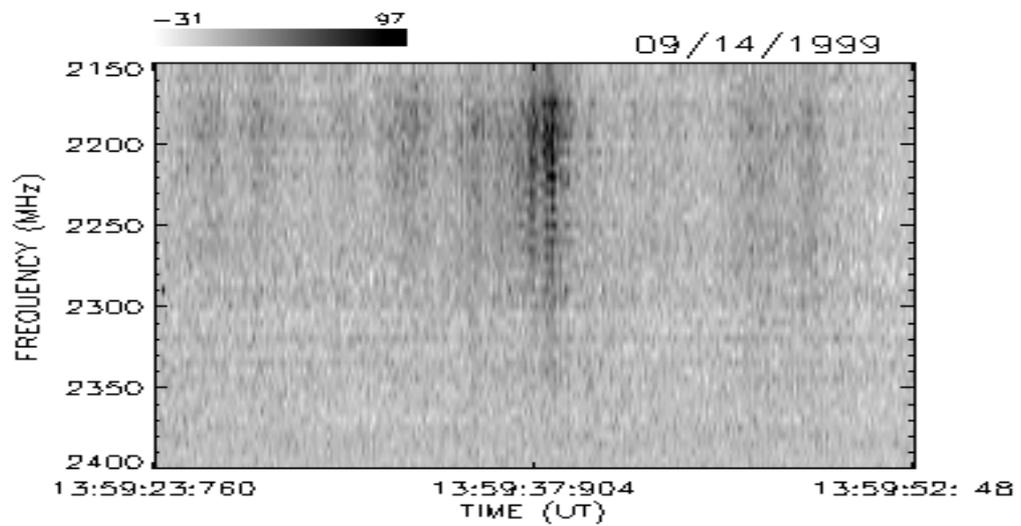
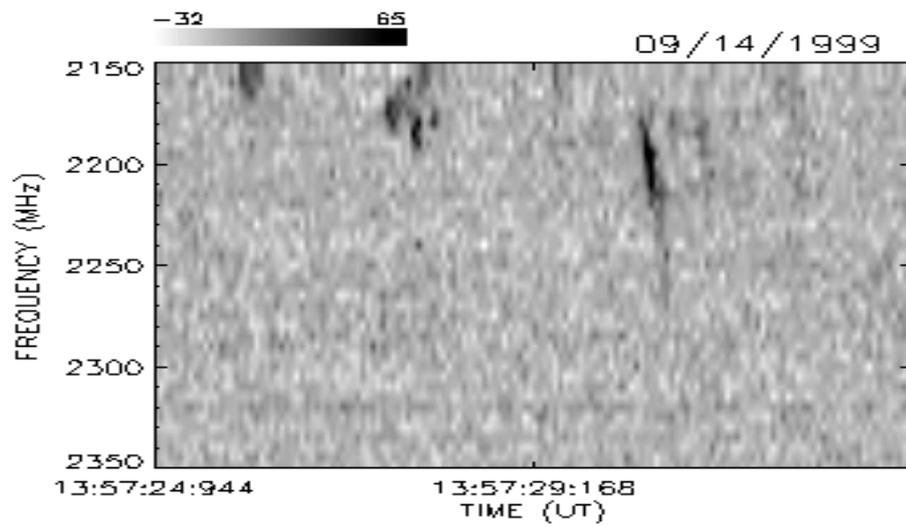
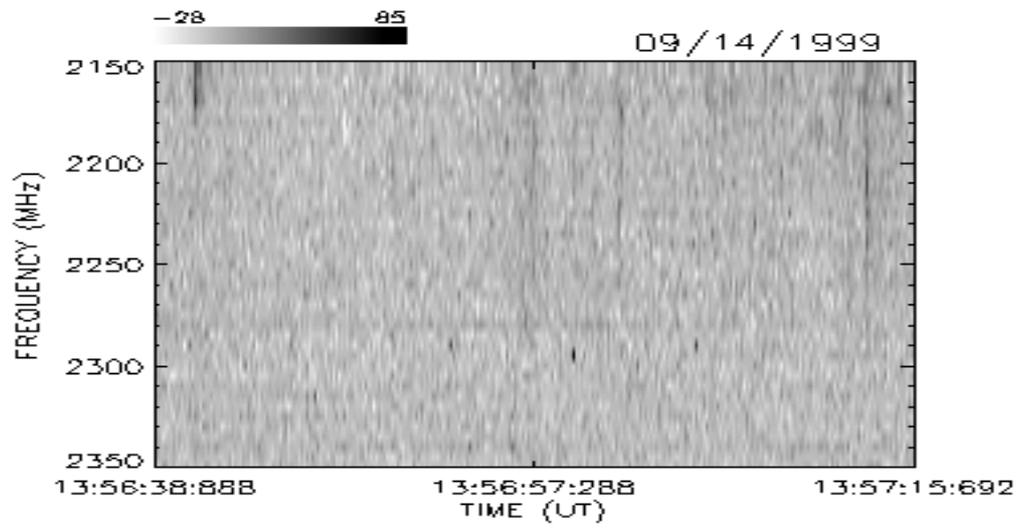
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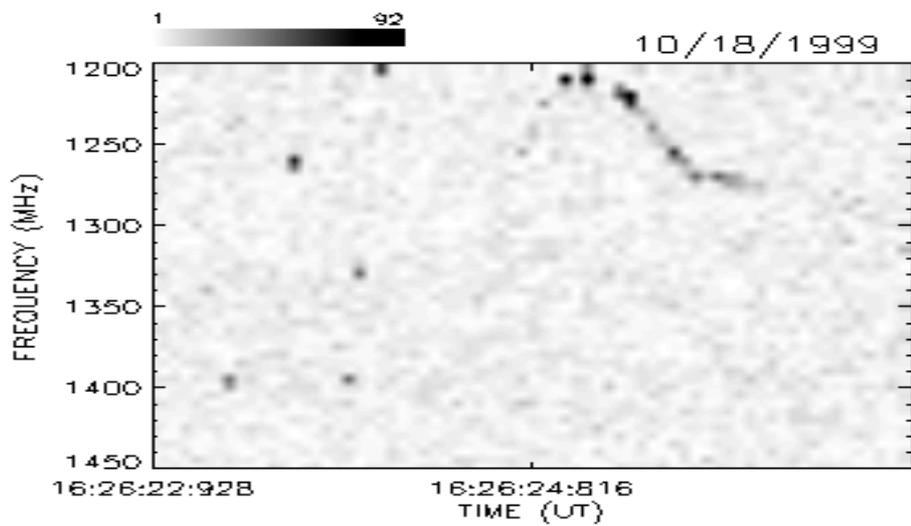
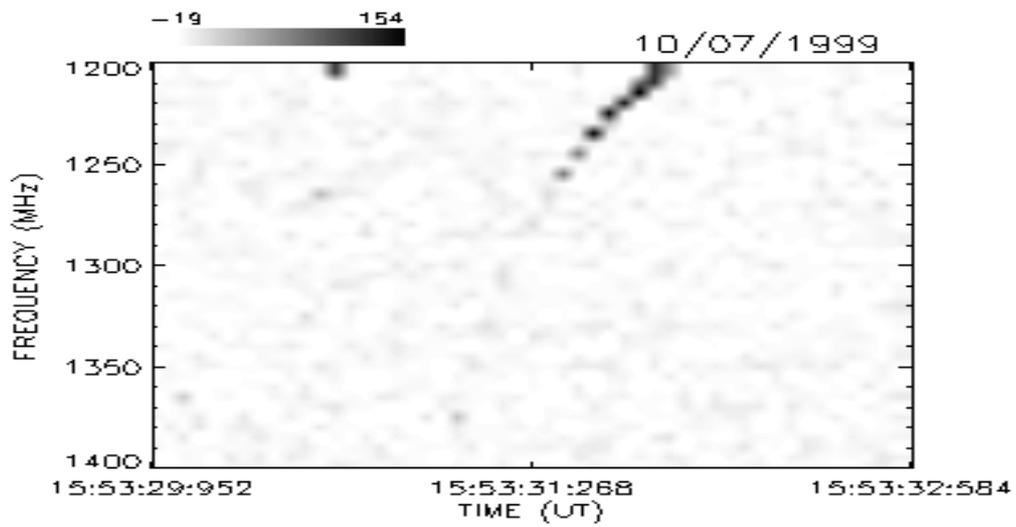
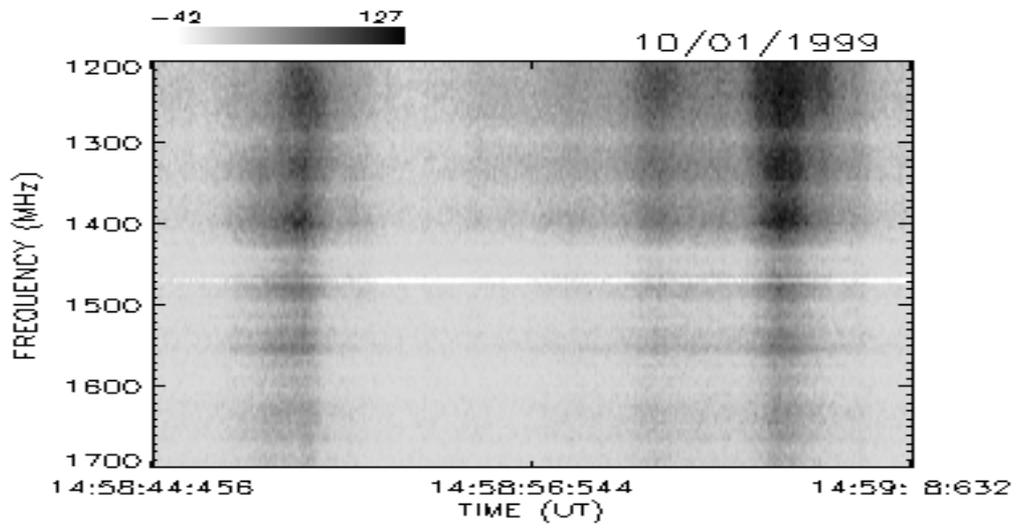
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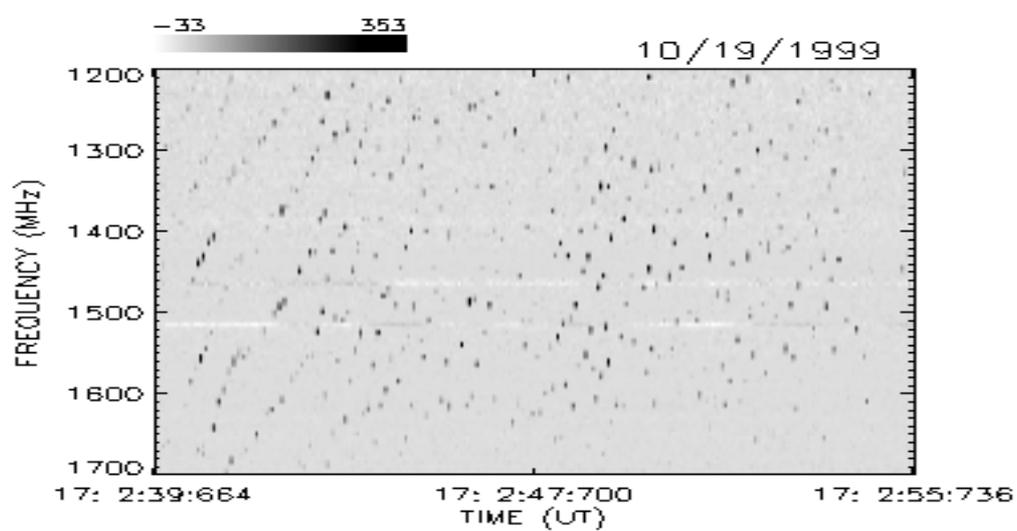
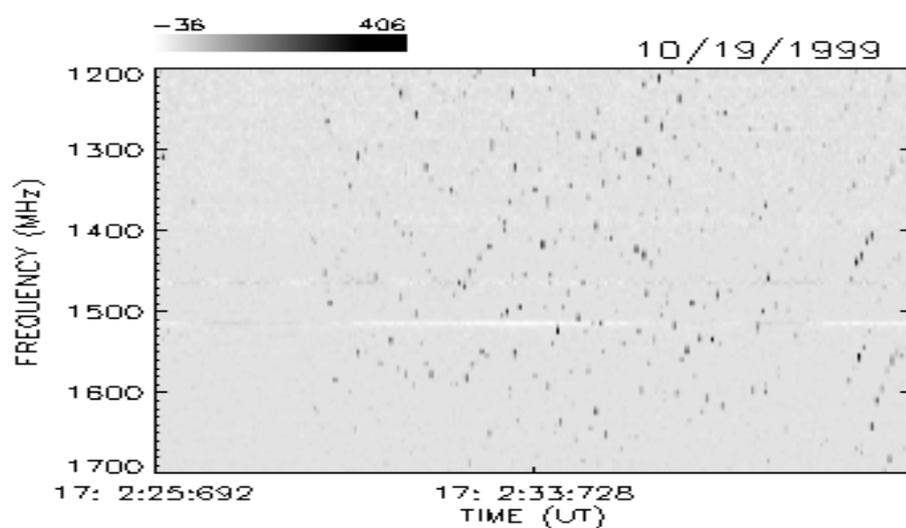
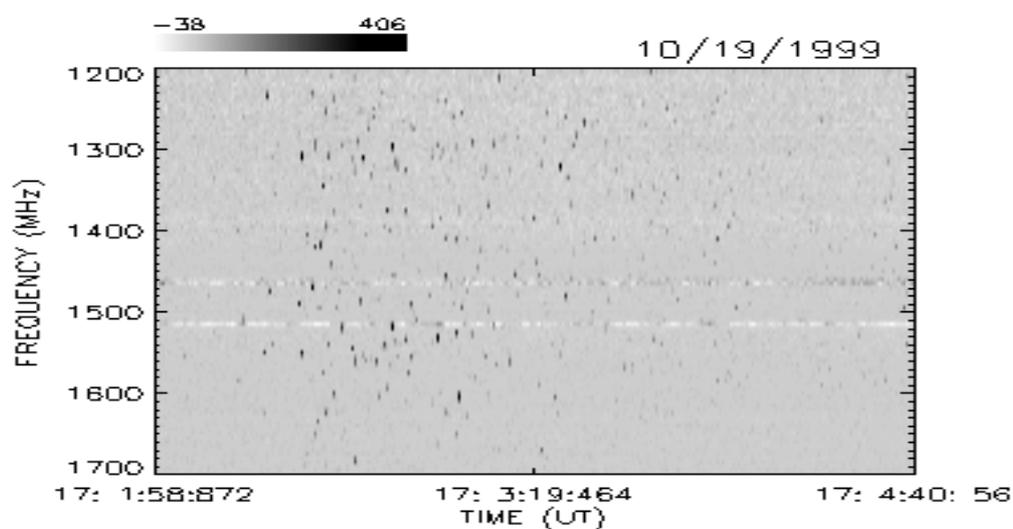
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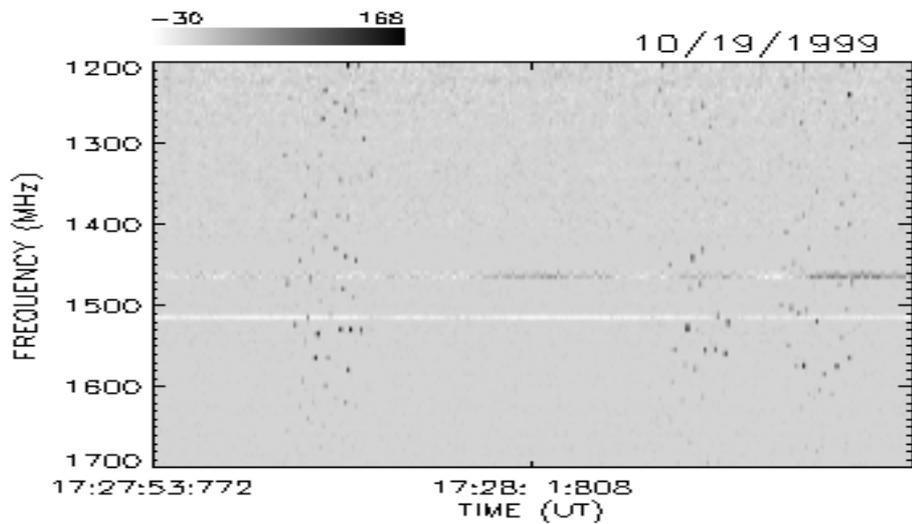
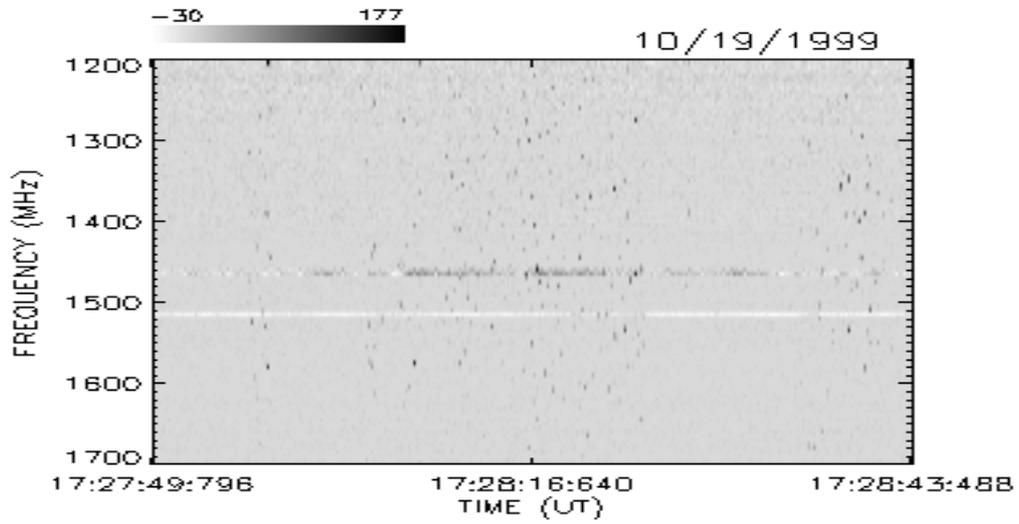
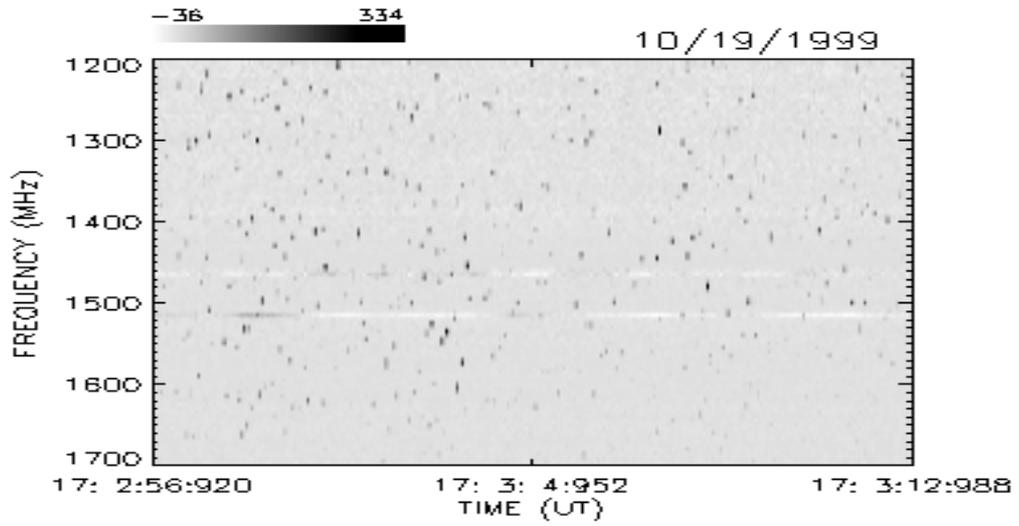
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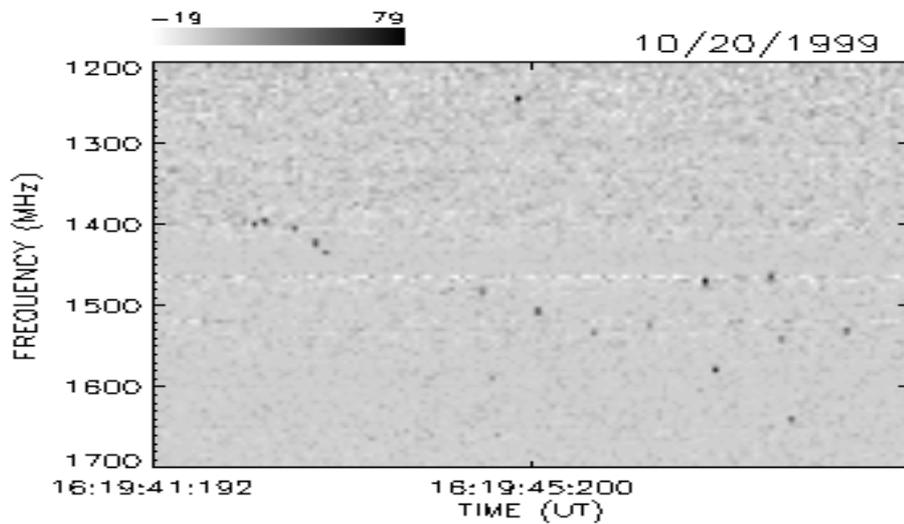
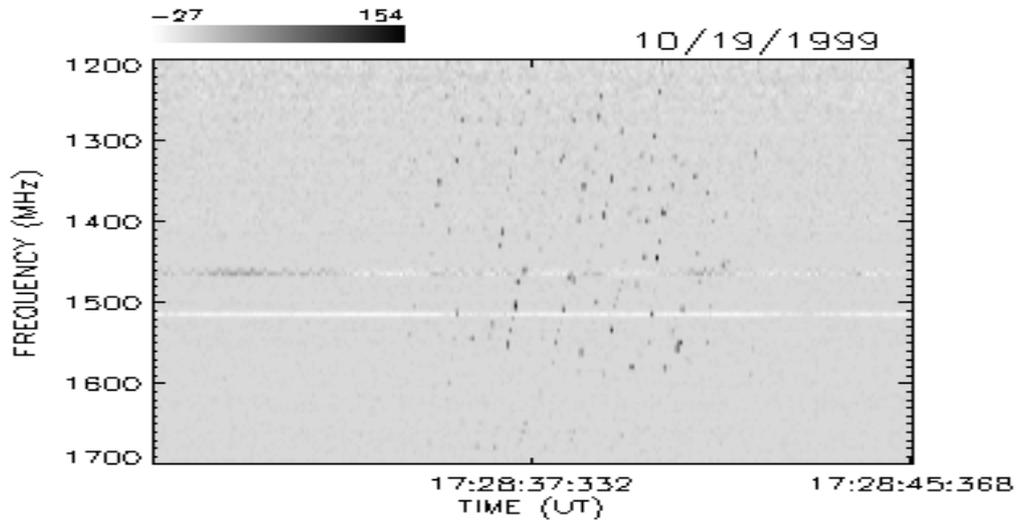
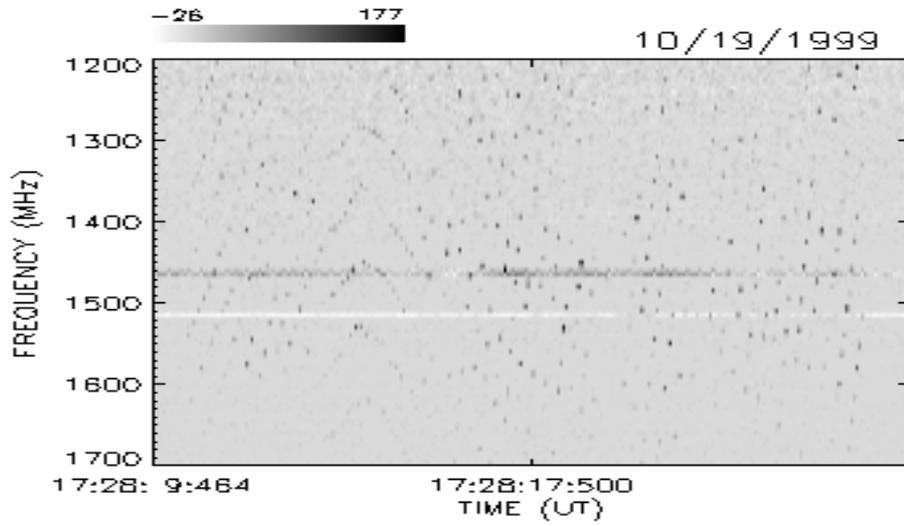
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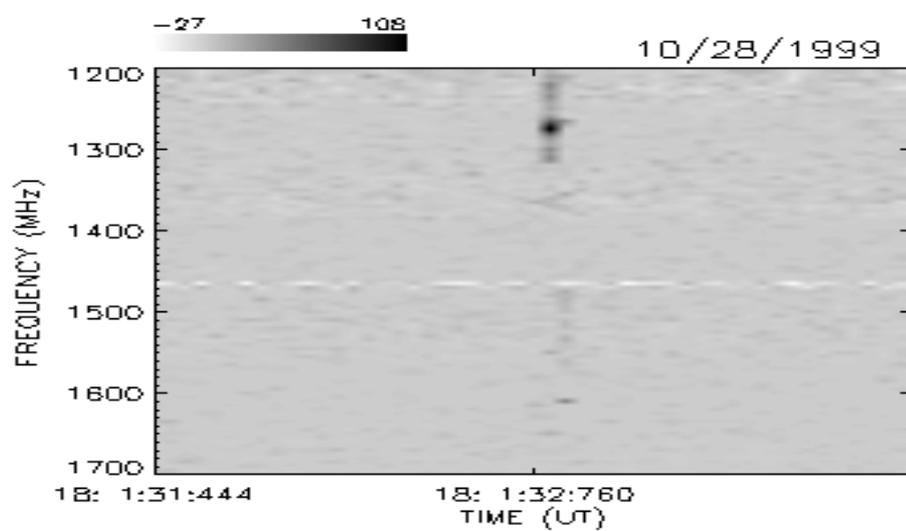
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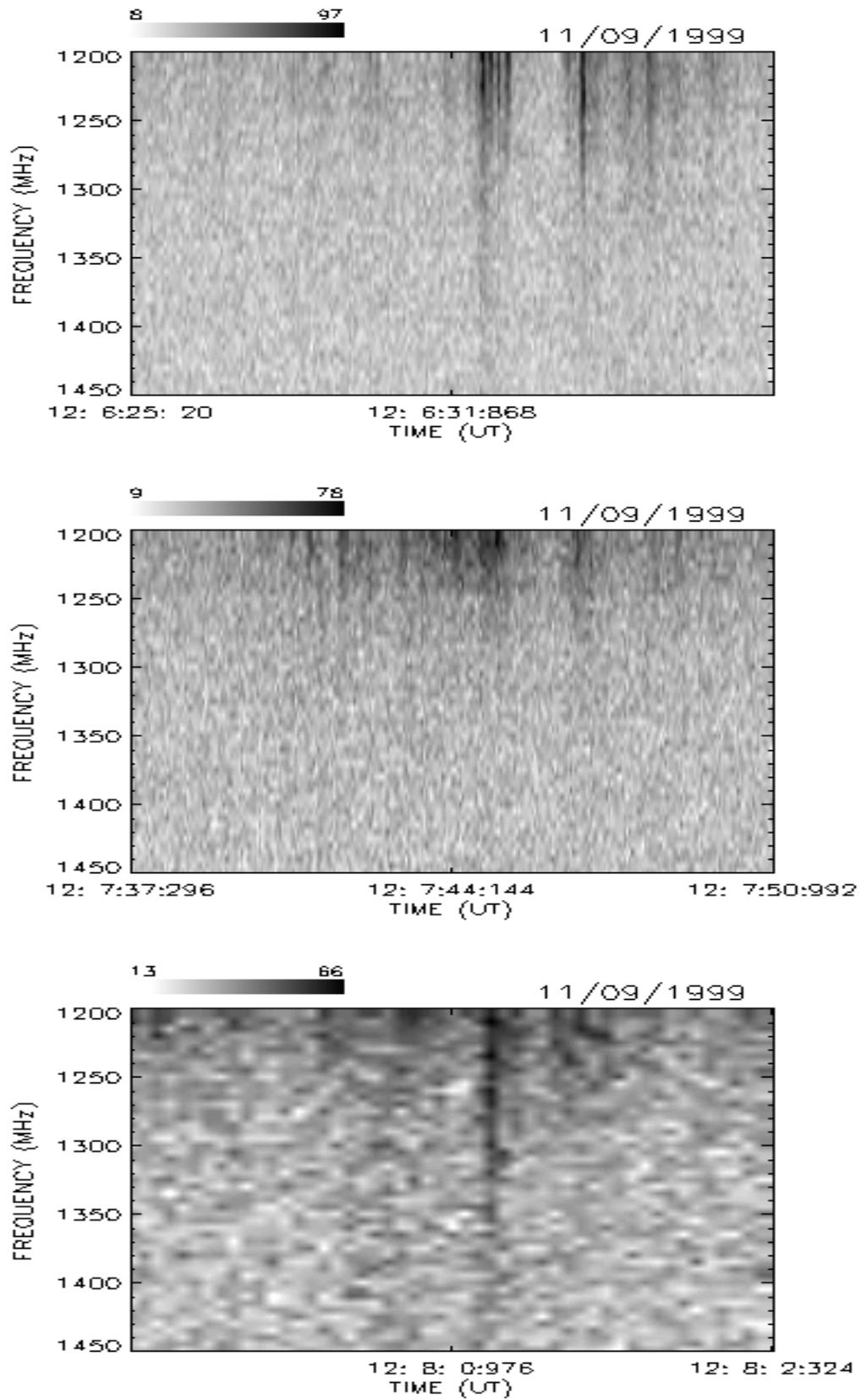
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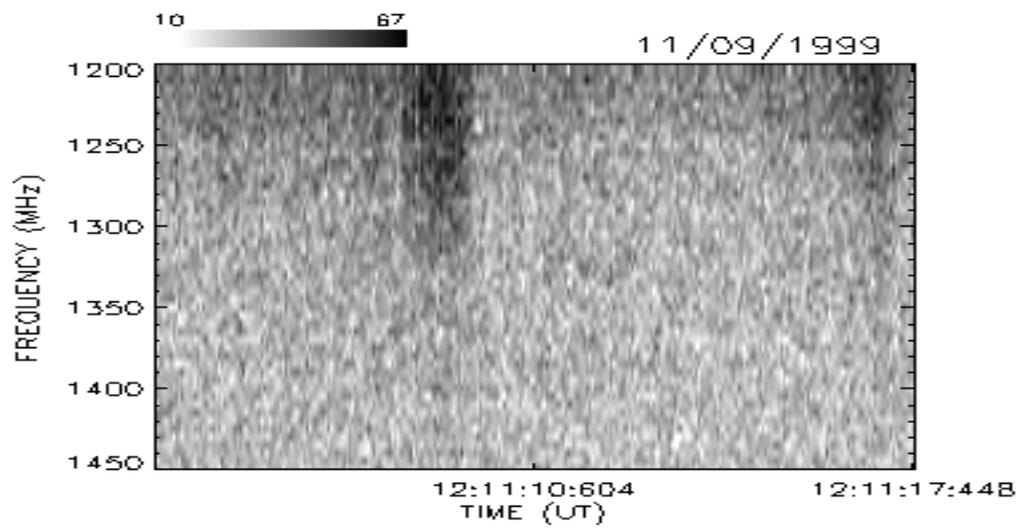
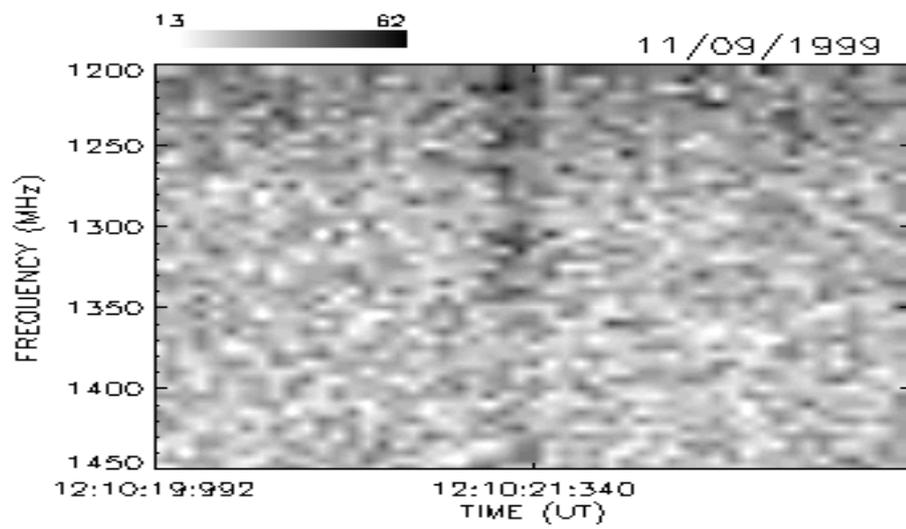
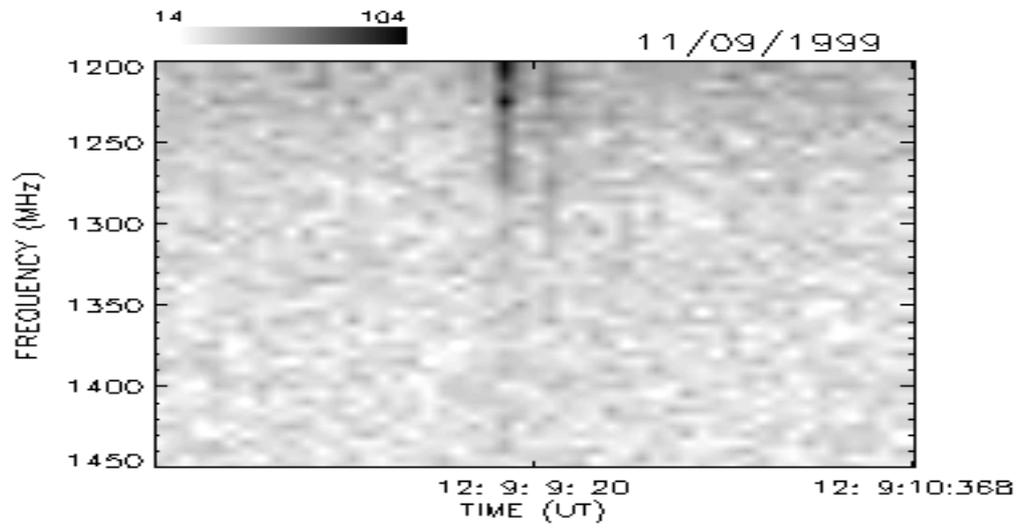
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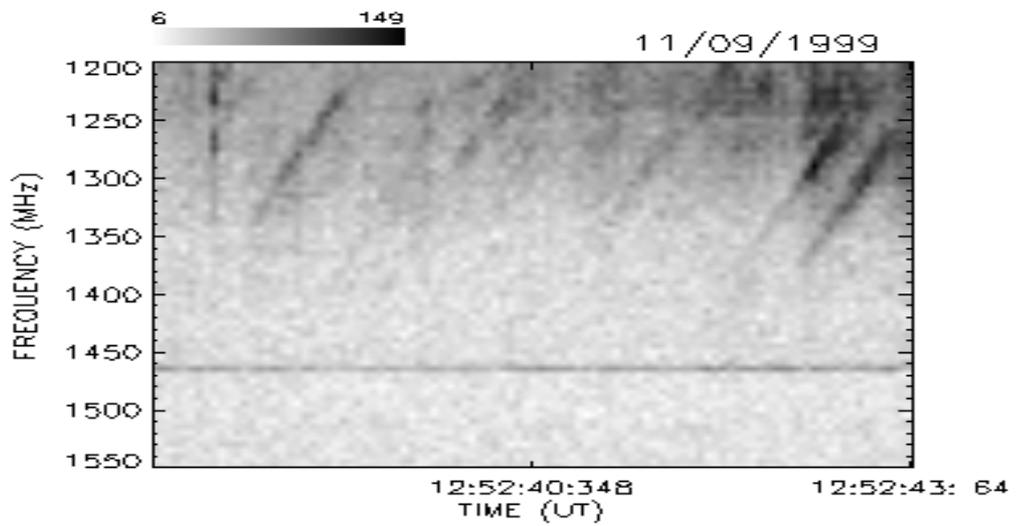
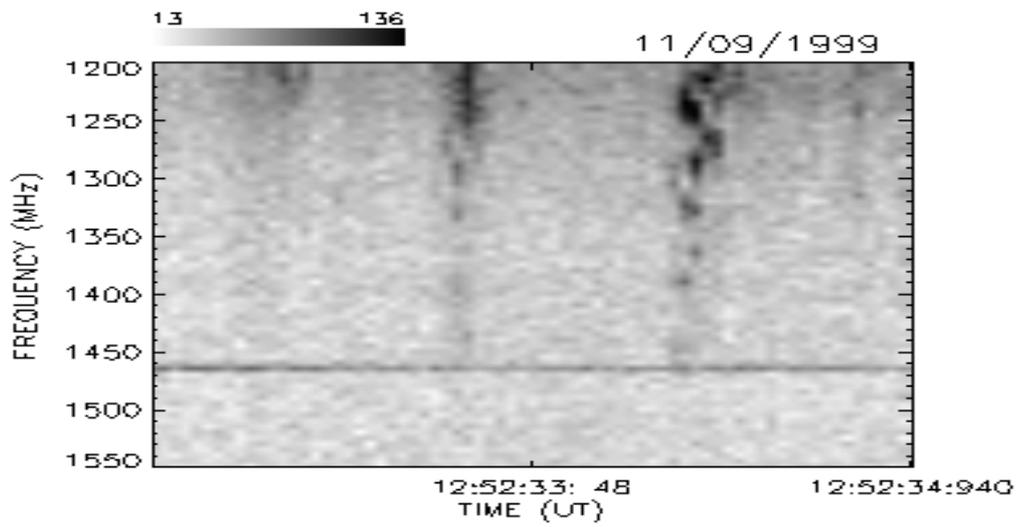
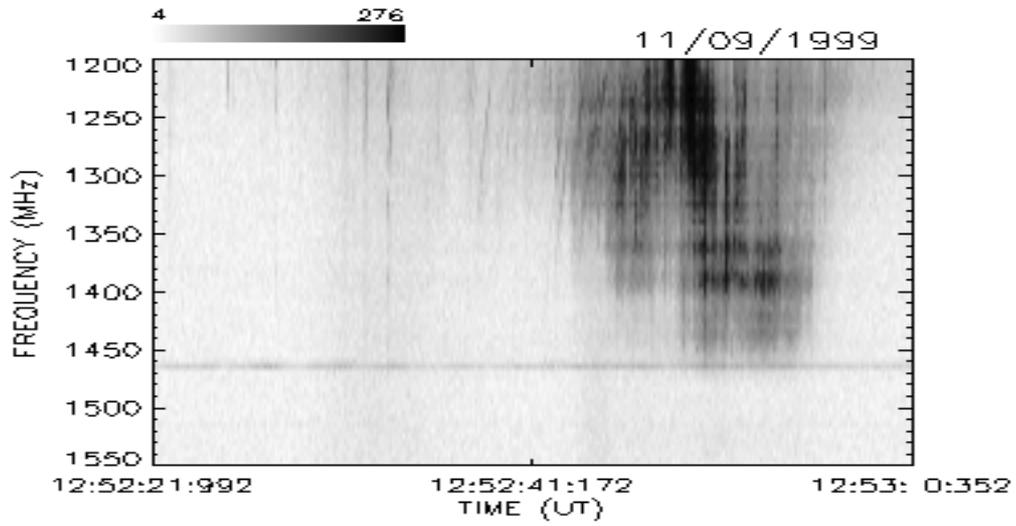
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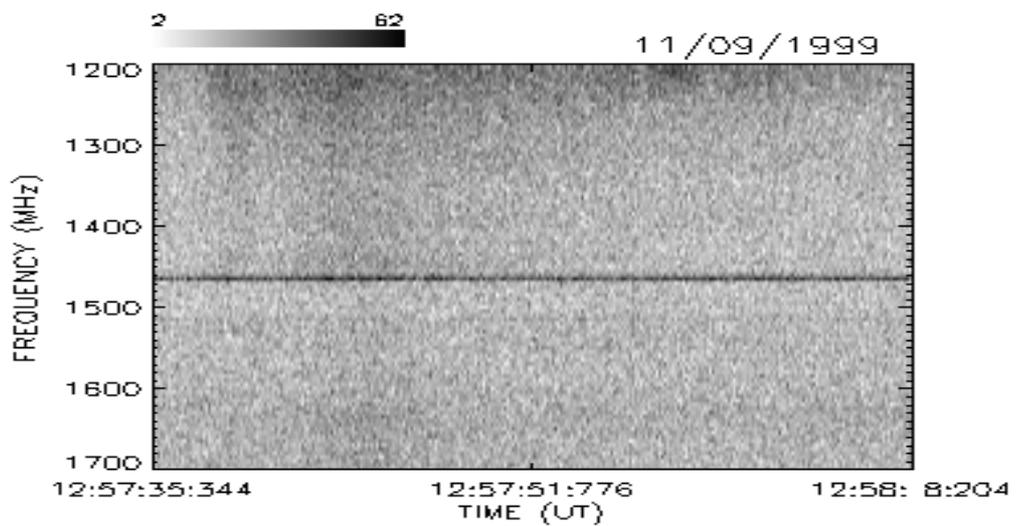
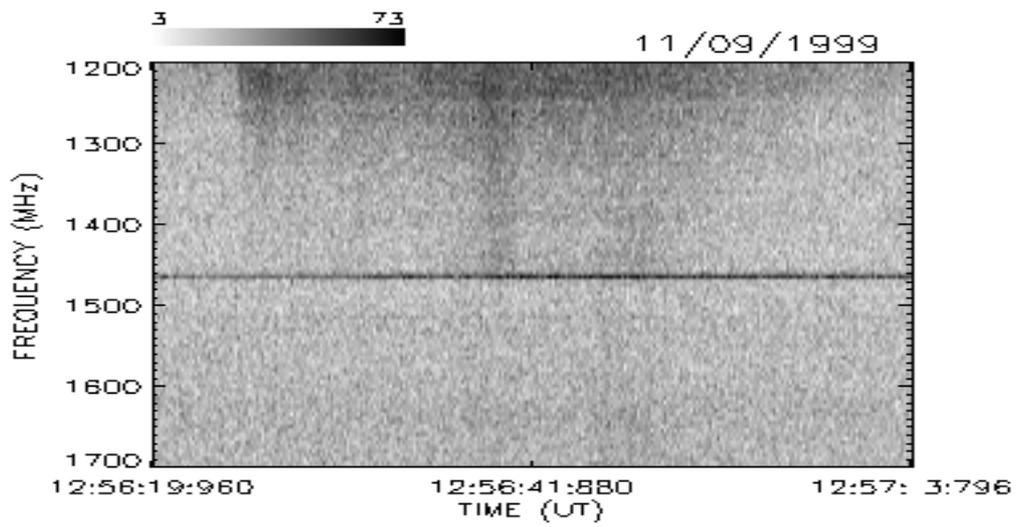
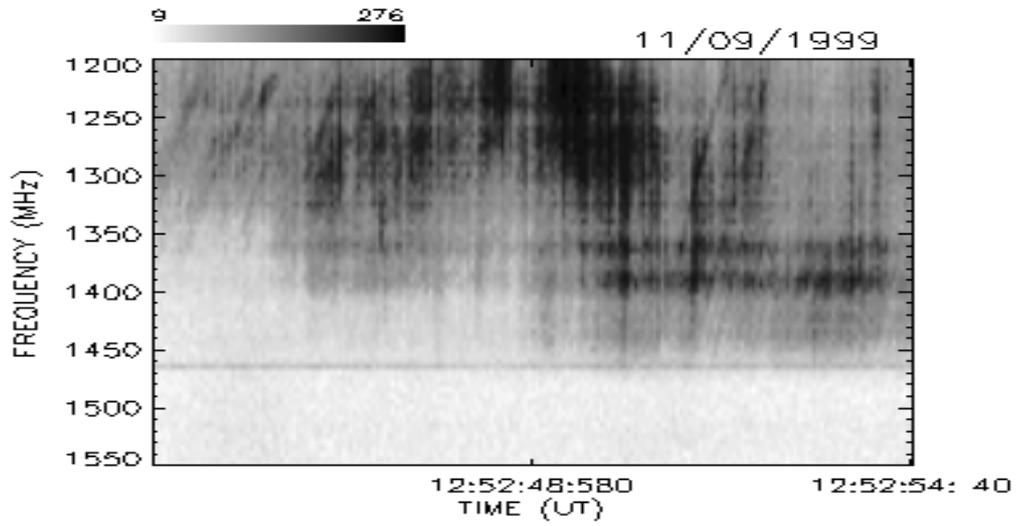
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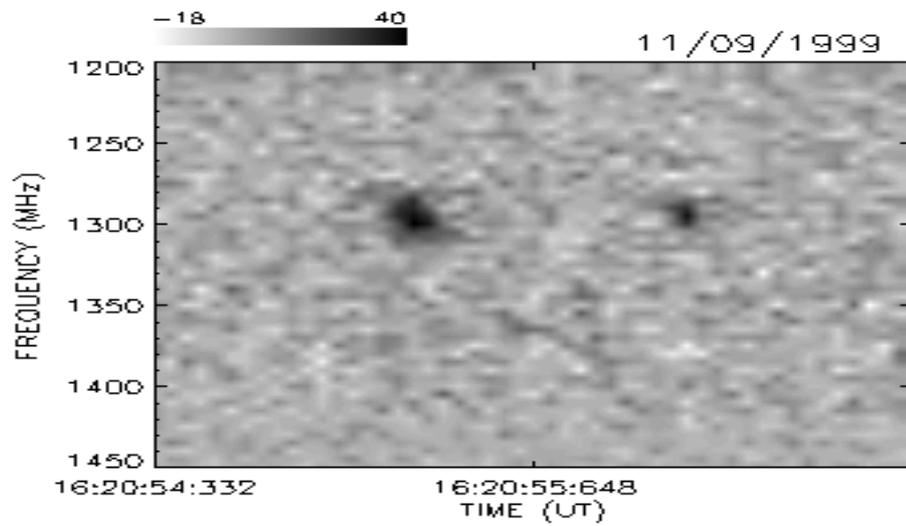
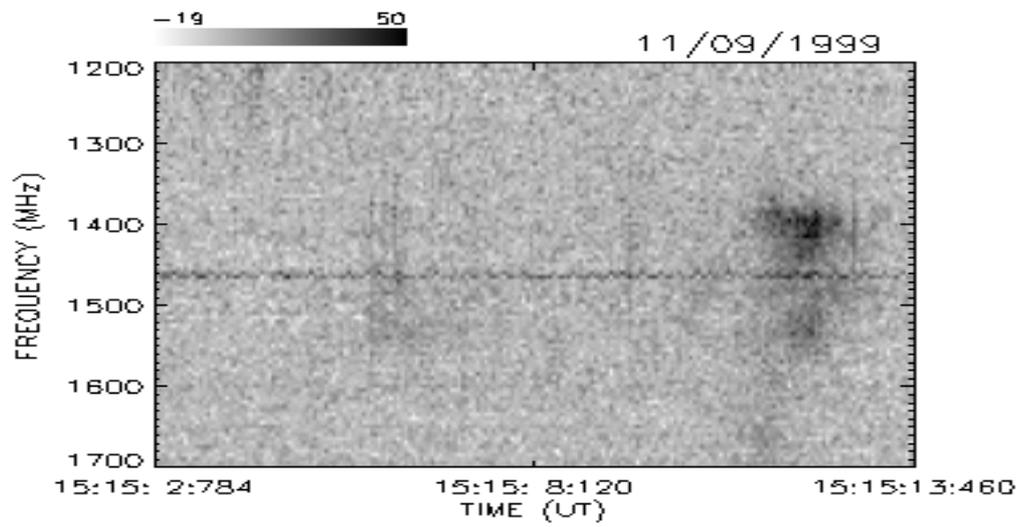
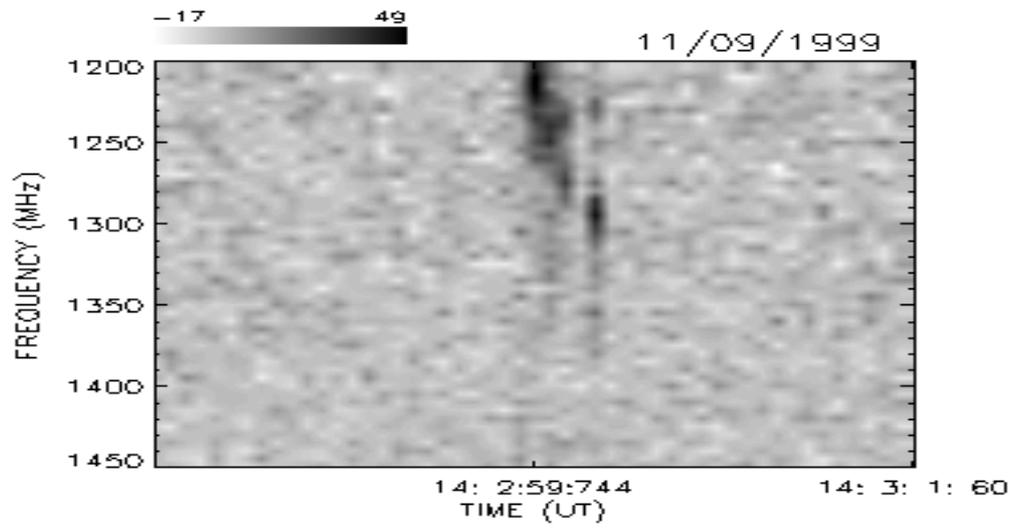
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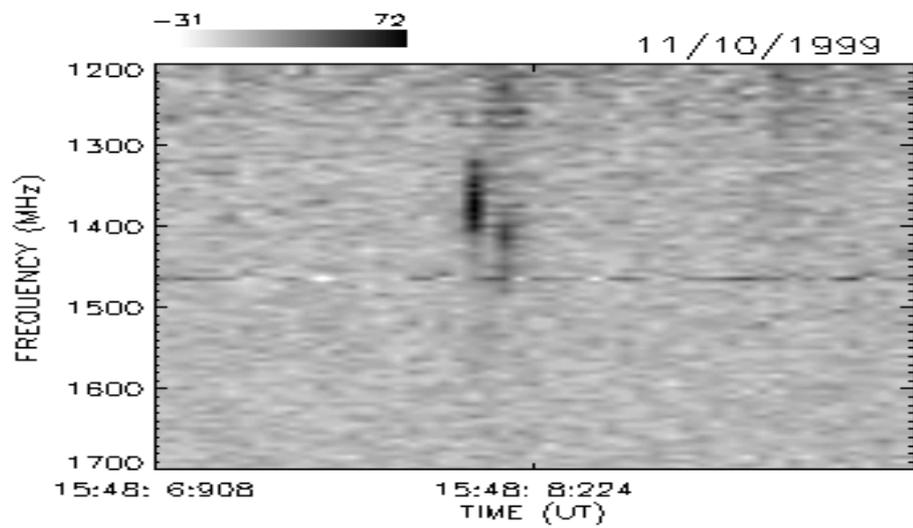
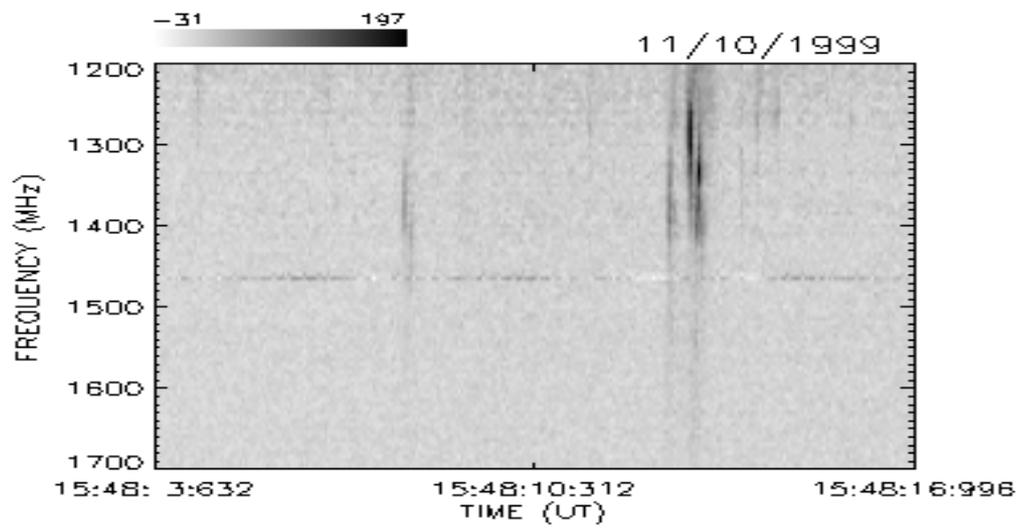
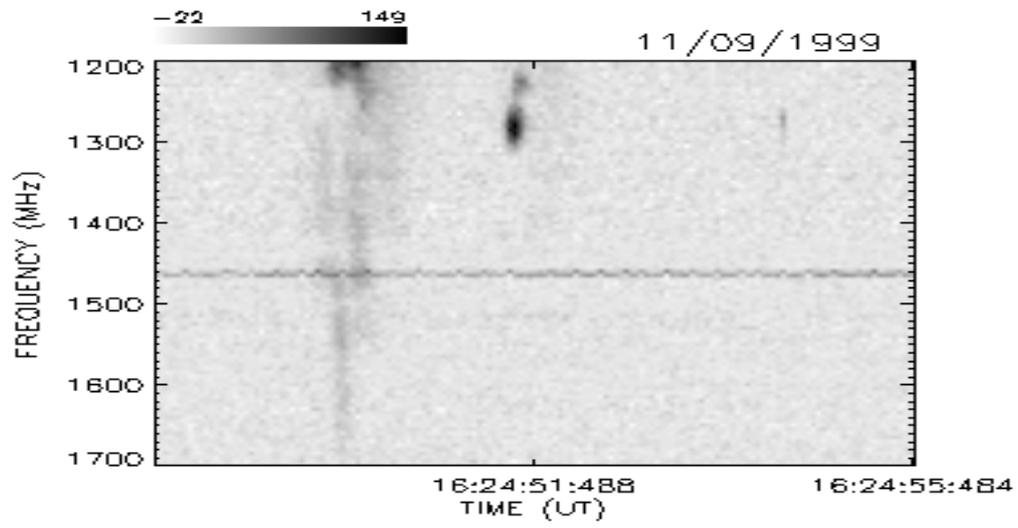
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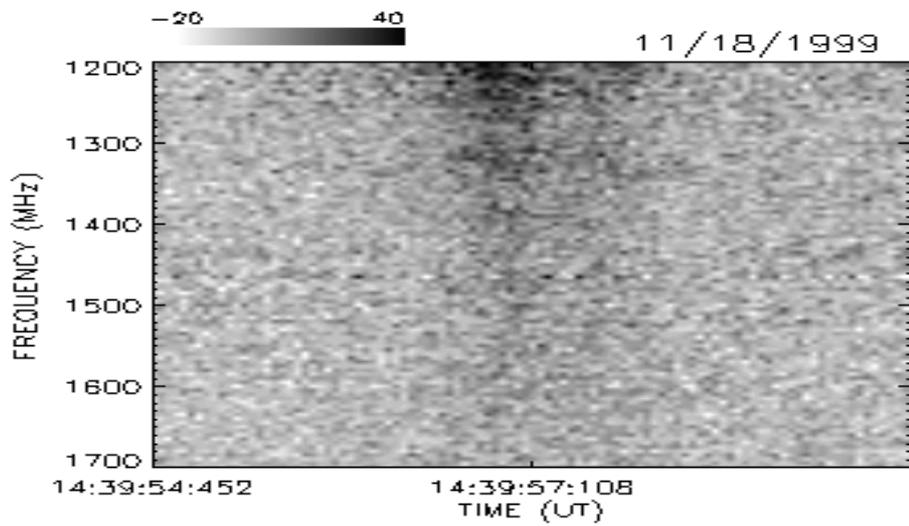
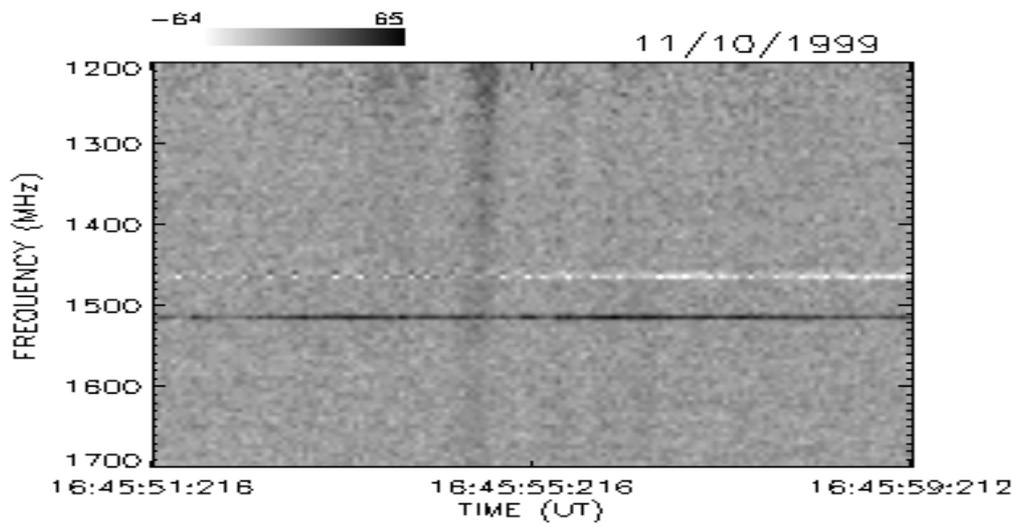
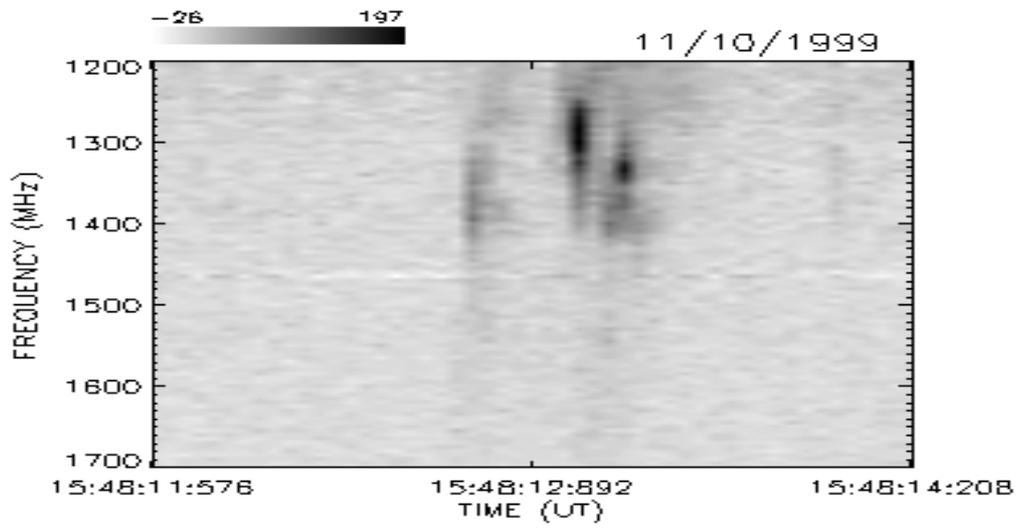
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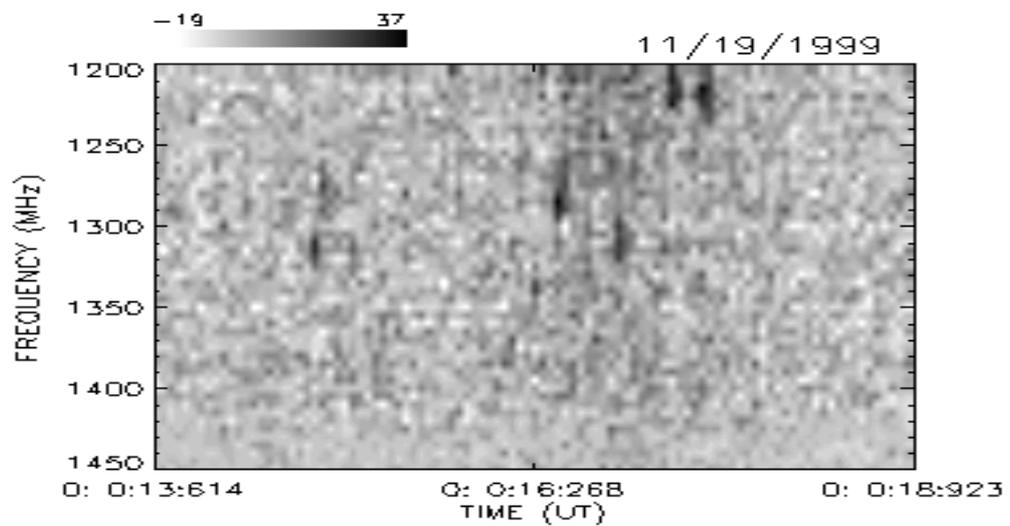
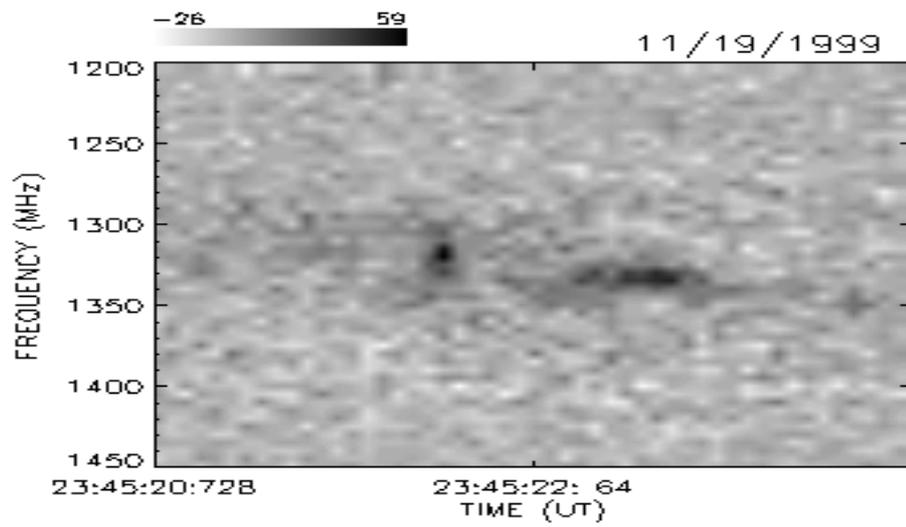
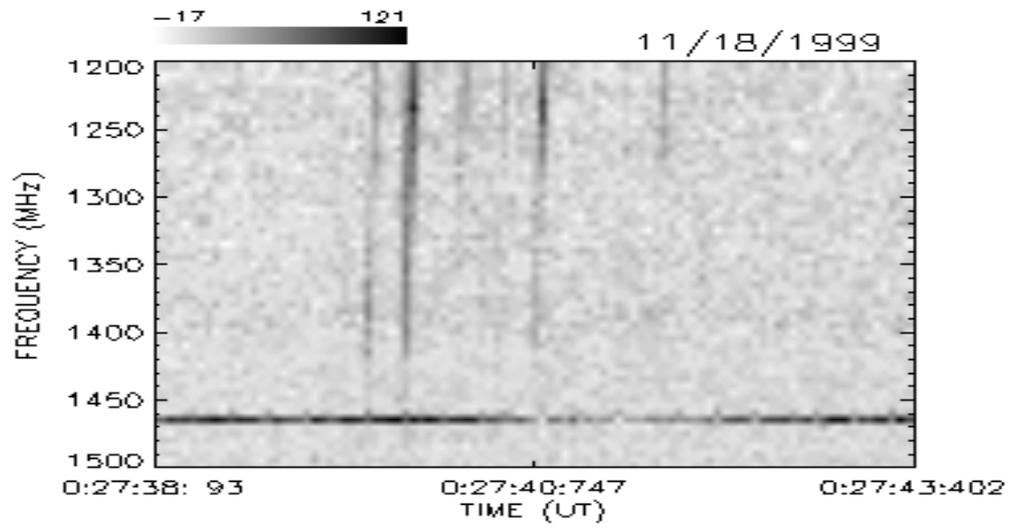
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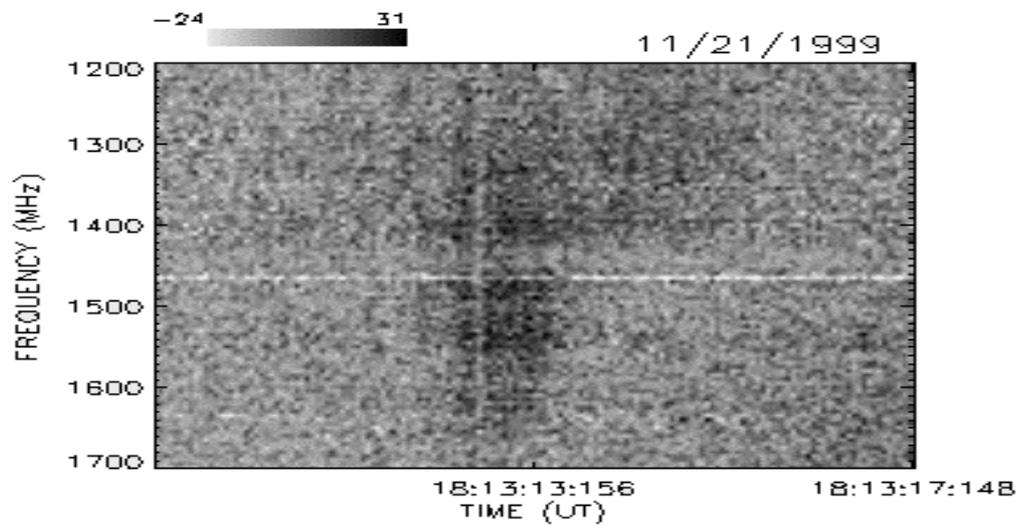
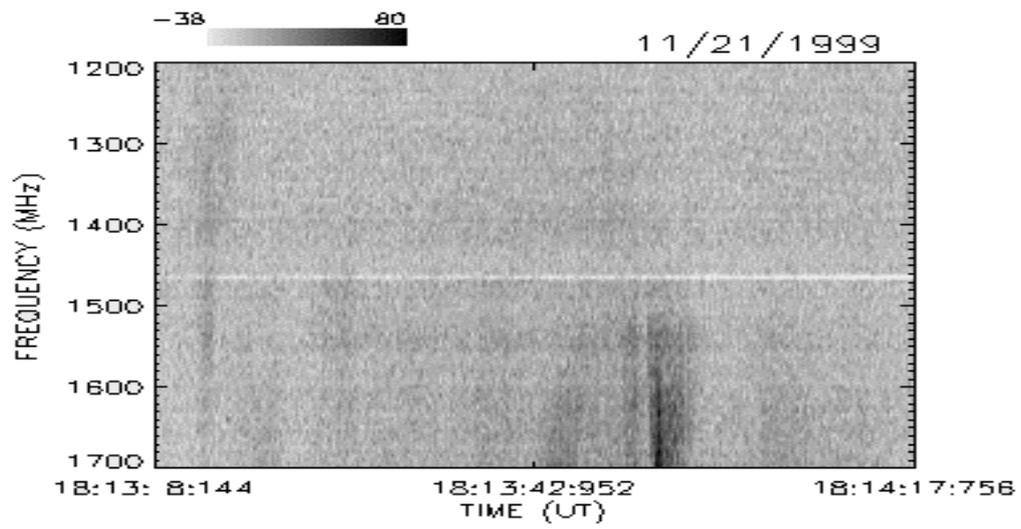
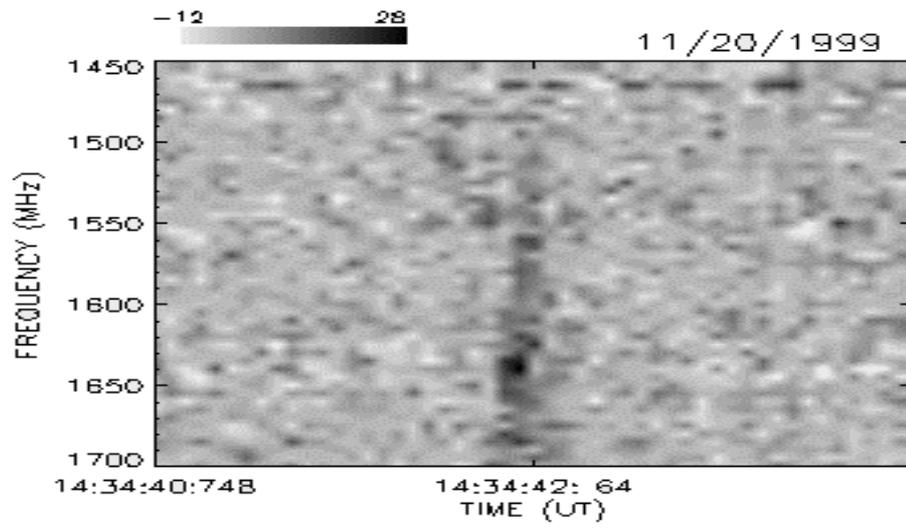
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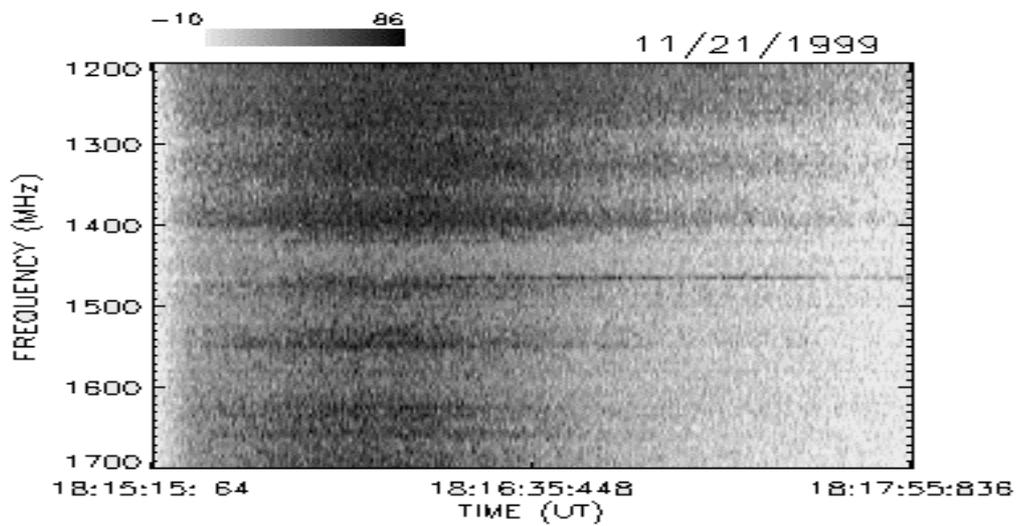
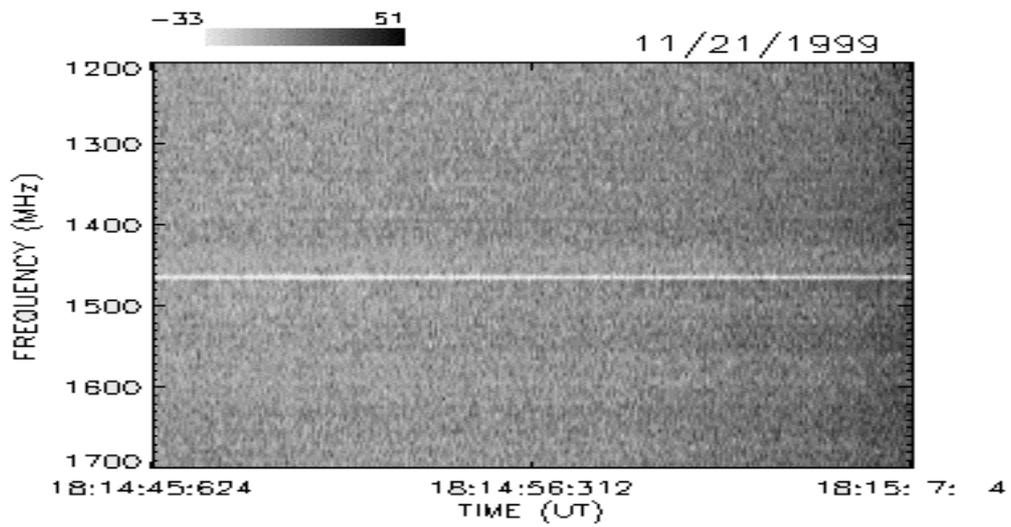
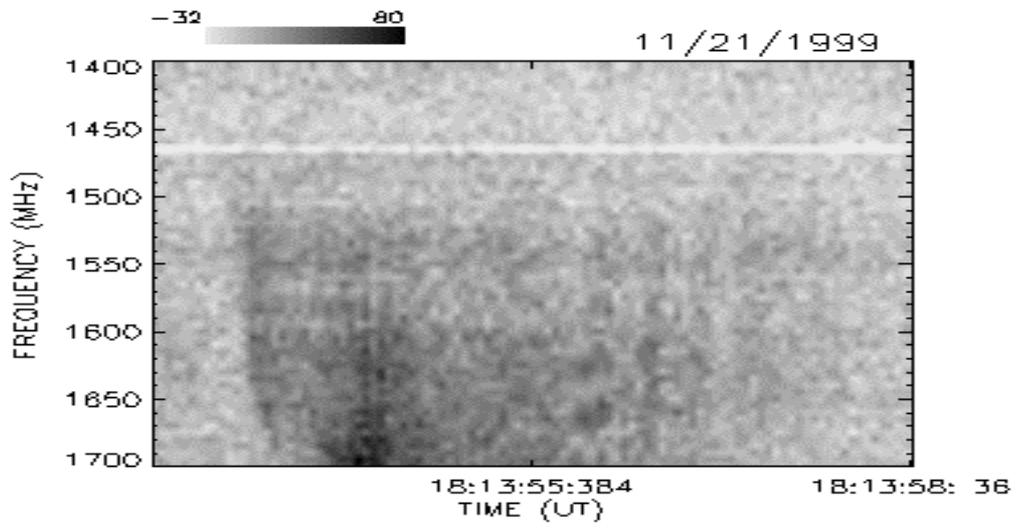
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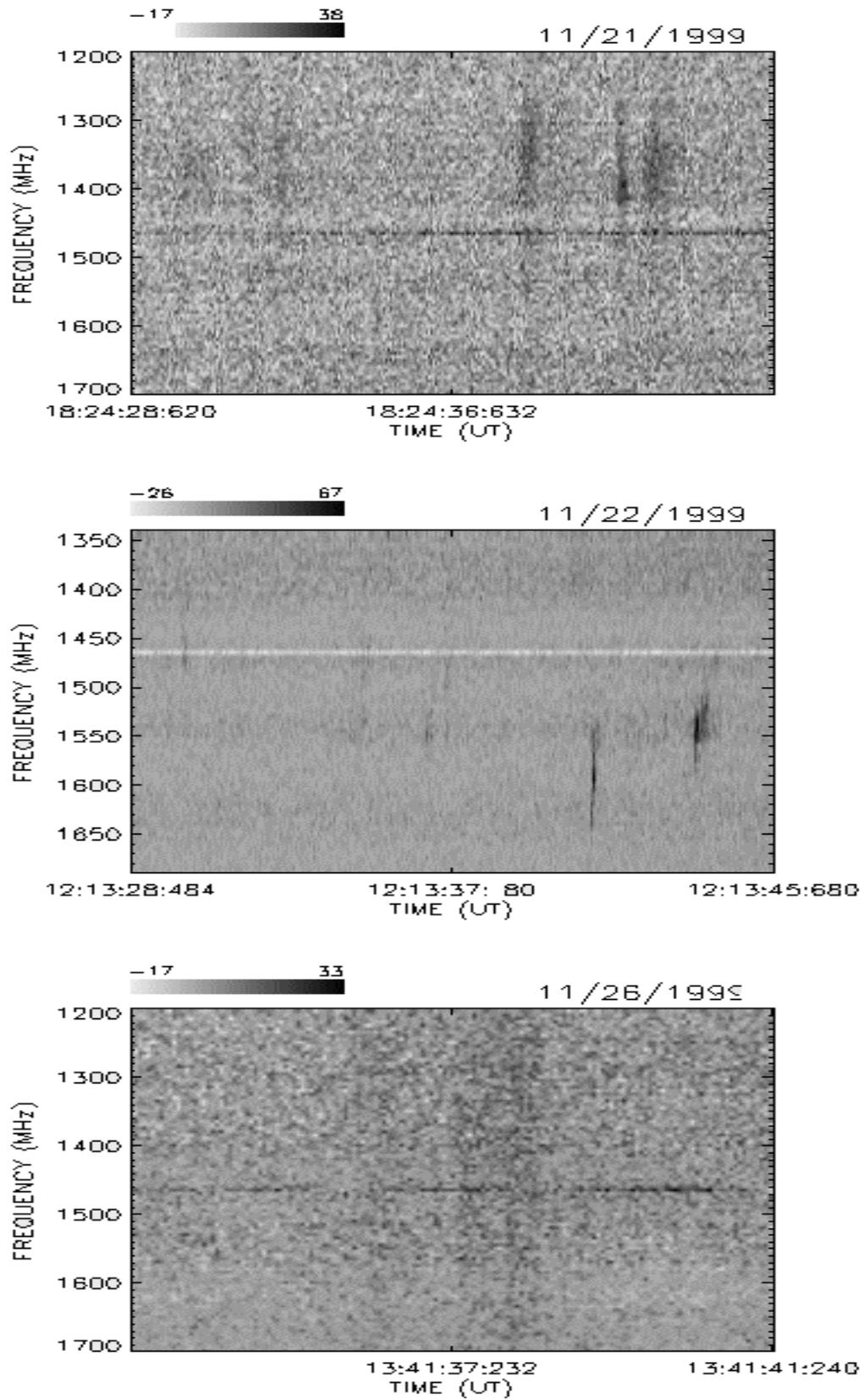
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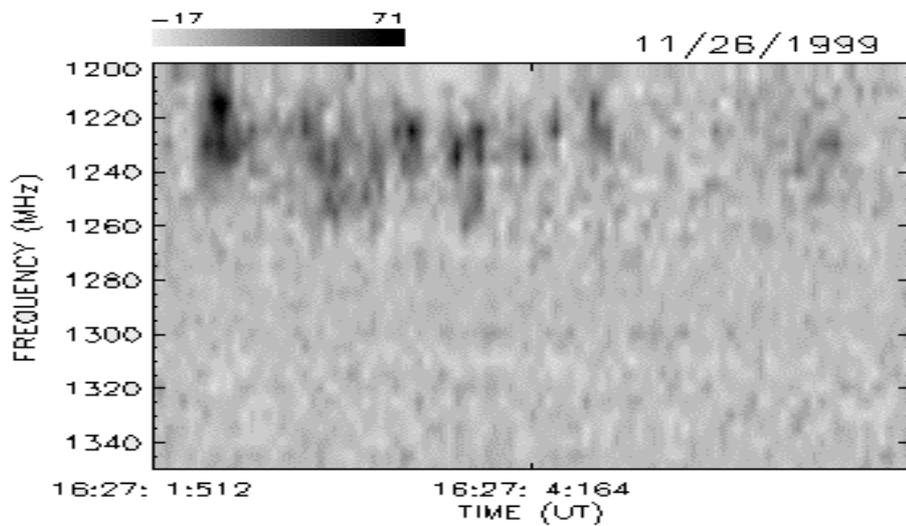
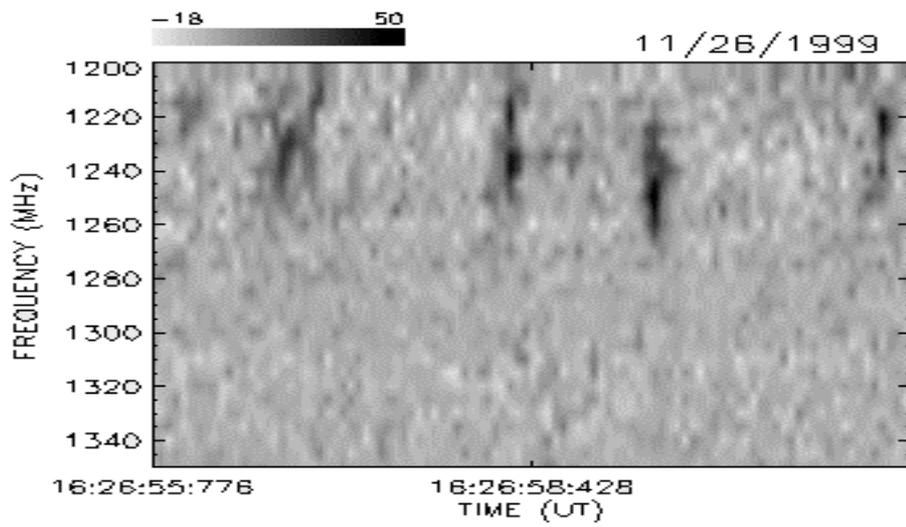
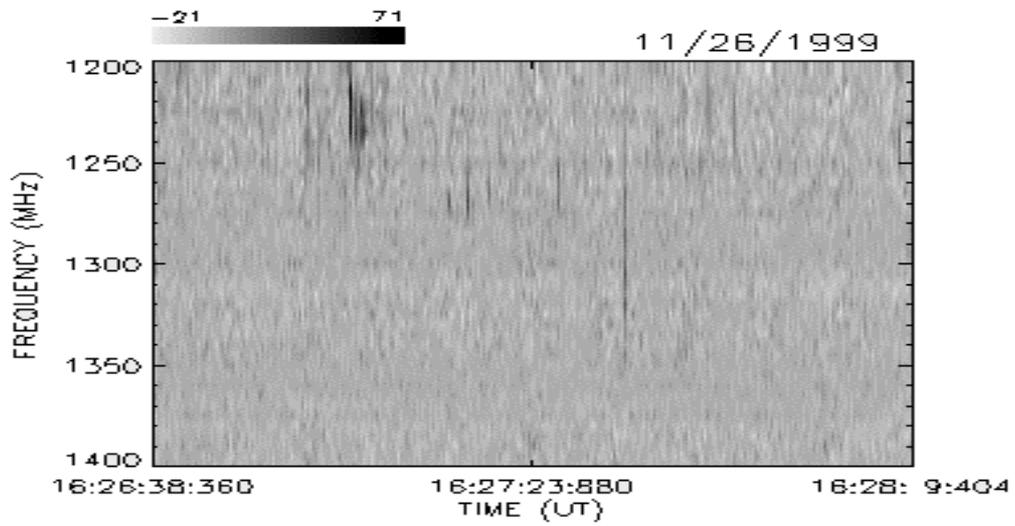
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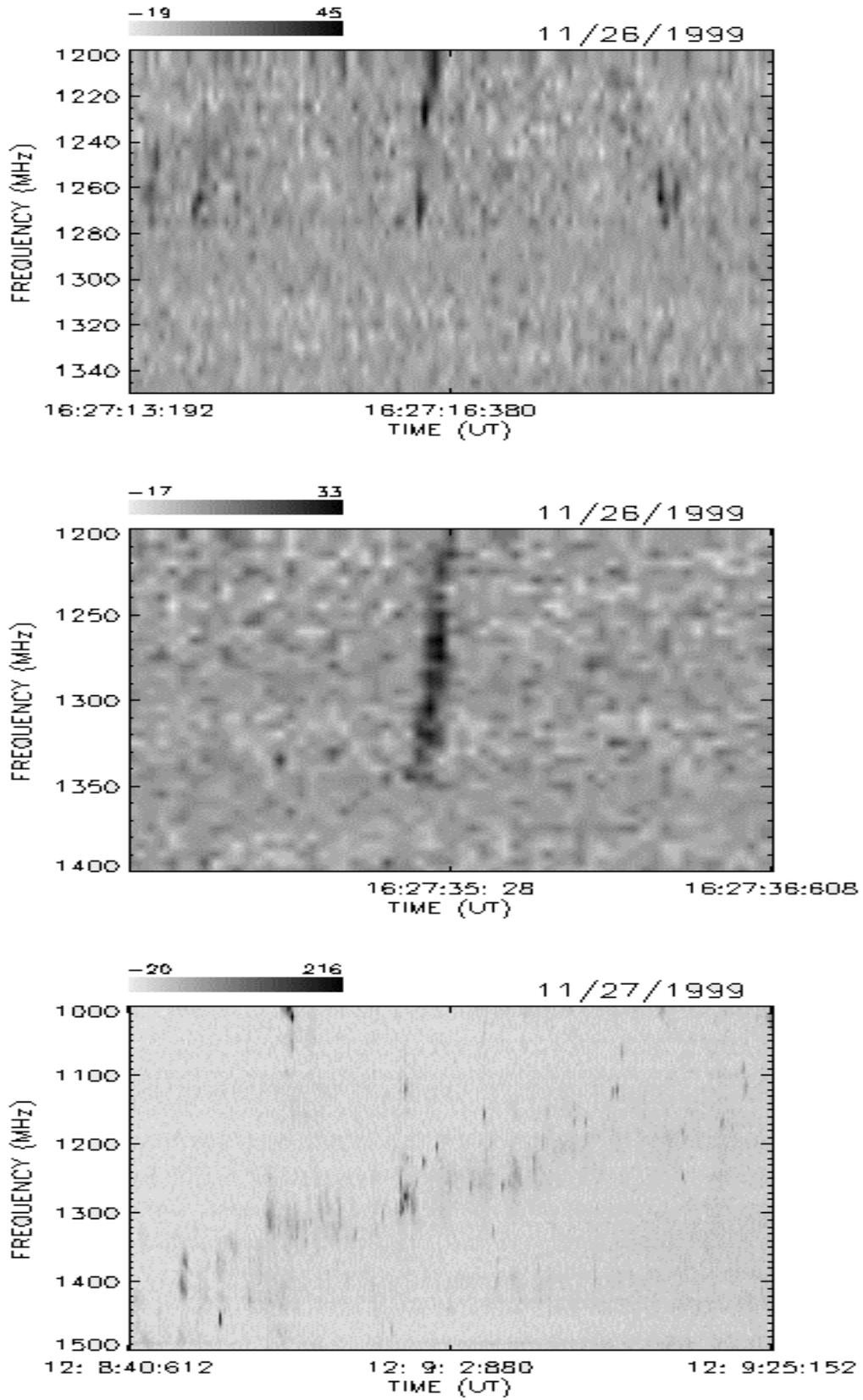
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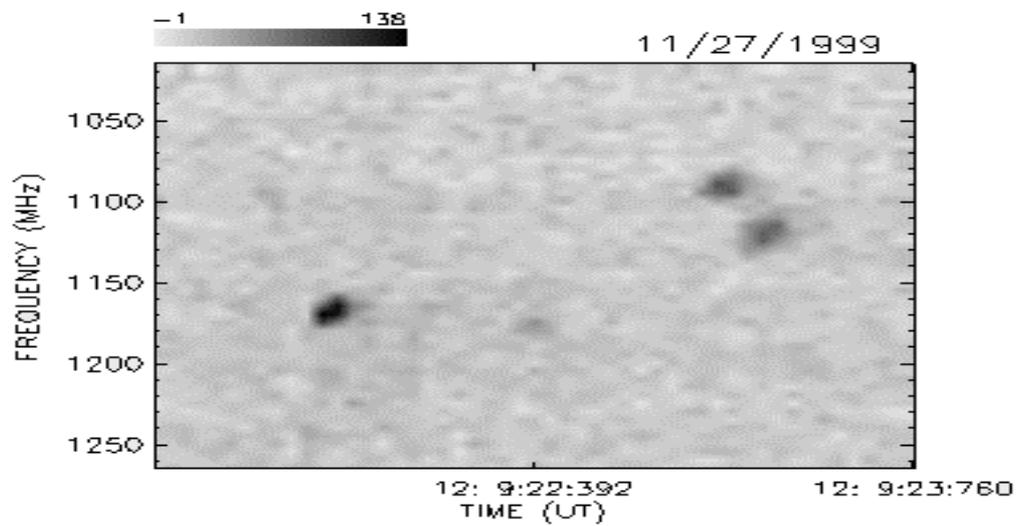
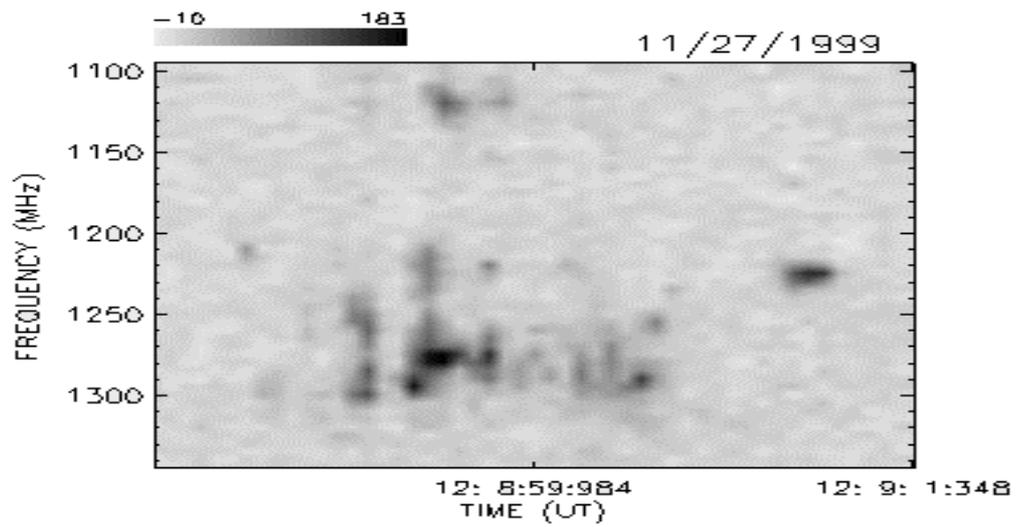
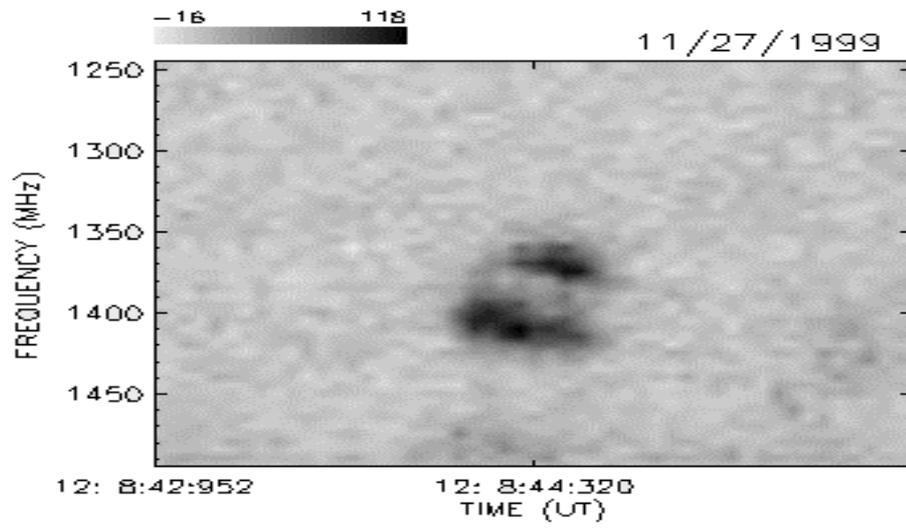
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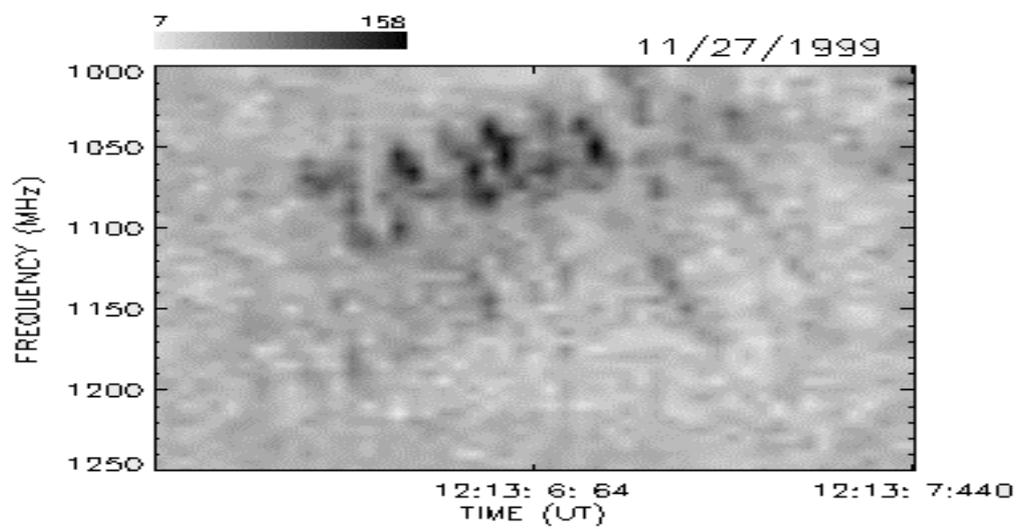
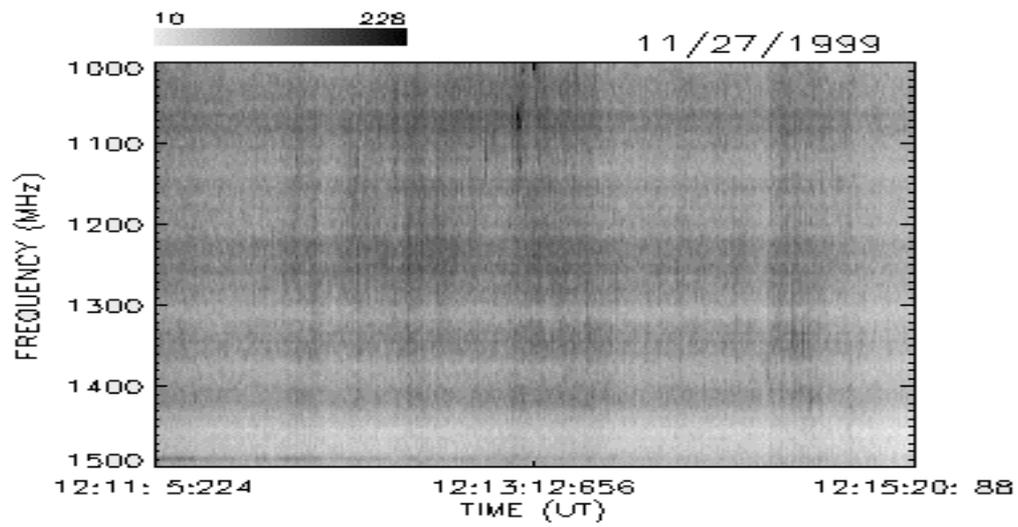
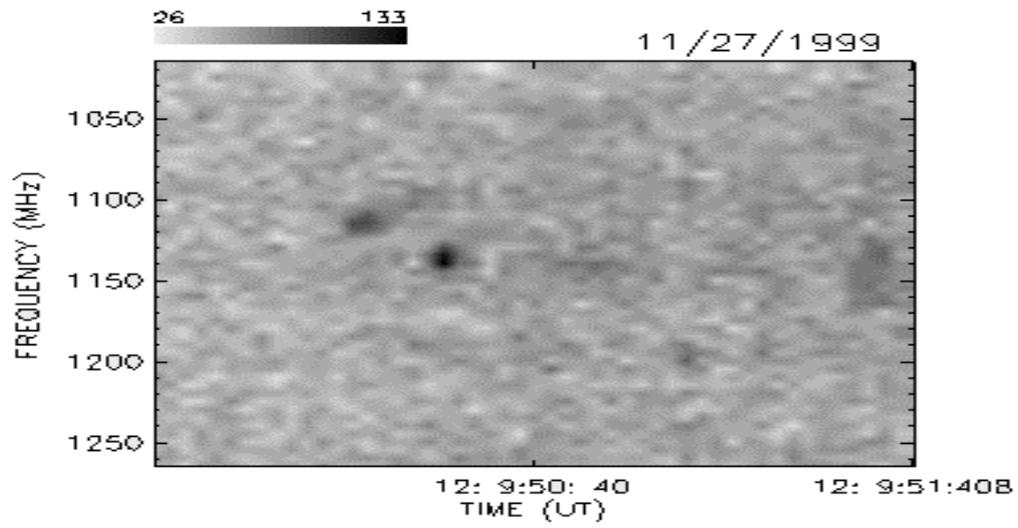
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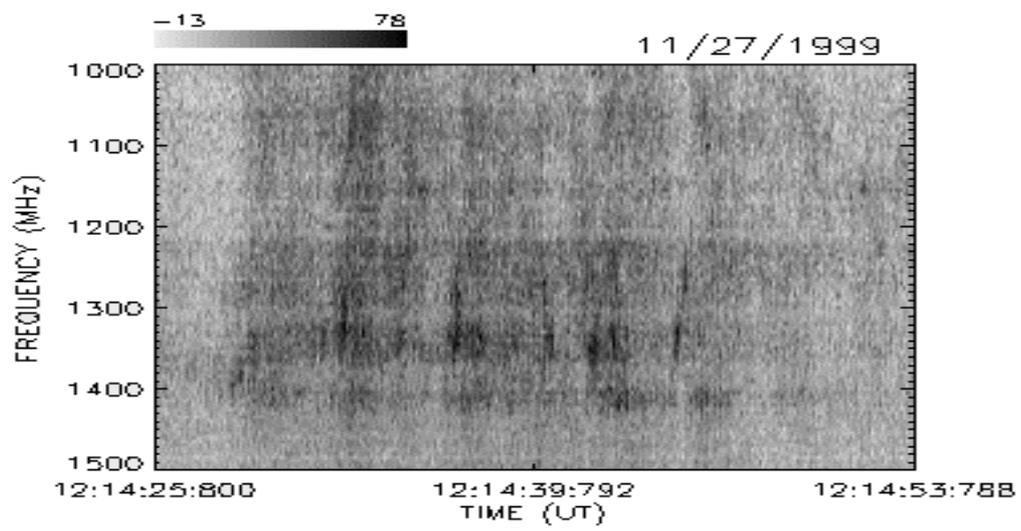
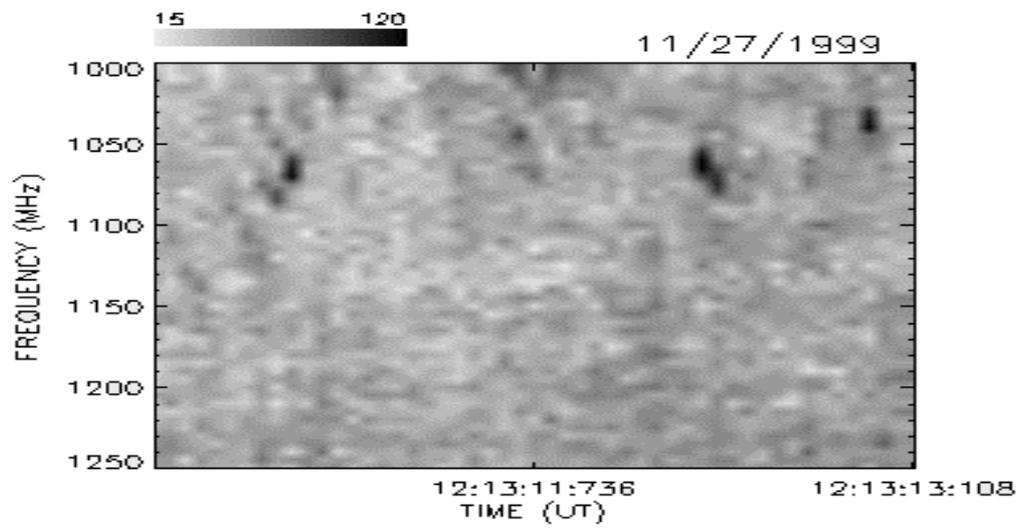
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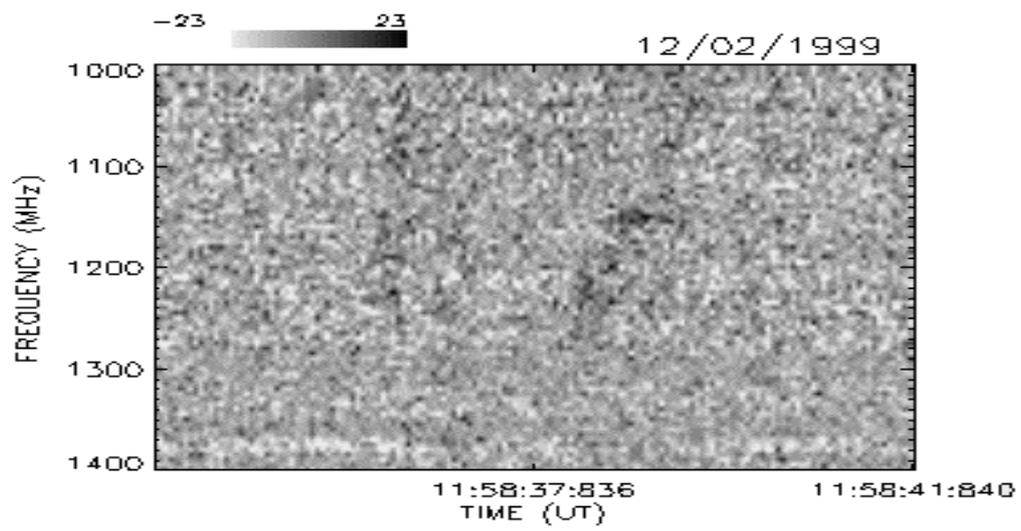
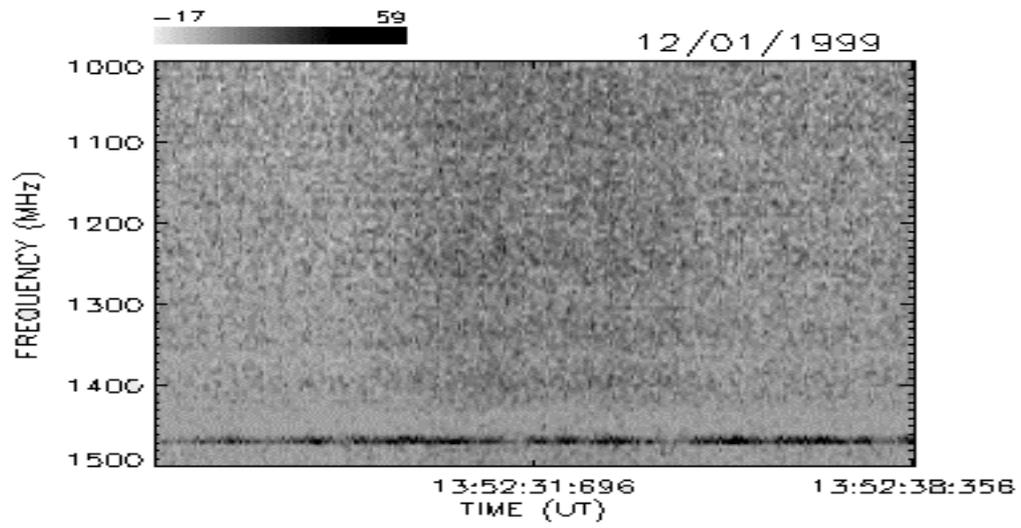
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