

Data driven models forecasting levels of geomagnetic disturbance related to GIC

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Sun—solar wind—Earth

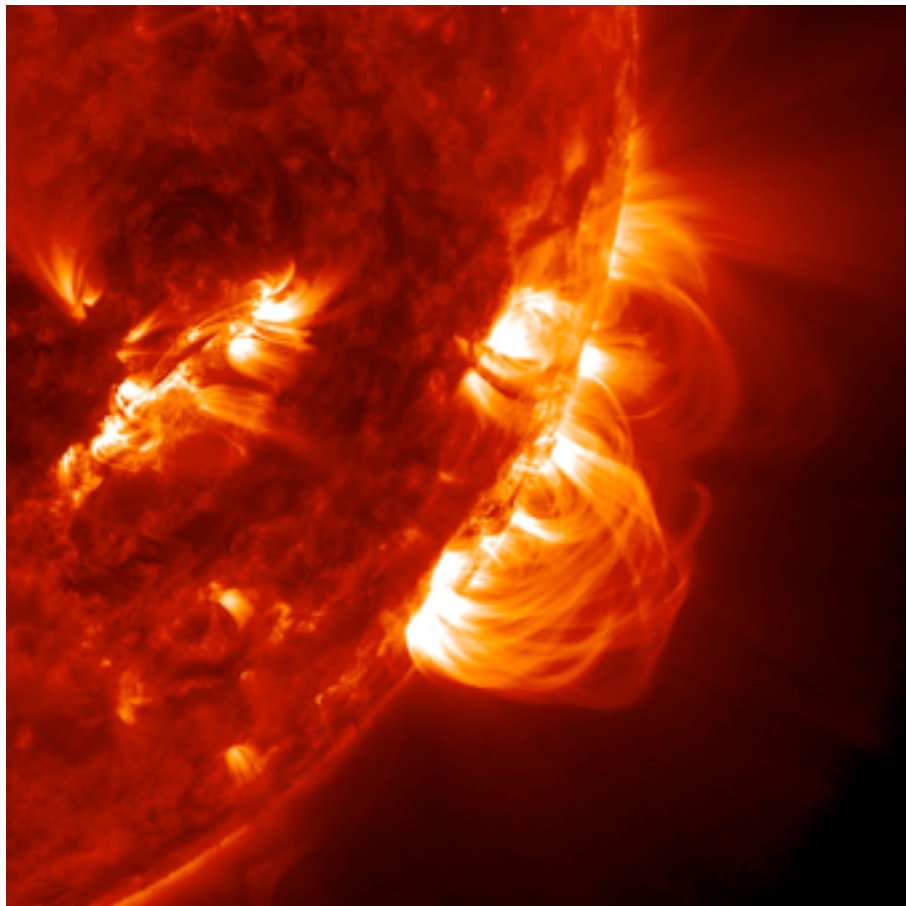
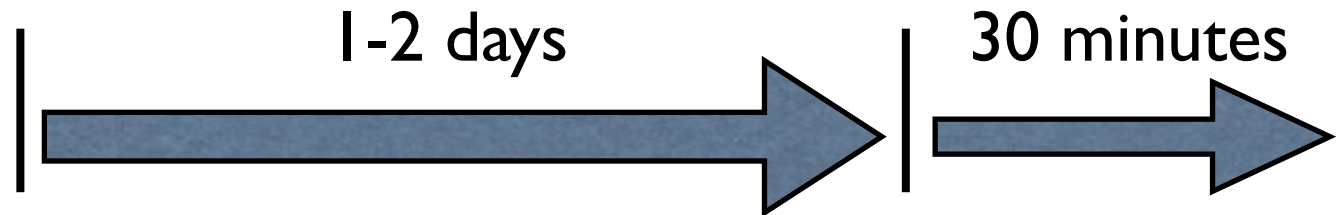


Image from
<http://sdo.gsfc.nasa.gov>

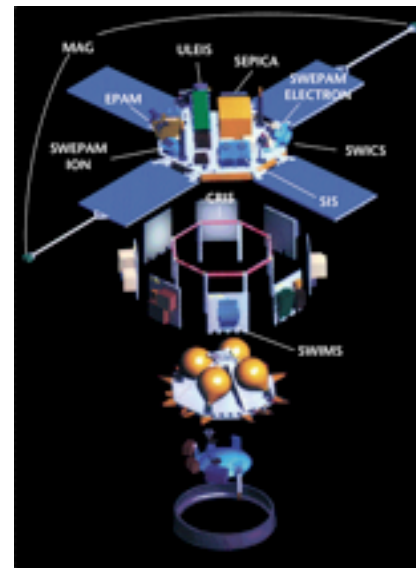


Image from
<http://www.srl.caltech.edu/ACE/>

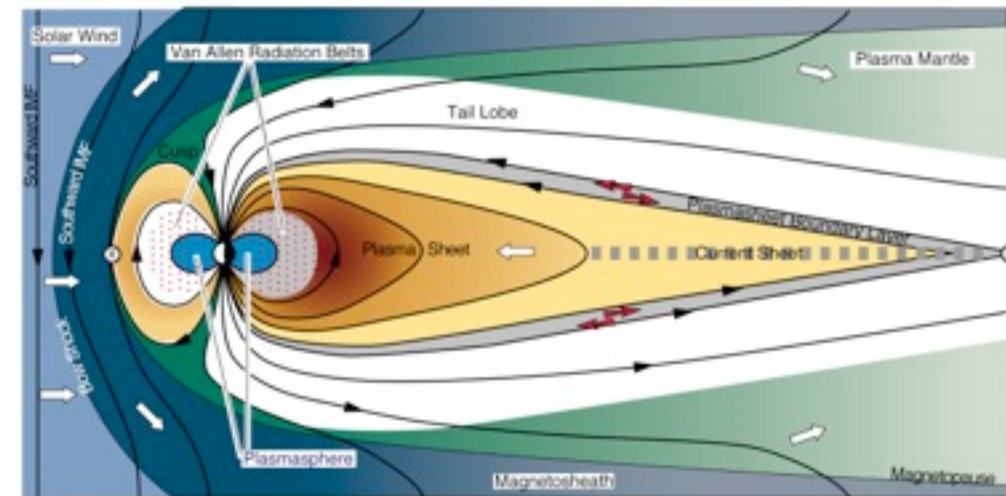
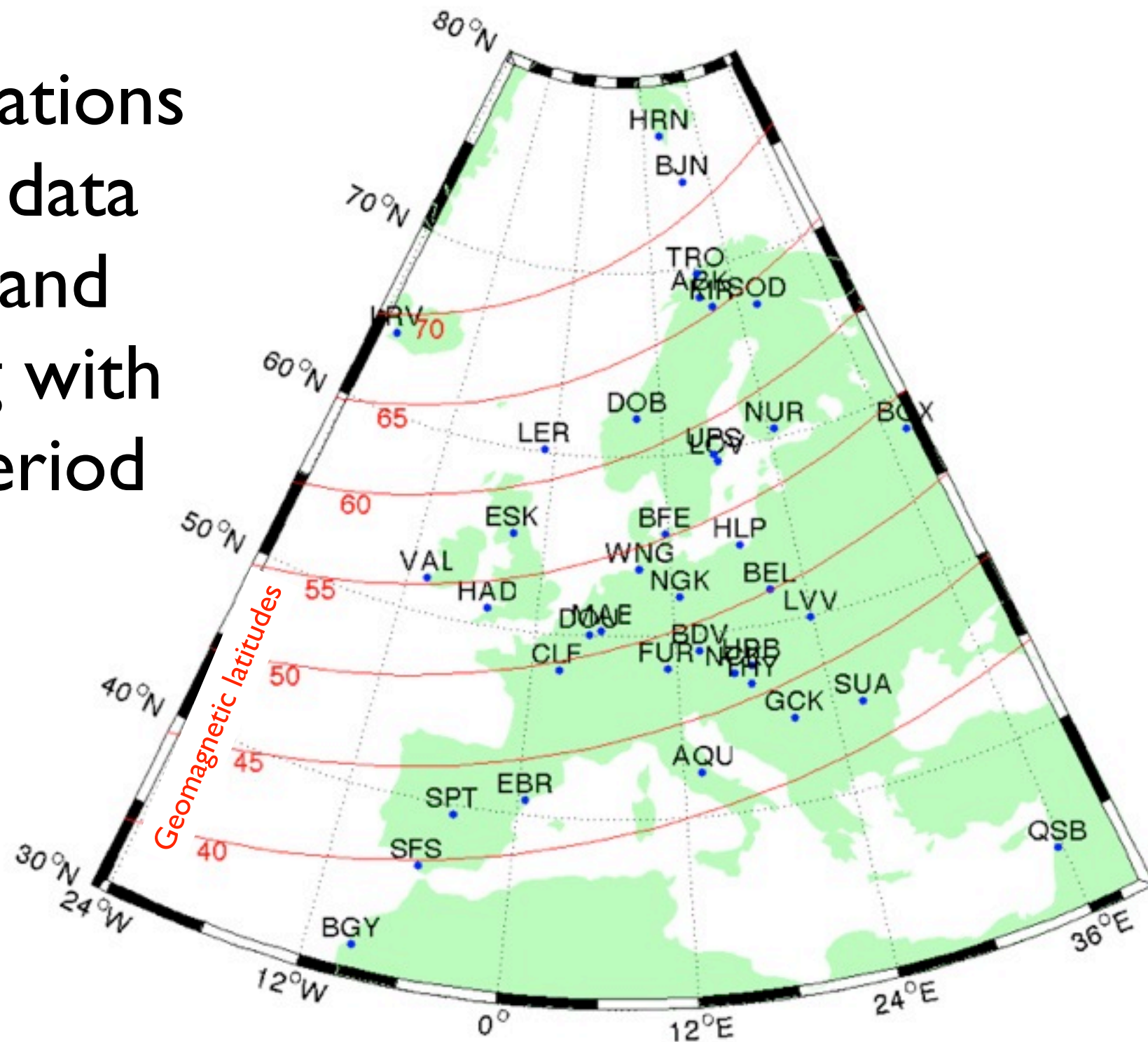


Image from
<http://space.rice.edu/IMAGE/>

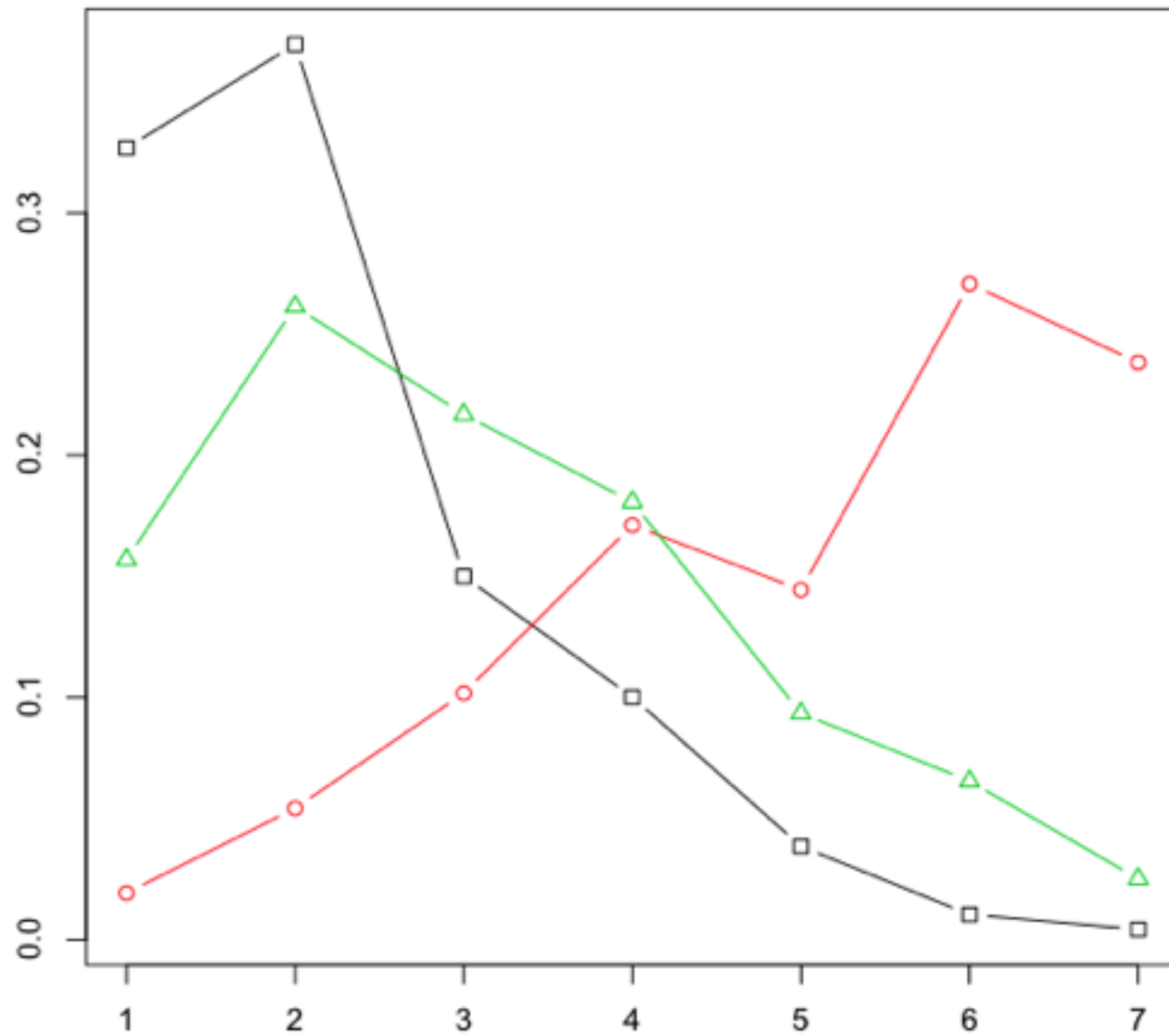
Geomagnetic stations in study

European stations
with good data
coverage and
overlapping with
the ACE period



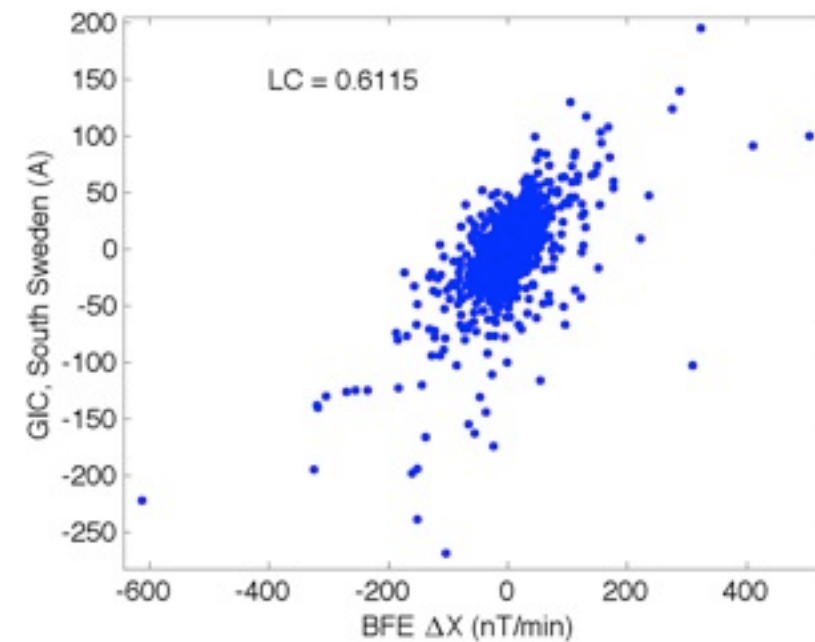
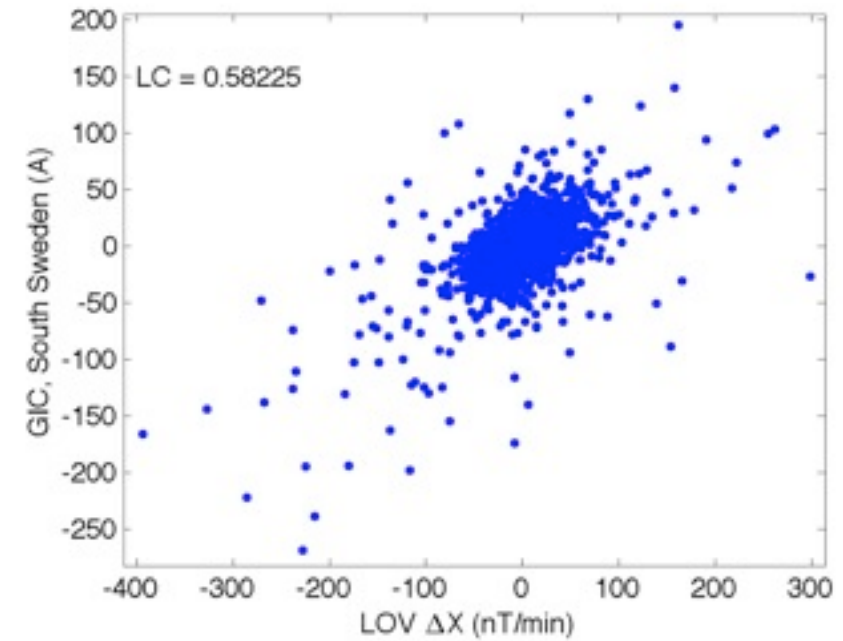
38 stations with 5 years of data or more in 1998-2010.

Local magnetic field variation



Relation between ΔX
and observed GIC

97 610 one-minute samples



The d_{30} index

Differenced 1-minute

local magnetic field: $\Delta X(t) = X(t) - X(t - 1)$

30 minute forward

maximum: $m_{30} = \max \{ |\Delta X(\tau)| \}$ for $t \leq \tau < t + 30$

Definition of d_{30} : $d_{30} = \frac{9}{7} \ln(m_{30} + 1)$ Numerically similar to Kp

d_{30}	m_{30}	CLF	WNG	BFE	ESK	UPV	ABK
0	0	1397	672	321	628	1047	287
1	1	396153	346442	322146	326718	333118	122946
2	4	19515	60902	79837	76255	67566	118021
3	9	2267	9845	15060	14117	15087	93647
4	21	396	1367	2066	1982	2790	56235
5	48	75	271	445	463	749	21457
6	105	9	72	127	133	273	5030
7	230	0	13	40	40	58	657
8	503	0	2	4	5	7	49
9	1096	0	0	1	1	1	2

Counts per station and bin
(years 1985–2008)

Storm events using plasma & magnetic field inputs

All big events are
missing due to the
ACE SWEPAM
outages during
proton events.

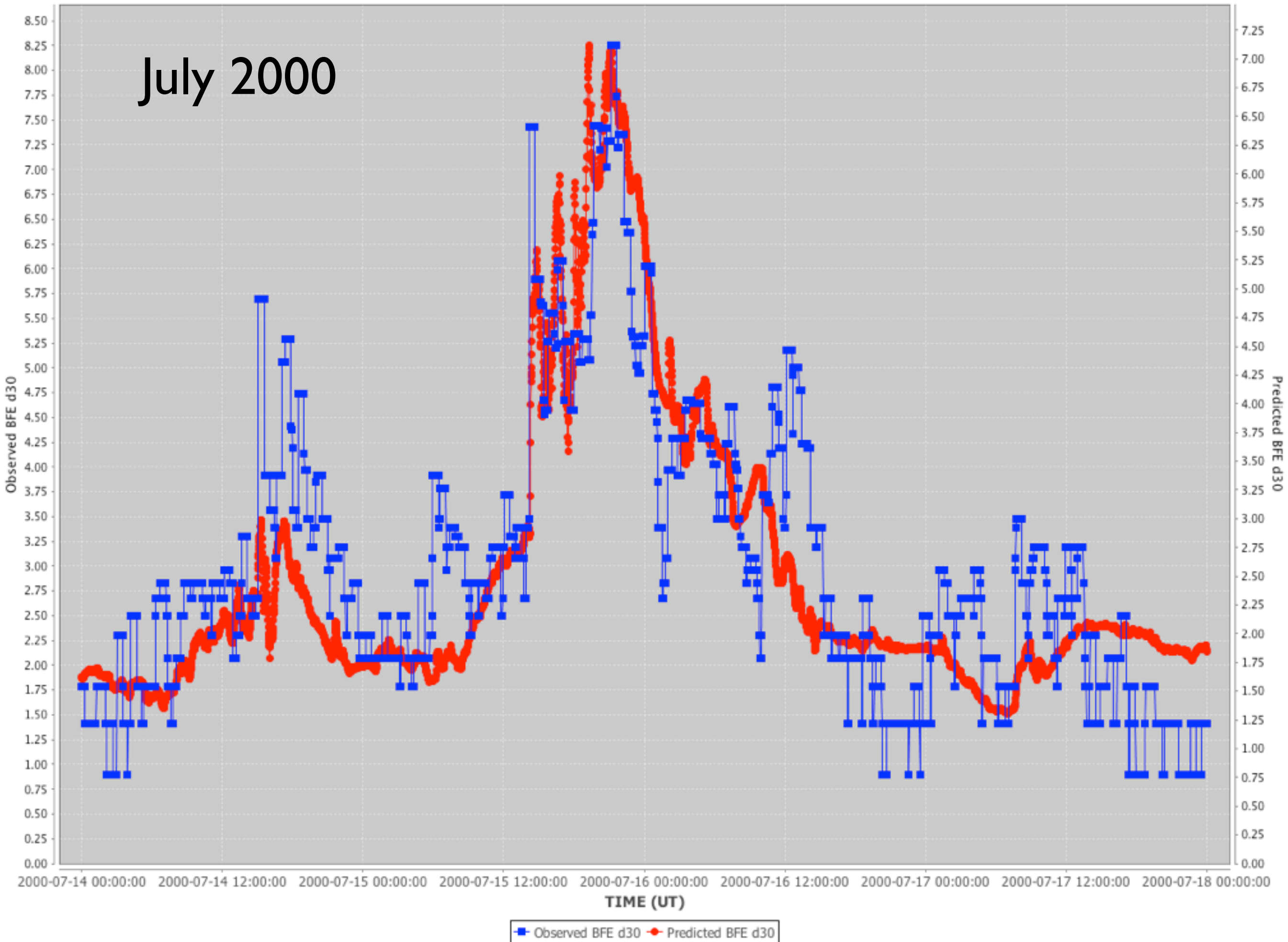
Id	Start date	End date	BFE	CLF	ESK	UPV	WNG
1	1998-03-10 03:50:00.0	1998-03-11 19:26:00.0	74	17	64	168	35
2	1998-05-03 10:05:00.0	1998-05-05 15:48:00.0	176	31	164	168	70
3	1998-09-23 22:53:00.0	1998-09-26 10:43:00.0	124	48	62	157	91
4	1998-11-12 21:03:00.0	1998-11-14 23:04:00.0	48	9	41	114	30
5	1999-01-12 20:45:00.0	1999-01-14 23:08:00.0	54	10	48	182	31
6	1999-09-21 20:21:00.0	1999-09-24 00:36:00.0	71	39	62	157	67
7	2000-04-05 15:42:00.0	2000-04-08 11:02:00.0	506	43	280	255	267
8	2000-06-07 12:09:00.0	2000-06-09 14:08:00.0	90	27	66	112	47
9	2000-09-16 20:16:00.0	2000-09-19 13:18:00.0	89	34	129	148	63
10	2000-11-05 17:06:00.0	2000-11-07 19:59:00.0	47	19	35	115	30
11	2001-03-19 10:22:00.0	2001-03-20 20:07:00.0	27	12	60	177	41
12	2001-03-29 23:51:00.0	2001-04-02 00:57:00.0	92	78	137	161	146
13	2001-04-10 14:49:00.0	2001-04-13 02:16:00.0	169	25	191	238	119
14	2002-05-22 14:44:00.0	2002-05-24 18:27:00.0	114	44	106	122	90
15	2002-09-04 13:05:00.0	2002-09-06 14:58:00.0	7	52	9	7	8
16	2002-09-06 16:04:00.0	2002-09-08 21:01:00.0	128	17	99	342	64
17	2002-09-30 15:26:00.0	2002-10-02 17:46:00.0	121	19	67	234	56
18	2003-02-01 14:49:00.0	2003-02-03 16:41:00.0	30	11	31	103	25
19	2003-05-28 12:34:00.0	2003-05-31 03:17:00.0	93	31	107	167	60
20	2003-08-17 13:21:00.0	2003-08-19 16:48:00.0	65	45	72	154	60
21	2003-10-13 17:24:00.0	2003-10-15 19:23:00.0	72	11	65	282	44
22	2003-11-19 07:14:00.0	2003-11-22 00:47:00.0	261	28	206	162	385
23	2004-07-25 21:49:00.0	2004-07-28 22:21:00.0	125	92	149	149	94
24	2004-11-07 01:54:00.0	2004-11-09 12:07:00.0	151	50	173	268	55
25	2005-01-21 04:02:00.0	2005-01-23 01:57:00.0	206	39	254	221	69
26	2005-05-07 12:17:00.0	2005-05-09 15:08:00.0	47	16	56	183	39
27	2005-05-14 01:38:00.0	2005-05-16 03:44:00.0	89	58	89	90	68
28	2005-05-29 16:57:00.0	2005-05-31 18:58:00.0	25	13	64	151	21
29	2006-12-13 21:42:00.0	2006-12-16 03:51:00.0	33	20	44	117	28

Storm events using only magnetic field inputs

Id	Start date	End date	BFE	CLF	ESK	UPV	WNG
1	1998-03-09 16:46:00.0	1998-03-11 19:28:00.0	74	17	64	168	35
2	1998-05-03 02:22:00.0	1998-05-05 15:50:00.0	176	31	164	168	70
3	1998-09-23 22:53:00.0	1998-09-26 10:45:00.0	124	48	62	157	91
4	1998-11-12 21:03:00.0	1998-11-14 23:06:00.0	48	9	41	114	30
5	1999-01-12 20:45:00.0	1999-01-14 23:10:00.0	54	10	48	182	31
6	1999-09-21 20:21:00.0	1999-09-24 00:49:00.0	71	39	62	157	67
7	2000-04-05 15:42:00.0	2000-04-08 11:04:00.0	506	43	280	255	267
8	2000-06-07 12:09:00.0	2000-06-09 14:21:00.0	90	27	66	112	47
9	2000-07-14 13:36:00.0	2000-07-17 02:28:00.0	613	166	394	394	237
10	2000-09-16 20:16:00.0	2000-09-19 13:20:00.0	89	34	129	148	63
11	2000-11-05 17:06:00.0	2000-11-07 20:01:00.0	47	19	35	115	30
12	2001-03-18 17:35:00.0	2001-03-20 20:09:00.0	27	12	60	177	41
13	2001-03-29 23:51:00.0	2001-04-02 00:59:00.0	92	78	137	161	146
14	2001-04-10 14:49:00.0	2001-04-13 02:18:00.0	169	25	191	238	119
15	2001-09-24 21:47:00.0	2001-09-27 00:16:00.0	69	44	87	149	70
16	2001-10-20 15:47:00.0	2001-10-23 02:16:00.0	74	53	90	170	77
17	2001-11-05 00:51:00.0	2001-11-07 14:53:00.0	108	80	159	219	75
18	2001-11-23 04:58:00.0	2001-11-25 16:57:00.0	109	78	155	336	104
19	2002-05-22 14:44:00.0	2002-05-24 18:29:00.0	114	44	106	122	90
20	2002-09-04 13:05:00.0	2002-09-06 15:00:00.0	7	52	9	7	8
21	2002-09-06 16:04:00.0	2002-09-08 21:03:00.0	128	17	99	342	64
22	2002-09-30 15:23:00.0	2002-10-02 17:48:00.0	121	19	67	234	56
23	2003-02-01 14:47:00.0	2003-02-03 16:43:00.0	30	11	31	103	25
24	2003-05-28 12:34:00.0	2003-05-31 03:19:00.0	93	31	107	167	60
25	2003-08-17 13:21:00.0	2003-08-19 16:50:00.0	65	45	72	154	60
26	2003-10-13 17:24:00.0	2003-10-15 19:25:00.0	72	11	65	282	44
27	2003-10-28 05:10:00.0	2003-10-31 04:18:00.0	399	133	621	693	713
28	2003-11-19 07:14:00.0	2003-11-22 00:49:00.0	261	28	206	162	385
29	2004-07-25 21:49:00.0	2004-07-28 22:23:00.0	125	92	149	149	94
30	2004-11-06 17:45:00.0	2004-11-09 12:09:00.0	151	50	173	268	55
31	2005-01-06 21:30:00.0	2005-01-09 00:36:00.0	46	15	35	145	23
32	2005-01-20 16:21:00.0	2005-01-23 01:59:00.0	206	39	254	221	69
33	2005-05-07 12:16:00.0	2005-05-09 15:10:00.0	47	16	56	183	39
34	2005-05-14 01:38:00.0	2005-05-16 03:46:00.0	89	58	89	90	68
35	2005-05-29 16:57:00.0	2005-05-31 19:00:00.0	25	13	64	151	21
36	2005-08-23 07:46:00.0	2005-08-25 13:52:00.0	92	38	97	144	68
37	2005-09-10 00:13:00.0	2005-09-12 02:14:00.0	142	73	151	95	111
38	2006-12-13 21:42:00.0	2006-12-16 03:53:00.0	33	20	44	117	28

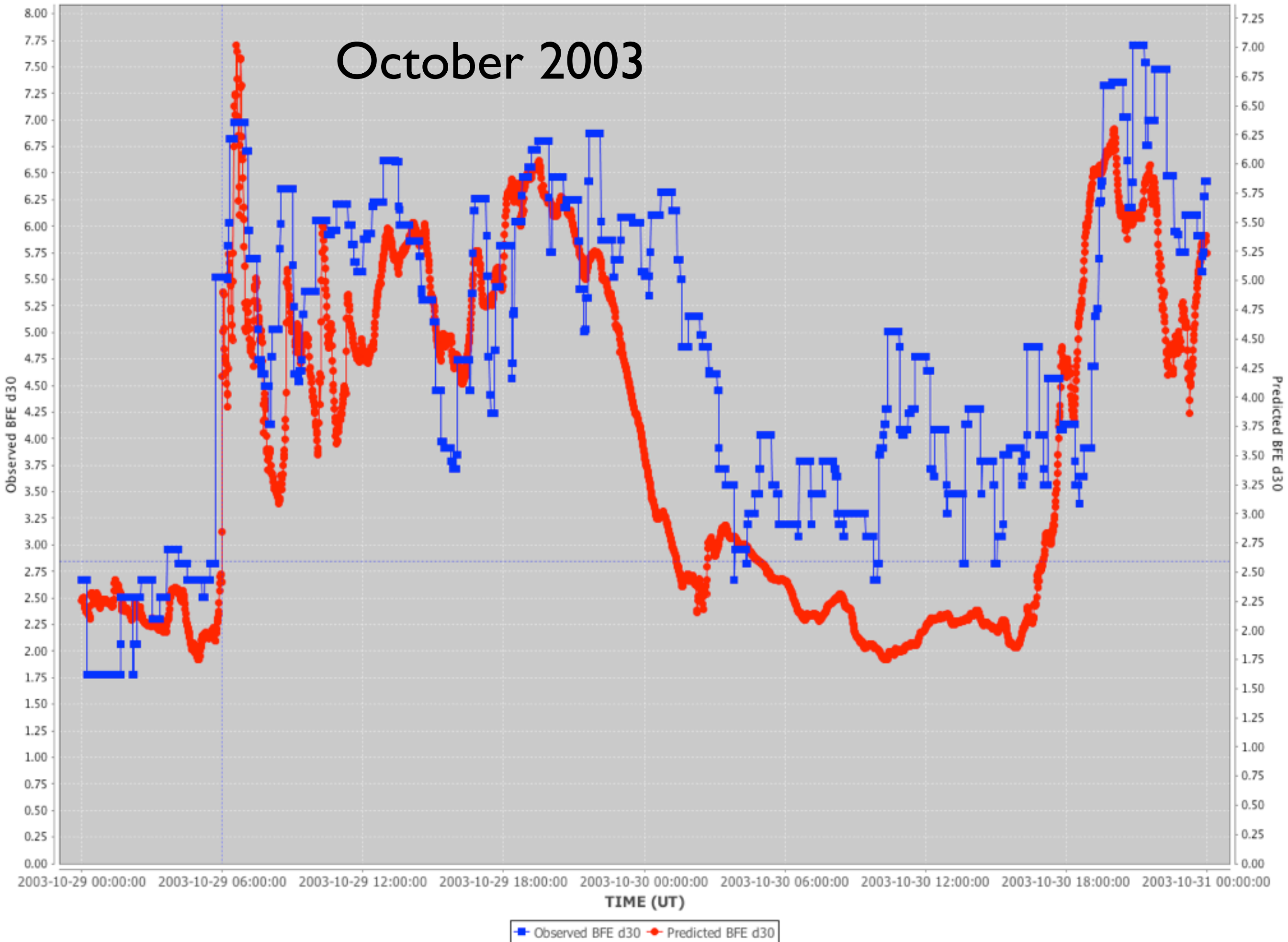
Observed and predicted d30 at BFE

July 2000



Observed and predicted d30 at BFE

October 2003



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 - ▶ NOAA/SWPC: ACE real time solar wind data
 - ▶ World Data Centre Edinburgh: Local geomagnetic data
 - ▶ DTU/Space, Denmark: Real time local geomagnetic data