



Geomagnetic forecast

Presentation by
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The magnetosphere as a black box

- Data-driven approach:

- Poor understanding
- A lot of data

- Inputs:

- geomagnetic indices
- upstream spacecraft data

- Outputs:

- forecast of the geomagnetic indices
(D_{ST} 1-4 hrs, K_p 3 hrs)





Statistics (archived Level 2 data)

Year	LT, hrs	MSE, nT		Max. error, nT		r, %		PE, %		SS, %
		F/c	Pers.	F/c	Pers.	F/c	Pers.	F/c	Pers.	
2009	1	2.4	2.6	30	28	96.2	95.4	92.7	90.8	18.4
	2	3.6	4.4	46	53	91.1	87.4	82.9	74.8	30.5
	3	4.4	5.5	40	72	86.3	79.7	74.5	59.4	35.8
	4	5.1	6.4	42	81	81.8	73.2	66.0	46.4	35.0
2010	1	2.7	3.0	30	33	97.3	96.6	94.7	93.2	23.6
	2	3.9	5.0	35	59	94.0	90.9	88.3	81.8	37.5
	3	4.9	6.3	48	78	90.5	85.3	81.6	70.6	39.2
	4	5.8	7.3	57	95	86.8	80.4	74.4	60.7	36.8
2011	1	3.9	3.9	61	62	96.8	96.5	93.8	93.0	2.5
	2	5.5	6.4	60	92	93.6	90.7	87.4	81.4	25.3
	3	6.8	8.0	81	117	89.9	85.2	80.6	70.3	27.8
	4	7.9	9.3	100	147	86.4	80.3	74.0	60.6	27.7
2012	1	3.7	4.1	47	50	98.1	97.7	96.2	95.4	17.0
	2	5.5	6.6	61	71	95.8	93.9	91.7	87.7	32.1
	3	6.7	8.4	69	91	93.5	90.1	87.3	80.3	36.8
	4	8.3	9.8	128	99	89.7	86.7	80.4	73.4	26.9
2013*	1	3.4	3.8	28	45	98.2	97.7	96.4	95.4	23.4
	2	4.8	6.3	44	77	96.2	93.9	92.4	87.7	40.6
	3	6.2	8.1	62	108	93.6	89.9	87.6	79.8	40.3
	4	7.4	9.4	77	120	91.0	86.3	82.8	72.5	37.6

* Only the first 7 months of 2013 are covered.





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unusual Sun's behaviour

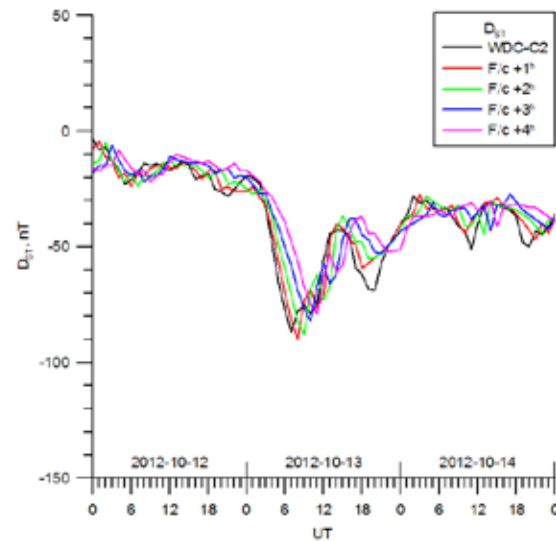
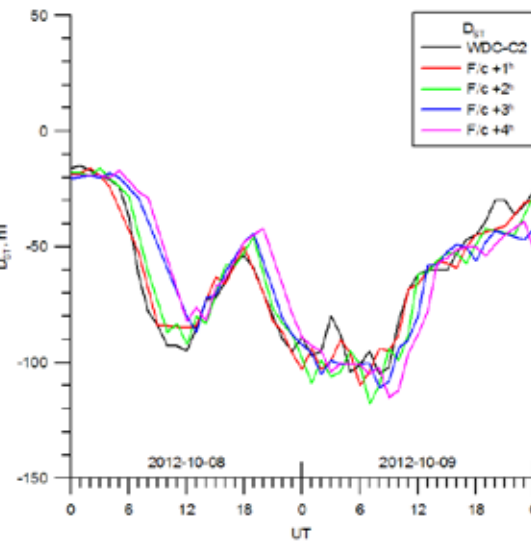
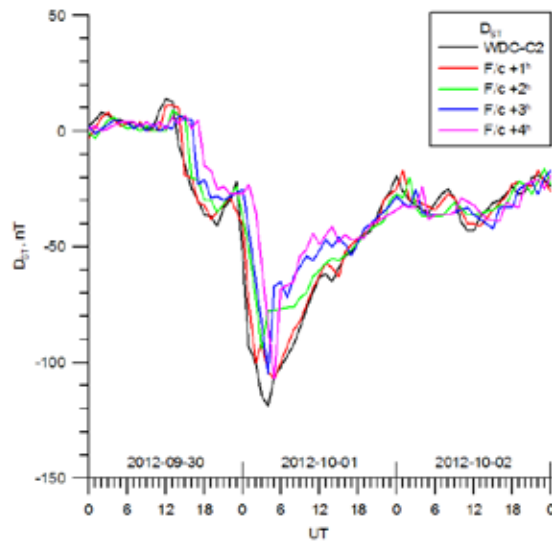




3 weak CMEs + CIR/HSS

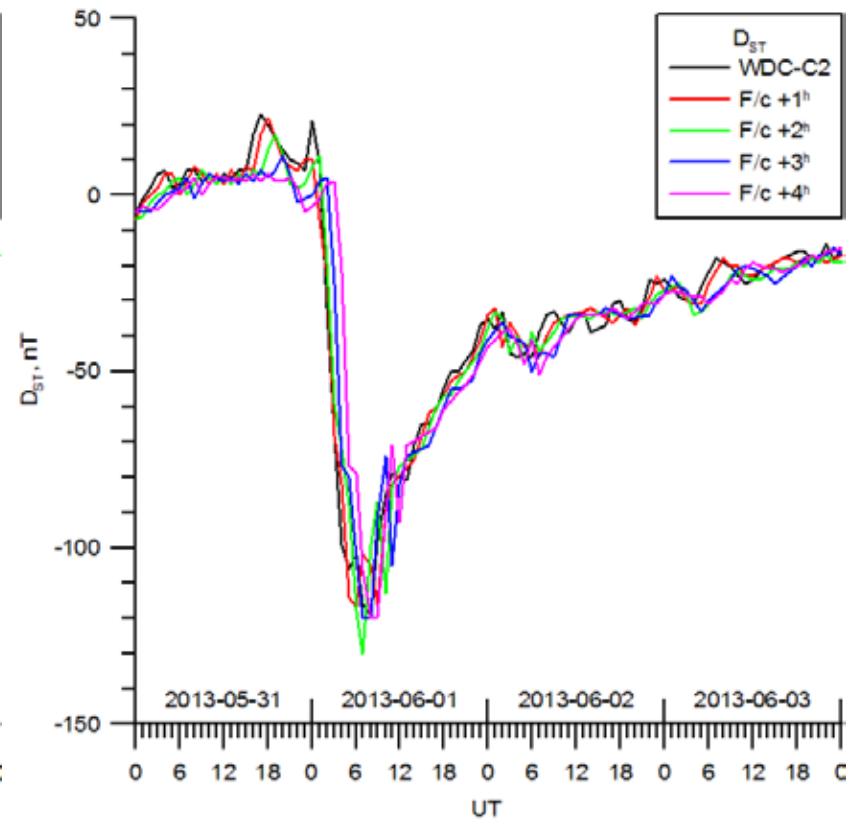
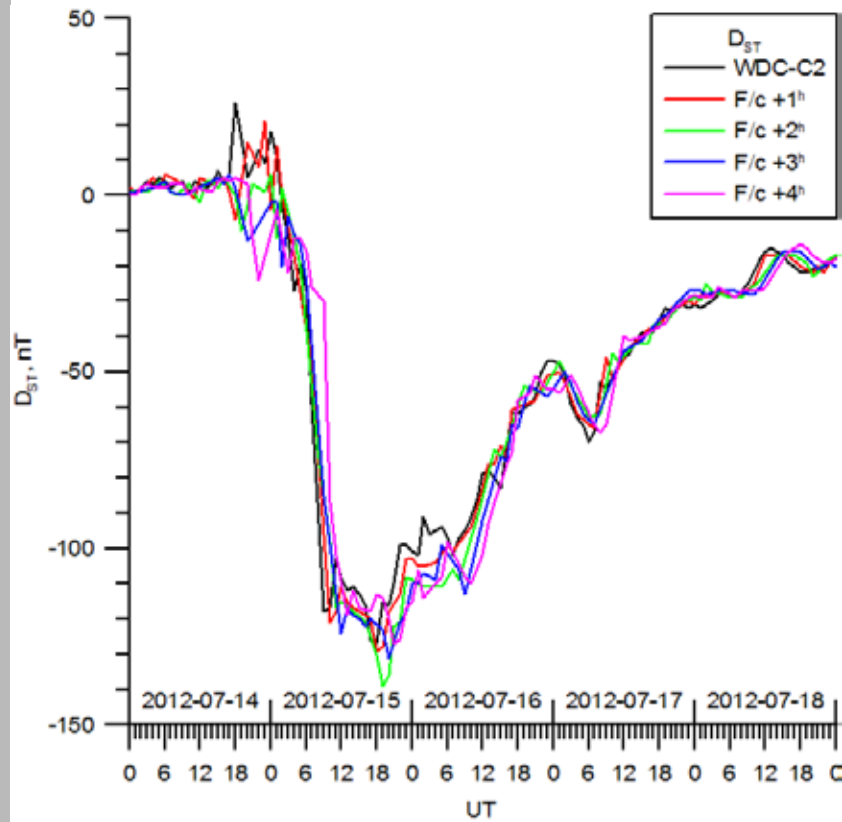
Performance stats of near-real time D_{ST} forecast, 2012-09-28T04:00:00Z to 2012-10-27T06:00:00Z

Lead time, h	1		2		3		4	
Model type	Forecast Persistence		Forecast Persistence		Forecast Persistence		Forecast Persistence	
MSE, nT	3.9	5.1	6.6	8.8	7.4	12	11	14
PE, %	97.6	96.0	93.3	88.2	91.7	79.7	82.6	70.8
r, %	93.1	98.0	89.8	94.1	86.0	89.9	84.4	85.5
Skill score, %	41.1		43.4		59.2		40.3	



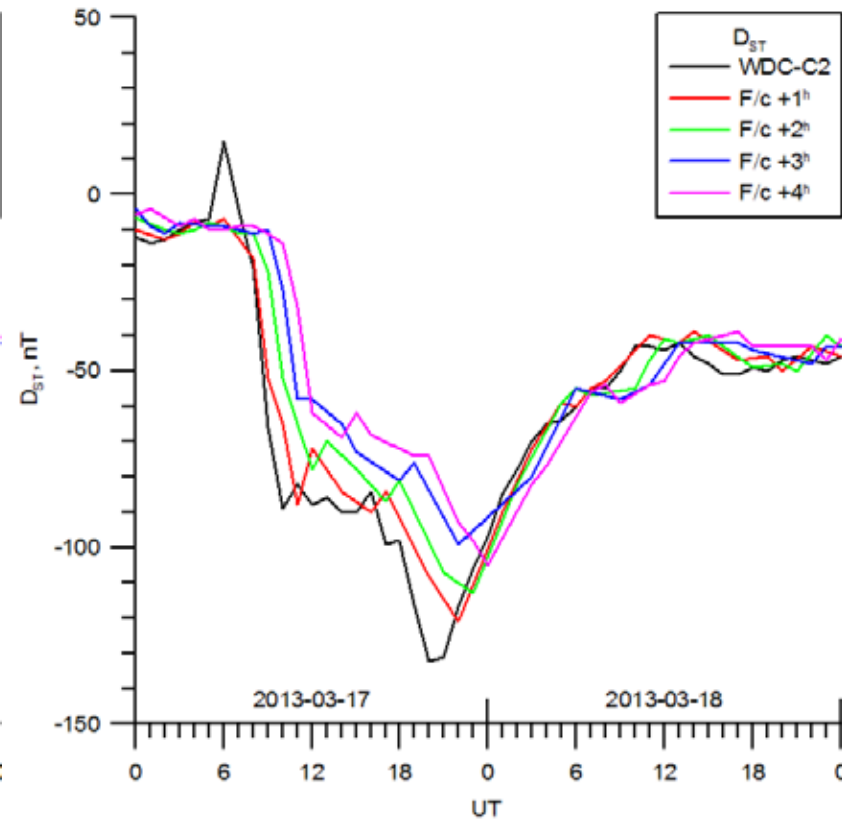
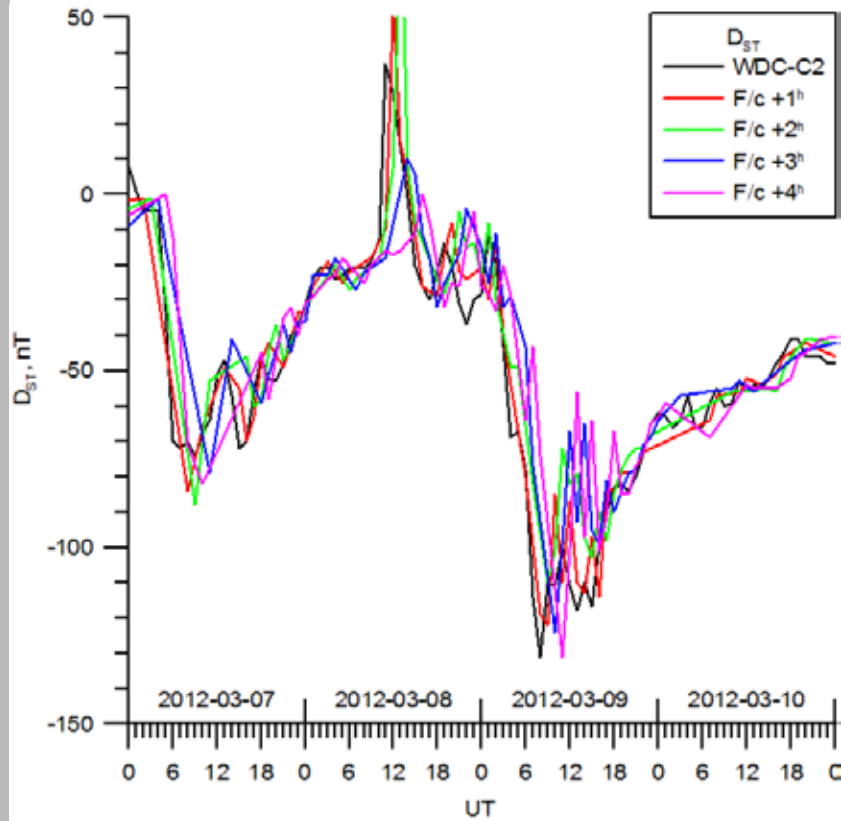


Single CMEs





Multiple CMEs





New software implementation

- Written in Python -> portability
- Missing values are filled, not skipped
- Time shifting for the Earth crossing
- NRT generation of OMNI2-like databases with 1 min and 1 hr cadence
- NRT calculation of Minkowski fractal dimensions for all L1 data (research phase)

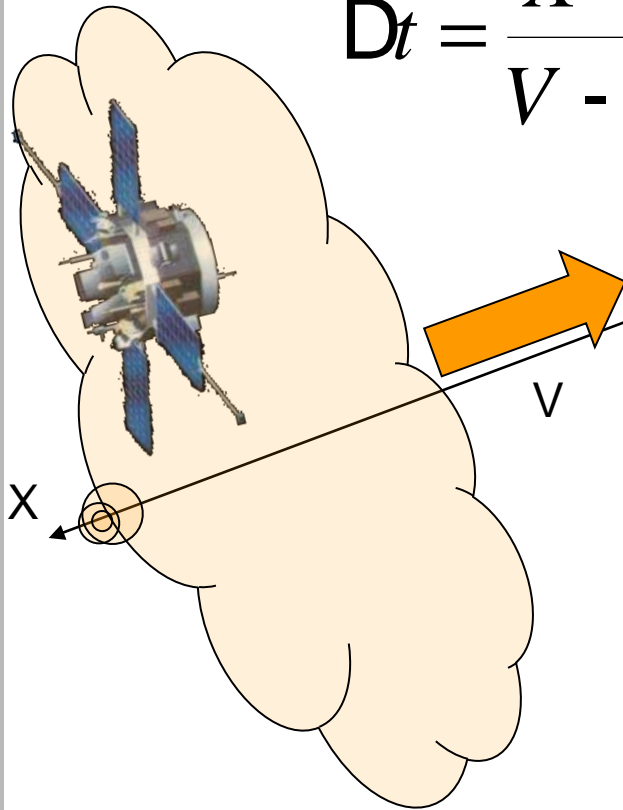




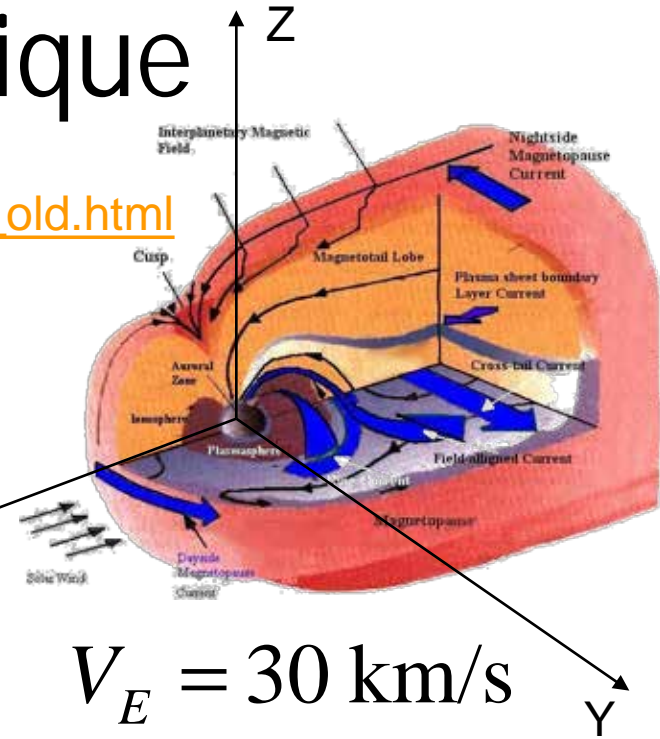
Time shifting: technique

OMNI2 (King & Papitashvili 2003 - 2013)

http://omniweb.gsfc.nasa.gov/html/omni2_doc_old.html



$$Dt = \frac{X + YW}{V - V_E W}$$



Midway between radial and Parker spiral

$$W = \tan \frac{\alpha}{2} \tan^{-1} \frac{V}{428 \text{ km/s}} \frac{\ddot{\theta}}{\dot{\theta}}$$





Time shifting: features

- Better matching of the training sample (OMNI2)
- Taking into account the actual spacecraft position – ability to use data from other upstream spacecraft, from ISEE 3 to SunJammer
- Lead time increased by the propagation time – typically about 1 hour





Product integration

- Old version integrated into SWACI (DLR):
<http://swaciwebdevelop.dlr.de/geomagnetic-indices/dst-index/>
- New version integrated into STAFF (ROB):
<http://www.staff.oma.be/>
- Final version will be also integrated into PROMIS (SRI NASU-NSAU):
<http://promis.ikd.kiev.ua/>



Questions?



Acknowledgement

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under the grant agreement n° 263506 (AFFECTS).

