Alert system for arrival and geo-effectiveness of CMEs

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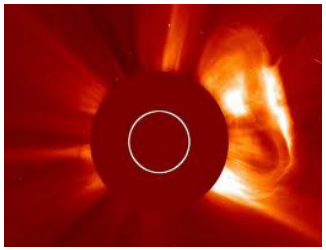
Outline

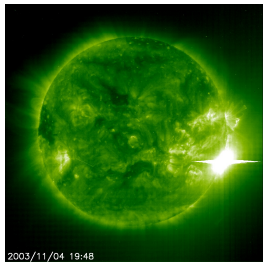
1. Structure of alert system
2. CME parameters
3. Forecast probability of arrival and geo-effectiveness
4. Remarks and next steps

Structure of CME alert system



CME

solar flare



CACTus using SOHO/LASCO

DBM using CACTus alert

CME magnetic forecast tool

Solar Demon using SDO/AIA

flaremail using GOES

Parameters

CACTus using SOHO/LASCO

CME speed

CME width

1.Structure

2.Parameters

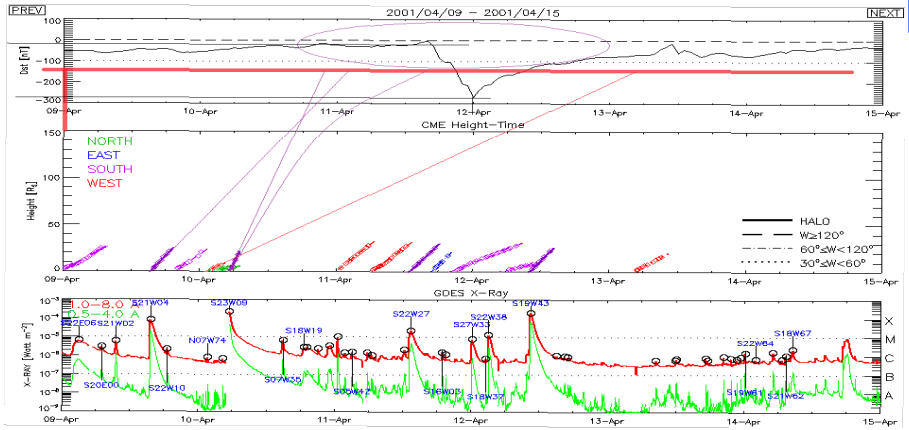
3.Forecast

4.Next steps

	t0	dt0	pa	da	v	dv	minv	maxv
027	2013/03/05 03:36	08	144	360	0946	0208	0419	1453

height-time plot

CME-CME interaction



Parameters

flaremail using GOES

flare class

```
:Product: documentation at http://www.sidc.be/products/flaremail
#-----------------------------------------------------------------------#
# Large flare alerts from the SIDC (RWC-Belgium), detected in GOES      #
# X-ray data                                                            #
#-----------------------------------------------------------------------#
A class M5.9 solar X-ray flare occurred on 2013/06/07 with peak time 22:49 UT
```

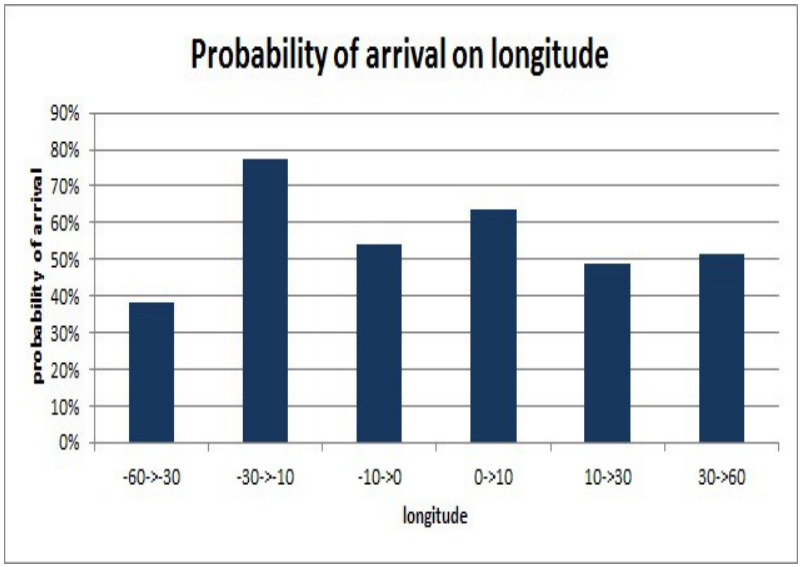
Solar Demon using SDO/AIA

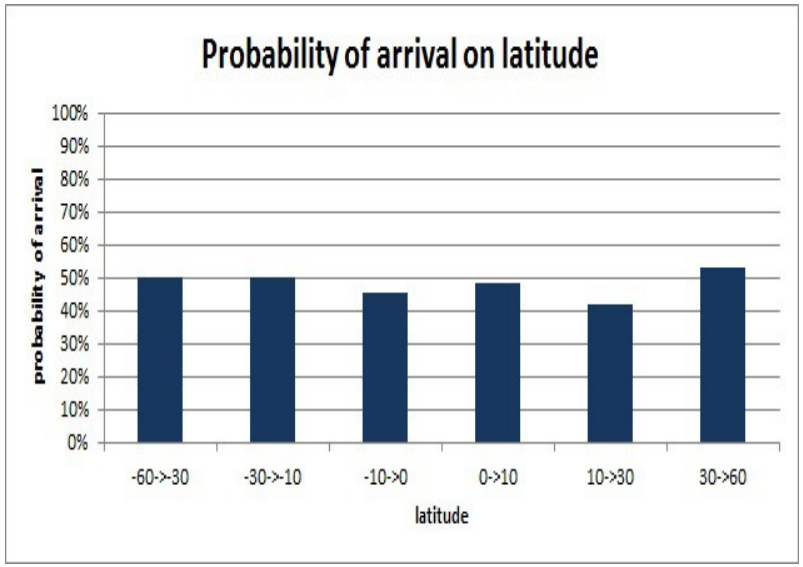
source position flare

	start	peak	class	cor	end	#	images	R	max brightness	Num pixels	sat. pixels	est. flux	FlareAlert flux	Peak Delay	COMESEP
June, 2013															
14	00:06	00:24	C1		01:15	259	24	0.98	37.6	124	0	12.5	12.3	-6	0
8	23:00	23:06	C2		23:18	250	7	1.02	73.5	212	0	24.5	23.4	5	0
8	19:09	19:18	C2		19:54	249	16	1.03	58.3	133	0	19.4	18.0	6	0
8	05:21	05:21	B6		05:24	248	2	1.01	19.5	49	0	6.5	7.3	3	0
7	22:39	22:54	M2	M6	01:09	247	51	1.03	639.2	734	42	563.1	597.0	5	98313

Forecast CME arrival

1. Relate in situ data[1,2] to full halo CMEs[3] (SOHO period)
2. Identify arrival (yes/no) for 295 cases
3. Statistics on source region





[1]http://omniweb.gsfc.nasa.gov/form/sc_merge_min1.html
[2]http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm
[3]http://cdaw.gsfc.nasa.gov/CME_list

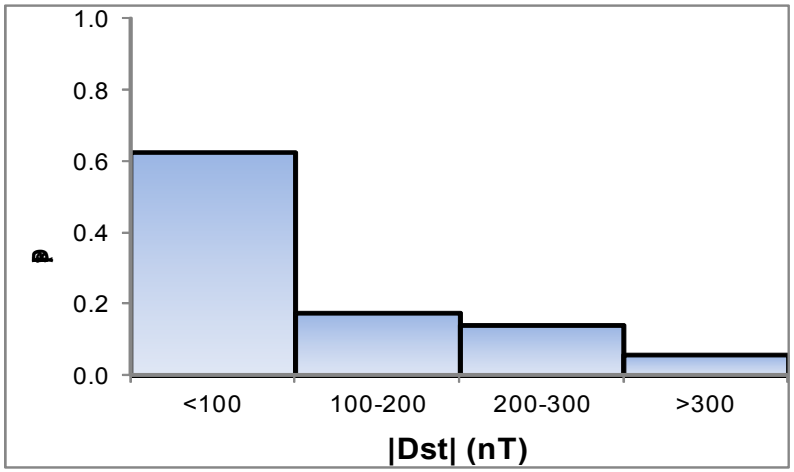
Forecast CME geo-effectiveness

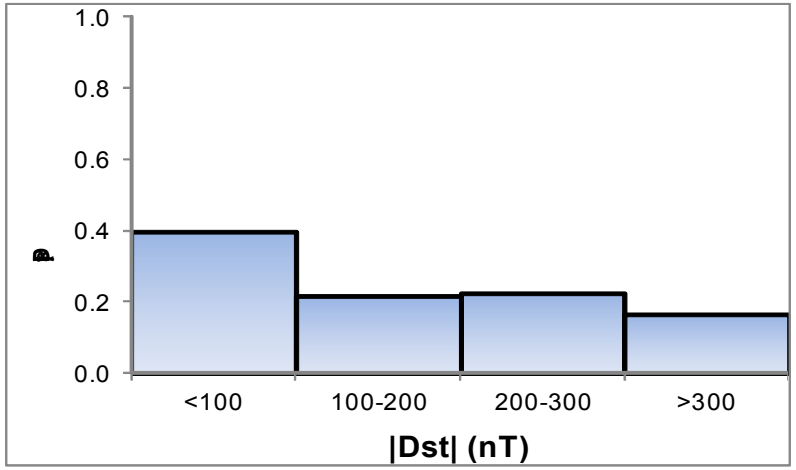
1. Relate in situ data[1] (Dst) to CMEs[2] (SOHO period)
2. 211 front-sided, flare associated CMEs, v ≥400 km/s
3. Statistics on CME speed, width, CME-CME interaction, flare source region, flare class
4. Each parameter was put in bins
5. Bins for|Dst|: <100nT; 100-200 nT; 200-300 nT; 300 – 400 nT

[1]http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm
[2]http://cdaw.gsfc.nasa.gov/CME_list

Forecast CME geo-effectiveness

Probability distributions for 2 situations





v=400 km/s

R=0.99 R_{SUN}

non-halo CME

B or C type flare

no CME-CME interaction

v=2500 km/s

R=0.01 R_{SUN}

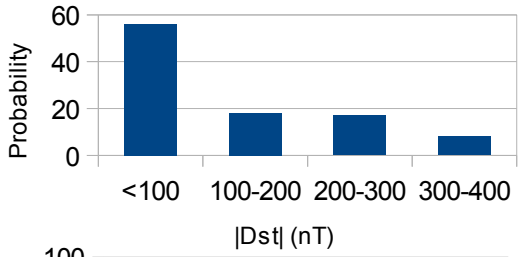
full halo CME

X type flare

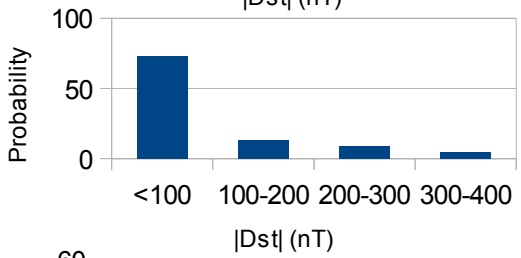
CME-CME interaction

Forecast CME geo-effectiveness

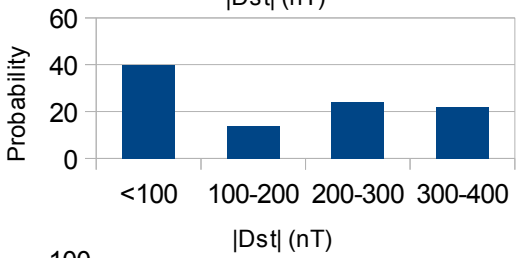
CME speed



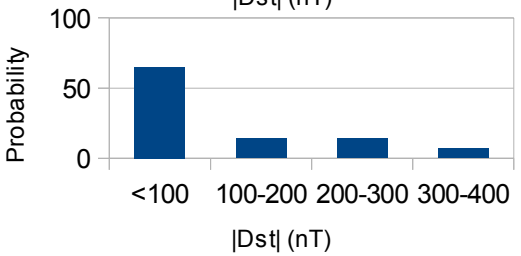
CME width



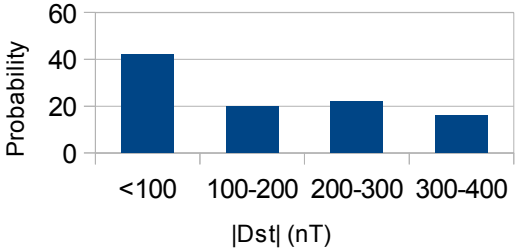
source position flare



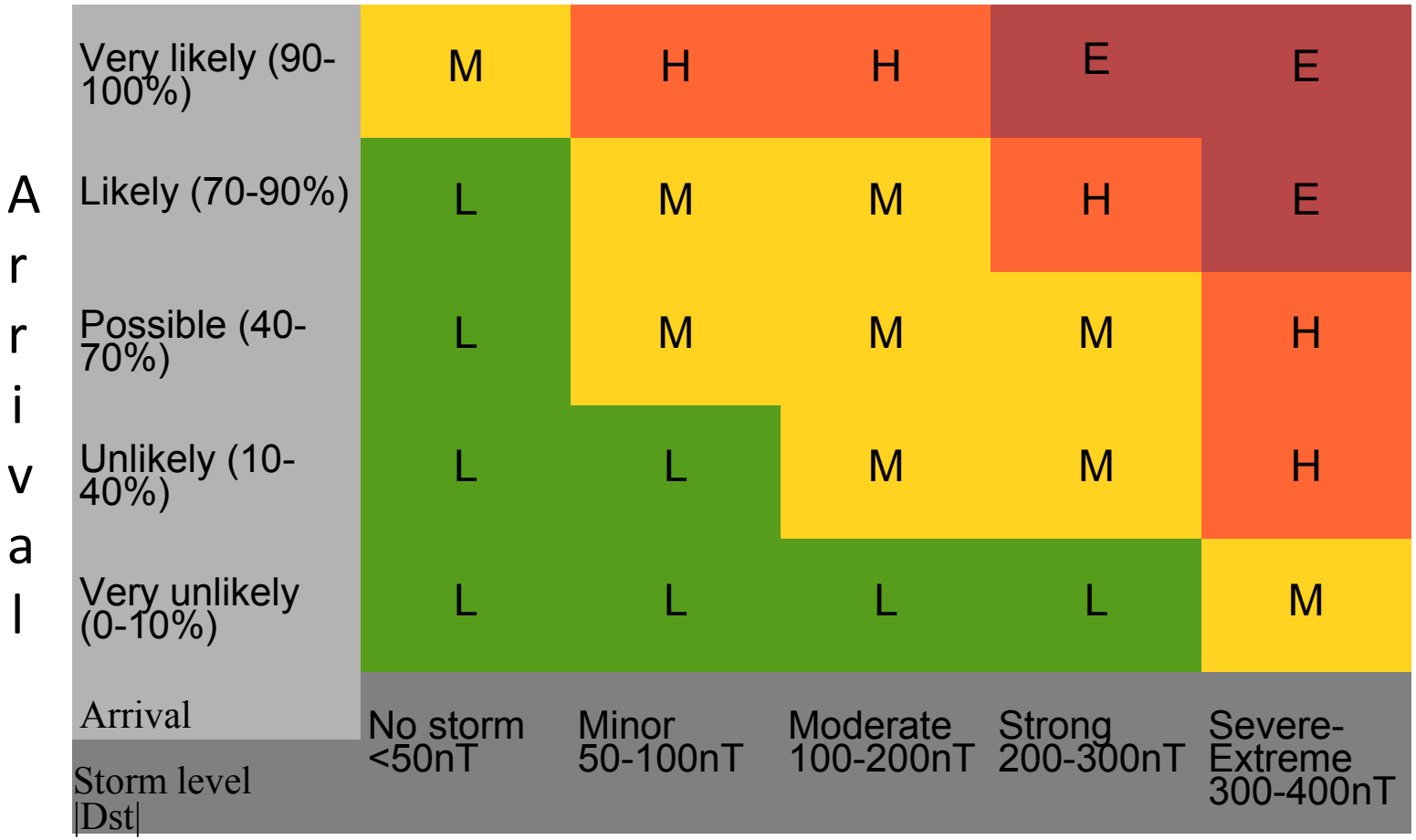
flare class



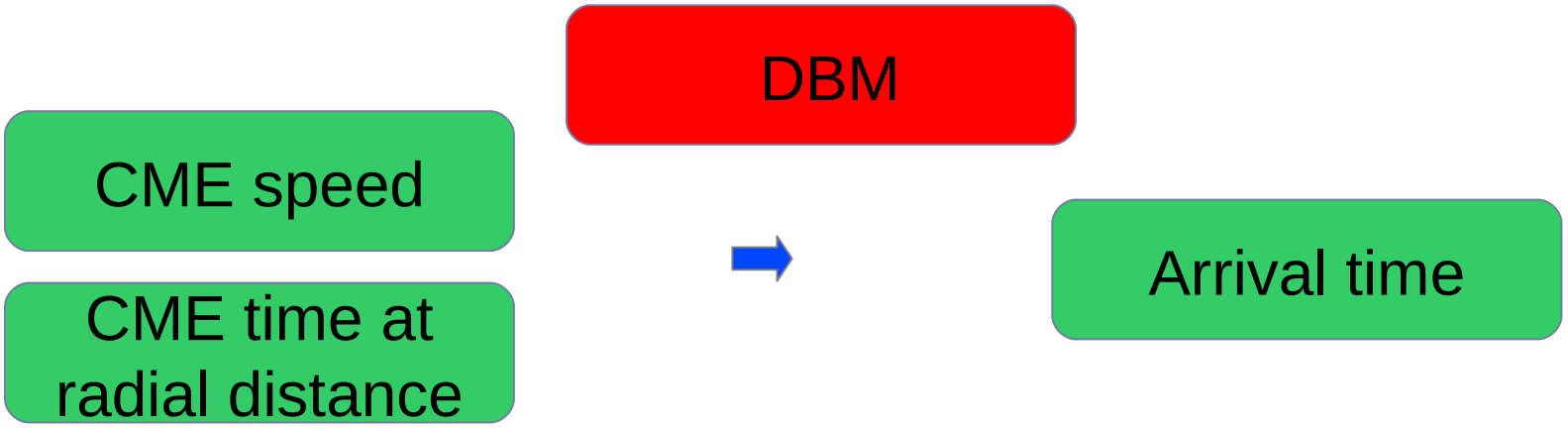
4 parameters



Forecast output



Forecast time of arrival



Assumptions:

- Radial distance: 20 R_{Sun}
- Asymptotic solar wind speed: 450 km/s
- Drag parameter: 0.2

http://oh.geof.unizg.hr/DBM/dbm.php

Remarks and next steps

1. Validation on historical and real-time events
2. Incorporate into current forecast process
3. Assumption of 'simple situation': now only one flare-associated CME at a time can be tackled
4. Geo-effectiveness for non flare-associated CMEs
5. Probability of arrival for non-halo CMEs
6. Use geometry of CME to improve estimation of CME arrival
7. Determination of front-sided CMEs
8. Add estimation CME-CME interaction taken into account in real-time
9. Use advanced DBM (geometry)

Thanks for your attention!

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