A Critical View on the Space Weather Forecasts at the Regional Warning Center in Belgium

A. Devos, C. Verbeeck, E. Robbrecht

Royal Observatory of Belgium

What do we forecast?

- since 2000: role of Regional Warning Center
- 8 forecasters with weekly duty
- daily forecast
- bulletins and fast alerts
- free subscription: www.sidc.be/registration

What do we forecast?

- probability of solar flares
- K-index
- 10.7 cm flux
- proton events

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:Issued: 2013 Sep 30 1259 UTC
:Product: documentation at http://www.sidc.be/products/meu
#-----------------------------------------------------------------#
# DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC   #
# (RWC Belgium)                                                   #
#-----------------------------------------------------------------#
SIDC URSIGRAM 30930
SIDC SOLAR BULLETIN 30 Sep 2013, 1209UT
SIDC FORECAST (valid from 1230UT, 30 Sep 2013 until 02 Oct 2013)
SOLAR FLARES   : Quiet conditions (<50% probability of C-class flares)
GEOMAGNETISM   : Quiet (A<20 and K<4)
SOLAR PROTONS  : Proton event in progress (>10 MeV)
PREDICTIONS FOR 30 Sep 2013  10CM FLUX: 103 / AP: 007
PREDICTIONS FOR 01 Oct 2013  10CM FLUX: 097 / AP: 007
PREDICTIONS FOR 02 Oct 2013  10CM FLUX: 097 / AP: 007
COMMENT: A yet unnumbered, flux emerging region in the South-Eastern solar
quadrant
might develop flaring potential in the coming days.    A large filament in
the solar north-western hemisphere erupted Sunday evening around 21:45UT.
The event was associated with a long duration C1.2 flare peaking at 23:39.
The GOES proton flux level has crossed the  event threshold (> 10 pfu for
10 MeV). LASCO observed a full-halo CME. In STEREO-B Cor2, the plane-of the
sky speed is of the order of 600km/s.   In the coming 3 days, we expect
quiet geomagnetic conditions. The halo-CME of midnight Sept 29/30 is
expected to arrive midnight October 2/3.
TODAY'S ESTIMATED ISN   : 037, BASED ON 17 STATIONS.

SOLAR INDICES FOR 29 Sep 2013
WOLF NUMBER CATANIA     : ///
10CM SOLAR FLUX         : 103
AK CHAMBON LA FORET     : 007
AK WINGST               : 003
ESTIMATED AP            : 003
ESTIMATED ISN           : 032, BASED ON 26 STATIONS.
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Verification analysis: what?

Quantitative evaluation:

- *Bias*: over/underestimation?
- *Accuracy*: how large are our errors?
- *Hit rate*: how well do we predict events?
- *Sharpness*: ability to predict extreme events?
- *Skill*: how accurate with respect to reference?
- ...

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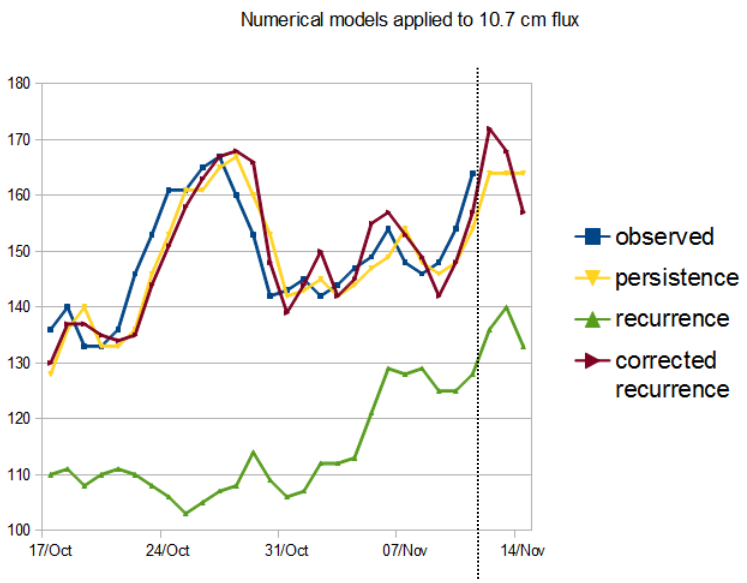
Benefits:

- *strong and weak points*
- *compare*
- *monitor*

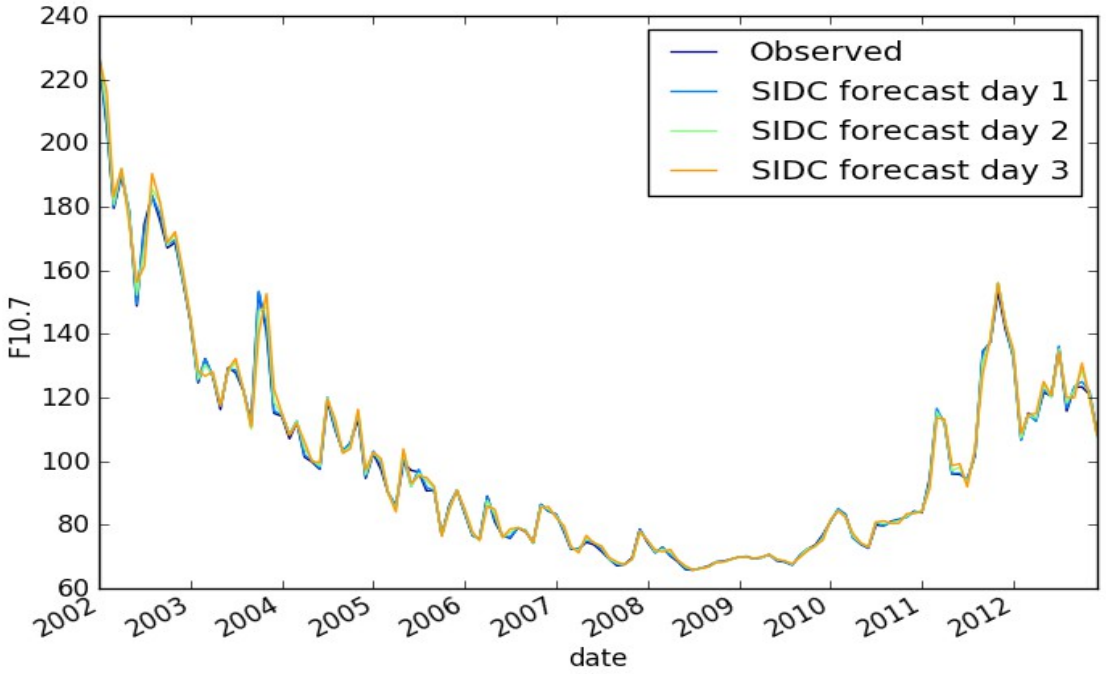
Numerical models



- *persistence*: same value as yesterday
- *recurrence*, with a time shift of 14 days and 27 days: value of one (or half) rotation ago reoccurs
- *corrected recurrence*, with a time shift of 14 days and 27 days: daily increment of one (or half) rotation ago reoccurs
- *linear fit* on observations of past 4 days

Solar flux

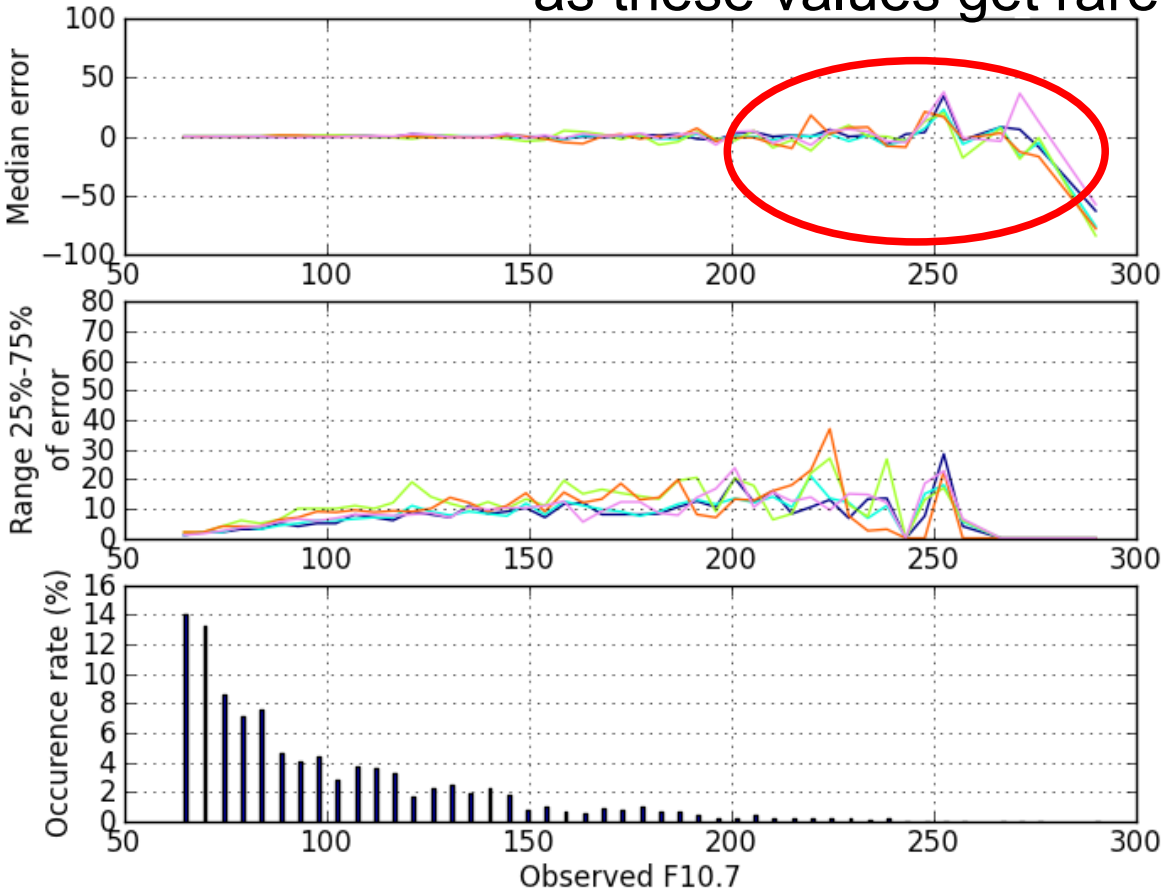
- solar radio flux at 10.7cm, measured in Penticton
- separate forecast for days 1, 2 and 3



Solar flux – error analysis

day 1

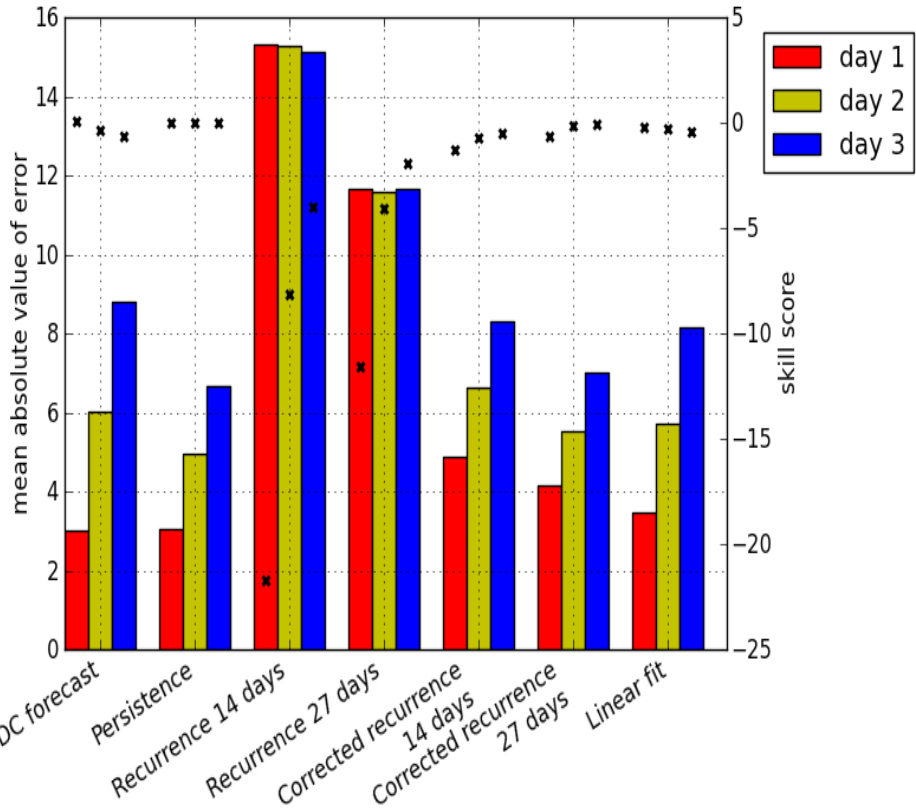
errors get larger if F10.7≥200 sfu,
as these values get rare



SIDC and persistence forecast: lowest range of errors

Solar flux – error analysis

'size of the errors'

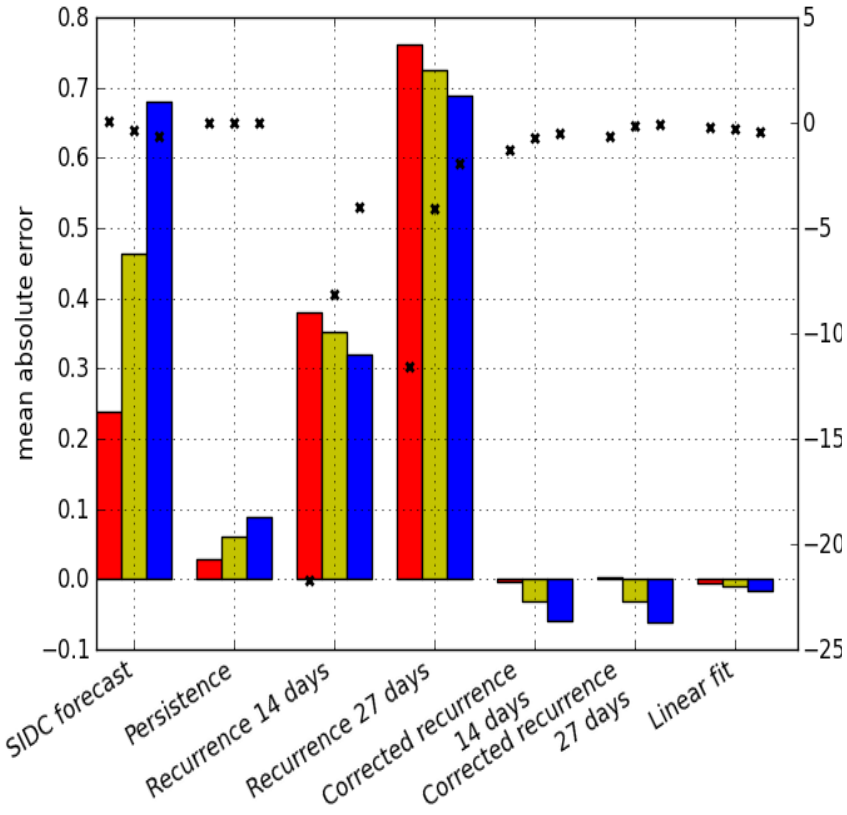


skill score (x): $1 - \frac{mse}{mse_{ref}}$

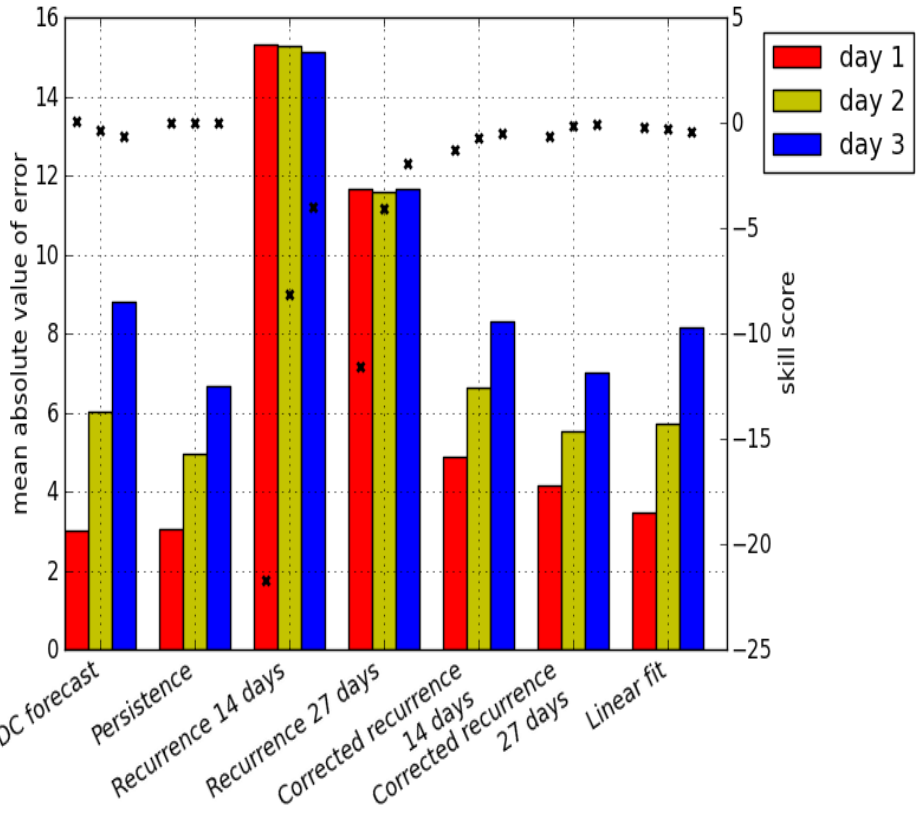
1: optimal, 0: as good as reference model

Solar flux – error analysis

‘bias of the errors’



‘size of the errors’



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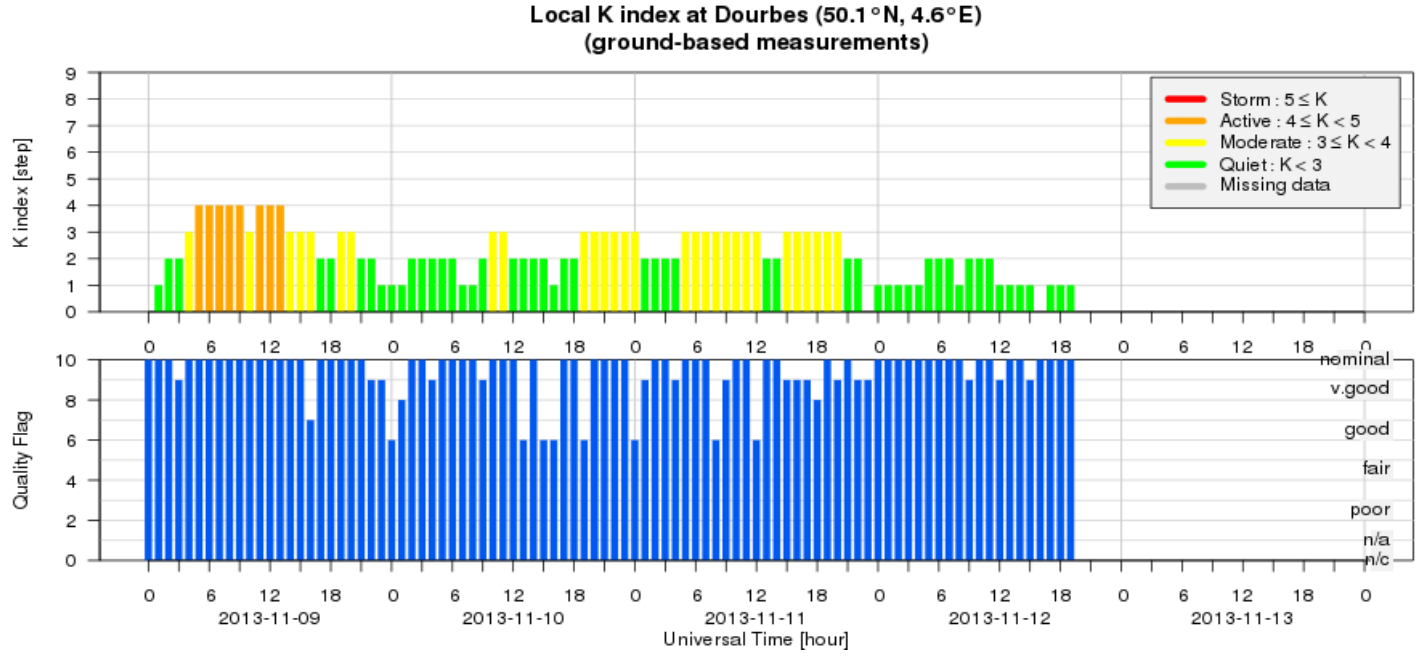
Geomagnetic K-index

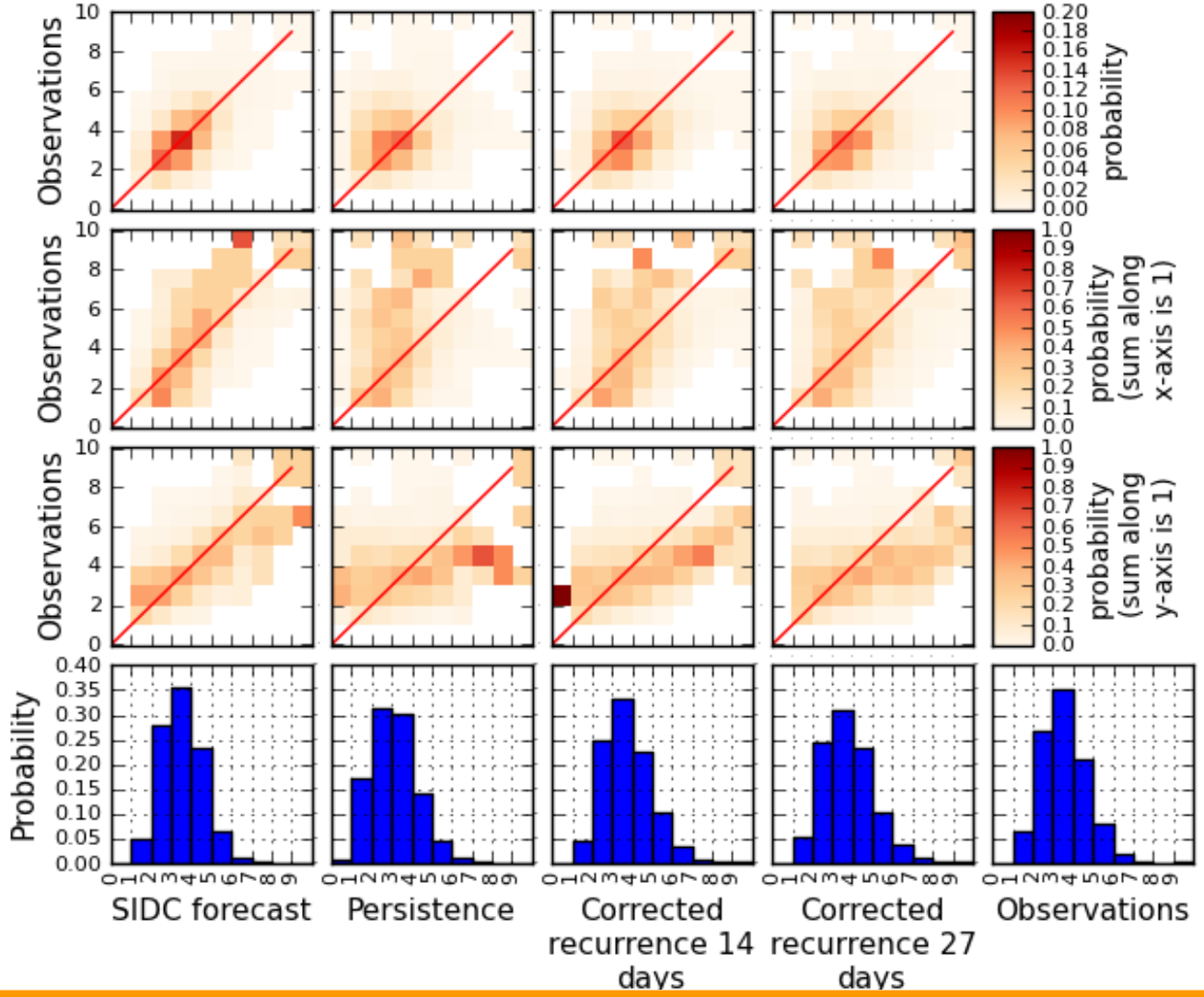
full scale (0-9)

- disturbances in the Earth's magnetic field
- range 0-9; 0-2: quiet, 3: unsettled, 4: active, 5 or more: geomagnetic storm
- forecast over next 48 hours
- local K-index at Dourbes



Geomagnetic K-index

full scale (0-9)



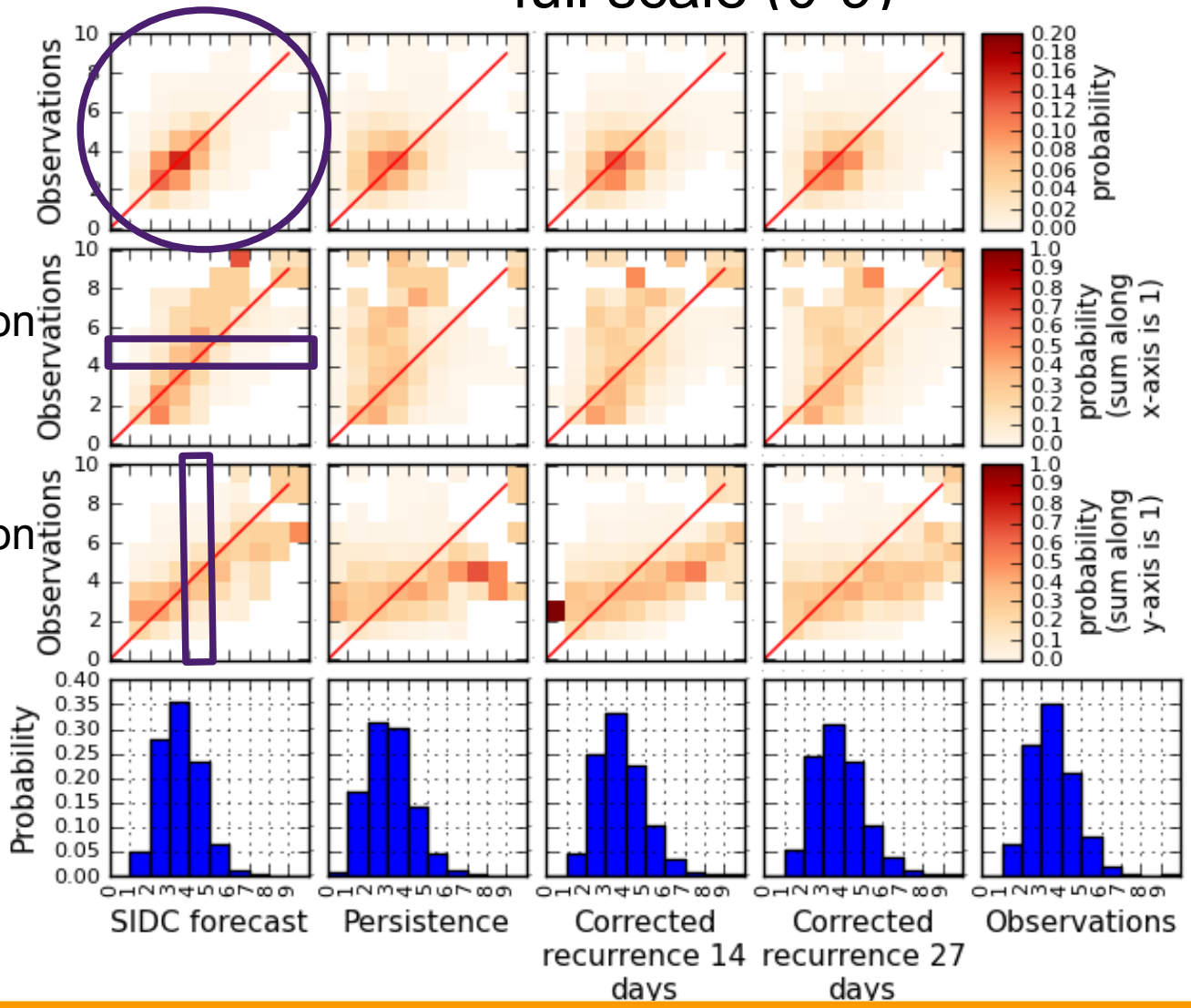
Geomagnetic K-index

full scale (0-9)

sum across grid= 1

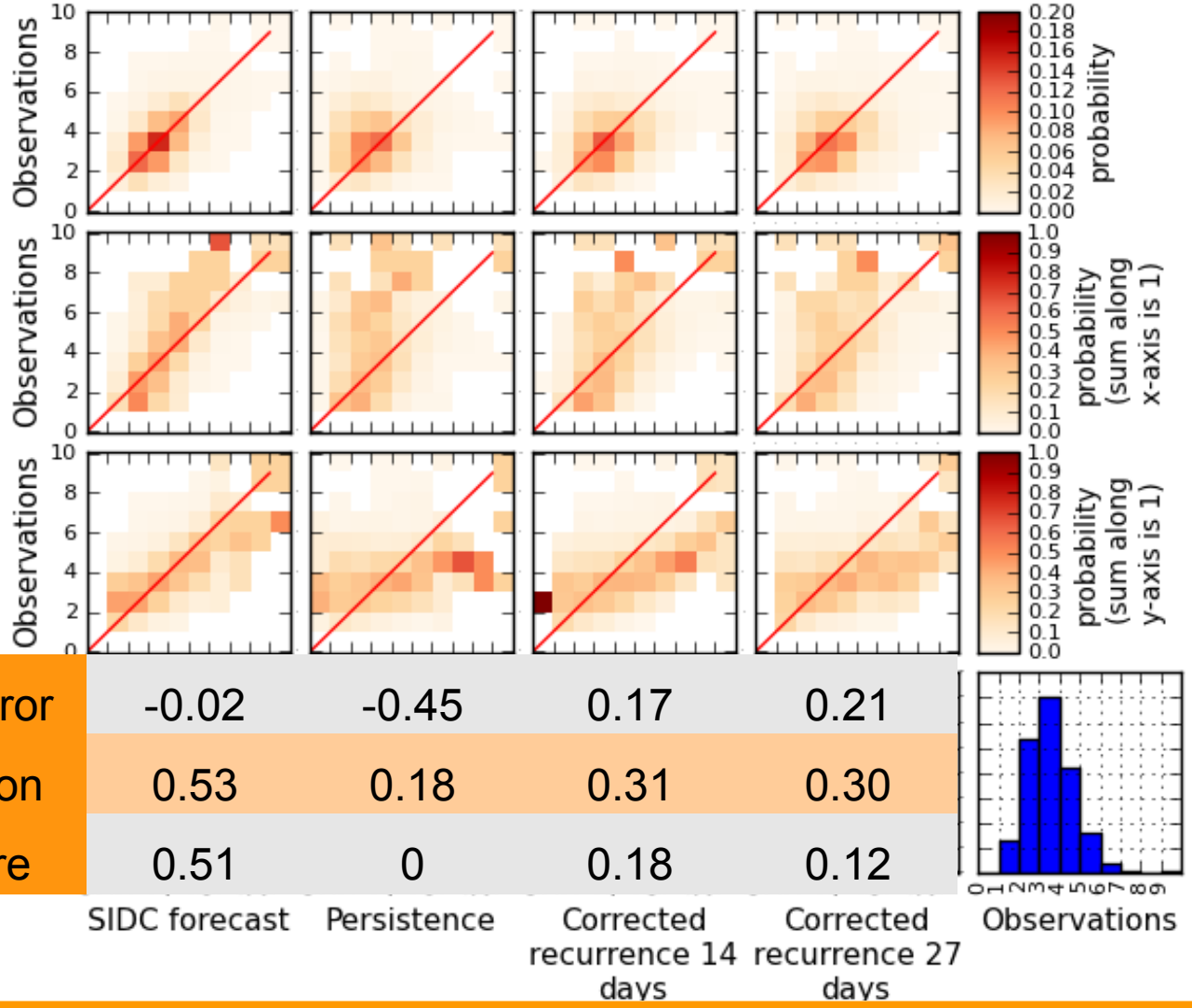
conditional on observation

conditional on forecast



Geomagnetic K-index

full scale (0-9)



	SIDC forecast	Persistence	Corrected recurrence 14 days	Corrected recurrence 27 days
mean error	-0.02	-0.45	0.17	0.21
correlation	0.53	0.18	0.31	0.30
skill score	0.51	0	0.18	0.12

Forecast of a geomagnetic storm (K≥5)

- Contingency table:

		Observation	
		Yes (K≥5)	No (K<5)
Forecast	Yes (K≥5)	a= #hits	b= #false alarms
	No (K<5)	c= #misses	d= #correct rejections

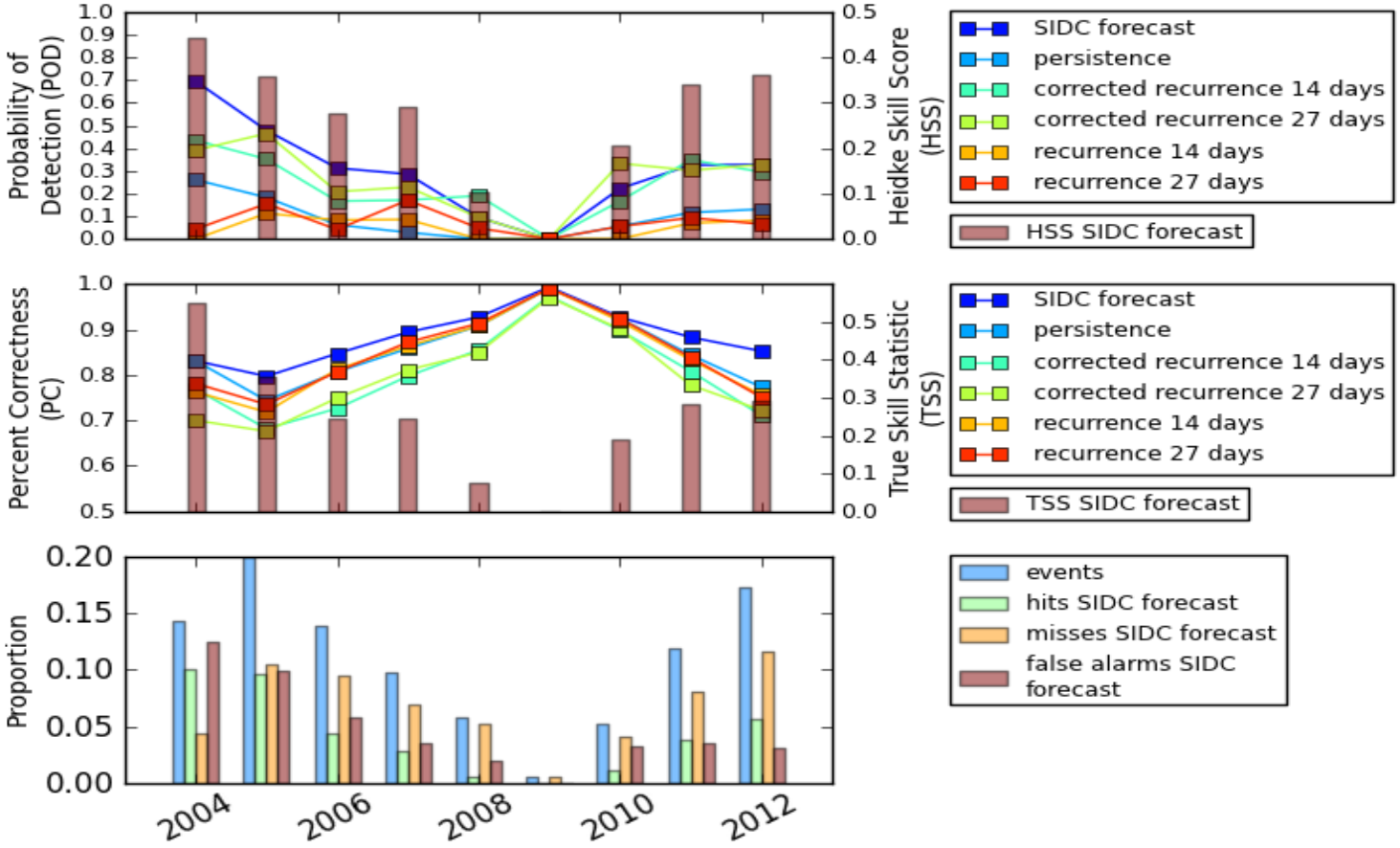
- Probability of detection (POD)= $a/(a+c)$
- Percentage correctness (PC)= $(a+d)/(a+b+c+d)$
- Heidke Skill Score (HSS)= $(PC-E)/(1-E)$

  with E = proportion of correct random forecasts
- True Skill Statistic (TSS)= $\frac{(ad-bc)}{(a+c)(b+d)}$

range POD, PC:$[0,1]$
range HSS, TSS: $[-1,1]$

Forecast of a geomagnetic storm (K≥5)

- SIDC forecast overall best
- rare events: hard to predict (high PC, but low POD)



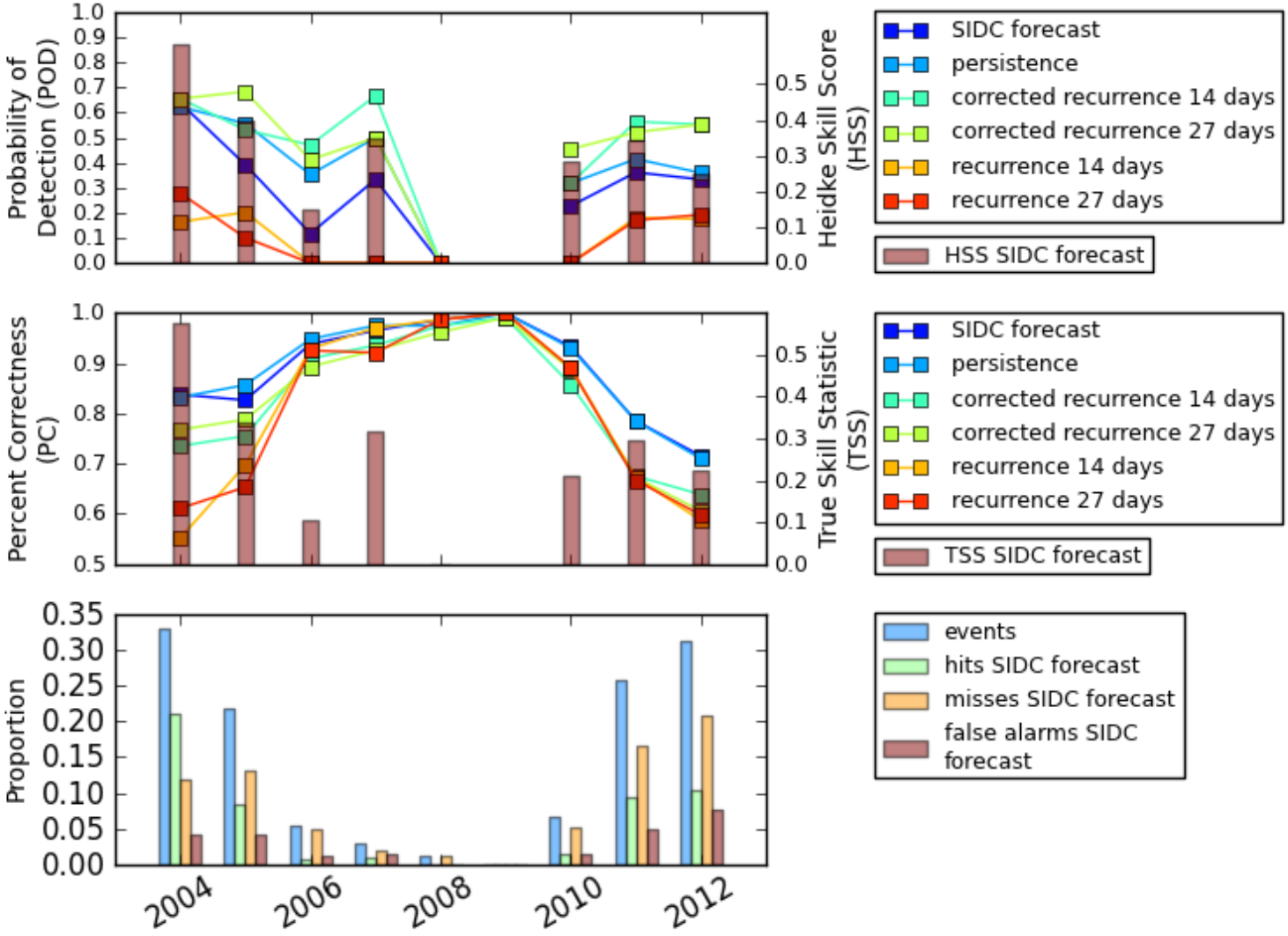
Forecast of solar flares

- flare classes: B, C, M, X measured in X-ray by GOES

level	flare class	wording in bulletin
<50% probability of C-class flares	B or lower	quiet conditions
C-class flares expected, probability>=50%	C	eruptive conditions
M-class flares expected, probability>=50%	M	active conditions
X-class flares expected, probability>=50%	X	major flares

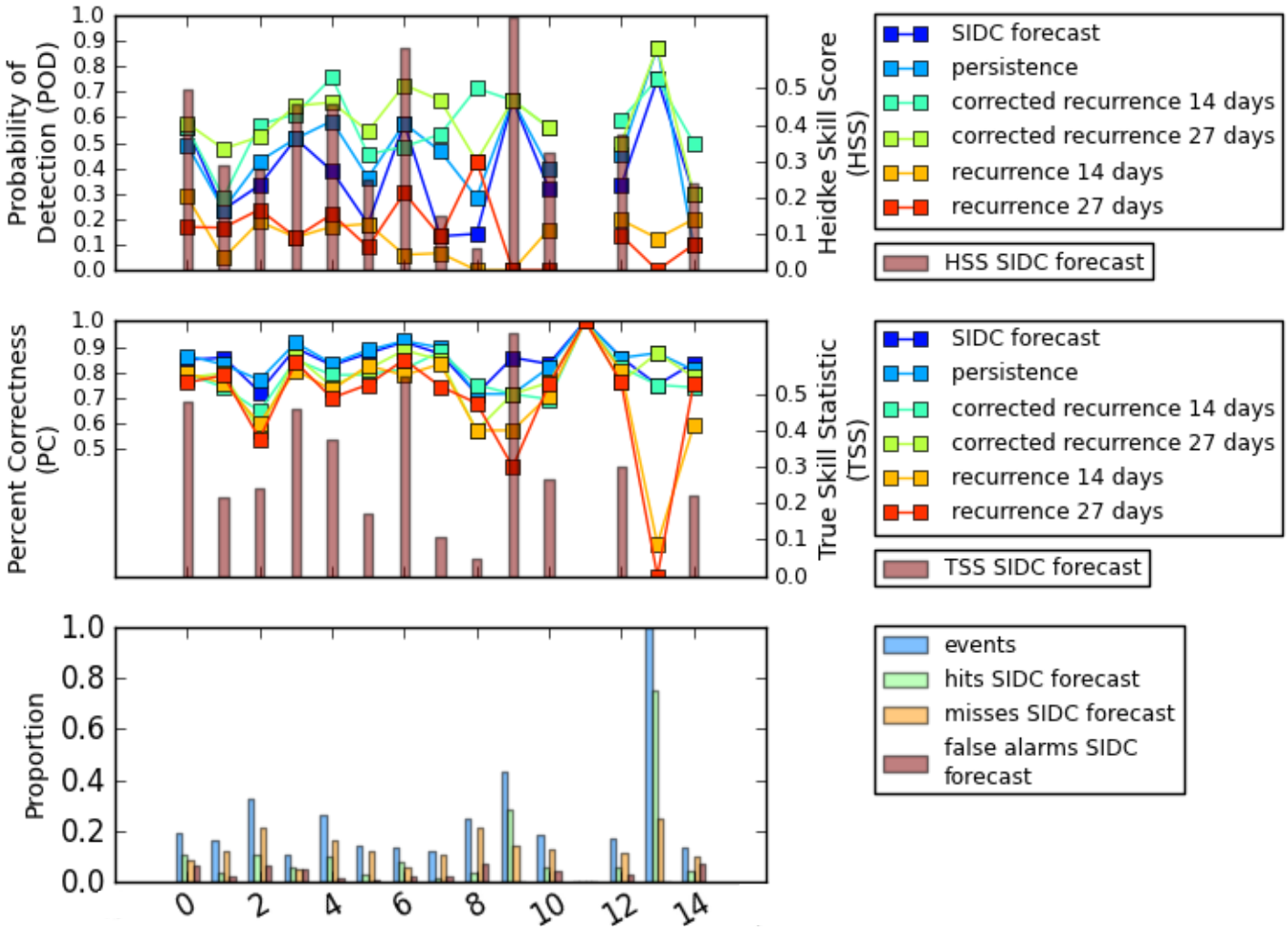
Forecast of solar flares

M/X flares



Effect of the forecaster

M/X flares



forecaster (on x-axis)	#days on duty
0	303
1	259
2	65
3	284
4	156
5	229
6	245
7	125
8	28
9	7
10	137
11	6
12	383
13	8
14	73

Summary

	Solar flux	Geomagnetic index	Solar flares
Accuracy SIDC	day 1: overall best days 2 & 3: worse	best skill score and correlation	high performance, but strong flares often missed
Bias SIDC	more frequently overestimated	frequently underestimated	frequently underestimated
Other models	days 2 & 3: persistence and corrected recurrence 27 days better	corrected recurrence 27 days:best numerical model, but often overestimating	persistence and corrected recurrence 27 days better
Opportunity?	days 2 & 3: error can be reduced by 1 to 2 sfu by using persistence	need to investigate cases with (minor) storms	by using corrected recurrence: 20% more M/X flares forecasted

Next steps

- implement insights from this analysis: e.g. (conditional) error bars
- continuously reevaluate SW forecasting
- better understand situations with correct versus erroneous forecast
- evaluate flare probabilities
- comparison to forecast of other RWCs
- comparison to more sophisticated numerical models
- extend analysis on influence of the forecaster
- …

Website: http://www.sidc.be/forecastverification

Thank you for the attention!

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