

O2R Workshop: Forecaster Perspective

Outline

- Introduction
- What forecasters have to do every day
- A challenging example
- Sources for forecasting errors
- Improving forecasts
 - What doesn't work
 - What does work
- Summary

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Bottom Line

- **Being required to produce actionable space weather forecasts and products on a daily basis, one quickly realizes there are critical gaps in observations and knowledge required to do this**
- **These gaps are golden opportunities for research to discover something new that has a practical application**
- **O2R is the process of using practical operational experience to help focus and prioritize research that will have the greatest positive impact**

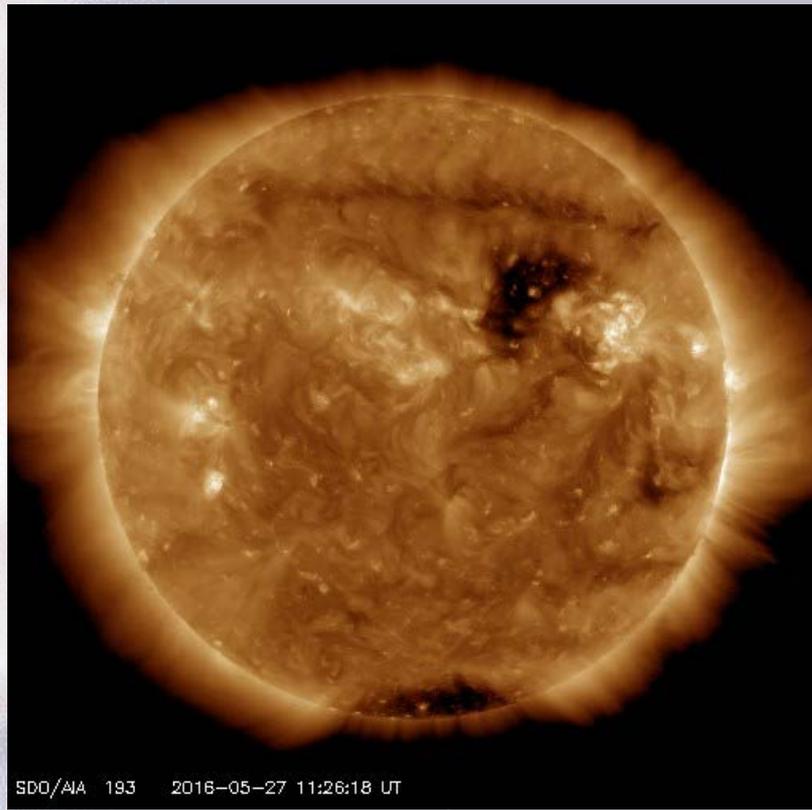
Space Wx Forecasts

- **Daily – forecasts for day 1, 2, & 3 ahead**
 - C, M, X flare probability
 - Proton Event probability
 - Global geomagnetic activity level (Kp/Ap)
 - F10.7 cm radio flux
- **Event-based decisions**
 - In response to a major solar event:
Quickly decide whether to issue a proton warning
 - In response to observations at L1 (ACE/DSCOVR)
Decide whether to issue a geomagnetic storm warning

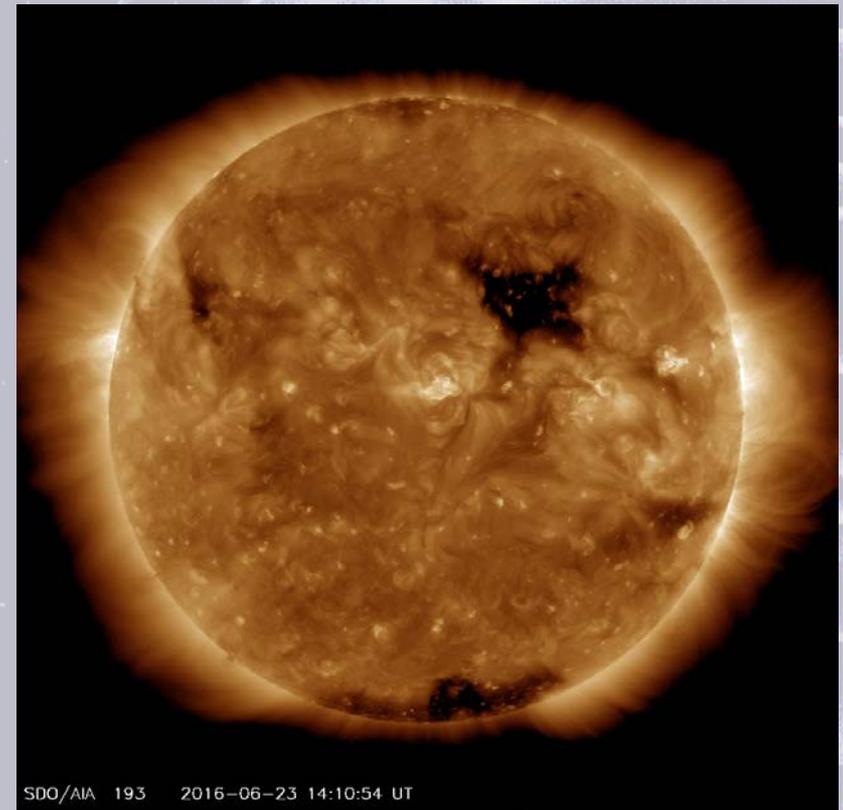
Problem Case Study

Forecast for Geomagnetic Response to coronal hole

Recurrence



Current



Forecast on 21 June 2016

Forecast Worksheet

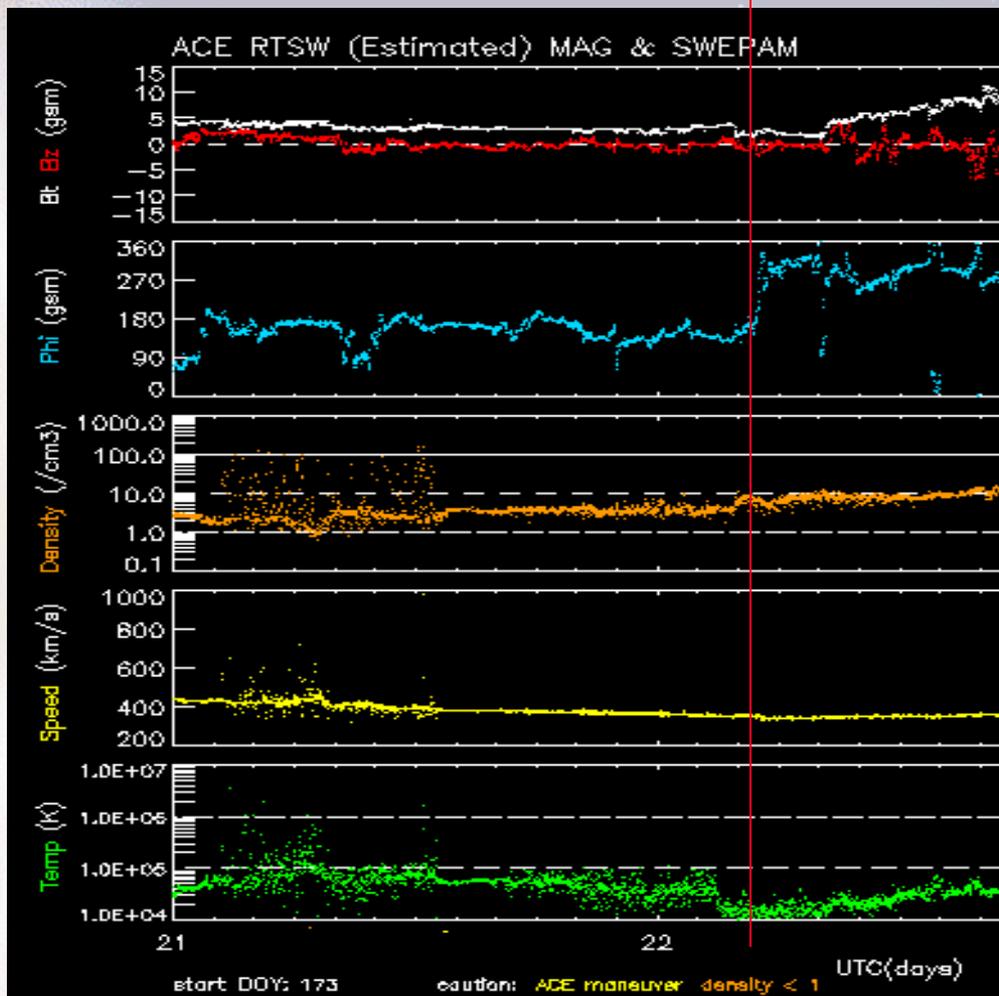
Date: 21 Jun 2016 D Shift: [Signature] S Shift: [Signature] AFWA: Sodofski SRAG: Jancz

Observed / Forecast														Recurrence									
Geomag Indices (NOAA & USAF)					Geomag Probabilities (Planetary)					Penticton 10.7cm (Flux)				Event Probabilities (Whole disk)				Geomag Indices (NOAA & USAF)			10.7cm (Flux)		
Date	CH / CME	NOAA Ap	NOAA Kp	USAF Ap	Quiet (K<=2)	Unsettled (K<=3)	Active (K<=4)	mS (K<=5)	MS (K<=6)	SS (K<=7-9)	Penticton Data			Class C	Class M	Class X	Protons	Date	CH / CME	NOAA Ap	NOAA Kp	USAF Ap	Penticton
Ystdy	<u>20</u> DD (-1)	<u>4</u>	<u>1</u>	<u>4</u>							<u>84</u> Ystdy							<u>24</u> DD (-28)		<u>6</u>	<u>3m</u>	<u>6</u>	<u>94</u>
Today	<u>21</u> DD	<u>5</u>	<u>2</u>	<u>5</u>							<u>82</u> AM	<u>80</u> Noon	<u>91</u> PM	<u>25</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>25</u> DD (-27)		<u>3</u>	<u>2m</u>	<u>3</u>	<u>94</u>
Day 1	<u>22</u> DD (+1)	<u>5</u>	<u>2</u>	<u>5</u>		<u>20</u>	<u>10</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>80</u> Rigns Ret		<u>53</u> Rigns Exit	<u>75</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>26</u> Day 1		<u>4</u>	<u>4</u>	<u>3</u>	<u>92</u>
Day 2	<u>23</u> DD (+2)	<u>10</u>	<u>3</u>	<u>10</u>		<u>40</u>	<u>25</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>75</u>		<u>58</u>	<u>10</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>27</u> Day 2	<u>CH</u>	<u>10</u>	<u>3E</u>	<u>12</u>	<u>90</u>
Day 3	<u>24</u> DD (+3)	<u>15</u>	<u>4</u>	<u>15</u>		<u>25</u>	<u>30</u>	<u>15</u>	<u>5</u>	<u>1</u>	<u>75</u>			<u>10</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<u>28</u> Day 3	<u>-CH</u>	<u>14</u>	<u>4p</u>	<u>16</u>	<u>88</u>
Day 4	<u>25</u> DD (+4)	<u>8</u>	<u>3</u>	<u>8</u>		<u>40</u>	<u>20</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>70</u>	<u>52</u>	<u>57</u>					<u>29</u> Day 4		<u>7</u>	<u>3E</u>	<u>8</u>	<u>83</u>
Day 5	<u>26</u> DD (+5)	<u>12</u>	<u>4</u>	<u>12</u>		<u>40</u>	<u>30</u>	<u>10</u>	<u>5</u>	<u>1</u>	<u>70</u>							<u>30</u> Day 5	<u>-CH</u>	<u>11</u>	<u>4E</u>	<u>12</u>	<u>86</u>
Day 6	<u>27</u> DD (+6)	<u>10</u>	<u>3</u>	<u>10</u>		<u>40</u>	<u>25</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>70</u>							<u>31</u> Day 6	<u>-CH</u>	<u>10</u>	<u>3p</u>	<u>11</u>	<u>87</u>
Day 7	<u>28</u> DD (+7)	<u>8</u>	<u>3</u>	<u>8</u>		<u>40</u>	<u>20</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>70</u>							<u>01</u> Day 7		<u>6</u>	<u>2E</u>	<u>6</u>	<u>86</u>

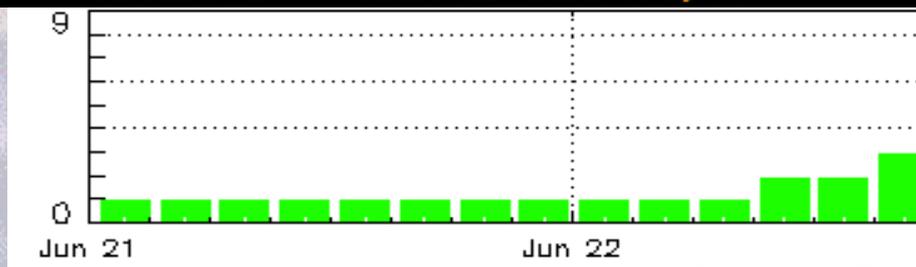
Forecast for 22nd: Ap = 5, Max Kp = 2
(recurrence was Ap = 4, Max Kp=1)



Solar Wind – 22 June



Time to issue the forecast



Forecast on 22 June 2016

Forecast Worksheet

Date: 22 Jun 2016

D Shift: DM

S Shift: el

AFWA: _____

Heath, Maxwell

SRAG: Janet

	Observed / Forecast					Recurrence										
	Geomag Indices (NOAA & USAF)			Geomag Probabilities (Planetary)		Penticton 10.7cm (Flux)	Geomag Indices (NOAA & USAF)			10.7cm (Flux)						
Date	CH / CME	NOAA Ap	NOAA Kp	USAF Ap	Quiet (K<=1-3)	Unsettled (K<=3)	Active (K<=4)	mS (K<=6)	MS (K<=8)	SS (K<=9)	Date	CH / CME	NOAA Ap	NOAA Kp	USAF Ap	Penticton
Ystdy	<u>21</u> DD (-1)		<u>4</u>	<u>1</u>	<u>4</u>						<u>80</u> Ystdy					
Today	<u>22</u> DD		<u>12</u>	<u>4</u>	<u>4</u>						<u>79</u> AM					<u>91</u> 90-Day
Day 1	<u>23</u> DD (+1)	<u>CH</u>	<u>12</u>	<u>4</u>		<u>40</u>	<u>25</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>79</u> Rgrs Ret					<u>(53)</u> Rgrs Exit
Day 2	<u>24</u> DD (+2)		<u>15</u>	<u>4</u>		<u>25</u>	<u>30</u>	<u>15</u>	<u>5</u>	<u>1</u>	<u>70</u>					
Day 3	<u>25</u> DD (+3)		<u>8</u>	<u>3</u>		<u>40</u>	<u>20</u>	<u>5</u>	<u>1</u>	<u>1</u>						<u>(57)</u>
Day 4	<u>26</u> DD (+4)	<u>CH</u>	<u>12</u>	<u>4</u>		<u>40</u>	<u>30</u>	<u>10</u>	<u>5</u>	<u>1</u>						
Day 5	<u>27</u> DD (+5)	<u>CH</u>	<u>10</u>	<u>3</u>		<u>40</u>	<u>25</u>	<u>5</u>	<u>1</u>	<u>1</u>						
Day 6	<u>28</u> DD (+6)		<u>8</u>	<u>3</u>		<u>40</u>	<u>20</u>	<u>5</u>	<u>1</u>	<u>1</u>						
Day 7	<u>29</u> DD (+7)		<u>5</u>	<u>2</u>		<u>20</u>	<u>5</u>	<u>1</u>	<u>1</u>	<u>1</u>						

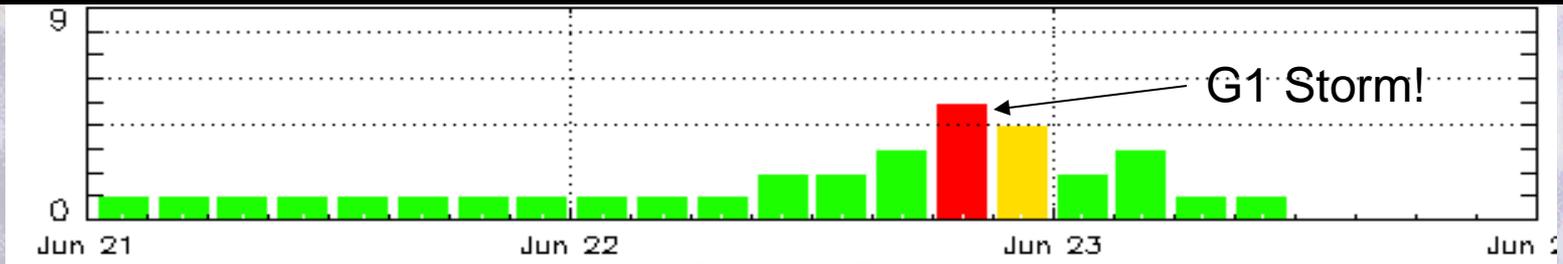
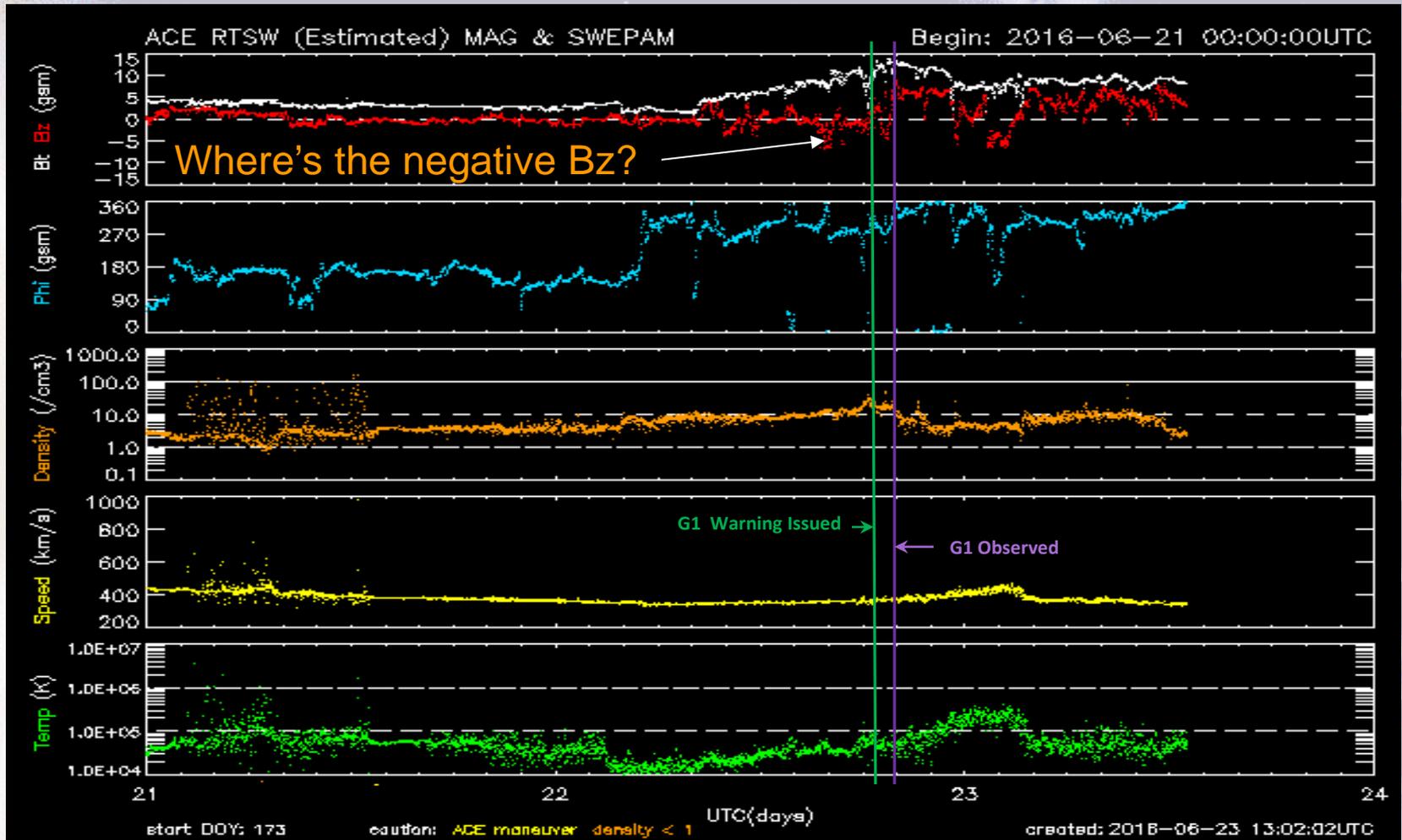
Event Probabilities (Whole disk)			
Class C	Class M	Class X	Protons
<u>15</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>10</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>10</u>	<u>1</u>	<u>1</u>	<u>1</u>

PCA Forecast:
G R P

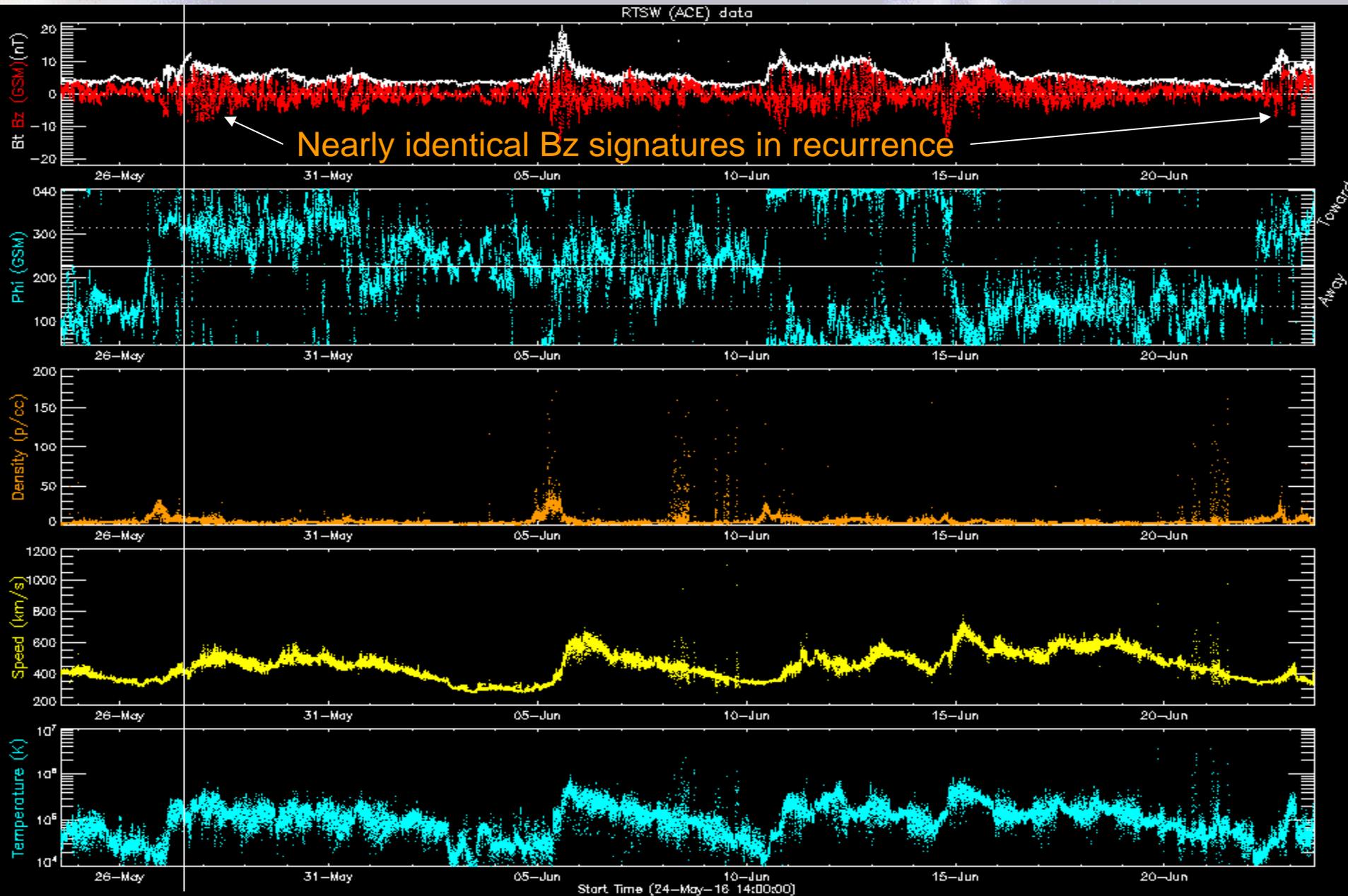
Forecast for 22nd: Ap = 12, Max Kp = 4
(Current day estimated, SSB observed)



What happened?



Recurrence Plot



Sources for Forecasting Errors

- **Situation where existing knowledge was not used or was used improperly**
 - **This is an education & training issue**
- **Situation where existing knowledge does not provide in help making the forecast decision**
 - **This is a potential research topic**
- **Case 2 defines O2R !**

Improving Forecasts: what doesn't work

- **Forecasters not learning the science**
 - Ongoing science education and training is needed
 - Training must be focused on applying the science
- **Not taking time to examine what 'went wrong' when forecasts failed**
 - Figuring out what 'went wrong' is not always easy or unambiguous

Improving Forecasts: what doesn't work

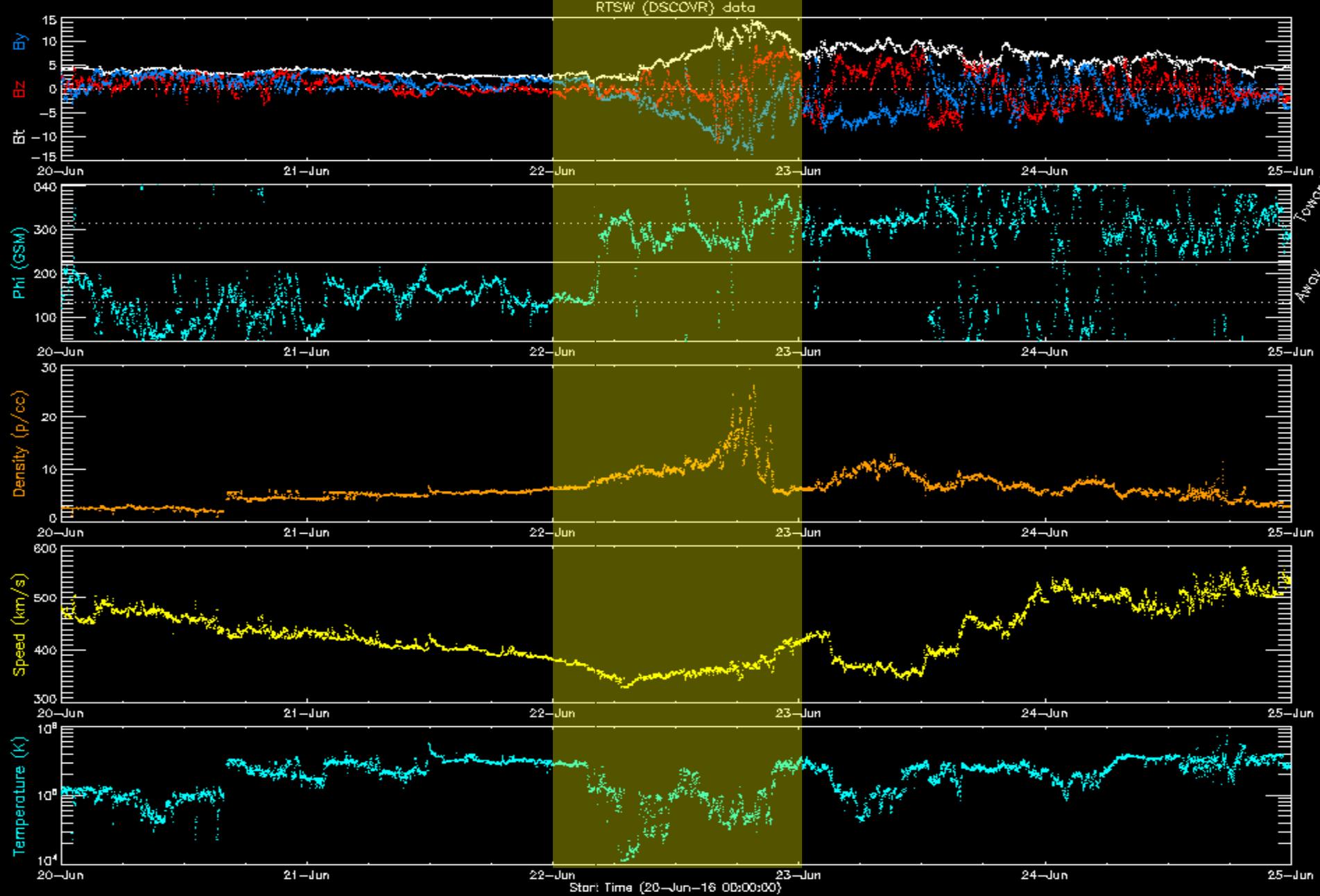
- **Research programs that do not include forecaster input, involvement, collaboration**
 - Researchers typically struggle to know what is relevant until they are informed of the practical objectives and problems
- **Implementing new ideas, theories, algorithms in operations before they have been thoroughly tested**
 - This happens all the time !
- **SWPC often has to take on the burden of doing the real testing to ensure a new idea really works**

Improving Forecasts: what can work?

- **Setting up a thorough testing process in a real-world environment**
- **Evaluation new ideas outside of operations but with forecasters and researchers collaborating**
 - Many of us have in fact done this on an ad-hoc basis
- **Use operational experience to highlight key research objectives or training needs (e.g. analysis of ‘busted forecasts’)**

Summary

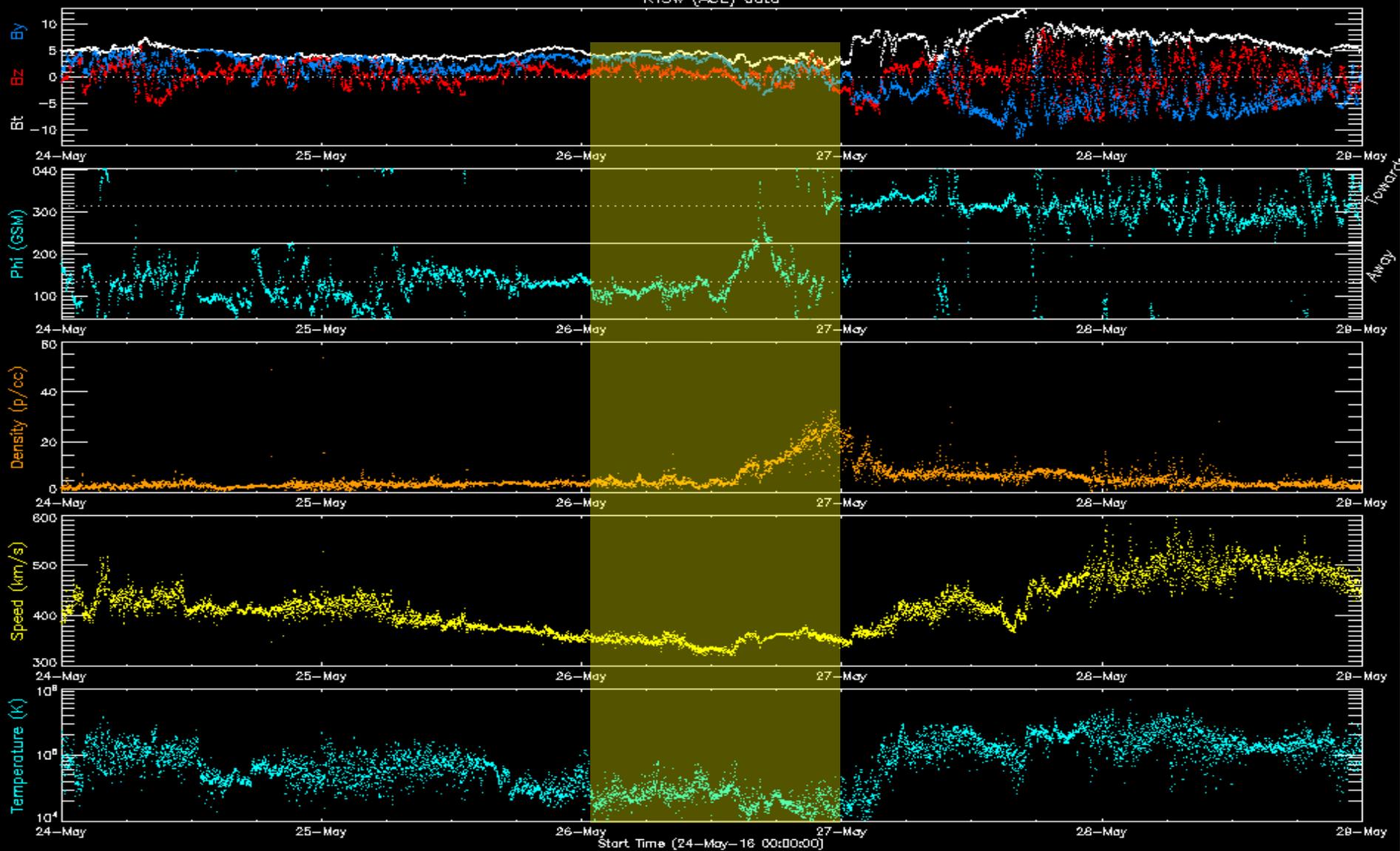
- **Producing space weather forecasts and products is challenging**
- **The action of producing these forecasts quickly highlights knowledge gaps that need to be addressed**
- **Gaps identified through forecaster experience are a great resource that can help researchers identify key science problems whose solution has a practical benefit**
- **O2R can provide a more intentional approach to ensure this process happens**



Kp 1 1 0 1 2 3 5 4



RTSW (ACE) data



$A_p = 4$, Max $K_p = 1$

$A_p = 10$, Max $K_p = 3$

$A_p = 14$, Max $K_p = 4$

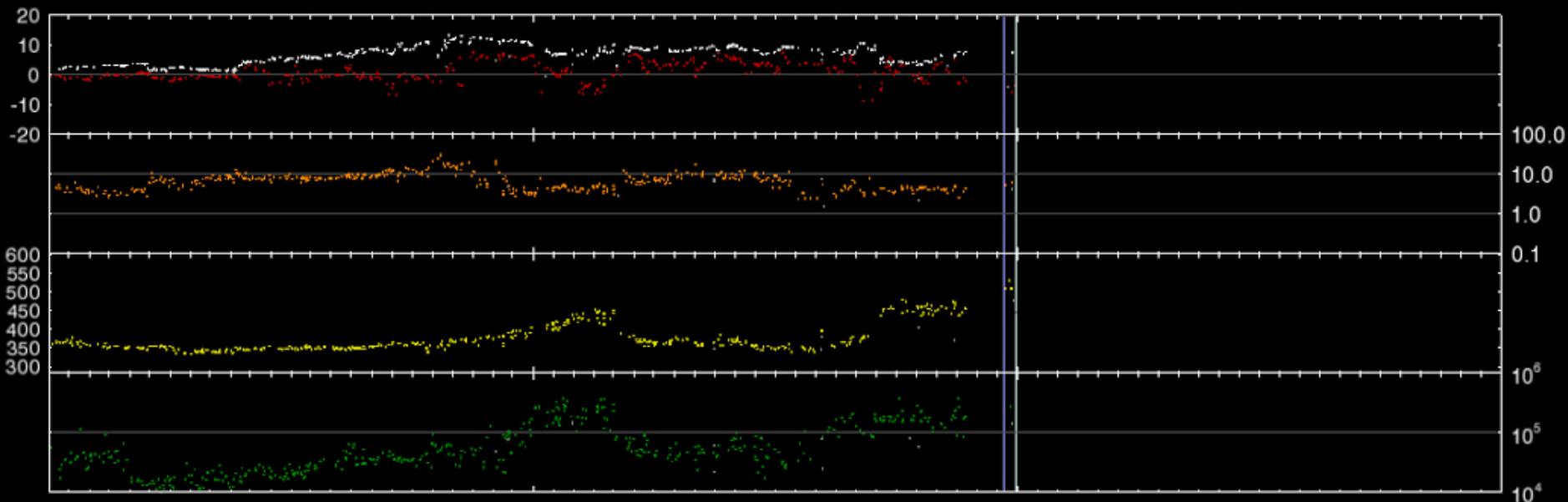


Solar Wind [Propagated]

Current time : 2016-06-23 23:20:01 UT

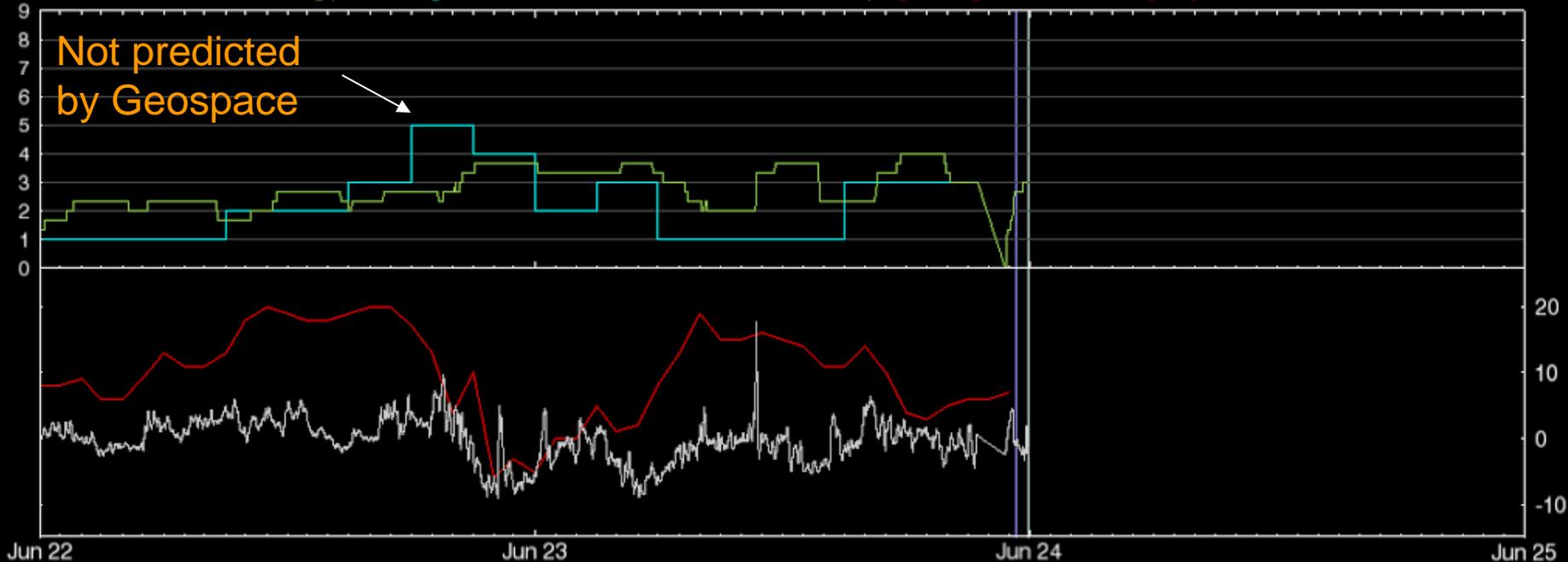
|B|, Bz[nT] Density[p/cm3] Speed[km/s] Temp[K]

Forecast : 2016-06-23 23:58:00 (38 mins ahead)



SWMF 1 min virtual Kp, SWPC Kp

SWMF 1 min DST, Kyoto quicklook DST[nT]



Jun 22

Jun 23

Jun 24

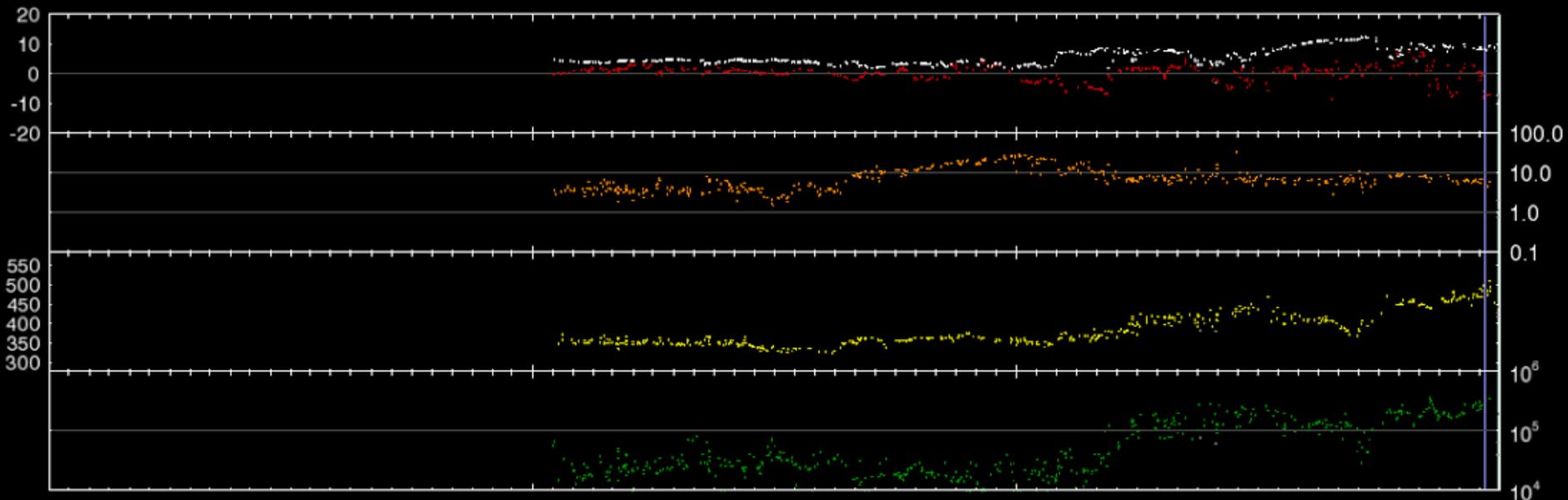
Jun 25

Solar Wind [Propagated]

Current time : 2016-05-27 23:17:01 UT

|B|, Bz[nT] Density[p/cm3] Speed[km/s] Temp[K]

Forecast : 2016-05-27 23:59:00 (42 mins ahead)



SWMF 1 min virtual Kp, SWPC Kp

SWMF 1 min DST, Kyoto quicklook DST[nT]

