VMR status and new ideas on model-data comparison systems

http://vmr.engin.umich.edu/

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Center for Space Environment Modeling, University of Michigan

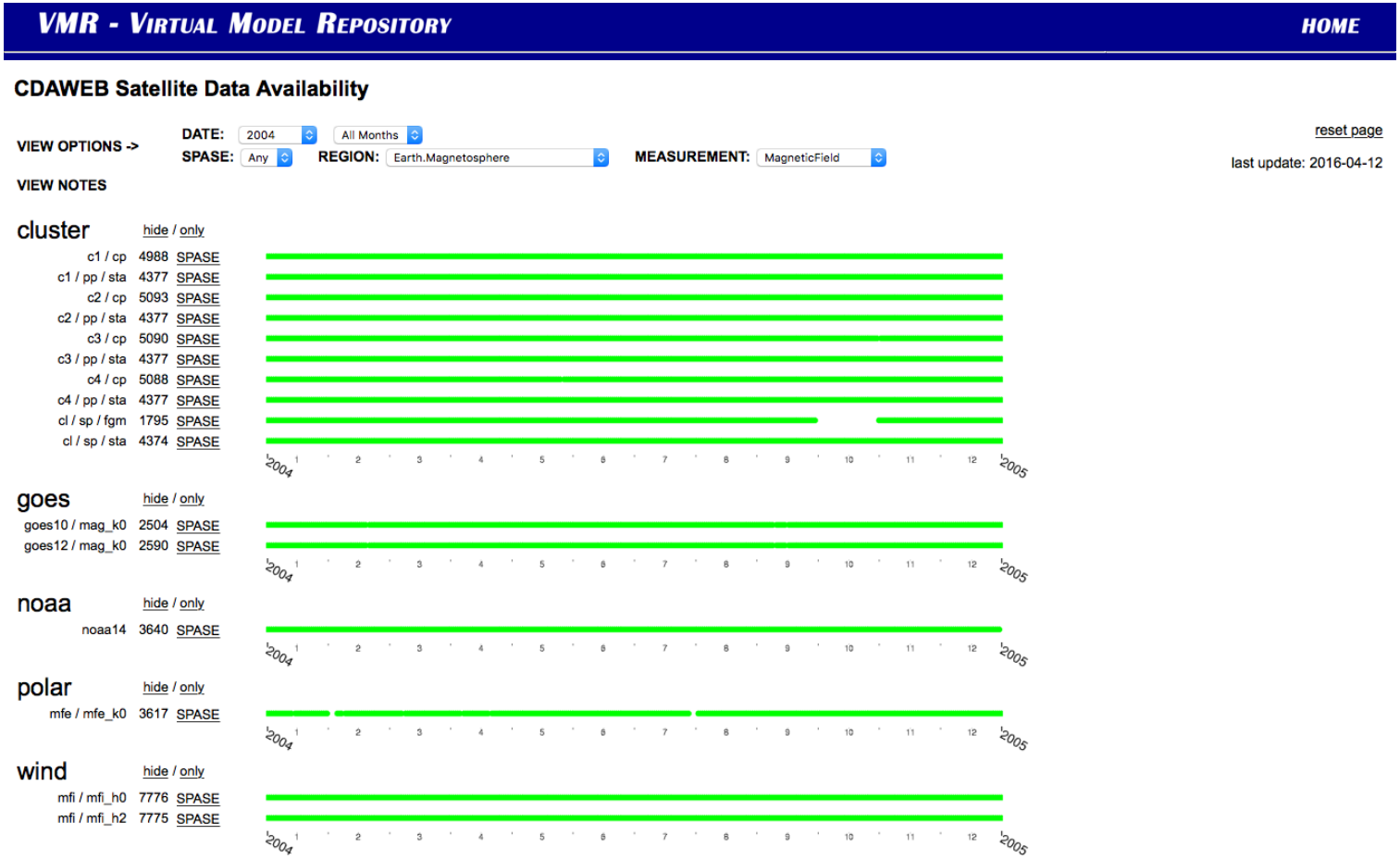
CCMC Workshop, April 15, 2016

Virtual Model Repository

- The VMR is a virtual observatory that enables scientific analysis of numerical model results. Model results are available in a consistent and intuitive way through visualization tools and data/model comparisons.
- The VMR enables browse/search of model output and satellite data. Data discovery and exchange is coordinated through various APIs from multiple sites to bring in the relevant data for visualization and analysis.
- Consistent APIs, metadata, and format standards are extremely important in this process.

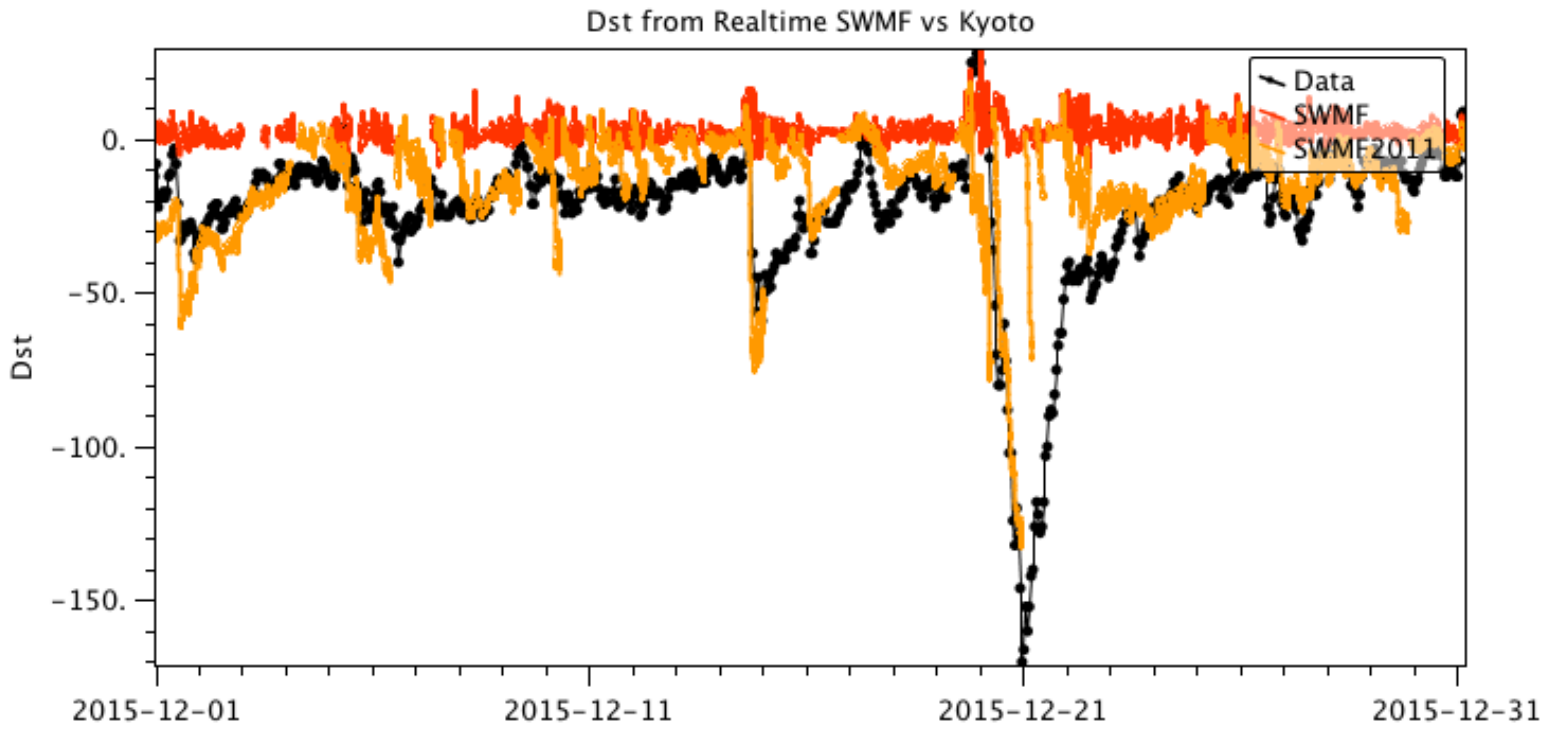
Using SPASE in CDAWeb

- SPASE records help to narrow search regions for data of interest.



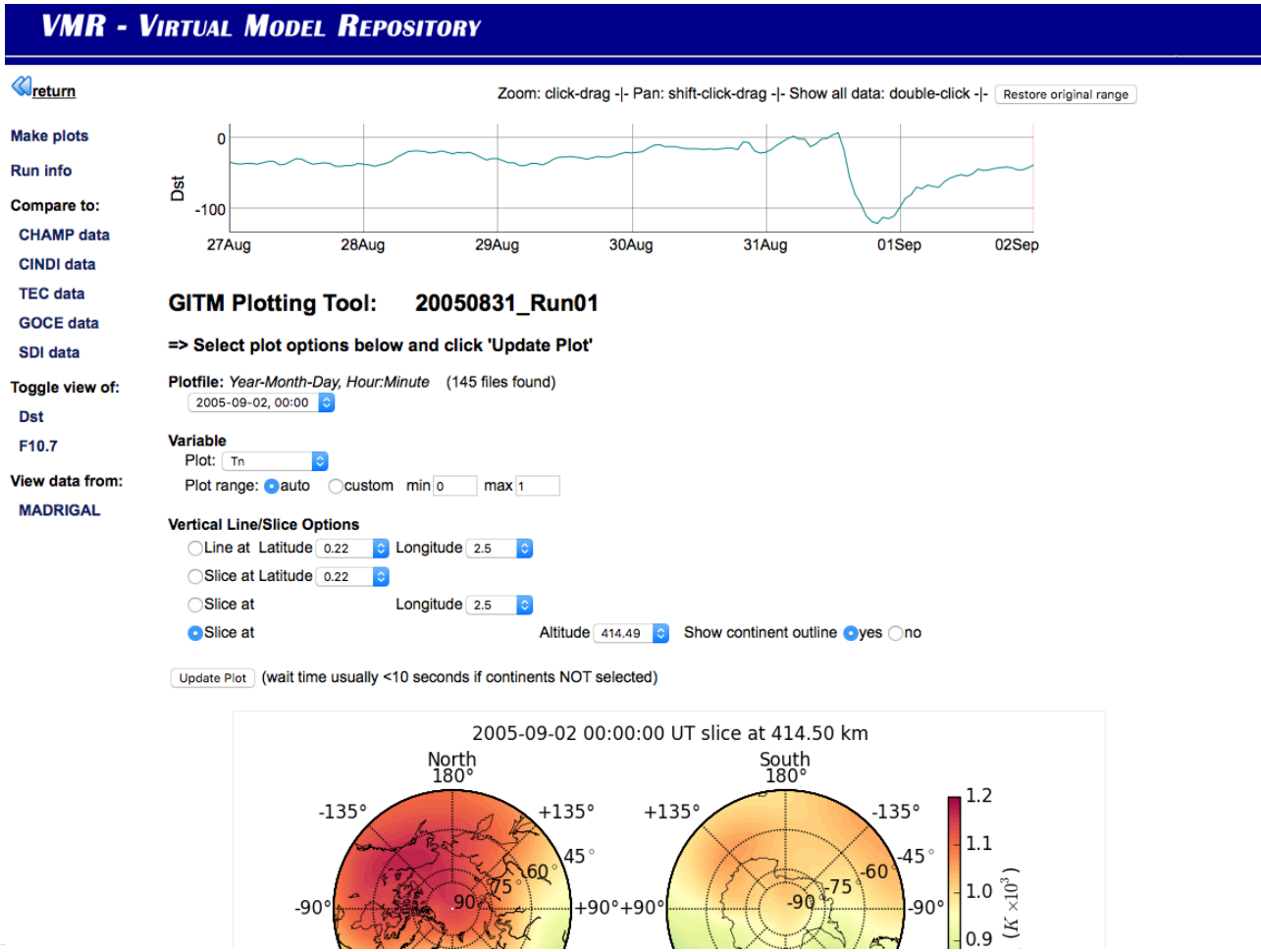
CCMC API in ISWA for Dst data

- APIs enable data collection for Dst from CCMC realtime runs and Kyoto, which then uses autoplot to easily script the creation of plots.



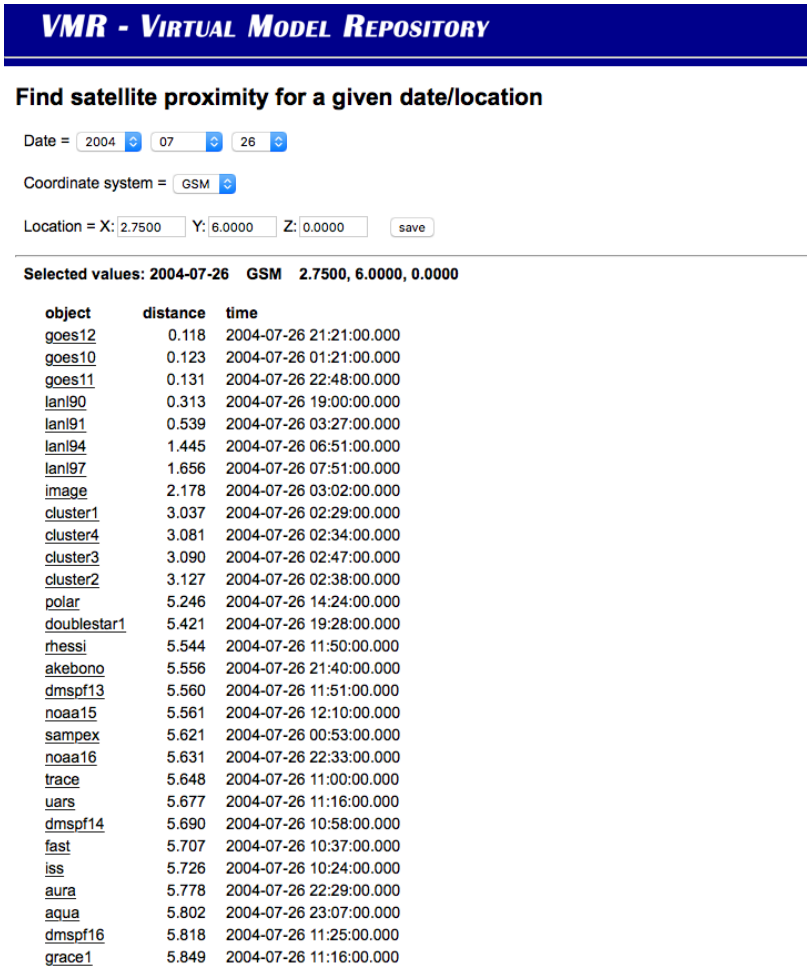
GITM data/model analysis

- Model visualization tools with several data/model options available when relevant.
- Javascript overlays of Dst or F10.7 are possible.
- Python plots using minimal metadata and standards formats.



Walkthrough science query …

- Suppose you have a date and location you are interested in.
- A SPASE based API called TSDS exists that make it easy to develop a tool to start your query.
- Such a tool was developed in the VMR as shown.
- For the values entered we see that GOES-12 came closest to the area of interest.



VMR - Virtual Model Repository

Find satellite proximity for a given date/location

Date = 2004 07 26

Coordinate system = GSM

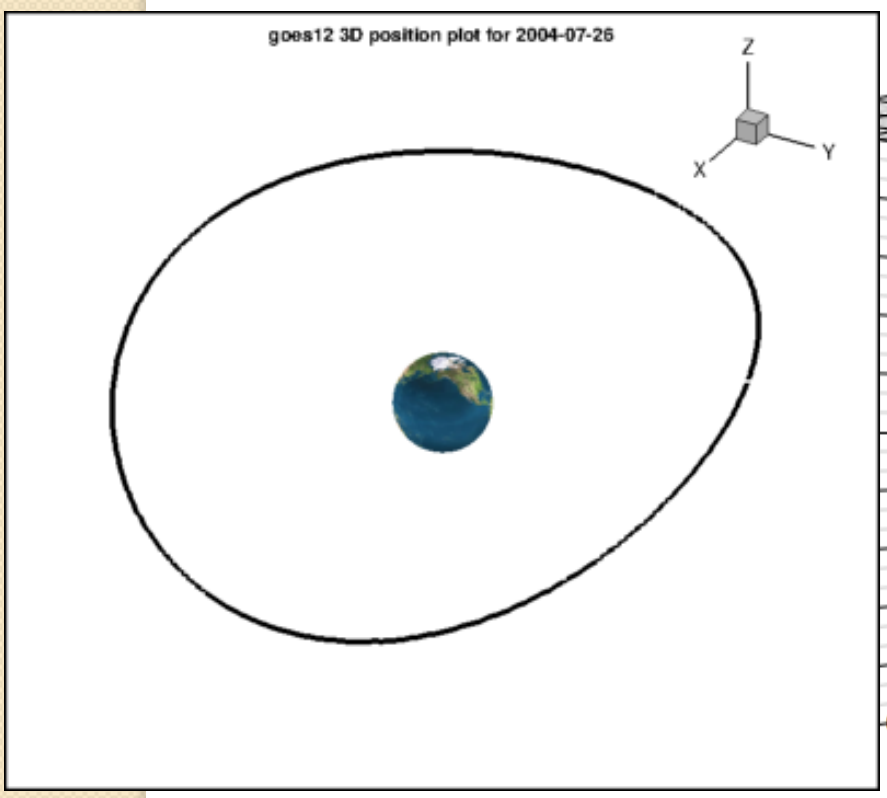
Location = X: 2.7500 Y: 6.0000 Z: 0.0000 save

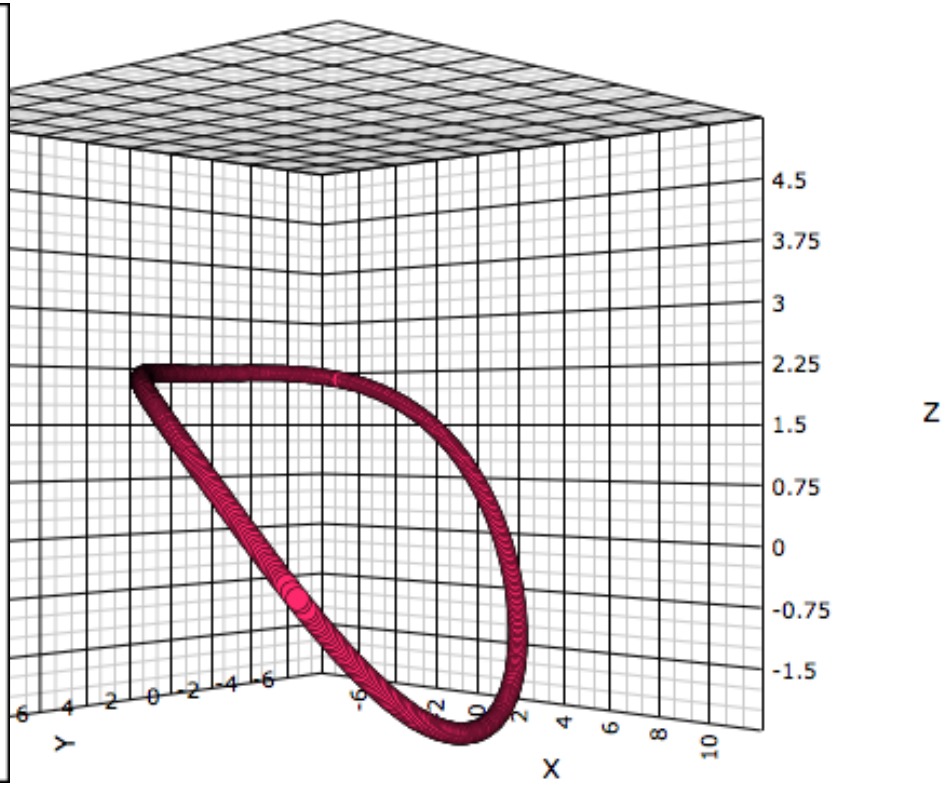
Selected values: 2004-07-26 GSM 2.7500, 6.0000, 0.0000

object	distance	time
goes12	0.118	2004-07-26 21:21:00.000
goes10	0.123	2004-07-26 01:21:00.000
goes11	0.131	2004-07-26 22:48:00.000
lanl90	0.313	2004-07-26 19:00:00.000
lanl91	0.539	2004-07-26 03:27:00.000
lanl94	1.445	2004-07-26 06:51:00.000
lanl97	1.656	2004-07-26 07:51:00.000
image	2.178	2004-07-26 03:02:00.000
cluster1	3.037	2004-07-26 02:29:00.000
cluster4	3.081	2004-07-26 02:34:00.000
cluster3	3.090	2004-07-26 02:47:00.000
cluster2	3.127	2004-07-26 02:38:00.000
polar	5.246	2004-07-26 14:24:00.000
doublestar1	5.421	2004-07-26 19:28:00.000
rhessi	5.544	2004-07-26 11:50:00.000
akebono	5.556	2004-07-26 21:40:00.000
dmspf13	5.560	2004-07-26 11:51:00.000
noaa15	5.561	2004-07-26 12:10:00.000
sampex	5.621	2004-07-26 00:53:00.000
noaa16	5.631	2004-07-26 22:33:00.000
trace	5.648	2004-07-26 11:00:00.000
uars	5.677	2004-07-26 11:16:00.000
dmspf14	5.690	2004-07-26 10:58:00.000
fast	5.707	2004-07-26 10:37:00.000
iss	5.726	2004-07-26 10:24:00.000
aura	5.778	2004-07-26 22:29:00.000
aqua	5.802	2004-07-26 23:07:00.000
dmspf16	5.818	2004-07-26 11:25:00.000
grace1	5.849	2004-07-26 11:16:00.000

Walkthrough science query …

- Static and interactive javascript plotting of the orbit is available.





Walkthrough science query …

- Next, go to the list of CCMC event runs and see which runs occurred during the date of interest.

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Analysis of NASA's Community Coordinated Modeling Center (CCMC)
Runs-On-Request Magnetosphere Event Runs

solar
heliosphere
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inner magnetosphere
ionosphere/thermosphere

Filters

Run start/end date as YYYYMMDD:
/

Run Name:

Keyword:

Model:

Run ID:

Satelite Data
-select-

Indices
ALL

submit reset

View anaysis for:

Cluster-1
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Cluster-4
GOES-8
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GOES-10
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THEMIS-A

Results

... displaying 1304 of 1304 runs ...
sort by run first or last name

		model	event date	run ID	F10.7	min Dst	3D files	stars
select	Cathal_Clavie_040416_3	LFM LTR-2_1_5	April 14, 2015	15579	147.7	-41	392	
select	Corinne_Florie_040816_1	OpenGGCM 4.0	July 15, 2001	15578	146.8	4	61	
select	Yash_Sarkango_040616_4	LFM LTR-2_1_5	July 18, 2008	15571	67.4	-11	362 *	3.7
select	Cathal_Clavie_040416_2	LFM LTR-2_1_5	April 7, 2015	15568	111.4	-9	392	
select	Yash_Sarkango_040616_3	SWMF v20140611	July 18, 2008	15565	67.4	-11	241 *	3.3
select	Yash_Sarkango_040616_2	OpenGGCM 4.0	July 18, 2008	15560	67.4	-11	241	3.3
select	Cathal_Clavie_040416_4	LFM LTR-2_1_5	April 21, 2015	15556	155.3	-29	392	
select	Cathal_Clavie_040416_1	LFM LTR-2_1_5	March 31, 2015	15555	127.8	-16	392	
select	Kirk_Olsen_033116_1	SWMF v20140611	October 27, 2003	15544	254	-383	1297	2
select	Corinne_Florie_040216_2	SWMF v20140611	July 15, 2001	15542	146.8	4	61	
select	Kirk_Olsen_040116_1	SWMF v20140611	October 29, 2003	15538	275.4	-350	721	
select	Kirk_Olsen_040116_2	OpenGGCM 4.0	October 29, 2003	15537	275.4	-350	721	1.3
select	Yash_Sarkango_033016_1	SWMF v20140611	January 1, 2000	15513	125.6	-50	31	
select	Iurii_Cherniak_030716_1	OpenGGCM 4.0	March 16, 2015	15511	116	-228	147	
select	Cynthia_Cattell_031616_1	LFM LTR-2_1_5	December 14, 2015	15509	120.2	-13	433	
select	Cynthia_Cattell_032316_1	SWMF v20140611	December 14, 2015	15507	120.2	-59	721	
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select	CHIH-PING_WANG_030516_1	OpenGGCM 4.0	February 13, 2014	15451	162.5	-2	2881	
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select	Hugh_Evans_012816_1	SWMF v20140611	April 5, 2010	15236	79.3	-81	1538	2.3
select	Denny_Oliveira_020216_2	SWMF v20140611	March 17, 2015	15228	113.2	-149	1141	
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select	Olga_Korolkova_011716_1	GUMICS 4-HC-20140	September 24, 1998	15180	#	-43	181	
select	Denny_Oliveira_012116_1	SWMF v20140611	March 17, 2015	14853	113.2	-149	1141	
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select	Yihua_Zheng_011116_2	SWMF v20140611	June 20, 2015	14796	139.8	-195	2191 *	
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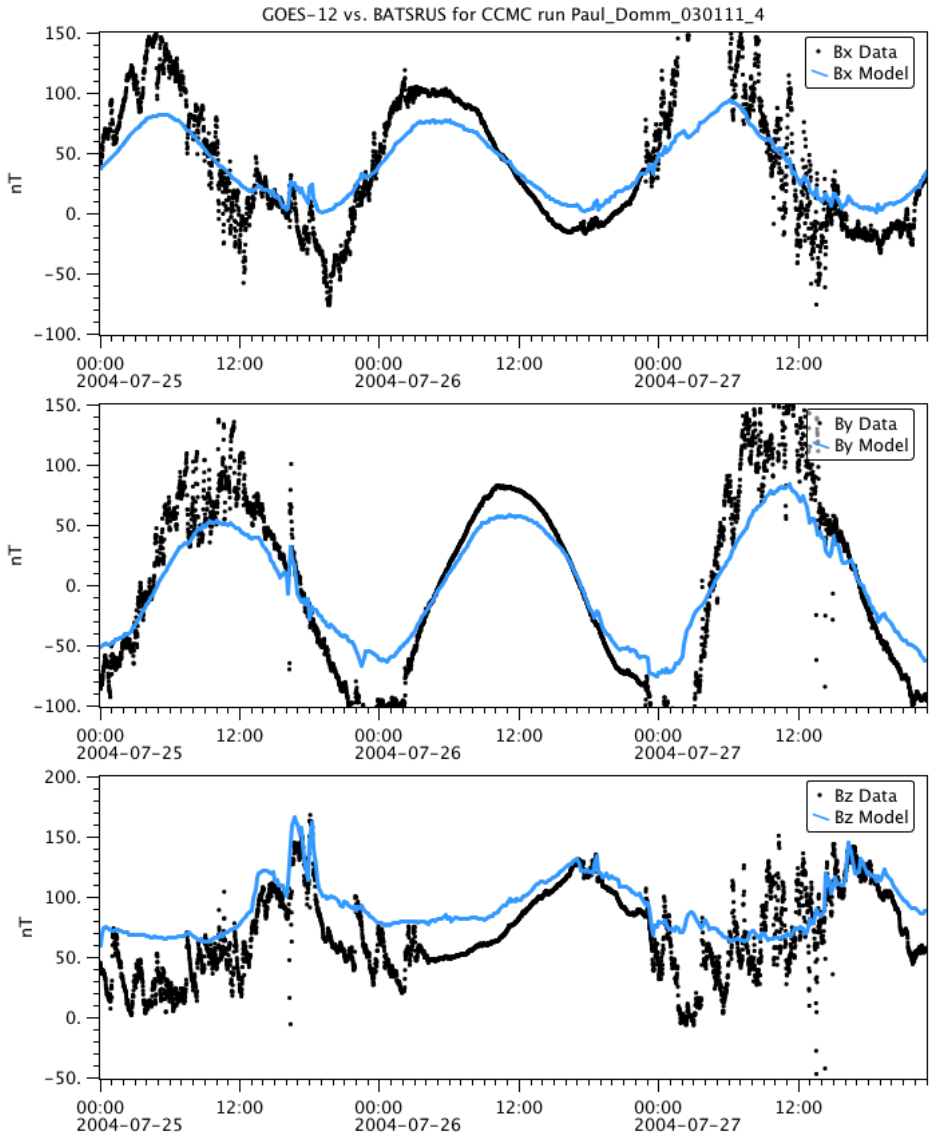
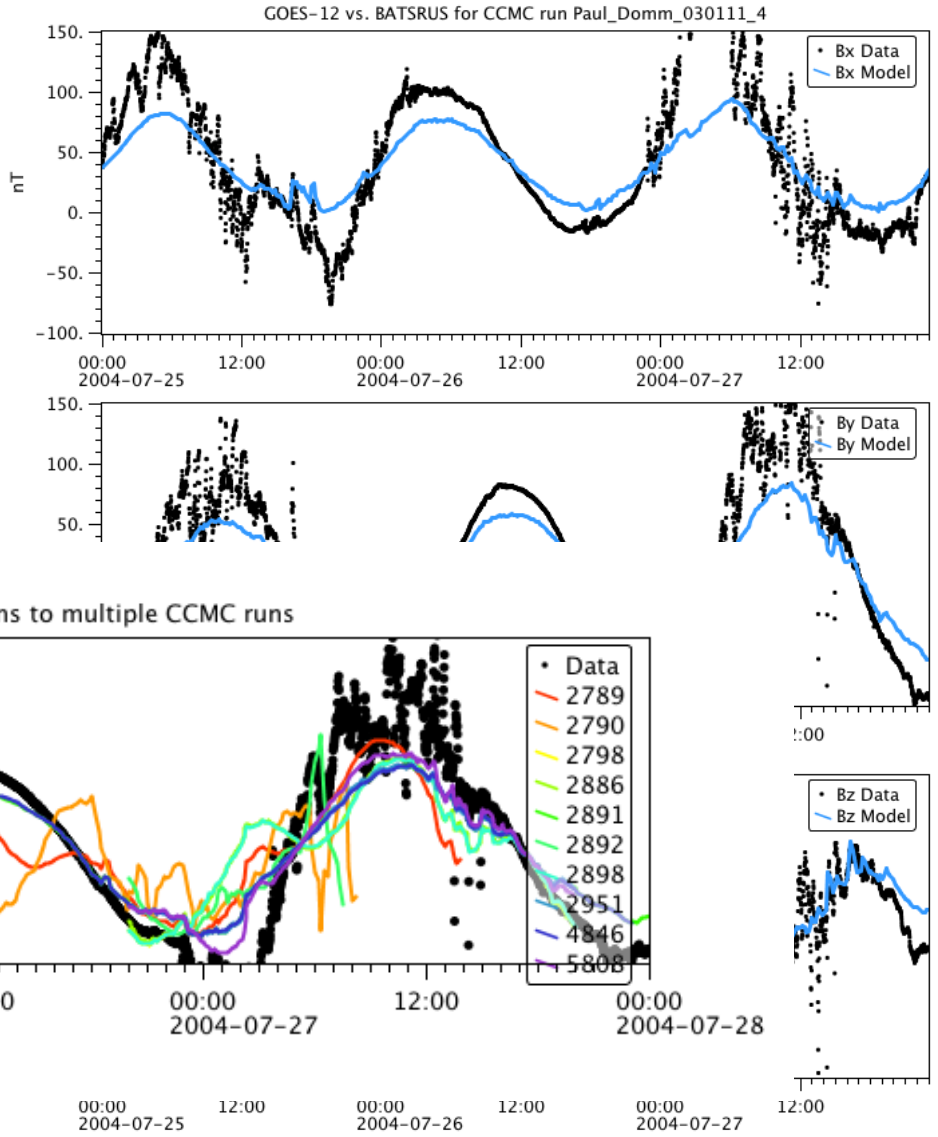
Walkthrough science query …

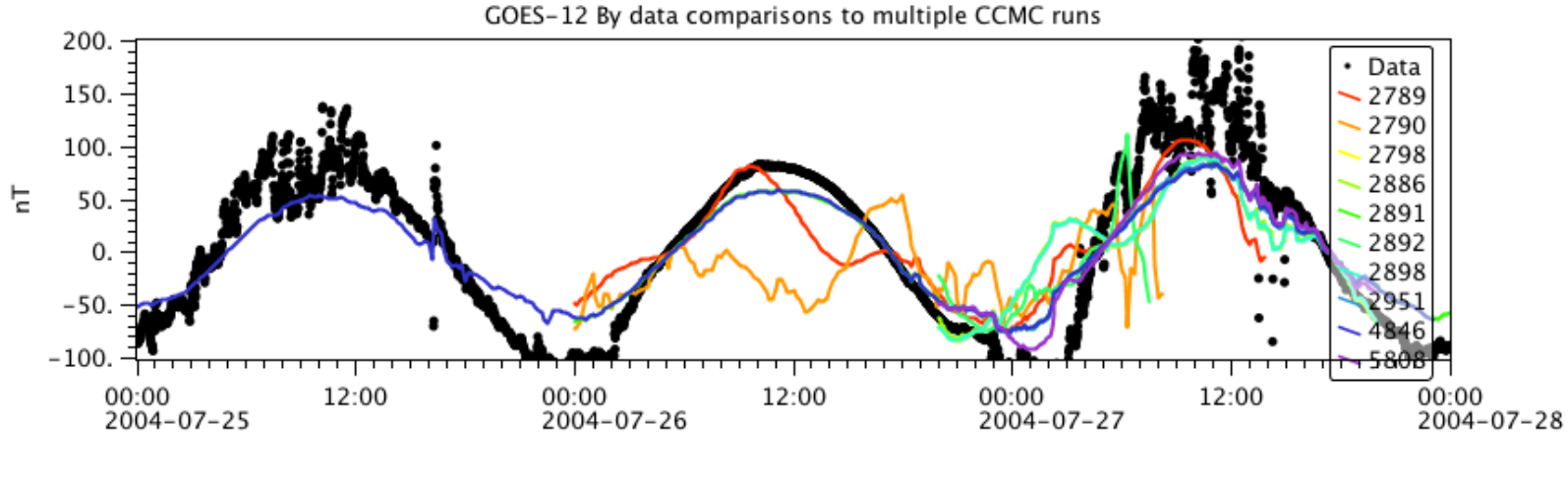
- The run is selected and comparison with GOES-12 is made.



Walkthrough science query …

- The run is selected and comparison with GOES-12 is made.
- BUT, we can do more!





Walkthrough science query …

- But the page has more information, RMS error analysis …

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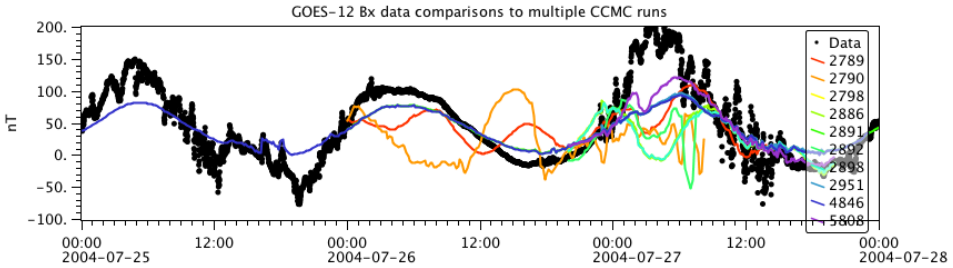
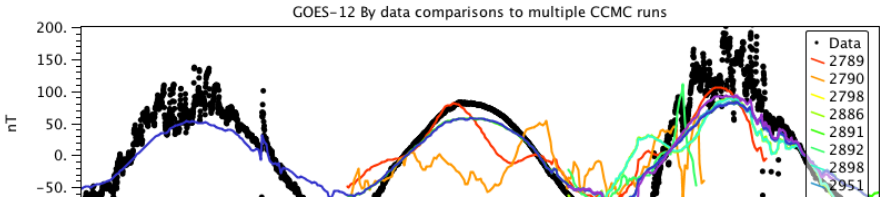
Plot of multiple CCMC event runs with GOES-12 data for 2004-07-25 through 2004-07-27

	RMS Error	Bx	By	Bz	points	*
2789 = Thea_Falkenberg_011609_2		56.84%	54.38%	16.56%	454	3
2790 = Thea_Falkenberg_011609_3		88.86%	86.68%	16.12%	386	4
2798 = Thea_Falkenberg_013009_1		308.39%	12.54%	1.98%	58	5
2886 = Thea_Falkenberg_013009_1a		78.07%	53.97%	18.58%	1441	3
2891 = Thea_Falkenberg_011609_1		48.74%	33.82%	27.01%	574	3
2892 = Thea_Falkenberg_031809_3		67.12%	61.42%	63.54%	139	2
2898 = Thea_Falkenberg_031909_1		83.41%	54.14%	18.52%	289	3
2951 = Thea_Falkenberg_032709_1		58.22%	44.53%	21.01%	1441	3
4846 = Paul_Domm_030111_4		45.34%	37.96%	34.80%	851	2
5808 = Zhao_Li_100711_1		40.64%	34.43%	17.25%	575	3

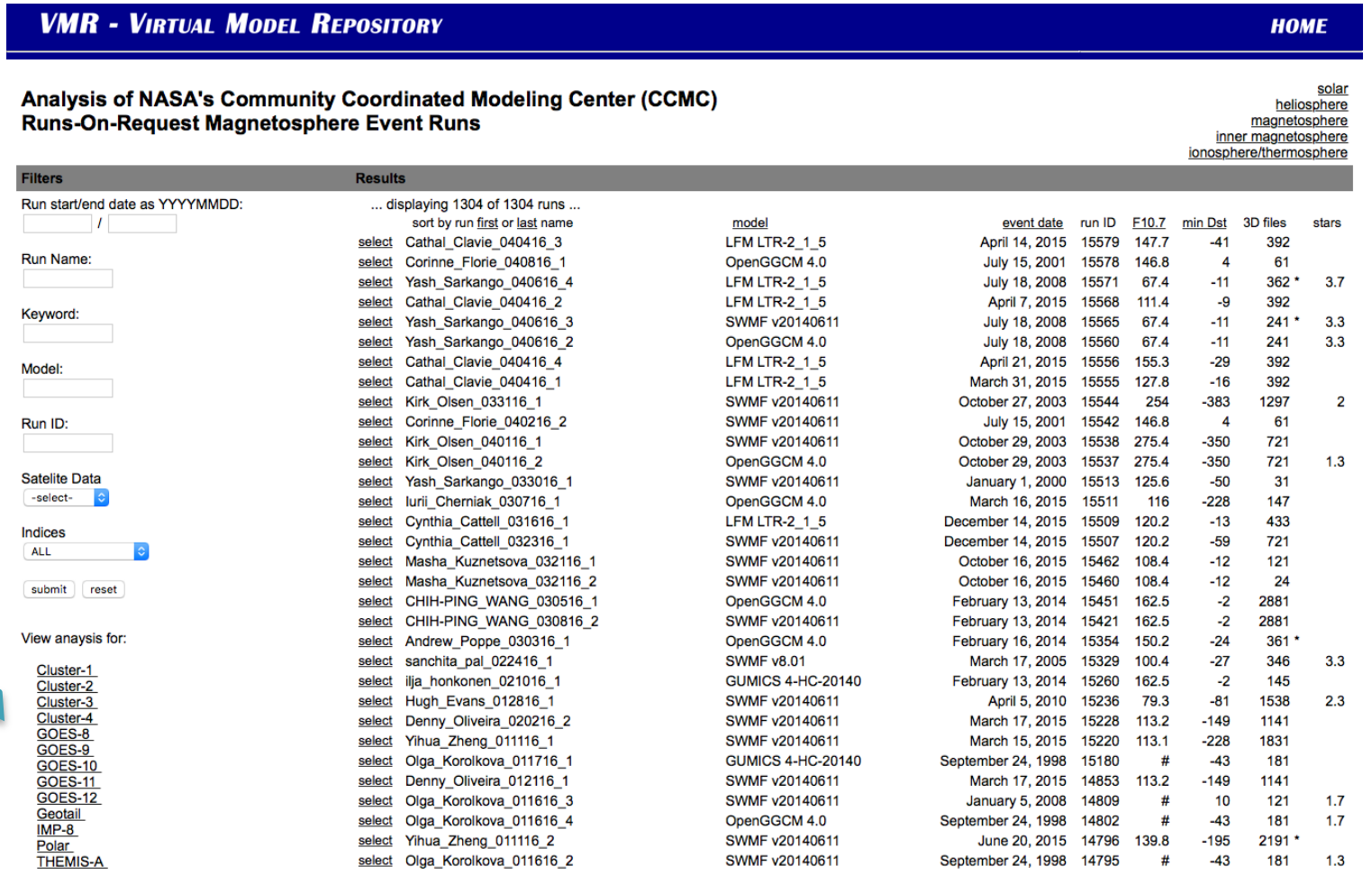


You can download this file and load it into autoplot to make further modifications.



Walkthrough science query …

- If we go back to CCMC run listings, we see that we have comprehensive satellite analysis available.



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Walkthrough science query …

- Over 1,000 runs with GOES-12 data available shows bias and accuracy of models as a whole.
- This in turn informs individual run interpretation.

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return **Analysis of CCMC runs for GOES-12**

		min	max	median	mean	stdev
shown = 354	Bx RMS nT	0.27	86.5	8.75	13.28	14.17
possible = 355	By RMS nT	0.56	72.52	16.38	11.63	12.79
all runs = 1304	Bz RMS nT	1.17	58.72	16.38	18.41	10.62
	points	0	11511	241	582.25	1049.22
	Bx AVE nT	-86.5	25.68	-3.37	-6.48	14.84
	By AVE nT	-40.42	63.64	1.95	3.22	10.55
	Bz AVE nT	-41.24	58.72	14.95	14.26	13.66

STARS: 1=81, 2=240, 3=399, 4=238, 5=83

Star ratings key:

5 star = Bz RMS nT <= 5.54
4 star = Bz RMS nT <= 12.46
3 star = Bz RMS nT <= 20.37
2 star = Bz RMS nT <= 36.66
1 star = Bz RMS nT > 36.66

Run	Error (RMS nT, AVE nT, RMS %)											
			Bx			By			Bz	points	STAR rating (ave Bx By Bz)	min Dst
view Sharad_Tripathi_011614_1	9.60	-8.08	49.34%	8.83	-2.75	20.41%	19.73	18.80	25.39%	04438	3 ★★★☆☆ (3)	-97
view Janet_Kozyra_011314_1	6.41	-0.45	19.65%	5.96	-0.98	14.41%	8.24	0.68	10.54%	02820	4 ★★★★☆ (3.3)	-97
view Anmin_Tlan_050614_1	0.57	-0.50	3.71%	1.38	1.18	2.30%	9.99	9.99	9.64%	00061	4 ★★★★☆ (4.7)	2
view Yaireska_Collado-Vega_053014_1	7.37	-7.37	35.03%	3.65	3.50	11.11%	23.95	23.95	32.18%	01081	2 ★★☆☆☆ (3)	-29
view tao_huang_082414_5	1.55	1.22	2.12%	5.95	5.95	35.86%	20.12	20.12	26.66%	00301	3 ★★★☆☆ (3.7)	-32
view tao_huang_082414_3	6.84	-4.92	25.46%	12.22	12.22	23.42%	15.96	15.96	18.86%	00360	3 ★★★☆☆ (2.7)	-27
view tao_huang_082414_4	1.64	-1.01	5.64%	1.80	1.80	3.93%	9.08	9.08	10.04%	00482	4 ★★★★☆ (4.7)	-2
view tao_huang_082414_7	3.94	3.94	20.64%	9.05	9.05	31.24%	15.94	15.94	15.52%	00302	3 ★★★☆☆ (3.3)	-14
view tao_huang_082414_8	5.43	5.43	78.09%	8.31	8.31	20.26%	10.05	10.05	9.77%	00302	4 ★★★★☆ (3.3)	-13
view tao_huang_082414_9	3.74	3.74	37.20%	7.60	7.60	18.31%	6.75	6.75	7.15%	00602	4 ★★★★☆ (3.7)	-5
view tao_huang_082814_3	6.84	-4.89	25.29%	12.24	12.24	23.47%	15.97	15.97	18.89%	00360	3 ★★★☆☆ (2.7)	-27
view tao_huang_082814_5	1.55	1.22	2.12%	5.95	5.95	35.86%	20.12	20.12	26.66%	00301	3 ★★★☆☆ (3.7)	-32
view tao_huang_082814_4	1.64	-1.01	5.64%	1.80	1.80	3.93%	9.08	9.08	10.04%	00482	4 ★★★★☆ (4.7)	-2
view tao_huang_082814_7	3.94	3.94	20.64%	9.05	9.05	31.24%	15.94	15.94	15.52%	00302	3 ★★★☆☆ (3.3)	-14
view tao_huang_082814_8	5.43	5.43	78.09%	8.31	8.31	20.26%	10.05	10.05	9.77%	00302	4 ★★★★☆ (3.3)	-13
view tao_huang_082814_9	3.74	3.74	37.20%	7.60	7.60	18.31%	6.75	6.75	7.15%	00602	4 ★★★★☆ (3.7)	-5
view tao_huang_082414_6	4.95	-4.60	9.78%	1.09	1.09	7.42%	11.45	11.45	11.35%	00024	4 ★★★★☆ (4.3)	-10

What did we learn in this exercise?

- Tools can be developed for any single data/model comparison, but are often challenging to develop and difficult to reuse or generalize.
- Standards (metadata and formats) help in developing tools that can "mine" model output for trends, features, etc.
- In order to really advance model use and utility, we need standards.

Specifics …

- SPASE is already used for much of our data holdings, and now is the time to describe our model output with SPASE as well.
- Output format also need standards. CCMC's Kameleon in CDF format is a good option for large complicated output, though large files are still not going to be available online for some time (if ever). Other formats for 1D output like satellite trajectories are possible.
- APIs should continue to be developed for more and more automated access.