On HMI's Mod-L Sequence: Test and Evaluation

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PURPOSE: HMI/SDO changed observational mode from mod-C to mod-L this April. In mod-C, HMI front camera takes circular polarization (CP) at 6 wavelengths every 45 seconds; the side camera takes both CP and linear polarization (LP) at 6 wavelengths every 135 seconds. In mod-L, the front camera uses the same observation sequence as mod-C, while the side camera only takes LP. This way, instead of measuring a full Stokes parameters in 135 seconds, Mod-L can provide full Stokes parameters in 90 seconds by combining two cameras. This poster presents an evaluation of mod-L observation and the resulting vector magnetic field data.

Table 1: Stokes Parameters [IQUV]: mod-C versus mod-L

	Camera	cadence	Polarization	[IQUV] for inversion
Mod-C	side	130 sec	LP + CP	720 sec averaging
Mod-L	front + side	90 sec	LP + 2CP	720 sec averaging

Mod-L: Advantages and Tests.

Advantage:

- Increase temporal resolution for measuring full Stokes parameters (Mod-C takes 135 seconds);
- Decrease the noise in inverted vector magnetic field when using the averaged [I,Q,U,V] over the same time as Mod-C does (currently 720-second average).

Tests:

- Scaling observations from two cameras;
- Testing current polarization calibration model with Mod-L observation;
- Testing phase maps: how does it impact the inverted vector field data if using phase map from one camera only?

Test with the polarization calibration model

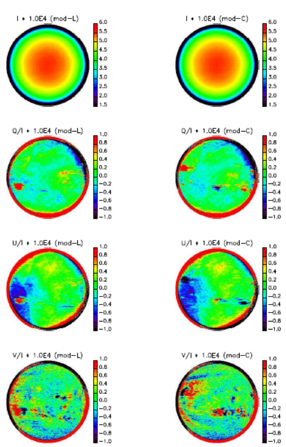

Figure 1: These average Stokes [IQUV] are computed from a 25-hour observation. The data are (1) rebinned to 256x256; (2) [QUV] are divided by corresponding Stokes [I]; (3) average wavelengths 0 and 5; and (4) for each pixel, take the median of the 25-hour data. The residuals of [QUV] are very small, indicating current polarization calibration model works well with Mod-L data.

ABSTRACT: HMI/SDO changed the observational mode from Mod-C to Mod-L in April. In previous Mod-C, the front camera takes circular polarization (CP, $I \pm V$) at 6 wavelengths in 45 seconds; the side camera takes both CP and linear polarization (LP, $I \pm Q$ and $I \pm U$) at 6 wavelengths in 135 seconds. In Mod-L, the front camera remains the same, while the side camera only takes LP. When combining measurements from two cameras, Mod-L can provide Stokes parameters in 90 seconds instead of 135 seconds in Mod-C. Combining two cameras need additional processing such as intensity scaling, modification of polarization calibration model, and combining phase maps. This poster presents tests and evaluations on potential impact from this change on resulting data products. We conclude Mod-L reduces the noise by 8% in inverted, 720-sec averaged, vector magnetic field data. Using current polarization calibration model and phase map does not show appreciable impact on the resulting data product. Mod-L does not introduce any notable systematic errors.

Comparison of Mod-C and Mod-L: Noise

Table 2: Noise of vector field data: Mod-C versus Mod-L

	B_total (G)	B_transverse (G)	B_los (G)
Mod-C	116	116	5.7
Mod-L	112	111	5.3

Table 3: Noise in Stokes [QUV]: Mod-C versus Mod-L

	V1	V2	V3	V4	V5	V6
Mod-C	40.4	47.5	45.9	43.1	46.7	39.8
Mod-L	31.7	40.7	39.6	37.5	38.8	31.2
	Q1	Q2	Q3	Q4	Q5	Q6
Mod-C	40.8	42.4	42.6	35.9	39.7	40.0
Mod-L	35.2	37.8	36.8	29.1	33.6	34.4
	U1	U2	U3	U4	U5	U6
Mod-C	40.5	41.9	41.6	35.9	39.6	39.8
Mod-L	35.1	37.4	38.5	29.0	33.6	34.5

Table 4: Mod-C versus Mod-L: Noise Reduced

	Q	U	V	B_total	B_trans	B_los
Noise reduced	14%	13%	17%	4%	4%	5%

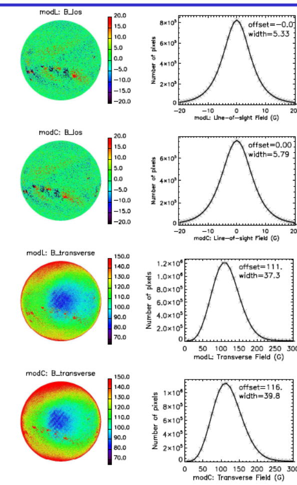

Figure 2: Comparison of Mod-L and Mod-C. Left: Images of line-of-sight and transverse fields. Right: distributions of the fields. Offset and width denote a Gaussian function that is used to fit distributions.

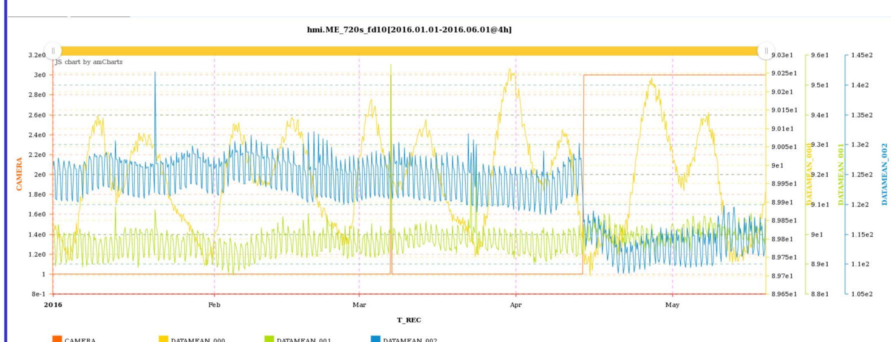

Figure 5: Temporal profiles of data mean of vector magnetic field from Jan 01 to May 15, 2016. Yellow curve refers to inclination, green is for azimuth, and blue for field strength. Brown curve refers to camera where camera = 1 represents side camera (Mod-C), and camera = 3 means combining two cameras (Mod-L). While inclination and azimuth show no significant change between two observational modes, mean of field strength decreases significantly. Because most pixels are in the quiet Sun regions, this data mean can be deemed to be a proxy of noise. It reduces by ~ 8% from Mod-C to Mod-L.

Scaling observations from two cameras: For each data set, calculate Stokes [*I*] for each camera, then derive the ratio for each pixel. The ratio is used to scale this set of data. This figure shows change of the ratio with time.

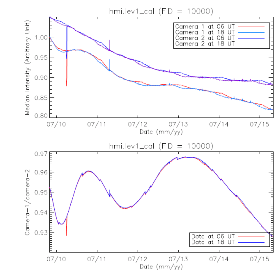

Figure 3: Temporal profiles of median of intensity from both cameras, normalized by the first data value of each camera (top), and ratio between them (bottom).

Testing phase map: Using phase maps from camera 1 or 2 does not impact the inverted vector field data very much.

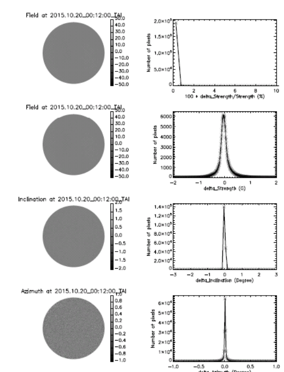

Figure 4: Left: difference of inverted vector field data using phasemaps from camera 1 or 2. Right: histograms of the difference.

CONCLUSIONS:

1. Mod-L observation leads to lower noise in the inverted, 720 sec averaged, vector magnetic field data;
2. Current polarization calibration model works with Mod-L observation pretty well; the cross talk is well corrected;
3. Using phase maps of camera 1 or 2 does not impact the inverted magnetic field data very much.