Stray Light Corrected HMI Data Compared to Hinode SOT-SP Data

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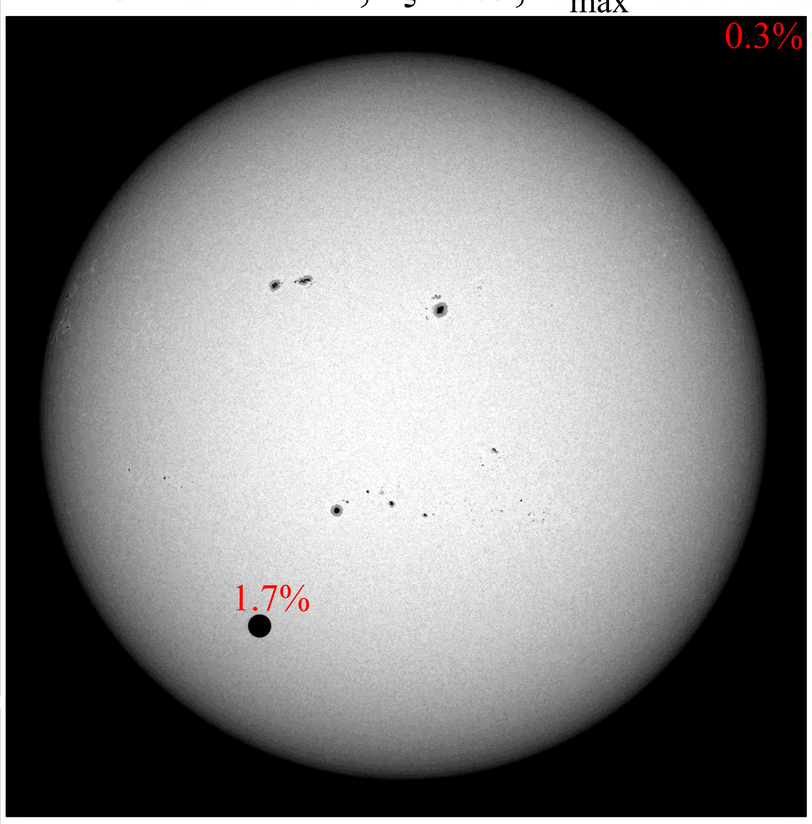
- ✓ **HMI has ~1% scattered light 10″ off limb**
- ✓ **We correct this. The data are beautiful & online**
- ✓ **See full-disk data made 1×day – I_c, V, M_{los}, Vector B, True I_c– data with '_*dcon*' or '_*dconS*' in name**
- ✓ **Full-disk images deconvolved in < 1 sec**

Abstract: An elegant PSF (an Airy convolved with a Lorentzian) is used to removed stray light from HMI and bring its data into better agreement with Hinode.

Construction of the PSF

From off-limb, lunar eclipse & Venus transit data

1) **short-distance** scattering $OTF_{ideal}(\rho)exp(-\pi\,\rho'/\gamma)$, γ=4.5, ρ & ρ' spatial / normalized spatial frequency
2) **long-distance** scattering described by additional term $PSF(r) = \mathcal{FT}(OTF) + c\ exp\ (-\pi\ r'/\xi\ r_{max})$ $c = 2 \times 10^{-9}$, ξ=0.7, r_{max}=2048 and r is in pixels.



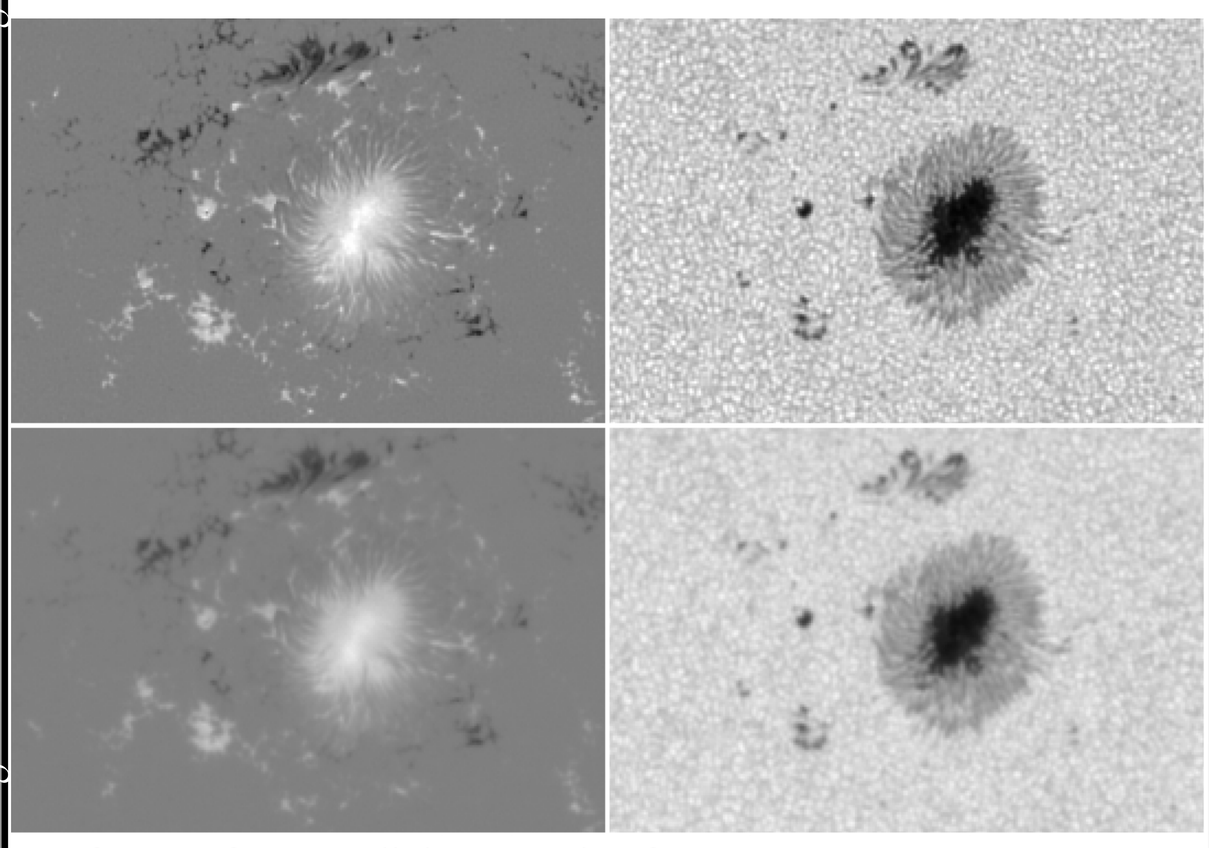
Stray light levels:

~1.7% in Venus disk

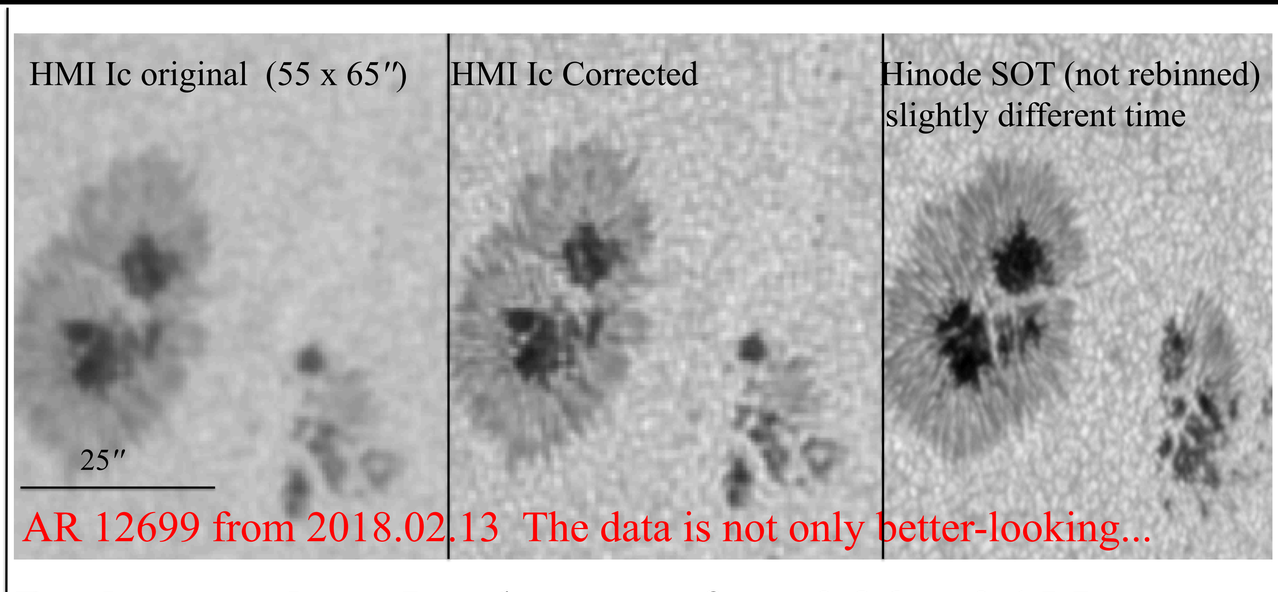
~0.3% 200 pixels off-limb in lunar eclipse.

Wedemeyer 2008 (for Hinode), Yeo et al. 2014, DB&AS 2018 don't account for scattering >10″ away in the PSF.

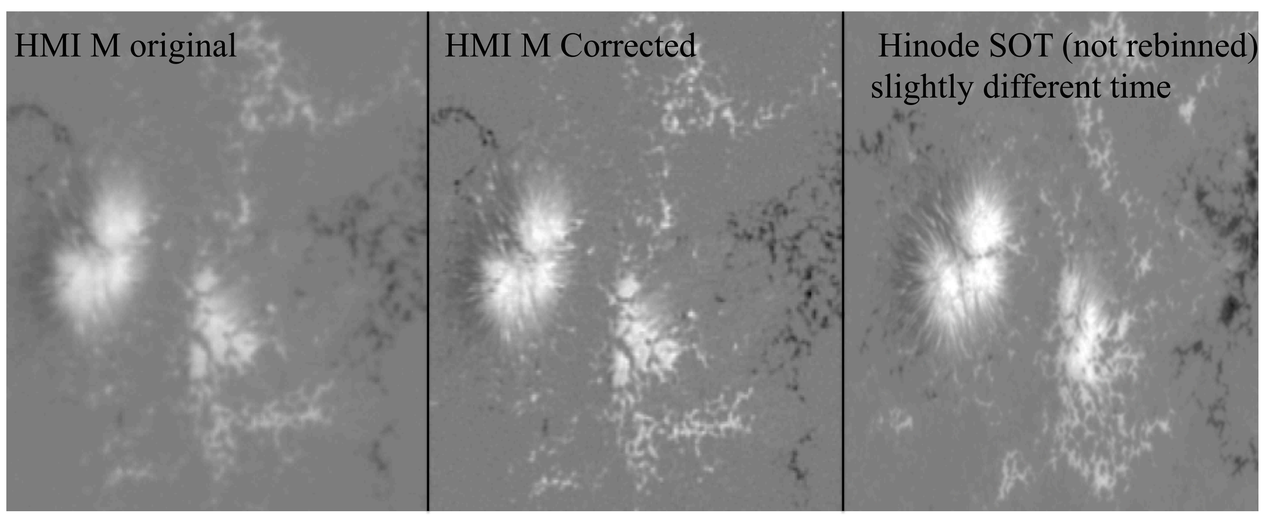
Application C Code runs in JSOC/HMI pipeline and the deconvolution is applied to intensity images, i.e. the 3s filtergrams and 720s summed polarization images, details in Couvidat et al., 2016, *SolPhys*, **291**, 1887.



Before & after stray light correction for a sunspot on 2012.06.06 04 UT. Corrected (top) & original (bottom) M_{LOS} & $I_{c,}$ 350 × 175 pixels.

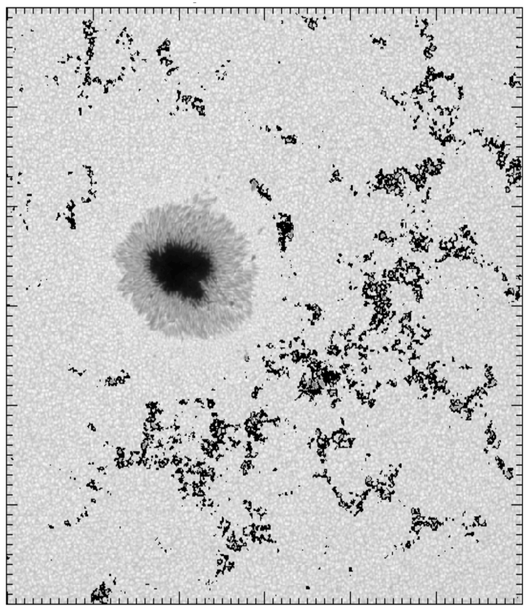


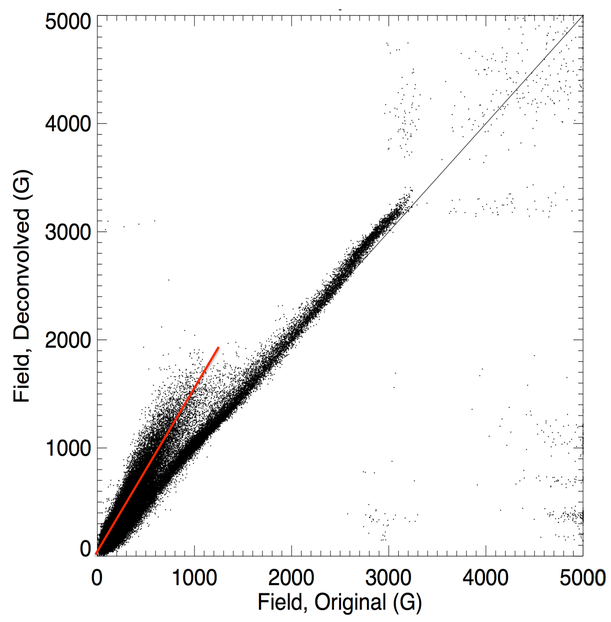
Darkens umbrae I_{min} decreases from 0.26 to 0.15 I_{avg}
Increases granulation contrast from 3.7 - 7.2%



Corrects for convective blueshift Quiet-Sun Doppler velocities show better resolution of downflows in granules.

Increases plage B strength by 1.4 –1.5. Locations of plage are denoted as black points in 600×600 HMI pixel Ic image. Scatter plot of ME solutions for field strengths of original and corrected data are shown. Slope of red line is 1.46.





Penumbra & umbra B are less affected depending on size of sunspot, i.e. larger sunspots show less change.

Díaz Baso & Asensio Ramos (2018) AI Paper:

- DB & AS super-resolve (2x resolution). We don't.
- DB & AS use neural networks trained on simulated data.
- We use measured properties of optics & data.
- Our corrections achieve the same granulation contrast.
- We correct the full disk image (not limited FOV).
- We already provide data *every day* for you!

Summary: Stray light removal brings HMI data into better agreement with Hinode SOT data (see Sainz- Dalda 2017). Please use the new data or ask us to process a time period as needed, email *aanorton@stanford.edu*.

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