

Synoptic 2001 M-TARPs (lines mark month boundaries)

Summary

We are developing complementary tracked active region (AR) data products from HMI and MDI images, indexed by region number and by time. They are intended for subsetting individual ARs, for space weather research, and to facilitate synoptic statistical studies of ARs.

HMI product

HARP = HMI Active Region Patch
Uses 720s (12m) HMI LOS magnetograms + intensitygrams
2300 regions and growing from 2010.05–present
Released on JSOC in 2011 as `hmi.Mharp_720s`
Also available: near-real-time, vector, & space weather products

MDI product

MDI-TARP = MDI Tracked Active Region Patch
Uses 96m MDI LOS magnetograms + intensitygrams
6200 regions from 1996.05–2010.10
Complete (see authors); 2014 release in MDI Resident Archive

Together, the two data products cover May 1996 to the present, and should eventually span two solar cycles.

Large spatially-coherent regions are identified within line-of-sight (LOS) magnetograms and intensitygrams, and tracked from image to image, accounting for merges as regions grow. The data series provide all geometric and heliographic information needed to locate active patches in HMI, MDI and other solar data sets. For each numbered AR, the data series defines at each time step a rectangular CCD cut-out, and it provides a mask within the cut-out indicating the active pixels within a regular, smoothly-evolving blob. Summary keywords such as areas and integrated fluxes are included for each appearance of the region.

Sponsored by NASA's Heliophysics HDEE Program and SDO.

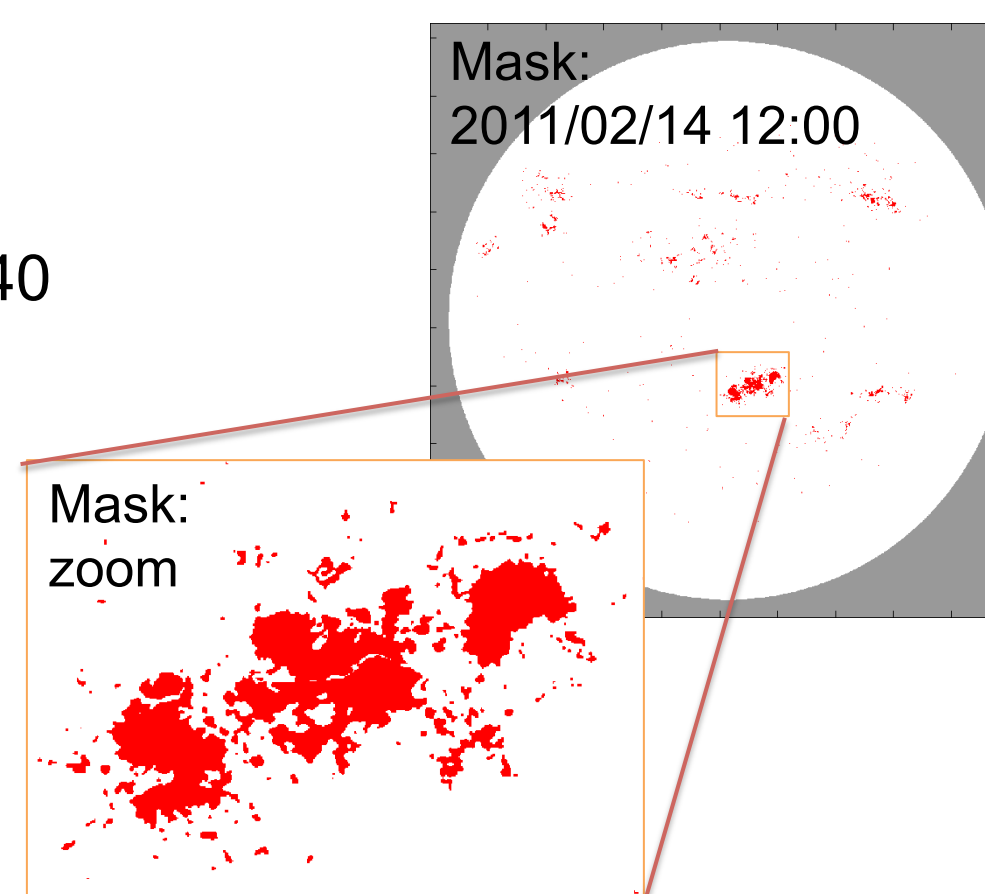
Methodology: Finding Active Regions

- We first compute a full-disk activity mask given input magnetogram and intensity images taking spherical geometry into account (Turmon et al. 2010).
- Bayesian approach trades off pixel-by-pixel agreement of the mask to the data against spatial coherence of labels (a prior).

Mask Model and Example

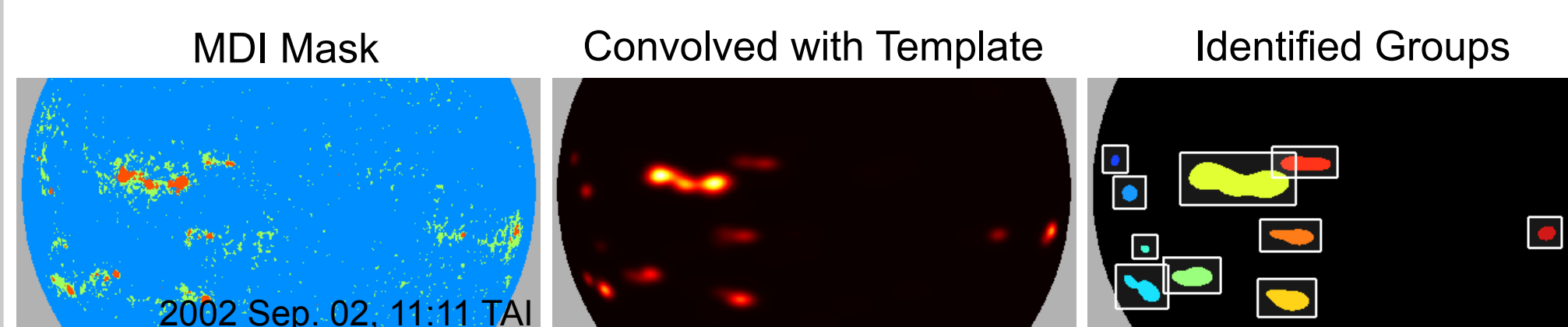
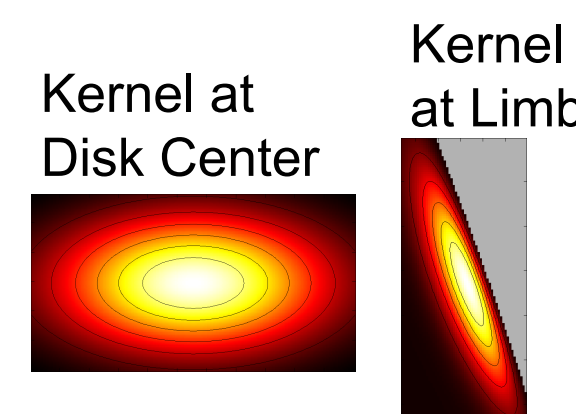
- MDI activity model relates to HMI model by scaling by ~1.40 (Liu et al. 2012).

- Sample HMI mask (right) shows typical mask appearance.



Active Region Grouping

- Group pixel-scale activity from masks into NOAA AR-scale regions
- We use a matched filter approach with an elongated Gaussian kernel of FWHM ~50x25Mm (~40x20 MDI pixels) at disk center.

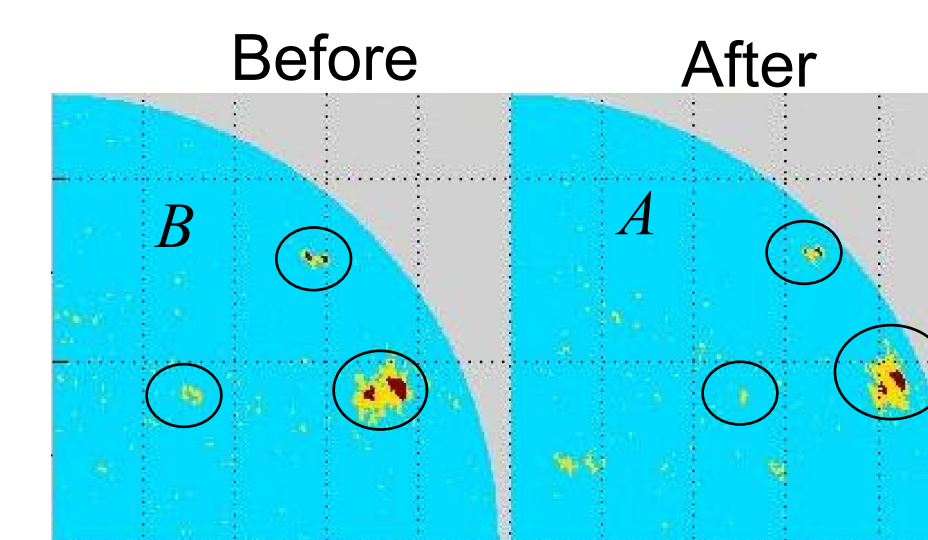


Methodology: Active Region Tracking

- Chain single regions together to make a track.
- Compute the overlap area $D(a,b)$ between extrapolated track (via latitude-dependent motion) and new region.
- Solve *linear assignment problem* to match A up to B:

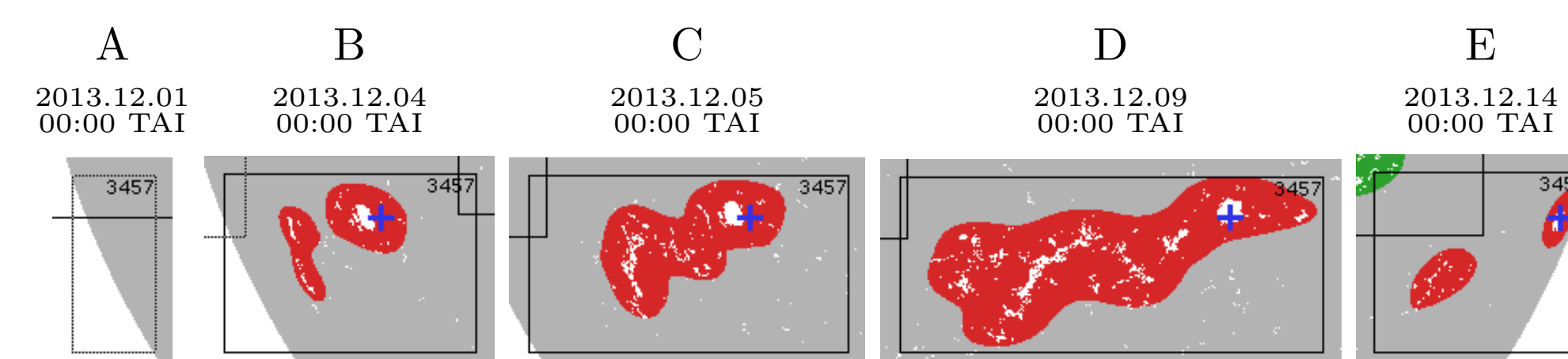
$$\max_P \sum_{a \in A} \sum_{b \in B} P(a,b) D(a,b)$$

where P is a permutation matrix giving the B -to- A mapping.



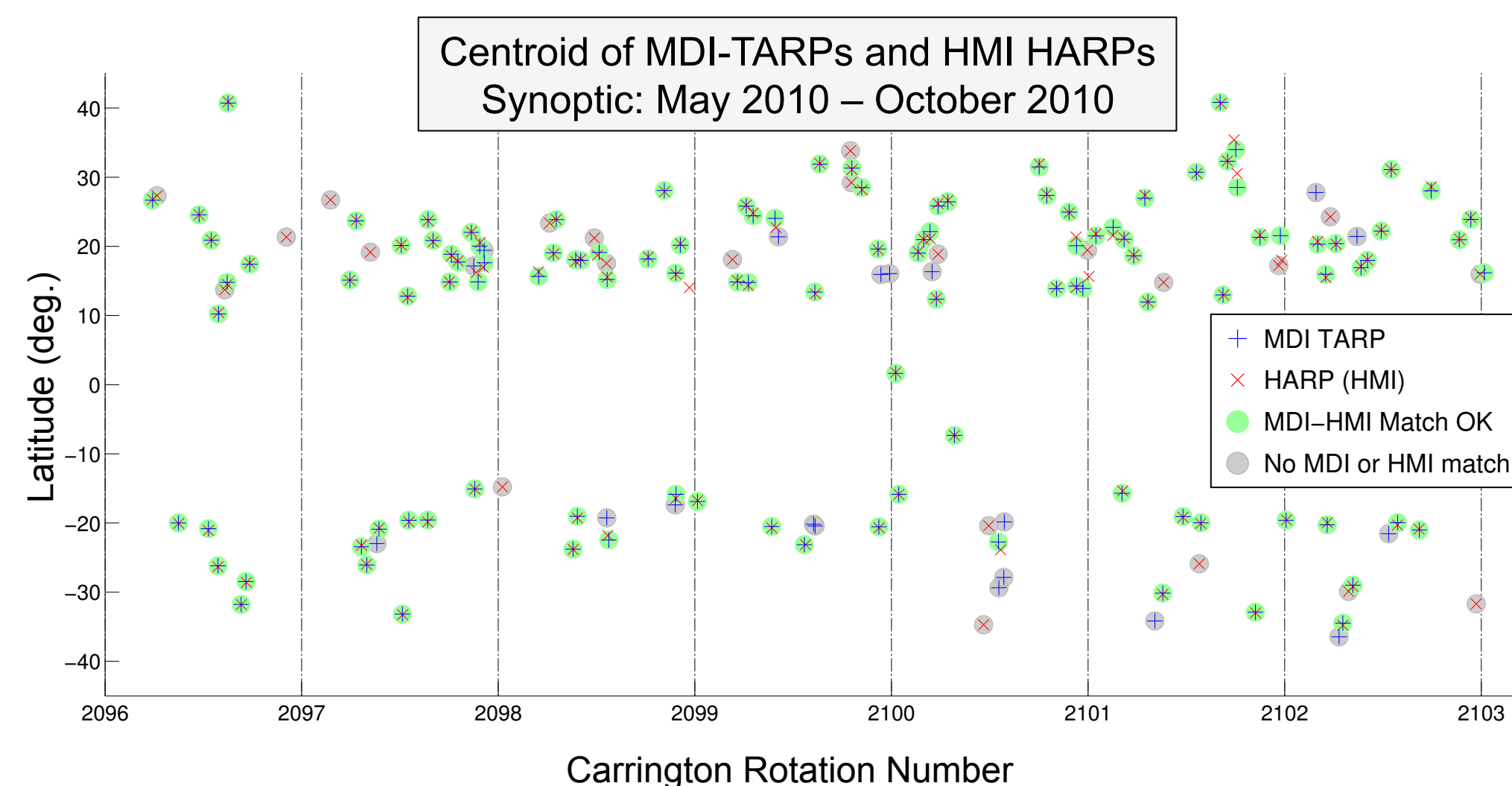
Merging Tracks and Complex ARs

- Tracks are first identified using past and current data. Thus, growing regions may merge in later appearances.
- Coping with the consequences of merges adds complexity to the implementation. This complexity is hidden in the final data product.
- The tracked patch is often not a contiguous region. Use the bitmap to determine what is part of the TARP.
- Below: HARP 3457 (NOAA 11912) with a merge (between B and C) and breakup (E) causing a non-contiguous HARP shape.



MDI vs. HMI Region Correspondence

We used the ~140 ARs in the May–October 2010 overlap to check correspondence between MDI TARPs and HMI HARPs. Comparing location and size, we found 130 matching regions (in green) and ~15 misses (in gray) of each type (TARP present but no HARP, and v/v).

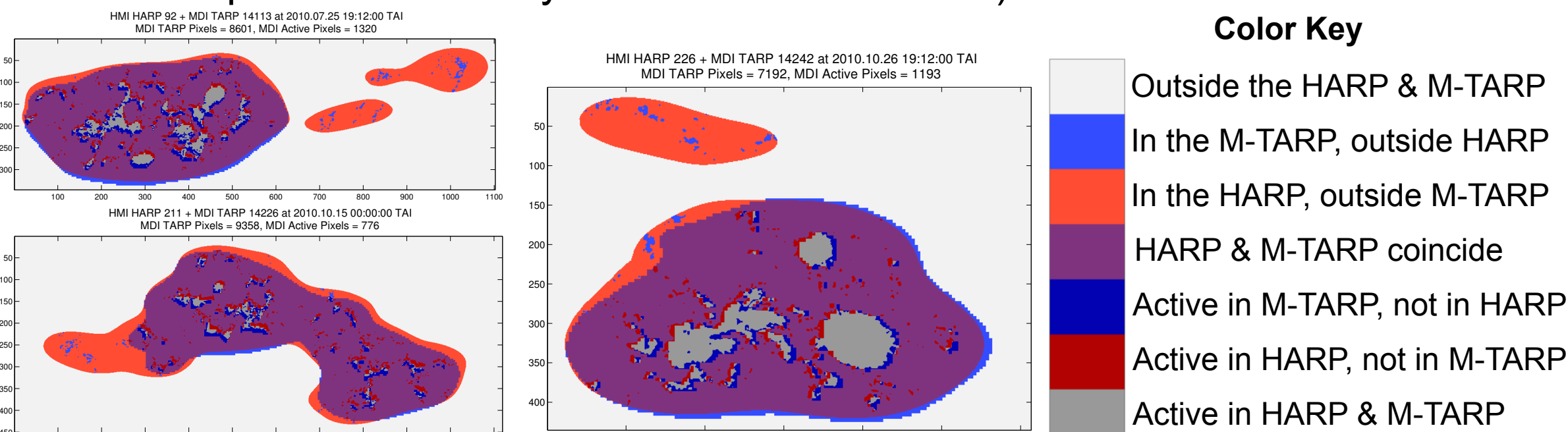


Some extra HARPs are found due to enhanced spatial/temporal resolution of HMI. With current settings, some extra M-TARPs are found due to grouping (see also next panel).

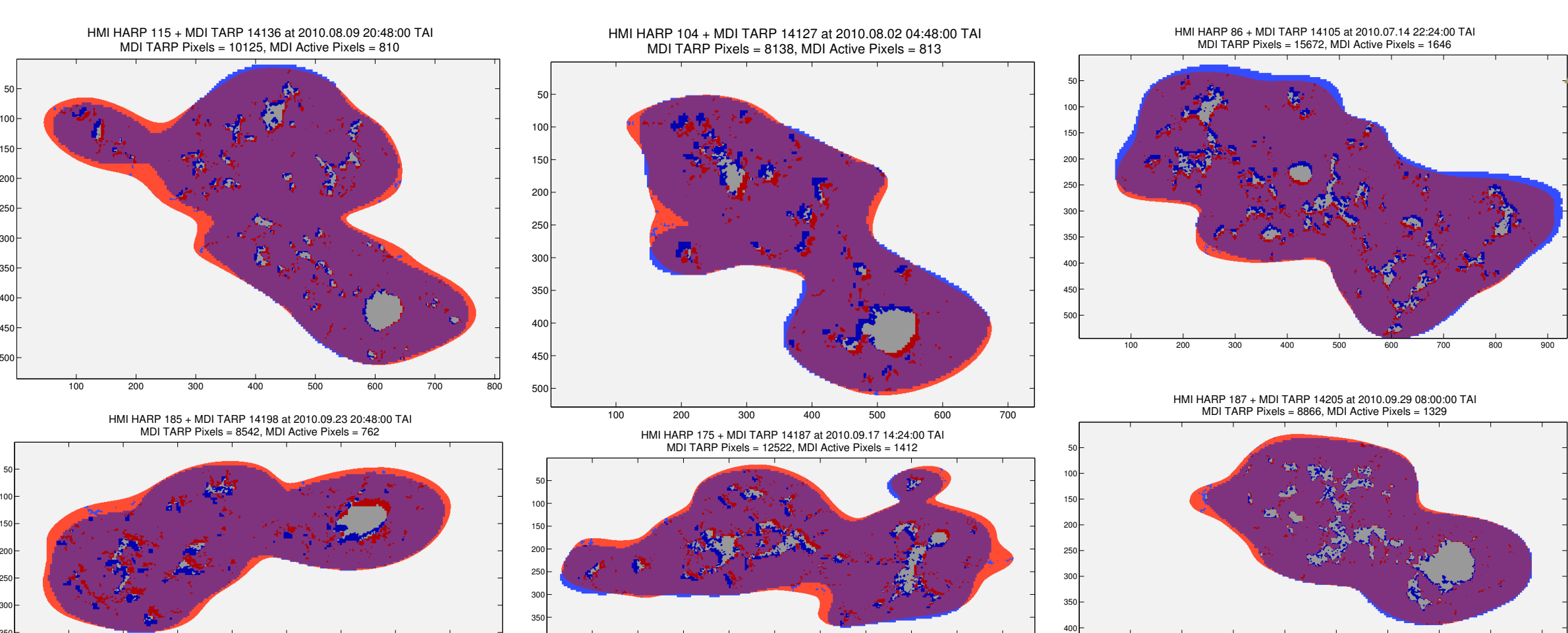
These results are consistent with the good MDI/HMI agreement found by Liu et al. (2012), especially for high LOS B.

MDI TARP vs. HMI HARP Region Boundaries

- For the 2010 overlap, we overlaid the nine largest MDI TARPs over the HMI HARPs, projecting the MDI TARPs into the HMI coordinates by image WCS.
- Some HMI HARPs enclose more activity within one HARP (blue blobs below correspond to differently-numbered MDI TARPs).



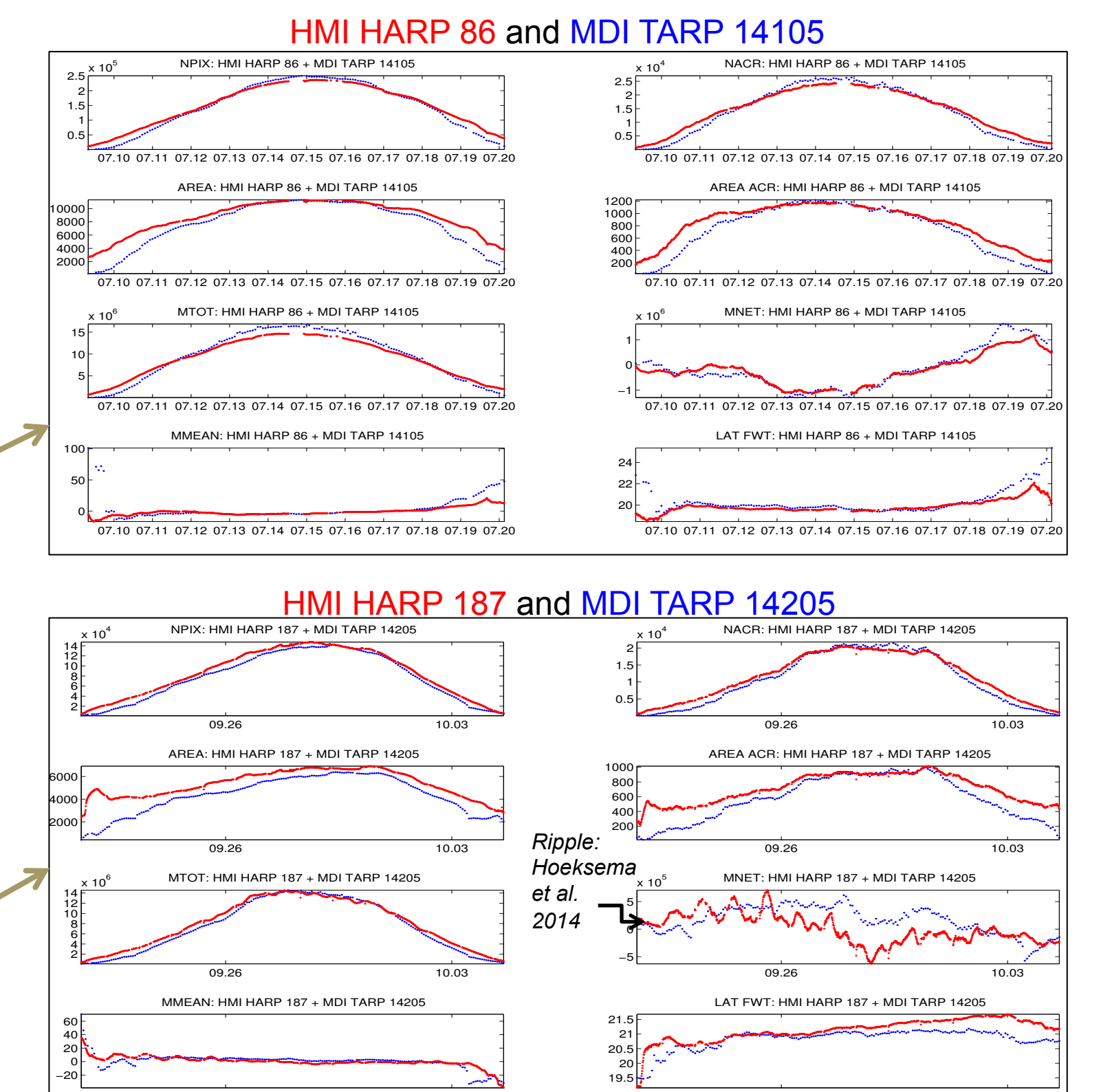
- More typically, as below, the HARP and the M-TARP coincide well.



MDI vs. HMI Summary Statistics

For each HARP/M-TARP at each time, we compute:

NPIX = #pixels in HARP NACR = #active pixels (\leq NPIX)
AREA = HARP area (μH) AREA ACR = active area (\leq AREA)
MTOT = $\sum_{\text{HARP}} \text{abs}(B_{\text{LOS}})$ MNET = $\sum_{\text{HARP}} B_{\text{LOS}}$
MMEAN = MTOT/NPIX LAT FWT = flux-weighted latitude
Below, MDI pixel counts scaled up by 4x4; MDI flux scaled down by 1.40 to account for known MDI-HMI calibration (Liu et al. 2012).



Status and Plans

Improve MDI data product before an expected August 2014 release:

- Better suppression of extraneous patches due to energetic particles.
- Improved correspondence of MDI TARPs to HMI HARPs.
- Identify sunspots within the activity mask.

Planned enhancements of HARP product: synoptic maps; gap filling.

For more on related space weather products, see Bobra et al. 2014.

References

- J. T. Hoeksema et al., "The HMI Vector Magnetic Field Pipeline: Overview and Performance," *Solar Phys.*, March, 2014.
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