

# Space weather at Mercury as observed by the THEMIS telescope from Earth

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## ABSTRACT

The dynamic changes of Mercury's Na exosphere are investigated here, in relation to space weather conditions. Sodium plays a special role in Mercury's exosphere: due to its strong resonance D lines at 5890-95Å it has been observed and monitored by Earth-based telescopes for decades. **Different and highly variable patterns of Na-emission have been identified.** (See the extended dataset images collected from 2009 to 2013 by Earth-based observations performed at the THEMIS solar telescope.)

The reasons for the changes have been studied for a long time. It is shown that long-term variability can be explained by: the distance to the Sun, position in relation to the ecliptic plane, TAA.

Here, the possible reasons for short-term variability are studied: solar wind dynamic pressure and solar UV radiation. Solar wind velocity and density values are propagated with the magnetic lasso method to the position of Mercury from nearby space probes and compared with Na emission intensity. Data of either ACE or one of the two STEREO spacecraft were used, depending on which spacecraft had a smaller angular distance to Mercury.

## SOLAR WIND CONDITIONS @ MERCURY ORBIT

We use 6h averages of unsigned magnetic field data (radial component) measured by MESSENGER and ACE, during 2006-2009. The data is **mapped back to the Sun** and arranged by Carrington longitude of origin- assuming a rotation rate of 25.3802 days. The method is based on a kinetic solar wind propagation model, enhanced by interpolation at resulting dwells. (Fig 1). It can be justified that:

- In the OMNI data there are **recurrent variations of the magnetic flux, lasting for several years** (declining phase of solar cycle 23) A detailed study shows that these flux enhancements are CIRs (Dósa and Erdős, 2017).

Comparing fluctuations at 1 AU with solar wind data of **MESSENGER** at about **0.5 AU** the following is found (correction by  $r^2$  applied):

- MESSENGER data shows roughly the same stripes of enhancements during 2006 (~ at 1 AU).
- MESSENGER data shows the 3 stripes of enhancements during 2007, but **the amplitude is smaller** (~ at 0.6 AU)
- MESSENGER data does not show stripes of enhancements in 2008.
- accumulated flux for each longitude shows **the same trend as OMNI data** at 1 AU, but **the fluctuations are smaller nearer to the Sun** (Fig 2).

Near the Earth, the strength of the radial magnetic field is one of the main factors of geoeffectiveness. Near Mercury, the gradients of the radial magnetic field are smaller, thus magnetic field plays a lesser role.

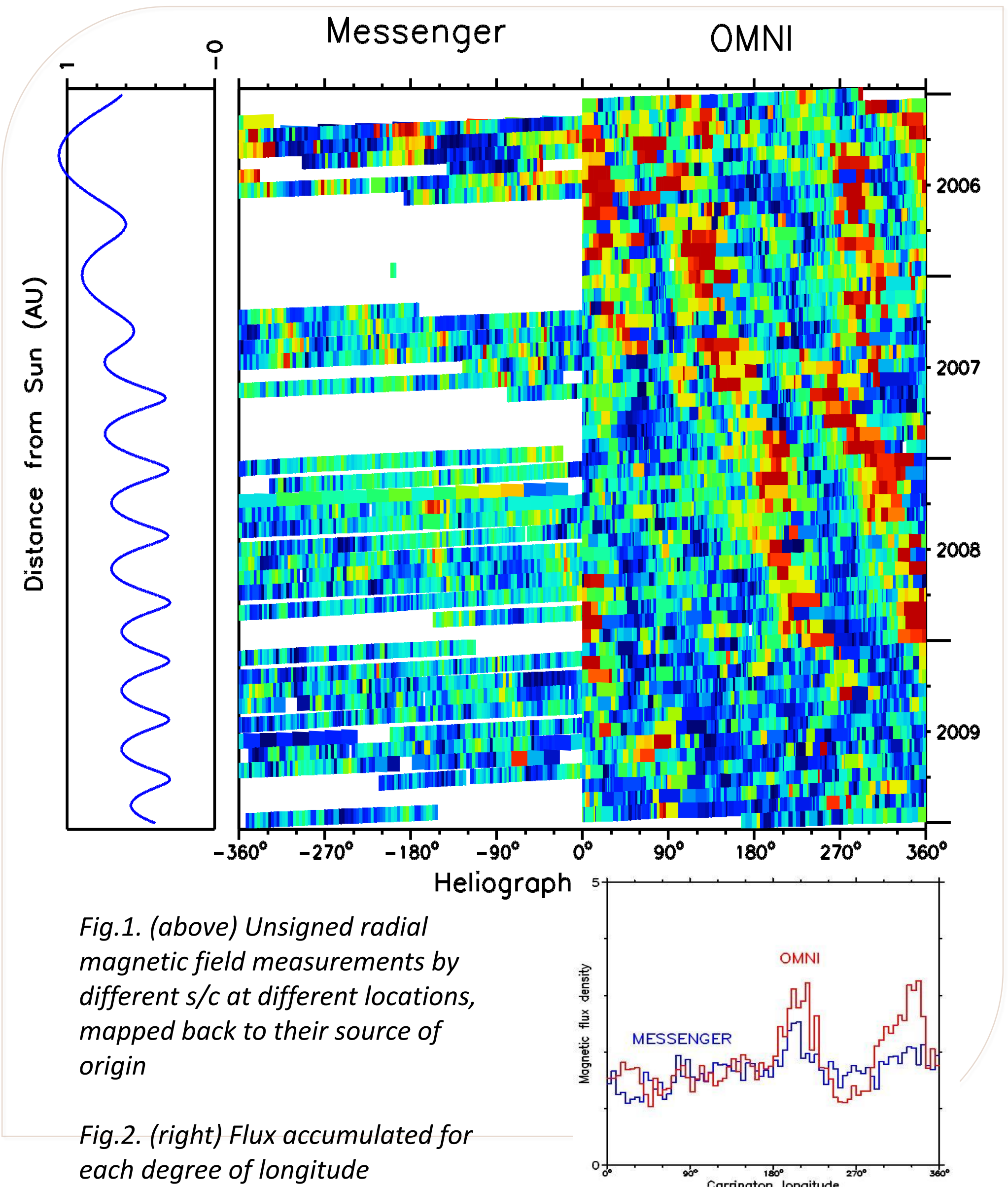


Fig.1. (above) Unsigned radial magnetic field measurements by different s/c at different locations, mapped back to their source of origin

Fig.2. (right) Flux accumulated for each degree of longitude

## CASE STUDY: 7-9th June, 2012.

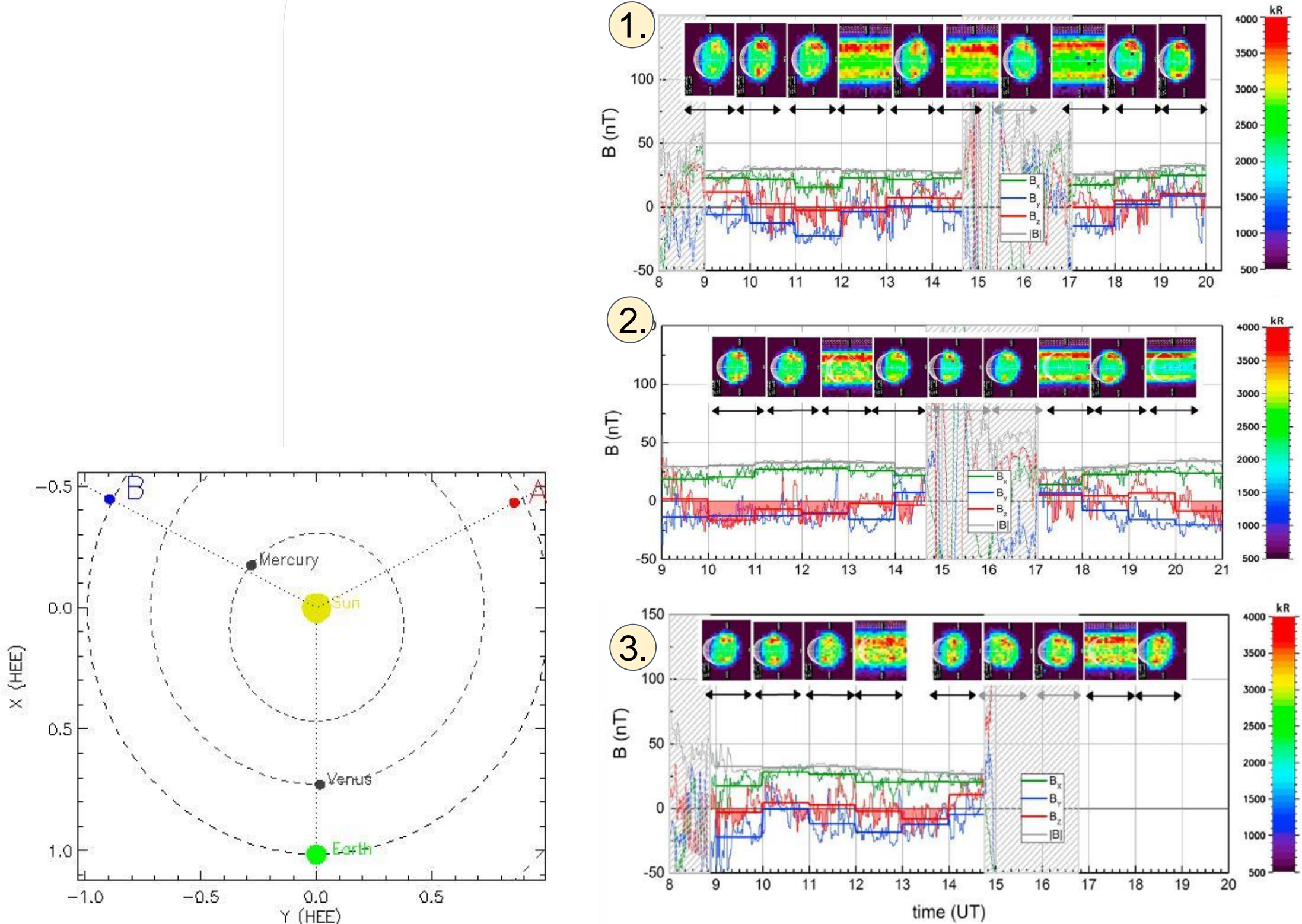


Fig.3. Positions of Mercury and solar wind data providing STEREO-B and near Earth s/c

Fig.4. THEMIS images of Na-escape and MESSENGER B-field data (Massetti, 2017)

Thanks to STEREO-B being located close to Mercury, the propagation of solar wind parameters measured by ST-B could be carried out with a high reliability. Below, the propagated solar wind velocity and density for 7-9th June. Lighter colours mean the time span, coinciding with that of THEMIS images. The small rise in velocity and density corresponds to a rise in Na-escape intensity (Fig.5.)

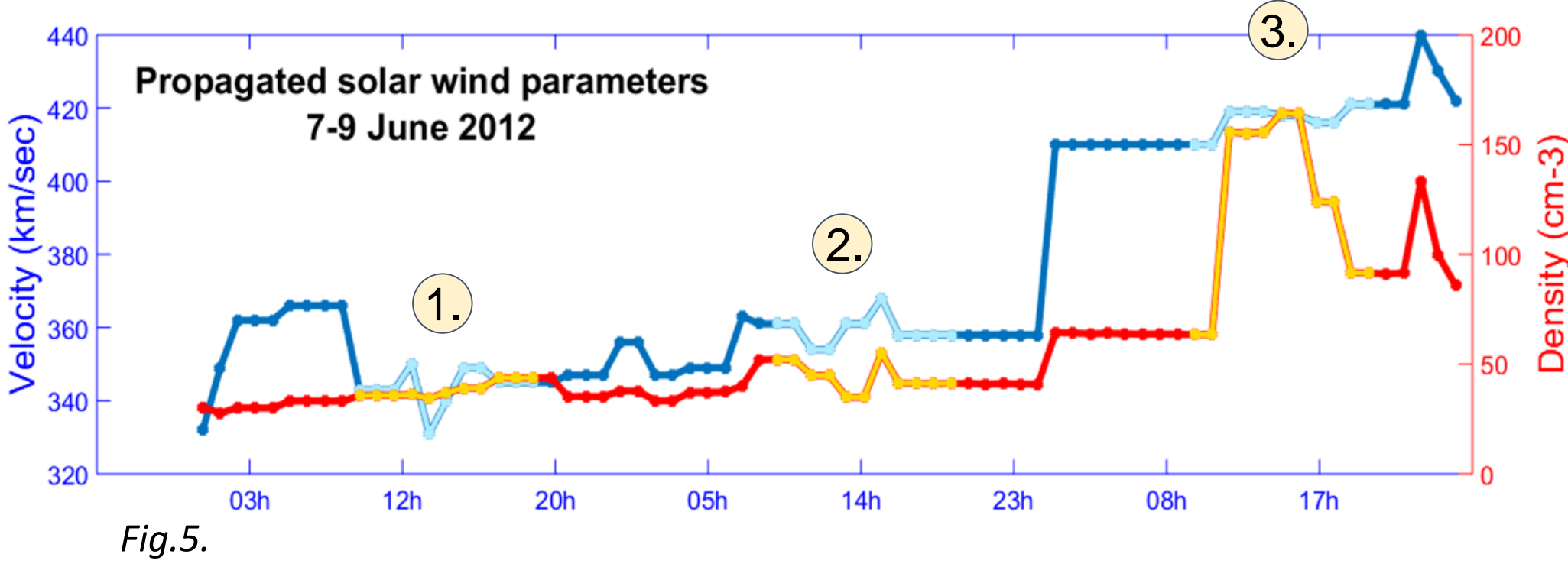


Fig.5.

## EM radiation environment

Solar UV radiation does not vary with time in such a rapid manner so that it could explain Na emission. X-ray emission on the other hand does, but its variations have a smaller amplitude.

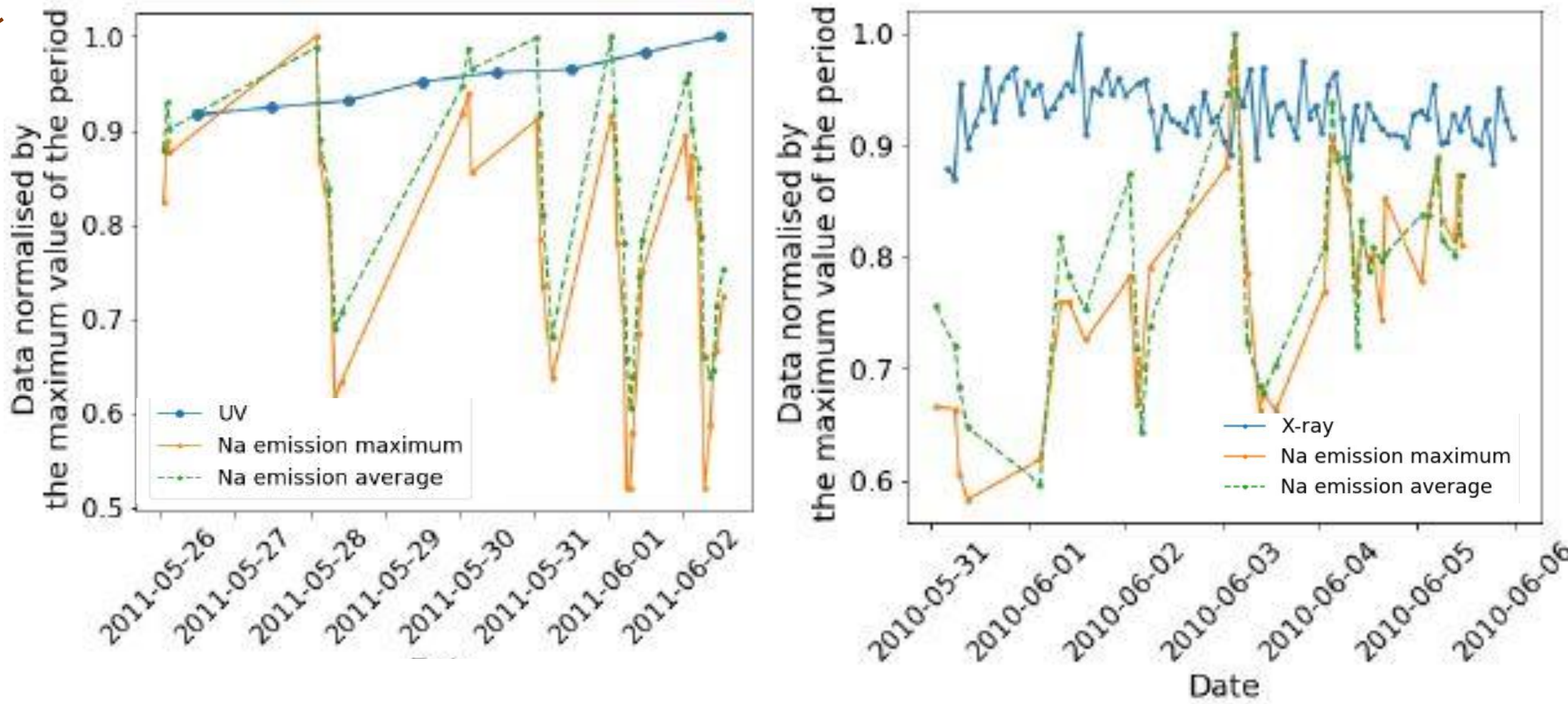


Figure 6-7: The comparison between solar wind pressure and Na-emission. The Na-emission maximum represents the maximum value of the emission on a given day while its average is the emission summed over all pixels representing the emission from Mercury divided by the number of such pixels. I plotted the normalized value for each curve since we are interested in the connection between the changes in them. Also because the measured quantities are on different scales of magnitudes.

## CONCLUSIONS

- Magnetic flux enhancements so typical near Earth are not yet evolved sharply at the orbit of Mercury.
- A case study is carried out to interpret THEMIS images taken on 7-9th June, 2012. Based on STEREO-B measured solar wind data, bulk velocity and density were propagated to the location of Mercury. A small rise in velocity may correspond to a rise in Na-escape intensity.
- 10 further cases were analysed and Na-emission compared with propagated solar wind pressure. 3 cases show some correlation, the rest does not.
- Solar UV radiation cannot explain Na-emission changes. We have a higher resolution data for X-ray radiation - this should be further analysed whether the peaks coincide with increased Na emission.

## REFERENCES

Massetti, S., V. Mangano, A. Milillo, A. Mura, S. Orsini, and C. Plainaki (2017), Short-term observations of double peaked Na emission from Mercury's exosphere, GRL 44, 2970–2977, Dósa and Erdős (2017), Long-term longitudinal recurrences of the open magnetic flux density in the heliosphere, ApJ Vol 838, 104 Gőrgői, A. M.: Mhd classwork