MID-LATITUDES EXOSPHERIC Na DISTRIBUTIONS ALONG THE MERCURY ORBIT

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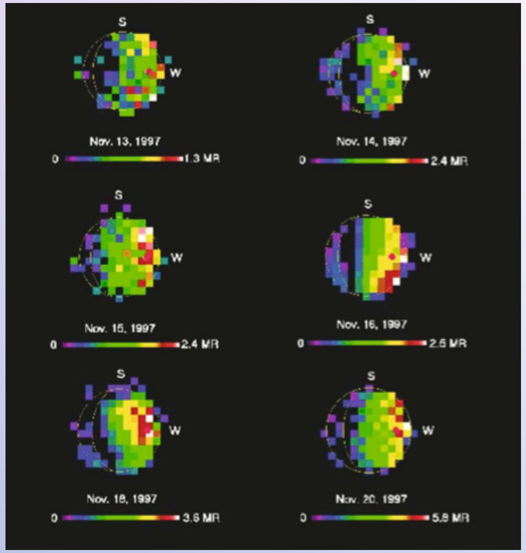
2 INAF/OATS, TRIESTE

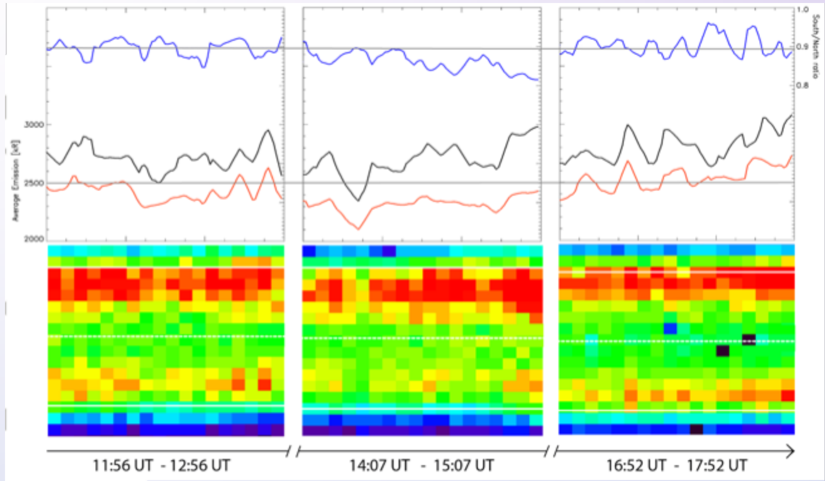
2 ASI, ROMA

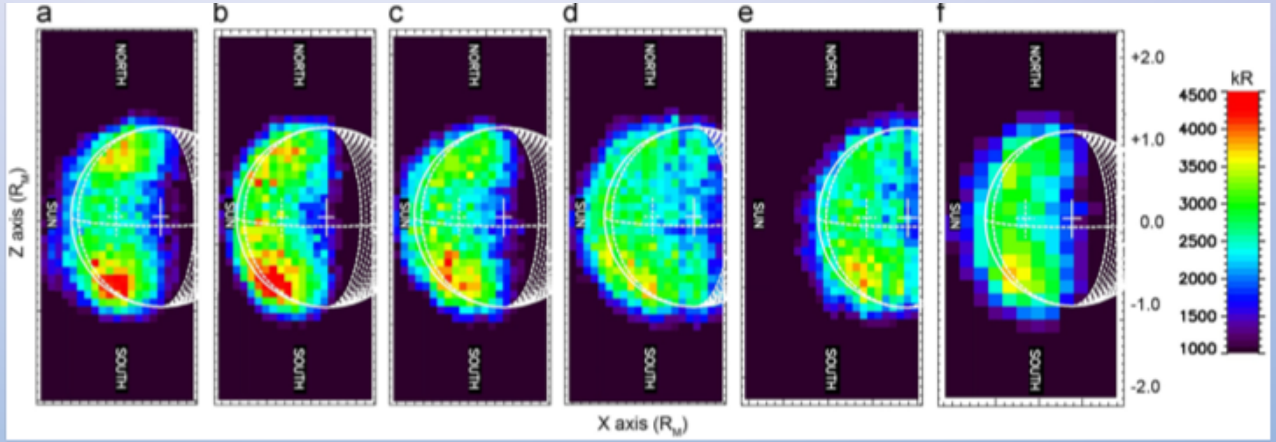
NA VARIABILITY FROM GROUND-BASED OBSERVATIONS

Different Na patterns observed (e.g.: Potter et al. 1999; Mangano et al., 2013)



Short time variability observed by THEMIS (Massetti et al 2017)





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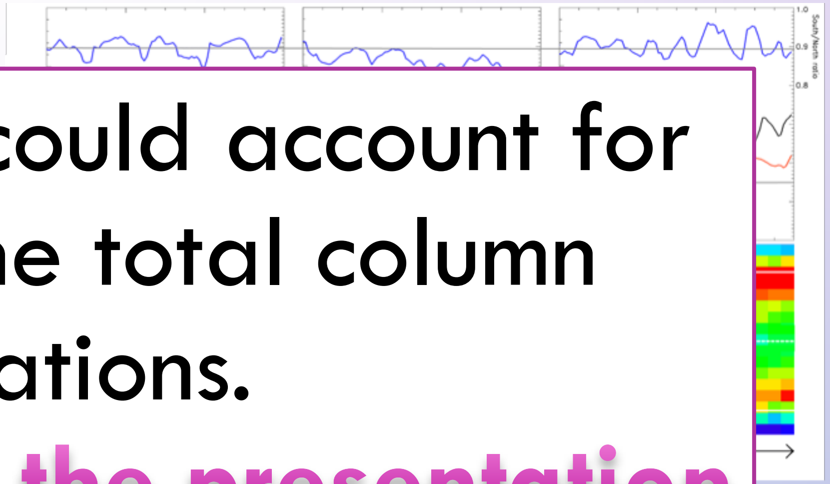
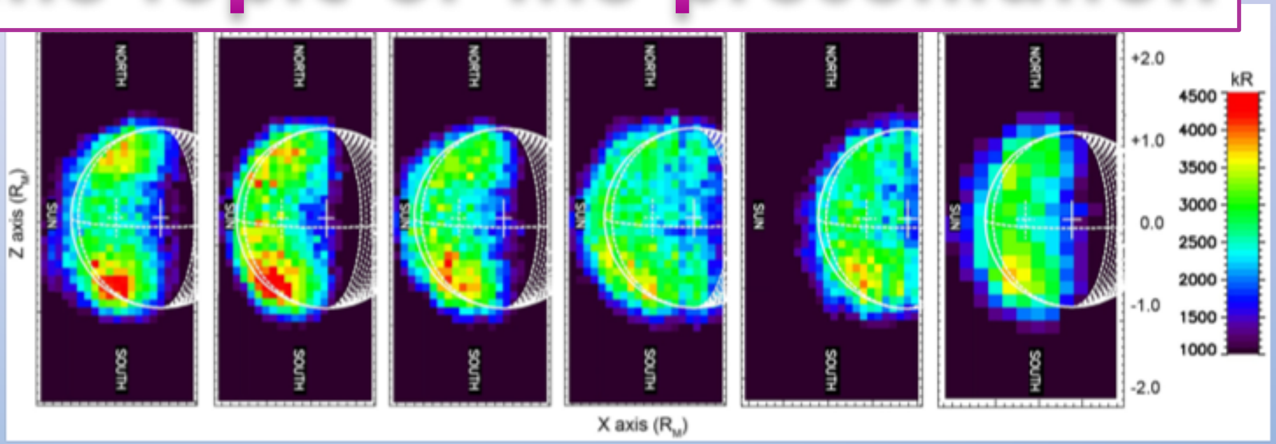


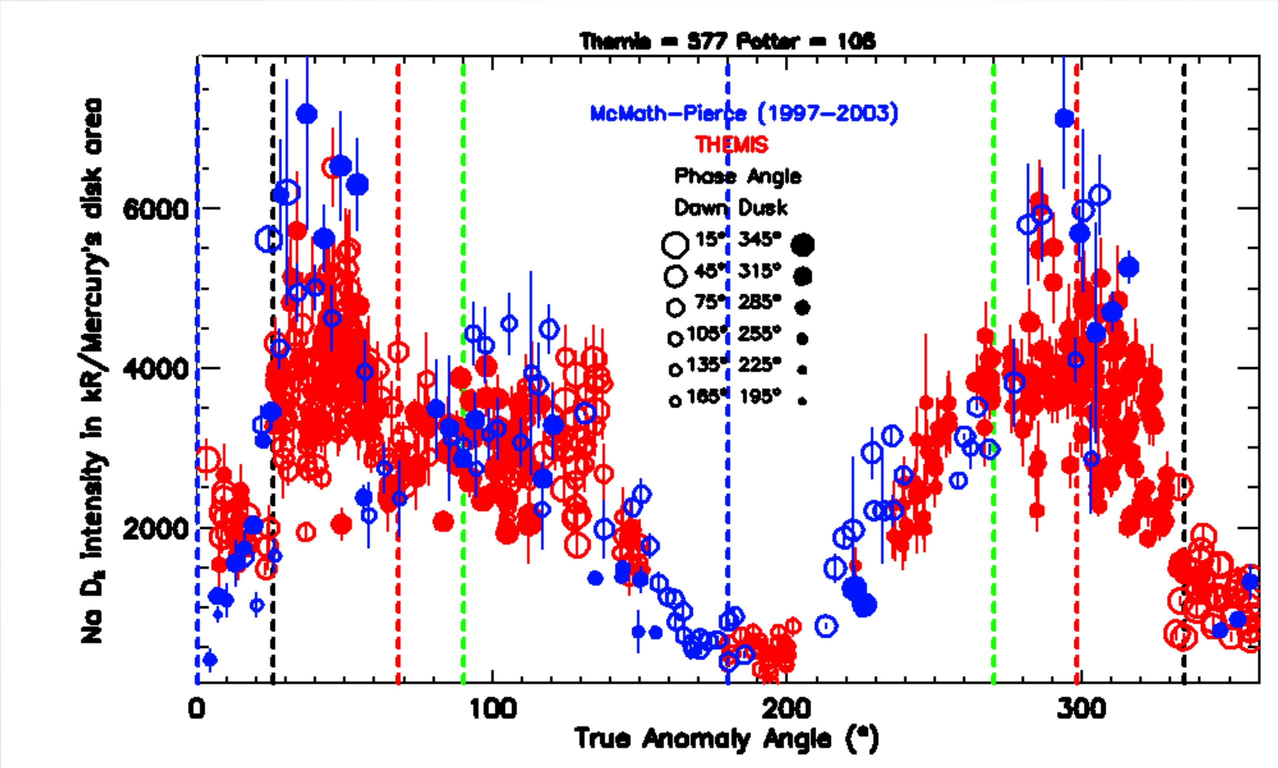


Short time variability could account for about 10-20% of the total column density variations.

This is not the topic of the presentation

GROUND-BASED OBSERVATIONS VS TAA

Disk Na emission along the Mercury's year:



Courtesy of F. Leblanc (data from THEMIS and McMath-Pierce: *Potter et al 2007*)

Most of the observed variability along the year is due to the variation of the g-factor, *g*, that is, the rate at which Na scatters solar photons (unit: photons/(atoms s))

Ground-Based Observations vs TAA

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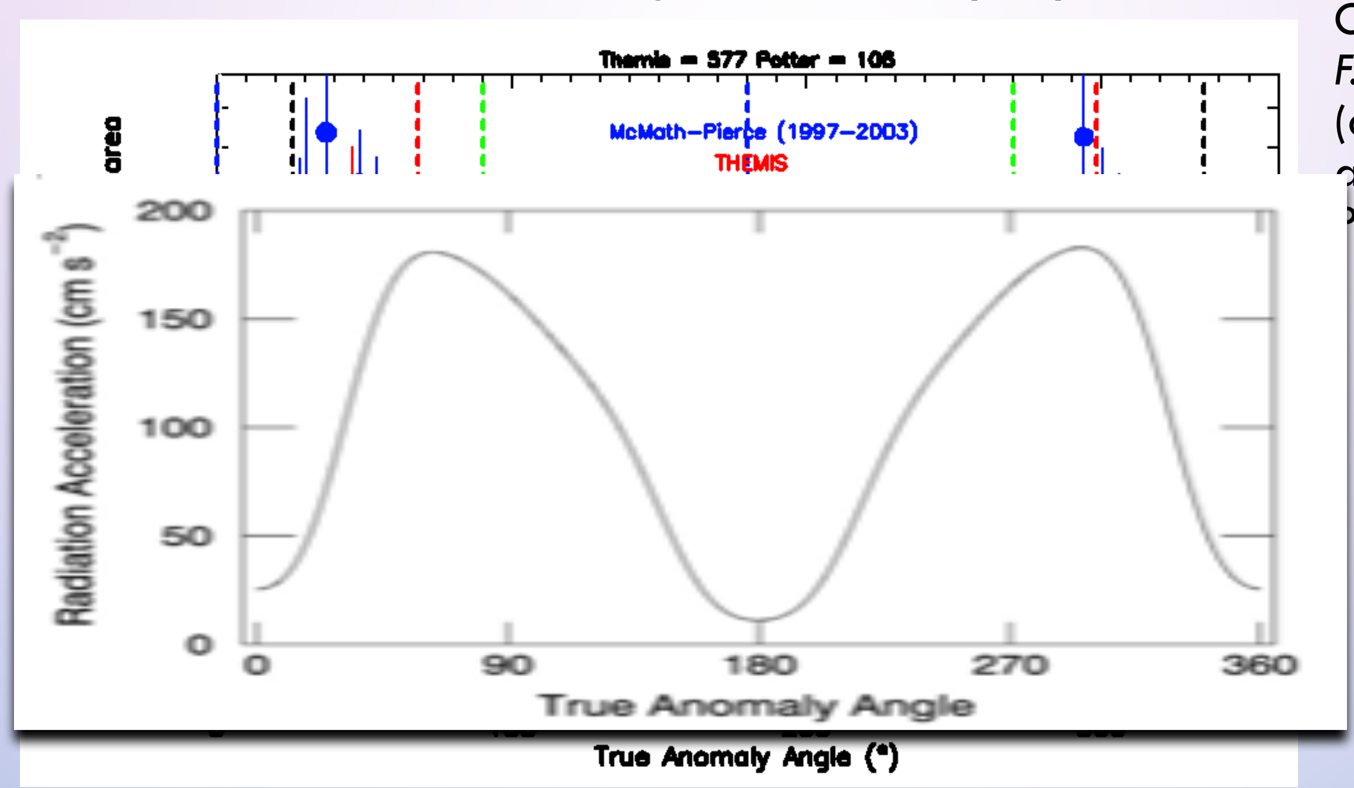

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For a quantitative analysis of the Na exosphere variability the observations **must be converted in column densities** (**CD** unit: atoms/cm^2)

New THEMIS Data Analysis

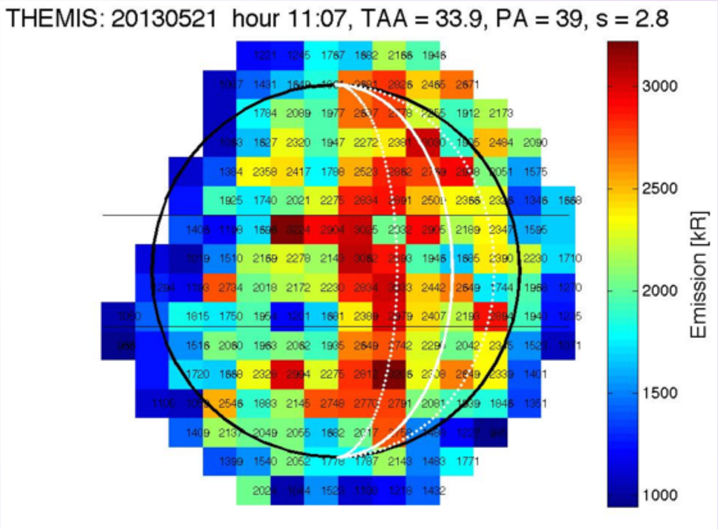
THEMIS D2 images obtained between 2009 and 2013.

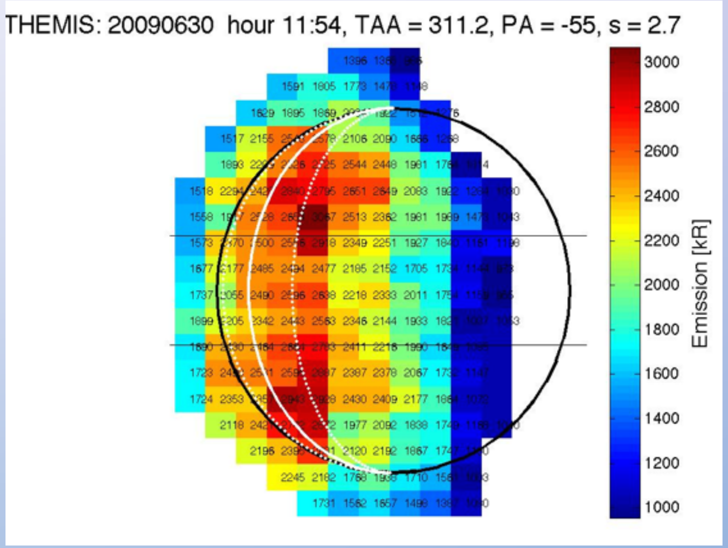
Selection in **latitude**:

- equatorial region -0.3 Rd<r<+0.3 Rd
- northern region r > 0.3Rd
- southern region r < 0.3 Rd

Selection in **local time** at the equator:

- From dusk terminator to +20° longitudes from subsolar point
- From dawn terminator to – 20° longitude from subsolar point
- Subsolar region between + and- 20°





New THEMIS Data Analysis -> Focus on High Latitudes

THEMIS D2 images obtained between 2009 and 2013.

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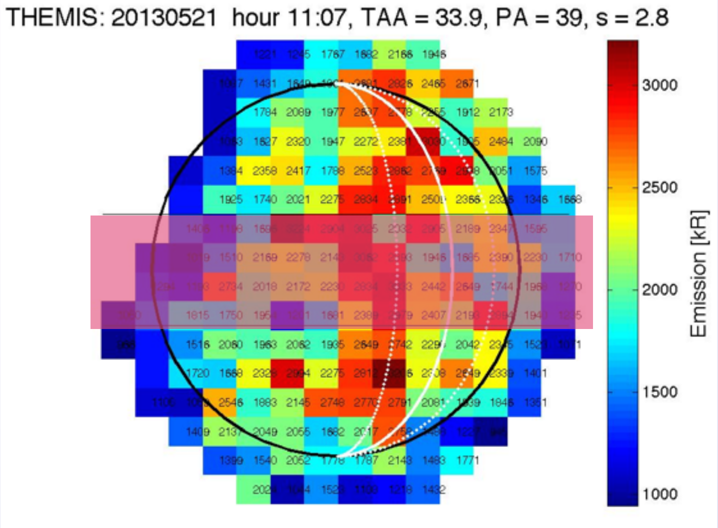
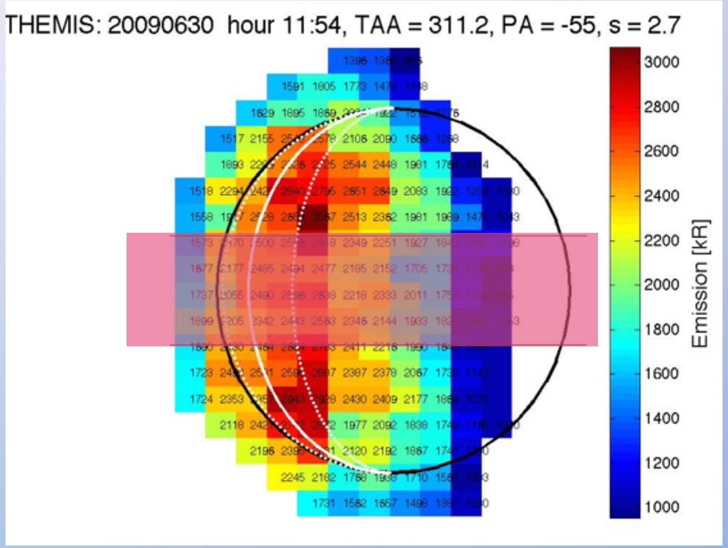




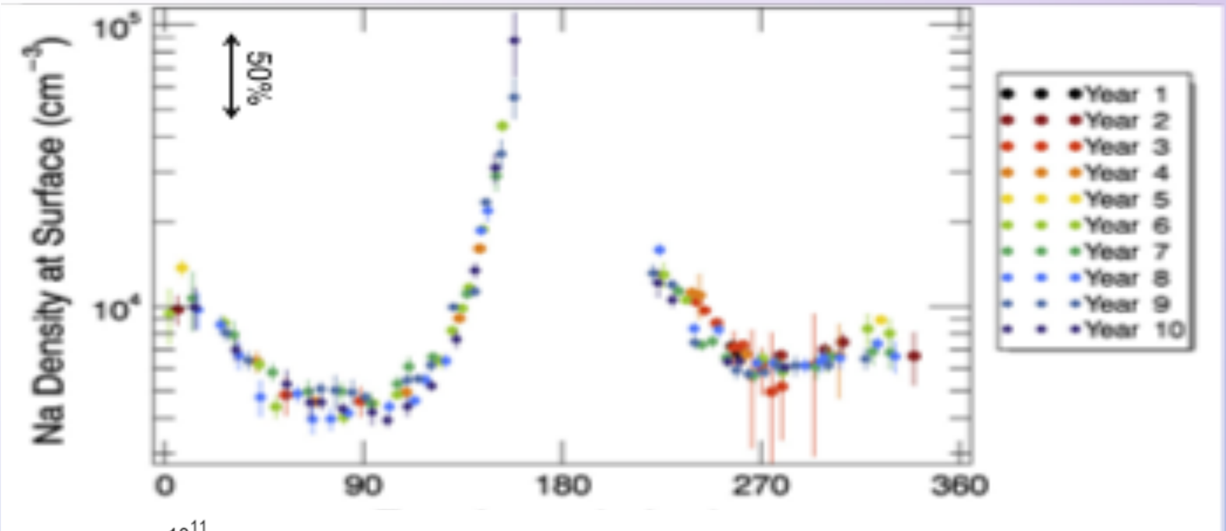
Equatorial Na Density

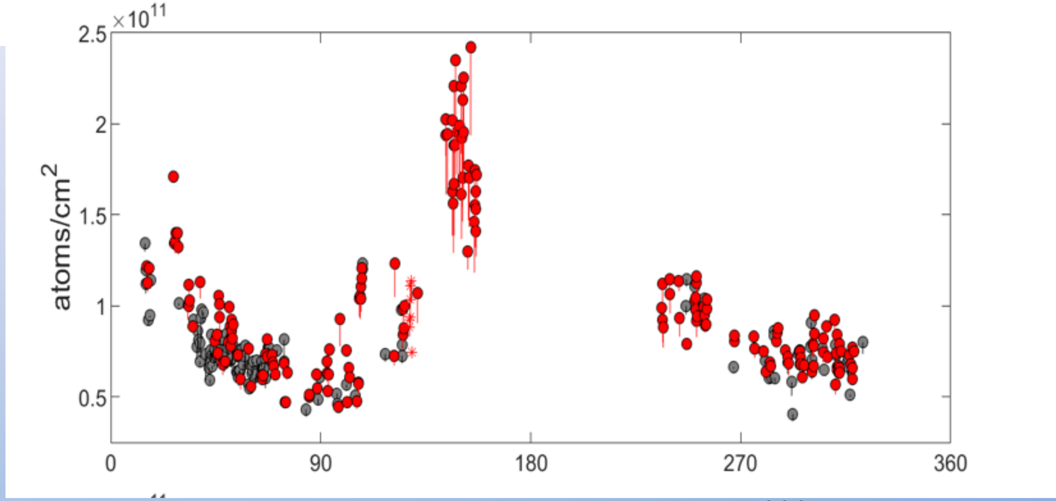
Cassidy et al. (2015) found that there is a general **increase in Na exosphere while approaching the perihelion and aphelion** as noted by *Potter et al (2007)* from ground-based observations.

It could be related to the lowest value of radiation acceleration and photoionization, hence to the lowest Na exosphere loss rate.

Our result is in **good agreement** with the MESSENGER ones.

In the Figure the red circles are the equatorial CD plotted when they are higher than disk averages. Grey circles are disk averages plotted when they are higher than equator. Lines show the difference between the two values

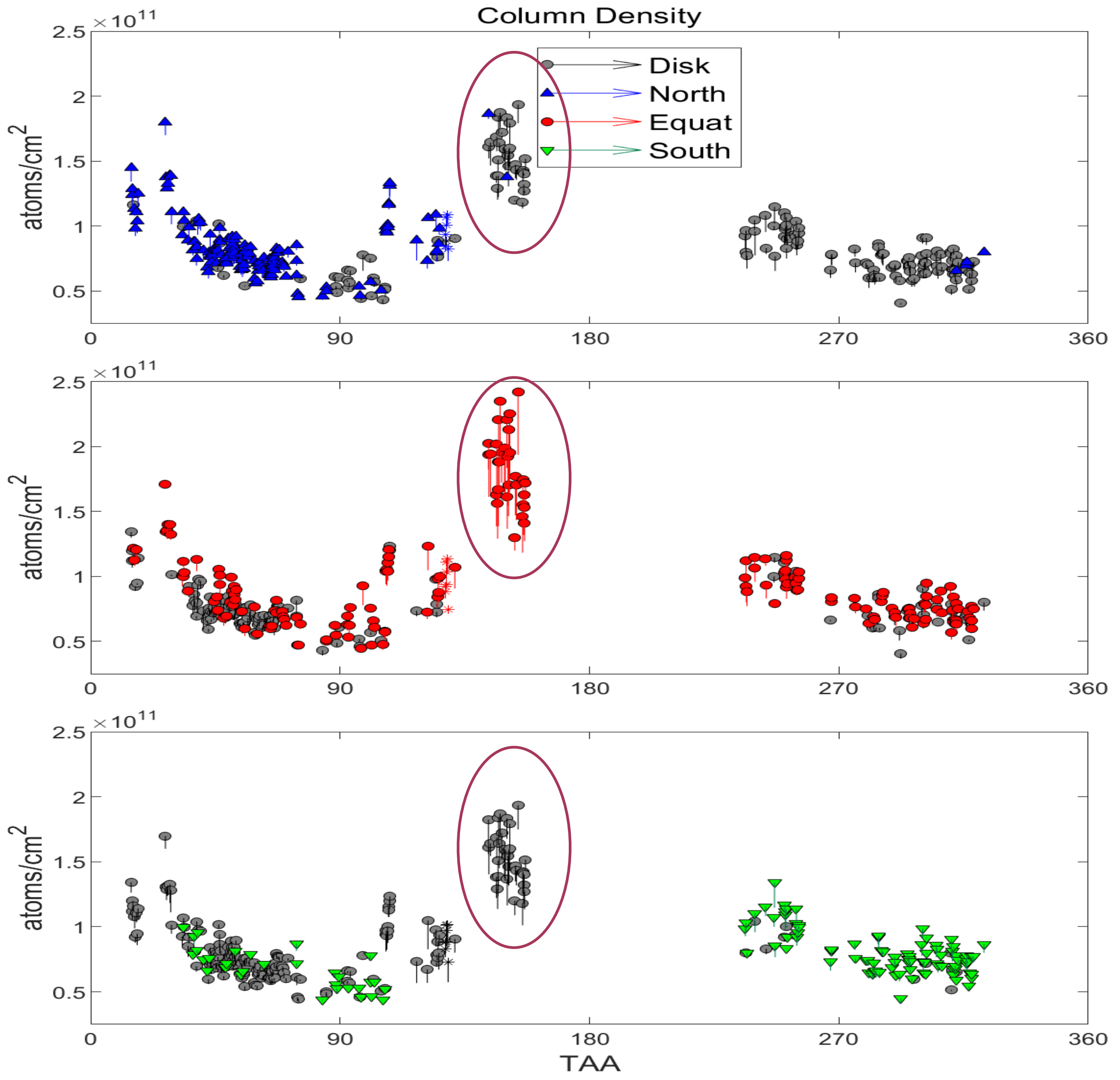




High Latitudes Na Density

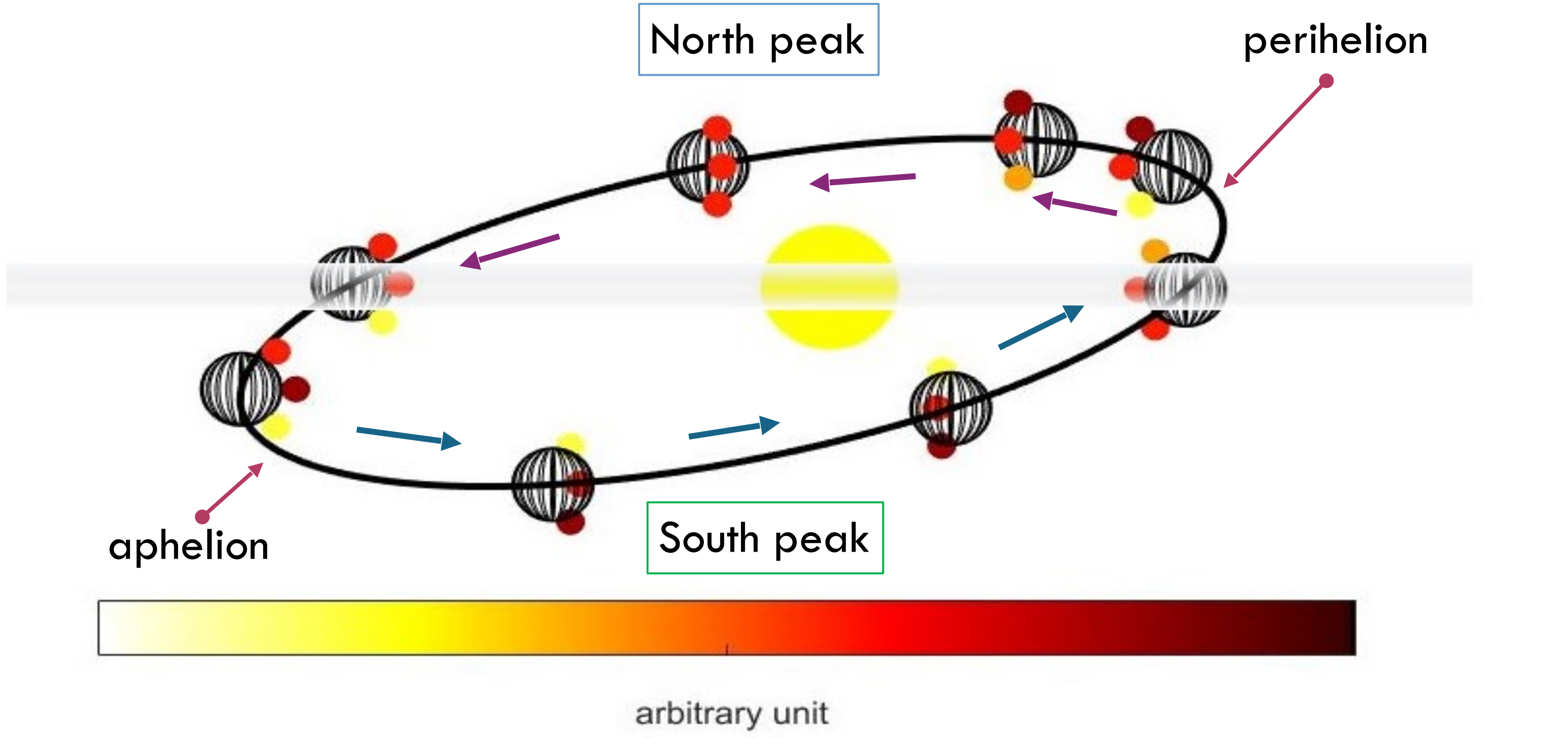
At aphelion, we find a similar but **less marked trend at higher latitudes.** Different effects seem to contribute.

The blue triangles/ red circles/ green triangles are the North/ Equatorial/ South CD plotted when they are higher than disk averages. Grey circles are disk averages plotted when they are higher. Lines show the difference between the two values



UNEXPECTED NORTH – SOUTH ASYMMETRIES ALONG THE ORBIT

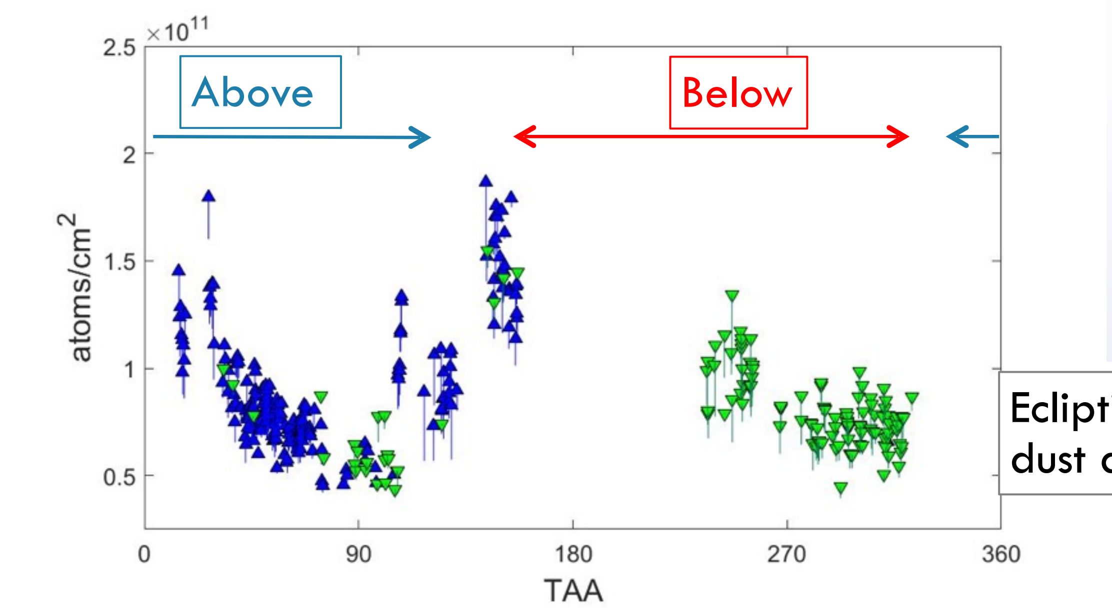
The **Northern** emission is generally **higher than the disk average from the perihelion phase toward aphelion** (**outbound**), while the **Southern** emission is **higher in the TAA range 225°-315°** (**inbound**).

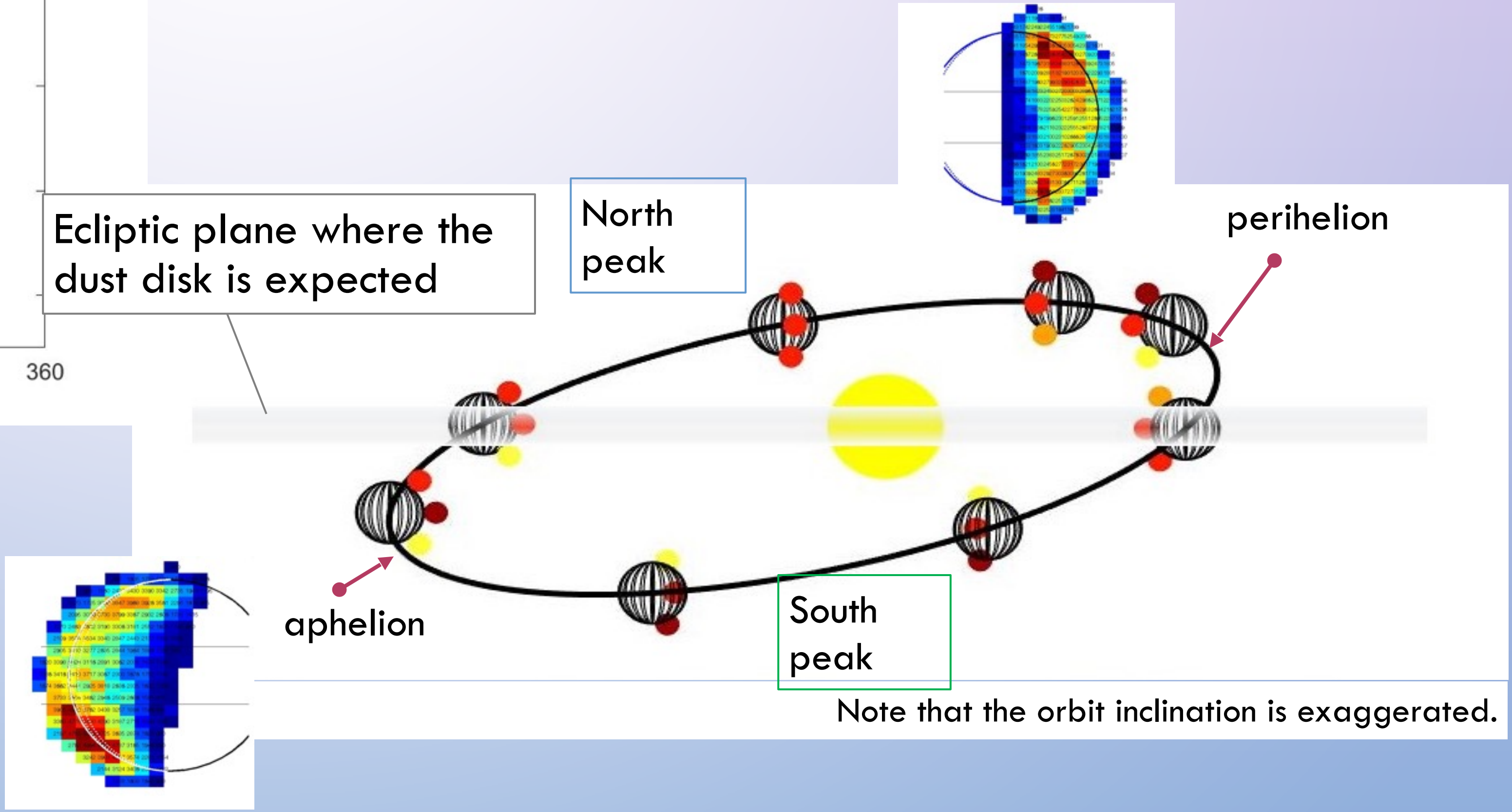


Note that the orbit inclination is exaggerated.

UNEXPECTED NORTH – SOUTH ASYMMETRIES VS SPACE ENVIRONMENT

Northern peaks are generally **higher above the ecliptic plane** and **Southern peaks below**





It seems that micrometeoroid impact vaporization is not the major driver of Na release

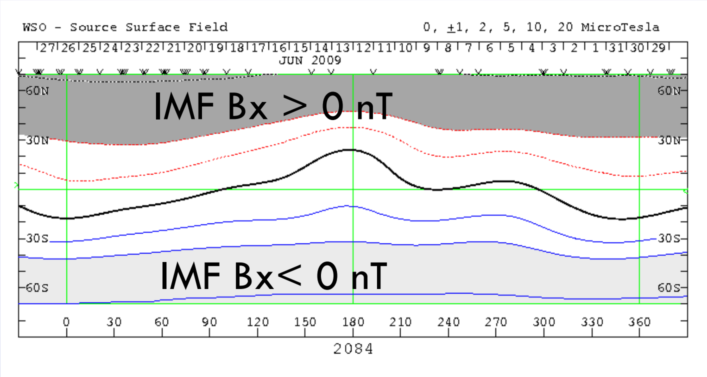
Na N/S Asymmetries vs Solar Magnetic Field Polarity

IMF Bx< 0 nT induces preferential Northward solar wind precipitation; while IMF Bx> 0 nT Southward (Sarantos et al. 2001; Massetti et al. 2003)

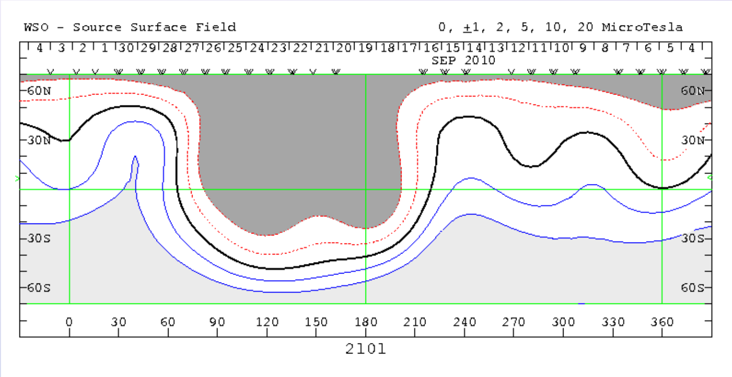
The IMF Bx component follows the heliospheric current sheet wrapping. A distinct difference in polarity vs solar latitude is visible only at solar minimum.

So, **it is difficult to see a relation with the IMF B_x component.**

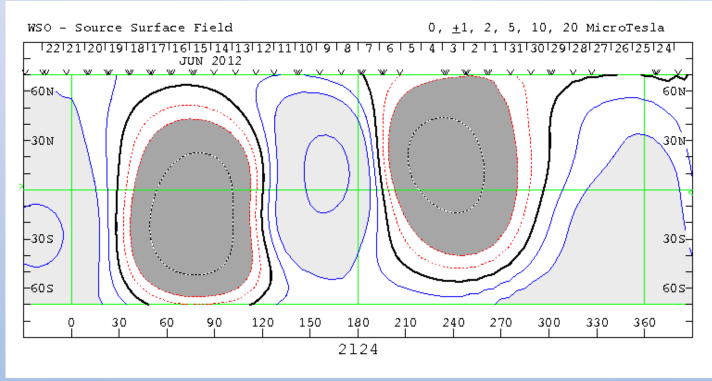
Some examples of extrapolated coronal magnetic field polarity during some years of the solar cycle 24



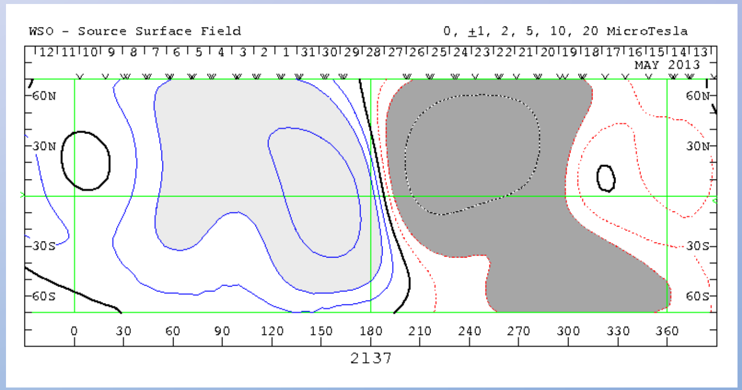
2009



2010



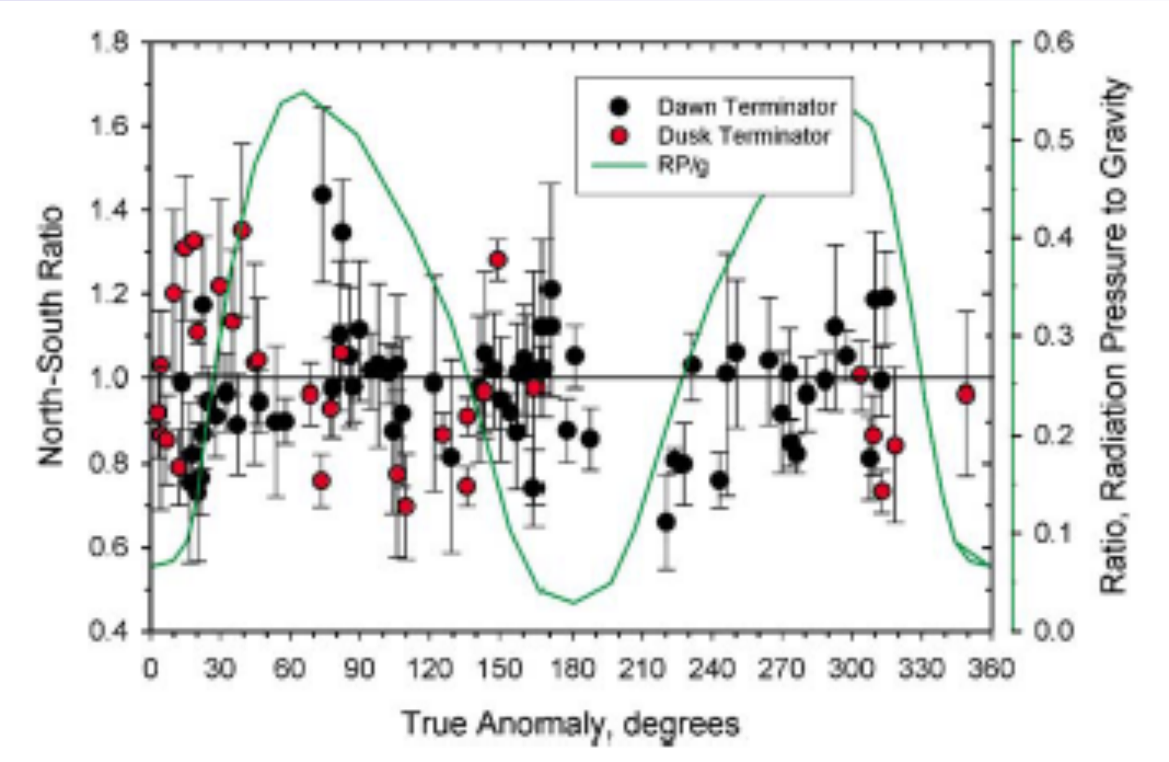
2012



2013

Asymmetries N/S vs Local Time

- Mangano et al. (2015) showed that the **Northern emission is predominant in the dawnward view,** while the Southern emission is predominant in duskward view. But our data set includes mostly dawnward view in the first half of the year and almost only duskward view in the second half of the year.



MMP observations (1997 and 2003) showed the **opposite relation: Southern peak predominance** for the **dawnward** observations (Potter et al 2006). But Southern peak prevalence could be related to most of observations at dawn in the inbound part of the orbit.

CONCLUSIONS

- On average the **North/South CD is higher in the outleg/inleg half year;**
- **North/South CD is higher above/below the ecliptic plane;**
- **North/South CD is higher in the dawnward/duskward view;**
- **It is difficult to see a relation with the IMF Bx component;**
- **We cannot find a clear explanation for the North/South asymmetries along Mercury's orbit.**

Additional Earth-based observations especially to cover TAA 180°-270° would be welcome to have full orbit coverage.

BepiColombo Era

In the next years, we will have a great opportunity to solve Mercury's Na exosphere mistery:

- The Na exosphere will be comprehensively observed by **BepiColombo** mission with Na imager **MSASI** on board Mio and with **SERENA-STROFIO** and **PHEBUS**;
- **Mio/MDM** will also monitor the micrometeoroids, while **MPO/SERENA** will monitor the plasma precipitation;
- **Simultaneous ground-based observations** campaigns should be organised during BepiColombo observations;

This study has been published in **Milillo et al.**, *Exospheric Na distributions along the Mercury orbit with the THEMIS telescope*, **Icarus 2020**