

AC cleaning status

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on behalf of the SOSMAG team

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1 Brief reminder

2 AMR-FGM correction

- Observed large disturbances types
- Version 1
- Long term stability

3 IB-OB correction

- Differences from AMR-FGM correction
- Version 1
- Long term stability

4 AC correction Issues

5 Forseeable improvements

6 Sensor alignment

Assumptions:

- Each disturbance to be corrected has a **well defined direction** of maximum variance
- The disturbance variance is **not much smaller** than the variance of the ambient field

Method (for each order n):

- The **difference $\Delta \mathbf{B}^{n,ij}$** between each (i,j) sensor pair is computed
- The correction is obtained from the **maximum variance component** of the difference
- The correction is applied to both sensors only to their maximum variance components

Restrictions:

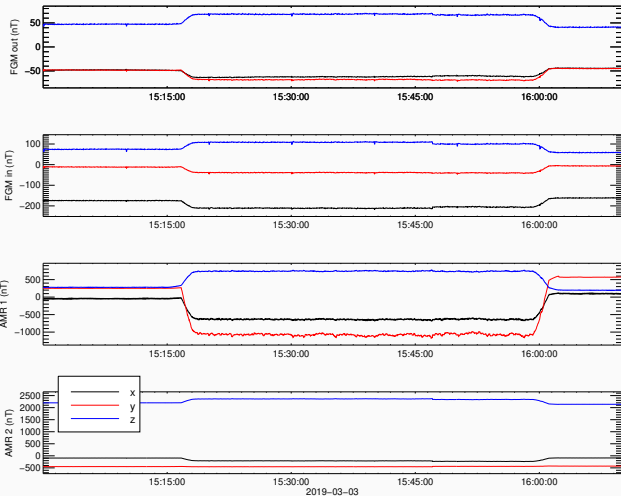
- The sensor **noise might increase** at each step
- The correction can be applied **maximum three times** per sensor pair
- Different sources disturbing the same component are difficult to correct if their positions differ

- AMR1–IB and AMR1–OB
 - corrects the “Midnight Event” (ME) daily single large disturbance
 - corrects only one component (1st order)
 - leaves residual disturbance in the other components
- OB–IB (AMR1 corrected)
 - corrects three disturbance types:
 - high frequency disturbance (seconds) – good
 - spikes (minutes) – good
 - steps (hours) – leaves some residual disturbance
 - corrects two components (up to 2nd order) of the OB sensor (and three of the IB)
 - might transfer sensor temperature effects between sensors

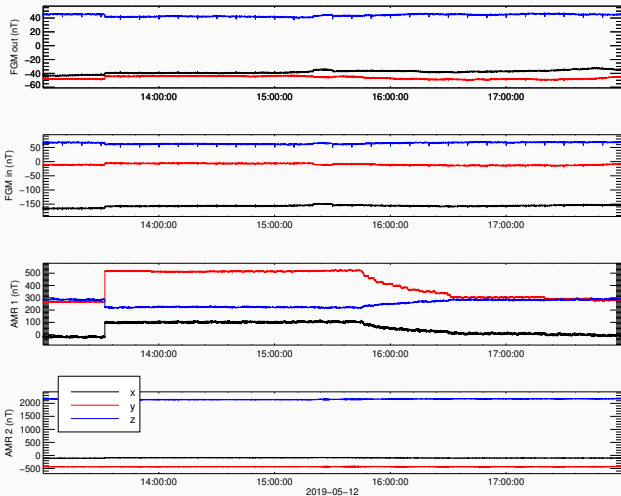
The combined corrections yield the \mathcal{M} -matrices uploaded to GK-2A

$$\mathbf{B} = \mathcal{M}^{\text{OB}} \mathbf{B}^{\text{OB}} + \mathcal{M}^{\text{IB}} \mathbf{B}^{\text{IB}} + \mathcal{M}^{\text{A1}} \mathbf{B}^{\text{A1}}$$

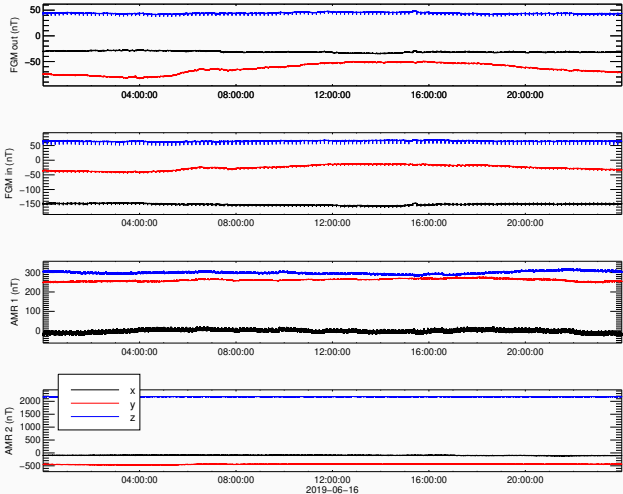
- the Midnight Event
- **largest** observed disturbance
- close to the ecliptic
- could be heater related
- most intense at **AMR1**
- used to determine V1 AMR1 cor.



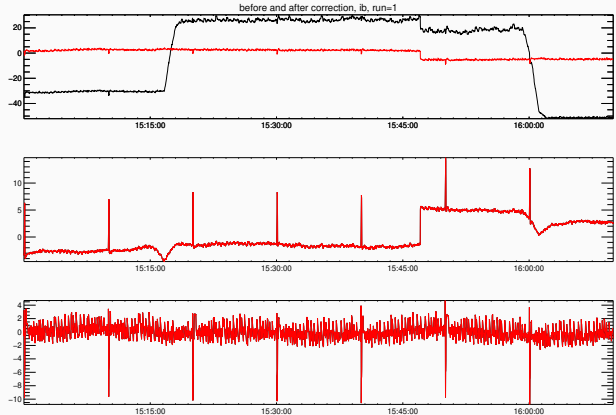
- **smaller** than the ME
 - intermittent
 - might be part of the ME
 - corrected with V1 AMR cor.
- same disturbance source



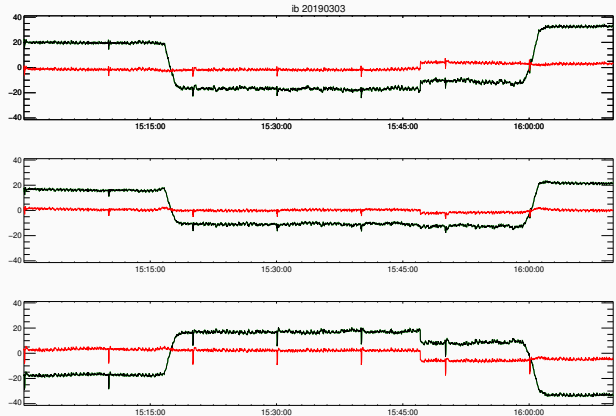
- NO large disturbance
 - AMR correction is still applied
 - very little variation
- negligible AMR contribution



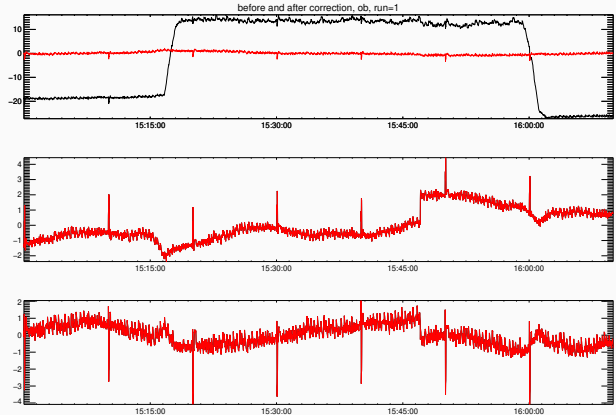
- Max var comp well corrected
- HF disturbance corrected
- middle step (x comp) remains
- **Residuum** left on **y** comp



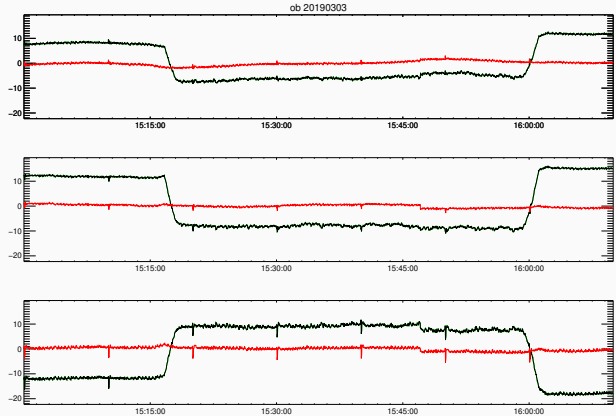
- residuum remains



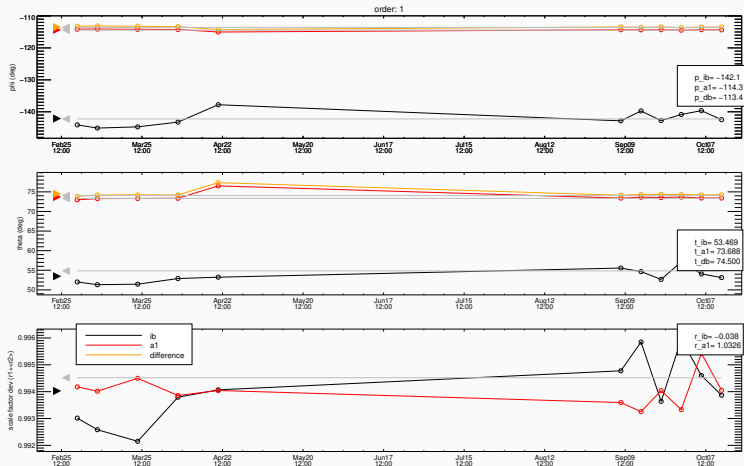
- Max var comp well corrected
- HF disturbance corrected
- no middle step on x comp (\perp)
- Residuum left on y and z comp



- residuum visible

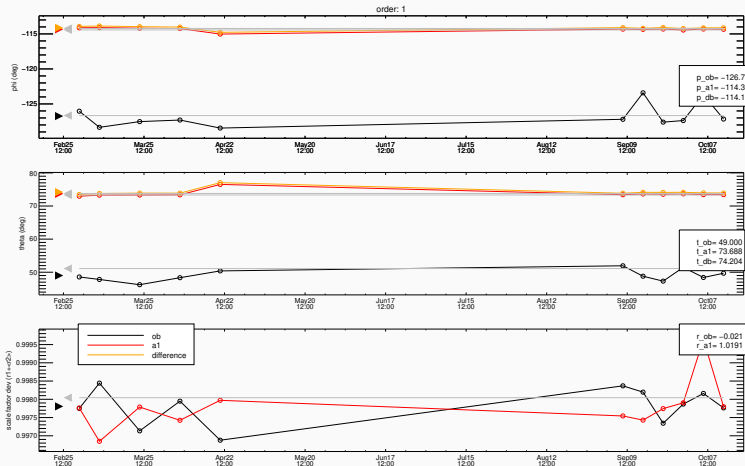


- used Sundays with ME
- 2 outliers excluded
- AMR more stable
- angular variation: 7°
- scale var: 4×10^{-3}



Mean values marked with colored triangles, V1 values marked with grey triangles

- used Sundays with ME
- 2 outliers excluded
- AMR more stable
- angular variation: 6°
- scale var: 3×10^{-3}

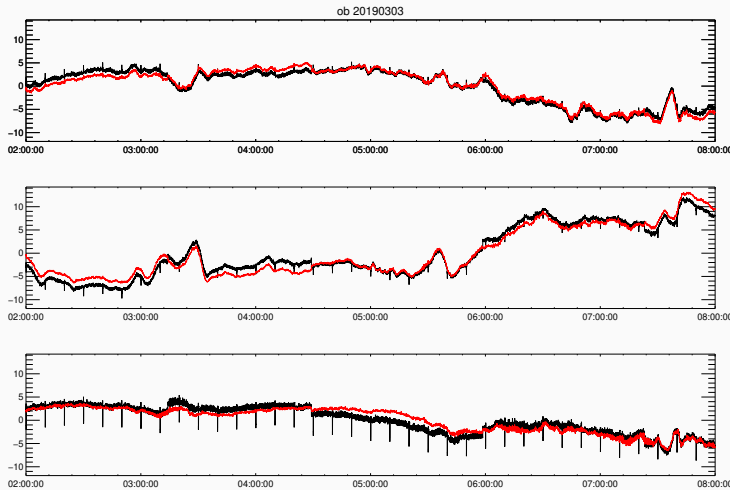


Mean values marked with colored triangles, V1 values marked with grey triangles

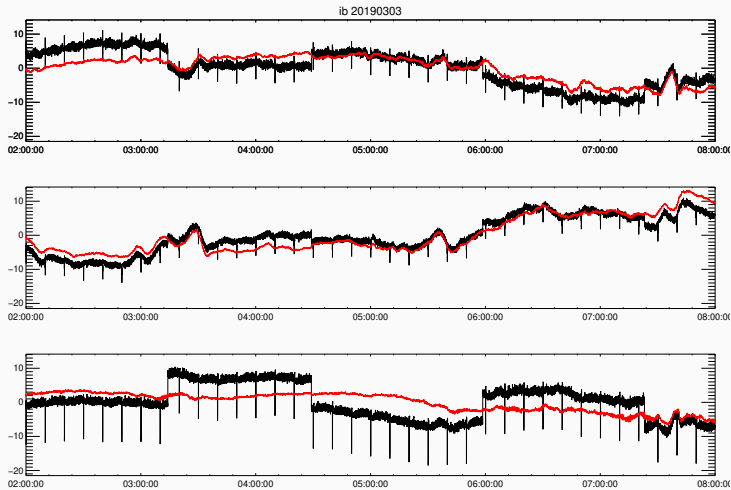
Differences from the AMR correction

- uses **sliding window** to obtain many parameter sets for one day
- the window width selects the desired disturbance to be cleaned
- different window widths/disturbance sources for different orders
- the final parameters are determined through **statistical methods**
- version one IB-OB correction goes up to **order 2 for OB** and **order 3 for IB**

- HF dist. removed
- spikes removed
- steps **reduced**



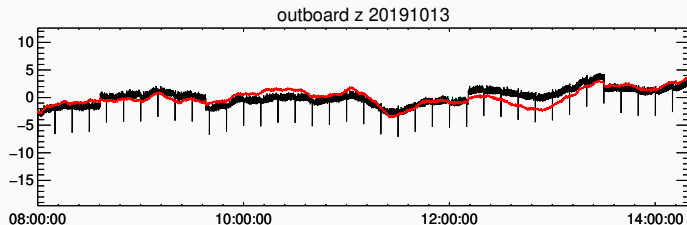
- HF dist. removed
- spikes removed
- steps **reduced**



Before correction:

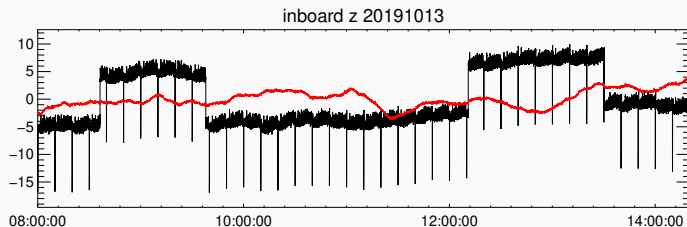
- OB oscillations
- NO IB oscillations

→ artificial cause

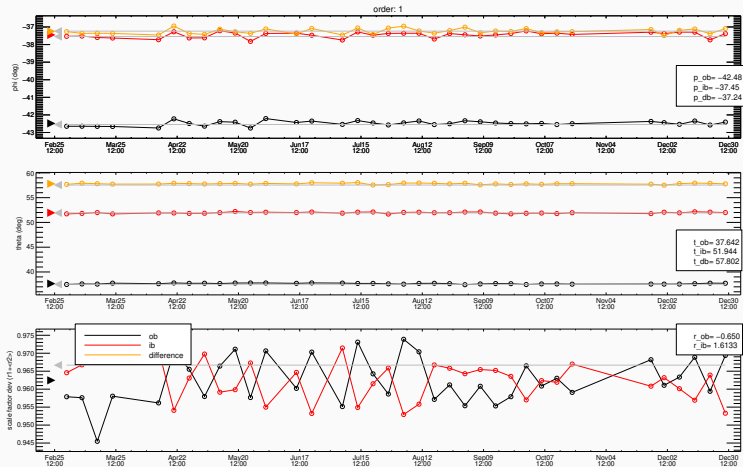


After correction:

- oscillations at both sensors

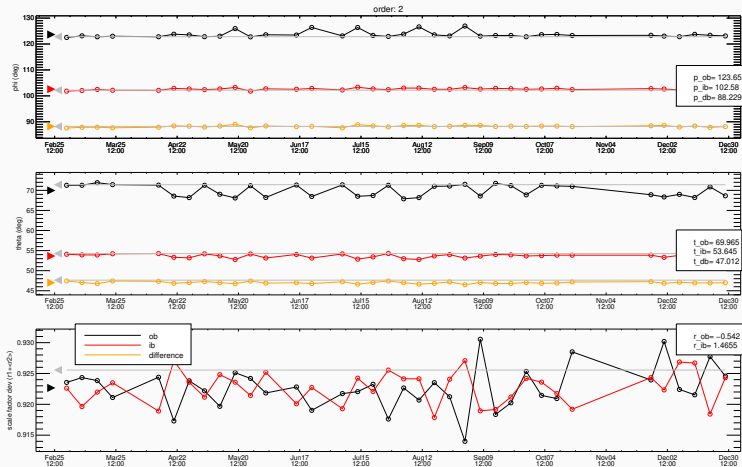


- used Sundays 2019
- 3 outliers excluded
- **very stable**
- angular variation: $< 1^\circ$
- scale var: 3×10^{-2}



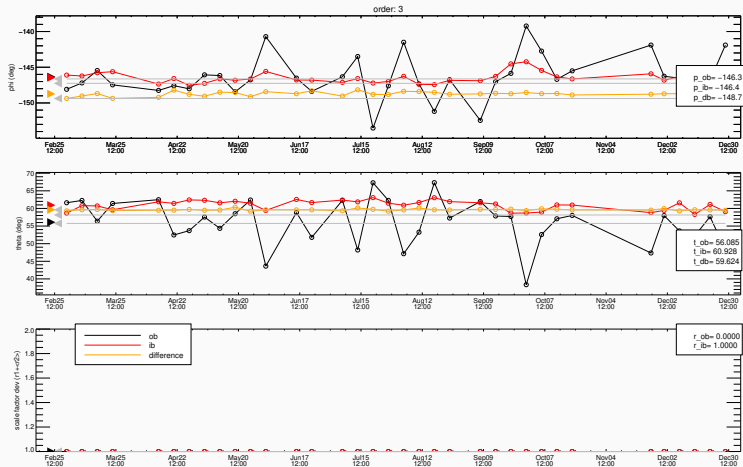
Mean values marked with colored triangles, V1 values marked with grey triangles

- 3 outliers excluded
- reasonably stable
- angular variation: 5°
- scale var: 1.5×10^{-2}



Mean values marked with colored triangles, V1 values marked with grey triangles

- only applied to IB
- 4 outliers excluded
- unstable
- angular variation: 20°
- most variation at OB
- scale var: –



Mean values marked with colored triangles, V1 values marked with grey triangles

Issues:

- AMR-FGM correction
 - residual disturbances around ME
- IB-OB correction
 - residual step-like disturbances
 - temperature driven FGM sensor disturbances

Potential solutions:

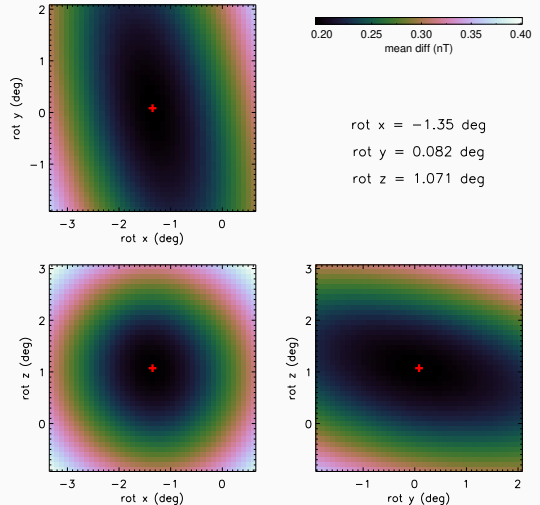
- use 2019 mean values
- increase the order for the AMR-FGM correction
 - use the intermediate and minimum variance directions from O1 to compute O2 and O3
- increase the accuracy of the IB-OB maximum variance direction determination
 - use the Kernel Density Estimator (KDE) instead of the histogram
- increase the accuracy of the IB-OB scale factor determination
 - optimize the scale factor by minimizing the correlation between ΔB and $B^{\text{corrected}}$

- Version 1 parameters are stable in time
- Remaining issues
 - residual disturbance due to ME around 4 nT
 - remaining step-like disturbance around 1 nT
 - temperature driven disturbance up to 4 nT
- Possible ways to improve the AC correction
 - mean values
 - increase AMR correction order
 - involve AMR2
 - use KDE to pinpoint the maximum variance directions and the scale factors
 - optimize the scale factors by minimizing the correlation between ΔB and B

- applied right after orthogonalization (**uncleaned data**)
- find rotation matrix which minimizes differences between sensors
- sensitive to disturbances
- **very large** ambient field variation necessary

- broad minimum
- only 0.2 nT variation over 2° rotation
- rotation angles in range of a few degrees
- the results depend on the data interval:

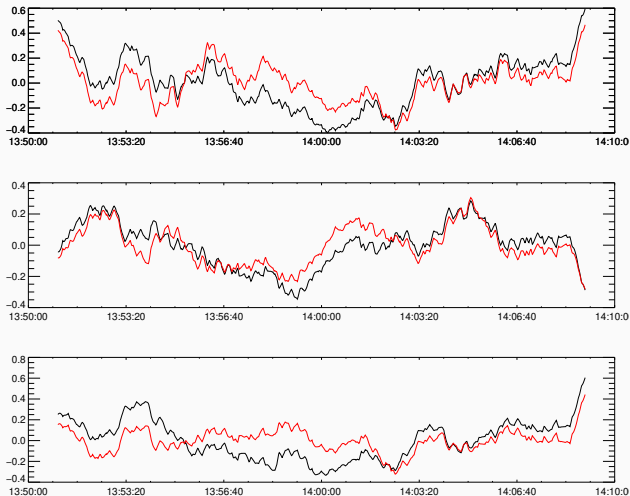
date	α_x	α_y	α_z
Aug 08	-1.35°	0.08°	1.07°
Jun 11	-1.26°	0.79°	0.15°
Nov 30	0.48°	0.65°	0.32°



2019-08-08

- ambient field variation: 30 nT
- rotation sensitivity: 0.5 nT/deg
- disturbance amplitude: 1 nT
- unreliable results

Larger ambient field variation needed



- procedure determined
- software developed and tested
- IB-OB aligned within 2°
- large event needed for accurate determination