Analysis of the Tragaldabas data for April 2015 (DOY 96-120) for multiplicities M2 and M3

1 Data

The data for M2 and M3 were pre-processed in the similar way as data for M1. The data were analysed in the form of hourly means and daily smoothed hourly values measured by different θ/φ channels plus in the form of Σφ for different θ channels.

2 Comparison to M1 data

Figure 1 shows variations of Σφ for five θ channels for the M2 and M3 series (M1 data are shown for comparison). As one can see, series of M2 and M3, on the first site, do not resemble series of M1. Besides, dispersion of the data from the θ4 channel increases with multiplicity (especially high for M3). Figures 2 shows correlation coefficients between the M1, M2 and M3 series for the different θ/φ channels for the hourly means and daily averaged data. As one can see, the M1 and M2 channels show more or less significant correlations only for φ3-φ5 channels with θ1 and θ2. θ4 data are uncorrelated.

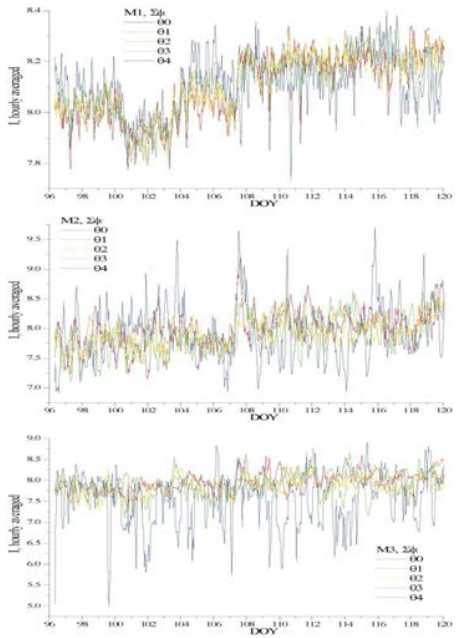
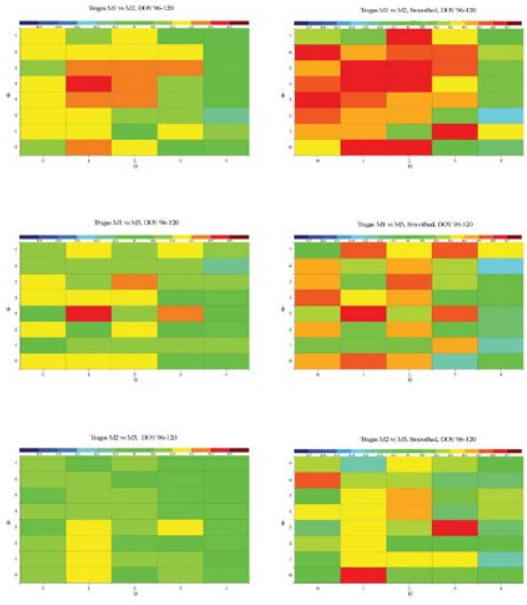
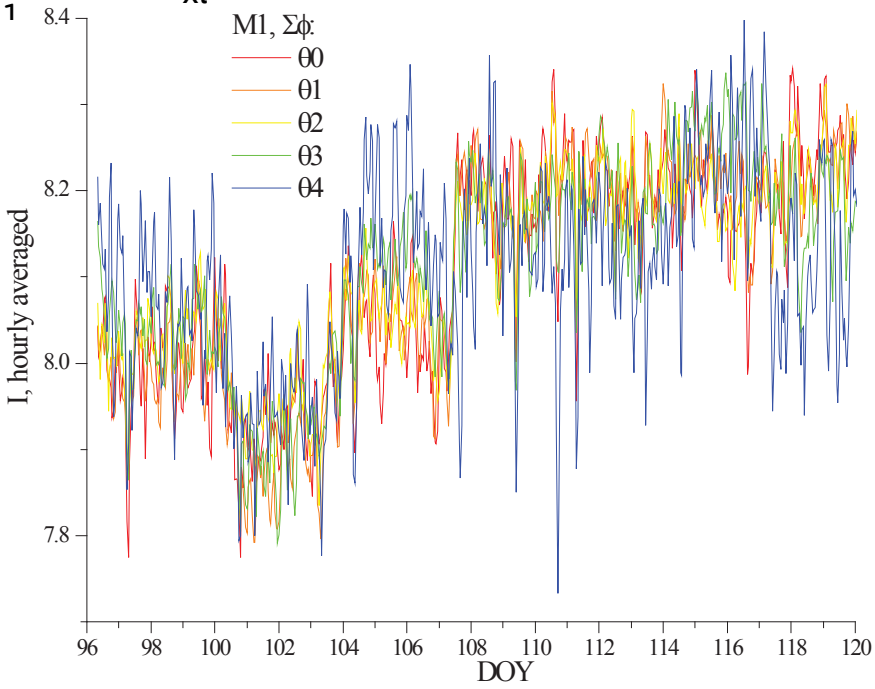


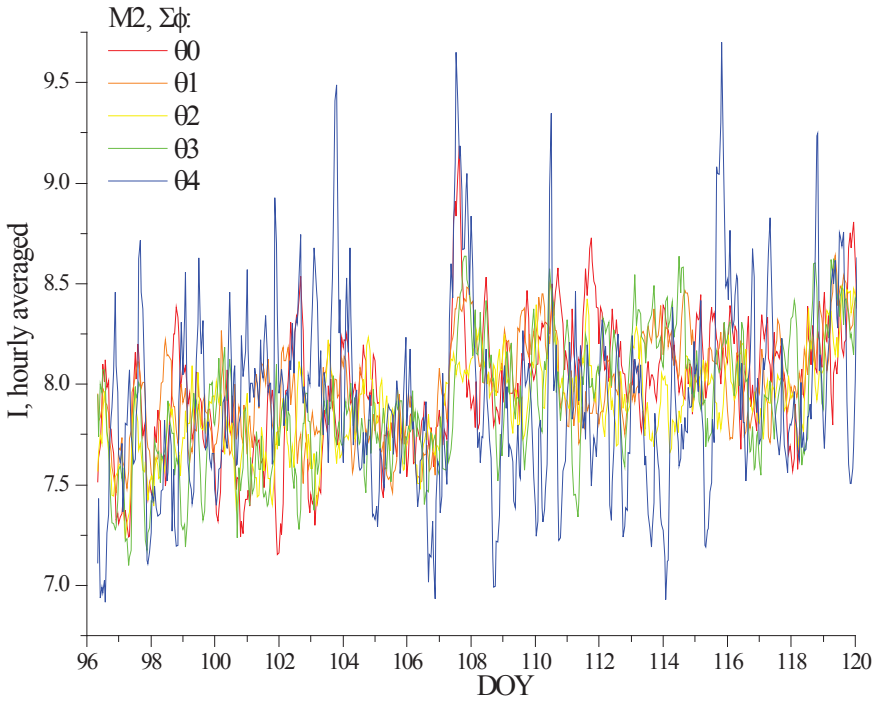
Figure 1. Variations of the Σφ for five θ channels for the M1 (top), M2 (middle) and M3 (bottom) series.



Figures 2. Correlation coefficients between the M1, M2 and M3 series for different θ/φ channels for the hourly means and daily averaged data.

Figure 1


M1, Σϕ:
θ0
θ1
θ2
θ3
θ4
I, hourly averaged
8.4
8.2
8.0
7.8
96
98
100
102
104
106
108
110
112
114
116
118
120
DOY


M2, Σϕ:
θ0
θ1
θ2
θ3
θ4
I, hourly averaged
9.5
9.0
8.5
8.0
7.5
7.0
96
98
100
102
104
106
108
110
112
114
116
118
120
DOY

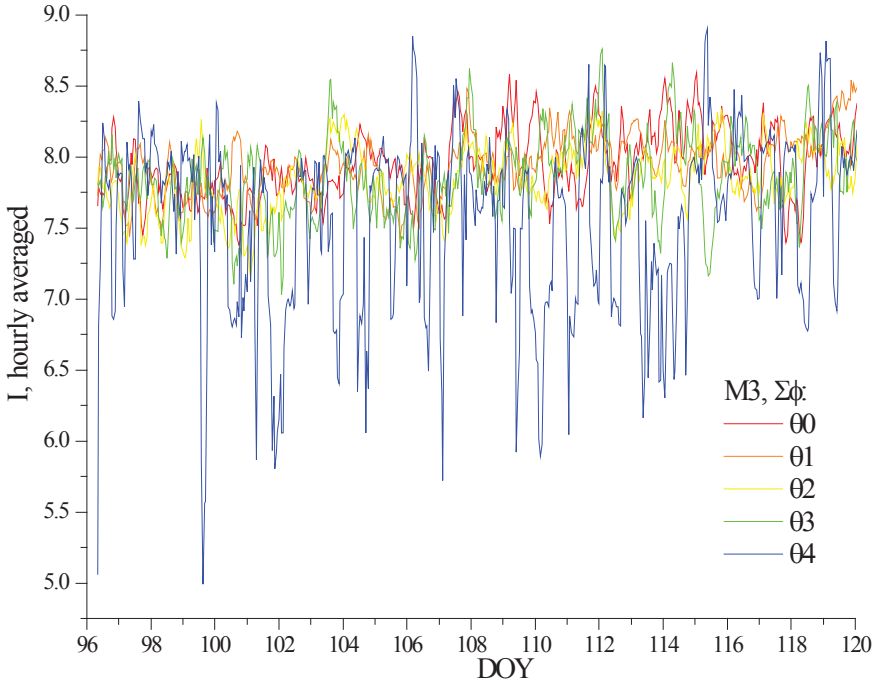
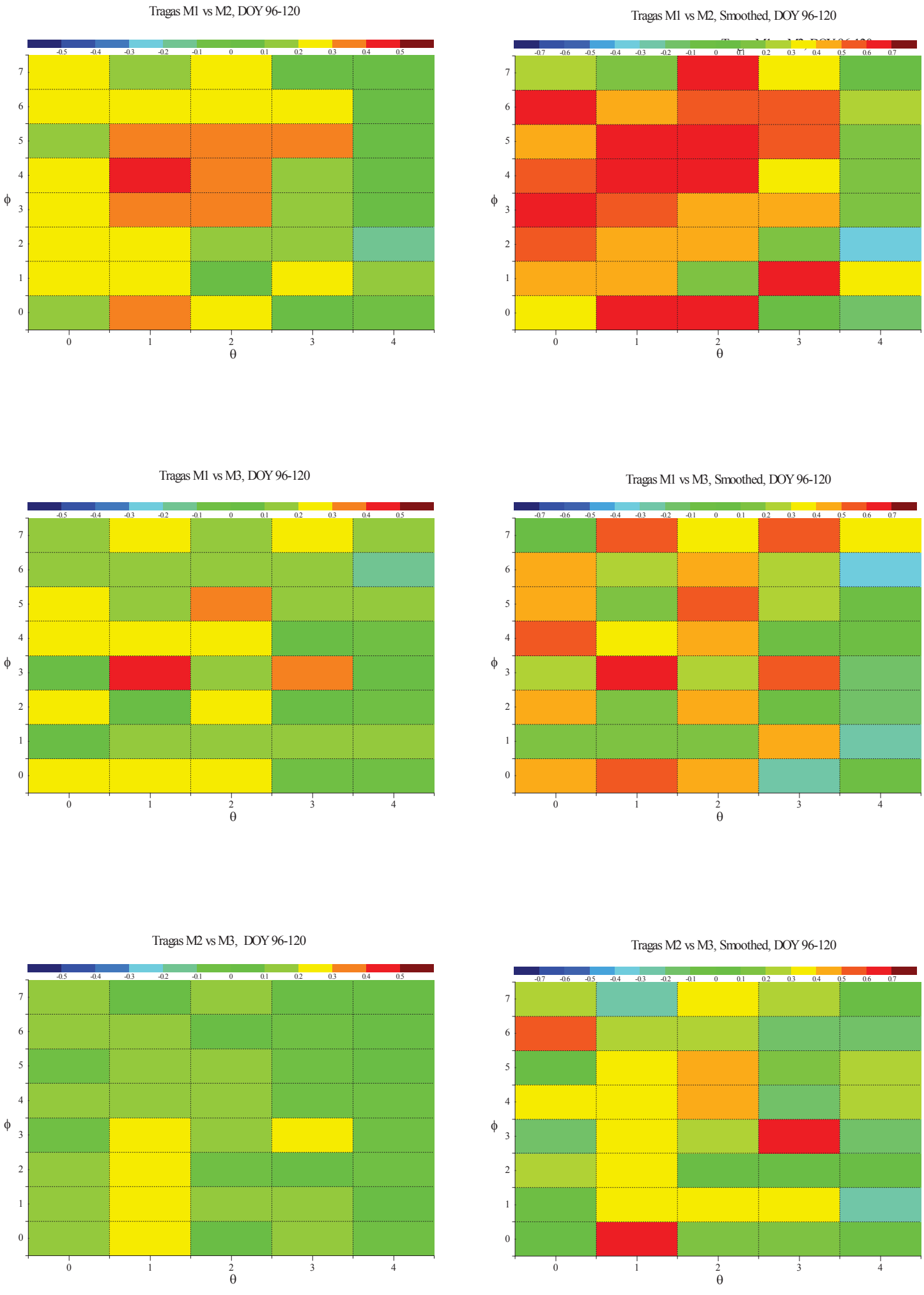

M3, Σϕ:
θ0
θ1
θ2
θ3
θ4
I, hourly averaged
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
96
98
100
102
104
106
108
110
112
114
116
118
120
DOY

Figure 2


Tragas M1 vs M2, DOY 96-120
Tragas M1 vs M2, Smoothed, DOY 96-120
Tragas M1 vs M3, DOY 96-120
Tragas M1 vs M3, Smoothed, DOY 96-120
Tragas M2 vs M3, DOY 96-120
Tragas M2 vs M3, Smoothed, DOY 96-120
ϕ
θ

3 Comparison to CaLMa and COI data

When M2 and M3 data are compared to NM and geomagnetic data, they show much weaker correlations with CaLMa and COI series than the same data for M1 – see Fig. 3. Only data from a number of θ/φ channels of M2 and M3 show more or less significant correlations with both NM and geomagnetic data.

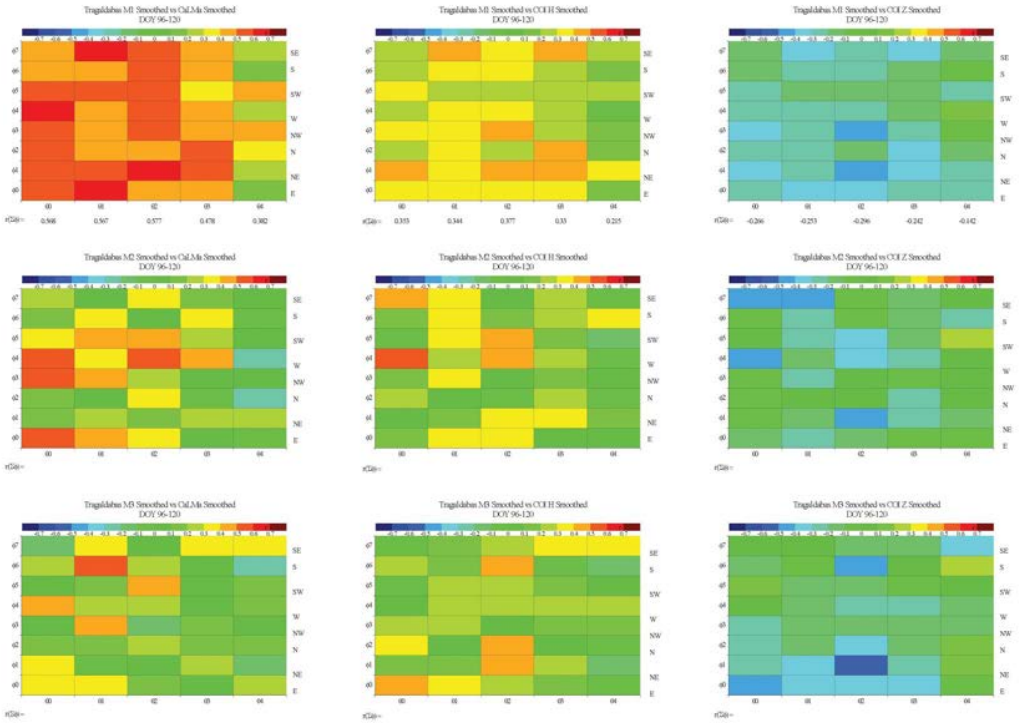
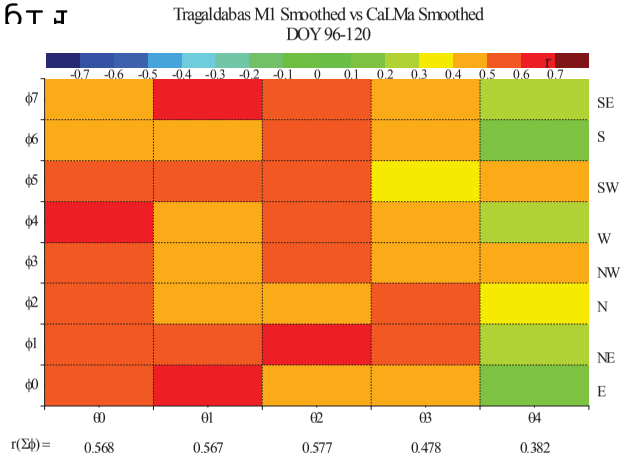
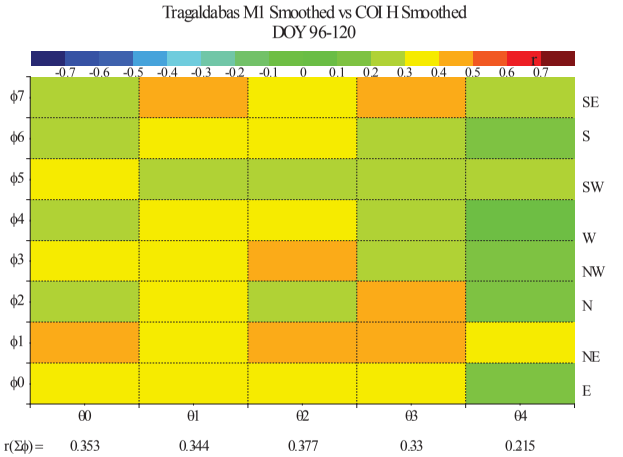


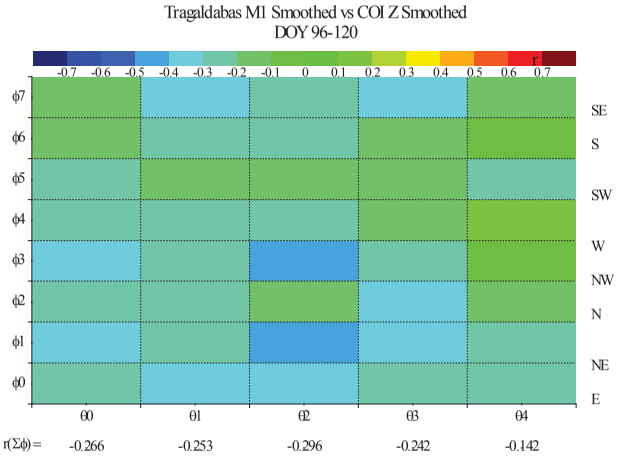
Figure 3. Correlation coefficients between the M1 (top row), M2 (middle row) and M3 (bottom row) series and CaLMa (left panels), COI H (middle panels) and COI Z (right panels), for different θ/φ channels for the daily smoothed data.

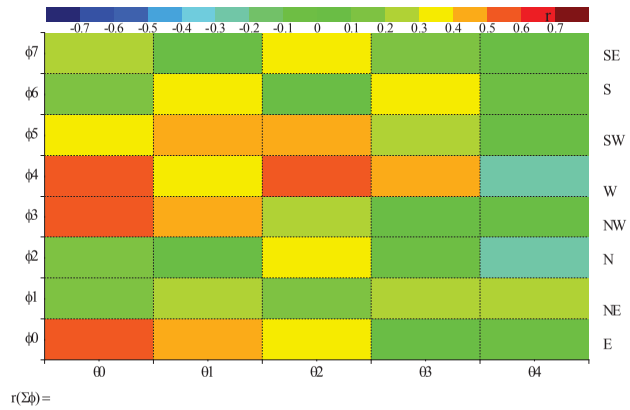
4 Principal component analysis

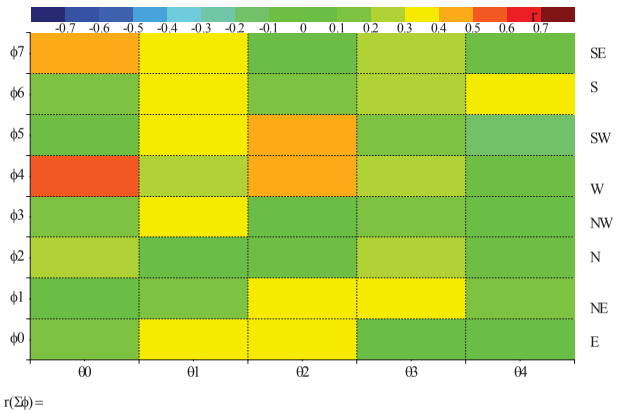
Figure 4 show first three PCs obtained by PCA of the M1, M2 and M3 series (only θ0-θ3 channels). See also Table 1 for explained variance associated with the first three PCs. As one can see, PC1 for M2 data set follow, more or less, the main trend of PC1 for M1, however without the fist decrease on DOY 101. The correlations coefficients calculated between the Tragas PCs series and NM, geomagnetic and Lab's meteorological data (see Table 2) show that the PC1 of M2 depend on both CaLMa and COI H data, more or less, to the same degree. PC2 and PC3 of the M2 data set anti-correlate with Lab's T series and PC2 also anti-correlates with CaLMa. Variations of the M3 data set have no significant mode that is correlated with NM data, however M3 data show small dependence on COI Z (PC2). As correlation analysis of PCs shows, the M3 data set is strongly affected by the Lab's conditions (p and T).

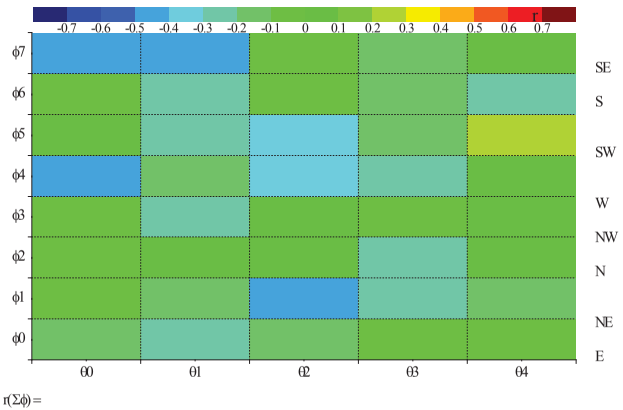

Tragaldabas M1 Smoothed vs CaLMa Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =
0.568 0.567 0.577 0.478 0.382

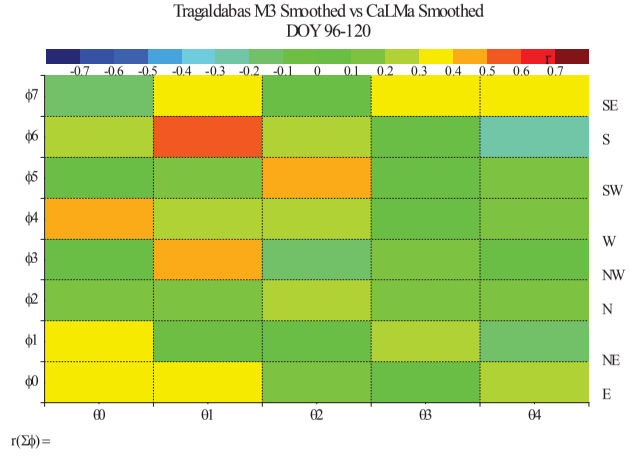

Tragaldabas M1 Smoothed vs COI H Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =
0.353 0.344 0.377 0.33 0.215

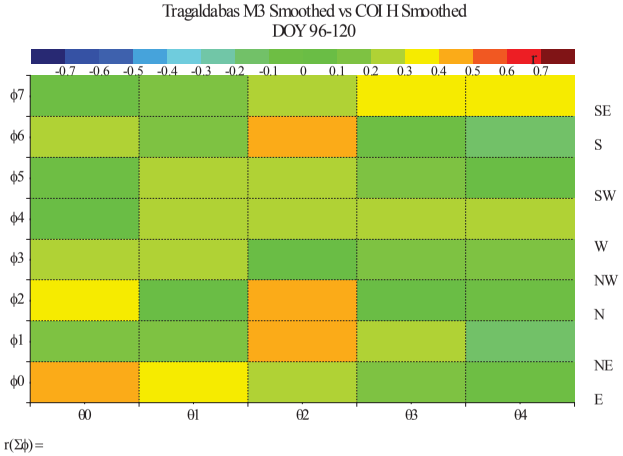

Tragaldabas M1 Smoothed vs COI Z Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =
-0.266 -0.253 -0.296 -0.242 -0.142


Tragaldabas M2 Smoothed vs CaLMa Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =


Tragaldabas M2 Smoothed vs COI H Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =


Tragaldabas M2 Smoothed vs COI Z Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =


Tragaldabas M3 Smoothed vs CaLMa Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =


Tragaldabas M3 Smoothed vs COI H Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =

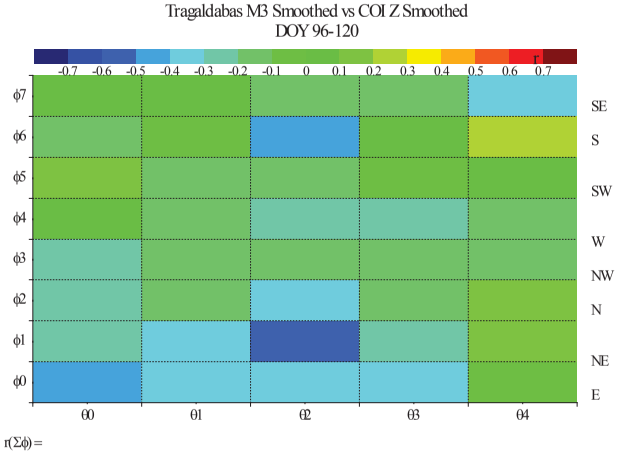

Tragaldabas M3 Smoothed vs COI Z Smoothed
DOY 96-120
r
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
ϕ7 ϕ6 ϕ5 ϕ4 ϕ3 ϕ2 ϕ1 ϕ0
SE S SW W NW N NE E
θ0 θ1 θ2 θ3 θ4
r(Σϕ) =

Table 1. Variance of the input data sets explained by first three PCs

	PC1	PC2	PC3
M1	59%	5%	2.8%
M2	19%	6.6%	5.8%
M3	12%	9%	8%

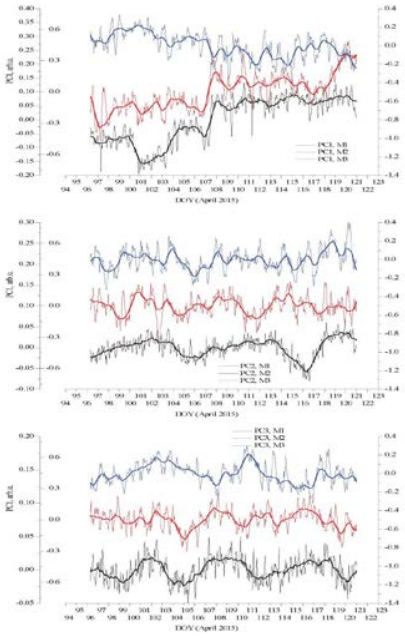


Figure 4. Comparison of the first three PCs for different multiplicity data sets.

Table 1. Correlation coefficients between first three PCs of M1, M2 and M3 series and CaLMa and COI data as well as Lab's T and p series. All for daily smoothed series.

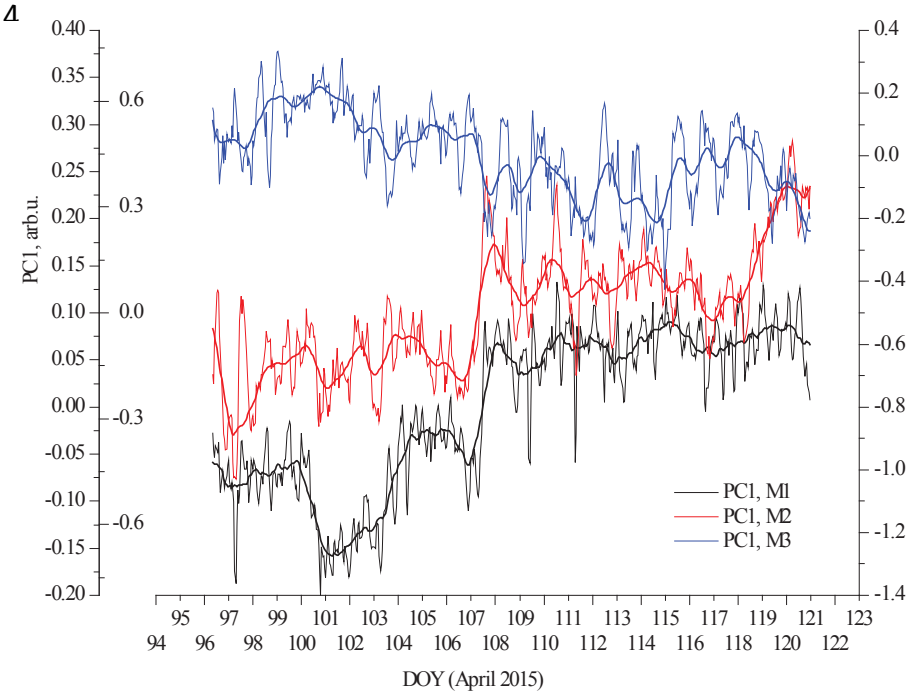
	PC1			PC2			PC3		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
CaLMa	**0.55**	**0.41**	0	0.18	**-0.45**	0.27	-0.14	-0.15	0
COI H	**0.34**	**0.35**	0	0	-0.23	0.27	-0.3	0	0
COI Z	-0.26	-0.25	0	0	0.24	**-0.36**	**0.38**	0.18	0
Lab p	**-0.56**	-0.23	**0.43**	**0.82**	0	-0.29	-0.14	-0.26	0
Lab T	**-0.37**	-0.23	0.29	0.24	**-0.51**	0	**-0.9**	**-0.58**	**0.37**

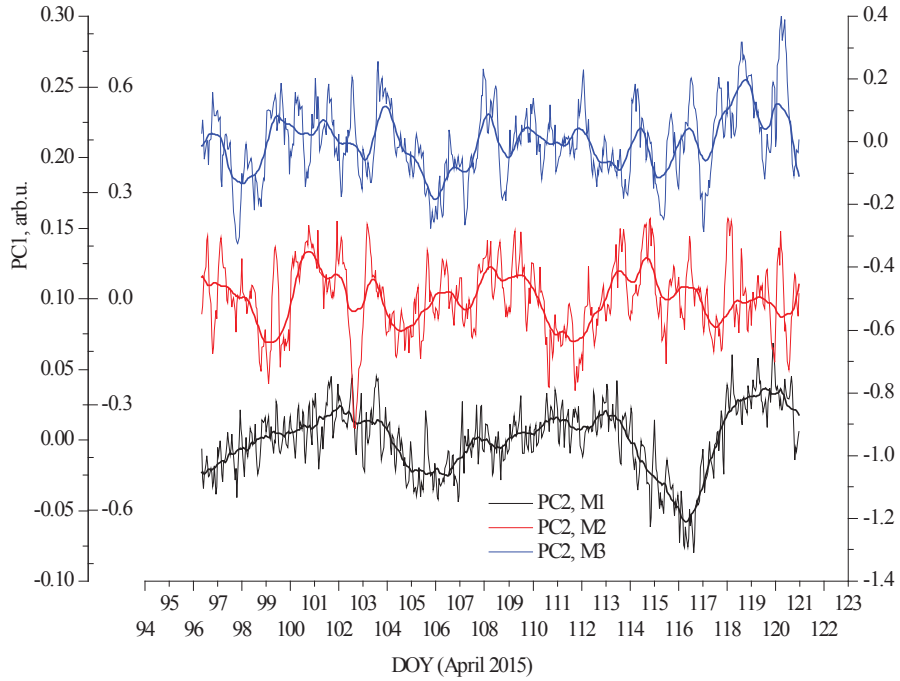
Conclusions

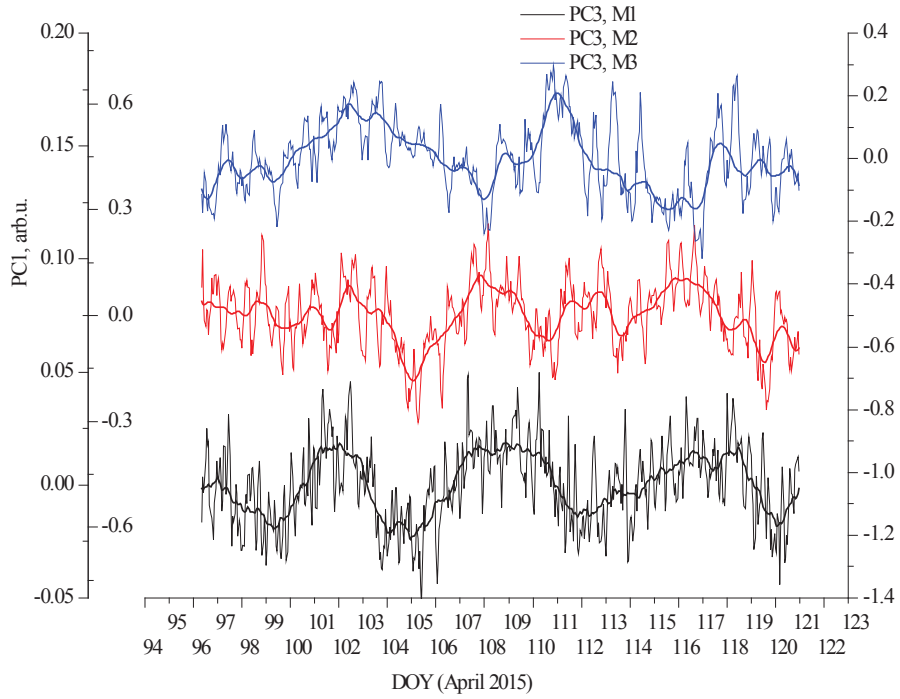
The analysis of the M2 and M3 data sets shows that

1. M2, and especially M3, data show weak correlations with M1 data;
2. M2 data set still contains variations that resemble main trend of the M1 data (that follows both Forbush decrease seen in CaLMa data and geomagnetic field variations);
3. There are specific θ/φ channels (at least for the events of April 2015) that show better correlations with CaLMa and/or COI data, however it could be just by chance;
4. M3 data are strongly affected by the atmospheric conditions in the Lab (p and T variations);
5. PCA applied to M2 and M3 doesn't allow one (contrary to the situation with M1) to separate modes related to space weather and atmospheric conditions;
6. Please note that I didn't estimated statistical significances of the correlation coefficients.

Figure 4


PC1, arb.u.
PC1, M1
PC1, M2
PC1, M3
DOY (April 2015)


PC1, arb.u.
PC2, M1
PC2, M2
PC2, M3
DOY (April 2015)


PC1, arb.u.
PC3, M1
PC3, M2
PC3, M3
DOY (April 2015)