Tragaldabas vs ionosphere
(April 2015)

Here is a short report on the analysis of the Tragaldabas (as well as other data like geomagnetic and CaLMa NM) data in relation to the ionospheric conditions.

Parameters:

1. Tragaldabas M1 data, sums for all φ for each of the θ channels;
2. Critical frequency for the F2 layer (f0F2) – measured, and total electron content (TEC) – calculated. Ionosonde @ Ebre Obs.;
3. CaLMa NM data;
4. H and Z component of the geomagnetic field from COI Obs.

Time period: 1-30 (or 6-30 for Tragas data) April, 2015 = DOY 91-120

Time resolution: daily means, for all parameters.
Why daily means? The reason is that ionospheric parameters show strong daily cycle (see Fig. 1). As one can see, even daily minima change with time, not to mention maxima. Traditional way to solve this problem is, of course, to calculate (e.g.) monthly mean daily cycle and then analyze differences between the measured and mean values. This is, by the way, how the geomagnetic field (GMF) variations are studied. This method has its pluses and minuses. One of the "minuses" is that the daily cycle itself changes during the disturbed period. I'm now looking for ways to solve this problem in a "safe" way, but at the moment, as a first step, I think, daily means give quite interesting results.

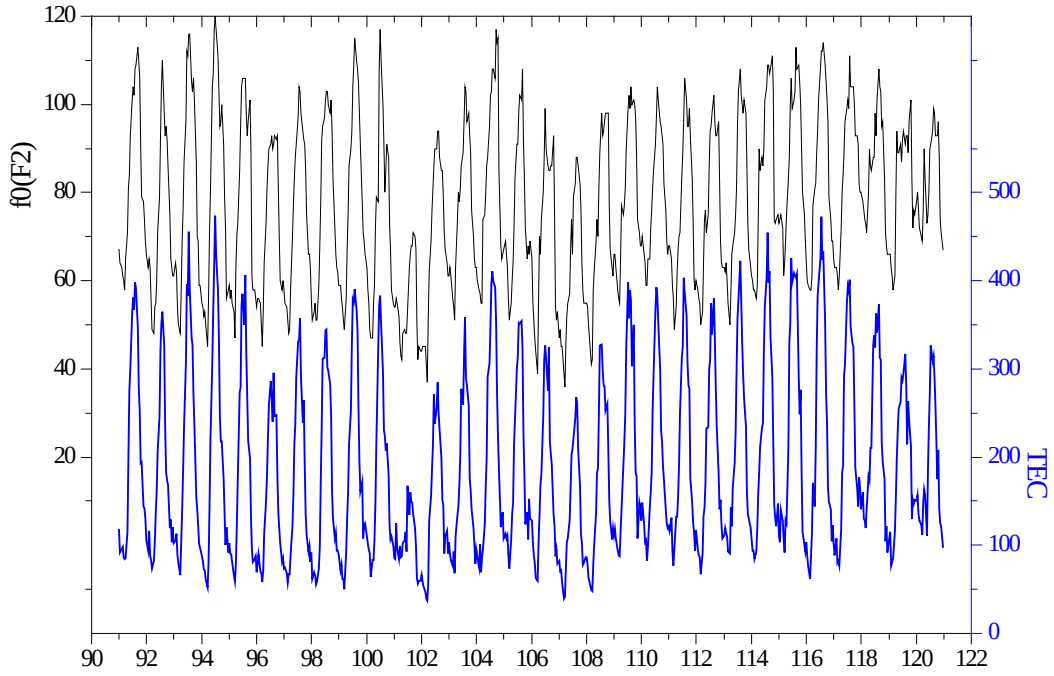
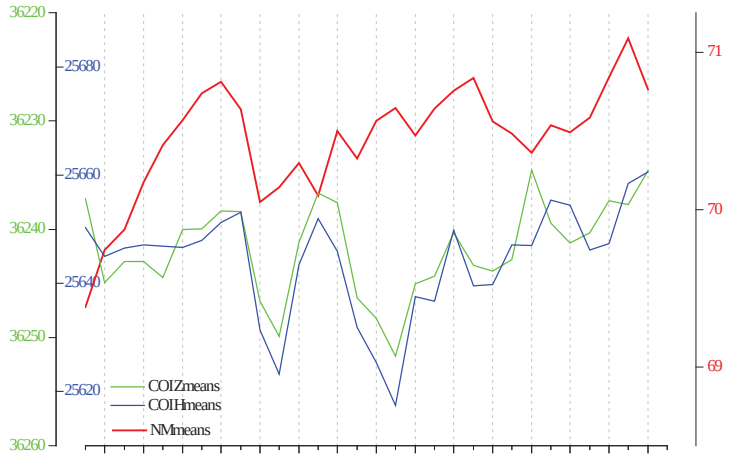
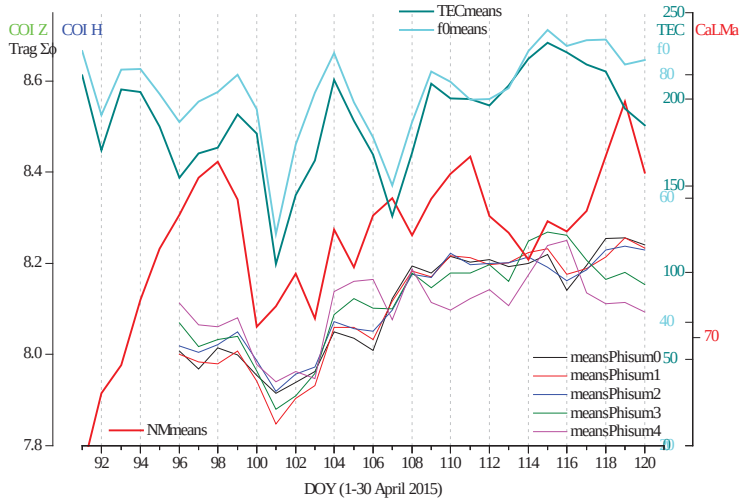
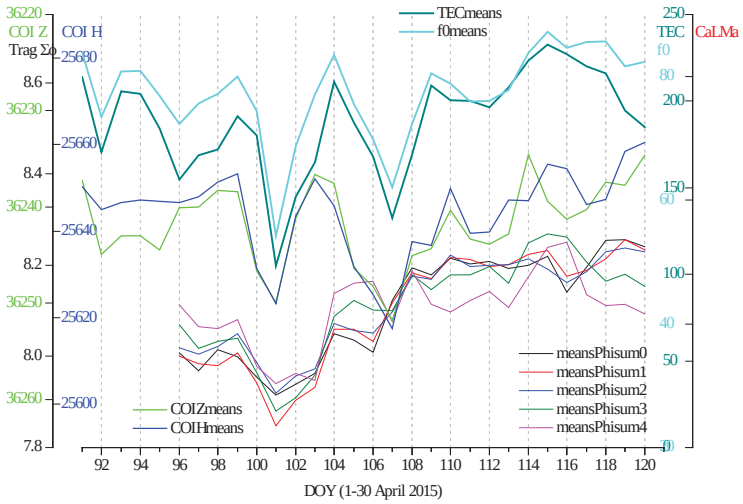
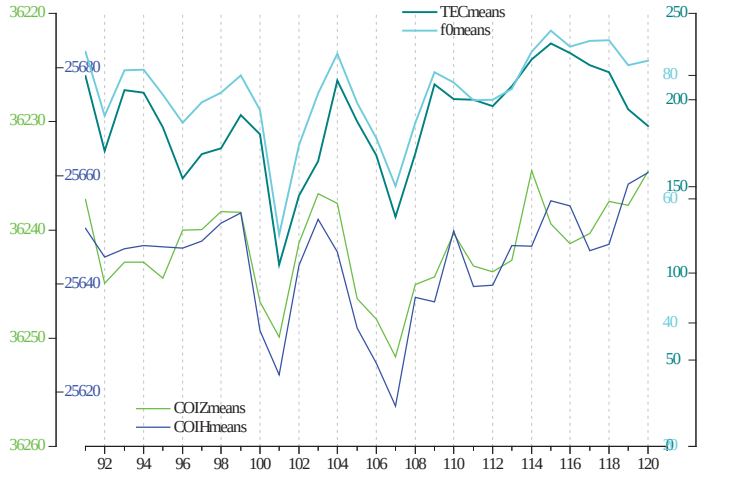


Figure 1. Variations (hourly data) of the ionospheric parameters f0 and TEC in April 2015.









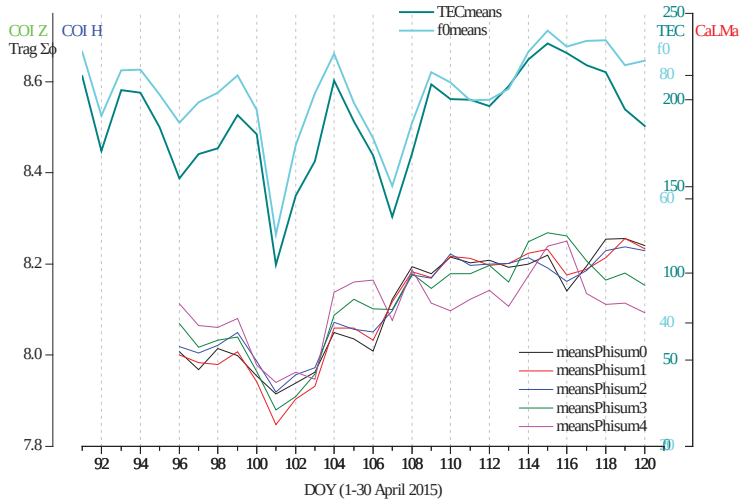


Figure 2. Plots of daily means of different parameters: CR (Tragas & CaLMa), GMF (COI H & COI Z) and ionospheric (f0 & TEC). 1-30 April 2015

Figure 2 show plots of daily means of CaLMa data (red), COI H (blue), COI Z (green), f0 (cyan), TEC (dark cyan) and Tragas Σφ for θ0-θ4 channels (a group of thin lines of different colors). The parameters are plotted in different combinations so their similarities/differences can be easily seen. Despite the fact that f0 and TEC series are highly correlated (r = 0.93) they show slightly different correlation with other parameters (see Figure 3). For example, f0 shows slightly higher r to the GMF parameters than to the Tragas data, whereas TEC shows higher correlation coefficients to the Tragas series. These differences aren't high but, nevertheless, persist. Does anyone know why?

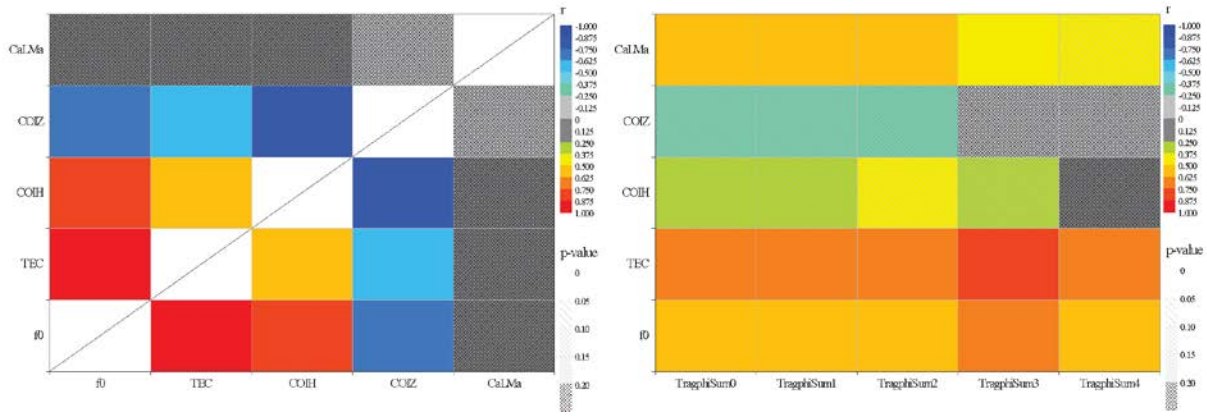


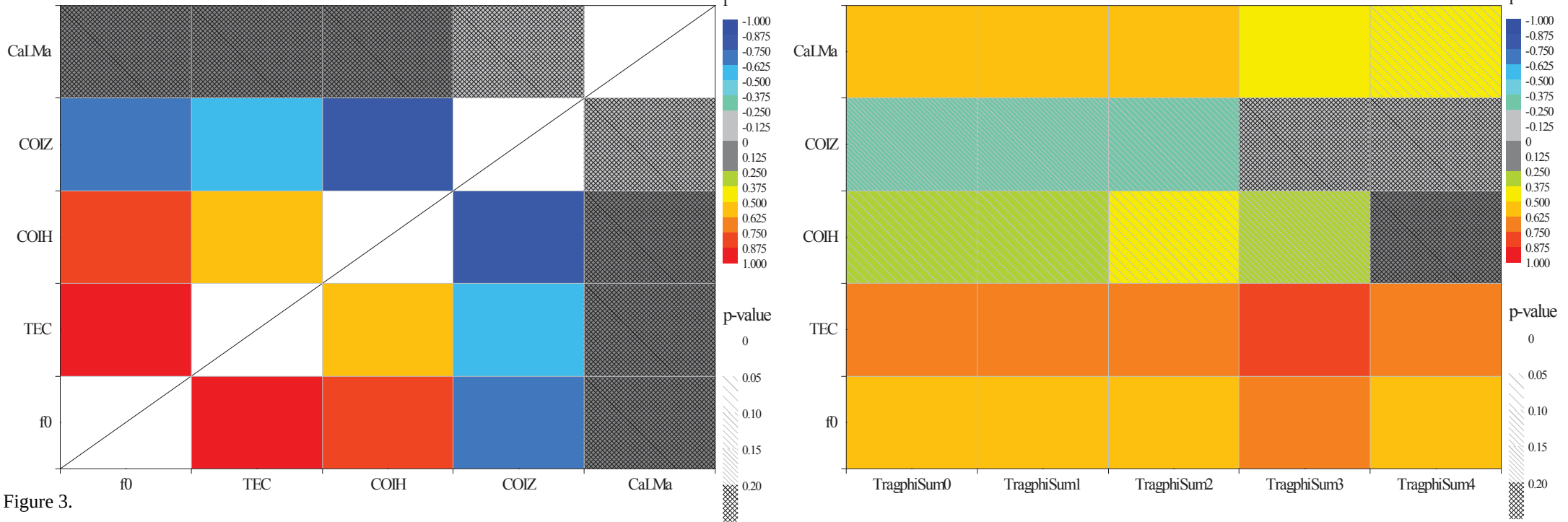
Figure 3. Correlation coefficients r (colors) with their statistical significances (*p values* – dashing, lighter dashing means higher stat. significance).

Correlation analysis of the ionospheric, geomagnetic and NM CR parameters (Fig. 3, left) show (the very well know fact) that GMF and ionospheric variations are correlated (as is also seen in Fig. 2, left panels), and NM CR variations are, overall, are not strongly correlated with GMF/ionosphere.

When the Tragas data are considered, they seem to be correlated with the ionospheric parameters (highest r, r = 0.6-0.7), NM CR (r = 0.5) and, finally, the correlation coefficients for the GMF are lowest ($|r|$ = 0.24-0.3). Besides, while for the CaLMa data the highest correlations are seen for the Tragas θ0-θ2 channels and θ3-θ4 channels are poorly correlated with NM data, the highest r between the Tragas and ionospheric series are obtained for θ3 channel (I think, because the series from this channel peaks on DOY 114-116). Next week I'll check all the φ channels separately to see if there any interesting features.

Short preliminary conclusions:

1. Tragas data show correlation with ionospheric parameters;
2. These correlations are higher than for NM CR and GMF parameters;
3. They could have some physical reasons, but, on the other side, the variations of the f0 and TEC series look suspiciously similar to variations of the atmospheric pressure and T measured in the Tragas' room. Since ionosphere is, in fact, an upper atmospheric layer, and gravity waves are known to travel up from tropo- and stratosphere to the meso- and thermosphere, the co-variability between the ionospheric and low atmospheric thermodynamic parameters is no news. This is another thing I'm going to check next week.


CaLMa
COlZ
COlH
TEC
f0
f0
TEC
COlH
COlZ
CaLMa
r
-1.000
-0.875
-0.750
-0.625
-0.500
-0.375
-0.250
-0.125
0
0.125
0.250
0.375
0.500
0.625
0.750
0.875
1.000
p-value
0
0.05
0.10
0.15
0.20
CaLMa
COlZ
COlH
TEC
f0
TragphiSum0
TragphiSum1
TragphiSum2
TragphiSum3
TragphiSum4
r
-1.000
-0.875
-0.750
-0.625
-0.500
-0.375
-0.250
-0.125
0
0.125
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0.375
0.500
0.625
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1.000
p-value
0
0.05
0.10
0.15
0.20

Figure 3.