Investigating the levels of Geomagnetically Induced Currents in the Mediterranean region during the most intense geomagnetic storms of solar cycle 24

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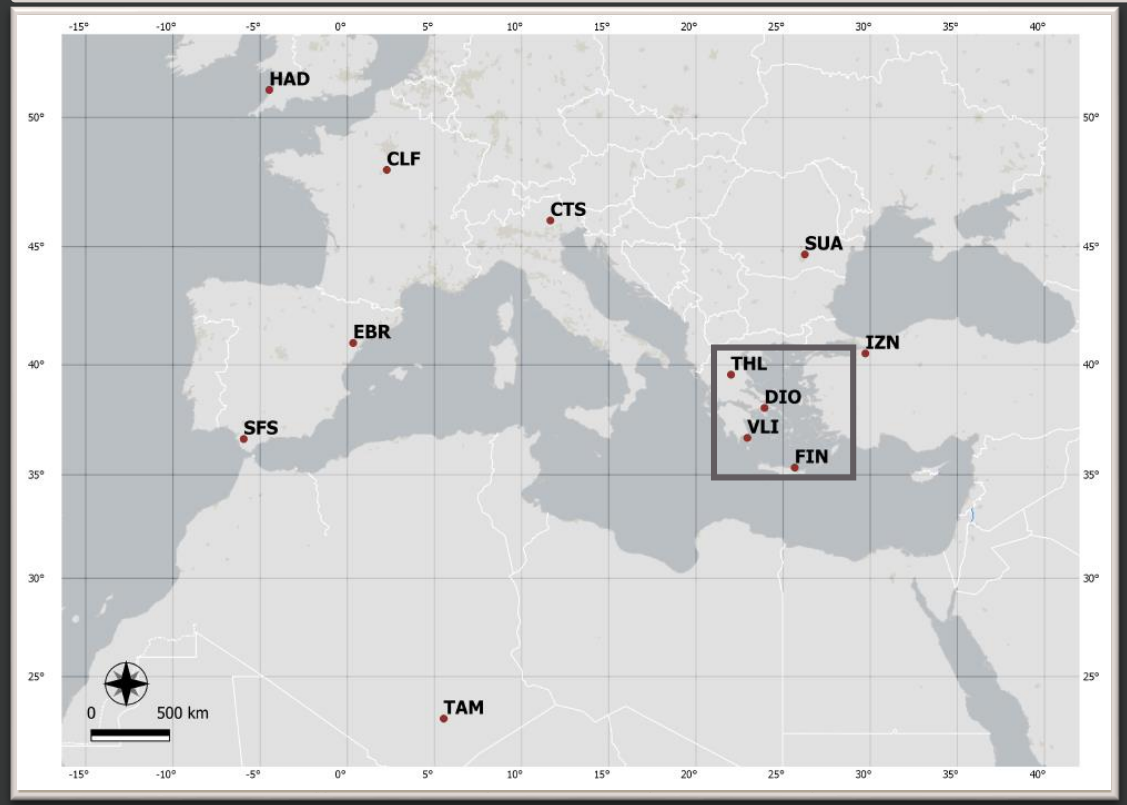
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Data

Geomagnetically Induced Currents (GIC) indices are calculated using ground-based magnetometer data from Greece, Italy, France, Spain, Algeria and Turkey around the most intense magnetic storms (Dst < -150 nT) of solar cycle 24



Station	Abbrev.	GLat ($N°$)	GLon ($E°$)	Alt. (m)
Hartland	HAD	51.000	355.52	95
Chambon la Forêt	CLF	48.025	2.260	145
Castello Tesino	CTS	46.047	11.649	1175
Surlari	SUA	44.680	26.250	84
Ebro	EBR	40.957	0.333	531.5
Iznik	IZN	40.500	29.720	256
Klokotos	THL *	39.565	22.014	86
Dionysos	DIO *	38.078	23.933	460
Velies	VLI *	36.718	22.947	220
San Fernando	SFS	36.667	354.055	111
Finokalia	FIN *	35.333	25.667	250
Tamanrasset	TAM	22.790	5.530	1373

* ENIGMA Magnetometer Network http://enigma.space.noa.gr/

Strongest geospace magnetic storms of solar cycle 24 (2008-2019), based on minimum Dst index values

A/A	SSC Date	SSC Time (UT)	Storm Date	Storm Time (UT)	Dst index (nT)
1	17/03/2015	04:45:00	17/03/2015	22:00:00	-223
2	22/06/2015	18:33:00	23/06/2015	04:00:00	-204
3	19/12/2015	16:16:12	20/12/2015	22:00:00	-155
4	N/A	N/A	26/08/2018	06:00:00	-174

Storm Sudden Commencements (SSCs) according to the SC list published by the ISGI.

Method

GIC index

- GIC index is a **proxy** of the geoelectric field and is estimated straightforwardly from **magnetic field data**
- In this study: Focus on the behavior of the GIC index around the Storm Sudden Commencement (SSC) of each magnetic storm

1. Remove linear trend from geomagnetic field time series
2. Apply the following formulas *(Marshall et al., Space Weather, 2011)* using moving windows of 1440 points, each:

$$GIC_x(t) = |FFT\{Y(f)Z(f)\}^{-1}|$$
$$GIC_y(t) = |FFT\{X(f)Z(f)\}^{-1}|$$

$Z(f) = e^{i\pi/4}\sqrt{f/f_N}$ (filter function)

f: variable frequency

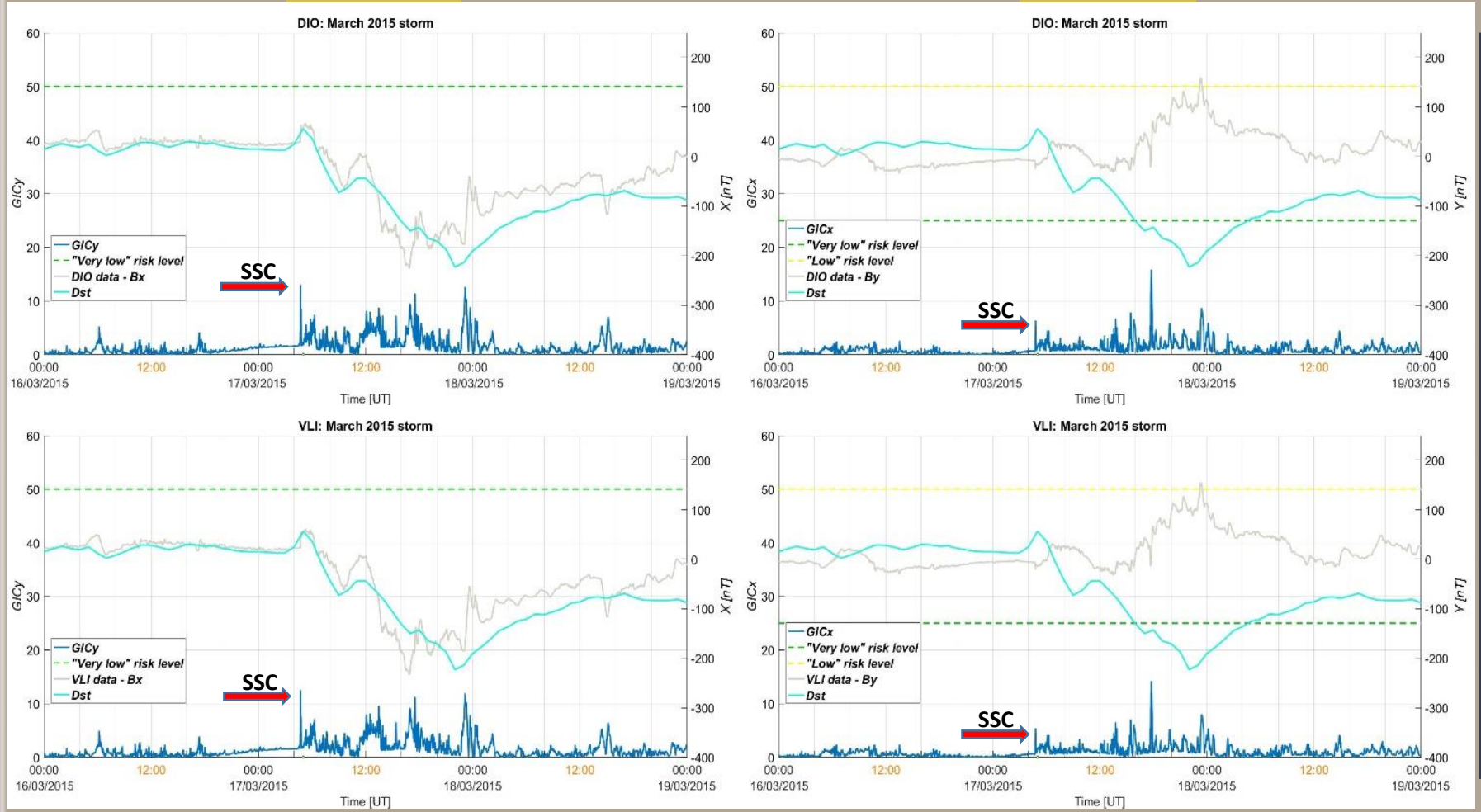
f_N: Nyquist frequency (f_N=8.3 mHz for sampling rate: 1 value/min)

16-18 March 2015
Dst = -223 nT

Example in display: DIO & VLI

X - GICy

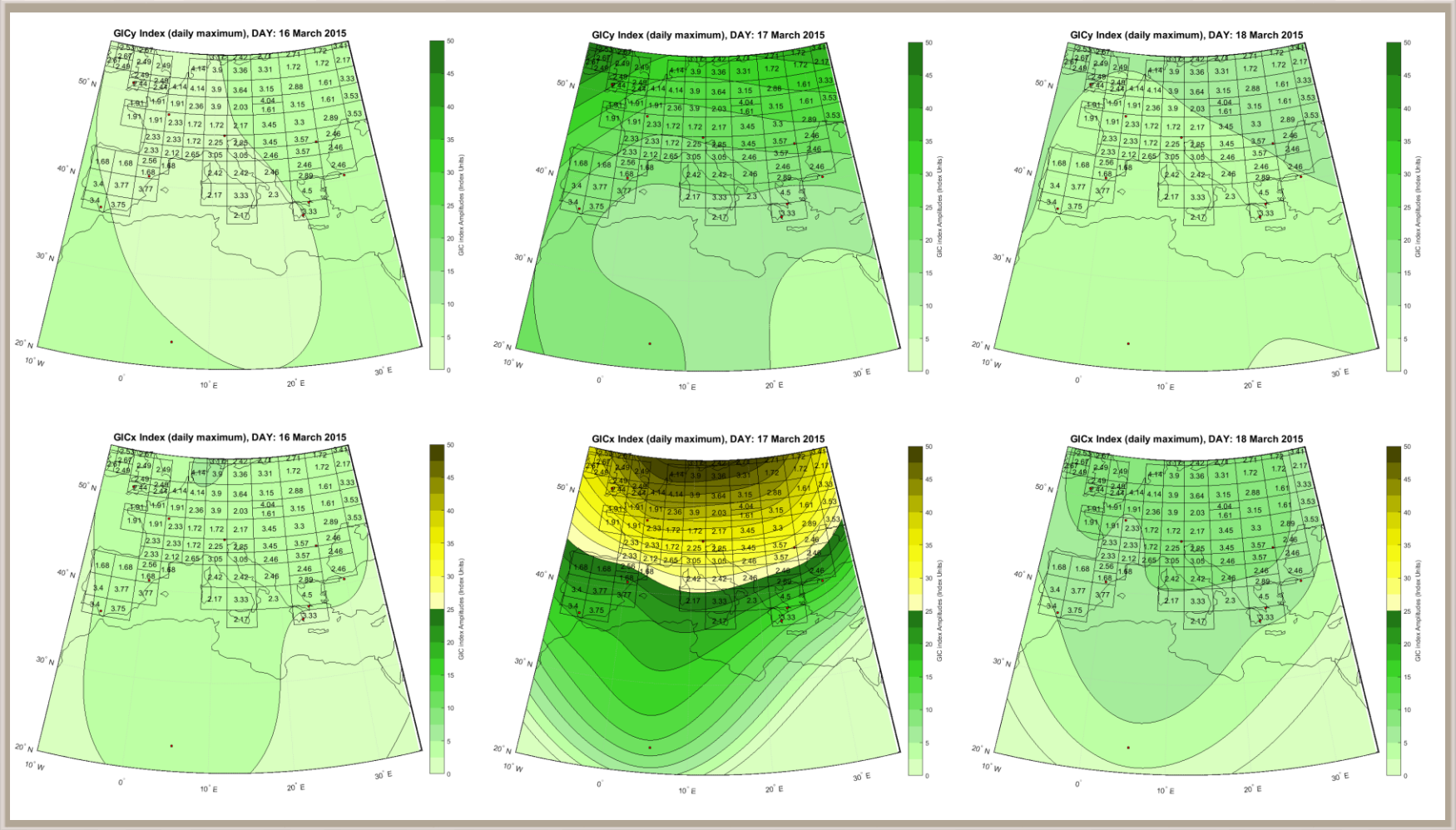
Y - GICx



Storm Date	17/03/2015
Storm Time (UT)	22:00:00
Dst (nT)	-223
SSC Date	17/03/2015
SSC Time (UT)	04:45:00
Mean amplit. (nT)	39.9
$GICy_{max}$ (DIO)	13.0276
Time (UT)	04:46:00
$GICx_{max}$ (DIO)	15.8637
Time (UT)	17:48:00
$GICy_{max}$ (VLI)	12.4856
Time (UT)	04:46:00
$GICx_{max}$ (VLI)	14.2315
Time (UT)	17:48:00

(Manuscript under revision)

Contour maps



16-18 March 2015

Based on daily maximum GIC index values

"Very Low" & "Low" GIC risk levels

Several interpolation methods have been tested

Conductivity estimates from 1D layer models produced by the EURISGIC project have been incorporated

Both GICy and GICx:

- vague contour lines before and after the storm
- contour lines tend to become more horizontal and structured, gradually increasing from South to North **on the day of the storm**

Risk level	GIC_x index range	GIC_y index range
Very low (<5%)	≤25	≤50
Low (5–35%)	25–50	50–100
Moderate (35–65%)	50–125	100–250
High (65–95%)	125–300	250–600
Extreme (>95%)	>300	>600

Thresholds need to be calibrated for countries at middle magnetic latitudes.

Discussion

During the investigated time intervals GIC indices do not exceed low activity levels despite the increases in their values (based on the current risk level thresholds).

GIC index increases are well correlated with Storm Sudden Commencements (SSCs).

However, it should be noted that the present GIC index is calculated without taking into account the geoelectrical structure of the area that the station is located (i.e., the electrical conductivity of the subsurface), which might seriously affect the development of GIC.