Modeling GIC in the Mexican Power Grid

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1. Introduction

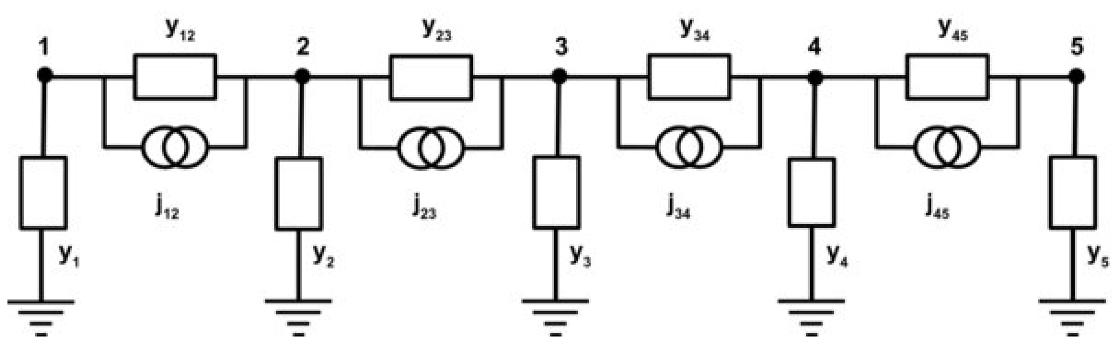
The Mexican electrical power grid occupies a broad territory and has several connections with the US and Central America. We present the first GIC estimates based on an one-dimensional model for four intense geomagnetic storms from solar cycles 23 and 24. GIC effects at low latitudes are scarcely studied.

2. Mexican Power Grid

The Mexican EHV grid consists of two AC networks interconnected at 400 and 230 kV, respectively. There are several connections with the US and Central America. These networks employ ca. 52000 km of transmission lines that interconnect more than 300 substations.

3. Methodology

The GIC was calculated using the Lehtinen-Pirjola method (Lehtinen & Pirjola 1985), at 115 substations of the Mexican 400 kV grid. The grid was modeled as a series of nodes (i.e., substations) interconnected by current sources and admittances.



The admittances y_{ij} and y_j are defined as:

$$y_{ij} = 1/r_{ij} \quad y_j = 1/r_j$$

Where r_{ij}, r_j are the conductor and earthing resistances respectively. The current sources J_{ij}, represent the GIC generated at each segment.
Four events were chosen from solar cycles 23 and 24 (see Table below).

Date	SC	Dst(nT)	Kp
2017-09-07/09	24	-124	8+
2015-03-17/18	24	-222	8-
2003-10-29/30	23	-350	9o
2000-07-15/16	23	-180	9o

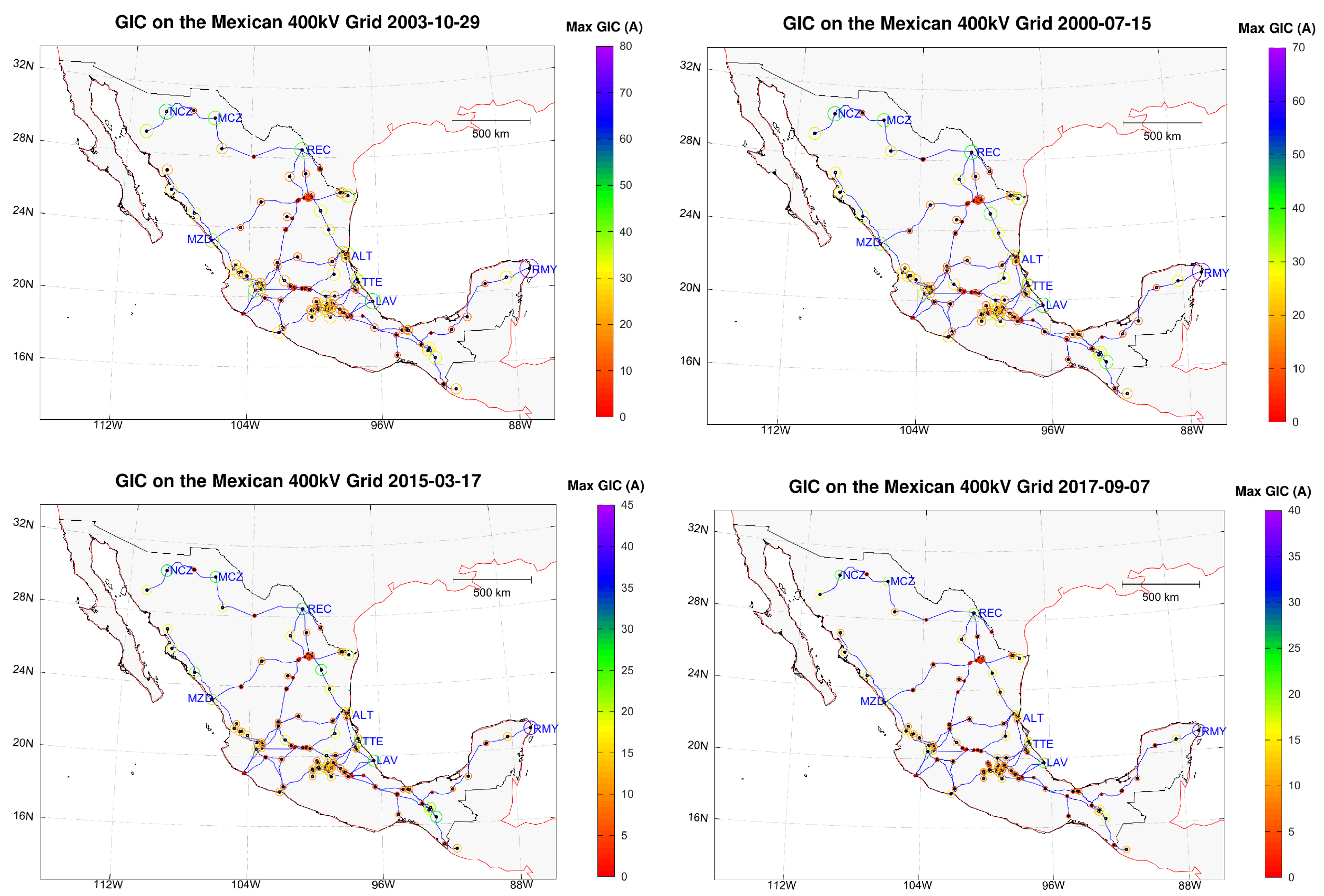
The geomagnetic disturbance dB/dt, was assumed uniform along the Mexican territory as well as the ground conductivity which was set to $\sigma = 0.007\ S/m$. The geoelectric field was calculated by using the convolution integral

$$E(t)_{x,y} = -\frac{1}{\sqrt{\pi\mu_0\sigma}} \int_t^\infty \frac{g(t-u)}{\sqrt{u}} du$$

where $g = \pm\frac{\partial B_{y,x}}{\partial t}$, are the derivatives of the horizontal components of the B-field at the Earth´s surface (with x, y the Northward and Eastward components respectively).

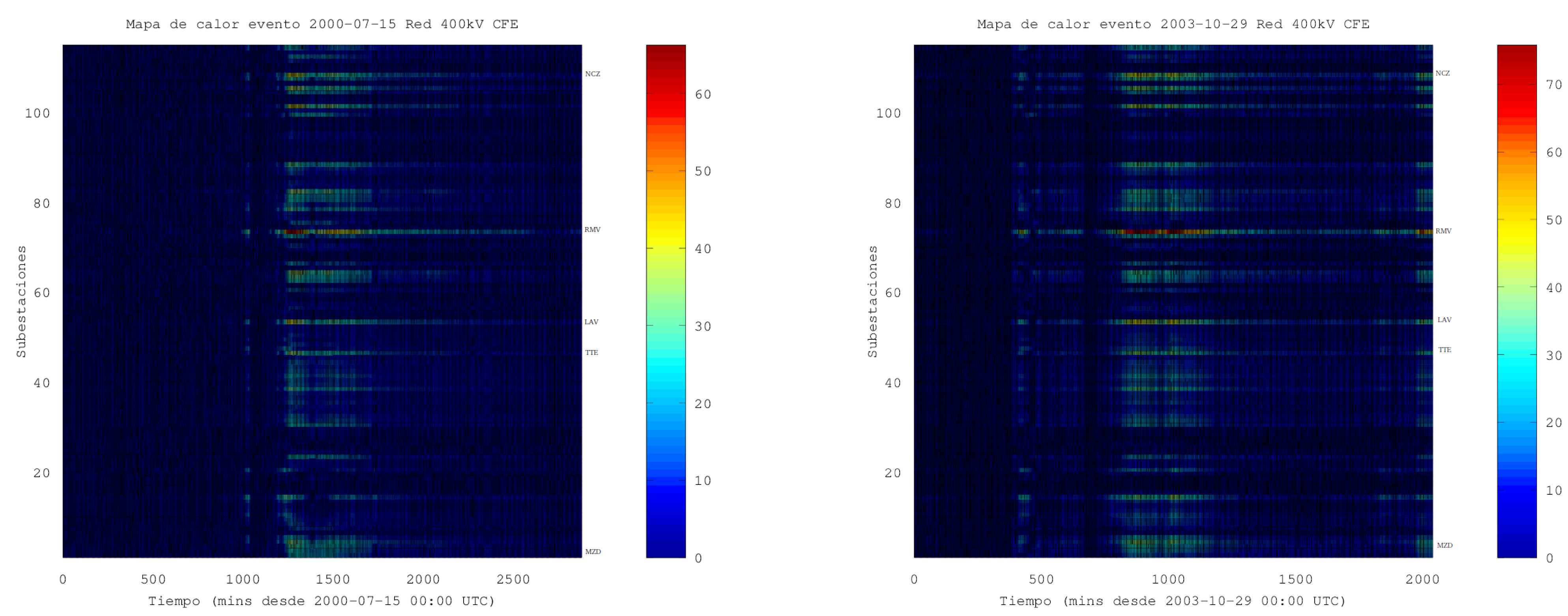
4. Results of GIC Estimates for 400kV Power Grid

Peak values of the GIC at each substation. Substations located at the edges of the power grid are strongly affected during long periods. In the case of the Halloween storm, GIC above 30 A lasted for 10 hrs approximately. In this one-dimensional model only the topological effect of the grid is evaluated. The assessment of other geophysical factors like lateral conductivity variations and non-uniform spatial distribution of dB/dt is in progress.



5. Evolution of the GIC at all Substations

The temporal evolution of the GIC is represented by stackplots composed by 115 colored ribbons, each ribbon represent a substation. Vertical axis is substation index. On the right, the acronyms of the most affected substations. Almost 70% of the substations show GIC activity between 20-70 A.



6. Conclusions

- The Mexican power grid can be affected by GIC during strong and severe magnetic storms.
- According to the 1D model, nodes located at the ends and in the coastal areas can be significantly affected by GIC between 20-70 A.
- Model results are used to plan the installation of GIC sensors at the most critical sites.
- Experimental data will be used to improve the model with the aim to develop a real time platform for now-casting and forecasting.

7. Acknowledgements

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