

Technical Report: Dr. Sushil Kumar and Dr. Samir Nait Amor
European Science Foundation: Visiting Fellowship 2016
Hosted by the DTU Space, Denmark

Introduction

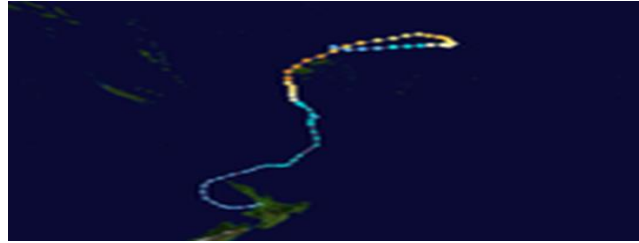
Dr. Sushil Kumar, School of Engineering and Physics, The University of the South Pacific (USP), Fiji, and Dr. Samir Nait Amor, Solar Astrophysics Division, CRAAG, Algeria, undertook visiting fellowship during 03 January to 02 February 2016 to work with Prof. Torsten Neubert and Dr. Olivier Chanrion of Space Science Institute, Technical University of Denmark (DTU Space). The visiting scholarship was under the SHORT and EXCHANGE VISITS support programme of European Science Foundation under which a financial support of Euro 2100 for travel and per diem were provided both to Dr. Kumar and Dr. Samir.

Summary of Work

The fellowship was provided to the project “*Ionosphere perturbations by severe oceanic storms*” in the South Pacific Region. Severe thunderstorms and Tropical Cyclones (TC) are thought to couple to the upper atmosphere and ionosphere via gravity waves and affect the sub-ionospheric VLF propagation which can also be affected by phenomena associated with Space Weather. The main aim was to analyse VLF perturbations of ground-based navigation transmitter signals recorded at Suva when TCs pass the transmitter-receiver GCP passes. The VLF data recorded using the SofTPAL receiving system at USP, Suva, and lightning data provided by WWLLN network were analysed to accomplish the aim which will further be strengthened using satellite data on stratospheric winds etc. The data analysis was carried out by Dr. Samir Nait Amor, Dr. Sushil Kumar, Dr. Olivier Chanrion, using the different software according to their expertise under the supervision of Prof. Torsten Neubert.

The effect of 4 tropical cyclones was analysed on NWC, VTX, JJI, NPM, NLK and NAA VLF transmissions received at Suva (18.1°S, 178.4°E). Initial observations from analysis are as follows;

1. *Severe Tropical Cyclone Evan: Cat. 4: Duration Dec 9–19, 2012*



It affected the areas about 800 -1000 km away from Fiji through which NPM, NLK and NAA signals propagate. It was a recurving cyclone.

NPM: The perturbation on NPM signal was observed on 9 Dec in the night-time between the period 06-18 hrs UT (18 -12 hrs LT) even during initial depression phase of TC. Further strong storm effect was seen during the daytime in terms of significant decrease in signal strength on 10th Dec when storm was about 50 km away from TRGCP. It extended to 11th Dec both day and night times when TC was about 500 km away. The effect was seen until 15th Dec when TC was 20 km away. So the NPM signal was affected all throughout from 9-15 Dec and cyclone was within 600 km of TRGCP.

The average night-time signal strength showed continuous decrease from 10 to 13 Dec and recovered on 14 Dec. The average daytime signal analysis showed similar decrease but very small.

NLK: Observed signal perturbation in the night-time during 9th Dec to 15 Dec. The perturbation on NLK was observed on 11 Dec (daytime) when TC was about 20 km from path. The disturbance was also seen on 13 (daytime) after that transmitter went off until 14th day time. VLF perturbation was again seen on 15 Dec (night-time).

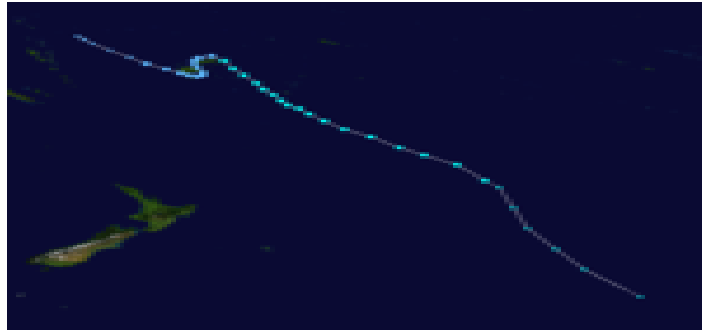
NAA: Observed signal perturbation 10th Dec both during day and nighttimes. Again disturbance was seen on 12th Dec (night-time) and on 13th and 15th Dec (night-time).

JJI: The analysis showed a significant decrease in signal strength on 14th Dec daytime when TC intercepted TRGCP of JJI.

The analysis of data for early VLF perturbations did not show any significant increase in VLF perturbation events, However, there were very short duration (1-3 s) signal increases

(5-10 dB) due sferics cluster arriving at receiving antenna from the enhanced lighting activity associated with storms.

2. *Tropical Cyclone Kofi: Cat : February 24 – March 4, 2014*



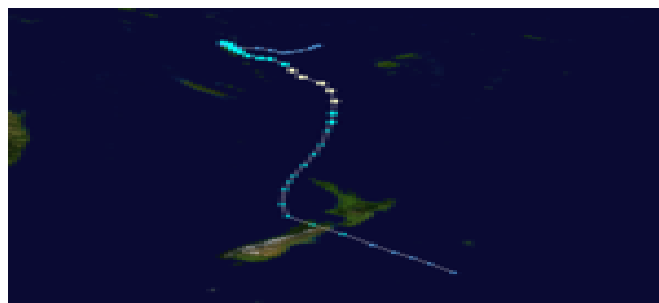
The NPM transmitter was off during the storm. NAA also was off air frequently. So NLK and NWC were been analysed.

NWC: The signal perturbation was seen on 25th Feb during night-time which was more evident on 26 and 27 Feb during night-time when cyclone was over the Fiji.

NLK: The signal perturbation was seen on 24th Feb during night-time and showed significant deviation from mean until 27th Feb when cyclone was over the Fiji.

JJI: JJI was off air during 00-08 hrs UT (daytime) the storm during 24-28 Feb. The night-time analysis showed no change in signal as compared to night-time of quite days before and after the storm.

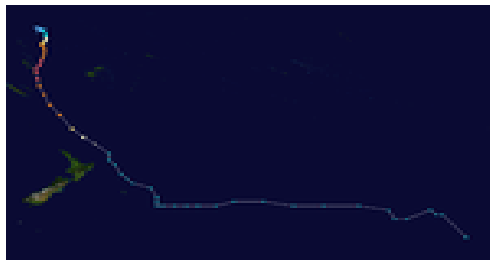
3. *Severe Tropical Cyclone Lusi, Cat 3, 7-14 March 2014*



TC appeared to have affected JJI, VTX and NWC signal propagations: The VTX was off air throughout. JJI was under the storm during its developing stage and showed no change in signal strength.

NWC: Analysis showed no change in signal amplitude both during day and night-time may be because it intercepted during decaying part of the storm and storm was quite away from receiver. There may be some other reasons also.

4. *Severe Tropical Cyclone Pam: Cat 5, March 6 – March 15, 2015*



Appeared to have affected JJI (during initial stage), VTX (mostly and during intense stage), and NWC during decay stage.

JJI: There was no change in signal strength.

VTX: Significant change in signal strength starting during night-time on 13 and 14 March.

NWC: No significant change on 14 and 15 March.

Implications of Visiting Fellowship

VLF is one of the most cost-effective radio wave techniques that has been used successfully to explore lower part of the ionosphere. VLF waves received from existing communication transmitters after propagating in the Earth-ionosphere waveguide enable us to study the morphology of D-region of the ionosphere, which is poorly understood. Study of Tropical cyclones is important for scientific interest as well as to reduce the damages by extreme natural events. The threats due these events are increasing due to increase in population, economic and infrastructure development etc. The output of the work carried out and further analysis of data with understanding developed of the subject during this fellowship shall enable us at least a publication in a high rank journal and probably presentation initial results in a conference. The collaboration among the team of this project will be continued and explore the areas of further collaborations. The

outcome of the project will help us prepare well to teach and conduct lab components better on the topics related to the propagational features of VLF/ELF signals in the Earth-ionosphere waveguide at low latitudes in the South Pacific Region at USP. It will certainly enhance our research area leading to Masters and probably PhD students.

Acknowledgements

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We are grateful to Prof. Torsten Neubert and Dr. Olivier Chanrion for numerous meetings on data analysis and useful scientific discussion. Their support and cooperation is gratefully acknowledged. Also they were very kind to organize social which we enjoyed very much- many thanks to Mrs Torsten. Finally, Dr Kumar wishes to thank his wife and daughters (Lavi and Kavya) for their moral support and encouragement throughout the fellowship.

Overall our stay at DTU Space was very productive and enjoyable.

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