TWENTY YEARS OF ELF ELECTROMAGNETIC FIELD MONITORING IN ANTARCTICA AT "VERNADSKY" STATION (REVIEW)

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The report presents the results of systematic twenty-year measurements of natural and industrial electromagnetic radiation in extremely low frequency (ELF) range at the Ukrainian Antarctic station (UAS) “Vernadsky”. The ELF waves propagate over long distances with low attenuation due to the channeling of energy in a spherical cavity between the Earth’s surface and the low boundary of ionosphere which forms the global Schumann resonator (SR). The emissions in this range are mainly provided by two sources – natural and man-made. The natural source of these emissions is the global lightning activity (GLA), the main three centers of which are located in the equatorial regions of Southeast Asia, Africa and America. The source of man-made emissions is the global network of powerful electric energy transmission lines (PTL) operating in the frequency range 50 (60) Hz. The Antarctic region, specifically the area close to “Vernadsky” station, where there are no local thunderstorms or any industrial activity, is an optimal place for monitoring of GLA and PTL radiations. Systematic continuous measurements of ELF fields were started at the UAS in 2002 using sensitive magnetometer system created in Ukraine. Then, in 2013, similar system was installed in Spitsbergen archipelago. Since then the two-position ELF interferometer has been operating in a synchronous mode in the polar regions of both hemispheres continuously. On-line access to Antarctic and Arctic database is provided via Internet.

WHY IS ELF (3 – 300 Hz) WAVE MONITORING IMPORTANT AND RELEVANT IN THE ANTARCTIC?

1. MAIN SOURCE OF THE ELF RADIATION IS THE GLOBAL LIGHTNING ACTIVITY (GLA)

2. FORMATION OF THE ELECTROMAGNETIC CLIMATE, AND ELECTROMAGNETIC "SMOG"

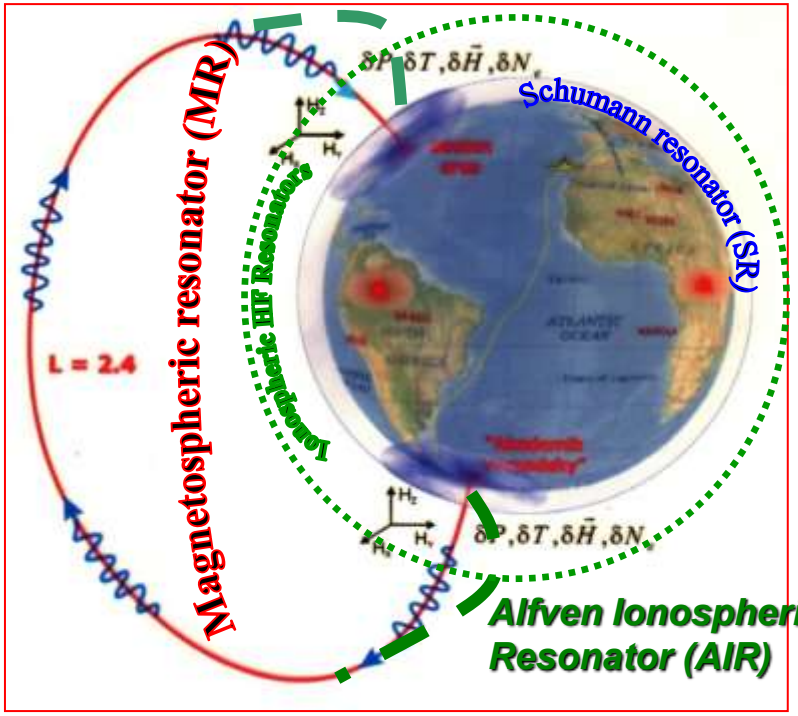
3. GLA IS AN INDICATOR FOR THE CONTINENTAL TEMPERATURES AND THE CLIMATE CHANGES

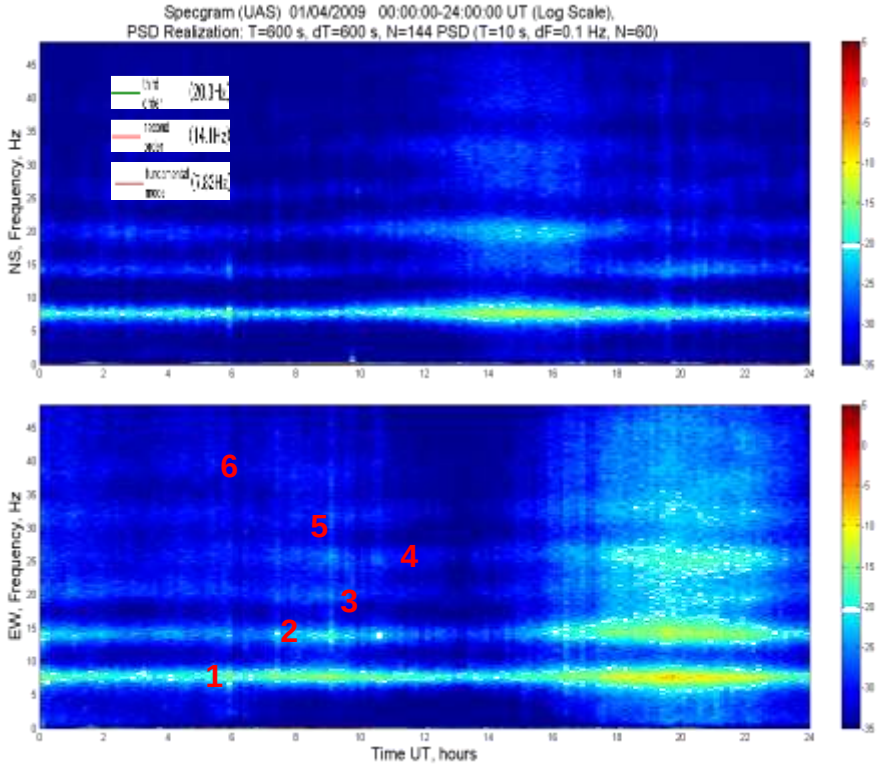
4. THE UPPER BOUNDARY OF SR (LOW IONOSPHERE) IS AN INDICATOR OF SOLAR ACTIVITY

5. THE ANTARCTIC IS THE UNIQUE ELECTROMAGNETICALLY CLEAN CONTINENT OF THE EARTH

CHANNELLING OF THE GLA ELF EMISSIONS DUE TO THE SCHUMANN RESONATOR (SR)

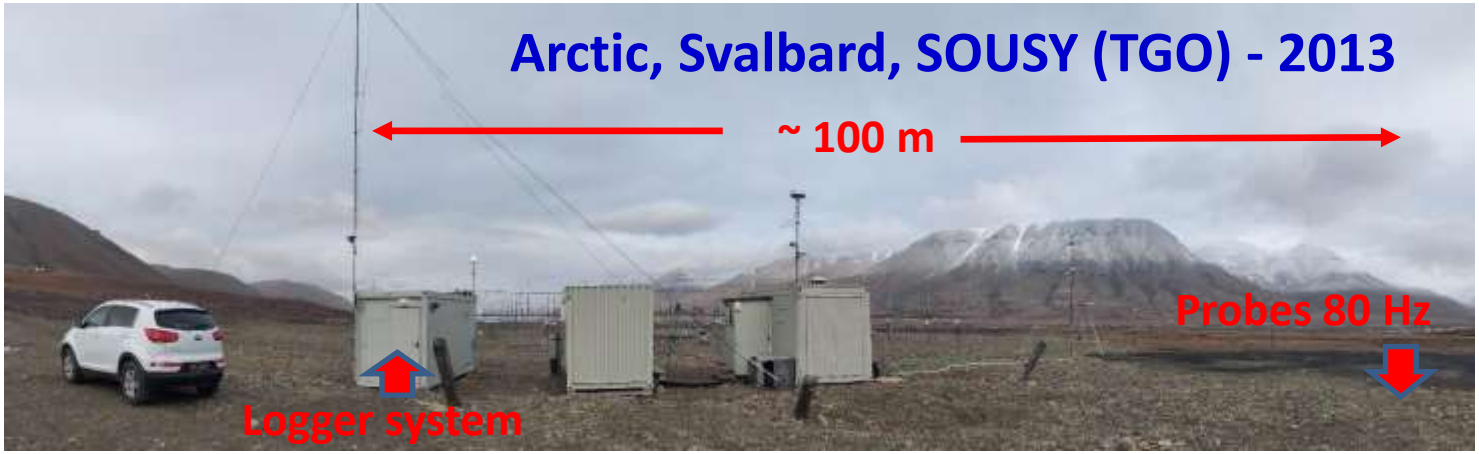
(EARTH – IONOSPHERE SPHERICAL CAVITY)





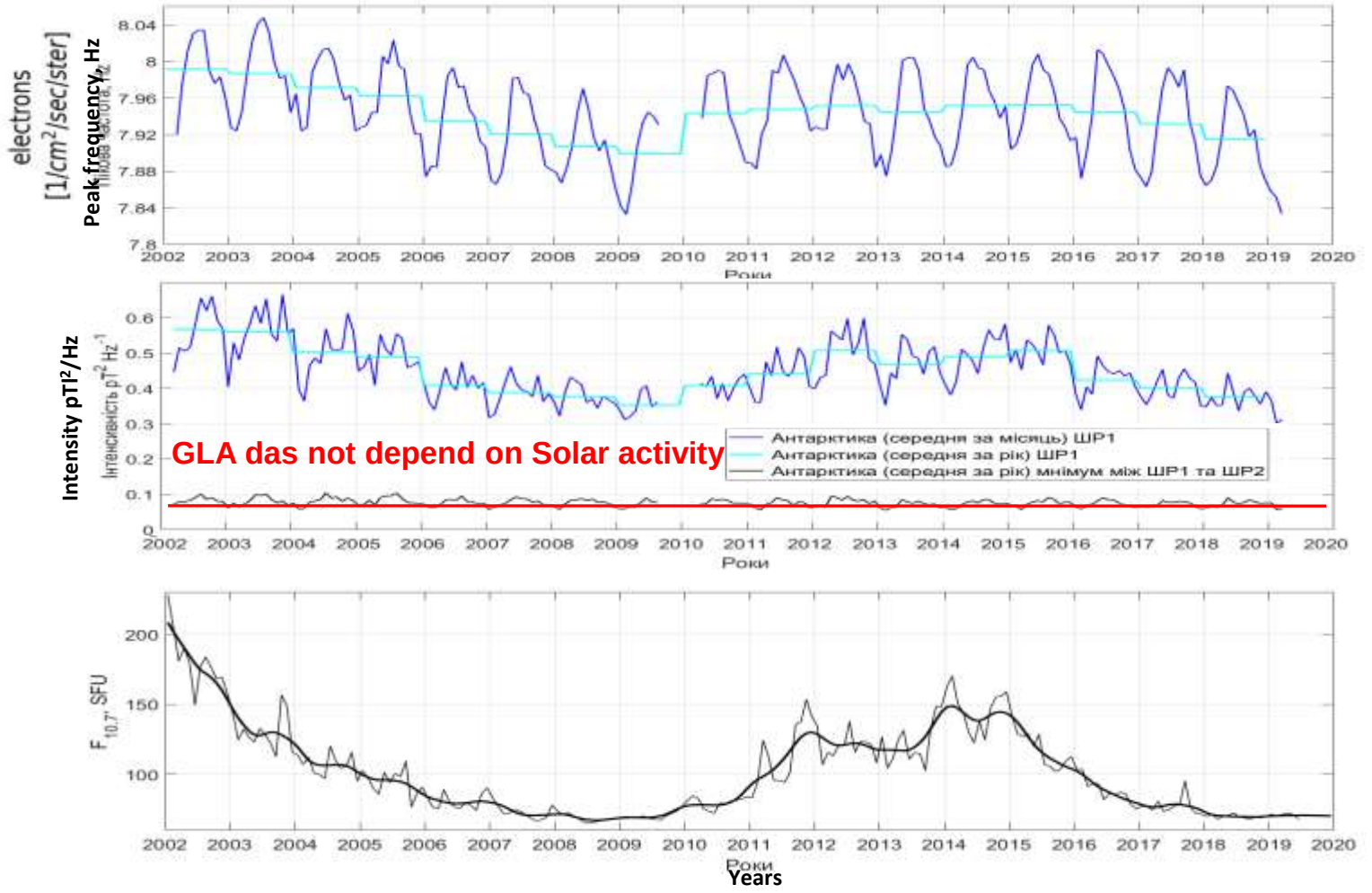
Eigen frequencies of SR modes: 7.83,14.3, 20.8, 27.3, 33.8 Hz, 39.1

ELF OBSERVATORIES OF IRA NAS – NASC OF UKRAINE

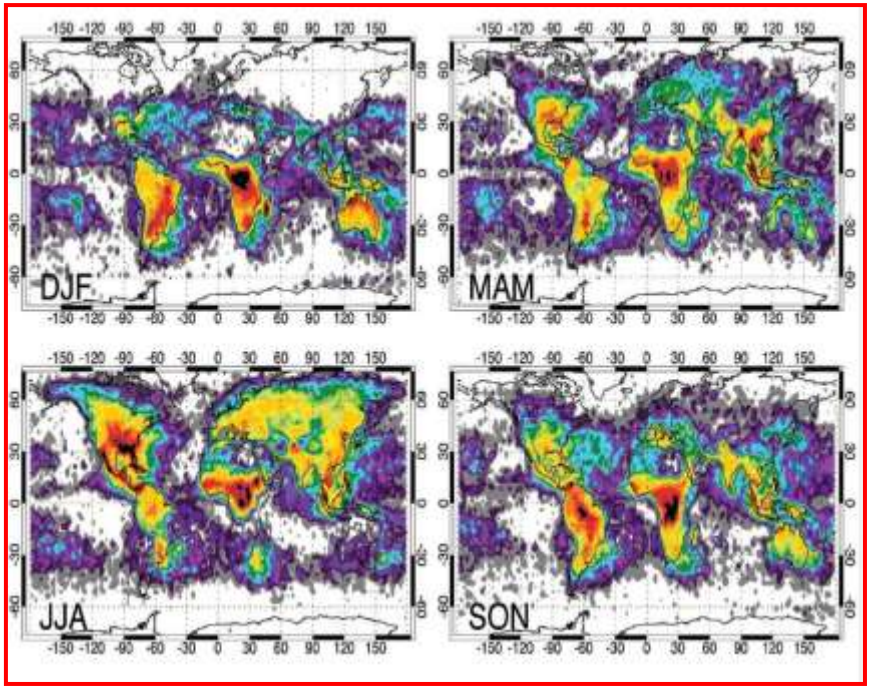


RESPONSES ON REGULAR SOLAR ACTIVITY

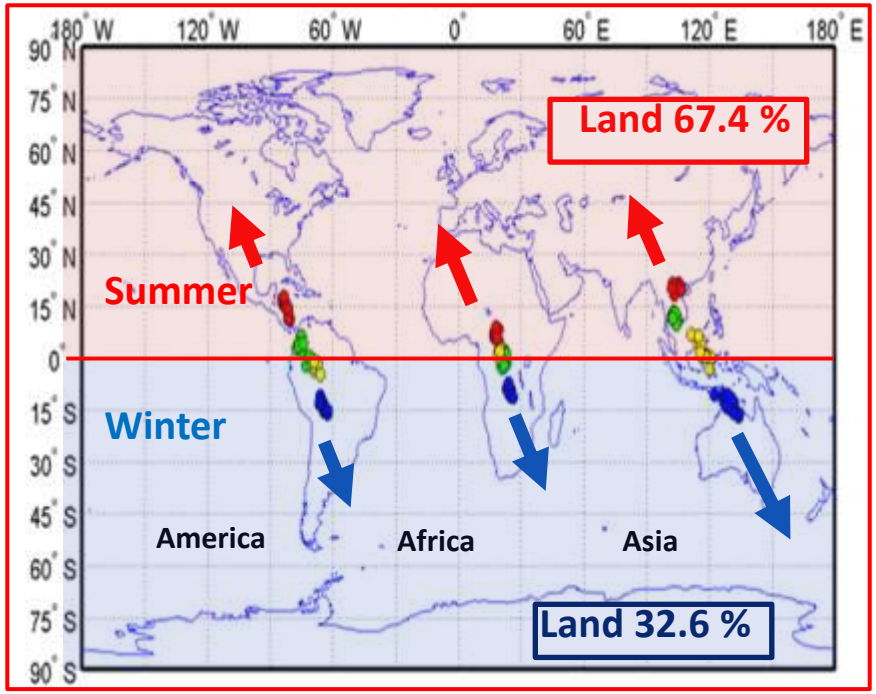
1) 11-YEAR SOLAR CYCLE IMPACT ON THE LOWER IONOSPHERE



2) SEASONAL BEHAVIORS OF THREE EQUATORIAL CENTERS OF THE GLA



OTD satellite data

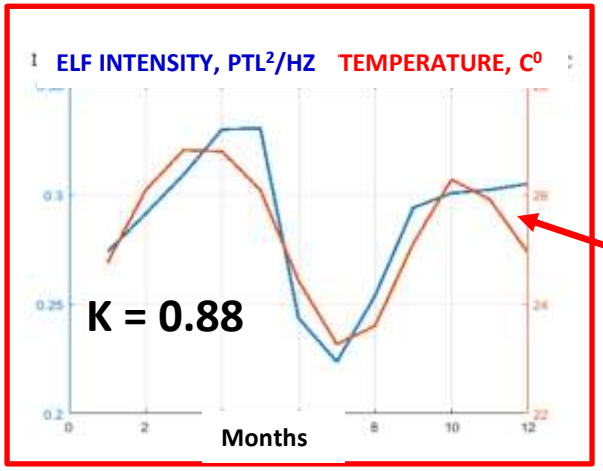


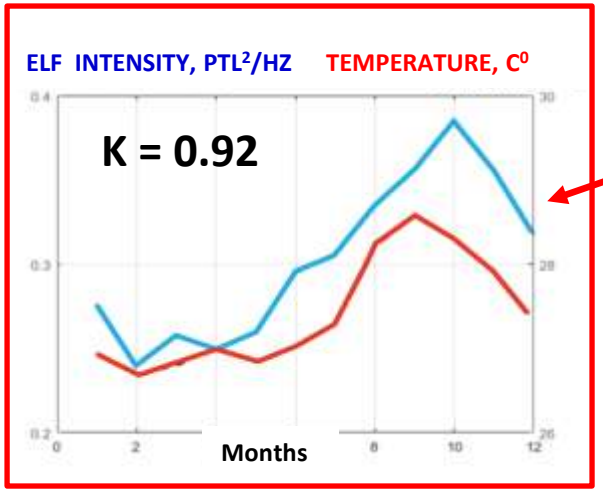
ELF measurements

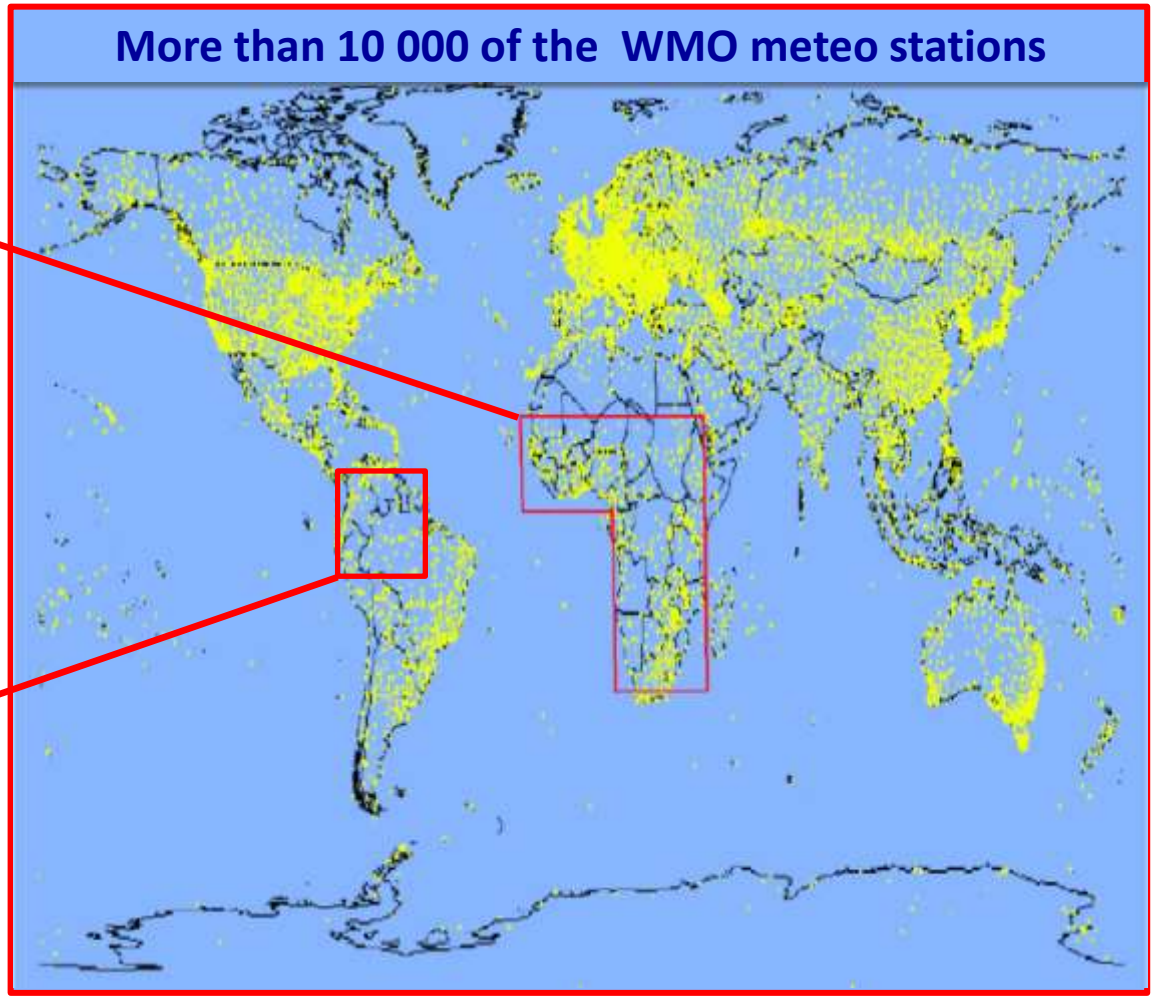
ANNUAL CHANGES OF THE ACTIVITY OF THUNDERSTORM CENTERS ACCORDING TO ELF MEASUREMENTS IN THE ANTARCTIC IS ~ 44.0% ,

ACCORDING TO THE ANNUAL CHANGES OF OBSERVATIONS FROM SPACE IS ~ 44.3%

3) COMPARISON OF THE GLA AND CONTINENTAL TEMPERATURES

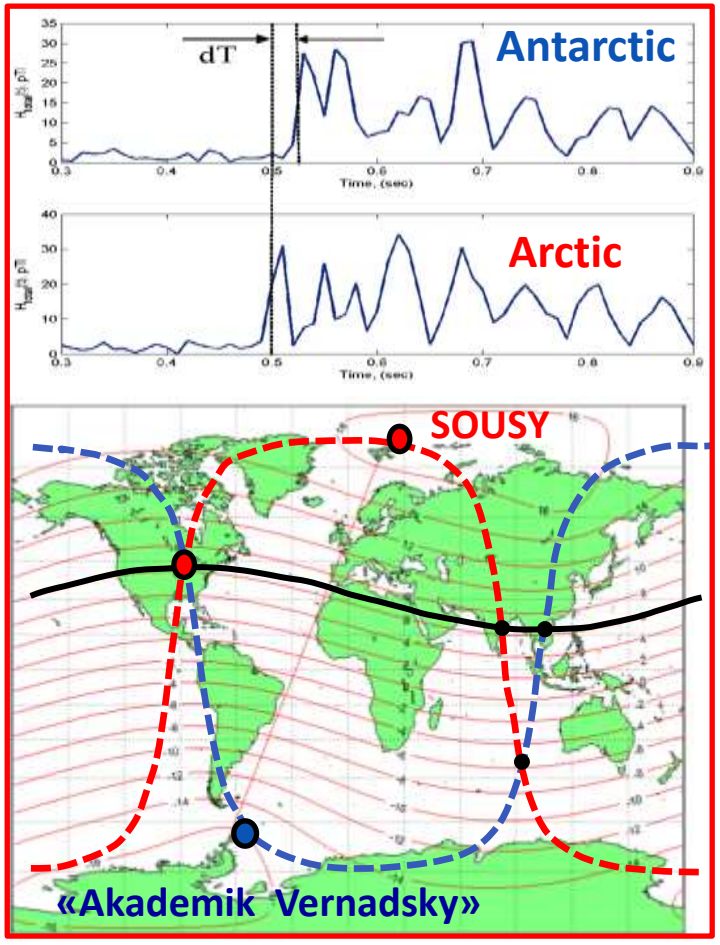


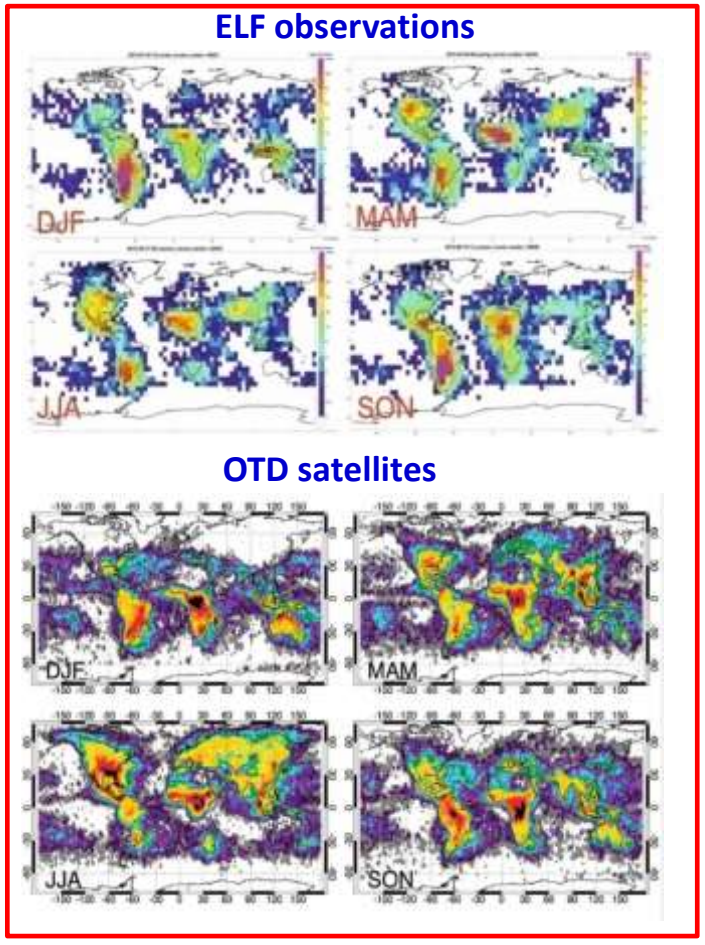




RESPONSES ON SPORADIC EVENTS AND DISASTERS

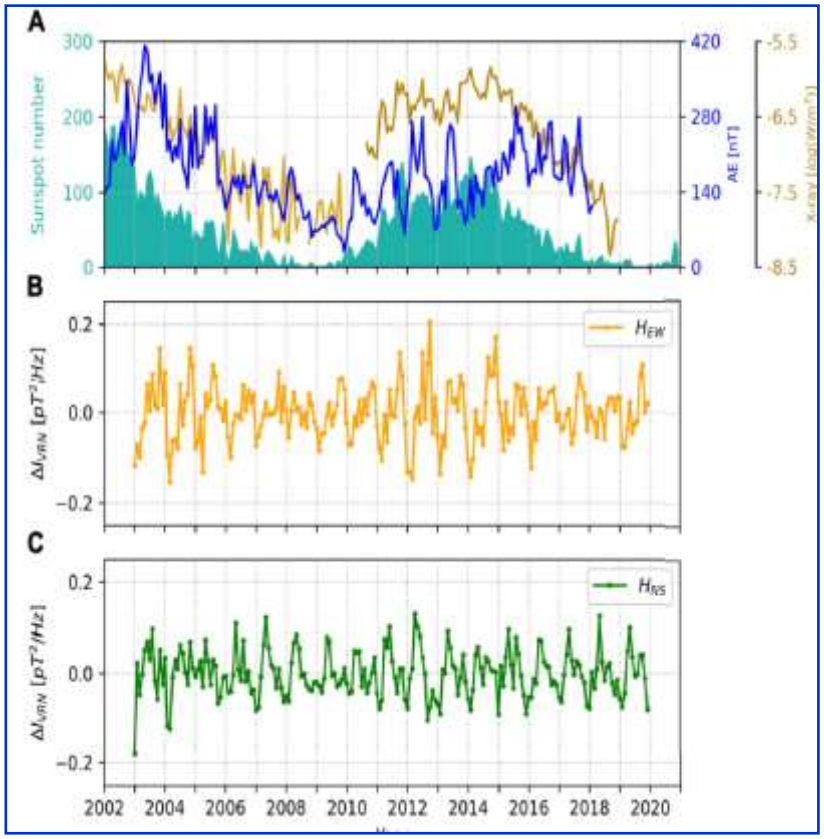
1) SUPER LIGHTNINGS - DETECTION AND LOCALIZATION
(Power ~ 10 000 GigaWatt per stroke)



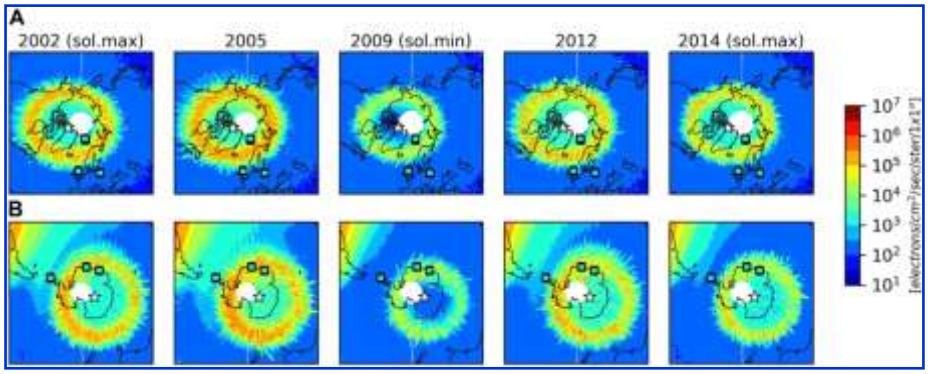


65 millions super discharges were analyzed

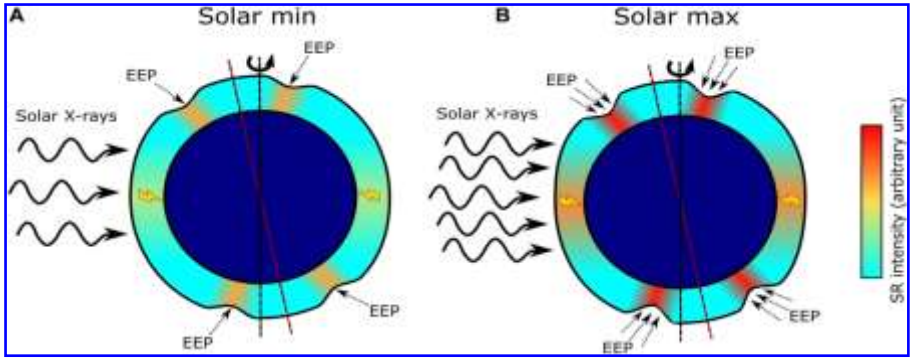
2) POWERFUL ELECTRON PRECIPITATION DUE TO A MINIMUM OR A MAXIMUM OF SOLAR ACTIVITY



A) Monthly average values of the sunspot number (turquoise), the AE index (blue) and the X-ray flux (GOES-10: gold, GOES-15: dark gold) as well as the residual monthly average SR intensities for the (B) HEW and (C) HNS components at the VRN station



The distribution of precipitated 30–300 keV electrons for the Northern (A) and Southern (B) polar regions for the years 2002, 2005, 2009, 2012 and 2014, together with the location of the high and mid-high latitude SR stations

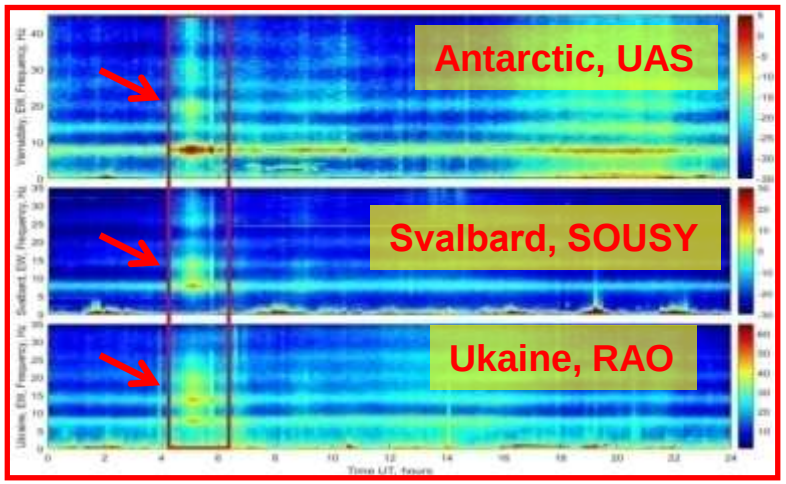


Deformations of low ionosphere boundaries due to the powerful electron precipitations for Solar minimum – (A), and Solar maximum - (B)

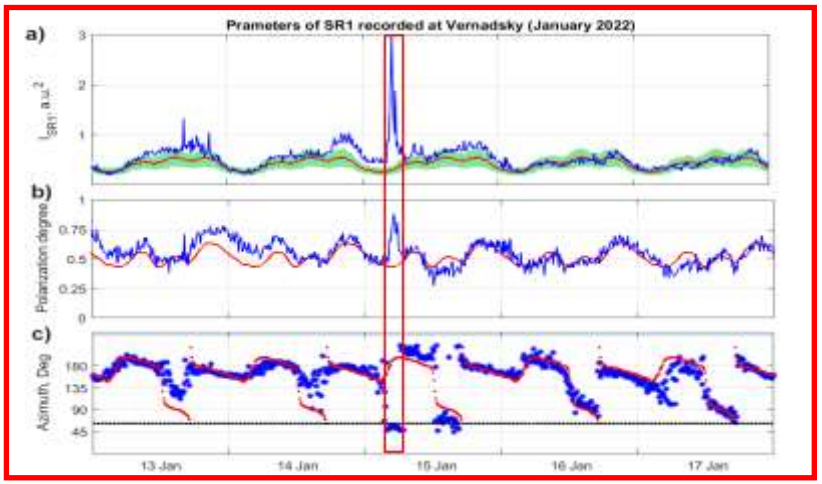
Bozóki T, Sátori G, Williams E, Mironova I, Steinbach P, Bland EC, Koloskov AV, Yampolski YM, Budanov OV et al. Deformation of the Earth – Ionosphere Cavity. Front. Earth Sci. 9:689127. doi: 10.3389/feart.2021.689127

3) VOLCANIC ERUPTIONS AND ELF TRANSIENTS

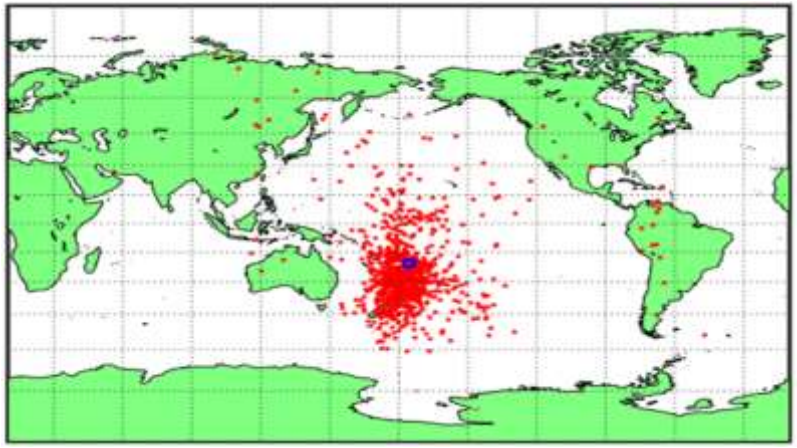
Abnormal thunderstorm activity due to the Tonga event – Jan. 15, 2022



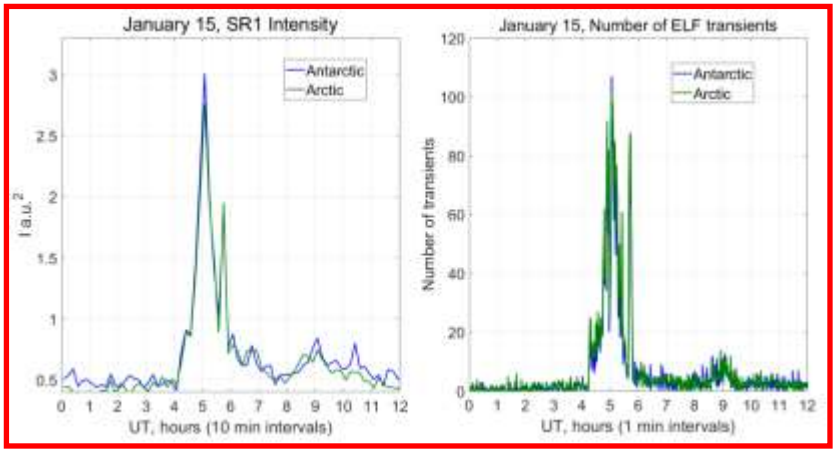
Three position ELF spectra



Azimuth, polarization angle and SR1 intensity



Antarctic-Arctic location of transients

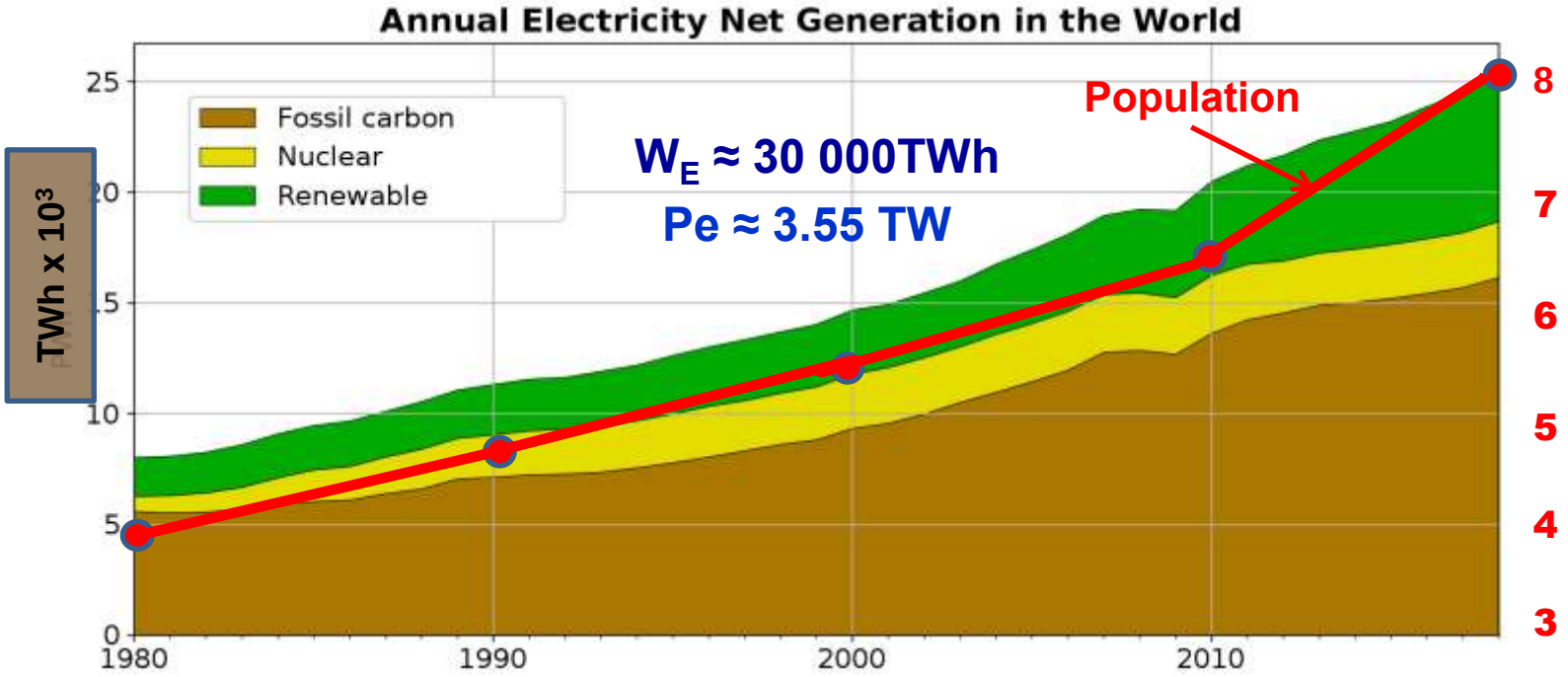


Comparison of Intensities and numbers of transients

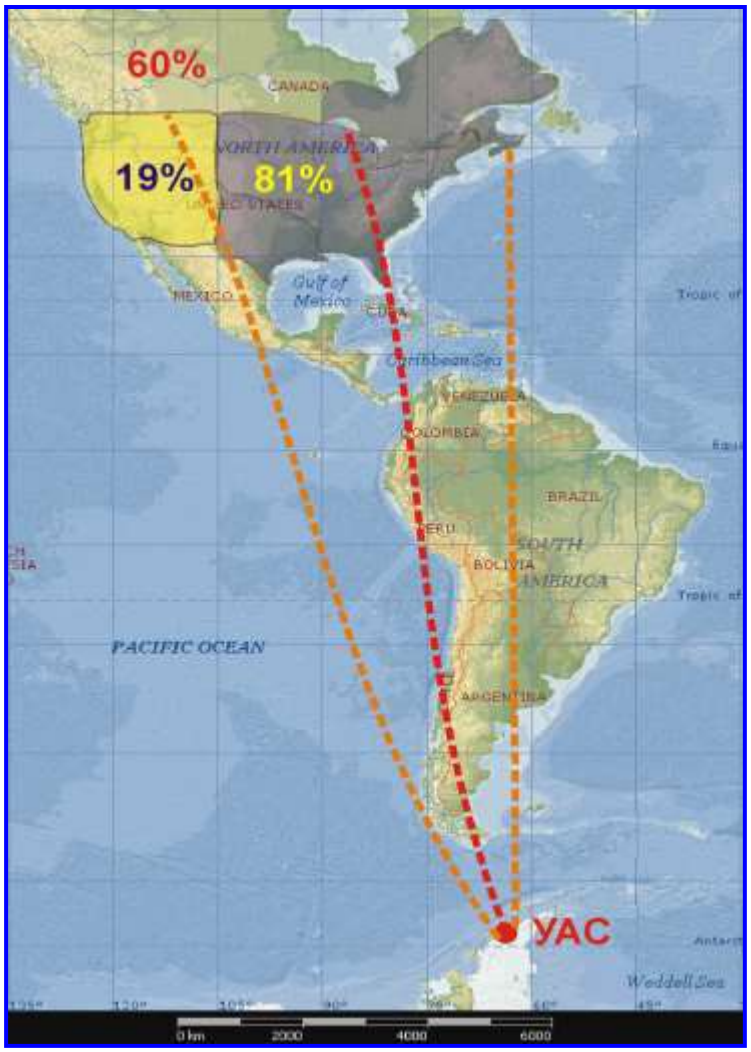
TECHNOGENIC IMPACTS ON ELECTROMAGNETIC ENVIRONMENT

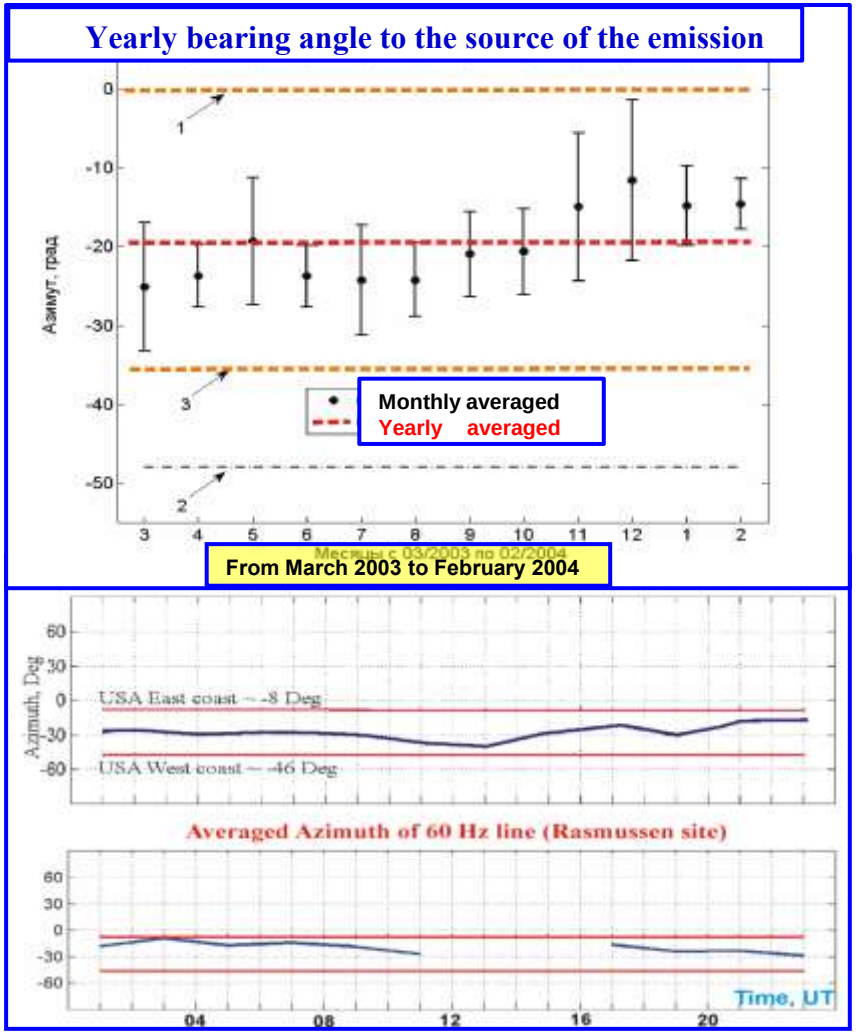
1) WORLD POWER SYSTEM AND ELECTROMAGNETIC "SMOG"

Radiation losses ~ 0,1% → Power of radiation ~ 3.5 GW

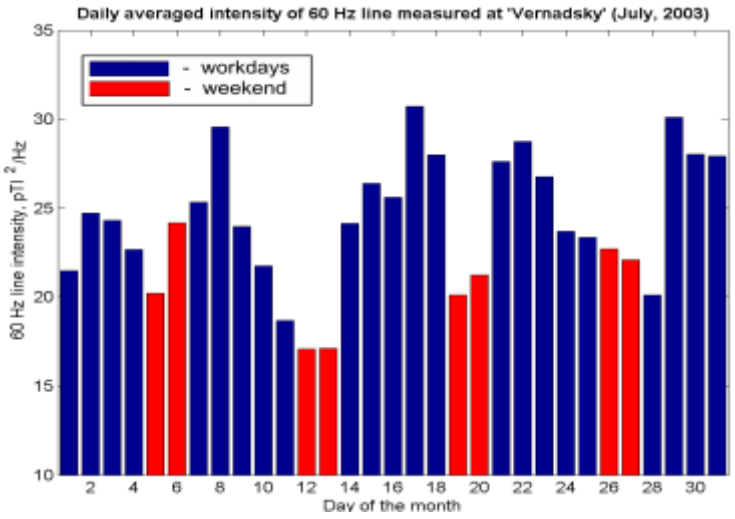


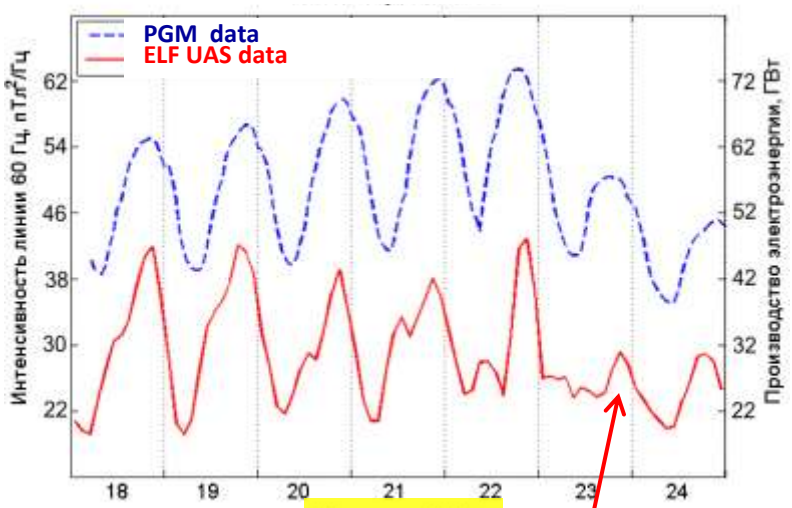
2) US POWER LINE EMISSIONS DETECTED AT THE UAS





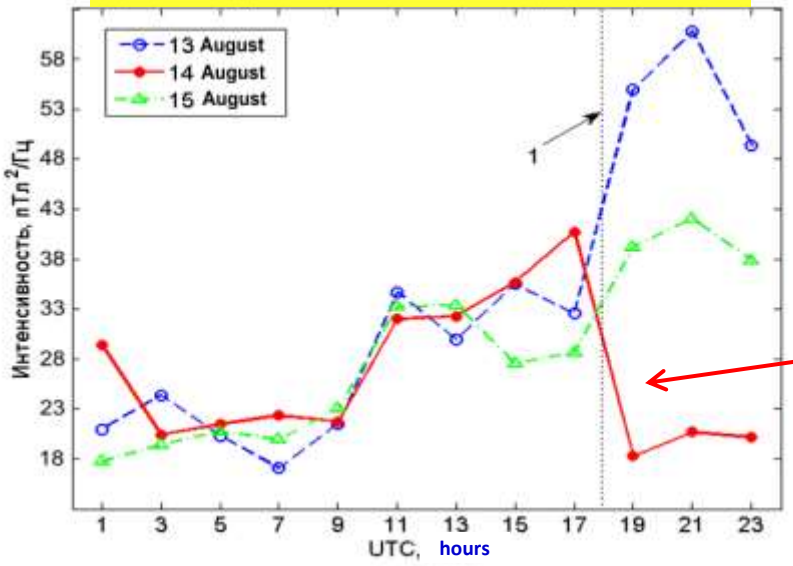
3) WEEK-END EFFECT AND BLACKOUT IN NORTH AMERICA





August 2003

Daily dependency of 60 Hz emission



CONCLUSIONS

What is interesting to explore:

1. **Compare the long-term ELF data with the seismic disasters such as powerful earthquakes.**
2. **Try to find a correlation between hurricanes and lightning activity in the ELF range.**
3. **Organize synchronous observations of powerful ELF transients with the Canadian observatories.**
4. **To investigate impacts of the GLA intensity variations on human medical and physiological indicators.**

THANK YOU