ITU WORKSHOP

**Activities of ITU-R Study Group 3
on radiowave propagation**

**Working Party 3L
Ionospheric Propagation & Radio Noise**

EuCAP 2024, Glasgow

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Thursday, 21 March 2024

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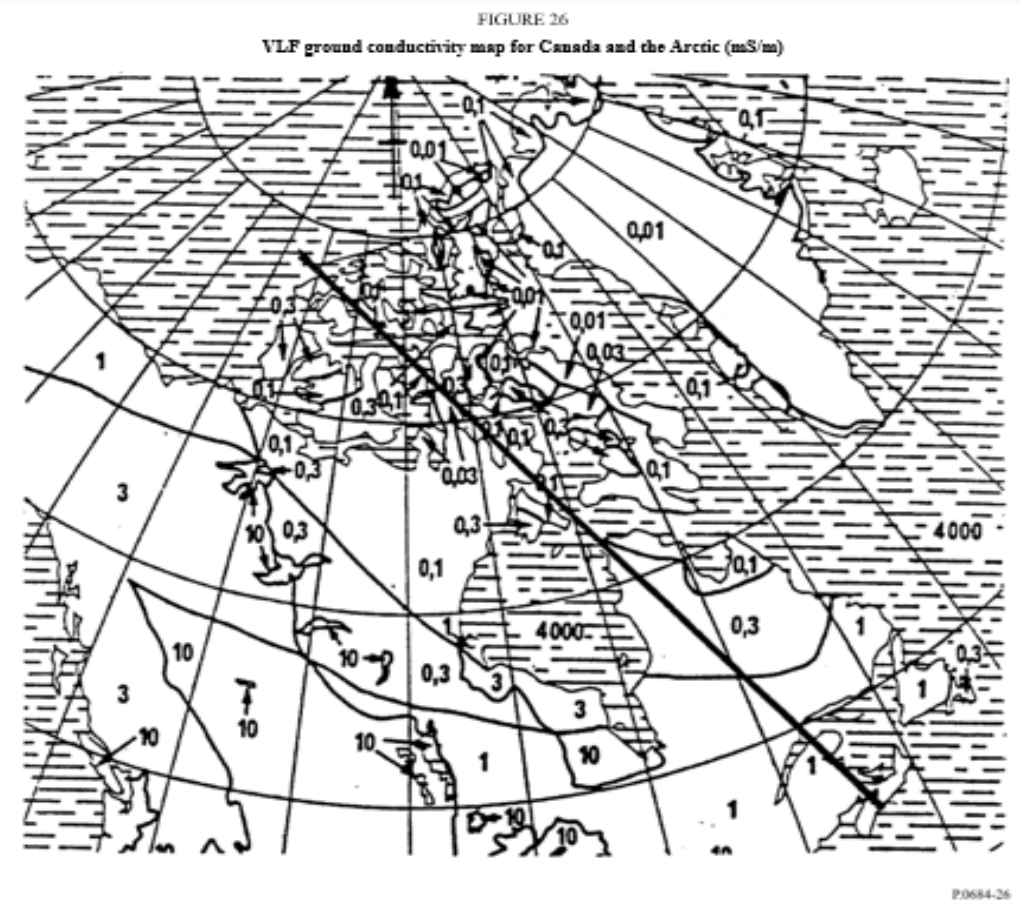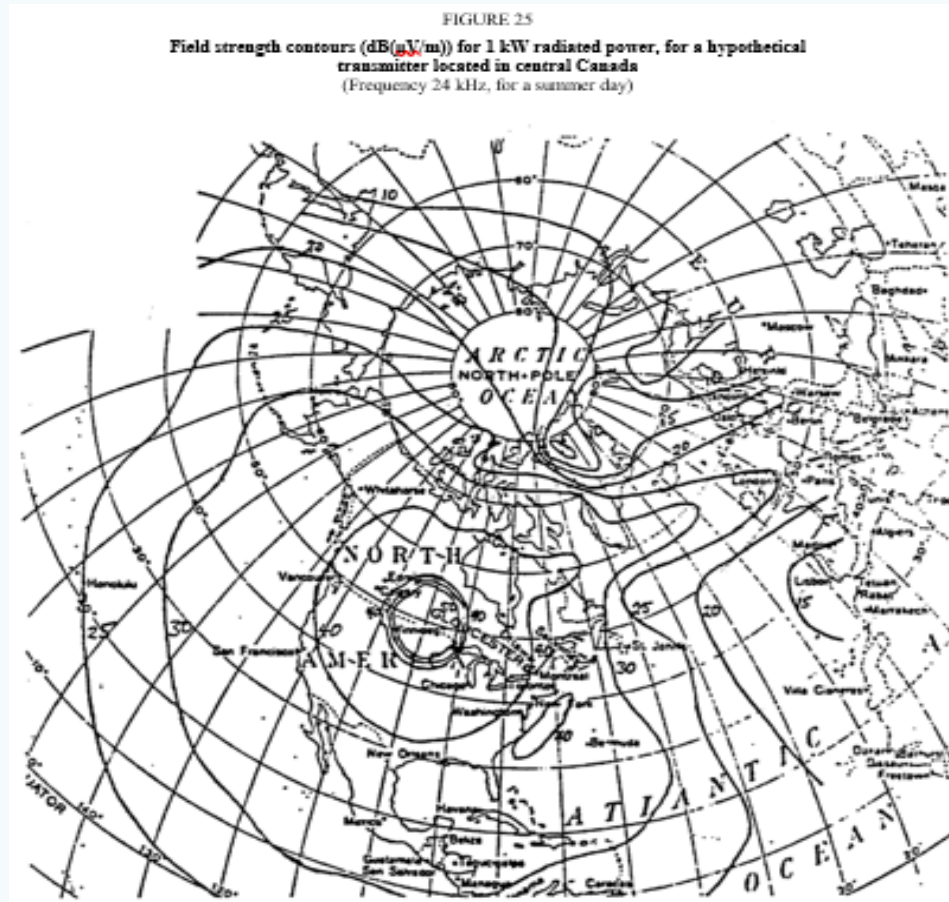6. Comments
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WP 3L Scope

- WP 3L studies all aspects of radiowave propagation in and through the ionosphere, as well as the characterization of radio noise.

- Recommendations are maintained describing, in mathematical terms, a reference model of ionospheric characteristics and maximum usable frequencies associated with the various ionospheric layers.

- Short-term and long-term ionospheric forecasting, with guidance on the use of ionospheric indices, is addressed.

Structure

- Working Party 3L – Ionospheric Propagation and Radio Noise
  - ✓ Chaired by Dr **Angelo Canavitsas** - Brazil
- Working Group 3L-1: LF, MF and HF Propagation - WG 3L-1
  - ✓ Chaired by Mr **Adam Hicks** - USA
- Working Group 3L-2: Trans-ionospheric Propagation – WG 3L-2
  - ✓ Chaired by Dr **Raül Orús Pérez** - ESA
- Working Group 3L-3: Radio Noise - WG 3L-3
  - ✓ Chaired by Mr **Erik Hill**, USA

Work in progress at WG 3L-1

Maps like these, of signal level contours and conductivity, need to be modernized, among other modifications, to improve Rec. ITU-R P.684-8.

FIGURE 25
Field strength contours (dB(µV/m)) for 1 kW radiated power, for a hypothetical transmitter located in central Canada
(Frequency 24 kHz, for a summer day)

FIGURE 26
VLF ground conductivity map for Canada and the Arctic (mS/m)

Work in progress at WG 3L-1

- WG 3L-1 is preparing proposals for a revision of Recommendation ITU-R P.684-8 – "Prediction of field strength at frequencies below about 150 kHz".

- This study is being developed by Correspondence Group 3L-20, and a draft proposal to improve the Recommendation has been developed. It will be presented at the next meeting of WP 3L, for adoption by SG 3.

Work in progress at WG 3L-1

- Recommendation ITU-R P.533 – "Method for the prediction of the performance of HF circuits", also needs improvement. The goal is to better predict the effects of ionospheric propagation on HF communications.

- Testing this Recommendation against practical measurements of HF systems is essential to progress this work.

- WP 3L encourages researchers to provide any results of measurements and testing of the prediction method.

Work in progress at WG 3L-1

- Recommendation ITU-R P.533 provides a method for the prediction of available frequencies, of signal levels and of the predicted reliability for both analogue and digital modulated systems at HF, taking into account not only the signal-to-noise ratio but also the expected time and frequency spreads of the channel.

  - Procedures from Rec. ITU-R P.1240 – "Methods of Basic MUF, operational MUF and Ray-path prediction".

  - Radio Noise data from Rec. ITU-R P.372 – "Radio Noise"

  - The reliability calculation procedure is from Rec. ITU-R P.842 – "Computation of reliability and compatibility of HF radio Systems".

  - Antenna directivity patterns from Rec. ITU-R BS.705 – "HF Transmitting and receiving antennas characteristics and diagrams".

  - A computer program (ITURHFProp) is available from the ITU-R SG 3 website.
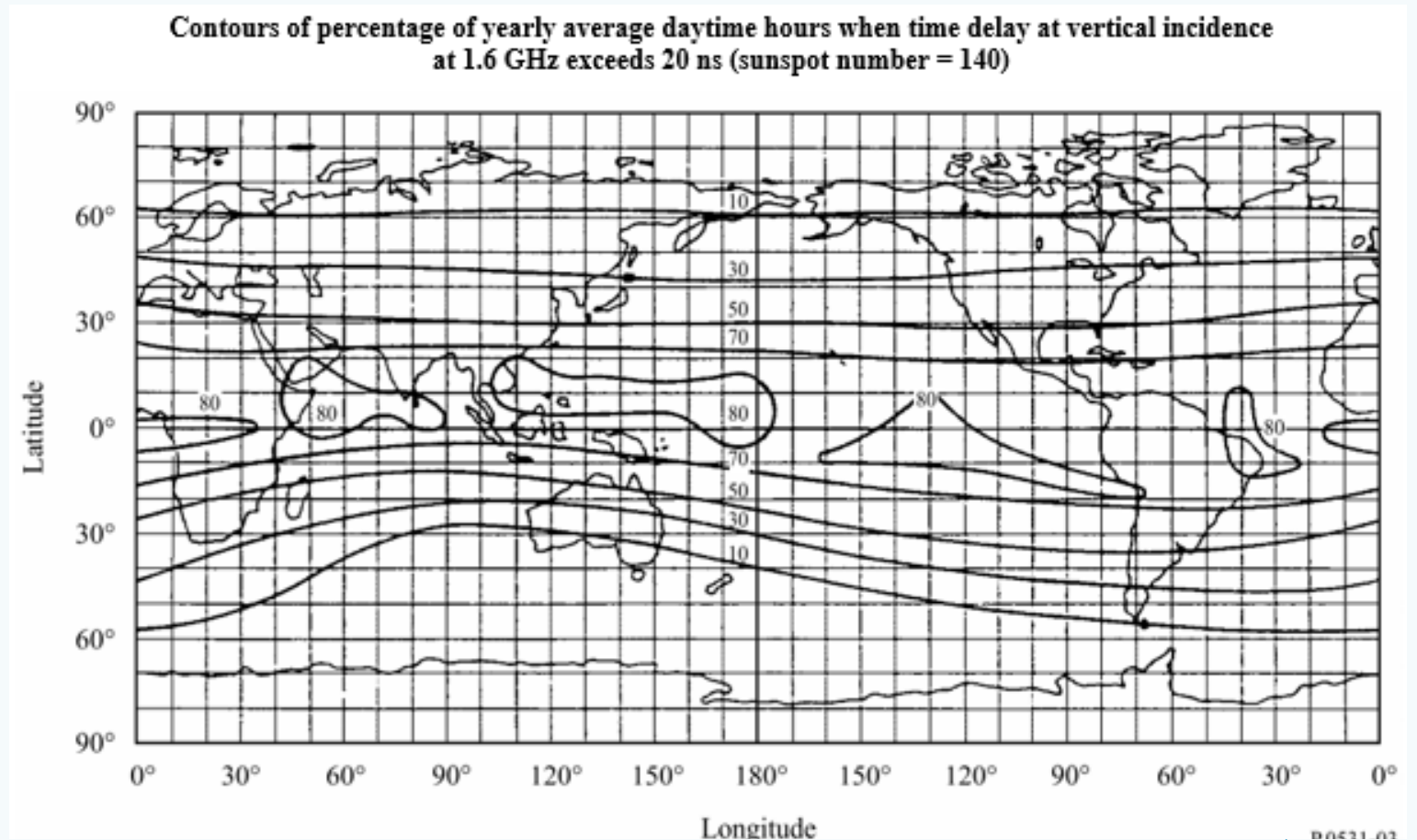
Work in progress at WG 3L-2

- WG 3L-2 is developing revisions to Recommendation ITU-R P.531-15 - "Ionospheric propagation data and prediction methods required for the design of satellite networks and systems."

- Rec. ITU-R P.531 describes a method for evaluating the ionospheric propagation on paths between Earth and space:

  - at frequencies from 0.1 to 12 GHz, or

  - at frequencies above the ionosphere critical frequency, where the ionosphere becomes transparent to radiowaves, to several tens of gigahertz.

- Several effects may take place on paths between Earth and space when the signal is passing through the ionosphere.
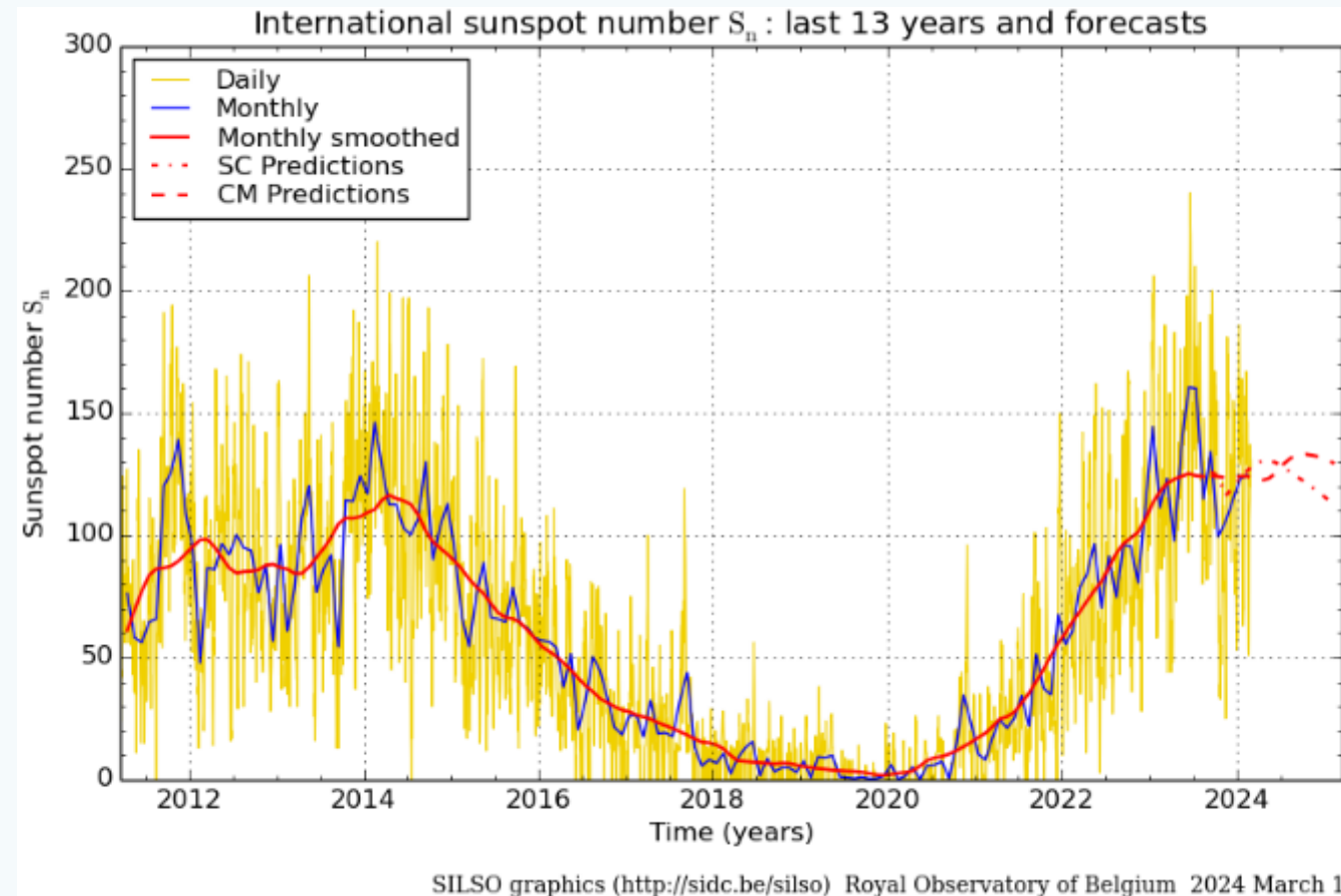
Work in progress at WG 3L-2

WG 3L-2 is considering several proposals for revision. The Global Ionospheric Scintillation Model (GISM) algorithm is included in Rec. ITU-R P. 531-15 and available as software.
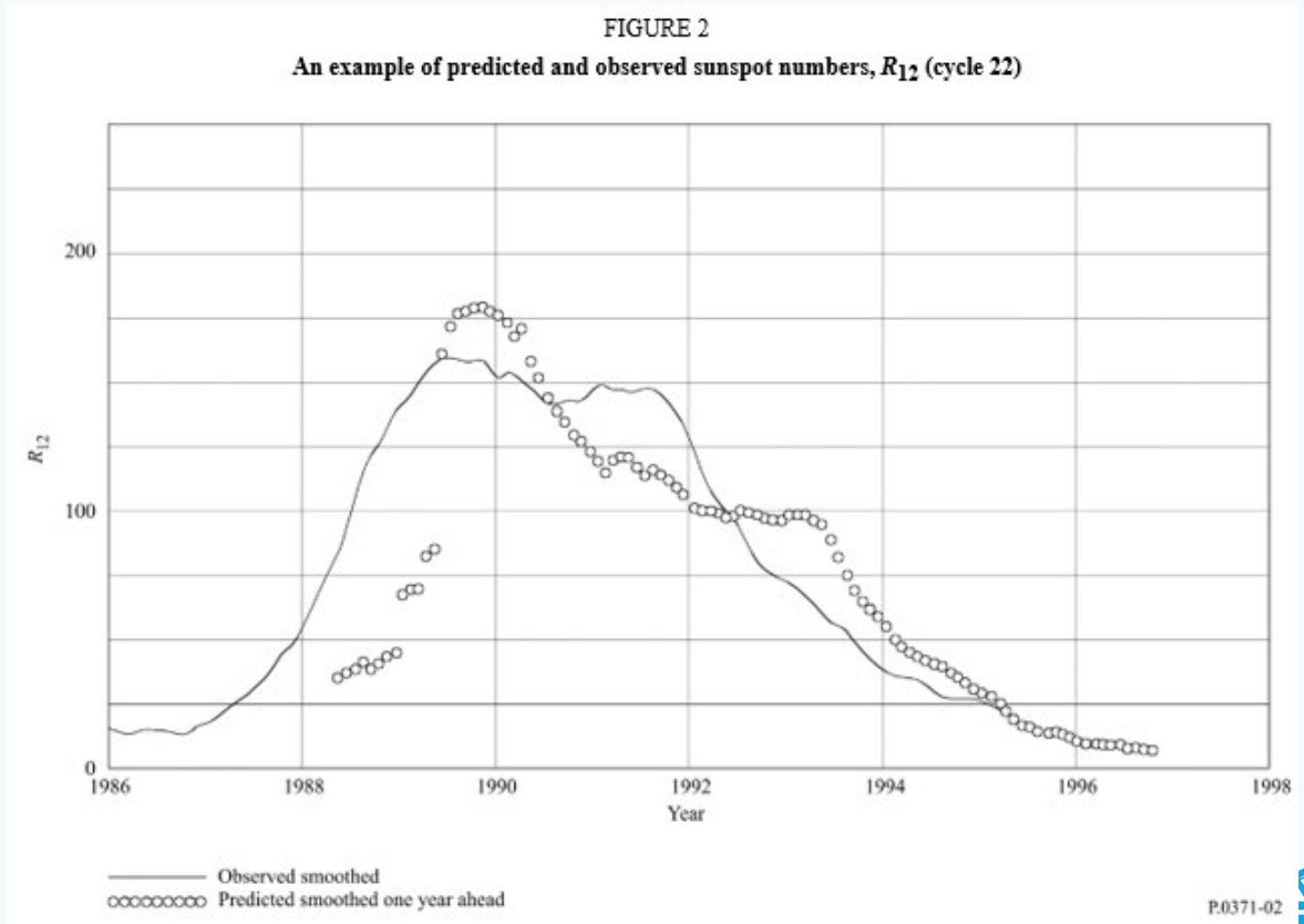

Contours of percentage of yearly average daytime hours when time delay at vertical incidence at 1.6 GHz exceeds 20 ns (sunspot number = 140)

Work in progress at WG 3L-2

Proposed revisions to Recommendations ITU-R P.371 – "Choice of indices for long-term ionospheric predictions" and ITU-R P.1239 - "ITU-R reference ionospheric characteristics", were accepted to the modify the calculation of the sunspot number.

International sunspot number S_n : last 13 years and forecasts

Legend:
- Daily
- Monthly
- Monthly smoothed
- SC Predictions
- CM Predictions

SILSO graphics (http://sidc.be/silso) Royal Observatory of Belgium 2024 March 1
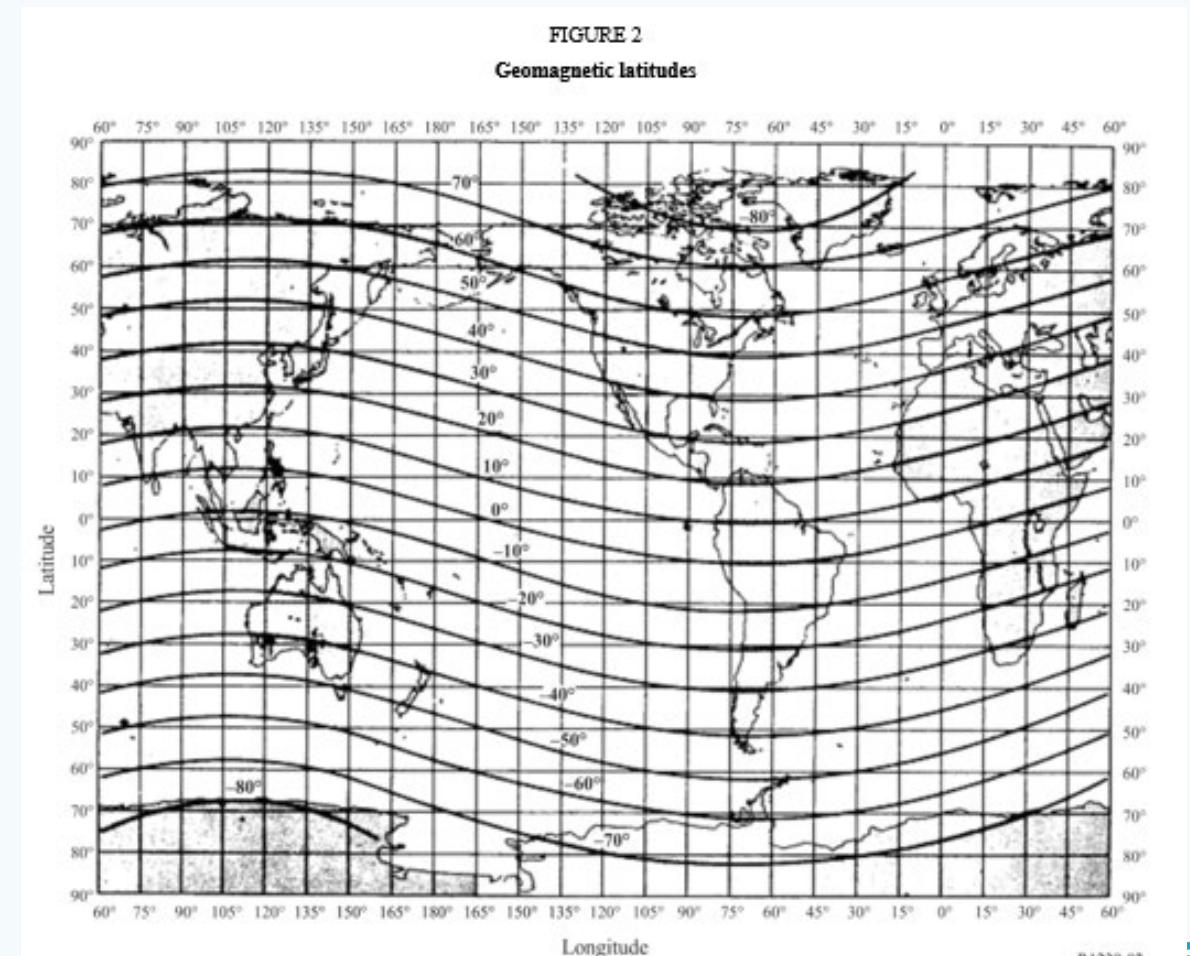
Work in progress at WG 3L-2

Classic cycle 22 sunspot number chart, available in Recommendation ITU-R P.371 – "Choice of indices for long-term ionospheric predictions".

FIGURE 2

An example of predicted and observed sunspot numbers, R_{12} (cycle 22)

Observed smoothed
Predicted smoothed one year ahead

P.0371-02

Work in progress at WG 3L-2

Rec. ITU-R P.1239 - "ITU-R reference ionospheric characteristics" provides models and numerical maps of the monthly median characteristics of the ionosphere, and information regarding the statistical variability.

The map show geomagnetic latitudes and is also available digitally.

FIGURE 2
Geomagnetic latitudes
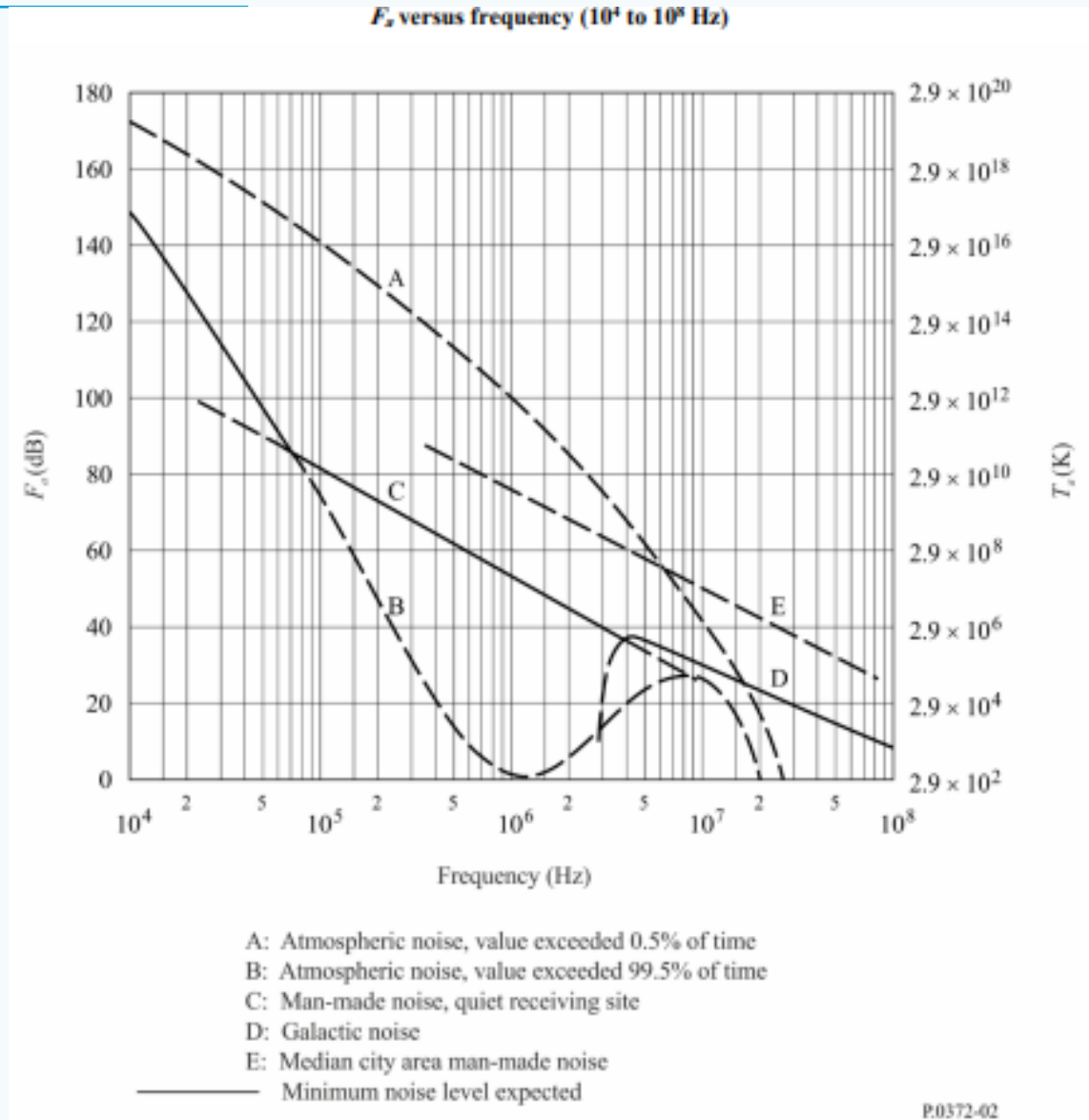
Work in progress at WG 3L-3

- Several ITU-R P-series Recommendations - under the purview of three WPs - contained identical or similar calculations of brightness and noise temperature, so alignment was needed.

- Some Recommendations also used inconsistent naming conventions for quantities such as "sky noise temperature".

- WG 3L-3 undertook the harmonization of those calculations, their nomenclature, and which Recommendation should contain those calculations and be referenced by other Recommendations using them for a particular purpose.

Work in progress at WG 3L-3

- It was agreed that the calculation of brightness and noise temperatures should be included in Recommendation ITU-R P.372 – "Radio Noise".

- Collaborative work is ongoing to develop a low-cost measurement system to capture radio noise globally, and to share and harmonize radio noise measurement reduction techniques among national administrations and companies.

Work in progress at WG 3L-3

This figure from Recommendation ITU-R P.372 covers the frequency range 10^4 to 10^8 Hz, i.e. 10 kHz to 100 MHz, for various categories of noise.

A: Atmospheric noise, value exceeded 0.5% of time
B: Atmospheric noise, value exceeded 99.5% of time
C: Man-made noise, quiet receiving site
D: Galactic noise
E: Median city area man-made noise
——— Minimum noise level expected

Other Comments

The WP 3L Handbooks also need to be updated to reflect changes in the Recommendation, and to improve figure quality:

- Handbook "Ground Wave Propagation"
- Handbook "Ionosphere and its Effects on Radiowave Propagation".

Conclusion

- A better understanding of the characteristics of the ionosphere, and how it affects the propagation of electromagnetic waves, continues to be very important for numerous radio systems.

- Trans-ionospheric propagation affects communication between satellites and ground stations and satellites. This includes particularly satellite navigation systems as well as radio astronomy at lower frequencies. Knowledge of the mechanisms of this type of propagation is fundamental to guarantee a high performance of future telecommunications systems.

- Characterising radioelectric noise has become even more important due to the proliferation of new electronic devices and consumer use of radiocommunications, so it is essential to improve the prediction of noise is all environments globally.