Variation of Solar Microwave Spectrum in the Last Half Century

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The total solar flux in microwaves, particularly the F10.7 index (total solar flux at 2.8 GHz), is widely used as an indicator of solar activity in the fields of heliophysics and geophysics, because the F10.7 index indicates the variation of solar UV emission in comparison to sunspot number. The time variation in microwaves is traditionally classified into three components based on the timescale of enhancements. The components are a background component from the quiet-Sun, a slowly varying component, and a sporadic (burst) component. The background component is considered to originate from optically thick thermal bremsstrahlung emission from the atmosphere above the upper chromosphere, and the slowly varying component originates in the thermal bremsstrahlung emission of coronal loops above active regions and thermal gyro-resonance emission from strong magnetic field regions, such as sunspots.

In Japan, continuous four-frequency solar microwave observations (1, 2, 3.75 and 9.4 GHz) began in 1957 at the Toyokawa Branch of the Research Institute of Atmospherics, Nagoya University. In 1994 the telescopes were relocated to NAOJ Nobeyama Campus, where they have continued observations up to the present. We analyzed the more than 60 years of solar microwave data from these telescopes. At first, we determined the month that solar activity is most minimum in each solar cycle using the standard deviation of the flux density of the solar microwave. Then, we investigate the microwave spectra of the months, and found that microwave intensities and spectra at the minimums of the latest five cycles were the same every time. In contrast, during the periods of maximum solar activity, both the intensity and spectrum varied from cycle to cycle.

These results show that the average atmospheric structure above the upper chromosphere in the quiet-Sun has not varied for half a century, and suggest that the energy input for atmospheric heating from the sub-photosphere to the corona have not changed in the quiet-Sun despite significantly differing strengths of magnetic activity in the last five solar cycles.

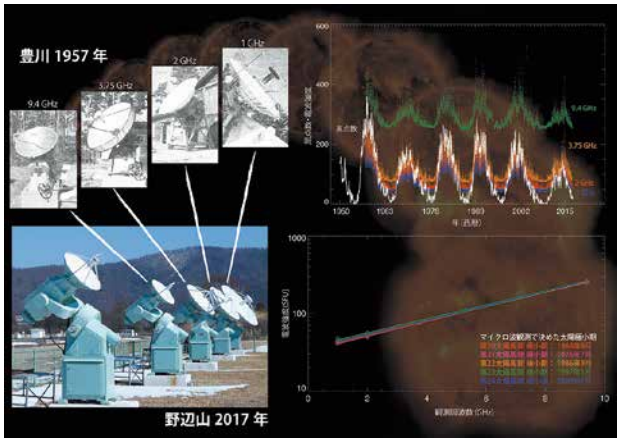

Figure 1: Left: Photos of the antennas at Toyokawa 1957, and Nobeyama 2017. Upper Right: Long-term variation of microwave and sunspot number. Lower Right: The microwave spectra at the solar minima.

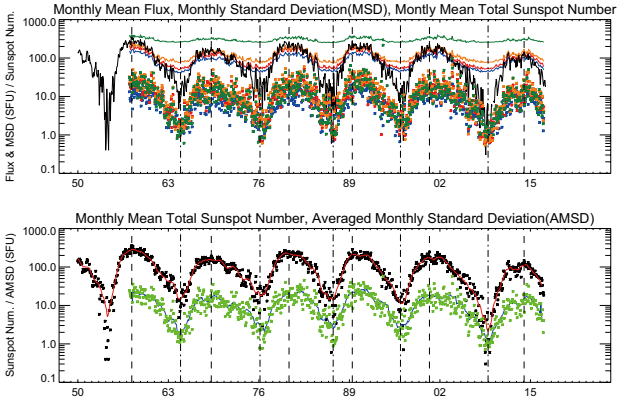

Figure 2: Upper panel: The monthly mean microwave fluxes, the monthly mean total sunspot number (solid lines), and the monthly standard deviations (MSD: asterisk). Lower Panel: The black asterisks indicate the monthly mean total sunspot number, and the red line is the 13-month smoothed monthly total sunspot number. The green asterisks indicate the Averaged MSD, and the blue line is the 13-month smoothed AMSD.

Reference

[1] Shimojo, M., et al.: 2017, *ApJ*, **848**, 62.