# The Advantages of Solar Radio Monitoring

- It is cheap. Capital and operating costs are small.
- It uses mature, well-understood technologies.
- It is easy to maintain, upgrade and keep calibrated.
- It is easy to build databases of long-term, uninterrupted, consistent and well calibrated data.
- It can be highly automated. The measurements are highly objective.
- Data acquisition, archiving and distribution can be done with a minimum staffing overhead.
- We know a lot about the underlying solar physics.
- We've been doing it for a long time, and have a lot of good data.

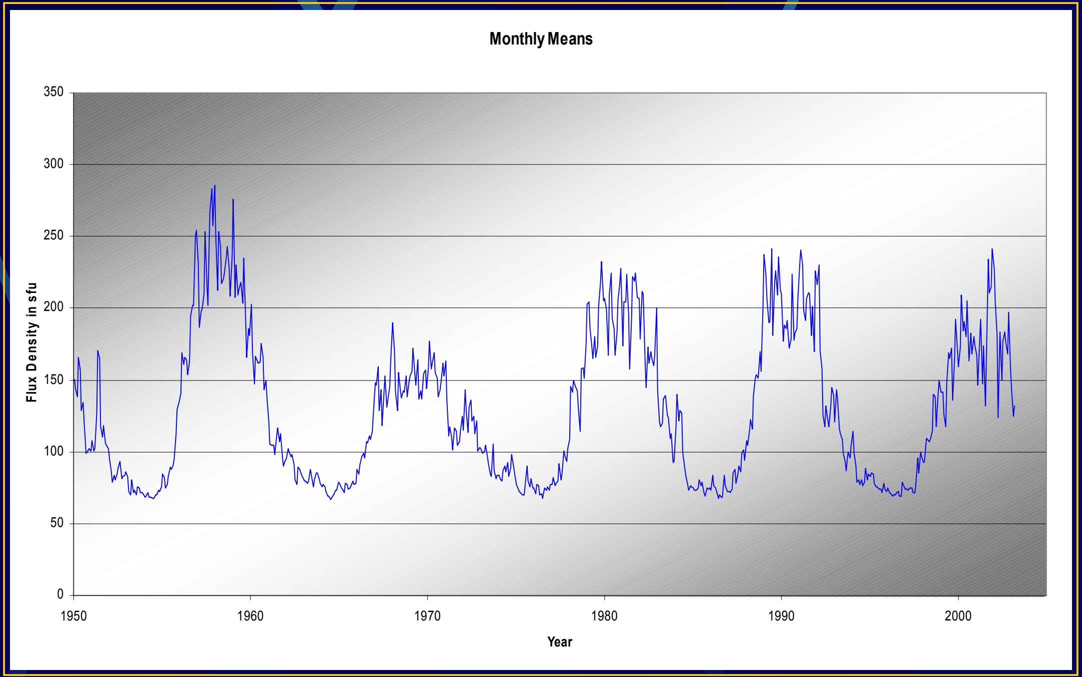
**We know how to do it!**

# The Solar Monitoring Do We Do?

- Whole-disc emission measurements (e.g. F10.7), at various frequencies.
- Single-frequency flare and transient event patrols
- Spectrum Measurements
- Full-disc imaging
- Special purpose observations, such as high time resolution measurements

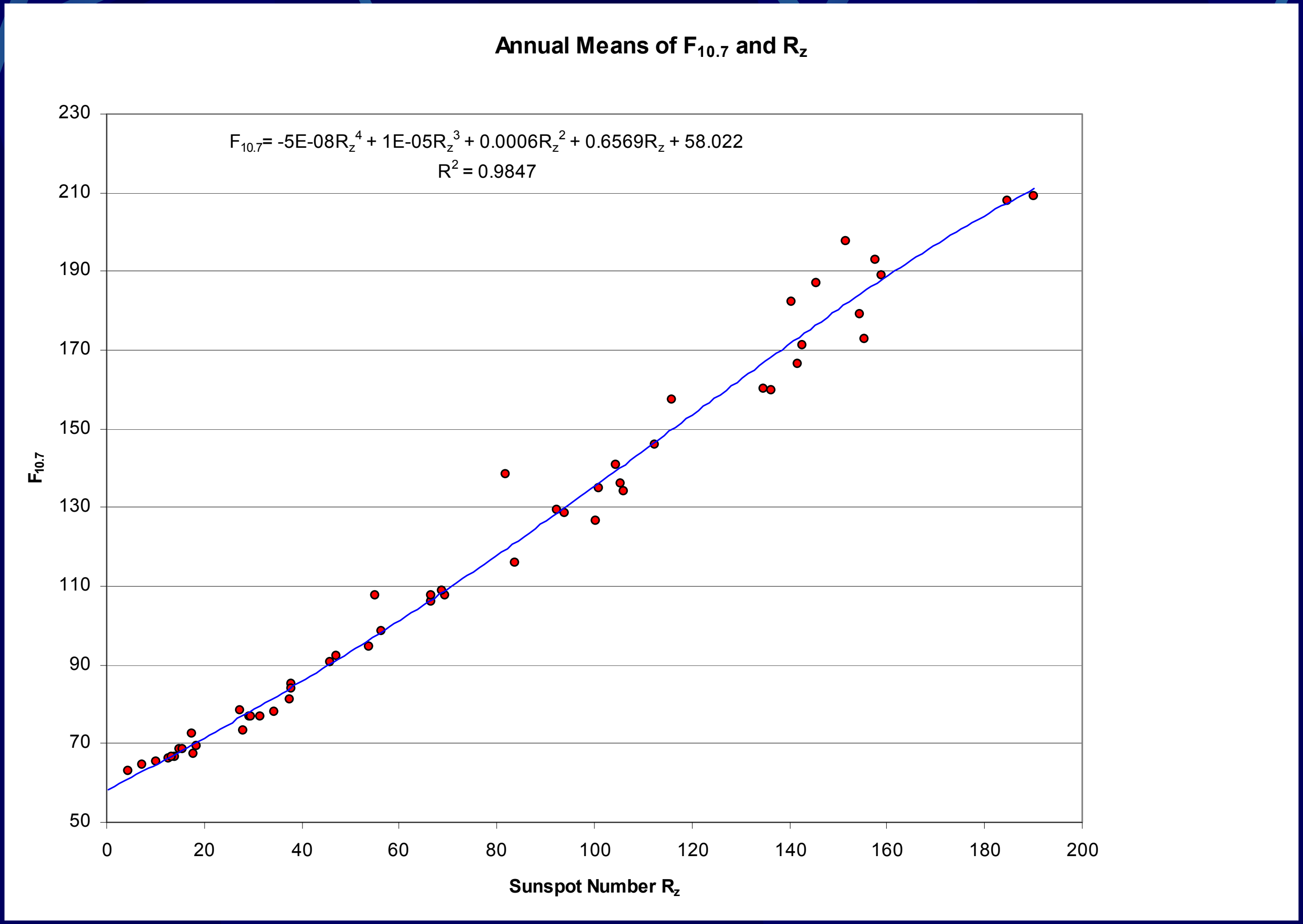
# Monitoring the S-Component

Flux monitors used to measure the 10.7 cm Solar Flux. The programme is based at Penticton, British Columbia

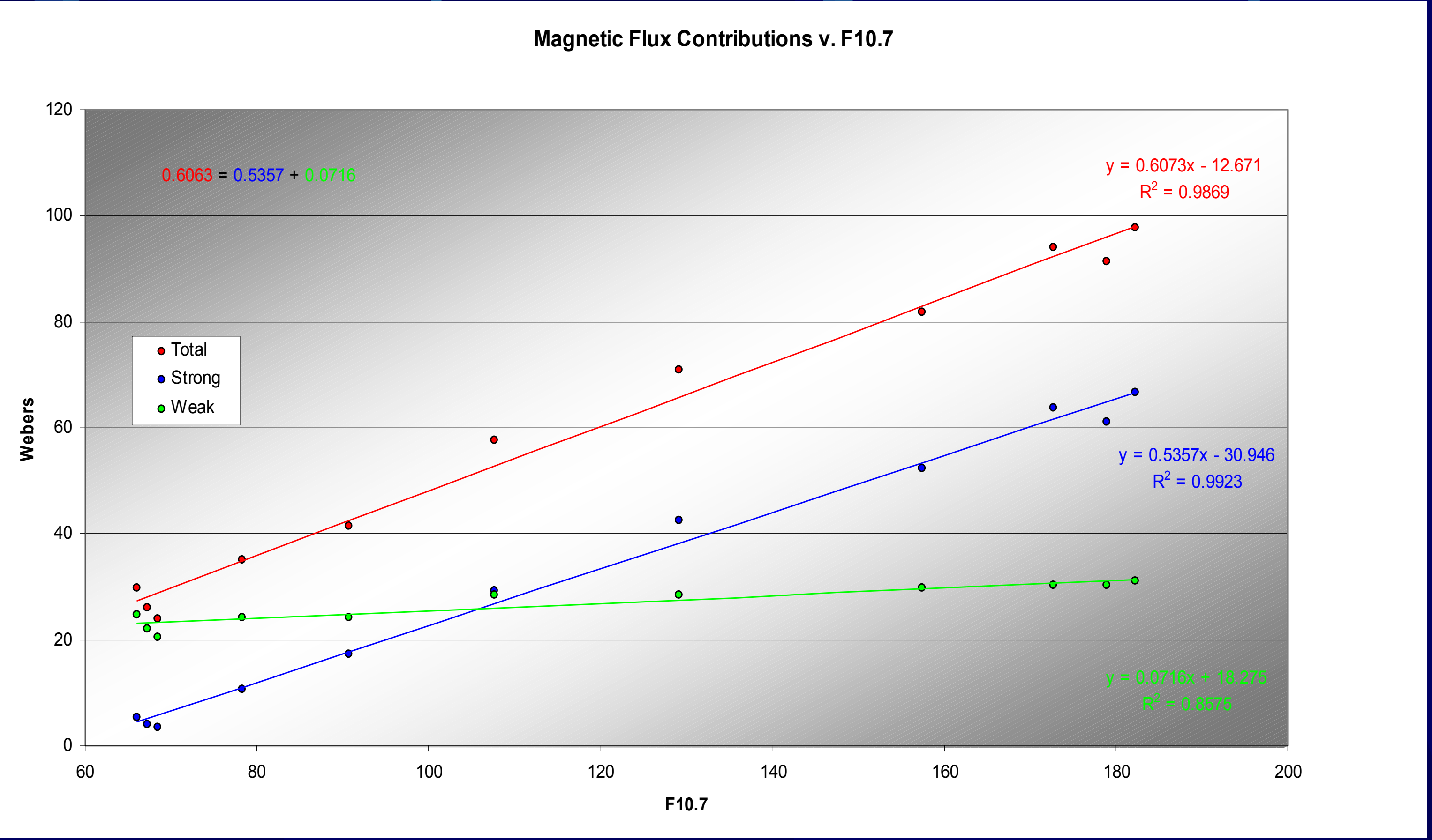



Solar Flux Monitors and Monthly Means of F10.7 since 1947, when the programme started

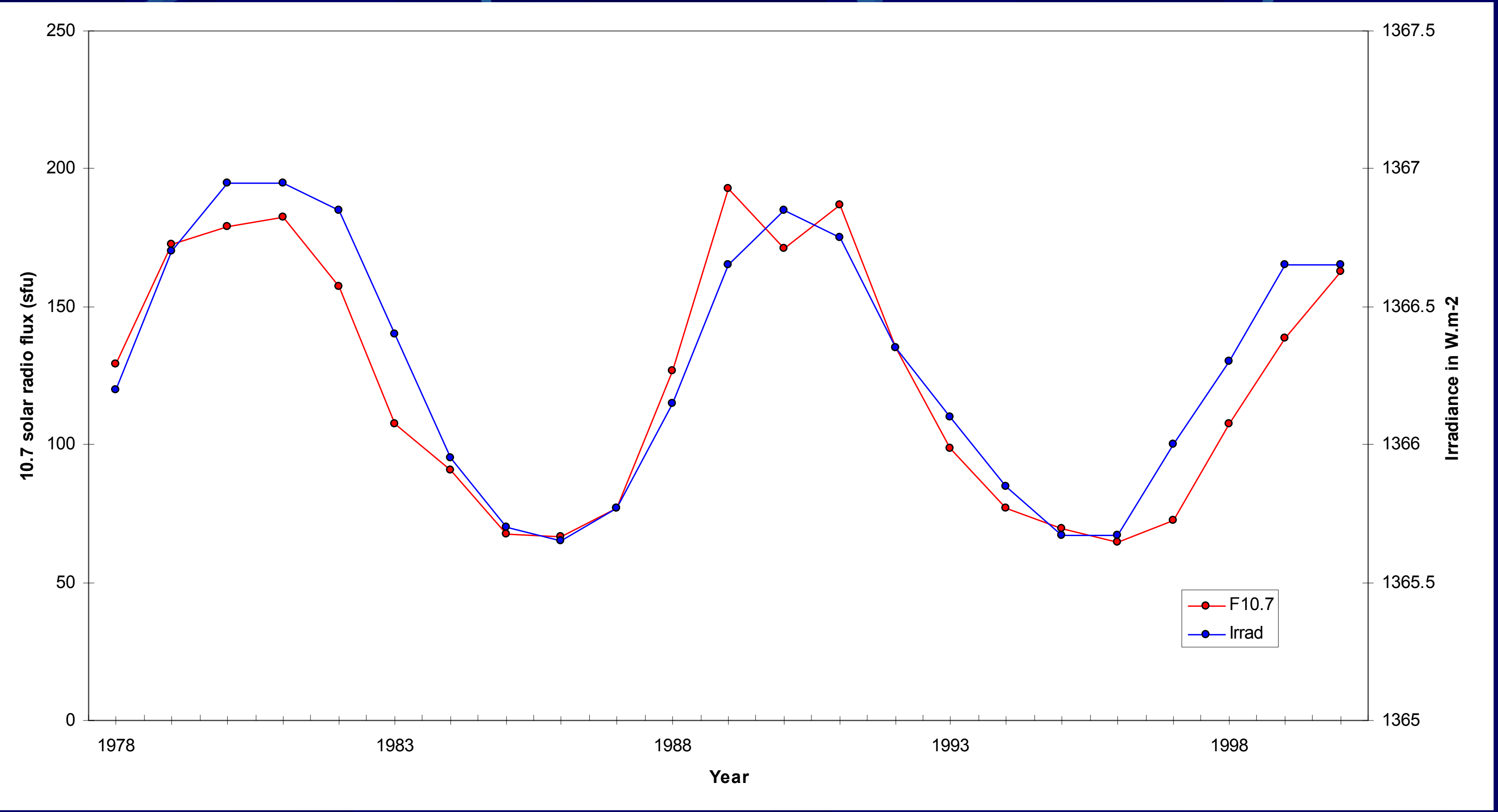
# $F_{10.7}$ and Sunspot Number



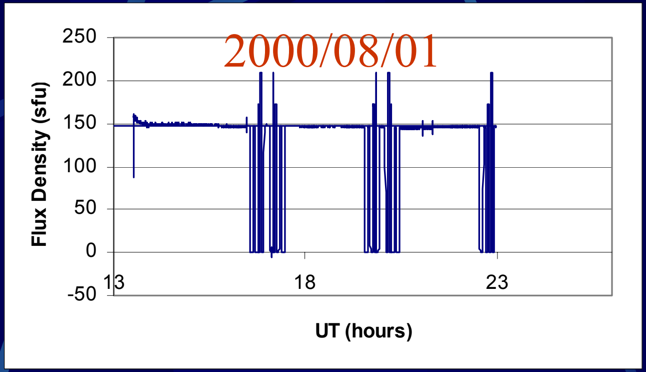
# A Measure of Magnetic Activity

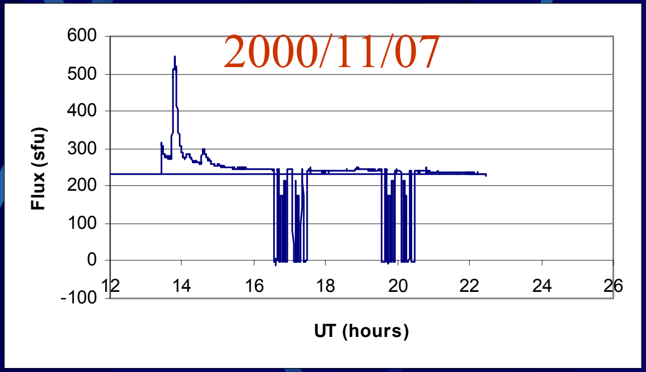


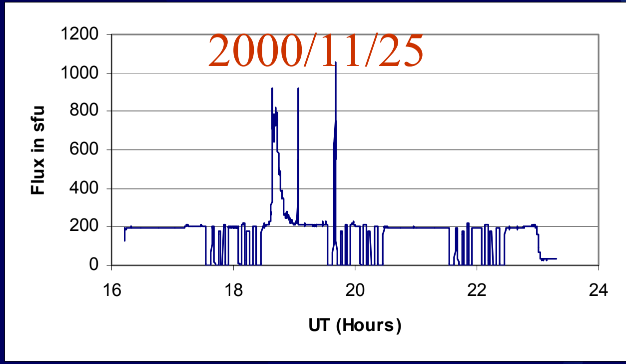
# F10.7 and Irradiance

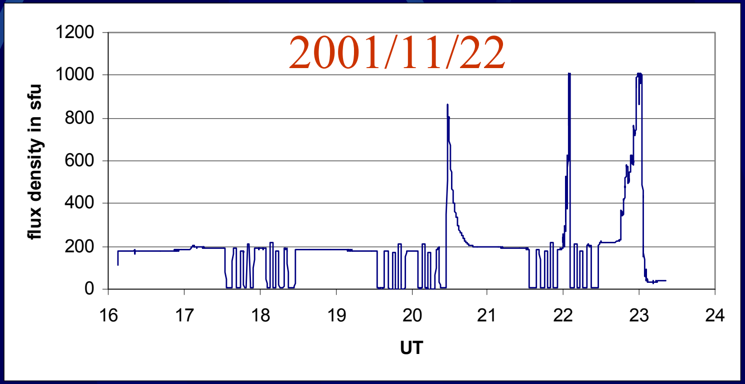


# What Flux are We Measuring?




Is sampling an issue?

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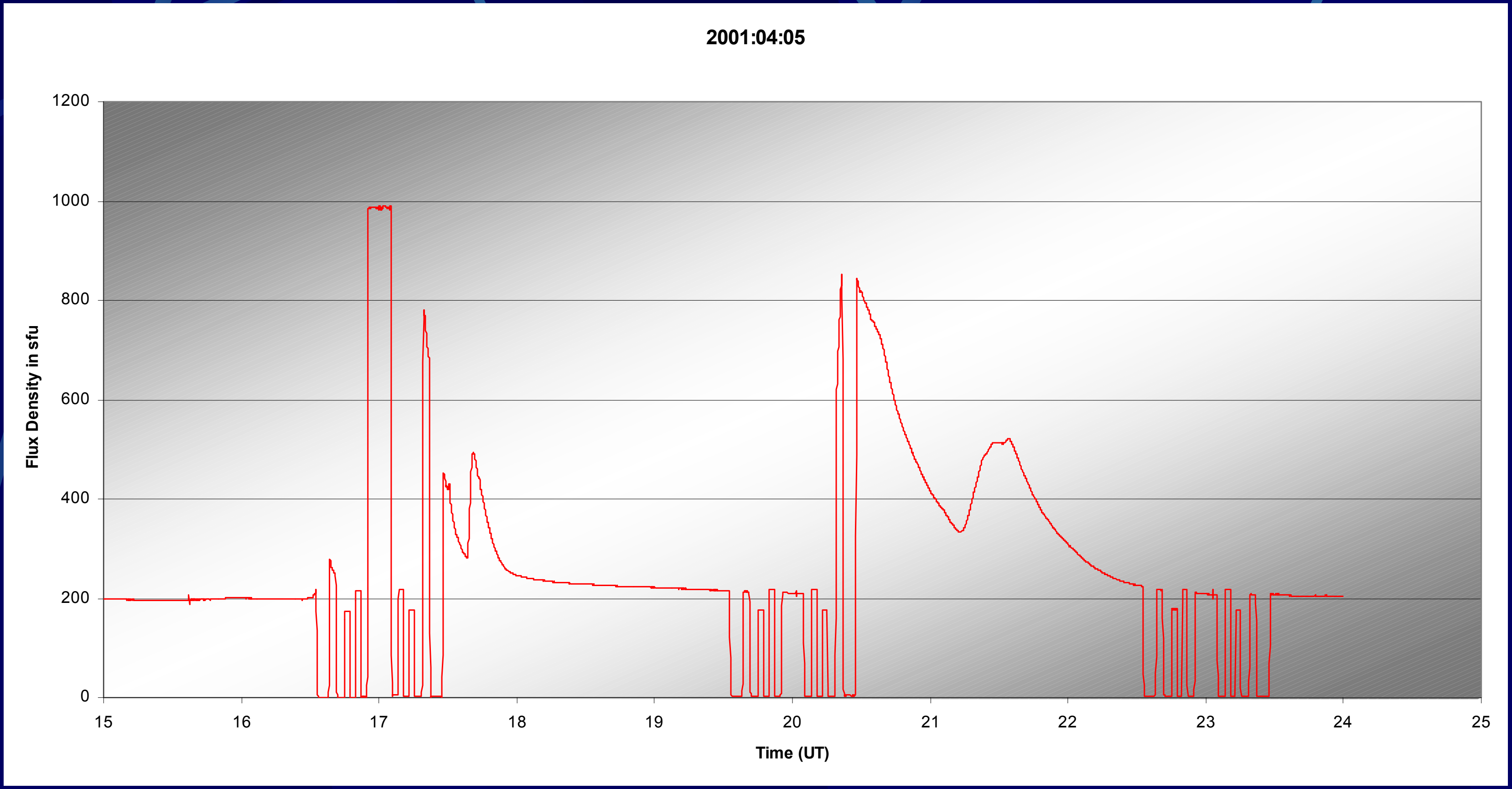

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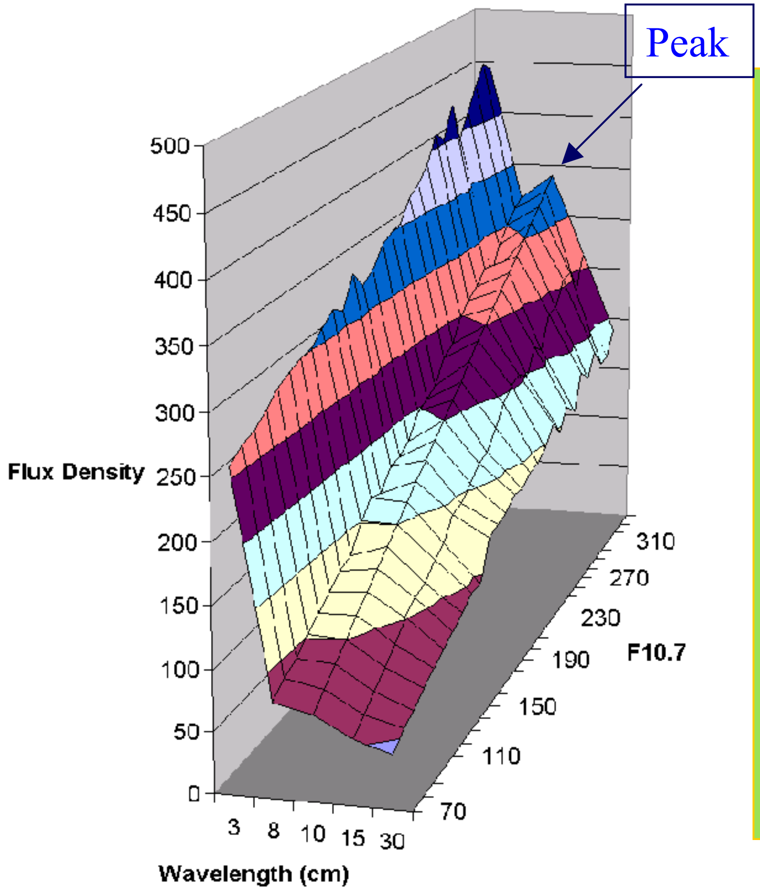
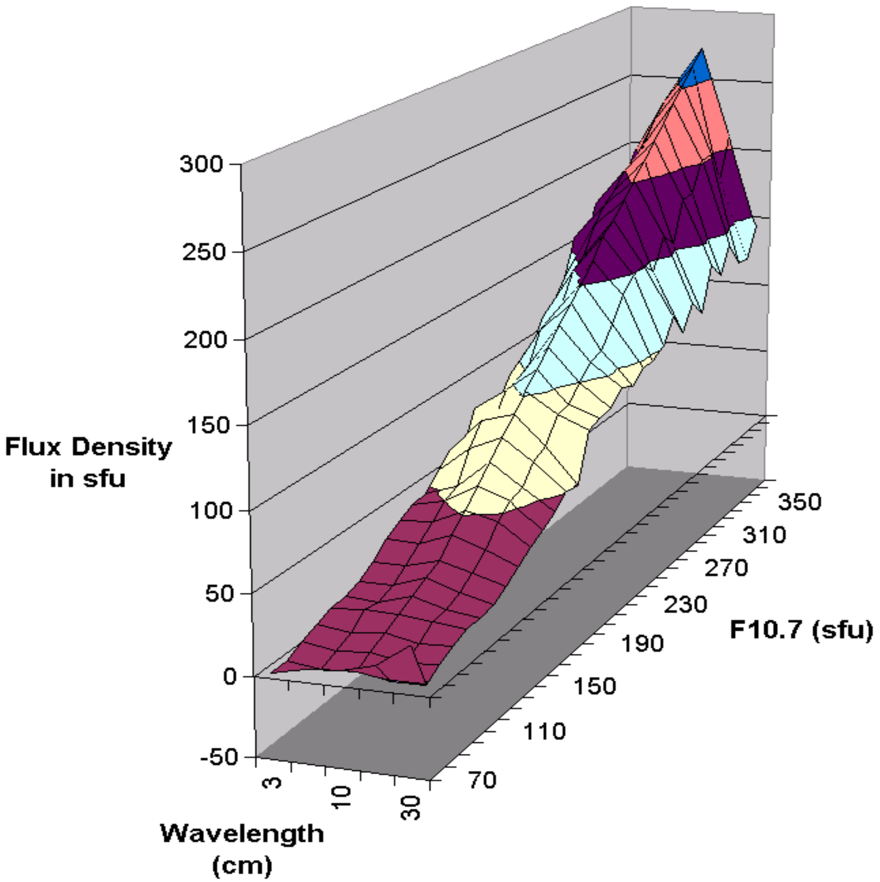



Spectrum of total solar radio emission with the bursts removed, as a function of the level of activity, as indicated by $F_{10.7.}$ The strong peak at the short wavelengths is due to quiet sun emission, which peaks at the short wavelengths.

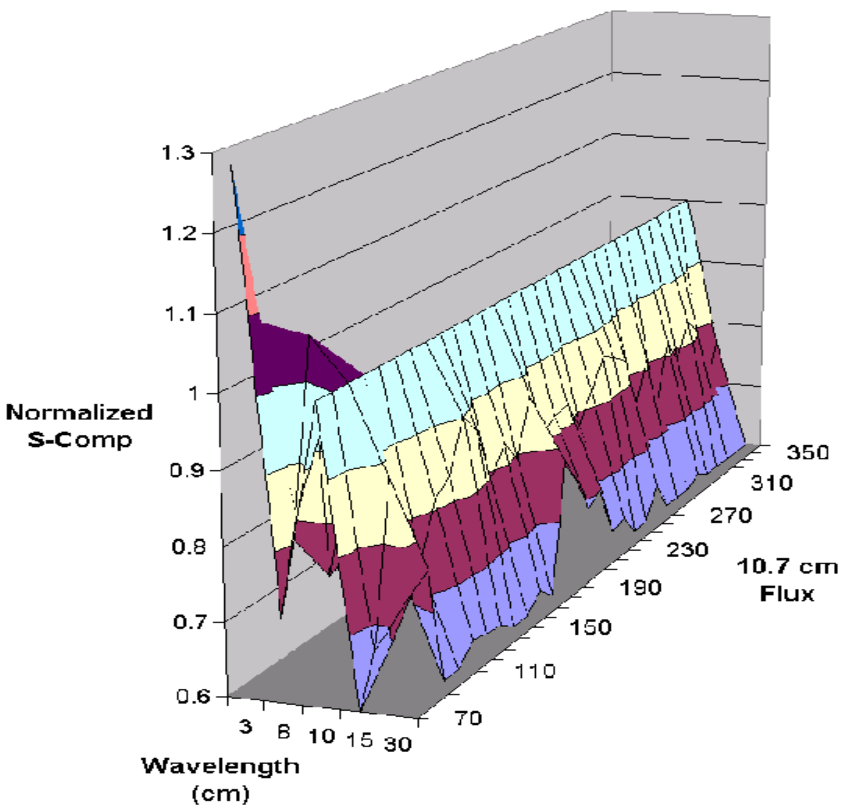
The spectral peak visible at high activity levels cannot be explained in terms of free-free thermal models.

# What Flux are We Measuring?




Spectrum of the S-component with the bursts removed, as a function of the level of activity, as indicated by $F_{10.7.}$ The S-component is defined as the flux density minus the quiet sun level at that wavelength.

# What Flux are We Measuring?



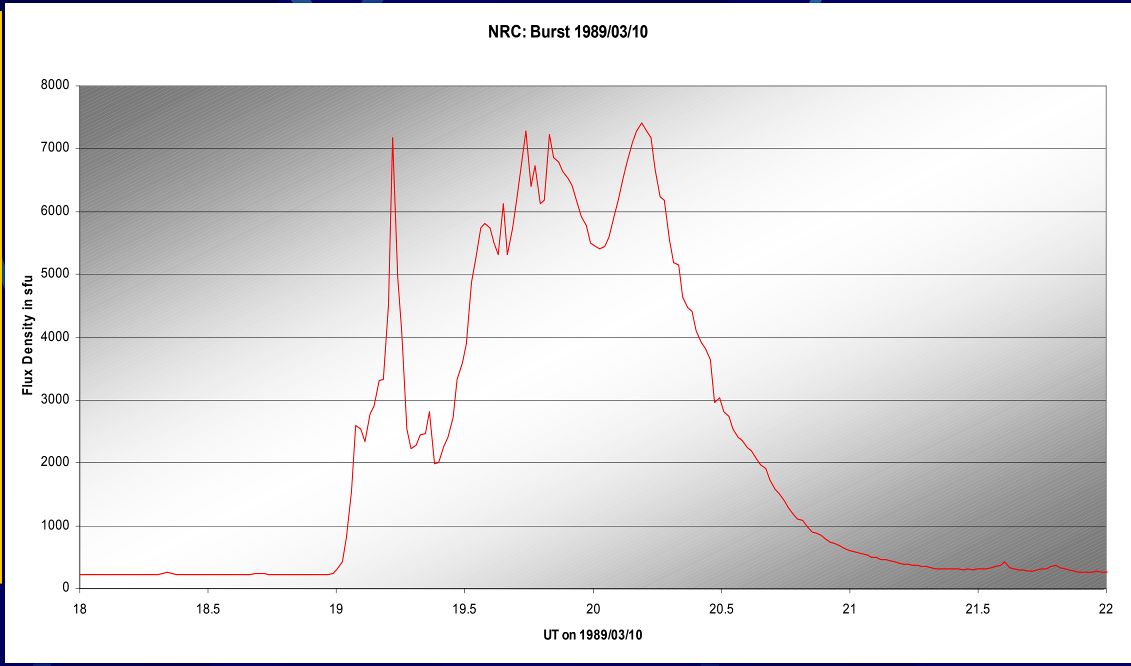

S-Component spectra scaled to a maximum value of unity. The spectrum shape is remarkable stable over a wide range of activity levels, as indicated by $F_{10.7}$.

# Which Suggests…

- That in the absence of flares, the solar emission at centimeter wavelengths consists of two components: an unchanging “quiet sun spectrum”, and the S-component.
- The shape of the spectrum of the S-component doesn’t change much either. It just changes height with the level of activity.
- By spectral measurements we might be better able to filter out bursts and get a better flux value.
- We might get useful burst information too!

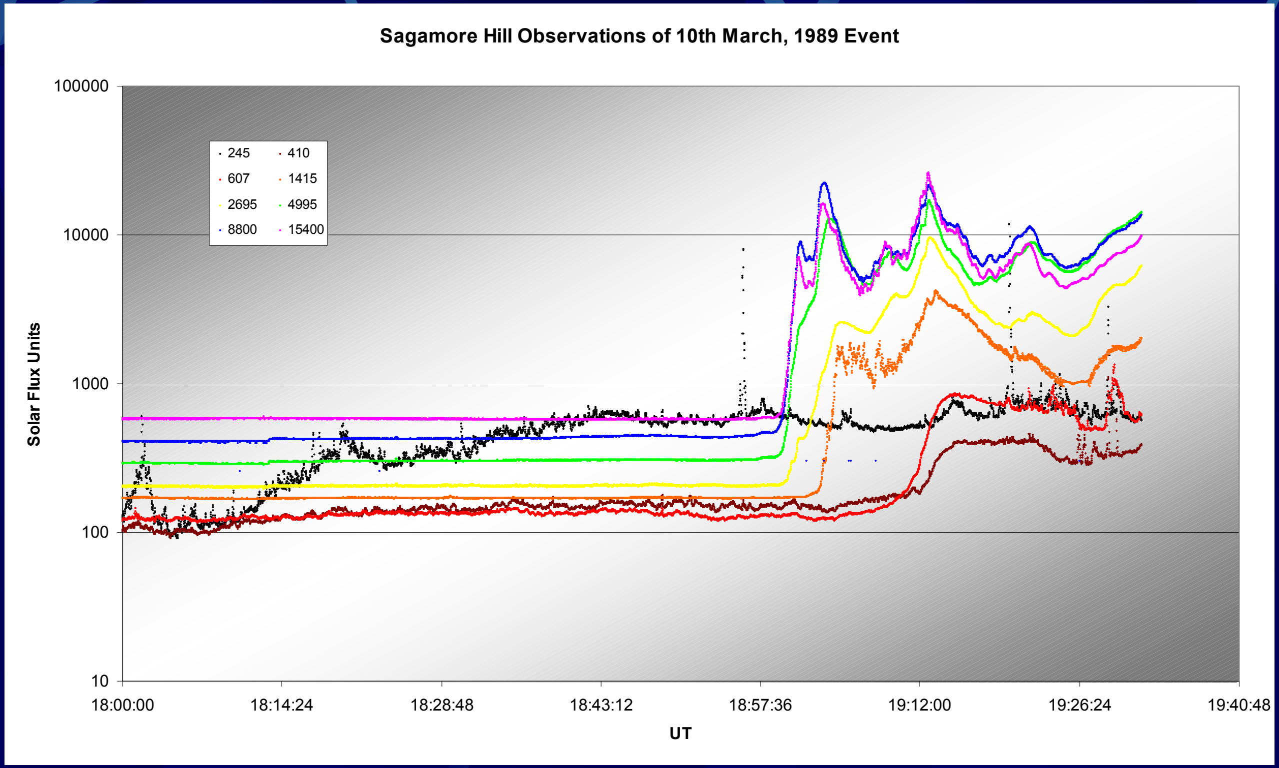
# Monitoring Transient Events

Flux monitors used to measure the 10.7 cm Solar Flux. The programme is based at Penticton, British Columbia




Radio emission at 10.7cm wavelength from the large flare of 1989/03/10, which produced severe geospace and terrestrial consequences.

# The 10 March, 1989 Event



# Estimating Radial Velocities

$$N(z) = \Psi(z) \qquad f(z) = \beta N(z)^{1/2}$$

$$\frac{df}{dt} = \frac{\beta}{2} N^{-1/2} \frac{dN}{dz} \frac{dz}{dt}$$

$$u_r = \frac{2}{\beta} \left( \frac{N^{1/2}}{\frac{dN}{dz}} \right) \frac{df}{dt}$$

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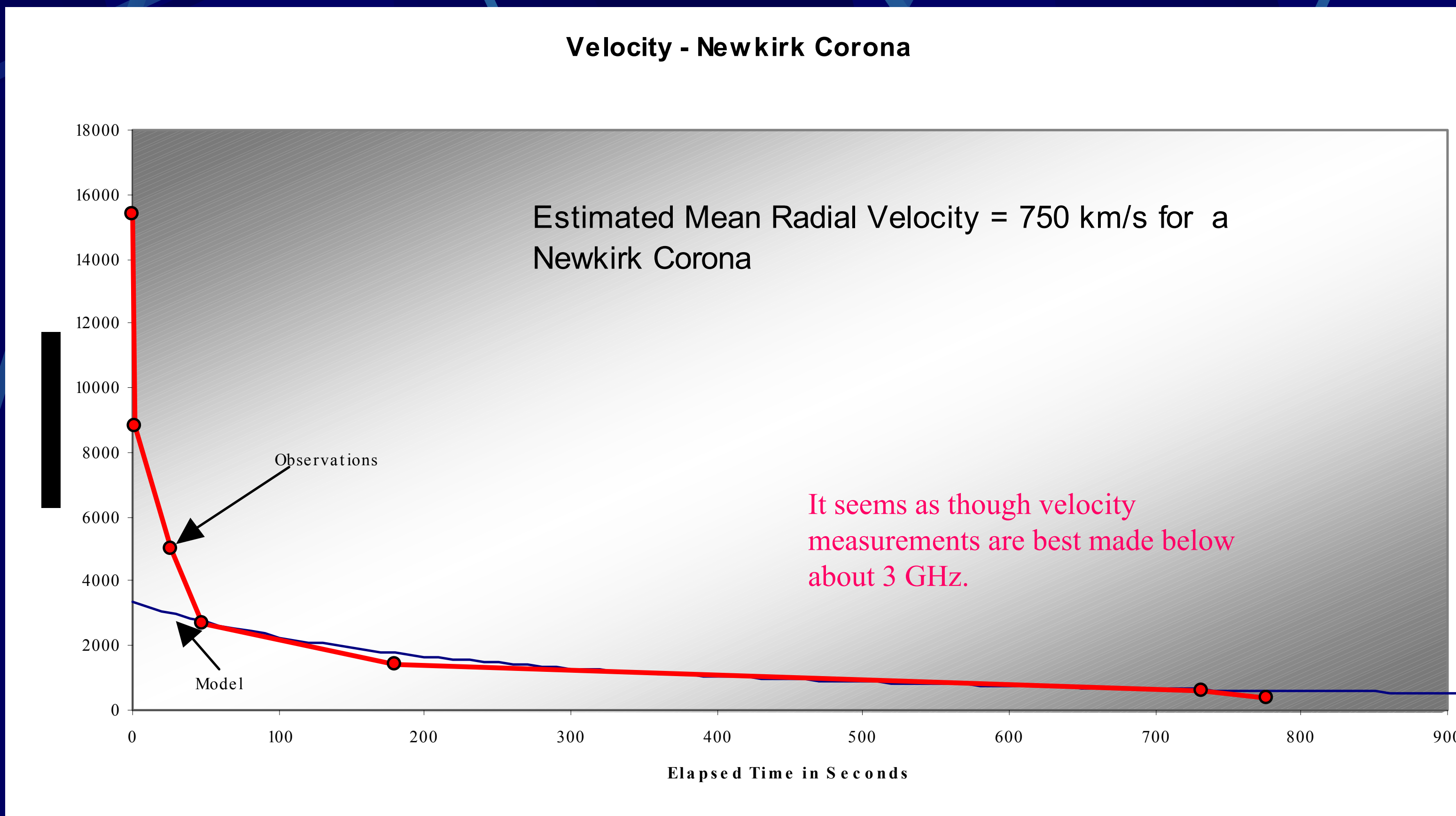
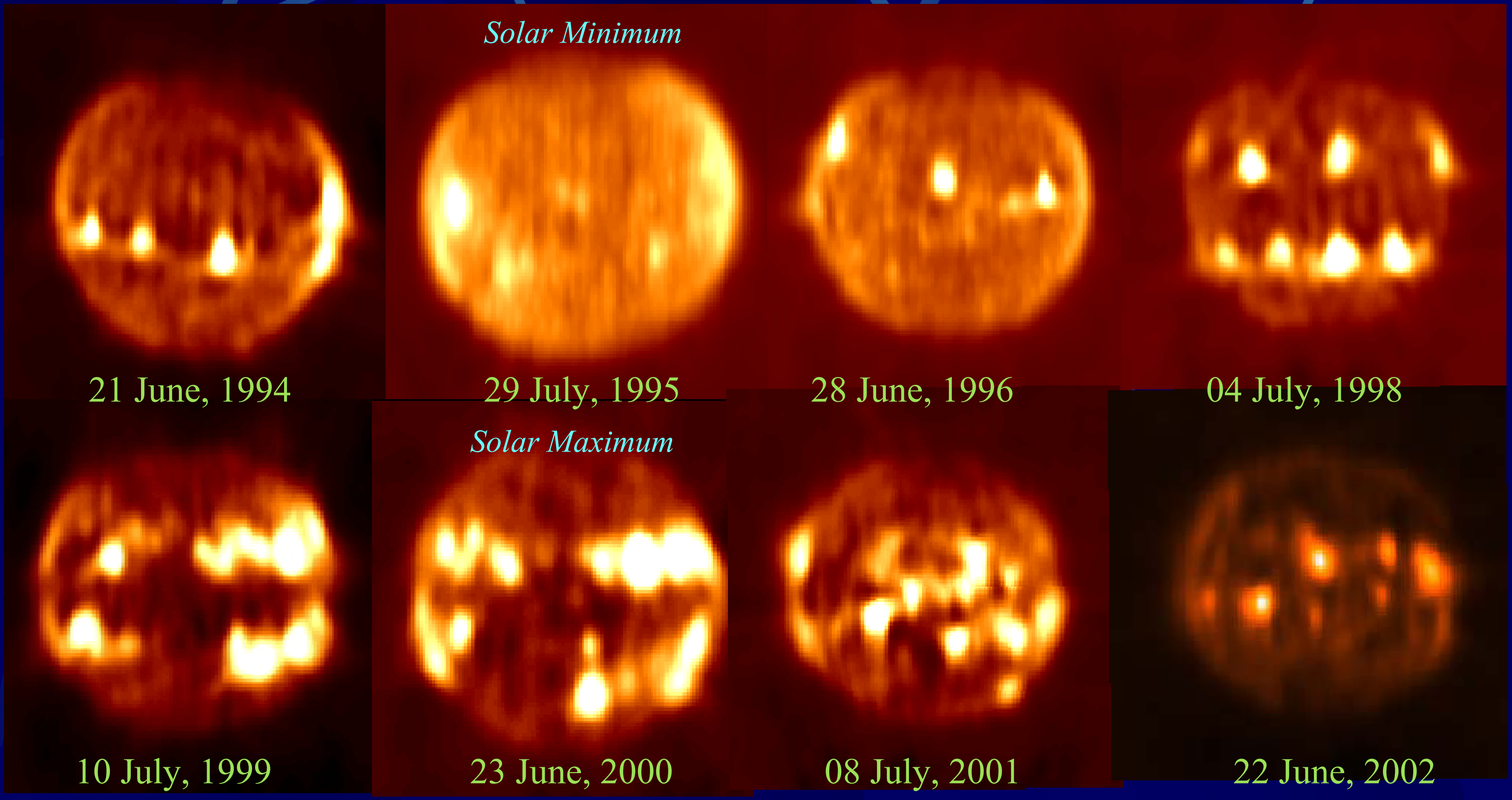
# Estimating Radial Velocities



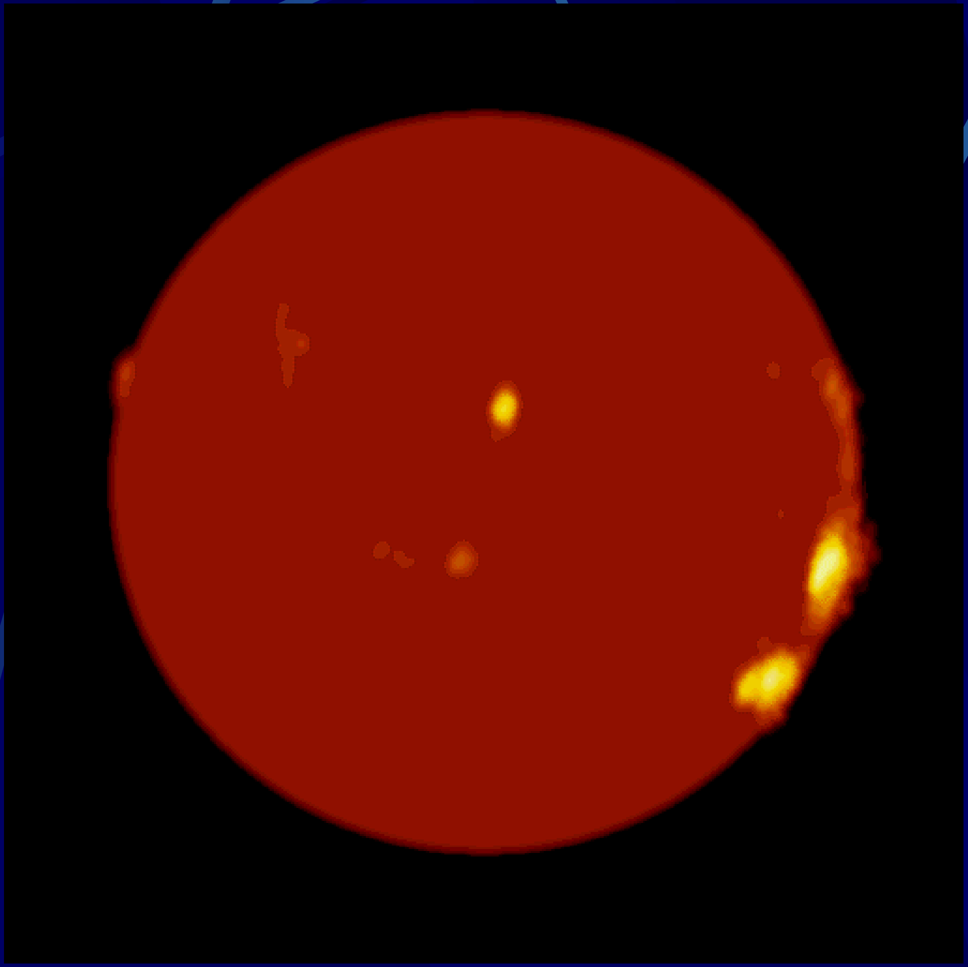
# Coronal Mass Ejections

- Would like a good, cheap way of detecting these.
- Even without a flare there has to be some reconnection when the CME lifts off.
- Can we consistently detect radio emissions driven by the reconnection with something cheap and reliable?

# The Sun at 1420 MHz - DRAO



# Sun at 5 GHz (Siberia Telescope)



This is a filled array, cross telescope, so it can make good solar images in minutes, and is specifically used for solar research.

# Conclusions

- That radio methods for monitoring solar activity will be useful and relevant for the foreseeable future.
- However, there are changes and improvements that can be made to make the data more relevant to current and anticipated applications.
- Radio methods provide cheap, reliable ground-based solar monitoring.
- That if we measure the spectrum accurately, we should be able to reduce the level of burst contamination, improving the flux index as an indicator of the general level of magnetic activity.
- We might get useful burst information too!