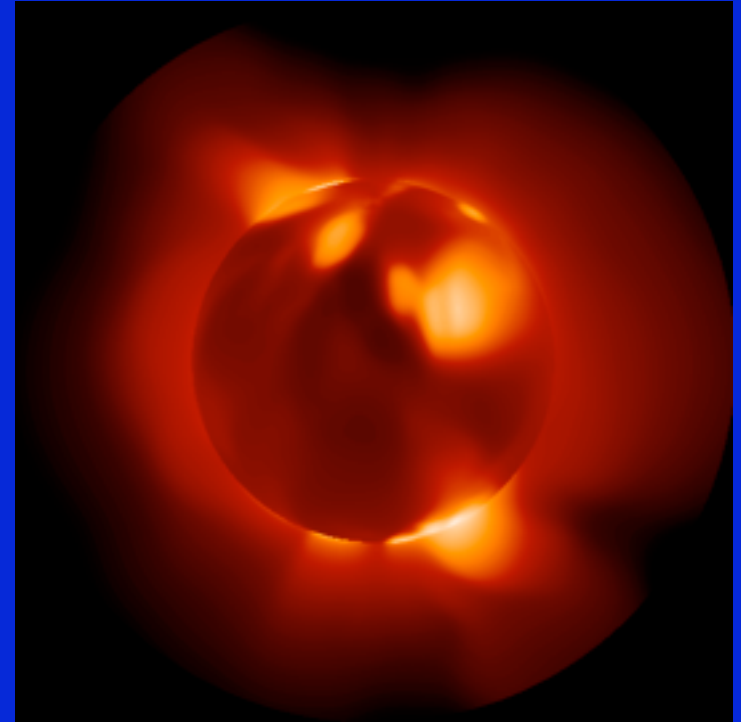
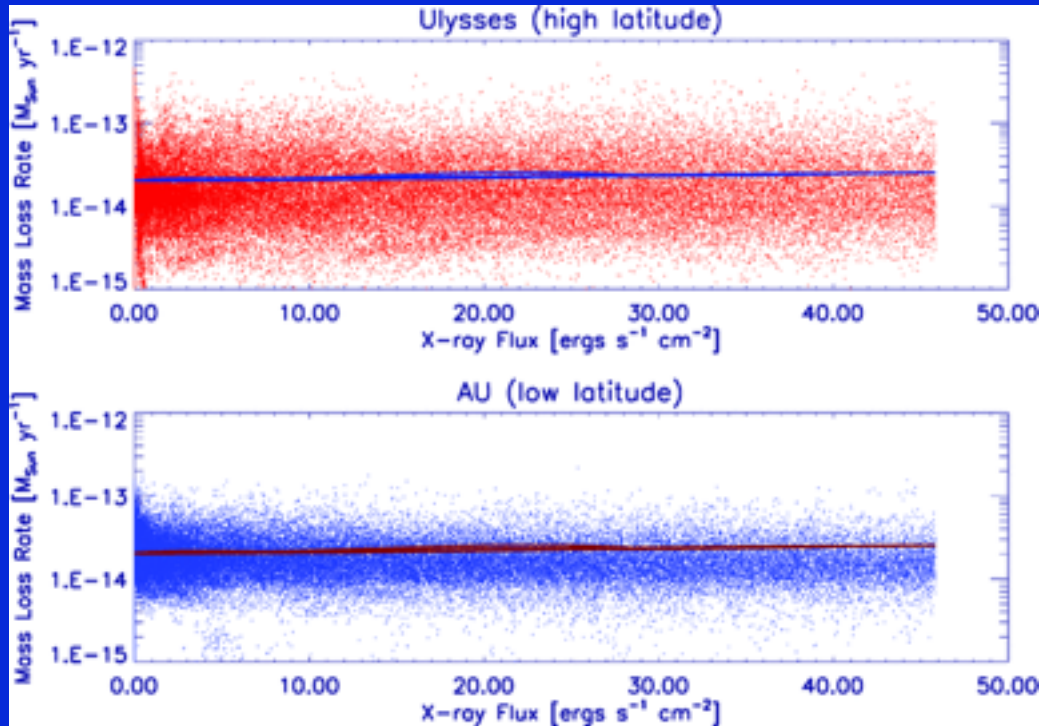


The Independence of Stellar Mass-loss Rates on Stellar Activity Based on Solar Observations



CfA Postdoc Symposium – 2013

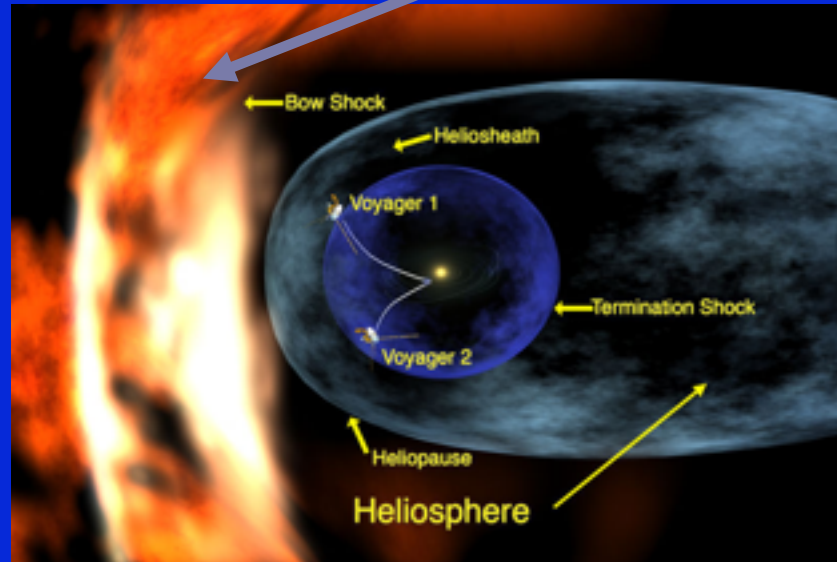
Cohen, MNRAS, 2011

Stellar mass-loss rate are important ingredient for stellar evolution models as they determine the spin-down of low-mass stars.

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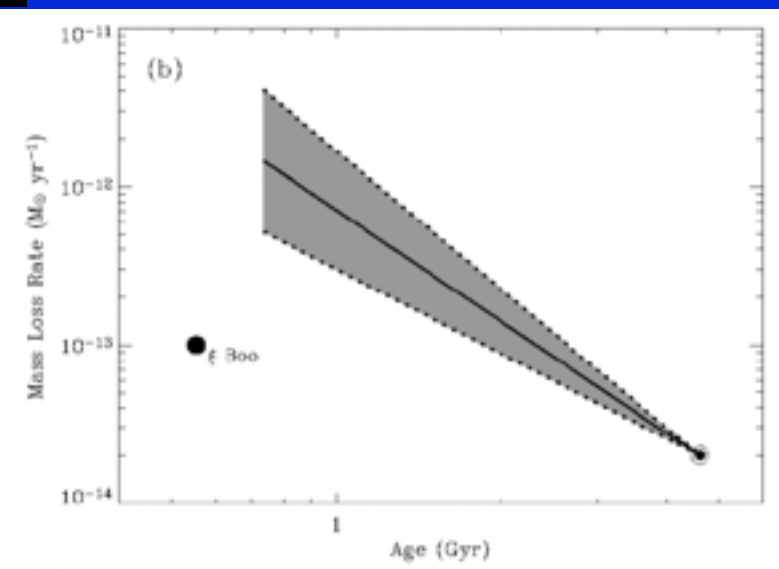
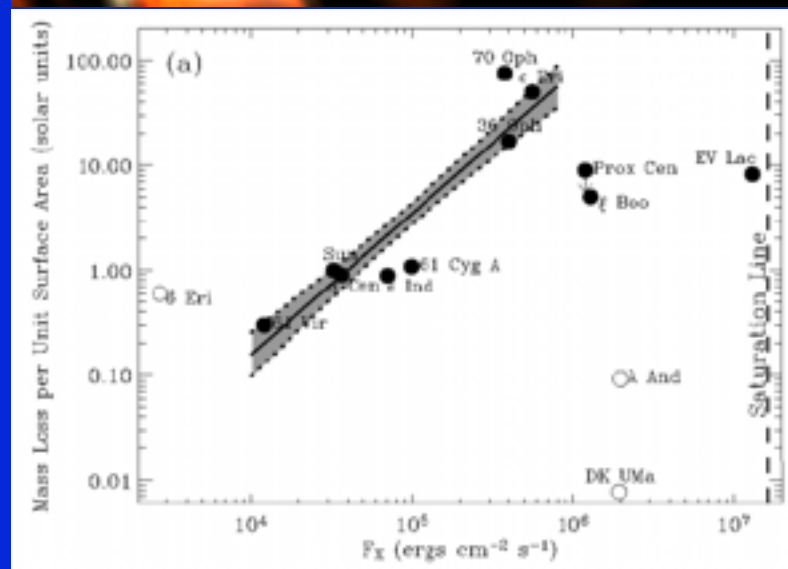
Unfortunately, mass-loss rates of cool stars cannot be directly observed.

Indirect measurements of stellar mass loss rates have been obtained by Wood et. al :



Mass-loss rate scales with X-ray flux

$$\dot{M} \propto F_X^{1.34 \pm 0.18}$$



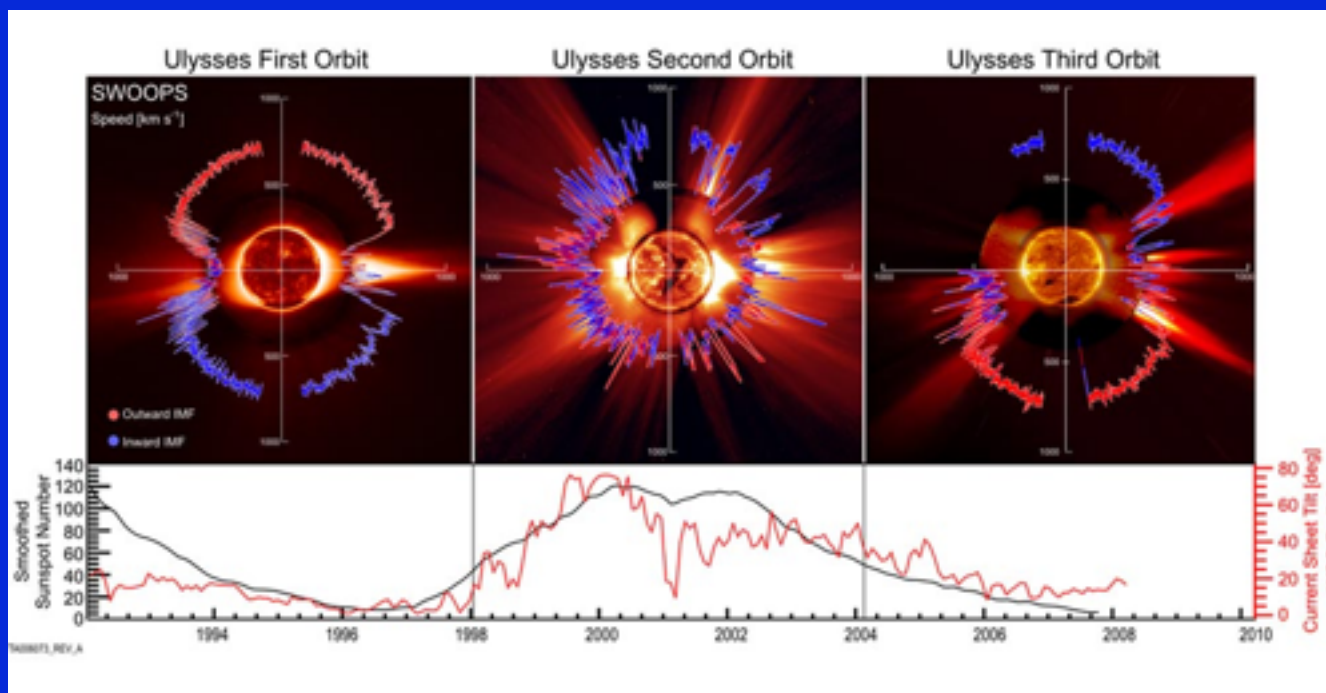
Wood et. al 2005

Since the dawn of the space era (early 1960s) heliospheric data gathered:

global and in-situ measurements of the magnetic field, solar wind speed densities and composition, global X-ray and UV images, global white-light images of the solar corona.

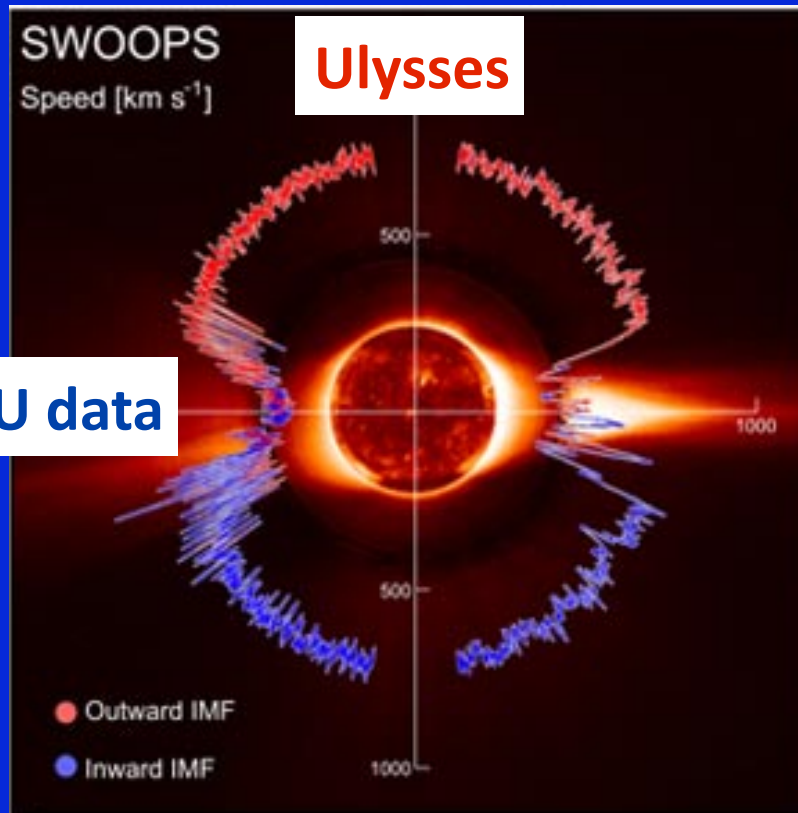
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The solar wind is dictated by the Sun's magnetic field:
Slow wind (400 km/s) - dense, hot, sporadic, enhanced FIP.
Fast wind (800 km/s) – less dense, cooler, steady.

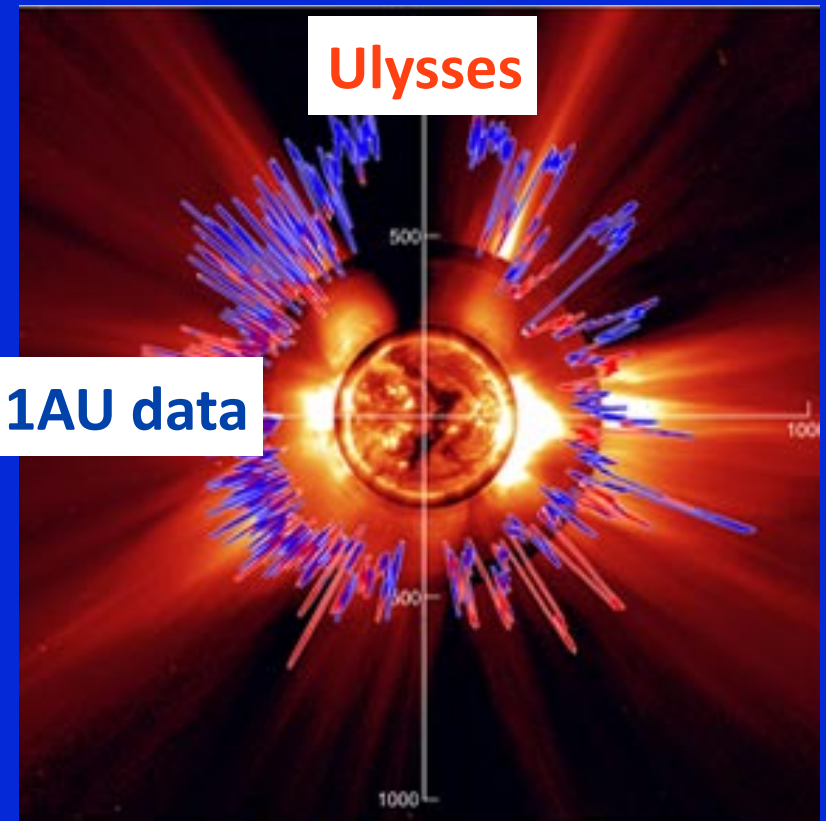


McComas et al. GRL, 2008.

The solar Mass-loss rate



solar minimum (1996)

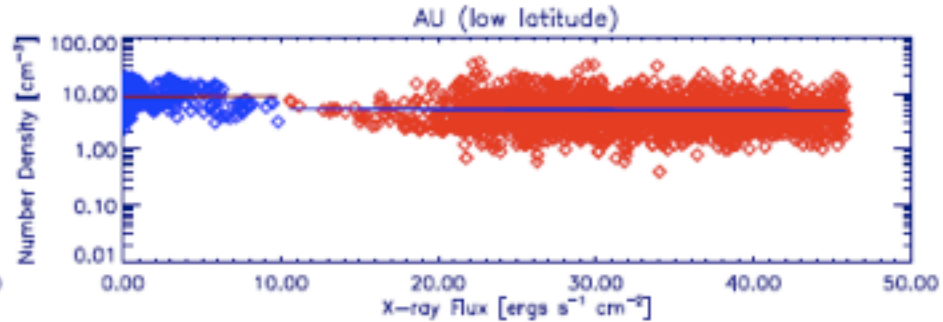
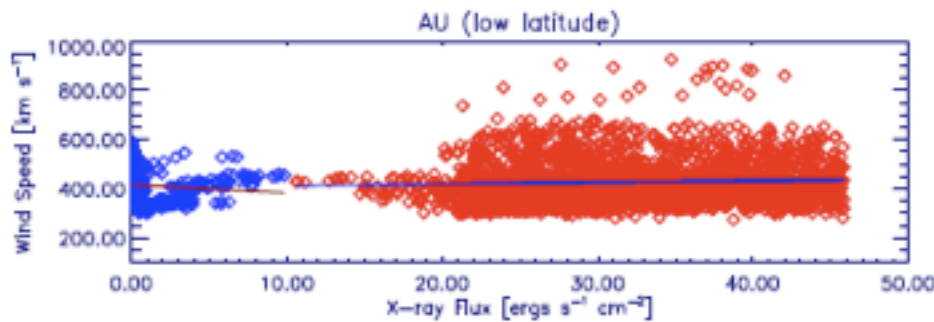
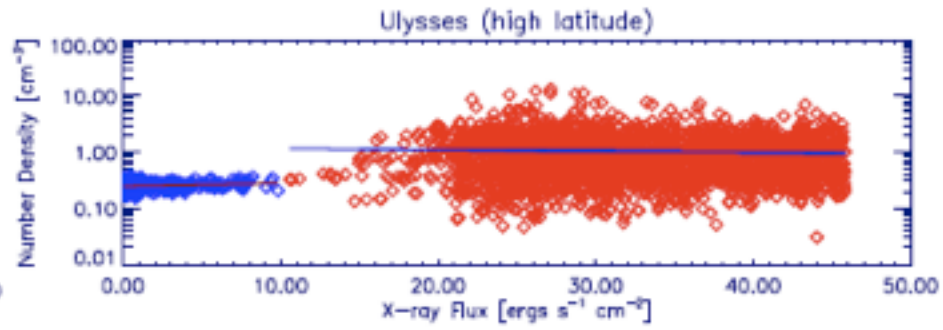
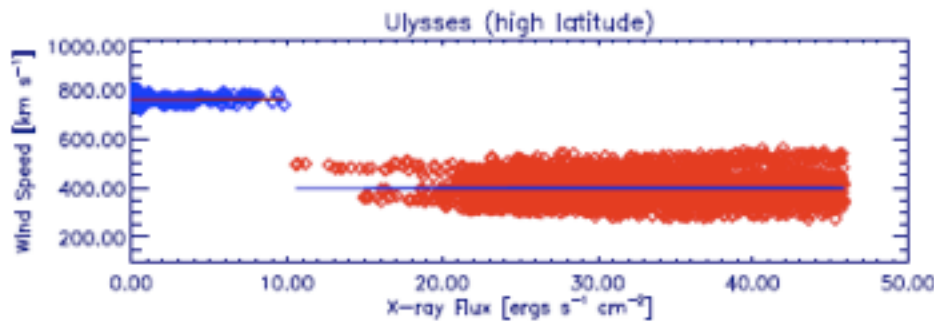


solar maximum (2000)

Solar wind speed

Solar wind density

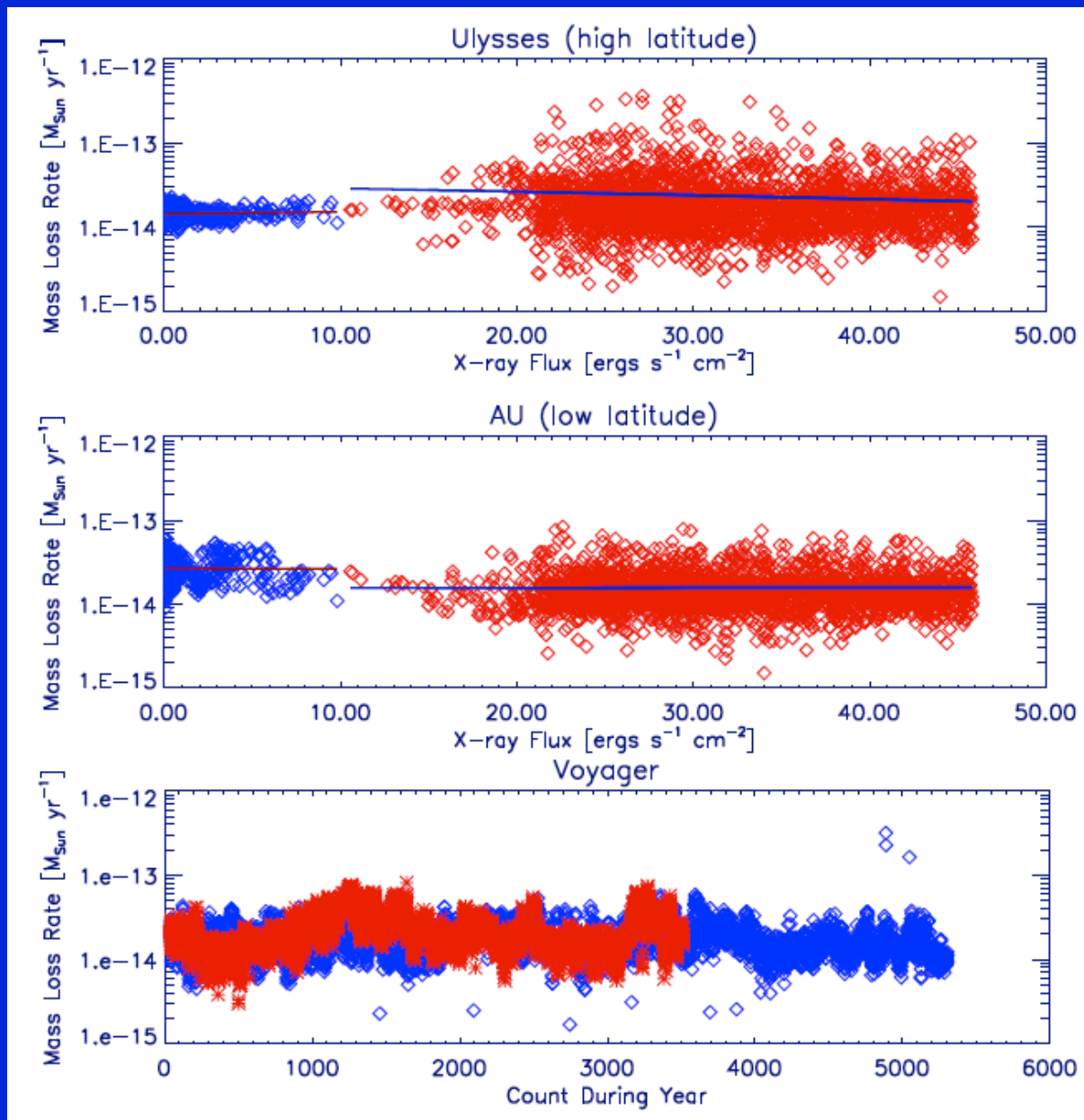
Ulysses at high heliographic latitudes



1AU (low heliographic latitudes)

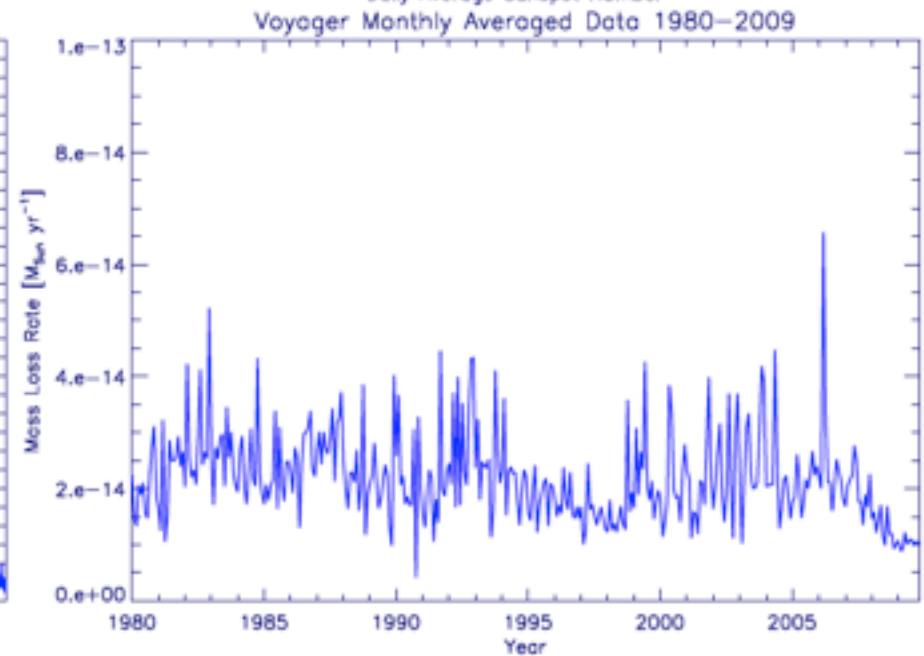
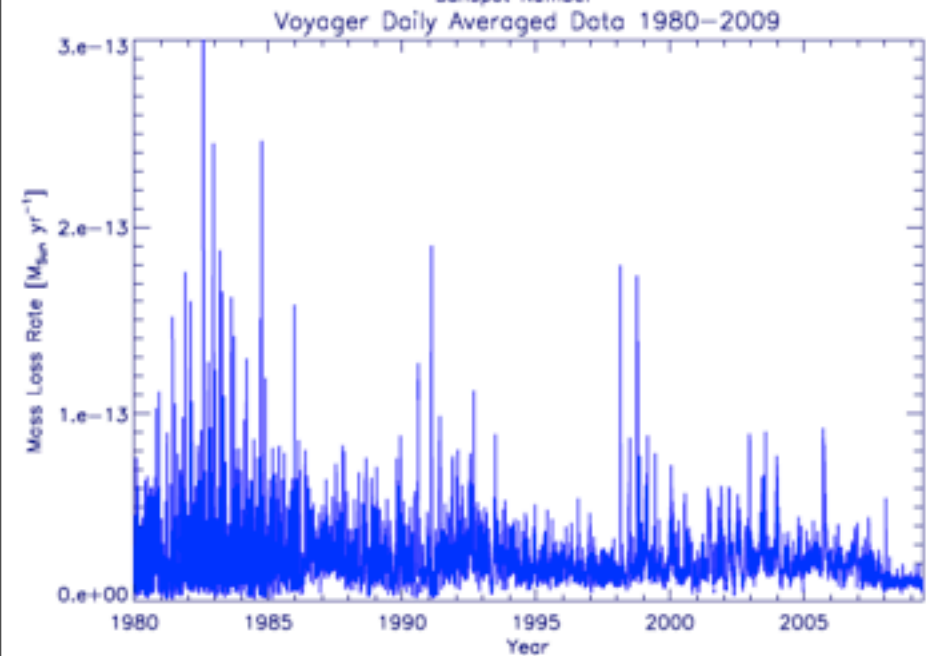
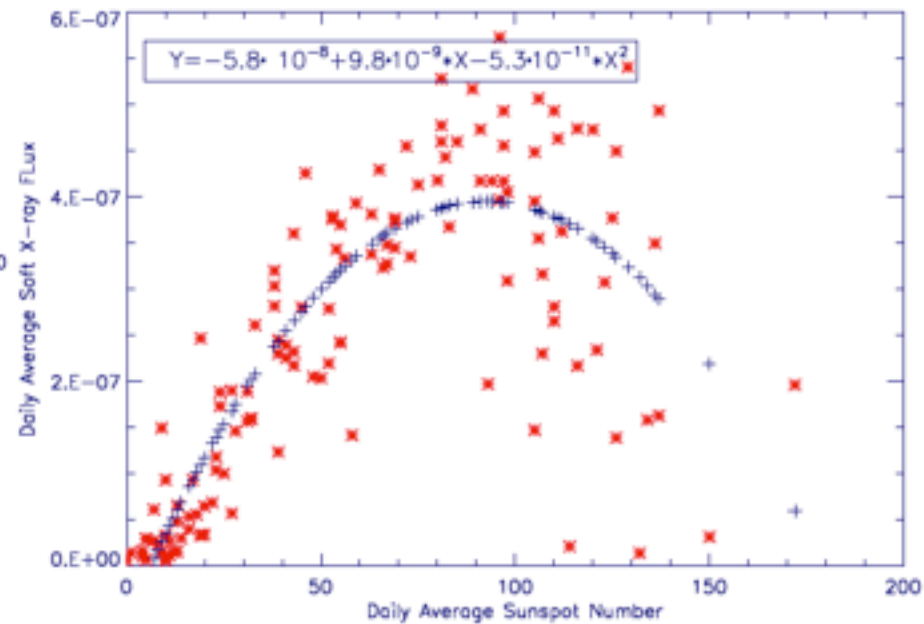
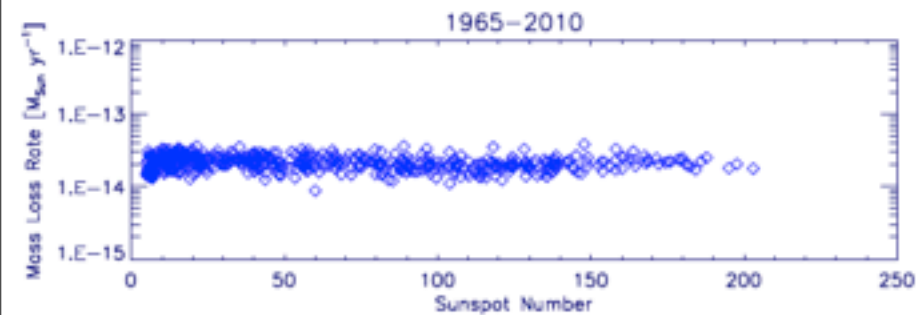
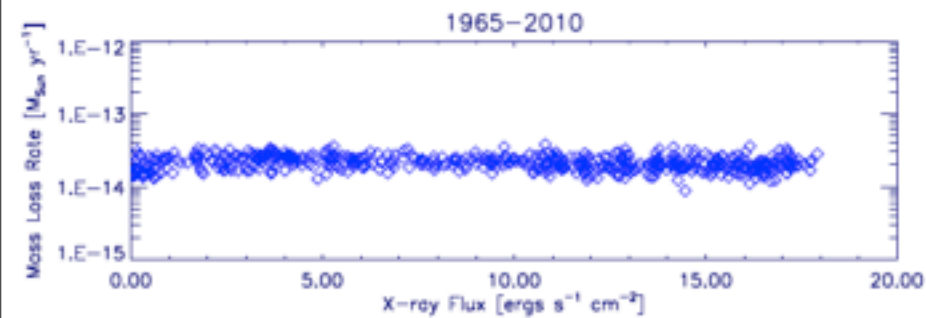
Blue - solar minimum (1996)

Red - solar maximum (2000)



Cohen, MNRAS, 2011

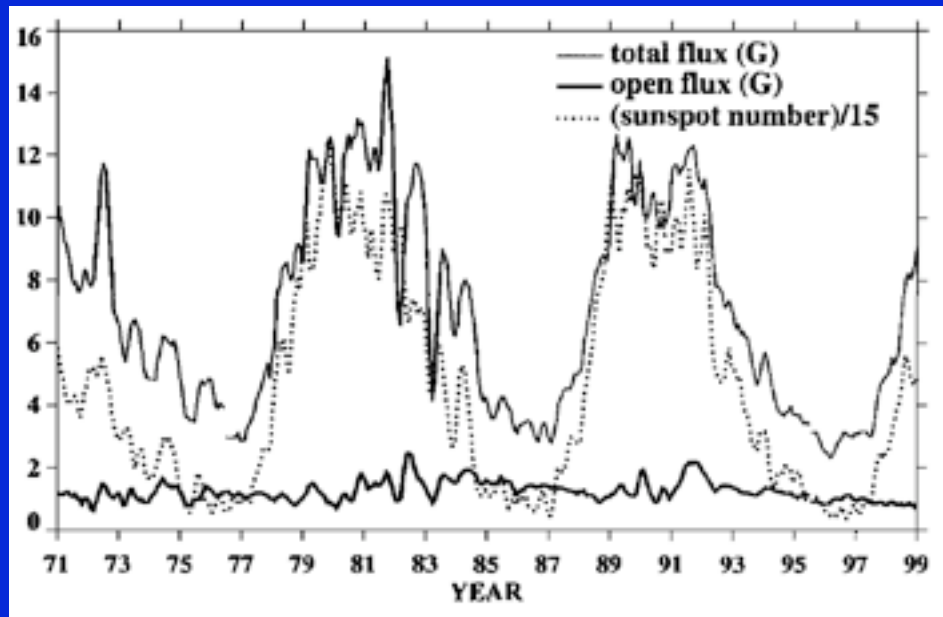
Monday, October 28, 13



**Solar activity is a bad proxy for its
mass-loss rate!!!**

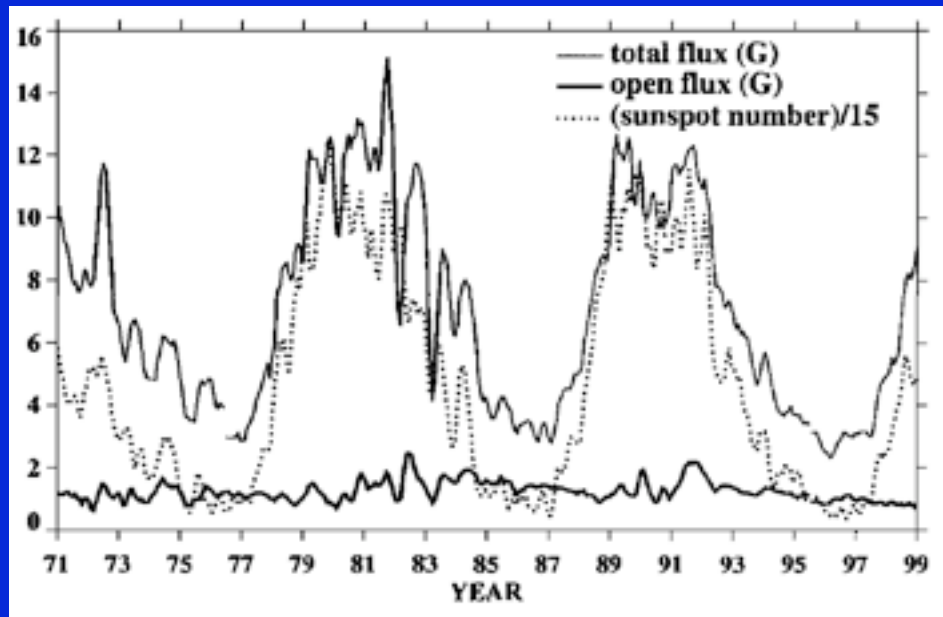
Why?

Solar mass loss rate is governed by the open flux, which is rather constant:



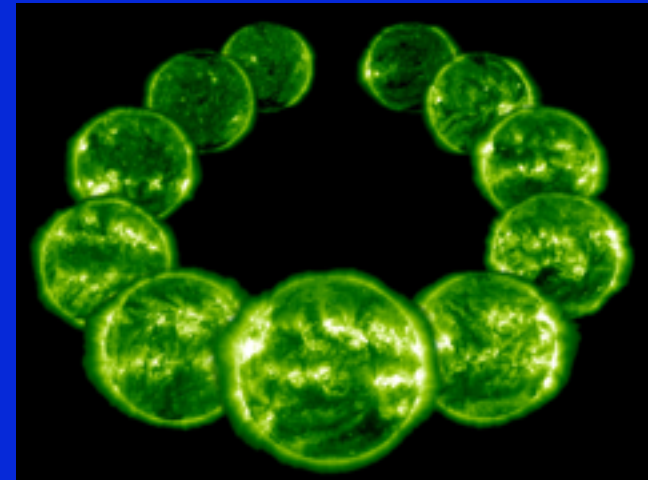
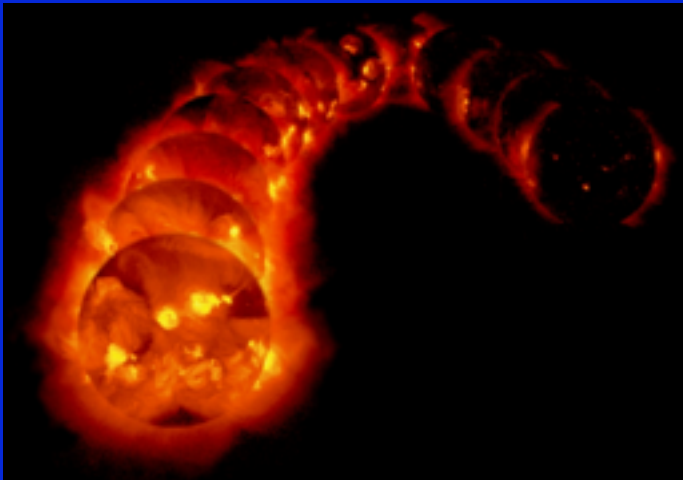
Wang, Lean & Sheeley, 2000.

Solar mass loss rate is governed by the open flux, which is rather constant:



Wang, Lean & Sheeley, 2000.

while solar activity (EUV, X-ray flux) is govern by the closed magnetic flux, which is highly variable through the solar cycle



Assuming that the mass loss rate is determined by the solar gravity and the pressure gradient between the Sun and space.

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The interpretation of B_0 can be one of the following:

1. The weak, continuous magnetic field on the stellar surface as observed on the Sun by Schrijver et al. (2011)
2. The weak dipole component of the stellar field.
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For the solar case, any choice will set B_0 to be of the order of 2–5G. With the choice of d ranging between $2-10R_\odot$, and solar escape velocity, we obtain a solar mass loss rate ranging between $10^{-15} - 10^{-13} M_\odot/\text{yr}$ - a range that is in agreement with observations.



Open questions:

Monday, October 28, 13

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The Sun is a good proxy for Sun-like stars - use it!!!