

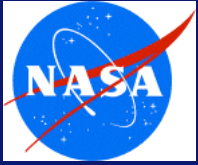
Reconstructing the solar VUV spectral irradiance over the past 60 years

Phillip Chamberlin

NASA Goddard Space Flight Center

Global Change and the Solar-
Terrestrial Environment, June 2010

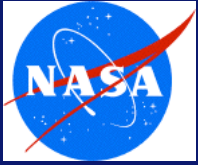
Aspen Global Change Institute



Outline

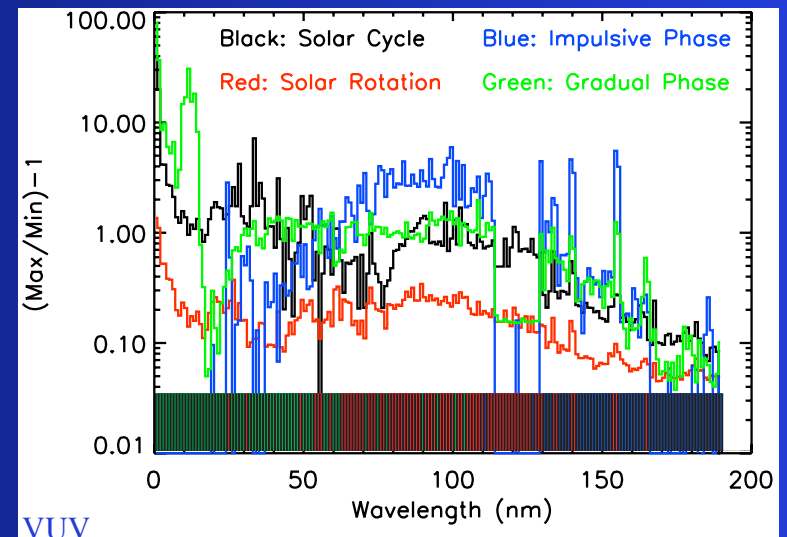
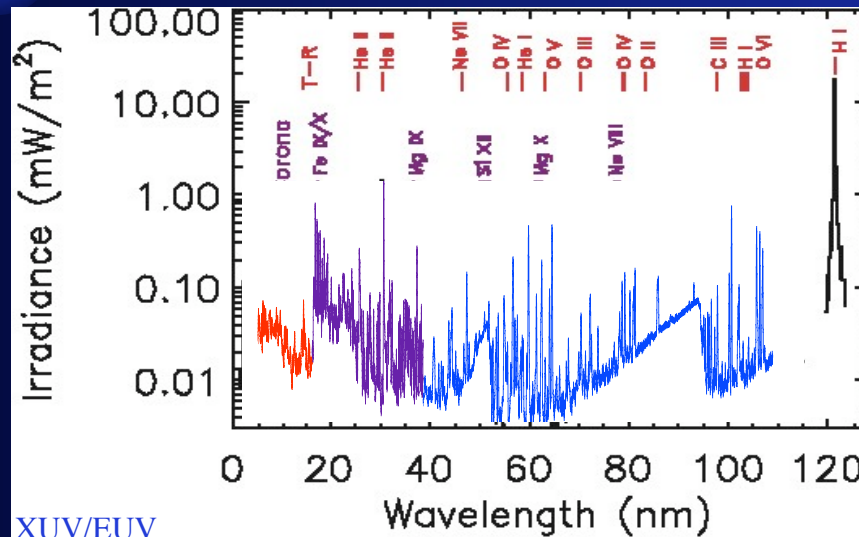
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- What is the solar VUV Irradiance?
- Questions
- FISM
 - Solar Cycle, Solar Rotation
 - Flares
- Variables to consider
- Conclusions

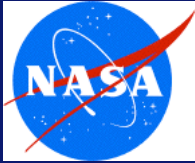


Solar VUV Irradiance

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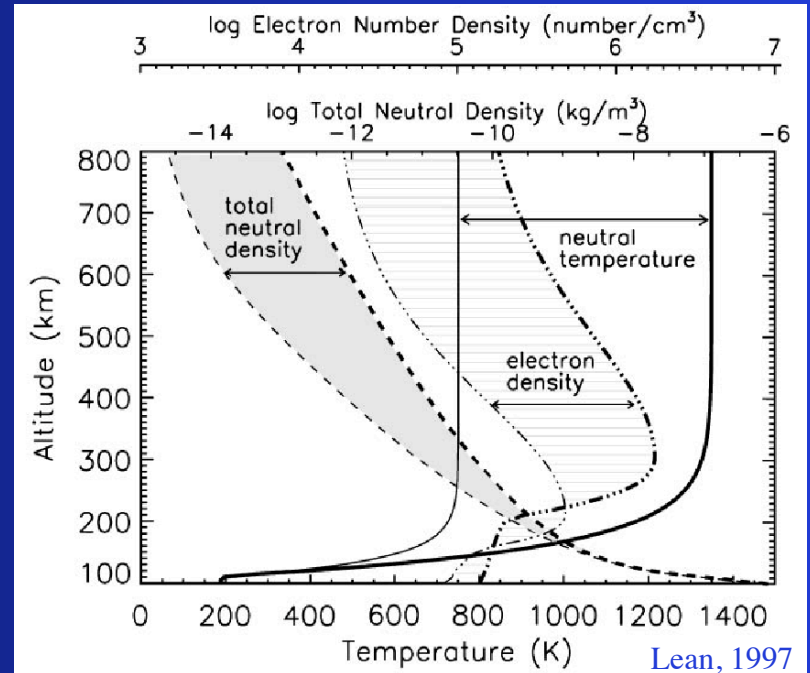
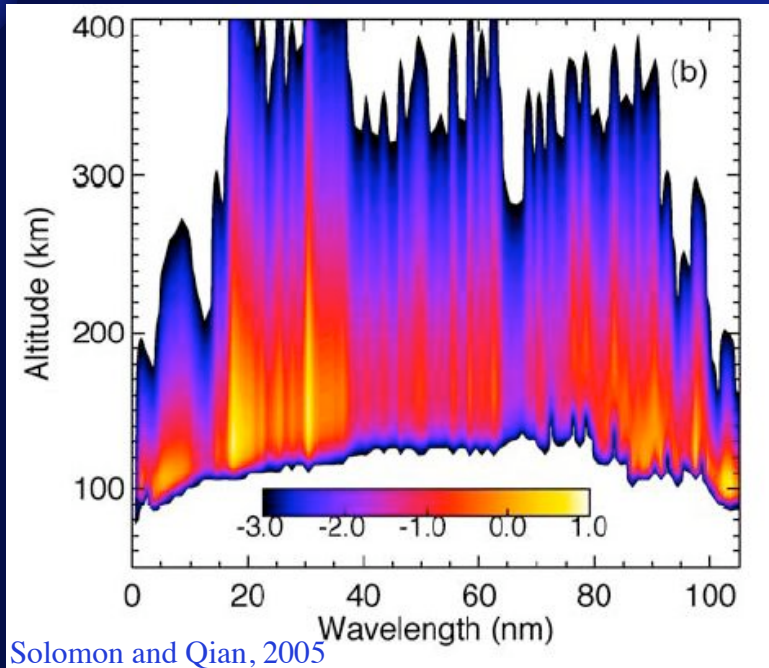


- The Vacuum Ultraviolet: 0.1-200 nm
 - XUV: 0.1-10; EUV: 10-121; FUV: 121-200
- Contains emissions from all regions of the solar atmosphere.
- Variations range from 10% to 6000%.

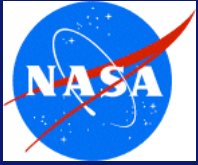


VUV Energy Deposition

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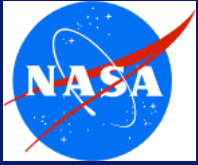
- Need spectral measurements!
 - Energy deposition is a function of wavelength
 - Due to atmospheric constituent cross-sections
 - Torr and Torr Bands, 'Stan-bands'



VUV Irradiance Questions

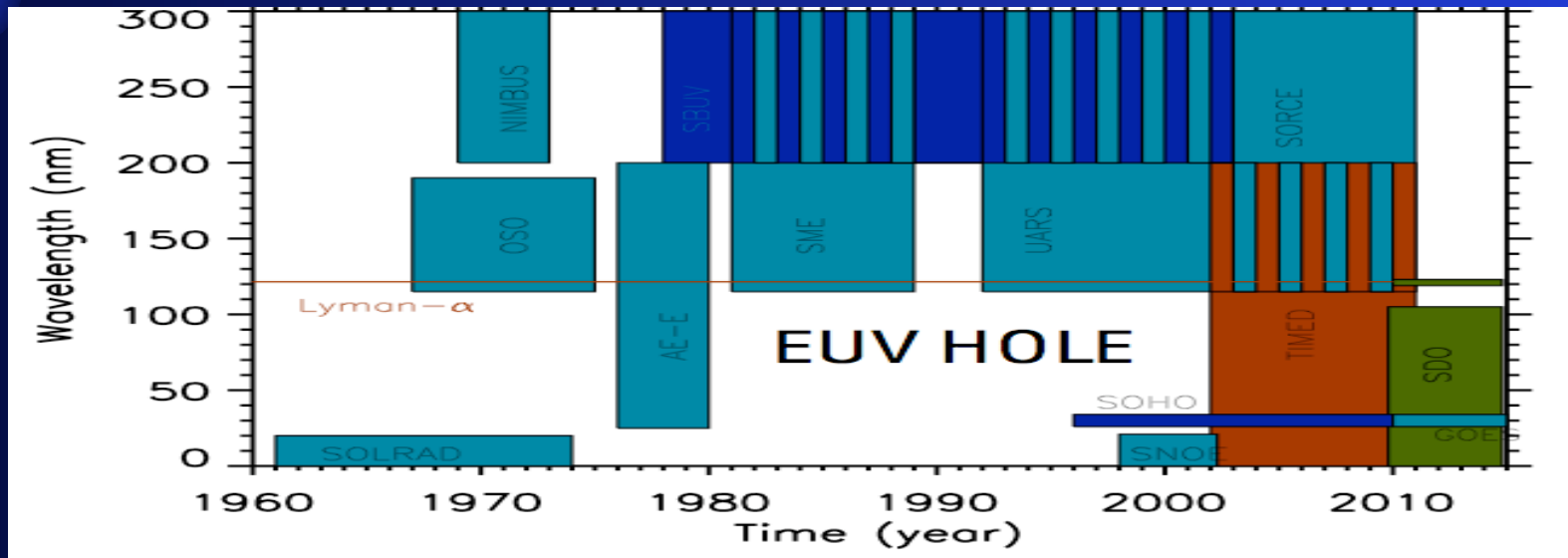
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- Do solar VUV (0.1-200 nm) irradiance and its variations matter for climate change?
- Do changes in the Thermosphere and Ionosphere propagate to the Stratosphere and Thermosphere (“very” top-down)?
- Do solar flares have effects at various timescales of interest (space weather vs space climate)?
- Do irradiance changes drive “Global” change and/or “Local” changes?

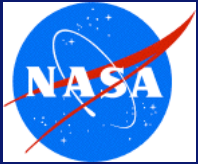


Measuring Solar Irradiance

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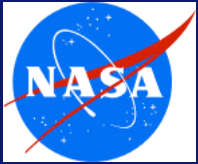
- Many data gaps exist due to the requirement of space-based observations of the solar VUV spectral irradiance.
- Other difficulties are present, e.g. long-term absolute calibration, full measurement space.



Modeling Questions

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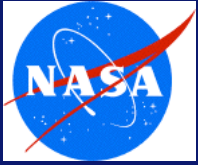
- Do solar VUV (0.1-200 nm) irradiance and its variations matter for climate change?
- What temporal and spectral resolution are needed?
- What spectral range is needed?
- How long of time series is needed?
- What accuracies are needed?
- Are these requirements interdependent?
 - **Need community input to define**



Flare Irradiance Spectral Model (FISM)

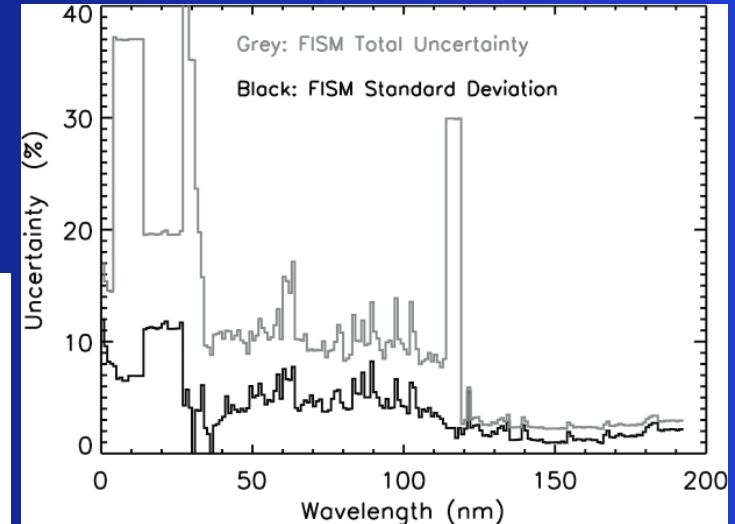
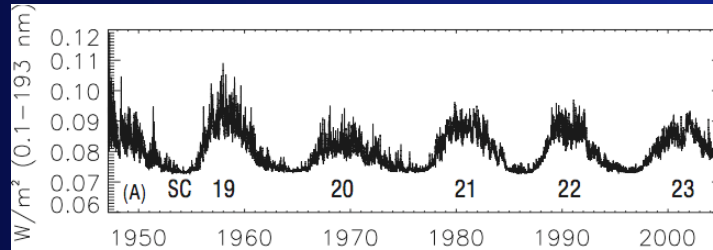
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- FISM is an empirical model of the solar VUV (0.1-190 nm) irradiance at 60 second temporal resolution and 1 nm bins.
- Models daily variations (solar cycle and solar rotation) from 1947-present, and solar flares from 1981-present.
- Current version is 1.1
 - Based on TIMED SEE V10 data and latest UARS SOLSTICE.
 - Version 2.0 will incorporate SDO EVE data
- Available at LASP/LISIRD
 - <http://lasp.colorado.edu/lisird/fism/fism.html>
 - Access to all other solar irradiance measurements!

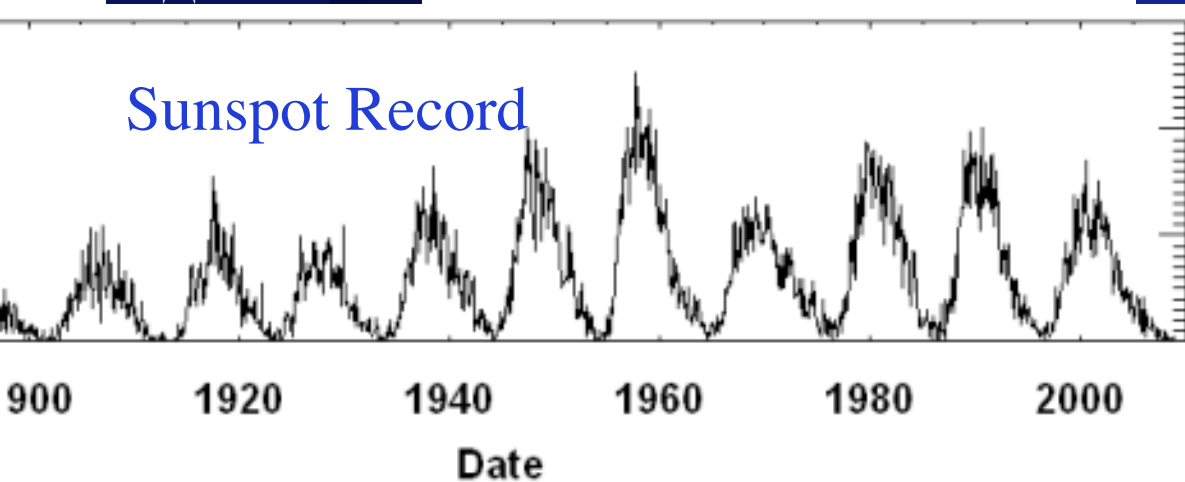


FISM Daily Median Results

Environment



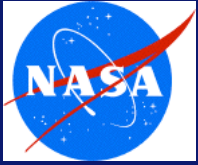
Sunspot Record



ally the FUV irradiance
XUV <35%.

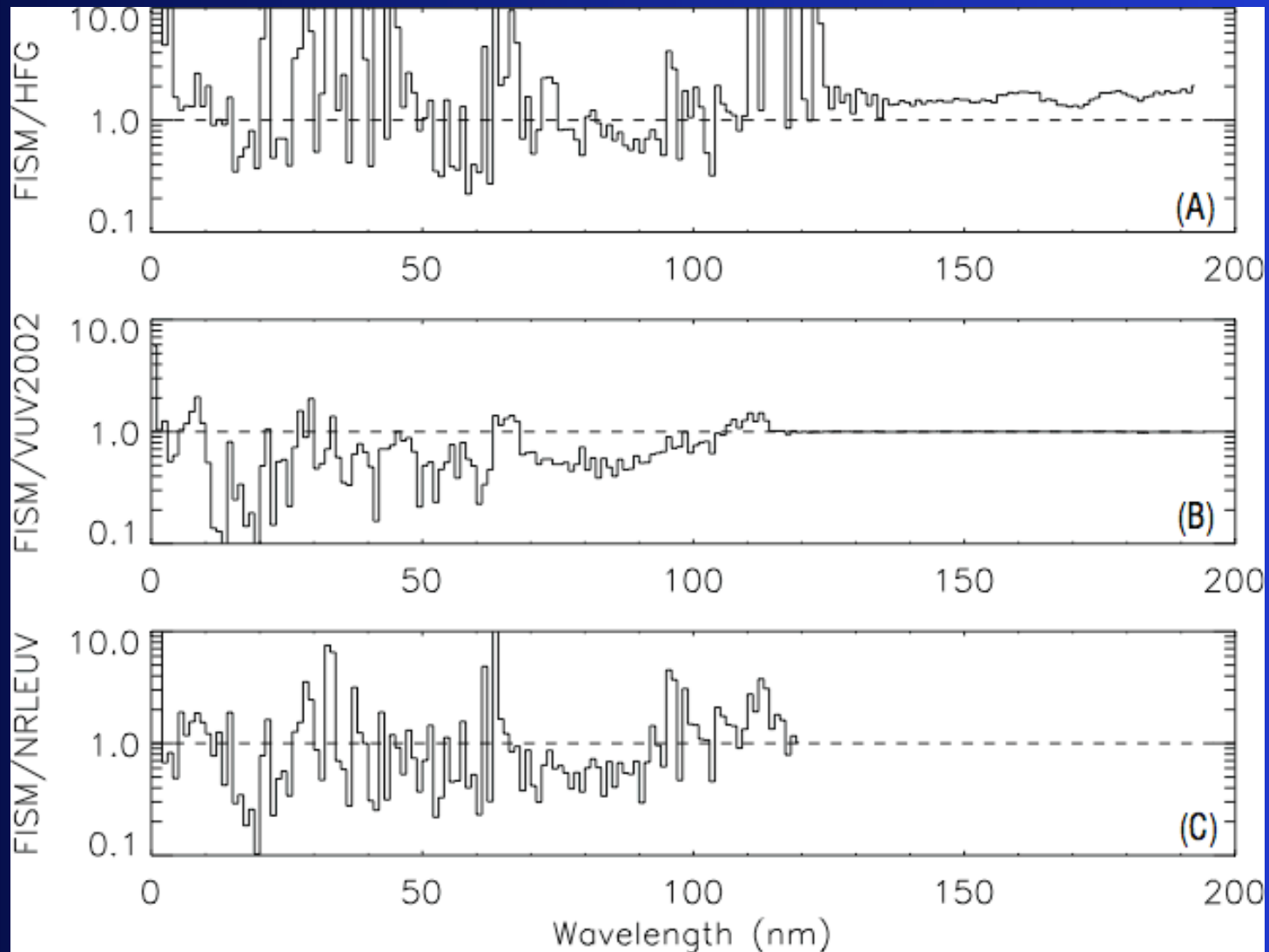
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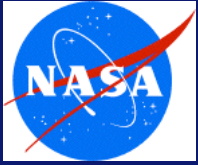
- Uncertainties increase further back in time due to losing representative proxies.
- Can use sunspot number or Be/C isotope records to extend results (uncertainties?)



FISM Daily Median Comparisons

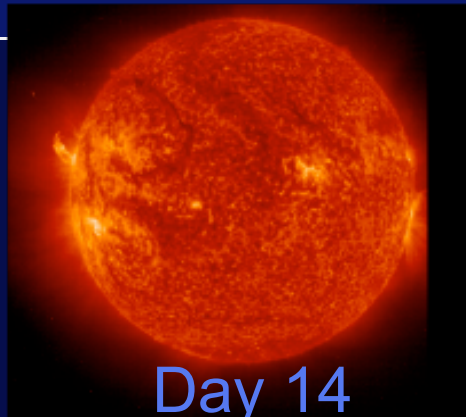
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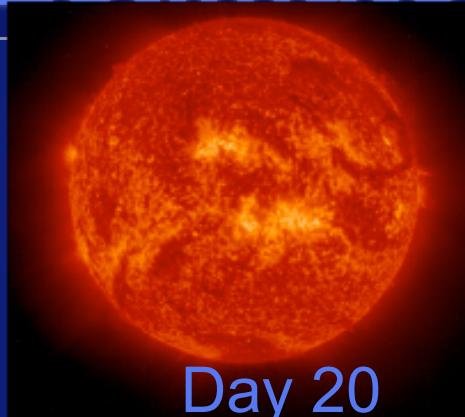


FISM Solar Rotation Estimates

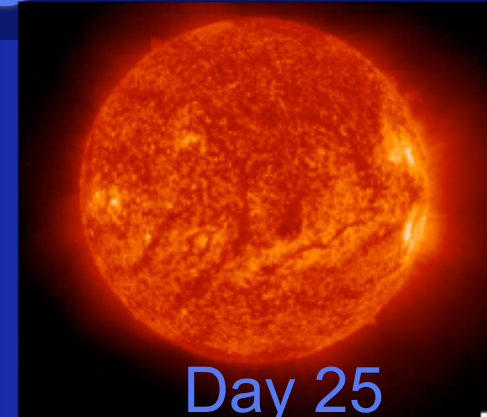
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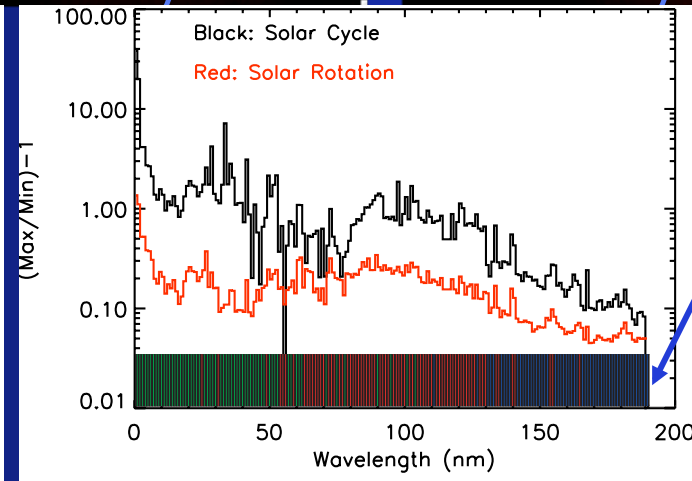
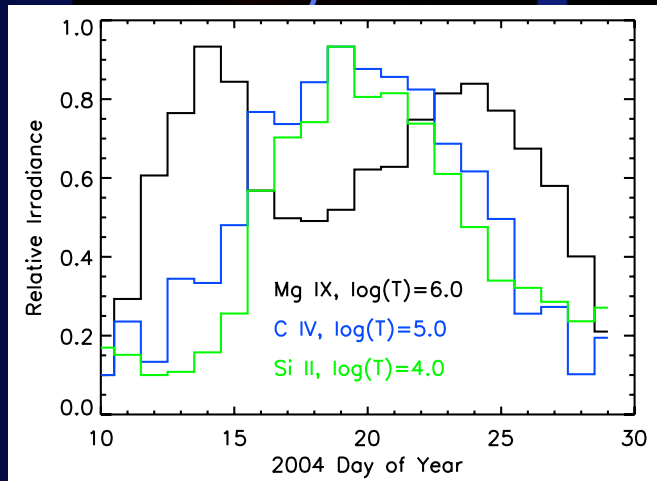
Day 14



Day 20

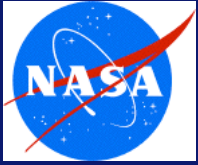


Day 25



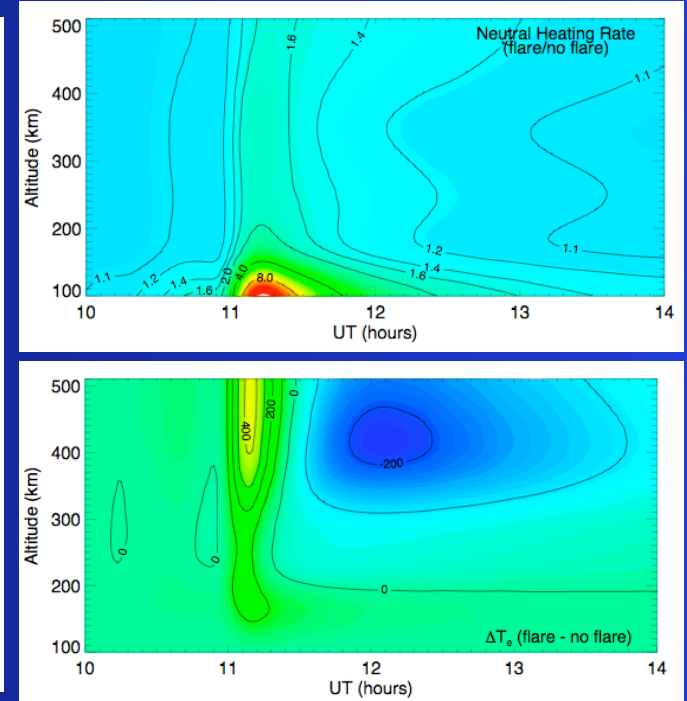
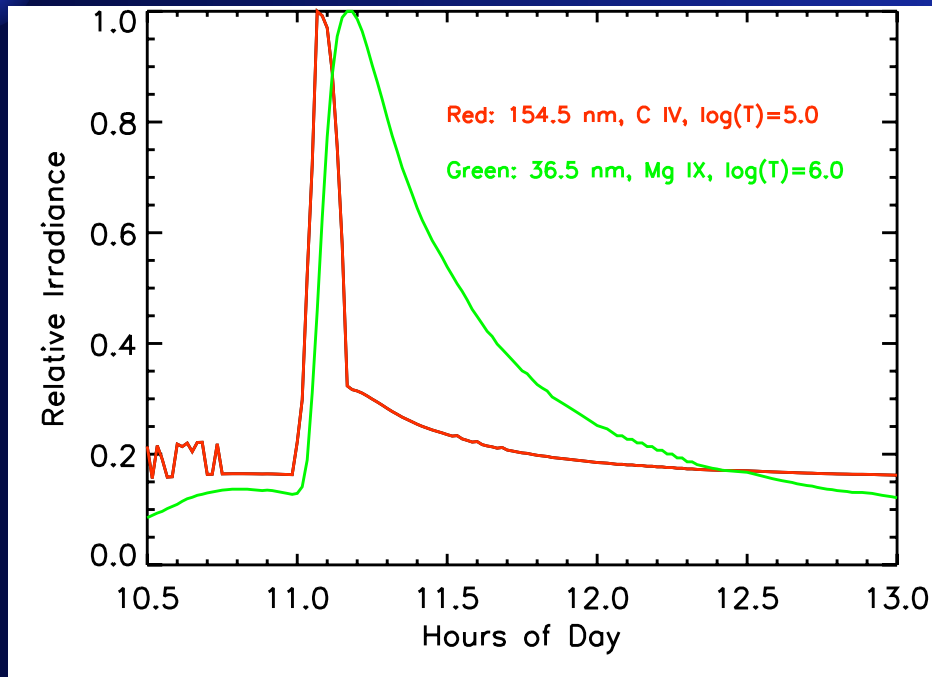
Coronal
Transition
Region
Chromo-
sphere

- Optical thickness - and therefore center-to-limb variations - affect solar rotation estimations.
- F10.7 is not a good proxy for solar rotation!

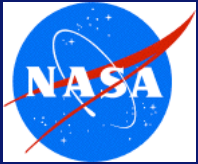


FISM Solar Flare Estimates

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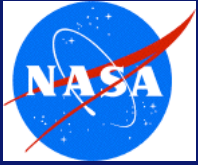
- Flares in a climate talk? Are they significant contributors?
- Can be used to refine physics and dynamics in models that can then lead to more accurate, longer-term simulations.
- Current I/T models show significant changes on short times scales due to solar flares.



Can flares contribute significantly to climate?

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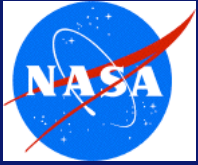
- A daily median QEUV (0-50 nm) is 6% lower in total energy output than if the radiative energy output from a single X10 flare is included.
 - This is still only 3.0×10^{-4} W/m² difference.
 - X10 flare frequency is only 0.7/year over all years, or 2.3/year during a large solar max year (SSN=200).
 - X1 flare frequency is higher at 12.5/year, but has a lower energy contribution ($\sim 3.0 \times 10^{-5}$ W/m²)
- Flares probably aren't a significant contribution compared to other, much larger uncertainties
- Woods et al, SPD 2010: Initial SDO/EVE results show FISM flare QEUV radiative output may be underestimated by a factor of 2-3.



Solar Variables for Atmospheric Modeling

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- Spectral
 - Different wavelengths deposit their energy into different layers of the planetary atmosphere due to atmospheric cross sections.
- Spatial
 - Photons deposit more energy in the equator allowing us to distinguish between photon and charged particle influences.
- Temporal
 - First use higher temporal resolution and more accurate data (solar drivers and atmospheric validation) to refine models, then we will be able to expand models to longer time ranges for climate.



Conclusion

- The solar VUV irradiance (0.1-190 nm) can be accurately modeled from solar cycle to solar flare time scales as far back as 1947.
 - Is it worth it to extend FISM, by way of isotopes or sunspot number, to climate time scales?
 - <http://lasp.colorado.edu/lisird/fism/fism.html>
- Many variables need to be considered when using solar models to correctly define (and not over-define) the solar irradiance input.
 - Still should use measurements if available.
- SDO/EVE will greatly contribute to these results on all time scales.
 - <http://lasp.colorado.edu/eve>