



# Space Weather: What /S the Sun Doing?

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## Outline



Solar Cycle 24 Prediction

 Extraordinary December 2006 Solar Radio Burst

Future needs



The solar x-ray images are from the Yohkoh mission of ISAS, Japan. The x-ray telescope was prepared by the Lockheed Palo Alto Research Laboratory, the National Astronomical Observatory of Japan, and the University of Tokyo with the support of NASA and ISAS. G.L. Slater and G.A. Linford





## Solar Cycle 24

Why is it important? Ionosphere "Bulks Up," due to a factor of 4 increase in solar EUV (more affecting GPS) Scintillation activity maximizes Large events cluster near the peak Sunspot number prediction gives an "envelope" of activity, similar to forecasts of the hurricane season

#### Why is solar cycle prediction important?





#### What is an Average Solar Cycle?

- Duration is 11.0±1.5 yrs [8.2, 15]
- Peak is 113.7±39.5 [48.7, 164.5]
- Rise to Max is 4.7±1.4 yrs [2.8, 7.5]
- Fall to Min is 6.3±1.3 yrs [3.5, 10.2]



#### What we're dealing with

- Aware of 29 predictions of Cycle 24 peak
  - Well, 3 are 'typical' climatology from Pesnell
    - Thanks for the table Dean
- The spread is from 42 to 185
  - SSN<sub>AVG</sub>=117±38
- Categories
  - Climatology -12
  - Spectral 8
  - Precursor 6
  - physics-Based\* 2
  - Neural Network 1

\* is this a good name for these?



## How Does A Solar Cycle Happen?

Need to create magnetic flux
Does the flux come from the last cycle?
And how do you know it when you see it?







## On the One Hand...

The flux is what's left over from the previous cycle
You see the remains when you measure the polar fields of the Sun
Lately the measurements of those fields are extremely low
ERGO, a really small cycle is coming!





# But On the Other Hand....



A new physics model has replicated magnetic flux emergence over the past 80 years

- It shows the meridional flow "conveyor belt" – is the prime mover
- It asserts the past 2 cycles are on the conveyor belt
- ERGO, the next cycle will be <u>very large</u>!



### Analogy with ocean conveyor belt



Broecker 1991



#### **Calibrated Flux-transport Dynamo Model**



Near-surface diffusivity same as used by Wang, Shelley & Lean, 2002; Schrijver 2002 in their surface flux-transport models.



#### Validity test of calibration



Simulating relative peaks of cycles 12 through 24 (model fed by surface poloidal source continuously)

□ We reproduce the sequence of peaks of cycles 16 through 23

□ We predict cycle 24 will be 30-50% bigger than cycle 23

□ We obtain similar results for diffusivities between  $3 \times 10^{10}$  and  $2 \times 10^{11} cm^2 s^{-1}$ 

(Dikpati, de Toma & Gilman, 2006, GRL, in press)



#### **CYCLE 24 SSN PREDICTIONS**

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Solar Radio Burst Of December 6, 2006: Observed by the Global GPS Network







#### Cornell University IGS Netw

#### IGS Network, 6 December 2006











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### FCC to Require Full E911 Adherence by 2012 (Sept. 12, 2007) – eLoran here?



Federal Aviation Administration











# Solar Cycle 24 starting soon – predictions diverge!

Solar Radio Burst of December 2006 severely affected GPS users (a new nemesis)

New demands from users raise the bar