**Climate And Weather of the Sun-Earth System**
**(CAWSES)**

# Theme 1: Solar Influences on Climate


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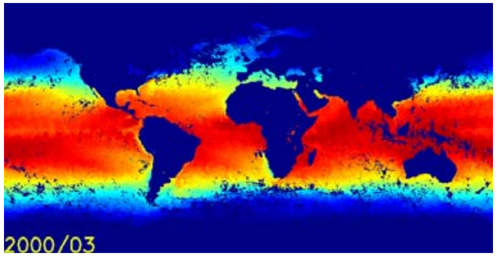
# Theme 1: Aims

1. Investigate effects of variable solar outputs on climate in the lower and middle atmosphere
   - Total solar Irradiance (TSI)
   - Spectral Irradiance
   - Solar Energetic Particles
   - Galactic Cosmic Rays (via heliospheric shielding)
2. Impacts on dynamic, thermal, chemical and micro-structure of atmosphere
3. Timescales: decadal to paleoclimatological
4. Emphasis on physical mechanisms
5. Multi-disciplinary and inter-disciplinary




# Climate Change

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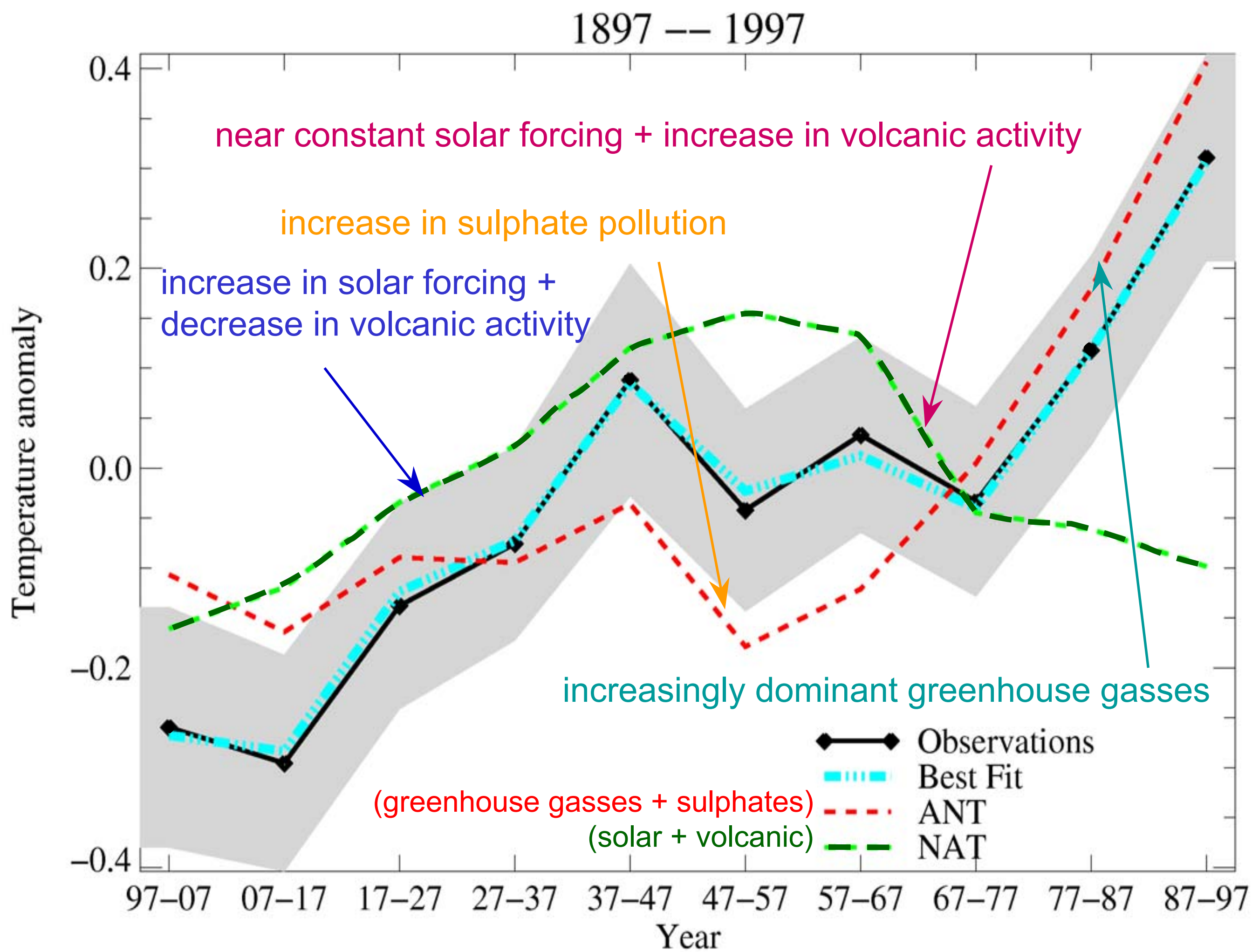
Solar Variability input to the HAD3CM global climate model needs amplification by a factor of about 3

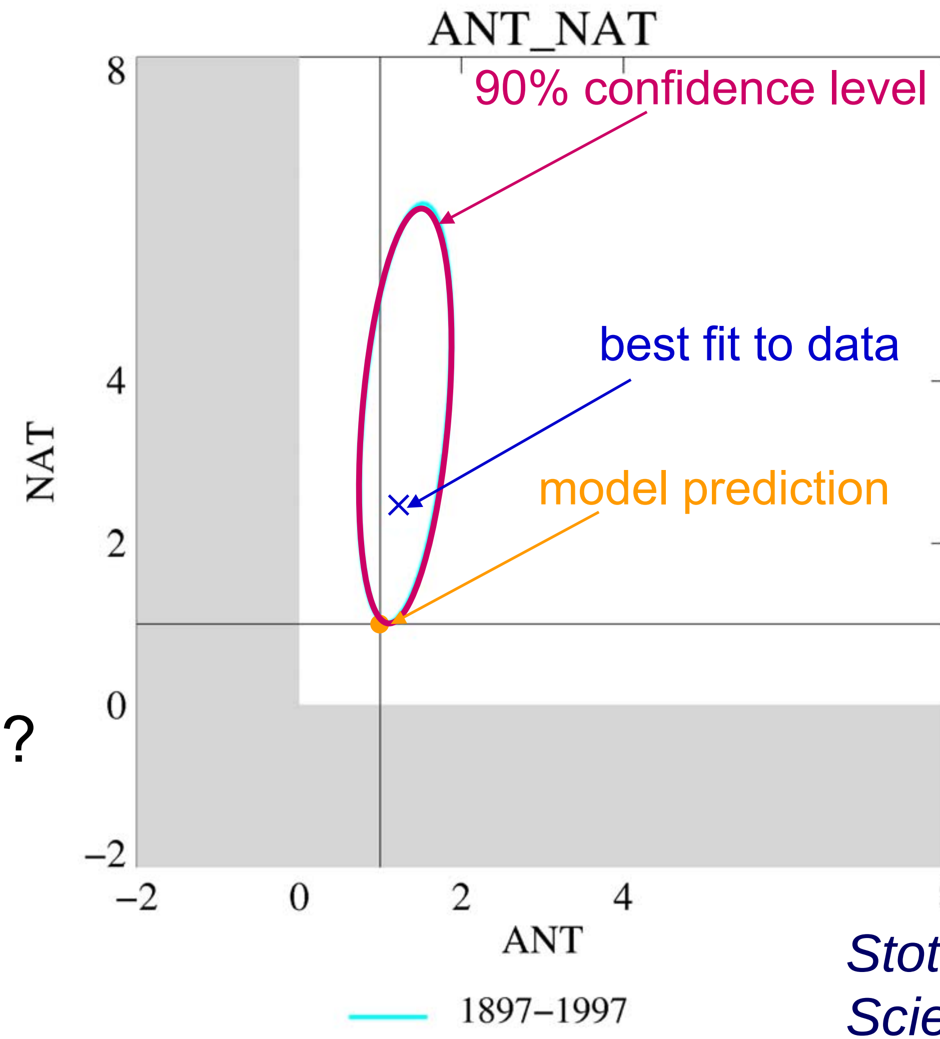


# Climate Change: Detection-Attribution

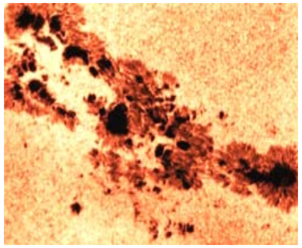
Natural & Anthropogenic Amplification Factors

Solar β factor ~ 3 for Lean et al. (1995)

>3 for more recent TSI reconstructions? (Lean, 2000; Lockwood and Foster, 2004)




*Stott et al., Science, 2001*



# TSI Reconstructions

## $Q_o$ from Lockwood and Foster (2004)

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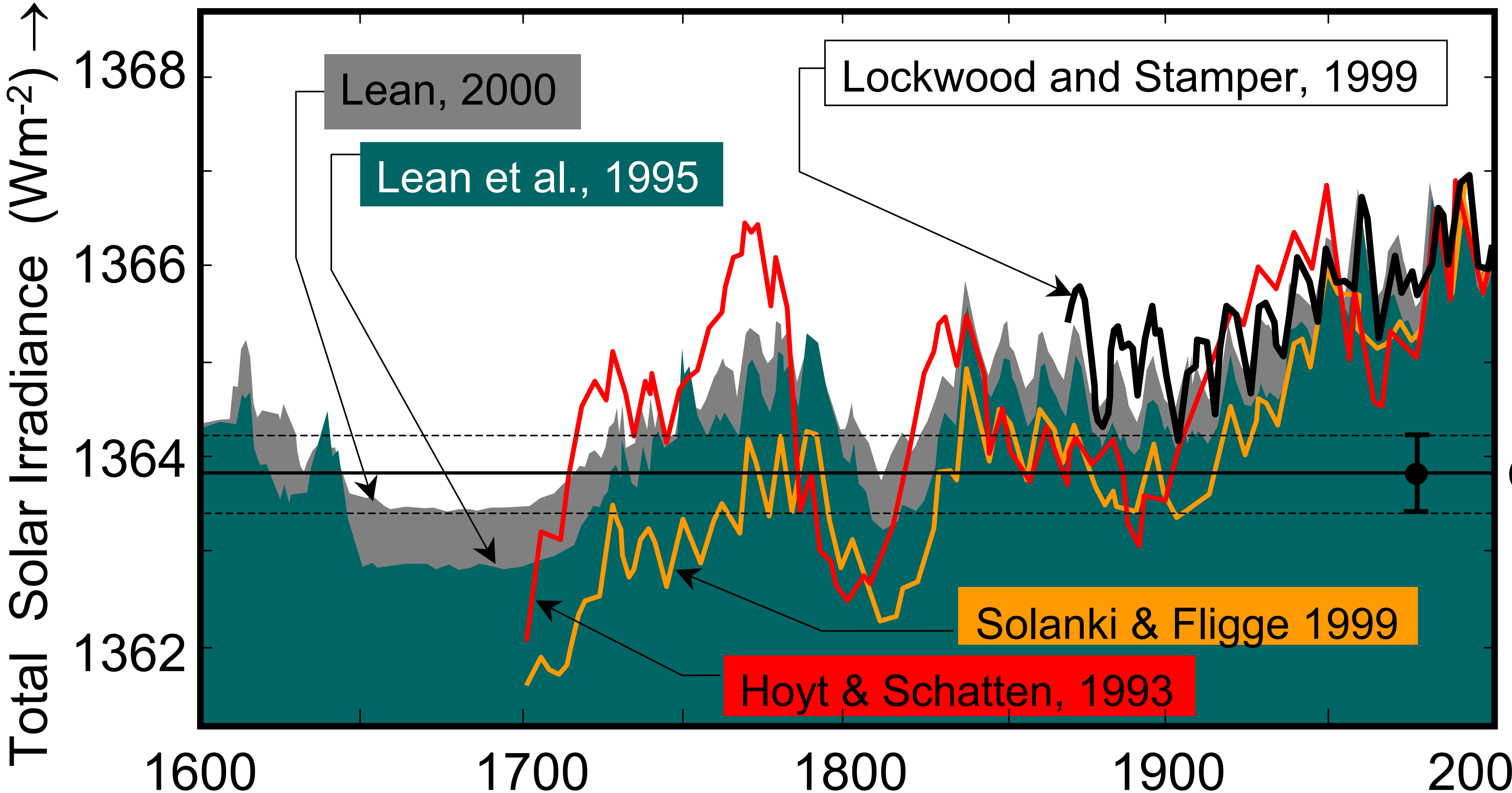


Hoyt and Schatten used solar cycle length, L, Lean et al. and Lean used a combination of sunspot number R and $R_{11}$, Solanki and Flkigge use a combination of R and L, Lockwood and

# Theme 1: Two Working Groups

- 1. Assessment of Evidence ……..
  for solar influence on climate
  (Chair: Jürg Beer, CH)

- 2. Investigation of Mechanisms ……
  for solar influence on climate
  (Chair: Ulrich Cubash, D)

# Theme 1: Science Issues

- Confirmation and quantification of solar amplification factor
- Origin of solar amplification factor
- Detection of solar variability signals in lower atmosphere and oceans
- Rigorous analysis of statistical significances
- Spatial Distributions
- Testing and evaluations of proposed mechanisms using data and models
  - UV variability amplification by ozone
  - Planetary wave propagation and effects on Hadley circulation
  - Global electric circuit
  - Direct Cosmic Ray effects (e.g. CCN formation)
  - Energetic particle effects

# Theme 1: Deliverables

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- Observing campaigns *generally* of low priority because timescales long and processes are global
- Modelling coordination a vital part of WG2's work
- Data mining and statistical techniques a vital part of WG1's work
- "Living Reviews" (discussions with Sami Solanki)
- Workshops. Funding for first has been bid for and awarded by ISSI:-

CAWSES ISSI workshop, Berne: Late Spring 2005

→ ISSI Proceedings and Space Sci. Rev(?) special issue

(N.B. Likely to be combined with…..

# ISSI Workshop on

## *Solar Variability and Atmospheric Composition, Temperature and Circulation Variations on Terrestrial Planets*

Bern, Switzerland

June 6 to 10, 2005

This not us!

(I hope to combine with ours tomorrow)

# Theme 1: Links to other themes

C
A
W
S
E
S

- Theme 3: Atmospheric coupling processes (stratosphere-thermosphere)
- Theme 3: photochemical effects ($O_3$ effects)
- Theme 3: planetary waves effects
- Theme 4: TSI and spectral variability needed as input
- Theme 4: TSI links to long-term variability in heliospheric field (GCRs) and SEPs
- Theme 2: global electric field
- Theme 2: solar energetic particle effects
- Theme 2: heliospheric structure and GCR shielding

# Theme 1:  WG1

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## Approach

- new data:- new ice/sediment cores
- novel exploitation of existing data
- absolute statistical rigour

# Combining modern and historic observations. 1.

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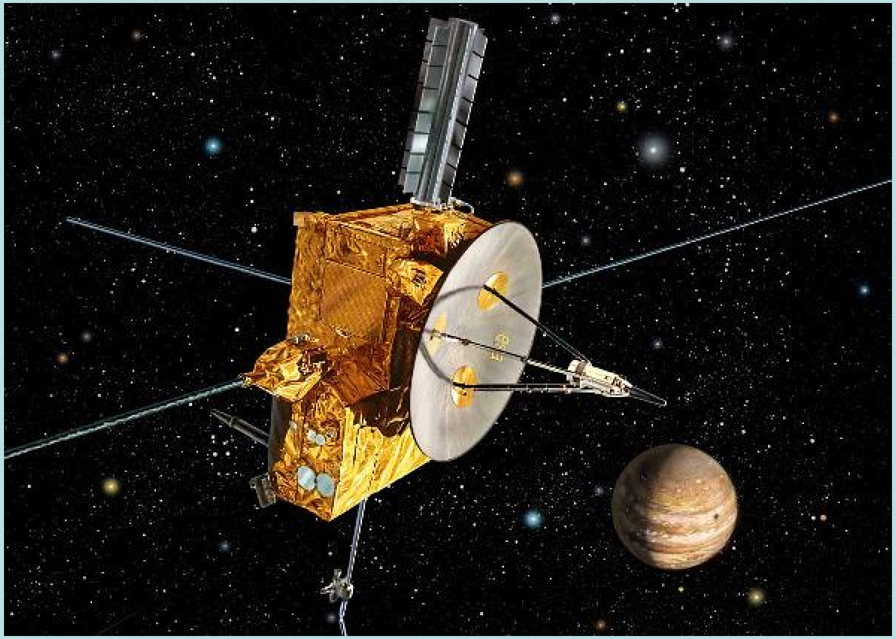

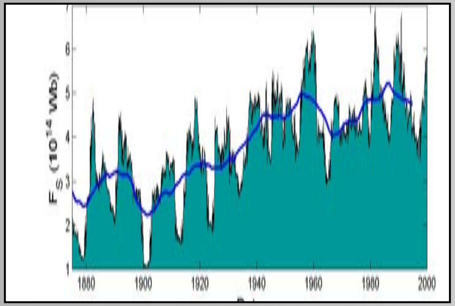


Using recent data from the **Ulysses satellite** with the unique sunspot observations by the **Kew Observatory** we can calculate the **Sun's Magnetic Field** since 1868

# Combining modern and historic observations. 2.

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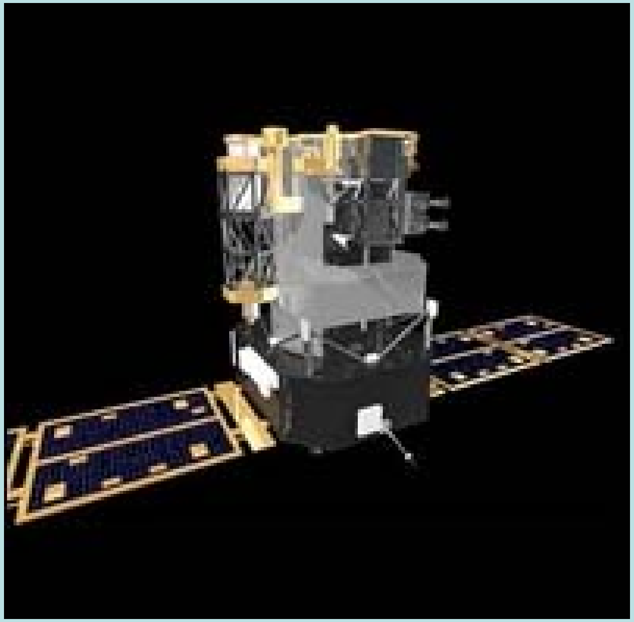

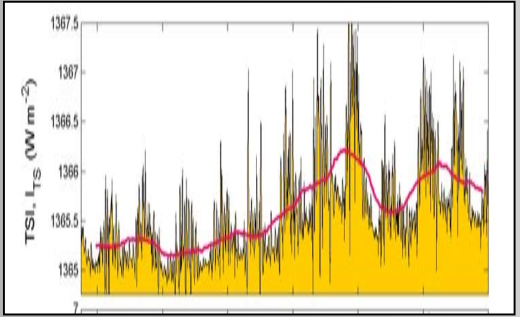


Using recent data from the **SoHO satellite** with the unique sunspot records by the **Greenwich Observatory** we can calculate the **Sun's Irradiance** since 1874

# The missing Link?

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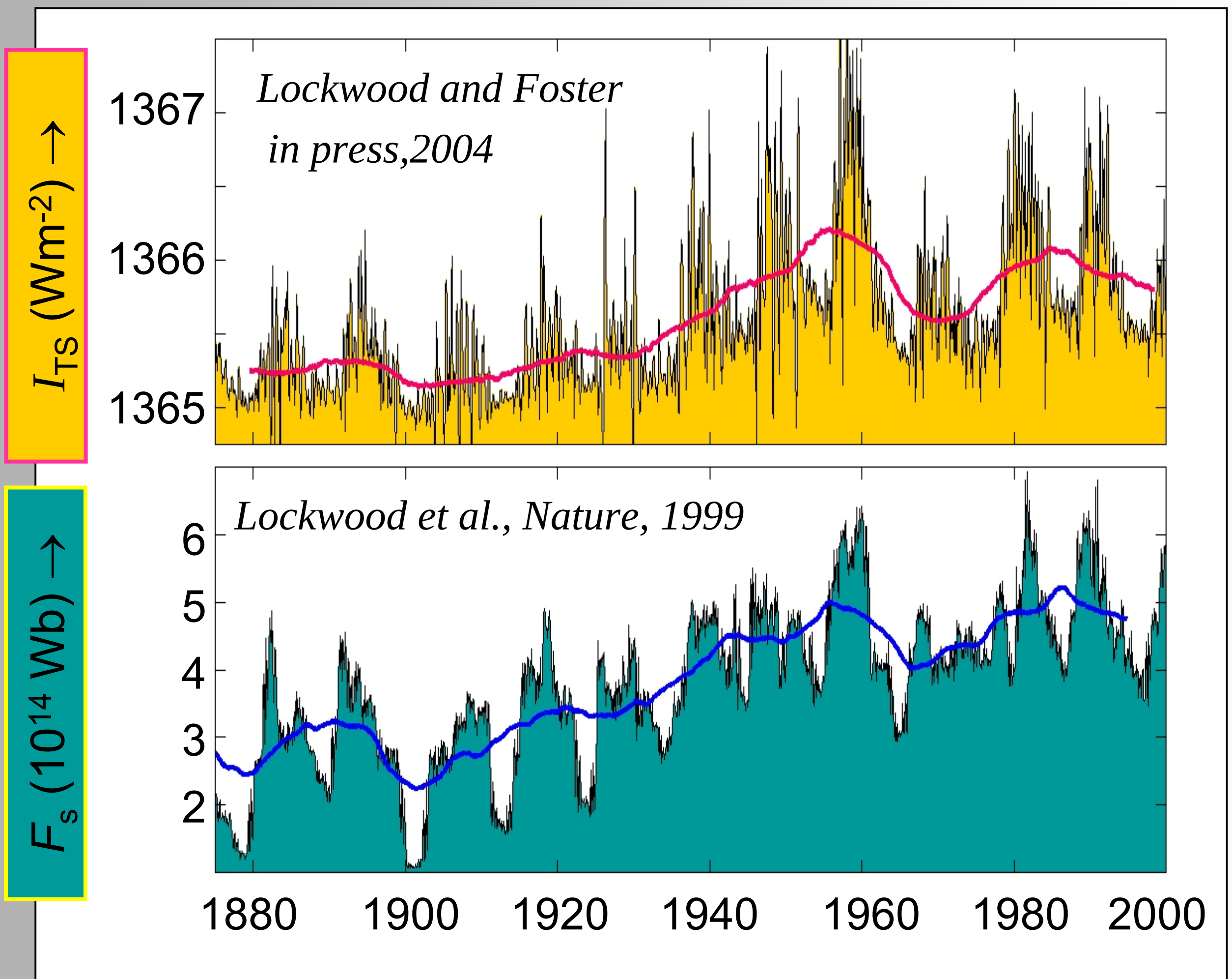


- The solar irradiance $I_{TS}$ deduced from the **Greenwich** sunspot data record using results from ESA's **SoHO** satellite

- The open solar magnetic field Fs, deduced from the **Kew** observatory magnetometer network using results from ESA's **Ulysses** satellite

# Theme 1: WG1

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## Approach

- new data:- new ice/sediment cores
- novel exploitation of existing data
- absolute statistical rigour
- intelligent choice of locations

# Stalagmite Growth in Oman

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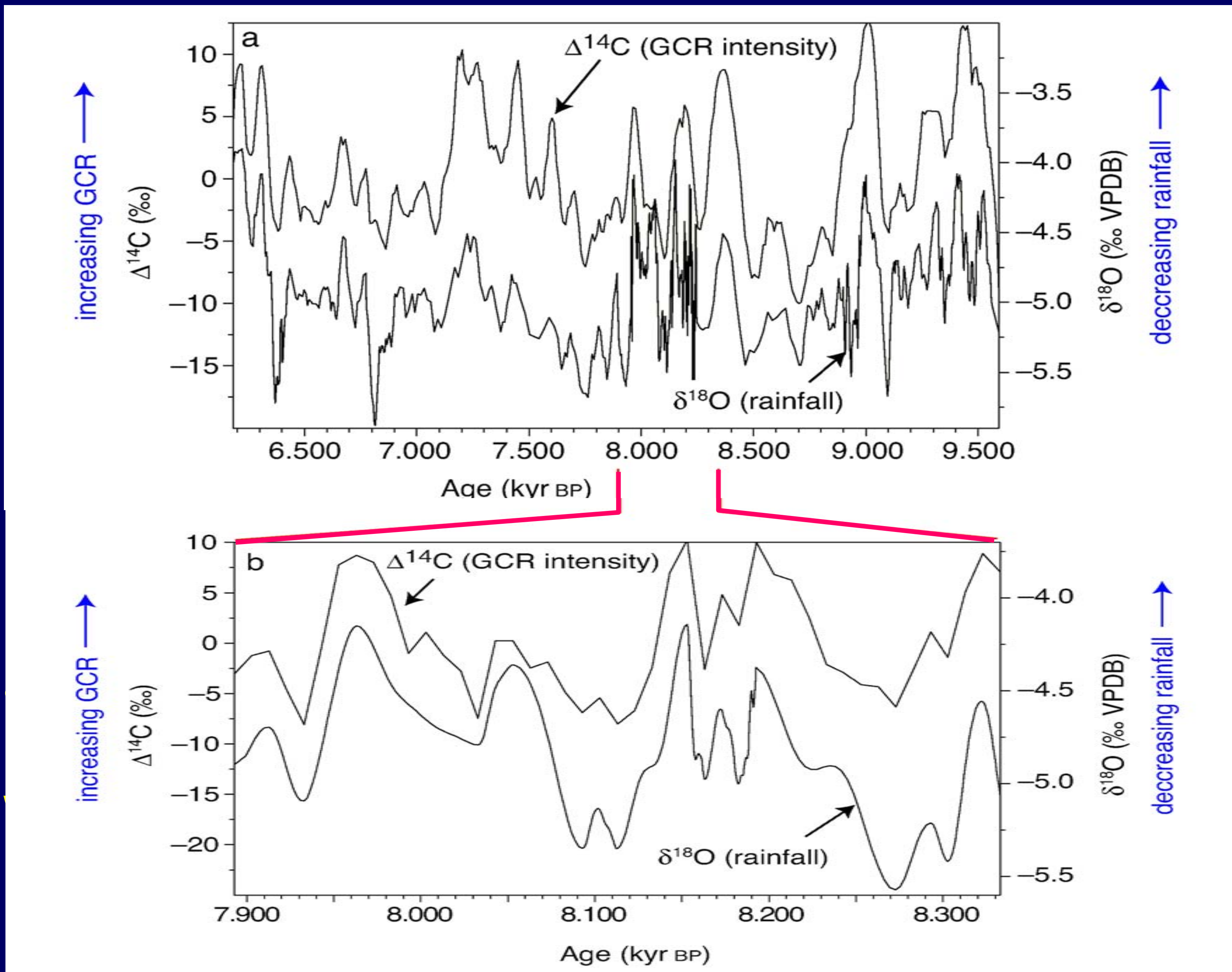


# Theme 1: WG1

## Approach

- new data:- new ice/sediment cores
- novel exploitation of existing data
- absolute statistical rigour
- intelligent choice of locations
- separating variables (e.g. Laschamp geomagnetic events coulds resolve TSI - cosmic rays debate)

# Climate forcing

Power: $4\ 10^{26}$ W    $2\ 10^{17}$ W

Production
Transport
Emission

Orbital parameters

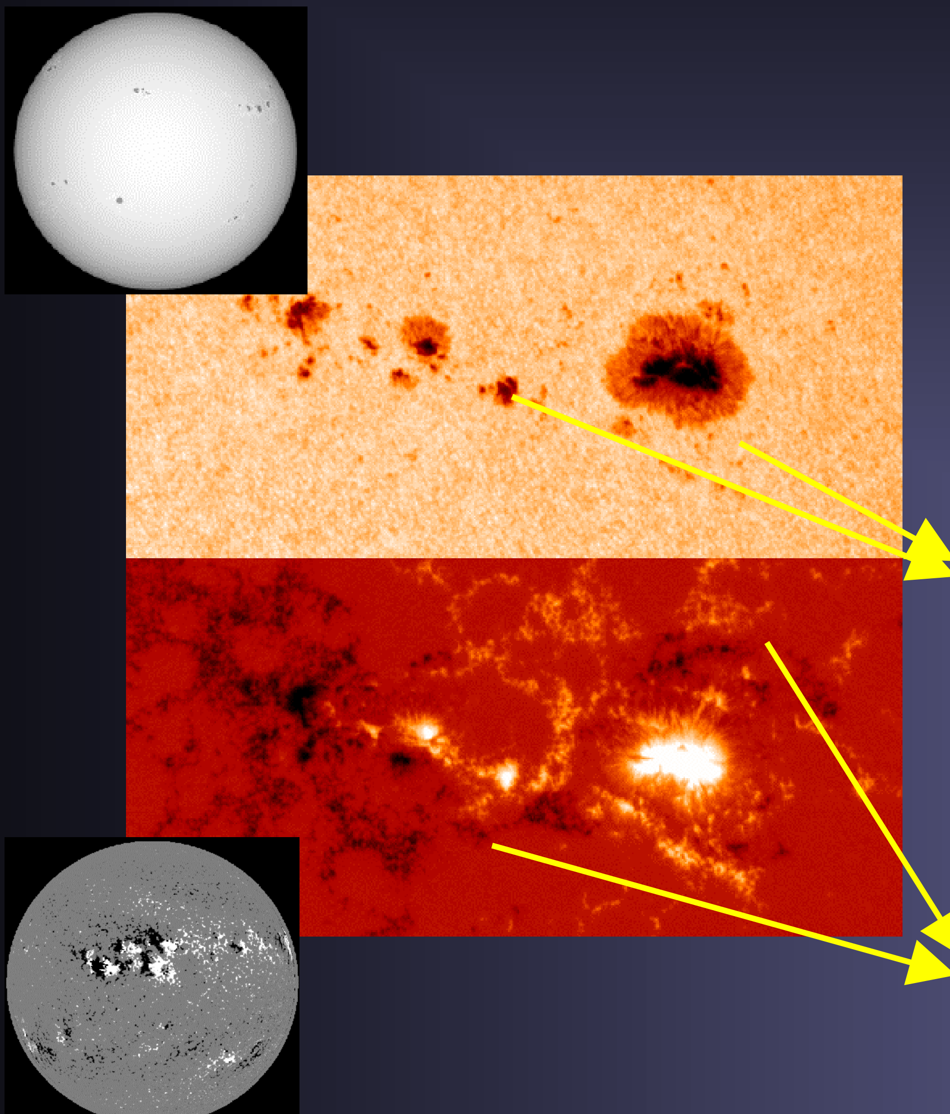
Albedo
Greenhouse gases
Aerosols
Internal

# Objectives, questions

- TSI
  - Mechanisms (convection zone, surface: theme 4)
  - Amplitudes (0.1%)
  - Reconstruction (100000 y)
  - Uncertainties

- Spectral irradiance
  - Amplitudes
  - Reconstruction
  - Uncertainties

# 4- COMPONENT MODEL



$F_q(\lambda)$ - quiet Sun flux
*(Fontenla et al. 1993)*

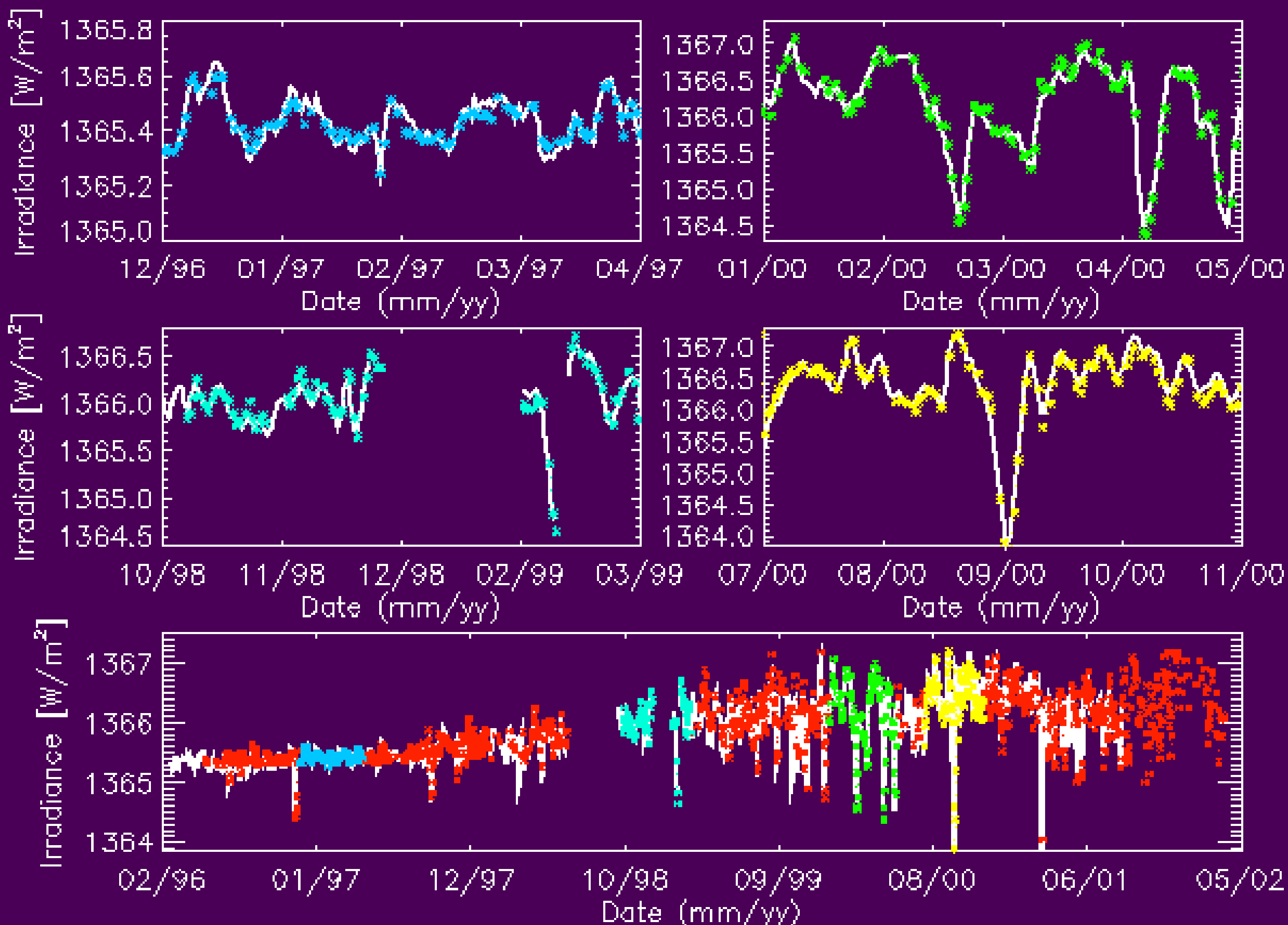
$F_s(\lambda)$ - sunspot flux; separate umbra/penumbra
*(cool Kurucz models)*

$\alpha_s(t)$ - filling factor of sunspots
*(MDI continuum)*

$F_f(\lambda)$ - facular flux
*(modified P-model; Fontenla et al. 1993; Unruh et al. 2000)*

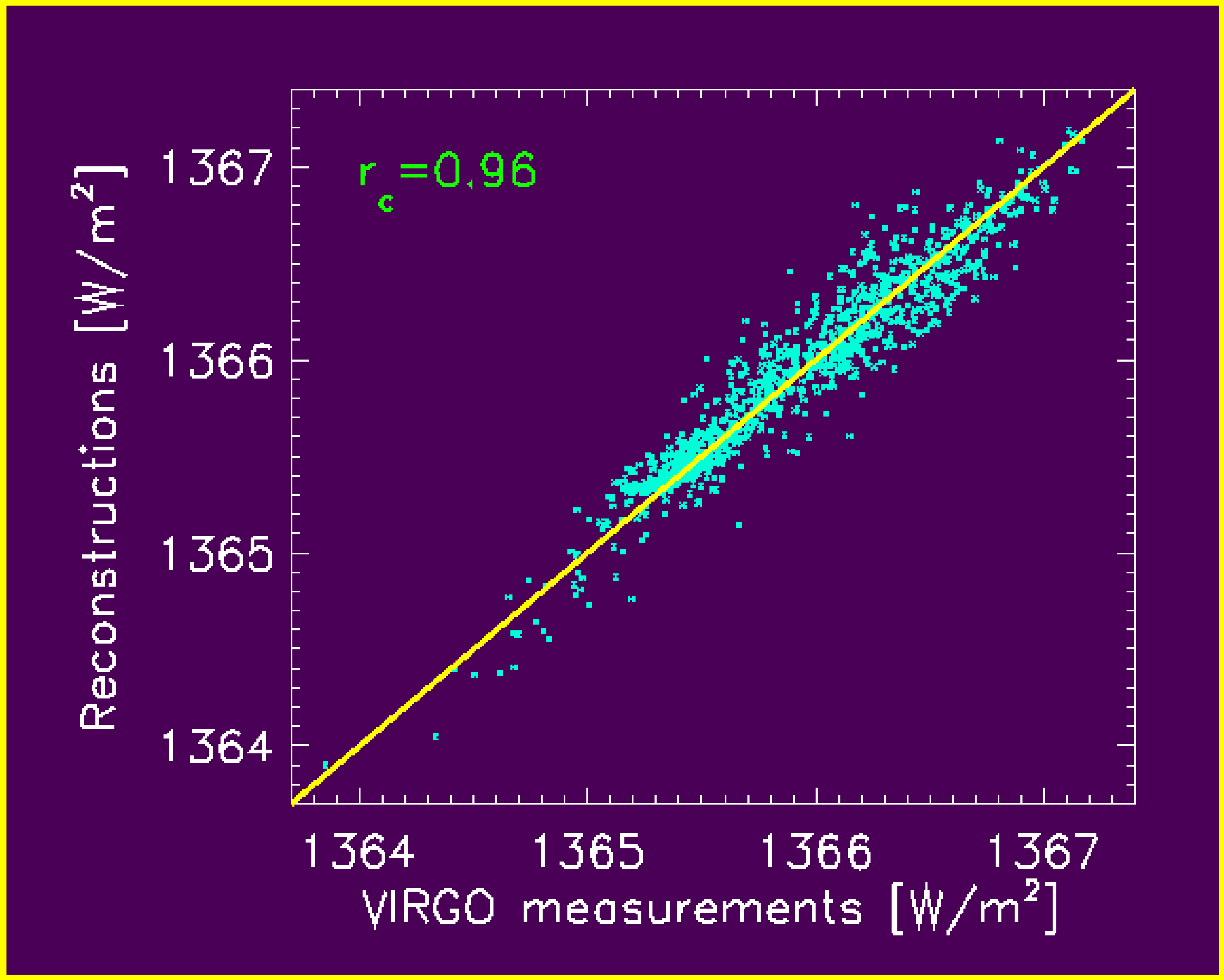
$\alpha_f(t)$ - filling factor of faculae
*(MDI magnetograms)*

# B as Source of Irradiance Changes

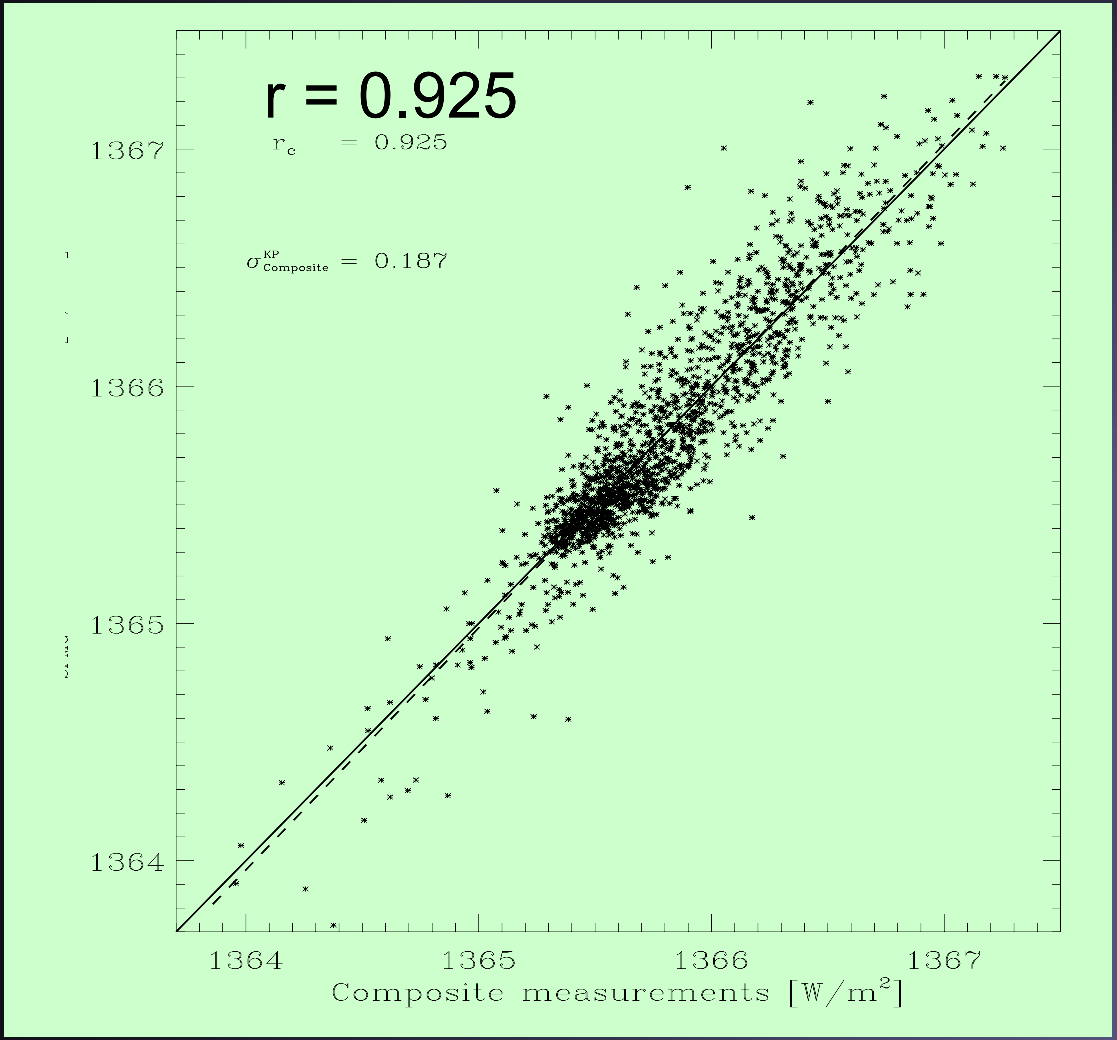



Krivova et al. 2003 A&A Lett

# Model vs. Observations



# TSI reconstructed from KP magnetograms vs. measured TSI composite (Fröhlich) (1992-2001)




When the irradiance is reconstructed using magnetograms and as much physics as possible, then no difference is found between the behaviour of the 2nd half of cycle 22 and 1st half of cycle 23

Wenzler et al. 2004

# Objectives, questions

- Cosmic rays and Clouds
  - Significance of effect
  - $10 Mio experiment at CERN
  - Event study (SPEs Forbush decreases)
    Diploma thesis EAWAG-University of Bern

- Orbital forcing
  - Sensitivity studies

# Solar signal in climate records

- Records of spatial and temporal climate variability
  - Direct records
  - Proxies ($\delta^{18}O$, tree rings,...)
  - Archives (ice, sediment,.....)
  - Calibration
  - Dating
  - Uncertainties

# Detection of solar signal: objectives, questions

- Selection of:
  - site (spatial variability)
  - Time (temporal variability)
  - Parameter (sensitivity)
- Combination of different proxies from different archives
- Models

# Theme 1: WG2

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Mechanisms

- $\Delta$TSI $\rightarrow$ Radiative Forcing $\rightarrow \Delta T_{surface}$
  inadequate and geographical patterns wrong
- $\Delta$UV $\rightarrow \Delta O_3 \rightarrow \Delta T_{stratosphere}$
  stratosphere – troposphere coupling
- SPEs $\rightarrow \Delta O_3 \rightarrow \Delta T_{stratosphere}$
  a complication, anticorrelates with UV effect
- $\Delta$GCRs $\rightarrow \Delta$CCN $\rightarrow$ Clouds $\rightarrow \Delta T_{surface}$
  also a function of geomag. field unlike the above
- $\Delta$GCRs $\rightarrow \Delta$E $\rightarrow$ Electro-scavenging in Clouds
  also a function of geomag. field unlike the above
- coupling/feedback of mechanisms

# Theme 1: WG2

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Approach

- Models v. Data – getting appropriate validation data
- Spatial patterns and temporal variability
    - use of advanced statistical methods
- Choice of model components needed
    - coupled oceans?
    - coupled stratospheric chemistry?
    - coupled tropospheric chemistry?
    - coupled cloud microphysics? How?!
    - self-consistent SW albedo (cloud, ice, vegetation)

# GCM Cloud Cover Prediction

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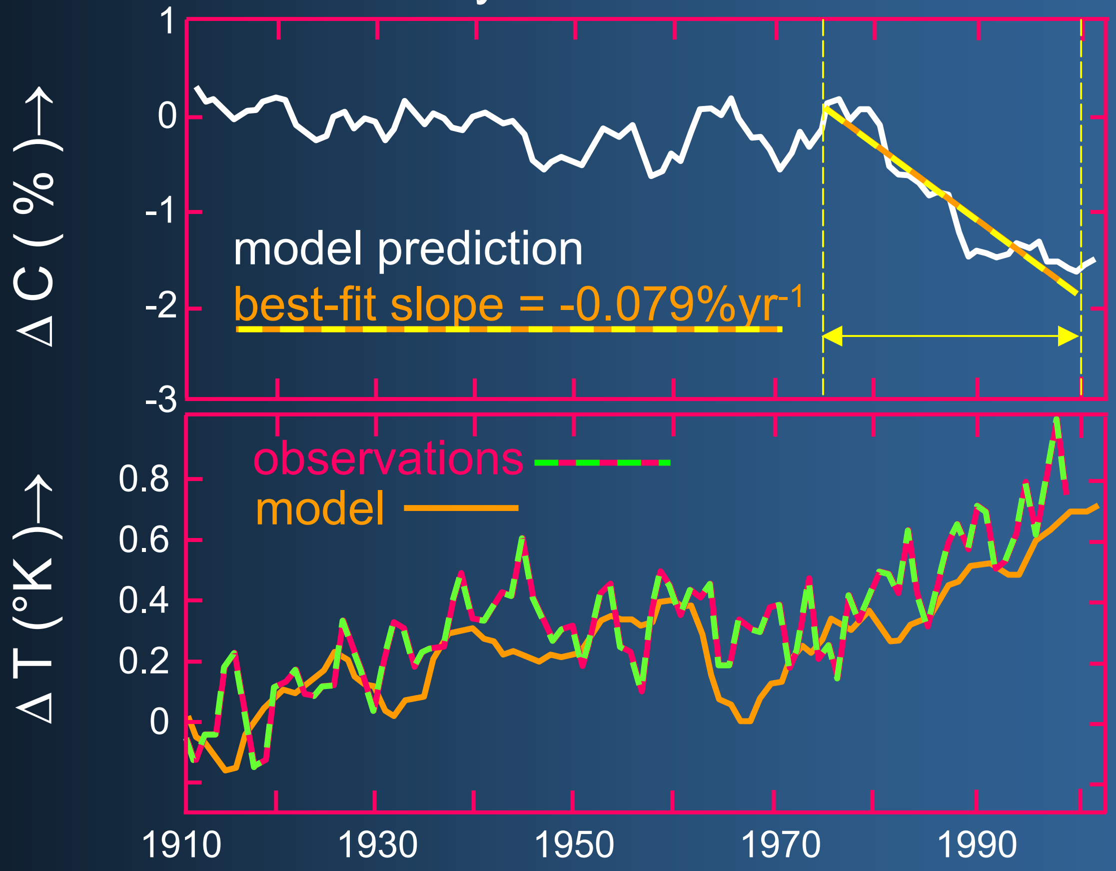
- Predictions from the Hadley Centre's HAD3CM model

- Global cloud cover anomaly

- Global surface temperature anomaly




- Simulation input conditions as in *Stott et al., Science, 2001*

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