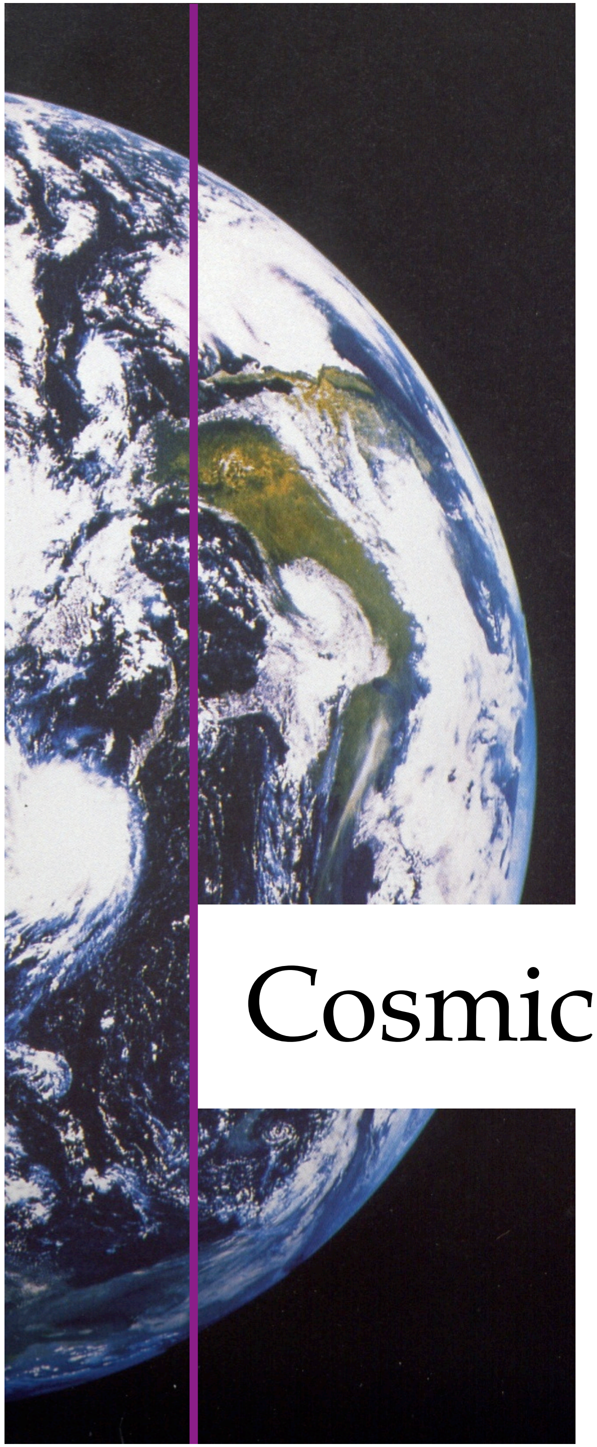
Cosmic Rays and Global Warming

an update

a. Physics Department, Durham University, UK
b. Geography Department, Sussex University, UK
c. Lebedeo Physical Institute, Moscow, Russia



Cosmic Rays and Global Warming

an update

- Determination of the fraction of terrestrial cloud attributable to cosmic rays.
- Estimate of the degree of Global Warming attributable to cosmic ray variations.
- Are there other sites of CR-cloud effects:

Noctilucent Cloud

Planetary atmospheres in general

And Neptune in particular?

The 11-year cycle

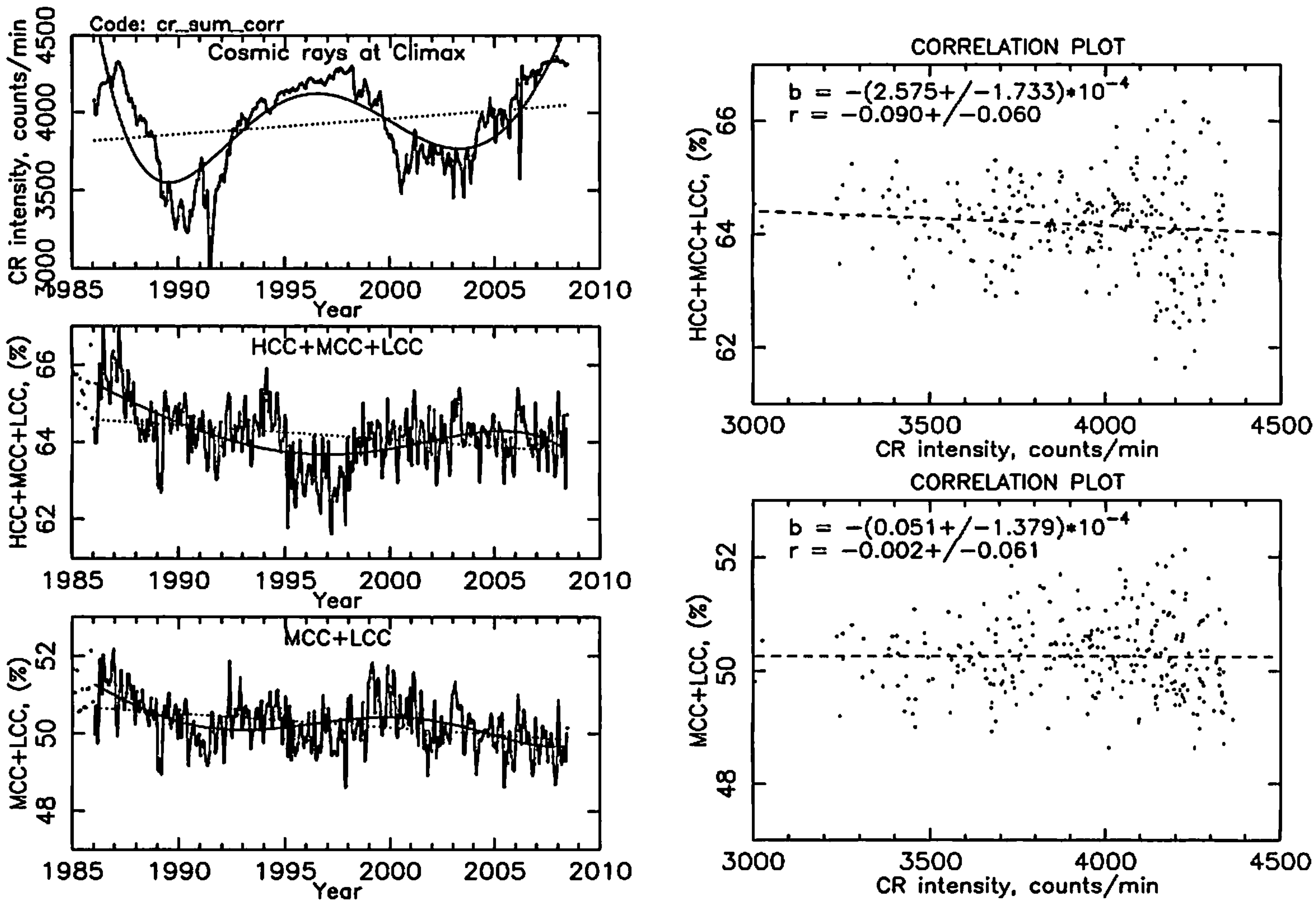
LCC. Sloan and Wolfendale (2008): less than 23% (2 σ -level) of the dip for Cycle 22 from CR.

Erlykin and Wolfendale (2010) – cause is changing height, thus, must study LCC + MCC.

LCC + MCC.

Erlykin, Laken and Wolfendale (2010): 1σ upper limit 1%

Fig. 1 *Correlation of Cosmic Rays, HCC+MCC+LCC and MCC+LCC*



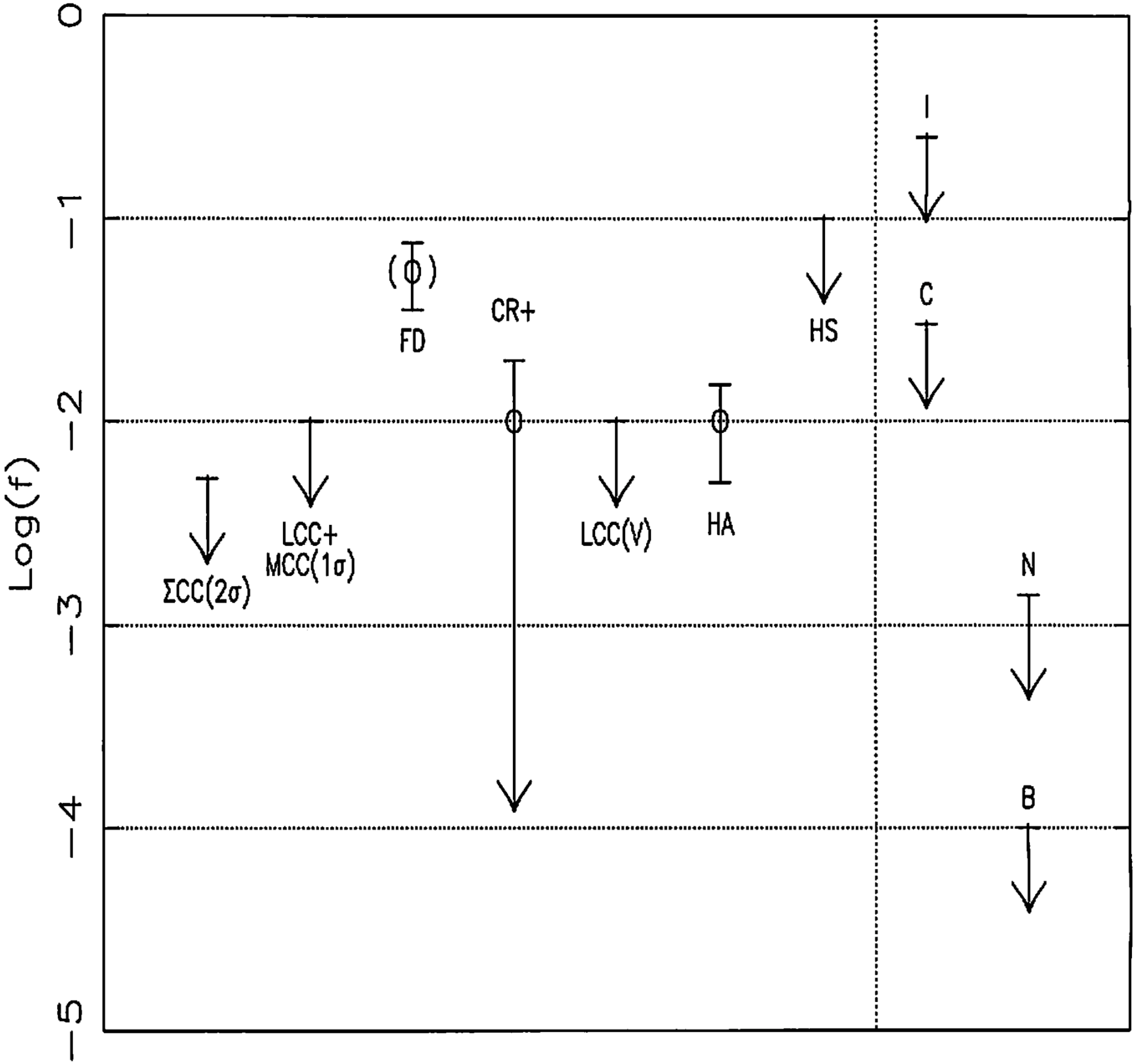
LCC + MCC + HCC (ELW). 1 σ upper limit is negative;

2 σ upper limit 0.5%

LCC + MCC

1 σ upper limit 1%

Fig. 2 *Fraction of CC affected by CR*



Key

FD	Forbush Decrease
CR+	Positive CR excursions
HA	Harrison and Ambaum
HS	Harrison and Stephenson
I	India
C	Chernobyl
N	Nuclear Bomb Tests
B	15Mt BRAVO

Forbush Decreases

[redacted]

Svensmark et al. (2009) claimed a correlation but Laken et al. (2009) & Calogovic et al. (2010) say no. τ too big (~6 days) – purely accidental

Forbush Decreases

Laken (2010) – a better analysis

Strong signal in the Antarctic, and in the stratosphere.

Weak, but finite, tropospheric signal, but at day – 2.
Probably solar irradiance changes. Nevertheless latitude – variation agrees with CR.
$f = (5.5 \pm 2.0)\%$

Positive CR excursions

Laken and Kniveton (2010) have searched for CR,CC correlations for positive CR excursions.

Importance of CR and CC. Small positive signal, near Poles and coincident in time (?)

$f = (1.0 \pm 1.0)\%$

More sensible, physically

Rapid mid-latitude cloud change

Laken et al. (2010) concentrated on latitudes 30^o – 60^o, N&S.

Studied rapid CC changes, day to day. Strong correlation of CC, CR and CC, SI (Mgii).

Problems, however:

CC & CR profiles differ

CC, SI best for UV, which doesn't reach the troposphere.

Regional variations of CR,CC correlations

Usoskin et al. (2004), Palle et al. (2004): regional variations. Voiculescu et al. (2006) maps of CC, CR and CC, SI (UV) – for clouds at the 3 levels.

Low cloud cover (LCC):

LCC, UV negative is strongest. See Figure 2.

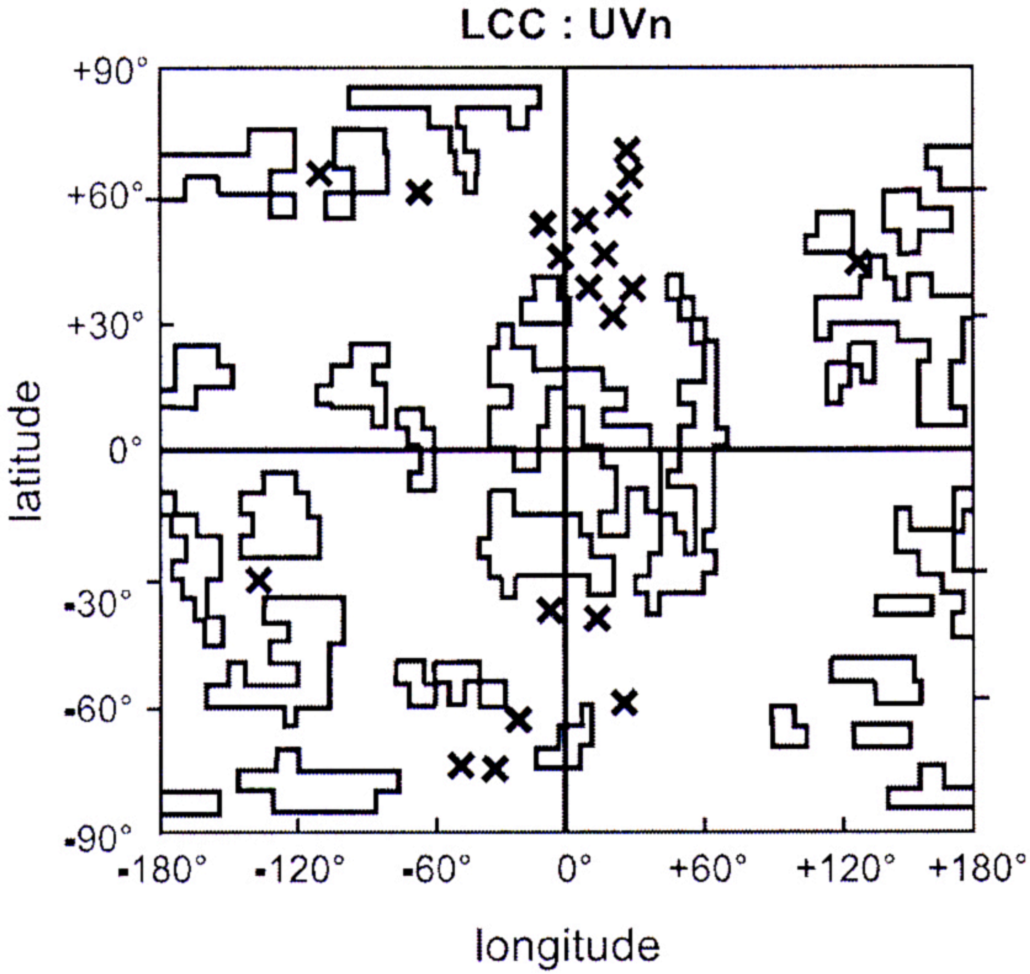
LCC, CR positive is poor –

and latitude variation does not follow CR expectation

f < 1%

Fig.3

Voiculescu et al. (2006) maps of LCC, UV (negative) correlations
Crosses: LCC, CRϱ



CR-induced electrical effects

Rycroft (2006), Tinsley (2008) etc.

Harrison & Ambaum (2008) – droplet charging due to electrical field perturbations.

Complex phenomena:

$$f \approx (1.0 \pm 0.5)\%$$

Harrison & Stephenson (2006): overcast days

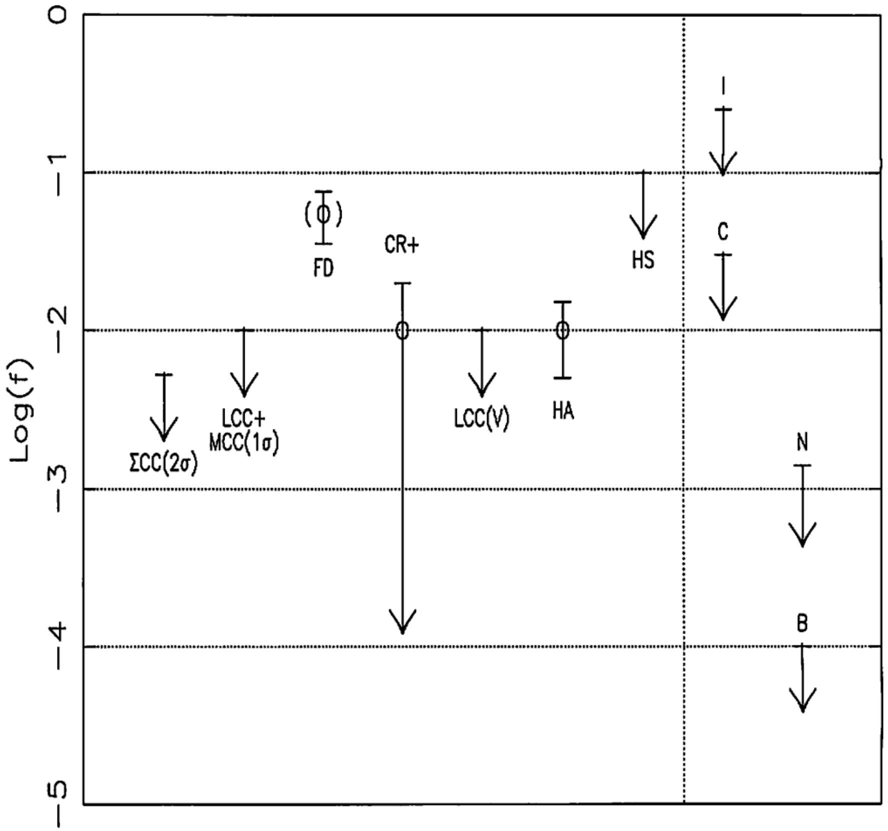
$$f < 10\%$$

Indirect analysis using other sources of ionization

Radon, India

Nuclear tests: 15mt BRAVO, 1954 and yearly averages, 1961 & 1962

Chernobyl, 1986



The Stratosphere

Polar regions, strong effects on aerosols, ozone, temperature…..due to solar proton events.

Can be >10% for Poles, but averaged over the Globe fall to ≈ 0.5%

Relevance to Global Warming

Very small CR intensity change over last 50 years (< 2%) so, with f = 1% and CC, T conversion of Erlykin & Wolfendale (2010), we expect

ΔT due to CR change

$< 10^{-4}$ ^{o}C

Quite negligible

Noctilucent Clouds

Polar mesopheric clouds: water ice.
76 – 85km high

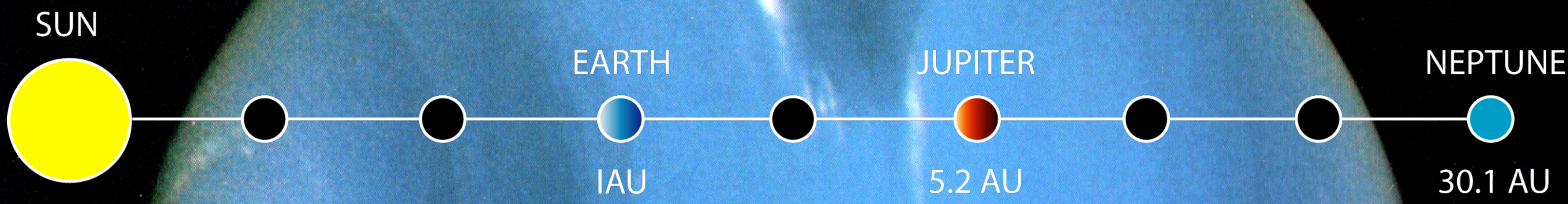
Dust & water vapour

Atmospheric depth $\sim 10^{-3}$ gcm $^{-2}$

Heavy CR nuclei? (2McV α's)

Worth studying….

Planetary Atmospheres in general and Neptune in particular



<u>Neptune:</u>

Bright blue clouds – frozen methane.

Periodic variability of brightness: several periods including 11-y and 1.68μ

CR have 1.68μ but not UV. However, coronal holes → interplan.field (Aplin)

❖ Perhaps CR effect

Conclusions

- ❖ Cosmic ray effect on terrestrial clouds $\leq 1\%$
- ❖ CR contribution to Global Warming quite negligible.
- ❖ Heavy CR nuclei & noctilucent clouds?
- ❖ Neptune cloud cover affected by cosmic rays?