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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cosmic rays linked to rapid mid-latitude cloud changes" *by* B. A. Laken et al.

Anonymous Referee #1

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General comments The paper provides additional evidence for cloud cover changes correlated with changes in cosmic ray flux. The authors have made a useful innovation by focusing the analysis on periods when cloud cover is changing most rapidly, thus, in periods when dynamical processes associated with energy transformation from baroclinic gradients or latent heat content into vertical motions are occurring. Under these conditions the very small energy content of the cosmic ray flux may plausibly be amplified enough by effects of atmospheric ionization or atmospheric electricity on nucleation processes in clouds to produce the much larger energy content manifest in cloud changes. However, there are non-essential parts of the paper where there is a need for revision.

Specific comments 1, The analysis in section 2 (p. 18238 line 25 to p. 18239 line 14)

and Fig 8 if the impacts of GCR on surface temperature in the last 50 years is confusing to say the least. There is no explanation of how the 0.03 K limit for the effects of the GCR flux trend over that period is arrived at. We are given the impression that it is calculated from the finding of a surface temperature change of 0.1K to a change of GCR flux of 1.2% of the amplitude of the solar cycle amplitude of the GCR flux, with the changes in temperature and flux measured relative to a baseline 3-5 days earlier. This amounts to a rate of change of 1.2%/4 = 0.3% of the 11-year amplitude per day. Figure 8a shows a trend line with a change of about 10% of the amplitude of the 11-year cycle over the last 50 years. If this change had occurred over a 4 day period it would correspond to about (10%/1.2%)x0.1K or 0.8 K. However, the change occurred over 50 years, so the rate of change of the GCR flux averaged over 50 years is 10%/(50X365d) which is 5.5X10ˆ-4 % of the 11-year amplitude per day. It would have a negligible daily effect, but a cumulative effect over 50 years of 0.1Kx(5.5X10ˆ-4x50x365%/day)/0.3%/day = 3.3K. This is in conflict with the 0.03K quoted. However, this whole exercise assumes that the only response of the atmosphere to GCR flux changes is by the short-term process as demonstrated in this paper. These short term processes are obviously not unidirectional and sustained for 50 years. But there could well be other processes (that might account for the Marsh and Svensmark 2% cloud cover changes) that operate in a different way on long time scales, and depend on the absolute level of GCR flux. My evaluation is that the whole discussion of the 50 year GCR trend, including Fig 8 and the last sentence of the abstract, are inconclusive and detract from the main results, and should be deleted.

2. The use of the 10.7 cm flux as a proxy for TSI (p. 18240, line 2) is inconclusive. The 10.7 cm flux is a good proxy for the solar extreme ultraviolet flux, which is absorbed above 120 km and heats the thermosphere, but it is a poor proxy for TSI. It is necessary to consider the variations of solar spectral irradiance (SSI) to evaluate the heat flux from the sun that penetrates into the lower atmosphere, (making the unreasonable assumption of no solar-related changes in cloud cover), and the 10.7 cm flux is an even worse proxy for SSI. My evaluation is that the 10.7 cm flux should not be used as

a proxy for TSI; this detracts from the main results, and the references to it should be removed.

3. The use of the terminology “rate of GCR flux” or “rate of cloud change” is awkward and does not represent the actual differencing procedure used. The terminology is defined clearly enough as the difference between the value for a given parameter for a given day minus its average for preceding days 5 to 3, representing a period centered 4 days previously. But this difference should not be called, for example, a “rate of GCR flux”, as the GCR flux is already a flux, measured in counts per day. The units are not, as in fig 1a and the text, units of “ %/day” of GCR flux, but rather percent change in four days of units of the 11-year solar cycle amplitude of the GCR flux. I recommend that units such as 1.2%/day be replaced by 1.2NU, where NU is defined as a normalized unit representing a change of 1% of the solar cycle amplitude in four days. Instead of calling these units a measure of “rate of change” of GCR flux or cloud cover, I suggest “short term change” be used as a more scientifically accurate and less confusing term, and the short term changes be expressed in NU.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 18235, 2010.