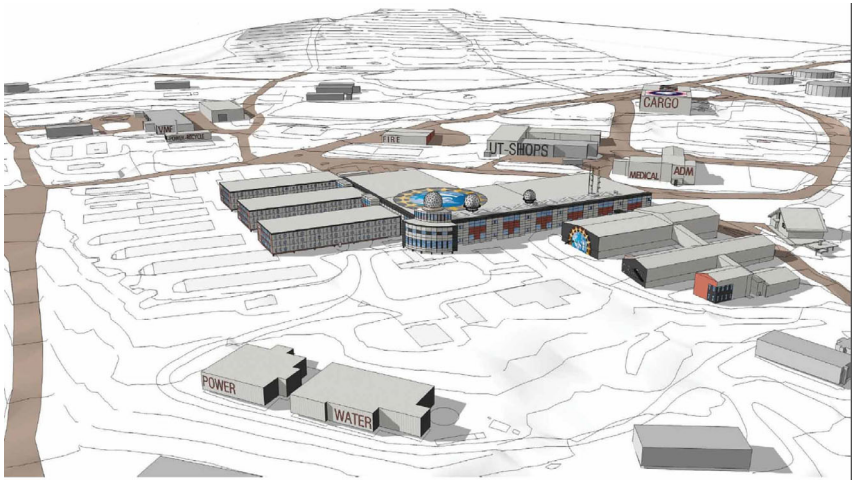

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Cosmic Ray Flux Correlation between McMurdo and Jang Bogo Neutron Monitor Stations Vs. Time Lag

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Outline

- MOTIVATION & ASYMPTOTIC DIRECTION
- DATA OVERVIEW
- AUTO CORRELATION OF SOLAR WIND SPEED
- AUTO & CROSS CORRELATIONS BETWEEN MCMURDO AND JANG BOGO NM STATIONS VS. TIME LAG

Scientific point: Correlation technique allows the statistical separation between temporal and directional (anisotropy) variations.

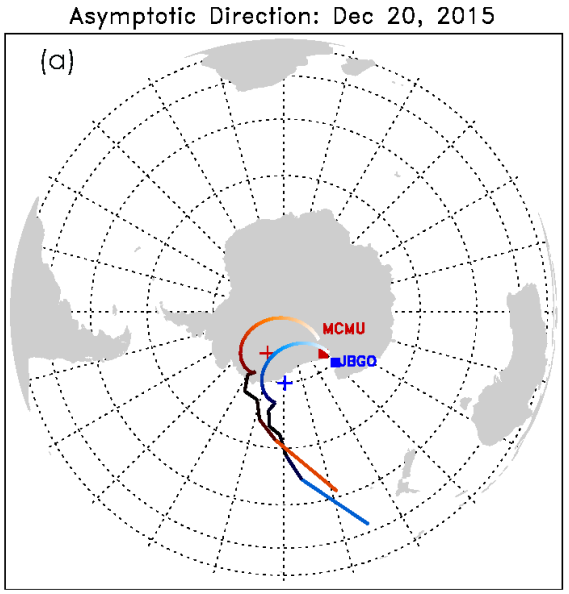
NM Station	Geographic Location	Geomagnetic Location	P_c (GV)	Altitude (m)	NM Configuration
Jang Bogo	74°37.4′S 164°13.7′E	77°3′S 85°18′E	<0.2	29	6-NM64
McMurdo	77°51′S 166°40′E	78°58.8′S 72°22.8′E	<0.2	48	12-NM64

FIGURE 1

(a) Asymptotic directions on December 20, 2015 at 18:00 UT. Colored lines indicate asymptotic directions of primary cosmic rays arriving at McMurdo (red) and Jang Bogo (blue) as a function of rigidity, and the color intensity indicates the differential response function. Plus signs indicate response-weighted asymptotic directions for each station.

(b) The hourly count rates as seen by Jang Bogo (blue) and McMurdo (red) neutron monitors a few days before and after Forbush decrease occurred on December 20, 2015.

The response weighted average directions have a substantial difference of **21.9** degrees in geographic longitude, so with Earth's rotation, time-independent anisotropy effects should induce a lag of **85 - 500** minutes.



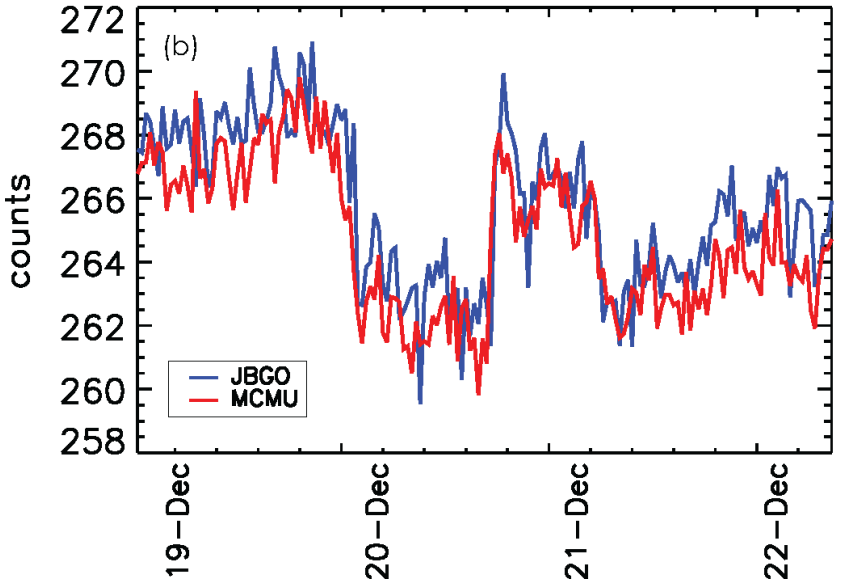
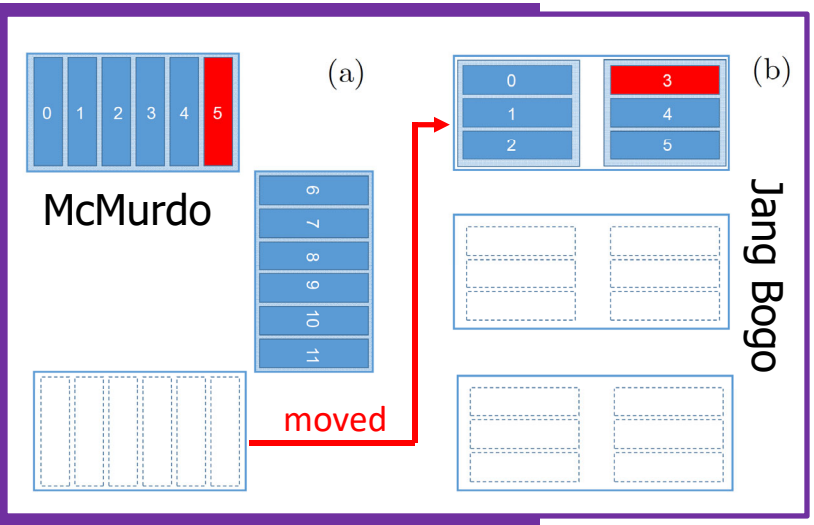


FIGURE 2

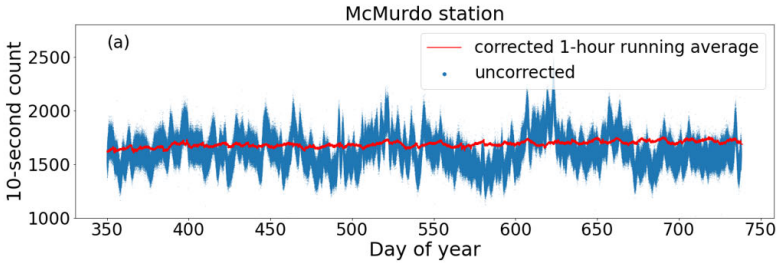


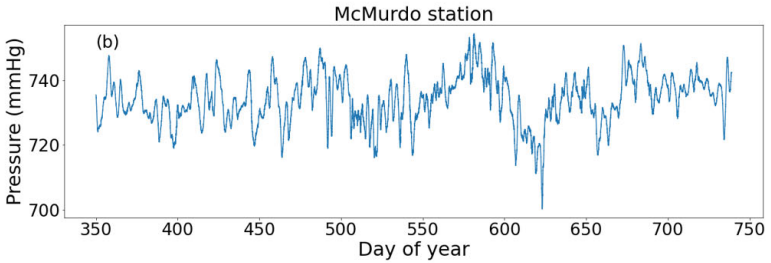
Ten-second resolution data set for McMurdo and Jang Bogo from December 17, 2015, to January 9, 2017.

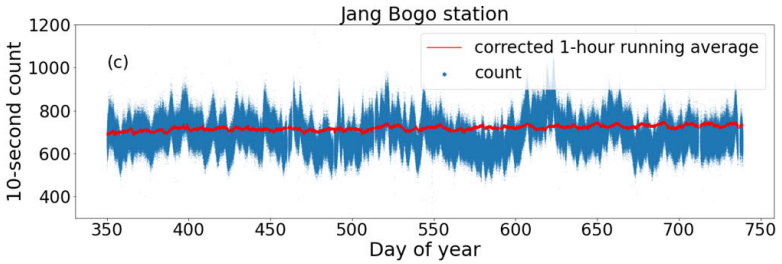
(a/c): Count rate summed over all eleven active NM64 detectors at McMurdo and five at Jang Bogo. Each ten-second count (after obviously bad readings were removed) is shown in blue. One-hour running averages, cleaned and corrected for barometric pressure appear in red.

(b/d): Barometric pressure (mmHg) for McMurdo and Jang Bogo stations.

We analyzed 1-minute data that cleaned and corrected for barometric pressure in this work.







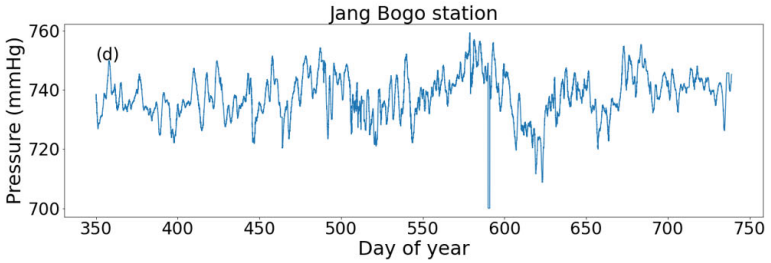


FIGURE 3

Auto-correlation analysis of 1-min solar wind speed data from December 17, 2015, to January 9, 2017. There are two prominent peaks. The major peak has periods every 27 days, and the smaller rise (2nd harmonic) has periods of 13.5 days.

CORRELATION

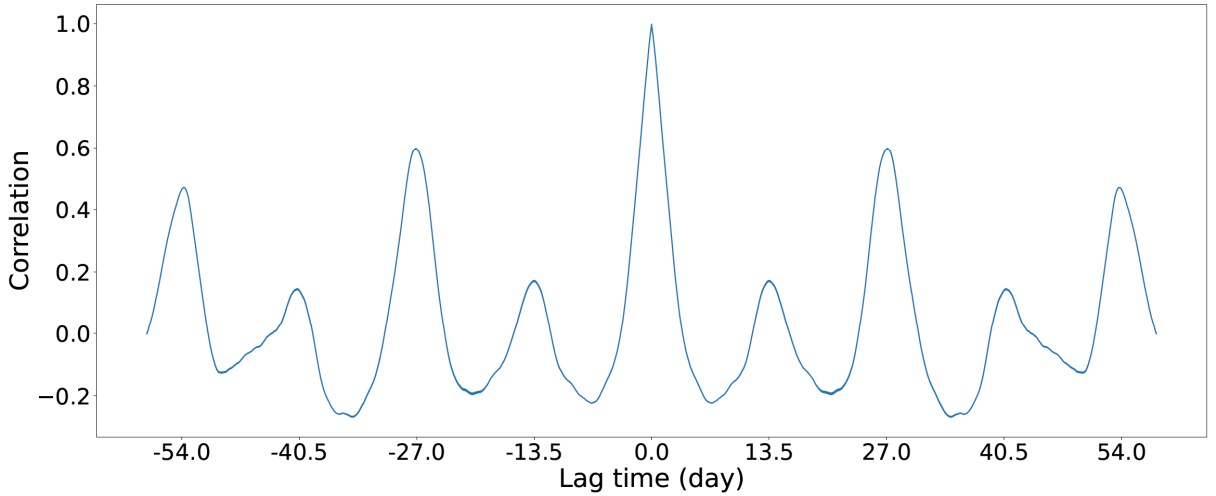
Count rate relative value

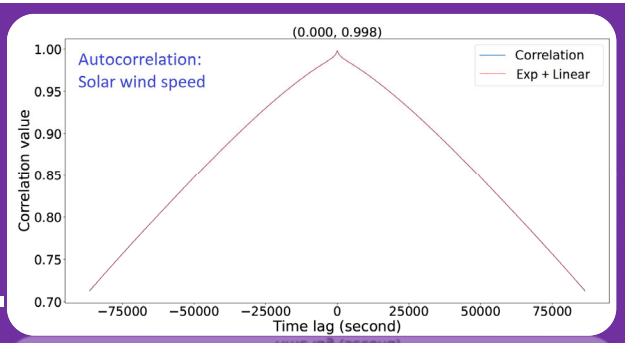
$$r = \frac{(c_{\mathrm{cor}} - \bar{c}_{\mathrm{cor}})}{\sigma}$$

Normalized correlation function

$$cf(\tau) = \frac{1}{N_\tau} \sum_m r_1[m] \cdot r_2[\tau + m],$$

where N_τ is number of terms in each summation.





SCIENTIFIC RESULTS

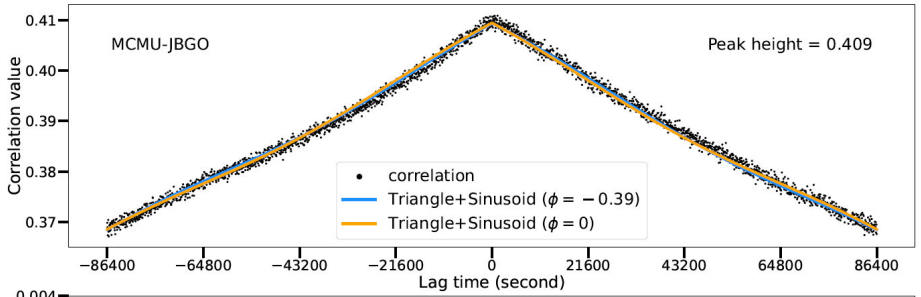
Temporal variations: Peak at zero lag in either autocorrelations or cross-correlation. Shape is similar to autocorrelation of the solar wind speed.

Directional variations: Peak at zero lag in autocorrelations but 89 minute lag in cross-correlation.

At a maximum length of diurnal variation, the time lag (τ) of cross-correlation can be computed by

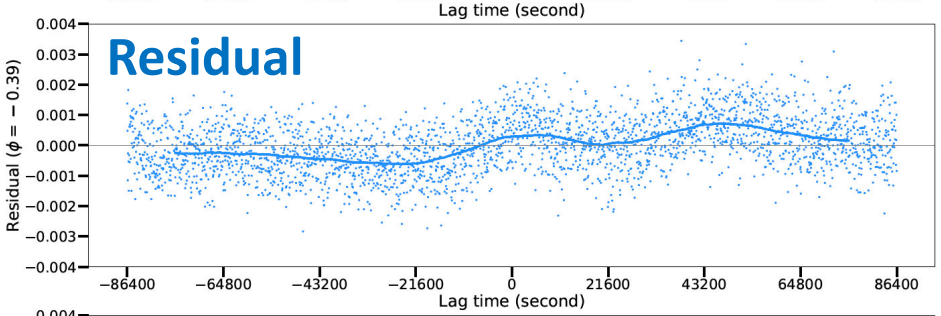
$$\tau = -\frac{\phi}{2\pi f} = -\phi\frac{T}{2\pi} = (-0.39)\left(\frac{1}{2\pi}\right) \approx 89 \text{ min}$$

Cross-correlation

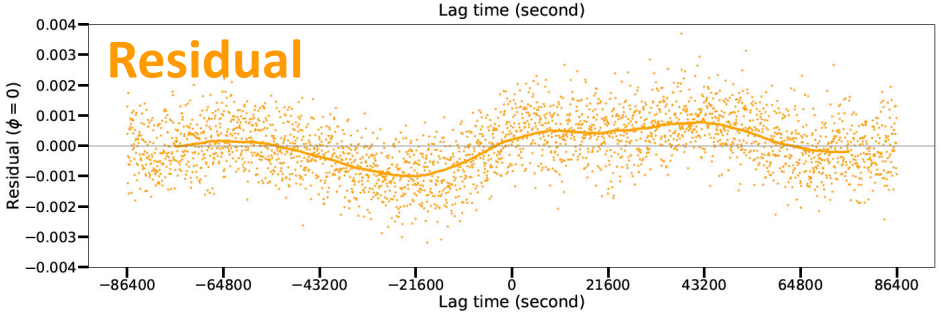


Best fit:

Sinusoid peaks at 89 min. lag



Sinusoid peaks at zero lag



$$y = \alpha e^{-\frac{|\tau|}{t_1}} + (y_0 - m|\tau|) + A\cos(2\pi f|\tau| + \phi)$$

Exponential (Only for autocorrelation): Local environmental conditions (including the atmosphere & magnetosphere above that location).
Linear: Temporal variation of cosmic ray flux
Sinusoid with 24-hour period: Directional variation of cosmic ray flux

THANK YOU

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