

Relationship Between NO Infrared Radiation and X-ray Radiation from 3 March to 3 April 2005

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Abstract

We investigate the relationship between NO infrared radiation and x-ray radiation at different local time (LT) and latitudes of NO average fluxes. The NO volume emission rates obtained by SABER instrument on board TIMED satellite and x-ray fluxes on long (0.1-0.8 nm) and short (0.05-0.4) channels measured by GOES 12 satellite were used. NO rates were vertically integrated to obtain fluxes, which are then separated into day (8

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Introduction

- Estimation of infrared radiation emitted by the NO₂ molecules in an energy loss mechanism in the lower thermosphere very sensitive to changes in temperature [Miyoshi et al., 2003].
- Increase in NO₂ abundance is caused by natural electron precipitation in high latitudes and solar X-rays in low latitudes. So, solar X-rays should be better correlated with NO₂ flux in lower latitudes [Banks et al., 2000].
- Since X-rays cause increase in NO₂ active latitudes, we are interested in a time lag between them.

Data and method

- NO₂ fluxes were calculated from volume emission rates measured by SABER instrument on board TIMED by vertical integration, division of them into local time windows: day (06:00-18:00) and night (18:00-06:00), and averaging for 25 latitude bins, each 1.0° wide.
- X-ray flux in two channels, long (0.3-0.8 nm) and short (0.08-0.3 nm), was obtained from GOES 12 satellite.
- Cross-correlation (CC) analysis was performed by calculating correlation coefficients between fluxes in different NO₂ latitude bins and both X-ray channels for time lags from 0 to 24 hours.
- Values of NO₂ emissions during five days are available for limited time periods, thus depend on the latitude bin. To compare day and night correlations, only time spans that have values in LT day or night are used (listed in table).

Figure and table

Table: Time spans for multichannel box-car analysis and maximal correlation coefficient with the corresponding time lag for day LT series and long X-ray channel.

Latitude bin	Time span (day)	No. of days	Max. CC (day)	Time lag (h)
25° to 50°	17.04.00 - 25.04.00	13.0	0.4715	0
50° to 75°	17.04.00 - 25.04.00	13.0	0.3738	0
75° to 100°	17.04.00 - 25.04.00	13.0	0.3738	0
25° to 50°	06.04.00 - 16.04.00	11.0	0.3738	0
50° to 75°	06.04.00 - 16.04.00	11.0	0.3738	0
75° to 100°	06.04.00 - 16.04.00	11.0	0.3738	0
25° to 50°	06.04.00 - 16.04.00	11.0	0.3738	0
50° to 75°	06.04.00 - 16.04.00	11.0	0.3738	0
75° to 100°	06.04.00 - 16.04.00	11.0	0.3738	0

Results and Conclusions

- X-rays are better correlated with NO₂ in low latitudes (between 25° and 50°). This is expected because X-rays are the main source of NO₂ production there.
- Correlation is better with the long X-ray channel. CC values for short X-ray channel become comparable with the long channel for latitudes above 50° north and south.
- Differences between day and night latitudes, more pronounced in low latitudes, especially for long X-ray channel.
- 5% determined maximum CC coefficients between NO₂ in day LT series and long X-ray channel with corresponding time lag for latitudes bins where these coefficients are above 0.2, given in the table. These time lags are zero for latitudes from 25° to 50°, 0 h from 50° to 75°, and 24 h from 75° to 100°.
- For both X-ray channels correlation is mostly better with NO₂ radiation in day LT series than in night LT series.

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INTRODUCTION

- Emission of infrared radiation emitted by the NO molecule is an energy loss mechanism in the lower thermosphere very sensitive to changes in temperature (Mlynchak et al, 2010).
- Increase in NO abundance is caused by auroral electron precipitation in high latitudes and solar x-rays in low latitudes. So, solar x-ray flux should be better correlated with NO flux in lower latitudes (Barth et al, 2003).
- Since x-rays cause increase in NO at low latitudes, we are interested in a time lag between them.

DATA AND METHOD

- NO fluxes were calculated from volume emission rates measured by SABER instrument on board TIMED by vertical integration, division of data into two local time sectors: day ($8 < LT < 16$) and night ($20 < LT < 4$), and averaging for 16 latitude bins, each 10° wide.
- X-ray flux in two channels, long (0.1 – 0.8 nm) and short (0.05 – 0.4 nm), was obtained from GOES 12 satellite.
- Cross-correlation (CC) analysis was performed by calculating correlation coefficients between fluxes in different NO latitude bins and both x-ray channels for time lags from 0 (no lag) to 24 hours.
- Values of NO radiation during the day are available for limited time periods that depend on the latitude bin. To compare day and night correlations, only time spans that have values in LT day sector are used (listed in table).

FIGURE AND TABLE

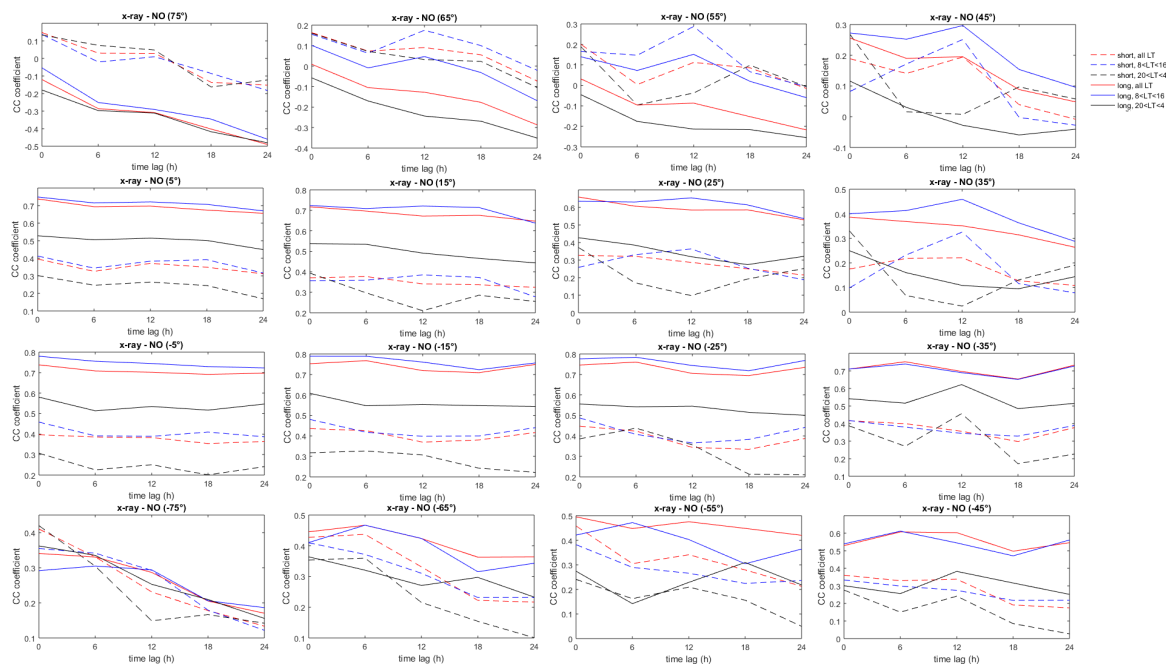


Figure: Each graph shows CC curves between NO in one latitude bin (central latitude in the title) and x-ray radiation: long (solid lines) and short (dashed lines) channel, as well as all (red lines), day (blue lines), and night (black lines) LTs. Resolution is 6h.

Table: Time span for each latitude bin used in analysis and maximal correlation coefficient with the corresponding time lag for day LT sector and long x-ray channel.

Latitude bin	Time span (DOY)	No. of days	Max CC coeff (day LT, long x-ray)	Time lag (h) (day LT, long x-ray)
-70° to -80°	77.75-91.25	13.5		
-60° to -70°	77.75-93	15.25		
-50° to -60°	77.75-93.25	15.5		
-40° to -50°	74-93.25	19.25	0.6115	6
-30° to -40°	70.75-93.25	22.5	0.739	6
-20° to -30°	68.25-93	24.75	0.7837	6
-10° to -20°	66.5-92.5	26	0.7888	0
0° to -10°	65.5-91.75	26.25	0.78	0
0° to 10°	64.5-90.75	26.25	0.7489	0
10° to 20°	63.75-89.5	25.75	0.7237	0
20° to 30°	63-88	25	0.6542	12
30° to 40°	62.75-85.5	22.75		
40° to 50°	62.5-82	19.5		
50° to 60°	62.5-77.75	15.25		
60° to 70°	63-77.75	14.75		
70° to 80°	64.25-77.75	13.5		

RESULTS AND CONCLUSIONS

- X-rays are better correlated with NO in low latitudes (between -30° and 30°). This is expected because x-rays are the main source of NO production there.
- Correlation is better with the long x-ray channel. CC curves for short x-ray channel become comparable with the long channel for latitudes above 30° north and south.
- Difference between day and night becomes more prominent toward low latitudes, especially for long x-ray channel.
- We determined maximum CC coefficients between NO in day LT sector and long x-ray channel with corresponding time lag for latitudinal bins where those coefficients are above 0.5, given in the table. These time lags are zero for latitudes from -30° to 20° , 6 h from -30° to -50° , and 12 h from 20° to 30° .
- For both x-ray channels correlation is mostly better with NO radiation in day LT sector than in night LT sector.
- Overall, highest correlation is between low latitudes, day LT, and long x-ray channel.

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ABSTRACT

We investigate the relationship between NO infrared radiation and x-ray radiation at different local time (LT) and latitudes of NO average fluxes.

The NO volume emission rates obtained by SABER instrument on board TIMED satellite and x-ray fluxes on long (0.1-0.8 nm) and short (0.05-0.4) channels measured by GOES 12 satellite were used. NO rates were vertically integrated to obtain fluxes, which are then separated into day ($8 < LT < 16$) and night ($20 < LT < 4$) LT sectors and averaged per 16 latitude bins each 10° wide.

The cross-correlation (CC) analysis between NO, for different latitude bins and LTs, and x-ray fluxes is performed. We found that x-ray fluxes are better correlated with NO at lower latitudes and during the day. Also, long x-ray fluxes are better correlated with NO than short ones. CC coefficients are maximal for both positive and negative time lags, depending on the latitude bin and LT span.