Large Scale Effects of J_Z on Clouds and Climate

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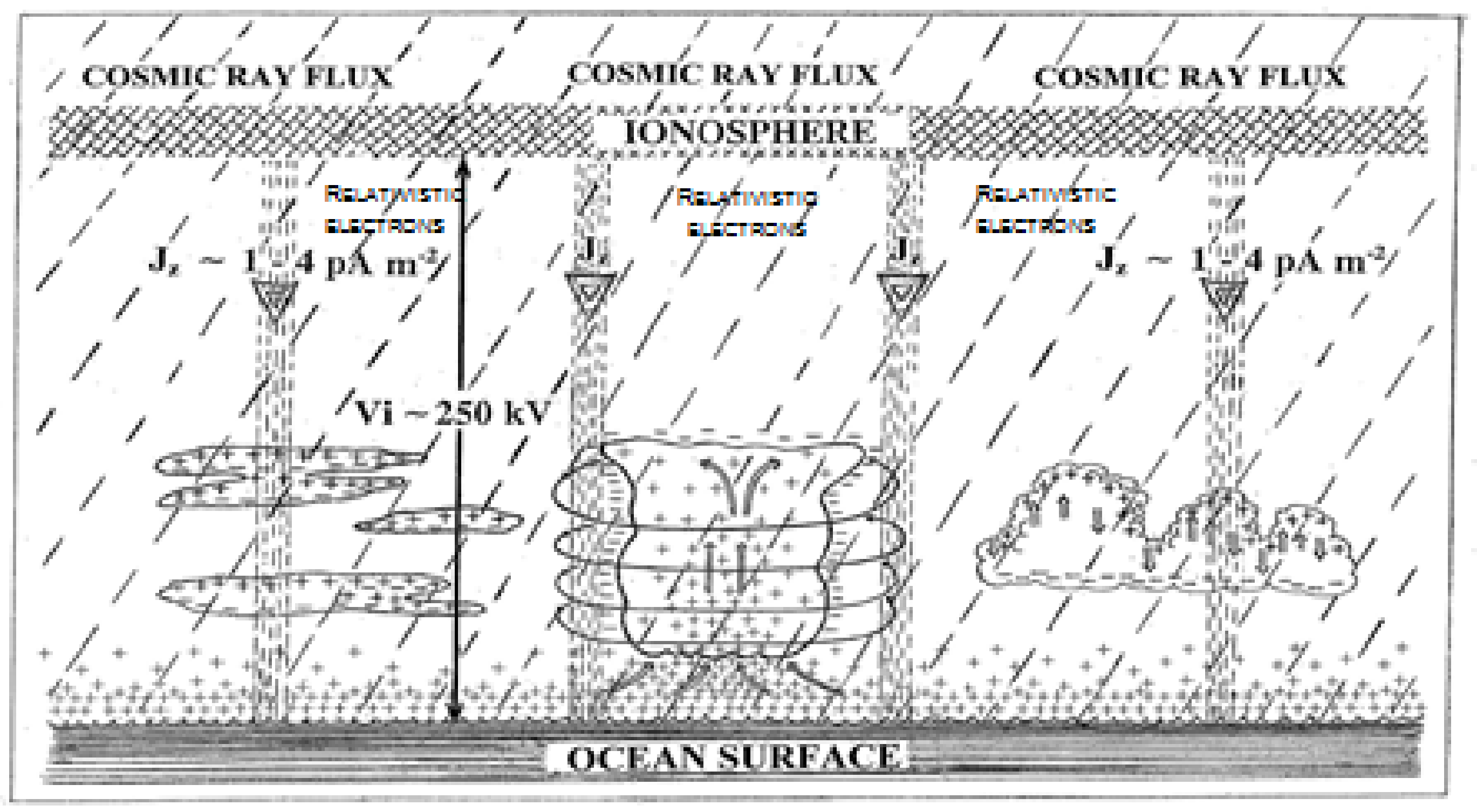
Solar wind ELECTRIC FIELDS
$E_{N\text{-}S} = V_{SW} \times B_Y$
$E_{E\text{-}W} = V_{SW} \times B_Z$
modulate high latitude IONOSPHERIC POTENTIAL and J_Z on the day-to-day and bi-decadal seasonal timescales

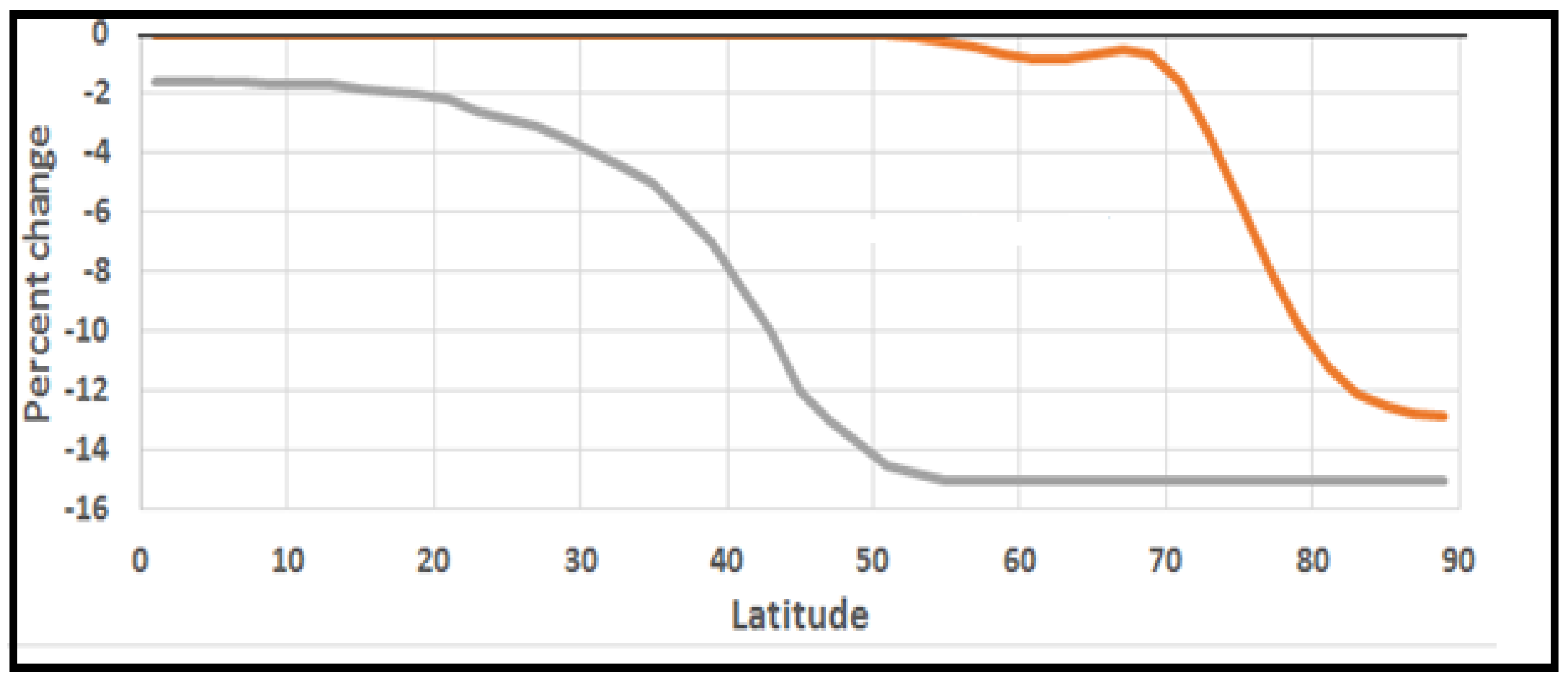


Ionosphere-Earth current density J_Z flows through clouds and aerosol layers and generates space charge, positive at tops and negative at bases.

J_Z equals ionospheric potential divided by column resistance.

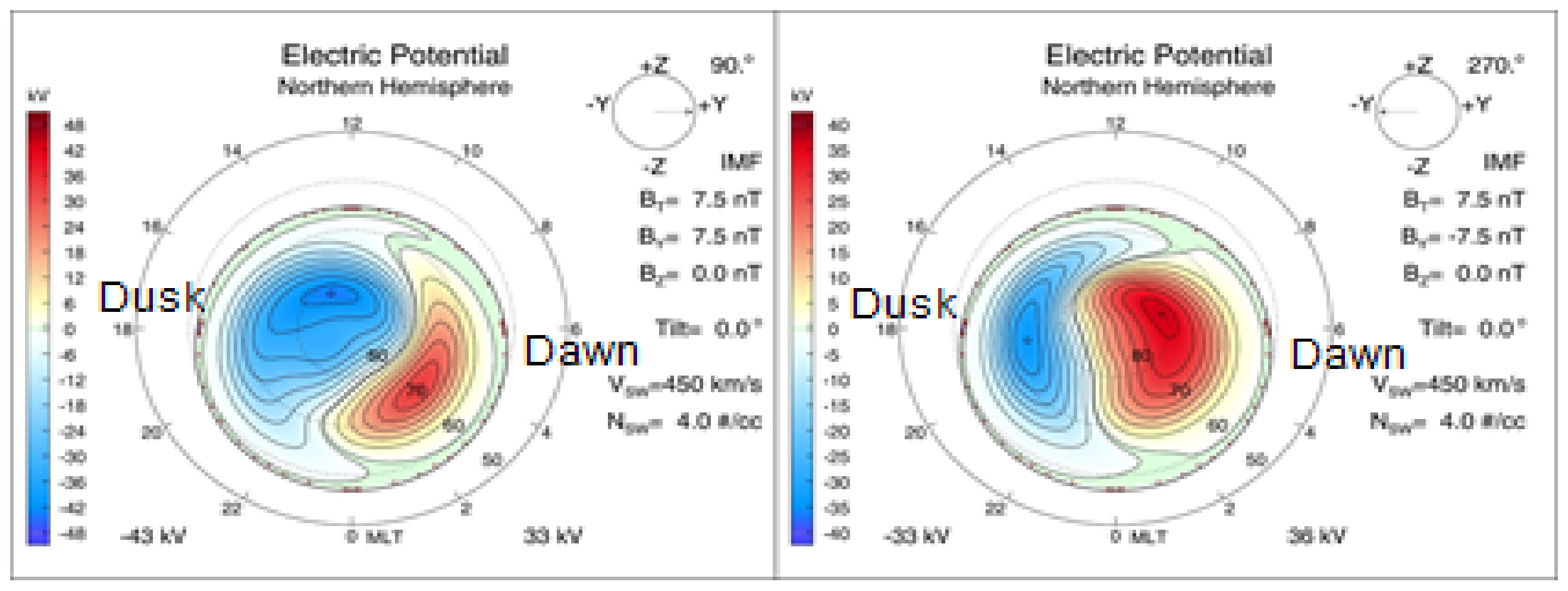
Solar wind MAGNETIC FIELDS modulates COSMIC RAY FLUX, column resistance and J_Z on the day-to-day, decadal, bi-decadal and century timescales.

Latitude variations of ionospheric potential (orange) and column resistance (grey) affecting J_Z From Tinsley (2024)



Potential Distributions in High Northern latitudes; GM Pole to 60° GM Lat.: Changing Distributions for IMF By Sign Changes

IMF By Positive | IMF By Negative



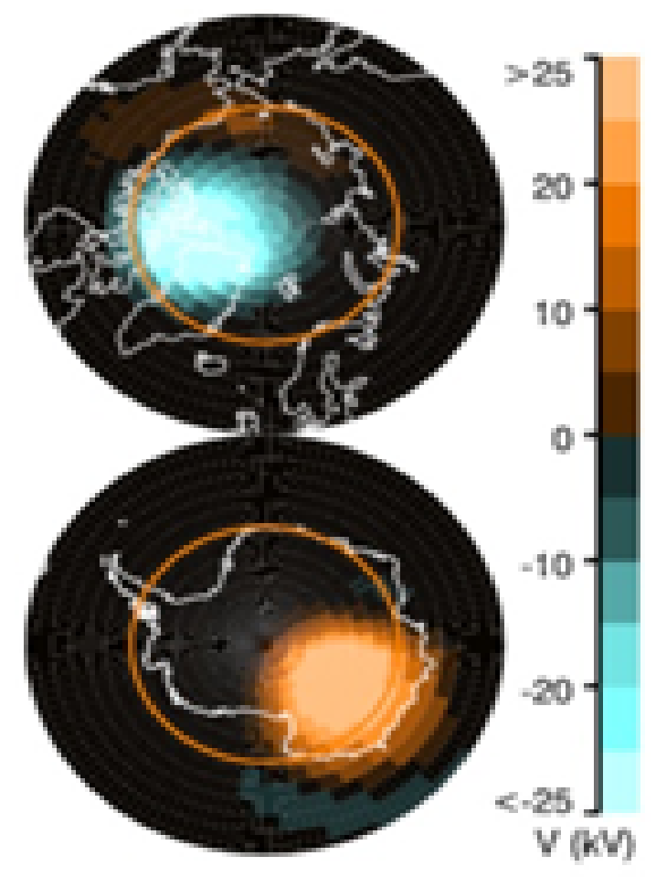
IMF By Positive adds negative potential, centered on N magnetic pole; positive potential for Antarctic

IMF By Negative adds positive potential, centered on N magnetic pole; negative potential for Antarctic

From Weimar, 1996

Annual average day-to-day response of surface pressure to solar wind forcing (By or Jz) (Lam et al, 2013), and to internal (thunderstorm) forcing (Zou et al., 2018).

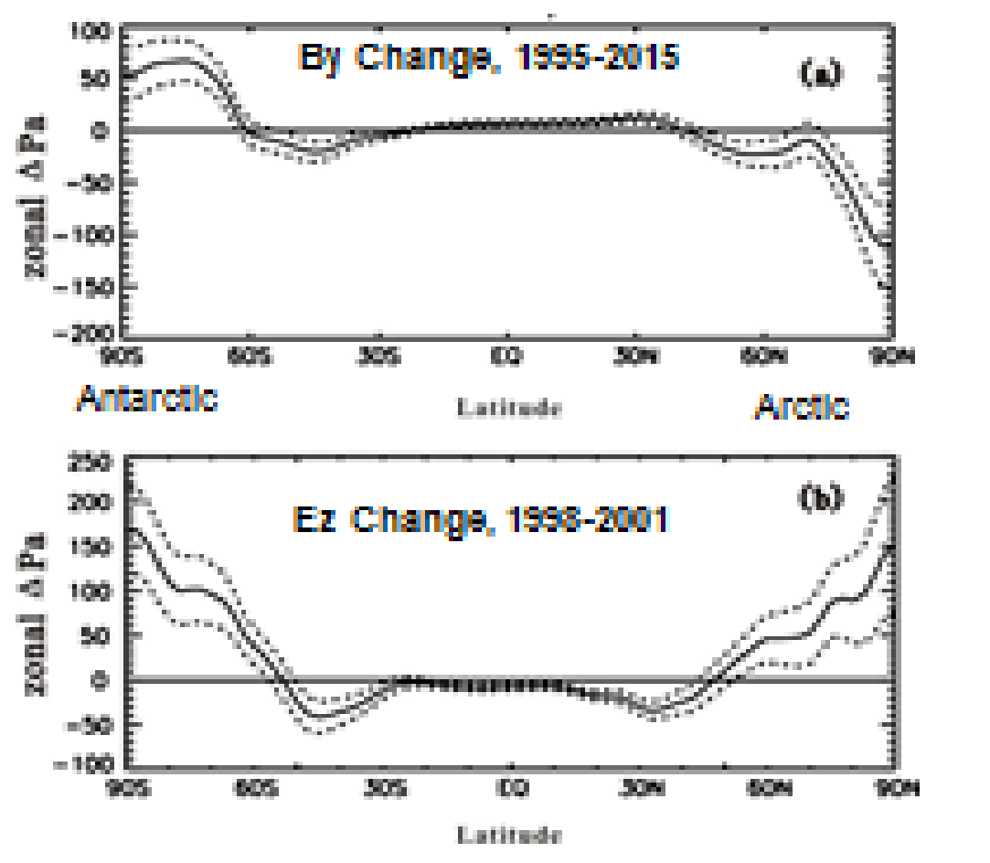
Opposite dependence of polarity of ionospheric potential change with By in Arctic vs Antarctic



Derived from Superdarm radar data and the Weimer model, with IMF By change from –ve to +ve, (-ve potential change blue, +ve potential change orange)

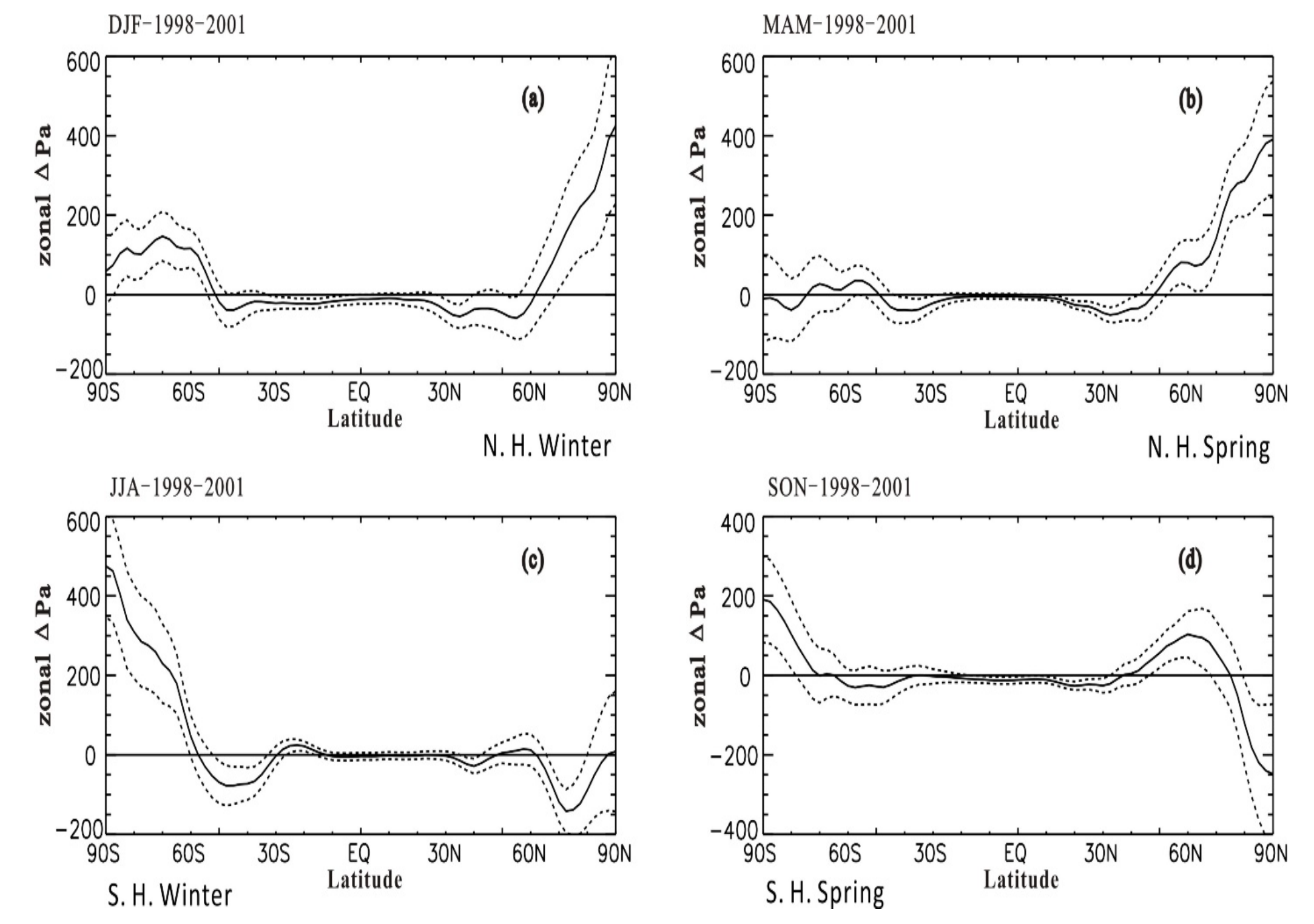
Lam et al., 2015

Surface pressure responses, in zonal mean, to external (By) and internal inputs to polar cap Ionospheric potential

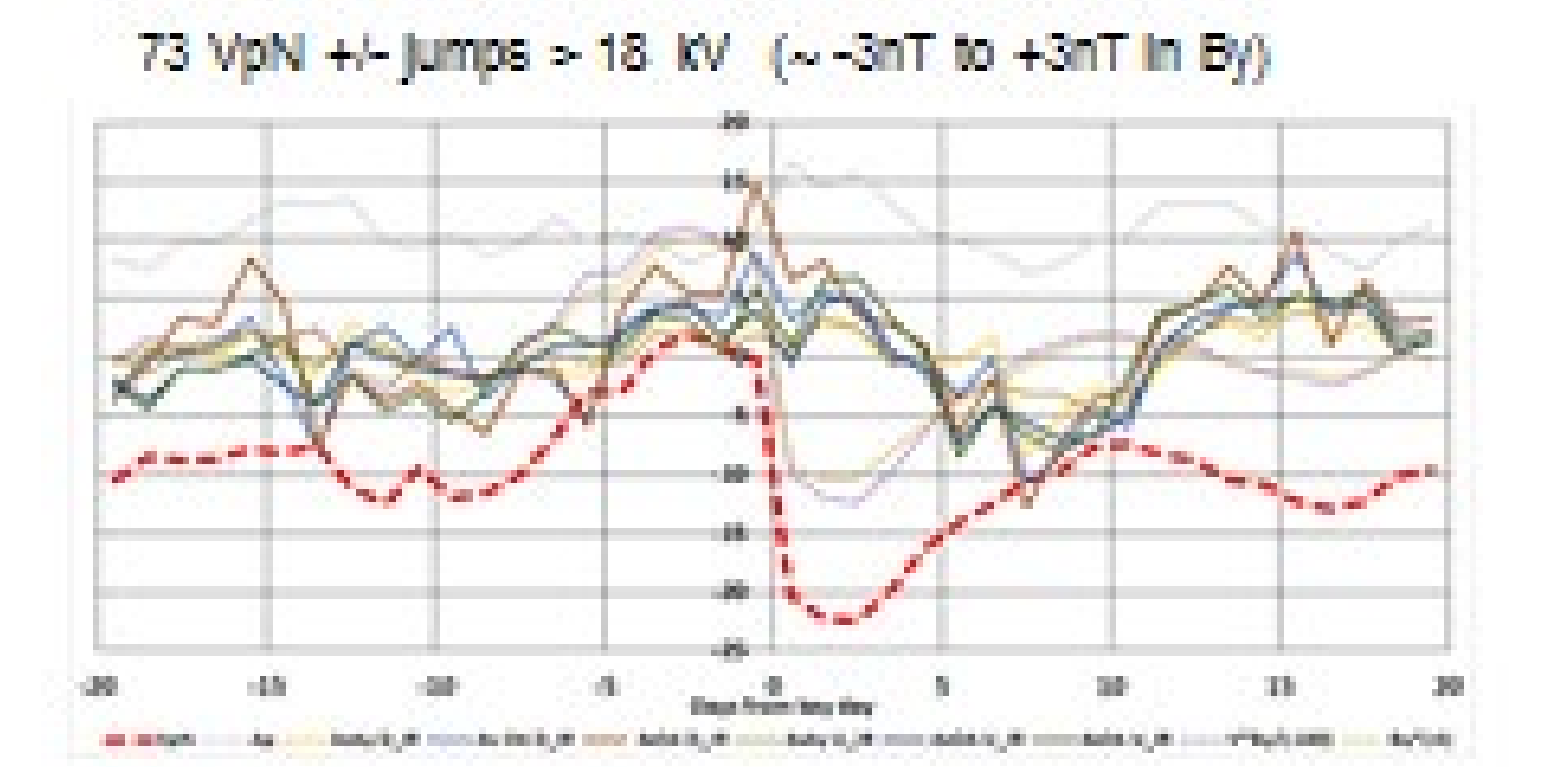


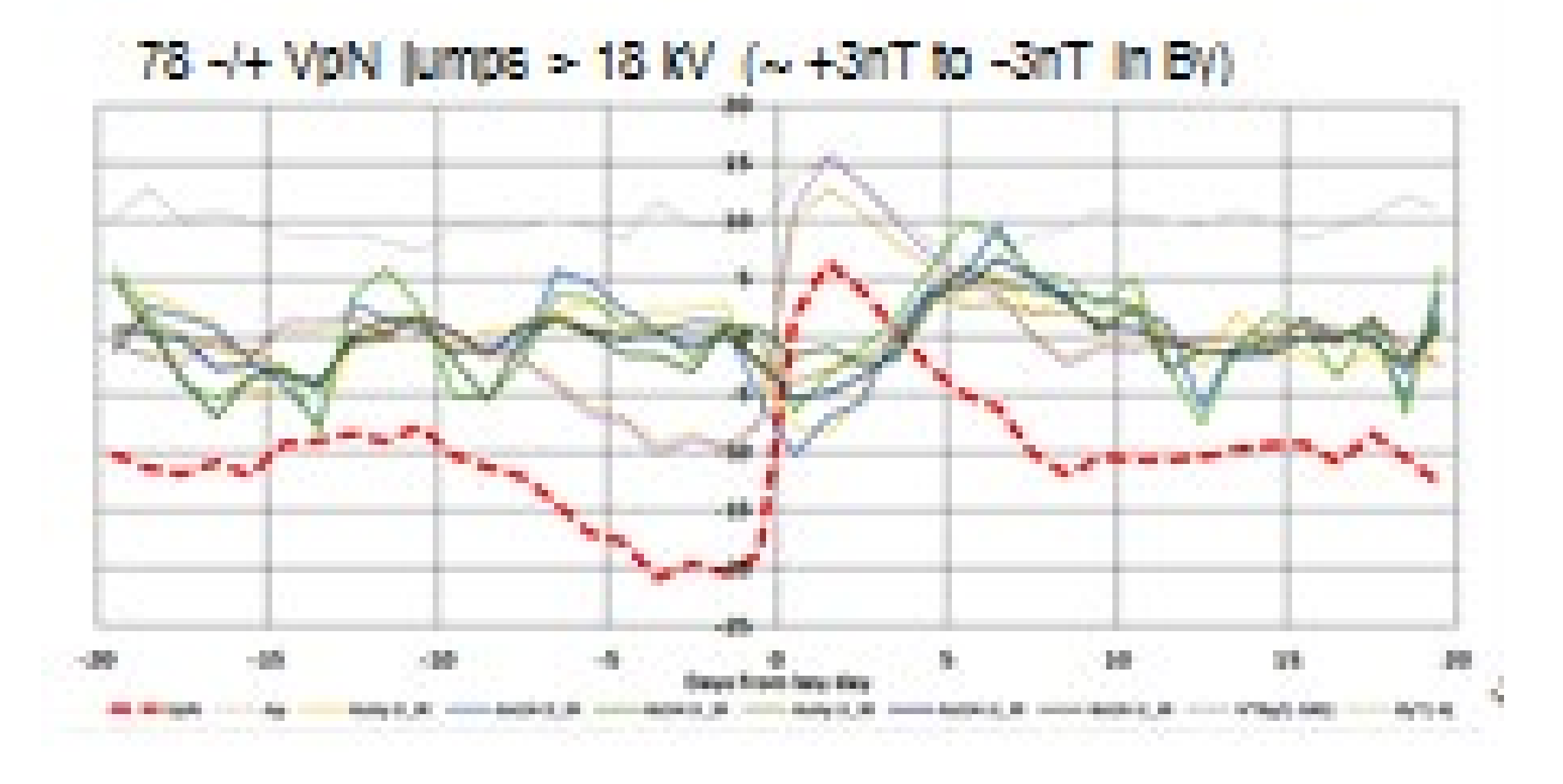
(a) Annual average responses to By changes > 6 nT.
(b) Annual average responses to Ez changes >10 V/m.
The responses to Ez are about twice those to By, corresponding to the larger Ionospheric potential changes with the meteorological generators.

Seasonally resolved day-to-day response of surface pressure to measured global E_Z (Zhou et al., 2018).

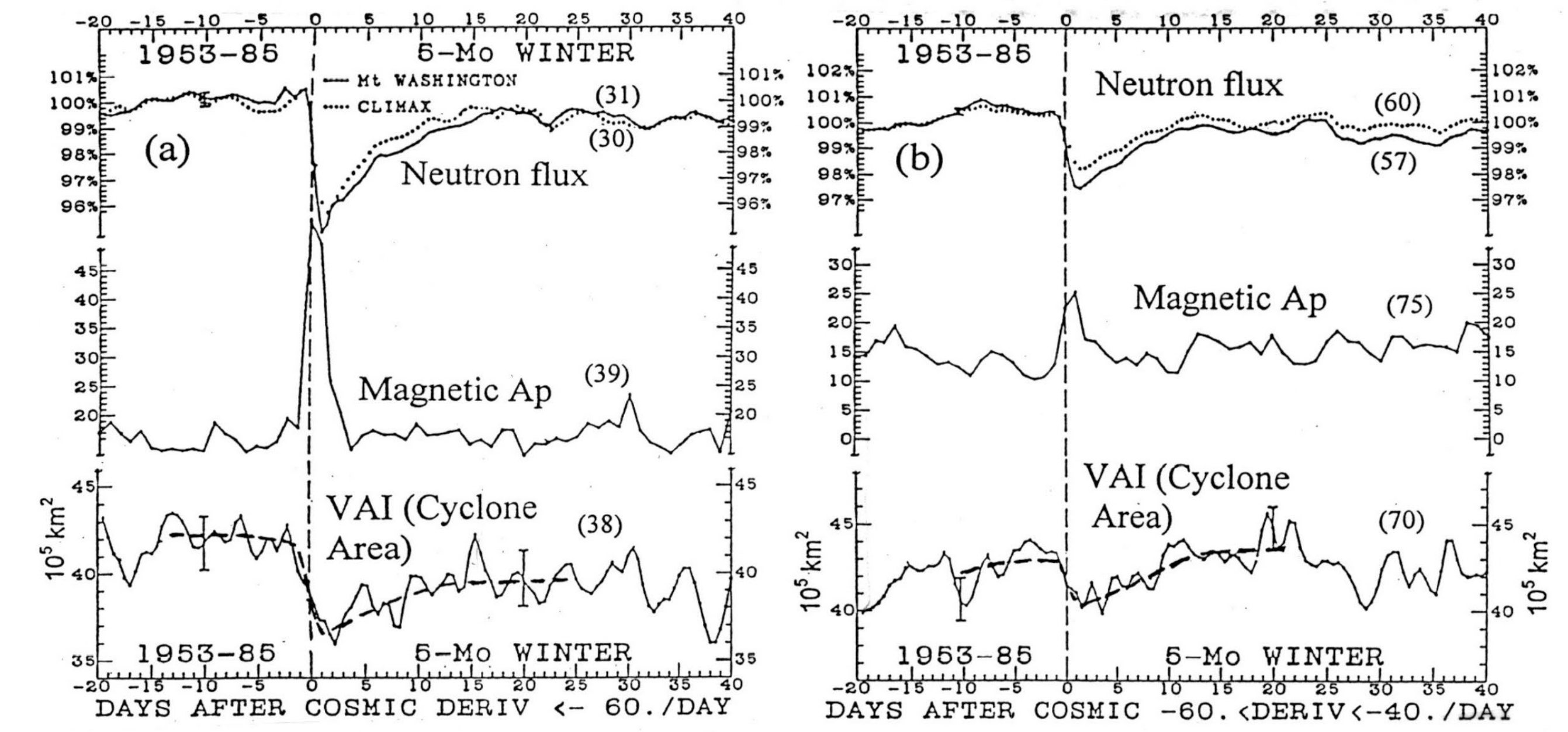


Day-to-day response of Alert cloud opacity to Jz, from Tinsley (2023)

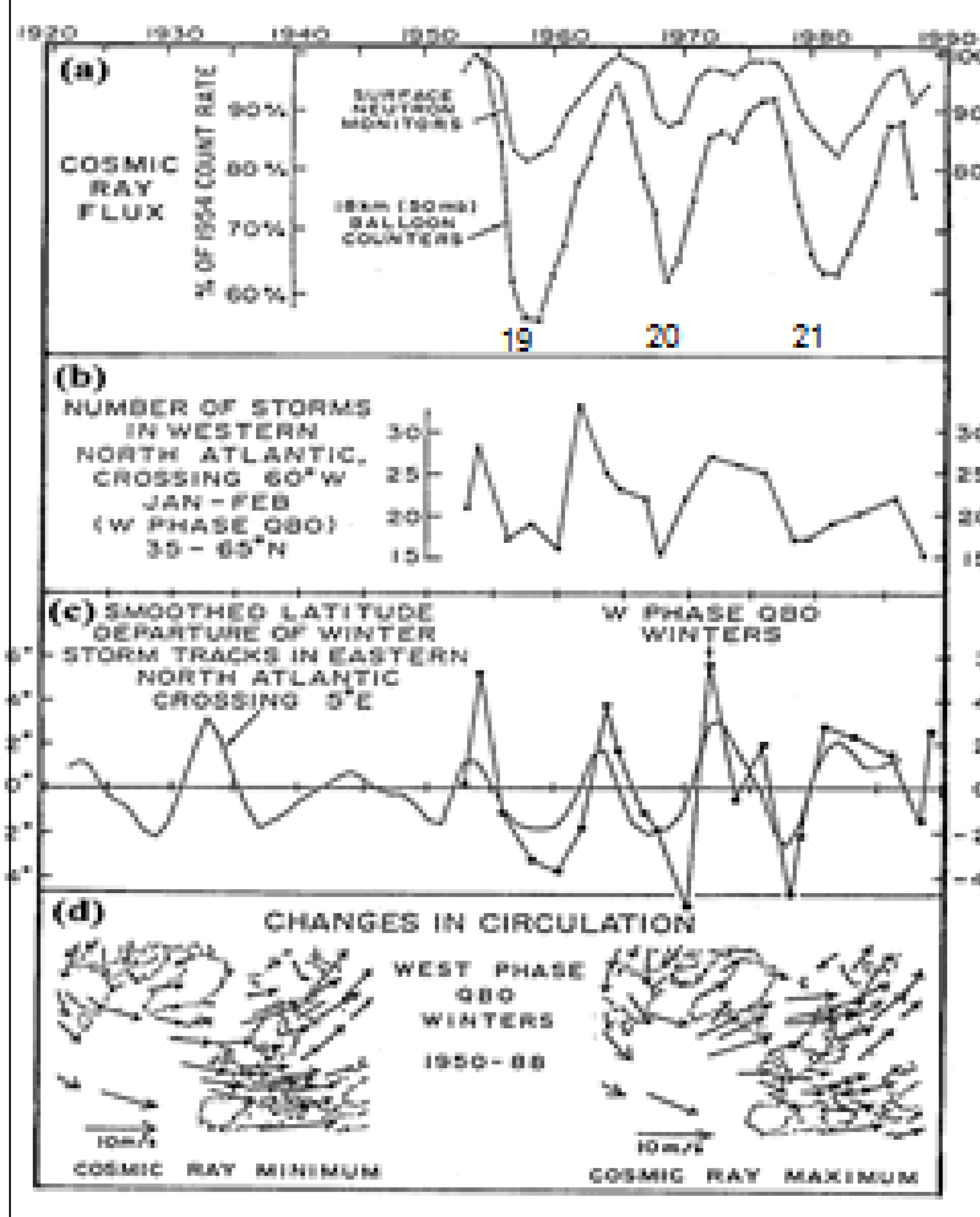




Vorticity Area Index Decreases with Forbush Decreases and Jz Decreases



Superposed epoch variations of GCR flux, Ap index, and 500 hPa northern hemisphere Vorticity Area Index, with key days onsets of Forbush decreases (and Jz decreases), November through March (Tinsley and Deen, 1991)



NORTH ATLANTIC ATMOSPHERIC DYNAMICS:

(a) a modulation of high latitude J_z due to solar modulation of the cosmic ray flux (CRF).

(b) An increase in cyclone frequency at CRF maximum (solar min.) in the Western North Atlantic cyclogenisis region (Labitzke and van Loon 1989).

(c) Storm track changes in the Eastern N. Atlantic follow, as in Tinsley (1988) and Tinsley and Deen, (1991).

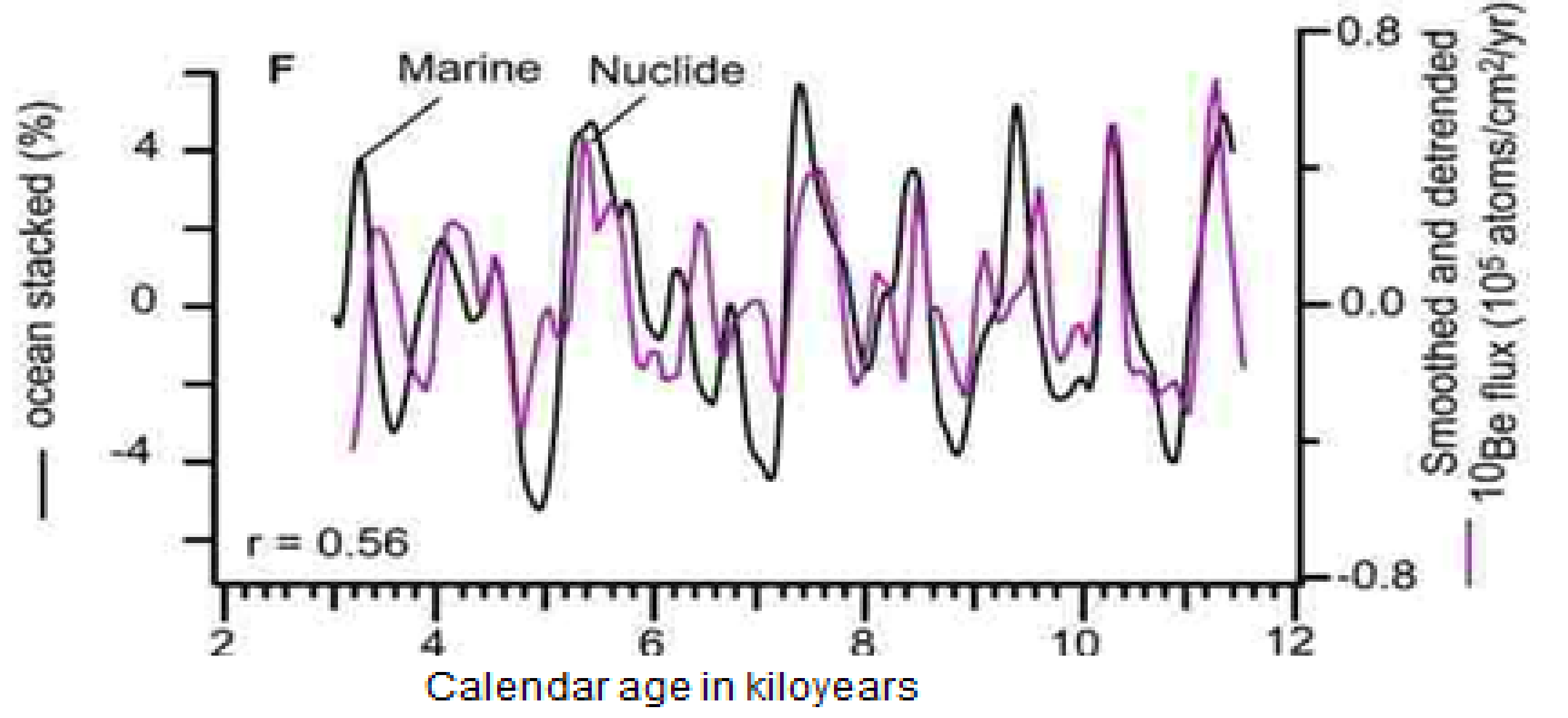
(d) There also changes in the 700 hPa wind speeds and directions in the North Atlantic and European regions, (Venne and Dartt, 1990).

Intensification of cyclones increases large scale ridging and anticyclonic blocking half a Rossby wave downstream (e.g., Wiedenmann et al., 2002, Pfahl et al. (2015).

The northward meridional flow in the eastern North Atlantic with enhanced blocking, reduces the zonal flow of moist air onto Europe for solar min. (J_z max.) and causes colder winters. This was also inferred for very cold winters in the Maunder minimum by Luterbacher et al. (2001).

CORRELATIONS OF COSMIC RAY FLUX AND CLIMATE ON THE CENTENNIAL AND MILLENIAL TIMESCALES

from Bond et al, Science, 294, 2130-2136 (2001)



Glacial debris rafted by drift ice into the North Atlantic Ocean, compared to ^{10}Be flux, changing up to 10% per century. Consistent with Δ^{14}C (a proxy for cosmic ray flux) variations and δ^{18}O (a proxy for climate) variations in cave stalagmite in Oman. (Neff et al, 2001)

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