

Multi-station Measurements of the Ionospheric Potential with GRUAN

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What is the ionospheric potential V_i ?

- Answer: The voltage difference between the conductive Earth and the conductive upper atmosphere
- Formally $V_i = \int_0^{\infty} E(z) dz$ volts
- with integration of electric field $E(z)$ from the surface to high altitude (at least 3 conductivity scale heights, or ~ 15 km)
- Typical values in range 200 to 300 kilovolts

Two proposed measurement methods for $E(z)$ by balloon sounding

- Pair of polonium probes spaced vertically by ~ 2.5 meters

Previously used by Mühleisen (1971) and by Markson et al.(1999)

Design by Smith Air Corporation (London, Ontario)

- Disposable electric field mill

Design by Quasar (San Diego, CA)

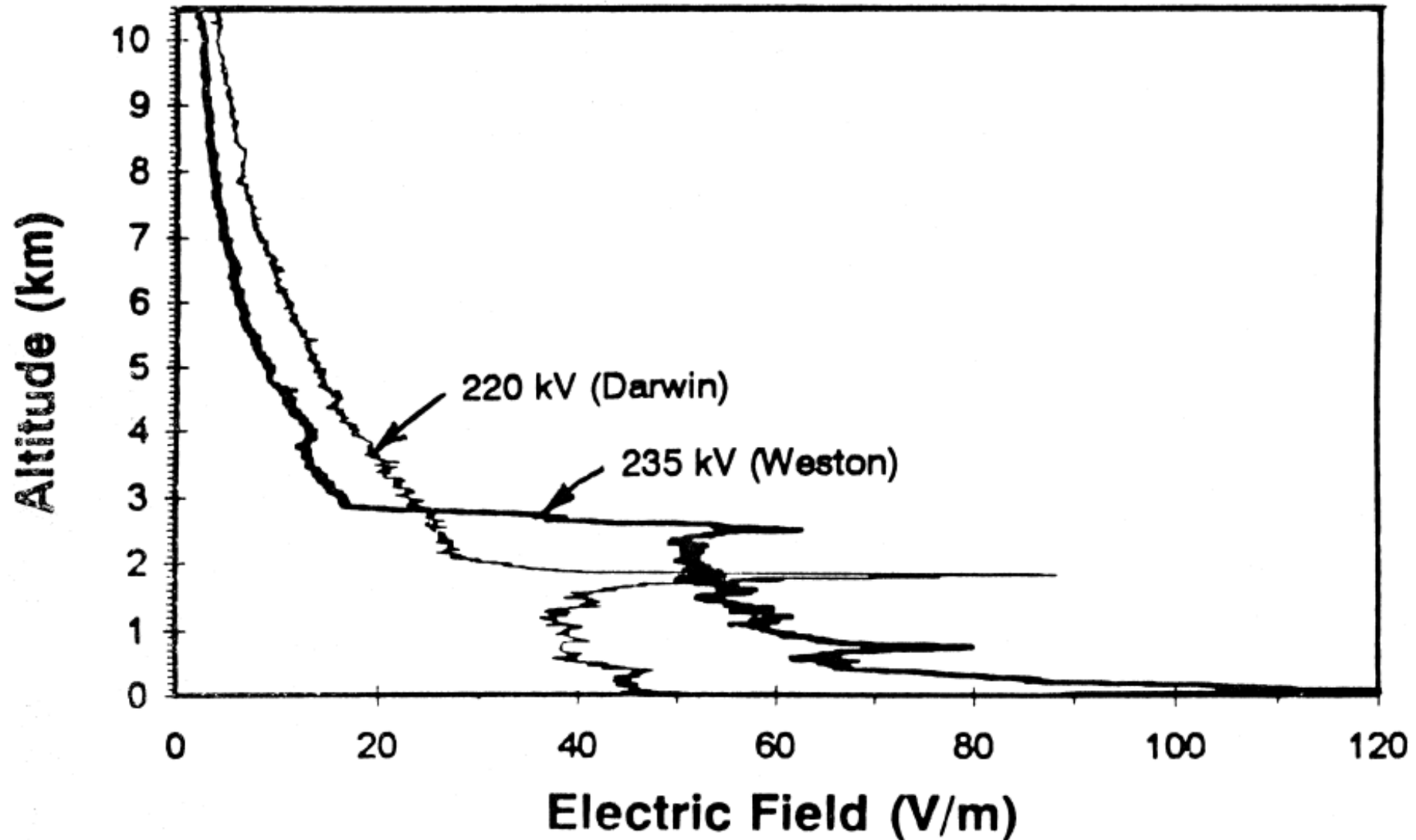
Historical datasets on ionospheric potential

Two researchers own the great majority of all Vi measurements:

- Richard Mühleisen (Germany) Mühleisen (PAGEO, 1971)
- Ralph Markson (USA) Markson (BAMS, 2007)
- Note: Vi has never been measured operationally

Comparison of simultaneous soundings for Vi

(Markson et al., 1999)



GRUAN Balloon Network

GCOS Reference Upper-Air Network



Priorities for Site Selection

- Unpolluted atmosphere: Marine environment far from continents
- Remoteness from thunderstorm activity
- Cloudless sky
- Flat terrain to minimize lateral heterogeneity
- Modest wind speed to make $E(z)$ measurement in vertical column
- Interest in multiple sites to verify global invariance of V_i

Graciosa (GRA), Portugal



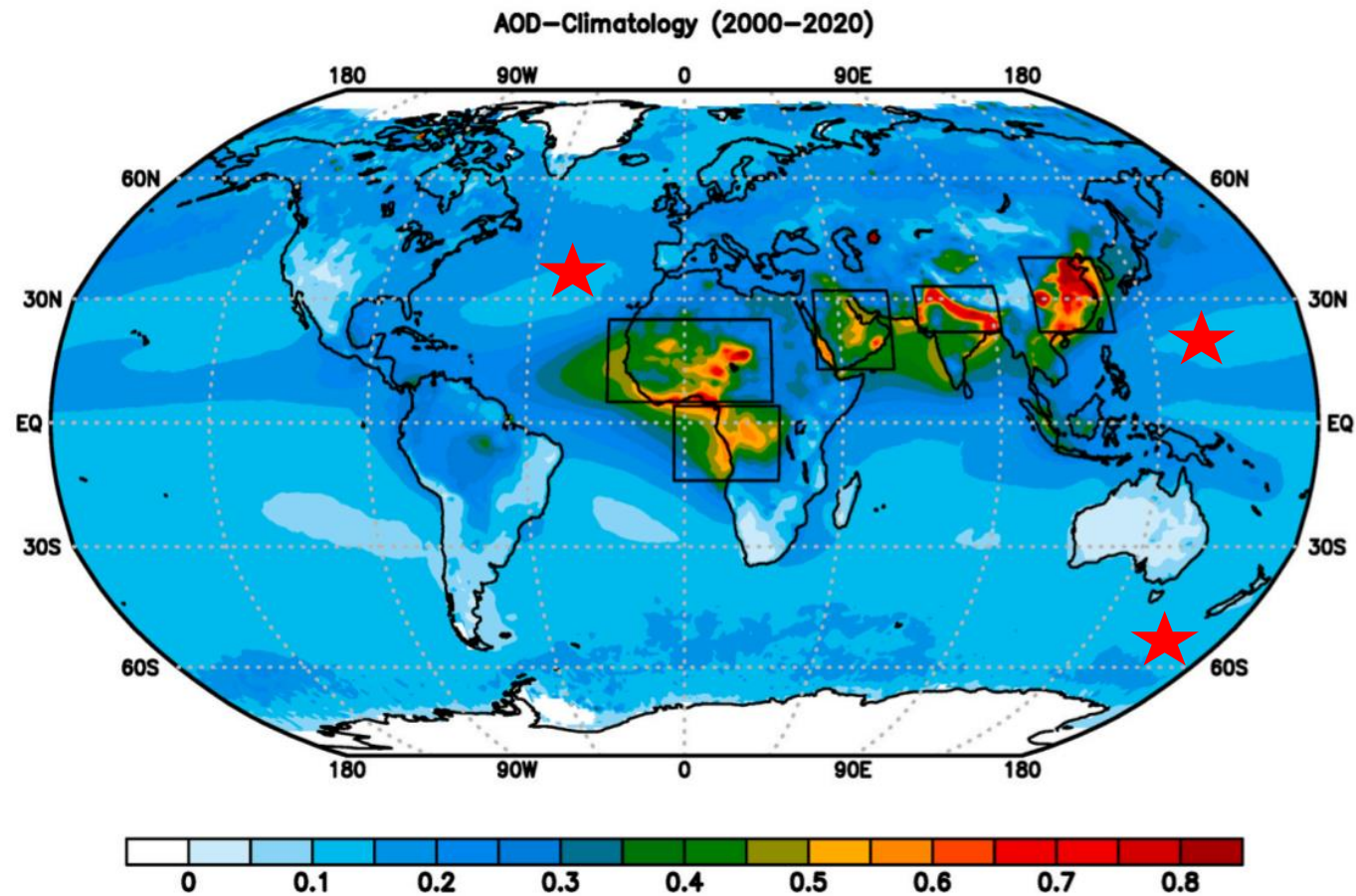
Minamitorishima (MTS), Japan



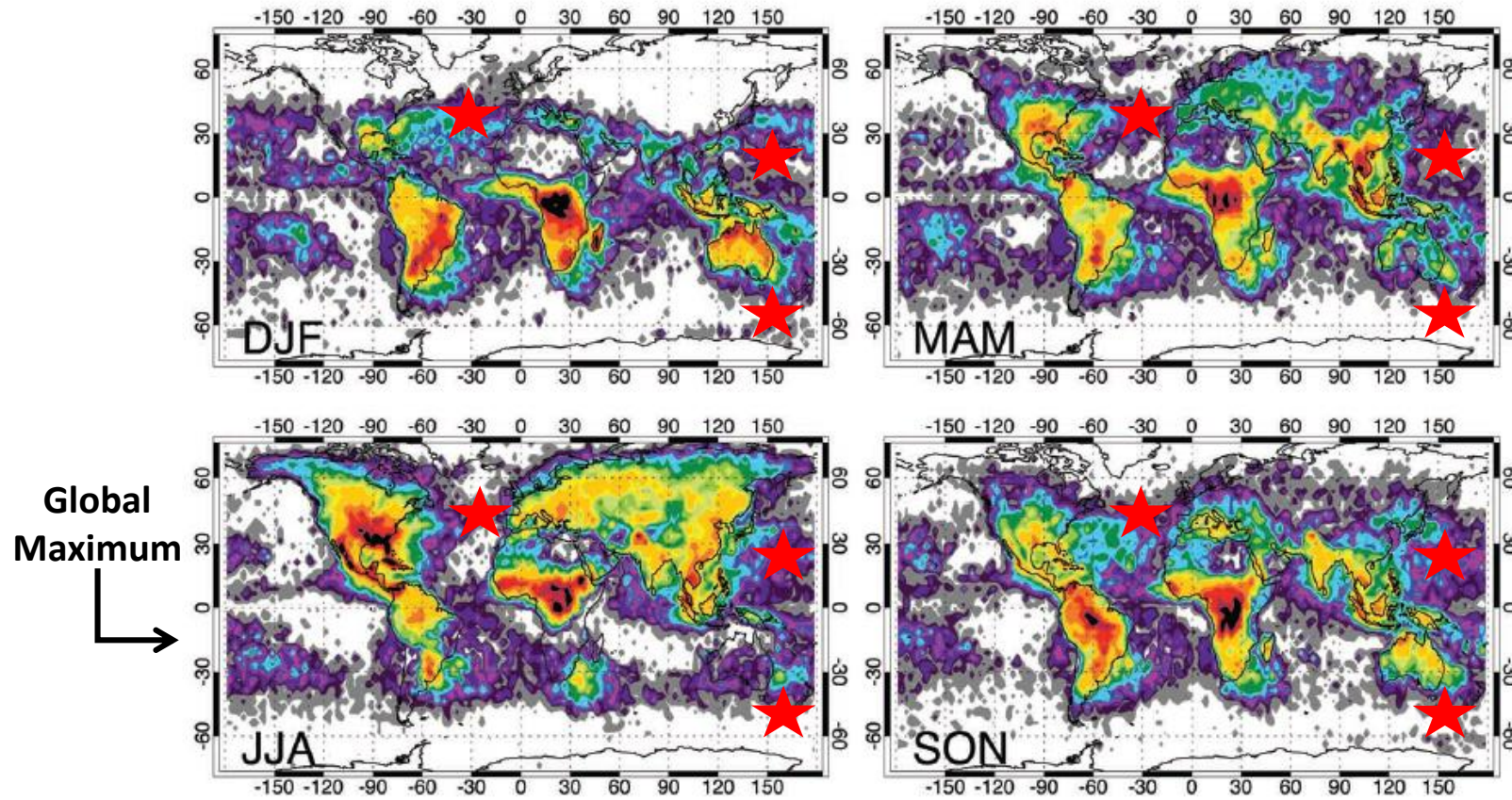
Aerosol (AOD) Climatology

(2020)

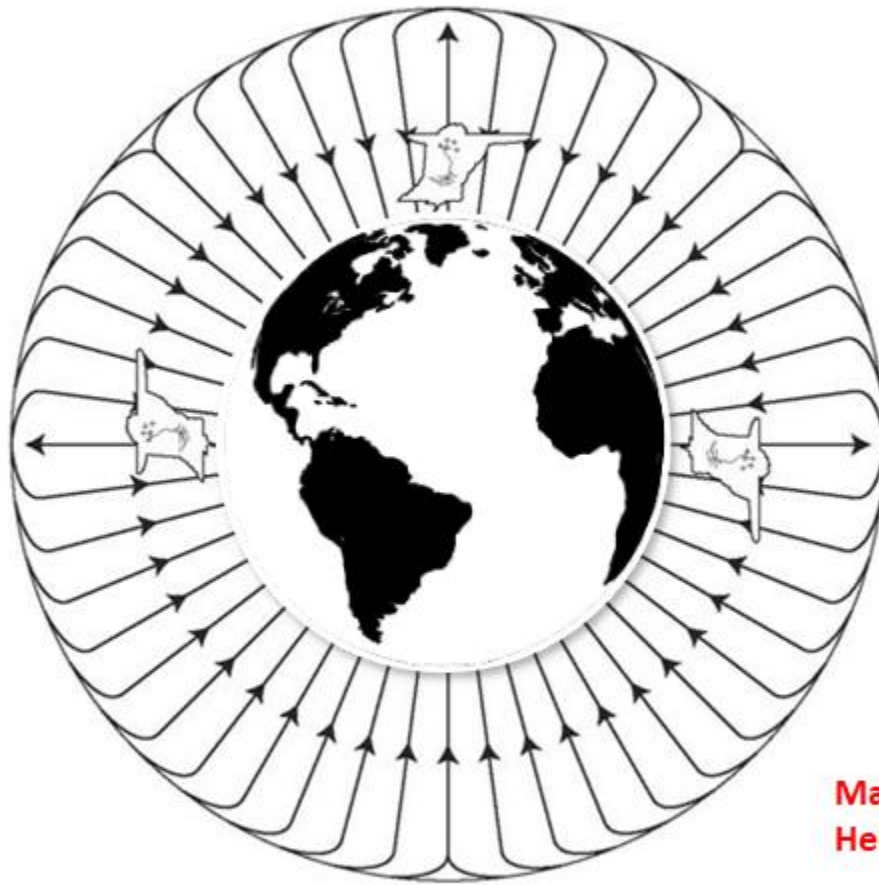
Sanap



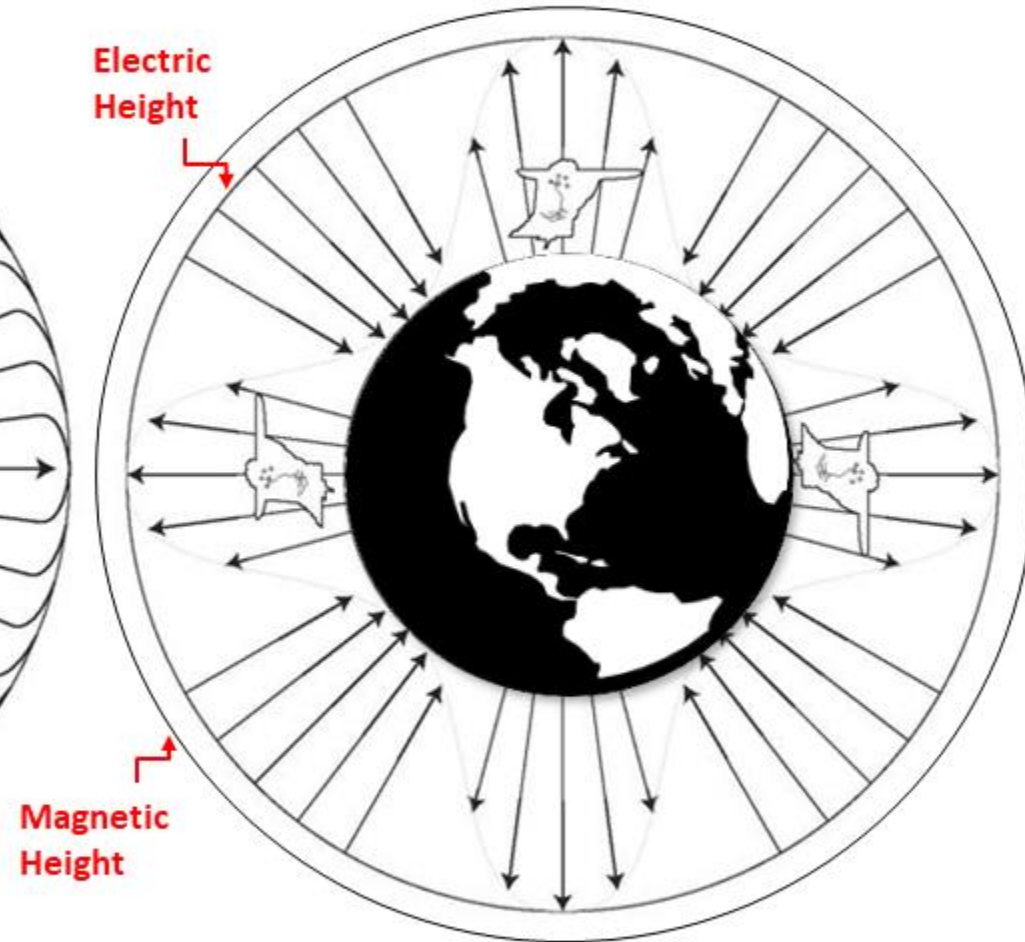
Seasonal variation of global lightning activity (Christian et al., 2003)



Two global circuits

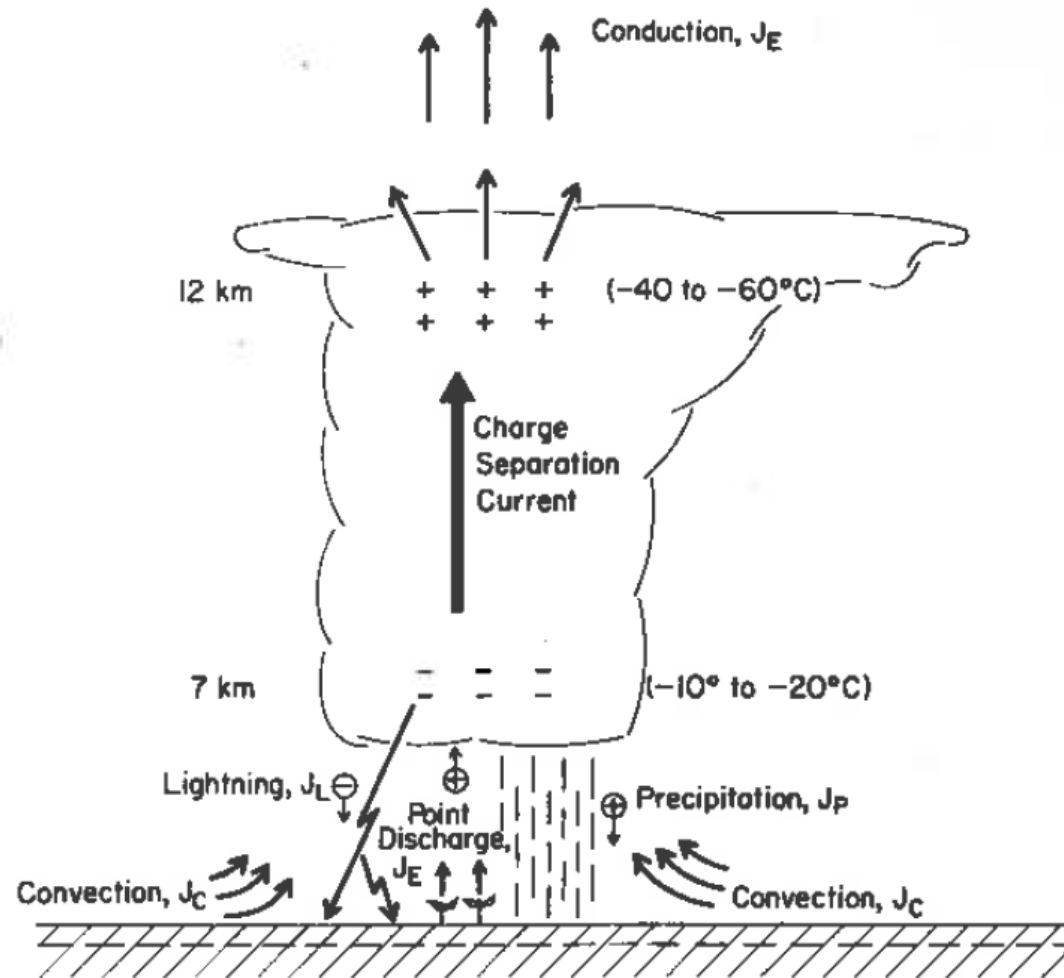


Integrator of Electrified Weather

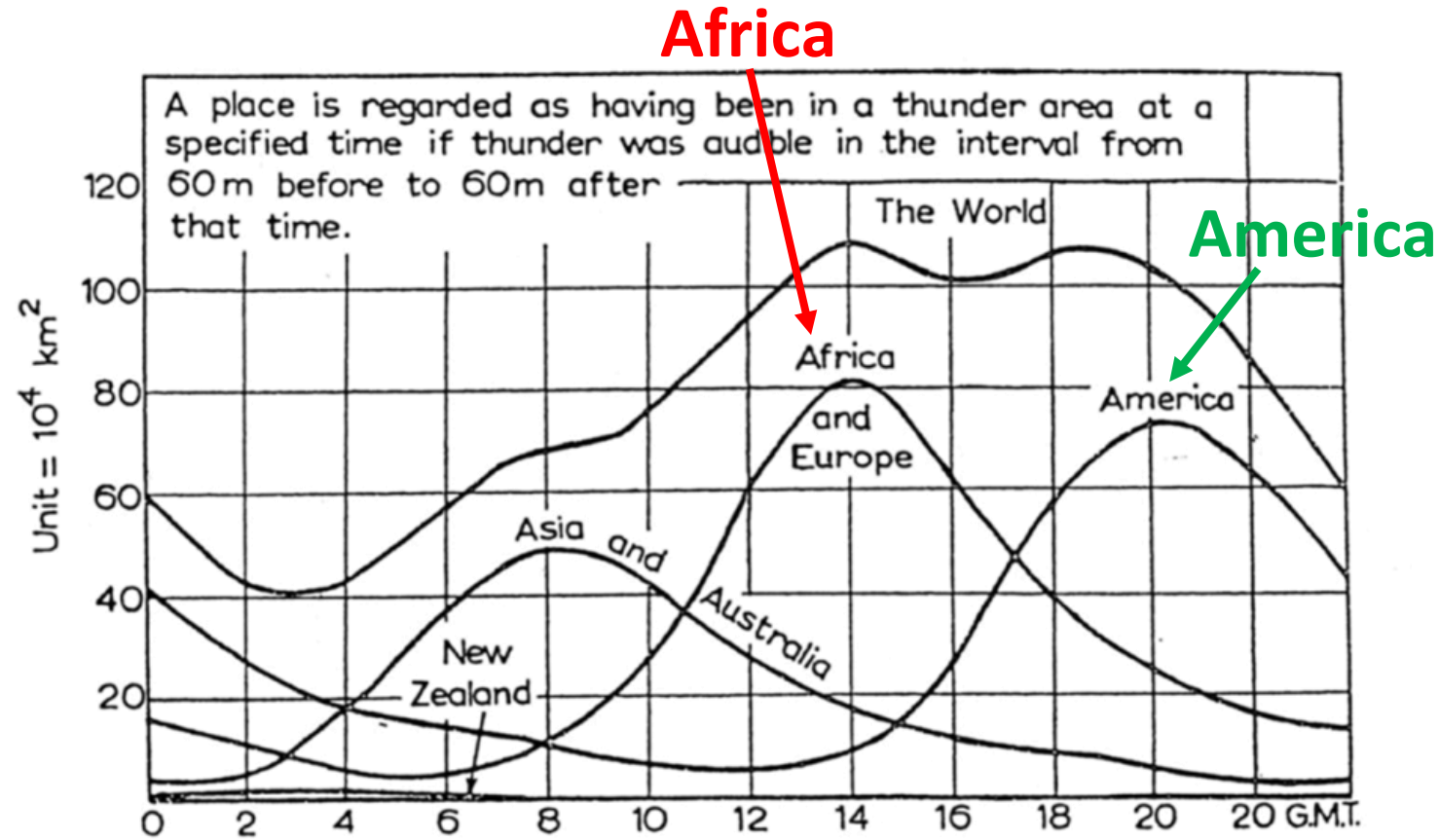


Integrator of Global Lightning

Thunderstorm source for DC and AC global circuits

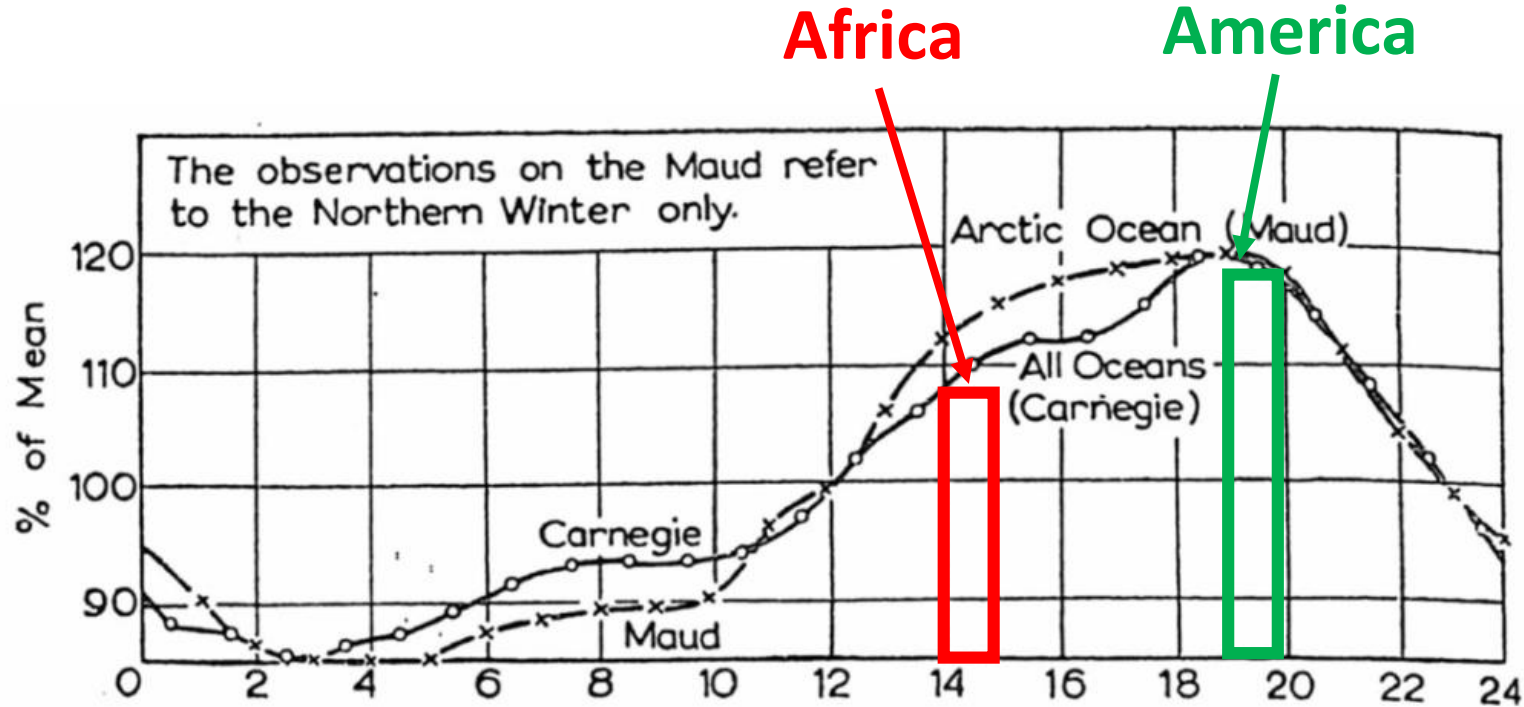


Long-standing puzzlement about the global electrical circuit: Africa vs America



Thunder Area vs UT time

Long-standing puzzlement about the global electrical circuit: Africa vs America



Carnegie Curve

Possible resolution of the Global Circuits Paradox

Two possibilities to check:

(1) South America has more electrified shower clouds than Africa and so gets a boost in current flow to the DC global circuit

(2) Africa is more polluted than South America and so gets a boost in lightning for the AC global circuit

Questions for GRUAN site managers

- Can we make soundings at UT times other than the standard 0 and 12 UT (when Africa and American thunderstorm activity is maximum)?
- Can we piggyback on the GRUAN radiosonde telemetry with our electric field sensors?
- Can we make use of balloons with higher than usual breaking height?
- Can we coordinate/communicate with multiple GRUAN sites to make simultaneous soundings of ionospheric potential?
- Can we visit selected GRUAN sites for purposes of training personnel for special soundings of electric field and for electrical site surveys?

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