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A NOTE ON IONOSPHERIC WIND

A number of dynamo calculations with up to date data on ionospheric winds have shown that these are reasonably consistent with the observed electric currents and fields. Most of the total *Sq* current flow appear to be due to a diurnal tidal wind whose dynamo effect is most important up to 200 km during day time as pointed out by Maeda (1955) and Tarpley (1970). To a large extent this tide may be due to the (1, —2) mode of wind modified by ion drag generated by solar heating. However, semi-diurnal tides also make a considerable contribution to the electric currents and fields while the diurnal (1, 1) tide probably become important below 120 km.

Rishbeth (1971) has pointed out that *F*-region winds can have appreciable dynamo effects, particularly at night, when the conductivities of *E*-region are greatly reduced. This effect is pronounced near magnetic equator where the magnetic field lines run through the *F*-region horizontally. In fact the mutual dynamic influence between neutral air and plasma motions are important in this region.

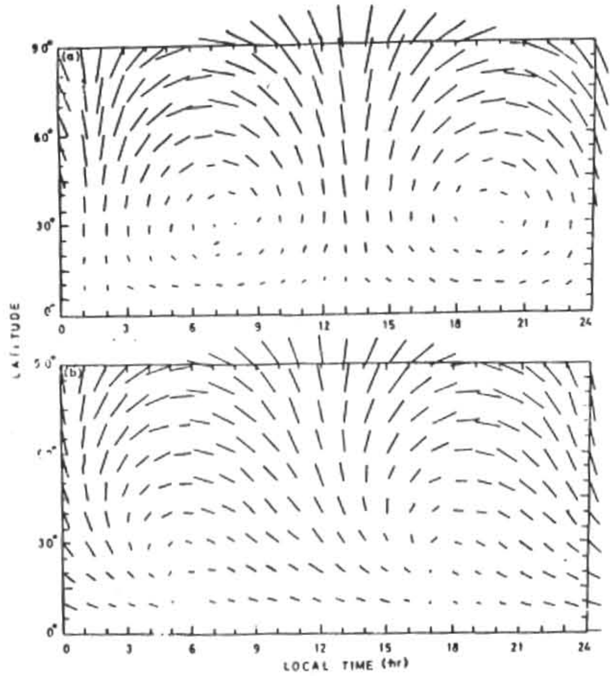
It is to be noted that longitudinal and seasonal variations of conductivity can account for much of the corresponding variations of *Sq* currents and electric fields, but universal time variations of the wind also appear to be important. On the other hand, non-periodic winds can generate significant currents but are not the main contributor to *Sq* currents as shown by Stening (1969) and Richmond (1976). Due to the tides a potential difference may be produced between the upper and lower parts of cloud in a cloudy weather as mentioned by Hays and Roble (1979).

The regular tidal wind systems can generate a large scale electric current within the dynamo region. These systems are excited by the solar thermal heat source (solar tides) or by the lunar gravitational force (lunar tides). Thermospheric winds are observed to exhibit strong oscillations having frequencies of one per day or some integral multiples.

This periodic nature of observed winds leads to atmospheric tides which are nothing but long period global atmospheric oscillations. Classical tidal theory finds it convenient to divide the oscillations into separate tidal modes, since the earth's atmosphere behaves like a large wave guide in which only individual wave modes can exist.

The wave modes are symbolized by wave numbers (m, n) both being integers. m, n is the zonal wave number characterising the number of waves spanning a zonal circle. The diurnal tides with a period of one solar (or lunar) day is having $m=1$ while for sem-diurnal tides $m=2$ etc. n is the meridional wave number related to wave structures along a meridional circle. n is positive for propagating waves having finite wave lengths while it is negative for evanescent waves having infinite wave lengths. A brief account of some modes appears below :

Steady wind — Van Sabben (1962) have shown that steady ionospheric winds can generate *Sq* like currents. Accurate observations of steady ionospheric winds are available below 110 km. The study of steady wind distribution in several works is based on the theoretical study of thermospheric dynamics by Dickinson (1975).



Figs. 1 (a & b). Wind pattern of (1, --2): (a) Mode as "in" Tarpley (1970) & (b) Tidal mode modified by a constant on drag appropriate to 150 km as in Richmond *et al.* (1976)

This shows that the steady wind in the *E*-region is primarily eastward. The maximum speed is about 45 m/sec at an altitude of 120 km and 60° latitude. This study leads to the possibility of significant steady winds at higher levels being in the low conducting portion of the ionosphere and hence would not have an important influence on electric fields and currents.

(1, 2) *and (1,—2) tidal modes* — Coherent scatterer observations show a generally poleward wind in the day time inconsistent with the theoretical concept that, day time solar heating in the thermosphere excites the diurnal tides which generally leads polewards in the day time and equatorward at nights. This tide may be described by (1, 2) and (1,—2) modes which means respectively the unmodified and ionic drag.

(2, 2) and (2, — 2) modes —Amayene's (1974) observations show a semi-diurnal oscillation which is smaller than the diurnal oscillation above about 130 km. It is possible that this wind is generated by interaction of diurnal wind with the time varying ion drag coefficient. This is associated with the lowest order semi-diurnal tidal mode, the (2, 2) is modified by ion drag to give what we call *(2, —2)* mode. The ion drag coefficient is the same as that used for (1, 2) mode.

(2,4) tidal mode — Observations of neutral temperature and velocity variation in the *E*-region together with dissipative tidal theory strongly point out the presence of (2, 4) mode as mentioned by Richmond (1973). Since the dissipative forces (*e. g.,* viscosity and ion drag) are relatively small below 120 km compared to inertial and Coriolis forces it is not necessary to consider the latitudinal structure of this mode as in the other cases, *e.g.*, (1, 2) and (2, 2) etc.

(1,1) tidal mode — This propagating diurnal tide has a vertical wavelength around 24 km in the thermosphere but these become strongly dissipated by viscous force at about 110 km. The diurnal tides below 120 km were studied by Harper (1977).

It is to be mentioned that the solar diurnal (1, 2) mode is mainly responsible for *Sq* current. This current can be observed magnetically on the ground as the solar quiet (*Sq*) geomagnetic variations. The main contribution to the lunar (*Lq*) variations come from the lunar semi-diurnal (2, 2) mode. The diurnal (1, 2) mode contributes about 80 - 90% of atmospheric current. The rest is due to diurnal (1, 1) mode and semi-diurnal (2, 2) and (2, 4) modes as discussed by Volland (1980).

Thus the atmospheric dynamo current is mainly produced due to (1, 2) mode. Figs. 1(a&b) show the unmodified wind patterns associated with the (1, 2) and (1, — 2) modes using a value of ion drag parameter appropriate to mean conditions at 150 km.

One can conclude the followings about the wind effects in dynamo theory:

(*i*) Winds in ionospheric dynamo region (80-120 km) which are consistent with both theory and observations are capable of explaining *Sq* current, (*ii*) Ionospheric winds can probably explain observed middle and low latitude electric fields, and

(*iii*) The primary source of *Sq* current can be attributed to diurnal winds in the upper *E* - region and *F* - regions.

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