Travelling convection vortices

Travel(l)ing Convection Vortex (TCV) is a name given to a specific type of daytime magnetic impulsive events observed by high-latitude ground based magnetometer arrays. Since the most likely source for TCVs is the solar wind, they are considered to be important processes in transfering energy from the solar wind into the magnetosphere. Two important early studies of the phenomenon are those by Friis-Christensen et al. (1988) and Glassmeier et al. (1989).

A TCV seen by a single magnetic station shows an isolated magnetic field variation with a bipolar structure in the H-component, i.e., a negative-positive (NP) or positive-negative (PN) deflection. The associated D-component shows a single positive or negative excursion (making the H-component variation the negative time derivative of the D-component variation). When several, longitudinally separated stations are used, this signature is seen to propagate tailward (westward in the morning sector): hence a "traveling" vortex. Furthermore, when a large, both longitudinally and latitudinally distributed grid of stations is used to calculate the 2D ground-equivalent ionospheric current system, a twin-vortex structure emerges. It has been shown that these oppositely rotating cells of current vortices are created by a pair of upward and downward flowing field-aligned currents (FAC). This can also been shown theoretically using basic plasma physics equations.

The main characteristics of TCVs as observed from the ground are:

- Occurrence peaks at about 09 and 14 MLT
  - This is because the perturbation amplitude increases during the first four minutes or so of the event!
- Occurrence peaks at about 73 degrees invariant latitude
  - Morning side vortices seem to occur on lower latitudes than the afternoon ones, and thus the Scandinavian magnetometers do not see the 14 MLT sector vortices!
- Tailward propagation speeds are 0.1-0.3 degrees/s, i.e.,
  - 3-10 km/s in the ionosphere
  - 130-400 km/s at the magnetopause
- The calculated equivalent currents flow opposite to the measured plasma drift (Lühr and Blawert, 1991)
  - This means that the magnetic deflections on the ground are caused by Hall currents
- Vortices are separated by 1000-2000 km
- FAC current densities can be several 10^-6 A/m^2 in the ionosphere
  - Total FAC amounting to a few hundred Amperes
- Some dynamic features of the dayside aurora may be related to TCVs (Oguti et al., 1988).
  - The high current densities observed provide possibilities for several plasma instabilities that could energize electrons
- Conjugate vortices in the two hemispheres have opposite senses of rotation

Although the ionospheric features of TCVs are well documented, the processes taking place on the other end of the FACs are more complicated. The most likely source region for TCVs is was thought to be the magnetopause, as one could assume from the high magnetic latitudes they are observed. However, some recent results suggest that the source could be inside the plasma sheet (Yahnin and Moretto, 1996; Yahnin et al., 1996). The high degree of conjugacy of the events suggest a source close to the equatorial plane, while the MLT distribution implies generation close to the subsolar magnetopause. Several processes have been suggested:

- Flux transfer events (FTE)
  - Currently not considered an important factor for several reasons:
    - It is still unclear what kind of ionospheric signatures FTEs should create (for example if the observed FAC pair can be produced)
    - IMF Bz seems not to control the TCV event occurrence
    - There is no poleward motion observed for the TCVs as reconnection would imply
    - FTEs should be associated with mass motion at the ionospheric foot point of the reconnected flux tube, whose velocity should not be larger than the speed of sound. This contradicts with the observed tailward velocities of TCVs.
- Impulsive plasma penetration events
  - The implications of these events are not very well understood
- Solar wind pressure pulses
  - Some TCV events have been correlated with measured pressure pulses
    - For example, one AMPTE Lithium release in the solar wind caused a TCV event
    - However, many events seem NOT to be related with important pressure variations!
  - Some models for the pressure pulse response in the magnetosphere/ionosphere system indicate formation of two pairs of vortices, one on either side of noon
    - However, all observed features cannot be explained
- Rapid changes of the IMF
  - No observational backing yet

Note also that multiple convection vortex systems related to Pc 5 pulsations (and most likely to Kelvin-Helmholtz instability in the LLBL) are considered to be different events from the TCVs (McHenry et al., 1990). Another important distinction is that TCV events are not related to the much larger scale twin-vortex structures accompanying sudden impulses (see SI & SSC). (Note, however, that Korotova and Sibeck (1994) do not agree on the latter point!)

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