The relationship between Auroral Westward Flow Channels (AWFCs) observed by TIGER and magnetospheric substorms

M. L. Parkinson¹, M. Pinnock², P. L. Dyson¹

(1) Department of Physics, La Trobe University, Melbourne, Victoria 3086, Australia
(2) British Antarctic Survey, NERC, Cambridge, CB3 0ET, U.K.
**Polarisation Jets or Sub-Auroral Ion Drifts (PJ/SAIDs)**

\[ \mathbf{J}_\perp = \sum p \mathbf{E}_\perp \]


**Figure 1.** Schematic view of the current sheet connecting the nightside ionosphere where a PJ/SAID is observed to the magnetosphere. The ionospheric magnetic field \( \mathbf{B}_{\text{iono}} \) points down, the ionospheric drift \( \mathbf{V}_{\text{iono}} \) is westward, and the electric field \( \mathbf{E}_{\text{iono}} \) is directed poleward. The arrows indicate the direction of the field-aligned and ionospheric currents.
Broad Research Objective:

To investigate and understand substorm, *AWFC (PJ/SAID)*, and main ionospheric trough dynamics using experimental data recorded with the following suite of coincident instruments:

- The Tasman International Geospace Environment Radar (TIGER) located on Bruny Island, Tasmania (43.4°S, 147.2°E; –54.5°Λ).
- The TIGER radar to be located at Awarua, New Zealand (46.5°S, 168.4°E, –54.2 °Λ).
- The magnetically conjugate, Communications Research Laboratory (CRL) radar located at King Salmon, Alaska (58.7°S, 156.7°E; 57.4°Λ).
- The suite of ground-based instruments include fluxgate and induction coil magnetometers, a CADI, and optical instruments located on Macquarie Island (54.5°S, 158.9°E; –64.3°Λ).
- Supporting space-based instruments including Defense Meteorology Satellite Program (DMSP) SS J/4 particle detectors.
TIGER I & II Field of Views:

Boresight = 227.9 Degrees

Beam 4

Awarua, Invercargill
Macquarie Island
Bruny Island
Awarua, Invercargill

AWFC

Beam 15

Beam 4
**Specific Research Tasks:**

- To understand the role of AWFCs in substorm evolution, including whether they commence before, during, or after substorm onset.
- To understand any distinction between AWFCs, PJ/SAIDs, SAEFs, SARASs, flux depletion regions (FDRs), and the sub-auroral polarisation stream (SAPS).
- To compile occurrence statistics for AWFCs, including their location and extent in MLT, their lifetimes, latitudinal widths, maximum drift speeds, etc.
- To identify what fraction of substorms are accompanied by AWFCs, and under what conditions.
- To classify and understand the diversity of AWFC morphology, including changes in the main FITACF parameters (power, LOS Doppler velocity, and spectral width).
- To understand the detailed instability processes occurring within AWFCs, including their relationship to auroral magnetometer and optical phenomena.
\[ \sum K_p = 22 \]

Substorm 1

0958 UTC

Substorm 2

1335 UT

1050 UTC

1424 UT

Ground-Based Magnetometer

Macquarie Island - MCQ, Day 27.2.2000 (1 days)

(Station location = 54°S 158°E)
Auroral Westward Flow Channel (AWFC), 27 Feb. 2000

Beam #15

(a) Power (dB)

(b) LOS Doppler Velocity (m/s)

(c) Spectral Width (m/s)
2-D Beam-Swinging Velocities, 27 February, 2000

Rapid Identification of AWFC, 7 February 2000

Beam 15

LOS Doppler Velocity (m/s)
Rapid Identification of AWFC, 7 February 2000
Rapid Identification of AWFC, 7 February 2000

[Diagram showing data with axes for Range (Km), Universal Time (Hours), Power (dB), LOS Doppler Velocity (m/s), and Spectral Width (m/s).]
Echoes with Extreme Spectral Width, 15 April 2000
AWFC, 6 April 2000

Beam 15

Universal Time (Hours)
AWFC, 15 August 2000

Universal Time (Hours)
AWFC, 31 August 2000
Occurrence of AWFCs in TIGER Observations, 2000
(NB. Not “Absolute Occurrence”)

>98 Events
(Directly Observed)
Occurrence of **AWFCs** in TIGER Observations, 2000
(NB. Not “Absolute Occurrence”)

>98 Events, ~146 Events

(Directly Observed, Missing Days Correction)
Occurrence of AWFCs in TIGER Observations, 2000
(NB. Not “Absolute Occurrence”)

>98 Events, ~146 Events, ~192 Events
(Directly Observed, Missing Days Correction,
Missing Echoes Correction)
Summary:

- **AWFCs** strongly resemble **PJ/SAIDs**, except they are more closely synchronised with the onset and recovery of substorms.
- **AWFCs** are the dominant electric field signature in the 20 to 24 MLT sector when substorms occur.
- Perhaps every quiet to moderate substorm is accompanied by an **AWFC** in the pre-midnight sector.
- **TIGER I** has the potential to observe ~150 well-defined **AWFCs** per annum during 8 to 13 UT (~20 to 01 MLT), and −60°Λ to 68°Λ (beam 15 range bins 10 to 38).
- **AWFCs** exhibit a diverse morphology, including narrow, snake-like events, events consisting of bifurcated narrow channels, and very broad intense events spreading in latitude to trough-like ionospheric scatter.
Summary:

- Usually the backscatter powers and spectral widths are moderate during the AWFC, and the subsequent main-trough like scatter has large backscatter power and small spectral widths.