MAGNETOTAIL FLOWS NEAR LUNAR ORBIT AND THEIR RELATION TO SUBSTORMS

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MAGNETOTAIL FLOWS

(a) Mid-tail origin (NENL)

Tailward (TW) flows @ ARTEMIS:
Source X_GSM > - 60 RE

Earthward (EW) flows @ ARTEMIS:
Source X_GSM < - 60 RE

Source of EW flows:
- DNL?
- retreating NENL?
- patchy reconnection?

(c) Distant-tail origin (tailward retreated NENL)

after Nishimura et al., 2013
ARTEMIS ORBITS 2011-2015

2011 Orbit in AGSM

2012 Orbit in AGSM

2013 Orbit in AGSM

2014 Orbit in AGSM

2015 Orbit in AGSM

THB (P1)
THC (P2)
Plasma sheet selection:
$T > 500 \text{ eV}$
$N < 0.5 \text{ cm}^{-3}$
43% (v_x > 400 km/s) to 56% (v_x > 100 km/s) of the flows are directed EW.

29% (v_perp_x > 400 km/s) to 44% (v_perp_x > 100 km/s) of the convective flows are directed EW.

The percentage of EW flows decreases with increasing flow speed.

Kiehas et al., JGR, 2018
Outflow speed ~ $v_A$ in inflow region

$v_A$ decreases with downtail distance

=> high speed flows are more likely to origin from near Earth region (= TW flows @ ARTEMIS)

=> for high speed flows the percentage of EW flows is smaller

Slavin et al., 1985
**BZ ASSOCIATION WITH FLOWS**

- **EW flows**: primarily associated with southward Bz
- **TW flows**: primarily associated with northward Bz, but less clear
  => plasmoids

![Diagram showing EW and TW flows with percentages]
No clear asymmetry for EW flows
60% of TW flows in dusk sector
Since TW flows originate from near-Earth region => indication that asymmetry is more pronounced closer to Earth
TW flows: dusk asymmetry similar for all AL thresholds

EW flows:
- low AL threshold: fairly symmetric
- high AL threshold: EW flows become strongly asymmetric toward dusk

=> RX EW of ARTEMIS asymmetric. Distant tail RX (slower EW flows during low geomagnetic activity) symmetric. Higher geomagnetic activity (AL>400 nT) near-Earth neutral line retreat downtail - passing by ARTEMIS.
Find flow events when s/c was inside PS before detection of flow

Criterion:
- s/c inside PS for at least 30 sec before flow detection
- Flows need to exceed 200 km/s

Result:
39 EW events
55 TW events
Clear correlation of TW flow onset with AL.
No correlation of EW flow onset with AL.
• 43% ($v_x > 400 \text{ km/s}$) to 56% ($v_x > 100 \text{ km/s}$) of the flows are directed EW
• 29% ($v_{\perp_x} > 400 \text{ km/s}$) to 44% ($v_{\perp_x} > 100 \text{ km/s}$) of the convective flows are directed EW
• The percentage of EW flows decreases with increasing flow speed

• EW flows: primarily associated with northward Bz
• TW flows: primarily associated with southward Bz, but less clear => plasmoids

• No clear asymmetry for EW flows
• 60% of TW flows in dusk sector
• => Dawn-dusk asymmetry stronger near Earth. In line with Hall E as asymmetry source (cf. San Lu et al.)

Asymmetry and AL: TW flows: dusk asymmetry similar for all AL thresholds. EW flows: for high AL threshold EW flows become strongly asymmetric toward dusk.

Clear correlation of TW flow onset (flows from within ~ -60 RE ) with AL. No correlation of EW flows (flows originating from beyond ~ -60 RE) with AL.