Integrated Science Operations of CASSIOPE e-POP with the Swarm Constellation for New Studies of Magnetosphere-Ionosphere Coupling

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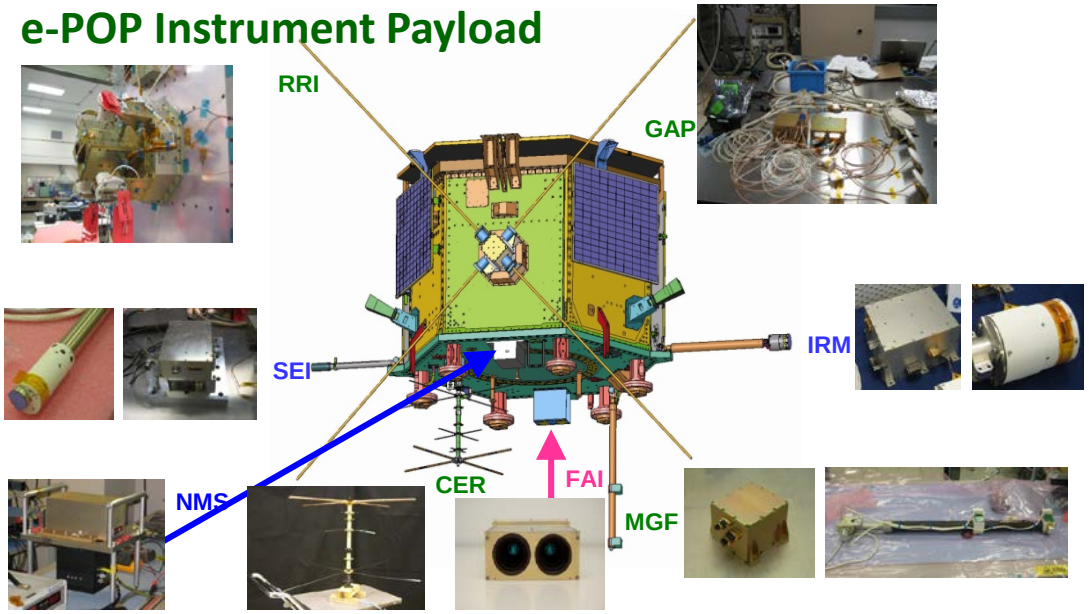
Key Points:

1. CASSIOPE e-POP currently in its 7th year of operation, as 4th component of Swarm
2. New/enhanced studies of magnetosphere-ionosphere coupling (MIC) enabled by:
   - Complementary orbital coverage, measurement capabilities, sampling resolutions
   - Integrated e-POP and Swarm science operations
   - Increased e-POP operation duty cycle and full altitude, latitude, local time sampling
3. Studies focus on space weather effects of MIC in the ionosphere and thermosphere
   - e.g. anomalous satellite orbit drag; radio scintillation
   - This presentation illustrates studies on small-scale plasma irregularities and orbit drag

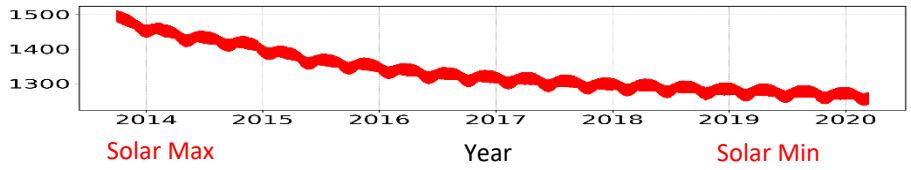
e-POP and Swarm data are highly complementary for studies of M-I coupling

e-POP Instrument Payload

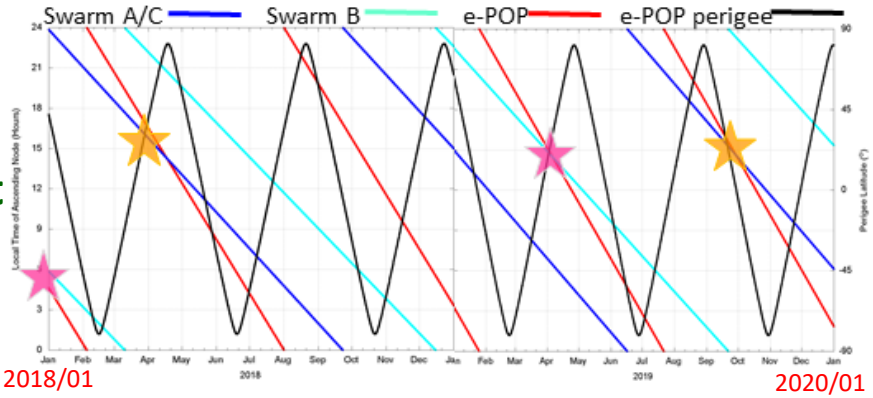


- e-POP aurora image (FAI), ion composition (IRM), VLF-HF wave (RRI), scintillation (CER) data complement Swarm **B**, **E**, N_e data
- e-POP data at high sampling rate (10^2 to 10^3 samples/s) enable studies of small-scale MIC structures and processes
- Elliptical e-POP orbit (325 × 1500 km, 81°) provides altitude sampling and frequent multi-spacecraft conjunction orbits

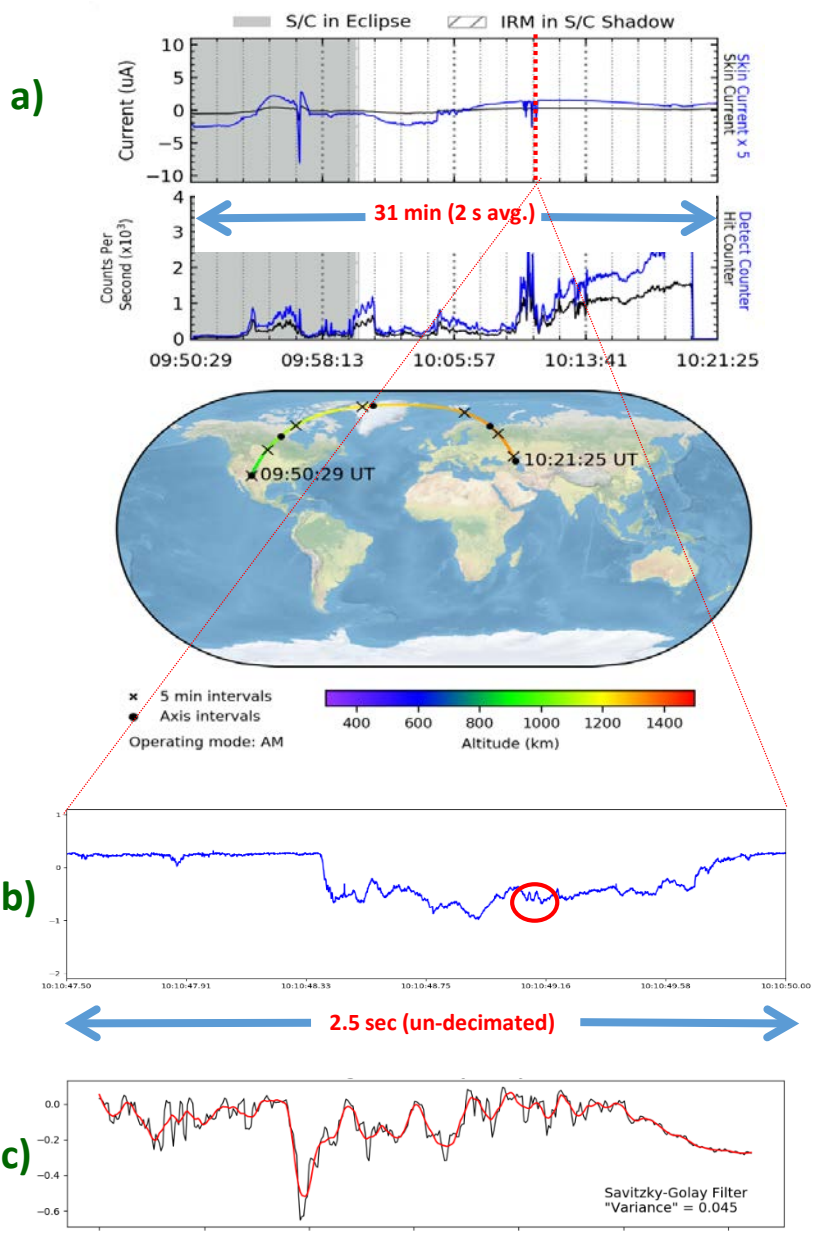
e-POP apogee



Swarm & e-POP orbit local time



Small-scale plasma density structure and variability



IRM measures incident plasma current at 10^3 samples/s, and uses data to infer small-scale (10-100 m) density structure (n_e, $\Delta n_e/n_e$)

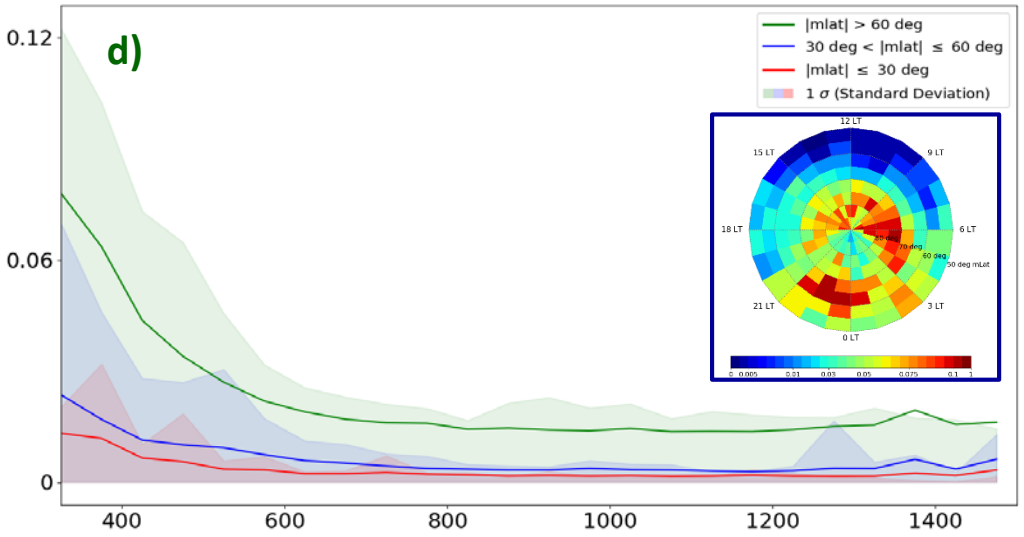
Objective: Extend Swarm mesoscale observations to small scale - determine occurrence, spectral characteristics, effect on scintillation

a) Summary data (example): 31-min orbit on 2017/01/27; 2 s avg. plasma current, ion count rate ($\propto$ density), ground track

b) Original (un-decimated) data showing ~10-m structures

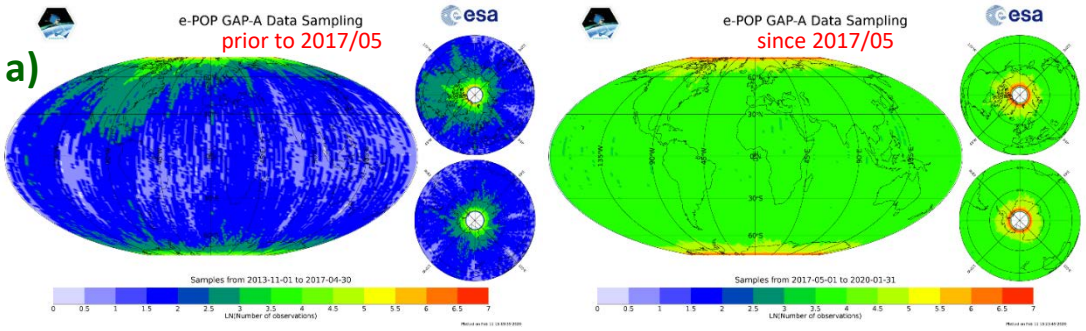
c) Filter small-scale 'variance' from mesoscale amplitude and width

d) Altitude distribution of mean variance (Δn_e) at high, mid, and low latitude; inset: magnetic latitude vs. local time distribution

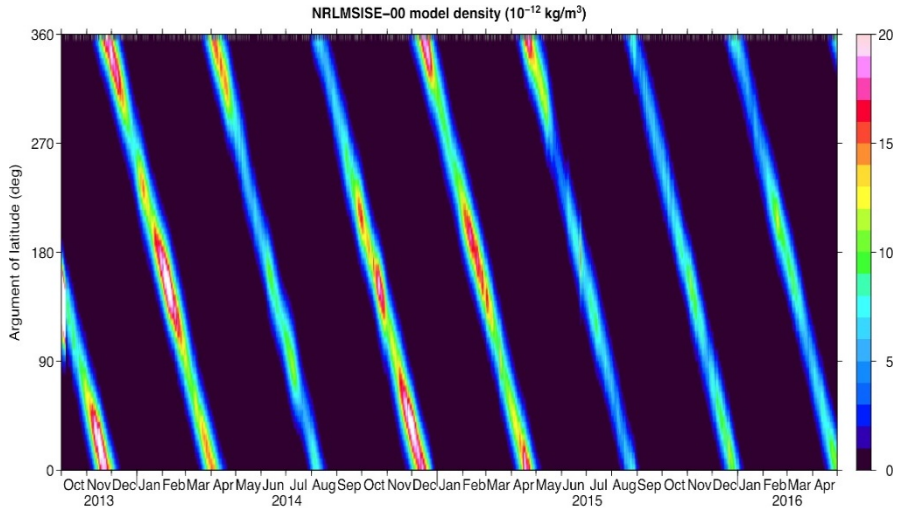


Thermospheric density variations and anomalous low-Earth-orbit decay

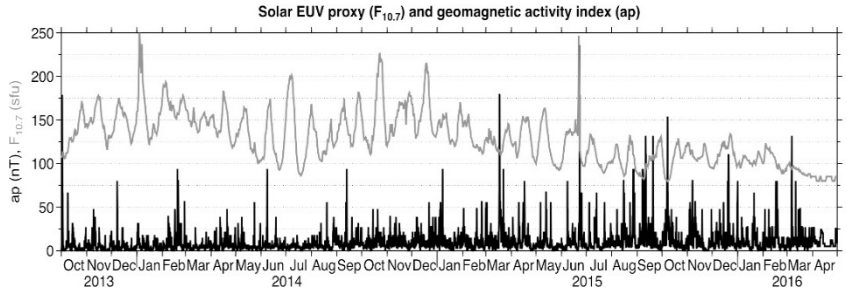
a)



b)



c)



Courtesy E. Doornbos, A. Nicholson, R.D. Langley

Full-orbit GAP-A data (1-20 Hz) are required to yield spacecraft positions of sub-decimeter RMS uncertainty and to derive *localized* spacecraft acceleration (or deceleration)

Spacecraft deceleration - anomalous orbit decay - is related to mass density near perigee

e-POP perigee is ~125 km (~2.5 scale heights near solar min) lower than Swarm A, C

Objective: More sensitive determination of thermospheric mass density near solar min

a) GAP-A data coverage before and since 2017/05

b) MSIS model density along e-POP orbit vs.

c) F10.7 and Ap