Rocket Experiment for Neutral Upwelling

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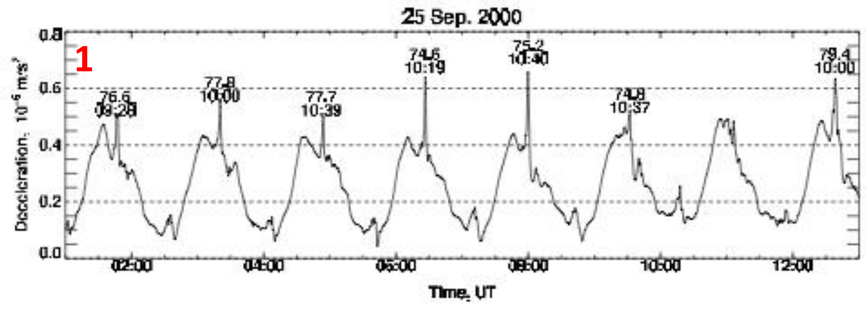
ABSTRACT: Observations from the CHAMP satellite from 2004 show relatively small scale heating in the thermosphere. Several different mechanisms have been proposed to explain this phenomenon. The RENU 2 rocket mission includes a suite of 14 instruments which will acquire data to help understand processes involved in neutral upwelling in the cusp. Neutral, ion, and electron measurements will be made to provide an assessment of the upwelling process. SUPERDarn measurements of large- scale Joule heating in the cusp during overflight will also be acquired. Small-scale data which could possibly be associated with Alfvén waves, will be acquired using onboard electric field measurements. *In-situ* measurement of precipitating electrons and all other measurements will be used in thermodynamic and electrodynamic models for comparison to the observed upwelling.

Motivation: Neutral upwelling in the cusp region has a measureable effect on the decay of satellite orbits. Results from CHAMP satellite reported by *Luhr et al. [2004]* (figure 1) indicate significant deceleration at cusp region, where strong FAC were also measured. Note that CHAMP observes cusp-upwelling regardless of whether or not the ionosphere is sunlit. Competing theories for the cause of the upwelling may be summarized as:

1. **Large scale convection (Joule heating)**
2. **Soft electron precipitation**
3. **Alfvén waves**
4. **Small scale currents (as observed by CHAMP)**

The goal of RENU2 is to acquire new data necessary to advance the state of knowledge regarding neutral upwelling in the cusp region



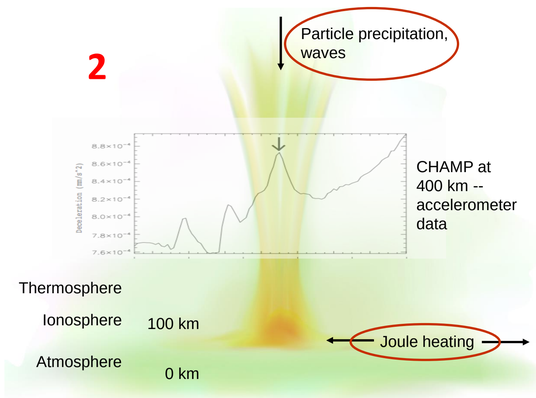
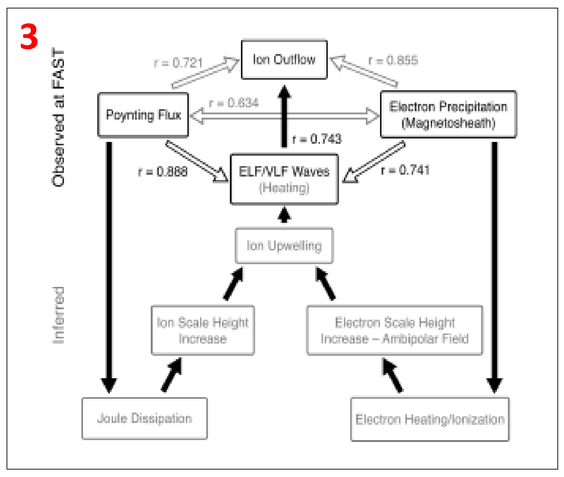


Fig 1. CHAMP satellite data showing deceleration 'bumps'. **Fig 2.** Diagram of competing theories for upwelling. CHAMP accelerometer data at 400km overlay.
Fig 3. Diagram shows processes in competing theories leading to upwelling.



Payload and Instrumentation

Instrument	Institution	Sensitivity
HEEPS Electrons	UNH/Dartmouth	6 eV – 18 keV
ERPA	UNH	.06 eV – 3 eV
HEEPS Ions (3)	Dartmouth	.1 eV – 1keV
Ion Gauge	Aerospace	$>10^{-10}$ T
COWBOY (E-field)	Cornell	0-20 kHz
Photometers	Aerospace	391, 630, 844.6 (nm) @ 30cts/s/R
Fluxgate Magnetometer	Cornell	+/- 60,000 nT
Racetrack Magnetometer	**UNH/SWRI**	**2.9 pT/√Hz @1Hz**

Direct Heating	Ambipolar Fields	Alfvénic Aurora	Strong FAC
Soft/cold FA electrons	Soft electrons	Cold, FA electrons	Large fluxes
Heated electrons	Heated electrons	Heated Electrons	Large fluxes
	Upflowing ions	Upflowing ions	
Heated Neutrals			
			∂B perturbations

Electron heating

Ion (Joule) Heating
Heated ions
Heated neutrals
Large and small scale flows

These instruments are chosen to measure neutral gas, ion and electron temperature enhancements as well as precipitating electron energy input. This will be compared with EISCAT to measure large- and small-scale Joule heating contributions. Finally, these results will be compared to model results to determine what extent, if any, electrodynamic processes contribute to upwelling.

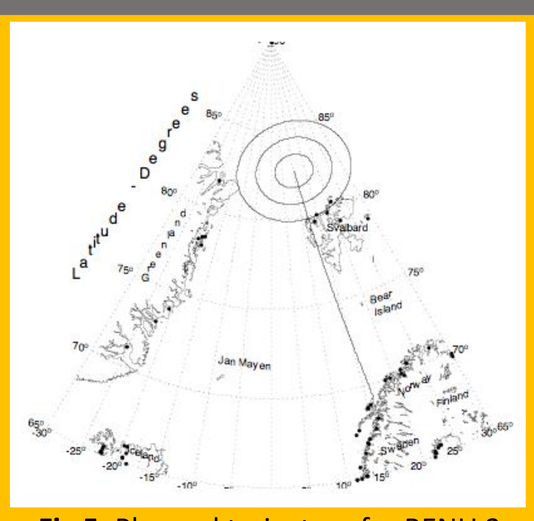


Fig 5. Planned trajectory for RENU 2

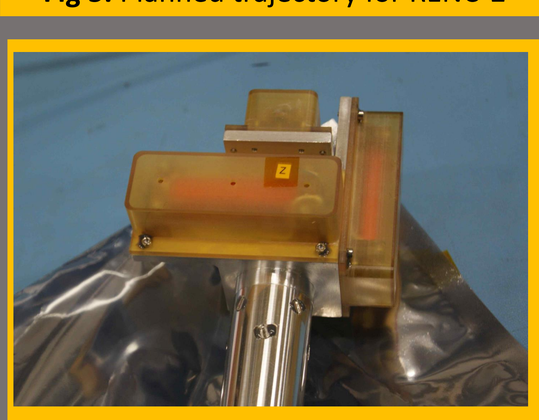


Fig 6. Close-up of Racetrack magnetometer on the end of it's boom-arm

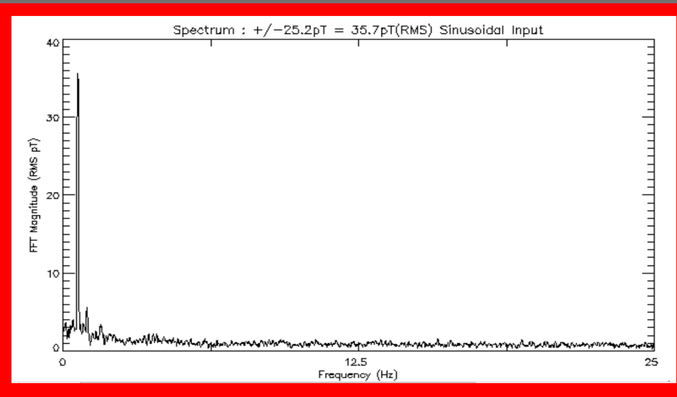


Fig 4. Racetrack magnetometer noise floor. Low noise achieved using new material UNH/Narod 6-81 (Collaboration with Dr. Barry Narod of Narod Geophysics)

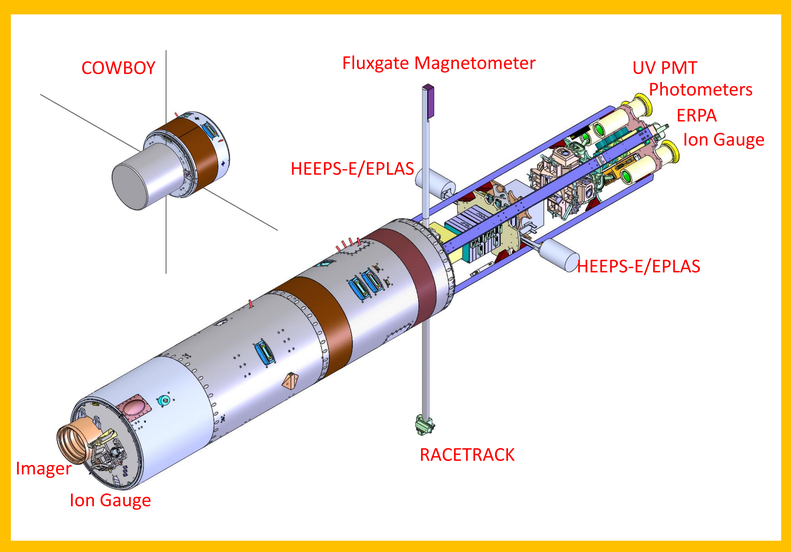


Fig 7. Layout of instrumentation on RENU2.

Fig 11. UV PMT with front baffle removed.

Fig 8. Imager, to be axially aligned on rocket and placed on de-spun platform.

Fig 10. RENU2 payload integration, ready for spin test.

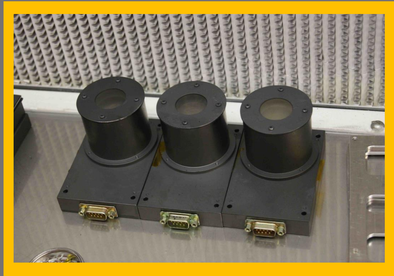


Fig 9. Electron Retarding Potential Analyzer (ERPA)

Citations: 1. Luhr et al., Thermospheric up-welling in the cusp region: Evidence from CHAMP observations, Geophys. Res. Lett., 31, 6805, 2004.