New Insights into Satellite Drag Variability from NADIR (Neutral Atmosphere Density Interdisciplinary Research)

A Multidisciplinary University Research Initiative (MURI)
Sponsored by the Air Force Office of Scientific Research

The **objective** of NADIR is to significantly advance understanding of drag forces on satellites, including density, winds, and factors affecting the drag coefficient.

We seek a level of understanding that will enable specification and prediction at the “next level” of performance.

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[http://ccar.colorado.edu/muri/](http://ccar.colorado.edu/muri/)
Terrestrial Processes and Sources Impacting Neutral Density
Focus Areas

I. Scales of Density Variability, Winds, and Drag Prediction
II. Internal Processes and Thermosphere-Ionosphere Coupling
III. Energy Partitioning at High Latitudes and Density Implications
IV. Wave Forcing from the Lower Atmosphere
V. Forecasting Geomagnetic Activity
VI. Forecasting Solar EUV/UV Radiation
VII. Driver-Response Relationships
VIII. Satellite Drag in the Transition Region
NADIR Participants

Co-Investigators
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~ Recent Highlights ~
VI. Forecasting Solar EUV/UV Radiation, *Juan Fontenla, Co-I*

**HIGHLIGHT: Far-Side Imaging**

Enhanced L-α radiation from active regions on the far side of the Sun, resonantly back-scattered from H atoms in the inner heliosphere.

Active regions on the far side of the Sun can be detected due to the difference in travel time between going into and out of an active region. This phase sensitivity is observed in waves appearing on the surface one the near side of the Sun.
V. Forecasting Geomagnetic Activity, Dusan Odstrcil, Co-I

HIGHLIGHT: Forecasting Solar Events Using Solar Magnetograms, David Falconer, Co-I

**Phase I:** Utilize “free magnetic energy” (~twist x size) of active regions on the Sun as a predictor of CMEs, Flares and SEP events.

Based on ~40,000 magnetograms from 1,300 Active regions (AR), 1996-2004, and NOAA’s flare, CME and Solar Energetic Particle (SEP) event catalog.

**Phase II:** Find secondary measures that influence an AR’s probability of producing an event, e.g., **size, flare history, magnetic isolation** (fewer flares for > 10 active regions on disk).
III. Energy Partitioning at High Latitudes and Density Implications, *Jeff Thayer, Co-I*

**HIGHLIGHT:** Rotating Solar Coronal Holes and Periodic Modulation of the Upper Atmosphere, *Lei, Thayer, Forbes et al.*

Rotating coronal holes give rise to periodic fast solar wind streams and corotating interaction regions (CIRs) that modulate the energy input into the geospace system.

![Graphs and images showing density changes and solar activity.](image)
IV. Wave Forcing from the Lower Atmosphere, Rashid Akmaev, Co-I

HIGHLIGHT: Midnight Temperature and Density Maximum, Akmaev, Fuller-Rowell

This is the first model simulation to capture the seasonal-latitudinal and amplitude of the MTM, and to account for its lower-atmosphere origin.
IV. Wave Forcing from the Lower Atmosphere, Rashid Akmaev, Co-I

HIGHLIGHT: Stratospheric Warming Effects on the Thermosphere, Akmaev, Fuller-Rowell, Forbes, Bowman

- Recent ionospheric and satellite drag data reveal potential signatures of stratwarming effects.
VII. Satellite Drag in the Reentry Region, Brian Argrow, Co-I

HIGHLIGHT: Large Longitudinal Density Variations Derived from SABER Temperature Measurements, Forbes, Bruinsma, Oberheide

Use tidal theory, wind and temperature observations to model density variability in the re-entry regime.

Longitude variability in density is observed near 400 km that is consistent, within the context of tidal theory, with the density variability derived between 80 and 110 km.
CONCLUSIONS

- Through NADIR we are understanding better the physical processes that drive satellite drag variability and that underly a predictive capability.

- The quiet Sun has enabled us to better isolate drag variability associated with “meteorological influences” from below.

- We look forward to new insights that derive from increasing levels of solar activity and different types of solar wind - magnetosphere - ionosphere - thermosphere coupling.
The IT System

- Magnetospheric Coupling
- Energetic Particles
- Polar/Auroral Dynamics
- Mass Transport
- Wave Generation
- Joule Heating
- Solar Heating
- Wind Dynamo
- IT System

- 1000 km
- 90 km
- 0 km

- Topographic Generation of Gravity Waves
- Planetary Waves
- Convective Generation of Gravity Waves & Tides
- NO
- O3
- solar-driven tides
- CO₂ Cooling
- CH₄
- H₂O

- Pole
- Equator

- Turbulence