The Role of Small Satellites in Aeronomy

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Aeronomy

- Aeronomy is the branch of science concerned with the upper atmosphere of the Earth and other planets, with specific attention to their physical properties, relative motion, and chemical compositions.
Frontiers in Aeronomy

- Talk for American Geophysical Union

- Need and Status of the Small Satellite Industry

- Summarized AIAA/USU Small Satellite Conferences
Major Points

• Aeronomy moving towards Space Weather

• Multi point observations of upper atmosphere required

• Limited by access to space
Experimental Vision

- Future Progress In Aeronomy will be tied to multipoint measurements in space
  - Deconvolve temporal/spatial ambiguities of \textit{in-situ} sensing techniques
  - Differentiate the integrated line-of-site quantities from remote sensing techniques
  - Sufficient observations for predictive space weather models.
Space Weather

- Forecast Capability?

- Upper atmosphere is dynamic.
  - Solar wind
  - Geomagnetic Storms
  - X-Rays, EUV and UV
  - The atmosphere below

- Existing models limited validity.
  - IRI, MSIS, Radiation
Space Weather Models

• Specifications and forecast models
  – State-of-the-art data assimilation techniques (Kalman filtering)
  – Physics based models of space environment
  – Driven with observational data

• Shown to be an effective method when dealing with a medium, such as the ocean or lower atmosphere, which has a complex and perhaps nonlinear response to both internal and external driving forces.
Driving Assimilative Models

- Utah Region Weather
  - 100 sites
  - Spatially uniform

- Global Space Weather
  - 125 sites
  - Not spatially uniform
In-Situ Observations

• The temporal-spatial ambiguity
  – Moving waves
  – Moving platform

• In-situ observations improved by constellations

\[ O = A \sin(k \cdot r - \omega \cdot t) \]

- Wavelength
- Frequency
- Observation Position
- Observation Time

Spacing 100 m to 2000 km along orbital track
Remote sensing

• A volume target
  – Single observations are integrated measurements

• Spatially diverse observations
  – Tomography
  – Stationary assumptions
  – Stereo imaging (lower limit)

• Remote sensing techniques improved by constellations
Current Constellation Missions

• FORMOSAT-3/COSMIC (6-Satellites)
  – 2006 Launch
  – 70 kg

• ST-5 (3-Satellites)
  – 2006 Launch
  – Mag Con

• THEMIS (5 satellite)
  – 2006 Launch
  – MIDEK Program

http://nmp.jpl.nasa.gov/st5/
Future Constellation Missions

- Radiation Belt Mappers ------------------ (3 Satellites)
- Ionospheric Mappers --------------------- (4 Satellites)
- Inner Heliospheric Sentinels -------------- (4 Satellites)
- Global Electrodynamics Connections --- (4-Satellites)
- Magnetospheric Constellation --------------(50 -100 Satellites)
- Magnetospheric Multiscale ----------------- (5 Satellites)
- Radio imaging of the magnetosphere---------(10 Satellites)
- Ionosphere/thermosphere coupling --------- (5 Satellites)
- Dedicated space weather constellations---(50 -500 Satellites)
Conclusion

• There is a need for small satellites in aeronomy to provide multi point measurements

• Need small satellite clusters and constellations

• Research manufacturability

• These future missions will never occur if:

\[(\text{constellation cost}) = N \times (\text{traditional satellite cost})\]

Where \(N\) is the number of satellites in the constellation.