

LWS Institute: Satellite drag
working group:
perspective on CCMC

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Outline

- LWS LEO Satellite Drag Institute
 - Goals and team members
- Major issues in drag estimation
- Future improvement
- Perspective on CCMC

Goals

- (a) Review the current status of atmospheric drag research and operational concerns for LEO satellites
- (b) Identify and understand the major issues in atmospheric drag estimation
- (c) Provide recommendations for future improvement in our ability to provide nowcast of satellite drag
- (d) Document the findings of the Institute in a comprehensive review paper

Team members

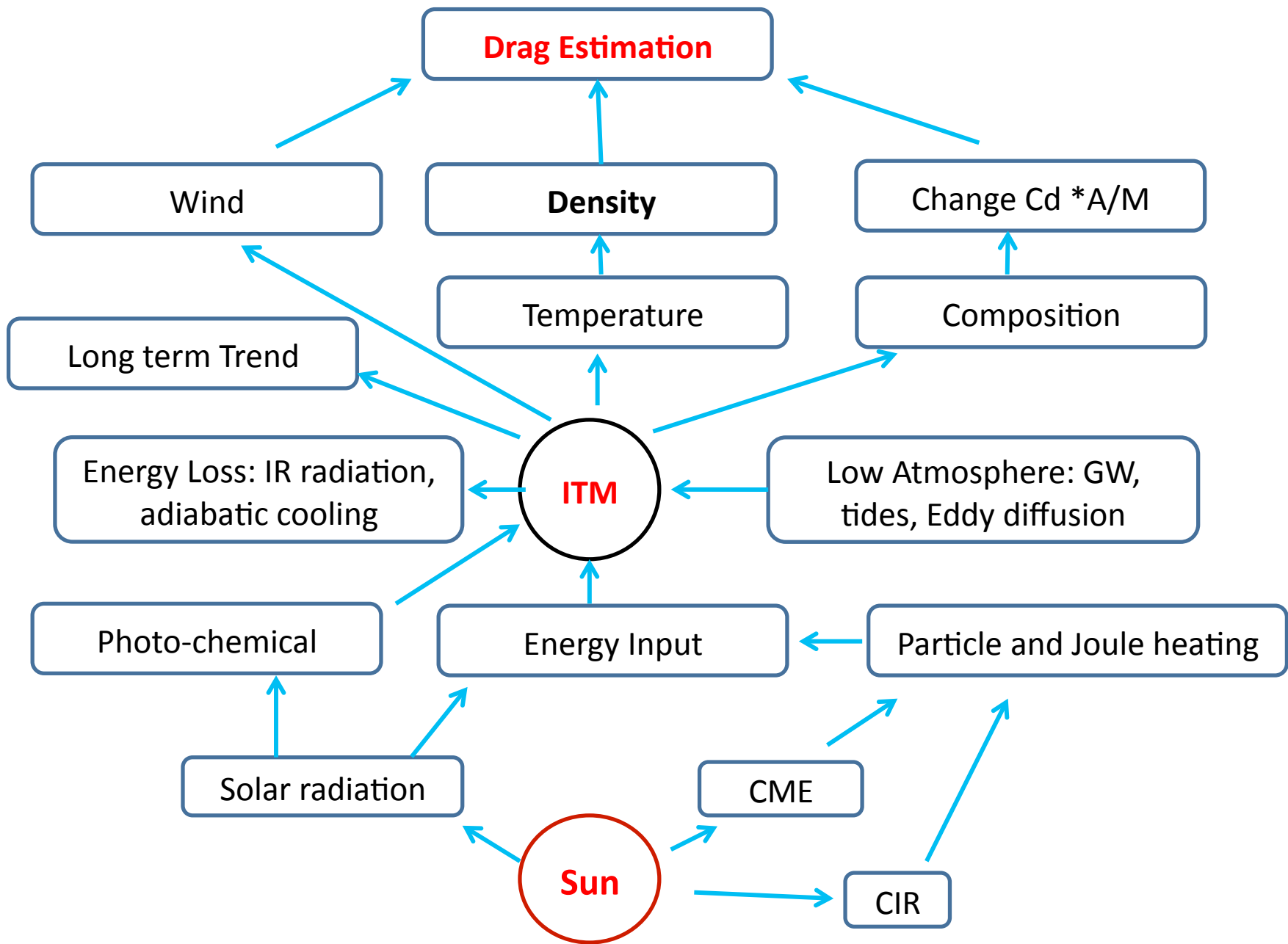
from government, industry and university in four countries

- ***Yongliang Zhang***, JHU/APL
- ***James C. Jones***, Northrop-Grumman
- ***Larry Paxton***, JHU/APL
- ***Gary Bust***, JHU/APL
- ***Aaron Ridley***, University of Michigan
- ***Angelos Vourlidas***, JHU/APL
- ***Delores Knipp***, University of Colorado
- ***Marty Mlynczak***, NASA
- ***Nancy Ericson (replaced by Dan Snow)***, Air Force Space Command
- ***Eric Sutton*** Air Force Research Laboratory
- ***Andrew Stephan***, NRL
- ***Yihua Zheng***, NASA CCMC
- ***Huixin Liu***, Kyushu University, Japan
- ***Matthew D. Hejduk***, Astrorum Consulting LLC
- ***Woo Kyoung Lee***, Korea Astronomy and Space Science Institute
- ***Jeff Thayer***, University of Colorado
- ***Sean Bruinsma***, CNES, France

Major issues in drag estimation

$$F = \frac{1}{2} C_d \frac{A}{M} \rho (V_{sat} - V_{atm})^2 \dots \dots \dots (1)$$

- ρ , neutral density, **the most variable term**
- V_{atm} , atmospheric neutral wind (not negligible during storm)



Density variations at 400 km

Variations	Change	Frequency
Solar cycle	1600%	11 yrs
Semiannual	125%	12 months
Solar UV rotation	250%	27 days
Major geomagnetic storms	800%	3 days
Diurnal effect	250%	1 day

Courtesy: Bruce Bowman

Accurately forecasting geomagnetic storm effects on orbit determination is needed

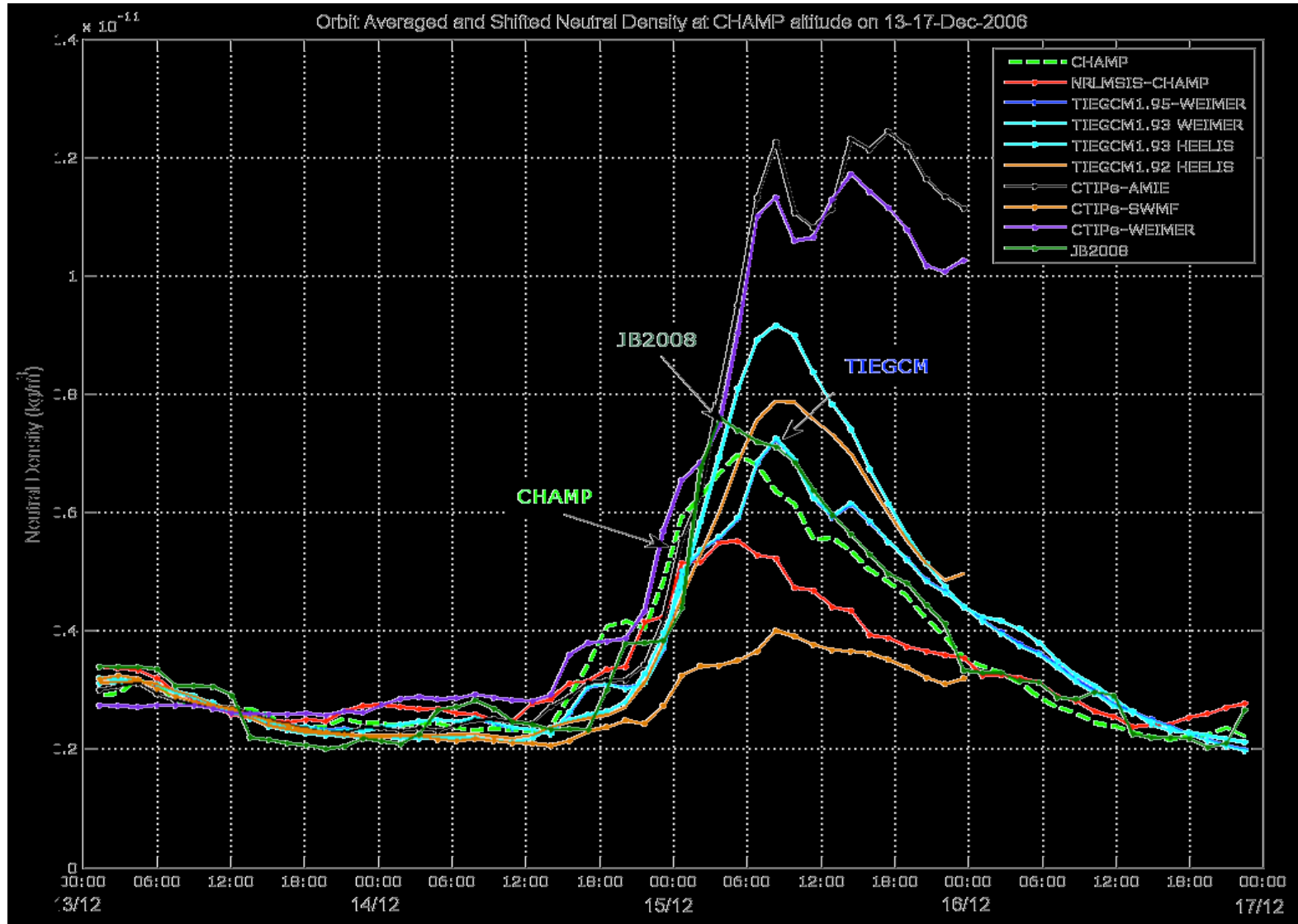
Future Improvement

- Measurements with true global coverage of thermospheric density, composition, temperature, heating and cooling rate.
- Advances in modeling work to include/update physical processes and minimize assumptions.

Neutral density comparison: CHAMP (orbital averaged) and models

Orbital average: ignore the spatial variation

2014 GEM mini-workshop report by Emine Ceren Kalafatoglu, Ja Soon Shim, Masha Kuznetsova, Zerefsan Kaymaz



Perspective on CCMC

- Ionosphere/thermosphere models in CCMC
 - SAMI3, CTIPe, USU-GAIM, TIE-GCM, GITM (physics based)
 - MSIS, IRI, etc. (empirical)
- Challenges
 - Determine the best model for thermosphere nowcast and forecast?
 - Combine the models?
 - Remove assumptions and improve boundary specification?
 - Make use of real-time data?