

**CHAMP, GRACE, GOCE and Swarm density and wind characterization with improved gas-surface interactions modelling (PPT)**

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**Publication date**

2018

**Document Version**

Final published version

**Citation (APA)**

March, G., Doornbos, E., & Visser, P. (2018). *CHAMP, GRACE, GOCE and Swarm density and wind characterization with improved gas-surface interactions modelling (PPT)*. 42nd COSPAR Assembly 2018, Pasadena, California, United States.

**Important note**

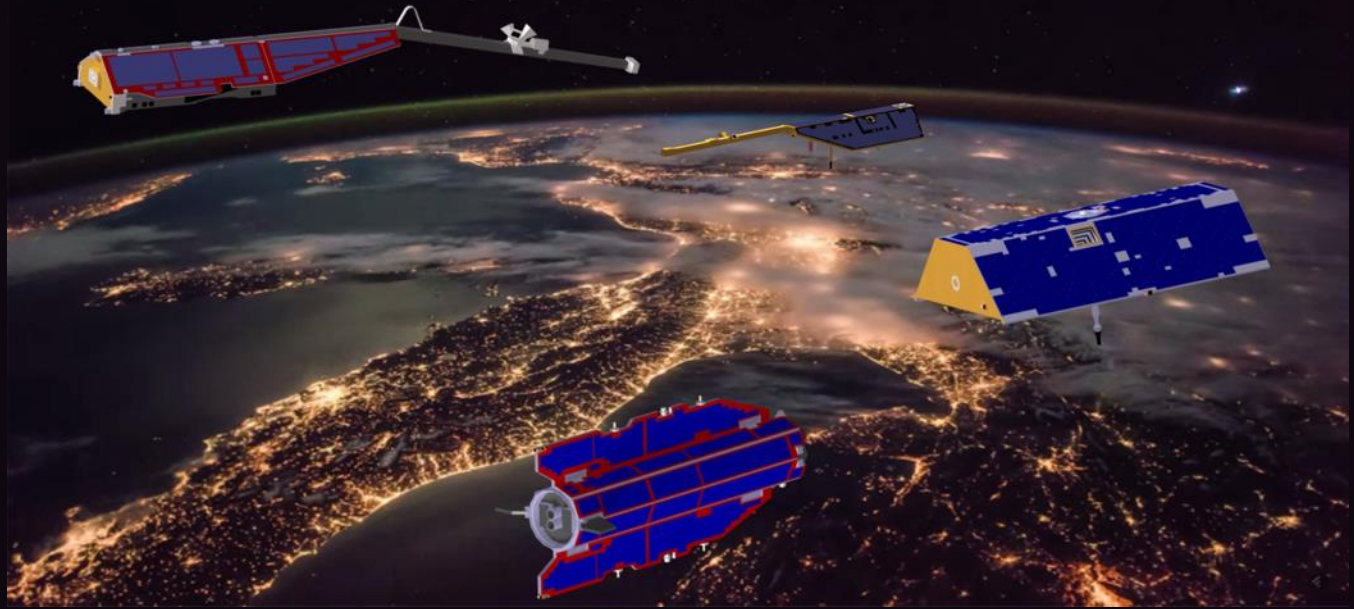
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## CHAMP, GRACE, GOCE and Swarm density and wind characterization with improved gas-surface interactions modelling

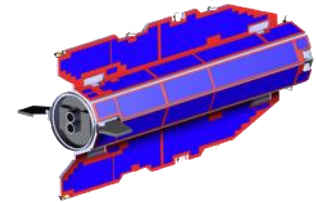
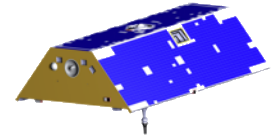
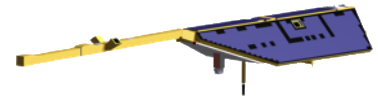
G. March, E. Doornbos, P.N.A.M. Visser

[g.march@tudelft.nl](mailto:g.march@tudelft.nl)

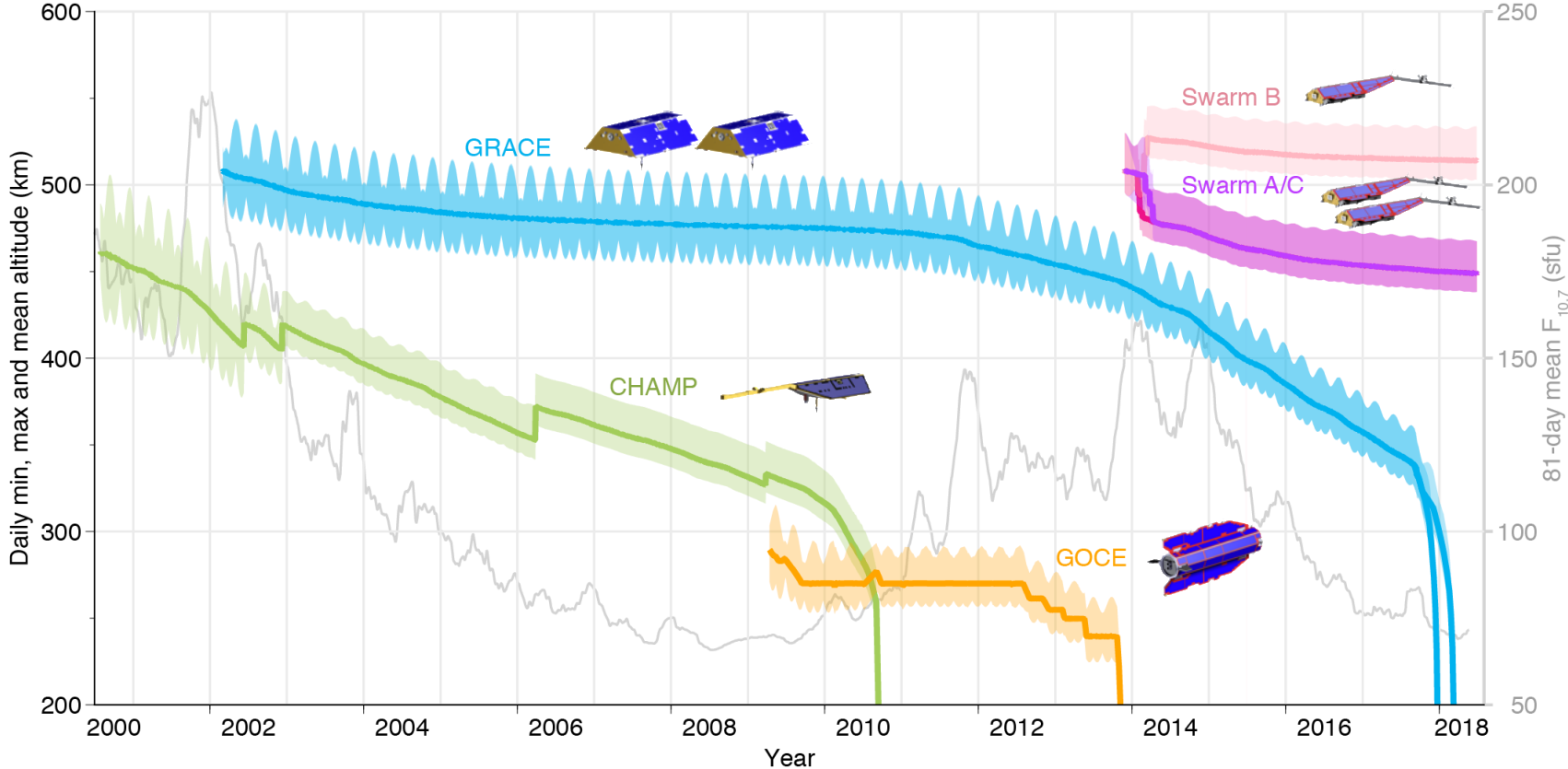
42<sup>nd</sup> COSPAR Assembly 2018,  
Pasadena, California, U.S.A.,  
Monday, July 16, 2018.

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- Gas-Surface Interactions (GSI);
- Influence on Aerodynamics;
- Influence on Wind;
- Influence on Density;
- Summary and Outlook.



# Introduction



# Improved SPARTA model

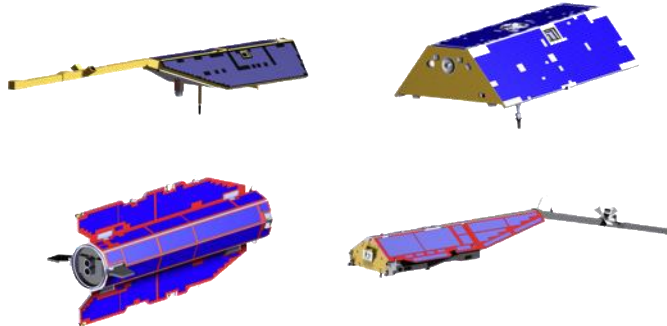
## Panel model

Panel	Area (m <sup>2</sup> )	Area Normal Vector			Area (%)	Material	IR-Emissivity	Solar-Absorptivity (BoL/EoL)
		X	Y	Z				
Nadir I	1.540	0.0	0.0	1.0	15%	Aluminum/Alodine Foil	0.100	0.368/0.52
					70%	OSR Radiator	0.780	0.050/0.230
					10%	Black Kapton	0.780	0.930
					5%	Beta Cloth	0.800	0.400

*ESA-EOPG-MOM-MO-15,  
Siemes (2018)*

Pros	Cons
Simple approach	Low fidelity geometry
Low computational cost	No Shadowing
	No Multiple reflections

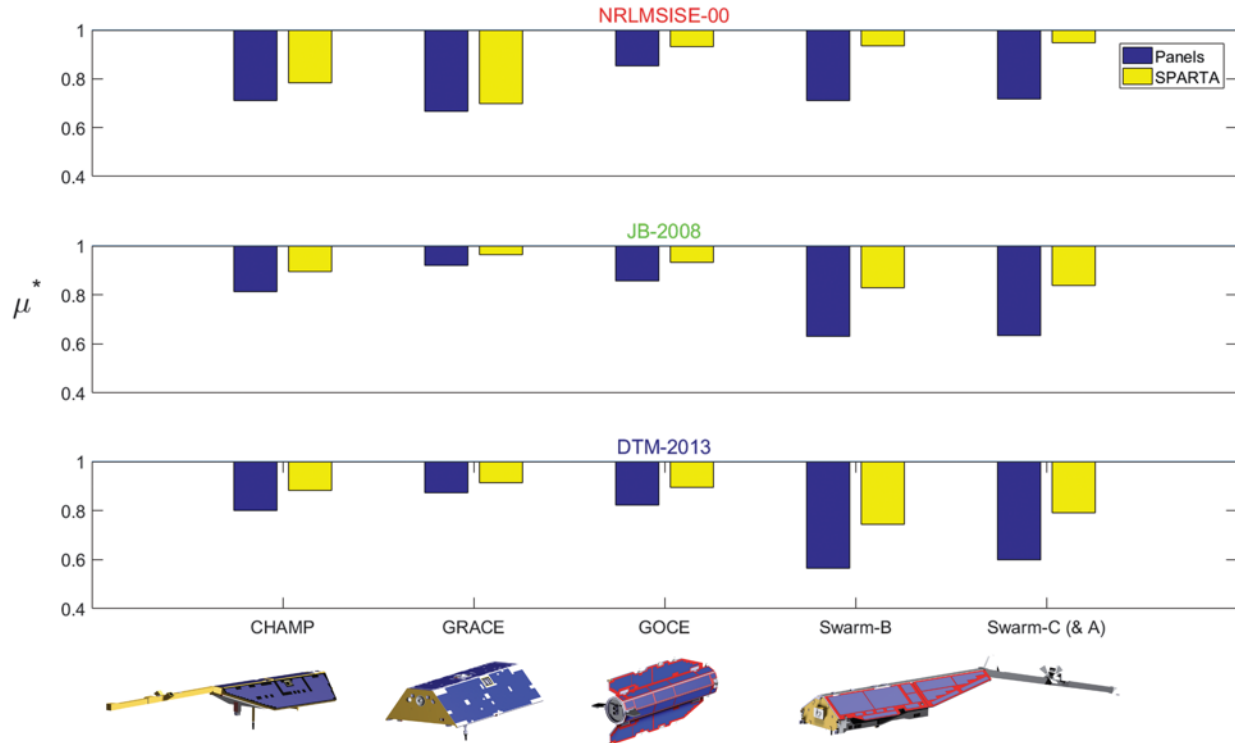
## SPARTA (Stochastic **P**arallel **R**arefied-gas **T**ime-accurate **A**nalyzer) model



Pros	Cons
High fidelity geometry	Complex approach
Shadowing	Expensive computational cost
Multiple reflections	

# Improved SPARTA model

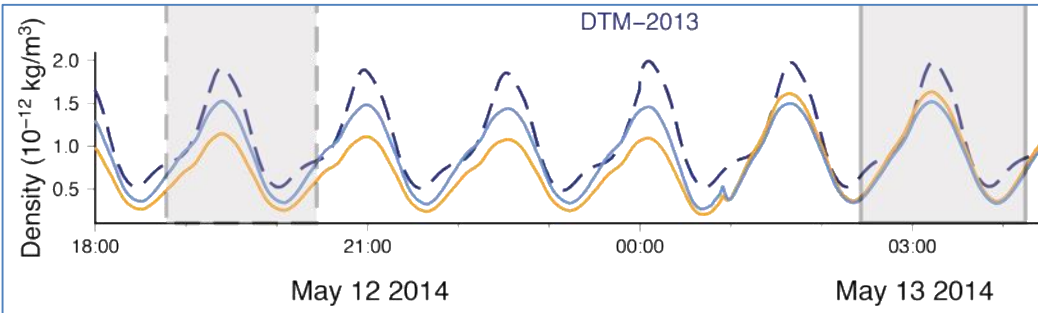
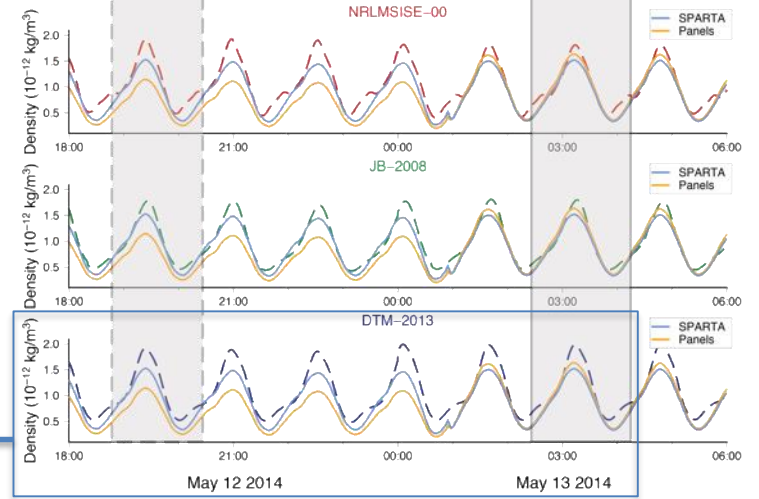
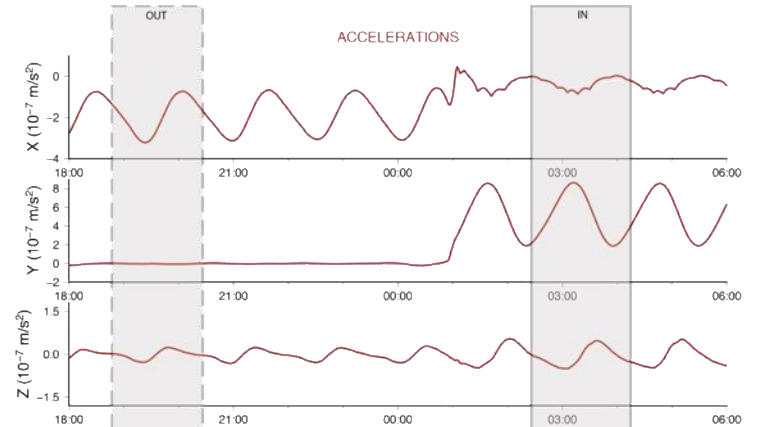
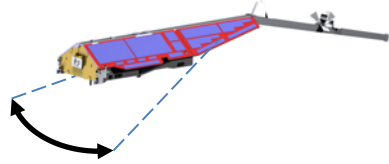
New densities turned out to be higher reaching a mean **+11%** for CHAMP, **+5%** for GRACE, **+9%** for GOCE and **+32%** for Swarm.



# Attitude manoeuvre Comparison

(90° Yaw man.)  
13/05/2014

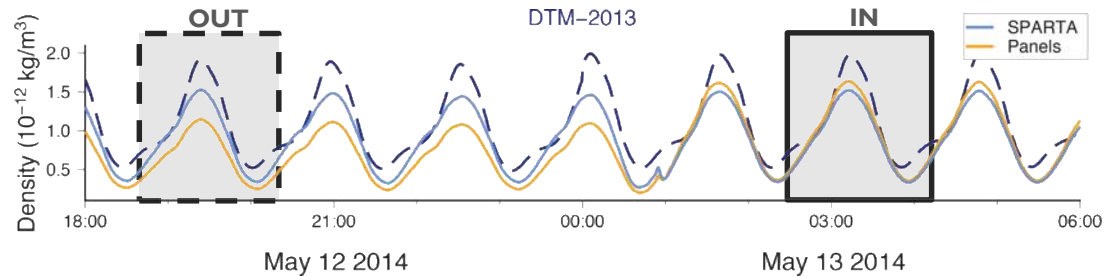
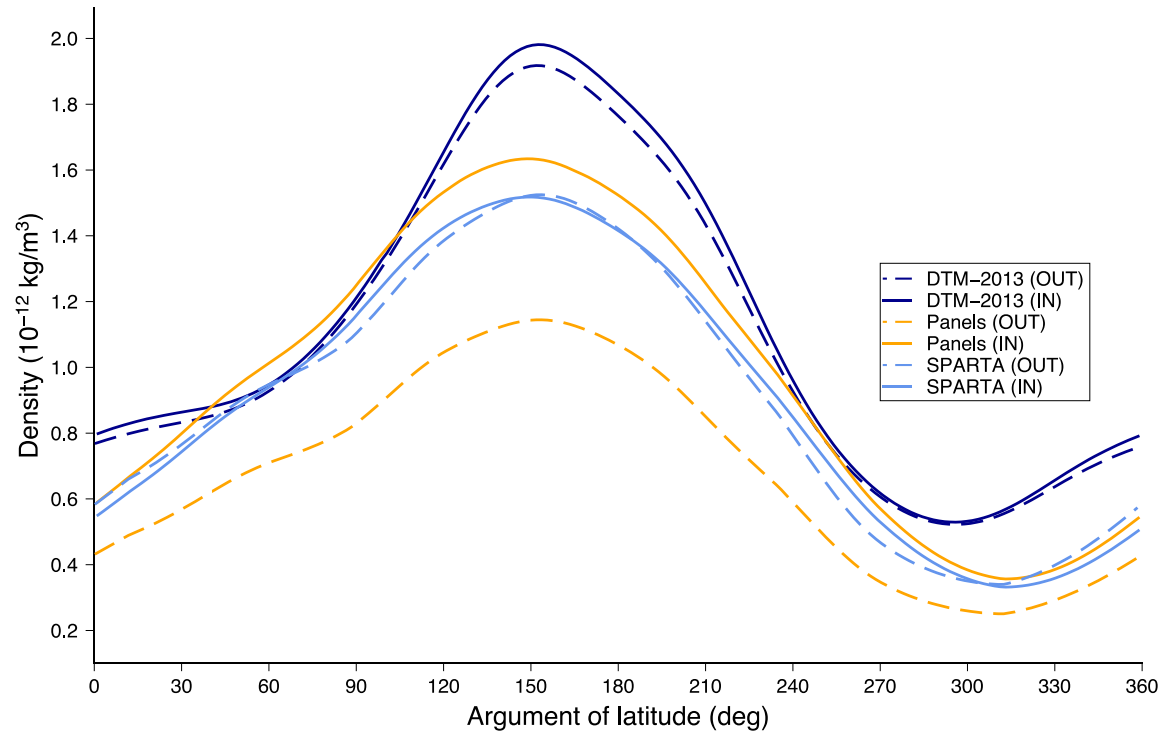
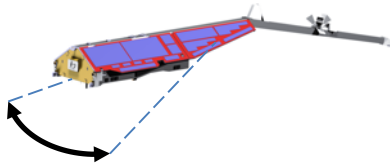
X-Y-Z Accelerations  
&  
Density comparison with 3  
atmospheric models



# Attitude manoeuvre Comparison

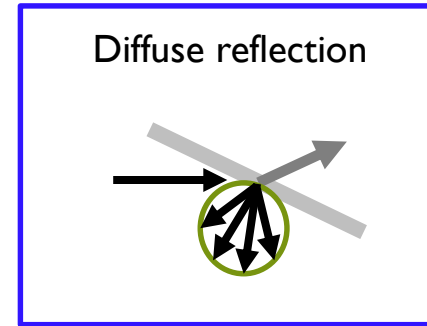
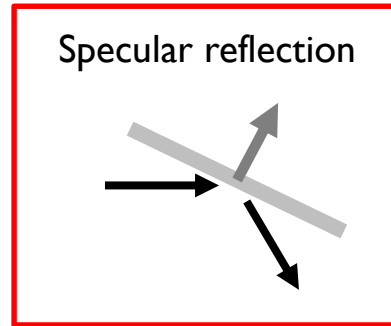
(90° Yaw man.)  
13/05/2014

X-Y-Z Accelerations  
&  
Density comparison with 3  
atmospheric models



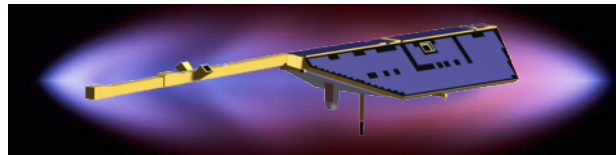


# Gas-Surface Interactions (GSI)



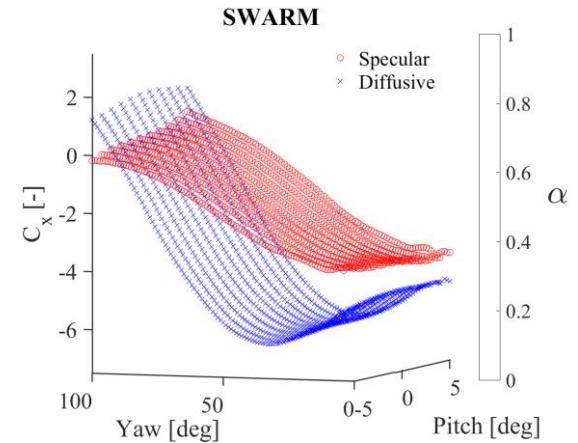
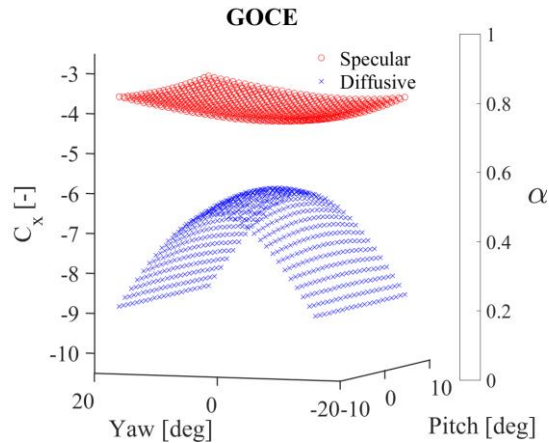
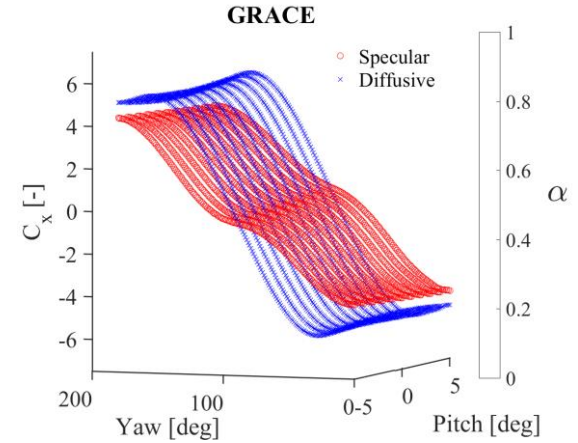
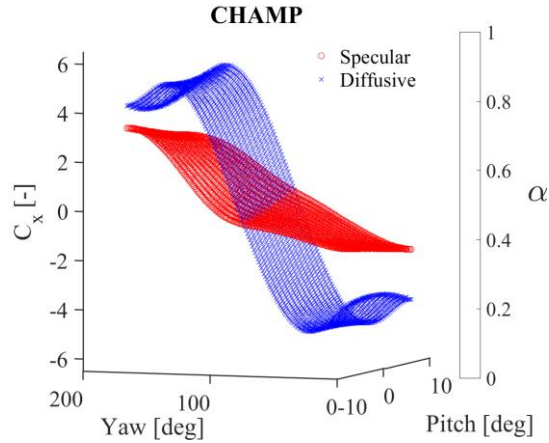
$$C_D = (1 - \sigma) C_{D,spe} + \sigma C_{D,dif}(\alpha_E)$$

$$\alpha_E = \frac{T_{inc} - T_{re}}{T_{inc} - T_w}$$



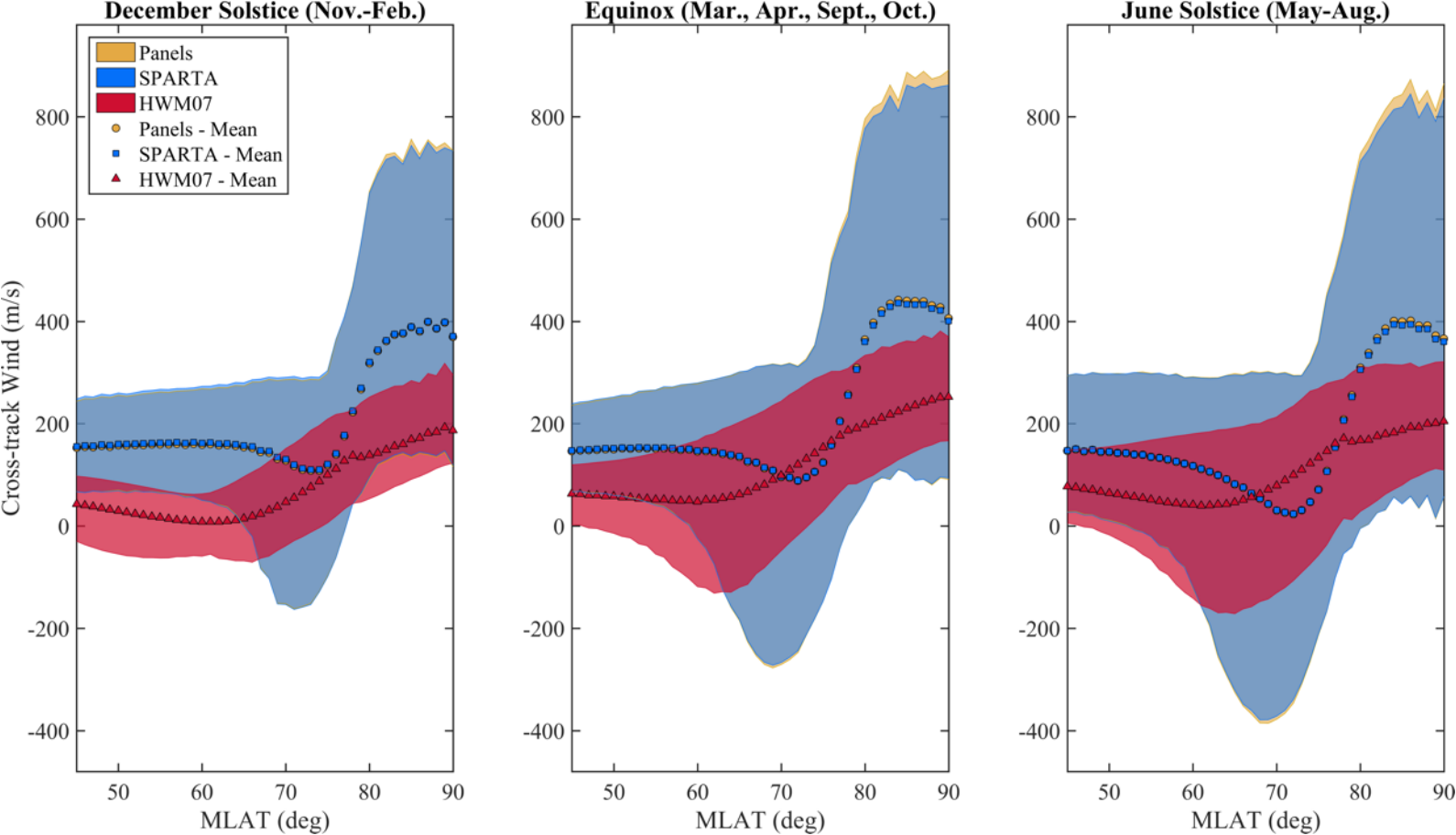
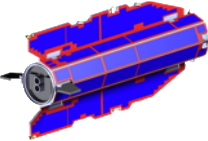
- Adsorption of gases on satellite surfaces;
- (Solar activity);
- (Altitude);
- ...?!

# Influence on Aerodynamics



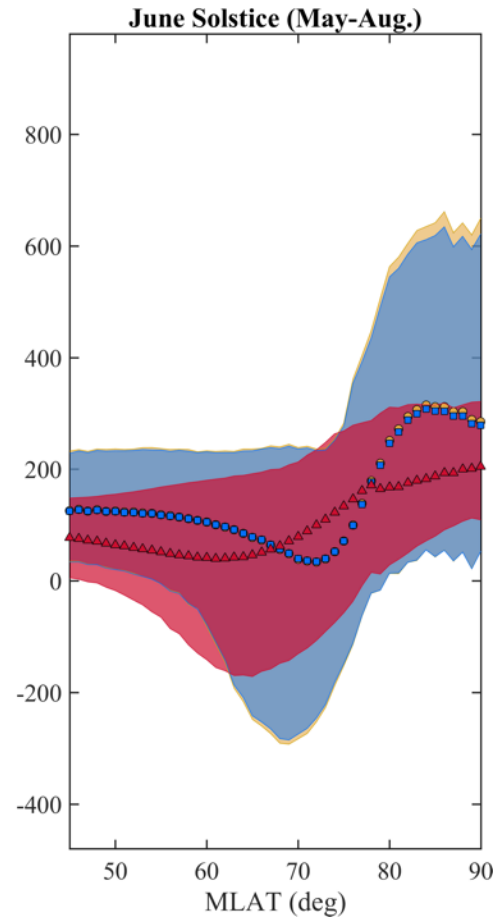
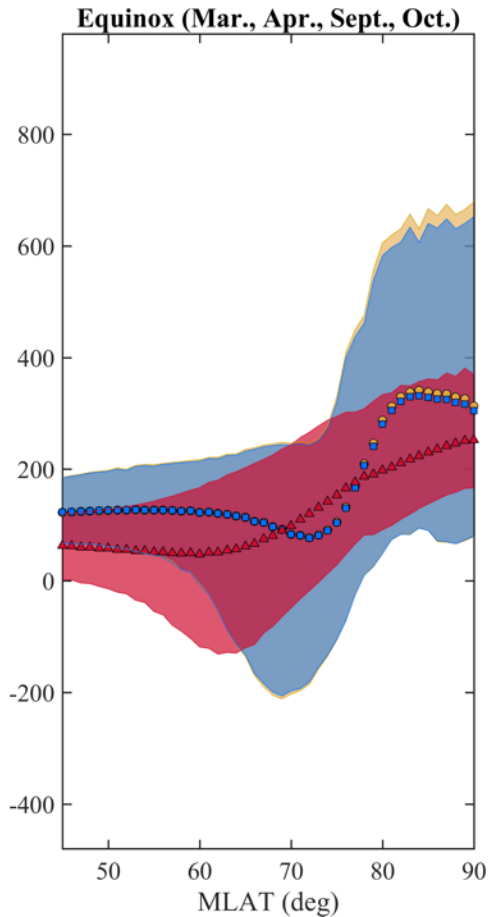
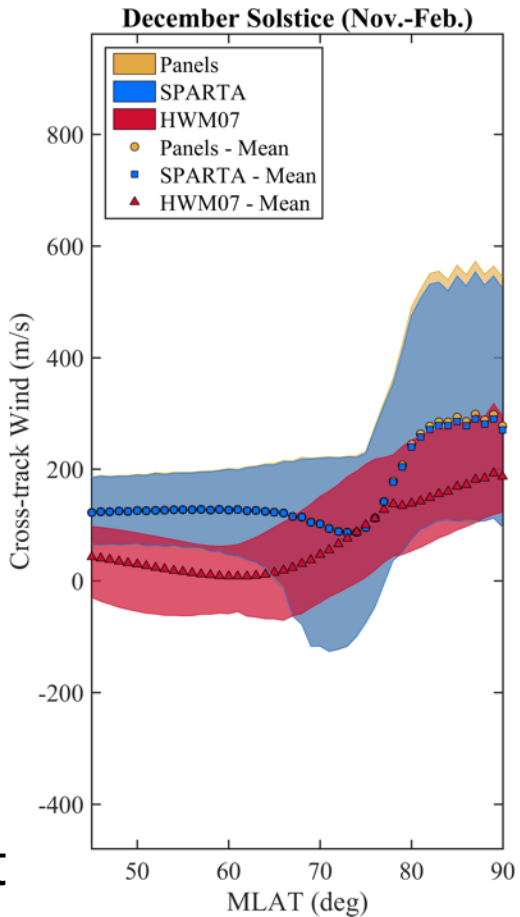
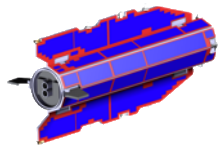
# Influence on Wind

GOCE winds between: 2010-01-01, 2013-01-01;  $\alpha_E = 1.00$



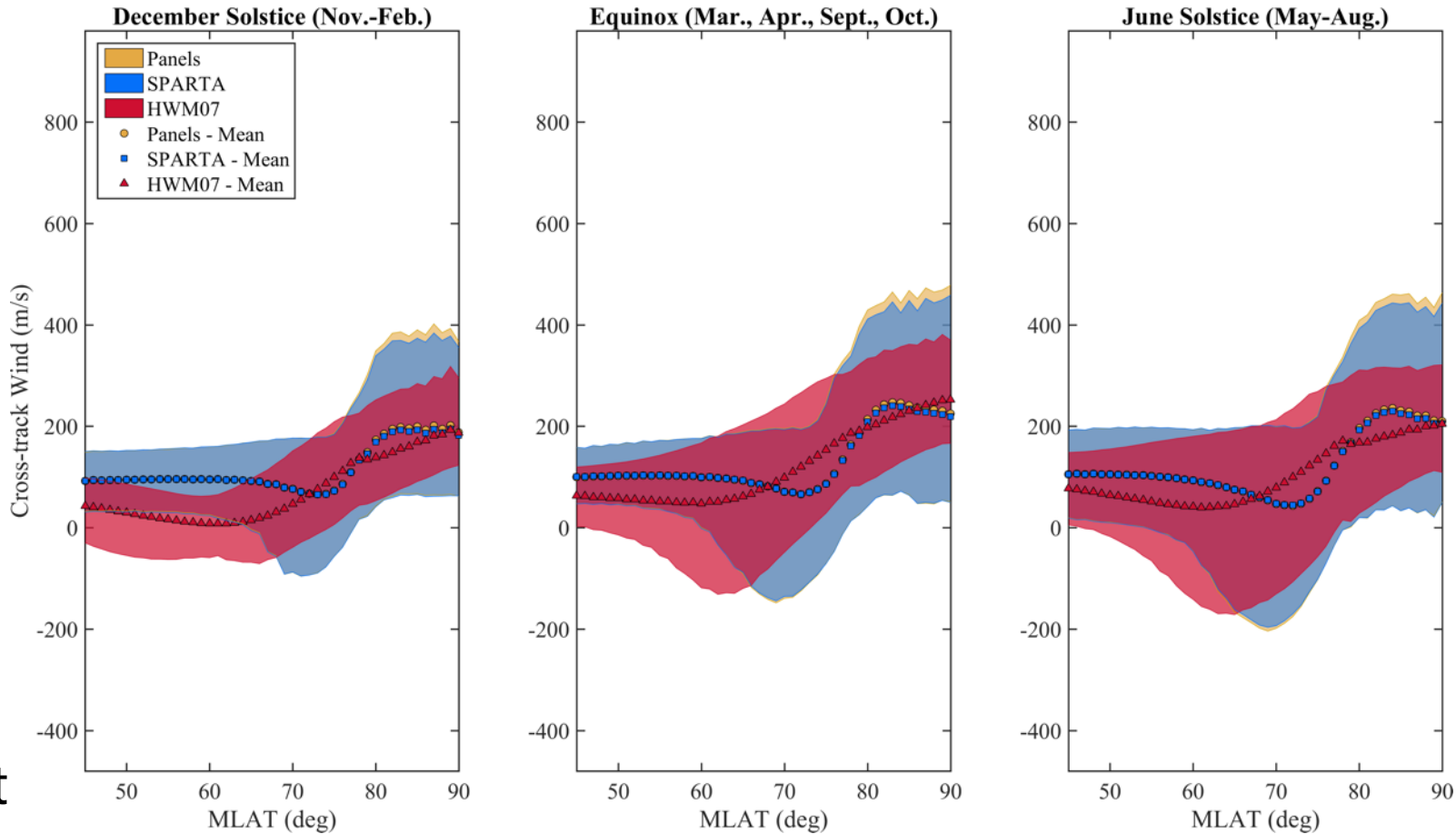
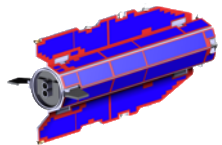
# Influence on Wind

GOCE winds between: 2010-01-01, 2013-01-01;  $\alpha_E = 0.93$



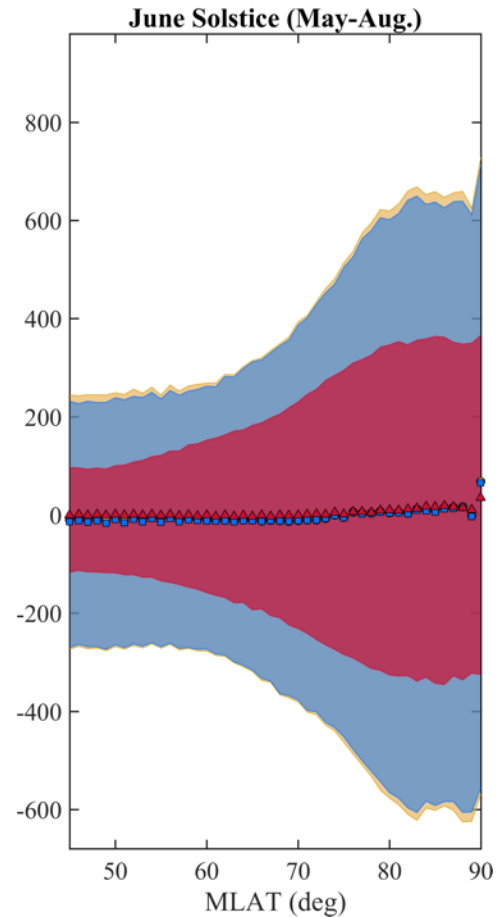
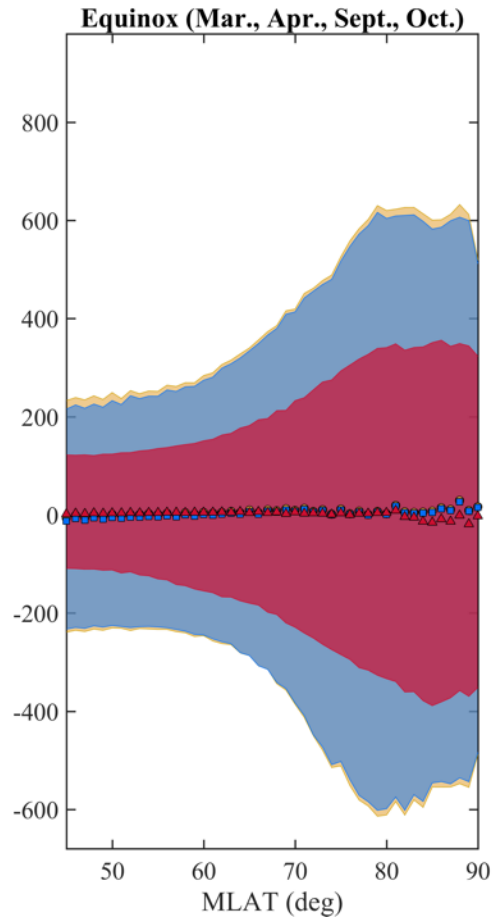
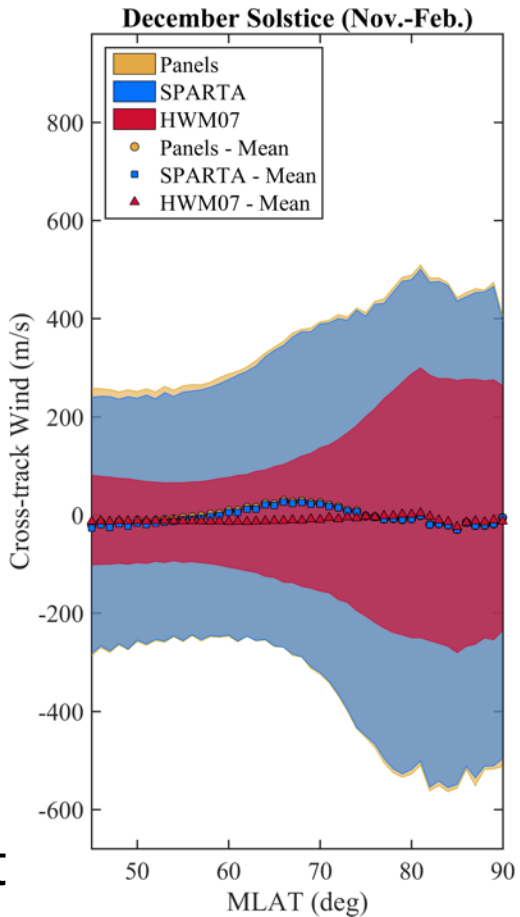
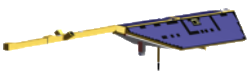
# Influence on Wind

GOCE winds between: 2010-01-01, 2013-01-01;  $\alpha_E = 0.60$



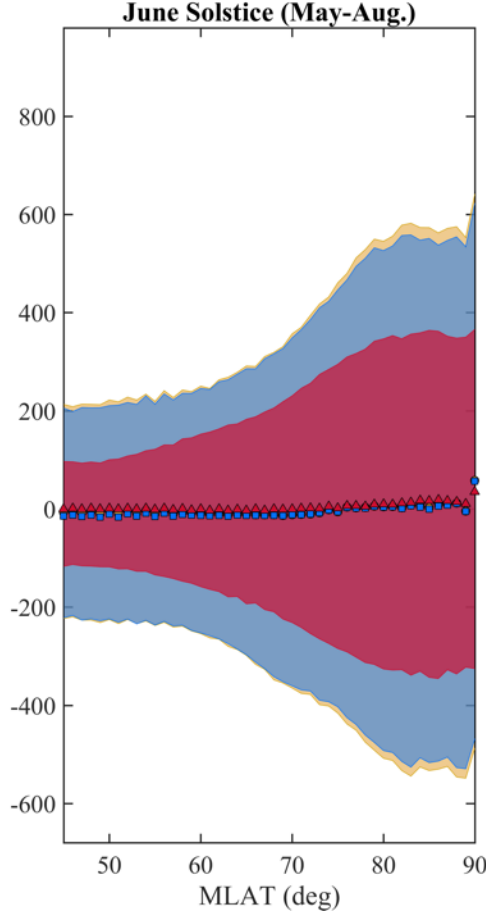
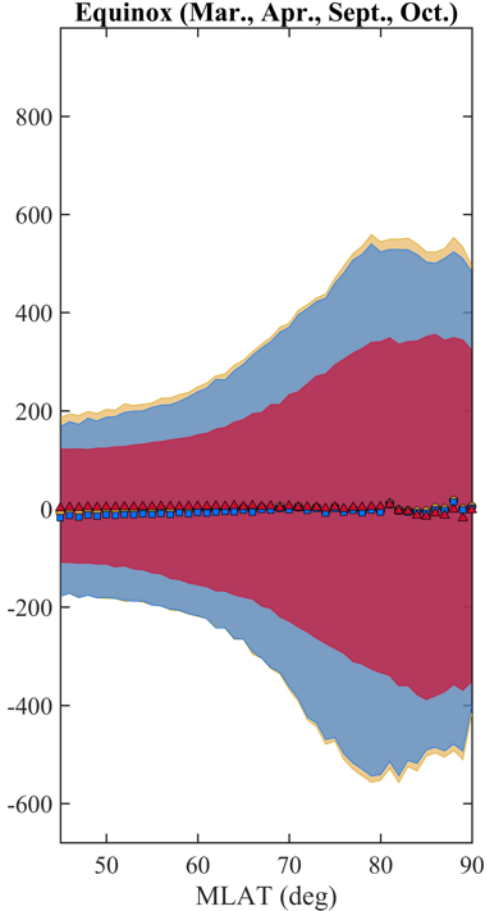
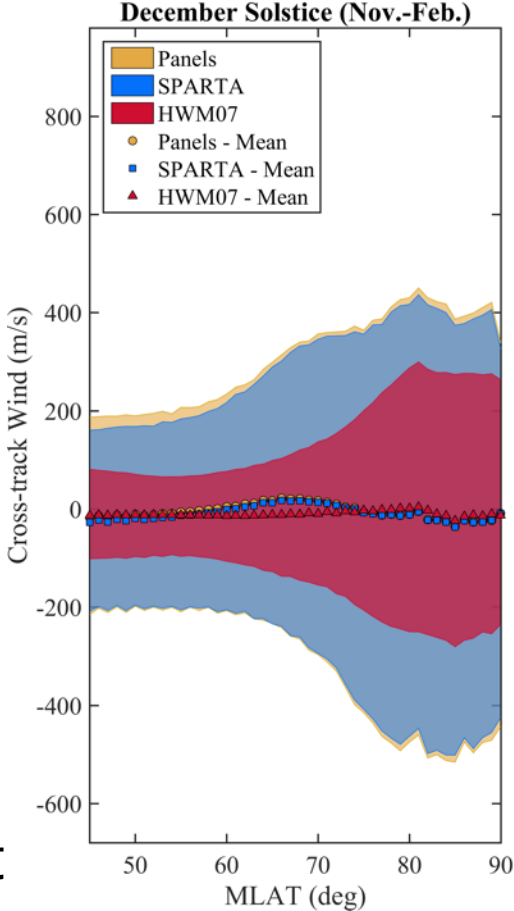
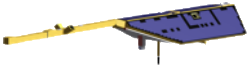
# Influence on Wind

CHAMP winds between: 2002-01-01, 2005-01-01;  $\alpha_E = 1.00$



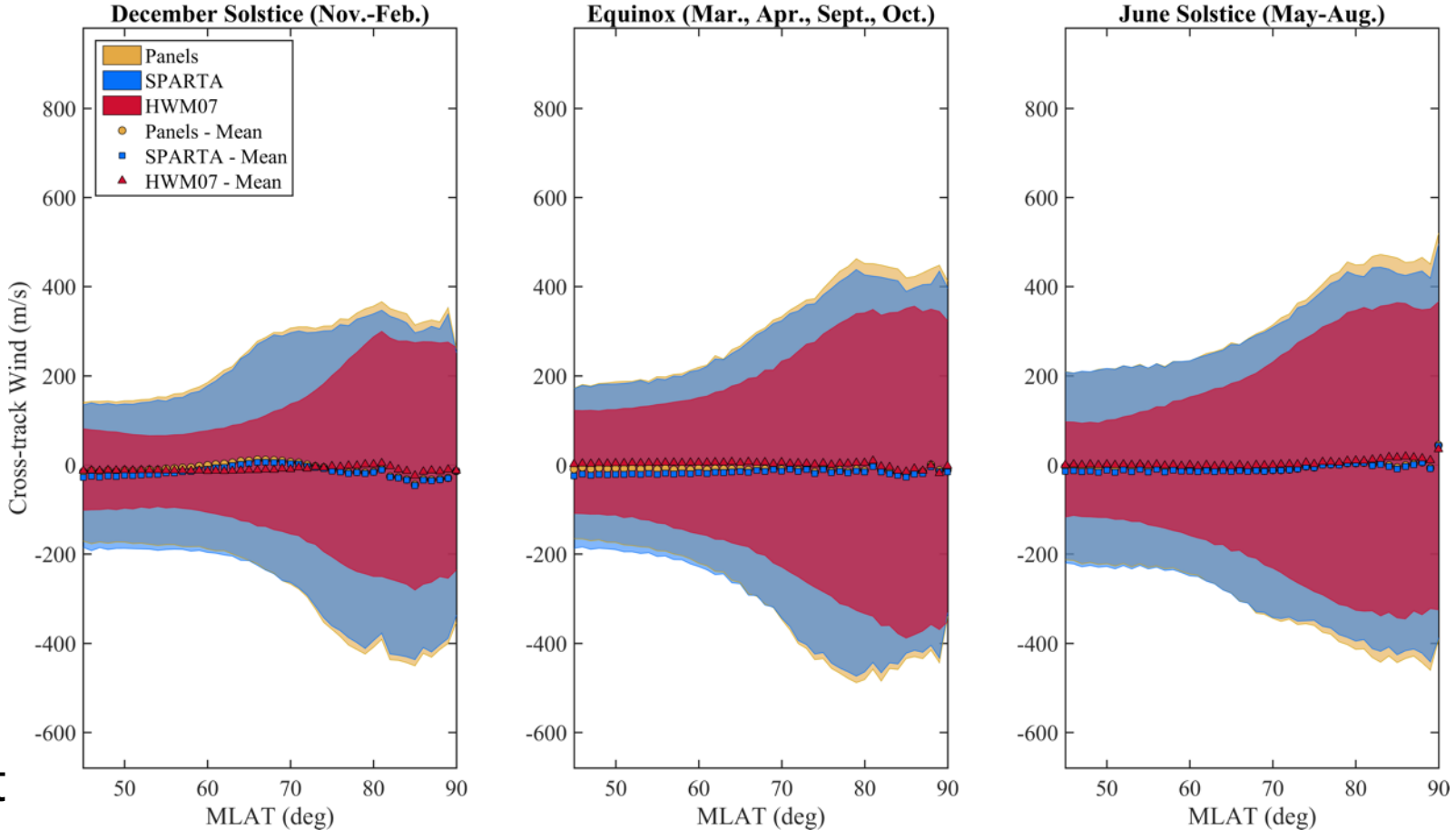
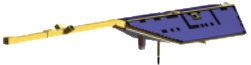
# Influence on Wind

CHAMP winds between: 2002-01-01, 2005-01-01;  $\alpha_E = 0.93$



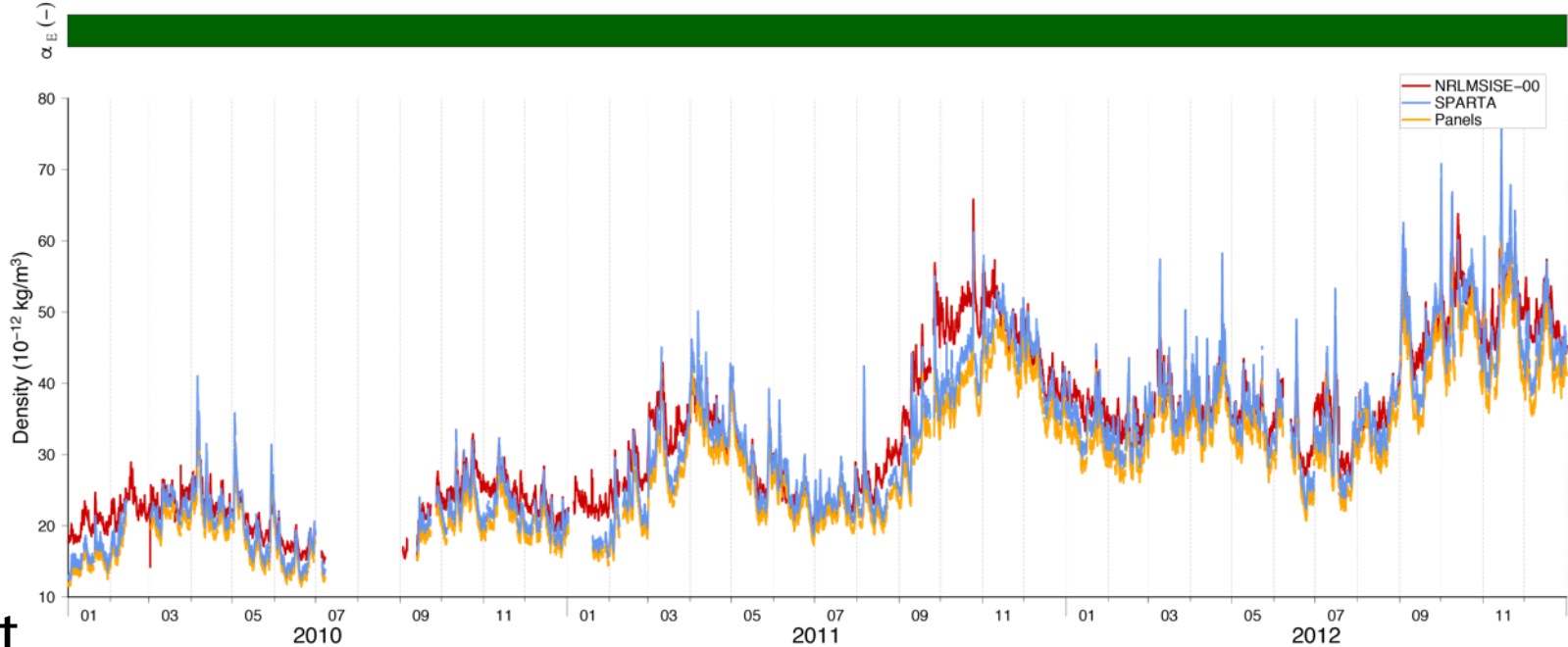
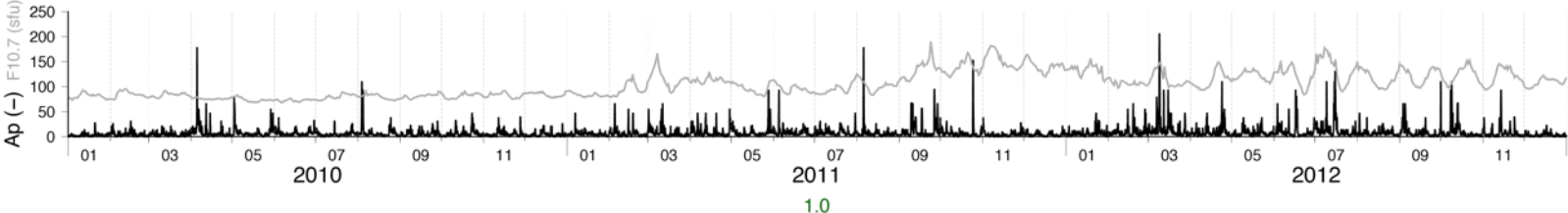
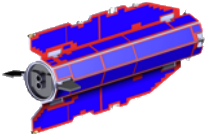
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CHAMP winds between: 2002-01-01, 2005-01-01;  $\alpha_E = 0.60$

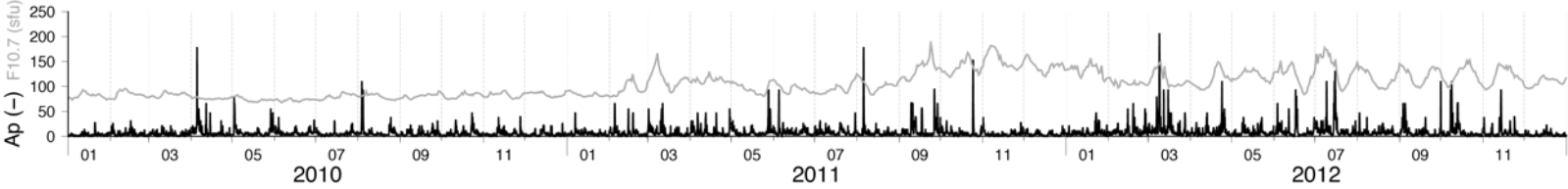
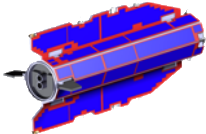




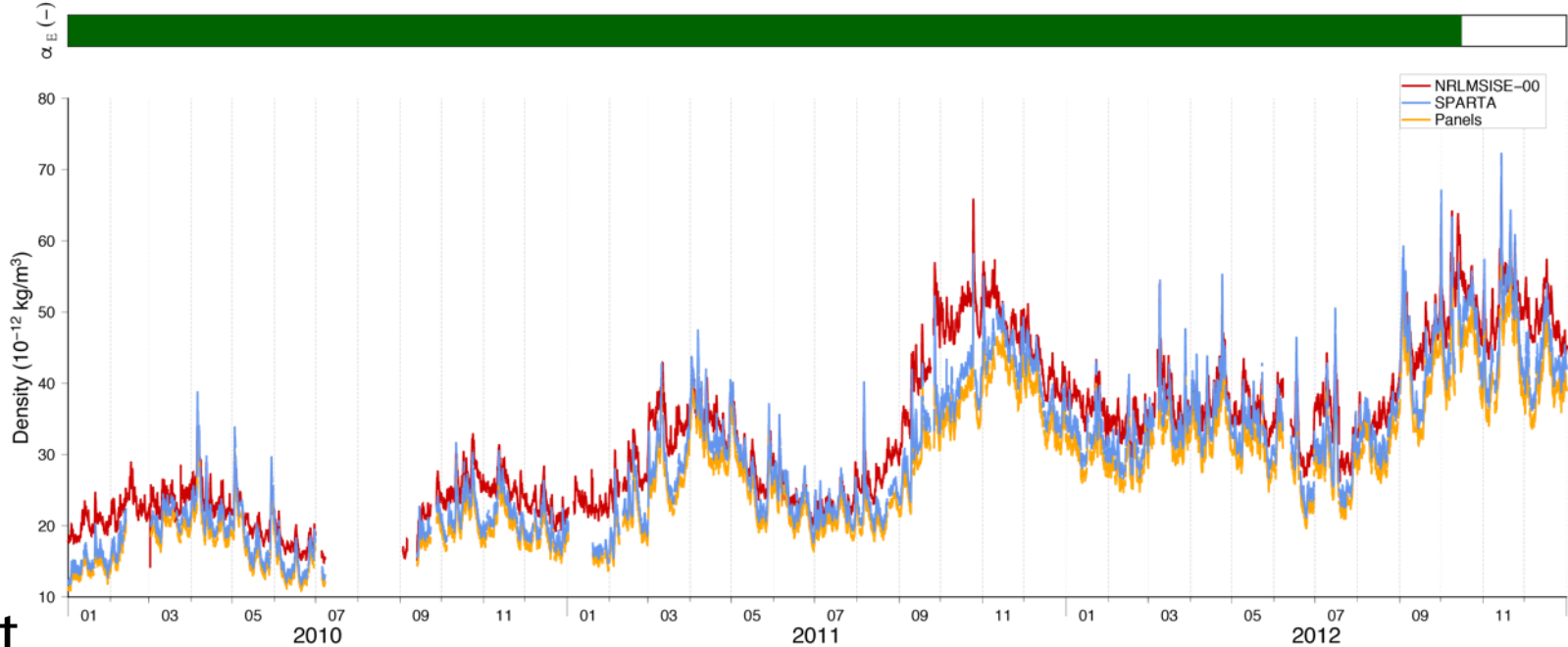
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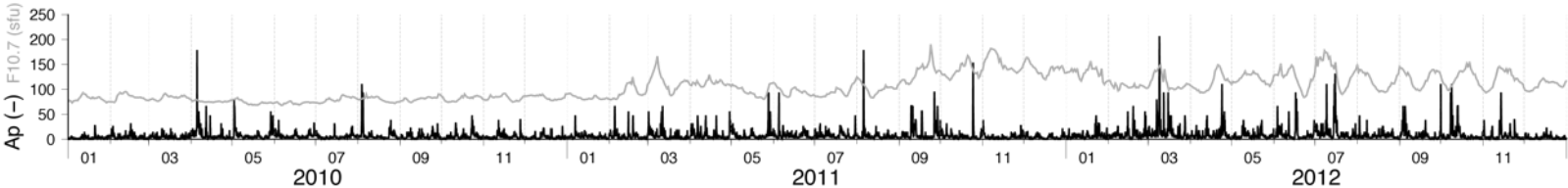
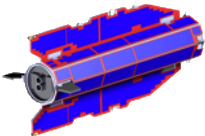
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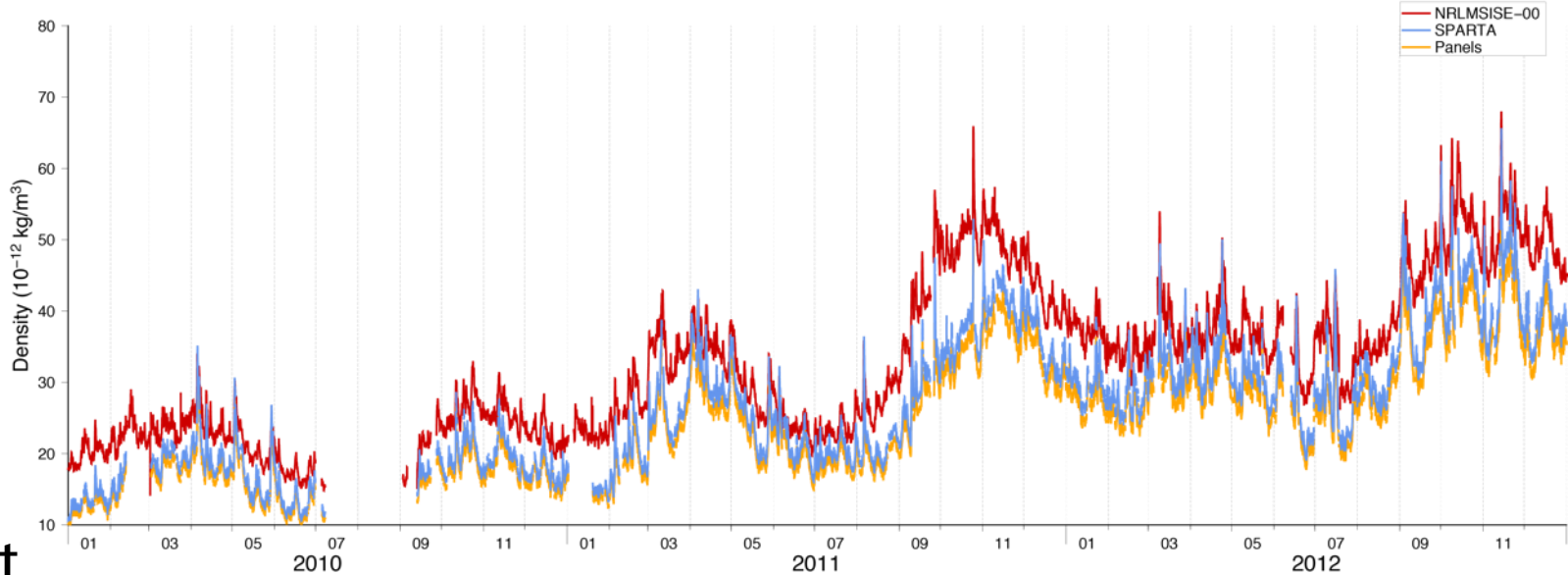
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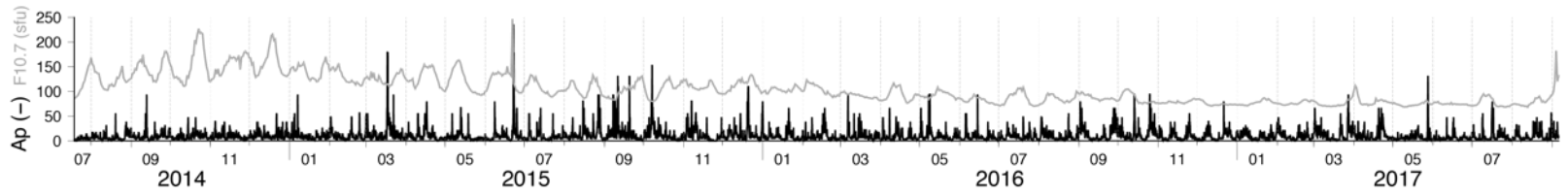
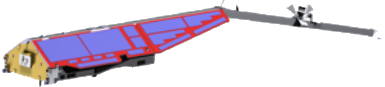
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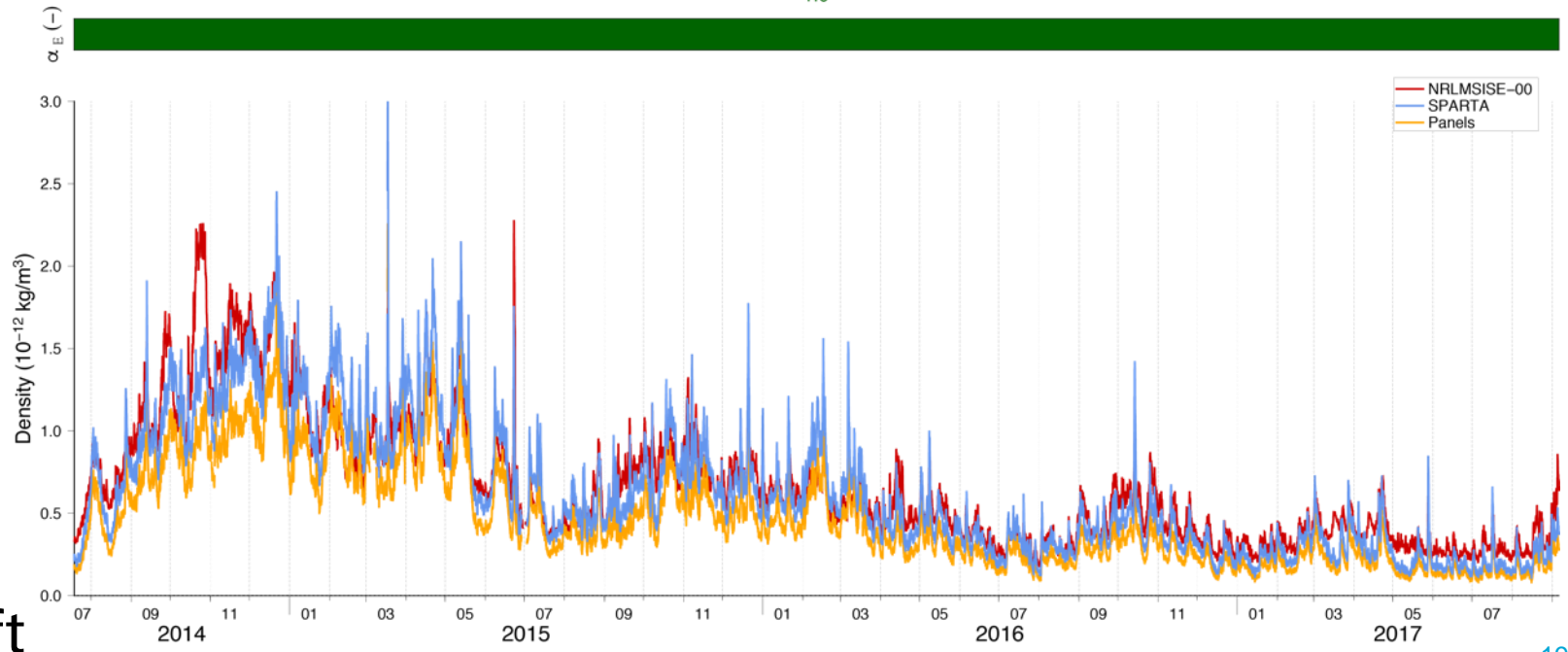
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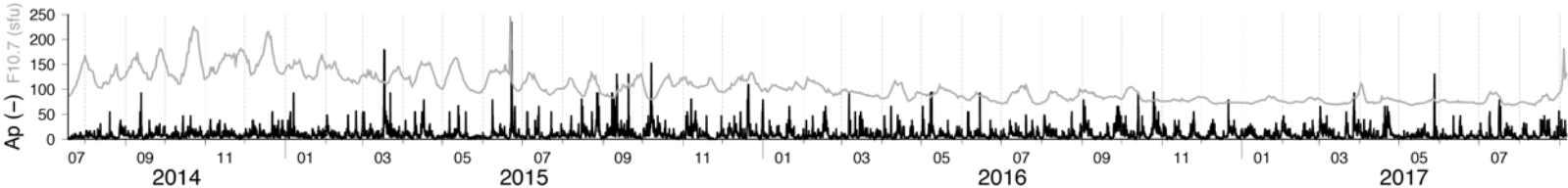
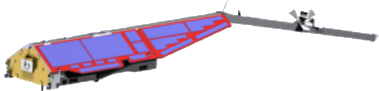
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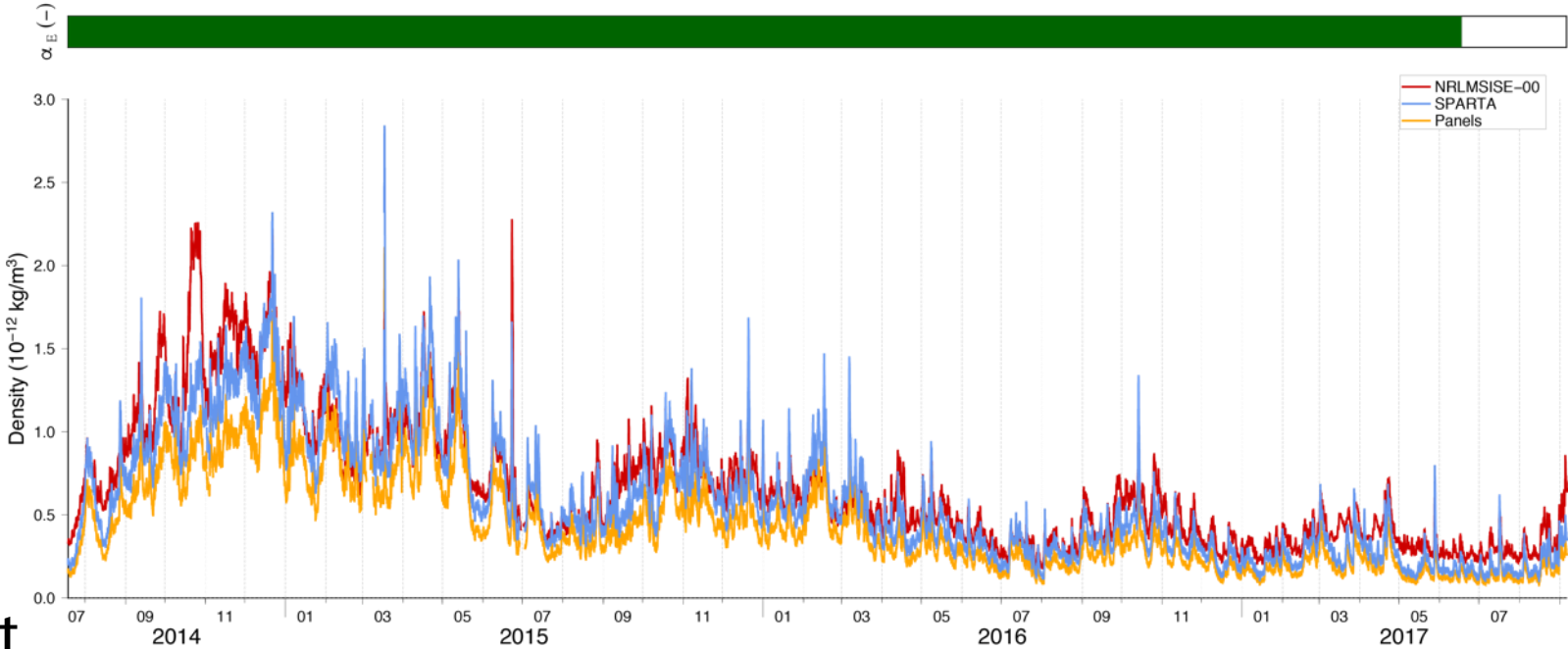
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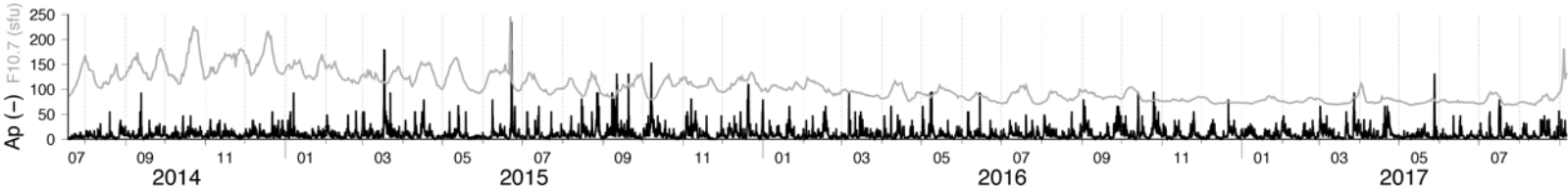
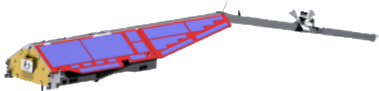
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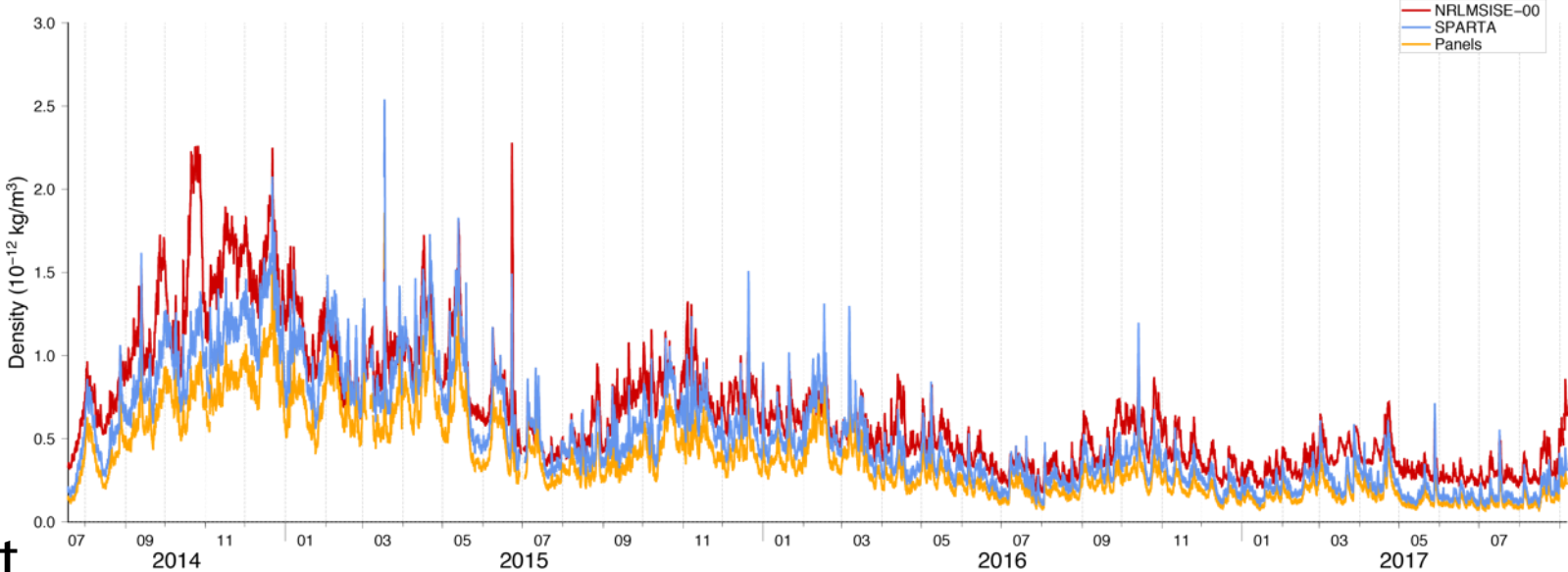
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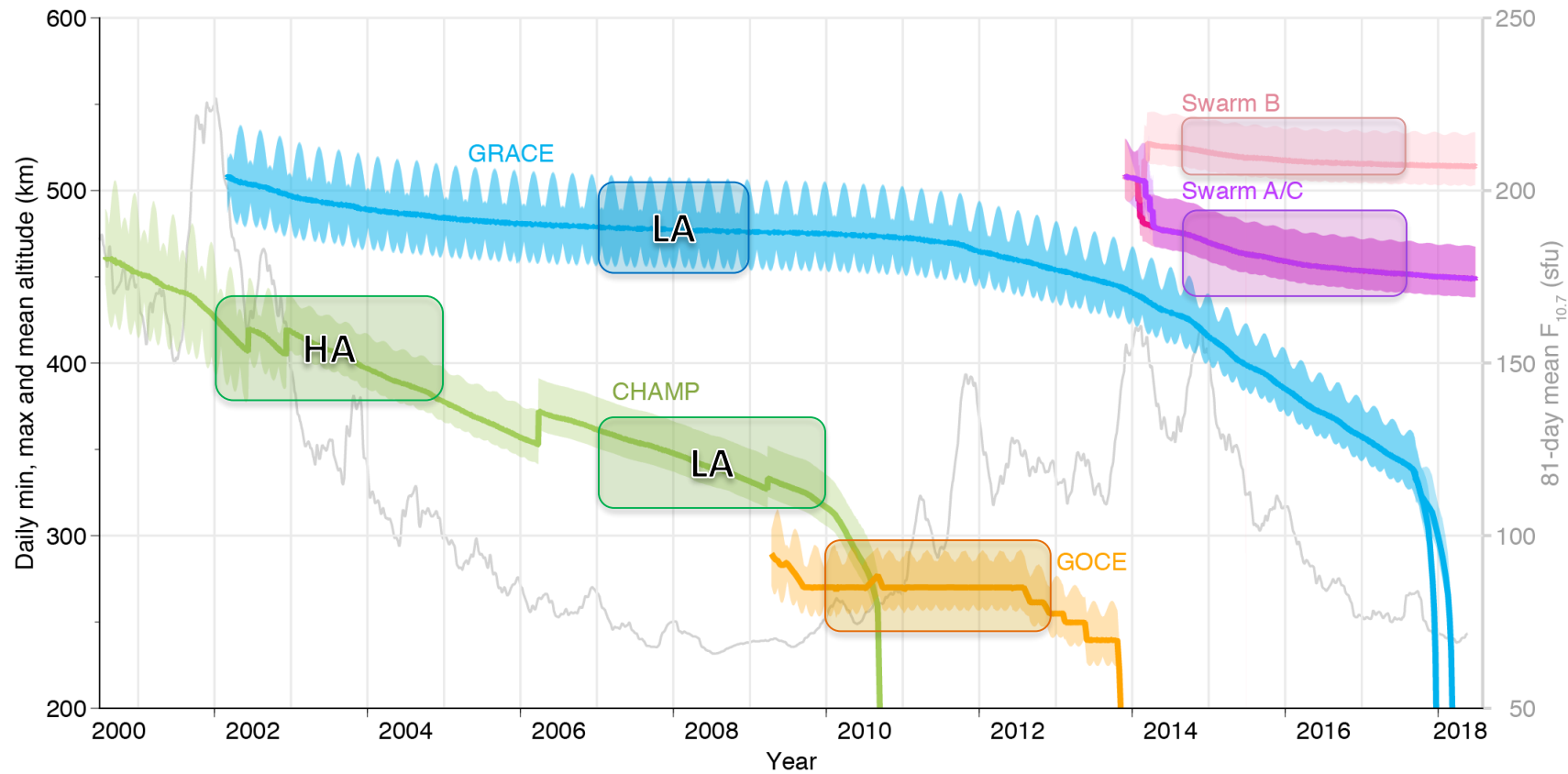
# Influence on Density: Swarm-A



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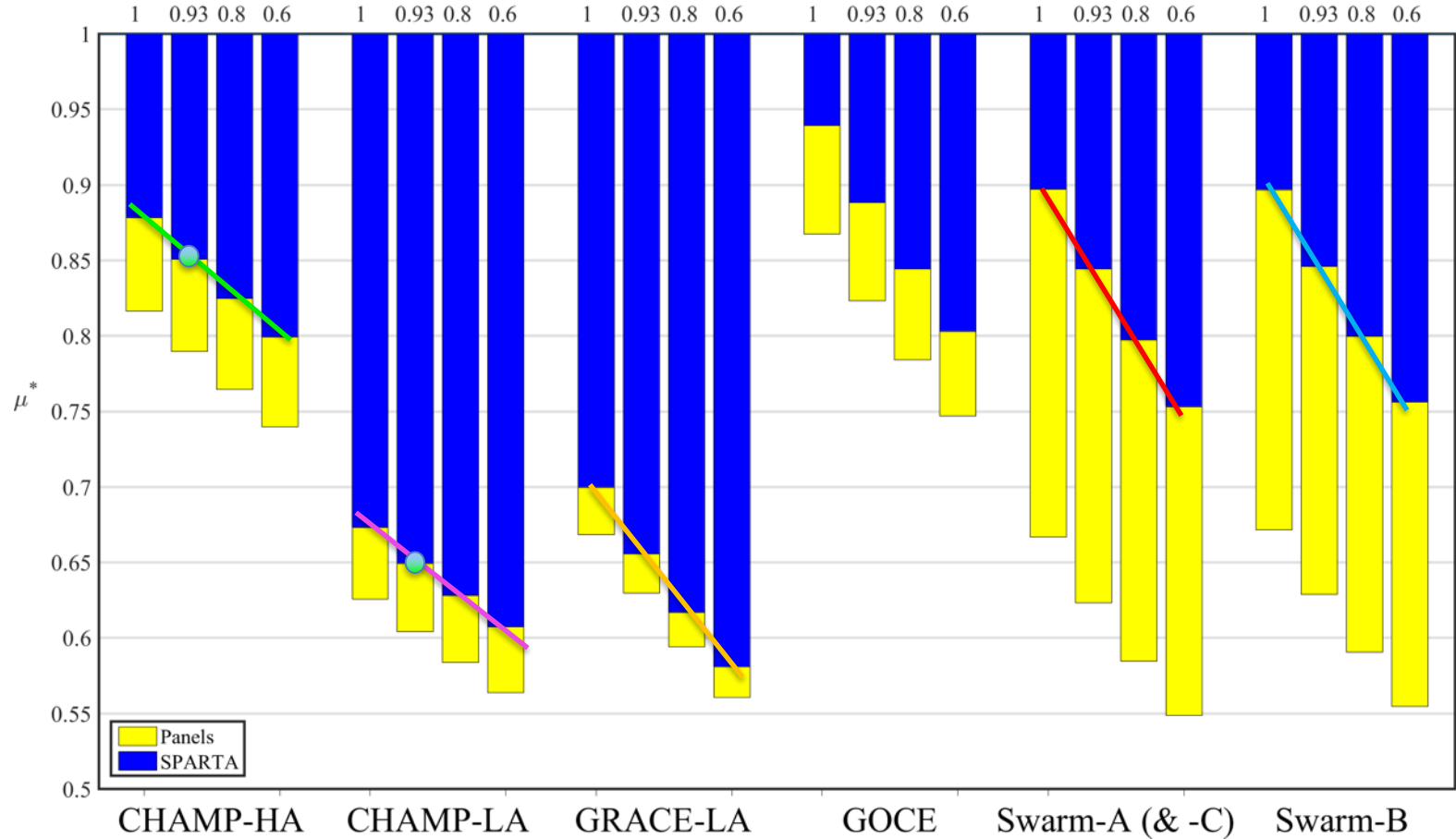


# Influence on Density (ratios)



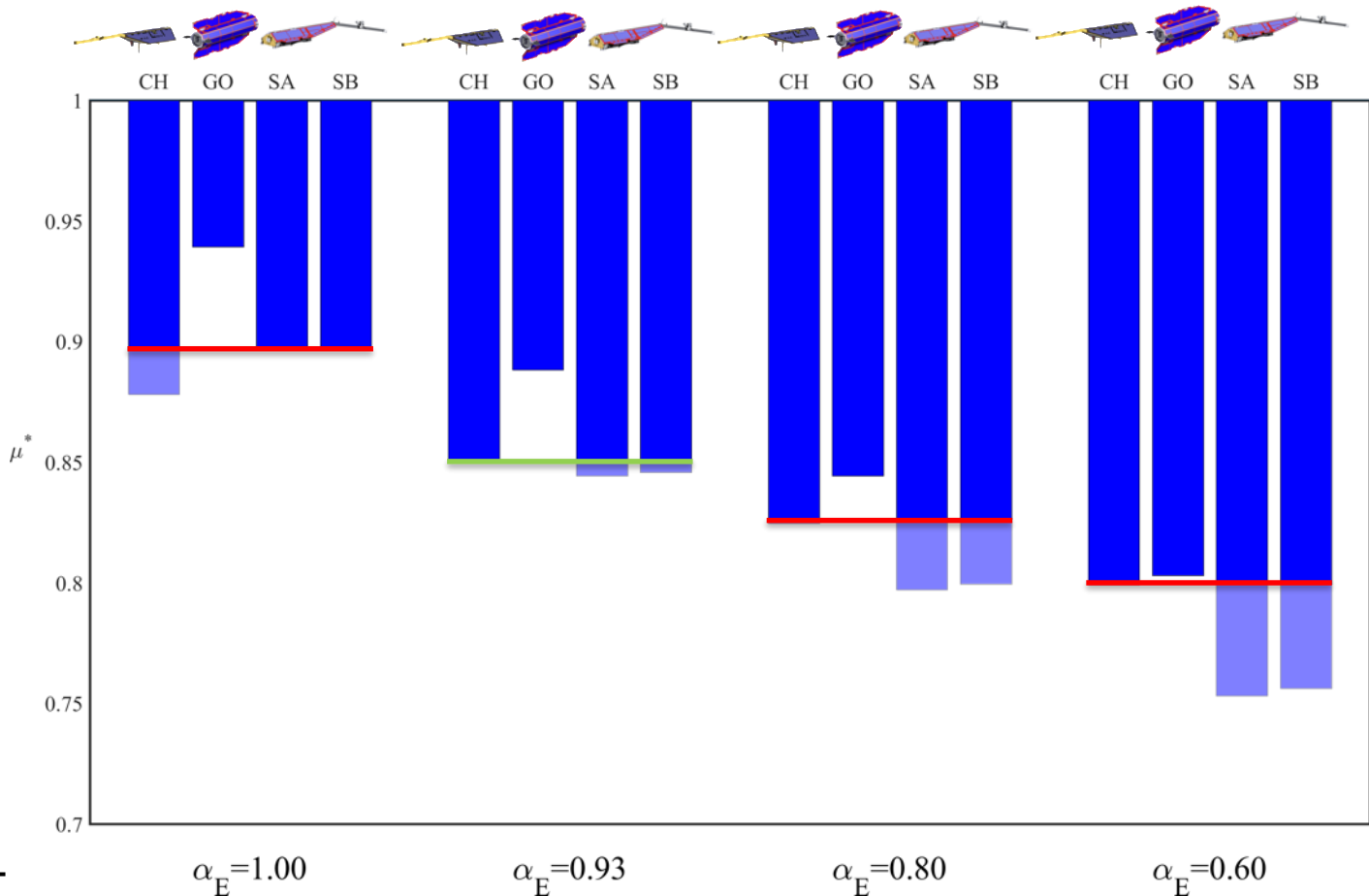
# Influence on Density (ratios)

Avg. Estimated/NRLMSISE-00 density ratios



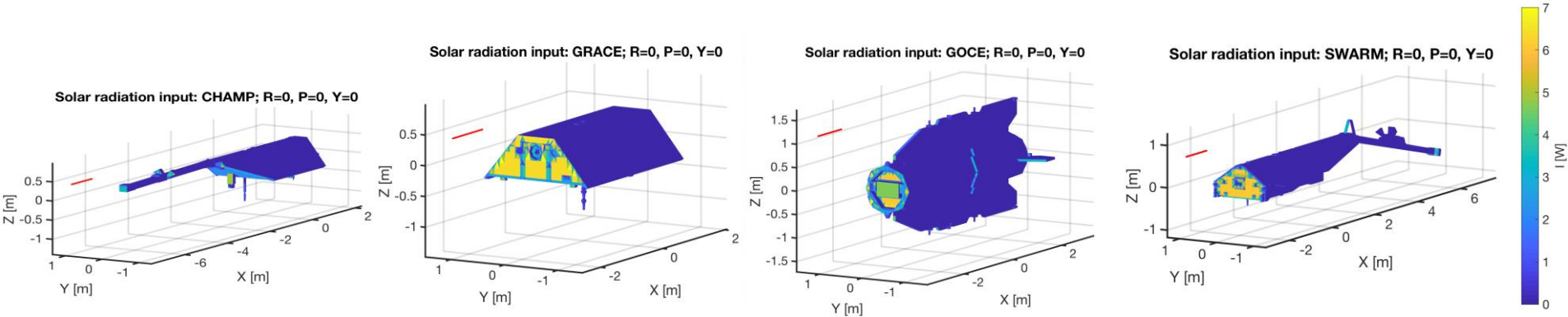


# Influence on Density (ratios)

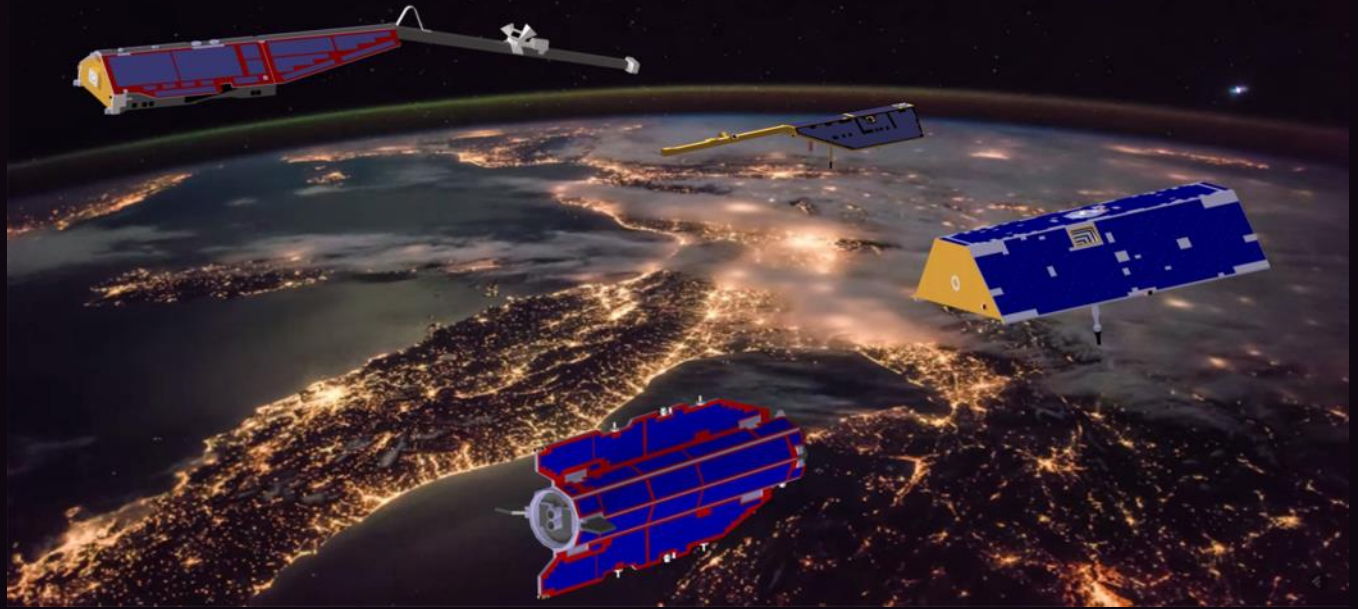


# Summary & Outlook

- Optimize coefficients for *diffusive* & *specular* reflections ( $\alpha_E$ ,  $\sigma$ );
- Improve Solar Radiation Pressure (SRP) accelerations;



- TU Delft works on the improvement of Swarm & GOCE thermospheric products [\[ESA contract \(Starting: Q1-2019\)\]](#);
- We are interested in revisiting GRACE data and work with GRACE-FO.



Thank you for your attention!

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42<sup>nd</sup> COSPAR Assembly 2018,  
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