Ringworld research presentation

Eric A. Comstock,
Álvaro Romero-Calvo

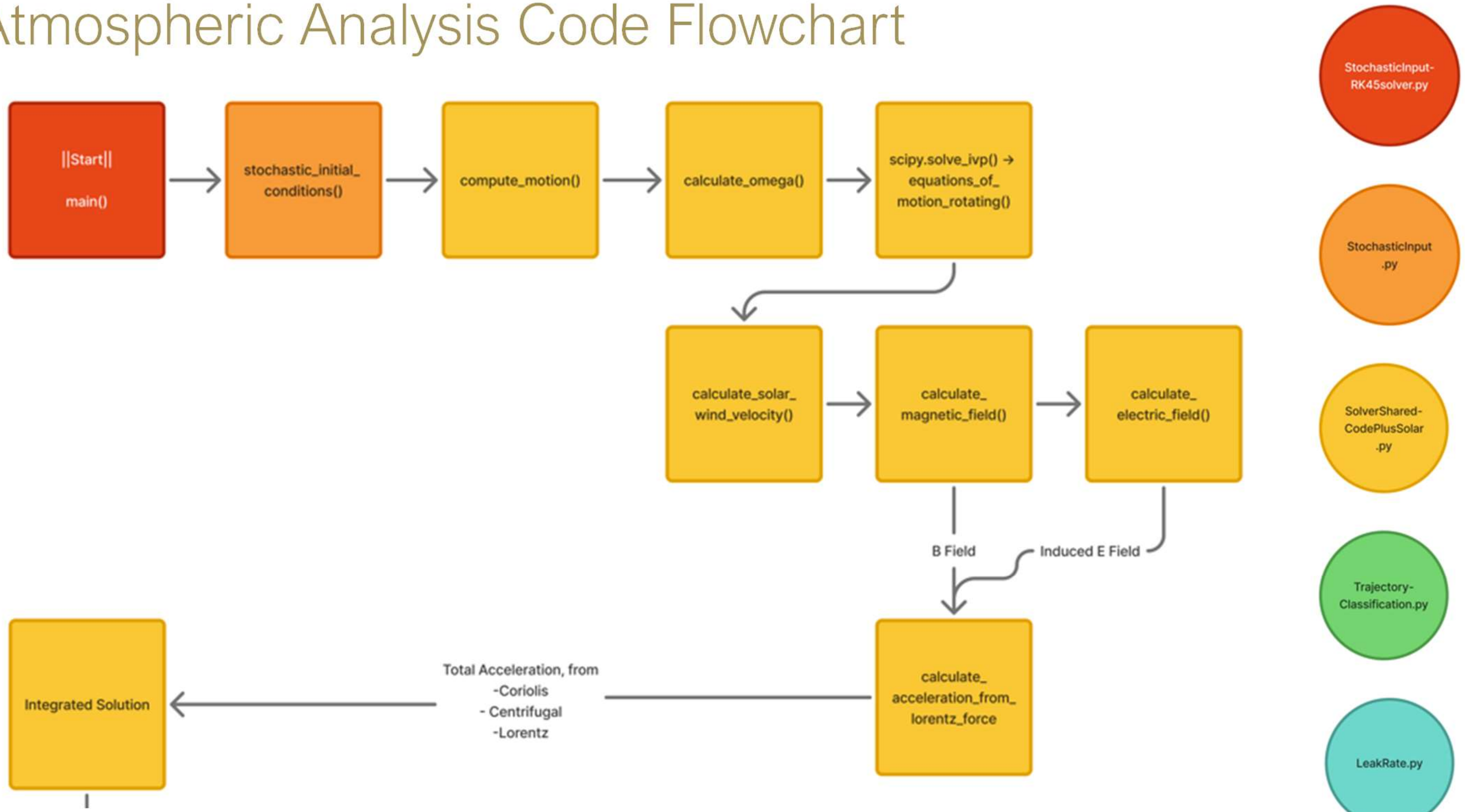
James Barritt Chambers, Usman Rafique, James Chen Stewart, Adrian Carrasco, Subhan Arshad, McKenzie Prince, Siyona Agarwal

December 1, 2025

Georgia Tech Space Systems Design Laboratory

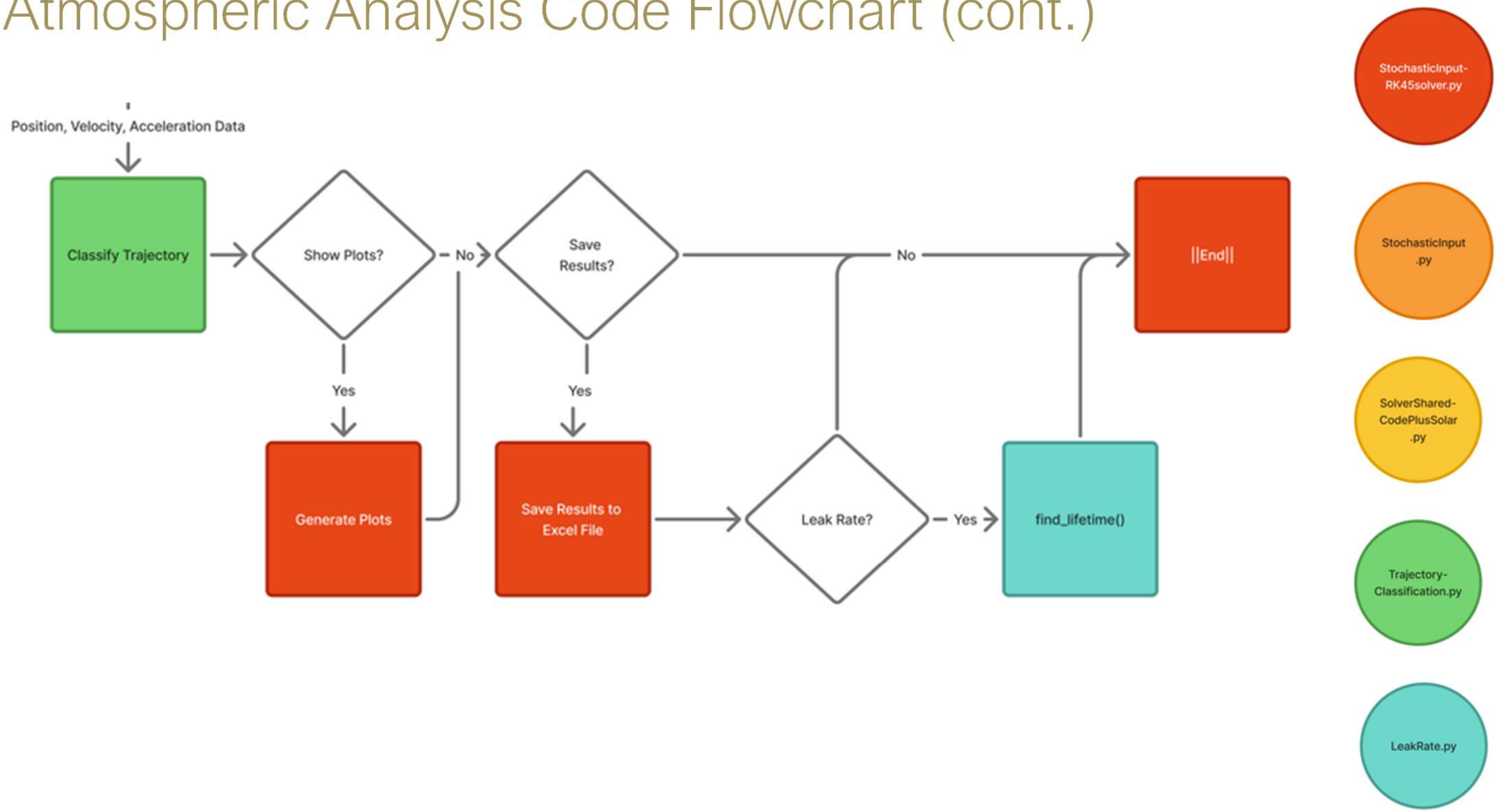
LGST Lab

Atmospheric Analysis Code Flowchart



LGST Lab

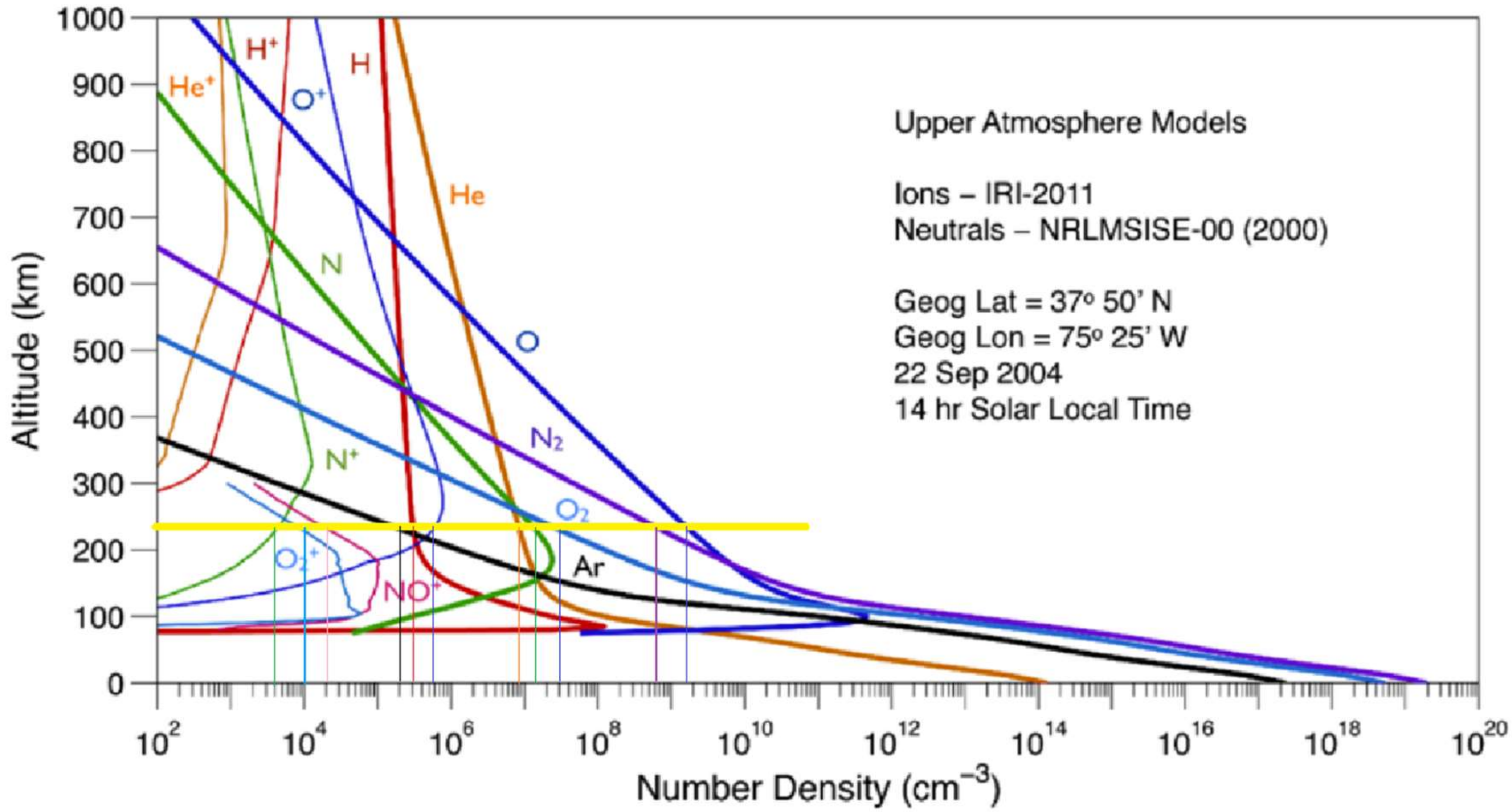
Atmospheric Analysis Code Flowchart (cont.)



LGST Lab

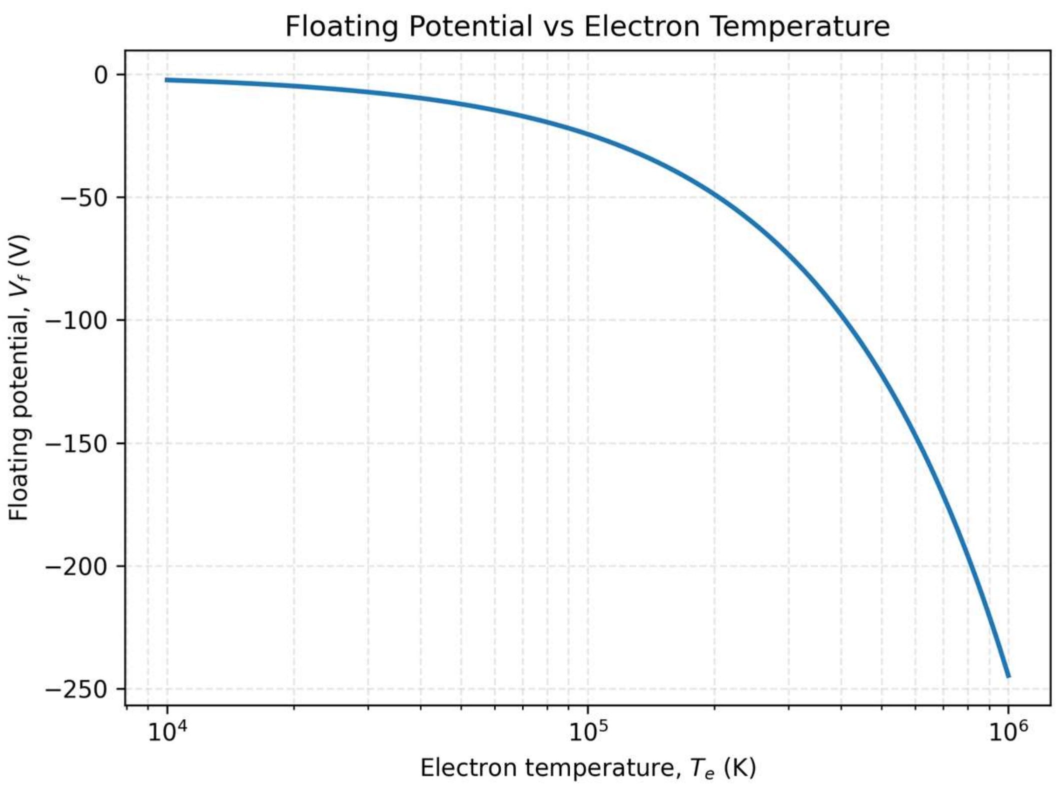
Atmosphere Composition

- The composition for the atmosphere was modelled off the Earth's atmosphere at an altitude of 218km.



Floating Potential

- Floating potentials were calculated over a range of temperatures and found to be negligible because of the Ringworld's scale.



Electromagnetic Effects of Solar Wind

Solar Wind Magnetic Field

B_r0 is magnetic field at Earth's location, r_0 is the distance from the Earth to the Sun, v_r is solar wind speed and omega is angular speed

$$B_r(r) = B_{r0}\left(\frac{r_0}{r}\right)^2 \quad B_\varphi(r) = -\frac{\omega r B_r}{v_r}$$

$$B = < B_r , 0 , B_\varphi >$$

Solar Wind Electric Field

The inertial_to_rotating function is used to convert from inertial frame to rotating frame for the solar wind velocity.

$$v_r = < v_r , 0, 0 >$$

$$v_{inertial} = v_r \frac{r}{r_{mag}}$$

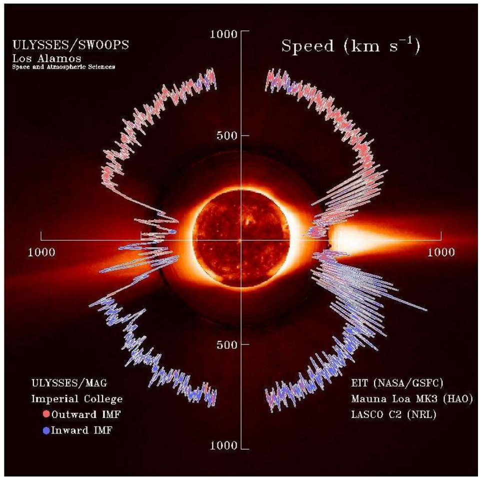
$$v_{rotating} = inertial\_to\_rotating\ (v_{inertial})$$

$$\omega = < 0 , 0 , \omega >$$

$$v_{combined} = v_{rotating} - \omega r$$

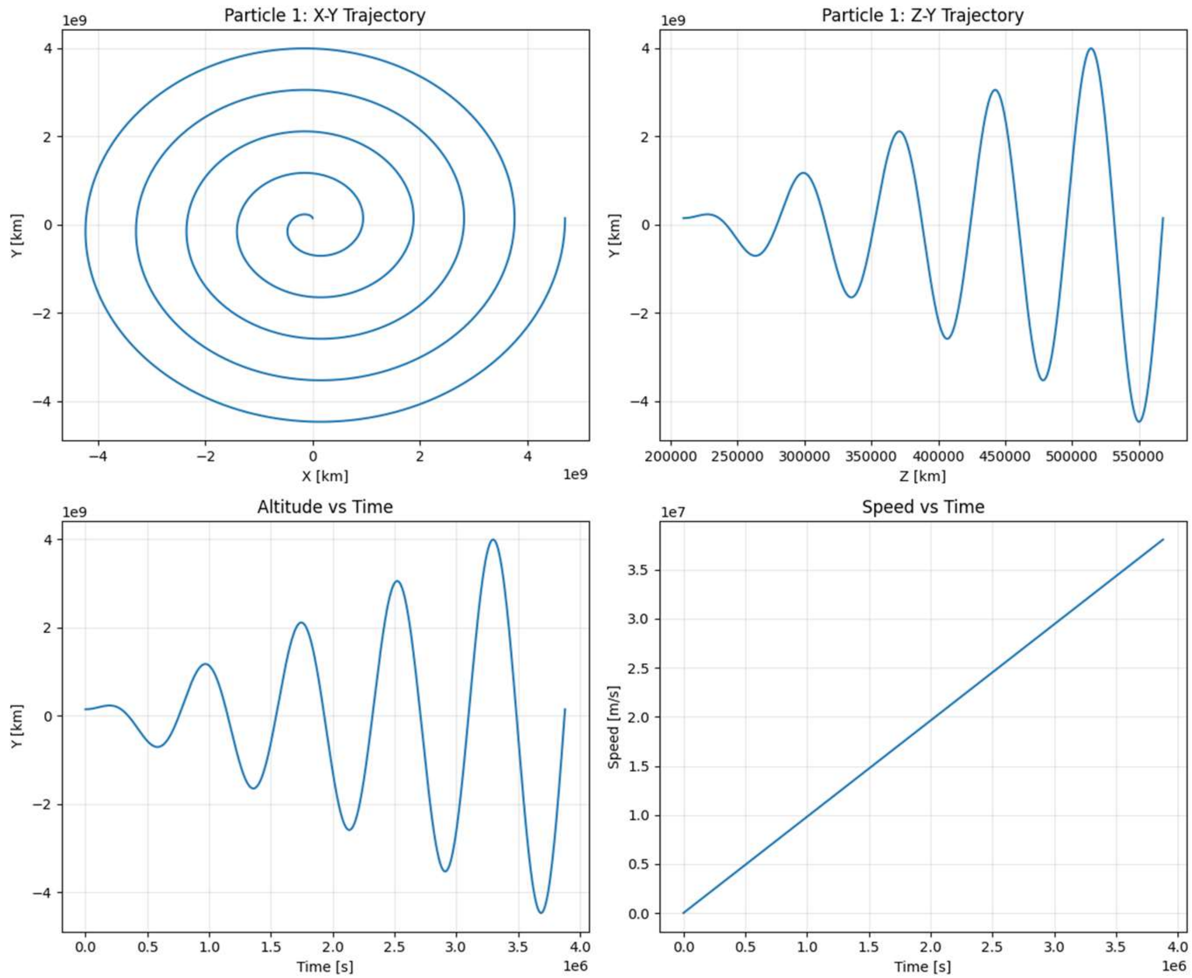
$$E = -v \times B$$

The solar wind speed was computed using this polar plot from the Ulysses results.



LGST Lab

Trajectory Graphs of Particles



LGST Lab

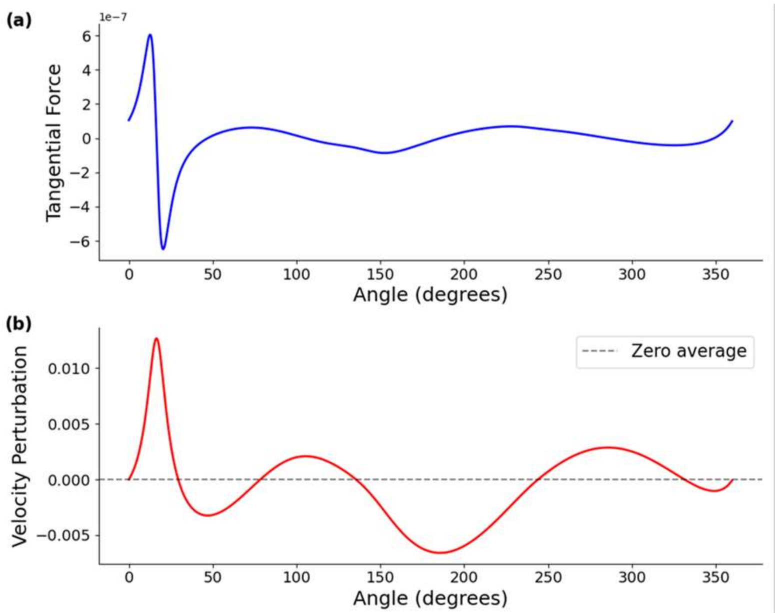
Third-Body Gravity Graphs

A simulation of gravity effects from third-body objects is conducted.

Gravity from third-body objects:

$$G \cdot \frac{m_1 \boldsymbol{d}}{|\boldsymbol{d}|^3} - G \cdot \frac{m_1 \boldsymbol{r}}{|\boldsymbol{r}|^3}$$

- m_1 is the mass of the the third-body object
- d is the vector distance between the center of the Ringworld and the third-body object
- r is the position of the center of the Ringworld.



PBL Wind Modeling

- Evaluated two boundary-layer velocity profiles:

$$\textbf{Power-law: } U(z) = U_{\text{ref}} \left(\frac{z}{z_{\text{ref}}} \right)^{\alpha}$$

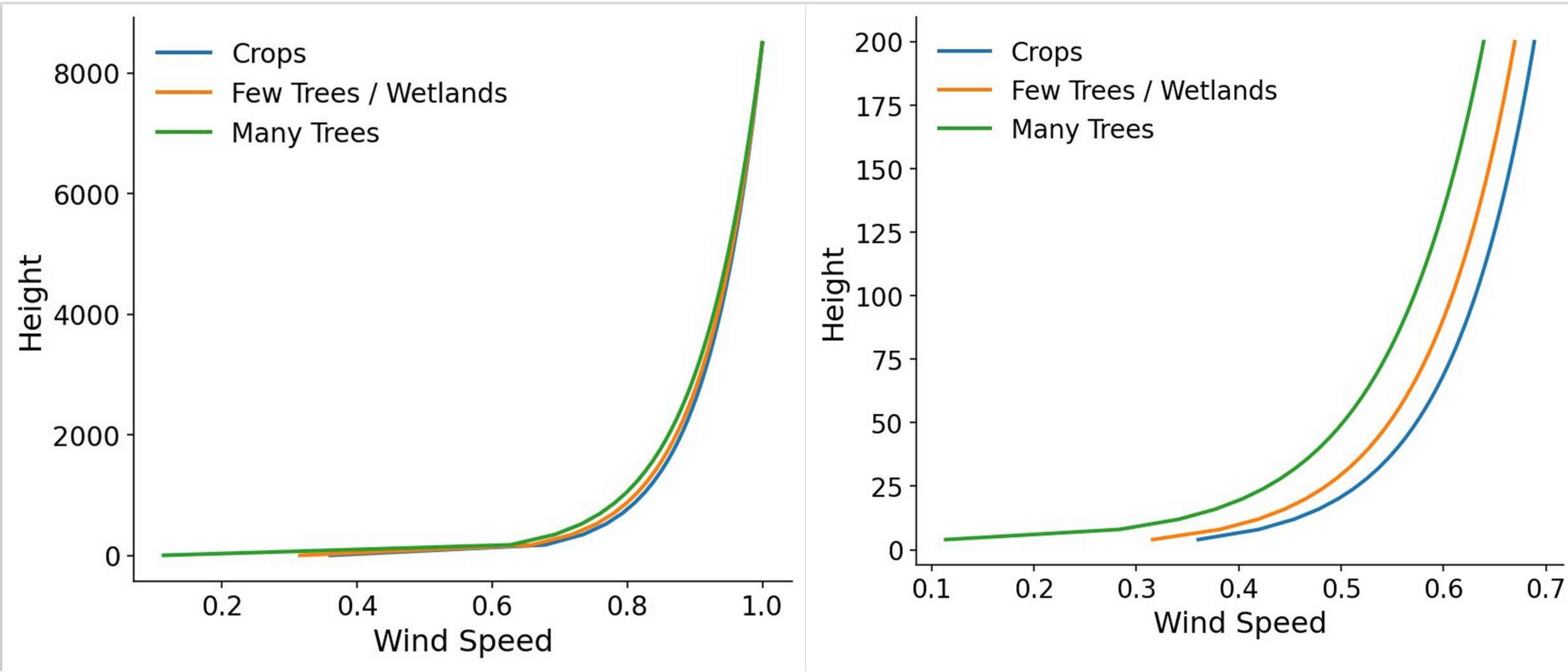
$$\textbf{Log-law: } U(z) = \frac{u_*}{\kappa} \ln \left(\frac{z-d}{z_0} \right)$$

- Chose the log-law because it represents heterogeneous terrain more realistically and avoids the power-law's monotonic assumptions.
- Generated two wind-speed curves for each surface type:

Surface Type	z_0 (m)	d (m)
Crops	0.05	0.16
Few trees / Wetlands	0.10	0.39
Many trees	0.25	3.18

0–200 m to capture near-surface PBL structure,
0–8500 m to scale up toward atmospheric height.

Normalized log-law velocity profiles for the three surface roughness categories across the two simulated domains



LGST Lab

Statistical Correlations

```
=== Normal Model ===
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.983
Model:                            OLS   Adj. R-squared:                  0.981
Method:                 Least Squares   F-statistic:                     375.3
Date:                Mon, 01 Dec 2025   Prob (F-statistic):           4.41e-17
Time:                        09:16:47   Log-Likelihood:                 15.490
No. Observations:                  23   AIC:                            -22.98
Df Residuals:                      19   BIC:                            -18.44
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.8513      0.134      6.357      0.000       0.571       1.132
x1            -0.5909      0.058    -10.116      0.000      -0.713      -0.469
x2            -1.0390      0.032    -32.400      0.000      -1.106      -0.972
x3             0.0306      0.017      1.846      0.081      -0.004       0.065
==============================================================================
Omnibus:                       11.846   Durbin-Watson:                   2.487
Prob(Omnibus):                  0.003   Jarque-Bera (JB):               20.340
Skew:                          -0.632   Prob(JB):                     3.83e-05
Kurtosis:                       7.430   Cond. No.                         40.4
==============================================================================
```

Key Model Results

- $R^2 = 0.983$ → strong model fit
- Adj. $R^2 = 0.981$
- F-statistic p = 4.41×10^-17 → model is statistically significant

Coefficient Significance

- Gravity (x1): –0.591, very significant *(p ~ 0)*
- Width (x2): –1.039, very significant *(p ~ 0)*
- Radius (x3): 0.031, weakly significant *(p = 0.081)*
- Intercept = 0.851 (baseline $\log_{10}$ escape rate)

Interpretation

- Higher gravity → lower escape probability
- Larger width → lower escape probability
- Radius has minimal effect in this dataset

Questions?

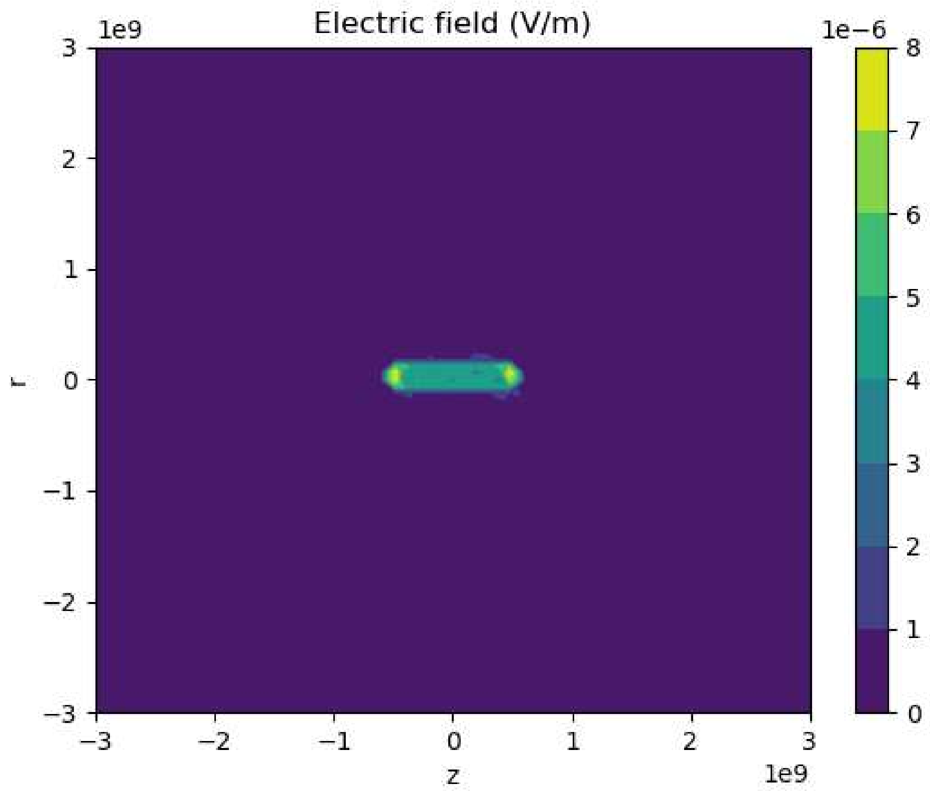
eric.comstock@gatech.edu

https://www.linkedin.com/in/eric-comstock-999483232

https://ericanthonycomstock.com

More information available at lowgravitylab.ae.gatech.edu

Backup: E-field plot



LGST Lab