PROGRESS Review Meeting
4 December 2017

WP2 Status

Propagation of the Solar Wind from the Sun to L1 SWIFT data and access to forecasts

Tony Arber, Warwick
Keith Bennett, Warwick

WARWICK
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Full timeline for WP2

GONG observations
> AWSoM coronal model
> SWIFT spherical MHD Inner Heliosphere model
Forecast of MHD variables at L1

Milestones

M6 Lare3d in spherical and renamed SWIFT

M9 2T SWIFT & Time accurate AWSoM

M15 Improved thermal conduction

M21 Couple AWSoM to SWIFT

M19-27 Validate coupled model against L1 data

M25-36 Real time test of L1 predictions

M36 Manuals

Deliverables

M12 Swift conversion to spherical geometry report - Approved

M20 Coupling codes report - **Submitted 31 August 2016**

M36 Documentation

Mathematical Models

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0,$$

$$\frac{\partial \mathbf{B}}{\partial t} + \nabla \cdot (\mathbf{u}\mathbf{B} - \mathbf{B}\mathbf{u}) = 0,$$

$$\frac{\partial (\rho \mathbf{u})}{\partial t} + \nabla \cdot \left(\rho \mathbf{u}\mathbf{u} - \frac{\mathbf{B}\mathbf{B}}{\mu_0} \right) + \nabla \left(P_i + P_e + \frac{B^2}{2\mu_0} + P_A \right) = -\frac{GM_\odot \rho \mathbf{R}}{R^3},$$

AWSoM and SWIFT

$$R = R_\odot \rightarrow L1$$

$$\frac{\partial}{\partial t}\left(\frac{P}{\gamma-1} + \frac{\rho u^2}{2} + \frac{\mathbf{B}^2}{2\mu_0}\right) + \nabla \cdot \left\{ \left(\frac{\rho u^2}{2} + \frac{\gamma P}{\gamma - 1} + \frac{B^2}{\mu_0}\right)\mathbf{u} - \frac{\mathbf{B}(\mathbf{u}\cdot\mathbf{B})}{\mu_0} \right\} =$$

$$= -(\mathbf{u}\cdot\nabla)P_A + \nabla \cdot (\kappa \cdot \nabla T) - Q_{\rm rad} + \Gamma_- w_- + \Gamma_+ w_+ - \frac{GM_\odot \rho \mathbf{r}\cdot\mathbf{u}}{r^3},$$

AWSoM
SWIFT ignores turbulent drive

$$R = R_\odot \rightarrow L1$$

$$\frac{\partial w_\pm}{\partial t} + \nabla \cdot [(\mathbf{u} \pm \mathbf{V}_A) w_\pm] + \frac{w_\pm}{2}(\nabla \cdot \mathbf{u}) = \mp \mathcal{R}\sqrt{w_- w_+} - \Gamma_\pm w_\pm$$

$$\Gamma_\pm = \frac{2}{L_\perp}\sqrt{\frac{w_\mp}{\rho}}$$

$$\mathcal{R} = \min\left\{ \sqrt{(\mathbf{b}\cdot[\nabla\times\mathbf{u}])^2 + [(\mathbf{V}_A\cdot\nabla)\log V_A]^2}, \max(\Gamma_\pm) \right\} \times$$

$$\times \left[\max\left(1 - \frac{I_{\max}}{\sqrt{w_+/w_-}}, 0\right) - \max\left(1 - \frac{I_{\max}}{\sqrt{w_-/w_+}}, 0\right) \right],$$

AWSoM only

$$R = R_\odot \rightarrow \ 20 R_\odot$$

“Free” Parameters for AWSoM

Poynting flux per unit magnetic field at lower boundary

$$S/B = 0.3 - 1.5 \times 10^{6} W m^{-2} T^{-1}$$

Scaling of GONG data field

$$B_{scale} = 1 - 4$$

Stochastic exponent - controls heating rate and partitioning between ions and electrons

$$h_S = 0.1 - 0.34$$

Could also vary collision less conduction fix and perpendicular cordeliation length.

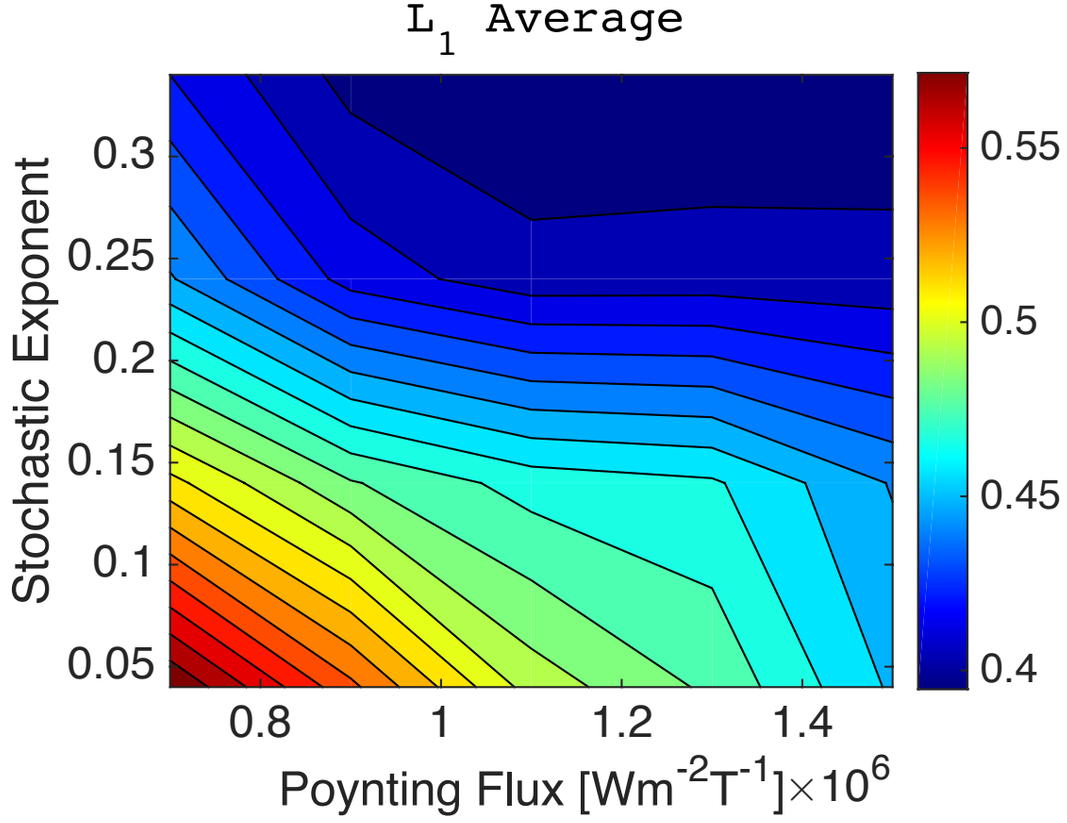
Optimisation procedure

Using Dakota Uncertainty Quantification (UQ) to complete sensitivity analysis

Each run of AWSoM coronal model from SWMF takes 14 hours on 128 cores

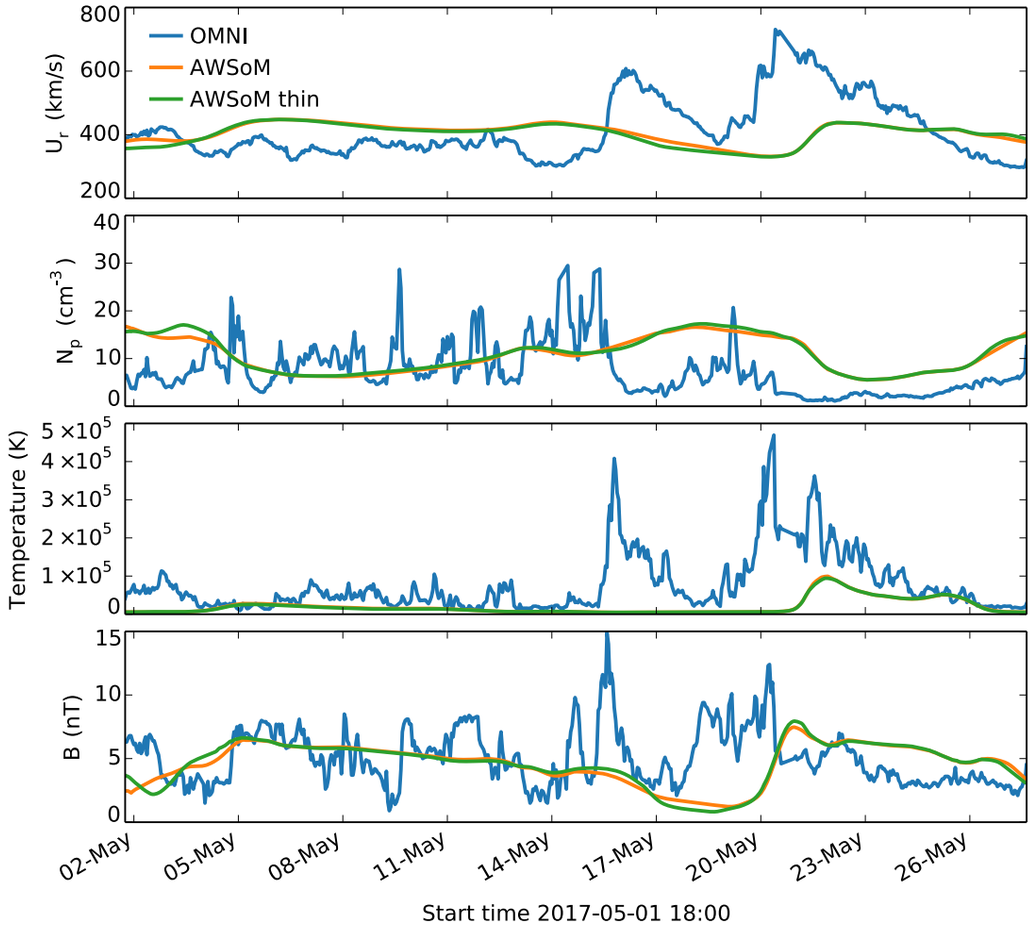
Provisional results presented here, final results should be ready next week

Based on these results we will update settings for AWSoM-SWIFT runs which should improve predictive accuracy

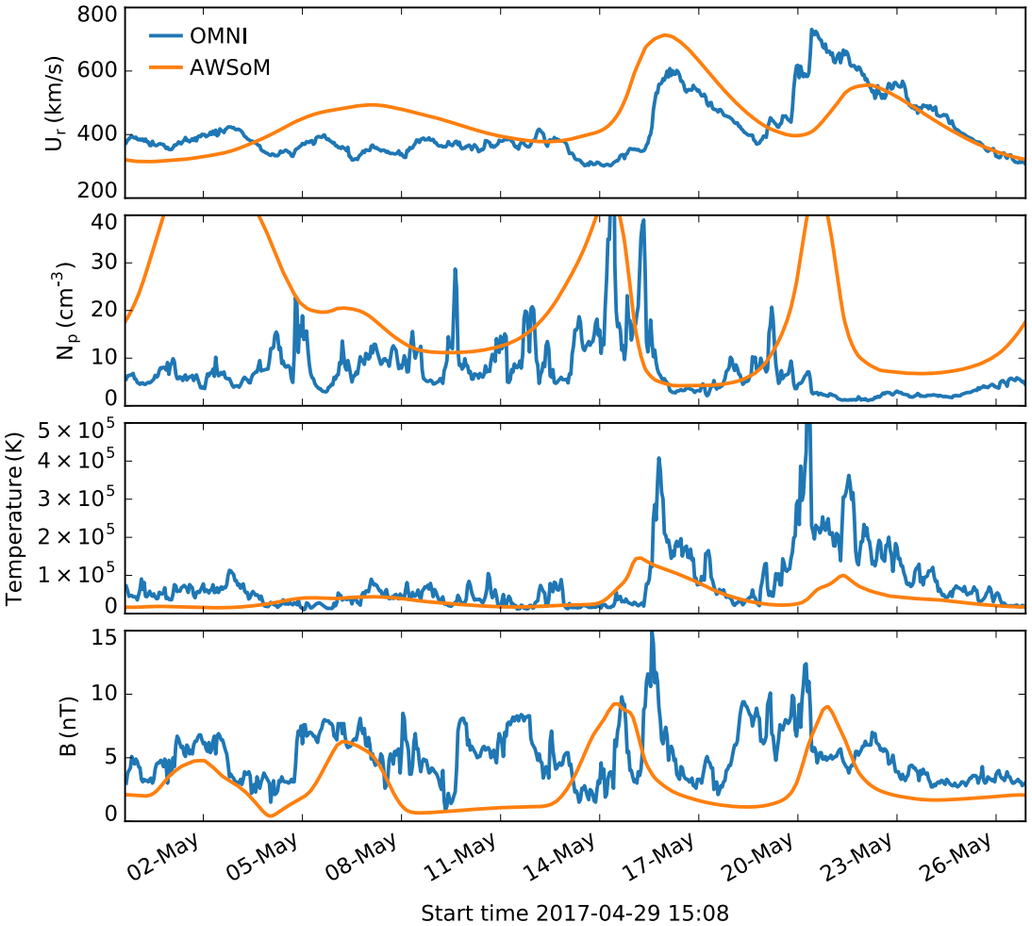


SWIFT data - access to forecasts

Default settings for SWMF for Carrington rotation in May 2017



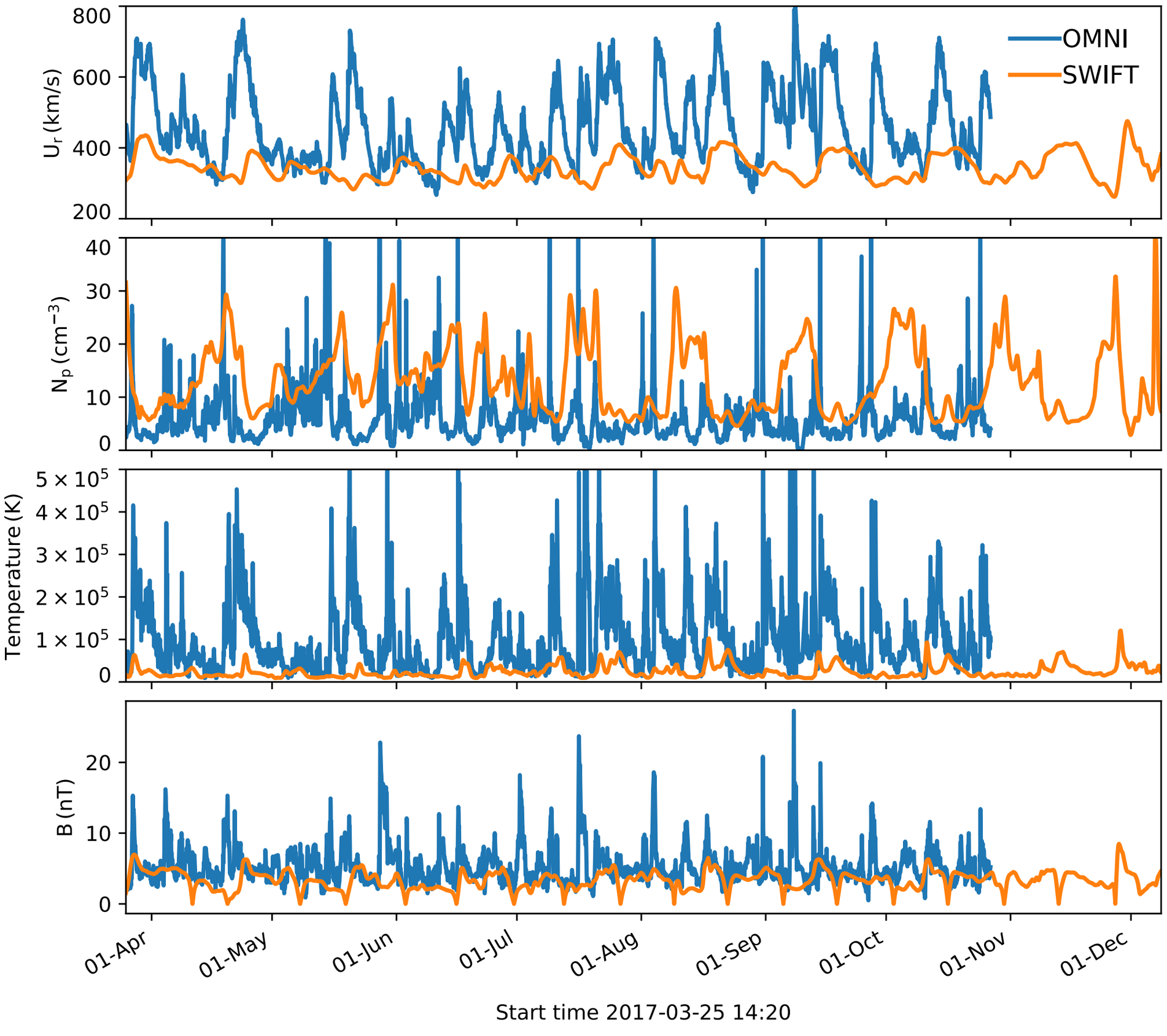
No GONG data scaling and vary h_s and Poynting flux for best fit for speed



Fit parameters vary across Carrington rotations tested

Either choose best compromise or slow varying based on previous months…

SWIFT data - historical data



SWIFT data - access to forecasts

Current setup is automated so that each day…

1. Automatically download latest GONG synoptic map
2. Run AWSoM to steady state out to 21.5 Solar radii
3. Interpolate boundary buffer regions between this and previous day
4. Use interpolated data to drive time dependent SWIFT, updating by one day
5. Continue running for a further 4 days with a fixed buffer region to generate predictive solution
6. SWIFT output used to predict up to around 3 days in advance
7. L1 data from SWIFT automatically formatted in JSON
8. JSON data uploaded to webpage https://warwick.ac.uk/fac/sci/physics/research/cfsa/people/bennett/swift-data

AWSoM - SWIFT plans

1. Complete Dakota-SA of AWSoM free parameters (next week)

2. Choose optimal values and update code for predictive runs (two week)

3. Re-check historical fits including Alfven wave pressure in MHD (December)

4. Complete SWIFT documentation for D2.3 (December)

5. Exploratory Dakota-UQ of SWIFT (by January)

6. Continue running AWSoM-SWIFT, although less often, on Warwick workstation

7. Keep updating JSON outputs at least until June 2018