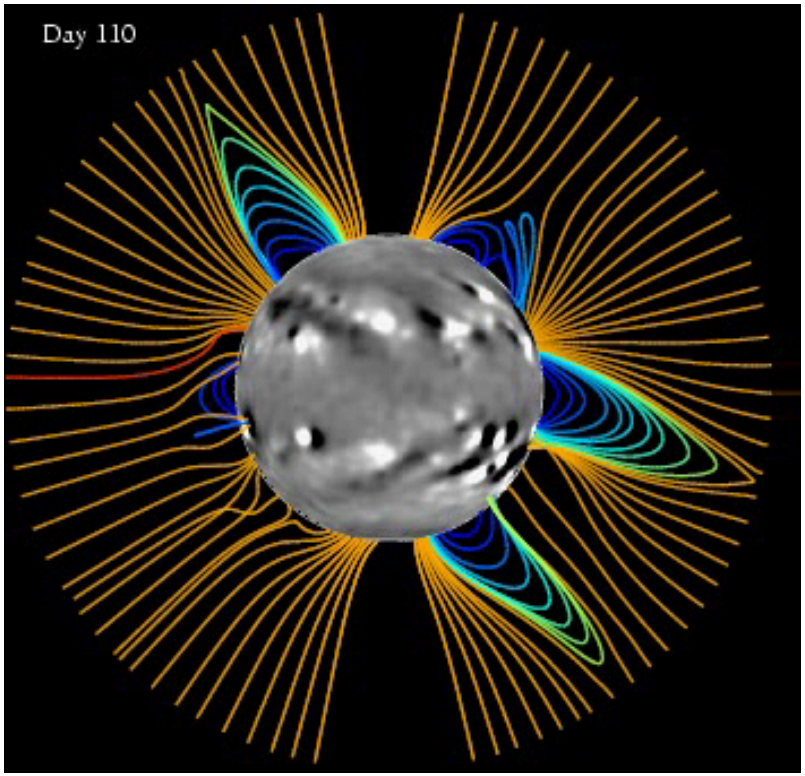
Impact of an L5 Magnetograph on Non-Potential Solar Global Magnetic Field Modelling



Duncan H Mackay (University of St Andrews)

Results published in Mackay, Yeates and Bocquet (2016), APJ, V825

Global Non-Potential Model

6 month: May-Aug 1999

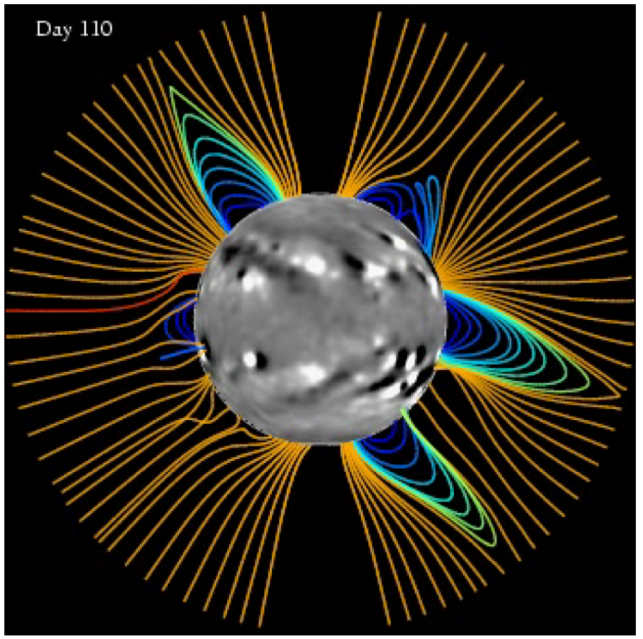
- Long Term continuous simulations (months to years).
  - Build up free magnetic energy and helicity

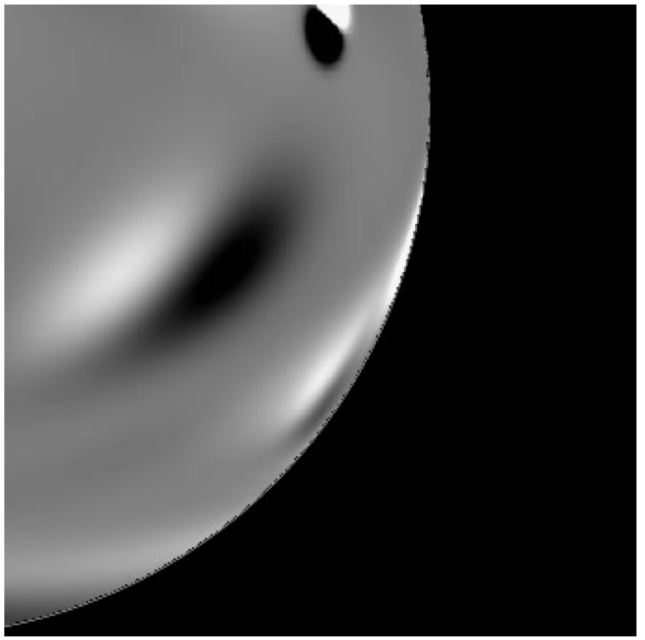
- Two coupled components:

Photosphere: Flux Transport Model
- accurately reproduces B_r obs. on Sun.
- includes flux emergence (+/- ve helicity).

Corona : Magnetofrictional Relaxation
- quasi-static evolution
- non-linear force-free states, **j** x **B = 0**
- development of sheared fields along PIL (van Ballegooijen and Martens 1989)

- Development and Application:
  Mackay et al. 2001, 2003;
  Mackay and van Ballegooijen 2006a,b;
  Yeates et al. 2007, 2008a,b, 2009a,b.





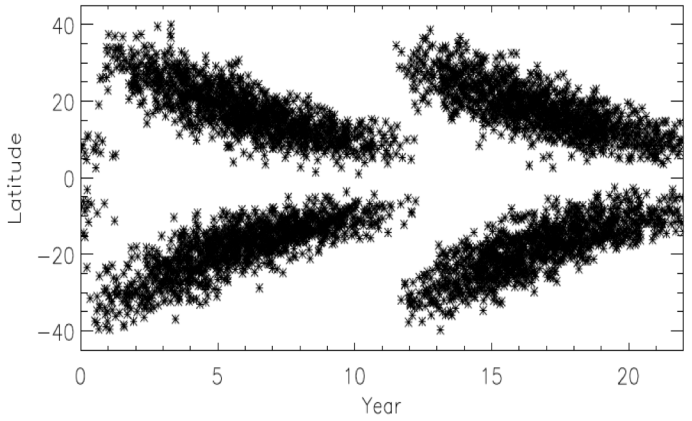
Stage 1: Reference Sun Simulation.

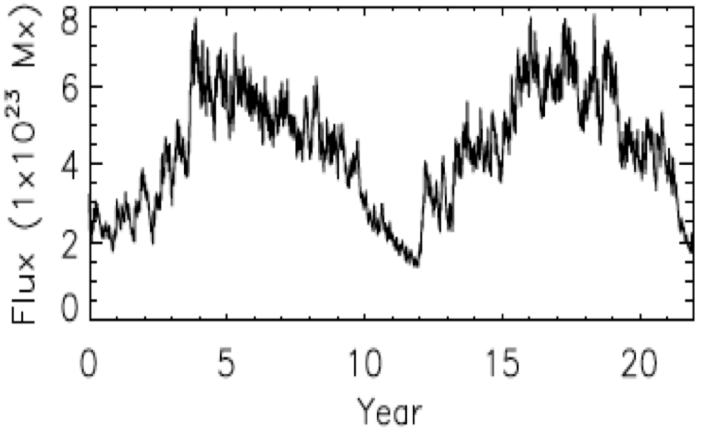
- Construct a reference data set:
  - 360^{o} magnetograph coverage of Sun.
  - Statistical emergence profile of bipoles.

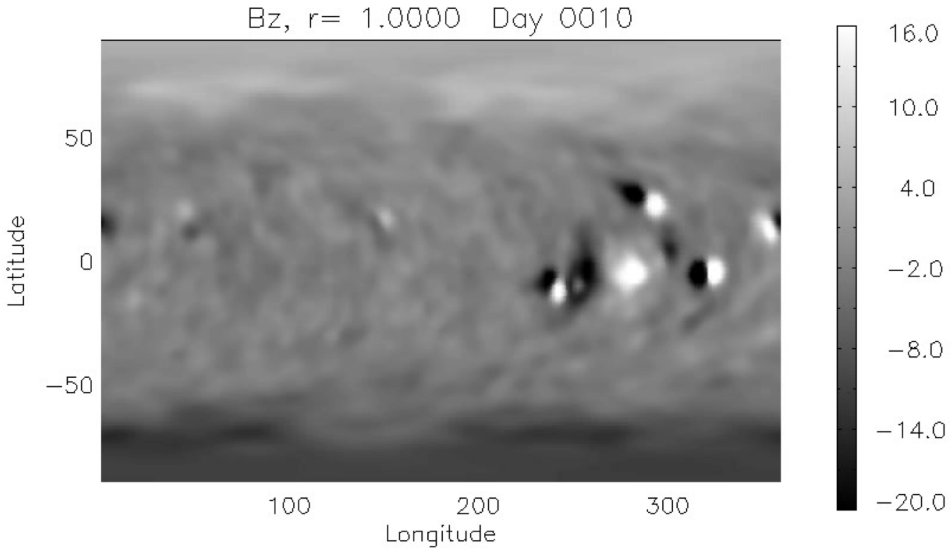
    22-yr 3D NLFFF simulation.

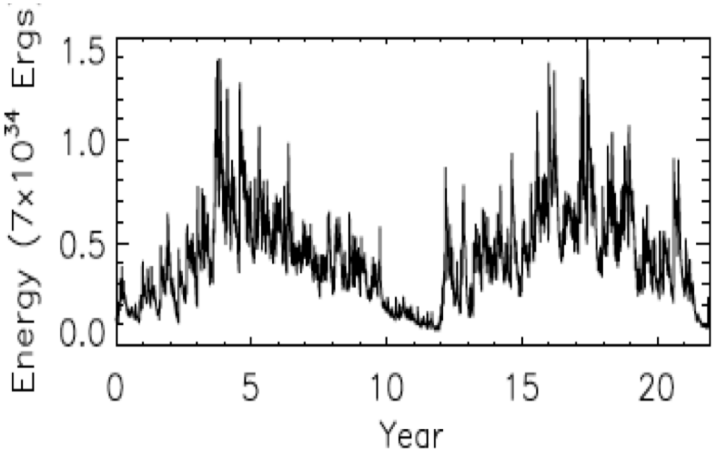
    No. of bipoles ~ 4770

    Total flux 3.21e25 Mx
  - Best representation of “Real Sun”.



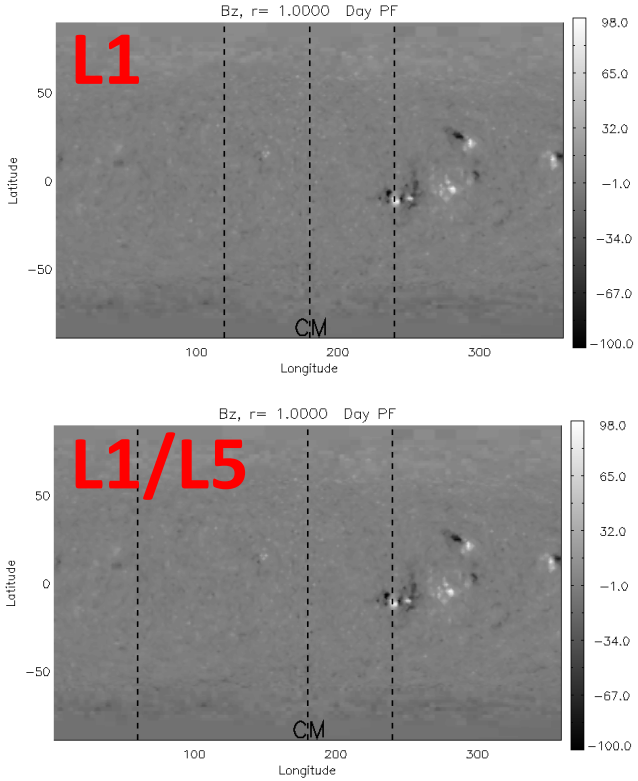




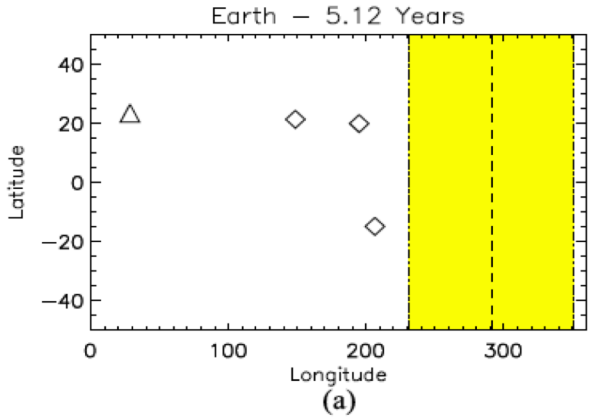


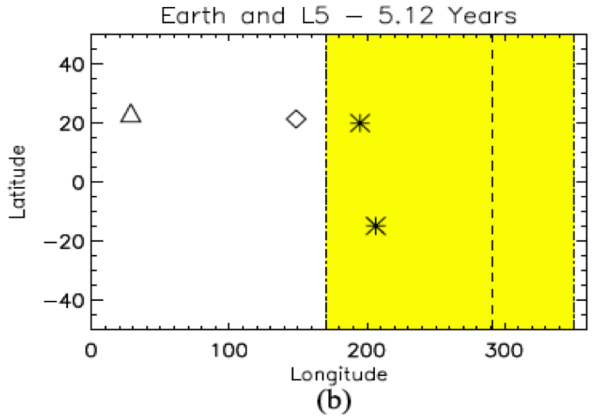
Stage 2: Limited FOV Simulations

- Consider present circumstances: limit FOV of the Sun.



- Use Reference Sun simulation as limited FOV magnetograph observations: L1 and L1/L5
- Identify bipole emergences in limited lon. range.
- Repeat 22yr 3D non-potential simulations with limited FOV bipoles.





- Reference Sun bipoles: 3 categories

  (i) Real Time (*) - emerges in FOV

  (ii) Rotational updates (◇) - bipole emerges outside FOV rotates into FOV.

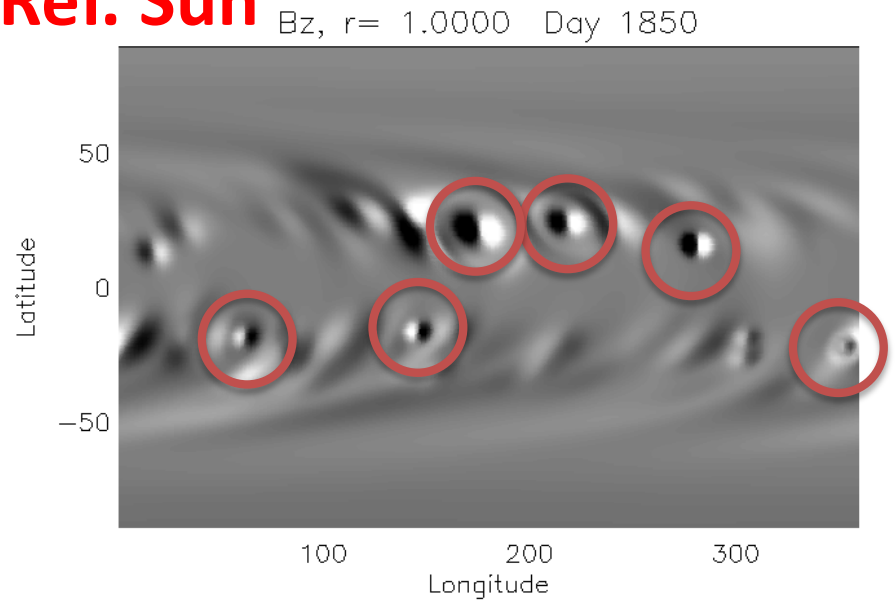
  (iii) Decayed bipoles(△) – decayed before entering FOV, not included.

Comparison of Photospheric Field

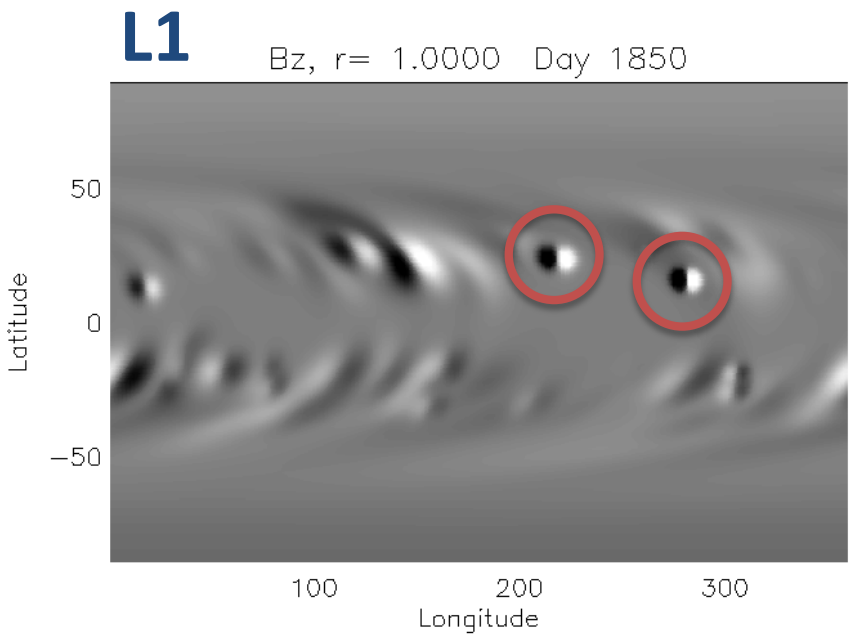
- Number of bipoles:

Simulation	Real Time	Rot. Update	Missing
L1	1427	1152	2146
L1 & L5	2140	1178	1407

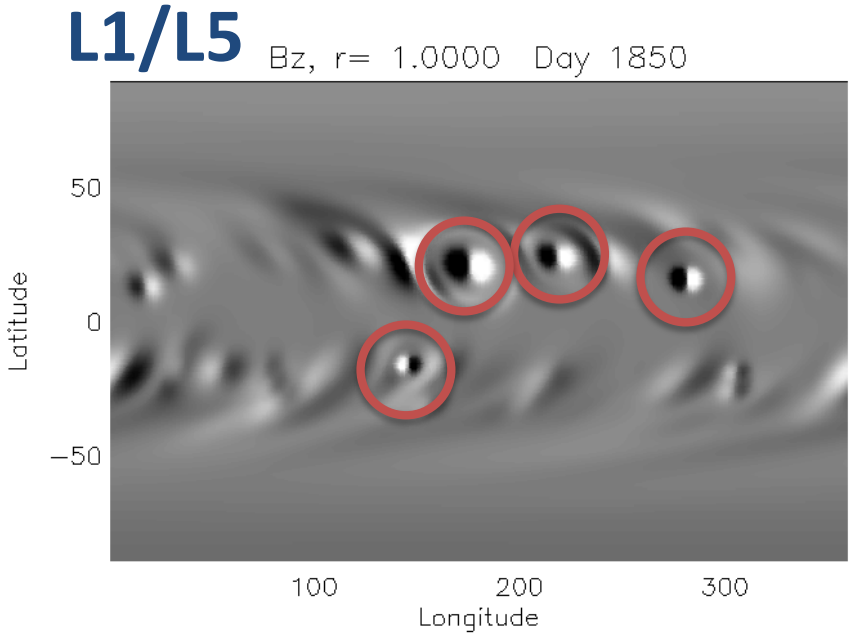
Ref. Sun



L1

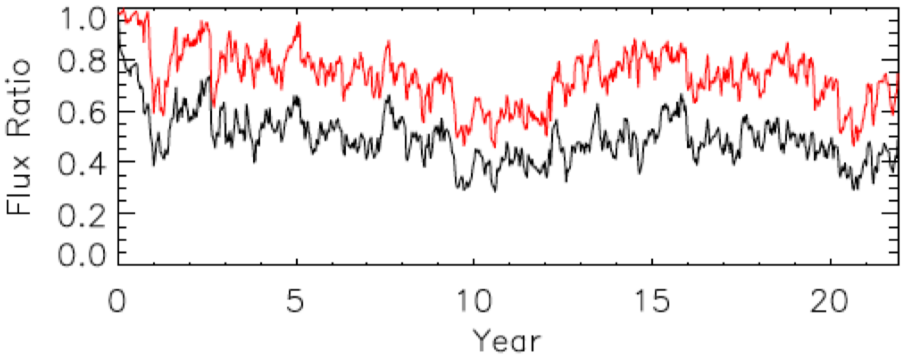


L1/L5

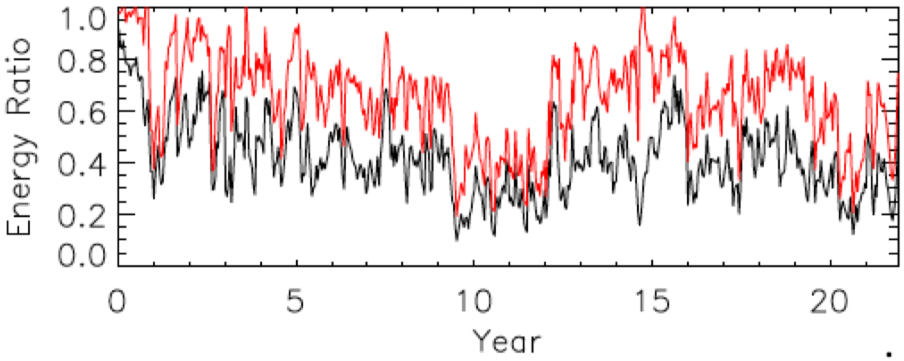


Relative Accuracy of L1 and L1/L5

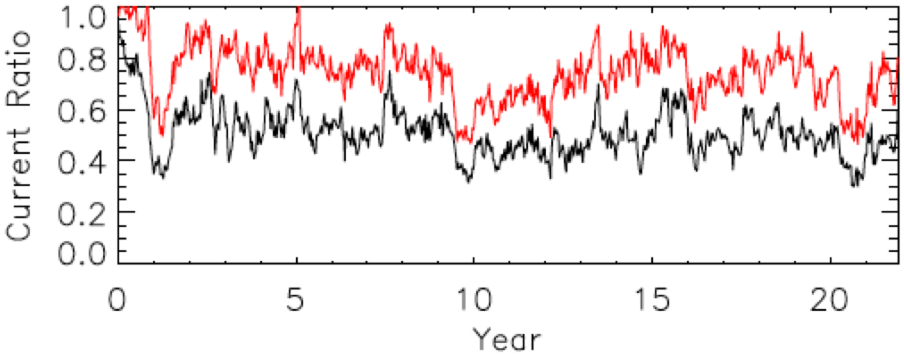
0.73 0.55 : 33%



0.65 0.46 : 41%



0.74 0.57 : 30 %



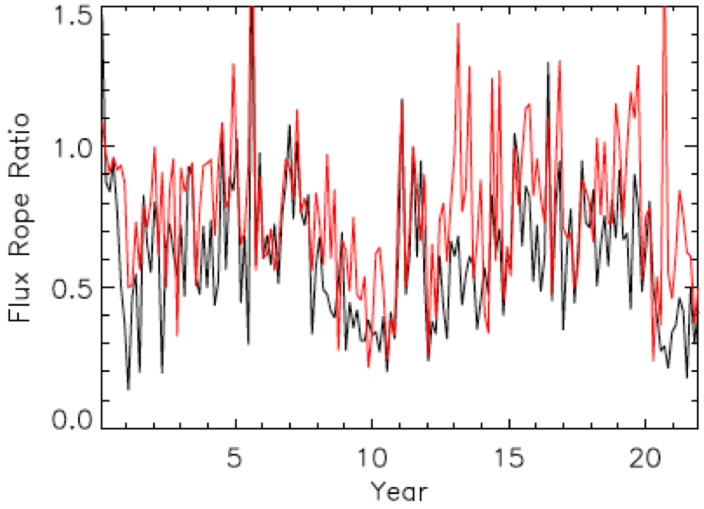
$$\Phi_s(t) = R_\odot^2 \int_s |B_r(R_\odot, \theta, \phi, t)| d\Omega,$$

$$E_m(t) = \int_V \frac{B^2(r, \theta, \phi, t)}{8\pi} d\tau,$$

$$J_V(t) = \int_V |j(r, \theta, \phi, t)| d\tau,$$

Number of flux ropes

0.78 0.62 : 26%



Red – L1 plus L5 FOV

Black – L1 only FOV

Blue - % improvement with L5

Summary

- Considered what improvements can be expected in the accuracy of global non-potential models if L5 magnetograph data exists.

- Used a reference sun simulation & two limited data simulations.

  Limited data: L1 only

  L1 & L5

- L1 & L5 simulation gives improvements of between 26-40% in global quantities dominated by low latitude contributions compared to Earth only.

- L1 & L5 attains an accuracy of 65-78% of reference global quantities (46-57% for Earth only).

- Full details given in published paper along with a comparison of other quantities and outline of future studies that are presently underway.

Mackay, Yeates and Bocquet (2016), APJ, V825