

# **The Use of Flux Transport Models in CGEM**

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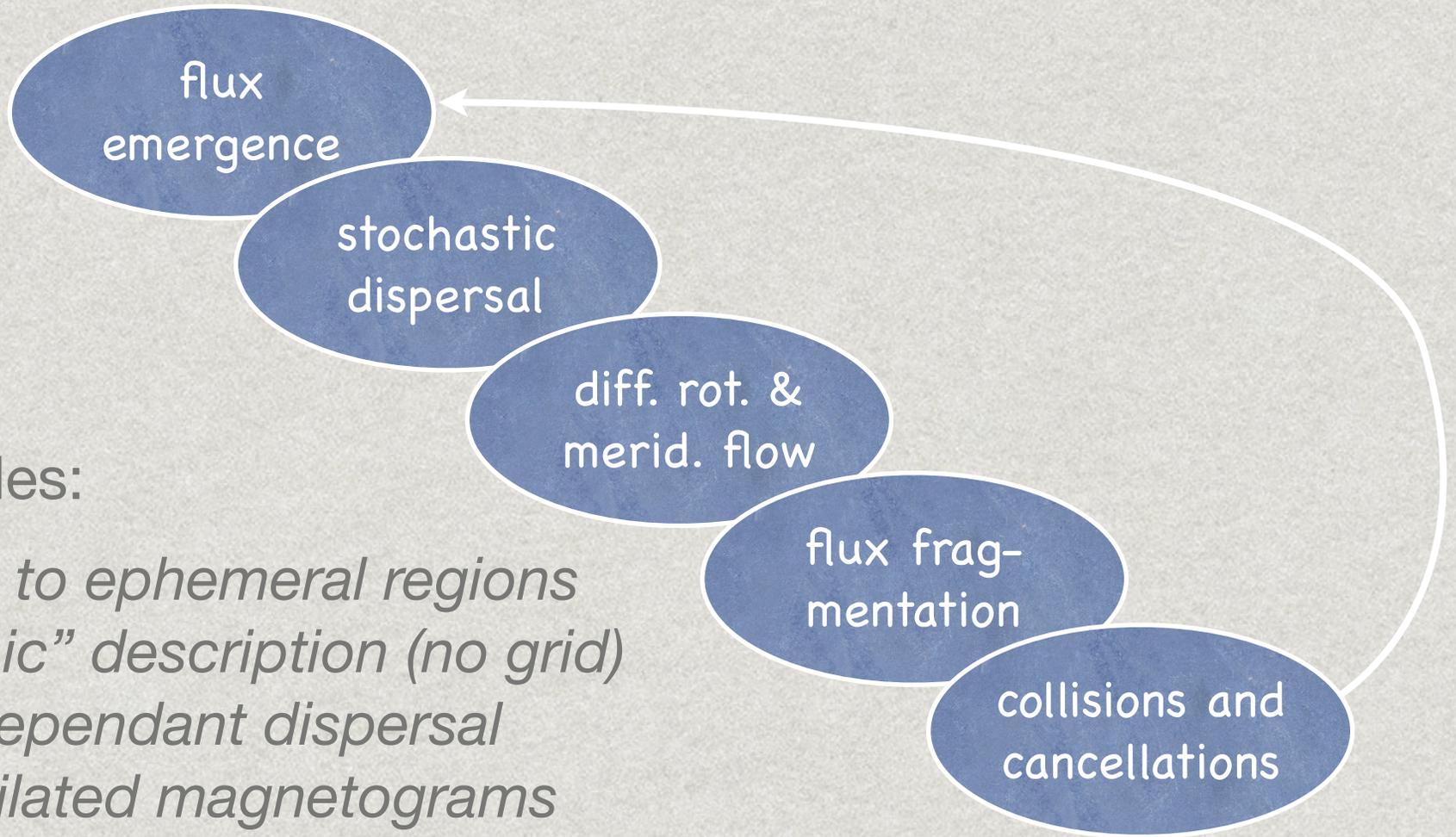
# Flux-Transport Models in CGEM

- \* CGEM involves transforming magnetogram data into a form suitable for use by global-scale numerical modeling.
- \* Such “data assimilation” activities are now more common in heliophysics as new data products come online and closer-to-real-time numerical modeling becomes feasible.

# Flux-Transport Models in CGEM

- \* For CGEM, magnetogram data are needed on a global scale in order to determine electric fields everywhere.
- \* Consequently, we will develop and use a new photospheric flux-transport model, into which SDO/HMI magnetograms will be regularly assimilated.

# Earlier Model

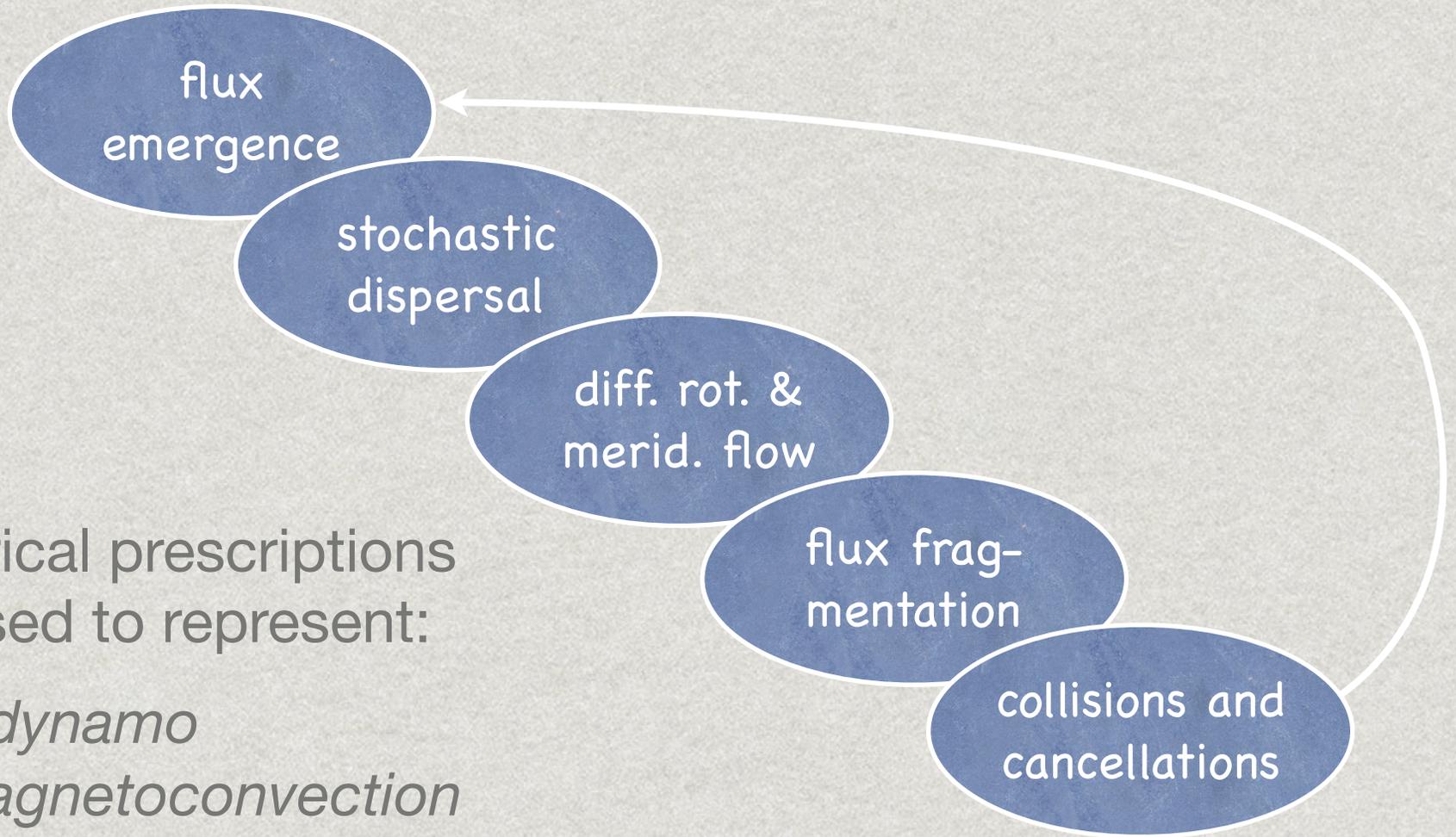


Includes:

- \* *active to ephemeral regions*
- \* *“atomic” description (no grid)*
- \* *flux-dependant dispersal*
- \* *assimilated magnetograms*

*References: Schrijver (2001), Schrijver & DeRosa (2003)*

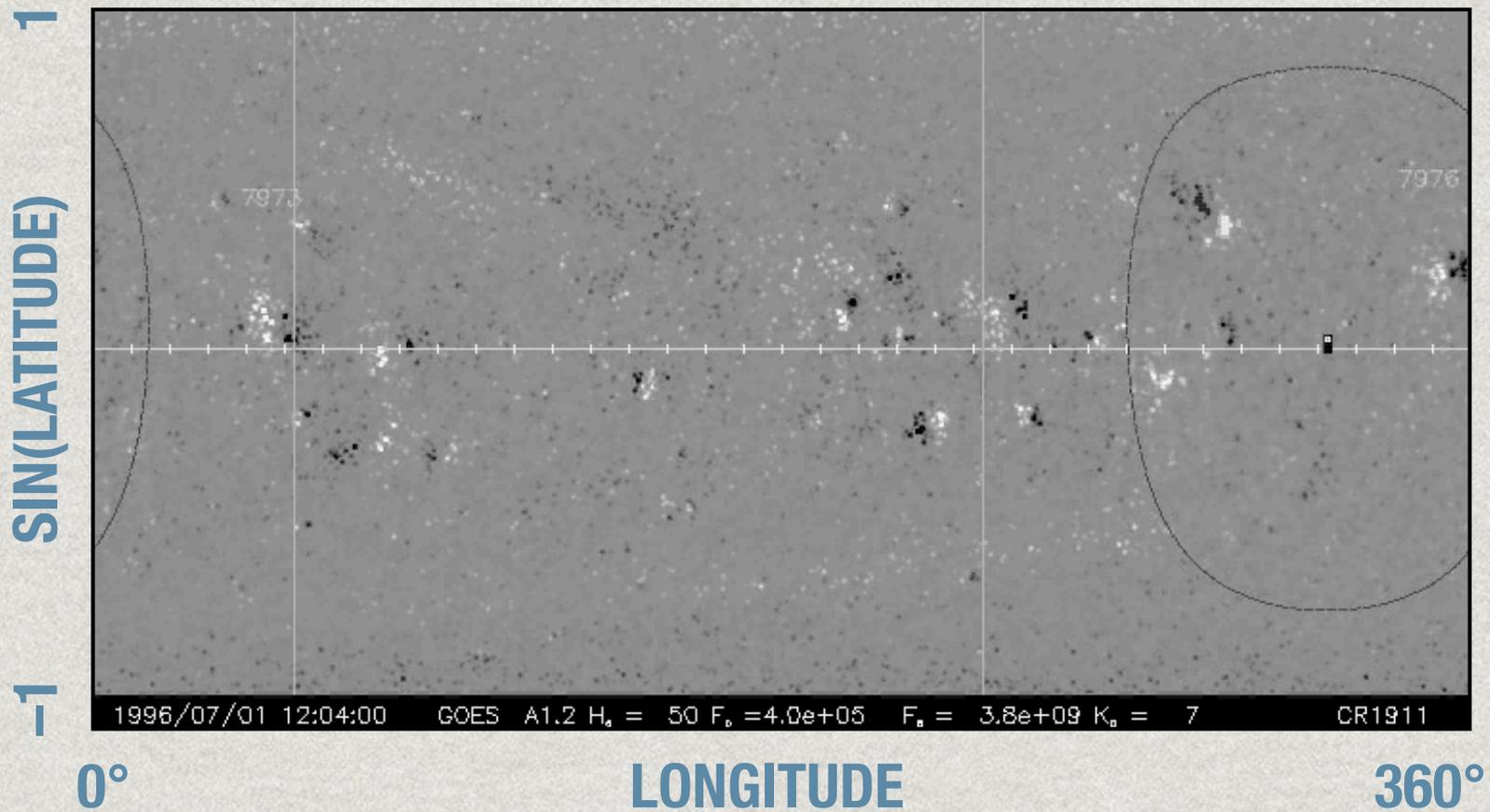
# Earlier Model



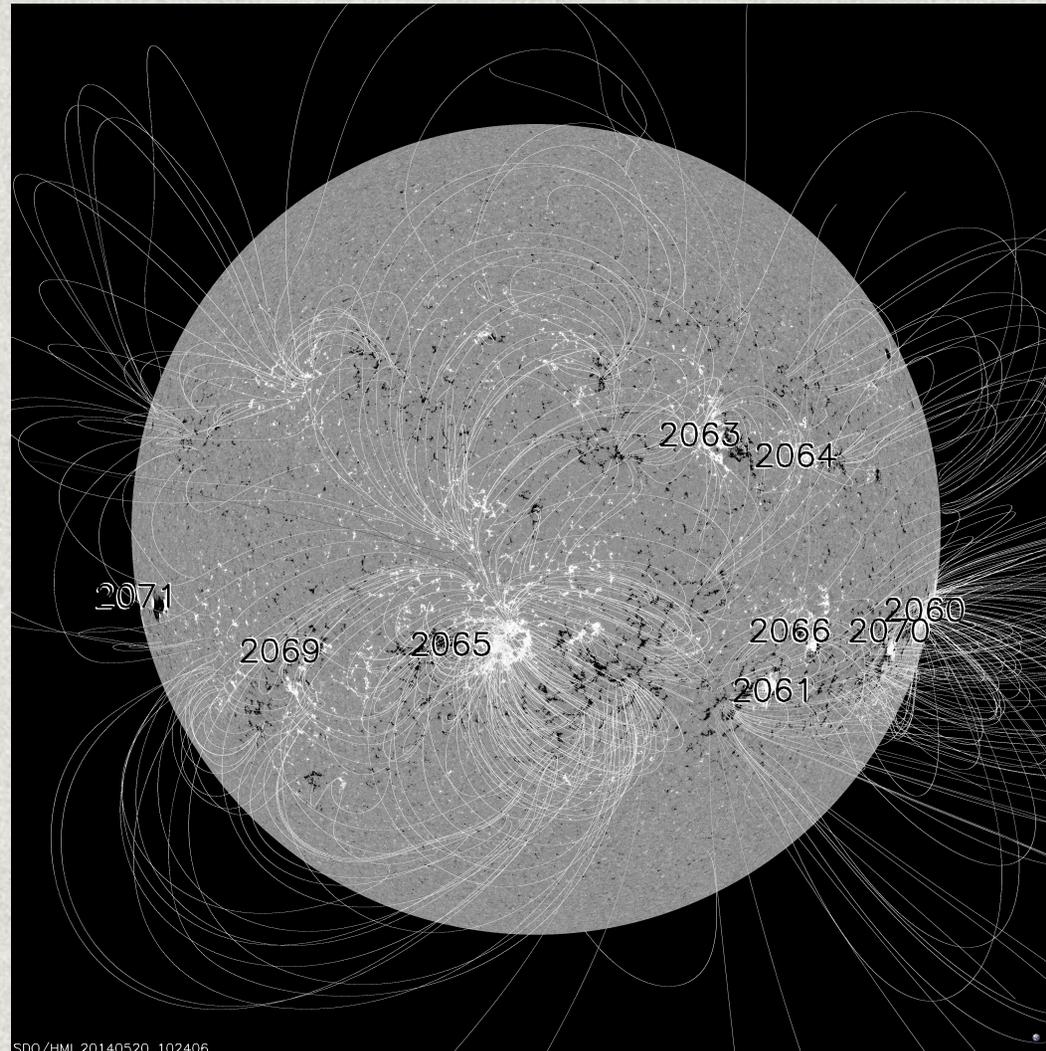
Empirical prescriptions are used to represent:

- \* *solar dynamo*
- \* *3D magnetoconvection*
- \* *global coupling between fields and flows*
- \* *sub-resolution dynamics*

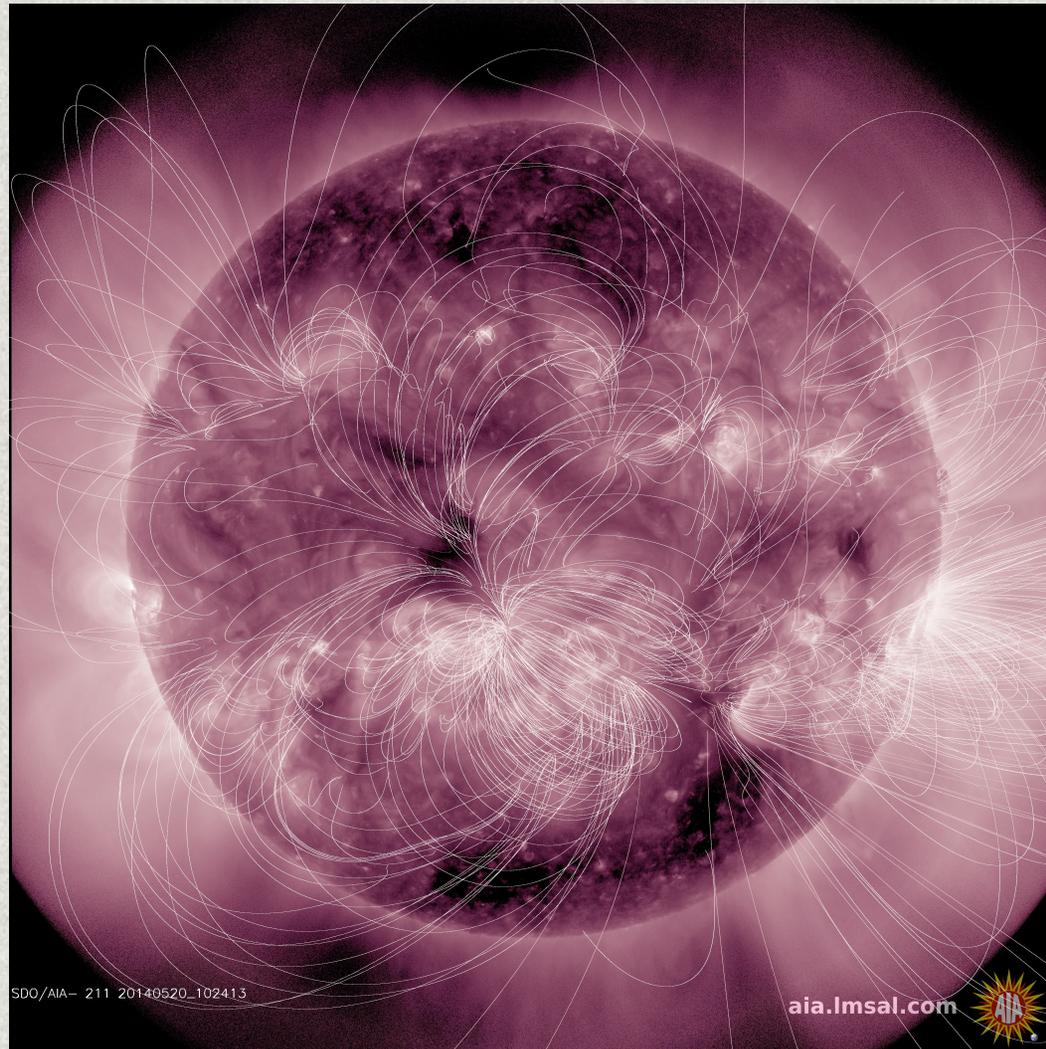
# Earlier Model



# Current-Free Models



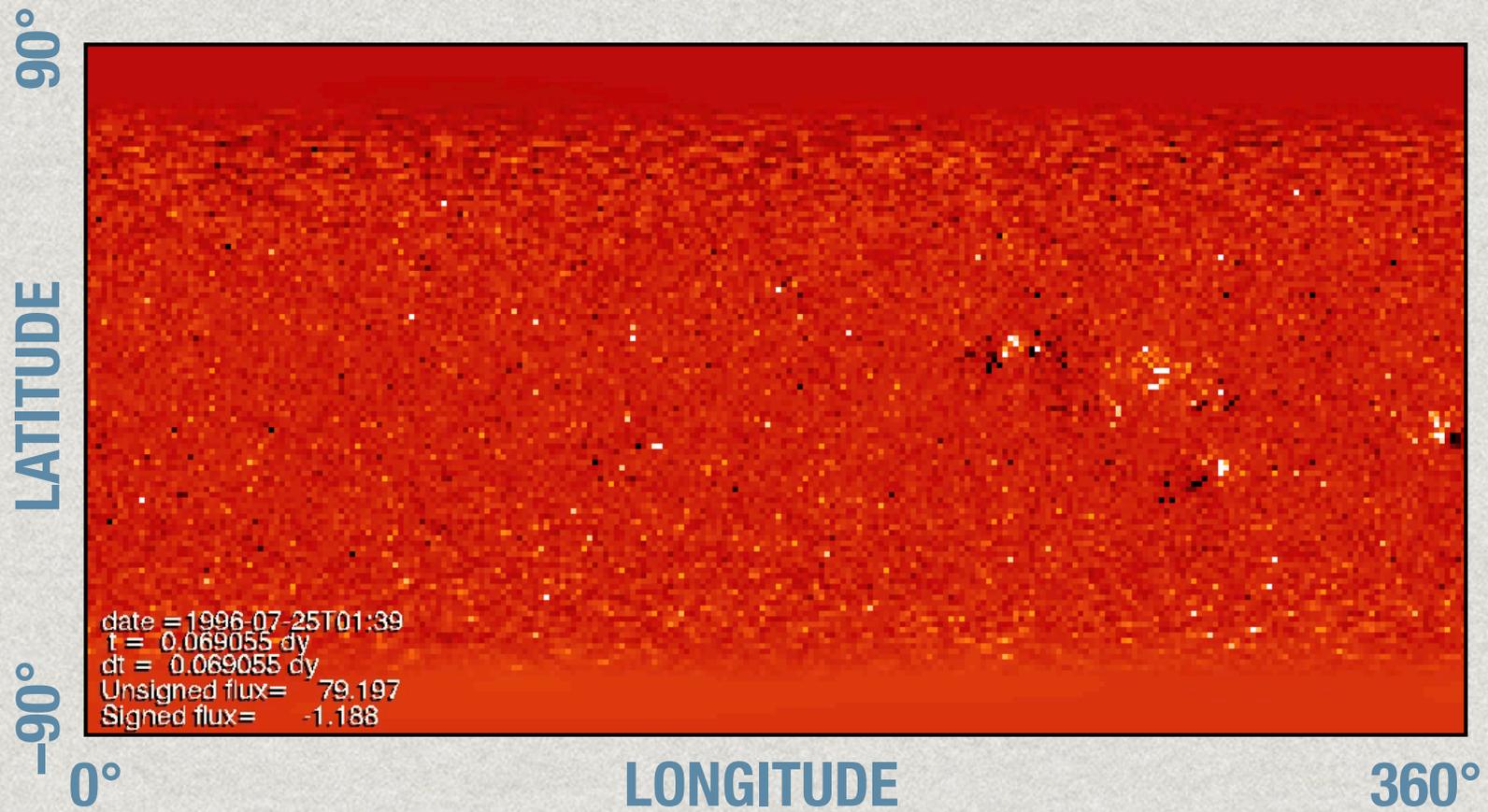
# Current-Free Models



# Newer Model

- \* Grids are commensurate with downstream modules of CGEM, thereby avoiding unnecessary interpolation steps.
- \* Hard to adapt atomic model for vector fields
- \* Numerical scheme used here involves computing flux of  $\mathbf{B}$  across cell boundaries, and so model readily provides  $\nabla \times \mathbf{E}$ .

# Newer Model



# Lessons Learned

- \* Surface flux-transport models are a practical way to approximate the distribution of magnetic flux over the photospheric surface.
- \* Long-term effects of surface flux dynamics have been studied using these models (e.g., polar-cap formation rates and phasing within the solar activity cycle).

# Lessons Learned

- \* Assimilation models are sensitive to instrumental calibrations, e.g., temporal variations in zero points, non-linearity response functions, variations across detector.
- \* Science can be affected by having only Earth perspective; many effects are global and models lack accurate descriptions of flux on sides and back of sun.

# Lessons Learned

- \* Advecting flows (especially poleward meridional flow, which is here constant) are known to be variable and may depend on sunspot cycle characteristics.
- \* Feedback of stronger fields affects flow dynamics; these are usually treated in flux-transport models in an idealized manner.

# Things to be Learned

- \* How discontinuities at edge of assimilation window (e.g., partially assimilated active region) will affect coronal modeling
- \* How uncertainties in measurements of flux, especially on sides and back of sun, will affect coronal modeling
- \* How to best use vector magnetogram data in flux-transport models

# The End

- \* Developers of many data-driven models in heliophysics are now facing similar issues, namely, how to provide the numerical model with consistent boundary conditions based on data.
- \* CGEM is eager to collaborate with other teams grappling with issues similar to those we are dealing with.