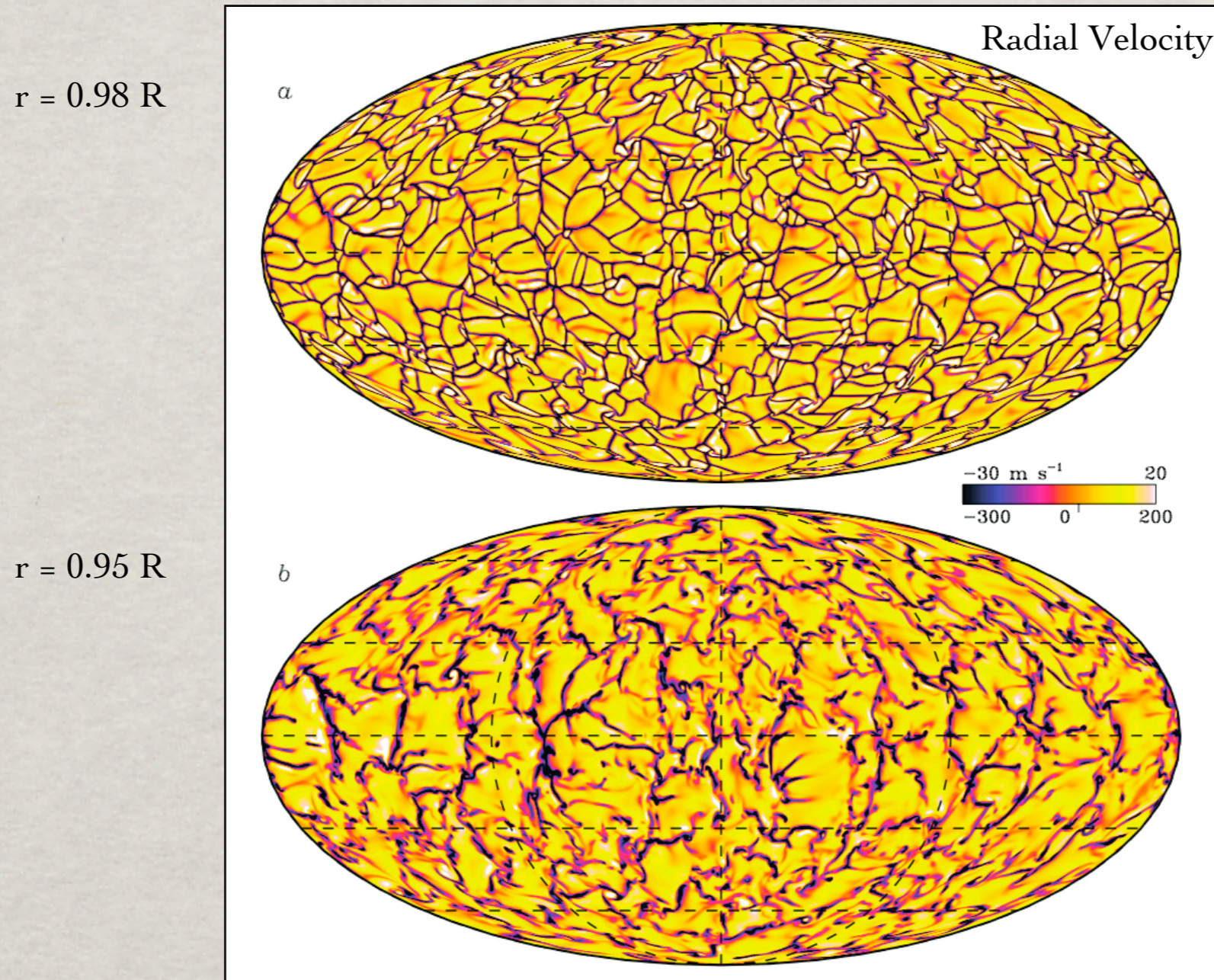


A SEARCH FOR
COHERENT STRUCTURES
IN SUBSURFACE FLOWS

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INTRODUCTION



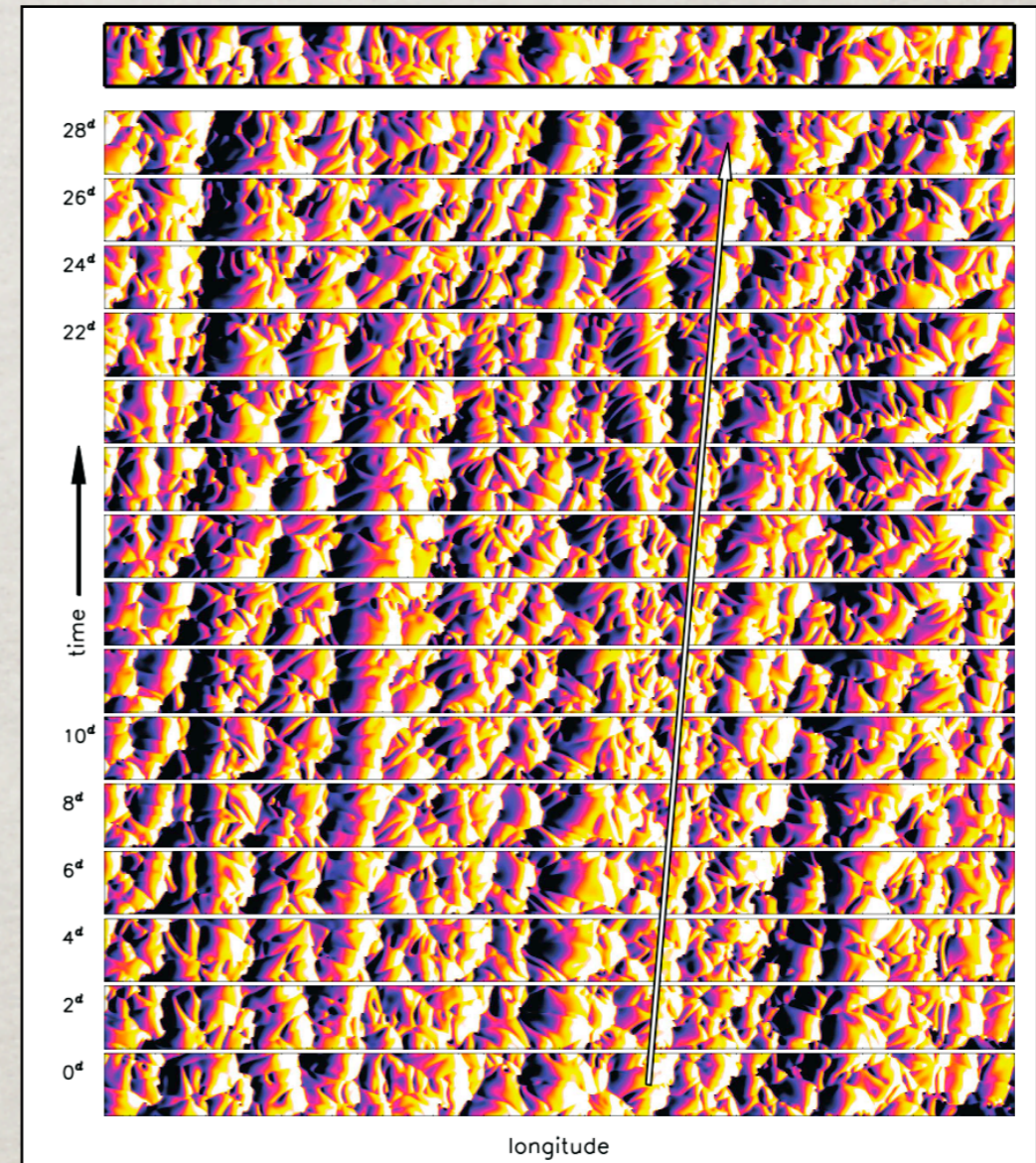
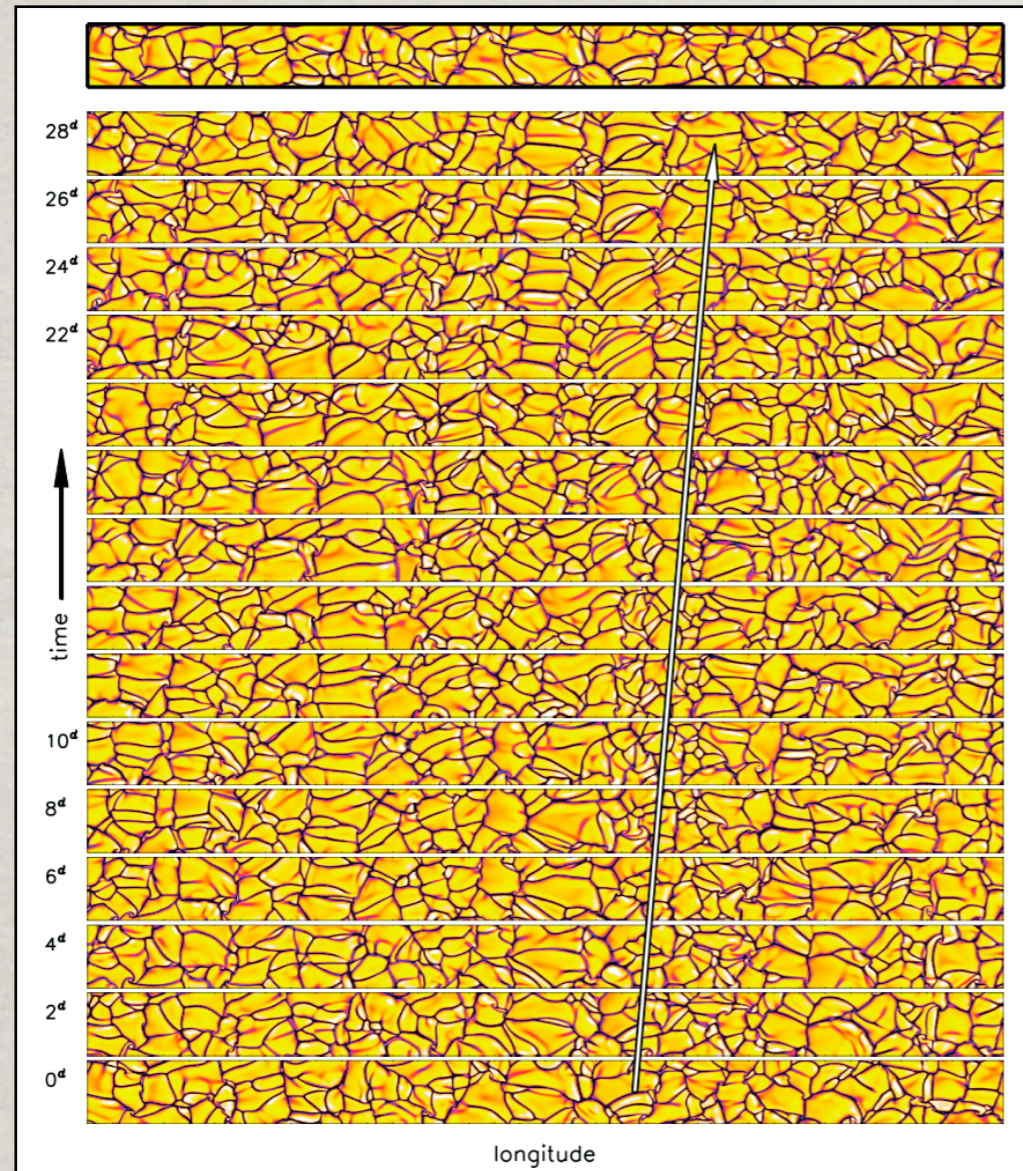
(Miesch et al., 2008)

Global models of solar convection show north-south aligned cells at the equator (remember: giant cells?)

INTRODUCTION

360° longitude, 0°-25° latitude, 2 day intervals

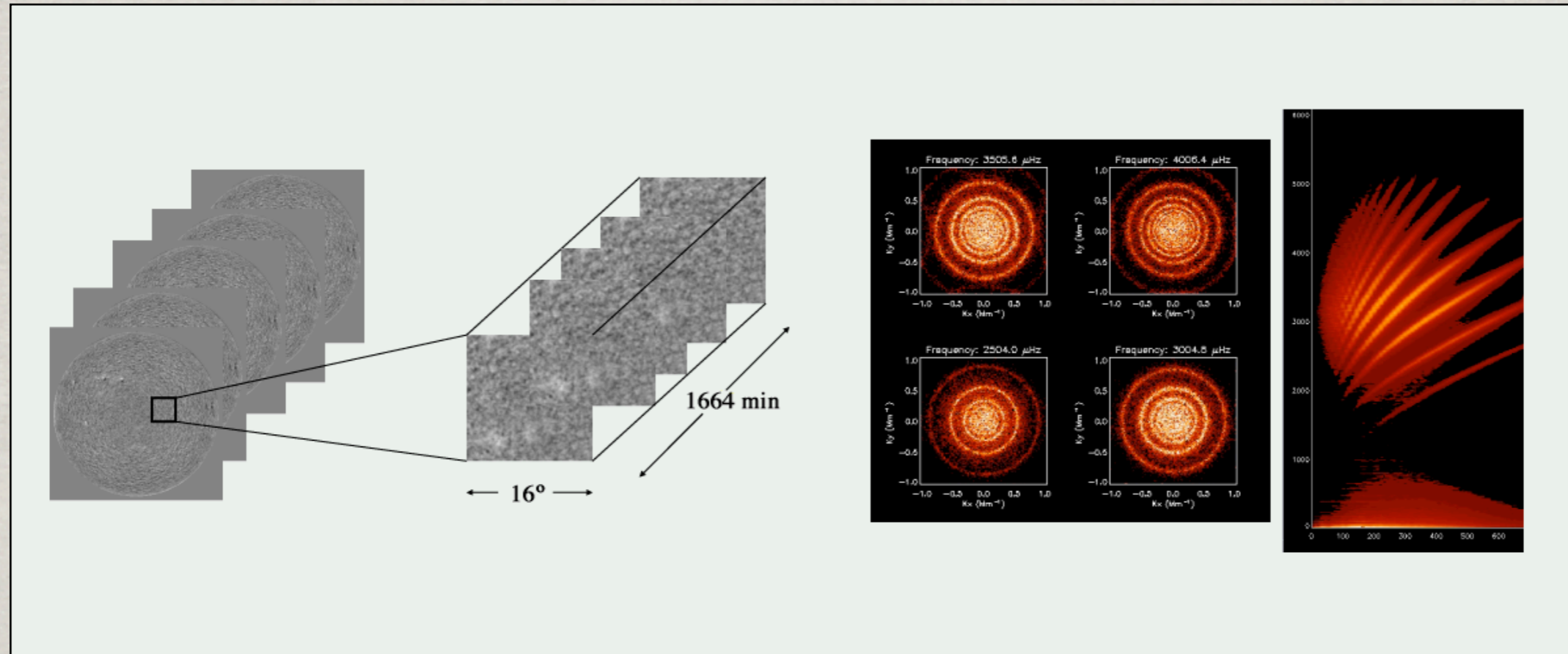
(Miesch et al., 2008)



$r = 0.98 R$

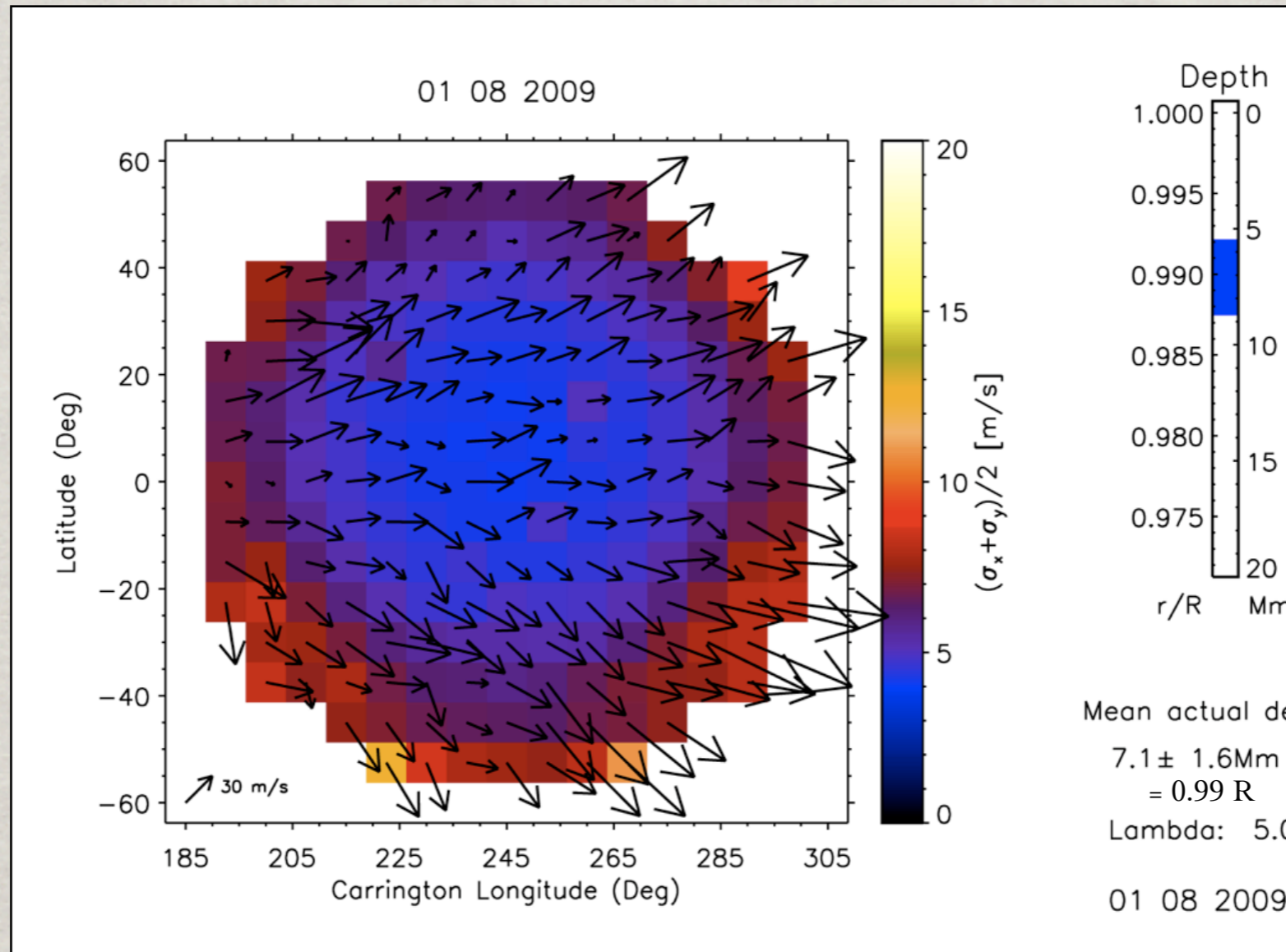
North-south downflow lanes are apparent in the radial velocity (left) and the zonal velocity derivative (right).

RING-DIAGRAM ANALYSIS



16° patch, circular apodized to 15°;
1664 min (1 ring day); 0 - 16 Mm depth.
Comparable to the size of convection cells
much larger than that of downflow lanes.

DAILY FLOW MAP



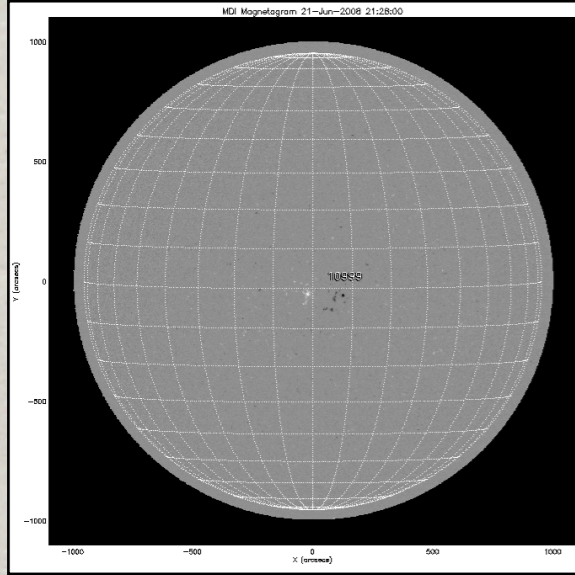
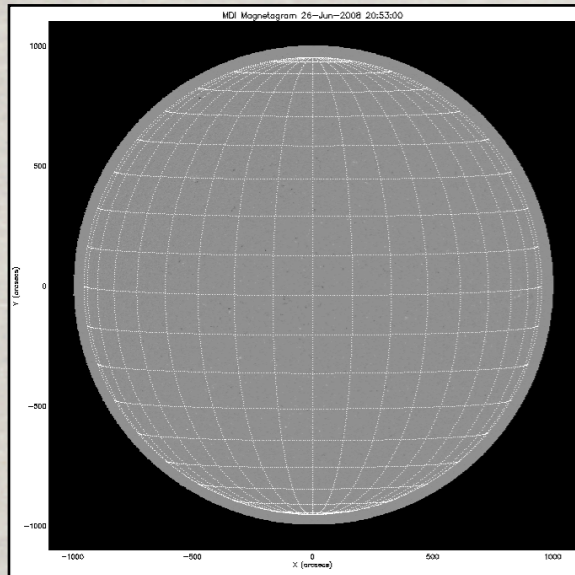
Daily flow maps show large-scale flows in the zonal and meridional direction.

Errors increase toward the solar limb.

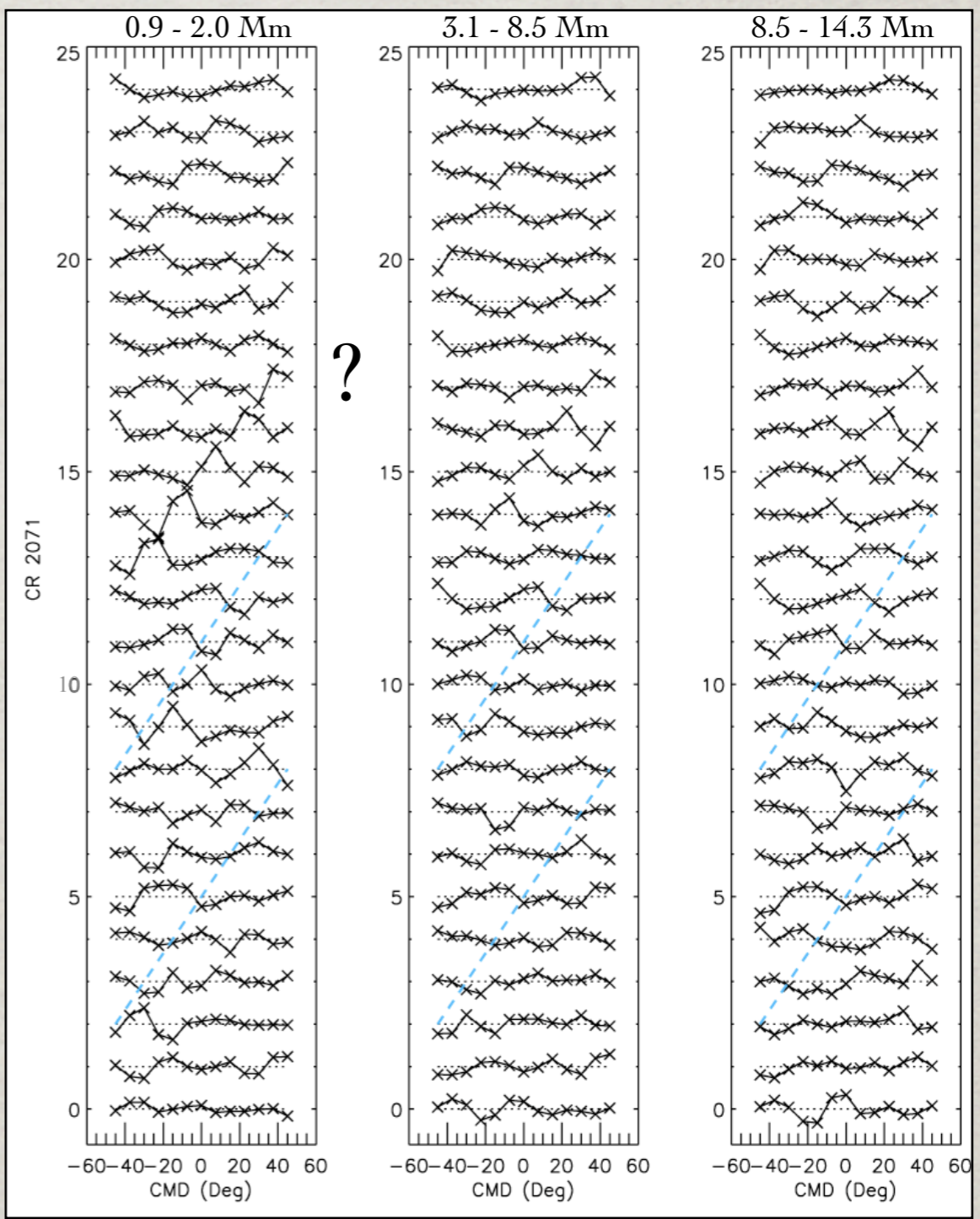
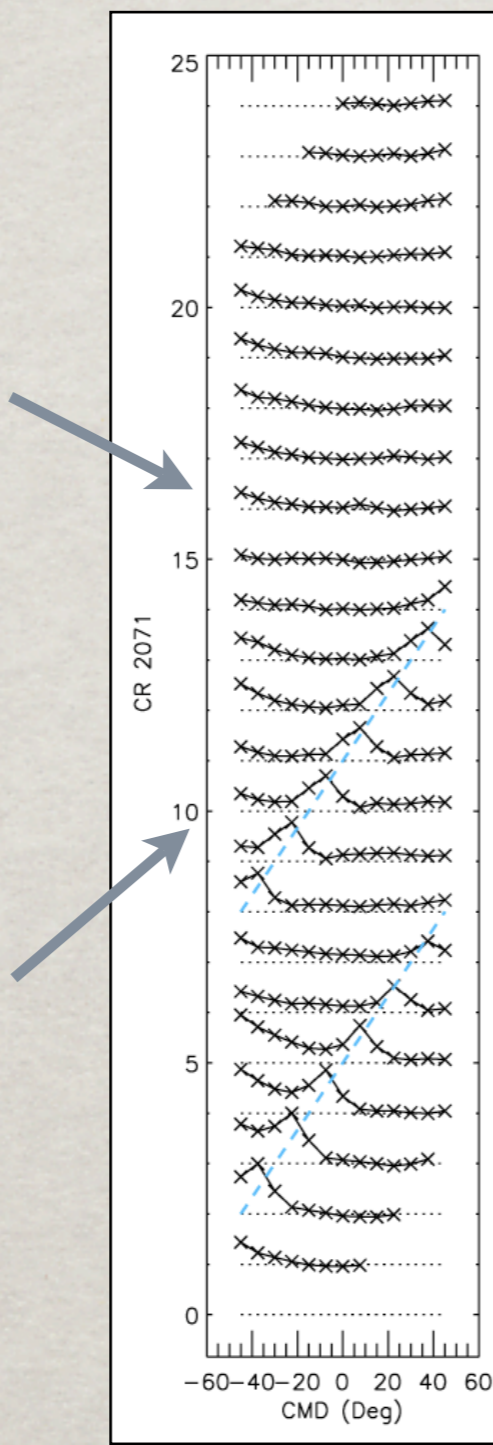
WHAT TO DO?

- ✱ Take daily flow maps
- ✱ Select equatorial strip and average flows in latitude ($|\Theta| < 30^\circ$) for each CMD ($|\Phi| \leq 45^\circ$)
- ✱ Search for a persistent pattern from day to day in the average flow
- ✱ Choose epoch of minimum activity (to avoid active regions)

ZONAL VELOCITY DERIVATIVE

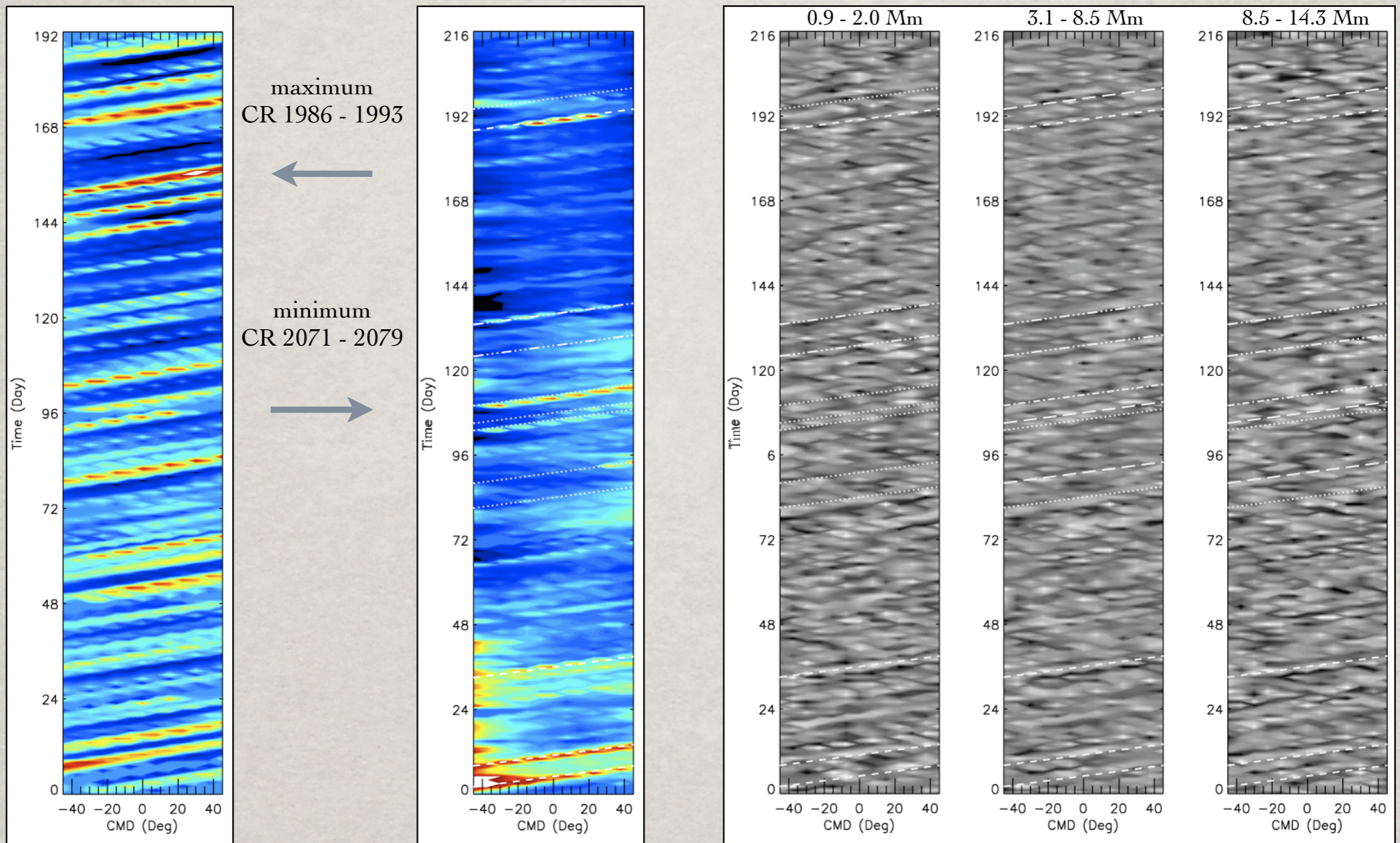


MDI magnetograms



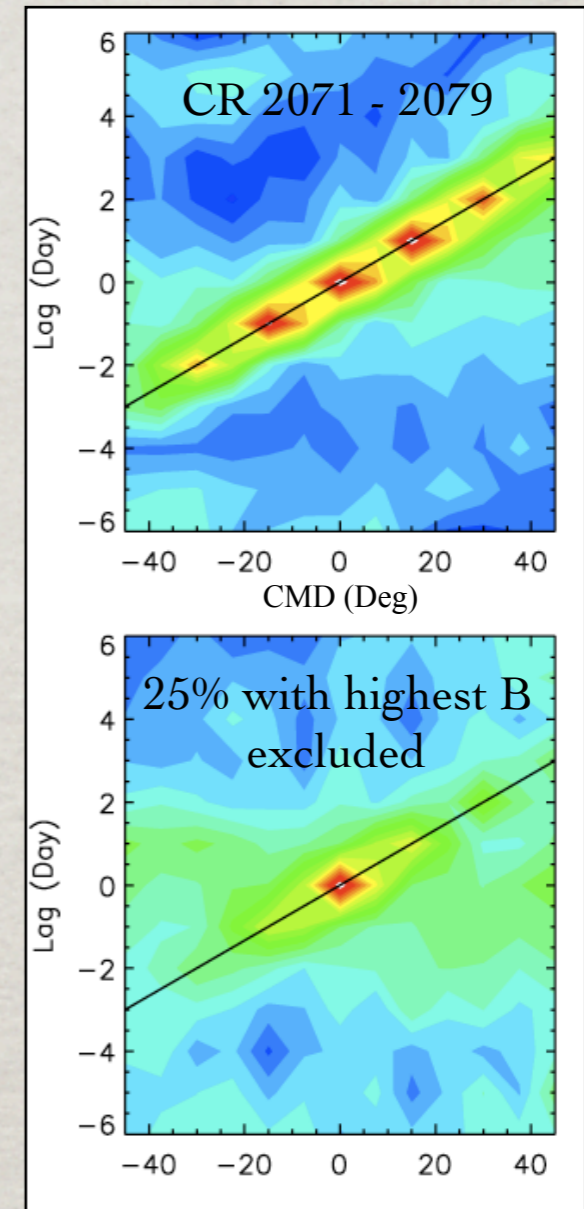
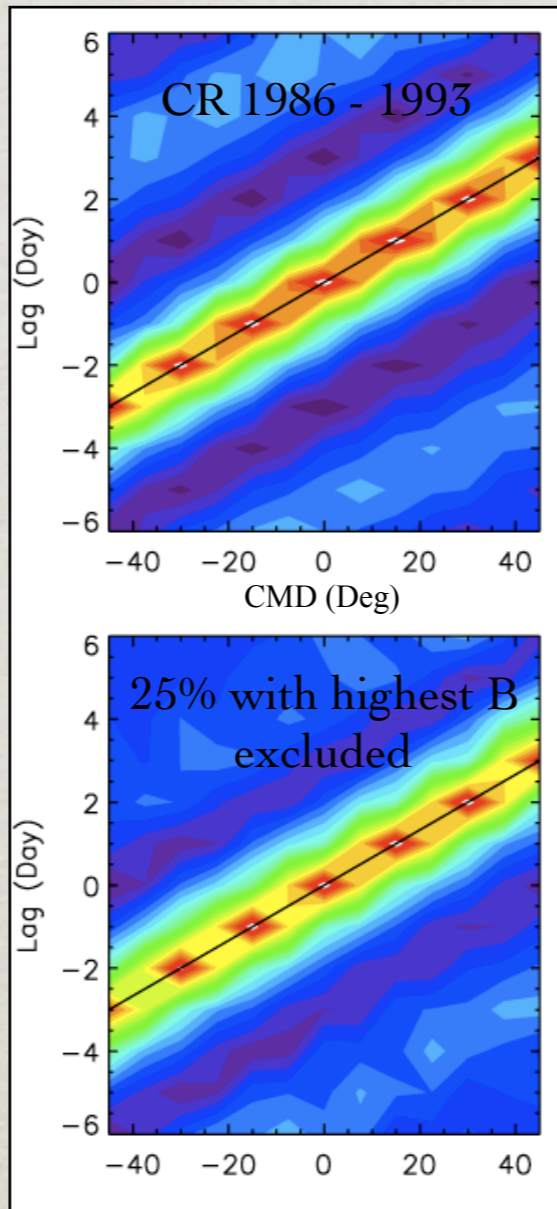
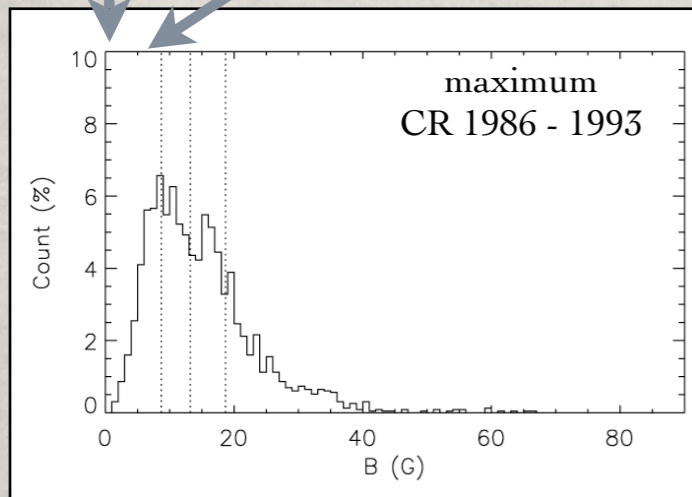
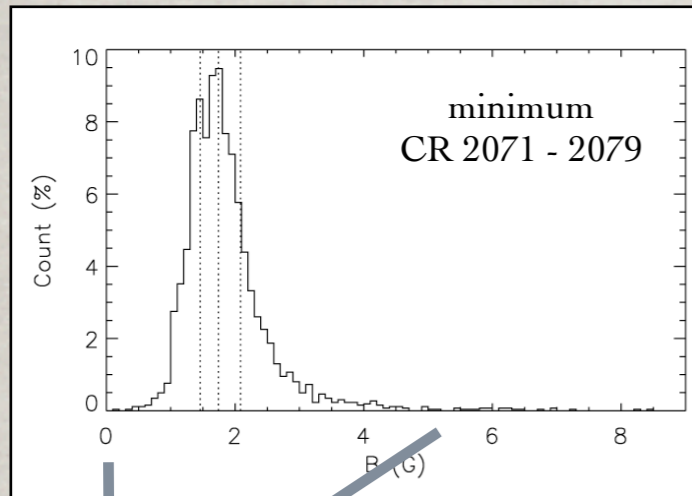
What is this pattern near day 15 of CR 2071?

ZONAL VELOCITY DERIVATIVE



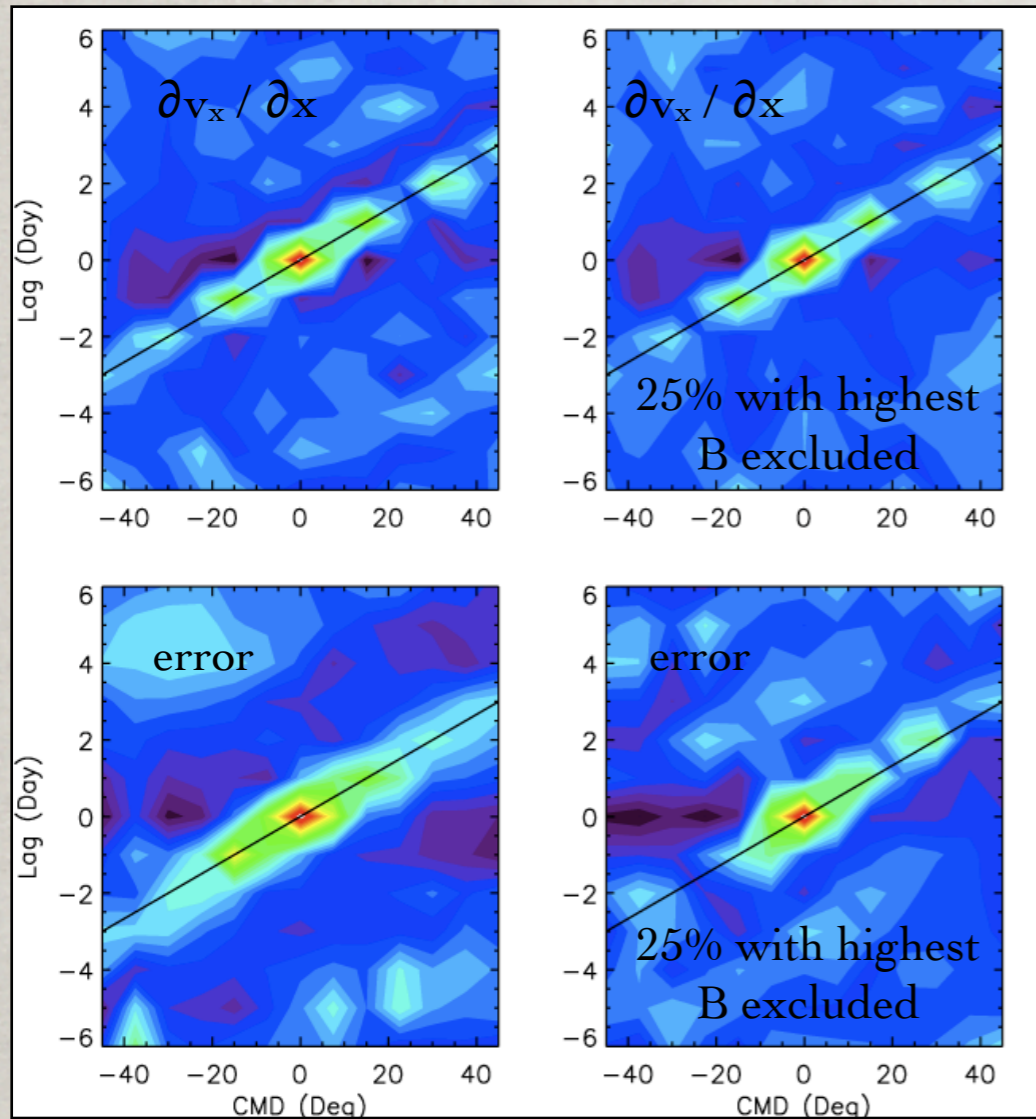
Magnetic and flow patterns move across the disk.

MAGNETIC-FIELD PATTERN



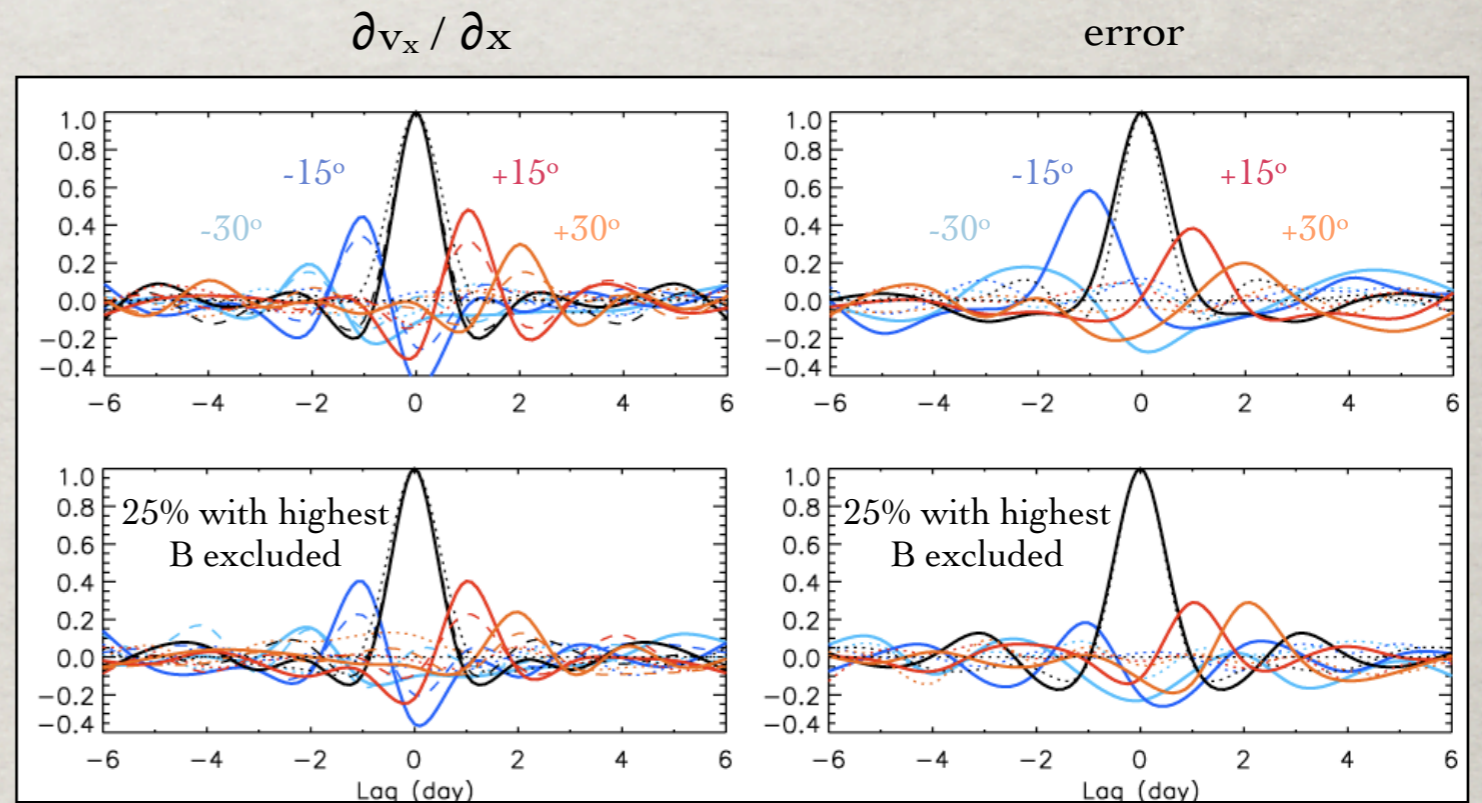
Correlations show patterns exist even during minimum.
The correlation is weaker during minimum.
Excluding largest 25% reduces the correlation at minimum.

FLOW-PARAMETER PATTERN



3.1 - 8.5 Mm

CR 2071 - 2082

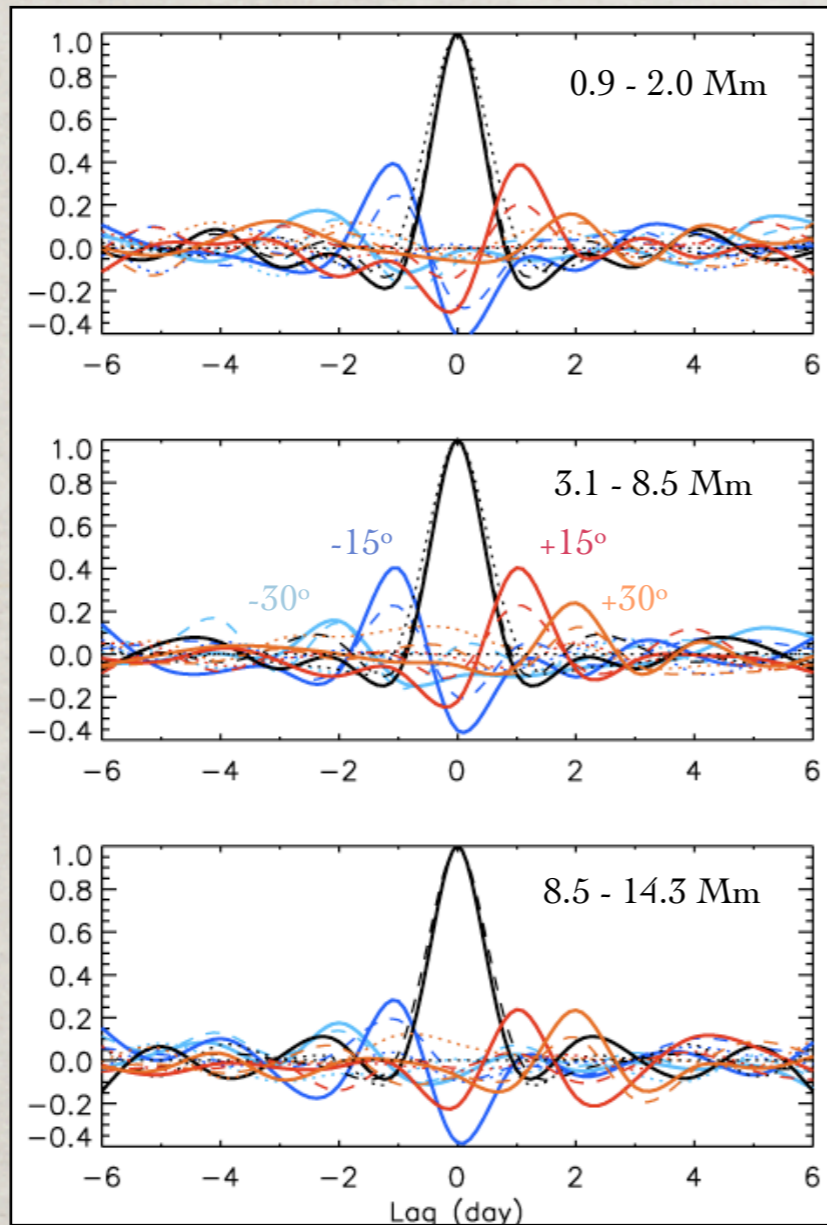


(1 day = 15° CMD : rotation)

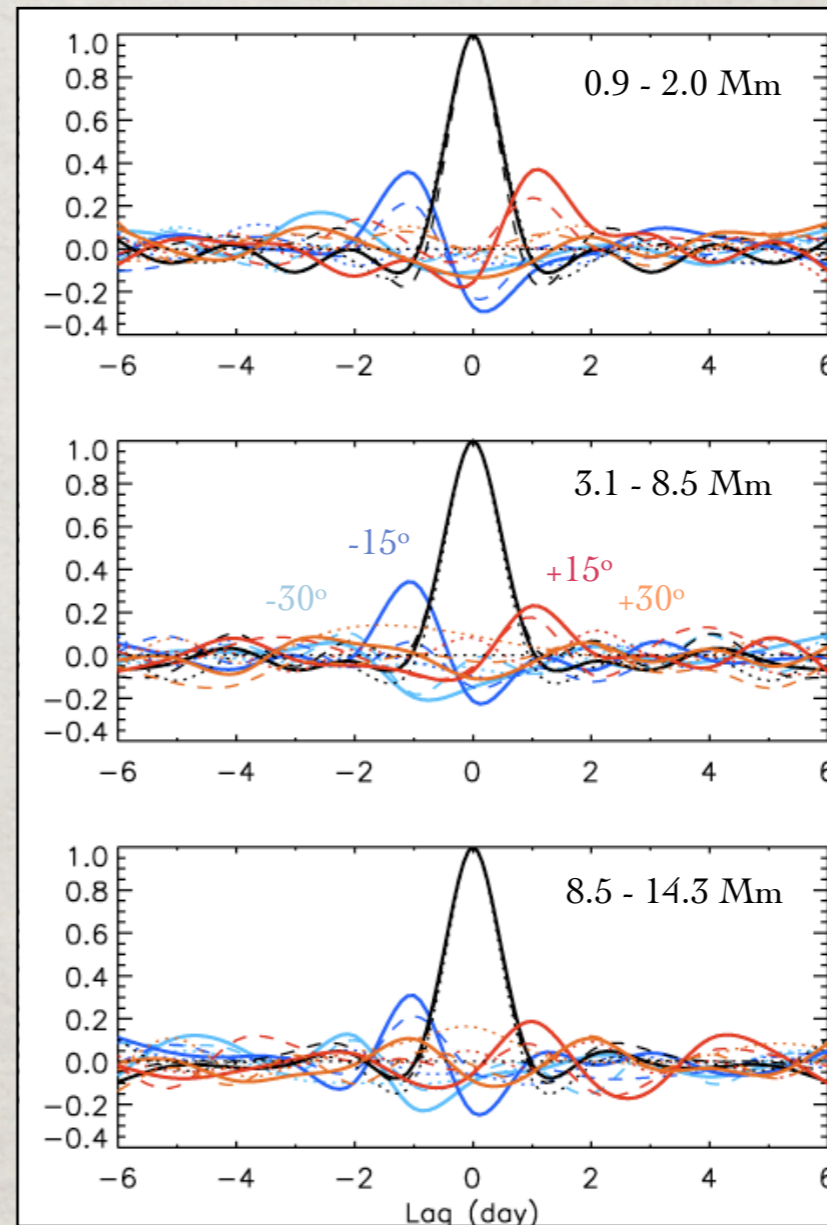
Errors correlate well with magnetic activity.
 Their correlation is reduced after excluding largest 25%.
 Pattern persists for days in zonal flow derivative.

FLOW-PARAMETER PATTERN

zonal
velocity
derivative
 $\partial v_x / \partial x$



vertical
velocity
 v_z



25% with largest B
excluded

CR 2071 - 2082

The correlation is weaker at greater depth (at $\pm 15^\circ$).
The correlation is larger than for a random set (dotted).
The correlation is less pronounced for v_z (at $\pm 30^\circ$).

SUMMARY

- ✻ Subsurface flows are sensitive to the presence of magnetic activity (even during minimum).
- ✻ We find structures that persist for several days in the zonal flow derivative and the vertical velocity.
- ✻ Consistent with other observations:
North-south aligned pattern in supergranulation
(Lisle, Rast, Toomre, 2004, Nagashima et al. 2010)

WHAT IS IT?

- ✻ CZ models and pattern in supergranulation: convective structures
- ✻ Some flow variations look too strong for such weak fields: submerged magnetic fields?
- ✻ Artifacts?