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(Dynamics of Magnetic Bright Points)



# Dynamics of small-scale granular cells

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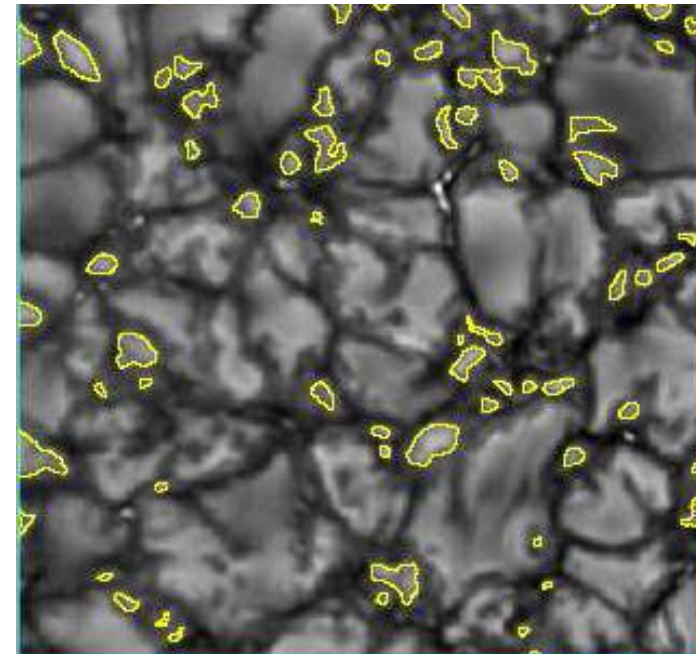
IGAM/Institute of Physics, University of Graz, Austria  
this work is done in cooperation with colleagues from Vienna



# Detection of small-scale granular cells

## Motivation

- Abramenko et al. (2012)
- NST observations
- Existence of sub-population of small granular structures  $< 600$  km
- Contributes significantly to total area
- Located in intergranular lanes, form clusters and chains



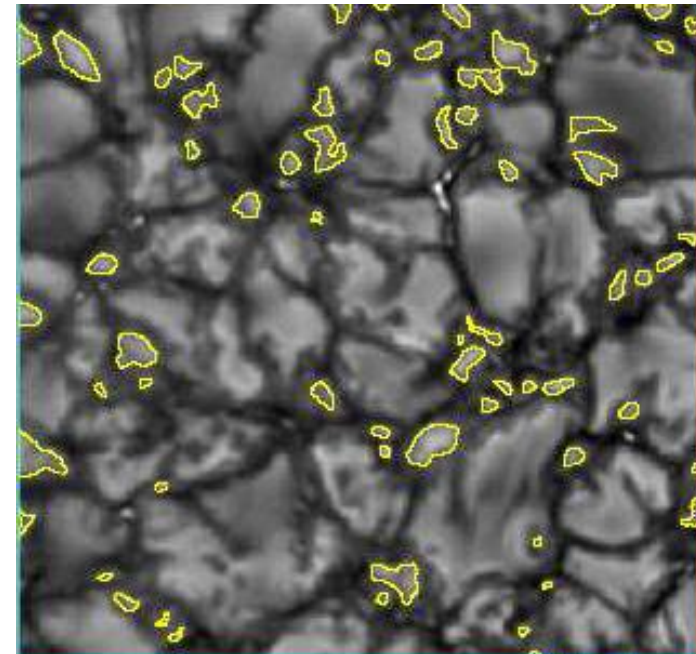
Abramenko et al. (2012)

- No characteristic scale  $\rightarrow$  sophisticated mechanism, small fluctuations affect dynamics

# Detection of small-scale granular cells

## Motivation

- Is detection matter of spatial resolution?
- Pure convective origin?
- Result of the influence of magnetic flux tubes? Suppressed by strong vortex flows?
- What are the main physical and structural properties?
- Evolution of convective cells?

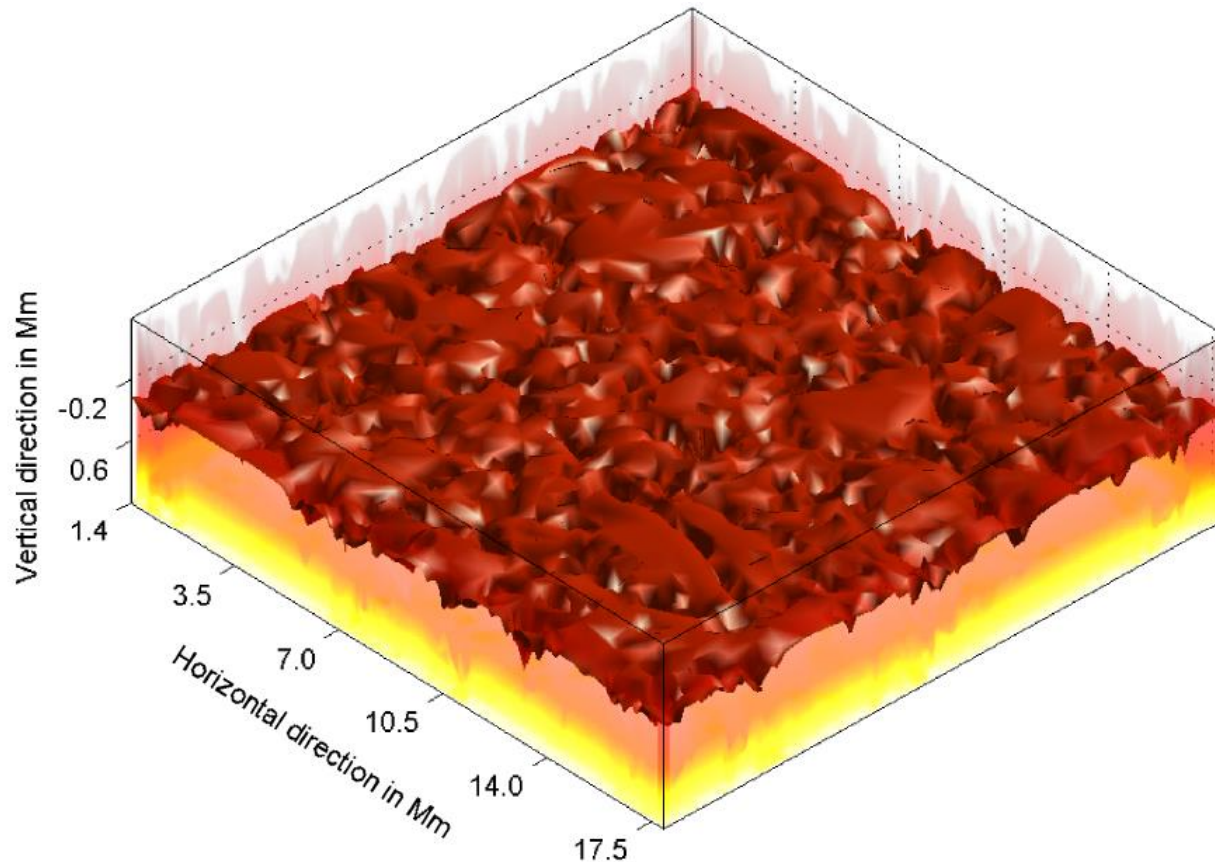


Abramenko et al. (2012)

# Detection of small-scale granular cells

Data: Simulations    Data: Observations    Segmentation algorithm

Development of automatic 2D segmentation algorithm using RHD Simulations carried out with ANTARES



6 Mm x 18 Mm x 18 Mm  
 vert. resolution: 15 km  
 hor. resolution: 35 km

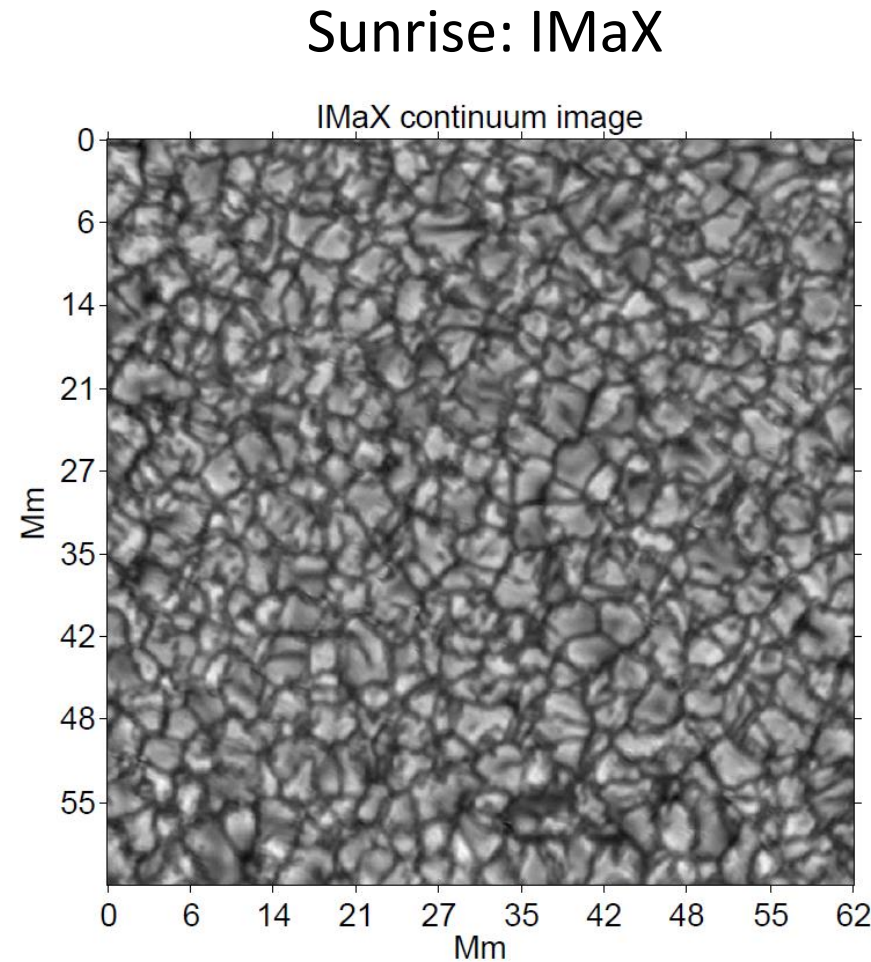
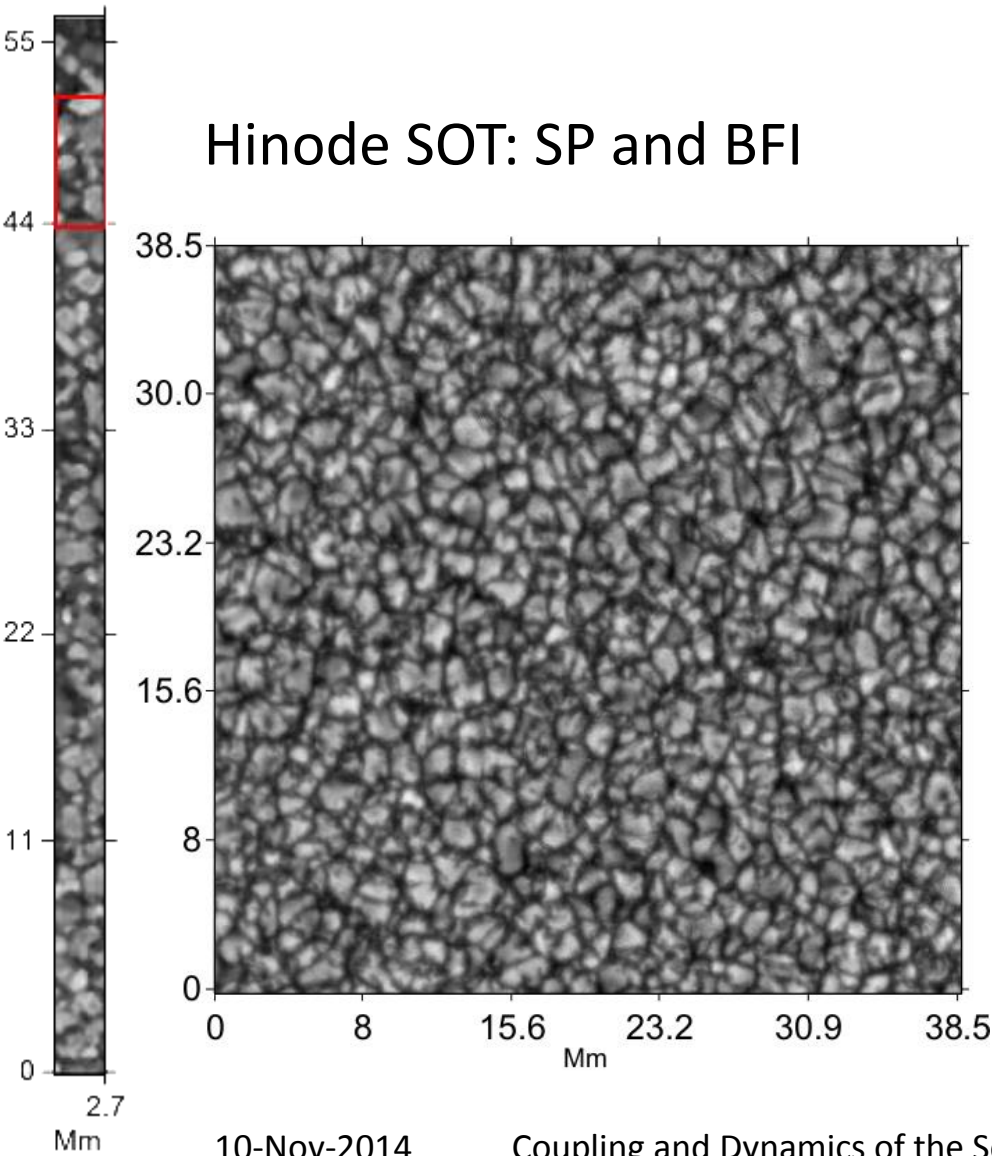
Muthsam et al. (2010)

# Detection of small-scale granular cells

Data: Simulations

Data: Observations

Segmentation algorithm

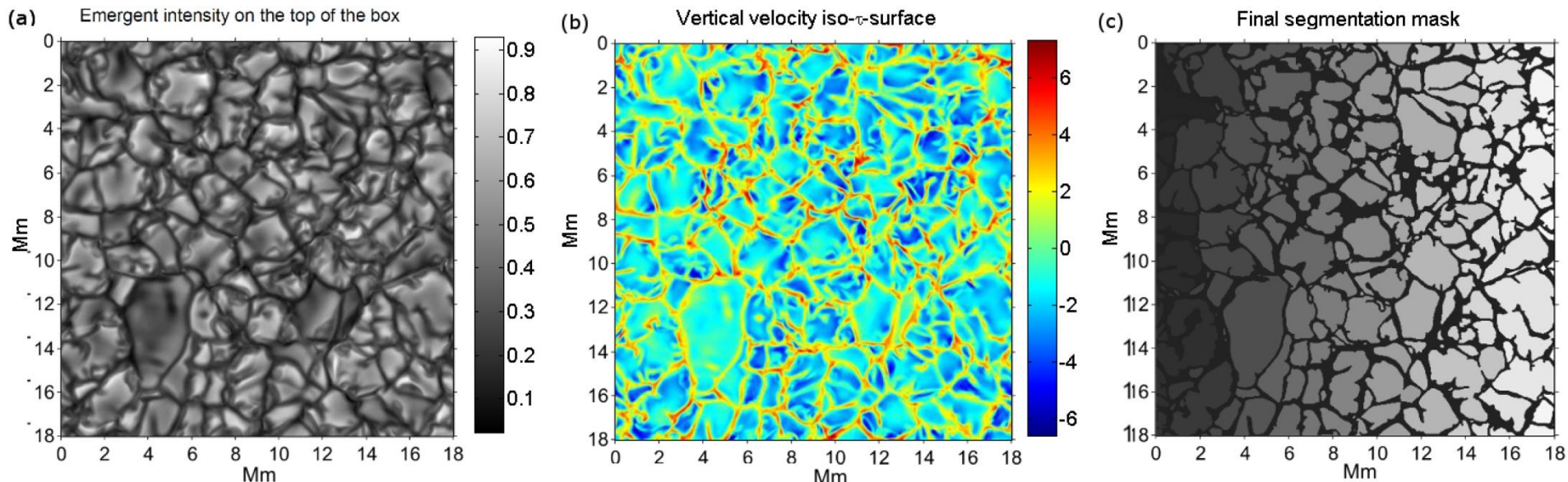


# Detection of small-scale granular cells

Data: Simulations    Data: Observations    Segmentation algorithm

## RHD simulation

- Iterative thresholding routine applied to vertical velocity
- Morphological operation applied to emergent intensity



Lemmerer et al. (2014)

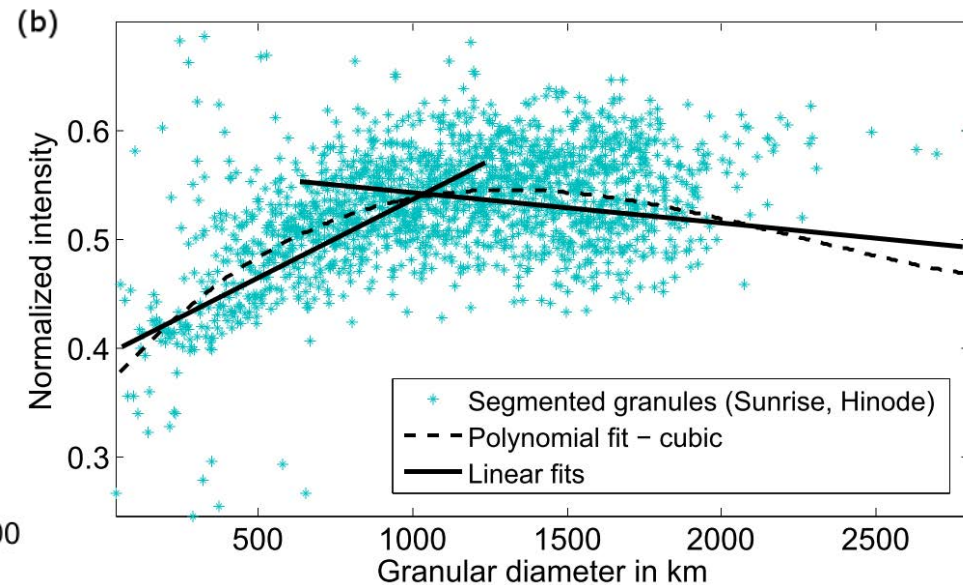
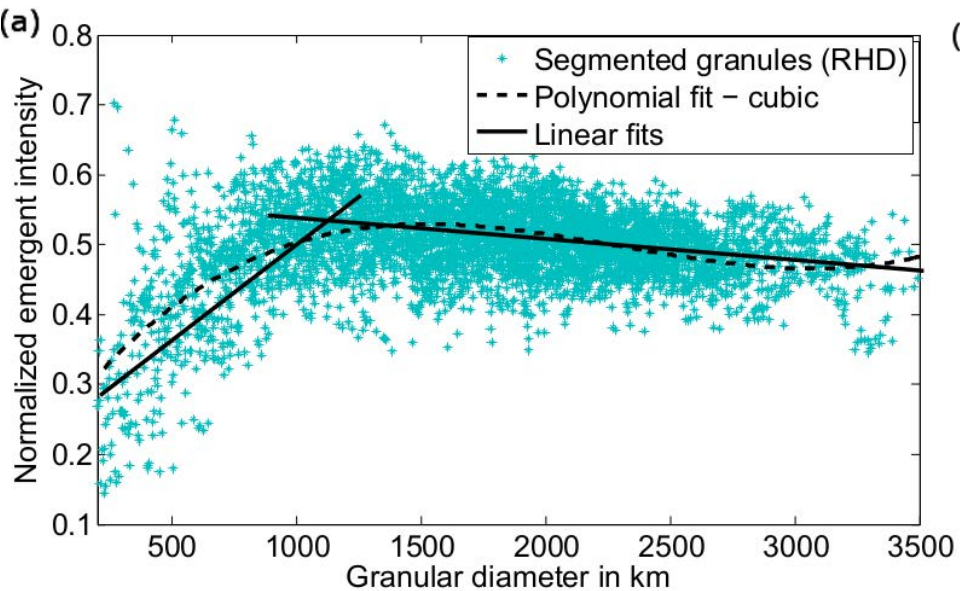
# Analysis of small-scale granular cells

Physical properties

Structural properties

Neighborhood

## Emergent intensity: Simulation vs. Observation



Lemmerer et al. (2014)

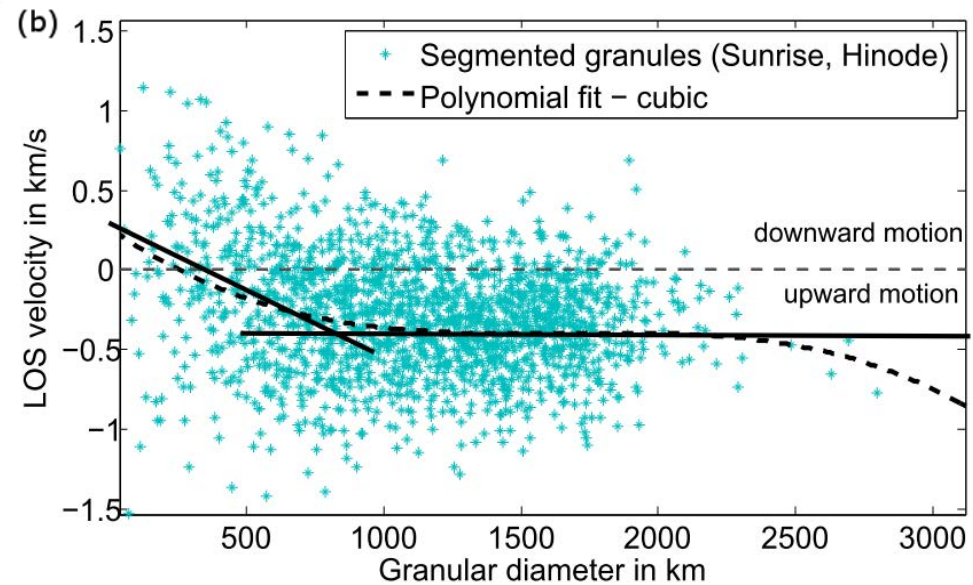
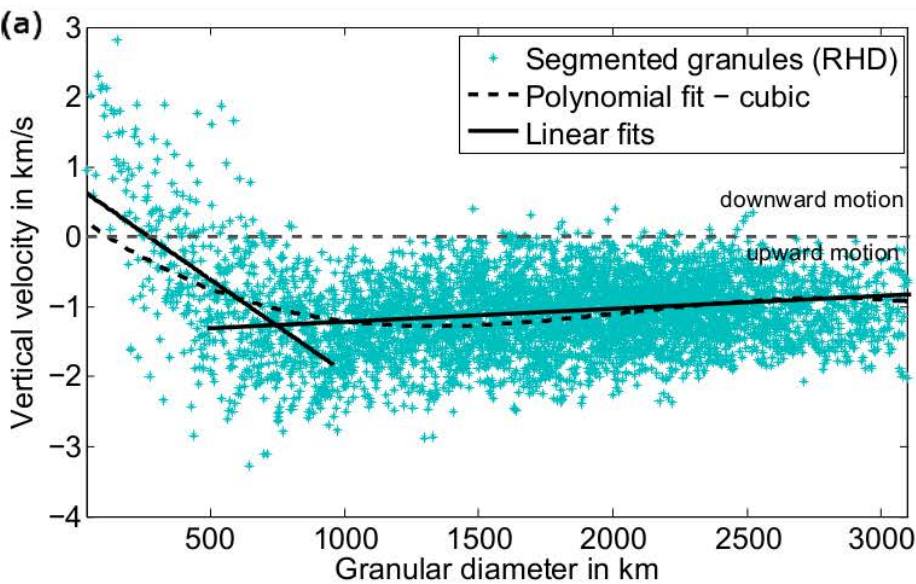
# Analysis of small-scale granular cells

Physical properties

Structural properties

Neighborhood

## Vertical Velocity: Simulation vs. Observation



Lemmerer et al. (2014)

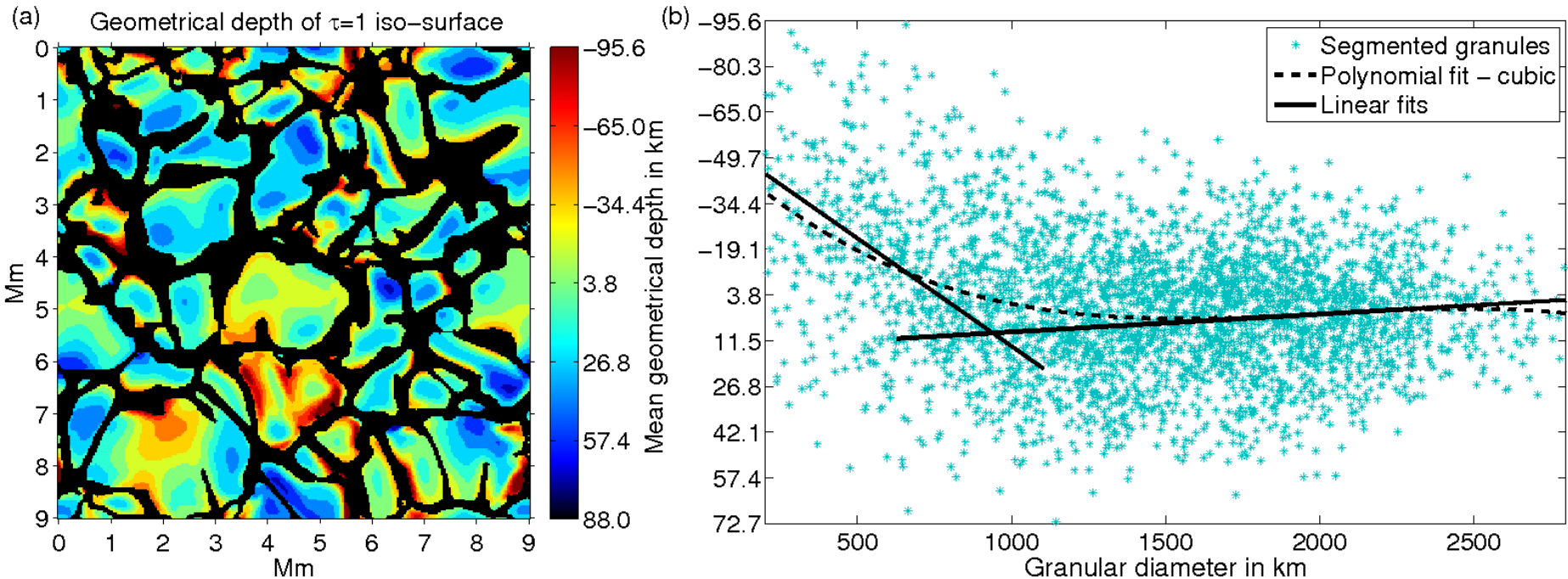
# Analysis of small-scale granular cells

Physical properties

Structural properties

Neighborhood

## Geometrical depth: Simulation

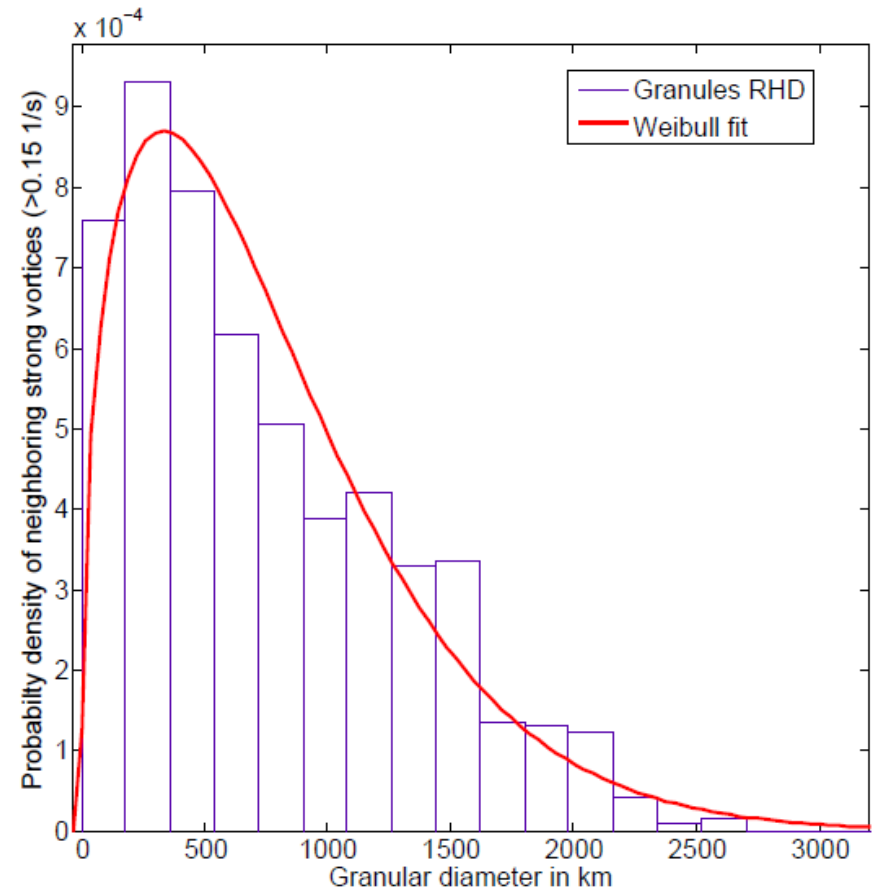
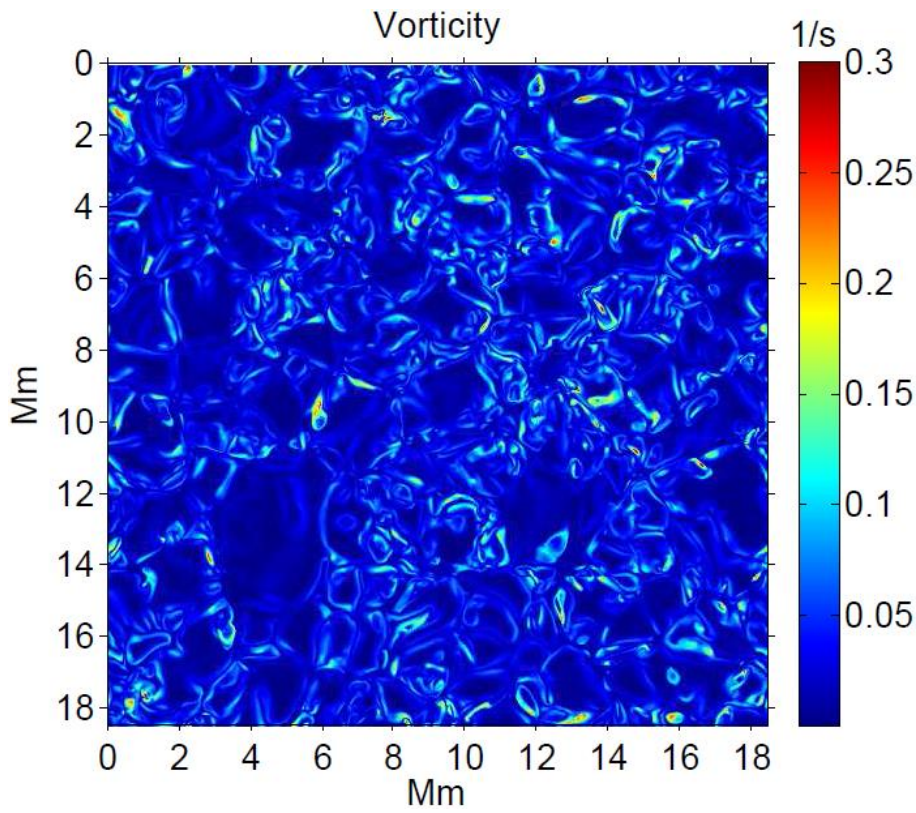


Lemmerer et al. (2014)

# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Neighboring horizontal vortex motions

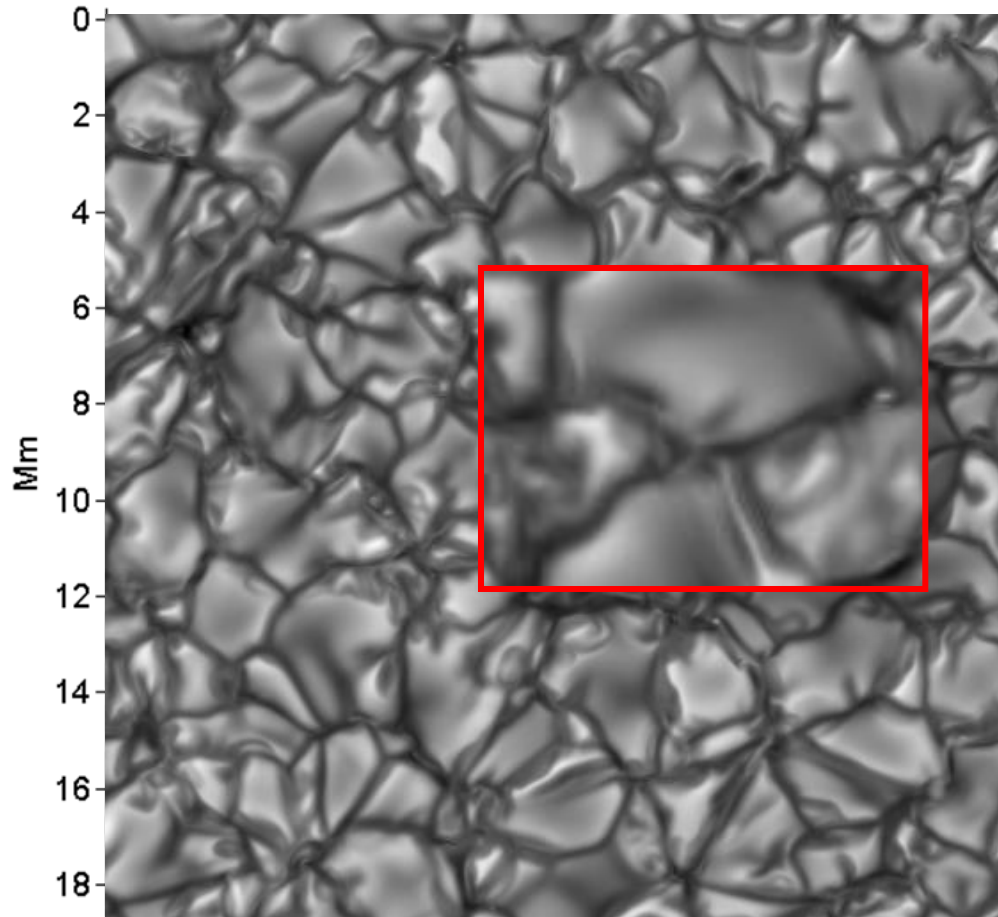


Lemmerer et al. (in prep.)

# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Observational signature of vorticity in simulations

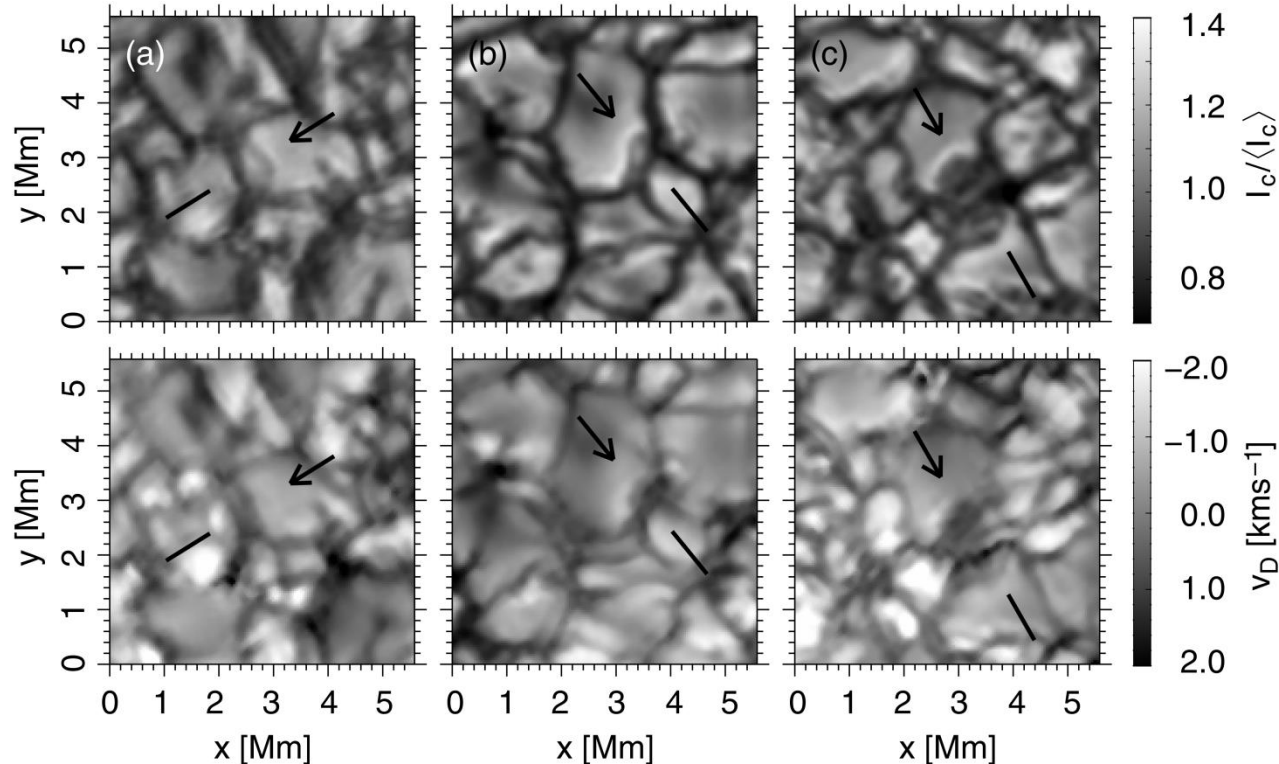


# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Observational signature of vorticity in observations

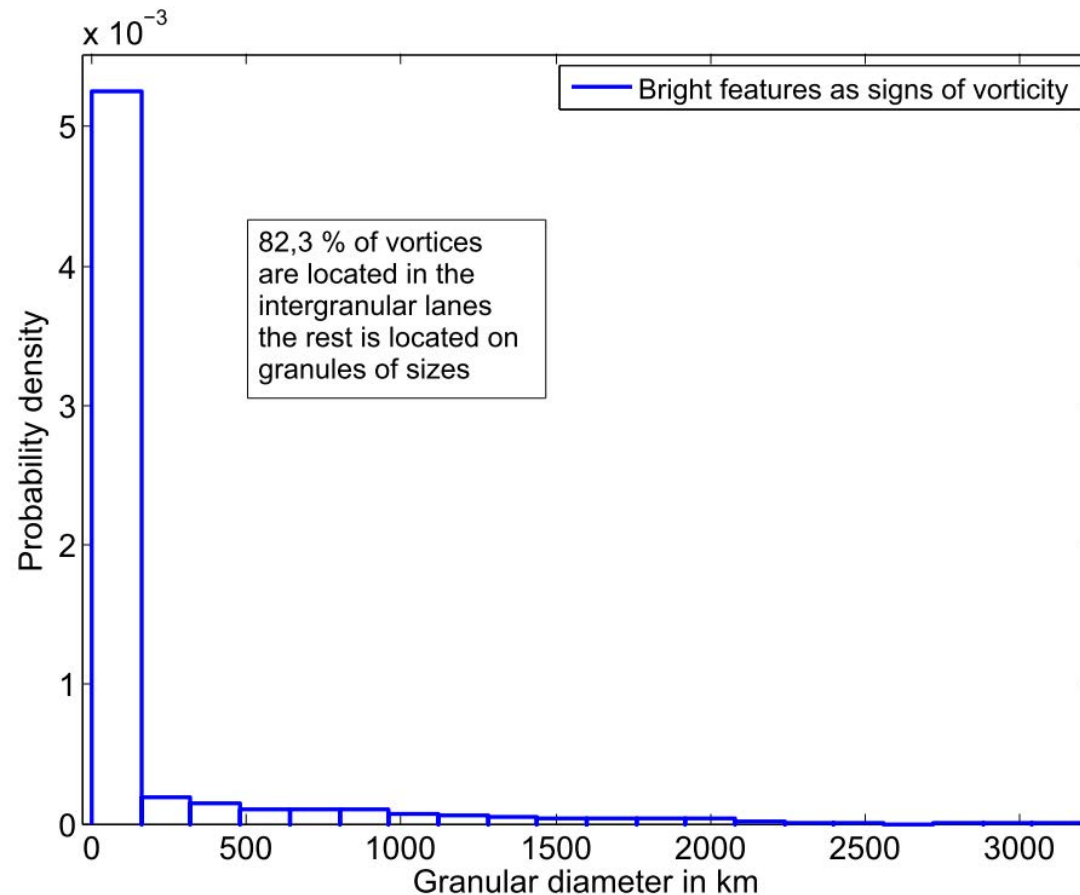
Steiner et al. (2010), Sunrise IMaX data



# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Bright features on granules

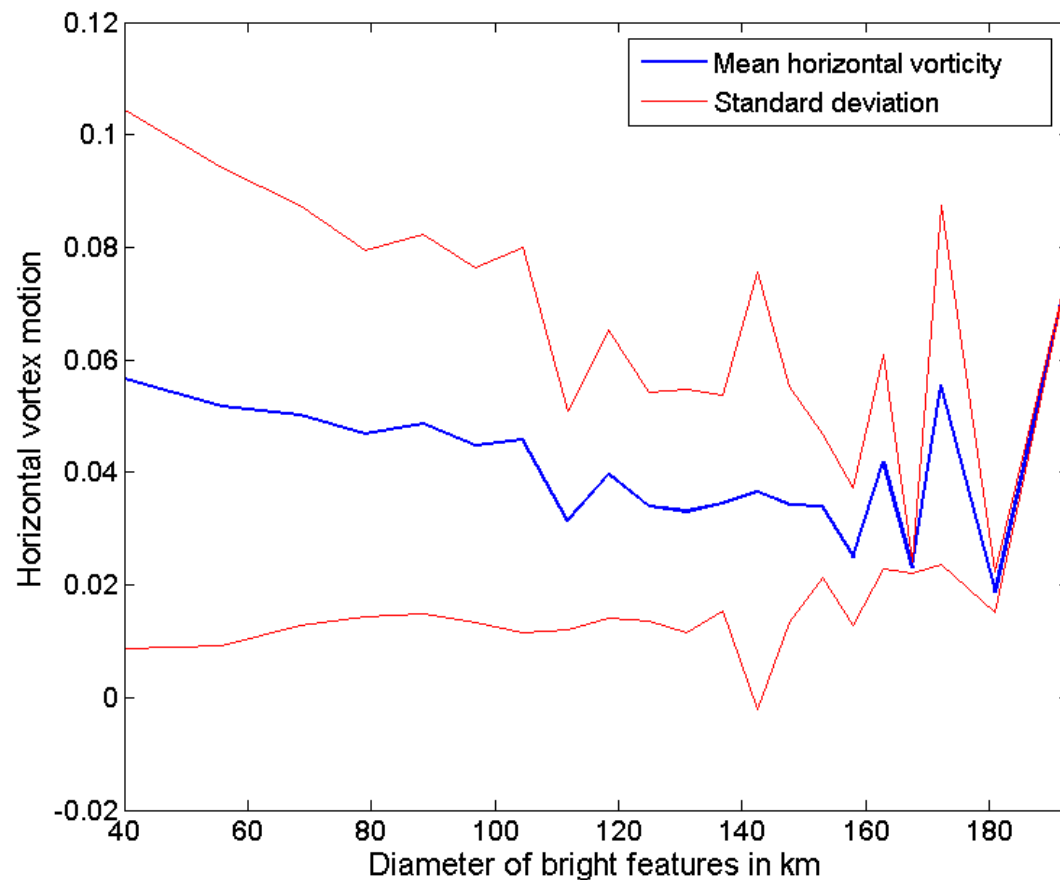


Lemmerer et al. (in prep.)

# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

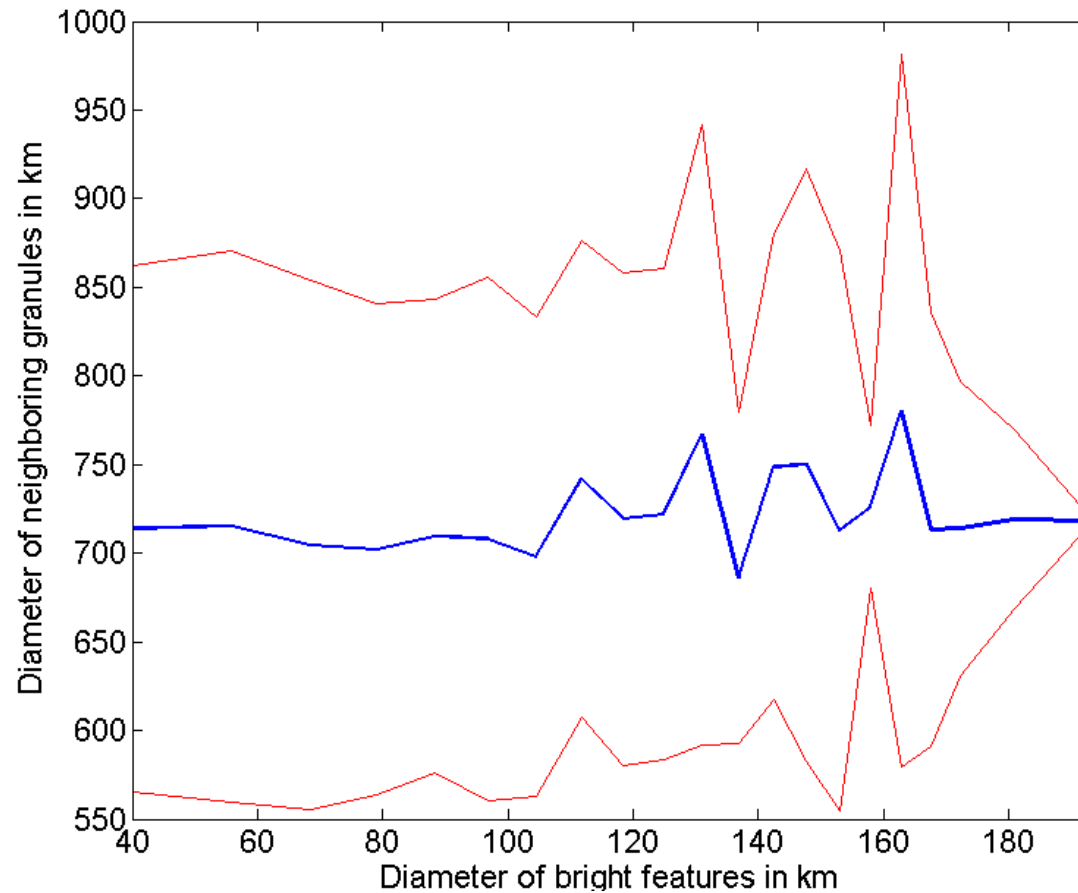
## Horizontal component of vortex motions on bright features



# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Diameter of granules in vicinity of bright features

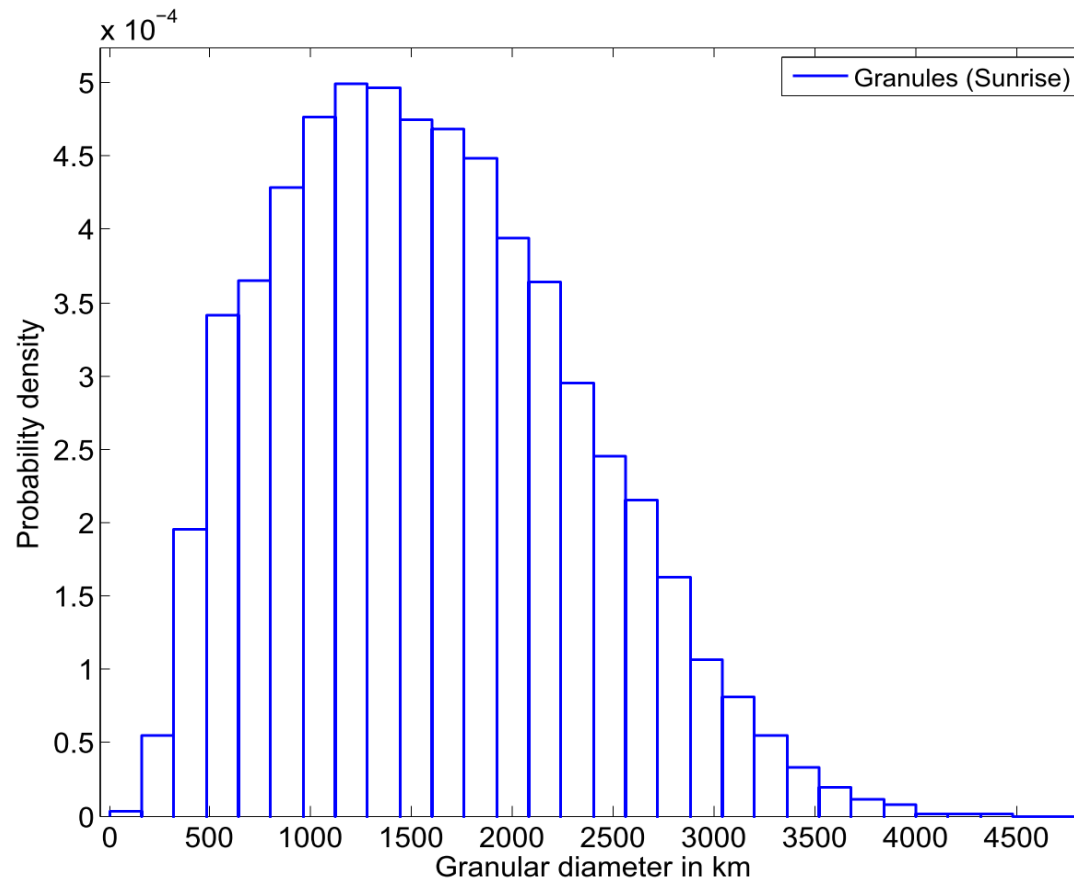


# Neighborhood of small-scale granular cells

Vortex flows    Magnetic fields

## Strong magnetic fields in vicinity of granules (SIR inversions)

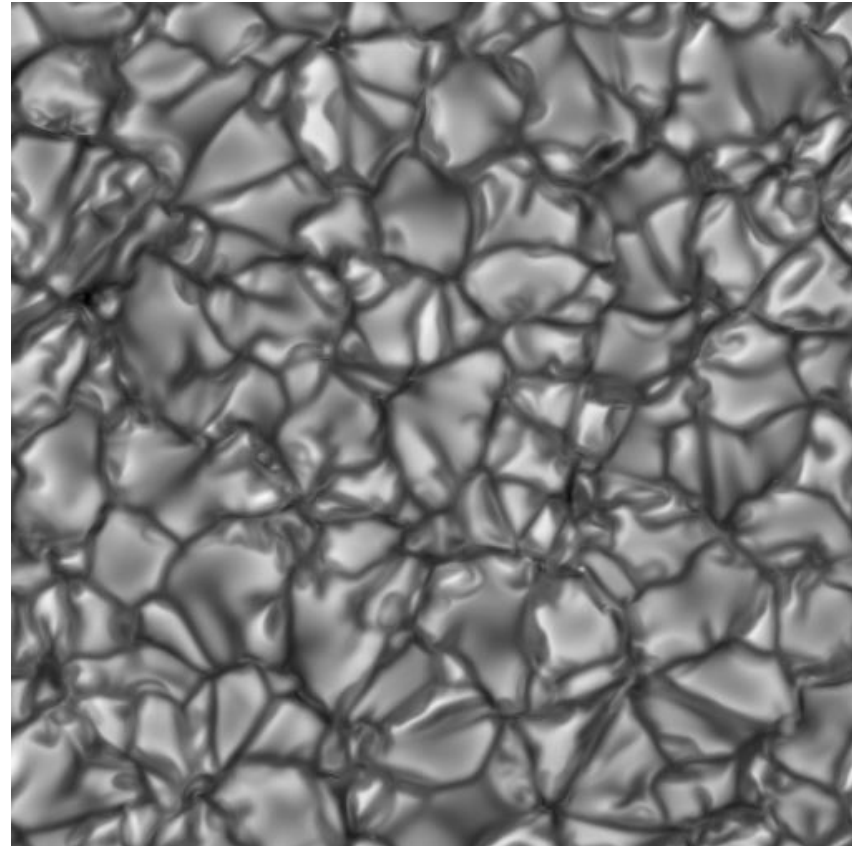
Sunrise IMaX



# Tracking of small-scale granular cells

Tracking algorithm    Tracking results

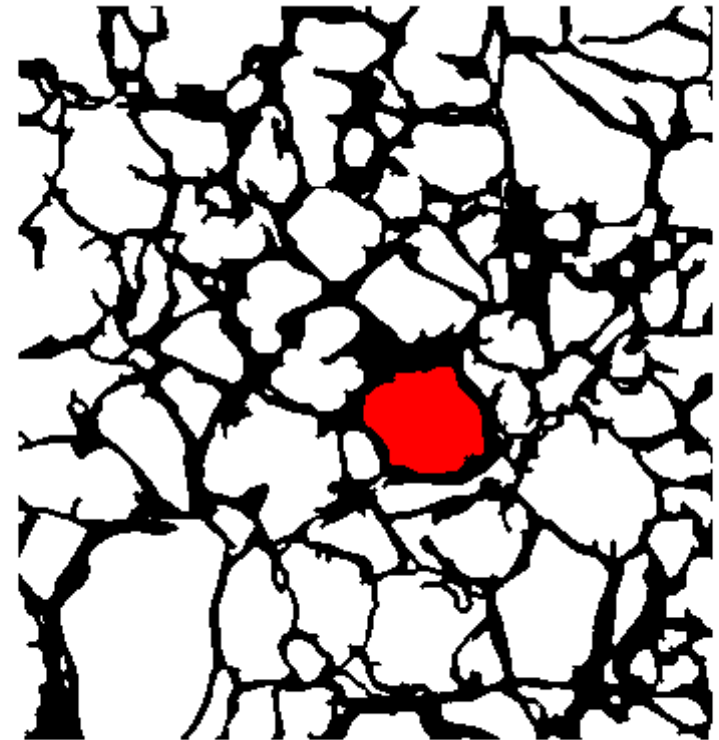
- Automated analysis of evolution of granules
  - High temporal cadence is necessary: 10 sec temporal resolution
- Tracking algorithm:
  - Fragmentation process
  - Statistical information
  - Comparison to observations



# Tracking of small-scale granular cells

Tracking algorithm    Tracking results

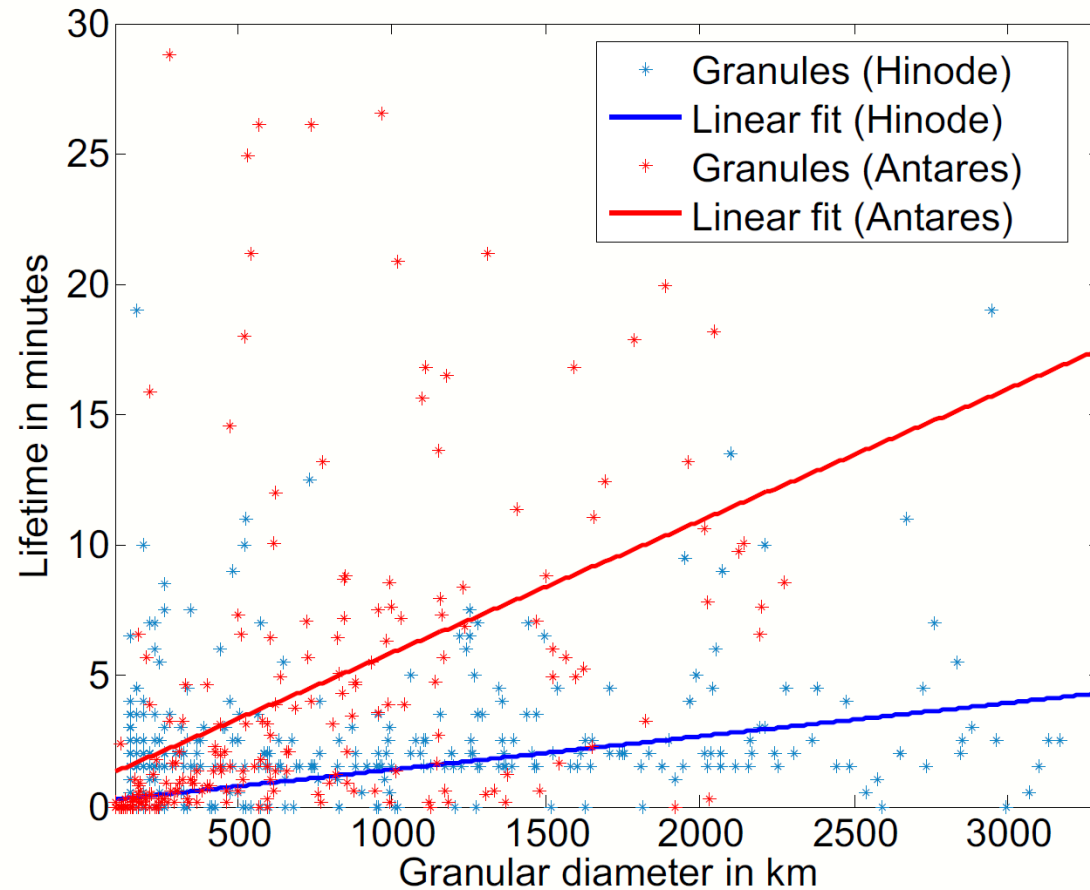
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# Tracking of small-scale granular cells

Tracking algorithm    Tracking results

## Lifetime of small-scale granular cells

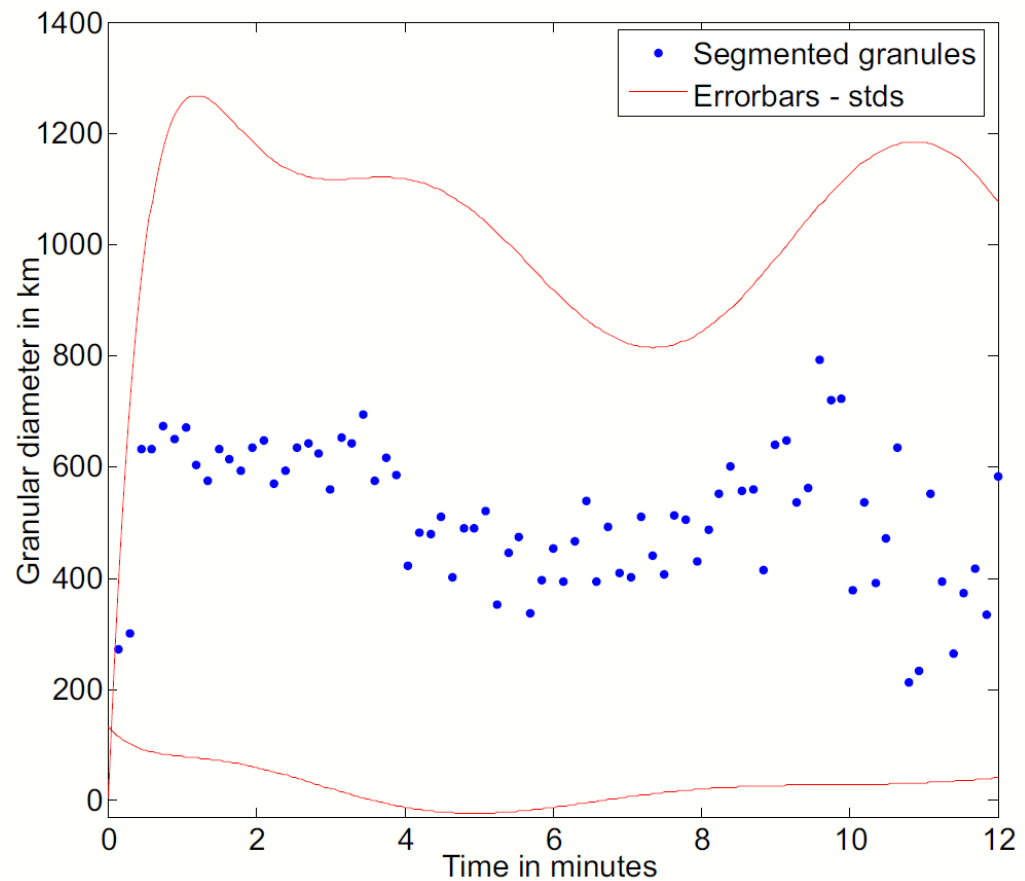


Lemmerer et al. (in prep.)

# Tracking of small-scale granular cells

Tracking algorithm    Tracking results

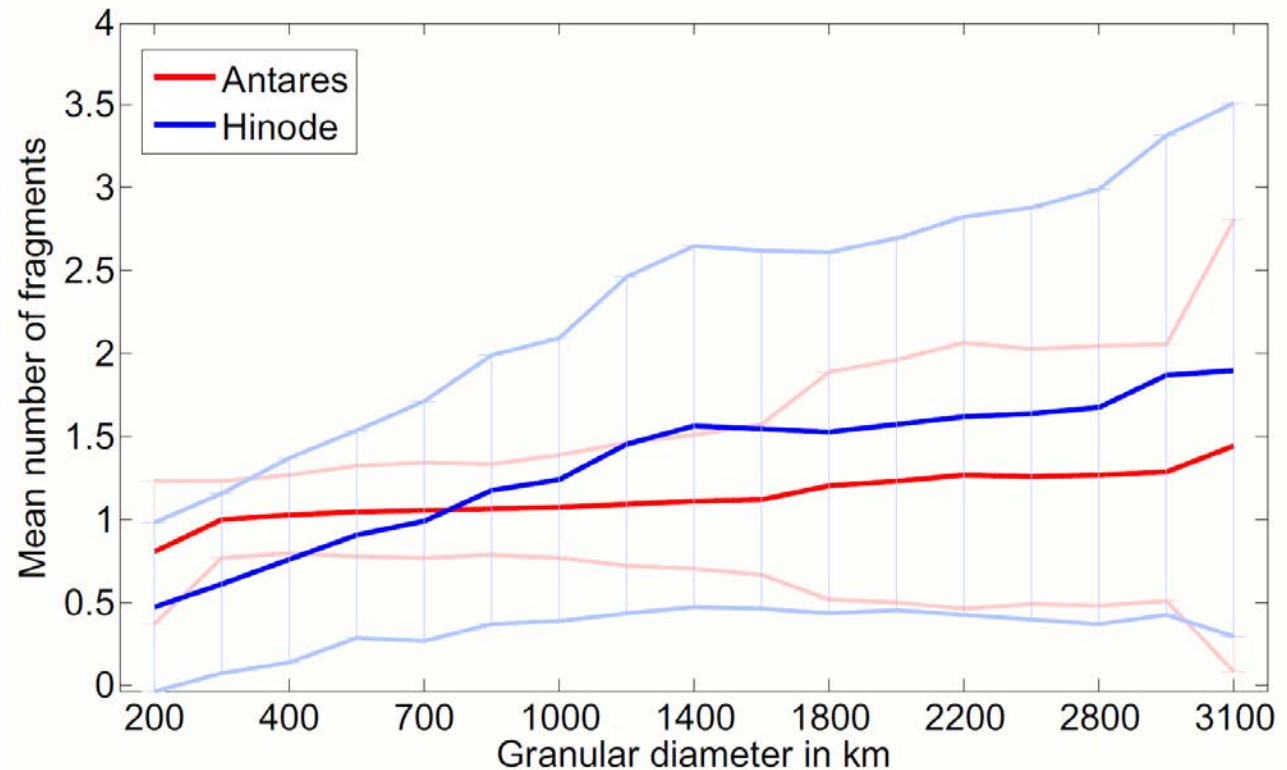
## Evolution of size of small-scale granular cells



# Tracking of small-scale granular cells

Tracking algorithm    Tracking results

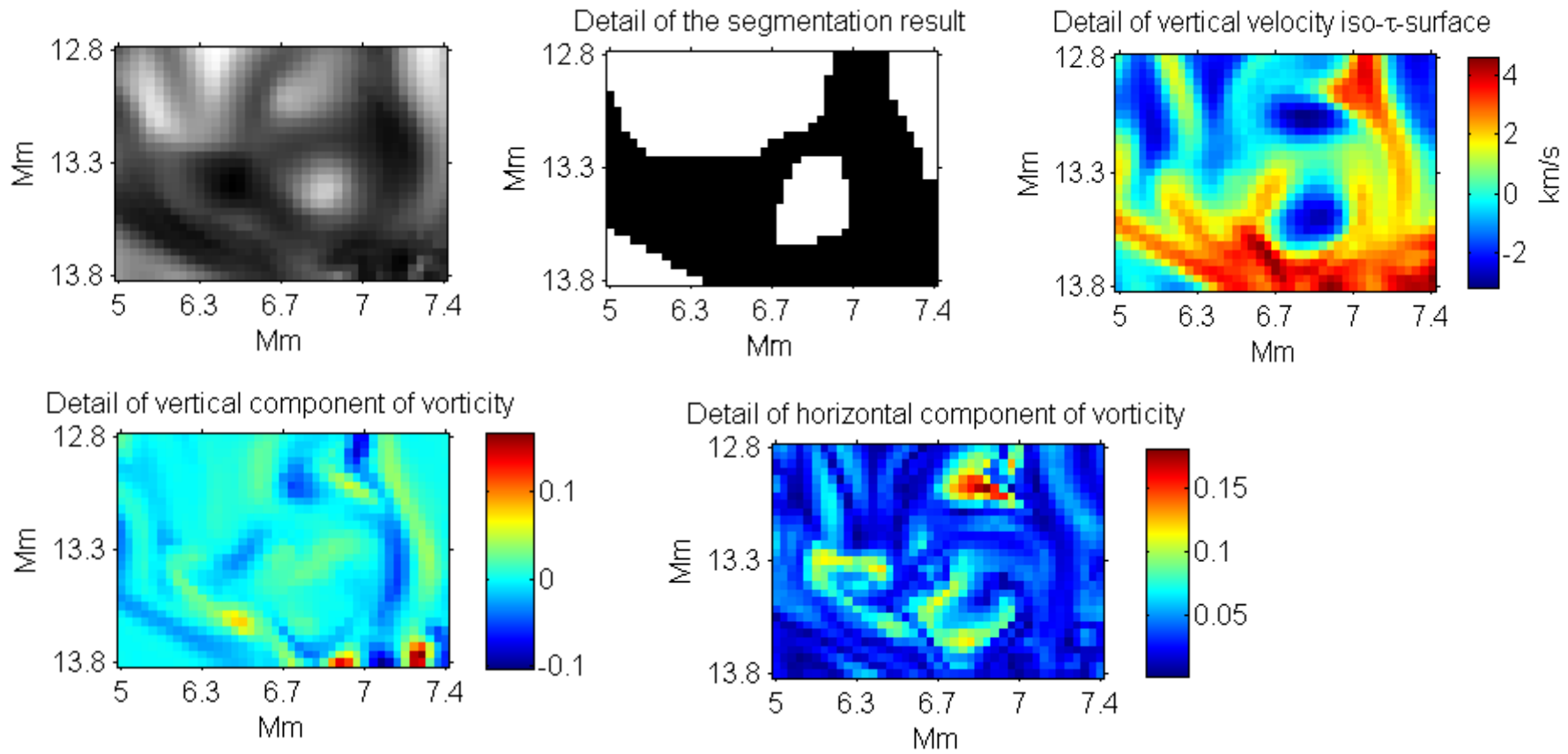
## Fragmentation



# 3D structure of small-scale granular cells

Analysis of upflow    3D tracking

## Properties of small-scale granular cell

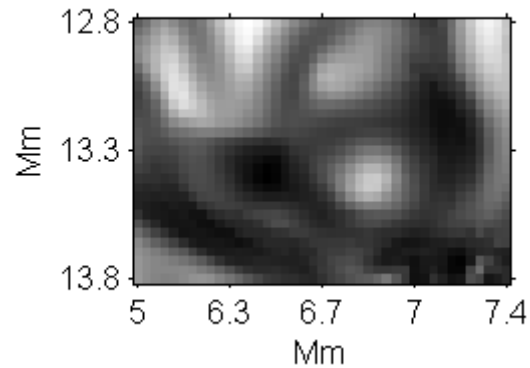


# 3D structure of small-scale granular cells

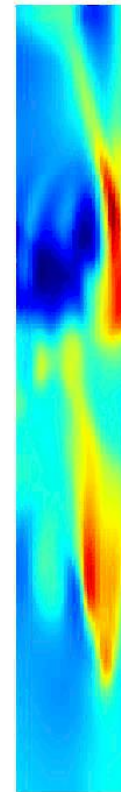
Analysis of upflow    3D tracking

Temporal evolution of upflow

Emergent intensity

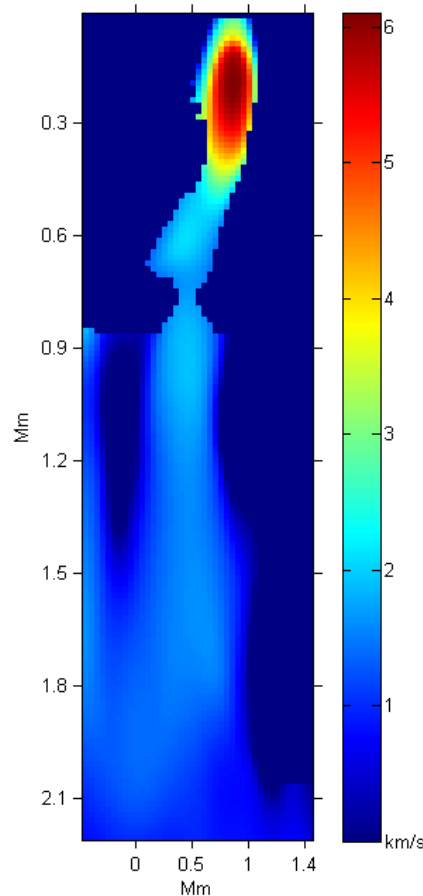
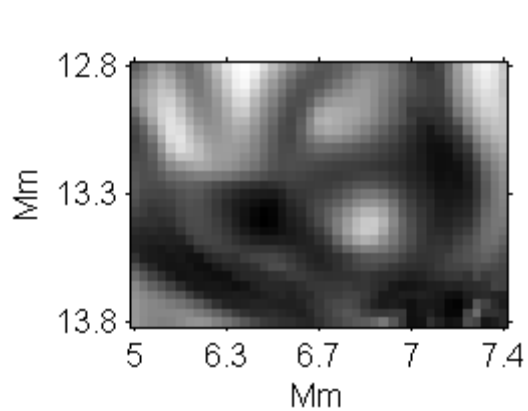


Vertical velocity



# 3D structure of small-scale granular cells

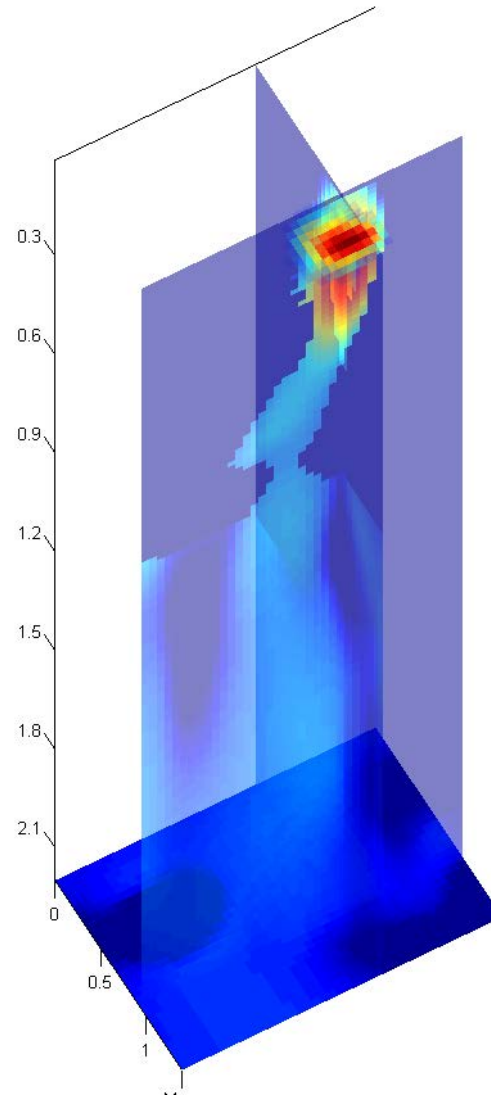
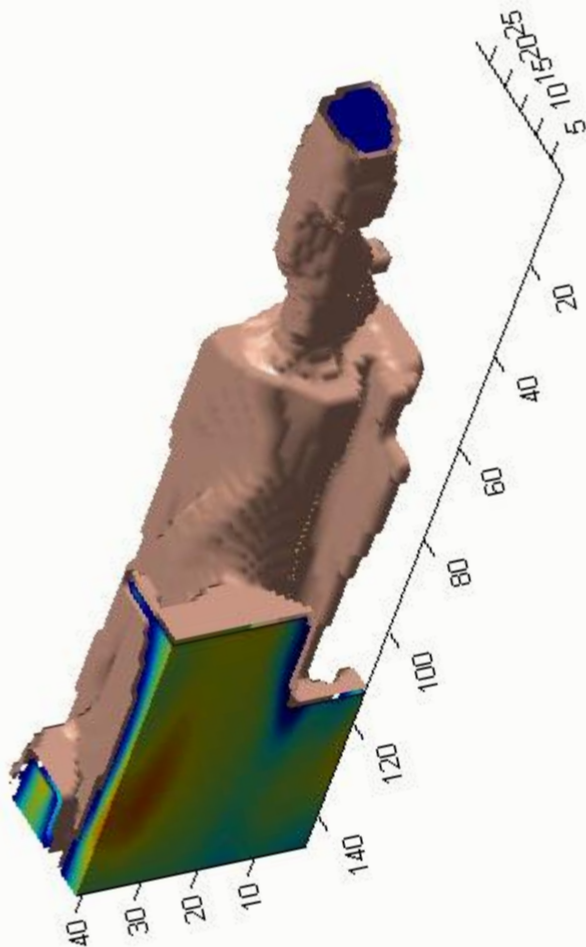
Analysis of upflow    3D tracking



# 3D structure of small-scale granular cells

Analysis of upflow    3D tracking

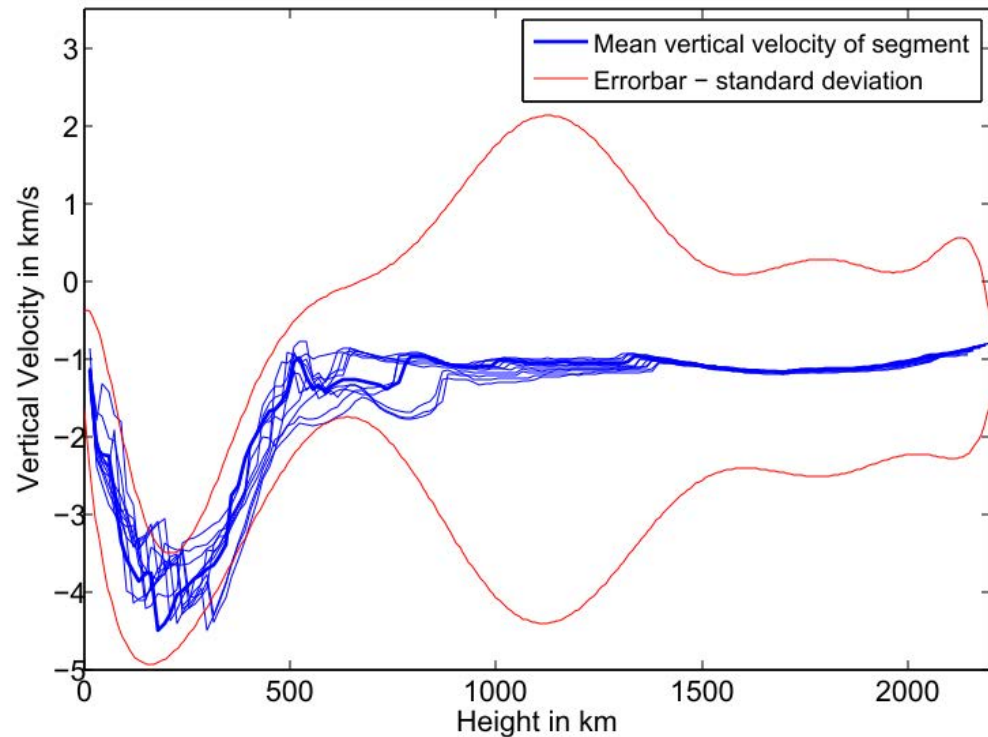
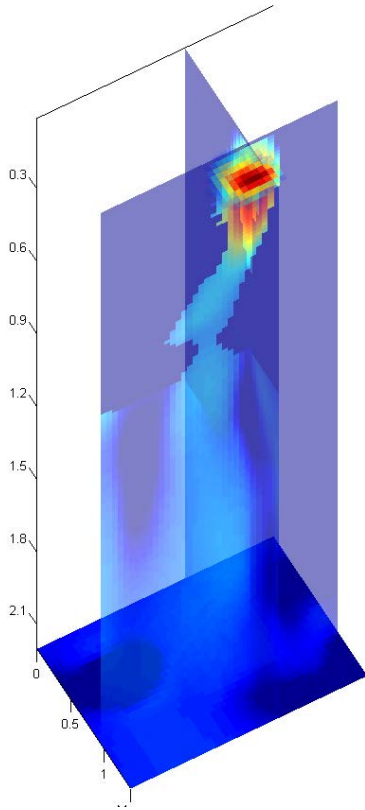
## 3D structure of upflow



# 3D structure of small-scale granular cells

Analysis of upflow 3D tracking

## Analysis vertical velocity



# Conclusion

## Dynamics of small-scale granules in 2D and 3D

- Successful detection of small granular cells in RHD simulations and observations
- Dynamics affected by strong vortex flows rather than strong magnetic fields
  - Strong vortices in vicinity
  - Suppress upflow and effect lifetime
  - Vortices are located in intergranulum → depress surface of optical depth
  - Show lower intensities
- Upflow is shaped by surrounding strong downflows

# Outlook



## Dynamics of convective motions and magnetic flux tubes in 2D and 3D

- Identification of vortex related bright features in observations
- Extend analysis to MHD simulation models
  - MURaM
  - CoBOLD
- 3D segmentation of magnetic flux tubes
  - Tracing flux tubes
  - Study interaction with convective motions
- Looking for a PostDoc Position next year