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Detection and multi-wavelength analysis of swirling structures in the solar atmosphere

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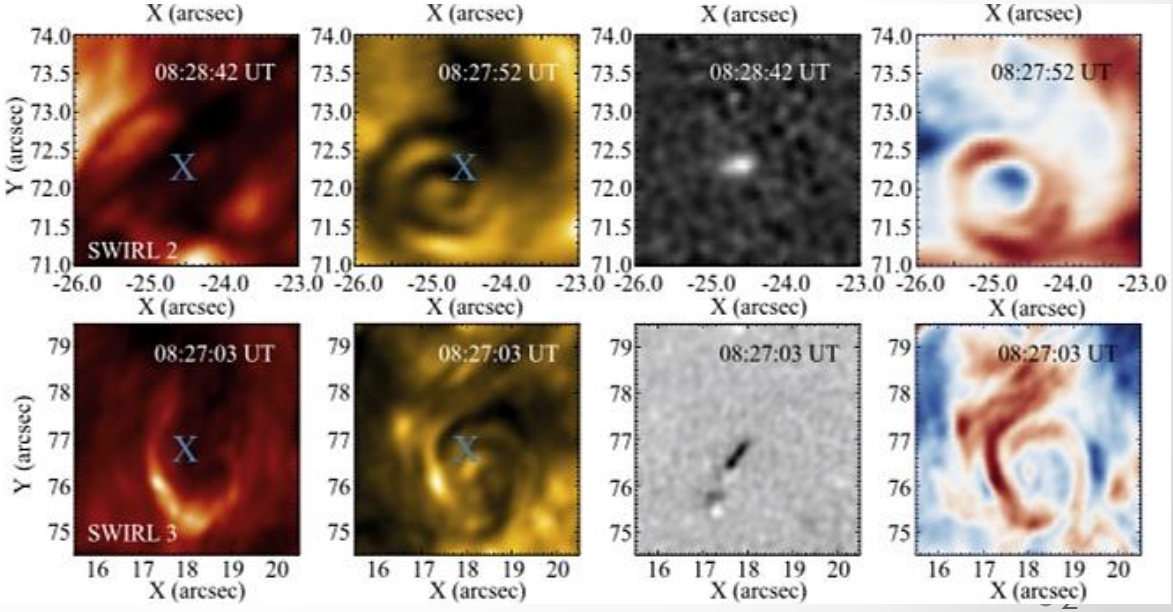
Chromospheric Swirls

Magnetic rotational motions throughout the solar atmosphere

Typical Radii : 1 – 2 Mm
Typical lifetimes: several minutes– several hours

- Predicted by theory of solar convection, appear in simulations
- Indications of major role in coronal heating and energy transfer
- Detection methods– Local Correlation Tracking – LCT – velocity fields

→ Revealed by high spatial resolution observations

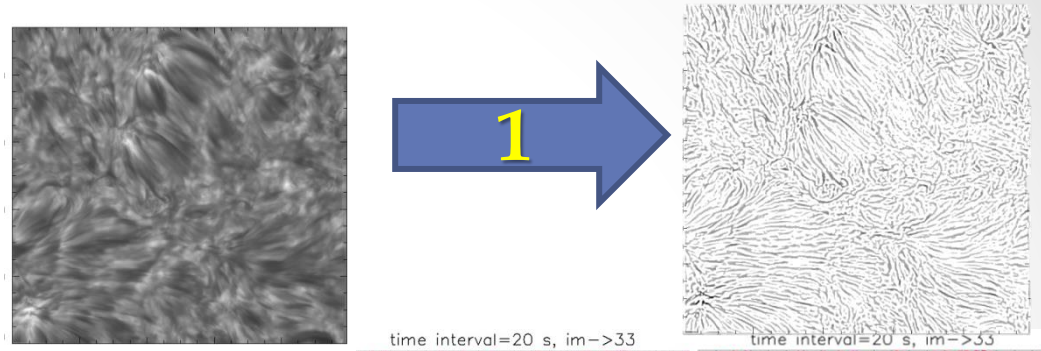


Snapshots in Hα 6563 Å, Ca II 8542.11 Å, and Stoke V of Fe 6302 Å, and Doppler difference images constructed in Ca II 8542 Å showing selected swirling events. (Shetye et al. 2019)

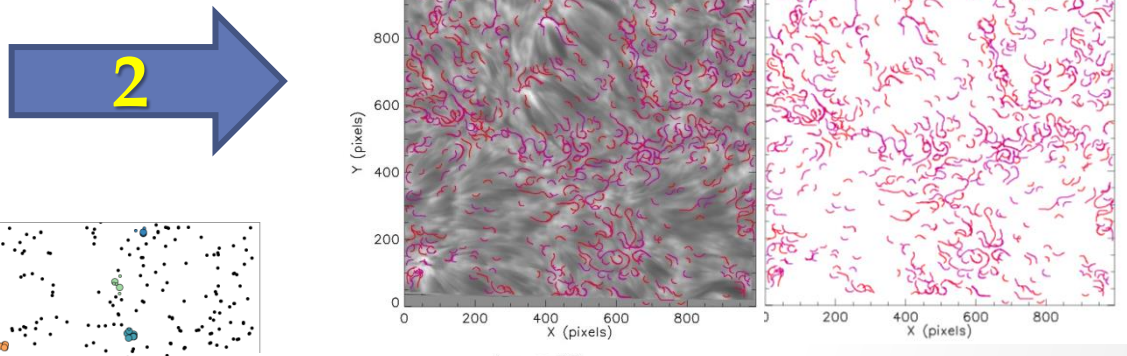
Morphological Method

Structure of the DETECTION ALGORITHM

1– Image processing

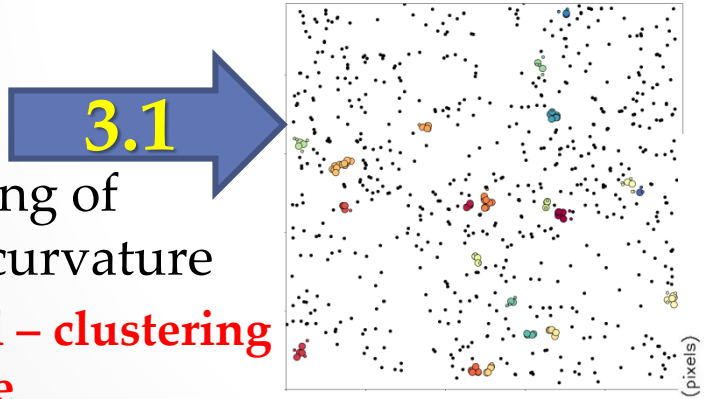


2– Tracing of dark spiral and/or circular shaped structures

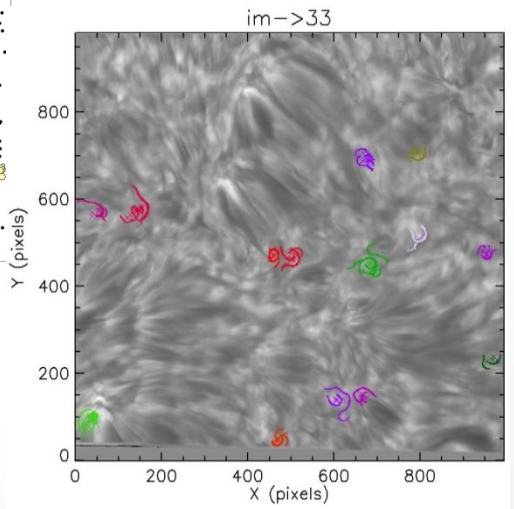


3– Clustering of centers of curvature

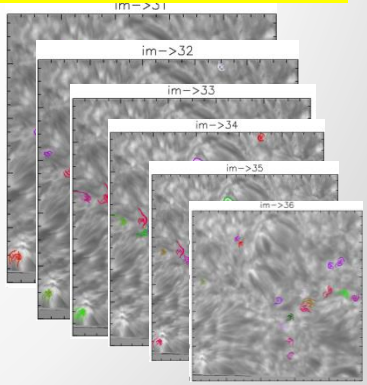
- 1st level – clustering in space
- 2nd level – clustering in time



1st level clustering result: Swirl Candidates – (SCs)



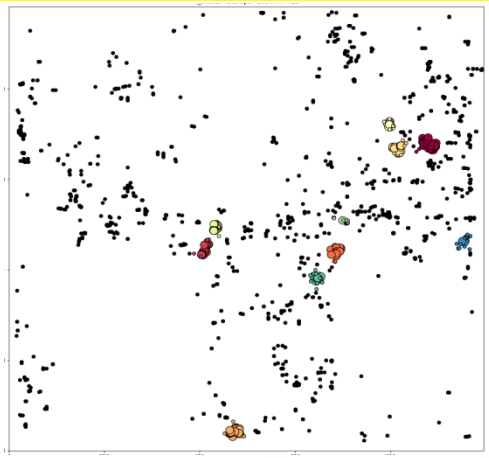
Repeated for each image

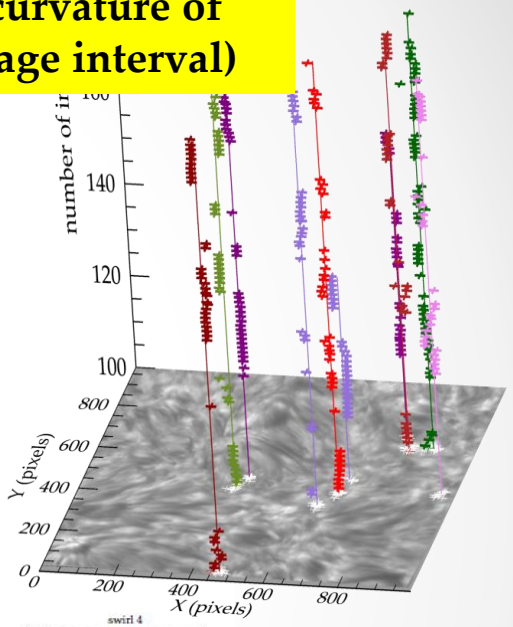


Morphological Method

Structure of the Algorithm

Projection of median centers of curvature of every SC over a time interval (image interval)

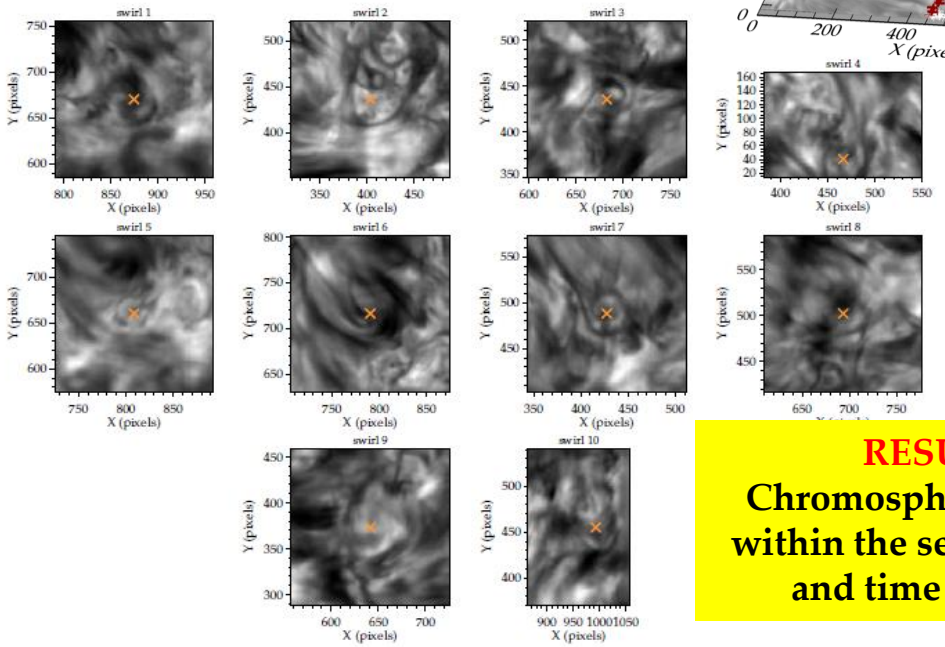




1– Image processing

2– Tracing of dark spiral and/or circular shaped structures

3.2



3– Clustering of centers of curvature

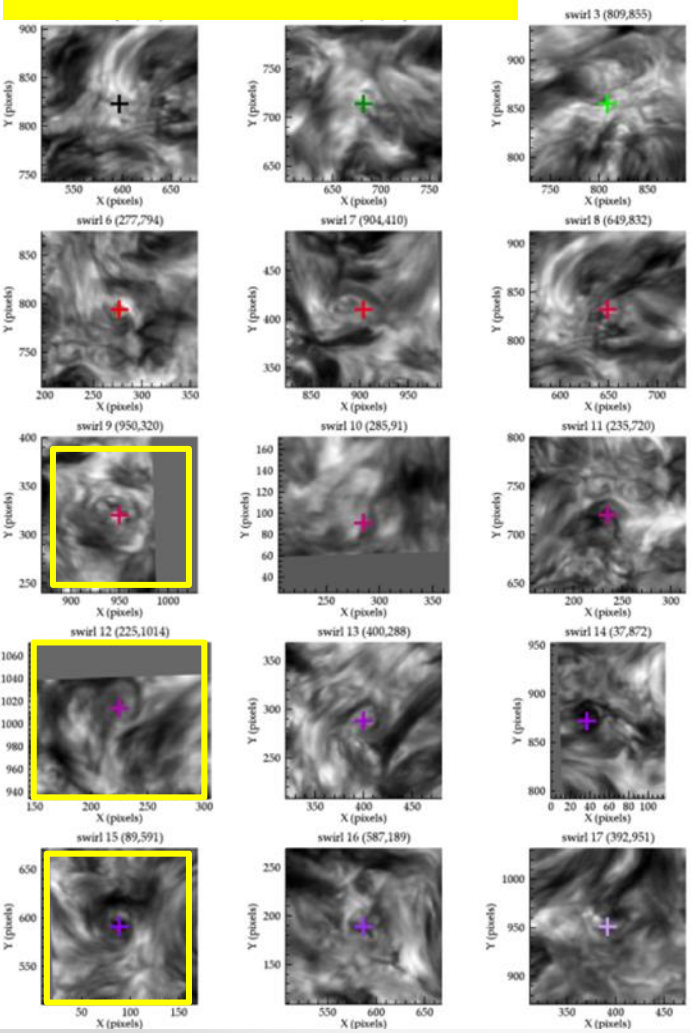
- 1st level – clustering in space
- **2nd level – clustering in time**

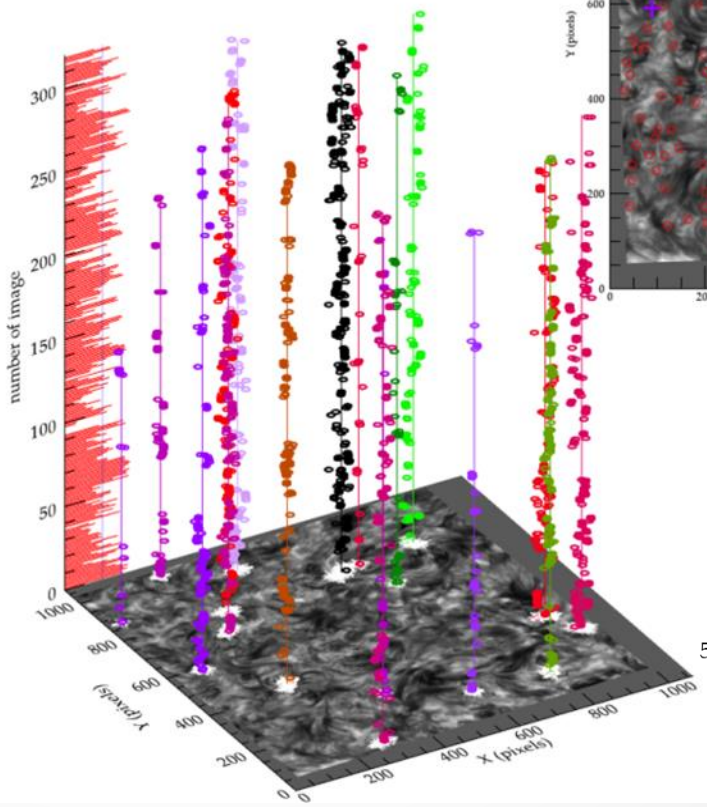
Dakanalis et al. 2021

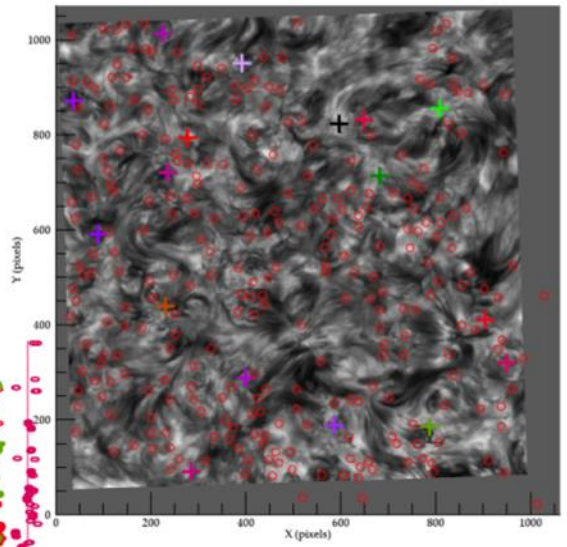
RESULT
Chromospheric Swirls within the selected FOV and time interval

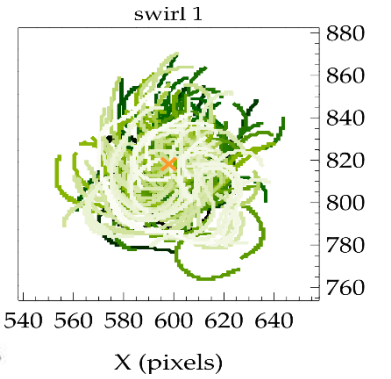
Application in NEW Hα observations

RESULT
303 chromospheric swirls in a ~ 1900 Mm² area in a ~ 30 min time interval





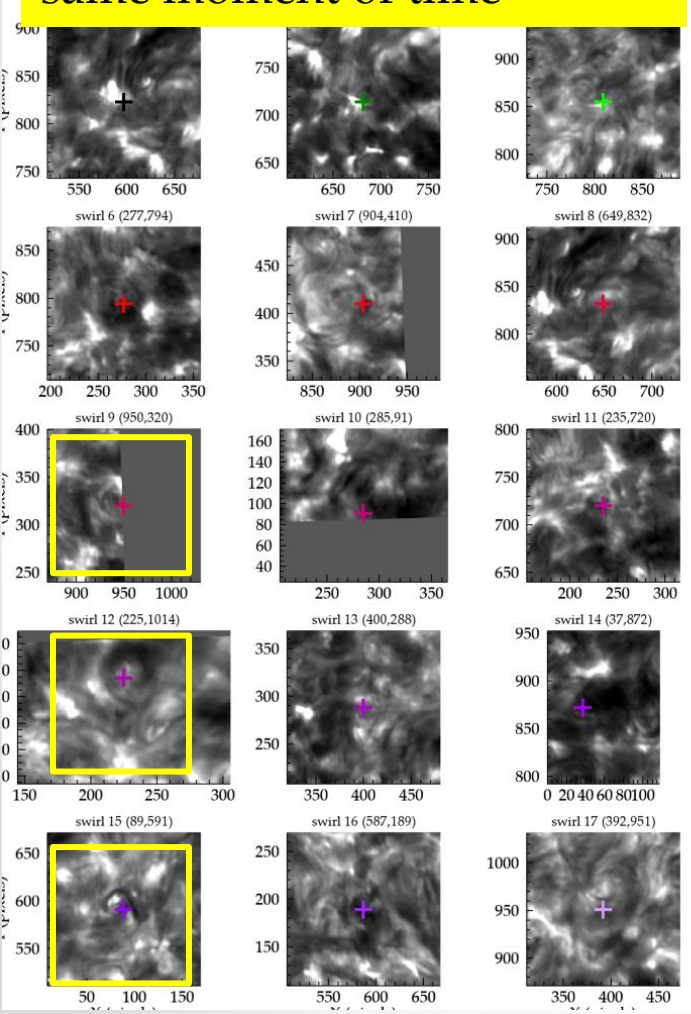


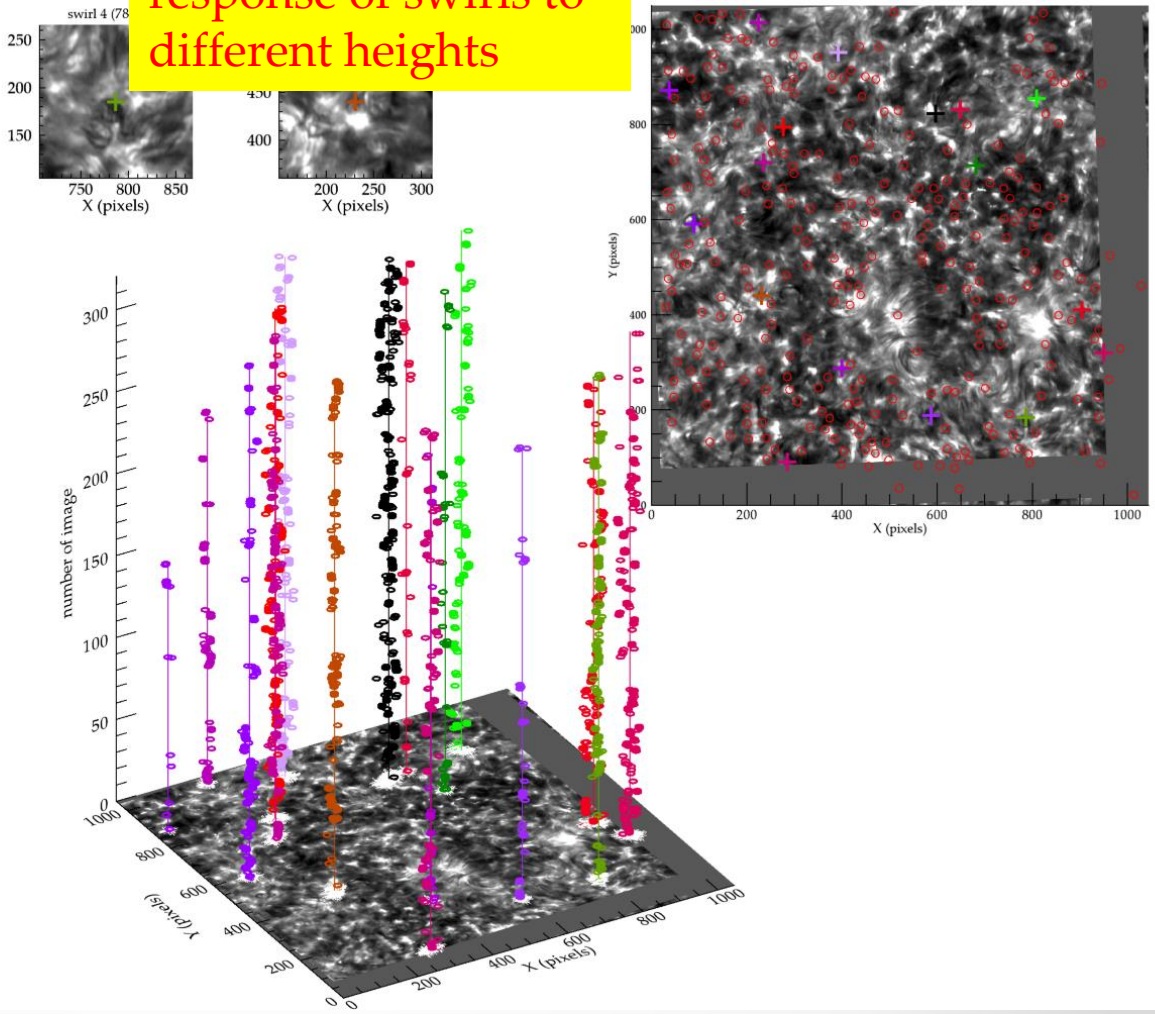


Application in Ca II IR observations

Detected swirl centers of the Hα to the Ca II IR FOV in the same moment of time

Straightforward determination of the response of swirls to different heights

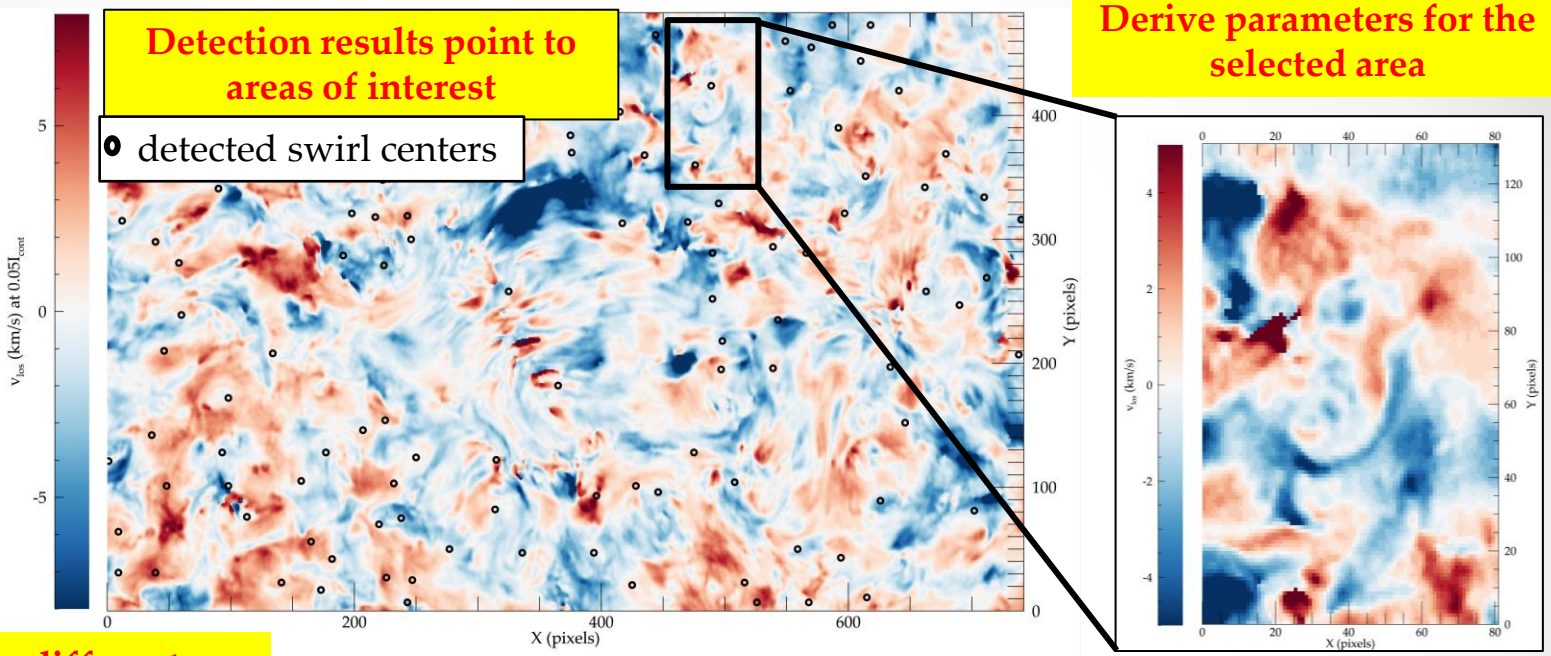




Study of Hα, Ca II IR and Ca II H line profiles in detected swirls - Derivation of parameters

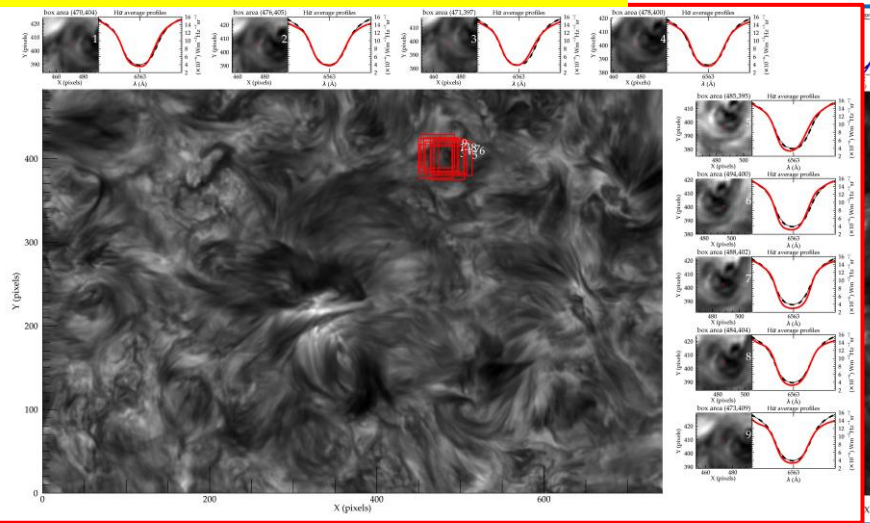
Methods - Parameters

- Line of Sight Velocities
- FWHMs
- Bisector analysis

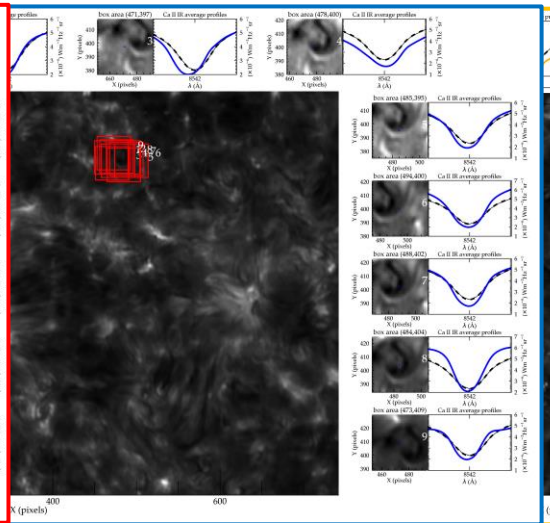


Study profiles in different spectral lines and wavelengths

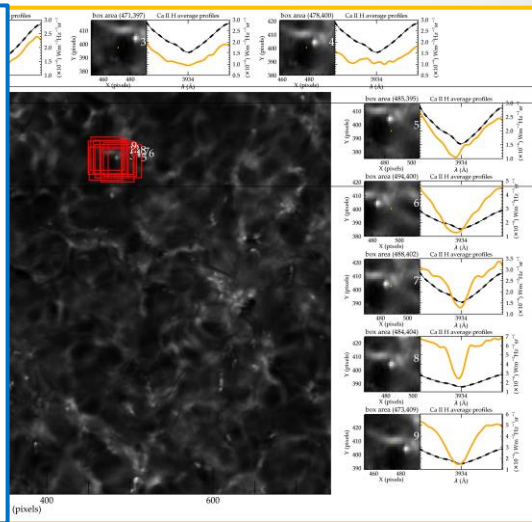
Hα



Ca II 8542



Ca II H



Conclusions - Discussion

- The designed algorithm detects swirling events based on their morphology in different datasets and wavelengths

The results help to:

- map the response of swirling events on different heights of the solar atmosphere
- extract statistical information about the populations of swirls in the chromosphere
- estimate significant physical parameters of swirls such as radii and LOS velocities
- conduct profile analysis to the detected swirl areas