Enhancing STEREO-HI data with machine learning for efficient CME forecasting

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FWF Österreichischer Wissenschaftsfonds

European Research Council
Established by the European Commission

HELIO4CAST

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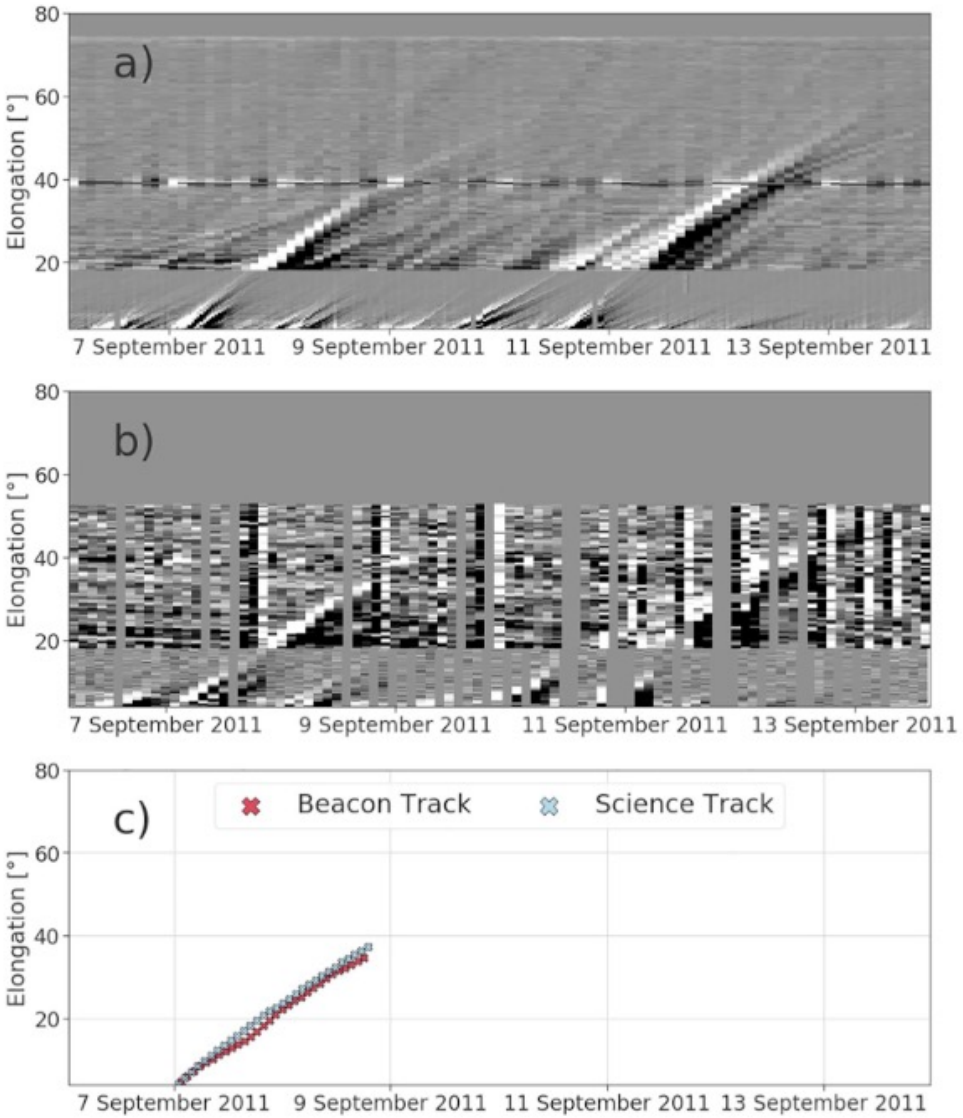
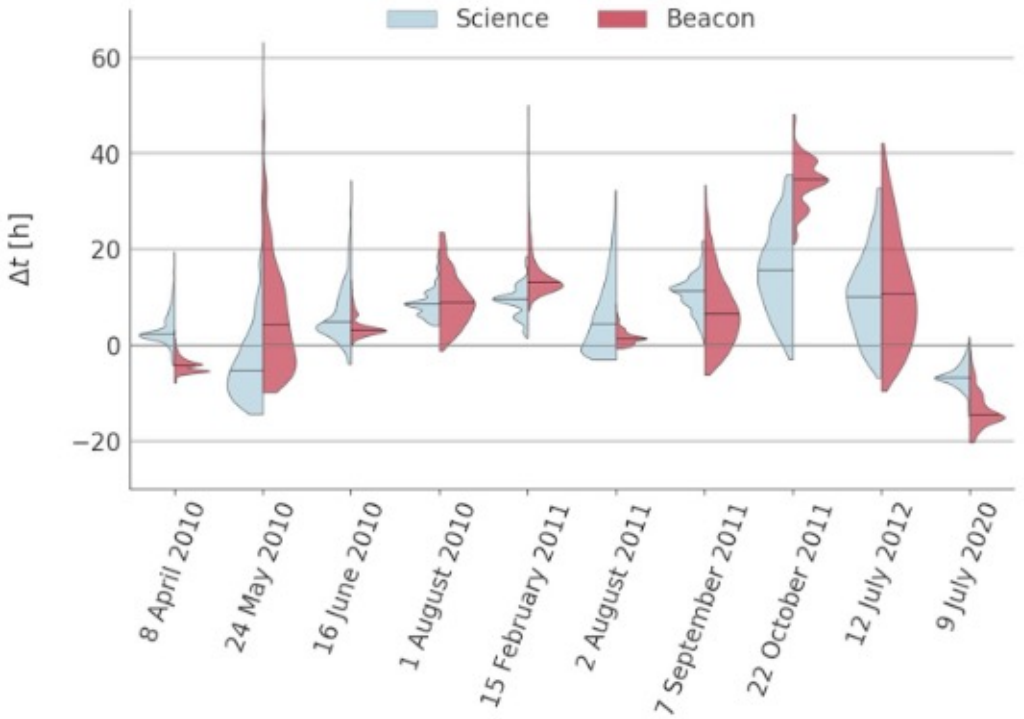
Beacon for CME forecasting

Science

Beacon





Predicting CMEs Using ELEvoHI With STEREO-HI Beacon Data

Maike Bauer[1,2], Tanja Amerstorfer[1], Jürgen Hinterreiter[1,2], Andreas J. Weiss[1,2], Jackie A. Davies[3], Christian Möstl[1], Ute V. Amerstorfer[1], Martin A. Reiss[1], and Richard A. Harrison[3]

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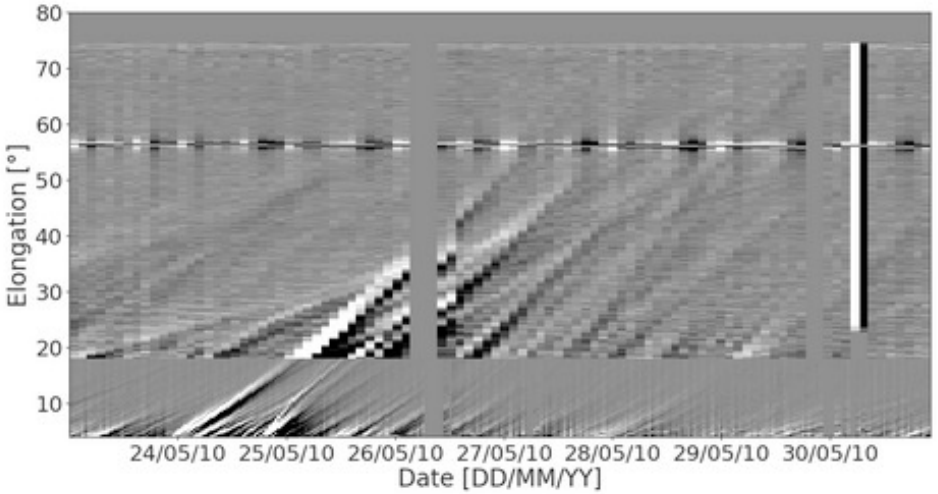
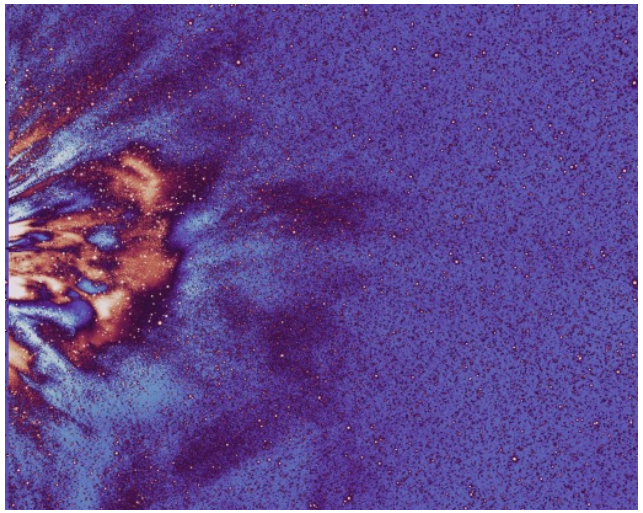
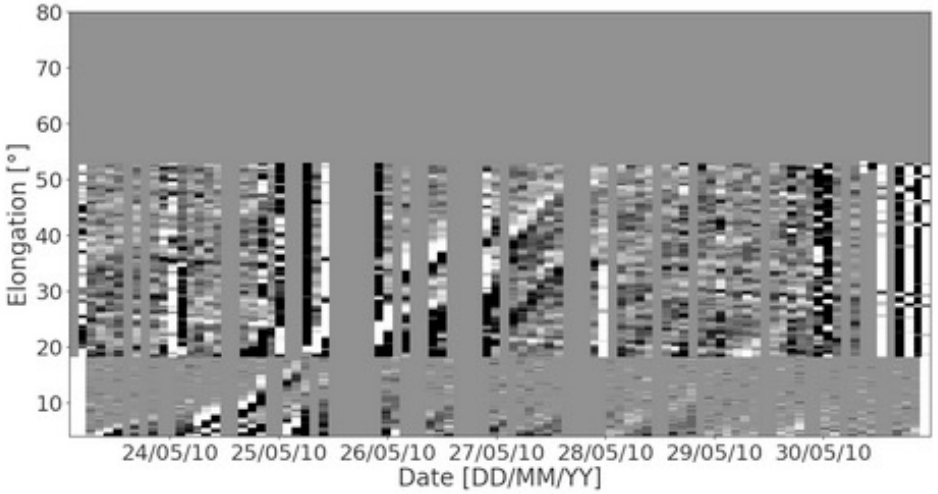
Beacon vs Science

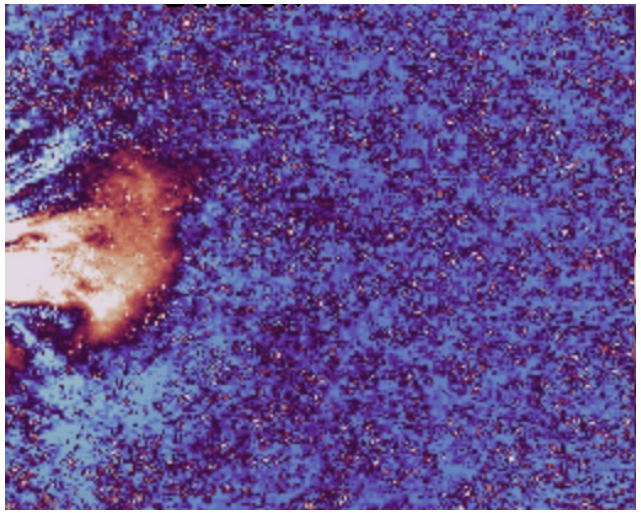
Science
Resolution: 1024x1024px
Cadence: 40 mins
Availability: ~4 days





Beacon
Resolution: 256x256px
Cadence: 120 mins
Availability: near-realtime

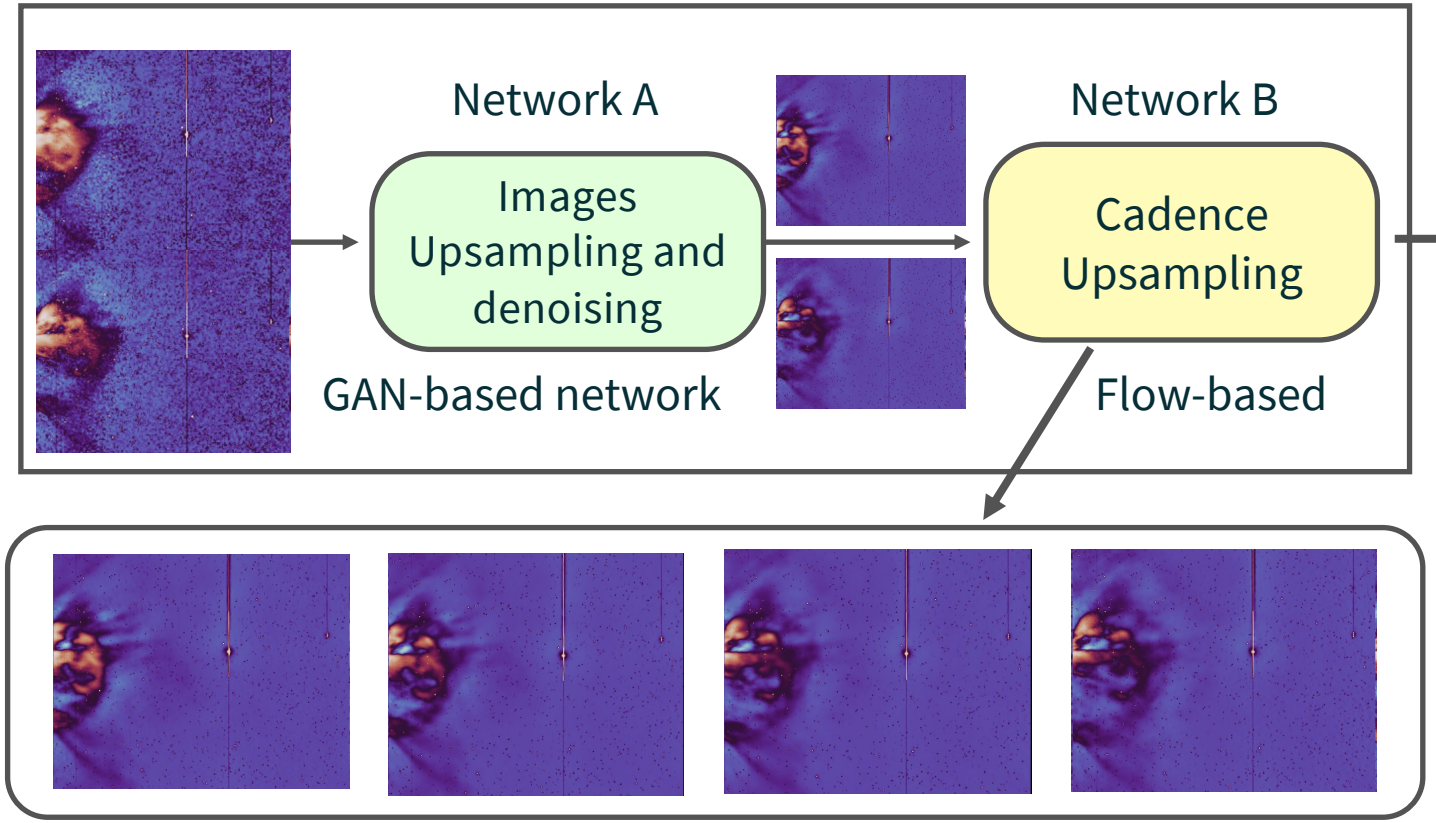




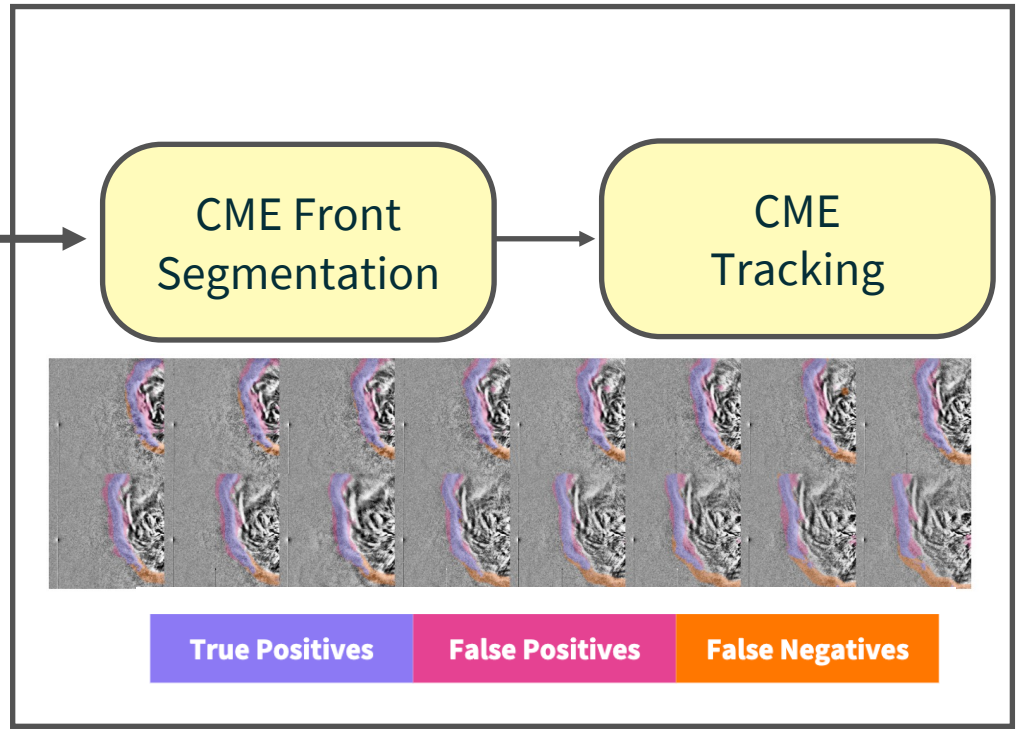
Pipeline presentation

GeoSphere Austria

Beacon2Science

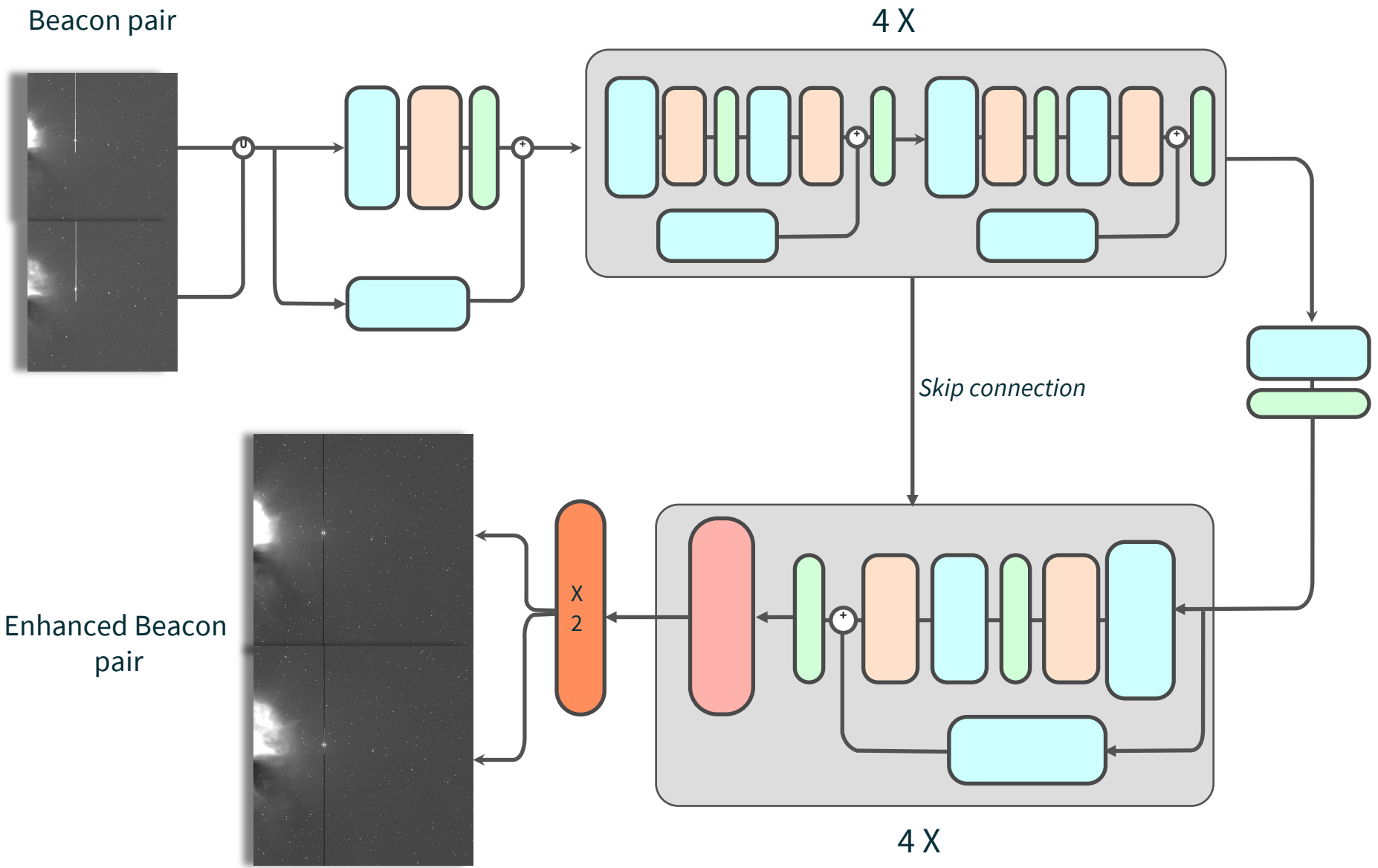


CME Automatic Detection and Tracking



Bauer et al., Automated detection and tracking of CMEs using HI-instruments
POSTER

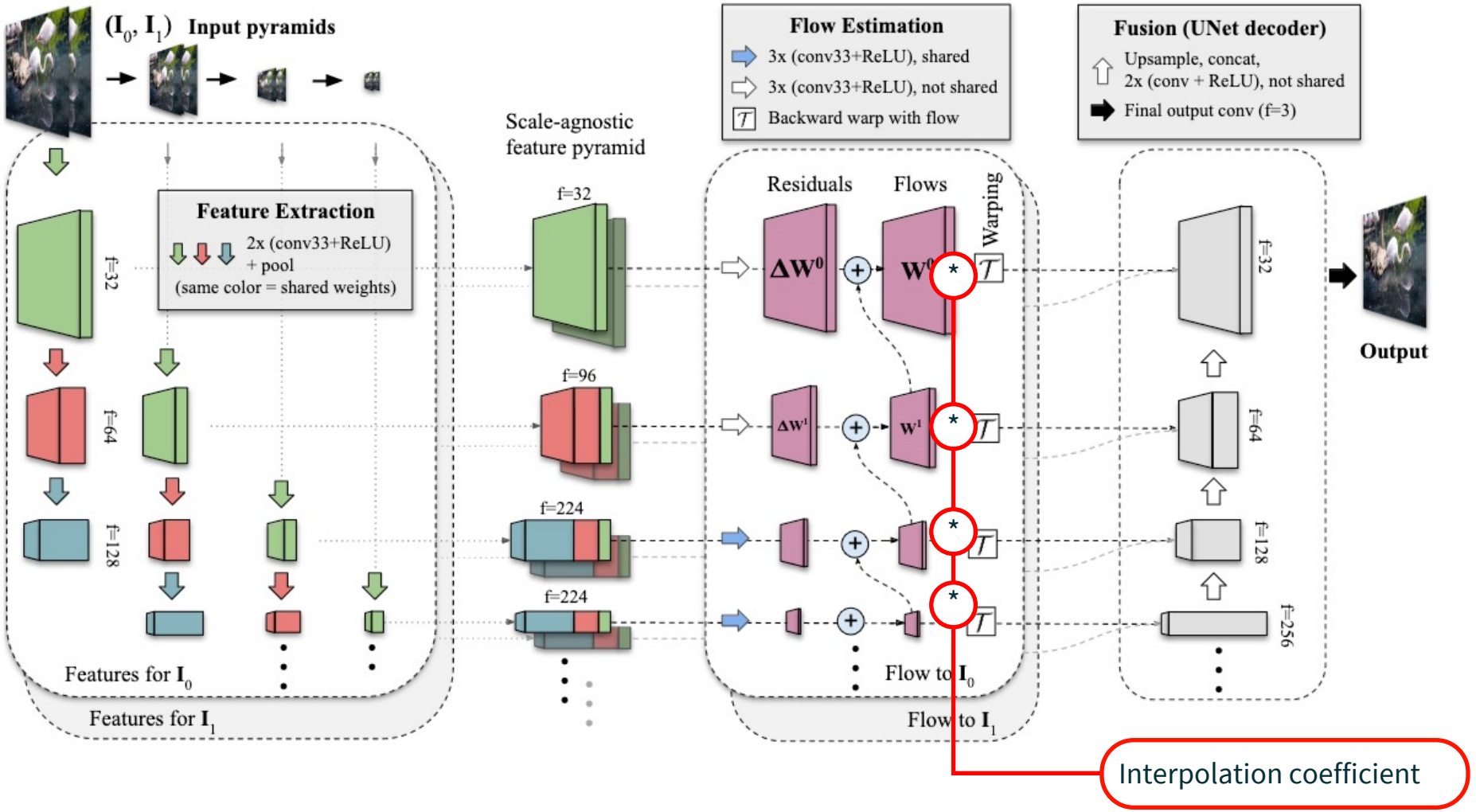
Neural Network A: Upsampling and Denoising -> Generator



Neural Network B: Frame interpolation and propagation

FILM: Frame Interpolation for Large Motion

Reda et al, ECCV 2022



Quantitative results

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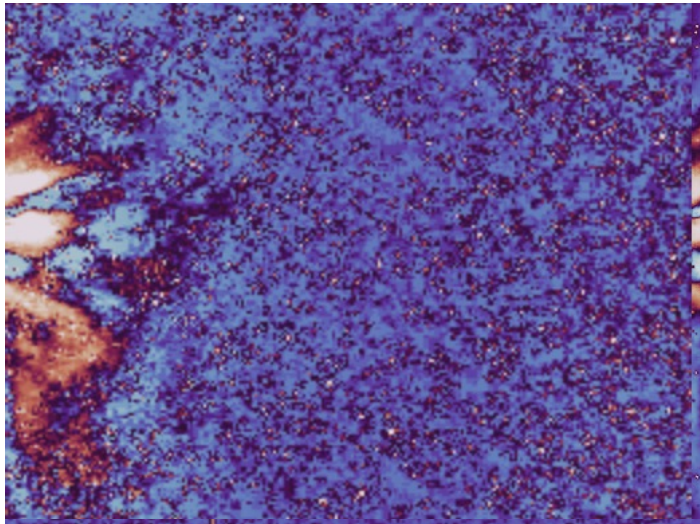
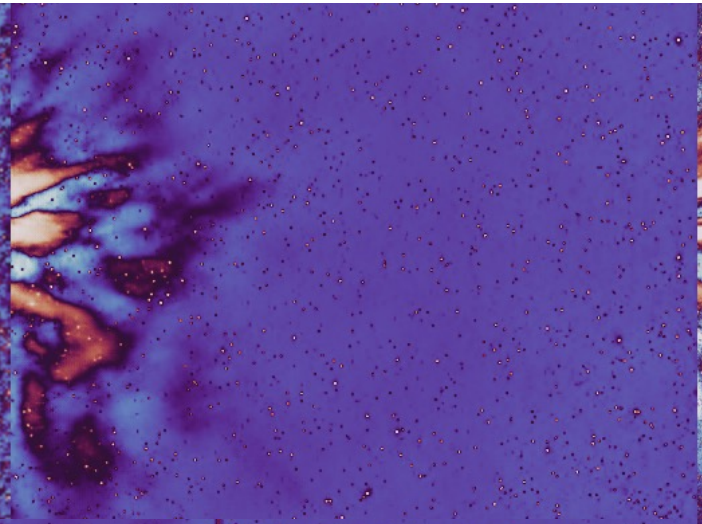
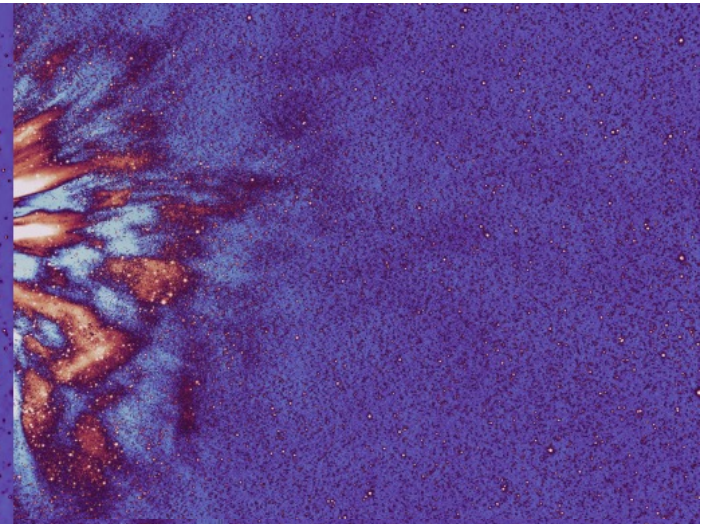
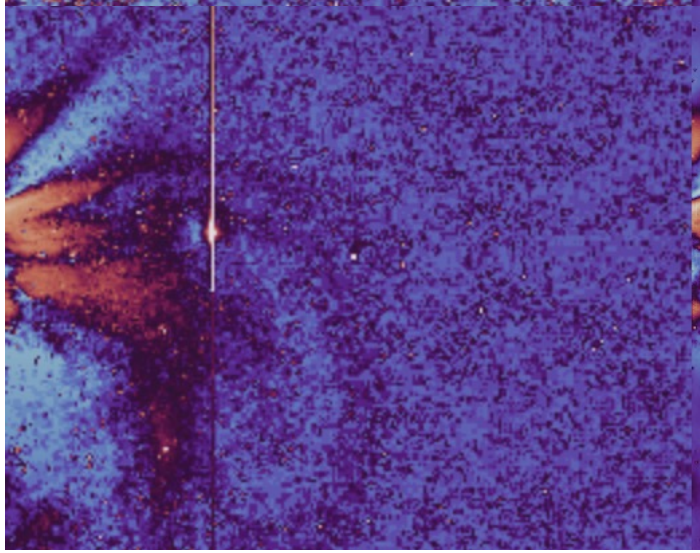
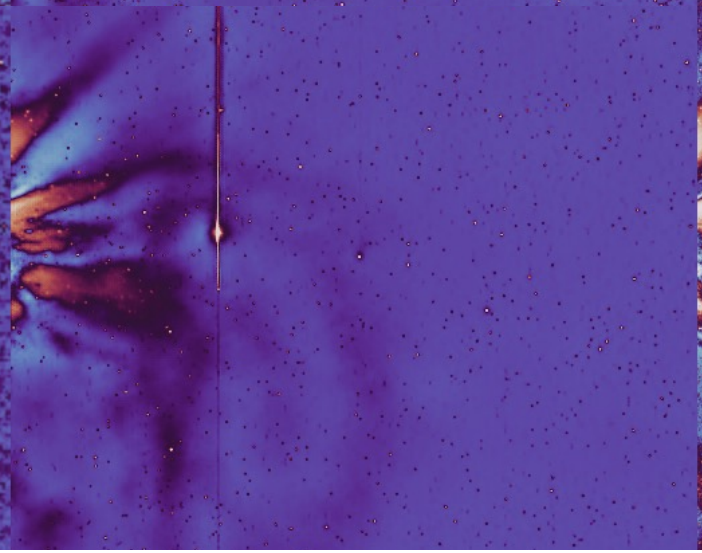
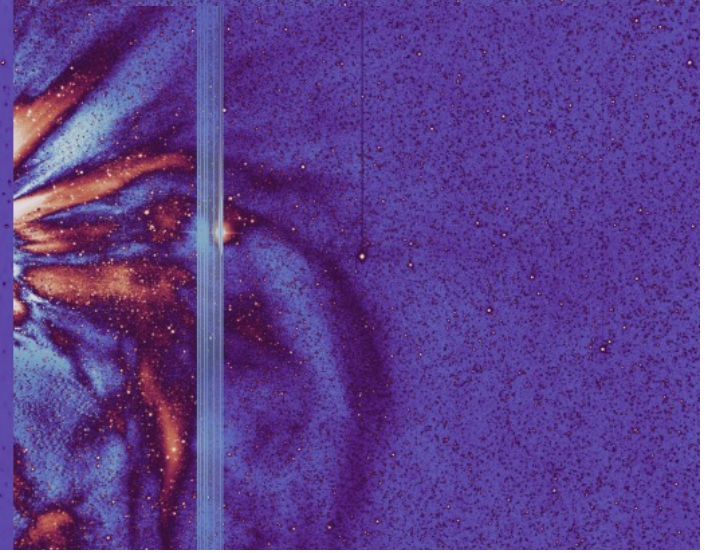
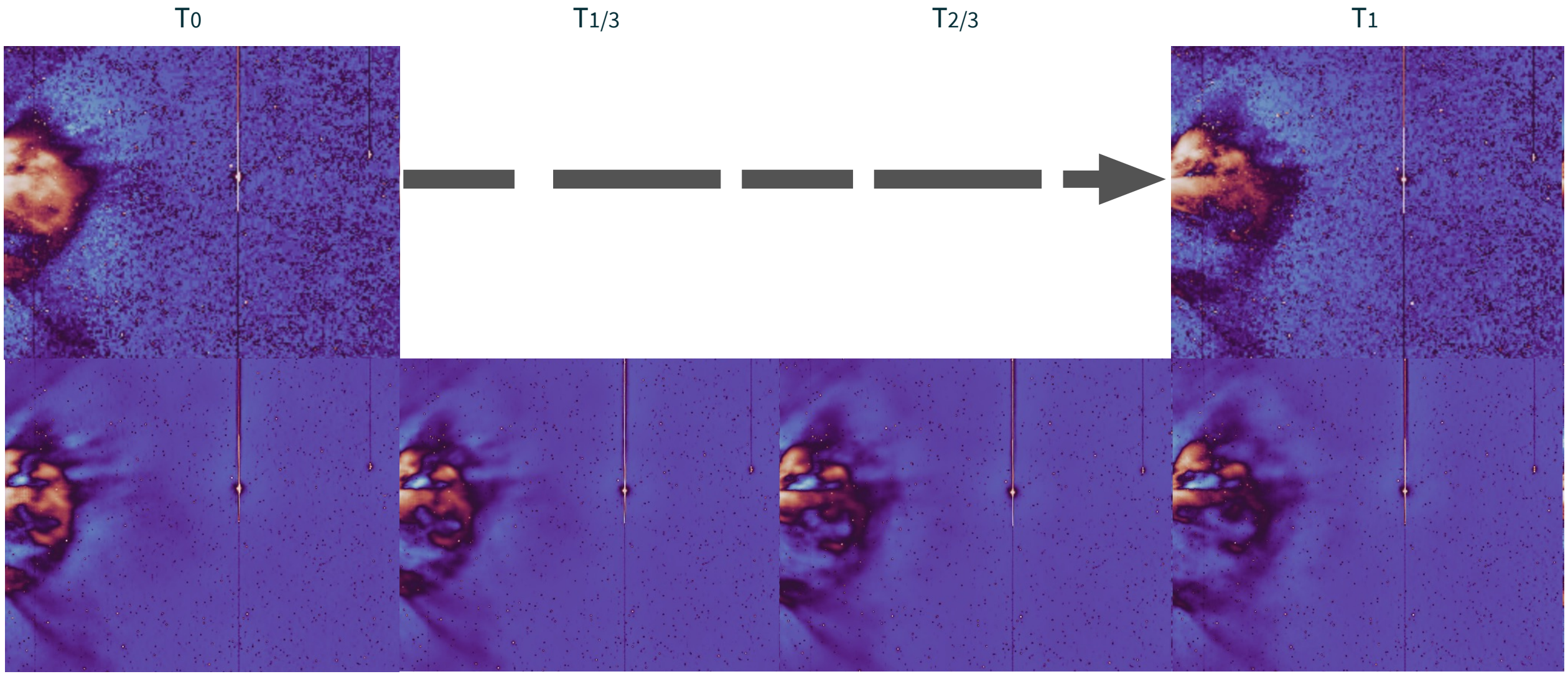
Model	↑ PSNR	↓ RMSE (1e-4)	↑ SSIM(1e-2)
Ours	22.95	59.95	62.24
Standard Upsampling	19.11	130.44	53.43

Qualitative results

GeoSphere Austria

	Beacon	Enhanced Beacon	Science
Image 1			
Image 2			

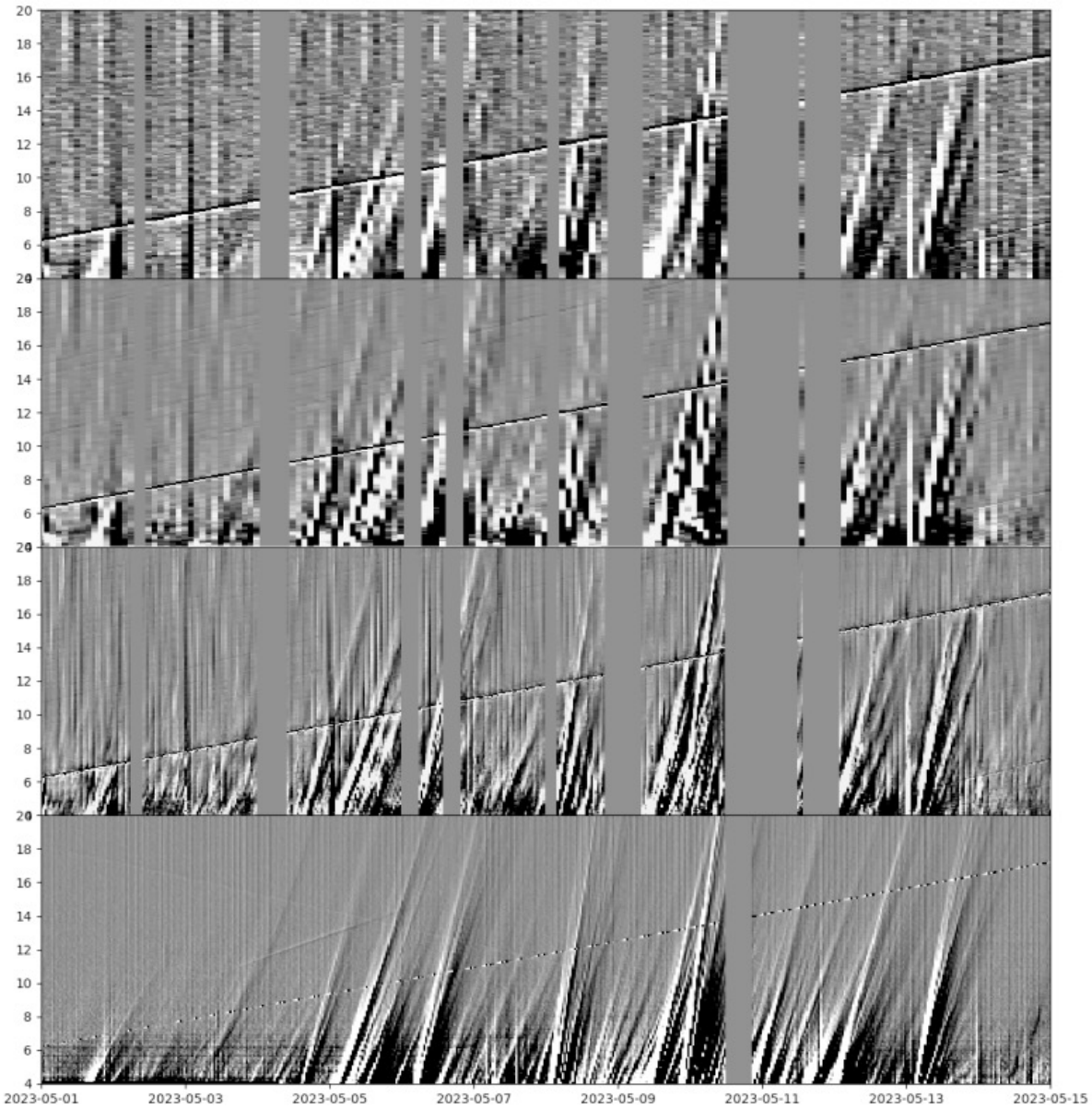
Qualitative results



Temporal Upsampling

Qualitative results

Improving JPLOTs with enhanced data



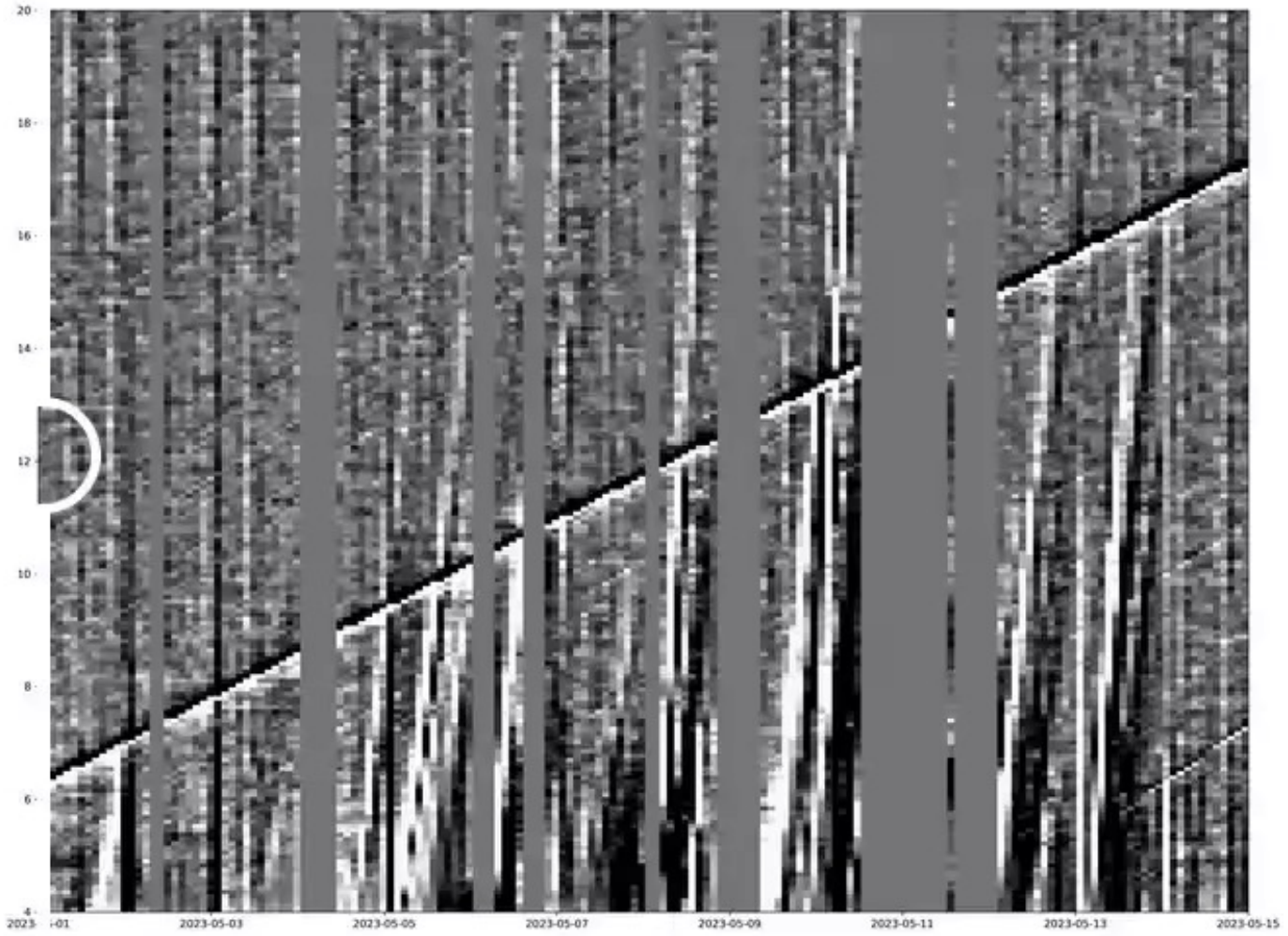
Beacon

Upsampling and Denoising

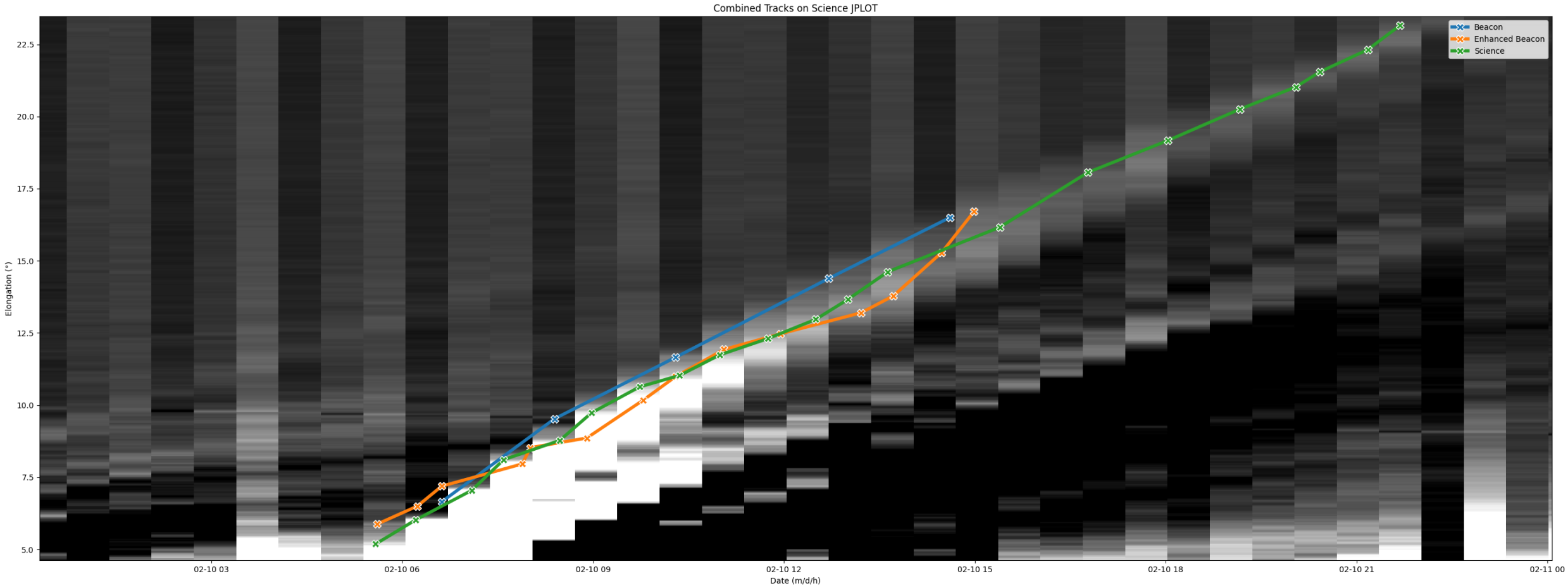
Temporal interpolation

Science

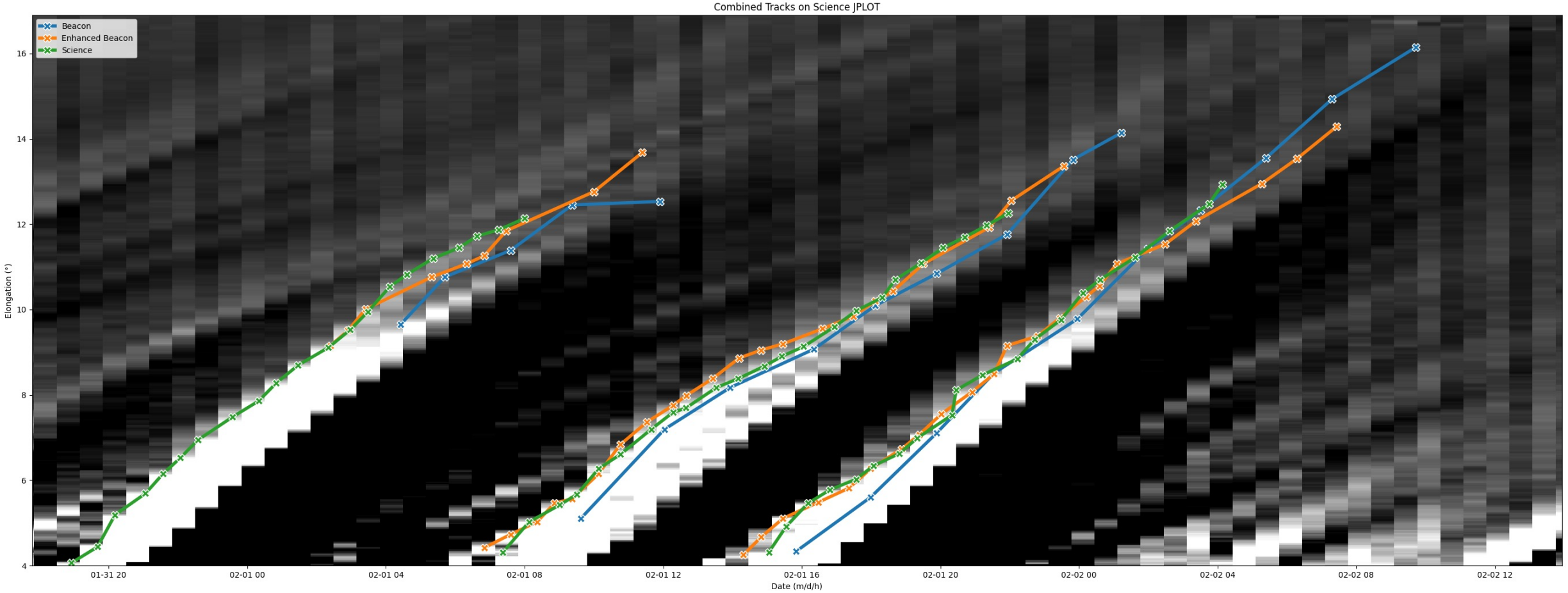
More results



Tracking on JPLOT



Tracking on JPLOT

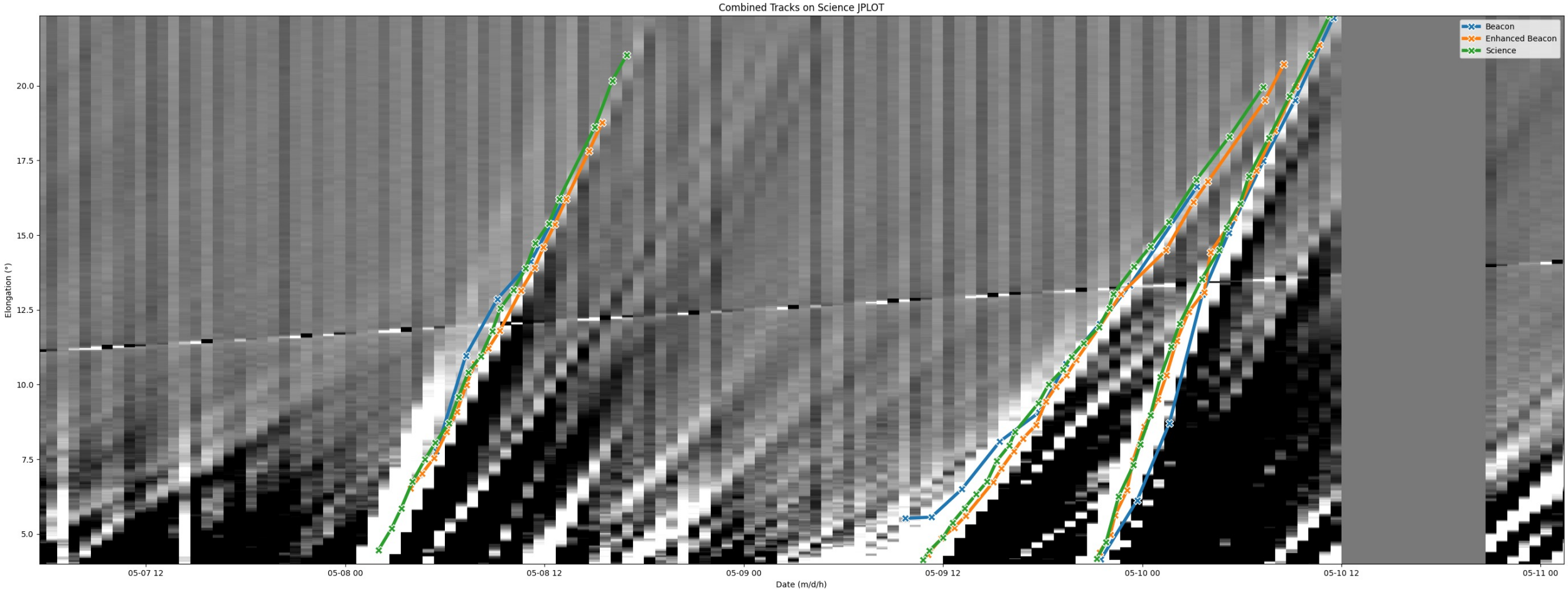


Beacon

Enhanced Beacon

Science

Tracking on JPLOT



Beacon

Enhanced Beacon

Science

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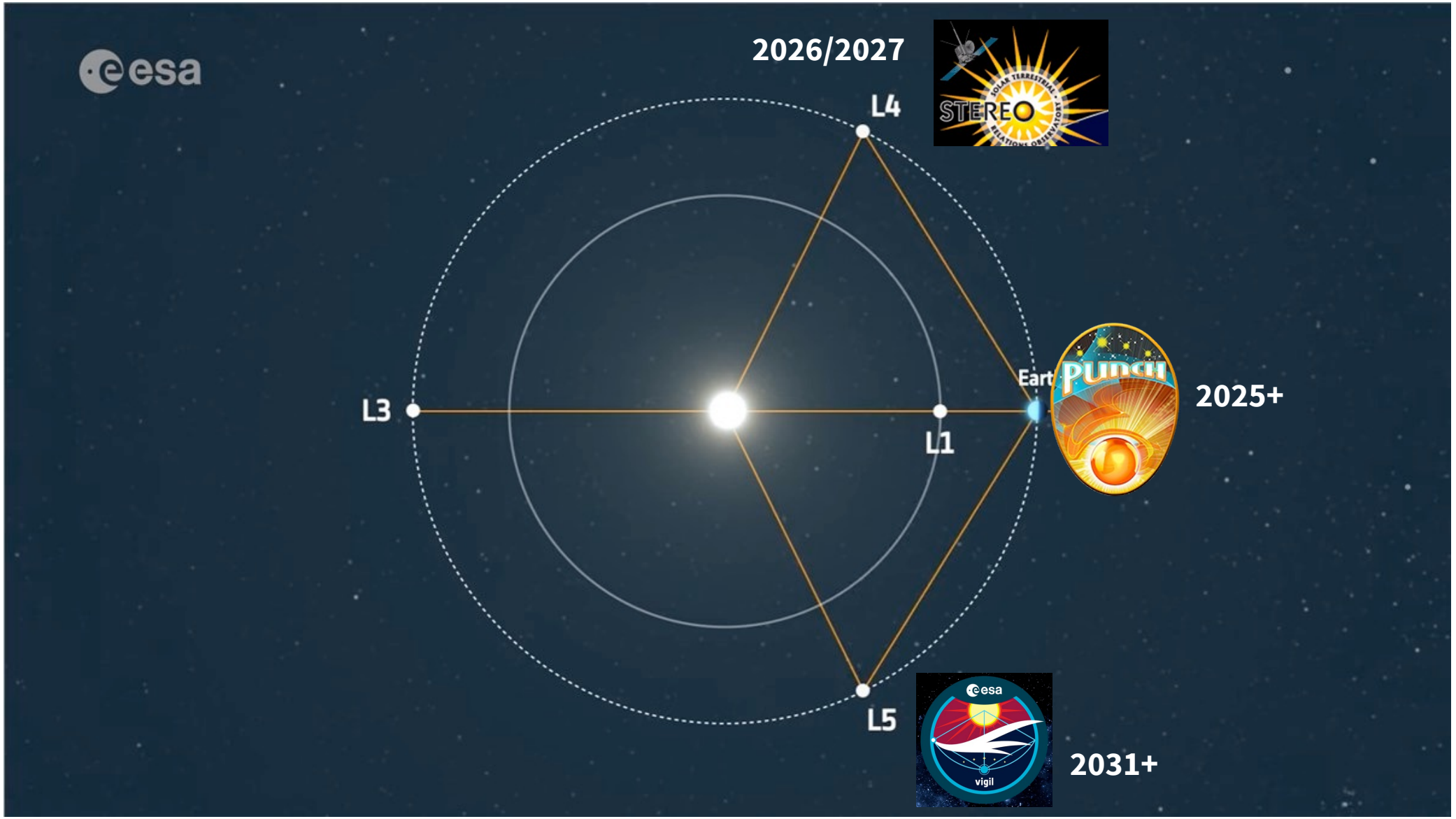
Conclusion

- We propose a new method for denoising and upsampling beacon data to a better quality
- Produced images allow a better readability of the CME characteristics
- Running differences and JPLOTS allow us to track the CME similarly to Science data in near-realtime

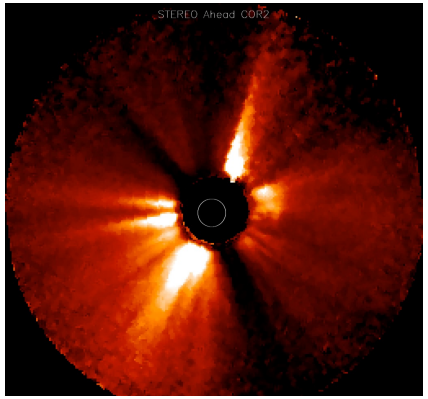
Future work

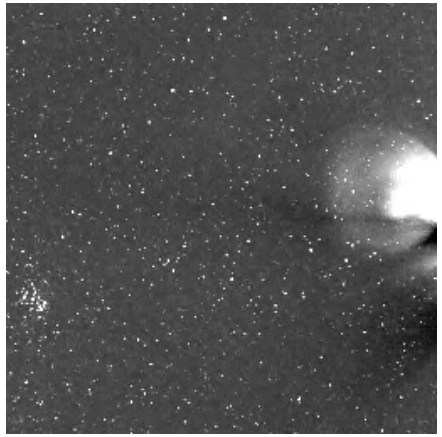
- Forecast CME arrival time for 40 selected events, using beacon, enhanced beacon and science JPLOTS (ongoing paper submission soon)
- Tackle the data gaps problem using other view points (COR2)
- Extend the enhancement to HI2

PUNCH and other missions

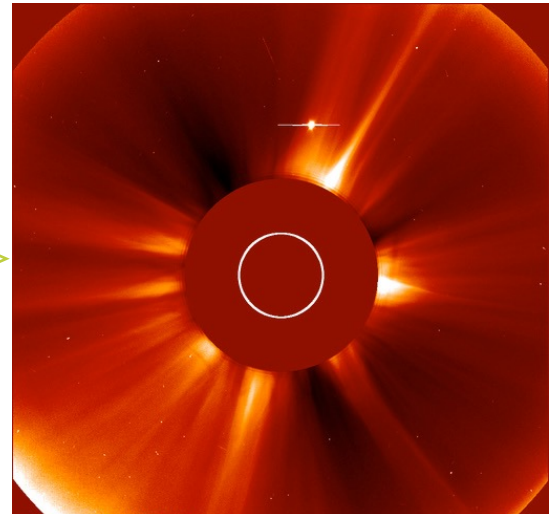


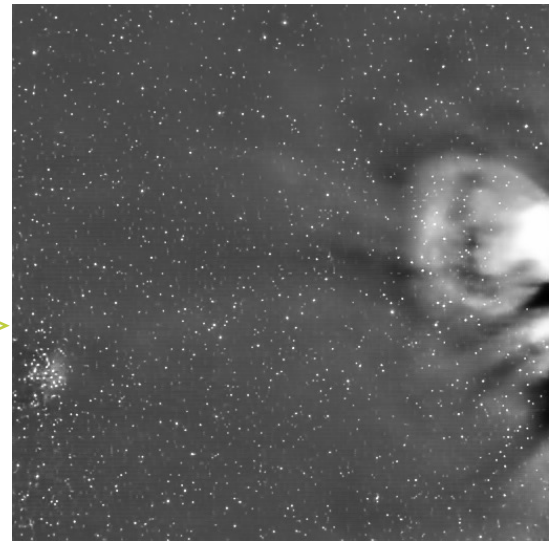
PUNCH+STEREO=?





Beacon2Science





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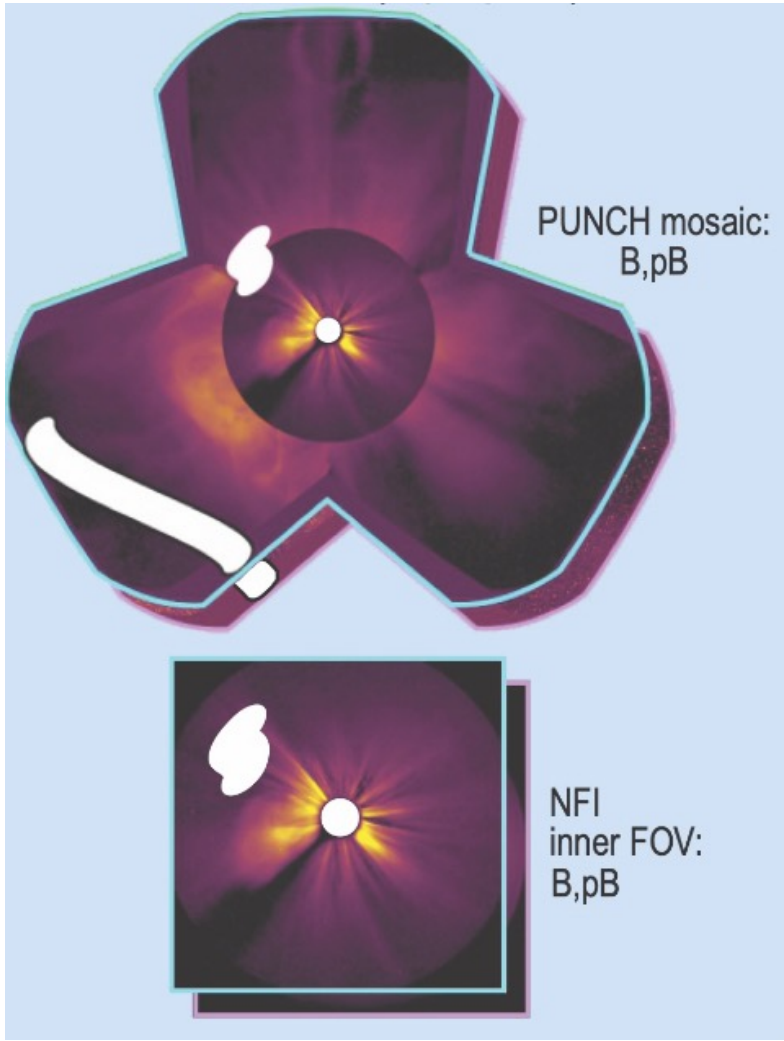

PUNCH+STEREO= Stereographic view & Depth

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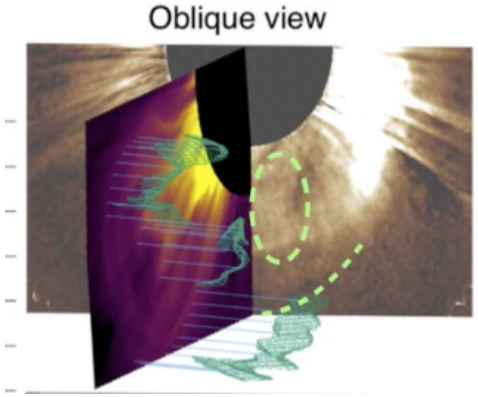
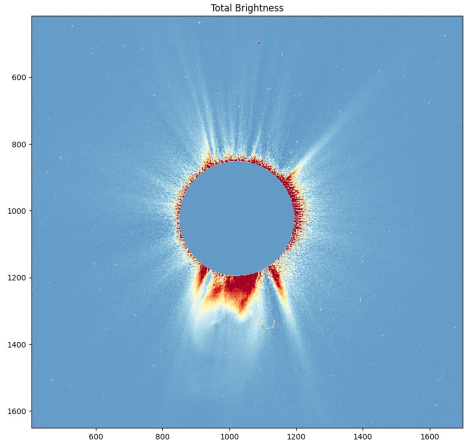
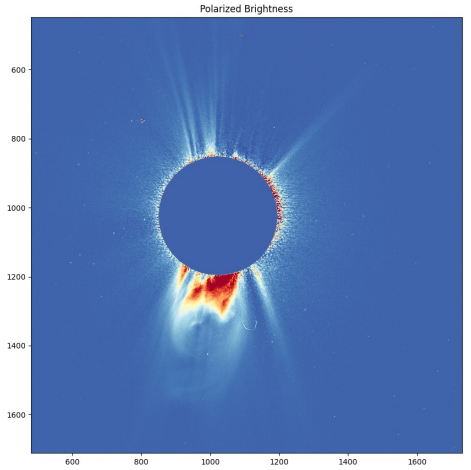
Multi-view of CME events

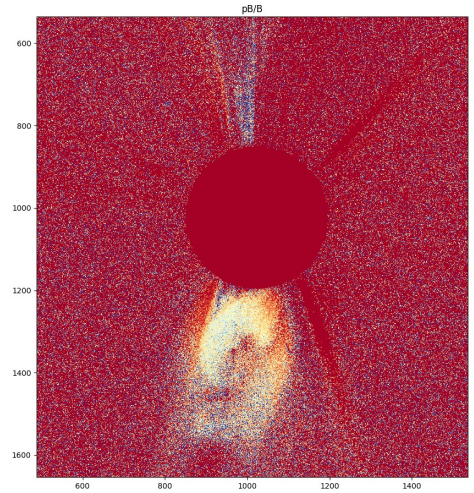


DeForest et al. 2017

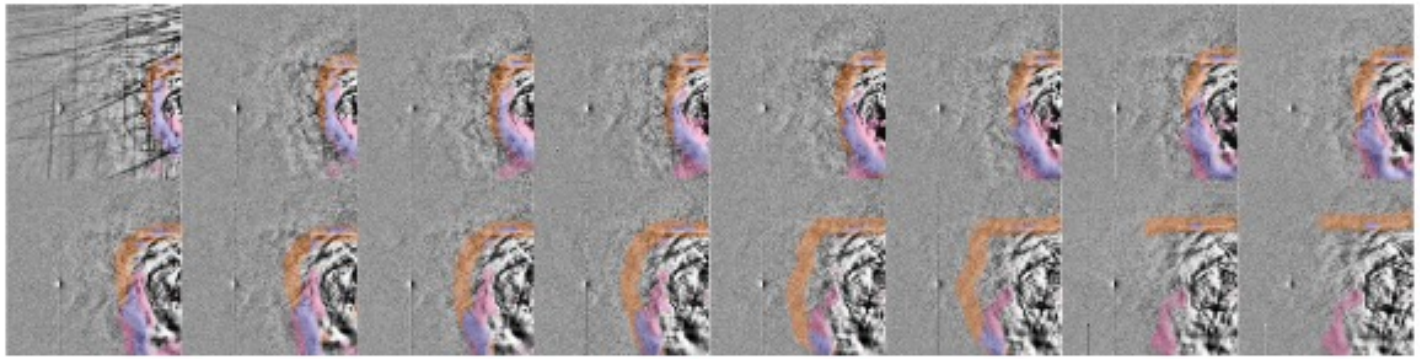
COR2 polarised sequence, pB/B ratio





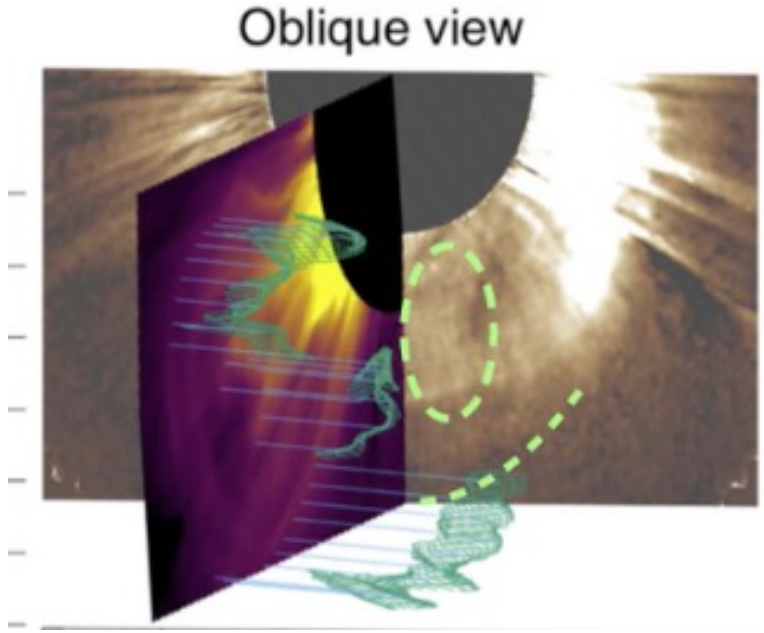


Combining multiple view points for tracking and reconstruction of CMEs, while obtaining localisation of important features with polarisation.



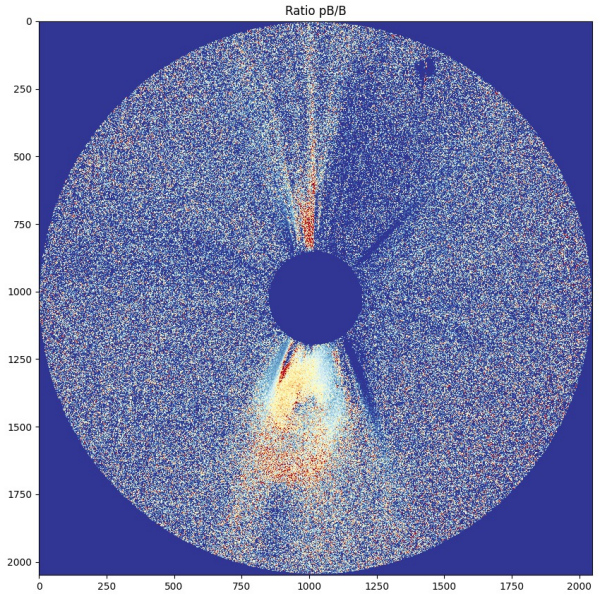
STEREO HI automatic tracking of CME (Bauer et al. poster)

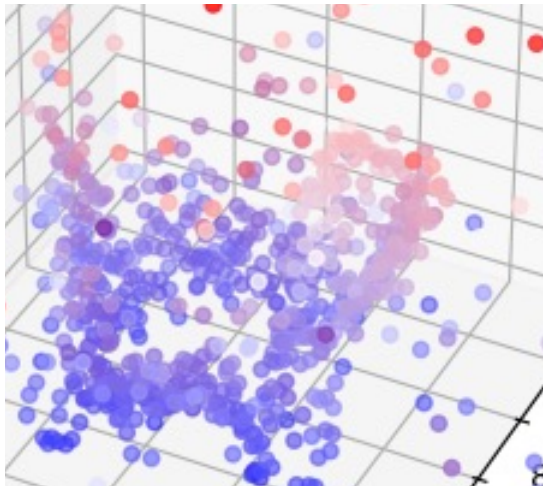
PUNCH+STEREO= Stereographic view & Depth

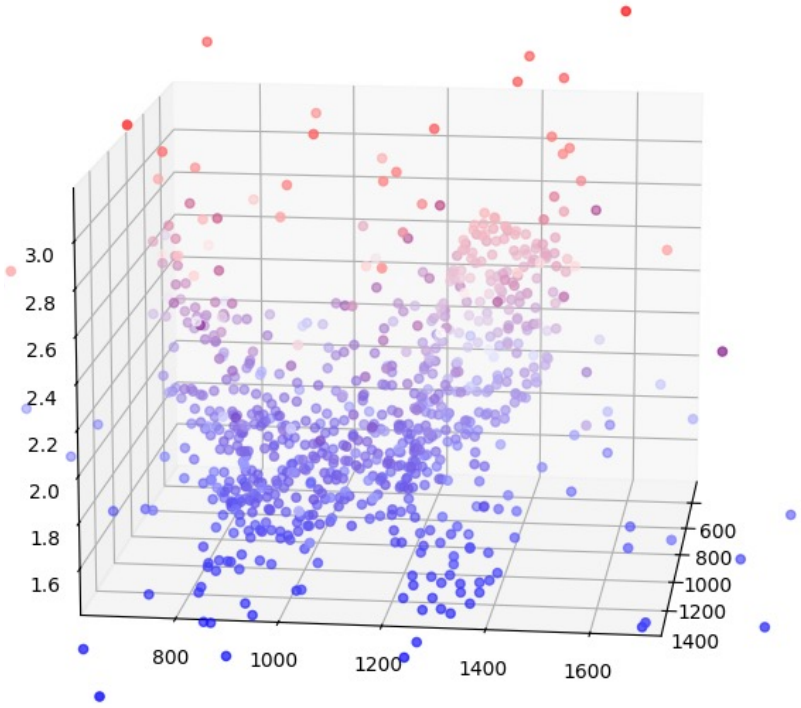


DeForest et al. 2017

Multi-view of CME events







COR2 polarised sequence -> 3D representation

Depth based 3D reconstruction

GeoSphere Austria

Summary

- Use Stereo + Punch data together for a more efficient tracking and reconstruction of CMEs
- Adding polarisation to multi-view reconstruction for better localisation and shape
- Tracking CMEs from very early on and for longer through STEREO HI1 and PUNCH WFI
  - + Inferring other physical properties such as chirality

Further ideas

- Combining other spacecraft's visual data (LASCO, WISPR …)
- Unified and open-source vision stack in Python (converting IDL code + new processing analysis codes)
  - *STEREO COR2 and H1 ready*
- ML ready datasets and processing code + computer vision models