

Multi-wavelength study of Recurrent Solar Jets on 11 December, 2010

Ramesh Chandra¹, G. R. Gupta², S. Mulay², Durgesh Tripathi²

¹ Department of Physics, DSB Campus, Kumaun University, Nainital – 263 001, India



Kumaun University

Sleepy Hollow, Nainital-263001,
Uttarakhand, India

² Inter-University Centre for Astronomy and Astrophysics, Pune 411 007, India

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Outline

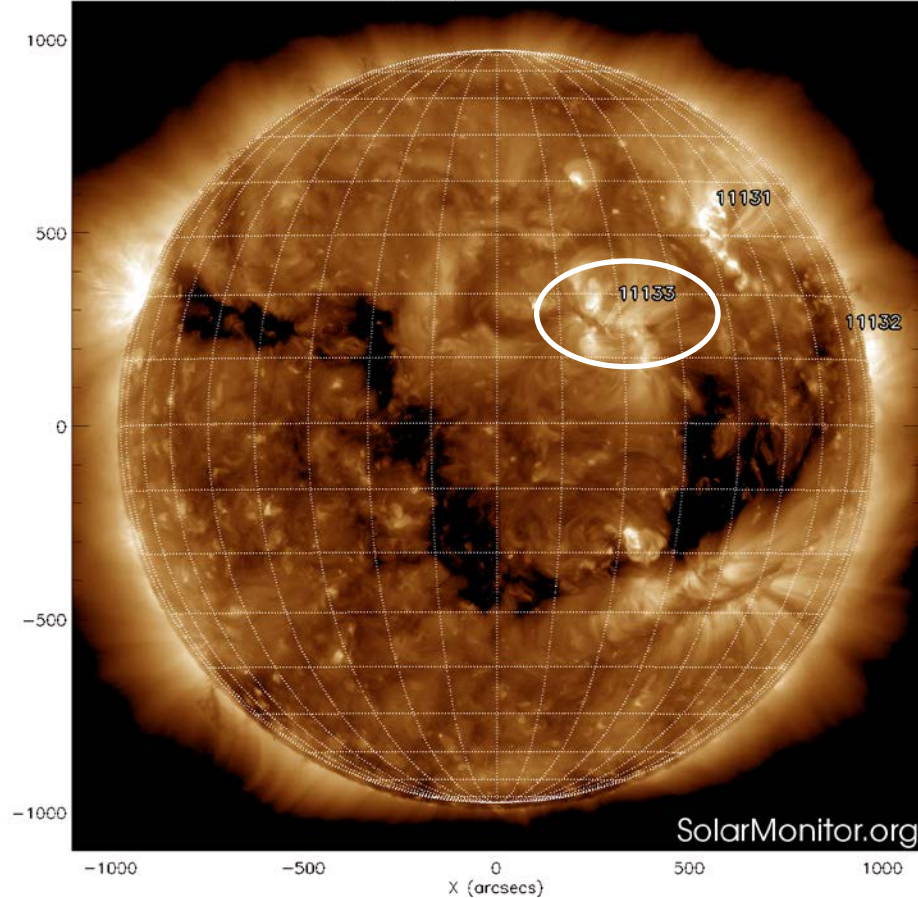
- Introduction
- Evolution of jets
- Evolution of magnetic field
- Associated type III radio bursts
- Sunspots Oscillations and jet triggering

Introduction

- Solar jets are dynamic, impulsive, well collimated plasma events developing at many different scales and in different layers of the solar atmosphere.
- These are believed to be induced by magnetic reconnection. Therefore studying their dynamics can help us to understand the processes acting in large solar eruptive events (e.g., flares and coronal mass ejections etc.)
- The role of the wave-induced reconnection in triggering the solar jets very recently proposed by Innes et al. (2011). However, need more confirmation.
- Sometime solar jets and type III radio bursts are associated, but this association is still under debate.

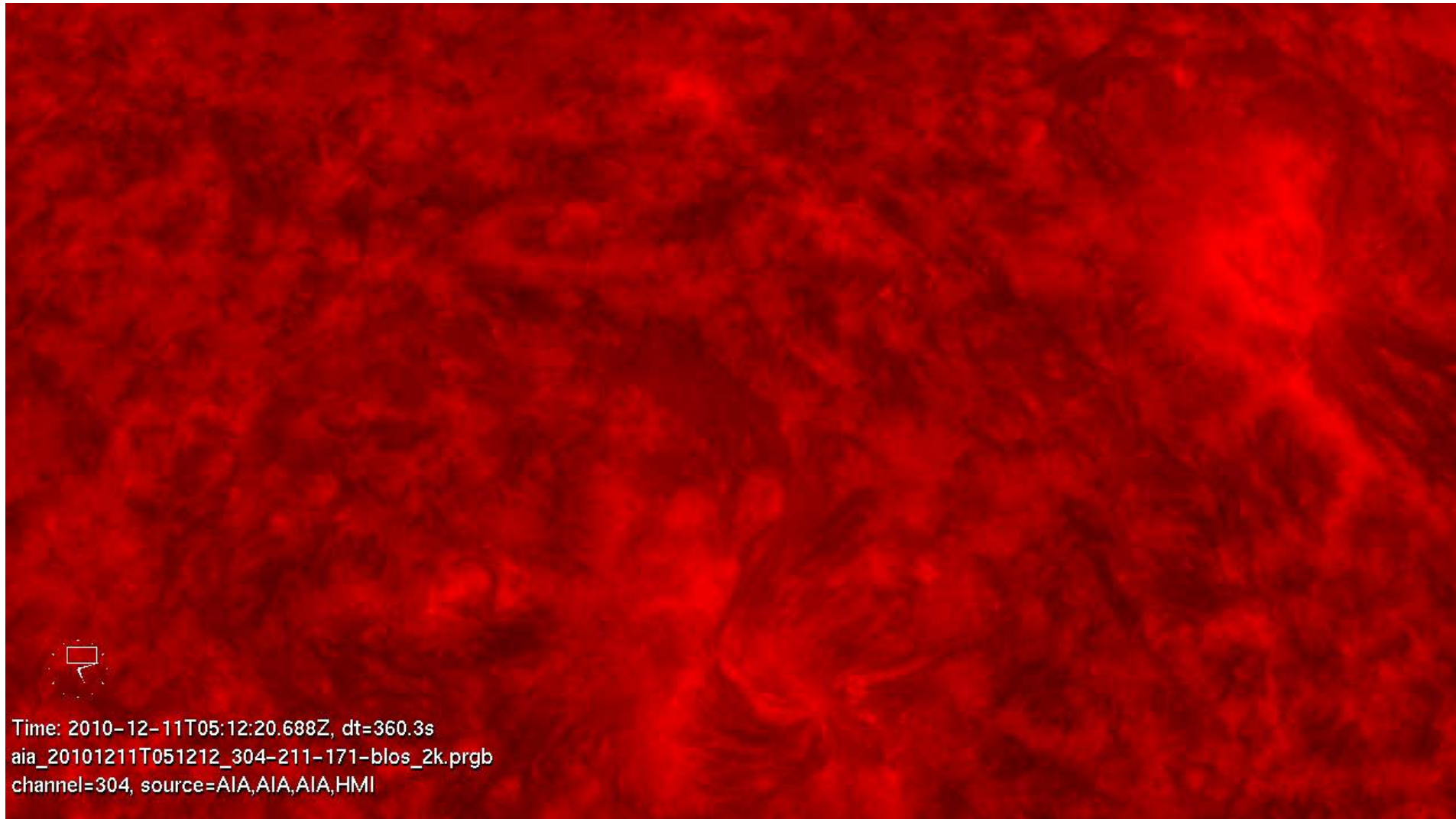
Observational data sets

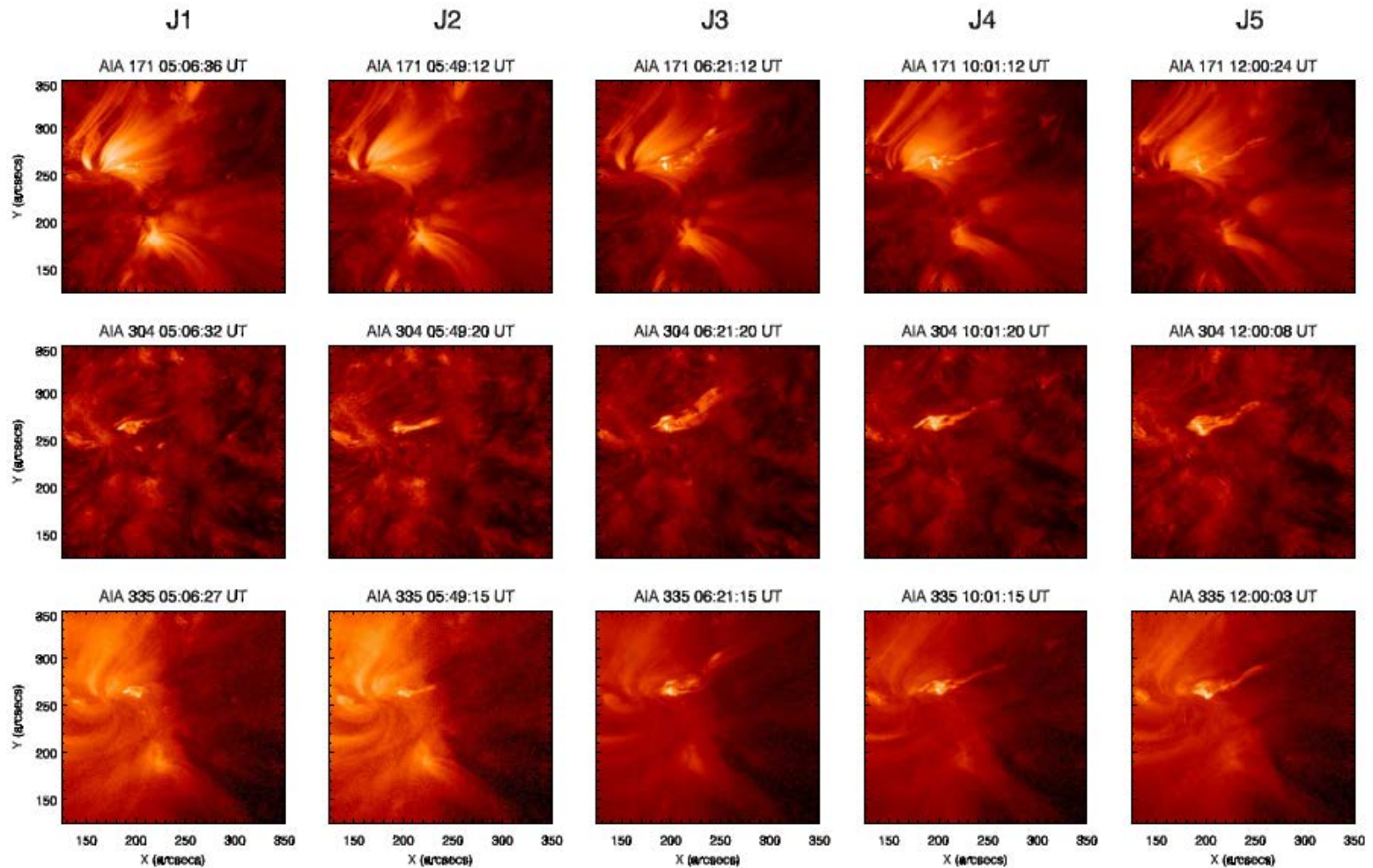
SDO AIA Fe XII (193 Å) 11-Dec-2010 23:40:31.840



- The recurrent homologous jets on 11 December, 2010 was observed in NOAA AR 11133 located at N15W23 on the solar disk.
- For our study, we used the data from different wavelengths of SDO/AIA, together with HMI data for the evolution of magnetic field.
- For the association between type III and jets, we used the data from WIND/WAVES instruments.

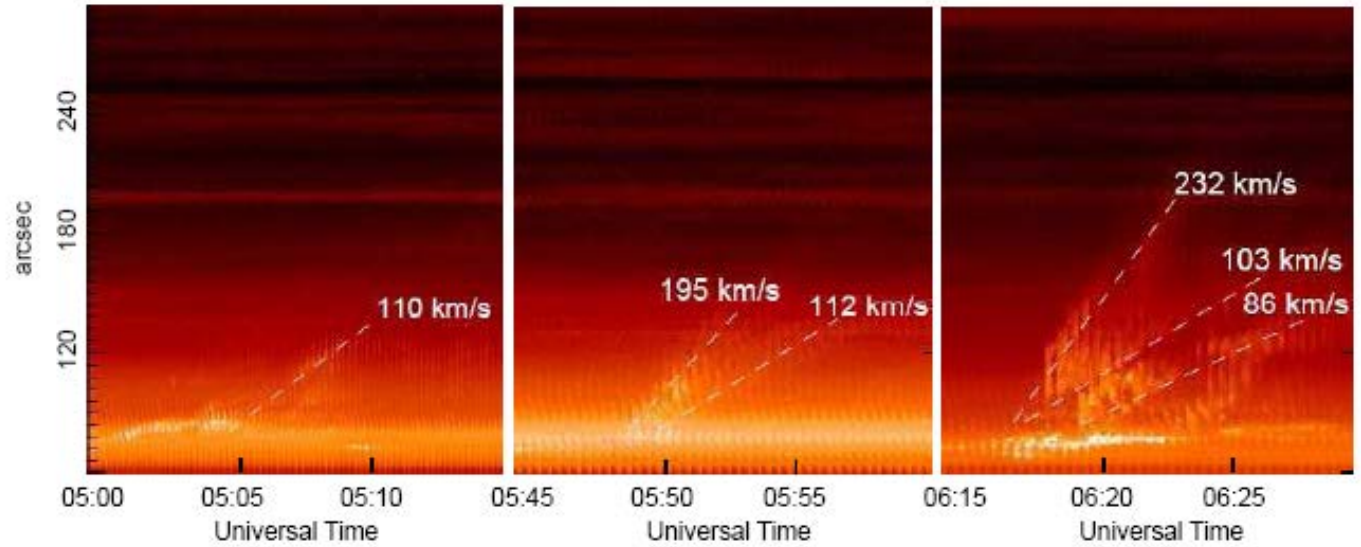
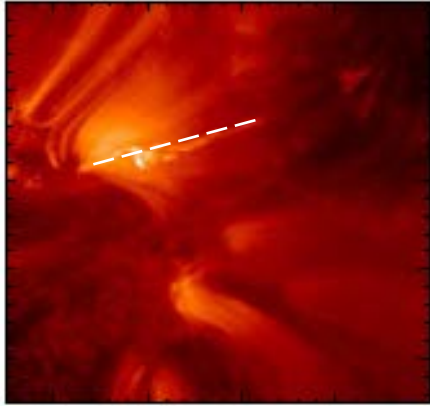
Evolution of jets





The recurrent jets on 11 December, 2010 was observed in NOAA AR 11133 located at N15W23 on the solar disk.

AIA 171 10:01:12 UT

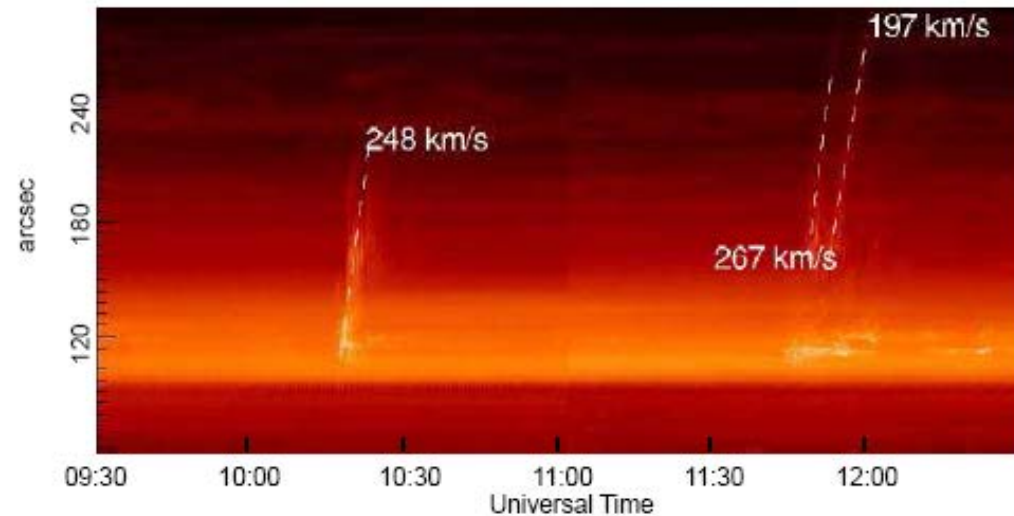


Time-slice analysis

Speed: 86 to 267 km/s

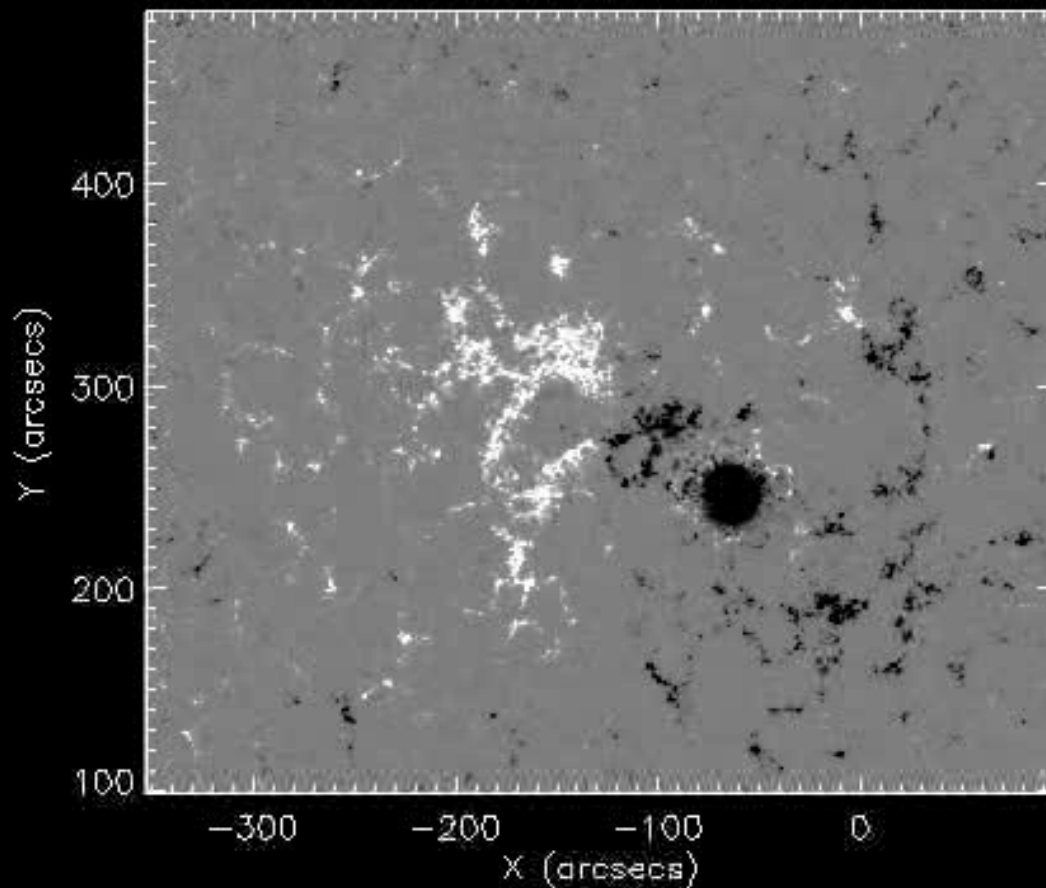
Lifetime: 10 to 15 minutes

Height: 80 to 200 Mm

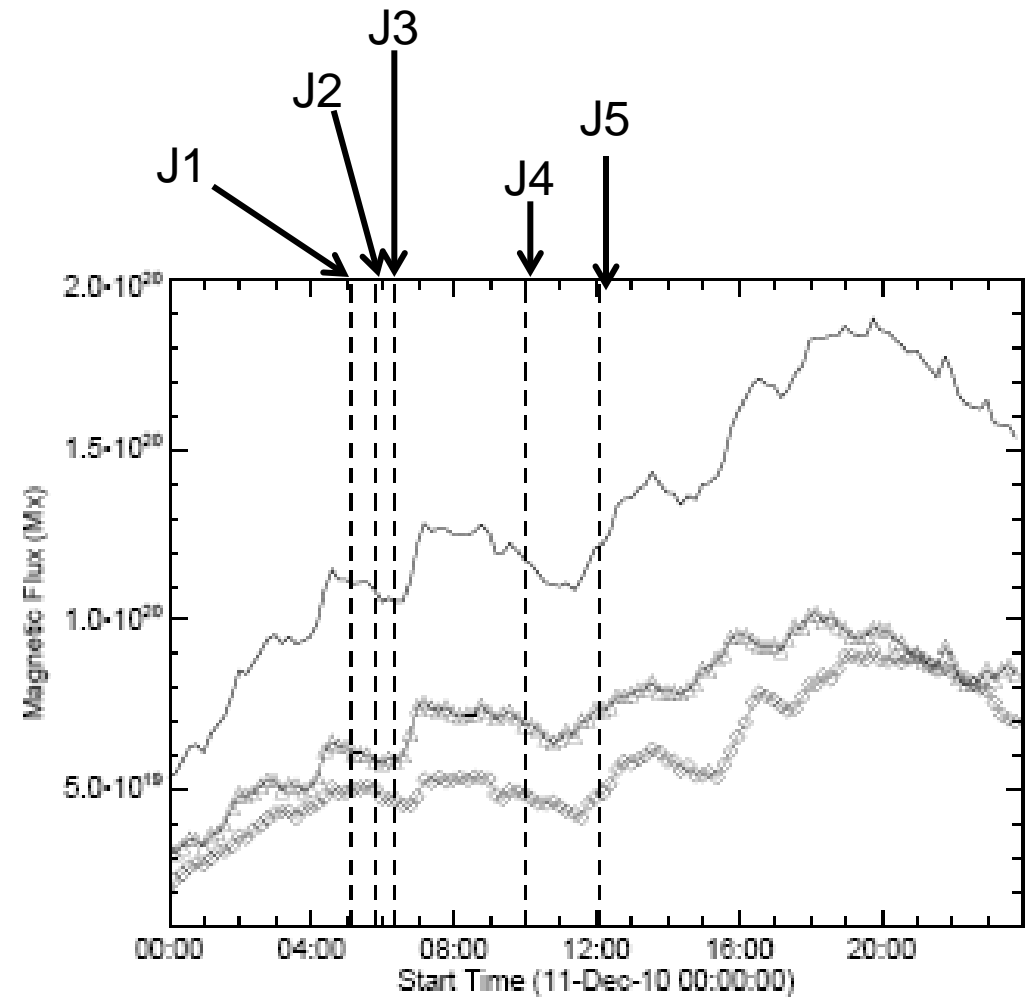
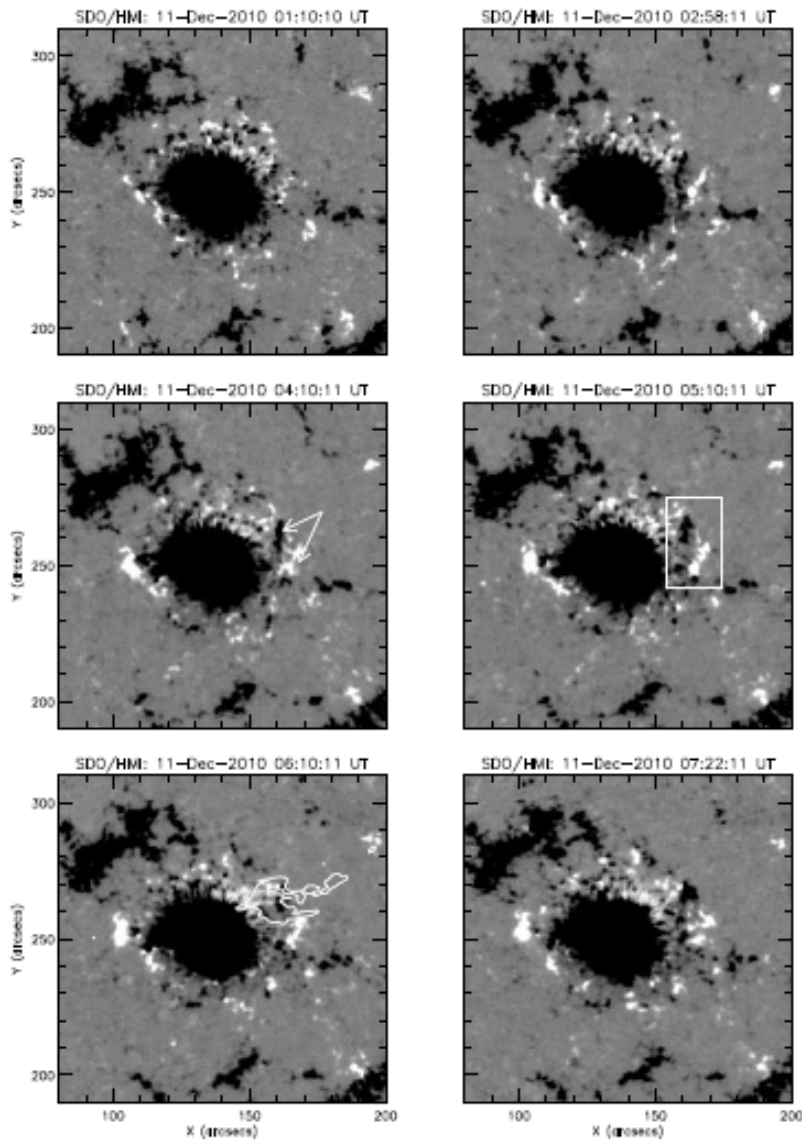


Evolution of magnetic field

SDO HMI_SIDE1 6173 9-Dec-2010 23:58:11.000 UT

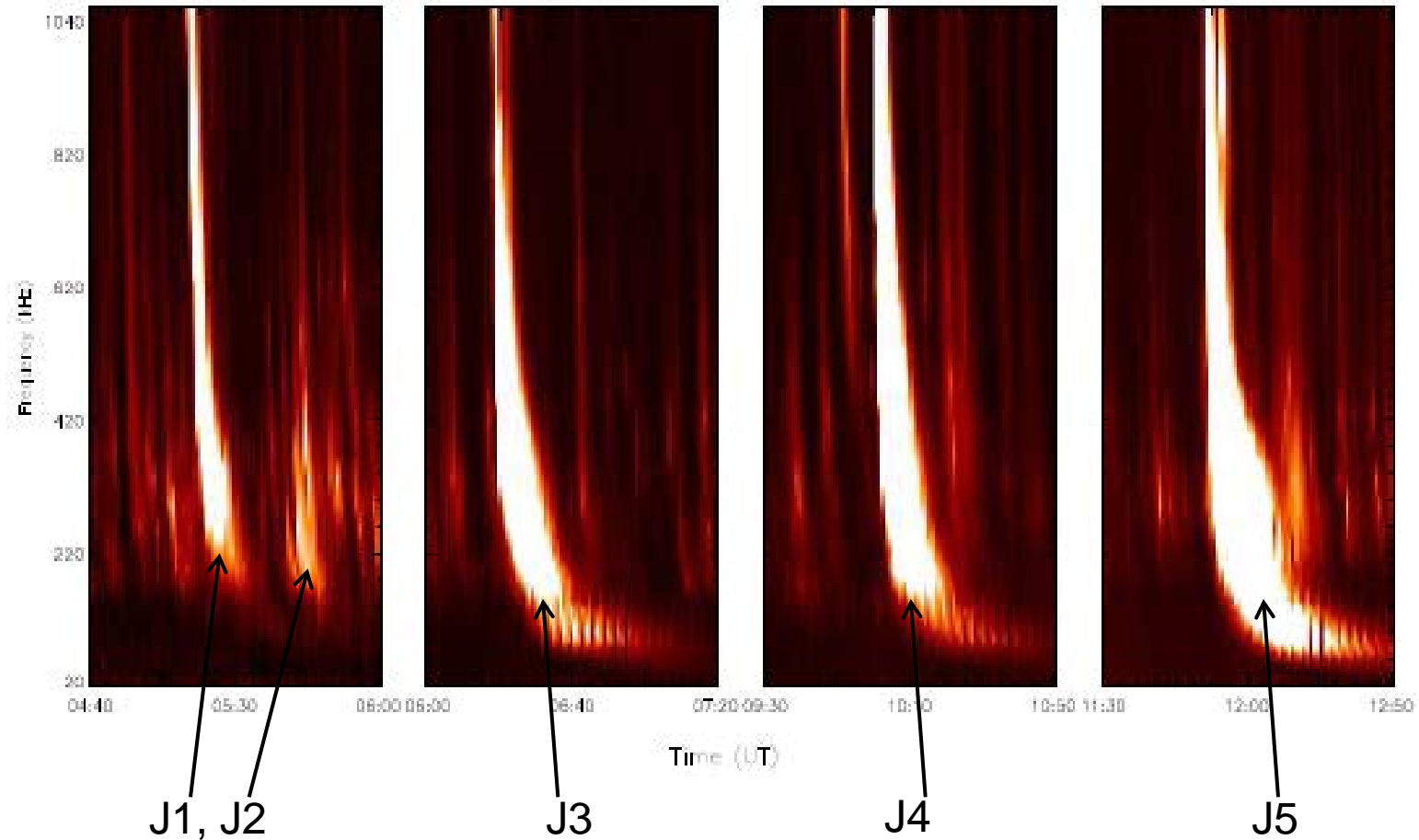


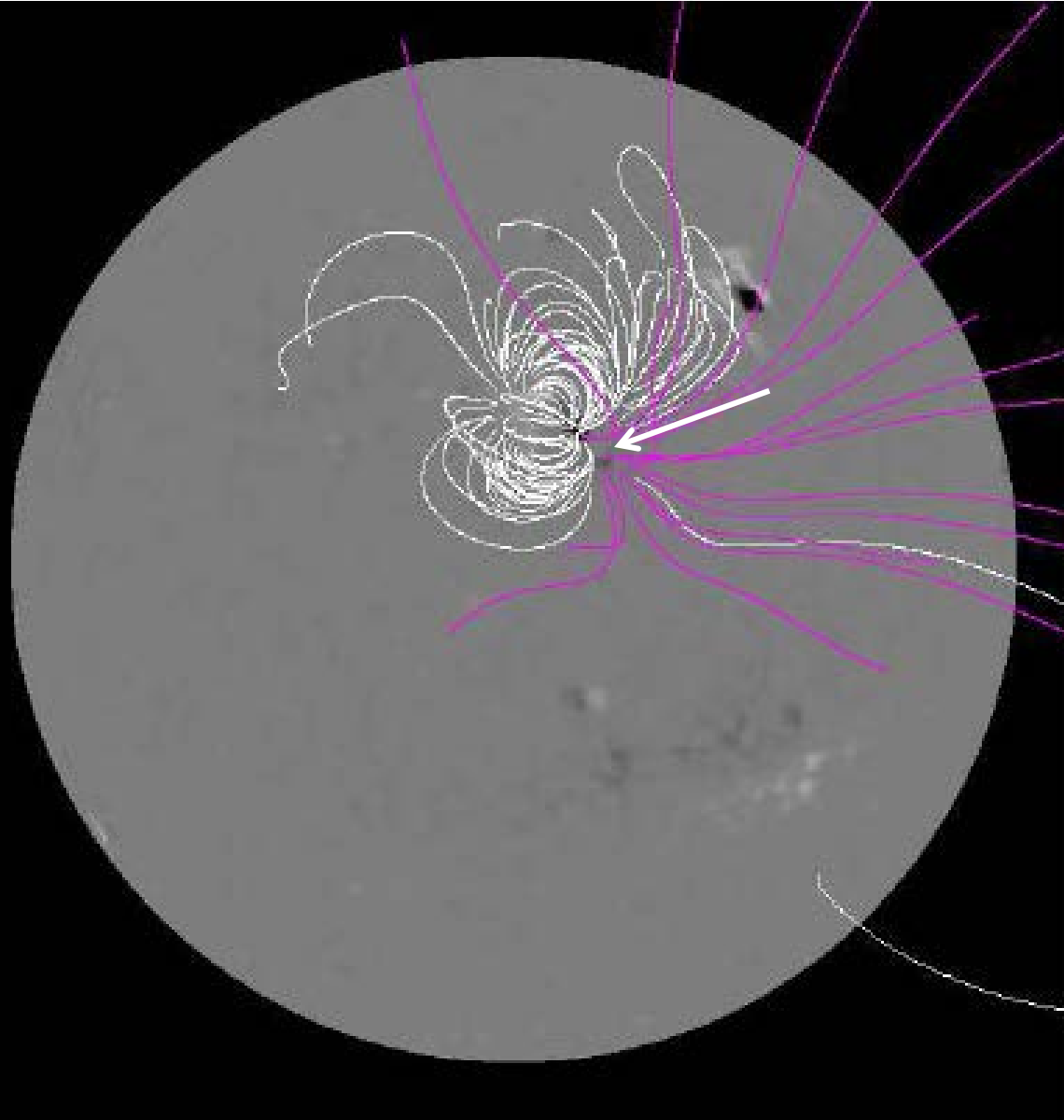
- Flux emergence started few hours before the jet J1 and continue during the jet activity.
- The jets J1, J2, J3, J4 are associated with localised cancellation of magnetic flux.



Associated type III radio bursts

WIND-WAVES Dynamic Spectrum PAD1 on 11 Dec. 2010



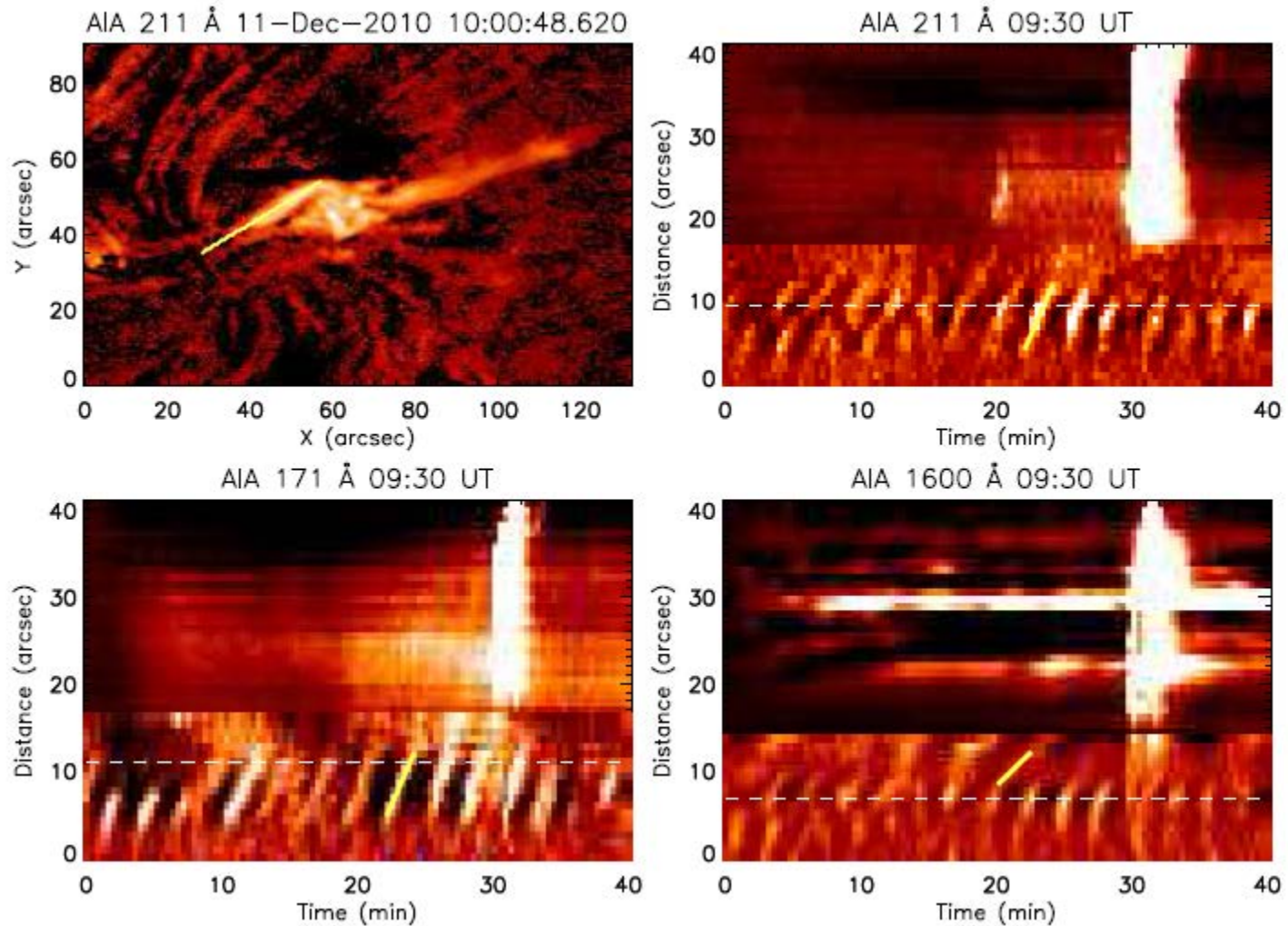


- Type III radio bursts generally represent the escaping electrons along open field lines (Dulk et al. 1979; Nitta & De Rosa 2008).

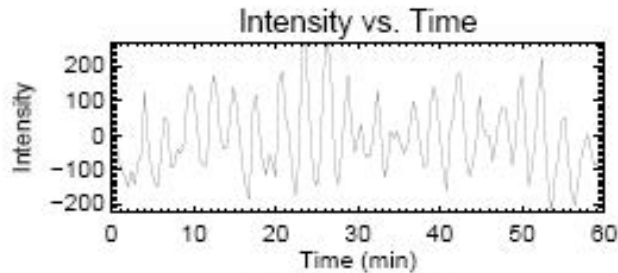
- The appearance of recurrent Type III bursts during the peak evolutionary phases of the jets may most likely be the signature of the generation of non-thermal particles due to reconnection episodes.

PFSS extrapolation of active region before jets.

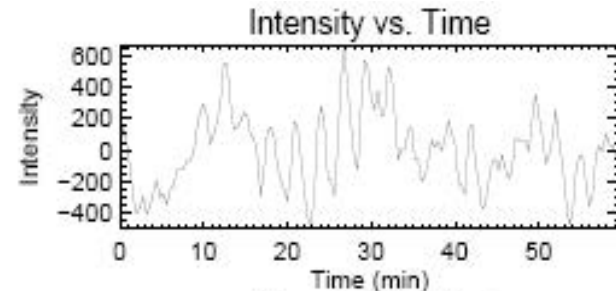
Sunspots Oscillations and triggering of jets



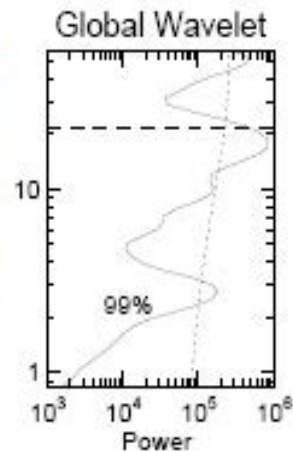
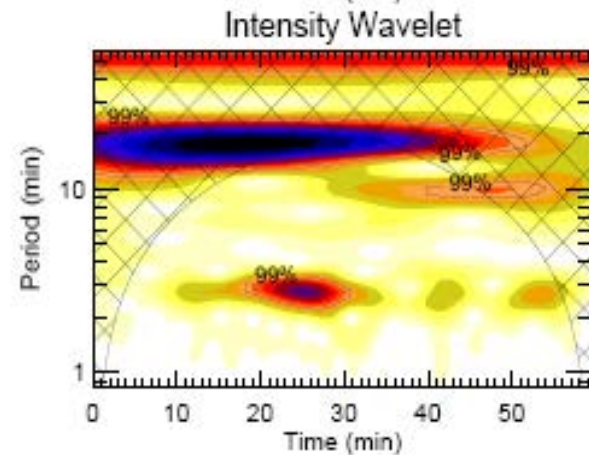
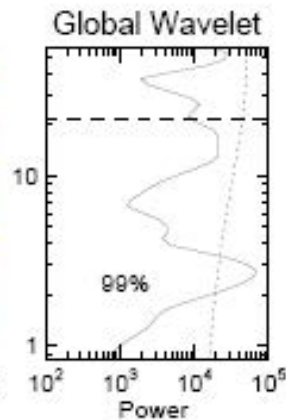
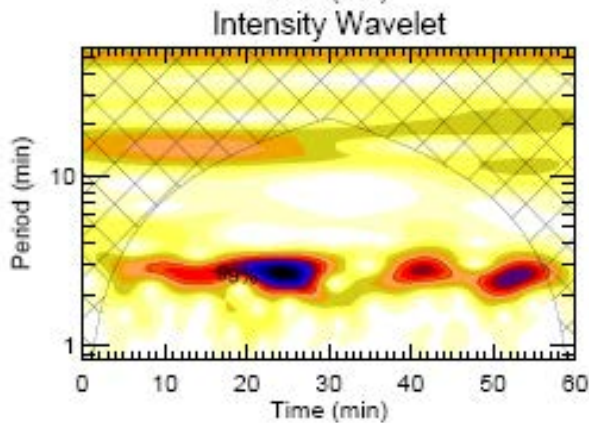
Time-slice for the jet J4, sunspots waves can be seen propagating towards the jet foot-points with a speed of 46, 44 and 18 km/s in 211, 171, & 1600 Å respectively



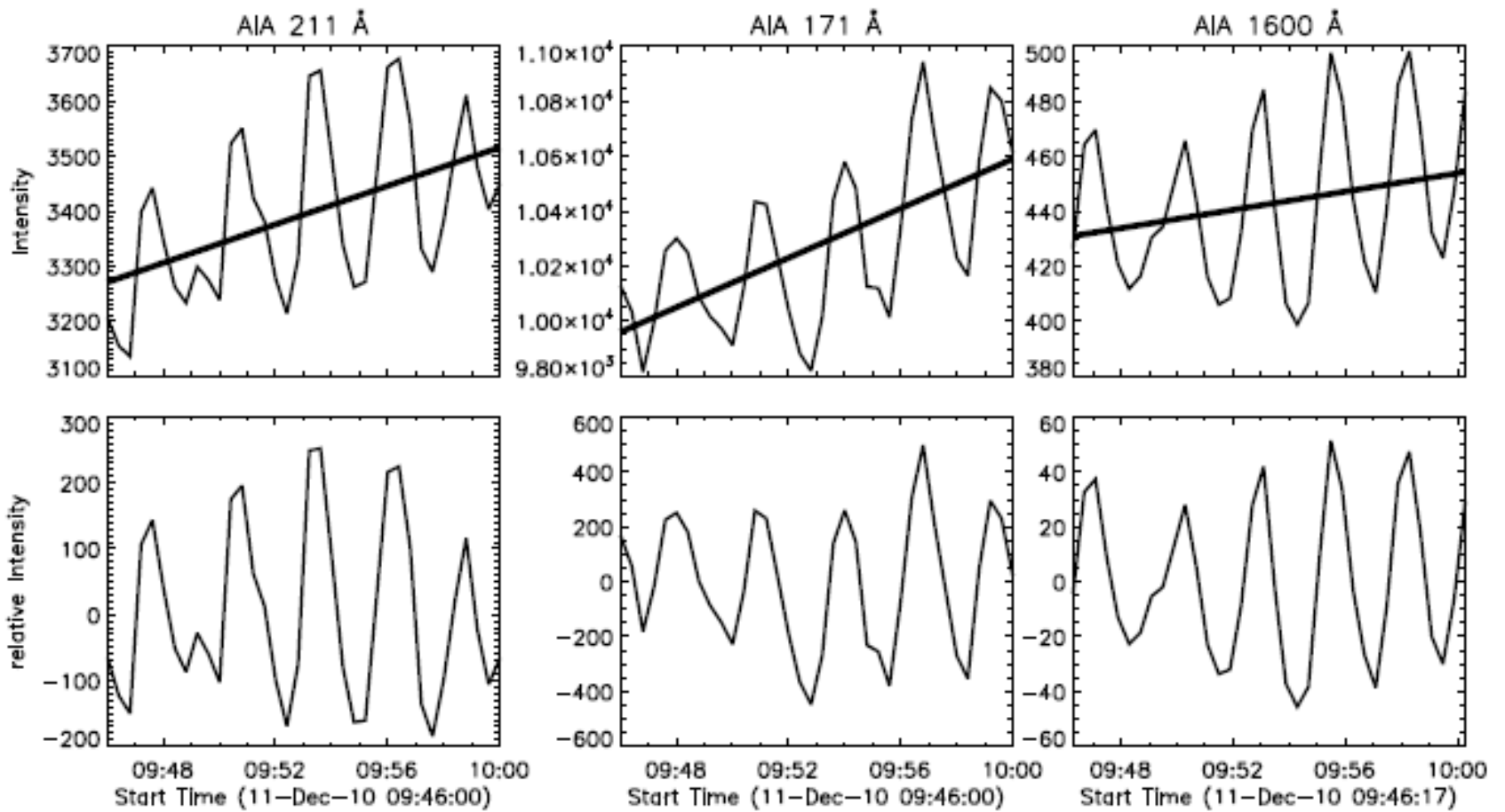
Global Period at max.
power (< 21.9 min.)
P1 = 2.78 min.
P2 = 13.22 min.



Global Period at max.
power (< 21.8 min.)
P1 = 17.15 min.
P2 = 2.78 min.



- Wavelet analysis for the Jet J4 in AIA 211 Å (left) and 171 Å (right). The results shows period ~ 3 min.
- We have observed an increase of amplitude of the oscillations in 211, 171, & 1600 Å passbands just before the jets were triggered.



Enlarge view intensity time profile just before the jet J4

Conclusions

- The observed jets are homologous and recurrent.
- Evolution of magnetic flux shows that both positive and negative flux regions emerged at the location of jets just before the appearance of the first jet. However, localised cancellation is observed during J1, J2, J3 and J4 jets.
- All the jets were associated with type III radio bursts. It support the idea that the non-thermal particles are accelerated at reconnection site in the current sheet, which forms between closed and open magnetic field lines.

- The analysis of the sunspot waves revealed a 3 minute oscillatory pattern. The analysis further revealed that an increase in the amplitude of the oscillations prior to the triggering of the jet. The oscillatory amplitudes decreased after the launch of the jets.
- The increasing of wave amplitude can be interpreted as growing expansion and contraction of flux tube. The increase in amplitude will bring neighbouring field line close, which induced reconnection and hence the trigger the jet.

Thank You