

SOLARNET School “week above the clouds”

(brief) Introduction Philip Lindner

06.08.2019



1. Introduction Philip Lindner

- Home Institute: **Leibniz-Institut fuer Sonnenphysik (KIS) in Freiburg**



- **Master Thesis in 2018**
- **Working on Phd project since October 2018**

Supervisors: Nazaret Bello Gonzalez, Rolf Schlichenmaier, Svetlana Berdyguina (official)

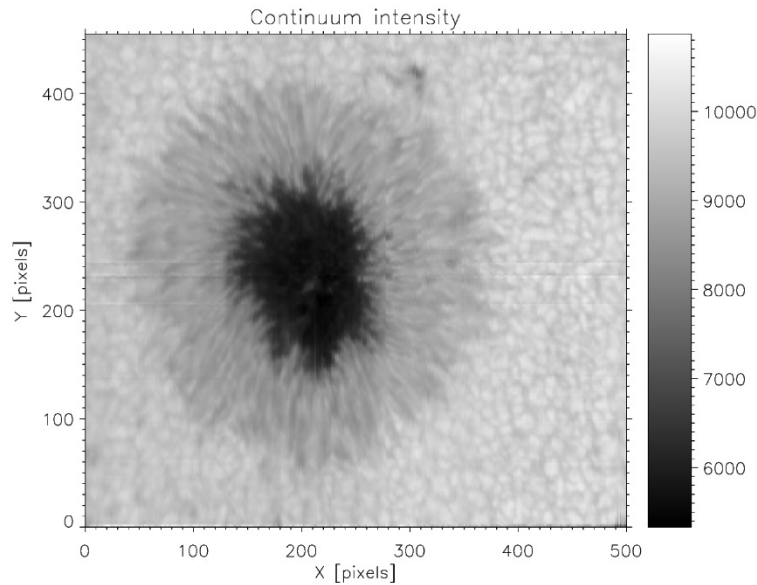
1. Fields of interest

Working title:

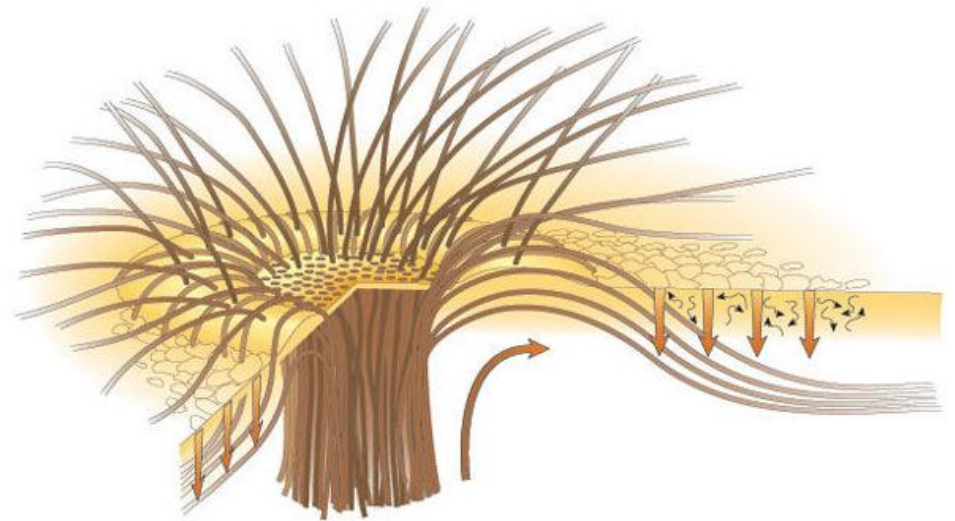
“Coupling between photospheric and chromospheric processes during the evolution of Active Regions”

- **Active Regions: Modes of magneto-convection + Evolution**
- **Photospheric magnetic activity and coupling to chromosphere**
- **Methods: So far: Ground-based observations, Inversion Techniques**

1. Fields of interest



GRIS data, 19sep15.003

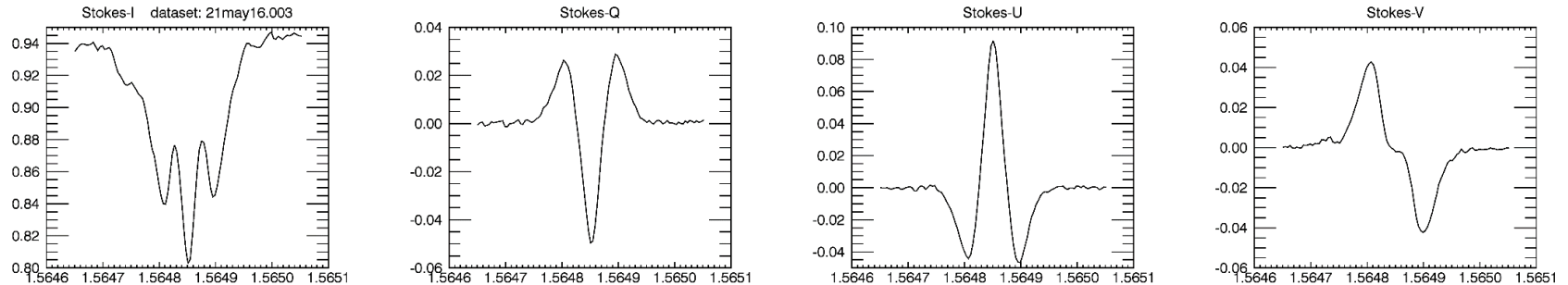


Adapted from Thomas, et al. 2002

- Jurcak 2011: *"The vertical component of the magnetic field [at the boundary between umbra and penumbra] is possibly independent of the umbral area"*
- Jurcak et al. 2018: Survey with 88 Hinode scans: Boundary between umbra and penumbra is defined by *"an invariant vertical component of the magnetic field."*

2. Past work

GRIS level1 data (Line: Fe I 15648 Å)



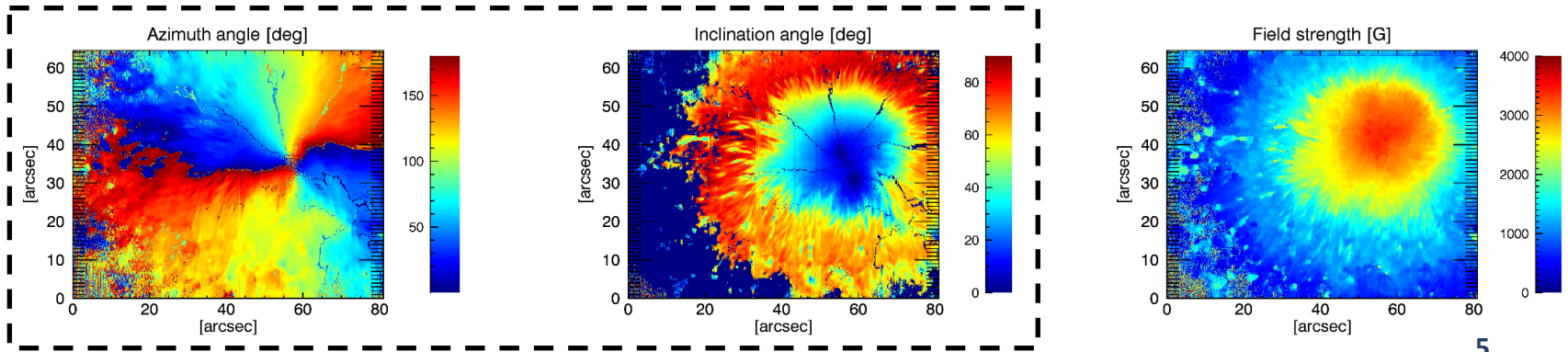
Auer et al. 1977

$$\tan(4\alpha) = \frac{2 \sum_i Q_i \cdot U_i}{\sum_i (Q_i^2 - U_i^2)}$$



$$\theta = \cos^{-1} \left(\frac{1}{2} (\sqrt{R^2 + 4} - R) \right)$$

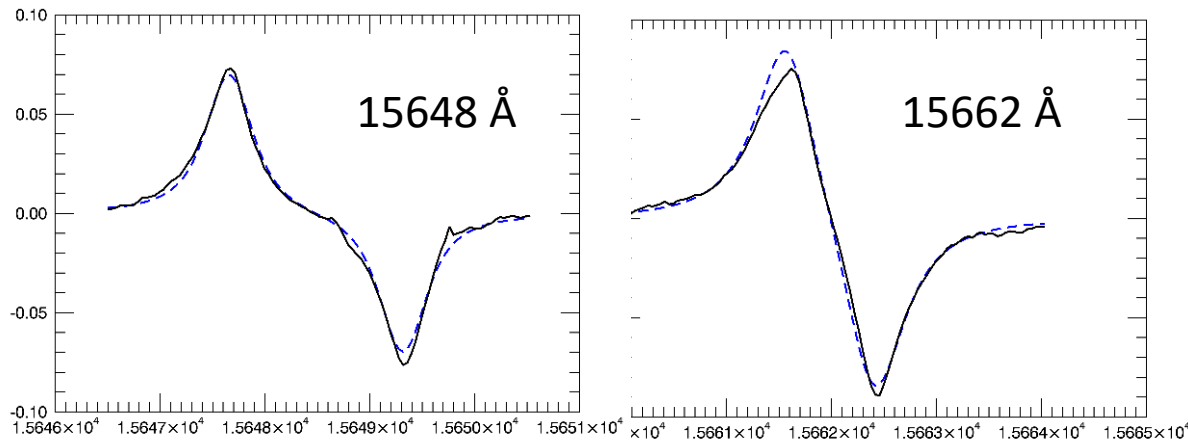
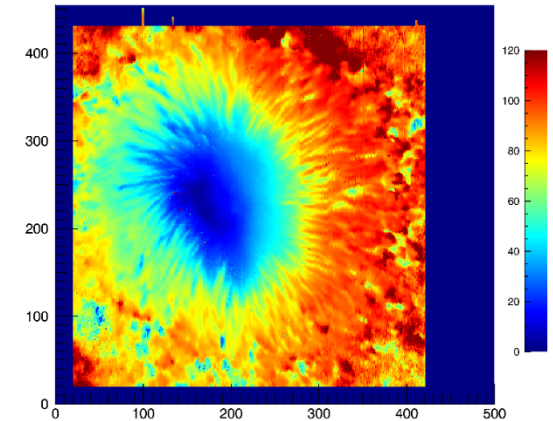
$$R := \frac{Q}{V}$$



Integrated into the data calibration pipeline for GRIS level2 data

2. Past and current work

- SIR inversions for full maps
- Computationally time consuming
- IDL: Parallelization used for SIR
=> computation time decreased
to $\approx 1-4$ days / dataset

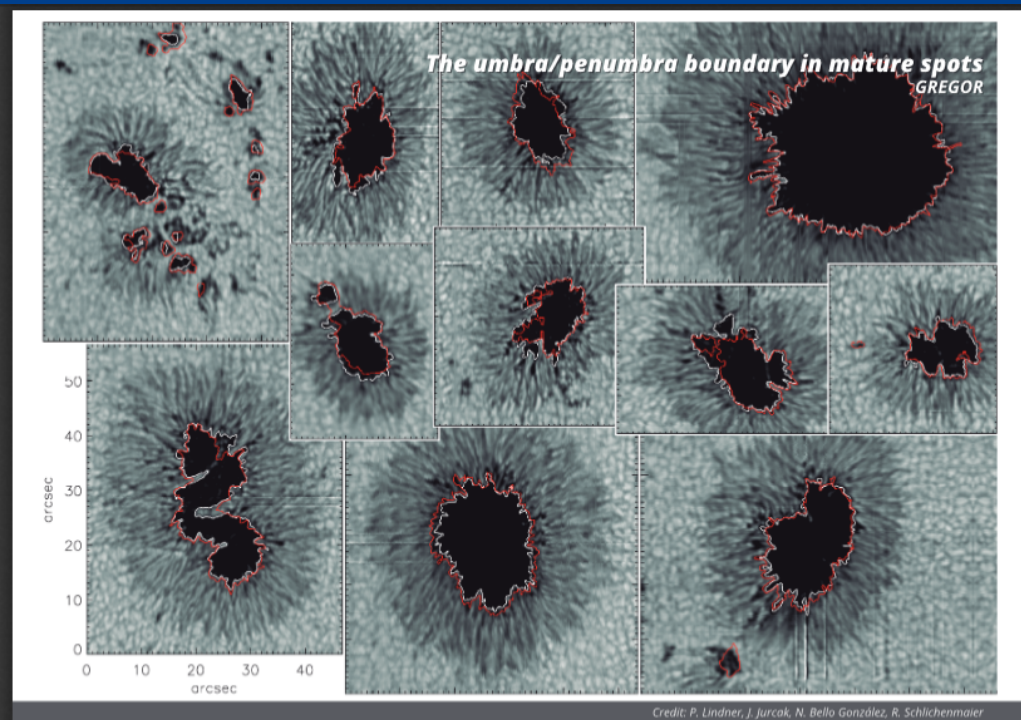


Stokes V, GRIS in black, SIR fit in blue, 19sep15.003

2. Past and current work

- Worked out limitations of Auer method using **synthetic spectra**
- Analyzing B_{\perp} values at the penumbra/umbra boundary
- Results support existence of a constant value
 $B_{\perp} = B_{\text{crit}} = (1843 \text{ G} ???)$

Too high!



Credit: P. Lindner, J. Jurcak, N. Bello González, R. Schlichenmaier

The umbra and penumbra of sunspots, the most prominent and renowned manifestations of solar activity, are separated by a boundary that has always been defined by an intensity threshold. Using data from the Hinode satellite, Jurcak and collaborators found that the umbra-penumbra boundary in stable sunspots is characterised by an invariant vertical component of the magnetic field. This law is known as the Jurcak criterion. For more details, see Jurcak et al., 2018, A&A 611, 4.

The figure shows a sample of sunspots scanned with the Gregor Infrared Spectrograph attached to the GREGOR telescope at the Observatorio del Teide (Tenerife, Spain). The white contours outline the umbral boundary as seen in intensity and the independently defined red contours outline the vertical component of the magnetic field at 1843 Gauss. This value is consistent with the results achieved with the Hinode data and validates the Jurcak criterion in the infra-red part of the spectrum.

	MON	TUE	WED	THU	FRI	SAT	SUN
FEBRUARY	28	29	30	31	01	02	03
	04	05	06	07	08	09	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
	25	26	27	28	01	02	03
	04	05	06	07	08	09	10



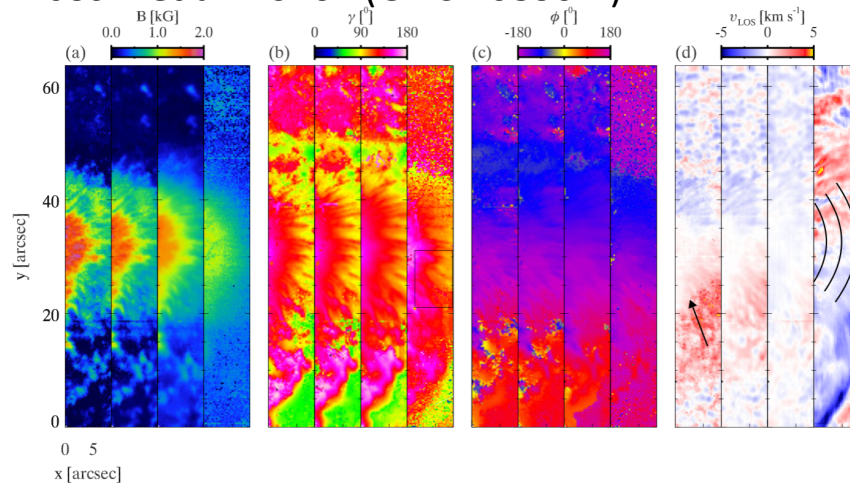
February 7-8: PROBA-2 Symposium, Reu, Belgium
February 11: International Day of Women and Girls in Science
February 11-15: Chapman Conference on Scientific Challenges Pertaining to Forecasting, Pasadena, USA

3. Plans for future

Chromosphere

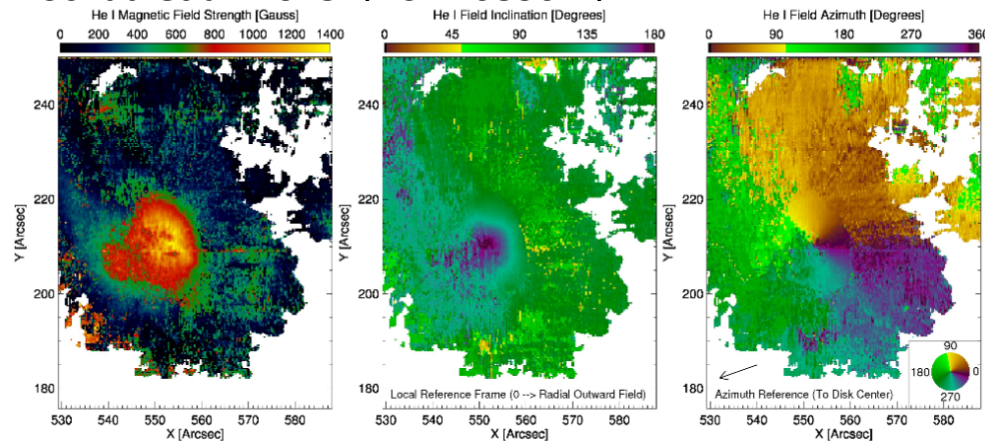
Already done:

— Joshi et al. 2016: (GRIS 10830 Å)



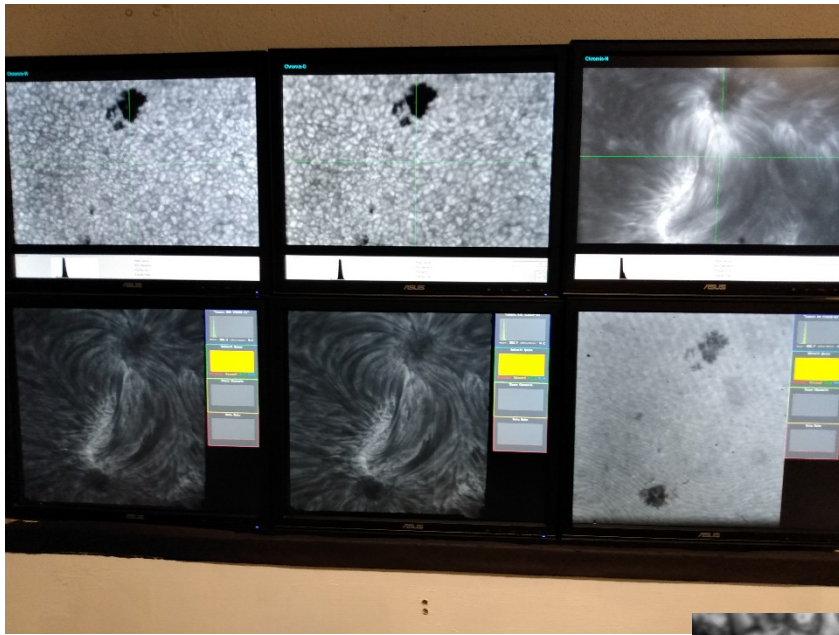
First three maps: Si I and Ca I (SPINOR)
last map: He I triplet (HeLIx+)

— Schad et al. 2015: (DST 10830 Å)



All maps: He I triplet (HAZEL code)

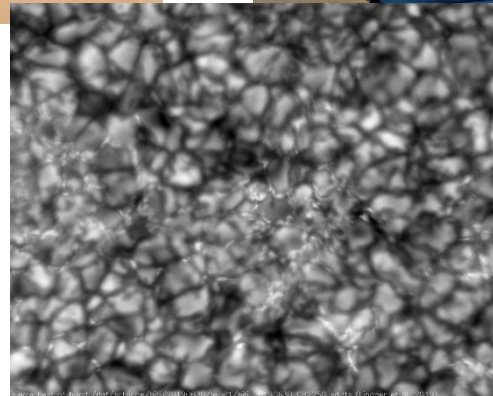
4. Observations



SST (La Palma)



GREGOR



4. Methods

Chromospheric Inversions

- **Plans:**
 - StiC Non-LTE inversion code at Stockholm from Jaime de la Cruz Rodriguez (SOLARNET mobility programme)
 - coupling mechanisms between chromosphere and photosphere

5. Private Interests

Travelling & Mountaineering

