MULTI-ZONAL PARAMETRIC MODEL OF THE JOVIAN SYNCHROTRON RADIATION BELT UPDATED FROM THE JUNO MISSION OBSERVATIONS

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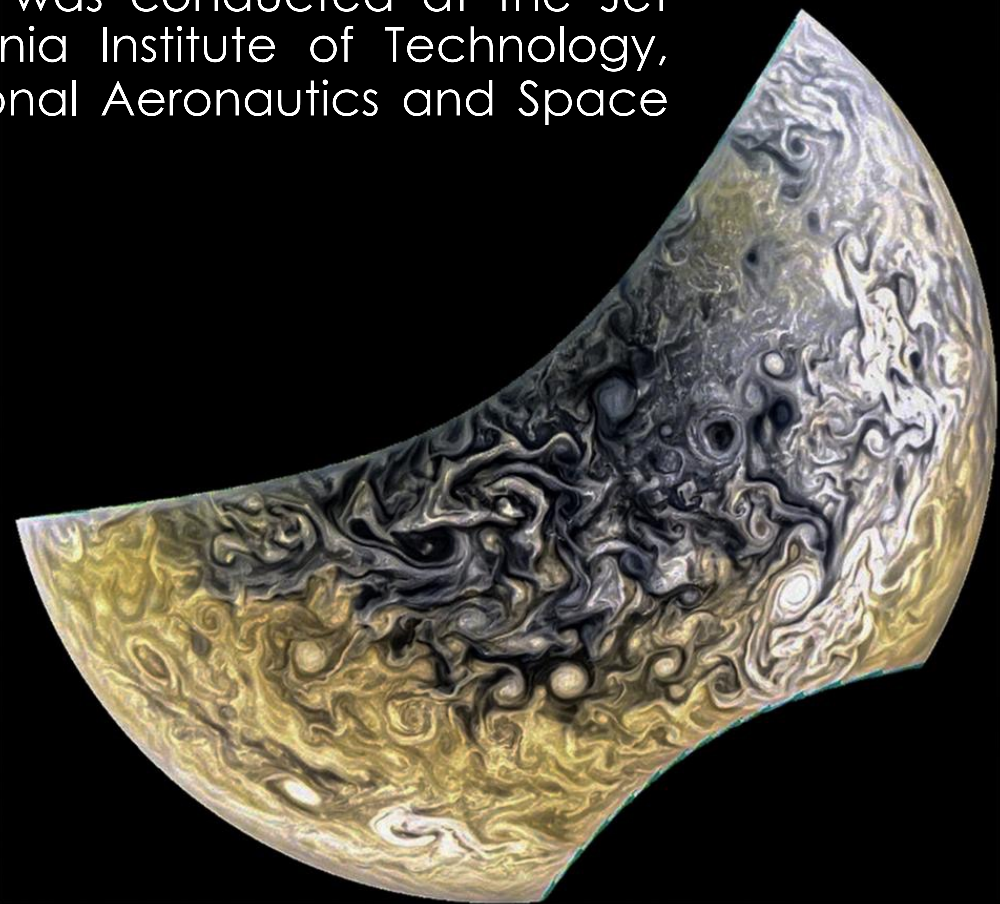
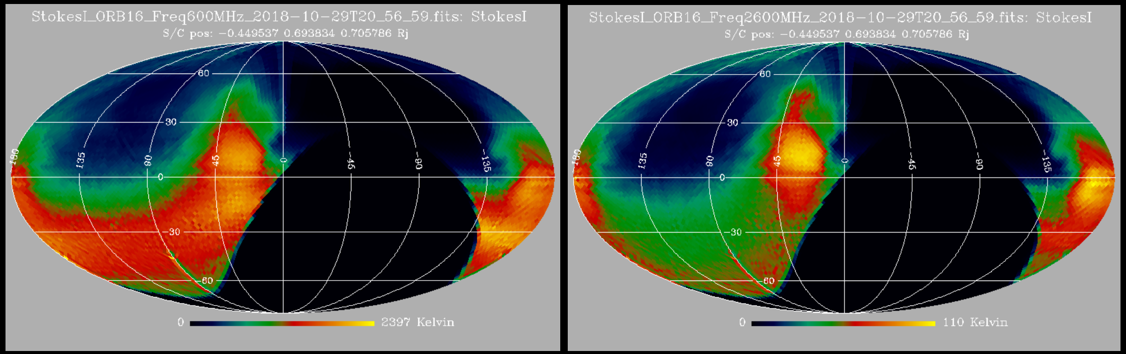


PJ36 JET N6
Credit : NASA / SwRI / MSSS/ Pia Valentin Sørensen

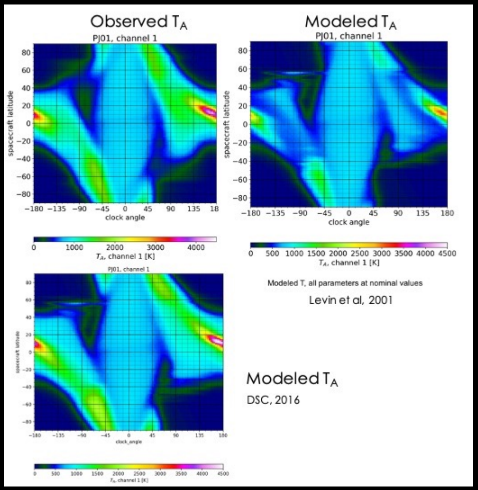
MOTIVATION

- The Microwave Radiometer (MWR) Experiment has the ability of sensing the thermal radiation of Jupiter's atmosphere.
- Simultaneousy, MWR captures the signature of synchrotron radiation belts, which at 600 Mhz exceeds the brightness temperature of the planet's atmosphere by one order of magnitude.
- In order to perform atmospheric composition retrievals the contributions from the two emission sources have to be disentangled.
- Daniel Santos-Costa's (2001, 2016) higher fidelity physics-based model is currently the model in use in the production runs.
- Levin et al. (2001) empirical multi-parameter zonal model is the focus of this effort, as the update of the model coefficients would provide a closer match to the observations and a computational faster scheme for the atmospheric retrievals.

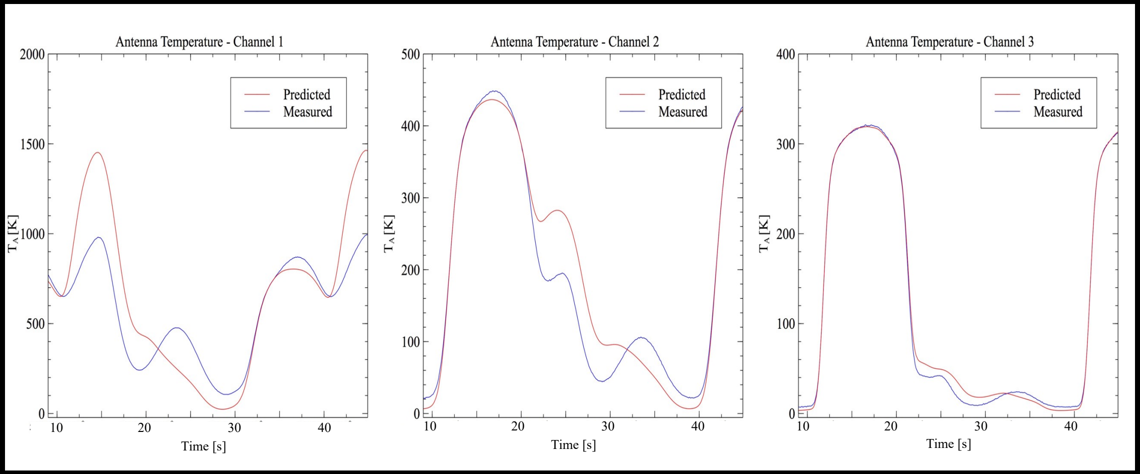
SYNCHROTRON RADIATION BELTS MODEL RESULTS VS. OBSERVATIONS



Mollweide projection maps of predicted synchrotron radiation for channel 1 (600 MHz) and channel 3 (2600MHz) at the beginning of the time series below.



Spinmaps PJ1, 600 MHz. Top left : Observed; Top right: Levin et al. model; Bottom: DSC model.

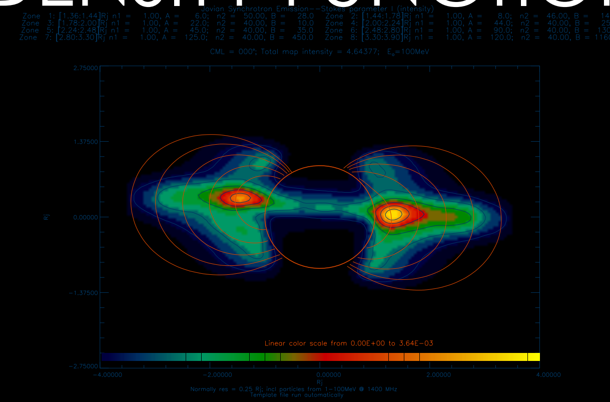


Sample time series of observed vs. predicted antenna temperatures in the synchrotron region during 2 spacecraft spins (first 3 MWR channels: 600MHz, 1250 MHz & 2600 MHz; PJ16).

Production baseline: electron density model from Daniel Santos-Costa (2008)

SYNCHROTRON RADIATION MULTI-ZONAL PARAMETRIC MODEL: ELECTRON DENSITY FUNCTION

$$\begin{cases} n_e(\alpha, L, B, E) = n_{e,\alpha}(\alpha, L, B) n_{e,E}(B, E) \\ n_{e,\alpha}(\alpha, L, B) = A_L \sin^{n_1}(\alpha_{eq}) + B_L \sin^{n_2}(\alpha_{eq}) \\ n_{e,E}(B, E) = E_0 / [E_0 + (E/\sqrt{B})^{\varepsilon + 0.75}] \end{cases}$$



8 zones

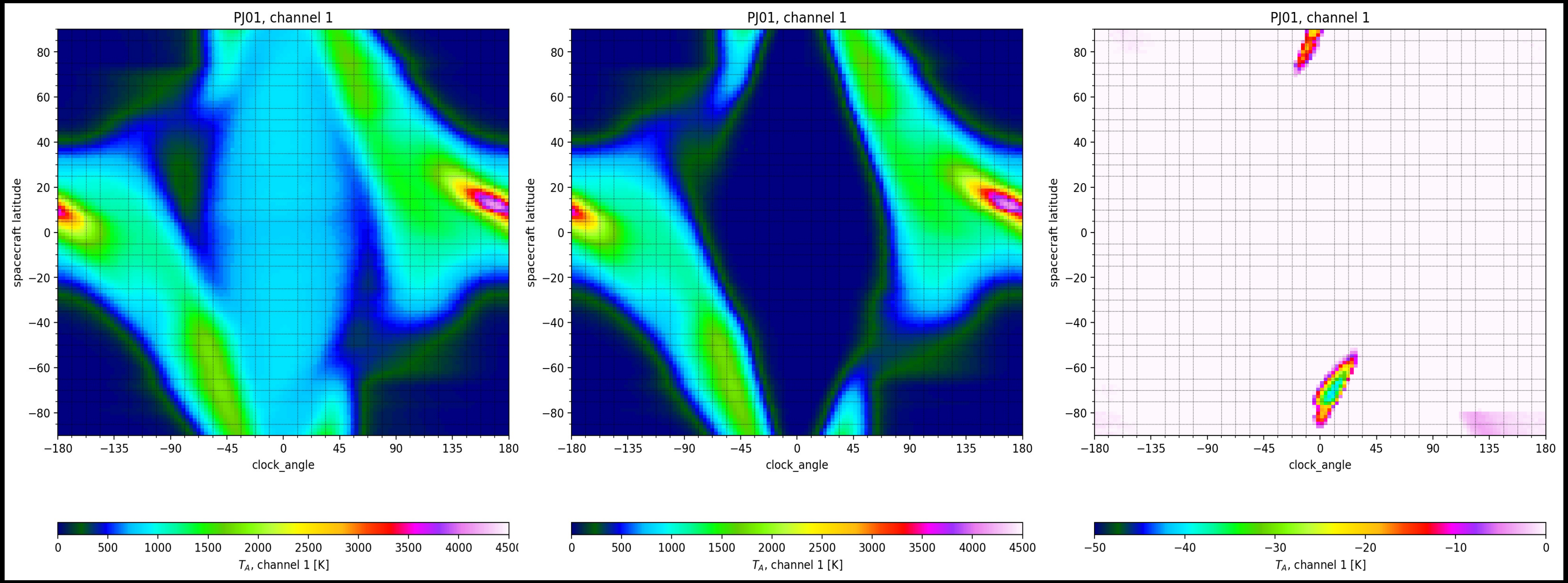
32 parameter values
8 zone delimiters

Levin et al. (2001)

L-Shell	n_1	n_2	A_L	B_L
1.36-1.44	1.0	50	6.0	28.0
1.44-1.78	1.0	46	8.5	14.5
1.78-2.00	1.0	40	22.0	10.4
2.00-2.24	1.0	40	44.0	25.5
2.24-2.48	1.0	40	45.0	35.7
2.48-2.80	1.0	40	90.0	130.0
2.80-3.30	1.0	40	125.0	450.0
3.30-3.90	1.0	40	120.0	1160.0

Processing time for skymaps covering each perijove:
- before:14 hours per channel (fits and image maps)
- currently: 7 minutes per channel (just the fits maps)

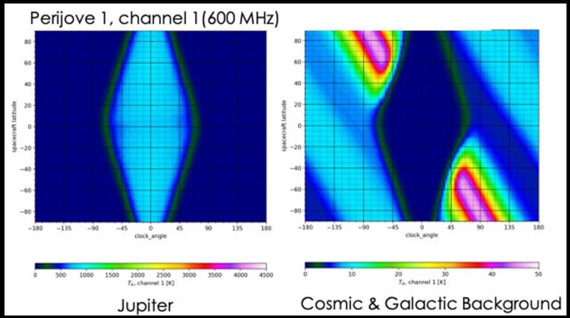
INPUT FOR SYNCHROTRON MODEL UPDATE



Measured T_A

Measured T_A – (Planet & C&GB)
(i.e. inferred synchrotron input)

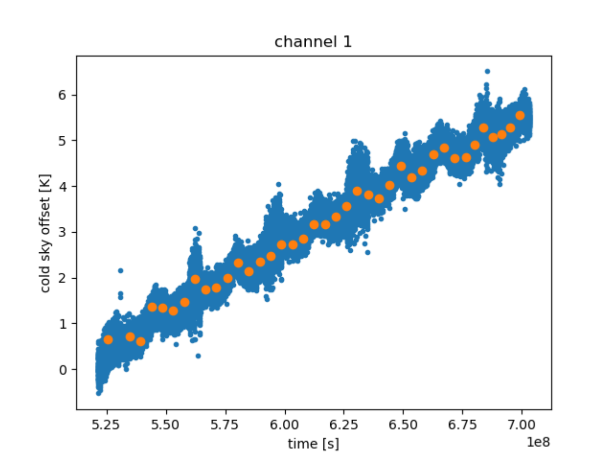
Spinmap overshoot

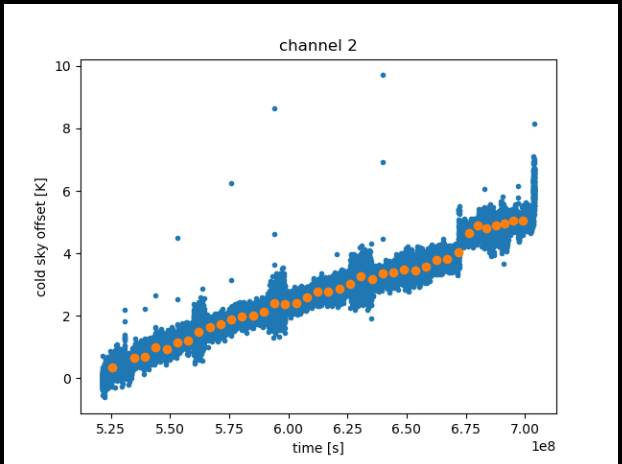


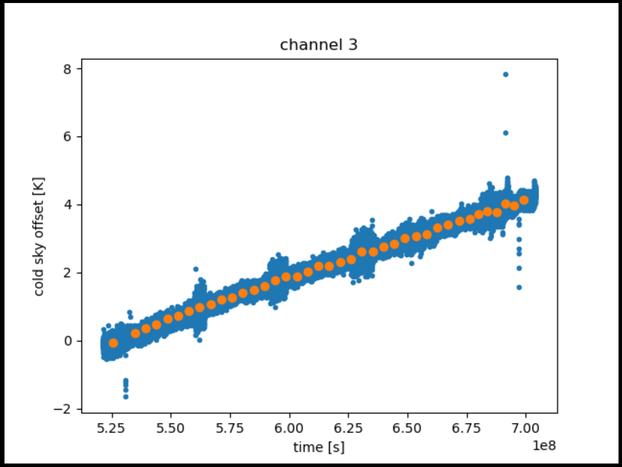
This circumstance demands an iterative (atmosphere <-> synchrotron) update process

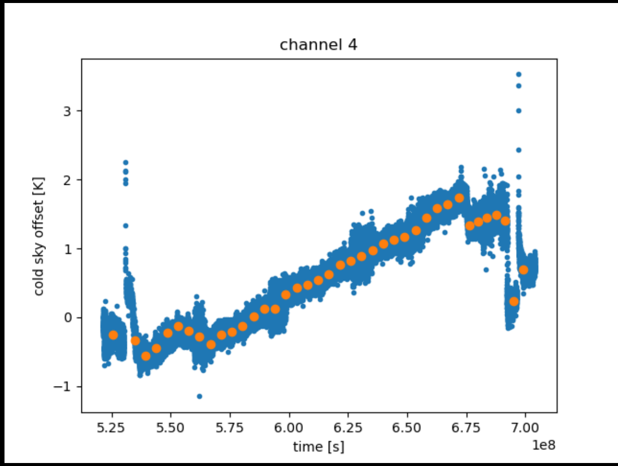
Planet (scale 0K->4500K) C&GB (scale 0K->50K)

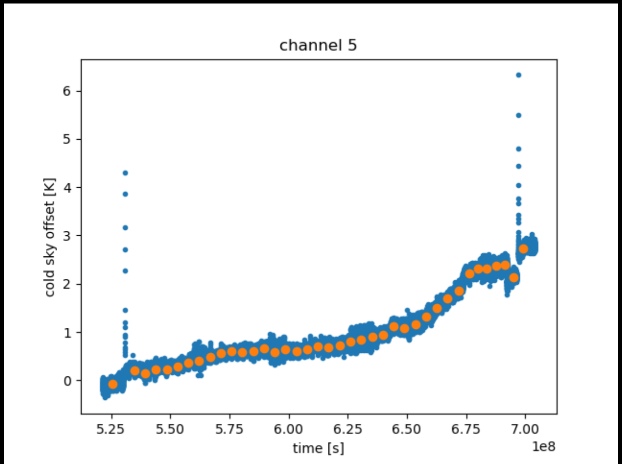
COLD SKY CORRECTION

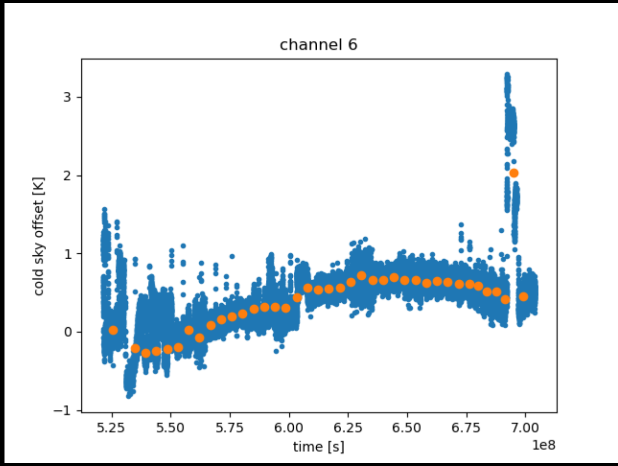






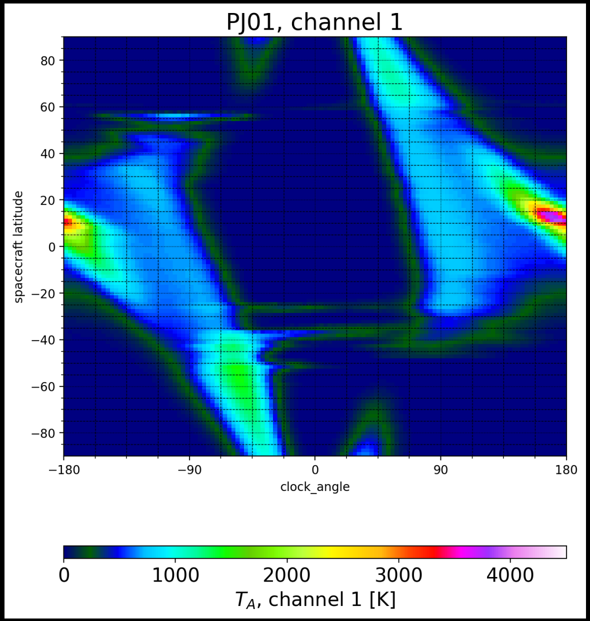


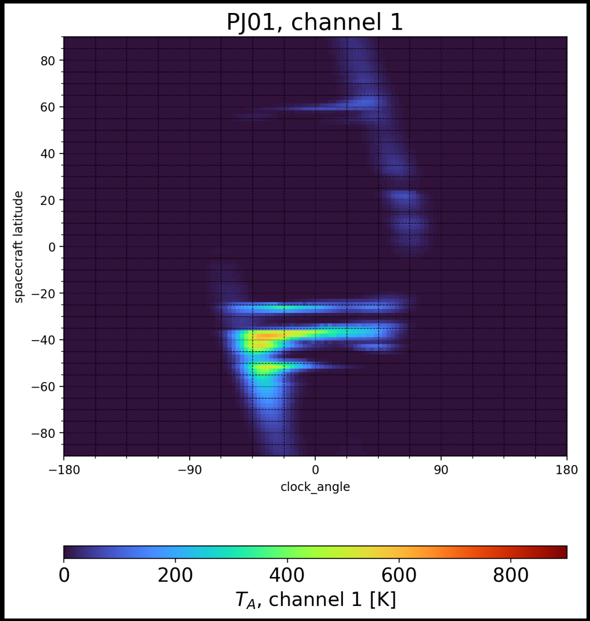


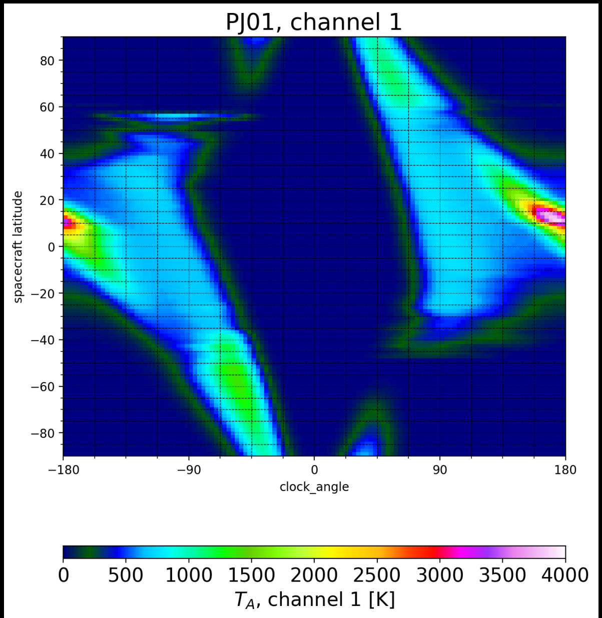


Using a Savitzky-Golay smoothing filter

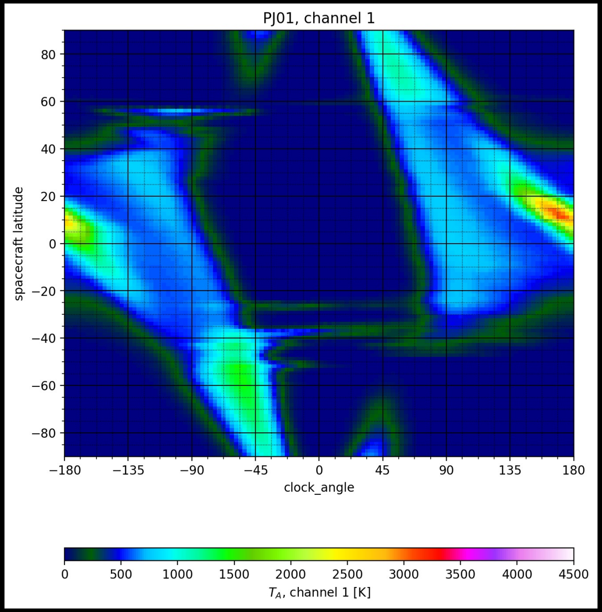
LOS MODEL PREDICTION







SPINMAP DECOMPOSITION



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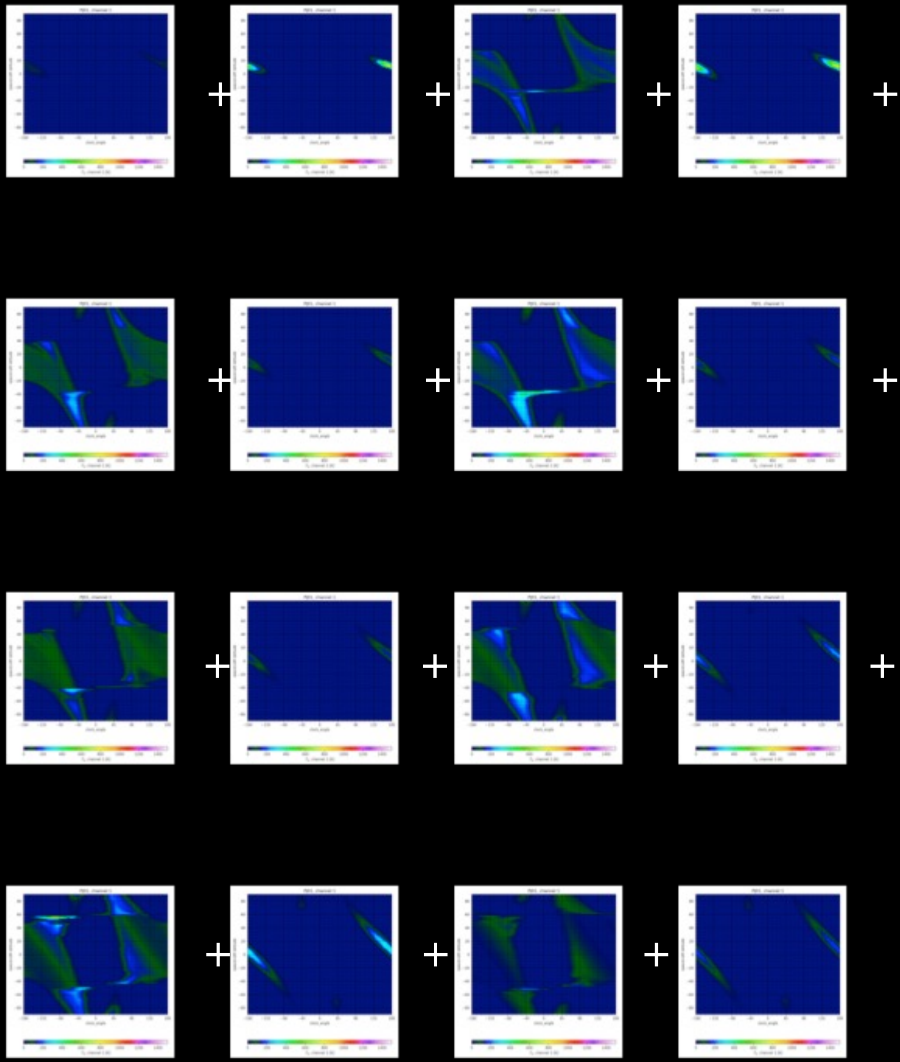
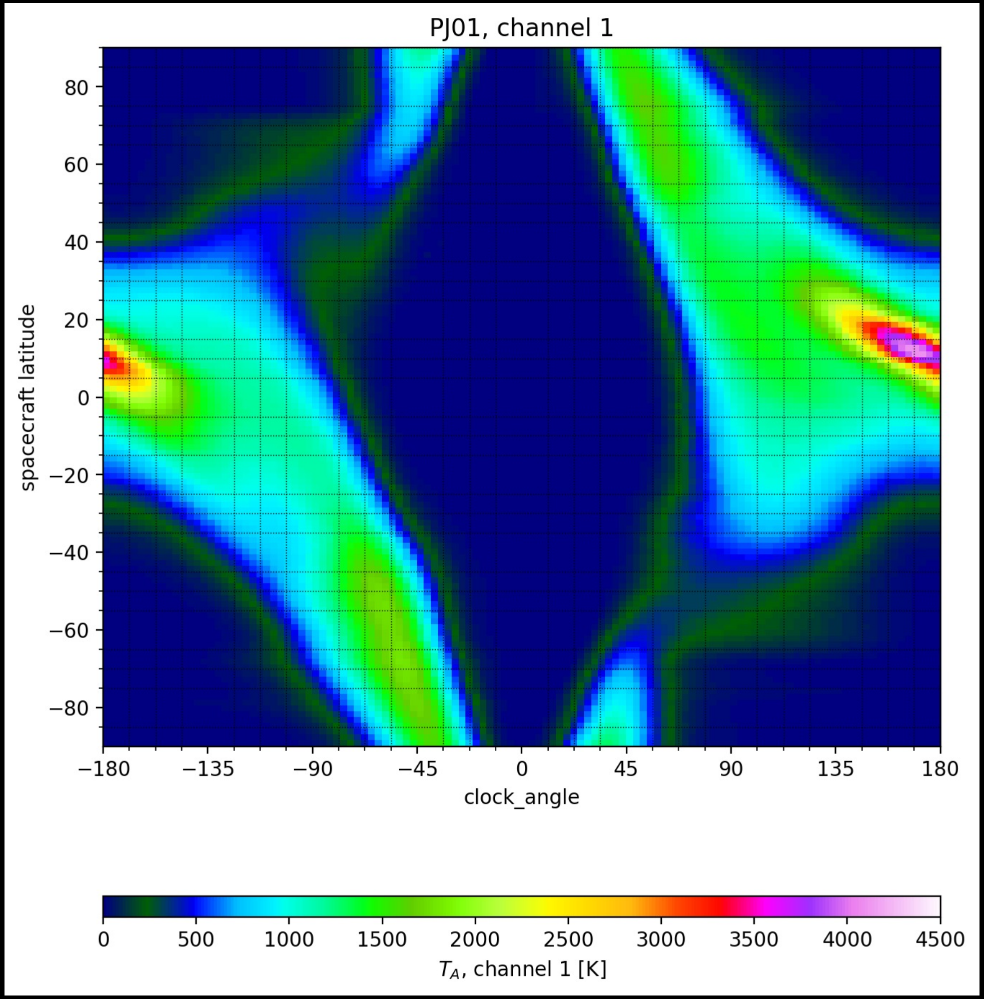
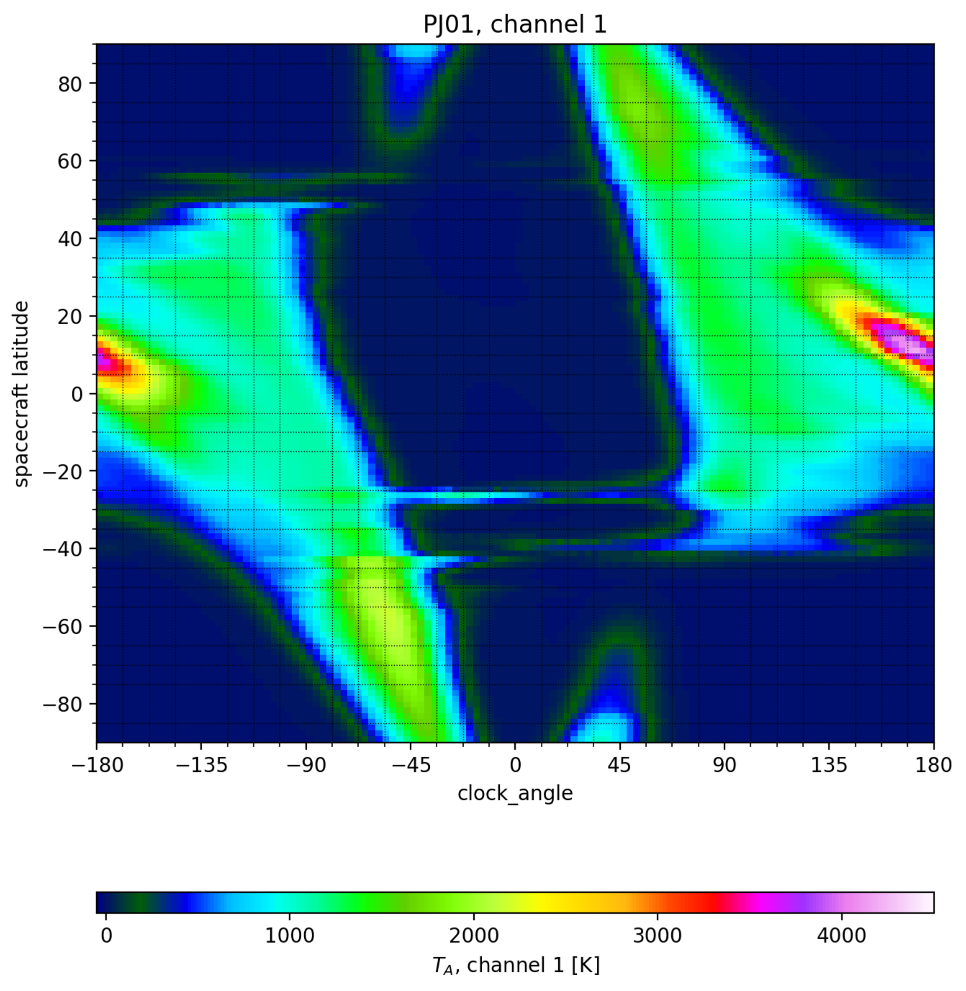


EGU General Assembly, Vienna, 2022

PJ1: MEASURED T_A



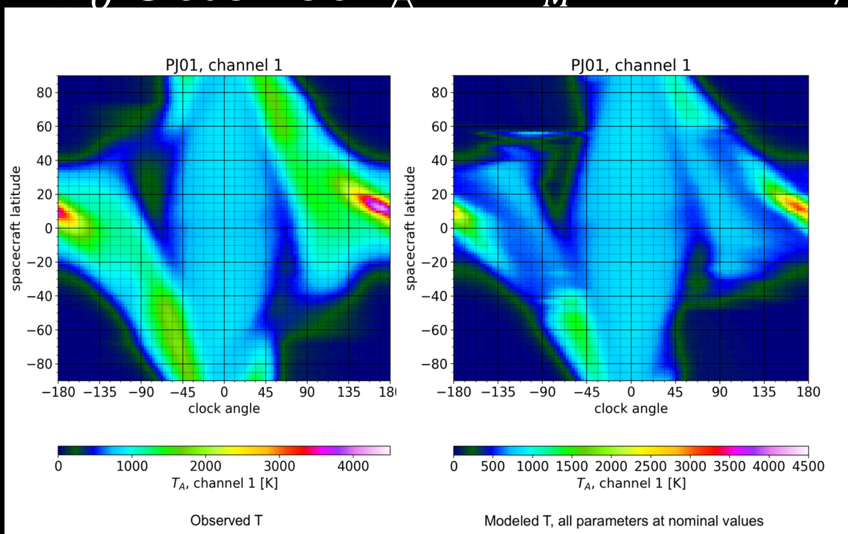


UPDATED LINEAR COEFFICIENTS VIA BOUNDED REGRESSION (on the set T_A > 1000K)

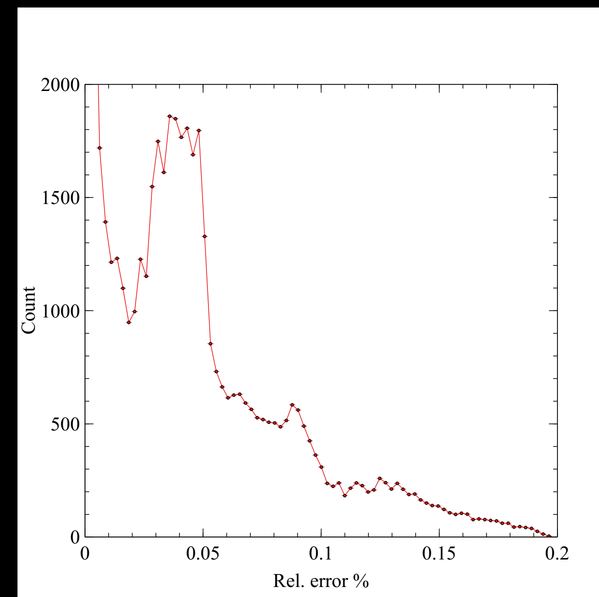
REGRESSION ON THE LINEAR COEFFICIENTS

- Max error 0.198% for the whole map
- Histogram shows most points have negligible errors.

M_O Observed T_A M_M Modeled T_A



Levin et al, 2001



$M_M = \sum_{k=1}^{8}[a_k M_k^A + b_k\ M_k^B]$ -> find $[a_k\ ,\ b_k\ ]$ such that min | M_O- M_M | is achieved, given the priors from Earth POV

New model will be $A_k = a_k\ A_k^{EPOV}$ & $B_k = b_k\ B_k^{EPOV}$, k =1,8 from PJ1.

Then, apply the procedure for the rest of the channels, then test on PJ3 and up, and repeat when necessary.

CONCLUSIONS AND FUTURE WORK

- In order to perform valid atmospheric composition retrievals using the planet's observed thermal signatures, it is necessary to separate as robustly as possible the contributions from the two emission sources, i.e. the planet and the synchrotron radiation belts.

- The numerical separation requires multiple refinements, based on the in-situ data, of an empirical model for the synchrotron emission, namely the multi-parameter, multi-zonal model of Levin at al. (2001).

- This model employs a parametrized electron density distribution, which prior to the Juno mission, has been adjusted from VLA observations.

- In progress: further tuning the linear parameters using all channels and then updating the exponential parameters