Jupiter Radiation Model: New results & Review

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✓ Magnetic parameters used to develop JOSE model

- **Very close to the planet,** \( L < 10 \)
  
  Salammbo model, based on \( L \) and \( B/Beq \) parameters will be used.

- **Close to the planet,** \( 10 < L < 20 \)
  
  According to the data analyzed until now (P10, P11, V1 and V2), \( L \) and \( B/Beq \) parameters allow to well organized the particles until \( L = 20 \) and will be used to construct the new model (based on in-situ data).

- **Far from the planet,** \( L > 20 \)
  
  Being given that far from the planet, the real magnetic equator cannot be represented by the dipole magnetic equator, the \( L \) parameter cannot be used.  
  A new parameter, \( nd_{cs} \) (distance from the current sheet or real magnetic equator) and the radial distance \( \rho \) will be used to construct the new model based on in-situ data.
JOSE model: Electron model development $(\rho, \text{ndcs}) > 16 \, \text{Rj}$

Spectrum is fitted with a single power law

Comparison with data (solid line) @ magnetic equator

![Graph showing differential and integral flux with energy in MeV on the x-axis and flux in units of cm$^{-2}$ s$^{-1}$ sr$^{-1}$ on the y-axis, with lines for different values of Rho.]
JOSE model: Electron model development ($\rho$, ndcs) $> 16$ Rj

Comparison with data outside magnetic equator

![Graphs showing comparison with data outside magnetic equator.](image)
JOSE model: Electron model development \((L, \alpha_{eq}) \leq 20\)

B/Beq profile: \(\sin(\alpha_{eq}) = B/B_{eq}\)
No data at small pitch angle (high latitude) = extrapolation

Extrapolation (no data there)
Comparison with data near magnetic equator
JOSE model: Electron model results

Exemple of results

E > 21 MeV Electrons

Flux (cm$^{-2}$ s$^{-1}$)

Rho JSO (Rj)

z JSO (Rj)
Energy coverage and region of validity of electron model

- no constraints at all
- poor constraints
- good constraints
Presentation of proton model

$L < 20$

Data: solid line
JOSE: dashed line
Presentation of proton model

\[ \rho > 20 \text{ Rj at magnetic equator} \]
JOSE model: Electron model development ($\rho$, ndcs) > 16 Rj

✓ Presentation of proton model

$\rho$ > 20 Rj, outside magnetic equator

![Graph showing differential flux vs energy for different rho values](image)
JOSE model: Region of validity of JOSE proton

- Energy coverage and region of validity of proton model

- No constraints at all
- Poor constraints
- Good constraints

Energy [MeV]

Radial distance [Rj]

Energy [MeV]

0.01 0.1 1 10 100 1000

0.85 µm 14.38 µm 0.62 mm 4.3 mm 36.8 mm
JOSE model: Proton model results

Exemple of results

E > 21 MeV Protons

Flux (cm$^{-2}$sr$^{-1}$s$^{-1}$)

Rho JSO (Rj)

z JSO (Rj)
JOSE model: Inputs and outputs of the model

Fortran 90 source code:

INPUTS:
- **species**: 1-electron, 2-proton, 3-carbon, 4-oxygen, 5-sulphur
- **whatf**: 1-differential flux (MeV^{-1}.cm^{-2}.sr^{-1}.s^{-1}), 3-integrated flux (cm^{-2}.sr^{-1}.s^{-1})
- **sysaxesIN**: coordinate system used: -1-S3(1957)RH, 0-JDZ, 1-S3(1965)LH, 2-S3(1965)RH, 3-MAG, 4-RLL, 5-JSO, 6-JSM, 7-JSE
- **xIN**: cartesian coordinates (array of (3,100000))
- **year**: year of the selected date (array of 100000)
- **doy**: day of year of the selected date (array of 100000)
- **UT**: seconds in the day of the selected date (array of 100000)
- **energy**: array of 25 energy values in MeV (for electron and proton) or MeV/Nuc (for other species)
- **byte_path**: path for the input files
- **strlen**: length of the byte_path variable
- **conflevel**: confidence level (-1. for no confidence level and 0<conflevel<1 otherwise)

OUTPUTS:
- **flux**: Differential [cm^{-2}.s^{-1}.sr^{-1}.MeV^{-1}] or integral [cm^{-2}.sr^{-1}.s^{-1}] flux for the specie and the energies selected (array of (25,100000))
- **L**: L parameter (array of 100000)
- **B**: Magnetic field (nT) (array of 100000)
Comparison of JOSE with P10 data and other model

Electrons flux > 21 MeV along the inbound trajectory of Pioneer 10

![Graph comparing JOSE model with in-situ data and other models.](image)
Comparison of JOSE with Galileo Orbiter data and other model

Electrons flux > 2 MeV at jovigraphic equator measured by Galileo and resulting from models

- x Galileo
- JOSE
- GIRE
- DG83
- JOE
- Galileo Average
Comparison of JOSE with Galileo Orbiter data and other model

0.304-0.527 MeV electrons flux at jovigraphic equator measured by Galileo and resulting for models.

- JOSE
- GIRE
- DG83
- JOE
- Galileo Average
JOSE model: Comparison of JOSE with in-situ data

➤ Comparison of JOSE with Galileo Orbiter data and other model

0.54-1.25 MeV protons flux at jovigraphic equator measured by Galileo and resulting from models

- JOSE
- DG83
- Galileo Average
A refined model has been developed including confidence level.

- It uses JOSE average as a baseline (Energy, L, B/Beq profiles)
- It provides flux intensities for confidence levels between 0.5 and 0.9999
- It is mainly based on Galileo EPD data
- It is extrapolated for energies higher than the highest available in data base following JOSE averaged model profiles
- This model substantiates the JOSE average model and is a net improvement
JOSE model: Confidence Level

- Comparison with Galileo Electron 0.304-0.527 MeV

At jovigraphic equator (-0.1<z<0.1Rj)

- JOSE Average
- Conf level 0.8
- Conf level 0.85
- Conf level 0.9
- Conf level 0.95
- Conf level 0.99

Flux (cm$^2$.s$^{-1}$.sr$^{-1}$.MeV$^{-1}$) vs. Rho (Rj)
JOSE model: Confidence Level

- Comparison with Galileo Electron >11 MeV

At jovigraphic equator (-0.1<z<0.1Rj)

x Galileo
- JOSE Average
- Conf level 0.8
- Conf level 0.85
- Conf level 0.9
- Conf level 0.95
- Conf level 0.99
Comparison with Pioneer 10 Electron > 21 MeV

 Flux of electrons > 21 MeV along the inbound trajectory of Pioneer 10
Conclusions

• A new Jovian radiation environment has been developed under ESA fundings part of the JOREM study

• The model provides outputs for any confidence levels (for risk assessment analysis)

• The JOSE model including confidence levels exhibits good comparisons with in-situ data for a confidence level of 0.85