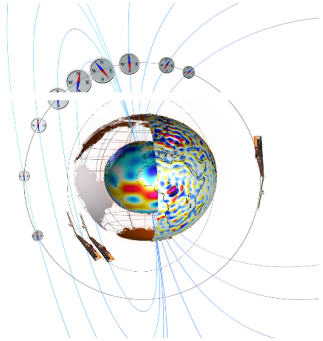

An empirical climatological model of the occurrence of F region equatorial plasma irregularities

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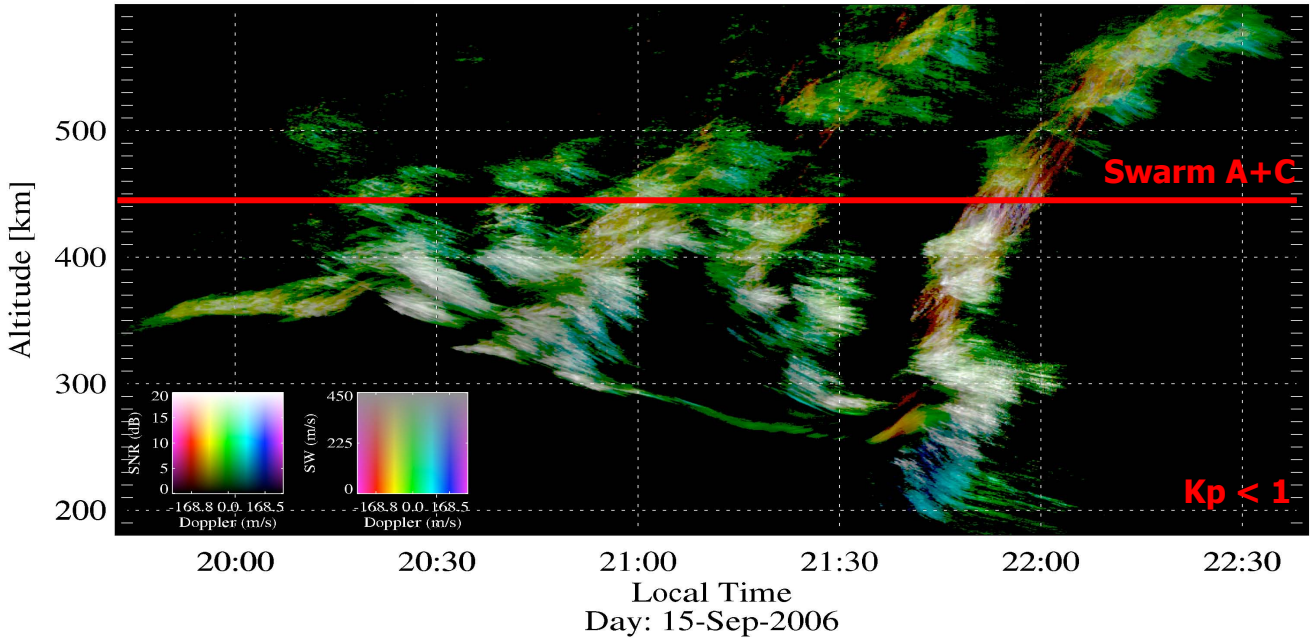
Equatorial plasma irregularities

- create strong plasma density gradients
- develop after sunset at low latitudes
- initiated at the lower F-region and occasionally expand into the upper ionosphere (day-to-day variability)
- occur during geomagnetic quiet and disturbed times

Jicamarca radar observations, Peru

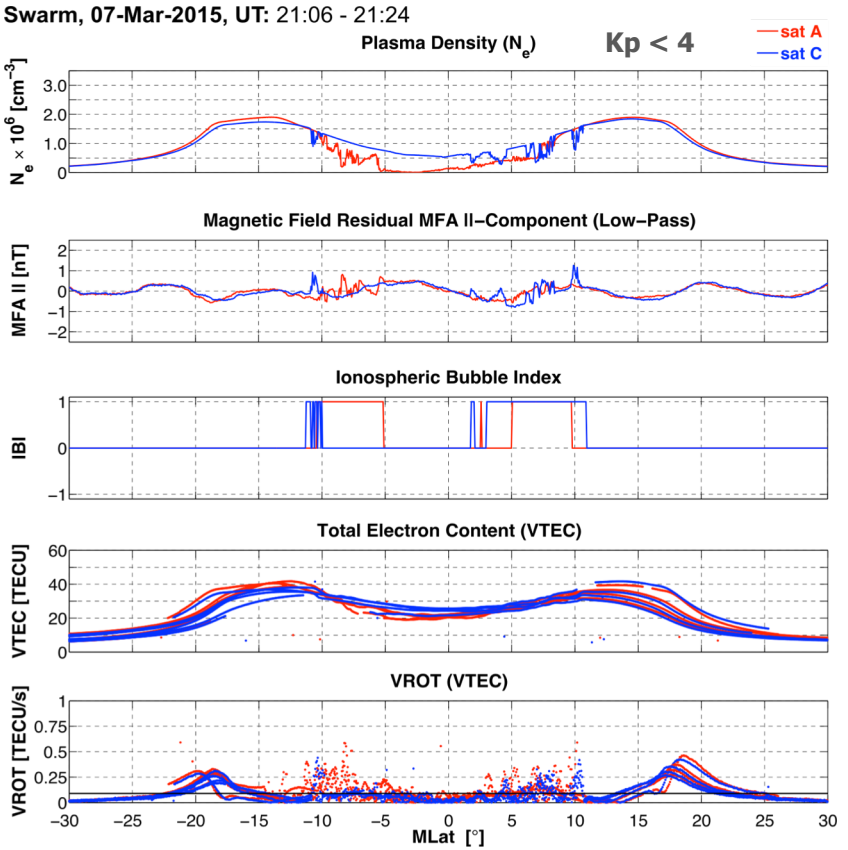


Equatorial plasma irregularities

- detected in satellite plasma density and magnetic observations
- affect GNSS (at ground and in space)

Aim:

occurrence probability of plasma irregularities for a given:
- month
- local time
- longitude
- solar flux level



Data (IBI index)

CHAMP:

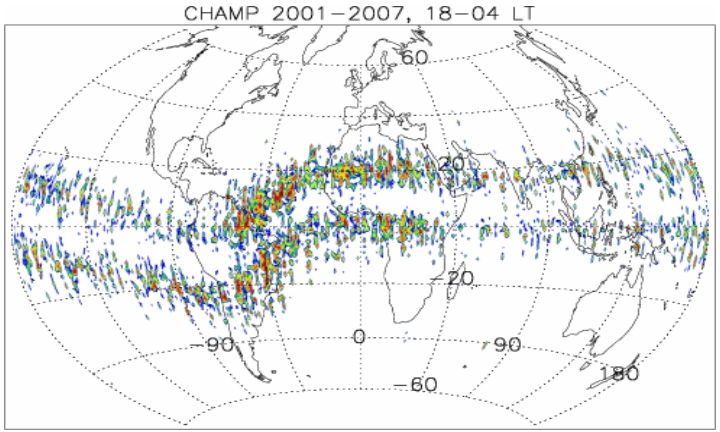
Years: 2000-2010

Altitude: 300-480km

Detection threshold: 0.25nT

Declining solar cycle 23 (F10.7>80sfu)

"IBI" detections at CHAMP



Swarm:

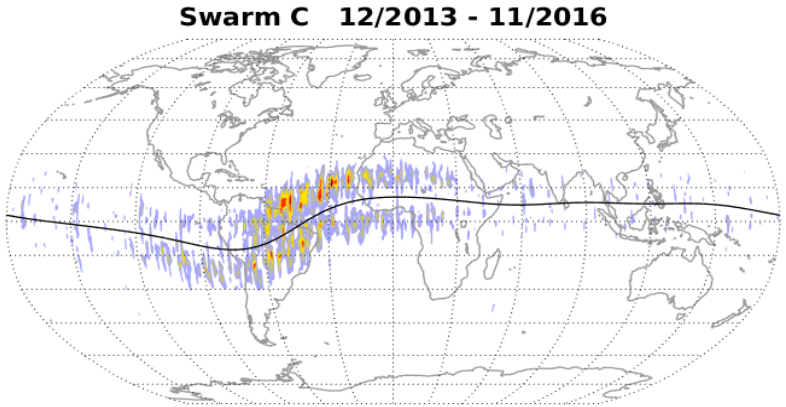
Years: 2013-2018 - Swarm A,B,C

Altitude: 450-520km

Detection threshold: 0.15nT
cc with e-density: >0.7

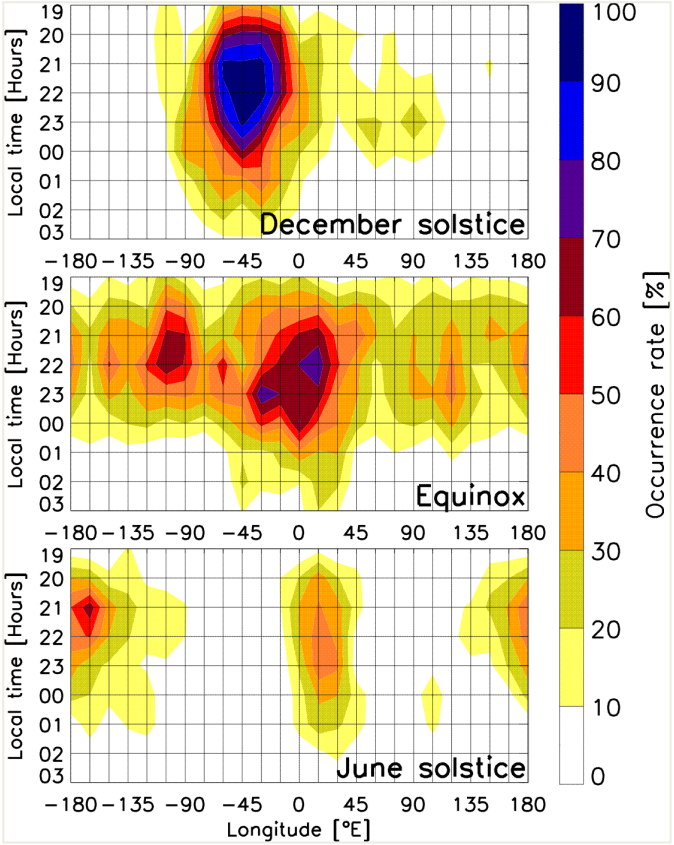
Declining solar cycle 24 (F10.7>80sfu)

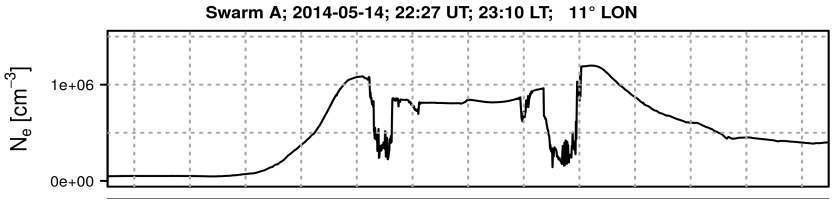
IBI detections at Swarm



Data (known distributions and constraints)

CHAMP magnetic signatures 2000-2004

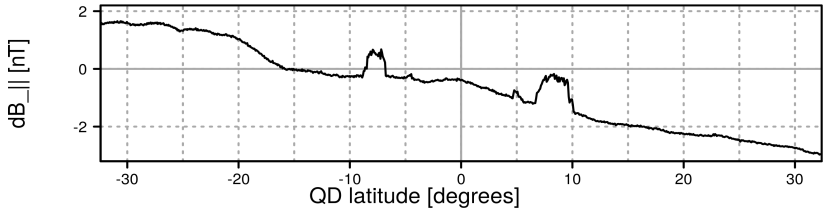




$$\mathbf{j} \propto \left\{ -k\nabla\left[\left(T_i + T_e \right) n_e \right] \times \mathbf{B} \right\} \frac{1}{B^2}$$

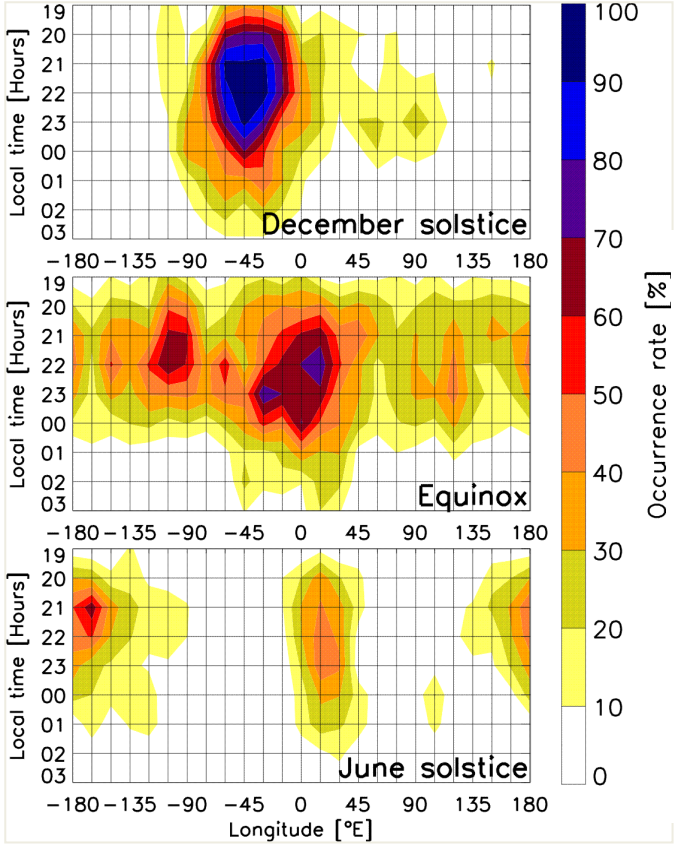
$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j}$$

$$n_e > 2 \times 10^5 \, cm^3$$

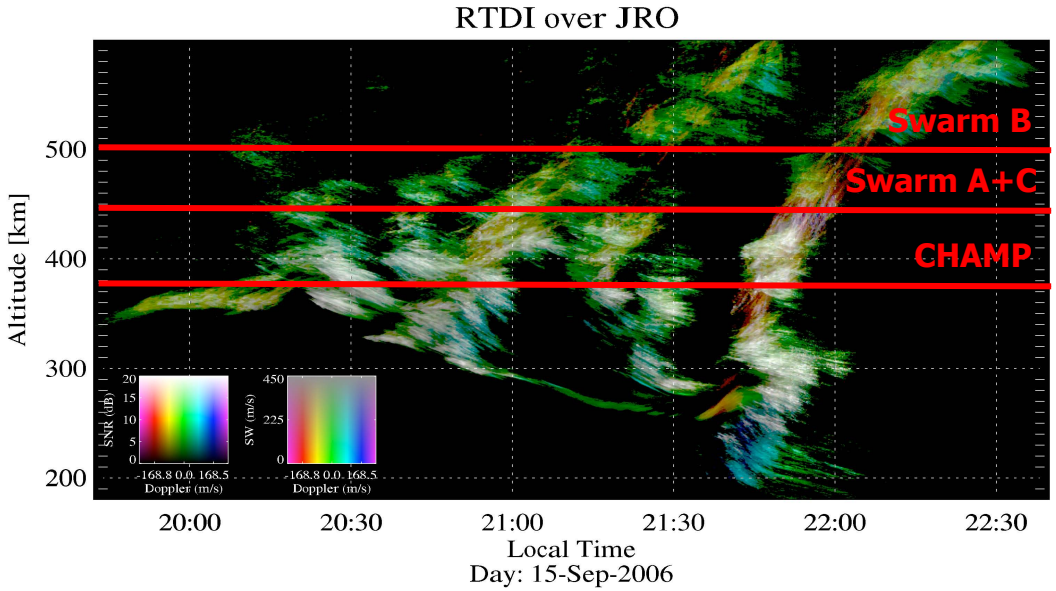


Data (known distributions and constraints)

CHAMP magnetic signatures 2000-2004



Detection of irregularities that expand to the upper ionosphere



Modeling concept

$$Z(t) = \sum_{i=1}^{N_\lambda} \mathbb{1}(T_0^{(i)} < t) \cdot \mathbb{1}(T_0^{(i)} + L^{(i)} > t)$$

$N_\lambda \sim \mathcal{P}(\lambda)$ $\quad \mu = \mu(doy, lon), \sigma = const.$

$T_0^{(i)} \sim \mathcal{N}(\mu, \sigma)$ $\quad \lambda = \lambda(doy, lon, F10.7)$

$L^{(i)} \sim \mathcal{E}(\gamma)$ $\quad \gamma = const.$

t:	time of observation
Z:	observed irregularity
N_λ:	total number of irregularities
T_0:	irregularity start time
L:	irregularity live time

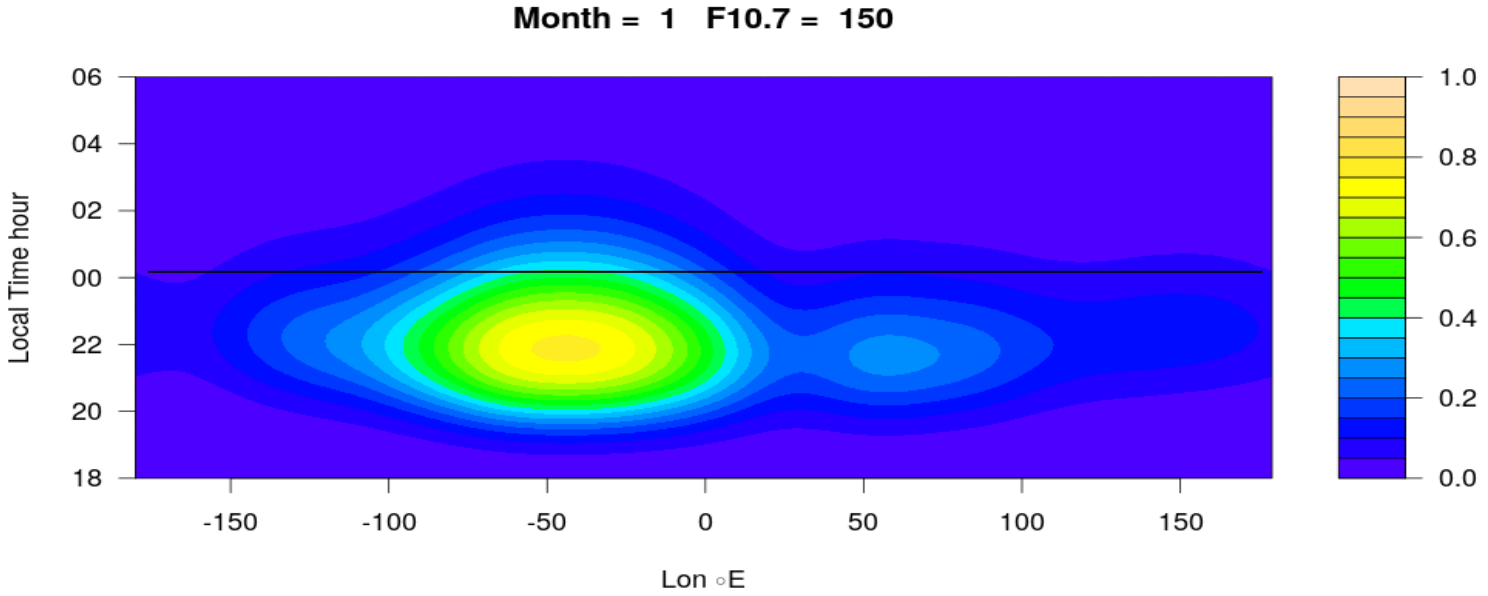
Forward modeling

Input:

- local time (continuous)
- longitude (continuous)
- month (DOY, attributed to month)
- solar flux (continuous)

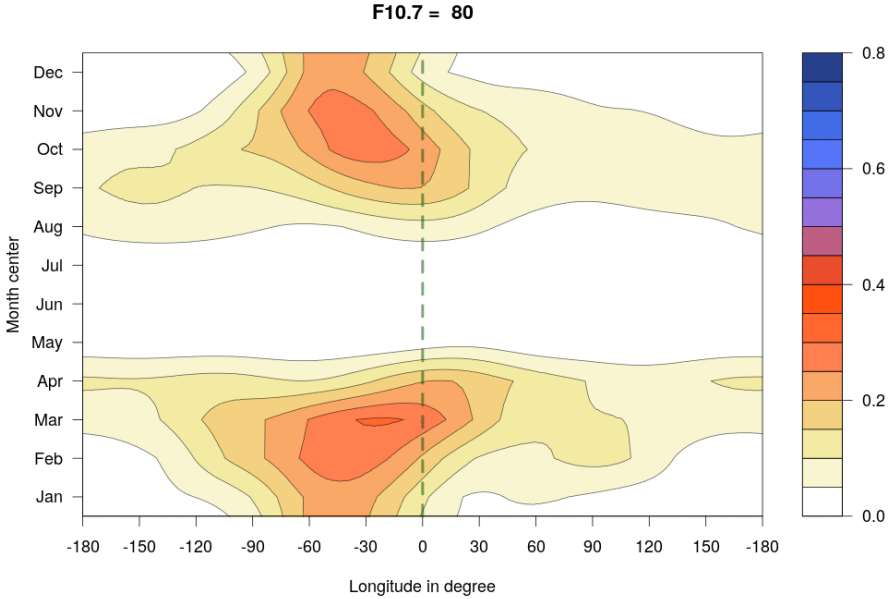
Output:

- Occurrence probability

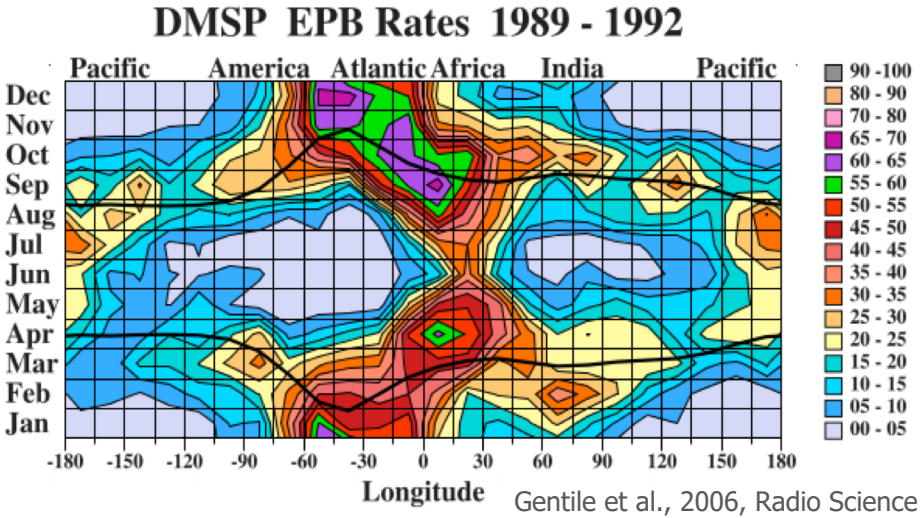


Comparison to independent data sets

CHAMP/Swarm forward model, 19-23LT



DMSP plasma depletions, 19-22LT, high solar flux years



Gentile et al., 2006, Radio Science

Summary:

- empirical model on occurrence probability of equatorial plasma depletions between 350-520km altitude
- forward modelling code (FORTRAN, Python) will be available soon