

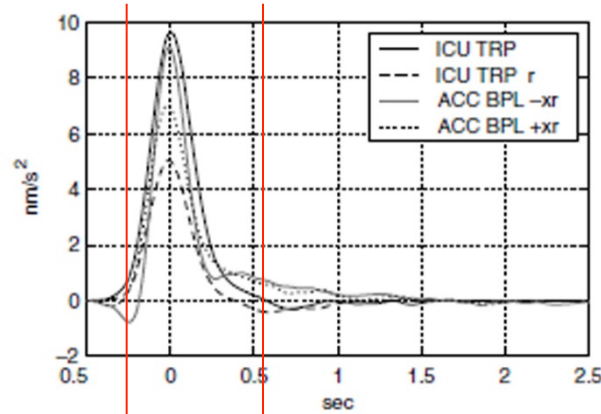
Supposed sensitivity of accelerometers in low Earth orbit to VLF

Anja Schlicht Technische Universität München,
Jakob Flury Leibniz Universität Hannover

High frequency phenomena on space accelerometers

Heater switching

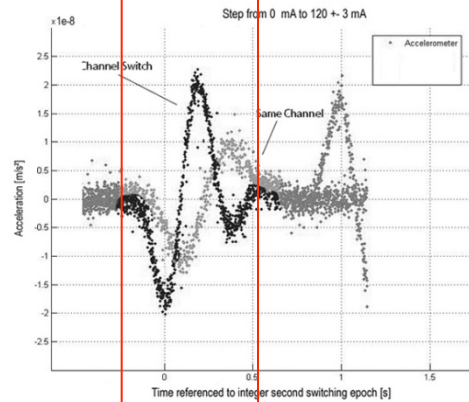
10^{-8} m/s^2



Flury et al. 2008

Torquer switching

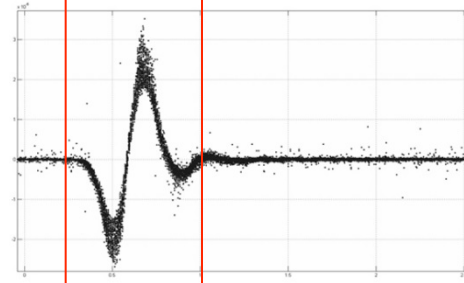
10^{-9} m/s^2



Peterseim et al. 2012

Twang

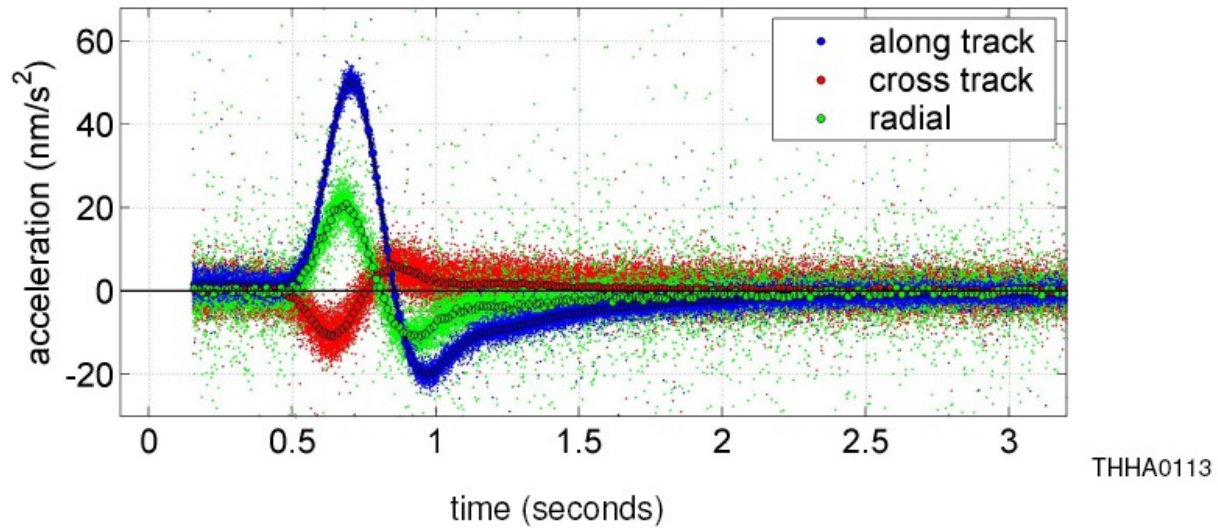
10^{-5} m/s^2



Peterseim 2014

Electromagnetic
or magnetic
source

Heater switching



Courtesy Jakob Flury

Coupling
accelerometer head or feedback loop

Schematic diagram of ONERA accelerometers

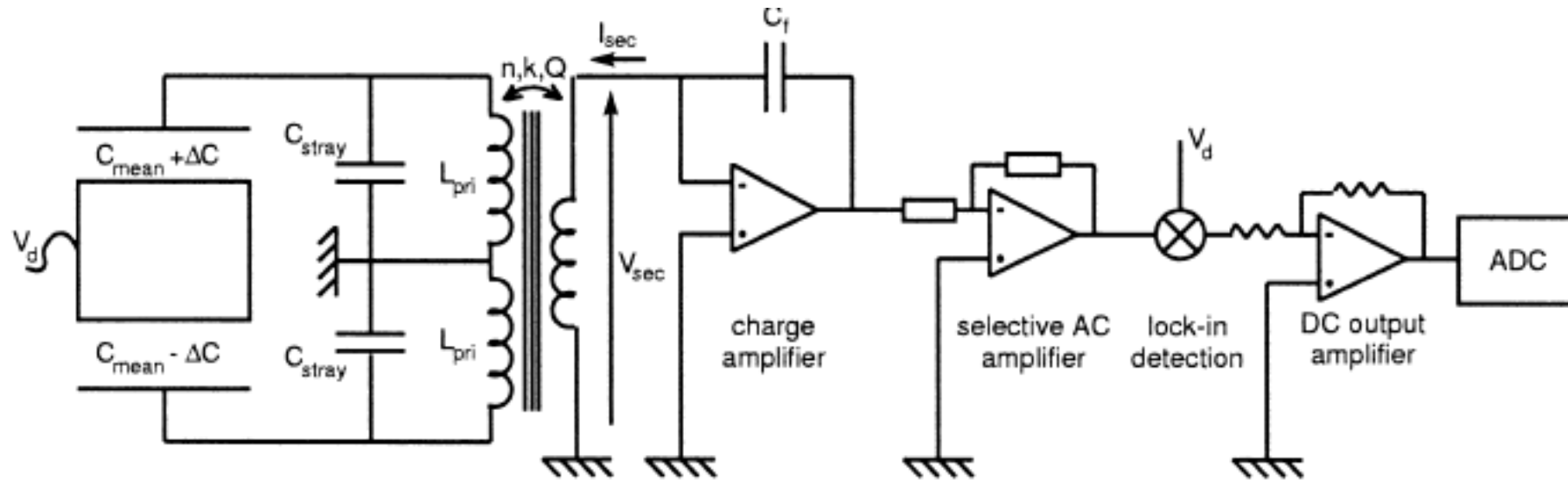


Fig. 3. Schematic of the capacitive detector electronics.

Josselin et al. 1999

μV – kV for proof-mass control
100 kHz capacitive read-out
100 Hz proof-mass control
10 Hz data available (GRACE, GOCE DFAC mode)

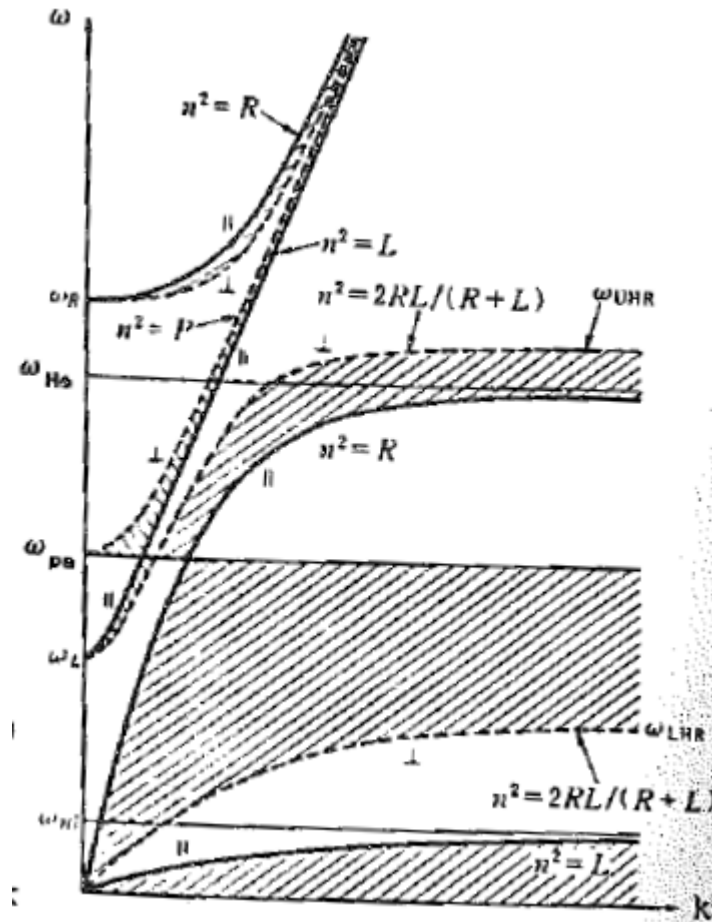
Dispersionrelation in the magnetized ionosphere

Depending on the orientation to the magnetic field

Only poorly electromagnetic parallel to the magnetic field.

Electron whistler mode

Ion whistler mode



ω_{He} cyclotron frequency of electron
 ω_{pe} plasma frequency of electron

ω_{Hi} cyclotron frequency of ion
 ω_{pi} plasma frequency of ion

ω_{UHR} upper hybrid resonance
 ω_{LHR} lower hybrid resonance

Very low frequency VLF

Resonances and antennas

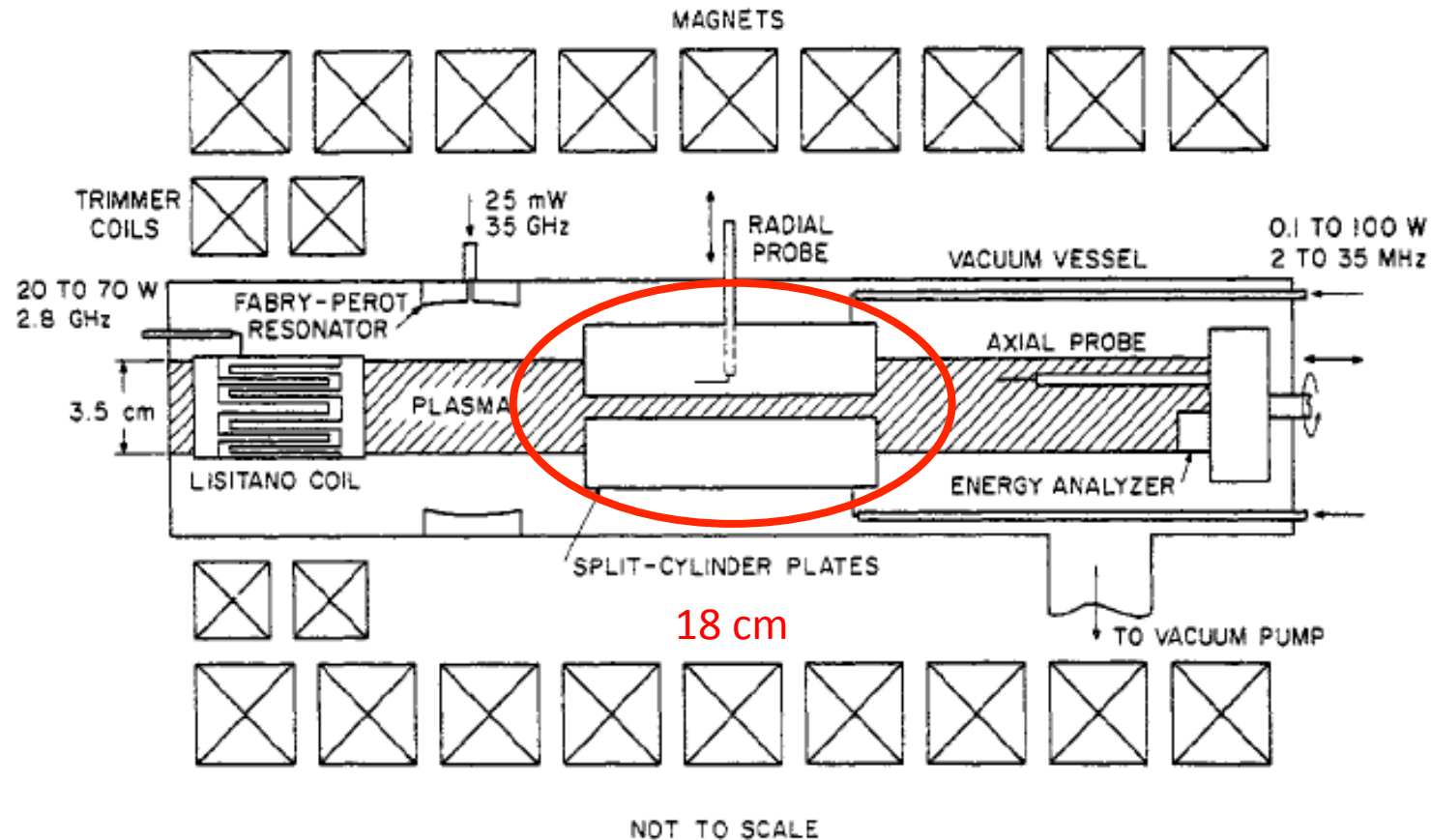
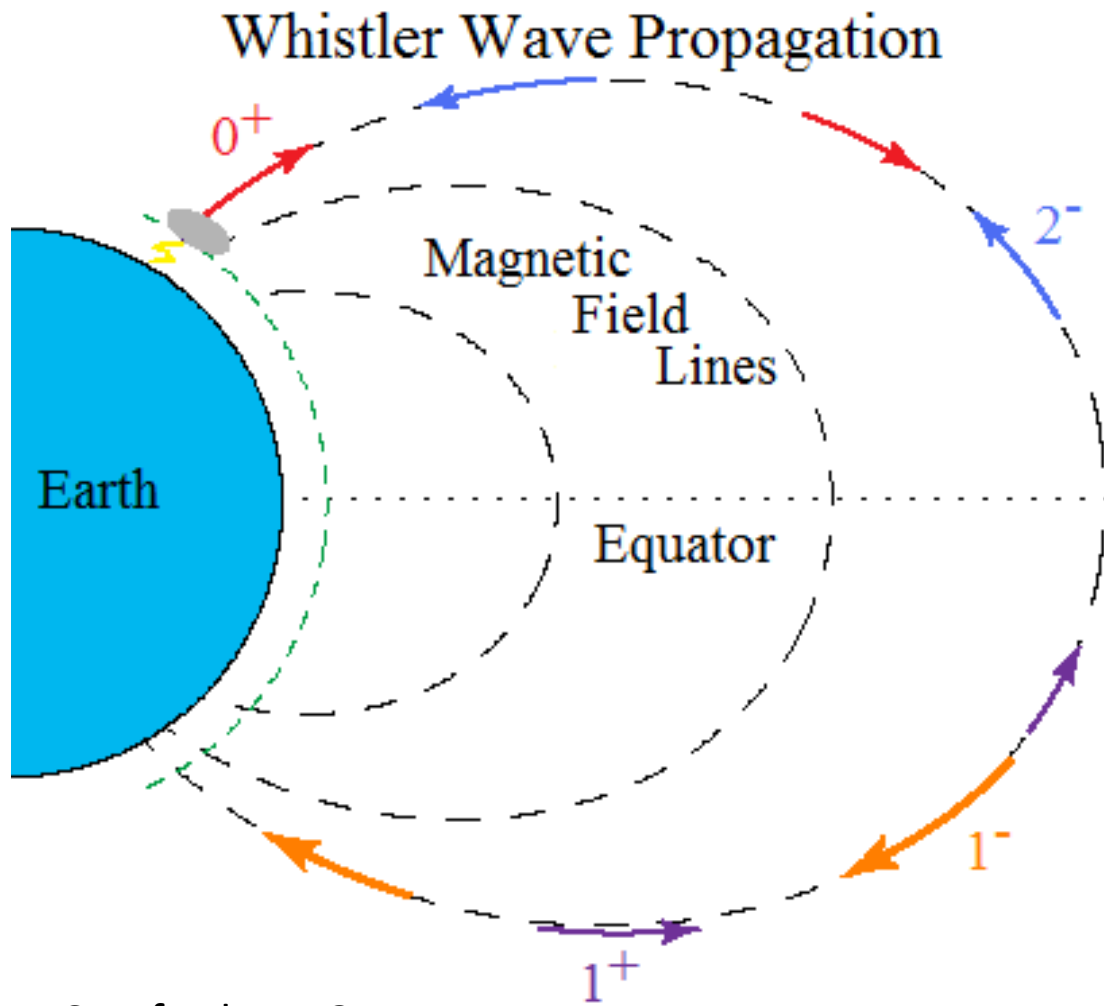


FIG. 1.—Experimental system. The total plasma length is 1.42 m.

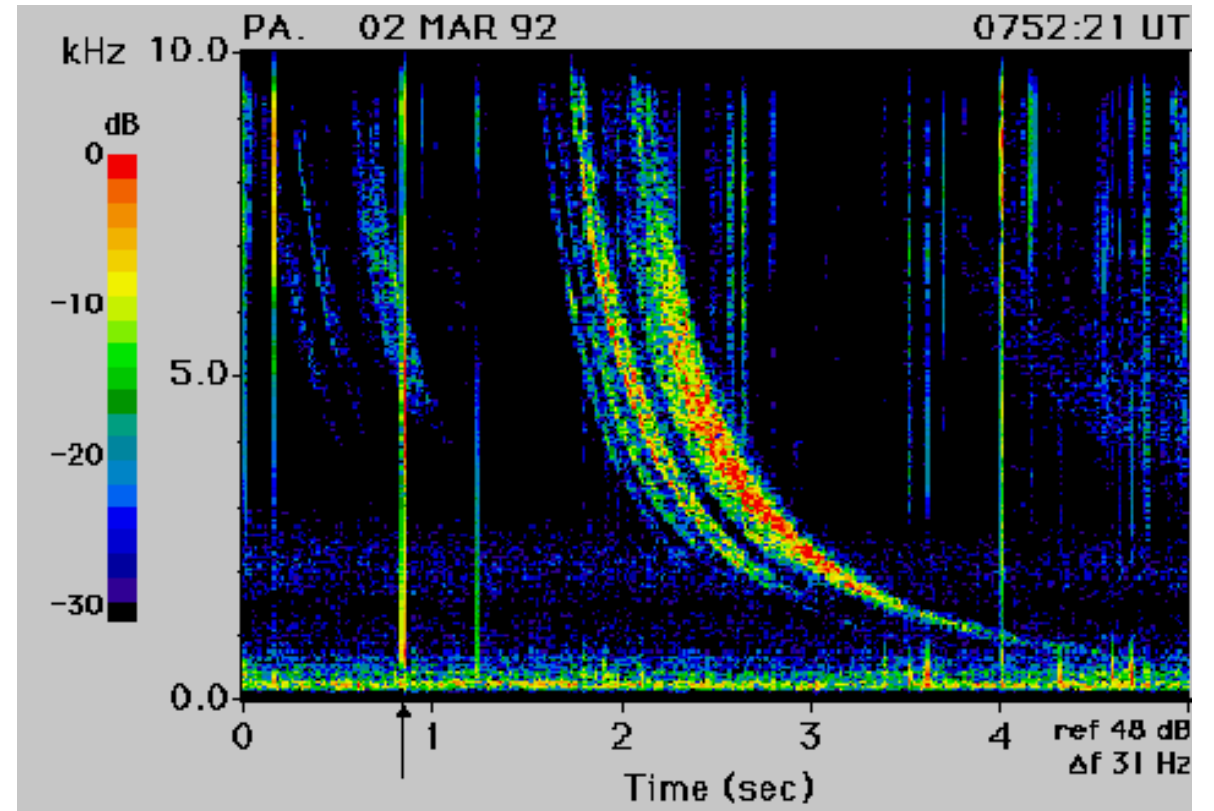
„The purpose of this measurements is to verify the theoretical prediction for excitation of resonance cones and other wave phenomena in a bounded plasma by finite-sized, wide k-spectrum sources.“

Colestock and Getty 1977

Whistler

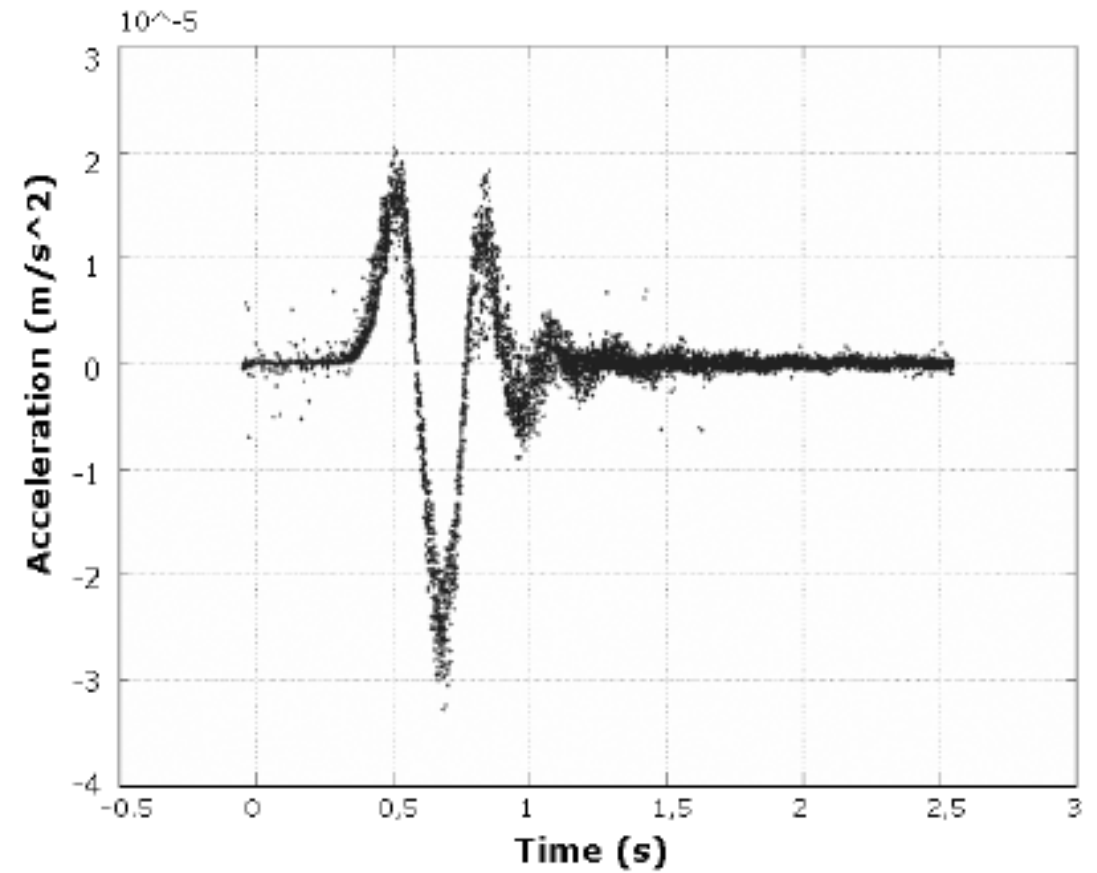
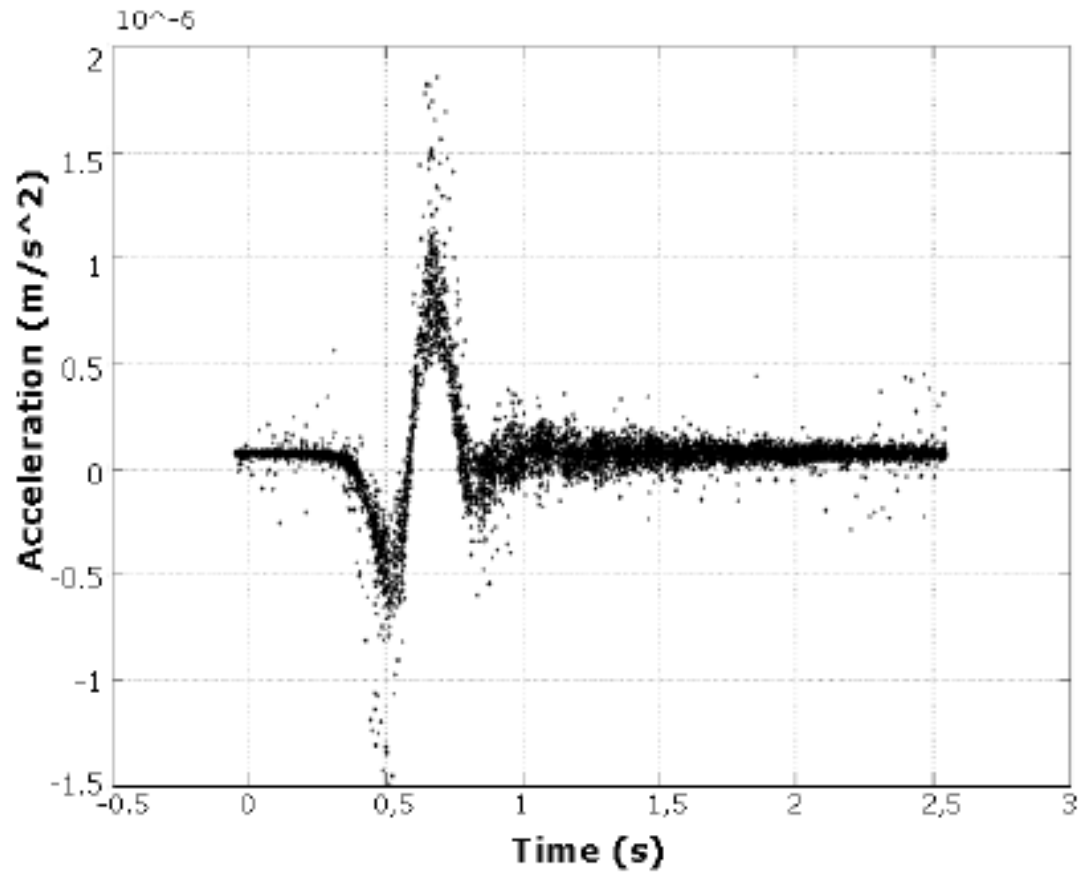


Stanford VLF Group

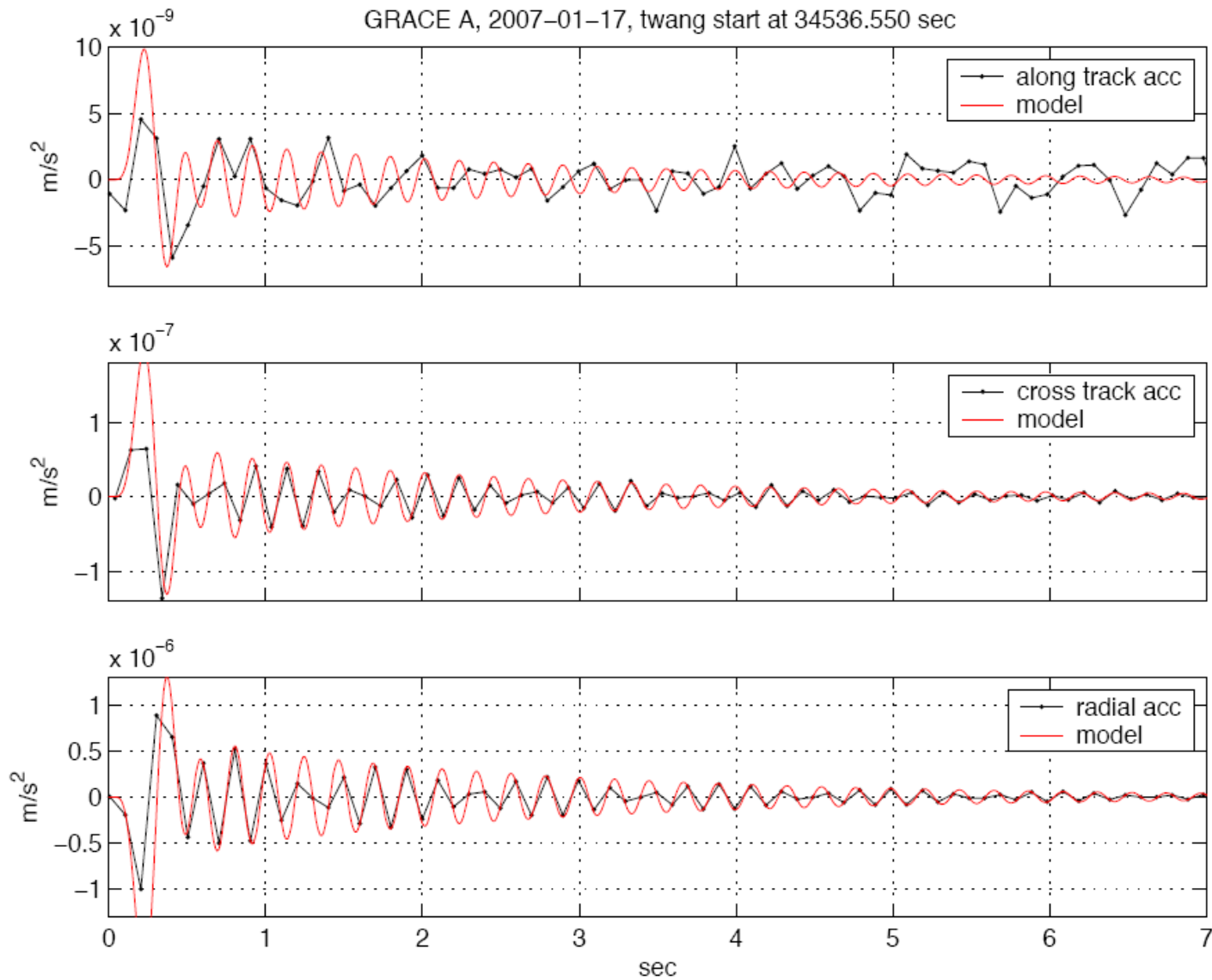


Twangs

Negative and positive twang in radial component of ACC1A, GR-B



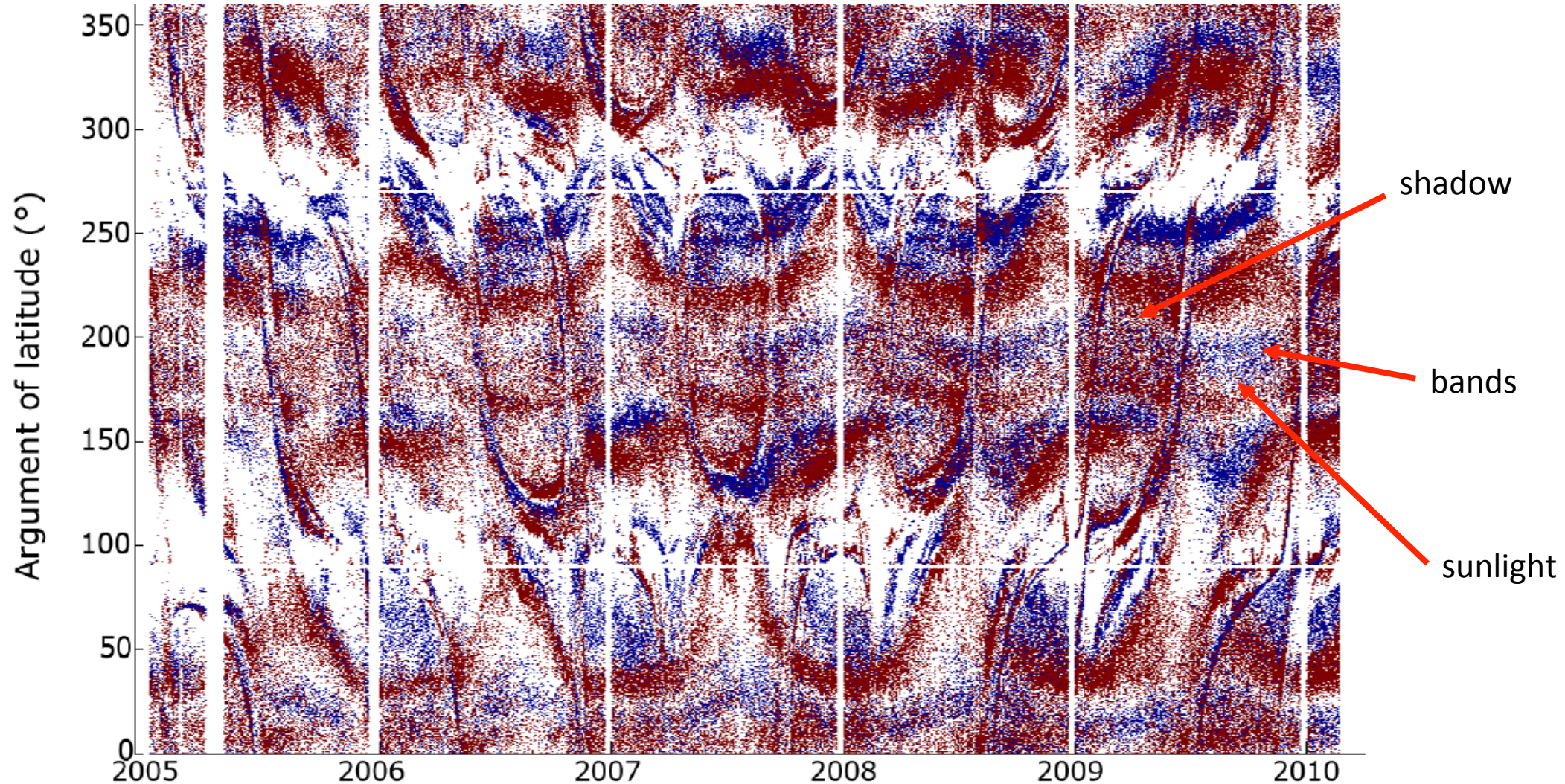
Twangs



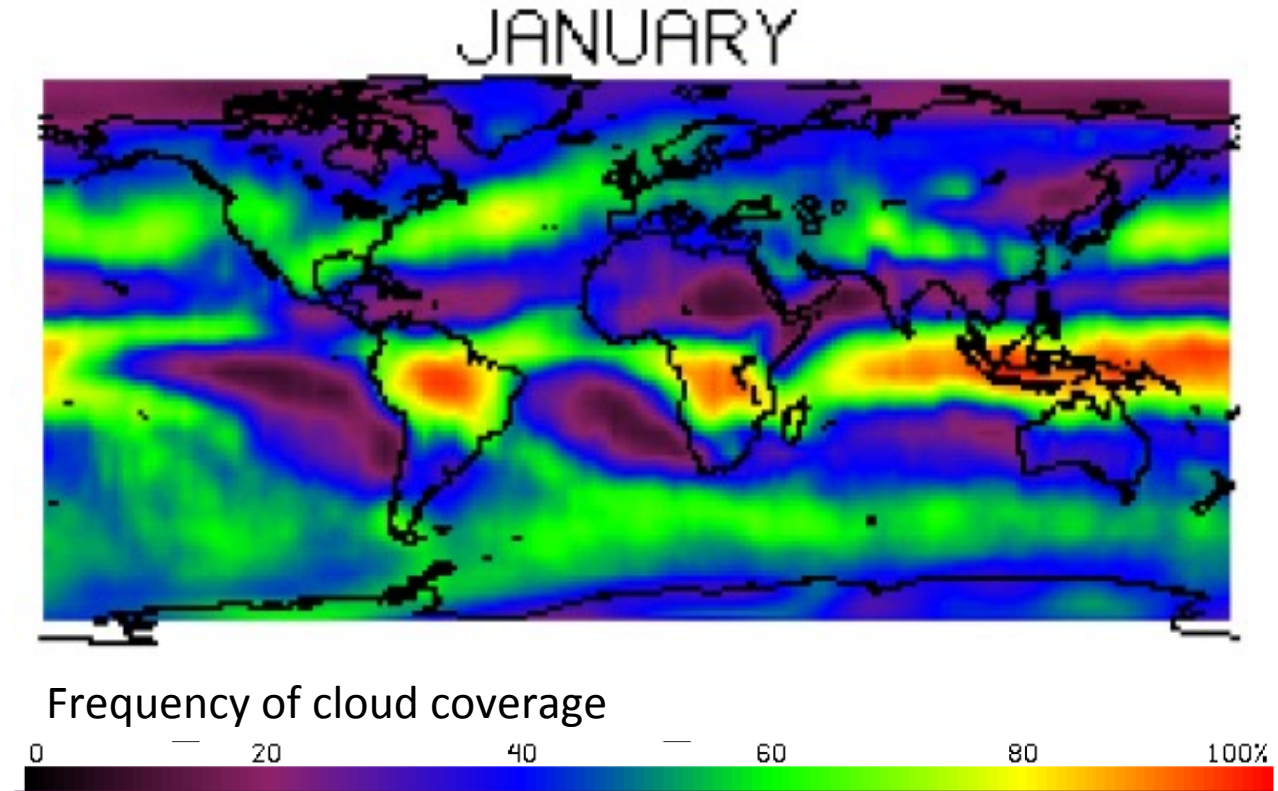
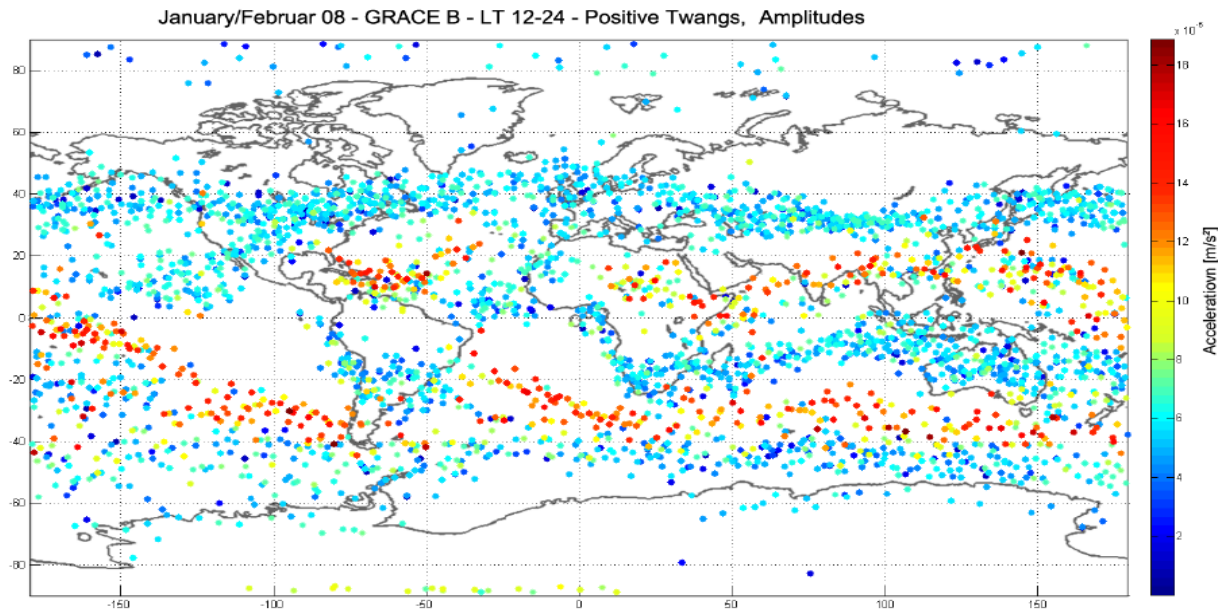
Jakob Flury

Occurance of twangs

GRACE B, radial, all twangs (2002-02/2010) - Orientation

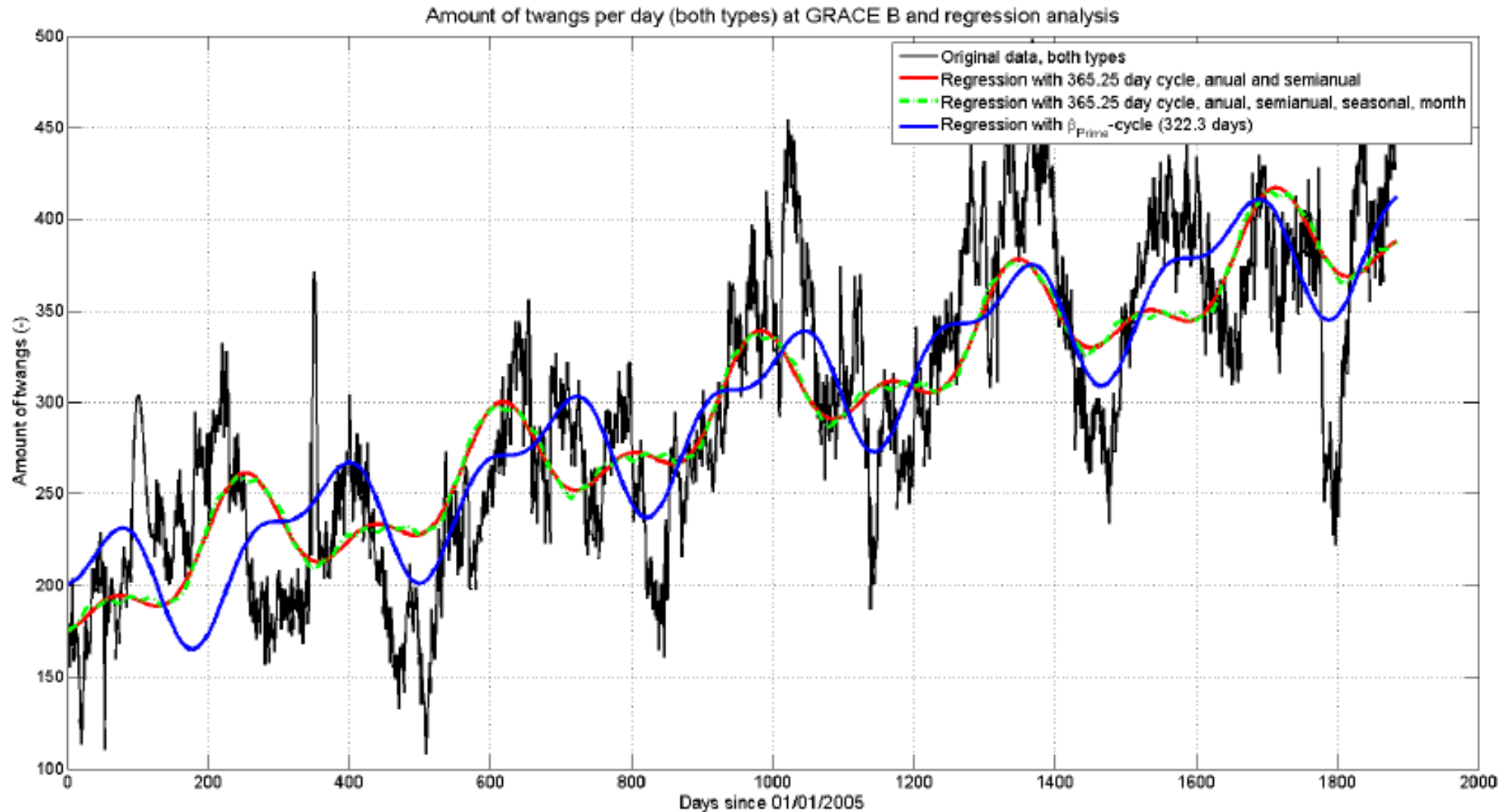


Occurance of twangs



Wylie et al. 1994

Occurance of twangs



Coupling of sferics into the ionosphere

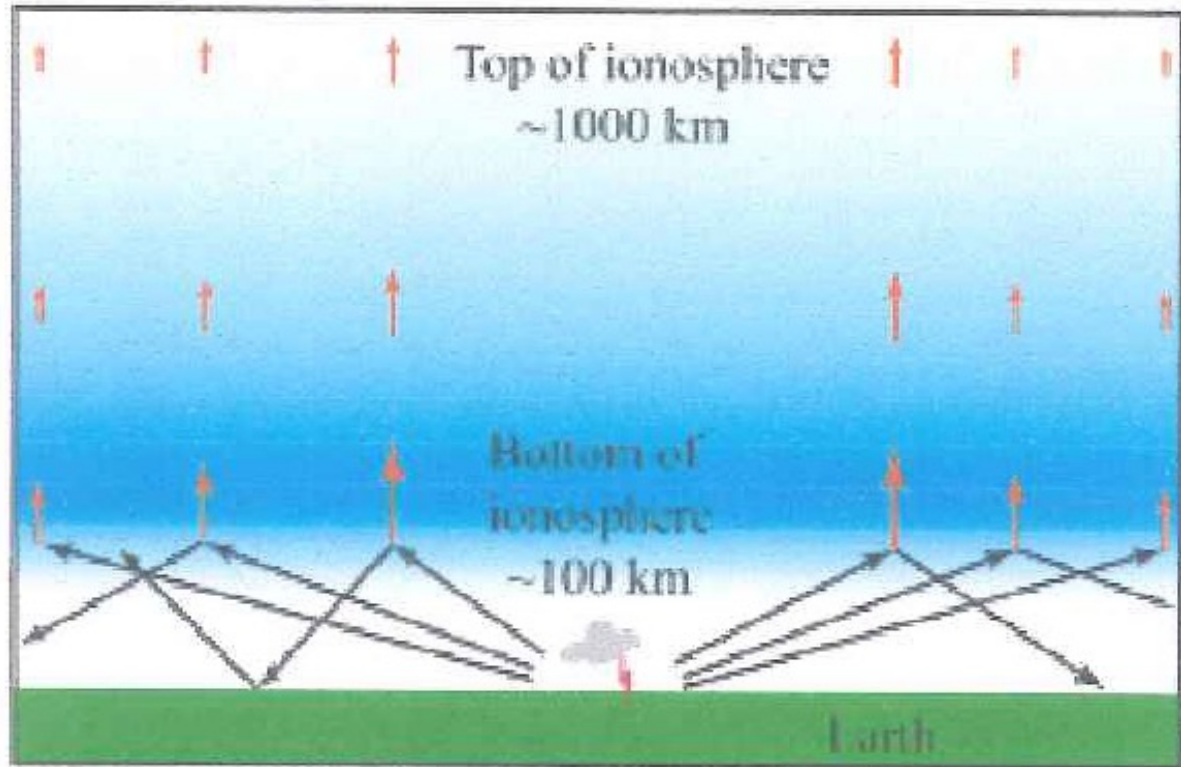


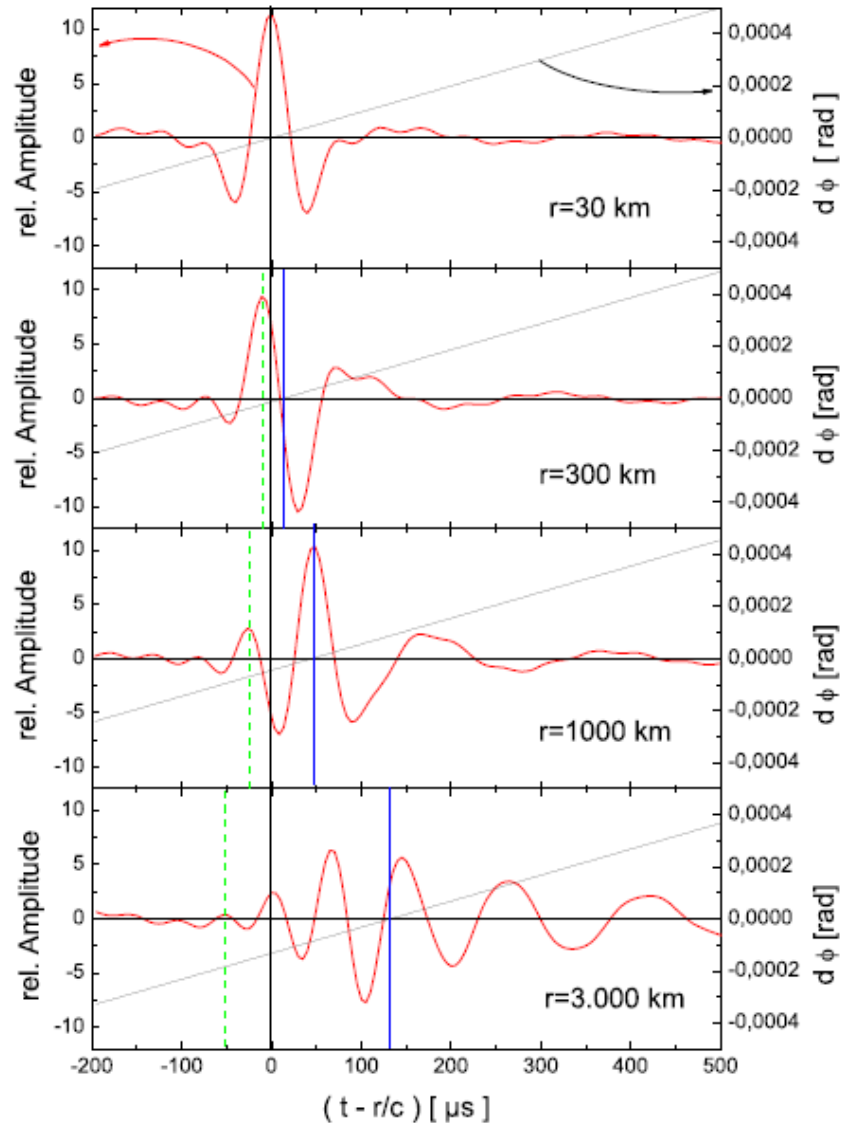
Abb. 4.7: Sferics und Whistler [Bortnik, 2005]

Refraction index depending on angle between propagation direction and magnetic field

Unducted whistler only in radial direction

Not strictly electromagnetic in nature but
Great longitudinal component

Dispersion of sferics



Cavity between conducting ground and ionosphere (70km)

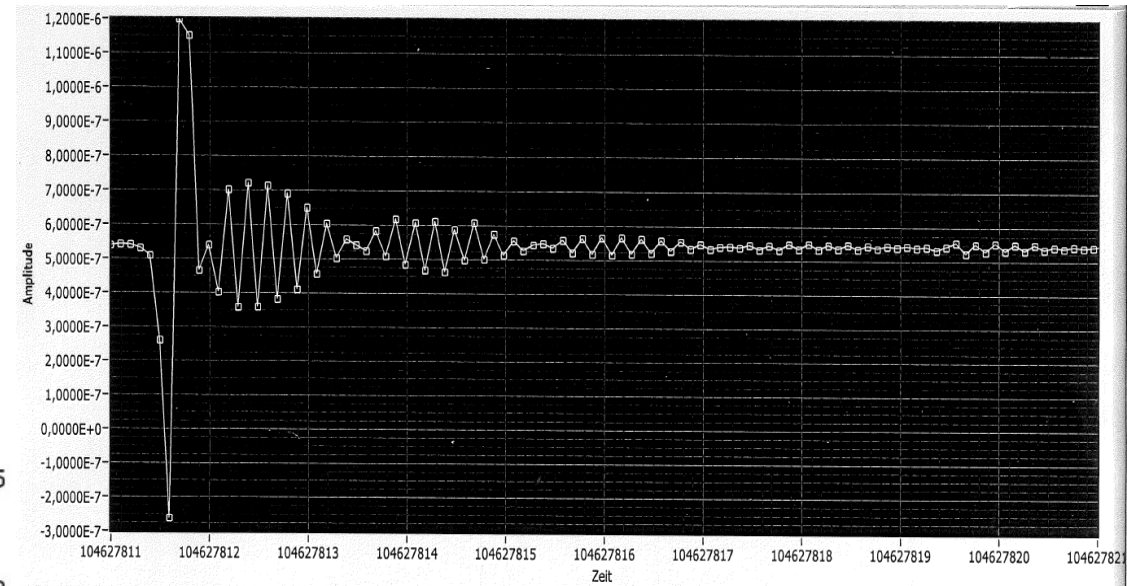
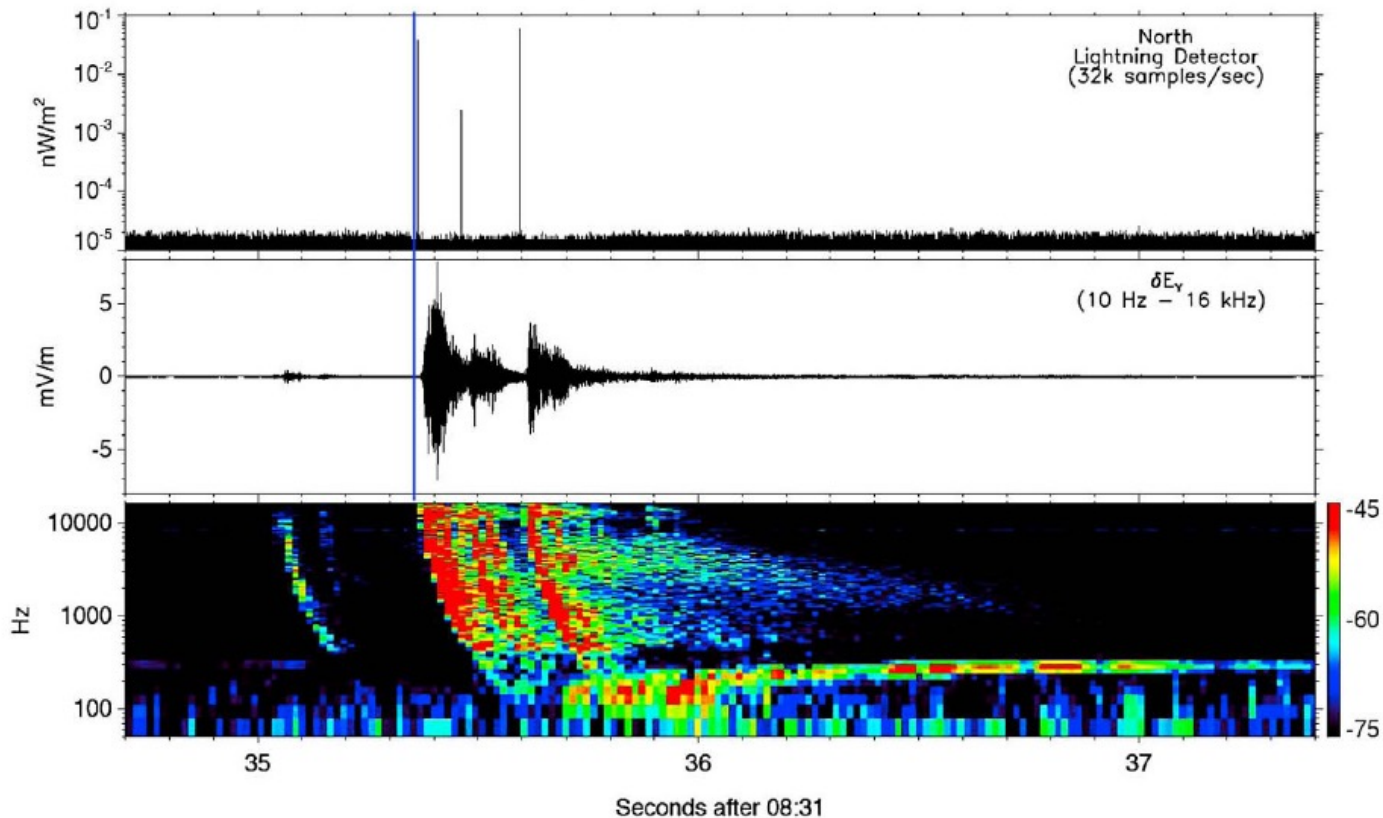
According to Dowden et al. 2002

Unducted whistler

C/NOFS Satellite -- Orbit 3260 -- VEFI Observations

22 November 2008

Alt: 828 km, Long: 284.7°, Lat: 0.6°, 3.7 L.T.



Whistler and lower hybrid frequency

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, A09315, doi:10.1029/2008JA013261, 2008

Numerical study of mode conversion between lower hybrid and whistler waves on short-scale density striations

B. Eliasson^{1,2} and K. Papadopoulos³

IEEE TRANSACTIONS ON PLASMA SCIENCE, VOL. 31, NO. 6, DECEMBER 2003

A Review of Lower Hybrid Solitary Structures

Peter W. Schuck, John W. Bonnell, and Paul M. Kintner, Jr., *Senior Member, IEEE*

Overview of natural VLF phenomena

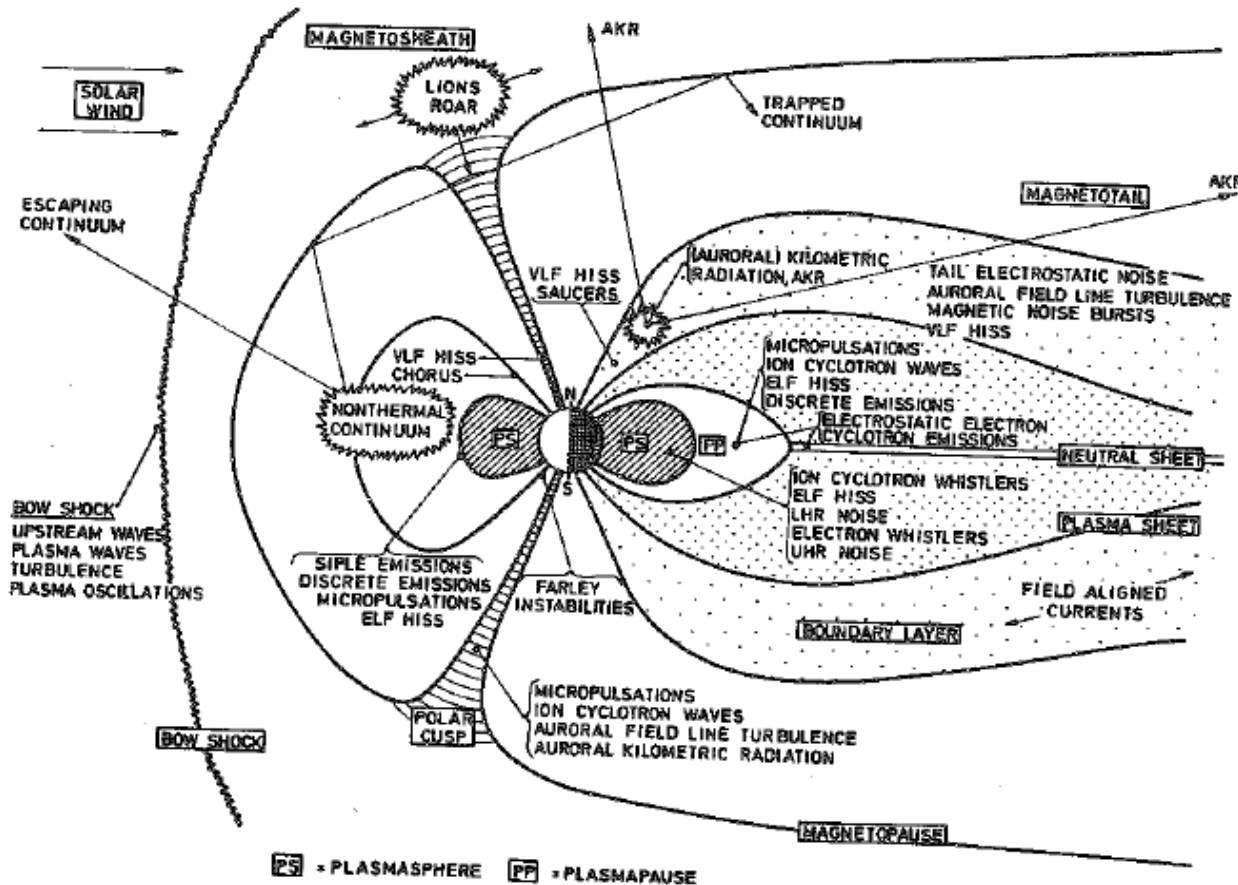


Figure 13.1.1 Regions of plasma wave occurrence located in a noon-midnight meridian cross section of the Earth's magnetosphere. (From Shawhan, S. D., *Solar System Plasma Physics*, 1979, Chap. III.1.6. With permission.)

Lightning-induced plasma turbulence and ion heating in equatorial ionospheric depletions

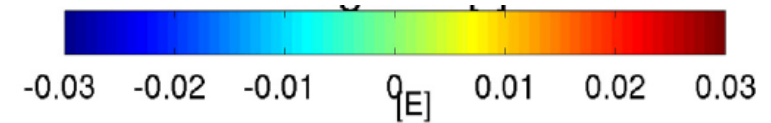
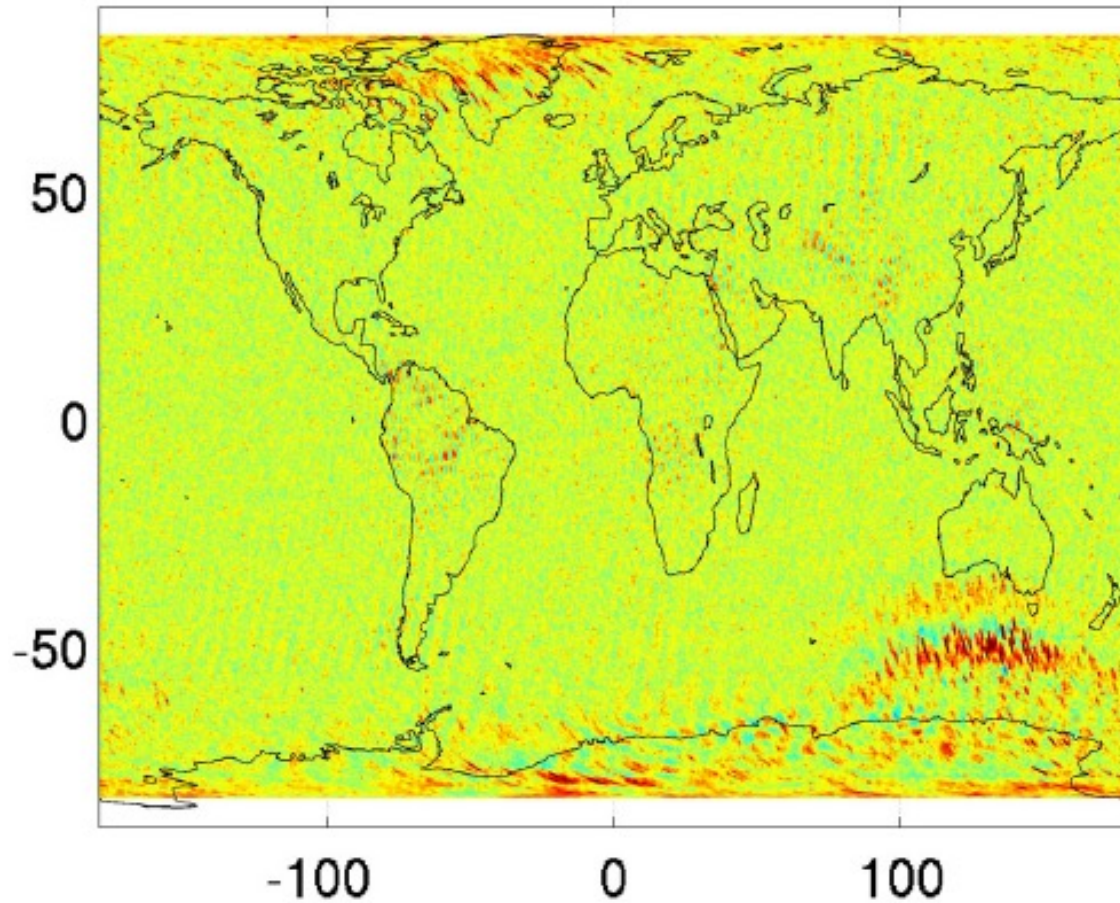
JEAN-JACQUES BERTHELIER^{1*}, MICHEL MALINGRE¹, ROBERT PFAFF², ELENA SERAN¹, RAYMOND POTTELETTE¹, JOHN JASPERSE³, JEAN-PIERRE LEBRETON⁴ AND MICHEL PARROT⁵

Nature geoscience 2008

„Since the energy source of the equatorial solitary structures is different from that involved in the auroral processes, our findings support the idea that the formation of lower-hybrid solitary structures may be a universal mechanism operating in inhomogeneous, magnetized plasma, ...“

Other observations?

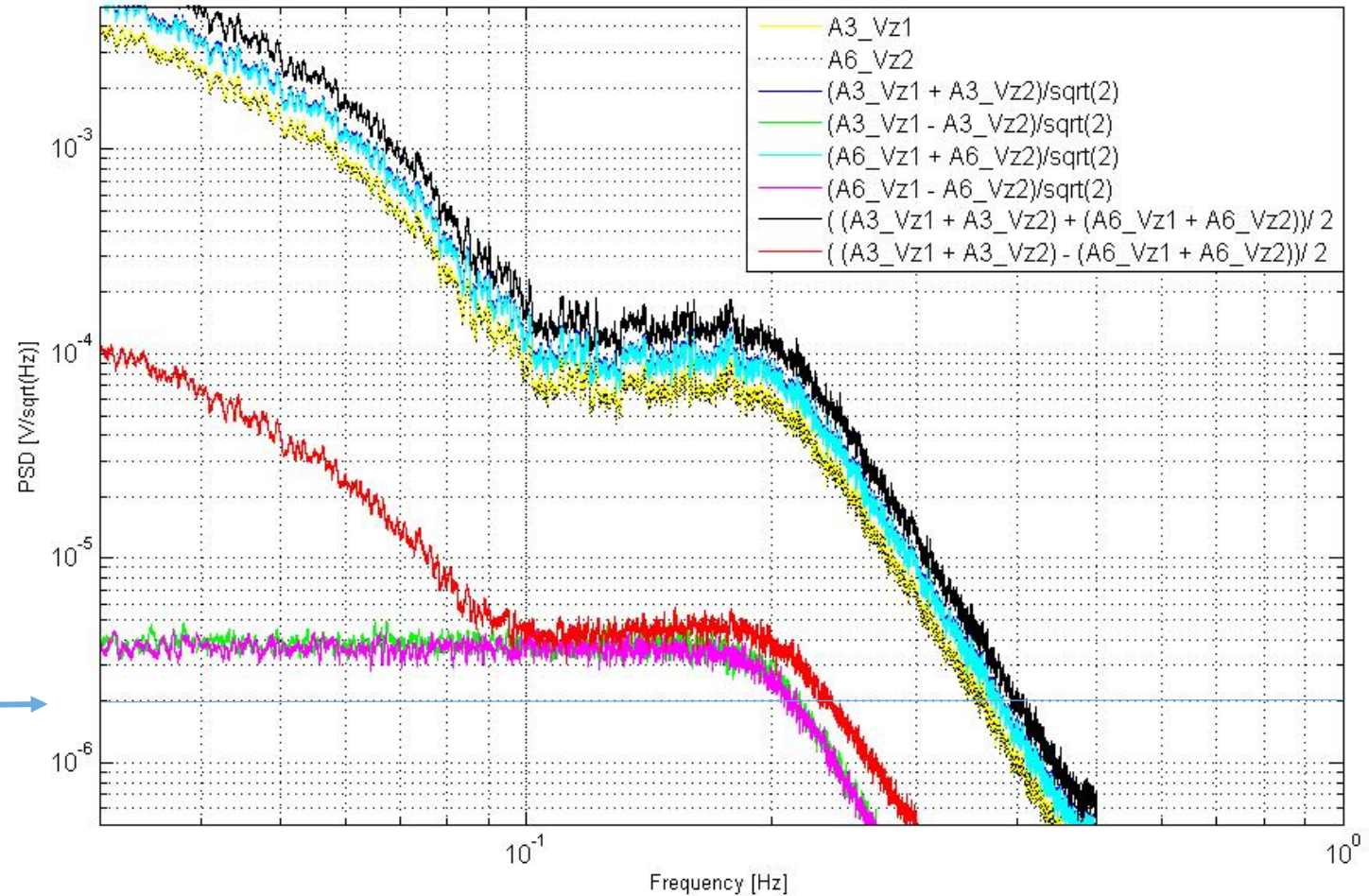
Filtered o-c of V_{yy} (ascending), from Oct/31/2009 to Dec/30/2009



Other observations?

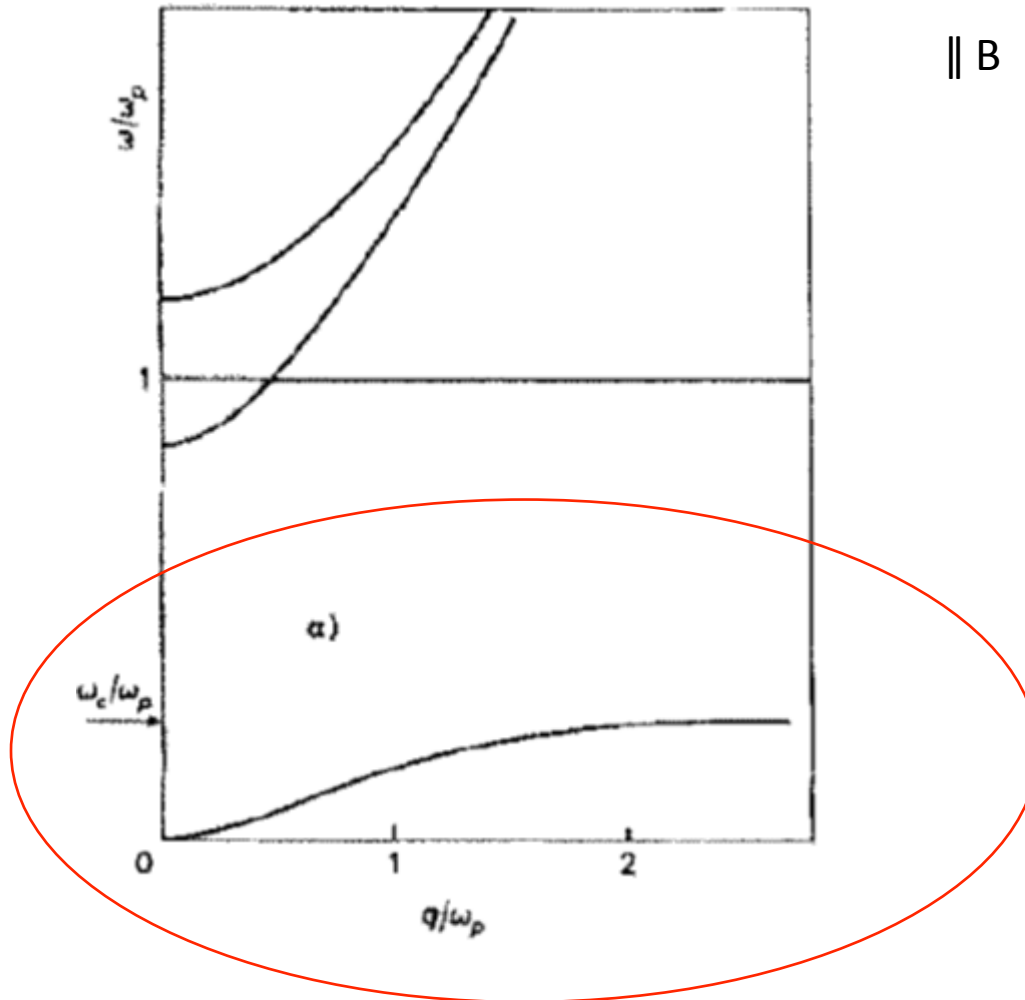
GOCE: correlated noise

specification



Shielding in GRACE

Helicon mode in metals

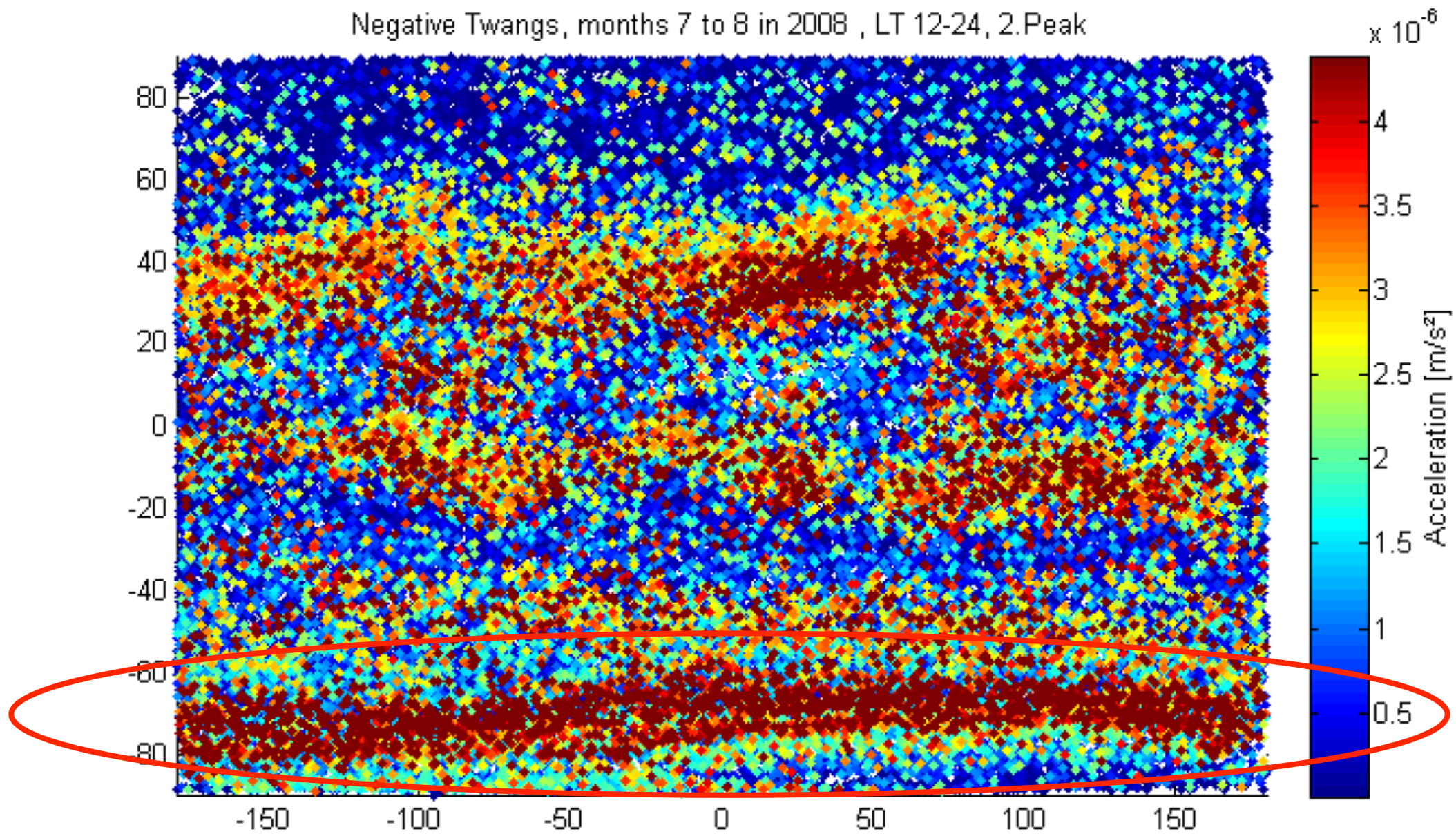


Chiu and Quinn
IL NUOVO CIMENTO 10
1972

Conclusion

- The ionospheric environment is complex with many resonances in the VLF regime.
- Experiments are necessary to proof this assumption of VLF incompatibility!
- Experiments on shielding!
- Effect not special for ONERA accelerometers!

Negative Twangs, months 7 to 8 in 2008 , LT 12-24, 2.Peak



Polar night jet