Control of Gravity waves on Equatorial Spread F day to day variability: An Empirical approach

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SPL Activities:

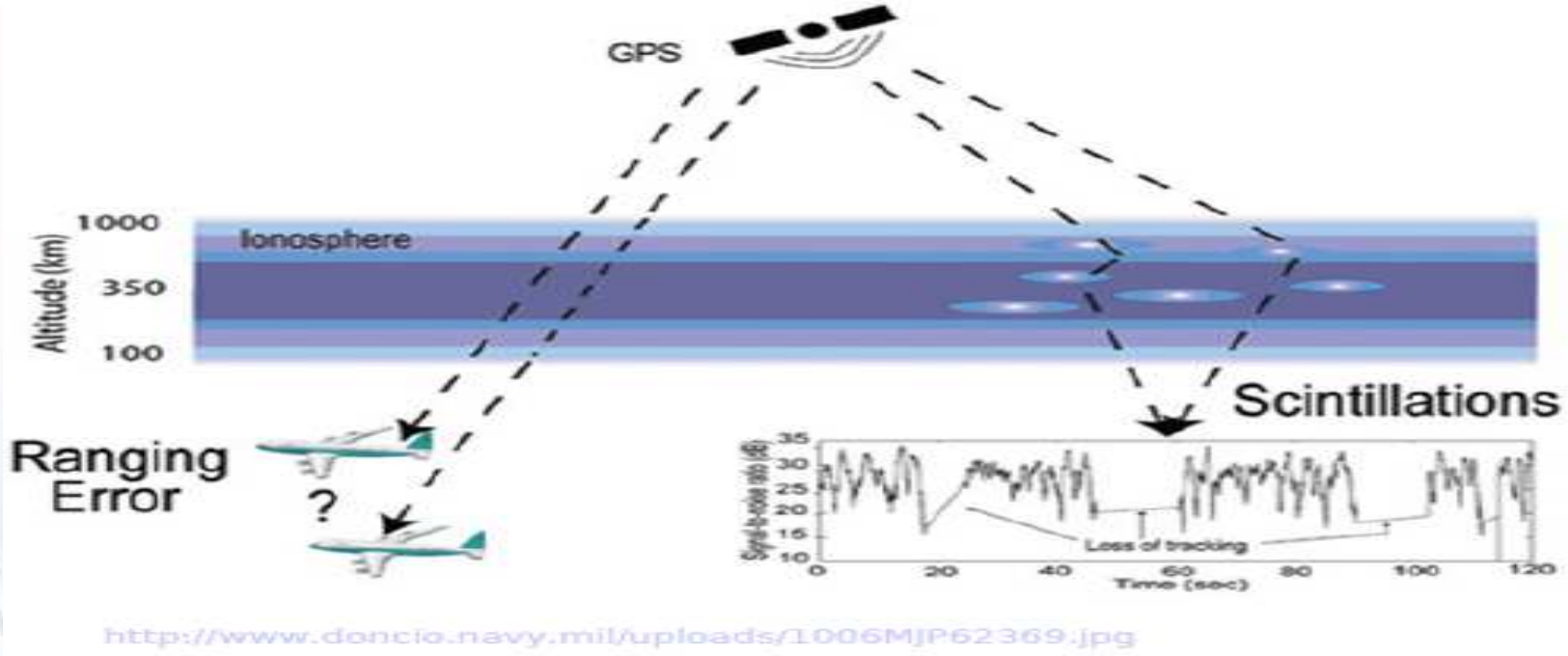
Scientific Research in different areas of Atmospheric Science from near surface to ionosphere (terrestrial) .
Planetary atmosphere/ionosphere studies
Development of scientific payloads

Space weather related activities in SPL

InSWIM network
(From Hanley to Antartica):
GNSS receivers
LEOS receivers
Magnetometers
Digisondes
Airglow measurements

Background:

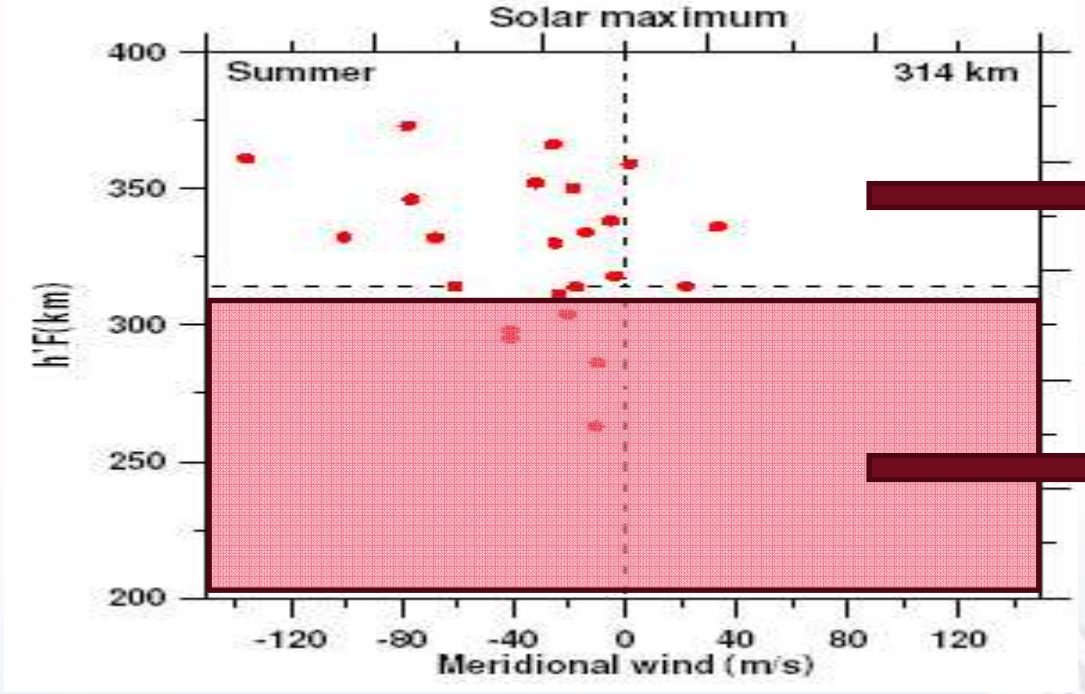
The Equatorial Spread – F Nocturnal Ionospheric irregularities which manifest during magnetically quiet times

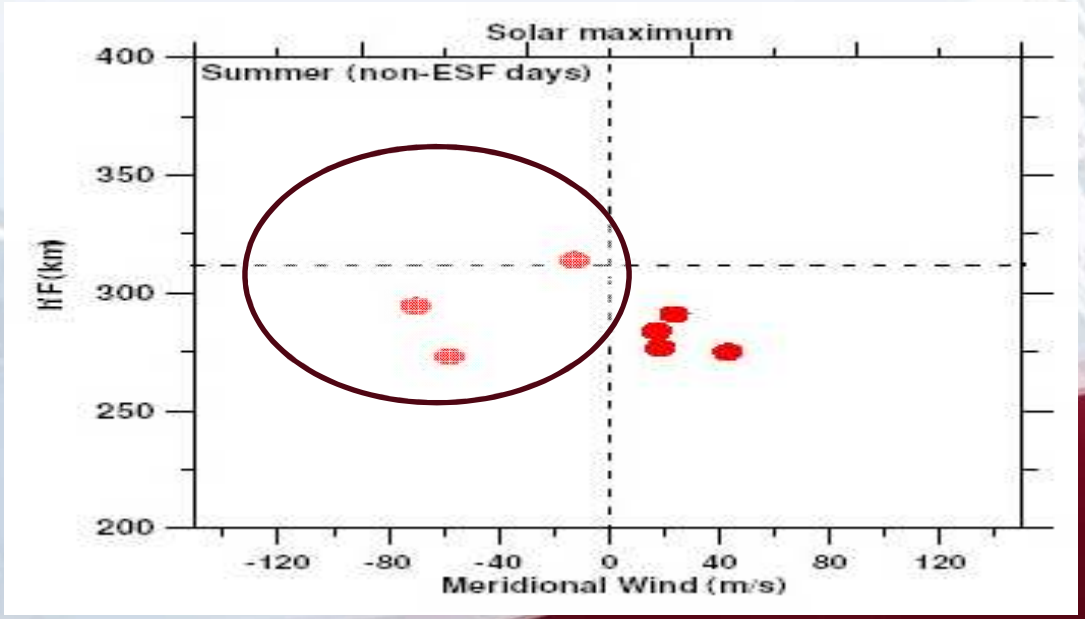


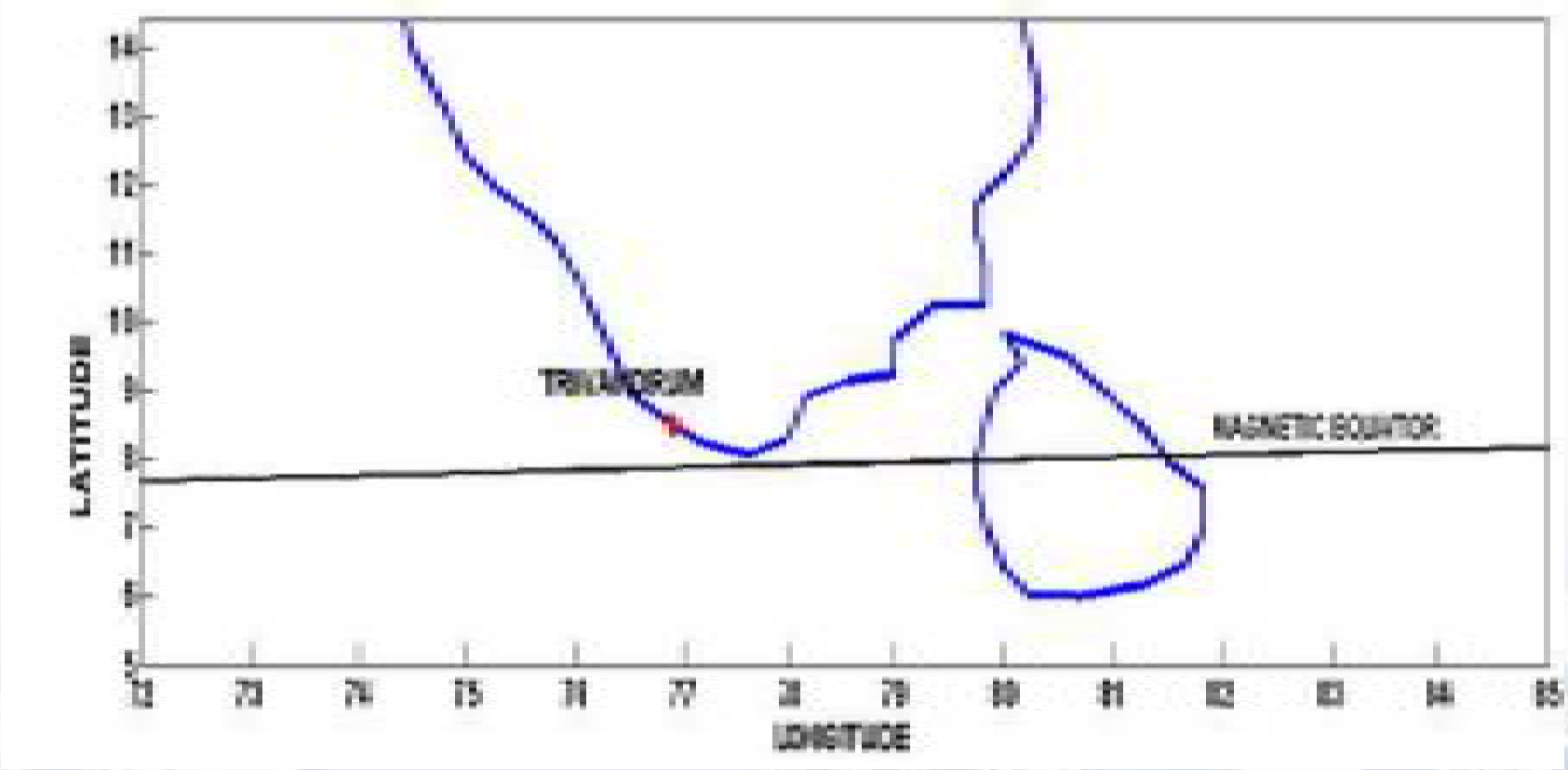
- **Satellite signal suffers transmission delays, phase fluctuations, Angle of arrival variations**

Motivation

Threshold height pattern (Manju et al., Ann. Geophys., 2007)





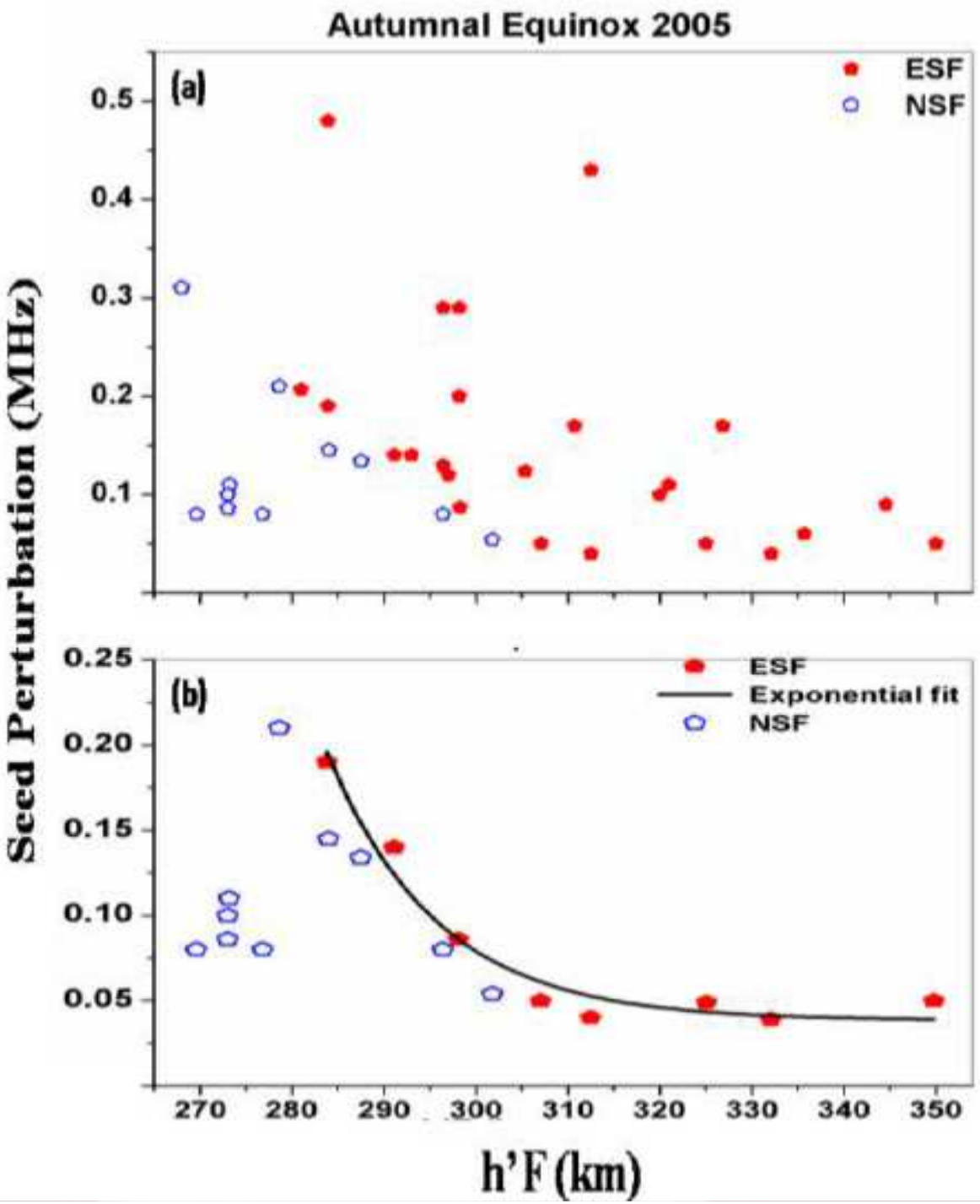


Ionosonde data from magnetic equatorial location Trivandrum

Methodology

- The peak frequency of the F layer (foF2) is scaled from 0600 to 2400 ST if height could be delineated clearly. for each day. The data cadence is 15 min.
- For each day, the scaled data for the above mentioned period is subjected to wavelet analysis to delineate the periodicities in the range of 30 min to 1 h considering these to represent the gravity wave seed perturbations.

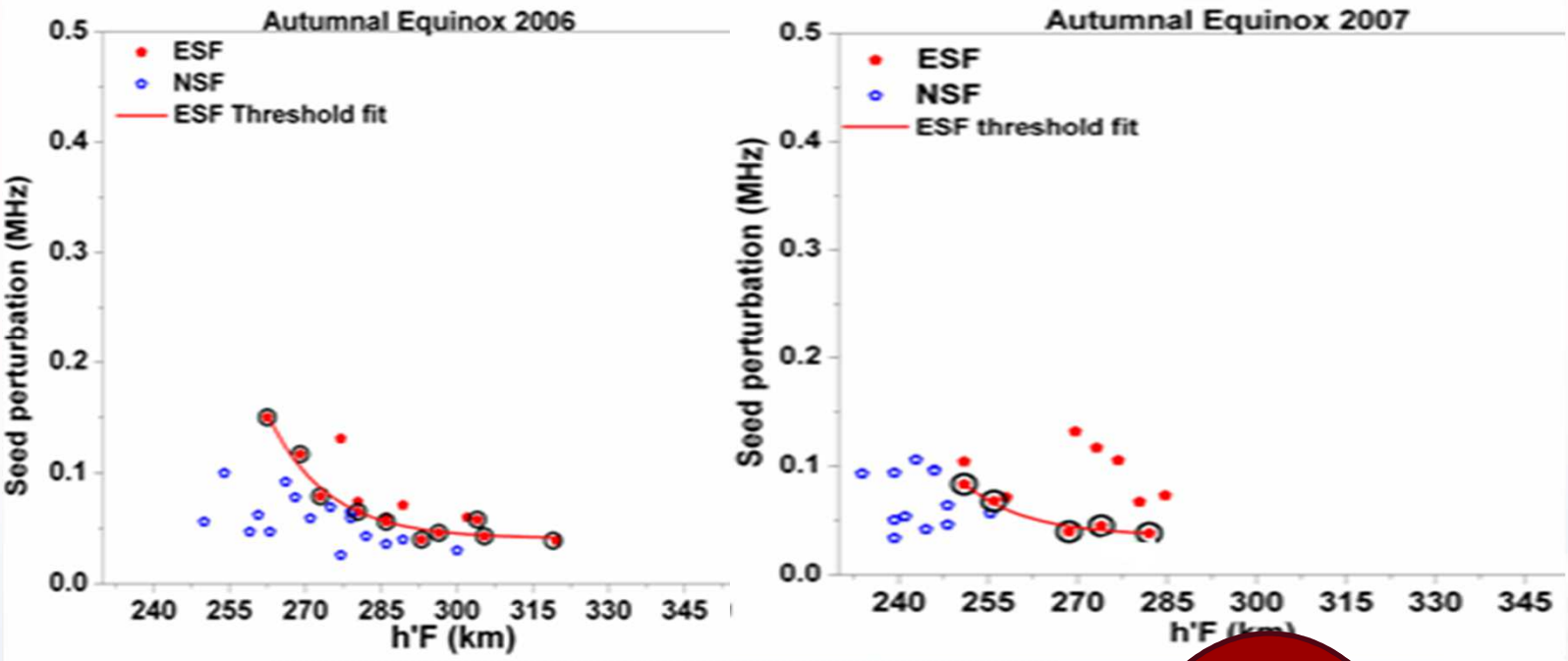
- We have used the average wavelet power of the periodicities in the 30–60 min range for the duration 1800–1845 h which is near the ESF start time, to represent the magnitude of the seed perturbations on a given day.
- The h'F (virtual height of the base of the F layer at 2.5 MHz) at 1900 h is considered as representative of the magnitude of the post sunset enhancement on each day.

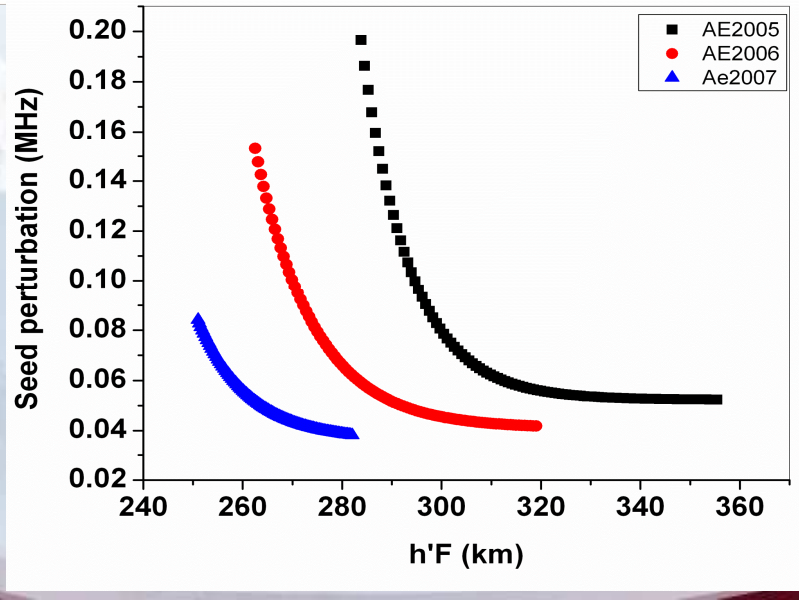


Manju et al, ASR, 2016

Ion-neutral coupling processes

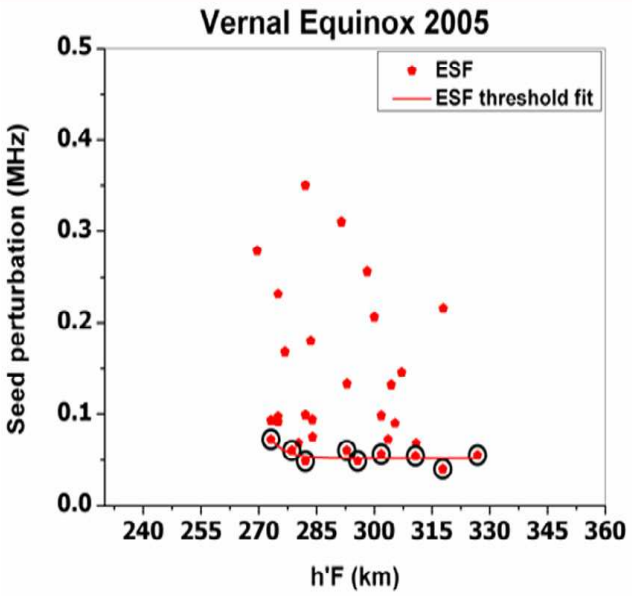
Ion-neutral coupling processes

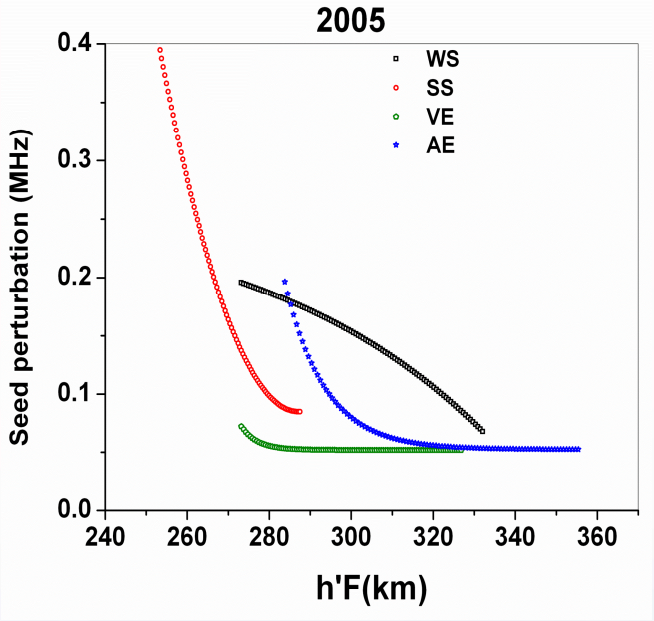


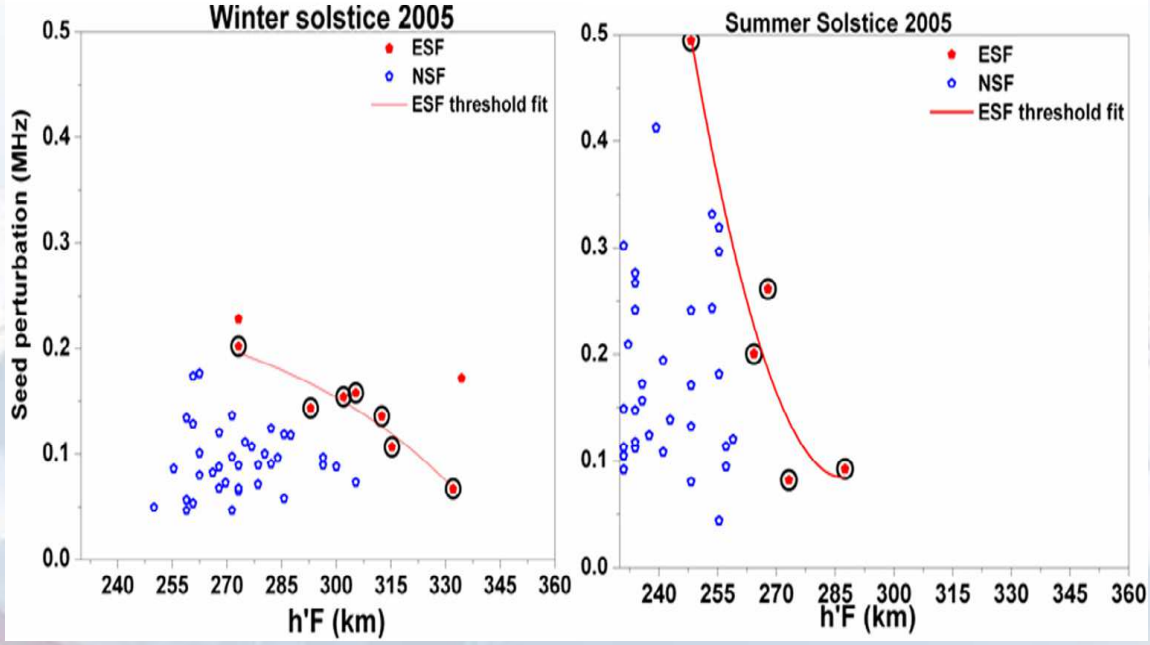


Solar cycle effect

Manju et al, ASR, 2016



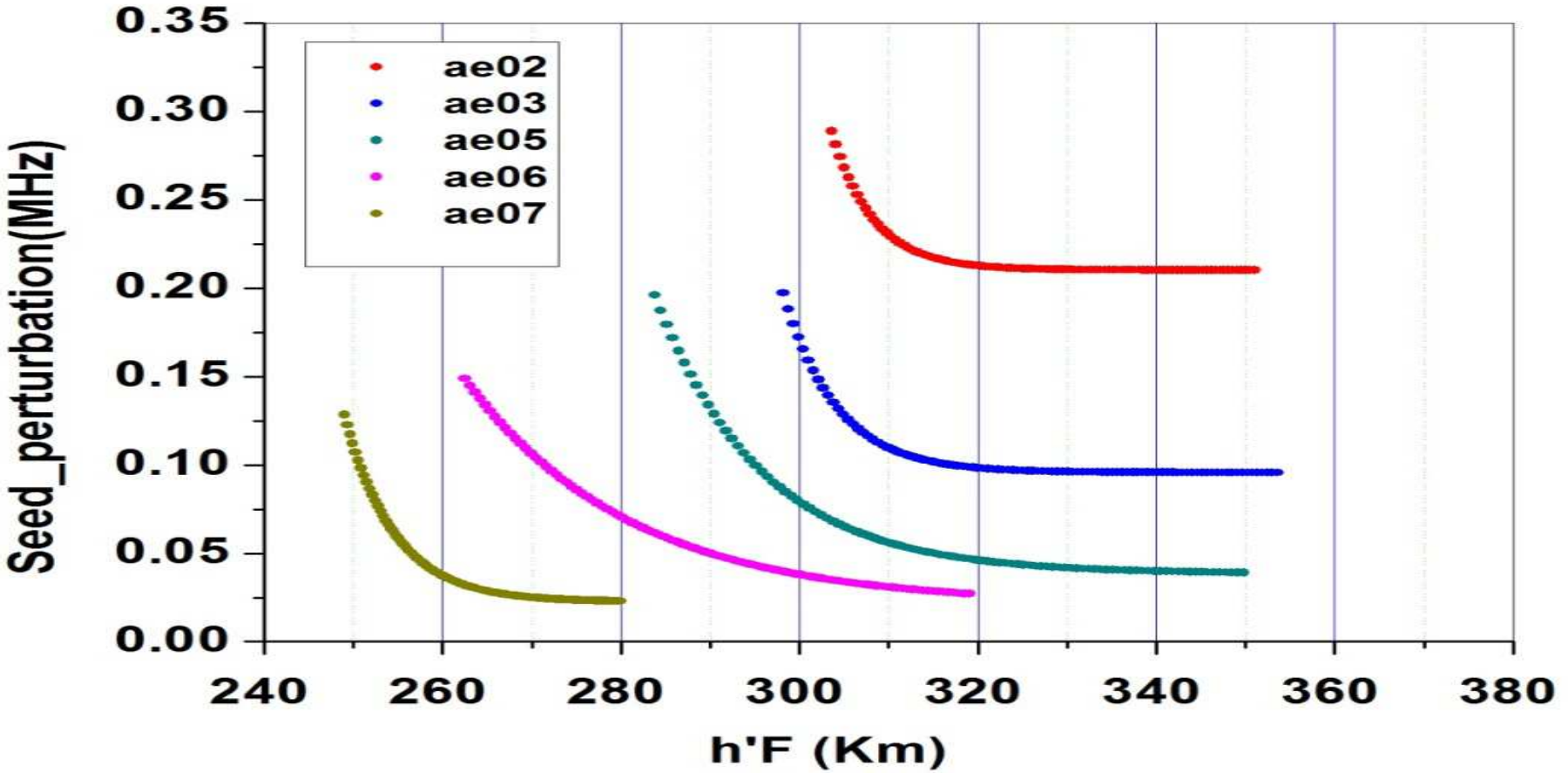




Seasonal variability

Manju et al, ASR, 2016

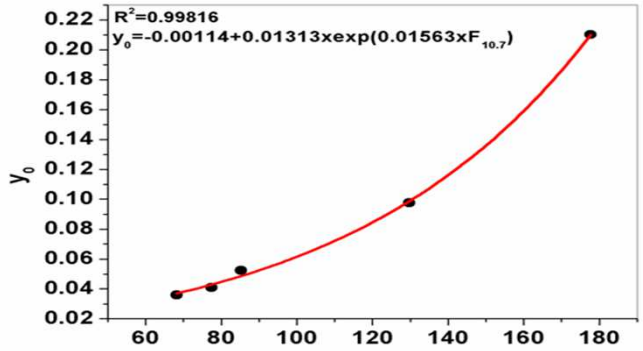
Solar cycle variability..cycle 23

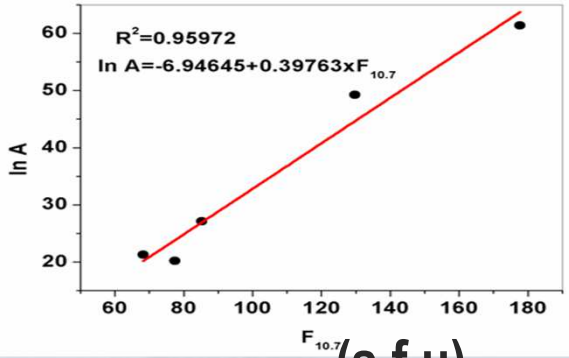


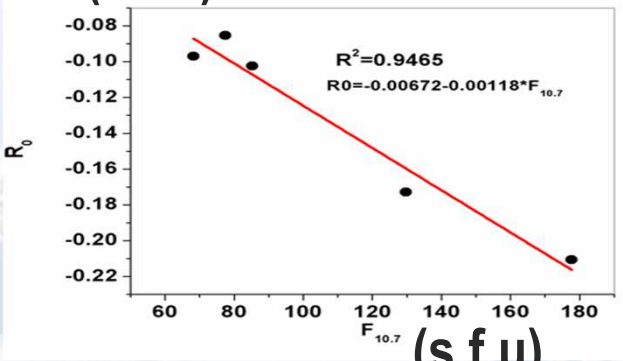
- Level of solar activity controls the seed perturbation
- Threshold curves are of the form, $y=y_0+A^* \exp(R_0 * h'F)$

Aswathy and Manju, JGR, 2017

Dependence of the coefficients of the exponential fits on the solar flux index ($F_{10.7}$ index)





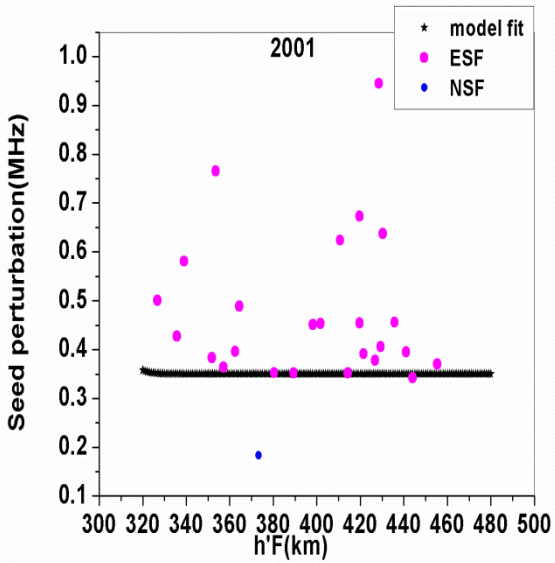


Seed = [0.00114+0.01313*exp(0.01563* $F_{10.7}$)]+ [exp(-6.94645 + 0.39763 x*F10.7)]*exp([-0.00672-0.00118 * $F_{10.7}$)] * h'F

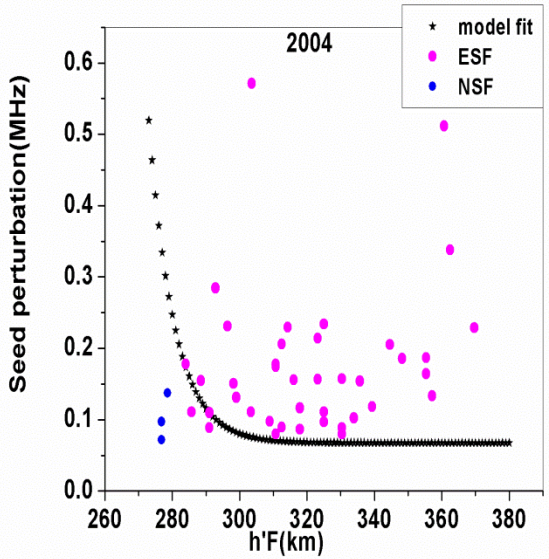
Aswathy & Manju,JGR,2017

Validation of the model:

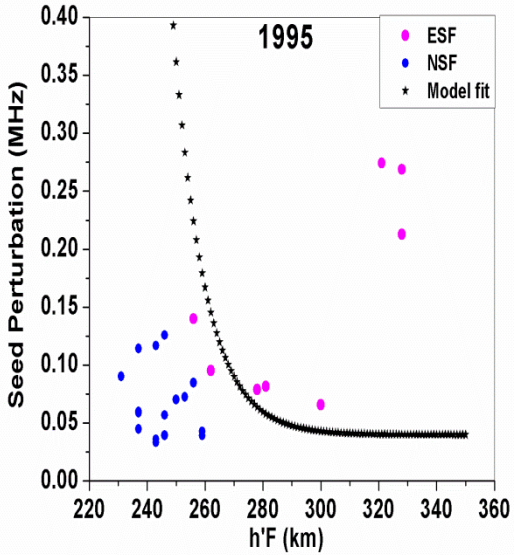
High solar activity year
$F_{10.7}$ =210.3



Moderate solar activity year
$F_{10.7}$ =105.8



Low solar activity year
$F_{10.7}$ =73



100%

96%

92%

Overall, 95.6% success is achieved in hindcasting ESF occurrence /non occurrence using the present model, considering the three years together.

Aswathy & Manju,JGR,2017

Summary

- An empirical model is developed wherein the threshold curve for autumnal equinox season of any year may be delineated provided the solar flux index ($F_{10.7}$) is known.
- The model is validated for high-medium-low solar activity years
- The role of ion-neutral coupling processes in controlling ESF day to day variability is unravelled in the study

Thank you…

- Gravity waves can exist in the ionosphere (Beer,1972)
- Observation of wavelike fluctuations in ionospheric temperature and density (Reitt et.al,1973)
- Gravity waves can initiate ESF(Kelley et.al ,1981)
- Gravity waves can penetrate in to thermosphere and cause triggering of ESF (Vadas et .al ,2004)
- Identifiable presence of gravity can cause the prompt development of irregularities (Abdu et al.2009)
- Observational evidence of gravity wave perturbations on ESF days in the Indian sector (Sreeja et al., 2009)
- Quantification of gravity wave amplitudes to trigger ESF (Manju et,al.,2016)