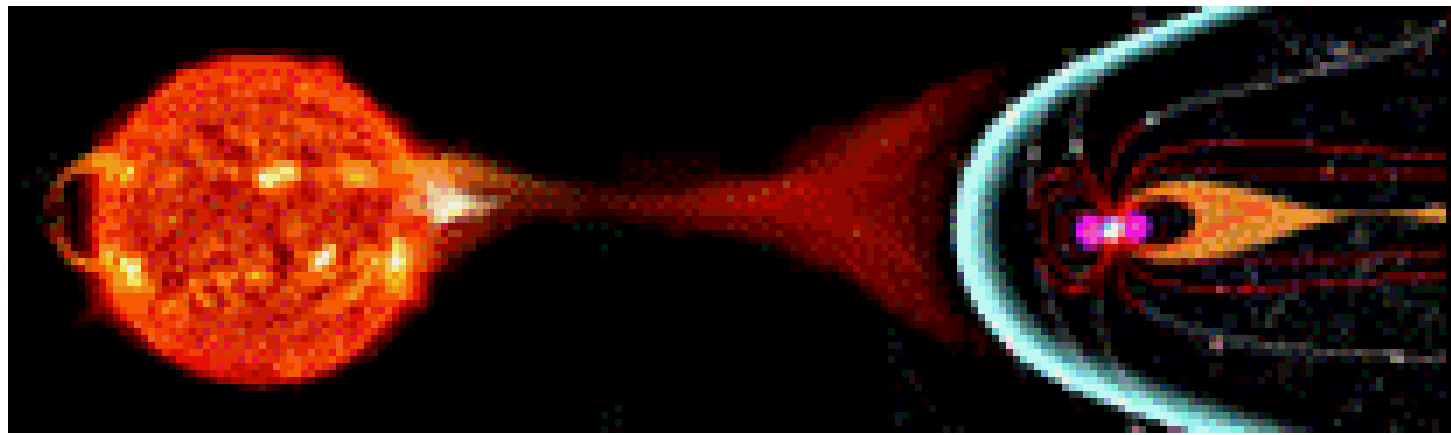




Australian Government
Bureau of Meteorology




An overview of our HF services and Ionospheric variability extremes

Vickal V. Kumar

Space Weather Users Workshop 2017

Current Ionospheric Products



Australian Government
Bureau of Meteorology

Space Weather Services

Click here for 2017 Space Weather Users Workshop details

Home | Space Weather | Aurora | Satellite | Geophysical | Solar | HF Systems | Products and Services | Educational | World Data Centre | Research

HF Systems

FORECAST SOL: Normal ● MAG: Disturbed ▼ ION: Normal ●

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Monday, Nov 06 2017 23:05 UT

Australasia

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- HF Conditions
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- Ionospheric Map
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High Latitude

- High Latitude Conditions
- High Latitude Links

Global HF

- HF Conditions
- Fadeout Charts
- Polar Cap Absorption
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- Ionospheric Map
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Online Tools

- Prediction Tools
- Index Plots

Section Information

- HF Systems Help Page
- HF Communications Problem Page
- Latest News

Note: Certain pages within the "HF Systems" category are updated frequently. Excluding warning notifications, update intervals will be specified where applicable.

To refresh the page, hold down the "SHIFT" key and click the "Refresh" or "Reload" button on your browser to refresh this page to obtain latest data.

HF Propagation Conditions

HF Comms Warning

No Event

Current HF Fadeout

No Event

HF Fadeout Warning


No Event

Polar Cap Absorption


-0.0d
AT
22:52 UT

Ionospheric Conditions

Australasia



World



These pages provide general propagation advice for HF communicators. Information available includes inferred global propagation conditions, real time HF fadeout coverage charts, regional ionospheric vertical MUF maps and Hourly Area Prediction charts.

Also available:

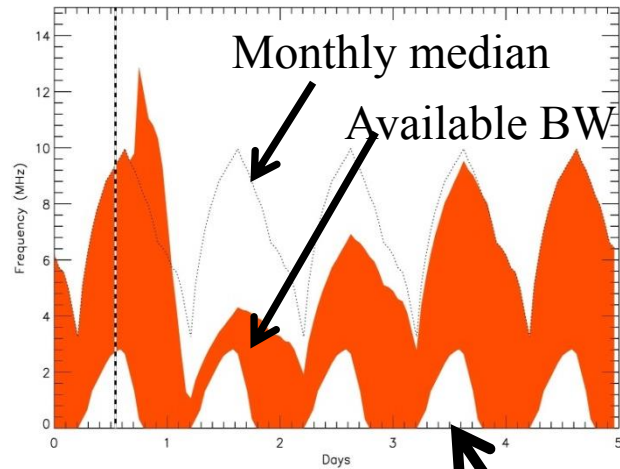
- [derived TEC Maps](#)
- [X-Ray Flux values](#)
- [background information](#) on HF propagation
- a (7 MB) [animation](#) on the effects of space weather on HF communications

[How do you rate this product?](#)

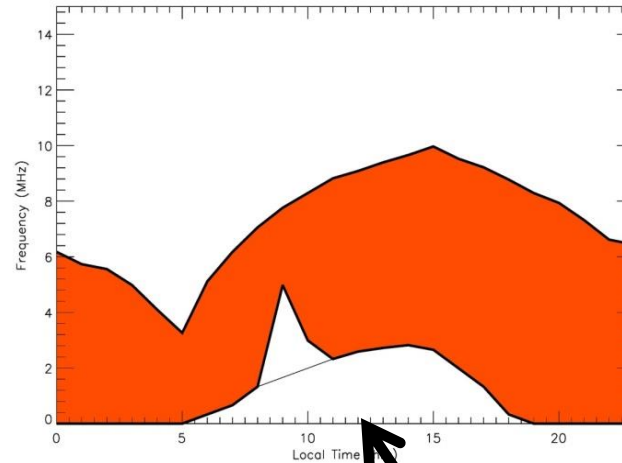
▲ Top

Current Ionospheric Products

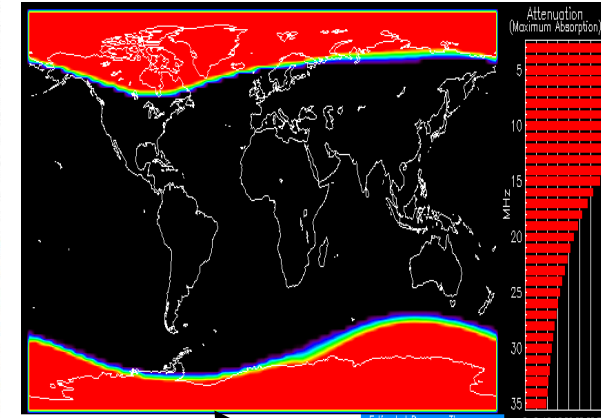
Magnetic storm-induced enhancements and depression



Solar flare induced density enhancements in D-region leading to absorption



High energy proton precipitation causing D-region density enhancements



HF Propagation Conditions

HF Comms Warning

No Event

Current HF Fadeout

No Event

HF Fadeout Warning

No Event

Polar Cap Absorption

No Event
AT
22:52 UT

New Ionospheric products

- Sporadic E occurrence
- F-spread
- TID

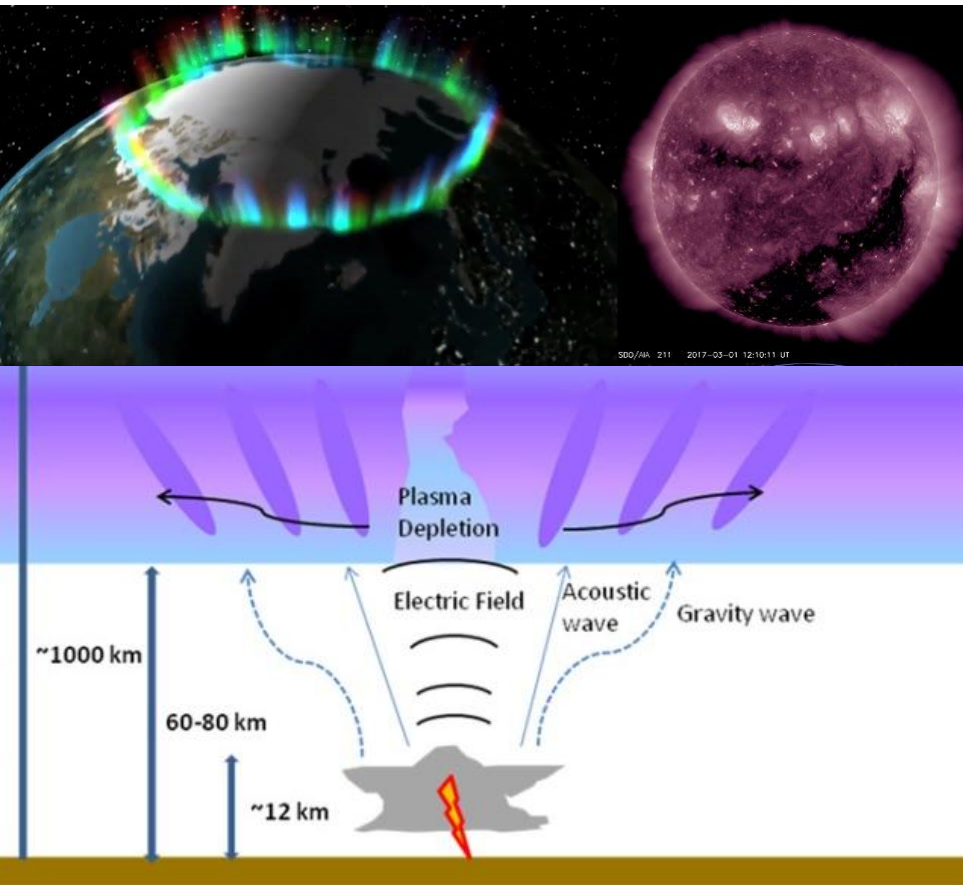
**Ionospheric Variability
Warning -new**

No Event

**Ionospheric Height
Changes Warning -new**

No Event

Sudden solar wind and solar flux changes, enhanced particle precipitation, disturbance thermospheric winds, large-scale TIDs - **COUPLING from ABOVE**

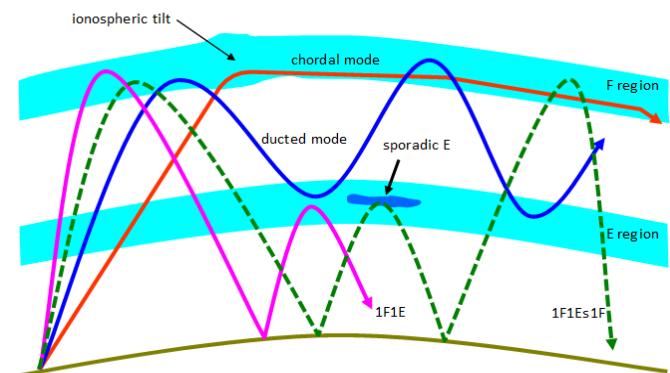


Natural and man-made disturbance causing medium and small scale TIDs – from below - **COUPLING from BELOW**

What causes Ionospheric Variability

Important to quantify variabilities:

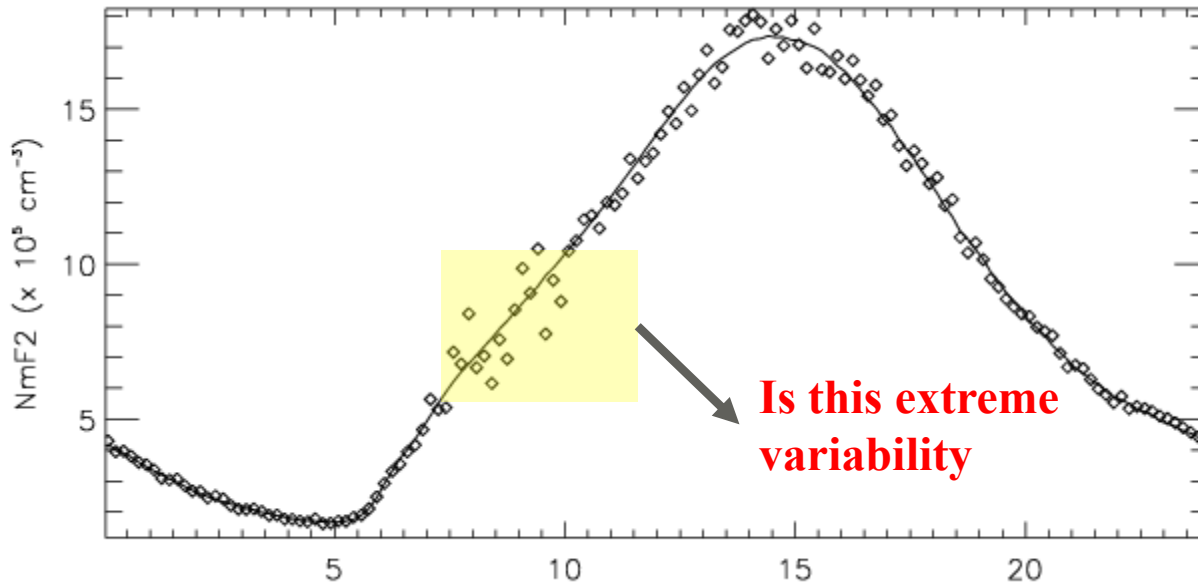
- To improve predictability of a system
- To warn on HF Directional errors and fading of HF comms links
- To warn on degradation of GPS-based timing and navigation accuracies



Ionospheric Variability and variability extremes

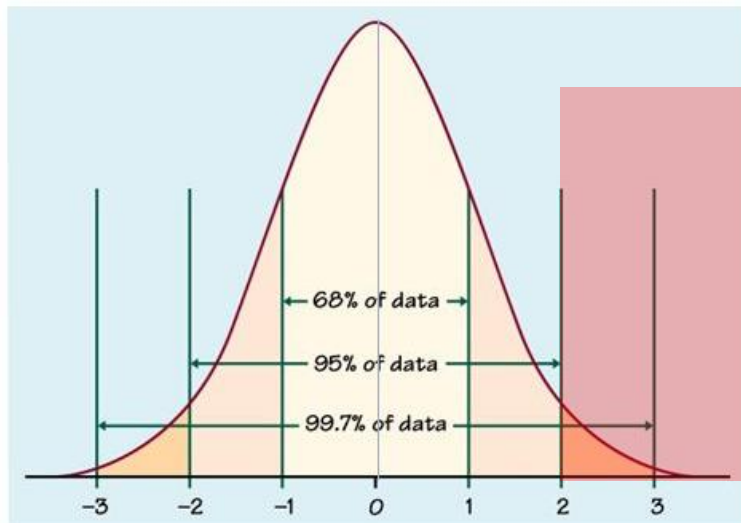


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Ionosphere is variable at nearly all temporal and spatial scales. **When and where are variabilities such larger than normal?**

Is this extreme variability



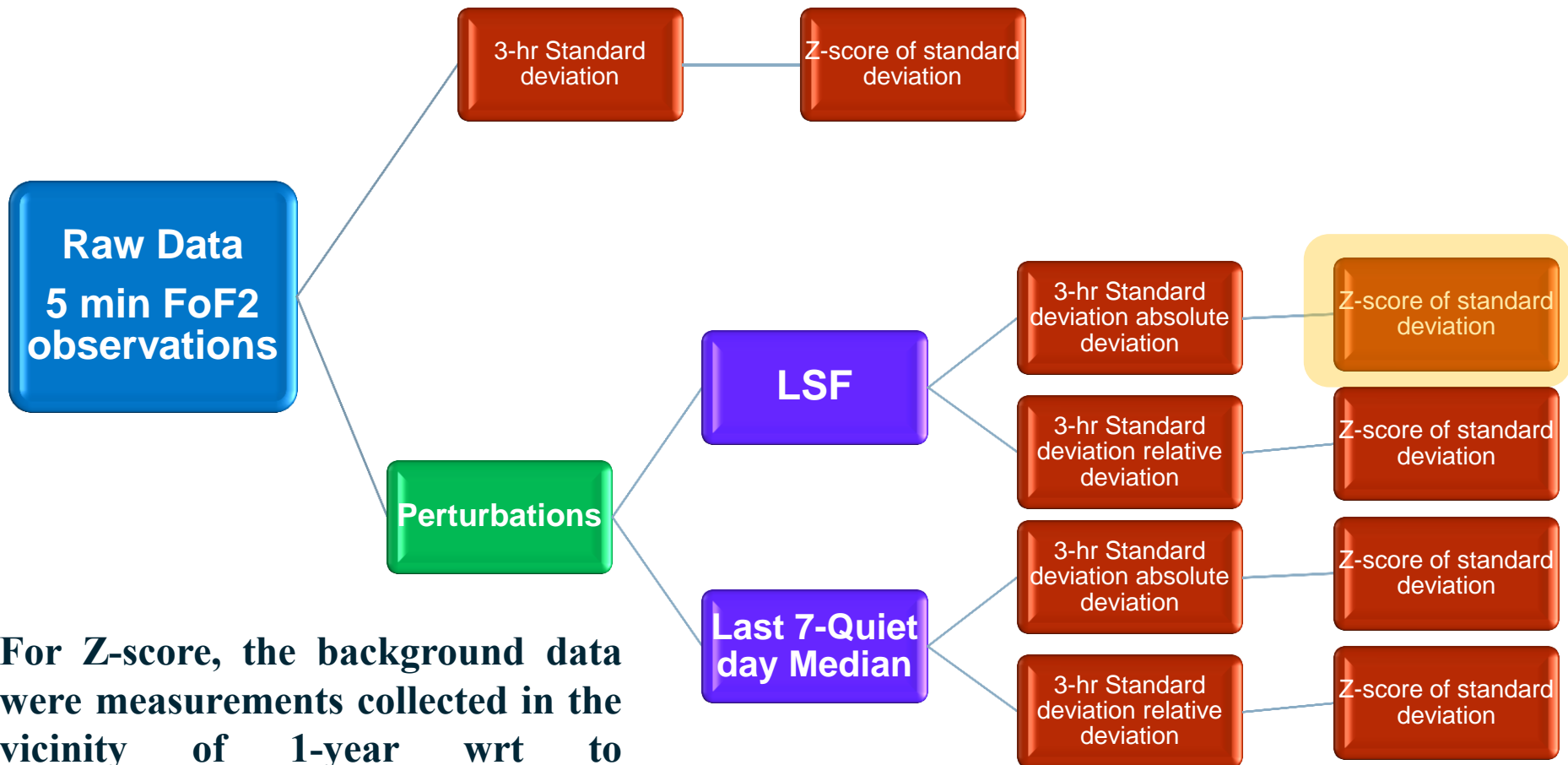
Extreme variability – when the observed variability is two-standard deviation larger than the normal variability. 2.5% of time.

$$Z = \frac{\text{Score} - \text{Mean}}{\text{Standard Deviation}}$$

Score – variability at given local time

Mean and Standard deviation are computed from data which have similar local time as the "score" and are collected over the nearest 1-year

Computation of Ionospheric variability – 3 hourly time-scale

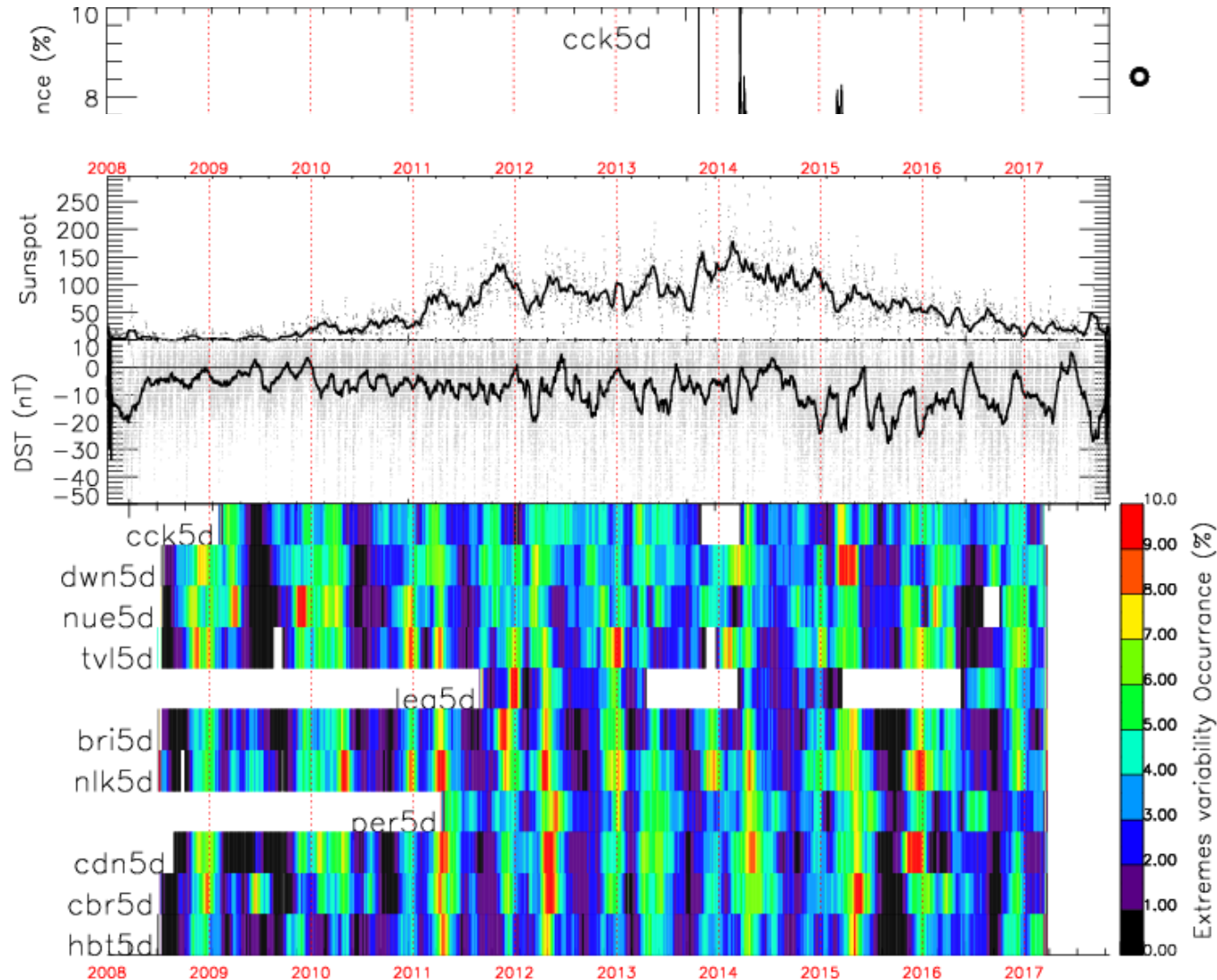


For Z-score, the background data were measurements collected in the vicinity of 1-year wrt to corresponding observation time.

Ionospheric variability extremes – how often do they occur



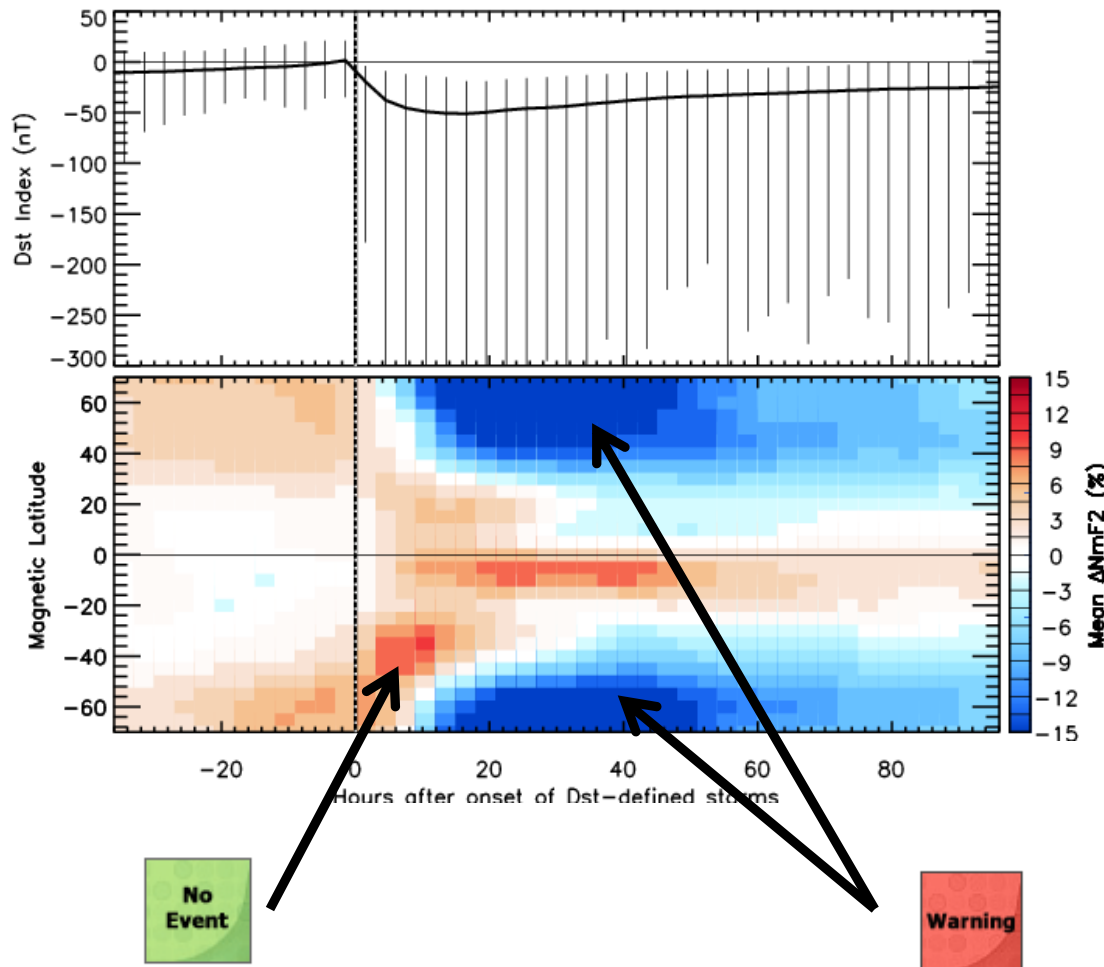
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Variability extremes are common during:

- summer
- peak of solar cycle
- Disturbed magnetic conditions

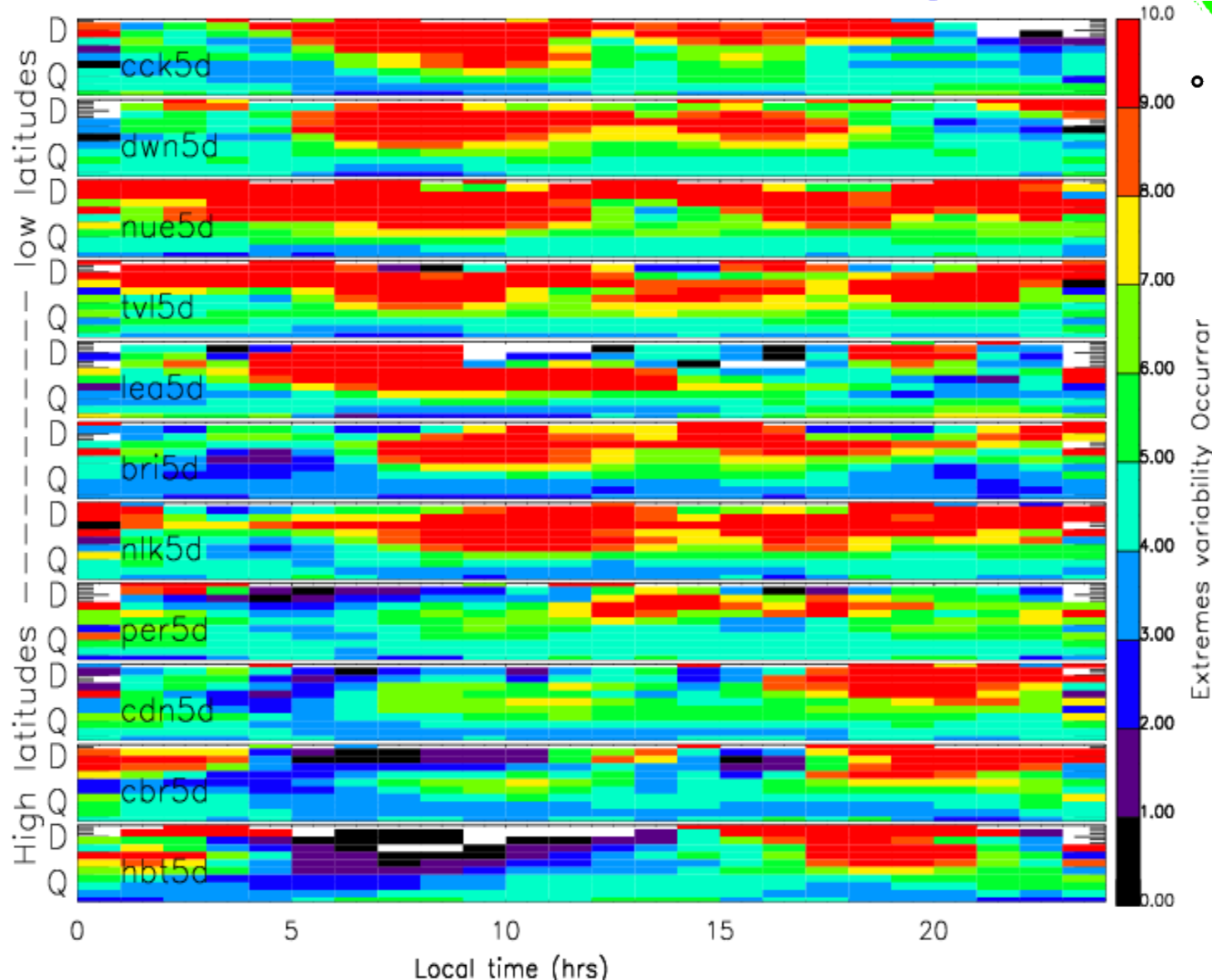
Ionospheric variability extremes and magnetic disturbance



Statistical analysis of 50-years plasma density data from a global network of 132- ionosondes. This investigation uses ~1000 geomagnetic storm incidence - Kumar and Parkinson, Space Weather, 2017

Does this imply that the density enhancement during prestorm and main-phase of storm support good HF propagation conditions. How about ionospheric variability. **Would there be increase in HF directional errors and HF signal fading despite the enhancements in densities.**

Ionospheric variability extremes and magnetic disturbance



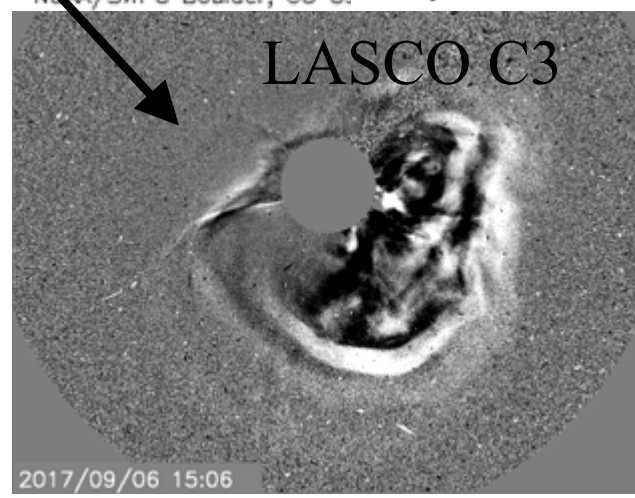
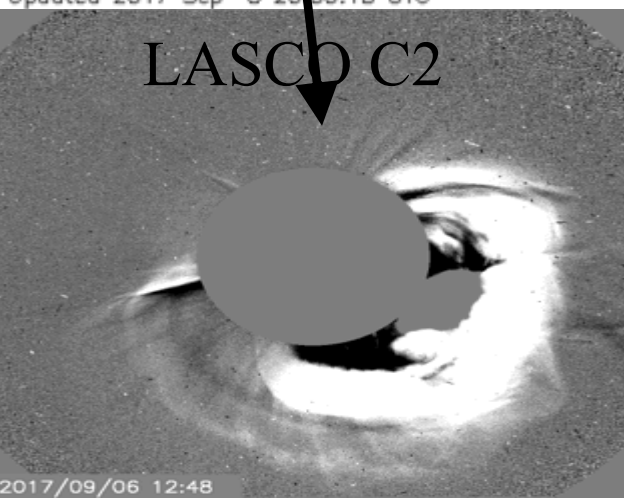
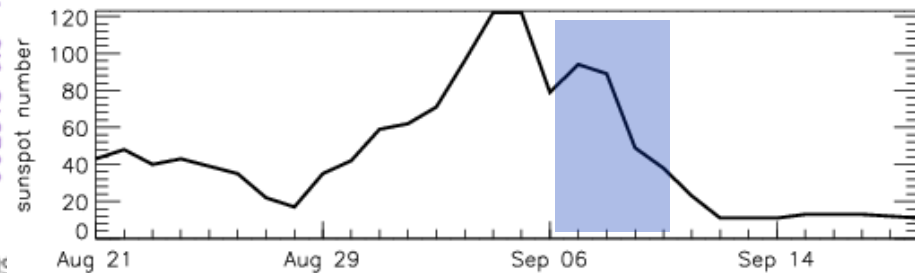
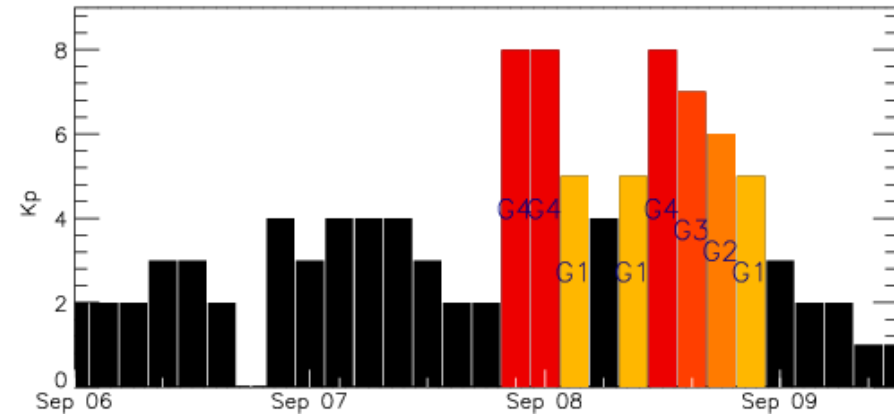
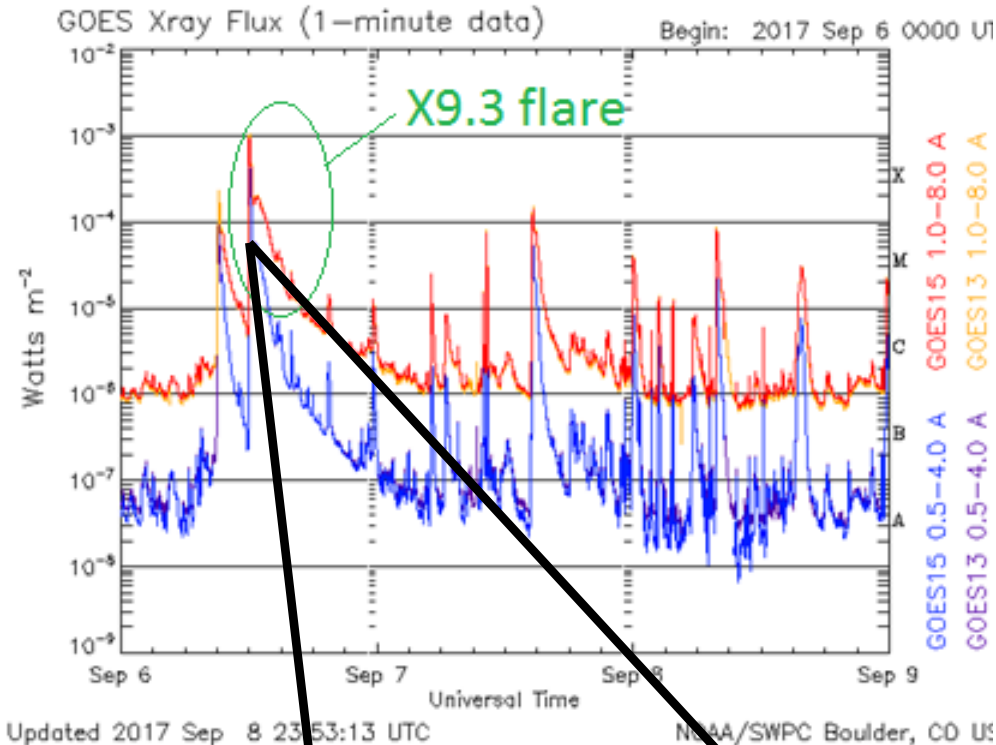
Variability extremes are common during:

- **Disturbed conditions in local time sectors in low latitudes.**
- **Disturbed conditions in afternoon through the night sectors in high latitudes.**

Major Space Weather Event (6-9 Sep)

Impact on HF support

Image courtesy SWPC



HF Comms Warning

Variability Warning

No Event

No Event

Direction finding Warning

No Event



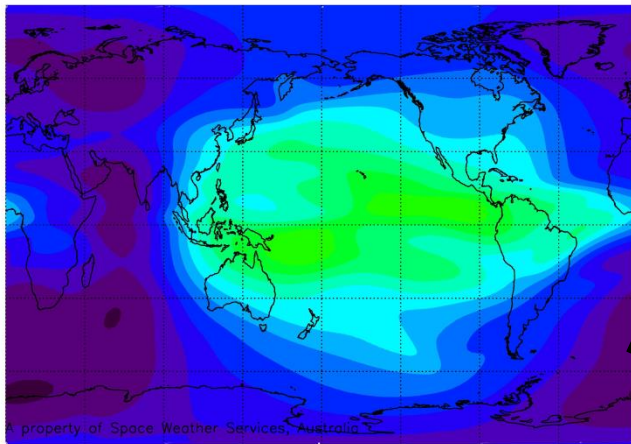
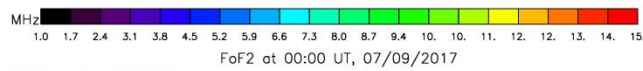
Major Space Weather Event (6-9 Sep)

FoF2 depression and enhancements

Depression

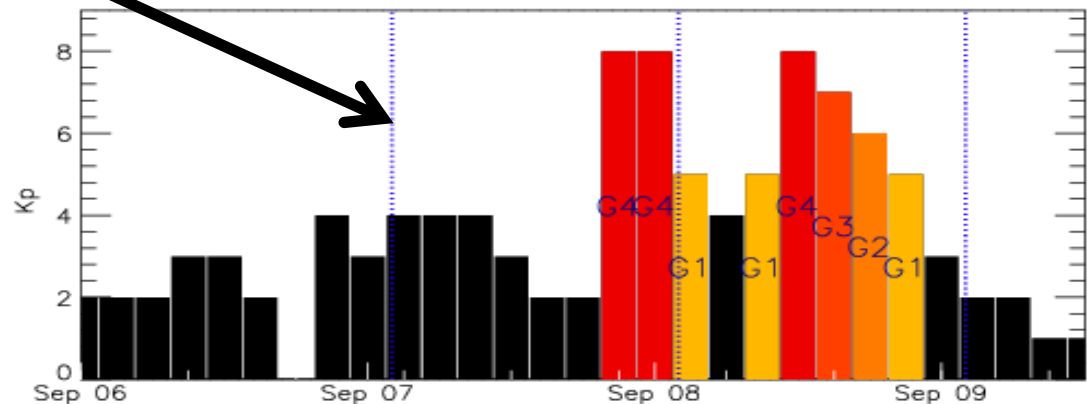
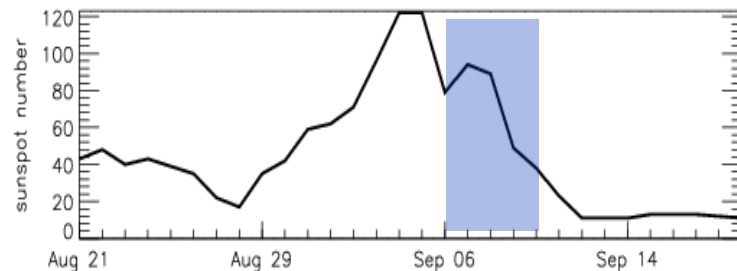
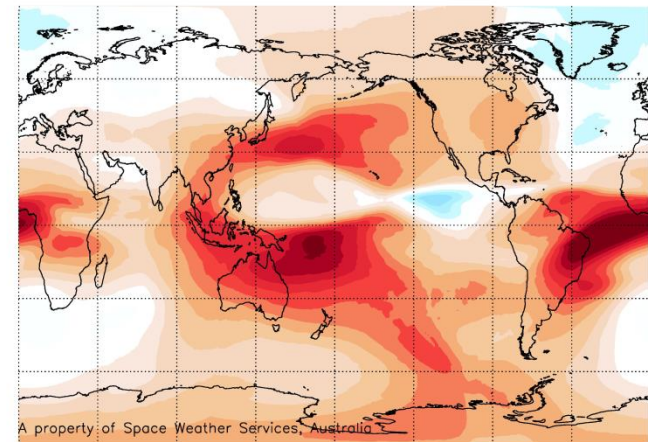
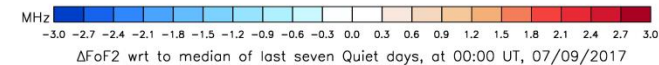
Enhancements

Near real-time FoF2 maps



Absolute perturbations:
removing the last 7 quiet day medians ($K_p < 2$)

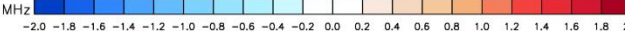
FoF2 Perturbation maps

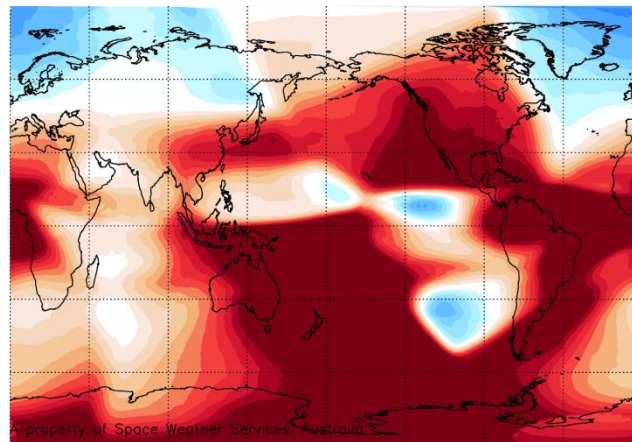





Major Space Weather Event (6-9 Sep)

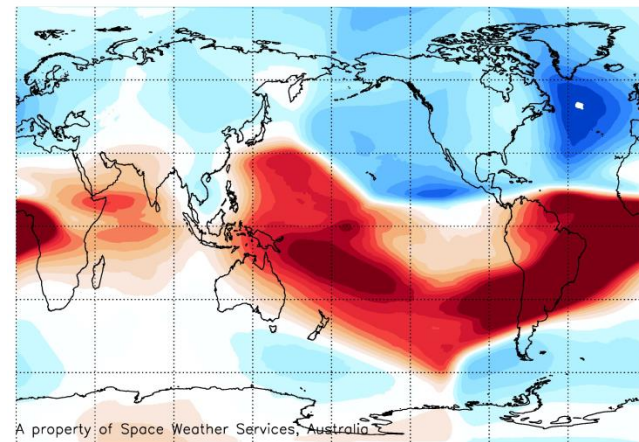
Storm main phase –
enhancements of up to 3-4 MHz

MHz 
Δf_oF₂ wrt to median of last seven Quiet days, at 01:00 UT, 08/09/2017

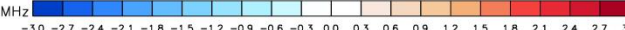


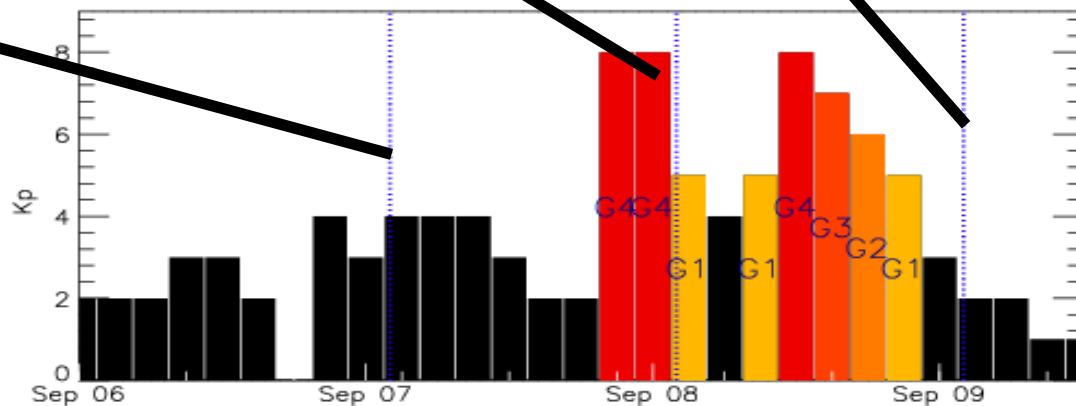
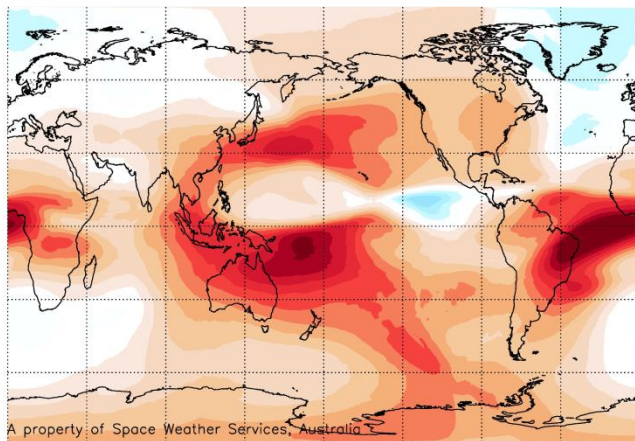
Storm recovery phase – onset of
depressions in high latitude
regions

MHz 
Δf_oF₂ wrt to median of last seven Quiet days, at 23:00 UT, 08/09/2017



Day before storm onset
– enhancements of up
to 2 MHz mainly due
large increases in solar
flux

MHz 
Δf_oF₂ wrt to median of last seven Quiet days, at 00:00 UT, 07/09/2017

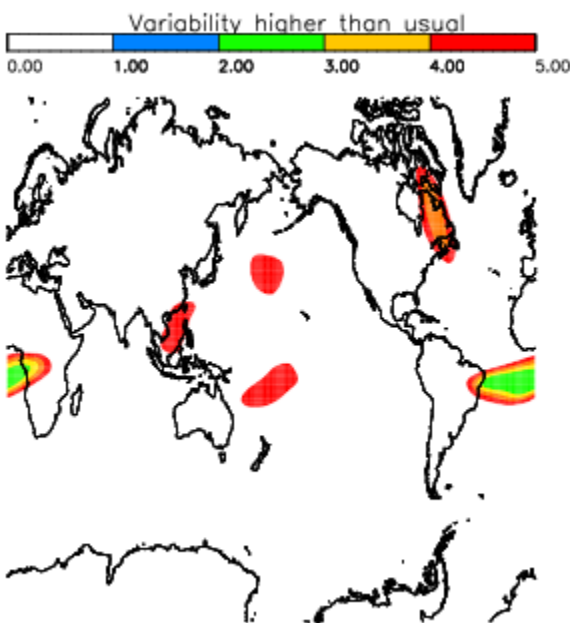


Major Space Weather Event (6-9 Sep)

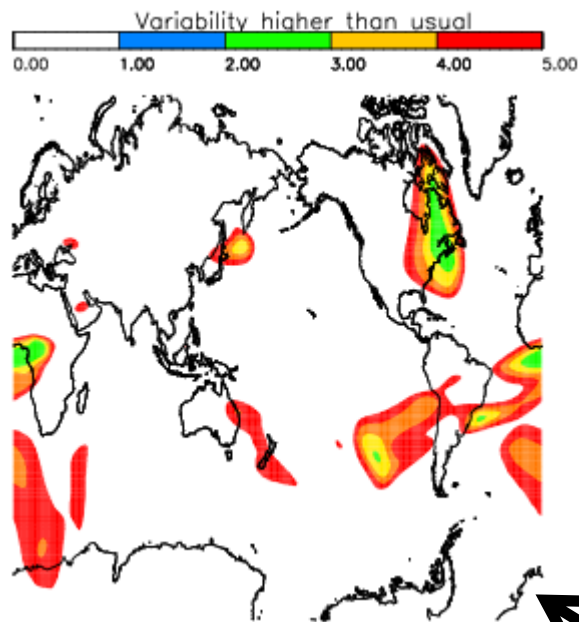


Z-score of
variability

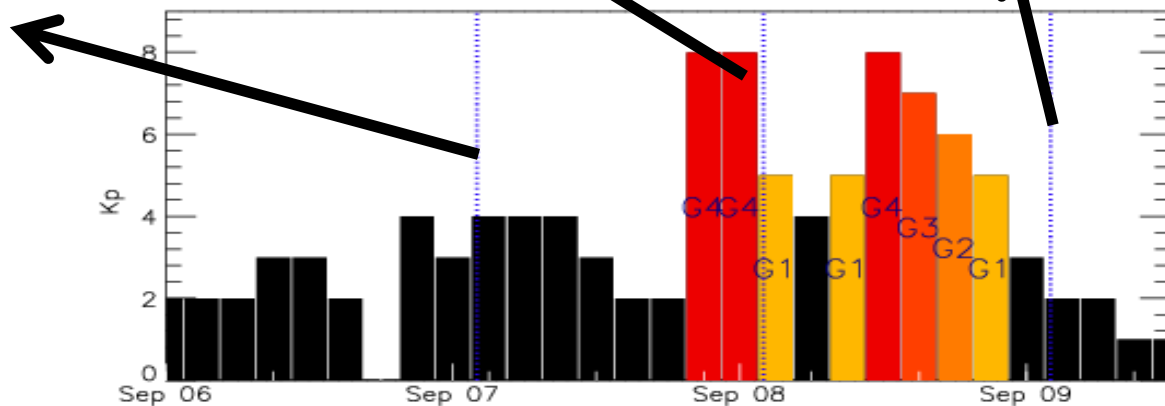
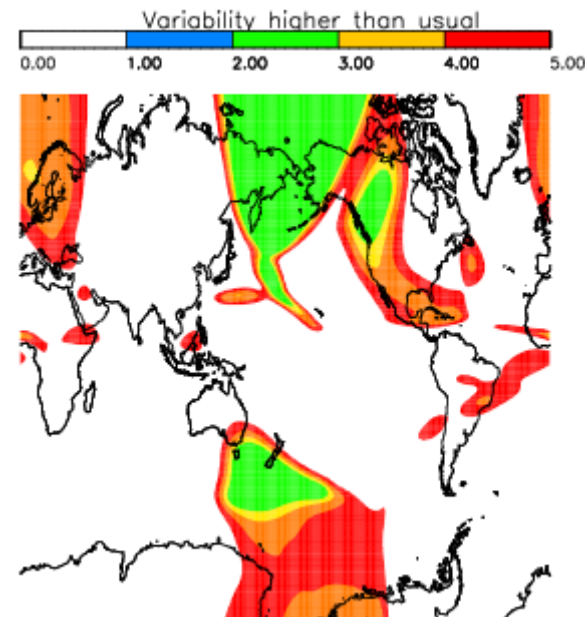
Day before storm onset
– few incidents of
extreme ionospheric
variability



Storm main phase – significant
increase in occurrence of
extreme variabilities



Storm recovery phase – more
wide spread occurrence of
extreme variabilities



Major Space Weather Event (6-9 Sep)

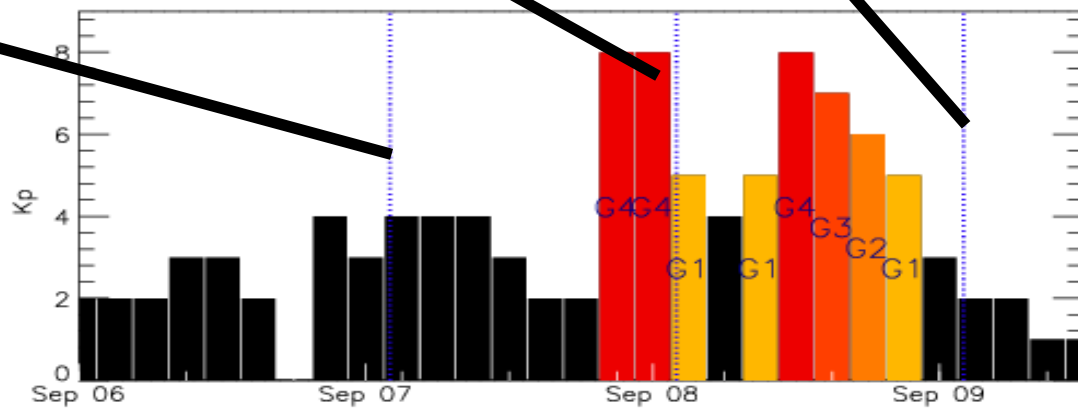
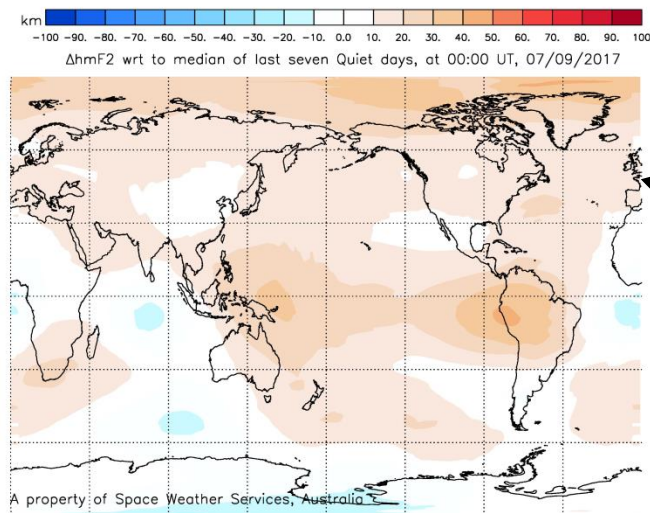
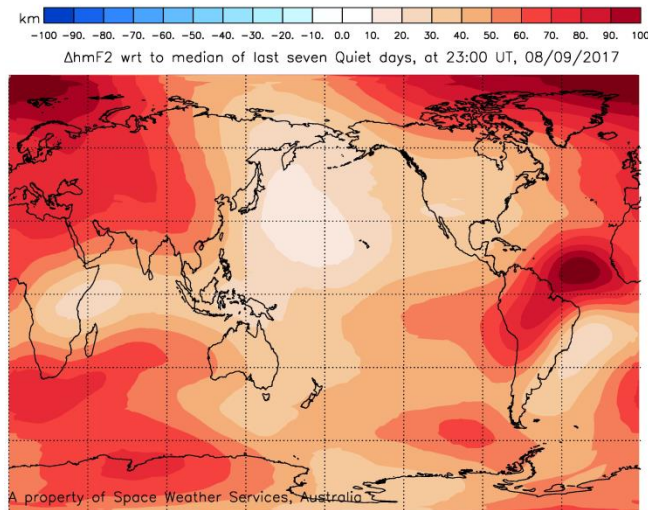
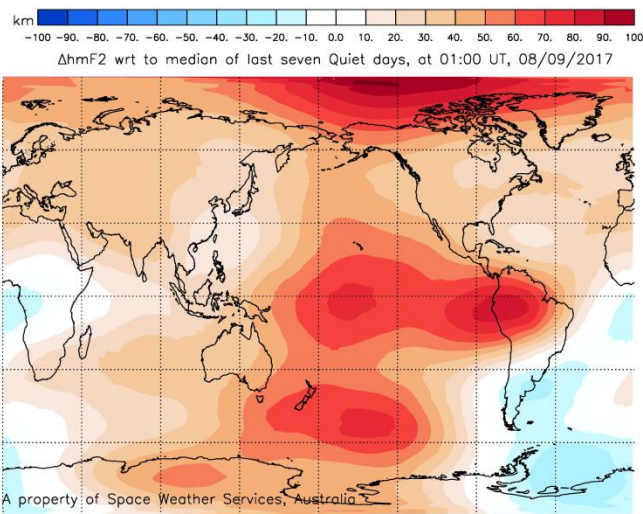


Storm main phase – significant increase in hmF2

Storm recovery phase – hmF2 continue to be enhanced

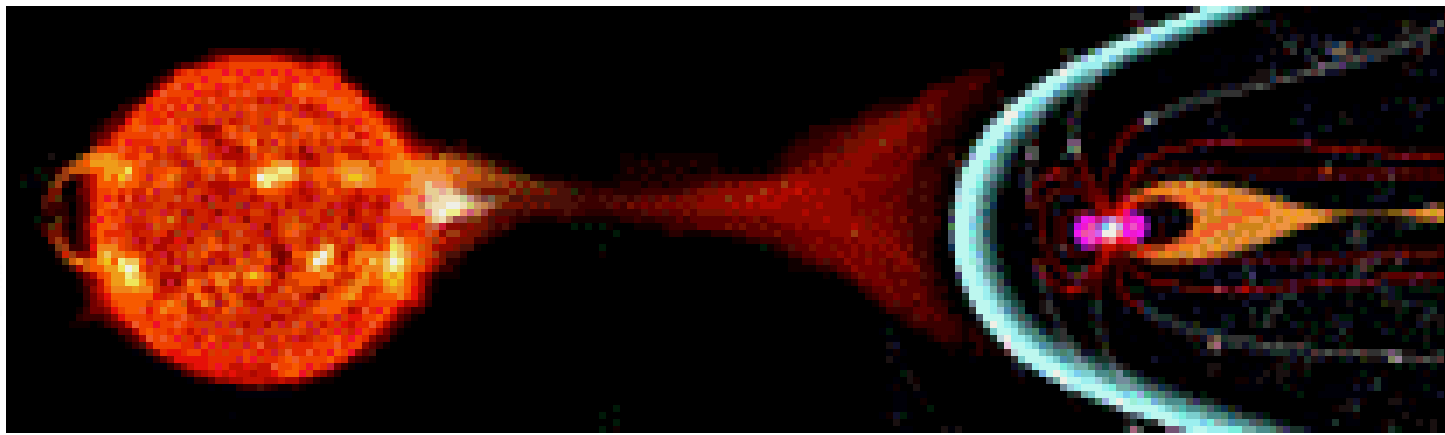
**Depression
Enhancements**

**Day before storm onset
– very weak few 10s of
km increases in hmF2**





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Thank you...

Vickal Kumar

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