Strong-Extreme Events of September 2017

- Moderators: Delores Knipp (CU Boulder), Hyunju Connor (UA Fairbanks)
- **15:30 - 15:45** Delores Knipp: Event Overview
  - Shasha Zou Merging of storm time midlatitude traveling ionospheric disturbances and equatorial plasma bubbles
- **15:45 - 16:00** Liying Qian: Solar Flare and Geomagnetic Storm Effects on the Thermosphere and Ionosphere
- **16:00 - 16:15** Tomoko Matsuo: High-latitude electrodynamics
- **16:15 - 16:30** Naomi Maruyama: Plasmaspheric Erosion
- **16:30 - 17:00** Discussion/2-3-slide presentations
  - Sebastijan Mrak (BU): MI-coupling over American sector: conjugated ionosphere-magnetosphere observations.”

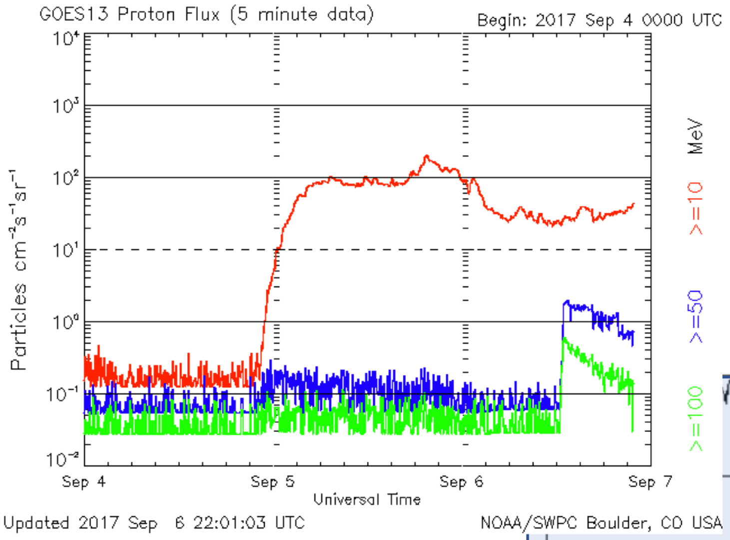
The strong to extreme events of September 2017

Emissions from active region 12673

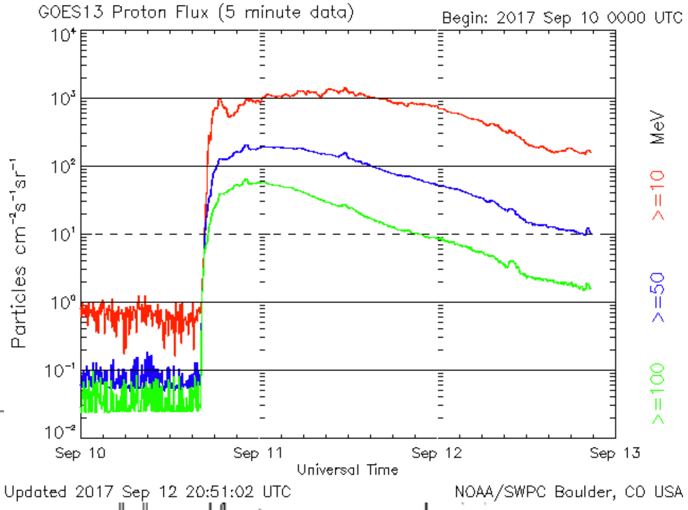
Impacts at Earth

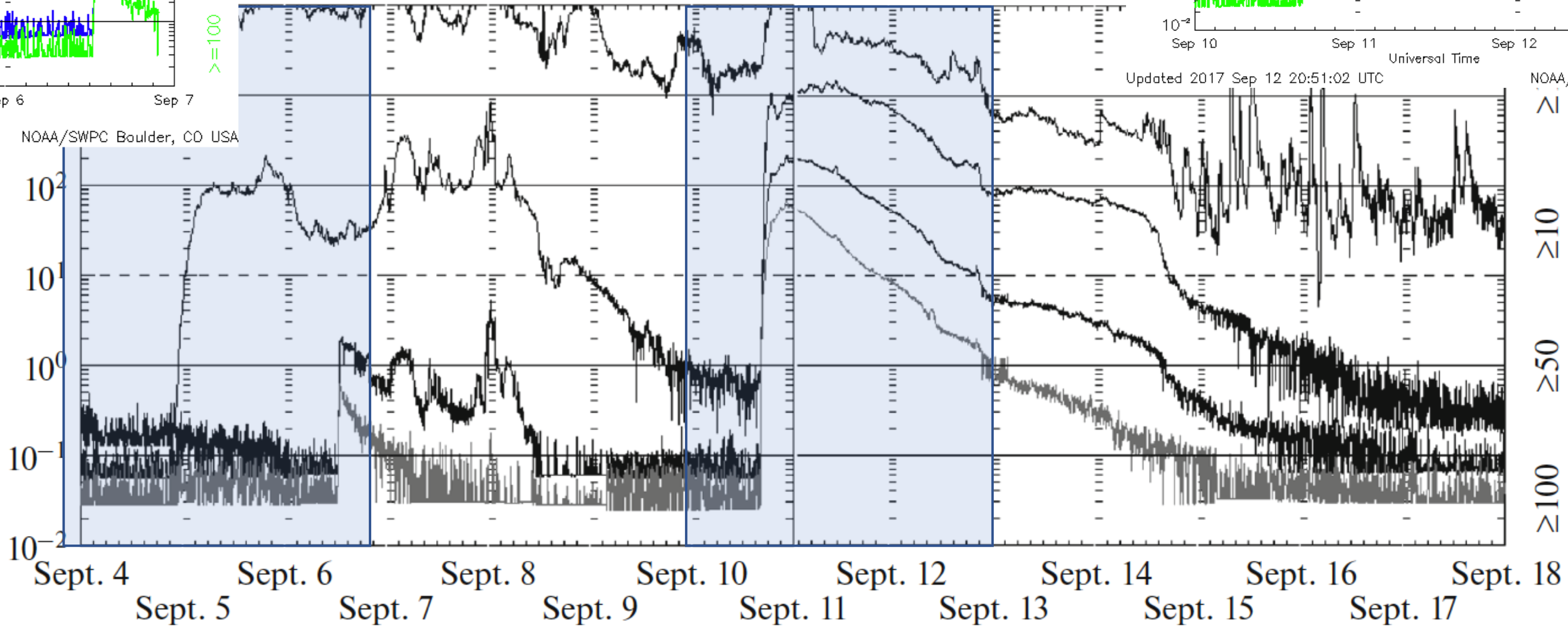
Delores Knipp CU Boulder
& many data providers and authors

S2



S3 & GLE



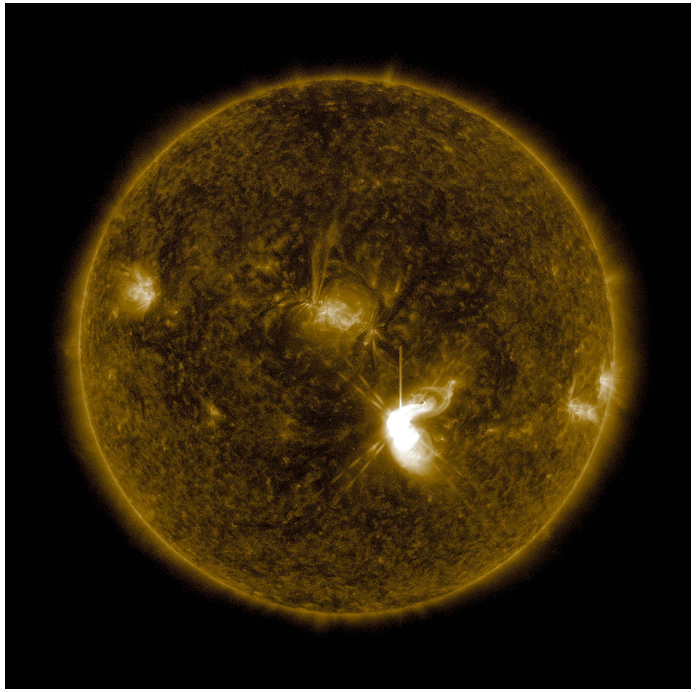


GOES 11
SEPs

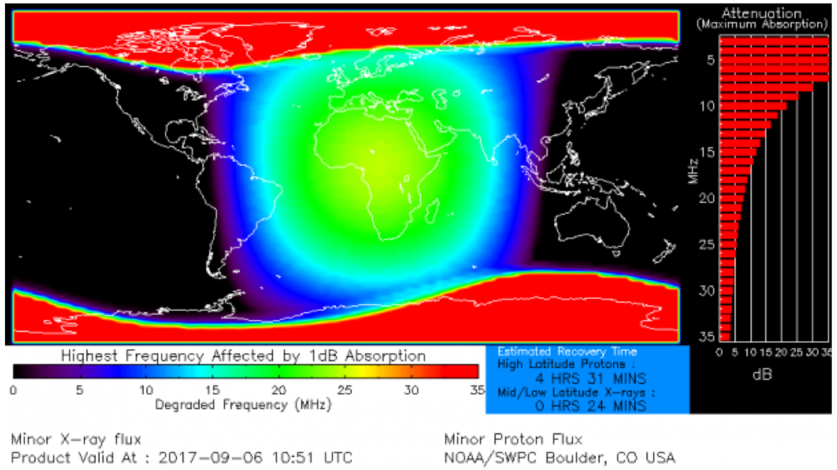
Ishkov, 2018

X2.2, X9.3, and X1.7 on Sep 6
and X1.3 on Sep 7 from AR 12673

SDO

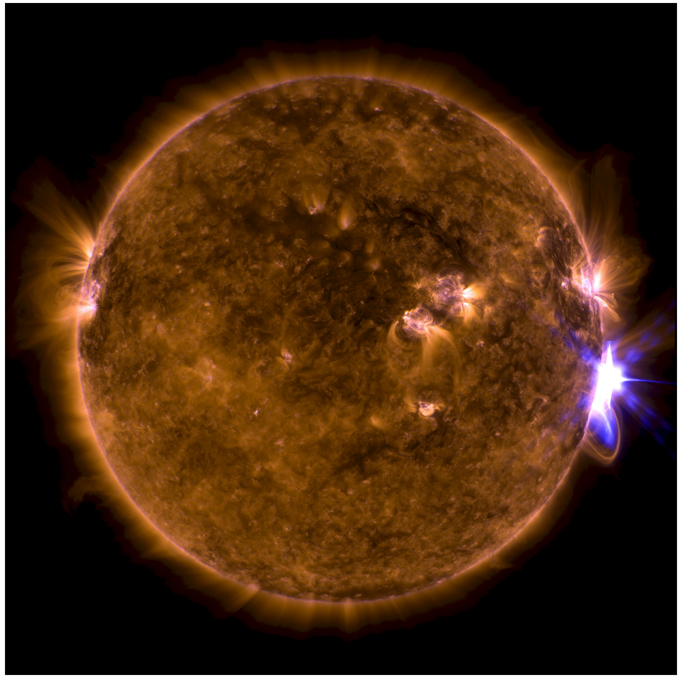


6 September SWPC
radio propagation disruption forecast

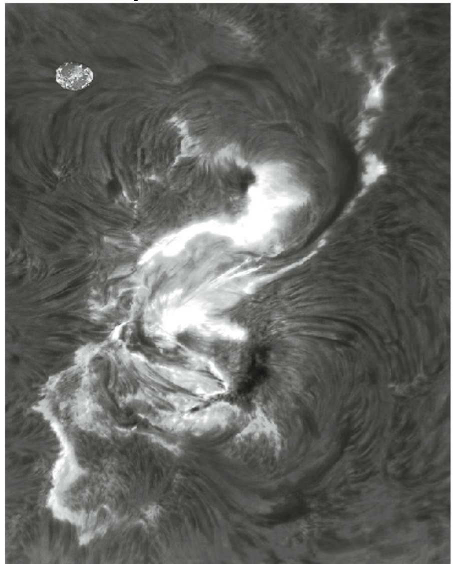


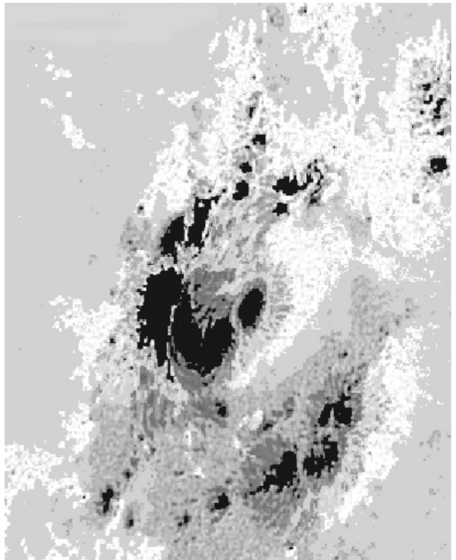
SWPC

X8.2 on Sep 10



H alpha 6 Sep White Light

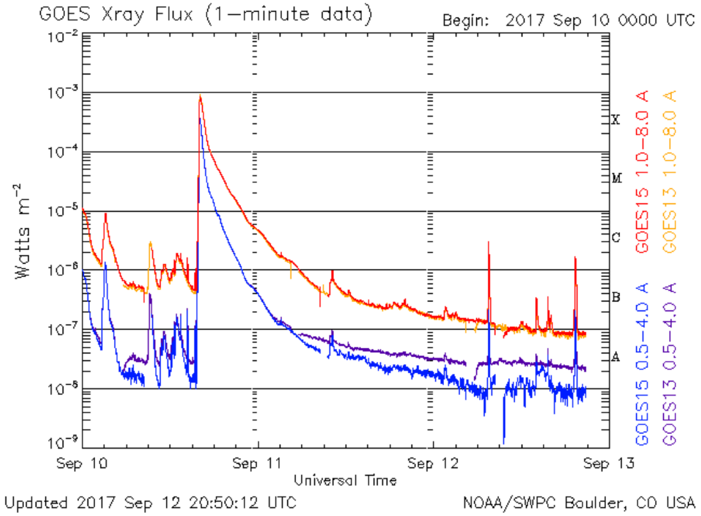




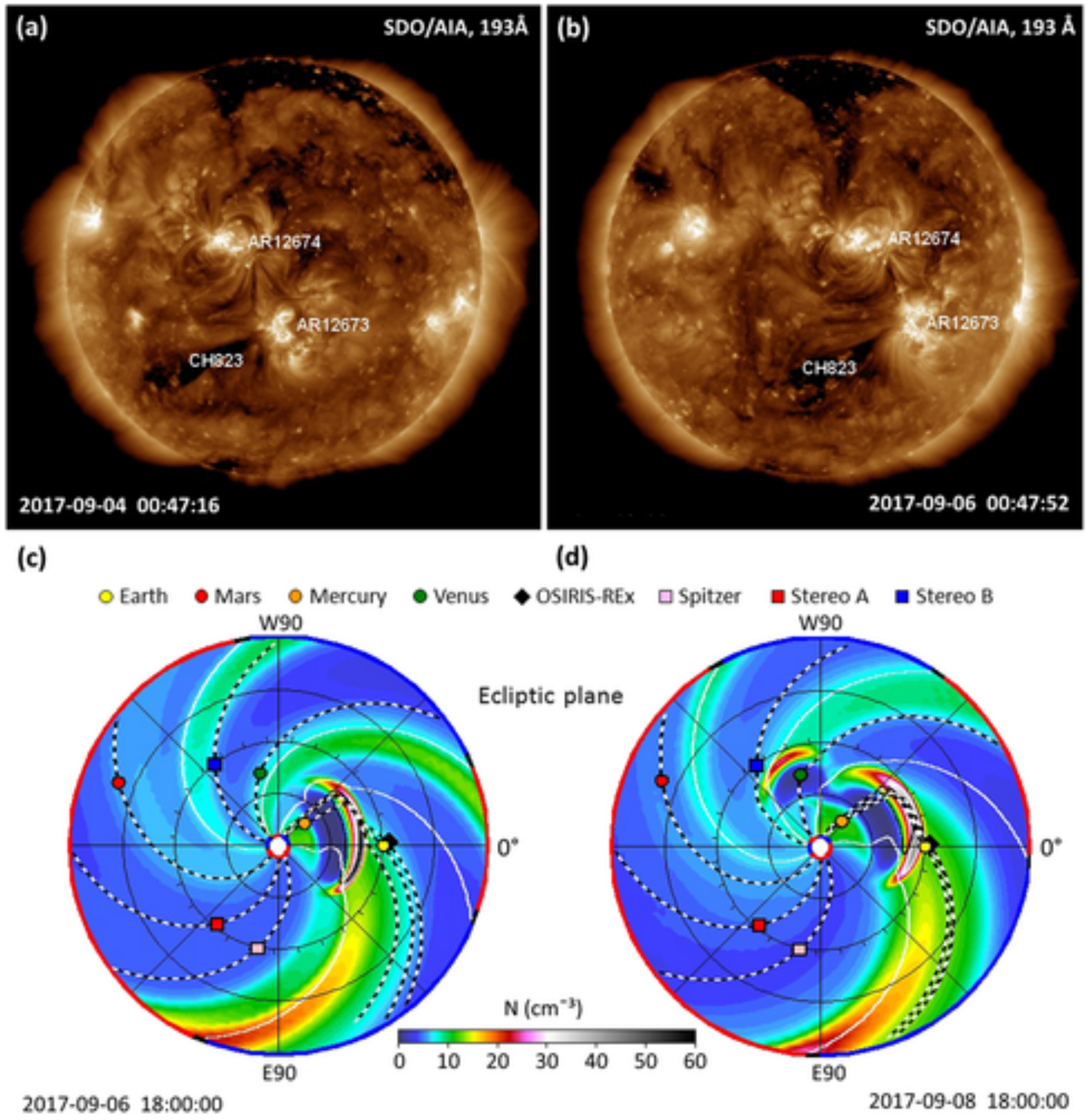
- Series of eruptions between 4 and 10 September produced extraordinary effects at Earth
- Kp 8 : Dst ~-150 nT
- Some effects just now coming to light
- MI coupling to be investigated

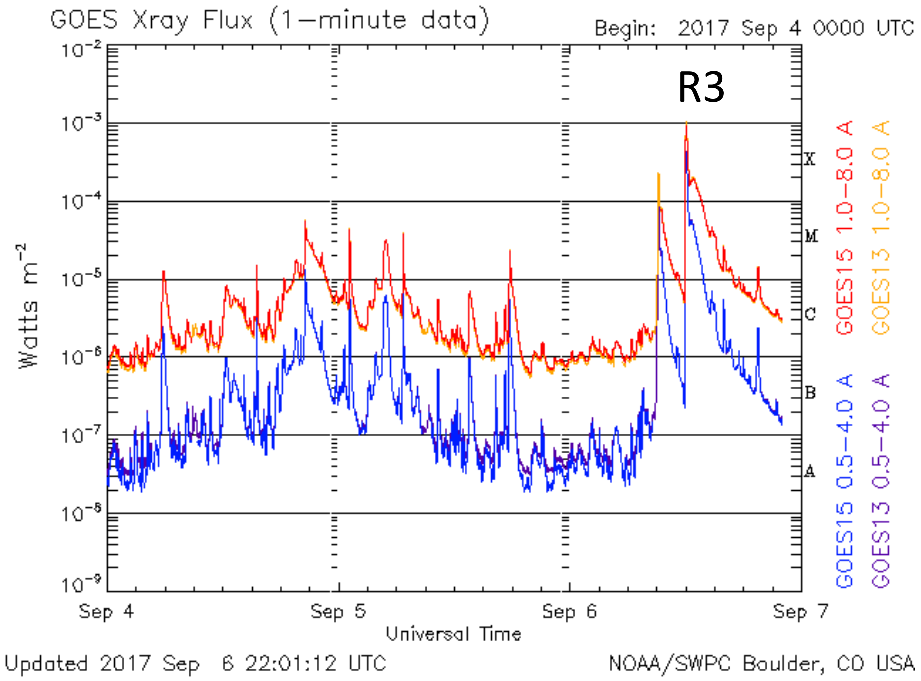
Ishkov, 2018

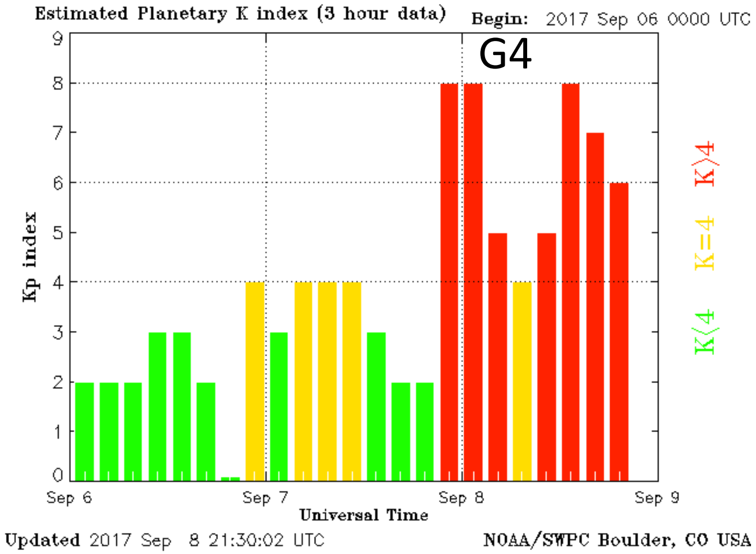
SDO



Solar Eruptions, Forbush Decreases, and Geomagnetic Disturbances From Outstanding Active Region 12673



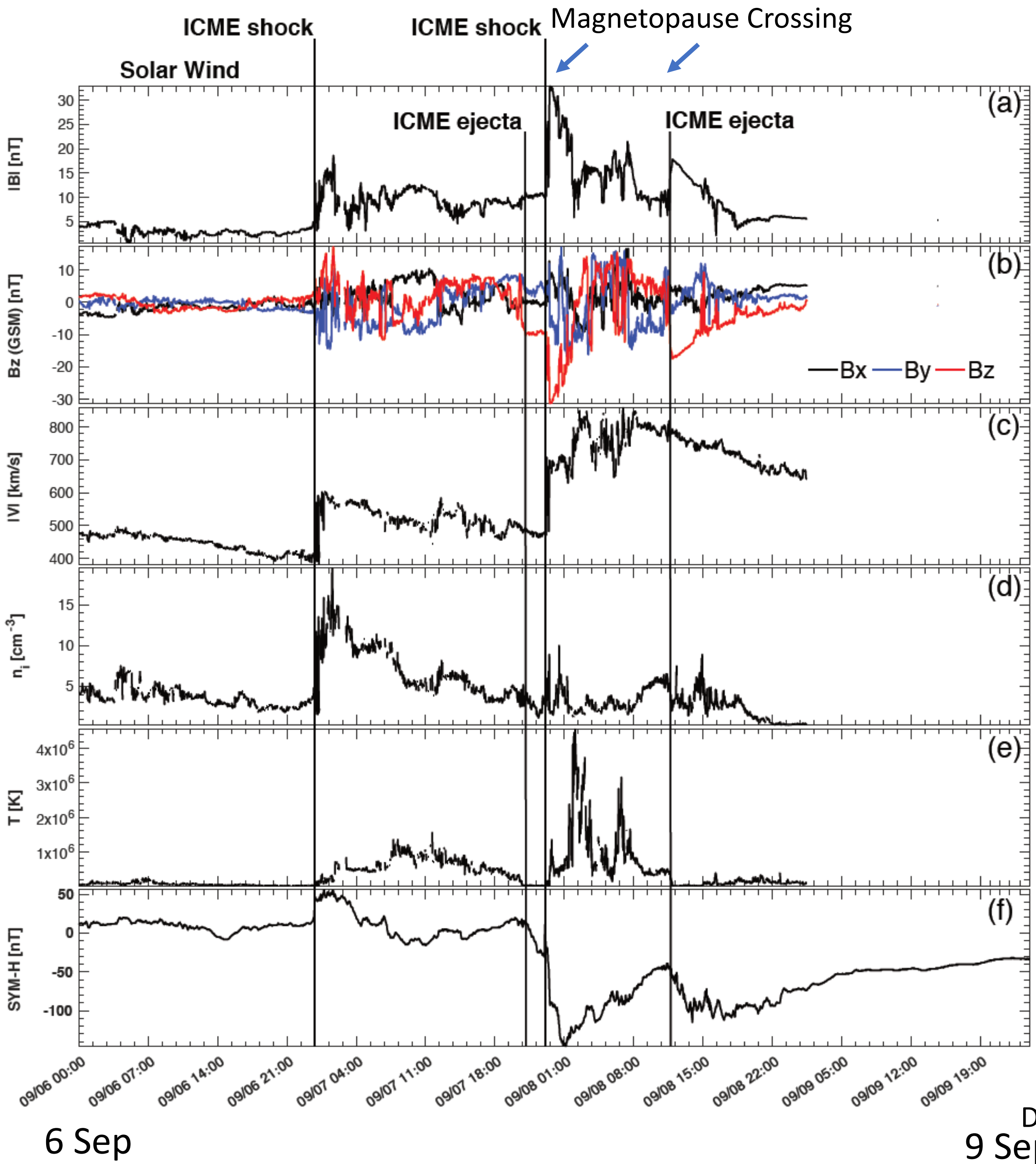




Chertok et al, 2018

Space Weather, Volume: 16, Issue: 10, Pages: 1549-1560, First published: 23 September 2018, DOI: (10.1029/2018SW001899)

6-9 Sep 2019



Dimmock et al., 2019, Space Weather

Sep 06/2300 UT IP1 Shock Arrival

Sep 07/2030 UT ICME 1 arrival Bz -

Sep 07/2300 UT IP2 Shock Arrival

Amplified Bz – in prior ICME

GICs Finland

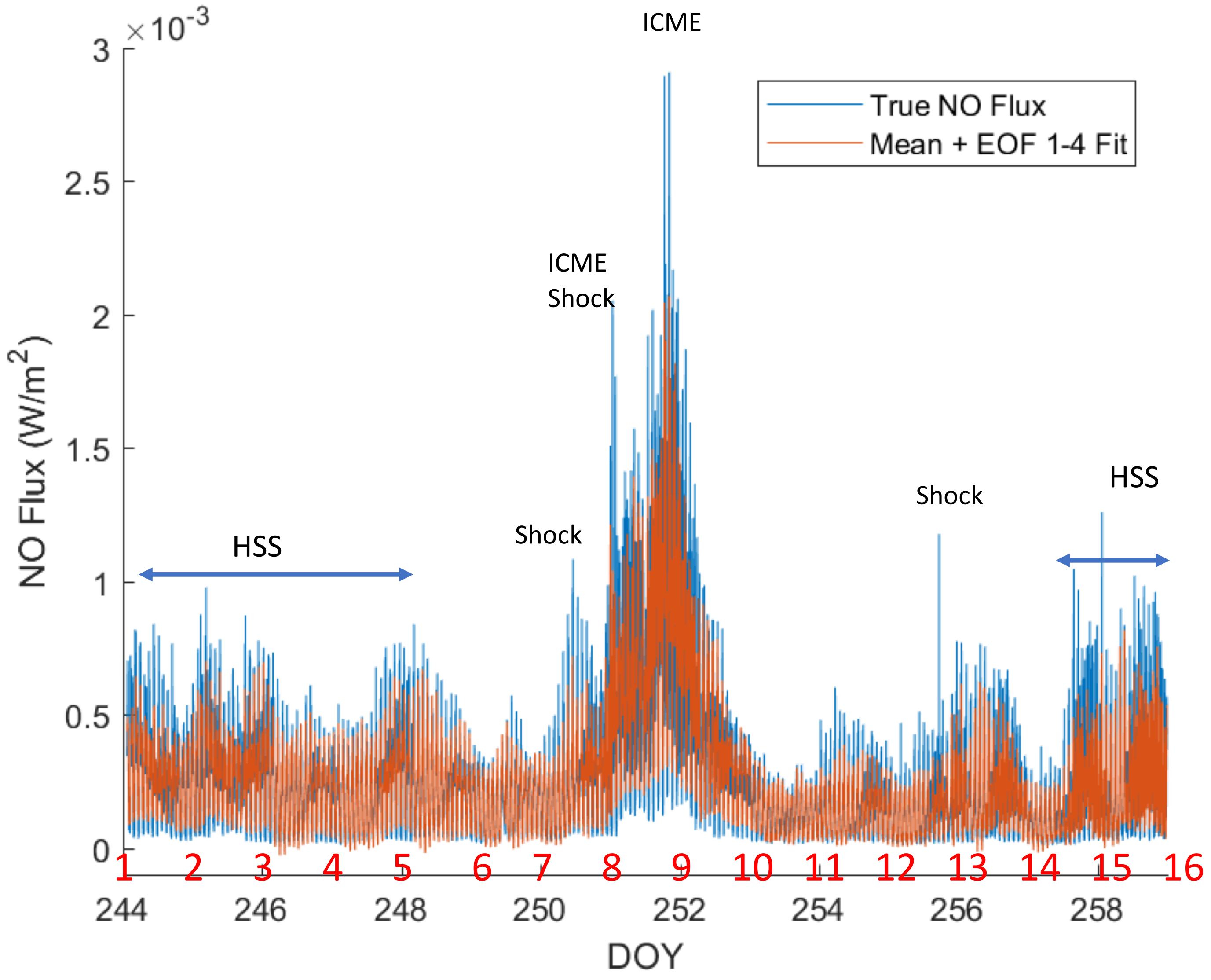
Sep 08/1100 UT ICME 2 arrival Bz –

GICs Finland

Sep 08/1800 UT Rarefaction?

GICs Finland

Nitric Oxide: Upper Atmosphere Thermostat

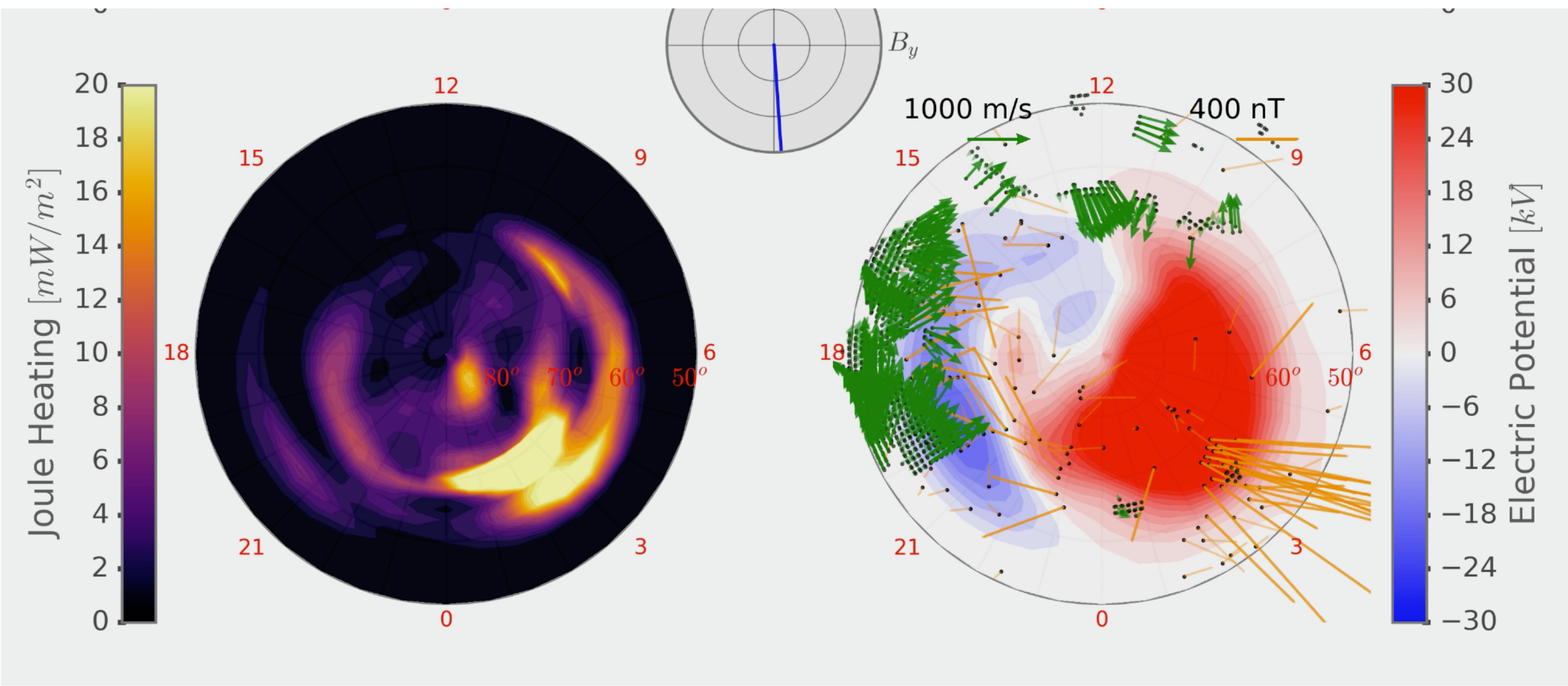


September 1-15 2017

Knipp and Flynn Work in Progress 2019

Assimilative Mapping of Geospace Observations

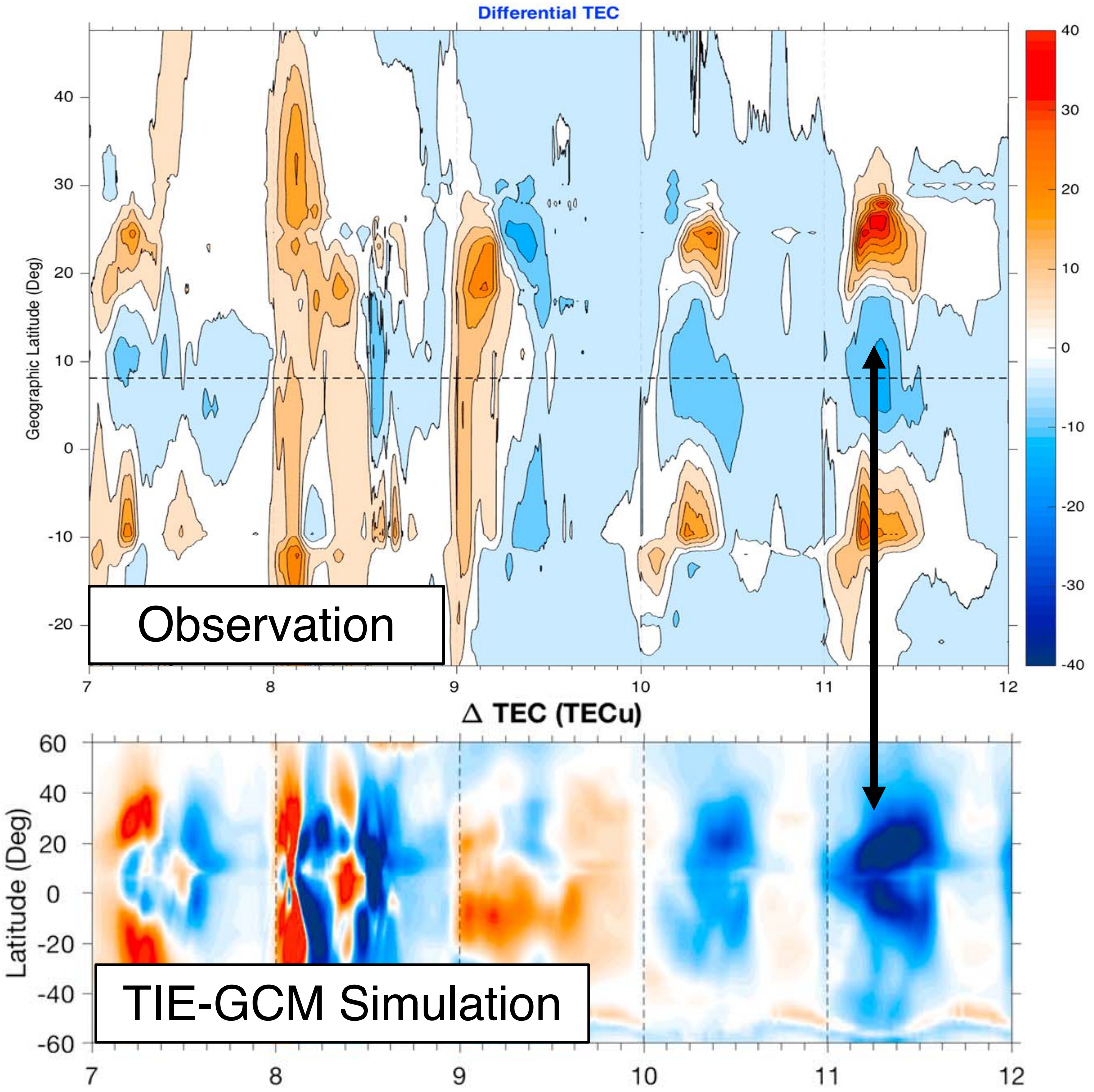
Matsuo and Kilcommons (to be presented next Work in Progress, 2019)

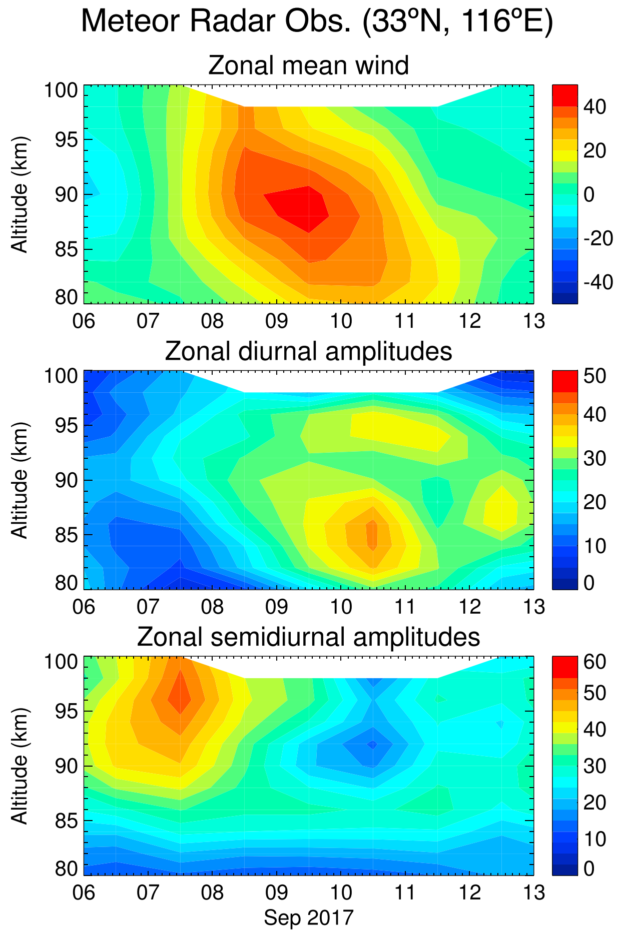


Sep 8 2017 0102 UT

September 2017 Observations and TIE-GCM Simulations

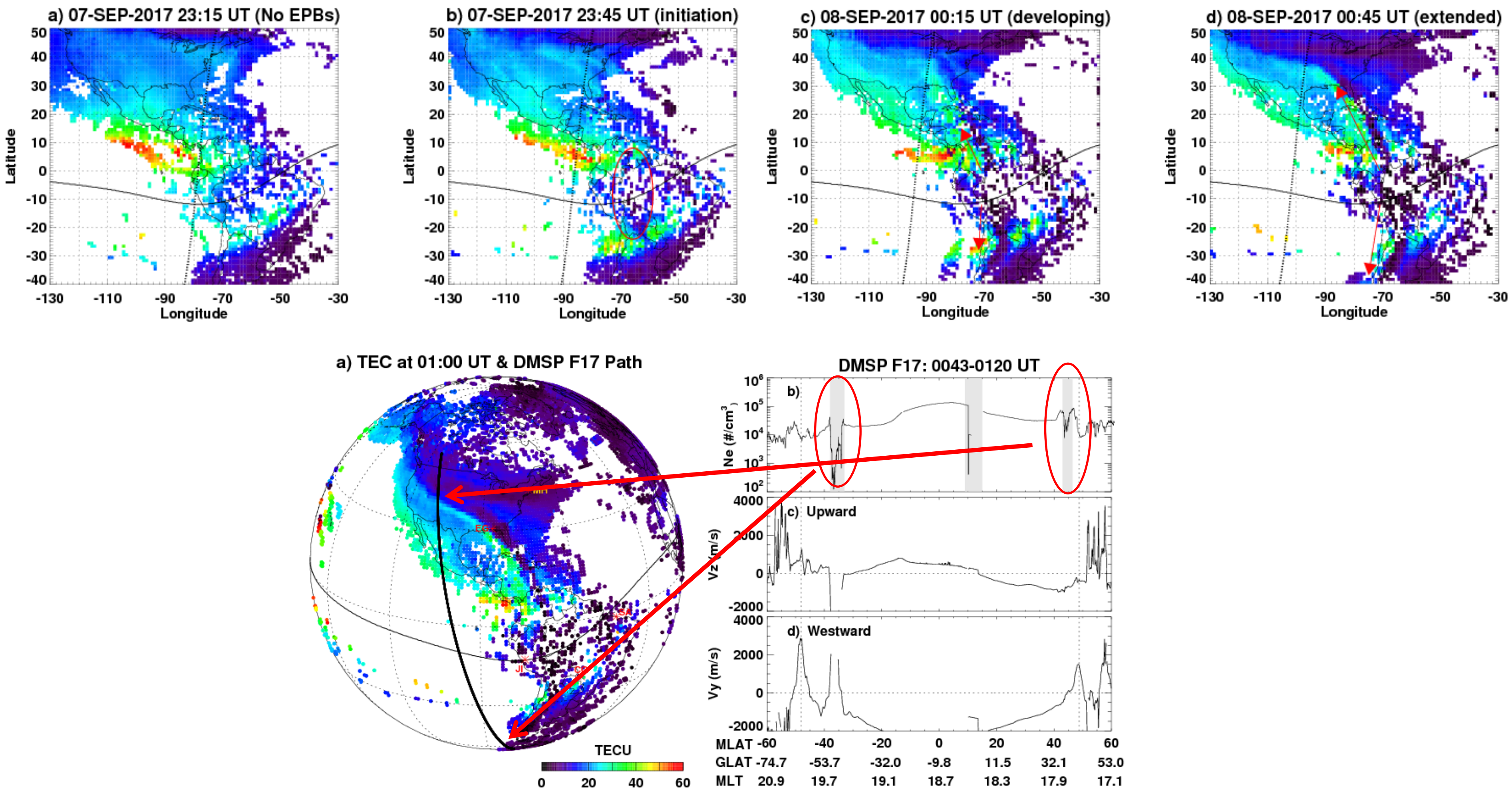
TEC





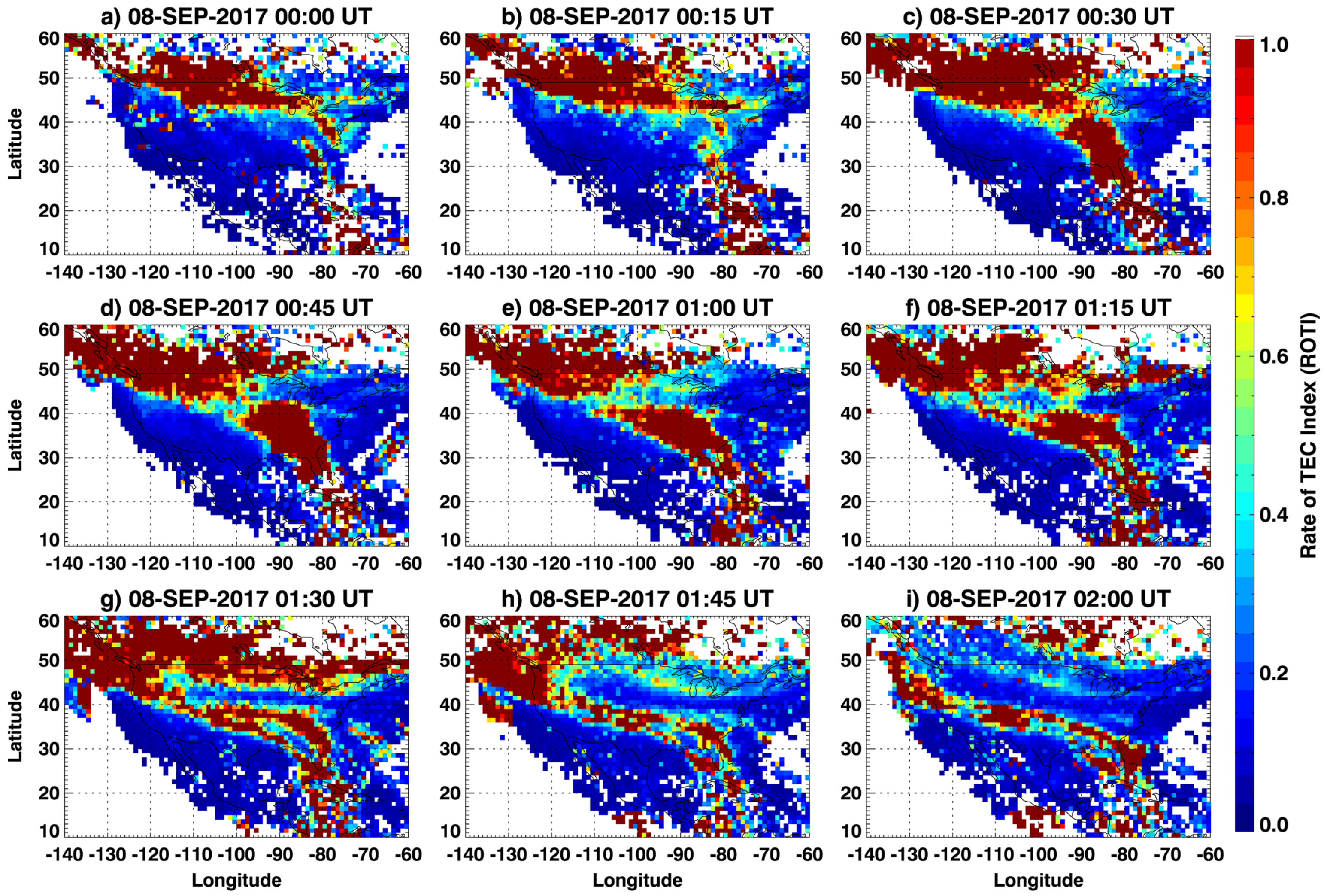
(Lei et al., 2018, https://doi.org/10.1029/2017JA025166)

Super Equatorial Plasma Bubble (EPB) observed in American Sector



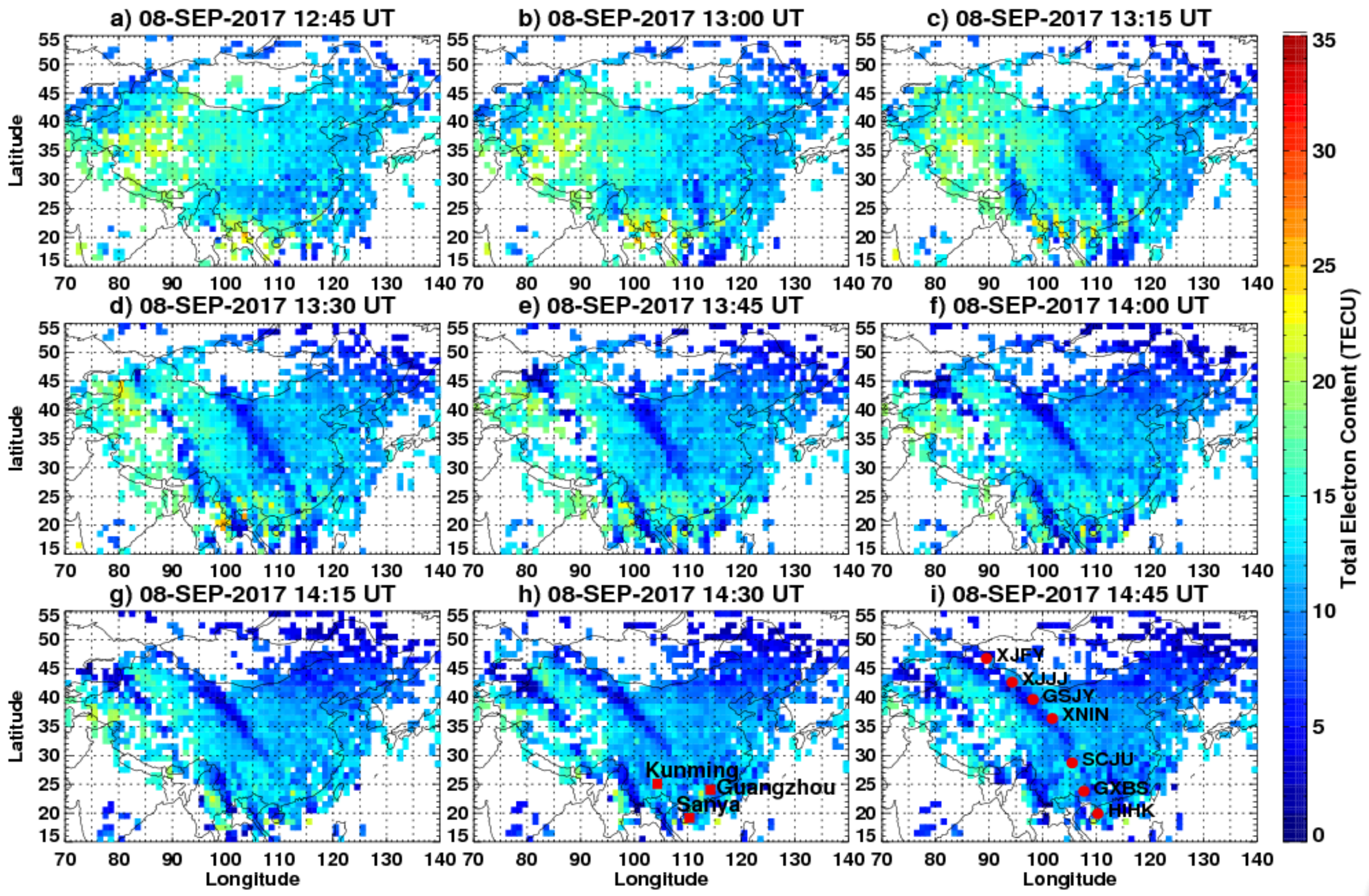
Aa, E., Zou, S., Ridley, A. J., Zhang, S.-R., Coster, A. J., Erickson, P. J., et al. (2019). Merging of storm time midlatitude traveling ionospheric disturbances and equatorial plasma bubbles. *Space Weather, 17.* https://doi.org/10.1029/2018SW002101

Merging of Storm Time Midlatitude Traveling Ionospheric Disturbances and Equatorial Plasma Bubbles



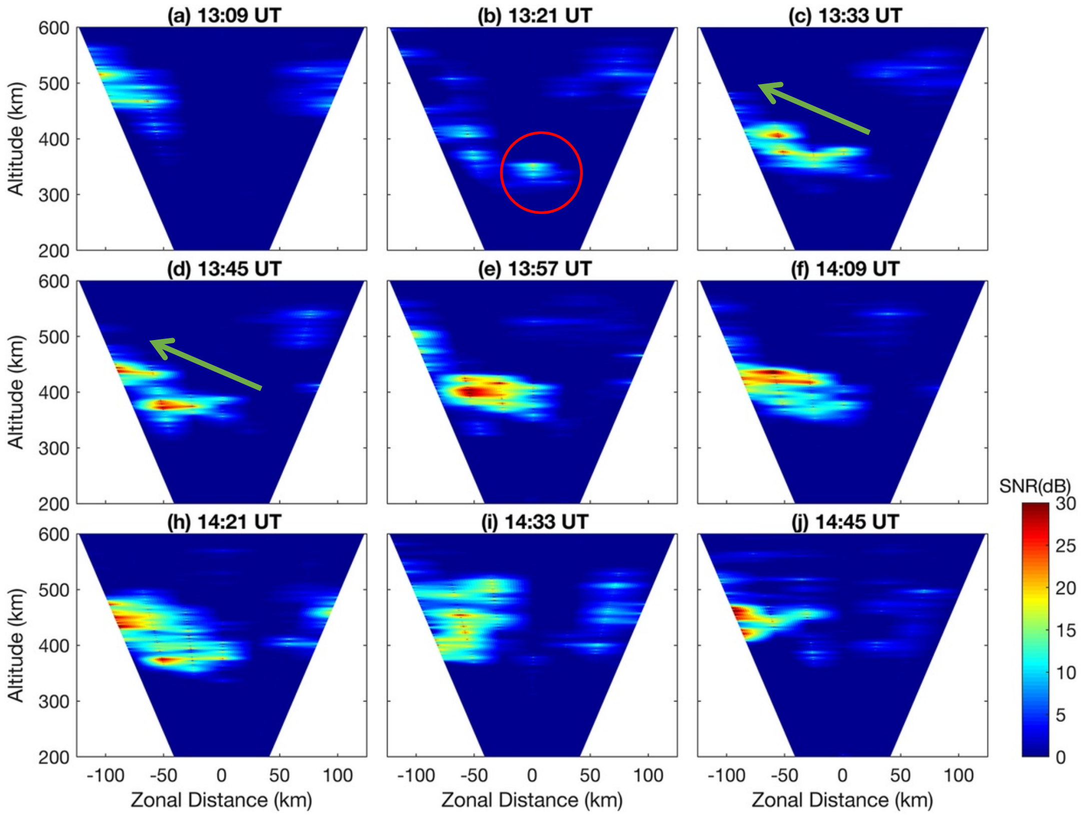
Space Weather, Volume: 17, Issue: 2, Pages: 285-298, First published: 16 December 2018, DOI: (10.1029/2018SW002101)

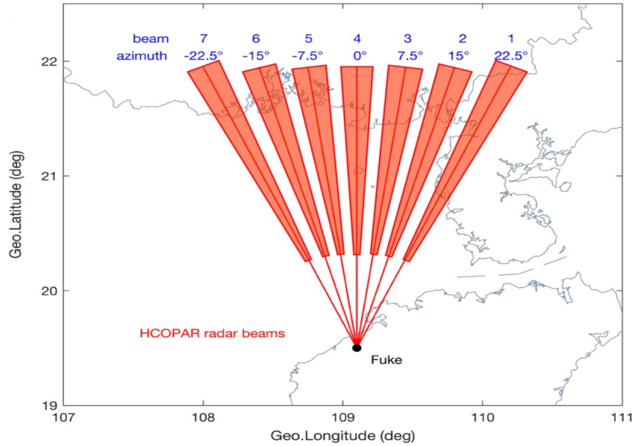
Super Equatorial Plasma Bubble (EPB) observed in Asian Sector



Aa, E., Huang, W., Liu, S., Ridley, A., Zou, S., Shi, L., et al. (2018). Midlatitude plasma bubbles over China and adjacent areas during a magnetic storm on 8 September 2017. Space Weather, 16, 321–331. https://doi.org/10.1002/2017SW001776

"Baby" Equatorial Plasma Bubble (EPB) seen by Hainan coherent scatter phased array radar (HCOPAR)





Fan sector maps of the backscattered echo SNR in the zonal-vertical plane on Sep 8, 2017.

Jin, H., Zou, S., Chen, G., Yan, C., Zhang, S., & Yang, G. (2018). Formation and evolution of low-latitude F region field-aligned irregularities during the 7–8 September 2017 storm: Hainan coherent scatter phased array radar and digisonde observations. Space Weather, 16, 648–659. https://doi.org/10.1029/2018SW001865

Flare and SEP effects September 2017 (See Ref list)

- **Solar events impacted high-frequency radio links** for ground and aviation communication
- Observations and models show flare-induced ionospheric enhancements of N_e and T_e lead quickly to plasma escape
- No GNSS losses-of-lock from 6 September X class flares,
  - **however GPS positioning error increased by ~3 times in precise point positioning solution.**
  - The critical effects are based on rapid changes of the dayside ionosphere during the peak phase of the flare event
- The SRB associated with the X9.3 flare did not impact GNSS communication,
  - but the X-ray emission caused blackout in HF propagation
- Strong L-band solar radio bursts associated with a severe solar flare interfered with GNSS signal frequencies at L2/L5
  - Dual-frequency positioning was more affected than single-frequency positioning
- The X9.3 flare on 6 September 2017 triggered enhancements of ionospheric electron density and temperature but not ion upflow immediately
- Up to 14-dB attenuation at 12 MHz was measured in the polar caps, **resulting in backscatter loss for SuperDARN radar**s

Space Weather Journal Special Collection of the September 2017 storms

Geomagnetic Storm Effects (See Ref list)

- A series of CMEs from 4–6 Sep 2017 interacted and formed two IP shocks reaching Earth on 6–9 September
- The solar wind plasma was preconditioned by several merged CMEs from 4–5 September to exert little resistance against the 6 September CME
- **Transformers in New Zealand** show a sequence of large geomagnetically induced currents (GIC) during storm
    - Primarily even harmonics generated by transformer saturation when GIC > 15 A
- Longer-lasting GIC generated observable harmonics but limited GIC impact from impulsive solar wind shocks
- **The maximum peak GIC in Sweden** did not coincide with the sudden storm commencement
- Largest GIC peak did not occur during particularly strong driving conditions

Space Weather Journal Special Collection of the September 2017 storms

Geomagnetic Storm Effects (See Ref list)

- Storm-induced **Prompt Penetration Electric Field (PPEF) is responsible for post-sunset Field Aligned Irregularities**, substorm-related overshielding *E* field leads to post-midnight FAIs
- The plasma bubbles were triggered by PPEF and Traveling Ionospheric Disturbances in equatorial regions and extended along the magnetic field lines to 50°N (45.5 MLAT)
- **Plasma bubbles might reach an altitude of 6,600 km** over the magnetic equator with the upper limit of upward drift speed being around 700 m/s
- Post-sunset Equatorial Plasma Bubbles (EQB) driven by PPEF were observed to merge with midlatitude TIDs forming stream-like depletion structures over American sector
- Depletions reached 46 MLAT that map to 6,800 km over the equator and drifted westward reaching the equatorward boundary of the main trough
- **Strong convection flow near SAPS region** and disturbance thermospheric wind contributed to the westward drift of the midlatitude depletions
- An **extreme erosion of the plasmasphere** was observed by the ERG/Arase spacecraft (LPP=1.6~1.7).
- The trough minimum location identified in GNSS-TEC moved equatorward as low as ~48° magnetic latitude (L=~2.2).
- The observed erosion was qualitatively reproduced by the IPE simulation by including the effect of the penetration electric field.

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Geomagnetic Storm Effects (See Ref list)

- Geomagnetic cutoff models do not capture the idiosyncratic and dynamic particle access to a satellite's location inside the magnetosphere

- The O^+ outflow in the polar cap and cusp is estimated to be 10^{13} $m^{-2}s^{-1}$ during the main phase of the geomagnetic storm

- **Input from GEM community needed for this event!**

Space Weather Journal Special Collection of the September 2017 storms

References

- **See partial Reference list in associated document on google drive.**