राज कुमार चौधरी / RAJ KUMAR CHOUDHARY

वै/अभि. एसजी Sci/ Engr. SG

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अनुशंधानिक अभिरुचि / Research Interests :

मैं एक अंतरिक्ष भौतिक विज्ञान शोधकर्मी हूँ तथा रेडियो तकनीकों का उपयोग कर पृथ्वी और ग्रहों के आयनमंडल एवं वायुमंडलीय प्रणाली का अध्ययन करता हूँ । निम्नलिखित मेरी शोध अभिरुचि में शामिल हैं:

- ग्रहों और पृथ्वी के आयनमंडल और वायुमंडल का अध्ययन हेतु रेडियो प्रच्छादन (आरओ) तकनीक का उपयोग
- पृथ्वी की आयनमंडलिय प्रणाली और अंतरिक्ष मौसम की घटनाओं के प्रति इसकी प्रतिक्रिया का अध्ययन करने के लिए जीसैट और जीपीएस रेडियो तरंगों का उपयोग
- भारतीय निम्न अक्षांश क्षेत्र के लिए आयनमंडलिय मॉडल (प्रथम-सिद्धांत एवं आंकड़ा (तथ्य) आधारित अर्ध-अनुभवजन्य मॉडल) का विकास।
- पृथ्वी के इलेक्ट्रोडायनामिक्स विषय सम्बंधित अध्ययन हेतु सुसंगत बैकस्कैटर वीएचएफ/एचएफ रडार का उपयोग
- पृथ्वी के विभिन्न वायुमंडलीय क्षेत्रों के बीच युग्मन का अध्ययन करने के लिए वायुमंडलीय गतिशील प्रक्रियाओं जैसे QBO, ENSO, गुरुत्वाकर्षण तरंगों, संवहन प्रक्रियाओं का अध्ययन।

I am an ionospheric physicist who uses radio techniques to study the Earth's and Planetary ionospheric & atmospheric system. My research interest involves :

- Use of **Radio Occultation (RO)** technique to study Planetary and the Earth's Ionosphere & atmosphere
- Use of **Radio signals from GSAT** and GNSS radio signals to study the Earth's ionospheric system and its response to the space weather events
- Development of **ionospheric model** (both the first-principle, and data based semi-empirical models) for Indian low latitude region.
- Use of **coherent backscatter VHF/ HF radar** to study the Earth's electrodynamics
- Study of **atmospheric dynamical processes** including QBO, ENSO**,** gravity waves, convection processes to study coupling between the Earth's different atmospheric regions.

शिक्षा / Educations :

1. **Ph.D.** University of Delhi, New Delhi, India, 1999
   Work at National Physical Laboratory(NPL-CSIR), New Delhi
   Thesis title: A Study of the tropical E-region field aligned

irregularities using Indian MST radar.

2. **M.Sc.** (Physics) University of Delhi 1991
3. **B.Sc.** (Physics), Ranchi University, Ranchi, Jharkhand 1988

व्यावसायिक अनुभव/ Professional Experience :

- Jan 2020 – till date , Scientist/ Engr. SG, SPL, VSSC
- Jan 2014 – Dec 2019, Scientist/Engr SF, SPL, VSSC
- Dec 2007– Dec 2013 Scientist/Engr. SE, SPL, VSSC
- Aug 2004– Nov 2007 Professional Research Associate, Institute of Space and Atmospheric Studies (ISAS), Saskatoon, Canada
- Jan 2002 - July 2004 Postdoctoral Fellow, Univ. of Western Ontario, London, Canada
- Dec 1999 – Dec 2001 Research Associate, NPL, New Delhi
- Dec 1998 – Nov 1999 Extended SRF (CSIR), NPL, New Delhi
- Nov 1997 – Nov 1998 Project Associate, NPL, New Delhi
- Nov 1994 – Oct 1997 SRF (CSIR), NPL, New Delhi
- Nov 1992 – Oct 1994 JRF (CSIR-NET), NPL, New Delhi

इसरो में शामिल होने के पष्चात नई पहल / New Initiatives after joining ISRO :

- Initiated, for the first time in India, the **use of satellites' radio signals in Radio Occultation** mode to study the ionosphere and atmosphere on the Moon and other planets :
  - Used single frequency **S-band radio signals to study the ionosphere on the Moon**. Results were published in Geophysical Research Letters (GRL), AGU
  - Proposed and conducted experiments with **RAMBHA-DFRS,** a dual frequency radio science experiment **onboard Chandrayaan-II Orbiter** which led to the discovery that the wake region of the Moon can have plasma density as high as the D-region of the Earth's ionosphere (results published in MNRAS-Letters)
  - As a lead scientist from India for **the Akatsuki (Japanese Satellite)** Radio Science Payload, conducted extensive experiments Indian Deep Station Network (IDSN), Byallau, Bangalore, to study the ionosphere and atmosphere of Venus.
- Conceived, and developed the algorithm to retrieve physical parameters for characterizing planetary atmosphere and ionosphere using radio occultation techniques
- Initiated a new science program in SPL to study and model the impact of space weather events over the Indian ionospheric region. Under this science program, called **InSWIM** (Indian network for Space Weather Impact Modeling), established ten stations in India (Trivandrum, Bangalore, Hyderabad, Bhopal, New Delhi, Hanle, Pune, Kadapa, Port-Blair, and Kavaratti) where multi-channel, multi-frequency GPS/ GSAT receiver systems are monitoring round-the-clock variations in the Indian ionospheric region.
- Initiated a science program, called **EcSES** (Energetic coupling between Sun-Earth System), to study the impact of solar dynamics on the near-Earth space environment. Under this plan, a multi-channel, multi-frequency GPS/GSAT receiver system has been placed at Indian Antarctica station Bharti. A similar system is planned to be established at Himadri, in the Arctic region as well.
- Developed a first-principle ionospheric model suitable for the Indian low-latitude ionospheric region. In its first phase, a quasi-two-dimensional ionospheric model was developed which includes photochemical and energetic plasma impacts on the production of ions. The model was later extended to Venus and Moon ionosphere too. This is the first theoretical model developed for the Indian ionospheric region

व्यावसायिक उत्तरदायित्व / Professional Responsibilities :

- **Principal Investigator** : **RAMBHA-DFRS** (Dual Frequency Radio Science) experiment on the Chandrayaan-II Lander and Orbiter
- **Principal Investigator** : **RAVI** (Radio Anatomy of Venus Ionosphere) experiment shortlisted for Venus Orbiter Mission, ISRO
- **Lead Scientist (India)** : **Akatsuki (Japanese mission to Venus) Radio Science** experiment for the study of ionosphere and atmosphere of Venus
- **Principal Investigator** : **InSWIM** (Indian network for Space Weather Impact Modeling), a science project of SPL, VSSC
- **Principal Investigator** : **EcSES** (Energetic coupling between Sun-Earth system)
- **Principal Investigator** : **PlasDEM** (Plasmaspheric Density Measurements), a technology development project for plasmaspheric electron density measurements.

शैक्षणिक उत्तरदायित्व / Academic Responsibilities :

Ph. D. thesis supervision
Completed : 03
Ongoing : 02

M. Phil thesis supervision
Completed : 01

M. Tech Project supervision
Completed : 03

M. Sc. Project supervision
Completed : 16

विद्या वाचस्पति शोध छात्र / Ph.D. Students :

- Dr Ambili K.M. (2008 – 2013) Scientist, SPL, VSSC
- Dr Shreedevi P.R. (2012-2017) PDF, Beihang University, Beijing, China
- Mr Keshav R. Tripathi (2018 - 2023)
- Ms Richa N. Jain (2020 – Ongoing)
- Mr Saumyaneal Banerjee (2023 - Ongoing)

अन्य उत्तरदायित्व / Other Responsibilities :

1. **Member, SPL – Internal Review Committee**
2. **Member, SPL – Academic Committee**
3. **Convener,** Inter – Center Experts' Committee for VHF Radar at SPL
4. **Member, Technical Review committee**, GPS-ROS for Megha-Tropiques (ROSA)
5. **Member, Algorithm Working Group**, GAGAN
6. **Member, Technical Review Committee**, GROS for Megha-Tropiques
7. **Member, Technical Review Committee**, Operationalization of GPS radiosonde for GSLV-PSLV
8. **Chair, Indian National URSI Commission – E (2014- 18)**

पुरस्कार और सम्मान / Awards and Honors :

Name of Award	Organization	Year awarded
National Merit Scholarship	Govt. of Bihar	1981
CSIR/UGC NET	CSIR, India	1991
Post-Doctoral Fellowship	NSERC, Canada	2002

वैज्ञानिक कार्यों की मुख्य विशेषताएं / Highlights of the scientific work :

1. Using S-band radio signals from India's Mars Orbiter Mission (MOM), studied the plasma characteristics in the near Sun solar coronal region and concluded that during a low solar active period, **solar wind attains saturation at lower heliocentric distances** compared to high solar activity period, a conclusion which was later supported by Parker probe measurements (**MNRAS, 2022)**.
2. Initiated in India the use of **satellite TTC radio signals** to study **planetary ionosphere** and atmosphere using Using **Radio Occupation technique**. Using measurements from Chandrayaan-I S band radio signals, proved the existence of ionosphere at Moon and proposed them to be of molecular origin (***GRL, 2016***).
3. Using measurements from the radio occultation payload DFRS on board Chandrayaan-2, for the first time, showed that in the wake region, Moon can have plasma density as high as that in the D-region of the Earth's ionosphere (***MNRASL, 2022***). This discovery gathered global interest equally among the media and the experts
4. Developed a novel Ionospheric Total Electron Content (TEC) model, **known as the ISRO-TEC model,** which was successfully used to accurately predict the temporal variations in TEC over the Indian region and **generate super-truth data for the GPS Aided Geo-Augmented Navigation (GAGAN) system for application in civil aviation sector**
5. Initiated a national level program **InSWIM** (**I**ndian **n**etwork for **S**pace **W**eather **I**mpact **M**odeling) to study impact of the space weather events on Indian low latitude ionospheric region. This program will be in great aid to India's own Satellite navigation program **NAVIC (NAV**igation with **I**ndian **C**onstellation**)**.
6. Studies the field aligned irregularities in the E-region of the Earth's ionosphere at low latitudes using Indian MST Radar, Gadanki. Some of important results, discovered for the first time, were
   - the existence of **Field aligned irregularities** at the low latitude E-region during daytime (*GRL, 1996*). It was earlier believed that such irregularities during daytime existed only in the electrojet region.
   - **Quasi-periodic** (**QP**) occurrence of field aligned irregularity **echoes** at low latitude regions during night. Such irregularity structures were earlier believed to be a mid latitude specific phenomenon (*JGR, 1999; 2005*)
   - daytime existence of meter scale size plasma irregularities at the F1 region of the Earth's ionosphere (**150-km echoes**). It was earlier believed to be an exclusive **dip-equator** phenomena (GRL, 2004).
   - demonstrated how the **VHF radar returned signal**s observed outside the electrojet belt can **provide useful means to study the metallic ion layer** variability in the earth's ionosphere (GRL,2008).
7. Used observations from VHF Radar at Phonpei, an equatorial station located in the Pacific Ocean, to study the phase velocity of radar echoes from the electrojet region (~100 – 110 km altitude). For the first time the theoretical explanation as given for the observations of **phase velocity of two-stream Farley-Bunmann waves exceeding 400 m/s**, well above the isothermal ion acoustic speed, during strong electrojet conditions (*JGR, 2003*).

8. During the annular solar eclipse event of 15 January 2010, used an ionosonde at Trivandrum to show, for the first time, experimental cum analytical evidence for the reversal of zonal electric within the electrojet region leading to the creation of a **reverse fountain effect which suppresses the Equatorial Ionization Anomaly (EIA).** Such reverse fountain led to the severe impacts on the distribution of plasma in entire low latitude ionospheric region (*JGR*, *2011*).
9. Using measurements from Ionosonde at Trivandrum, during the solar eclipse of 2010, showed how the electrodynamical plasma processes lead to the occurrence of the double Pre-Reversal Enhancement (PRE) in the equatorial F-region at the time of maximum solar obscurity during an annular solar eclipse (GRL, 2011). PRE is a post-evening phenomena.
10. Using an Ionosonde at Trivandrum, and incoherent backscatter radar at Jicaramca, we conclusively proved that the Pre-Reversal **Enhancement in the height of F-region Peak electron density during pre-sunrise** period is purely a **chemical effect** and electrodynamics plays only a secondary role, if any. Since last six decades, PRE during pre-surise period was believed to be an aftereffect of electrodynamics processes (GRL, 2013, 2014).
11. Used the Indian MST Radar in the discovery of **sporadic ionization associated with Kelvin-Helmholtz (KH) billows. D**emonstrated, for the first time, how the **breaking of an originally uniform sporadic E layer into pieces by the Kelvin Helmholtz billows resulted in the quasi-periodic alignments of field aligned irregularities** (*JGR 2005*).
12. Demonstrated **the ionospheric impact on the temperature** measured by GPS based **Radiosonde**s, particularly in the low latitude regions. It was shown that the atmospheric temperature, estimated by GPSsondes, were varying in unison with the Total Electron Content of the ionosphere (GRL, 2013). This result would have a **great impact on the studies related to climate change and global warming.**

Dr. R.K. Choudhary

List of Publications

2023

- ✔ The particularly clean response of the Indian sector to a strong but short lived geomagnetic storm; Choudhary, R. K., St.-Maurice, J.-P., and Ambili, K. M., ***Advances in Space Research***. https://doi.org/10.1016/j.asr.2023.05.048, 2023
- ✔ The role of the storm-time prompt penetrating electric field on the net distribution of plasma density over the low latitude ionospheric regions; K.M. Ambili, and R.K. Choudhary, ***Advances in Space Research, ISSN 0273-1177***, https://doi.org/10.1016/j.asr.2023.04.046. , 2023
- ✔ Venusian ionosphere during deep solar minima: Some new insights using Akatsuki radio science experiment. Tripathi, K.R., Choudhary, R.K., Ambili, K.M. and Imamura, T., ***Journal of Geophysical Research: Planets***, p.e2023JE007768, 2023
- ✔ Gravity wave modulations at the lower altitudes of Venus ionosphere; Tripathi, K. R., Choudhary, R. K., Jose, J. S., Ambili, K. M., & Imamura, T. ***Geophysical Research Letters***, *50*(4), e2022GL101793. 2023

2022

- ✔ On the impact of meridional wind circulation changes in the electron density distribution over the Indian equatorial and low latitude ionospheric region during a severe geomagnetic storm, K. M. Ambili, and R K Choudhary, ***Advances in Space Research (2022),***
- ✔ On the estimation of frequency residuals in a radio occultation experiment, Keshav R Tripathi, R K Choudhary, Lakshmi Jayalal, ***Monthly Notices of the Royal Astronomical Society,*** Volume 517, Issue 1, November 2022, Pages 776–786, *https://doi.org/10.1093/mnras/stac2653*
- ✔ On the origin and characteristic features of the V_1 layer in Venus ionosphere using Akatsuki radio science experiment and the one-dimensional photochemical model, K M Ambili, K R Tripathi, R K Choudhary, T Imamura, ***Monthly Notices of the Royal Astronomical Society***, Volume 516, Issue 4, November 2022, Pages 5555–5562, *https://doi.org/10.1093/mnras/stac2624*
- ✔ Temperature Perturbations in the Troposphere and Lower Stratosphere Over a Semi-arid Region During the 2010 Solar Eclipse. Kumar, Vinay, S. B. Prasad, K. Krishna Reddy, S. K. Dhaka, R. K. Choudhary, M. Venkatarami Reddy, and Shu-Peng Ho, ***Pure and Applied Geophysics*** (2022): 1-13. *https://doi.org/10.1007/s00024-022-03045-5*
- ✔ On the significant impact of the 17 March 2015 St. Patrick's Day geomagnetic storm on the ionosphere over Indian region, Mridula, N., Manju, G., Sijikumar, S., Pant, T. K., and Choudhary, R. K. , ***Advances in Space Research,*** *70*(11), 3674-3685. 2022
- ✔ Dynamical effect on static stability of the Venus atmosphere simulated using a general circulation model: A comparison with radio occultation measurements. Ando, H., Takaya, K., Takagi, M., Sugimoto, N., Imamura, T., Sagawa, H., et al.

Journal of Geophysical Research: Planets (2022), 127, e2021JE006957. *https://doi.org/10.1029/2021JE006957*.

- ✔ A study on the characteristic features of the lunar ionosphere using dual frequency radio science (DFRS) experiment onboard Chandrayaan-2 orbiter K. R. Tripathi, R K Choudhary, K. M. Ambili, R. Manikantan, and Umang Parikh, ***Monthly Notices of the Royal Astronomical Society Letters*** *(2022)*, https://doi.org/10.1093/mnrasl/slac058, 2022
- ✔ Quantification of errors in the planetary atmospheric profiles derived from radio occultation measurements, K. R. Tripathi, and R K Choudhary, ***Earth and Space Science*** *(2022)* , https://doi.org/10.1029/2022EA002326, 2022
- ✔ Characteristic features of V0 layer in the Venus ionosphere as observed by the Akatsuki orbiter : evidence for its presence during the local noon and post-sunset conditions, K. R. Tripathi, R K Choudhary, K. M. Ambili, T. Imamura, and H. Ando, ***Geophysical Res. Letters*** *(2022)* , 49, e2022GL097824. https://doi.org/10.1029/2022GL097824
- ✔ A study on the solar coronal dynamics during the post-maxima phase of the solar cycle 24 using S-band radio signals from the indian mars orbiter mission. Jain, R.N., Choudhary, R.K., Bhardwaj, A., Parikh, U. and Dai, B.K., **Monthly Notices of the Royal Astronomical Society,** 2022.
- ✔ Three-dimensional distribution of ions and electrons in the lunar ionosphere originated from the photochemical reactions, K M Ambili, and R K Choudhary, **Monthly Notices of the Royal Astronomical Society,** 2021; *https://doi.org/10.1093/mnras/stab3734*, 2022

2021

- ✔ A study on latitudinal variations of daytime and nighttime amplitude scintillations observed by GSATs over Indian sector, Sreekumar Haridas, K. Unnikrishnan, *and* R. K. Choudhary; AIP Conference Proceedings 2379, 020001 *https://doi.org/10.1063/5.0058292*, 2021
- ✔ The response of the D and E regions of the equatorial ionosphere to solar flare events; P. G. Gopika, K. M. Ambili, and R. K. Choudhary, R. K.; **Journal of Geophysical Research: Space Physics,** 126, e2021JA029350; *https://doi.org/10.1029/2021JA029350*, 2021
- ✔ A study on seasonal and latitudinal variations of Fresnel frequency and drift velocity of amplitude scintillation over Indian sector, M. S. Soumya, K. Unnikrishnan, Sreekumar Haridas, P. Dinil Bose, *and* R. K. Choudhary , AIP Conference Proceedings 2379, 020005 *https://doi.org/10.1063/5.0058299*, 2021
- ✔ Prediction of Total Electron Content (TEC) using Neural Network over Anomaly Crest Region Bhopal; S. Sahu, R. Trivedi, R. K. Choudhary, A. Jain, and S. Jain ; **Advances in Space Research,** *68*(7), pp.2919-2929; *https://doi.org/10.1016/j.asr.2021.05.027*, 2021
- ✔ Identifying equatorial plasma bubble evolution with scintillation index–A case study, Remya S. Nair, K. Unnikrishnan, Sreekumar Haridas, *and* R. K Choudhary, AIP Conference Proceedings 2379, 020007; *https://doi.org/10.1063/5.0058301*, 2021
- ✔ A study on equatorial plasma bubbles over Indian sub-continent using various satellite constellations and techniques, Sreekumar Haridas, K. Unnikrishnan, R. K. Choudhary, Dinil Bose P., *and* P. B. Rao , AIP Conference Proceedings 2379, 020003, *https://doi.org/10.1063/5.0058294*, 2021

✔ A study on the various modes of parallel heat conduction in the coronal loops of small and large solar flares using scaling laws; Pramod Kumar, and Choudhary R.K., **Solar Physics**, *https://doi.org/10.1007/s11207-021-01884-4*, 2021.

✔ Asmar, S., et al., Solar System Interiors, Atmospheres, and Surfaces Investigations via Radio Links: Goals for the Next Decade. *Bulletin of the American Astronomical Society*, *53*(4), p.109. *https://doi.org/10.3847/25c2cfeb.9d29ef85*, 2021

✔ Interaction between nighttime MSTID and mid-latitude field-aligned plasma depletion structure over the transition region of geomagnetic low-mid latitude: First results from Hanle, India; Yadav, V., Rathi, R., Gaur, G., Sarkhel, S., Chakrabarty, D., Krishna, M.S., Chaitanya, P.P., Patra, A.K., Choudhary, R.K., Pant, T.K. and Upadhayaya, A.K.; ***Journal of Atmospheric and Solar-Terrestrial Physics***, *217*, p.105589, 2021

2020

✔ Nighttime enhancements in the VTEC at anomaly crest region Bhopal: Solar and magnetic activity effects, Sahu, S., Pal, A., Choudhary, R.K., Jain, A. and Jain, S., ***Advances in Space Research***, *66*(10), pp.2289-2301, 2020.

✔ Geomagnetic storm induced plasma density enhancements in the southern polar ionospheric region : a comparative study using St. Patrick's day storms of 2013 and 2015, Shreedevi P.R, R. K. Choudhary, et al., **Space Weather,** e2019SW002383, 2020

✔ Reverse fountain and the nighttime enhancement in the ionospheric electron density over the equatorial region: A case study; Yadav, Sneha, R. K. Choudhary, Jyoti Kumari, Surendra Sunda, P. R. Shreedevi, and Tarun K. Pant. **Journal of Geophysical Research: Space Physics**: e2019JA027286., 2020

✔ Mid-latitude Spread-F structures over the geomagnetic low-mid latitude transition region: An observational evidence; Sivakandan, M., S. Mondal, S. Sarkhel, D. Chakrabarty, M. V. Sunil Krishna, P. Pavan Chaitanya, A. K. Patra et al. **Journal of Geophysical Research: Space Physics:** e2019JA027531, 2020

✔ Thermal structure of the Venusian atmosphere from the sub-cloud region to the mesosphere as observed by radio occultation; Ando, H., Imamura, T., Tellmann, S., Pätzold, M., Häusler, B., Sugimoto, N., Takagi, M., Sagawa, H., Limaye, S., Matsuda, Y. and Choudhary, R.K., ; **Nature Scientific Reports**, *10*(1), pp.1-7, 2020

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✔ Dual Frequency Radio Science experiment onboard Chandrayaan-2: a radio occultation technique to study temporal and spatial variations in the surface-bound ionosphere of the Moon; Choudhary, R.K., Bindu, K.R., Harshit, K., Karkara, R., Ambili, K.M., Pant, T.K., Shenoy, D., Kumar, C., Reddy, N., Rajendran, T.K. and Nazer, M., **Current Science** *(00113891)*, *118*(2), 2020

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the Equatorial Ionosphere, Sneha Yadav, C. Vineeth, K. Kishore Kumar, R.K. Choudhary, T.K. Pant, and S. Sunda; **Journal of Geophysical Research**, 124, 6047-6-63, 2019

✔ Morphological study on the ionospheric variabilities at Bharati, a polar cusp station in the southern hemisphere. Shreedevi P. R., and R. K. Choudhary, **Journal of Atmospheric and Solar-Terrestrial Physics**, 193,105018, 2019

2018

✔ On the relative roles of the neutral density and photo chemistry on the solar zenith angle variations in the V2 layer characteristics of the Venus ionosphere under different solar activity conditions, Ambili K.M., Sneha Susan Babu, and R. K. Choudhary, **Icarus**, 321, 661-670, 2018

✔ Variation of the TEC at a dip equatorial station, Trivandrum and a mid latitude station, Hanle during the descending phase of the solar cycle 24 (2014–2016). Shreedevi, P.R., R.K. Choudhary, S. Yadav, S. Thampi, and A. Ajesh; **Journal of Atmospheric and Solar-Terrestrial Physics**, *179*, pp.425-434, 2018

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2017

✔ Impact of oscillating IMF B z during 17 March 2013 storm on the distribution of plasma over Indian low-latitude and mid-latitude ionospheric regions. Shreedevi, P. R., & R. K. Choudhary, ***Journal of Geophysical Research: Space Physics*****,** 122, 11,607 –11,623. https://doi.org/10.1002/ 2017JA023980, 2017

✔ Impact of sudden stratospheric warming of 2009 on the equatorial and low-latitude ionosphere of the Indian longitudes: A case study. Yadav, S., T. K. Pant, R. K. Choudhary, C. Vineeth, S. Sunda, K. K. Kumar, and S. Mukherjee; ***Journal of Geophysical Research: Space Physics*****,** 122. https://doi.org/10.1002/2017JA024392, 2017

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2016

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